

INSTRUMENT MECHANIC (CHEMICAL PLANT)

NSQF LEVEL - 4

1st Year

TRADE THEORY

SECTOR : CHEMICALS AND PETROCHEMICALS

(As per revised syllabus July 2022 - 1200 Hrs)



Directorate General of Training

**DIRECTORATE GENERAL OF TRAINING
MINISTRY OF SKILL DEVELOPMENT & ENTREPRENEURSHIP
GOVERNMENT OF INDIA**



**NATIONAL INSTRUCTIONAL
MEDIA INSTITUTE, CHENNAI**

Post Box No. 3142, CTI Campus, Guindy, Chennai - 600 032

Sector : Chemicals & Petrochemicals

Duration : 2 Years

**Trades : Instrument Mechanic (Chemical Plant) - 1st Year - Trade Theory - NSQF Level - 4
(Revised 2022)**

Developed & Published by



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FOREWORD

The Government of India has set an ambitious target of imparting skills to 30 crores people, one out of every four Indians, by 2020 to help them secure jobs as part of the National Skills Development Policy. Industrial Training Institutes (ITIs) play a vital role in this process especially in terms of providing skilled manpower. Keeping this in mind, and for providing the current industry relevant skill training to Trainees, ITI syllabus has been recently updated with the help of Media Development Committee members of various stakeholders viz. Industries, Entrepreneurs, Academicians and representatives from ITIs.

The National Instructional Media Institute (NIMI), Chennai, has now come up with instructional material to suit the revised curriculum for **Instrument Mechanic (Chemical Plant) - 1st Year - Trade Theory NSQF Level - 4 (Revised 2022) in Chemicals & Petrochemicals Sector** under Yearly Pattern. The NSQF Level - 4 (Revised 2022) Trade Theory will help the trainees to get an international equivalency standard where their skill proficiency and competency will be duly recognized across the globe and this will also increase the scope of recognition of prior learning. NSQF Level - 4 (Revised 2022) trainees will also get the opportunities to promote life long learning and skill development. I have no doubt that with NSQF Level - 4 (Revised 2022) the trainers and trainees of ITIs, and all stakeholders will derive maximum benefits from these Instructional Media Packages IMPs and that NIMI's effort will go a long way in improving the quality of Vocational training in the country.

The Director General of Training, Executive Director & Staff of NIMI and members of Media Development Committee deserve appreciation for their contribution in bringing out this publication.

Jai Hind

ATUL KUMAR TIWARI, I.A.S

Secretary

Ministry of Skill Development & Entrepreneurship,
Government of India.

July 2024

New Delhi - 110 001

PREFACE

The National Instructional Media Institute (NIMI) was established in 1986 at Chennai by then Directorate General of Employment and Training (D.G.E & T), Ministry of Labour and Employment, (now under Directorate General of Training, Ministry of Skill Development and Entrepreneurship) Government of India, with technical assistance from the Govt. of Federal Republic of Germany. The prime objective of this Institute is to develop and provide instructional materials for various trades as per the prescribed syllabus under the Craftsman and Apprenticeship Training Schemes.

The instructional materials are created keeping in mind, the main objective of Vocational Training under NCVET/NAC in India, which is to help an individual to master skills to do a job. The instructional materials are generated in the form of Instructional Media Packages (IMPs). An IMP consists of Theory book, Practical book, Test and Assignment book, Instructor Guide, Audio Visual Aid (Wall charts and Transparencies) and other support materials.

The trade practical book consists of series of exercises to be completed by the trainees in the workshop. These exercises are designed to ensure that all the skills in the prescribed syllabus are covered. The trade theory book provides related theoretical knowledge required to enable the trainee to do a job. The test and assignments will enable the instructor to give assignments for the evaluation of the performance of a trainee. The wall charts and transparencies are unique, as they not only help the instructor to effectively present a topic but also help him to assess the trainee's understanding. The instructor guide enables the instructor to plan his schedule of instruction, plan the raw material requirements, day to day lessons and demonstrations.

IMPs also deals with the complex skills required to be developed for effective team work. Necessary care has also been taken to include important skill areas of allied trades as prescribed in the syllabus.

The availability of a complete Instructional Media Package in an institute helps both the trainer and management to impart effective training.

The IMPs are the outcome of collective efforts of the staff members of NIMI and the members of the Media Development Committees specially drawn from Public and Private sector industries, various training institutes under the Directorate General of Training (DGT), Government and Private ITIs.

NIMI would like to take this opportunity to convey sincere thanks to the Directors of Employment & Training of various State Governments, Training Departments of Industries both in the Public and Private sectors, Officers of DGT and DGT field institutes, proof readers, individual media developers and coordinators, but for whose active support NIMI would not have been able to bring out this materials.

Chennai - 600 032

EXECUTIVE DIRECTOR

ACKNOWLEDGEMENT

National Instructional Media Institute (NIMI) sincerely acknowledges with thanks for the co-operation and contribution extended by the following Media Developers and their sponsoring organisation to bring out this IMP (**Trade Theory**) for the trade of **Instrument Mechanic (Chemical Plant)** under the **Chemicals & Petrochemicals** Sector for ITIs.

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Shri. Nirmalya Nath	-	Deputy Director, NIMI, Chennai - 32.
Shri. V. Gopala Krishnan	-	Manager, NIMI, Chennai - 32.

NIMI records its appreciation of the Data Entry, CAD, DTP Operators for their excellent and devoted services in the process of development of this Instructional Material.

NIMI also acknowledges with thanks, the invaluable efforts rendered by all other staff who have contributed for the development of this Instructional Material.

NIMI is grateful to all others who have directly or indirectly helped in developing this IMP.

INTRODUCTION

TRADE PRACTICAL

The trade practical manual is intended to be used in practical workshop. It consists of a series of practical exercises to be completed by the trainees during the course of the **Instrument Mechanic (Chemical Plant) 1st Year** trade supplemented and supported by instructions/ informations to assist in performing the exercises. These exercises are designed to ensure that all the skills in compliance with NSQF LEVEL - 4 (Revised 2022) syllabus are covered.

This manual is divided into ten modules. The ten modules are given below

Module 1	Safety & Basic Chemistry
Module 2	Basic Fitting
Module 3	Metal Joining Methods
Module 4	Basic Physics
Module 5	Basic Electricity
Module 6	Electrical Measuring Instruments
Module 7	Soldering & Desoldering
Module 8	Basic Electronics
Module 9	Voltage Regulator & Electronic Power Supply Circuit
Module 10	Computer Hardware

The skill training in the shop floor is planned through a series of practical exercises centred around some practical project. However, there are few instances where the individual exercise does not form a part of project.

While developing the practical manual a sincere effort was made to prepare each exercise which will be easy to understand and carry out even by below average trainee. However the development team accept that there is a scope for further improvement. NIMI, looks forward to the suggestions from the experienced training faculty for improving the manual.

TRADE THEORY

The manual of trade theory consists of theoretical information for the Course of the **Instrument Mechanic (Chemical Plant) 1st Year NSQF Level - 4 (Revised 2022) in Chemicals & Petrochemicals**. The contents are sequenced according to the practical exercise contained in NSQF Level - 4 (Revised 2022) syllabus on Trade Theory attempt has been made to relate the theoretical aspects with the skill covered in each exercise to the extent possible. This correlation is maintained to help the trainees to develop the perceptual capabilities for performing the skills.

The trade theory has to be taught and learnt along with the corresponding exercise contained in the manual on trade practical. The indications about the corresponding practical exercises are given in every sheet of this manual.

It will be preferable to teach/learn trade theory connected to each exercise at least one class before performing the related skills in the shop floor. The trade theory is to be treated as an integrated part of each exercise.

The material is not for the purpose of self-learning and should be considered as supplementary to class room instruction.

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LEARNING / ASSESSABLE OUTCOME

On completion of this book you shall be able to

S.No	Learning Outcome	Ref. Ex.No.
1	Separate the mixture of liquids and prepare standard solutions. Perform various types of titration and separate elements from mixtures. Measure PH, and conductivity of various substances following safety precautions. (NOS:MIN/N9461)	1.1.01 - 12
2	Perform basic workshop operations using suitable tools for measuring, holding, cutting, filing, riveting, drilling, reaming and threading. Observing suitable care & safety. (NOS:MIN/N9462)	1.2.13 - 38
3	Plan and organize the work in familiar predictable/routine environment for different types of welding/riveting/reaming and allied operations (NOS:MIN/N9463)	1.3.39 - 51
4	Apply and execute various physical properties of materials and verify different physical laws by operating various instruments. (NOS:MIN/N9464)	1.4.52 - 66
5	Identify, test various electrical components using proper measuring instruments and apply this knowledge to troubleshoot power supplies. (NOS:MIN/N9465)	1.5.67 - 71
6	Select and execute electrical/electronic measurement of single range meters and calibrate the instrument and record the data. (NOS:MIN/N9466)	1.6.72 - 96
7	Plan and execute soldering & desoldering of various electrical/electronic components in different circuits. (NOS:MIN/N9467)	1.7.97 - 102
8	Test various electronic components using proper measuring instruments and compare the data using standard parameter. (NOS:MIN/N9468)	1.8.103 - 121
9	Assemble simple voltage regulators and electronic power supply circuit and test for functioning. (NOS:MIN/N9469)	1.9.122 - 129
10	Perform basic computer hardware like identify of various parts, connect cables, replace parts, and test of desktop computer. (NOS:MIN/N9470)	1.10.130 - 149

SYLLABUS FOR INSTRUMENT MECHANIC (CHEMICAL PLANT)

Duration	Reference Learning Outcome	Professional Skill (Trade Practical) (With indicative hour)	Professional Knowledge (Trade Theory)
Professional Skill 100Hrs.; Professional Knowledge 20Hrs.	Separate the mixture of liquids and prepare standard solutions. Perform various types of titration and separate elements from mixtures. Measure PH, and conductivity of various substances following safety precautions.(NOS:MIN/ N9461)	Trade and Orientation 1 Visit to various sections of the institute and identify location of various installations. (05 hrs.) 2 Identify safety signs for danger, warning, caution & personal safety message. (03 hrs.) 3 Use of personal protective equipment (PPE). (05 hrs.) 4 Practice elementary first aid. (05 hrs.) 5 Preventive measures for electrical accidents & steps to be taken in such accidents. (02 hrs.) 6 Use of Fire extinguishers. (05 hrs.) 7 Familiarization with glassware used in chemical lab (20 hrs.) 8 Find out action of acids & bases on metals and alloys. (10 hrs.) 9 Determine PH of different solutions by using Ph paper & PH meter. (15 hrs.) 10 Determine boiling point of different liquids. (07 hrs.) 11 Determine melting point of different solids. (09 hrs.) 12 Measure conductivity of different liquids using conductivity meter. (14 hrs.)	Familiarization with the working of Industrial Training Institute system. Importance of safety and precautions to be taken in the industry/shop floor. Introduction to PPEs. Introduction to First Aid. Response to emergencies e.g., power failure, fire, and system failure. Importance of housekeeping & good shop floor practices. Occupational Safety & Health: Health, Safety and Environment guidelines, legislations & regulations as applicable. (04hrs.) Atom, molecule, Element, compound, mixture, Physical change, chemical change, Acids, bases, salts-their properties. Molecular weight, equivalent weight, atomic weight, Normality, molarity. Metals & Non-Metals Water- sources, hard and soft water, causes and removal of hardness, water for industrial purposes. Introduction to Effluent treatment plant (CETP). Corrosion- causes, effects and prevention. Allotropy of hydrogen, carbon, phosphorus and Sulphur ORGANIC CHEMISTRY: Introduction, purification processes, organic reactions substitution, addition, Elimination, rearrangement reactions, examples. Nomenclature-Basic rules for Common name & IUPAC name system for alkanes, alkenes & alkynes, their examples, Definition of pH, pH scale, measurement of pH. Conductivity. (16hrs.)
Professional Skill 175Hrs.; Professional Knowledge 32Hrs.	Perform basic workshop operations using suitable tools for measuring, holding, cutting, filing, riveting,	Hand tools and their uses 13 Identify the different hand tools. (05 hrs.) 14 Selection of proper tools for operation and precautions in operation. (07 hrs.)	Description, construction and uses of different hand tools such as Files, Chisels, Hacksaw & Hammer, etc. Description, construction and uses of different marking tools such as steel rule, caliper, punches, scribing block, etc. (07hrs.)

drilling, reaming and threading. Observing suitable care & safety. (NOS:MIN/N9462)	15 Care & maintenance of trade tools. (07 hrs.) 16 Practice safety precautions while working in fitting jobs.(10 hrs.) 17 Workshop practice on filing and hacks awing. (10 hrs.) 18 Practice simple fitting job in workshop, fitting and drilling. (08 hrs.)	
	19 Cut square size job as per drawing from MS flat by using hacksaw blade. (10 hrs.) 20 Hold the job using bench vice. (01 hr.) 21 Measure the selected job using steel rule, calipers and Vernier caliper. (07 hrs.) 22 Prepare edges of square size job using proper tools and equipment. (15 hrs.) 23 Finally check flatness and squareness using try square, surface gauges etc. (04 hrs.)	JOB HOLDING DEVICES : Description, construction and uses of different job holding devices such as vice, 'V' Block. (08hrs.)
	24 Hold the job using bench vice. (01 hrs.) 25 Prepare another four edges job using proper tools and equipments. (10 hrs.) 26 Measure all dimension using measuring instruments like steel rule, caliper, vernier caliper etc. (05 hrs.) 27 Mark parallel lines & curve lines using scribe, divider, surface gauge and dot punch. (05 hrs.)	LINEAR MEASUREMENT : Description, construction, calculation and uses of different Linear Measuring Instruments - Vernier Caliper, Vernier Depth gauge, Height gauge, Micrometer outside, Bevel protector.(03hrs.)
	28 Make simple step fitting job (male and female) (28 hrs.) 29 Mark drilling position on a job. (03 hrs.) 30 Operate centre drill for drilling a hole. (05 hrs.)	LINEAR MEASUREMENT : Description, construction, calculation and uses of different Linear Measuring Instruments - Vernier Caliper, Vernier Depth gauge, Height gauge, Micrometer outside, Bevel protector.(08hrs.)
	31 Practice of drilling (06 hrs.) 32 Determine the reaming drill size. (01 hrs.) 33 Practice of reaming (03 hrs.) 34 Practice of counter sinking (04 hrs.) 35 Practice of counter boring. (04 hrs.)	DRILLING, REAMING AND THREADING : Nomenclature and uses of Drill, Reamer, and Thread. (03hrs.)
	36 Determine the tap drill size for internal threading. (03 hrs.) 37 Make BSW or Metric thread using tap. (05 hrs.) 38 Make BSW or Metric thread using die. (08 hrs.)	THREADS : Description, nomenclature and uses of different types of threads - metric, BSW, BSF, BSP etc. Calculation of tap drill size.(03 hrs.)

Professional Skill 75Hrs.; Professional Knowledge 14Hrs.	Plan and organize the work in familiar predictable/routine environment for different types of welding/riveting/seaming and allied operations (NOS:MIN/N9463)	39 Use safety equipment in relevant workshop. (10hrs.) 40 Take general precaution in welding workshop. (07hrs.)	GAS WELDING SAFETY : Safety & General precautions observed in welding workshop. Importance of Welding in maintenance of chemical plant and equipment's. Welding terms and their definition. Types of welding. (03 hrs.)
		41 Copper tube fitting flaring practice (02 hrs.) 42 Copper tube fitting ferrule joint (02 hrs.) 43 Fit nut and bolt with over pipe flanges. (06hrs.) 44 Practice riveting on metal sheet. (06hrs.) 45 Practice seaming on metal sheet. (06hrs.)	METAL JOINING METHOD : General introduction about Mechanical method (Riveting, Nut bolting, Seaming etc.) Thermal method (Soldering, Brazing & Welding) (03hrs.)
		46 Practice lightening. (04hrs.) 47 Practice carburizing flame adjustment. (05hrs.) 48 Practice Neutral flame adjustment. (04hrs.) 49 Practice Oxidize flame adjustment. (05hrs.)	GAS WELDING : Principal of Gas Welding. Safety precaution before, after & during Gas Welding. Common Gas used in Welding OXY-ACETYLENE WELDING : Equipment's such as cylinder trolley, regulator, blow pipe, Hose pipe, Assembling, care & maintenance. (03 hrs.)
		50 Prepare edges using file, try square, steel rule, vernier caliper etc. (10hrs.) 51 Prepare edge joint using arc welding/gas welding with or without filler rod. (08hrs.)	OXY-ACETYLENE FLAME : Types of flame, uses & Effect of Atmospheric oxidation. (05 hrs.)
Professional Skill 75 Hrs.; Professional Knowledge 14Hrs.	Apply and execute various physical properties of materials and verify different physical laws by operating various instruments.(NOS:MIN/N9464)	52 Verify law of parallelogram of force using mechanical board. (04 hrs.) 53 Determine co-efficient of static friction by inclined plane. (04 hrs.) 54 Determine mechanical advantage, velocity ratio and percentage efficiency of Simple Machine. (08 hrs.) 55 Operate simple machine e.g., Lever, Pulley, Block & Screw Jack. (04 hrs.) 56 Determine Young's Modulus. By Searle's apparatus. (05 hrs.) 57 Verify Ohm's law. (05 hrs.) 58 Measure Electric cell parameters by series & parallel connection. (06 hrs.) 59 Determine specific resistance using Wheatstone's bridge. (06 hrs.) 60 Verify Faraday's first law of electrolysis. (06 hrs.)	PHYSICS Introduction to Physics, Measurement with Vernier caliper, Micrometer, Wire gauge. Scalar and Vector quantities, their representation, resultant. Triangle and parallelogram laws of forces. Newton's laws of motion, Inertia, force, momentum, types of force. Friction definition, unit, types of friction, laws of friction, advantages and disadvantages of friction. ELASTICITY : Stress, strain, elastic limit, Hooke's law. Types of modulus of elasticity, work done in a stretching wire, determination of Young's modulus

		61 Determine mechanical equivalent of heat by Joule's method. (08 hrs.) 62 Determine co-efficient of expansion of solid. (04 hrs.) 63 Determine co-efficient of expansion of liquid. (03 hrs.) 64 Determine co-efficient of thermal conductivity of metal rod. (05 hrs.) 65 Determination of density of solid. (04 hrs.) 66 Determination of density of liquid. (03 hrs.)	CURRENT ELECTRICITY : Ohm's law, series & parallel connections, specific resistance, Kirchhoff's law, Wheatstone's bridge, applications of Wheatstone bridge. ELECTROLYSIS : Faraday's laws of electrolysis. Thermodynamics- first law of thermodynamics, mechanical equivalent of heat, 'J' by electrical method. Modes of heat transfer, determination of thermal conductivity. Temperature & its measurement, expansion of solid, liquid and gases. (14 hrs.)
Professional Skill 50 Hrs.; Professional Knowledge 07Hrs.	Identify, test various electrical components using proper measuring instruments and apply this knowledge to troubleshoot power supplies. (NOS:MIN/ N9465)	BASIC ELECTRICITY : 67 Identify $\pm$ polarities. (07 hrs.) 68 Identify various electrical components with symbols. (12 hrs.) 69 Use various electrical components. (15 hrs.) 70 Measure electrical wire size using SWG (standard wire gauge) and micrometer. (06 hrs.) 71 Measure voltage, current & resistance. (10 hrs.)	BASICS ELECTRICAL : Conductor, semiconductor & insulators. Standard wire gauge (SWG). Introduction of electricity-static electricity. Current, voltage, P.D, E.M.F, resistance. Their units. Electrical circuit - D.C & A.C circuit differences. Importance of grounding. TYPES OF SWITCHES: SPST, SPDT, DPST, DPDT, Toggle, etc. (07 hrs.)
Professional Skill 80 Hrs.; Professional Knowledge 16Hrs.	Select and execute electrical/ electronic measurement of single range meters and calibrate the instrument and record the data. (NOS:MIN/ N9466)	ELECTRICAL MEASURING INSTRUMENTS : 72 Dismantle, part testing part repairing, part replacement and assemble, adjustment, calibration, final testing of Moving coil instrument. (02 hrs.) 73 Dismantle, part testing part repairing, part replacement and assemble, adjustment, calibration, final testing of Moving iron instrument. (02 hrs.) 74 Dismantle, part testing part repairing, part replacement and assemble, adjustment, calibration, final testing of Wattmeter. (02 hrs.) 75 Dismantle, part testing part repairing, part replacement and assemble, adjustment, calibration, final testing of P.F.meter. (02 hrs.) 76 Dismantle, part testing part repairing, part replacement and assemble, adjustment, calibration, final testing of frequency meter. (02 hrs.) 77 Dismantle, part testing part repairing, part replacement and assemble, adjustment, calibration, final testing of Energy meter. (02 hrs.)	TYPE OF ELECTRICAL MEASURING INSTRUMENTS : MC & MI, Construction & working principles of Ammeter, Voltmeter, Wattmeter. Energy meter, P.F. meter, frequency meter, multimeter, clamp meter, megger. (08 hrs.)

		78 Measurement of voltage, current & resistance in different circuits using voltmeter, ammeter and multimeter. (03 hrs.) 79 Measure directly & indirectly of electrical power & energy using watt meter and energy meter. (04 hrs.) 80 Calibrate energy meters. (06 hrs.) 81 Test Insulation using megger. (07 hrs.) 82 Insulation to insulation test. (02 hrs.) 83 Conductor to conductor test. (01 hrs.) 84 Conductor to insulator test. (02 hrs.) 85 Measure high current using clamp meter. (03 hrs.)	
		86 Identify different types of resistor (include NTC, PTC, W/W, linear, preset, VDR, LDR) (03 hrs.) 87 Identify different types of capacitors (02 hrs.) 88 Testing of charging and discharging of capacitor. (02 hrs.) 89 Find out polarity of capacitor. (02 hrs.) 90 Examine the behavior of resistance when connected in series and parallel. (04 hrs.) 91 Find values and power rating of resistor. (04 hrs.) 92 Identify resistors and its value Using color code (03hrs.)	RESISTORS : Laws of Resistance. Series, parallel and combination circuits, Different Types of resistors & their properties. Different methods of measuring values of resistance. CAPACITOR : Construction details, charging, discharging, types, uses. Factors on which capacitance depends. Formulae & simple problems. (04 hrs.)
		93 Identify live, neutral and earth on power socket using test lamp. (04 hrs.) 94 Use a tester to monitor AC power. (04 hrs.) 95 Read and interpret the settings, sockets on analog and digital multimeters. (05 hrs.) 96 Measure unwanted voltage between the neutral and ground. Reduce it. (07 hrs.)	BASIC TERMS : Such as electric charges, Potential difference, Voltage, Current, Resistance, Frequency, Amplitude, Single phase and Three phase power. Familiarization with Digital Multimeter. Uses, handling & precautions of Digital Multimeter. (04 hrs.)
Professional Skill 25 Hrs.; Professional Knowledge 07 Hrs	Plan and execute soldering & desoldering of various electrical/electronic components in different circuits. (NOS:MIN/N9467)	97 Identify the different types of soldering gun. (03 hrs.) 98 Preparation of component for soldering, cleaning, tinning, fluxing. (03 hrs.) 99 Select and practice soldering of different electronic active and passive components on PCB. (03 hrs.) 100 Practice de-soldering the components and clean the surface of track on PCB using de-soldering pump/de-soldering wick. (05hrs.)	SOLDERING : Different type of soldering guns, relate temperature with wattages, types of tips. Solder materials and their grading. Use of wax and other materials. Selection of a soldering gun for specific requirement. Soldering and Desoldering stations and their specifications. (07hrs.)

		101 Repair and test the broken PCB track. (05hrs.) 102 Mount digital ICs on verities of PCBs. (06hrs.)	
Professional Skill 80 Hrs.; Professional Knowledge 16Hrs.	Test various electronic components using proper measuring instruments and compare the data using standard parameter. (NOS:MIN/N9468)	103 Find various types of diode (solid state) (05 hrs.) 104 Check various types of diode. (03 hrs.) 105 Find characteristics of diode. (06 hrs.) 106 Find the characteristics of Zener diode. (03 hrs.) 107 Construct and test Zener based voltage regulator circuit. (03 hrs.)	STUDY OF SEMICONDUCTOR : Doping, Intrinsic and extrinsic semiconductor, Covalent bond. PN junction diode, Forward and Reverse characteristics. Specification of diodes (data sheets). Applications of diode. Special semiconductor diode, Zener diode, Photo diode etc. (04hrs.)
		108 Construct rectifiers (half wave) (06 hrs.) 109 Construct rectifiers (full wave) (07 hrs.) 110 Construct bridge (four diodes) for full wave rectifier. (07 hrs.) 111 Construct a rectifier with capacitor filter circuit. (04 hrs.) 112 Construct a rectifier with inductor filter circuit. (04 hrs.) 113 Construct a rectifier with RC filter circuit. (04 hrs.) 114 Find ripple factors in rectifiers. (Half wave and full wave) in various filter circuits. (08 hrs.)	RECTIFIERS : Half wave rectifier, full wave (bridge & center tapped) rectifier. Filters: Introduction, purpose and use of ripple filter. Types of filters. Capacitance filter, inductance filters, RC filters, LC filters, voltage dividers and bypass filters. (08 hrs.)
		115 Identify PNP and NPN transistor. (02 hrs.) 116 Record the different specification of transistor using data book (02 hrs.) 117 Identify the different transistors with respect to different packing style. (02 hrs.) 118 Identify power switching transistor. (03 hrs.) 119 Measure E-B, C-B and C-E terminal resistance and infer (04 hrs.) 120 Identify by its number and testing of FET. (03 hrs.) 121 Identify by its number and testing of MOSFET. (04 hrs.)	TRANSISTORS : Defining transistors, NPN & PNP transistor, Symbol, operation, Biasing of Transistor & mode of Application. Introduction to FET, MOSFET. (04 hrs.)
Professional Skill 100Hrs.; Professional Knowledge 20 Hrs.	Assemble simple voltage regulators and electronic power supply circuit and test for functioning. (NOS:MIN/N9469)	122 Assemble various types of simple fixed voltage regulator on zero PCB. (07hrs.) 123 Assemble variable voltage regulator on zero PCB (07hrs.) 124 Assemble a simple power supply unit regulated 12V, 1Amp. (13 hrs.)	VOLTAGE REGULATORS : Introduction & purpose of Zener regulators, Regulated Power supply using 78XX series, 79XX series, etc.

		125 Identify different fixed $\pm$ voltage regulator ICs of different current ratings (78xx/79xx series) along with i/o, reference pins. (08 hrs.) 126 Identify proper heat sinks for different IC based voltage regulators. (10 hrs.) 127 Verify the input voltage and observe the fixed output for the above-mentioned series. (15 hrs.)	UPS : Types of UPS. Block diagram and working principle of different types UPS. Most frequently occurring faults and their remedies. Concept of UPS, OFFLINE and ONLINE. Difference between Inverters and UPS. (12hrs.)
		128 Modulate various signals using AM and FM on the trainer kit and observe the waveforms. (15 hrs.) 129 Demodulate various signals using AM and FM on the trainer kit and observe the waveforms. (15 hrs.)	ADVANCED COMMUNICATION : Need of Modulation, types of modulation. Demodulation techniques. Introduction to AM, FM & PWM. (08 hrs.)
Professional Skill 80 Hrs.; Professional Knowledge 16Hrs.	Perform basic computer hardware like identify of various parts, connect cables, replace parts, and test of desktop computer.(NOS:MIN/N9470)	Computer Hardware, 130 Identify various indicators, cables, connectors and ports on the computer cabinet. (03 hrs.) 131 Demonstrate various parts of the system unit and motherboard components. (05 hrs.) 132 Identify various computer peripherals and connect it to the system. (04 hrs.) 133 Disable certain functionality by disconnecting the concerned cables SATA / PATA. (05 hrs.) 134 Replace the CMOS battery and extend a memory module. (05 hrs.) 135 Test and Replace the SMPS (04 hrs.) 136 Replace the given DVD and HDD on the system (03 hrs.) 137 Dismantle the desktop computer system. (07 hrs.) 138 Assemble desktop computer system. (07 hrs.) 139 Identify different types of cables and network components e.g., Hub, switch, router, modem etc. (05 hrs.) 140 Prepare terminations, make UTP and STP cable connectors and test. (09 hrs.) 141 Connect network connectivity and wireless connectivity hardware and check for its functioning connectivity (07 hrs.) 142 Boot the system from different options. (05 hrs.) 143 Practice various futures of OS. (04hrs.)	Basic blocks of a computer, Components of desktop and motherboard. Hardware and software, I/O devices, and their working. Different types of printers, HDD, DVD Various ports in the computer. Windows OS MS widows: Starting windows and its operation, file management using explorer, Display & sound properties, screen savers, font management, installation of program, setting and using of control panel., application of accessories, various IT tools and applications Concept of word processing, MS word - Menu bar, standard tool bar, editing, formatting, printing of document etc. Excel - Worksheet basics, data entry and formulae. Moving data in worksheet using tool bars and menu bars, Formatting and calculations, printing worksheet, creating multiple work sheets, creating charts. Introduction to power point Basics of preparing slides, different design aspects of slides, animation with slides etc. Concept of Internet, Browsers, Websites, search engines, email, chatting and messenger service. Downloading the Data and program files etc.

		144 Perform maintenance of computer using standard tools provided in the OS. (02 hrs.) 145 Install the printer driver software and test for prints outs. (01 hr.) 146 Install the antivirus software and scan the system.(02hrs.) 147 Install the MS Office software and test for prints outs. (01 hr) 148 Use start Menu, check available programs in computer.(01 hr) 149 Create folder and files. (01 hr)	Computer Networking : Network features - Network Medias Network topologies, protocols- TCP/ IP, UDP, FTP, models and types. Specification and standards, types of cables, UTP, STP, Coaxial cables. Network components like hub, Ethernet switch, router, NIC Cards, connectors, media and firewall. Difference between PC & Server. (16 hrs)
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Familiarization with the working of industrial institute system

Objectives: At the end of this lesson you shall be able to

- identify the staff structure of the institute
- list the available trades in the institute and their functions
- describe the ITI training system.

Industrial Training Institutes (ITI) plays a vital role in the economic development of the country, especially in terms of providing skilled manpower requirements by training competent, quality craftsmen.

The Directorate General of Training (DGT) comes under the Ministry of Skill Development and Entrepreneurship (MSDE) offers a range of vocational training under engineering and non engineering trades affiliated with the National Council for Vocational Education Training (NCVT) New Delhi. NCVET is the Govt of India body responsible for framing the policies, approving the syllabus for Craftsman Training System (CTS), carrying out the All India Trade Test and issuing the National Trade Certificates (NTC) to the successful candidates.

In India there are about 2293 Govt. ITIs and 10872 Private ITIs. (Based on the Govt. of India, Ministry of Labour Annual report of 2016-2017). The Govt. ITIs in each state functioning under the Directorate of Employment and Training Dept (DET) under the state Govts.

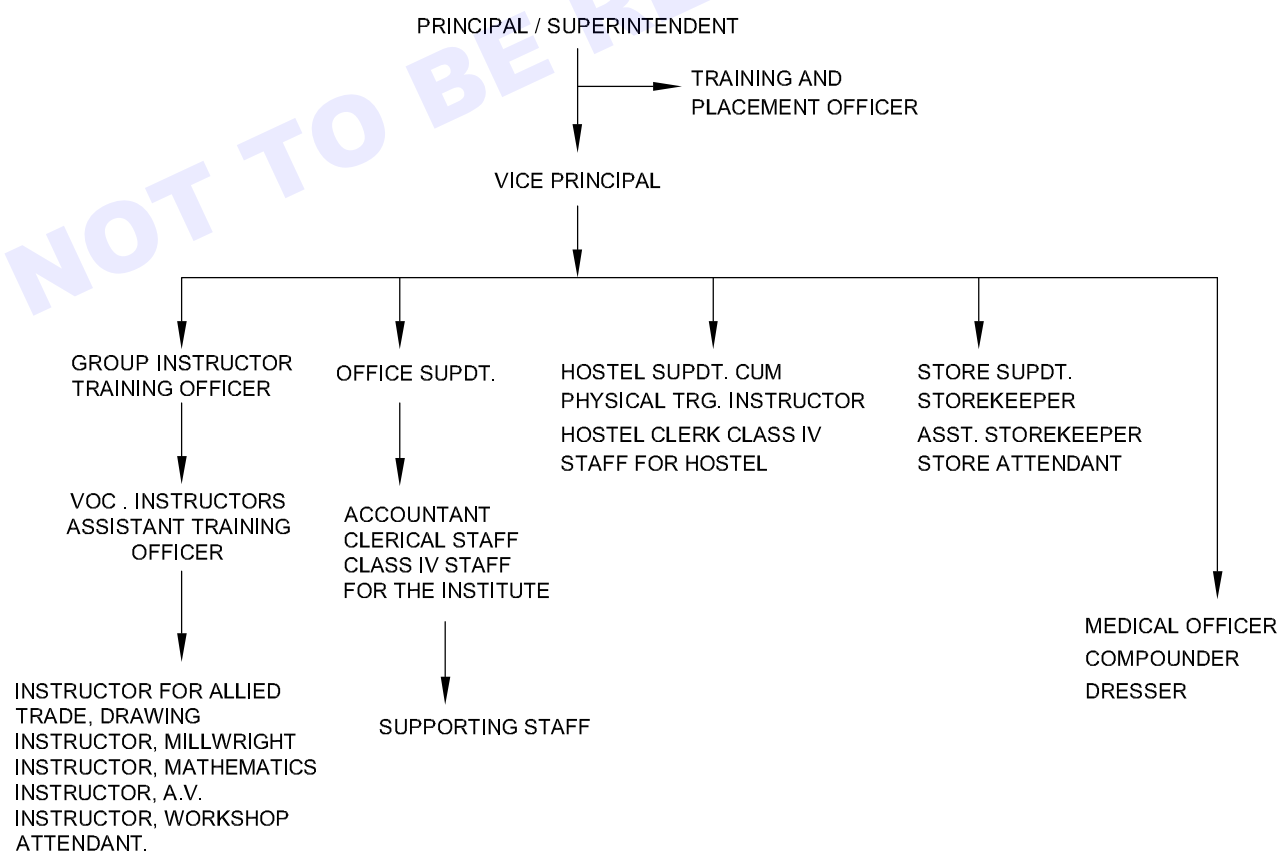
The head of the ITI is the Principal, under whom there is one Vice-Principal, Group Instructor/ Training officer/ A.T.O and a number of trade instructors as shown in the Organisation chart of ITI.

There are 133 trades selected for vocational training and 261 trades identified for Apprenticeship training, according to the requirement of industrial needs and the duration of the training is from 1 year to 2 years.

At present the Electronic Mechanic trade has been included under National Skill Qualification Framework (NSQF) with level - 4 competency. The trainees are advised to make a list of other trades available in their ITI, the type of training and the scope of these trades in getting self employment or job opportunity in the rural and urban areas and also identify the location of the ITI, nearby hospital, fire station and police station etc.

Fig 1

FAMILIARIZATION CHART OF ITI



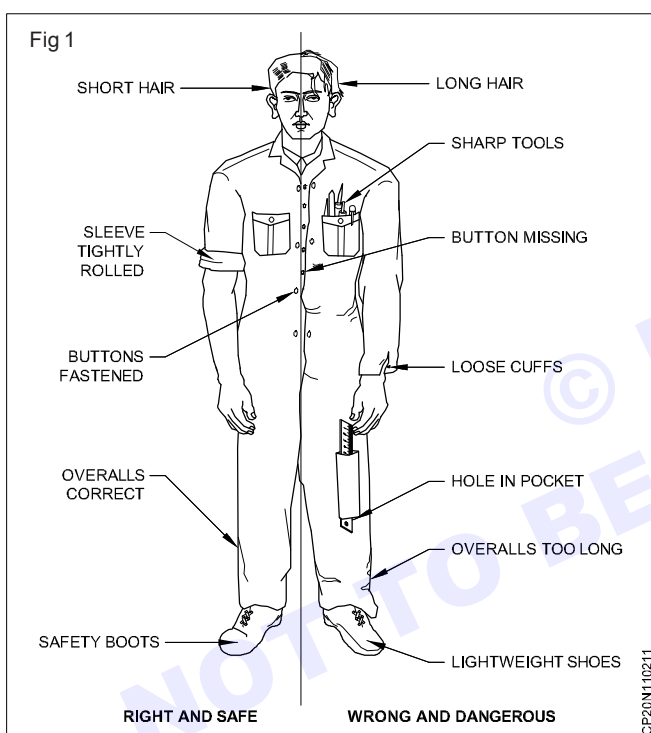
Importance of safety and precautions to be taken in the industry/ shop floor

Objectives: At the end of this lesson you shall be able to

- **state the importance of safety**
- **state the personal safety precautions to be observed**
- **list out the safety precautions to be observed while working on the machines.**

Importance of safety

Generally accidents do not happen; they are caused. Most accidents are avoidable. A Good craftsman, having a knowledge of various safety precautions, can avoid accidents to himself and to his fellow workers and protect the equipment from any damage. To achieve this, it is essential that every person should follow safety procedure. (Fig 1)



Safety in a workshop can be broadly classified into 3 categories.

- General safety
- Personal safety
- Machine safety

General safety

Keep the floor and gangways clean and clear.

Move with care in the workshop, do not run.

Don't leave the machine which is in motion.

Don't touch or handle any equipment/ machine unless authorised to do so.

Don't walk under suspended loads.

Don't cut practical jokes while on work.

Use the correct tools for the job.

Keep the tools at their proper place.

Wipe out split oil immediately.

Replace worn out or damaged tools immediately.

Never direct compressed air at yourself or at your co-worker.

Ensure adequate light in the workshop.

Clean the machine only when it is not in motion.

Sweep away the metal cuttings.

Know everything about the machine before you start it.

Personal safety

Wear a one piece overall or boiler suit.

Keep the overall buttons fastened.

Don't use ties and scarves.

Roll up the sleeves tightly above the elbow.

Wear safety shoes or boots or chain.

Cut the hair short.

Don't wear a ring, watch or chain.

Never lean on the machine.

Don't clean hands in the coolant fluid.

Don't remove guards when the machine is in motion.

Don't use cracked or chipped tools.

Don't start the machine until

- the workpiece is securely mounted
- the feed machinery is in the neutral
- the work area is clear.

Don't adjust clamps or holding devices while the machine is in motion.

Never touch the electrical equipment with wet hands.

Don't use any faulty electrical equipment.

Ensure that electrical connections are made by an authorised electrician only.

Concentrate on your work.

Have a calm attitude.

Do things in a methodical way.

Don't engage yourself in conversation with others while concentrating on your job.

Don't distract the attention of others.

Don't try to stop a running machine with hands.

Machine safety

Switch off the machine immediately if something goes wrong.

Keep the machine clean.

Replace any worn out or damaged accessories, holding devices, nuts, bolts, etc., as soon as possible.

Do not attempt operating the machine until you know how to operate it properly.

Do not adjust tool or the workpiece unless the power is off.

Stop the machine before changing the speed.

Disengage the automatic feeds before switching off.

Check the oil level before starting the machine.

Never start a machine unless all the safety guards are in position.

Take measurements only after stopping the machine.

Use wooden planks over the bed while loading and unloading heavy jobs.

Safety is a concept, understand it.

Safety is a habit, cultivate it.

Safety Sign Boards

Signboards are a common sight in almost all places such as roadways, railways, hospitals, offices, institution, industrial units and so on.

Signboards are visual indicators. The signs on the signboards may be just a symbol, a small text, a figure or a combination of these.

Signboards carry a single clear message. These messages are to ensure safety.

Signboards can be classified into four basic categories.

a Prohibition signs

Indicating a behaviour which is prohibited (not allowed) in that situation or environment. Refer to chart 1 for examples.

b Mandatory signs

Indicating a behaviour which is a must, which when not obeyed may cause accidents. Refer to chart 1 for examples.

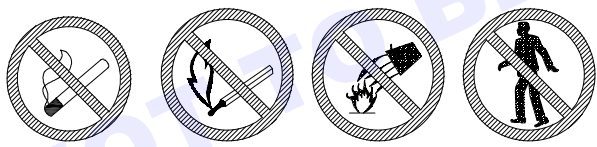
c Warning signs

Indicating a warning such that suitable precaution is taken. Refer to chart 1 for examples.

d Information signs

Giving information which is very useful and reduces waste of time. Refer to chart 1 for examples.

Chart 1

a Prohibition signs  SMOKING AND NAKED FLAMES PROHIBITED DO NOT EXTINGUISH WITH WATER PEDESTRIANS PROHIBITED	Shape Circular. Colour Red border and crossbar. Black symbol on white background. Meaning Shows what must not be done. Example No smoking and naked flames
b Mandatory signs  WEAR HEAD PROTECTION WEAR EYE PROTECTION WEAR HEARING PROTECTION WEAR FOOT PROTECTION WEAR HAND PROTECTION WEAR RESPIRATOR WEAR SAFETY HARNESS/BELT USE ADJUSTABLE GUARD WASH HAND	Shape Circular. Colour White symbol on blue background. Meaning Shows what must not be done. Example Wear hand protection.

c Warning signs



RISK OF FIRE



RISK OF ELECTRIC SHOCK



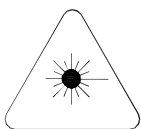
TOXIC HAZARD



CORROSIVE SUBSTANCES



RISK OF IONIZING RADIATION



LASER BEAM



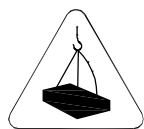
RISK OF EXPLOSION



OVERHEAD (FIXED) HAZARD



GENERAL WARNING RISK OF DANGER



OVERHEAD LOAD



FRAGILE ROOF
WARNING SIGNS



FORK LIFT TRUCK

Shape

Triangular.

Colour

Yellow background with black border and symbols.

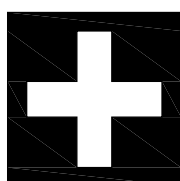
Meaning

Warns of hazard or danger.

Example

Caution, risk of electric shock.

d Information signs



Shape

Square or oblong

Colour

White symbols on green background.

Meaning

Indicates or gives information of safety provision/First aid

Example

Caution, risk of electric shock.

Introduction to PPEs

Objectives: At the end of this lesson you shall be able to

- **state the personal protective equipment and its purpose**
- **list the most common type of personal protective equipment**
- **list the conditions for selection of personal protective equipment.**

Personal protective equipment (PPE)

Devices, equipments, or clothing used or worn by the employees, as a last resort, to protect against hazards in the workplace. The primary approach in any safety effort is that the hazard to the workmen should be eliminated or controlled by engineering methods rather than protecting the workmen through the use of personal protective equipment (PPE). Engineering methods could include design change, substitution, ventilation, mechanical handling, automation, etc. In situations where it is not possible to introduce any effective engineering methods for controlling hazards, the workman shall use appropriate types of PPE.

As changing times have modernized the workplace, government and advocacy groups have brought more safety standards to all sorts of work environments. The Factories Act, 1948 and several other labour legislations 1996 have provisions for effective use of appropriate types of PPE. Use of PPE is an important.

Ways to ensure workplace safety and use personal protective equipment (PPE) effectively.

- Workers to get up-to-date safety information from the regulatory agencies that oversees workplace safety in their specific area.
- To use all available text resources that may be in work area and for applicable safety information on how to use PPE best.
- When it comes to the most common types of personal protective equipment, like goggles, gloves or bodysuits, these items are much less effective if they are not worn at all times, or whenever a specific danger exists in a work process. Using PPE consistently will help to avoid some common kinds of industrial accidents.
- Personal protective gear is not always enough to protect workers against workplace dangers. Knowing more about the overall context of your work activity can help to fully protect from anything that might threaten health and safety on the job.

- Inspection of gear thoroughly to make sure that it has the standard of quality and adequately protect the user should be continuously carried out.

Categories of PPEs

Depending upon the nature of hazard, the PPE is broadly divided into the following two categories:

- 1 **Non-respiratory:** Those used for protection against injury from outside the body, i.e. for protecting the head, eye, face, hand, arm, foot, leg and other body parts
- 2 **Respiratory:** Those used for protection from harm due to inhalation of contaminated air.

They are to meet the applicable BIS (Bureau of Indian Standards) standards for different types of PPE.

The guidelines on 'Personal Protective Equipment' is issued to facilitate the plant management in maintaining an effective programme with respect to protection of persons against hazards, which cannot be eliminated or controlled by engineering methods listed in table 1.

Table 1

No.	Title
PPE1	Helmet
PPE2	Safety footwear
PPE3	Respiratory protective equipment
PPE4	Arms and hands protection
PPE5	Eyes and face protection
PPE6	Protective clothing and cover all
PPE7	Ears protection
PPE8	Safety belt and harnesses

Personal protective equipments and their uses and hazards are as follows

Types of protection	Hazards	PPE to be used
Head Protection (Fig 1)	1 Falling objects 2 Striking against objects 3 Spatter	Helmets

Foot protection (Fig 2)	1 Hot spatter 2 Falling objects 3 Working wet area	Leather leg guards Safety shoes Gum boots
Nose (Fig 3)	1 Dust particles 2 Fumes/ gases/ vapours	Nose mask
Hand protection (Fig 4)	1 Heat burn due to direct contact 2 Blows sparks moderate heat 3 Electric shock	Hand gloves
Eye protection (Fig 5, Fig 6)	1 Flying dust particles 2 UV rays, IR rays heat and High amount of visible radiation	Goggles Face shield Hand shield Head shield
Face Protection (Fig 6, Fig 7)	1 Spark generated during Welding, grinding 2 Welding spatter striking 3 Face protection from UV rays	Face shield Head shield with or without ear muff Helmets with welders screen for welders
Ear protection (Fig 7)	1 High noise level	Ear plug Ear muff
Body protection (Fig 8, Fig 9)	1 Hot particles	Leather aprons

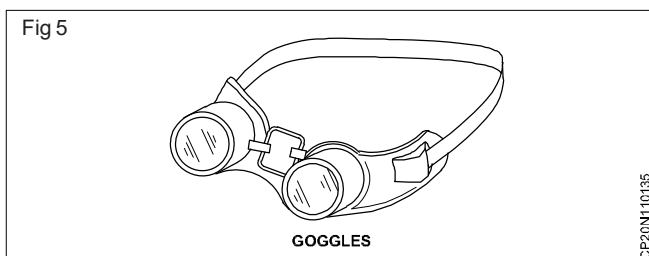
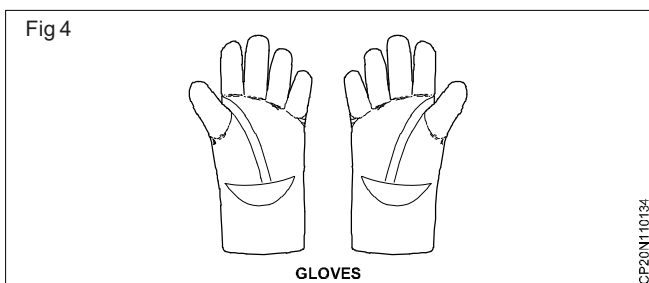
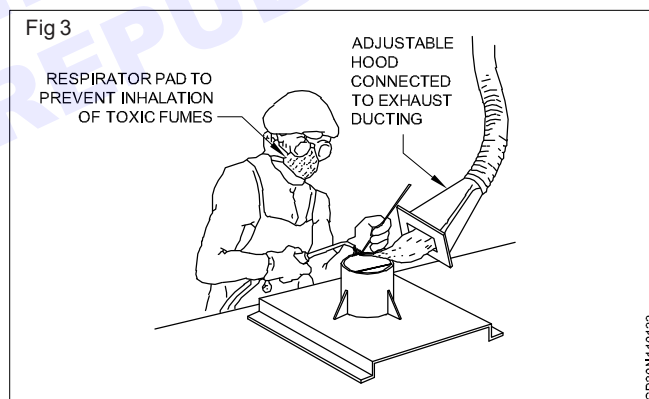
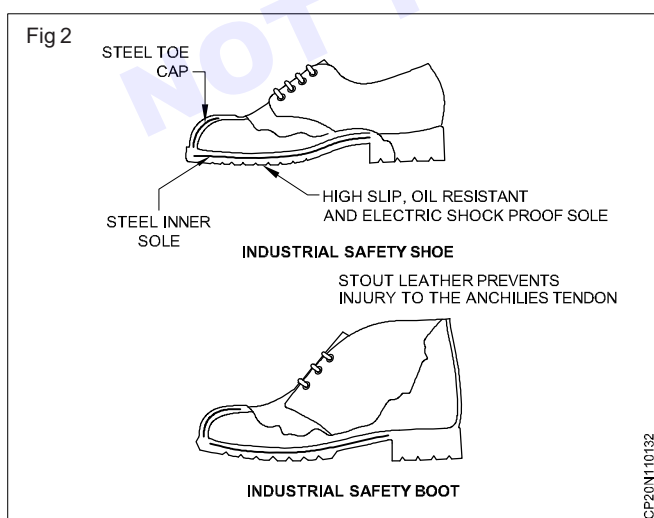
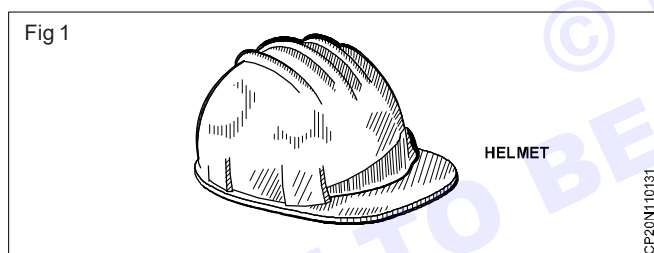
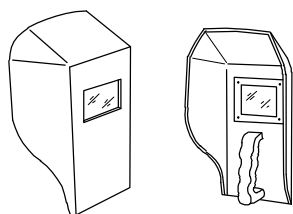


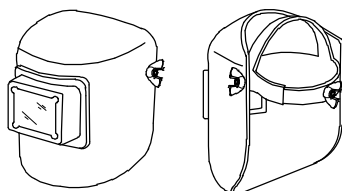
Fig 6



HAND SCREEN

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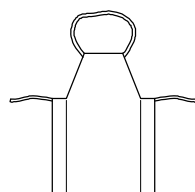
Fig 7



WELDING HELMET

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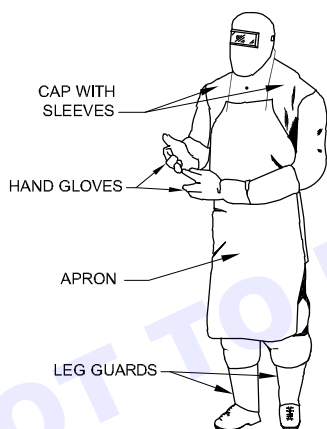
Fig 8



APRON

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Fig 9



LEG GUARDS

CP20N110139

Quality of PPE's

PPE must meet the following criteria with regard to its quality-provide absolute and full protection against possible hazard and PPE's be so designed and manufactured out of materials that it can withstand the hazards against which it is intended to be used.

Selection of PPE's requires certain conditions

- Nature and severity of the hazard
- Type of contaminant, its concentration and location of contaminated area with respect to the source of respirable air
- Expected activity of workman and duration of work, comfort of workman when using PPE
- Operating characteristics and limitations of PPE
- Ease of maintenance and cleaning.
- Conformity to Indian/ International standards and availability of test certificate.

Proper use of PPEs

Having selected the proper type of PPE, it is essential that the workman wears it. Often the workman avoids using PPE. The following factors influence the solution to this problem.

- The extent to which the workman understands the necessity of using PPE
- The ease and comfort with which PPE can be worn with least interference in normal work procedures
- The available economic, social and disciplinary sanctions which can be used to influence the attitude of the workman
- The best solution to this problem is to make 'wearing of PPE mandatory for every employee.
- In other places, education and supervision need to be intensified. When a group of workmen are issued PPE for the first time.

Introduction to First aid

Objectives: At the end of this lesson you shall be able to

- state the first aid
- explain the ABC of the first aid
- explain the first-aid treatment for a victim
- state the importance of house keeping
- explain environment, health and safety
- state the importance of safety and safety signs.

First aid is defined as the immediate care and support given to an acutely injured or ill person, primarily to save life, prevent further deterioration or injury, plan to shift the victim to safer place, provide best possible comfort and finally help them to reach the medical centre/ hospital through all available means. It is an immediate life-saving procedure using all resources available within reach.

Imparting knowledge and skill through institutional teaching at younger age group in schools, colleges, entry point at industry level is now given much importance. Inculcating such habits at early age, helps to build good healthcare habits among people.

First aid procedure often consists of simple and basic life saving techniques that an individual performs with proper training and knowledge.

The key aims of first aid can be summarized in three key points:

- **Preserve life:** If the patient was breathing, a first aider would normally then place them in the recovery position, with the patient leant over on their side, which also has the effect of clearing the tongue from the pharynx. It also avoids a common cause of death in unconscious patients, which is choking on regurgitated stomach contents. The airway can also become blocked through a foreign object becoming lodged in the pharynx or larynx, commonly called choking. The first aider will be taught to deal with this through a combination of 'back slaps' and 'abdominal thrusts'. Once the airway has been opened, the first aider would assess to see if the patient is breathing.
- **Prevent further harm:** Also sometimes called prevent the condition from worsening, or danger of further injury, this covers both external factors, such as moving a patient away from any cause of harm, and applying first aid techniques to prevent worsening of the condition, such as applying pressure to stop a bleed becoming dangerous.
- **Promote recovery:** First aid also involves trying to start the recovery process from the illness or injury, and in some cases might involve completing a treatment, such as in the case of applying a plaster to a small wound.

Training

Basic principles, such as knowing to use an adhesive bandage or applying direct pressure on a bleed, are often acquired passively through life experiences. However, to provide effective, life-saving first aid interventions requires instruction and practical training. This is especially true where it relates to potentially fatal illnesses and injuries, such as those that require cardiopulmonary resuscitation (CPR); these procedures may be invasive, and carry a risk of further injury to the patient and the provider. As with any training, it is more useful if it occurs before an actual emergency, and in many countries, emergency ambulance dispatchers may give basic first aid instructions over the phone while the ambulance is on the way. Training is generally provided by attending a course, typically leading to certification. Due to regular changes in procedures and protocols, based on updated clinical knowledge, and to maintain skill, attendance at regular refresher courses or re-certification is often necessary. First aid training is often available through community organization such as the Red cross and St. John ambulance.

ABC of first aid

ABC stands for airway, breathing and circulation.

- **Airway:** Attention must first be brought to the airway to ensure it is clear. Obstruction (choking) is a life-threatening emergency.
- **Breathing:** Breathing if stops, the victim may die soon. Hence means of providing support for breathing is an important next steps. There are several methods practiced in first aid.
- **Circulation:** Blood circulation is vital to keep person alive. The first aiders now trained to go straight to chest compressions through CPR methods.

When providing first aid one needs to follow some rule. There are certain basic norms in teaching and training students in the approach and administration of first aid to sick and injured.

Not to get panic

Panic is one emotion that can make the situation more worse. People often make mistake because they get panic. Panic clouds thinking may cause mistakes. First aider need calm and collective approach. If the first aider himself is in a state of fear and panic gross mistakes may result.

It's far easier to help the suffering, when they know what they are doing, even if unprepared to encounter a situation. Emotional approach and response always lead to wrong doing and may lead one to do wrong procedures. Hence be calm and focus on the given institution. Quick and confident approach can lessen the effect of injury.

Call medical emergencies

If the situation demands, quickly call for medical assistance. Prompt approach may save the life.

Surroundings play vital role

Different surroundings require different approach. Hence first aider should study the surrounding carefully. In other words, one need to make sure that they are safe and are not in any danger as it would be of no help that the first aider himself get injured.

Do no harm

Most often over enthusiastically practiced first aid viz. administering water when the victim is unconscious, wiping clotted blood (which acts as plug to reduce bleeding), correcting fractures, mishandling injured parts etc., would leads to more complication. Patients often die due to wrong FIRST AID methods, who may otherwise easily survive. Do not move the injured person unless the situation demands. It is best to make him lie wherever he is because if the patient has back, head or neck injury, moving him would causes more harm.

This does not mean do nothing. It means to make sure that to do something the care gives feel confident through training would make matters safe. If the first aider is not confident of correct handling it is better not to intervene of doing it. Hence moving a trauma victim, especially an unconscious one, needs very careful assessment. Removal of an embedded objects (Like a knife, nail) from the wound may precipitate more harm (e.g. increased bleeding). Always it is better to call for help.

Reassurance

Reassure the victim by speaking encouragingly with him.

Stop the bleeding

If the victim is bleeding, try to stop the bleeding by applying pressure over the injured part.

Golden hours

India have best of technology made available in hospitals to treat devastating medical problem viz. head injury, multiple trauma, heart attack, strokes etc, but patients often do poorly because they don't gain access to that technology in time. The risk of dying from these conditions, is greatest in the first 30 minutes, often instantly. This period is referred to as Golden period. By the time the patient reach the hospital, they would have passed that critical period. First aid care come handy to save lives. It helps to get to the nearest emergency room as quickly as possible through safe handling and transportation. The shorter that time, the more likely the best treatment applied.

Maintain the hygiene

Most important, the first aider need to wash hands and dry before giving any first aid treatment to the patient or wear gloves in order to prevent infection.

Cleaning and dressing

Always clean the wound thoroughly before applying the bandage gently wash the wound with clean water.

Not to use local medications on cuts or open wounds

They are more irritating to tissue than it is helpful. Simple dry cleaning or with water and some kind of bandage are best.

CPR (Cardio-Pulmonary Resuscitation) can be life-sustaining

CPR can be life sustaining. If one is trained in PR and the person is suffering from choking or finds difficulty in breathing, immediately begin CPR. However, if one is not trained in CPR, do not attempt as you can cause further injury. But some people do it wrong. This is a difficult procedure to do in a crowded area. Also there are many studies to suggest that no survival advantage when bystanders deliver breaths to victims compared to when they only do chest compressions. Second, it is very difficult to carry right maneuver in wrong places. But CPR, if carefully done by highly skilled first aiders is a bridge that keeps vital organs oxygenated until medical team arrives.

Declaring death

It is not correct to declare the victim's death at the accident site. It has to be done by qualified medical doctors.

How to report an emergency?

Reporting an emergency is one of those things that seems simple enough, until actually when put to use in emergency situations. A sense of shock prevail at the accident sites. Large crowd gather around only with inquisitive nature, but not to extend helping hands to the victims. This is common in road side injuries. No passer-by would like to get involved to assist the victims. Hence first aid management is often very difficult to attend to the injured persons. The first aiders need to adapt multi-task strategy to control the crowd around, communicate to the rescue team, call ambulance etc., all to be done simultaneously. The mobile phones helps to a greater extent for such emergencies. Few guidelines are given below to approach the problems.

Assess the urgency of the situation. Before you report an emergency, make sure the situation is genuinely urgent. Call for emergency services if you believe that a situation is life-threatening or otherwise extremely critical.

- A crime, especially one that is currently in progress. If you're reporting a crime, give a physical description of the person committing the crime.
- A fire - If you're reporting a fire, describe how the fire started and where exactly it is located. If someone has already been injured or is missing, report that as well.

- A life-threatening medical emergency, explain how the incident occurred and what symptoms the person currently displays.
- A car crash - Location, serious nature of injuries, vehicle's details and registration, number of people involved etc.

Call emergency number

The emergency number varies - 100 for Police & Fire, 108 for Ambulance.

Report your location

The first thing the emergency dispatcher will ask is where you are located, so the emergency services can get there as quickly as possible. Give the exact street address, if you're not sure of the exact address, give approximate information.

Give the dispatcher your phone number

This information is also imperative for the dispatcher to have, so that he or she is able to call back if necessary.

Describe the nature of the emergency

Speak in a calm, clear voice and tell the dispatcher why you are calling. Give the most important details first, then answer the dispatcher's follow-up question as best as you can.

Do not hang up the phone until you are instructed to do so. Then follow the instructions you were given.

How to do basic first aid?

Basic first aid refers to the initial process of assessing and addressing the needs of someone who has been injured or is in physiological distress due to choking, a heart attack, allergic reactions, drugs or other medical emergencies. Basic first aid allows one to quickly determine a person's physical condition and the correct course of treatment.

Important guideline for first aiders

Evaluate the situation

Are there things that might put the first aider at risk. When faced with accidents like fire, toxic smoke, gasses, an unstable building, live electrical wires or other dangerous scenario, the first aider should be very careful not to rush into a situation, which may prove to be fatal.

Remember A-B-Cs

The ABCs of first aid refer to the three critical things the first aiders need to look for.

- Airway - Does the person have an unobstructed airway?
- Breathing - Is the person breathing?
- Circulation - Does the person show a pulse at major pulse points (wrist, carotid artery, groin)

Avoid moving the victim

Avoid moving the victim unless they are in immediate danger. Moving a victim will often make injuries worse, especially in the case of spinal cord injuries.

Call emergency services

Call for help or tell someone else to call for help as soon as possible. If alone at the accident scene, try to establish breathing before calling for help, and do not leave the victim alone unattended.

Determine responsiveness

If a person is unconscious, try to rouse them by gently shaking and speaking to them.

If the person remains unresponsive, carefully roll them on the side (recovery position) and open his airway.

- Keep head and neck aligned.
- Carefully roll them onto their back while holding his head.
- Open the airway by lifting the chin.

Look, listen and feel for signs of breathing

Look for the victim's chest to raise and fall, listen for sounds of breathing.

If the victim is not breathing, see the section below

- If the victim is breathing, but unconscious, roll them onto their side, keeping the head and neck aligned with the body. This will help drain the mouth and prevent the tongue or vomit from blocking the airway.

Check the victim's circulation

Look at the victim's colour and check their pulse (the carotid artery is a good option; it is located on either side of the neck, below the jaw bone). If the victim does not have a pulse, start CPR.

Treat bleeding, shock and other problems as needed

After establishing that the victim is breathing and has a pulse, next priority should be to control any bleeding. Particularly in the case of trauma, preventing shock is the priority.

- **Stop bleeding:** Control of bleeding is one of the most important things to save a trauma victim. Use direct pressure on a wound before trying any other method of managing bleeding.
- **Treat shock:** Shock may cause loss of blood flow from the body, frequently follows physical and occasionally psychological trauma. A person in shock will frequently have ice cold skin, be agitated or have an altered mental status, and have pale colour to the skin around the face and lips. Untreated, shock can be fatal. Anyone who has suffered a severe injury or life-threatening situation is at risk for shock.
- **Choking victim:** Choking can cause death or permanent brain damage within minutes.
- **Treat a burn:** Treat first and second degree burns by immersing or flushing with cool water. Don't use creams, butter or other ointments, and do not pop blisters. Third degree burns should be covered with a damp cloth.

Remove clothing and jewellery from the burn, but do not try to remove charred clothing that is stuck to burns.

- **Treat a concussion:** If the victim has suffered a blow to the head, look for signs of concussion. Common symptoms are: loss of consciousness following the injury, disorientation or memory impairment, vertigo, nausea, and lethargy.
- **Treat a spinal injury victim:** If a spinal injury is suspected, it is especially critical, not move the victim's head, neck or back unless they are in immediate danger.

Stay with the victim until help arrives

Try to be a calming presence for the victim until assistance can arrive.

Unconsciousness (COMA)

Unconscious also referred as Coma, is a serious life threatening condition, when a person lie totally senseless and do not respond to calls, external stimulus. But the basic heart, breathing, blood circulation may be still intact, or they may also be failing. If unattended it may lead to death.

The condition arises due to interruption of normal brain activity. The causes are too many.

The following symptoms may occur after a person has been unconscious:

- Confusion
- Drowsiness
- Headache
- Inability to speak or move parts of his or her body (see stroke symptoms)
- Light headedness
- Loss of bowel or bladder control (incontinence)
- Rapid heartbeat (palpitation)
- Stupor

First aid

- Call EMERGENCY number.
- Check the person's airway, breathing, and pulse frequently. If necessary, begin rescue breathing and CPR.
- If the person is breathing and lying on the back and after ruling out spinal injury, carefully roll the person onto the side, preferably left side. Bend the top leg so both hip and knee are at right angles. Gently tilt the head back to keep the airway open. If breathing or pulse stops at any time, roll the person on to his back and begin CPR.
- If there is a spinal injury, the victims position may have to be carefully assessed. If the person vomits, roll the entire body at one time to the side. Support the neck and back to keep the head and body in the same position while you roll.

- Keep the person warm until medical help arrives.
- If you see a person fainting, try to prevent a fall. Lay the person flat on the floor and raise the level of feet above and support.
- If fainting is likely due to low blood sugar, give the person something sweet to eat or drink when they become conscious.

Do not

- Do not give any food or drink of an unconscious person
- Do not leave the person alone.
- Do not place a pillow under the head of an unconscious person.
- Do not slap an unconscious person's face or splash water on the face and try to revive him.

Loss of consciousness may threaten life if the person is on his back and the tongue has dropped to the back of the throat, blocking the airway. Make certain that the person is breathing before looking for the cause of unconsciousness. If the injuries permit, place the casualty in the recovery position (Fig 2) with the neck extended. Never give any thing by mouth to an unconscious casualty.

How to diagnose an unconscious injured person

- Consider alcohol: look for signs of drinking, like empty bottles or the smell of alcohol.
- Consider epilepsy: are there signs of a violent seizure, such as saliva around the mouth or a generally disheveled scene?
- Think insulin: might the person be suffering from insulin shock (see 'How to diagnose and treat insulin shock')?
- Think about drugs: was there an overdose? Or might the person have under dosed - that is not taken enough of a prescribed medication?
- Consider trauma: is the person physically injured?
- Look for signs of infection: redness and/ or red streaks around a wound.
- Look around for signs of Poison: an empty bottle of pills or a snakebite wound.
- Consider the possibility of psychological trauma: might the person have a psychological disorder of some sort?
- Consider stroke, particularly for elderly people.
- Treat according to what you diagnose.

Shock

A severe loss of body fluid will lead to a drop in blood pressure. Eventually the blood's circulation will deteriorate and the remaining blood flow will be directed to the vital organs such as the brain. Blood will therefore be directed away from the outer area of the body, so the victim will appear pale and the skin will feel ice cold.

As blood flow slows, so does the amount of oxygen reaching the brain. The victim may appear to be confused, weak, and dizzy and may eventually deteriorate into unconsciousness. Try to compensate for this lack of oxygen, the heart and breathing rates both speed up, gradually becoming weaker, and may eventually cease.

Potential causes of shock include: sever internal or external bleeding; burns; severe vomiting and diarrhea, especially in children and the elderly; problems with the heart.

Power Failure

Minor electric shock, fire, or product failure may occasionally occur. Do not disassemble, modify, or repair the product or touch the interior of the product.

Minor injury due to electric shock may occasionally occur. Do not touch the terminals while power is being supplied.

Minor burns may occasionally occur. Do not touch the product while power is being supplied or immediately after power is turned OFF.

Fire may occasionally occur. Tighten the terminal screws with the specified torque.

Minor electric shock, fire, or product failure may occasionally occur. Do not allow any pieces of metal or conductors or any clippings or cuttings resulting from installation work to enter the product.

Precautions for Safe Use

Input Voltage

Use a commercial power supply for the power supply voltage input to models with AC inputs.

Inverters with an output frequency of 50/60 Hz are available, but the rise in the internal temperature of the power supply may result in ignition or burning. Do not use an inverter output for the power supply of the product.

Grounding

Connect the ground completely. Electric shock occur if the the ground is not connected completely.

Operating Environment

Use each product within the rated range for ambient operating temperature, ambient operating humidity, and storage temperature specified for that product.

Use the power supply within the ranges specified for vibration and shock resistance.

Do not use the power supply in locations subjects to excessive amount of dust or where liquids, foreign matter, or corrosive gases may enter the interior of the product.

Install the power supply well away from devices that produce strong, high-frequency noise and surge.

Do not use the power supply in locations subject to direct sunlight.

Mounting

The installation screws can be tightened into the power supply only to a limited depth. Make sure that the lengths

of the screws protruding into the power supply are within the specified dimensions.

Wiring

Use caution when connecting the input cable to the power supply.

The power supply unit may be destroyed if the input cable is connected to the wrong terminals. Use caution when using a model with a DC input. The power supply unit may be destroyed if the polarity is reversed.

Do not apply more than 75-N force to the terminal block when tightening the terminals.

Wiring materials

Use a wire size that suits the rated output current of the power supply to be used in order to prevent smoking or ignition caused by abnormal loads.

Caution is particularly required if the output current from one power supply is distributed to multiple loads. If thin wiring is used to branch wiring, the power supply's overload protection circuit may fail to operate depending on factors such as the impedance of the load wiring even the load is short-circuited.

Therefore insertion of a fuse in the line or other protective measures must be considered.

Precautions against ingress of metal fragments (Fillings)

Drilling on the upper section of an installed power supply may cause drilling fragments to fall onto the PCB, thereby short-circuiting and destroying the internal circuits. Whether the power supply cover is attached or not, cover the power supply with a sheet to prevent ingress of fragments when performing work on the upper sector of the power supply.

Be sure to remove the sheet covering the power supply for machining before power-ON so that it does not interface with heat dissipation.

Load

Internal parts may possibly deteriorate or be damaged if a short-circuited or over current state continues during operation.

Charging a battery

When connection a battery at the load, connect an overcurrent limiting circuit and overvoltage protection circuit.

Output and Ground connections

The power supply output is a floating output (i.e., the primary side and secondary side are separated). so the output line (i.e., +V or -V) can be connected externally directly to a ground. Though the ground, however, the insulation between the primary side and secondary side will be lost. Confirm that no loops are created in which the power supply output is short-circuited through the internal circuits of the load.

Example: When the +V side of the power supply is connected directly to a ground and a load is used for which the internal 0-V line uses the same ground.

Fire safety

Prepare before a fire

Always familiarize yourself to “where you are” and be sure to know how to reach the two nearest exits.

Remember that in a fire situation, smoke is blinding and will bank down in the rooms and hallways. This condition may force you to crouch or crawl to escape to safety. By always being aware of your surroundings, your knowledge of the nearest exits and having a plan will greatly increase your ability to deal with sudden

If you are notified of, or discover a fire:

- Move quickly to the nearest accessible exit.
- Notify, and assist others to evacuate along the way.
- If the building fire alarm is not yet sounding, manually activate the alarm pull station located near the exit.
- Exit the building and proceed to the “Area of gathering”

Evacuation procedures for persons with mobility issues:

In the event of an actual emergency incident, persons with mobility issues or who are unable to safely self-evacuate should follow this procedure:

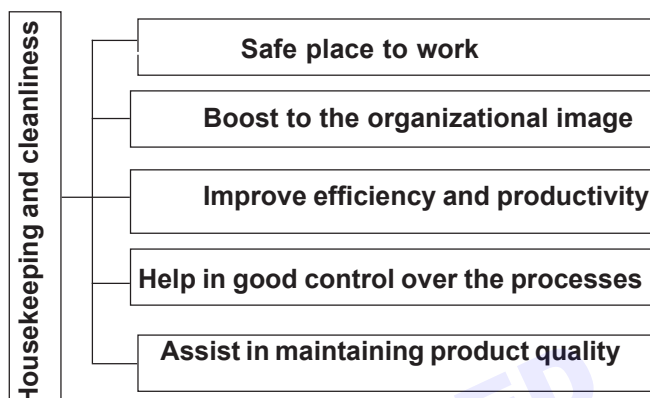
- Relocate to an entry to an evacuation stairwell, marked by a red exit sign.
- Wait near the enclosed exit stairwell if there is no smoke or other threats to your safety. Most fire alarm activations are brief, allowing occupants to return within a few minutes.

If smoke, fire, or other threat is imminent, move into the stairwell:

- After the stairwell crowd has passed below your floor level, enter the stairwell with assistant(s) and wait on the stair landing. Make sure that the door is securely closed.

Housekeeping and cleanliness at workplace

Housekeeping and cleanliness at the workplace are closely linked to the industrial safety. The degree, to which these activities are effectively managed, is an indicator of the safety culture of the organization. House keeping and cleanliness not only make the organization a safer place to work in but also provide a big boost to the image of the organization. These activities also (i) improve efficiency and productivity, (ii) helps in maintaining good control over the processes, and (iii) assist in maintaining the quality of the product. These important aspects of housekeeping and cleanliness are furnished below.



There are several signs which reflect poor housekeeping and cleanliness at the workplace in the organization. Some of these signs are (i) cluttered and poorly arranged work areas, (ii) untidy or dangerous storage of materials (such as materials stuffed in corners and overcrowded shelves etc.), (iii) dusty and dirty floors and work surfaces, (iv) items lying on the shop floor which are in excess or no longer needed, (v) blocked or cluttered aisles and exits, (vi) tools and equipment left in work areas instead of being returned to proper storage places, (vii) broken containers and damaged materials, (viii) overflowing waste bins and containers, and (ix) spills and leaks etc.

Housekeeping and cleanliness is crucial to a safe workplace. It can help prevent injuries and improve productivity and morale, as well as make a good imprint on the people visiting the workplace.

Response to emergencies - power failure, fire and system failure

Objectives: At the end of this lesson you shall be able to

- state the reason of emergency power failure
- state the cause of system failure
- state the fire safety and immediate actions.

- 1 If there is a power failure, start the emergency generator. This provides power to close the shutter, which is the first priority. The generator will also keep the UPSs and the cryogenic compressors running,
 - Get a flash light.
 - Look out for power transfer switch and switch over to normal power to emergency power by pressing the latch.

- Check the fuel valves open or not - Open the valves.
- Check to see that the main breaker switch ON the generator is in OFF position.
- Move the starter switch of the generator to run position. The engine will start at once.
- Allow few minutes to warm up the engine.
- Check all the gauges, pressure, temperature, voltage and frequency.

- Check the "AC line" and "Ready" green light on the front panel.
- 2 System failure
 - If the bug or virus, invades the system. The system failure happens.
 - Several varieties of bugs are there
- 1 Assassin bug
- 2 Lightening bug
- 3 Brain bug

For more details, refer instruction manual for "System failure".

3 Fire failure

When fire alarm sounds in your buildings

- 1 Evacuate to outside immediately.
- 2 Never go back
- 3 Make way for fire fighters and their trucks to come
- 4 Never use an elevator
- 5 Do not panic

Reporting emergency

Objectives : At the end of this lesson you shall be able to

- **explain and report an emergency.**

Report an emergency

Reporting an emergency is one of those things that seems simple enough, until actually when put to use in emergency situations. A sense of shock prevails at the accident sites. Large crowd gather around only with inquisitive nature, but not to extend helping hands to the victims. This is common in road side injuries. No passerby would like to get involved to assist the victims. The first aiders need to adapt multitask strategy to control the crowd around, communicate to the rescue team, call ambulance etc, all to be done simultaneously. The mobile phones help to a greater deal for such emergencies. Few guidelines are given below to approach the problems.

Assess the urgency of the situation. Before you report an emergency, make sure that the situation is genuinely urgent. Call for emergency services if you believe that a situation is life-threatening or otherwise extremely disruptive.

- A fire - If you're reporting a fire, describe how the fire started and where exactly it is located. If someone has already been injured, missing, report that as well.
- A life - threatening medical emergency, explain how the incident occurred and what symptoms the person currently displays.

Call emergency service

The emergency number varies - 100 for Police & Fire, 108 for Ambulance.

Report your location

The first thing the emergency dispatcher will ask where you are located, so that the emergency services can get there as quickly as possible. Give the exact street address, if you're not sure of the exact address, give approximate information like landmarked etc.

Importance of housekeeping

Objectives : At the end of this lesson you shall be able to

- **list the steps involves in house keeping**
- **state good shop floor practices followed in industry.**

Housekeeping

The following activities to be performed for better up keep of working environment:

- **Cleaning of shop floor:** Keep clean and free from accumulation of dirt and scrap daily
- **Cleaning of machines :** Reduce accidents to keep machines cleaned well
- **Prevention of leakage and spillage:** Use splash guards in machines and collecting tray
- **Disposal of scrap-** Empty scrap, wastage, sward from respective containers regularly
- **Tools storage-** Use special racks, holders for respective tools

- **Storage spaces:** Identify storage areas for respective items. Do not leave any material in gangway
- **Piling methods-** Do not overload platform, floor and keep material at safe height.
- **Material handling:** Use forklifts, conveyors and hoist according to the volume and weight of the package.

Good shop floor practices followed in industry

Good Shop floor practices are motivating action plans for improvement of the manufacturing process.

- All workers are communicated with daily target on manufacturing, activities.
- Informative charts are used to post production, quality and safety results compared to achievements.

- Workers are trained on written product quality standards.
- Manufactured parts are inspected to ensure adherence to quality standards.
- Production processes are planned by engineering to minimize product variation.
- 5s methods are used to organize the shop floor and production lines.
- Workers are trained on plant safety practices in accordance with Occupational Safety Health (OSH) standards.
- Workers are trained on "root cause" analysis for determining the causes of not following.
- A written preventive maintenance plan for upkeep of plant, machinery & equipment
- Management meets with plant employees regularly to get input on process improvements.
- Process Improvement Teams are employed to implement "best practices"

Introduction to 5S concept and its application

Objectives : At the end of this lesson you shall be able to

- **stat what is 5S**
- **state the general benefits of implementing 5S**
- **explain the terms in 5S and its concept of implementation.**

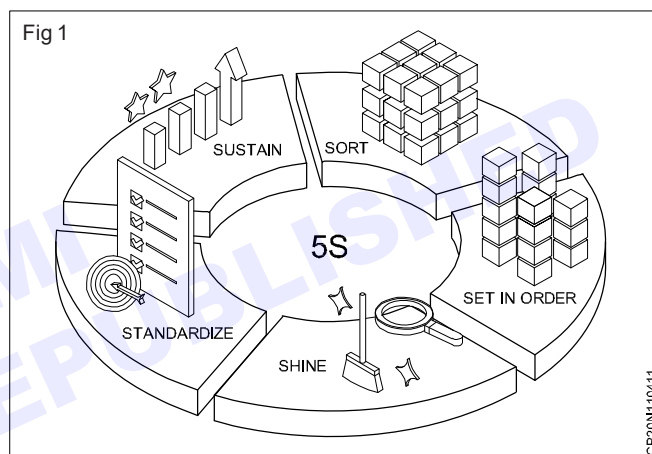
Introduction

5S is a philosophy and a way of organizing and managing the workspace and work flow with the intent to improve efficiency by eliminating waste, improving flow and reducing process unreasonableness. There are five steps in the system, each starting with the letter S:

- | | | |
|---------------|----------------|---------|
| 1 Sort | 2 Set in order | 3 Shine |
| 4 Standardize | 5 Sustain | |

The Steps of 5S (Fig 1)

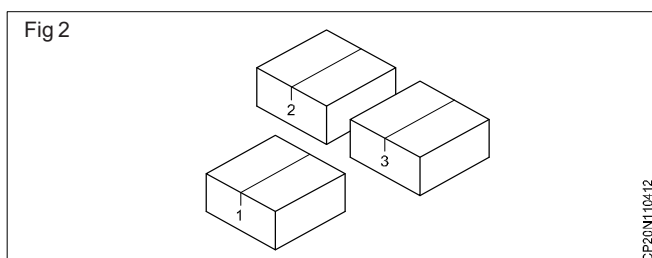
5S was created in Japan, and the original "S" terms were in Japanese, so English translations for each of the five steps may vary. The basic ideas and the connections between them are easy to understand, though.



Step Name	Japanese term	Explanation
1	Seri (tidiness)	Remove unnecessary items from each area
2	Seiton (orderliness)	Organize and identify storage for efficient use
3	Seiko (cleanliness)	Clean and inspect each area regularly
4	Seiketsu (standardization) operating procedures	Incorporate 5S into standard
5	Shinseki (discipline)	Assign responsibility, track progress, and continue the cycle

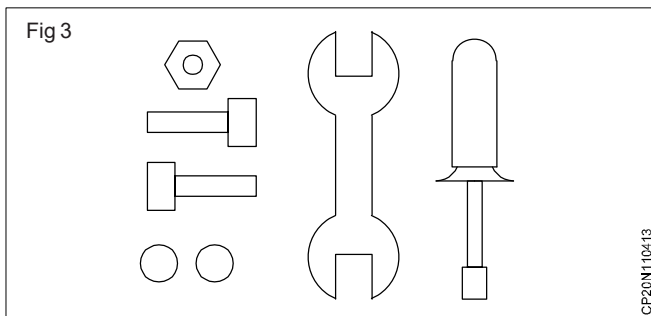
Step 1 Sort

The first step in the 5S process is Sort, or "seiri," which translates to "tidiness." The goal of the Sort step is to eliminate clutter and clear up space by removing things that don't belong in the area. (Fig 2)



Step 2: Set In Order

The second step, Set in Order, was originally called "seiton," which translates to "orderliness." A variety of names have been used in English: "Systematic Organization," "Straightening Out," and "Simplify," for example. No matter what it's called, the goal of this step is to organize the work area. Each item should be easy to find, use, and return: a place for everything, and everything in its place. (Fig 3)

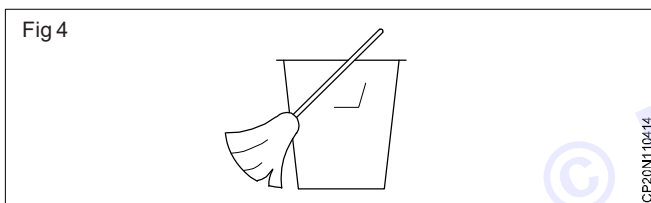


Implementation steps of Set in order

- Draw up a map, and then implement it
- Physically arrange the workplace first, and then map it out
- Map as you go, testing ideas and writing down what works well

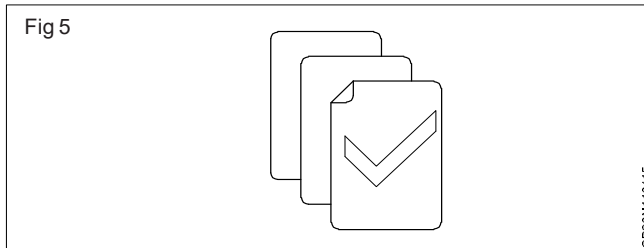
Step 3: Shine

The third step of 5S is Shine, or "seiso," which means "cleanliness." While the first and second steps cleared up space and arranged the area for efficiency, this step attacks the dirt and grime that inevitably builds up underneath the clutter, and works to keep it from coming back. (Fig 4)



Step 4: Standardize

The fourth step is Standardize, or "seiketsu," which simply means standardization. By writing down what is being done, where, and by whom, you can incorporate the new practices into normal work procedure. This paves the way for long-term change. (Fig 5)

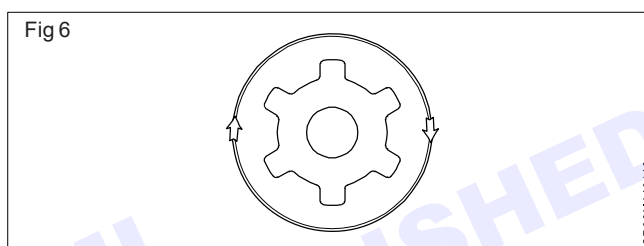


Tools for Standardizing

- 5S checklists
- Job cycle charts
- Procedure labels and signs

Step 5: Sustain

The fifth step of a 5S program is Sustain, or "shitsuke," which literally means "discipline." The idea here is continuing commitment. It's important to follow through on the decisions that you've made and continually return to the earlier steps of 5S, in an ongoing cycle. (Fig 6)



Sustaining a 5S program can mean different things in different work places, but there are some elements that are common in successful programs.

- Management support
- Department tours
- Updated training
- Progress audits
- Performance evaluations

Occupational safety and health

Objectives: At the end of this lesson you shall be able to

- describe occupational safety and its importance at work place to prevent unsafe act and conditions in work-related activities
- brief the environmental guidelines, legislations & regulations in India, framed to protect workplace health and safety.
- list the occupational safety and health tips.

Occupational safety, and health

Occupational safety, and health means actions or working conditions which are safe from any cause resulting in danger to life, physique, mentality or health arising out of or related to working environment. OSH includes the laws, standards and programs that are aimed at making the workplace better for workers, along with co-workers, family members, customers, and other stakeholders.

The goal of Occupational safety and health

The goal of Occupational safety and health program is to foster a safe and healthy occupational environment. OSH

also protects all the general public who may be affected by the occupational environment.

Environmental safety

Environmental safety is defined by the guidance, policies, and practices enforced in order to ensure that the surrounding environment is free from hazards that will warrant the safety and well-being of workers and employees, residents near industrial operations, as well as the prevention of accidental environmental damage

The surrounding areas include industrial facilities, work areas, and laboratories. Environmental safety is a crucial

issue for any industrial activity as negligence and non-compliance heighten the risk resulting in injuries, illnesses, and accidental environmental releases.

Environmental safety is usually divided into three subcategories: Occupational safety and Health Programs, Environmental Control, and Chemical Safety.

In order to protect the workers against work related sickness, disease and injury. The International labour organization(ILO) came up with an official order on OSH.

Similarly government of India is enacted the following acts

- The legislation for labour welfare, known as the Factories Act 1948, was enacted with the prime objective of protecting workmen employed in factories against industrial and occupational hazards. There are number of Acts enacted by the government of India and amended from time to time; among them the following are the most important ones in this regard:
- Factories Act, 1948,
- Mines Act, 1952,
- Dock workers (Safety, Health and welfare) Act, 1986,
- Building and other Construction workers (Regulation of Employment and conditions of service) Act, 1996,
- Plantation Labour Act, 1951,
- Contract Labour (Regulation and Abolition) Act, 1970
- The Child labour (Prohibition and Regulation) Act, 1986, etc.

Constitutional provisions form the basis of workplace safety and health laws in India by imposing a duty on the State governments to implement policies that promote the safety and health of workers at workplaces. In addition, safety and health statutes for regulating occupational safety and health (OSH) of persons at work exist in different sectors, namely manufacturing, mining, ports, and construction sector.

The health and safety at work Act, 1974 states employers are responsible for protecting the safety of their employees at work by preventing potential dangers in the workplace. It places general duties on employers to ensure the health, safety and welfare of all persons while at work.

Legislation is a directive proposed by a legislative body while a regulation is a specific requirement within legislation. Legislation is broader and more general while regulation is specific and details how legislation is enforced.

The difference between legislation and regulation is that legislation is the act of process of making certain laws while regulation is maintaining the law or set of rules that govern the people. It is a government-driven or ministerial order having the force of law.

The ILO's primary goal is to promote opportunities for women and men to obtain decent and productive work in conditions of freedom, equity, security and human dignity. In 2003 the ILO adopted a global strategy to improve preventive standards on occupational safety and health to provide essential tools for governments, employers, and workers to establish safe practices and health culture for providing maximum safety at work.

The four important aims of health and safety legislation is to

- i secure the safety, health and welfare of employees and other people at work;
- ii protect the public from the safety and health risks of business activities;
- iii amend statutes relating to safety aspects of substances, equipment and environment;
- iv eliminate workplace risks at the source.

Occupational safety and health Tips:

- Be aware of your surroundings.
- Maintain a correct posture.
- Take break regularly.
- Use Equipment properly.
- Locate Emergency Exits.
- Report Unsafe conditions.
- Practice Effective Housekeeping.
- Make use of mechanical aids.
- Wear the correct Safety equipment.
- Reduce workplace stress.

Elements, atom and molecule

Objectives : At the end of this lesson you shall be able to

- define, atom , molecule, element, compound, mixture
- explain physical change, chemical change
- describe acid bases, salts their properties
- define molecular weight, equivalent weight, atomic weight, normality, molarity
- explain metals & non-metals and their properties and uses.

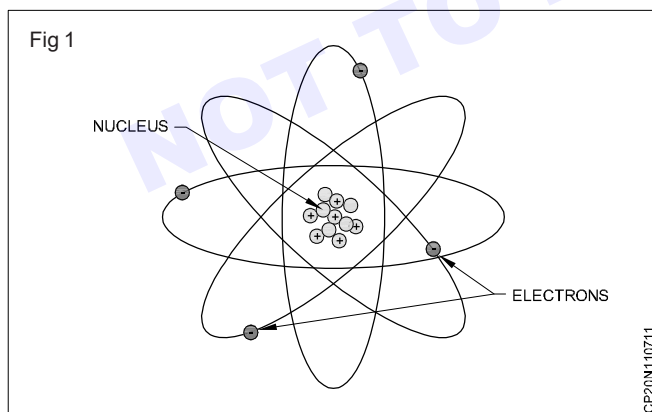
Introduction

Element

An element is a pure chemical substance composed of atoms with the same number of protons. Common examples of elements are iron (Fe), copper (Cu), silver (Ag), gold (Au), hydrogen (H), carbon (C), nitrogen (N), oxygen (O), etc. In total, 117 elements have been observed as of 2008, of which 94 occur naturally on Earth. All chemical matter consists of these elements. New elements of higher atomic number are discovered from time to time, as products of artificial nuclear reactions.

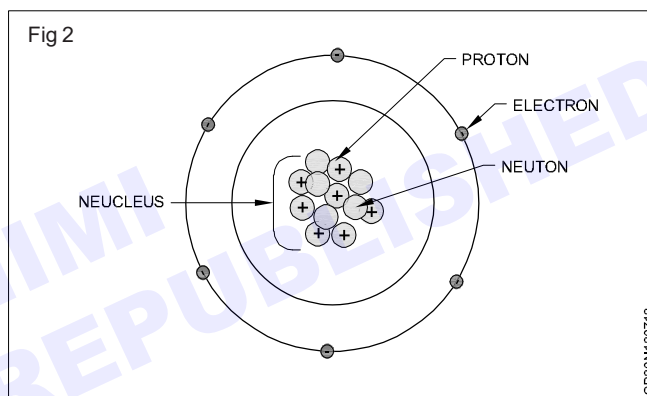
Atom (Fig 1 & 2)

An atom is the smallest particle of an element that cannot be in free state and take part in a chemical reaction. The atom is made up of two basic regions: the nucleus and neutrons make up almost the entire mass of the atom. Neutrons do not have a charge on them. Protons have a +ve charge. Electrons have a -ve charge. Electrons can be lost or gained to make the atom charged. Protons and neutrons have roughly the same mass of 1 amu (atomic mass unit). The electron cloud contains electrons that surround the nucleus.



Molecule

A molecule is the smallest particle of a compound that can exist in a free state. Molecule of compounds consists of two or more different atoms. For example: (i) A carbon dioxide molecule (CO_2) consist of one atom of carbon and two atom of oxygen; (ii) A molecule of hydrogen (H_2) consist of two atoms, both of hydrogen; (iii) A molecule of zone (O_2) consist of three atoms all of oxygen.



Compound

When two or more atoms combine through a chemical reaction in a fixed ratio, a compound is formed.

Mixture

It is formed when two or more compounds or elements are mixed in a ratio.

Physical change

Physical change is a change in properties such a texture, shape, or state.

Chemical change

Chemical change represents the formation of a new substance after atoms are rearranged in a chemical reaction.

Acids, Bases, Salts, Element, Atom and Molecule

Objectives : At the end of this lesson you shall be able to

- **classify substance having acid, base, and salt characteristic**
- **distinguish the element, atom and molecule.**

Acids, Base and Salts

Introduction:

acids, bases and salts are the three main categories of chemical compounds. These have certain definite properties which distinguish one class from the other.

Acids

In everyday life we deal with many compounds that chemists classify as

acids for example orange juice and grapeful juice contain citric acids.

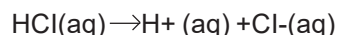
These juices and others also contain ascorbic acid, a substance more commonly known as Vitamin C. Salads are often flavoured with vinegar, which contains dilute acetic acid. Boric acid is a substance that is sometimes used to wash the eyes.

In any chemistry laboratory, we find acids such as hydrochloric acid, sulfuric acid, and nitric acid. These acids are called mineral acids because they can be prepared from naturally occurring compounds called minerals mineral acids are generally stronger than household acids, and should be handled with great care because they can burn skin and clothing.

Properties of acids:

- 1 **Acids taste sour.** Citric acid is responsible for the sour taste of lemons, limes, grapefruits, and oranges. Acetic acid is responsible for the sour taste of vinegar.
- 2 **Acids turn litmus (or indicator papers) red.** Litmus is a vegetable dye that may be either red or blue, depending on the acidity. When a sample of an acid is placed on red litmus paper, the color of the litmus does not change. red litmus has been previously treated with acid. Adding more acid does not change the red color. However, when the same acid is placed on blue litmus paper, the color turns from blue to red.
- 3 **Acids contain combined hydrogen.** When a sample of zinc, a fairly reactive metal, is dropped into a test tube containing an acid such as hydrochloric acid, a reaction occurs. The bubbling in the tube indicates that a gas is released. When we test this gas by inserting a burning splint into the test tube, the gas burst into flame and produces a small popping sound. This is the characteristic test for hydrogen gas. In genera, when certain acids react with metals, hydrogen gas is released. See following reactions:
$$\text{Zn (s)} + 2\text{HCl (aq)} \rightarrow \text{H}_2\text{(g)} + \text{ZnCl}_2\text{(aq)}$$
- 4 **Acids release hydrogen in water solution** When an acid dissolves in water, the acid ionizes, releasing both hydrogen ions and ions of a nonmetal or nonmetallic polyatomin ion. Thus, when hydrochloric

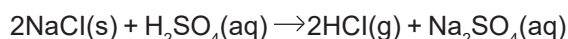
acid is dissolved in water, the acid ionizes, forming hydrogen ions and chloride ions, as shown in the following equation:



Acids are defined as substances that release hydrogen ions in solution. It is thus $\text{H}^+(\text{aq})$ that are responsible for the properties of acids.

How acids are prepared

Acids may be prepared when certain gases are dissolved water and when certain salt compounds are allowed to react with sulfuric acid.

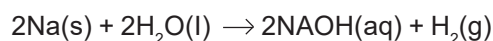


Uses of acids

- 1 **Sulfuric acid:** Sulfuric acid is the chemical most widely used in industry. Sulfuric acid is also used to make other acids such as hydrochloric and nitric acid because the boiling point of sulfuric acid is higher than that of other acids. This allows the acid being produced to be distilled and collected separately from the starting material. Sulfuric acid is also used to remove the surface oxide layers on metals for example, before iron is coated with chromium (in chromium plating,) the iron is dipped into dilute sulfuric acid to remove the iron oxide normally present on the surface on the iron. Another important use of sulfuric acid is the storage cell. In a lead storage cell, dilute sulfuric acid serves as the electrolyte. Several such cells connected together make up the type of storage battery used in automobiles.
- 2 **Nitric acid:** Nitric acid, another important industrial acid, is used in the manufacture of fertilizers, plastics, photographic film, and dyes. Nitric acid is also used in the preparation of such explosives as dynamite and TNT.
- 3 **Hydrochloric acid:** Hydrochloric acid, like sulfuric acid, is used to clean metals. Hydrochloric acid is also used to clean brick and tile. It is used in the manufacture of sugar and glue. Hydrochloric acid is produced in small quantities in the stomach where the acid aids digestion.

Bases

Bases are ionic compounds containing metal ions and hydroxide ions. For example, when sodium metal is placed in water, sodium hydroxide is formed and hydrogen gas is released.



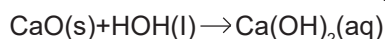
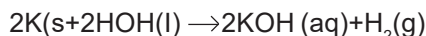
Properties of Bases

- 1 Bases taste bitter:** A bitter taste is characteristic of all bases. It is the presence of a base that give unflavored milk of magnesia its bitter taste.
- 2 Bases feel slippery:** If you rub a drop or two of household ammonia between your fingers, you experience the slippery feeling of a base. Wet soap is also slippery because of the presence of a base.
- 3 Bases turn red litmus blue:** A common indicator used to detect the presence of a base is phenolphthalein which when mixed with a base turns pink.
- 4 Bases release hydroxide ions in water solutions:** When dissolved in water bases ionize releasing metal ions and hydroxide ions.

Thus bases are defined as substances that release hydroxide ions in solution. It is these $\text{OH}^-(\text{aq})$ ions that responsible for the properties of bases.

How Bases are prepared

Bases may be prepared by the reaction of water and very reactive metals & by the reaction of water and certain oxides.



Uses of Bases:

- 1 Ammonium hydroxide:** Ammonium hydroxide or ammonia water is used in the home for cleaning because bases generally dissolve grease. It is used in the preparation of important related compounds such as nitric acid and ammonium chloride
- 2 Magnesium hydroxide:** Milk of magnesia (magnesium hydroxide) is used as an antacid.
- 3 Sodium hydroxide:** Sodium hydroxide is used in the manufacture of soap, rayon and paper.
- 4 Calcium hydroxide:** Calcium hydroxide (slaked lime) is used in the preparation of plaster and mortar. Water solutions of calcium hydroxide (limewater) can be used in the lab as a test for the presence of carbon dioxide.

Salts

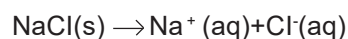
A salt is formed when an acid and a base are mixed and the acid releases H^+ ions while the base releases OH^- ions. This process is called hydrolysis. The most familiar salt to all of us is table salt- sodium chloride. Baking soda is the salt sodium bicarbonate. Magnesium sulfate (Epsom salts) is often found in the home. the pH of the salt depends on the strengths of the original acids and bases (Table 1):

Table 1

Acid	Base	Salt pH
Strong	Strong	pH = 7
Weak	Strong	pH > 7
Strong	Weak	pH < 7
Weak	Weak	Depends on which is stronger

Properties of Salts

- 1 Salt water** the salty taste of ocean water is due to the presence of salts such as sodium chloride and magnesium bromide. There are many different salts present in salt water:
- 2 Salts dissociate in water.** Salts consist of tightly bonded ions. In water, these bonds are weakened and the ions become mobile. This accounts for the fact that salt solutions are generally electrolytes. In water, for example, sodium chloride ionizes as below:



Uses of salts:

Name of salt	Formula	Uses
Ammonium chloride	NH_4Cl	in soldering, as electrolyte in dry cells
Sodium bicarbonate	NaHCO_3	in baking powder, in manufacture of glass
Sodium chloride	NaCl	for seasoning and preserving food, essential in life processes
Calcium chloride	CaCl_2	as a drying agent to absorb moisture, in freezing mixtures
Silver bromide	AgBr	in making photographic film
Potassium nitrate	KNO_3	in manufacture of explosive, fertilizer
Sodium nitrate	NaNO_3	fertilizer, source of nitric acid

How salts are prepared

Salts may be prepared by three methods:

Neutralization of acid and base: When an acid and base react they results in the formation of water and a salt. Such a reaction is known as a neutralization reaction. For example, when sodium hydroxide and hydrochloric acid react, water and the salt sodium chloride are formed. This occurs because the hydrochloric acid and the sodium hydroxide first ionize forming hydrogen, chloride, sodium, and hydroxide ions. Since these are mobile in solution, hydrogen ions meet hydroxide ions and unite to form water. At the same time sodium ions and chloride ions remain as aqueous salt.

- Direct combination:** When a metal reacts with a non metal, a salt is generally formed. For example, when the metal magnesium is burned in chlorine gas, the salt magnesium chloride is formed.
- Metal oxide and acid:** When a metal oxide reacts with an acid, a salt is formed. For example, when calcium oxide reacts with nitric acid, the salt calcium nitrate is formed.

Molecular weight, equivalent weight and atomic weight, normality, molarity and molality

Atomic weight

The total weight of an atom is called the atomic weight. It is approximately equal to the number of protons and neutrons.

For any element,

Number of Protons = Atomic number

Number of Electrons = Number of Protons = Atomic Number

Number of Neutrons = Mass Number - Atomic Number

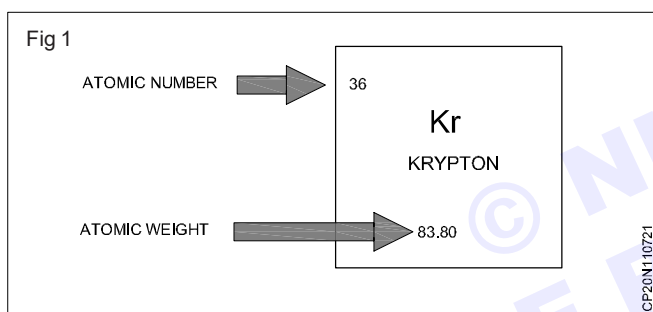
For example, krypton (Fig 1):

Number of Protons = Atomic Number = 36

Number of electrons = Number of Protons = Atomic Number = 36

Number of Neutrons = Mass Number - Atomic Number = 84 - 36 = 48

Therefore, atomic weight of Krypton = Protons + neutrons = 84



Molecular weight

Molecular mass is generally termed as molecular weight and is abbreviated as MW. Molecular weight of an element is defined as the product of the atomic weight of each atom and the number of atoms present in the formula.

$$\text{MW} = \text{Atomic weight of each atom} \times \text{number of atoms}$$

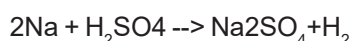
For example, molecular weight of carbon dioxide (CO_2) = $12 \times 1 + 16 \times 2 = 44$

Equivalent weight

Equivalent weight of an element is defined the number of parts by weight of an element or compound which will combine with or replace, directly or indirectly say 1.008 parts by weight of hydrogen, 8.00 parts of oxygen, or the equivalent weight of any other element or compound. Equivalent weight is only a relative number. It has no unit.

Examples:

Equivalent of an element, Na



2 sodium atom ($2 \times 23 = 46$) displaces two hydrogen atom (2×1.008)

Then 23f of sodium displaces 1.008g of hydrogen.

\Equivalent weight of Na = Atomic weight of element / Valency i.e., $23/1.008 = 23$

Equivalent of an acid, H_2SO_4

Atomic weight of H = 1, S = 32, O = 16

Molecular weight of H_2SO_4 = $(2 \times 1) + 32 + (4 \times 16) = 98$ parts by weight

Replaceable hydrogen atoms = 2.

/Equivalent weight of sulphuric acid = Molecular weight / Basicity of the acid i.e., $98/2 = 49$.

Equivalent of a base, NaOH

Atomic weight of Na = 23, O = 16, H = 1

Molecular weight of NaOH = $23 + 16 + 1 = 40$

Replaceable hydroxide atoms = 1

Equivalent weight of NaOH = Molecular weight / Acidity of the base i.e. $40/1 = 40$

Equivalent weight of salts, CaCl_2

Atomic weight of Ca = 40 and Cl = 35.5

/Molecular weight of CaCl_2 = $40 + (35.5 \times 2) = 111$

/Equivalent weight of CaCl_2 = Molecular weight of CaCl_2 /

Total valency of calcium i.e., $111/2 = 55.5$

Molarity, Molality and Normality

The concentration of a chemical solution refers to the amount of solute that is dissolved in a solvent. Concentration may be expressed in several different ways using percent composition by mass, mole fraction, molarity, molality, or normality.

Molarity is probably the most commonly used unit of concentration. It is the number of moles of solute per liter of solution or refers to the number of molecules of a substance in a solution.

$$\text{Molarity (M)} = \frac{\text{no. of moles of solute}}{\text{liters of solution}}$$

Example : A 4g sugar cube (sucrose: $\text{C}_{12}\text{H}_{22}\text{O}_{11}$) is dissolved in a 350mL teacup filled with hot water. What is the molarity of the sugar solution ?

Step 1- Determine number of moles of sucrose in 4g $\text{C}_{12}\text{H}_{22}\text{O}_{11}$ = $(12)(12) + (1)(22) + (16)(11) = 342$ g/mol

Divide this amount into the size of the sample: $4\text{g} / (342\text{g/mol}) = 0.0117$ mol

Step 2 - Determine the volume of solvent in liters : 350 ml / 1000ml = 0.350L

Step 3- Determine the molarity of the solution : $M = m/V$

$3 = 0.0117 \text{ mol} / 0.350 \text{ L} = 0.033 \text{ M}$

Molality is the number of moles of solute per kilogram of solvent.

Molality (m) = moles of solute/kilogram of solvent

Example: What is the molality of a solution of 10 g NaOH in 500 g water?

Step 1- Determine number of moles of NaOH in 10 g

$\text{NaOH} = 23 + 16 + 1 = 40 \text{ g/mol}$

Divide this amount into the size of the sample: $10\text{g}/40\text{g}$

$\text{mol} = 0.25 \text{ mol}$

Step 2- Determine the volume of solvent in kilogram : $500\text{g}/1000 \text{ mg} = 0.5\text{kg}$

Step 3- Determine the molality of the solution: $M = m/\text{kg}$

$M = 0.25 \text{ mol} / 0.5\text{kg} = 0.05\text{m}$

Normality is equal to the gram equivalent weight of a solute per liter of solution. A gram equivalent weight or equivalent is a measure of the reactive capacity of a given molecule. Normality is the only concentration unit that is reaction dependent.

Normality (N) = equivalent weight of solute/ liters of solution

Example: if W gram of a substance is dissolved in V ml of solution and the equivalent weight of substance is E, the normality is equal to $(W \times 1000)/(E \times V)$.

Definition , properties and uses of metals and non-metals

Definition

Metals and non-metals are two different types of materials that have different properties and uses. Elements can be classified as metals or non-metals based on their characteristics.

Properties of metals

- They have a shiny surface or metallic lustre.
- They are hard, malleable (can be beaten into thin sheets) and ductile (can be drawn into thin wires)
- They are good conductors of heat and electricity.
- They have high melting points and densities.
- They tend to lose electrons and form positive ions or cations.
- They form basic oxides and react with acids.

Properties of non-metals

- They have a dull surface or no lustre.
- They are soft, brittle (break easily) and non ductile.(cannot be drawn into wires)
- They are poor conductors of heat and electricity except for carbon (in the form of graphite) and some other non-metals like iodine and selenium.
- They have low melting points and densities.
- They tend to gain electrons and form negative ions or anions.
- They form acidic oxides and react with bases.

Uses of metals & non-metals

- Metals are used for making utensils, coins, jewellery, machinery, Vehicles, buildings, etc.
- Non-metals are used for making fertilizers medicines, fuels, plastics, rubber etc.,

Water

Objectives: At the end of this lesson you shall be able to

- state sources of water
- explain hard and soft water
- state causes and removal of hardness
- water for industrial purposes
- introduction to effluent treatment plant
- definition, causes, effect and prevention of corrosion.
- define Allotropy of hydrogen, carbon, phosphorus and sulphur.

Sources of water

The two important sources of water are;

- 1 Surface water
- 2 Under ground water.

Surface water

Water available on the earth's surface is called as surface water.

Underground water

Underground water includes water present between the rocks in the earth crust, spring water, well water etc.

Hard and soft water

The hardness or softness of water is determined by the mineral content of both calcium and magnesium.

Soft water has less than 17 parts per million. Slightly hard water has 17 to 60 parts per million. Moderately hard water has 60 to 120 Parts per million. Hard water has 120 to 180 parts per million.

Soft water

Soft water readily gives lather

Hard water

Hard water does not give lather

Causes and removal with soap of Hardness

There are two types of hardness in water

- i Temporary hardness (carbonate hardness). It is due to presence of calcium bicarbonate (CaHCO_3)₂ and magnesium bicarbonate [$\text{Mg}(\text{HCO}_3)_2$]. Temporary hardness can be removed by boiling.
- ii Permanent hardness (Non-Carbonate hardness) It is due to the presence of chloride and sulphate salts of calcium and magnesium (CaCl_2 , CaSO_4 , MgCl_2 , MgSO_4). It cannot be removed by boiling. Hence it is known as permanent hardness. Permanent hardness is caused by other salts and often requires water softeners, which exchange calcium and magnesium ions for sodium ions.

Water for industrial purposes:

Industries use water for cooling, processing cleaning and more. They often require significant quantities of water, and the quality of water matters. Depending of the industry,

water might need to be treated for contaminants, softened, or even purified to meet specific requirements.

Effluent Treatment Plant (CETP)

An Effluent Treatment Plant (ETP) is a facility designed to treat and remove pollutants from industrial waste water before it is discharged into the environment. The goal of an ETP is to reduce the environmental impact of industrial effluents by treating them to meet regulatory standards and minimize harm to water bodies and ecosystems.

Key components and processes of an ETP

- 1 **Primary treatment:** This involves physical Processes like screening, sedimentation and setting to remove larger solids and particles from the waste water.
- 2 **Secondary Treatment:** Biological processes are used here, such as activated sludge, trickling filters, or biofilm reactors. Microorganisms break down organic pollutants in the waste water.
- 3 **Tertiary Treatment:** This step involves additional process to further polish the effluent and remove any remaining contaminants. Methods include filtration, chemical treatment, and advanced oxidation
- 4 **Sludge Treatment:** The solids that settle during treatment (sludge) need to be treated separately. common methods include thickening, dewatering and sometimes anaerobic digestion incineration.
- 5 **Disinfection:** Before discharge the treated water might undergo disinfection to kill harmful bacteria and pathogens.

Effluent treatment varies based on the type of industry, the pollutants present, and local regulations.

Corrosion

Corrosion is the process of deterioration of materials, usually metals, due to chemical or electrochemical reactions with their environment. It can have significant impact on structures, equipment, and various industrial processes.

- 1 **Causes of corrosion:** Chemical reaction with oxygen (oxidation) and moisture is a common cause. Acids, bases, and salts in the environment can also initiate corrosion.
- 2 **Electrochemical Reactions:** When metals are in contact with an electrolyte (usually water or a solution

containing ions) they can form a galvanic cell, where one metal acts as an anode (corrodes) and the other as a cathode

- 3 Localized Factors:** Concentration differences, impurities temperature variations, and stress can accelerate localized corrosion, such as pitting or crevice corrosion.

Effects of corrosion

- 1 Structural Damage:** Corrosion can weaken metal structures, causing them to fail prematurely.
- 2 Loss of Functionality:** corrosion can effect the performance of mechanical and electrical equipment, reducing efficiency and reliability.
- 3 Safety Risks:** corroded structures may pose safety hazards particularly in critical applications like bridges, pipelines and industrial equipment
- 4 Environmental impact:** Corroded materials may release pollutants into the environment.

Prevention of corrosion

- 1 Coatings:** Applying protective coatings like paint, epoxy, zinc can create a barrier between the metal and the environment

- 2 Cathodic protection:** sacrificial anodes (usually made of a more reactive metal) are connected to the metal to be protected. They corrode instead of the target metal.
- 3 Alloying:** Using corrosion-resistant alloys can enhance the material's resistance to corrosion.
- 4 Proper Design:** Design structures to minimize water retention crevices, which can accelerate corrosion.
- 5 Environmental control:** Limit exposure to corrosive environments through ventilation, humidity control, and other measures
- 6 Regular maintenance:** Regular inspections, clearing, and repair can prevent mirror corrosion from escalating.
- 7 Corrosion inhibitors:** chemical compounds can be added to the environment to slow down the corrosion process.

preventing corrosion requires a combination of materials selection, design considerations and maintenance practices tailored to the specific environment and applications.

Allotropy of hydrogen, carbon, phosphorus and sulphur

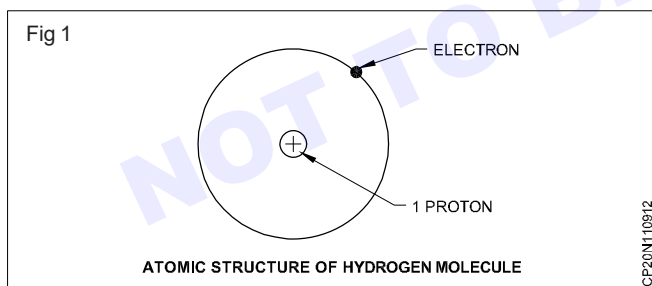
Objectives: At the end of this lesson you shall be able to

- state about Allotropy of hydrogen, carbon, phosphorus and sulphur.

Allotropy

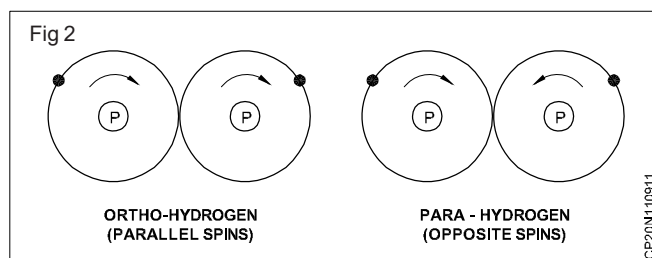
The existence of an element in multiple structural forms, known as allotropes, with different physical and chemical properties.

Hydrogen (Fig 1)



1 Orthohydrogen and Parahydrogen

These are two forms of molecular hydrogen (H_2). Orthohydrogen has parallel spins of its hydrogen nuclei (Protons), while parahydrogen has antiparallel spins. They have slightly different energy levels and behave differently under certain conditions (Fig 2).



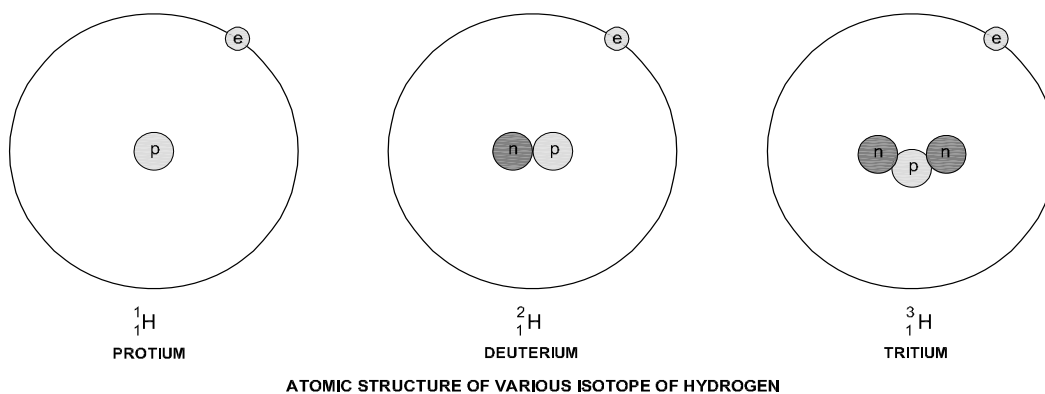
The Hydrogen has 3 isotopes

- 1 Protium with one electron & one Proton (Fig 3).
- 2 Deuterium has one electron, one Proton & one Neutron (Fig 3).
- 3 Tritium has one electron, one proton & 2 Neutrons (Fig 3)

Carbon

- 1 Diamond:** Each carbon atom in diamond is bonded to four other carbon atoms in a tetrahedral arrangement, forming a three-dimensional crystal lattice. Diamond is known for exceptional hardness and brilliance.
- 2 Graphite:** Carbon atoms in graphite are arranged in flat hexagonal layers, with each carbon atom bonded to three others. The layers are held together by weak vander waals forces. Graphite is a good conductor of electricity and is used as a lubricant and as pencil leads.
- 3 Graphene:** A single layer of graphite consisting of a two-dimensional hexagonal lattice of carbon atoms. It has remarkable electrical, thermal, and mechanical properties.
- 4 Fullerenes:** These are molecules composed entirely of carbon such as buckminsterfullerene (C_{60}) or "buckyballs" and carbon nanotubes. They have unique geometries and properties, with potential applications in various fields.

Fig 3

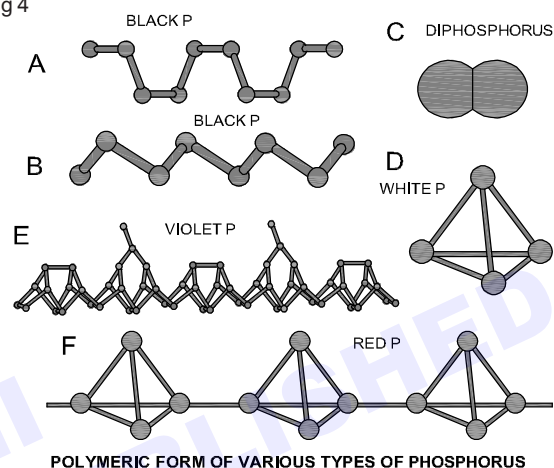


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Phosphorus (Fig 4 & 5)

- 1 White phosphorus:** made up of tetrahedral P_4 molecules, white phosphorus is highly reactive and toxic. It glows in the dark due to its slow oxidation. It's used in various chemical applications.
- 2 Red phosphorus:** Composed of long chains of phosphorus atoms. It's less reactive and safer to handle than white phosphorus. Red phosphorus is used in matches, flame retardants, and electronic components.
- 3 Black phosphorus:** Formed by stacking layers of phosphorus atoms. It has semiconducting properties and is being explored for its potential in electronics.

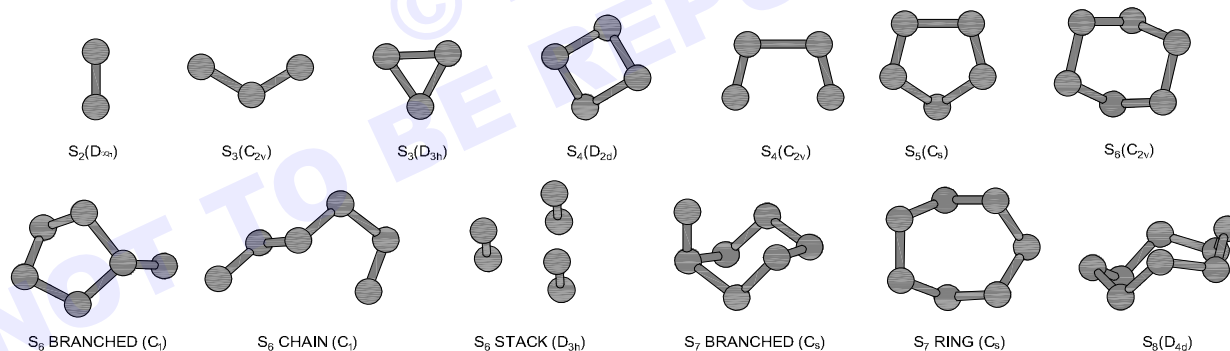
Fig 4



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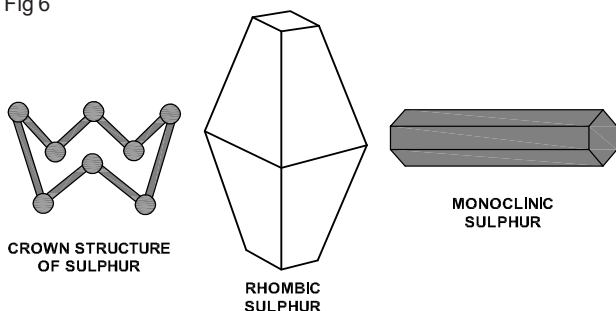
Sulphur (Fig 6)

Fig 5



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Fig 6

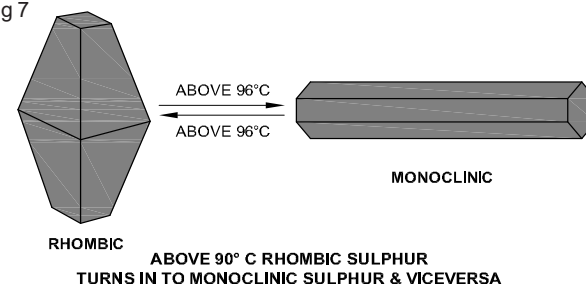


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- 1 Rhombic sulphur :** Consists of S_8 rings arranged in a puckered hexagonal lattice. It's a pale yellow solid and is stable at room temperature.
- 2 Monoclinic sulphur:** Also composed of S_8 rings, but arranged in monoclinic crystal structure. It's denser and more stable than rhombic sulphur.

- 3 Plastic sulphur:** Sulphur can also exist in an amorphous, rubbery form known as plastic sulphur. It forms when sulphur is melted and then cooled rapidly.
- 4 Cyclic sulphur molecules:** Various cyclic forms of sulphur, like S_6 and S_7 rings, can exist in certain conditions.

Fig 7



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Organic chemistry

Objectives: At the end of this lesson you shall be able to

- introduction to purification processes, organic reactions substitution, addition, elimination, rearrangement reactions
- explain Nomenclature basic rules for common name & IUPAC name system for alkanes, alkenes & alkynes, their examples
- definition of PH, PH scale, measurement of PH
- explain types & applications of conductivity.

Introduction to organic chemistry

Organic chemistry is a branch of chemistry that focuses on the study of compounds containing carbon and hydrogen atoms often with other elements like oxygen nitrogen sulfur, and more carbon unique ability to form diverse bonds with itself and other elements gives due to an incredible variety of organic molecules which are the building blocks of life and play a crucial role in many chemical

Key concepts in organic chemistry

- 1 Carbon can form up to four covalent bonds with other atoms leading to complex and diverse molecular structures. This property allows for the creation of intricate organic compounds
- 2 Functional groups organic compounds often have specific groups of atoms known as functional groups that determine their chemical behavior. Examples include hydroxyl (-OH) carbonyl (C=O) and amino (NH₂) groups
- 3 Isomerism isomers are molecules with the same molecular formula but different structural arrangements leading to distinct properties Structural isomers geometric isomers, and enantiomers are common types
- 4 Nomenclature organic compounds are named using a systematic nomenclature system that provides information about their structure functional groups and arrangement of atoms
- 5 Reactivity organic molecules can undergo various types of chemical reactions, including addition, elimination substitution and rearrangement reactions Reaction mechanisms often involve electron movement and bond formation/breakage
- 6 Stereochemistry. Stereoisomerism involves molecules with the same connectivity of atoms but different spatial arrangements. This is important in understanding how molecules interact in biological systems and chemical reactions
- 7 Biomolecules organic chemistry is central to understanding the structures and functions of biomolecules like proteins carbohydrates lipids, and nucleic acids which are essential to life.
- 8 Synthesis organic synthesis involves creating new organic compounds through various reactions. It's a

fundamental part of drug development materials science, and other applications

- 9 Polymers: Many organic compounds can link together to form polymers, which are long chains or networks of repeating units. Polymers have diverse industrial applications including plastics and fibers.
- 10 Environmental impact organic chemistry plays a role in understanding pollution toxicology, and environmental chemistry It's important in addressing issues like air quality waste management, and chemical contamination.

Organic chemistry is a dynamic field that contributes to our understanding of biological processes drug development, materials science and much more it's a foundation for numerous scientific disciplines and has a significant impact on our daily lives.

Purification processes

Purification processes are methods used to separate and remove impurities from substances such as chemicals liquids gases and materials. These processes are essential in various industries research, and everyday applications to ensure the desired quality and properties of the final product Here are some common purification processes:

- 1 **Distillation:** Distillation involves heating a mixture to separate its components based on their different boiling points. The vaporized components are then condensed back into liquids Fractional distillation is a variation that improves separation of components with closer boiling points.
- 2 **Filtration:** Filtration separates solids from liquids or gases using a physical barrier. Different types of filters (eg paper, membrane sand) are used depending on the particle size and nature of the mixture.
- 3 **Crystallization:** This process involves cooling a solution to allow the solute to crystallize while leaving impurities behind. The crystals are then separated from the remaining solution.
- 4 **Chromatography:** Chromatography is used to separate mixtures into their individual components based on their interactions with a stationary phase and a mobile phase Techniques like gas chromatography (GC) and liquid chromatography (LC) are widely used.

- 5 Extraction:** Extraction involves selectively removing one component from a mixture using a solvent that can dissolve the desired substance. Liquid-liquid extraction and solid-phase extraction are common methods.
- 6 Sublimation:** Sublimation is the direct conversion of a substance from a solid to a vapor without passing through the liquid phase. It's used to purify substances that readily sublime.
- 7 Electrolysis:** Electrolysis involves passing an electric current through a substance to cause a chemical reaction. It can be used to purify metals and other materials.
- 8 Decantation:** Decantation is a simple separation method where liquids of different densities are allowed to settle and the top layer (the less dense liquid) is carefully poured off leaving the denser liquid or solid behind.
- 9 Ion Exchange:** Ion exchange resins are used to remove specific ions from solutions. Common applications include water softening and purification in industries like water treatment and pharmaceuticals.
- 10 Adsorption:** Adsorption uses a solid material (adsorbent) to attract and hold into specific components of a mixture. Activated carbon is often used to remove impurities from liquids and gases.
- 11 Evaporation:** Evaporation is used to remove a solvent from a solution leaving behind the solute. It's common in the production of salts and other crystalline materials.

These purification processes are chosen based on the nature of the mixture and the desired end product. The choice of method depends on factors such as the physical properties of the substances, the scale of the operation, and the specific requirements for purity.

- 1 Substitution, addition, elimination, and rearrangement reactions are fundamental types of chemical reactions that play a crucial role in organic chemistry. They involve changes in the connectivity of atoms with molecules and the formation of new products with distinct structures and properties.
- 2 **Addition Reactions** occur when two or more reactants combine to form a single product molecule. In these reactions, pi bonds (double or triple bonds) are broken and new sigma bonds are formed. An example is the addition of hydrogen to an unsaturated hydrocarbon, alkyne, or alkene, resulting in a saturated molecule with hydrogen.
- 3 **Elimination Reactions** involve the removal of atoms or groups of atoms from a molecule to form a double bond or a triple bond. These reactions often occur in the presence of a strong base. An example is the elimination of hydrogen halides (HX) from alkyl halides, resulting in the formation of an alkene.
- 4 **Rearrangement Reactions** involve the migration of atoms or groups within a molecule to form a different structural isomer. These reactions often occur through a carbocation intermediate and are characterized by shifts of atoms

or groups to form more stable products. An example is the Wagner-Meerwein rearrangement where a hydride shift leads to the rearrangement of a carbocation.

- 5 These four types of reactions are fundamental to understanding the behavior of organic compounds and the mechanisms by which they undergo chemical transformations. Reaction mechanisms involve the movement of electrons and the breaking and forming of bonds, leading to the conversion of reactants into products. The study of these reactions is essential for predicting the outcomes of organic synthesis and understanding the behavior of complex molecules in various chemical processes.

- 6 Nomenclature - basic rules for common name & IUPAC name system for alkanes, alkenes & alkynes, their examples

Alkanes

Common Name: Alkanes are often referred to by their common names, where the prefixes "meth", "eth", "prop", "but", and so on, indicate the number of carbon atoms in the chain. For example, "ethane" has two carbon atoms, "propane" has three, and "butane" has four.

IUPAC Name: In the IUPAC (International Union of Pure and Applied Chemistry) naming system, alkanes follow a systematic approach:

- 7 Identify the longest continuous carbon chain and use the appropriate suffix ("-ane").
- 8 Number the carbons in the chain starting from the end closest to a substituent, and assign locants (numbers) to substituents.
- 9 List the substituents in alphabetical order and indicate their position using locants.

Example: CH₃CH₂CH₂CH₃ Common Name: Butane
IUPAC Name: Butane

Alkenes

- 10 Common Name: Alkenes are often named using common names similar to alkanes but with the suffix "-ene". For example, "ethene" has two carbon atoms and a double bond.

IUPAC Name:

- 11 Identify the longest carbon chain containing the double bond.
- 12 Number the chain to give the lowest possible locants to the double bond carbons.
- 13 Name the substituents and indicate their positions using locants.

Example: CH₃-CH=CH₂ Common Name: Propene
IUPAC Name: Prop-1-ene

Alkynes

- 14 Common Name: Alkynes follow common names with the suffix "-yne". For instance, "ethyne" has two carbon atoms and a triple bond.

IUPAC Name

- 15 Identify the longest carbon chain containing the triple bond.

16 Number the chain to give the lowest possible locants to the triple bond carbons.

17 Nomenclature-Basic rules for Common name & IUPAC name system for alkanes alkenes & alkynes their examples.

Example: CH₃-C≡CH Common Name Propyne IUPAC Name Prop-1-yne

It's important to note that the IUPAC system provides a consistent and unambiguous way to name organic compounds while common names are often used for simpler compounds or those with historical significance. The IUPAC system becomes particularly useful as compounds become more complex and have multiple substituents functional groups or branches.

Definition of pH. pH scale measurement of pH.

pH: pH is a measure of the acidity or alkalinity of a solution. It indicates the concentration of hydrogen ions (H⁺) present in the solution. Solutions with a low pH are considered acidic while those with a high pH are considered alkaline or basic.

pH Scale: The pH scale is a numerical scale that ranges from 0 to 14 with 7 as the neutral point. A pH of 7 indicates a neutral solution where the concentration of hydrogen ions is equal to the concentration of hydroxide ions (OH⁻). Solutions with a pH below 7 are acidic, and solutions with a pH above 7 are basic. Each unit change on the pH scale represents a tenfold change in the concentration of hydrogen ions.

Measurement of pH: pH can be measured using various methods with the most common being pH indicators, pH meters and litmus paper.

pH Indicators: pH indicators are substances that change color in response to changes in pH. They are often used in chemical tests or in the lab to visually determine the pH range of a solution.

pH Meters: pH meters are electronic devices that provide a more precise and accurate measurement of pH. They consist of a pH-sensitive electrode and a reference electrode. When the electrodes are immersed in the solution, they generate an electrical potential that is converted into a pH reading displayed on the meter.

Litmus Paper: Litmus paper is treated with a natural dye that changes color based on the pH of the solution. Red litmus paper turns blue in a basic solution and stays red in an acidic solution while blue litmus paper turns red in an acidic solution and stays blue in a basic solution.

The pH of a solution is an important parameter in various fields, including chemistry, biology, environmental science, and medicine. It affects chemical reactions, enzymatic activity, and the behavior of molecules in solution. Water, for example, has a pH of 7, while acidic substances like lemon juice might have a pH around 2, and basic substances like household ammonia can have a pH around 11 or 12.

Conductivity

Conductivity refers to the ability of a substance to conduct electric current. It is a property that depends on the presence of charged particles, such as ions or electrons,

which can carry electric charges through a material. Conductivity is an essential concept in various fields including physics, chemistry, materials science, and engineering.

Types of Conductivity

- 1 Electrical Conductivity:** This is the most common type of conductivity and involves the flow of electric current through a material due to the movement of electrons. Metals are excellent conductors of electricity due to their abundance of free electrons that can move easily.
- 2 Ionic Conductivity:** This type of conductivity involves the movement of ions in a solution or through an electrolyte. It's common in electrolytes, such as solutions of salts, acids, or bases. Ionic conductivity is important in batteries, fuel cells, and other electrochemical systems.

Conductivity is typically measured in units called Siemens per meter or reciprocal Ohm per meter ($\Omega^{-1}m$) in practical terms, it is often measured in milli Siemens per centimeter (mS/cm).

Conductivity measurements are carried out using devices called conductivity meters. These meters measure the resistance to the flow of electric current between two electrodes placed in the material being tested. Conductivity meters can be simple handheld devices or more sophisticated instruments used in research and industrial applications.

Factors affecting conductivity

- 1 Temperature:** Conductivity often increases with temperature as particles have more energy to move.
- 2 Concentration:** In solutions, higher concentrations of charged particles (ions) lead to higher conductivity.
- 3 Type of Material:** Different materials have varying levels of conductivity. Metals are generally good conductors due to their delocalized electrons.
- 4 Purity:** Impurities or defects in a material can affect its conductivity.

Applications of conductivity

- 1 Electronics:** Conductivity is crucial in the design and operation of electronic devices and circuits.
- 2 Electrochemical cells:** Batteries, fuel cells and other electrochemical systems rely on conductivity for their function.
- 3 Materials science:** Studying conductivity helps understand the behavior of materials and their applications.
- 4 Environmental monitoring:** Conductivity measurements are used in water quality assessments and pollution monitoring.
- 5 Medical applications:** Conductivity is used in medical devices like electrodes for measuring bioelectric signals.

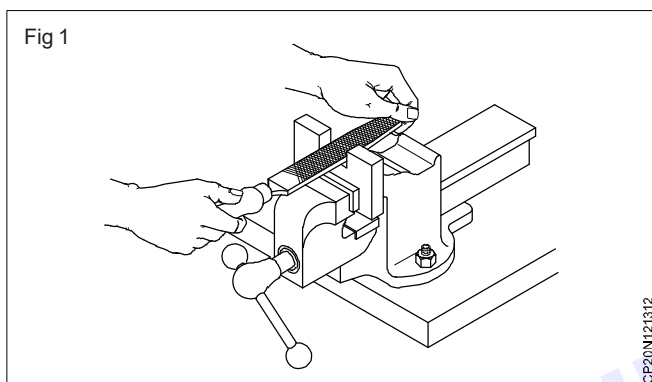
Conductivity plays a vital role in understanding the behavior of materials and the functioning of various technologies in our daily lives.

Description, construction and uses of different hand tools

Objectives: At the end of this lesson you shall be able to

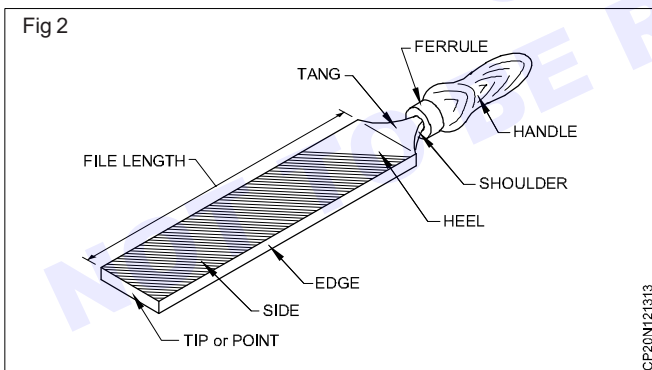
- explain the construction and uses of different types of files
- explain the construction and uses of chisels
- name the different types of hacksaw frames and blades
- state the different types and uses of hammer
- state the types and purposed steel rule
- name the commonly used calipers
- name the different punches and its uses
- define scribing block and its type.

Construction and uses of different types of files (Fig 1)



Parts of a file (Fig 2)

The parts of a file can be seen in Fig 2, are



Tip or Point

the end opposite to tang

Face or side

The broad part of the file with teeth cut on its surface

Edge

The thin part of the file with a single row of parallel teeth

Heel

The portion of the broad part without teeth

Shoulder

the curved part of the file separating tang from the body

Tang

The narrow and thin part of a file which fits into the handle

Handle

The part fitted to the tang for holding the file

Ferrule

A protective metal ring to prevent cracking of the handle.

Materials

Generally files are made of high carbon or high grade cast steel. The body portion is hardened and tempered. The tang is however not hardened.

Cut of files

Objectives: At the end of this lesson you shall be able to

- name the different cuts of files
- state the uses of each type of cut.

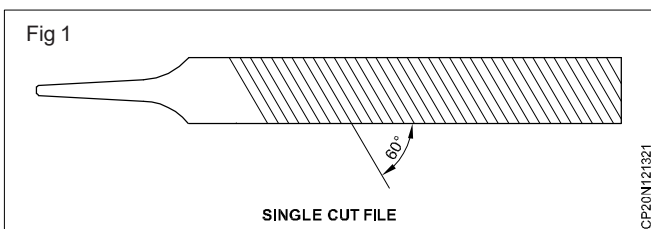
The teeth of all file are formed by cuts made on its face. Files have cuts of different types. Files with different cuts have different uses.

Types of cuts

Basically there are four types.

Single cut, Double cut, Rasp cut and Curved cut.

Single cut file (Fig 1)

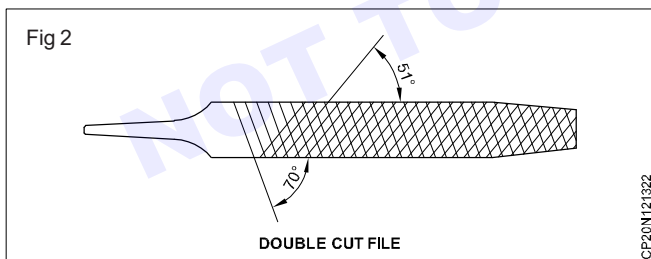


A single cut file has rows of teeth cut in one direction across its face. The teeth are at an angle of 60° to the centre line. It can cut chips as wide as the cut of the file. Files with this cut are useful for filing soft metals like brass, aluminium, bronze and copper.

Single cut files do not remove stock as fast double cut files, but the surface finish obtained is much smoother.

Double cut file (Fig 2)

A double cut file has two rows of teeth cut diagonal to each other. The first row of teeth is known as OVERCUT and they are cut at an angle of 70° . The other cut, made diagonal to this, is known as UPCUT, and is at an angle of 51° . This removes stock faster than the single cut file.



File specifications and grades

Objectives: At the end of this lesson you shall be able to

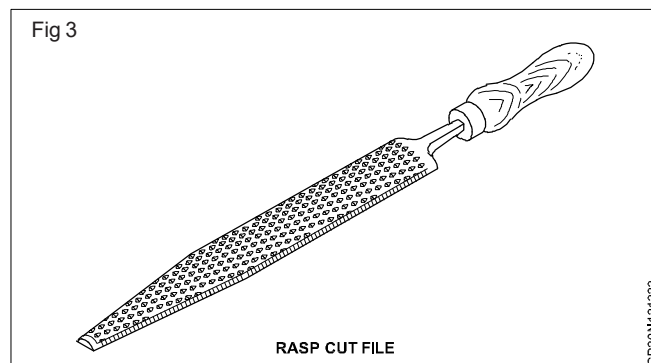
- state how files are specified
- name the different grades of files
- state the application of each grade of file.

Files are manufactured in different types and grades to meet the various needs.

Files are specified according to their length, grade, cut and shape.

Length is the distance from the tip of a file to the heel.

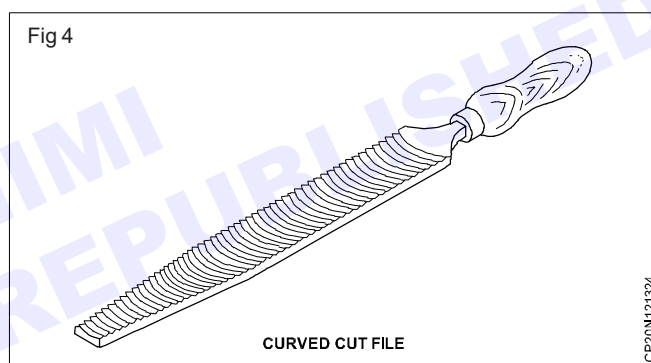
Rasp cut file (Fig 3)



The rasp cut has individual, sharp, pointed teeth in a line, and is useful for filing wood, leather and other soft materials.

These files are available only in half round shape.

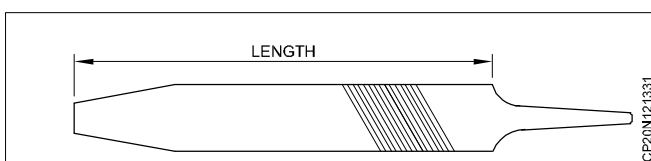
Curved cut file (Fig 4)



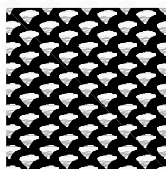
These files have deeper cutting action and are useful for filing soft materials like - aluminium, tin, copper, and plastic.

The curved cut files are available only in a flat shape.

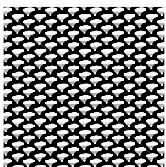
The selection of a file with a particular type of cut is based on the material to be filed. Single cut files are used for filing soft materials. But certain special files, for example, those used for sharpening saws, are also of single cut.



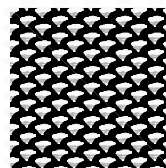
File grades are determined by the spacing of the teeth.



A **rough file** is used for removing rapidly a larger quantity of metal. It is mostly used for trimming the rough edges of soft metal castings.

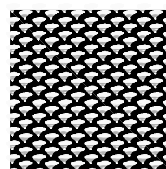


A **bastard file** is used in cases where there is a heavy reduction of material

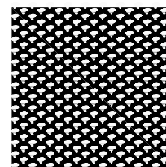


A **second cut file** is used to give a good finish on metals. It is excellent to file hard metals. It is useful for bringing the jobs close to the finishing size.

It may also be observed that the number of cutting edges in rows of a file changes according to the Length of a file.



A **smooth file** is used to remove small quantity of material and to give a good finish.



A **dead smooth file** is used to bring the material to accurate size with a high degree of finish.

The most used grades of files are bastard, second cut, smooth and dead smooth. These are the grades recommended by the bureau of Indian standards (BIS)

Different sizes of files with the same grade will have varying sizes of teeth. In longer files, the teeth will be coarser.

The number of cutting edge in rows in each of the above grades over a Length of 10mm as shown in Table (1).

TABLE 1

Grade of files (Number of cuts over the length of 10mm)					
Length of file	Rough	Bastard	Second cut	Smooth	Dead smooth
150mm	8	13	17	24	33
200mm	7	11	16	22	31
250mm	6	10	15	20	30
300mm	5	9	14	19	28

Types of files

Objectives: At the end of this lesson you shall be able to

- identify the different shape of files (types)
- state the uses of flat files, Hand files square, round, half round, triangular and knife-edge files
- state the correct shape of files for filing different profiles.

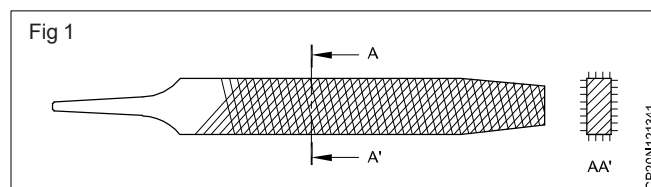
For filing and finishing different profiles, files of different shapes are used

The shape of files is stated by its cross section.

Common files of different shapes: Flat file, Hand file, Square file, Round file, Half round file, Triangular file and Knife-edge file.

Flat file (Fig 1)

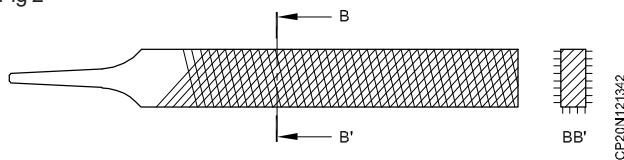
These files are of a rectangular cross section. The edges along the width of these files are parallel up to two-thirds of the length, and then they taper towards the point. The faces are double cut, and the edges single cut. These files are used for general purpose work. They are useful for filing and finishing external and internal surfaces.



Hand file (Fig 2)

These files are similar to the flat files in their cross section. The edges along the width are parallel throughout the length. The faces are double cut. One edge is single cut whereas the other is safe edge. Because of the safe edge, they are useful for filing surfaces which are at right angles to surfaces already finished.

Fig 2

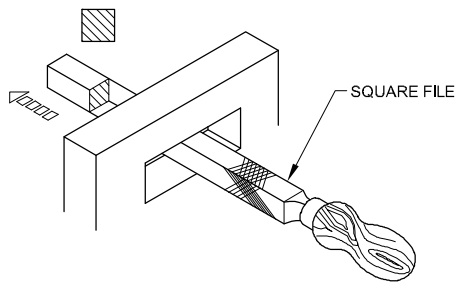


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Flat files are general purpose files. They are available in all grades. Hand files are particularly useful for filing at right angles to a finished surface.

Square File: The square file is square in its cross section. It is used for filing square holes, internal square corners, rectangular openings, keyways and splines. (Fig 3)

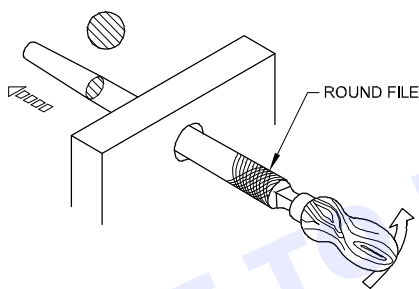
Fig 3



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Round file: A round file is circular in its cross section. It is used for enlarging the circular holes and filing profiles with fillets. (Fig 4)

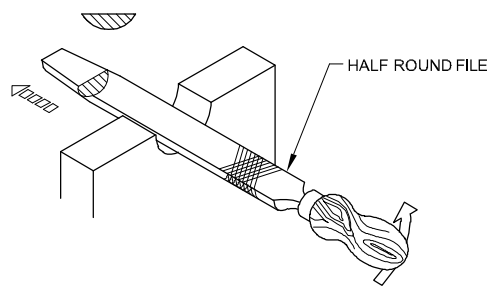
Fig 4



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Half round file: A half round file is in the shape of a segment of a circle. It is used for filing internal curved surfaces. (Fig 5)

Fig 5

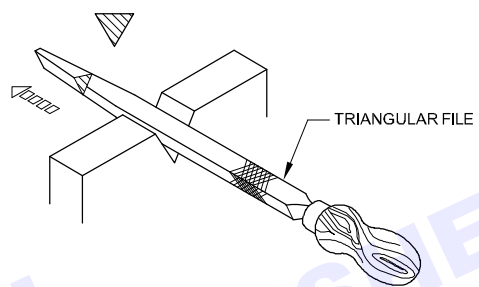


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Triangular file: A triangular file is of a triangular cross section. It is used for filing corners and angles which are more than 60° . (Fig 6)

Square, round, half-round and triangular files are available in lengths of 100, 150, 200, 250, 300 and 400mm. These files are made in bastard, second cut and smooth grades.

Fig 6

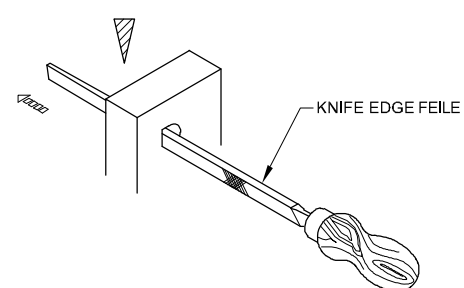


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Knife edge file: A knife edge file has the cross section of a sharp triangles. It is used for filing narrow grooves and angles above 10° (Fig 7)

The above files have one third of their lengths tapered. They are available both single and double cuts.

Fig 7



CP20N121347

Needle files

Objectives: At the end of this lesson you shall be able to

- name the different shapes of needle files
- designate needle files as per BIS.

Needle files are usually available in sets with assorted shapes. These types of files are used for delicate, light kinds of work. These files are available in bastard and smooth grade.

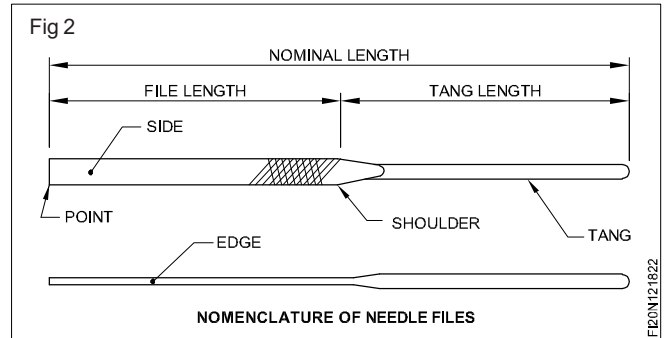
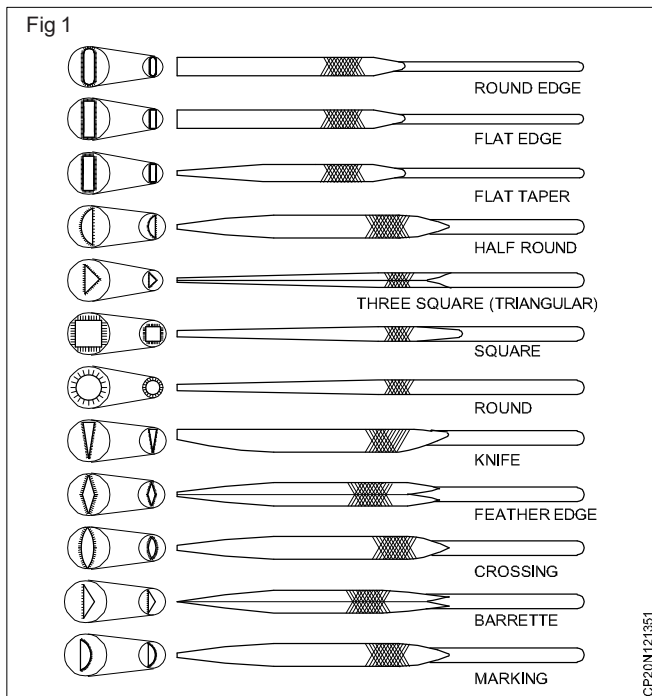
Shapes: The common shapes of needle files are shown in figure 1. The shapes are round edge, flat edge, flat taper, half round, triangular, square, round, knife, feather edge, crossing, barred and marking. (Fig 1)

Nomenclature of needle files. (Fig 2)

Length: These files are available in a nominal length of 120mm to 180mm.

Grades: The grades of cut may be identified by the cut number as follows

- bastard - Cut 0.
- smooth - Cut 2.



Designation of needle files: The needle files are designated by their names

- grade of cut
- nominal length
- BIS number

Example

A flat edge needle file with grade of cut bastard, having a nominal length of 160mm shall be designated as flat edge needle file bastard, 160 IS 3152

Convexity of files

Objective: At the end of this lesson you shall be able to

- list the reasons for convexity on files.

Most files have the faces slightly bellied lengthwise. This is known as convexity of a file. This should not be confused with the taper of a file. A flat file has faces which are convex and it also tapers slightly in width and thickness.

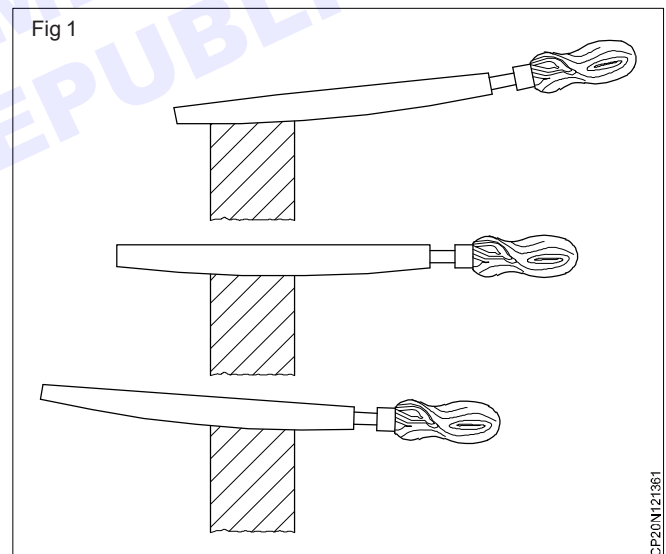
Purpose: If the file is parallel in thickness, all the teeth on the surface of the work will cut. This would require more downward pressure to make the file 'bite' and also more forward pressure to make the file to cut.

It is more difficult to control a file of uniform thickness.

To produce a flat surface with a file of parallel thickness, every stroke should be straight. But it is not possible due to the see-saw action of the hand.

If the file is made with parallel faces, while giving heat treatment, one face may warp and become concave, and the file will be useless for flat filing.

Excessive chip removal at the front or rear workpiece edge is prevented and filing of the flat surface is made easier because of the convexity on the cutting faces. (Fig 1)



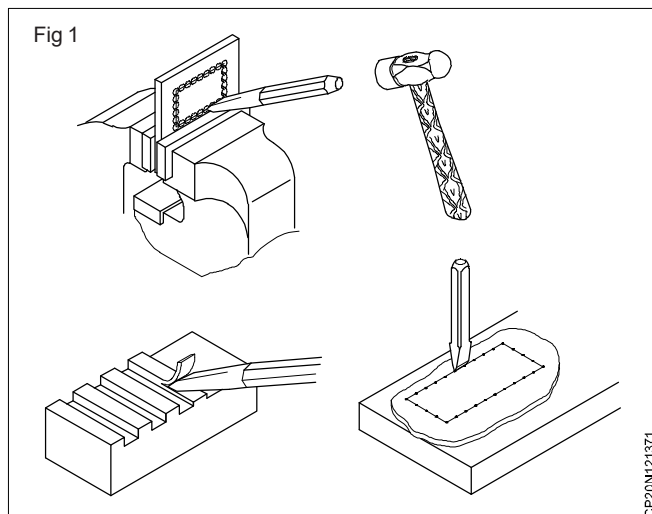
Cold Chisel

Objectives: At the end of this lesson you shall be able to

- list the uses of a cold chisel
- name the parts of a cold chisel
- state the different types of chisels
- specify the chisel.

The cold chisel is a hand cutting tool used by fitters for chipping and cutting off operations. (Fig 1)

Chipping is an operation of removing excess metal with the help of a chisel and hammer. Chipped surfaces being rough, they should be finished by filing.

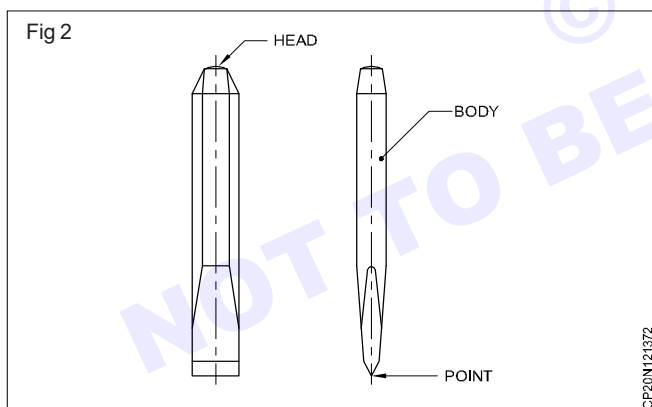


Parts of a Chisel (Fig 2): A chisel has the following parts. Head, body, point or cutting edge.

Chisels are made from high carbon steel or chrome vanadium steel. The cross-section of chisels is usually hexagonal or octagonal. The cutting edge is hardened and tempered.

Common types of chisels: There are five common types of chisels.

- Flat chisel
- Cross-cut chisel
- Half-round nose chisel
- Diamond point chisel
- Web chisel



Flat chisels (Fig 3a): They are used to remove metal from large flat surfaces and chip-off excess metal of welded joints and castings.

Cross-cut or cape chisels (Fig 3b): These are used for cutting key ways, grooves and slots.

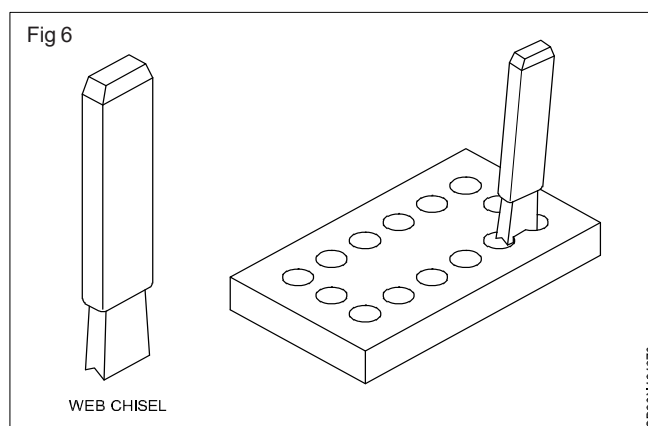
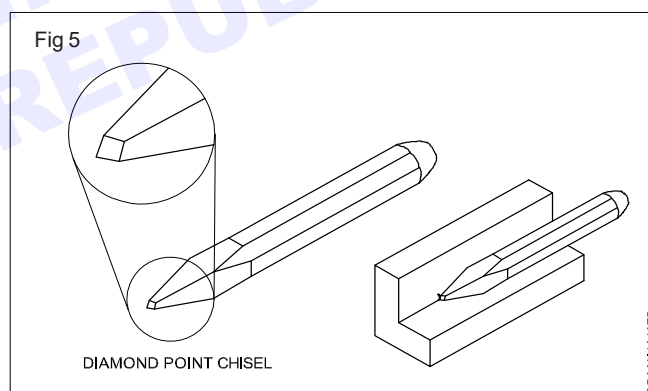
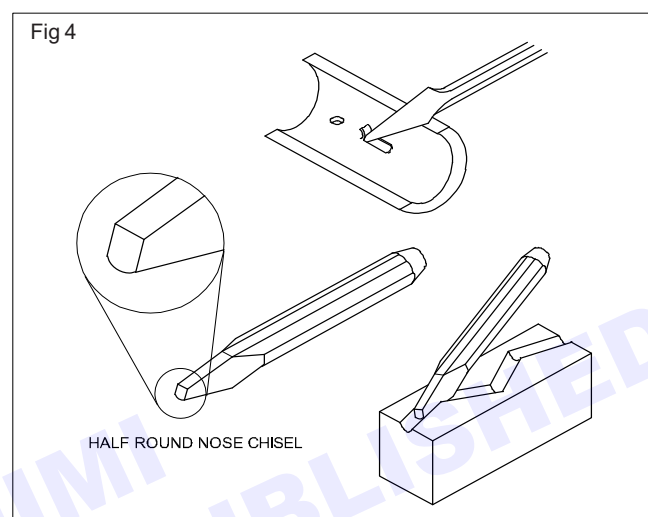
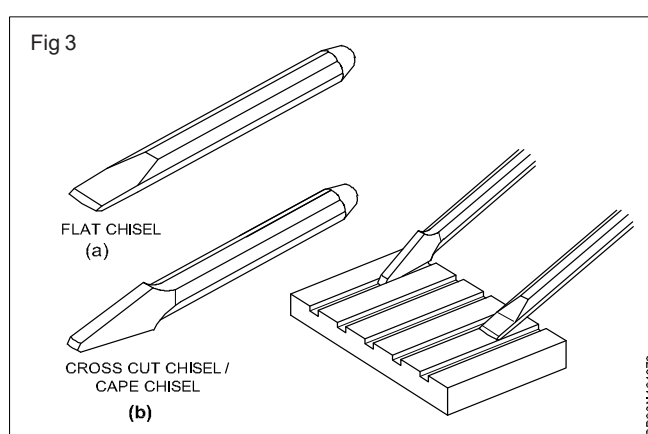
Half-round nose chisels (Fig 4): They are used for cutting curved grooves (oil grooves).

Diamond point chisels (Fig 5): These are used for squaring materials at the corners, joints.

Web chisels/ punching chisels (Fig 6): These chisels are used for separating metals after chain drilling.

Chisels are specified according to their

- length
- width of the cutting edge



- type
- cross-section of the body.

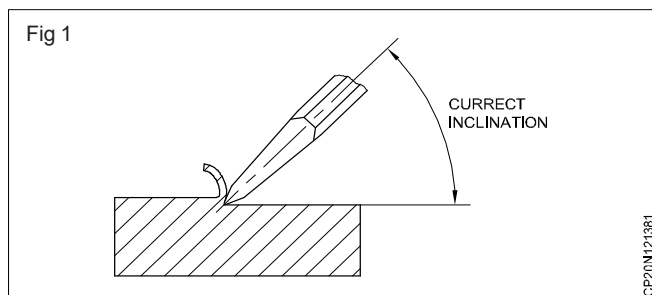
Angles of chisels

Objectives: At the end of this lesson you shall be able to

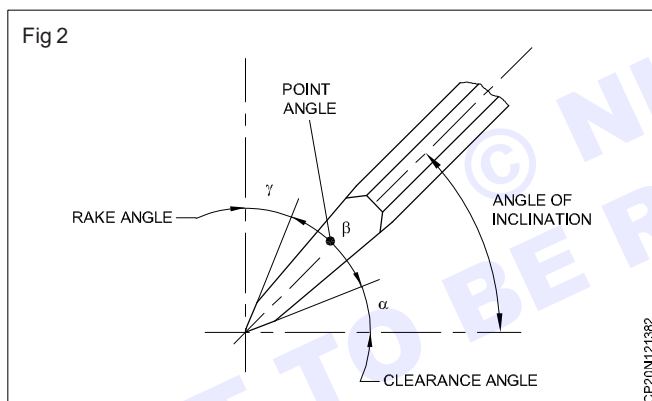
- select the point angles of chisels for different materials
- state the effect of rake and clearance angles
- brief the care and maintenance of chisels.

Point angles and materials: The correct point/cutting angle of the chisel depends on the material to be chipped. Sharp angles are given for soft materials, and wide angles for hard materials.

The correct point and angle of inclination generate the correct rake and clearance angles. (Fig 1)

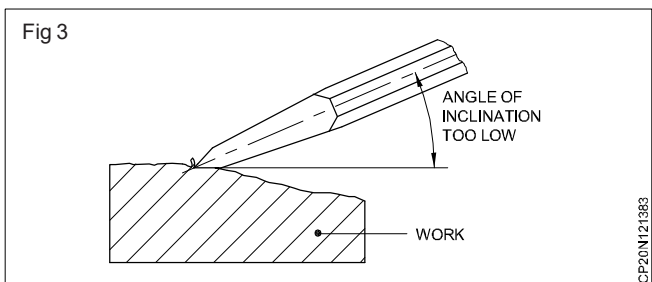


Rake angle: Rake angle is the angle between the top face of the cutting point, and normal (90°) to the work surface at the cutting edge. (Fig 2)

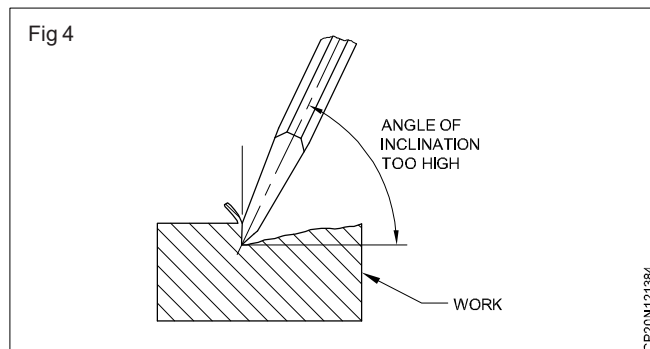


Clearance angle: Clearance angle is the angle between the bottom face of the point and the tangent to the work surface originating at the cutting edge. (Fig 2)

If the clearance angle is too low or zero, the rake angle increases. The cutting edge cannot penetrate into the work. The chisel will slip. (Fig 3)



If the clearance angle is too great, the rake angle reduces. The cutting edge digs in and the cut will become deeper and deeper. (Fig 4) The correct point angle and angle of inclination for different materials for chipping is given in Table 1.



Crowning: A slight curvature is ground called "Crowning" to the cutting edge of the chisel, to prevent digging of corners, which leads to breakage of chisel point. "Crowning" allows the chisel to move freely along a straight line while chipping.

Table 1

Material to be cut	Point angle	Angle inclination
High Carbon Steel	65°	39.5°
Cast iron	60°	37°
Mild steel	55°	34.5°
Brass	50°	32°
Copper	45°	29.5°
Aluminium	30°	22°

Care & maintenance

- Sharpen the chisel before use.
- Apply oil to avoid rust.
- Don't use the mushroom head chisel.
- Use safety goggles while chipping.
- While chipping.
- No greasy subject on the head of the chisel.

Hacksaw frames and blades

Objectives: At the end of this lesson you shall be able to

- name the different types of hacksaw frames
- specify hacksaw blades
- name the different type of hacksaw blades
- describe the method of sawing.

Hacksaw frame: A hacksaw frame is used along with a blade to cut metals of different sections, and is specified by the type and maximum length of the blade that can be fixed.

Example

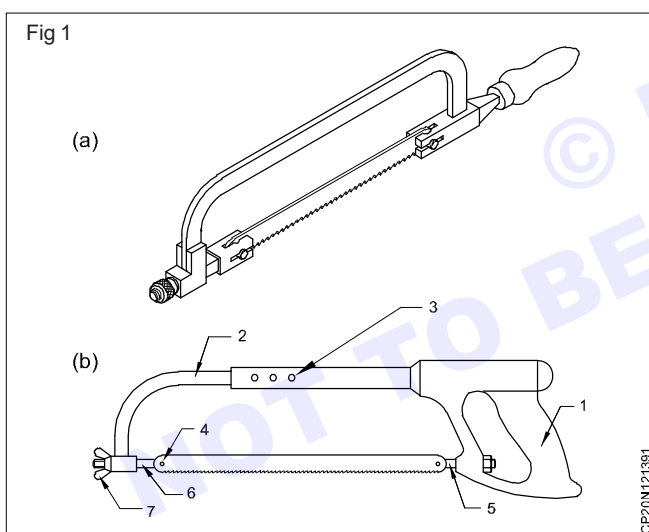
Adjustable hacksaw frame - tubular - 250 - 300mm or 8" - 12"

Types of hacksaw frames

Solid frame (Fig 1a): Only a blade of a particular standard length can be fitted to this frame. e.g 300 mm or 250 mm.

Adjustable frame (flat type): Different standard lengths of blades can be fitted to this frame i.e. 250 mm and 300 mm.

Adjustable frame (tubular type) (Fig 1b): This is the most commonly used type. It gives a better grip and control, while sawing.



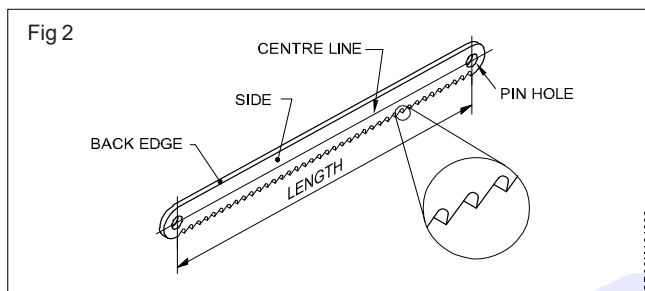
Parts of a hacksaw frame

- 1 Handle
- 2 Frame
- 3 Tubular frame with holes for length adjustment
- 4 Retaining pins
- 5 Fixed blade-holder
- 6 Adjustable blade-holder
- 7 Wing-nut

A hacksaw blade is made of either low alloy steel (LA) or high speed steel (HSS), and is available in standard lengths of 250 mm and 300mm. (Fig 2)

Parts of a hacksaw blade (Fig 2)

- 1 Back edge
- 2 Side
- 3 Centre line
- 4 Pin holes



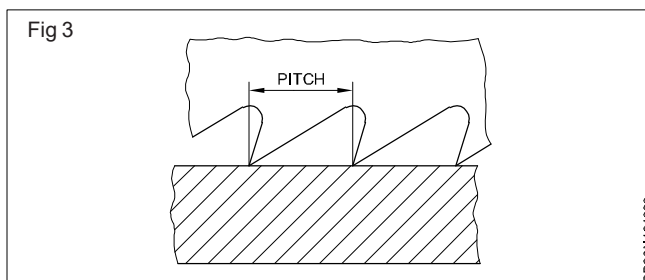
Type of hacksaw blades

All-hard blade: The full length of the blade between the pins is hardened and it is used for harder metals such as tool steel, die steel and HCS.

Flexible blade: Only the teeth are hardened. Because of their flexibility these blades are useful for cutting along curved lines. Flexible blades should be thinner than all-hard blades.

Pitch of the blade (Fig 3): The distance between adjacent teeth is known as the 'pitch' of the blade.

Classification	Pitch
Coarse	1.8 mm
Medium	1.4 mm & 1.0 mm
Fine	0.8 mm



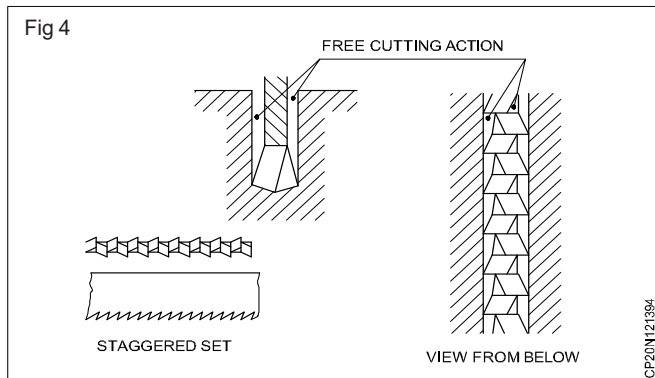
Specification: Hacksaw blades are specified by the length, pitch and type of material. (The width and thickness of blade is standardised)

Example

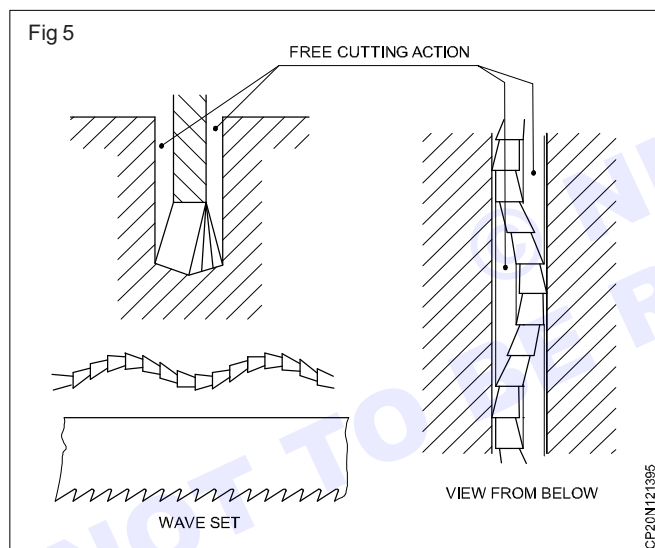
300 x 1.8 mm pitch LA all-hard blade.

To prevent the hacksaw blade binding when penetrating into the material, and to allow free movement of the blade, the cut is to be broader than the thickness of the hacksaw blade. This is achieved by the setting of the hacksaw teeth. There are two types of hacksaw teeth settings.

Staggered set (Fig 4): Alternate teeth or groups of teeth are staggered. This arrangement helps for free cutting, and provides for good chip clearance.



Wave set (Fig 5): In this, the teeth of the blade are arranged in a wave-form. The types of sets for different pictures are as follows:

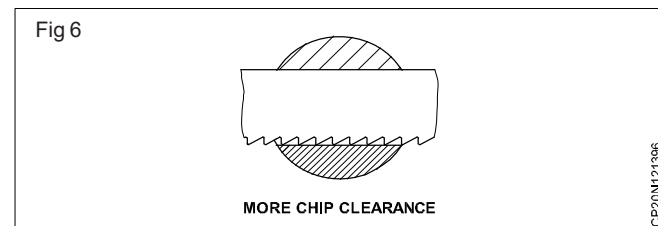


Pitch	Type of set
0.8 mm	Wave-set
1.0 mm	Wave-set or staggered
Over 1.0 mm	Staggered

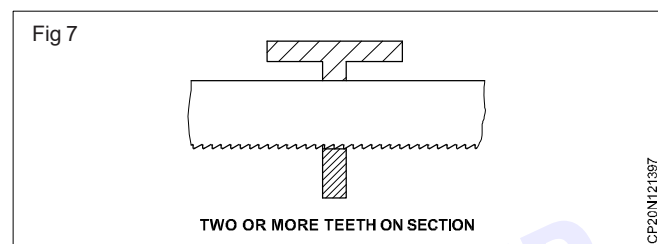
For the best results, the blade with the right pitch should be selected and fitted correctly.

Selection of blade: The selection of the blade depends on the shape and hardness of the material to be cut.

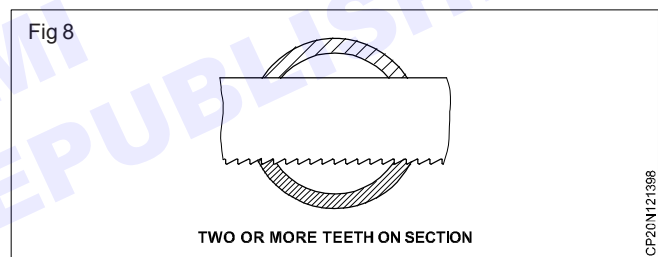
Pitch selection (Fig 6): For soft materials such as bronze, brass, soft steel, cast iron, heavy angles etc. use a 1.8 mm pitch blade.



For tool steel, high carbon, high speed steel etc. use a 1.4 mm pitch. For angle iron, brass tubing, copper, iron pipe etc. use a 1 mm pitch blade. (Fig 7)



For conduit and other thin tubing, sheet metal work etc. use a 0.8 mm pitch. (Fig 8)



Method of sawing

Select the correct blade for the material to be cut.

HSS - Blades are used for tough resistant materials

High Carbon Steel - General cutting

Select the correct number of teeth / inch the general rule is that atleast 3 teeth should extend across the surface of the material to be cut.

The hand holds the hacksaw handle, and the index finger is support the handle and also points in the direction of cutting.

The other hand holds the frame, near the wing nut. Cutting/ sewing should be carried out close to the jaws of the vice. This ensures that the metal does not flex or bend under the force of the hacksaw and the sawing motion.

Hammers

Objectives: At the end of this lesson you shall be able to

- state the uses of an engineer's hammer
- identify the parts of an engineer's hammer
- name the types of engineer's hammer
- specify the engineer's hammer.

An engineer's hammer is a hand tool used for striking purposes while punching, bending, straightening, chipping, forging or riveting.

Major parts of a hammer: The major parts of a hammer are the head and the handle.

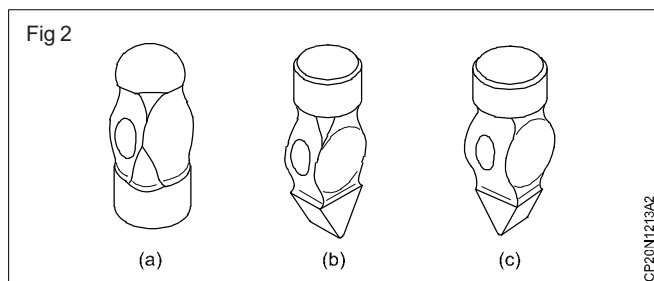
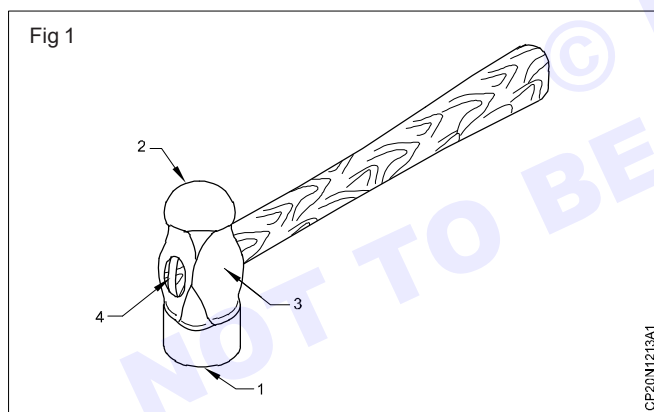
Hammer is made of drop-forged carbon steel, while the wooden handle must be capable of absorbing shock.

The parts of a hammer-head are the face (1), pein (2), cheek (3) and the eyehole (4).

Face: The face is the striking portion. A slight convexity is given to it to avoid digging of the edge. It is used for striking while chipping, bending, punching, etc.

Pein: The pein is the other end of the head. It is used for shaping and forming work like riveting and bending. The pein is of different shapes such as:

- ball pein (Fig.2a)
- cross-pein (Fig.2b)
- straight pein. (Fig 2c)

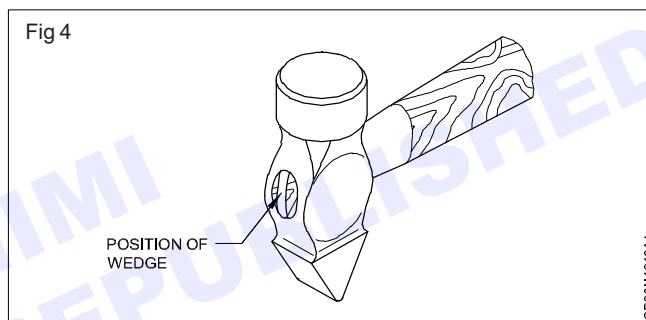
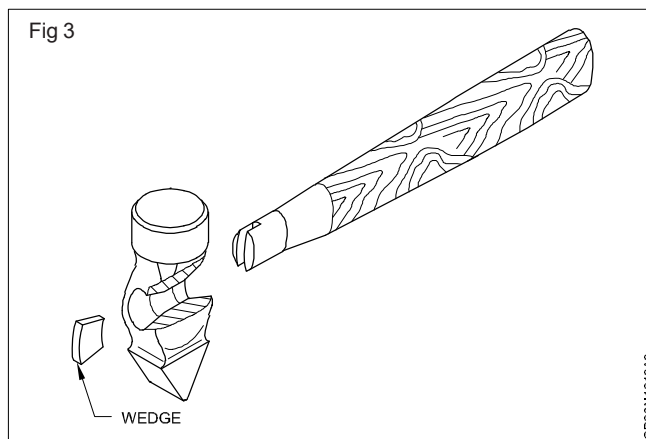


The face and the pein are case hardened.

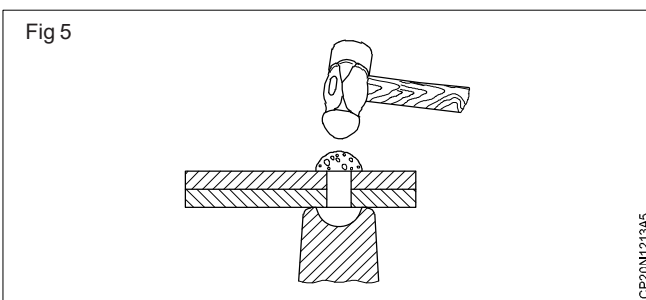
Cheek: The cheek is the middle portion of the hammer-head. The weight of the hammer is stamped here.

This portion of the hammer-head is left soft.

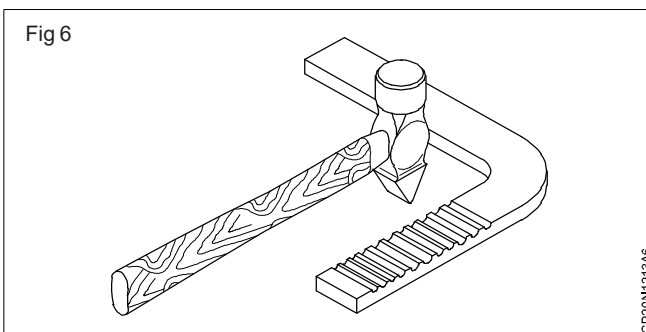
Eyehole: The eyehole is meant for fixing the handle. It is shaped to fit the handle rigidly. The wedges fix the handle in the eyehole. (Figs 3 and 4)



Application of hammer pein: The ball pein is used for riveting. (Fig 5)

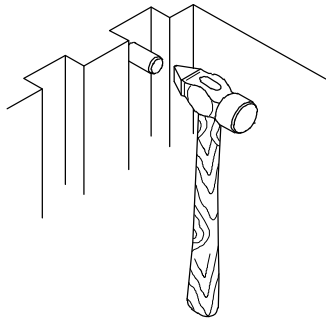


The cross-pein is used for spreading the metal in one direction. (Fig 6)



The straight pein is used at the corners. (Fig 7)

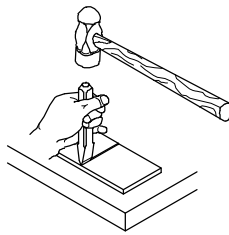
Fig 7



CP20N1213A7

The ball pein hammer is used for driving a chisel in parting metal. (Fig 8)

Fig 8



CP20N1213A8

Specification: An engineer's hammers are specified by their weight and the shape of the pein. Their weight varies from 125 gms to 750 gms.

The weight of an engineer's hammer, used for marking purposes, is 250 gms.

The ball pein hammers are used for general work in a machine/ fitting shop.

Before using a hammer

- make sure the handle is properly fitted
- select a hammer with the correct weight suitable for the job
- check the hammer head and handle whether any crack is there
- ensure that the face of the hammer is free from oil or grease.

Linear measurement

Objectives: At the end of this lesson you shall be able to

- name the base unit of linear measurement as per the International System of units of measurement (SI)
- state the multiples of a metre and their values
- state the purpose of steel rule
- name the types of steel rule
- state the precautions to be followed while using a steel rule.

When we measure an object, we are actually comparing it with a known standard of measurement.

The base unit of length as per SI is METRE.

Length - SI UNITS and MULTIPLES

Base unit

The base unit of length as per the Systems International is metre. The table given below lists some multiples of a meter.

METRE(m) = 1000 mm

CENTIMETRE (cm) = 10 mm

MILLIMETRE (mm) = 1000 μ

MICROMETRE (μ m) = 0.001 mm

Measurement in engineering practice

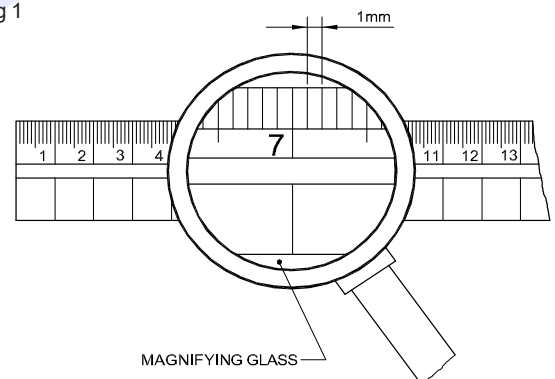
Usually, in engineering practice, the preferred unit of length measurement is millimetre. (Fig 1)

Both large and small dimensions are stated in millimetres. (Fig 2)

The British system of length measurement

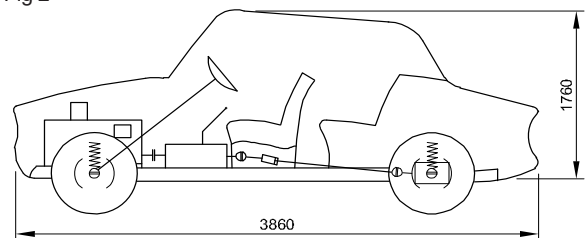
An alternative system of length measurement is the British system. In this system, the base unit is the Imperial Standard Yard. Most countries, including Great Britain itself, have however in the last few years, switched over to SI units.

Fig 1



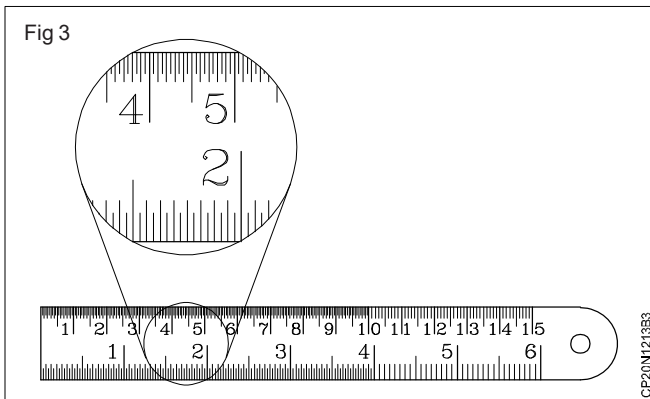
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Fig 2



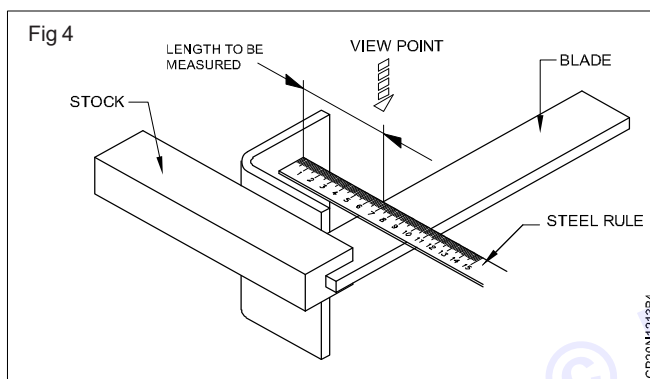
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Engineer's steel rule (Fig 3) are used to measure the dimensions of work pieces.

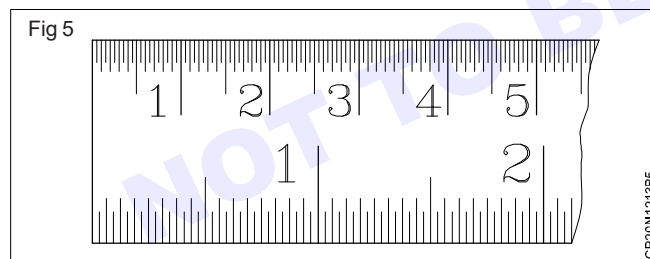


Steel rules are made of spring steel or stainless steel. These rules are available in length 150mm, 300mm and 600mm. The reading accuracy of steel rule is 0.5 mm and 1/64 inch.

For accurate reading it is necessary to read directly to avoid errors arising out of parallax. (Fig 4)



Steel rule in English measure, they can also be available with metric and English graduation in a complete range of sizes 150, 300, 500 and 1000 mm. (Fig 5)

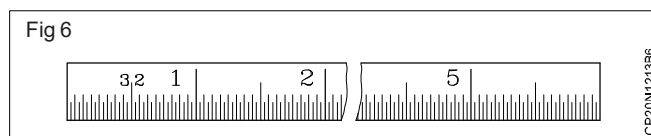


Other types of rule

- narrow steel rules
- short steel rules
- full flexible steel rule with tapered end.

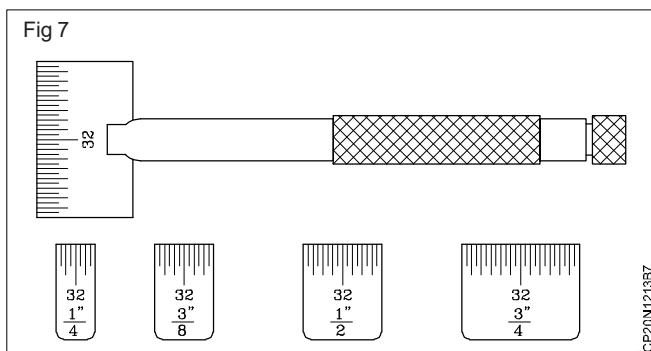
Narrow steel rule

Narrow steel rule is used to measure the depth of key-ways and depth of smaller dia, blind holes of jobs, where the ordinary steel rule can not reach. Its width is approximately 5 mm and thickness 2 mm. (Fig 6)



Short steel rule (Fig 7)

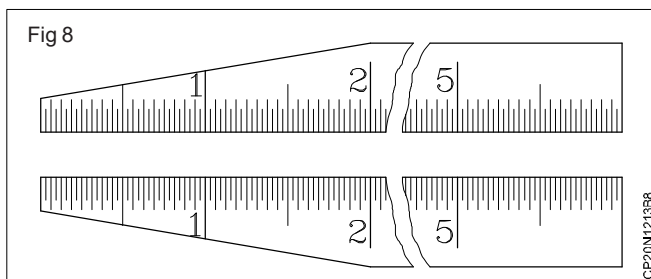
This set of five small rules together with a holder is extremely useful for measurements in confined or hard to reach locations which prevent the use of ordinary steel rules. It is used suitably for measuring grooves, short shoulder, recesses, key ways etc. in machining operation on shapers, millers and tool and die work.



The rules are easily inserted in the slotted end of the holder and are rigidly clamped in place by a slight turn of the knurled nut at the end of the handle. Five rule lengths are provided 1/4", 3/8", 1/2", 3/4" and 1" and each rule is graduated in 32^{nds} on one side and 64ths on the reverse side.

Steel rule with tapered end

This rule is a favorite with all mechanics since its tapered end permits measuring of inside size of small holes, narrow slots, grooves, recesses etc. This rule has a taper from 1/2 inch width at the 2 inch graduation to 1/8 inch width at the end. (Fig 8)



For maintaining the accuracy of a steel rule, it is important to see that its edges and surfaces are protected from damage and rust.

Do not place a steel rule with other cutting tools. Apply a thin layer of oil when not in use.

Angular measurement

Angular measurement of angles of an object is usually expressed in degrees, minutes and seconds. One degree is divided into 60 minutes and one minute is to 60 seconds.

Measurements of fundamental, derived units

Measurement of length

Metric			British	
Micron	1 μ	= 0.001 mm	Thousand th of an inch	= 0.001"
Millimetre	1 mm	= 1000 μ	Inch	= 1"
Centimetre	1 cm	= 10 mm	Foot 1 ft	= 12"
Decimeter	1 dm	= 10 cm	Yard 1 yd	= 3 ft
Metre	1 m	= 10 dm	1 furlong 1 fur	= 220 yds
Decametre	1 dam	= 10 metre	1 mile	= 8 fur

Calipers

Objectives: At the end of this lesson you shall be able to

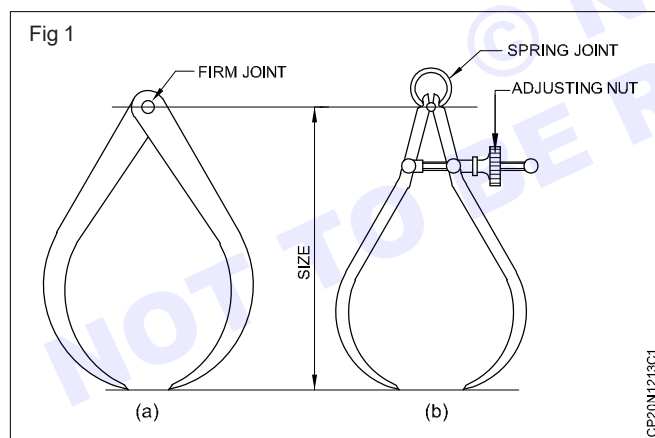
- name the commonly used calipers
- state the advantages of spring joint calipers.

Calipers are indirect measuring instruments used for transferring measurements from a steel rule to a job, and vice versa.

Calipers are classified according to their joints and their legs.

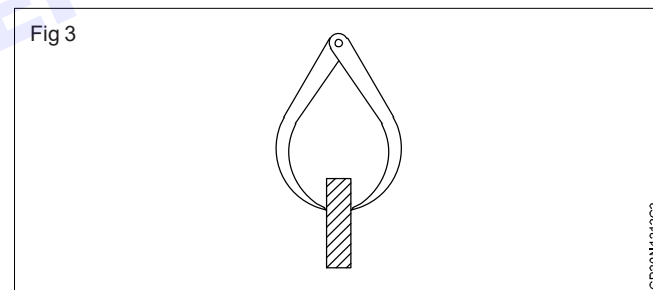
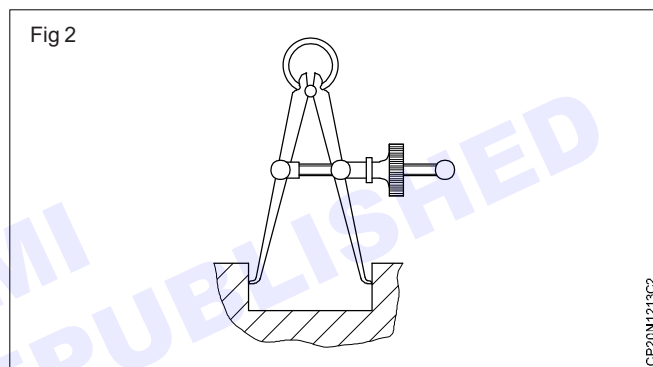
Joint

- Firm joint calipers (Fig 1a)
- Spring joint calipers (Fig 1b)



Legs

- Inside caliper for internal measurement. (Fig 2)
- Outside caliper for external measurement. (Fig 3)



Calipers are used along with steel rules, and the accuracy is limited to 0.5 mm; parallelism of jobs etc. can be checked with higher accuracy by using calipers with sensitive feel.

Spring joint calipers have the advantage of quick setting with the help of an adjusting nut. For setting a firm joint caliper, tap the leg lightly on a wooden surface.

Jenny calipers

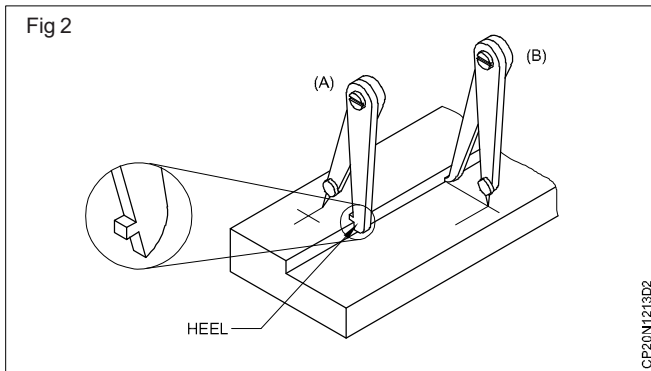
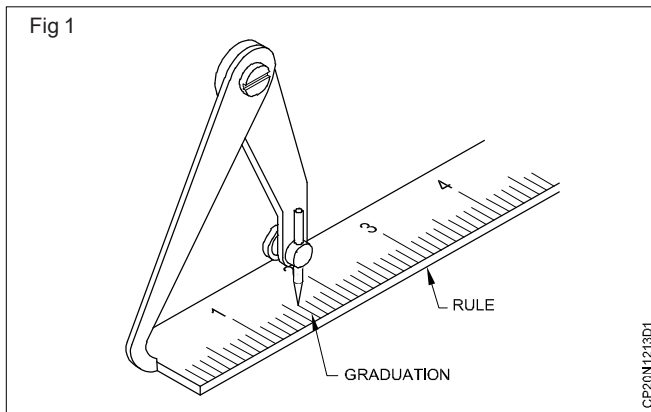
Objectives: At the end of this lesson you shall be able to

- state the uses of a jenny caliper
- state the two types of legs of a jenny caliper.

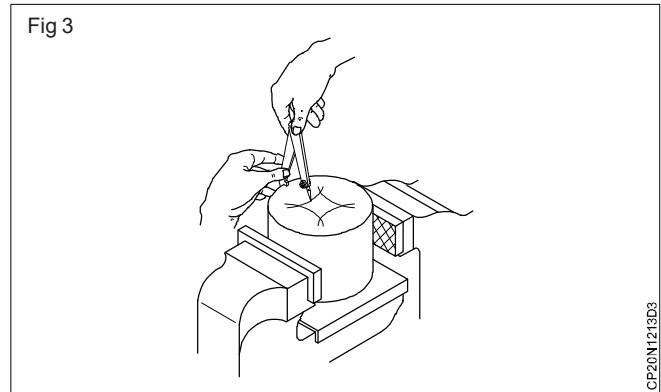
Jenny calipers have one leg with an adjustable divider point, while the other is a bent leg. (Fig 1) These are available in sizes of 150 mm, 200 mm, 250 mm and 300 mm.

Jenny calipers are used

- for marking lines parallel to the inside and outside edges. (Fig 2)



- for finding the centre of round bars. (Fig 3)



Calipers with bent leg (Fig 2B) are used for drawing lines parallel along an inside edge, and the heel type (Fig 2A) is used for drawing parallel lines along the outer edges.

The other names for this caliper are:

- hermaphrodite calipers
- leg and point calipers
- odd leg caliper.

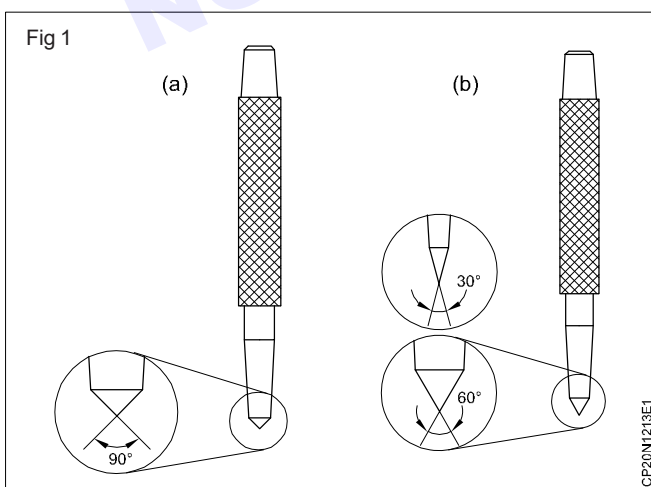
Types of marking punches

Objectives: At the end of this lesson you shall be able to

- name the different punches in marking
- state the features of each punch and its uses.

Punches are used in order to make certain dimensional features of the layout permanent. There are two types of punches. They are centre punch and prick punch made of high carbon steel, hardened and ground.

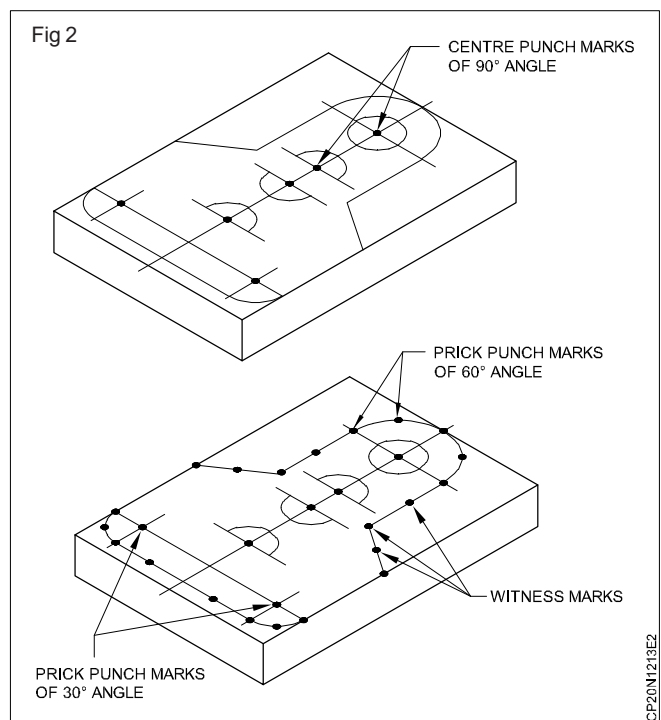
Centre Punch: The angle of the point is 90° in a centre punch. The punch mark made by this is wide and not very deep. This punch is used for locating centre of the holes. The wide punch mark gives a good seating for starting the drill. (Fig 1a)



Prick Punch/Dot punch: The angle of the prick punch is 30° or 60° . (Fig 1b) The 30° point punch is used for making light punch marks needed to position dividers. The divider

point will get a proper seating in the punch mark. The 60° punch is used for marking witness marks and called as dot punch. (Fig 2)

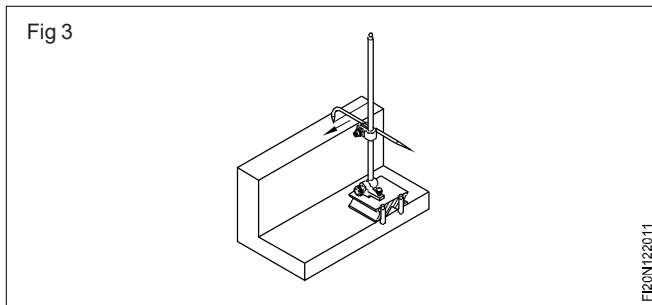
The witness marks should not be too close to one another.



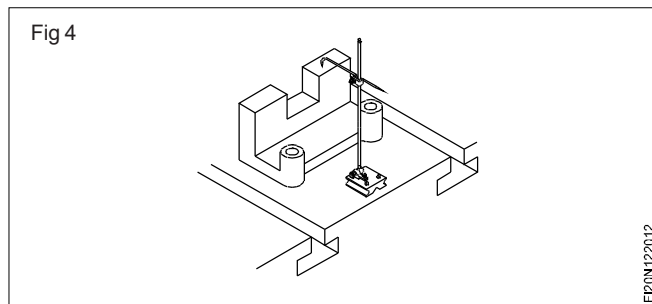
Surface gauge / Scribing block

The surface gauge is one of the most common marking tools used for:

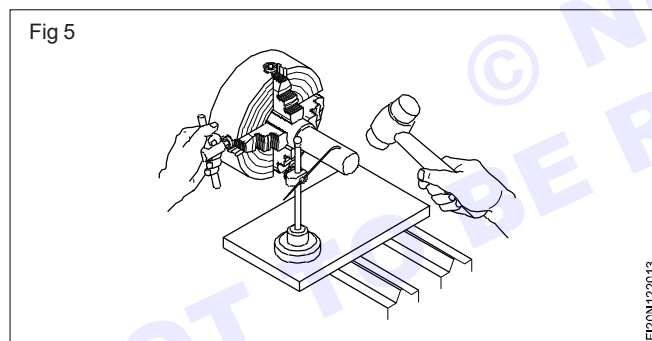
scribing lines parallel to a datum surface (Fig 3)



Setting jobs on machines parallel to a datum surface (Fig 4)



Checking the height and parallelism of jobs, setting jobs concentric to the machine spindle. (Fig 5)



Types of surface gauges

Surface gauges/scribing blocks are of two types, fixed and universal.

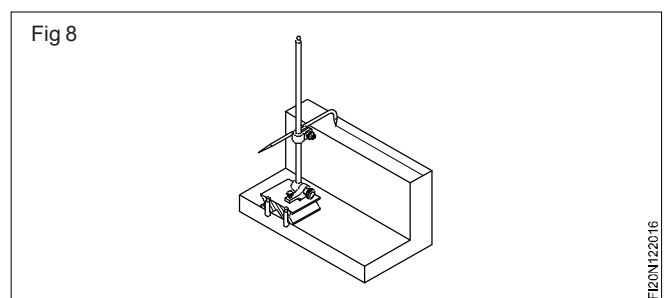
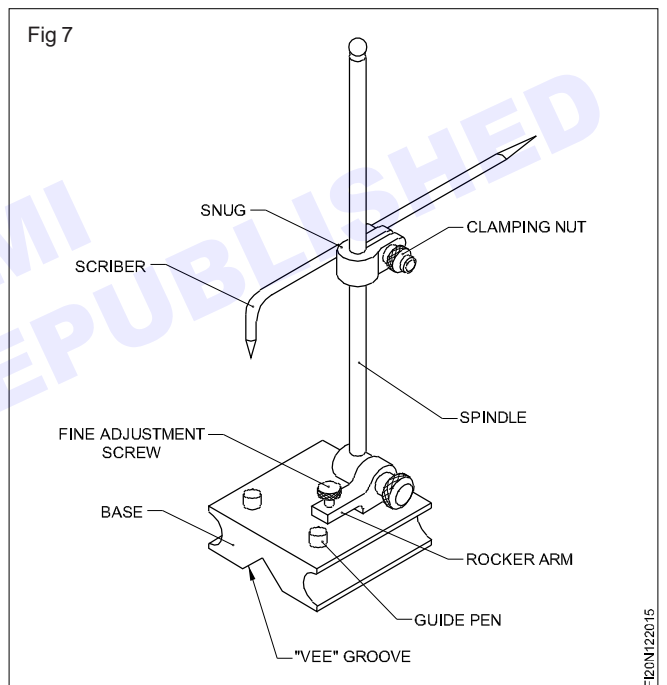
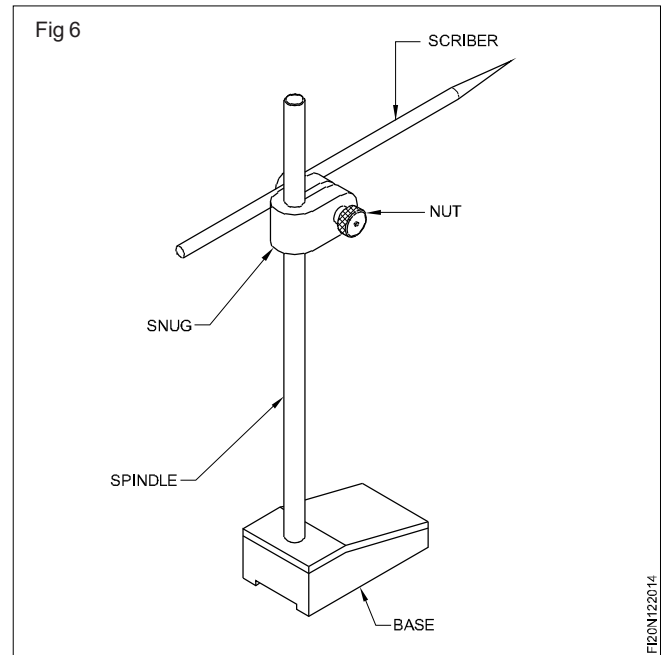
Surface gauge - fixed type (Fig 6)

The fixed Type of surface gauge consists of a heavy flat base and a spindle, fixed upright, to which a scribe is attached with a snug and a clamp nut.

Universal surface gauge (Fig 7)

This has the following additional features: The spindle can be set to any position. Fine adjustment can be made quickly. Can also be used on cylindrical surfaces.

Parallel lines can be scribed from any datum edge with the help of guide pins. (Fig 8)



Parts and functions of a Universal Surface Gauge

Base

The base is made of steel or cast iron with a 'V' groove at the bottom. The 'V' groove helps to seat on circular work. The guide-pins, fitted in the base, are helpful for scribing lines from any datum edge.

Rocker arm

The rocker arm is attached to the base along with a spring and a fine adjustment screw. This is used for fine adjustments.

Spindle

The spindle is attached to the rocker arm.

Scriber

The scriber can be clamped in any position on the spindle with the help of a snug and a clamping nut.

Care and maintenance

- Clean before and after the use
- Apply thin layer of oil to the bottom of the surface base before using for marking.
- Sharpen the scriber if necessary.
- Do not exert more pressure while marking

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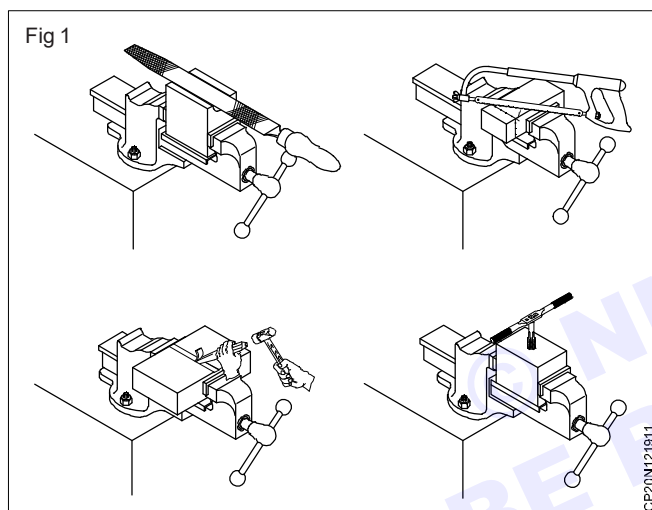
Bench vice

Objectives: At the end of this lesson you shall be able to

- state the uses of bench vice
- specify the size of the bench vice
- name the parts of the bench vice
- state the uses of vice clamps
- mention the care and maintenance of vices.

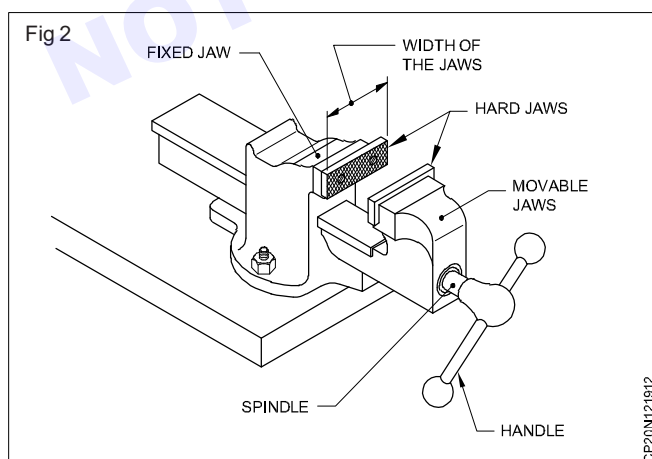
Vices are used for holding the workpieces. They are available in different types. The vice used for bench work is the bench vice or called Engineer's vice.

A bench vice is made of cast iron or cast steel and it is used to hold work for filing, sawing, threading and other hand operations. (Fig 1)



The size of the vice is stated by the width of the jaws.eg. 150mm parallel jaw bench vice

Parts of a bench vice (Fig 2)

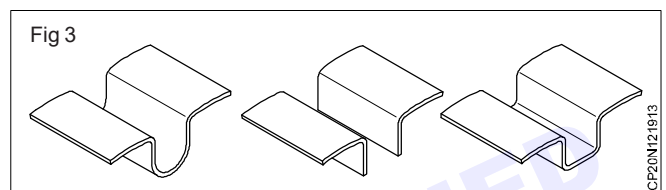


The following are the parts of a vice.

Fixed jaw, movable jaw, hard jaws, spindle, handle, box-nut and spring are the parts of a vice.

The box-nut and the spring are the internal parts.

Vice clamps or soft jaws (Fig 3)



To hold a finished work use soft jaws (vice clamps) made of aluminium over the regular jaws. This will protect the work surface from damage.

Do not over-tighten the vice as, the spindle may be damaged.

Care and maintenance of vices

- Always keep all threaded and moving parts clean by wiping the vice with a cloth after each use.
- Make sure to oil and lubricate the joints and sliding parts.
- To oil the sliding section, open the jaws completely and apply a layer of grease to the screen.
- Remove the rust if appears on the vice using rust remover chemical.
- When the vice is not in use bring the jaws lightly gap together and place the handle in a vertical position.
- Avoid striking the handle of the vice by a hammer for tightening fully, otherwise the handle will become bend or damaged.

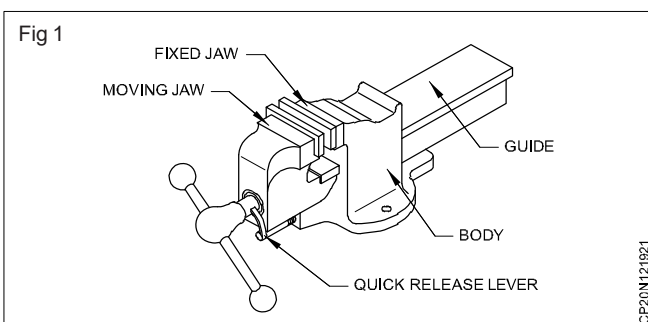
Types of vices

Objectives: At the end of this lesson you shall be able to

- state the different types of vices
- state the uses of quick releasing vice, pipe vice, hand vice, pin vice and leg vice.

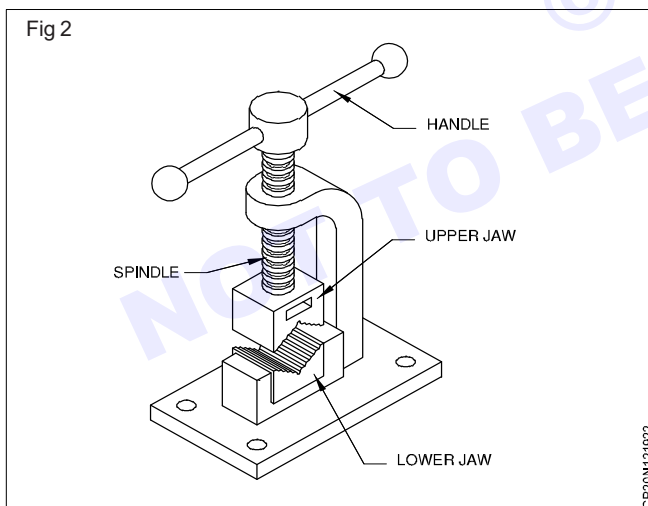
There are different types of vices used for holding work-pieces. They are quick releasing vice, pipe vice, hand vice, pin vice and toolmaker's vice.

Quick releasing vice (Fig 1): A quick releasing vice is similar to an ordinary bench vice but the opening of the movable jaw is done by using a trigger (lever). If the trigger at the front of the movable jaw is pressed, the nut disengages the screw and the movable jaw can be set in any desired place quickly.



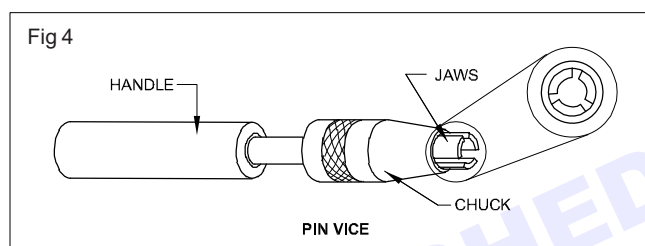
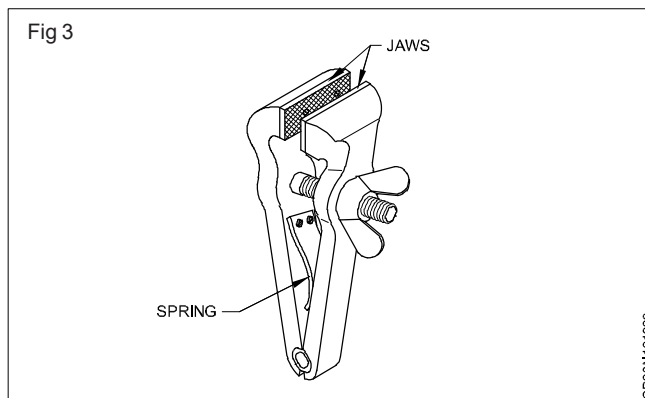
Pipe vice (Fig 2): A pipe vice is used for holding round sections of metal, tubes and pipes. In the vice, the screw is vertical and movable. The jaw works vertically.

The pipe vice grips the work at four points on its surface. The parts of a pipe vice are shown in Fig 2.



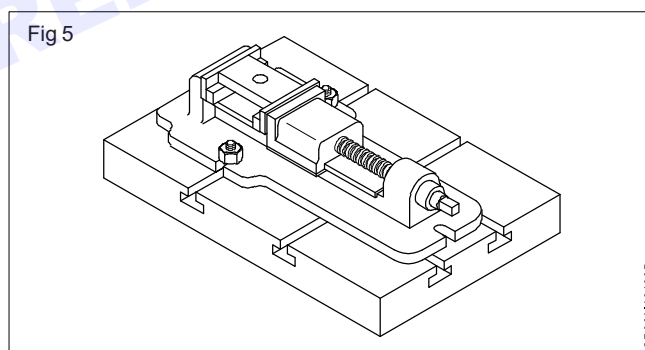
Hand vice (Fig 3): Hand vices are used for gripping screws, rivets, keys, small drills and other similar objects which are too small to be conveniently held in the bench vice. A hand vice is made in various shapes and sizes. The length varies from 125 to 150 mm and the jaw width from 40 to 44 mm. The jaws can be opened and closed using the wing nut on the screw that is fastened to one leg, and passes through the other.

Pin vice (Fig 4): The pin vice is used for holding small diameter jobs. It consists of a handle and a small collet chuck at one end. The chuck carries a set of jaws which are operated by turning the handle.



Toolmaker's vice (Fig 5): The toolmaker's vice is used for holding small work which requires filing or drilling and for marking of small jobs on the surface plate. This vice is made of mild steel.

Toolmaker's vice is accurately machined.



Leg vice

A leg vice is a holding device generally used in a forge shop for bending and forging work. It is made of mild steel to avoid breakage while hammering.

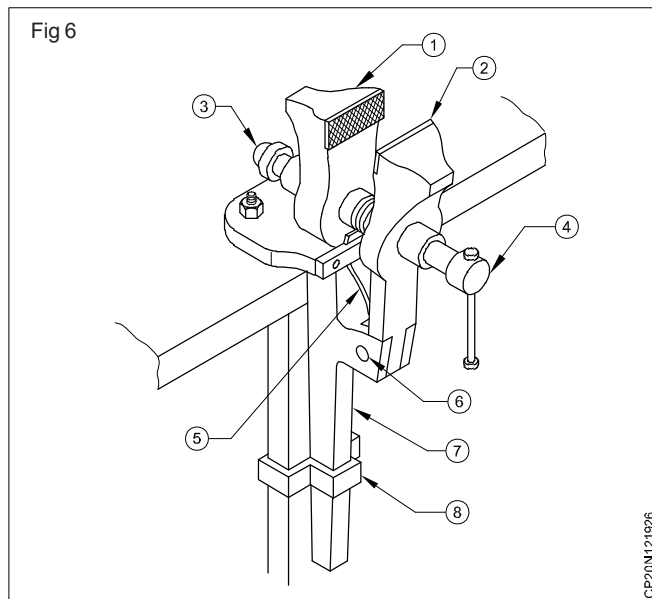
Main parts of a leg vice (Fig 6)

The following are the main parts of a leg vice.

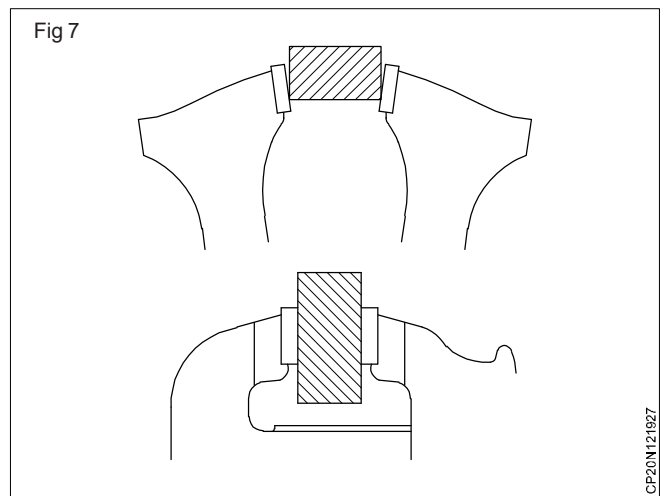
- 1 Solid jaw
- 2 Movable jaw
- 3 Threaded jaw
- 4 Spindle
- 5 Spring
- 6 Pivot

7 Leg

8 Clamp



Since the hinged jaw moves in a radial path, the job held in this vice is not gripped properly because of the line contact. (Fig 7) Hence a work which can be carried out on a bench vice is not held on a leg vice. Jobs which require hammering only are held on a leg vice.



Top side, and the end of a piece of work. Production units of this type are seldom used in a tool room that usually does highly skilled work.

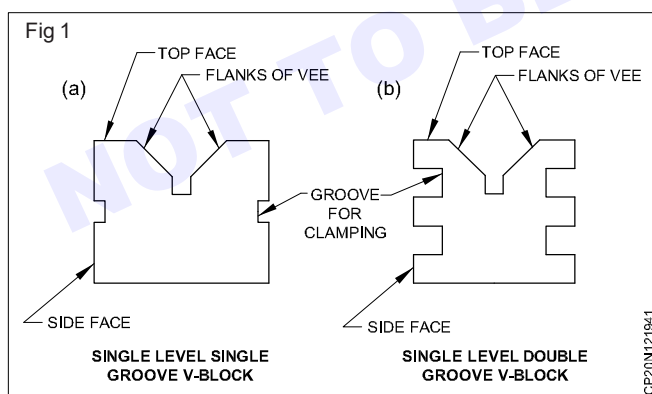
'V' Blocks

Objectives: At the end of this lesson you shall be able to

- state the constructional features of 'v' blocks
- name the types of 'v' blocks and state their uses
- specify 'v' blocks as per B.I.S standard.

Constructional features

'V' Blocks are devices used for marking and setting up work on machines. The features of the common type of 'V' Blocks are as given in Figs 1 and 2.



The included angle of the VEE is 90° in all cases. 'V' Blocks are finished to a high accuracy in respect of dimension, flatness and squareness.

Types

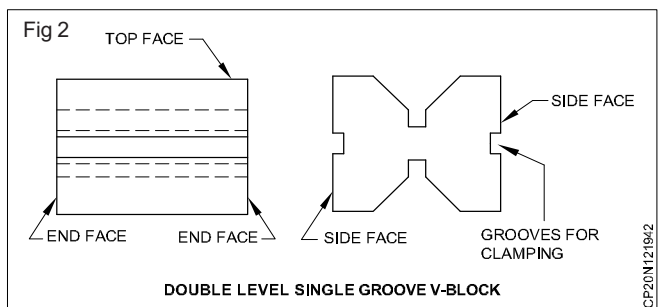
Different types of 'V' blocks are available. As per BIS, there are four types, as listed below.

Single level single groove 'V' Block (Fig 1)

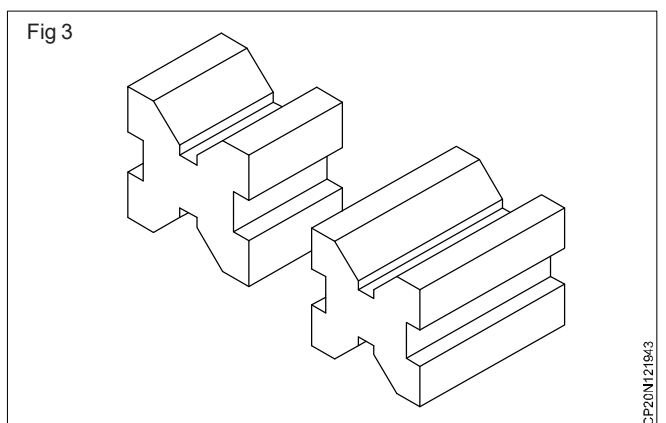
This type has only one 'V' groove, and has single groove (slots) on either side. These grooves are for accommodating the holding clamps.

Single level double groove 'V' Block (Fig 2)

This type will have one 'V' groove, and two grooves (slots) on either side for clamping in two positions.



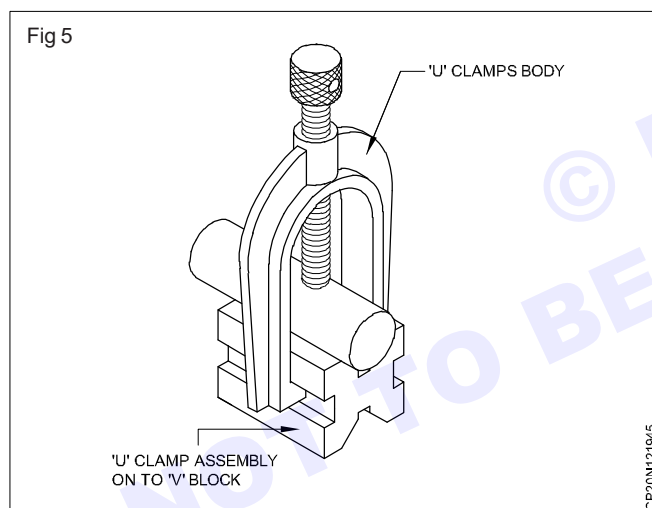
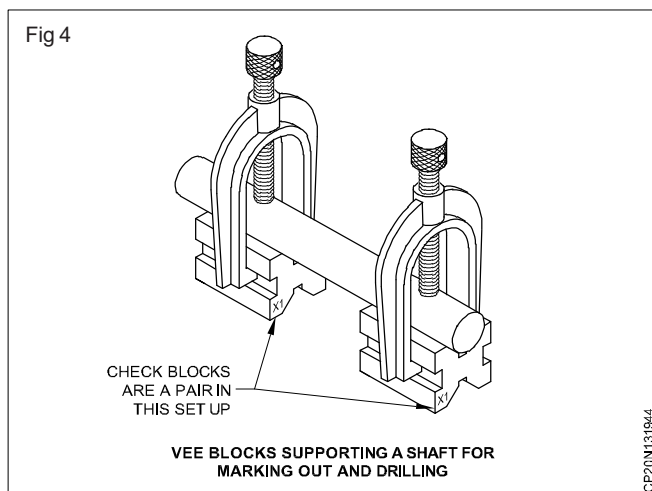
Double level single groove 'V' Block (Fig 3)



In this case, the 'V' Block will have two 'V' grooves on the top and bottom, and a single groove for clamping on either side.

Matched pair 'V' Block (Figs 4 and 5)

These blocks are available in pairs which have the same size and the same grade of accuracy. They are identified by the number or letter given by the manufacturer. These sets of blocks are used for supporting long shafts parallel on machine tables or marking off tables.



Grades and materials

'V' Blocks are available in Grade A and Grade B.

Grade A 'V' Blocks

These are more accurate, and are available only up to 100 mm length. They are made of high quality steel.

Grade B 'V' Blocks

These blocks are not as accurate as the ones in Grade A. These blocks are used for general machine shop work. These blocks are available up to 300 mm length. These 'V' Blocks are made of closely grained cast iron.

Clamping devices for 'V'-Blocks

'U' clamps are provided for holding cylindrical jobs firmly on 'V' Blocks.

Designation

'V' Blocks are designated by the nominal size (length) and the minimum and maximum diameter of the workpiece capable of being clamped, and the grade and the number of the corresponding B.I.S. standard.

In the case of matched pairs, it should be indicated by the letter M.

For 'V' Blocks with clamps it should be indicated as, 'WITH CLAMPS'.

Example

A 50 mm long (nominal size) 'V' Block capable of clamping workpieces between 5 to 40 mm in diameter and of Grade A will be designated as

'V' Block 50/5 - 40 A - I.S.2949.

In the case of a matched pair, it will be designated as

'V' Block M 50/5 - 40 A I.S.2949.

For 'V' Block supplied with clamps, the designation will be

'V' Block with clamp 50/5 - 40 A I.S. 2949.

Care and maintenance

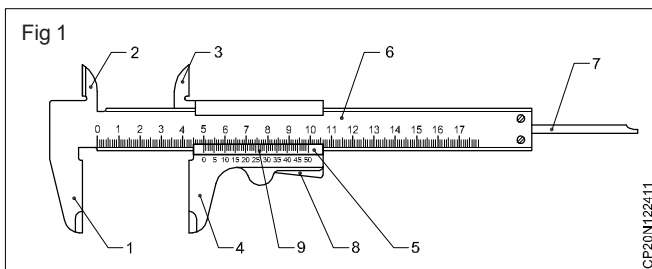
- Clean before and after use.
- Choose the correct size of 'V' block according to the job requirement.
- Apply oil after the use.

Vernier calipers

Objectives : At the end of this lesson you shall be able to

- name the parts of a vernier caliper
- describe the parts of a vernier calipers
- state the uses of a vernier caliper.

A vernier caliper is a precision measuring instrument. It is used to measure up to an accuracy of 0.02 mm. (Fig 1)

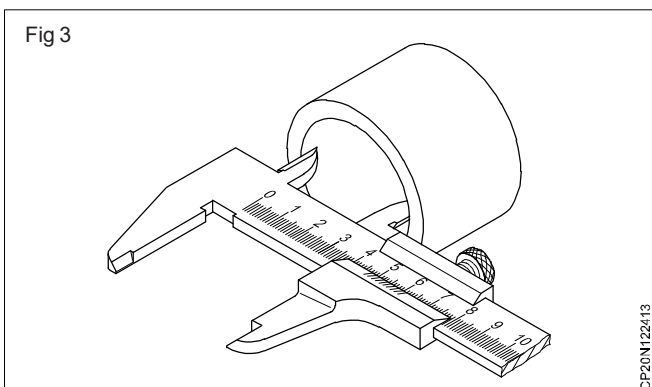
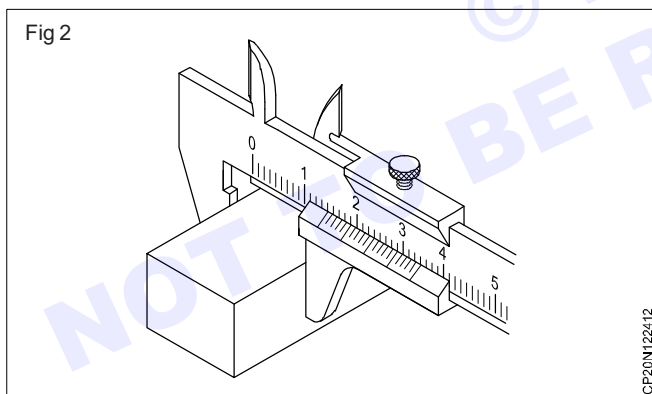


Parts of a vernier caliper

(Numbers as per Fig 1)

Fixed jaws (1 and 2): Fixed jaws are part of the beam scale. One jaw is used for taking external measurements, and the other for taking internal measurements.

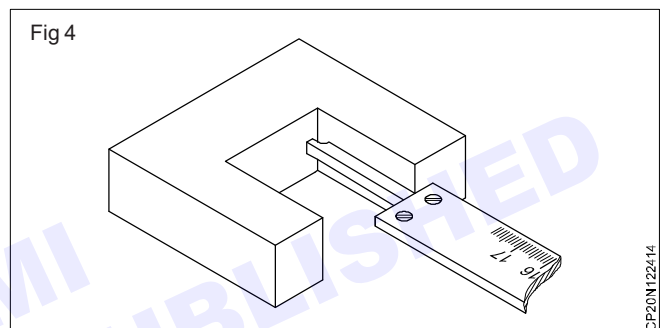
Movable jaws (3 and 4): Movable jaws are part of the vernier slide. One jaw is used for external measurements, and the other for internal measurements. (Figs 2 and 3)



Vernier slide (5): A vernier slide moves over the beam and can be set in any position by means of a spring-loaded thumb lever.

Beam (6): The vernier slide and the depth bar attached to it, slide over the beam. The graduations on the beam are called the main scale divisions.

Depth bar (7) (Fig 4): The depth bar is attached to the vernier slide and is used for measurement of depth.



Thumb lever (8): The thumb lever is spring-loaded which helps to set the vernier slide in any position on the beam scale.

Vernier scale (9): The vernier scale is the graduation marked on the vernier slide. The divisions of this scale are called vernier divisions.

Main scale: The main scale graduations or divisions are marked on the beam.

Sizes: Vernier calipers are available in sizes of 150 mm, 200, 250, 300 and 600 mm. The selection of the size depends on the measurements to be taken. Vernier calipers are precision instruments, and therefore, extreme care should be taken while handling them.

Never use a vernier caliper for any purpose other than measuring.

Vernier calipers should be used only to measure machined or filed surfaces.

They should never be mixed with any other tools.

Clean the instrument after use, and store it in a box.

Graduations and reading of vernier calipers

Objectives : At the end of this lesson you shall be able to

- determine the least count of a vernier caliper
- state how graduations are made on a vernier caliper with 0.02 mm least count
- read vernier caliper measurements.

Vernier calipers: Vernier calipers are available with different accuracies. The selection of the vernier caliper depends on the accuracy needed and the sizes of the job to be measured.

This accuracy/least count is determined by the graduations of the main scale and the vernier scale divisions.

Vernier Principle: The vernier principle states that two different scales are constructed on a single known length of line and the difference between them is taken for fine measurements.

Determining the least count of vernier calipers: In the vernier caliper shown in Fig 1 the main scale divisions (9 mm) are divided into 10 equal parts in the vernier scale.

i.e. One main scale division (MSD) = 1 mm

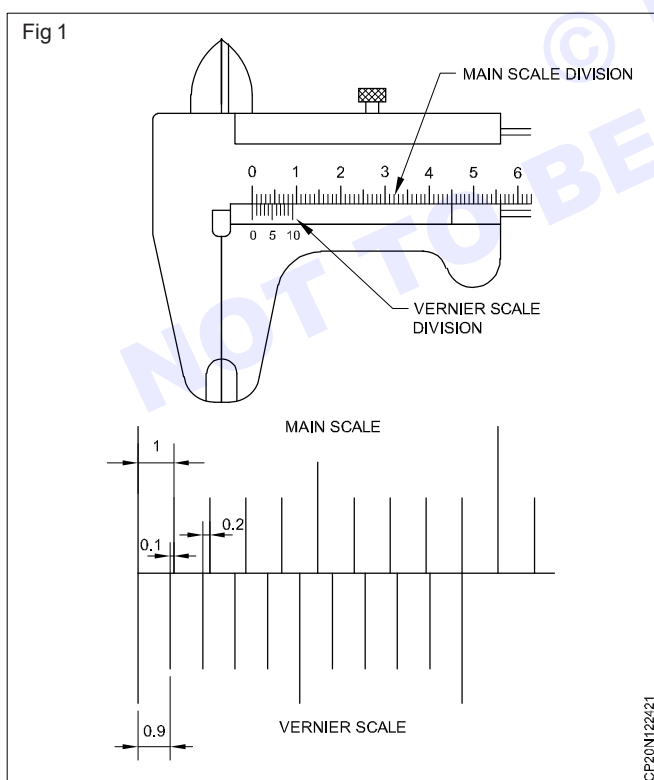
One vernier scale division (VSD) = 9/10 mm

Least count = 1 MSD - 1 VSD

$$= 1 \text{ mm} - 9/10 \text{ mm}$$

$$= 0.1 \text{ mm}$$

The difference between one MSD and one VSD = 0.1 mm

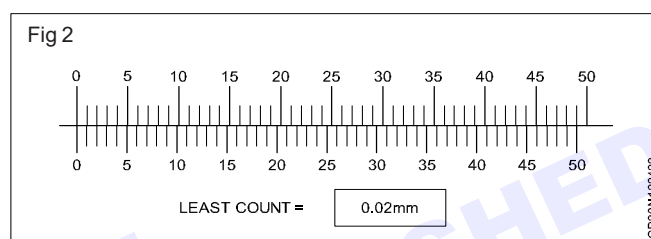


Reading vernier measurements: Vernier calipers are available with different graduations and least counts. For reading measurements with a vernier caliper, the least count should be determined first. (The least count of calipers is sometimes marked on the vernier slide)

Fig 2 shows the graduations of a common type of vernier caliper with a least count of 0.02 mm. In this, 50 divisions of the vernier scale occupy 49 divisions (49 mm) on the main scale.

Example

Calculate the least count of the vernier given in Fig 2.

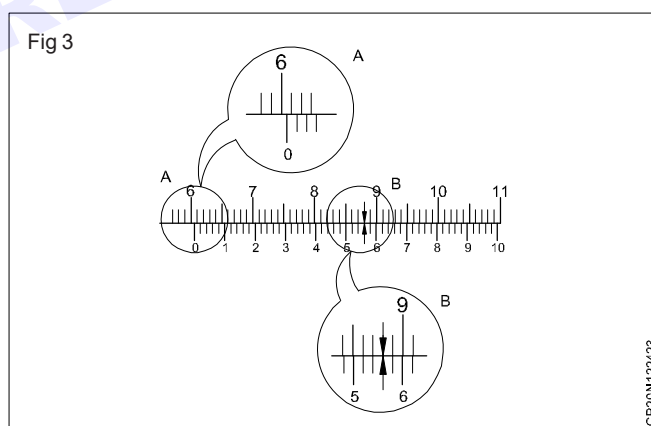


Least count = 1 mm - 49/50 mm

$$= 1/50 \text{ mm}$$

$$= 0.02 \text{ mm.}$$

Example for reading vernier caliper (Fig 3)



Main scale reading = 60 mm

The vernier division coinciding with the main scale is the 28th division, value = 28 x 0.02mm

$$= 0.56 \text{ mm}$$

$$\text{Reading} = 60 + 0.56$$

$$\text{Total Reading} = 60.56 \text{ mm}$$

The British system of measurement

Objectives : At the end of this lesson you shall be able to

- name the different units and multiples of liner measurements in the British System
- state the metric equivalent of the unit in the inch system.

The metric system for measurement is most widely used for industrial measurements. But in certain industries, the British system of measurement is still being used.

In this system of measurement, the inch, its multiples and sub-divisions are used to represent length measurements.

36 inches or 3 feet make 1 yard. 5280 feet or 1760 yards make 1 mile.

Coverons from inch to metric and vice versa

CONVERSION FACTORS

1"	= 25.4 mm or 2.54 cm
1 yard	= 36" or 0.9144 m
1 mm	= 0.03937"
1 metre	= 1000 mm or 39.37"

FRACTIONS/DECIMALS EQUIVALENT

1/64"	= 0.015625"
1/32"	= 0.03125"
1/16"	= 0.0625"
1/8"	= 0.125"
1/4"	= 0.25"
1/2"	= 0.5"
1.00 unit inch	
0.1 one tenth	

0.01 one hundredth

0.001 one thousandth

0.0001 one ten thousandth

0.00001 one hundred thousands

0.000001 one millionth (one micro inch)

Example of conversion (Metric to inch)

1 105mm = .00196 inch (.05x0.3937 = 0.0019685 inch)

2 1.25m = 49.215 inch (1.25x39.37 = 49.215 inches)

Example of conversion (Inch to Metric)

1 3/4" = .75" = 19.05 mm (.75x 25.4 = 19.05 mm)

2 1/1000" = 0.001 = 0.0254 mm (.001x25.4 = 0.0254mm)

(One thousandth of an inch = 25 micrometre approx)

ASSIGNMENT

Convert the following.

1 38.1mm = _____ inches

2 300 mm = _____ inches

3 8" = _____ mm

4 40" = _____ mm.

5 Express the tolerance $\pm .05"$ in metric terms to the nearest mm. _____

6 Express the tolerance $\pm .02$ mm in terms of inches to the nearest 1/10,000". _____

Reading vernier caliper and micrometer with inch graduations

Objectives : At the end of this lesson you shall be able to

- state the graduations of vernier calipers in the inch system
- state the graduations of micrometers in the inch system
- read the measurement of vernier calipers and micrometers with inch graduations.

Reading vernier caliper and micrometer

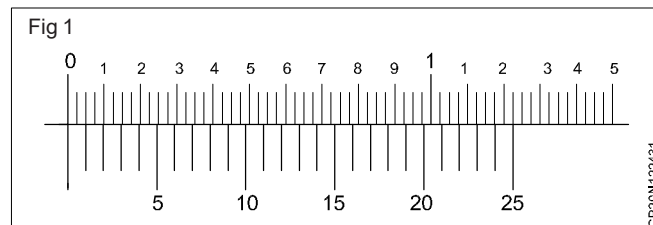
The universal vernier calipers generally used in machine shop will have graduations in both metric units and inches.

The vernier caliper with inch graduation will have a least count of 0.001".

The vernier scales for these calipers have graduation with 25 division or 50 divisions.

Vernier caliper with 25 divisions in vernier scale. (Fig 1)

One inch of the main scale is divided into 10 major divisions, and each of these is further divided into 4 equal parts. The value of each sub-division is 0.025 inch. Such 49 divisions of the main scale are equal to 25 divisions of the vernier scale.



Least count

25 vernier scale divisions = 49 x 0.025 = 1.225"

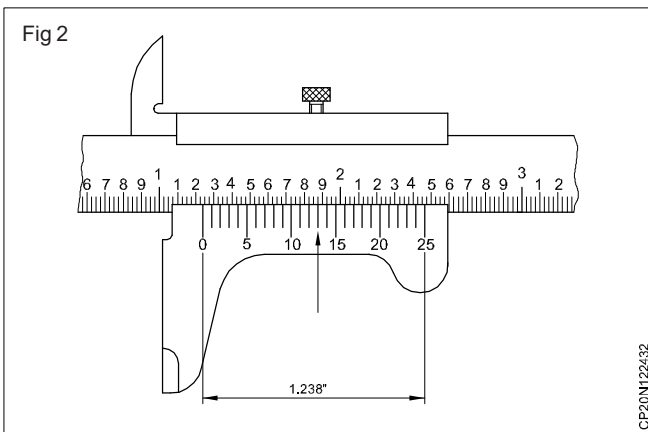
Value of vernier scale division = 0.049"

Value of 2 main scale divisions = 0.025 x 2 = 0.50"

Least count = Value of main scale division - value of 1 vernier scale division

= 0.05" - 0.049" = 0.001" or 1/1000"

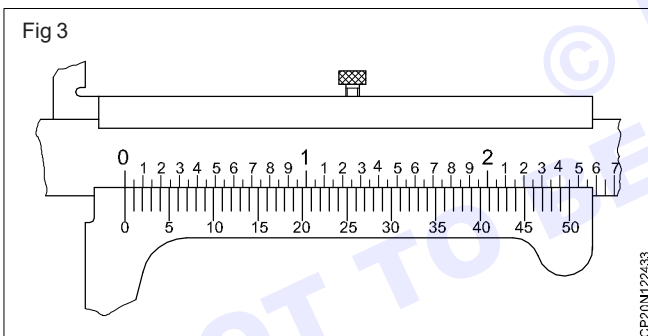
Example of reading (Fig 2)



In Figure 2 the vernier '0' line is after 1" on the scale

Full inch	= 1.000"
2 main scale divisions	= .200"
Value of 1 subdivision	= .025"
coinciding (13 x .001")	= .013"
Reading	1.238"

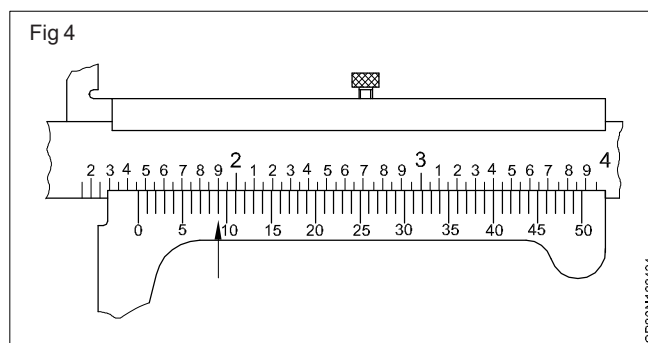
In the vernier caliper given in Fig 3 (50 divisions vernier scale), each inch of the main scale is divided into 10 major divisions, and they are further sub-divided into two equal parts. The value of each subdivision is 0.05". 50 divisions of the vernier scale are equal to 49 sub divisions of the main scale.



Least count

Value of 50 V.S.D.	= 49 x 0.05	= 2.45"
1.V.S.D.	= 2.45"/50	= 0.049"
Least count = Value of 1 MSD - Value of 1 VSD	= 0.05" - 0.049"	= 0.001"

Example of reading (Fig 4)



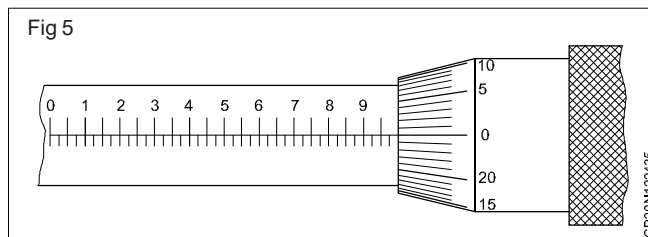
Vernier '0' line is after 1" on the main scale

Full inch	= 1.000"
The value of 4 major divisions (4 x 0.1")	= .400"
The value of 1 subdivision (1 x 0.05")	= .050"
The value of 9th vernier division coinciding (9 x 0.001")	= .009"

Reading **1.459"**

Micrometer with graduations in inches

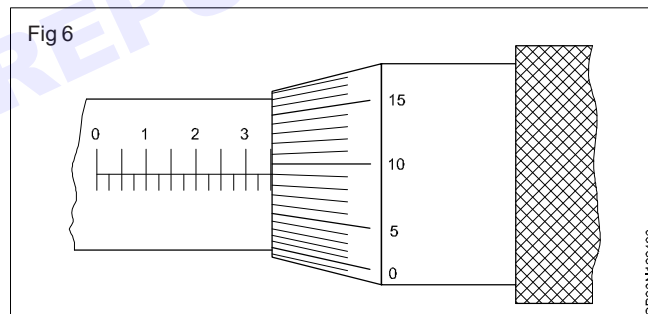
On micrometers with graduations in the inch system, the datum line on the barrel of the micrometer is graduated to a distance of 1 inch. This one inch is divided into 10 equal parts, and each of this is further subdivided into 4 equal parts. (Fig 5)



The value of each subdivision = 1/40" or 0.025". The thimble had 25 equal divisions marked on the circumference. The least count is = 1/40" x 1/25 = 1/1000" = .001".

When the spindle of the micrometer advances by one division on the thimble, the actual value of the linear movement is = .001".

Example of reading (Fig 6)



Main divisions	3 x .1	= .300"
Subdivisions	2 x .025	= .05"
Thimble divisions	9 x .001	= .009"
Reading		= .359"

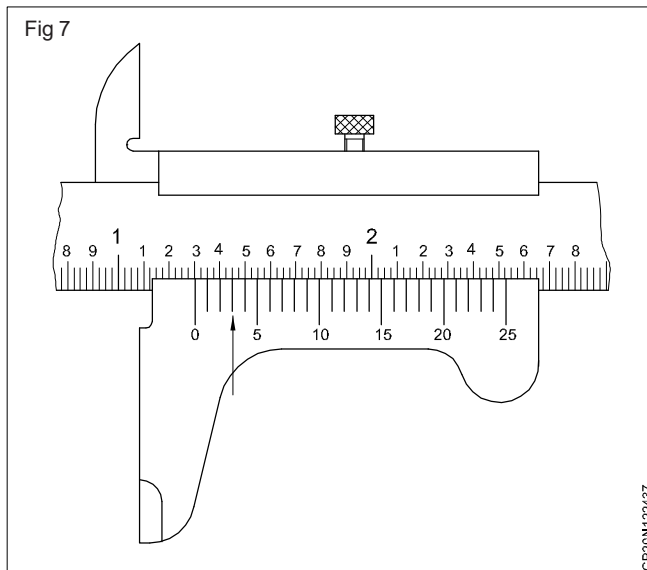
The barrel is graduated into 10 equal divisions each of which is further subdivided into 4 smaller divisions. The length of the sleeve graduations is 1". It is the distance the thimble travels in 40 complete revolutions.

Barrel main divisions = 1/10 of an inch or 0.100" the distance the thimble moves in four complete revolutions. The thimble has 25 equal graduations on its circumference. Each graduation of the thimble is equal to 1/25 of 1/40 or 0.001".

Barrel subdivision $1/40$ or 0.025 of an inch is equal to the distance the thimble moves in one complete revolution. The spindle screw has 40 TPI.

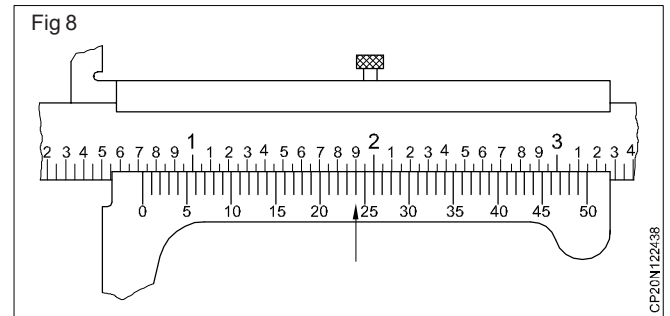
Assignment

- 1 Read the vernier caliper measurement as shown in Fig 7 and 8.

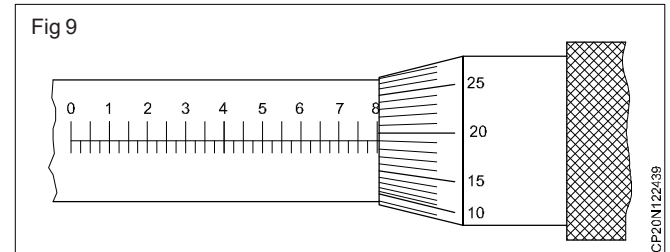


Answer inch.

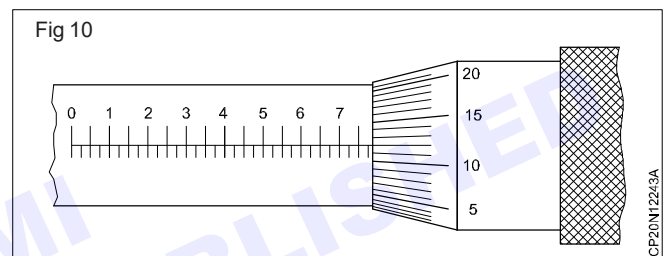
- 2 Read and record the measurements of an outside micrometer shown in the Fig 9 and 10.



Answer inch.



Answer inch.



Answer inch.

Vernier height gauge

Objectives: At the end of this lesson you will be able to

- name the parts of a vernier height gauge
- state the constructional features of a vernier height gauge
- state the functional features of a vernier height gauge
- state the various applications of the vernier height gauge in engineering.

Parts of a vernier height gauge (Fig 1)

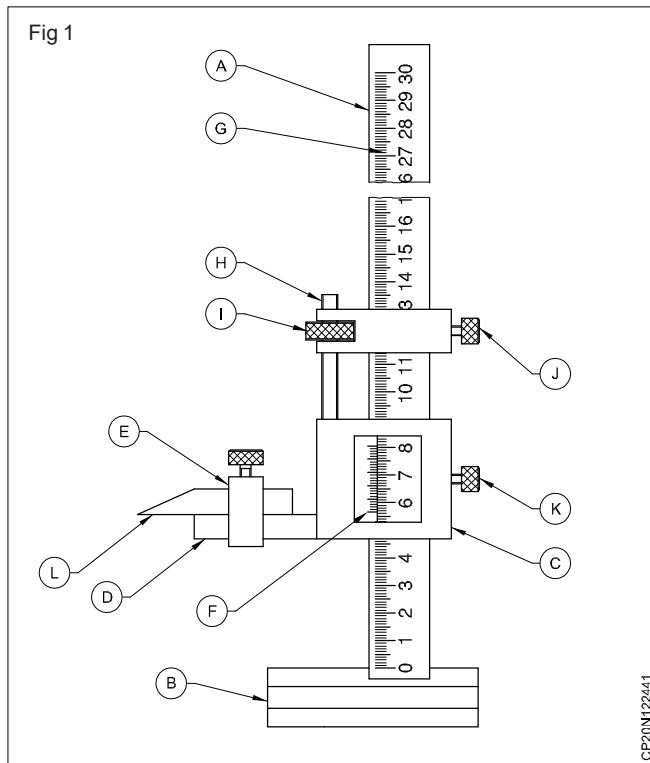
- | | |
|-----|-----------------------|
| A | Beam |
| B | Base |
| C | Main slide |
| D | Jaw |
| E | Jaw clamp |
| F | Vernier scale |
| G | Main scale |
| H | Finer adjusting slide |
| I | Finer adjusting nut |
| J&K | Locking screws |
| L | Scriber blade |

Constructional features of a vernier height gauge:

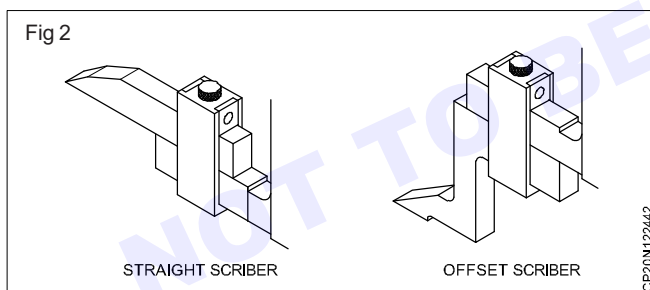
The construction of a vernier height gauge is similar to that of the vernier caliper that it is vertical with a rigid base. It is graduated on the same vernier principle which is applied to the vernier caliper.

The beam is graduated with the main scale in mm as well as in inches. The main slide carries a jaw upon which various attachments may be clamped. The jaw is an integral part of the main slide.

The vernier scale is attached to the main slide which has been graduated, to read metric dimensions as well as the inch dimensions. The main slide is attached with the finer adjusting slide. The movable jaw is most widely used with the chisel pointed scriber blade for accurate marking out as well as for checking the height, steps etc. Care should be taken to allow for the thickness of the jaw depending on whether the attachment is clamped on the top or under the jaw for this purpose.



The thickness of the jaw is marked on the instrument. As like in a vernier caliper, the least count of this instrument is also 0.02 mm. An offset scriber is also used on the movable jaw when it is required to take measurement from the lower planes. (Fig 2) The complete sliding attachment along with the jaw can be arrested on the beam to the desired height with the help of the locking screws. The vernier height gauges are available in ranges of capacities reading from zero to 1000 mm.



Functional features of the vernier height gauge: Vernier height gauges are used in conjunction with the surface plate. In order to move the main slide, both the locking screws of the slide and the finer adjusting slide have to be loosened. The main slide along with the chisel pointed scriber has to be set by hand, for an approximate height as required.

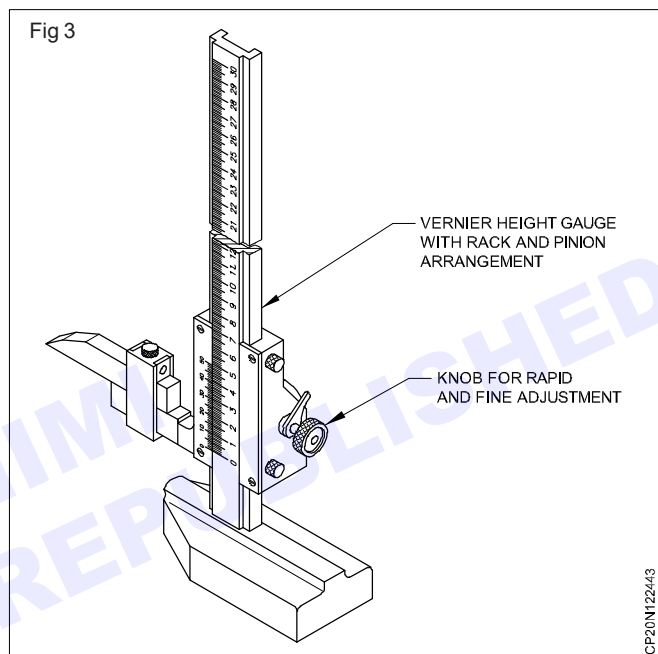
The finer adjusting slide has to be locked in position, for an approximate height as required. To get an exact markable height, the finer adjustments have to be carried on the slider with the help of the adjusting nut. After obtaining the exact markable dimension, the main slide is also to be locked in position.

Modern vernier height gauges are designed on the screw rod principle. In these height gauges, the screw rod may be operated with the help of the thumb screw at the base.

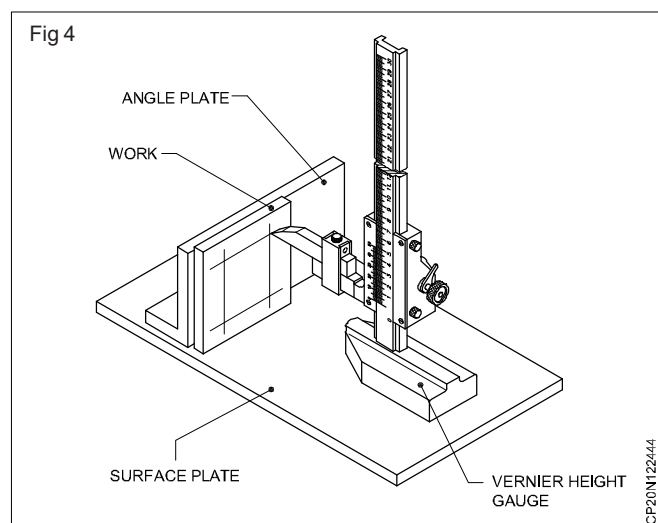
In order to have a quick setting of the main slide, it is designed with a quick releasing manual mechanism. With the help of this, it is possible to bring the slide to a desired approximate height without wastage of time. For all other purposes, these height gauges work as ordinary height gauges. In order to set the 'zero' graduation of the main scale for the initial reading.

Some vernier height gauges are equipped with a sliding main scale which may be set immediately for the initial reading. This minimises the possible errors in reading the various sizes in the same setting.

Another kind of modern vernier height gauge has a rack and pinion set up for operating the sliding unit. This is shown in Fig 3.



Various applications of a vernier height gauge: The vernier height gauge is mainly used for layout work. (Fig 4)



It is used for measuring the width of the slot and external dimension.

The vernier height gauge is used with the dial indicator to check hole location, pitch dimensions, concentricity and eccentricity.

It is also used for measuring depth, with a depth attachment.

It is used to measure sizes from the lower plane with the help of an offset scribe.

Care and Maintenance

Store after use in room with controlled

Care and maintenance

- Store after use in room with controlled temperature
- Do not drop (or) knock it
- Clean tool before and after use
- Do not take measurement on rotating specimen.
- Do not keep with other working tools.

Ordinary depth gauge

Objectives: At the end of this lesson you shall be able to

- state the uses of ordinary depth gauge
- name the parts of depth gauge.

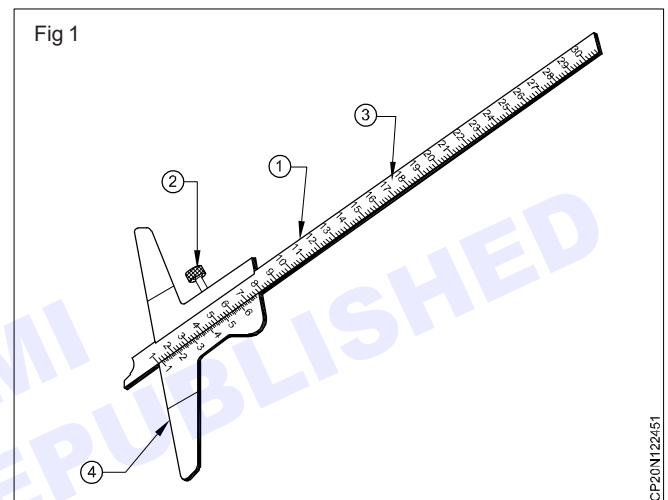
Ordinary depth gauge

Ordinary depth gauge is semi precision instrument used for measuring of depth of recesses, slots and steps.

Parts of ordinary depth gauge

- 1 Graduated beam
- 2 Clamping screw
- 3 Scale
- 4 Base

Available in the ranges of 0-200 mm. Ordinary depth gauge is used to measure an accuracy of 0.5 mm.



Outside micrometer

Objectives: At the end of this lesson you shall be able to

- name the parts of an outside micrometer
- state the functions of the main parts of an outside micrometer.

A micrometer is a precision instrument used to measure a job, generally within an accuracy of 0.01 mm.

Micrometers used to take the outside measurements are known as outside micrometers. (Fig 1)

The parts of a micrometer are listed here.

Frame

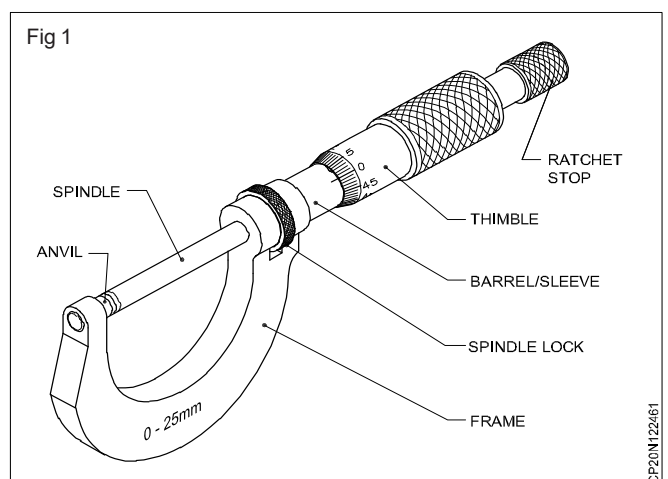
The frame is made of drop-forged steel or malleable cast iron. All other parts of the micrometer are attached to this.

Barrel/Sleeve

The barrel or sleeve is fixed to the frame. The datum line and graduations are marked on this.

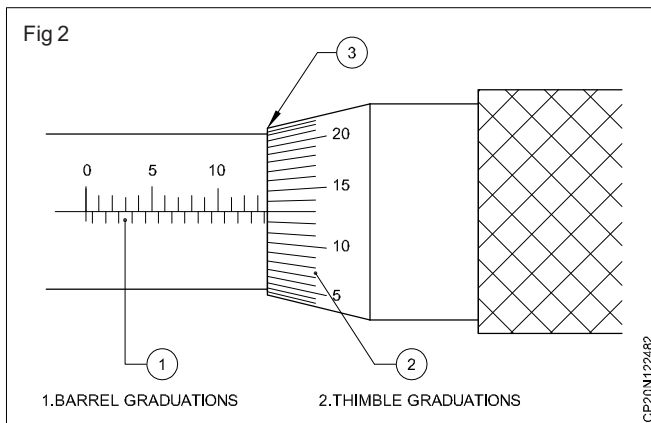
Thimble

On the beveled surface of the thimble also, the graduation is marked. The spindle is attached to this.



Spindle

One end of the spindle is the measuring face. The other end is threaded and passes through a nut. The threaded



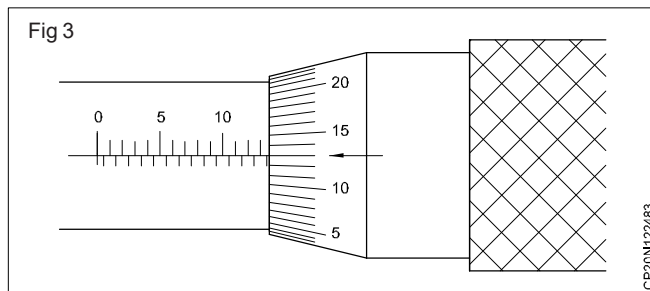
First note the minimum range of the outside micrometer. While measuring with a 50 to 75 mm micrometer, note it as 50 mm.

Then read the barrel graduations. Read the value of the visible lines on the left of the thimble edge.

13.00 mm (Main division reading on barrel)
 + 00.50 mm (Sub division reading on barrel)
 13.50 mm (Main division + sub - division value)

Next read the thimble graduations.

Read the thimble graduations in line with the barrel datum line, 13th div. (Fig 3)



Multiply this value with 0.01 mm (least count).

$$13 \times 0.01 \text{ mm} = 0.13 \text{ mm.}$$

Add

Minimum range	50.00 mm
Barrel reading	13.50 mm
Thimble reading	00.13 mm
Total	<u>63.63 mm</u>

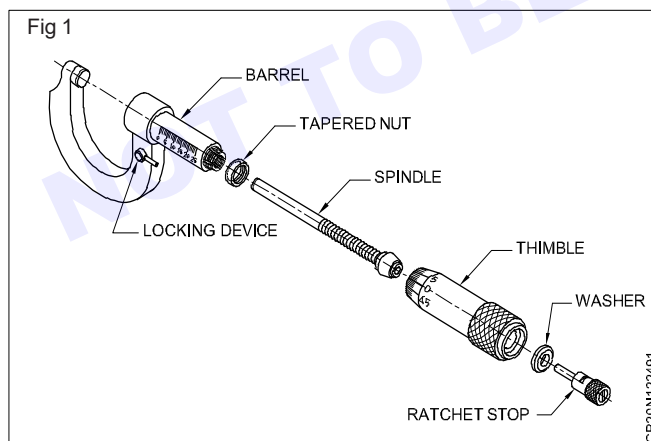
The micrometer reading is 63.63 mm.

Constructional features of outside micrometer

Objectives: At the end of this lesson you shall be able to

- name the internal parts of a micrometer
- state the functions of the various parts of a micrometer
- state the precautions to be observed while dismantling and assembling micrometers.

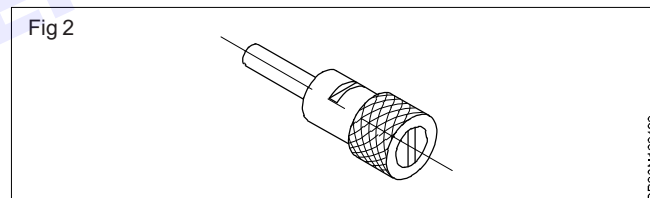
In order to dismantle and carry out cleaning or adjustment of a micrometer, it is essential to know the functions of its various parts. (Fig 1)



Ratchet stop (Fig 2)

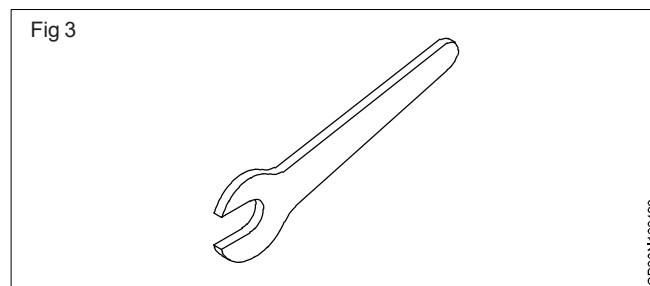
This is a device fitted on micrometers to ensure uniform pressure between the measuring face of the micrometer while measuring.

The ratchet stop will slip beyond certain pressure, thus preventing further advancement of the spindle when excessive pressure is used.



This is mounted on the thimble of the micrometer, and it connects with the spindle when assembled.

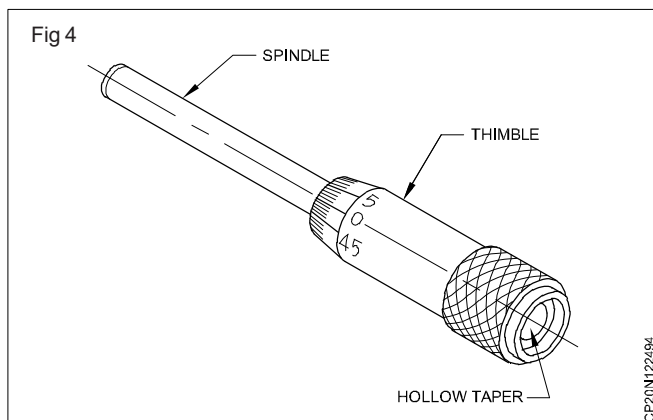
A special spanner is provided along with the micrometer for fixing and removing the ratchet stop. (Fig 3)



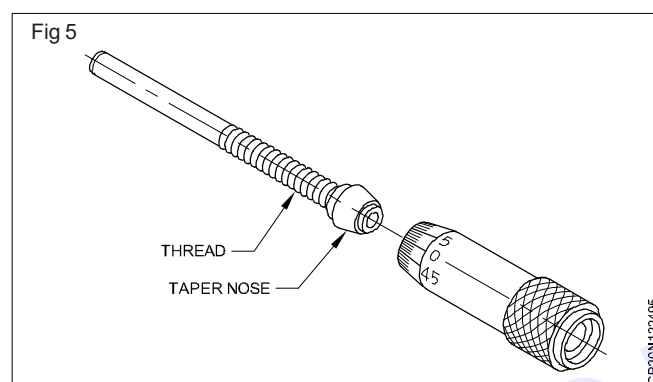
Thimble: The thimble has a hollow taper (Fig 4) to match with the taper nose fitted on the spindle.

Spindle

One end of the spindle forms the measuring face. The other end of the spindle is threaded, the tapered nose is fitted on it. (Fig 5)



CP20N122494



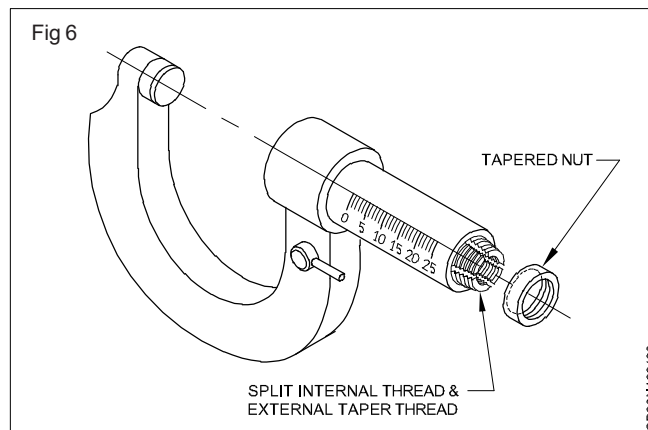
CP20N122495

The taper nose is very accurately finished for axial alignment and it also permits positioning of the thimble in any required place during the adjustment of zero error.

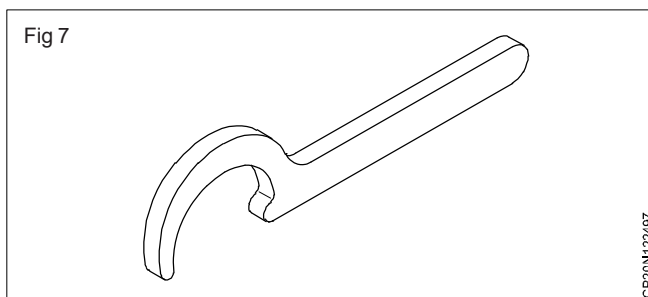
The spindle passes through a split internal thread (Fig 6) which forms part of the barrel. The outer portion of this split internal thread has tapered external threads. A taper threaded nut is fitted on this.

Tightening and loosening of this nut enables the split internal thread to close or open. This permits the wear adjustment in the mating threads.

A special spanner is provided for this purpose. (Fig 7)



CP20N122496



CP20N122497

The locking device provided on the spindle is to arrest the movement of the spindle after taking the measurement.

Precautions while dismantling micrometers

Avoid touching the measuring faces with bare fingers as it might cause rusting.

Protect the components of the micrometer free from dust while dismantling and assembling.

Use carbon tetrachloride for cleaning the parts after dismantling.

While assembling - apply a few drops of thin oil.

Do not use metallic surface for placing the parts after dismantling. An enameled tray is preferable.

Apply a thin coating of oil when placing the micrometer back after the adjustment.

Avoid frequent dismantling and assembling.

Vernier bevel protractor

Objectives : At the end of this lesson you shall be able to

- name the parts of a vernier bevel protractor
- state the functions of each part
- list out the uses of a vernier bevel protractor.

The vernier bevel protractor is a precision instrument meant for measuring angles to an accuracy of 5 minutes. (5')

Parts of a vernier bevel protractor

The following are the parts of a vernier bevel protractor. (Fig 1)

Stock: This is one of the contacting surfaces during the measurement of an angle. Preferably it should be kept in contact with the datum surface from which the angle is measured.

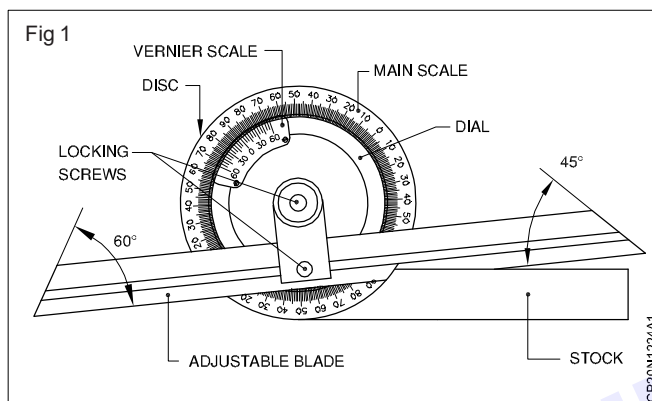
Dial: The dial is an integrated part of the stock. It is circular in shape, and the edge is graduated in degrees.

Blade: This is the other surface of the instrument that contacts the work during measurement. It is fixed to the dial with the help of the clamping lever. A parallel groove is provided in the centre of the blade to enable it to be longitudinally positioned whenever necessary.

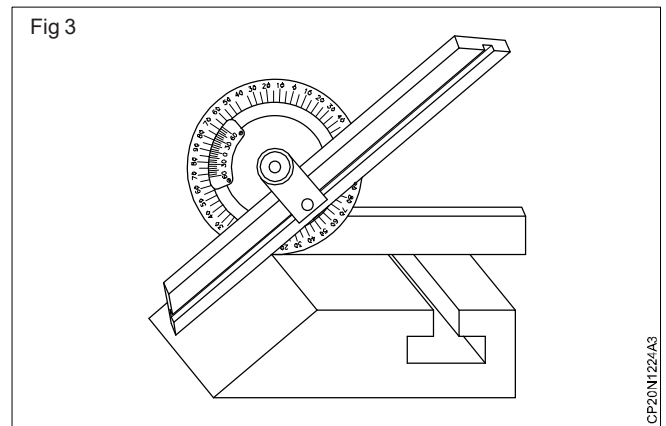
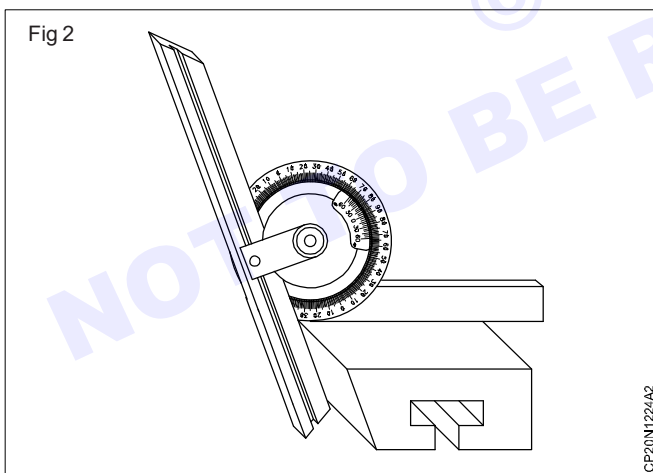
Locking screws: Two knurled locking screws are provided, one to lock the dial to the disc, and the other to lock the blade to the dial..

All parts are made of good quality steel, properly heat-treated and highly finished. A magnifying glass is sometimes fitted for clear reading of the graduations.

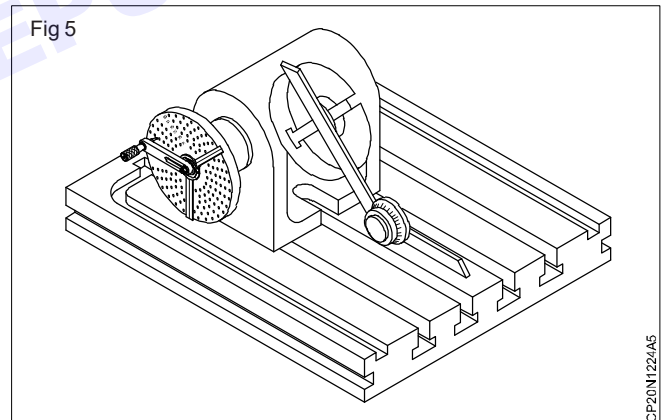
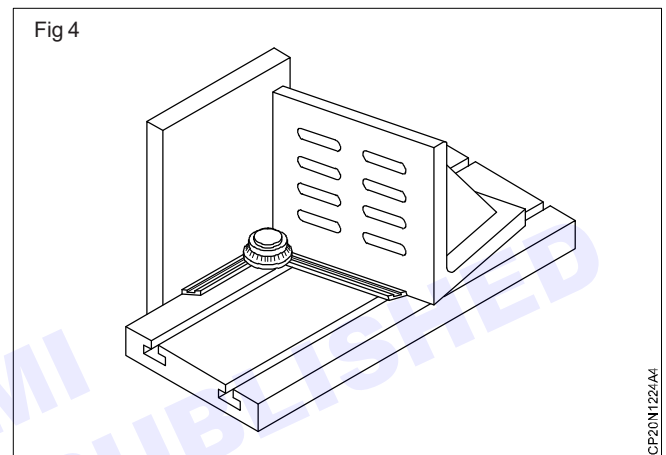
Uses of a vernier bevel protractor: Apart from being used for measuring angles a vernier bevel protractor is also used for setting work-holding devices on machine tools, work-tables etc.



The vernier bevel protractor is used to measure acute angles (Fig 2) obtuse angles more than 90° (Fig 3).



For setting work-holding devices to angles on machine tools, work tables etc., (Fig 4 & Fig 5)



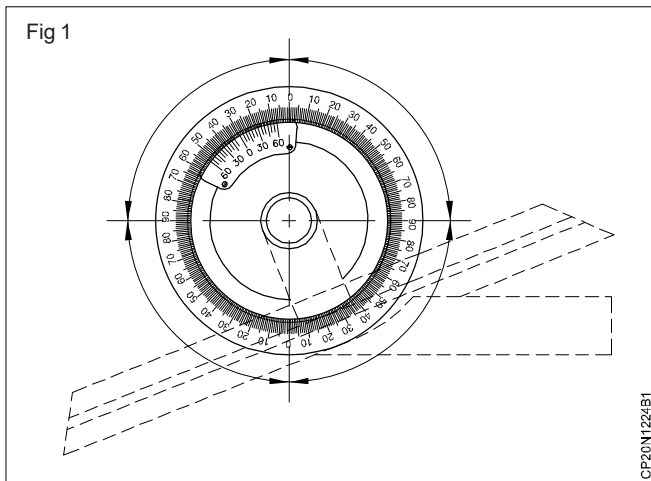
Graduations on universal bevel protractor

Objectives: At the end of this lesson you will be able to

- state the main scale graduations on the disc
- state the vernier scale graduations on the dial
- determine the least count of the vernier bevel protractor.

The main scale graduations (Fig 1 & 2): For purposes of taking angular measurements, the full circumference of the dial is graduated in degrees. The 360° are equally divided and marked in four quadrants, from '0' degree to 90 degrees, 90 degrees to '0' degree. Every tenth division is marked longer and numbered. Each division represents 1 degree. The graduations on the dial are known as the

main scale divisions. On the disc, 23 divisions spacing of the main scale is equally divided into 12 equal parts on the vernier. Each 3rd line is marked longer and numbered as 0, 15, 30, 45, 60. This constitutes the vernier scale. Similar graduations are marked to the left of '0' also. (Fig 1)



One vernier scale division VSD

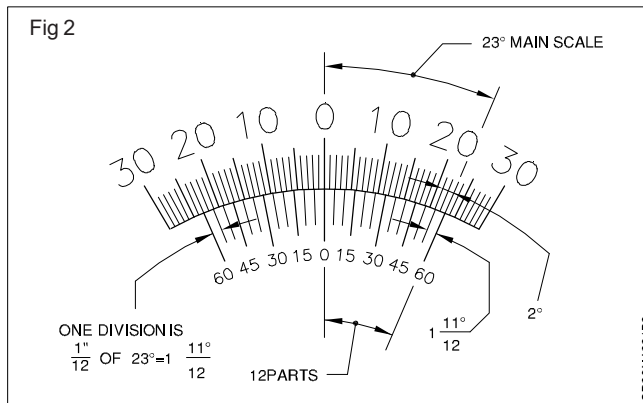
The least count of the vernier bevel protractor: When the zero of the vernier scale coincides with the zero of the main scale, the first division of the vernier scale will be very close to the 2nd main scale division. (Fig 2)

Hence the least count is

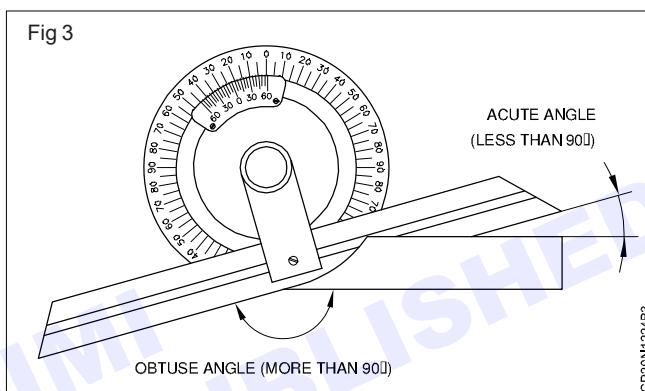
$$2 \text{ MSD} - 1 \text{ VSD}$$

i.e the least count = 2°

$$= \frac{24}{12} - \frac{23^0}{12} = \frac{1^0}{12} \text{ or } 5'$$



For any setting of the blade and stock, the reading of the acute angle and the supplementary obtuse angle is possible, and the two sets of the vernier scale graduations on the disc assist to achieve this. (Fig 3)

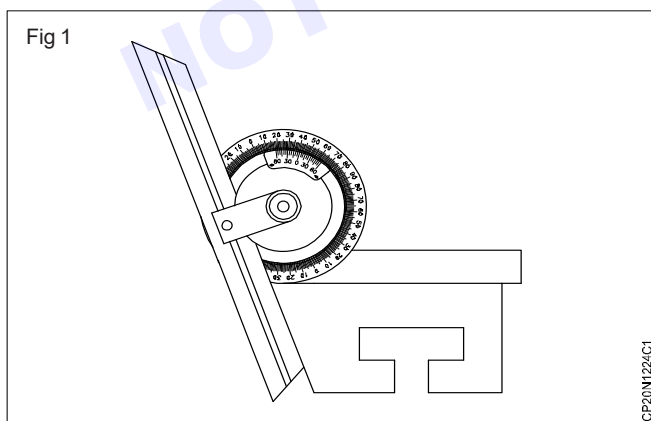


Reading of universal bevel protractor

Objectives: At the end of this lesson you will be able to

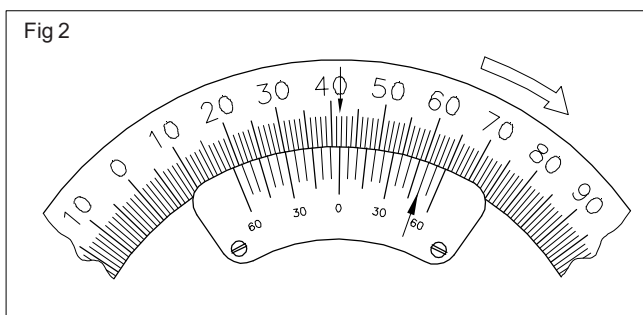
- read a vernier bevel protractor for acute angle setting
- read a vernier bevel protractor for obtuse angle setting.

For reading acute angle set up (Fig 1): First read the number of whole degrees between zero of the main scale and zero of the vernier scale.



Note the line on the vernier scale that exactly coincides with any one of the main scale divisions and determine its value in minutes. (Fig 2)

To take the vernier scale reading, multiply the coinciding divisions with the least count.



Example

$$10 \times 5' = 50'$$

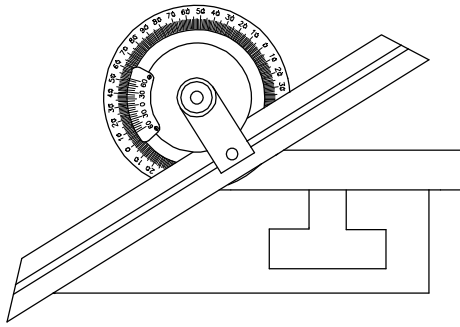
Total up both the readings to get the measurements = 41° 50'.

If you read the main scale in an anticlockwise direction, read the vernier scale also in an anticlockwise direction from zero.

For obtuse angle set up (Fig 3)

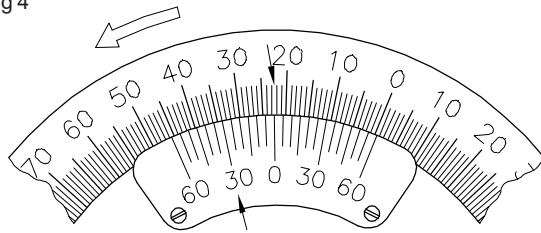
The vernier scale reading up is taken on the left side as indicated by the arrow (Fig 4). The reading value is subtracted from 180° to get the obtuse angle value.

Fig 3



CP20N1224C3

Fig 4



CP20N1224C4

Reading $22^{\circ}30'$

Measurement $180^{\circ}-22^{\circ}30'=157^{\circ}30'$

Care and maintenance of vernier bevel protractor

- 1 Clean the vernier bevel protractor before use.
- 2 Loosen the locking screw of dial to move the blade according to the angle measurement.
- 3 While taking a measurement apply light pressure on vernier bevel protractor
- 4 Heavy pressure will force the two scales out of parallel and show the false reading.
- 5 After using vernier bevel protractor wipe it clean and apply a thin coating of oil and keep it in safe place.

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Drills

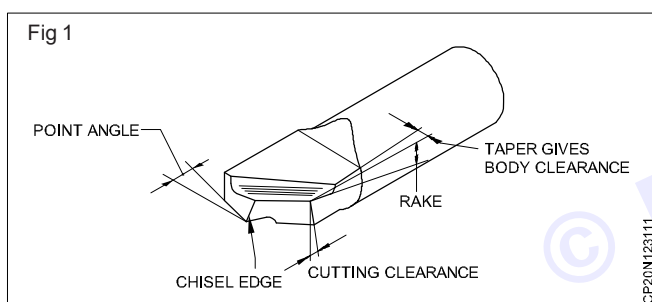
Objectives : At the end of this lesson you shall be able to

- state drilling and drill material
- state the necessity of drilling
- name the types of drills used
- list the parts of a twist drill.

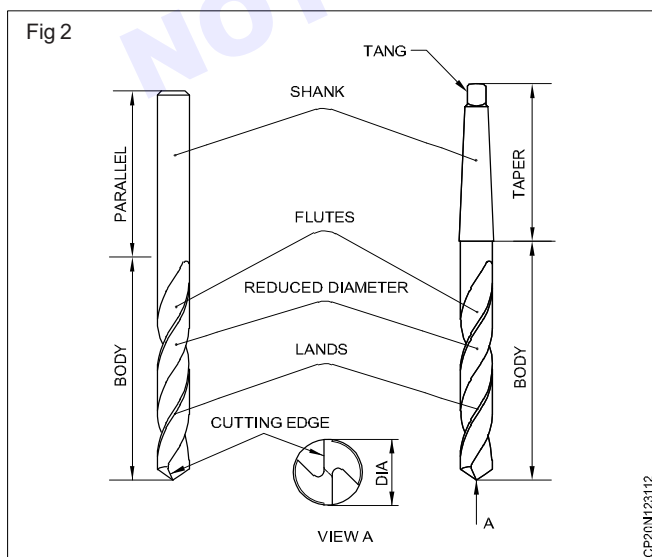
Drilling: Drilling is the production of cylindrical holes of definite diameters in workpieces by using a multi-point cutting tool called a 'drill'. It is the first operation done internally for any further operation. The fluted part (or) body of a drill is made of either high carbon steel (or) High speed steel.

Types of drills and their specific uses

Flat drill (Fig 1) : The earliest form of drill was the flat drill which is easy to operate, besides being inexpensive to produce. The chip removal is poor and its operating efficiency is very low.

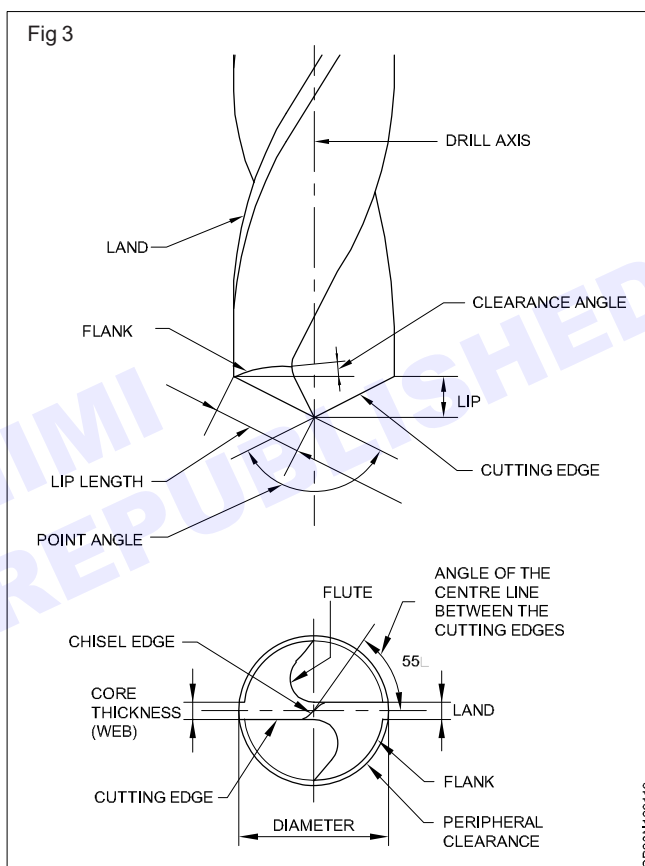


Twist drill : Almost all drilling operation is done using a twist drill. It is called a twist drill as it has two or more spiral or helical flutes formed along its length. The two basic types of twist drills are, parallel shank and taper shank. Parallel shank twist drills are available below 13mm size (Fig 2).



Parts of a twist drill : Drills are made out of high speed steel. The spiral flutes are machined at an angle of $27\frac{1}{2}^\circ$ to its axis.

The flutes provide a correct cutting angle which provides an escape path for the chips. It carries the coolant to the cutting edge during drilling. (Fig 3)



The portions left between the flutes are called 'lands'. The size of a drill is determined and governed by the diameter over the lands.

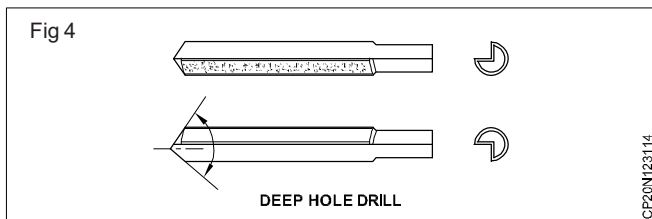
The point angle is the cutting angle, and for general purpose work, it is 118° . The clearance serves the purpose of clearing the back of the lip from fouling with the work. It is mostly 8° .

Deep hole drills

Deep hole drilling is done by using a type of drill known as 'D' bit (Fig 4)

Drills are made of high speed steel.

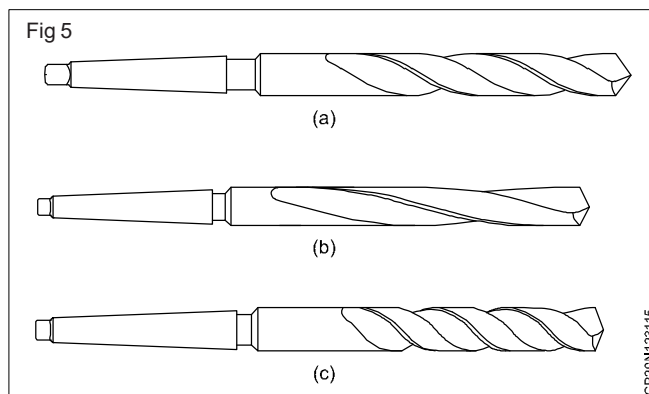
Drills are manufactured with varying helix angles for drilling different materials. General purpose drills have a standard helix angle of $27\frac{1}{2}^\circ$. They are used on mild steel and cast iron. (Fig 5a)



A slow helix drill is used on materials like brass, gun metal, phosphor-bronze and plastics. (Fig 5b)

A quick helix drill is used for copper, aluminium and other soft metals (Fig 5c)

A quick helix drill should never be used on brass as it will 'dig in' and the workpiece may be thrown from the machine table.

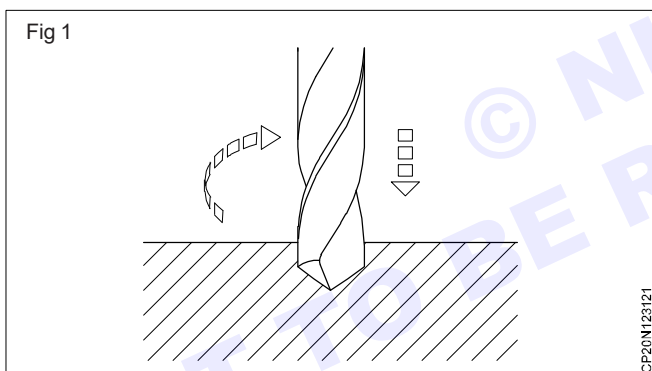


Drill (Parts and functions)

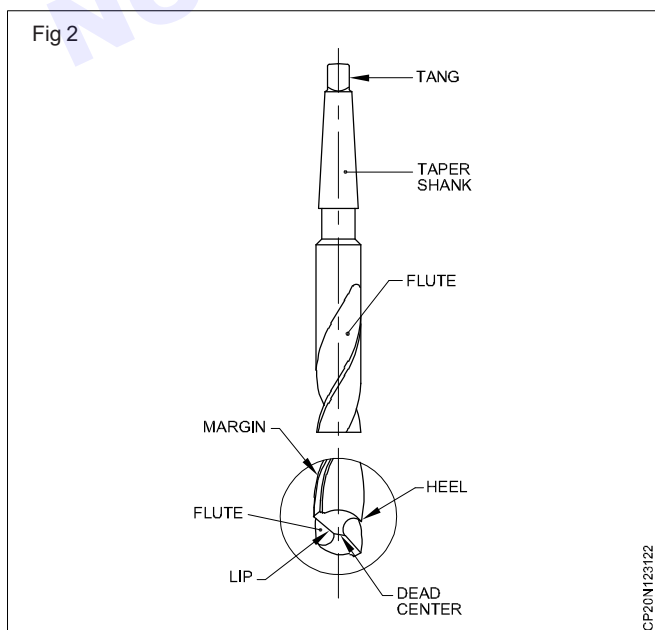
Objectives: At the end of this lesson you shall be able to

- state the functions of drills
- identify the parts of a drill
- state the functions of each part of a drill.

Drilling is a process of making holes on workpieces. The tool used is a drill. For drilling, the drill is rotated with a downward pressure causing the tool to penetrate into the material. (Fig 1)



Parts of a Drill (Fig 2)



The various parts of a drill can be identified from figure 2.

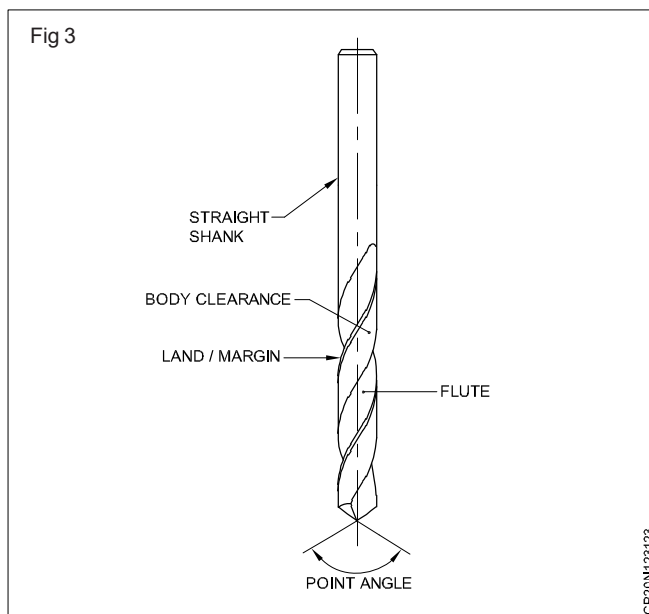
Point

The cone shaped end which does the cutting is called the point. It consists of a dead centre, lips or cutting edges, and a heel.

Shank

This is the driving end of the drill which is fitted on to the machine. Shanks are of two types.

Taper shank, used for larger diameter drills, and straight shank, used for smaller diameter drills. (Fig 3)



Tang

This is a part of the taper shank drill which fits into the slot of the drilling machine spindle.

Body

The portion between the point and the shank is called the body of a drill.

The parts of the body are flute, land/margin, body clearance and web.

Flutes (Fig 3)

Flutes are the spiral grooves which run to the length of the drill. The flutes help

- To form the cutting edges
- To curl the chips and allow these to come out
- The coolant to flow to the cutting edge.

Land/Margin (Fig 3)

The land/margin is the narrow strip which extends to the entire length of the flutes.

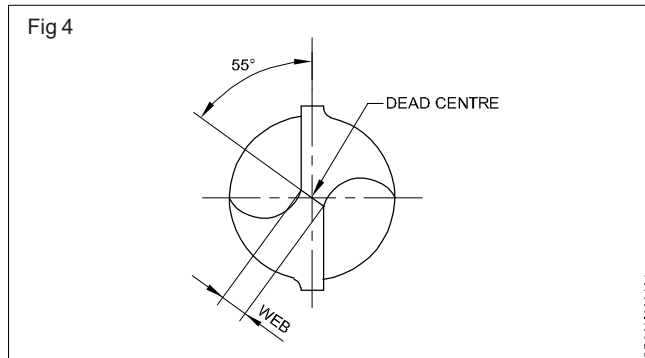
The diameter of the drill is measured across the land/margin.

Body clearance (Fig 3)

Body clearance is the part of the body which is reduced in diameter to cut down the friction between the drill and the hole being drilled.

Web (Fig 4)

Web is the metal column which separates the flutes. It gradually increases in thickness towards the shank.



Drill angles

Objectives: At the end of this lesson you shall be able to

- list the various angles of a twist drill
- state the functions of each angle
- list the types of helix for drills as per ISI
- distinguish the features of different types of drills
- designate drills as per ISI recommendations.

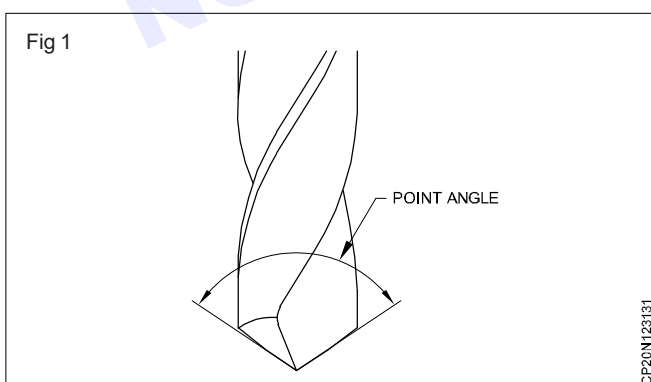
Like all cutting tools the drills are provided with certain angles for efficiency in drilling.

Drill angles

They are different angles for different purposes. They are listed below.

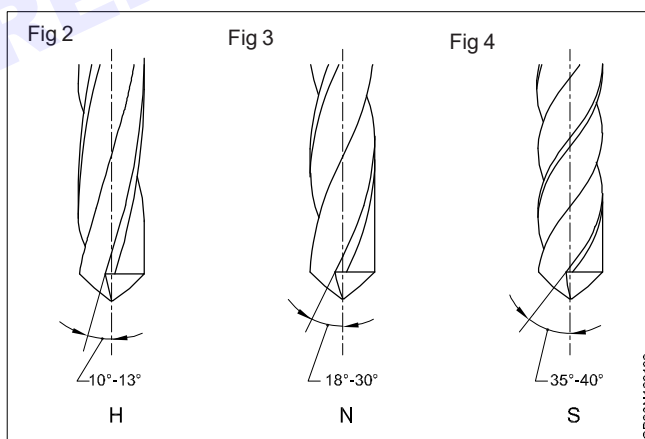
Point angle, helix angle, rake angle, clearance angle and chisel edge angle.

Point angle/ cutting angle (Fig 1)



The point angle of a general purpose (standard) drill is 118°. This is the angle between the cutting edges (lips). The angle varies according to the hardness of the material to be drilled. (Fig 1)

Helix angle (Figs 2,3 and 4)



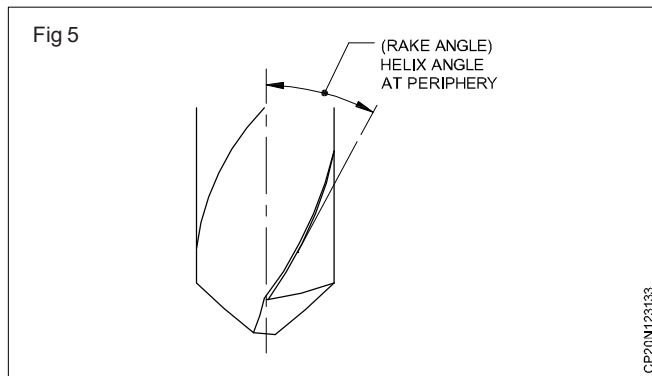
Twist drills are made with different helix angles. The helix angle determines the rake angle at the cutting edge of the twist drill.

The helix angles vary according to the material being drilled. According to Indian standards, three types of drills are used for drilling various materials.

- Type N - For normal low carbon steel.
- Type H - For hard and tenacious materials.
- Types S - For soft and tough materials.

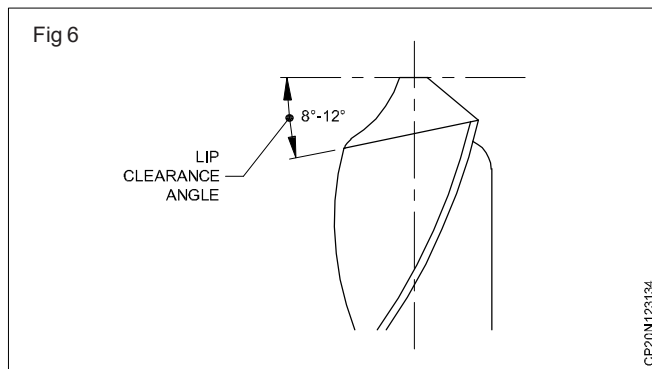
The type of drill used for general purpose drilling work is type N.

Rake angle (Fig 5)



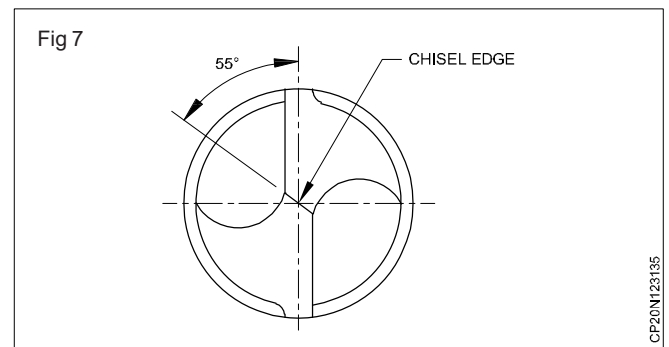
Rake angle is the angle of flute (helix angle).

Clearance angle (Fig 6)



The clearance angle is meant to prevent the friction of the tool behind the cutting edge. This will help in the penetration of the cutting edges into the material. If the clearance angle is too much, the cutting edges will be weak, and if it is too small, the drill will not cut.

Chisel edge angle/web angle (Fig 7)



This is the angle between the chisel edge and the cutting lip.

Designation of drills

Twist drills are designated by the

- Diameter
- Tool type
- Material

Example

A twist drill of 9.50 mm dia. of tool type 'H' for right hand cutting and made from HSS is designated as:

Twist drill 9.50 - H - IS5101 - HS

where H = tool type

IS5101 = IS Number

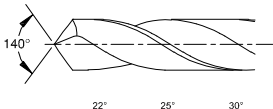
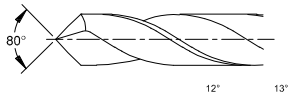
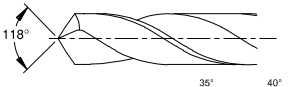
HS = tool material

9.5 = diameter of the drill.

If the tool type is not indicated in the designation, it should be taken as type 'N' tool.

DRILLS FOR DIFFERENT MATERIALS

Recommended drills					
Material to be drilled	Point angle	Helix angle d=3.2-5 5-10 10-	Material to be drilled	Point angle	Helix angle d=3.5-5 5-
Steel and cast steel up to 70 kgf/mm ² strength Gray cast iron Malleable cast iron Brass German silver, nickel.	118°	22° 25° 30°	Copper (up to 30 mm drill diameter) Al-alloys, forming curly chips Celluloid	140°	35° 40°
Brass, CuZn 40	118°	12° 13° 13°	Austenitic steels Magnesium alloys	140°	12° 13°
Steel and cast steel 70...120 Kgf/mm ²	130°	27° 25° 30°	Moulded plastics (with thickness s>d)	80°	35° 40°

Stainless steel; Copper (drill diameter more than 30 mm) Al-alloy, forming short broken chips		with thickness $s < d$ Laminated plastics, hard rubber (ebonite) marble, slate, coal	
		Zinc alloys	

Drilling - Cutting speed, feed and r.p.m, drill holding devices

Objectives : At the end of this lesson you shall be able to

- define cutting speed
- state the factors for determining the cutting speed
- determine r.p.m/spindle speed.

Cutting speed is the speed at which the cutting edge passes over the material while cutting, and is expressed in metres per minute.

Cutting speed is also sometimes stated as surface speed or peripheral speed.

The selection of the recommended cutting speed for drilling depends on the materials to be drilled, and the tool material.

Tool manufacturers usually provide a table of cutting speeds required for different materials.

The recommended cutting speeds for different materials are given in the Table 1. Based on the cutting speed recommended, the r.p.m, at which a drill has to be driven is determined.

TABLE 1
Recommended cutting speeds

Materials being drilled (HSS Tool)	
Aluminium	70 - 100
Brass	35 - 50
Bronze(phosphor)	20 - 35
Cast iron (grey)	25 - 40
Copper	35 - 45
Steel (medium carbon/mild steel)	20 - 30
Steel (alloy, high tensile)	5 - 8
Thermosetting plastic (low speed due to abrasive properties)	20 - 30

Cutting speed calculation

Cutting speed (V)

$$\text{r.p.m}(n) = \frac{V \times 1000}{d \times \pi}$$

n - r.p.m.

v - Cutting speed in m/min.

d - diameter of the drill in mm.

$\pi = 3.14$

Examples

Calculate the r.p.m for a high speed steel drill $\varnothing 24$ to cut mild steel.

The cutting speed for mild steel is taken as 30 m/min from the table.

$$n = \frac{1000 \times 30}{3.14 \times 24} = 398 \text{ r.p.m}$$

It is always preferable to set the spindle speed to the nearest available lower range.

The r.p.m. will differ according to the diameter of the drills. The cutting speed being the same, larger diameter drills will have lesser r.p.m and smaller diameter drills will have higher r.p.m.

The recommended cutting speeds are achieved only by actual experiment.

Feed in drilling

Objectives: At the end of this lesson you shall be able to

- state about feed
- state the factors that contribute to an efficient feed rate.

Feed is the distance a drill advances into the work in one complete rotation. (Fig 1)

Feed is expressed in hundredths of a millimeter.

Example - 0.040mm/ rev

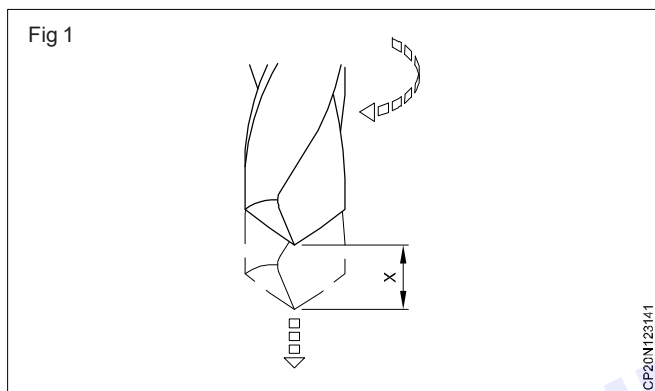
The rate of feed is dependent up on a number of factors.

- The finish required
- Type of drill (drill material)
- Material to be drilled

Too coarse a feed may result in damage to the cutting edges or breakage of the drill.

Too slow a rate of feed will not bring improvement in surface finish but may cause excessive wear of the tool point, and lead to chattering of the drill.

For optimum results in the feed rate while drilling, it is necessary to ensure the drill cutting edges are sharp. Use the correct type of cutting fluid.



Factors like rigidity of the machine, holding of the work-piece and the drill, will also have to be considered while determining the feed rate. If these are not to the required standard, the feed rate will have to be decreased.

It is not possible to suggest a particular feed rate taking all the factors into account.

The table gives the feed rate which is based on the average feed values suggested by the different manufacturers of drills. (Table 1)

TABLE 1

Drill diameter (mm) H.S.S	Rate of feed (mm/rev)
1.0 - 2.5	0.040 - 0.060
2.6 - 4.5	0.050 - 0.100
4.6 - 6.0	0.075 - 0.150
6.1 - 9.0	0.100 - 0.200
9.1 - 12.0	0.150 - 0.250
12.1 - 15.0	0.200 - 0.300
15.1 - 18.0	0.230 - 0.330
18.1 - 21.0	0.260 - 0.360
21.1 - 25.0	0.280 - 0.380

Cutting Tool	Mild Steel	Carbon steel	Aluminium	Brass	Cast iron	Stainless steel
HSS	100	80	250 to 350	175	100	80 to 100
Carbide	300	200	750 to 1000	500	250	200 to 250

Drill-holding devices

Objectives: At the end of this lesson you shall be able to

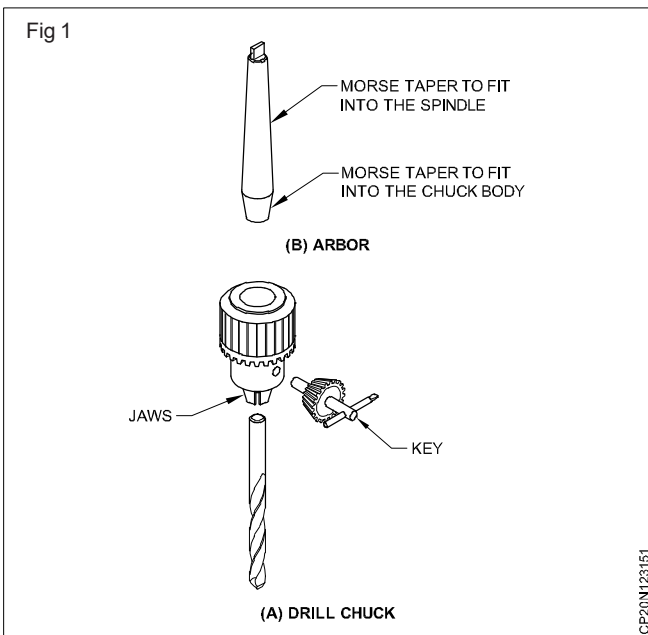
- name the different types of drill-holding devices
- state the features of drill chucks
- state the functions of drill sleeves
- state the function of drift.

For drilling holes on materials, the drills are to be held accurately and rigidly on the machines.

The common drill-holding devices are drill chucks, sleeves and sockets.

Drill chucks: Straight shank drills are held in drill chucks. (Fig 1A) For fixing and removing drills, the chucks are provided either with a pinion and key or a knurled ring.

The drill chucks are held on the machine spindle by means of an arbor (Fig 1B) fitted on the drill chuck.



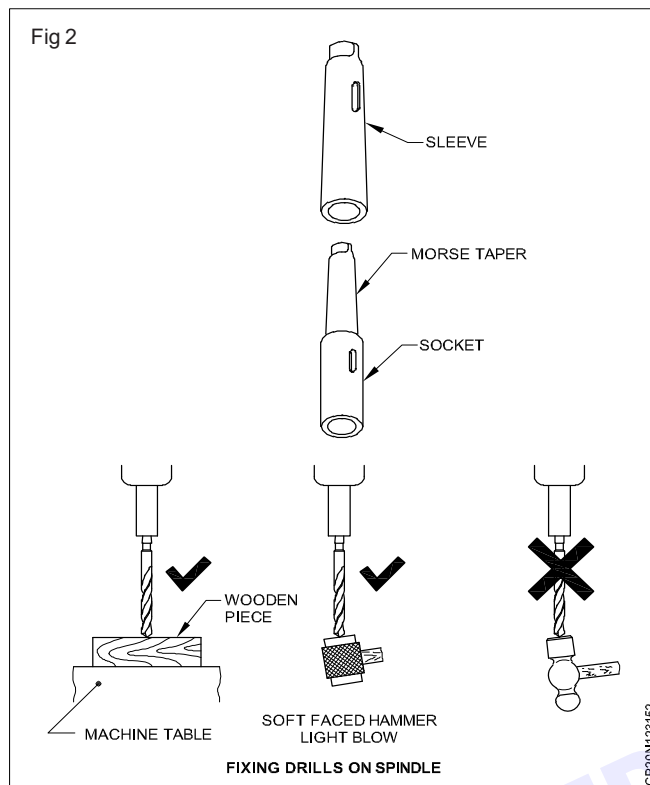
Taper sleeves and sockets (Fig 2): Taper shank drills have a Morse taper.

Sleeves and sockets are made with the same taper so that the taper shank of the drill, when engaged, will give a good wedging action. Due to this reason Morse tapers are called self-holding tapers.

The drills are provided with five different sizes of Morse tapers, and are numbered from MT 1 to MT 5.

In order to make up the difference in sizes between the shanks of the drills and the bore of machine spindles, sleeves of different sizes are used. When the drill taper shank is bigger than the machine spindle, taper sockets are used. (Fig 2)

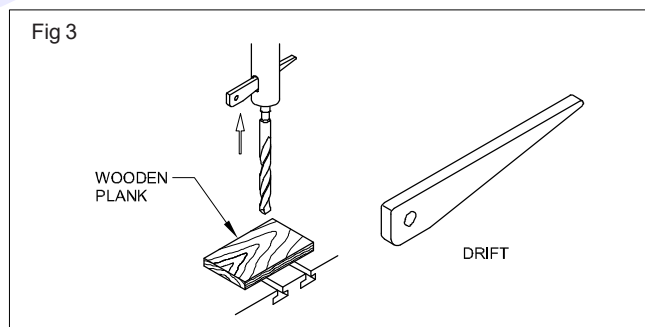
While fixing the drill in a socket or sleeve, the tang portion should align in the slot. This will facilitate the removal of the drill or sleeve from the machine spindle.



Use a drift to remove drills and sockets from the machine spindle. (Fig 3)

While removing the drill from the sockets/sleeves don't allow it to fall on the table or jobs.

Drill chucks are made from special alloy steel
Drill sleeves are made from case hardened steel.



Reamers

Objectives: At the end of this lesson you shall be able to

- state the use of reamers
- state the advantages of reaming
- distinguish between hand and machine reaming
- name the elements of a reamer and state their functions.

What is a reamer?

A reamer is a multipoint cutting tool used for enlarging by finishing previously drilled holes to accurate sizes. (Fig 1)

Advantages of 'reaming'

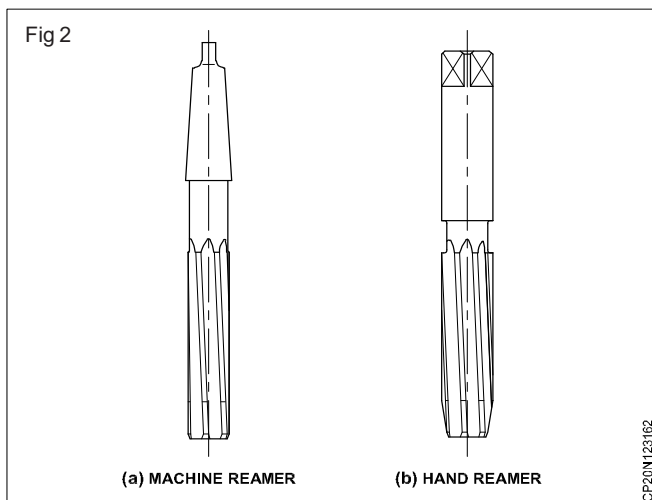
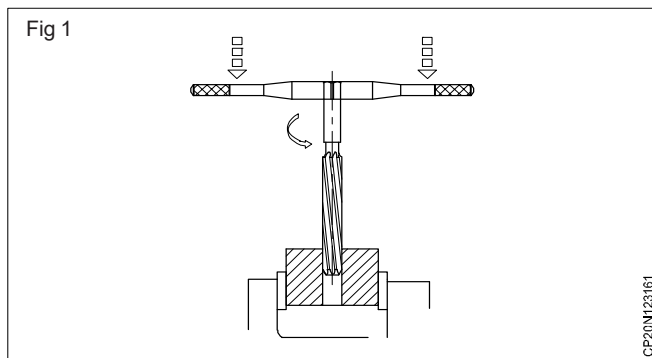
Reaming produces

- High quality surface finish

- Dimensional accuracy to close limits.
- Also small holes which cannot be finished by other processes can be finished.

Classification of reamers

Reamers are classified as hand reamers and machine reamers. (Figs 2a and 2b)



Reaming by using hand reamers is done manually for which great skill is needed.

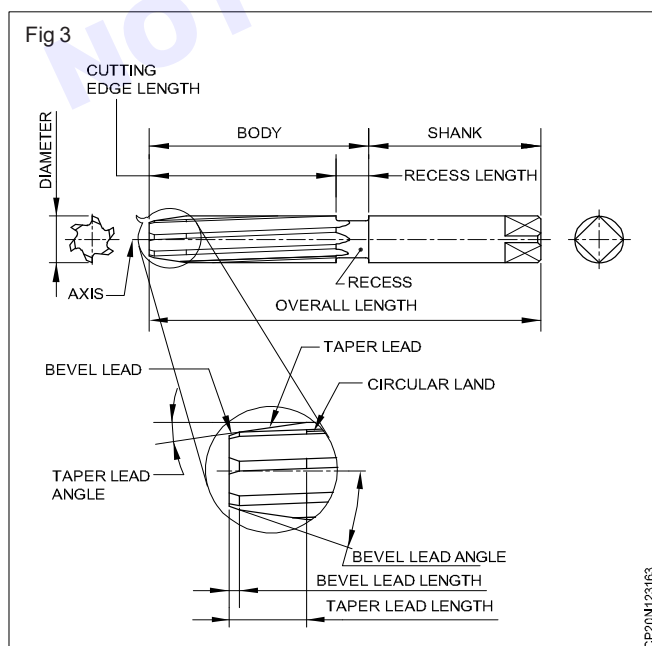
Machine reamers are fitted on spindles of machine tools and rotated for reaming.

Machine reamers are provided with more taper shanks for holding on machine spindles.

Hand reamers have straight shanks with 'square' at the end, for holding with tap wrenches. (Figs 2 (a) and (b))

Parts of a hand reamer

The parts of a hand reamer are listed hereunder. Refer to Fig 3.



Axis: The longitudinal centre line of the reamer.

Body: The portion of the reamer extending from the entering end of the reamer to the commencement of the shank.

Recess: The portion of the body which is reduced in diameter below the cutting edges, pilot or guide diameters.

Shank: The portion of the reamer which is held and driven. It can be parallel or taper.

Circular land: The cylindrically ground surface adjacent to the cutting edge on the leading edge of the land.

Bevel lead: The bevel lead cutting portion at the entering end of the reamer cutting its way into the hole. It is not provided with a circular land.

Taper lead: The tapered cutting portion at the entering end to facilitate cutting and finishing of the hole. It is not provided with a circular land.

Bevel lead angle: The angle formed by the cutting edges of the bevel lead and the reamer axis.

Taper lead angle: The angle formed by the cutting edges of the taper and the reamer axis.

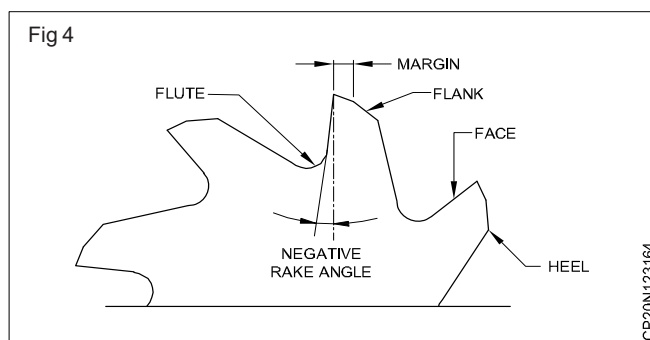
Terms relating to cutting geometry

Flutes: The grooves in the body of the reamer to provide cutting edges, to permit the removal of chips, and to allow the cutting fluid to reach the cutting edges. (Fig 4)

Heel: The edge formed by the intersection of the surface left by the provision of a secondary clearance and the flute. (Fig 4)

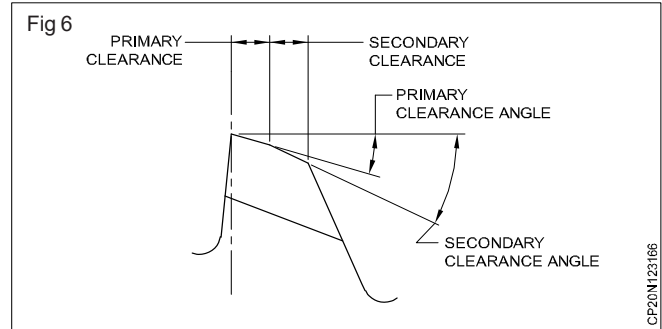
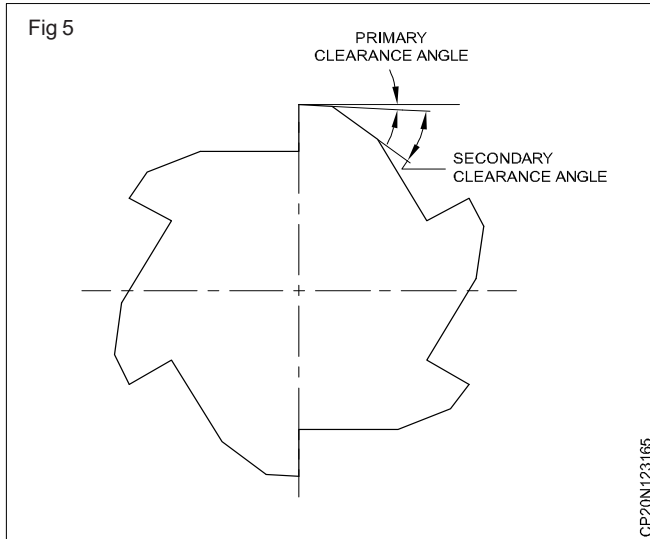
Cutting edge: The edge formed by the intersection of the face and the circular land or the surface left by the provision of primary clearance. (Fig 4)

Face: The portion of the flute surface adjacent to the cutting edge on which the chip impinges as it is cut from the work. (Fig 4)

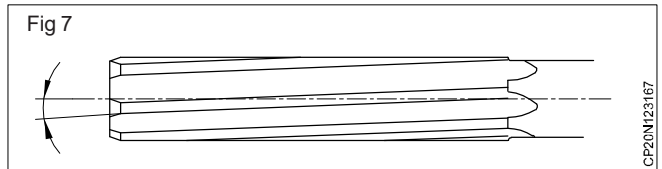


Rake angles: The angles in a diametric plane formed by the face and a radial line from the cutting edge. (Fig 5)

Clearance angle: The angles formed by the primary or secondary clearances and the tangent to the periphery of the reamer at the cutting edge. They are called primary clearance angle and secondary clearance angle respectively. (Fig 6)



Helix angle: The angle between the edge and the reamer axis. (Fig 7)

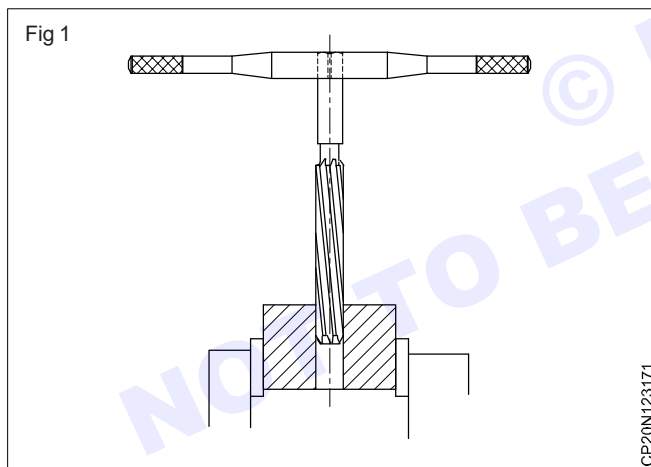


Hand reamers

Objectives: At the end of this lesson you shall be able to

- state the general features of hand reamers
- identify the types of hand reamers
- distinguish between the uses of straight fluted and helical fluted reamers
- name the materials from which reamers are made and specify reamers.

General features of hand reamers (Fig 1)



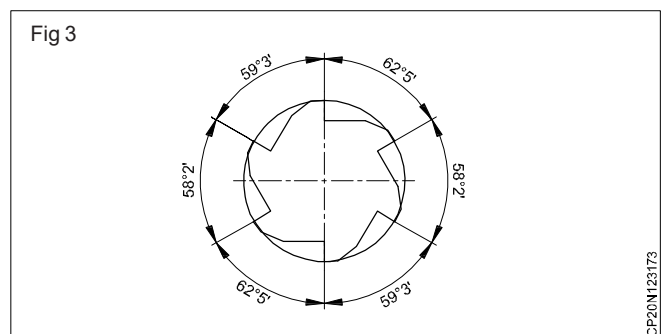
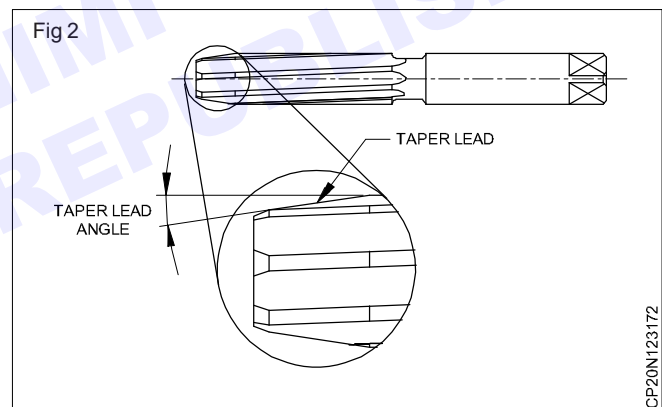
Hand reamers are used to ream holes manually using tap wrenches.

These reamers have a long taper lead. (Fig 2) This allows to start the reamer straight and in alignment with the hole being reamed.

Most hand reamers are for right hand cutting.

Helical fluted hand reamers have left hand helix. The left hand helix will produce smooth cutting action and finish.

Most reamers, machine or hand, have uneven spacing of teeth. This feature of reamers helps to reduce chattering while reaming. (Fig 3)



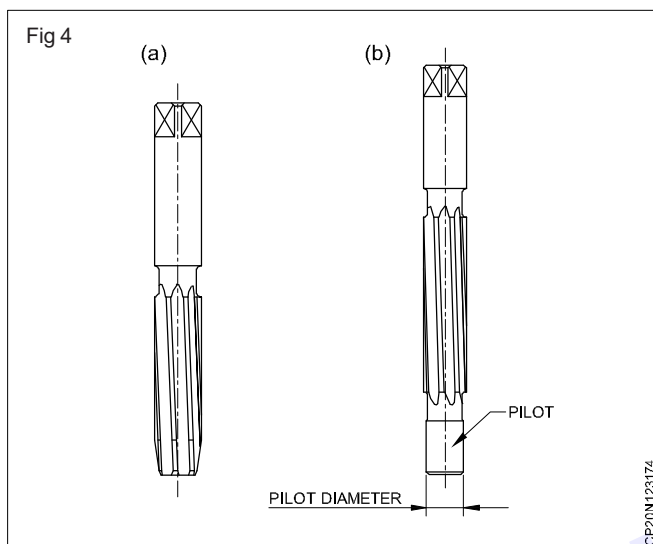
Types, features and functions: Hand reamers with different features are available for meeting different reaming conditions. The commonly used types are listed here under:

Parallel hand reamer with parallel shank (Fig 4a)

A reamer which has virtually parallel cutting edges with taper and bevel lead. The body of the reamer is integral with a shank. The shank has the nominal diameter of the cutting edges. One end of the shank is square shaped for tuning it with a tap wrench. Parallel reamers are available with straight and helical flutes. This is the commonly used hand reamer for reaming holes with parallel sides.

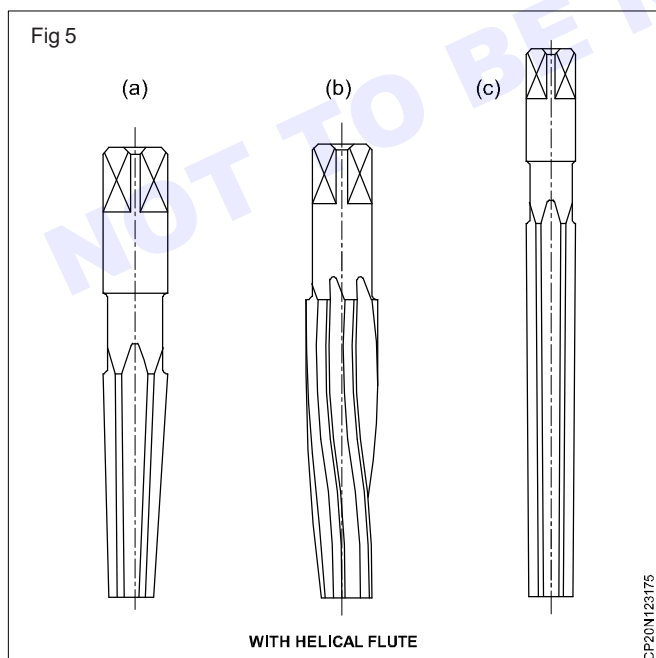
Reamers commonly used in workshop produce H7 holes.

Hand reamer with pilot (Fig 4b)



For this type of reamer, a portion of the body is cylindrically ground to form a pilot at the entering end. The pilot keeps the reamer concentric with the hole being reamed.

Socket reamer with parallel shank (Figs 5a and 5b)



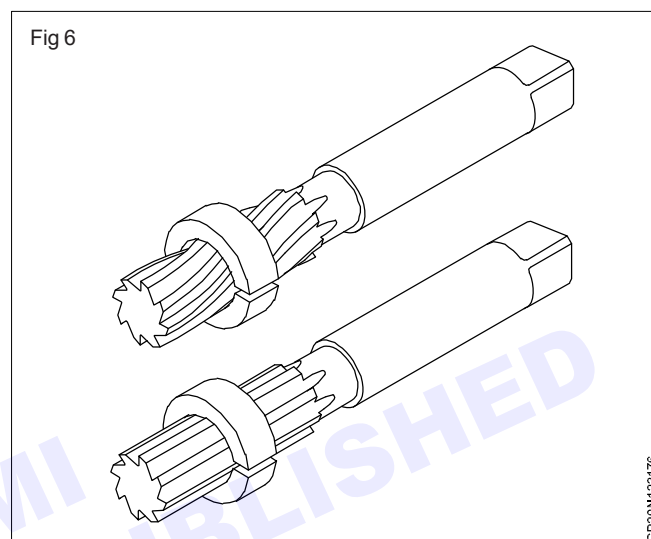
This reamer has tapered cutting edges to suit metric morse tapers. The shank is integral with the body, and is square shaped for driving. The flutes are either straight or helical.

The socket reamer is used for reaming internal morse tapered holes.

Taper pin hand reamer (Fig 5c)

This reamer has tapered cutting edges for reaming taper holes to suit taper pins. A taper pin reamer is made with a taper of 1 in 50. These reamers are available with straight or helical flutes.

Use of straight and helical fluted reamers (Fig 6)



Straight fluted reamers are useful for general reaming work. Helical fluted reamers are particularly suitable for reaming holes with keyway grooves or special lines cut into them. The helical flutes will bridge the gap and reduce binding and chattering.

Material of hand reamers

When the reamers are made as a one-piece construction, high speed steel is used. When they are made as two-piece construction then the cutting portion is made of high speed steel while the shank portion is made of carbon steel. They are butt-welded together before manufacturing.

Specifications of a reamer: To specify a reamer the following data is to be given.

- Type
- Flute
- Shank end
- Size

Example : Hand reamer, Straight flute, Parallel shank of $\varnothing$ 20 mm.

Drill size for reaming

Objective: At the end of this lesson you shall be able to

- **determine the hole size for reaming.**

For reaming with a hand or a machine reamer, the hole drilled should be smaller than the reamer size.

The drilled hole should have sufficient metal for finishing with the reamer. Excessive metal will impose a strain on the cutting edge of the reamer and damage it.

Calculating drill size for reamer: A method generally practised in workshop is by applying the following formula.

Drill size = Reamed size – (Undersize + Oversize)

Finished size: Finished size is the diameter of the reamer.

Undersize: Undersize is the recommended reduction in size for different ranges of drill diameter. (Table 1)

Table 1

Under sizes for reaming	
Diameter of ready reamed hole (mm)	Undersize of rough bored hole (mm)
under 5	0.1.....0.2
5.....20	0.2.....0.3
21....50	0.3.....0.5
over 50	0.5.....1

Oversize: It is generally considered that a twist drill will make a hole larger than its diameter. The oversize for calculation purposes is taken as 0.05 mm - for all diameters of drills.

For light metals the undersize will be chosen 50% larger.

Example: A hole is to be reamed on mild steel with a 10 mm reamer. What will be the diameter of the drill for drilling the hole before reaming?

Drill size = Reamed size – (Undersize + Oversize)

(Finished size) = 10 mm

Undersize as per

table = 0.2 mm

Oversize = 0.05 mm

Drill size = 10 mm -- 0.25 mm

= 9.75 mm

Determine the drill hole sizes for the following reamers:

i 15 mm

ii 4 mm

iii 40 mm

iv 19 mm

Answer

i _____

ii _____

iii _____

iv _____

Note: If the reamed hole is undersize, the cause is that the reamer is worn out.

Always inspect the condition of the reamer before commencing reaming.

For obtaining good surface finish

Use a coolant while reaming. Remove metal chips from the reamer frequently. Advance the reamer slowly into the work.

Defects in reaming - Causes and Remedies

- **Reamed hole undersize**

- If a worn out reamer is used, it may result in the reamed hole bearing undersize. Do not use such reamers.
- Always inspect the condition of the reamer before using.

- **Surface finish rough**

- The causes may be any one of the following or a combinations thereof.
- Incorrect application
- Swarf accumulated in reamer flutes
- Inadequate flow of coolant
- Feed rate too fast
- While reaming apply a steady and slow feed-rate.
- Ensure a continuous supply of the coolant.
- Do not turn the reamer in the reverse direction.

Determining the drill size for reaming

Use the formula,

drill diameter = reamed hole size. (undersize + oversize)

Refer to the Table 1 for the recommended under sizes in Related Theory on drill sizes for reaming.

Reaming

Objective : At the end of this lesson you shall be able to

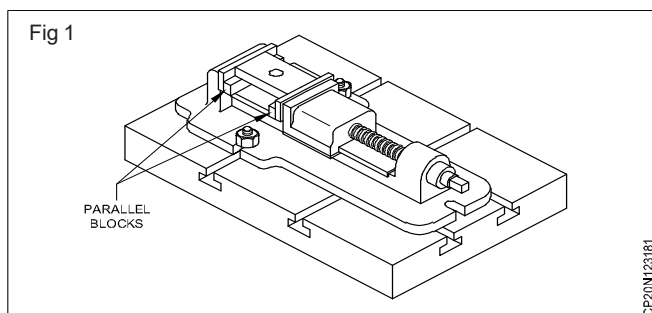
- state the procedure for hand reaming and machine reaming.

Reaming: Reaming is the operation of finishing and sizing a hole which has been previously drilled, bored, casted holes. The tool used is called a reamer, which has multiple cutting edges. Manually it is held in a tap wrench and reamed. Machine reamer are used in drilling machine using sleeves (or) socket. Normally the speed for reaming will be 1/3rd speed of drilling.

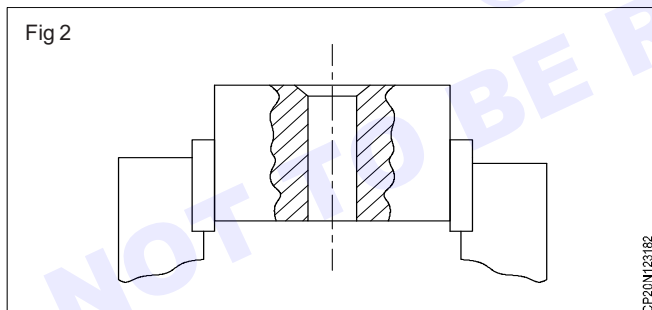
Hand Reaming

Drill holes for reaming as per the sizes determined.

Place the work on parallels while setting on the machine vice. (Fig 1)

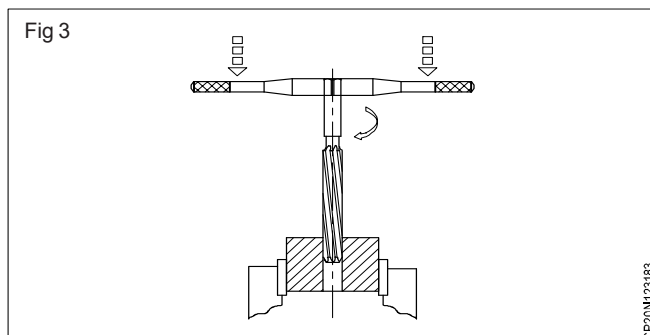


Chamfer the hole ends slightly. This removes burrs and will also help to align the reamer vertically. (Fig 2) Fix the work in the bench vice. Use vice clamps to protect the finished surfaces. Ensure that the job is horizontal. (Fig 2)



Fix the tap wrench on the square end and place the reamer vertically in the hole. Check the alignment with a try square. Make corrections, If necessary. Turn the tap wrench in a clockwise direction applying a slight downward pressure at the same time. (Fig 3) Apply pressure evenly at both ends of the tap wrench.

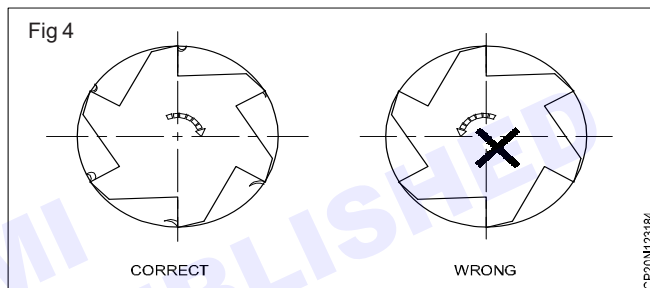
Fig 3



Apply cutting force: Turn the tap wrench steadily and slowly, maintaining the downward pressure.

Do not turn in reverse direction it will scratch the reamed hole. (Fig 4)

Fig 4



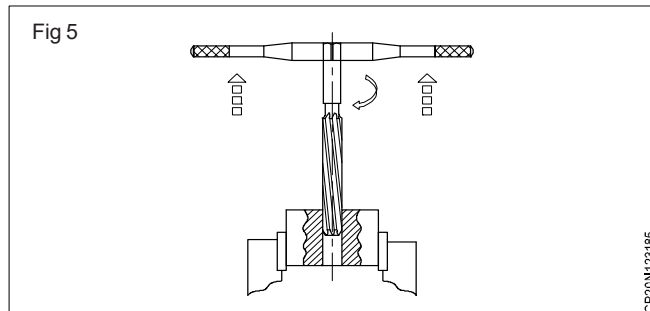
Ream the hole through, ensure that the taper lead length of the reamer comes out well and clear from the bottom of the work. Do not allow the end of the reamer to strike on the vice.

Remove the reamer with an upward pull until the reamer is clear of the hole. (Fig 5)

Remove the burrs from the bottom of the reamed hole.

Clean the hole. Check the accuracy with the cylindrical pins supplied.

Fig 5



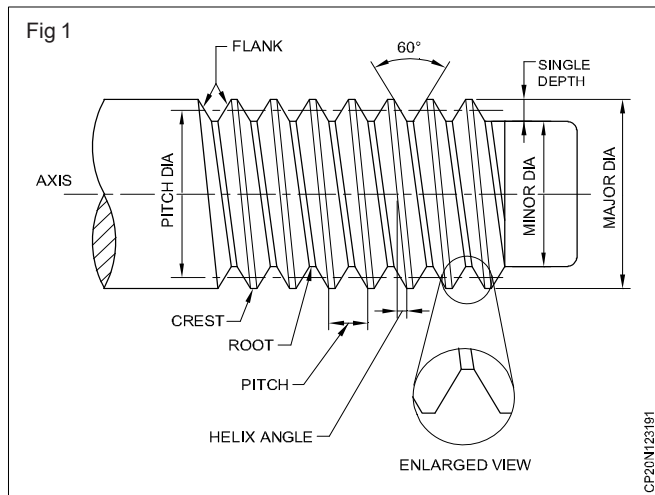
Screw thread and elements

Objectives: At the end of this lesson you shall be able to

- state the terminology of screw threads
- state the types of screw threads.

Screw thread terminology

Parts of screw thread (Fig 1)



Crest: The top surface joining the two sides of a thread.

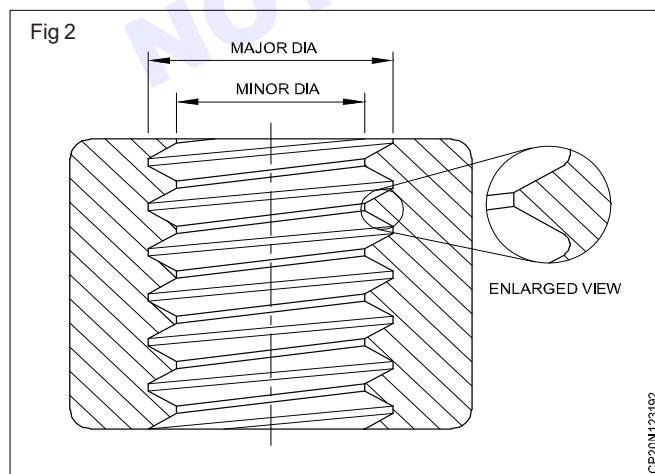
Root: The bottom surface joining the two sides of adjacent threads.

Flank: The surface joining the crest and the root.

Thread angle: The included angle between the flanks of adjacent threads.

Depth: The perpendicular distance between the roots and crest of the thread.

Major Diameter: In the case of external threads it is the diameter of the blank on which the threads are cut and in the case of internal threads it is the largest diameter after the threads are cut that are known as the major diameter. (Fig 2)



This is the diameter by which the sizes of screws are stated.

Minor Diameter: For external threads, the minor diameter is the smallest diameter after cutting the full thread. In the case of internal threads, it is the diameter of the hole drilled for forming the thread which is the minor diameter.

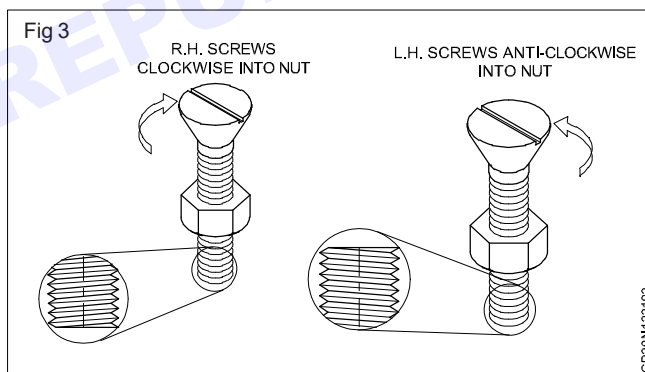
Pitch Diameter (effective diameter): The diameter of the thread at which the thread thickness is equal to one half of the pitch.

Pitch: It is the distance from a point on one thread to a corresponding point on the adjacent thread measured parallel to the axis.

Lead: Lead is the distance of a threaded component moves along the matching component during one complete revolution. For a single start thread the lead is equal to the pitch.

Helix Angle: The angle of inclination of the thread to the imaginary perpendicular line.

Hand: The direction in which the thread is turned to advance. A right hand thread is turned clockwise to advance, while a left hand thread is turned anticlockwise. (Fig 3)



Screw threads - types of 'V' threads and their uses

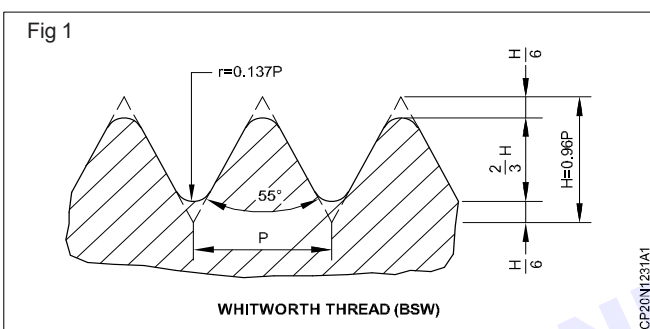
Objectives: At the end of this lesson you shall be able to

- state the different standards of 'V' threads
- indicate the angle and the relation between the pitch with the other elements of the thread
- state the uses of the different standards of 'V' threads.

The different standards of 'V' threads are:

- BSW thread: British Standard Whitworth thread
- BSF thread: British Standard fine thread
- BSP thread: British Standard pipe thread
- B.A thread: British Association thread
- I.S.O Metric thread: International Standard Organisation metric thread
- ANS: American National or sellers' thread
- BIS Metric thread: Bureau of Indian Standard metric thread.

BSW thread (Fig 1): It has an included angle of 55° and



the depth of the thread is $0.6403 \times P$. The crest and root are rounded off to a definite radius. The Fig 1 shows the relationship between the pitch and the other elements of the thread.

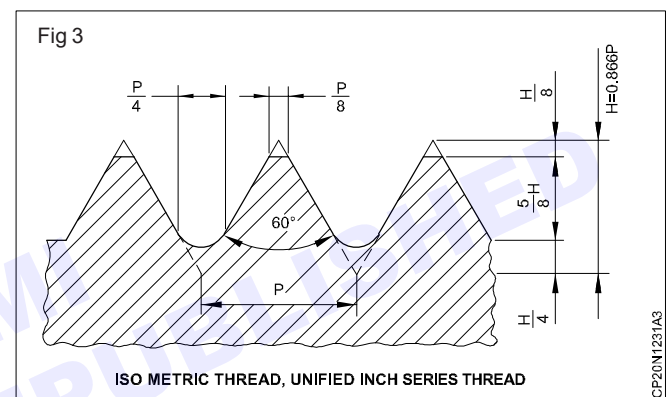
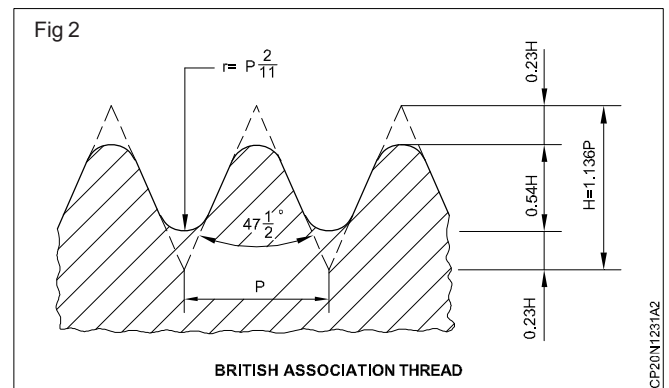
BSW thread is represented in a drawing by giving the major diameter. For example: $1/2"$ BSW, $1/4"$ BSW. The table indicates the standard number of TPI for different diameters. BSW thread is used for general purpose fastening threads.

BSF thread: This thread is similar to BSW thread except the number of TPI for a particular diameter. The number of threads per inch is more than that for the BSW thread for a particular diameter. For Example, $1"$ BSW has 8 TPI and $1"$ BSF has 10 TPI. The table indicates the standard number of TPI for different dia. of BSF threads. It is used in automobile industries.

BSP thread: This thread is recommended for pipe and pipe fittings. The table shows the pitch for different diameters. It is also similar to BSW thread. The thread is cut externally with a small taper for the threaded length. This avoids the leakage in the assembly and provides for further adjustment when slackness is felt.

BA thread (Fig 2): This thread has an included angle of $47\frac{1}{2}^\circ$. Depth and other elements are as shown in the figure. It is used in small screws of electrical appliances, watch screws, screws of scientific apparatus.

Unified thread (Fig 3): For both the metric and inch series, ISO has developed this thread. Its angle is 60° . The crest and root are flat and the other dimensions are as shown in the Fig 3. This thread is used for general fastening purposes.



This thread of metric standard is represented in a drawing by the letter 'M' followed by the major diameter for the coarse series.

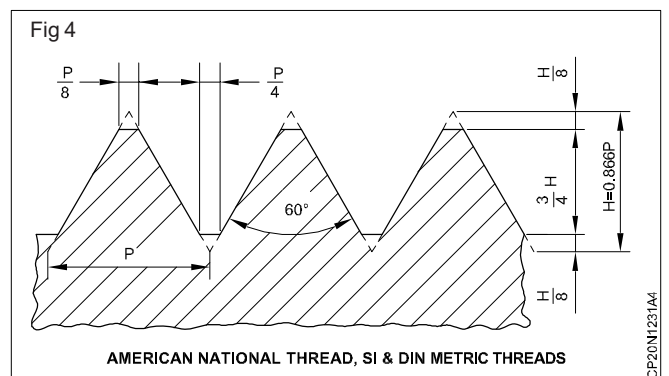
Ex : M14, M12 etc.

For the fine series, the letter 'M' is followed by the major diameter and pitch.

Ex : M14 x 1.5

M24 x 2

American National Thread (Fig 4): These threads are also called as seller's threads. It was more commonly used prior to the introduction of the ISO unified thread.



Screw pitch gauge

Objectives: At the end of this lesson you shall be able to

- state the purpose of a screw pitch gauge
- state the features of a screw pitch gauge.

Purpose

A screw pitch gauge is used to determine the pitch of a thread.

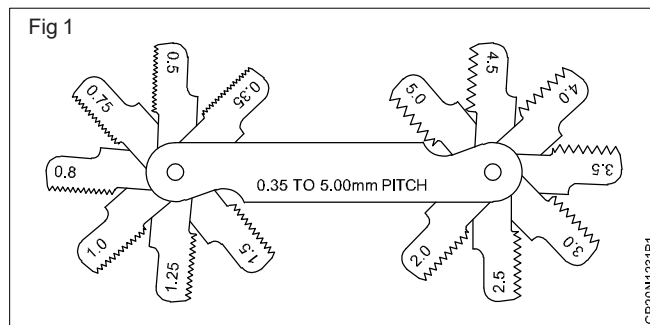
It is also used to compare the profile of threads.

Constructional features

Pitch gauges are available with a number of blades assembled as a set. Each blade is meant for checking a particular standard thread pitch. The blades are made of thin spring steel sheets, and are hardened.

Some screw pitch gauge sets will have blades provided for checking British Standard threads (BSW, BSF etc.) at one end and the metric standard at the other end.

The thread profile on each blade is cut for about 25 mm to 30 mm. The pitch of the blade is stamped on each blade. The standard and range of the pitches are marked on the case. (Fig 1)



Taps

Objectives: At the end of this lesson you shall be able to

- state the uses of hand taps
- state the features of hand taps
- distinguish between the different taps in a set.

Use of hand taps: Hand taps are used for internal threading of components.

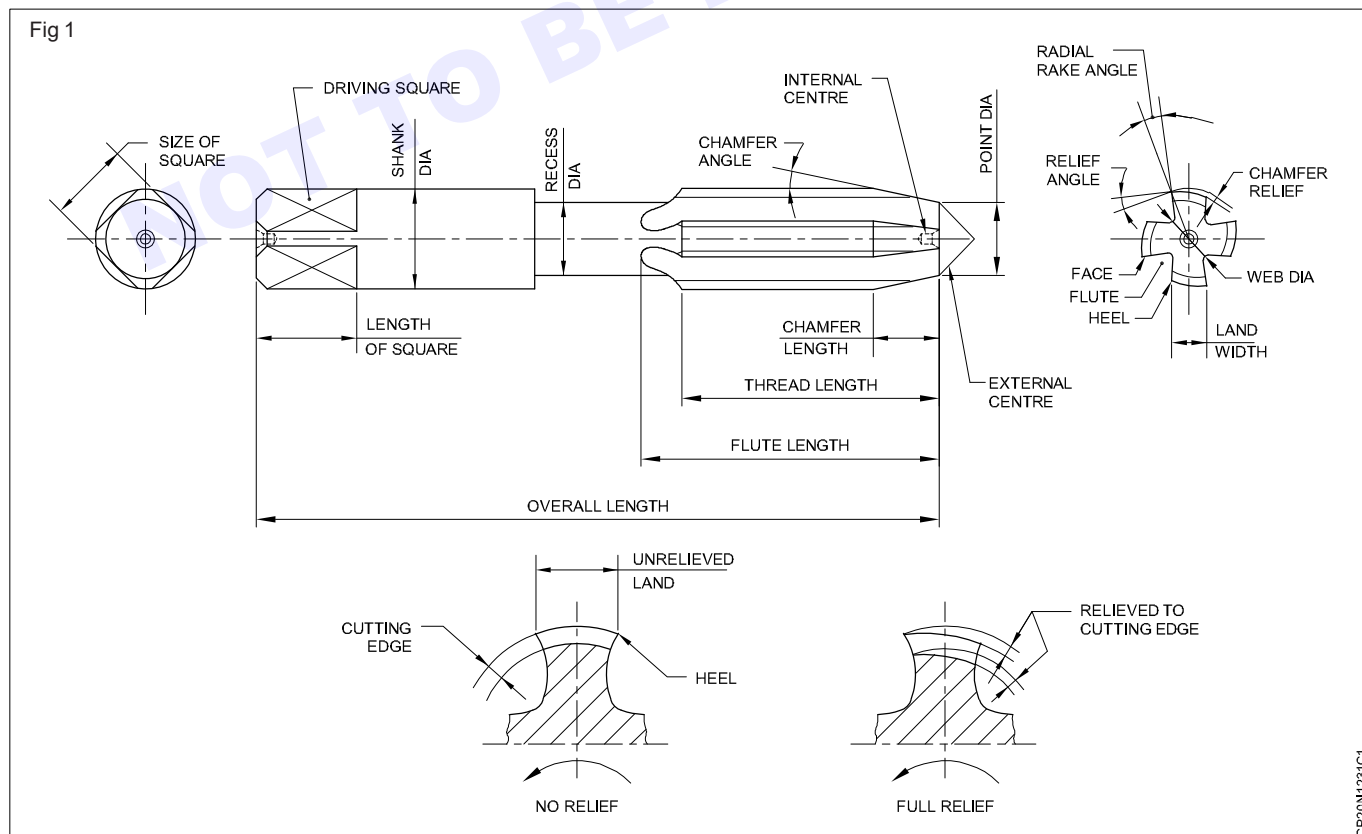
Features (Fig 1): They are made from high speed steel.

The threads are cut on the periphery and are accurately finished.

To form the cutting edges, flutes are cut across the thread.

The end of the shank of the tap is made of square shape for the purpose of holding and turning the taps.

The end of the taps are chamfered (taper lead) for assisting, aligning and starting of the thread.



The size of the taps, the thread standard, the pitch of the thread, the dia. of the tapping hole are usually marked on the shank.

Marking on the shank are also made to indicate the type of tap i.e. first, second and plug.

Types of taps in a set : Hand taps for a particular thread are available as a set consisting of three pieces. (Fig 2)

These are:

- First tap or taper tap
- Second tap or intermediate tap
- Plug or bottoming tap.

These taps are identical in all features except in the tap lead.

The taper tap is to start the thread. It is possible to form full threads by the taper tap in through holes which are not deep.

The bottoming tap (plug) is used to finish the threads of a blind hole to the correct depth.

For identifying the type of taps quickly - the taps are either numbered 1,2 and 3 or rings are marked on the shank.

The taper tap has one ring, the intermediate tap has two and the bottoming tap has three rings. (Fig 2)

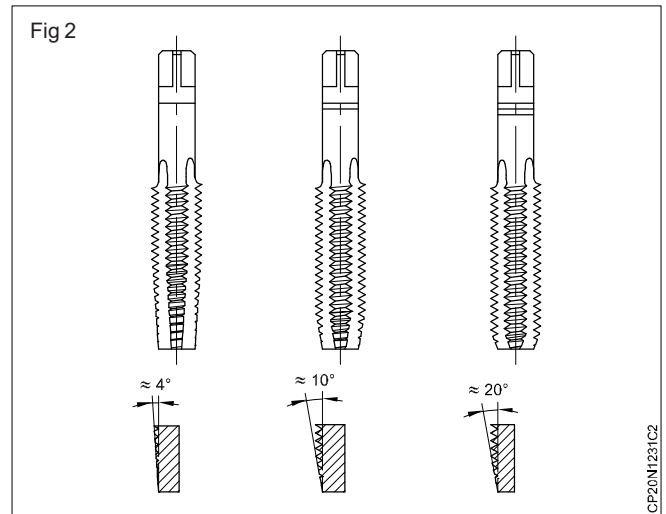


Table for tap drill size

B.S.W. (55°)			B.S.F. (55°)		
Tap size (inch)	Threads per inch	Tap drill size (mm)	Tap size (inch)	Threads per inch	Tap drill size (mm)
3/16	24	3.7 mm	3/16	32	3.97 mm
7/32	24	4.5 mm	7/32	28	4.6 mm
1/4	20	5.1 mm	1/4	26	5.3 mm
5/16	18	6.5 mm	5/16	22	6.75 mm
3/8	16	7.94 mm	3/8	20	8.2 mm
7/16	14	9.3 mm	7/16	18	9.7 mm
1/2	12	10.5 mm	1/2	16	11.11 mm
9/16	12	12.1 mm	9/16	16	12.7 mm
5/8	11	13.5 mm	5/8	14	14 mm
11/16	11	15 mm	11/16	14	15.5 mm
3/4	10	16.257 mm	3/4	12	16.75 mm
7/8	9	19.25 mm	7/8	11	19.84 mm
1"	8	22 mm	1"	10	22.75 mm

NPT National pipe thread

Tap size (inch)	Threads per inch	Tap drill size inch	Tap size (inch)	Threads per inch	Tap drill size inch
1/8	27	11/32	1	11 1/2	1 5/32
1/4	18	7/16	1 1/4	11 1/4	1 1/2
3/8	18	19/32	1 1/2	11 1/2	1 23/32
1/2	14	23/32	2	11 1/2	2 23/16
3/4	14	15/16	2 1/2	8	2 5/8

Tap drill sizes ISO Inch (Unified) thread

NC National coarse			NF National Fine		
Tap size (inch)	Threads per inch	Tap drill size inch	Tap size (inch)	Threads per inch	Tap drill size inch
1/4	20	13/64	1/4	28	7/32
5/16	18	17/64	5/16	24	17/64
3/8	16	5/16	3/8	24	21/64
7/16	14	3/8	7/16	20	25/64
1/2	13	27/64	1/2	20	29/64
9/16	12	31/64	9/16	18	33/64
5/8	11	17/32	5/8	18	37/64
3/4	10	21/32	3/4	16	11/16
7/8	9	49/64	7/8	14	13/16
1"	8	7/8	1"	14	15/16
1 1/8	7	63/64	1 1/8	12	1 3/6
1 1/4	7	17/64	1 1/4	12	1 11/6
1 3/8	6	17/32	1 3/8	12	1 19/64
1 1/2	6	1 11/32	1 1/2	12	1 27/64
1 3/4	5	1 9/16			
2"	4 1/2	1 25/32			

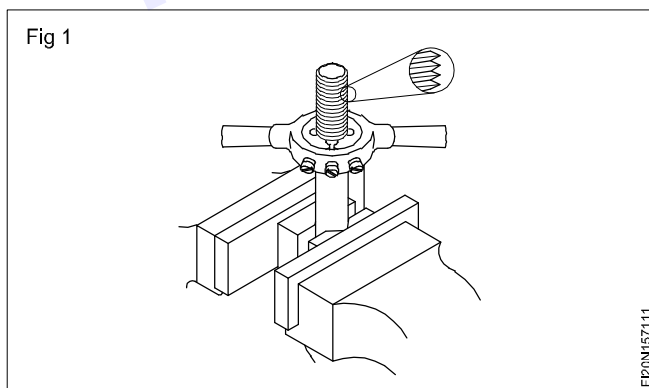
Dies and die stock

Objectives: At the end of this lesson you shall be able to

- list the different types of dies
- state the features of each type of die
- state the use of each type of die
- name the type of diestock for each type of die.

Uses of dies

Threading dies are used to cut external threads on cylindrical workpieces. (Fig 1)



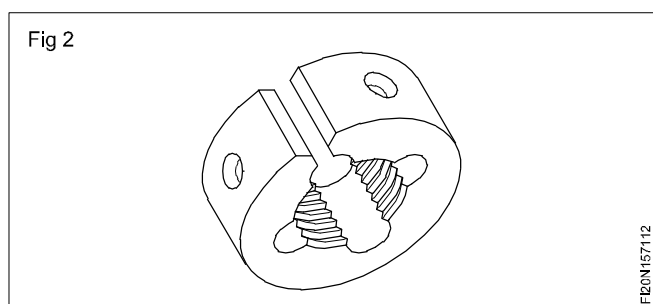
Types of dies

The following are the different types of dies.

- Circular split die (Button die)
- Half die

- Adjustable screw plate die

Circular split die/button die (Fig 2)

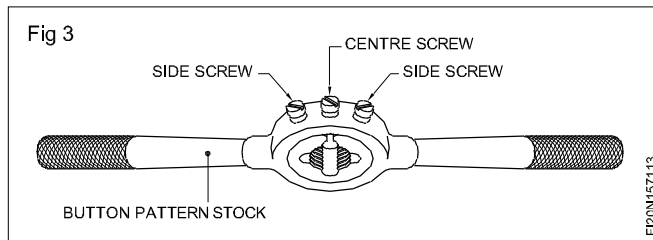


This has a slot cut to permit slight variation in size.

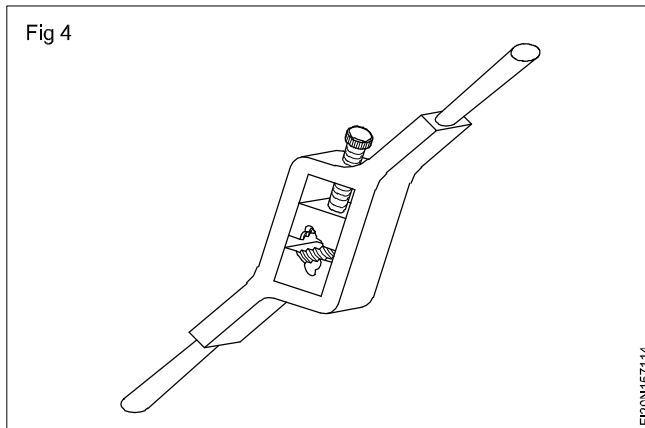
Dies are made of high speed steel

When held in the diestock, variation in the size can be made by using the adjusting screws. This permits increasing or decreasing of the depth of cut. When the side screws are tightened the die will close slightly. (Fig 3) For adjusting the depth of the cut, the centre screw is advanced and locked

in the groove. This type of die stock is called button pattern stock



Half die (Fig 4)



Half dies are stronger in construction.

Adjustments can be made easily to increase or decrease the depth of cut.

These dies are available in matching pairs and should be used together.

By adjusting the screw of the diestock, the die pieces can be brought closer together or can be moved apart.

They need a special die holder.

Adjustable screw plate die (Fig 5)

This is another type of a two piece die similar to the half die.

This provides greater adjustment than the split die.

The two die halves are held securely in a collar by means of a threaded plate (guide plate) which also acts as a guide while threading.

When the guide plate is tightened after placing the die pieces in the collar, the die pieces are correctly located and rigidly held.

The die pieces can be adjusted, using the adjusting screws on the collar. This type of die stock used is called quick cut diestock. (Fig 6)

Fig 5

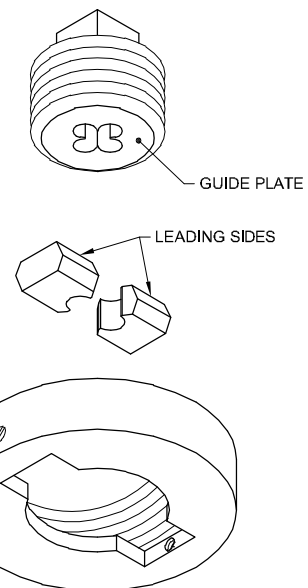
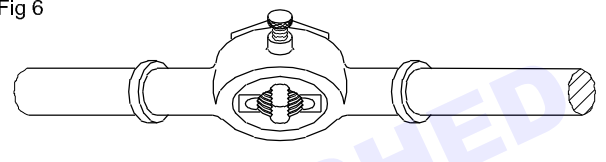


Fig 6

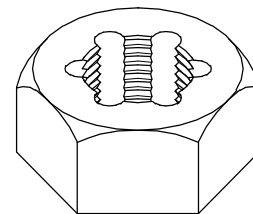


The bottom of the die halves is tapered to provide the lead for starting the thread. On one side of each die head, the serial number is stamped.

Both pieces should have the same serial numbers.

Die Nut (Solid Die) (Fig 7)

Fig 7



The die nut is used for chasing or reconditioning the damaged threads.

Die nuts are not to be used for cutting new threads.

The die nuts are available for different standards and sizes of threads.

The die nut is turned with a spanner.

Blank size for external threading

Objective: At the end of this lesson you shall be able to

- **determine the diameter of blank size for external thread cutting.**

Why should the blank size be less?

It has been observed from practice that the threaded diameters of steel blanks show a slight increase in diameter. such increase in the diameter will make assembly of external and internal threaded components very difficult. To overcome this, the diameter of the blank is slightly reduced before commencing the threading.

What should be the blank size?

The diameter of the blank should be less by 1/10th of the pitch of the thread.

Example

For cutting the thread of M12 with 1.75mm pitch the diameter of the blank is 11.80.

Formula, $D = d - p/10$

$= 12\text{mm} - 0.175\text{mm}$

$= 11.825$ or 11.8 mm.

d = diameter of bolt

D = the blank diameter

p = pitch of thread

Calculate the blank size for preparing a bolt of M16 x1.5?

Answer

.....
.....
.....

External threading using dies

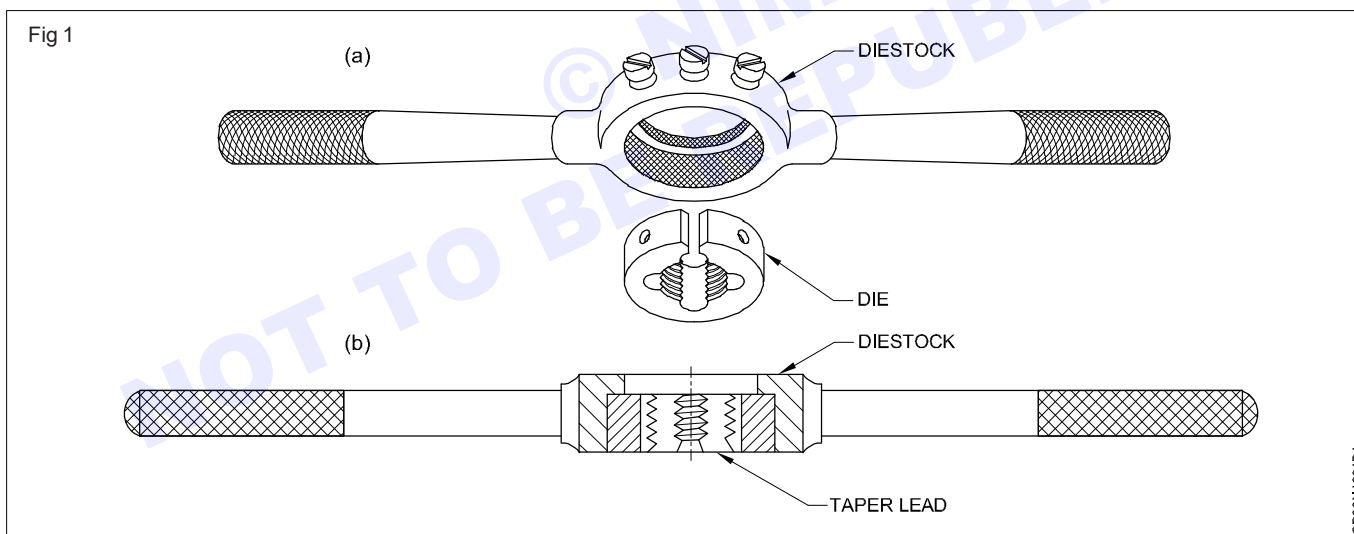
Objective: At the end of this lesson you shall be able to

- **cut external threads using dies.**

Check blank size.

Blank size = Threads size $- 0.1 \times$ pitch of thread

Procedure: Fix the die in the diestock and place the leading side of the die opposite to the step of the diestock. (Fig 1a & 1b)



Use false jaws for ensuring a good grip in the vice.

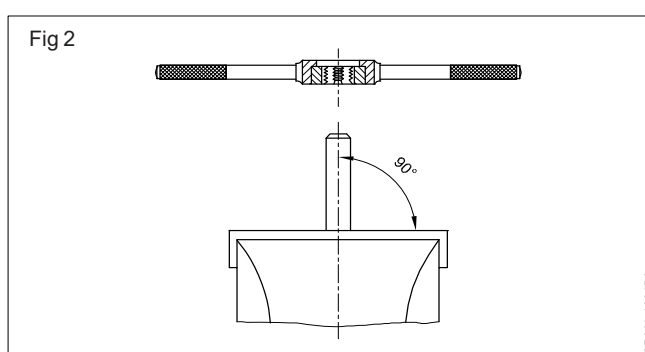
Project the blank above the vice - just the required thread length only.

Place the leading side of the die on the chamfer of the work (Fig 2)

Make sure that the die is fully open by tightening the centre screw of the diestock. (Fig 3)

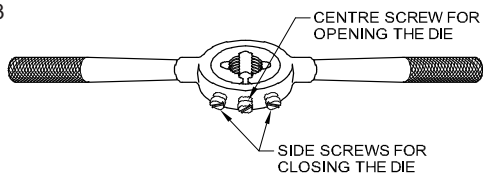
Start the die, square to the bolt centre line. (Fig 4)

Apply pressure on the diestock evenly and turn clockwise direction to advance the die on the bolt blank. (Fig 5)



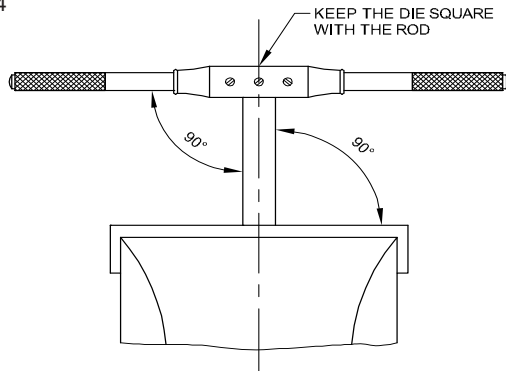
Cut slowly and reverse the die for a short distance in order to break the chips

Fig 3



CP20N1231D3

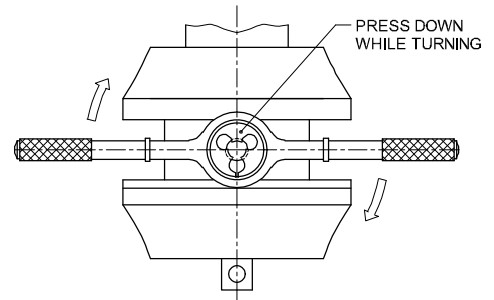
Fig 4



CP20N1231D4

Use a cutting lubricant.

Fig 5



CP20N1231D5

Increase the depth of the cut gradually by adjusting the outer screws.

Check the thread with a matching nut.

Repeat the cutting until the nut matches.

Too much depth of cut at one time will spoil the threads. It can also spoil the die.

Clean the die frequently to prevent the chips from clogging and spoiling the thread.

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Safety & general precautions observed in welding workshop

Objectives: At the end of this lesson you shall be able to

- **state the importance of safety in welding shop**
- **list the general safety precautions to be observed in welding shop.**

Safety

Welding can be dangerous and unhealthy if the proper precautions are not taken. However, using new technology and proper protection greatly reduces risks of injury and death associated with welding. Since many common welding procedures involve an open electric arc or flame, the risk of burns and fire is significant, that is why it is classified as a hot work process.

To prevent injury, welders wear personal protective equipment in the form of heavy leather gloves and protective long-sleeve jackets to avoid exposure to extreme heat and flames. Additionally, the brightness of the weld area leads to a condition called arc eye or flash burns in which ultraviolet light causes inflammation of the cornea and can burn the retinas of the eyes. Goggles and welding helmets with dark UV-filtering face plates are worn to prevent this exposure.

Since the 2000s, some helmets have included a face plate which instantly darkens upon exposure to the intense UV light. To protect bystanders, the welding area is often surrounded with translucent welding curtains. These curtains, made of a polyvinyl chloride plastic film, shield people outside the welding area from the UV light of the electric arc, but can not replace the filter glass used in helmets.

Welders are often exposed to dangerous gases and particulate matter. Processes like flux-cored arc welding and shielded metal arc welding produce smoke containing particles of various types of oxides. The size of the particles in question tends to influence the toxicity of the fumes, with smaller particles presenting a greater danger. This is because smaller particles have the ability to cross the blood brain barrier. Fumes and gases, such as carbon-di-oxide, ozone, and fumes containing heavy metals, can be dangerous to welders lacking proper ventilation and training. Exposure to manganese welding fumes, for example, even at low levels ($<0.2 \text{ mg/m}^3$) may lead to neurological problems or to damage to the lungs, liver, kidneys, or central nervous system. Nano particles can

become trapped in the alveolar macrophages of the lungs and induce pulmonary fibrosis. The use of compressed gases and flames in many welding processes possess an explosion and fire risk. Some common precautions include limiting the amount of oxygen in the air, and keeping combustible materials away from the workplace.

General safety

- To prevent injury to personnel, extreme caution should be exercised when using any types of welding equipment. Injury can result from fire, explosions, electric shock, or harmful agents. Both the general and specific safety precautions listed below must be strictly observed by workers who weld or cut metals.
- Do not permit unauthorized persons to use welding or cutting equipment.
- Do not weld in a building with wooden floors, unless the floors are protected from hot metal by means of fire resistant fabric, sand, or other fireproof material. Be sure that hot sparks or hot metal will not fall on the operator or on any welding equipment components.
- Remove all flammable material, such as cotton, oil, gasoline, etc., from the vicinity of welding.
- Before welding or cutting, warn those in close proximity who are not protected to wear proper clothing or goggles.
- Remove any assembled parts from the component being welded that may become warped or otherwise damaged by the welding process.
- Do not leave hot rejected electrode stubs, steel scrap, or tools on the floor or around the welding equipment. Accidents and/or fires may occur.
- Keep a suitable fire extinguisher nearby at all times. Ensure the fire extinguisher is in operable condition.
- Mark all hot metal after welding operations are completed. Soapstone is commonly used for this purpose.

Safety precautions in handling gas welding plant

Objectives : At the end of this lesson you shall be able to

- state the general safety precautions in oxy-acetylene plants.
- state the safety rules for handling gas cylinders
- state the safety practices for handling gas regulators and hose-pipes.
- state the safety precautions related to blowpipe operations.

To be accident-free, one must know the safety rules first and then practice them as well. As we know can 'accident starts when safety ends'.

Ignorance of rules is no excuse!

In gas welding, the welder must follow the safety precautions in handling gas welding plants and flame-setting to keep himself and others safe.

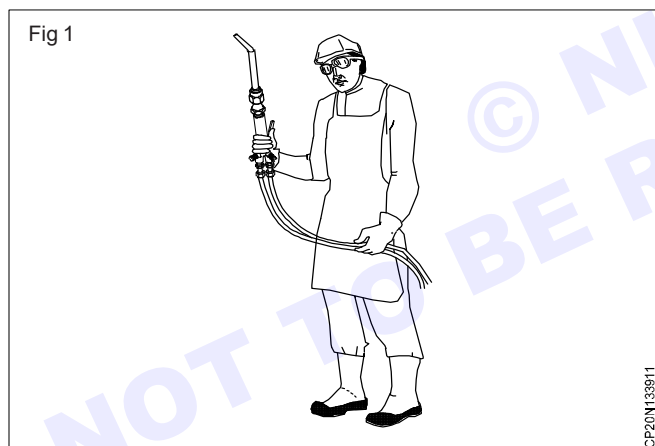
Safety precautions are always based on good common sense.

The following precautions are to be observed, to keep a gas welder accident-free.

General safety

Do not use lubricants (oil or grease) in any part or assembly of a gas welding plant. It may cause explosion.

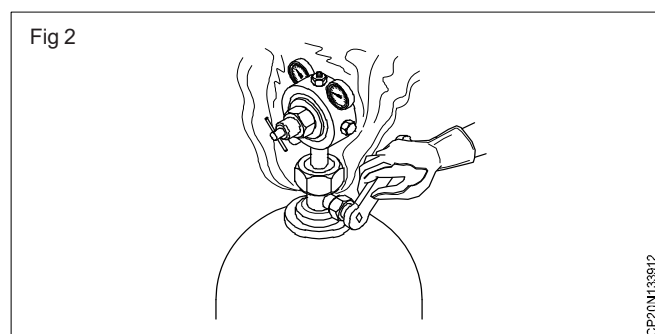
Keep all flammable material away from the welding area. Always wear goggles with filter lens during gas welding. (Fig 1)



Always wear fire resistant clothes, asbestos gloves and apron.

Never wear nylon, greasy and torn clothes while welding.

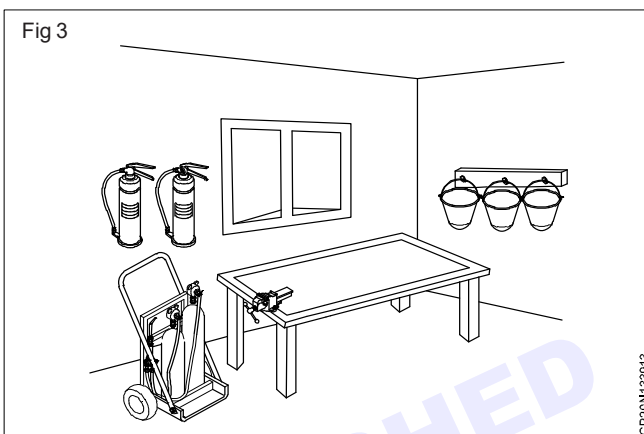
Whenever a leakage is noticed rectify it immediately to avoid fire hazards. (Fig 2)



Even a small leakage can cause serious accidents.

Always keep fire-fighting equipment handy and in working order to put out fires. (Fig 3)

Keep the work area free from any form of fire.



Safety precautions before gas welding

Safety for cylinders.

Do not roll gas cylinders or use them as rollers.

Use a trolley to carry the cylinders.

Close the cylinder valves when not in use or empty.

Keep full and empty cylinders separately.

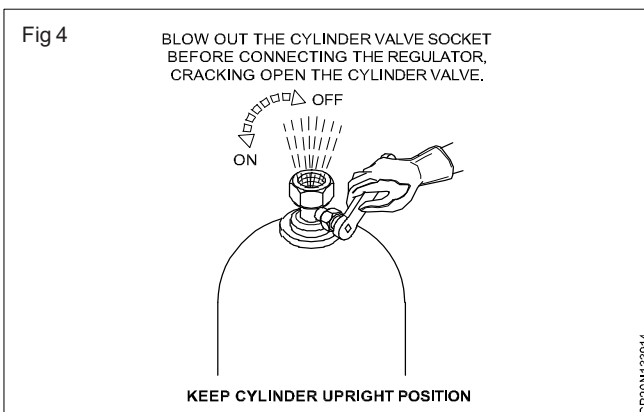
Always open the cylinder valves slowly, not more than one and a half turn.

Use the correct cylinder keys to open the cylinders.

Do not remove the cylinder keys from the cylinders while welding. It will help to close the cylinders QUICKLY in the case of a back-fire or flash-back.

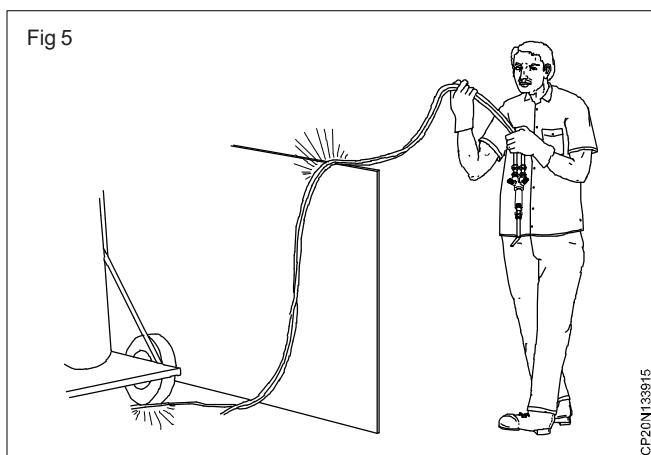
Always use the cylinders in an upright position for easy handling and safety.

Always crack the cylinder valves to clean the valve sockets before attaching regulators. (Fig 4)



Safety for rubber hose pipes (Fig 5)

Inspect the rubber hose pipes periodically and replace the damaged ones.



Do not use odd bits of hose pipes / tubes.

Do not replace the hose pipes for acetylene with the ones used for oxygen.

Always use a black hose pipes for oxygen and maroon hosepipes for acetylene.

Safety for regulators

Prevent hammer blows to the gas cylinders and ensure that water, dust and oil do not settle on the cylinders.

One right hand threaded connection for oxygen and left hand threaded connection for acetylene.

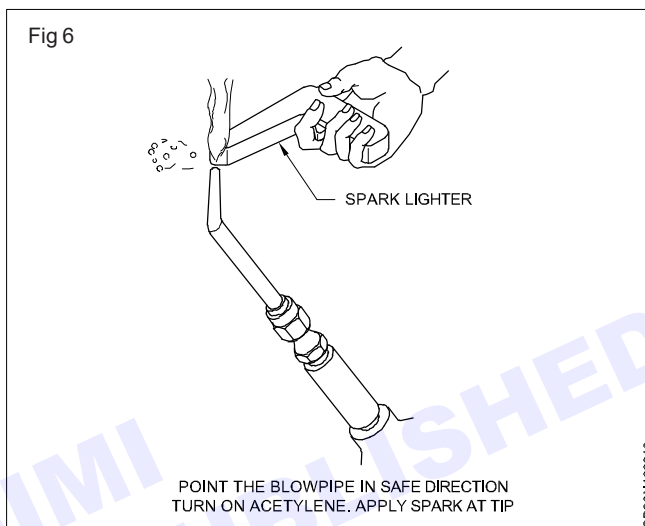
Safety for blowpipes

When a blowpipe is not in use put out the flame and place the blowpipe in a safe place.

When flame snaps out and backfires, quickly shut both the blowpipe valves (oxygen first) and dip in water.

While igniting the flame, point the blowpipe nozzle in a safe direction. (Fig 6)

While extinguishing the flame, shut off the acetylene valve first and then the oxygen valve to avoid a backfire.



Importance of welding in maintenance of chemical plant and equipment

Objectives: At the end of this lesson you shall be able to

- state the importance of welding in chemical plant.

Importance of welding in maintenance of chemical plant and equipment

Welding is integral to the maintenance of chemical plants and equipment due to several key factors:

- 1 Structural Integrity:** Chemical plants often operate in harsh environments, exposing equipment to corrosive substances and high temperatures. Welding is essential for repairing and reinforcing structural components, ensuring they can withstand the demanding conditions and maintain their integrity over time.
- 2 Leak Prevention:** Welding is a critical technique for sealing leaks in pipes, vessels, and other equipment. This is especially vital in chemical plants where even small leaks can lead to hazardous situations, environmental damage, and loss of valuable materials. Proper welding repairs help maintain a tight seal and prevent leakage.
- 3 Corrosion Mitigation:** Chemical processes can contribute to corrosion, weakening equipment over time. Welding allows for the removal and replacement of corroded sections, preventing further deterioration and ensuring the longevity of the equipment.

- 4 Equipment Modification and Upgrades:** As technology advances or process requirements change, chemical plants may need to modify or upgrade their equipment. Welding facilitates these changes by allowing the integration of new components or alterations to existing structures, ensuring equipment remains up-to-date and compliant with industry standards.
- 5 Emergency Repairs:** Unforeseen issues or equipment failures can occur, leading to emergency repair situations. Welding provides a rapid and effective solution for on-the-spot repairs, minimizing downtime prolonged disruptions in plant operations.
- 6 Cost-Effective Maintenance:** Regular maintenance through welding is a cost-effective strategy compared to replacing entire pieces of equipment. Welding allows for targeted repairs, extending the life of existing structures and reducing the financial burden associated with frequent equipment replacements.
- 7 Safety Compliance:** Ensuring the safety of plant personnel and surrounding communities is a top priority in the chemical industry. Welding helps maintain equipment integrity, reducing the risk of accidents, leaks, and other potential hazards that could compromise safety standards.

8 Quality Assurance: Welding processes undergo stringent quality control measures to meet industry standards. Properly executed welds contribute to the reliability and performance of chemical equipment, providing assurance that the repairs will withstand the operational demands of the plant.

In summary, welding is indispensable in the maintenance of chemical plants and equipment, addressing structural issues, preventing leaks, managing corrosion, facilitating modifications, and contributing to overall safety and efficiency in plant operations.

Welding terms & their definition

Objectives: At the end of this lesson you shall be able to

- state the terms and definitions of welding.

- 1 Butt Weld:** joining of two pieces placed in 180° (surface level) & the welding performed is called as Butt weld.
- 2 Fillet weld:** joining of two pieces placed in 90° (surface level / one surface & another edge surface/both edge surface) & the welding performed is called as fillet weld.
- 3 Weld reinforcement:** the material which is above the place surface/mitter surface is called as weld reinforcement.
- 4 Miter line:** the straight line which is bisecting two toe points is known as miter line.
- 5 Toe of weld:** the point at which the weld reinforcement is resting on base metal surface is known as toe point.
- 6 Toe Line:** the line on which the weld reinforcement is resting on base metal surface.
- 7 Concave bead:** the weld metal below the miter line is known as concave bead.
- 8 Convex bead:** the weld metal above the miter line is known as convex bead.
- 9 Miter bead:** If the weld bead is up to the level of miter line it is known as miter bead.
- 10 Gas welding torch:** A device which is used for mixing, carrying, flow control and flame igniting of gases is known as gas welding torch.
- 11 Gas cutting torch:** A device which is used for mixing, carrying, flow control and flame igniting of gases is known as gas cutting torch.
- 12 Gas pressure regulator:** A device which monitors content of gas pressure in cylinder and regulates drawing/working gas pressure.
- 13 Gas Rubber hose pipe:** A rubber hose which carries gases from gas pressure regulators and supplies to gas welding/cutting torches.
- 14 Back fire:** If gas flame is snapped out due to wrong gas pressure setting is known as back fire.
- 15 Flash back:** When the gas flame is snapped out and starts reverse burning towards cylinder with hissing sound which is very hazardous is known as flash back,
- 16 Flash back arrestor:** Sometimes during backfire, the flame goes off and the burning acetylene gas travels backward in the blowpipe, towards the regulator or cylinder. At the time in between the device which has to be arrested the backfire.
- 17 Electrode holder:** A device by which electricity provided by cable will be carried to the electrode and which holds the electrode in desired angles. (This device is available with different capacities and type i.e. 300 Amps, 400 Amps and 600 Amps partly, semi and fully insulated).
- 18 Earth clamp:** A device by which electricity will carry provided by cable will be carried to the job table. (This device is available with different capacities and type i.e. 300 Amps, 400 Amps and 600 Ams. It is prepared by brass casting, G.I. Coated in spring or fixed form.
- 19 Arc welding cable:** This is made of copper/aluminium strands to carry electricity from welding machine to electrode holder and earth cable.
- 20 Cable Lug:** This is available with different capacities and type i.e. 300Amps, 400Amps and 600Amps. This is preferably made of copper metal.
- 21 SMAW:** Shielded Metal Arc Welding. Also known as manual metal arc welding and stick welding. (In this process the electrode is consumable).
- 22 GMAW:** Gas Metal Arc welding covers CO₂ welding (MAG), metal inter gas arc welding (MIG) & flux cored arc welding. (In these processes the electrode is consumable).
- 23 GTAW:** Gas Tungsten Arc welding. (In this process the electrode is consumable).
- 24 FCAW:** Flux cored Arc welding. Flux cored arc welding. (In the process the electrode is consumable).
- 25 Electrode (Flux coated)** A metal stick which is coated with flux and having parts indicated as stub end, tip, bare/core wire and flux coating. The size of this is determined by size of bare/core wire diameter. (This is used in shielded Metal Arc welding as consumable material).

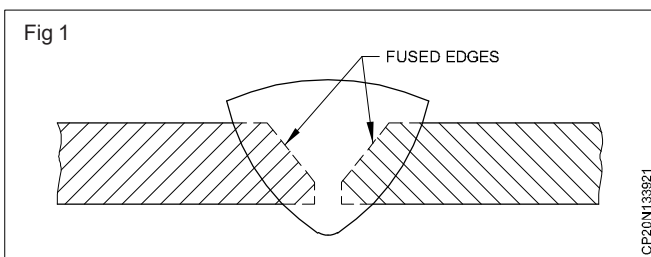
Types of welding

Objectives : At the end of this lesson you shall be able to

- state what is welding
- list the different types of welding and its uses.

Fusion welding (Fig 1)

Welding is a fabrication process where by two or more parts are fused together by means of heat pressure or both forming a join as the parts cool. Welding is usually used on metals and thermoplastics but can also be used on wood. The completed welded joint may be referred to as a weldment welding process.



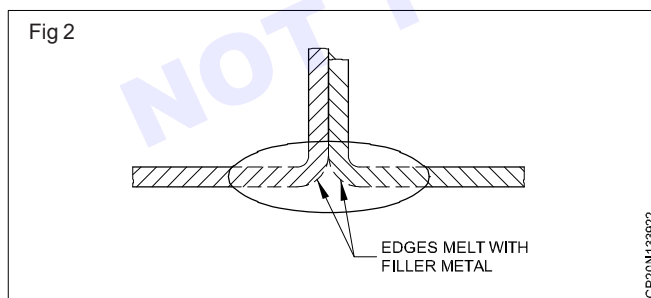
A method of welding in which similar metals are joined together by melting and fusing their joining edges with or without the addition of filler metal but without the application of any kind of pressure is known as fusion welding. The joint made is permanent. The common heating sources are arc welding and gas welding.

Non fusion welding

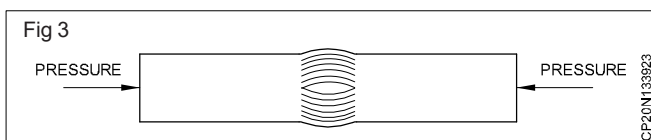
A method of welding in which similar or dissimilar metals are joined together without melting the edges is known as non - fusion welding. A low melting point filler rod is fused between the joints without the application of pressure (Fig 2) the joint made is temporary

The heat source may be arc, gas welding.

Examples of non - fusion welding are silver soldering, brazing etc.



Pressure welding (Fig 3)



Pressure welding is a method of welding in which similar metals are joined together by heating them to plastic or molten state and are then joined by pressing or hammering without the use of the filler metal.

The joint made is permanent

The heat source may be a blacksmith forge (forge welding) or electric resistance (resistance welding).

Types of welding

There are many type welding the process differs greatly in the manner in which heat and pressure are applied and the type of equipment used.

They are

- Forge welding
- Shield metal ARC welding
- Carbon ARC welding
- Submerged ARC welding
- Co₂ welding (gas metal ARC welding)
- TIG welding (gas tungsten ARC welding)
- Atomic hydrogen welding
- Electro slag welding
- Plasma ARC welding
- Spot welding
- Seam welding
- Projection welding
- Butt welding
- Electron beam welding
- Laser welding
- MIG welding (Metal insert gas welding).

Applications of various welding processes

Forge welding : It is used in olden days for joining metals as a lap and butt joint.

Shielded Metal arc welding is used for welding all ferrous and non-ferrous metals using consumable stick electrodes.

Carbon arc welding is used for welding all ferrous and non-ferrous metals using carbon electrodes and separate filler metal. But this is a slow welding process and so not used now-a-days.

Submerged arc welding is used for welding ferrous metals, thicker plates and for more production.

Co₂ welding (Gas Metal Arc Welding) is used for welding ferrous metals using continuously fed filler wire and shielding the weld metal and the arc by carbon-di-oxide gas.

TIG welding (Gas Tungsten Arc Welding) is used for welding ferrous metals, stainless steel, aluminium and thin sheet metal welding.

Atomic hydrogen welding is used for welding all ferrous and non-ferrous metals and the arc has a higher temperature than other arc welding processes.

Electro slag welding is used for welding very thick steel plates in one pass using the resistance property of the flux material.

Plasma arc welding: The arc has a very deep penetrating ability into the metals welded and also the fusion is taking place in a very narrow zone of the joint.

Spot welding is used for welding thin sheet metal as a lap joint in small spots by using the resistance property of the metals being welded.

Seam welding is used for welding thin sheets similar to spot welding. But the adjacent weld spots will be overlapping each other to get a continuous weld seam.

Projection welding is used to weld two plates one over the other on their surfaces instead of the edges by making projection on one plate and pressing it over the other flat surface. Each projection acts as a spot weld during welding.

Butt welding is used to join the ends of two heavy section rods/blocks together to lengthen it using the resistance property of the rods under contact.

Flash butt welding is used to join heavy sections of rods/blocks similar to butt welding except that arc flashes are produced at the joining ends to melt them before applying heavy pressure to join them.

Electron beam welding used aerospace, nuclear power and automotive industry

Laser beam welding used in automotive industry.

MIG welding is suitable for both thick and thin sheets.

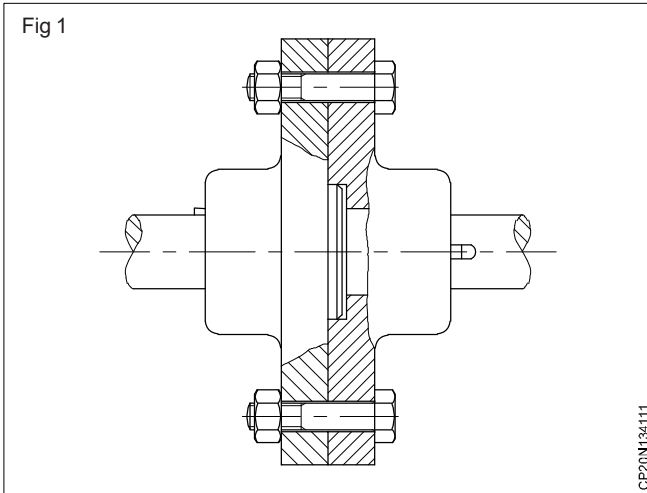
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Metal joining method

Objectives: At the end of this lesson you shall be able to

- identify the different types of bolts and nuts and their uses
- identify the types of reverts and its uses
- explain soldering and brazing methods.

Bolts and nuts (Fig 1)

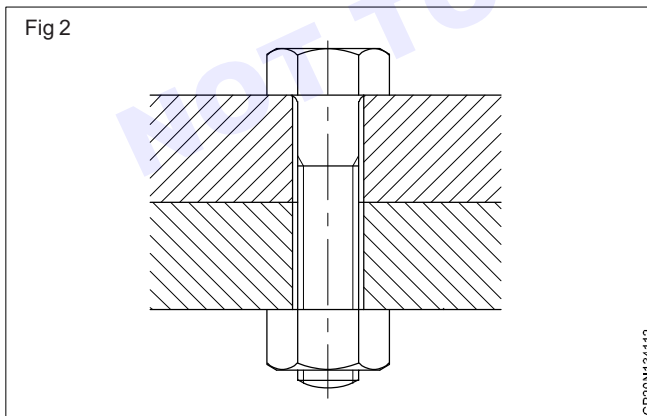


These are generally used to clamp two parts together.

When bolts and nuts are used, if the thread is stripped, a new bolt and nut can be used. But in the case of a screw directly fitted in the component, when threads are damaged, the component may need extensive repair or replacement.

Depending on the type of application, different types of bolts are used.

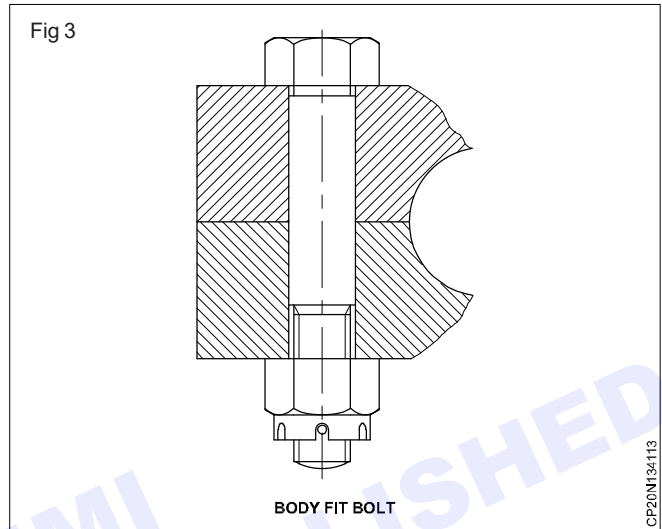
Bolts with clearance hole (Fig 2)



This is the most common type of fastening arrangement using bolts. The size of the hole is slightly larger than the bolt (Clearance hole).

Slight misalignment in the matching hole will not affect the assembly.

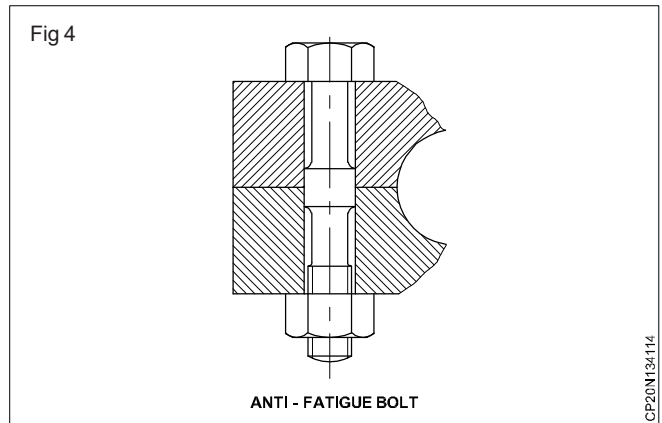
Body fit bolt (Fig 3)



This type of bolt assembly is used when the relative movement between the work pieces has to be prevented. The diameter of the threaded portion is slightly smaller than the shank diameter of the bolt.

The bolt shank and the hole are accurately machined for achieving perfect mating.

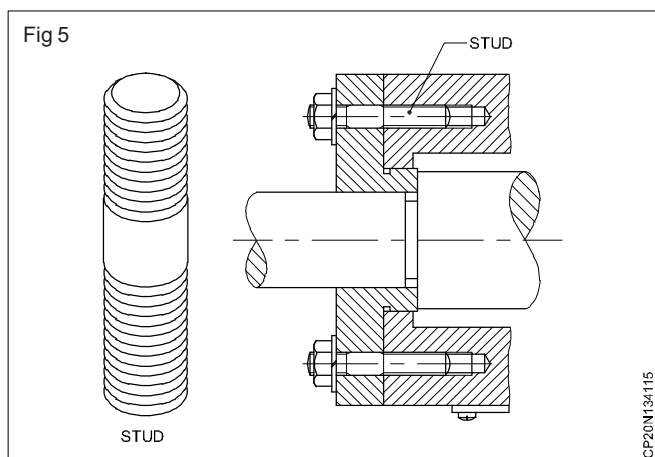
Anti-fatigue bolt (Fig 4)



This type of bolt is used when the assembly is subjected to alternating load conditions continuously. Connecting rod with big ends in engine assembly are examples of this application.

The shank diameter is in contact with the hole in a few places and other portions are relieved to give clearances.

Studs (Fig 5)



Studs are used in assemblies which are to be separated frequently.

When excessively tightened, the variation in the thread pitch allows the fine thread or nut end to strip. This prevents damage to the casting.

Designation of bolts as per B.I.S. specifications

Hexagonal head bolts shall be designated by name, thread size, nominal length, property class and number of the Indian Standard.

Example

A hexagonal head bolt of size M10, nominal length 60mm and property class 4.8 shall be designated as:

Hexagonal head bolt M10 60 - 4.8 - IS: 1363 (Part)

Explanation about property class.

The part of the specification 4.8 indicates the property class (mechanical properties). In this case it is made of steel with minimum tensile strength - 40 kgf/mm² and having a ratio of minimum yield stress to minimum tensile strength = 0.8.

NOTE

Indian standard bolts and screws are made of three product grades - A, B, & C and 'A' being precision and the others, of lesser grades of accuracy and finish.

While there are many parameters given in the B.I.S. Specification, the designation need not cover all the aspects and it actually depends on the functional requirement of the bolt or other threaded fasteners.

Rivets are used to join together two or more sheets of metal permanently. In sheet metal work riveting is done where;

- brazing is not suitable,
- the structure changes owing to welding heat,
- the distortion due to welding cannot be easily removed etc.

Specification of rivets

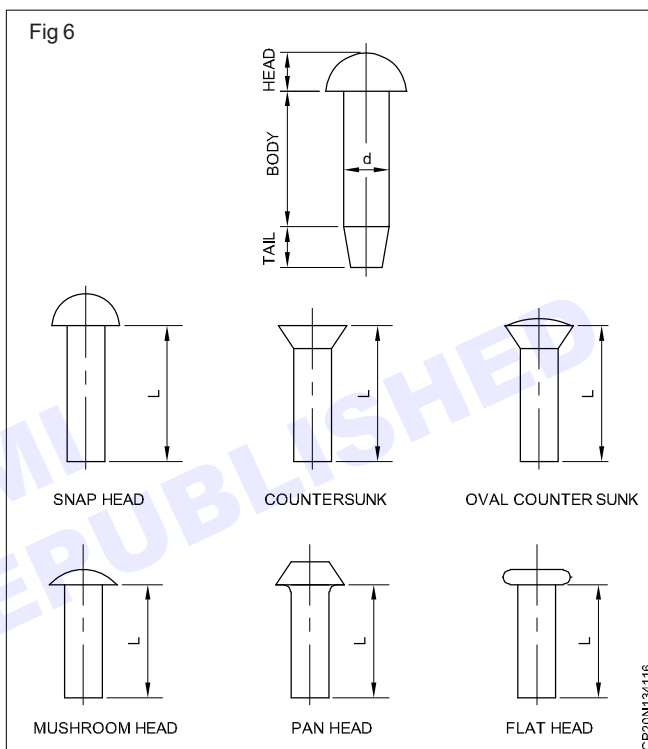
Rivets are specified by their length, material, size and shape of head.

Rivets

There are various kinds of rivets as shown in Fig 1. Snap head rivets, countersink rivets and thin bevel head rivets are widely used in sheet metal work.

The materials used for rivets are mild steel, copper yellow brass, aluminium and heir alloys.

The length of the rivets 'L' is indicated by the shank length. (Fig 6)



Rivet joints (Fig 7)

Rivet joints are classified as lap joints and butt joints.

In the case of butt joints, a plate called a butt strap is used.

Rivet interference

The length required to form the head in riveting is called rivet interference.

When forming a round head (Fig 8) the interference X is given as

$$X = d \times (1.3, \text{ -- } 1.6)$$

where = rivet interference(mm)

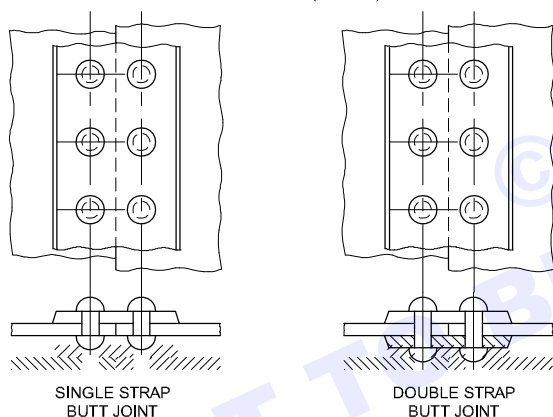
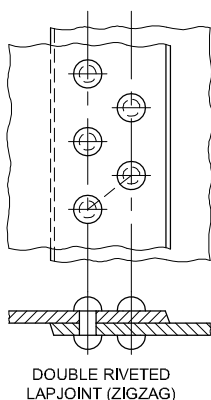
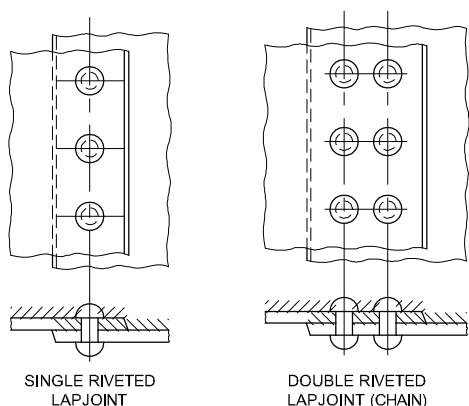
d = rivet diameter (mm)

Therefore, the length of the rivet (L mm) to form a round head when the total thickness of the piled plates is T mm will be, as given below.

$$L = T + d (1.3 - 1.6)$$

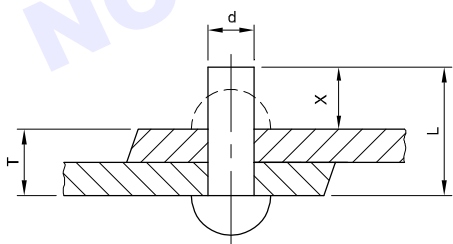
When forming a flat head (Fig 9) the length of the rivet (L'mm) will be as given below.

Fig 7



CP20N134117

Fig 8



CP20N134118

$$L' = T + d (0.8 - 1.2)$$

When the appropriate values of the rivet diameter and the length for the plate thickness are found out, choose the rivets with the standard size close to the calculated values.

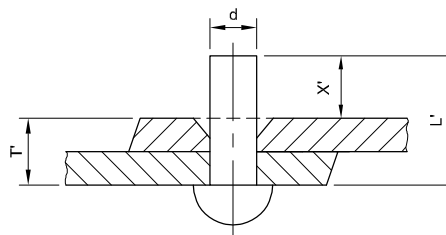
Soldering

Soldering method: There are different methods of joining metallic sheets. Soldering is one of them.

Soldering is the process by which metals are joined with the help of another alloy called solder without heating the

base metal to be joined. The melting point of the solder is lower than that of the materials being joined.

Fig 9



CP20N134119

The molten solder wets the base material which helps in binding the base metal to form a joint.

Soldering should not be done on joints subjected to heat and vibration and where more strength is required.

Soldering can be classified as soft soldering and hard soldering. Hard soldering is further divided as (a) brazing (b) silver brazing.

The process of joining metals using tin and lead as a soldering alloy which melts below 420°C is known as soft soldering.

The process of joining metals using copper, zinc and tin alloy as filler material in which the base metal is heated above 420°C below 850°C is called brazing.

Silver brazing is similar to brazing except that the filler material used is a silver-copper alloy and the flux used is also different.

Brazing: Brazing is a metal joining process which is done at a temperature of above 450°C as compared to soldering which is done at below 450°C

So brazing is a process in which the following steps are followed.

- Clean the area of the joint thoroughly by wire brushing, emerging and by chemical solutions for removing oil, grease, paints etc.
- Fit the joints tightly using proper clamping. (Maximum gap permitted between the two joining surfaces is only 0.08 mm)
- Apply the flux in paste form (for brazing iron and steel a mixture of 75% borax powder with 25% boric acid (liquid form) to form a paste is used). Usually the brazing flux contains chlorides, fluorides, borax, borates, fluoroborates, boric acid, wetting agents and water. So suitable flux combination is selected based on metal being used.

Brazing is employed where a ductile joints is required.

Brazing filler rods/ metals melt at temperature from 860°C to 950°C and are used to braze iron and its alloys.

Brazing fluxes: Fused borax is the general purpose flux for most metals.

Advantages of brazing

The completed joint requires little or no finishing.

The relatively low temperature at which the joint made minimizes distortion.

There is no flash or weld spatter.

The brazing technique does not require as much skill as the technique for fusion welding.

The process can be easily mechanised.

The process is economical owing to the above advantages.

Disadvantages of brazing

If the joint is exposed to corrosive media, the filler metal used may not have the required corrosive resistance.

All the brazing alloys lose strength at an elevated temperature

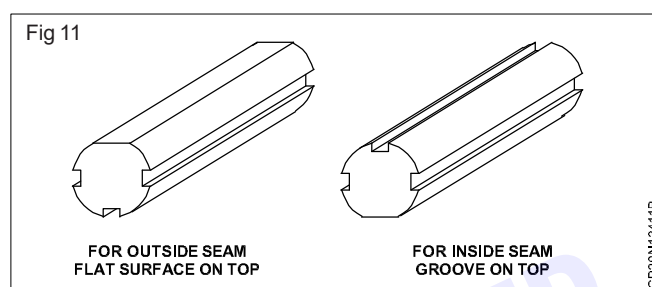
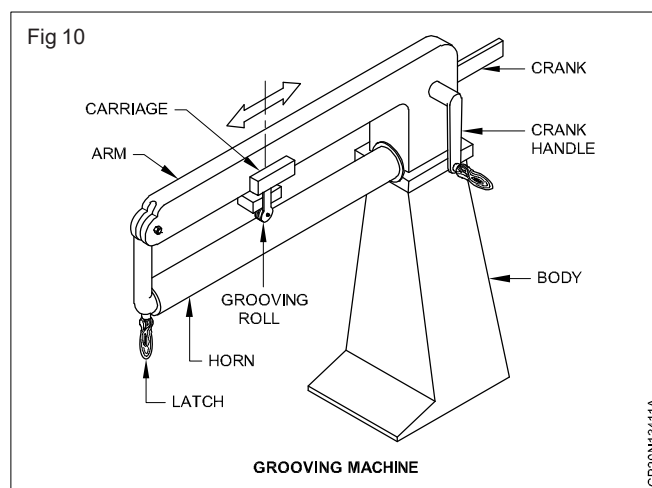
The colour of the brazing alloy which ranges from silver white to copper red may not match the base metal very closely.

Seaming and Machine

Grooved seam can also be closed or locked mechanically by means of the seam closing machine. This machine is also called "Seaming machine"

Parts shown in Fig 10 are Body, Arm, Pressure roller, Carriage, Crank handle, Latch and Crank rack.

Horn: It contains grooves of various widths on throughout the length as shown in Fig 11.



Pressure roller: Two types of pressure rollers are available along with the machine. One is flat roller and the other is grooved one. Grooved roller is having grooves of 3 mm, 4 mm, 5 mm and 6 mm widths.

Sheet metal seams

Objectives: At the end of this lesson you shall be able to

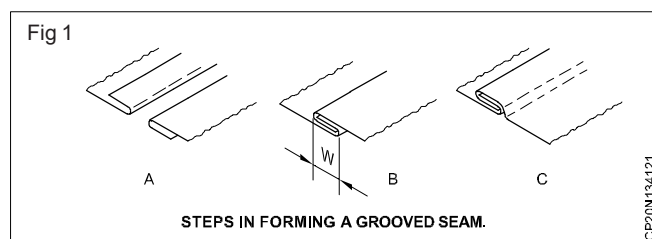
- state the types of seams.

Introduction

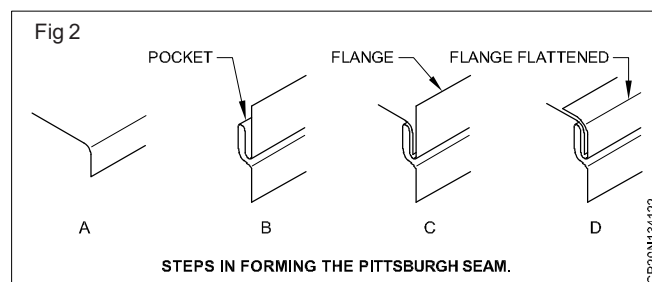
In Sheet metal construction, mechanical seams are employed when joining light and medium gauge metal sheets. While fabricating sheet metal articles, the sheet metal worker should be able to select the type of seam that is best suited for the specific job.

Types of seams

- Grooved seam :** Grooved seam is most commonly used for joining sheet metal. This seam consists of two folded edges called locks as shown in Fig 1. The edges are hooked together and locked with a hand groove or a grooving machine.



- Pittsburgh seam:** This seam is also called hammer lock or hobo lock. This seam is used as a longitudinal corner seam for various types of pipes such as duct work. The single lock is placed in a pocket lock and then the flange is hammered over, step by step as shown in Fig 2.



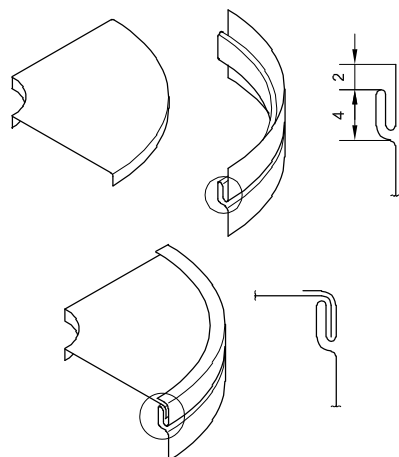
The advantage of the Pittsburgh seam is that the single lock can be turned on a curve and the pocket lock can be formed on a flat sheet and rolled to fit the curve as shown in Fig 3. If roll forming machine is not available in shop, Pittsburgh seam is formed on the brake.

- Dovetail seam :** This seam is an easy and convenient method of joining flanges to collars. There are three types of dovetail seams - plain dovetail, beaded dovetail and the flange dovetail as shown in Fig 4.

Dovetail seams are used mainly on round or elliptical pipe and rarely on rectangular ducts.

- Plain dovetail seam :** It is used when joining a collar to a flange without the use of solder, screws or rivet. It is made by slitting the end of the collar and bending every other tab as shown in Fig 5.

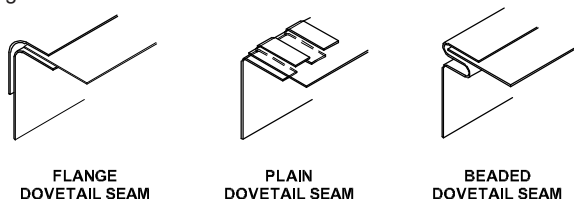
Fig 3



PITTSBURGH SEAMS CAN BE FORMED ON CURVES.

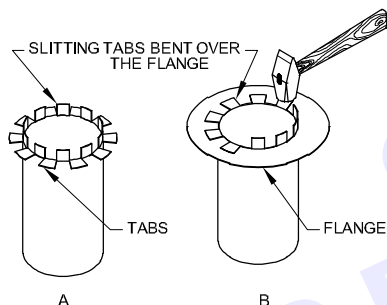
CP20N134123

Fig 4



CP20N134124

Fig 5



PLAIN DOVETAIL SEAM.

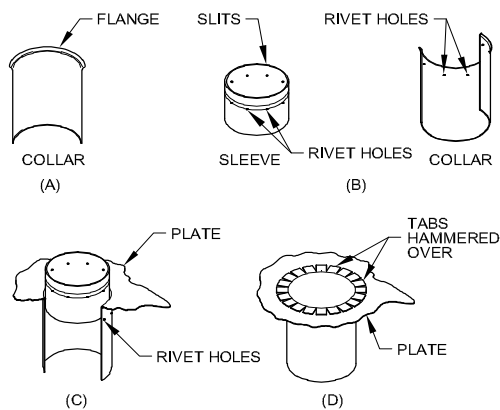
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The straight tabs are bent over the part to be joined and the bent tabs act as stops. This seam may be made water tight by soldering around the joint.

B Flange dovetail seam : This seam is used where neat appearance and strength are important. The seam shown in Fig 6 is the assembly of a flange type dovetail seam for a cylindrical pipe. It is commonly used where pipes intersect with a metal plate such as furnace flues, ceilings etc. Steps in forming a flange dovetail seam are shown in Fig 6. First, a flange is turned on the collar, next, slits are cut at regular intervals at the end of the sleeve and matching rivet holes are drilled in the sleeve and the collar. The rivet holes are aligned and the rivets are installed and finally the tabs are hammered over to complete the seam.

C Beaded dovetail seam : This is similar to the plain dovetail seam, except a bead is formed around one end of the cylinder by a beading machine. This bead acts as the stop for the flange to rest upon and the tabs are bent over to hold the flange in the desired place.

Fig 6

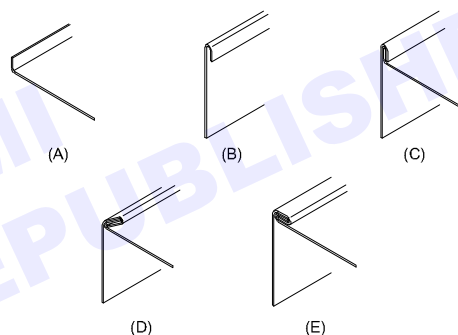


STEPS IN FORMING A FLANGE DOVETAIL SEAM.

CP20N134126

4 Double seam : There are two types of double seams. One type is used for making irregular fittings such as square elbows, boxes, offsets, etc. This seam is used on corners and can also be used as a longitudinal seam on small square and rectangular ducts. A double edge is formed and placed over the single edge and the seam is completed step by step as shown in Fig 7.

Fig 7



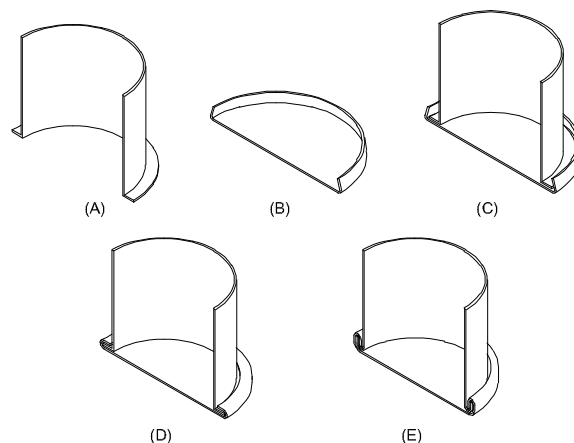
MAKING A DOUBLE SEAM.

CP20N134127

The other type is used to fasten bottoms to cylindrically shaped jobs such as pails, tanks etc.

The steps in making this type of double seam is shown in Fig 8, where A is turned on the machine. B is burred

Fig 8



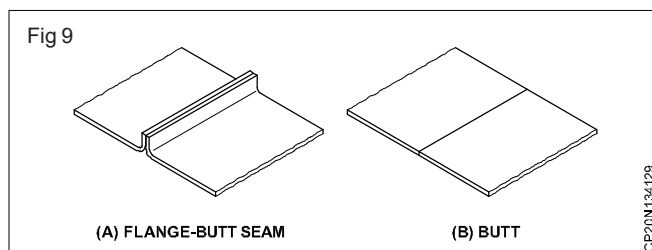
STEPS IN MAKING A BOTTOM DOUBLE SEAM.

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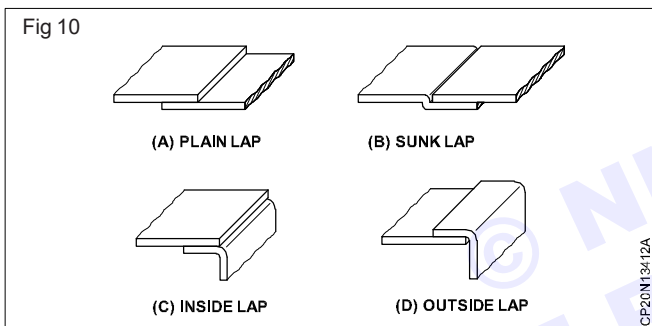
on the burring machine. The bottom is snapped on the body as in C and is peened down as in D. Finally the seam is completed by using a mallet as in E. This seam is called Bottom double seam or Knocked up seam.

If the seam is not turned up, as in D, the seam is called paned down seam.

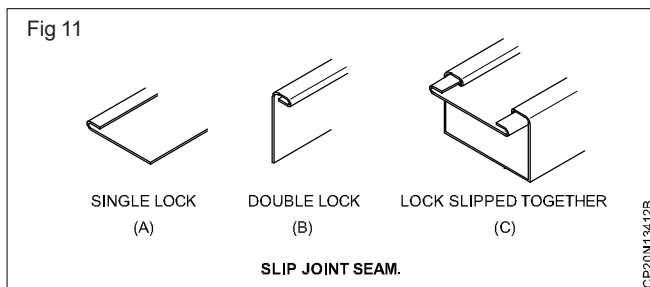
- 5 Butt seam :** This seam has two pieces butt together and soldered as shown in Fig 9. Figure shows two types of butt seams. One is flanged butt seam and the other one is butt seam.



- 6 Lap seam :** The lap seam is made by lapping the edge of one piece over the other piece and soldered as shown in Fig 10. Figure shows plain lap, sunk lap, inside lap and outside lap seams.

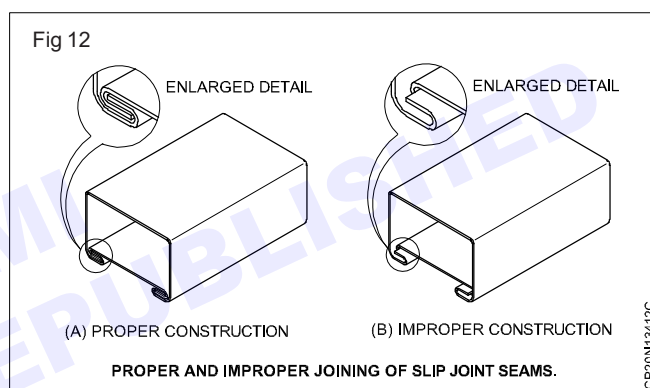


- 7 Slip joint seam :** This seam is used for a longitudinal corner seam as shown in Fig 11.



The assembly of the seam consists of a single lock A and a double lock B. The single lock is slipped into the double lock C to complete the seam.

For making pipes with a slip joint seam, proper care should be taken to see that the corners of the metal are squared and the edges are trimmed. The proper slip joint is shown as A and improper as B in Fig 12. If the edges are not trimmed, it will twist the pipe out of shape and may cause the edges of the pipe to be uneven.



Safety & general precautions

Objectives: At the end of this lesson you shall be able to

- **state the importance of safety in welding shop**
- **list the general safety precautions to be observed in welding shop.**

Principle of gas welding

Gas welding, also known as oxy-fuel welding, is a process that involves using a flame produced by the combustion of a fuel gas mixed with oxygen to melt and join metals. The principle of gas welding is based on the controlled combination of oxygen and a fuel gas, such as acetylene, propane, or natural gas, in order to create a high-temperature flame.

The process involves

- 1 **Combustion:** The fuel gas and oxygen are mixed in specific proportions to create a flame with a high temperature. The oxygen supports the combustion of the fuel gas, creating a hot flame capable of melting the metal.
- 2 **Preheating:** The workpiece is heated to a temperature slightly below its melting point using the outer flame envelope. This makes the metal more malleable and easier to work with.
- 3 **Welding:** A filler metal may be added to create a bond between the two pieces of metal being joined. The filler metal melts and fuses with the base metals, forming a strong joint when it solidifies.
- 4 **Controlled cooling:** After the welding is complete, the workpiece is allowed to cool gradually, which helps to prevent cracking and distortion.

Gas welding is versatile and can be used on various metals, but it has become less common in industrial applications due to the rise of more efficient welding methods such as electric arc welding. However, it is still used in some specialized applications and for artistic welding due to its level of control and precision.

Safety precautions before, after, and during gas welding

Safety is paramount when working with gas welding. Here are some essential safety precautions to follow before, during, and after gas welding.

Before Gas Welding

- 1 **Training:** Ensure that you and anyone involved in the welding process have received proper training in gas welding techniques, equipment operation, and safety procedures.
- 2 **Appropriate Location:** Choose a well-ventilated and properly lit area for welding. Avoid welding in confined spaces or areas with flammable materials.
- 3 **Protective Gear:** Wear appropriate personal protective equipment (PPE) including welding gloves, flame-

resistant clothing, a welding helmet with the correct shade lens, and safety goggles.

- 4 **Fire Safety:** Keep a fire extinguisher nearby and ensure that it's appropriate for extinguishing flammable metal fires. Make sure you know how to use it.
- 5 **Clear Workspace:** Remove any flammable materials, debris, or clutter from the welding area to prevent fire hazards.
- 6 **Gas Cylinder Storage:** Store gas cylinders upright and secure them to prevent falling. Store them away from heat sources and direct sunlight.

During Gas Welding

- 1 **Ventilation:** Maintain proper ventilation to ensure that any potentially harmful fumes or gases are effectively removed from the work area.
- 2 **Gas Leaks:** Regularly check for gas leaks using a leak detection solution. If you detect a leak, shut off the gas supply immediately and address the issue before resuming work.
- 3 **Flame Control:** Maintain proper flame control and avoid overheating. Adjust the torch flame appropriately for the material you are working with.
- 4 **Proper Ignition:** Use proper ignition procedures to light the torch. Never use matches or lighters; use appropriate spark igniters.
- 5 **Welding Position:** Maintain a stable and comfortable welding position to avoid unnecessary movements that could cause accidents.
- 6 **Personal Safety:** Be cautious of your surroundings and the positions of other individuals in the vicinity. Keep bystanders at a safe distance from the welding area.

After Gas Welding

- 1 **Cool Down:** Allow the welded metal to cool down before handling it. Hot metal can cause burns.
- 2 **Gas Cylinder Closure:** Close the cylinder valves and relieve any pressure in the regulator before disconnecting hoses.
- 3 **Secure Equipment:** Safely store all equipment, including hoses, regulators, torches, and cylinders, in their designated places.
- 4 **Inspect the Area:** After welding, inspect the area for any signs of fire, sparks, or smoldering materials. Ensure that the welding area is free from hazards.

- 5 **Gas Cylinder Storage:** Properly store and secure gas cylinders after use. Ensure that cylinder valves are fully closed.
- 6 **PPE Removal:** Only remove your PPE after ensuring that the equipment is properly stored, the area is safe, and all hazards have been addressed.

Following these safety precautions can help you minimize risks, prevent accidents, and create a safe working environment for gas welding. Always prioritize safety to protect yourself and those around you.

Safety precautions in handling oxy-acetylene gas welding plant

Objectives: At the end of this lesson you shall be able to

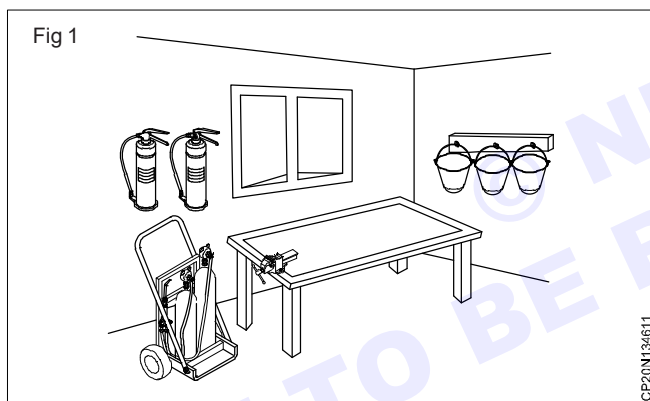
- state the general safety precautions to be observed while handling oxy-acetylene gas welding equipment.

To be accident free one must observe safety rules in day-to-day working. Accident starts when safety ends.

In gas welding, the welder must follow certain safety precautions while handling gas welding plants in order to prevent accidents to others and himself. Observing the following precautions will help the gas welder to avoid accidents to a great extent.

General safety precautions: Never use oil or grease in any part or assembly of a gas welding plant as it may cause an explosion.

All inflammable materials should be kept away from the welding area (Fig 1).



Always wear goggles with filter glasses during welding.

Wear fire-resistant clothes, asbestos gloves and an apron while welding (Fig 2).

Never wear nylon or greasy clothes while welding

Rectify the gas leakages noticed immediately as even a small leakage can lead to serious accidents.

Always keep fire extinguishing devices handy and in working order. (Fig 1)

While leaving the work area, make sure the place is free from any form of fire.

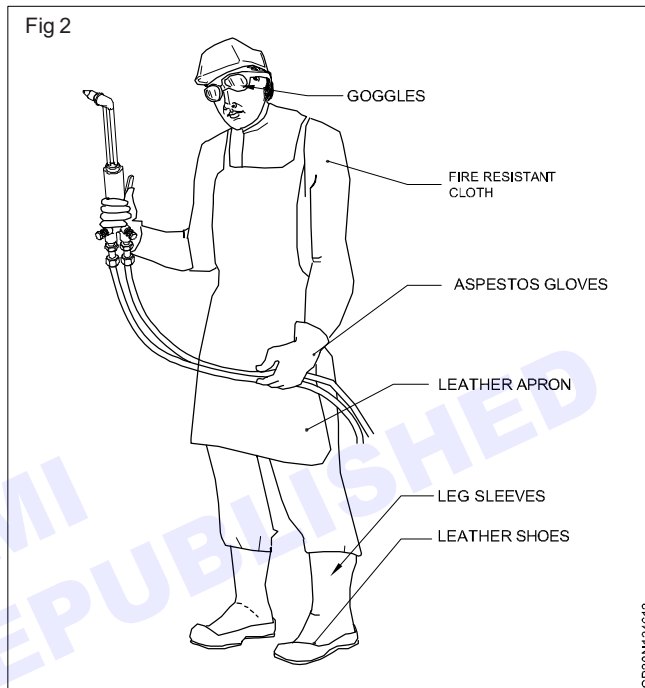
Safety concerning gas cylinders: Do not roll gas cylinders for shifting, always use a trolley to carry cylinders.

Do not drop the gas cylinders.

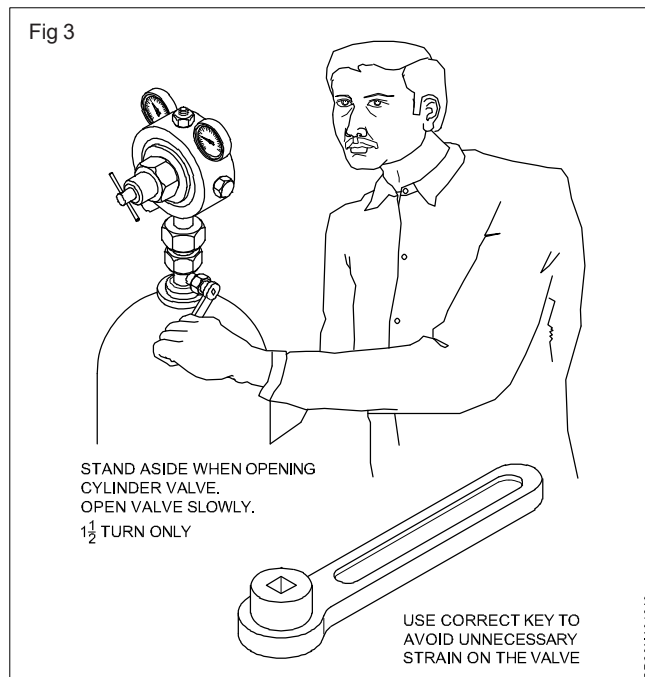
Close the cylinder valves when not in use or empty.

Keep the empty cylinders and full cylinders separately.

Always open the cylinder valves slowly and not more than one and a half turns.



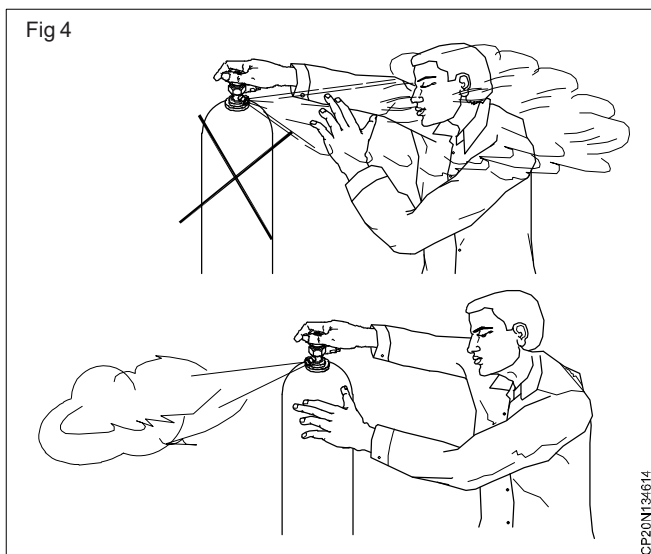
Use always the correct size cylinder keys (Fig 3).



Stand aside when opening the cylinders (Fig 4).

Do not remove the cylinder keys from the cylinders during welding. It will help to close the cylinders quickly in case of an emergency.

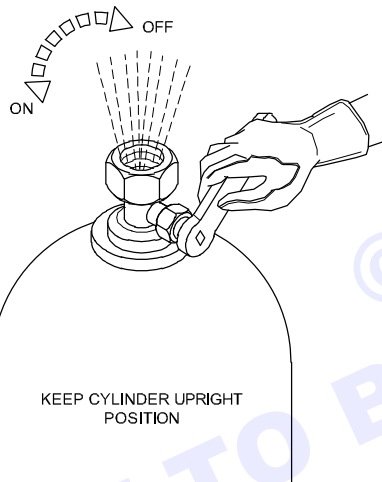
Fig 4



Always keep the cylinders in an upright position keeping in view safety and ease in handling (Fig 5)

Fig 5

BLOW OUT THE CYLINDER VALVE SOCKET BEFORE CONNECTING THE REGULATOR CRACKING OPEN THE CYLINDER VALVE MOMENTARILY



Always crack the cylinder valves to clean the valve socket before attaching the regulators.

Safety of rubber hose-pipes: Use only the type of hose recommended for use in gas welding.

Use only black coloured hoses for oxygen and maroon coloured ones for acetylene gas.

Avoid damage to the hose-pipes caused by rubbing against hard or sharp edges. (Fig 6)

Ensure that the hoses do not cross the gangways

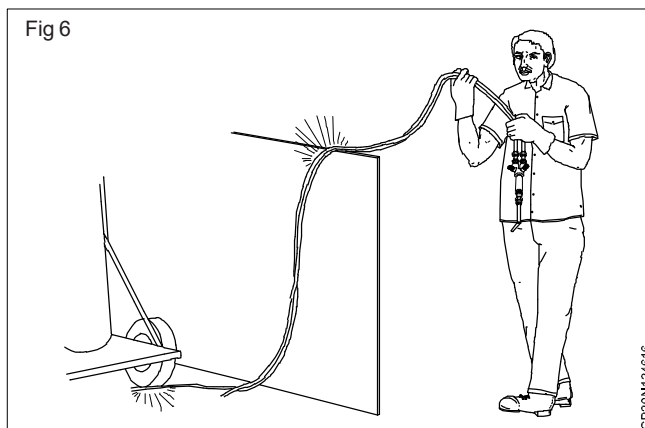
Do not add bits of hose together to make up the length.

Blowout the hose-pipes before connecting to the blowpipe to remove dirt or dust

Protect the regulators from water, dust, oil etc.

Never attempt to interchange oxygen and acetylene regulators while fitting as it can damage the threads.

Fig 6



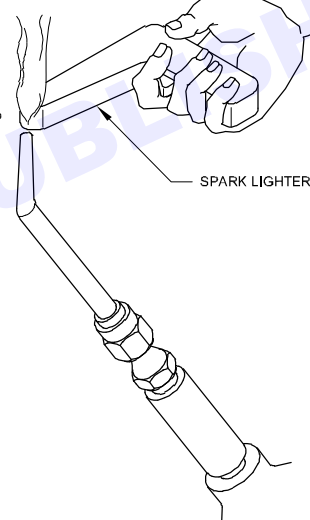
Always remember the oxygen connection is right- hand threaded and the acetylene connections have left hand threads.

In the event of backfire shut both the blowpipe valves (oxygen first) quickly and dip the blowpipe in water

While igniting the flame, point the blowpipe nozzle in a safe direction (Fig 7)

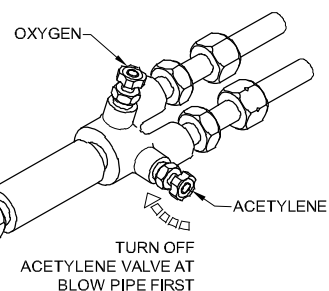
Fig 7

ACETYLENE BURNS USING OXYGEN IN THE ATMOSPHERIC AIR



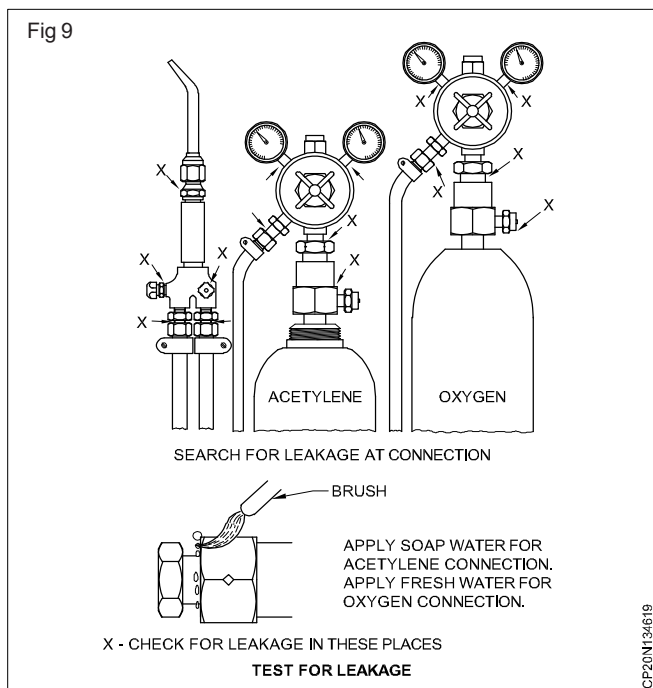
While extinguishing the flame, shut off the acetylene valve first and then the oxygen to avoid backfire (Fig 8)

Fig 8



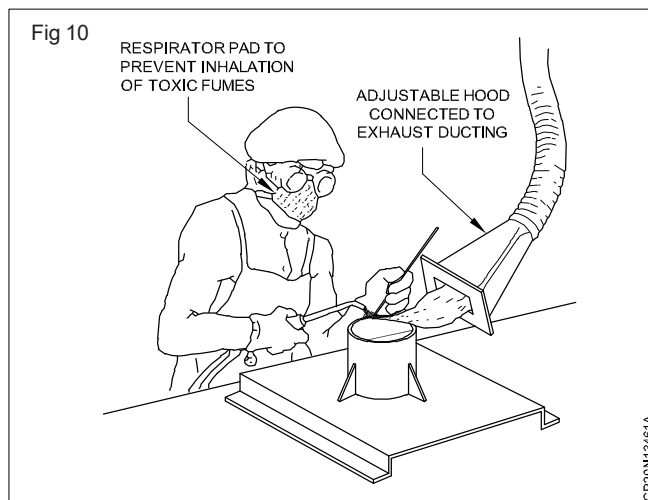
Check for leakage before using oxy-acetylene welding equipment. (Fig 9)

Use the spark lighter to ignite the flame to avoid fire hazards (Fig 7)



Toxic and poisonous fumes given out during welding of some materials should be collected and cleared so as to be prevented from inhaling. For this an exhaust ducting and a respirator are used. (Fig 10)

Containers used for the storage of flammable materials should not be welded without thorough cleaning as otherwise the containers may explode (Fig 11)



Flash back and backfire

Objectives: At the end of this lesson you shall be able to

- state the causes of backfire, flash back and their preventive methods.

Backfire: At certain times during flame ignition in gas welding, a small explosion of the flame occurs at the torch tip.

The flame may or may not go off. This is backfire.

Causes: A backfire is caused when

- the gas pressure setting is low
- the nozzle is overheated
- the nozzle orifice is blocked by carbon or spark deposit
- the nozzle touches the molten pool
- there is leakage near the nozzle.

Common gas used to welding

Objectives: At the end of this lesson you shall be able to

- name the different types of gases used for welding
- state the different types of gas flame combinations
- describe uses and applications of gas flames.

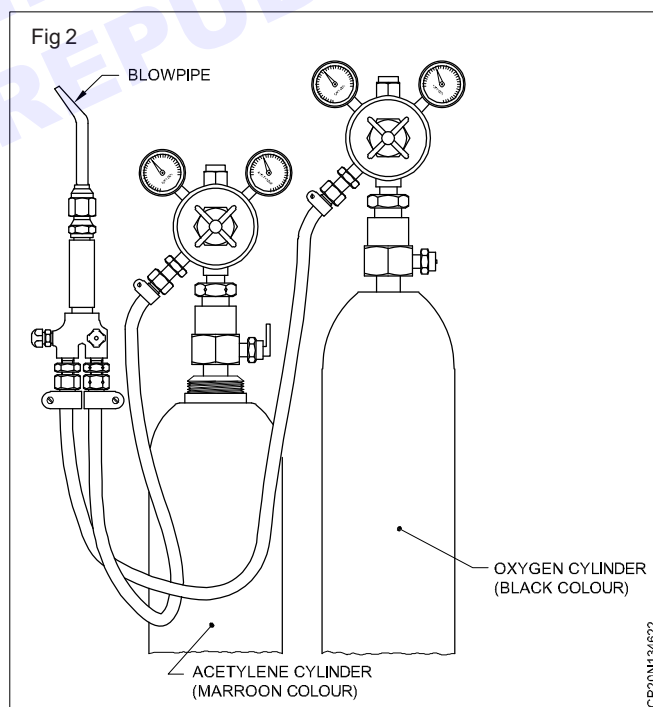
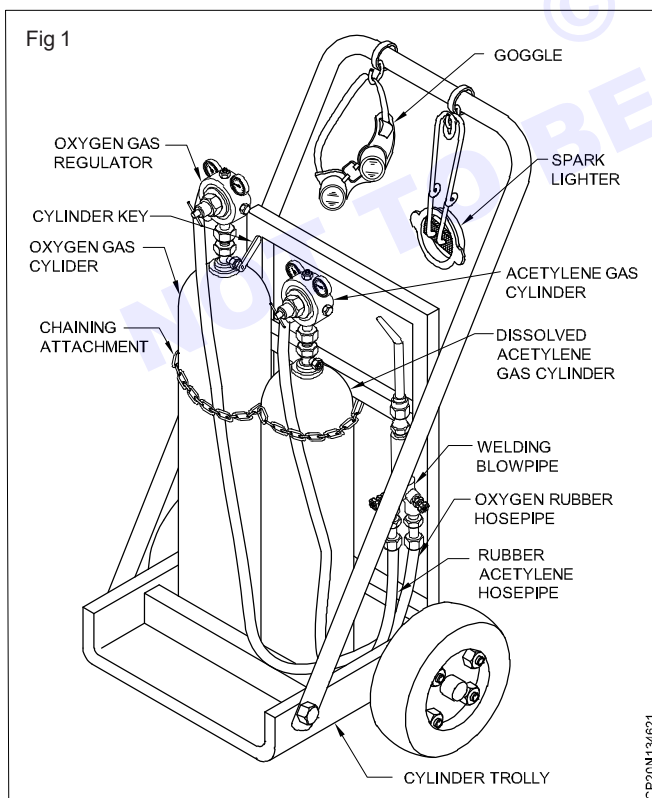
In the gas welding process, the welding heat is obtained from the combustion of fuel gases in the presence of a supporter of combustion (oxygen).

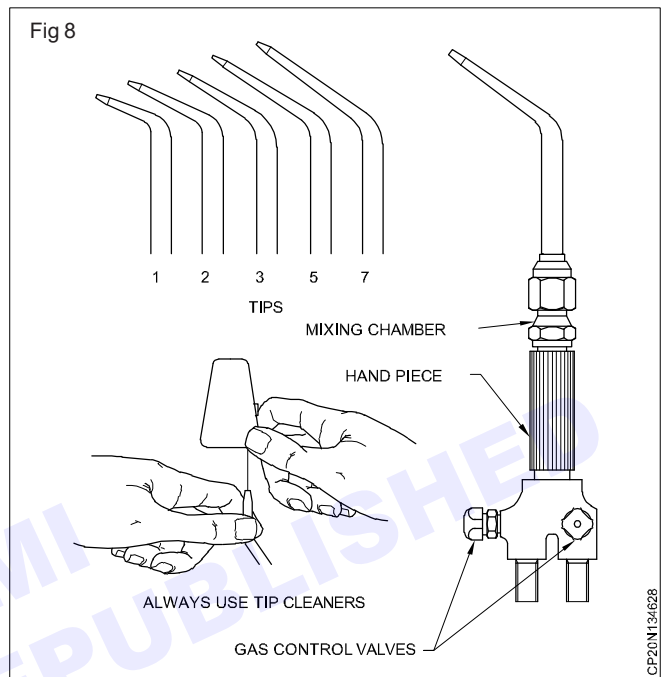
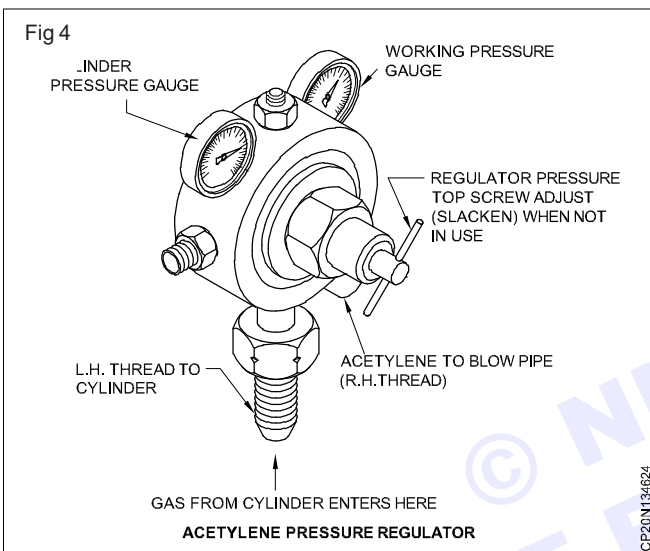
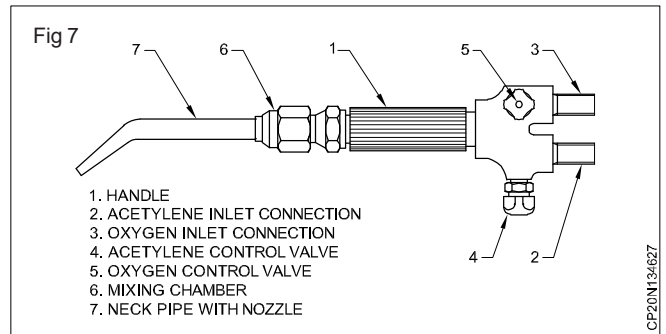
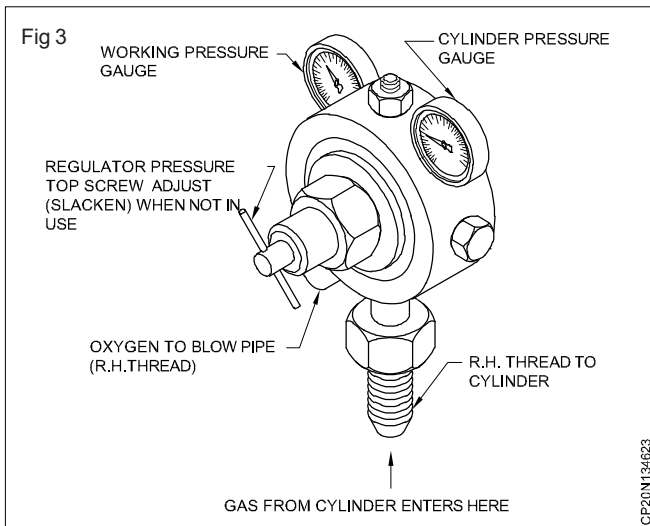
(Oxy-acetylene gas flame combination is used in most gas welding processes because of the high temperature and heat intensity)

Comparison of different gas flame combinations and their uses

Sl. No	Fuel gas	Supporter of combustion	Name of the gas flame	Temperature	Application/uses
1	Acetylene	Oxygen	Oxy-acetylene flame	3100 to 3300°C (Highest temperature)	To weld all ferrous and non-ferrous metals and their alloys; gas cutting & gouging of steel; brazing bronze welding; metal spraying and hard facing.
2	Hydrogen	Oxygen	Oxy-hydrogen flame	2400 to 2700°C (Medium temperature)	Only used for brazing, silver soldering and underwater gas cutting of steel.
3	Coal gas	Oxygen	Oxy-coal gas flame	1800 to 2200°C (Low temperature)	Used for silver soldering underwater gas cutting of steel.
4	Liquid petroleum gas (LPG)	Oxygen	Oxy-liquid petroleum gas flame	2700 to 2800°C (Medium temperature)	Used for gas cutting steel heating purposes. (Has moisture and carbon effect in the flame.)
5	Acetylene	Air	Air-acetylene flame	1825 to 1875°C (Low temperature)	Used only for soldering, brazing, heating purposes and lead burning.

Oxy-acetylene welding equipment and accessories

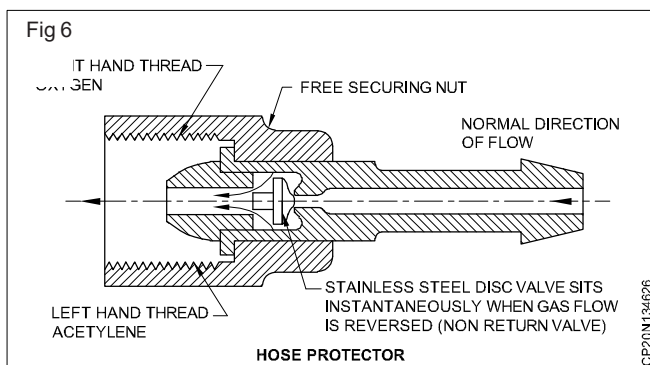
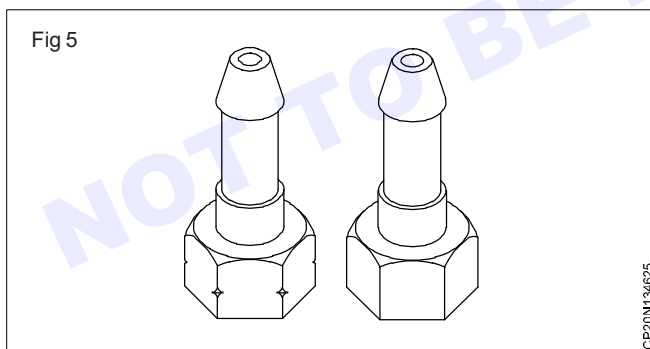




The size of the nozzle varies according to the thickness of the plates to be welded. (Table)

Table 1

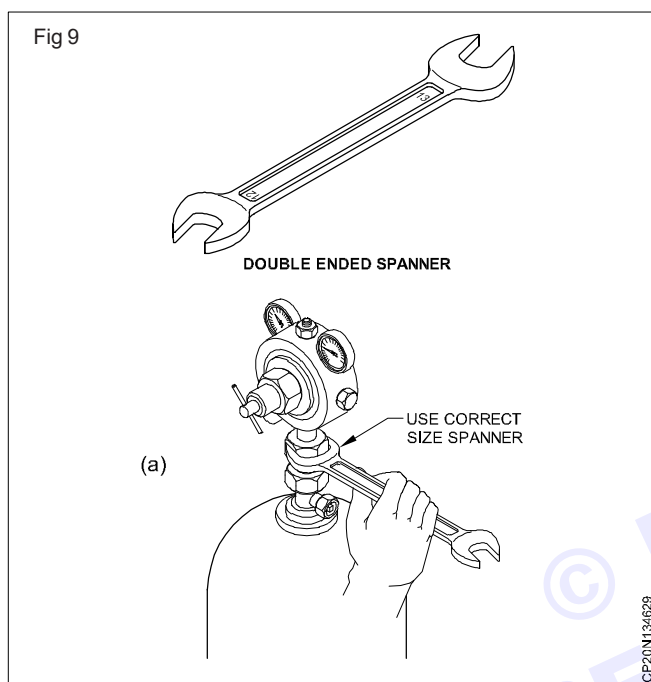
plate thickness	Nozzle size
mm	Number
0.8	1
1.2	2
1.6	3
2.4	5
3.0	7
4.0	10
5.0	13
6.0	18
8.0	25
10.0	35
12.0	45
19.0	55
25.0	70
Over 25.0	90



Gas welding hand tools

The following are the details of different hand tools used by a welder.

Double ended spanner: A double ended spanner is shown in Fig 9. It is made of forged chrome vanadium steel. It is used to loosen or tighten nuts, bolts with hexagonal or square heads. The size of the spanner is marked on it as shown in Fig 9. In welding practice, the spanners are used to fix the regulator onto the gas cylinder valves, hose connector and protector to the regulator and blow pipe, fix the cable lugs to the arc welding machine output terminals, etc.



Do not use any size of hammer; use the correct size of spanner to avoid damage to the nut/bolt head,

Cylinder Key: A cylinder key is shown in Fig 10. It is used to open or close the gas cylinder valve socket to permit or stop the gas flow from the cylinder to the regulator.

Always use correct size key to avoid damage to the square rod used to operate the valve. The key must always be left on the valve socket-itself so that the gas flow can be stopped immediately in case of flash back/back fire.

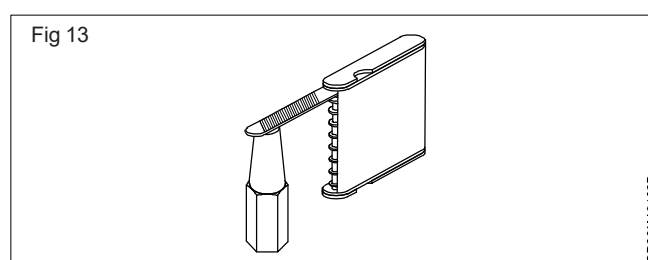
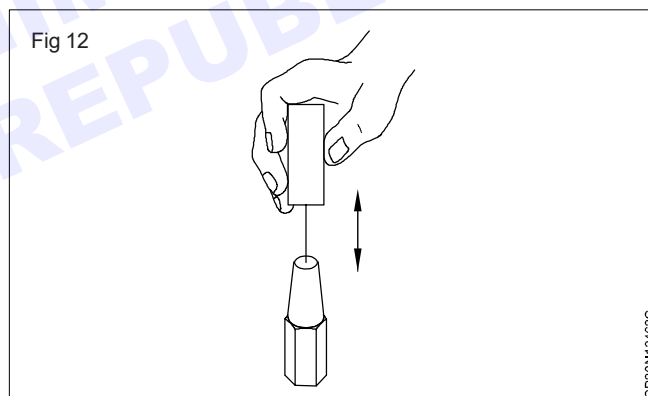
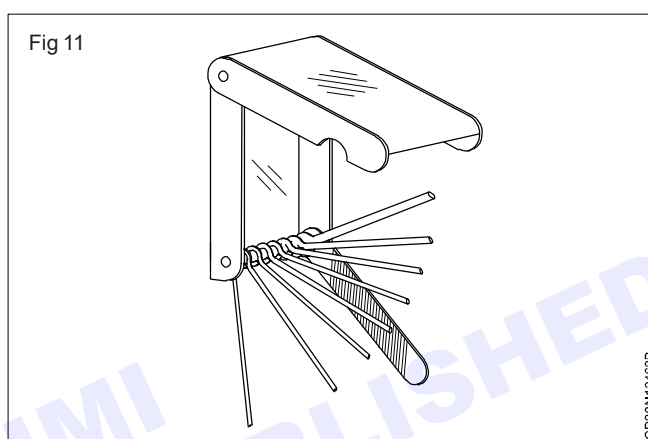
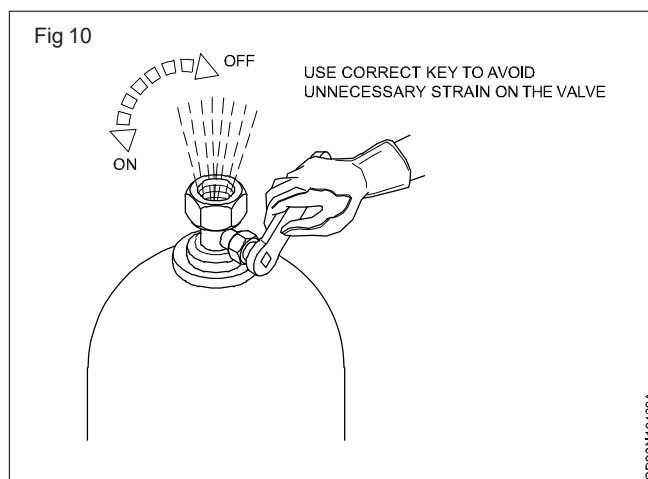
Nozzle or tip cleaner

Cleaning the tip: All welding torch tips are made of copper alloy. They can be damaged by the slightest rough handling. Dropping, tapping or chopping with the tip on the work may damage the tip beyond repair.

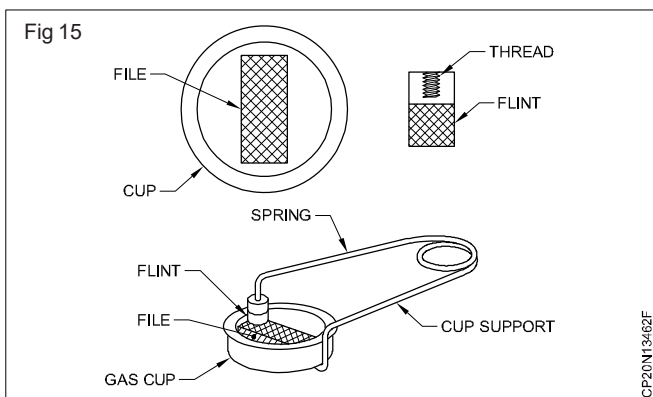
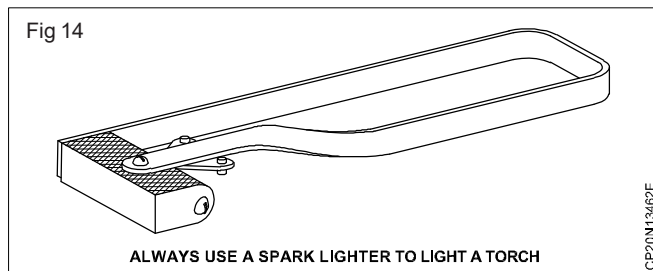
Tip cleaner: A Special tip cleaner is supplied with the torch container. For each tip there is a kind of drill and a smooth file. (Fig 11)

Before cleaning the tip, select the correct drill and move it, without turning, up and down through the tip Fig 12.

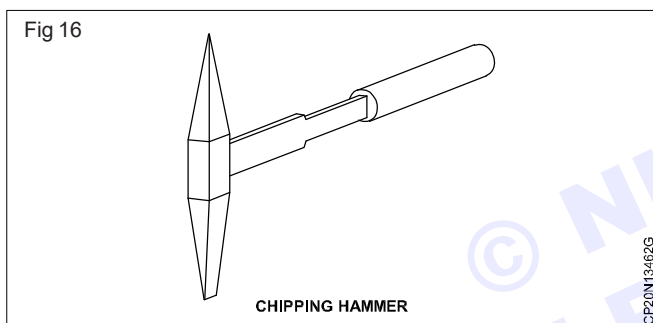
The smooth file is then used to clean the surface of the tip Fig 13. While cleaning, leave the oxygen valve partly open to blow out the dust.



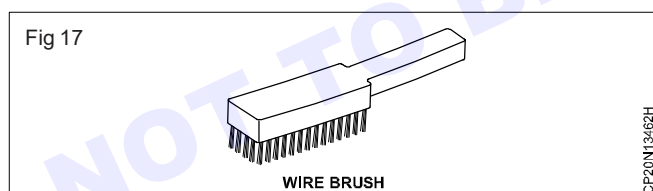
Spark lighter : The spark lighter, as illustrated in Fig 14 & 15 is used for igniting the torch. While welding, form the habit of always employing a spark lighter to light a torch. Never use matches. The use of matches for this purpose is very dangerous because the puff of the flame produced by the ignition of the acetylene flowing from the tip is likely to burn your hand.



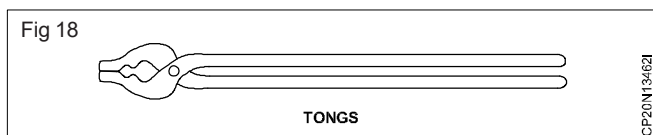
Chipping hammer: chipping hammer is a tool used to remove welding slag after arc welding (Fig 16).



Wire brush: A wire brush is used for cleaning the welding surface, removal of slag, rust etc. (Fig 17).



Tongs: an instrument with two movable arms that are joined at one end. It is used to pick up and hold hot pieces of metal (Fig 18).



Care and maintenance of gas welding plant and equipments

Proper care and maintenance of gas welding equipment are essential to ensure Safety, efficiency, and the longevity of the equipment. Here are some guidelines for maintaining gas welding plant and equipment:

1 Regular Inspection: Conduct routine visual inspections of all equipment components, including hoses, regulators, torches, valves, and cylinders. Look for signs of wear, damage, or corrosion.

- 2 Cleanliness:** Keep all components clean and free from dirt, dust, and debris. Cleaning prevents contamination and ensures proper functioning
- 3 Storage:** Store gas cylinders in a well-ventilated, dry area away from direct sunlight, heat, and sources of ignition. Proper storage prevents corrosion and potential hazards
- 4 Pressure Testing:** Periodically test regulators and hoses for leaks and pressure control accuracy. Replace any damaged or faulty components immediately
- 5 Hose Inspection:** Check hoses for cracks, cuts, or signs of deterioration. Replace hoses that show signs of wear to prevent gas leaks.
- 6 Regulator Maintenance:** Clean and lubricate regulators according to the manufacturer's instructions. Make sure regulators are properly adjusted for the specific gas being used.
- 7 Torch Maintenance:** Clean torch tips regularly to prevent clogging. Replace worn tips and ensure proper gas flow and ignition
- 8 Check Valves:** Inspect flashback arrestors and check valves for proper functioning. These safety devices prevent flame from traveling back into the gas lines
- 9 Leak Testing:** Regularly check for gas leaks using soapy water or a leak detection solution. Bubbles will form if there is a leak. Address leaks promptly.
- 10 Replace Worn Parts:** Replace worn or damaged parts with genuine manufacturer-approved replacements. Using substandard parts can compromise safety and performance
- 11 Ventilation:** Ensure proper ventilation in the welding area to prevent the buildup of potentially hazardous gases.
- 12 Training:** Train operators and users in the proper use and maintenance of gas welding equipment. Knowledgeable operators are more likely to use equipment safely and effectively.
- 13 Cylinder Handling:** Follow proper procedures for handling and transporting gas cylinders. Secure cylinders properly and avoid dropping or mishandling them.
- 14 Emergency Equipment:** Keep fire extinguishers and first aid kits readily accessible in case of emergencies.
- 15 Documentation:** Maintain records of maintenance and inspections for each piece of equipment. This helps track maintenance schedules and identify any recurring issues.
- 16 Periodic Servicing:** Schedule regular maintenance with a qualified technician to ensure that the equipment is in optimal working condition. This may include professional cleaning, calibration, and adjustment.

By following these care and maintenance practices, you can ensure the safe and efficient operation of your gas welding equipment, reducing the risk of accidents and maintaining the quality of your welding work.

Types of oxy - acetylene flames and uses

Objectives: At the end of this lesson you shall be able to

- identify the different types of oxy-acetylene flames
- explain the uses of flames.

The oxy-acetylene gas flame is used for gas welding because

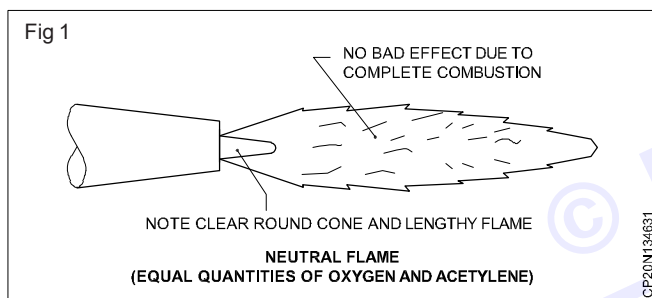
- it has a well controlled flame with high temperature
- the flame can be easily manipulated for proper melting of the base metal
- it does not change the chemical composition of the base metal /weld.

Three different types of oxy-acetylene flames as given below can be set.

- Neutral flame
- Oxidising flame
- Carburising flame.

Characteristics and uses

Neutral flame (Fig 1): Oxygen and acetylene are mixed in equal proportion in the blowpipe.

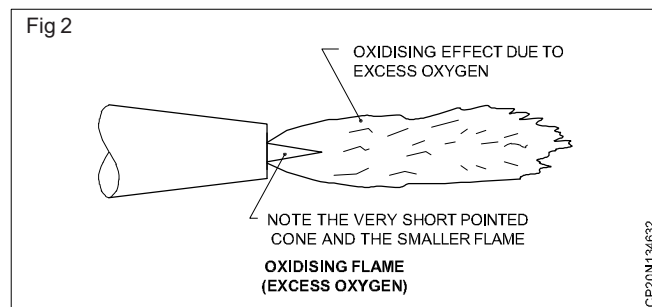


Complete combustion takes place in this flame.

This flame does not have a bad effect on the base metal/weld i.e. the metal is not oxidised and no carbon is available for reacting with the metal.

Uses: It is used to weld most of the common metals, i.e. mild steel, cast iron, stainless steel, copper and aluminium.

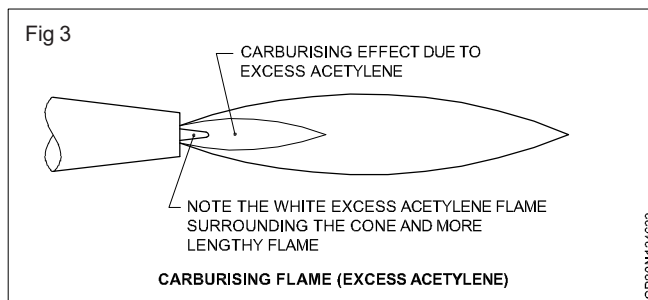
Oxidising flame (Fig 2): It contains excess of oxygen over acetylene as the gases come out of the nozzle.



The flame has an oxidising effect on metals which prevents evaporation of zinc/tin in brass welding/brazing.

Uses: Useful for welding of brass and for brazing of ferrous metals.

Carburising flame (Fig 3): It receives an excess of acetylene over oxygen from the blowpipe.



Uses : Useful for stellating (hard facing), 'Linde' welding of steel pipes, and flame cleaning.

The selection of the flame is based on the metal to be welded

The neutral flame is the most commonly used flame. (See the chart given below.)

Metal	Flame
1 Mild steel	Neutral
2 Copper (de-oxidised)	Neutral
3 Cast iron	Neutral (slightly oxidising)
4 Stainless steel	Neutral
5 Aluminium (Pure)	Neutral (slightly carburising)
6 Brass	Oxidising
7 Stellite	Carburising

Effect of atmospheric oxidation

Atmospheric oxidation can have several effects on gas welding.

- 1 Contamination of Weld Pool:** Atmospheric oxygen can react with the hot metal surfaces in the weld pool, causing oxidation. This forms oxides on the metal's surface, making it difficult for the filler metal to bond properly. This can weaken the weld joint and reduce its strength
- 2 Porosity:** Oxidation products can trap gas bubbles in the weld pool, leading to porosity in the finished weld. Porosity weakens the weld and can make it susceptible to cracking.
- 3 Reduced Weld Quality:** Oxidation can lead to poor fusion between the filler metal and the base metal. This can result in incomplete penetration and incomplete bonding, leading to weak and unreliable welds.
- 4 Surface Defects:** Oxides formed on the surface of the weld pool can create irregularities and surface imperfections, affecting the overall appearance and smoothness of the weld.

5 Increased Heat Input: Oxidation reactions can release heat, causing an increase in the heat input to the welding process. This can lead to distortion and warping of the welded components.

To mitigate the effects of atmospheric oxidation in gas welding

Flux: Flux compounds can be used to shield the weld area from the surrounding atmosphere. Flux creates a protective barrier that helps prevent atmospheric gases from coming into contact with the hot metal surfaces

Gas Shielding: In some cases, inert gases such as argon or helium can be used to create a shielding atmosphere

around the weld. This helps to minimize the contact of atmospheric oxygen with the weld pool

Reduced Torch Flame Oxygen: Adjusting the oxygen-to-fuel gas ratio torch flame can reduce the amount of oxygen reaching the weld pool, minimizing oxidation.

Clean Surfaces: Properly cleaning the metal surfaces before welding reduce the presence of contaminants that could react with atmospheric oxygen.

Overall, managing atmospheric oxidation is crucial in gas welding to ensure quality, strength, and reliability of the weld joints.

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Introduction to physics

Objectives: At the end of this lesson you shall be able to

- **state the role of physics in science.**

Physics

Physics is the science of nature. It is the scientific study of matter and energy and how they interact with each other. This energy can take the form of motion, light, electricity, radiation, gravity. Physics deals with matter on scales ranging from sub-atomic particles (ie the particles that make up the atom and the particles that make up those particles) to stars and even entire galaxies .

Physics is the most fundamental and all-inclusive of the sciences. It has a profound effect on all scientific development. Physics is the basic to the understanding of almost all branches of science and technology. The Economists and Commerce experts use the ideas and concepts of Physics. The intricacies in understanding the concept of basic principles of Physics is relaxed by bringing in a conceptual coherence between the theory and the practical session in the syllabi.

Nature exhibits many forms, matter or wave or either. The bulk property of matter exhibiting particle behavior form the basis of Properties of matter. A theoretical knowledge of music, the basics of the developments in modern sound engineering and the applications of sound are imparted through Sound.

The ideas of calorie, Specific heat capacities, the thermodynamics of systems are dealt with Heat and Thermodynamics. Light as a wave exhibits the phenomenon of diffraction, interference and as a transverse wave polarizes. The relevant theory and the instrument used to observe or measure them are discussed in Optics. The idea of light quanta is imparted through laser and spectroscopy which forms the basis for almost every analyzing instrument.

The idea of short range forces namely electrostatic force the basis for electricity where a practical knowledge about the domestic power connection and motor are emphasized. The movement of electrons in a loop causing a magnetic field and its vice versa are taught in detail in electromagnetism which also ponders the magnetic elements of the earth. A transition from classical and quantum World and the need for the same are emphasized through adequate knowledge of the concepts. The importance of Classical Mechanics for Macroscopic world is stressed through lagrangian and Hamiltonian formalism and the visualization of a wave associated with a particle in motion and the notion of wave function, the probability of locating a particle through its wave functions, their eigen values and functions are discussed in basic Quantum Mechanics.

Formation of solids, the forces that bind them and many things related to them are answered by solid state Physics. The application of the flow of electrons through a semiconductor forms the basis for solid state electronics. Electronics and Communication plays a leading role in modern communication systems. Energy Physics, the need of the hour, is immensely useful.

Atomic physics is the scientific study of the structure of the atom, its energy states, and its interactions with other particles and with electric and magnetic field. Atomic physics has proved to be a spectacularly successful application of quantum mechanics, which is one of the cornerstones of modern Physics. While atomic physics deals with atoms as a whole, nuclear physics deals specifically with the nucleus of the atom. Nuclear energy now plays a predominant role as we all know.

Vernier calipers

Objectives: At the end of this lesson you shall be able to

- **identify the parts of a vernier caliper**
- **state the constructional features of a vernier caliper**
- **state the uses of a vernier caliper.**

Refer Exercise No. 1.2.24 - 30

Graduations and reading of vernier calipers

Objectives: At the end of this lesson you shall be able to

- **determine the least count of a vernier caliper**
- **state how graduations are made on a vernier caliper with 0.02mm least count**
- **read vernier caliper measurements.**

Refer Exercise No. 1.2.24 - 30

Outside Micrometer

Objectives: At the end of this lesson you shall be able to

- identify the parts of an outside micrometer
- state the functions of the main parts of an outside micrometer.

Refer Exercise No. 1.2.24 - 30

Graduations of metric outside micrometer

Objectives: At the end of this lesson you shall be able to

- state the principle of a micrometer
- determine the least count of an outside micrometer.

Refer Exercise No. 1.2.24 - 30

Reading dimensions with outside micrometers

Objectives: At the end of this lesson you shall be able to

- select the required range of a micrometer
- read micrometer measurements.

Refer Exercise No. 1.2.24 - 30

Scalar and vector quantities

Objectives: At the end of this lesson you shall be able to

- state scalar and vector quantities and their representation
- state different forces.

Statics is the part of mechanics which deals with forces acting on bodies at rest. The weight of the body, the tension of a string, the load and the reaction are the different names of forces that are used in statics.

Any force can be represented in magnitude and direction by a straight line with an arrow head. The beginning of the line represents the point of application of the force. The arrow head represents the direction of the force. The magnitude of the force is given by the length of the line drawn to scale.

Scalar and Vector quantities

Physical quantities which have magnitude only are called scalar quantities.

(eg) Mass, Volume, Speed

Physical quantities which have both magnitude and direction are called vector quantities.

Physical quantities which have both magnitude and direction are called vector quantities.

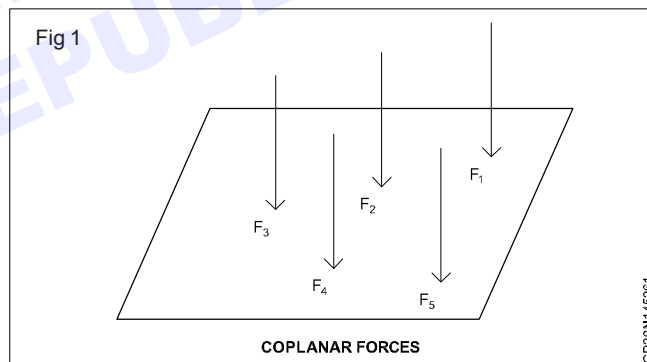
(e.g) Velocity, Momentum, force

Concurrent forces

Two or more than two forces acting at a point are called concurrent forces.

Coplanar forces

Two or more than two forces lie on same plane are called coplanar forces.



Resultant

Resultant is that single force which produces the same effect as that produced by two or more forces acting on the body.

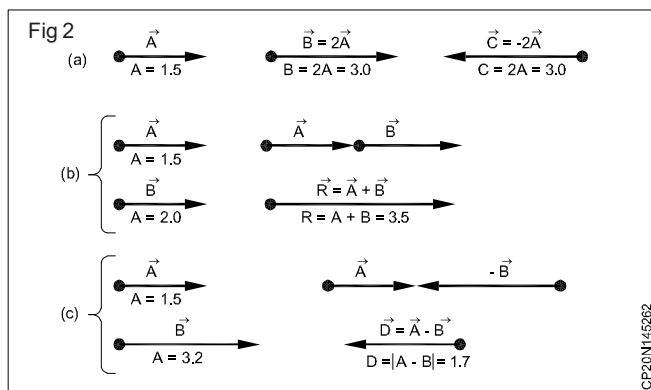
Equilibrant

Equilibrant is the single force which acting along with the other forces keeps the body in equilibrium.

Resolution of a vector into two perpendicular components

The process of splitting up a vector (force) into two perpendicular component parts is known as resolution of a vector. As the two component forces are mutually perpendicular, they are called rectangular components.

Let a force R act at a point O at an angle θ with x -axis. This force can be resolved into two rectangular components along x and y axis. Two lines CA and CB are drawn perpendicular to x and y axis as shown in the figure.



In the right angled triangle OAC,

$$\cos \theta = \frac{OA}{OC}$$

$$OA = OC \cos \theta$$

$$= R \cos \theta$$

Therefore the horizontal component of the force R is $R \cos \theta$. In the right angled triangle OBC,

$$\cos (90 - \theta) = \frac{OB}{OC}$$

$$\sin \theta = \frac{OB}{OC}$$

$$OB = OC \sin \theta = R \sin \theta$$

The vertical component of the force R is $R \sin \theta$.

Low of oscillations: Oscillation is defined as the process of repeating variations of any quantity or measure about its equilibrium value in time. Oscillation can also be defined as a periodic variation of a matter between two values or about its central value.

The term vibration is used to describe the mechanical oscillations of an object. However, oscillations also occur in dynamic systems or, more accurately, in every field of science. Even the beating of our hearts creates oscillations.

Parallelogram and triangle law of forces

If two forces acting at a point are represented in magnitude and direction by the adjacent sides of a parallelogram, then their resultant is represented in magnitude and direction by the diagonal passing through the point.

Explanation

Consider two forces Vector P and Vector Q acting at a point O inclined at an angle θ as shown in Fig.

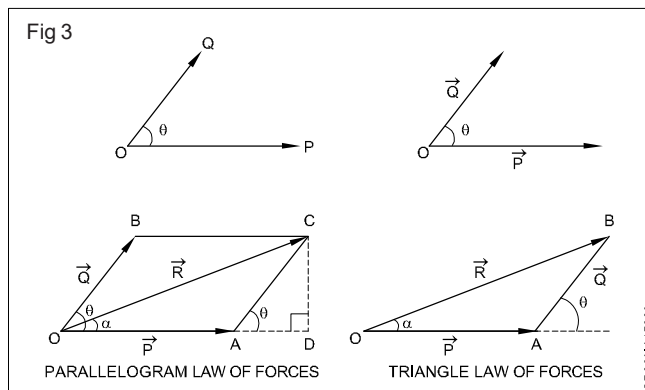
The forces Vector P and Vector Q are represented in magnitude and direction by the sides OA and OB of a parallelogram OACB as shown in Fig

The resultant Vector R of the forces Vector P and Vector Q is the diagonal OC of the parallelogram. The magnitude of the resultant is

$$R = \sqrt{P^2 + Q^2 + 2PQ \cos \theta}$$

The direction of the resultant is $\tan^{-1} \frac{Q \sin \theta}{P + Q \cos \theta}$: Triangle law of forces

The resultant of two forces acting at a point can also be found by using triangle law of forces.



Newton's Laws of Motion

The laws governing the motions of bodies in general, under the action of a force or otherwise, and the influence of a force on motion are summed up by Newton (1642-1727) in the following three laws called after him Newton's laws of motion.

First Law of Motion:

This law is worded as -

Every body tends to preserve in its state of rest or of uniform motion in a straight line unless it be compelled by an impressed force to change that state.

This law states two distinct facts>

- 1 Matter has inertia i.e. does not (and cannot) change its state of rest or of uniform motion by itself, unless compelled to do so by some external agencies
- 2 The change of motion (either in direction or magnitude or both) can take place only as the result of the action of a force, not otherwise.

From this fact a force can be defined as, force is that which produces or tends to produce change in motion (in magnitude or direction or both).

Proof of the 1st law:

Sometimes motion seems to ensue in a body at rest without any apparent existence of application of force. In all such cases, however, although no force may be directly evident, the existence of a force can definitely be traced to gravitational, magnetic, electrical, chemical or some such other origin. As for example a ripe fruit falling down from a tree, the motion of a body down a slope, or the deflection of a magnetic needle in the presence of a magnet, of a piece of iron, or of an electric current etc.

These are, of course from general considerations, good proofs of the law.

Force of Inertia :

If the train, in which we are travelling, slows down suddenly we feel, as if, a forward force is pulling us ahead. The reverse happens if the train accelerates. We thus experience a force in a direction opposite to which the change in velocity is tended to be produced in us. This is termed as the Force of Inertia. It is obvious, however, that no such opposite force actually acts on the accelerated (or retarded) body. The inertia of a body its tendency to

continue with unchanged velocity or rather its incapability of changing the velocity, alone is responsible for these effects.

Second Law of Motion:

By "change in motion as mentioned in the law in original form, is meant the rate of change of motion" and by "motion" Newton meant the "quantity of motion or what is now commonly termed as momentum.

Momentum (quantity of motion) is defined as the product mass X velocity (mxv).

Units of Momentum

$$\begin{aligned}\text{Momentum} &= \text{Unit mass} \times \text{Unit velocity.} \\ &= \text{gm} \times \text{cm/sec. in CGS system.} \\ &= \text{lb} \times \text{ft/sec. in FPS. system.}\end{aligned}$$

The 2nd law is now defined in this way

The rate of change of momentum is proportional to the impressed force; and the change in momentum takes place in the direction of the force.

$$\begin{aligned}\text{Momentum} &= mxv \\ \text{if mass, } m &\text{ is constant.}\end{aligned}$$

Change in momentum depends directly on the change of the velocity in magnitude and direction. Thus if by the action of force F for a time L the velocity v, of a body (of mass m) changes to v₂. then,

$$\begin{aligned}\text{Initial momentum} &= mv_1 \\ \text{Final momentum} &= mv_2 \\ \therefore \text{Change in momentum} &= mv_2 - mv_1 \\ &= m(v_2 - v_1) \\ &= \text{mass} \times \text{net change in velocity.}\end{aligned}$$

If this change in velocity in the time t is produced at a constant rate. then the constant rate of change of momentum

$$\begin{aligned}&= m(v_2 - v_1) \\ \therefore \text{From the above form of the 2nd law we get.} \\ &\quad m \text{ acceleration.} \\ \therefore F &= \text{mass} \times \text{acceleration} \\ &F = ma \\ \therefore F &= ma \text{ or } F = K ma \text{ or } m \times a = 1 \\ &\quad a = 1 \\ \therefore F &= ma, \quad \therefore K=1\end{aligned}$$

From this it is very clear that the force that can produce unit change in momentum in unit time is a unit force. This is true irrespective of whether or not the mass is constant.

Third Law of Motion:

The third law of motion may best be explained with the help of a few familiar illustration -

- a A book laid down on a table is at rest inspite of the downward pull of earth's attraction on it.

There must, therefore, be acting an exactly equal and opposite force on the book. The book exerts a downward force (action) equal to its own weight on the table, and the table in return exerts an equal, opposite force (reaction) on the book.

- b A bullet fired from a rifle experiences a forward impulsive force (action) from the rifle. In return the bullet exerts an equal backward impulsive force (reaction) on the rifle. This is exhibited by the back kick of a rifle.
- c When a person jumps from a boat into the water he pushes the boat backward with his feet with the necessary force (action). and as a reaction he receives an equal forward push which gives him the motion.
- d When we walk over the ground we push the ground back with our foot with a certain force (action) and the ground exerts an equal forward push (reaction) on our foot. Similarly in taking a long or high jump the performer pushes the ground in the necessary direction with large impulsive forces and gets a corresponding reaction which gives him the necessary motion.

This may be generalized by saying that

- i When a body wholly resists a certain impressed force, without yielding to it, the whole impressed force is utilized as action.
- ii When, however, a body resists a certain impressed force only partly (not wholly) and thus yields to the force, only a part of the impressed force (not the whole) is utilized as action. The unbalanced part of the impressed force produces the motion of the body on which the force acts.

This may be expressed in a slightly different way. There is a limit upto which different bodies can sustain action. Action, which is produced by the impressed force, is equal to it only within the yielding limit.

Momentum

Momentum is the product of an object's mass and velocity. Momentum is a vector quantity, meaning that its direction is important. Objects traveling opposite directions have positive and negative momentums $p = mv$.

Types of Force and Examples

Force is simply defined as the push or pull movement. Different types of force are contact forces and non-forces. Some examples of force are Nuclear force, gravitational force, Frictional force, magnetic force, electrostatic force, spring force and so on.

Force

Force is defined as the push or pull movement that changes the motion of the body. It is an external agent that is applied on the body. Force is divided into two main types, contact forces and Non-contact forces. Force is a vector quantity and hence has both magnitude and direction. Forces can also long-range force or short-range force. Long range is

gravitational force or electrostatic force while short range force is the atomic or nuclear force The long-range force decreases with increase in distance rapidly as they have an inverse relation

Force can perform the following actions of the body -

Pull the object

Push the object

Change or alter the shape of the object

Change the direction of motion of the object, alter speed of the object.

Stop a moving body or object

Units of force

SI unit of force is Newton, Cgs unit is Dyne while the British unit is Slug

Measurement of force

Applying acceleration to a body

For measuring force at times, the change that it has caused can be considered like in the case of the body that has changed its shape So the degree of change can be the measurement of force.

Contact forces

Contact forces are the one as the name suggests there is a contact between the two bodies under consideration. That means one body is exerting force on the other body because of the contact between the two

So, the force that is found due to or by the means of physical contact between two bodies known as contact force.

Some of the examples of contact forces in day to day life are - Pushing a door, Playing Basketball, Hitting the football, working on laptop, pushing sofa and so on.

Force does not have contact with the body, but acts through the space in between. Examples nuclear force and gravitational force.

Types of contact forces

Contact forces are subdivided into some types these are as follows-

Spring force : The Hooke's law talks about spring force. The spring force is a result of movement or displacement of molecules. The displacement of molecules is in a direction opposite to the displacement of spring. It is a type of Normal force.

Applied force : Muscular force is the other name for applied force. The force due to action of muscles

Air resistance force : It is a type of Normal force Air resistance force is the one in which the force acts in the opposite direction in presence of gas. Air resistance force is directly proportional to the area under contact, if the area increases the air resistance force increases and also if the velocity through the gas increases.

Frictional force : Friction is a dissipative force that acts opposite to the direction of motion and offers resistance to the motion of the object. It is a result of contact with the surface or when there is an interaction between the object and the surface and the object tries to Move this force offered by resistance. It is a type of Normal force

Normal force : It is a force that is result of contact between surfaces. As this force acts perpendicular to the surface under consideration this is known as Normal force. Some examples of Normal force are spring force, air resistance force, tension force and so on Tension force-The force that is produced with the Help of rope, cable or string This force only pulls the suspended mass attached to it. It doesn't have the pushing ability Non-contact forces

Non-contact forces are those that don't have contact between the two bodies. This force doesn't arise due to physical contact between the surfaces but acts through the space between the two bodies.

Some of the examples of Non-contact forces are as follows-

Gravitational force

Nuclear force - Strong

Weak Nuclear force

Electromagnetic force

Gravitational force : The force that is present due to the attraction between the two objects is defined as the gravitational force

Electromagnetic force- it is due to the electric or magnetic affinity of the molecules that generates this force and results in binding of atoms and solids.

Nuclear force - it can divide based on strength as - Weak and strong Weak nuclear force- The force is present between radioactive decay molecules and is generated during their decay While, Strong nuclear force is required in Binding of the nucleus.

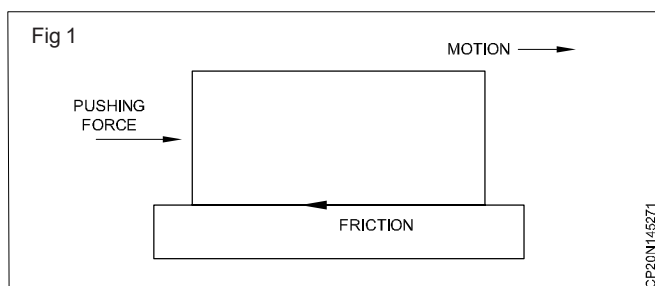
Friction

Objectives: At the end of this lesson you shall be able to

- define friction
- state different type of friction
- state advantages and disadvantages of friction.

Definition

A force which is responsible for changing the state of motion of objects is known as force or Friction. Friction is actually a force that appears whenever two things rub against each other. The force acting along the two surfaces in contact which opposes the motion of one body over the other is known as the force of friction or frictional force (Fig 1)



For example, a ball rolling along the ground gradually slows down and finally comes to rest. When we stop pedalling a bicycle, it gradually slows down and finally comes to a stop. A car or a scooter also comes to rest once its engine is switched off. Similarly, a boat comes to rest if we stop rowing it. In all these situations no force appears to be acting on the objects, yet their speed gradually decreases and they come to rest after some time. This is due to the cause of friction. The force of friction always acts on all moving objects and its direction is always opposite to the direction of motion.

Friction arises due to the irregularities on the two surfaces in contact. Those surfaces which appear very smooth have a less force of friction compared to rough surfaces. Thus frictional force increases with increase in roughness of the surfaces.

Unit of friction

Friction, which is a force, is measured in Newton.

All forces are measured in Newton

Effects of Friction

- 1 Friction depends on the nature of surfaces. For example, take a ball and roll it on the cemented floor. Measure the distance covered by the ball. Repeat this on a wooden floor again, measure the distance covered by the ball. The ball should be rolled with the same force. It will cover a larger distance on the cemented floor because frictional force between the cemented floor and the ball is less.
- 2 Friction can produce heat. For example, striking a matchstick produces fire by friction, rubbing of your palms makes you feel warm.

- 3 Friction causes wear and tear. For example, when two parts of a machine rub against each other, heat is produced and the efficiency of the machine decreases. There will be greater wear and tear in different parts of a machine due to friction. Thus friction reduces the efficiency of machines.

Advantages of friction

Without friction we wouldn't be able to walk, sit in a chair or drive safely. Everything would keep sliding and falling over. We need friction between our feet and the ground or we would not be able to stand up. When you are riding a bike and press the brakes, friction slows down your bike.

Disadvantages of friction

If you want to push something heavy, friction makes it difficult to move. Friction produces heat. Causing heat to build up is not always a good thing, especially inside a car engine.

The substances which reduce friction are called Lubricants

Lubricant reduces friction. It is used in machines as oil reduces friction. An air cushion between the moving parts is used to reduce friction.

Types of friction

Friction is a force that resists the motion of an object that is in contact with another object or material. If the objects are not moving relative to each other, the friction force is called static. If they are moving, the friction is kinetic. On the basis of its nature, frictional force can be divided into three types, they are

- 1 Fluid Friction
- 2 Sliding friction
- 3 Rolling friction

Fluid Friction

When a solid object is in contact with a fluid, such as a liquid or gas, and a force is applied to either the object or the fluid, there is a friction force that resists the motion called fluid friction. Examples where fluid friction occurs are water flowing through a hose, an airplane flying through the atmosphere and oil lubricating moving parts.

Causes of fluid friction:

Causes of fluid friction are turbulence effects from surface roughness and deformities, molecular attraction or adhesion between the materials, and deformation resistance of the fluid. This deformation resistance is called its viscosity.

Sliding friction

When two solid objects are in contact and a force is applied to slide one object against the other, sliding friction force

resists the motion. The friction that exists between a surfaces sliding on another surface is called the sliding friction.

Causes of sliding friction; The causes of sliding friction are molecular attraction or adhesion between the materials, surface roughness of the materials, and deformation resistance in the case of soft materials.

Elasticity

Objectives: At the end of this lesson you shall be able to

- explain terms stress strain
- provide definition of young's modulus and give its unit.

Stress: Consider a lump of ,clay. We can stretch it, squeeze it or twist it. In terms of physics, we say that we apply "tensile", "compressional" or "torsional" forces, respectively. We define the "stress" which we apply to the clay across any cross Section of it as the force per unit area. The resulting deformation the clay experiences are called strain. For instance, if its initial length was 10 cm, and it stretched an additional 2 cm, the strain which it experienced was $\frac{2 \text{ cm}}{10 \text{ cm}} = 0.2$.

The restoring force per unit area of the body is called Stress.

The internal resoring force is equal and opposite to the applied force.

$$\sigma = \frac{F}{A}$$

where σ = stress (Pa (N/m²)), F = deforming force (Newton) and A = area(m²).

It has the same units as pressure, and in fact pressure is one special variety of stress. However, stress is a much more complex quantity than pressure because it varies both with direction and with the surface it acts on. Stress that acts to shorten an object is compression. Stress that acts to lengthen an object is called tension. The two types of stress are

- 1 Normal stress
- 2 Shear stress

Normal Stress: Stress that acts perpendicular to a surface.

Can be either compressional or tensional.

Shear stress: Stress that acts parallel to a surface. It can cause one object to slide over another. The most general definition is that shear acts to change the angles in an object. It is denoted by the symbol "t".

Elastic Limit

The maximum value of the stress within which a body completely regains its original shape and size when the deforming forces are removed is known as elastic limit.

Strain

Strain is defined as the amount of deformation an object experiences compared to its original size and shape due to stress.

Rolling Friction

When a body rolls on the surface of another, the friction that exists between the surfaces is known as rolling friction

Causes of rolling friction: The causes of rolling friction are similar to that of sliding friction. They are molecular attraction or adhesion between the materials, surface roughness of the materials, and deformation resistance in the case of soft materials.

where ϵ = strain, dL = change in length (m) and L_0 = initial length, σ = Stress and E = Young's modulus.

$$\text{Strain} = \frac{\text{Change in dimension}}{\text{Original dimension}}$$

$$\epsilon = \frac{dL}{L_0} \text{ Or } \frac{\sigma}{E}$$

Note that strain is dimensionless. Longitudinal strain that shortens an object is called compression strain. Longitudinal strain that lengthens an object is called tension strain. There are two types of strain.

- 1 Longitudinal or Linear Strain
- 2 Shear strain

Longitudinal or Linear Strain: Strain that changes the length of a line without changing its direction. Can be either compressional or tensional.

Shear strain: Strain that changes the angles of an object. Shear causes lines to rotate.

Hook's law

Robert Hooke, an English physicist, gave the relation between stress and strain, know as Hooke's law.

Hooke's law states that within the elastic limit, the stress is directly proportional to strain. That is the ratio of stress to the strain is a constant. This constant is called of elasticity of a body.

$$\text{Modulus of elasticity} = \frac{\text{stress}}{\text{strain}} = \text{Constant}$$

Types of moduli of Elasticity

Corresponding to the longitudinal, volume and shearing the strain, there are three types of elasticity. They are

- 1 Young's modulus or elasticity of length or linear elasticity
- 2 Bulk modulus or elasticity of volume
- 3 Rigidity modulus or elasticity of shape or shear

1 Young's modulus (Y)

Young's modulus (Y) is a measure of the stiffness of an isotropic elastic material. When the deforming force is

applied to the body only along a direction, the change per unit length is called longitudinal or linear strain. The force applied per unit area of cross section is called longitudinal or linear stress.

Within the elastic limit, the ratio of longitudinal or linear stress to the longitudinal or linear strain is called Young's modulus

$$\text{Young's Modulus } Y = \frac{\text{Linear stress}}{\text{Linear strain}}$$

$$\frac{F/A}{l/L} = \frac{FXL}{A \times l} \text{ Nm}^{-2} \text{ (or) Pascal}$$

where F is the force applied normal to the area of cross section A, l is the change in length produced in an original length L.

2 Bulk modulus (K)

When the force is applied normally and uniformly to the whole surface of the body, it produces a change in volume and no change in shape. The force applied per unit area gives the bulk stress, and the change in volume per unit volume gives the bulk strain. Thus the bulk modulus 'K' is defined as the ratio of the bulk stress to the bulk strain.

where $F/A = P$ is the normal stress or bulk stress or pressure acting on a surface area A. v is the change in volume produced in an original volume V

The reciprocal of the bulk modulus of a substance is called compressibility. Bulk modulus is sometimes referred to as incompressibility.

$$\text{Bulk Modulus } K = \frac{\text{Bulk or volume stress}}{\text{Bulk or volume strain}}$$

$$\frac{F/A}{v/V} = \frac{FXV}{AXv} = \frac{P \times V}{v} \text{ Nm}^{-2} \text{ (or) Pascal}$$

3 Rigidity Modulus (N)

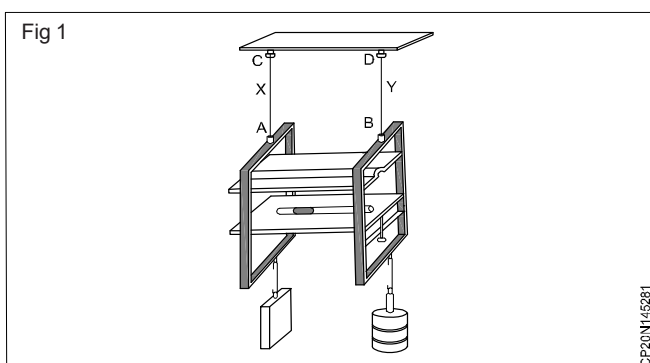
The rigidity modulus 'N' is defined as the ratio of shearing stress to the angle of shear or shearing strain.

$$\text{Rigidity modulus } N = \frac{\text{Shearing Stress}}{\text{Angle of shear}}$$

$$= \frac{F/a}{\theta} = \frac{F}{a \times \theta} \text{ Nm}^{-2} \text{ (or) Pascal}$$

Determination of young's modules

1 Searle's apparatus is shown in the Fig 1.



Searle's apparatus consists of two metal frames A and B. It is suspended from two torsion heads C and D by means of wires X and Y of the same material. To keep wire rigid, a dead load is suspended at the lower end of the frame A. A hanger is suspended at the lower end of the frame B.

- 2 The dead load and a weight hanger with a mass (m) are suspended in the two frames to keep the wires rigid.
- 3 The length of the wire Y is measured.
- 4 Find the diameter and hence the radius of the wire Y using screw gauge.
- 5 Calculate the pitch and least count of the micrometer screw.
- 6 Rotate the micrometer screw head so that the air bubble of the spirit level lies exactly at the centre.
- 7 Note the reading on the vertical scale just below the edge of the screw. This is the pitch scale reading (PSR).
- 8 Note the division on the screw head which is just outside the vertical scale edge.
- 9 Multiplying this with the least count gives the head scale reading (HSR).
- 10 The correct reading is PSR+HSR.
- 11 Add a mass of 0.5 kg in the hanger.
- 12 After a minute adjust the micrometer screw till the air bubble comes at the centre
- 13 Note the reading of the micrometer.
- 14 Repeat the process by increasing the mass in steps of 0.5 kg and record the readings.

Increase the load in equal steps.

- 15 Repeat the same procedure by removing the mass in steps of 0.5 kg.

Whenever the load is added or removed wait for some time in order to allow the wire to extend.

- 16 Note the readings for unloading
- 17 Plot a graph mass in kg in X-axis versus extension in mm on y-axis
- 18 From the graph find the extension corresponding to a convenient mass (m) say 3 kg.

Ohm's law - simple electrical circuits and problems

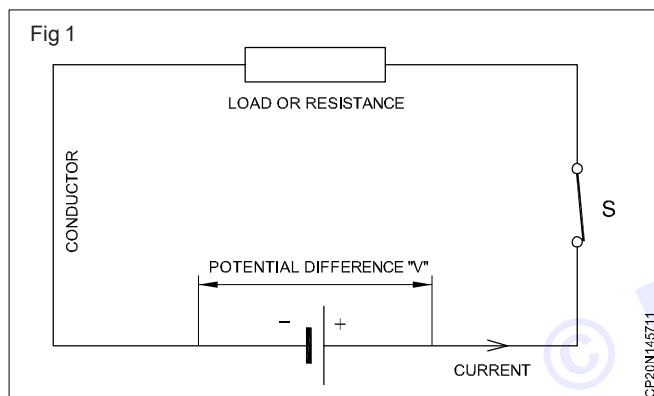
Objectives: At the end of this lesson you shall be able to

- describe the essential factors in an electrical circuit
- state the relation between circuit factors through Ohm's law
- apply Ohm's law in an electric circuit.
- define electrical power and energy and calculate related problems.

Simple electric circuit

In the simple electric circuit shown in Fig 1, the current completes its path from the positive terminal of the battery via the switch and the load back to the negative terminal of the battery.

The circuit shown in Fig 1 is a closed circuit. In order to make a circuit to function normally the following three factors are essential.



- Electromotive force (EMF) to drive the electrons through the circuit.
- Current (I), the flow of electrons.
- Resistance (R) - the opposition to limit the flow of electrons.

Ohm's law

In 1826 George Simon Ohm discovered that for metallic conductor, there is a substantially constant ratio of the potential difference between the ends of the conductor

Ohm's law gives the relation between the voltage, current and resistance of a circuit.

Ohm's law states that the ratio of the voltage (V) across any two points of a circuit to the current (I) flowing through is constant provided physical conditions, namely temperature etc. remain constant. This constant is denoted as resistance (R) of the circuit.

(or)

In simple,

Ohm's law states that in any electrical closed circuit, the current (I) is directly proportional to the voltage (V), and it is inversely proportional to the resistance 'R' at constant temperature.

(ie) $I \propto V$ (When 'R' is kept constant)

$I \propto \frac{1}{R}$ (When 'V' is kept constant)

$I \propto \frac{V}{R}$ (Relation between I, V and R)

$$I \propto \frac{V}{R}$$

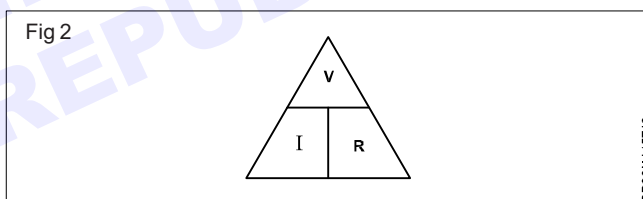
It means $I = \frac{V}{R}$

V = Voltage applied to the circuit in 'Volt'

I = Current flowing through the circuit in 'Amp'

R = Resistance of the circuit in Ohm (Ω)

The above relationship can be referred to in a **triangle** as shown in Fig 2. In this triangle whatever the value you want to find out, place the thumb on it then the position of the other factors will give you the required value.



For example for finding 'V' close the value 'V' then readable values are IR, so $V = IR$.

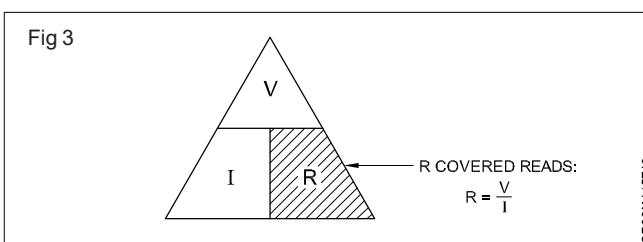
Again for finding 'R', close the value R, then readable values

are V/I so $R = V/I$, like that $I = \frac{V}{R}$.

Written as a mathematical expression, Ohm's Law is

$$\text{Resistance} = \frac{\text{Voltage (V)}}{\text{Current (I)}} \quad (\text{Refer Fig 3})$$

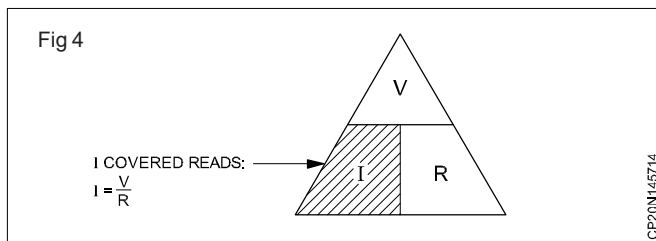
$$(\text{or}) R = \frac{V}{I} \quad (\text{Refer Fig 3})$$



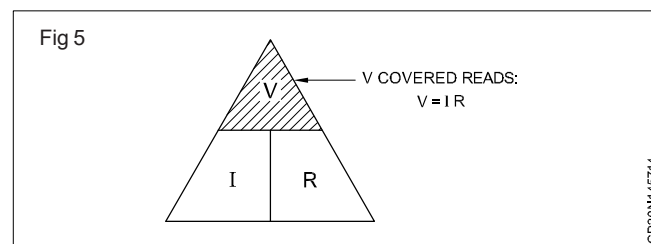
Of course, the above equation can be rearranged as:
In the same way, 'V' can be found by covering 'V'

$$\text{Current (I)} = \frac{\text{Voltage (V)}}{\text{Resistance (R)}}$$

$$\text{(or) } I = \frac{V}{R} \text{ (Refer Fig 4)}$$



Voltage (V) = Current (I) x Resistance (R)
or $V = IR$ (Fig 5)

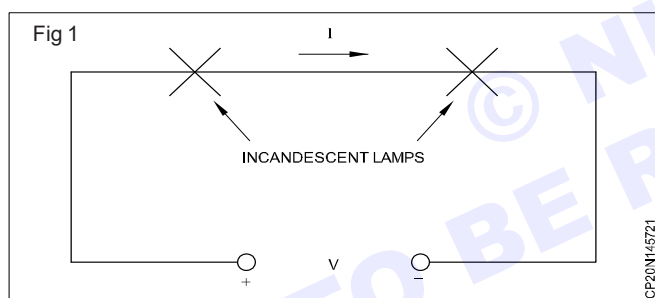


DC series and parallel circuits

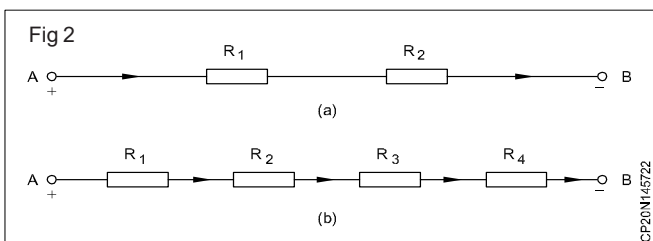
Objectives: At the end of this lesson you shall be able to

- state the characteristics of series circuit and determine the current and voltage across each resistors
- determine the total voltage sources in series circuit
- state the relation between EMF potential difference and terminal voltage
- determine the polarity of voltage drops with respect to ground.

The series circuit: If more than one resistors are connected one by one like a chain and if the current has only one path is called as series circuit. It is possible to connect two incandescent lamps in the way shown in Fig 1. This connection is called a series connection, in which the same current flows in the two lamps.

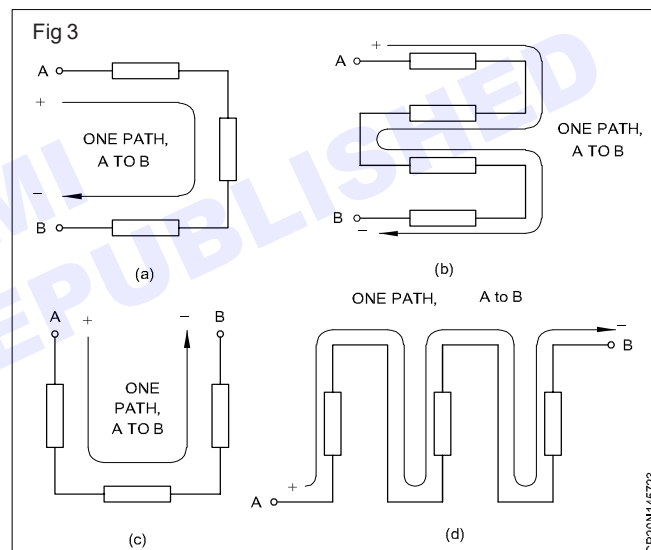


The lamps are replaced by resistors in Fig 2. Fig 2 (a) shows two resistors are connected in series between point A and point B. Fig 2(b) shows four resistors are in series. Of course, there can be any number of resistors in a series connection. Such connection provides only one path for the current to flow.



Identifying series connections

In an actual circuit diagram, a series connection may not always be as easy to identify as those in the figure. For example, Fig 3(a), 3(b), 3(c) & 3(d) shows series resistors drawn in different ways. In all the above circuits we find there is only one path for the current to flow.



Current in series circuits

The current will be the same at any point of the series circuit. This can be verified by measuring the current in any two points of a given circuit as shown in Figs 4(a) and 4(b). The ammeters will show the same reading.

The current relationship in a series circuit is

$$I = I_{R1} = I_{R2} = I_{R3} \text{ (Refer Fig 4a \& 4b)}$$

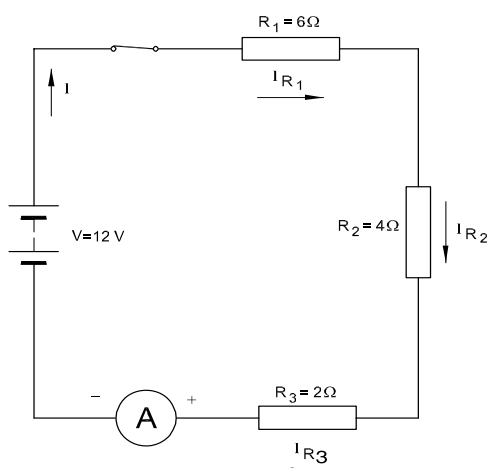
We can conclude that there is only one path for the current to flow in a series circuit. Hence, the current is the same throughout the circuit.

Total resistance in series circuit

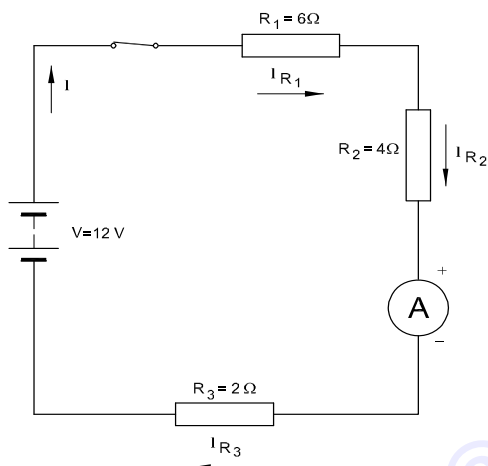
You know how to calculate the current in a circuit, by Ohm's law, if resistance and voltage are known. In a circuit consisting of two resistors R_1 and R_2 we know that the resistor R_1 offers some opposition to the current flow. As the same current should flow through R_2 in series it has to overcome the opposition offered by R_2 also.

If there are a number of resistors in series, they all oppose the flow of current through them.

Fig 4



(a)



(b)

The 2nd characteristic of a DC series circuit could be written as follows (R).

The total resistance in a series circuit is equal to the sum of the individual resistances around the series circuit. This statement can be written as

$$R = R_1 + R_2 + R_3 + \dots + R_n$$

where R is the total resistance

$R_1, R_2, R_3, \dots, R_n$ are the resistors connected in series.

When a circuit has more than one resistor of the same value in series, the total resistance is $R = r \times N$

where 'r' is the value of each resistor and N is the number of resistors in series.

Voltage in series circuits

In DC circuit voltage divides up across the load resistors, depending upon the value of the resistor so that the sum of the individual load voltages equals the source voltage.

The 3rd characteristic of a DC circuit can be written as follows.

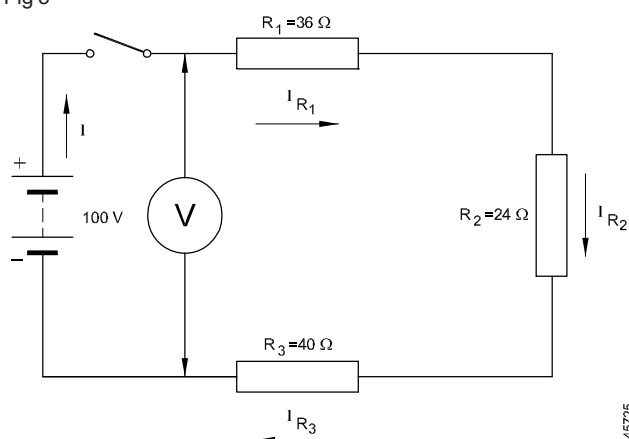
As the source voltage divides/drops across the series resistance depending upon the value of the resistances

$$V = V_{R1} + V_{R2} + V_{R3} + \dots + V_{RH}$$

the total voltage of a series circuit must be measured across the voltage source, as shown in Fig 5.

Voltages across the series resistors could be measured using one voltmeter at different positions as illustrated in Fig 6.

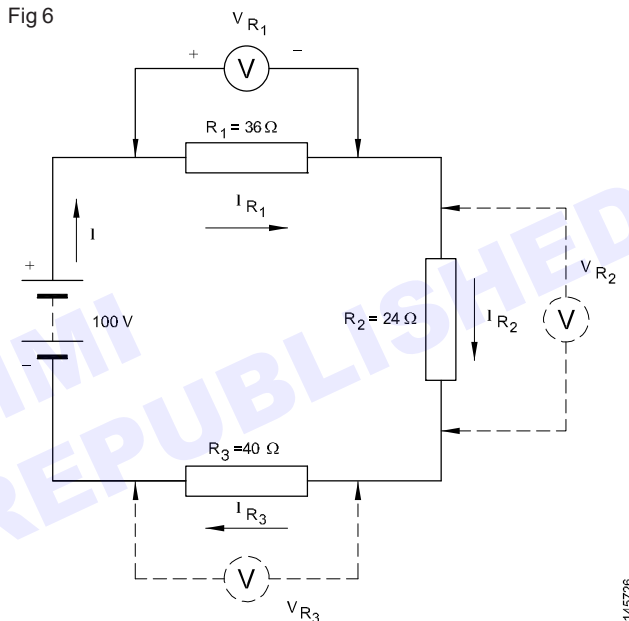
Fig 5



MEASURING THE TOTAL VOLTAGE OF SERIES CIRCUIT

CP20N145725

Fig 6



VOLTAGE DROP IN A SERIES CIRCUIT

CP20N145726

When Ohm's law is applied to the complete circuit having an applied voltage V, and total resistance R, we have the current in the circuit as

$$I = \frac{V}{R}$$

Application of Ohm's law to DC series circuits

Applying to Ohm's law to the series circuit, the relation between various currents could be stated as below

$$I = I_{R1} = I_{R2} = I_{R3}$$

$$\text{This could be stated as } \frac{V}{R} = \frac{V_{F1}}{R_1} = \frac{V_{F2}}{R_2} = \frac{V_{F3}}{R_3}$$

You can use any of the above formulae to calculate current in a series circuit.

We know the total supply voltage

$$V = V_{R1} + V_{R2} + V_{R3}$$

$$\text{i.e. } IR = R_1 I_{R1} + R_2 I_{R2} + R_3 I_{R3}$$

$$\text{and Total resistance } R = R_1 + R_2 + R_3$$

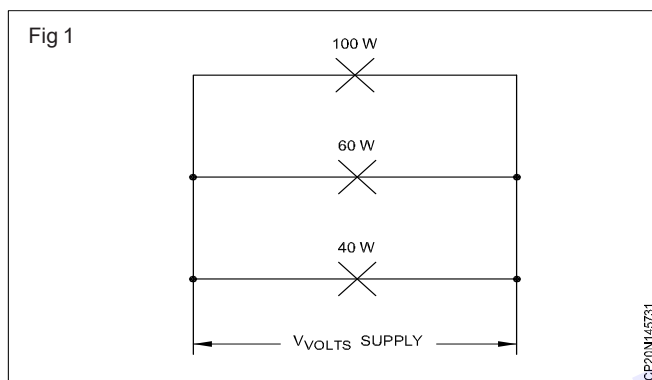
DC parallel circuit

Objectives: At the end of this lesson you shall be able to

- explain a parallel circuit
- determine the voltages in a parallel circuit
- determine the current in a parallel circuit
- determine the total resistances in a parallel circuit
- state the application of a parallel circuit.

In an electrical circuit, if the current has more than one paths and equal voltage in each branch is called parallel circuit.

It is possible to connect three incandescent lamps as shown in Fig 1. This connection is called parallel connection in which, the same source voltage is applied across all the three lamps.



Voltage in parallel circuit

The lamps in Fig 1 are replaced by resistors in Fig 2. Again the voltage applied across the resistors is the same and also equal to the supply voltage.

We can conclude that the voltage across the parallel circuit is the same as the supply voltage.

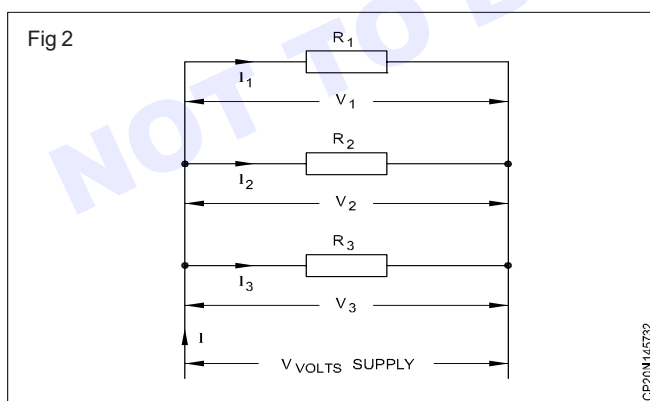


Fig 2 could also be drawn as shown in Fig 3.

Mathematically it could be expressed as $V = V_1 = V_2 = V_3$.

Current in parallel circuit

Again referring to Fig 2 and applying Ohm's law, the individual branch currents in the parallel circuit could be determined.

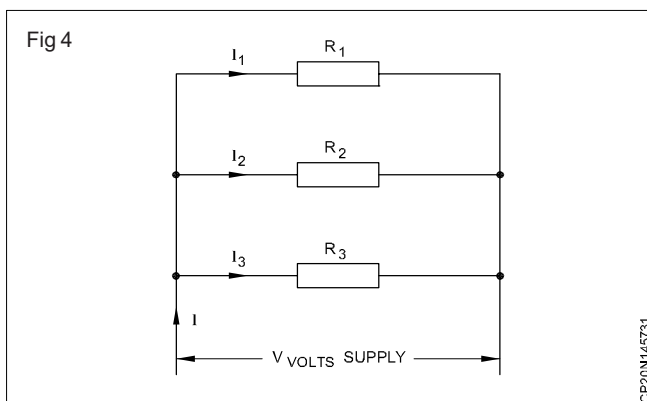
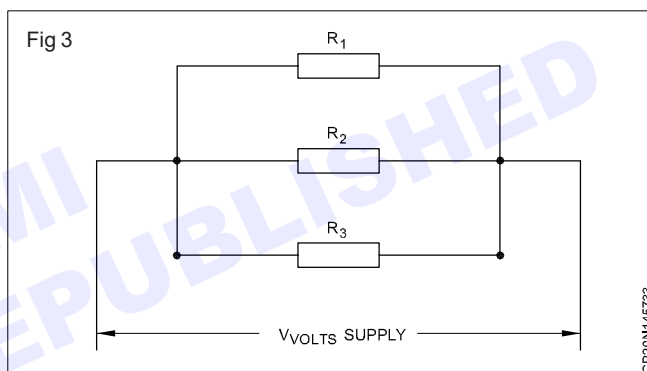
$$\text{Current in resistor } R_1 = I_1 = \frac{V_1}{R_1} = \frac{V}{R_1}$$

$$\text{Current in resistor } R_2 = I_2 = \frac{V_2}{R_2} = \frac{V}{R_2}$$

$$\text{Current in resistor } R_3 = I_3 = \frac{V_3}{R_3} = \frac{V}{R_3}$$

$$\text{as } V_1 = V_2 = V_3.$$

Refer to Fig 4 in which the branch currents I_1 , I_2 and I_3 are shown to flow into resistance branches R_1 , R_2 and R_3 respectively.



The total current I in the parallel circuit is the sum of the individual branch currents.

Mathematically it could be expressed as $I = I_1 + I_2 + I_3 + \dots + I_n$.

Resistance in parallel circuit

In a parallel circuit, individual branch resistances offer opposition to the current flow though the voltage across the branches will be same.

Let the total resistance in the parallel circuit be R ohms.

By the application of Ohm's law

we can write

$$R = \frac{V}{I} \text{ ohms or } I = \frac{V}{R} \text{ amps.}$$

where

R is the total resistance of the parallel circuit in ohms

V is the applied source voltage in volts, and

I is the total current in the parallel circuit in amperes.

We have also seen

$$I = I_1 + I_2 + I_3$$

$$\text{or } \frac{V}{R} = \frac{V}{R_1} + \frac{V}{R_2} + \frac{V}{R_3}$$

As V is the same throughout the equation and dividing the above equation by V, we can write

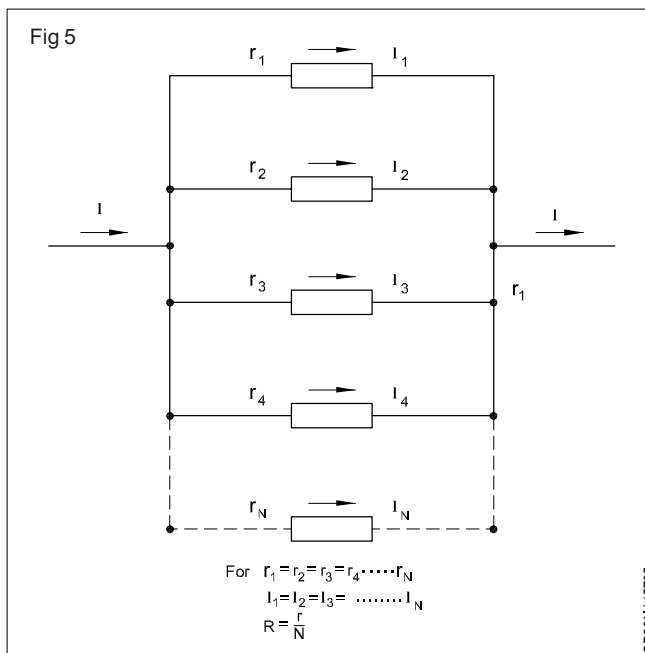
$$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$

The above equation reveals that in a parallel circuit, the reciprocal of the total resistance is equal to the sum of the reciprocals of the individual branch resistances.

Special case: Equal resistances in parallel

Total resistance R, of equal resistors in parallel (Fig 5) is equal to the resistance of one resistor, r divided by the number of resistors, N.

$$R = \frac{r}{N}$$



Applications of parallel circuits

An electric system in which one section can fail and other sections continue to operate has parallel circuits. As previously mentioned, the electric system used in homes consists of many parallel circuits.

An automobile electric system uses parallel circuits for lights, horn, motor, radio etc. Each of these devices operates independent of the others.

Individual television circuits are quite complex. However, the complex circuits are connected in parallel to the main power source. That is why the audio section of television receivers can still work when the video (picture) is inoperative.

Laws of resistance and various types of resistors

Objectives: At the end of this lesson you shall be able to

- state the laws of resistance, compare resistances of different materials
- state the relationship between the resistance and diameter of a conductor
- calculate the resistance and diameter of a conductor from the given data (i.e. dimensions etc.)
- explain various types of resistors.

Laws of resistance: The resistance R offered by a conductor depends on the following factors.

- The resistance of the conductor varies directly with its length.
- The resistance of the conductor is inversely proportional to its cross-sectional area.
- The resistance of the conductor depends on the material with which it is made of.
- It also depends on the temperature of the conductor.

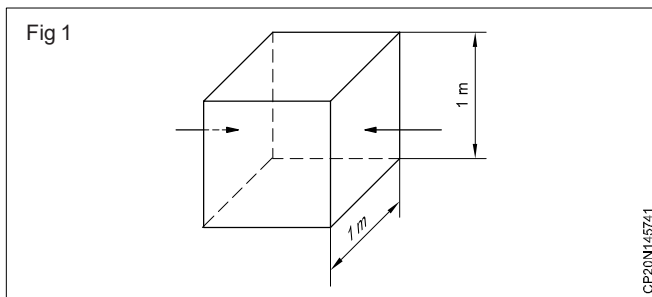
Ignoring the last factor for the time being, we can say that

$$R = \frac{\rho l}{a}$$

where 'ρ' (rho - Greek alphabet) - is a constant depending on the nature of the material of the conductor, and is known as its **specific resistance** or **resistivity**.

If the length is one metre and the area, 'a' = 1 m², then R = ρ.

Hence, specific resistance of a material may be defined as 'the resistance between the opposite faces of a metre cube of that material'. (or, sometimes, the unit cube is taken in centimetre cube of that material) (Fig 1).



We have $\rho = \frac{aR}{L}$

In the SI system of units

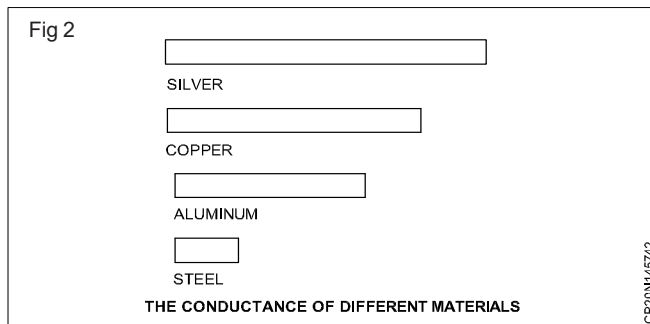
$$\rho = \frac{a \text{ metre}^2 \times R \text{ ohm}}{L \text{ metre}}$$

$$= \frac{aR}{L} \text{ ohm - metre}$$

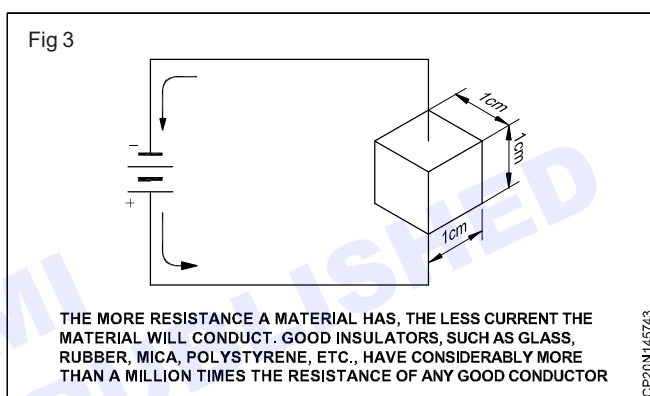
Hence the unit of specific resistance is ohm metre (Ωm).

Comparison of the resistance of different materials:

Fig 2 gives some relative idea of the more important materials as conductors of electricity. All the conductors shown have the same cross-sectional area and the same amount of resistance. The silver wire is the longest while that of copper is slightly short and that of aluminium is shorter still. The silver wire is more than 5 times longer than the steel wire.



Since different metals have different conductance ratings, they must also have different resistance ratings. The resistance ratings of the different metals can be found by experimenting with a standard piece of each metal in an electric circuit. If you cut a piece of each of the more common metals to a standard size, and then connect the pieces to a battery, one at a time, you would find that different amounts of current would flow. (Fig 3)



The bar graph shows the resistance of some common metals as compared to copper. Silver is a better conductor than copper because it has less resistance. Nichrome has 60 times more resistance than copper, and copper will conduct 60 times as much current as Nichrome, if they were connected to the same battery, one at a time.

Kirchhoff's law and its applications

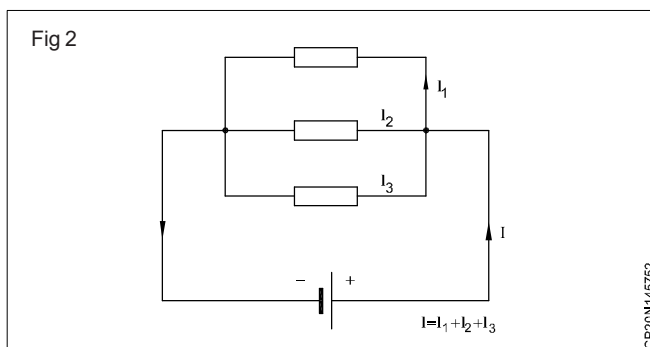
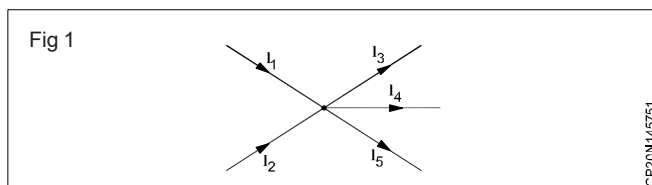
Objectives: At the end of this lesson you shall be able to

- state Kirchhoff's first law
- apply Kirchhoff's first law to find the circuit current
- state Kirchhoff's second law and apply the same to find the voltage drop in branches
- solve problems by applying Kirchhoff's laws.

Kirchhoff's laws are used in determining the equivalent resistance of a complex network and the current flowing in the various conductors.

Kirchhoff's laws

Kirchhoff's first law: At each junction of currents, the sum of the incoming currents is equal to the sum of the outgoing currents. (Figs 1 & 2) (or) The algebraic sum of all branch currents meeting at a point/node is zero



If all inflowing currents have positive signs and all outflowing currents have negative signs, then we can state that

$$I_1 + I_2 = I_3 + I_4 + I_5$$

$$+ I_1 + I_2 - I_3 - I_4 - I_5 = 0$$

In the above example the sum of all the currents flowing at the junction (node) is equal to zero.

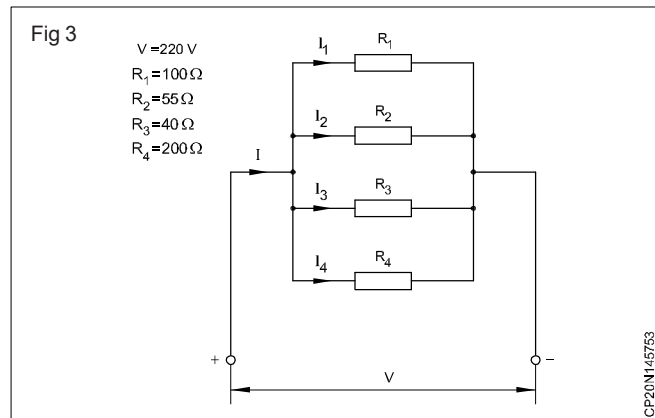
$$\Sigma I = 0$$

$$I = I_1 + I_2 + I_3 + \dots$$

Example: Apply Kirchhoff's First Law to find the current shown in circuit Fig 3.

Find current

$$I, I_1, I_2, I_3, I_4$$



Solution

$$I_1 = \frac{V}{R_1} = \frac{220 \text{ V}}{100 \text{ ohms}} = 2.2 \text{ A}$$

$$I_2 = \frac{V}{R_2} = \frac{220 \text{ V}}{55 \text{ ohms}} = 4 \text{ A}$$

$$I_3 = \frac{V}{R_3} = \frac{220 \text{ V}}{40 \text{ ohms}} = 5.5 \text{ A}$$

$$I_4 = \frac{V}{R_4} = \frac{220 \text{ V}}{200 \text{ ohms}} = 1.1 \text{ A}$$

$$I = I_1 + I_2 + I_3 + I_4$$

$$= 2.2 \text{ A} + 4 \text{ A} + 5.5 \text{ A} + 1.1 \text{ A} = 12.8 \text{ A}$$

Checking the calculation

$$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \frac{1}{R_4}$$

$$= \frac{1}{100} + \frac{1}{55} + \frac{1}{40} + \frac{1}{200}$$

$$= \frac{22 + 40 + 55 + 11}{2200} = \frac{128}{2200} = \frac{16}{275}$$

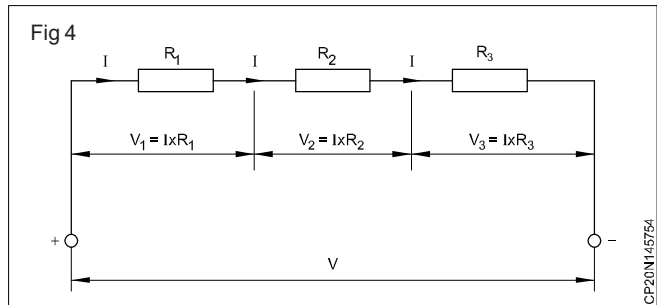
$$\frac{1}{R_{\text{TOT}}} = \frac{16}{275}$$

$$R_{\text{TOT}} = 17.19 \text{ ohms}$$

$$I = \frac{V}{R_{\text{TOT}}} = \frac{220 \text{ V}}{17.19 \text{ ohms}} = 12.798 \text{ A}$$

Kirchhoff's second law

A simple case: In closed circuits, the applied terminal voltage V is equal to the sum of the voltage drops $V_1 + V_2$ and so forth. (Fig 4)



If all the generated voltages are taken as positive, and all the consumed voltages are taken as negative, then it can be stated that:

in each closed circuit the sum of all voltages is equal to zero.

$$\Sigma V = 0$$

Example

Given

$$V = 220 \text{ V}$$

$$R_1 = 36 \text{ ohms}$$

$$R_2 = 40 \text{ ohms}$$

$$R_3 = 60 \text{ ohms}$$

$$R_4 = 50 \text{ ohms}$$

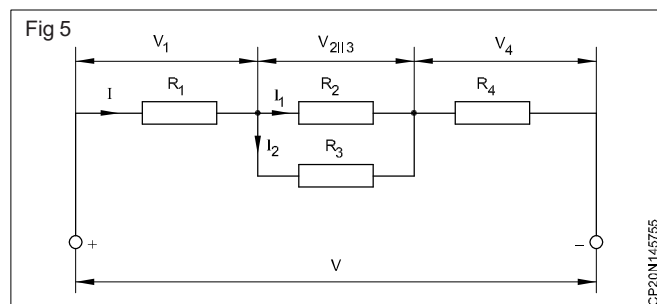
Find

$$R, I, I_1, I_2,$$

$$V_1, V_2, V_3, V_4$$

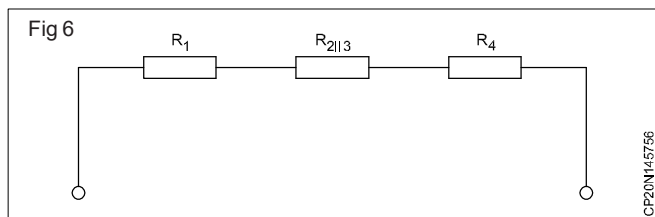
Solution

Apply Kirchhoff's First Law to find the voltage drops in the branches (Fig 5).



Calculate the total resistance R of the series circuit according to Kirchhoff's Second Law. (Fig 6)

First simplify by calculating the equivalent resistance for R_2, R_3 according to Kirchhoff's First Law.



$$R_{2||3} = \frac{R_2 \times R_3}{R_2 + R_3} = \frac{40 \text{ ohms} \times 60 \text{ ohms}}{(40 + 60) \text{ ohms}}$$

$$= 24 \text{ ohms}$$

$$R_{\text{TOT}} = R_1 + R_{2||3} + R_4$$

$$= 36 \text{ ohms} + 24 \text{ ohms} + 50 \text{ ohms}$$

$$= 110 \text{ ohms}$$

The total current I can now be calculated by means of Ohm's Law:

$$I = \frac{V}{R_{\text{TOT}}} = \frac{220 \text{ V}}{110 \text{ ohms}} = 2 \text{ A}$$

The partial voltages are accordingly:

$$V_1 = I \times R_1 = 2 \text{ A} \times 36 \text{ ohms} = 72 \text{ V}$$

$$V_{2||3} = I \times R_{2||3} = 2 \text{ A} \times 24 \text{ ohms} = 48 \text{ V}$$

$$V_4 = I \times R_4 = 2 \text{ A} \times 50 \text{ ohms} = 100 \text{ V}$$

Checking the calculation

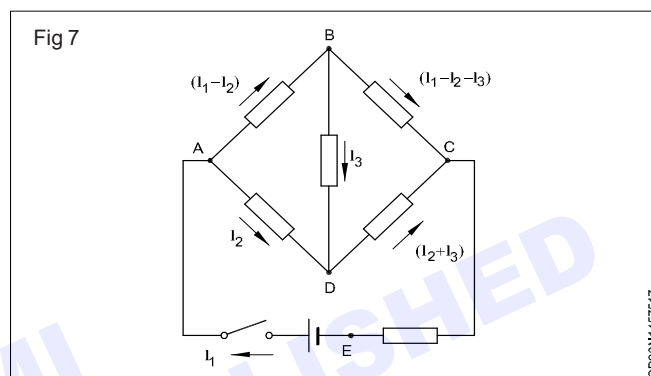
$$V = V_1 + V_{2||3} + V_4$$

$$220 \text{ V} = 72 \text{ V} + 48 \text{ V} + 100 \text{ V}$$

$$220 \text{ V} = 220 \text{ V}$$

Suggested steps for the application of Kirchhoff's Laws to solve problems.

- 1 Mark the nodes (junction points) in the given network.
- 2 Mark the current direction over each element (resistor) in the circuit. The current direction is arbitrary. But it is often convenient to use a direction that goes from $-ve$ to $+ve$ through an emf.
- 3 Indicate the loop currents with I_1, I_2, I_3 etc. Apply Kirchhoff's First Law to the junction nearer to it. (Fig 7)



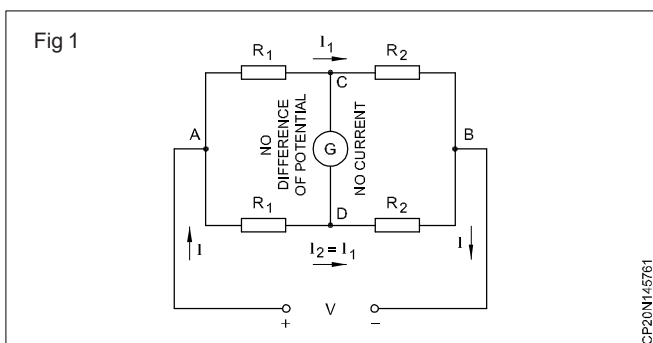
Wheatstone bridge - principle and its application

Objectives: At the end of this lesson you shall be able to

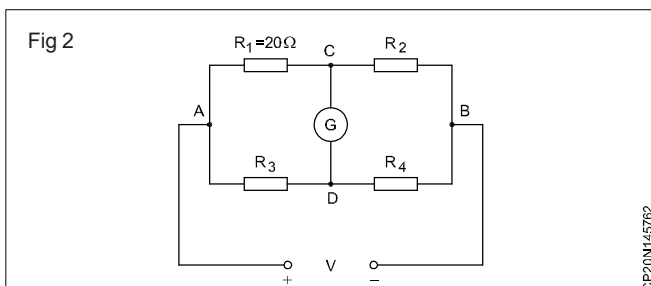
- describe the method of obtaining equal potential points in two branches of a parallel circuit
- state wheatstone bridge circuit, construction, function and uses.
- determine the unknown resistance by the wheatstone bridge.

Points of equal potential in parallel circuits: An electrical current flows only when a potential difference is present. Without a potential difference, current will not flow.

In the Fig 1, the resistances R_1 and R_2 in each of the parallel branches are equal. Therefore, the potential differences across the two resistors R_1 are equal, i.e. from A to C and from A to D. Hence, even when the points C and D are connected with the galvanometer no current will flow.



Four resistors R_1, R_2, R_3 and R_4 are arranged as shown in Fig 2. Select the values of R_2, R_3 and R_4 from the list so that no current flows between points C & D. Resistance values are 20 ohms, 30 ohms, 40 ohms, 70 ohms, 15 ohms.

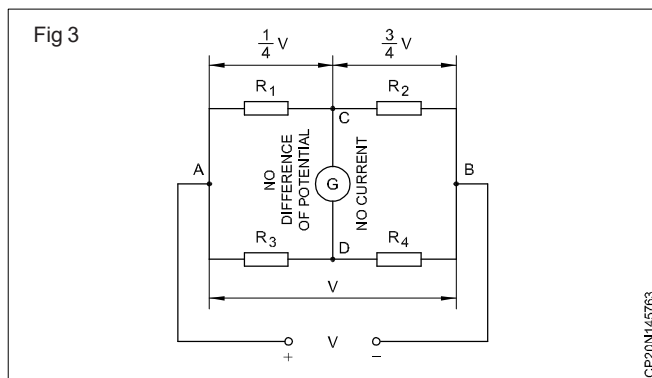


Equal resistance ratio in parallel circuit: One does not need equal resistances in the parallel circuits to obtain equal potential nodes. It suffices if the resistances are in the same ratio to each other.

In the circuit diagram (Fig 3), the resistances in the top conductor branch are in the ratio 1 : 3.

The resistances in the bottom conductor branch are also in the ratio 1:3. The supply emf V , is therefore, divided in the both conductor branches in the same ratio 1:3. The first potential difference is

$$= \frac{1}{4} V \text{ and second} = \frac{3}{4} V$$



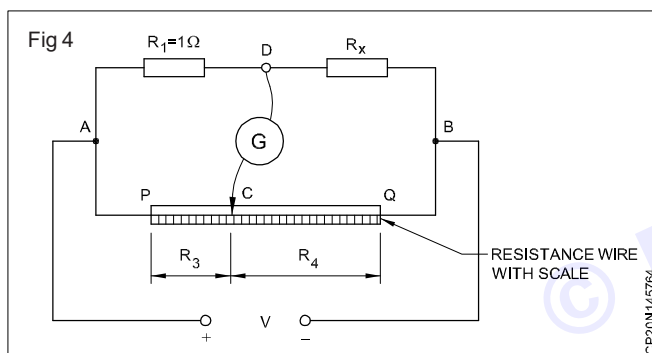
Again no current can flow in a conductor connected across the points C and D.

A conductor between C and D is called a bridge connection.

The wheatstone bridge circuit

The equal resistance ratio in parallel circuits can be used for the measurement of resistance.

In the circuit arrangement shown in Fig 4, the sliding contact C slides along a resistance wire.



R_1 is a standard resistor, e.g. 1 ohm.

The sliding contact C is moved along the resistance wire until the detector or bridge galvanometer across C-D reads zero. Then the resistance ratios in the two parallel branches are equal.

$$R_x : R_1 = R_4 : R_3$$

If $R_1 = 1$ ohm then

$$R_x = \frac{R_4}{R_3}$$

This circuit arrangement can, therefore, be used to measure an unknown resistance R_x . The resistance can be directly read from a scale on the resistance wire. (Fig 4)

For determining the unknown resistance by Wheatstone Bridge

- The current flowing through the bridge connection should be zero.
- The values of the other three resistances should be precisely known.

How to find no current flows through the bridge connection?: An instrument, that can indicate the flow of even a few micro amperes (millionth of an ampere), called

galvanometer, is used. There are galvanometers that give full scale deflection for 25 microamperes.

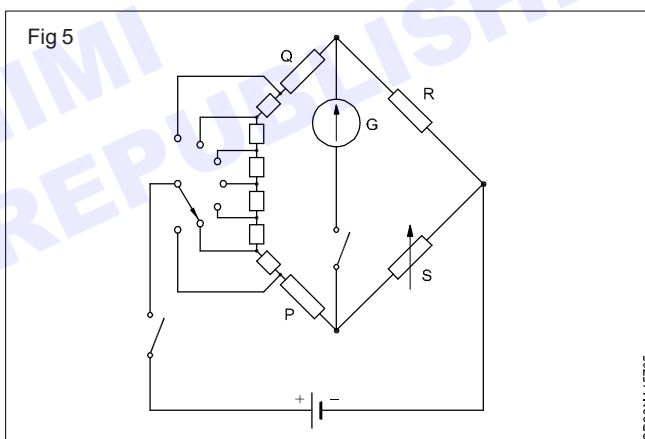
In the professional Wheatstone bridges, the galvanometer is provided with a parallel resistance and switch. The bridge connection is made only by pressing a push button. This enables the user to check a momentary deflection of the meter. In the case of excessive deflection, adjustment of the variable resistor is done. Final and precise adjustment of the variable resistance is made keeping the shunt resistor of the galvanometer open.

The three arms of the bridge are made of standard/precision resistors. The contact resistance is kept very low to increase the accuracy of the measurement made by the Wheatstone bridge.

In short, the use of the galvanometer is to ensure that the current through the bridge connection is zero, i.e. both parallel branches have equipotential points connected by the bridge connector.

This arrangement is named after its inventor and is called the Wheatstone Bridge.

The Wheatstone Bridge is used for measurements in the range of about 1.0 ohm to 1.0 megohm. In Fig 5, resistors P, Q and S are internal to the instrument. R is the resistor of unknown value to be measured.



The instrument is adjusted until the ratio $\frac{Q}{P} = \frac{R}{S}$

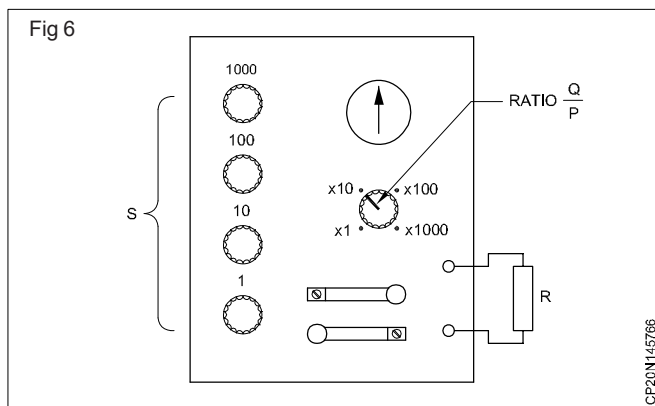
This is indicated by a zero reading on the galvanometer with its switch in the closed position.

The resistors P and Q are called ratio arms. P and Q are varied in steps to give a range of values and the resistance value of 'S' is set by the decade resistance S. (Fig 6)

$$R = \frac{Q}{P} \text{ multiplied by } S.$$

The ratio $\frac{Q}{P}$ is arranged to be 1, 10, 100 or 1,000 for ease of calculation.

S is the variable resistance. Four decade resistances are connected in series. The value of S can be set in steps of one ohm from 1.0 ohm to 9999 ohms by suitably setting the four decade resistance units.



Example 1: The Wheatstone Bridge circuit is used to determine the value of the unknown resistor R_x . The bridge is balanced when $P = 100$ ohms, $Q = 1000$ ohms and S is adjusted to 130 ohms. Calculate the value of the unknown resistor R_x . (Fig 7)

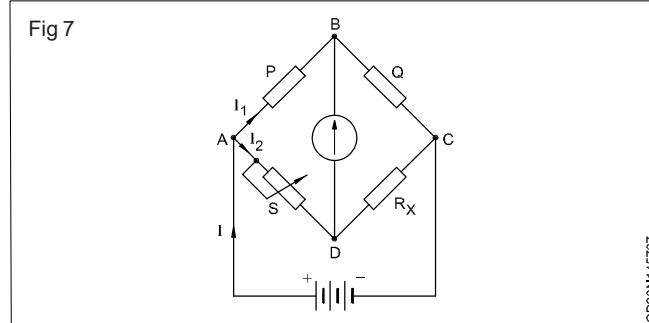
Solution

$$\text{At balance } V_{AB} = V_{AD}$$

$$\text{and } V_{BC} = V_{DC}$$

$$\text{therefore, } I_1 P = I_2 S$$

$$\text{and } I_1 Q = I_2 R_x$$



$$\frac{I_1}{I_2} = \frac{S}{P} = \frac{I_1}{I_2} = \frac{R_x}{Q}$$

$$\frac{S}{P} = \frac{R_x}{Q}$$

Electrolysis

Objectives: At the end of this lesson you shall be able to

- state the definition of electrolysis
- state definition of electrolytic and non electrolytic solutions
- state the first law of electrolytic.

Electrochemistry

The branch of chemistry which deals with the study of relationship between electrical energy and chemical energy and interconversion of one form of energy into another is called Electrochemistry.

Some common terms in Electrochemistry

Conductors and non - conductors : The substances which allow the passage of electricity through them are called conductors and which do not allow electricity is called non - conductors. The conductors can be broadly classified into two categories; metallic and electrolytes.

Metallic conductors: These are the metallic substances which allow the passage of electricity through them without undergoing any chemical change. Eg. Copper, Silver, Aluminium.

Electrolyte conductors : These are the substances which allow the passage of electricity through their molten state or through their aqueous solutions and also undergo chemical decomposition at the same time.

Definition of Electrolysis

Electrolysis is a chemical process that uses on electric current to drive a non - spontaneous reaction, causing a substance to decompose or a chemical change to occur at the electrodes it is commonly employed for extracting elements from compounds or separating them.

Classification of electrolytes

The electrolytes are classified based on their extent of ionization. These are strong and weak electrolytes Strong electrolytes.

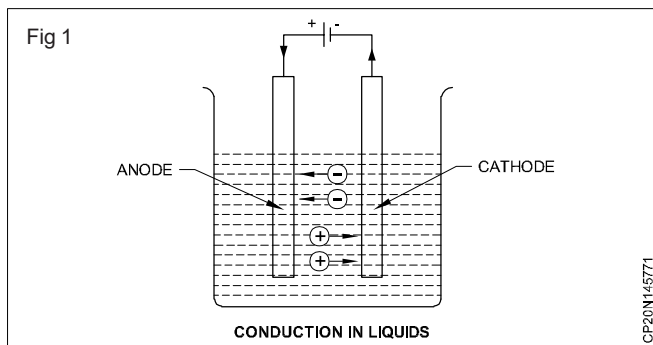
Strong electrolytes : These are almost completely ionized in their aqueous solutions Eg: HCl, H₂SO₄, etc., bases of this lesson you swash like NaOH, KOH, etc.,

Weak electrolytes : They ionize in aqueous solutions to the smaller extent. Eg: NH₂OH, CH₃COOH.

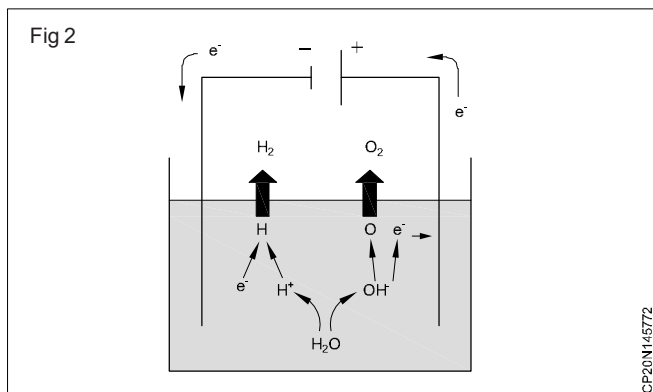
The substance which do not conduct electricity either in their molten state or through aqueous solution are called non-electrolyte. Eg: ethylalchol, sugar, glucose, etc.

Electrolysis

Electrolysis is the passage of an electric current through an ionic substance that is either molten or dissolved in a Suitable solvent, resulting in chemical reactions at the electrodes and separation of materials, Such solutions called electrolytes. The plated through which current enters and leaves an electrolyte areas electrodes are known as electrodes. The electrode towards which positive ions travel is called cathete and towards which negative ion travel is called cathode and towards which negative ion travel is called anode. The positive ions are called cations and negative ions are called anions (Fig 1)



Example: Electrolysis of water is the decomposition of water (H_2O) into oxygen (O_2) and hydrogen (H_2) due to an electric current being passed through the water (Fig 2)



Faraday's Law of Electrolysis

The factors affecting quantities of matter liberated during the process of electrolysis were investigated by Faraday.

Faraday's First Law of electrolysis

The quantity of a substance produced by electrolysis proportional to the quantity of electricity used i.e. $Q \propto W$

$$Q = z \times I \times t$$

where Q quantity of electricity or charge in coulombs (C), I current in amps (A), t = time (seconds) and z is a constant for the substance being liberated called as electrochemical equivalent.

The electrochemical equivalent of a substance is the mass of substance liberated in electrolysis when one coulomb charge is passed through the electrolyte.

Faraday's Second Law of Electrolysis

For a given quantity of electricity the quantity of substance produced is proportional to its weight i.e. $m \propto E$.

$$Q = n(e) \times F$$

where Q = quantity of electricity in coulombs (C), $n(e)$ = moles of electrons and F = Faraday constant = $96,500 \text{ C mol}^{-1}$.

The Faraday constant, F , is the quantity of electricity came by one mole of electrons.

$F = \text{Avogadro's Number} \times \text{Charge on electron in coulombs}$

$$F = 6.022 \times 10^{23} \text{ mol}^{-1} \times 1.602192 \times 10^{-19} \text{ C}$$

$$F = 96,484 \text{ C mol}^{-1}$$

This is usually rounded off to $96,500 \text{ C mol}^{-1}$ for calculation in chemistry

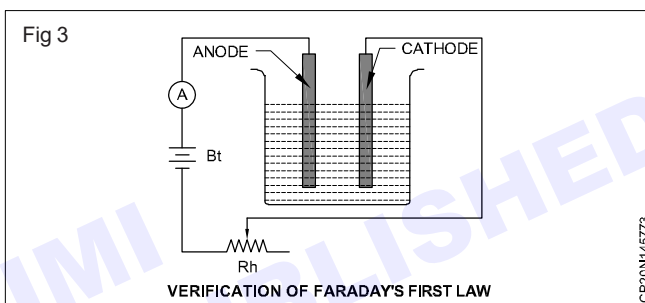
Verification of Faraday's Law of electrolysis

First Law: A battery, a rheostat, a key and an ammeter are connected in series to an electrolytic cell (Fig 3) The cathode is weighed. Then the cathode and anode are inserted in the cell. A current I_1 is passed for time t . The current is measured by the ammeter. The cathode is taken out and weighed. Hence the mass m_1 of the substance deposited is obtained. The cathode is reinserted in the cell and a different current is passed for the same time t . The mass m_2 is obtained.

$$\frac{m_1}{m_2} = \frac{I_1}{I_2}$$

$$\therefore m \propto I$$

The experiment is repeated for same current but, different time t_1 and t_2

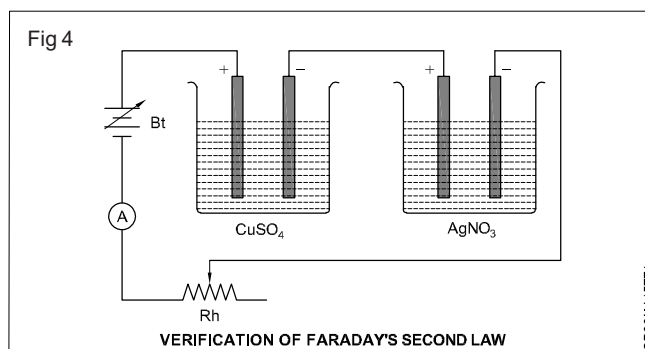


$$\frac{m_3}{m_4} = \frac{t_1}{t_2}$$

$$\therefore m \propto t$$

Therefore $m \propto it$. Thus first law is verified.

Second law: Two electrolytic cells containing different electrolytes CuSO_4 and AgNO_3 solution are connected in series as shown in Fig 4



Copper electrodes are inserted in CuSO_4 , and silver electrodes are inserted in AgNO_3 . The cathodes are cleaned, dried and weighed and then inserted in the respective cells. The current is passed for some time the cathodes are taken out and their masses of copper and silver are obtained.

Thus the second law is verified.

$$\frac{m_1}{m_2} = \frac{E_1}{E_2}$$

$$\therefore m \propto E$$

Thermodynamics

Thermodynamics in physics is a branch that deals with heat, work and temperature, and their relation to energy, radiation and physical properties of matter.

To be specific, it explains how thermal energy is converted to or from other forms of energy and how matter is affected by this process. Thermal energy is the energy that comes from heat. This heat is generated by the movement of tiny particles within an object, and the faster these particles move, the more heat is generated.

Thermodynamics is not concerned about how and at what rate these energy transformations are carried out. It is based on the initial and final states undergoing the change. It should also be noted that Thermodynamics is a macroscopic science. This means that it deals with the bulk system and does not deal with the molecular constitution of matter.

Modes of heat transfer

Objectives: At the end of this lesson you shall be able to

- state conduction, convection and radiation
- state determination of thermal conductivity
- state temperature and expansion of solid liquid.

Transmission of Heat

Heat is a form of energy and is capable of doing work. Heat flows from a hot body to a colder body or from a point of high temperature to a point of low temperature. The greater is the temperature difference the more rapidly will be the heat flow. Heat is transmitted in three ways.

- By Conduction
- By Convection
- By Radiation

Conduction

Conduction is the name given to the transmission of heat energy by contact. The heat source is in contact with the Conductor. (metal rod). The rod is in contact with a thermometer. Due to Conduction heat is transferred from the heated end to the free end. In general good electrical conductors are also good heat conductors and good electrical insulators are also good heat insulators. A good heat insulator does not necessarily withstand high temperature.

Convection

Convection is the name given to the transmission of heat energy by the up-ward flow. When heated, the fluid (liquid/gas) becomes less dense and because of its mobility, is

First Law of Thermodynamics

The first law of thermodynamics states that heat is a form of energy, and thermodynamic processes are, therefore, subject to the principle of conservation of energy. This means that heat energy cannot be created or destroyed. It can, however, be transferred from one location to another and converted to and from other forms of energy.

First Law of Thermodynamics Equation

The equation for the first law of thermodynamics is given as

$$\Delta U = q + W$$

Where,

ΔU = Change in internal energy of the system

q = Algebraic sum of heat transfer between system and surroundings

W = Work interaction of the system with its surroundings

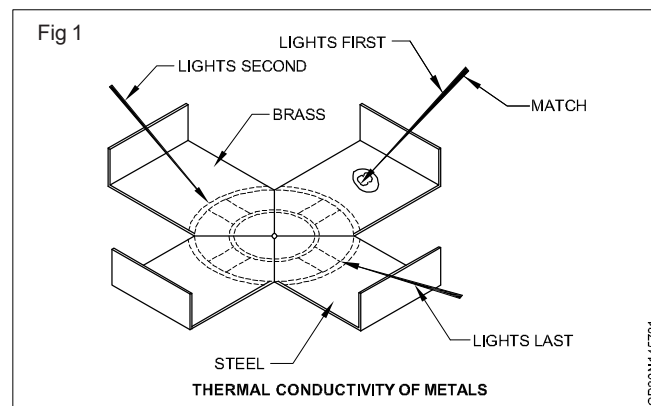
Mechanical equivalent of heat (J):

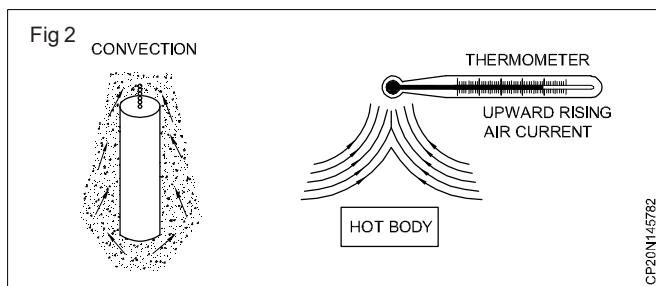
It is defined as the amount of work needed to produce 1 calorie of heat. or Mechanical equivalent of heat states that 4.1868 J of mechanical energy or work is required to raise the temperature of 1g of water for 1°C change in temperature.

displaced upwards, by a similar but colder and more dense fluid. e.g., The domestic hot water system, The cooling system in motor cars.

Radiation

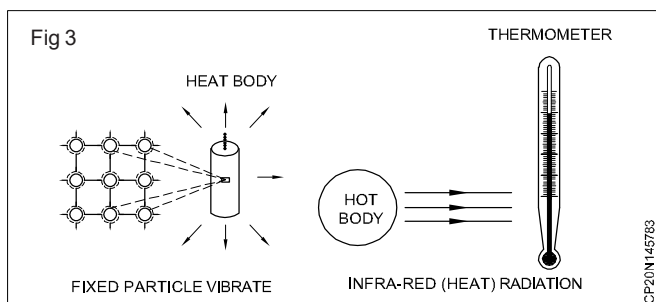
Heat is radiated or transmitted from one object to the other in space without actually being in contact, by means of electro-magnetic waves. These waves are similar to light waves and radio waves. They can be refracted by lenses and reflected by mirrors. This radiation is called infrared. It requires no medium to carry the radiation. (e.g) The heat of the sun travels through the space.





**Transmission of heat takes place in three ways
Conduction, Convection and Radiation.**

Expansion due to heat



When a solid, liquid or gaseous substance is heated, it expands and volume is increased. Similarly when it is cooled, it contracts (shrinks) and volume is decreased.

E.g : small gaps are left in between the lines of railway track to allow for expansion during summer. If this is not done, the rails would expand and bend thereby causing derailment of trains.

Except a few substances, all solids, liquids and gases expand. For the same amount of heat given, the expansion of liquids is greater than solid and expansion of gas is more than liquid.

Volume of water is reducing while heating from 0°C to 4°C. After that volume is increasing. The data at 4°C of water will be taken as reference point for any calculations relating with water.

Heat convection, conduction & radiation

Heat is the total amount of energy possessed by the molecules in a piece of matter. Heat is the process of energy transfer from one body to another. Energy transfer by heat can occur between objects by radiation, conduction and convection. This energy is both kinetic energy and potential energy.

When heat (i.e., energy), goes into a substance one of two things can happen.

- 1 The substance can experience a raise temperature, that is, the heat can be used to speed up the molecules of the substance. increase in temperature causes an equal increase in the average kinetic energy of the and the kinetic energy of the molecules the speed of the molecules will increase. The kinetic energy of a body is proportional to the square of the speed of the body
- 2 The substance can change state. For example, if the substance is ice, it can melt into water. The energy is

used to change the bonding between the molecules. Changing the manner in which the molecules bond to one another constitutes a change in potential energy. Heat comes in and there is an increase in the potential energy of the molecules. Their kinetic energy remains unchanged. So, when heat comes into a substance, energy comes into a substance. That energy can be used to increase the kinetic energy of the molecules, which would cause an increase in temperature. Or that heat could be used to increase the potential energy of the molecules causing a change in state that is not accompanied by an increase in temperature.

Amount of Heat Required to Rise temperature

The amount of heat needed to heat a subject from one temperature level to another can be expressed as:

$$Q = C_p m dT$$

Where Q = amount of heat (kJ), C_p = specific heat capacity (kJ/kg.K), m = mass (kg) and dT = temperature difference between hot and cold side (K).

Heat transfer

The three ways that heat transfer in our environment: convection, conduction and radiation.

Conduction: Conduction is the transfer of heat between substances that are in direct contact with each other. The better the conductor, the more rapidly the heat will transfer.

Good conductor Poor conductor (Insulators)

Copper	Wood
Silver	Styrofoam

Determination of thermal conductivity

The thermal conductivity of a material is after determined experimentally using various methods. One common method is the steady state heat conduction experiment here or the basic steps

- 1 **Set up:** A sample of the material is prepared in a specific shape, after a rod or a stop the ends of the sample are maintained at different temperatures.
- 2 **Measurement :** Heat is allowed to flow through the material and the temperature difference across the sample is measured. This is done under steady state conditions, where the temperatures do not change with time.
- 3 **Calculation:** Using fourier's law of heat conduction, which states that heat transfer is directly proportional to the temperature gradient, the thermal conductivity can be calculated.

Q = is the heat transfer

A = is the cross sectional Area

t = Temperature difference

d = is the thickness of the material

- 4 Considerations it is important to consider the materials properties such as its specific heat and density during the experiment to ensure accurate results.

Temperature

$$Q = \frac{KA}{\Delta t d}$$

The coefficient of cubical expansion (β) measures how the volume of a substance changes with temperature. It's defined as the fractional change in volume per degree celsius. The relationship is $V_2 = V_1 * (1 + \beta * \Delta T)$, where V_1 is the initial volume, V_2 is the final volume, β is the coefficient of cubical expansion, and ΔT is the change in temperature. Like the linear expansion coefficient, the cubical expansion coefficient varies for different materials.

Expansion of solid

When a solid is heated, its particles gain energy and vibrate more, causing the material to expand. This phenomenon is known as thermal expansion. The extent of expansion depends on the material's coefficient of linear or cubical expansion, as well as the temperature change. For linear expansion, the change in length is given by $\Delta L = \alpha * L_0 * \Delta T$, and for cubical expansion, the change in volume is given by $V_2 = V_1 * (1 + \beta * \Delta T)$. These formulas describe how solids respond to temperature changes by altering their dimensions.

Expansion of liquid: Similar to solids, liquids also undergo thermal expansion when heated. The molecules in a liquid

gain kinetic energy with an increase in temperature, leading to increased movement and, consequently, expansion. The expansion of liquids is often more noticeable in volume changes.

For liquids, the coefficient of volume expansion (β) is used to describe how the volume changes with temperature. The formula for the change in volume (ΔV) is given by $\Delta V = \beta * V_0 * \Delta T$, where ΔL is the change in length, L_0 is the initial length, and ΔT is the change in temperature. Different materials have different coefficients of linear expansion.

Coefficient of linear expansion: The coefficient of linear expansion (α) describes how a material's length changes with temperature. It's the fractional change in length per degree celsius. The formula is $\Delta L = \alpha * L_0 * \Delta T$, where ΔT is the change in temperature. Different materials have different coefficients of linear expansion.

Coefficient of cubical expansion: The coefficient of cubical expansion (β) measures how the volume of a substance changes with temperature. It's defined as the fractional change in volume per degree celsius. The relationship is $V_2 = V_1 * (1 + \beta * \Delta T)$, where V_1 is the change in volume, and ΔT is the change in temperature. Like the linear expansion coefficient, the cubical expansion coefficient varies for different materials.

Fundamental terms

Objectives: At the end of this lesson you shall be able to

- explain the current, its units and method of measurement (ammeter)
- explain the emf, potential difference, their units and method of measurement (voltmeter)
- explain resistance and its unit, and quantity of electricity.

Conductors, insulators and semiconductors

Conductors

A conductor is a material that has many valence electrons permitting electrons to move through it easily. Generally, conductors have many valence shells of one, two or three electrons. Most metals are conductors.

Some common good conductors are Copper, Aluminium, Zinc, Lead, Tin, Eureka, Nichrome, are conductors, where as silver and gold are very good conductors

Insulators

An insulator is a material that has few, if any, free electrons and resists the flow of electrons. Generally, insulators have full valence shells of five, six or seven electrons. Some common insulators are air, glass, rubber, plastic, paper, porcelain, PVC, fibre, mica etc.

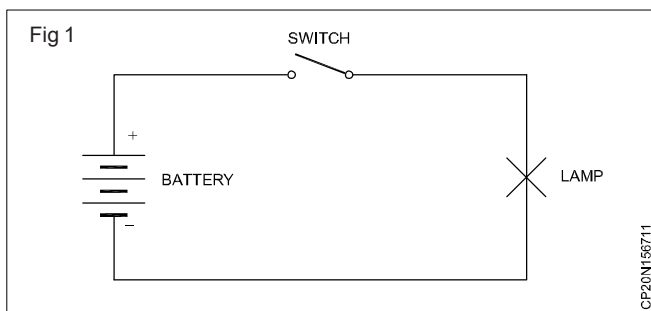
Semiconductors

A semiconductor is a material that has some of the characteristics of both the conductor and insulator. Semiconductors have valence shells containing four electrons.

Common examples of pure semiconductor materials are silicon and germanium. Specially treated semiconductors are used to produce modern electronic components such as diodes, transistors and integrated circuit chips.

Electric current

Flow of electric current is nothing but the flow of free electrons also called as electric current. Actually the electrons flow is from the negative terminal of the battery to the lamp and reaches back to the positive terminal of the battery. (Fig 1)



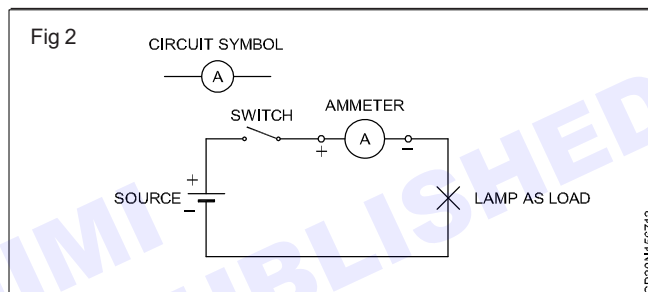
Ampere

The unit of current (abbreviated as I) is an ampere (symbol A). If 6.24×10^{18} electrons pass through a conductor per

second having one ohm resistance with a potential difference of one volt causes one ampere current has passed through the conductor.

Ammeter

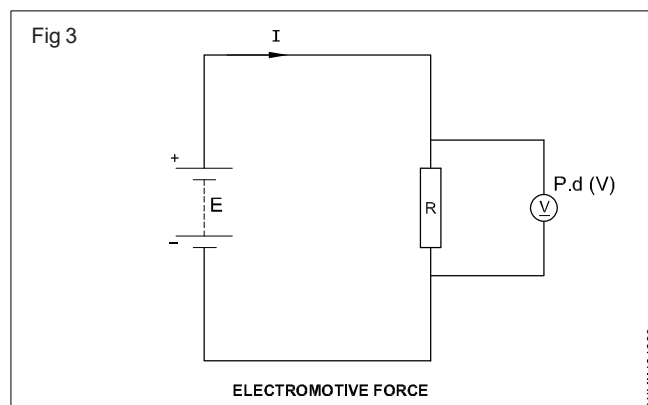
We know the electrons cannot be seen and no human being can count the electrons. As such an instrument called ammeter is used to measure the current in a circuit. It should be connected in series with the resistance (Load). (Fig 2)



Electro Motive Force (EMF) (Fig 3)

The terminals of the battery are indicated in the circuit symbol by two lines, the longer line for the positive and the shorter for the negative terminal.

Within the battery the negative terminal contains an excess of electrons whereas the positive terminal has a deficit of electrons. The battery is said to have an electromotive force (emf) which is available to drive the free electrons in the closed path of the electrical circuit. The difference in the distribution of electrons between the two terminals of the battery produces this emf.



In Simple,

Electromotive force (EMF) is the electrical force, which is initially available in electrical source, cause to move the free electrons in a conductor

Its unit is 'Volt'

It is denoted by letter 'E'

It cannot be measured by any meter. It can be only calculated by using the formula

$E = \text{Potential Difference (P.D)} + V. \text{ drop}$

$$= p.d + V. \text{ drop}$$

$$E = V + IR$$

Electromotive force is essential to drive the electrons in circuit

This force is obtained from the source of supply i.e. Torch lights, dynamo

System International (SI) unit of electromotive force is Volts (symbol 'E')

Potential Difference (PD)

The difference of voltage or force across two points in a circuit is called a potential difference (p.d) and is measured in volts.

The force which causes current to flow in the circuit is called emf. Its symbol is E and its unit is Volts (V). It can be calculated as

$\text{EMF} = \text{voltage at the terminal of source of supply} + \text{voltage drop in the source of supply}$

$$\text{or emf} = V_T + IR$$

Terminal voltage (V_T): It is the voltage available at the terminal of the source of supply. Its symbol is V_T . Its unit is also the volt and is also measured by a voltmeter. It is given by the emf minus the voltage drop in the source of supply, i.e.

$$V_T = \text{EMF} - IR$$

where I is the current and R is the resistance.

Types of electrical supply

Objectives: At the end of this lesson you shall be able to

- explain the difference types of electrical supply
- differentiate between alternating current and direct current
- explain the method of identification of polarity in DC source
- state the effect of electric current

There are various types of instruments working on different principles. Each instrument is designed to measure a particular electrical quantity or more than one quantity with suitable modification and necessary instruction. Further they may be designed to measure AC or DC supply quantities or can be used in either supply.

To enable proper use of the instruments, the technician should be able to identify the type of supply with the help of the details given below.

Type of electrical supply (Voltage)

There are two types of electrical supply in use for various technical requirements. The alternating current supply (AC) and the direct current supply (DC).

Hence EMF is always greater than p.d [$E.M.F > p.d$]

Voltmeter: Electrical voltage is measured with a voltmeter. In order to measure the voltage of a source, the terminals of the voltmeter must be connected to the terminals of the source. Positive to the positive terminal and negative to the negative terminal, as shown in Fig 4. The voltmeter connection is across or it is a parallel connection.

Resistance (R)

In addition to the current and voltage there is a third quantity which plays a role in a circuit, called the electrical resistance. Resistance is the property of a material by which it opposes the flow of electric current.

In absence of resistance in a circuit, the current will reach an abnormal high value endangering the circuit itself

Ohm: The unit of electrical resistance (abbreviated as R) is ohm (symbol Ω).

International Ohm

It is defined as that resistance offered to an unvarying current (DC) by a column of mercury at the temperature of melting ice (i.e. 0°C), 14.4521 g in mass, of constant cross-sectional area (1 sq. mm) and 106.3 cm in length.

International ampere

One international ampere may be defined as that unvarying current (DC) which when passed through a solution of silver nitrate in water, deposits silver at the rate of 1.118 mg per second at the cathode.

International volt

It is defined as that potential difference which when applied to a conductor whose resistance is one international ohm produces a current of one international ampere. Its value is equal to 1.00049V.



DC is represented by this symbol.

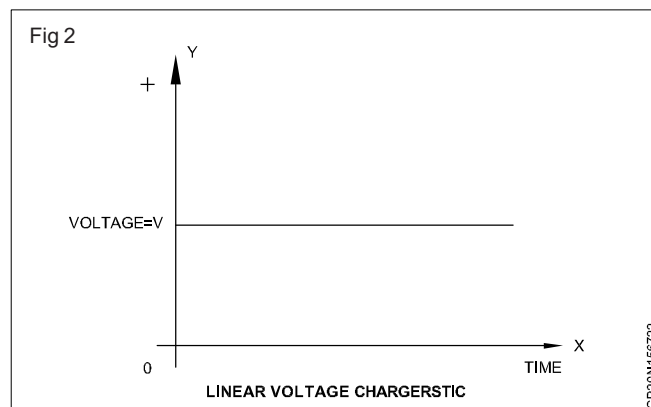
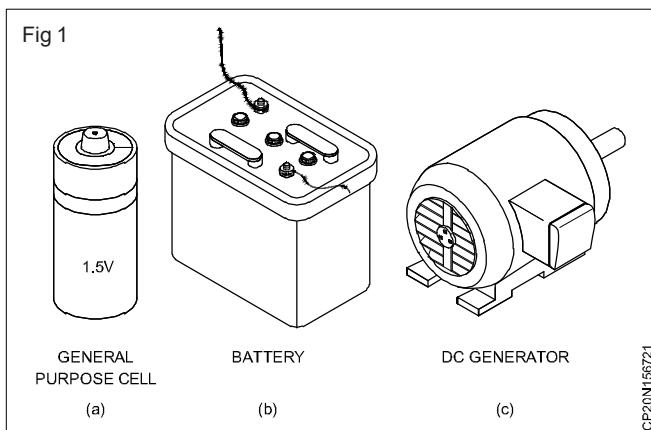


AC is represented by this symbol.

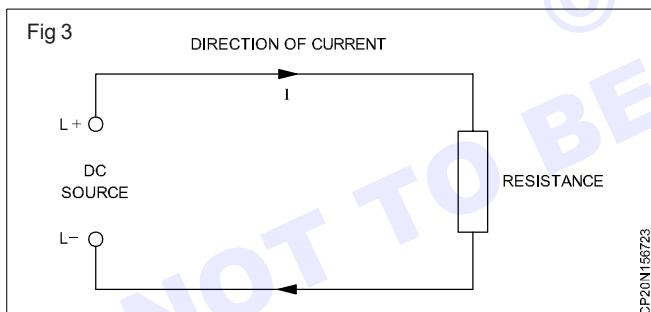
DC Supply

The most common sources of DC supply are the cells/batteries (Figs 1a and 1b) and DC generators (dynamos). (Fig 1C)

Direct voltage is of constant magnitude (amplitude). It remains at the same amplitude from the moment of switching on to the moment of switching off. The polarity of the voltage source does not change. (Fig 2)

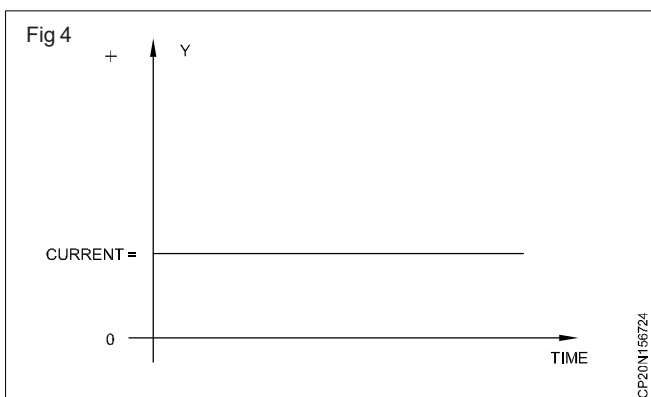


The polarity of direct voltage (commonly known as DC voltage) is positive (+ve) and negative (–ve). The direction of conventional flow of current is taken as from the positive to the negative terminal outside the source. (Fig 3)



Direct Current (DC) (Fig 4)

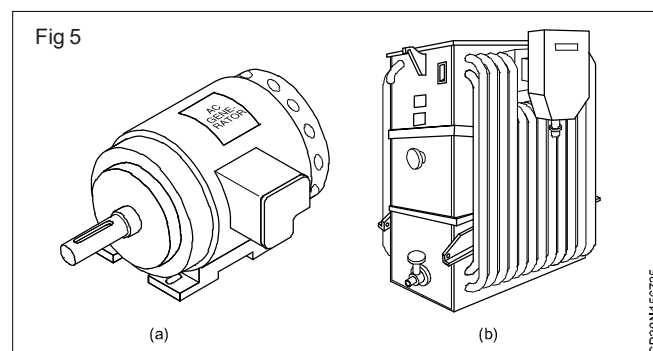
Voltage is the cause of electrical current. If a direct current flows through a circuit, the movement of electrons in the circuit is unidirectional.



Thus direct current remains at the same value from the moment of switching on to the moment of switching off. (Direct current in common usage is known as DC current.)

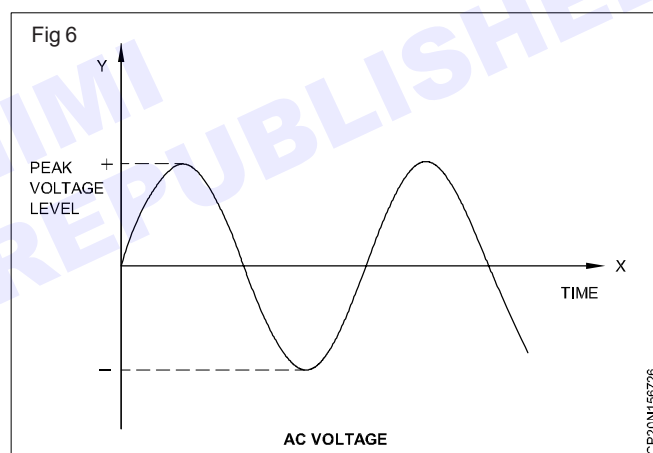
AC Supply

The source of AC supply is AC generators (alternators). (Fig 5a) The supply from a transformer (Fig 5b) is also AC.



Alternating voltage

AC supply sources change their polarity constantly, and consequently the direction of voltage also magnitude. The voltage supplied to our homes by power plants is alternating. Fig 6 shows a sinusoidal alternating voltage over time (wave-form).



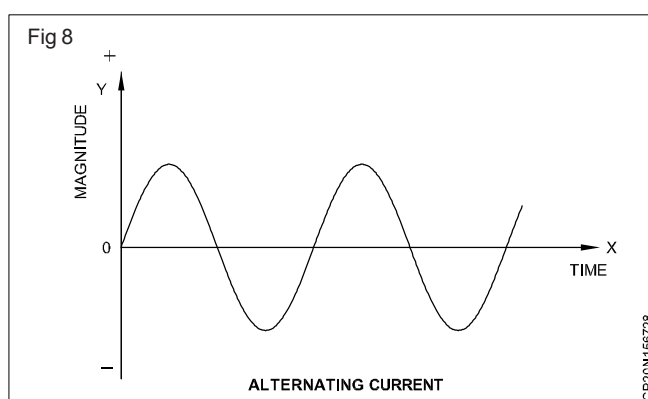
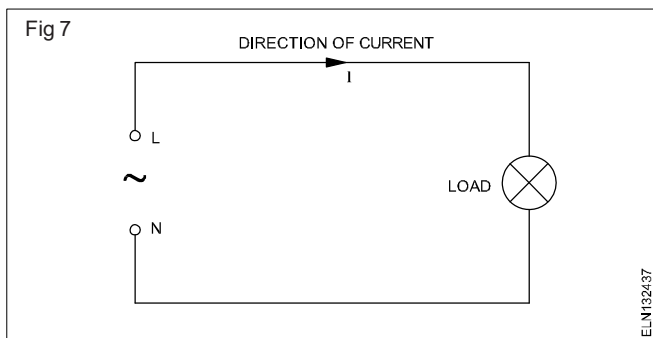
AC supply is expressed by the effective value of the voltage, and the number of times it changes in one second is known as frequency. Frequency is represented by 'F' and its unit is in Hertz(Hz).

For example, the AC supply used for lighting is 240V 50 Hz. (Alternating voltage in common use is known as AC voltage.) AC supply terminals are marked as phase/line(L) and neutral(N).

Current is caused in an electric circuit due to the application of voltage. If an alternating voltage is applied to an electrical circuit, an alternating current (commonly known as AC current) will flow. (Figs 7 and 8).

Importance of Grounding

Grounding is the process of connecting a conductor or an electrical device to the earth, effectively providing a safe and stable path for excess electricity to escape.



Comparison of AC and DC

	Alternating current	Direct current
Amount of energy that can be carried	Safe to transfer over longer city distances and can provide more power.	Voltage of DC cannot travel very far until it begins to lose energy.
Cause of the direction of flow of electrons	Rotating magnet along the wire.	Steady magnetism along the wire.
Frequency	The frequency of alternating current is 50Hz or 60Hz depending upon the country.	The frequency of direct current is zero.
Direction	It reverse its direction while	It flows in one direction in the circuit.
Current	It is the current of magnitude varying with time.	It is the current of constant magnitude.
Flow of electrons	Electrons keep switching directions - forward and backward.	Electrons move steadily in one direction or 'forward'.
Obtained from	AC generator and mains.	Cell or battery.
Passive parameters	Impedence.	Resistance only.
Power factor	Lies between 0 to 1.	It is always 1.
Types	Sinusoidal, trapezoidal, triangular, square	Pure and pulsating. flowing in a circuit.

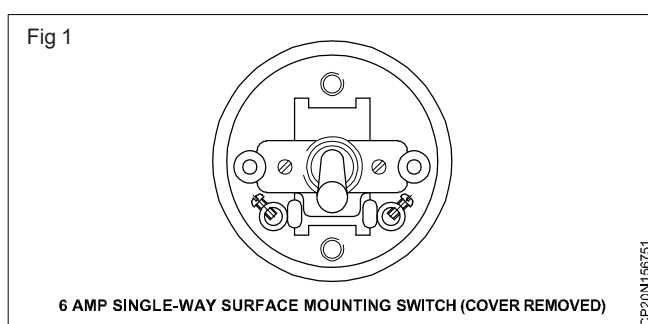
Types of switches : According to their function and place of use

- 1 Single pole, one-way switch
- 2 Single pole, two-way switch
- 3 Intermediate switch
- 4 Bell-push or push-button switch
- 5 Pull or ceiling switch
- 6 Double pole switch (DP switches)
- 7 Iron clad double pole, (ICDP) switch.
- 8 Iron clad triple - pole (ICTP) switch.

Of the above 1,2,3,4 and 6 may be either surface mounting type or flush-mounting type.

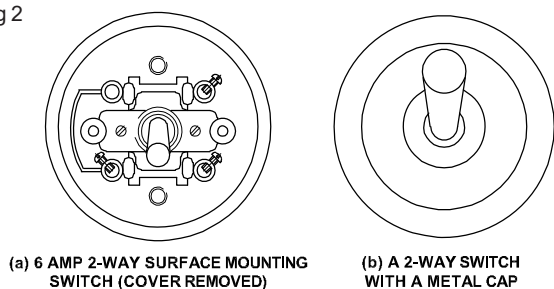
Single pole, one-way switch: This is a two terminal device, capable of making and breaking a single circuit only. A knob is provided to make or break the circuit

(Fig 1). It is used for controlling light or fan or 6 amps socket.



Single pole, two-way switch : This is a terminal device capable of making or breaking two connections from a single position (Fig 2). These switches are used in stair case lighting where one lamp is controlled from two different places. Though four terminals could be seen two are short circuited and only three terminals are available for connection.

Fig 2

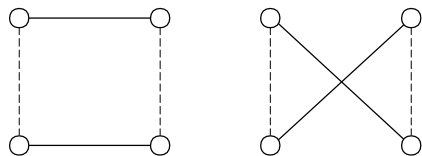


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However, both single way and two-way switches with their cover look alike (Fig 2b) but can be differentiated by looking at the bottom. Single way switches will have two terminal posts whereas two-way switches will have four terminal posts.

Intermediate switch : This is a four-terminal device capable of making or breaking two connections from two positions (Fig 3). This switch is used along with 2 way switches to control a lamp from three or more positions.

Fig 3



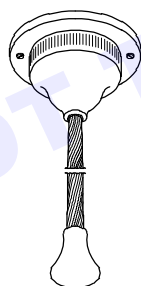
INTERMEDIATE SWITCH CONNECTIONS

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Bell-push or push-button switch: This is a two-terminal device having a spring-loaded button. When pushed it 'makes' the circuit temporarily and attains 'break' position when released.

Pull or ceiling switch (Pendent switch): This switch is normally a two-terminal device functioning as a one-way switch to make or break a circuit (Fig 4).

Fig 4



PULL SWITCH

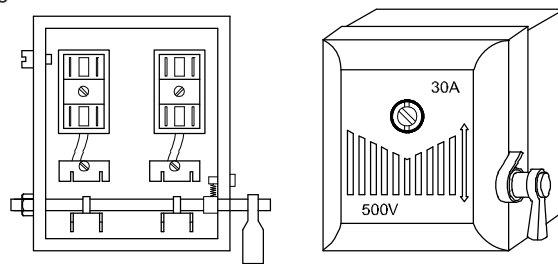
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This switch is mounted on ceilings. As the user could operate the switch from a distance through the insulated cord, this could be used safely for operating water heaters in bathrooms or fan or lights in bedrooms.

Double pole switch (DP switch): This is a switch with two poles, the two poles being mechanically coupled together. It is operated with a knob. It is also provided with a fuse and a neutral link. These switches are used as main switches to control main or branch circuits in domestic installation.

Iron - Clad Double pole (ICDP) main switch : This switch is also referred to as DPIC switch and is mainly used for single phase domestic installations, to control the main supply. It controls phase and neutral of the supply simultaneously (Fig 5).

Fig 5



DPIC MAIN SWITCH

CP20N156755

This switch consists of two fuse-carriers. The one in the phase circuit is wired with the fuse and the other in neutral is linked with a brass plate or thick copper wire. These switches should be earthed properly to safeguard the user. The current rating of the switch varies from 16 amps to 200 amperes.

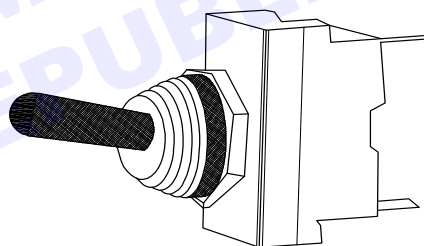
Specification of these switches should have:

- current rating
- voltage rating
- type of enclosure (sheet steel or cast iron).

Toggle switches (Fig 6)

It is an electric switch operated by means of a projecting lever that can be moved upward and downward and is also called as snap switches.

Fig 6



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The toggle switches are generally specified based on

- Number of poles (single / double/ triple etc.)
- Number of throws (single / double/ double with center OFF etc.)
- Current rating (3,6,10,16,20 & 25A)
- Voltage rating (125V & 250V , AC)
- Size (8,10,12,15mm etc.)
- Knob type (Brass/ plastic and oval/ round/flat etc.)

The two methods of damping, commonly employed are:

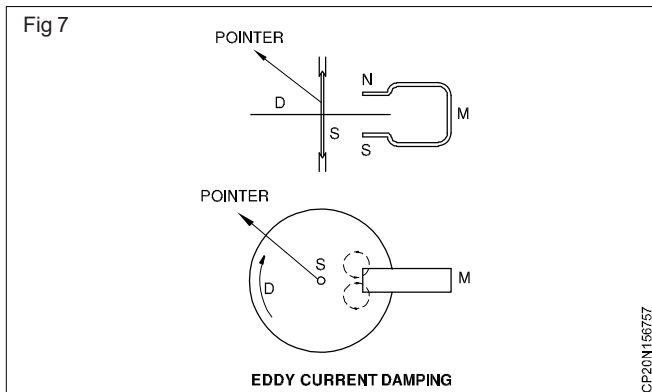
- eddy current damping
- air friction damping.

Eddy current damping: Fig 7 shows one form of eddy current damping. A copper or aluminium disc D, is attached to the spindle 'S'. When the pointer moves, the disc also moves.

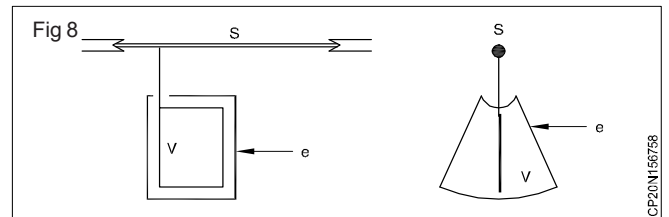
The disc is made to move in the air gap between the poles of a permanent magnet M. The moving disc cuts the flux, thereby inducing eddy currents in the disc. According to

Lenz's law, the flux produced by the eddy current opposes the movement of the disc, thereby effecting the damping force.

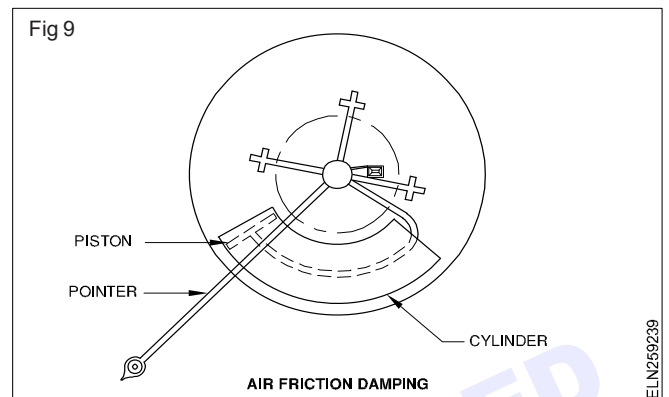
In the case of moving coil instruments, the moving coil is wound on a thin aluminium former. The eddy currents induced in the former produces the damping force.



Air friction damping: Fig 8 shows the method of obtaining air friction damping. Accordingly a thin metal vane V is attached to the spindle S, and the vane is made to move inside a sector shaped box 'e' while the pointer moves on the graduated scale.



Alternatively, the vane in the form of a piston could be arranged to move inside an air chamber (cylinder) as shown in Fig 9. In the above two cases, the air inside the air chamber opposes the movement of the vane/piston, and, thereby, the damping force is created.



Permanent Magnet Moving Coil (PMMC) instruments

Objectives: At the end of this lesson you shall be able to

- state the principle of a permanent magnet moving coil (P.M.M.C) instrument
- describe the construction and operation of a P.M.M.C instrument
- state the uses, advantages and disadvantages of a P.M.M.C instrument.

Moving Coil and Moving Iron Instruments :

Instruments are classified based on their moving system
 They are :

- Moving Coil Instruments (MC)
 - Permanent Magnet Moving Coil Instrument (PMMC)
 - Dynamo meter type instruments
- Moving Iron Instruments (MI)
 - Attraction type
 - Repulsion type

Permanent magnet moving coil (PMMC) instruments

The most commonly used instrument to measure DC quantities like voltage and current, is the permanent magnet moving coil (PMMC) instrument.

Principle: The working of the PMMC instrument is based on the principle that when a current-carrying conductor is placed in a magnetic field, it is acted upon by a force which tends to move the conductor. The DC motor also works on this principle.

Construction: The PMMC instrument consists of a permanent magnet and a rectangular coil wound with a very fine gauge insulated copper wire on a thin light aluminium former.

The aluminium former not only supports the coil, but also produces eddy current for damping. The coil and the former are attached with spindles on either side, and supported by jewelled bearings so as to make the assembly move freely in the air gap (Fig 1).

The two ends of the coil are connected to two phosphor-bronze springs, fixed one on each spindle to lead in and lead out the current. The springs are spirated in the opposite direction in order to neutralize the effect of temperature changes.

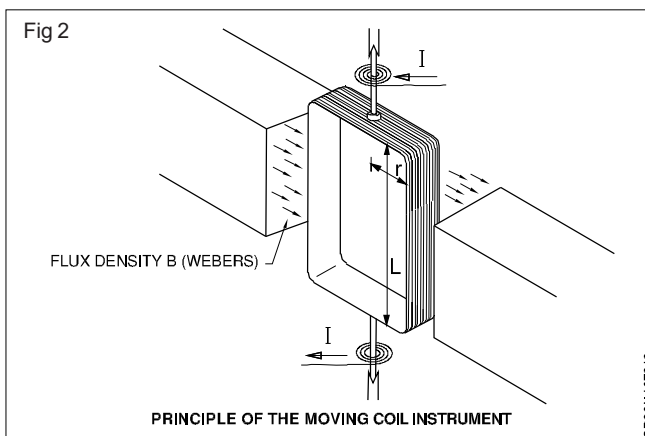
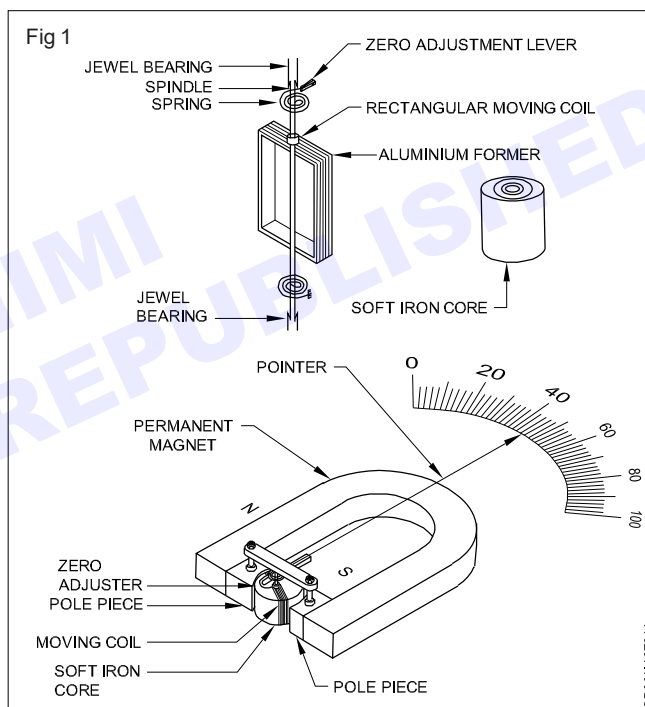
The horseshoe shaped permanent magnet is made of an alloy called 'Alnico' and it has soft iron pole pieces which are shaped to distribute uniform flux in the air gap.

A soft iron core is fixed in such a way that the moving coil can move within the gap, between the soft iron core and the pole pieces. The function of the soft iron core is (i) to decrease the reluctance of the magnetic path between the poles and thereby increase the magnetic flux and (ii) to make the flux uniformly distributed in the air gap.

The pointer is attached to one of the spindles, and it moves on a graduated scale when the coil is deflected by the quantity to be measured.

Operation: When the current is passed through the coil, the coil experiences a force due to the interaction of the magnetic fluxes, produced by the permanent magnet and the current in the moving coil.

We have the force 'F' in the coil equal to $BLIN$ Newtons
 Fig 2



where

- B - The flux density in the air gap in Webers/square metre,
- L - The active length of one conductor in the air gap in metres
- I - The current in amperes passing through the coil and N is the number of turns.

Torque produced in the coil

= force X perpendicular distance between the centre of the conductor to the centre of the spindle in metres.

Let us assume the distance as 'r' metres.

Hence we have

$$T = Fr \text{ Newton metres}$$

$$T = BLINr \text{ Newton metres.}$$

$$(F = BLIN \text{ Newton})$$

But B, L, N and r are constants for a particular instrument and can be denoted by a letter 'K'. As such

$$\text{Torque} = KI$$

Torque proportional to I

From the above equation we can infer that the deflecting torque of a PMMC instrument is directly proportional to the current, and, therefore, the scale of the PMMC instrument is uniform that is the scale in which the space between numbers are equal.

Full scale deflection current: This is the maximum current flowing through the moving coil to give full scale deflection of an instrument.

Meter sensitivity: It is an important characteristic of any meter. The amount of current necessary to cause full scale deflection of the meter pointer is the meter sensitivity. The typical current meter sensitivity varies from about 5 microamperes to 75 milliamperes.

However, the direction of deflection of the moving coil depends upon the direction of the current flowing through the coil. As such, if the instrument is connected with

reverse polarity, the deflection of the coil will be reversed, and the pointer will try to move in an anticlockwise direction and read below zero.

Hence, while connecting the instrument in DC the polarity should be correctly observed. Further the instrument will not deflect when connected to an AC supply.

Uses/advantages/disadvantages: As a PMMC instrument is a polarized instrument, it could be used only in DC.

The PMMC instrument could be directly used to measure milli or micro amperes as the moving coil can carry a low current only. With proper shunts, this instrument could be used to measure large currents, and with proper series resistors, called multipliers, it could be converted into a voltmeter. (The procedure of extending the range of an ammeter or converting it into a voltmeter will be dealt with in another lesson).

Advantages: The PMMC instrument

- consumes less power
- has uniform scale and can cover an arc up to 270°
- has high torque/weight ratio
- can be modified as voltmeter or ammeter with suitable resistors
- has efficient damping
- is not affected by stray magnetic fields, and
- has no loss due to hysteresis.

Disadvantages: The PMMC instrument

- can be used only in DC
- is very delicate
- is costly when compared to a moving iron instrument
- may show errors due to loss of magnetism of the permanent magnet.

Uses:

It can be used as volt meter and Ammeter

Moving-iron instruments

Objectives: At the end of this lesson you shall be able to

- state the principle of moving-iron instruments - attraction and repulsion type
- describe the construction and working of a moving-iron instrument
- state the use, advantages and disadvantages of moving-iron instruments.

Moving-iron instruments: This instrument derives its name from the fact that a piece of soft iron which is attached to the spindle and needle moves in a magnetic field, produced by the current or by a current proportional to the quantity of electricity being measured.

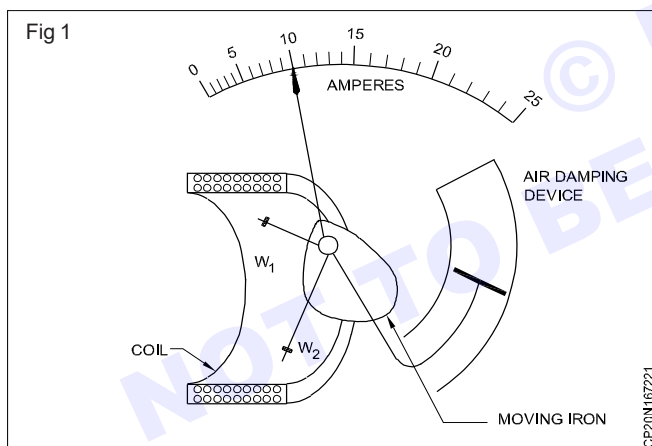
There are two types of this instrument which are used either as voltmeter or ammeter.

They are:

- attraction type
- repulsion type.

Principle of operation: The attraction type instrument works on the principle of magnetic attraction, and the repulsion type instrument works on the principle of magnetic repulsion between two adjacent pieces of soft iron, magnetised by the same magnetic field.

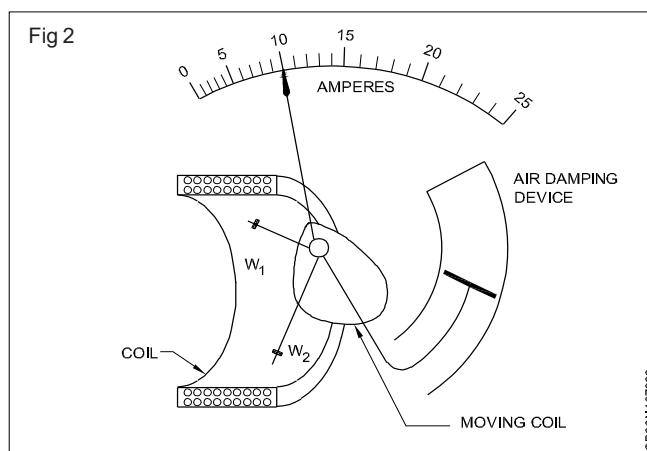
Construction and working of attraction type moving-iron instrument: This instrument consists of an electromagnetic coil having an air core (Fig 1). Just in front of the air core, an oval shaped soft iron piece is eccentrically pivoted in a spindle (Fig 1).



The spindle is free to move with the help of the jewelled bearings, and the pointer, which is attached to the spindle, could thus move over the graduated scale. When the electromagnetic coil is not connected to the circuit, the soft iron piece hangs vertically down, due to gravitational force and the pointer shows zero reading.

When the electromagnetic coil is connected to the supply, the magnetic field created in the coil attracts the soft iron piece (Fig 2). Due to the eccentricity of pivoting of the iron piece, the enlarged portion of the iron piece is pulled towards the coil. This in turn moves the spindle and makes the pointer to deflect.

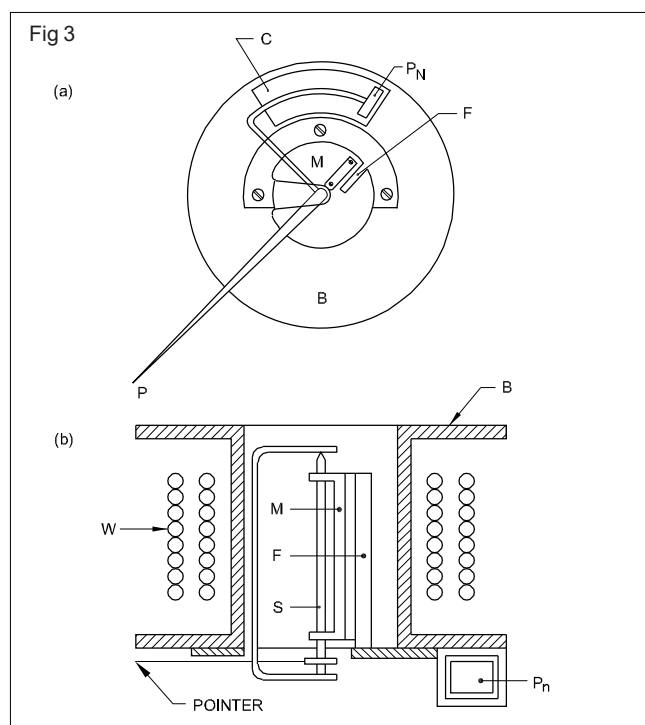
The amount of deflection of the pointer will be greater when the current producing the magnetic field is greater. Further the attraction of the soft iron piece is independent on the current direction in the coil. This characteristic enables the instrument to be used both in DC and AC.



Construction and working of repulsion type moving-iron instrument: This instrument consists of a coil wound on a brass bobbin B, inside which two strips of soft iron M and F are set axially (Fig 3a). Strip F is fixed whereas the iron strip M is attached to the spindle S, which also carries the pointer P.

Spring control is used, and the instrument is designed such that when no current is flowing through W, the pointer is at zero position and the soft iron strips M and F are almost touching. (Fig 3a & 3b)

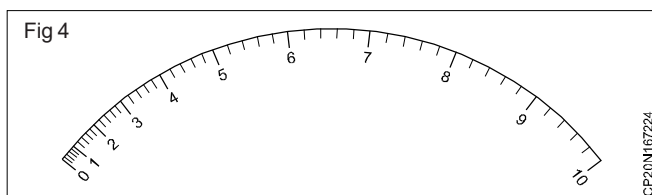
When the instrument is connected to the supply, the coil W carries current which in turn produces a magnetic field. This field makes the fixed and moving-iron F and M respectively to produce similar poles in the ends. Therefore, the two strips repel each other.



The torque set up produces a deflection of the moving system end. Therefore it brings into play a controlling torque due to torsion of the control springs or weights. The moving system comes to rest in such a position that the deflecting and controlling torques are equal.

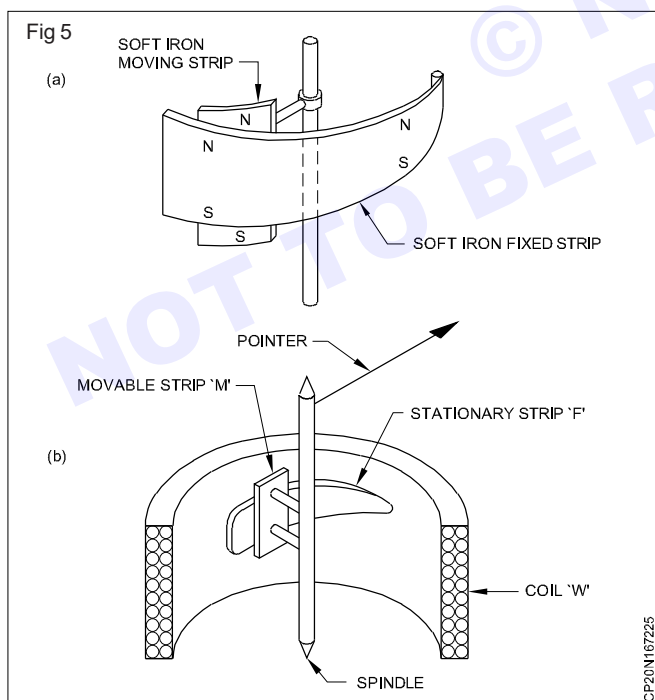
In this type of instrument, air damping is used commonly which is provided by the movement of a piston P_N in a cylindrical air chamber C (Fig 3a).

Deflecting torque and graduation of scale: However, in the moving-iron instruments, the deflecting torque is proportional to the square of the current passing through the coil. As such the scale of this instrument will be uneven. It is cramped at the beginning and open at the end (Fig 4).



In order to achieve uniformity of scale, some manufacturers have designed tongue shaped strip as fixed soft iron (Fig 5a).

The fixed iron consists of a tongue-shaped soft iron sheet bent into a cylindrical form, while the moving iron is made of another soft iron sheet, and is so mounted as to move parallel to the fixed iron and towards its narrower end (Fig 5b).



The torque, which is proportional to the square of the current, is proportionally reduced by the narrow portion of the fixed iron, resulting in more or less even torque and thereby uniform scale.

These instruments are either gravity or spring controlled, and the damping is achieved by the air friction method

Uses, advantages and disadvantages of Moving-iron instruments

Uses: They are used as voltmeters and ammeters.

They can be used on both A/C and DC and, hence, are called unpolarized instruments.

Advantages

- They have a small value of friction errors as the torque/weight ratio is high.
- They are less costly when compared to the moving coil instruments.
- They are robust owing to their simple construction.
- They have satisfactory accuracy levels within the limits of both precision and industrial grades.
- They have scales covering 240° .

Disadvantages

- They have errors due to hysteresis, frequency changes, wave-form and stray magnetic fields.
- They have non-uniform scale usually. However, special manufacturing designs are utilized to get more or less uniform scales.

Moving Iron Instruments as an ammeter

It may be constructed for full scale deflection ϕ 0.1 to 30A without the use of shunts or current transformers. To obtain full scale deflection with currents less than 0.1A. If required a coil with a large number of fine wire same, which results in an ammeter with a high impedance.

The range of the instrument, when used as an ammeter, can be extended by using a suitable shunt across its terminals. No problem arises during operation with DC but the division of current between instrument and shunt changes with the change in applied frequency while using AC.

Ammeter

Objectives: At the end of this lesson you shall be able to

- explain the construction of Ammeter
- explain the working principles of Ammeter.

Meter is an electronic device used to measure a particular quantity and it is associated with the measurement system. Similarly, the ammeter is nothing but ampere-meter used to measure ampere value. Here ampere is the unit of current and ammeter is used to measure current. There are two kinds of electric current namely AC and DC. AC changes the flow of current direction at regular intervals whereas the DC supplies the current in one direction. This article discusses an overview of what is an ammeter, circuit, types and applications.

Definition: A device or instrument that is used to measure the current is called the ammeter. The unit of the current is ampere. So this device measures the current flow in ampere is named as an ammeter or ampere meter. The internal resistance of this device is '0' however in practical, it has some amount of internal resistance. The measuring range of this device mainly depends.

The working principle of an ammeter mainly depends on resistance as well as inductive reactance. This device includes extremely less impedance because it must include less amount of voltage drop across it. It is connected in series because the flow of current within the series circuit is the same.

The main function of this device is to measure the flow of current with the help of a set of coils. These coils have very low resistance & inductive reactance. The ammeter symbolic representation is shown below.

The construction of ammeter can be done in two ways like series and shunt. The following circuit represents the basic circuit diagram and the connection of the ammeter circuit in series and parallel are shown below.

Digital VoltMeter (DVM)

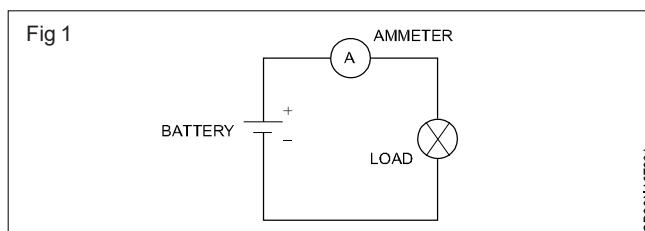
Objectives: At the end of this lesson you shall be able to

- distinguish between analogue and digital voltmeter
- list out the advantage of DVM
- explain the working principle of DVM.

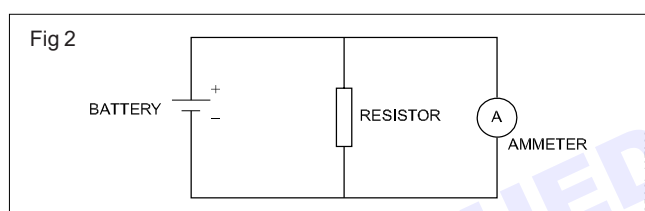
Digital VoltMeter (DVM)

The Digital VoltMeter(DVM) is an electrical measuring instrument which is used to measure line potential difference (P.D) between two points. The voltage to be measured may be AC or DC. Two types of voltmeters are available for the purpose of voltage measurement i.e. analog and digital. Analog voltmeters generally contain a dial with a needle moving over it according to the measure and hence displaying the value of the same.

Digital voltmeters display the value of AC or DC voltage being measured directly as discrete numerical instead of a pointer deflection on a continuous scale as in analog instruments.



Once this device is connected in series in the circuit, then the total measured current will flow through the meter, So the loss of power occurs within ammeter due to their internal resistance & the measurement current. This circuit includes less resistance so less voltage drop will occur within the circuit.



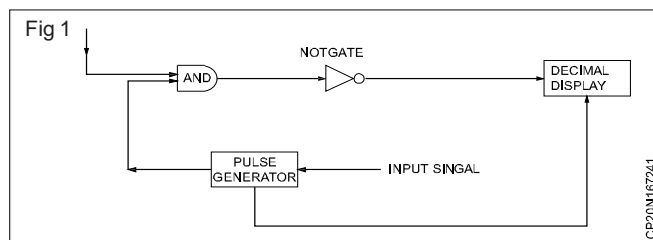
When the high current flows through this device, the internal circuit of the device will be damaged. To overcome this problem in the circuit the shunt resistance can be connected within parallel to the ammeter. If the huge measured current supplies throughout the circuit, the main current will pass throughout the shunt resistance. This resistance will not have an effect on the function of a device.

Advantages of Digital Voltmeters

- Read out of DVMs is easy as it eliminates observational errors in measurement
- Parallax error is eliminated
- Reading can be taken very fast
- Output can be fed to memory devices for storage and future computations
- More versatile and accurate
- Compact portable and cheap
- Requires low power

Working Principle of Digital Voltmeter

The block diagram of a simple digital voltmeter is shown in the Fig 1 It consists the following blocks



Input signal: It is basically the signal of voltage to be measured.

Wattmeters

Objectives: At the end of this lesson you shall be able to

- state the advantages of measuring power directly
- state the types of single phase wattmeters
- explain the construction and working of the induction type single phase wattmeter.

Advantages of measuring power supply

Power in a single phase AC circuit can be calculated by using an ammeter, a voltmeter and a power factor meter with the help of the formula

Power in a single phase circuit = $E I \cos \phi$ watts.

In the same way power in a 3-phase balanced circuit can be measured by using one ammeter, one voltmeter and one power factor meter with the help of the formula

$$\text{Power in a balanced 3-phase circuit} = 3E_P I_P \cos \phi$$
$$\text{or } \sqrt{3} E_L I_L \cos \phi$$

where $E_P I_P$ are the phase values and

$E_L I_L$ are the line values

This indirect method of measuring power in an AC circuit has the following disadvantages.

- Low accuracy due to a number of meters.
- Reading errors due to a number of meter readings.
- Involves calculation every time the load changes and hence not suitable for changing loads.

To get an on the spot true power reading, a wattmeter is used. The power dissipated in the circuit can be read directly from the scale of the meter. The wattmeter takes the power factor of the circuit into account and always indicates the true power.

Types of wattmeters

There are three types of wattmeters in use as stated below.

- Dynamometer wattmeter
- Induction wattmeter
- Electrostatic wattmeter

Among the three, the electrostatic type is very rarely used. Information given here is for the other two types only.

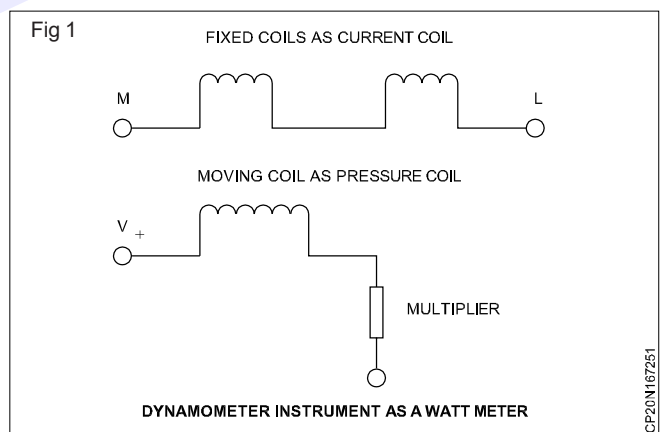
Pulse generator: Actually it is a voltage source. It uses digital, analog or both techniques to generate a rectangular pulse. the width and frequency of the rectangular pulse is controlled by the digital circuit inside the generator while amplitude with rise and fall time is controlled by analog circuitry

AND gate: It gives high output only when both the input are high, when a train pulse is fed to it along with rectangular pulse, it provides output having train time duration as same and the rectangular pulse from the pulse generator.

Dynamometer type, single phase wattmeter: This type is commonly used as a wattmeter. Construction details and the working of this type of meter have already been discussed . Hence the trainees are advised to read the information before proceeding further.

Dynamometer used as a Wattmeter: The dynamometer is commonly used as a wattmeter to measure power in both AC and DC circuits and will have uniform scale.

When this instrument is used as a wattmeter, the fixed coils are treated as current coil, and the moving coil is made as pressure coil with necessary multiplier resistance (Fig 1).



Advantages

- This instrument can be used both in AC and DC.
- As this is an air cored instrument, the hysteresis and eddy current losses are eliminated.
- This instrument has better accuracy.
- When used as wattmeter, the scale is uniform.

Disadvantages

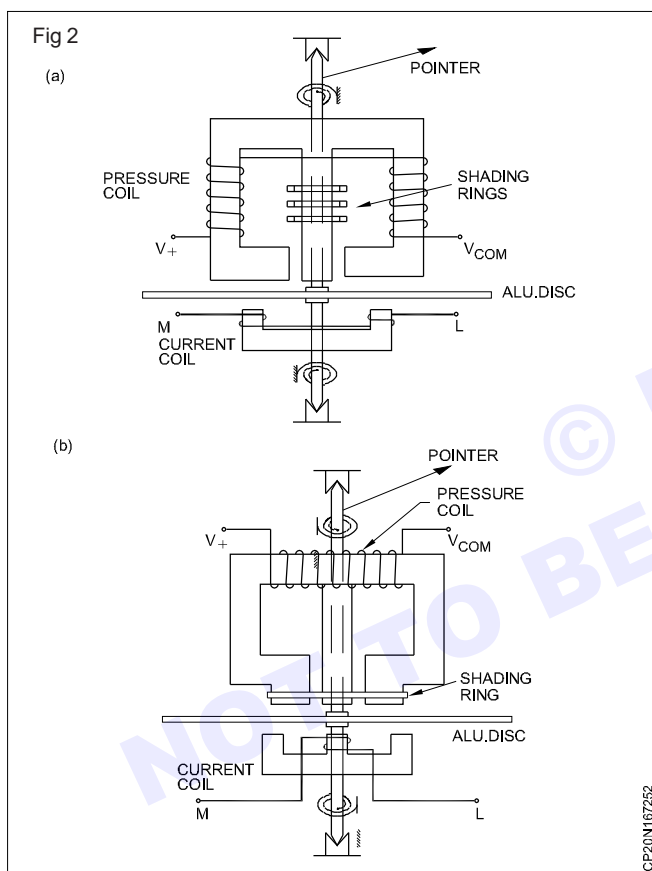
- It is more expensive than PMMC and moving iron instruments.

- When used as voltmeter or ammeter the scale will not be uniform.
- It has a low torque/weight ratio-as such has low sensitivity.
- Sensitive for over loads and mechanical impact. Hence careful handling is necessary.
- It consumes more power than PMMC meters.

Induction type single phase wattmeter: This type of wattmeters could be used only in AC circuits whereas a dynamometer type wattmeter could be used in both AC and DC circuits.

Induction type wattmeters are useful only when the supply voltage and frequency are almost constant.

Construction: Induction wattmeters having two different types of magnetic cores (Figs 2a and 2b).



Both the types have one pressure coil magnet and one current coil magnet. The pressure coil carries a current proportional to the voltage whereas the current coil carries the load current.

A thin aluminium disc is mounted on a spindle in between the space of the magnets and its movement is controlled by springs. The spindle carries a weightless pointer at one end.

Working: The alternating magnetic fluxes produced by the pressure and current coils cut the aluminium disc and

produce eddy currents in the disc. Due to the interaction between the fluxes and the eddy currents a deflecting torque is produced in the disc and the disc tries to move. Control springs attached to the two ends of the spindle control the deflection and the pointer shows the power in watts on a graduated scale.

Shaded rings provided in the pressure coil (shunt) magnet could be adjusted in order to cause the resultant flux in the magnet to lag in phase by exactly 90° behind the applied voltage.

Method of connecting wattmeter in single phase circuits - pressure coil connection to reduce erroneous measurement.

There are two ways of connecting the pressure coil of the wattmeter (Fig 3).

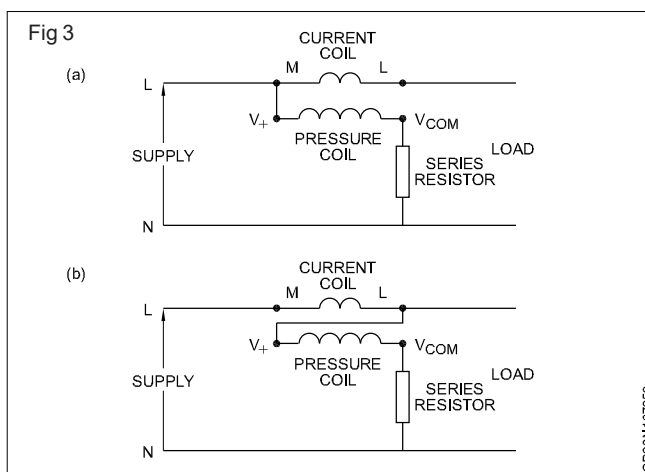
Both the methods shown in Figs 3a & b need correction in power measurement due to the reasons stated below.

In the method of connection shown in Fig 3a, the pressure coil is connected on the 'supply' side of the current coil, and hence, the error in power measurement is due to the fact that the voltage applied to the voltage coil is higher than that of the load on account of the voltage drop in the current coil. As such the wattmeter measures the load power in addition to the power lost in the current coil.

On the other hand, in the method of connection shown in Fig 3b, the current coil carries the small current taken by the voltage coil, in addition to the load current, thereby introducing errors in power measurement. As such the wattmeter measures the load power in addition to the power lost in the pressure coil.

If the load current is small, the voltage drops in the current coil will be small, so that the method of connection, shown in Fig 3a, introduces a very small error and, hence, preferable.

On the other hand, if the load current is large the power lost in the pressure coil will be negligible when compared to the load power in the method of connection shown in Fig 3b, and, hence, a very small error is introduced resulting in the preference of this connection.



Energy meter (analog and digital)

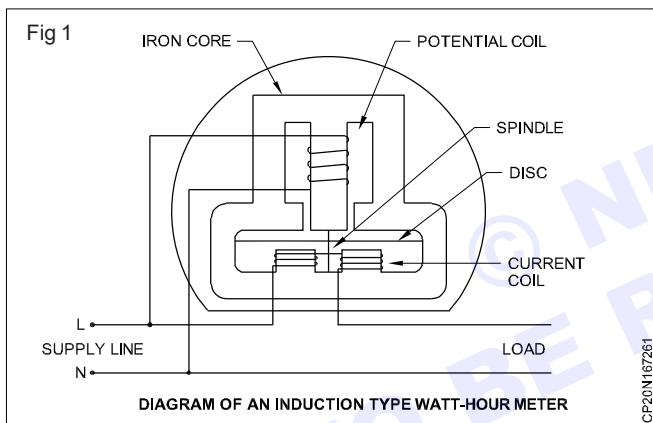
Objectives: At the end of this lesson you shall be able to

- describe the construction and working principle of single phase energy meters
- state and explain creeping error in energy meter.

Necessity of energy meter: The electrical energy supplied by the electricity board should be billed, based on the actual amount of energy consumed. We need a device to measure the energy supplied to a consumer. Electrical energy is measured in kilowatt hours in practice. The meter used for this is an energy meter.

In AC, an induction type of energy meter is universally used for measurement of energy in domestic and industrial circuits.

Principle of a single phase induction type energy meter: The operation of this meter depends on the induction principle. Two alternating magnetic fields produced by two coils induce current in a disc and produce a torque to rotate it (disc). One coil (potential coil) carries current proportional to the voltage of the supply and the other (current coil) carries the load current. (Fig 1) Torque is proportional to the power as in wattmeter.



The watt-hour meter must take both power and time into consideration. The instantaneous speed is proportional to the power passing through it.

The total number of revolutions in a given time is proportional to the total energy that passes through the meter during that period of time.

Parts and functions of an energy meter: The parts of the induction type single phase energy meter are (Fig 1).

Iron core: It is specially shaped to direct the magnetic flux in the desired path. It directs the magnetic lines of force, reduces leakage flux and also reduces magnetic reluctance.

Potential coil (voltage coil): The potential coil is connected across the load and is wound with many turns of fine wire. It induces eddy current in the aluminium disc.

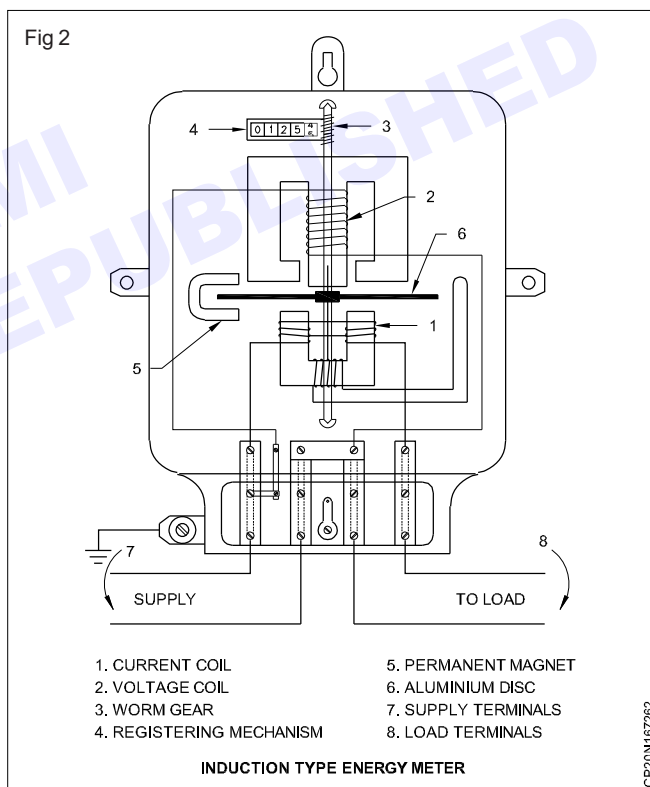
Current coil: The current coils, connected in series with load, are wound with a few turns of thick wire, since they must carry the full load current.

Disc: The disc is the rotating element in the meter, and is mounted on a vertical spindle which has a worm gear at one end. The disc is made of aluminium and is positioned in the air gap between the potential and current coil magnets.

Spindle: The spindle ends have hardened steel pivots. The pivot is supported by a jewel bearing. There is a worm gear at one end of the spindle. As the gear turns the dials, they indicate the amount of energy passing through the meter.

Permanent magnet/brake magnet: The permanent magnet restrains the aluminium disc from racing at a high speed. It produces an opposing torque that acts against the turning torque of the aluminium disc.

Functioning of energy meters: The rotation of the aluminium disc (Fig 2) is accomplished by an electromagnet, which consists of a potential coil and current coils. The potential coil is connected across the load. It induces an eddy current in the aluminium disc. The eddy current produces a magnetic field which reacts with the magnetic field produced by the current coils to produce a driving torque on the disc.



The speed of rotation of the aluminium disc is proportional to the product of the amperes (in the current coils) and the volts (across the potential coil). The total electrical energy that is consumed by the load is proportional to the number of revolutions made by the disc during a given period of time.

A small copper ring (shading ring) or coil (shading coil) is placed in the air gap under the potential coil, to produce a forward torque, large enough to counteract any friction produced by the rotating aluminium disc.

This counter torque is produced when the aluminium disc rotates in the magnetic field established by the permanent magnet. The eddy currents, in turn, produce a magnetic field that reacts with the field of the permanent magnet, causing a restraining action that is proportional to the speed of the disc.

The faster the disc rotates, the greater the induced eddy currents, and greater the restraining action. This restraining action is necessary to make the speed of rotation proportional to the current taken by the load and also to stop the disc from further rotation due to inertia when the supply is disconnected.

Creeping error and adjustment: In some meters the disc rotates continuously even when there is no current flow through the current coil i.e. when only the pressure coil is energised. This is called creeping. The major cause for creeping is over-compensation for friction. The other causes for creeping are excessive voltage across the pressure coil, vibrations and stray magnetic fields.

Digital Energy meters

Objectives: At the end of this lesson you shall be able to

- distinguish the merits of digital type over electromechanical type energy meter
- describe the functional operation of digital type energy meter from block diagram.

Energy meter

An electric meter or energy meter is an essential device enables systematic pricing of energy consumed by individual consumer as it measures the amount of electrical energy consumed by a residence, business or equipment.

Generally, energy meters operate by continuously measuring the instantaneous voltage and current and finding the product of these to give instantaneously electrical power (watts) which is then integrated against time to give energy is used in joules, kWh

The energy meters are classified into two basic categories. They are

- Electromechanical type
- Electronic (digital) type

Electro mechanical type energy meter

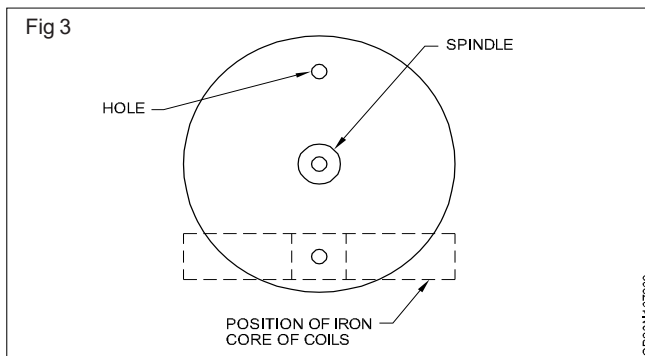
This meter has spinning disc and a mechanical counter display. It operates by counting the revolutions of a metal disc that rotates at a speed proportional to the power drawn through the main switch. Nearby coils spin the disc by inducing eddy currents and a force proportional to the instantaneous current and voltage

A permanent magnet exerts a damping force on the disc, stopping its spin after power has been removed

This type meter has these limitations

- Less accuracy
- Many methods for error correction
- Percentage error is more
- Installation is difficult
- No interface capability to external devices

In order to prevent creeping, two diametrically opposite holes are drilled in the disc (Fig 3). The disc will come to rest with one of the holes under the edge of a pole of the potential coil magnet, the rotation being thus limited to a maximum of half a revolution.



The above mentioned disadvantages are overcome in digital meter, such as more accuracy, error correction method is only by A/D converters, percentage of error is 0 (Zero), installation is more easier. The display makes energy reducing from time to time can be obtained.

Electronic (Digital energy meter)

This meters measure the energy using highly integrated components and it digitizes the instantaneous voltage and current in a high-resolution sigma-delta analogue to digital converter (ADC), gives the instantaneous power in watts. Integration over time gives energy used, measured in kilo-Watt hour. The block diagram for a digital meter is shown in Fig 1. The two sensors, voltage and current sensors are employed.

True energy is calculated from the ammeter, voltmeter, power factor meter and time.

$$\text{Hence True energy} = \frac{EI \cos \phi \times t (\text{sec})}{1000 \times 3600}$$

where 't' is in seconds.

The true energy can also be obtained from the reading of the substandard energy meter connected in the circuit instead of the ammeter, voltmeter and power factor meter and the

$$\% \text{ error} = \frac{\text{Recorded energy} - \text{True energy}}{\text{True energy}} \times 100$$

In the second method the constant of the meter is compared with the constant calculated from the standard meter readings and time (test constant). When the error is calculated by this method it is usual to express the constant in watt secs. per revolution, instead of revolutions per KWH.

$$\text{Meter constant (Watt secs/rev.)} = \frac{3600 \times 1000}{\text{Rev. / KWH}}$$

$$\text{Test constant} = \frac{E \times I \times T (\text{sec})}{\text{Rev.}}$$

$$\text{and \% error} = \frac{\text{Meter constant (T)} - \text{Test constant (T}_1)}{\text{Test constant (T}_1)} \times 100$$

By comparing time for certain revolutions of the rotor

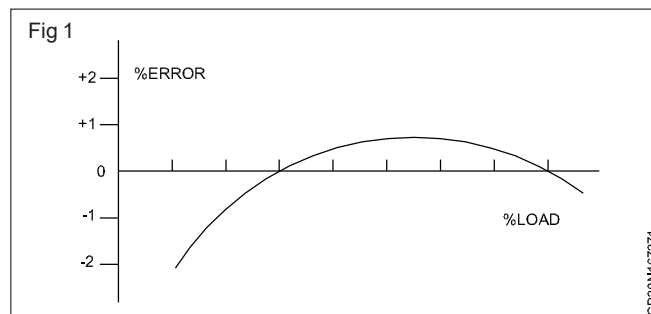
$$\% \text{ error} = \frac{T - T_1}{T_1} \times 100$$

Where T = correct time for a given number of revolutions

$$= \frac{3600 \times 1000}{\text{Rev. / KWH}} \times \frac{\text{Rev.}}{\text{Watts}}$$

T_1 = actual time for the same number of revolutions as found by a stopwatch.

From the readings a curve is plotted for percentage error Vs. percentage load on the meter. If the meter records more than the true energy (i.e. runs fast) the error is +ve and if it reads less error is -ve. (Fig 1)



Recommendations as per BIS 722: As per Bureau of Indian Standards IS 722 (Part II 1977), a single phase energy meter should have the following ratings and accuracies.

- Standard basic current (I_b) 2.5, 5, 10, 20 and 30A.
- Rated maximum current (I_{max}) 200% of the rated basic current.
- Starting current at unity power factor shall be 0.5 of basic current.
- Limits of error shall be as follows.

Values of current	Power factor	%error limit
5% I_b	1	± 2.5
10% I_b to I_{max}	1	± 2
10% I_b	0.5 lagging	± 2.5
20% I_b to I_{max}	0.5 lagging	± 2

Power factor meter

Objectives: At the end of this lesson you shall be able to

- state the disadvantage of the indirect method of measuring power factor
- state the different types of power factor meters
- explain the construction and connection of 3-phase dynamometer type power factor meter
- explain the construction, connection and operation of a 3-phase moving iron type power factor meter
- explain the construction, connection and operation of a single phase moving iron type power factor meter.

Power factor of a single phase AC circuit can be calculated by the formula

$$\text{P.F.} = \frac{\text{Power}}{EI}$$

provided an ammeter, a voltmeter and a wattmeter are connected to the circuit.

On the other hand, for measuring power factor in a balanced 3-phase circuit we have to use the formula

$$\text{P.F.} = \frac{3\text{-phase power}}{3E_{PH}I_{PH}} \text{ or } \frac{3\text{-phase power}}{\sqrt{3}E_LI_L}$$

However when the, 3-phase circuit is unbalanced, the above formula cannot be used.

This indirect method has the following disadvantages.

- Low accuracy due to the number of meters
- Reading errors

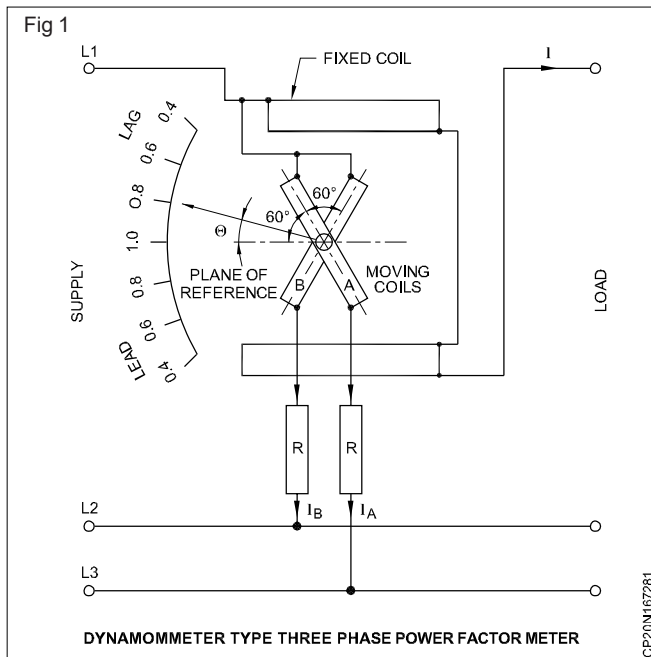
- complex connections
- Involves calculation every time when the load changes and hence not suitable for changing load.

To get the instantaneous reading of the power factor, direct reading P.F. meters are used which are reasonably accurate.

3-phase dynamometer type power factor meter for balanced load: Fig 1 shows the construction and connections of a 3-phase power factor meter used for balanced loads.

In this meter, the field coils are connected in series with the load along with one phase. The two moving coils are rigidly attached to each other at an angle of 120° . These coils are connected to two different phases. A resistance is connected in series with each coil.

Phase splitting through reactance is not necessary since the required phase displacement between currents in the two moving coils can be obtained by the supply itself.



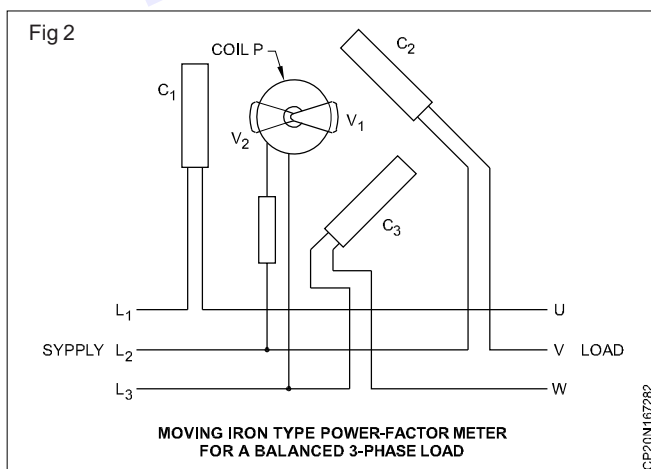
Operation of the meter is in the same way as in a single phase meter. However this meter is suitable only for balanced loads.

Since the currents in the two moving coils are both affected in the same way by any change in frequency or wave-form, this meter is independent of frequency and wave-form.

Moving iron power factor meters: This type of power factor meter is more popular than the dynamometer type due to the following advantages.

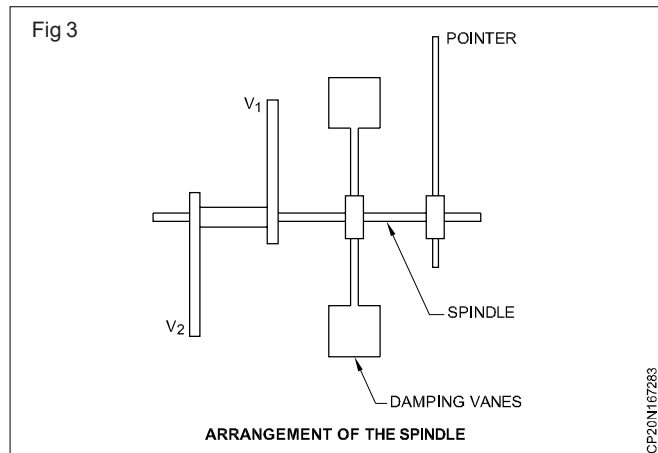
- Torque-weight ratio (working forces) is large compared to the dynamometer type meter.
- As all the coils are fixed there is no ligament connection necessary.
- The scale can be extended to 360°.
- This meter is simple and robust in construction.
- Comparatively cheaper in cost.

Fig 2 shows the construction and connection of a moving iron type power factor meter used for balanced loads.



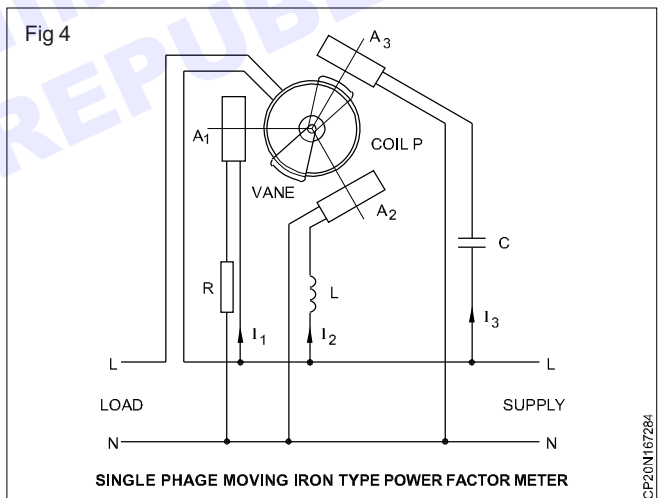
There are three similar coils at C_1 , C_2 and C_3 placed 120° degrees apart and connected to 3-phase supply directly (Fig 2) or through the secondary of the current transformers.

Coil P is placed in the middle of the three coils C_1 , C_2 and C_3 and connected in series with a resistance across two lines of the supply. Inside the coil B there are two vanes V_1 and V_2 mounted at the ends of a freely moving spindle but kept at 180° to each other. The spindle also has damping vanes and the pointer (Fig 3).



The rotating magnetic field produced by the three coils C_1 , C_2 and C_3 interacts with the flux produced by the coil P. This causes the moving system to take up an angular position depending upon the phase angle of the current.

Single phase moving iron power factor meter: A single phase moving iron power factor meter (Fig 4) uses a phase splitting network comprising of a capacitor, an inductor and a resistor.



3-phase power factor meters for unbalanced load: For measurement of power factor in 3-phase unbalanced systems 2-element or 3-element power factor meters with each element with a current coil and pressure coil is used. The pressure coils are (moving coils) similar to that of single phase P.F. meters are mounted one below the other on a single spindle. The pointer shows the resultant power factor.

Low power factor meter: Power factor meters are generally available to read power factor from 0.5 lag-unity - 0.5 lead. Low power factor meters specially constructed to read power factor 0.0 lag to unity power factor are also used.

Frequency meter

Objectives: At the end of this lesson you shall be able to

- state the types of frequency meters
- describe the principle, construction and working of a mechanical resonance (vibrating reed) type frequency meter
- describe the construction and working principle of an electrical resonance type frequency meter
- describe the construction and working principle of a ratio meter type frequency meter.

The following types of frequency meters are used for measuring power frequencies.

- Mechanical resonance type
- Electrical resonance type
- Electro-dynamic type
- Electro-dynamometer type
- Weston type
- Ratiometer type
- Saturable core type

Apart from the above power frequency meters, there are other types of equipment, like electronic frequency counters, frequency bridges, stroboscope and oscilloscope which are used for measuring a wide range of frequencies.

The explanation given here is for three types of power frequency meters only as indicated below.

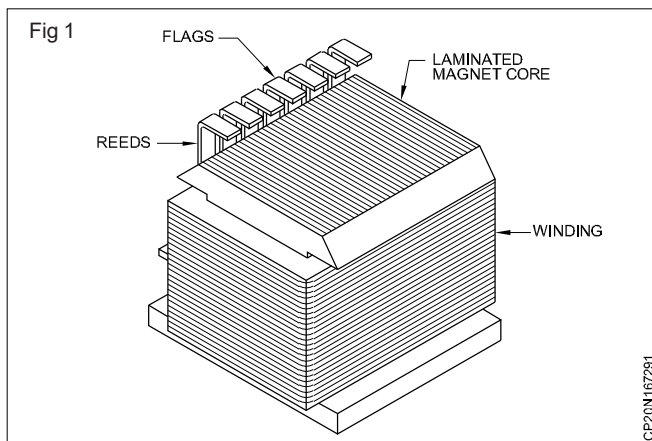
They are :

- mechanical resonance type
- electrical resonance type
- ratiometer type.

The trainees are advised to refer to books on electrical measuring instruments for learning about the other types of frequency meters.

Mechanical resonance type frequency meter (vibration reed type)

Principle: The vibration reed type frequency meter shown in Fig 1 works on the principle of natural frequency. Every object in the world has its natural frequency, depending upon its weight and dimensions. When an object is kept in a vibrating medium, it starts vibrating, if the frequency of the medium attains the natural frequency of the object.



If the vibrations are not controlled, the object may even get totally destroyed. A good example of this phenomenon is the shattering of window glass panes due to the vibration caused by low flying aircraft.

Construction: Mechanical resonance type frequency meters consist of an electromagnet and a set of metallic reeds arranged in front of the electromagnet. The frequency meter is connected across the supply like a voltmeter, taking care about the voltage rating (Fig 2).

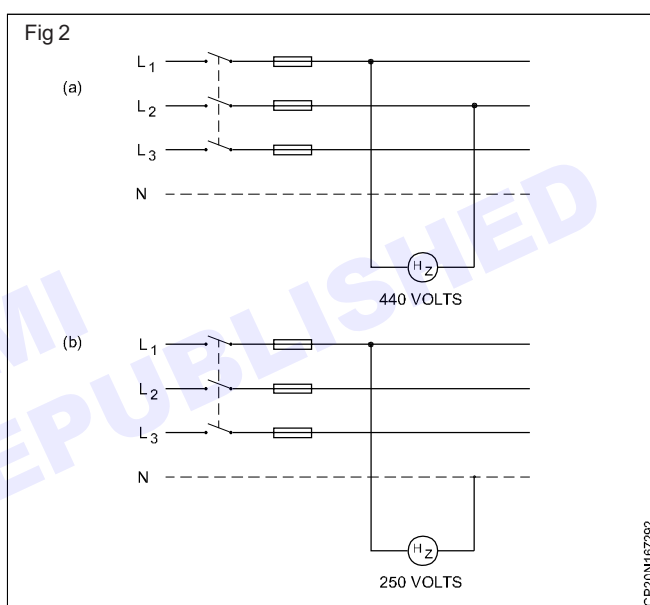
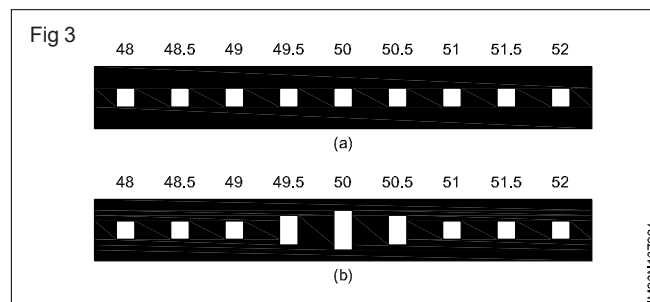
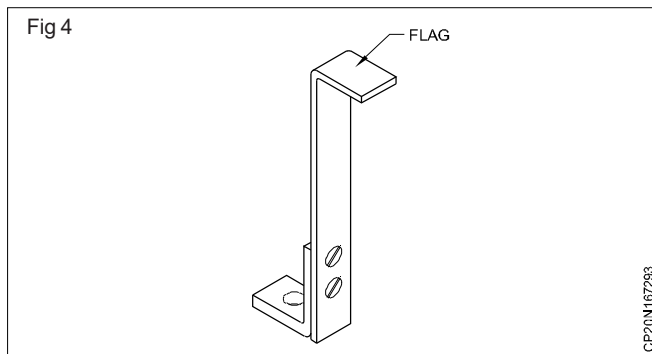


Fig 3 shows the shape of the reed and these reeds are of about 4mm wide and 0.5 mm thick. One end of the reed is fitted on a base, and the other overhanging end carries a white painted surface as the indicator and sometimes referred to as flag.



The reeds are arranged in a row and the natural frequency of the reeds differs by 1/2 cycle. This 1/2 cycle difference is possible between the reeds due to the difference in the weights of the reeds. The reeds are arranged in an ascending order (Fig 4a), and generally the natural frequency of the centre reed is the same as that of the supply frequency (50Hz).



Working: When the frequency meter is connected to the supply, the electromagnet produces a magnetic field which alternates at the rate of the supply frequency. The reed, which has its natural frequency coincident with that of the alternating magnetic field, vibrates more than the adjacent reeds Fig 4(b).

The flag of this vibrating reed makes it possible to note the frequency of the supply from the scale marking of the frequency meter. Though the other reeds also vibrate, Fig 4(b), their magnitude will be much less than the reed whose natural frequency is exactly in coincidence with the supply frequency.

Advantages and disadvantages

The reed type frequency meter has the following advantages.

The indications are independent of i) the wave form of the applied voltage and ii) magnitude of the applied voltage, provided that the voltage is not too low. At a low voltage the flag indication of the reed will not be reliable.

The disadvantages are the meter cannot read closer than half the cycle frequency difference between adjacent reeds and the accuracy greatly depends upon the proper tuning of the reeds.

Multimeters

Objectives: At the end of this lesson you shall be able to

- state what is a multimeter
- explain the construction of multimeter
- explain the working principle of analog multimeter
- explain the method of measuring direct / alternating voltages and current with a multimeter
- explain the method of measuring resistance by a multimeter
- explain the precautions to be observed while measuring voltage, current and resistance in the circuit.

The three most commonly measured electrical quantities are current, voltage and resistance. Current is measured by an ammeter, voltage by a voltmeter and resistance by an ohmmeter.

A single instrument used for measuring all the above three quantities is known as a multimeter. It is a portable, multi range instrument.

It has a full scale deflection accuracy of $\pm 1.5\%$. The lowest sensitivity of multimeters for AC voltage range is 5 K ohms/volts and for the DC voltage range it is 20 K ohms/volts. The lowest range of DC is more sensitive than the other ranges.

Figs 1a and 1b show typical multimeters.

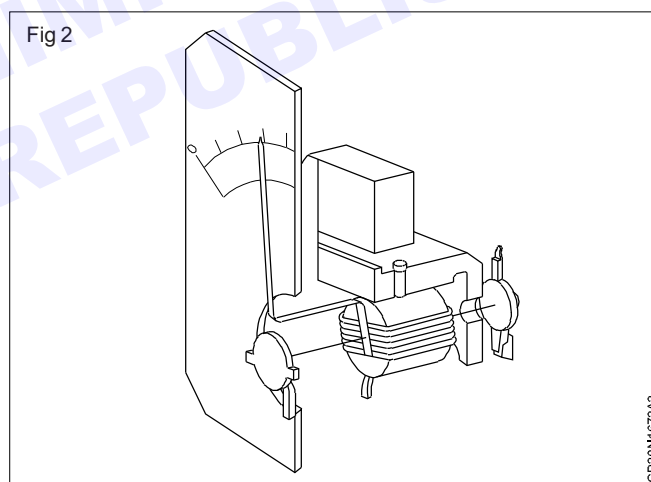
Construction of a multimeter

A multimeter uses a single meter movement (Fig 2), with a scale calibrated in volts, ohms and milliamperes. The necessary multiplier resistors and shunt resistors are all contained within the case. Front panel selector switches are provided to select a particular meter function and a particular range for that function.

On some multimeters, two switches are used, one to select a function, and the other the range. Some multimeters do not have switches for this purpose; instead, they have separate jacks for each function and range.

Batteries/cells fixed inside the meter case provide the power supply for the resistance measurement.

The meter movement is that of the moving coil system as used in DC ammeters and voltmeters. (Fig 2)



Rectifiers are provided inside the meter to convert AC to DC in the AC measurement circuit.

Parts of a multimeter

A standard multimeter consists of the main parts and controls (Fig 3).

Controls

The meter is set to measure the current, voltage (AC and DC) or resistance by means of the FUNCTION switch. In the example given in Fig 4 the switch is set to mA, AC.

The meter is set to the required current, voltage or resistance range - by means of the RANGE switch. In Fig 5, the switch is set to 2.5 volts or mA, depending on the setting of the FUNCTION switch.

Fig 1

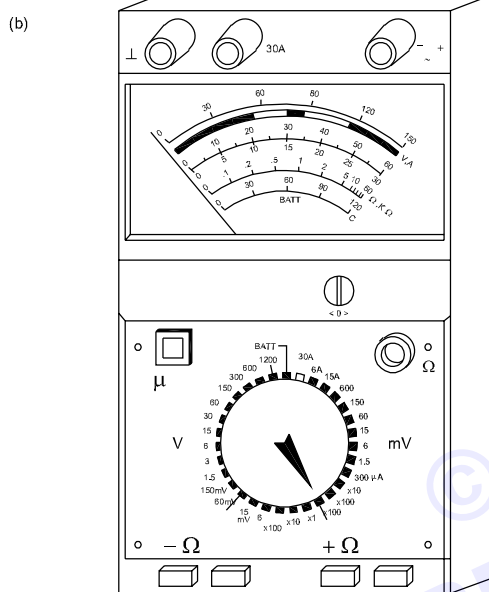
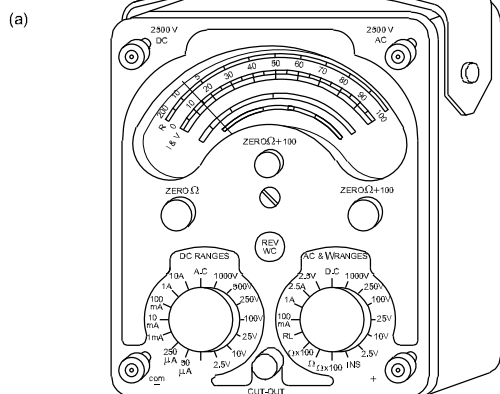
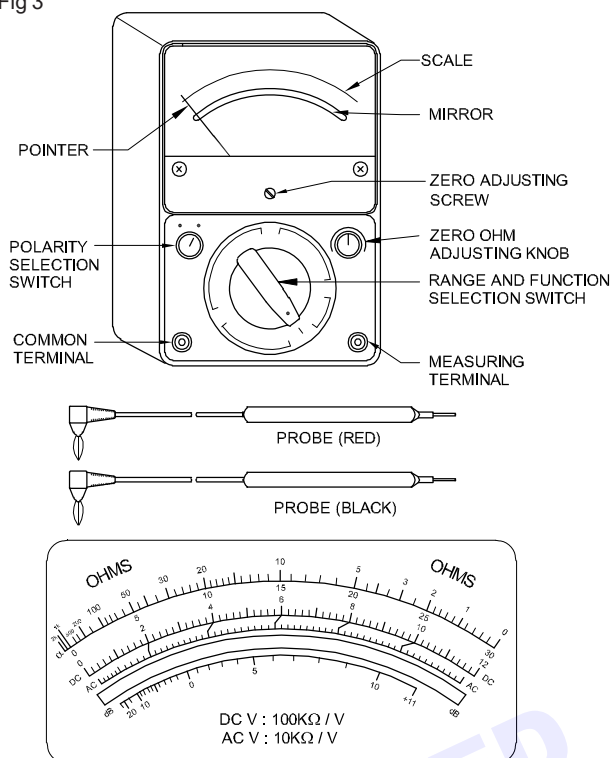
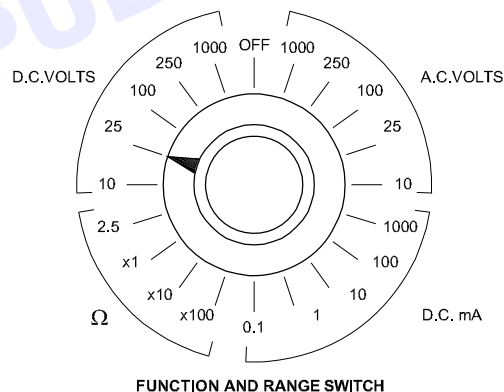


Fig 3



The example in Fig 6 shows the switch set to 25V DC of a meter having the function and the range selected by a single switch.

Fig 6



The example in Fig 7 shows the switches set to 250V AC of a meter that uses two function/range switches, one for DC ranges and the other for AC and resistance (ohms) ranges.

Fig 7

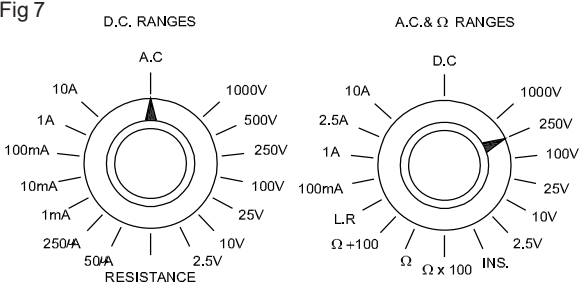


Fig 4

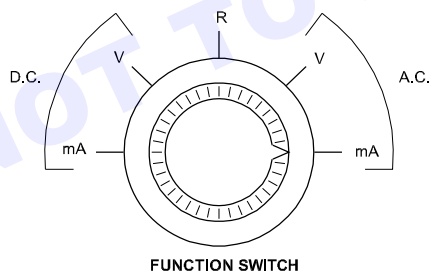
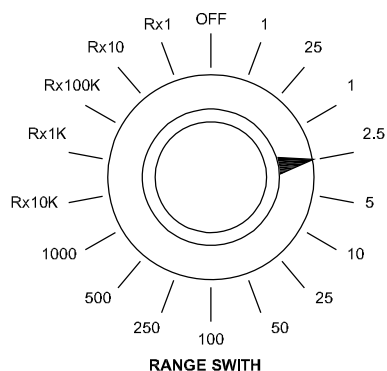
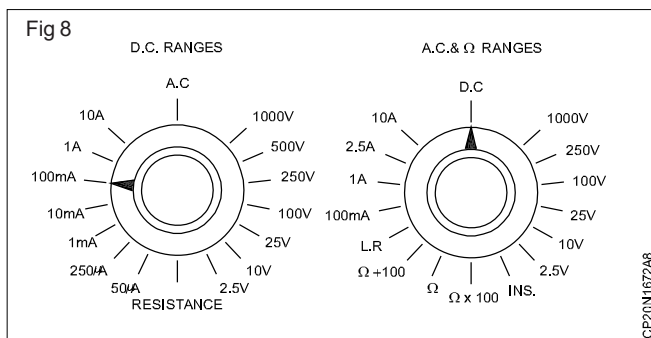


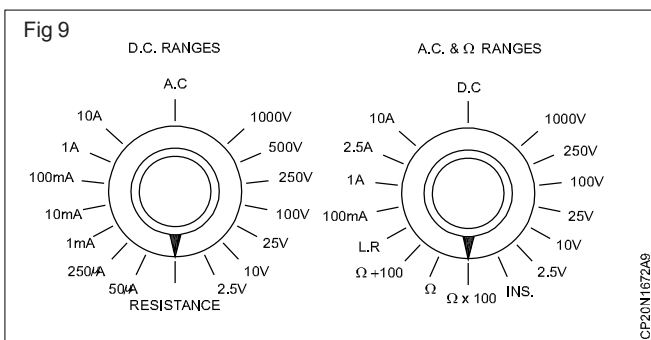
Fig 5



Switches set to 100 mA DC. (Fig 8)



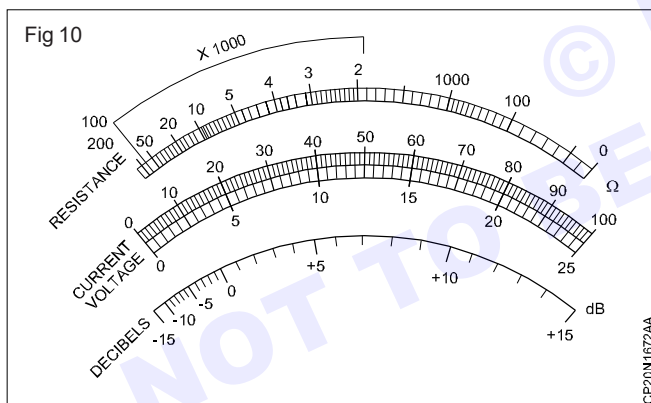
Switches set to resistance, ohms x 100 range. (Fig 9)



Scale of multimeter

Separate scales are provided for:

- resistance
- voltage and current. (Fig 10)



The scale of current and voltage is uniformly graduated.

The scale of the ohmmeter is non-linear. That is, the divisions between zero and infinity (∞) are not equally spaced. As you move from zero to the left across the scale, the divisions become closer together.

The scale is usually 'backward', with zero at the right.

Principle of working

A circuitry when working as an ammeter is shown in Fig 11.

Shunt resistors across the meter movement bypass current in excess of 0.05 mA at fsd. A suitable value of shunt resistor is selected through the range switch for the required range of current measurement.

A circuitry when working as a voltmeter is shown in Fig 12.

The voltage drop across the meter coil is dependent on the current and the coil resistance. To indicate voltages greater than 50 mV at fsd as per the circuit, multiplier resistances of different values are connected in series with the meter movement through the range switch for the required range of measurement.

A circuitry when working as an ohmmeter is shown in Fig 13.

To measure resistance, the leads are connected across the external resistor to be measured (Fig 13). This connection completes the circuit, allowing the internal battery to produce current through the meter coil, causing deflection of the pointer, proportional to the value of the external resistance being measured.

Zero adjustment

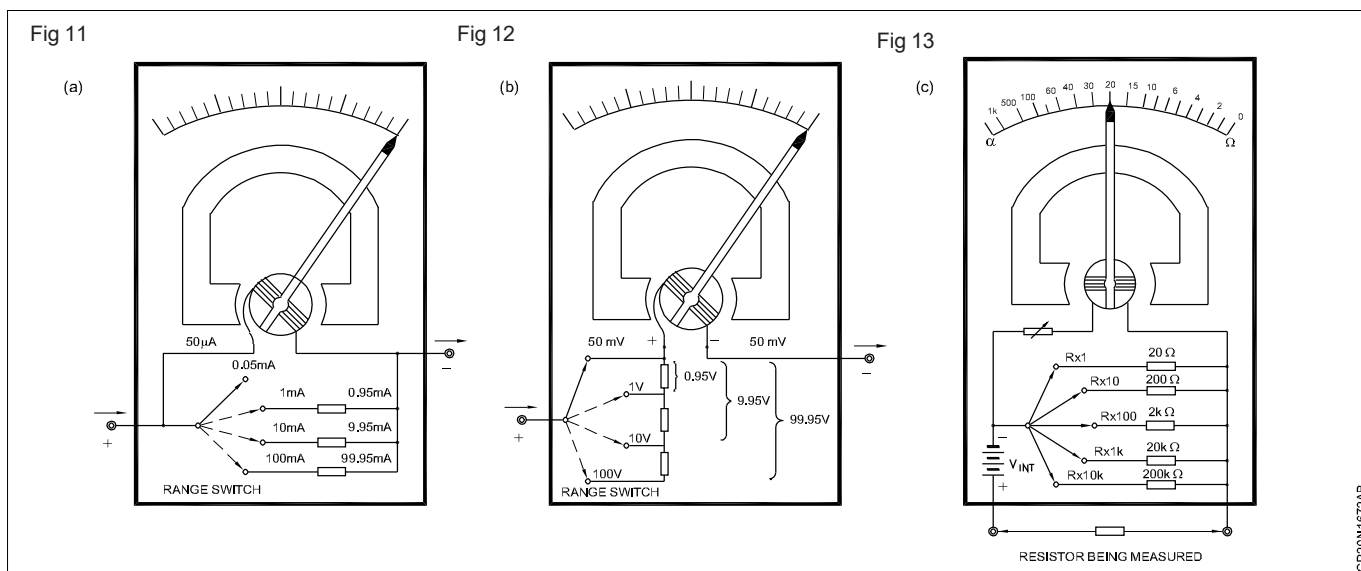
When the ohmmeter leads are open, the pointer is at full left scale, indicating infinite (∞) resistance (open circuit). When the leads are shorted, the pointer is at full right scale, indicating zero resistance.

The purpose of the variable resistor is to adjust the current so that the pointer is at exactly zero when the leads are shorted. It is used to compensate for changes in the internal battery voltage due to aging.

Multiple range

Shunt (parallel) resistors are used to provide multiple ranges so that the meter can measure resistance values from very small to very large ones. For each range, a different value of shunt resistance is switched on. The shunt resistance increases for the higher ohm ranges and is always equal to the centre scale reading on any range. These range settings are interpreted differently from those of the ammeter or voltmeter. The reading on the ohmmeter scale is multiplied by the factor indicated by the range setting.

Remember, an ohmmeter must not be connected to a circuit when the circuit's power is on. Always turn the power off before connecting the ohmmeter.



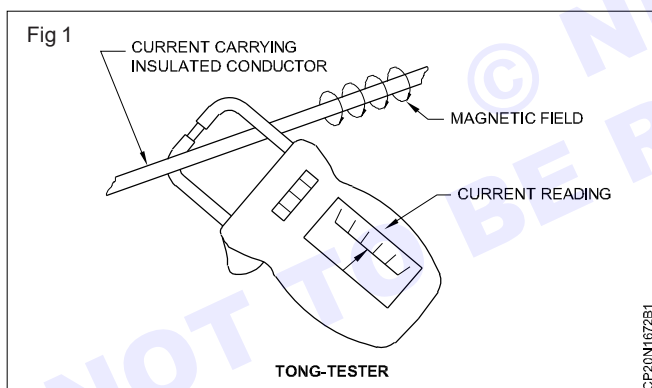
CP20N1672AB

Tong - tester (clamp - on ammeter)

Objectives: At the end of this lesson you shall be able to

- state the necessity of tong-testers
- state the construction and working of a tong-tester
- state the precautions to be observed while using a tong-tester.

A tong-tester is an instrument devised for the measurement of A.C current, without interrupting the circuit. It is also called clip-on ammeter, or sometimes a clamp-on ammeter (Fig 1).



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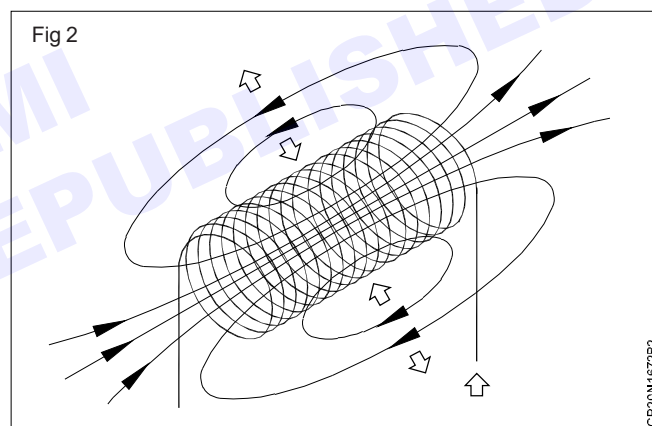
Working principle

The instrument can function only when current passes through its deflecting system. It works under the mutual induction principle.

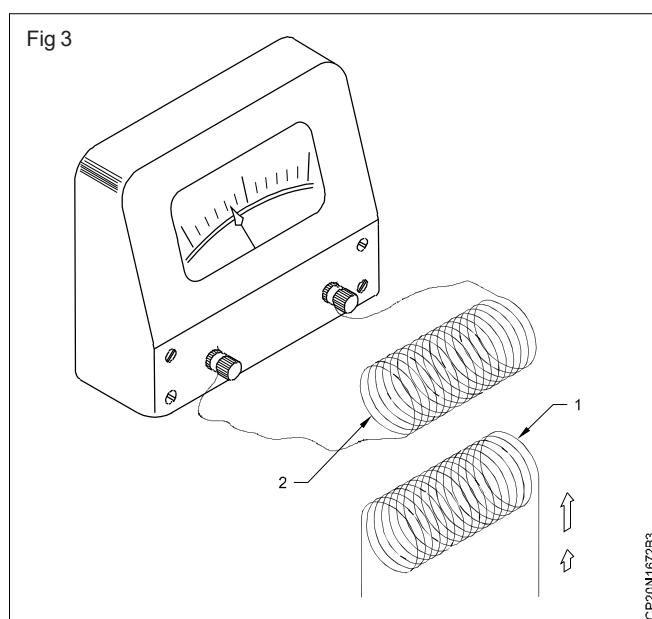
Electromagnetic induction: When a changing flux is linked with the coil, an emf is induced in the coil. The current in a coil so produced changes as that of the changing magnetic flux. If an alternating current is flowing through the coil, the magnetic flux produced is also alternative i.e. changing continuously.(Fig 2)

Placing another coil (2) in the changing flux of coil (1), an emf will be induced. (Fig 3)

This induced emf will send the current, causing deflection of the meter. Introduction of a magnetic core between the coils increases the induced emf. The coil (1) is called primary and the coil (2) is called secondary.

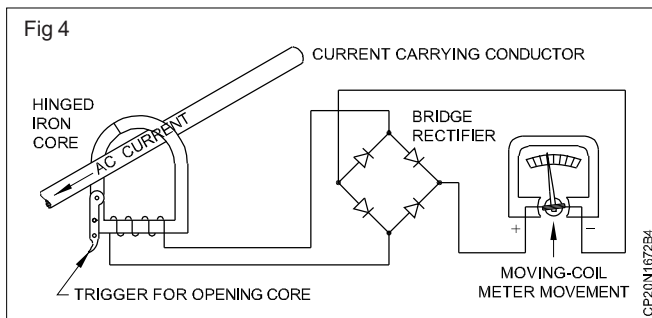


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Construction: Fig 4 shows a tong-tester (the clamp-on ammeter) circuit. The split-core meter consists of a secondary coil with the split-core and a rectifier type instrument connected to the secondary. The current to be measured in the conductor serves as the primary of one turn coil. It induces a current in the secondary winding and this current causes the meter to deflect.

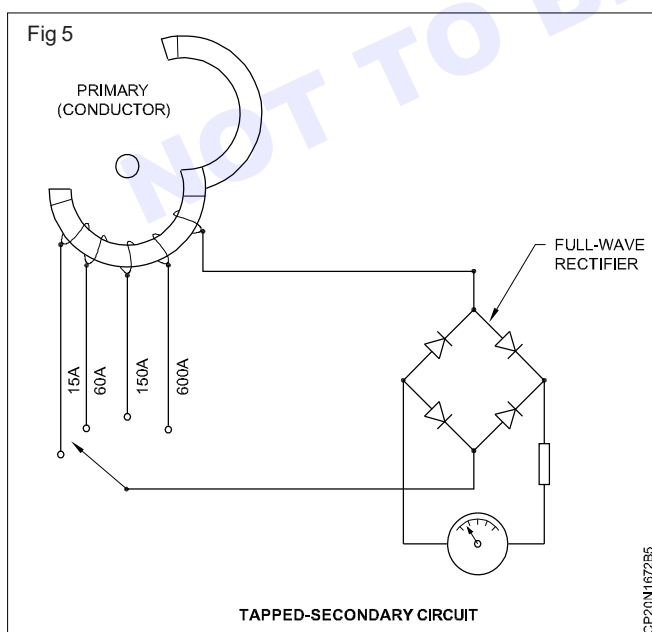


The core is so designed that there is only one break in the magnetic path. The hinge and the opening both fit tightly when the instrument closes around the conductor. The tight fit of the instrument ensures minimum variation in the response of the magnetic circuit.

To measure current with a clamp-on meter, open the jaws of the instrument and place them around the conductor in which you want to measure the current. Once the jaws are in place, allow them to close securely. Then, read the indicator position on the scale.

When the core is clamped around a current-carrying conductor, the alternating magnetic field induced in the core, produces a current in the secondary winding.

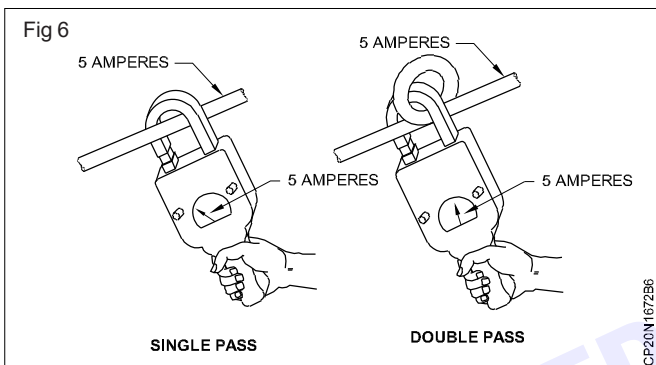
This current causes a deflection on the scale of the meter movement. The current range can be changed by means of a 'range switch', which changes the taps on the transformer secondary (Fig 5).



Safety: The secondary winding of the current transformer should always be either shunted or connected to the ammeter; otherwise, dangerous potential differences may occur across the open secondary.

Before taking any measurement, make sure the indication is at zero on the scale. If it is not, reset by the zero-adjustment screw. It is usually located near the bottom of the meter.

Looping the conductor more than once through the core is another means of changing the range. If the current is far below the meter's maximum range, we can loop the conductor through the core two or more times (Fig 6).



Application

- 1 For measuring the incoming current in the main panel board.
- 2 Primary current of AC welding generators.
- 3 Secondary current of AC welding generators.
- 4 Newly rewinded AC motor phase current and line current.
- 5 Starting current of all AC machines.
- 6 Load current of all AC machines and cables.
- 7 For measuring the unbalanced or balanced loads.
- 8 For finding the faults in AC, 3-phase induction motors.

Precaution

- 1 Set the ampere range from higher to low if the measuring value is not known.
- 2 The ampere-range switch should not be changed when the clamp is closed.
- 3 Before taking any measurement make sure the indication is at zero on the scale.
- 4 Do not clamp on a bare conductor for current measurement.
- 5 Seating of the core should be perfect.

Insulation resistance tester (Megger)

Objectives: At the end of this lesson you shall be able to

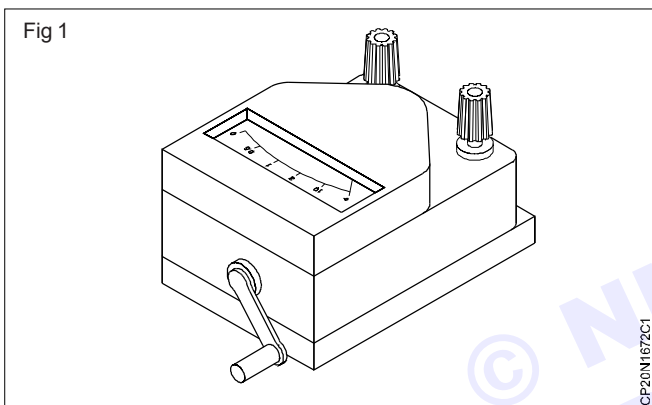
- define megger
- state the working principle of an insulation tester (Megger)
- explain the construction and working of megger
- state the uses of an insulation tester like insulation test, continuity test etc
- state the safety precautions to be observed while using an insulation tester.

Megger

It is an electrical measuring instrument generally used to measure the insulation resistance of an installation/equipment etc in terms of Megaohms.

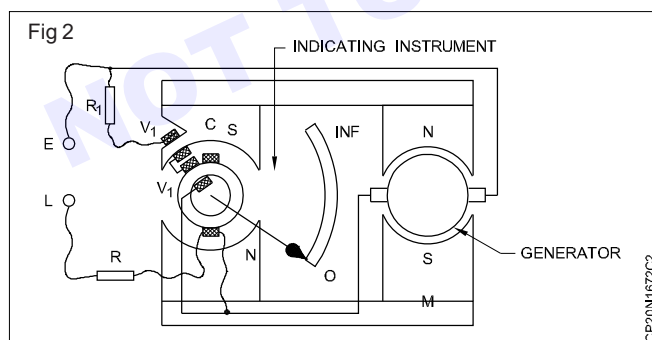
Necessity of megohmmeter

Ordinary ohmmeters and resistance bridges are not generally designed to measure extremely high values of resistance. The instrument designed for this purpose is the megohmmeter. (Fig 1) A megohmmeter is commonly known as MEGGER.



Construction

The megohmmeter consists of (1) a small DC generator, (2) a meter calibrated to measure high resistance, and (3) a cranking system. (Fig 2)



A generator commonly called a magneto is often designed to produce various voltages. The output may be as low as 500 volts or as high as 1 megavolt. The current supplied by the megohmmeter is in the order of 5 to 10 milliamperes. The meter scale is calibrated: kilo-ohms (K Ω) and megohms (M Ω).

Working principle

The permanent magnets supply the flux for both the generator and the metering device. The voltage coils are connected in series across the generator terminals. The current coil is arranged so that it will be in series with the

resistance to be measured. The unknown resistance is connected between the terminals L and E.

When the armature of the magnet is rotated, an emf is produced. This causes the current to flow through the current coil and the resistance being measured. The amount of current is determined by the value of the resistance and the output voltage of the generator.

The torque exerted on the meter movement is proportional to the value of current flowing through the current coil.

The current through the current coil, which is under the influence of the permanent magnet, develops a clockwise torque. The flux produced by the voltage coils reacts with the main field flux, and the voltage coils develop a counter-clockwise torque.

For a given armature speed, the current through the voltage coils is constant, and the strength of the current coil varies inversely with the value of resistance being measured. As the voltage coils rotate counter-clockwise, they move away from the iron core and produce less torque.

A point is reached for each value of resistance at which the torques of the current and voltage coils balance, providing an accurate measurement of the resistance. Since the instrument does not have a controlling torque to bring the pointer to zero, when the meter is not in use, the position of the pointer may be anywhere on the scale.

The speed at which the armature rotates does not affect the accuracy of the meter, because the current through both the circuits changes to the same extent for a given change in voltage. However, it is recommended to rotate the handle at the slip speed to obtain steady voltage.

Because megohmmeters are designed to measure very high values of resistance, they are frequently used for insulation tests.

Connection for measurement

When conducting insulation resistance test between line and earth, the terminal 'E' of the insulation tester should be connected to the earth conductor.

Precautions

- A megohmmeter should not be used on a live system.
- The handle of the megohmmeter should be rotated only in a clockwise direction or as specified.
- Do not touch the terminals of a megohmmeter while conducting a test.
- Support the instrument firmly while operating.
- Rotate the handle at slip speed.

Uses of a megohmmeter

- Checking the insulation resistance
- Checking the continuity.

Specification of Megger :

Nowadays electronically operated, Meggers are available,

called as push button type for general application and for industrial application motorised megger are also available. Hence a megger is basically specified based on the voltage generated by it .

example: 250 V, 500V, 1KV, 2.5KV, 5KV.

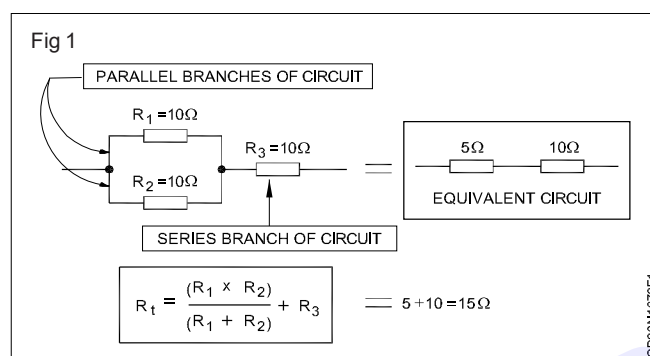
Series and parallel combination circuit

Objectives: At the end of this lesson you shall be able to

- explain series and parallel circuits.

Formation of series parallel circuit : Apart from the series circuit and parallel circuits, the third type of circuit arrangement is the series parallel circuit. In this circuit, there is at least one resistance connected in series and two connected in parallel. The two basic arrangements of the series-parallel circuit are shown here. In one, resistor R_1 and R_2 are connected in parallel and this parallel connection, in turn is connected in series with resistance R_3 (Fig 1).

Application : Series parallel circuits can be used to form a non-standard resistance value which is not available in the market and can be used in the voltage divider circuits.

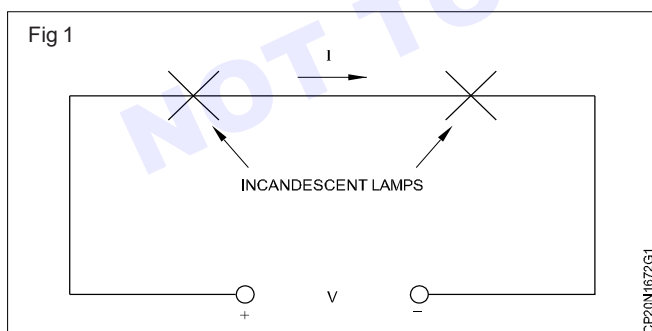


DC series circuit

Objectives: At the end of this lesson you shall be able to

- state the characteristics of series circuit and determine the current and voltage across each resistor
- state the relation between EMF potential difference and terminal voltage.

The series circuit : If more than one resistors are connected one by one like a chain and if the current has only one path is called as series circuit. It is possible to connect two incandescent lamps in the way shown in Fig 1. This connection is called a series connection, in which the same current flows in the two lamps.



Current in series circuits

The current will be the same at any point of the series circuit. This can be verified by measuring the current in any two points of a given circuit as shown in Fig 2(a) and 2(b). The ammeters will show the same reading.

The current relationship in a series circuit is

$$I = IR_1 = IR_2 = IR_3$$

We can conclude that there is only one path for the current to flow in a series circuit. Hence, the current is the same throughout the circuit.

Total resistance in series circuit

The total resistance in a series circuit is equal to the sum of the individual resistances around the series circuit. This statement can be written as

$$R = R_1 + R_2 + R_3 + \dots + R_n$$

where R is the total resistance

$R_1, R_2, R_3, \dots, R_n$ are the resistors connected in series.

Voltage in series circuits

In DC circuit voltage divides up across the load resistors, depending upon the value of the resistor so that the sum of the individual load voltages equals the source voltage.

As the source voltage divides/drops across the series resistance depending upon the value of the resistances

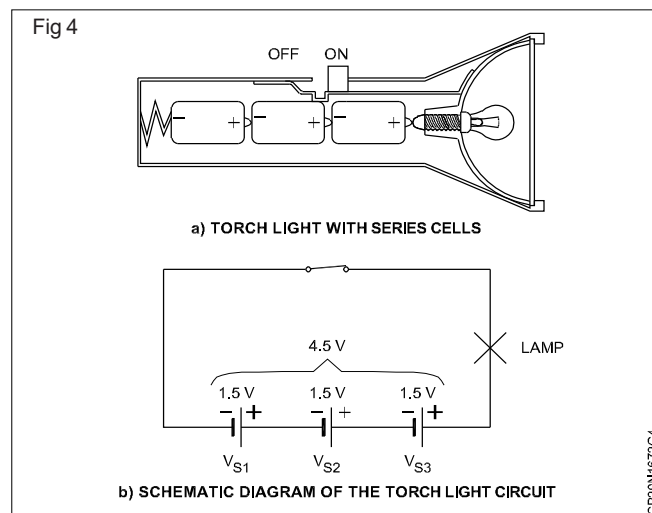
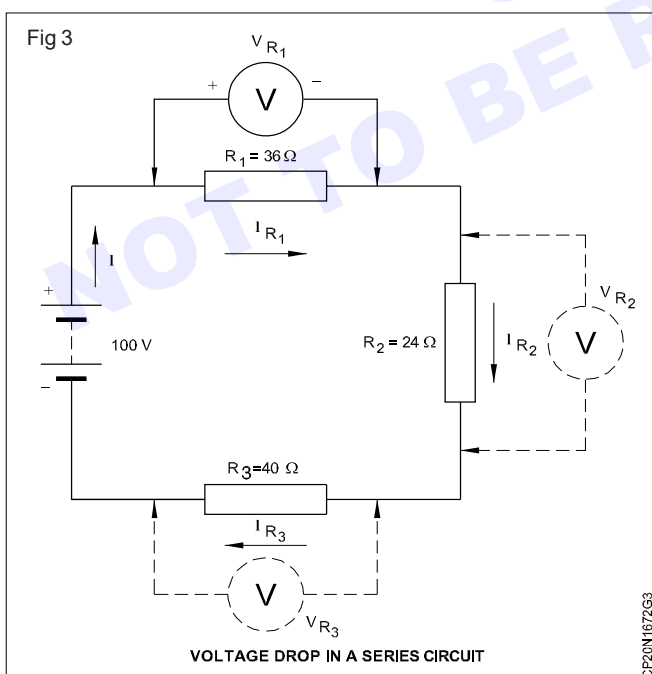
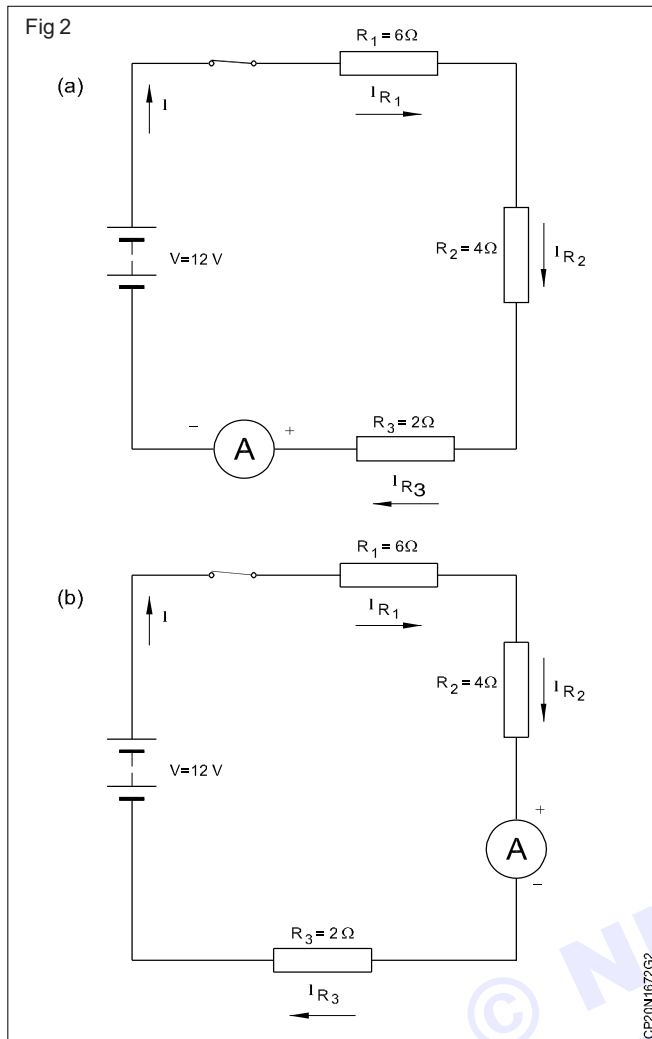
$$V = V_{R1} + V_{R2} + V_{R3} + \dots + V_{RH}$$

Voltages across the series resistors could be measured using one voltmeter at different positions as illustrated in Fig 3.

Voltage sources in series

When cells are placed in a torch light, they are connected in series to produce a higher voltage as shown in Fig 4.

$$\begin{aligned} V_{\text{Total}} &= V_{S1} + V_{S2} + V_{S3} \\ &= 1.5V + 1.5V + 1.5V = 4.5V \end{aligned}$$



Use of series connection

- 1 Cells in torch light, car batteries, etc.
- 2 Cluster of mini-lamps used for decoration purposes.
- 3 Fuse in circuit.
- 4 Overload coil in motor starters.
- 5 Multiplier resistance of a voltmeter.

Definitions

Electromotive force (emf)

We have seen that the electromotive force (emf) of a cell is the open circuit voltage, and the potential difference (PD) is the voltage across the cell when it delivers a current. The potential difference is always less than the emf.

Potential difference

PD = emf - voltage drop in the cell

Potential difference can also be called by another term, the terminal voltage, as explained below.

Terminal voltage

It is the voltage available at the terminal of the source of supply. Its symbol is V_T . Its unit is also the volt. It is given by the emf minus the voltage drop in the source of supply, i.e. $V_T = \text{emf} - IR$

where I is the current and R the resistance of the source.

Voltage drop (IR drop)

The voltage lost by resistance in a circuit is called the Voltage drop or IR drop.

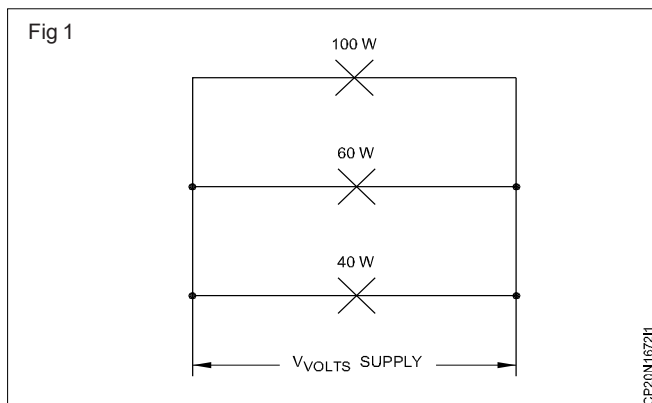
DC parallel circuit

Objectives: At the end of this lesson you shall be able to

- determine the voltages in a parallel circuit
- determine the current in a parallel circuit
- determine the total resistances in a parallel circuit
- state the application of a parallel circuit.

Voltage in parallel circuit

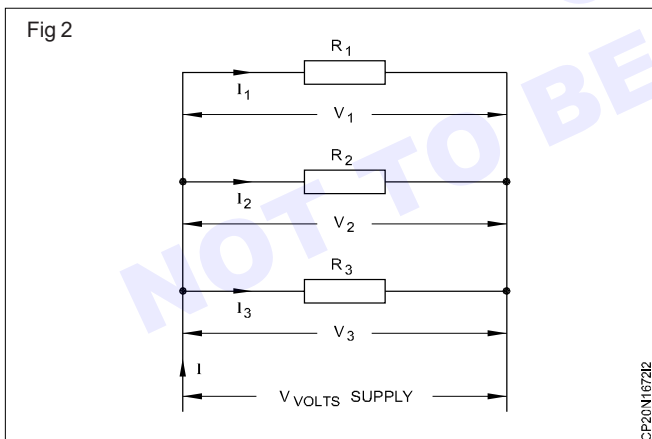
When 3 lamps are connected as shown (Fig 1) the voltage applied across the resistors is the same and also equal to the supply voltage.



We can conclude that the voltage across the parallel circuit is the same as the supply voltage.

Mathematically it could be expressed as $V = V_1 = V_2 = V_3$

Current in parallel circuit : Again referring to Fig 2 and applying Ohm's law, the individual branch currents in the parallel circuit could be determined.



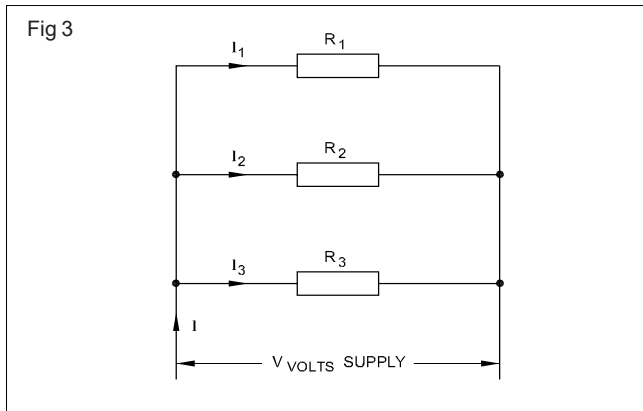
Current in resistor $R_1 = I_1 =$

Current in resistor $R_2 = I_2 =$

Current in resistor $R_3 = I_3 =$

as $V_1 = V_2 = V_3$

Refer to Fig 3 in which the branch currents I_1 , I_2 , and I_3 , are shown to flow into resistance branches R_1 , R_2 and R_3 respectively.



The total current I in the parallel circuit is the sum of the individual branch currents.

Mathematically it could be expressed as $I = I_1 + I_2 + I_3 + \dots I_n$

Resistance in parallel circuit

In a parallel circuit, individual branch resistances offer opposition to the current flow though the voltage across the branches will be same.

Let the total resistance in the parallel circuit be R ohms.

By the application of Ohm's law

we can write

$$R = \frac{V}{I} \text{ ohms or } I = \frac{V}{R} \text{ amps,}$$

where

R is the total resistance of the parallel circuit in ohms

V is the applied source voltage in volts, and

I is the total current in the parallel circuit in amperes.

We have also seen

$$I = I_1 + I_2 + I_3$$

$$\text{Or } \frac{V}{R} = \frac{V}{R_1} + \frac{V}{R_2} + \frac{V}{R_3}$$

As V is the same throughout the equation and dividing the above equation by V , we can write

$$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$

The above equation reveals that in a parallel circuit, the reciprocal of the total resistance is equal to the sum of the reciprocals of the individual branch resistance.

Applications of parallel circuits : An electric system in which one section can fail and other sections continue to operate has parallel circuits. As previously mentioned, the

electric system used in homes consists of many parallel circuits.

An automobile electric system uses parallel circuits for lights, horn, motor, radio etc. Each of these devices operates independent of the others.

Resistors

Objectives: At the end of this lesson you shall be able to

- explain the construction and characteristics of various types of resistors
- explain the functions and applications of the resistors in electrical and electronic circuits.

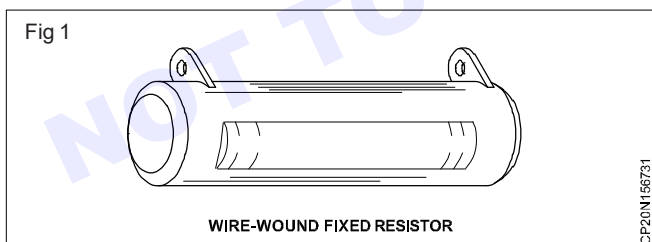
Resistors: These are the most common passive component used in electrical and electronic circuits. A resistor is manufactured with a specific value of ohms (resistance). The purpose of using a resistor in circuit is either to limit the current to a specific value or to provide a desired voltage drop (IR). The power rating of resistors may be from fractional watts to hundreds of Watts.

There are five types of resistors

- 1 Wire-wound resistors
- 2 Carbon composition resistors
- 3 Metal film resistors
- 4 Carbon film resistors
- 5 Special resistors

1 Wire-wound resistors

Wire-wound resistors are manufactured by using resistance wire (nickel-chrome alloy called Nichrome) wrapped around an insulating core, such as ceramic porcelain, bakelite pressed paper etc. Fig 1, shows this type of resistor. The bare wire used in the unit is generally enclosed in insulating material. Wire wound resistors are used for high current application. They are available in wattage ratings from one watt to 100 watts or more. The resistance can be less than 1 ohm and go up to few thousand ohms.

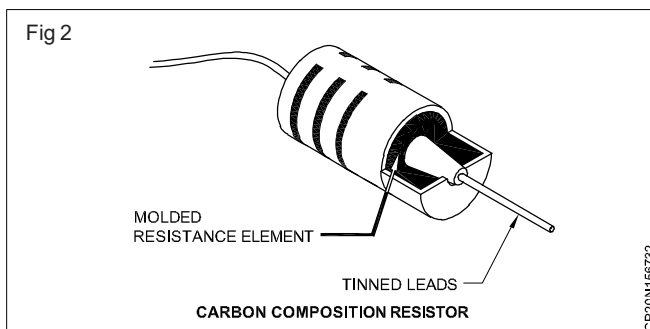


One type of wire-wound resistor is called as fusible resistor enclosed in a porcelain case. This resistor is designed to open the circuit when the current through it exceeds certain limit.

2 Carbon composition resistors

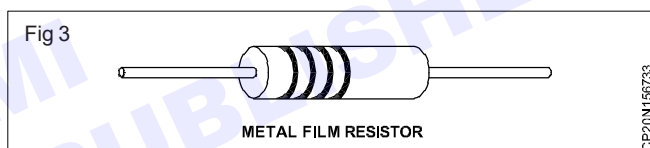
These are made of fine carbon or graphite mixed with powdered insulating material as a binder in the proportion needed for the desired resistance value. Carbon-resistance elements are fixed with metal caps with leads of tinned copper wire for soldering the connection into a circuit. Fig 2 shows the construction of carbon composition resistor.

Carbon resistor are available in values of 1 ohm to 22 megohms and of different power ratings, generally 0.1, 0.125, 0.25, 0.5, 1.0 and 2 watts.



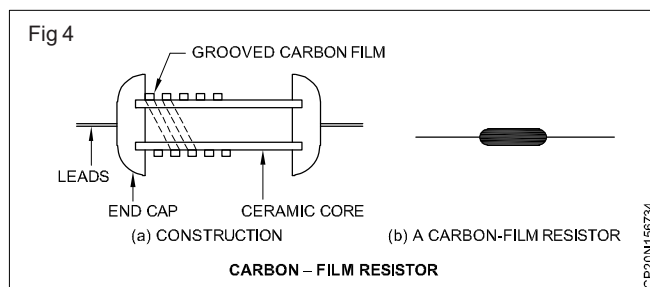
3 Metal film resistors (Fig 3)

Metal film resistors are manufactured by two processes. Thick film resistors are pasted with metal compound and powdered glass which are spread on the ceramic base and then backed.



Thin film resistors are processed by depositing a metal vapour on a ceramic base. Metal film resistors are available from 1 ohm to 10 M Ω , upto 1W. Metal film resistors can work from 120°C to 175°C.

4 Carbon film resistors (Fig 4)



In this type, a thin layer of carbon film is deposited on the ceramic base/tube. A spiral groove is cut over the surface to increase the length of the foil by a specialised process.

Carbon film resistors are available from 1 ohm to 10 meg ohm and up to 1 W and can work from 85°C to 155°C.

All the above four types of resistors are coated with synthetic resin to protect them against mechanical damages and climatic influences, It is therefore, difficult to distinguish them from each other externally.

Specification of resistors: Resistors are specified normally with the four important parameters

- 1 Type of resistor

- Nominal value of the resistors in ohm (or) kilo ohm (or) mega ohm.
- Tolerance limit for the resistance value in percentage.
- Loading capacity of the components in wattage

Example

$100 \pm 10\%$, 1W, where as nominal value of resistance is 100Ω .

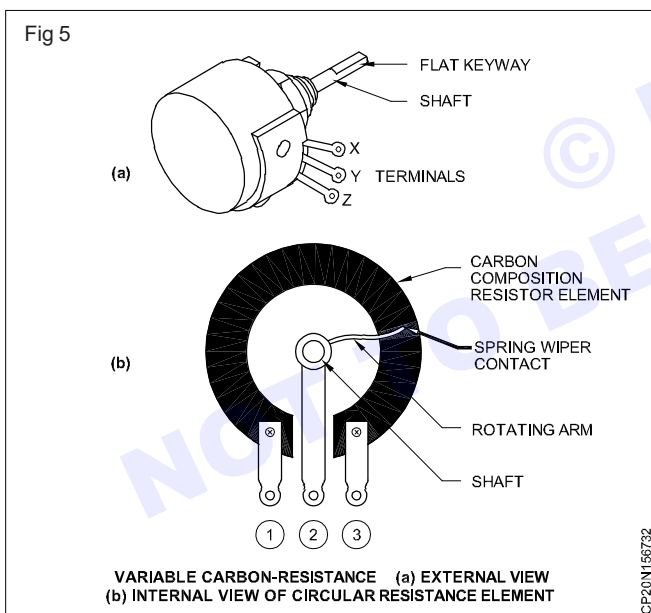
The actual value of resistance may be between 90Ω to 110Ω , and the loading capacity is maximum 1 watt.

The resistors can also be classified with respect to their function as

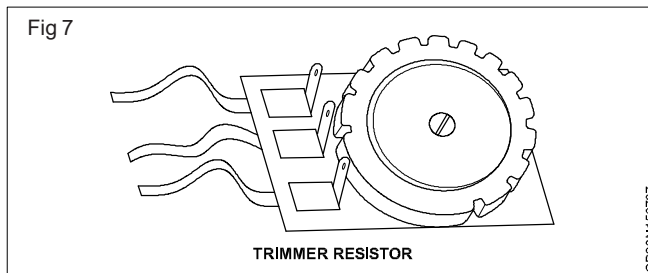
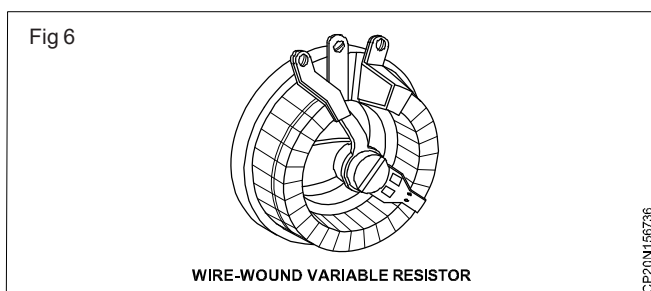
- Fixed resistors
- Variable resistors

Fixed resistors : The fixed resistors is one in which the nominal value of resistance is fixed. These resistors are provided with pair of leads. (Fig 1 to 4)

Variable resistors (Fig 5) : Variable resistors are those whose values can be changed. Variable resistors includes those components in which the resistance value can be set at the different levels with the help of sliding contacts. These are known as potentiometer resistors or simply as potentiometers.



It is provided with 3 terminals as shown in Fig 5 and 6. They are available with carbon tracks (Fig 5) and wire wound (Fig 6) types. Trimmer potentiometers (or) resistor which can be adjusted with the help of a small screw drivers. (Fig 7).



Resistance depends upon temperature, voltage, light : Special resistors are also produced whose resistance varies with temperature, voltage, and light.

PTC resistors (Sensistors) : Since, different materials have different crystal structure, the rate at which resistance increases with raising temperature varies from material to material. In PTC resistor (positive Temp. coefficient resistor), as the temp increases, the resistance increases non linearly. For example, the resistance of PTC at room temperature may be of nominal value 100Ω when the temperature rises say 10°C , it may increase to 150Ω and with further increase of another 10°C , it may increase to 500Ω .

NTC Resistors (Thermistors) : In case of NTC resistors (Negative temperature co-efficient resistors) as the temperature increases, the value of resistance decreases non-linearly. For example, NTC resistor, which has nominal value of resistance is 500Ω at room temperature may decrease to 400Ω with the rise of 10°C temperature and further decrease to 150Ω when the temperature rises to another 10°C .

The PTC and NTC resistors can perform switching operation at specific temperature. They are also used for measurements and temperature compensators.

VDR (Varistors) : The VDR (Voltage dependent resistor) resistance falls non-linearly with increasing voltage. For example, a VDR, may have 100Ω resistance at 10V , and it may decrease to 90Ω at rise in 5V . By further increasing the voltage to another 5V , the resistance may fall to 50Ω . The VDRs are used in voltage stabilisation, arc quenching and over voltage protection.

Light dependent resistor (LDR) : The LDRs are also known as photo-conductors. In LDRs the resistance falls with increase in intensity of illumination. The phenomena is explained as the light energy frees some electron in the materials of the resistors, which are then available as extra conducting electrons. The LDR shall have exposed surface to sense the light. These are used for light barriers in operating relays. These are also used for measuring the intensity of light.

Marking codes for resistors

Objectives: At the end of this lesson you shall be able to

- interpret the coded marking of colours on the resistors
- interpret the letter and digit codes for resistance values
- state the tolerance value for resistors.

Resistance and tolerance value of colour coded resistors

Commercially, the value of resistance and tolerance value are marked over the resistors by colour codes (or) letter and digital codes.

The colour codes for indicating the values to two significant figure and tolerances are given in Table 1 as per IS 8186.

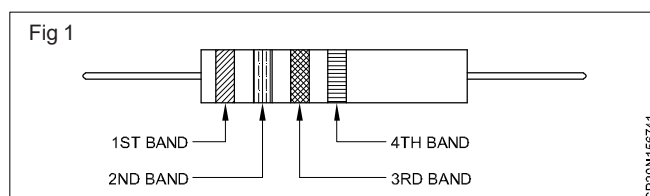
Table 1

Values to two significant figures and tolerances corresponding to colours

Colour	First Band/ Dot	Second Band/ Dot	Third Band/ Dot	Fourth Band/ Dot
	First Figure	Second Figure	Multiplier	Tolerance
Silver	—	—	10^{-2}	$\pm 10\%$
Gold	—	—	10^{-1}	$\pm 5\%$
Black	—	0	1	—
Brown	1	1	10	$\pm 1\%$
Red	2	2	10^2	$\pm 2\%$
Orange	3	3	10^3	—
Yellow	4	4	10^4	—
Green	5	5	10^5	—
Blue	6	6	10^6	—
Violet	7	7	10^7	—
Grey	8	8	10^8	—
White	9	9	10^9	—
None	—	—	—	$\pm 20\%$

The two significant figures and tolerances colour coded resistors have 4 bands of colours coated on the body as in Fig 1.

The first band shall be the one nearest to one end of the component resistor. The second, third and four colour bands are shown in Fig 1.



The first two colour bands indicate the first two digits in the numeric value of resistance. The third colour band indicates the multiplier. The first two digits are multiplied by the multiplier to obtain the actual resistance value. The fourth colour band indicates the tolerance in percentage.

Example

Resistance value : If the colour band on a resistor are in the order- Red, Green, Orange and Gold, then

First colour	Second colour	Third colour	Fourth colour
Red	Violet	Orange	Gold
2	7	$1000(10^3)$	$\pm 5\%$

the value of the resistor is 27,000 ohms with $\pm 5\%$ tolerance.

Tolerance value : The fourth band (tolerance) indicates the resistance range within which is the actual value falls. In the above example, the tolerance is $\pm 5\%$. $\pm 5\%$ of 27000 is 1350 ohms. Therefore, the value of the resistor is any value between 25650 ohms and 28350 ohms. The resistors with lower value of tolerance (precision) are costlier than normal value of resistors.

Methods of measuring low and medium resistance

Objectives: At the end of this lesson you shall be able to

- state the different methods of measuring resistance
- describe the ammeter & voltmeter method.

Classification of resistance: Based on the ohmic value of resistance, we name it as low, medium and high resistance.

A resistance is classified on its ohmic value as low, medium, or high.

Ranges

Low resistance	- one ohm and below one ohm
Medium resistance	- above one ohm up to 100,000 ohms (100 k Ω)

High resistance - above 100 k Ω (i.e 100000 Ω)

The above classification is not rigid.

Uses

Low resistance: Armature winding, ammeter shunt, cable length, contact resistance.

Medium resistance: All electrical apparatus normally used have resistance in this range - bulbs, heaters, relay, motor starters.

High resistance: Insulation resistance, carbon composition resistors above 100K in the circuit.

We shall limit for the present to the methods used for measuring low and medium resistances in the following section.

Question

- 1 The lamp resistance of a mini-torch light, operating on 1.5 volts is classified as _____ resistance.

Methods of measuring low resistance: The following three methods are used to measure low resistance.

- Voltmeter and ammeter method.
- Comparison of unknown with standard using potentiometer.
- Kelvin bridge
- Shunt type Ohmmeter

Ammeter and voltmeter method: This method, which is the simplest of all, is very commonly used for the measurement of low resistance.

In Fig 1, R_m is the resistance to be measured and V is a high resistance voltmeter of resistance R_v . A current from a steady direct current supply is passed through R in series with a suitable ammeter. Then assuming the current through the unknown resistance to be the same as that measured by the ammeter A , the formula is given as

$$R_m = \frac{\text{Voltmeter reading}}{\text{Ammeter reading}}$$

$$R_m = \text{Measured value}$$

If the voltmeter resistance is not very large, compared with the resistor to be measured, the voltmeter current will be an appreciable fraction of the current I , measured by the ammeter, and a serious error may be introduced on this account.

Medium resistance: The following three methods are used to measure medium resistance.

- Series type Ohmmeter
- Voltmeter and ammeter method
- Substitution method
- Wheatstone bridge method

The first method has been considered in the section on low resistance measurement. Substitution method and the wheatstone bridge method is explained subsequently.

Controlling accessories: The accessories which are used to control the circuits or an electrical point like switches are called 'controlling accessories'. All the switches are specified in accordance with their function, place of use, type of mounting, current capacity and working voltage. For example - S.P.T. (Single pole tumbler) flush-mounted switch 6 amps 240 volts.

Methods of measuring the value of resistance

Objectives: At the end of this lesson you shall be able to

- state the different methods of measuring resistance
- describe the ammeter & voltmeter method.

Methods of measuring low resistance : The following three methods are used to measure low resistance.

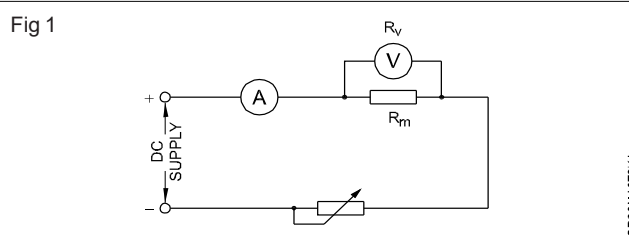
- Voltmeter and ammeter method.
- Comparison of unknown with standard using potentiometer.
- Kelvin bridge
- Shunt type Ohmmeter

Ammeter and voltmeter method: This method, which is the simplest of all, is very commonly used for the measurement of low resistance.

In Fig 1, R_m is the resistance to be measured and a voltmeter connected across resistance R_v . A direct current supply is passed through R in series with a suitable ammeter. Then assuming the current through the unknown resistance to be the same as that measured by the ammeter A , the formula is given as

$$R_m =$$

$$R_m = \text{Measured Value}$$



Measurement of resistances

Medium resistances could be measured by instruments like Kelvin's bridge, Wheatstone bridge, Slide wire bridge, Post Office box and Ohmmeter.

However, for measuring high resistances, instruments like megohmmeter or megger are used.

Ohmmeter

The ohmmeter is an instrument that is used for measuring resistance. There are two types of ohmmeters: the series ohmmeter is used for measuring medium resistances and the shunt type ohmmeter is used for measuring low and medium resistances. The ohmmeter in its basic form consists of an internal dry cell, a PMMC meter movement and a current limiting resistance.

Before using an ohmmeter in a circuit, for resistance measurement, the current in the circuit must be switched off and also any electrolytic capacitor in the circuit should

be discharged. Remember that the ohmmeter has its own source of supply.

Capacitors - types - functions, grouping and uses

Objectives: At the end of this lesson you shall be able to

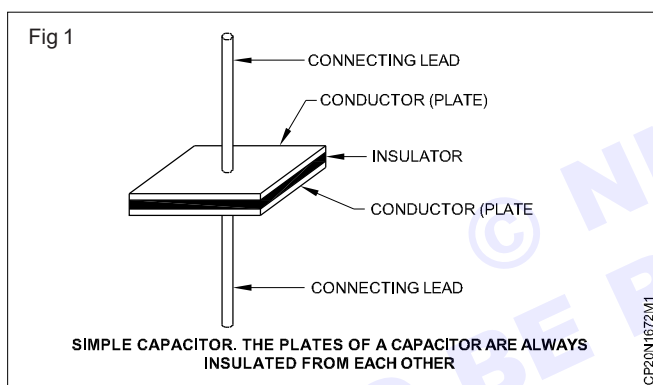
- describe capacitor its construction and charging
- explain capacitance and the factors determining
- state the different types and application of capacitors
- state the testing and defects of capacitors.

Capacitor

Capacitor is a passive two terminal electrical/electronic component that stores potential energy in the form of electrostatic field

The effect of capacitor is called as capacitance. It consists of two conducting plates separated by an insulating material called as dielectric. In simple, capacitor is a device designed to store electric charge.

Construction: A capacitor is an electrical device consisting of two parallel conductive plates, separated by an insulating material called the dielectric. Connecting leads are attached to the parallel plates. (Fig 1)



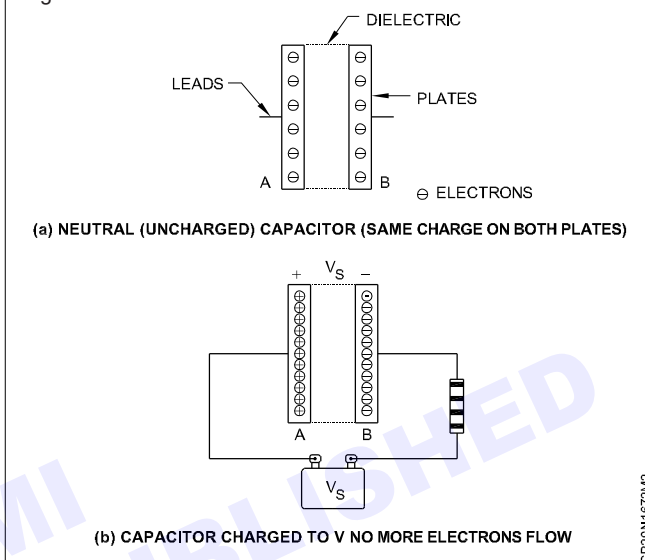
Function: In a capacitor the electric charge is stored in the form of an electrostatic field between the two conductors or plates, due to the ability of dielectric material to distort and store energy while it is charged and keep that charge for a long period or till it is discharged through a resistor or wire. The unit of charge is coulomb and it is denoted by the letter 'C'.

How a capacitor stores charge?: In the neutral state, both plates of a capacitor have an equal number of free electrons, as indicated in Fig 2a. When the capacitor is connected to a voltage source through a resistor, the electrons (negative charge) are removed from plate A, and an equal number are deposited on plate 'B'. Plate A becomes positive with respect to plate B as shown in Fig 2b.

The current enters and leaves the capacitor, but the insulation between the capacitor plates prevents the current from flowing through the capacitor.

As electrons flowing into the negative plate of a capacitor have a polarity opposite to that of the battery supplying the current, the voltage across the capacitor opposes the battery voltage. The total circuit voltage, therefore, consists of two series-opposing voltages.

Fig 2



As the voltage across the capacitor increases, the effective circuit voltage, which is the difference between the battery voltage and the capacitor voltage, decreases. This, in turn, causes a decrease in the circuit current.

When the voltage across the capacitor equals the battery voltage, the effective voltage in the circuit is zero, and so the current flow stops. At this point, the capacitor is fully charged, and no further current can flow in the circuit.

Capacitance : The ability or capacity to store energy in the form of electric charge is called capacitance. The symbol used to represent capacitance is C.

Unit of capacitance: The base unit of capacitance is the **Farad**. The abbreviation for **Farad** is **F**. One farad is that amount of capacitance which stores 1 coulomb of charge when the capacitor is charged to 1 V. In other words, a Farad is a coulomb per volt (C/V).

Farad

A farad is the unit of capacitance (C), and a coulomb is the unit of charge(Q), and a volt is the unit of voltage(V). Therefore, capacitance can be mathematically expressed

$$\text{as } f = \frac{1}{2\pi \times X_C C}$$

This relationship is very useful in understanding voltage distribution in series-capacitor circuits. The other forms of

$$\text{equation are } V = \frac{Q}{C}$$

Example 1: What is the capacitance of a capacitor that requires 0.5 C to charge it to 25V?

Given: Charge(Q) = 0.5C

Voltage(V) = 25V

Find :

Capacitance(C)

$$C = \frac{Q}{V}$$

Solution $C = \frac{0.5 \text{ C}}{25 \text{ V}} = 0.02 \text{ F}$

Answer : The capacitance is 0.02F.

Capacitive reactance

Similar to resistors and inductors, a capacitor also offers opposition to the flow of AC current. This opposition offered to the flow of current by a capacitor is called **capacitive reactance** abbreviated as X_C .

Recall expressions,

$$I = \frac{Q}{t} \text{ and } Q = CV$$

Substituting $Q = CV$ in $I = Q/t$

$$I = \frac{CV}{t}$$

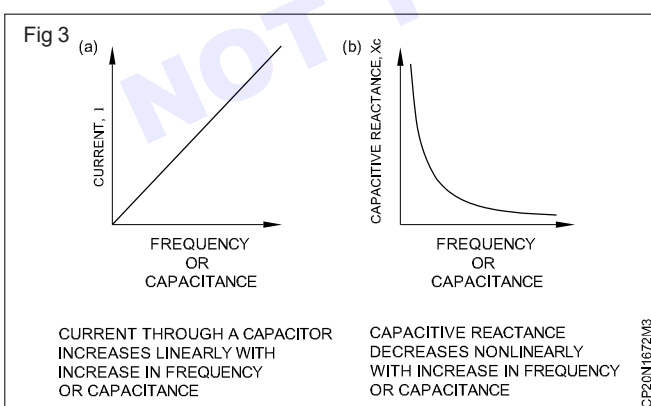
This means,

$I \propto C$, $I \propto V$ and $I \propto f$ (Because, $1/t = f$)

From the above equation, the amount of AC current that a capacitor conducts depends on;

- the frequency (f) of the applied voltage
- the capacitance (C) of the capacitor
- the amplitude of the applied voltage(V).

Fig 3a shows the graph of variation of current(I) through a capacitor with frequency or capacitance when the applied voltage is kept constant.



Since current flow through a capacitor is directly proportional to frequency and capacitance, the opposition to current flow by the capacitor is inversely proportional to these quantities.

Capacitive reactance, X_C can be mathematically represented as;

$$X = \frac{1}{2\pi f C}$$

where

X_C is the capacitive reactance in ohms

f is the frequency of the applied voltage in Hz

and C is the capacitance in farads.

Fig 3b shows the graph of variation of X_C with frequency or capacitance.

Capacitive reactance, X_C , expressed in ohms, acts just like a resistance in limiting the AC current flow.

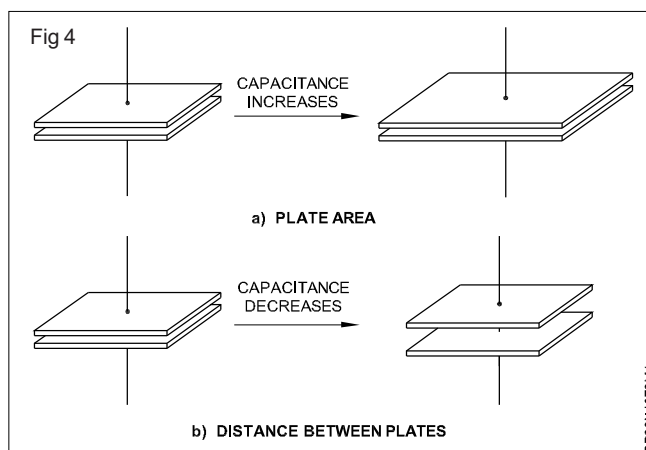
Sub-units of a farad: Most capacitors that you will use in electronics work, have capacitance values in microfarads (μF) and picofarads (pF). A microfarad is one-millionth of a farad ($1\mu\text{F} = 1 \times 10^{-6} \text{ F}$), and a picofarad is one-trillionth of a farad ($1 \text{ PF} = 1 \times 10^{-12} \text{ F}$) one nano farad ($1 \text{ nF} = 1 \times 10^{-9} \text{ F}$).

Factors determining capacitance: The capacitance of a capacitor is determined by four factors.

- Area of the plates ($C \propto A$)
- Distance between the plates ($C \propto d$)
- Type of dielectric material
- Temperature
- Resistance of the plates

Area of the plates: The capacitance of a capacitor is directly proportional to the area of its plates (or the area of its dielectric). All other factors remaining the same, doubling the plate area doubles the capacitance.

Thus, when the dielectric area is increased, the amount of energy stored in the dielectric is increased and the capacitance is also increased. (Remember, capacitance is defined as the ability to store energy) (Fig 4a)



Distance between the plates: Other factors being equal, the amount of capacitance is inversely proportional to the distance between the plates. The strength of the electric field between the plates decreases, when the distance between the plates increases. The force on the electrons in the dielectric decreases accordingly. Again the amount of energy stored in the capacitor, for a given voltage applied to the capacitor, would decrease. Thus, the capacitance decreases. (Fig 4b)

Type of dielectric material: In general, those materials which undergo the greatest distortion store the most capacitance. The ability of a dielectric material to distort and store energy is indicated by its **dielectric constant (K)**.

The dielectric constant of a material is a mere number (that is, it has no units). It compares the material's ability to distort and store energy, when in an electric field, with the ability of air to do the same.

Since air is used as the reference, it has been given K equal to 1. Mica, often used as a dielectric, has a dielectric constant approximately 5 times that of air. Therefore, for mica, $K = 5$ (approximately). Suppose all the other factors (plate area, distance between plates, and temperature) are the same, then a capacitor with a mica dielectric will have 5 times as much capacitance as the one using air as its dielectric.

Dielectric constants for materials commonly used for dielectrics range from 1 for air to more than 4000 for some types of ceramics.

Temperature: The temperature and resistance of the capacitor is the least significant of the four factors. It need not be considered for many general applications of capacitors.

Types of capacitors: Capacitors are manufactured in a wide variety of types, sizes and values. Some are fixed in value, in others the value is variable.

Fixed capacitors

Ceramic capacitors: Ceramic dielectrics provide very high dielectric constants (1200 is typical). As a result, comparatively high capacitance values can be achieved in a small physical size.

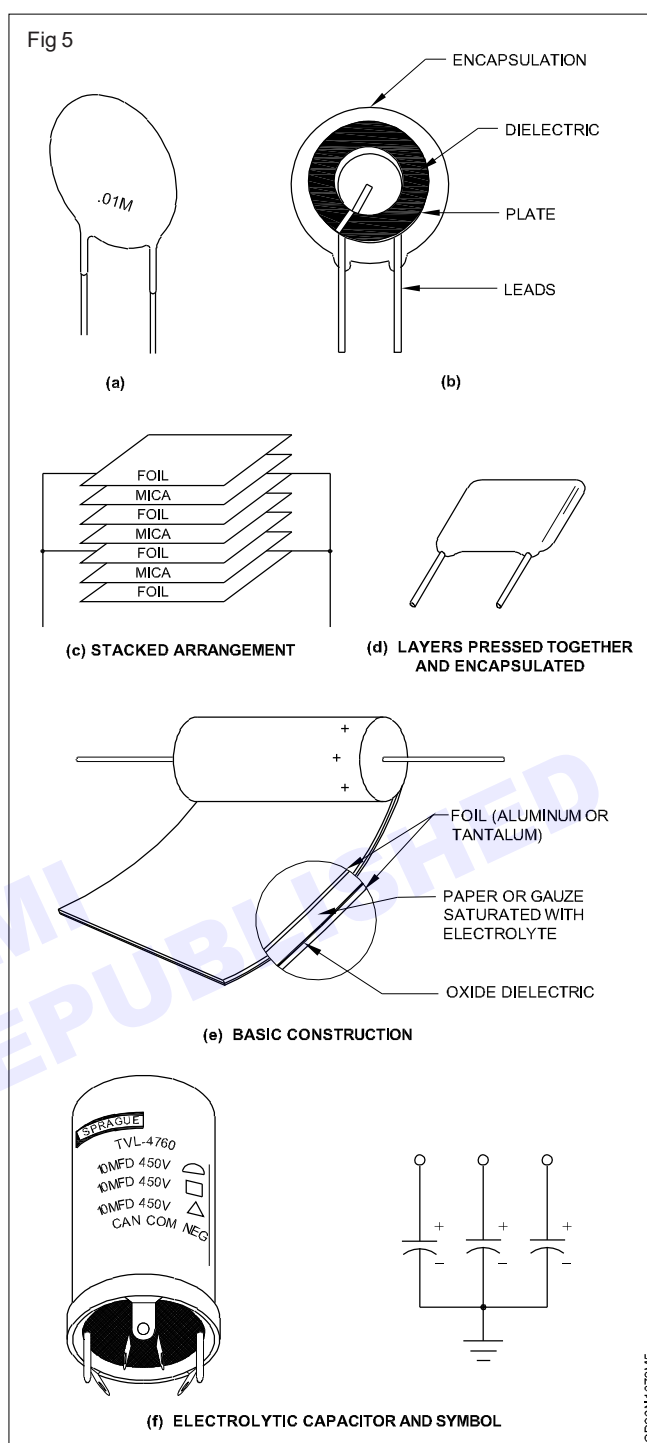
Ceramic capacitors are illustrated in Figs 5a) and (b). These discs are made by using ceramic as an insulator with a silver deposit on each side of the plates. These are used for small values of capacitance and an ordinary TV set might contain several dozens in its circuitry.

Ceramic capacitors are typically available in capacitance values ranging from $1\mu\text{F}$ to $2.2\mu\text{F}$ with voltage ratings up to 6 KV. A typical temperature coefficient for ceramic capacitors is $200,000\text{ PPM}/^\circ\text{C}$.

Mica capacitors: There are two types of mica capacitors, stacked foil as shown in Fig 5(c). It consists of alternate layers of metal foil and thin sheets of mica. The metal foil forms the plate, with alternate foil sheets connected together to increase the plate area, thus increasing the capacitance.

The mica foil-stack is encapsulated in an insulating material such as bakelite, as shown in Fig 5d of the figure. The silver-mica capacitor is formed in a similar way by stacking mica sheet with silver electrode material screened on them.

Mica capacitors are available with capacitance values ranging from 1 pF to 0.1 pF and voltage ratings from 100 to 2500 V DC. Temperature coefficients from -20 to $+100\text{ PPM}/^\circ\text{C}$ are common. Mica has a typical dielectric constant of 5.



Electrolytic capacitors: Electrolytic capacitors are polarised so that one plate is positive and the other negative.

These capacitors are used for high capacitance values up to over $200,000\mu\text{F}$, but they have relatively low breakdown voltages (350 V is a typical maximum) and high amounts of leakage.

Electrolytic capacitors are available in two types: aluminium and tantalum. The basic construction of an electrolytic capacitor is shown in Figs 5(e) and (f).

The capacitor consists of two strips of either aluminum or tantalum foil separated by a paper or gauze strip, saturated with an electrolyte. During manufacturing, an electrochemical reaction is induced which causes an oxide layer (either aluminum oxide or tantalum oxide) to

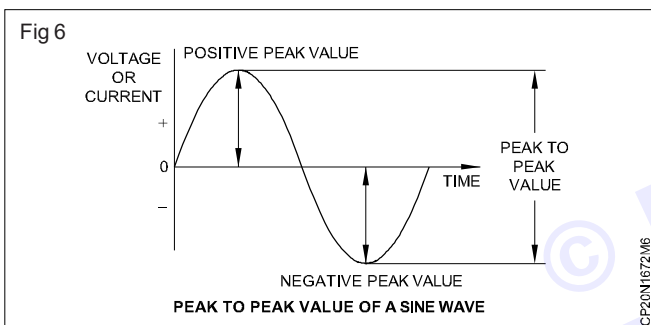
form on the inner surface of the positive plate. This oxide layer acts as the dielectric.

One particular point you must always remember about the electrolytic capacitor is that one end is positive (+) and the other negative (-). You must always observe this polarity when connecting in your circuit. The symbol on a drawing will have positive and negative marks. These polarity marks will tell you it is an electrolytic capacitor.

Since an electrolytic capacitor is polarized, the positive plate must always be connected to the positive side of a circuit. Be very careful to make the correct connection and to install the capacitor only in a DC, not AC, circuit.

Reverse polarity on an electrolytic capacitor causes excessively high current in the capacitor. It causes the capacitor to heat up, and possibly to explode. Thus, the common electrolytic capacitor is limited to use in DC circuits.

Special electrolytic capacitors are manufactured for use in AC circuits. These capacitors are usually listed in catalogues as 'non-polarised' or 'AC' electrolytic capacitors. An AC electrolytic capacitor is really two electric capacitors packaged in a single container. (Fig 6)



AC voltage and current values: Since the value of a sine wave of voltage or current continuously changes, one must be specific, while referring to and describing the values of the wave-form. There are several ways of expressing the value of a sine wave.

Peak value or maximum value: Each alternation of the sine wave is made up of a number of instantaneous values. These values are plotted at various heights above and below the horizontal line to form a continuous wave-form.

Single phase current is an Alternating Current (AC) that flows through a single conductor and completes one cycle in a single phase of an electrical system/ It's commonly used in residential and light commercial applications. Here are the key points about single phase current.

- 1 Basic Concept :** In a single phase AC system, the voltage varies sinusoidally with time and completes one full cycle of a waveform in one period.
- 2 Voltage and Frequency :** Common voltage levels for single phase systems are 120V or 240V (depending on the country), with a frequency of 50Hz or 60Hz.
- 3 Components :** A single phase system typically includes a phase wire (live wire) and a neutral wire. The current through the live wire to the load and returns through the neutral wire.

4 Applications : Single phase power is commonly used for household appliances, lighting and small machinery. It's suitable for applications that require less power compared to three phase systems.

5 Advantages

Simplicity : Single phase systems are simpler to design and maintain.

Cost : Generally, Single phase equipment and installation costs are lower than three phase systems.

6 Disadvantages

Power Capacity : Single phase systems have limitations on power capacity and are less efficient for high power applications.

Voltage Fluctuations : More susceptible to voltage fluctuations compared to three phase systems.

Three Phase Current

Three phase current is an alternating current (AC) system that consists of three individual AC waveforms, each phase offset by 120 degrees from the others. This type of power is commonly used in industrial and commercial settings due to its efficiency and ability to handle larger loads. Here are the key points about three phase current.

- 1 Basic Concept :** In a three phase AC system, three waveforms (phases) are generated, each separated by 120 degrees. This results in a more constant and balanced power flow compared to single phase systems.
- 2 Voltage and Frequency :** Common voltage levels for three phase systems vary widely, but standard levels include 208V, 400V and 480V with a frequency of either 50Hz or 60Hz.
- 3 Components :** A three phase system typically includes three live wires (phases) and a neutral wire. The current flows through the live wires, and the neutral wire provides a return path for any unbalanced load.
- 4 Applications :** Three phase power is used for industrial motors, heavy machinery, large HVAC systems, and other high power equipment. It's also used in data centres, commonly buildings and for electrical distribution over long distances.

5 Advantages

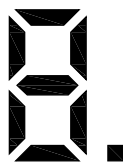
Efficiency : Three phase power is more efficient for transmitting electricity over long distances and for powering large motors and equipment.

Balanced Load : The power load is distributed more evenly the three phases, reducing the risk of voltage drops and fluctuations.

Power Capacity : Three phase systems can deliver more power compared to single phase systems with the same current.

Smoother Operation : Motors powered by three phase systems operate more smoothly and with less vibration than those powered by single phase systems.

Fig 3



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The following safety precautions should always be taken.

- Never use the ohmmeter section on a live circuit.
- Never connect the ammeter section in parallel with a voltage source.
- Never overload the ammeter or voltmeter sections by attempting to measure currents or voltages far in excess of the range switch setting.
- Check the meter test leads for frayed or broken insulation before working with them. If damaged insulation is found the test leads should be replaced.
- Avoid touching the bare metal clips or tips of the test probes.
- Whenever possible, remove the supply before connecting the meter test leads into the circuit.

Applications of Digital multimeter: A multimeter is used for testing and fault finding in electrical/electronic circuits, electrical appliances and machines. A multimeter is a portable handy instrument used for

- checking continuity of circuit, appliances and devices.
- measuring/checking the supply presence at the source
- for testing components like capacitors, diodes, and transistors for checking their condition.
- measuring the current drawn by the circuit to infer its condition
- measuring resistance of the electrical appliances and devices for checking their condition.

Note: Some meters have provision also for temperature measurement with suitable sensing probes.

Soldering & Desoldering

Objectives : At the end of this lesson you shall be able to

- explain the purpose of solder and flux and their types
- describe the soldering technique
- describe the features of soldering iron
- explain desoldering and desoldering tools
- study the soldering and desoldering station and their specification
- explain the desoldering methods using pump and wick.

Need for soldering

Requirements of an electrical joint

- 1 The electrical joint must provide ideally zero resistance or at least a very low resistance path, for the flow of current.
- 2 The electrical joint made should be strong enough to withstand vibrations, physical shock, bumps etc, without causing any deterioration to the quality and strength of the joint.
- 3 The electrical joint should be able to withstand corrosion and oxidation due to adverse atmospheric conditions.

All the above requirements of an electrical joint can be achieved by making a solder joints.

Solder

In a soldered joint, the solder is a mixture of metals, generally TIN and LEAD. It is made to melt at a certain temperature. It acts as a filler between the parts of the connection/joint to form a continuous, low resistance metallic path for conduction of electricity.

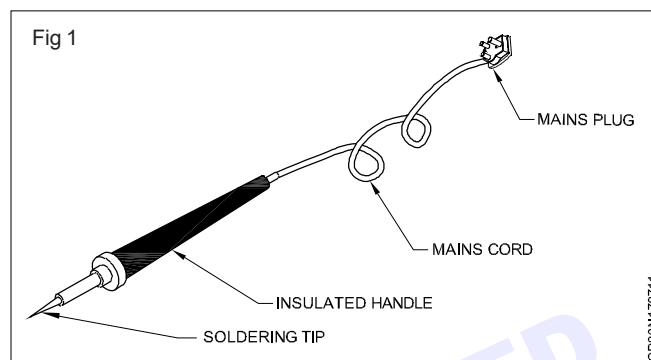
In soldering, as the metal surface is wetted (free flow of liquid solder over a surface) by the solder, a complex chemical reaction, bonds the solder to the metal surface.

The tin content of the solder diffuses with the metal surface to form a layer of a completely new alloy. The alloy so formed will have the same structure as the constituent metals and retain their metallic properties and strength.

Soldering and soldering irons

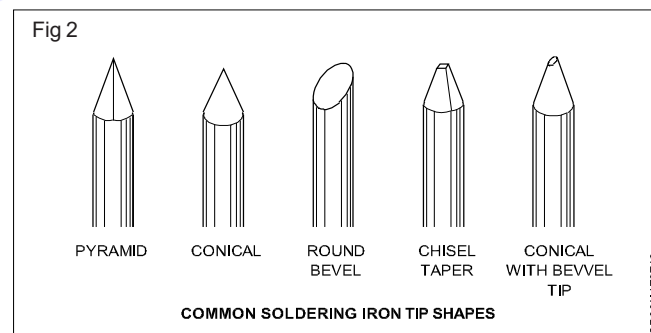
While soldering, the solder is made to melt between the metallic surfaces of the joint, using a soldering iron, as shown in Fig 1. A **soldering iron** is an instrument used to produce the required heat to carry out soldering.

Soldering irons of different wattage ratings starting from 10 watts to more than 150 watts are available commercially. Depending on the type, size and heat sensitivity of the components being soldered, the most suitable wattage soldering iron should be chosen. Most of these soldering iron work on 240V, 50Hz AC mains supply. There are special type irons which work on dc supply also. For soldering delicate components, soldering irons with temperature controlling facility are used. These are known as soldering stations.



Soldering iron tips

Soldering irons are designed to take, a variety of tip sizes and shapes as shown in Fig 2. The choice of the iron and the tip to use depends on, the nature of the joint to be soldered. A proper selection of the soldering iron and tip is important for obtaining good quality soldered joint. To solder effectively, the tip of the soldering iron must be kept clean all times.



Types of solders

Solders are available in many forms. The type to be chosen depends on, the type of soldering to be carried out. The wire type solder is the most commonly used solder for hand soldering work, using low wattage soldering iron.

Solders available in the market may have different tin-lead proportion in it. For general electronic circuit soldering work, solder with 60% tin and 40% lead is most suited. This solder is commonly called 60/40 solder. This solder has been specially developed to possess superior properties required for electronic circuit work.

Soldering FLUX

A protective oxide layer forms on the exposed surface of most metals. The rate at which the oxide layer is formed varies from metal to metal. The layer forms quickly on newly exposed metal, and over time, the layer slowly become quite thick.

This oxide layer on metals interferes with soldering. Hence, it must be removed before a soldered joint can be made.

The purpose of flux is to first dissolve the thin layer of oxide from the surface of the metals to be joined, and then form a protective blanket over them until the solder can flow over the joint surfaces to form the joint.

However, thick layers of oxide must be removed using an abrasive method as all types of flux are not capable of dissolving their oxide layers.

Types of flux

There are several types of fluxes used in different types of soldering. The type of flux used for soldering electronic components is called **rosin**. Rosin is made from a resin obtained from the sap of trees.

Rosin flux is ideal for soldering electronic components because, it become active at the soldering temperature, but revert to an inactive state when cooled again. An additional advantage is that it is non-conductive.

The rosin has activators or halides added to it. The activators used in rosins are mild acids that become very active at soldering temperatures. These acids dissolve the oxide layer on the metals to be soldered.

Organic and inorganic acid fluxes are available. These fluxes are not suitable for soldering electronic circuits.

Common forms of flux

Flux is available in a variety of forms to suit various types of application. Flux is available as a liquid, paste or a solid block. For most applications flux is often put in the solder itself during manufacture.

Not all flux types are available in all forms. For hand soldering work on electronic circuits, the best form for the flux is either as a liquid or a paste.

Rosin cored solder

Several manufacturers produce solder wire with the flux already included in one or more cores running along its length. This is known as **cored solder**.

The most popular type of cored solder for electronic hand soldering contains rosin type flux. Such solder is known as **rosin cored solder**.

When the solder is heated, the rosin flux melts before the solder. The rosin then flows out over the surface to be soldered ahead of the solder.

The amount of flux contained in the core is carefully controlled by the manufacturer and for most applications it will be sufficient. However, it is a common practice to

apply additional liquid flux or flux paste to the joint, just prior to making the joint. This additional flux ensures that, sufficient flux available while the joint is being made. When the soldering has been completed, excess flux if any has to be removed.

Rosin-cored solder is available in different gauges as. It is important to choose a size suitable for the job at hand as given below;

- use 22 gauge for small joints
- use 18 gauge for medium joints
- use 16 gauge for large joints.

Soldering Technique

Soldering a joint

Selection and preparation of the soldering materials is the most time consuming phase of making a solder joint. Heating the joint and applying solder is the least time consuming but, it is the most important part of the soldering process.

Critical factors during soldering

- 1) Controlling the temperature of the workpiece
- 2) Limiting of time that a workpiece is held at soldering temperature. These factors are specially critical while soldering electronic components like resistors, capacitors, transistors, ICs etc., Failure to correctly time and coordinate the heating of the joint and add solder, will result in a poor quality joint and may even damage the components.

Stages in soldering

The soldering process can be divided into several distinct stages or phases as given below:

- 1 Selection and preparation of materials.
- 2 Heating the joint and adding solder.
- 3 Cooling the joint.
- 4 Cleaning the joint.
- 5 Inspecting the joint.

SELECTION AND PREPARATION OF MATERIALS

Selection of soldering iron wattage

Soldering irons are available in different wattage ratings starting from 10 watts to several 100 watts. The wattage of a soldering iron specifies the amount of heat it can produce. As a thumb rule, higher the physical dimension of the workpiece, higher should be the wattage rating of the soldering iron. Some of the suggested wattage choices are given below:

- i For soldering less temperature sensitive components such as, resistors on lug boards, tag boards, use 25 to 60W iron. For soldering on printed circuit boards, use 10 to 25 W iron.
- ii For soldering highly temperature sensitive components such as, diodes, transistors and integrated circuits, use 10 to 25 watts iron.

Selection of soldering iron tip

To ensure that the joint is heated to the required temperature ideally,

- the area of the tip face should be approximately equal to the area of the joint to be soldered
- the tip should be long enough to allow easy access to the joint.
- the tip should not be too long, as this may result in too low temperature at the tips working face.

In most soldering irons, the tip can be easily removed and replaced.

Selection of tip temperature

Good quality soldering iron tips have numbers punched on them. These numbers indicate the temperature to which the tip can be heated.

Tip No.	Temperature °C	Temperature °F
5	260	500
6	316	600
7	371	700
8	427	800

Selection of tip shape

Suggested soldering tip shapes selection table is given below;

Type of soldering work	Soldering tip shape to choose
Wires, resistors and other passive components on to lug/tag boards	CHISEL TIP
All miniature electronic components except ICs on to lug boards and printed circuit boards (PCB)	BEVEL TIP
Integrated circuits (ICs) on to printed circuit boards (PCBs)	CONICAL TIP

Selection of solder and flux

There are several sizes of the cored solders whose choice depends on the size of the joints to be soldered. Also the tin and lead percentage of the solder should be checked before using the solder. Different tin and lead combinations of solder need different temperatures for it to melt and reach the liquid state.

For electronic soldering applications, solder of tin and lead of 60/40 proportion is used. This solder proportion has a melting point of 200°C which is the required temperature for general purpose soldering irons.

While soldering to make a strong solder joint the flux should melt first, and then the solder. Therefore, while using rosin cored solder, cut off the first 5 to 10mm of the

solder using a side cutter, so that any earlier melted portion of the solder blocking the rosin core is removed.

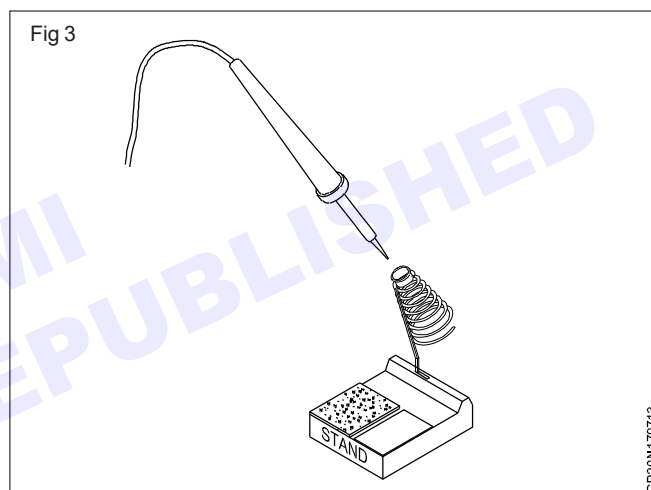
For ease of application, the flux used in addition to the cored flux in solder should be of paste form.

Flux is a chemical substance which has acidic properties. Therefore, it is advised not to touch flux by hand. Use a stick or a thin stiff brush to apply flux on workpieces. Hands should be washed after soldering work.

Soldering stand

Soldering stand plays an important role of retaining the soldering iron tip temperature around the required soldering temperature. The soldering stand should not allow the external temperature to cool the bit. At the same time the stand should not contain all the heat generated.

Soldering stands are specially designed as shown in Fig 3 to fulfill the above requirements. Such a design also prevents accidental burn injuries to the user of the soldering iron.



Another important requirement of a soldering stand is its mechanical stability. When the iron is taken out or placed in the stand frequently, the stand should not topple. An unstable stand is sure to cause burn injuries while carrying out serious soldering work.

Inspection of soldering iron

Most soldering irons are powered by AC mains voltage. This voltage level is high and can give shock if one is careless. Soldering irons will generally have lengthy mains cable. While using the iron, the mains cable gets twisted and will have to bear physical strain. Because of this strain, the insulation of cable may get cut. This may lead to live wires protruding out. The live wires give severe electrical shocks if it touches the user.

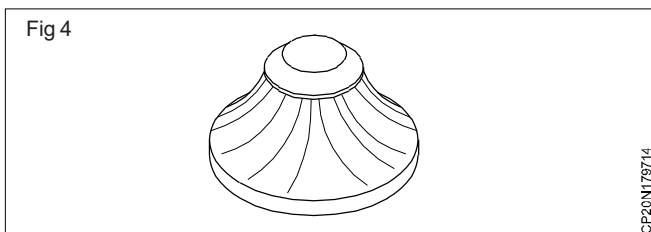
Hence, a thorough inspection of the soldering iron is a must before using through it.

Preparation of soldering iron for soldering

Heating the joint and adding solder

Tips for heating and applying solder to a joint to be soldered are given below:

- Do not apply additional flux required for a joint in one place. Apply a small amount of flux around the joint. Do not allow the flux to flow outside the area to be soldered.
- Place the iron tip at the connection such that the tip gets maximum contact with parts to be joined.
- Slowly feed the solder into the joint starting close to the soldering tip and moving towards the edge of the joint.
- Continue applying the solder to the joint until complete wetting of the joint has been achieved and the joint has a concave fillet as shown in Fig 4.



- After enough solder has been applied and solder removed, keep the soldering iron tip on the joint for a moment to ensure that all the flux on the joint has reached the soldering temperature. This will allow majority of the acids within the joint to break down, which otherwise will corrode the joint after a period of time.

Generally the time taken to make a good soldered joint is between 3 to 7 seconds from applying the soldering iron.

Cooling the joint

Tips for cooling a solder joint are given below:

- Allow the joint to cool without assistance. Do not blow air from your mouth or from any other source to cool the joint. Forced cooling, cools the joint much earlier than it has to, resulting in a dry or brittle solder joint which will lead to mechanical and electrical defects of the joint.
- Do not move any part of the joint while it is cooling. This disturbs the chemical bonding taking place. Movement of the joint while it is cooling results in a dry joint.

Cleaning the joint

When a solder joint is made, the amount of flux applied should be just sufficient to make a good joint. But, quite often, there will be a brown waxy substance left on the joint. This is nothing but the flux residue. In its original state this residue is corrosive. Hence, the flux residue or excess flux must be removed from the joint before soldering can be considered as complete.

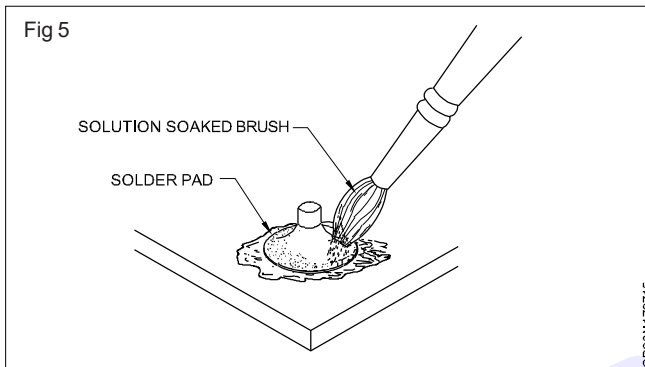
If the flux residue and excess flux are not properly removed, their corrosive nature of the flux will gradually destroy the component leads and the circuit board. The flux residue is also *tacky* and, if not removed, will collect dust and debris often leading to circuit failure.

Removal of flux residue requires the use of solvents. The type of solvent depends on the flux used.

IsoPropyl Alcohol (IPA) is one of the solvents used for removing residual flux. It is available either undiluted or pre-mixed with water and can be obtained in pump sprays, aerosols, cans and drums depending on the quantity and style of use.

Cleaning using water/IPA solution

Determine the right method of application. (spray or liquid). Apply the solvent to the soldered joint. Use a clean acid brush, or some other type of stiff brush, to gently scrub the joint as shown in Fig 5, to help dissolve the residue, taking care to avoid splashing the mixture.



When the residue has been dissolved, dry the joint with a lint-free cloth to remove as much of the dissolved residue as possible.

Don't's do While Soldering

- Do not use a poorly tinned soldering tip.
- Do not cool the tip of the iron by wiping it excessively on a damp sponge.
- Do not allow the solder to be carried to the joint on the tip of the soldering iron.
- Do not attempt to speed up the cooling of the joint by blowing on it.
- Do not move the soldered joint until the solder has cooled to solid state.
- Do not try and improve a bad solder joint by reheating. All the original solder must be removed and the joint preparation and soldering should be redone.

Features of soldering iron

There are a number of features that the soldering irons posse need to be examined before a choice of a particular soldering iron is made. These include: size, wattage or power consumption, voltage method of temperature control, anti-static protection, type of stand available, and general maintenance and care issues.

Size: There is a wide variety of sizes of soldering iron available. Obviously those that are smaller will be more suited to fine work, and those that are larger will be more suited to the solder of items that are less delicate. The physical size will also run in parallel with the wattage or power consumption of the iron.

Wattage or power consumption: The power consumption or wattage of a soldering iron is often quoted. The wattage can vary. For basic non-temperature controlled irons, a wattage of 40 watts may be good for general work, and higher if heavy soldering is envisaged. For small PCB work, 15 or 25 watts is good value. For temperature controlled irons slightly higher wattages are common as the temperature control acts more quickly if more heat can be directed to the bit more quickly to compensate for removal of heat via the work item.

Voltage: While most soldering irons on sale in a particular will country have the correct mains voltage, 230V AC and there are also soldering irons that can run from 12 V. Some irons may be made for specialist applications where they need to run from low voltages.

Temperature control: Soldering irons use two main varieties of temperature control. The less expensive irons are regulated by the fact that when they come up to temperature, the loss of heat is the same as the heat generated. In other words they employ no form of electronic regulation. Other, more costly types have thermostatic control. This naturally regulates the temperature far better. Usually the temperature can be adjusted to the required value. These irons come into their own because when heat is drawn away by a large object being soldered, they will maintain their temperature far better. Those with no regulation may not be able to maintain their temperature sufficiently when soldering a large object, with the result that it is more difficult to melt the solder under these conditions.

Anti-static protection: With the increasing susceptibility of many electronic components, particularly the very advanced integrated circuit chips, static protection is becoming more of an issue. While most components being used by home constructors are often not damaged by static, some are. It is therefore a wise precaution to at least consider whether the soldering iron that is bought is one that has static protection.

Maintenance: When using any soldering iron it is essential that spare parts can be obtained. The soldering iron "bits" used to undertake the actual soldering have a limited life and even though the rest of the iron may work for many years, it will be necessary to change the bits at regular intervals. Additionally it is worth ensuring for the more expensive soldering irons, such as those with temperature control, that spare parts are available should they need repair.

Desoldering and desoldering tools

Desoldering

Many a time it may be necessary to disconnect/remove components and wires from a soldered or wired circuit due to the following reasons;

- Component failure(open,short etc).
- Incorrect component installation(polarity,position etc).
- Faulty or defective solder connections(dry solder etc).
- Circuit modifications(replacing,removing components etc).

Disconnecting a component or wire from any soldered circuit involves two separate actions. These are:

- 1 **Desoldering the connection** - this action involves removal of the solder from a joint
- 2 **Removal of the component** - this action involves removing the component lead from the joint.

De-soldering the connection

De-soldering is a process of heating a soldered joint, to melt the existing solder and removing the molten solder from the joint.

De-soldering makes it easy to separate or pull-out the components, wires from the joint without unnecessary damage to the components and wires.

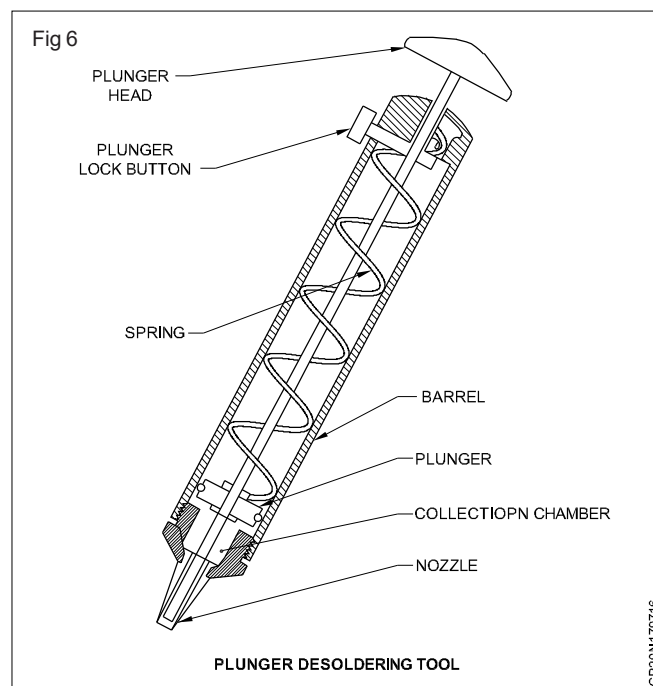
The heat required to melt the solder is supplied by a soldering iron. But removal of the molten solder from the joint requires the use of one of the following;

- Plunger de-soldering tool or desoldering pump
- Wicking braid

But, in many cases, desoldering is done using a nose plier and a soldering iron. First, the joint to be disconnected is heated using the soldering iron. Once the solder at the joint melts, the component lead is pulled away using a nose plier. This method of desoldering can be used for heavy components with strong leads. But this method should not be used for desoldering thin lead delicate components such as transistors, integrated circuits etc., This is because, in this method there is likelihood of component getting overheated or the leads getting cut or leads getting detached from the body of the component.

Plunger de-soldering tool

A typical plunger de-soldering tool is shown in Fig 6.



Plunger type desoldering tool is the most commonly used desoldering tool. This tool works on the principle of air suction. When the plunger head is pushed fully inside gets locked with the help of the plunger button. This is known as cocking tool.

In this condition, the nozzle of the desoldering tool is kept almost touching the joint to be desoldered. If the joint is heated, the solder at the joint melts. If the plunger button of the desoldering pump is pressed, it releases the spring tension and moves the plunger up with a jerk. This causes the air to be sucked-in through the nozzle. Since the nozzle is now in contact with the molten solder, the molten solder is also sucked-in through the nozzle and gets collected in the collection chamber.

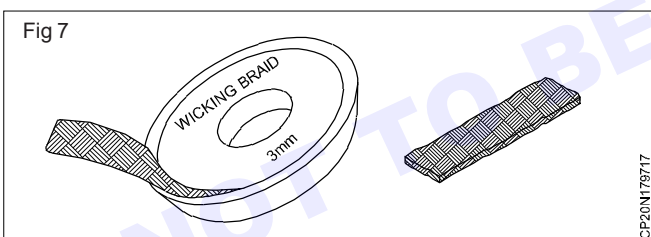
When the solder is removed using a plunger de-soldering tool, all the molten solder of a joint may not be sucked by the de-soldering tool at the first attempt, the joint must be reheated and the solder removed in two or three attempts.

After doing one suction of molten solder, while cocking the tool for second suction, face the nozzle into a dirt collector. This is because, the solder collected at the tip of the nozzle gets pushed out every time the tool is cocked.

After several operations, the waste solder collected within the tool will begin to interfere with its operation. To prevent clogging of nozzle, this solder must be removed periodically and the tool must be cleaned and lubricated.

Wicking Braid

Wicking braid as shown in Fig 7 is another simple de-soldering aid. This is made of copper and is soaked in flux. Wicking braid is nothing but a tape made of thin strands of copper knitted to form a mesh Fig 7.



A wicking braid relies on the tendency of the hot solder to flow towards the heat source. When a soldered joint is heated via a wicking tape as shown in Fig, the molten solder gets drawn into the wicking braid as shown in Fig. Thus the joint is now free from solder and the component can be removed easily.

The flux content of the wicking braid varies from brand to brand. Generally, the higher the level of flux in the braid, the more efficient it will be at drawing the solder from the joint.

Wicking braids are available in small, hand-held rolls and is supplied in a range of sizes from 0.8 to 6 mm wide so that the correct width of wicking braid can be selected for the joint to be de-soldered.

De-soldering using a wicking braid is commonly used for removing miniature components soldered on printed circuit boards(PCB's).

Removal of component

When solder is removed from the joint, the component can then be removed from the circuit board. If a component was soldered using clinched lead method. it is essential to remove the bridge of solder holding the lead.

To remove the solder bridge, follow the steps.

There are other special tools used for de-soldering such as De-soldering iron and multi-contact de-soldering block.

Soldering and desoldering station

Printed circuit board have changed the face of Electronics industry. Comparing the today's PCBs with the old hardwired, steel chassis devices, they lack the strength making them vulnerable to cracks and related defects. It may sometimes be possible to repair a broken PCB but it is very difficult process. Locating the cracked copper trace on the PCB is the most difficult part of the repair PCBs get damaged very easily. A little rough handling during installation or troubleshoot will invite a crack in the trace. While placing or removing PCBs from their sockets, one needs to put little extra force. This itself might cause a crack in the trace. Similarly when a component on a PCB is removed or inserted a little more heat for a little long period will make copper trace to come off the board's substrate. There may result a microscopic crack in the trace.

Soldering and Desoldering Stations

A typical competitive soldering station with ESD safe by design will comprise of hot air station soldering, LED double digital display. This kind of stations will come with PID controlled closed loop of sensor. The desolder station can give rapid heating, precise and stable temperature, suitable for soldering and de-soldering surface mounted. Such as QFPM PLCC, SOP, BGA etc package of ICs. Hot air station and intelligent cooling system, adopts imported heating wire, for a long life. There are normally light portable handle and suitable for mounting and reworking SMD component by hand for a long time.

Typical specifications of a Solder and Desolder stations :

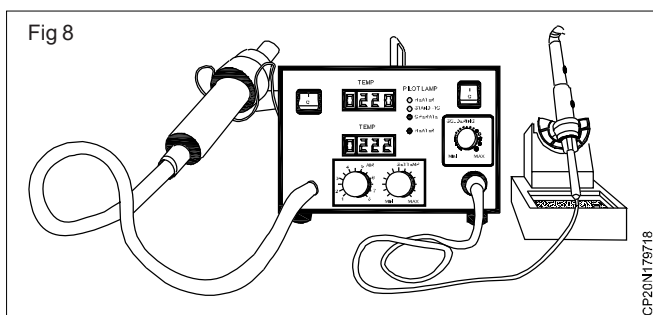
Hot Soldering Station :

Air Flow	:	0.16 - 1.2 Nm ³ /h
Pump Consumption	:	45W
Temp. Control	:	150-450°C
Heater	:	250W Metal
Rated Voltage	:	110V/220V 50/60Hz AC
Power Consumption	:	270W
Air Pump	:	Membranous
Solder Equipment :		
Power Consumption	:	60W
Output Voltage	:	24V AC
Temp. Control	:	200-480

Ground Resistance : 20 ohms

Heater : Ceramic Heating Element

A typical hot soldering station is shown in Fig 8.



Desoldering by using pump and wick

Desoldering is the process of removing soldered components from a circuit made on PCB. Desoldering pump along with the soldering iron is used for this purpose. A desoldering pump also known as solder sucker is a small mechanical device which sucks the liquid/molten solder from the joint where the components are mounted. In order to desolder a component from the PCB, we first heat up the solder joint with the soldering iron till the solder liquefies/melts. At the same moment we actuate the soldering pump by pressing the trigger lever and bring the tip over the molten metal and pull the trigger back by pressing a button. At this instant the lever is pulled back and the tip of the pump sucks the molten solder. This process is repeated until all the residue solder is sucked by the pump and the hole on the PCB is clear to solder a fresh component.

To actuate the pump the lever is pressed until there is a click sound which indicates that the lever will remain locked in the same position.

The desoldering pump's bottom head contains a hole through which the molten solder is sucked when the pump is triggered. The head is designed such that the extracted solder does not solidify and block it, consequently the sucked metal can be removed and discarded easily.

Desoldering Wick / braid

Place the braid over a connection and heat the opposite side with an iron. Sometimes adding a small amount of solder to the iron tip can actually speed up the process because that solder will help the iron transfer heat into the braid faster. Cut off and discard the used wick. The only concern with using desoldering wick/braid is that the components and pads can easily become overheated, especially surface mount pads. As always, try to minimize the time parts are heated. This wick is 1" wide and 5 feet long, which should be satisfactory for most through-hole and many surface mount connections. Width is important because it dictates how much solder a certain length of braid can hold. Too thin, and the solder will quickly fill up the braid and stop it from absorbing. Too thick, and it will be hard not to touch neighboring joints. This particular braid is coated in pure resin - based flux that will leave a non-corrosive, non-conductive, and environmentally friendly residue the residue can be cleaned with alcohol if desired for cosmetic reason, but unless you are making military spec devices, cleaning should not be necessary. The casing is ESD safe.

Basic Electronics

Objectives : At the end of this lesson you shall be able to

- **define semiconductors**
- **state the types of semiconductors**
- **state the unique property of a PN junction**
- **explain the classifications of diodes**
- **list out type numbers/code numbers of diodes.**

Semiconductors

Semiconductors are materials whose electrical property lies between that of Conductors and Insulators. Because of this fact, these materials are termed as semiconductors. In conductors the valence electrons are always free. In an insulator the valence electrons are always bound. Whereas in a semiconductor the valence electrons are normally bound but can be set free by supplying a small amount of energy. Several electronic devices are made using semiconductor materials. One such device is known as Diode.

Semiconductor theory

Basic semiconductor materials like other materials have crystal structure. The atoms of this structure, are bonded to each other as shown in Fig 1. This bonding is known as covalent bonding. In such a bonding, the valence electrons of the atoms are shared to form a stable structure as shown in Fig 1.

Intrinsic semiconductors

The most important of the several semiconductor materials are Silicon (Si) and Germanium (Ge). Both these semiconductor materials have four valence electrons per atom as shown in Fig 1. These valence electrons, unlike in conductors, are not normally free to move. Hence, semiconductors in their pure form, known as Intrinsic semiconductors, behave as insulators.

However, the valence electrons of a semiconductor can be set free by applying external energy. This energy will tear-off the bound electrons from their bond and make them available as free electrons as shown in Fig 2. The simplest method of turning bonded valence electrons into free electrons is by heating the semiconductor.

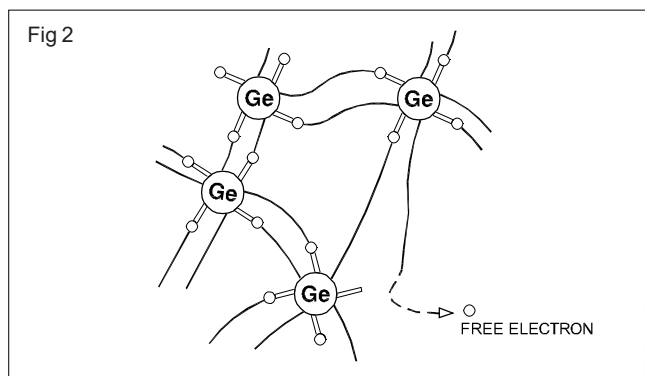
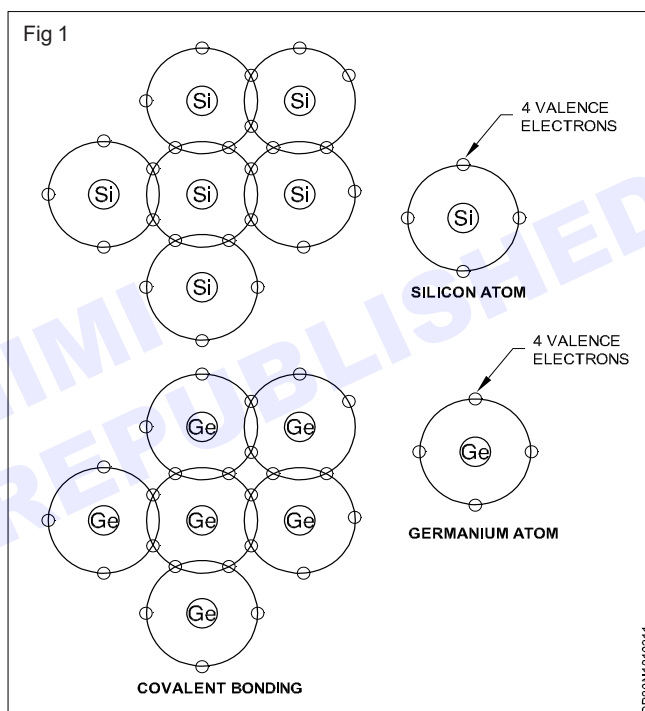
The higher the temperature to which the semiconductor is heated, more the bound electrons becoming free and will be able to conduct electric current. This type of conduction in an intrinsic semiconductor (pure semiconductor) as a result of heating is called intrinsic conduction.

From the above said phenomena, it is important to note that semiconductors are temperature-sensitive materials.

Extrinsic semiconductor

The number of free electrons set free by heating a pure semiconductor is comparatively small to be used for any useful purpose. It is found experimentally that, when a

small quantity of some other materials such as Arsenic, Indium, Gallium etc. is added to pure semi conductor material, more number of electrons become free in the mixed material. This enables the semiconductor to have higher conductivity.



These foreign materials added to the pure semiconductor are referred to as impurity materials.

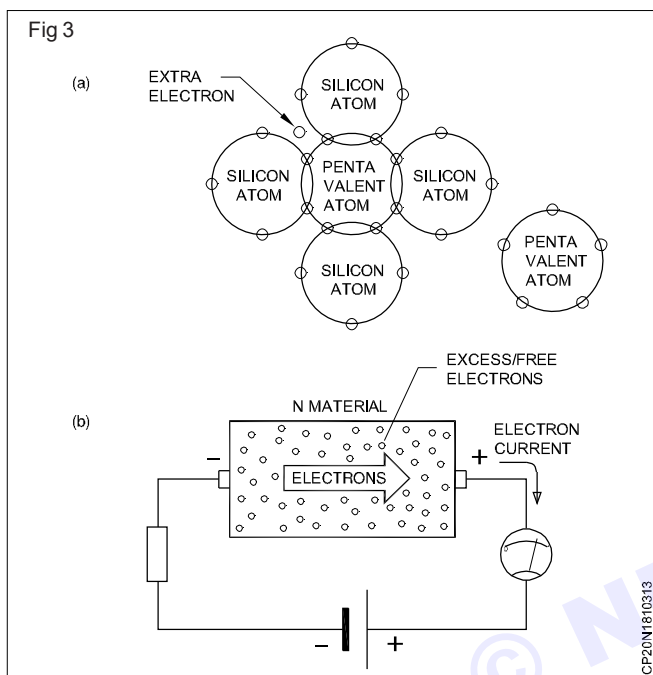
Doping

The process of adding impurity to an Intrinsic semiconductor material is known as Doping. Since the doped semiconductor materials are no longer pure, they are called impure or **extrinsic semiconductors**.

Depending upon the type of impurity used, extrinsic semiconductors can be classified into two types;

1 N-type semiconductors

When a pentavalent material like Arsenic (As) is added to a pure Germanium or pure Silicon crystal, one free electron results per bond as shown in Fig 3a. As every arsenic atom donates one free electron, arsenic is called the donor impurity. Since a free electron is available and since the electron is of a Negative charge, the material so formed by mixing is known as **N type material**.



When a N-type material is connected across a battery, as shown in Fig 3b, current flows due to the availability of free electrons. As this current is due to the flow of free electrons, the current is called electron current.

In N type semi conductor the current is due to electrons, therefore the electrons are the majority charge carriers.

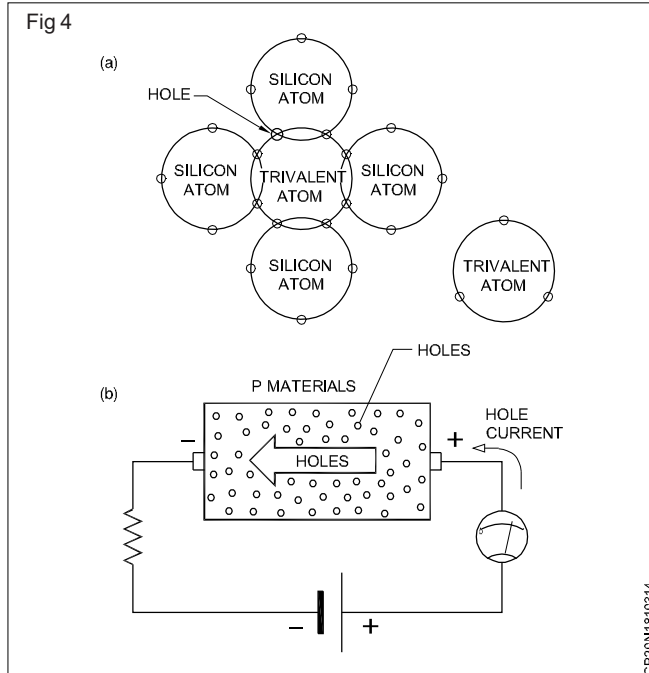
The semi conductor materials are temperature sensitive, heating causes the covalent bonds to break down by creating electron-hole pair. The holes are minority charge carriers - in N type semi-conductors.

2 P-type semiconductors

When a trivalent material like Gallium(Ga) is added to a pure Germanium or pure Silicon crystal, one vacancy or deficit of electron results per bond as shown in Fig 4a. As every gallium atom creates one deficit of electron or hole, the material is ready to accept electrons when supplied. Hence gallium is called acceptor impurity. Since vacancy for an electron is available, and as this vacancy is a hole which is of Positive charge, the material so formed is known as **P-type material**.

When a P-type material is connected across a battery as shown in Fig 4b, current flows due to the availability of free holes. As this current is due to flow of holes, the current is called hole current.

The holes are the majority charge carriers in P type semi conductor and the electrons are the minority charge carriers.

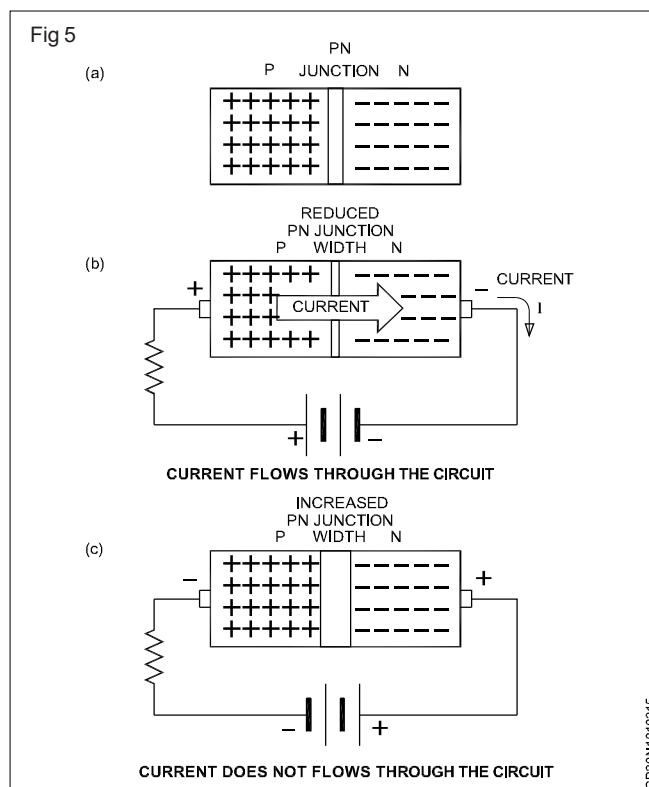


Covalent Bond

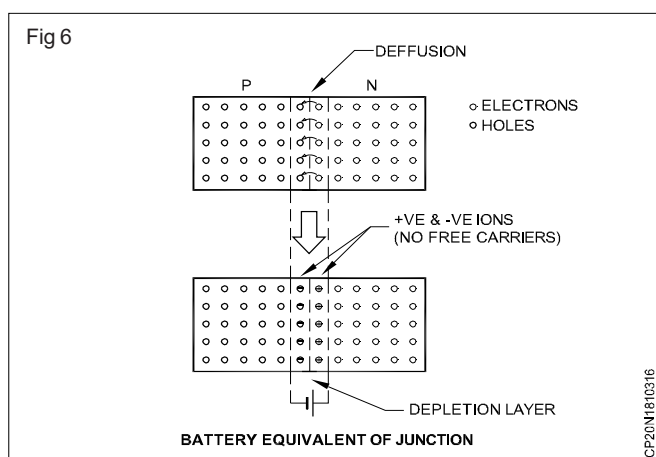
A Covalent bond consists of the mutual sharing of one or more pairs of electrons between two atoms.

P - N junction

When a P-type and a N-type semiconductors are joined, a contact surface between the two materials called PN-junction is formed. This junction has a unique characteristic. This junction, has the ability to pass current in one direction and stop current flow in the other direction. To make use of this unique property of the PN junction, two terminals one on the P side and the other on the N side are attached. Such a PN junction with terminals attached is called a **Diode**.



When a P and N material is put together, at the junction of P and N materials, as shown in Fig 6, some electrons from the N-material jump across the boundary and recombine with the hole near the boundary of the P-material. This process is called diffusion. This recombination makes atoms near the junction of the P-material gaining electrons and become negative ions, and the atoms near the junction of the N-material, after losing electrons, become positive ions. The layers of negative and positive ions so formed behave like a small battery. This layer is called the depletion layer because there are neither free electrons nor holes present (depleted of free carriers). This depletion region prevents further the movement of electrons from the N-material to the P material, and thus an equilibrium is reached.



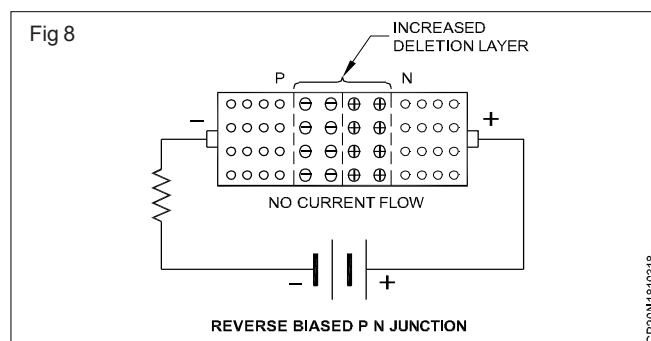
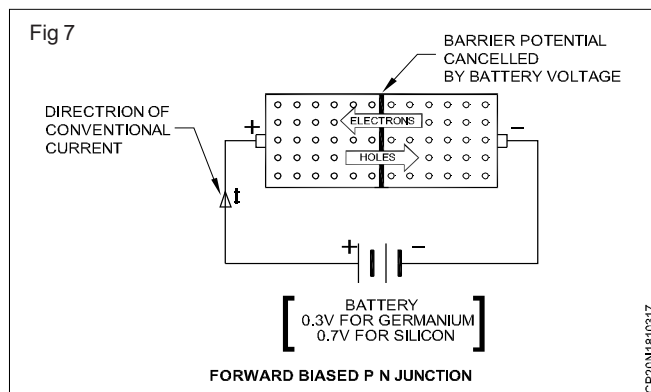
The internal voltage set up due to +ve and -ve ions at the junction is called barrier potential. If any more electrons have to go over from the N side to the P side, they have to overcome this barrier potential. This means, only when the electrons on the N side are supplied with energy to overcome the barrier potential, they can go over to the P side.

In terms of voltage applied across the terminals of the PN junction diode, a potential difference of 0.7V is required across the terminals in the case of silicon diode and 0.3V in the case of Germanium diode for the electrons, in order to cancel off the barrier potential and cross over the barrier as shown in Fig 7. Once the barrier potential gets canceled due to external voltage application, current flows through the junction freely. In this condition the diode is said to be forward biased.

When the applied external battery polarity is as shown in Fig 8, instead of canceling the barrier potential, the external battery voltage adds up to the barrier potential, and, hence, no current flows through the junction. In this condition the diode is said to be reverse biased.

Since current flows through a PN junction diode when it is forward biased and does not when reverse biased, the diode can be thought of to be a unidirectional current switch.

The two leads connected to the P and N terminals are known as Cathode and Anode.



To forward-bias a diode, the Anode should be connected to the +ve terminal of the battery and the Cathode to the -ve terminal of the battery. When a diode is in the forward biased condition, the resistance between the terminals will be of the order of a few ohms to a few tens of ohms. Hence, current flows freely when a diode is forward biased.

On the other hand, when a diode is reverse biased, the resistance between the terminals will be very high, of the order of several tens of megohms. Hence, current does not flow when a diode is reverse biased. As a rule, the ratio of resistance in forward to reverse bias should be of at the minimum order of 1:1000.

Types of diodes: The PN junction diodes discussed so far are commonly referred to as rectifier diodes. This is because these diodes are used mostly in the application of rectifying AC to DC.

Classification of Diodes

1 Based on their current carrying capacity/power handling capacity, diodes can be classified as

- **low power diodes:** can handle power of the order of several milli watts only
- **medium power diodes:** can handle power of the order of several watts only
- **high power diodes:** can handle power of the order of several hundreds of watts.

2 Based on their principal application, diodes can be classified as,

- **Signal diodes:** low power diodes used in communication circuits such as radio receivers etc. for signal detection and mixing
- **Switching diodes:** low power diodes used in switching circuits such as digital electronics etc. for fast switching ON/OFF of circuits

- **Rectifier diodes:** medium to high power used in power supplies for electronic circuits for converting AC voltage to DC.

3 Based on the manufacturing techniques used, diodes can be classified as,

- **Point contact diodes:** a metal needle connected with pressure on to a small germanium(Ge) or silicon(Si) tip.
- **Junction diodes:** made by alloying or growing or diffusing P and N materials on a semiconductor substrate.

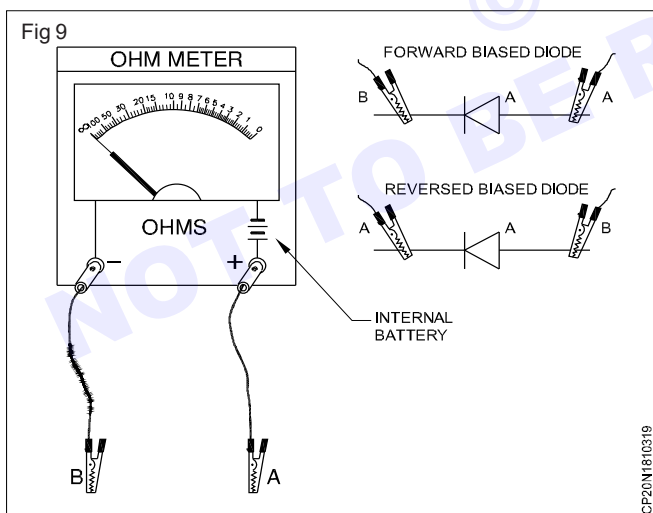
Types of diode packaging

The type of packaging given to diodes is mainly based on the current carrying capacity of the diode. Low power diodes have either glass or plastic packaging. Medium power diodes have either plastic or metal packaging. High power diodes will invariably have either metal can or ceramic packaging. High power diodes are generally of stud-mounting type.

Testing rectifier diodes using ohmmeter

A simple ohmmeter can be used to quickly test the condition of diodes. In this testing method, the resistance of the diode in forward and reverse bias conditions is checked to confirm its condition.

Recall that there will be a battery inside an ohmmeter or a multimeter in the resistance range. This battery voltage comes in series with the leads of the meter terminals as shown in Fig 9 and lead A is positive, lead B negative.



If the positive lead of the ohmmeter, lead A in the Fig 10, is connected to the anode of a diode, and the negative (lead B) to the cathode, the diode will be forward-biased. Current will flow, and the meter will indicate low resistance.

On the other hand, if the meter leads are reversed, the diode will be reverse-biased. Very little current will flow because a good diode will have very high resistance when reverse biased, and the meter will indicate a very high resistance.

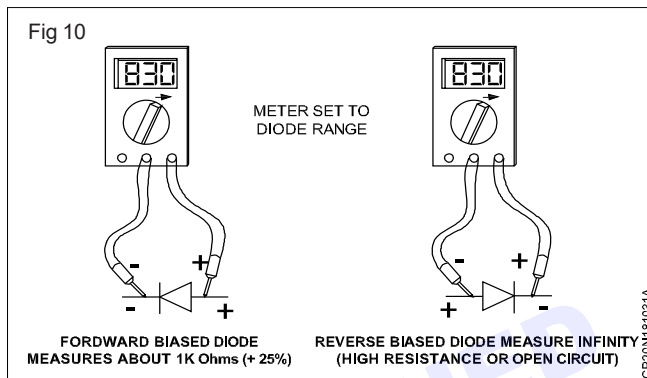
While doing the above test, if a diode shows a very low resistance in both the forward and reverse biased conditions, then, the diode under test must have got damaged or more specifically shorted. On the other hand, a diode is said to

be open if the meter shows very high resistance both in the forward and reverse biased conditions.

Testing of diodes using digital Multimeter

If the digital multimeters are used for testing the diodes, first the selector switch must be kept at diode testing position. The +ve terminal of the MM (lead A as in the Fig 10 must be connected to the anode of a diode and the negative terminal (lead) to the cathode, the diode is forward biased the MM will display the barrier voltage of the diode in the forward biased condition.

On the other hand, if the meter leads are reversed, the diode will be reverse biased and MM will display 1.



BYxxx,	xxx- from 100 onwards,	examples: BY127, BY128 etc.
DRxxx,	xxx- from 25 onwards.	examples: DR25, DR150 etc.,
1Nxxxx	examples: 1N917	1N4001, 1N4007 etc.

Behaviour of diode when FORWARD BIASED

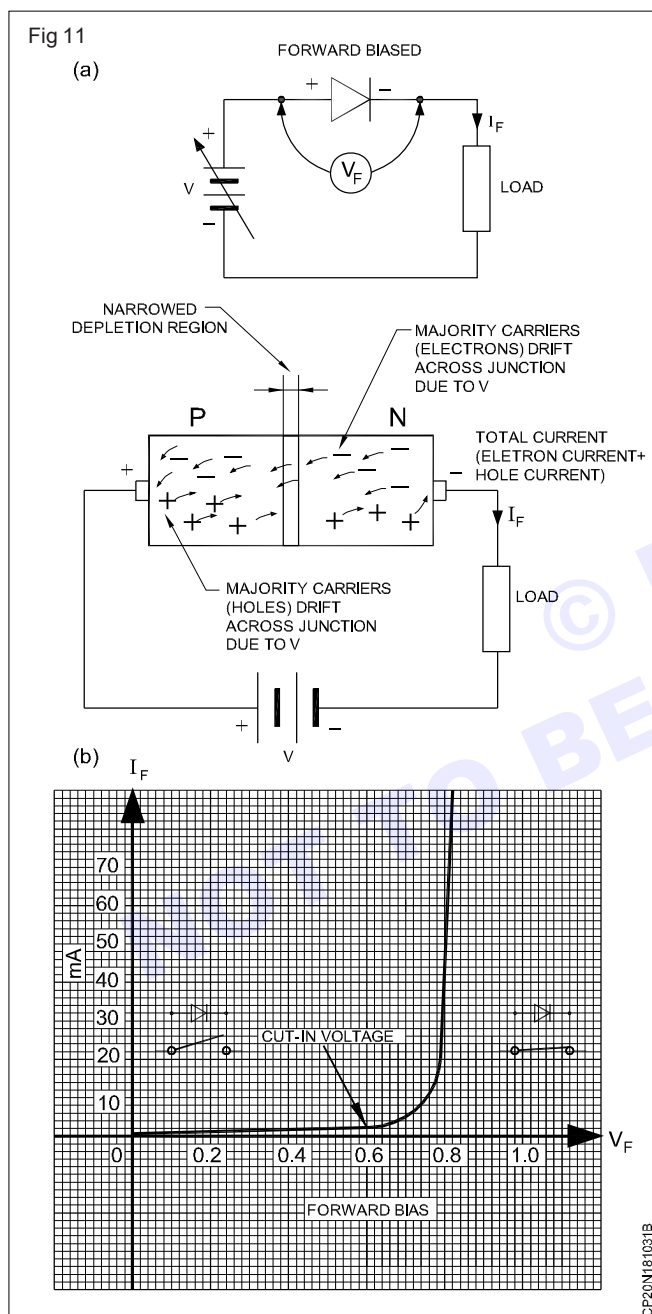
Fig 11a shows a forward biased silicon PN junction diode using a variable DC supply. When the applied voltage is slowly increased starting from 0 volts as long as the voltage across the diode V_F is less than that of the depletion barrier potential (0.7 volts for Si diodes), no current or a negligible current flows through the diode, and, hence, through the circuit. This is shown in the graph at Fig 11b.

But once the voltage V_F across the diode becomes equal to or greater than the barrier potential 0.6 to 0.7V, there will be a canceling effect of the barrier potential. Hence, the free electrons from the N region get pushed away by the -ve battery terminal (remember like charges repel) and cross over the junction, pass through the P region and get attracted by the + terminal of the battery. This results in the *electron current* passing through the diode, and, hence, through the Load.

In a similar way, the holes in the P region are pushed away by the +ve battery terminal, cross over the junction, pass through the N region and get attracted by the -ve terminal of the battery. This results in *hole current* through the diode, and hence, through the Load.

Thus current flows through the diode when the forward bias potential is higher than the barrier potential. This current flow through the diode is because of both electrons and holes. The total current in the circuit is the sum of the hole current and the electron current. Hence, diodes are called bipolar devices in which both hole current and electron current flows.

From the graph at Fig 11b, it can be seen that, once the forward voltage goes above 0.6V the diode starts conducting, resulting in considerable current through the circuit. This voltage level across the diode is referred to as cut-in or knee or threshold voltage.

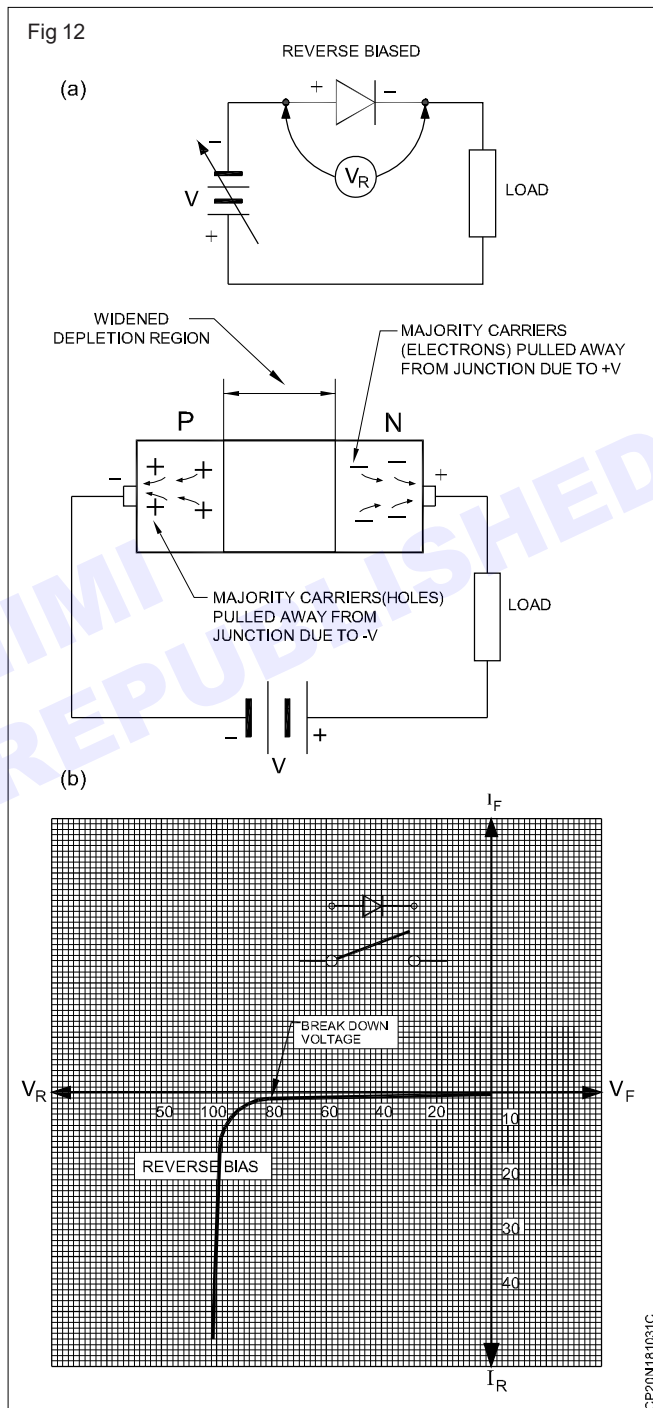


If the applied forward voltage is further increased beyond the cut-in voltage, the depletion layer further narrows down allowing more and more current to flow through the diode. It can be seen from the graph at Fig 11b, that beyond the cut-in voltage, the current increases sharply for very small voltage increase across the diode. In this region, above the cut-in voltage, the forward biased diode behaves almost

like a closed switch. The only limiting factor for the current at this stage is the maximum current the diode can handle without getting burnt or the junction getting punctured permanently. This current limit is given in diode data books as *maximum forward current*, I_{Fmax} .

Behaviour of diode when reverse biased

When an external DC voltage is connected across the diode with the polarity as shown in Fig 12, the diode is said to be reverse biased.



In this condition, when the battery voltage is increased from 0 to several tens of volts, the polarity of the applied voltage instead of canceling the barrier potential, aids the barrier potential. This, instead of narrowing the depletion layer, widens the depletion layer. The widening of the depletion layer results in, not allowing the current to flow through the junction, and, hence, the load. In other words, the polarity

of the applied voltage is such that the holes and electrons are pulled away from the junction resulting in a widened depletion region.

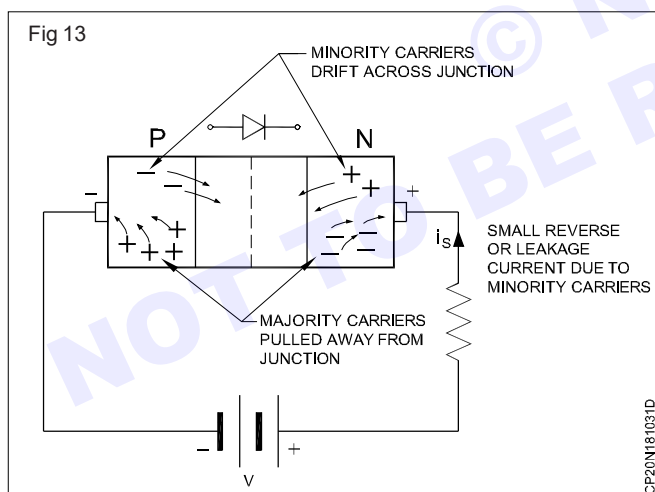
Referring to the graph shown in Fig 12b, it can be seen that there is no current even when the voltage V_R across the diode is several tens of volts.

If the applied reverse voltage is kept on increased, say to hundred volts (this depends from diode to diode), at one stage the applied voltage V_R across the junction is so large that it punctures the junction damaging the diode. This results in shorting of the diode. This short results in uncontrolled heavy current flow through the diode as shown in graph at Fig 12b. This voltage at which the diode breaks down is referred to as reverse break-down or avalanche breakdown.

The maximum reverse voltage that a diode can withstand varies from diode to diode. This reverse voltage withstanding capability of a diode is referred to as the *peak-inverse-voltage* or PIV of the diode. This value for diodes is given in the diode data manual. The PIV of diodes varies from a minimum of 50 volts in small signal diodes to several thousands of volts in high power diodes.

Minority current in Diodes

When a PN junction is reverse biased, due to the increased width of the depletion layer, there can be no current through the diode. But, in practice there will be a small current of the order of a few nano-amperes or a few micro-amperes through the diode as shown in Fig 13.



The reason for this small current is due to the creation of a very limited number of free electrons and holes on both sides of the junction due to thermal energy. Semiconductors are highly sensitive to temperature. Even a temperature of 25°C is sufficient to create a small number of electrons and holes resulting in a current of the order of a few nano-amperes. These current carriers created are referred to as minority current carriers. This current, due to minority current carriers, which flows through the diode when reverse biased, is known as reverse current or leakage current or saturation current, i_s . Based on experiments, for all silicon diodes, this reverse current doubles for each 10°C rise in temperature. For example, if it is 5nA at 25°C , it will be approximately 10nA at 35°C and so on.

Effect of temperature on barrier voltage: It is known that semiconductors are highly sensitive to temperature. Since the functioning of a diode is basically due to the unique property of its junction and its barrier voltage, the barrier voltage also depends on the junction temperature. If the temperature of the junction is increased beyond a limit (25°C), electrons are produced due to thermal agitation in the semi-conductor crystal structure. These electrons, having sufficient energy, drift across the junction. This decreases the barrier voltage. It is experimentally found that the barrier voltage decreases by $2\text{ mV}/^\circ\text{C}$ increase in temperature. This reduced barrier voltage allows more current through the junction. More current heats up the junction further, reducing the barrier voltage further. If this cumulative effect continues, the junction will get damaged making the junction no more useful. Therefore, diodes should not be allowed to go above a specified temperature. This maximum limit a diode junction can withstand safely is given in the diode manual as *junction temperature*, $T_{j\text{max}}$.

Diode specification

Semiconductor diodes are used for various applications. Some of the major areas of application are listed below.

- Modulation and demodulation in communication receivers.
- Switching high speed and digital circuits.
- Low power and high power rectification.
- As surge protectors in EM relay and other circuits.
- For clipping, clamping wave-forms.

For different applications, diodes of different current carrying capacity, different PIV capacity and so on are required. Therefore, manufacturers of diodes make diodes to cater to varied applications with different specifications. Before using a diode for a particular application, it is a must to find out whether the voltage, current, and temperature characteristics of the given diode match the requirement or not.

Important specifications of a diodes

- The material the diode is made-of: This could be Silicon or Germanium or Selenium or any other semiconductor materials. This is important because the cut-in voltage depends upon the material the diode is made-of. For example, in Ge diodes the cut-in voltage is around 0.3 V , whereas in Si diodes the cut-in voltage is around 0.7 V .
- Maximum safe reverse voltage denoted as V_R or V_i that can be applied across the diode. This is also known as peak-inverse-voltage or PIV. If a higher reverse voltage than the rated PIV is applied across the diode, it will become defective permanently.
- Maximum average forward current, I_F or I_t that a diode can allow to flow through it without getting damaged.
- Forward voltage drop, V_F or V_i that appears across the diode when the maximum average current, I_F flows through it continuously.
- Maximum reverse current, I_{vr} that flows through the diode when the Maximum reverse voltage, PIV is applied.

- Maximum forward surge current, I_S that can flow through the diode for a defined short period of time.
- The maximum junction temperature in degree centigrade the diode junction can withstand without malfunctioning or getting damaged.

- Suggested application indicates application for which the diode is designed and produced.

Application of diodes : The most basic application would be changing AC current to DC current by removing some part of the signal. This functionality would make them rectifiers. They are used in electrical rectifiers.

Working principle of zener diodes

Objectives : At the end of this lesson you shall be able to

- state the need of regulators in power supplies
- state the formula to calculate the % load regulation factor
- explain the important specifications of a zener diode
- explain working characteristic, application and specification of varactor diode.

Voltage regulators: The DC output voltage level of power supplies such as, full-wave and bridge rectifiers, tend to decrease or increase,

- when the load current increases or decreases
- when the AC input voltage level decreases or increases.

Such variations in the output DC voltage level of power supply is not acceptable for most of the electronic circuits. Hence, it is required to regulate the DC output of power supplies so as to keep the DC output level constant, inspite of variations in the DC load current or the AC input voltage. Circuits or components used to keep the DC output voltage of a power supply constant are called voltage regulators.

Regulation factor: The ability of a power supply to maintain a constant DC output voltage for variations in the load current is referred to as load regulation. Load regulation of a power supply is generally given as a percentage.

$$\text{Load regulation factor \%} = \frac{V_{NL} - V_{FL}}{V_{NL}} \times 100$$

where,

V_{NL} = DC output at no load or open circuit

and V_{FL} = DC output at rated full load.

It should be noted that lower the percentage of load regulation factor, better is the voltage regulation.

Example: The DC output of a power supply is 12 volts at no-load and 11 volts at full load.

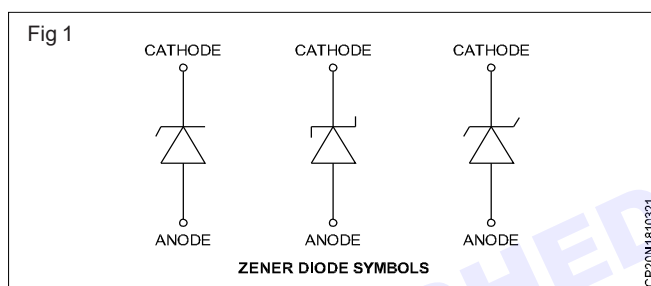
$$\% \text{ Load regulation} = \frac{12 - 11}{12} \times 100 = 8.33\%$$

In practice the load regulation of a good power supply should be less than 0.1 %.

Regulating the DC output voltage for variations in the input AC level is termed as line regulation. This is discussed in further units.

The zener diode: In a power supply one of the simplest ways of regulating the DC output voltage (keeping the output voltage constant) is by using a zener diode. With zener in reverse breakdown condition, the voltage across the zener diode remains constant for a wide range of input and load variations.

Because of this property, zener diodes are also known as voltage regulators or voltage reference diodes. Fig 1 shows the symbol used for zener diodes.



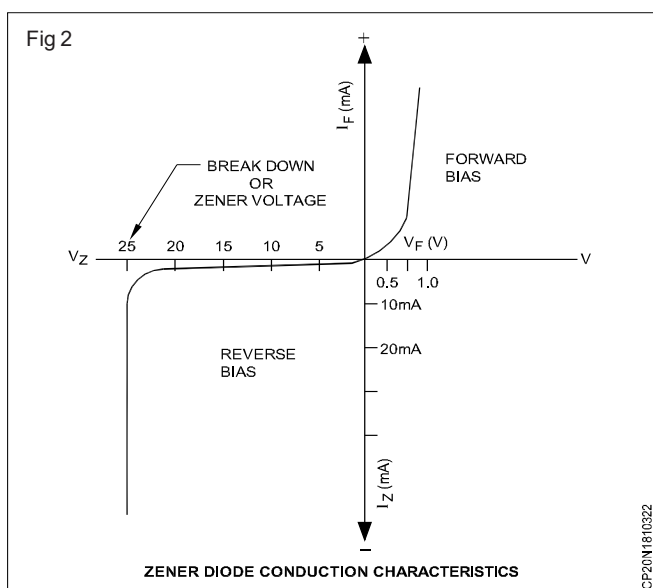
The difference between a rectifier diode and a zener diode are listed below;

- Compared to normal rectifier diodes, zener diodes are heavily doped.
- Unlike ordinary diodes which do not work in the breakdown region, zener diodes work only in the breakdown region.
- Generally rectifier diodes are used in forward-biased condition, whereas zeners are always used in reverse-biased condition.
- The reverse breakdown voltage of zener diodes is very much less (3 to 18V) compared to rectifier diodes (minimum 50V).

The similarities of a zener diode with those of general purpose rectifier diodes are listed below;

- Zener diodes are also PN junction diodes, which are also generally made of silicon.
- Zener diodes also have two terminals (anode and cathode).
- In physical appearance, the zener diodes and ordinary diodes look alike.
- Like rectifier diodes, zener diodes are also available with glass, plastic and metal casing.
- The anode and cathode marking technique on the body is same for both zener and rectifier diodes.
- The zener can be tested with an ohmmeter in the same way as in rectifier diodes.
- Zener requires approximately the same voltage for it to be forward-biased into conduction as that of an ordinary diode.

Fig 2 shows the conduction characteristics of a typical zener diode. Because of the nature and heavy doping in a zener, its characteristics are different compared to a rectifier diode.



Note that, the zener diode acts as a rectifier diode when forward biased. It also behaves as a rectifier diode when reverse-biased, till the voltage across it reaches the breakdown voltage. As can be seen from Fig 2, even the reverse or leakage current remains almost negligible and constant despite the increase in the reverse-biased voltage till the break down voltage, also called zener voltage is reached. But, Once the zener breakdown voltage is reached, the diode current begins to increase rapidly and the zener suddenly begins to conduct. In the case of a normal rectifier diode, once the break down voltage is reached the diode gets punctured and starts conducting heavily whereas, in a zener diode, the diode does not get punctured even though it conducts current in the reverse biased condition.

The cause for this reverse conduction is referred to as the avalanche effect. The avalanche effect cause, the electrons to be knocked loose from their bonds in the crystal structure. As more electrons are loosened, they in turn knock others and current builds quickly. This action causes the voltage drop across the zener to remain constant regardless of the zener current. As shown in Fig 2, once the zener voltage is reached, very small voltage changes create much greater current changes. It is this characteristic, which makes the zener useful as a constant voltage source or as a voltage regulator.

Unlike in a rectifier diode, the reverse current through the zener is not destructive. If the current is kept within the specified limits depending upon the wattage rating of the zener, using a suitable series resistance, no harm is done to the zener diode.

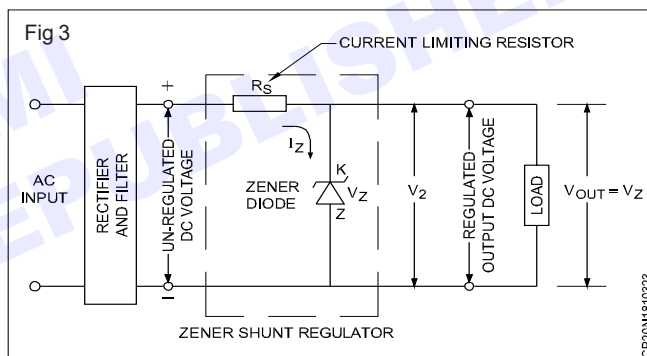
Because the zener diode is designed to operate as a breakdown device, the zener can be brought out of condition easily. A zener is brought out of its zener conduction by lowering the reverse-biased voltage below the zener voltage or by reversing the polarity of the applied voltage.

Application of zener diodes: The most popular use of zener diodes is as voltage regulators in DC power supplies. Fig 3 illustrates a simple zener regulated power supply.

In the circuit at Fig 3, the zener diode is in parallel with the output or load of the power supply. It is very important to note that the zener is connected in the reverse-biased condition. Such a parallel circuit connection is often called a shunt. When used in this way, the zener is said to be a shunt regulator.

In Fig 3, the zener begins to conduct in the reverse-biased condition as the voltage across it reaches the zener voltage V_Z . The voltage across the zener remains constant immaterial of the input DC voltage. Since the load is in parallel with the zener, the voltage across the load V_{OUT} will be same as the voltage across the zener V_Z ($V_{OUT} = V_Z$).

If the input DC voltage to the zener increases, as can be seen from its characteristics in Fig 2, the current I_Z through the zener increases but the voltage across the zener remains the same due to avalanche effect. Because the zener voltage, V_Z does not change, the output voltage V_{OUT} , does not change and so the voltage across the load is constant. Thus, the output is said to be regulated.

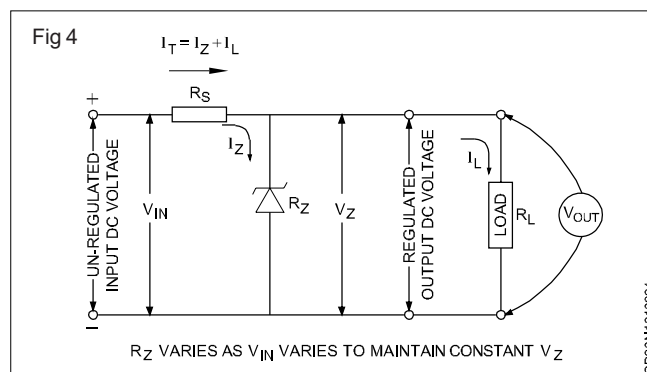


Referring to Fig 4, the zener can be looked at as an automatically changing resistance. Total current through the resistance R_s is given by,

$$I_T = I_Z + I_L$$

Thus the voltage across R_s is,

$$V_R = (I_Z + I_L) R_s$$



If the input DC voltage V_{IN} increases, output voltage V_{OUT} , tends to increase. In the meantime, the zener conducts more heavily, causing more current (more I_Z) to flow through

R_S . Hence, more voltage drop occurs across R_S . This increase in drop across R_S offsets the increase in the output voltage V_{OUT} , thus retaining the voltage across load R_L at its original value. Likewise, if the value of R_L is decreased (increased I_L), current through the zener I_Z decreases, retaining the value of I_T through R_S . This ensures sufficient load current through the load R_L without decrease in the level of V_{OUT} .

Zener specifications: Like in rectifier diodes, the type-code number is marked generally on the body of the zener. From the type-code marked, detailed specifications of the zener can be found referring to any standard diode data manual.

Important zener diode specifications are listed below;

- **Nominal Zener voltage, V_Z :** This is the reverse biased voltage at which the diode begins to conduct in reverse bias.
- **Zener voltage tolerance:** Like the tolerance of a resistor, this indicates the percentage above or below V_Z . For example, $6.3\text{ V} \pm 5\text{ percent}$.
- **Maximum zener current, $I_{Z,max}$:** This is the maximum current that the zener can safely withstand while in its reverse-biased conduction (zener) mode.
- **Maximum power dissipation, P_Z :** is the maximum power the zener can dissipate without getting damaged.
- **Impedance (Z_Z):** The impedance of the zener while conducting in zener mode.
- **Maximum operating temperature :** The highest temperature at which the device will operate reliably.

These specifications of zener diodes are given in diode data books.

The example given below enables to interpret the specifications of certain types of zener diodes without the need to refer diode data book:

Example 1: The type-code printed on a zener is BZ C9V1.

BZ C9V1

B	Z	C	9V1
silicon	zener	5% tolerance	9.1V

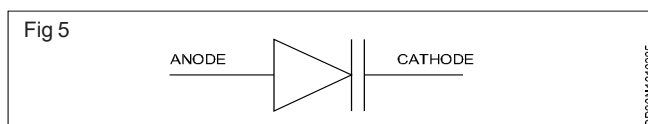
Example 2: The type-code printed on a zener is 1Z 12.

1Z 12

1	Z		12
Means a semiconductor with one PN junction	zener	No tolerance code means, 10% tolerance	12V

Other popular zener diode type-codes are, 1N750, 1N4000, ZF27, ZP30, DZ12, BZ148, Z6, etc.

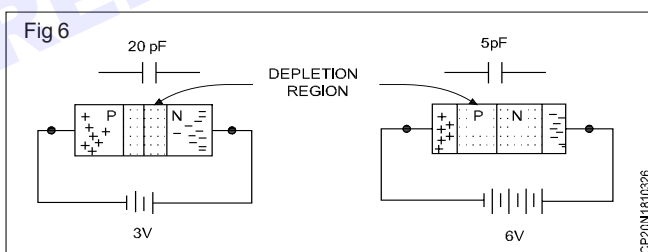
Varactor diode or varicap diode: Varactor diode is a one kind of semiconductor microwave solid-state device and the applications of this diode mainly involve in where variable capacitance is preferred which can be accomplished by controlling voltage. These diodes are also named as varicap diodes. Even though the outcome of the variable capacitance can be showed by the normal P-N junction diodes, but these diodes are chosen for giving the desired capacitance changes as they are special types of diodes (Fig 5). Varactor diodes are specifically fabricated and optimized such that they permits a high range of changes in capacitance.



The different types of varactor diodes are available in the market such as hyperabrupt, abrupt and gallium - arsenide varactor diodes. The symbol of the varactor diode is shown in the above figure that includes a capacitor symbol at one end of the diode that signifies the characteristics of the variable capacitor of the varactor diodes.

The symbol of the varactor diodes looks like a common PN-junction diode that includes two terminals namely the cathode and the anode. And at one end this diode is inbuilt with two lines that specifies the capacitor symbol.

Working of a Varactor diode: To know the varactor diode working principle, we must know the function of capacitor and capacitance. Let us consider the capacitor that comprises of two plates alienated by an insulator as shown in the Fig 6.



We know that, the capacitance of a capacitor is directly proportional to the region of the terminals, as the region of the terminals increases the capacitance of the capacitor increases. When the diode is in the reverse biased mode, where the two regions of P-type and N-type are able to conduct and thus can be treated as two terminals. The depletion area between the P-type & N-type regions can be considered as insulating dielectric. Therefore, it is similar to the capacitor shown above.

The volume of the depletion region of the diode varies with change in reverse bias. If the reverse voltage of the diode is increased, then the size of the depletion region increases. Likewise, if the reverse voltage of the Varactor diode is decreased, then the size of the depletion region decreases.

Photodiodes and Phototransistors

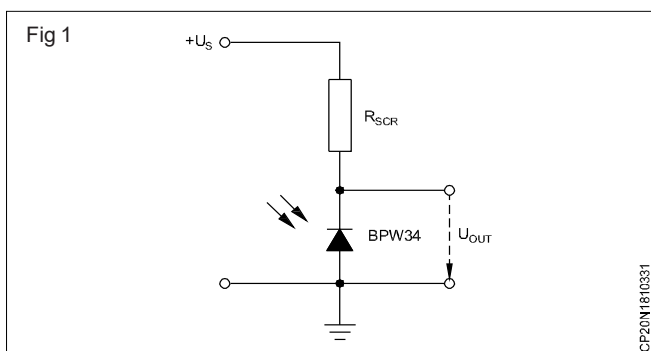
Objectives: At the end of this lesson you shall be able to

- explain working of photodiode
- explain the advantages of PIN photodiode
- list the application of photodiodes
- explain working of photodiode
- explain the working of a light controlled switch using photo transistor.

Photodiodes

P-N Photo diodes

Photodiodes are produced by silicon techniques. Photodiodes are operated in the reverse direction. A supply voltage and a series resistor are therefore required to operate photodiodes. The basic circuit for the operation of photodiodes is shown in Fig 1



When no light is incident on the photodiode, a reverse current flows through the p-n junction, as it does in any normal semiconductor diode, but in photodiodes it is usually referred to as the “dark current” I_{Ro} .

When light strikes the p-n junction, crystal bonds are broken as a result of the supply of energy. Mobile charge-carrier pairs are produced, which immediately migrate as a result of the electric field present. The holes travel towards the p-layer and the electrons towards the n-layer. As a result of illumination, an additional photocurrent I'_{photo} occurs, which increases linearly with the illuminance. This photocurrent is superimposed as a reverse current on the relatively small dark current, so that for the total photocurrent occurring with illumination, the following applies:

$$I_{photo} = I_{Ro} + I'_{photo}$$

Since I_{Ro} is far smaller than I'_{photo} then:

$$I_{photo} = I'_{photo}$$

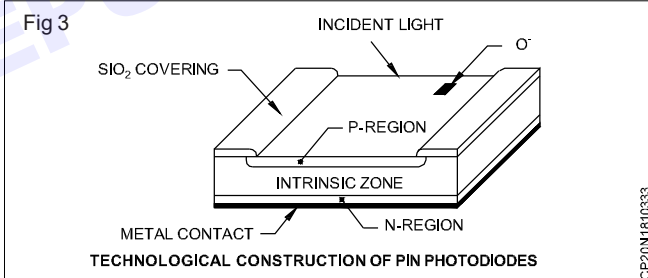
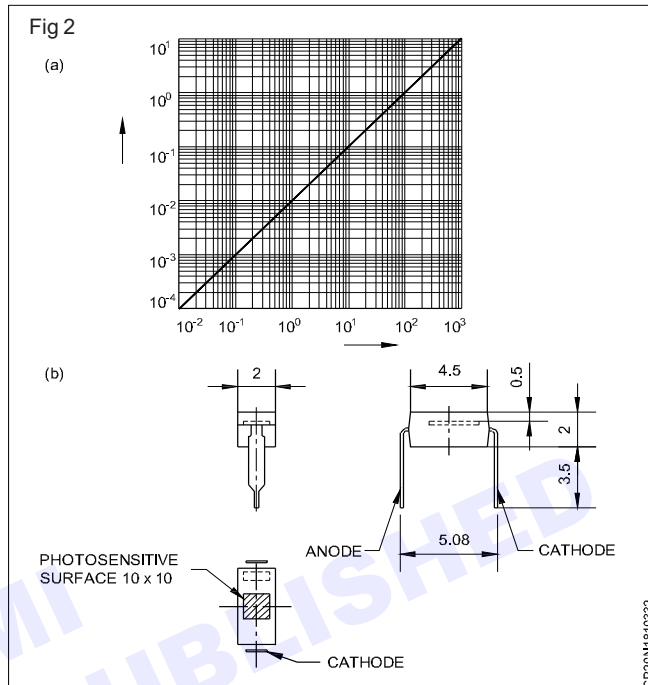
The rise in I_{photo} is almost linear. Photodiodes are therefore particularly suitable for the accurate measurement of illuminance. Physical appearance and dimensions of a typical photodiode BPW 32 is shown in Fig 2.

PIN Photo diodes

PIN photodiodes were developed to overcome the drawbacks of p-n photodiodes. The letters PIN indicate the zone sequence as given below;

P-layer/Intrinsic-layer/N-layer

A typical internal construction of a PIN photodiode is shown in Fig 3.



The advantages of PIN photodiodes are;

- high sensitivity in the infrared range
- short switching times,

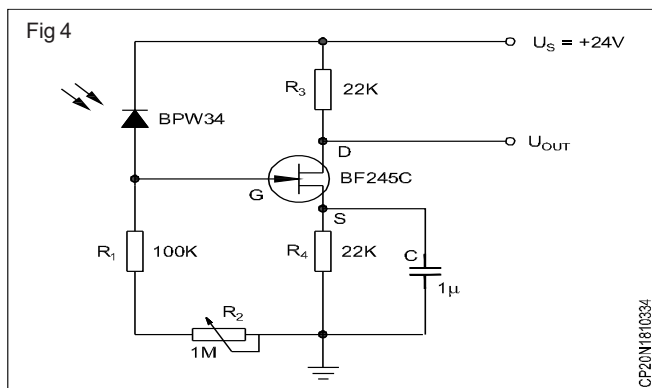
because of which, they are extensively used in remote control using modulated infrared light.

In operation they are similar to p-n photo diodes as shown in Fig 1.

Typical application of Photodiodes

Because of the very small photocurrent, photodiodes are generally used with an amplifier as shown in Fig 4. Amplifier stages with FET(Field Effect Transistor) are usually used with photodiodes because of the high input resistance of FET.

NOTE: Field Effect Transistors well known as FET is another type of transistor. Details of FET is discussed in lessons to follow.

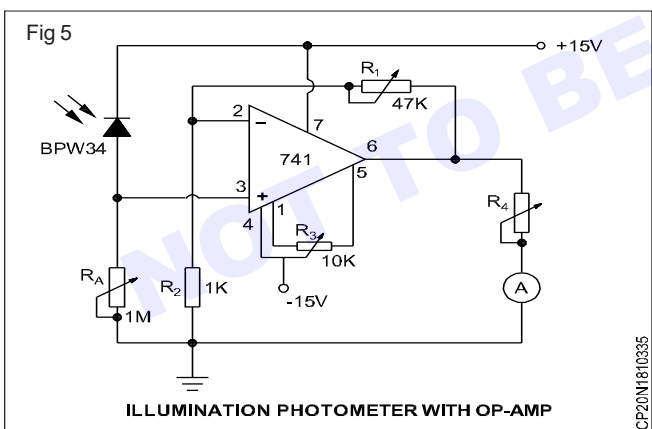


Circuit diagram of a simple Light controlled amplifier is shown in Fig 5. This circuit uses a single FET for amplifying the output of the photodiode connected in series with a resistor.

The working point of the FET can be adjusted with trimmer R_2 . As the illumination on the photo diode increases, the negative gate is reduced and therefore V_{out} reduces. The same value of R_3 and R_4 are chosen to ensure linear relationship between I_{photo} and V_{out} over a wide range. Thus this photoamplifier works satisfactorily not only for very slow changes in illumination but also with alternating light.

Illumination Photometer using photodiode and Opamp

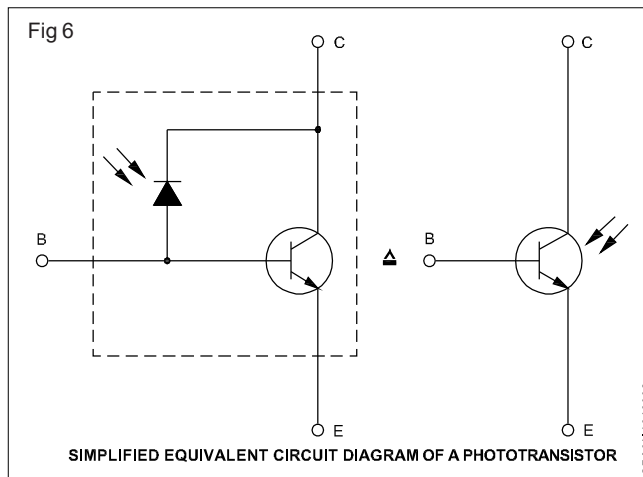
An illumination Photometer with an op-amp as an amplifier is shown in Fig 5. The output of the photo sensor follows the illuminance linearly, which may be in the range between 0.05 lx and 5000 lx, with a sensitivity of 5μA/lx. The sensor has the type designation TFA 1001W and is intended for use in video cameras and optical instruments.



Phototransistor

Both in the construction and in their mode of operation, phototransistor's can be thought of as a combination of a photodiode and a normal bipolar transistor. The simplified equivalent circuit diagram of a phototransistor is shown in Fig 6.

Without illumination, only a very small dark current I_{Ro} flows through the photodiode. This dark current, at the same time is the base current of the transistor. The following is then obtained for the dark current I_{Co} of the transistor,



$$I_{Co} = B \times (I_{CBo} + I_{Ro}),$$

Where,

I_{CBo} , is the reverse current of the collector/base diode and B is the current gain of the transistor.

When the photodiode is illuminated, a photocurrent I_{photo} flows, which is amplified by the current gain B and is super imposed on the dark current.

Therefore, the collector current of the phototransistor is,

$$I_C = I_{Co} + B \times I_{photo}$$

Since the dark current I_{Co} is much less than $B \times I_{photo}$, I_{Co} can generally be neglected, so in practice,

$$I_C \text{ approximately } = B \times I_{photo}$$

Advantage of Phototransistors over Photodiodes

Advantages of phototransistors over photodiodes are,

- their considerably greater sensitivity and
- the illuminance-dependent collector current I_C , which is increased by a factor B .

Type and availability

Phototransistors are produced with and without external base terminals. If no base terminal exists, the collector current is exclusively controlled by the change in the illuminance. It is then no longer possible to specify a working point. Such phototransistors are therefore usually used only as light-sensitive switches.

Example of phototransistors without an external base terminal;

Type number BPX81

Limiting data for BPX81:

$$\begin{aligned} U_{CEmax} &= 32V & i_{Cmax} &= 50 \text{ mA} \\ V_{Jmax} &= 90^\circ\text{C} & P_{tot} &= 100\text{mW} \\ R_{thJA} &= 750 \text{ K/W} \end{aligned}$$

Rectifiers

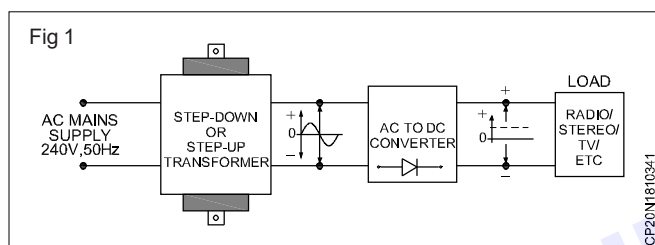
Objectives : At the end of this lesson you shall be able to

- describe working of half wave, full wave & bridge rectifier
- describe ripple frequency, R.C filter, inductor filter and L.C filters.

Rectifier

Almost all electronic circuits need DC voltage for their working. This DC voltage can be obtained by dry cells and batteries. Use of a dry cell is practicable only in portable electronic circuits such as transistor radio, tape recorders etc. But in circuits requiring large voltages and currents, like high power audio amplifiers, television sets etc. batteries will not only be very expensive but also be voluminous.

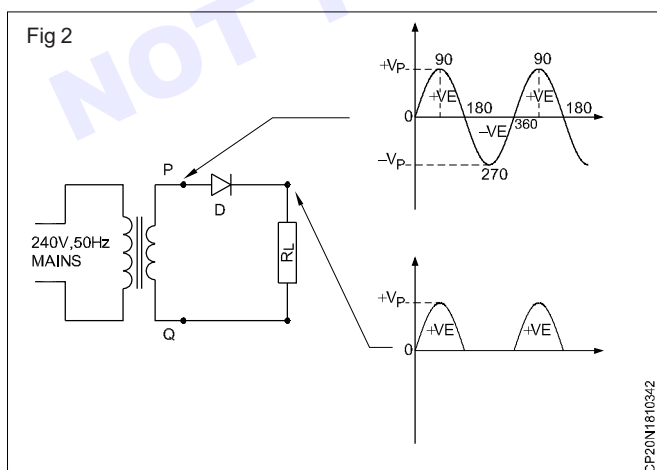
An alternative method of obtaining DC voltage is by converting the AC mains supply of 240V, 50Hz into DC voltage. This technique is not only convenient but also takes very small space compared to battery packs. This process of converting AC to DC is known as rectification. Fig 1 shows the principle of converting AC to DC of required voltage level.



The transformer will step-down or step-up the mains AC to the required level. The stepped-up or stepped-down AC from the output of the transformer is then converted to DC using diodes making use of their unique unidirectional property.

Half wave rectifier

The simplest form of AC to DC converter is obtained by using one diode. Such an AC to DC converter is known as half-wave rectifier as shown in Fig 2.



At the secondary of the transformer, across terminals P & Q, when seen on a CRO, the electric signal is a sinusoidal wave with its peak value of V_p and a frequency determined by the rate at which the alternations (+ve to -ve) are taking place. In Fig 10, the frequency is 50Hz as this voltage is taken from 50Hz AC mains supply.

If the voltage across P and Q is measured using an AC voltmeter, the voltmeter shows the rms (root mean square) value, V_{rms} of the sinusoidal wave which will be less than the peak value. The relationship between V_{peak} and V_{rms} is given by,

$$V_{rms} = 0.707 V_{peak} \quad \dots\dots[1]$$

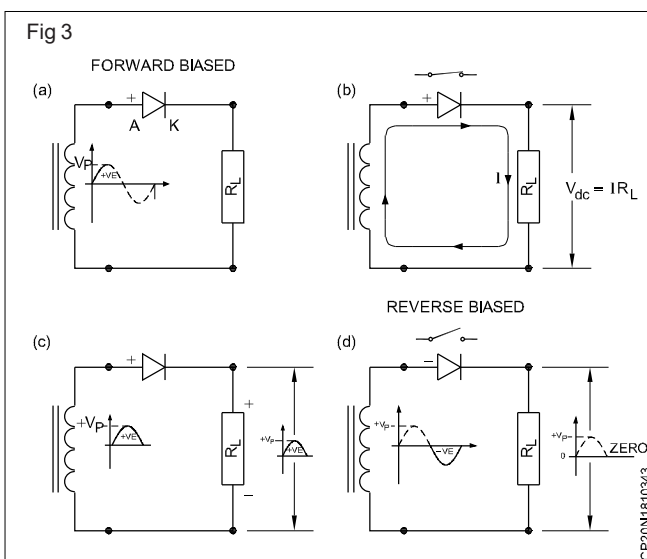
conversely,

$$V_{peak} = \frac{V_{rms}}{0.707} = \sqrt{2} V_{rms}$$

When this sinusoidal signal is applied across the diode D as shown in Fig 2, the diode conducts (behaves as a closed switch) only during the +ve half cycle of the input sinusoidal voltage and does not conduct (behaves as an open switch) during the -ve half of the input sinusoidal voltage. This process repeats again and again thus producing a pulsating +ve wave form at the output across the load, R_L as shown in Fig 2.

The operation of a half-wave rectifier circuit can be summarised with the help of Fig 3 as follows:

- 1 During the positive half cycle of AC input, the diode is forward biased as the anode of diode is positive as shown in Fig 3a.
- 2 Hence current flows from anode to cathode, through load R_L to secondary of transformer as shown in Fig 11b. The IR_L drop across load resistor R_L is the DC voltage V_{dc} with the polarity as shown in Fig 3b.
- 3 When the +ve half cycle of the input sinusoidal is completed, the voltage across the R_L will be a positive half sine wave as shown in Fig 3c. The peak of rectified voltage is also equal to the peak of the input AC voltage.



- 4 During the negative half cycle of the input AC, the diode is reverse biased as the anode of diode is negative as shown in Fig 3d.

- 5 Hence, the diode behaves as an open switch and no current flows through the load and hence there is no voltage output across load R_L as shown in Fig 3d.
- 6 After completing the -ve half cycle, when the input signal goes positive again, the whole operation repeats starting from step 1.

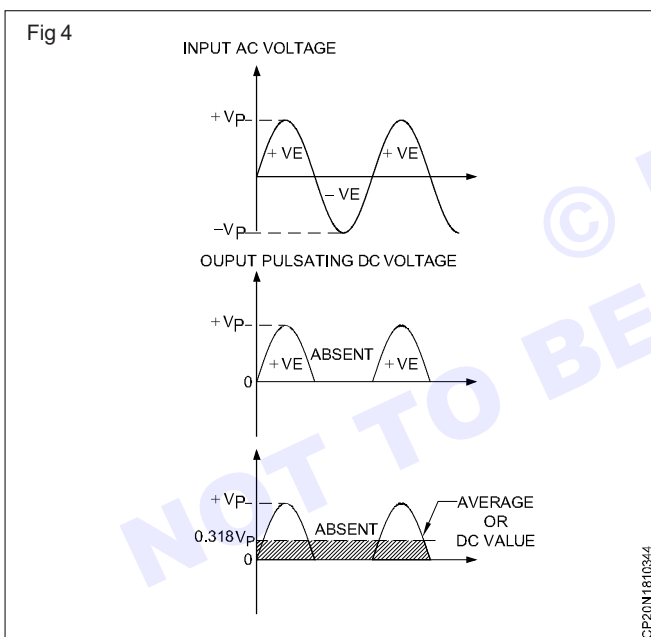
As can be seen from Fig 2, the output of the half-wave rectifier is always a +ve voltage (DC) although it is pulsating. In other words, the output is either positive (during +ve half cycle of the AC input) or zero (during -ve half cycle of AC input) but never negative. Hence, the output of a rectifier is a pulsating +ve DC voltage.

The circuit at Fig 2 is known as a half-wave rectifier as the rectification is done by the circuit only during one half cycle of the input AC signal.

Calculating output DC level in half-wave rectifiers

Two important points to note for calculating the output DC level of a halfwave rectifier are;

- the output of a halfwave (HW) rectifier across the load resistor is a pulsating DC whose peak voltage is equal to the peak value of the +ve half cycle of the AC input as shown in Fig 4. This can be checked using an oscilloscope.



The small forward voltage drop of the diode (0.7 for Si) when forward biased is ignored for simplicity in understanding.

- the pulsating signal level is zero when the input AC is in the -ve half cycle as shown in Fig 12.

Hence, when a DC voltmeter is connected across the load resistor R_L , the meter reads the average DC value of the pulsating signal. Ignoring the diode drop, the average DC value of the pulsating output in a half wave rectifier is given by,

$$V_{\text{average}} \text{ or } V_{\text{dc}} = 0.318 V_p \quad \dots\dots[2]$$

Example: If the total secondary voltage of the transformer (V_s) in Fig 2 is $24 V_{\text{rms}}$ (measured by AC meter), the output V_{dc} will be,

$$\text{From ...1, } V_p = \sqrt{2} V_{\text{rms}}$$

$$\text{From ...2, } V_{\text{dc}} = (0.318) V_p = 0.45 V_{\text{S(rms)}}$$

Therefore, for a half-wave rectifier the level of output DC is given by,

$$V_{\text{dc}} = 0.45 V_{\text{S(rms)}} \quad \dots\dots[3]$$

Where $V_{\text{S(rms)}}$ is the input rms AC voltage.

In the example considered above, the output DC voltage at Fig 10 will be,

$$V_{\text{dc}} = 0.45 \times V_{\text{S(rms)}} = 0.45 \times 24 = 10.8 \text{ volts.}$$

Ripple frequency

From Fig 4 it is evident that the frequency of the rectified pulsating DC is same as the frequency of the input AC signal. This is true for all half-wave rectifiers.

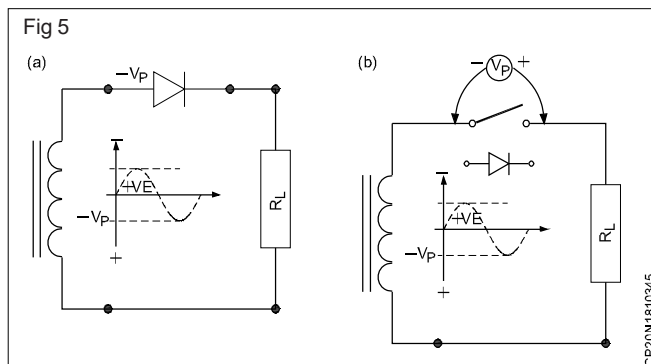
Peak inverse voltage

Fig 5a shows the half-wave rectifier at the instant the secondary voltage is at its maximum negative peak.

In this condition, since the diode is reverse biased, it behaves as an open switch as shown in Fig 5b. Since the diode is reverse biased, there is no voltage across the load R_L . Therefore, From Kirchhoff's voltage law, all the secondary voltage appears across the diode as shown in Fig 5b. This is the maximum reverse voltage that appears across the diode in the reverse biased condition. This voltage is called the peak reverse voltage or more commonly as the **peak inverse voltage (PIV)**. Therefore, in a half-wave rectifier the peak inverse voltage across the diode is equal to the -ve peak value of the secondary voltage $V_{\text{S(peak)}}$. Since, the -ve peak voltage and +ve peak voltage in a sinusoidal wave is same in magnitude, the peak inverse voltage (PIV) across the diode in a half wave rectifier can be taken as a $V_{\text{S(peak)}}$.

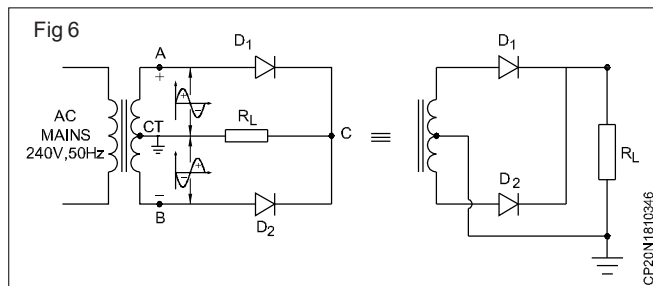
In the example considered earlier, the PIV across the diode will be,

$$V_{\text{S(peak)}} = \frac{V_{\text{S(rms)}}}{0.707} = \frac{24}{0.707} = 33.9 \approx 34 \text{ volts.}$$



To avoid break down of the diode used, the PIV appearing across the diode of the designed HW rectifier must be less than the PIV rating of the diode. For instance, in the above example to avoid break down of the diode, the PIV rating of the diode should be greater than 34 volts.

Two diode full wave rectifier: In a half-wave rectifier there is no rectification action during the -ve half cycle of the input AC voltage. Because of this the output DC level is low ($0.318 V_{S(\text{peak})}$). This limitation of a half-wave rectifier can be overcome by using two diodes and a centre-tap-transformer as shown in Fig 6.

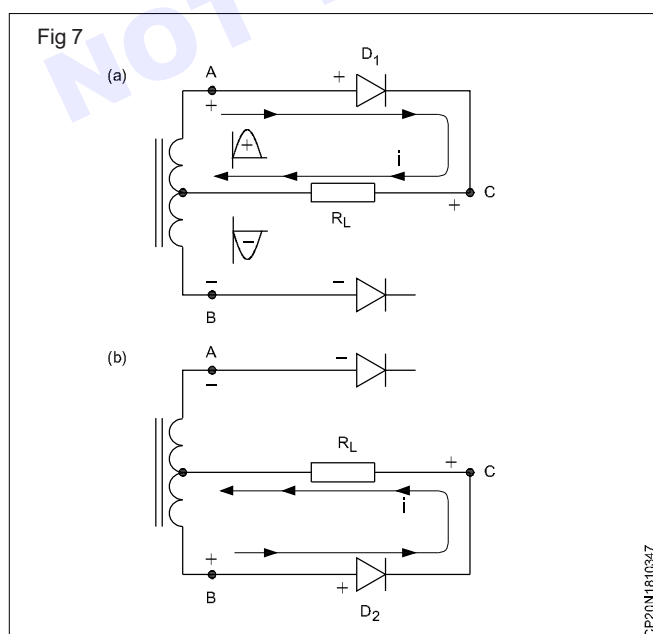


In Fig 6, each diode and the common load resistor R_L form two independent half-wave rectifiers. Because of the centre-tapped secondary winding, each diode receives only half of the total secondary voltage.

The opposite ends of the transformer secondary windings always have opposite polarities with respect to the centre tap. As shown in Fig 6, when end A of the secondary winding is positive, the bottom end B will be negative.

For the polarity shown in Fig 7a, the anode of D_1 is positive and, hence, forward biased. Whereas, the anode of D_2 is negative, and, hence, does not conduct. Current flows from the transformer (end A) $\rightarrow D_1 \rightarrow R_L \rightarrow$ back to the transformer centre-tap. This direction makes point C across the load R_L as the +ve terminal of the output DC voltage.

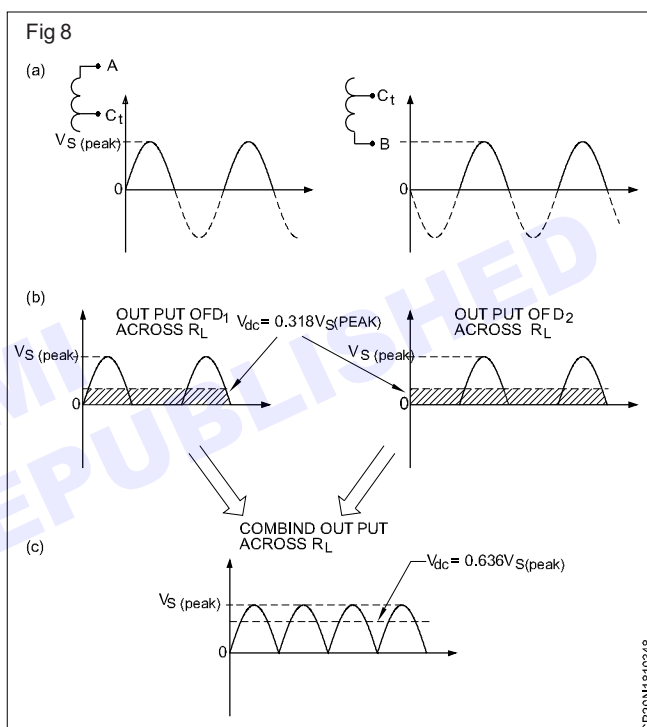
During the next half cycle, end B of transformer is +ve and A is -ve as shown in Fig 7b. Hence the anode of D_2 is +ve and this diode conducts whereas D_1 does not. Current flows from the transformer (end B) $\rightarrow D_2 \rightarrow R_L \rightarrow$ back to the transformer centre-tap. This direction of current again makes point C across the load R_L as the +ve terminal of the output DC voltage.



It is important to note the following two points;

- At any instant of time either D_1 or D_2 conducts but never both.
- While any of the two diodes is conducting, the rectified current i , flows through R_L in the same direction as shown in Fig 7a and Fig 7b. So the DC output voltage is positive at the common cathodes of the diodes D_1, D_2 .

Fig 8 shows the input and output wave-forms of a fullwave rectifier. As can be seen from Fig 8, the rectifier works both in the positive and negative half cycles of the AC input to produce a DC output across the load resistor R_L . Although only one diode conducts at a time, the outputs are combined in R_L . Hence, fullwave rectifier provides double the DC current to the load compared to that of a half-wave rectifier.



Since both the half cycles of the input AC signal are rectified by the circuit at Fig 6, this circuit is known as a fullwave rectifier. Since this fullwave rectifier uses two diodes this circuit is also known as two diode fullwave rectifier.

Output DC level in a two-diode full wave rectifier

Since a full wave rectifier is nothing but a combination of two half-wave rectifiers, the average or DC value of a fullwave rectifier is naturally twice the output of a half-wave rectifier driven by the same secondary voltage.

From Fig 8 it is evident that the average or DC value of a fullwave rectified output is

$$V_{dc} = 0.318 V_{S(\text{peak})} + 0.318 V_{S(\text{peak})}$$

$$V_{dc} = 0.636 V_{S(\text{peak})}$$

where, $V_{S(\text{peak})}$ is the equal peak voltage between the centre-tap and any one end A or B of the transformer secondary.

In terms of $V_{S(\text{rms})}$, V_{dc} of a fullwave rectifier is given by,

$$V_{S(\text{rms})} = 0.707 V_{S(\text{peak})}$$

Therefore,

$$V_{dc} = 0.636 \cdot \frac{V_{s(rms)}}{0.707}$$

$$= 0.9 V_{s(rms)}$$

Example: Suppose the secondary voltage of the transformer is 24-0-24_{V(rms)}, the DC output voltage of a full wave rectifier using this transformer will be,

For a two diode fullwave rectifier

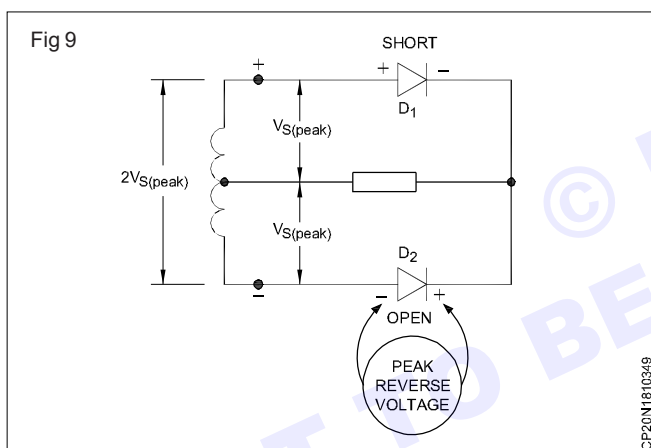
$$V_{dc} = 0.9 V_{s(rms)}$$

Therefore, in the given example,

$$V_{dc} = 0.9 \times V_{s(rms)} = 0.9 \times 24 = 21.6 \text{ volts.}$$

Ripple frequency in a full wave rectifier: From Fig 16c it can be seen that two cycles of output occur for each input cycle of AC voltage. This is because, the full input voltage. As a result, the output of a full wave rectifier has a frequency double the input AC frequency. If mains AC is used as input to a fullwave rectifier, since mains frequency is 50 Hz, the output frequency of the pulsating DC will be 100 Hz.

Peak inverse voltage: Fig 9 shows the fullwave rectifier at the instant the secondary voltage reaches its maximum positive value.



Applying Kirchhoff's law around the outside loop, we get,

$$2V_{s(peak)} - \text{Reverse voltage (PIV) across } D_2$$

$$+ \text{Forward voltage across } D_1 = 0$$

Neglecting the small forward voltage across D_1 we have,

$$2V_{s(peak)} - \text{PIV across } D_2 + 0 = 0$$

$$\text{or PIV across } D_2 = 2V_{s(peak)}$$

From the above it can be seen that each diode in a fullwave rectifier must have a PIV rating greater than the peak value of the full secondary voltage. ($2V_{s(peak)}$)

In the example considered earlier, the PIV of diodes should be greater than 34V.

Current rating of diodes in a fullwave rectifier

If the load, R_L connected in the fullwave rectifier is, say 10Ω , the DC current through it will be,

$$I_{dc} = \frac{V_{dc}}{10\Omega}$$

In the example considered above, $V_{dc} = 21.6$ volts.

Therefore,

$$I_{dc} = \frac{21.6}{10} = 2.16 \text{ amps.}$$

It is interesting to note this current I_{dc} is shared by the two diodes D_1 and D_2 . This is because each diode conducts only for one half cycle. Therefore, the DC current through each diode is half the total DC load current I_{dc} . Hence, the maximum current through each diode with 10Ω load will be $2.16/2 = 1.08$ amps. From this it follows that the current rating ($I_{f(max)}$) of each diode need only be half the maximum/rated load current.

In a halfwave rectifier since there is only one diode, the current rating of the diode used should be the maximum current through the load unlike in the case of a fullwave rectifier in which the current rating of the diodes used is only half the maximum current through the load.

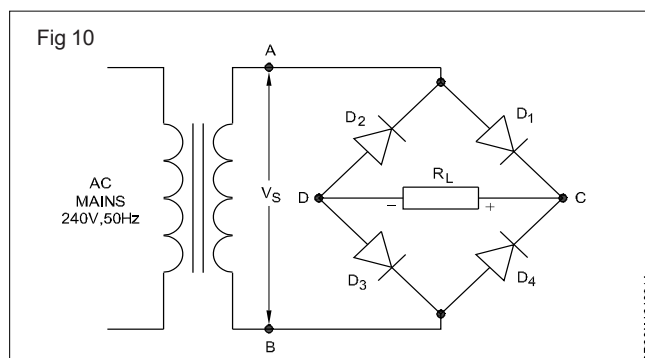
Example: In a two diode fullwave rectifier, with a load current requirement of 1.8 amps, what should be the current ratings of the diodes used?

Since it is a two diode fullwave rectifier, the current rating of each diode should be $1/2$ the total load current.

Therefore, $I_{f(max)}$ of diodes should be $1.8 \text{ amps}/2 = 0.9$ amps.

It is fine if a diode of 1 amp current rating is used for this rectifier circuit.

The Bridge rectifier: The disadvantages of a full wave rectifier using two diodes and centre-tap transformer can be overcome by a modified fullwave rectifier as shown in Fig 10. In Fig 10, since the diodes are connected in the form of a bridge, this rectifier circuit is commonly known as a Bridge rectifier.

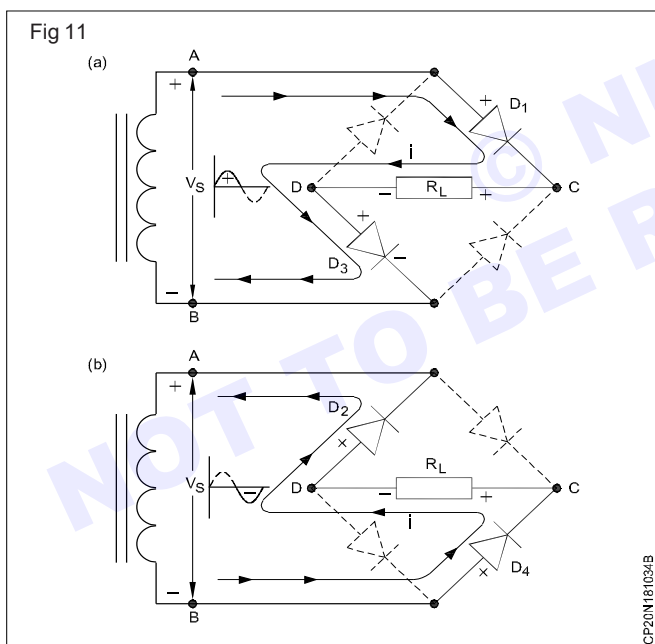


As can be seen in Fig 10, the bridge rectifier does not need a centre-tapped transformer. Also, all the secondary voltage is used for rectification at any given time.

The operation of a bridge rectifier can be summarized in the following steps;

- When end A of the transformer secondary is +ve, as shown in Fig 11a, diodes D_1 and D_3 are forward biased whereas, D_2 and D_4 are reverse biased, and, hence, D_2 and D_4 do not come in the circuit.
- Current flows from the transformer(end A) $\rightarrow D_1 \rightarrow R_L \rightarrow D_3 \rightarrow$ back to the transformer(end B). From the direction of the current flow point C is the positive terminal of the DC output across R_L .
- During the other half cycle of the input (–ve half cycle), end B of the transformer becomes +ve as shown in Fig 19b. Diodes D_4 and D_2 are forward biased, whereas D_1 and D_3 are reverse biased.
- Current flows from the transformer(end B) $\rightarrow D_4 \rightarrow R_L \rightarrow D_2 \rightarrow$ back to the transformer (end A). From the direction of the current flow, point C is again the +ve terminal of the DC output across R_L .

Note: The current I is in the same direction through R_L during both +ve and –ve half cycles of the input AC. The result is, a +ve rectified DC voltage appears at the end of R_L connected to the cathodes of D_1 and D_4 .



Output DC level in a bridge rectifier

Fig 12 shows the input AC and the output pulsating DC wave-form of a bridge rectifier.

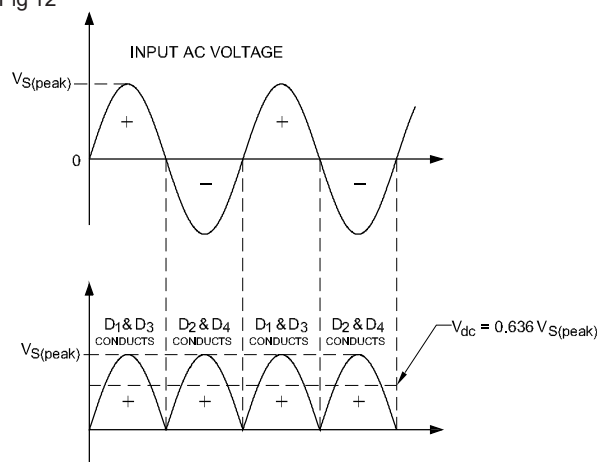
This wave-form is similar to that of the full wave rectifier using a centre-tap transformer. Hence, the average DC value of the output is,

$$V_{dc} = 0.636 V_{S(\text{peak})}$$

$$\text{or } V_{dc} = 0.9 V_{S(\text{rms})}$$

where, $V_{S(\text{rms})}$ is the full secondary AC rms voltage.

Fig 12



In a two-diode fullwave rectifier $V_{S(\text{rms})}$ refers to only half of the total secondary voltage whereas in a bridge rectifier $V_{S(\text{rms})}$ refers to full secondary voltage.

Example: In Fig 11, if the transformer secondary voltage $V_{S(\text{rms})}$ is 24 volts, the rectified DC voltage V_{dc} across the load R_L will be,

From equation 2, V_{dc} for a bridge rectifier is given by,

$$V_{dc} = 0.9 V_{S(\text{rms})}$$

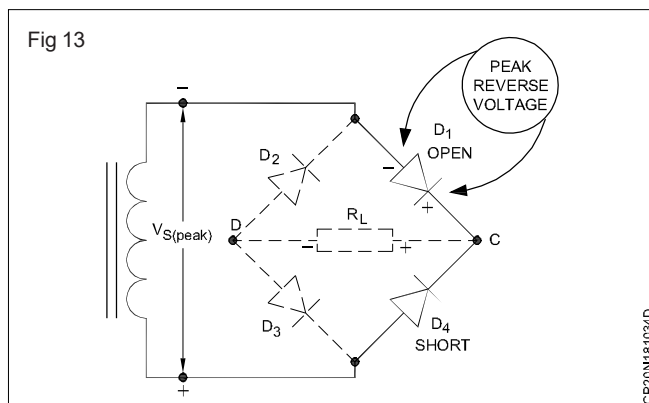
In the given example, $V_{S(\text{rms})} = 24$ volts

Therefore, $V_{dc} = 0.9 \times 24 = 21.6$ volts

NOTE: Using the same transformer, a two-diode fullwave rectifier would have given only 10.8 volts which is half of that of a bridge rectifier output.

Ripple frequency - Bridge rectifier: The pulsating DC output of a bridge is similar to the two diode fullwave. Hence, as in a two diode fullwave rectifier, the output ripple frequency of the bridge rectifier is also twice the input AC frequency.

Peak inverse voltage - Bridge rectifier: Fig 13 shows a bridge rectifier at the instant the secondary voltage has reached its maximum value.



Diode D_4 is ideally short (as it is conducting) and D_1 is ideally open. Summing the voltages around the outside loop and applying Kirchhoff's law,

$$V_{S(\text{peak})} - \text{PIV across } D_1 + 0 = 0$$

or $\text{PIV across } D_1 = V_{S(\text{peak})}$

Therefore, the peak inverse voltage across D_4 is equal to the peak secondary voltage $V_{S(\text{peak})}$.

In a similar way, the peak inverse voltage across each diode will be equal to the peak secondary voltage $V_{S(\text{peak})}$ of the transformer secondary. Hence the PIV ratings of the diodes used should be greater than $V_{S(\text{peak})}$.

Example: In Fig 13, if the transformer secondary voltage $V_{S(\text{rms})}$ is 24 volts, find the minimum PIV of diodes used.

In a bridge rectifier PIV across the diodes is same and is equal to $V_{S(\text{peak})}$.

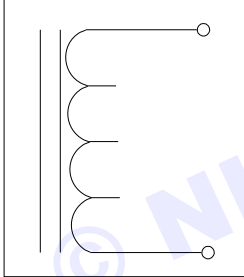
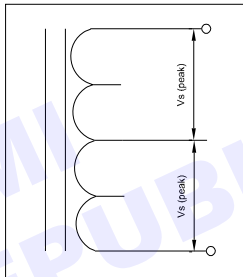
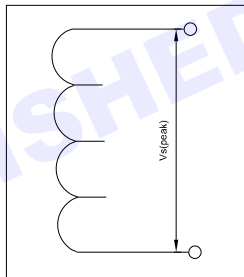
Therefore, in the given example,

$$\text{PIV} = V_{S(\text{peak})} = \frac{V_{S(\text{rms})}}{0.707} = \frac{24}{0.707} = 34 \text{ volts.}$$

Current rating of diodes in bridge rectifiers: As in the case of a two diode fullwave rectifier even in a bridge rectifier shown in Fig 11, diode pairs D_1, D_3 and D_2, D_4 carry half the total load current I . This is because each diode pair is conducting only during one half of the AC input cycle.

The only disadvantage of bridge rectifiers, if it is treated as a disadvantage, is that, this circuit uses four diodes for fullwave rectification instead of two as in two-diode fullwave rectifier. But this disadvantage is compensated by the simple transformer requirement of the bridge rectifier and higher DC output level. Hence, bridge rectifiers are the most popular AC to DC rectifiers for most applications.

A comparison of **half-wave**, **fullwave** and **bridge rectifier** is given below in a tabular form;

	Half wave	Full wave	Bridge
• Number of diodes required	Fig 14 1	2	4
• Transformers Peak output voltage			
• DC output voltage in terms of $V_{S(\text{peak})}$	$0.318 V_{S(\text{Peak})}$	$0.636 V_{S(\text{Peak})}$	$0.636 V_{S(\text{Peak})}$
• DC output voltage in terms of $V_{S(\text{rms})}$	$0.45 V_{S(\text{rms})}$	$0.9 V_{S(\text{rms})}$	$0.9 V_{S(\text{rms})}$
• Diode current rating	$I_{L(\text{max})}$	$0.5 I_{L(\text{max})}$	$0.5 I_{L(\text{max})}$
• Peak inverse voltage	$V_{S(\text{peak})}$	$2V_{S(\text{peak})}$	$V_{S(\text{peak})}$
• Ripple frequency	f_{input}	$2f_{\text{input}}$	$2f_{\text{input}}$

Efficiency of the Rectifier

Rectifier efficiency is defined as the ratio of DC power to the applied input AC power.

Rectifier efficiency, η = DC output power/input AC power

$$I_{dc} = I_m / \pi$$

The DC output is given by : $P_{dc} = I_{dc}^2 \times R_L = (I_m / \pi)^2 \times R_L$

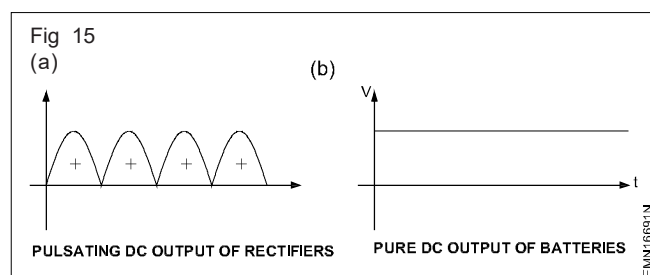
The AC input power is given by: $P_{ac} = I_{rms}^2 \times (r_f + R_L)$, where r_f is diode resistance.

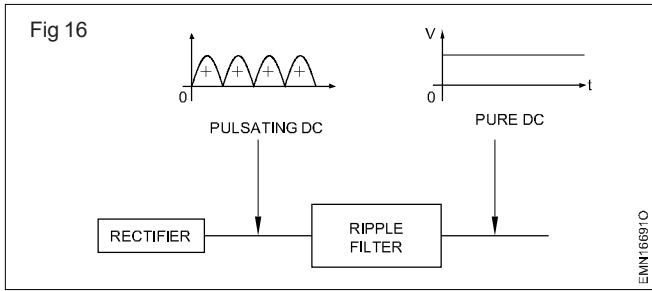
Ripple filters

The output of rectifiers is a pulsating DC voltage as in Fig 15 a and not a pure DC voltage like the output of cells or a battery as shown in Fig 15b.

Pulsating DC voltages cannot be used in most of the electronic circuits like radios, tape recorders etc. These

circuits require pure DC voltage similar to that of the output of a battery as shown in Fig 23b. Hence, it is required to remove or at least reduce the pulsation in the output of the rectifier circuits. The circuits used to filter off or reduce the pulsation in the DC output of rectifiers are known as smoothing circuits or more popularly as ripple filters as shown in Fig 16.





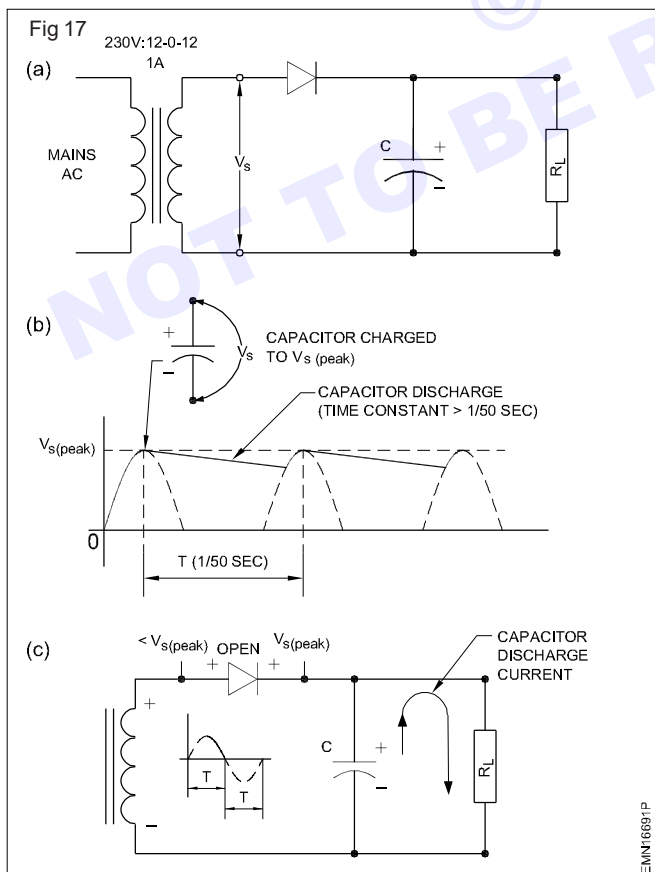
Capacitor input filters: The most important component used in any ripple filter circuit is the capacitor. Recall capacitors store electrical energy and release it when required. This property of a capacitor is made use of in smoothing the pulsating output of rectifiers.

Filtering output of Half-wave rectifiers

Fig 17a shows a capacitor input filter connected at the output of a half-wave rectifier.

During the first quarter cycle of source voltage V_s , the diode is forward-biased and ideally behaves like a closed switch. Since the output of diode is connected directly across the capacitor, the capacitor charges to the peak voltage $V_{s(\text{peak})}$ as shown in Fig 17b.

As shown in Fig 17b, when the input V_s just passes the positive peak, the diode stops conducting. This is because, the capacitor has $V_{s(\text{peak})}$ volts across it with the polarity shown in Fig 17c. When V_s passes its +ve peak, the voltage at the anode of diode is slightly less than $V_{s(\text{peak})}$. Hence, the diode is reverse biased and behaves like an open switch.



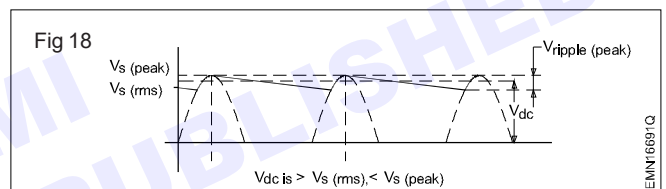
With the diode open, the capacitor discharges through the load resistance R_L . By deliberate design, the discharging time constant (product of R_L and C) is made much greater than the period T of the input signal. Because of this, the capacitor will discharge only a small portion of its stored charge during the OFF time of the diode, as shown in Fig 25b.

By the time the capacitor loses a small portion of its charge, the source voltage again reaches its peak, the diode again conducts and recharges the capacitor to the peak voltage $V_{s(\text{peak})}$. This process of charging during a brief period of positive peak and discharging during the falling period of the positive peak continues as shown in Fig 25b.

From Fig 25b, it can be seen that the voltage across the load resistor is almost a pure DC voltage. The only variation from the pure DC voltage is the small ripple caused by charging and discharging of the capacitor.

As the capacitor charges to the peak value of the input $V_{s(\text{peak})}$ and discharges only a small portion of it, the DC output of the half-wave rectifier, instead of $0.45 V_{s(\text{rms})}$ is only slightly less than $V_{s(\text{peak})}$ as shown in Fig 18.

From Fig 18, the exact value of DC voltage and ripple voltage can be calculated as given below;



$$V_{dc(\text{HW})} = V_{s(\text{peak})} - \frac{V_{\text{rip}(p-p)}}{2} \quad \dots[1]$$

Example 1: If $V_{s(\text{peak})} = 34 \text{ V}$ and $V_{\text{rip}(p-p)} = 3.4 \text{ V}$,

$$\text{then, } V_{dc} = 34\text{V} - \frac{3.4}{2} = 32.3 \text{ Volts}$$

Refer example given in half wave rectifier lesson. Without the capacitor the same halfwave rectifier gave only 10.8V DC. Adding just one capacitor the output has increased 3 fold for the same halfwave rectifier.

While designing a filter circuit, the following methods can be used to calculate theoretically the ripple voltage in the output of the filter circuit;

Method 1

Knowing the required load current I_L , for a given value of frequency f and capacitance C , the peak-to-peak ripple voltage can be found using the formula,

$$V_{\text{rip}(p-p)} = \frac{I_L}{fC} \quad \dots[2]$$

where,

$V_{\text{rip}(p-p)}$ = peak-to-peak ripple voltage, in volts

I_L = required DC load current, in Amps

f_r = ripple frequency, in HZ

C = capacitance in Farads.

Fixing the permissible $V_{r(p-p)}$ and knowing f and I_L the required value of C can also be found using this formula.

Method 2

Another method of expressing the ripple in the output DC is by ripple factor r , defined as,

$$\text{Ripple factor, } r = \frac{V_{r(rms)}}{V_{dc}}$$

where,

r = ripple factor (dimensionless)

$V_{r(rms)}$ = rms value of ripple voltage

$$= \frac{V_{rip(p-p)}}{2\sqrt{3}}$$

V_{dc} = DC output voltage.

If the $R_L C$ time constant is large enough such that the capacitor is recharged in a short time compared with half the period T of input AC, the theoretical value of the ripple factor can be calculated using the formula,

$$r = \frac{1}{2\sqrt{3} f R_L C} \quad (\text{for half-wave}) \quad \dots\dots[3]$$

where,

r = the theoretical ripple factor for a half-wave

C = capacitance in μF

R_L = load resistor in ohms

f = mains supply frequency in hertz.

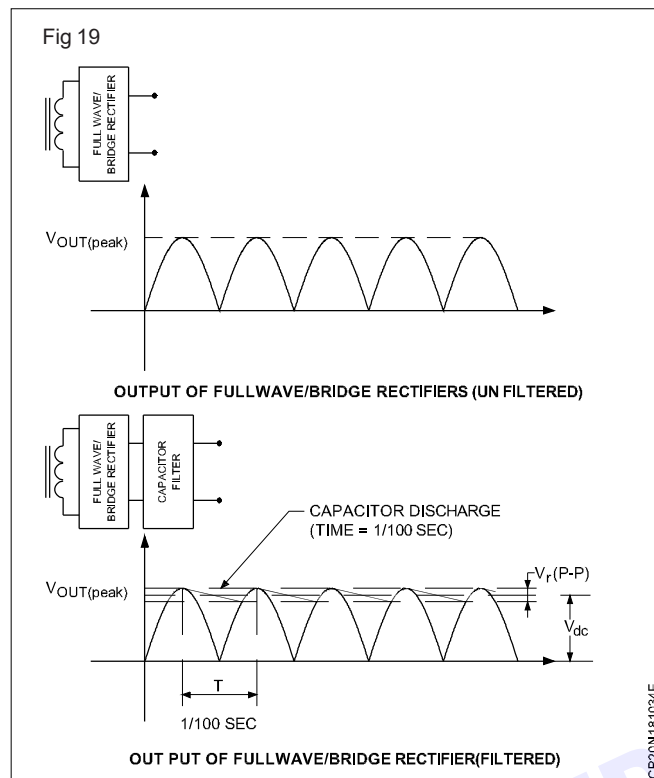
From equation 3 above, it is clear that one way to reduce the ripple is by increasing the discharging time constant, $R_L C$. In other words, increasing the value of C or R_L the time constant becomes larger, and, larger the time constant, purer is the DC output of the filter.

These formulae are used many times while troubleshooting, analyzing, or designing a capacitor-input filter. Hence, it is worthwhile memorizing these key formulae.

Filtering output of Full wave and Bridge rectifiers:

From equation 2, it is clear that another way to reduce the ripple is to increase the ripple frequency f_r . In a fullwave rectifier or bridge rectifier, the ripple frequency is double the supply frequency as shown in Fig 19. As a result of higher ripple frequency, when compared with halfwave rectifier (Fig 18), the capacitor gets charged twice as often and has only half the discharge time as shown in Fig 11. Therefore, the ripple in the filtered output is smaller and the DC output voltage approaches more closely the peak voltage $V_{S(peak)}$.

The formulae used for calculating the ripple in the output or the ripple factor is the same as discussed for half-wave rectifiers.



Example: In a bridge rectifier with a capacitance input filter, suppose the DC load current drawn is approximately 10 mA and the filter capacitor is 470 μF , for a line frequency of 50 Hz, the peak-to-peak ripple in the output will be,

from equation (2), $V_{rip(p-p)} = \frac{I_L}{f_r C}$

Therefore,

$$V_{rip(p-p)} = \frac{10\text{mA}}{100\text{Hz} \times 470 \mu F} = 0.213 \text{ V}$$

For the same conditions in a half-wave rectifier, the ripple will be 0.426 V, which is twice as much because the ripple frequency is only 50 Hz (same as AC input frequency).

Examples If the peak voltage $V_{S(peak)}$ is 34 V, then, select a capacitor that makes the peak-to-peak ripple 10% of $V_{S(peak)}$. This means $V_{r(p-p)}$ should be around 3.4V. (Refer Example 1).

For a bridge rectifier, for a DC load current of 10mA, the value of C using 10% rule should be,

$$V_{r(p-p)} = \frac{I_L}{f_r C}$$

$$\text{or } C = \frac{I_L}{f_r V_{r(p-p)}} = \frac{10\text{mA}}{100(3.4)}$$

$$= 29.4 \mu F \text{ minimum.}$$

As a standard value, use 100 μF . Recalculating $V_{r(p-p)}$,

$$V_{r(p-p)} = \frac{I_L}{f_r C} = \frac{10\text{mA}}{100 \times 100 \mu F} = 1 \text{ Volt.}$$

With the 10 percent design rule, the DC voltage is more than 95 percent of the peak voltage which is reasonably a good design.

Assignment: Calculate value of C if the required load current is 1 Amps.

PIV rating of diodes with capacitance-input filters

Recall that the PIV across the diode in a half-wave rectifier without a filter capacitor is equal to $V_{S(\text{peak})}$. This PIV rating changes when a filter capacitor is connected across the output of the half-wave rectifier.

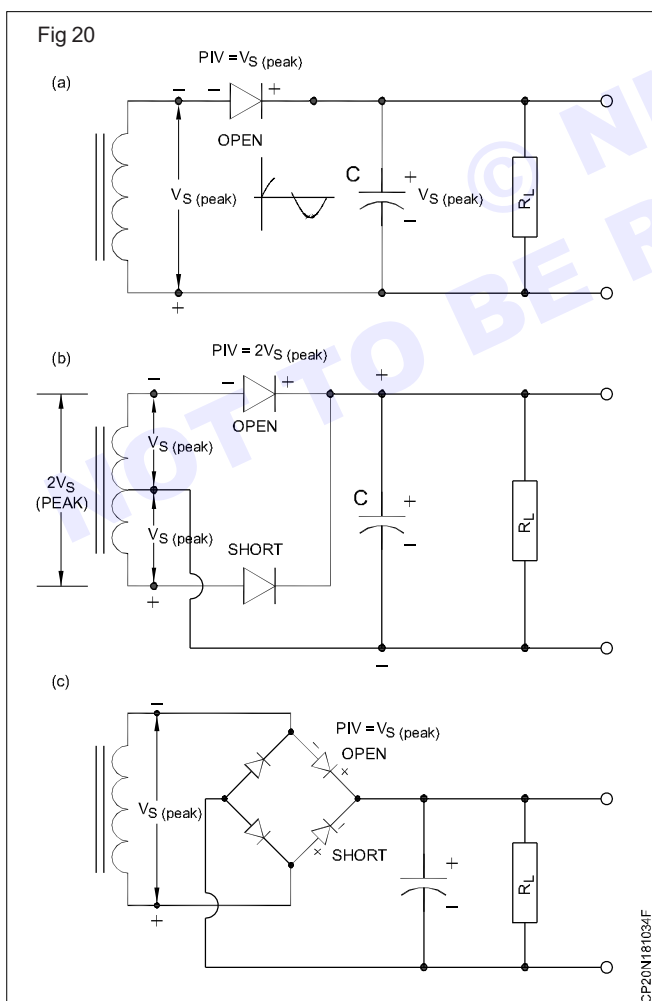
Fig 20a shows a half-wave rectifier driving a capacitor-input filter. At the negative peak of the secondary voltage, the diode is reverse-biased and a peak inverse voltage appears across it. Summing up the voltages around the loop gives,

$$\text{PIV across diode} - V_{S(\text{peak})} - V_{S(\text{peak})} \text{ across } C = 0$$

or,

$$\text{PIV across diode} = 2V_{S(\text{peak})}$$

From this it can be seen that, with capacitance-input filter across the diode, the PIV rating of the diode in a half-wave rectifier must be two times the peak secondary voltage $V_{S(\text{peak})}$ or higher.



In the case of a fullwave rectifier with filter shown in Fig 20b, summing voltages around the left loop gives,

$$\text{PIV} - 2V_{S(\text{peak})} + 0 = 0$$

or,

$$\text{PIV} = 2V_{S(\text{peak})}$$

This means that the PIV rating of the diodes must be greater than the peak total secondary voltage ($V_{S(\text{peak})} + V_{S(\text{peak})}$). Note that this is same as in the fullwave rectifier without a filter capacitor.

In the case of a bridge rectifier circuit shown in Fig 20c, summing voltages of the outside loop gives,

$$\text{PIV} + 0 - V_{S(\text{peak})} = 0$$

or,

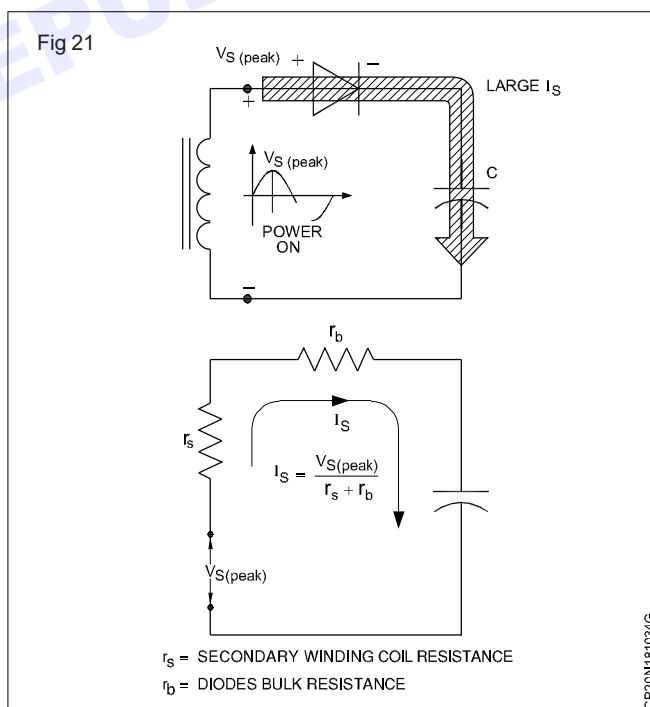
$$\text{PIV} = V_{S(\text{peak})}$$

So the PIV rating of each diode in the bridge must be greater than the peak secondary voltage $V_{S(\text{peak})}$. This is same as in a bridge rectifier without a filter capacitor.

Surge current in rectifiers with filter capacitors

In rectifiers with filter capacitors, before the input power is switched ON, the filter capacitor is uncharged. The instant the circuit is switched ON, the capacitor behaves as a short circuit. This results in a large initial charging current through the diode. This initial, sudden rush of current is called the **surge current**.

The worst case of a surge current flowing is when, the circuit is switched ON, at the very instant the secondary voltage is $V_{S(\text{peak})}$, as shown in Fig 21. The only resistance to this rushing surge current are,



- 1 The transformer secondary winding resistance, r_s
- 2 The bulk resistance r_b of the diode(s).

Generally, the secondary winding resistance will be less than 1 W. The bulk resistances of diodes are given in data sheets. In general purpose diodes, r_b will be of the order of 0.2 W.

For example, if $V_{S(\text{peak})}$ is 34 V AC and the sum of the secondary winding resistance and the diode bulk resistance is $1\Omega + 0.2\Omega$, then the surge current I_s would be,

$$I_s = \frac{V_{S(\text{peak})}}{1\Omega + 0.2\Omega} = \frac{34}{1.2\Omega} = 28.3 \text{ amps.}$$

It is important to note that this large current is not a continuous current. This current decreases exponentially as the capacitor gets charged. However, if the capacitor is of an extremely large value, the surge current will remain at a high level for quite some time, and, hence, may damage the diode.

From the above, two important points are to be noted,

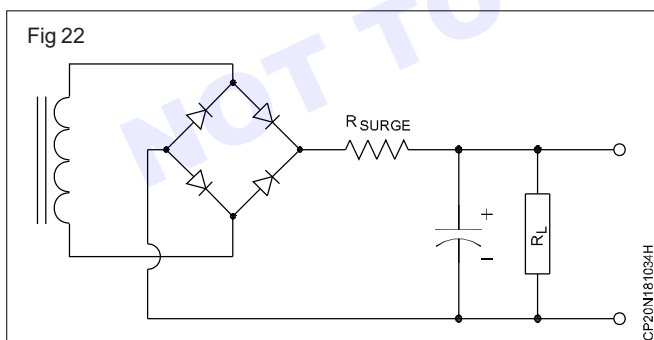
- The diode used must have the capability to withstand a large surge current of a short duration, generally one time period(T) of input cycle. This data is given in the diode data books.
- The value of the filter capacitor should not be excessively large as this will increase the value and duration of surge current.

Use of surge limiting resistor

In case the diode selected for a rectifier has a surge current rating less than the estimated surge current, a small resistor is included in the surge current path as shown in Fig 22. This resistor is known as surge limiting resistor or simply surge resistor.

This surge resistor limits the surge current because, this resistance gets added to the winding and diode bulk resistances. Using a surge resistor of a suitable value, the surge current can be restricted to any desired value.

As an example, in Fig 22, if $V_{S(\text{peak})}$ is 34V and if a surge resistor of 4Ω is selected, then the surge current will be,



$$\begin{aligned} & V_{S(\text{peak})} \\ & \text{winding resistance} + \text{diode bulk resistance} + \text{surge resistor} \end{aligned}$$

$$= \frac{34}{1\Omega + 0.2\Omega + 4\Omega} = 6.5 \text{ Amps}$$

Note that the surge current has reduced from 28.3 amps to 6.5 amps by the use of a surge resistor.

When a surge resistor is used for calculating I_s , you may neglect the winding and bulk resistances, as their values are comparatively smaller.

One disadvantage in using a surge resistor is that, since it comes in series with the output, the DC voltage across the load decreases by an amount equal to the I_R drop across the surge resistor. Hence, surge resistors should not be used indiscriminately.

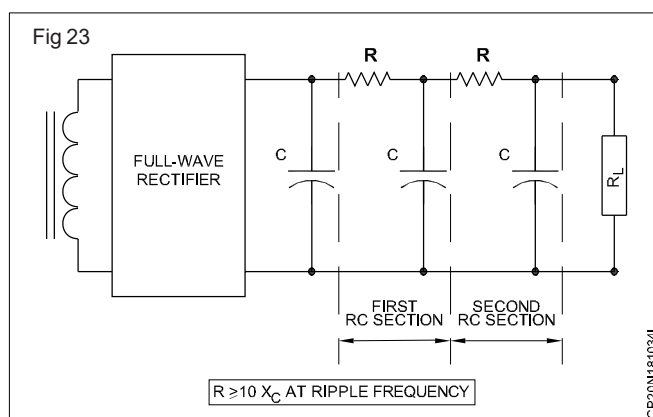
Filter capacitors of values less than $1000\mu\text{F}$ usually do not produce a surge current for a long period to damage the diodes. Hence, for values of C less than $1000\mu\text{F}$ use of surge resistors are not essential.

Table No.25 of the pocket table books summarizes the key information discussed so far. This table is useful for designing and troubleshooting power supplies.

RC filters

Recall that with the 10 % ripple rule we get a peak-to-peak ripple of around 10 percent of the DC load voltage. To further reduce the ripple at the output, filters as shown in Fig 31 may be connected between the filter capacitor and the load. These are known as RC filters. These filters reduce the ripple in the output to less than 1 percent making the output a pure DC similar to the output of a battery.

In Fig 23, the two RC filter sections are connected between the input capacitor C and the load resistor R_L . While designing these filter sections, the value of R is made much greater than X_C at the ripple frequency. Therefore, a major portion of the ripple voltage gets dropped across R instead of across the load resistor R_L . Typically, the value of R must be at least 10 times greater than X_C at the ripple frequency. This results in each RC section attenuating (reducing) the ripple by a factor of 10. Thus more the number of sections of RC, less is the ripple across R_L and purer is the DC output voltage across R_L .



The main disadvantage of the RC filter sections is the loss of DC voltage across each R . Hence, RC filter circuits are suitable only for small load currents or for large load resistance.

Inductor input filters

An alternative to using a capacitor in parallel with the load resistor, is to use an inductor in series with the load as

shown in Fig 24a. Since an inductor opposes any change in current through it, the inductor coil will cause a smoothing effect in the output as shown in Fig 24b. Here the inductors are called Chokes as they choke the ripple.

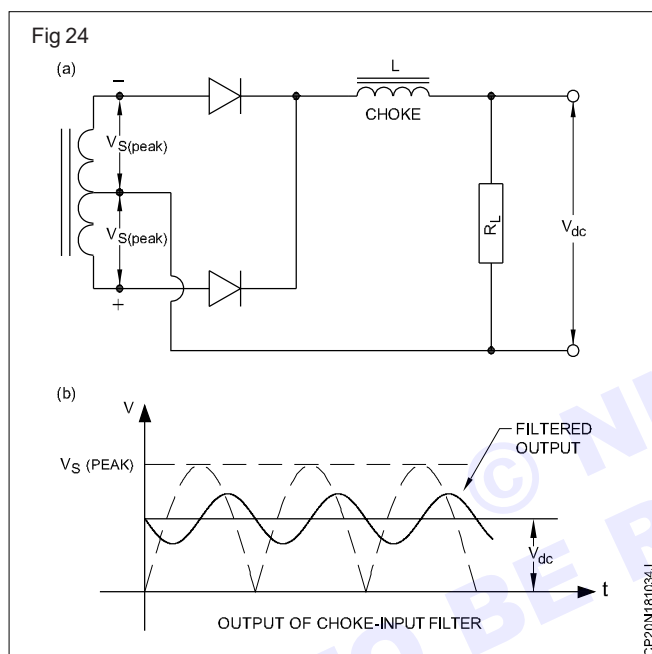
If the coil resistance of the inductor is neglected (being very small), inductor is neglected (being very small), the DC output will be,

$$V_{dc} = 0.636 V_{S(peak)} \text{ as in the case of capacitance filter.}$$

If the resistance of the coil is considered, the DC output will be slightly less due to the I_R drop across the coil.

The ripple factor r in a full wave rectifier with inductor filter is given by,

$$r = \frac{R_L}{1618L} \dots [4]$$

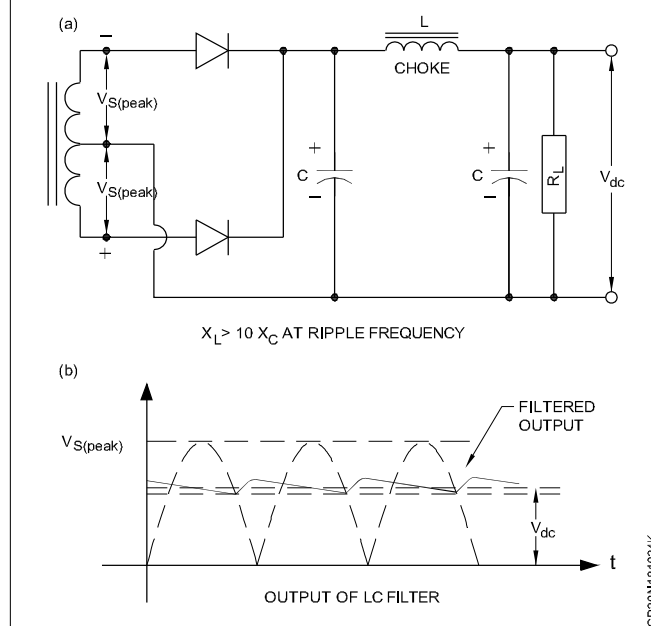


LC filters

For large load current requirements, instead of RC filters, LC filters as shown in Fig 25 are preferred. The reason is, a large portion of the ripple voltage is dropped across the inductor with minimum DC voltage drop because inductors have only a small winding resistance.

In Fig 25, X_L is made much greater than X_C at the ripple frequency. Hence, the ripple across the load is reduced to extremely low levels.

Fig 25



Neglecting the choke's resistance, the DC output voltage is given by,

$$V_{dc} = 0.636 V_{S(peak)} \text{ as in the case of a capacitor input filter.}$$

The ripple factor, r is given by,

$$r = \frac{0.7}{LC} \dots [5]$$

From the above equation for r , unlike in case of capacitor input filter, it can be seen that in a LC filter circuit the ripple factor is not determined by the value of the load resistor. Hence, with a capacitor and inductor in the filter circuit, the ripple is independent of the load current.

These days, LC filters are becoming obsolete because of the size and cost of the inductors. LC filters are being replaced by integrated circuit (IC) voltage regulators, active filter circuits which reduce the ripple and keep the DC voltage constant. IC regulators and active filters are discussed in detail in further lessons.

Voltage dividers : It is a simple circuit which turns a large voltage into a smaller one using just two series resistors and an input voltage we can create an output voltage that is a fraction of the input.

Bypass filter : The bypass capacitor acts as a filter providing infinite resistance to steady state voltage and bypassing high frequency noise.

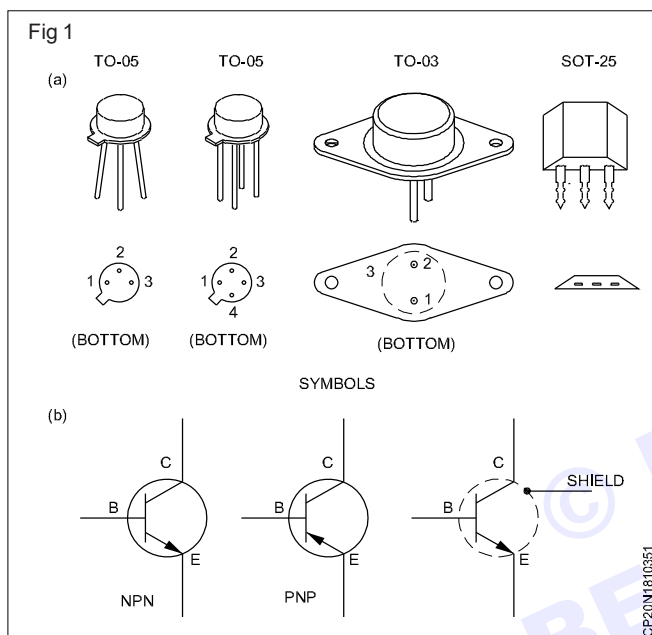
Transistors

Objectives: At the end of this lesson you shall be able to

- introduction of transistors
- list the advantages of transistors over vacuum tubes
- list the important classifications of transistors
- state the name and functions of terminals of a transistor
- name of the types of transistor packages
- describe the two tests to be conducted on a transistor before using it
- working principle of transistor.

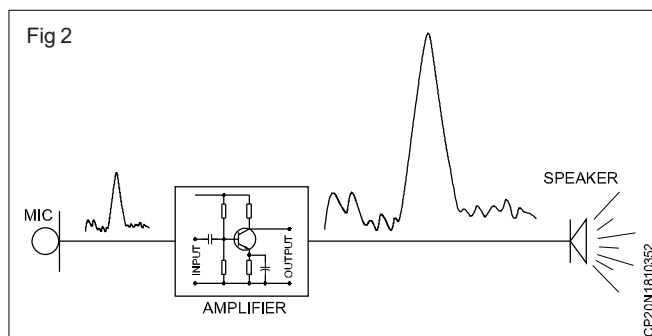
Introduction

Transistors are the semiconductor devices having three or four leads/terminals. Fig 1a shows some typical transistors. Fig 1b shows the symbols used for different types of transistors.



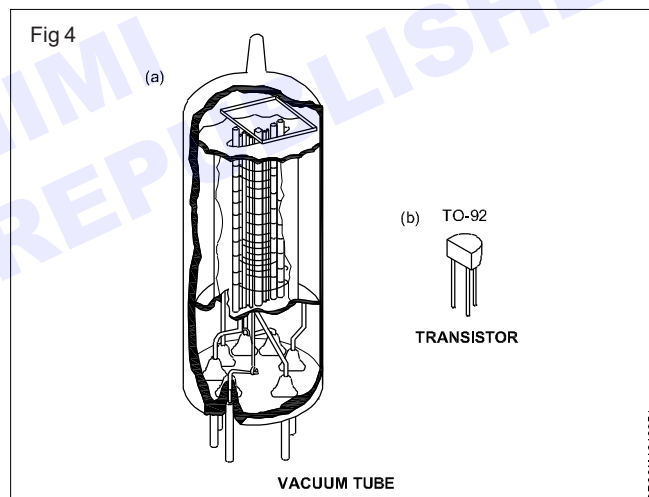
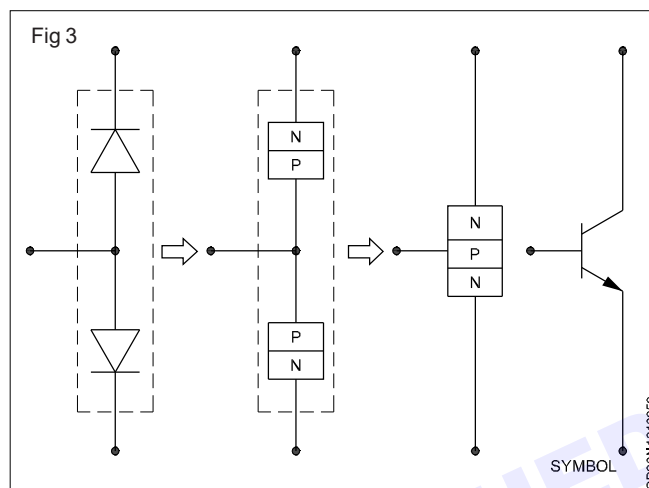
Transistors are mainly used for enlarging or amplifying small electric/electronic signals as shown in Fig 2. The circuit which uses transistors for amplifying is known as a transistor amplifier.

One other important application of transistors is its use as a solid state switch. A solid state switch is nothing but a switch which does not involve any physical ON/OFF contacts for switching.



Transistors can be thought of as two PN junction diodes connected back to back as shown in Fig 3.

Before the transistors were invented (1947), there was what were known as vacuum tubes which were used in amplifiers. A typical vacuum tube is shown in Fig 4a.



Compared with the present day transistors the vacuum tubes were big in size, consumed more power, generated lot of unwanted heat and were fragile. Hence vacuum tubes became obsolete as soon as transistors came to market.

Transistors were invented by Walter H. Brattain and John Bardeen of Bell Telephone Laboratories on 23rd Dec. 1947. Compared to vacuum tubes (also known as valves), transistors have several advantages. Some important advantages are listed below;

- Very small in size (see Fig 4b)
- Light in weight
- Minimum or no power loss in the form of heat
- Low operating voltage
- Rugged in construction.

To satisfy the requirements of different applications, several types of transistors in different types of packaging are

available. As in diodes, depending upon the characteristics, transistors are given a type number such as BC 107, 2N 6004 etc., The characteristics data corresponding to these type numbers are given in *Transistor data books*.

Classification of transistors

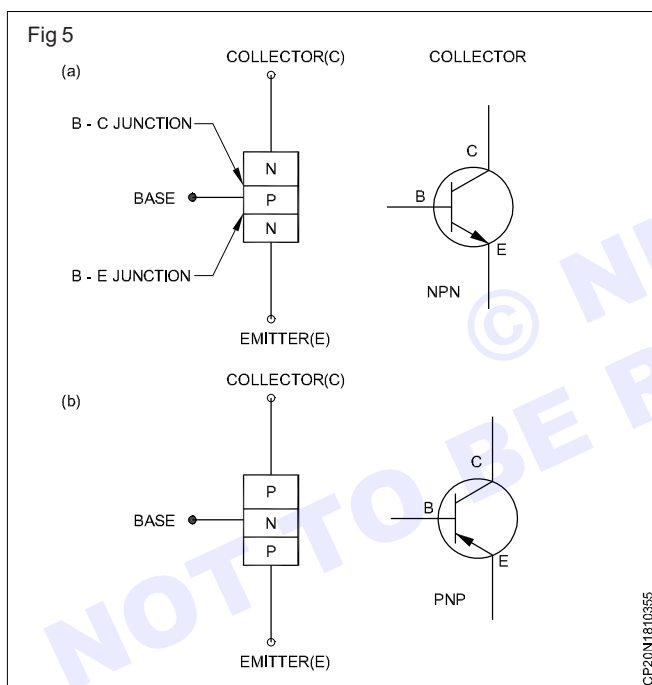
1 Based on the semiconductor used.

- Germanium transistors
- Silicon transistors

Like in diodes, transistors can be made, using any one of the above two important semiconductors. However, most of the transistors are made using silicon. This is because, silicon transistors work better over a wide temperature range (higher thermal stability) compared to germanium transistors.

Transistor data books give information about the semiconductor used in any particular transistor.

2 Based on the way the P and N junctions are organized as shown in Fig 5.



- NPN transistors
- PNP transistors

Both NPN and PNP transistors are equally useful in electronic circuits. However, NPN transistors are preferred for the reason that NPN has higher *switching speed* compared to PNP.

Details of switching speed is discussed in further lessons.

Whether a transistor is PNP or NPN can be found with the help of transistor data book.

3 Based on the power handling capacity of transistors as shown in Table below (Fig 6).

Low power transistors, also known as small signal amplifiers, are generally used at the first stage of amplification in which the strength of the signal to be

amplified is low. For example, to amplify signals from a microphone, tape head, transducers etc.,

Low power transistors (less than 2 watts)	Medium power transistors (2 to 10 watts)	High power transistors (more than 10 watts)
Fig 6 TO-92 	TO-05 	TO-03

Medium power and high power transistors, also known as large signal amplifiers are used for achieving medium to high power amplification. For example, signals to be given to loudspeakers etc. High power transistors are usually mounted on metal chassis or on a physically large piece of metal known as heat sink. The function of heat sink is to, take away the heat from the transistor and pass it to air.

Transistor data books give information about the power handling capacity of different transistor.

4 Based on the frequency of application

- Low freq. transistors (Audio frequency or A/F transistors)
- High freq. transistor (Radio frequency or R/F transistors)

Amplification required for signals of low or audio range of frequencies in Tape recorders, PA systems etc., make use of A/F transistors. Amplifications required for signals of high and very high frequencies as, in radio receivers, television receivers etc., use R/F transistors.

5 Based on the manufacturing method

- Grown junction
- Alloy junction
- Planar type
- Point contact
- Epitaxial
- Mesa

The aim of each manufacturing process is to yield transistors most suitable for a particular type of application.

Transistor data books generally do not give information about the adopted manufacturing process of transistor. However, the relevant details can be obtained from the transistor manufacturer.

6 Based on the type of final packaging

- Metal
- Plastic
- Ceramic

Metal packaged transistors are generally used in medium and high power amplifications. Plastic packaging is generally used for low power amplification. Some plastic packages come with a metal heat sink. Such transistors are used for medium power amplification. Ceramic packaging is used for special purpose very high frequency applications, for higher temperature stability etc.,

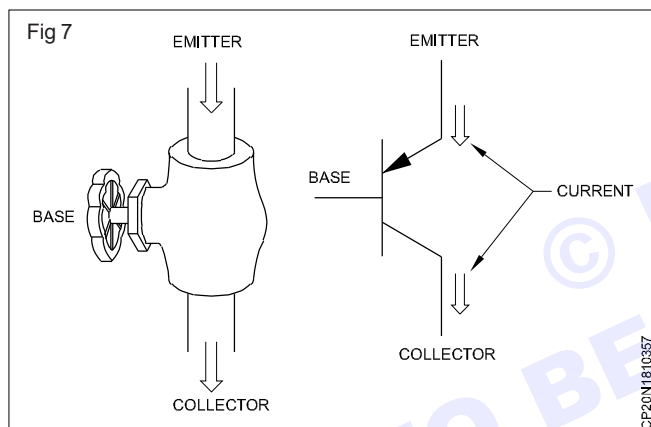
Some examples of packaging type codes used with transistors are, TO-3, TO-92, SOT-25 and so on.

Transistor data books give information about the type of packaging and its case outline.

Inside a transistor

Inside a transistor there are two PN junctions connected to each other as shown in Fig 3 and Fig 5. Outside a transistor, one can see only three leads. These leads are known as **base**, **emitter** and **collector** as shown in Fig 5. As shown in Fig 5, the three leads/pins/pigtails called **base**, **emitter** and **collector** are taken from each of doped semiconductor material.

In simple terms, as shown in Fig 7, the function of the **base**, **emitter** and **collector** regions of a transistor are,



Emitter - emits current carriers (electrons/holes)

Collector - collects current carriers

Base - controls flow of current carriers from emitter to collector.

While connecting a transistor to a circuit, it is necessary to identify the base, the emitter and the collector pins. A Transistor data book gives information on pin identification of transistors. However, it is convenient to put sleeve wires over the transistor pins for the following reasons;

- for easy identification while wiring
- sleeves act as spacers while mounting and soldering
- they ensure the required minimum lead distance from the solder joint to the transistor body.

Following colour scheme is suggested for putting sleeves to transistor pins although, any convenient colour scheme may be adopted.

Base pin - Blue colour sleeve

Emitter pin - Red colour sleeve

Collector pin - Yellow colour sleeve

Shield pin - Black colour sleeve

Transistor type packages

The popular transistors with different ratings used for general purpose to special applications are manufactured in a variety of package styles. some of the commonly used transistors with their package numbers and lead identifications.

Biassing of Transistors

Objectives: At the end of this lesson you shall be able to

- describe the operation of a NPN transistor & PNP transistor
- state the typical percent of base current and collector current in a properly biased transistor
- state the relationship between I_E , I_B and I_C
- state when a transistor is said to be properly biased
- state the meaning of leakage current I_{CO} .

Biassing of transistors

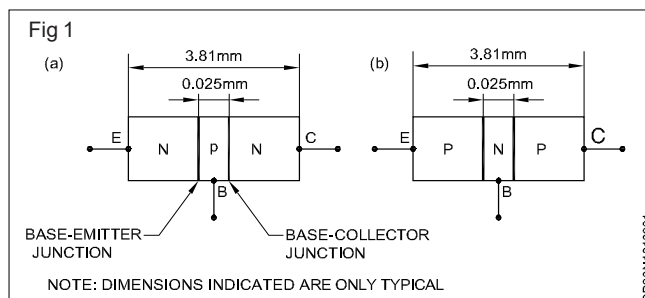
Biassing a transistor means giving correct polarity and current level of voltages at the terminals of a transistor, such that, it functions as intended. (as an amplifier or as a solid state switch etc.)

Recall, transistors are three-layer semiconductor devices consisting of either a P-type layer sandwiched between two N-type layers as shown in Fig 1a or N-type layer between two P-type layers as shown in Fig 1b.

From Fig 1, the following points are important to note;

- The widths of the outer layers, i.e. emitter and collector layers are much greater than that of the base layer.

- The emitter layer is heavily doped compared to both the base and collector layers.
- The base layer is very thin, of the order of 1/10th the width of the outer layers, and is very lightly doped.

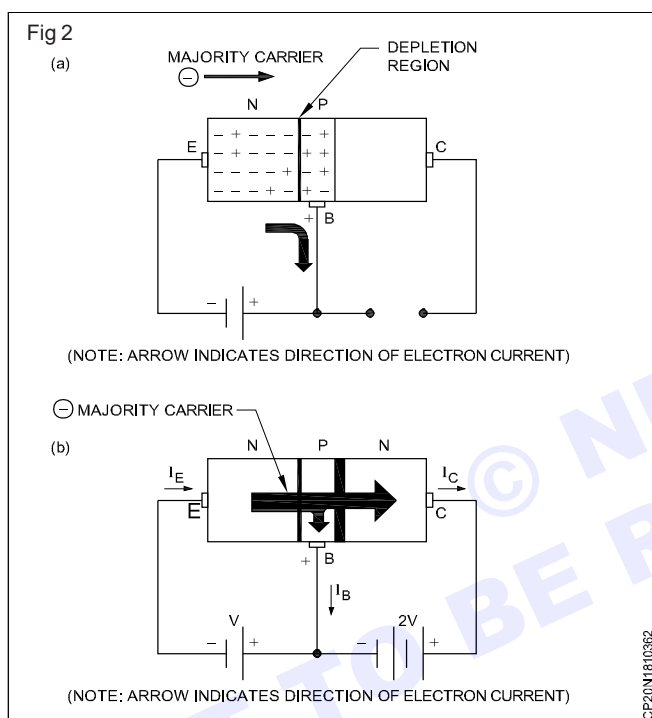


Transistor operation

As transistors have three layers, there are two junctions as shown in Fig 1. The **base-emitter** junction behaves as one diode junction. The **base-collector** junction behaves as the other diode junction.

Recall that a diode junction conducts only when +ve supply is connected to the P material and -ve supply to the N material. Fig 2a shows a NPN transistor where the base-emitter junction is forward-biased. Hence, the diode conducts resulting in large flow of majority carriers (electrons) from N-type to P-type material.

Fig 2b shows the base-emitter junction forward biased and the base-collector junction is reverse-biased. Why is the base-collector reverse biased? what effect does this connection have on the transistor operation?

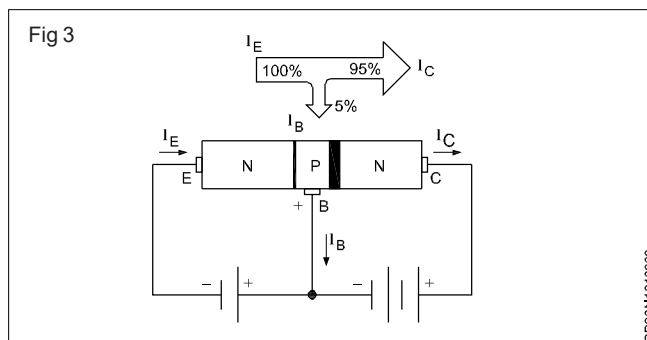


The answer is, in a NPN transistor, majority carriers are electrons, because, the emitter and collector are N-type materials. Free electrons are generated in the N-type emitter because of the forward-biased base-emitter junction. If the collector voltage is not there, then all the generated electrons flow to the base as shown in Fig 2a.

When the base-collector is reverse-biased, then, a positive voltage appears at the collector. This positive voltage at the collector completely changes the path of the electron current flow. Because of the thin base and the low base-to-emitter voltage (0.7V for silicon), about 95 percent of the electrons pass through the thin base and are attracted to the more positive potential collector as shown in Fig 2b. Only a very small percentage of the electrons from the emitter combine with holes in the base.

It can be seen from Fig 3, that the,

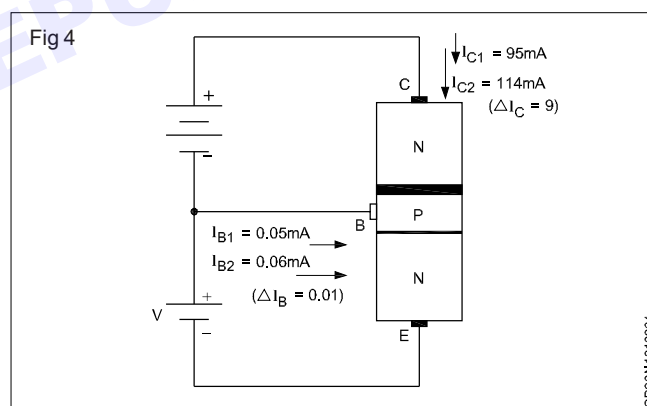
- current carriers come from the emitter
- base current is small (5% of emitter current)
- and, the collector current is high (95% of emitter current).



Under such conditions, it can be seen that, small changes in the emitter-base current will result in large change in the collector current. For example, an increase of say one electron in base current will result in an increase of 19 electrons in the collector current. This is because the collector current is 95% of the emitter current whereas the base current is only 5% of emitter current. This means that the value of the collector current can be easily controlled by changes in the bias on the emitter-base junction.

Summarizing, small changes in the base current results in large changes in the collector current as shown in Fig 4. This is nothing but amplification which is the intended function of a transistor. This behaviour of a transistor is known as Transistor action.

The ratio of the change in output current to the change in the input current is called the **amplification** or **gain**. In Fig.4, change in output current is ΔI_C due to the change in the input current ΔI_B . Therefore the current gain introduced by the transistor is,



Current gain

$$= \frac{\text{Output current change } \Delta I_C}{\text{Input current change } \Delta I_B} = \frac{19\text{mA}}{0.01\text{mA}} = 1900$$

Gain is a dimension-less quantity

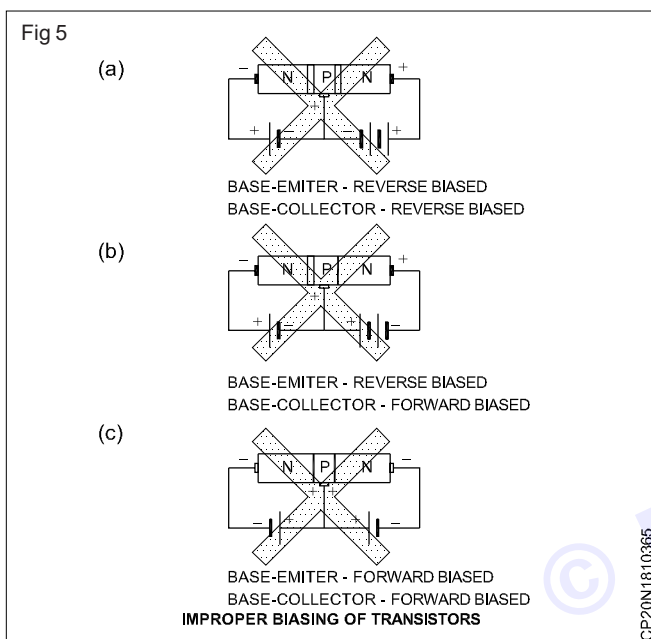
This condition as shown in Fig 4, in which the two junctions of the transistor are connected to such polarities of the voltage source, such that the transistor behaves as an amplifier, the transistor is then said to be properly biased or correctly biased.

Some books use the term Forward biased instead of the term properly biased.

Summarising a transistor is said to be properly biased or correctly biased or forward biased if,

- its base-emitter junction is forward biased
- and, its base-collector junction is reverse biased.

On the other hand, if the polarities of voltages connected to transistor junctions is as shown in Fig 5a and 5b, because the base-emitter junction is reverse biased, no electrons are available for conduction, and, hence, the transistor action does not exist. If the base-emitter is forward biased but the base-collector is not reverse biased as shown in Fig 5c, then, there is no amplification as both the junctions simply conduct as diodes.



In a properly biased transistor as shown in Fig 3 and Fig 4, the relationship between I_E , I_B and I_C is given by,

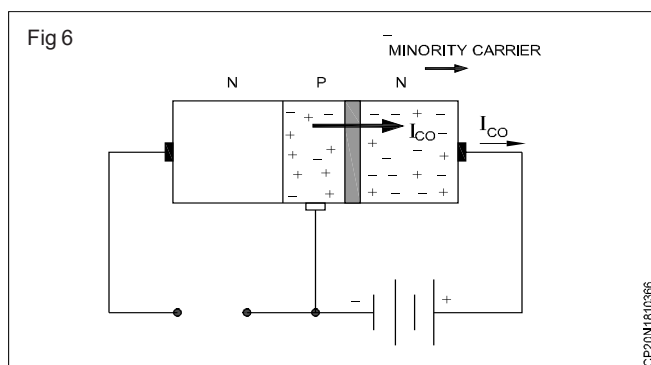
$$I_E = I_B + I_C \quad \dots [1]$$

$$\text{or } I_C = I_E - I_B$$

$$\text{or } I_B = I_E - I_C$$

Minority current in transistors

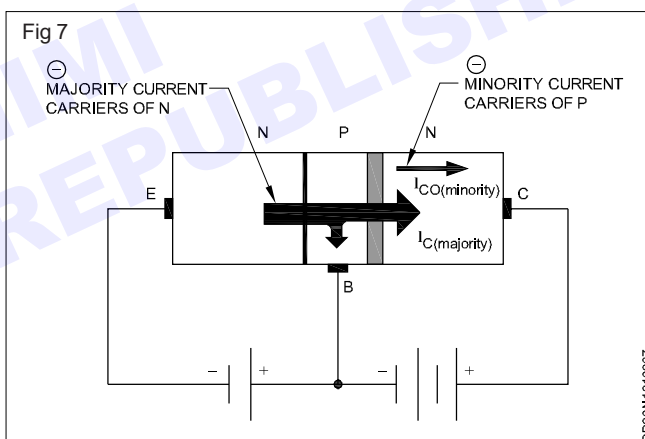
In NPN transistor, as shown in Fig 6, if no voltage is applied across the base-emitter junction, but a reverse-bias is applied across the base-collector junction, the following things happen,



- There is no current in the base-emitter path as no bias voltage exists.
- The base-collector diode is reverse biased; hence, the forward current due to the majority current carriers (electrons) is zero.
- A small quantity current of the order of a few nanoamperes to microamperes flows in the base-collector. This small reverse current is due to minority current carriers, electrons in the **P-type** base material.
- The minority current increases if the voltage applied to the base-collector increases or the junction temperature increases. This is because current increases temperature and temperature releases current carriers from the covalent bond structure.

This minority current is called the leakage current and is shown by the symbol I_{CO} . I_{CO} means, collector current I_C with emitter terminal open. The value of this leakage current I_{CO} will be given in the transistor data sheets for all transistors.

As shown in Fig 7, since the forward collector current I_C due to majority carriers and the leakage current I_{CO} due to minority current carriers flow in the same direction, they are combined. Therefore, the total collector current will be equal to,



$$I_C = I_{C(\text{majority})} + I_{CO(\text{minority})} \quad \dots [2]$$

Because of the minority current I_{CO} , the value of collector current I_C will be slightly more than that, given in the equation $I_C = I_E - I_B$. However, this slight increase in I_C value can be neglected because, the value of I_{CO} will be very small compared to I_C (due to I_E) at normal working temperature.

In any typical general purpose transistor,

- value of I_C and I_E will be in milliamps
- value of I_{CO} will be in nanoamps to microamps
- value of I_B will be in microamps.

Operation of PNP transistors

Working of a PNP transistor is exactly the same as that of NPN transistors discussed earlier, if the role played by the electrons in NPN transistors is interchanged with holes as given below;

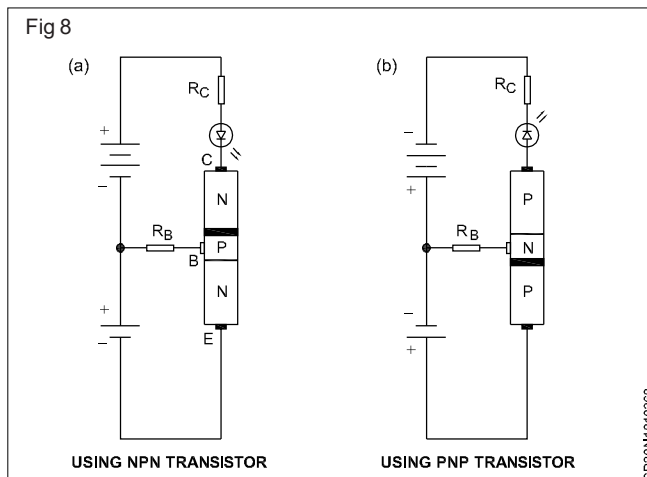
In a PNP transistor,

- The majority current carriers are holes instead of electrons
- The minority current I_{CO} , is due to electrons in the N-type base material instead of holes.

Test circuit for testing proper transistor biasing

If a transistor is properly biased (i.e. B-E junction forward biased and C-B junction reverse biased), then, there will be collector current I_C of the order of milliamps. To check this an LED is connected in the collector circuit of the transistors as shown in Figs 8a and 8b. The LED in the collector glows only when the transistor is properly biased otherwise the LED remains OFF.

Resistor R_B and R_C are introduced in the circuit to limit the base and collector currents such that the transistor does not get damaged due to excessive current.



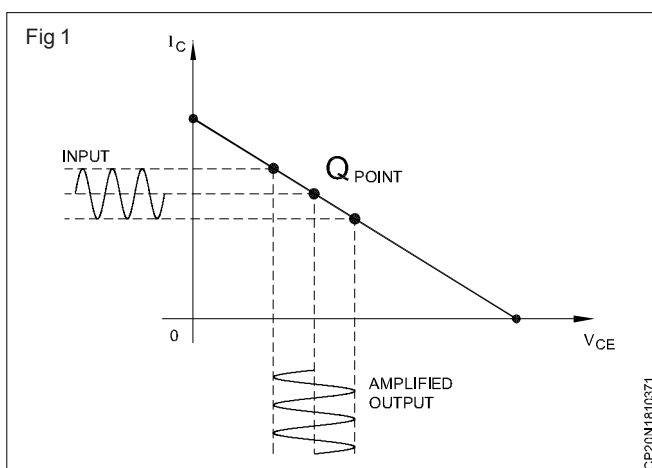
Types of transistor biasing

Objectives: At the end of this lesson you shall be able to

- state the need for biasing of transistors
- state the reason for shifting of Q due to temperature and β_{dc} changes
- name the three main types of transistor biasing
- state the reason why base-bias is not preferred
- state the definition of amplifier
- list the classification of amplifier
- state the meaning of feedback
- state the reason why emitter-bias is also known as emitter feedback bias
- state why voltage divider bias is the most preferred type of biasing
- state the design guidelines for voltage divider type biasing.

Before any one rides a motor cycle or drives a car, he has to start the engine and keep the engine running. In simple terms biasing transistors is similar to keeping the transistor started before making the real use of it. Once the transistor is started, like the engine of a car, it can be made to amplify, like covering the distance by riding the car.

Before an AC signal is fed to a transistor, it is necessary to set up an operating point or the quiescent(Q) point of operation. Generally this Q point is set at the middle of the DC load line. Once the Q point is set, then the incoming ac signals can produce fluctuations above and below this Q point as shown in Fig 1.



The need for biasing of a transistor can also be explained as follows;

For a transistor to remain operating in the linear region, the emitter diode must remain forward biased and the collector diode must remain reverse biased as long as the amplifier is amplifying. In other words, the amplitude variations in current and voltage of the input signal must not drive the transistor either into saturation or cut off.

Transistor stabilization with proper biasing a required quiescent operating point of transistor amplifier in the active region of transistor characteristics is obtained. It is necessary that once operation point is selected it should remain stable the maintenance of a point stable is called stabilisation.

Stable Q point

A set Q point of a transistor amplifier may shift due to increased temperature and transistor β value changes. Therefore, the objective of good biasing is to limit this shifting of the Q point or to achieve a stable Q point.

Recall that, the Q point is nothing but a point in the output characteristic of the transistor. This point corresponds to a particular value of I_B , I_C and V_{CE} . Also recall that, the collector current I_C depends both on I_B and β of the transistor. If I_B changes, I_C changes, and hence, the Q point changes. If β changes, again I_C changes, and hence, the Q point gets shifted.

Shifting of Q due to temperature

Remember that a transistor is a temperature sensitive device. Any increase in the junction temperature results in leakage current. This increased leakage current in turn increases the temperature and the effect is cumulative. This chain reaction is called thermal run away. If this thermal run away is not stopped, it may result in the complete destruction of the transistor due to excessive heat. In transistors, due to this increased leakage current, the base current increases, and hence, the Q point gets shifted. This change in the set Q point affects the performance of the amplifier resulting in distortion.

Shifting of Q due to β_{dc} changes

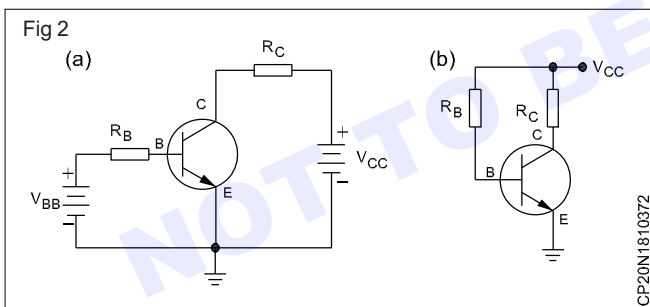
Recall that two transistors of the same type number may have different values of β . This is due to the manufacturing process of transistors. Hence, when a transistor is replaced or changed, due to different β of the replaced transistor, the Q point again gets shifted.

Therefore, a stable biasing is one which does not shift the Q-point even if temperature varies and/or the β of the transistor changes.

Types of transistor biasing

There are several ways to bias a transistor for linear operation. This means, there are several ways of setting up a Q point near the middle of the dc load line. Important biasing arrangements used with transistors are explained below:

Fig.2 Shows one type of biasing of transistor known as base-bias. As shown in Fig 2b, usually, the collector voltage supply itself is used for the base voltage instead of a separate supply.



The value of the base resistor R_B is fixed such that it allows the necessary Q point base current I_B . The value of R_B ensures that the base-emitter diode is always forward biased by allowing 0.7V (for silicon) across V_{BE} .

This type of biasing is the simplest of all. However, this is the worst possible way to bias a transistor because the DC Q point changes when,

- temperature increases and
- β of the transistor is changed.

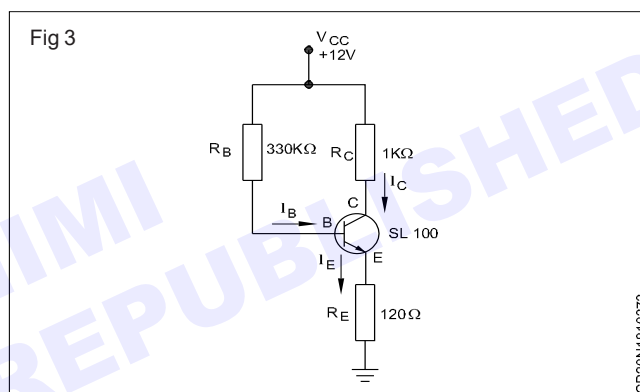
Hence, in a base-biased transistor, it is impossible to set up a stable Q point. Therefore, base biasing of transistors is not generally done in linear amplifier circuits. However, base biasing is commonly used in digital circuits (discussed in further lessons) where transistors are used as a switch and not as a linear amplifier.

2 EMITTER BIAS or emitter feedback bias: Fig.3 shows a emitter-biased transistor. This type of biasing compensates for the variations in β_{dc} and keeps the Q point fairly stable.

In Fig 3, if β_{dc} increases, the collector current increases. This in turn increases the voltage at the emitter. This increased emitter voltage decreases the voltage across the base-emitter junction and therefore, the base current reduces. This reduced base current results in less collector current, which partially offsets the increase in I_C due to increased β_{dc} .

Emitter bias is also referred to as emitter feedback bias. This is because an output quantity, i.e., the collector current, produces a change in an input quantity i.e., the base current. The term feedback means a portion of the output is given back to the input. In emitter bias, the emitter resistor is the feedback element because it is common to both the output and input circuits.

In Fig 3, if we add the voltages around the collector loop, we get,



$$I_C R_C + V_{CE} + I_E R_E - V_{CC} = 0 \quad \dots\{1\}$$

Since I_E approximately equals I_C , (as I_B is comparatively very small), equation..(1) can be arranged as,

$$I_C = \frac{V_{CC} - V_{CE}}{R_C + R_E} \quad \dots\{2\}$$

If we add voltages around the base loop, we get,

$$I_B R_B + V_{BE} + I_E R_E - V_{CC} = 0. \quad \dots\{3\}$$

Since $I_E \approx I_C$ and $I_B = I_C / \beta_{dc}$, we can rewrite the equation as,

$$I_C = \frac{V_{CC} - V_{BE}}{R_E + R_B / \beta_{dc}} \quad \dots\{4\}$$

From equation ... (4), the presence of term β indicates that I_C is dependent on β . The intention of emitter-feedback bias is to swamp out the effect β_{dc} . This is possible when R_E is made much larger than R_B / β_{dc} . However, in practical circuits R_E cannot be made very large because, large value of R_E takes the transistor out of the linear operating region. Due to this problem, the emitter-feedback bias is almost as sensitive to changes in β_{dc} as is the base-bias. Therefore, emitter-feedback bias is also not a preferred form of transistor bias and should be avoided.

In emitter-bias, the saturation current will be,

$$I_{C(sat)} = \frac{V_{CC} - V_{CE(set)}}{R_E + R_C} \dots [1]$$

When the transistor is saturated, the value of V_{CE} will be between 0.2 to 0.3V. Hence can be neglected for all practical purposes.

In Fig 3, the saturation current is,

$$I_{C(set)} = \frac{12 \text{ V}}{1000 \Omega + 120 \Omega} = 10.71 \text{ mA.}$$

Note: $V_{CE(sat)}$ of 0.2 volts is neglected.

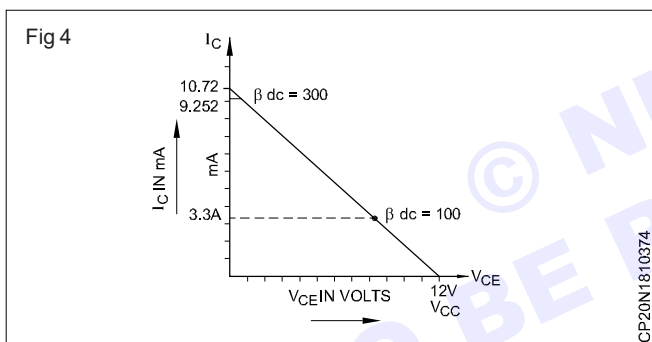
When $\beta_{dc} = 100$, equation ... (4) gives,

$$I_C = \frac{12 \text{ V} - 0.7 \text{ V}}{120 \Omega + 330 \text{ K}\Omega / 100} = 3.3 \text{ mA.}$$

When $\beta_{dc} = 300$, the same equation... (4) gives,

$$I_C = \frac{12 \text{ V} - 0.7 \text{ V}}{120 \Omega + 330 \text{ K}\Omega / 300} = 9.262 \text{ mA}$$

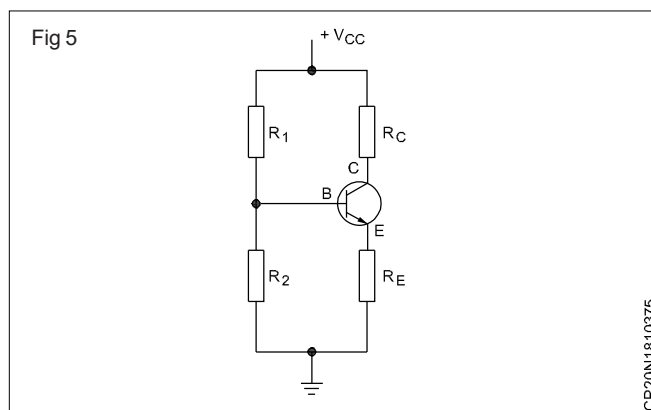
Fig 4 summarizes the calculations by showing the DC load line and the two Q points. As can be seen, a 3:1 change in β_{dc} produces almost a 3:1 change in the collector current. This change is unacceptable as a stable-biased state.



TIP: For linear operation of the transistor, the base resistor R_B should be greater than βR_C . A base resistance of less than $\beta_{dc} R_C$ produces saturation in an emitter-feedback-biased circuit.

3 Voltage - Divider bias: Fig 5 shows a typical voltage-divider bias. This type of biasing is also called the universal

bias because, this is the most widely used type of biasing in linear circuits.



This type of biasing is known as voltage divider bias because of the voltage divider formed by resistors R_1 and R_2 . The voltage drop across R_2 should be such that it forward biases the emitter diode.

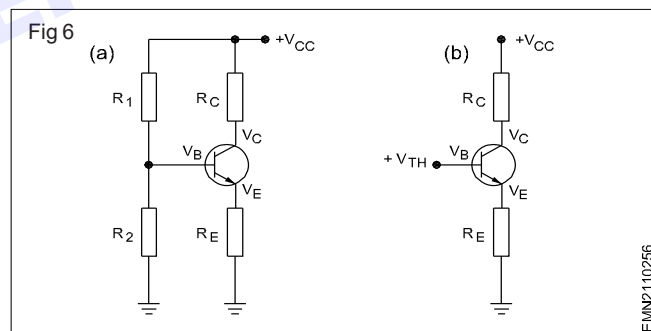
Emitter current in voltage divider bias

Assume that the base lead is open as shown in Fig 6b.

Looking back at the unloaded voltage divider,

$$V_{TH} = \frac{R_2}{R_1 + R_2} V_{CC}.$$

Now assume that, the base lead is connected back to the voltage divider as in Fig 6a. Then, voltage V_{TH} drives the base of the transistor. In other words, the circuit simplifies to Fig 6a and the transistor acts like the controlled current source.



Field Effect Transistors

Objectives: At the end of this lesson you shall be able to

- identify various power electronic component
- construction of FET & JFET
- difference between FET & BJT
- difference between JFET & BJT
- heat sink and its purposes
- FET amplifiers in measuring device applications.

Identification & different power electronic components

A thristor is an improved diode. Besides anode (A) and cathode (K) it has another lead which is commonly described as a gate (G), as found on picture. The same

way a diode does, a thyristor conducts current when the anode is positive compared to the cathode, but only if the voltage on the gate is positive and sufficient current is flowing into the gate to turn on the device. When a thyristor starts conducting current into the gate is of on importance

and thyristor can only be switched off by removing the current between anode and cathode. If S1 is closed, the thyristor will not conduct, and the globe will not light. If S2 is closed for a very short time, the globe will illuminate. To turn off the globe S1 must be opened. Thyristors are marked in some circuits as SCR, which is an acronym for silicon controlled rectifier. A triac is very similar to thyristor, with the difference that it can conduct in both directions. It has three electrodes called anode 1 (A1), anode 2 (A2), and gate (G). It is used for regulation of alternating current circuits. Devices such as hand drills or globes can be controlled with a triac. Thyristor and triacs are marked alphanumerically, KT430, for example. Low power thyristors and triacs are packed in same housings as transistors, but high power devices have completely different housing. Pin-outs of some common thyristors and triacs are shown in a and b. Diacs or two-way diodes as they are often referred to, are used together with thyristors and triacs. Their main property is that their resistance is very large until voltage on their ends exceeds some predefined value. When the voltage is under this value, a diac responds as a large value resistor, and when voltage rises it acts as a low value resistor.

Field effect transistors (FET)

The main difference between a bipolar transistor and a field effect transistor is that,

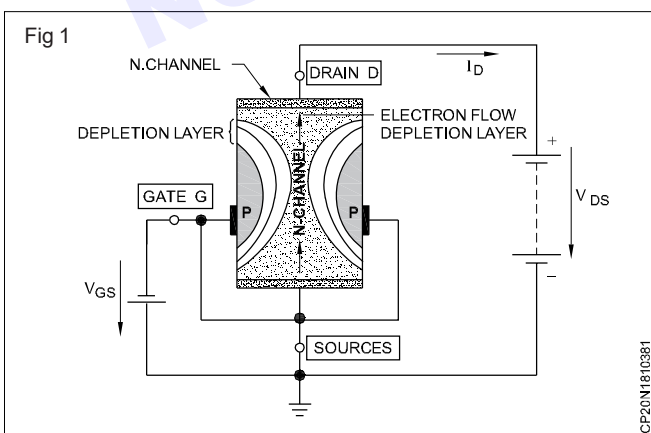
Bipolar transistor is a current controlled device.

In simple terms, this means that the main current in a bipolar transistor (collector current) is controlled by the base current.

Field effect transistor is a voltage controlled device.

This means that the voltage at the gate (similar to base of a bipolar transistor) controls the main current.

In a bipolar transistor (NPN or PNP) the main current always flows through N-doped and P-doped semiconductor materials. Whereas, in a field effect transistor the main current flows either only through the N-doped semiconductor or only through the P-doped semiconductor as shown in Fig 1.



If the main current flow is only through the N-doped material, then such a FET is referred to as an N-channel or N-type FET. The current through the N-doped material in the N-type FET is only by electrons.

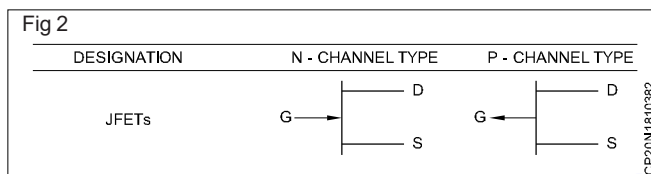
If the main current flow is only through the P-doped material, then such a FET is referred to as a P-channel or P-type FET. The current through the P-doped material in the P-type FET is only by holes.

Unlike in bipolar transistors in which the main current is both by electrons and holes, in contrast in FET depending on the type of (P or N type) the main current is either by electrons or by holes and never both. For this reason FETs are also known as unipolar transistors or unipolar devices.

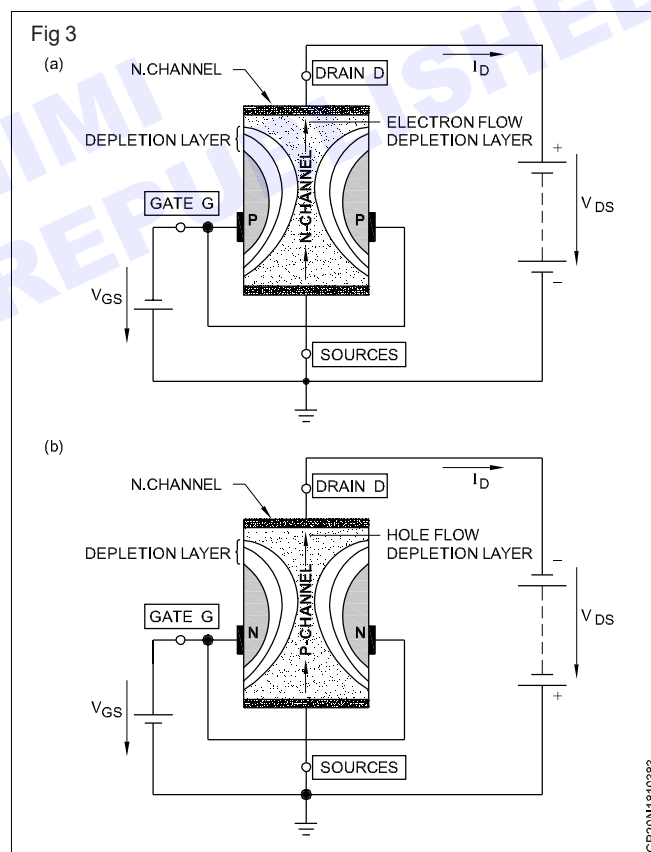
There are a wide variety of FETs. One of the fundamental types is called a junction field effect transistor (JFET) and is discussed.

Junction Field effect Transistor (JFET)

It is a three-terminal device and looks similar to a bipolar transistor. The standard circuit symbols of N-channel and P-channel type FETs are shown in Fig 2.



The internal diagram of an N-channel FET is shown in Fig 3.



Construction

As shown in Fig 3a, an N-channel JFET has a narrow bar of n-type. To this, two p-type junctions are diffused on opposite sides of its middle part Fig 3a. These diffused junctions form two P-N diodes or gates. The n-type semiconductor area between these junctions/gates is called the channel. The diffused P regions on opposite sides of the channel are internally connected and a single lead is

brought out which is called gate lead or terminal. Direct electrical connections are made at the two ends of the bar. One of which is called source terminal, S and the other drain terminal, D.

A p-channel FET will be very similar to the n-channel FET in construction except that it uses P-type bar and two N type junctions as shown in Fig 3b.

FET notation listed below are essential and worth memorizing,

- 1 Source terminal: It is the terminal through which majority carriers enter the bar (N or P bar depending upon the type of FET).
- 2 Drain terminal: It is the terminal through which majority carriers come out of the bar.
- 3 Gate terminal: These are two internally connected heavily doped regions which form two P-N junctions.
- 4 Channel: It is the space between the two gates through which majority carriers pass from source to drain when FET is working (on).

Working of FET

Similar to Bipolar transistors, the working point of adjustment and stabilization are also required for FETs.

Biassing a JFET

- Gates are always reverse biased. Therefore the gate current I_g is practically zero.
- The source terminal is always connected to the end of the supply which provides the necessary charge carriers. For instance, in an N-channel JFET source terminal S is connected to the negative of the DC power supply. And, the positive of the DC power supply is connected to the drain terminal of the JFET.

Whereas in a P channel JFET, Source is connected to the positive end of the power supply and the drain is connected to the negative end of the power supply.

Let us now consider an N channel JFET, the drain is made positive with respect to source by voltage V_{DS} as shown in Fig 4a. When gate to source voltage V_{GS} is zero, there is no control voltage and maximum electron current flows from source (S) - through the channel - to the drain (D). This electron current from source to drain is referred to as Drain current, I_D .

When gate is reverse biased with a negative voltage (V_{GS} negative) as shown in Fig 4b, the static field established at the gate causes depletion region to occur in the channel as shown in Fig 4b.

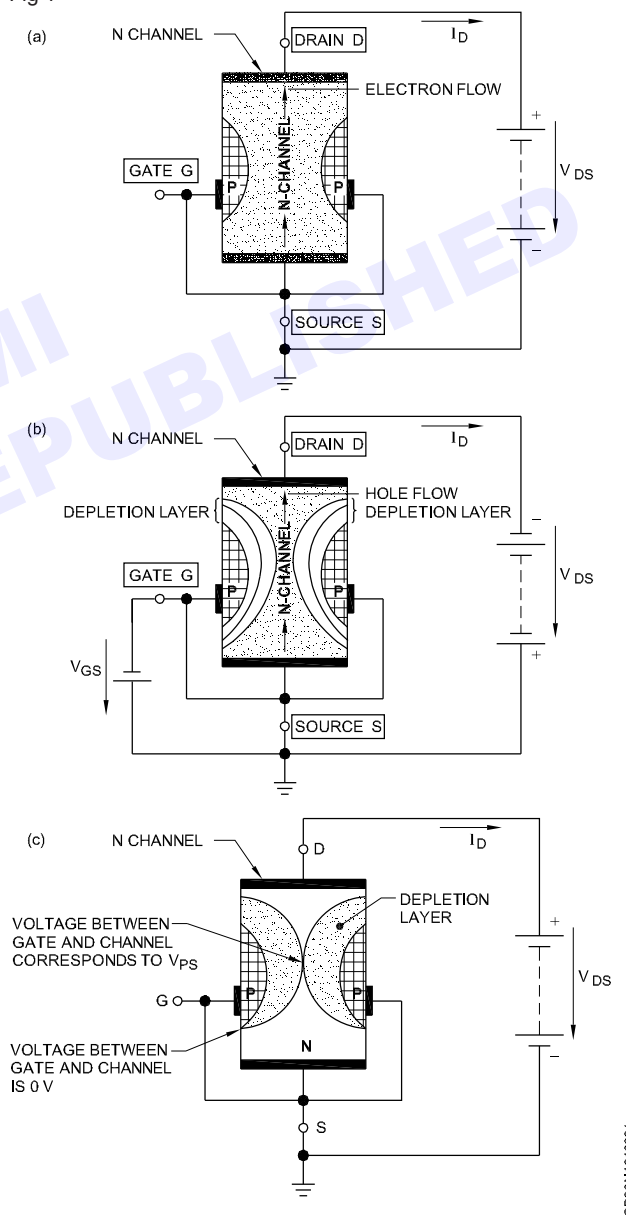
This depletion region decreases the width of the channel causing the drain current to decrease.

If V_{GS} is made more and more negative, the channel width decreases further resulting in further decrease in drain current. When the negative gate voltage is sufficiently high, the two depletion layers meet and block the channel cutting off the flow of drain current as shown in Fig 4c. This voltage at which this effect occurs is referred to as the Pinch off voltage, V_p .

Thus, by varying the reverse bias voltage between gate and source ($-V_{GS}$), the drain current can be varied between maximum current (with $-V_{GS}=0$) and zero current (with $-V_{GS}$ =pinch off voltage). So, JFET can be referred as a voltage controlled devices.

P channel JFET operates in the same way as explained above except that bias voltages are reversed and the majority carrier of channel are holes.

Fig 4



MOSFET

Objectives : At the end of this lesson you shall be able to

- state the principle of operation of MOSFET and its types
- list the special type of MOSFETs
- explain the features of MOSFETs.

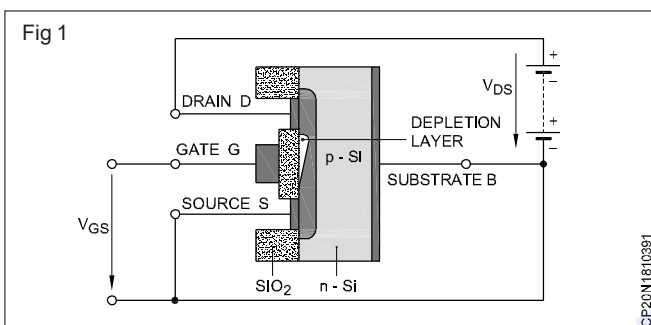
In MOSFETs, control is via an insulating layer instead of a junction (as in JFETs). This insulating layer is generally made of silicon dioxide, from which the very name MOSFET is derived (Metal Oxide Semiconductor). Some times the MOSFETs are also referred to as Insulated-gate FET, for which the abbreviation used are IFET or IGFET.

Types of MOSFETs

Depletion-type MOSFETs

Construction and mode of operation

Fig 1 shows the construction of a depletion MOSFET of the n-channel type.



Here, two highly doped n-zones are diffused into a p-doped silicon plate, which is referred to as the substrate, and are provided with junction-free drain and source connections. Between the two zones there is a thin weakly n-doped channel, which produces an electrical connection between the source and drain without an external field-action. This channel is covered by an insulating layer of silicon dioxide (SiO_2), to which a metal electrode is applied as the gate connection.

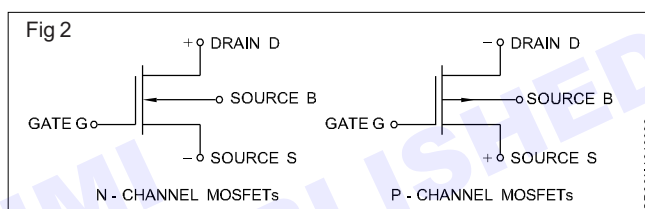
If a voltage U_{DS} is applied between source and drain, at $U_{GS} = 0V$ an electron current flows from the source electrode via the n-channel to the drain electrode. If, however, a negative voltage is applied to control electrode G, the electrons present in the n-channel are forced out of the vicinity of the gate electrode, so that a zone depleted of charge carriers is produced there. This causes a constriction of the n-channel and consequently also a reduction of its conductivity. If the gate voltage becomes more negative, the conductivity of the channel is reduced, as is consequently also the drain current I_D . Another peculiarity of depletion-type MOSFETs is that they can also be controlled with a positive gate-voltage. Charge carriers are then drawn out of the p-doped substrate into the n-channel and its conductivity is increased even further, compared with the conductivity at $U_{GS} = 0V$.

Designations and circuit symbols

The same designations are used for the connections of MOSFETs as they are for JFETs, i.e source, drain and gate. MOSFETs, however, have another electrode, which

is referred to as the substrate connection. Together with the semiconductor material of the channel, this substrate forms a p-n junction, which can be used as a second control-electrode. It is then led out of the casing, like the other electrodes. In a number of versions, however, the substrate electrode is connected directly to the source connection in the casing, which rules out the additional control possibility.

Fig 2 shows the circuit symbols for depletion-type n-channel MOSFETs and p-channel MOSFETs. For the n-channel type, the arrow points towards the line representing the channel; in the case of the p-channel type, on the other hand, it points away from the line representing the channel. The continuous line representing the channel indicates that it is a depletion-type MOSFET.

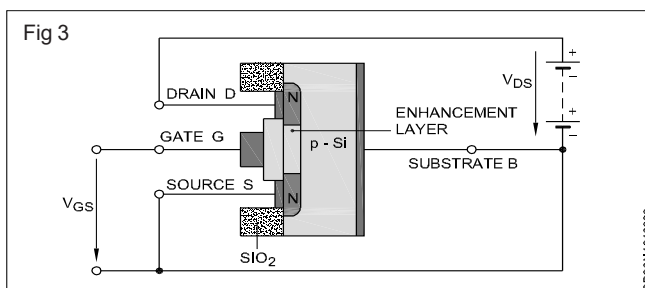


N-channel MOSFETs are operated with a positive drain-source voltage. They have a considerably greater practical significance than p-channel MOSFETs, which require a negative drain-source voltage for their operation.

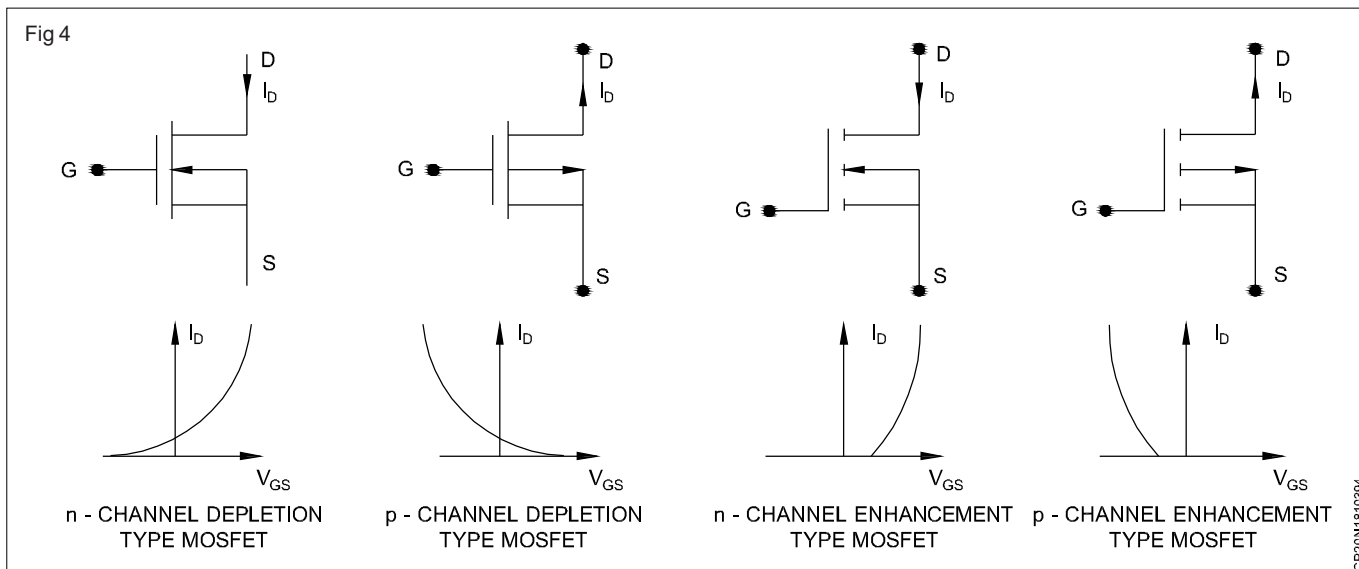
Enhancement-type MOSFETs

Construction and mode of operation

Enhancement-type MOSFETs have a similar technological construction to the depletion types. Without the external action of a field, however, no conducting channel exists between the drain connection and the source connection, so that at $U_{GS} = 0V$, no drain current can flow. Fig 3 shows the construction of an enhancement-type n-channel MOSFET.



The same circuit designations are used for the four electrodes of the enhancement-type MOSFET as they are for the depletion types: drain, source, gate and substrate. The circuit symbols used are different. The line representing the channel in the circuit symbol is discontinuous for an enhancement-type MOSFET. This indicates that no drain current I_D flows at $U_{GS} = 0V$. The circuit symbols for the two types of enhancement MOSFET are given in Fig 4.

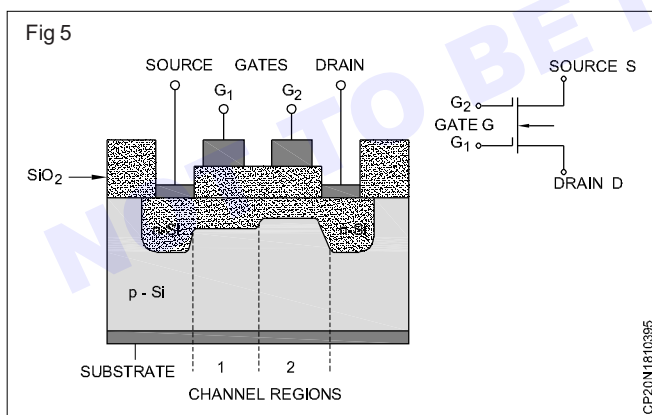


Enhancement-type MOSFETs are only rarely produced as individual transistors. Their construction and working principle are, however, widely used in integrated MOS switching circuits.

Special types of MOSFET

Dual-gate MOSFET

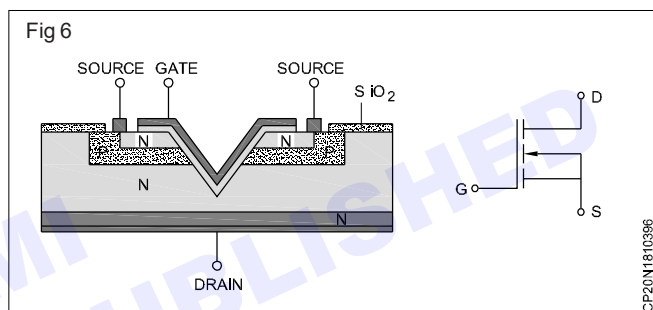
The dual-gate MOSFET is a special type of depletion MOSFET. It has two series-connected channel regions as the current path. The conductivity of each of these two channel regions can be independently controlled via its own gate. The construction and circuit symbol of a depletion-type dual-gate MOSFET of the n-channel type are reproduced in Fig 5. Because of the four connections, this special type is also referred to as a "MOSFET tetrode".



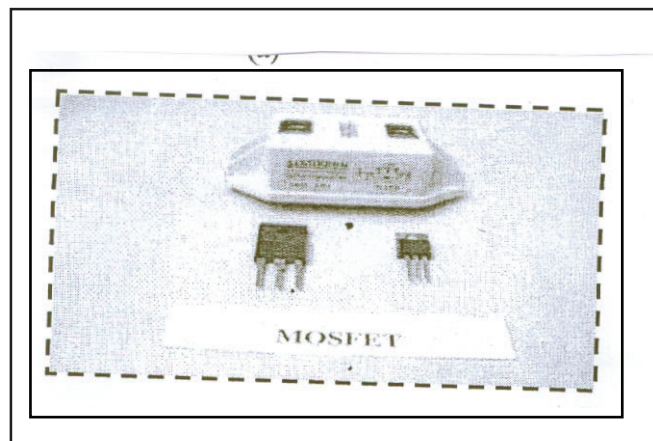
VMOSFET

The field-effect transistors dealt with so far, can handle only relatively small powers during amplification or switching. The reason for this is the relatively long channel of approximately $5\text{ }\mu\text{m}$ with a forward resistance of approximately $1\text{ k}\Omega$ to $10\text{ k}\Omega$. With present-day manufacturing techniques, it is possible to produce a vertical structure for field-effect transistors, instead of the customary horizontal sequence of layers. Consequently, higher allowable currents and voltages are obtained, so that considerably greater powers can be amplified or switched.

Fig 6 shows the construction of an enhancement-type n-channel VMOSFET and the associated circuit symbol.



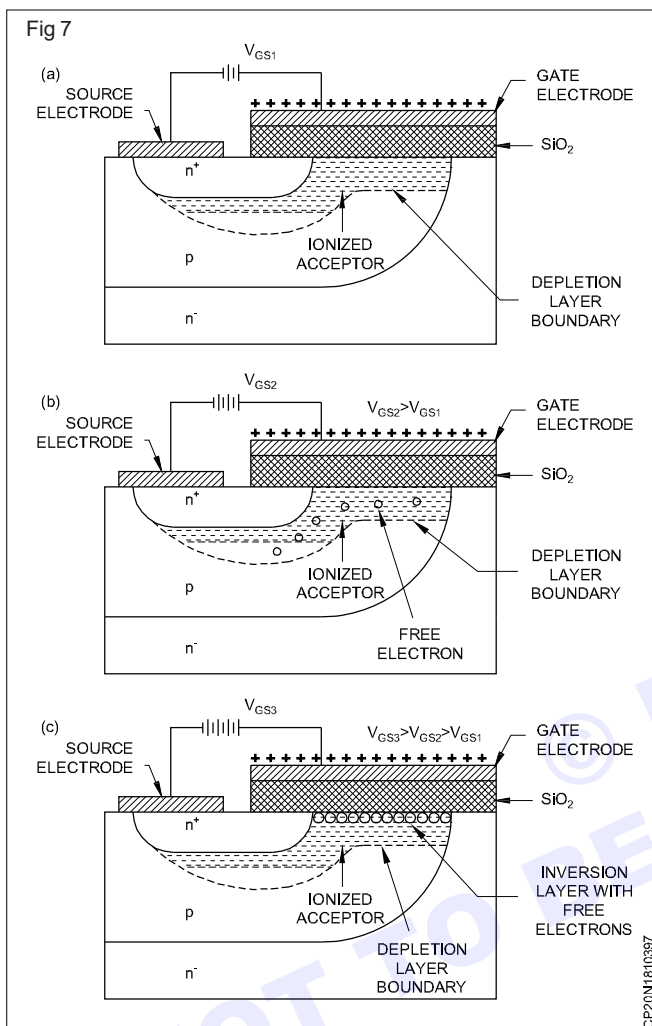
From above Fig 7 it can be concluded that depletion type MOSFETs are normally ON type switches i.e., with the gate terminal open a nonzero drain current can flow in these devices. This is not convenient in many power electronic applications. Therefore, the enhancement type MOSFETs (particularly of the n-channel variety) is more popular for power electronics applications. This is the type of MOSFET which will be discussed in this lesson. Fig. 6(b) shows the photograph of some commercially available n-channel enhancement type power MOSFETs.



Operating principle of a MOSFET

At first glance it would appear that there is no path for any current to flow between the source and the drain terminals since at least one of the **p n** junctions (source - body and body-drain) will be reverse biased for either polarity of the

applied voltage between the source and the drain. There is no possibility of current injection from the gate terminal either since the gate oxide is a very good insulator. However, application of a positive voltage at the gate terminal with respect to the source will convert the silicon surface beneath the gate oxide into an n type layer or "channel", thus connecting the source to the drain as explained next.



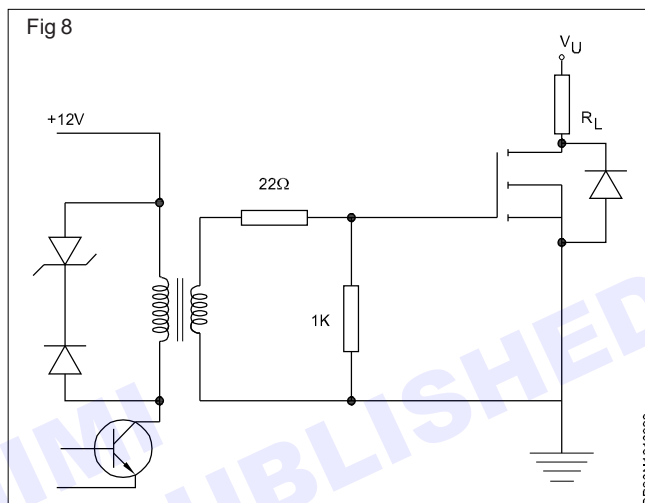
The gate region of a MOSFET which is composed of the gate metallization, the gate (silicon) oxide layer and the p-body silicon forms a high quality capacitor. When a small voltage is applied to this capacitor structure with gate terminal positive with respect to the source (note that body and source are shorted) a depletion region forms at the interface between the SiO_2 and the silicon as shown in the Fig 8(a)

The positive charge induced on the gate metallization repels the majority hole carriers from the interface region between the gate oxide and the P type body. This exposes the negatively charged acceptors and a depletion region is created.

Further increase in V_{GS} causes the depletion layer to grow in thickness. At the same time the electric field at the oxide-silicon interface gets larger and begins to attract free electrons as shown in Fig 8b. The immediate source of electron is electron-hole generation by thermal ionization. The holes are repelled into the semiconductor bulk ahead

of the depletion region. The extra holes are neutralized by electrons from the source.

As V_{GS} increases further the density of free electrons at the interface becomes equal to the free hole density in the bulk of the body region beyond the depletion layer. The layer of free electrons at the interface is called the inversion layer and is shown in Fig 8(c). The inversion layer has all the properties of an n type semiconductor and is a conductive path or "channel" between the drain and the source which permits flow of current between the drain and the source. Since current conduction in this device takes place through an n-type "channel" created by the electric field due to gate source voltage it is called "enhancement type n-channel MOSFET".



The value of V_{GS} at which the inversion layer is considered to have formed is called the "gate-source threshold voltage $V_{GS(th)}$ ". As V_{GS} is increased beyond $V_{GS(th)}$ the inversion layer gets somewhat thicker and more conductive, since the density of free electrons increase further with increase in V_{GS} . The inversion layer screens the depletion layer adjacent to it from increasing V_{GS} . The inversion layer screens the depletion layer adjacent to it from increasing V_{GS} . The depletion layer thickness now remains constant.

FET Vs MOSFET

The transistor, a semiconductor device, is the device that made all our modern technology possible. It is used to control the current and even to amplify it based on an input on an input voltage or current. There are two major types of transistors, the BJT and the FET. Under each major category, there are many subtypes. This is the most significant difference between FET and MOSFET. FET stands for field effect transistor and is a family of very different transistors that collectively rely on an electric field created by the voltage on the gate in order to control the current flow between the drain and the source. One of the many types of FET is the Metal - Oxide Semiconductor field effect transistor or MOSFET. The Metal - Oxide Semiconductor (i.e) silicon di oxide is used as an insulating layer between the gate and the substrate of the transistor.

The silicon dioxide is basically a capacitor is basically a capacitor that holds charge whenever voltage is applied to the gate. This charge then creates a field by pulling

oppositely charged particles or repelling particles with the same charge and allows or restricts the flow of the current between the drain and source.

CMOS (complementary Metal -Oxide Semiconductor) basically uses a p-type and n-type MOSFETs in pairs to complement each other. In this configuration, MOSFETS only have significant power consumption during switching and not while it holds its state. This is very desirable, especially in modern computing equipment where power and thermal limits are pushed to the edge. Other types of FET cannot replicate this capability or are too expensive to manufacture.

Advancements in MOSFETs are constantly evolving, both in size as companies keep going into smaller architectures. But also in design like the 3D MOSFETs that show a lot of promise. MOSFETs are the transistor of choice for today as researchers try to find other types of transistors that can be a suitable replacement for it.

Advantages of MOSFET

- 1 Low gate signal power requirement.
- 2 Fast switching speed. No storage time effect as in transistors.
- 3 Power MOSFETs are not subjected to forward or reverse bias secondary breakdowns.

Drive circuit for MOSFETs

There are several circuits for turning a power MOSFET ON or OFF. The type of circuit depends on application. As a thumb rule, the higher the gate current at turn-on and turn-off, the lower will be switching losses. A sample drive circuit for a MOSFET is shown in the figure below.

A common method of coupling the drive circuitry is to use a pulse transformer. PTs are used to isolate logic circuitry from MOSFETs operating at high voltages.

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Regulated power supply

Objectives: At the end of this lesson you shall be able to
 • explain the regulated and unregulated power supply.

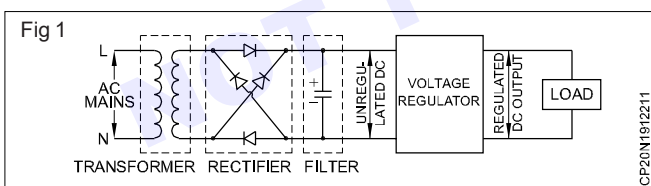
DC regulated power supply : The main purpose of a DC regulated power supply is to get a constant DC supply for electrical and electronic circuits for conducting experiments in laboratories and also to provide testing voltage for equipments like radio, TV, tape recorders, computers etc.

DC unregulated power supply : The most common method of obtaining DC from AC supply is to use a transformer for stepping down/up of the AC voltage and to use a rectifier circuit for converting AC supply into DC. Often capacitors/inductors are used to filter the DC output. In this type of circuits the DC output voltage changes with a change in load and is generally used in a circuit where load current is constant eg. battery charging, electroplating, communication system etc.

Types of regulated power supply : There are two basic ways of deriving a stable DC supply from an AC supply. They are the conventional way and a system using switch mode technique.

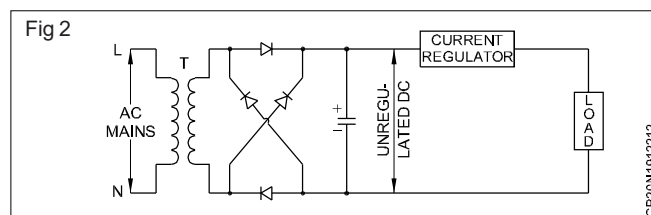
Most of the electronic equipment uses the conventional type of power supply. In this type, voltage and current regulation are used combinely.

Voltage regulated power supply: The voltage regulated power supply consists of a step down transformer, rectifier and a storage capacitor to generate an unregulated DC supply that is electrically isolated from the AC mains supply. Then this DC output voltage which is not regulated is passed through voltage regulator circuitry to get the regulated DC voltage. (Fig 1).



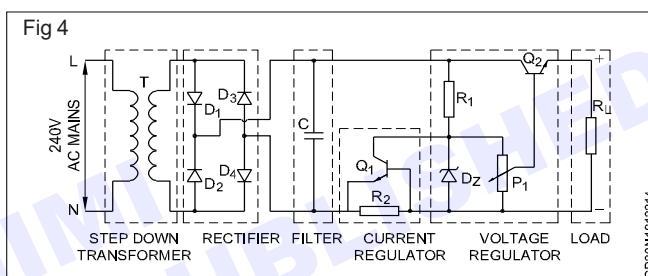
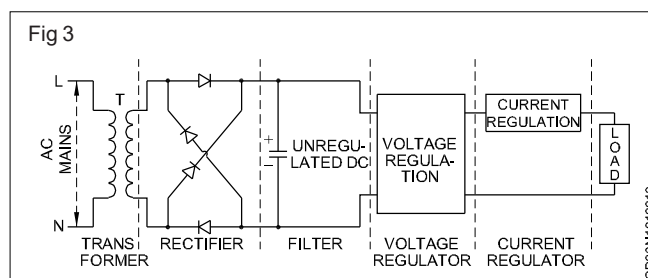
The regulator circuit parameter may consist of zener diodes, transistors or integrated circuits.

Current-regulated power supply : A current regulated power supply consist of an unregulated power supply similar to voltage-regulated power supply and a current limiting circuit. (Fig 2)



By suitably designing the current regulator circuit it is possible to get current regulation for a single range or a multi-range of currents.

Voltage and current regulation combined : Commercially available DC regulated power suppliers provide both voltage and current regulation combined in the supply unit (Figs 3 and Fig 4).



Circuit description : Fig 4 shows a circuit diagram of a simple voltage and current regulated power supply. The functions of circuit elements are as follows. Transformer 'T' is used for stepping down AC voltage to the required AC voltage. Full wave bridge rectifier 'D₁ to D₄' is used to rectify AC to DC voltage. A capacitor 'C' is used for filtering. The voltage across zener diode 'D_z' is used as a reference voltage source which is constant. The potentiometer 'P₁' is used for controlling the DC output voltage. Transistor Q₂ works as a voltage regulator. For a set voltage by potentiometer 'P₁' that is when there is no load, transistor Q₂ conducts less and voltage drop across collector and emitter is maximum. When the load current increases transistor 'Q₂' conducts more and the voltage drop across collector and the emitter decreases almost compensating the drop in unregulated DC output, thereby keeping the regulated output voltage constant. Transistor 'Q₂' also works as a current regulator. The conduction of transistor 'Q₁' depends upon the voltage drop across resistor 'R₂'. In turn the voltage drop across 'R₂' depends upon the resistance value of R₂ and load current ($I_L \times R_2$). When the load current increases the voltage drop across 'R₂' also increases and for a set current transistor 'Q₁' conducts resulting the base of transistor 'Q₂' to almost at negative potential reducing the output voltage. The ultimate result is the current will not increase above the set value of current but the voltage goes on decreasing for any reduction of load resistance "R_L".

Terms used in specifying regulated power supplies

The regulation requirement of a regulated power supply is often associated with its application. Hence the following terms are considered while selecting a regulated power supply.

Line regulation (Source regulation) : The line regulation is also called a source regulation specifying the change in DC output voltage due to the variation in the line voltage.

$$\% \text{ Source regulation} = \frac{\% \text{ of variation of DC output voltage for a given constant load}}{\% \text{ of variation of AC input line voltage}} \times 100$$

Load regulation : The load regulation is also called load effect which is defined as the change in the regulated output voltage when the load current changes from minimum to maximum.

Load regulation = No load voltage E_{NL} – Full load voltage E_{FL}

$$\text{Load regulation} = E_{NL} - E_{FL}$$

Load regulation is often expressed as a percentage by dividing the change in the load voltage by the no load voltage.

$$\% \text{ Load regulation} = \frac{E_{NL} - E_{FL}}{E_{NL}} \times 100$$

Ripple : The term ripple implies that the residue of AC delivered to the load as a result of imperfect rectification and filtering.

The ripple may be mentioned as AC voltage available for a given or nominal DC output voltage. In general the 'Ripple factor' is defined as the percentage ratio of the AC voltage available in the DC output.

$$\% \text{ Ripple factor} = \frac{\text{AC voltage available in DC output}}{\text{Normal DC voltage at the output}} \times 100$$

The size of the power supply unit depends upon the maximum DC output power required i.e. DC voltage and DC amperes. The circuit of the regulated power supply becomes more and more sophisticated depending upon the high precision in regulation and a number of protection circuits incorporated in the equipment. The circuit may use a number of ICs transistors, controls and other components depending on the accuracy required.

It is important to note that, different manufacturers of 78XX/79XX series such as Fair Child ($\mu A/\mu pc$), Motorola, Signetics (SS) adopt slightly different coding schemes to indicate the rated maximum current of the three pin regulated ICs. One such scheme is given below.

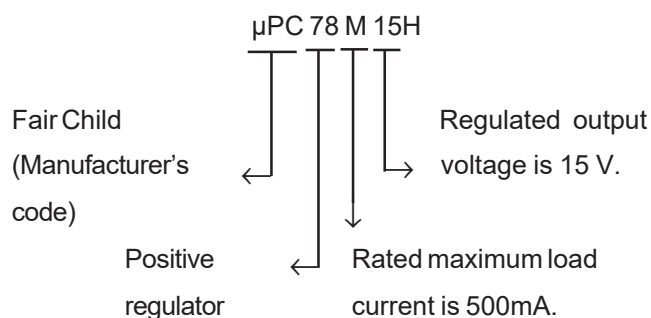
78LXX - L indicates rated maximum load current as 100mA.

78MXX- M indicates rated maximum load current as 500mA

78XX - Absence of an alphabet between 78 and XX indicates that the rated maximum load current is 1A.

78SXX - S indicates rated maximum load current is 2 amps.

Example:



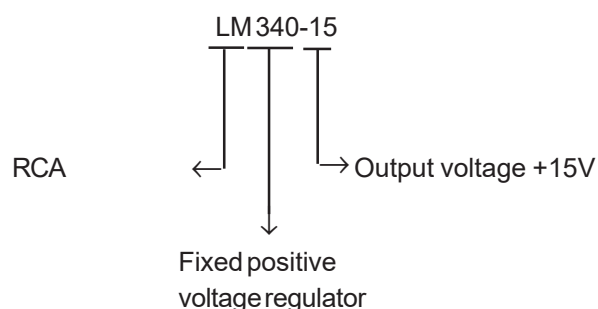
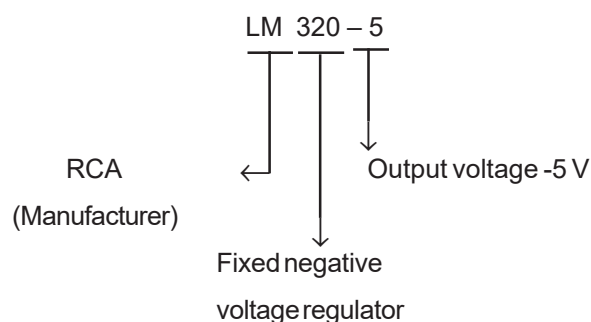
LM 3XX series of 3 terminal voltage regulators

In LM series of three terminal regulators, to find the specifications, it is suggested to refer to its data manual. However, the following tips will help in identifying whether the IC is a fixed positive or fixed negative regulator.

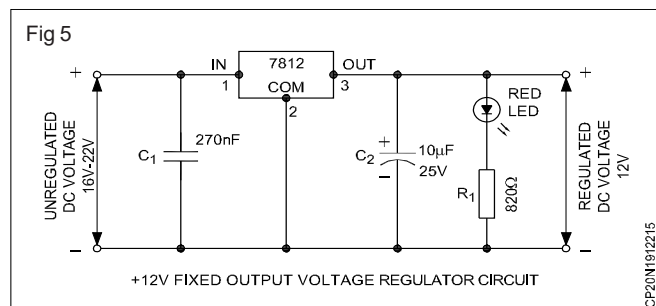
LM320-X and LM320-XX Fixed -ve voltage regulators.

LM340-X or LM340-XX Fixed +ve voltage regulators.

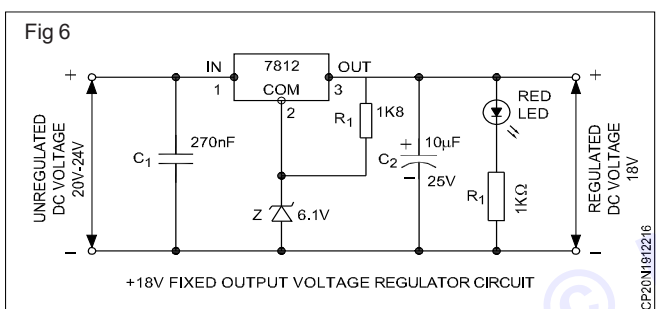
Examples:



Practical 78XX and 79XX voltage regulator circuits: Fig 5 shows the circuit connections of a 12 V, 1 A regulated power supply using 7812.

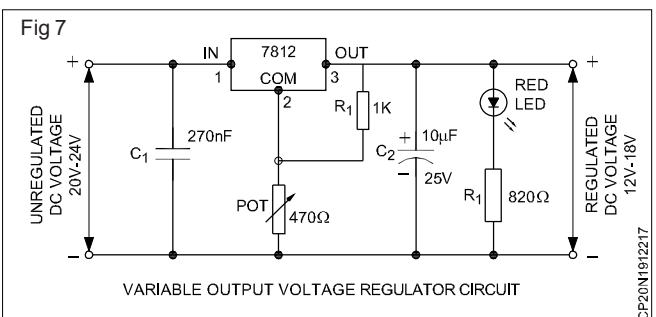


The output voltage of a 3-terminal regulator IC is with reference to the IC's common terminal (COM). When the COM terminal is grounded, the output voltage of the regulator will be the specified output voltage of the IC as shown in Fig 3. But the output voltage of the IC can be increased above the specified value by raising the voltage at the COM terminal as shown in Fig 4. Because of 6.1V zener, the output voltage will be $6.1V + 12V = 18.1V$ or approximately 18V as shown in Fig 6.



When the COM terminal of the IC is grounded as shown in Fig 3, the quiescent current flowing from the COM terminal to ground in 78 series is around $8\mu A$. This current decreases as the load current increases. When a zener is connected at COM terminal as shown in Fig 4, to ensure that the zener is always in the reverse ON condition, resistor R_1 is used. If $R_1 = 1.8K$, I_Z will be 7mA which is sufficient to keep the zener ON always.

Fig 7 shows a variable output voltage regulator using a fixed voltage regulator. The variable reference voltage at COM terminal is obtained using a POT.



Since the quiescent current through the pot is very low (around $8\mu A$) and it decreases with load resistor R_1 is used to compensate the changes in the quiescent current due to loading. Therefore, the bias voltage is determined by the sum of the quiescent current I_Q and the bias current set by R_1 . In Fig 7, when the resistance of the POT is set to 0,

COM is grounded and hence output will be 12V. As the set value of pot increases the output voltage also increases.

Fig 8 shows a negative voltage regulator using 7912. The working of this circuit is similar to that of Fig 9 except that it is a negative voltage regulator and hence the voltage at pin no.3 of the IC will be -12volts.

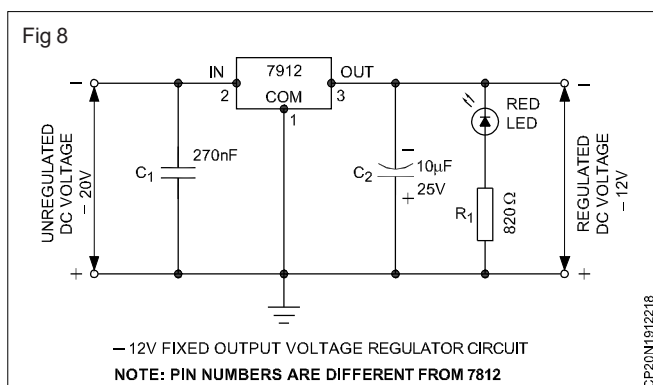
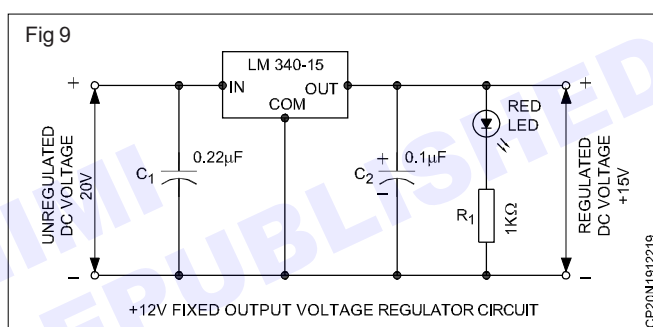


Fig 9 shows a +15 volts regulator using LM340. This circuit connection is very much similar to that of the 78XX series regulator.



Multiple voltage using three-terminal fixed voltage regulator

Fig 10 shows how a three-terminal IC can be used to obtain multiple voltages. Such economical and elegant circuits are very useful for electronic circuits and for service technicians.

Recall, than the value input unregulated DC to a regulator should always be less than twice the output of the regulator. As shown in the third regulator (7805) of Fig 10, when it is necessary to operate with a large input voltage, a series resistance R_s can be added in series to drop required voltage.

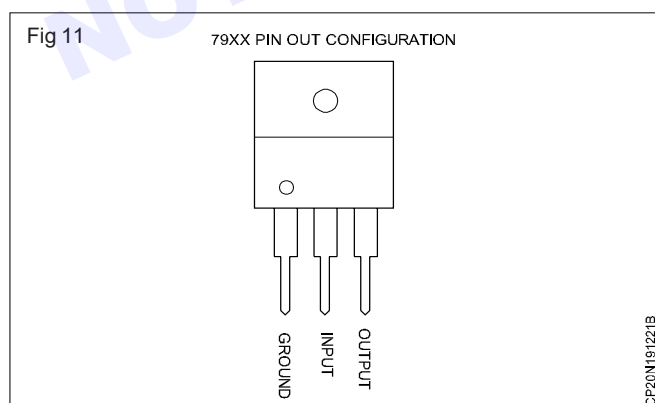
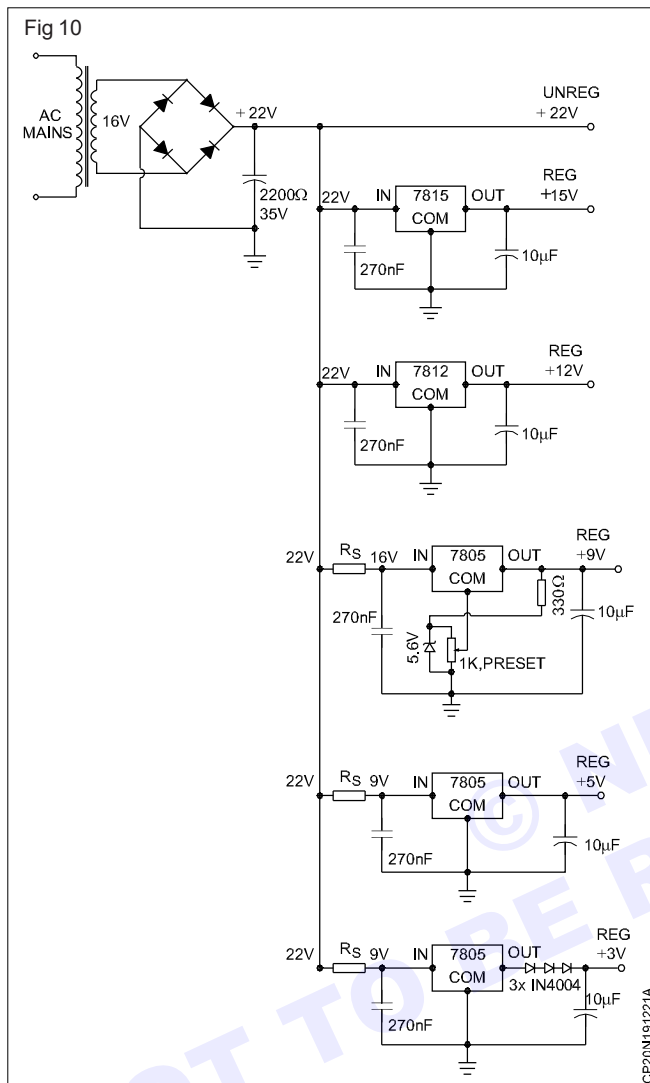
The scheme shown in Fig 10 is one of the several schemes that can be adopted to get multiple voltage output.

IC 79XX voltage regulator

79XX voltage regulators are very commonly used in electronic circuits. The main purpose of this IC is to supply required regulated negative voltage to the circuits. IC 79XX can supply a constant negative voltage output. In spite of any voltage fluctuations in its input voltage. It can be mainly found in the circuits in which integrated circuits that require $+V_{CC}$ and $-V_{CC}$ are used.

IC79xx is a three pin negative voltage controller IC as shown in Fig 11. It is a small integrated circuit used in a circuit to supply a constant negative input voltage. The number 79 indicates that it is a negative voltage regulator and xx

indicates the output voltage of the IC. 'xx' can be replaced by the controlled output voltage provided by the regulator, for example, if it is 7905, then the output voltage of the IC is -5 V. Similarly if it is 7912, then output voltage of the IC is -12 volts and so on. The name of the IC may vary based on the manufacturer as LM79xx, L79xx, MC79xx etc.



Heat sink

IC 79xx requires heat sink for its safe operation. Heat sink boosts heat dissipation therefore the life of the device can be extended

79xx ICs and output voltages

IC Number	Output Voltage
7905	-05 Volts
7912	-12 Volts
7915	-15 Volts
7918	-18 Volts

The pin 1 acts as the ground terminal (0V). The pin 2 acts as the input terminal (5V to 24 V). The pin 3 acts as the output terminal (constant regulated 5V).

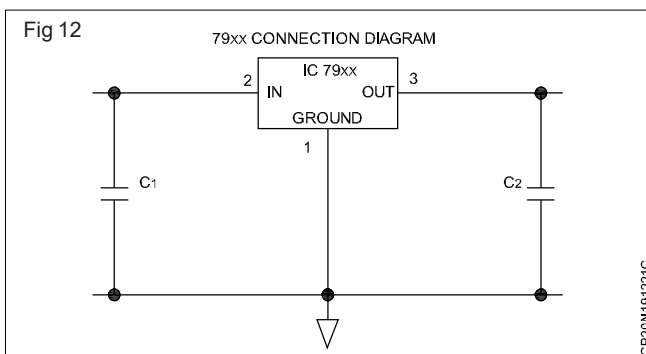
Pin out configuration of IC 79xx.

The pin out configuration of IC 79xx is shown in the diagram below

- The pin 1 acts as the ground terminal (0V).
- The pin 2 acts as the input terminal (5V to 24V)
- The pin 3 acts as the output terminal (constant regulated 5V)

Connection diagram

IC 78xx is used in circuit as shown in the Fig 12. In order to improve stability two capacitors C_1 and C_2 are used. The capacitor C_1 is used only if the regulator is separated from filter capacitor by more than 3". It must be a 2.2μF solid tantalum capacitor or 25μF aluminium electrolytic capacitor. The capacitor C_2 is required for stability. Usually 1μF solid tantalum capacitor is used. One can also use 25μF aluminium electrolytic capacitor. Values given may be increased without limit.



IC 78xx

Similar to IC 79xx, IC 78xx is a three pin IC that gives a constant output voltage of +5V irrespective of the varying input voltages. The maximum value of input voltage that the IC can withstand is 24 volts.

Uninterruptible Power Supply

Objectives : At the end of this lesson you shall be able to

- state the need of UPS
- differentiate inverter and UPS
- explain the block diagram of UPS.

Uninterruptible Power Supply (UPS)

An uninterruptible power supply (UPS) is a device that allows a computer to keep running for at least a short time when the primary power source is lost. It also provides protection from power surges.

Need of UPS

An Uninterruptible Power Supply (UPS) is used to protect critical loads from mains supply problems, including spikes, voltage drops, fluctuations and complete power failures using a dedicated battery.

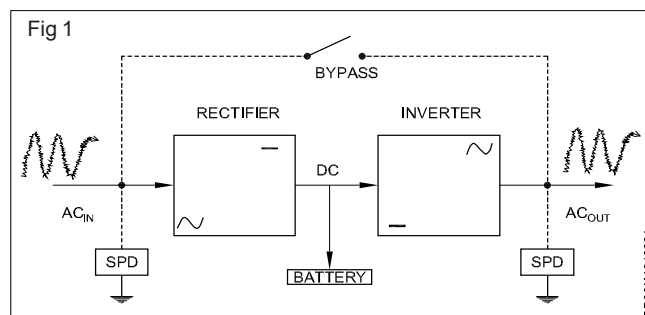
A surge protector (or surge suppressor or surge diverter) is an appliance or device designed to protect electrical devices from voltage spikes. A surge protector attempts to limit the voltage supplied to an electric device by either blocking or shorting to ground any unwanted voltages above a safe threshold.

Difference between Inverter and UPS (TABLE 1)

The differences between inverter and UPS under certain important parameters are given in TABLE 1 below.

Block diagram of UPS

The simplified block diagram of UPS is shown in Fig 1.



In UPS, the AC from the mains power is transformed to DC. This DC is continuously charging the battery. The DC output from the battery is fed to inverter that converts it into AC output and supplies to the equipment.

Rectifier

A rectifier is an electrical device that converts alternating current (AC), which periodically reverses direction, to direct current (DC), which flows in only one direction. The process is known as rectification.

Battery

Battery is a device consisting of one or more electrochemical cells with external connections provided, to power electrical devices.

Table 1

Difference between Inverter and UPS

Sl. No.	Parameters	Inverter	UPS
1	Back-up time	In inverter, the back up time is not rapid. So the computers may break down or data loss.	In UPS, the back up time of power supply is rapid. It will not make any computer crash or loss of data.
2	Technical variation	The power is consistently drawn from battery.	The AC is changed into DC. This DC helps to charge the battery.
3	Time delay	500 ms	3 to 8 ms
4	Connection	The inverter connected to main power supply for providing electricity to different applications such as fan, lights, etc.	UPS directly connected to different application such as computer, printers, etc.
5	Price	Low	High

Inverter

Inverter is an electronic circuit that converts low voltage DC into high voltage AC power. In solar-electric systems, an inverter may take the 12, 24, or 48 volts DC and convert to 230 volts AC, conventional household power.

The main power AC is supplied to the inverter, and it is transformed into DC simultaneously, which keeps charging the battery continuously. There is a sensor and relay structure that always monitors the ON or OFF status of the main supply.

As soon as there is a power failure, the relay actuator activates the inverter switch. Every other action is similar to the UPS, but because of the sensor and relay process, there is a delay while activating the switch.

Static transfer switch

Static transfer switches (STS) are such electrical devices which are used for very fast switching between electrical

power sources. It is used in UPS immediately switch main power supply, to its stored backup power.

They perform instantaneous switching operations and thus supply immediate power to the load.

Types of UPS

Objectives : At the end of this lesson you shall be able to

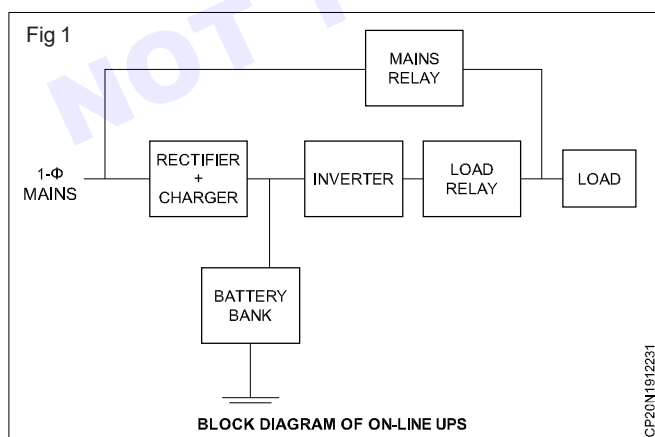
- list different types of UPS
- compare ON-line, OFF-line and line interactive types of UPS
- state specification of UPS, power factor, calculating battery back-up
- explain types of indications and protection.

Different types of UPS

- 1 ON line UPS
- 2 OFF line UPS
- 3 Line interactive UPS

ON line UPS

ON line UPS are also known as double conversion UPS or True ON Line UPS. There are two stages in its operation. In the first stage the mains AC is rectified to DC. There is a DC bus. DC bus can get power from both the DC battery and DC obtained by rectifying the mains AC. In the second stage DC power available from DC bus is converted to AC by the inverter and this AC is connected to the output. In normal operation output comes from mains AC via rectifier and inverter. When mains AC fail, output comes from DC battery via inverter. The changeover is instantaneous. There is no power transfer switch and hence no time delay. When mains AC is available normal operation continues and the rectifier recharges the battery. A bypass switch connects mains AC directly to the output in case there is some problem with the UPS. (Fig 1)



Metal Oxide Semiconductor Field Effect Transistor (MOSFET) power transistors, Insulated Gate Bipolar Transistor (IGBT) devices, microprocessor ICs, Operational amplifier ICs, adjustable voltage regulator ICs, Oscillator and pulse width modulator ICs, GATE ICs, timer etc. are some the important components found in on line UPS.

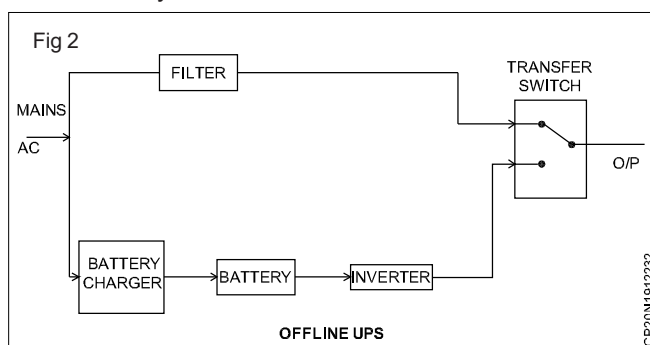
On line UPS offer the best power protection against all types of disturbances. The output voltage of an On Line

UPS is highly stabilized with typical value of tolerance of 1 percent i.e. the output voltage is between 227 and 233 volt and frequency is between 49.95 Hz and 50.05 Hz. The output waveform is purely sinusoidal. A typical modern on line UPS is equipped with protections against short circuit, over-voltage and under-voltage etc, MCB for input, output and battery, and has digital LCD display with facility for displaying input and output voltage and frequency, battery status, output power delivered and error codes and messages.

On line UPS models generally have capacity more than 5kVA. High capacity On Line UPS can be built for all possible requirements and battery backup time can be increased to suit particular need by adding batteries. Sophisticated on Line UPS are available with many advanced features and are highly reliable but are costlier.

OFF line UPS

An OFF line UPS is shown in Fig 2. It is also known as stand by UPS or Backup UPS and supplies emergency power when mains AC fail. The capacity of an off line UPS is generally below 1kVA. A very common application is with PC. In the event of sudden load shedding the off line UPS supplies emergency power to the PC so that work can be continued till normal power is restored or the PC can be safely switched off.



In normal mode mains AC is directly connected to the output through a filter unit. The filter unit filters noise present in the mains AC. When mains AC fails the inverter converts DC power of battery to AC and transfer switch connects this AC to the output. This changeover happens very quickly but is not instantaneous and a time delay of few milliseconds is involved. This time delay normally does not affect ordinary load. Again when mains AC

comes, the transfer switch connects mains AC to output. Thus the transfer switch keeps on changing connection of output to between mains AC and AC output of inverter. When mains AC is available, the charger unit recharges the battery. An offline UPS does not have provision for stabilizing the mains AC. Under voltage and over voltage of mains AC activates the power transfer switch and connects AC obtained from inverter to the output. Thus in case of off line UPS under voltage and over voltage of mains AC has similar impact as absence of mains AC.

Line interactive UPS

In a line interactive UPS mains AC is connected to the output through a filter and voltage regulating unit. The voltage regulator usually is an auto transformer with number of tapping and stabilizes the mains input by bucking or boosting as per requirement. A single unit called Inverter converter unit performs the functions of battery charger and inverter. When mains AC is available inverter converter unit charges the battery. When mains AC fails it inverts DC to AC and supplies power to load. The transition is not instantaneous and time delay of few milliseconds is involved. Compared to Off line UPS, line interactive UPS performs better as the mains AC is regulated. Line interactive UPS are generally available with capacity between 750VA and 5KVA and are commonly used for computer network with small group of computers.

Comparison between OFF-line, ON-line and LINE-interactive UPS

OFF-Line UPS

OFF-line UPS passes the input AC to the output sockets if the AC power is available. It always monitor the voltage level in the mains, and if there is a voltage drop or mains failure, it switches ON the inverter to give AC power to the device until the mains supply returns to normal. The switch over time from AC to inverter AC is less than five milli seconds so that the functioning of the equipment is not affected.

ON-Line UPS

ON-Line UPS uses an inverter which always ON to give sine wave AC to the output socket. The incoming AC is first converted into DC to charge the battery as well as to give power to the inverter. The inverter converts the DC to AC continuously to power the load. If power fails, the battery backup circuit switches ON and takes the load. Online UPS is more efficient than the Offline UPS and uses a "constant duty inverter". It also has a "static bypass" system that transfers the load to the AC power if the inverter system fails. The advantage of the online UPS is that, it clean up the AC waveform by converting it into DC then reconverting this DC to fresh AC. ON-Line UPS regulate voltage within $\pm 2-3\%$.

Specification of UPS

Sl. No.	Parameter	Details
1	Type of UPS	TRUE ONLINE
2	Capacity	2 KVA/5 kVA
3	Technology	The UPS shall be based on IGBT, and microprocessor controlled for providing better sine wave output.
4	AC input voltage range	175V to 275 V AC, single phase
5	Input frequency	47-53 Hz, (Suitable for working with generator supply)
6	UPS power factor	0.9 or better
7	AC output voltage	230V AC, Single phase
8	Output frequency	50 Hz
9	Waveform	Sinusoidal
10	Efficiency	90% (at rated output voltage and frequency)
11	Total harmonics distortion	2% maximum
12	Indications	Standard visual indications for proper function of UPS.
13	Protections	Over & Under voltage cut-off, overload, and short
14	Back up time	2kVA = 8 hour at 400 watt load, 5kVA = 8 hr at 1000W load
15	Type of batteries	Sealed maintenance free (SMF) Lead Acid Battery
16	Remote monitoring	SNMP based monitoring

Line-interactive UPS

Line-interactive UPS system use automatic voltage regulation (AVR) to correct abnormal voltages without switching to battery. The UPS detects when voltage crosses a preset low or high threshold value and uses transformers to boost or lower the voltage by a set amount to return it to the acceptable range. Line-interactive UPS system typically regulate output within $\pm 8\text{-}15\%$ of the nominal voltage.

Power factor

Power factor is a quantity which has important implications when sizing a UPS system and power distribution equipment. Power is a measure of the delivery rate of energy and in DC (direct current). Electrical circuits is expressed as the mathematical product of Volts and Amps (Power = Volts x Amps). However, in AC (alternating current) power system, a complication is introduced; namely that some AC current (Amps) may flow into and back out of the load without delivering energy. This current, called reactive or harmonic current, gives rise to an "apparent" power (Volt x Amps) which is larger than the actual power consumed. This difference between the apparent power and the actual power gives rise to the power factor. The power factor is equal to the ratio of the actual power to the apparent power. The apparent power is expressed as the Volt-Amp or VA rating. Therefore, the actual power in any AC system is the VA rating multiplied by the power factor.

"Watts = volts x amps x power factor". Unfortunately, the PF is rarely stated for most equipment, but it is always a number of 1.0 or less.

A double-conversion UPS gives voltage distortion problem created by the UPS. The input of a double-conversion UPS is essentially a big rectifier. The current drawn by the UPS is non-sinusoidal. This can cause the voltage from the AC mains also to become non-sinusoidal. The voltage distortion can cause problems in all electrical equipment connected to that power source, including the UPS itself. It will also cause more power to be lost in the wiring supplying power to the UPS due to the spikes in current flow. This level of "noise" is measured as a percentage of "total harmonic distortion of the current" (THDI). Classic UPS rectifiers have a THDI level of around 25%-30%.

There are several solutions to reduce the THDI in a double-conversion UPS:

Passive power-factor correction

Classic solutions such as passive filters reduce THDI to 5%-10% at full load. They are reliable, but big and only work at full load.

Active power-factor correction

An alternative solution is an active filter. Through the use of such a device, THDI can drop to 5% over the full power range. The newest technology in double-conversion UPS units is a rectifier that does not use classic rectifier components (thyristors and diodes) but uses high-frequency components instead. A double-conversion UPS with an

insulated-gate bipolar transistor rectifier and inductor can have a THDI as small as 2%.

Uninterruptible power supply (UPS) systems are rated in kilowatts (kW) and others in kilo-volt-amperes (kVA).

1 kW and kVA simply mean 1,000 watts or 1,000 volt-amperes - the "kilo" prefix being used for larger numbers.

For large UPS systems have been designed based on a PF of 0.8, which means that a 100 kVA UPS will only support 80 kW of "real" power load. Most UPS systems has power factors of 0.95 - 0.98.

Neither the kW nor the kVA capacity of the UPS can be exceeded, but because of the higher PF numbers, it is usually the kW rating. There are some UPS systems on the market that are PF-corrected so that the kW and kVA ratings are the same.

Calculating UPS/Inverter battery backup

Before calculating the Battery Backup, let us know a few factors that vary battery backup.

For UPS with 875VA we can use a maximum load of 640 watts.

677VA we can use a maximum load of 540 watts.

The main thing is that what ever may be the UPS wattage the battery backup will not vary. The battery backup will only vary depending on the battery Ah and the Usage Load.

To calculate UPS backup, We have a simple formula.

UPS Backup = Battery AH x (Volts/Load) x (1/Powerfactor)

Example : Let us calculate the backup for a system UPS

Load is the usage power, suppose we are running a PC then the load is around 300 watts.

Power factor varies for device to device, the average power factor is 1.4

Voltage is the voltage of the battery.

For a single battery the voltate is 12v.

If the batteries are connected in a series Voltage = 12 x no. of batteries.

Battery AH is the battery ampere used for the ups, system UPS battery AH is 7.

$$\begin{aligned}\text{Then battery backup} &= 7 \times (12/300) \times (1/1.4) \\ &= 7 \times (0.04) \times (0.7) \\ &= 0.19 \text{ hours} \\ &= 19 \text{ Minutes}\end{aligned}$$

Battery rating calculation

The formula for battery rating calculation is as below :

Formula employed

$$\text{Capacity of Battery(AH)} = \frac{\text{DC current} \times \text{Duration in Hrs.}}{\% \text{age capacity utilization}}$$

Where, DC Current =

$$\frac{\text{UPS(KVA)} \times 1000 \times \text{Load power factor(PF=1)}}{\text{Inverter efficiency} \times \text{End voltage}}$$

Hence , VAH = AH x Nominal Voltage

For example : for 3 KVA UPS , 1 hour Backup :

$$\text{DC current} = \frac{3 \times 1000 \times 1}{0.93 \times 10.5 \times 18} = 17.0\text{A}$$

$$\text{Battery "AH"} = \frac{17.0 \times 1.0}{0.62} = 27.4\text{AH}$$

Hence, 18 nos of 12V/28AH batteries are required.

Total VAH = 18 x 12 x 28 = 6048 VAH

The following assumptions have been made in the above calculations:-

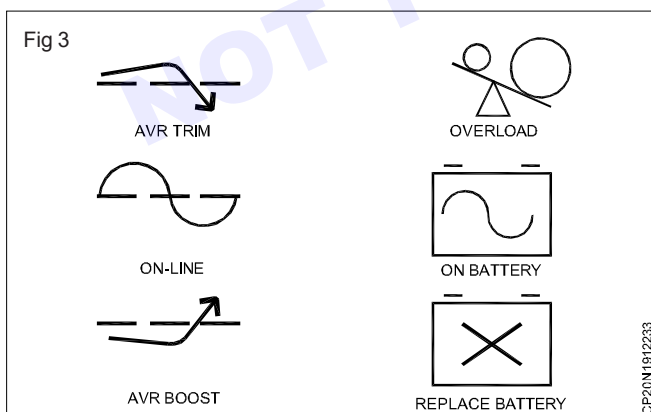
- 1 DC voltage – 216 for 3 KVA
- 2 End cell voltage / battery of 10.5 V
- 3 Load Power Factor = 1.0
- 4 Inverter efficiency = 93%

% Capacity utilization is :

Duration	% Capacity utilization
½ hr (30 mins)	52%
1 hrs	62%
2 hrs	74%
3 hrs	83%
4 hr	85%

Types of indications and protections

Front panel Indicators (Fig 3)



On-Line

The online LED illuminates when the UPS is supplying utility power to the connected equipment. If the LED is not lit, the UPS is either not turned ON, or is supplying battery power.

AVR Trim

This LED illuminates to indicate the UPS is compensating for a high utility voltage. While the UPS can run in this

mode indefinitely without any negative impact on the UPS, the circuit should be checked by a qualified electrician if the utility voltage is consistently high.

AVR boost

This LED illuminates to indicate the UPS is compensating for a low utility voltage. While the UPS can run in this mode indefinitely without any negative impact on the UPS, the circuit should be checked by a qualified electrician if the utility voltage is consistently low.

ON battery

This LED illuminates to indicate the UPS is supplying battery power to the connected equipment.

Overload

This LED illuminates to indicate the equipment plugged into the UPS exceeds the total capacity of the UPS. Some of the equipment (the load) on the UPS should be removed or turned off.

Replace battery

This LED will illuminate when the battery in the UPS has failed.

Some standard UPS incorporates both audio and visual warnings for the user to understand that the power is being consumed from the battery and not from the AC mains.

Visual warning

There are UPS that have ONE LED, TWO LED's and THREE LED's.

1 For UPS with a single LED

The LED glows a green color, indicating the system is working on the main power line. When the power fails, the LED turns either amber or a red with blinking at an interval of thirty seconds indicating that the UPS is working with back up power; power being supplied from the battery that is in the UPS. After for a particular duration of time and if by then the power is not restored by switching on a generator / alternator, the light turns a bright red along with continuous blinking indicating that it has critical two minutes left for the power of the battery to drain out and crash abruptly.

2 For UPS with Two LEDs

If the UPS is having two lights then the green is a solo type indicating mains and the other only one green light is visible. If the green LED is "ON" and the other LED is off indicating main power line consumption. When the main power fails, the other LED either a red or amber turns ON indicating the power is OFF after last two minutes. This is accompanied by continuous blinking of the LED indicator.

3 For UPS that have Three LEDs

The green indicates UPS working from main lines, the amber indicates the UPS working from battery back up and the red LED indicates UPS working from critical backup. As mentioned in the UPS with two LED's the blinking of the UPS is the same here too. For back up it is blinking at the rate of thirty seconds per blink and for

critical power it is blinking at the rate of almost one second per blink.

Audio warning

Almost all UPS have an audio warning incorporated into the circuit. The audio warning is a beep sound produced by a piezo buzzer circuit. During critical back up power being consumed the beep is continuous with a frequency that is equal to the blink rate. The audio warning gives an indication to shut down UPS after saving data.

Conditioning and Protection

Sag

A reduction of the AC voltage, at the power frequency, that lasts from a half cycle to a few seconds.

Spike

This is a transient electrical impulse with a duration much less than 1/2 cycle.

Surge / Overvoltage

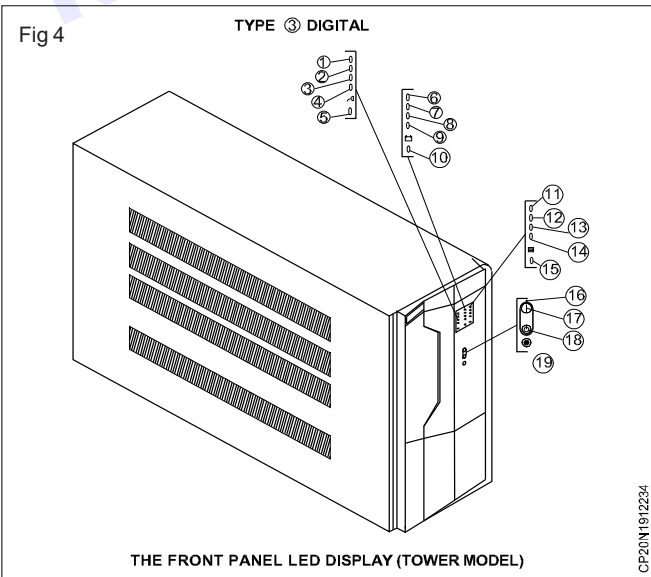
A voltage that exceeds specified limits either for a short time (seconds) or longer periods.

These types of disturbances can occur several times per day throughout most of the country. When a UPS is in a normal mode (not on battery power) these disruptions will not generally cause the UPS to switch to battery mode. Some UPS manufacturers have adjustable threshold settings that can activate the back up at various levels of interference. To avoid excessive switchovers, a conditioning and protection sub-system should be used in the normal mode.

		Symbol
①—④	AC input level	Power cord
⑤	Site wiring fault indicator	
⑥—⑨	Battery charge level	Battery
⑩	Battery service indicator	
⑪—⑭	Load level	Load devices
⑮	Communications	
⑯	ON LED	
⑰	ON button	⓪
⑱	STANDBY button	Ⓢ
⑲	TEST/ALARM RESET button	Ⓡ

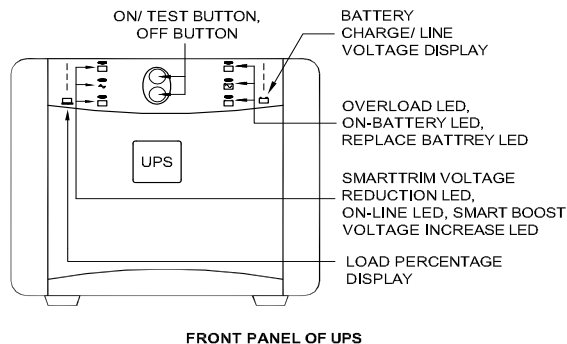
Indicators on UPS (Fig 4 - 7)

Type 1 : The front panel LED Display (Digital)



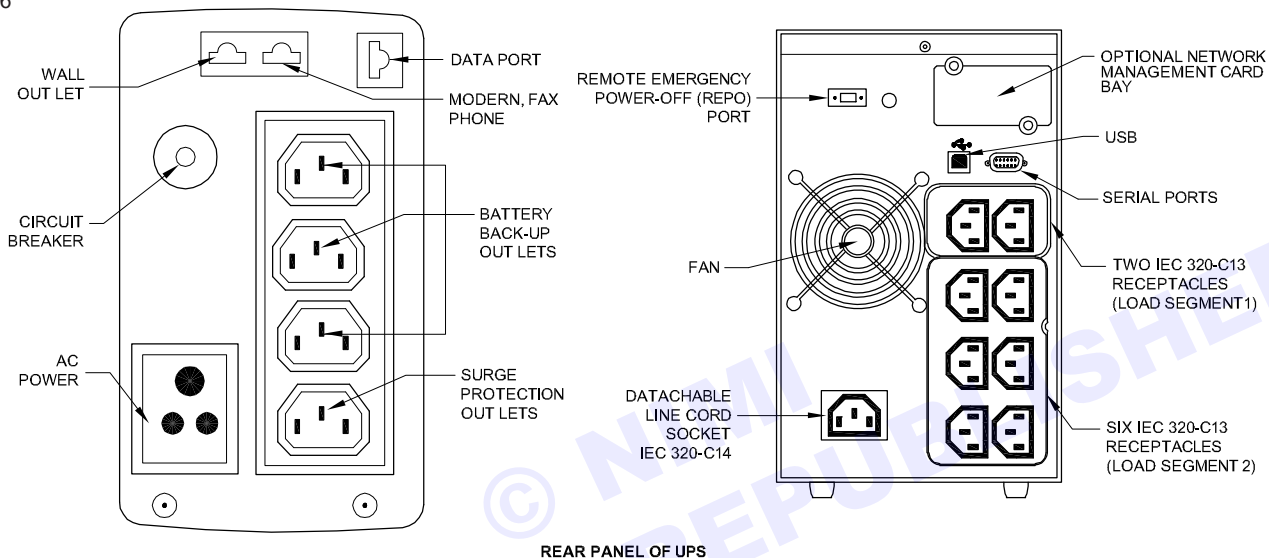
Type 2 :

Fig 5



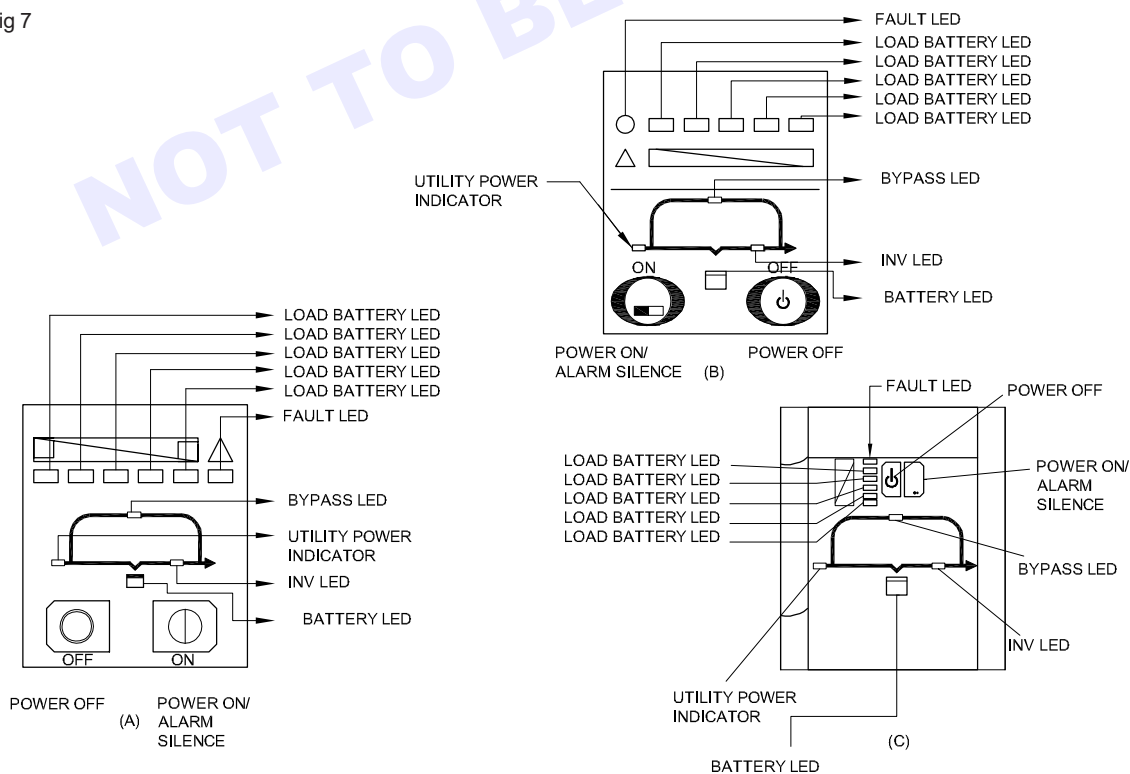
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Fig 6



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Fig 7



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Need for modulation & types of modulation

Objectives : At the end of this lesson you shall be able to

- explain the need for modulation
- explain various types modulation & demodulation techniques.

Need for modulation

The velocity of electromagnetic waves is $3 \times 10^8 \text{ ms}^{-1}$. On the other hand, the velocity of sound waves cannot be used to transmit intelligence to far off place. Only electromagnetic waves can be made to do this.

Modulation is extremely necessary in communication systems due to the following reasons.

Sub topics

- 1 Practical antenna length (L)
- 2 Wireless communication
- 3 Operating range

Practical antenna length (L)

When free space is the communication channel, antennas operate effective only when their dimensions are of the order of the magnitude of wave length of the signal being transmitted.

$$\text{Now, } L = \lambda = \frac{u}{v} = \frac{3 \times 10^8}{v} \text{ Hz}$$

λ = Wave length

u = Velocity of electro magnetic wave

v = Frequency to be radiated in Hz

The audio frequencies range from 20 Hz to 20 kHz. Suppose a frequency of 20 kHz is to be radiated directly into space. For this,

$$\text{Length of antenna} = \frac{3 \times 10^8}{20 \times 10^3} \text{ m} = 15000 \text{ m} = 15 \text{ km}$$

this is too long antenna to be constructed practically. So, it is impracticable to radiate audio signal directly into space.

Let us now calculate the length of the antenna if a carrier wave of say, 1000 kHz is used to carry the signal.

$$\text{Length of antenna} = \frac{3 \times 10^8}{10^6} \text{ m} = 300 \text{ m}$$

An antenna of 300 m length can be easily construct.

Wireless communication

One desirable feature of radio transmission is that it should be carried without wires (i.e) radiated into space. At audio frequencies, radiation is not practicable because the efficiency of radiation is poor. However, efficient radiation of electrical energy is possible at high frequencies (>20kHz). For this reason, modulation is always done in communication systems.

Operating range

The energy of a wave depends upon its frequency. The greater the frequency of the wave, the greater is the energy possessed by it. As the audio signal frequencies are small, these cannot be transmitted over large distance if radiated directly into space. The only practical solution is to modulate a high frequency carrier wave with audio signal and permit the transmission to occur at this high frequency (carrier frequency).

What is modulation?

The best way to define modulation is

The process of impressing low -frequency information to be transmitted on to a high -frequency wave, called the carrier wave, by changing the characteristics of either its amplitude, frequency, or phase angle is called modulation.

Another definition for modulation is.

The process of altering the characteristics of the amplitude, frequency, or phase and of the high - frequency signal in accordance with the instantaneous value of the modulating wave is called modulation.

Types of modulation

The sinusoidal carrier wave can be given by the equation.

$$V_c = V_c \sin (Wc t + \theta) = V_c \sin 2\pi f_c t + \theta$$

V_c = Maximum value

f_c = Frequency

θ = Phase relation

Wc = Angular velocity

t = time

Since the three variables are the amplitude, frequency, and phase angle, the modulation can be done by varying any one of them. Thus there are three modulation types namely.

- Amplitude modulation (AM)
- Frequency modulation (FM)
- Phase modulation (PM)

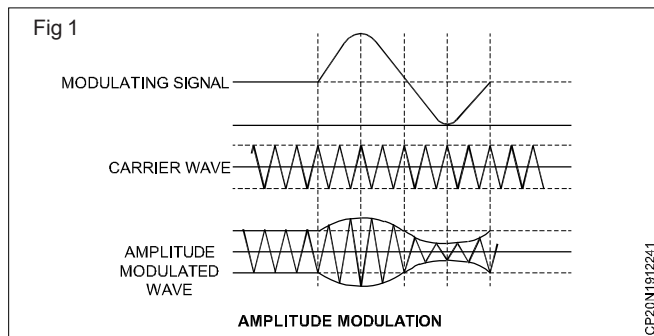
In India, radio broadcasting is done through amplitude modulation. Television broadcasting is done with amplitude modulation for video signals and frequency modulation for audio signals.

Amplitude modulation (AM)

Definition

The method of varying amplitude of a high frequency carrier wave in accordance with the information to be transmitted, keeping the frequency and phase of the carrier wave unchanged is called amplitude modulation. The information considered as the modulating signal and it is

super imposed on the carrier wave by applying both of them to the modulator. The detailed diagram showing the amplitude modulation process is given below. (Fig.1)



As shown above, the carrier wave has positive and negative half cycles. Both these cycles are varied according to the information to be sent. The carrier then consists of sine waves whose amplitudes follow the amplitude variations of the modulating wave. The carrier is kept in an envelope formed by the modulating wave. From the figure, you can also see that the amplitude variation of the high frequency carrier is at the signal frequency and the frequency of the carrier wave is the same as the frequency of the resulting wave.

Analysis of amplitude modulation carrier wave

$$\text{Let } v_c = V_c \sin \omega_c t$$

$$V_m = v_m \sin \omega_m t$$

V_c - Instantaneous value of the carrier

V_c - Peak value of the carrier

ω_c - Angular velocity of the carrier

v_m - Instantaneous value of the modulating signal

V_m - Maximum value of the modulating signal

ω_m - Angular velocity of the modulating signal

f_m - Modulating signal frequency

It must be noted that the phase angle remains constant in this process. Thus it can be ignored. The amplitude of the carrier wave varies at f_m .

The amplitude modulated wave is given by the equation.

$$A = v_c + v_m = v_c + v_m \sin \omega_m t = v_c [1 + (v_m/V_c) \sin \omega_m t]$$

m - Modulation index. The ratio of v_m/V_c

Instantaneous value of amplitude modulated wave is given by the equation.

$$v = A \sin \omega_c t = v_c (1 + m \sin \omega_m t) \sin \omega_c t$$

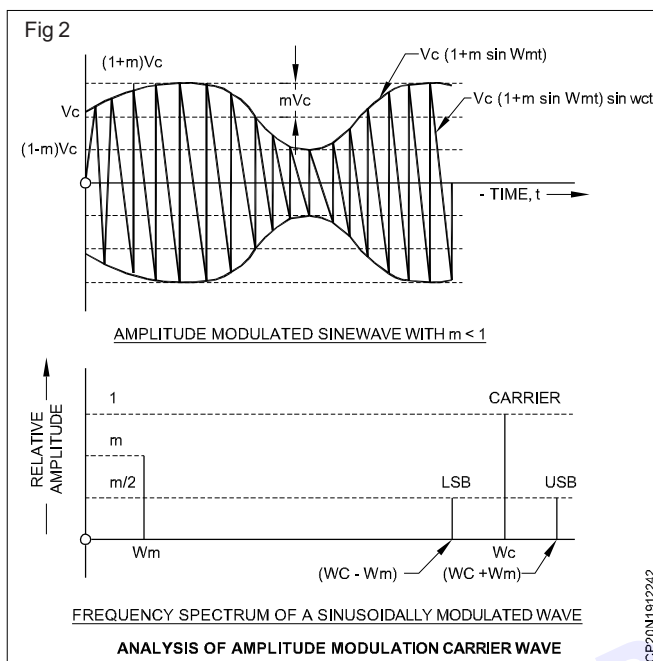
$$= v_c \sin \omega_c t + m v_c (\sin \omega_m t \sin \omega_c t)$$

$$v = V_c \sin \omega_c t + [m V_c / 2 \cos (\omega_c - \omega_m) t - m V_c / 2 \cos (\omega_c + \omega_m) t]$$

The above equation represents the sum of three sin waves. One with amplitude of V_c and a frequency of $(\omega_c - \omega_m)/2$ and the third one with an amplitude of $m V_c / 2$ and a frequency of $(\omega_c + \omega_m)/2$.

In practice the angular velocity of the carrier is known to be greater than the angular velocity of the modulating signal

($\omega_c \gg \omega_m$). Thus, the second and third cosine equations are more close to the carrier frequency. The equation is represented graphically as shown below. (Fig.2)



Amplitude modulation frequency spectrum

Frequency spectrum of AM wave

Lower side frequency - $(\omega_c - \omega_m)/2$

Upper side frequency - $(\omega_c + \omega_m)/2$

The frequency components present in the AM wave are represented by vertical lines approximately located along the frequency axis. The height of each vertical line is drawn in proportion to its amplitude. Since the angular velocity of the carrier is greater than the angular velocity of the modulating signal, the amplitude of side band frequencies can never exceed half of the carrier amplitude.

Thus there will not be any change in the original frequency, but the side band frequencies $(\omega_c - \omega_m)/2$ and $(\omega_c + \omega_m)/2$ will be changed. The former is called the upper side band (USB) frequency and the latter is known as lower side band (LSB) frequency.

Since the signal frequency $\omega_m/2$ is present in the side bands, it is clear that the carrier voltage two side banded frequencies will be produced when a carrier is amplitude modulated by a signal frequency. That is, an AM wave has a band width from $(\omega_c - \omega_m)/2$ to $(\omega_c + \omega_m)/2$, that is $2\omega_m/2$ or twice the signal frequency is produced. When a modulating signal has more than one frequency, two side band frequencies are produced by every frequency. Similarly for two frequencies of the modulating signal 2 LSB's and 2 USB's frequencies will be produced.

The side bands of frequencies present above the carrier frequency is known to be the upper side band and all those below the carrier frequency belong to the lower side band. The USB frequencies represent the sum of the individual modulating frequencies and the LSB frequencies represent the difference between the modulating frequency and the carrier frequency. The total

bandwidth is represented in terms of the higher modulating frequency and is equal to twice this frequency.

Modulation index (m)

The ratio between the amplitude change of modulated carrier wave to the amplitude of the normal carrier wave is called modulation index. It is represented by the letter 'm'.

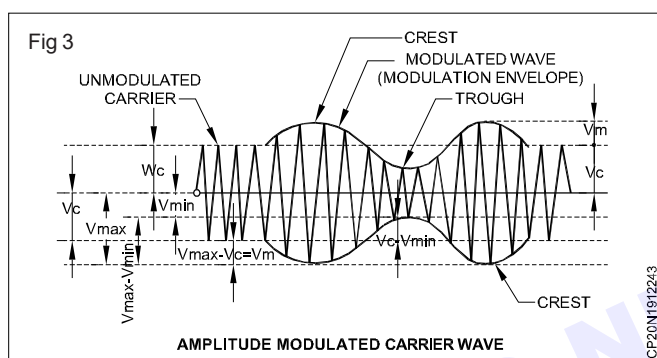
It can also be defined as the range in which the amplitude of the carrier wave is varied by the modulating signal.

$$m = V_m / V_c$$

Percentage modulation, $\%m = m \times 100 = V_m / V_c \times 100$

The percentage modulation lies between 0 and 80%

Another way of expressing the modulation index is in terms of the maximum and minimum values of the amplitude of the modulated carrier wave. This is shown in the figure below. (Fig 3)



Amplitude modulated carrier wave

Amplitude modulated carrier wave

From the figure we know that

$$2V_{in} = V_{max} - V_{min}$$

$$V_{in} = (V_{max} - V_{min}) / 2$$

$$V_c = V_{max} - V_{in}$$

$$= V_{max} - (V_{max} - V_{min}) / 2$$

$$= (V_{max} + V_{min}) / 2$$

Substituting the values of $V_{in} = V_m$ and V_c in the equation $m = V_m / V_c$, we get

$$m = \frac{V_{max} - V_{min}}{V_{max} + V_{min}}$$

As told earlier, the value of 'm' lies between 0 and 0.8. The value of m determines the strength and the quality of the transmitted signal. In an AM wave, the signal is contained in the variations of the carrier amplitude. The audio signal transmitted will be weak if the carrier wave is only modulated to a very small degree. But if the value of m exceeds unity, the transmitter output produces erroneous distortion.

Power relations in an AM wave

A modulated wave has more power than had by the carrier wave before modulating. The total power components in amplitude modulation can be written as;

$$P_{total} = P_{carrier} + P_{LSB} + P_{USB}$$

Considering additional resistance like antenna resistance R.

$$P_{carrier} = [(V_c / \sqrt{2}) / R]^2 = V_c^2 / 2R$$

Each side band has a value of $m / \sqrt{2} V_c$ and r.m.s value of $m V_c / 2\sqrt{2}$. Hence power in LSB and USB can be written as

$$P_{LSB} = P_{USB} = (m V_c / 2\sqrt{2})^2 / R = m^2 / 4 \cdot V_c^2 C / 2R = m^2 / 4 P_{carrier}$$

$$P_{total} = V_c^2 C / 2R + [m^2 / 4 \cdot V_c^2 C / 2R] + [m^2 / 4 \cdot V_c^2 C / 2R] = V_c^2 C / 2R (1 + m^2 / 2) = P_{carrier} (1 + m^2 / 2)$$

In some applications, the carrier is simultaneously modulated by several sinusoidal modulating signals. In such a case, the total modulation index is given as.

$$M_t = \sqrt{(m^2 + m_2^2 + m_3^2 + m_4^2 + \dots)}$$

If I_c and I_t are the r.m.s values of unmodulated current and total modulated current and R is the resistance through which these current flow, then,

$$P_{total} / P_{carrier} = (I_t R / I_c R)^2 = (I_t / I_c)^2$$

$$P_{total} / P_{carrier} = (1 + m^2 / 2)$$

$$(I_t / I_c)^2 = 1 + m^2 / 2$$

Limitations of amplitude modulation

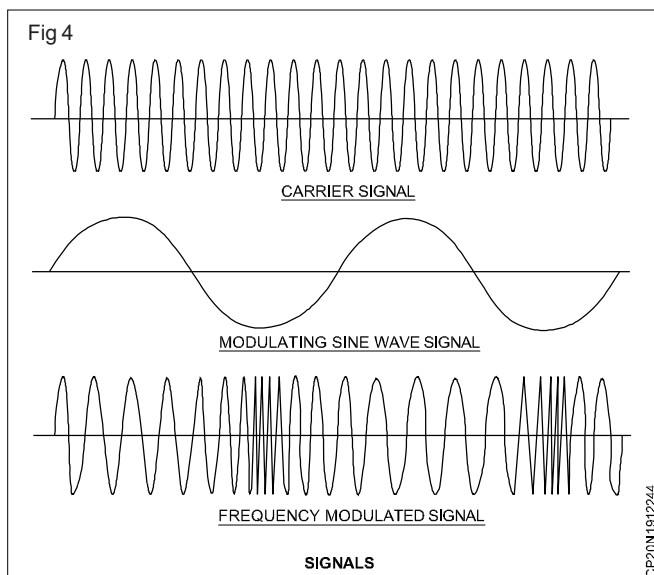
- 1 Low efficiency- since the useful power that lies in the small bands is quite small, so the efficiency of AM system is low.
- 2 Limited operating range - The range of operation is small due to low efficiency. Thus, transmission of signals is difficult.
- 3 Noise in reception- As the radio receiver finds it difficult to distinguish between the amplitude variations that represent noise and those with signals, heavy noise is prone to occur in its reception.
- 4 Poor audio quality - To obtain high fidelity reception, all audio frequencies till 15 kilo Hertz must be reproduced and this necessitates the band width of 10 Kilo Hertz to minimize the interference from the adjacent broadcasting stations. Therefore in AM broadcasting stations audio quality is known to be poor.

Frequency modulation

The carrier frequency is varied according to the instantaneous amplitude of message signal or modulating signal by keeping the amplitude of carrier signal constant is called frequency. (Fig.4)

Advantages of frequency modulation

- Frequency modulation has more noise resistivity when compared to other modulation techniques. That is why they are mainly used in broadcasting and radio communications. And we are all well aware that radio communication use mainly frequency modulation for transmission. We know that noise will occur mainly to the amplitude of the signal. In frequency modulation, amplitude is made constant and only frequency is varied, so we can easily find out the noise in the amplitude by using a limiter.



- The frequency modulation is having greater resistance to rapid signal strength variation, which we will use in FM radios even while we are travelling and frequency modulation is also mainly used in mobile communication purposes.
- For transmitting messages in frequency modulation, it does not require special equipments like linear amplifiers or repeaters and transmission levels or higher when compared to other modulation techniques. It does not require any class C or B amplifiers for increasing the efficiency.
- Transmission rate is good of frequency modulation when compared to other modulation that is frequency modulation can transmit around 1200 to 2400 bits per second.
- Frequency modulation has a special effect called capture effect in which high frequency signal will capture the channel and discard the low frequency or weak signals from interference.

Disadvantages of frequency modulation

In the transmission section, we do not need any special equipment but in the reception, we need more complicated demodulations for demodulating the carrier signal from message or modulating signal.

Frequency modulation cannot be used to find out the speed and velocity of a moving object. Static interferences are more than compared to phase modulation. Outside interference is one of the biggest disadvantages in the frequency modulation. There may be mixing because of nearby radio stations, pagers, construction walkie-talkies etc.

To limit the band width in the frequency modulation, we use some filter which will again introduce some distortions in the signal.

Transmitter and receiver should be in same channel and one free channel must be there between the systems.

Application of frequency modulation (FM)

- Frequency modulation is used in radio which is very common in our daily life.
- Frequency modulation is used in audio frequencies to synthesize sound.
- Used in applications of magnetic tape storage.

Phase modulation

PM, is used in many applications to carry both analog and digital signals. Keeping the amplitude of the carrier signal constant, the phase is varied according to the instantaneous amplitude of information signals.

Advantages and disadvantages of phase modulation

- The main advantages of phase modulation is that it has less interference from static, which is why we use this type of modulation in finding out the speed or velocity of a moving object. In frequency modulation, we cannot find out the velocity of moving object.
- The main disadvantage is phase ambiguity comes if we increase the phase modulation index, and data loss is more and we need special equipment like frequency multiplier for increasing the phase modulation index.

Applications of phase modulation

- Phase modulation application is not different from frequency modulation. Phase modulation is also used in communication systems.
- It may be used in binary phase shift keying

Introduction to AM, FM & PM, SSB-SC, DSB - SC modulation & demodulation techniques

Objectives : At the end of this lesson you shall be able to

- explain the AM modulation & demodulation techniques
- explain the modulation techniques of SSB-SC, DSB - SC in AM
- explain the FM modulation & demodulation techniques
- explain the PM modulation & demodulation techniques.

Amplitude modulation index & depth

Amplitude modulation index and modulation depth are key parameters for any AM transmission as it is necessary to keep the index or depth within limits to reduce distortion and interference.

It is often necessary to define the level of modulation that is applied to a signal.

In order to have a standard method of achieving this a factor or index known as the modulation index is widely used for this. A complementary figure known as the amplitude modulation depth is also seen on many occasions.

As an indicator of the level of modulation on an amplitude modulated signal, the modulation index is important - too low level of modulation and the modulation does not utilize the carrier efficiently - too high and the carrier can become over modulated causing sidebands to extend out beyond the allowed bandwidth causing interference to other users.

AM modulation index basics

Modulation indices are described for various forms of modulation. The amplitude modulation, AM, modulation index can be defined as the measure of extent of amplitude variation about an unmodulated carrier.

As with other modulation indices, the modulation index for amplitude modulation (AM) indicates that amount by which the modulated carrier varies around its static unmodulated level.

When expressed as a percentage it is the same as the depth of modulation. In other words it can be expressed as.

$$\text{Modulation index } m = \frac{M}{A}$$

A = carrier amplitude

M = modulation amplitude

Where :

A is the carrier amplitude . M is the modulation amplitude and is the peak change in the RF amplitude from its unmodulated value.

From this it can be seen that for an AM modulation index of 0.5, the modulation causes the signal to increase by a factor of 0.5 and decrease to 0.5 of its original level.

Amplitude modulation depth

A complementary figure to modulation index is also used for amplitude modulation signals. Known as the modulation

depth, it is typically the modulation index expressed as a percentage.

Thus a modulation index of 0.5 would be expressed as a modulation depth of 50%.

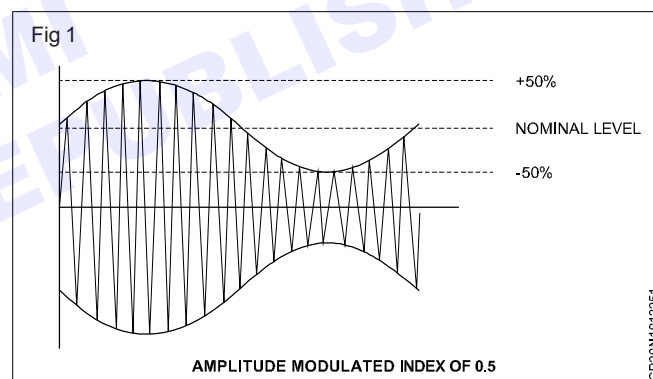
However often the two terms and figures are used interchangeably and figures for a modulation index of 50% are often seen where the index is 0.5

Modulation index / modulation depth examples

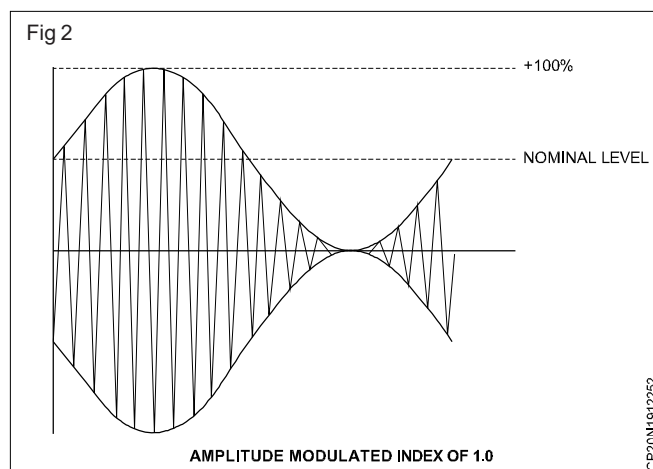
Typically the modulation index of a signal will vary as the modulating signal intensity varies. However some static values enable the various levels to be visualized more easily.

Amplitude modulated index of 0.5 (Fig 1)

When the modulation index reaches 1.0, i.e. a modulation depth of 100% the carrier level falls to zero and rises to twice its unmodulated level.



Amplitude modulated index of 1.0 (Fig 2)

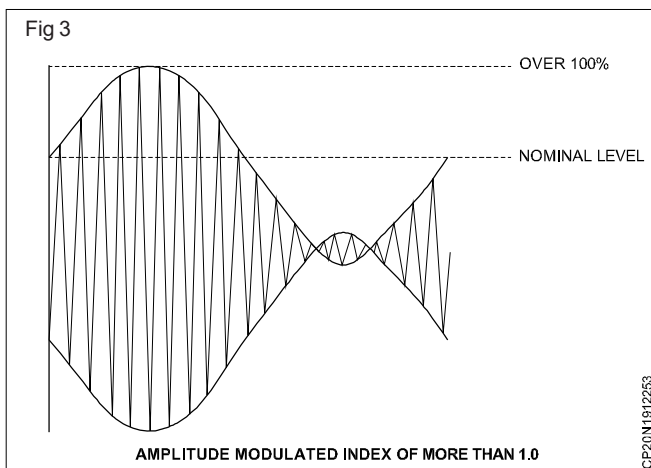


Any increase of the modulation index above 1.0, i.e. 100% modulation depth causes over modulation. The carrier experiences 180° phase reversals where the carrier level would try to go below the zero point. These phase reversals give rise to additional side bands resulting from the phase

reversals (phase modulation) that extend out, in theory to infinity. This can cause serious interference to other users if not filtered.

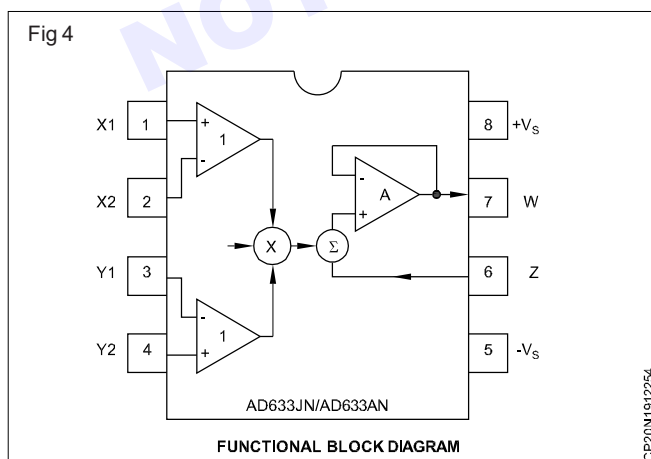
Amplitude modulated index of more than 1.0 i.e over - modulated (Fig 3)

Broadcast stations in particular take measures to ensure that the carrier of their transmissions never become over modulated. The transmitters incorporate limiters to prevent more than 100% modulation. However they also normally incorporate automatic audio gain controls to keep the audio levels such that near 100% modulation levels are achieved for most of the time.



AM - Modulator & demodulator

In this section we describe the circuits used for generation and demodulation of amplitude modulated signals. An analog multiplier IC AD633(Analog devices) has been used to generate the AM signal. The AD 633 is a functionally complete, four quadrant, analog multiplier. It includes high impedance, differential X and Y inputs, and a high impedance summing input (Z). The low impedance output voltage is a nominal 10V full scale provided by a buried zener. The functional diagram of the AD633 is shown in Fig 4.



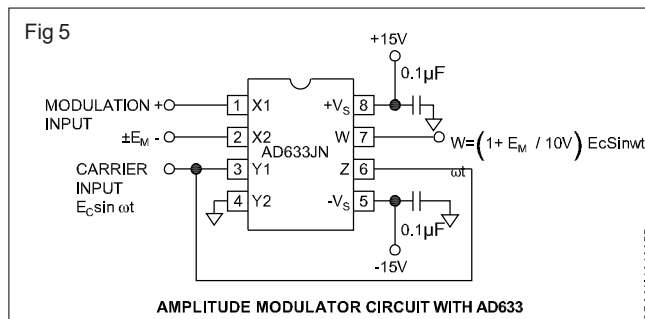
Functional block diagram from figure 4, we find that

$$W = \frac{(X1 - X2)(Y1 - Y2)}{10V} + Z$$

Details of AD633 is available in the data sheet.

Amplitude modulator circuit with AD633

The AD633 can be used as a linear amplitude modulator with no external components. Fig 5 shows the circuit. The carrier and modulation inputs to the AD633 are multiplied to produce a double sideband signal. The carrier signal is fed forward to the Z input of the AD633 where it is summed with the double sideband signal to produce a double side band with the carrier output.



For single tone modulation, $E_m A_m \sin(\omega_m t)$ is used. The index of modulation can be varied by changing A_m .

Demodulation of AM signal

As stated earlier, an envelope detector has been used here for demodulation. An envelope detector (Fig 6) is an electronic circuit that takes a high frequency modulated signal as input and provides an output which is the "envelope" of the original signal. The capacitor in the circuit stores charge on the rising edge and release it slowly through the resistor when the signal falls. The diode in series rectifies the incoming signal, allowing current flow only when the positive input terminal is at a higher potential than the negative input terminal (Fig 6).

Envelope detection process

For a sinusoidally modulated signal, if the time constant of the detector is chosen such that

$$RC \leq \frac{1}{2\pi f_m} \left(\frac{\sqrt{1-m^2}}{m} \right), \text{ the detector can always follow the}$$

message envelope.

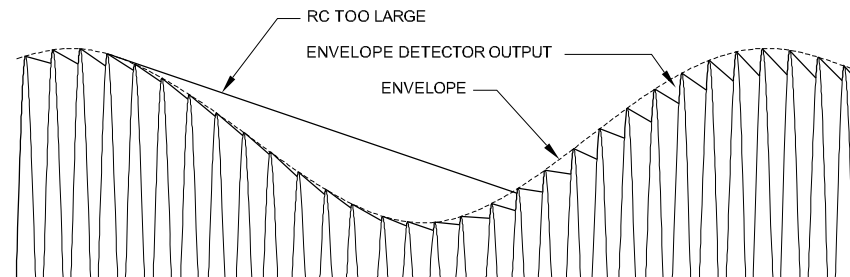
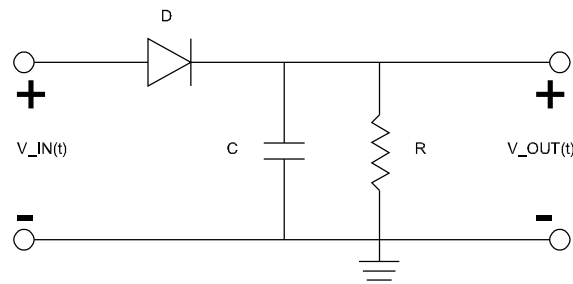
Double - side band suppressed carrier transmission (DSB-SC)

It transmission in which frequencies produced by amplitude modulation (AM) are symmetrically spaced above and below the carrier frequency and the carrier level is reduced to the lowest practical level, ideally being completely suppressed.

In the DSB - SC modulation, unlike in AM, the wave carrier is not transmitted; thus, much of the power is distributed between the side bands, which implies an increase of the cover in DSB-SC, compared to AM, for the same power used.

DSB-SC transmission is a special case of double - side band reduced carrier transmission. It is used for radio data systems.

Fig 6



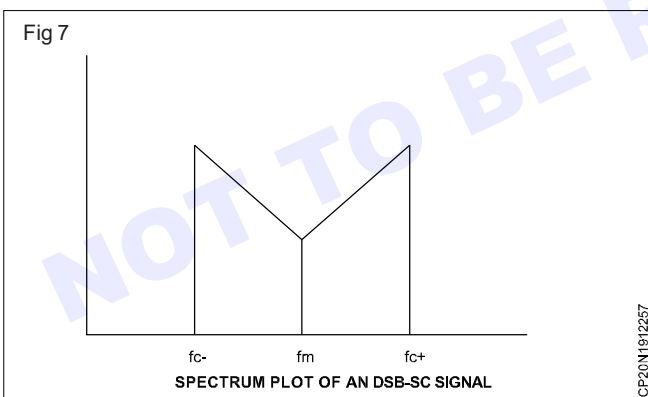
AMPLITUDE MODULATOR CIRCUIT WITH AD633

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Spectrum

DSB- SC is basically an amplitude modulation wave without the carrier, therefore reducing power waste, giving it a 50% efficiency. This is an increase compared to normal AM transmission (DSB), which has a maximum efficiency of 33.333%, since 2/3 of the power is in the carrier which carries no intelligence, and each side band carries the same information. Single side band (SSB) suppressed carrier is 100% efficient.

Spectrum plot of an DSB- SC signal (Fig 7)



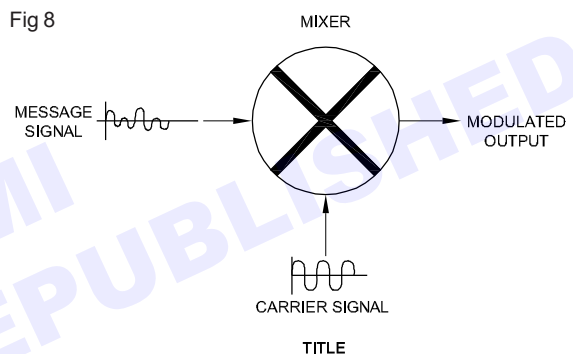
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Generation

DSB- SC is generated by a mixer. This consists of a message signal multiplied by a carrier signal. The mathematical representation of this process is shown below, where the product-to-sum trigonometric identity is used. (Fig 8)

$$\frac{V_m \cos(\omega_m t)}{\text{Message}} \times \frac{V_c \cos(\omega_c t)}{\text{Carrier}} = \frac{V_m V_c}{2 \text{ Modulated signal}} [\cos(\omega_m + \omega_c)t + \cos((\omega_m - \omega_c)t)]$$

Fig 8



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Demodulation

Demodulation is done by multiplying the DSB - SC signal with the carrier signal just like the modulation process. This resultant signal is then passed through a low pass filter to produce a scaled version of original signal. DSB- SC can be demodulated by a simple envelope detector, like AM, if the modulation index is less than unity. Full depth modulation requires carrier re-insertion.

Modulated signal

$$\begin{aligned} \frac{V_m \cos(\omega_m t)}{\text{Message}} \times \frac{V_c \cos(\omega_c t)}{\text{Carrier}} &= \frac{V_m V_c}{2 \text{ Modulated signal}} [\cos(\omega_m + \omega_c)t + \cos((\omega_m - \omega_c)t)] \\ &= \left(\frac{1}{2} V_c V_c' \right) \frac{V_m \cos(\omega_m t)}{\text{Original message}} + \\ &\quad \frac{1}{2} V_c V_c V_m [\cos((\omega_m - 2\omega_c)t)] \end{aligned}$$

The equation above shows that by multiplying the modulated signal by the carrier signal, the result is a scaled version of the original message signal plus a

second term. Since $\omega_c \gg \omega_m$ this second term is much higher in frequency than the original message. Once this signal passes through a low pass filter, the higher frequency component is removed, leaving just the original message.

Distortion and attenuation (Fig 9)

For demodulation, the demodulation oscillator's frequency and phase must be exactly the same as modulation oscillator's otherwise, distortion and / or attenuation will occur.

To see this effect, take the following conditions.

Message signal to be transmitted : $f(t)$

Modulation (carrier) signal : $V_c \cos(\omega_c t)$

Demodulation signal (with small frequency and phase deviations from the modulation signal)

$$V'_c \cos[(\omega_c + \Delta\omega)t + \theta]$$

The resultant signal can then be given by

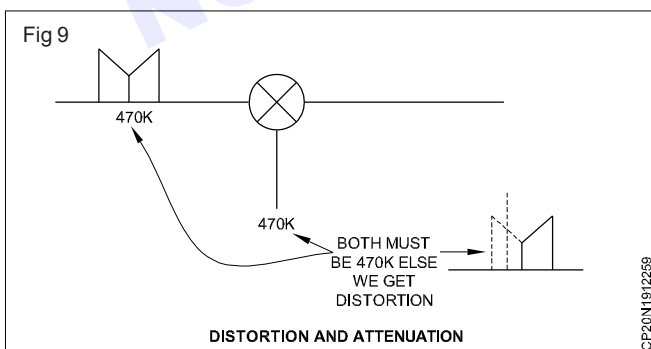
$$f(t) \times V_c \cos(\omega_c t) \times V'_c \cos[(\omega_c + \Delta\omega)t + \theta]$$

$$= \frac{1}{2} V_c V'_c f(t) \cos(\Delta\omega t + \theta) + \frac{1}{2} V_c V'_c f(t) \cos[(2\omega_c + \Delta\omega)t + \theta]$$

After low pass filter

$$= \frac{1}{2} V_c V'_c f(t) \cos(\Delta\omega t + \theta)$$

The $\cos(\Delta\omega t + \theta)$ terms results in distortion and attenuation of the original message signal. In particular, if the frequencies are correct, but the phase is wrong, contribution from θ is a constant attenuation factor, also $\Delta\omega.t$ represents a cyclic inversion of the recovered signal, which is a serious form of distortion.

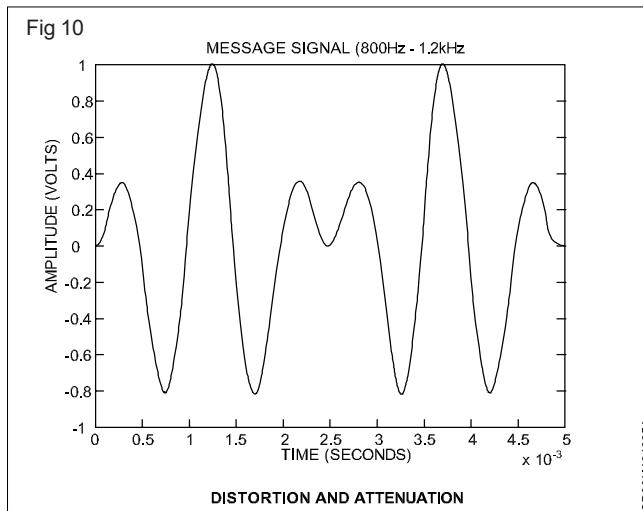


How it works (Fig 10)

This is best shown graphically. Below is a message signal that one may wish to modulate into a carrier, consisting of a couple of sinusoidal components.

The equation for this message signal in (Fig 10) is

$$s(t) = \frac{1}{2} \cos(2\pi 800t) - \frac{1}{2} \cos(2\pi 1200t)$$



The carrier, in this case, is a plain 5 kHz $c(t) = \cos(2\pi 5000t)$

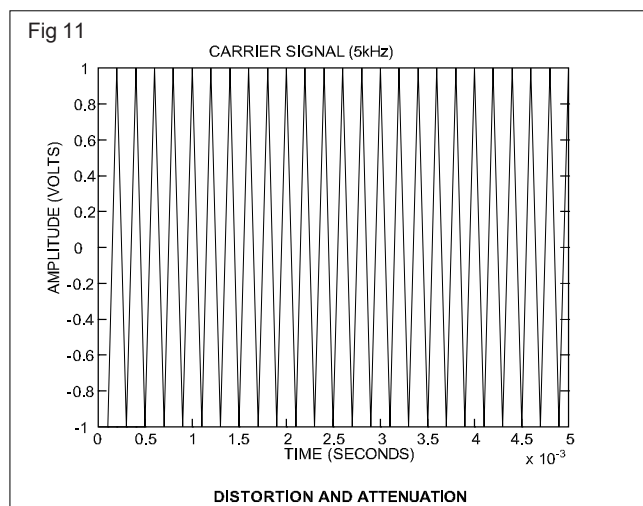
The modulation is performed by multiplication in the time domain, which yields a 5 KHz carrier signal, whose amplitude varies in the same manner as the message signal.

$$x(t) = \frac{\cos(2\pi 5000t)}{\text{Carrier}} \times \left[\frac{1}{2} \cos(2\pi 800t) - \frac{1}{2} \cos(2\pi 1200t) \right] \text{ Message signal}$$

The name "suppressed carrier" comes about because the carrier signal component is suppressed -it does not appear in the output signal. This is apparent when the spectrum, of the output signal is viewed. (Fig 11, 12 & 13)

Single - side band modulation

In radio communications, single - side band modulation (SSB) or single - side band suppressed - carrier (SSB-SC) is a refinement of amplitude modulation which uses transmitter power and band width more efficiently. Amplitude modulation produces an output signal that has twice the bandwidth of the original base band signal. Single - side band modulation avoids this band width doubling, and the power wasted on a carrier, at the cost of increased device complexity and more difficult tuning at the receiver.



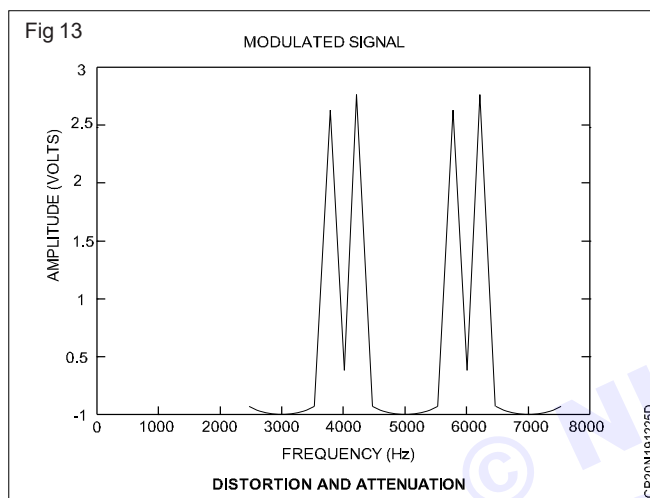
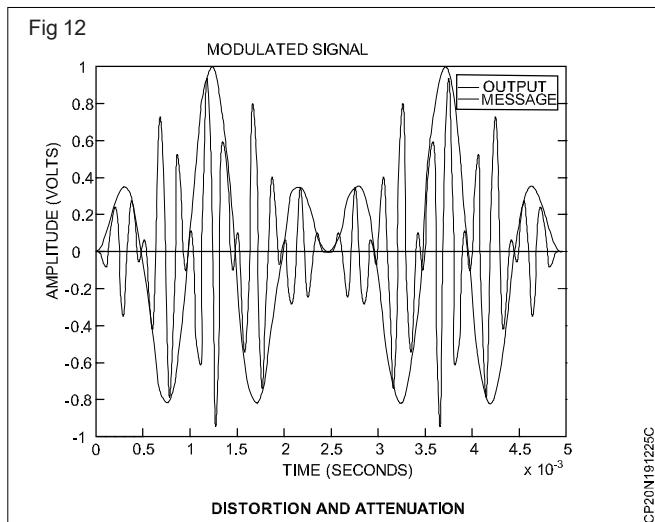


Illustration of the spectrum of AM and SSB signals is shown in Fig 14. The lower side band (LSB) spectrum is inverted compared to the baseband. As an example, a 2 KHz audio base band signal modulated onto a 5 MHz carrier will produce a frequency of 5.002 MHz if upper side band (USB) is used or 4.998 MHz if LSB is used.

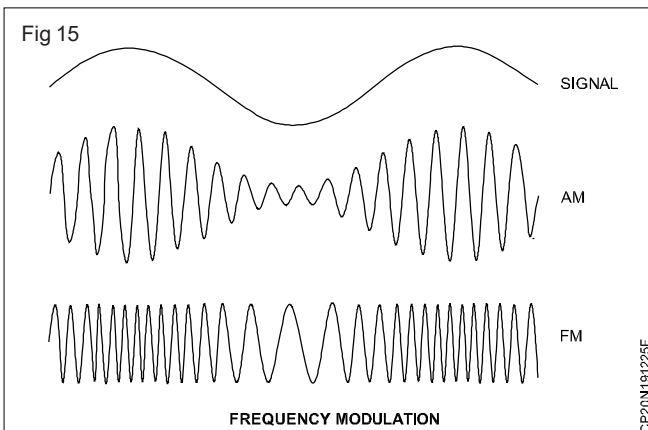
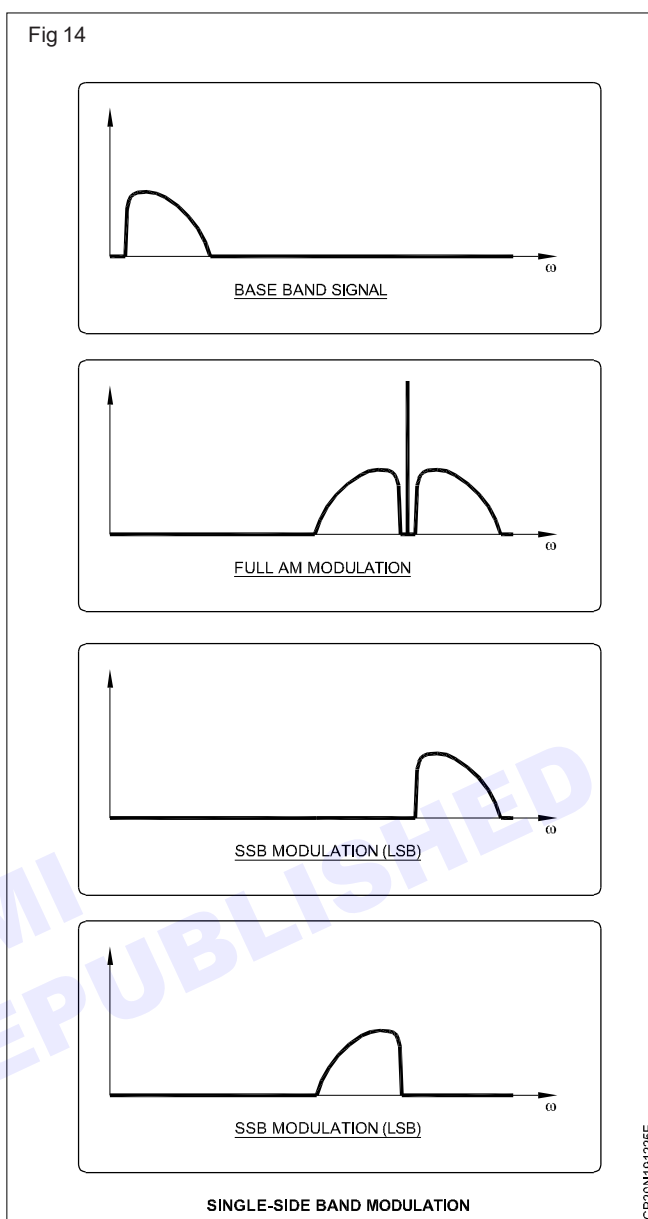
Frequency modulation

A signal may be carried by an AM or FM radio wave.

In telecommunications and signal processing, frequency modulation (FM) is the encoding of information in a carrier wave by varying the instantaneous frequency of the wave. (Compare with amplitude modulation, in which the amplitude of the carrier wave varies, while the frequency remains constant) Fig 15.

In analog signal applications, the difference between the instantaneous and the base frequency of the carrier is directly proportional to the instantaneous value of the input - signal amplitude.

Digital data can be encoded and transmitted via a carrier wave by shifting the carrier's frequency among a pre defined set of frequencies - a technique known as frequency - shift keying (FSK). FSK is widely used in modems and fax modems, and can also be used to send morse code. Radio teletype also uses FSK.



Frequency modulation is used in radio, telemetry, radar, seismic prospecting, and monitoring newborns for seizures via EEG. FM is widely used for broadcasting music and speech, two - way radio systems, magnetic tape- recording systems and some video- transmission systems. In radio systems frequency modulation with sufficient bandwidth provides an advantage in cancelling naturally - occurring noise.

Frequency modulation is known as phase modulation when the carrier phase modulation is the time integral of the FM signal.

Modulation index

As in other modulation systems, the value of the modulation index indicates by how much the modulated variable varies around its unmodulated level. It relates to variations in the carrier frequency.

$$h = \frac{\Delta f}{f_m} = \frac{f \Delta |x_m(t)|}{f_m}$$

where f_m is the highest frequency component present in the modulating signal $x_m(t)$, and Δ is the peak frequency deviation - i.e the maximum deviation of the instantaneous frequency from the carrier frequency. For a sine wave modulation, the modulation index is seen to be the ratio of the amplitude of the modulating sine wave to the amplitude of the carrier wave (here unity)

If $h < 1$, the modulation is called narrowband FM, and its bandwidth is approximately $2f_m$. Sometimes modulation index $h < 0.3$ rad is considered as narrowband FM otherwise wideband FM.

Noise reduction

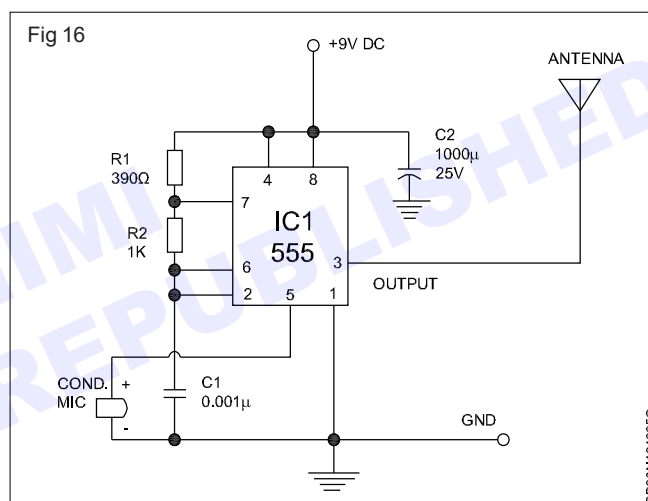
A major advantage of FM in a communications circuit, compared for example with AM, is the possibility of improved signal to noise ratio (SNR). Compared with an optimum AM scheme, FM typically has poorer SNR below a certain signal level called the noise threshold, but above a higher level - the full improvement or full quieting threshold - the SNR is much improved over AM. The improvement depends on modulation level and deviation. For typical voice communications channels, improvements are typically 5-15 dB. FM broadcasting using wider deviation can achieve even greater improvements. Additional techniques, such as pre-emphasis of higher audio frequencies with corresponding de-emphasis in the receiver, are generally used to improve overall SNR in FM circuits. Since FM signals have constant amplitude, FM receivers normally have limiters that remove AM noise, further improving SNR.

IC based AM transmitter circuit

IC 555 (IC1) is used as a free running multivibrator designed for a frequency of around 600 kHz. The frequency of the multivibrator can be calculated as follows: $f = 1.443(R_1 + 2R_2)C_1$ where R_1 and R_2 in ohms, capacitor C_1 in microfarads, and frequency f in hertz. This frequency can be changed by simply replacing R_2 with a variable resistor or C_1 with gang capacitors. A condenser microphone is used for audio signal input.

The IC 555 multivibrator is used as a voltage-to-frequency converter. The output of the condenser microphone is given to pin 5 of IC1, which converts the input voltage or voice signal into appropriate frequency at output pin 3. This frequency produces an electromagnetic wave, which can be detected by a near by AM radio receiver, and you can hear your own voice in that radio. (Note that if there is no noise in receiver, tune it to 600 kHz.)

The circuit operates with a 9V regulated power supply or a 9V battery. For antenna, connect 2-3m long wire at pin 3.



Block diagram of AM & FM transmitter, FM generation & detection

Objectives : At the end of this lesson you shall be able to

- explain the working of AM transmitters
- explain the working of FM transmitters
- list the types of FM detection
- sketch the different types of FM detector circuits.

AM transmitters

Transmitters that transmit AM signals are known as AM transmitters. These transmitters are used in medium wave (MW) and short wave (SW) frequency bands for AM broadcast. The MW band has frequencies between 530 KHz and 1650 KHz, and the SW band has frequencies ranging from 3 MHz to 30 MHz. The two types of AM transmitters that are used based on their transmitting powers are.

High level AM transmitters

Low level AM transmitters

High level transmitters are high level modulation, and low level transmitters use low level modulation.

The choice between the two modulation schemes depends on the transmitting power of the AM transmitter. In broadcast transmitters, where the transmitting power may

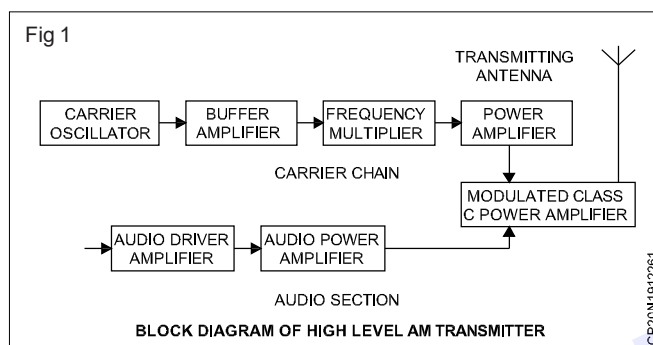
be of the order of kilowatts, high level modulation is employed. In low power transmitters, where only a few watts of transmitting power are required, low level modulation is used.

High level and low level transmitters

Below figure 1 show the block diagram of high level and low level transmitters. The basic difference between the two transmitters is the power amplification of the carrier and modulating signals.

High level AM transmitter

Fig 1 is drawn for audio transmission. In high level transmission, the powers of the carrier and modulating signals are amplified before applying them to the modulator stage, as shown in Fig 1. In low level modulation, the powers of the two input signals of the modulator stage are not amplified.



The various sections of the Fig 1 are:

- Carrier oscillator
- Buffer amplifier
- Frequency multiplier
- Power amplifier
- Audio section
- Modulated class C power amplifier

Carrier oscillator

The carrier oscillator generates the carrier signals, which lies in the RF range. The frequency of the carrier is always very high. Because it is very difficult to generate high frequencies with good frequency stability, the carrier oscillator generates a sub multiple with the required carrier frequency. This sub multiple frequency is multiplied by the frequency multiplier stage to get the required carrier frequency. Further, a crystal oscillator can be used in this stage to generate a low frequency carrier with the best frequency stability. The frequency multiplier stage then increases the frequency of the carrier to its required value.

Buffer amplifier

The purpose of the buffer amplifier is to first matches the output impedance of the carrier oscillator with the input impedance of the frequency multiplier, the next stage of the carrier oscillator. It then isolates the carrier oscillator and frequency multiplier.

This is required so that the multiplier does not draw a large current from the carrier oscillator. If this occurs, the frequency of the carrier oscillator will not remain stable.

Frequency multiplier

The submultiples frequency of the carrier signal, generated by the carrier oscillator, is now applied to the frequency multiplier through the buffer amplifier. This stage is also known as harmonic generator.

The frequency multiplier generates higher harmonics of carrier oscillator frequency. The frequency multiplier is a tuned circuit that can be tuned to the requisite carrier frequency that is to be transmitted. Power amplifier

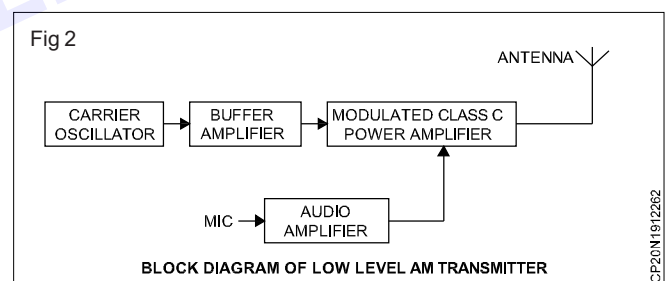
The power of the carrier signals is then amplified in the power amplifier stage. This is the basic requirement of a high level transmitter. A class C power amplifier gives high power current pulses of the carrier signal at its output.

Audio section

The audio signal to be transmitted is obtained from the microphone, as shown in figure (1). The audio driver amplifiers the voltage of this signal. The amplification is necessary to drive the audio power amplifier. Next, a class A or a class B power amplifier amplifies the power of the audio signal.

Low level AM transmitter

The low level AM transmitter shown in the Fig 2 is similar to a high level transmitter, except that the powers of the carrier and audio signals are not amplified. These two signals are directly applied to the modulated class C power amplifier.

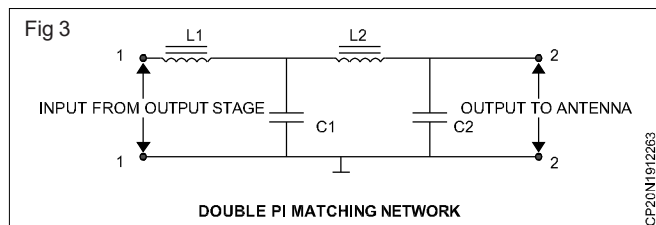


Modulation takes place at the stage, and the power of the modulated signal is amplified to the required transmitting power level. The transmitting antenna then transmits the signal.

Coupling of output stage and antenna

The output stage of the modulated class C power amplifier feeds the signal to the transmitting antenna. To transfer maximum power from the output stage to the antenna it is necessary that the impedance of the two sections match. For this, a matching network is required. The matching between the two should be perfect at all transmitting frequencies. As the matching is required at different frequencies, inductors and capacitors offering different impedance at different frequencies are used in the matching networks.

The matching network must be constructed using these passive components. This is shown in Fig 3.



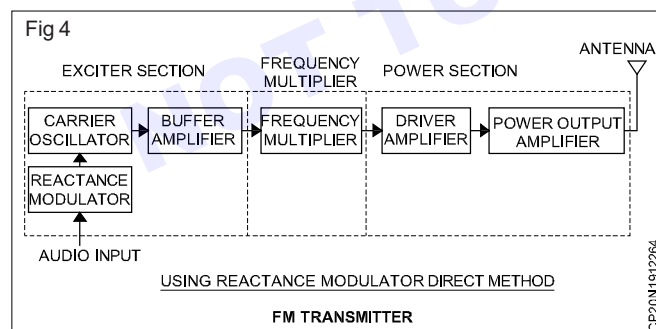
The matching network used for coupling the output stage of the transmitter and the antenna is called double TT network. This network consists of two inductors, L1 and L2 and two capacitors, C1 and C2. The values of these components are chosen such that the input impedance of the network between 1 and 1. Shown in figure (3) is matched with the output impedance of the output stage of the transmitter. Further, the output impedance of the network is matched with the impedance of the antenna.

The double TT matching network also filters unwanted frequency components appearing at the output of the last stage of the transmitter. The output of the modulated class C power amplifier may contain higher harmonics, such as second and third harmonics, that are highly undesirable. The frequency response of the matching network is set such that these unwanted higher harmonics are totally suppressed, and only the desired signal is coupled to the antenna.

FM transmitter (Fig 4)

The FM transmitter has three basic sections

- 1 The exciter section contains the carrier oscillator, reactance modulator and the buffer amplifier
- 2 The frequency multiplier section, which features several frequency multipliers.
- 3 The power output section, which includes a low level power amplifier, the final power amplifier, and the impedance matching network to properly load the power section with the antenna impedance.



The essential function of each circuit in the FM transmitter may be described as follows.

The exciter

- 1 The function of the carrier oscillator is to generate a stable sine wave signal at the rest frequency, when no modulation is applied. It must be able to linearly change frequency when fully modulated, with no measurable change in amplitude.
- 2 The buffer amplifier acts as a constant high impedance load on the oscillator to help stabilize the oscillator frequency. The buffer amplifier may have a small gain.

- 3 The modulator acts change the carrier oscillator frequency by application of the message signal. The positive peak of the message signal generally lowers the oscillator's frequency to a point below the rest frequency, and the negative message peak raises the oscillator frequency to a value above the rest frequency. The greater the peak to peak message signal, the larger the oscillator deviation.

Frequency multiplier

Frequency multipliers are tuned input, tuned output RF amplifiers in which the output resonant circuit is tuned to a multiple of the input frequency. Common frequency multipliers are 2x, 3x and 4x multiplication. A 5x frequency multiplier is sometimes seen, but its extreme low efficiency forbids widespread usage. Note that multiplication is by whole numbers only.

Power output section

The final power section develops the carrier power, to be transmitted and often has a low power amplifier driven the final power amplifier.

The impedance matching network is the same as for the AM transmitter and matches the antenna impedance to the correct load on the final over amplifier.

Frequency Multiplier

A special form of class C amplifier is the frequency multiplier. Any class C amplifier is capable of performing frequency multiplication.

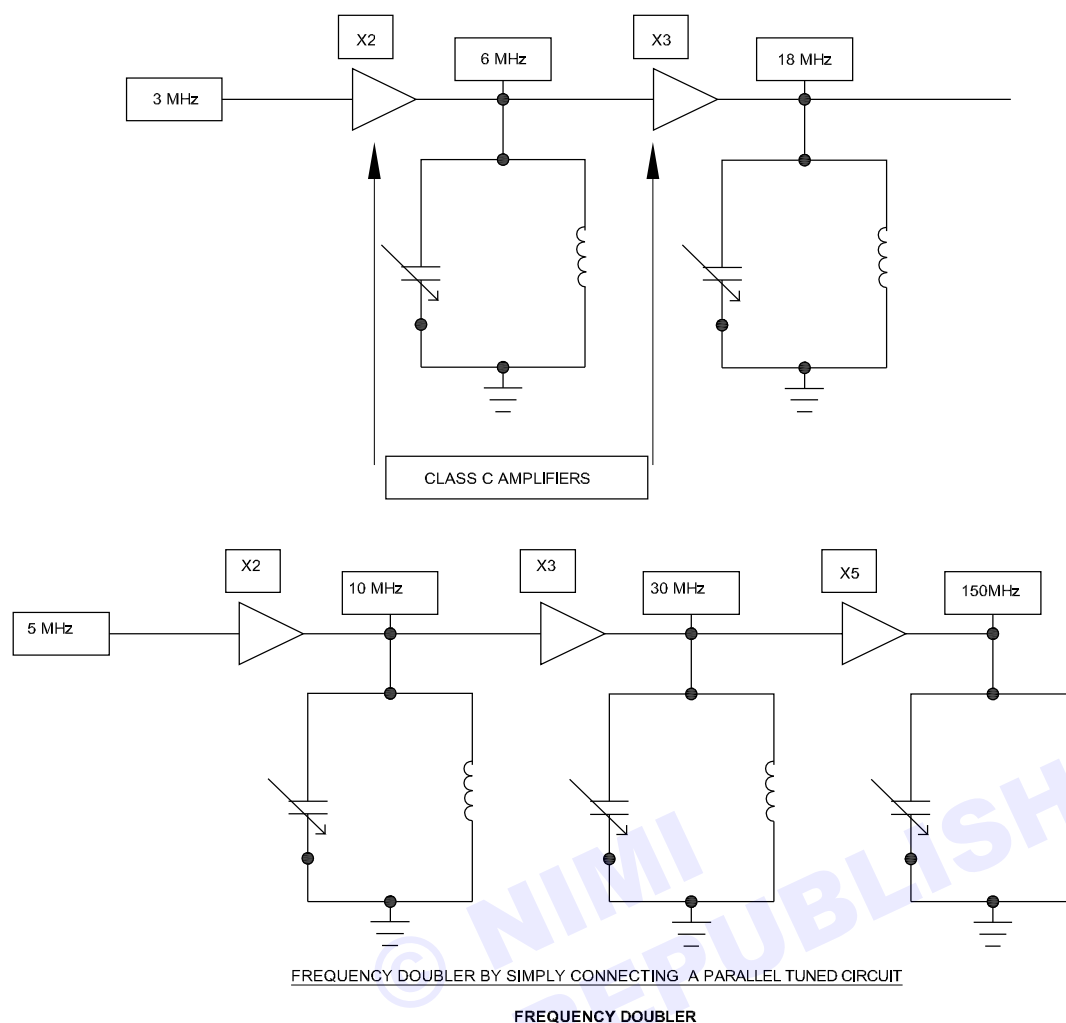
For example a frequency doubler can be constructed by simply connecting a parallel tuned circuit in the collector of a class C amplifier that resonates at twice the input frequency when the collector current pulse occurs, it excites or rings the tuned circuit at twice the input frequency.

Frequency doubler by simply connecting a parallel tuned circuit (Fig 5)

A current pulse flows for every other cycle of the input. A tripler circuit is constructed in the same way except that the tuned circuit resonates at 3 times the input frequency. In this way, the tuned circuit receives one input pulse for every three cycles of oscillation it produces multipliers can be constructed to increase the input frequency by any integer factor up to approximately 10. As the multiplication factor gets higher, the power output of the multiplier decreases. For most practical applications, the best result is obtained with multipliers of 2 and 3. Another way to look the operation of class C multipliers is to remember that the no sinusoidal current pulse is rich in harmonics. Each time the pulse occurs, the second, third, fourth, fifth, and higher harmonics are generated. The purpose of the tuned circuit in the collector is to act as a filter to select the desired harmonics.

In many applications a multiplication factor greater than that achievable with a signal multiplier stage is required. In such cases two or more multipliers are cascaded to produce an overall multiplication of 6. In the second examples, three multipliers provide an overall multiplication

Fig 5



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30. The total multiplication factor is simply the product of individual stage multiplication factors.

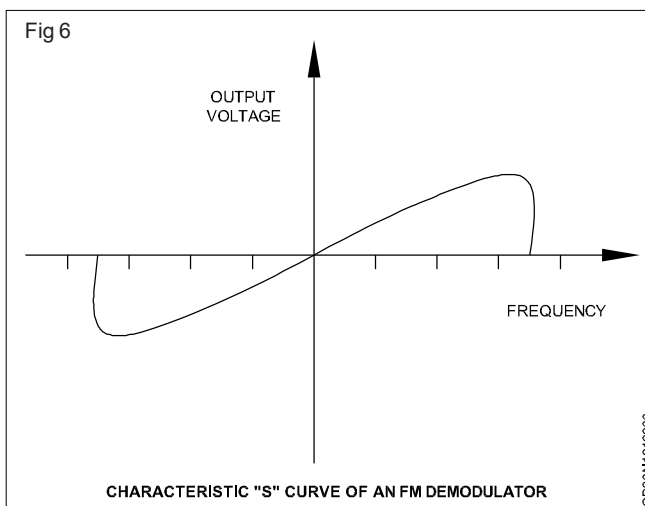
Reactance modulator

The reactance modulator takes its name from the fact that the impedance of the circuit acts as a reactance (capacitive or inductive) that is connected in parallel with the resonant circuit of the oscillator. The varicap can only appear as a capacitance that becomes part of the frequency determining branch of the oscillator circuit. However, other discrete devices can appear as a capacitor or as an inductor to the oscillator, depending on how the circuit is arranged. A colpitts oscillator uses a capacitive voltage divider as the phase reversing feedback path and would most likely tapped coil as the phase reversing element in the feedback loop and most commonly uses a modulator that appears inductive.

FM generation & Detection

In order to be able to receive FM signal, a receiver must be sensitive to the frequency variations of the incoming signals. As already mentioned these may be wide or narrow band. However the set is made insensitive to the amplitude variations. This is achieved by having a high gain IF amplifier. Here the signals are amplified to such a degree that the amplifier runs into limiting. In this way any amplitude variations are removed.

In order to be able to convert the frequency variations into voltage variations, the demodulator must be frequency dependent. The ideal response is perfectly linear voltage to frequency characteristics. Here it can be seen that the centre frequency is in the middle of the response curve and this is where the un-modulated carrier would be located when the receiver is correctly tuned into the signal. In other words there would be no offset DC voltage present. (Fig 6)



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The ideal response is not achievable because all systems have a finite bandwidth and as a result a response curve known as an "S" curve is obtained. Outside the bandwidth of the system, the response falls, as would be expected. It can be seen that the frequency variations of the signal are converted into voltage variations which can be amplified by an audio amplifier before being passed into headphones, loudspeaker, or passed into other electronic circuitry for the appropriate processing.

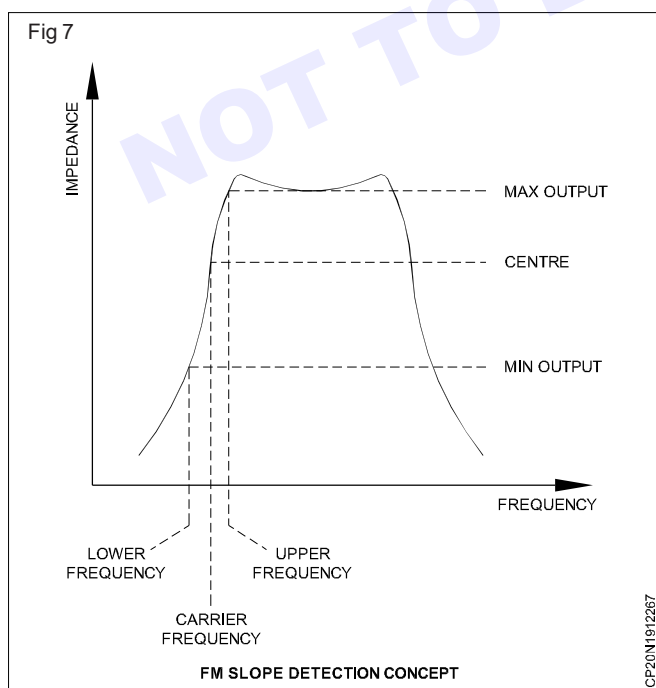
To enable the best detection to take place the signal should be centred about the middle of the curve. If it moves off too far then the characteristic becomes less linear and higher levels of distortion result. Often the linear region is designed to extend well beyond the bandwidth of a signal so that this does not occur. In this way the optimum linearity is achieved. Typically the bandwidth of a circuit for receiving VHF FM broadcasts may be about 1MHz whereas the signals is only 200 KHz wide.

There are a number of circuits that can be used to demodulate FM. Each type has its own advantages and disadvantages, some being used when receivers used discrete components, and others now that ICs are widely used.

Below is a list of some of the main types of FM demodulator or FM discriminator / detector. In view of the widespread use of FM, even with the competition from digital modes that are widely used today, FM demodulators are needed in many new designs of electronics equipment.

Slope FM detector (Fig 7)

The very simplest form of FM demodulation is known as slope detection or demodulation. It consists of a tuned circuit that is tuned to a frequency slightly offset from the carrier of the signal.



As the frequency of the signals varies up and down in frequency according to its modulation, so the signal moves up and down the slope of the tuned circuit. This causes the amplitude of the signal to vary in line with the frequency variations. In fact at this point the signal has both frequency and amplitude variations.

It can be seen from the diagram that changes in the slope of the filter, reflect into the linearity of the demodulation process. The linearity is very dependent not only on the filter slope as it falls away, but also the tuning of the receiver - it is necessary to tune the receiver off frequency and to a point where the filter characteristic is relatively linear.

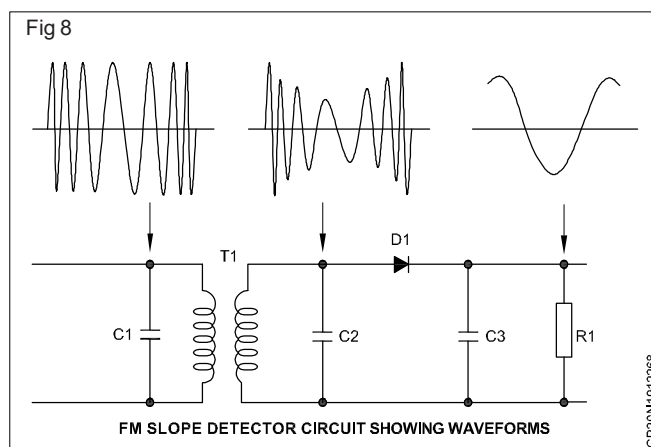
The final stage in the process is to demodulate the amplitude modulation and this can be achieved using a simple diode circuit. One of the most obvious disadvantages of this simple approach is the fact that both amplitude and frequency variations in the incoming signal appear at the output. However the amplitude variations can be removed by placing a limiter before the detector.

A variety of FM slope detector circuits may be used, but the one below shows one possible circuit with the applicable wave forms. The input signal is a frequency modulated signal. It is applied to the tuned transformer (T1, C1, C2 combination) which is offset from the centre carrier frequency. This converts the incoming signal from just FM to one that has amplitude modulation superimposed upon the signal.

This amplitude signal is applied to a simple diode detector circuit. D1, Here the diode provides the rectification, while C3 removes any unwanted high frequency components, and R1 provides a load

FM slope detection advantages & disadvantages

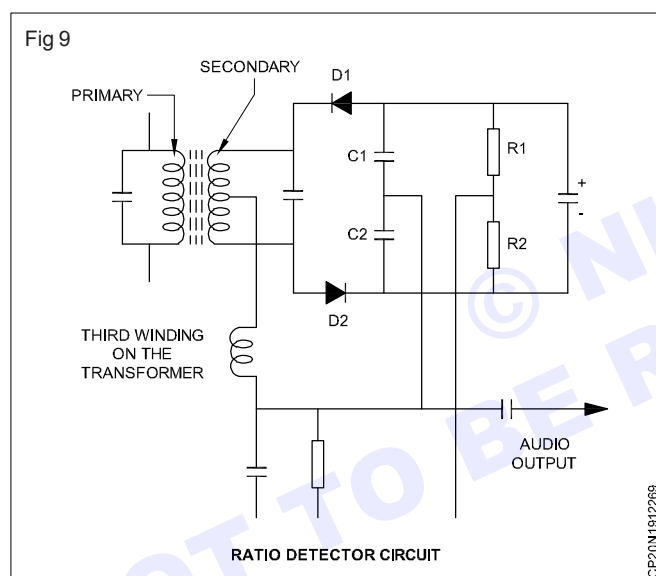
FM slope detection is not widely used, and yet it has some limited applications. Knowing the advantages and disadvantages enables the technique to be used where applicable. (Fig 8)



Advantages	Disadvantages
Simple - can be used to provide of FM demodulation when only an AM detector is present Enable FM to be detected without any additional circuitry	Not linear as the output is dependent upon the curve a filter Not particularly effective as it relies on centring the signal part of the way down the filter curve where signal strengths are less. Both frequency and amplitude variations are accepted and therefore much higher levels of noise and interference are experienced

Ratio detector

When circuits employing discrete components were more widely used, the Ratio and Foster - seeley detectors were widely used. Of these the ratio detector was the most popular as it offers a better level of amplitude modulation rejection of amplitude modulation. This enables it to provide a greater level of noise immunity as most is amplitude noise, and it also enables the circuit to operate satisfactorily with lower levels of limiting in the preceding IF stages of the receiver. (Fig 9)



The operation of the ratio detector centres around a frequency sensitive phase shift network with a transformer and the diodes that are effectively in series with one

another. When a steady carrier is applied to the circuit the diodes act to produce a steady voltage across the resistors R1 and R2, and the capacitor C3 charges up as a result.

The transformer enables the circuit to detect changes in the frequency of the incoming signal. It has three windings. The primary and secondary act in the normal way to produce a signal at the output. The third winding is untuned and the coupling between the primary and the third winding is very tight, and this means that the phasing between signals in these two windings is the same.

The primary and secondary windings are tuned and lightly coupled. This means that there is a phase difference of 90 degrees between the signals in these windings at the centre frequency. If the signal moves away from the centre frequency the phase difference will change. In turn the phase difference between the secondary and third windings also varies. When this occurs the voltage will subtract from one side of the secondary and add to the other causing an imbalance across the resistors R₁ and R₂. As a result this causes a current to flow in the third winding and the modulation to appear at the output.

The capacitors C₁ and C₂ filter any remaining RF signal which may appear across the resistors. The capacitor C₄ and R₃ also act as filters ensuring no RF reaches the audio section of the receiver.

Ratio detector advantages & disadvantages

As with any circuit there are a number of advantages and disadvantages to be considered when choosing between several options.

Advantages	Disadvantages
Simple to construct using discrete components Offers good level of performance and	High cost of transformer Typically lends itself to use in only circuits using discrete components and not integrated within an IC

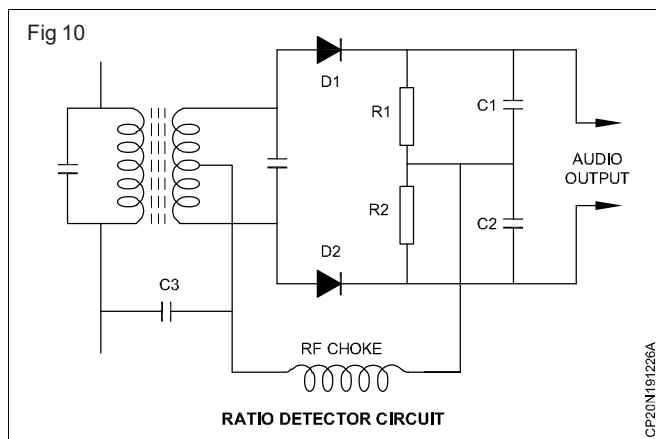
As a result of its advantages and disadvantages the ratio detector is not widely used these days. Techniques that do not require the. Use of a transformer with its associated costs and those than can be more easily incorporated within an IC tend to be used.

Foster -Seeley FM detector

The foster seeley detector or as it is sometimes described the foster seeley discriminator has many similarities to

the ratio detector. The circuit topology looks very similar, having a transformer and a pair of diodes, but there is no third winding and instead a choke is used. (Fig 10)

Like the ratio detector, the foster - seeley circuit operate using a phase difference between signals. To obtain the different phased signals a connection is made to the primary side of the transformer using a capacitor, and this is taken to the centre tap of the transformer. This gives a signals that is 90 degrees out of phase.



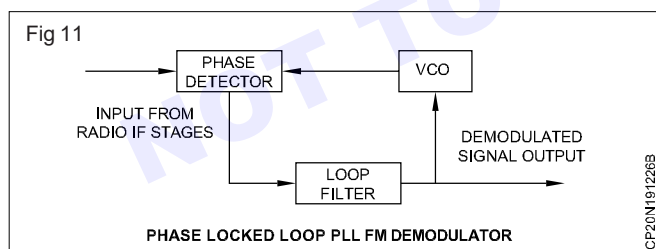
When an un-modulated carrier is applied at the centre frequency, both diodes conduct, to produce equal and opposite voltage across their respective load resistors. These voltages cancel each one another out at the output so that no voltage is present. As the carrier moves off to one side of the centre frequency the balance condition

Advantages	Disadvantages
Offers good level of performance and reasonable linearity	Does not easily lend itself to being incorporated within an integrated circuit
Simple to construct using discrete components	High cost of transformer

As a result of its advantages and disadvantages the foster seeley detector or discriminator is not widely used these days. Its main use was within radios constructed using discrete componetns.

PLL, Phase locked loop FM demodulator (Fig 11)

The way in which a phase locked loop, PLL FM demodulator works is relatively straight forward. It required no changes to the basic locked loop, itself, utilizing the basic operation of the loop to provide the required output.



When used as an FM demodulator, the basic phase locked loop can be used without any changes. With no modulation applied and the carrier in the centre position of the pass - band the voltage on the tune line to the VCO is set to the mid position. However if the carrier deviates in frequency, the loop will try to keep the loop in lock. For this to happen the VCO frequency must follow the incoming signal, and in turn for this to occur the tune line voltage must vary. Monitoring the tune line shows that the variations in voltage correspond to the modulation applied to the signal. By amplifying the variations in voltage on the tune line it is possible to generate the demodulated signal.

The PLL FM demodulator is normally considered a relatively high performance form of FM demodulator or

is destroyed, and one diode conducts more than the other. This results in the voltage across one of the resistors being larger than the other, and a resulting voltage at the output corresponding to the modulation on the incoming signal.

The choke is required in the circuit to ensure that no RF signals appear at the output. The capacitors C_1 and C_2 provide a similar filtering function.

Both the ratio and foster - seeley detector are expensive to manufacture. Wound components like coils are not easy to produce to the required specification and therefore they are comparatively costly. Accordingly these circuits are rarely used in modern equipment.

Foster - Seeley detector advantages & disadvantages

As with any circuit there are a number of advantages and disadvantages to be considered when choosing between the various techniques available for FM demodulation.

detector. Accordingly they are used in many FM receiver applications.

Linearity : The linearity of the PLL FM demodulator is governed by the voltage to frequency characteristic of the VCO within the PLL. As the frequency deviation of the incoming signal normally only swings over a small portion of the PLL bandwidth, and the characteristic of the VCO can be made relatively linear, the distortion levels from phase locked loop demodulations are normally very low. Distortion levels are typically a tenth of a percent.

Manufacturing costs : The PLL FM demodulator lends itself to integrated circuit technology. Only a few external components are required, and in some instances it may not be necessary to use an inductor as part of the resonant circuit for the VCO. These facts make the PLL FM demodulator particularly attractive for modern applications.

PLL FM demodulator design considerations

When designing a PLL system for use as an FM demodulator, one of the key considerations is the loop filter. This must be chosen to be sufficiently wide that it is able to follow the anticipated variations of the frequency modulated signal. Accordingly the loop response time should be short when compared to the anticipated shortest time scale of the variations of the signal being demodulated.

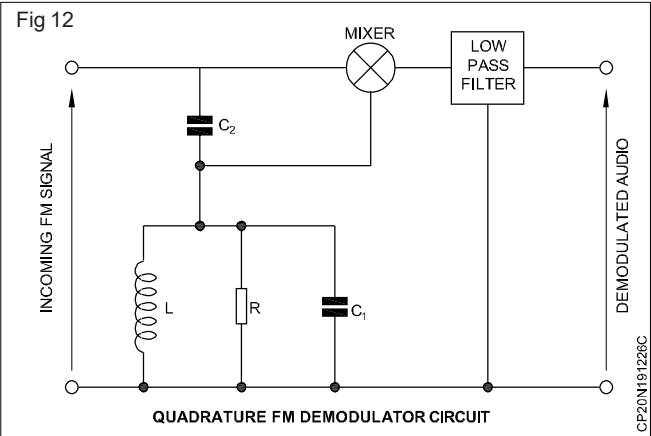
A further design consideration is the linearity of the VCO. This should be designed for the voltage to frequency curve to be as linear as possible over the signal range that will be encountered, i.e the centre frequency plus and minus the maximum deviation anticipated

In general the PLL VCO linearity is not a major problem for average systems, but some attention may be required to ensure the linearity is sufficiently good for hi-fi systems.

Quadrature FM demodulator (Fig 12)

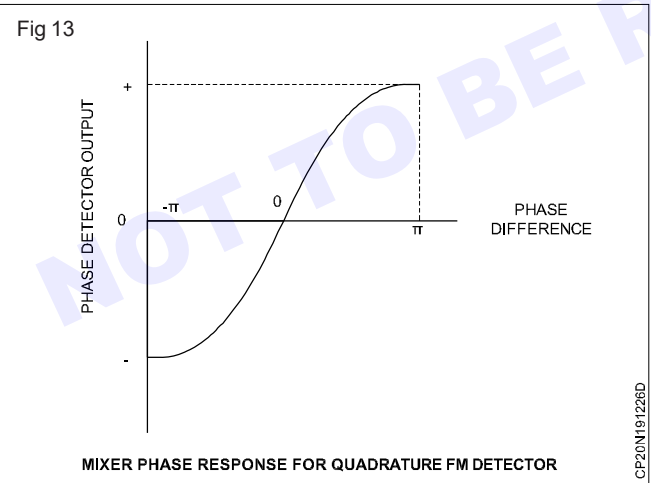
The basic format of the quadrature detector is shown below

It can be seen that the signal is split into two components. One of these passes through a network that provides a basic 90° phase shift, plus an element of phase shift dependent upon the deviation.



The original signal and the phase shifted signal are then passed into a multiplier or mixer.

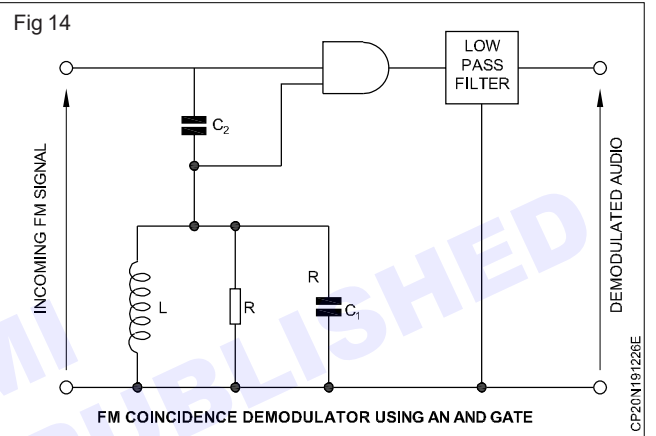
The mixer output is dependent upon the phase difference between the two signals, i.e. it acts as a phase detector and produces a voltage output that is proportional to the phase difference and hence to the level of deviation on the signal. (Fig 13)



If the operation of the system is designed to ensure that the deviation remains well away from the 90° points, then the linearity remains very good.

In terms of performance, the quadrature detector is able to operate with relatively low input levels, typically down to levels of around 100 microvolts and it is very easy to set up requiring only the phase shift network to be tuned to the centre frequency of the expected signal. It also provides good linearity and this results in low levels of distortion.

Coincidence FM demodulator: This form of demodulator has many similarities to the quadrature detector. It uses digital technology and replaces a mixer with a logic NAND gate. Often the analogue multiplier is replaced by a logic AND gate and the input signal is hard limited to produce a variable frequency waveform. (Fig 14)



The operation of the circuit is fundamentally the same, but it is known as a coincidence detector. Also the output of the AND gate has an integrator to 'average' the output waveform to provide the required audio output, otherwise it would consist of a series of square wave pulses

Quadrature detector advantages & disadvantages

The quadrature detector offers significant advantages for many circuits, but as with any decision, a number of different advantages and disadvantages have to be considered when selecting a given circuit for FM demodulation.

Advantages	Disadvantages
Offers good level of performance and including linearity	Requires the use of a coil
Can be incorporated into an integrated circuit	Some designs may require setting during manufacture

Despite the disadvantages, the quadrature FM detector is the circuit of choice for many radio receivers.

Introduction to computer devices, parts and their working

Objectives : At the end of this lesson you shall be able to

- **explain the basics of computer**
- **identify computer hardware**
- **identify various peripheral devices.**

What is a computer?

The term computer is used to describe a device made up of electronic and electro mechanical components. The computer itself cannot perform any task and is referred to as hardware.

A computer system consists of three elements.

- 1 Hardware
- 2 Software
- 3 People

Hardware : The physical components which you can see, touch and feel in

the computer system are called hardware (eg) monitor, keyboard, mouse etc.

Software : Software is used to describe the instructions that tells the computer how to perform a task. Software is categorized

- 1 System softwares (eg . operating systems, compilers, editors etc)
- 2 Application softwares (MS-word, excel, accounting packages etc)

People : People who operate the computer and also create computer software instructions.

Computer hardware

Basic components in a computer system are central processing unit (CPU), memory, the input device and output device.

Computer systems – Micros, Minis and Mainframes.

Micro computer : Micro computer is also called as personal computer or PC. It has a processor based on a single silicon chip. Personal computers come in three different physical sizes, pocket pc's, lap pc's and desktop pc's. Pocket pc's and lap pc's belong to portable category. Microcomputer is used in small businesses.

Ex : IBM compatible or IBM clone and Apple Macintosh systems.

Multiuser microcomputers. Until recently microcomputers were personal

computers for individual use only. But now days several microcomputers can be networked together for simultaneous used by several people.

Mini computers: Mini computer is simply a small mainframe computer. It is a reduced version of mainframe. Attached printers are not so fast. So it has less storage capacity less processing speed of that of mainframe computers. They are usually used by small businesses. For example research groups, engineering firms, colleges etc. use mini computers.

Mainframe computers: A mainframe computer is a large expensive machine whose processing speed is very high and has large amount of secondary storage and fast printers. A large mainframe computer may be used to meet the data processing requirements of the entire organization.

Examples: airline booking systems, Railway booking systems , weather forecast etc.

System types

We can classify systems into the following categories :

8-bit, example : 8085 microprocessor

16-bit, example : 8086, 286, 386 processor

32-bit , example : 486

64-bit, example : Pentium - II

This gives us two basic system types or classes of hardware.

8-bit (PC/XT) class systems

16/32/64 (AT) class systems

PC stands for personal computers, XT stands for extended PC, and AT stands for an advance technology PC.

The XT basically was a PC system that included a hard disk for storage in addition to the floppy drive found in the basic PC system. These systems has an 8-bit processor and an 8-bit INDUSTRY STANDARD ARCHITECTURE

(ISA) bus for system expansion. Bus is the name given to expansion slots in which additional plug in circuit board can be installed.

16-bit and greater systems are said to be AT class. 16-bit (and latter 32 and 64 bit) processors and expansion slots are included. The first AT class systems had a 16-bit version of the ISA bus which is an extension of the original 8-bit ISA bus found in the PC/XT class systems. Afterwards several expansion slots were developed for AT class systems.

Example

16/32 bit PS/2 microchannel architecture (MCA) bus.

16-bit PC card (PCMCIA) bus

16 bit ISA bus

16/32 bit Extended ISA(EISA) bus

32/64 - bit card Peripheral Component Interconnect (PCI) bus.

The easiest way to identify a PC/XT system is by the 8-bit ISA expansion slots regardless of the processor present in the system. AT systems can be similarly identified by having 16-bit of greater slots of any type (ISA, EISA, PCI) slots.

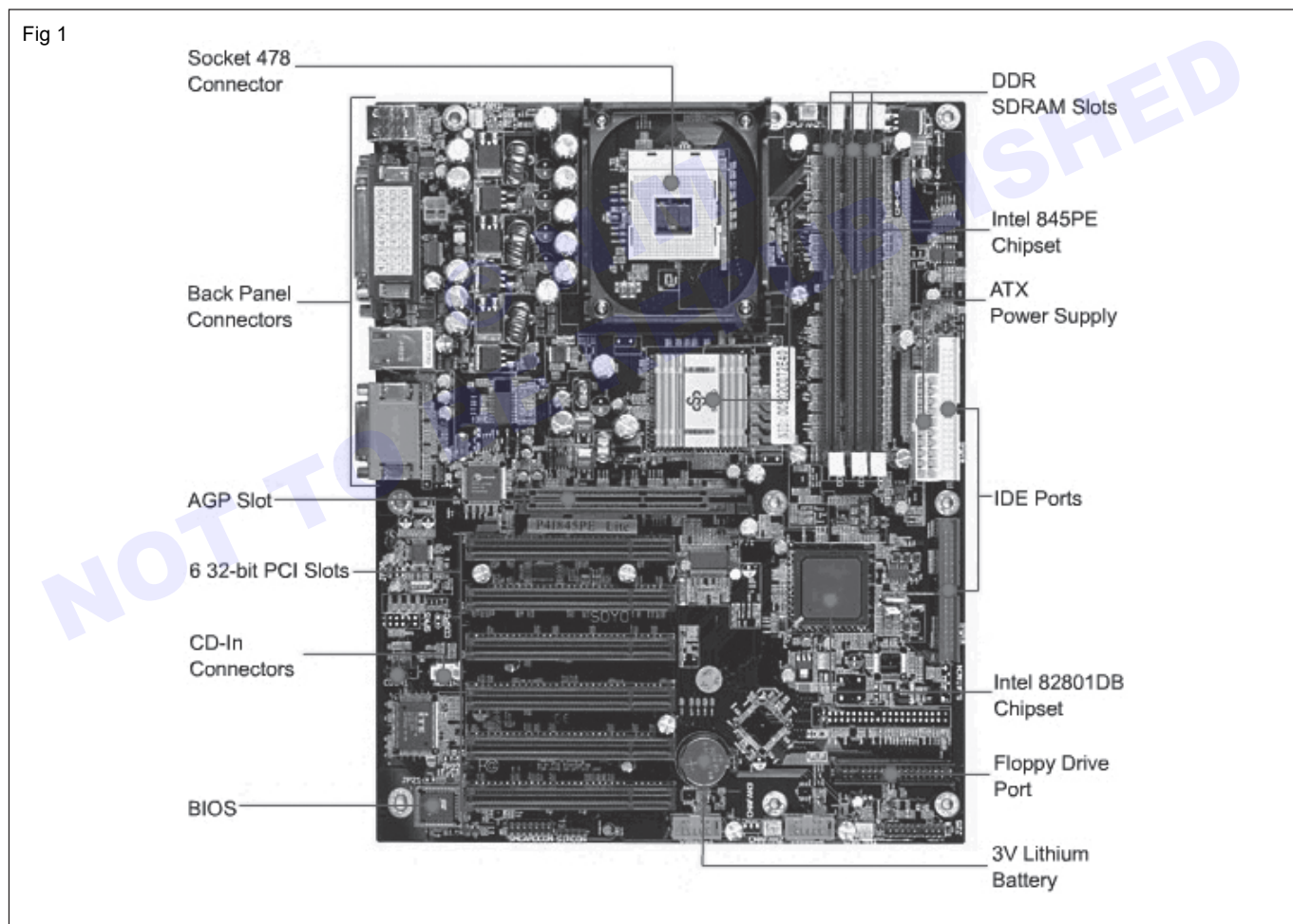
System components

Component needed to assemble a basic modern PC system.

- Motherboard
- Processor

- Memory (Primary)
- Hard disk
- CD-ROM
- Floppy Drive
- Keyboard
- Mouse
- Monitor
- Power Supply
- Cabinet

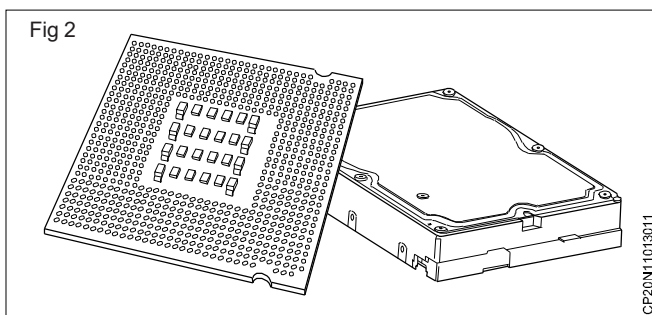
Motherboard : motherboard is the important component of the computer as everything else is connected to it. And it controls everything in the system. Motherboard are available in several different shapes. Motherboard usually contain the following individual components shown in Fig1.



- 1 Processor slot
- 2 Processor voltage regulators
- 3 Motherboard chipset
- 4 Level 2 cache
- 5 Memory SIMM or DIMM sockets

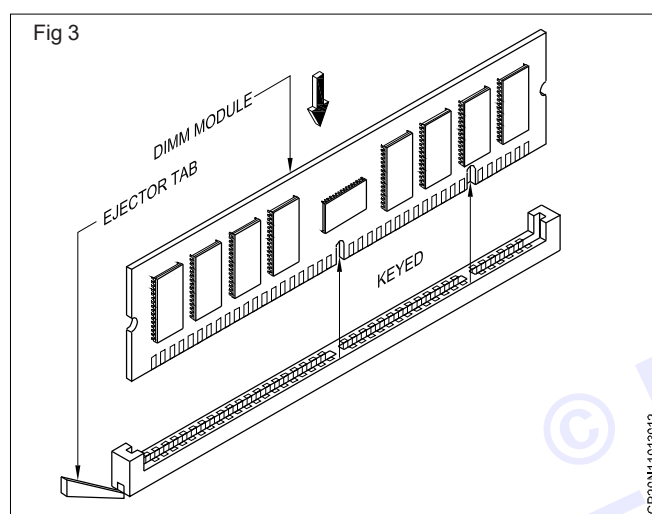
- 6 Bus slots
- 7 ROM BIOS
- 8 Clock / CMOS battery
- 9 Super I/O chips

Processor (Fig 2)



The processor is often thought as the engine of the computer shown in Fig 2. Then the processor reads the commands from the memory and then executes them. the processor is one of the most expensive parts of the computers and is also one of the smallest parts.

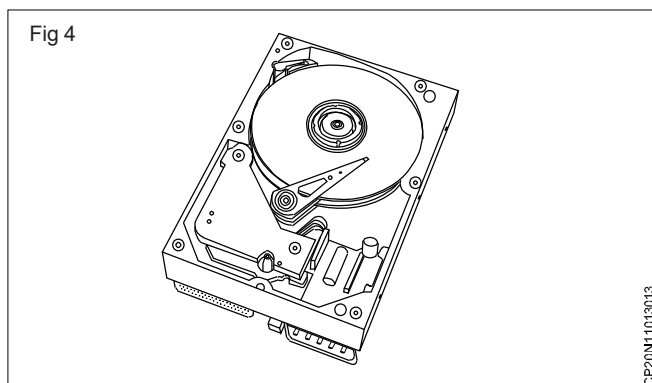
Primary Memory (Fig 3)



Memory: Is used to hold programs and data during execution.

Primary memory is often called as RAM(Random Access Memory) shown in Fig 3. It holds all the programs and data the processor is using at a given time. RAM is volatile because its contents are erased when power is switched off. The other type of system memory is ROM(Read only Memory)which is permanent because it contents are not erased even when power is switched off. It is usually used to load an operating system.

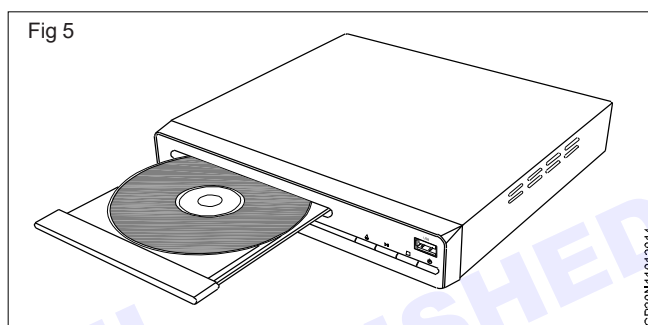
Hard disk drive (Fig 4)



A hard drive consists of spinning platters made up of aluminum or ceramic that is coated with magnetic media shown in Fig 4. The platters come in various sizes. The hard drive with many different storage capacities can be created depending upon the density, size and number of platters. This is also called as Secondary memory. There can be several programs in the system, which cannot be stored in RAM, so we need a very huge non-volatile memory, which can be used for storing all the programs, and data when the system is not in use are called as Hard disks.

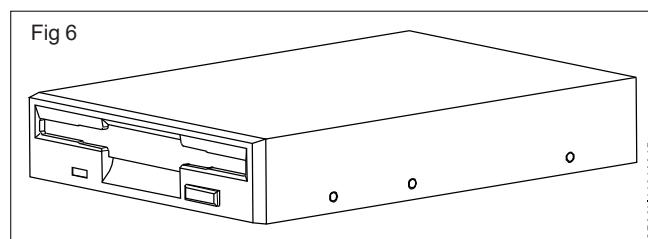
CD-ROM drive (Fig 5)

CD-ROM stands for compact disk read only memory. It consists of small disks similar to the gramophone records to hold digital information shown in Fig 5. As the name applies they are read only medium. With the advancement in technology writable CD's are also available.



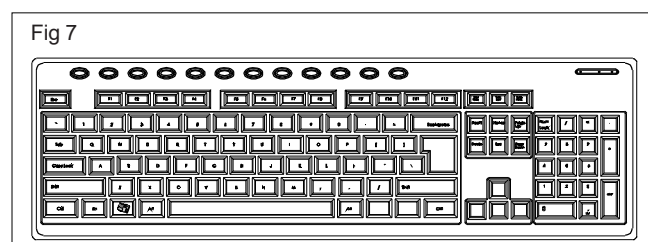
Floppy Disk Drive (Fig 6)

Floppy disks are the slowest and the smallest form of secondary storage shown in Fig 6. They provide a simple way to carry information from one place to another, and backup small amount of files. In modern days floppy drive component is not as important as it was years ago. All PC's made in the last 10 years use a standard 3 ½ inch, 1.44 MB capacity floppy drive.



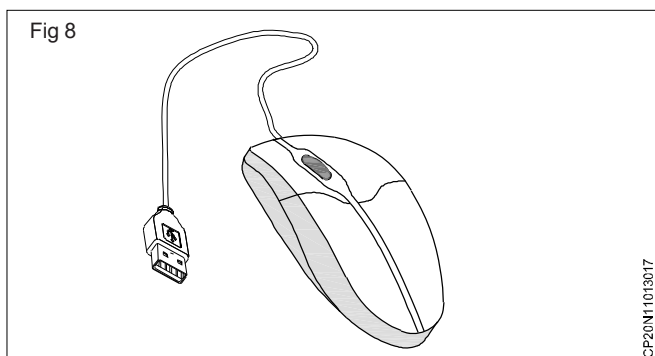
Keyboard (Fig 7)

The keyboard is the main input device for most computers shown in Fig 7. It is used to input text or enter commands into the PC. Now a days keyboards with additional features are available like multimedia keyboard, wireless keyboard.



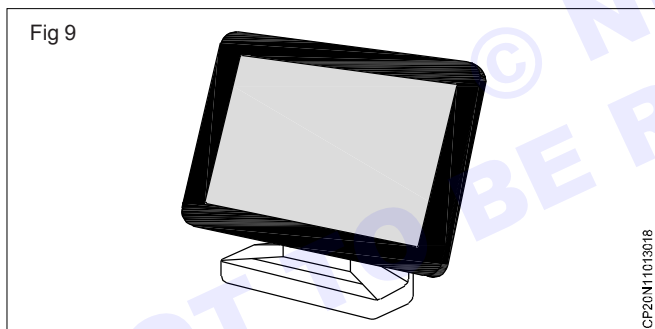
Mouse (Fig 8)

With the invention of graphical user interface mouse is used to input information into the computer shown in Fig 8. Users simply point and click to enter information. The main advantage of mouse over keyboard is simplicity. And there are many operations that are much easier to perform with a mouse than a keyboard.



Monitor (Fig 9)

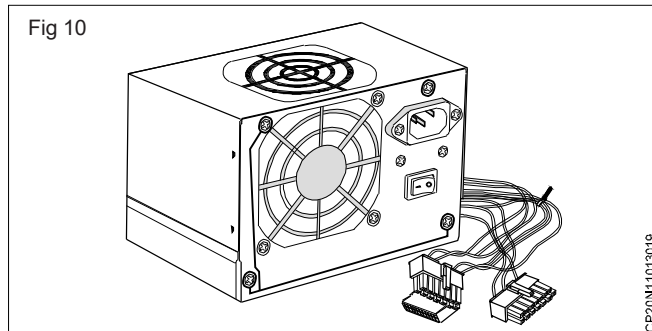
The monitor is the specialized high-resolution screen similar to a television shown in Fig 9. The video card sends the contents of its video memory to the monitor at a rate of 60 or more times per second. The actual display screen is made up of red, green and blue dots that are illuminated by electron beam from behind. The video card DAC chip controls the movement of the electron beam, which then controls what dots are turned on and how bright they are. Which then determines the picture you see on the screen.



Power supply (Fig 10)

SMPS(Switch Mode Power Supply): The power supply supplies power to every single part in the PC shown in Fig 10. The main function of the power supply is to convert the 230 V AC into

3.3 V, 5 V and 12 V DC power that the system requires for the operations. In addition to supplying power to run the system, the power supply also ensures that the system does not run unless the power supplied is sufficient to operate the system properly. The power supply completes internal checks and tests before allowing the system to start. If the tests are successful, the power supply sends a special signal to the motherboard called **Power Good**. If this signal is not present continuously, the computer does not run. Therefore, when the AC voltage dips and the power supply becomes stressed or overheated, the **Power Good** signal goes down and forces a system reset or complete shutdown.

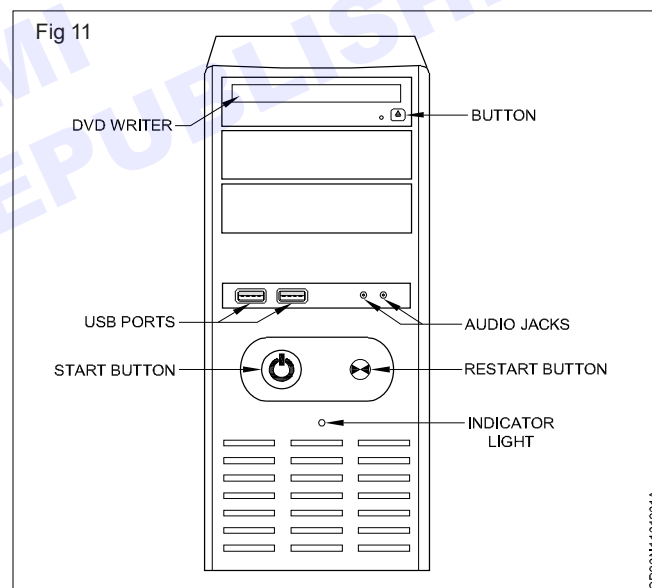


Cabinet (Fig 11)

The box or outer shell that houses most of the computers shown in Fig 11. The cabinet actually performs several important functions for your PC including protection to the system components, directing cooling airflow, and allowing installation of and access to the system components. The cabinet often includes a matching power supply and must also be designed with shape of the motherboard and other system components in mind.

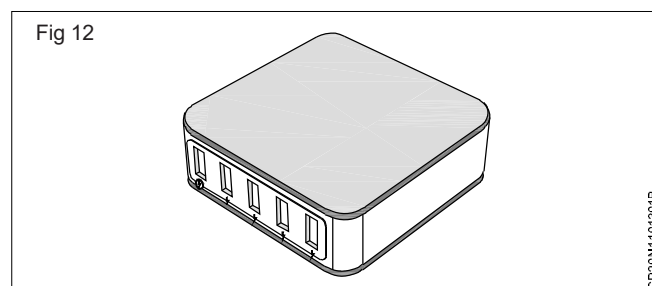
Peripheral Devices

Any external device, which is not necessary to perform the basic operation of computer, is called as peripherals. They provide additional computing capabilities. For ex : Printers, Modems, Speakers etc.



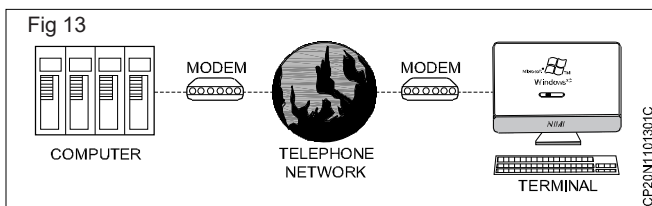
Modem (Fig 12)

Modem (Modulator and Demodulator) is typically used to send digital data over a phone line shown in Fig 12. The sending modem converts digital data into analog data, which can be transmitted over telephone lines, and the



receiving modem converts the analog data back into digital form. This is used to connect to Internet.

A typical arrangement is shown below in Fig 13



Modems are available in different capacities.

- 300 bps - 1960s through 1983 or so
- 1200 bps - Gained popularity in 1984 and 1985
- 2400 bps

- 9600 bps - First appeared in late 1990 and early 1991
- 19.2 kilobits per second (Kbps)
- 28.8 Kbps
- 33.6 Kbps
- 56 Kbps - Became the standard in 1998
- ADSL, with theoretical maximum of up to 8 megabits per second (Mbps)

Gained popularity in 1999

Printers

The capability to produce a printed version often called a hard copy of a document is the primary function of a printer. Different types of printers are 1) Laser 2) Inkjet 3) Dot-Matrix.

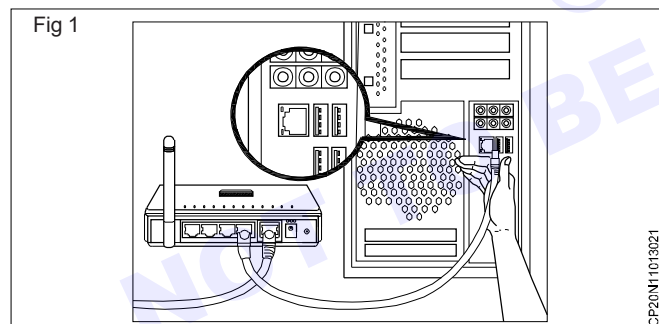
Introduction to computer ports & connectors

Objectives : At the end of this lesson you shall be able to

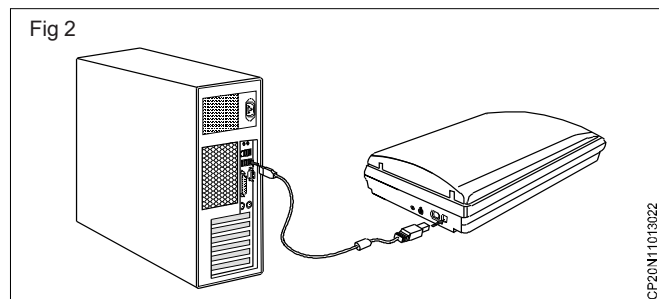
- identify and explain about computer connectors
- identify and explain about computer ports.

Network Connector (Fig 1)

The Network Connector, also referred to as a NIC card, is how your CPU talks to the network. A network cable is plugged into the back of the computer in this location shown in Fig 1. The other end of the network cable is plugged into a network jack in the wall. If the wall jack is "live", meaning it has been wired to talk to the network, then your computer will connect to the network



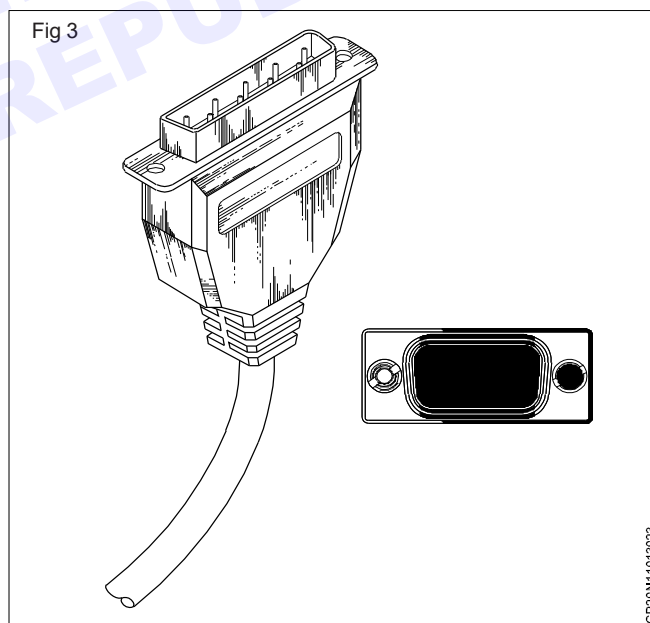
USB Ports (Fig 2)



The USB ports are present on newer machines and most often require Windows 98 or higher. If you have Windows 95, the USB ports may not work. USB ports allow you to connect an external device, such as a printer, camera, scanner, or other device to your computer shown in Fig 2. USB ports transfer information from the connected device to your computer.

Monitor Connector (Fig 3)

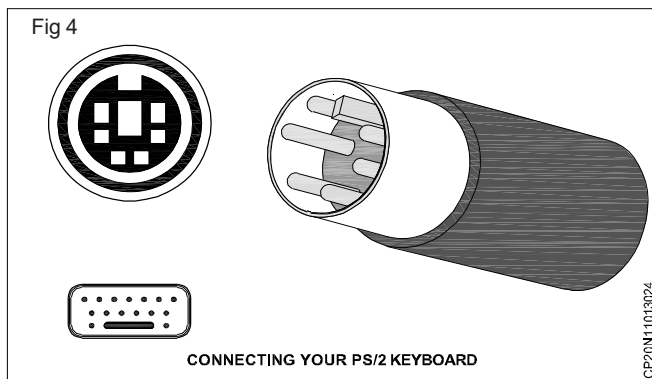
The monitor connector is a 15 pin female connector shown in Fig 3. This is how the monitor is connected to the computer. On the back of the monitor, there is a 15 pin male connector. The monitor cable gets plugged into the back of the computer in this location.



Keyboard Connector (Fig 4)

PS/2 Keyboard connector

The PS/2 Keyboard connector is where the keyboard gets connected to the computer shown in Fig 4. The keyboard cable, has a round connection with one flat side.



Mouse Connector (Fig 5)

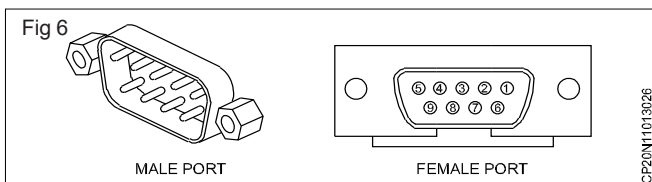
PS/2 Mouse Connector

The PS/2 Mouse connector is where the mouse gets connected to the computer shown in Fig 5. Although the keyboard connector and the mouse connector look the same, they are not interchangeable. In newer PC's, the components are color coded and it is clear where the mouse and keyboard go. In older models, the keyboard connector comes first.



Com Port 1 & 2 (Fig 6)

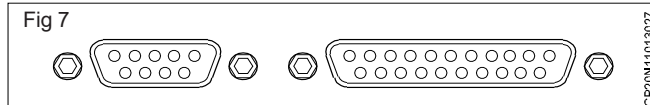
Com Ports are usually have 9 pins and are male connectors shown in Fig 6. Com Port stands for communication port and is how your computer talks to external devices such as modems, scanners or digital cameras.



Parallel Port (Fig 7)

25 Pin Parallel Port

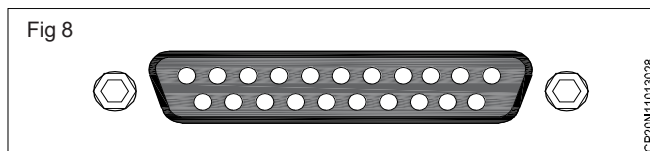
The parallel port is sometimes referred to as a printer port (or LPT1) because that is the typical device that is attached to this port. The parallel port is a 25 pin female connector shown in Fig 7. If you have a direct connect printer, the male end of the printer cable (pictured later in this manual) is connected here.



Game Stick Port (Fig 8)

Game Stick Port

The game stick port is where you would connect an external device like a game stick or joystick. It is a 15 pin female connector shown in Fig 8.



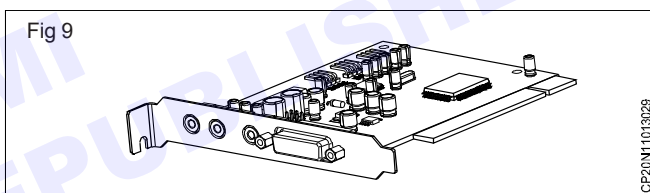
Sound Card (Fig 9)

Sound Card – Speaker Connector

Sound Card – Audio Out Connector

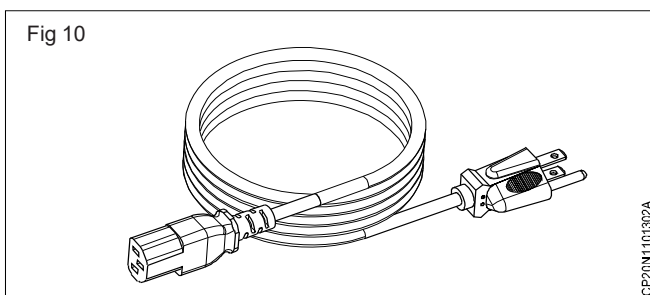
Sound Card – Microphone Connector

A sound card allows you to hear sounds from a CDROM or audio file. The connectors allow you to attach speakers, microphones or headphones shown in Fig 9. If your computer does not have these connectors, you will not be able to hear sound.



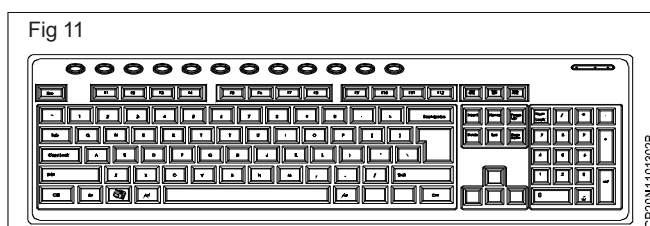
CPU Power Cord (Fig 10)

The CPU power cord connects the CPU to the electrical supply shown in Fig 10



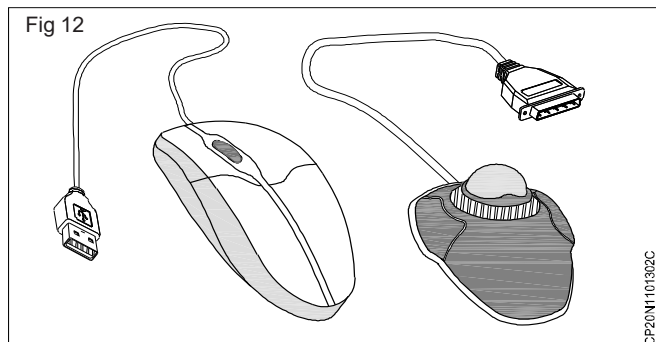
Keyboard (Fig 11)

The illustration above(Fig 11) shows two examples of keyboard connectors – the left is the larger connector and the right is the smaller. On the larger connector, there is an arrow that should face up when you are connecting it to the CPU. On the smaller connector, there is a flat side that should face up when connecting it to the CPU.



Mouse (Fig 12)

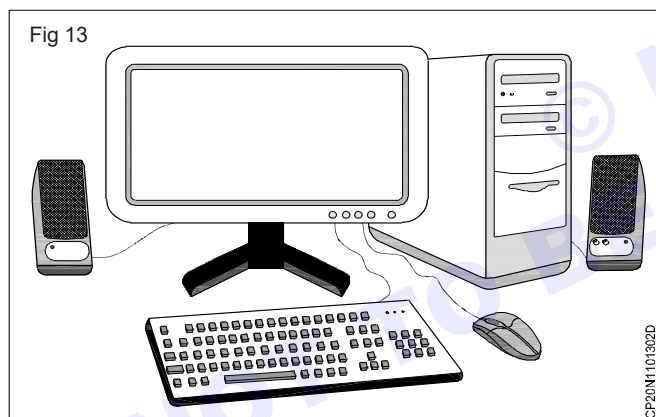
The illustrations above (Fig 12) show two examples of mouse connectors. The left is a PS/2 mouse connector (circle) and the right is a serial connector that would plug into one of your com ports



Speakers (Fig 13)

The following cords are connected to a set of speakers shown in Fig 13:

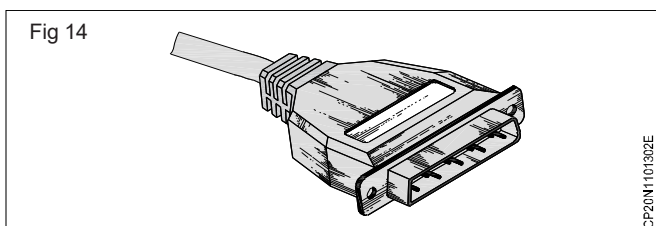
- Power cord – connecting one speaker to the power source
- Left to Right speaker connector – connecting one speaker to the other
- Speaker to CPU connector – connecting speakers to the CPU



Monitor (Fig 14)

There are two cords attached to the back of the monitor. The first is a power cord that connects the monitor to the power source. The second is a monitor cable as shown in

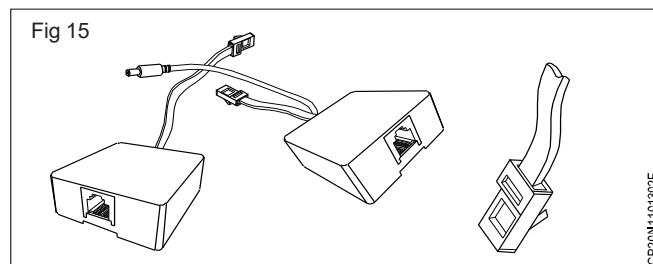
The monitor cable is a 9 pin male connector that gets connected to the monitor connector on the back of the CPU (refer to picture of the back of the CPU)



Network Cable and Network Jack (Fig 15)

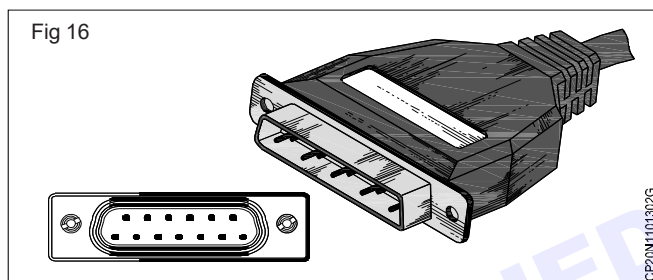
The network cable can be blue, purple or off-white. One end is connected to the back of the computer (in location A) and

the other end is plugged into the network jack on the wall shown in Fig 15



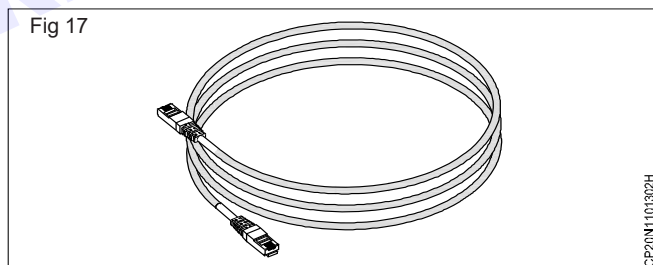
Parallel Printer Cable (Fig 16)

The parallel printer cable has one connector on each end. The 25 pin male connector gets connected to the back of the CPU in location G and the other end is connected to the local printer shown in Fig 16.



USB Printer Cable (Fig 17)

Newer computers and printers will support the use of a USB printer cable. A USB cable will transfer information more quickly than a parallel cable shown in Fig 17. The flat end of the USB cable gets connected to the back of the CPU in location B. The square end is connected to the local printer.



The following should help you put the pieces together. Please refer to the illustrations to help identify the components.

- 1 Position the CPU in the desired location
- 2 Connect one end of the **network cable** to the back of the CPU (location A) and the other to the wall jack.
- 3 Connect the **keyboard** to the back of the CPU (location D)
- 4 Connect the **mouse** to the back of the CPU (location E)
- 5 Connect the **monitor cable** to the back of the CPU (location C)
- 6 Connect the monitor power cable to the power source
- 7 If you have speakers, connect the speaker power cord to the power source, connect the left and right speaker and connect the speaker to the sound card on the back

of the CPU (location J) – note, some speakers are color coded to assist in the set-up, if yours are, follow the color codes.

- 8 If you have a local printer, connect one end of the parallel printer cable or USB Printer Cable to the back of the

CPU (location G or location B) and the other end to the printer

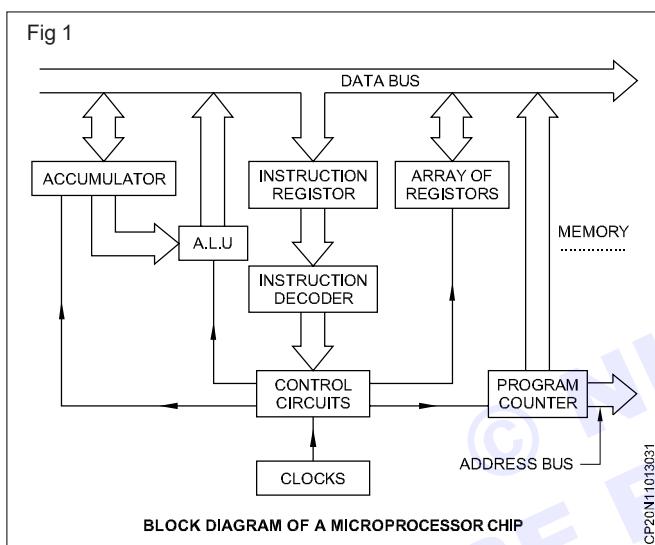
- 9 Connect one end of the power cord to the back of the CPU and the other end to the power source.

Introduction to Motherboard and CPU Architecture

Objectives : At the end of this lesson you shall be able to

- explain the constituents of the system unit, main components on the motherboard and their specifications
- explain the instruction execution – fetch and execute cycle, microprogramming concept and speed mismatch of CPU and memory
- state binary, octal and hexadecimal number system along with the ASCII and EBCDIC codes
- explain positive, negative and floating point number
- Identify different memory devices & their parts and state their uses.

System unit: The system unit consists of the following



- 1 **Memory:** This is the area used by the processor to store raw data and instructions
- 2 **Microprocessor:** This is the CPU, which is the main component in a computer that does all the processing work of the data fed into the computer.

It contains three units viz.,

- 1 Memory units (internal, called as registers)
- 2 Arithmetic Logic Unit (ALU)
- 3 Control Unit

Memory Unit: It is the nervous system of the computer. It controls as arithmetic operations to be performed. These unit co-ordinates the activities of all other units in the system. It has two main functions. They are:

- 1 To control the transfer of data and information between various units

- 2 To indicate appropriate functions by the arithmetic unit

Arithmetic Logic Unit (ALU): This unit does arithmetic calculations and logical operations involved in the program. Such as addition, multiplication, comparison etc.,

- 3 **Bus:** These are the pathways through which data and instructions pass from one area to another within the computer. The bus carries the signals to various devices that are attached to the computer. There are three buses: Address bus, Control Bus and Data bus.

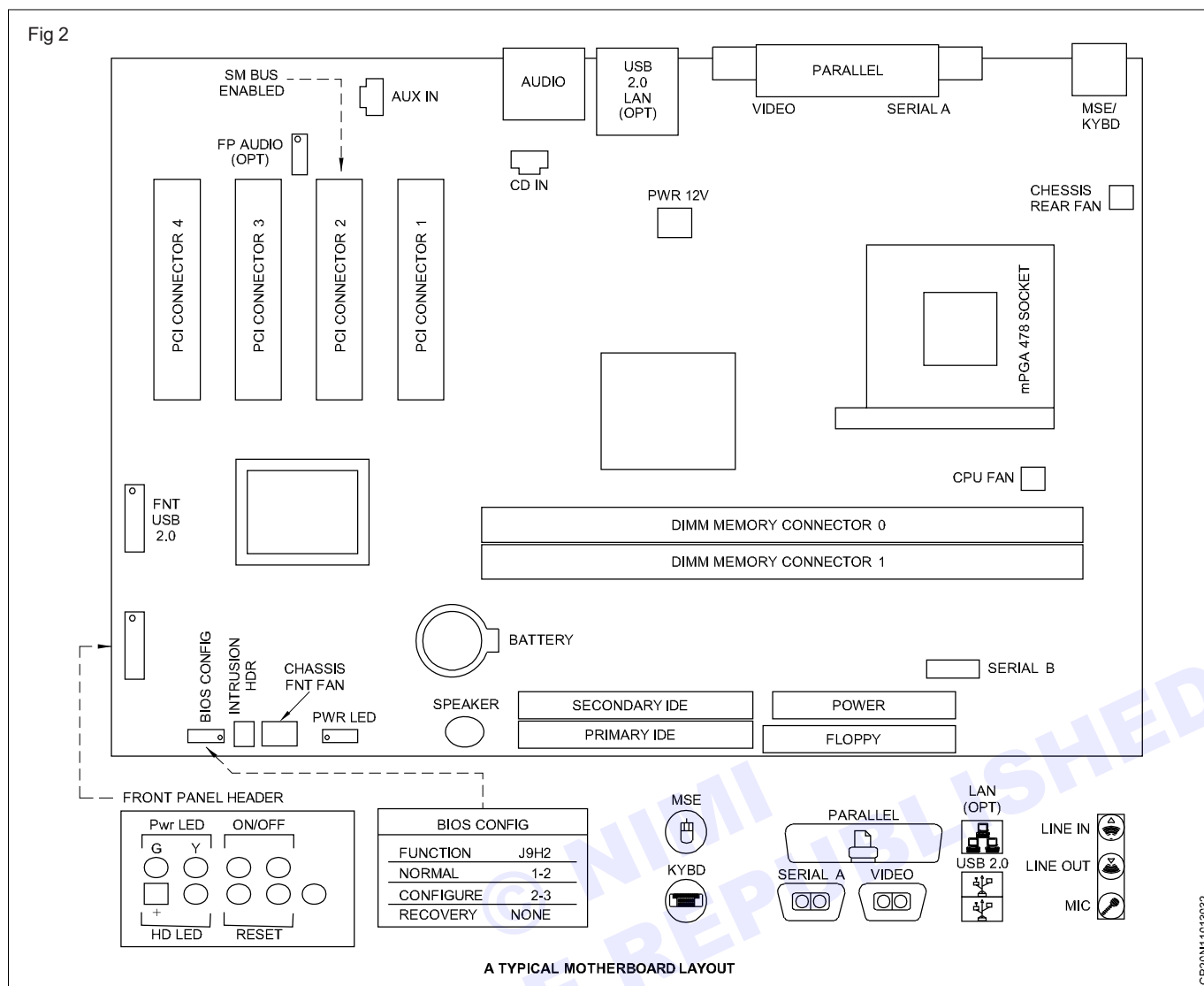
The CPU uses the address bus to select the memory address of the device in order to read and write data. The actual data is sent using the data bus. Control bus carries the control information like instructing the ALU which operation to perform. Out of these buses the address and control buses are unidirectional where as the data bus is bidirectional.

- 4 **Storage Devices:** These are the floppy drives and hard disk drives, both of which we would discuss in detail in the lesson on secondary memory devices.

- 5 **Motherboard:** The motherboard is the primary component of the entire system. Without the support circuitry and functions that this device provides, even the CPU is unable to function. The detailed diagram of a motherboard is given below.

The various slots are provided to mount add-on cards like display cards, sound card, internal modem, hard disk controller cards etc. However, now a days most of these cards come in built within the motherboard itself.

Fig 2



CP20N11013032

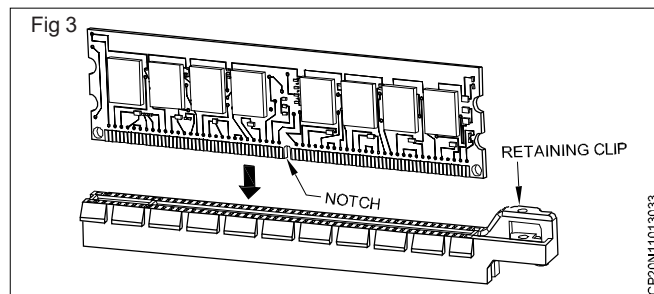
Tips for removing add-on cards from the motherboard

- 1 Put on anti-static wrist strap.
- 2 Ensure that all the cables from the add-on card connected on to the motherboard is removed. Label the removed cable with suitable information. Before removing, record to which slot on the motherboard it was plugged.
- 3 Remove the boards mounting screw which fixes the metal mounting bracket of the add-on card.
- 4 Hold the board along its two edges as shown in Fig 3 and rock it up gently using equal force at both holding ends and remove the card.

After removing the card, Avoid touching the edge connector of the card.

- 5 Place the card preferably in an antistatic mat such that the components on the card are visible to you.
- 6 Identify and record the jumper settings on the card.
- 7 Identify and record the switch setting if any on the motherboard.

Fig 3



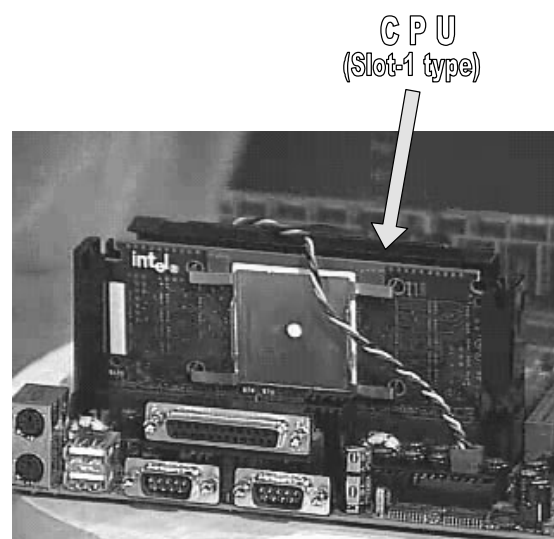
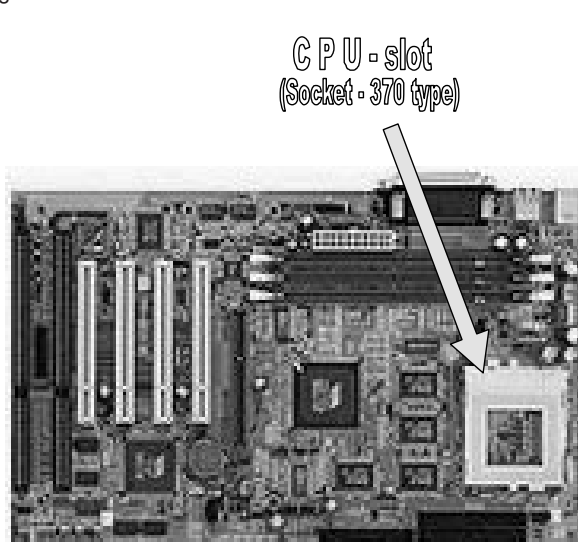
CP20N11013033

- 8 Place the add-on card safely in anti-static pouch and keep it safely in the drawer of your working table or in a shelf.

Tips for removing the Mother board from the cabinet

When all the cables and add-on board are taken out from the processor unit of PC, then it looks quite easy to work further

Fig 4



- 1 Ensure that all the cables from, the mother board is removed
- 2 Ensure that all the add-on cards connected on to the mother board is removed.
- 3 Plan/determine your most likely exit route for the mother board.
- 4 Remove the two screws holding motherboard on the chassis of the cabinet.
- 5 Locate the plastic pinch spacers holding the motherboard on to the chassis of the cabinet.
- 6 slide the motherboard until the plastic pinch spacers feel free of the motherboard using nose pliers

Make sure that you don't accidentally remove any jumper switches with rough handling. Correct jumper settings are crucial for proper operation of the motherboard.

Most CPU's of both types will generate have micro fan mounted right on the chip.

RAM Modules: These memory modules can be seen as small PCB strips(much smaller than add -on cards) plugged into lengthy slots(DIMM-168-pin) (SIMM-72 pin) (SIMM-30 pin) perpendicularly on the motherboard as shown in Fig5. You may see only one RAM module strip or more than one. Each RAM module strip may have capacity ranging from 4 MB to more than 128 MB .Some types of memory module cards are shown in Fig 5. You will generally see two small plastic card extractors on the edges of the connector as shown in Fig 6.

- 7 Store the PC cabinet in a safe place.
- 8 Keep the working table clean and place the mother board for studying.
- 9 Record the jumper and switch setting on the motherboard.

Fig 5

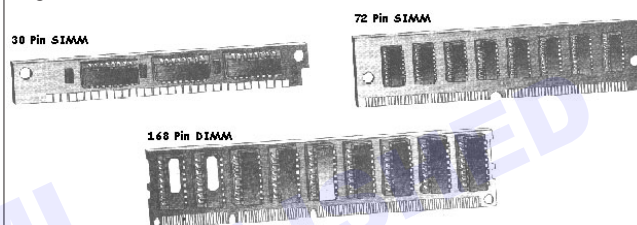
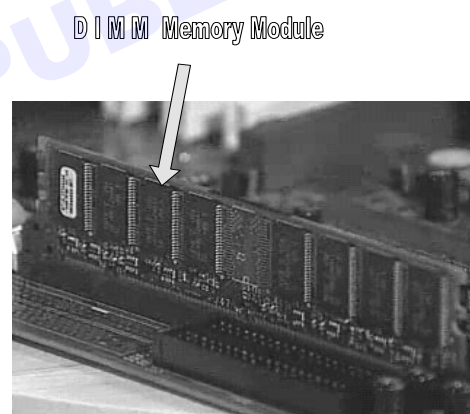


Fig 6



128 MB DIMM Memory module

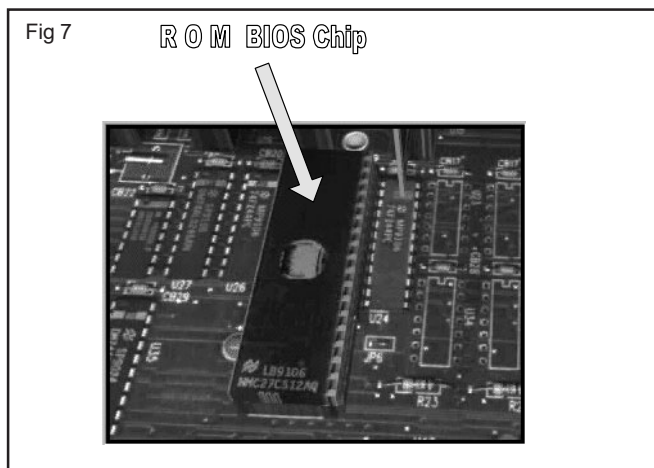
Tips for identifying the major components an the mother board

CPU: The Central Processing Unit or CPU ,is an integrated Circuit(IC). This will be biggest IC which you can easily identify. This IC can be of two basic types:

- 1 A super socket-7 or socket 370 types as shown in Fig 4.

- 2 A socket -1 type as shown in Fig 4.
- 3 **ROM BIOS Chip:** This means Read Only Memory Basic input-output System. These Chips contain permanent code that the PC uses when the PC is first turned-On.

This chip looks similar to the one as shown in Fig 7. Most ROM Bios Chips will have a glass window at its center as shown in figure. Some times this window is closed using a adhesive glossy paper slip on which it would be marked the marker of this Bios such as AWARD or AMI or PHOENIX and like. On this glossy paper slip ,a few other details including the year will be printed. This is an important data to be recorded.



- 4 **Battery:** A round shining big coin like thing ,held in a plastic enclosure with a '+' mark can be seen on the mother board. This is technically called as a button cell. This is actually a Lithium ion battery. This provides power supply to the CMOSRAM for maintenance of Real Time Clock(RTC) and BIOS settings. This small but most important component on the mother board is shown in Fig 8

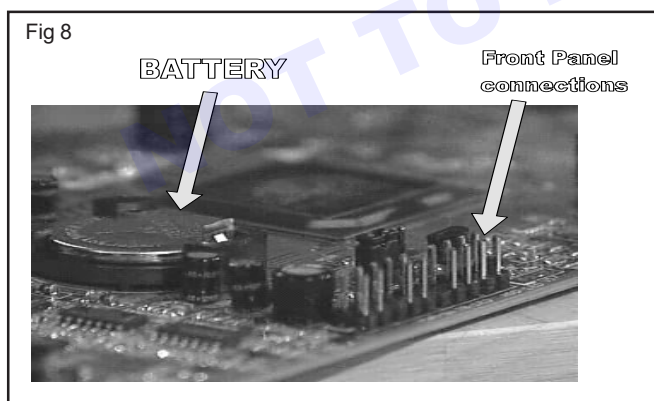
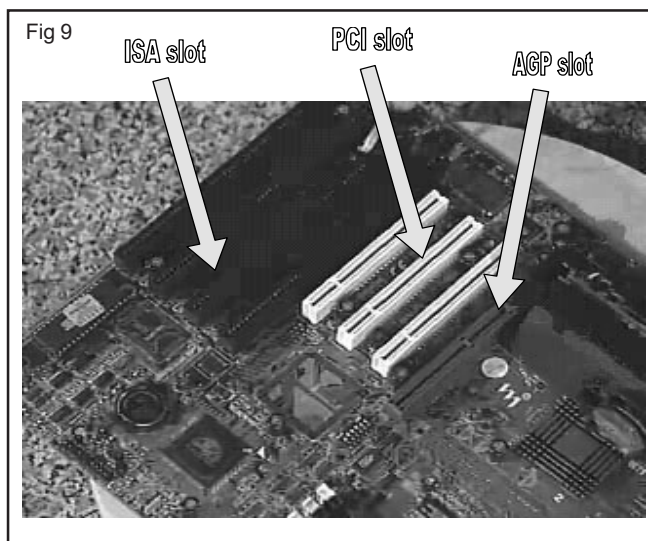


Fig 8 also shows a connector with lot of pins, generally in pairs . These provide necessary signal for the LED's and switches mounted on the front panel of the PC. Right by the sides of this connectors, markings can be seen as to which it should be connected, such as, LED,SPK, RST, etc.

- 5 **ADD-ON Cards/Expansion Card SLOTS:** There will generally be three different types of slot female edge connectors as shown in Fig 9



ISA slots: ISA means Industry Standard Architecture. This type of connector will be Black in color and is the longest of the three types. This slot is called as the ISA slots. These are the old versions and hence your PC mother board may have just one slot of this type or more. Note that your mother board may not have this type of slot also. If so, don't be worried as ISA is an old type and not very essential.

PCI slots: PCI means Peripheral Component Interconnect. These are more recent type compared to ISA and are very popular. These slots are generally white in color and smaller in size compared to ISA slots. A PC Motherboard will definitely have one PCI slot but generally more than one.

AGP slots: AGP means Accelerated Graphics Port. This slot is much more recent than the PCI slot and this slot holds the add-on graphic card to enhance the graphic capabilities of your PC. This slot is generally brown in color and there will be only one such slot on the mother board. If the AGP control circuit is integrated on the mother board itself, then you may not find an AGP on the mother board.

L2 Cache Slot: Some mother board will have small slots for placing cache memory chip modules. These slots are generally white in color . Not all mother boards will have this slot.

IDE/EIDE Connectors: These are 40 pin male black colored connectors as shown in Fig 10. Most motherboards will have two such connectors, one slot marked as IDE1 or Primary and other as IDE2 or Secondary. Through these connectors IDE/EIDE devices such as HDD's and CD ROM drives are connected to the motherboard.

Floppy Diskette Drive Connector: This is a 34 pin mate black plastic connector as shown in Fig 11. On most motherboards there will be only one such connector. The cable used with connector will have facility to connect two floppy diskette drivers.

Power supply connector on the Motherboards: This will generally be a plastic male Molex connector will be one connector strip of 12 pins in single line .In case of ATX models, there will two rows of 10 pin connectors. Fig 12 shows the power supply connector on the mother board.

Fig 10

IDE-1 and IDE-2

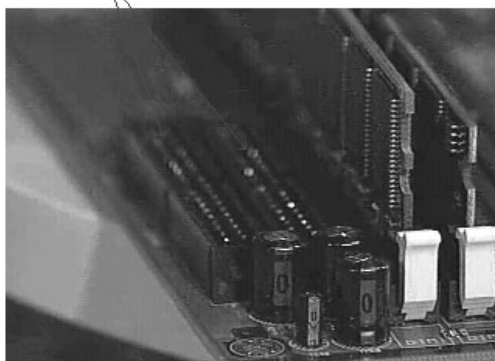


Fig 11

34-pin FDD Connector

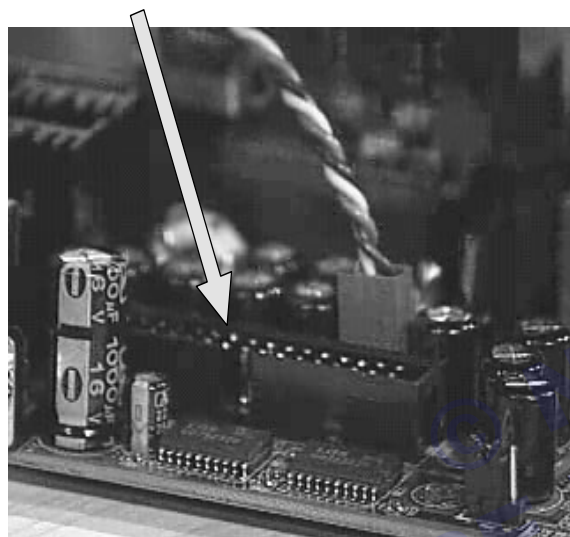
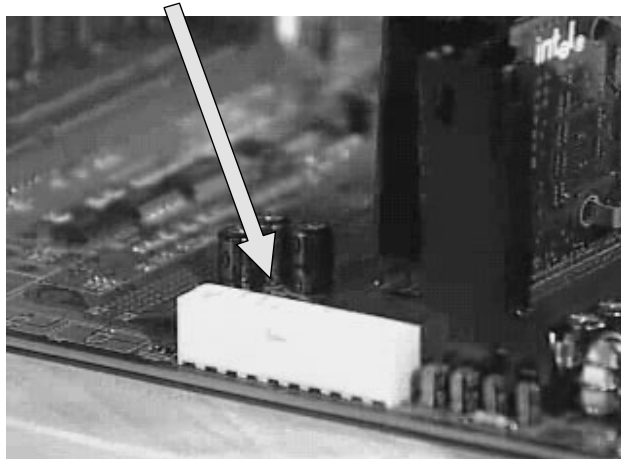


Fig 12

POWER SUPPLY CONNECTOR (AT)



Keyboard port, Mouse Port, On Board Serial and Parallel Port: Keyboard Port is one which is always on the Mother. The key board port can be of these types listed below and shown in Fig13.

- 1 The olden type-5 pin –DIN connector
- 2 The more recent type -6 pin P/S -2 connector.
- 3 The most modern USB port

These motherboards having only the 5-pin DIN port can also use P/S 2-keyboards using a cross adapter cable.

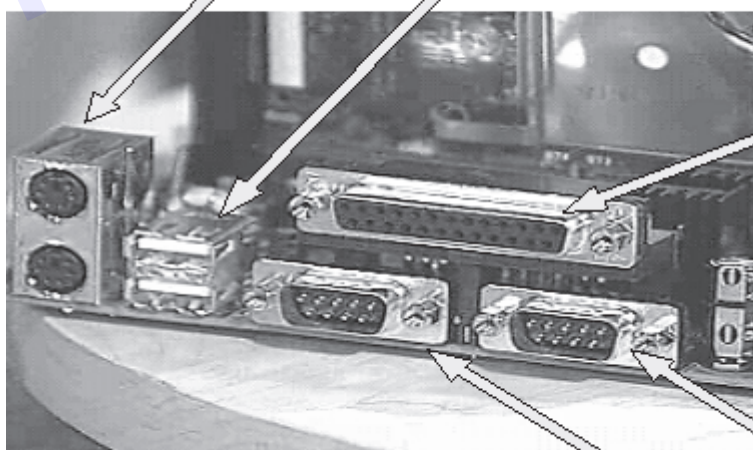
Those motherboard not having USB(Universal Serial Bus) circuitry on board can place a USB adapter card in one of the PCI slots. Then use the USB connector for connecting a USB keyboard.

Fig 13

PS/2 Ports
Mouse and Keyboard

U S B Ports

Parallel Port

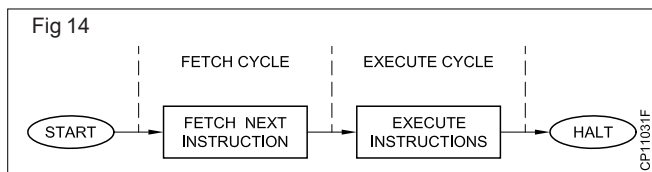


SERIAL Ports

Serial ports are generally a 9 pin male mini D shell type(DB-9) connector. Generally any motherboard will have at least

two serial ports. All motherboard may not have the serial port connectors mounted right on the motherboard at its

edge as shown in figure above. But there will be a two 9 pin connector on the motherboard some where, using which, you have to run 9 wire flat cables to the ports mounted on a metal plate and fixed at one of the metal slots found at the rear of the cabinet.



Some devices need a 25 pin serial port(DB-25). However there will be only 9 pin connections at it. These DB-25 serial port can be easily identified because, this 25 pin slot is a male connector(Where as a DB-25 pin female is a parallel port).

Mouse is connected to any one of the DB-9 serial port or a P/S-2.6 pin mini DIN connector or a USB port. Where is the mouse to be connected depends upon the type of connector your mouse has. However, you can use cross adapter cable to connect a mouse to a P/S-2 port or vice versa.

CPU Architecture: The basic function performed by a computer is execution of a program, which is a set of instructions stored in memory. The processor does the actual work by executing instructions specified in the program. The instruction execution takes place in the CPU registers, which are:

Memory Address Register (MAR): It specifies the address of memory location from which data or instruction is to be accesses (for read operation) or to which the data is to be stored (for write operation).

Program Counter (PC): It keeps track of the instruction which is to be executed next, after the execution of an on-going instruction.

Instruction Register(IR): Here the instructions are loaded before their execution.

Instruction Execution: The simplest model of instruction processing can be a two step process. The CPU reads (fetches) instructions (codes) from the memory one at a time, and executes or performs the operation specified by the instruction. Instruction fetches involves reading of an instruction from a memory location to the CPU register. The execution of this instruction may involve several operations depending on the nature of the instruction.

The processing needed for a single instruction (fetch and execution) is referred to as **instruction cycle**. The instruction cycle consist of the fetch cycle and the execute cycle. Program execution terminates if the electric power supply is discontinued or some sort of unrecoverable error occurs, or by a program itself.

Fetch Cycle: For fetch cycle, typically the program counter is used. Program counter keeps track of the instructions which is to be fetched next. The fetched instructions is in the form of binary code and is loaded into an instruction register in the CPU.

Execute Cycle: The CPU interprets the instructions in the instruction register and does the required action. In general, these action can be divided into the following categories.

- 1 Data may be transferred from processor to memory or from memory to processor.
- 2 Data may be transferred to or from a peripheral device and an I/O module.

Following are few of the important output devices, which are used in Computer Systems

Computer - Memory

A memory is just like a human brain. It is used to store data and instruction. Computer memory is the storage space in computer where data to be processed and instructions required for processing are stored.

The memory is divided into large number of small parts. Each part is called cell. Each location or cell has a unique address, which varies from zero to memory size minus one.

For example, if computer has 64k words, then this memory unit has $64 * 1024 = 65536$ memory locations.

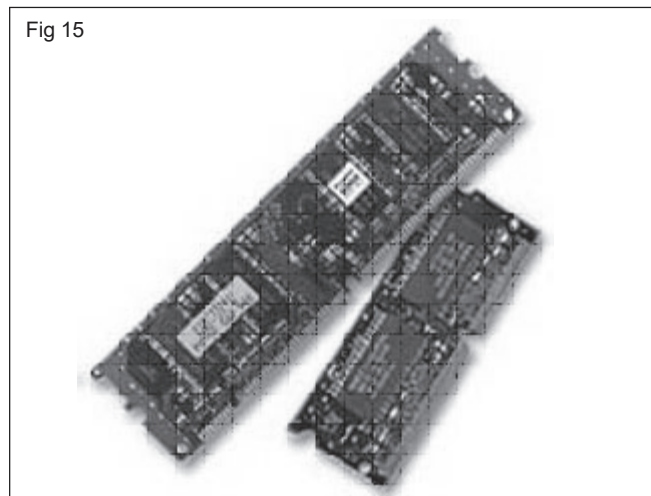
Memory is primarily of three types:

- 1 Cache Memory
- 2 Primary Memory/Main Memory
- 3 Secondary Memory

Computer - RAM (Fig 15)

A RAM constitutes the internal memory of the CPU for storing data, program result. It is read/write memory. It is called random access memory (RAM).

Since access time in RAM is independent of the address to the word that is, each storage location inside the memory is as easy to reach as other location & takes the same amount of time. We can reach into the memory at random & extremely fast but can also be quite expensive.



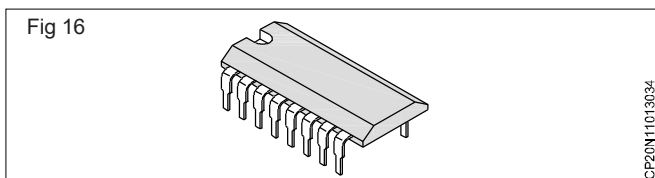
RAM is volatile i.e. data stored in it is lost when we switch off the computer or if there is a power failure. Hence, a backup uninterruptible power system (UPS) is often used with computers. RAM is small, both in terms of its physical size and in the amount of data it can hold.

RAM is of two types

- 1 Static RAM (SRAM)
- 2 Dynamic RAM (DRAM)

Computer - ROM (Fig 16)

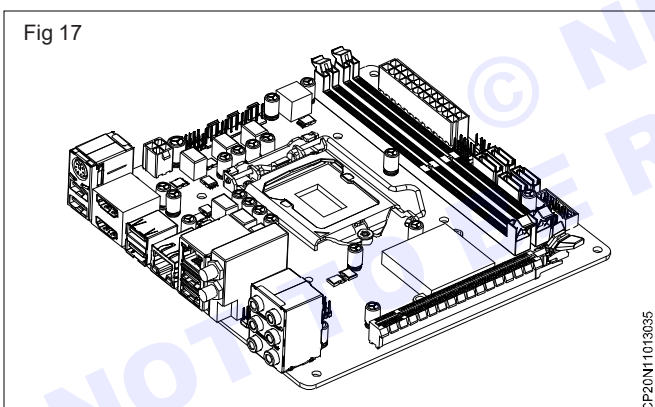
ROM stands for Read Only Memory. The memory from which we can only read but cannot write on it. This type of memory is not-volatile. The information is stored permanently in such memories during manufacture.



A ROM stores such instructions as are required to start computer when electricity is first turned on, this operation is referred to as bootstrap. ROM chip are not only used in the computer but also in other electronic items like washing machine and microwave oven.

Computer - Motherboard (Fig 17)

The motherboard serves as a single platform to connect all of the parts of a computer together. A mother board connects CPU, memory, hard drives, optical drives, video card, sound card and other ports and expansion cards directly or via cables. It can be considered as the backbone of a computer



Features

- 1 Motherboard varies greatly in supporting various types of components
- 2 Normally, a motherboard supports a single type of CPU and few types of memories
- 3 Video Cards, Hard disks, Sound Cards have to compatible with motherboard to function properly
- 4 Mother boards, cases and power supplies must be compatible to work properly together

Computer - Memory Units

- 1 It is the amount of data that can be stored in the storage unit.
- 2 The storage capacity are expressed in terms of Bytes

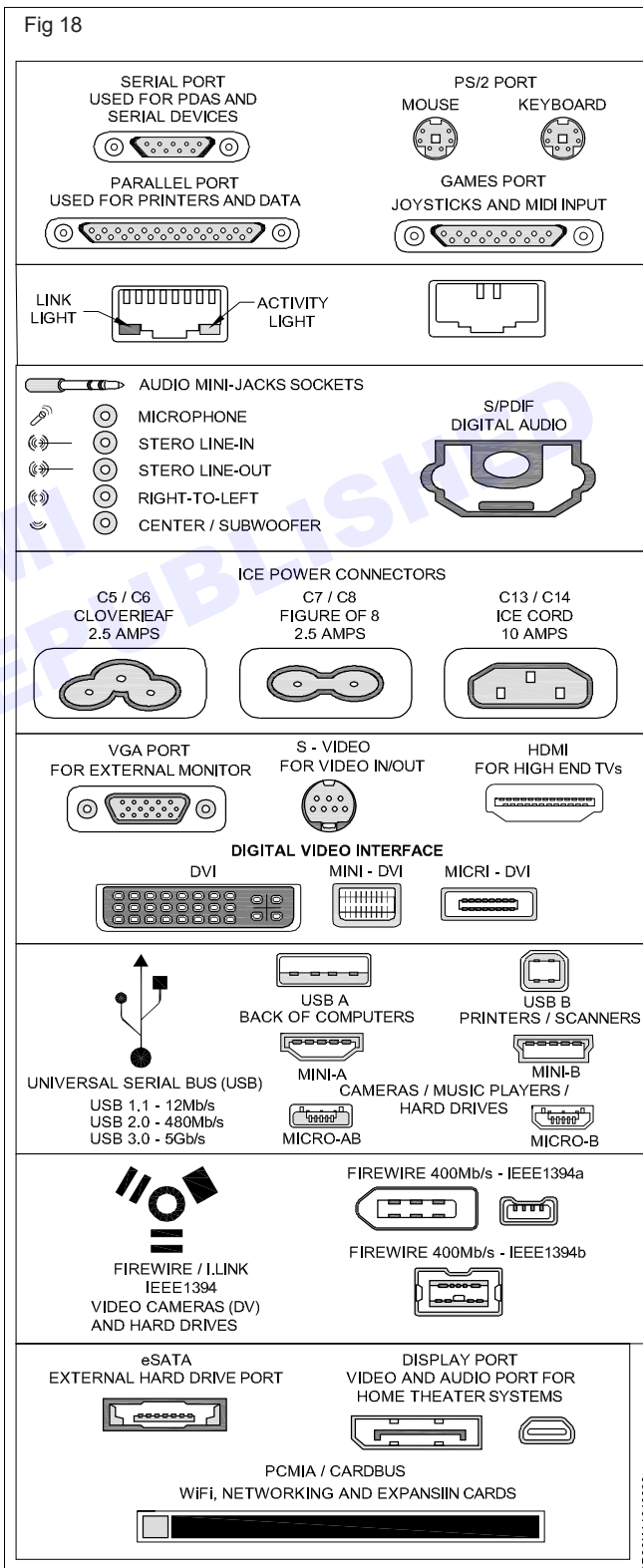
Computer - Ports

- 1 A computer port is a physical docking point using which an external device can be connected to the computer

- 2 A computer port can also be programmatic docking point through which information flows from a program to computer or over the internet.

Characteristics

- 1 External devices are connected to a computer using cables and ports
- 2 Ports are slots on the motherboard into which a cable of external device is plugged in. Examples of external devices attached via pots are mouse, keyboard, monitor, microphone, speakers etc. (Fig 18).



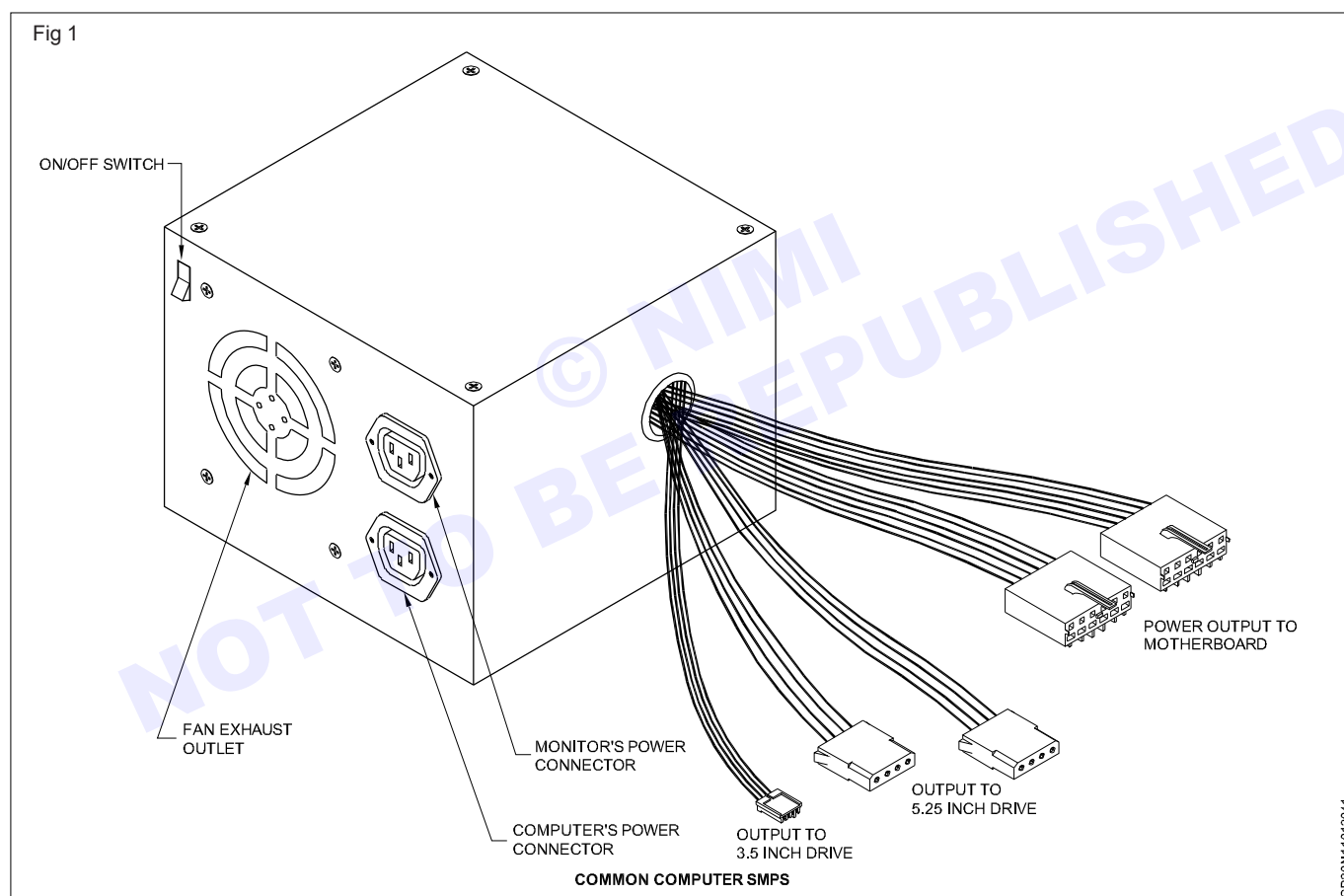
Switch Mode Power Supply for PC

Objectives: At the end of this lesson you shall be able to

- list the parts of SMPS
- list the various power capacities of SMPS
- explain the use of fan
- explain with block diagram the working principle of an SMPS
- explain the working of TL494 PWM IC
- list the precautions to be taken while testing and troubleshooting SMPS
- state the advantages and disadvantages SMPS over conventional power supply
- state the difference between AT and ATX power supplies.

Switch Mode Power Supply of a PC is housed in a metal box. SMPS consists of an electronic circuit board, a fan, AC power sockets, power supply interface connectors for motherboard, hard disk drive and floppy disk drive. AC power switch connected to the power cable from the SMPS. The connectors are polarised and standards are followed so that any PC SMPS can be interchanged. A typical SMPS is shown in Fig 1.

The SMPS comes in various capacities for PCs. The capacities are 80W, 150W, 200W, 230W, 250W and 280W. For PC nodes/ unix terminals 80W supply is used. The connector details are printed on the cover of the SMPS as shown in Fig 2. Table 1 gives the colour of wire for different voltages and the current ratings.



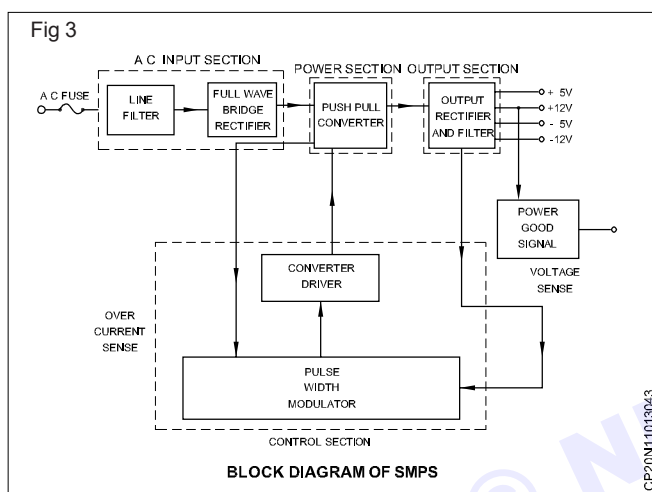
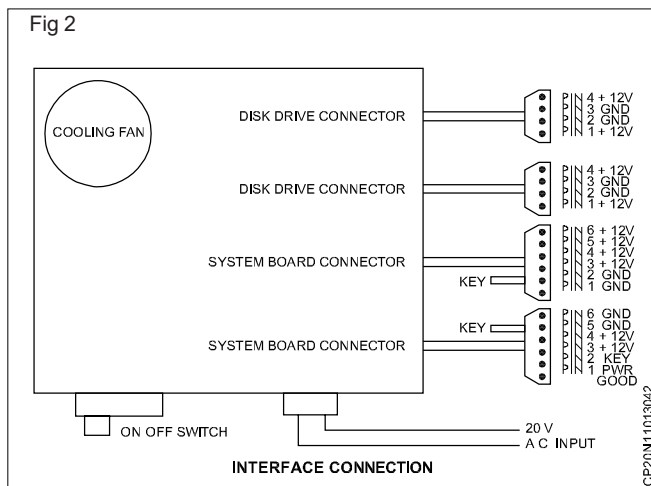
DC outputs

Red	+5V	20A max	Total power	200W
Yellow	+12V	8A max	AC Input	220-240V
White	-5V	0.5A max		
Orange	PG			

A 12V DC fan is used for removing the heat generated inside the power supply. The fan blows out air from the SMPS. The fan also helps in air circulation inside the cabinet. Proper working of fan is ensured by periodic cleaning. Whenever the fan is working intermittently the fan should be cleaned for dust near the motor. A failed fan can result in the failure of the SMPS because of excess heat.

Block diagram of SMPS

The block diagram in Fig 3 shows the various functional sections in SMPS.



The AC input section consists of a line filter and current limiting resistors/thermistors. Line filter is a protective circuit. Any variations in main supply is suppressed by the filter area. Line filter circuit consists of inductor and high voltage capacitors. A MOV (Metal Oxide Varistors) is connected across the AC supply to prevent any over voltages.

AC input is converted to DC voltage by a bridge rectifier and filter capacitors. Around 300 volt DC is developed across the capacitors. The power section consists of high frequency ferrite core transformer and switching power transistors to switch DC voltage across the transformer winding. A current sense circuit is provided to sense overload current and to protect the SMPS from over loading.

The output section consists of output rectifiers and filter circuits. A voltage sense circuit is used for feedback to the control section. The 5 volt is sensed for regulating the pulse width of the controller. The diodes used for rectification are schott key diodes. Since the AC outputs of the transformer are at 20KHz, normal silicon diodes cannot be used. Special fast recovery schott key diodes are used. Example of schott key diode are BA157. The filter circuit consists of an inductor and capacitor.

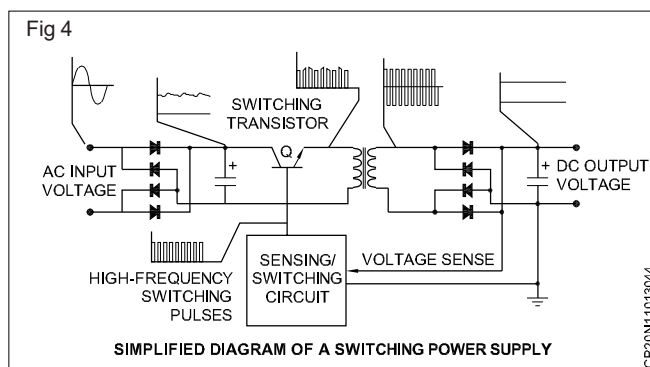
Power good signal section checks for the correct level of DC voltages and gives a power good signal to the motherboard. Power good signal is connected to the reset

pin of the processor. Power good signal is given to reset pin after a delay when the voltage levels are correct and satisfactory.

The controller section consists of a pulse width modulator circuit. The output voltage of 5V is sensed and compared with a reference voltage. Any change in 5V with respect to load creates an error voltage. This error voltage modifies the pulse width of output pulses. The output pulses in turn drives the power switching transistor. The output pulses are not directly connected to the power switching transistors. Isolation is provided by a driver transformer. Over current is sensed through a current transformer. The output of current transformer is rectified and used to shutdown the power controller when an excess current is drawn.

Working principle of SMPS

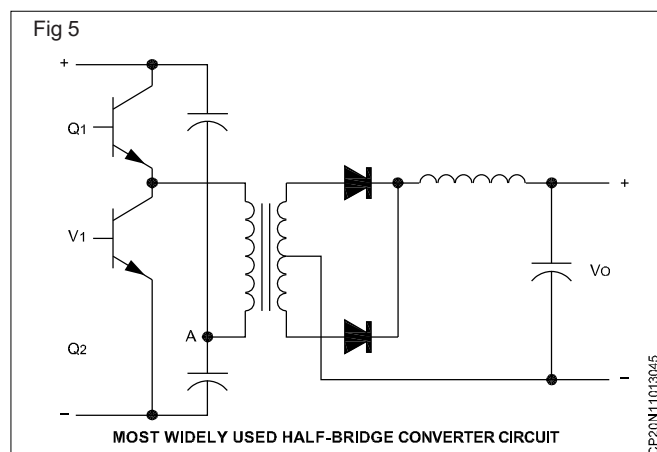
AC line input is rectified and converted to DC voltage. The DC voltage is switched at high frequency nearly 20 KHz. The switched voltage is fed to the high frequency step down transformer. The output of the transformer is rectified and energy is stored in an inductor and smoothened by a capacitor. The switching period (pulse width) is controlled by the feed back given to the controller section. Power switching transistors ON time is varied according to the load. When the load increases the output voltage tends to drop. This drop in voltage is fed as the error signal to power controller which increases the ON period of switching pulses. When the load decreases the output goes high. The error voltage is fed to the controller which reduces the ON period of switching pulses. Since there are many outputs in a PC SMPS i.e. 12V, -12V, -5 only the main 5 volts which supplies maximum current is sensed and regulated. The transformer winding is designed taking care of this aspect. A simplified diagram of a switching power supply is shown in Fig 4.



Most widely used configuration in PC SMPS is half bridge converter circuit as shown in Fig 5. Power transistors Q1 and Q2 switch the DC voltage through the windings in a push pull manner.

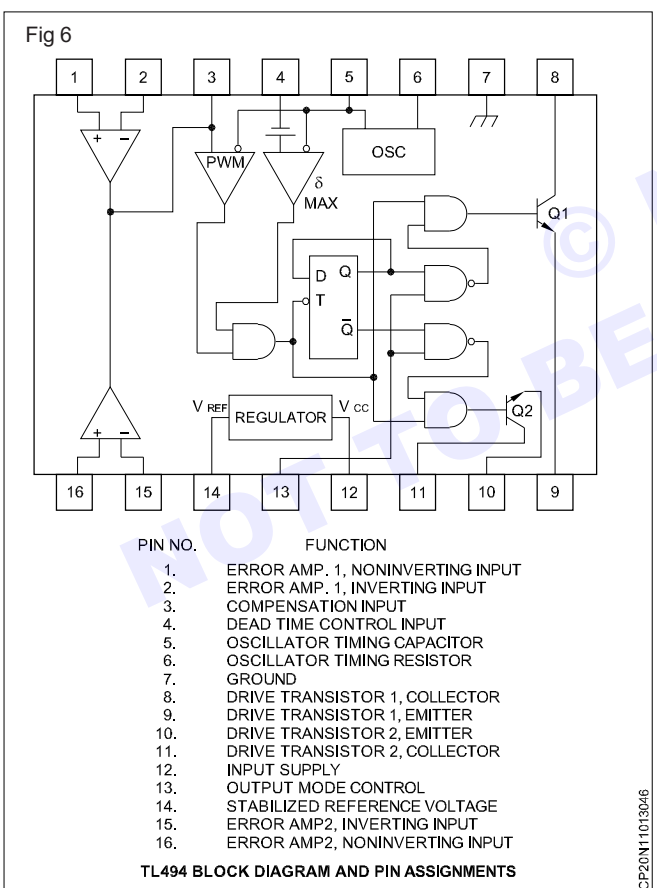
In most of PC SMPS there is no separate step down transformer used for the power supply of the PWM IC. It is derived from the main ferrite core transformer output. Primary winding of the transformer with a capacitor and resistor along with part of driver transformer form a self oscillating circuit. This oscillation produces secondary output. The 12V winding output is used to power the PWM IC. Once powered the PWM IC takes over the switching

operation. Thus the need for separate power supply for the IC is eliminated.



Pulse width modulation control IC 494

Most widely used PWM IC in a PC SMPS is TIL 494. Fig 6 show the pin details and functional details of IC 494. The IC contains an oscillator circuit with external resistor and capacitor. A 5 volt reference is available for feedback control. Two error amplifiers are used to control pulse width and current limit.



The dead time control input is useful in starting the switching operation gradually so that the switching transistors are not loaded suddenly. There are two driver transistors. They are used to drive the power switching transistors.

Good power

In addition to providing converted power to the motherboard and the other parts of the PC, the power supply also sends

a very important signal to the motherboard called - the Power-Good signal.

When the PC is powered on, the power supply performs a self test and checks to see if the required voltages (in and out) are correct. If so, the Power-Good signal line is set high (on) to indicate that the motherboard can relay on the power being supplied. If the signal is not set, the processor's timing chip (to which this signal line is attached) will send the processor a Reset command that starts the basic input/output (BIOS) initialization code. The effect of the Power-good signal not being set is that the PC is trapped in a loop continuously calling the BIOS. In this situation, the power supply appears to be working and some power is being supplied to the PC and its peripherals. The front panel lights may be on, the disk drives spinning, and the power supply fan running, but the BIOS will never reach the power-on self-test (POST) process and will appear to be hung up on something.

Power On and Off

On ATX and most of the other later form factors, the motherboard can turn the power supply on or off. This is done through the PS-ON (power supply on) signal that passes between the motherboard and the power supply. If your PC powers off when windows is finished shutting down, you have this feature.

Another indicator that your power supply supports PS-ON is the use of Momentary On or Always On power switches that are connected to the motherboard in place of an exterior switch connected to the power supply. When this signal line is pulled to a low voltage signal, the +12V DC, +5V DC, +3.3V DC, -5V DC and -12V DC power lines are turned on. When it is pulled to a high-voltage signal, or open-circuited, the DC output lines should no longer have current. The +5V DC output is always on as long as the power supply is receiving AC power. Because the ATL, NLX, LTX and other form factor motherboards have some power running to them at all times, you will always want to unplug the PC before working on it.

Advantages and disadvantages of SMPS

SMPS for the power rating is smaller in size. A conventional power supply for similar power rating will be heavy and big in size.

SMPS efficiency is very high so heat dissipation is low. A conventional power supply efficiency is less and heat generated is more.

SMPS output has high frequency noise. So cannot be used for critical applications. In conventional power supply the noise is very minimal

Servicing of SMPS is difficult because of interdependence of circuits and components.

Servicing of linear power supply is relatively straightforward.

Difference between AT and ATX power supply

AT power supply does not have soft start option.

AT power supply does not generate 3.3V DC.

AT motherboard supply connectors come with 2x6 pin connection.

ATX power supply has a soft start.

ATX power supply does not shut down completely. Always the ATX power supply gives 5 volt to the mother board.

ATX power supply generates a 3.3V DC for the processor core voltage.

Precaution to be taken while testing and servicing an SMPS

Since the SMPS is operating directly from rectified 220V

AC, potentially hazardous DC voltage exist inside. So care should be taken while opening and testing.

High voltage capacitors must be discharged safely using a resistor.

When using any AC powered instrument to test an SMPS the instrument must be isolated. To isolate use isolation transformer.

Some SMPS start with sufficient load only.

Troubleshooting SMPS with the complaint “Momentary fan rotation on power up”

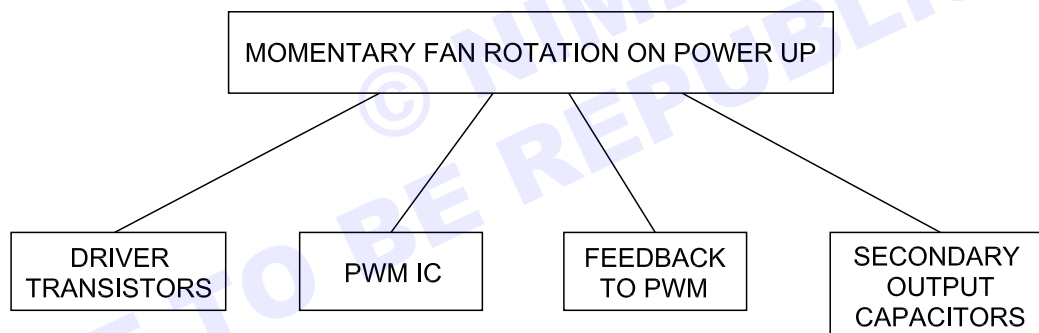
Objectives: At the end of this lesson you shall be able to

- list the probable defect and symptoms in the faulty SMPS
- analyse the causes for the complaint “Momentary fan rotation on power up” with the help of a problem tree and TSC
- state the shortest path for servicing the defect using SFS.

PROBLEM TREE : PT-01

Observed symptom : Momentary fan rotation on power up

Additional symptom : No output



Troubleshooting SMPS with the complaint “No output”

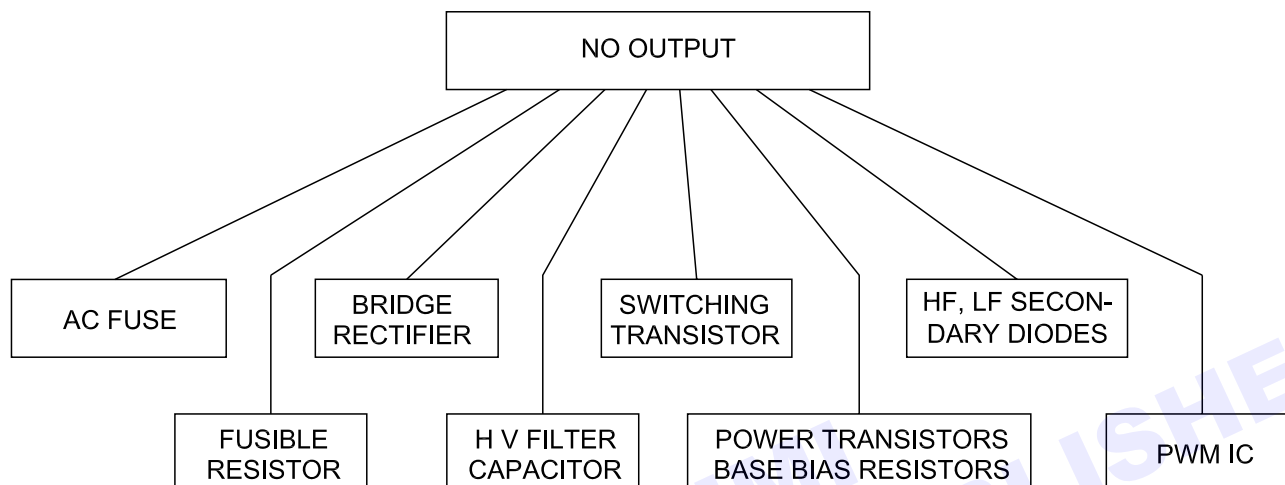
Objectives: At the end of this lesson you shall be able to

- list the probable defect and symptoms in the faulty SMPS
- analyse the causes for the complaint “No output” with the help of a problem tree and TSC
- state the shortest path for servicing the defect using SFS.

PROBLEM TREE : PT-02

Observed symptom : No output

Additional symptom :



Troubleshooting SMPS with the complaint “No Power Good signal”

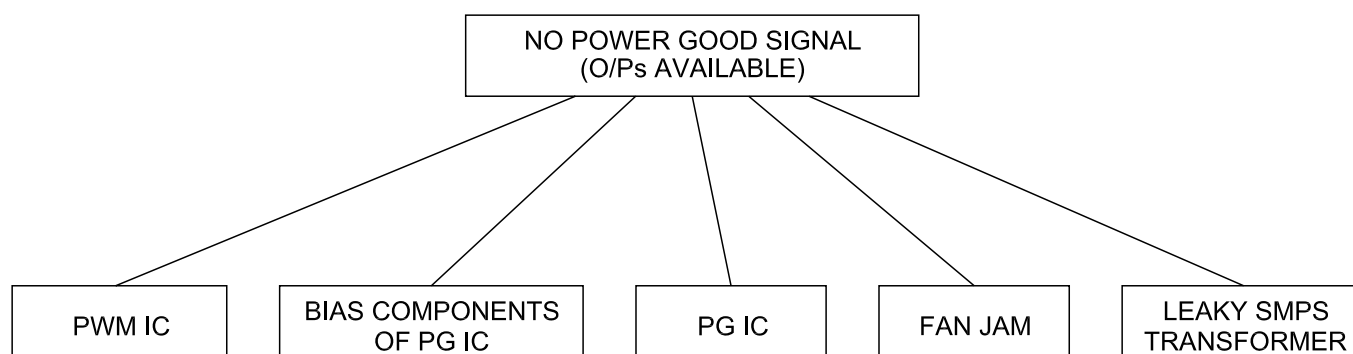
Objectives: At the end of this lesson you shall be able to

- list the probable defect and symptoms in the faulty SMPS
- analyse the causes for the complaint “No power good signal” with the help of a problem tree and TSC
- state the shortest path for servicing the defect using SFS.

PROBLEM TREE : PT-03

Observed symptom : No power good signal

Additional symptom : Erratic output voltages



Troubleshooting SMPS with the complaint (1)“No Power Good signal” (2)“PC system resets/restarts automatically”

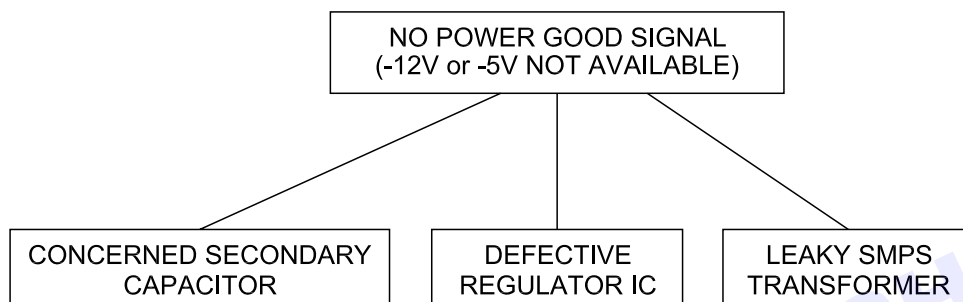
Objectives: At the end of this lesson you shall be able to

- list the probable defect and symptoms in the faulty SMPS
- analyse the causes for the complaint “No power good signal” & “PC system resets/restarts automatically” with the help of a problem tree and TSC
- state the shortest path for servicing the defect using SFS.

PROBLEM TREE : PT- 04

Observed symptom : No power good signal

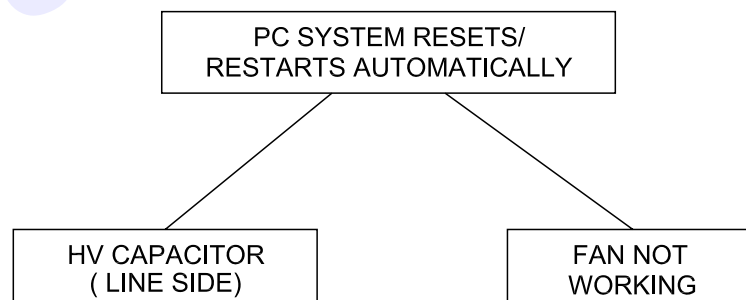
Additional symptom : -12V or -5V not available



PROBLEM TREE : PT- 05

Observed symptom : Pc system resets/restarts automatically

Additional symptom :



Secondary memory devices of computer and external drives

Objectives: At the end of this lesson you shall be able to

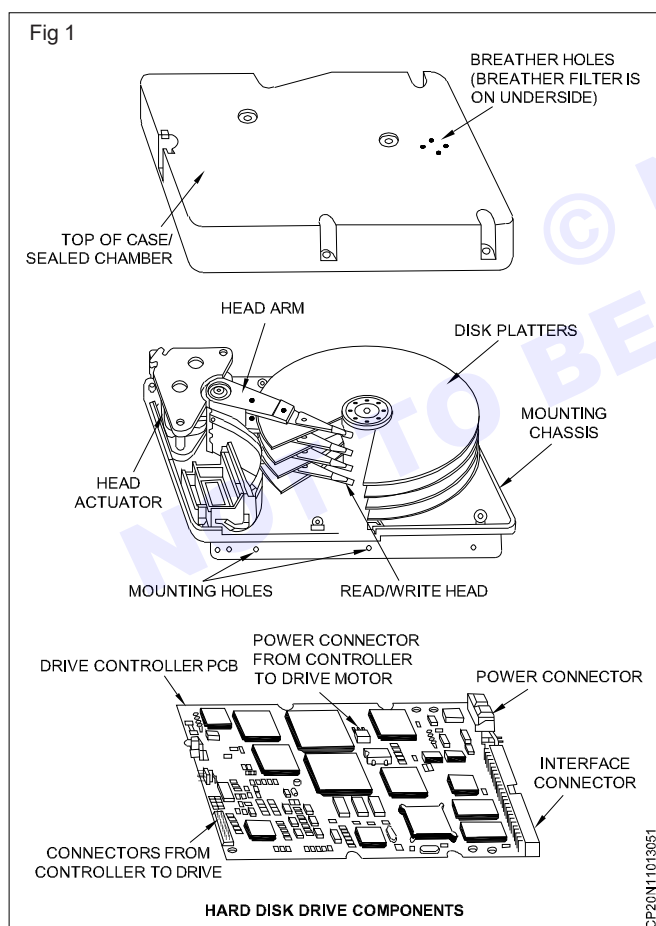
- explain the basic components of a hard disk
- explain what is a partition table
- explain high level formatting
- explain boot process
- explain read/write operation
- list precaution on handling/using HDD.

Introduction

Magnetic disks are the most common form of permanent data storage. Their capacities may range from a few kilobytes to several Gigabytes. An aspect common to all magnetic drives is the scheme that determines how the data on the disk is organised. The operating system determines this scheme before any information can be stored on a magnetic disk, provided the disk is formatted. Formatting allows the drive to store and retrieve data in an orderly manner.

The basic parts of hard disk

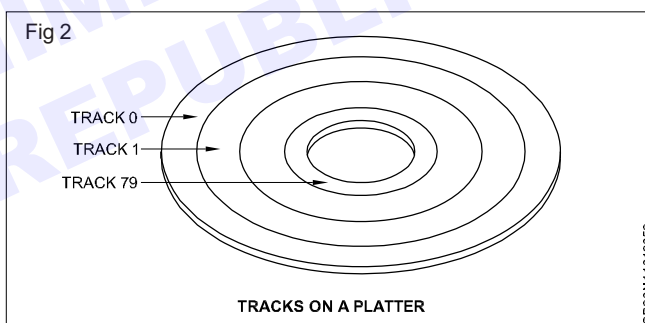
The basic hard disk drive components are as shown in the Fig 1.



Disk platters, Logic board, Read/write head, Head - actuate mechanism, connectors, Spindle motor, spindle, platter motor, heads and Actuator are assembled inside a sealed chamber. Drive electronics (PCB) is located outside the chamber.

Hard Disk has one or more platters. Platter is made of aluminium or glass, coated with magnetic media to store information. A read/write head is placed on a spring loaded arm. The arm is moved along the radius by actuator mechanism. Motor that spins the platter is called spindle motor. It rotates at 3600 to 7200 rpm. Logic board controls the drive motor and head actuator mechanism. Data is transferred to and from the platter in a standard format. Hard disk has a FRC connector for data cable and molex connector for power. Power supply requirements are +12V 1 amp, +5V, 500 mA

Hard disk platter is divided into tracks of a particular width as shown in Fig 2. Each track is divided into sectors (Fig 3). Outermost track is numbered '0'. Similar numbered track on each platter is combined to form a cylinder as shown in Fig 4. Capacity of the hard disk is determined by number of cylinders, number of heads, sectors and data storage mode.



Detection

This feature available in CMOS setup to detect what type of HDD is installed or connected to the system.

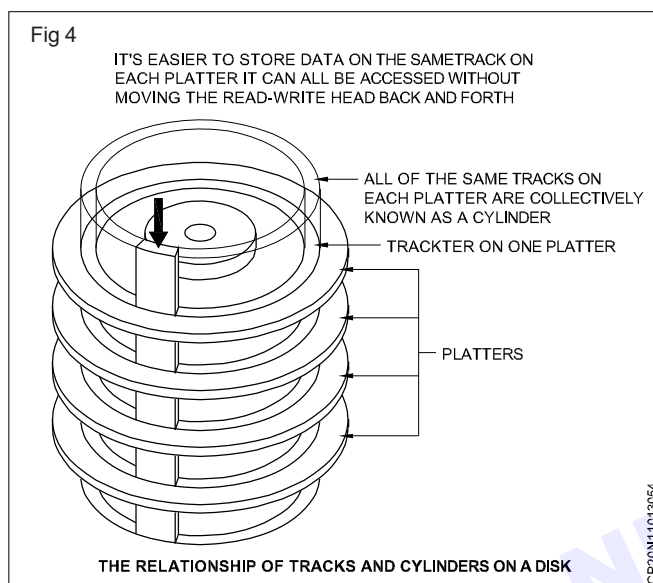
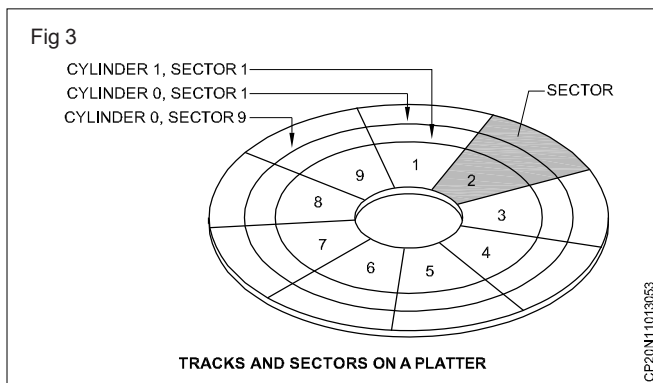
In AT286, 386 entry level 486 we had to select manually the capacity of HDD. In some cases we had to enter the cylinder, head, sector details according to the specification given by the HDD vendor.

Now a days from pentium onwards, the option for auto detection of HDD is available, which will automatically detect the type and capacity of the HDD. The following are the modes of operation.

LBA - large block accessing used for Win95, Win98, NT,2000

Normal - unix

Large - rarely used for windows 95,98



Partition table

It is a table which maintains the size of the partition. We can create, modify, delete size by using F disk common. Here large single physical disk is partitioned as small logical disks.

Disk formatting

A fresh hard disk has to be formatted before it can store information. There are two types of formatting - physical low level and logical high level formatting.

Low level formatting: Factory formatted. Usually we do not use this. In some cases, if the HDD has bad blocks low level format is used to remove the bad blocks to a certain extent, depends on the severity. In older 386,486 systems (BIOS) CMOS setup will have this utility. Now a days HDD vender gives the utility for example: segate gives DM(disk manager) which manage and remove bad blocks.

High level format: After partitioning the HDD using format command, primary and logical partitions are made. This will write the structure for managing the file and data on the HDD

Before formatting the hard disk an operation is performed on the hard disk using Fdisk program. It is called partitioning. Partitioning allows a large physical drive into several small logical drives. Information has to be stored in a file system. Where a file is stored is indicated by a file allocation table called as FAT system.

FAT 16 - format used for DOS, WIN95.

FAT 32 - used for WIN98, 2000 and XP

A partition which has a Boot program and FAT record, is called an active partition. A primary hard disk must have atleast one partition and that must be set active.

Master boot record (MBR) is written to track 0, sector 0 of hard disk portion. Partition table can be noted down for future use. The MBR can get corrupted by a virus or power fluctuation. Restoring its original value can save the data on the hard disk. If Hard disks track '0' is bad or damaged, the hard disk becomes unusable.

"F disk" programme is a DOS utility. It is used to partition the hard disk or to display the existing partition table on the hard disk. It can set active partition, delete partition table or create extended DOS partition and logical drives. "F disk" utility gives an option to use higher capacity hard disk. Any modifications made using F disk utility program comes in to effect after restarting the computer.

High level formatting

High level formatting is done after partitioning the hard disk using format command. Operating system (DOS, windows, windows NT) writes the structure for managing the file and data on the disk.

Read/write operation in a hard disk

Data which comes in parallel form from the IDE controller on the mother board to the controller on the hard disk drive converts it to a serial format and sent to read/write head. Depending on the available location assigned by the FAT, ZERO's and ONES's are written. The data written need not be in continuous locations. The platter rotates at a high speed. The data is stored at next available space. This is called interleaving. Because of this a single file need not be stored continuously, hence a file is fragmented. Defragment command is used to relocate the files on an orderly fashion. Periodic defragmentation is advisable in Win 95, Win 98. In DOS environment, one has to use utilities for defragmentation.

Boot process

Computer initialisation is a process from the time a PC is switched on until the PC displays A>:\C:> or windows Desk top, is called boot process. Number of steps are involved in this process.

When power is applied, the power good signal (PG) resets the CPU into its process. Program starts by fetching an instruction from ROM BIOS. The BIOS programme as explained earlier does the POST and looks for the operating system from drive A. If booting programme is not found in drive A, automatically it looks for a boot program in C:. In BIOS setup one can alter the sequence C to A or A to C.

Once operating system is found, the boots trap loader programme loads the operating system components into the memory and hands over the control to the operating system. When the process is complete, the monitor displays A>:/,C:> or windows desktop.

Handling hard disk

Hard disk should not be dropped. It will permanently damage the platter. Hard disk electronics should not be handled with bare hands as it is more sensitive to static

The optic medias

Objectives: At the end of this lesson you shall be able to

- describe about various optical drives
- describe their working
- explain booting process.

CD-ROM and DVD are optic readable media, contrary to hard disks, floppy disks and tapes, which are magnetic.

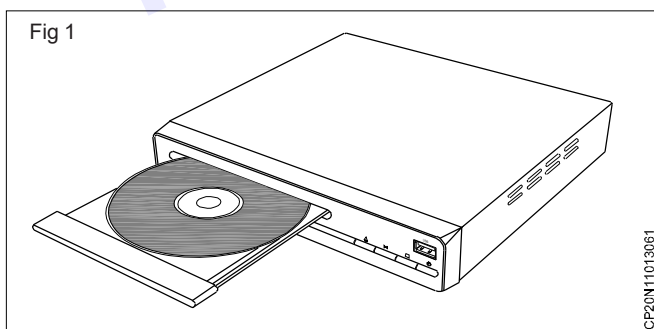
The optic storage media are read with a very thin and very precisely aimed laser beam. They supplement the magnetic media. They have clear advantages in the areas of data density and stability: Data can be packed much more densely in optic media than in magnetic media. And they have much longer life span. It is presumed that magnetic media, such as a hard disk or DAT (digital audio tape) can maintain their data for a maximum of five years. The magnetism simply fades away in time. Conversely, the life span of optic media are counted in tens of years.

Let us take a closer look at these disks, which are becoming increasingly popular for all types of information, education and entertainment. There are different types:

The Compact Disk

The compact disk (CD) was introduced by Philips and Sony in 1980 to replace LP records. It is a small plastic disk with a reflecting metal coating, usually aluminum. Myriads of tiny indentations are burned into this coating. These indentations contain the music in millions of bits. The CD is organized in tracks. Each track is assigned a number.

The big advantage of the CD is its high quality music reproduction and total absence of back ground noise as well as a great dynamic. During operation, the software in the drive can correct errors caused by such things as finger marks on the disk. All in all, CDs are excellent music storage media.



The CD-ROM

The CD-ROM (Read Only Memory) came as an extension of the CD in 1984. In principle, the media and the drives are the same. The difference is in the data storage organization. In a CD-ROM, the data are stored in sectors, which can be read independently - like from a hard disk.

charges. Hard disk interface cable and power supply should be connected/removed only after switching off mains power. No magnetic material should be placed near HDD.

The CD-ROM has become an important media in the PC world. It can hold 650/700 MB of data, and it is very inexpensive to produce. Today, there are three types of CD drives and DVD drives are on their way:

Drives and operating system

The drive must be assigned a drive letter. That is a task for the operating system, which must be able to recognize the CD-ROM drive. That is usually no problem in Windows 95/98. However, the alphabet can be quite messy, if there are many different drives attached.

Each drive must have its own letter. They are assigned on a first come first-serve-basis. The CD-ROM drive usually gets the first vacant letter after other existing drives, typically D, E, or F. But the letter can be changed.

Once the CD-ROM spins and the operating system (DOS or Windows) has "found" the CD-ROM drive, data can be read for processing. Now the CD-ROM works like any other drive. Only, it is Read Only Memory.

While floppy and hard disks are magnetic media, the CD-ROM is an optic media. The magnetic media work in principle like an audio cassette tape player. They have a read/write head, which reads or writes magnetic impressions on the disk. The magnetic media contains myriads of microscopic magnets, which can be polarized to represent a zero or numeral one (one bit).

In the optic readable CD-ROM, the data storage consists of millions of indentations burnt into the lacquer coated, light reflecting silver surface. The burnt dents reflect less light than the shiny surface. A weak laser beam is sent to the disk through a two-way mirror and the sensor registers the difference in light reflection from the burnt and shiny areas as zeros and ones.

A power-on self-test (POST) is a process performed by firmware or software routines immediately a computer or other digital electronic device is powered on.

The principal duties of the main BIOS during POST are as follows:

- verify CPU registers
- verify the integrity of the BIOS code itself
- verify some basic components like DMA, timer, interrupt controller
- find, size, and verify system main memory
- initialize BIOS

- pass control to other specialized extension BIOSes (if installed)
- identify, organize, and select which devices are available for booting

The functions above are served by the POST in all BIOS versions back to the very first. In later BIOS versions, POST will also:

- discover, initialize, and catalog all system buses and devices
- provide a user interface for system's configuration
- construct whatever system environment is required by the target operating system

Booting

Booting (or booting up) is the initialization of a computerized system. The system can be a computer or a computer appliance. The booting process can be "hard", after electrical power to the CPU is switched from off to on (in order to diagnose particular hardware errors), or "soft", when those power-on self-tests (POST) can be avoided. Soft booting can be initiated by hardware such as a button press, or by software command. Booting is complete when the normal, operative, runtime environment is attained.

A boot loader is a computer program that loads an operating system or some other software for the computer after completion of the self-tests. Within the hard reboot process, it runs after completion of the self-tests, then loads and runs the software. A boot loader is loaded into main memory from persistent memory, such as a hard disk drive or, in some older computers, from a medium such as punched cards, punched tape, or magnetic tape. The boot

loader then loads and executes the processes that finalize the boot. Like POST processes, the boot loader code comes from a "hard-wired" and persistent location; if that location is too limited for some reason, that primary boot loader calls a second-stage boot loader or a secondary program loader.

On modern general purpose computers, the boot up process can take tens of seconds

Bootstrapping

Bootstrapping usually refers to the starting of a self-sustaining process that is supposed to proceed without external input. In computer technology the term (usually shortened to booting) usually refers to the process of loading the basic software into the memory of a computer after power-on or general reset, especially the operating system which will then take care of loading other software as needed.

Booting is the process of starting a computer, specifically in regards to starting its software. The process involves a chain of stages, in which at each stage a smaller simpler program loads and then executes the larger more complicated program of the next stage. It is in this sense that the computer "pulls itself up by its bootstraps", i.e. it improves itself by its own efforts. Booting is a chain of events that starts with execution of hardware-based procedures and may then hand-off to firmware and software which is loaded into main memory. Booting often involves processes such as performing self-tests, loading configuration settings, loading a BIOS, resident monitors, a hypervisor, an operating system, or utility software.

Various features of windows operating system

Objectives : At the end of this lesson you shall be able to

- list components of windows desktop
- explain function of start button and start menu
- explain the use of help feature
- list contents of task bar
- list components of a window
- explain the meaning and method of scrolling
- explain the method(s) of closing applications
- explain the method of ending a window session.

Starting Windows : When a computer installed with Windows is switched on, after booting and running certain essential programs, (viz., config.sys, autoexec.bat etc.) a fairly big Microsoft Windows logo flashes on the screen and vanishes after few seconds. Then appears the screen as shown in Fig 1, from where user starts working. This is referred to Desktop in Windows.

Components of the Windows desktop

Desktop: It is an area on the screen available for the user to place items of his choice. As shown in above figure, on the desktop there are some small pictures (Icons).

If required, you can have shortcuts for any application / movie / picture etc. with an icon of your own choice.

For example you can create a picture file shortcut to display the center of the garden city of Bangalore and give the icon the picture of a tree as shown in Fig 2.

Icon: It is a small picture with a text label. Windows uses this kind of graphical representation for objects viz. documents, applications, folders, services, shortcuts, devices etc.

Fig 1



Fig 2



Taskbar: It is the long horizontal bar positioned at the bottom of the desktop. The taskbar contains four elements.

- found at the left edge of the task bar

- found at the right edge of the task bar

- to display the windows desktop or start a program (for example, Internet Explorer) with a single click.

Although the task bar is placed at bottom edge of the desktop, it can be moved to any of four sides of the desktop/ screen.

In Fig 3 you can observe an active application (**Microsoft Word**) and other hidden/minimized applications (**Windows media player**).

When you click on the  button, **Start menu** pops up, as shown in Fig 4. Start button and the start menu are the most frequently while working on Windows. The figure as shown below lists the tasks that can be performed using items of the popped-up Start menu.

The list of programs on the **Start** menu is divided into two parts.

- the programs on the pinned item list remain there and are always available for you to click to start them. Programs are added to the most frequently used programs list when you use them.

The basic mouse usage in Windows can be listed as below:

- Cursor** is a small picture/image, which moves on the screen as you move the mouse.

The other cursor shapes are shown in the Fig 5

Fig 3

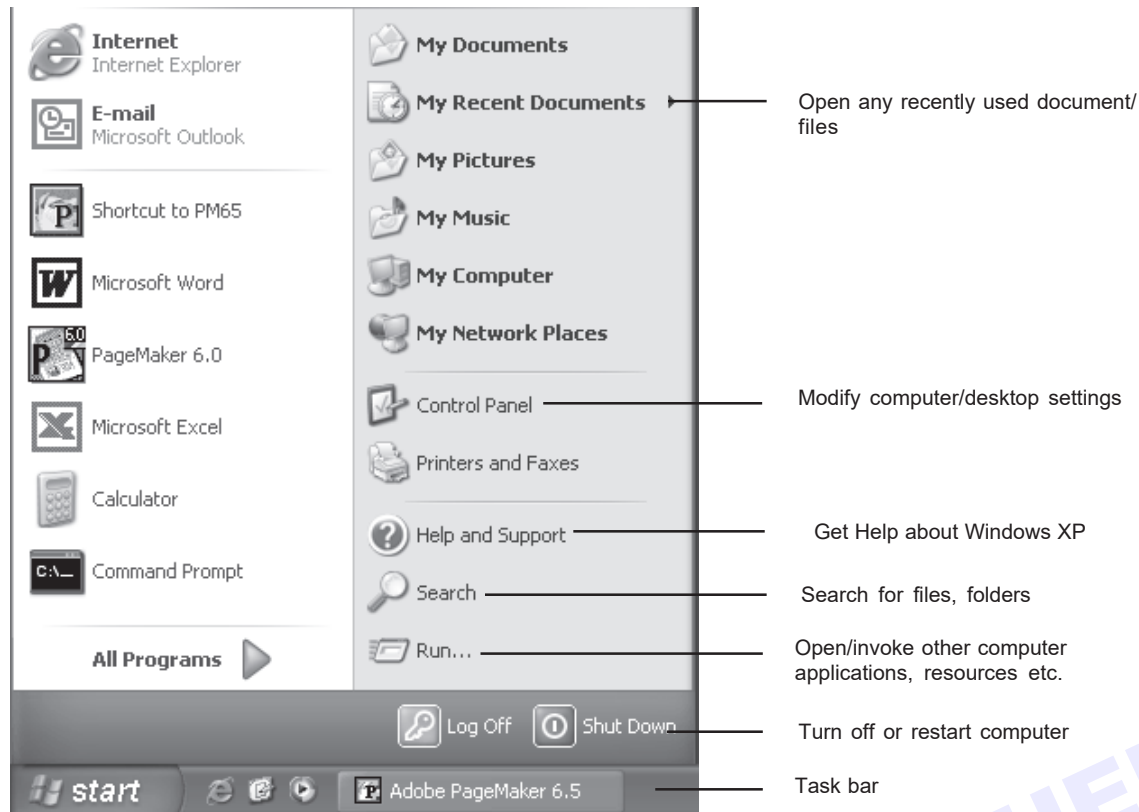


Fig 4



Fig 5



Moving the Cursor: This is the most common action performed using the mouse. When you move the mouse on a piece of rubber pad called the **mouse pad**, the cursor on your screen moves accordingly. i.e. as you move upwards cursor moves upwards and as you move downwards cursor moves downwards.

Selecting: This is the next most commonly performed action. Move the cursor so it is positioned on top of the object (viz. Icon, Menu, button etc.) and click the left mouse button once. When an item is selected by clicking on it, you can then perform actions with that item. Any command, which affects an object, will affect that object. For e.g. if you clicked upon an object and then press **DEL**, the object that you selected will be deleted.

Right Clicking: In Windows environment, this mouse action is introduced. In the earlier versions like Windows 3.1, the right mouse button had no application. In Windows when you click right mouse button, it displays a pop-up menu. To right click on an object, you position the cursor over the object and press the right mouse button, once. This not only selects the object, but also displays a pop-up menu.

The pop-up menu is *context-sensitive*, which means it changes depending upon what you have selected when you press the right mouse button. The menu, which is in Fig 6, is displayed when you right click on empty desktop area.

Fig 6

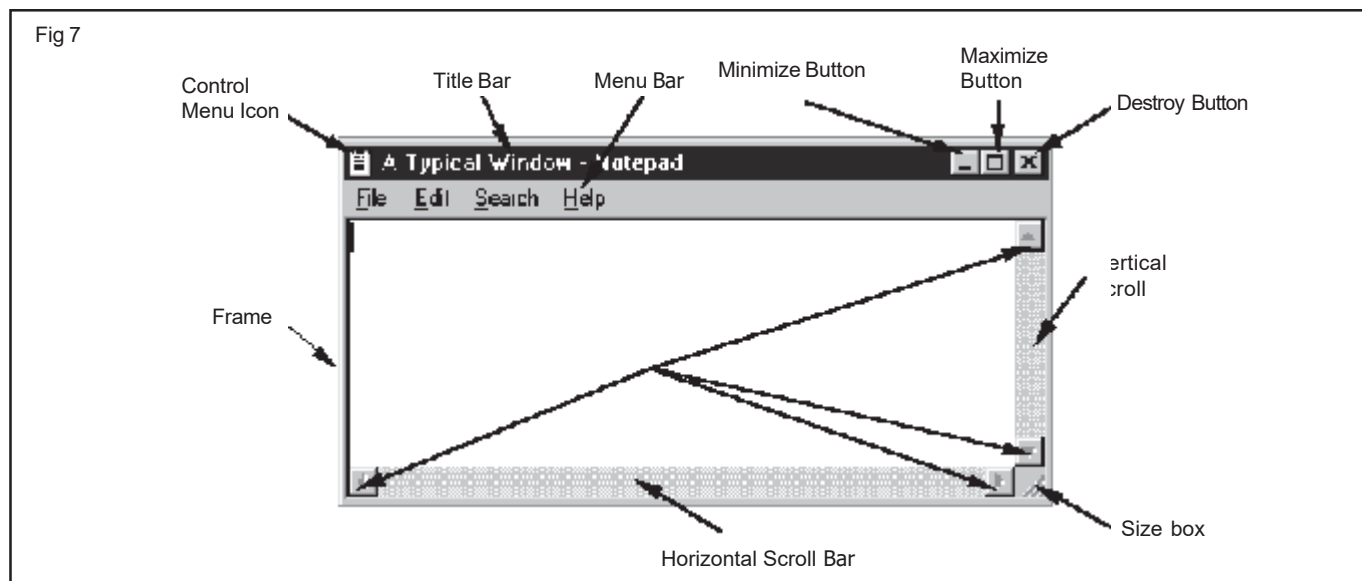


Double Clicking: One of the most common actions in the Windows environment from its evolution, is double clicking. To double click, you position your cursor over an object and press the left button twice in rapid succession, so that the computer considers it as a double click, rather than two single clicks.

Drag and Drop: Dragging is the another most important mouse action in Windows. Dragging consists of moving an object from one location to another. To drag an object you position the cursor over the object, press the mouse button, and leave it down as you move the cursor (dragging). Once the object is located where you want to put, you simply release the mouse button (dropping) and the object is moved to the new location.

What is a Window? A window is a graphical object that can represent a folder, a running program or a dialog box in a program. A folder is a directory in MS-DOS system. A running program can be any Windows based application

package. Dialog boxes are interactive windows with which Windows and other applications communicate with you. A typical window looks as shown in the Fig 7



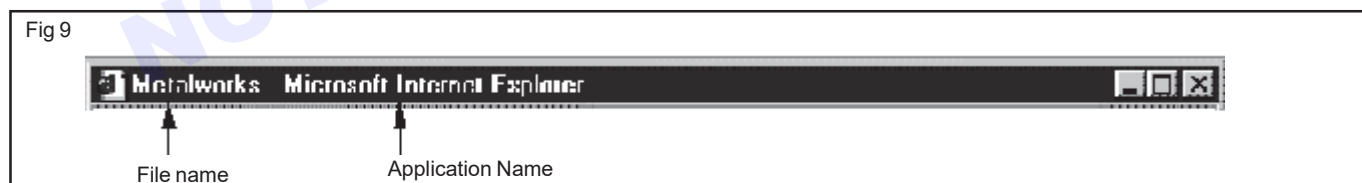
Control Menu (Fig 8) : Each window has a control menu, which contains commands for manipulating the window. To open the control menu of that window click on the icon in the upper-left corner of the window. The control menu is displayed as shown in Fig 8. The commands to manipulate the window will be Restore, Move, Size, Minimize, Maximize and Close. The Close command has a keyboard shortcut (i.e. through the keyboard the command can be activated) **Alt + F4**.



Title Bar: The title bar displays the title associated with the window and indicates by its color when window has the focus, i.e. when it is active. When the focus is lost the title bar will be of different color to identify that it is inactive. It is also means for moving the window – when you point the mouse cursor to the title bar and drag the mouse, you move the window. A typical title bar is as shown in Fig 9.

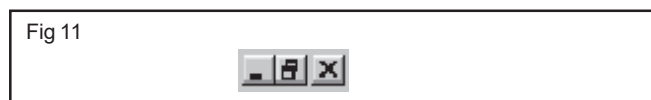
Frame: The frame surrounds the window. When you point the mouse to one of the frame edges or corners, the mouse cursor changes to an arrow cursor with points at both ends, indicating that the window can be resized.

Menu Bar (Fig 10): Most Windows applications have a menu bar, which contains the title of pull down menus. These titles vary from application to application, but standards exist. For e.g., the most of the applications have File, Edit, and Help menus. A menu bar is as shown in Fig 10.



Control Box: The control box is at the top right corner of the window. It consists of two buttons, which manages three states of a window. Viz., the window can be maximized, which means that it fills the desktop. The other state is window can be minimized, which means that it is represented by a short title bar on the taskbar. And the another state is the window can be restored, which means it is returned to its former size. The control box has another button, clicking which closes that window. It is called as destroy button.

When the window is in maximized state the control box is as shown in Fig 11



And when the window is about to be maximized, the control box is as shown below Fig 12.



And when the window is minimized they aren't really windows at all, but are displayed as buttons. They reside on the taskbar as shown in Fig 13 when they are mini-

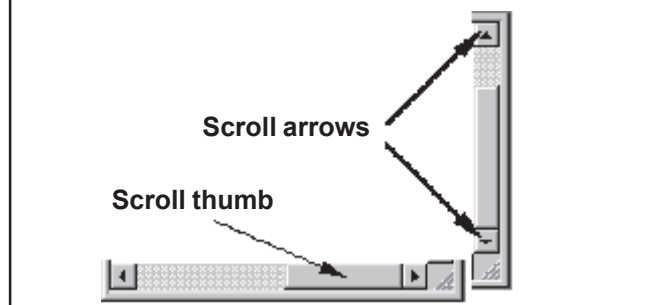
mized. And when they are in minimized state, they can't be removed.

Fig 13



Scroll bars: The data inside the window is usually more than what the window size is. For e.g., a Resume can be of more than one page, but a window can display maximum only one page at a time. So to see the rest of the data the scrolling the window technique is implemented. To achieve this, some windows components are called as scroll bars. There are two types of scroll bars; Horizontal scroll bars and vertical scroll bars as shown in the Fig 14

Fig 14



The scroll bar that is attached to a window at the right edge is called vertical scrollbar, and the one, which is attached at the bottom, is horizontal scrollbar.

Invoking applications: Invoking/Starting an application can be done in various ways. All the applications, which are installed, will be having their shortcut in the Start Menu.

Shortcuts are quick ways to get to the items you use often. Shortcuts can be created for any object in Windows, i.e. to a program, folder, document or printer etc.

So to start an application by name Microsoft Excel resides in All Programs, as shown in Fig 15 open the Start Menu, highlight Programs and click on Microsoft Excel icon to select it. This starts the Microsoft Excel application.

The another way of invoking an application is through desktop shortcuts. If the application has a desktop shortcut, you can start that application, just by double clicking on it.

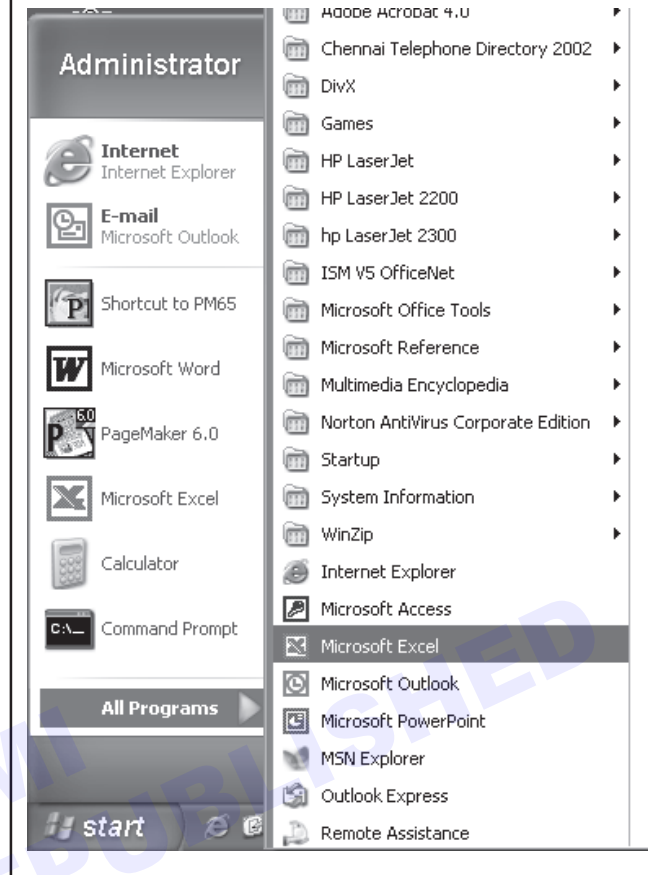
For e.g. to start Paint accessory, double click on the  icon available on the desktop.

Closing applications: To close an application/window take the cursor over the destroy button and click on it. This closes the window and if it is main window for the application, then it closes the application. Before closing an application, it prompts for saving the work if any changes are made.

The another way of closing an application is selecting Close from the System menu (Control menu).

You can also use the keyboard shortcut for the same. The keyboard shortcut is **Alt + F4**, i.e. hold the modifier key **Alt** and then press function key **F4**.

Fig 15



End current working session: In Windows, to close all the running applications by saving the work being done and exit, the **Turn off computer** command is provided in the **Start** menu. When you select **Turn off computer** command from the Start menu, a dialog appears as shown in the Fig 16 with set of options to end the current session.

Fig 16



The options on the **Turn off computer** Windows dialog box enable you to prepare your computer to be turned off, to have your computer shut down Windows and restart Windows, to shut down Windows and or to simply close all of the current programs and activate a new profile.

Printers, its types and their working

Objectives : At the end of this lesson you shall be able to

- different types of print technologies and printers
- impact printers/dot matrix printers
- non-impact printers, inkjet printers & laserjet printers.

Printers are electro-mechanical devices that enable a user to print whatever is displayed by the monitor - letters, contracts, business documents, images.

Print Technologies

A printer outputs data that is seen on the computer screen on to a paper. Most printers are used through a parallel port, but some newer ones use USB connections. The most crucial printer measurement is dots per inch rating. Printers are best chosen by actually seeing the quality of the printer output. There are many types of print technologies like Daisy wheel, Laser, Inkjet etc. Printers are normally categorized into impact and non-impact types. You will learn more about this as you go further in this lesson.

Printers can be divided into two categories

- Impact
- Non-Impact

Impact: The impact printers incorporate a built-in mechanism to print images on paper using a series of pins or hammers which strike on an inked ribbon to create the image. For Example: Dot matrix, Daisy Wheel, etc.

Non-Impact: The non-impact printers include those printers that do not have any kind of contact with the paper while printing either text or image. For Example: Inkjet, Laser, Bubble Jet, etc.

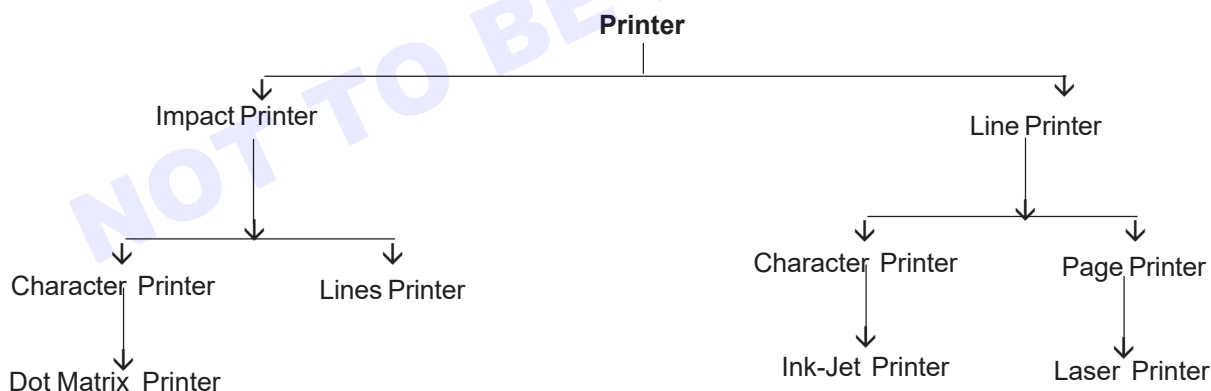
These printers use different technology to print an image. For Example, a laser printer uses heat to attach microscopic particles of dry toner to specific parts of the page. An Inkjet printer has tiny nozzles through which it sprays droplets of ink on to the page.

Impact Printers: In this hammers or pins strike against a ribbon and paper to print the text. This mechanism is known as electro-mechanical mechanism. They are of two types.

- 1 Character Printer
- 2 Line Printer

Character Printer: It prints only one character at a time. It has relatively slower speed. Eg. Of them are Dot Matrix Printers

Dot Matrix Printer: It prints characters as combination of dots. Dot matrix printers are the most popular among serial printers. These have a matrix of pins on the print head of the printer which form the character. The computer memory sends one character at a time to be printed by the printer. There is a carbon between the pins & the paper. The words get printed on the paper when the pin strikes the carbon. There are generally 24 pins.



Non-Impact Printers: These printers use non-Impact technology such as ink-jet or laser technology. These printers provide better quality of O/P at higher speed. These printers are of two types :

Ink-Jet Printer: It prints characters by spraying patterns of ink on the paper from a nozzle or jet. It prints from nozzles having very fine holes, from which a specially made ink is pumped out to create various letters and shapes. The ink comes out of the nozzle in a form of vapors. After passing through a reflecting plate, it forms the desired letter/shape at the desired place.

Laser Printer is a type of printer that utilizes a laser beam to produce an image on a drum. The light of the laser alters the electrical charge on the drum wherever it hits. The drum is then rolled through a reservoir of toner, which is picked up by the charged portions of the drum. Finally, the toner is transferred to the paper through a combination of heat and pressure.

This is also the way copy machines work. Because an entire page is transmitted to a drum before the toner is applied, laser printers are sometimes called page printers. There are two other types of page printers that fall under the

category of laser printers even though they do not use lasers at all. One uses an array of LEDs to expose the drum and the other uses LCDs. Once the drum is charged, however, they both operate like a real laser printer. One of the chief characteristics of laser printers is their resolution - how many dots per inch (dpi) they lay down.

The available resolutions range from 300 dpi at the low end to 1,200 dpi at the high end. In addition to text, laser printers are very adept at printing graphics, so you need significant amounts of memory in the printer to print high-resolution graphics. To print a full-page graphic at 300 dpi, for

example, you need at least 1 MB (megabyte) of printer RAM. For a 600 dpi graphic, you need at least 4 MB RAM.

Because laser printers are non-impact printers, they are much quieter than dotmatrix or daisy-wheel printers. They are also relatively fast, although not as fast as some dotmatrix or daisy-wheel printers. The speed of laser printers ranges from about 4 to 20 pages of text per minute (ppm). A typical rate of 6ppm is equivalent to about 40 characters per second (cps).

Introduction to MS office, its installation and MS office

Objectives : At the end of this lesson you shall be able to

- explain the basics of computer
- identify computer hardware
- identify various peripheral devices.

Introduction

Microsoft Word is an essential tool for the creation of documents. Its ease of use has made Word one of the most widely used word processing applications currently on the market. Therefore, it's important to become familiar with the various facets of this software, since it allows for compatibility across multiple computers as well as collaborative features. Word is a fairly simple program to use for completing simple tasks. However, it may be more difficult to learn how to explore the more advanced possibilities of Word.

Opening Microsoft Word

To run Word on your computer: "Start" >> "Programs" >> "Microsoft Office" >> "Microsoft Office Word 2003." If there is an icon of Microsoft Word available on your desktop (shaped like a square with a "W" in the middle), you can open up the program by double-clicking it, as well.

Making a New Blank Document

When Word is opened, a new blank document should automatically open. If not, then you can begin a new blank document in a variety of ways. First, find the "New Blank Document" icon, which looks like a blank sheet of paper, located underneath the menu bar in Word in what is called the "standard toolbar." shown in Fig 1 Click on the icon to bring up a new blank document.

Also, you can go to the menu bar and select File >> New... (shortcut: Ctrl+N).

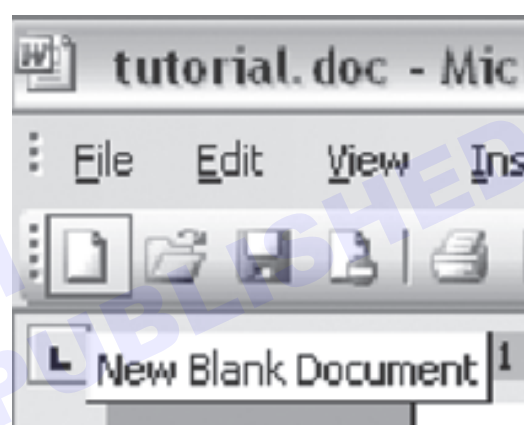
To begin typing, just click the cursor anywhere within the new blank document.

Opening a Document

To open to view, edit, or print a document, you must first open up that file in Word.

You can open a file by clicking on the "Open" folder icon (with a picture of a folder) located in the standard toolbar. Or, you can use the menu bar and navigate to File >> Open... (shortcut: Ctrl+O).

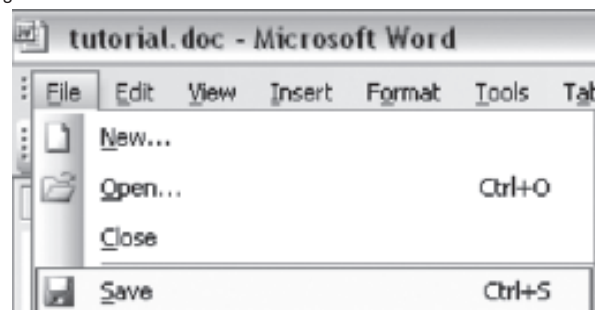
Fig 1



Saving a Document

When you are working with any sort of media in any software, you should be sure to save your work often. In Word, there are numerous options for saving documents in a variety of file types. To save a new, unsaved document, you can click on the Save icon, shaped like a disk located on the standard toolbar shown in Fig 2. Or, you can go to the menu bar and select File >> Save... (shortcut: Ctrl+S).

Fig 2



A dialogue box should appear, offering you a number of options. To save the document in the desired location on your computer, locate and select the folder on your computer. Give your document a name in the file name text box. While you can give your document long names, make sure you save it with a name you can remember. Please

note that it's good practice not to use spaces or special characters in file names. For example, long file name may look like this: expos_sample_paper1.doc To save a completely new document using previously existing (and opened) text, you use the Save As option. Open the document that you wish to save as an entirely new file, go to the menu bar, and click on File >> Save as. In the file name text box, give your document a new name. Using this option allows you to save multiple versions (with different file names) of a document based on one original file.

Formatting Text/Paragraphs Using Toolbars

In a word processing program such as Word, there are numerous options available for presenting your text. This part of the tutorial will guide you through several of the important features in Word that will allow you to edit, modify, and display text (and non-text) components.

The Standard Toolbar

Word allows all toolbars to be customized, so you may not find all options listed here. There are several buttons that may or may not appear immediately in your version of Word. Use the following graphic as a guide to the Standard Toolbar.

1 New Blank Document

To begin a new document, click on the New Blank Document icon, shaped like a blank sheet of paper.

2 Open

Clicking on this icon opens up a previously saved document on your computer.

3 Save

Clicking on the Save icon saves the document you are currently working on. If you are saving a document for the first time, you can click on this button. However, if you want to save a new file from a pre existing document, then you must go to the menu bar and select "File" >> "Save As" and give the file a new name. When working on any document, you should be sure to save frequently, so that you don't lose any work.

4 Permission

Microsoft has enabled Information Rights Management (IRM) within the new version of Word, which can help protect sensitive documents from being copied or forwarded. Click this for more information and options.

5 Print

Clicking on the Print icon automatically prints the document currently active in Word. If you wish to explore more print options, then go to the menu bar and select "File" >> "Print."

6 Print preview

To get an idea of the appearance of your document in print before you actually print it out, you can click on this icon to view your document from a zoom-out distance.

7 Spelling and Grammar

Clicking begins a review of your document in search of spelling and grammatical errors that may need to be corrected.

8 Copy

Copy the current selection to the clipboard, which can then be pasted else where in the document, or into a completely separate program/document.

9 Paste

Clicking on the Paste button inserts the text that has been most recently added to the Clipboard (the text would have been added there by Cutting or Copying). With Paste, you can either insert the copied text into a document or replace selected text.

10 Undo Typing

The Undo Typing button goes back and removes the last addition or change made to your document.

11 Insert Hyperlink

You may find that you want to make links to a particular web site, web page, or some other kind of online file in your Word document. Using the Insert Hyperlink button, you can turn selected text into hyperlinks. When the icon is clicked, a window will appear that will allow you to insert the URL (web address) of the web page you want to link to. You can type in the URL yourself or insert a pre existing bookmark. Once the link is inserted, the link in your Word document can be clicked and the web page will open up in a web browser.

12 Insert Table

When this icon is clicked, a small window will appear in the form of a grid of squares. Use this window as a guide to indicate how many rows and columns you would like your table to contain. Once selected, a table will automatically appear in Word. Clicking the Tables and Borders button will allow you to modify the table. To modify an aspect of the table, select, or place the cursor in, the area and apply changes such as borders and colors.

The Formatting Toolbar

Word allows all toolbars to be customized, so you may not find all options listed here. There are several buttons that may or may not appear immediately in your version of Word. Use the following graphic as a guide to the Formatting Toolbar.

1 **Style:** Styles in Word are used to quickly format portions of text. For example, you could use the "Normal" or "Default Paragraph Font" for the body text in a document. There are also three preset styles made for headings.

2 **Font:** Font is a simple but important factor in Word documents. The choice of font (the style of the text itself) can influence the way others view documents, either on the screen or in print. For example, Arial font

looks better on screen, while Times New Roman is clearer in print. To apply a font to text, select desired text with your cursor, and choose a font from the font drop down menu.

- 3 **Font Size:** You may encounter times in which you need to display some text larger or smaller than other text. Selecting desired text with the cursor and choosing a font size from the drop down menu changes the size of text.
- 4 **Bold:** Places the text in **bold**.
- 5 **Italic:** Places the text in italics.
- 6 **Underline:** Underlines the text.
- 7 **Align Left:** Aligns the selection to the left of the screen/paper.
- 8 **Center:** Aligns the selection to the center of the screen/paper.
- 9 **Align Right:** Aligns the selection to the right of the screen/paper.
- 10 **Justify:** Aligns the selection to both the left and right of the screen/paper.
- 11 **Line Spacing:** Adjust the line spacing (single-spaced, double-spaced, etc.)
- 12 **Numbering:** Create a numbered list.
- 13 **Bullets:** Create an unordered, bulleted list.
- 14 **Decrease Indent:** Decreases the indentation of the current selection (to the left).
- 15 **Increase Indent:** Increases the indentation of the current selection (to the right).
- 16 **Outside Border:** Places a border around the current selection; click the drop-down for a wide selection of bordering options.
- 17 **Highlight:** Highlight the current selection; default color is yellow.
- 18 **Font Color:** Change the font color; the default/automatic color is black.

More Formatting: Besides the toolbars, Word provides a great deal of ways to customize and format your text and documents.

Paragraph Spacing: To access the Paragraph formatting options, navigate to the menu bar, and select "Format" >> "Paragraph," or right-click within a paragraph shown in Fig3.

A window will appear with options for modifying spacing and indenting. Here, you can choose to make the text in your document single or double spaced, as well as edit the margins for the document shown in Fig4.

Headers/Footers

Headers and footers are important aspects of a Word document if you wish to include information such as page numbers and headings on every page. To access the header and footer options, go to the menu bar and select "View" >> "Header and Footer." shown in Fig 5.

A dotted-line box called "Header" will automatically appear, as well as a sub-menu for formatting header and footer properties shown in Fig 6. The cursor will already be placed in the Header box. If you scroll down on your current page opened in Word, you will see a dotted-line box called "Footer." To add text in the Header or the Footer, simply click the cursor inside either one of the boxes, and type the text you want.

To add page numbers to your document, click your cursor inside of the footer box. Then, click on the icon shaped like a sheet of paper with a "#" inside. The page number will then be inserted and applied to all of the pages in your document.

Inserting an Image

In Word, it's possible to add clipart or other images to a document. Click the cursor in your document where you wish to place an image. Then go to the menu bar and select "Insert" >> "Picture." shown in Fig 7.

From there, you will find a number of options to choose from. "Clipart" searches through your computer's Clipart library. "From File" will allow you to insert an image saved elsewhere on your computer. Other options include "AutoShapes" and "WordArt."

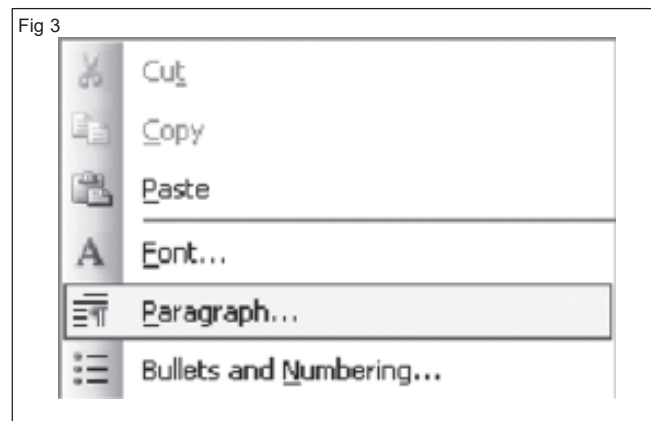


Fig 4

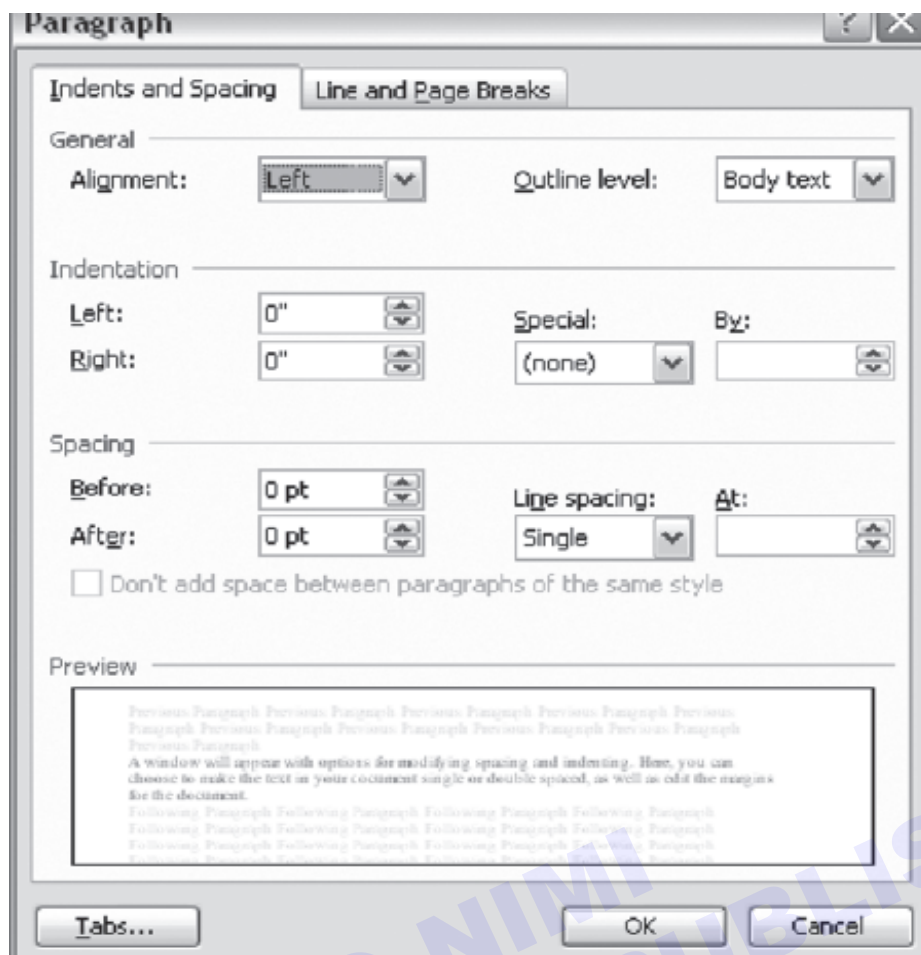


Fig 5

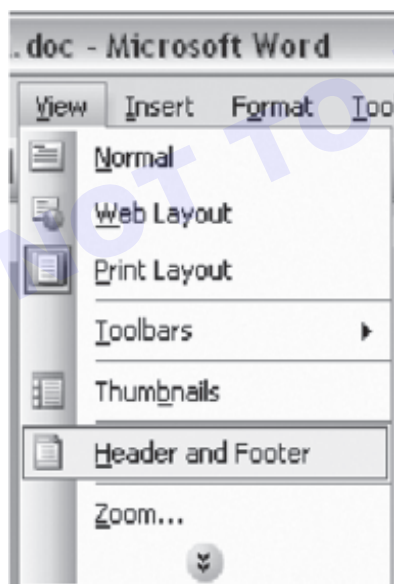


Fig 7

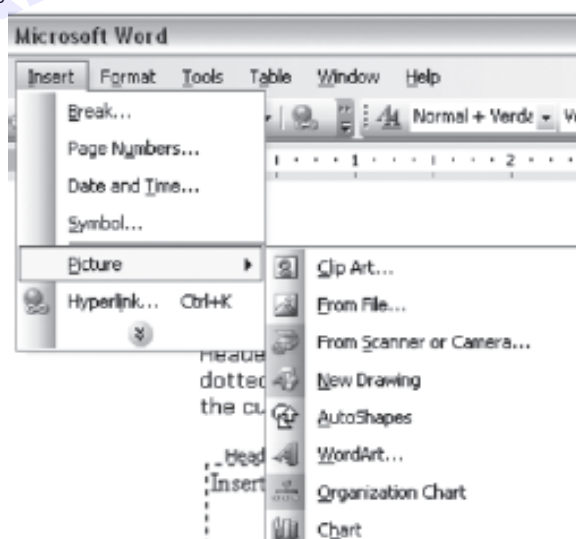
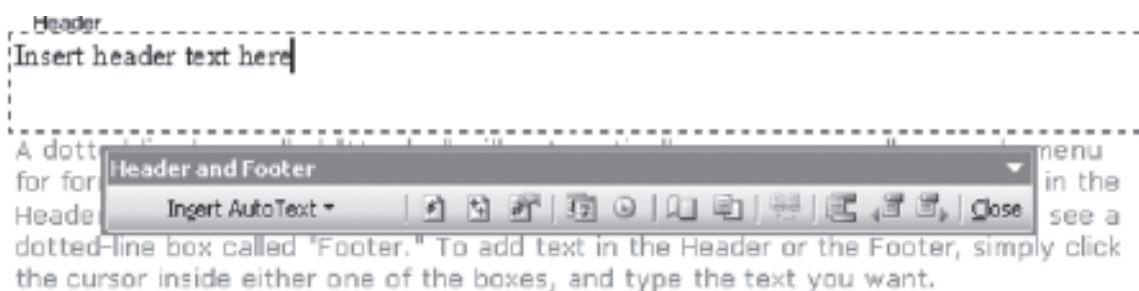


Fig 6



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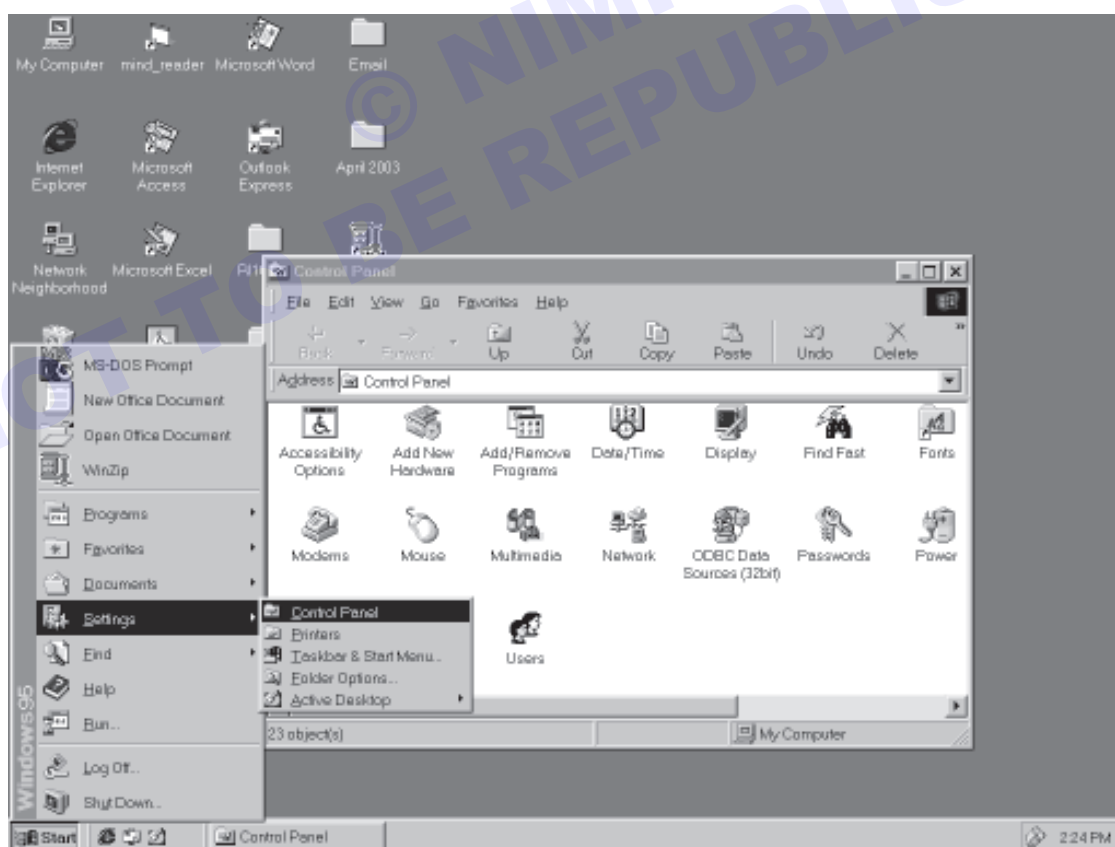
Windows OS desktop shortcuts & various display options

Objectives : At the end of this lesson you shall be able to

- explain the components of control panel
- change the system date and time
- change the desktop wall paper
- change the screen saver
- change the window appearance
- work with keyboard settings
- change the mouse properties
- change the regional settings.

Control Panel: It is presented as a folder full of icons. To view Control panel, click the Start button, point the settings and then click Control panel (Fig 1) shows the contents of Control panel.

Fig 1



Accessibility options: Change your computer screen, mouse, keyboard, features, and sound to make windows more accessible for people with disabilities.

Add / Remove programs: Install and remove software automatically, and add or remove installed components in windows NT.

Console: Change the appearance of your MS-DOS screen by changing screen colors, screen size and position, fonts, cursor size and more.

Date / Time: Change the system date, time, and time zone.

Devices: Start, stop and configure the start up type for device drivers.

Display: Change the appearance of your screen by changing screen, colors, fonts, the appearance and size of windows, background design, icons and other visuals.

Fonts: Add or remove screen, vector, True type, and Type 1 fonts, some printer fonts are installed automatically when you install a printer. Other printer fonts must be installed using a font installation program provided by the font manufacturer.

Keyboard: Adjust the keyboard delay and repeat rate, and add keyboard symbols that are exclusive to other languages.

Modems: Add modems using the Add modem wizard, a step-by-step modem set up program.

Multimedia: Adjust audio, video, CD (music), and MIDI, and add or remove multimedia devices.

Network: Configure network adapter cards, network services and protocols, and join a workgroup or a domain.

PC Card (PCMCIA): Display resources used by any PC cards, if you have these devices.

Ports: Set parameters for, and add and remove serial communications ports.

Printers: Add and remove printers and remove, control and create share access to printers using the Add printer wizard, a step-by-step printer set up program.

Regional Settings: Change sort dates, time currency and numbers to reflect regional standards.

SCSI Adapters: Display adapters and devices connected to your computer.

Server: Display user and share information.

Services: Start, Stop, Pause, or continue the services available on the computer, and configure start up options.

Sounds: Assign sounds to system and application events, and turn on or off the warning beep and system sounds.

System: Specify the default operating system for startup, change user environment variables and define paging file size.

Tape Devices: Display, add and remove tape devices.

Telephony: Display, add, and remove telephony drivers change telephony properties. Adjust telephony conditions depending on whether your computer is docked or undocked.

UPS: Create settings for uninterrupted power supply.

The control panel is thus the place where most of the system working can be controlled. The following are the various settings that can be done:

Date and Time properties: The date and time properties dialog is used to change the systems date and time which is shown in the system tray at the right end corner of the task bar.

Changing the following (As shown in the above figure)

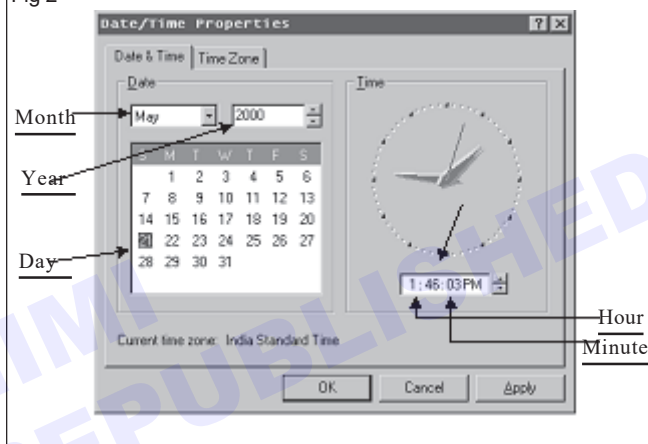
Changes the date as shown in Fig 2.

- Day
- Month
- Year

Changing can change the time

- Hour
- Time
- Seconds

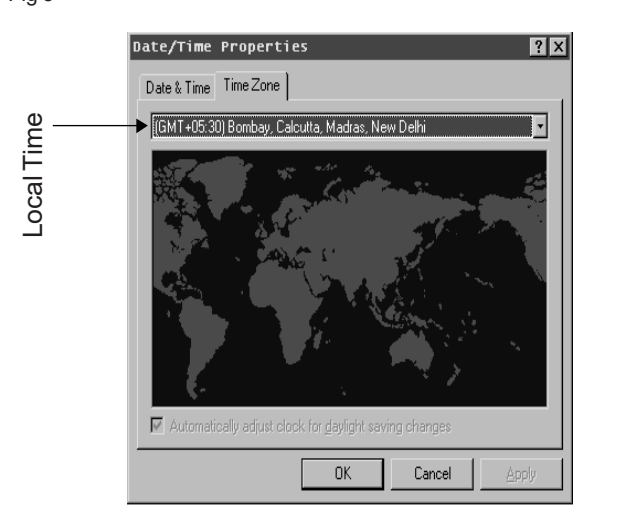
Fig 2



The spinner button is used to change the meridians, i.e. AM. and PM.

There is one more tab in the Date & Time properties i.e. Time Zone that is used to set the local time in tune with the Greenwich Meridian Time (GMT) as shown in Fig 3.

Fig 3



Click on the down arrows button in the box indicated in above figure and change it to Colombo GMT+6:00. Watch how the World map shifts itself towards left.

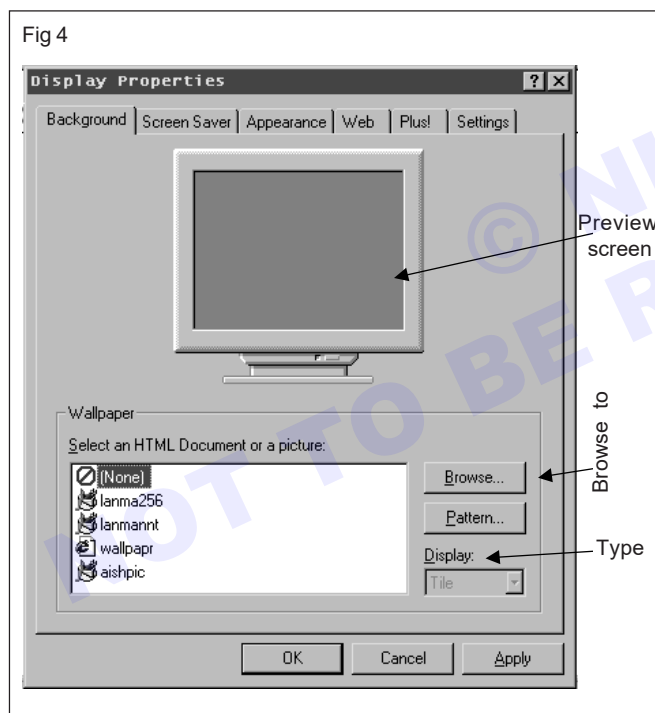
Also observe time now in the system tray. It will be changed now.

Changing the Wall Paper and screen savers: Wallpapers are the screen patterns that can be set as the background of the desktop. There are built in wallpapers available that can be selected in the Background tab of the Display property dialog as shown in the Fig 4 below.

A HTML document (called the Hyper Text Markup Language used as Web pages) or a picture (called Windows Bitmap pictures i.e. BMP created using Paint Brush application) are the two types of images that can be set as background image.

- 1 To set the Windows picture created by the user himself using Paint brush click on the Browse button.
- 2 Select the file created in the open dialog.
- 3 Observe the preview in the screen within the dialog (as shown above)
- 4 Then click on the apply button and observe the desktop background now.

There is one more display option called the Display type as shown in Fig 4



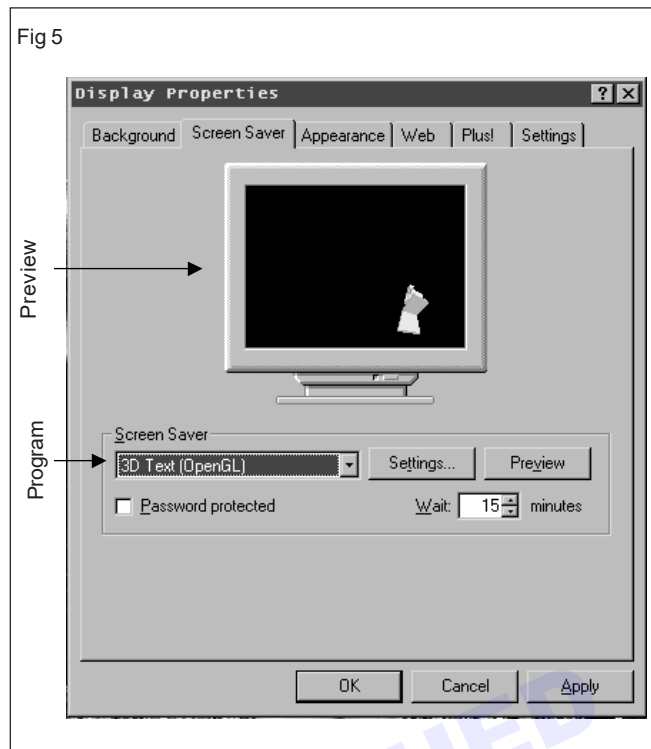
It is used to display the wallpapers in 2 different styles

- 1 Centered in which the picture is centered in the desktop
- 2 Tile in which the same copy of the picture is shown as a number of tiles scattered on the desktop.

Screen Saver Settings : Screen saver is a program that gets invoked when your system is idle i.e. when you are not pressing any key and moving the mouse as shown in Fig 5.

There are a lot of programs that can be selected for the display during the system's idle state. Each program is having its own type of settings by which its behavior can be

controlled. This is invoked by clicking on the Settings buttons as shown in Fig 5.



The Wait minute box represents how much of time the system can wait until the screen saver can be invoked.

The screen program that is used to display any message in the form of text is the 3D text. In this the message can be typed in the given text box as shown in Fig 6.

- Click on Ok button to effect the settings. This will return to the previous tab.
- Clicks on Preview button to see the screen saver running (do not move the mouse or press any key). Once you move the mouse or hit any key the screen saver automatically stops.

Appearance of Window : The look and feel of windows can be changed using the Appearance Tab of the Display property dialog. This tab can be used to change the whole appearance of windows like the color, size of icons, fonts that are used in the menus and title bars etc. each type of these appearance is presented as a set of schemes as shown in Fig 7

Click in the Scheme list box and select the Windows standard as the type of the appearance for the windows.

- Watch how immediately the window in the top box appears (as shown in Fig 7).
- Clicking on the respective items individually can change the appearance of each individual item. For instance clicking on the active window in the box can change the appearance of the active.

The Save as button is used to save your own scheme of colors, fonts, size etc under a different name. Delete button is used remove the schemes.

Fig 6

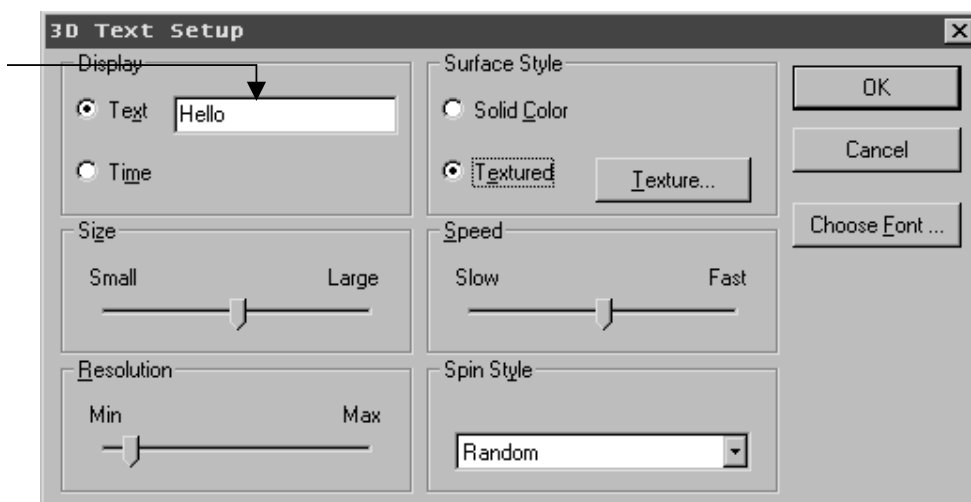
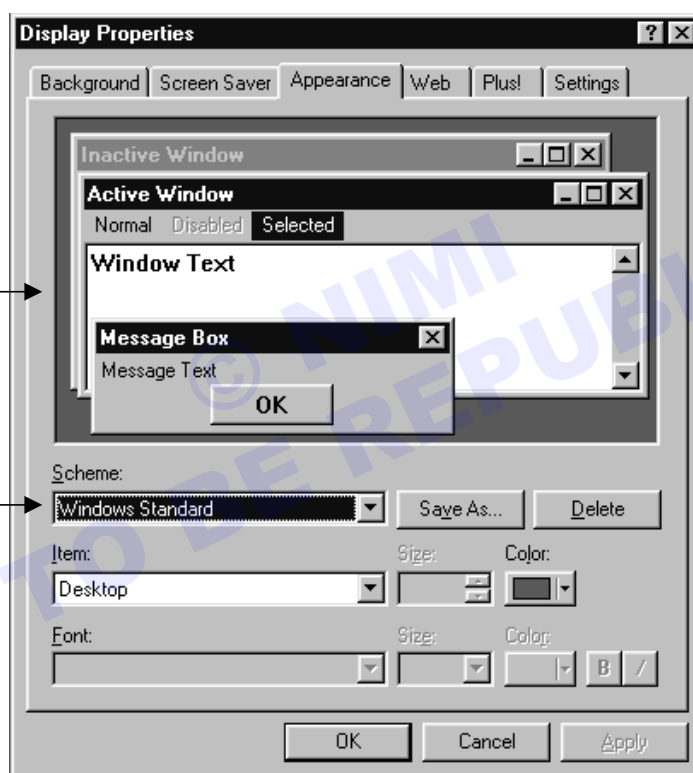


Fig 7

Click anywhere
Here to select
Individual items

Different
appearances



Working with Keyboard : If you open the Keyboard control panel by double-clicking on the Keyboard icon as shown in Fig 8, you will find that there are several different pages that can affect the way your keyboard works.

Fig 8



These various settings make it easier to control how your keyboard actually behaves as you type. Fig 9 shows the first of the three pages in the standard Keyboard Properties dialog box. If you have a special keyboard, there may be other card options.

The Speed card controls how your keys behave when you type, specifically how much your keyboard resembles an electric typewriter in how it repeats keys. There are two settings for this, both of which influence what happens when you hold a single key down. Repeat delay controls how long it takes before the key starts repeating - in other words, how long you can hold down the key before it starts to repeat the symbol rapidly. If you set this for a long time, you can be a show typist without unintentionally typing double letters on-screen.

The Repeat rate controls how quickly the letter repeats once it starts repeating. If this is set very fast, it becomes very easy to draw a line of x's across the screen; however, on a fast system, it will go much too fast for you to control

the number of repeated letters. In general, most people find that setting both of these sliders towards the midpoint works best. The blank box slightly below the middle of the screen is for testing the repeat rate. Simply click there and hold down a key to see how long the delay is and how quickly it repeats once it starts.

Fig 9

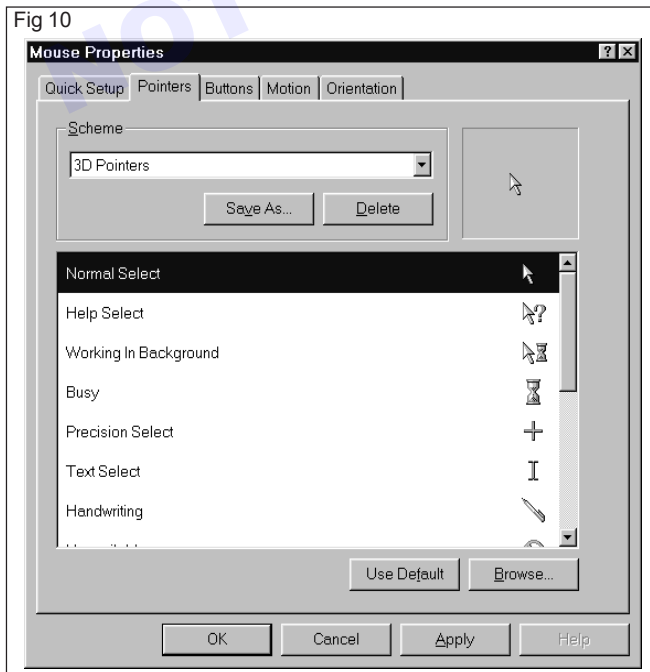


At the very bottom of the Speed card is the option to control the Cursor blink rate. This is how quickly the cursor blinks when it is used as the insertion point in a document or a dialog box.

Using Different Keyboard Layouts : The second card in the Keyboard Properties dialog box is for Language. Each language has its own keyboard layout. Foreign languages require different characters, and the appropriate keyboard layout makes them more accessible.

The Language card is truly useful only if you have more than one language installed on your system.

Fig 10



General Keyboard Settings: The final card, General, allows you to select the current keyboard type. In general most modern keyboards are covered by the standard 101/102 key or Microsoft Natural Keyboard selection. However, there is a Change button that allows you to select from a list of other possible keyboard descriptions for other systems.

Working with Mouse : The actual features installed for your mouse can vary depending upon the mouse driver currently used. When you double-click on the Mouse control panel to open the Mouse Properties dialog box, you can use the General card to select the specific mouse that you have installed. The options discussed in this section are for the standard mouse driver. The first card within the Mouse Properties dialog box is the Buttons card.

The top portion of the dialog box lets you control which of the two mouse buttons is used as the primary (selecting) button and which is used for pop-up menus. The Right-handed feature makes the left button the selecting button and the right button the pop-up menu button. The Left-handed feature reverses that, making the right button the select button and the left button the pop-up menu button.

The bottom part of the screen controls the double-click speed, which can be set as fast or as slow as you want. After using the slider bar to set the speed, you can double-click in the test area to see whether or not the speed that you have set is appropriate. If you double-click successfully, the jack-in-the-box will popup or retreat into its box.

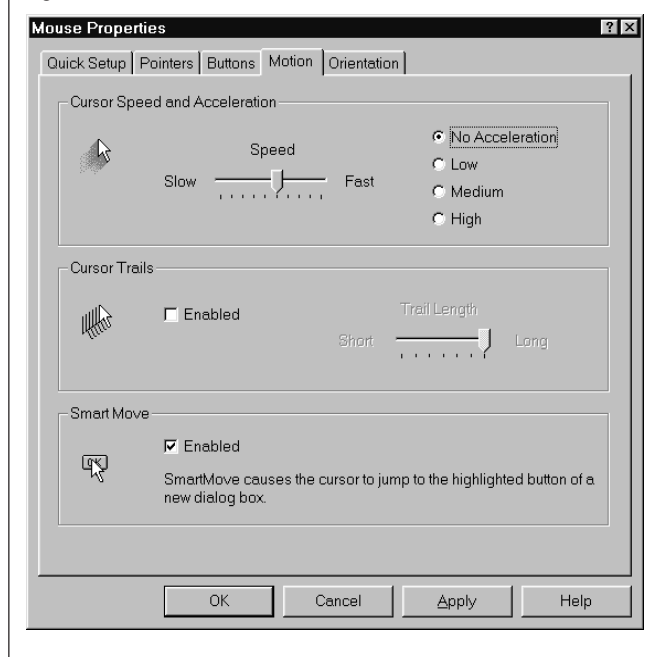
Selecting Cursors and Pointers : the second card within the Mouse Properties dialog box is the Pointers card, as shown in Fig 10. This card is used to select which pointers are used for various mouse actions. You can select a scheme of mouse pointers using the Scheme drop-down list at the top to choose from one of the standard install schemes.

Controlling the Motion of the Mouse: The Motion card as shown in Fig 11 in the Mouse Properties dialog box controls how the cursor moves on screen as you move the physical mouse or track ball. The first option on the dialog box is for Pointer speed, the higher this setting, the greater the distance travelled by the cursor as you move your mouse across the desk.

The only other feature on the Motion card is the Pointer trail. With the Show pointer trails option selected, when you move your mouse across the screen, it leaves a trail of ghost images how long or how short this trail is depends upon the setting of the slide bar. This is particularly useful for locating the mouse on a portable machine.

Regional Settings: The Regional settings properties sheet controls a variety of features that can be used by your programs to adjust the way they behave. Double clicking on the Regional Settings icon allows you to examine these regional settings.

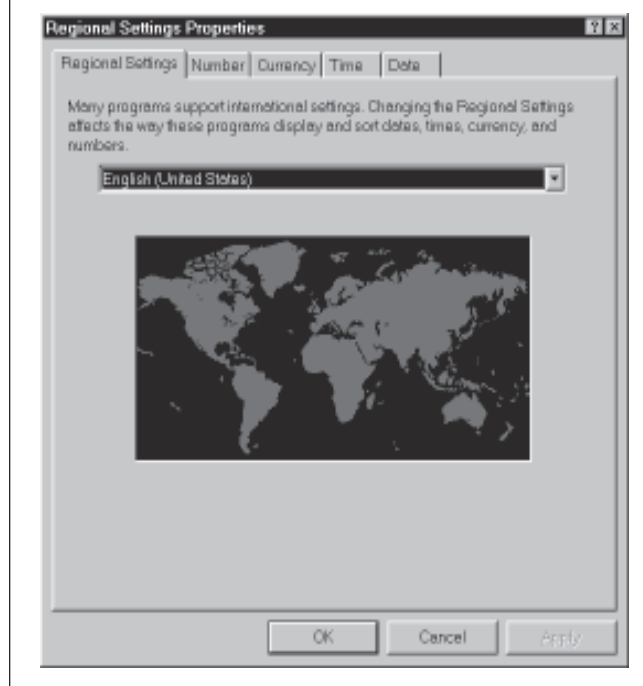
Fig 11



The Regional Settings properties dialog box has five different pages. The first of these is as shown in Fig 12 lets you set the general region, which then influences the settings used in the other four pages. If you are going to change this setting, we suggest changing the region first. The map changes to highlight the region of the world that you have selected, and the choices available on the other four pages are changed to ones appropriate to that region.

The Number card includes settings for what should be used for the Decimal Symbol, the No. of digits after decimal, the symbol that should be used to group digits (in the U.S. this is referred to as the “thousands separator”), and the Number of digits in group.

Fig 12



The Currency pages allows you to set some characteristics specific to currency such as the Currency symbol, the Position of currency symbol, the Negative number format, as well as the features just mentioned for use in the Number pages.

The formats for time and date information allow you to select from a drop-down list of features. The choices for time include the Time style; the Time separator between hours, minutes, and seconds; and the choice for AM symbols and for PM symbols.

MS word file, folder, editing, formatting text & labels

Objectives : At the end of this lesson you shall be able to

- **introduce and open microsoft word**
- **make a new blank document**
- **format text/paragraphs using toolbars.**

Introduction

Microsoft Word is an essential tool for the creation of documents. Its ease of use has made Word one of the most widely used word processing applications currently on the market. Therefore, it's important to become familiar with the various facets of this software, since it allows for compatibility across multiple computers as well as collaborative features. Word is a fairly simple program to use for completing simple tasks. However, it may be more difficult to learn how to explore the more advanced possibilities of Word.

Opening Microsoft Word

To run Word on your computer: “Start” >> “Programs” >> “Microsoft Office” >> “Microsoft Office Word 2003.” If there is an icon of Microsoft Word available on your desktop shown in Fig 1 (shaped like a square with a “W” in the

middle), you can open up the program by double-clicking it, as well.

Making a New Blank Document

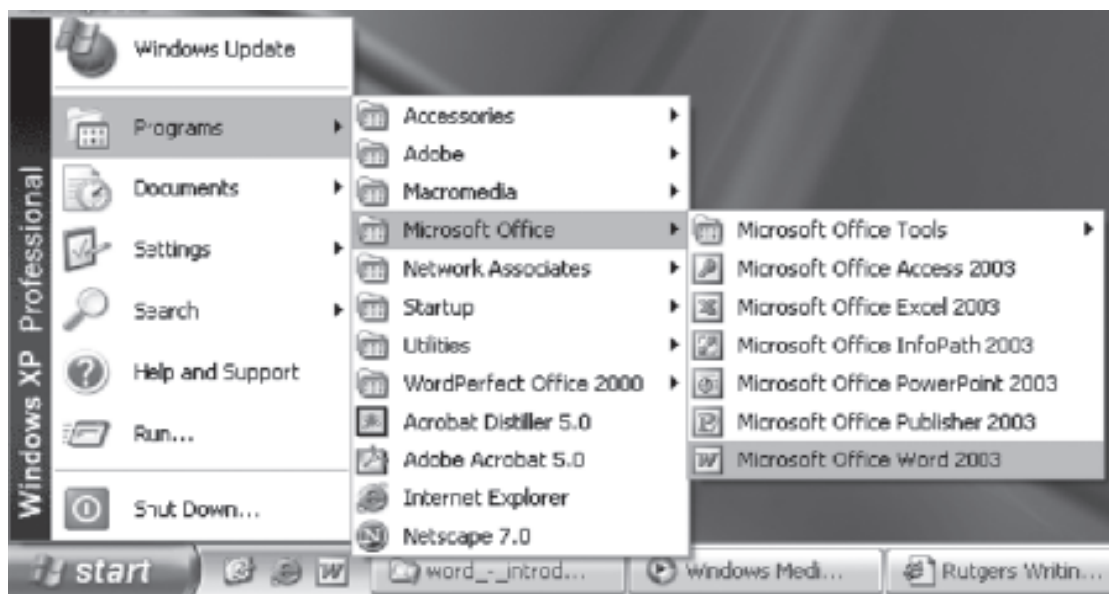
When Word is opened, a new blank document should automatically open. If not, then

you can begin a new blank document in a variety of ways. First, find the “New Blank Document” icon, which looks like a blank sheet of paper, located underneath the menu bar in Word in what is called the “standard toolbar.” shown in Fig 2 Click on the icon to bring up a new blank document.

Also, you can go to the menu bar and select File >> New... (shortcut: Ctrl+N).

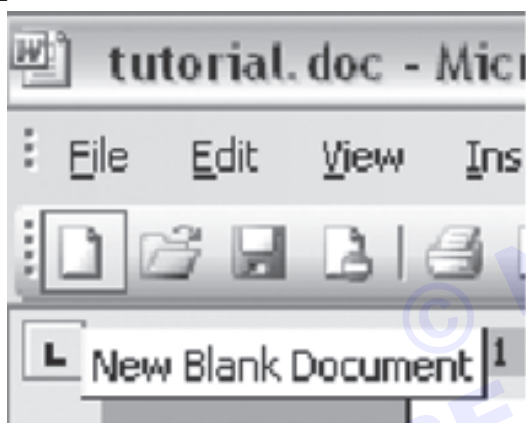
To begin typing, just click the cursor anywhere within the new blank document.

Fig 1



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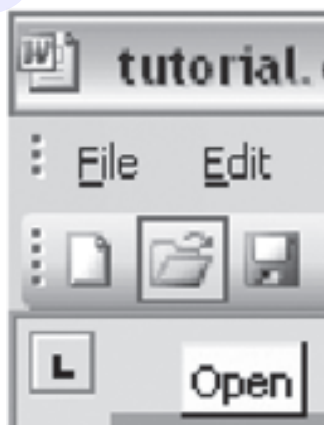
Fig 2



Opening a Document

To open to view, edit, or print a document, you must first open up that file in Word shown in Fig 3.

Fig 3



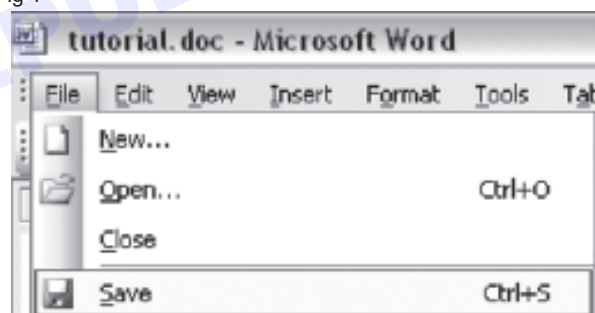
You can open a file by clicking on the "Open" folder icon (with a picture of a folder)

located in the standard toolbar. Or, you can use the menu bar and navigate to File >> Open... (shortcut: Ctrl+O).

Saving a Document

When you are working with any sort of media in any software, you should be sure to save your work often. In Word, there are numerous options for saving documents in a variety of file types. To save a new, unsaved document, you can click on the Save icon, shaped like a disk located on the standard toolbar shown in Fig 4. Or, you can go to the menu bar and select File >> Save... (shortcut: Ctrl+S).

Fig 4



A dialogue box should appear, offering you a number of options. To save the document in the desired location on your computer, locate and select the folder on your computer shown in Fig 5. Give your document a name in the file name text box. While you can give your document long names, make sure you save it with a name you can remember. Please note that it's good practice not to use spaces or special characters in file names. For example, long file name may look like this: expos_sample_paper1.doc To save a completely new document using previously existing (and opened) text, you use the Save As option. Open the document that you wish to save as an entirely new file, go to the menu bar, and click on File >> Save as. In the file name text box, give your document a new name. Using this option allows you to save multiple versions (with different file names) of a document based on one original file.

Fig 5



Formatting Text/Paragraphs Using Toolbars

In a word processing program such as Word, there are numerous options available for presenting your text. This part of the tutorial will guide you through several of the important features in Word that will allow you to edit, modify, and display text (and non-text) components.

The Standard Toolbar

Word allows all toolbars to be customized, so you may not find all options listed here. There are several buttons that may or may not appear immediately in your version of Word shown in Fig 6. Use the following graphic as a guide to the Standard Toolbar.



- 1 **New Blank Document:** To begin a new document, click on the New Blank Document icon, shaped like a blank sheet of paper.
- 2 **Open:** Clicking on this icon opens up a previously saved document on your computer.
- 3 **Save:** Clicking on the Save icon saves the document you are currently working on. If you are saving a document for the first time, you can click on this button. However, if you want to save a new file from a preexisting document, then you must go to the menu bar and select "File" >> "Save As" and give the file a new name. When working on any document, you should be sure to save frequently, so that you don't lose any work.
- 4 **Permission:** Microsoft has enabled Information Rights Management (IRM) within the new version of Word, which can help protect sensitive documents from being copied or forwarded. Click this for more information and options.
- 5 **Print:** Clicking on the Print icon automatically prints the document currently active in Word. If you wish to explore more print options, then go to the menu bar and select "File" >> "Print."
- 6 **Print Preview:** To get an idea of the appearance of your document in print before you actually print it out, you can click on this icon to view your document from a zoom-out distance.
- 7 **Spelling and Grammar:** Clicking begins a review of your document in search of spelling and grammatical errors that may need to be corrected.
- 8 **Copy:** Copy the current selection to the clipboard, which can then be pasted elsewhere in the document, or into a completely separate program/document.
- 9 **Paste:** Clicking on the Paste button inserts the text that has been most recently added to the Clipboard (the text would have been added there by Cutting or Copying). With Paste, you can either insert the copied text into a document or replace selected text.
- 10 **Undo Typing:** The Undo Typing button goes back and removes the last addition or change made to your document.

- 11 **Insert Hyperlink:** You may find that you want to make links to a particular web site, web page, or some other kind of online file in your Word document. Using the Insert Hyperlink button, you can turn selected text into hyperlinks. When the icon is clicked, a window will appear that will allow you to insert the URL (web address) of the web page you want to link to. You can type in the URL yourself or insert a pre existing bookmark. Once the link is inserted, the link in your Word document can be clicked and the web page will open up in a web browser.
- 12 **Insert Table:** When this icon is clicked, a small window will appear in the form of a grid of squares. Use this window as a guide to indicate how many rows and columns you would like your table to contain. Once selected, a table will automatically appear in Word. Clicking the Tables and Borders button will allow you to modify the table. To modify an aspect of the table, select, or place the cursor in, the area and apply changes such as borders and colors.

The Formatting Toolbar

Word allows all toolbars to be customized, so you may not find all options listed here. There are several buttons that may or may not appear immediately in your version of Word shown in Fig 7. Use the following graphic as a guide to the Formatting Toolbar.



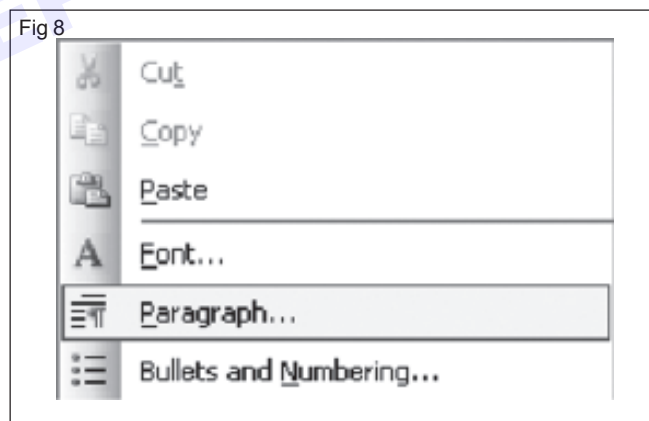
- 1 **Style:** Styles in Word are used to quickly format portions of text. For example, you could use the "Normal" or "Default Paragraph Font" for the body text in a document. There are also three preset styles made for headings.
- 2 **Font:** Font is a simple but important factor in Word documents. The choice of font (the style of the text itself) can influence the way others view documents, either on the screen or in print. For example, Arial font looks better on screen, while Times New Roman is clearer in print. To apply a font to text, select desired text with your cursor, and choose a font from the font drop down menu.
- 3 **Font Size:** You may encounter times in which you need to display some text larger or smaller than other text. Selecting desired text with the cursor and choosing a font size from the drop down menu changes the size of text.
- 4 **Bold:** Places the text in **bold**.
- 5 **Italic:** Places the text in italics.
- 6 **Underline:** Underlines the text.
- 7 **Align Left:** Aligns the selection to the left of the screen/paper.
- 8 **Center:** Aligns the selection to the center of the screen/paper.

- 9 **Align Right:** Aligns the selection to the right of the screen/paper.
- 10 **Justify:** Aligns the selection to both the left and right of the screen/paper.
- 11 **Line Spacing:** Adjust the line spacing (single-spaced, double-spaced, etc.)
- 12 **Numbering:** Create a numbered list.
- 13 **Bullets:** Create an unordered, bulleted list.
- 14 **Decrease Indent:** Decreases the indentation of the current selection (to the left).
- 15 **Increase Indent:** Increases the indentation of the current selection (to the right).
- 16 **Outside Border:** Places a border around the current selection; click the drop-down for a wide selection of bordering options.
- 17 **Highlight:** Highlight the current selection; default color is yellow.
- 18 **Font Color:** Change the font color; the default/automatic color is black.

More Formatting: Besides the toolbars, Word provides a great deal of ways to customize and format your text and documents.

Paragraph Spacing

To access the Paragraph formatting options, navigate to the menu bar, and select "Format" >> "Paragraph," or right-click within a paragraph shown in Fig 8.



A window will appear with options for modifying spacing and indenting. Here, you can choose to make the text in your document single or double spaced, as well as edit the margins for the document shown in Fig 9.

Headers/Footers

Headers and footers are important aspects of a Word document if you wish to include information such as page numbers and headings on every page. To access the header and footer options, go to the menu bar and select "View" >> "Header and Footer." shown in Fig 10.

A dotted-line box called "Header" will automatically appear, as well as a sub-menu for formatting header and footer properties shown in Fig 11. The cursor will already be placed in the Header box. If you scroll down on your current

page opened in Word, you will see a dotted-line box called "Footer." To add text in the Header or the Footer, simply

click the cursor inside either one of the boxes, and type the text you want.

Fig 9

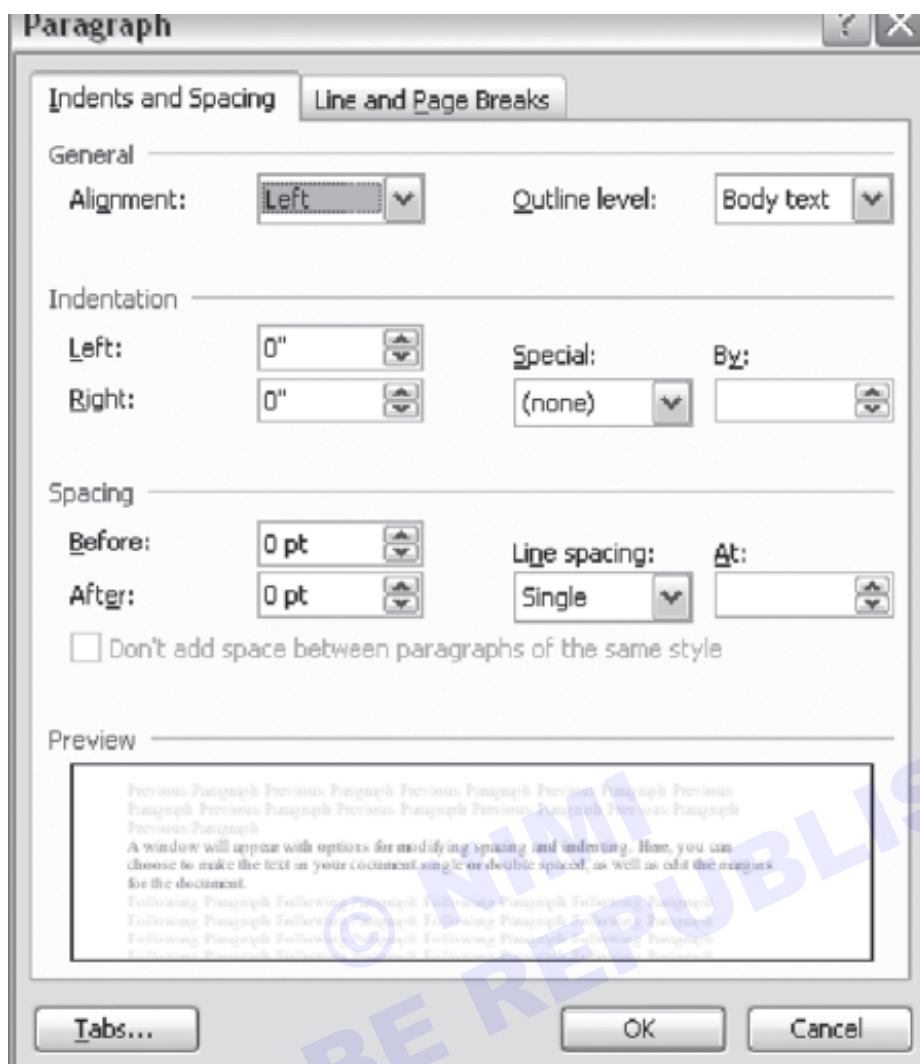


Fig 10

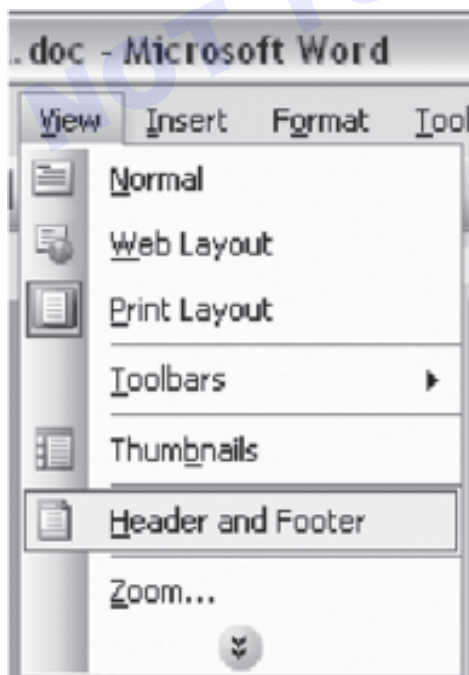
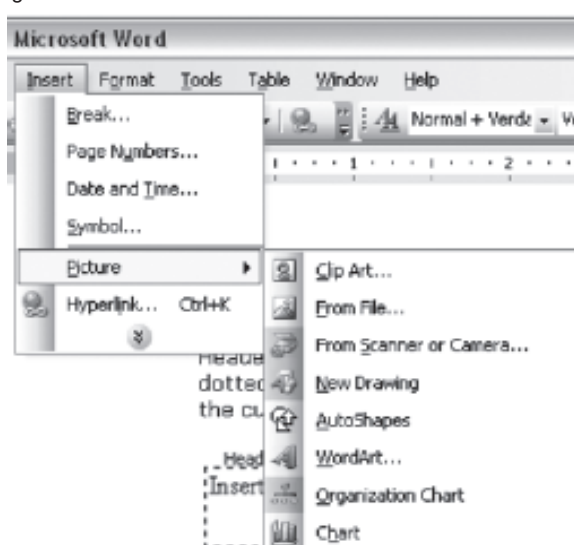


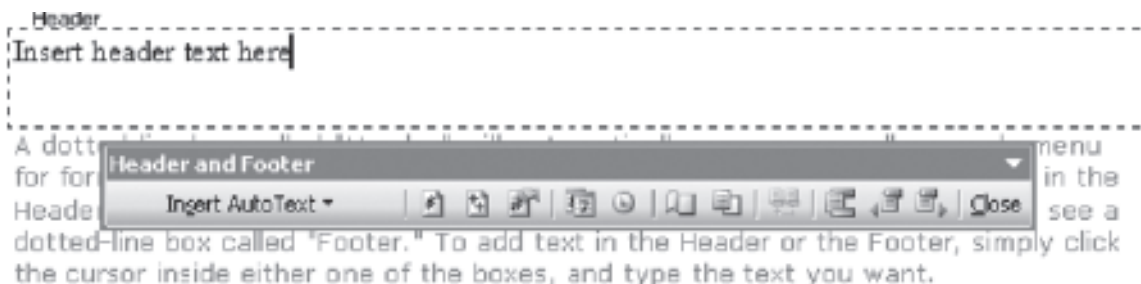
Fig 12



To add page numbers to your document, click your cursor inside of the footer box. Then, click on the icon shaped like

a sheet of paper with a “#” inside. The page number will then be inserted and applied to all of the pages in your document.

Fig 11



Introduction to mail merge in MS word

Objectives : At the end of this lesson you shall be able to

- explain the overview of mail merge
- identify terminology used in mail merge
- create the source data file.

Mail Merge Overview

Mail Merge is used to produce multiple printed copies of a document, with customized information in each copy. This process combines two files together to make one file. One of the two original files contains data records (the source document) and the other contains “placeholders” or field names (the main document). Mail Merge can be used to create letters going out to multiple individuals or to send emails to multiple individuals. You may also use it to create labels for mailings or name tags for an event. It can save you time because you only have to create the document once and the merge will do the rest. Before you begin working with the merge, it is a good idea to shut down your computer. This will decrease the chances the computer might run out of memory while you are working on the merge.

Terminology

Main Document

The document that contains the text and graphics that are the same in each version of the merged document. For example, the main document could contain the body of a letter in which all information common to all the letters is typed. The information that changes from letter to letter is represented by merge fields.

Source File

A file, usually a Word table or Excel spreadsheet, that contains the information to be merged into a document. For example, the list of names and addresses you want to use in a mail merge. You must connect to the data source before you can use the information in it.

Merge Fields

Placeholders that you insert in the main document. For example, insert the merge field «Last Name» to have Word pull the last name from the source file and insert it into the document.

Merged Document

This document is created from a mail merge and contains the main document with its fields replaced by the information from the data document. It contains as many copies as records in the data document.

Create the Source Data File

The most important thing to remember when setting up the data source is it must be formatted properly. The easiest way to set up a data source is using table format. You can use an Excel spreadsheet, or set up a table in a Word document. The first row of the table or spreadsheet must be a header row with fieldnames that can be used in the merge. Each column must have a header for the merge to work properly. You can have columns in the source file that you are not using in the merge document. You can also have some cells in each column that are not used. For example, we have an Address1 and an Address2 column. If someone does not have a 2nd line in their address, this field will be skipped (it will not print a blank line). You should not have any heading information (title, extra spaces, etc) above the header row. If you are using a Word table, the table should be the only information in the document. You cannot use a table that is inserted into a Word document as your source file. Here is an example of what an Excel spreadsheet should look like Fig 1.

Fig 1

1	2	3	4	5	6	7	8	9	10	11
Title	First Name	Last Name	Address 1	Address 2	City	State	Zip	Telephone	Donation To	Donation Amount
Mr.	Thomas	Jones	1001 Mt. Pleasant St		Charleston	SC	29403	(843) 792-1111	foster care	\$100
Mr. and Mrs.	Richard	Martin	1154 Ambling Way		Mt. Pleasant	SC	29454	(843) 684-1111	general	\$50
Mrs.	Joseph	Parks	212 Bonaparte Dr.		North Charleston	SC	29420	(843) 797-1111	pet food	\$150
Mr.	Steven	Spurrier	University of South Carolina	1001 Sumter St	Columbia	SC	29201	(803) 777-1111	foster care	\$200
Mr. and Mrs.	Thomas	Bowden	Clemson University	105 Sikes Hall	Clemson	SC	29634	(864) 656-1111	medical	\$200
Mr.	John	Smith	312 Live Oak Rd.		Summerville	SC	29483	(843) 621-1111	pet food	\$75
8										
9										
10										
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14										
15										
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Introduction to MS Excel

Objectives : At the end of this lesson you shall be able to

- explain few advantages and application
- explain few advantages and application of electronic spread sheet
- open and move around worksheet
- explain cell and its contents, naming the cell
- move copy paste content of worksheet
- setup page and print worksheet.

Spread sheet : A Spread sheet is simply a paper with rows and columns in which one can enter data which may be text or numbers. For instance, Balance sheet of company is a spread sheet. An Electronic spread sheet Excel is like a paper spread sheet spread on the screen of a computer monitor. Electronic spread sheet has the following advantages;

- Making modification to the content of the sheet is much faster and easier.
- Taking copies of the sheet is easier
- Has the facility to view only a part of the whole sheet which gives better clarity and is like seeing the spread sheet through a window.
- Allows formulae to be entered into the work sheet resulting in rapid calculation.

The popular Electronic spread sheet programs are;

- LOTUS 123 - this has become relatively old.
- Microsoft EXCEL - most popular as on day.

The rows and columns are numbered as 1,2,3, ... and A,B,C,.... The electronic spread sheet is also called as worksheet.

A few popular applications of Spread sheet are listed below;

- 1 Pay roll - where pay details of employee in a big organisation can be stored in a single spread sheet. The details could be Employee Name, Employee Identity No., Basic Salary, HRA, DA, etc. which will be helpful to the employee as well as employer to keep a track of the record.
- 2 Human Resource Development of a company where the Personal details of individual Employee like Name,

Address, Date of Birth, Date of Joining the Present Company, Personnel Details. This data will be useful to get the details of an employee.

- 3 Accounting - This is the area where the spread sheet is widely used. The companies ledger, trial balances, balance sheet for determining the profit and loss of the company.

Some of other areas where the spread sheets are widely used are

- a Tax assessment
- b Stores Maintenance (Ordering / Invoicing)
- c Quality control, etc.

The Microsoft Excel provides three basic component that perform different tasks.

- 1 Spread Sheet component is used to display and analyse text and numbers in grids i.e. rows and columns.

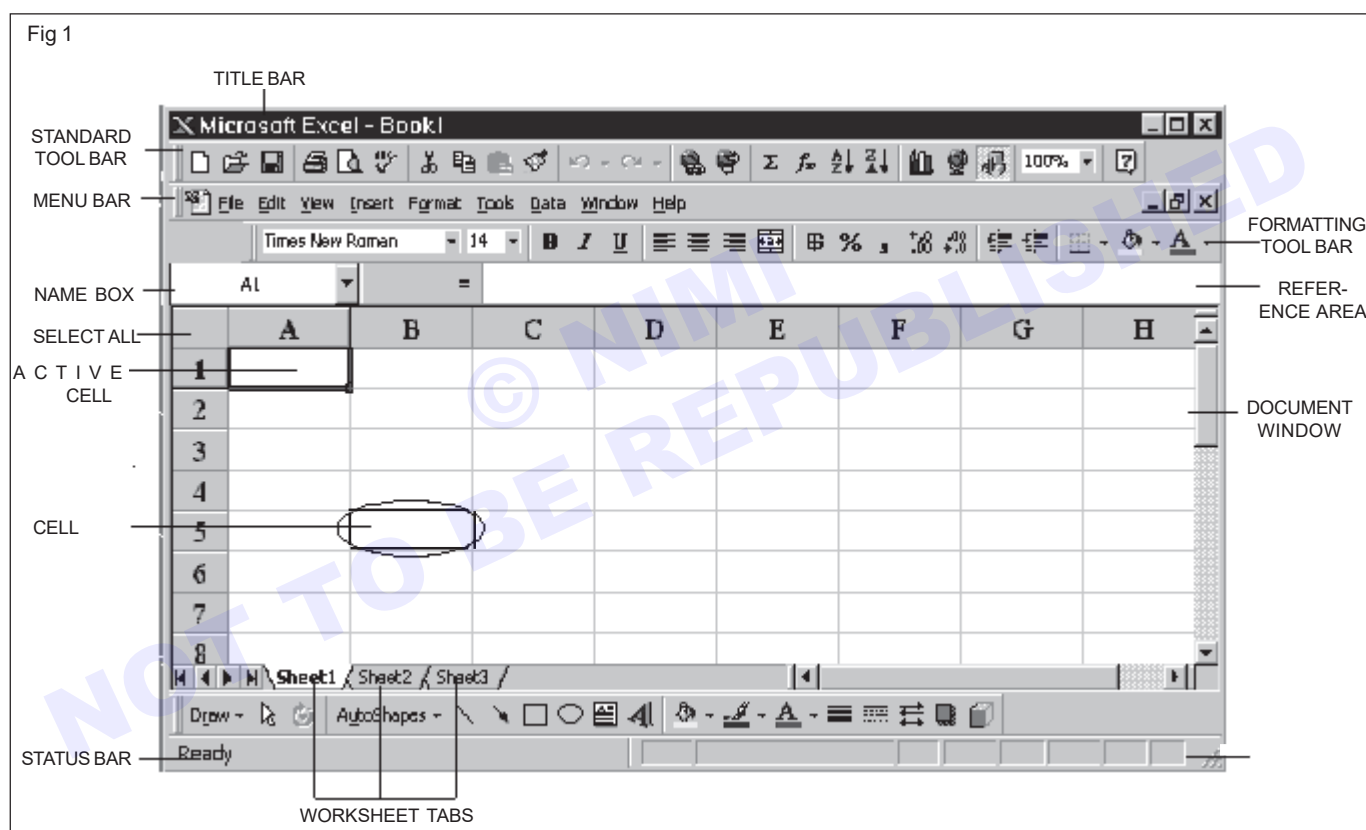
- 2 Database component is used to manipulate lists of information of particular company.
- 3 Chart component is used to produce the charts to present data graphically.

The Application package Excel has a capability of transferring and manipulate data easily with all the three above components.

Opening of Excel Worksheet : A Microsoft Excel is invoked using the sequence.

Start → **Programs** → **Microsoft Excel**, two windows appears as shown in the Fig 1. One is Application window which is an interface between the Excel and the outer world and the other one is Document window which is used as Excel worksheet and charts.

The basic component of Excel Window are explained below:



Title bar : Appears on the top of Excel Window. This consists of Application control menu at the left and minimize and restore button at right.

Menu Bar : Below the title bar is the menu bar which is similar to any other Microsoft Window for example Microsoft Word, lists the menus like File, Edit, View... etc. which contains commands to Excel.

Standard Tool Bar : Contains tool buttons which are used to carry out standard operations like Autosum, Spell Check, etc.

Formatting Toolbar : Contains tools to choose frequently used formatting commands; example Bold, Italics, Left, Centre, Right, Alignment, etc...

Formula Bar : Contains the Name box at the left end which will display the active cell address. The right area is called reference area/formula bar and is used to display data present in the cells.

Status Bar : Contains the messages and prompts. The message **Ready** in Status bar indicates Excel is ready to accept data. The Edit indicates that Excel is in Edit mode. The status bar appears at the bottom of the window.

Excel document window displays the present active worksheet. Similar to application window the document window consists of the following.

Title bar : displays the name of the work book.

Control menu : contains the maximise / restore button.

Sheet tabs : Contains the different work sheets within the current work book.

Scroll bars : Used to scroll through the work sheet.

Column / Row : The letter at the top of the column A,B, C,D... denotes the column heading. The number at the left of each work sheet 1,2,3,... denotes the row heading.

Excel stores the data in a worksheet by location. The work sheet is a grid of 65,536 rows and 256 columns. The columns are numbered A to Z, AA to AZ, BA & BZ... etc., the rows are numbered 1 to 256. The work sheets are numbered automatically as sheet 1, sheet 2, sheet 3, etc.

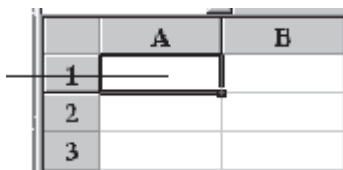
Work sheets are organised in workbook. Each new work-book opened contains three work sheets by default. User can add work sheets upto a maximum of 255 work sheets.

Cell : The intersection of row and column is called a cell. Each cell is surrounded by a grey lines called gridlines.

Each Cell is addressed by a cell address. With row and column element. For example the cell address of 3rd row and 3rd column is C3. Similarly cell address of 7th row and 2nd column is B7. The first cell address is A1.

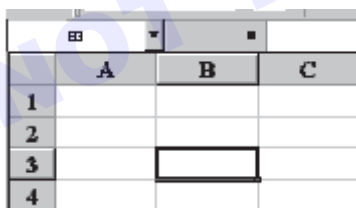
To Enter the text / number into cell, first it should be made active i.e. selected. Any cell can be selected / made active by clicking on the cell. Selected cell is indicated by a dark border as shown in the Fig 2.

Fig 2



The selected cell address will be displayed on the name box as shown in the Fig 3.

Fig 3



Entering data : To Enter Data in the active cell user can type the text directly. You can also use Cut, Copy command to Paste the data from another file in the active cell. As the text is typed, the typed text will appear in both the cell and the reference area as shown in the Fig 4.

As the first character is entered the cancel button, Enter button and the Edit formula button appear in the reference area as shown in the Fig 5.

Once the data is entered user can either press Enter key or press one of the arrow keys to move to the next cell. Excel will move the active cell to the cell in the direction of the arrow key. Alternatively user can just click the desired cell to select and type the data.

Fig 4

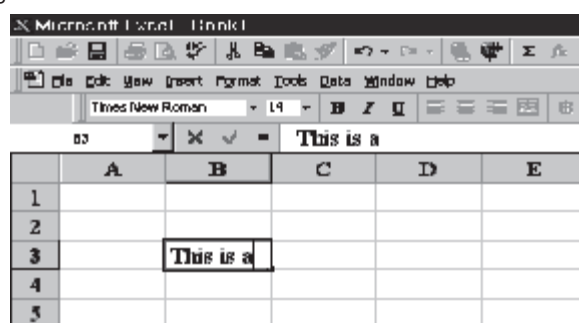
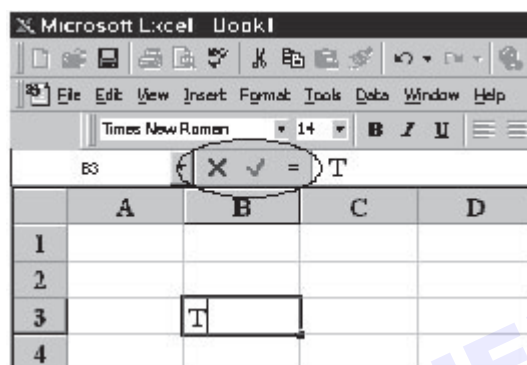
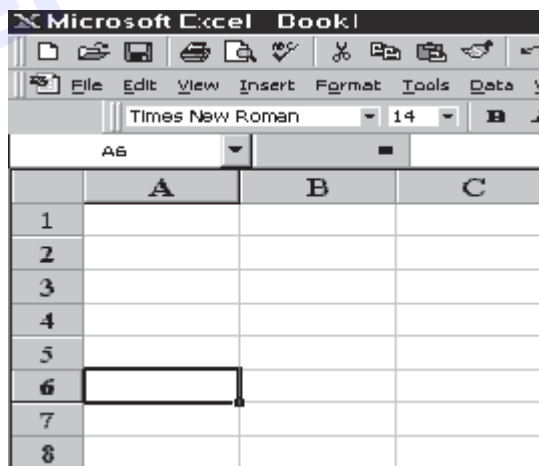


Fig 5



User can select the cell by Entering the cell address inside the name box. For example user wants to Enter the data in A6 Cell. By typing the address A6 in Name box, Excel will display the A6 cell as active cell as shown in the Fig 6.

Fig 6



The entered information will be displayed in the active cell as well as in the reference area / formula bar. User can Enter / Edit the information in the reference area also.

If the text entered is too long for the cell, the text entered will be displayed in the cells to the right if they are empty; other wise only the part that fits will be displayed.

Printing the Worksheet : The information entered in the Worksheet need to be Printed in order to allow user to share the information with others. Excel provides number of options to print the way user wants. The options for both setting parameters and printing the worksheet are contained in several dialog boxes.

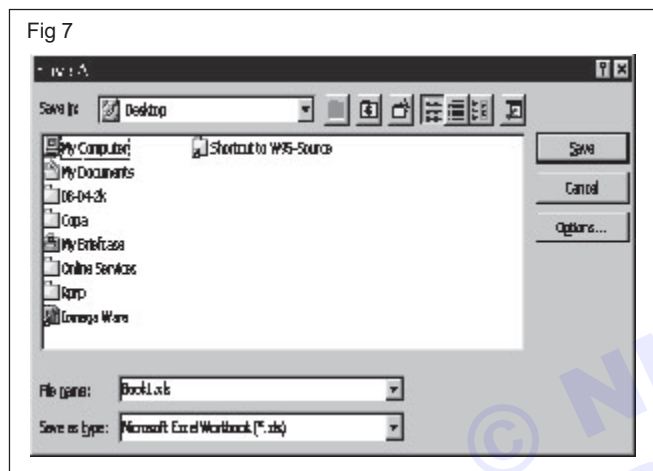
By default Excel select every thing for printing that is entered on the present work sheet in case where only a portion of the work sheet is to be printed, the user has to highlight the required range. User have an option of Print Preview where preview of the selected work sheet will appear in a print preview window.

Details of print dialog box will be discussed in future sections as and when applicable.

Saving Work Book : After entering required data in the work sheet, the work sheet need to be saved so that it can be used after a period of time.

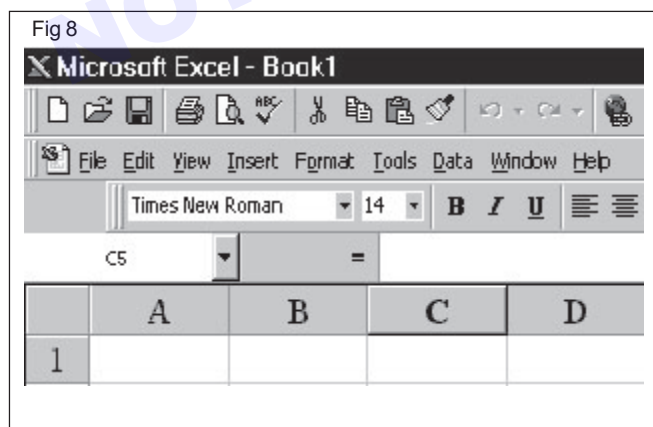
Work sheet can be saved by choosing **File** ➔ **Save**

from the main menu or save file tool bar button . On invoking Excel opens up a Save as dialog box as shown in the Fig 7.



User can Choose the folder of their choice and the file name. Once the file name and the folder is specified Excel gives the extension **.xls** automatically and the file is saved.

Creating Work Sheet / Work Book : On invoking the Microsoft Excel Application package a Work book with a label "Book1" is displayed on title bar of the Excel window as shown in the Fig 8.



By default the Excel opens a new unsaved work book. A work book is an Excel file where the user data is stored. The default work book 'Book1' consists of three blank work sheets with label Sheet1, Sheet2, Sheet3. Each work book consists of several work sheet. The work book can be thought of as a folder, each work sheet as a page in the folder.

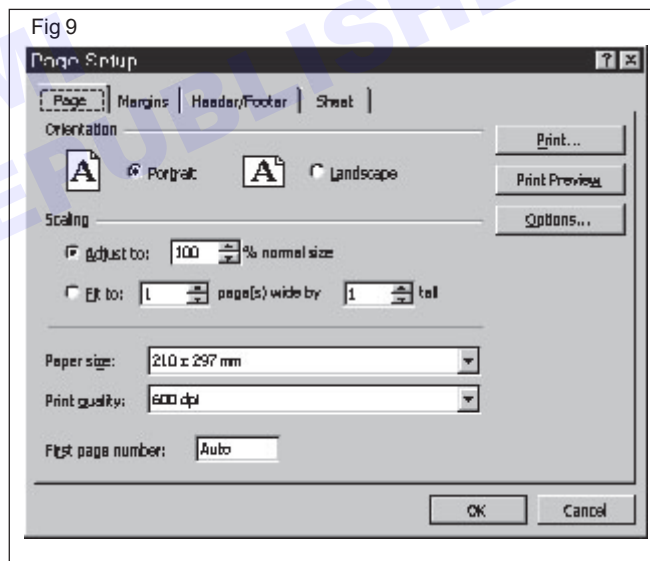
To create a work book user can click on the New button

 on the standard tool bar. On clicking ,the new dialog box appears on the screen with options. User can choose one of the options available on the dialog box. To open a workbook based on a spread sheet template user need to choose **File** ➔ **New** to display the New dialog box. On clicking on the spread sheet solution tab the Excel template will be displayed. The previous Window displays the selected template first. User can choose the appropriate template and click on OK button to open the same.

Page Setup : The Screen gives the required information which user needs, for example, mark sheet, budget, sales details are to be distributed among people as well as to have a hard copy to the institution, company, etc. To have a hard copy some Parameters should be set before the actual printing is done.

By default Microsoft Excel selects every thing entered on the current work sheet. Where only a portion of the work sheet is required to be printed, the user need to highlight the Print range.

To setup the required parameters user should choose **File** ➔ **Page Setup**. On choosing **Page Setup** dialog box appears as shown in the Fig 9.



The Page Setup dialog box provides option for setting up Page Margins, Header / Footer and Sheet width.

Page tab provides the option to setup the

Page Orientation : User can choose Portrait or Landscape orientation.

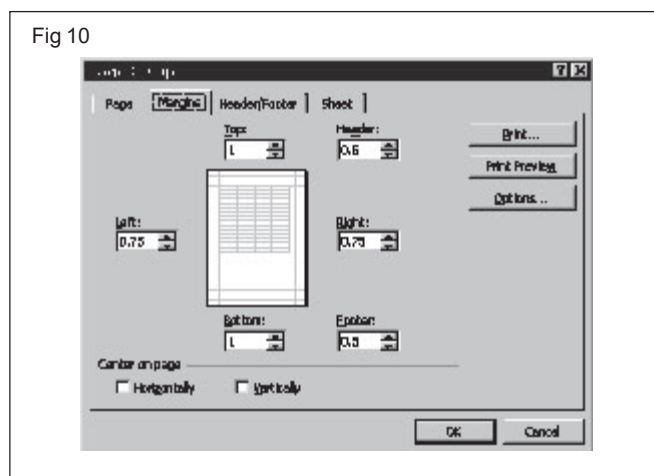
Scaling : This option provides to adjust the size of printing. By selecting the **Adjust to** radio button user can enter the percentage of normal size. By default 100% is selected.

By selecting the **Fit to** radio button user can specify the number of pages wide by the number of Pages tall.

Paper Size : The paper size drop down list provides the different paper size.

Print Quality : User can select the resolution of Printer from the drop-down list.

The Margins tab provides the option to Setup the distances in inches from the edge of the page to the printed data on four sides. The four margin top, bottom, left and right preview can be viewed in the center of the dialog box as shown in the Fig 10.



Microsoft Excel can automatically Center the contents using the center on Page check box available in the dialog box.

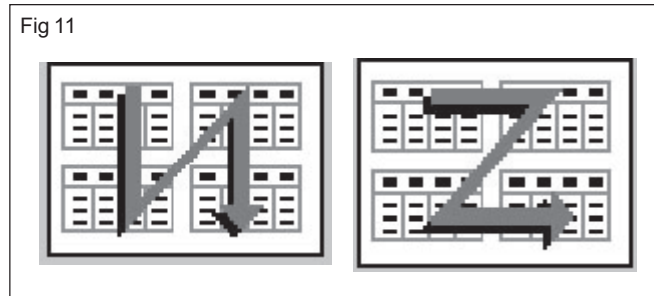
Header / Footer tab provides the user to add a text at the top of the work sheet as Header and at the bottom of page called Footer. The header normally contains the description of company, filename, etc. The footer contains the Page number.

The default header is the sheet name and the default footer is the "Page" and the Page Number. Header / Footer tab is explained in detail in future exercises.

The sheet tab provides the option to printing of grid between each cell, printing of cell notes, row and column heading on and off.

User can select the draft quality print and take only black and white printout.

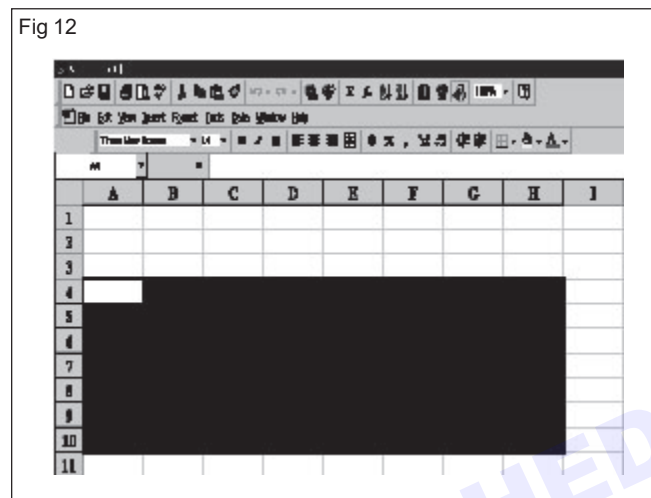
Most useful option in the sheet tab is that the user can determine how a multipage work book is to be printed. Across then down or down then across as shown in the Fig 11. This is very useful in printing reports, budgets, etc.



Range : Range is a group of rectangular cells. The smallest range is a single cell. Range can contain cells from single sheet or cells from adjacent sheets. Excel allows only rectangular ranges. Angular ranges are not allowed.

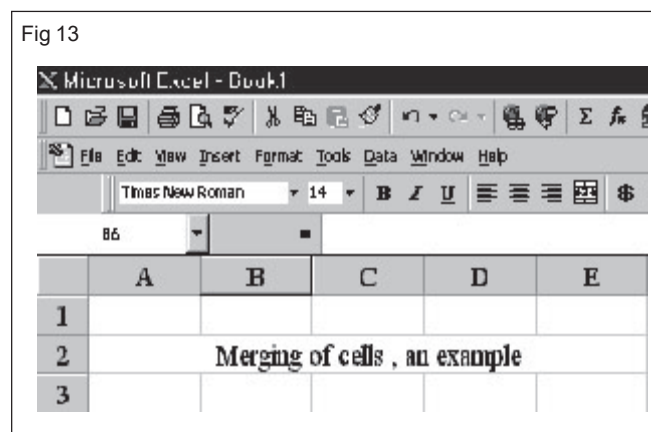
Use of ranges helps in performing a single operation on selected data at once. Ranges are defined by the cell address of two opposite corner. For example A4 : B6 or B10 : H12. The pairs of cells are separated by [:] or [..] to denote it is a range.

To select a range of cells with the mouse move the mouse pointer to one corner of the range eg. A4 and drag the mouse to opposite corner of the range say H10. The cells covering the A4 to H10 get highlighted as shown in the Fig 12.



Selecting the range of cells with the Key board select the cell in A4 cell and hold shift key pressed. Use Arrow keys to move the cursor and bring it to H10. The selected range gets highlighted.

By selecting the range, the cells can be merged by a single click of mouse. Excel provides a merge and center button  in the formatting tool bar which merges the cells and centers the text to the selected range of cells as shown in the Fig 13.

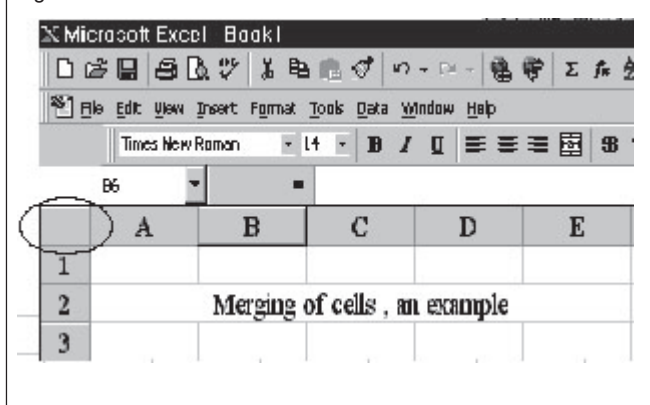


User can select the whole work sheet with a single click on the select all button available on the intersection point of row and column as shown in the Fig 14.

Increasing / Decreasing the cell width : Excel provides two methods to increase or decrease the cell width and height. User can increase the width of the cell by placing the cursor on the intersection cell column label, the cursor changes to  . This denotes that the width can be increased dragging the mouse right and decreased dragging

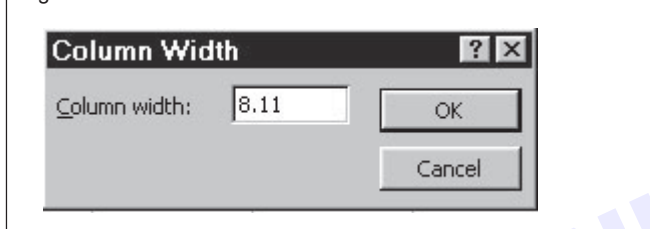
the mouse left. While dragging a rectangle yellow box prompts the cell width value.

Fig 14



Another method is to enter the value of the width directly in the column width dialog box. Column width dialog box can be invoked by choosing **Format** → **Column** → **Width**. The dialog box appears as shown in the Fig 15.

Fig 15



User can select the entire worksheet and change the column width at once or select the columns to which the width to be changed choose the above sequence to invoke the column width dialog box.

Auto sum : The Autosum tool  available on the main menu automatically builds a sum formula. For example by

selecting the range B6 to G6 and clicking on Autosum tool button the formula = Sum (B6:G6) is formed automatically. The sum will be placed on the H6. The formula can be viewed on the reference area / Edit area by selecting the H6 in this case or any where, where the value of sum is placed.

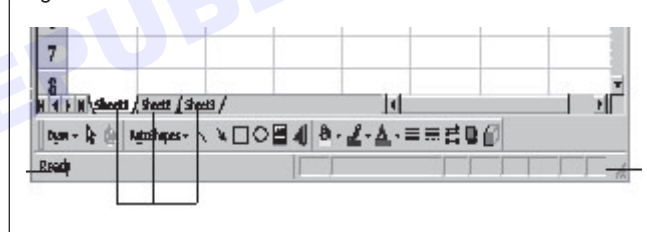
Entering Text : On Excel Work Sheet the text / Numerals can be entered by selecting the desired cell. User can type the text directly. The text is terminated by entering Enter key or choosing the check button  on the formula bar.

After entering the text, some text may not appear properly, since the column width of cell may not be enough to contain the text. To view the text in a cell fully, increase the width of the cell.

Moving around work sheet : Microsoft Excel organizes work sheets by work book.

As discussed earlier each work sheet contains 65, 536 rows and 256 columns. The work sheets are numbered automatically as Sheet 1, Sheet 2, ... Sheet 256. The name of the work sheet can be changed by user to suit the information entered in the worksheet, for example Income Tax, Budget, etc. Work sheet name can be upto 31 characters. It is advisable to have a label with short name so that number of sheet label can be viewed on the monitor. The sheet tabs are available at the bottom of the Excel windows as shown in the Fig 16.

Fig 16



MS Excel formatting in tables & using formula

Objectives : At the end of this lesson you shall be able to

- select data type
- increase & decrease decimal points
- align cell contents
- increase & decrease indent
- align text
- apply borders
- apply color to borders.

Data Types : Excel handles data in five different types.

- 1 Numbers are values that are numerals 0 through 9, with a decimal point (.) as a separator for decimal and comma (,) as a separator for thousands.

Numbers can start from the currency symbol \$, Rs, or with a + (Positive) or - (Negative) sign. They can end with a % sign.

- 2 Dates are handled as serial numbers in Excel which represent the number of days elapsed since 1-1-1900. Excel will recognise the dates in the following format.

1. DD - MMM - yy - 04-Dec - 99
2. MM/DD./YY - 10/4/00
Where 00 -> 2000
3. DD-MMM - 04 - Jan
4. MMM - YY - Feb -99.

- 3 Time is also represented as serial numbers. Excel represents 24 hours of the day as values between 0 and 24. Time can be entered in the following format

HH : MM : SS 12:12:15

HH : MM AM/PM 12:30 PM
 HH : MM : SS AM/PM 12:12:15 PM
 HH : MM - 12:15

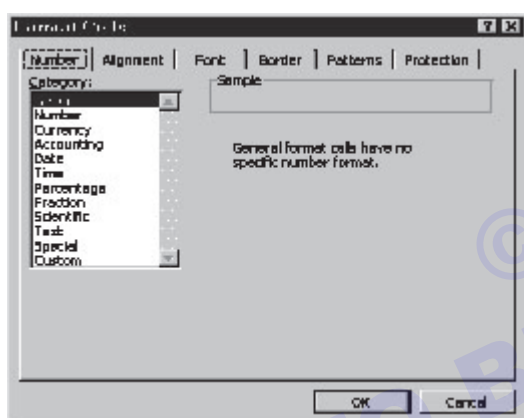
- 4 Formulas are Mathematical formulas which perform calculation on data should be entered into cell. For example to sum the values in cell B2, B3 and B4 user would enter the formula = B2 + B3 + B4 in cell B5.

5 Text

Excel recognises data as text which is not number, time, date or formula. Excel will treat the numeric value that are outside of its accepted number, date and time formats as text. For example 10:52AM will be treated as text because it does not fit in the time format.

User have an option to select to entered data as Number or Text by choosing **Format** ➡ **Cells**. Select the Number tab from the Format Cells dialog box. Text or Number can be selected from the category box as shown in the Fig 1.

Fig 1

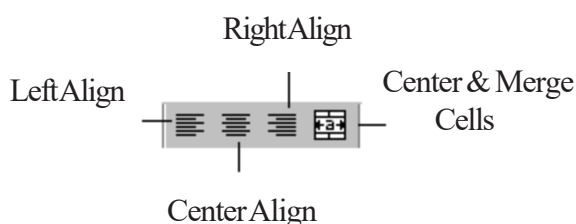


Adding Worksheet : As discussed earlier the new work book opens with three worksheet by default. User can insert worksheet as many as 255 worksheets.

To add a new worksheet choose **Insert Worksheet** from the main menu. Excel will add new worksheet to the left of the worksheet selected.

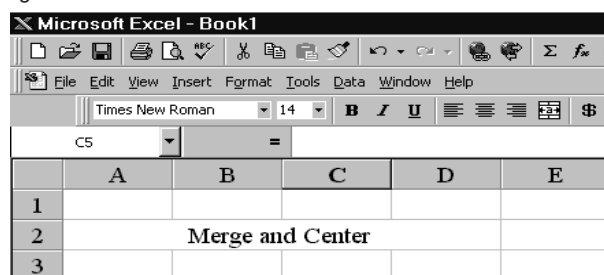
Alignment : Excel aligns the text and numbers entered in the cell automatically. By default numbers are right aligned and Text are left aligned. User can overwrite this by selecting the cell and selecting the one of the button on the formatting tool bar as shown in the Fig 2.

Fig 2



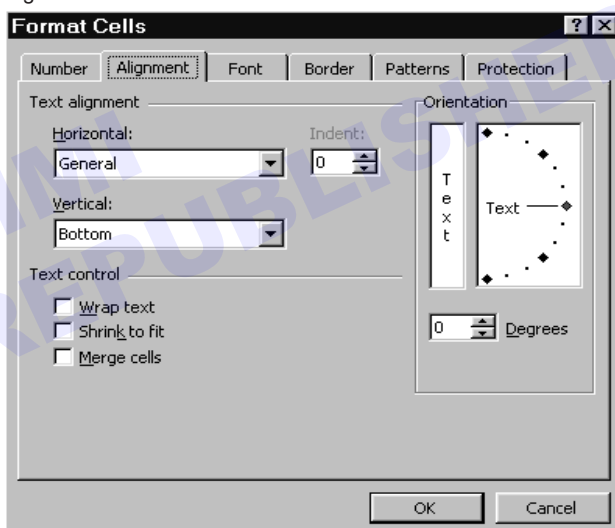
Merge and Center button allows user to center the contents of cell across a number of columns as shown in the Fig 3.

Fig 3



The text can be aligned Horizontal, Vertical and Orientation to the text can be given with the help of format cells dialog box. The format cell dialog box can be invoked by choosing **Format** ➡ **Cell**. Selecting Alignment tab in the format cell dialog box the option of alignment of text, text orientation appears as shown in the Fig 4. User will also have the option of wrapping the text, shrink the text to fit in the cell.

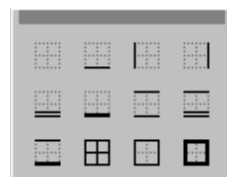
Fig 4



To change the orientation of the text user can either enter the value directly in the Degree box or use the Up/Down arrow to increase or decreases the value. Another way is to use the protractor shown in the orientation box.

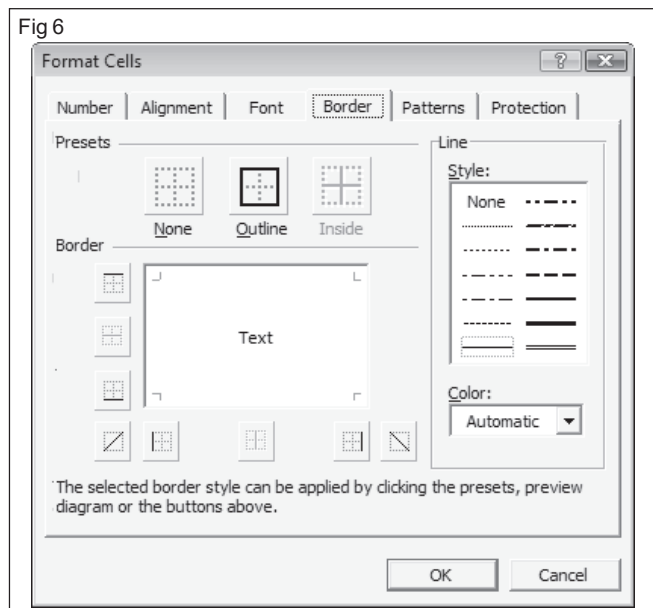
Applying Border : User can apply the border to the active cell or range of cells by clicking the border button on the formatting tool bar. On clicking the preset border drop down list appears as shown in the Fig 5.

Fig 5



User can apply the border to the active cell by Choosing **Format** ➡ **Cell** to display the format cells dialog box.

Border tab gives more option of border and style as shown in the Fig 6.

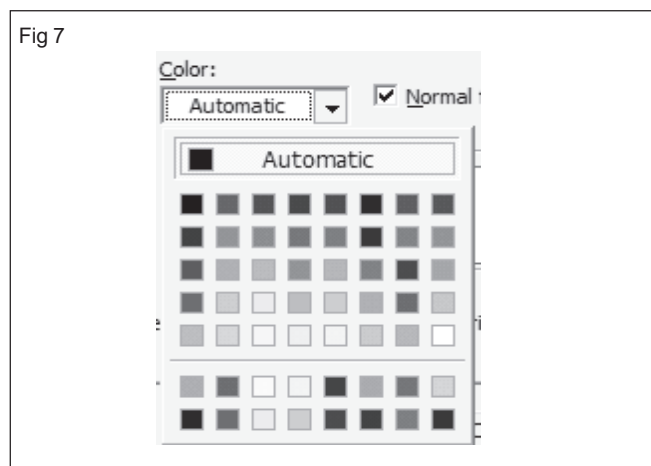


Applying Colors to borders : The Border Tab in Format dialog box provides an option to user to apply a color to

the border. This will help in highlighting the contents of the cell.

The Color window under the style opens up a color palette as shown in the Fig 7.

By selecting the choice color from the palette, the selected color is applied to the border.



Creating charts in Excel

Objectives: At the end of this lesson you shall be able to

- explain the basic elements of a chart
- list the types of charts
- create chart using chart wizard
- change chart types
- work with auto format
- print charts.

Excel provides graphical component which allows to represent data in the worksheet graphically. Graphically represented data helps in understanding, analysing easier.

Chart:- A chart is graphical representation of entered data in the worksheet. Graphical representation of data makes the data more clearer and easier to read. Chart can be viewed, edited and can be embedded in the worksheet.

Chart can be either two dimensional (2D) or three dimensional (3D). The basic elements of the charts are

AXIS	Charts have X-axis (horizontal) and Y- axis (Vertical). The 3-D charts will have Z axis (depth).
Title	Each axis will have chart titles.
Legend	This identifies each data series (Color, Pattern, etc.)
Data Series	This is set of data from which the chart is drawn. Most of charts can have two or more data series. Except Pie chart has only one data series.

Categories Is the data by which the data series is separated. If data series in years 1900 to 2000, each year is a category.

Gridlines These are the lines drawn across the chart from the axis for visual reference.

The Fig 1 shows the basic elements of chart.

Types of Charts: Excel offers different types of charts. Some of them discussed below are very often used to represent the data.

1 Area Charts : Shows the magnitude of change over time. It is used where several components are changing and the user needs sum of the components. It is a stacked line chart with the area between the lines filled with color or shading.

An example of area chart is shown in Fig 2.

2 Bar Charts : Are very frequently used charts which consists of a series of horizontal bars that allow comparison of the relative size of two or more item at single point of time.

An example of bar chart is shown in Fig 3.

Fig 1

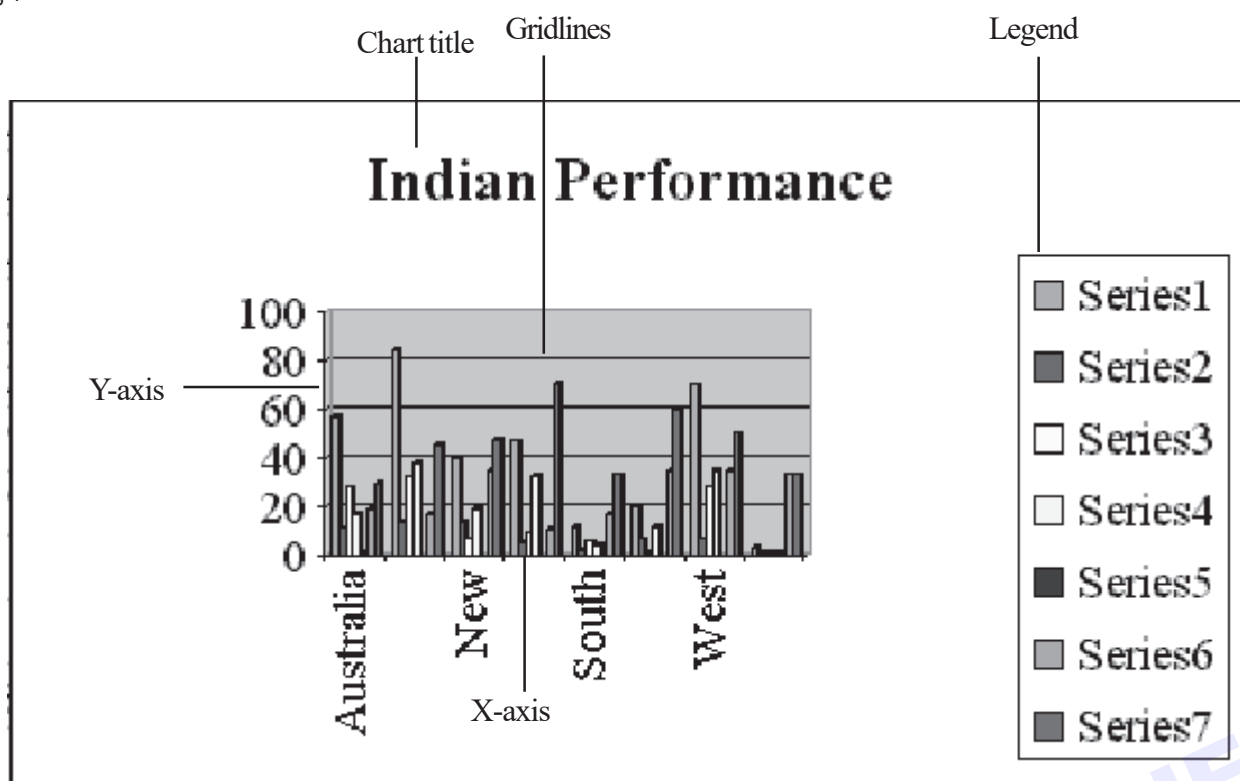


Fig 2

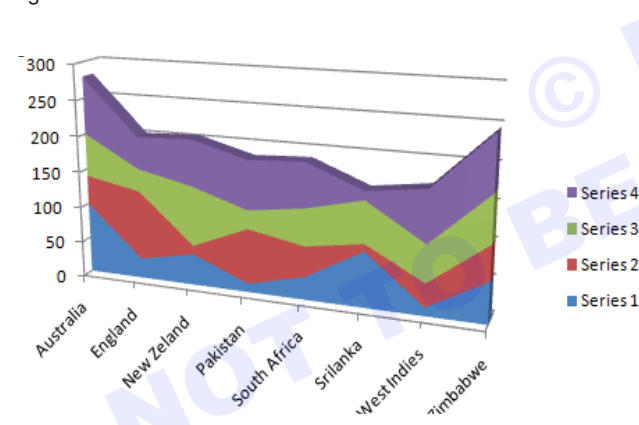
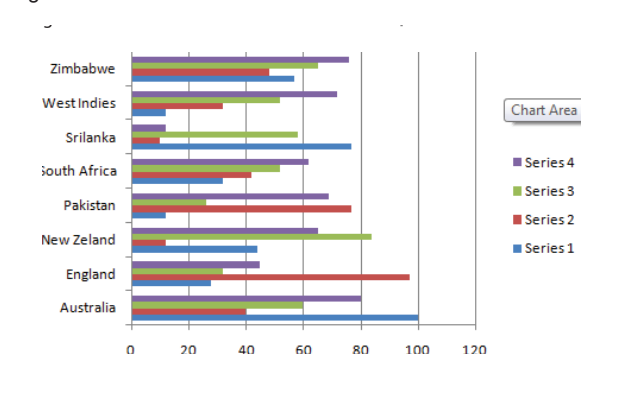


Fig 3



Bar chart are of three types.

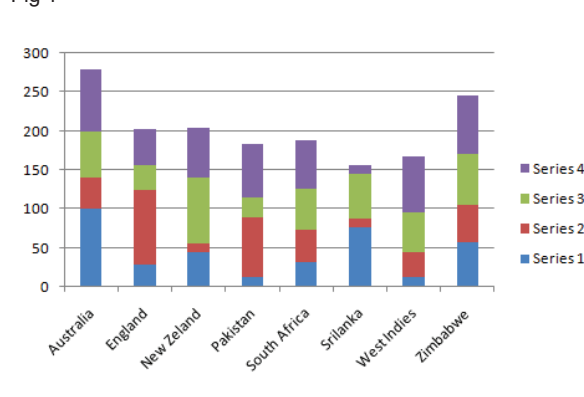
- Stacked bar chart
- 3D bar chart

c 100% stacked bar chart

3 Column Charts : Consists of a series of Vertical columns that allow comparison of the relative size of two or more data items. Here also each column represent single data point.

An example of column chart is shown in Fig 4.

Fig 4



4 Line chart : Is used to show the trends over time. Each data series is used to produce a line on the chart.

An example of Line chart is shown in Fig 5.

5 Pie Chart : Is very widely used to compare the percentage of sum that several numbers represent.

An example of Pie chart is shown in Fig 6.

Each number can be represented by a slice. One of the slices can be separated from the other slices.

The major difference between all other charts and pie chart is that it has only one data series.

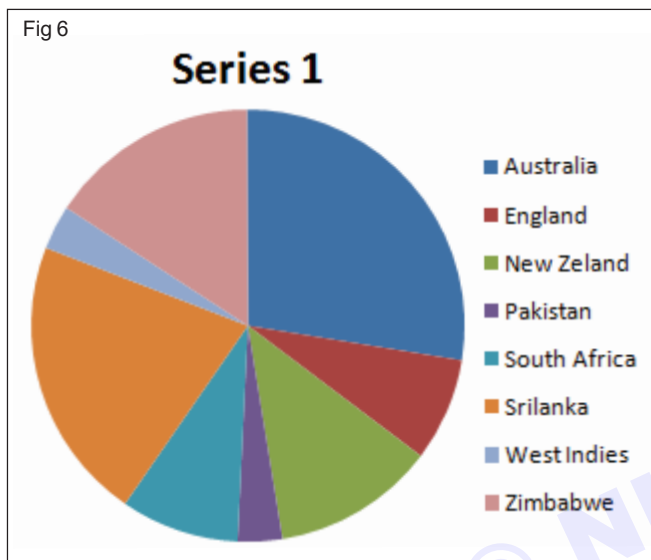
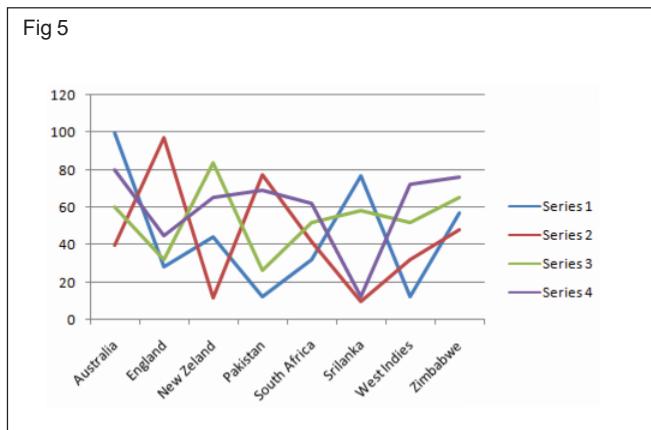
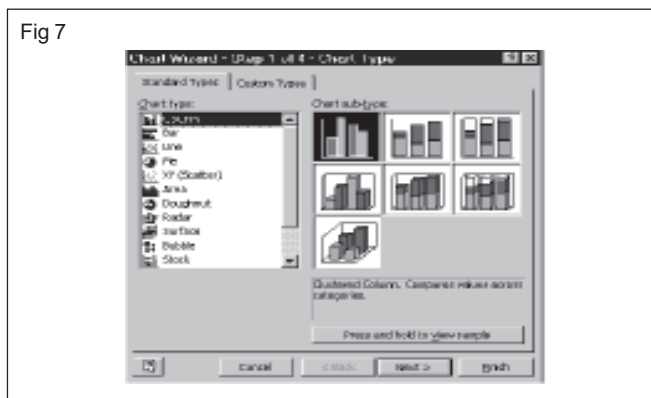


Chart Wizard : Excel allows user to create chart either on a separate sheet as a chart sheet or it can be embedded on the current worksheet. The easiest way and the best way to create a chart is using the chart wizard.

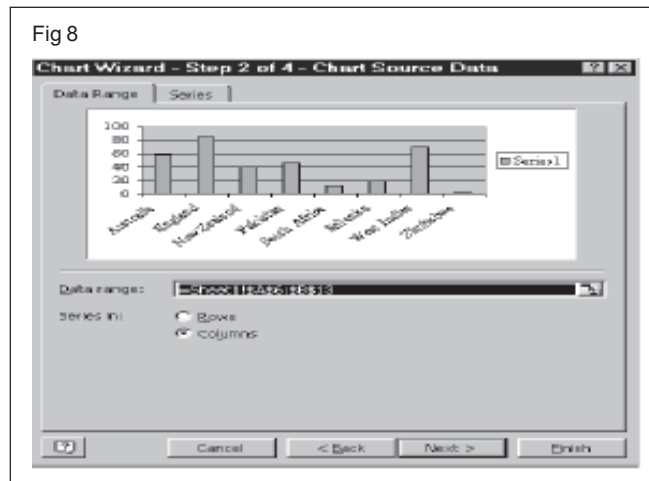
The chart wizard button  is available on the standard tool bar.

The chart wizard guides the user step by step in creating the chart.

In the Step 1 of 4 user will select the chart type, after selecting the data which user wants to chart. The choice of selecting the chart type is given in the Step 1 of 4 wizard dialog box as shown in the Fig 7.

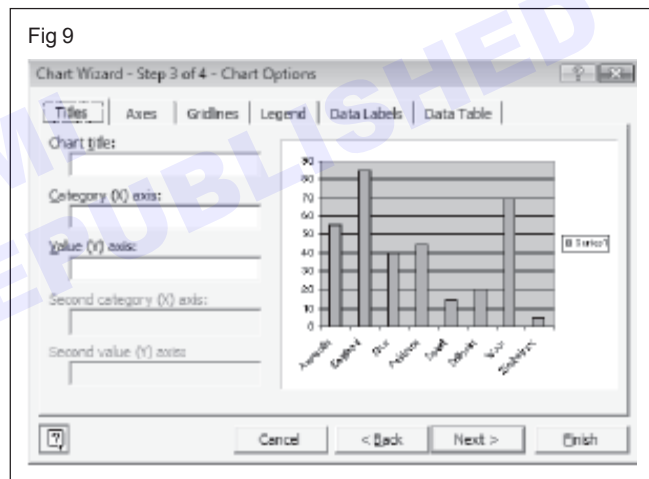


On clicking the next button on the first dialog box user enters to Step 2 of 4 which is the chart source dialog box as shown in the Fig 8.



User will select the data range and the data series in Row or Column.

In the Step 3 of 4 user will enter the chart title, details of x and y co-ordinates as shown in Fig 9.



It also gives the option to user to

- 1 Suppress the axis.
- 2 Choosing the gridlines to display
- 3 To display legend and placing the legend
- 4 To display data labels or not.
- 5 To display the data table which is very useful in chart sheet.

In the step 4 of 4 user will be given an option to place the chart in a new sheet or embedded in the existing worksheet.

Excel allows user to move, resize, delete and edit the chart. On clicking the chart size handles appears around the chart. Using the handles user can resize the charts.

Changing chart types : User is also allowed to change the chart from one type to another. The chart tool bar provides the quick access to important parts of a chart as shown in the Fig 10.

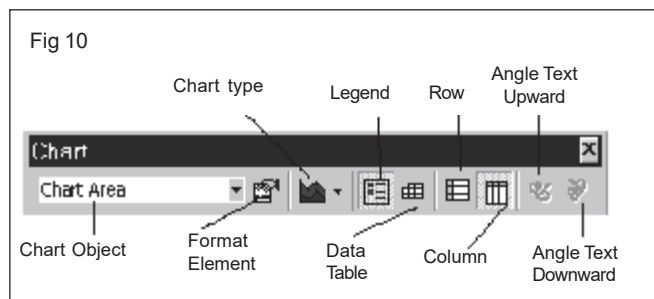
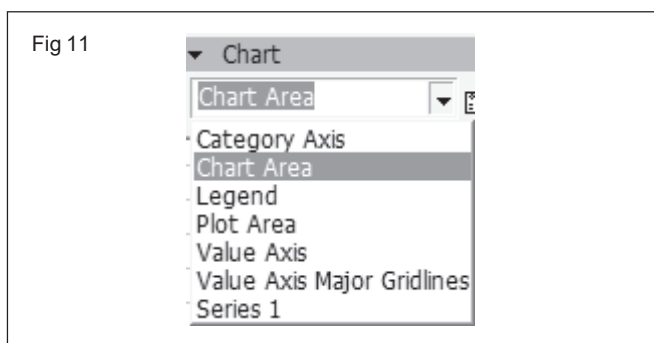


Chart objects is used to pick the object user wants from the drop down list. The drop down list displays the item currently selected as shown in the Fig 11.



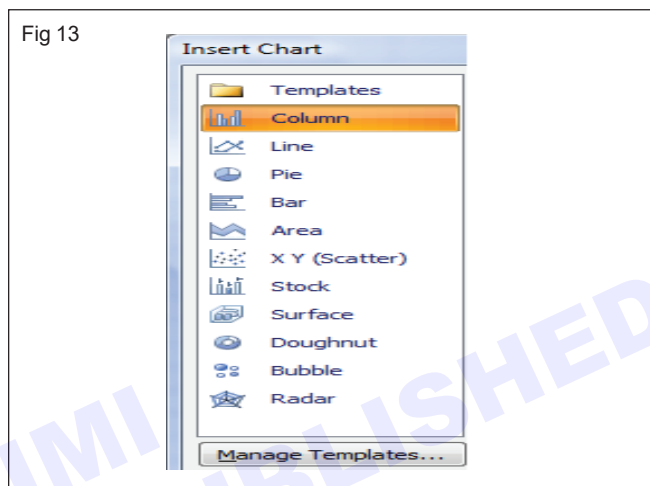
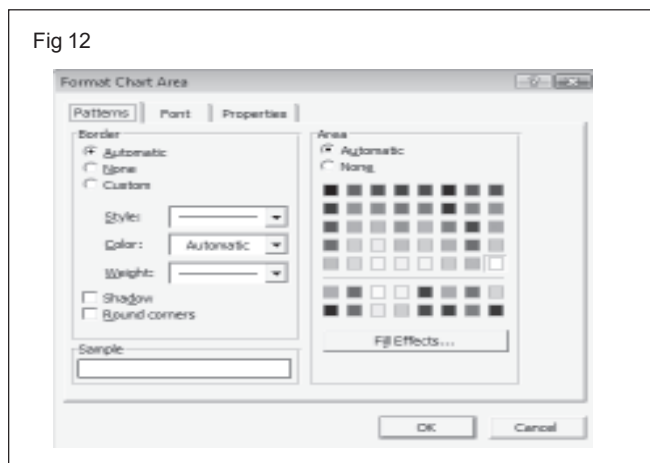
Format element displays the format dialog box for the element chosen as shown in the Fig 12.

Chart type button applies the indicated chart type to the chart .On clicking the drop down list displays as shown in the Fig 13 from which user can change the chart type.

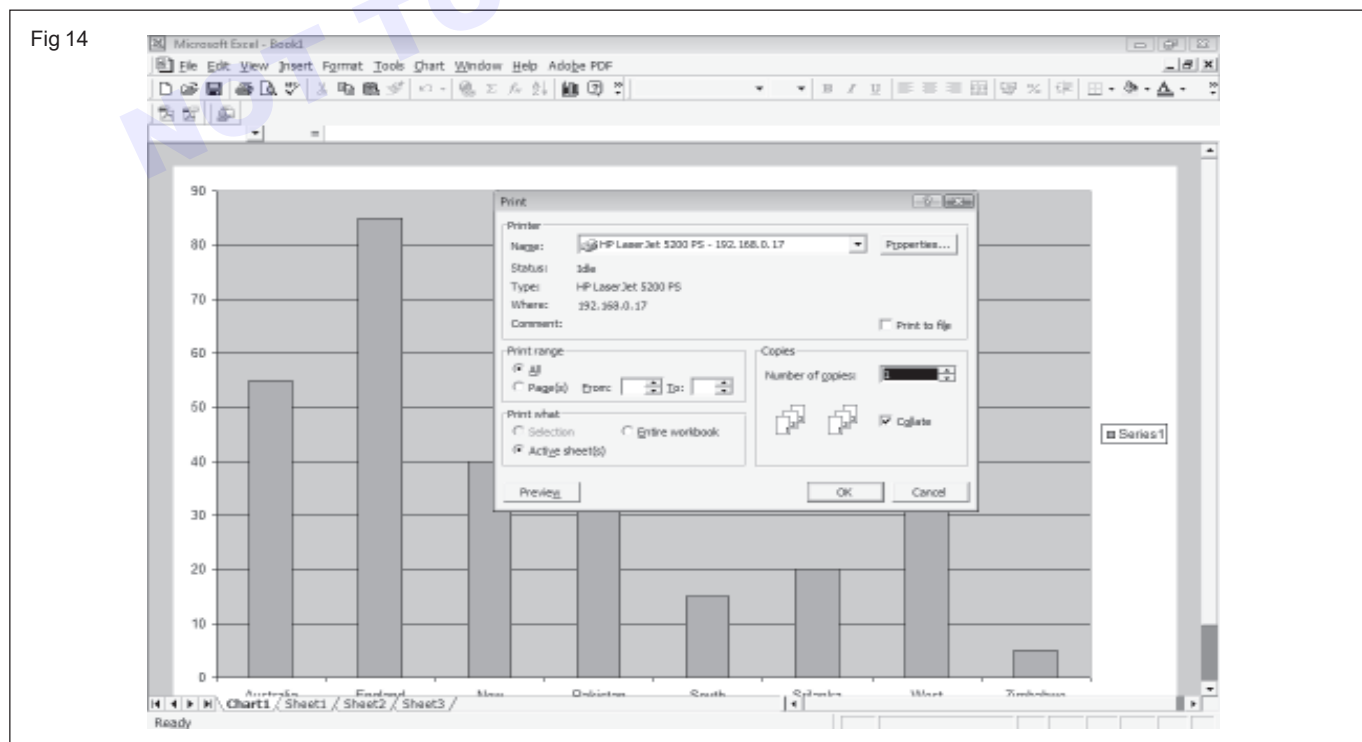
Legend button toggles the display of the legend.

Data table button toggles the display of the data table.

Angle text downward and Angle text upward tilts the selected text at a 45 degree angle. By clicking the respective buttons that are present in the chart tool bar we can add legend, title and gridlines for a chart. Alternatively, these can also be added using the Insert menu.



Printing of Charts : Since charts are stored with worksheet pages, the tasks of saving and printing charts are so different from saving and printing worksheets. If it is an embedded chart, you can size and place it on the worksheet and view it in print preview. If it is a chart sheet, you can size and scale it in your required manner (Refer Fig 14).



Working with cells, columns and rows

Objectives: At the end of this lesson you shall be able to

- insert rows & columns
- insert cells
- hide rows and columns.

Inserting Rows & Columns : It is easy to insert rows or columns in Excel Work Sheet. One method is to select the entire row below the place where you want to insert new blank row. Choose **Insert**  **Rows** from the main menu.

For example, click on the row number 5 in your worksheet to select the full row as shown in the Fig 1.

Fig 1

	A	B	C	D	E	F	G
1	Details of Employees						
2							
3	Name	Age	Sex	Department	Designation	Salary	
4	S.Shivu	38	Male	Lab	Technician	6000/-	
5	N.Vishwa	40	Male	Lab	Technician	6000/-	
6	R.Swamy	52	Male	Accounts	Clerk	3500/-	
7	K.Swamy	48	Male	Accounts	Clerk	3500/-	
8	Anitha	30	Female	Accounts	Clerk	3000/-	
9	Shilpa	26	Female	Lab	Technician	5000/-	
10	Ramanna	32	Male	Sales	Executive	8000/-	
11	Chitra	28	Female	Admin	Clerk	3000/-	
12	S.Raj	42	Male	Sales	Sales Assistant	4000/-	
13							

The new blank row 5 gets inserted. The contents of the previous row 5 will be now content of row 6. All other rows are pushed down and re-numbered as shown in the Fig 2.

Fig 2

	A	B	C	D	E	F	G
1	Details of Employees						
2							
3	Name	Age	Sex	Department	Designation	Salary	
4	S.Shivu	38	Male	Lab	Technician	6000/-	
5							
6	N.Vishwa	40	Male	Lab	Technician	6000/-	
7	R.Swamy	52	Male	Accounts	Clerk	3500/-	
8	K.Swamy	48	Male	Accounts	Clerk	3500/-	
9	Anitha	30	Female	Accounts	Clerk	3000/-	
10	Shilpa	26	Female	Lab	Technician	5000/-	
11	Ramanna	32	Male	Sales	Executive	8000/-	
12	Chitra	28	Female	Admin	Clerk	3000/-	
13	S.Raj	42	Male	Sales	Sales Assistant	4000/-	
14							

User can insert multiple rows by selecting multiple rows before issuing the insert rows command.

Another method to insert rows is to select the row below the place where you want to insert new blank row. Click on the right mouse button. The context menu appears as shown in the Fig 3. Choose **Insert** from the context menu, the row gets inserted.

To Delete the unwanted rows click on the row number label which is to be deleted. Click on the right mouse button. From the context menu choose **Delete**. The selected row gets deleted.

Similarly to insert a column select the label of the column where you want the new column to appear.

For example if you want a blank column at column C. Select Column C and use any one method used to insert the rows and select column instead of rows. The column

gets inserted with label C. The contents of C becomes the contents of D. The columns that follow will also be pushed right and renamed as shown in Fig 4.

Fig 3

	A	B	C	D	E	F	G	H
1	Details of Employees							
2								
3	Name	Age	Sex	Department	Designation	Salary		
4	S.Shivu	38	Male	Lab	Technician	6000/-		
5	N.Vishwa	40	Male	Lab	Technician	6000/-		
6	R.Swamy	52	Male	Accounts	Clerk	3500/-		
7	K.Swamy	48	Male	Accounts	Clerk	3500/-		
8	Anitha	30	Female	Accounts	Clerk	3000/-		
9	Shilpa	26	Female	Lab	Technician	5000/-		
10	Ramanna	32	Male	Sales	Executive	8000/-		
11	Chitra	28	Female	Admin	Clerk	3000/-		
12	S.Raj	42	Male	Sales	Sales Assistant	4000/-		
13								
14								
15								
16								
17								
18								

Fig 4

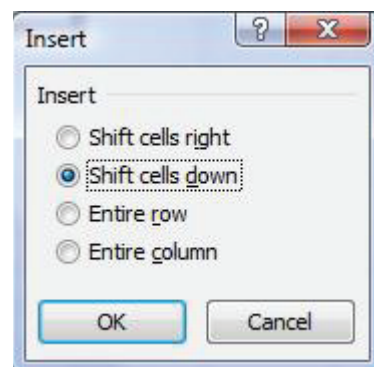
	A	B	C	D	E	F	G	H
1	Details of Employees							
2								
3	Name	Age	Sex	Department	Designation	Salary		
4	S.Shivu	38	Male	Lab	Technician	6000/-		
5	N.Vishwa	40	Male	Lab	Technician	6000/-		
6	R.Swamy	52	Male	Accounts	Clerk	3500/-		
7	K.Swamy	48	Male	Accounts	Clerk	3500/-		
8	Anitha	30	Female	Accounts	Clerk	3000/-		
9	Shilpa	26	Female	Lab	Technician	5000/-		
10	Ramanna	32	Male	Sales	Executive	8000/-		
11	Chitra	28	Female	Admin	Clerk	3000/-		
12	S.Raj	42	Male	Sales	Sales Assistant	4000/-		
13								

To delete the column follow the same method as deleting rows.

Inserting Cells : You can insert empty cell into an existing worksheet, by pushing existing cell either to the right of the insertion point or down from the insertion point.

For example to insert a cell at C6, Activate cell C6 and choose **Insert**  **Cells...** from the main menu. The insert dialog box appears as shown in the Fig 5.

Fig 5



The dialog box gives an option to shift cells right or down. You also have an option to insert an entire row or entire column. If you select the Shift cells down radio button a cell gets inserted and the contents of the earlier cell get pushed down as shown in the Fig 6.

Fig 6

	A	B	C	D	E	F
1	Details of Employees					
2						
3	Name	Age	Sex	Department	Designation	Salary
4	N. Vishnu	25	Male	Admin	HR	50,000
5	S. Abdul	30	Male	Accounts	Accountant	45,000
6	R. Shivani	27	Female	Computer	Analyst	75,000
7	Q. Stepen	25	Male	Labs	Technician	42,000
8	K. Porkodi	23	Female	Sales	Sales Assistant	35,000
9	A. Archana	28	Female	Admin	Clerk	25,000
10	R. Suganya	32	Female	Computer	Senior Engineer	75,000
11	S. Raguram	45	Male	Admin	Manager	87,000
12	R. Jagan	31	Male	Sales	Telecaller	35,000

A range of cells can be deleted or inserted. The insert and Delete commands in case of a range of cells work only with rectangular selections. Non contiguous range of cells cannot be inserted or deleted with a single command. When the selected cell or cells are deleted, they are removed from the worksheet and the adjacent cells shift to fill in the space.

Hiding Rows and Columns : Some times you may wish to hide some information which is already entered in the worksheet. Excel provides an option to hide the rows or column without displaying their contents. It can be revealed later when it is required.

To hide rows, select the row by clicking on the row label choose **Format** ➡ **Row** ➡ **Hide** from the main menu.

The Fig 7 shows a hiding of row 4. Observe that you will not see the continuous row numbers, when hide is performed. You can also hide numbers of rows. To do this select the rows to be hidden and choose hide command.

Fig 7

	A	B	C	D	E	F
1	Details of Employees					
2						
3	Name	Age	Sex	Department	Designation	Salary
5	S. Abdul	30	Male	Accounts	Accountant	45,000
6	R. Shivani	27	Female	Computer	Analyst	75,000
7	Q. Stepen	25	Male	Labs	Technician	42,000
8	K. Porkodi	23	Female	Sales	Sales Assistant	35,000
9	A. Archana	28	Female	Admin	Clerk	25,000
10	R. Suganya	32	Female	Computer	Senior Engineer	75,000
11	S. Raguram	45	Male	Admin	Manager	87,000
12	R. Jagan	31	Male	Sales	Telecaller	35,000

To unhide the rows at the later stage select the rows where the row is hidden. For example the fig shows the row 4 is hidden. Select row 3 and 5 as shown in the Fig 8.

Fig 8

	A	B	C	D	E	F
1	Details of Employees					
2						
3	Name	Age	Sex	Department	Designation	Salary
5	S. Abdul	30	Male	Accounts	Accountant	45,000
6	R. Shivani	27	Female	Computer	Analyst	75,000
7	Q. Stepen	25	Male	Labs	Technician	42,000
8	K. Porkodi	23	Female	Sales	Sales Assistant	35,000
9	A. Archana	28	Female	Admin	Clerk	25,000
10	R. Suganya	32	Female	Computer	Senior Engineer	75,000
11	S. Raguram	45	Male	Admin	Manager	87,000
12	R. Jagan	31	Male	Sales	Telecaller	35,000

Choose **Format** ➡ **Row** ➡ **Unhide** from the main menu. The hidden row will appears as shown in Fig 9.

Fig 9

	A	B	C	D	E	F
1	Details of Employees					
2						
3	Name	Age	Sex	Department	Designation	Salary
4	N. Vishnu	25	Male	Admin	HR	50,000
5	S. Abdul	30	Male	Accounts	Accountant	45,000
6	R. Shivani	27	Female	Computer	Analyst	75,000
7	Q. Stepen	25	Male	Labs	Technician	42,000
8	K. Porkodi	23	Female	Sales	Sales Assistant	35,000
9	A. Archana	28	Female	Admin	Clerk	25,000
10	R. Suganya	32	Female	Computer	Senior Engineer	75,000
11	S. Raguram	45	Male	Admin	Manager	87,000
12	R. Jagan	31	Male	Sales	Telecaller	35,000

Similarly if you want to hide column C. Select the column label C and repeat the procedure you have done to hide the rows. Choose column instead of rows. The hidden column worksheet will appear similar to Fig 10.

To Unhide the column select, the columns B and D and Unhide.

Fig 10

	A	B	D	E	F
1	Details of Employees				
2					
3	Name	Age	Department	Designation	Salary
4	N. Vishnu	25	Admin	HR	50,000
5	S. Abdul	30	Accounts	Accountant	45,000
6	R. Shivani	27	Computer	Analyst	75,000
7	Q. Stepen	25	Labs	Technician	42,000
8	K. Porkodi	23	Sales	Sales Assistant	35,000
9	A. Archana	28	Admin	Clerk	25,000
10	R. Suganya	32	Computer	Senior Engineer	75,000
11	S. Raguram	45	Admin	Manager	87,000
12	R. Jagan	31	Sales	Telecaller	35,000

Introduction to MS power point presentation

Objectives : At the end of this lesson you shall be able to

- list the powerpoint toolbars
- state the options available in Power point
- create presentation by using auto content wizard
- explain the creation of new slides
- explain adding text to slide, resizing the text
- explain adding bullet
- explain outline view.

Introduction

Power Point is part of Office 97 package which provides tools to create presentation. The Presentation can be created from scratch or taking material from word documents, or excel spread sheets. User can even mix in sound and video to give a asthetic look. Presentation can be run either manually or automatically.

Earlier the presentation were done with physical slides, overhead projectors, transparency, etc. Now with computer, one can create these material with in minutes.

For any presentation, the materials required are:

Slides are images which can contain text, graphics, charts, sound and video etc.,

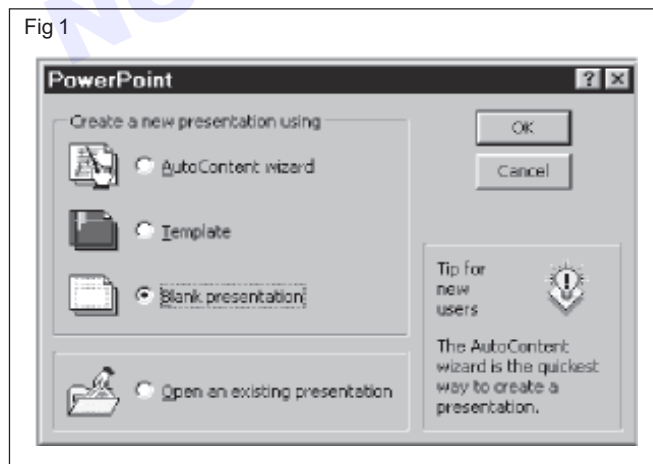
Speaker's Note are speaking aids that consist of an image of each slide with notes which are not available on slides.

Handouts are printed master/document containing images of the slides.

PowerPoint can be invoked by two ways. One following the sequence **Start** → **Program** → **PowerPoint** or double clicking on the desktop icon which will be normally present on the desk top screen, if Office 97 is loaded in the Computer.

Once the Power Point invoked, the Power Point start up dialog box is displayed on the screen as shown in the Fig 1.

Fig 1



The Start-up dialog box gives three option

- 1 **Auto Content Wizard** : To create Presentation automatically by the application package with selected type.

- 2 Template allows user to choose this.
 - a Creating of blank presentation
 - b Presentation designs selection
 - c Presentation type selection
 - d Templates for creating web pages
- 3 Blank presentation allows user to choose use of the auto layout from the new slide dialog box.

The bold gray line indicates either a title or subtitle on the layout. The dot and a zig zag line indicates bulleted list. A picture indicates cliparts and so on.

Power Point offers different views for entering, editing and previewing the information.

Power point has several tool bars on screen by default when user invokes the Power point as shown in the Fig 2. User can customise Power Point to display other tool bars, or even add or delete tools from the tool bars so that user finds most useful area readily available on the screen.

Tool bars are shortcuts to initiate actions with a single mouse click. Many of the tool bars can also be activated through menus.

Standard tool bar

The standard tool bar is very similar to many window - based programs which enables user to open a new or existing file, saving, printing file, cutting, copying and pasting text etc. Some special tools which are pertaining to Powerpoint are explained below.



New Slide allows user to open new slide along box.



Slide layout allows user to select a different layout for slide.



Apply design allows user to change the design template.



Insert Hyperlink and web tool bar is related to connecting the internet and move around the world wide web.



Tools for inserting objects into presentation like clip art.



Insert Word table, Chart and Excel worksheet.



Increase and decrease Paragraph spacing between selected lines of text.



Black and White view displays the slide show in black and white.



Increase/decrease font size for selected text.

Formatting tool bar will be displayed by default. Similar to standard tool bar many of the tools contained on this tool bar are common to many window program. Some special tools which are used in Power Point are explained below.



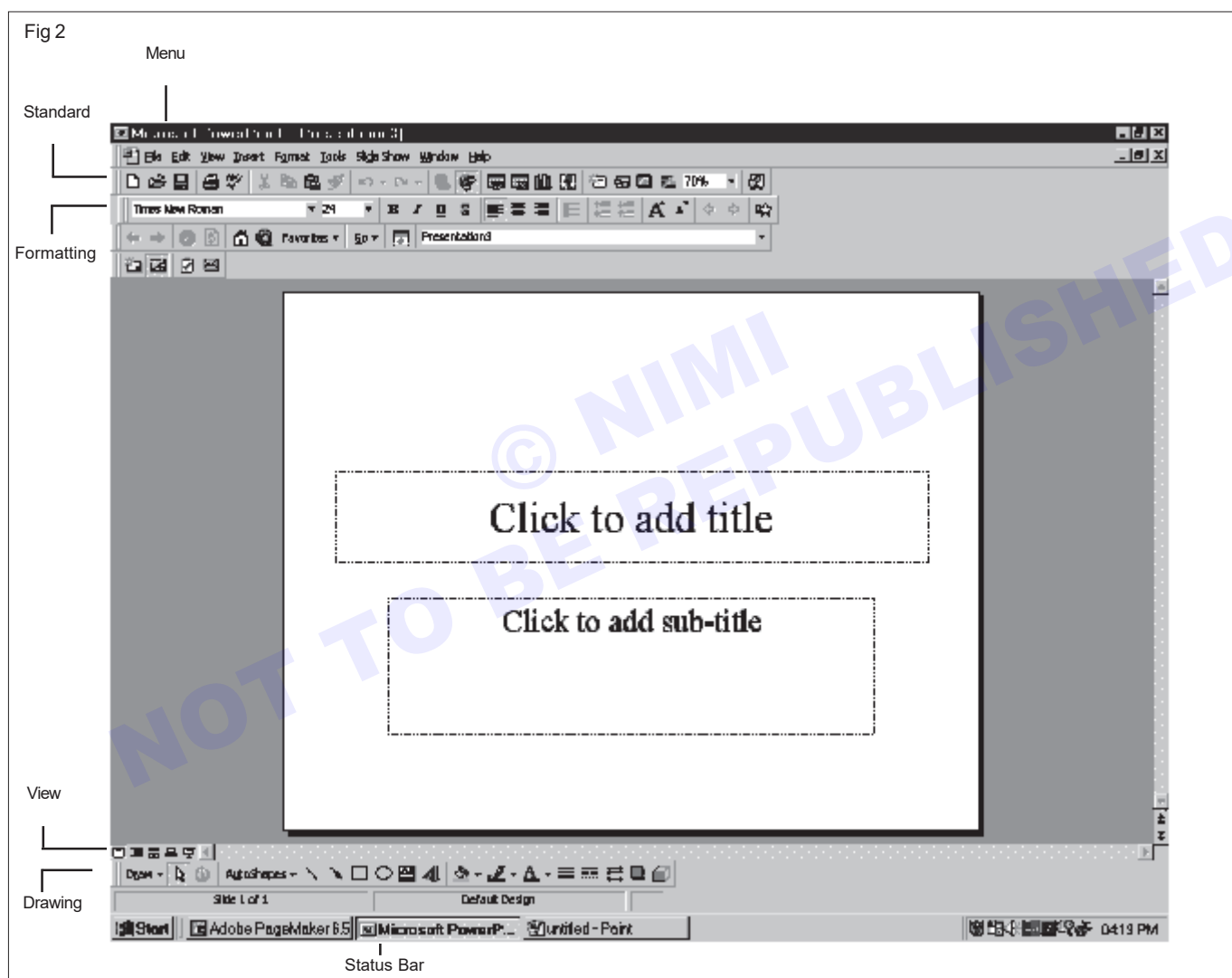
Promote / demote menus the selected text one level up / down in the outline hierarchy.



Animation effects open the animation effect dialog box.



Bullets used to apply bullet list to selected text.



Drawing tool bar

This contains the tools for formatting and manipulate drawn objects such as lines, shapes and clipart drawings. Some of the frequently used tools are explained below

Select object  This tool is used to select the object for applying the effects.

Free rotate  Will manipulate the orientation of shapes on the slide.

Autoshapes  Will help user in drawing lines, rectangles, circles and shapes such as stars and flowcharts.

Text box  Is used to create text objects.

Fill color, line color  This can add color to objects, lines from the available drop-down list of colors.



Shades and 3D will allow to add shadows or three dimensional effects to objects.

Menu commands will help in File management including opening a new or existing file, editing function such as undoing, redoing actions, cutting, copying, pasting, viewing the presentation on screen, placing a variety of objects, slides.

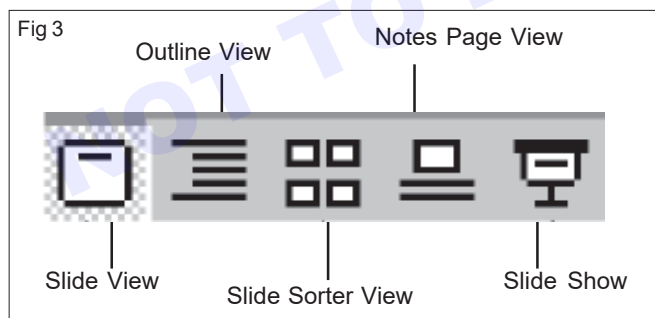
Finally Power point will give the commands under slide show for managing timing, animation, transition effects of slide shows.

The status bar, a feature found in most window based software is at the bottom of Power point screen. This will indicate the user, which slide is currently on the screen, No. of slides in whole presentation. This also indicate the design template currently applied and provide a tool to initiate spelling check of the file.

Power point offers five different views which can be used to gain a different perspective on the presentation. The five views icons are available at the bottom of the Power point screen, just above the drawing tool bar. User can click on one of the icon to get the view or choose the view menu from the standard tool bar and select one of the view from the menu the five views are as shown in the Fig 3.

Slide view as the name indicates displays the single slide with place holders for layout element such as title, bulleted list etc. This view is used to work on the details of the individual slide.

Outline view will show the contents of all slides in the Presentation the flow of information in presentation. User can enter text in slide or outline view, typing text into outline view is faster and will help to focus on presentation ideas. Outline view has its own toolbar at the left of the screen as shown in the Fig 3.



Slide sorter view will allow user to look at slide design details, sequence of the slide presentation in miniature size. The slides are numbered to indicate their sequence in slide show.

Note Page view helps the user to create note pages for the presentation. This will help the presenter/speaker to remember the information or key points to make at the Presentation during that particular slide. User can have hard copy of the notes.

Slide show view displays each slide in an on-screen slide show. This gives the idea of slide appearance to audience during Presentation. This is very useful in design process, fine tune design and rehearsal of presentation.

Auto Content Wizard

Power Point gives four options to the user to open a presentation.

Auto content wizard which walks through step-by-step creating a new presentation. This is the best choice for those who are new to Power point.

Template Offers a built-in design templates through a dialog box.

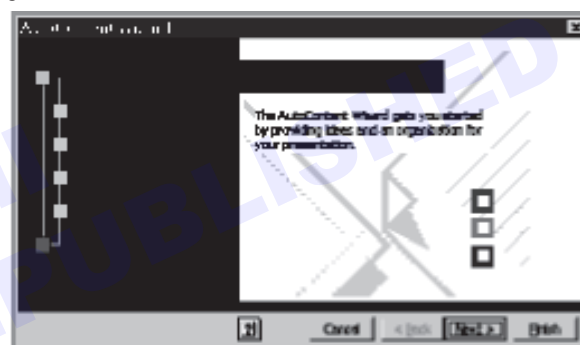
Blank presentation opens a presentation with no elements or design background. User can create presentation from scratch.

Open an existing presentation opens a dialog box from which user can browse to locate Power point file that was previously saved.

By default the blank presentation is selected. By clicking on radio button user can select the other options.

When user selects the Auto content wizard, the dialog box appears as shown in the Fig 4.

Fig 4



On the left hand side of the dialog box displays the various steps that the wizard will take you through. User can navigate through the items by choosing Next and Back button or more directly to one of the items by clicking the check box.

User can select the Presentation type from the second dialog box. i.e. Presentation type dialog box which is similar to the Fig 5.

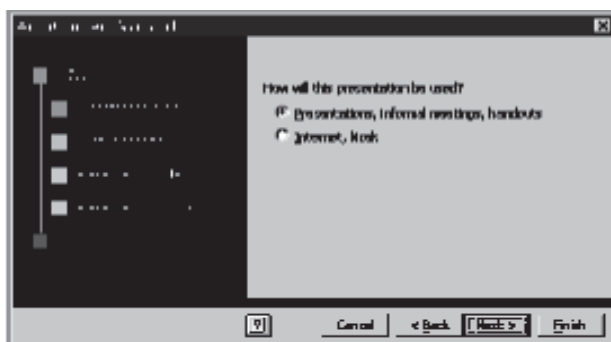
Fig 5



User can select by category or by selecting the All button, lists the complete presentation types available in the wizard.

Once the Presentation type is selected the wizard will allow user to choose designating output options from the third wizard window as shown in the Fig 6.

Fig 6

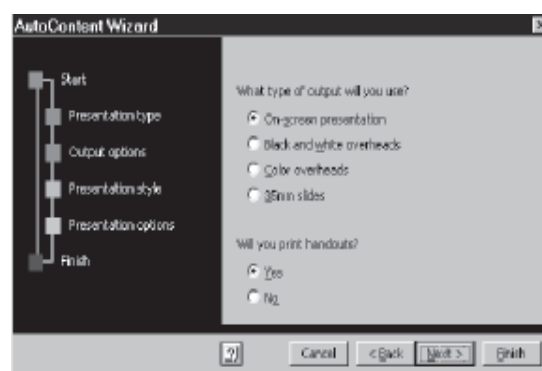


Presentations, informal meetings, handouts, this is the choice to make if a speaker will guide an audience through presentation.

Internet, option to create presentation that the viewer will move through independently.

On selecting the output option wizard allows user to choose presentation style. This dialog box allows to designate the medium on which user will generate the presentation as shown in Fig 7.

Fig 7

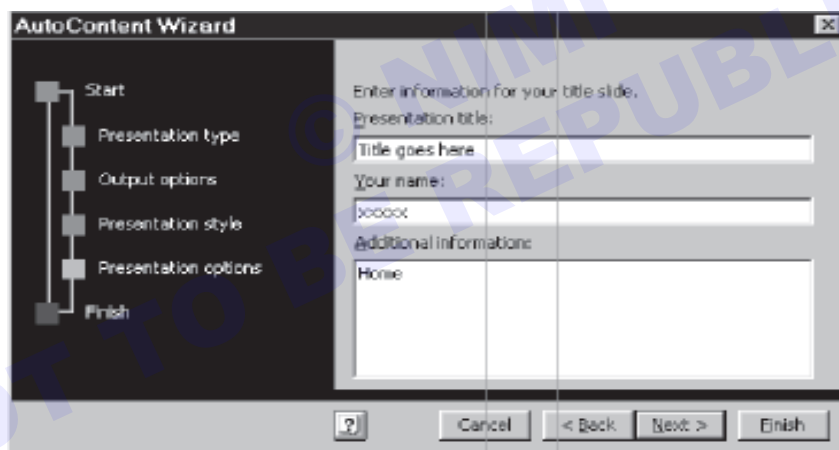


The next wizard window will allow user to enter the presentation title, users name etc. as shown in the Fig 8. User can click on finish button once all the entry is over.

If user feels any entry is not current, he can go back to the previous wizard window by clicking Back button and Correct the option of his choice and continue.

Once finish button is chosen wizard creates the Presentation according to the option selected and places in outline view as shown in the Fig 9. Color preview of the design choice is shown at the right hand side of the screen.

Fig 8



Working with Text

Every slide in a Presentation contains text of some kind title, subtitle, bulleted list, etc. Entering and Editing text in Power Point is similar to entering text in any Microsoft Office Application package.

There are many ways to add text to Power Point Presentation. The simplest is of entering text or replacing the sample text in a slide place holder as shown in the Fig 10. Some auto layouts contains a sample title and some contain bulleted list. Dotted line surrounds the place holder once the place holder is selected by clicking within the place holder, the dotted outline becomes a hashed border as shown in the Fig 11.

The hashed border indicates the place holder is selected. The sample text "Click to add text" disappears and the insertion point appear inside the place holder. This indicates that the text can be entered.

Fig 10

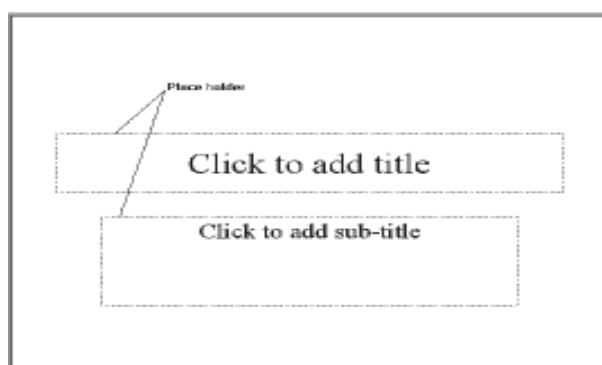


Fig 9

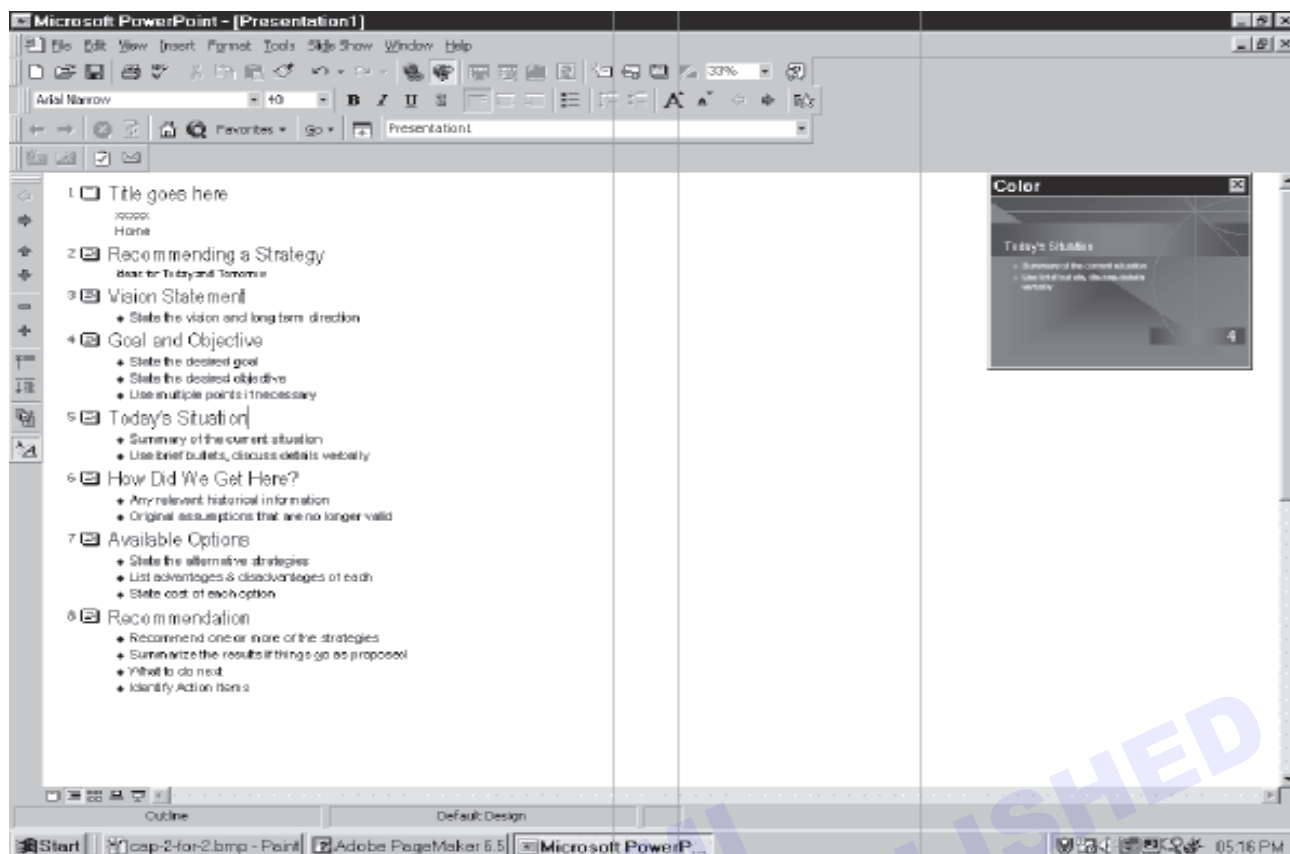
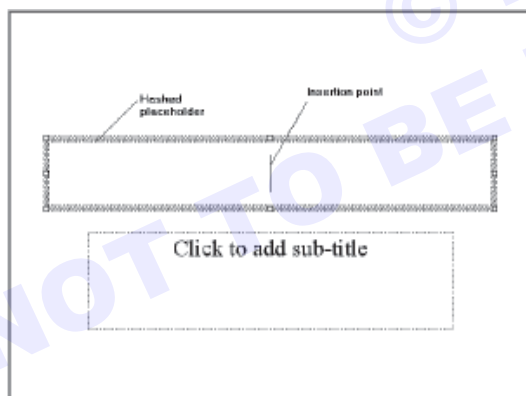


Fig 11



The text can be typed inside the place holder. In the case of titles and subtitles, Enter key should be pressed when user wants to begin a new line of text. In case of bulleted list Enter key should be pressed when a new bulleted item to be added. If the bulleted list too long Power point automatically wraps the text to the next line and aligns appropriately.

If it is a bulleted list, the insertion point can be brought to below bulleted text and text can be typed. User can choose the different bullet from the bullet dialog box. To quickly turn bullets OFF or ON on the slide user can click bullet button  on the formatting tool bar and toggle the state.

Creating Text outside a Placeholder

User is not restricted to use a text place holder to place the text. Text can be placed outside the place holder or any where on the slide by using the text tool  available on the drawing tool bar.

On clicking the Text box, the cursor changes to . This pointer can be placed at a place where the text to be added. Once the place is selected and the mouse is clicked a new text box appears with a hashed border as shown in the Fig 12 indicating it is active and ready to accept the text.

Fig 12



As the text is typed the text box expands to accommodate the entered text.

The entered text can be aligned by using the alignment tool available on the formatting tool bar.

Inserting Slide

User can insert new slide by clicking on new slide button  available on the standard toolbar. On clicking the new slide layout dialog box appears from which one of the layout can be selected.

The new slide can be inserted in between the presentation. User should select the slide first. The slide will be inserted next to the selected slide.

Re-size the text

The font size is measured in points, which is a height measurement. Each point is 1/72 of an inch. The size of the text can be increased or decreased by selecting the text first and the size from the size box available on the formatting tool bar.

The size of the individual character or a word also can be increased or decreased by selecting the character/word/

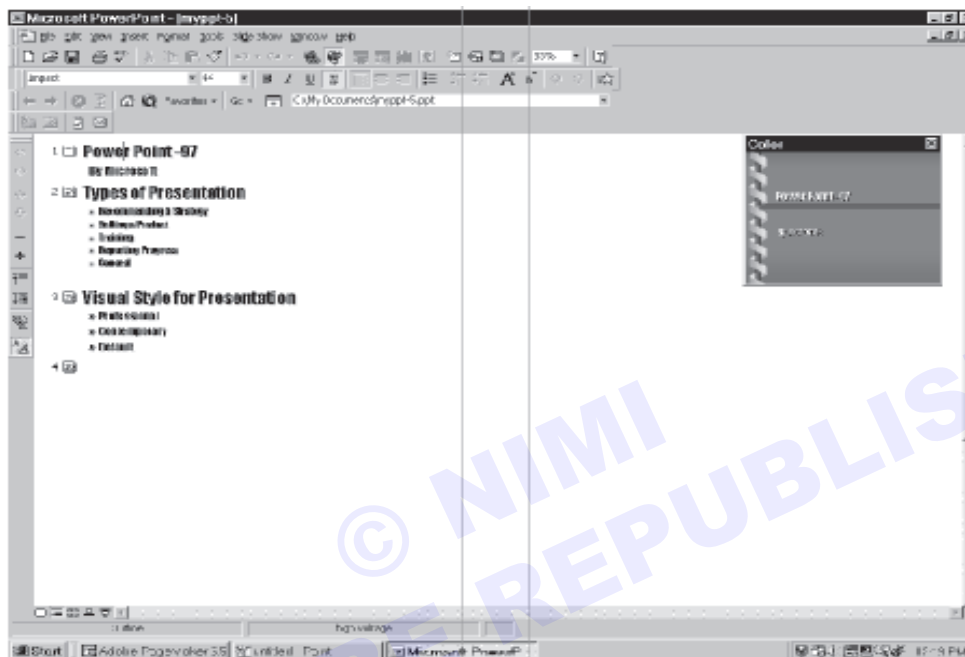
line first and using the Increase Font Size button  or decrease font size button  on the formatting tool bar.

Outline View

Outline view in Power Point allows user to place and organize the Presentation. Presentation can be created by typing the text, by importing the text from another source or by starting the Presentation with Auto Content Wizard.

To Enter the outline view click on the outline view button  available at the bottom of the screen. Outline view opens a presentation as shown in the Fig 13.

Fig 13



By default a floating window on the right side will appear which is an active slide.

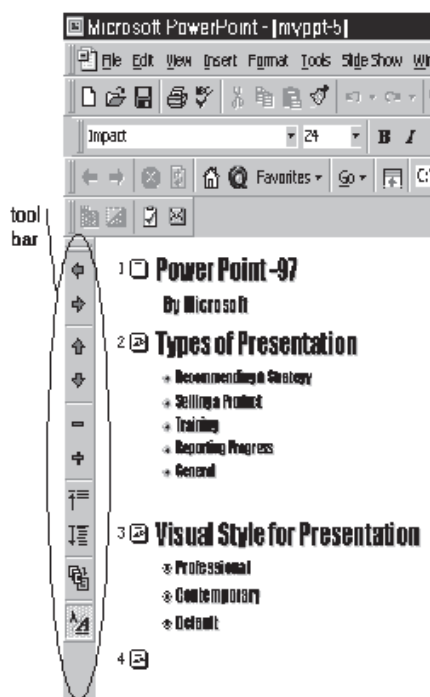
If miniature slide is not present on the screen user can choose **View**  **Slide Miniature**. The Miniature slide displays the slide as if it is displayed on slide view. To make the slide active click on any line of the slide, that slide details will be shown on the miniature slide.

The slide titles will have a slide number in the left followed by a slide icon. By double clicking on the slide icon the user can enter to slide view of the particular slide. The slide icons for text looks different than slides that contain graphs, art work, charts, etc.

Outline view provides toolbar for controlling the indicating of text, moving text up and down, collapsing and expanding the slide text as shown in Fig 14.

The toolbar appears at the left of the screen. If the toolbar is not visible user can choose **View**  **Toolbars** and select outlining. The tools are delt in detail in the exercise.

Fig 14

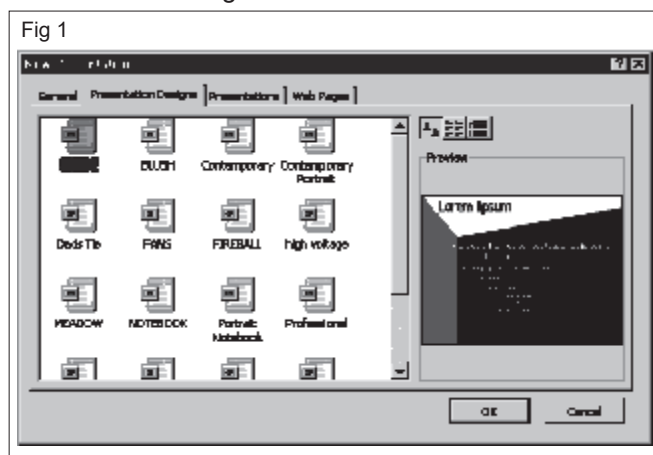


Customise Powerpoint presentation

Objectives: At the end of this lesson you shall be able to

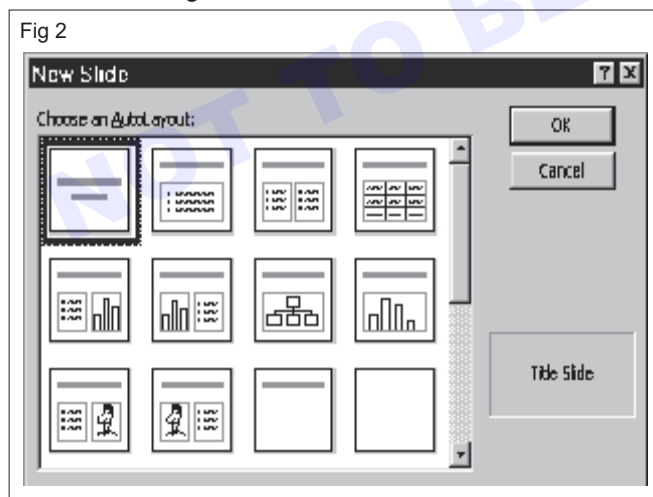
- create presentation using standard templates
- change slide appearance
- change presentation template
- change colour scheme
- add background colour.

From the opening Power Point screen user can select the template radio button to select the template option. User can select one of the design from the Template dialog box as shown in the Fig 1.



The dialog box provides three buttons which can be used templates as icons, in a list or as a detailed list. The new presentation dialog box contains tabs from which user can create Blank Presentation, Select design, background, color scheme, creating templates for web pages.

Once the template is selected Powerpoint allows user to select the slide layout from the New slide dialog box as shown in the Fig 2.

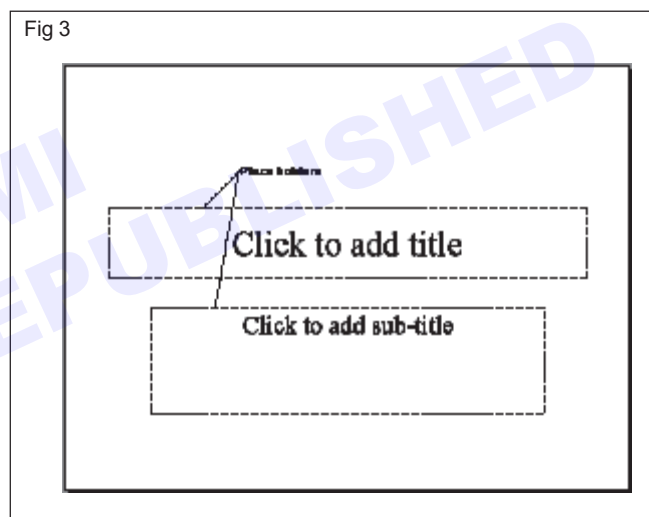


The new slide layout dialog box contains the Auto layout which predetermines the slide elements such as title, bulleted list, and clip art. The additional layout can be seen by using the scroll bar. When Auto layout is selected its name appears in the right hand side of the dialog box. In the layout the gray line indicates either a title or sub title element with in the box indicates the bulleted list. A small picture in a box indicates clipart. A bar lines indicates the graph etc.

Once the type of slide is selected from the new slide dialog box, depending on the layout place holders appear on the slide as shown in Fig 3 i.e. Click to add title, click to add sub title and so on.

To choose the layout quickly double click on the layout rather than selecting it then clicking OK Button.

Some Place holders such as Title and Text, open up editable text block when clicked. Place holders such as clip art open up a gallery of art work to insert on the slide. Once the type of slide is selected from the new slide dialog box, depending on the layout place holders appear on the slide as shown in Fig 3 i.e. Click to add title, click to add sub title and so on.



Changing the Slide look

Power Point allows the user to change the layout of the slide at any time of creating presentation. Just because user have chosen a template and the auto layout with a specific back ground and elements user is not limited to change the choice. User can easily change the layout, template and color to modify the look of the slide.

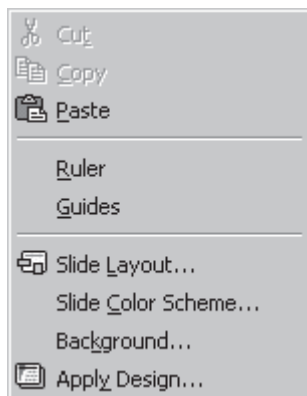
User can also add objects without using the place holder, switch to a different layout. If layout is selected with more place holders than needed, user need not to change the layout, instead if nothing is placed in the place holder, it will not appears in the final presentation.

Changing to a different layout can be done in three ways.

- Click on the slide layout button  on the standard tool bar to open slide layout dialog box from which one of the layout can be selected.
- Choose **Format**  **Slide Layout**.

- Right click anywhere outside the placeholder, context menu appears as shown in the Fig 4 from that select Slide Layout.

Fig 4



By selecting one of the layout and clicking on apply button will change the layout.

User should be careful in changing layouts after entering information on slide because the information entered may rearrange objects to accommodate the new place holders.

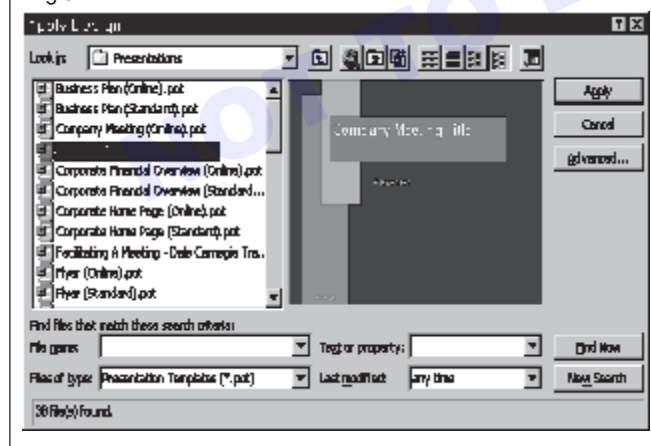
Changing Presentation Template

Similar to changing layout, changing template is also simple. The ready made templates changes the background of the slide.

Changing Presentation template can be done in two ways.

- Click on the Apply design button  from the standard tool box to open a browse window as shown in the Fig 5 allowing user select and preview a template. Choosing Apply button will change the template.

Fig 5



- Choose **Format**  **Apply Design** also opens the browse window.

User can choose one template for all the slides in the Presentation, so changing the design while displaying one slide changes all the slides design.

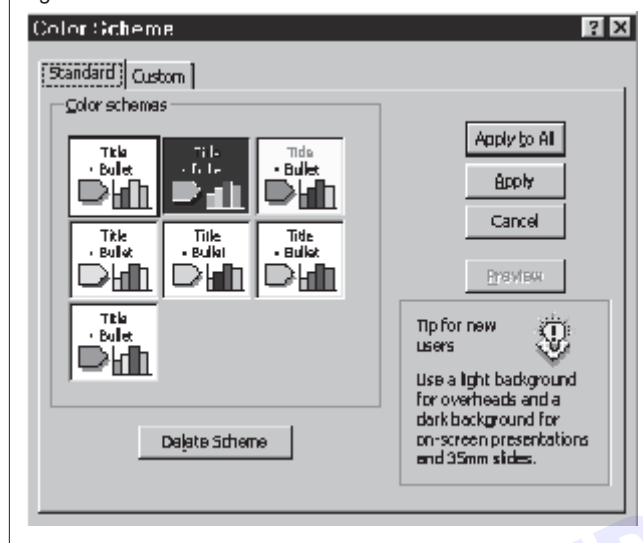
Changing Color Scheme

Each design template is associated with a color scheme. PowerPoint allows user to change the color scheme of a

design template, change the color scheme of charts, tables or pictures on the slide.

Color scheme can be applied by Choosing **Format Slide Color Scheme...** from the main menu. This opens color scheme dialog box as shown in the Fig 6.

Fig 6

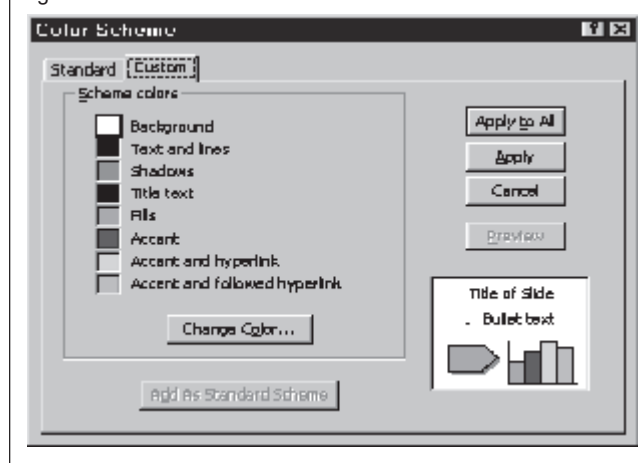


User can select one of the seven scheme available on the dialog box and click on Apply button. Similarly user can click on Apply to All button to apply the same scheme to all slides in the presentation.

If user wishes to change the color scheme of just few slides, first select those slides in the slide sorter view before opening the color scheme dialog box.

Color scheme dialog box allows user to create custom scheme using the Custom tab.. Selecting custom tab opens the color scheme as shown in the Fig 7.

Fig 7

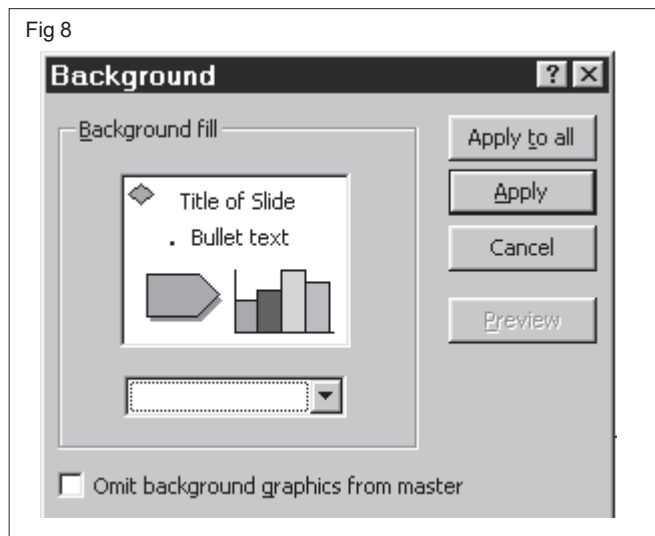


User can select each one of the option in the dialog box and change Color, Background Color, Shadows, etc. Preview of any changes made to custom color scheme is displayed in the right bottom corner of the dialog box.

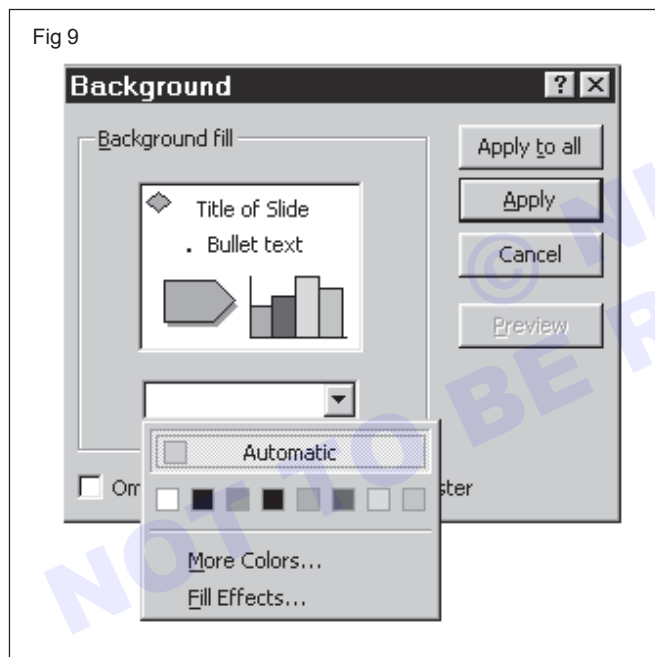
Adding Background

Slide Background is that completely fills the slide by choosing the color from the standard color tab or custom color tab from the background dialog box.

To change the background choose **Format** ➡ **Background...** from the main menu to display the dialog box as shown in the Fig 8.

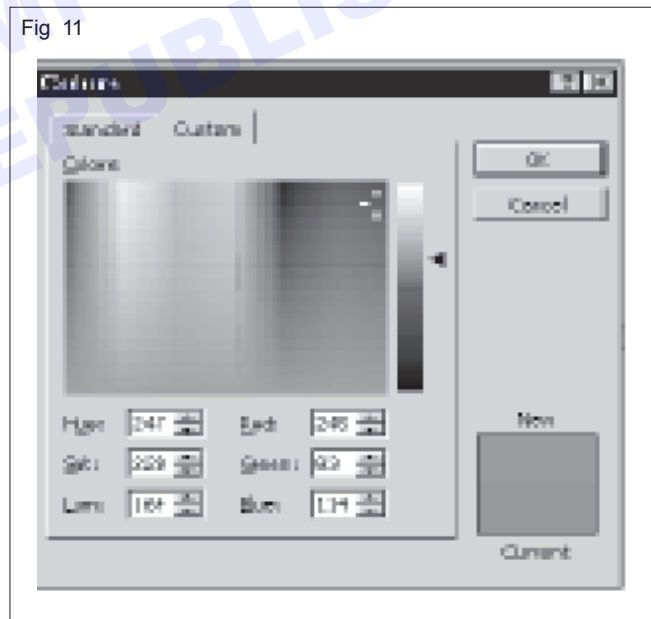
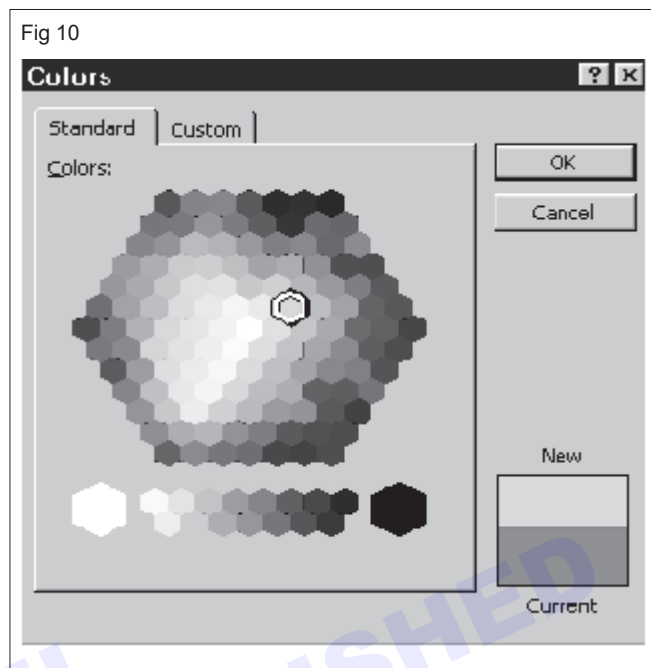


The new background can be selected by opening the drop-down list in the background fill area as shown in the Fig 9.



More Colors... will provide the color palette as shown in Fig 10 to choose background. The custom tab displays the color shades to select the color shade of the choice as shown in the Fig 11.

The right bottom corner window displays the color selected and the previous color.



Browsing & searching websites text/images & use of E- mails

Objectives : At the end of this lesson you shall be able to

- explain the term internet
- list the services of internet
- explain the terms world wide web and website
- explain the Domain Name system used in internet
- explain the purpose of a browser
- explain the use of Search Engines
- explain the terms Email and FTP.

1 What is Internet ?

The internet is a world wide collection of network, servers, gateways and computers using a common set of telecommunication protocol to link and inter operate them together.

The internet provides world wide access to information and resources. It is possible to find information about almost any subject imaginable from universities, government or organisations, the military or libraries which may be in any part of the world.

The internet evolved from a US department of defence project. The advanced Research Projects Agency (ARPA) of the department funded a project to connect university computer scientists and engineers together via their computers and telephone lines. This project called ARPANET, allowed researchers to share each others computer facilities over long distances. It was also used to exchange electronic mail (e-mail) with other users. The network protocol used by the project was TCP/IP which continues to be used on the Internet today. With the combination of electronic mail, file transfers and mailing lists this network of networks called internet began to take shape.

The simplest definition of internet is that its the longest computer network in the world. A study in 1997 estimated that the internet has 16.1 million hosts or computers connected to it.

Technically, the internet is actually a network which is made up of many smaller networks that exist all over the world, but this is as invisible to the user as the telephone network which provides national to international calls (STD/ISD). There is no particular person or company who controls the internet. It can be considered as a vast and growing online library in which anyone can publish anything they want.

2 Services of the internet

Over the last few years the primary users of the internet have shifted from research based activity and business use of the internet is increasing. All types of software and hardware companies are finding new ways to promote and sell their products on the internet. Lot of business applications like stock market trading, shopping on line, ordering of parts, booking of tickets, train accommodation and reservations etc. have been developed and already in use. An engineer can use the internet as a resource for current topic relating to products, technologies, tools and trouble-shooting. One can also find latest news update, weather,

sports and other information like travel advice, listen to music etc. Even internet telephony has come into place and at the expense of local call charges long distance and international calls can be established through the internet.

Some of the best known services available on the internet are

- WWW or World Wide Web
- FTP or File Transfer Protocol
- E-mail or Electronic mail
- Mailing lists
- Newsgroups
- Search engines
- Telnet
- Telephony
- VPN

World Wide Web

It is the internet's multimedia service. It is also the widely used part of internet. It is a vast storehouse of documents known as hyper text documents. These documents are written using the hypertext markup language (HTML). Hypertext is a method for presenting text, images, sound and videos that are linked together in a document. It allows a user to browse through topics in any order. It also includes dynamic links or connections which will take you to access those pages. Using WWW, you have access to millions of pages of information.

The sum of all the hypertext and connecting links connected via the internet form is known as the world wide web or www or the web. The web allows you to move among linked documents stored on host computers that may be physically very distant from one another.

You can read a hyper text file, look at its illustrations and even listen any audio in it and also follow its links. Certain words or phrases appear in text of a different colour than the text and is also underlined. When you move the cursor and point it on these words a small hand appears which indicates that it is a link. You click this word and a new hypertext document gets opened.

Website

A website is a collection of hypertext documents. A document on the site is called a web page. The first page in a series of related documents or a site is called a home page. The first document you access at any site is called

the home page. Many individuals on the internet have their own home page - a document about them and their interests - that anyone on the internet can access. This is a very useful way to represent a company or individual.

The web combines TCP/IP, the protocol for sending documents across network, with an entirely new method of locating and accessing documents on different networks. It involves a simple coding mechanism around a string of characters called a URL or a Universal Resource Locator. The URL identifies the name and address of each document available to the web.

The URLs specify the server to access as well as the access method and the location. Each website on the internet has its own URL.

An URL consists of

- 1 The server protocol to be used where the document is located. A server setup specifically for web documents uses hypertext transfer protocol (HTTP).
- 2 A colon
- 3 The type of site generally world wide web (WWW), file transfer protocol (FTP), a protocol used specifically to transfer files from one computer to another or Gopher, a client server application that organizes the files on a server, so users need not know or enter the exact file name.
- 4 The address of the host computer. Also known as domain address. The address begins with two forward slashes. It consists of the name of server or site, the network, university or computer name and the domain (two or three letter designation of the type of institution). The specific location of the document on that computer's network

Example:

- 1 `http://www.microsoft.com/home.htm`
`http` - Server protocol
`www` - Type of site
`microsoft` - Company name
`com` - Domain name
`home.htm` - Location of the document
- 2 `ftp://ftp.microsoft.com`
- 3 `gopher://gopher.microsoft.com`

Domain name system

In addition to URLs every computer on the internet has a unique IP address. The IP address is four sets of digits separated by dots. (198.64.3.20)

Because these numbers are hard to remember and difficult to type, the domain name system was created. Domain names enable short, alphabetical names to be assigned to IP addresses to describe where a computer is located. In the e.g. `http://www.microsoft.com`, `www.microsoft.com` is the domain name.

The last three characters of DNS or URL address indicate the type of domain. Some common domain names used in US are

com	- commercial organisations
edu	- educational institutions
gov	- government organisations
mil	- military
net	- network, companies and groups who administer the internet
org	- organisation

Countries outside the US use a two letter country code as their domain name.

au	- australia
in	- india
fr	- france
uk	- united kingdom

Browser

To view the web sites/pages you need a graphical user interface, called a web browser. It is a piece of software, that lets you visit different web sites on the internet and display their pages on your own computer. You can visit the site by supplying the browser with an address or URL.

A browser displays a document from the internet on the computer screen. Like any windows based program, a browser has a number of features - buttons, menus, scroll bars, toolbars etc, that let you control its operation. The latest version of the browser is recommended, since the technologies involved in publishing information on the internet are constantly changing.

Once you have your browser and a internet connection, accessing the internet is fairly straight forward. Commonly used browsers are Netscape Navigator and Microsoft Internet Explorer.

Fig 1 gives the home page of Microsoft internet explorer.

Title bar: Shows the name of the page you are currently viewing on the documents file name if it is not a web page.

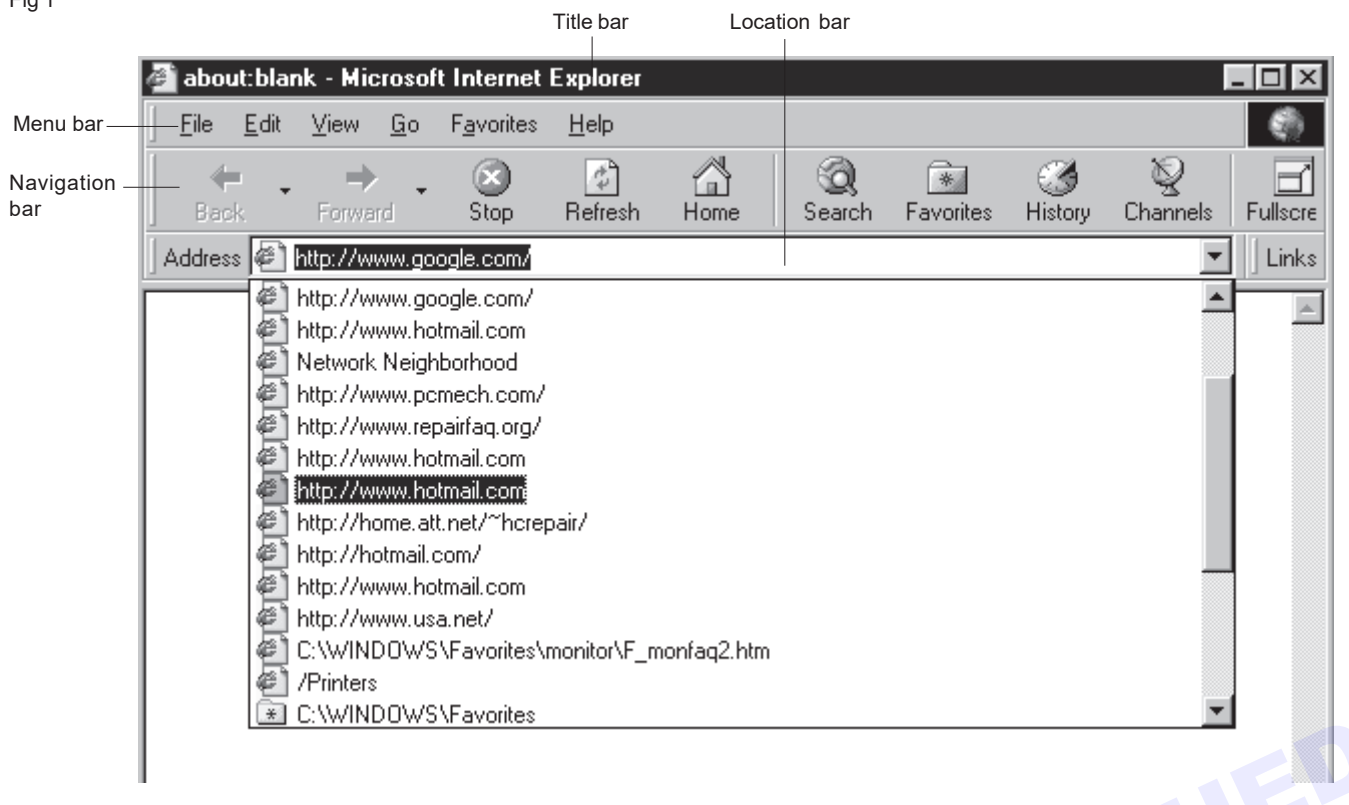
Menu bar: Provides with drop down menus contains almost all the commands you will need in the browser.

Navigation toolbar: Provides command action buttons. Click the icon for the specified action to occur. If you point at a button for a few seconds, without clicking, a tooltip will appear describing the action of the button.

Location tool bar: Type the URL you want to connect in the "document URL" area of the location toolbar. On the right side of the window a small arrow appears. Click the arrow and the URLs you have most recently visited will pop up as a list.

Internet options: Select view on the menu bar and select internet options to edit internet explorers default settings.

Fig 1



Search Engines

A search engine is an application on the web that allows you to search for particular web pages on sites based on key words or concepts. There are growing number of search engines found on the world wide web and each one produces different results.

Some of the popular search engines are www.msn.com, www.rediff.com, www.google.com etc.

In the window provided, type the text to be searched for and click 'submit'. You will be returned with the matching documents and related websites. Point the mouse cursor over the URL and a hand appears and click to open the document.

Chat: When you send email or post news, you have to wait till the mail is sent, read by the recipient and he has to reply the mail and receive the answer. Instead chat allows people to converse more in the way, as it happens in person or on the phone. You talk something, people hear it and respond on the spot. In case of chat, this exchange happens on your computer screen. The communication happens in real time without delay.

E mail: Electronic mail, the sending and receiving of electronic messages, is currently one of the most popular activities on the internet. E-mail is used on most commercial online services, and for many people, is the primary reason for getting onto the internet or an online service.

To send e-mail, you must know the recipients e-mail address. These addresses are composed of the user's identification, followed by the @ sign, followed by the location of the recipients computer. For example, the email address of an individual will be name@hotmail.com

When you access the internet through a local service provider or one of the large commercial online services, you can exchange email without incurring the long distance charges of a telephone call. Email has the added advantage of allowing you to access messages at your convenience. You can also send an identical message to any number of people at one time.

News

Network News Transfer Protocol (NNTP) is an Internet standard protocol defined for distribution, inquiry, retrieval and posting of news articles. Network news (USENET) is a popular use of NNTP. It offers bulletin boards, chat rooms, and Network News. Network News is a massive system with over 5000 ongoing conferences, called newsgroups, conducted 24 hours a day, 365 days a year. To access these newsgroups, download a special program from the internet that allows you to participate in any newsgroup you want. Most commercial browsers, including the Microsoft Internet Explorer, have this capability built in. You then “subscribe” to the newsgroups that interests you and communicate through a message system similar to email. The difference between Network News and email is that the Network News conversations take place in a public forum called a news group.

You can simply view an ongoing dialog without participating; this is called lurking and is encouraged for newcomers. To enter the conversation, you post an article in the newsgroup and you become part of the forum. As with email, Network News is usually informal communication with little distillation of content. However, some newsgroups are managed by a monitor who may elect not to post responses that are deemed inappropriate for that forum. Network News operated at a very high speed, with posting

appearing quickly and constantly. Group administrators set the length of time that messages remain posted before being deleted from the system. Most do not keep postings longer than a week.

FTP: File transfer protocol is the internet's standard method for moving/downloading text files, data files and binary program files from one computer to another. A browser can be used for some FTP transfers. Its often faster and easier to use a dedicated FTP client software to download.

The procedure is essentially the same for all.

- 1 Connect your client program/browser to an FTP server
- 2 Log on as 'anonymous' and give your email address as the password
- 3 Move to the directory on the server that contains the file you want
- 4 Specify the directory on your computer where you want to store downloaded files
- 5 Transfer the file from the FTP server to your computer
- 6 Disconnect the server.

Telnet: Telnet makes your computer as a remote terminal that sends commands and receives data from the remote server through internet. When you type on your own keyboard, the data goes directly to the remote computer, as if you are directly connected to it. You should have an account and connection to the remote computer.

To make a telnet connection, one has to use the terminal emulation program such as hyper terminal in windows.

Making an internet connection

In order to access servers on the internet, your computer needs to be connected to the internet service provider.

It can be achieved through

- a PSTN dial up lines
- b ISDN dial up
- c Dedicated leased line

Dial up link: Requires a telephone line, a dial up modem and dial up account with the ISP. Whenever IE needs access to internet, it has to establish the dial up connection first. Use dial up networking which makes the call and gets connected. But only 33kbps speed is achieved typically, can be used to connected only one computer to the ISP.

ISDN: This service connects networks through digital lines. It provides a faster connection and can be more economical than dial up service. A special ISDN modem can be used to access the ISP. An ISDN dial up account should also be taken from the ISP.

ISDN can be used from a LAN, which connects multiple users at a specific location to the internet. To enable this, a special type of computer called proxy server is required to act as a gateway between their local network and the

internet. The proxy server filters the requests from internet and makes it more difficult for unauthorised requests to reach local network.

Leased line connection: For users demanding more bandwidth and internet availability for 24 hrs all days, leased lines are recommended. The typical speeds which can be used are 64 kbps, 128 kbps and 2.048 Mbps. It requires a router attached with a leased line modem to be interfaced with the leased line. A leased line account is also required from the ISP.

Web server

A Web server is a program that, using the client/server model and the World Wide Web's HyperText Transfer Protocol (HTTP), serves the files that form Web pages to Web users.

Every computer on the Internet that contains a Web site must have a Web server program. The most popular Web servers are; The Microsoft's Internet Information Server which comes with the Windows NT server; Netscape FastTrack and Enterprise servers; and Apache, a Web server for UNIX-based operating systems. Other Web servers include Novell's Web Server for users of its NetWare operating system and IBM's family of Lotus Domino servers, primarily for IBM's OS/390 and AS/400 customers.

Web servers often come as part of a larger package of Internet related programs for serving e-mail, downloading requests for File Transfer Protocol(FTP) files and building and publishing Web pages. Considerations in choosing a Web server include how well it works with the operating system and other servers, its ability to handle server-side programming, and publishing, search engine, and site building tools that may come with it.

Internet Service Provider (ISP)

An ISP (Internet service provider) is a company that provides individuals and other companies access to the Internet and other related services such as Web site building and virtual hosting.

An Internet service provider (ISP) has the equipment and the telecommunication line access required to have POP on the Internet for the geographic area served. Larger ISPs have their own high-speed leased lines so that they are less dependent on the telecommunication providers and can provide better service to their customers. Among the largest ISPs are AT&T WorldNet, IBM Global Network, MCI, Netcom, UUNet, PSINet, etc.

ISPs also include regional providers such as VSNL, NEARNet, BARNet etc. They also include thousands of local providers. In addition, Internet users can also get access through online service providers (online service provider) such as America Online and Compuserve.

An ISP is also sometimes referred to as an IAP (Internet Access Provider). ISP is sometimes used as an abbreviation for independent service provider to distinguish a service provider that is an independent, separate company from a telephone company.

Internet Access Provider

The basic service that any Internet Service Provider (ISP) offers is the means to provide a dial-up link via a public telecommunication service such as telephone or ISDN, which supports an IP (Internet Protocol) packets coming from and going to that link.

In order to support the IP link across the telephone system, an additional protocol is required, which an ISP must also be able to support. This will either be the Point-to-Point Protocol (PPP) or Serial Line Internet Protocol (SLIP). PPP has largely replaced SLIP access now a days, hence in the following discussions will assume PPP.

The ISP must also provide a means of resolving what are known as 'Domain Name' address queries. This process will be supplied by the ISP's Domain Name Server. The IP protocol provides a means of converting Domain Names which people can understand, into IP addresses (e.g., 012.345.678.9) which computers can understand. Thus when you type a URL into your web browser, the Domain Name part of the URL must first be converted into its IP address before the web page can be located and delivered to the browser. Each Domain Name is assigned its specific IP address when it is created, and so the process of converting one to the other is simply a matter of looking up its entry in a database. Finding where that particular Domain Name/IP address relationship is recorded and then using this information to make the correct conversion is the job of the 'Domain Name Server' (DNS).

The minimum basic services that an ISP must provide can be summarized as follows:

- Dial-up access for either analogue (public telephone) or digital (ISDN) telecom links.

Introduction to search engine

Objectives : At the end of this lesson you shall be able to

- identify the growth of internet
- explain what is search engine
- identify different parts of search engine
- explain how does a search engine work and advantages of using search engine.

According to another survey done by **Netcraft** in August 2006, there are **92,615,362** sites

(**92 million**) and this is an increase of 4.4 million sites (4.8%) from the July, 2006 survey.

The end user uses the Internet heavily in accessing information in their day to day needs

since the Internet is the biggest repository of knowledge in the history of mankind. Thus

the Internet has become the world's widely accessed information source and Websites are added, updated, and obsolete daily. Therefore, "Finding the right information at the right time" is the challenge in the Internet age. Hence there is a need for a more effective way of retrieving information on the Internet.

There are three ways of finding information on the Internet.

- 1 Guessing the URL (Uniform Resource Locator)

- Support for handling IP packets
- Support for the PPP protocol
- Access to a Domain Name Server

As these are the basic minimum, most ISPs will provide these as a matter of course and will not necessarily advertise these capabilities.

Cc: stands for "carbon copy". Anyone listed in the Cc: field of a message receives a copy of that message when you send it. All other recipients of that message can see that the person you designated as a Cc: recipient has received a copy of the message.

Bcc: stands for "blind carbon copy". This is similar to the Cc: feature, except that Bcc: recipients are invisible to all the other recipients of the message (including other Bcc: recipients). For example, if you send a message To: suryaamehta@yahoo.co.in and Bcc: jayashrimehta@yahoo.co.in, then suryaamehta sees himself as the message's only recipient. Jayashrimehta, on the other hand, is "in the know" - she can see that you sent the message To: suryaamehta, and that you blind-copied her. To add an entry in the Bcc: field, click the "Show BCC" link to the right of the "To:" field.

Note: To send a message, you must always specify atleast one recipient in the "To:" field. If you don't an error message appears when you attempt to send the message.

The maximum attachment size using Yahoo! Mail account for sending and receiving messages upto 10MB.

- 2 Using a Search engine

- 3 Using a Subject Directory or a Subject Gateways

If the URL (Uniform Resource Locator) is known, it can be typed in the Internet browsers' (Example: Internet Explorer, Netscape Navigator, etc.) address bar and can be accessed the Website soon. Otherwise use directories (Yahoo!, dmoz, LookSmart) for broad, general topics. Subject directories select and classify resources into subject categories and subcategories. Some include reviews and/or ratings which can be accessed by keyword search or by browsing the classifications.

A subject gateway can be defined as a facility that allows easier access to network-based resources in a defined subject area. The simplest types of subject gateways are sets of Web pages containing lists of links to resources. The resources accessible through these gateways are reviewed, selected, evaluated and catalogued by information professionals or subject experts.

What is a search engine?

A search engine is a searchable database which collects information on web pages from the Internet, and indexes the information and then stores the result in a huge database where it can be quickly searched. The search engine then provides an interface to search the database.

Examples : Google, Alta Vista, Exite

A Search engine has **three** parts.

- **Spider:** Deploys a robot program called a spider or robot designed to track down web pages. It follows the links these pages contain, and add information to search engines' database. Example: **Googlebot** (Google's robot program)
- **Index:** Database containing a copy of each Web page gathered by the spider.
- **Search engine software :** Technology that enables users to query the index and that returns results in a schematic order.

How does a search engine work?

Types of search engines

In broad sense, search engines can be divided into two categories.

1 Individual search engines

An individual search engine uses a spider to collect its

information regarding websites for own searchable index. There are two types of individual search engines.

i General search engines

Examples: Google, AltaVista, HotBot, Lycos

ii Subject specific search engines

Examples: MetaPhys, Chritech, ReligionExplorer, Chordie, ChemFinder

2 Meta search engines

A Meta search engine searches multiple individual engines simultaneously. It does not have its own index, but uses the indexes collected by the spiders of other search engines.

Example: metacrawler, Ixquick, mamma

Advantages of using search engines

Search engines are best at finding unique keywords, phrases, quotes, and information buried in the full-text of web pages since they normally index WWW documents word by word. Search engines allow the user to enter keywords, and then they are searched against its database. Users can use advanced search techniques such as phrase searching, truncation/wildcard searching, as well as for Boolean operators (AND, OR, NOT combinations). With comparison to web directories, search engines are huge databases and contain a large amount of materials. Also, the database is updated at a variable rate.

Download content from the internet

Objectives : At the end of this lesson you shall be able to

- explain the basics of downloading content from the internet
- identify the key terms used in the internet
- explain different types of content to download
- explain various protocols used on the internet.

Introduction

Downloading content from internet has become a commonplace activity for all internet users – in the home, in business and in schools. All internet users download content from time to time – typically programs, games, pictures, music, video and documents. Downloading content can be troublesome. Downloads can fail. Downloads can take excessive time. Downloads can be password-protected. Some content cannot be downloaded using your web browser. A download manager is a utility designed to fix all the problems you may be having downloading content from the internet. They have quickly become a must-have utility for all internet users. Download managers can accelerate your downloads, allow you to resume broken downloads and contain numerous features that allow to you get hard-to-get files from the internet.

Key terms

URL

A URL (or Uniform Resource Locator) is the location of a resource on the internet. The format of a URL includes the

protocol (e.g. http://, https://, ftp://, mms://, etc.), the domain name (or IP address), and additional path information (or folder & file name). A URL may address a web page file, a program file, an image file, a CGI file, or any other type of file, folder or program. Download managers use URLs to find the location of files, web sites and FTP sites that you want to download. You input URLs when download content from the internet.

Examples of URLs are:

- <http://www.conceiva.com/downloads/downloadstudio2200.exe>
- <ftp://ftp.microsoft.com/pub/msoffice.zip>
- <http://www.google.com>
- <http://www.itunes.com/hiphop/newtrack.mp3>

Servers, Domains and Groups

A server name represents a single web server. For example, "www.conceiva.com" and "www.google.com" are examples of server names. Even "google.com" counts as a different server name since it is not the same as "www.google.com"

– even though if you visit “http://www.google.com” and “http://google.com” in your web browser you may see the same content. A domain name is the most general part of a server name. For example, “conceiva.com”, “google.com” and “zdnet.co.uk” are examples of domain names. When downloading files, if you set the download job to span across Domains, it will download files from any servers that share the same domain name. For example, “www.conceiva.com”, “images.conceiva.com” and “downloads.conceiva.com” all belong to the same domain “conceiva.com”.

A group name refers to any number of servers that share the same name regardless of the country-specific part of the name. For example, “www.conceiva.net”, “ftp.conceiva.org.au” and “images.conceiva.co.jp” would all be part of the same group, because they all contain the word “conceiva” directly before the country specific part of the name.

Using the URL “http://www.conceiva.com/images/logo.gif” as an example:

- “www.conceiva.com/images” is the folder name
- “www.conceiva.com” is the server name
- “conceiva.com” is the domain name
- “conceiva” is the group name

MIME Type

MIME (Multipurpose Internet Mail Extensions) types are a standard for defining the types of files attached to standard internet mail messages and on web servers. The MIME standard is used by software applications such as download managers to communicate with web servers to determine what type of file is being transferred. The MIME type of a file can be a more accurate method of determining the type of a file rather than using the file extension of a file to guess the type of file on a web site.

Examples:

- HTML files have a MIME type of “text/html”
- JPEG files have a MIME type of “image/jpeg”

RSS feed

RSS feeds have become a popular way for web sites to inform you about its latest news or its latest content. RSS stands for Really Simple Syndication and is an XML based file that contains information and links about content from a web site. Popular RSS feeds are latest headlines from news web sites, latest music titles from music sites, latest company news from business web sites, latest topics from blogs, and more.

Podcast

Pod casts are RSS feeds that contain information and links to audio and video files. They have become very a popular way to get your favorite music, due mainly to the popularity of portable media players such as Apple’s iPod.

Streaming media

Streaming audio and video is used to view movies and listen to music from the internet. Media players such as Windows Media Player and Real One Player can connect to streaming media servers and play streaming audio and video. Streaming media servers send audio and video as small packets of data to your media player on your computer. Once played, the packets of data are discarded – so there is no way for you to save the file using your web browser or media player.

Important: Notice about copyright ownership

Download managers, including Download Studio, are designed to assist you to download files from the internet. If you do not own the copyright to these files or do not have permission to copy these files from the copyright owner, you may be violating copyright law and be subject to payment of damages and other remedies. If you are uncertain of your rights, contact your legal advisor. All examples of downloading that are contained in this White Paper are for illustration purposes only. These URLs (or web site addresses) may or may not exist. The use of the example URLs does not imply that you have consent to download content from them.

Various types of content to download

The internet has many different types of files and content that you may be interested in downloading. Some popular examples of content are:

Programs

Programs are executable files that usually are downloaded and installed onto your computer. Programs can be large files that take significant bandwidth and time to download.

Images & pictures

Images are located all over the internet on web sites and ftp sites. They are probably the most popular content downloaded by internet users. The popular image file formats are JPEG, GIF and PNG. Images are typically small files (< 100 kilobytes) so that they can be displayed quickly in web browsers. Images can be small thumbnails or larger-sized images. Typically, internet users want to download the larger-sized images.

Movies & video

Video content has become very popular for internet users who have broadband connections. Video content is either streamed onto your computer from a streaming media server into your media player, or it is a file that can be downloaded and then played in your media player. Video content is typically very large in size and can take significant bandwidth and time to download. Video content that is streamed into your media player cannot be downloaded in the traditional file based manner using your web browser or media player.

Music, audio & pod casts

With the popularity of portable media players, audio has become a very popular download for internet users. Audio is either streamed onto your computer from a streaming media server into your media player, or it is a file that can be downloaded and then played in your media player. Pod casts have become a very popular way to subscribe to music and video you are interested in. Pod casts are specialized RSS feed (XML-based) files on the internet that describe and link to a collection of audio or video files. Audio content is typically medium-to-large in size. Audio that is streamed directly into your media player cannot be downloaded in the traditional file-based manner using your web browser or media player.

Websites

Some internet users often wish to download a complete web site (or certain pages of a web site) so that they can view it later at their convenience. This is called offline browsing. All files for a web site are downloaded and saved onto your computer so that you can view the web site locally on your computer in your web browser. Web site content typically contains many small files.

Flash

Macromedia Flash (.SWF) content is used widely on web sites to enhance sites with a more dynamic presentation. Flash content can be diverse in nature – ads, games, movies, complete web sites and more. Flash content is displayed in your web browser using an additional component (e.g. ActiveX control). The use of these additional components can make downloading flash content onto your computer difficult. Typically, flash content is small-to-medium in size.

RSS feeds

Really Simple Syndication (RSS) feeds are now being used widely on web sites to provide up-to-the-minute news and information about topics of interest on a web site. RSS feeds are XML based files that describe topics of interest and contain links for internet users to gain more information. Typically, RSS feeds are viewed in RSS readers that are capable of presenting the RSS feed in a well formatted manner. RSS feeds are typically small files that are updated regularly.

Games and game files

Games are executable files that are usually downloaded and installed onto your computer. Games files are typically extensions or additions to existing games that you have already installed onto your computer. Games are typically large files that take significant bandwidth and time to download.

Compressed files

Compressed files are collections of files that have been compressed to make them smaller to download. Internet users require a program installed on their computer to decompress the files once downloaded. Popular formats for compressing files are ZIP, TAR and RAR. Typically, compressed files are very large in size and can take significant bandwidth and time to download.

Documents

Document files are often available for download on the internet. Popular document formats are Acrobat PDF files, Word DOC files, EXCEL XLS files and PowerPoint PPT files. Document files can be large in size, requiring significant bandwidth and time to download.

Data files

An increasing number of businesses download data files from the internet on a daily basis – often as a regular scheduled backup of their online data or to simply get the latest up-to-date data for their business. Data files can be any type of file and can be large in size, requiring significant bandwidth and time to download.

Various protocols used on the internet

Along with different types of content on the internet, there are several standard protocols that are used to access files and content. The popular internet protocols are:

- **http://**. The hypertext transfer protocol is used to access and view web sites and is the most widely-used protocol by internet users. Any type of file may be accessed using this protocol. Example: <http://www.example.com/folder/file.zip>.
- **https://**. The secure hypertext transfer protocol is used to access and view web sites. Any type of file may be accessed using this protocol. Example: <https://www.example.com/folder/file.zip>.
- **ftp://**. The file transfer protocol is one of the oldest protocols still in use today and is used to upload and download to servers. Example:

<ftp://ftp.example.com/folder/file.zip>.

- **mms://**. The multi-media server protocol is used to connect to Windows media streaming servers so that Windows media streaming audio and video can be played. Valid file types are .WMA, .WMV, .WAX, .WVX, .ASF and .ASX. Example:

<mms://www.example.com/folder/file.wmv>.

- **rtsp://**. The real-time streaming protocol is used to connect to streaming servers so that streaming audio and video can be played. Valid file types include Real Audio/Video (.RA, .RM), Windows Media (.WMA, .WMV, .WAX, .WVX, .ASF, .ASX) and QuickTime (.QT, .MOV). Example: <rtsp://www.example.com/folder/file.rm>.

Introduction to E-mail

Objectives : At the end of this lesson you shall be able to

- describe what is Email
- differentiate internal and external Email addresses
- describe Email features
- explain How E-mail works.

What is Email?

Most people will be familiar with the term email (electronic mail) in this day and age. It basically covers all messages sent over the Internet, normally between computer users, but also is now used with other internet-connected devices such as mobile phones. Email messages can be just text based or can also contain graphical or other multimedia information. One common misconception with email is that messages will always arrive immediately or at least very quickly (within minutes). Whilst this is often the case, any email relies on many computers and networks to be working, therefore emails are at risk of delays at any stage. However, sending messages within one system (such as the SHU First Class email service) should be immediate. To send email messages all you need to know is a valid address of the recipient - see addressing below. Messages can either be like formal letters or increasingly they are much more "conversational" where the emotions of the writer are expressed as emoticons (also called "smilies").

Internal and External Email Addresses

To send an email to someone else, you need to know their email address. Users can have internal and external email addresses.

Internal Email Addresses

Internal email addresses are listed in the directory of the email system you are using. At Sheffield Hallam University this is on First Class which is the email system used by all students. Staff use another system, Exchange, but are also listed in the First Class directory. All you need to know when you are searching for someone in the internal directory is usually their real name and the faculty they belong to. Using the directory to find the internal address of users depends a little on whether you are using the First Class client or the web interface. You can normally find the name you want by just typing part of the first and last names of a particular user.

Example: Open a New Message in First Class.

Typing in: **VirWoo** into the To: field will match to a fictitious student user called "Virginia Woolf". If you are using First-Class client software you will need to press **Enter** to complete the name; if you are logging into your mailbox using the web interface via the Portal you will need to click on the **Add** button.

External Email Addresses

External email addresses are required for sending or receiving email outside the university. An external email address is also often known as an Internet email address. External email addresses have a very specific format - please see the example below. When using them you must

type them exactly as specified. And if you quote your address for others to use it must be exactly right. External email addresses are made up of two parts separated by an @ (pronounced "at") sign: - the first part is the email name - the second part is the Internet address of an Internet "post box". The post box address is the address of a central server within the organisation in which the mailbox is located which handles all email before relaying on to personal mailboxes.

Example: Below is the external email address of our example student Virginia Woolf at Sheffield Hallam University.

virginia.woolf@student.shu.ac.uk is Internet email name and student postbox address. This address would be pronounced as:

" **virginia dot woolf at student dot S H U dot A C dot U K** ".

You can try sending test messages to Virginia Woolf to try out the different address formats.

Other Email Features

Other features you will commonly find when using email:

Cc: This stands for "carbon copy" or "courtesy copy" and is the field where you can put extra addresses in to send to other mailboxes if not the main recipient.

Bcc: Like c:, but the mailbox address entered in this field is not visible to the main recipient of the mail.

Attachment: Any file being sent along with the main message; eg a Word file, a picture etc.

SPAM: Any unwanted and often malicious unsolicited emails. At SHU we try and detect these and mark them appropriately so that they can be deleted by the user without needing to open them.

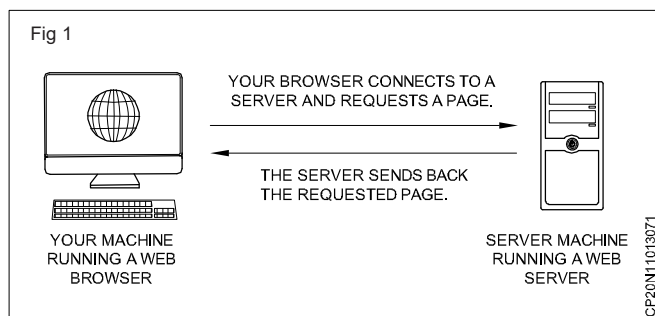
How E-mail Works

A Simple E-mail Server

Given that you have an e-mail client on your machine, you are ready to send and receive e-mail. All that you need is an **e-mail server** for the client to connect to. Let's imagine what the simplest possible e-mail server would look like in order to get a basic understanding of the process shown in Fig 1. Then we will look at the real thing.

If you've read How Web Servers Work, then you know that machines on the Internet can run software applications that act as **servers**. There are Web servers, FTP servers, telnet servers and e-mail servers running on millions of machines on the Internet right now. These applications run all the time on the server machine and they listen to specific **ports**, waiting for people or programs to attach to the port. The

simplest possible e-mail server would work something like this:



- 1 It would have a list of e-mail accounts, with one account for each person who can receive e-mail on the server. My account name might be **mbrain**, John Smith's might be **jsmith**, and so on.
- 2 It would have a text file for each account in the list. So, the server would have a text file in its directory named MBRAIN.TXT, another named JSMITH.TXT, and so on.
- 3 If someone wanted to send me a message, the person would compose a text message ("Marshall, Can we have lunch Monday? John") in an e-mail client, and indicate that the message should go to mbrain. When the person presses the Send button, the e-mail client would connect to the e-mail server and pass to the server the name of the recipient (mbrain), the name of the sender (jsmith) and the body of the message.
- 4 The server would format those pieces of information and append them to the bottom of the MBRAIN.TXT file. The entry in the file might look like this:

From: jsmith

To: mbrain

Marshall,

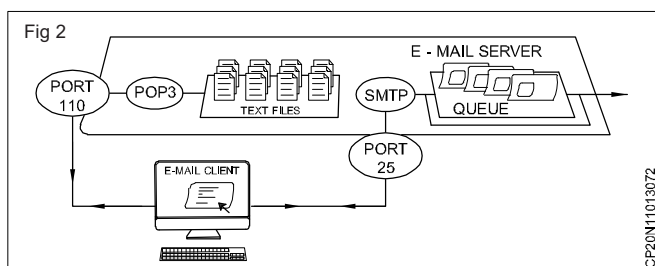
Can we have lunch Monday?

John

There are several other pieces of information that the server might save into the file, like the time and date of receipt and a subject line; but overall, you can see that this is an extremely simple process.

The SMTP Server

Whenever you send a piece of e-mail, your e-mail client interacts with the SMTP (Simple Mail Transfer Protocol) server to handle the sending. The SMTP server on your host may have conversations with other SMTP servers to deliver the e-mail shown in Fig 2.



Let's assume that you want to send a piece of e-mail. your e-mail ID is brain, and you have account on howstuffworks.com. You want to send e-mail to jsmith@mindspring.com. You are using a stand-alone e-mail client like Outlook Express.

When you set up account at howstuffworks, Outlook Express the name of the mail server — mail.howstuffworks.com. When you compose a message and press the Send button, here's what happens:

- 1 Outlook Express connects to the SMTP server at mail.howstuffworks.com using port 25.
- 2 Outlook Express has a conversation with the SMTP server, telling the SMTP server the address of the sender and the address of the recipient, as well as the body of the message.
- 3 The SMTP server takes the "to" address (jsmith@mindspring.com) and breaks it into two parts: the recipient name (jsmith) and the domain name (mindspring.com). If the "to" address had been another user at howstuffworks.com, the SMTP server would simply hand the message to the POP3 server for howstuffworks.com (using a little program called the **delivery agent**). Since the recipient is at another domain, SMTP needs to communicate with that domain.
- 4 The SMTP server has a conversation with a **Domain Name Server**, or **DNS**, It says, "Can you give me the IP address of the SMTP server for mindspring.com?" The DNS replies with the one or more IP addresses for the SMTP server(s) that Mindspring operates.
- 5 The SMTP server at howstuffworks.com connects with the SMTP server at Mindspring using port 25. It has the same simple text conversation that my e-mail client had with the SMTP server for HowStuffWorks, and gives the message to the Mindspring server. The Mindspring server recognizes that the domain name for jsmith is at Mindspring, so it hands the message to Mindspring's POP3 server, which puts the message in jsmith's mailbox.

If, for some reason, the SMTP server at HowStuffWorks cannot connect with the SMTP server at Mindspring, then the message goes into a queue. The SMTP server on most machines uses a program called **sendmail** to do the actual sending, so this queue is called the **sendmail queue**. Sendmail will periodically try to resend the messages in its queue. For example, it might retry every 15 minutes. After four hours, it will usually send you a piece of mail that tells you there is some sort of problem. After five days, most sendmail configurations give up and return the mail to you undelivered.

The SMTP server understands very simple text commands like HELO, MAIL, RCPT and DATA. The most common commands are:

- **HELO** - introduce yourself
- **EHLO** - introduce yourself and request extended mode

- **MAIL FROM:** - specify the sender
- **RCPT TO:** - specify the recipient
- **DATA** - specify the body of the message (To, From and Subject should be the first three lines.)
- **RSET** - reset
- **QUIT** - quit the session
- **HELP** - get help on commands
- **VERFY** - verify an address
- **EXPN** - expand an address
- **VERB** - verbose

- 1 Ask the server to send a copy of the MBRAIN.TXT file
- 2 Ask the server to erase and reset the MBRAIN.TXT file
- 3 Save the MBRAIN.TXT file on my local machine
- 4 Parse the file into the separate messages (using the word "From:" as the separator)
- 5 Show me all of the message headers in a list

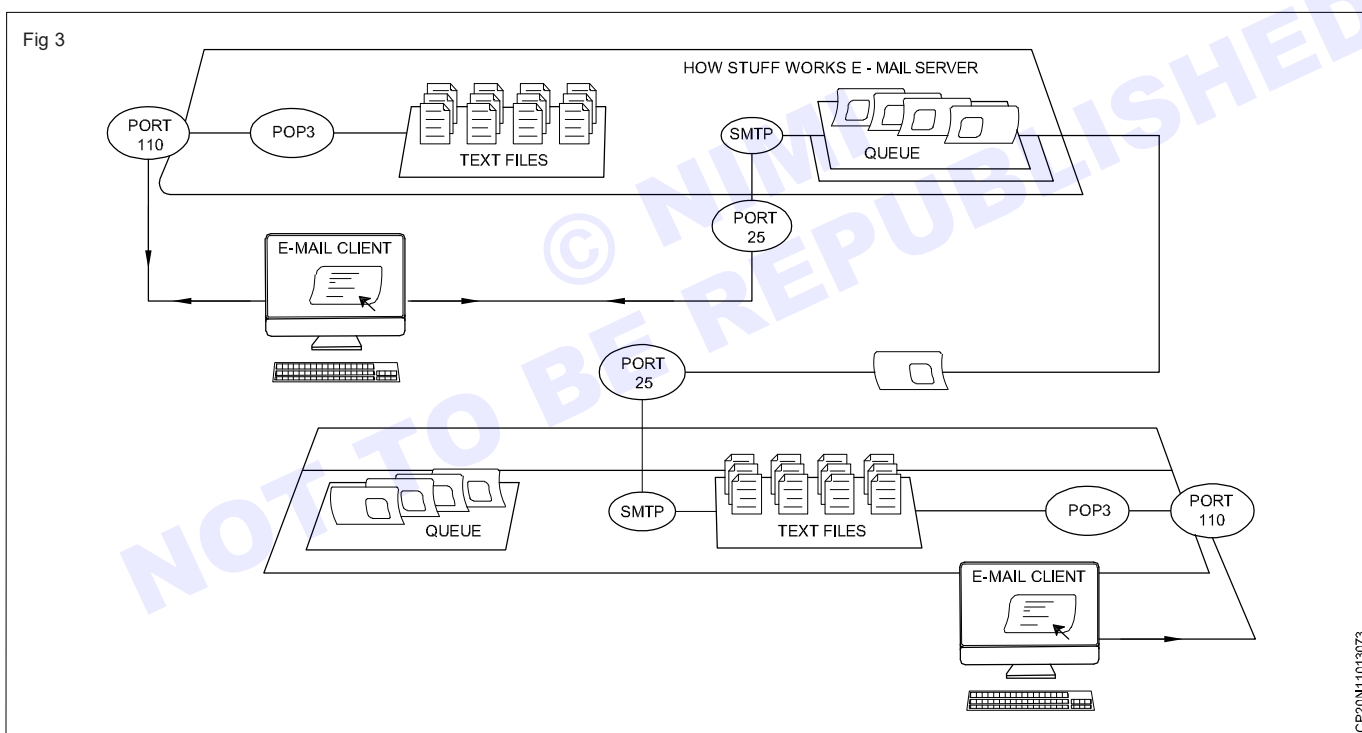
When you double-clicked on a message header, it would find that message in the text file and show me its body.

As you can see, this is a very simple system. Surprisingly, the real e-mail system that you use every day isn't much more complicated than this.

More Complex Servers

As other people sent mail to mbrain, the server would simply append those messages to the bottom of the file in the order that they arrived. The text file would accumulate a series of five or 10 messages. When I wanted to look at my e-mail, my e-mail client would connect to the server machine. In the simplest possible system, it would:

The Real E-mail System For the vast majority of people right now, the real e-mail system consists of two different servers running on a server machine. One is called the **SMTP server**, where SMTP stands for Simple Mail Transfer Protocol. The SMTP server handles outgoing mail. The other is either a **POP3 server** or an **IMAP server**, both of which handle incoming mail. POP stands for Post Office Protocol, and IMAP stands for Internet Mail Access Protocol. A typical e-mail server looks like Fig 3:



Computer networking cables, ports & peer to peer network

Objectives : At the end of this lesson you shall be able to

- explain what is a network
- list the components of a network
- list different types of network
- explain analog and digital connectivity.

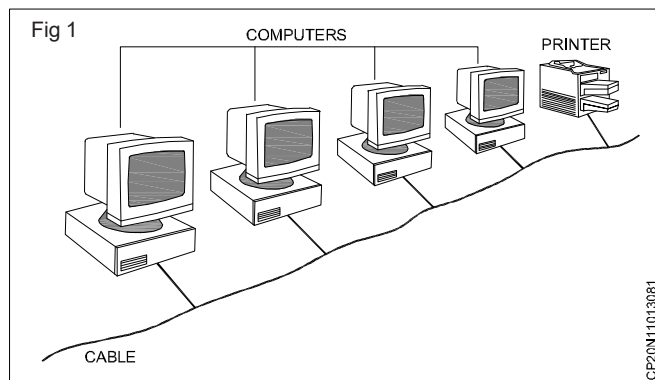
Introduction

If there is one concept that facilitates a global community, it is networking. A network by definition is a collection of

two or more computers connected together. Through these networked computers, people can share almost anything that include:

- **Data files:** Word processing, electronic spread sheet or presentation documents.
- **Peripheral devices:** Printers, monitors, scanners etc.
- **Software applications:** Bundled PC software such as MS-Office or Lotus Smart suite, Financial accounting software, database software etc.
- **An internet connection:** Going On line to connect to another network or to send e-mail to another person.

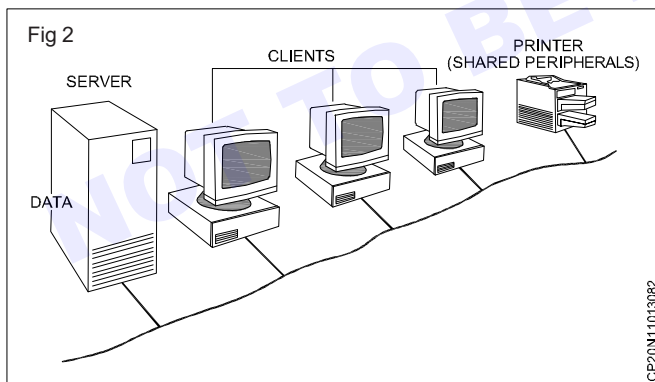
A simple network is shown in Fig 1.



In essence a network is a group of computers, printers and other devices that are connected together with cables. Information travels over the cables, allowing network users to share any hardware or software that is connected to the network.

Components of a network: All networks have certain components in common. They are:

Servers - computers that provides shared resources.
Fig 2



Shared resources: Files, directories, applications, printers, CD rom drives, and other peripherals which are accessed by the users on the network.

Clients: Computers that access or use shared resources from server

Media: The physical cable that connects the computers in a network.

Network interface card: To convert a standalone computer to be connected to a network, first a network interface card has to be plugged into the PCs expansion slot and configured.

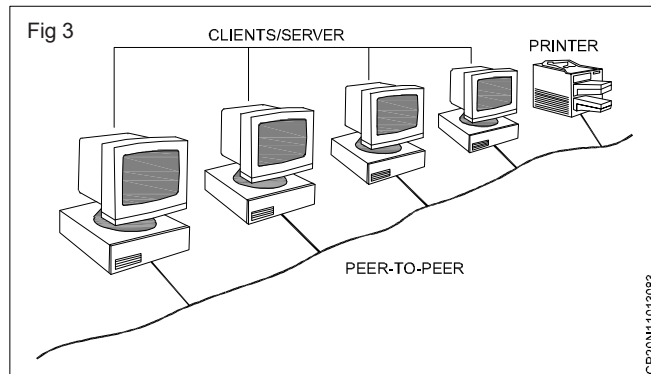
Network devices: Used to interconnect the computers over a network.

There are two basic types of network, about how one computer connects to another computer over the network.

1 Peer-to-peer

2 Client-server

1 Peer-to-peer Network (Fig 3)

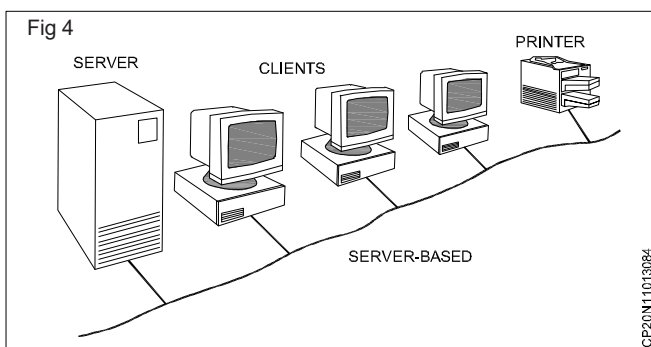


All computers on this type of network, communicate with equal priority. There is no separate server. No one need to be assigned as an administrator (who manages the network). The user at each computer decides what data on their computer gets shared on the network. The resources may be files, directories, application programmes, or printers, modems, fax cards etc. The peer-to-peer networks are also called work group. It is easy to set up and administer. They do not require any additional network operating system like Win Nt/Unix etc. You can build a peer-to-peer network using just Win 95/98 on all the PCs. Any failure of a PC will effect only that user and the rest of the network is not affected. Networks are suitable for environments where users on a network are in the same area or room and the number of users is less than 10. But the disadvantage is that the level of security offered is very low and there is a good chance of data getting accessed by unwanted users in the network.

A reliable, single point back up cannot be taken as the data is spread on all the computers.

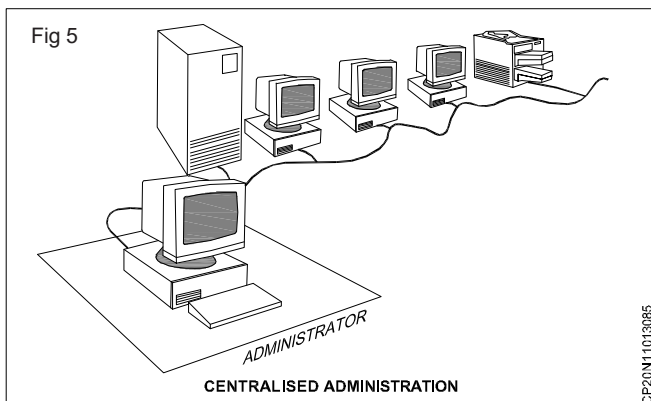
2 Client-Server Networks

A server is a computer that provides its resources to the clients. They have higher memory, hard disk space and processors than clients (Fig 4). They have centralised storage devices like tapes.



They are expensive than standard computers. A client is a computer that uses the resources of a server.

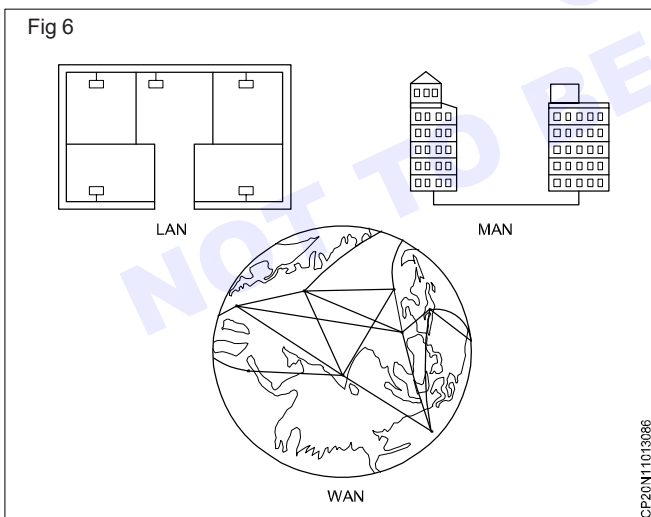
The client server networks are very secure. Since all the files are stored centrally, it can be managed by a single person who is known as an administrator as shown in Fig 5.



All the data can be backed up on a back up device like magnetic tapes centrally, from the server. An operating system that resides on the server is called a Network operating system or NOS. Examples of NOS are windows NT, SCO Unix, Novell network, Linux etc. The network operating systems are capable of handling multiuser environments. Multitasking means that multiple applications can run parallelly. Multiuser is many users accessing the files on a single server at the same time.

Classification of Networks (Fig 6)

Computer networks are classified by the number of computers (size), the distance covered (the area of the network) as follows.



I Local Area network (LAN)

A combination of computers connected with a cable that is relatively small and manageable. Normally uses only one type of cable medium, does not exceed a distance of over 600 feet. Such a network might be on a single floor of a building, or within one small company. Operates within a limited area. Popularly known as campus-wide network when used within a campus. A campus houses multiple buildings located in the same geographic area.

II Metropolitan Area network (MAN)

A MAN is usually larger than LAN. It is covered within a city (a few tens to hundred kms.) Different hardware and cables on transmission media are often used in MANs because they have to cover these distances and do not have direct access to locations between the networked sites.

III Wide area network (WAN)

A WAN is typically larger than a MAN. WANs interconnect isolated LANs which may be at opposite sides of a country or located around the world. LANs work well, but they have physical and distance limitations. Because they cannot be extended beyond a certain distance, there must be connectivity between LANs and other types of environments.

Using components such as bridges, switches, modems or routers and with the help of communications service providers like BSNL, VSNL etc, the LAN can be expanded to support data communications over a state, a country or even the globe. When a network does this, it is called a wide area network or WAN.

But to the end user, the WAN appears to function in the same way as a LAN. Most WANs are combinations of LANs and other types of communications equipments connected by communication links called WAN links.

WAN links can be implemented by using:

Packet-switching networks, fibre-optic cable, wireless media, satellite links, POTS or plain old telephony system, ISDN, DSL etc. The communication over a WAN link can be Analog, Digital or packet switches. The WAN connections can be switched or dedicated. A switched WAN link is not connected to the other end at all times. For example, a dial up modem connection from one location to another would be available only when you dial the other end and it can always be disconnected at any time.

A dedicated WAN link is one that is always up and running. Example is leased lines from BSNL can be used to connect two ends using leased line modems. The connection/link is always available. But it is costlier than dial up solution. When the link is required 24 hours a day, and when the data is very important or reliable, one can go for dedicated links.

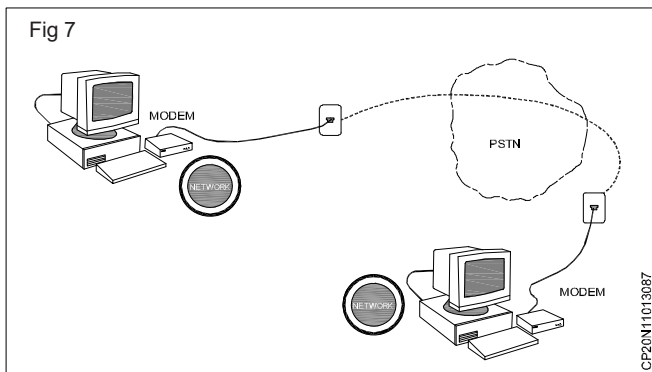
Communication between LANs will be implemented using one of the transmission technologies.

- 1 Analog
- 2 Digital

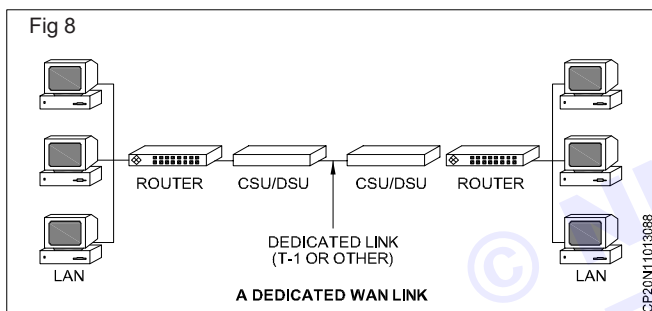
Analog connectivity:

Dial up lines: The same network that your telephone uses is available to computers also. PSTN or Public Switched Telephone Network is a world wide network for providing telephony services. Primarily they serve voice-grade communication. They are also known as POTS or Plain old telephone service. These lines can help to connect two or more sites together at very slow speeds. The standard speed achieved is only 33.6 Kbps, provided the quality of line is good without much noise. POTS carry only analog

signals. The data sent between system is converted from digital to analog data using a modem. It is an inexpensive way to get connected. A typical setup is shown in Fig 7.



Dedicated Analog lines: Unlike dial-up links, which must be reopened each time they are used, dedicated or leased lines provide a ready communication link at all times. It is relatively expensive than dial-up. You can achieve speeds even upto 2 Mbps. Special leased line modems are used for this purpose. Routers can be used to interface leased links and provide connectivity to the entire LAN as shown in Fig 8.



Digital connectivity

Even though dial up links are used for WAN connectivity, when a large data has to be transmitted or a high speed is required, digital lines have to be used.

Network topology

Objectives: At the end of this lesson you shall be able to

- explain what is network topology
- list various network topologies
- explain the term network architecture.

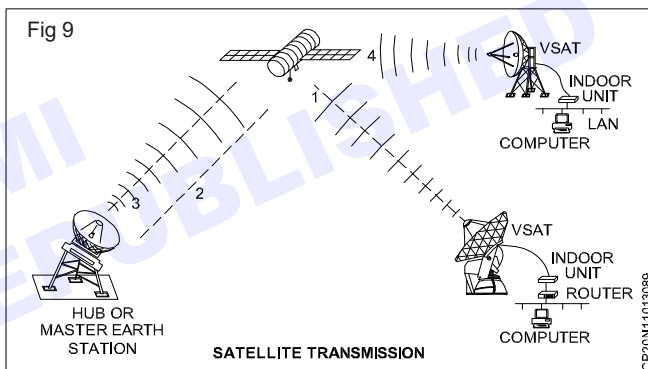
The term network topology refers to the arrangement or physical layout of computers, cables and other components on the network. The term Topology is also commonly used to refer to the network's basic design. Topology is an important issue when you plan for a network. It depends on the type of cable and protocol to be used in the network.

The most common topologies are:

- 1 Bus
- 2 Star
- 3 Ring

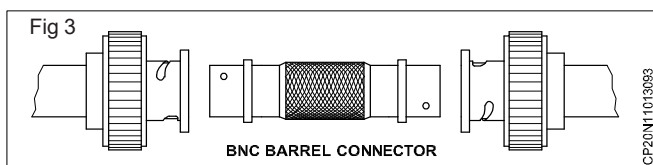
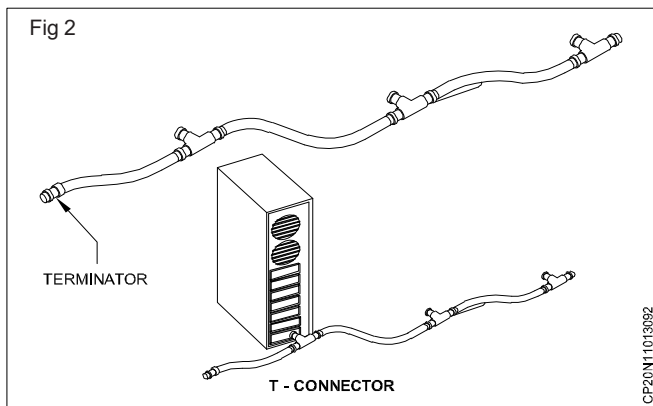
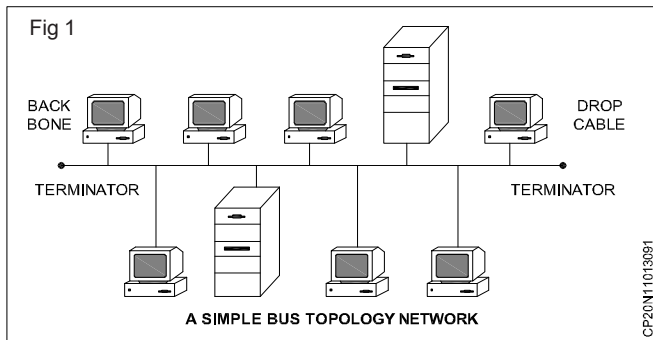
Popular technology that is used is ISDN. It is a high speed digital communications network based on existing telephone services. You can achieve upto 128 Kbps on a single ISDN BRI link.

Satellite transmission: WAN links can be established by using satellites also. In some remote places, the services discussed earlier may not be available. Wherever, there is no service provider for WAN links the only option left is to use satellite transmission. VSAT is a small dish antenna erected at the roof top. VSAT or very small Aperture Terminal is used at the customer premises for establishing line of sight to the satellite. Three satellites are required to cover the entire area of the earth. The VSAT is connected to an indoor unit called earth station through a cable. The signals transmitted by the indoor unit to the dish antenna is beamed to the satellite. The satellite again reflects this signal to a master earth station or Hub station which has a huge dish antenna. The Hub station in turn beams the signal to the intended receiver through the satellite. But the equipment and service provider cost is very high. But it can be erected anywhere in the world and provides secure environment. Typical speed would be by 64/128 kbps. A typical satellite transmission is shown in Fig 9.



Bus Topology:

In this type of arrangement as shown in Fig 1, computers are connected in a row. This is the simplest and most common method of networking computers. The cable that is used to connect all the computers is also called as backbone. Bus topology networks use coaxial cable. They use BNC connectors to connect all the individual cables. Each computer is connected to the network through the use of a BNC T-connector as shown in Fig 2. This connection allows the backbone cable to be continued to the next computer. To make a longer piece of cable, a component called a barrel connector (Fig 3) is used.

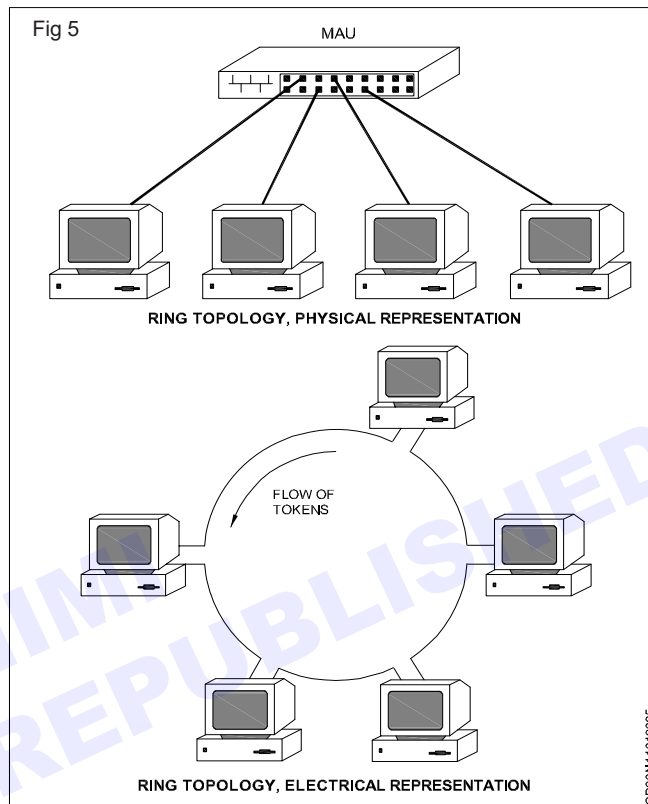
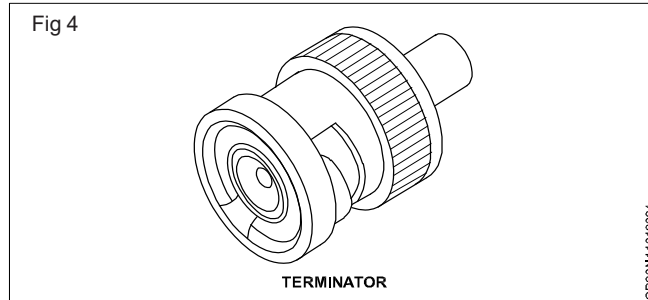


In this topology, the network data is sent in the form of an electronic signal along with the MAC (Manufacturer address code) address of the machine to which data has to be sent. All the computers on the network receive this data. But only the computer whose address matches the address in the data sent over the network will accept the information. Only one computer at a time can send messages over the network.

Because the data, or electronic signal, is sent to the entire network, it will travel from one end of the cable to the other. If the signal were allowed to continue uninterrupted, it would keep bouncing back and forth along the cable and prevent other computers from sending signals. Therefore, the signal must be stopped after it has reached the proper computer. To stop the signal from bouncing, a component called Terminator is placed at each end of the cable to absorb free signals. Absorbing the signal clears the cable so that other computers can send data. The protocol that is used in bus topology is Ethernet.

If the cable is physically cut or if any one end of the cable gets disconnected from the terminator (Fig 4) or T-connector, the entire network is down. Then the computers will not be able to communicate with each other.

Ring Topology: The ring topology connects computers on a single circle of cable. There are no terminators at the end of cable like in bus topology. Refer to the Fig 5 shown below.



The signals travel around the loop in one direction and pass through each computer. Each computer boosts the signal and sends it to next computer. Because the signal passes through each computer in the ring, the failure on one computer effect the entire network.

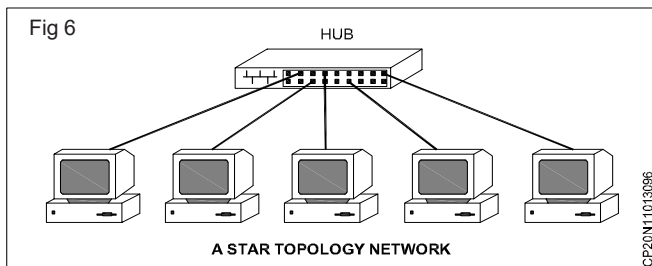
Though the computers are logically connected in a ring fashion, the actual cables from the NIC of the computer gets connected to the MAU or Multistation Access Unit centrally. The function of the MAU is to accept signals transmitted from one computer and direct the signals to the computer to which it is addressed.

One method of transmitting data around a ring is called token passing. A token is passed from one computer to the next and so on. When a station wants to transmit on the ring, it waits for a free token to pass by. The sending computer takes the token. It modifies by putting an electronic address of the computer to which it has to transmit. Then it sends the token out on the rings. As the busy token passes by, each computer on the ring checks the token's address. If the address does not match with its own address, it sends the token to the next computer. If the address matches, the computer copies the data from the token. It also returns a message on the token to the sending computer indicating that the data has been re-

ceived. After verification, the sending computer creates a new token and releases it on the network.

Token ring topology uses category 3/4/5 UTP or fibre optic cable. Though originally 4 Mbps speed was used, the typical speed used now is 16Mbps. A newer version of fast token ring standard also exists that enhances the speed to 100 Mbps.

Star Topology: In this type, computers are connected by cables to a centralised component, called a hub. Signals are transmitted from the sending computer through the Hub to all the computers on the network as shown in Fig 6.



Star topology is easy to install. You must install a separate cable from the Hub to the computer. So it may require more cabling than other topologies. Shifting, adding and removal of nodes are very simple. Even if one cable breaks down, only that computer gets affected on the network and the rest is operational. UTP or FTP cables Cat5 or Ecat5 may be used for achieving speeds upto 100/1000 Mbps. They are limited to a length of 100 meters (328 feet) for each node connection.

There is no limitation in the number of nodes in a segment. Uses RJ-45 connectors for all connections.

Network Architecture

Network architecture combines standards, topologies and protocols to produce a working network. Ethernet is currently the most popular network architecture. It uses a bus topology, it follows the IEEE's 802.3 specification.

The Ethernet media draws power from the computer and this will not fail unless the media is physically cut or improperly terminated. The transfer speed is 10/100 Mbps. It supports Thin, Thick coaxial cables and UTP.

10 Base-What?

The various Ethernet standards referred to as, for instance, 10Base-2, 10Base-T, 100Base-T and so on contain in their name all you need to know about what they do. The first portion-the number-can be 10, 100 or 1000 and this number indicates the data rate (in Mbps) that the standard carries. The word Base means the network is baseband connection only carries one signal at a time, while broadband connection carries multiple signals at a time). The terminating letter or number indicates what sort of cable is used, with T denoting twisted-pair, 2 denoting thin coaxial, and 5 denoting thick coaxial. Here is a quick reference guide to the different standards commonly seen.

10Base-2	10 Mbps, coaxial (RG-58) cable.
10Base-5	10 Mbps, coaxial (RG-8) cable.
10Base-T	10Mbps, twisted-pair (two pairs, Cat-3 mor higher cable).
100Base-T	100 Mbps, twisted-pair (four pairs, Cat-5) cable; also called 100 Base-T4 to designate four pairs.
100Base-TX	100 Mbps, twisted-pair (two pairs, Cat-5 cable)
100Base-FX	100 Mbps, fiber-optic cable
1000Base-T	1Gbps, twisted-pair (four pairs, Cat-5) cable

Different types of cables and connectors used in LAN

Objectives : At the end of this lesson you shall be able to

- list different types of cables used in networking
- explain the construction of a twisted pair cable
- explain the construction of a coaxial cable
- explain the construction of a fiber optic cable
- list the common types of fiber optic cable
- list the network connectivity hardware
- explain modems, repeaters, hubs and bridges.

Cables or transmission media

Network computers must have a pathway to contact other computers. The physical path through which the electrical signals travel is called transmission media or cables.

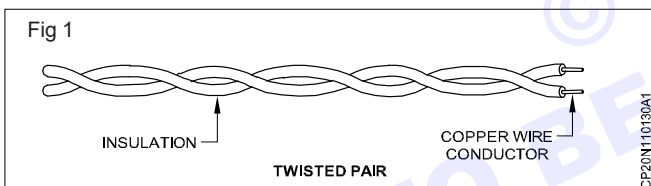
Cable media are wires or fibres that conduct electricity or light. The following types of cables are used in LAN.

- 1 Twisted pair cable
- 2 Co-axial cable
- 3 Fiber optical cable

1 Twisted pair cable

Twisted pair is a common scheme for using copper wire as telecommunication cable because copper is a good conductor of electrons. Twisted copper wires reduces cross talk and signal emissions.

Twisted pairs are formed by two insulated 22 to 26 gauge copper wires that are twisted about each other as in Fig 1. These twisted cables are available in two types.



Category 3/Cat 3	-	10 Mbps	-	used for voice grade telephone or 10 mbps ethernet
Category 4/Cat 4	-	16 Mbps	-	Token ring network
Category 5/Cat 5	-	100 Mbps	-	For 100 Mbps Ethernet
/ECat 5	-	100/1000 Mbps		

ECategory 5 and category 5 UTP are commonly used in computer networking.

UTP cables are limited to a length of 100 meters (328 feet) for each node to Hub connection.

Shielded twisted pair cable

Today, the mostly used cable is UTP. But some forms of shielded twisted pair (STP) still exist. The below Fig 3 shows the STP cable. It is used in places where electromagnetic interference caused by electric motors, power lines and other sources.

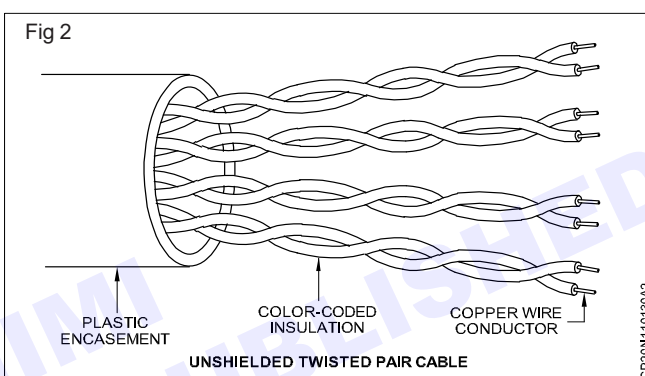
The STP is insulated cable which includes bundled pair wrapped in a foil shielding.

The two types of cables are:

- Unshielded twisted pair cable.
- Shielded twisted pair cable.

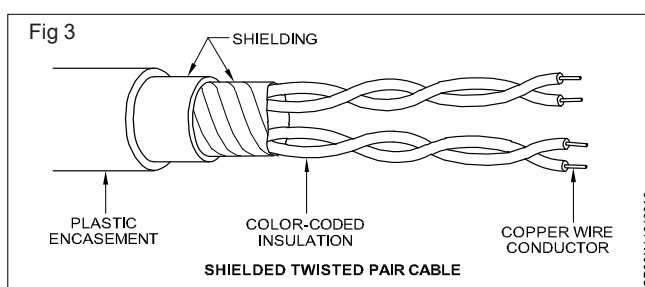
Unshielded twisted pair cable (UTP)

Unshielded twisted pair cable is composed of a set of twisted pairs with a simple plastic encasement as in Fig 2.



It is commonly used in telephone systems and has been largely standardized.

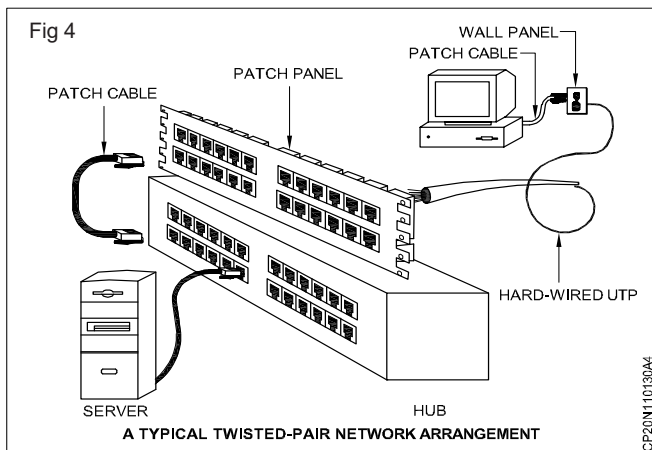
Twisted pair network cables are rated in terms of their capability to carry network traffic. They are referred as category 3, 4 and 5.



UTP

UTP is a popular choice for structured cabling systems used widely in office network environments. Structured cabling system is a network cabling pattern which follows strict engineering design rules. It allows voice, data and

video to be transmitted/received on the same cabling system. It allows shifting, adding and replacing the nodes easily. The arrangement is as shown in Fig 4.

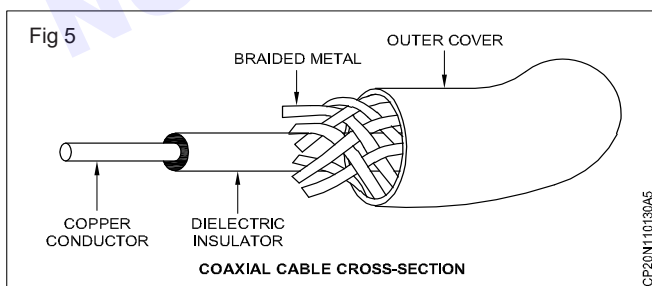


The cabling starts from the Hub or switch which is placed in a Rack centrally. A patch cable (usually 6-10 feet long) connects a port on the hub to a patch panel which is also in the Rack using RJ-45 connectors on each end. On the back side of the patch panel, the UTP cable is hard-wired or crimped to the panel connector. From the patch panel, the UTP cable runs continuously to a wall jack or information outlet (I/O). The information outlet contains a RJ-45 jack called I/O jack in it.

The UTP cable is crimped to the information outlet. Another patch cable connects to the RJ-45 jack in the information outlet and the other end gets connected to the NIC of the computer. Note that the distance from the connector on the hub to the connector on the computer's NIC cannot exceed 100 metres of cable length.

2 Co-axial cable

Co-axial cable commonly called ("Coax") is made of two conductors that share a common axis, hence the name ("co", "axis"). typically, the centre of the cable is relatively stiff solid copper wire or stranded wire surrounded by an insulating plastic foam. The foam is surrounded by the second conductor, a wire mesh tube as in Fig 5.



Several co-axial cable standards are in common use for computer networking. The most common types meet one of the following ohm and size standards.

- 50 ohm RG-8 and RG-11 (used in thick Ethernet specifications.)
- 50 ohm RG-58 (used in thin Ethernet specifications.)
- 75 ohm RG-62 (used for ARC net specifications)

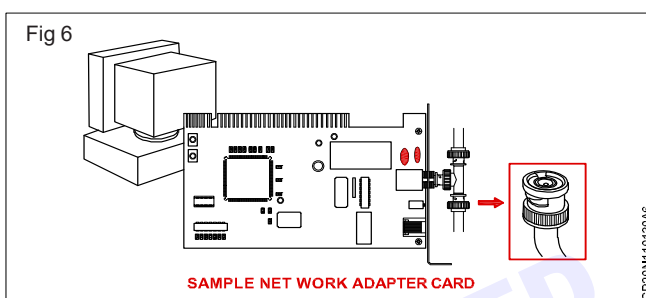
The co-axial cable can handle a speed of only 10 Mbps maximum and the distance it can drive is only 185 m maximum.

Types of Co-axial cable

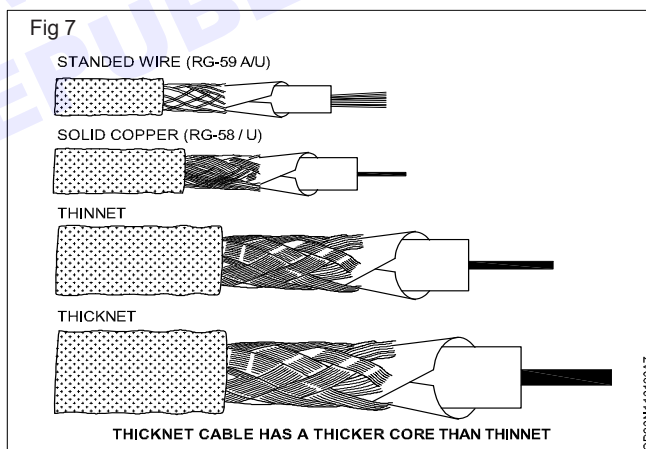
There are two types of co-axial cable

- Thin (Thinnet)
- Thick (Thicknet)

Thinnet: Thinnet is a flexible coaxial cable about 0.25 inch thickness. Because this type of coaxial is flexible and easy to work with, it can be used in almost any type of network installation. Networks that use a thinnet have the cable connected directly to a computer's network interface card as in Fig 6.



Thinnet is included in a group referred to as the RG-58 family and has a 50-ohm impedance. The main difference in the RG-58 family is the center core of copper. It can be either stranded wire or solid copper core as in Fig 7.

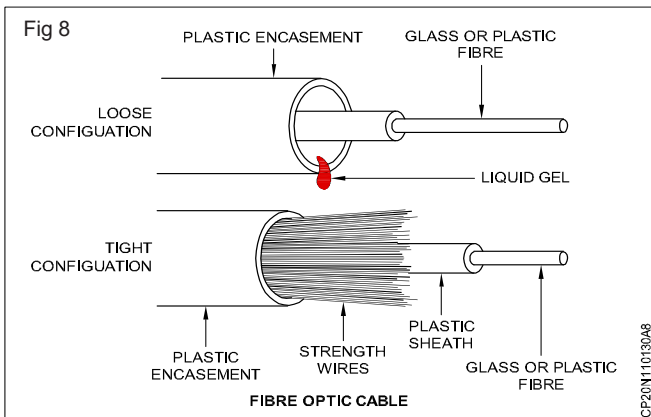


Thicknet: Thicknet is relatively rigid co-axial cable about 0.405 inches in diameter. The copper core is thicker than a thinnet core as shown in Fig 7. This cable is typically installed along the floor of the site. They are usually yellow in colour and is marked every 2.5 metres for the taps to which the computers connect. To connect a computer to the cable, you apply a vampire tap. A vampire tap is a clamp that you connect to the cable after drilling a hole in the sheath. The Vampire tap includes a component called transceiver which connects to the NIC with an AVI cable that has 15 pin shell connectors at both ends. The thick Ethernet segment can have max. cable distance upto 500 metres and a speed of 10 Mbps.

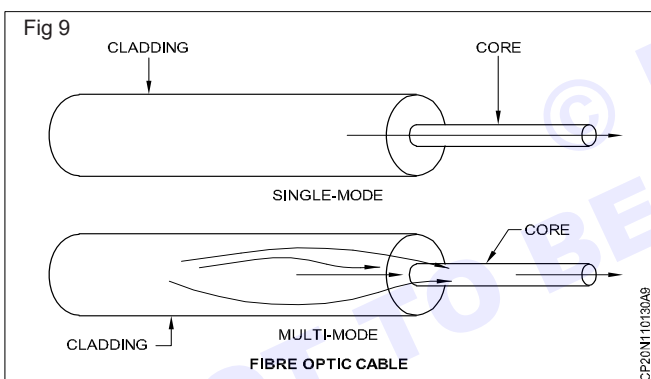
3 Fiber Optic Cable

Fiber optic cable is made of light-conducting glass or plastic core surrounded by more glass and a tough outer

sheath as in Fig 8. The center core provide the light path or wave guide while the glass or cladding is composed of varying layers of reflective glass. The glass cladding is designed to refract light back into the core. Each core and cladding strand is surrounded by a tight or loose sheath in tight configurations, the strand is completely surrounded by the outer plastic sheath. Loose configuration use a liquid gel or other material between the strand and the protective sheath.



The optical fibers may be multimode or single mode in nature. Single mode fiber has been optimized to allow only one light path while multimode fiber allows various paths. The following figure explains the single mode and multimode fibers. (Fig 9)



Single mode fiber cable can be used for distances upto 10 kms. and multimode cable for upto 2.5 km. The typical speeds are 100/1000 Mbps. The types of optic cable are differentiated by mode, composition (glass or plastic) and core/cladding size.

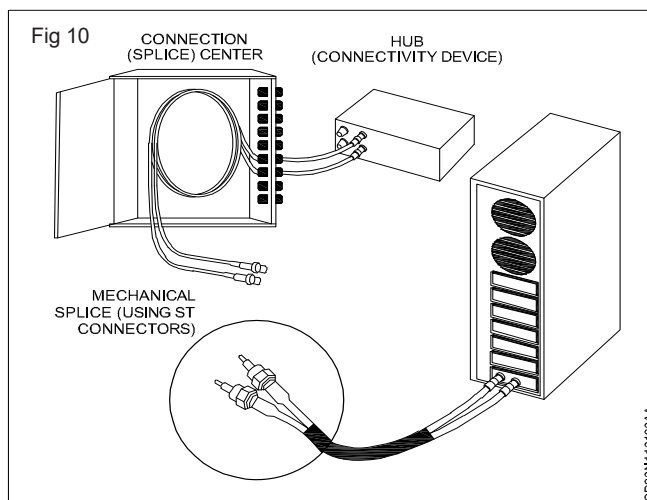
Common types of fiber optical cables:

- 8.3 micron core/125 micron cladding single mode
- 62.5 micron core/125 micron cladding multimode
- 50 micron core/125 micron cladding multimode
- 100 micron core/140 micron cladding multimode

The common fiber optic cables installation is given in the following Fig 10.

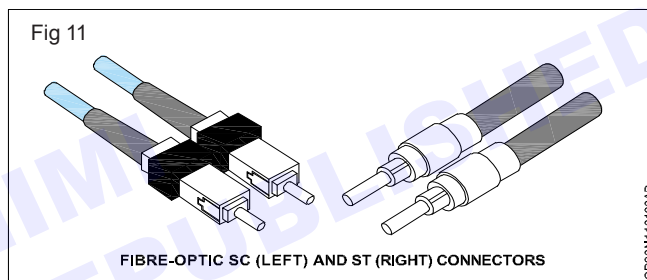
The signal carried by a single mode cable is generated by a laser source and that of a multimode by light emitting diode (LED). Together, these qualities allow single mode cable to operate at higher bandwidths than multimode and traverse distances upto 50 times longer. Single mode

cable is cheaper than multimode and has a relatively high bend radius, which makes it more difficult to work with. MMF is most commonly used.



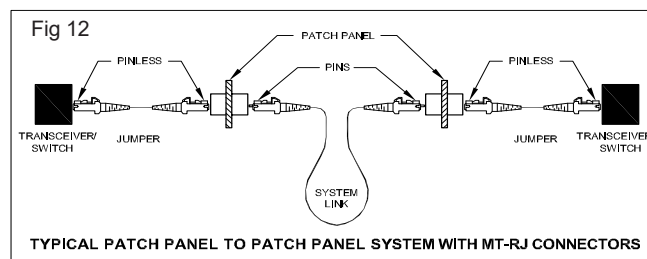
Fiber optic connectors

The connector used on fiber optic cables is called an ST (straight tip) connection shown in Fig 11.



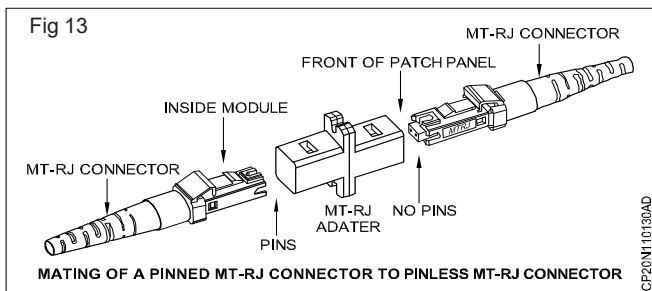
One more connector type is SC (subscriber connector) is coming up popularly. It has a square body and locks by simply pushing it into the socket.

The MTRJ is a new fiber optic connector being used widely. It can operate at Gigabit ethernet speeds (1000 Mbps) easily. The MT-RJ has a latching mechanism similar to the RJ-45 UTP connector. A standard MT-RJ connection consists of 3 components: a male connector (with pins), a female MT-RJ (with guide holes) and as MTRJ adapter. It is easy to install and maintain and should be considered for any new installation. The Fig 12 and 13 show the MTRJ connectors and connections in use.



Fiber-optic connectors can attach to the cable in several ways, using either a crimped compression fitting or an epoxy glue.

Fiber cables are mainly used for backbone connectivity across the floors or when the distance cannot be covered by UTP cable limitation or when the network path to be connected is exposed to sky.



Fiber cables come in three varieties depending on the place of usage.

- 1 Indoor cable - for in-house usage within buildings.
- 2 Outdoor cable/Armoured cable - to be used in areas which are exposed to sky. Has an additional hard shield to prevent any occasional damage.
- 3 Indoor/outdoor cable can be used inside and outside buildings. Does not carry heavy shield as in outdoor cable, but better than indoor cable.

Different types of network connectivity hardware

In a network number of hardware devices are used to connect each computer to a media segment. These devices are:

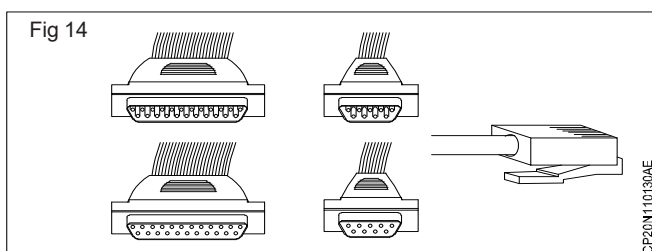
- 1 Transmission media connectors
- 2 Network interface boards
- 3 Modems

We can also connect multiple separate segments of transmission media to form one large network. For this purpose we use the following networking devices.

- 1 Repeaters
- 2 Hubs
- 3 Bridges
- 4 Multiplexers
- 5 Transceiver
- 6 Routers

1 Transmission media connectors

Every medium has one or more physical connectors to which you can attach various devices (Fig 14).

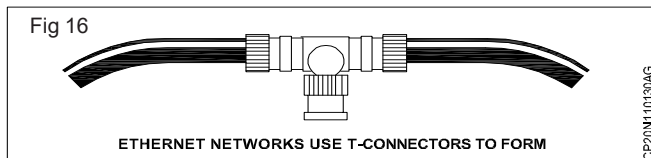
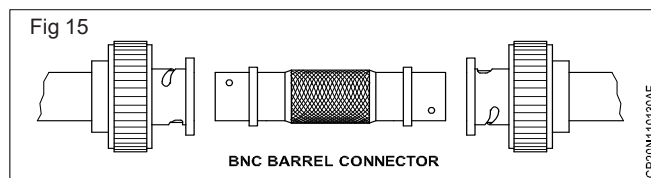


BNC (Bayonet nut connector)

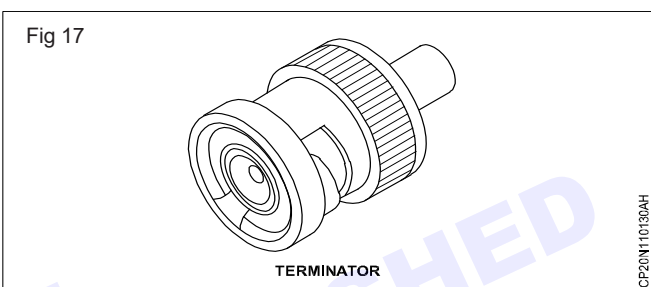
It is a connector for co-axial cable that locks when one connector is inserted into another and is rotated 90 degrees as in Fig 15.

T-connecor: A T-shaped co-axial connector that connects two thinnet co-axial cables while supplying an

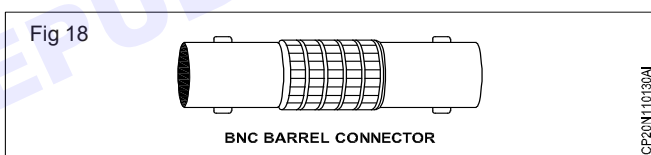
additional conenctor for a network interface card as in Fig16.



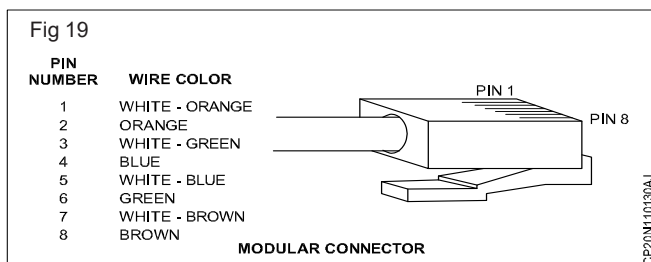
Terminators: A resistor used at each end of a co-axial cable to ensure that signals do not reflect back and cause errors. The terminators should be of 50 ohm resistance Fig17.



Barrel connector: Barrel connector is used to connect two pieces of cable together to make a longer piece of cable as in Fig 18.



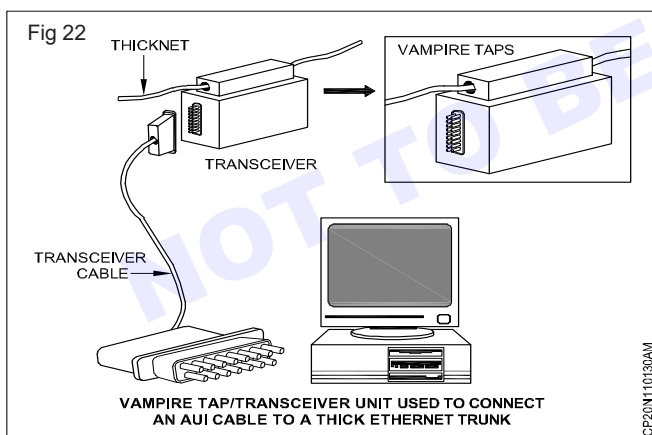
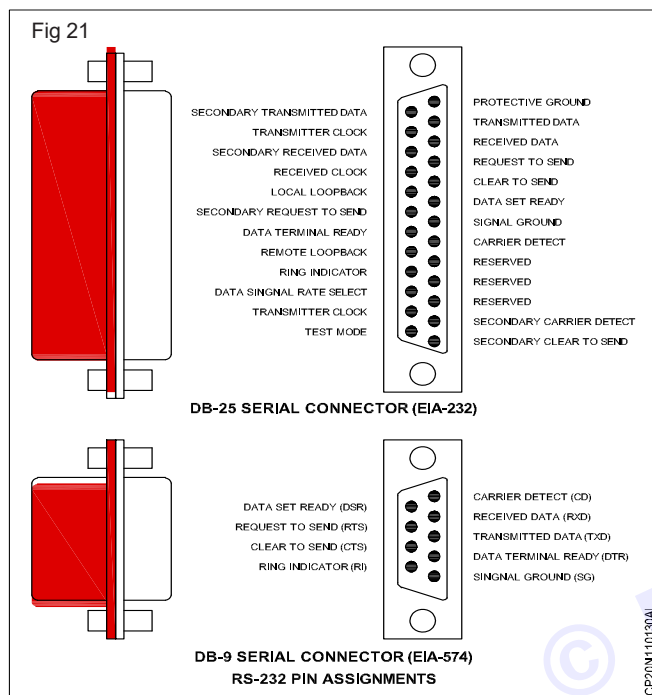
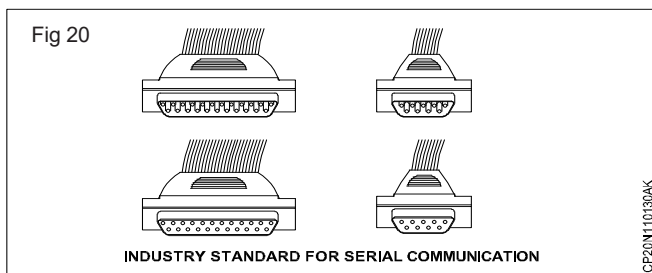
RJ-45: An eight wire modular connector used to join a network cable to a wall plate or some other device. It is similar to an RJ-11 telephone conenctor but has twice the number of conductors. The number of pins are explained in below table. (Fig 19).



RS 232: (Reference Standard 232) An industry standard for serial communication connections. Adopted by the Electrical Industries Association (EIA). This recommended standard (RS) defines the specific lines and signal characteristics used by serial communications controllers to standardise the transmission of serial data between devices. RS 232 pin assignments details are given in the following Fig 20 and 21.

Transceiver: A device that connects a computer to the network. The term transceiver is derived from transmitter/receiver, so a transceiver is a device that receives and

transmits the signals. It switches the parallel data stream used in the cables connecting the computers.(Fig 22).

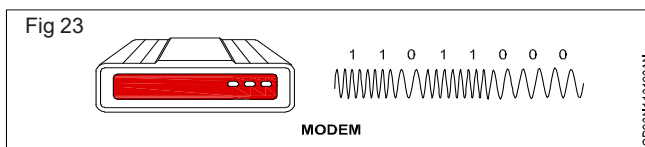


Network interface cards

Network interface cards act as the physical interface or connection between the computer and the network cable. The cards are installed in an expansion slot in each computer and server on the network.

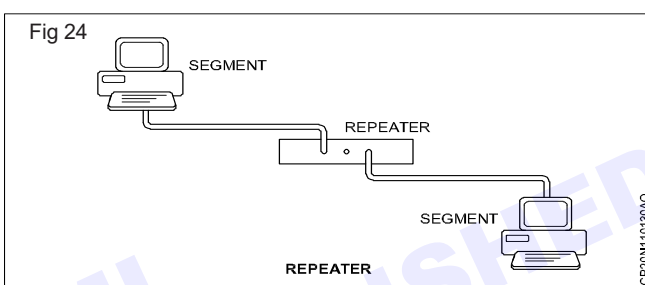
After the card has been installed, the network cable is attached to the card's port to make the actual physical connection between the computer and the rest of the network.

Modems (Modulator/Demodulators) converts your computers digital signals to an analog transmission signal to use with telephone lines or microwave transceivers. The Fig 23 shows modem.

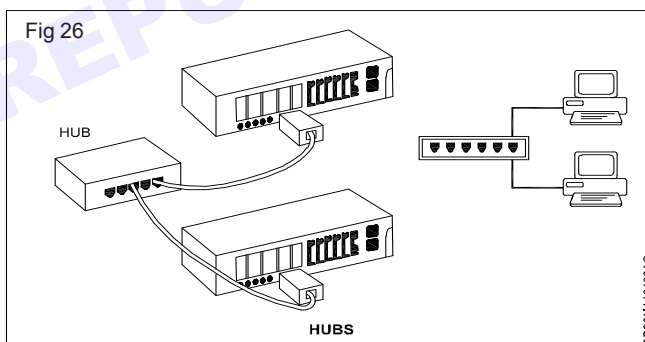


Suppose that one of your computers was located across the city. You can use a modem to connect to that computer using telephone line or microwave transceivers.

Repeaters: Electro magnetic waves become weaker as they pass through transmission medium. Each transmission medium can only be used for a certain distance. One can exceed the physical mediums maximum effective distance by using an amplification device called repeater. Repeater is shown in the following Figs 24 and 25.



Hubs: Some networks require a central point of connection between media segments. These central points are referred to as hubs. The Fig 26 shows hub.



Bridges: A bridge extends the maximum distance of your network by connecting separate network segments. Bridges selectively pass signals from one medium segment to another as in below Fig 27 and 28.

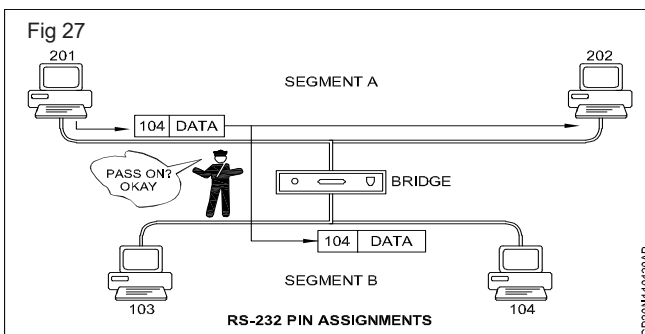


Fig 25

Diagram illustrating the installation of a repeater for a network. The diagram shows a 'NETWORK MODEM' connected to a 'REPEATER' via a cable. The 'REPEATER' is then connected to another 'NETWORK MODEM' via a cable. A lightning bolt symbol indicates a connection to a 'PUBLIC DATA NETWORK' cloud. Below this, a red-bordered box shows a network topology with three servers and two repeaters connected in a loop, with a cloud symbol in the center, indicating a mesh or ring topology.

REPEATER INSTALLATION

CP20N110130AP

Fig 28

Diagram illustrating the installation of a bridge between two networks.

The diagram shows a computer connected to a network modem, which is connected to a repeater. The repeater is connected to a bridge. The bridge is connected to a hub, which is connected to two desktop computers.

The diagram also shows a logical representation of the same setup, with a cloud labeled "PUBLIC DATA NETWORK" connected to a computer, which is connected to a bridge. The bridge is connected to a hub, which is connected to two desktop computers.

BRIDGE INSTALLER

CP20N110130AS

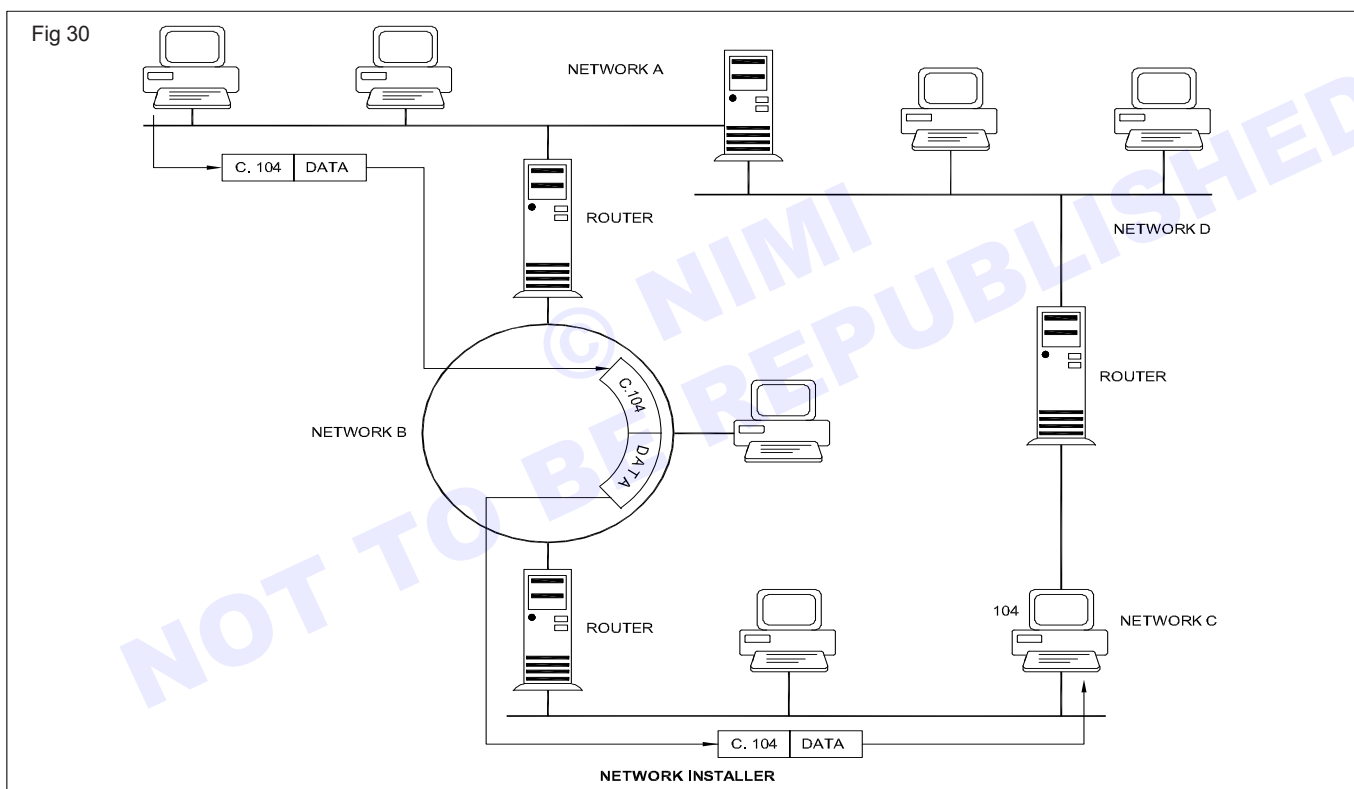
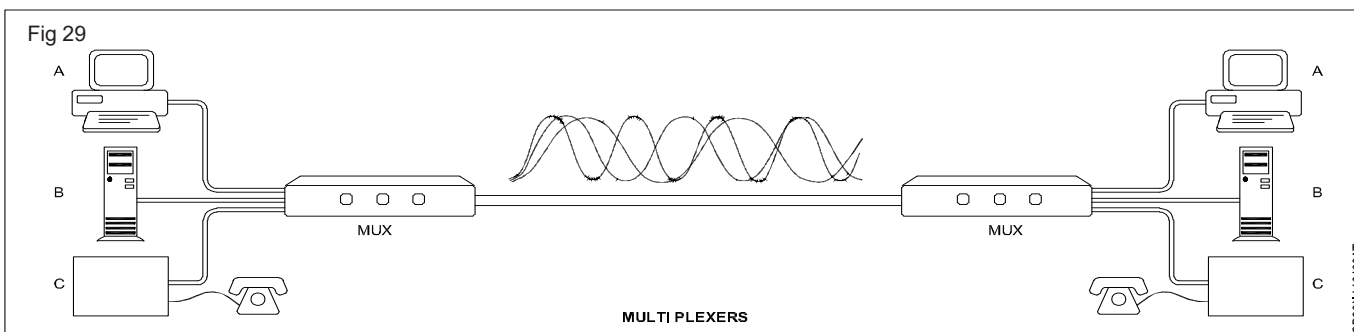
The above figure explains that

- Receive all signals sent on segment A.
- Discard signals addressed to other nodes on segment A.
- Retransmit all other signals out of the appropriate ports
- Perform the same functions for data on other connected segments.

Multi plexers: A multiplexer combines two or more separate signals on a single transmission media segments i.e. to efficiently use the entire transmission media band width, we can use multiplexers.

Multiplexers shown in below Fig 29.

Routers: Routers connect two or more logically separate networks (consisting of several network segments with different protocols and architectures) is called router. The following figure explains the operation of Routers Fig 30.



PC - Server

Objectives : At the end of this lesson you shall be able to

- explain PC-server model, centralised computing and client computing with central file storage
- explain web server.

PC-Server : The term Client-Server can describe hardware, in which case it is referring to network servers and client computers, or it can refer to a way of organising software applications and services on a network. Client-server computing is a powerful way of constructing programs on a network. In order to describe its advantage and how it works, we will first describe two alternatives to client-server computing:

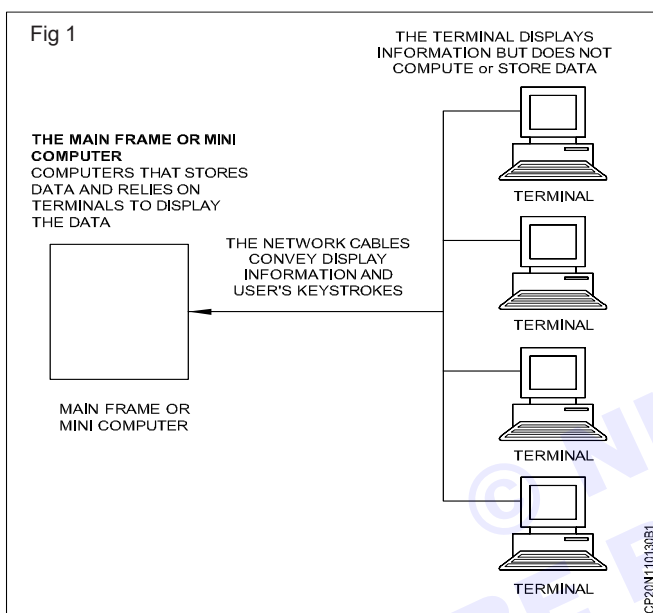
- Centralised computing
- Client computing with central file storage

Centralized computing : Centralized computing originated with mainframe computers and time-sharing. The principle behind centralized computing is that a central computer executes a program, such as a database or a transaction-processing program (for instance, an airline reservations system or a bank records program) and

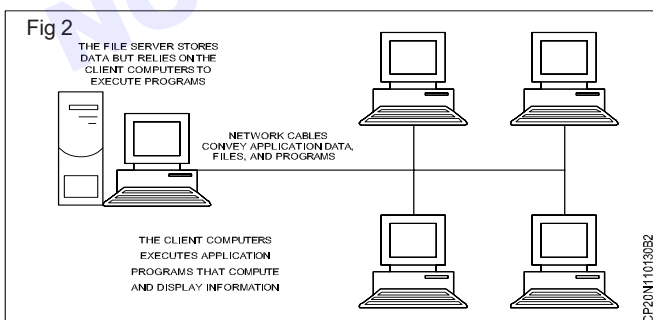
remote terminals merely display data on a screen and convey keyboard data back to the central computer.

In modern networks, personal computers can perform the role of dumb terminals. With Windows software, the PC can appear to the central computer as many terminals, each virtual terminal accessing different data or performing a separate transaction on the mainframe.

In centralized computing it is the central computer that does all the work. The data resides on the central computer and the program executes on the central computer. The personal computer or dumb terminal only display screen data and accepts keystrokes for the central computer to process. Centralized computing does not fully use the capabilities of today's powerful network clients. (Fig 1) illustrates centralized computing.



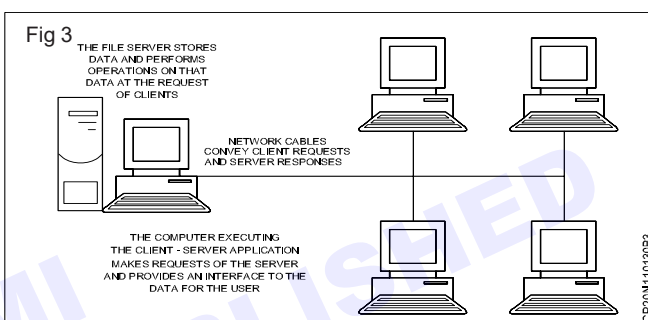
Client computing with Central file storage : At the opposite end of the spectrum from centralized computing is client computing with central file storage (see Fig 2). In this way of organizing an application, the client computer does all the work. A central file server stores, but that is all.



Client computers cooperate to ensure that central files are not corrupted by attempts by several computers to access them at the same time. When a client computer needs to perform an operation, the file is transferred to the client computer to perform the operation. Two examples of this type of application are networked database programs that do not use a SQL. (Structured Query Language) server and any network-aware application that does not communicate with a special program executing on the server, such as network scheduling programs and groupware.

While it fully exploits the capabilities of client computers and provides a richer and more customizable environment for the user, this type of program can place heavy demands on the network if the data files in which program works with are large. It also takes time to transmit data from the server to the client, process the data, and transfer it back to the server so other network programs can access the data.

The Client-Server Model : The Client-server model combines the advantages of both the centralized computing model and the client model of computing. It does this by performing the operations that are best executed by a central computer on the file server and performing those operations that are best done close to the user on the client computer (see Fig 3). The client-server model works best when many people need access to large amounts of data. Simply stated, a client-server system is any system in which the client computer makes a request over a network to a server computer that then satisfies the request.



The Client : When you use a client-server system, what you see is the client, or front end. It presents the interface to manipulate or search for data. The request you make by manipulating windows, menu, check boxes and so on, is translated into a compact form that the client transmits over the network for the server to perform.

One example of a front end is Microsoft Access when it is used with a SQL back end. (You can also use Access without a SQL back end.) Access displays tables in windows or in forms you can browse. It allows you to modify and search the tables in an easy-to-use graphical environment. All the actual data manipulation, however, occurs on the SQL server. Access translates all the data-base operations into SQL for the server to perform. The results of the operations are transmitted back to Access to display in an intuitive, graphical form.

SQL is not limited to database programs such as Microsoft Access. User programs such as Microsoft Excel can use SQL to query the back-end data-base server for values to use in spreadsheet calculations. Program tools allow custom programs to store and retrieve data in server-based databases. Query tools provide direct access to the SQL data.

The Server : The server is where data operations in a client-server system occur. The central computer can service many client requests quickly and efficiently, which is the traditional advantage of centralized computing. The central computer can also provide enhanced security by performing only authorized operations on the data.

Back-end database software is optimized to perform searches and sorts and the back-end computer is often more powerful than the front-end computer.

Web server : A web server is a program using the client/server model and the World Wide Web's Hyper Text Transfer Protocol (HTTP) serves the files that form web pages to web users.

Every computer on the internet that contains a web site must have a web server program. The most popular web servers are: The Microsoft's Internet Information Server (IIS) which comes with the Microsoft's Windows NT Server; Netscape Fast Track and Enterprises Servers and Apache, a web server for Unix-based operating systems. Other web

servers include Novell's Web Server for users of its Netware Operating System and IBM's family of Lotus Domino Servers. Primarily for IBM's OS/390 and AS/400 customers.

Web servers often come as a part of a larger package of Internet related programs for serving e-mail, downloading requests for File Transfer Protocol (FTP) files and building and publishing web pages. Consideration in choosing a web server include how well it works with the operating system and other servers, its ability to handle server side programming and publishing, search engine and site building tools that may come with it.

Sharing folders in computer network

Objectives: At the end of this lesson you shall be able to

- state about the planning, sharing, and connecting to shared folders
 - state about the shared application folders
 - state about the shared data folders.
-

Planning, Sharing, and connecting to shared folders

When you plan shared folders, you can reduce administrative overhead and ease user access by organizing resources that will be shared and putting them into folders according to common access requirements. You can also determine which resources you want shared, organize resources according to function and use, and decide how you will administer the resources.

Shared folders can contain applications and data. Use shared application folders to centralize administration and provide a central location for users to store and access common files. If all data files are centralized in one shared folder, users can find them easily. You will be able to back up data folders more easily if they are centralized. And you will be able to upgrade application software more easily if applications are centralized.

You can share resources with others by sharing folders containing those resources. To share a folder, you must be a member of one of several groups, depending on the role of the computer where the shared folder resides. When you share a folder, you can control access to the folder by limiting the number of users who can simultaneously gain access to it, and you can also control access to the folder and its contents by assigning permission to selected users and groups. Once you have shared a folder, users must connect to the shared folder and must have the appropriate permissions to access it. After you have shared a folder, you might want to modify it. You can stop sharing it, change its share name, and change user and group permissions to gain access to it.

Shared Application Folders

Shared application folders are used for applications that are installed on a network server and can be used from client computers. The main advantage of shared applications is that you don't need to install and maintain most components of the applications on each computer. Although program files for applications can be stored on a server,

configuration information for most network applications is often stored on each client computer. The exact way in which you share application folders will vary depending on the application and your particular network environment and company organization.

When you share application folders, consider the following points.

- Create one shared folder for applications and organize all of your applications under this folder. This designates one location for installing and upgrading software.
- Assign the Administrators group the Full Control permission for the applications folder so that members of this group can manage the application software and control user permissions.
- Remove the Full control permission from the Everyone group and assign Read permission to the Users group.
- Assign the Change permission to groups that are responsible for upgrading and troubleshooting applications.
- Create a separate shared folder outside your application folder hierarchy for any application for which you need to assign different permissions. Then assign the appropriate permissions to that folder.

Shared Data folders

Users on a network use data folders to exchange public and working data. Working data folders are used by members of a team who need access to shared files. Public data folders are used by larger groups of users who all need access to common data,

Create and share common data folders on a separate volume from the operating system and applications. Data files should be backed up frequently, and keeping data folders on a separate volume makes this convenient. If the operating system requires reinstallation, the volume containing the data folder remains intact.