# ELECTRONIC MECHANIC

## NSQF LEVEL - 5

## 2nd Semester

## TRADE PRACTICAL

**SECTOR:** Electronics and Hardware

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 : Electronics & Hardware**

**Duration : 2 - Year**

**Trade : Electronic Mechanic 2nd Semester - Trade Practical - NSQF level 5**



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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 Mentor Councils comprising various stakeholder's 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 **Electronic Mechanic 2nd Semester Trade Practical NSQF Level - 5 in Electronics & Hardware Sector under semester pattern .** The NSQF Level - 5 Trade Practical 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 - 5 trainees will also get the opportunities to promote life long learning and skill development. I have no doubt that with NSQF Level - 5 the trainers and trainees of ITIs, and all stakeholders will derive maximum benefits from these IMPs and that NIMI's effort will go a long way in improving the quality of Vocational training in the country.

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

Jai Hind

**RAJESH AGGARWAL**
Director General/ Addl. Secretary
Ministry of Skill Development & Entrepreneurship,
Government of India.

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 the Federal Republic of Germany. The prime objective of this institute is to develop and provide instructional materials for various trades as per the prescribed syllabi under the Craftsman and Apprenticeship Training Schemes.

The instructional materials are created keeping in mind, the main objective of Vocational Training under NCVT/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.

**R. P. DHINGRA**
**EXECUTIVE DIRECTOR**

**Chennai - 600 032**

# 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 organisations to bring out this Instructional Material **(Trade Practical)** for the trade of **Electronic Mechanic** under Electronics and Hardware sector for ITIs.

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NIMI records its appreciation for 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 NIMI staff who have contributed towards the development of this Instructional Material.

NIMI is also grateful to everyone who has directly or indirectly helped in developing this Instructional Material.

# INTRODUCTION

**TRADE PRACTICAL**

The trade practical manual is intented to be used in workshop . It consists of a series of practical exercies to be completed by the trainees during the Second Semester course of the Electronic Mechanic 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-5 prescribed syllabus are covered.

The manual is divided into ten modules. The distribution of time for the practical in the ten modules are given below.

| | | |
|---|---|---|
| Module 1 | **Transistor Amplifier** | 75 Hrs |
| Module 2 | **Oscillators** | 25 Hrs |
| Module 3 | **Wave shaping circuits** | 25 Hrs |
| Module 4 | **Power Electronic components** | 50 Hrs |
| Module 5 | **MOSFET & IGBT** | 25 Hrs |
| Module 6 | **Opto-Electronics** | 25 Hrs |
| Module 7 | **Basic Gates, Combinational circuits, Flip Flops** | 75 Hrs |
| Module 8 | **Electronic Circuit Simulator** | 50 Hrs |
| Module 9 | **Counter & Shift Registers** | 75 Hrs |
| Module 10 | **Op - Amp & Timer 555 Applications** | 100 Hrs |
| | **Project work** | 50 Hrs |
| | Total | 575 Hrs |

The skill training in the computer lab is planned through a series of practical exercises centred around some practical project. However, there are few instance 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 traninee. 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 First Semester couse of the Electronic Mechanic Trade. The contents are sequenced according to the practical exercise contained in the manual on Trade practical. Attempt has been made to relate the theoretical aspects with the skill covered in each exercise to the extent possible. This co-relation is maintained to help the trainees to develop the perceptional 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 indicating about the corresponding practical exercise are given in every sheet of this manual.

It will be preferable to teach/learn the trade theory connected to each exercise atleast 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 the purpose of self learning and should be considered as supplementary to class room instruction.

## CONTENTS

# LEARNING/ ASSESSABLE OUTCOME

On completion of this book you shall be able to

- **Construct, test and verify the input/output characteristics of various analog circuits.**
- **Plan and construct different power electronic circuits and analyze the circuit functioning.**
- **Select the appropriate optoelectronic components and verify the characteristics in different circuits.**
- **Simulate and analyze the analog and digital circuits using Electonic simulator software.**
- **Identify, place, solder, desolder and test different SMD discrete components and ICs package with due care and following safety norms using proper tools/setup.**
- **Constrct and test different circuits using ICs 741 Operational Amplifiers & ICs 555 Timer, Linear integrated circuits and Execute the result.**

**SYLLABUS FOR ELECTRONIC MECHANIC TRADE**

**SECOND SEMESTER** **Duraction: 06 Months**

| Week No. | Learning outcome Reference | Professional Skills (Trade Practical) With indicative hours | Professional Knowledge (Trade Theory) with respect to different |
|---|---|---|---|
| **27** | • Construct, test and verify the input/ output characteristics of various analog circuits. | **Transistor**<br>102. Identify different transistors with respect to different package type, B-E-C pins, power, switching transistor, heat sinks etc. (5 hrs)<br>103. Test the condition of a given transistor using ohm-meter. (5 hrs)<br>104. Measure and plot input and output characteristics of a CE amplifier. (7 hrs) 105. Construct and test a transistor based switching circuit to control a relay (use Relays of different coil voltages and Transistors of different ß) (8 hrs) | Construction, working of a PNP and NPN Transistors, purpose of E, B & C Terminals. Significance of a, ß and relationship of a Transistor. Need for Biasing of Transistor. VBE, VCB, VCE, IC, IB, Junction Temperature, junction capacitance, frequency of operation. Transistor applications as switch and amplifier. Transistor input and output characteristics. Transistor power ratings & packaging styles and use of different heat sinks. |
| **28-29** | • Construct, test and verify the input/ output characteristics of various analog circuits. | **Amplifier**<br>106. Construct and test fixed-bias, emitter-bias and voltage devider-bias transistor amplifier. (12 hrs)<br>107. Construct and Test a common emitter amplifier with and without bypass capacitors (5 hrs)<br>108. Construct and Test common base amplifier. (5 hrs)<br>109. Construct and Test common collector/emitter follower amplifier. (5 hrs)<br>110. Construct and Test Darlington amplifier. (5 hrs)<br>111. Construct and test a two stage RC Coupled amplifier. (5 hrs)<br>112. Construct and test a Class B complementary push pull amplifier. (8 hrs)<br>113. Construct and test class C Tuned amplifier. (5 hrs) | Different types of biasing, various configurations of transistor (C-B, C-E & C-C), their characteristics and applications. Transistor biasing circuits and stabilization Techniques. Classification of amplifiers according to frequency, mode of operation and methods of coupling. Voltage amplifiers - voltage gain, loading effect. Single stage CE amplifier and CC amplifier. Emitter follower circuit and its advantages. RC coupled amplifier, Distinguish between voltage and power amplifier, Push pull amplifier and class C tuned amplifier. Alpha, beta, voltage gain, Concept of dB dBm. Feedback and its types. |
| **30** | • Construct, test and verify the input/ output characteristics of various analog circuits. | **Oscillators**<br>114. Demonstrate Colpitts oscillator, Hartley oscillator circuits and compare the output frequency of the oscillator by CRO. (7 hrs)<br>115. Construct and test a RC phase shift oscillator circuits. (5 hrs)<br>116. Construct and test a crystal oscillator circuits. (5 hrs) | Introduction to positive feedback and requisites of an oscillator. Study of Colpitts, Hartley, Crystal and RC oscillators. Types of multi vibrators and study of circuit diagrams. |

| | | | |
|---|---|---|---|
| | | 117. Demonstrate Astable, monostable, bistable circuits using transistors. (8 hrs) | |
| **31** | • Construct, test and verify the input/ output characteristics of various analog circuits | **Wave shaping circuits**<br>118. Construct and test shunt clipper. (6 hrs)<br>119. Construct and test series and dual clipper circuit using diodes. (7 hrs)<br>120. Construct and test clamper circuit using diodes. (5 hrs)<br>121. Construct and test Zener diode as a peak clipper. (7 hrs) | Diode shunt clipper circuits, Clamping / limiting circuits and Zener diode as peak clipper,uses their applications. |
| **32-33** | • Plan and construct different power electronic circuits and analyse the circuit functioning. | **Power Electronic Components**<br>122. Identify different power electronic components, their specification and terminals. (6 hrs)<br>123. Construct and test a FET Amplifier. (6 hrs)<br>124. Construct a test circuit of SCR using UJT triggering. (7 hrs)<br>125. Identify different heat sinks used in SCRs. (3 hrs)<br>126. Construct a snubber circuit for protecting SCR use freewheeling diode to reduce back emf. (7 hrs)<br>127. Construct a jig circuit to test DIAC. (7 hrs)<br>128. Construct a simple dimmer circuit using TRIAC. (7 hrs)<br>129. Construct UJT based free running oscillator and change its frequency. (7 hrs) | Construction of FET & JFET, difference with BJT. Purpose of Gate, Drain and source terminals and voltage / current relations between them and Impedances between various terminals. Heat Sink- Uses & purpose. Suitability of FET amplifiers in measuring device applications. Working of different power electronic components such as SCR, TRIAC, DIAC and UJT. |
| **34** | • Plan and construct different power electronic circuits and analyse the circuit functioning | **MOSFET & IGBT**<br>130. Identify various Power MOSFET by its number and test by using multimeter. (5 hrs)<br>131. Identify different heat sinks used with various power MOSFET devices. (5 hrs)<br>132. Construct MOSFET test circuit with a small load. (5 hrs)<br>133. Identify IGBTs by their numbers and test by using multimeter. (5 hrs)<br>134. Construct IGBT test circuit with a small load. (5 hrs) | MOSFET, Power MOSFET and IGBT, their types, characteristics, switching speed, power ratings and protection.<br><br>Differentiate FET with MOSFET.<br><br>Differentiate Transistor with IGBT. |
| **35** | • Select the appropriate opto electronics components and verify the characteristics in different circuit. | **Opto Electronics**<br>135. Test LEDs with DC supply and measure voltage drop and current using multimeter. (5 hrs)<br>136. Construct a circuit to test photo voltaic cell. (5 hrs)<br>137. Construct a circuit to switch a lamp load using photo diode. (5 | Working and application of LED, IR LEDs, Photo diode, photo transistor, their characteristics and applications. |

| | | | |
|---|---|---|---|
| | | hrs)<br>138. Construct a circuit to switch a lamp load using photo transistor. (5 hrs)<br>139. Identify opto coupler input and output terminals and measure the quantum of isolation between input/output terminals and operate a relay by connecting a switch. (5 hrs) | Optical sensor, opto-couplers, circuits with opto isolators.<br><br>Characteristics of LASER diodes. |
| **36** | • Assemble, test and troubleshoot various digital circuits. | **Basic Gates**<br>140. Identify different Logic Gates (AND, OR, NAND, NOR, EXOR, EX-NOR, NOT ICs) by the number printed on them. (6 hrs)<br>141. Verify the truth tables of all Logic Gate ICs by connecting switches and LEDs. (8 hrs)<br>142. Construct and verify the truth table of all the gates using NAND and NOR gates. (6 hrs)<br>143. Use digital IC tester to test the various digital ICs (TTL and CMOS). (5 hrs) | Introduction to Digital Electronics. Difference between analog and digital signals. Logic families and their comparison, logic levels of TTL and CMOS. Number systems (Decimal, binary, octal, Hexadecimal). BCD code, ASCII code and code conversions. Various Logic Gates and their truth tables. |
| **37** | • Assemble, test and troubleshoot various digital circuits. | **Combinational Circuits**<br>144. Construct Half Adder circuit using ICs and verify the truth table. (3 hrs)<br>145. Construct Full adder with two Half adder circuit using ICs and verify the truth table. (5 hrs)<br>146. Construct the adder cum subtractor circuit and verify the result. (5 hrs)<br>147. Construct and Test a 2 to 4 Decoder. (3 hrs)<br>148. Construct and Test a 4 to 2 Encoder. (3 hrs) 149. Construct and Test a 4 to 1 Multiplexer. (3 hrs)<br>150. Construct and Test a 1 to 4 De Multiplexer. (3 hrs) | Combinational logic circuits such as Half Adder, Full adder, Parallel Binary adders, 2-bit and four bit full adders. Magnitude comparators. Half adder, full adder ICs and their applications for implementing arithmetic operations. Concept of encoder and decoder. Basic Binary Decoder and four bit binary decoders. Need for multiplexing of data. 1:4 line Multiplexer / Demultiplexer. |
| **38** | • Assemble, test and troubleshoot various digital circuits.. | **Flip Flops**<br>151. Identify different Flip-Flop (ICs) by the number printed on them. (5 hrs)<br>152. Construct and test four bit latch using 7475. (5 hrs)<br>153. Construct and test R-S flipflop using IC7400 with clock and without clock pulse. (5 hrs)<br>154. Verify the truth tables of FlipFlop ICs (RS, D, T, JK, MSJK) by connecting switches and LEDs. (10 hrs) | Introduction to Flip-Flop. S-R Latch, Gated S-R Latch, D- Latch. Flip-Flop: Basic RS Flip Flop, edge triggered D Flip Flop, JK Flip Flop, T Flip Flop. Master-Slave flip flops and Timing diagrams. Basic flip flop applications like data storage, data transfer and frequency division. |

| | | | |
|---|---|---|---|
| **39-40** | • Simulate and analyze the analog and digital circuits using Electronic simulator software. | **Electronic circuit simulator**<br>155. Prepare simple digital and electronic circuits using the software (10 hrs)<br>156. Simulate and test the prepared digital and analog circuits (16 hrs)<br>157. Convert the prepared circuit into a layout diagram. (10 hrs)<br>158. Prepare simple, power electronic and domestic electronic circuit using simulation software. (14 hrs) | Study the library components available in the circuit simulation software. Various resources of the software. |
| **41-43** | • Assemble, test and troubleshoot various digital circuits. | **Counter & shift Registers**<br>159. Construct and test a four bit asynchronous binary counter using 7493 (4 hrs)<br>160. Construct and test 7493 as a modulus-12 counter. (4 hrs)<br>161. Construct and test a four bit Synchronous binary counter using 74163. (5 hrs)<br>162. Construct and test synchronous Decade counter. (4 hrs)<br>163. Construct and test an up/down synchronous decade counter using 74190 and monitor the output on LEDs. (5 hrs)<br>164. Identify and test common anode and common cathode seven segment LED display using multi meter. (3 hrs)<br>165. Display the two digit count value on seven segment display using decoder/driver ICs. (4 hrs)<br>166. Construct a shift register using RS/ D/JK flip flop and verify the result. (5 hrs)<br>167. Construct and test four bit SIPO register. (5 hrs)<br>168. Construct and test four bit PIPO register. (5 hrs)<br>169. Construct and test bidirectional shift registers. (5 hrs) | Basics of Counters, types, two bit and three bit Asynchronous binary counters and decade counters with the timing diagrams. 3-bit Synchronous counters and synchronous decade counters. Types of seven segment display. BCD display and BCD to decimal decoder. BCD to 7 segment display circuits. Basics of Register, types and application of Registers. |
| **44-47** | • Construct and test different circuits using ICs 741operational amplifiers & ICs 555 linear integrated circuits and execute the result. | **Op – Amp & Timer 555 Applications**<br>170. Use analog IC tester to test the various analog ICs. (5 hrs)<br>171. Construct and test various Op-Amp circuits Inverting, Non-inverting and Summing Amplifiers. (15 hrs)<br>172. Construct and test Differentiator and Integrator (10 hrs)<br>173. Construct and test a zero crossing detector. (5 hrs)<br>174. Construct and test Instrumentation amplifier (10 hrs)<br>175. Construct and test a Binary weighted and R-2R Ladder type | Block diagram and Working of Op-Amp, importance, Ideal characteristics, advantages and applications. Schematic diagram of 741, symbol. Non-inverting voltage amplifier, inverting voltage amplifier, summing amplifier, Comparator, zero cross detector, differentiator, integrator and instrumentation amplifier, other popular Op-Amps. Block diagram of 555, functional |

| | | | |
|---|---|---|---|
| | | Digital-to-Analog Converters (15hrs.)<br>176. Construct and test Astable timer circuit using IC 555 (10 hrs)<br>177. Construct and test mono stable timer circuit using IC 555. (10 hrs)<br>178. Construct and test VCO (V to F Converter) using IC 555. (10 hrs)<br>179. Construct and test 555 timers as pulse width modulator (10 hrs) | description w.r.t. different configurations of 555 such as monostable, astable and VCO operations for various application. |
| **48-49** | **Project work / Industrial visit**<br>**Broad Areas:**<br>1. Delayed automatic power on circuit.<br>2. Neon flasher circuit using IC 741<br>3. UJT act as a relaxation oscillator<br>4. Up/down synchronous decade counter<br>5. Portable continuity cum capacitor tester | | |
| **50-51** | Revision | | |
| **52** | Examination | | |

# Identify different transistors with respect to different package type, B-E-C pins, power, switching transistor, heatsink etc

**Objectives :** At the end of this exercise you shall be able to
- **identify transistor by different package type, pin configuration**
- **identify power, switching transistor, heat sinks etc from the data manuals/books.**

## Requirements

**Tools/Equipments/Instruments**

- Trainees tool kit - 1 Set
- Transistor databook - as reqd
- Multimeter/DMM with probes - 1 No

**Materials/Components**

- Different types of transistor packages from T0-1, T0-5, T0-18, T0-39, T0-72, T0-92, T0-3, T0-66, T0-126, T0-202, T0-220, T0-3P, T0-247 - 15 Nos
- Different Heat sinks suitable for above transistors - 10 Nos

**Note:**

**1 The Instructor has to select and label the transistors used for this exercise.**

**2 A minimum of one number in each type of package has to be arranged.**

**3 Label the heat sinks also in the similar way**

## PROCEDURE

TASK 1 : **Identification of transistor by different package type, pin configuration, power rating, type of transistor & heat sink**

1 Pick one of the Labelled transistors from given assorted lot, identify the code number, and record them in Table 1.

2 Refer to the Chart 1 semiconductor data book, identify the type of package, all other details as required in Table 1 and record them.

3 Refer to the Chart 2, different types of heat sinks used for transistors, compare, verify the details of a transistor in the above Table 1 and select the heat sink suitable for the transistor in hand.

4 Record the heat sink type in Table 1 and repeat the above step for remaining labelled transistors.

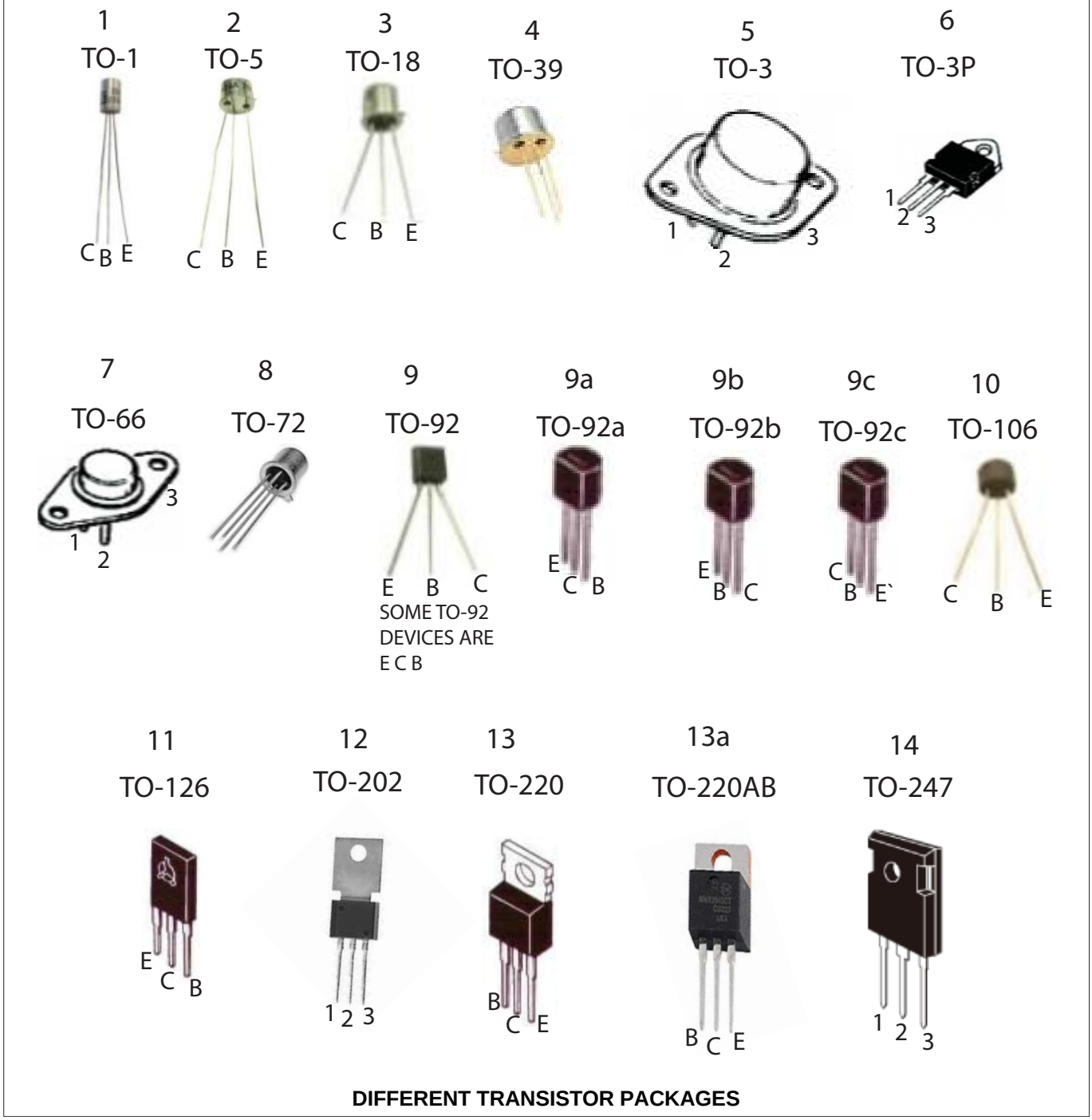
5 Some metallic transistor have notch on its surface. Identify the mark or notch available in transistor. (Terminal adjacent to the notch or mark will be emitter.)

Table 1

| Sl.No. | Label No | Transistor code number | Transistor package type | Package diagram with pin description | Current & Voltage | | Power rating | Suitable Heatsink type |
|---|---|---|---|---|---|---|---|---|
| | | | | | Current rating | Voltage rating | | |
| | | | | | | | | |

6 Get the work checked by the Instructor.

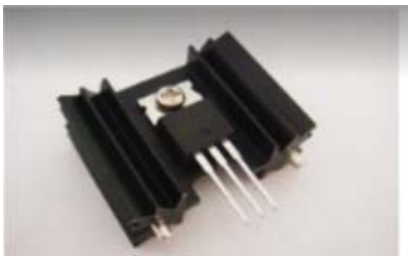
**CHART 1**

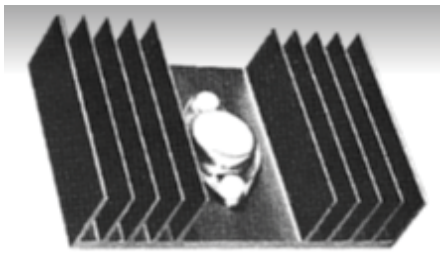


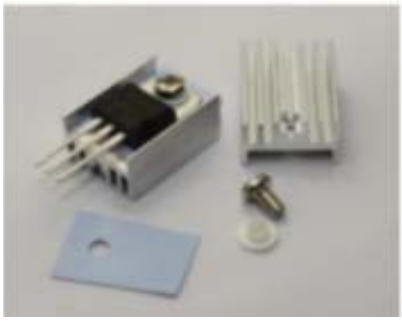

**DIFFERENT TRANSISTOR PACKAGES**

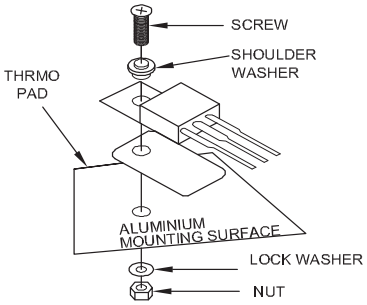
**CHART 2**

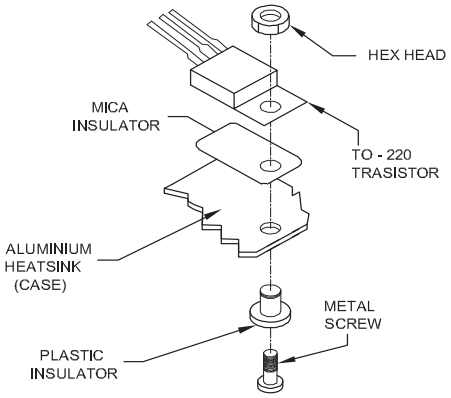
**Chart showing different types of heatsinks used for transistor packages**









# Test the condition of a given transistor using Ohm-meter

**Objectives:** At the end of this exercise you shall be able to
- **test the condition of transistor using ohm meter/multimeter.**

## Requirements

**Tools/Equipments/Instruments**

- Trainees tool kit - 1 Set
- Digital multimeter/Analog multimeter with crocodile clip probes - 1 Set

**Materials/Components**

- Transistor assorted types (T0-3, T0-5, T0-66, T0-18, T0-72, T0-92A, 92B, T0-202, T0-220, T0-247) - 10 Nos
- Transistor data book - as reqd

**Note :**

1 **The instructor has to arrange a minimum of one number in each type and label the transistors used for this exercise**

2 **Incase, the Analog type multimeter is not available, skip the Task 1 and proceed with Task 2 of this exercise using Digital multimeter.**

## PROCEDURE

TASK 1 : **Testing transistor using analog multimeter**

1 Pick one of the labelled transistor from given assorted lot and enter its number in the Table -1.

2 Verify the label number, and other details recorded in the Table 1 of Exercise No.2.1.102. Refer the databook, identify the transistor type, pin diagram and record details in Table 1.

**In some power transistor,the metal body itself is connected to the collector terminal. All transistors will not have shield pin.**

Fig 1

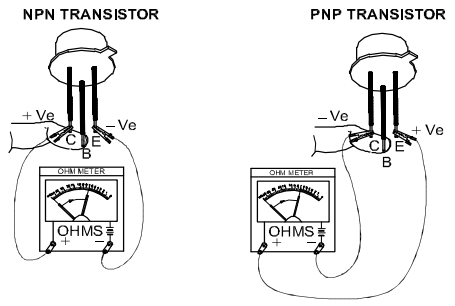



Table 1

| Sl.No. | Label No | Code no.of transistor | Package type | Forward/Reverse | Measured resistance between | | | Remarks |
|---|---|---|---|---|---|---|---|---|
| | | | | | B-E | B-C | E-C | |
| 1 | | | | Forward | | | | |
| 2 | | | | Reverse | | | | |
| 3 | | | | Forward | | | | |
| 4 | | | | Reverse | | | | |
| 5 | | | | Forward | | | | |
| 6 | | | | Reverse | | | | |
| 7 | | | | | | | | |
| 8 | | | | | | | | |
| 9 | | | | | | | | |
| 10 | | | | | | | | |

3 Connect crocodile clip probes to the analog multimeter & select ohms range for testing.

**In using analog multimeter, select resistance range RX100 Ohm, low range may damage low power transistors.**

4 Identify the transistor terminals as Base, Emitter and Collector.

**Testing the transistor using the analog type Ohm meter is shown in Fig 1 for guidance.**

5 Test resistance value between Base & Emitter terminals in forward and reverse direction by connecting probes as shown in Fig 1 and record readings in Table 1.

6 Repeat the above step between Base & collector terminals and record readings.

7 Repeat the step between Emitter & collector and record readings.

8 Repeat steps 4 to 7 for all the remaining labelled transistors.

9 Get the work checked by the Instructor.

– – – – – – –

Task 2: **Testing the condition of transistor using Digital multimeter (DMM)**

1 Pick one of the labelled transistor from the given lot, enter its number in Table 2.

2 Verify the details like transistor type, pin configuration etc recorded in the Table 1 of Ex.No.2.1.102/Refer to the data book, identify all the details required.

3 Connect the crocodile clip probe to the DMM and set the selector, switch to the Diode testing position/range.

4 Connect the positive test probe of the DMM to the Base (B) terminal and the negative probe to the Emitter (E) of the transistor as shown in Fig 2.

**For a good NPN transistor, the meter should show between 0.45V to 0.9V and for a PNP transistor, the meter should show "OL" (Over Limit) means infinity.**

5 Observe the reading displayed on the DMM, record the value in Table 2.

6 Keep the positive probe at Base and connect the negative probe to the collector (C) terminal, observe the reading on the DMM, record it in Table 2.

**For a good NPN transistor the meter should show between 0.45 to 0.9V and for a PNP type transistor, the meter should show "OL" (Over Limit) means infinity.**

7 Repeat setps 4,5 and 6 with reversed polarities of DMM and record those readings in Table 2.

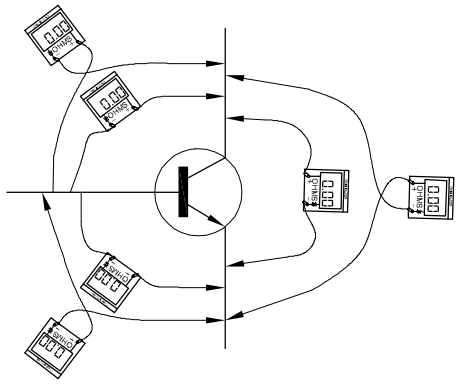
8 Connect the positive probe to the Emitter terminal and negative probe to the Collector (C) of transistor as shown in Fig 2; Record the observations in Table 2.

9 Repeat step 8 with reversed polarities of DMM.

10 Carry out steps 4 to 9 for all the remaining labelled transistors and record readings in Table 2.

11 Get the work checked by the Instructor.

Fig 2



TESTING TRANSISTOR USING DMM

EMN211103H2

**Note:**

**Compare the resistance values recorded in forward and reverse directions between B-E, B-C and E-C terminals.**

**Conclude the condition of tested transistor is defective/unserviceable if the resistance value is same on both directions for B-E or B-C junctions, shorted / open junctions show same resistance value in both directions otherwise, the transistor is good/serviceable.**

Table 2

| Sl.No. | Lable No NPN/PNP | Transistor Code No and type | Meter reading between the terminals | | | | Remarks |
|---|---|---|---|---|---|---|---|
| | | | Direction | Base to emitter | Base to collector | Emitter to collector | |
| 1 | | | Forward | | | | |
| 2 | | | Reverse | | | | |
| 3 | | | Forward | | | | |
| 4 | | | Reverse | | | | |
| 5 | | | Forward | | | | |
| 6 | | | Reverse | | | | |
| 7 | | | Forward | | | | |
| 8 | | | Reverse | | | | |
| 9 | | | Forward | | | | |
| 10 | | | Reverse | | | | |

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# Measure and Plot input and output characteristics of a transistor CE amplifier

**Objectives:** At the end of this exercise you shall be able to
- **measure and plot the input characteristics of a transistor in CE configuraton**
- **measure and plot the output characteristics of a transistor in CE configuration.**

## Requirements

**Tools/Equipments/Instruments**

- Trainees tool kit
- DC milliammeter, 0-100mA - 1 Set
- DC microammeter, 0-500µA - 1 No
- DC millivoltmeter, 0-1000mV - 1 No
- Regulated DC dual power supply 0-30V/2A - 1 No
- Semiconductor data manual - 1 No

**Materials/Components**

- Tag board - 1 No
- Transistors, SL 100, - 1 No
- Resistors
  - 120Ω, ¼ W - 1 No
  - 10kΩ, ¼ W - 1 No
  - 3.3kΩ, ¼ W - 1 No
  - 1 kΩ, POT, linear - 1 No
- Hook up wires and patch cords - as reqd

## PROCEDURE

TASK 1 : **Measurement and plotting of input characteristics ($V_{BE}$ versus $I_B$ ) of given transistor as CE amplifier**

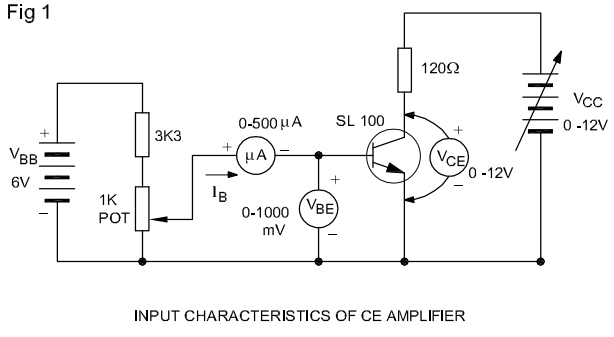
1 Collect the transistor, identify the number, refer the data book and record the details and condition of the transistor in Table 1.

**Table - 1**

| Label No | Transistor No and type | β or $h_{FE}$ (typical) | Condition from quick tests |
|---|---|---|---|
| | | | |

2 Construct the circuit as shown in Fig 1.

Fig 1




INPUT CHARACTERISTICS OF CE AMPLIFIER

3 Switch ON 6V DC supply $V_{BB}$ and adjust 1 K pot such that $V_{BE}$ = 0V.

4 Adjust the DC supply for $V_{CC}$ to 0 volt such that $V_{CE}$ = 0 volt.

5 Increase $V_{BE}$ from zero volt, in steps of 100 mV upto 700 mV; At each setting record value of base current $I_B$ in Table 2.

**Table - 2**

| $V_{CE}$ set at 0 volts, constant | | | | | | | |
|---|---|---|---|---|---|---|---|
| $V_{BE}$ in mV | 0 | 200 mV | 300 mV | 400 mV | 500 mV | 600 mV | 700 mV |
| $I_B$ in µA | | | | | | | |

6 Set $V_{BE}$ = 0 volts by adjusting the pot; Set $V_{CE}$ = 6 volts, repeat step 5 and record readings in Table 3.

**Table - 3**

| $V_{CE}$ set at 6 volts constant | | | | | | | |
|---|---|---|---|---|---|---|---|
| $V_{BE}$ in mV | 0 | 200 mV | 300 mV | 400 mV | 500 mV | 600 mV | 700 mV |
| $I_B$ µA | | | | | | | |

7 Set $V_{BE}$ = 0 volts; Set $V_{CE}$ = 12 volts, repeat step 6 and record the readings in Table 4.

**Table - 4**

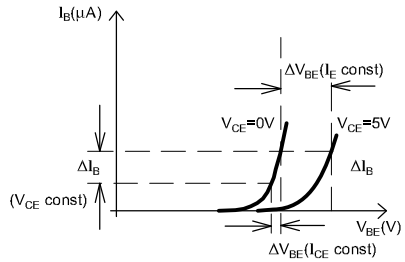
| $V_{CE}$ set at 12 volts constant | | | | | | | |
|---|---|---|---|---|---|---|---|
| $V_{BE}$ | 0 | 200 mV | 300 mV | 400 mV | 500 mV | 600 mV | 700 mV |
| $I_B$ µA | | | | | | | |

8 Get the recorded readings checked by the instructor.

9 Draw the graph of input characteristics of given transistor in CE configuration by taking the readings recorded in Tables 2,3 and 4 shown in Fig 2. (Mark $V_{BE}$ in X-axis and $I_B$ in Y-axis).

10 Get the plotted graph checked by the Instructor.

Fig 2




INPUT CHARACTERISTICS OF $V_{BE}$ VS $I_B$

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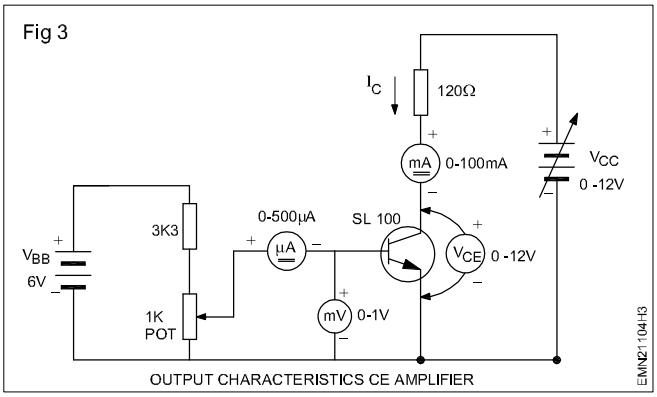
TASK 2: **Measurement and plotting of output characteristics of given transistor as CE amplifier.**

1 Modify the circuit connections of Task 1 to make variations in $V_{CE}$ and observe/measure $I_C$ at different values of $I_B$ as shown in Fig 3.

Fig 3




OUTPUT CHARACTERISTICS CE AMPLIFIER

2 Set $V_{CC}$ to 0V such that $V_{CE}$ = 0V and adjust the supply $V_{BB}$ such that $I_B$ = 100 μA.

3 Vary $V_{CC}$ such that $V_{CE}$ is increased in steps of 0.2V upto 1V and continue as per the Table 5; observe the output current $I_C$ at each step of $V_{CE}$ and record the readings in Table 5.

4 Increase $I_B$ to values 200 μA, 300 μA, 500 μA and at each setting repeat step 3; Record the readings in Table 6, 7 and 8 respectively.

5 Get your recorded readings checked by the Instructor.

6 Draw the graph of output characteristics of given transistor in CE configuration by taking, plotting the readings recorded in Tables 5,6,7 and 8 as shown in Fig 4.

7 Get the plotted graph and get it checked by the instructor.

8 Calculate the βdc using the formula with recorded readings, find the dc current gain β of the transistor at $V_{CE}$ of 6V. Record the calculation and result inTable 9.

9 Compare the calculated value of β in step 8 and value noted from the data book at step 1.

**Output characteristics of transistor**

**Table - 5**

| **$I_B$ set at 100 μA microAmps constant** | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **$V_{CE}$** | **0.2V** | **0.4V** | **0.6V** | **0.8V** | **1V** | **2V** | **3V** | **4V** | **5V** | **6V** | **7V** | **8V** |
| **$I_C$** | | | | | | | | | | | | |

**Table - 6**

| **$I_B$ set at 200 μA constant** | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **$V_{CE}$** | **0.2V** | **0.4V** | **0.6V** | **0.8V** | **1V** | **2V** | **3V** | **4V** | **5V** | **6V** | **7V** | **8V** |
| **$I_C$** | | | | | | | | | | | | |

**Table - 7**

| $I_B$ set at 300 μA constant | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $V_{CE}$ | 0.2V | 0.4V | 0.6V | 0.8V | 1V | 2V | 3V | 4V | 5V | 6V | 7V | 8V |
| $I_C$ | | | | | | | | | | | | |

**Table - 8**

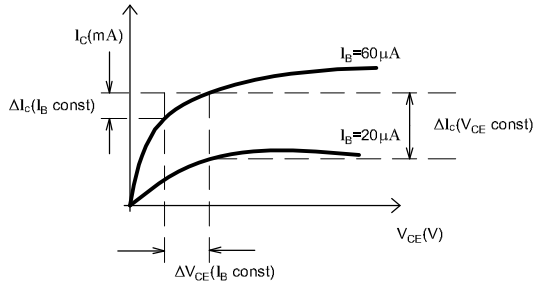
| $I_B$ set at 500 μA constant | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $V_{CE}$ | 0.2V | 0.4V | 0.6V | 0.8V | 1V | 2V | 3V | 4V | 5V | 6V | 7V | 8V |
| $I_C$ | | | | | | | | | | | | |

**Table - 9**

Current gain, $\beta = \frac{I_C}{I_B}$

| $V_{CE}$ | $I_B$ | $I_c$ | $\beta_{dc}$ | $I_B$ | $I_C$ | $\beta_{dc}$ | $I_B$ | $I_C$ | $\beta_{dc}$ |
|---|---|---|---|---|---|---|---|---|---|
| 6V | 100μA | | | 300μA | | | 500μA | | |

Fig 4




OUTPUT CHARACTERISTIC

EMN21104H4

10 Get the work checked by the Instructor.

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# Construct and test a transistor based switching circuit to control a relay (use relays of different coil voltages and transistors of different β)

**Objectives :** At the end of this exercise you shall be able to
- **construct and test transistor based switching circuit to control a relay**
- **construct and test transistor based relay control circuit using different Beta.**

## Requirements

**Tools/Equipments/Instruments**

- Digital multimeter with probes - 1 Set
- Trainees tool kit - 1 Set
- Regulated DC Power supply 0-30V/2A - 1 No
- Soldering Iron 25W/230V - 1 No

**Materials/Components**

- Transistor -BC 147, SL100 - 1 No each
- Semiconductor data manual - as reqd
- General purpose PCB - 1 No
- Resistor
- 10 kΩ , ¼ W/CR25 - 1 No
- Solder wire - 1 No
- Solder flux - as reqd
- SPDT switch - 1 No
- Connecting wires - as reqd
- Diode -1N4001 - 1 No
- 12V/30mA/10A/1CO - 1 No each
- Relay 5V/50 mA/10A 1CO - 1 No each
- Bulb (100W/230V A/C) with holder - 1 No
- Twisted pair flexible wire - 2 m

## PROCEDURE

TASK 1 : **Construction and testing of transistor based switching circuit to control a relay**

1 Collect all the components required, test them and plan the layout of components on the general purpose PCB.

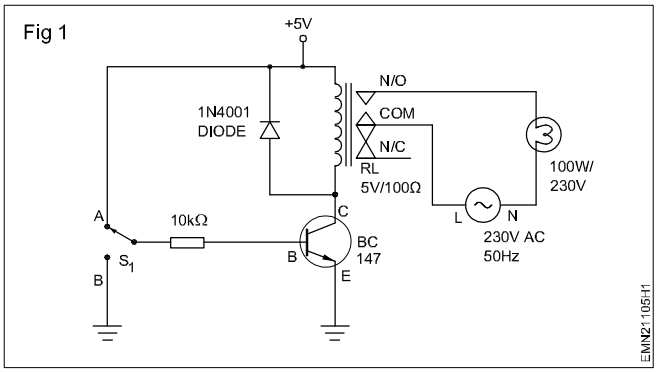
2 Identify the transistor number their leads and record the $h_{FE}$ of given transistor and other parameters with reference to the data sheet in Table 1.

Table 1

| Code No.of transistor | Type | $I_C$ | $V_{CEO}$ | $V_{CBO}$ | $V_{EBO}$ | $h_{FE}$ |
|---|---|---|---|---|---|---|
| | | | | | | |

3 Assemble the circuit as shown in Fig 1.

Fig 1




4 Get the circuit checked by the Instructor.

5 Keep the switch $S_1$ in position B.

6 Switch ON the 5V, DC supply and AC mains to the circuit.

**Take care of 230V AC manins supply link.**

7 Measure voltage at Base and collector terminals with respect to Emitter terminal; Record the readings in Table 2.

8 Change the switch to point A, observe the condition of relay and record the observations in Table 2.

Table 2

| Sl. No. | Switch position | Voltage a | | Relay condition | Status of bulb |
|---|---|---|---|---|---|
| | | Base ($V_{BE}$) | Collector ($V_{CE}$) | | |
| 1 | A | | | | |
| 2 | B | | | | |

9 Switch OFF the DC and AC manis supply.

10 Get the work checked by the Instructor.

TASK 2 : **Construction and testing of switching circuit to control a relay of higher coil voltage with transistor of different $h_{FE.}$**

1 Modify the circuit of Task 1 with 12 V relay and transistor SL 100 for switching circuit.

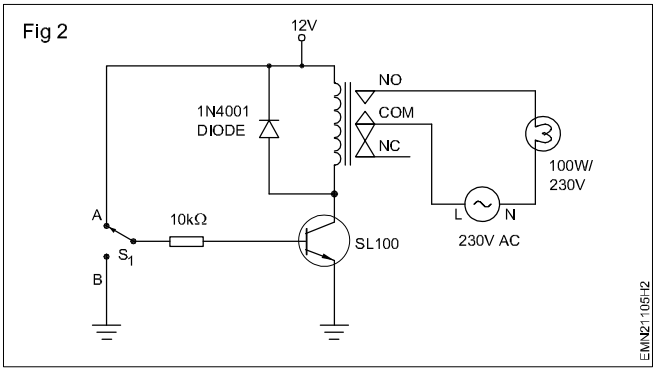
2 Identify the transistor leads, find Beta ($h_{FE.}$) and other parameters in the data sheet, record them in Table 3.

Table 3

| Code No.of transistor | Type | $I_C$ | $V_{CEO}$ | $V_{CBO}$ | $V_{EBO}$ | $h_{FE}$ |
|---|---|---|---|---|---|---|
| | | | | | | |

3 Assemble the circuit as shown in Fig 2 and get it checked by the Instructor.

Fig 2




4 Keep the switch $S_1$ in position 'B', switch ON the 12 VDC supply and AC mains supply to the circuit.

**Safety: Take care of 230 VAC mains supply lines**

5 Measure voltage at Base, collector terminals with respect to Emitter terminals and record the readings in Task 4.

6 Change the switch $S_1$ to point 'A', measure voltages status of relay, lamp and record the observations in Task 4.

Table 4

| Sl. No. | Switch position | Voltage a | | Relay condition | Status of bulb |
|---|---|---|---|---|---|
| | | Base ($V_{BE}$) | Collector ($V_{CE}$) | | |
| 1 | | A | | | |
| 2 | | B | | | |

7 Switch OFF the DC and AC supply to the circuit.

8 Get the work checked by the Instructor.

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# Construct and test fixed bias, emitter bias, and voltage divider bias transistor amplifier

**Objectives :** At the end of this exercise you shall be able to
- **construct and test fixed bias arrangement to transistor amplifier circuit**
- **construct and test emitter bias arrangement to transistor amplifier circuit**
- **construct and test voltage divider bias arrangement to transistor amplifier circuit.**

## Requirements

**Tools/Equipments/Instruments**

- Trainees tool kit - 1 Set
- Digital multimeter with probes - 1 No
- CRO, 20 MHz, Dual Trace - 1 No
- Regulated DC Power Supply, 0- 30V/2A - 1 No
- AF signal generator - 1 No
- DC micro ammeter 0-500 μA - 1 No
- DC miliammeter 0-30 mA - 1 No

**Materials/Components**

- Breadboard - 1 No
- Transistor BC 107, SL100 - 1 No each
- Capacitor
  - 1 μF/25V - 1 No
  - 10kpf - 2 Nos
  - 25μF/25V - 2 Nos
- Resistor/¼ W/CR25
  - 220kΩ - 1 No
  - 5.1kΩ - 1 No
  - 1.5kΩ - 2 Nos
  - 5.6kΩ - 1 No
  - 12kΩ - 1 No
  - 120Ω -1 No
  - 470Ω - 1 No
  - 1kΩ - 3 Nos
- Hook up wires - as reqd

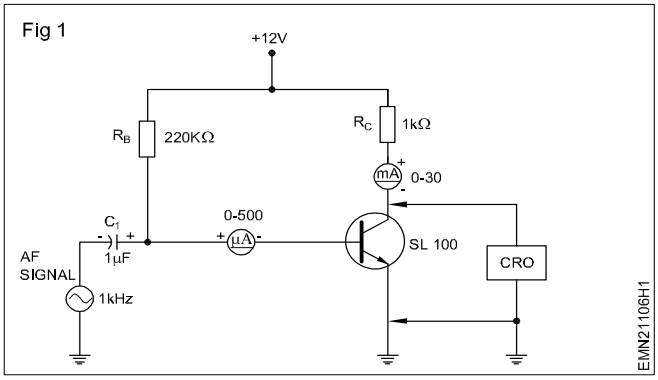
## PROCEDURE

TASK 1 : **Construction and testing of fixed bias arrangement for transistor amplifier circuit using BJT**

1 Collect all the components required and check them for good working condition using multimeter.

2 Assemble the circuit as shown in Fig 1.

Fig 1




3 Calculate base current '$I_B$' using the formula.

$$I_B = \frac{V_{CC} - V_{BE}}{R_B}$$

4 Now switch - ON the DC supply to the circuit and record readings in Table 1 without signal.

5 Prepare CRO for measurement and apply AF signal kHz/20mV sine wave from AF signal generator as input.

6 Observe and record the values of $I_B$, $I_C$ and $V_{CE}$ for the fixed bias amplifier circuit in Table-1.

7 Compare the calculated values with the observed values.

8 Get the values checked by the Instructor.

**Note:**

**1 We assume that the Amplifier operation is in the active region, and hence $V_{BE}$= 0.7 V.**

**2 β is the amplification factor of the transistor by which the base current gets amplified.**

**3 β dc refers to current gain, when DC bias voltage is applied.**

**4 Output collector current '$I_C$' = β dc x $I_B$.**

**5 When transistor is in active region, $I_C$ gradually increases towards higher values. At the same time, $V_{CE}$ decreases from peak towards lower values.**

**6 When saturation is attained by amplifier, $I_C$ goes to peak but $V_{CE}$ drops to less than 0.7V.**

**7 For calculating $I_C$ and $V_{CE}$ , following formulae should be used.**

**$V_{CE} = V_{CC} - I_C.R_C$ Say β = 100 &** $I_C = \frac{V_{CC} - V_{CE}}{R_C}$

**Table 1**

| Input condition | Base Current $I_B$ | Collector current $I_C$ | $V_{CE}$ | Voltage across load $V_{RL}$ | Current gain $A_i = I_C / I_B$ | $A_V = \frac{V_C}{V_{in}}$ |
|---|---|---|---|---|---|---|
| Without signal | | | | | | |
| With input Signal | | | | | | |

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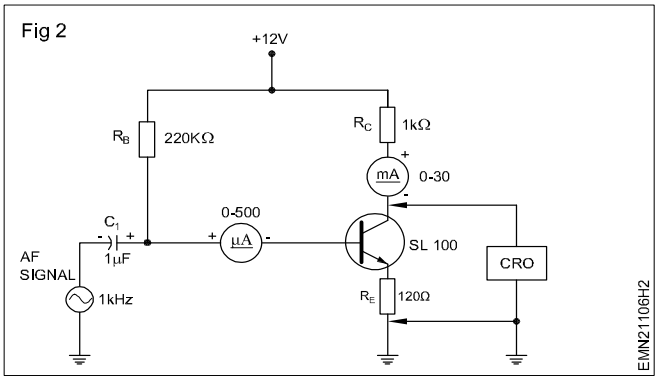
TASK 2 : **Construction and testing of emitter feedback bias amplifier circuit using BJT**

1 Modify the circuit as shown in Fig 2.

Fig 2




2 Calculate the values of $I_B$, $I_C$ $\beta_{dc}$ and $V_{CE}$ by using the formulae given in the note and record the values in Table 2.

3 Switch ON the 12V DC supply and AF signal generator input to the circuit assembled and measure base current $I_B$, collector current $I_C$,$V_{BE}$ (forwad bias of transistor) and the voltage drops across base resistor $R_B$ the emitter resistor $R_E$, collector resistor $R_C$ and $V_{CE}$ record the observed values in Table 3.

**Table 2**

| Calculated Observed values | Collector Current $I_C$ | Base current $I_B$ | $V_{CE}$ | Current gain Ai ($\beta_{dc}$) | Volatage gain $A_V$ |
|---|---|---|---|---|---|
| Calculated values | | | | | |
| Observed values | | | | | |

4 Prepeare CRO for measurements, connect and observe the peak-to-peak AC signal input from AF signal generators at CH1 and amplified AC signal output of the emitter feedback bias amplifier circuit at CH-2 and record the readings.

5 Increase the input A/C signal voltage applied to emitter feedback amplifier gradually and repeat the observations of the parameters given in step 3.

6 Note that the collector current '$I_C$' remains stable to maintain constant 'Q' - operating point of the amplifier.

7 Get the values checked by the Instructor.

8 Calculate and record the $I_C$ (sat) of the emitter-bias circuit

9 Get the values checked by the Instructor

**Note:**

1 **Emitter bias is also refered to as emitter feedback back bias (i.e) a portion of the output is given back to the input as feedback.**

2 **In this circuit, the voltage across resistor '$R_E$' is used to offset changes is $\beta_{dc}$.**

3 **This type of biasing compensates for the variation in $\beta_{dc}$ and keeps the 'Q' point fairly stable.**

4 **If $\beta_{dc}$ increases, the collector current increases, which in turn increases the voltage at the emitter.**

5 **This increased emitter voltage (plus the VBE drop of transistor) decreases the voltage across the base-resistor.**

**6 There fore base current reduces, and hence collector current reduces. This prevents $I_C$ from action varying continuosly.**

$$I_B = \frac{V_{CC} - (V_{BE} + V_E)}{R_B}$$

**7 It partially offsets the original increase in $I_C$ due to increased $\beta_{dc}$. Due to feedback only the output '$I_C$' could change the input $I_B$ this maintain stable Q print.**

**8 In emitter-bias, the current '$I_C$' will be**

**$I_C$ - $\beta_{IB}$ (i.e) $I_C = \beta$**

$$\frac{V_{CC} - V_{BE}}{R_B + (\beta + 1)R_E} \text{ \& } I_B = \frac{V_{CC} - V_{BE} - I_E R_E}{R_B}$$

**Assuming $I_E$ $I_C$ ; $V_{CE}$ - ($R_C$ + $R_E$) $I_C$**

**Table 3**

**AF Signal Generator - AC input = Sinewave 1kHz/20mV**

| Value/ signal condition | Base Current $I_B$ | Collector current $I_C$ | Current gain $\beta = \frac{I_C}{I_B}$ | $V_{BE}$ | $V_{CE}$ | DRB | Drop across $R_E$ | Drop across $R_C$ |
|---|---|---|---|---|---|---|---|---|
| Calculated Value | | | | | | | | |
| Measured Values | | | | | | | | |
| Without Signal | | | | | | | | |
| With signal | | | | | | | | |

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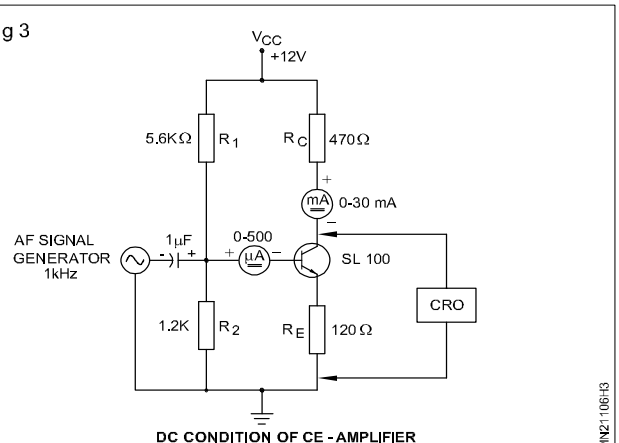
TASK 3 : **Construction and testing of voltage divider biased transistor CE amplifier**

1 Check all the components and assemble the circuit as shown in Fig 3.

2 Get the assembled circuit checked by the Instructor.

3 Measure and record $I_B$ and $I_C$ in Table 4, calculate current gain $\beta_{dc}$and record it.

Fig 3




DC CONDITION OF CE - AMPLIFIER

**Table 4**

| Collector current $I_C$ | Base current $I_B$ | Current gain $A_i$ $\beta_{dc}$ |
|---|---|---|
| | | |

4 Apply AC input signal of 1 kHz, 20 mV from AF signal generator to the voltage divder biased CE amplifier.

5 Prepare the CRO for measurements connect CRO to observe/measure AC signal input to amplifier from AF signal generator to CH-1 and amplified AC signal output of voltage divider bias to CH-2.

6 Measure and record the observed values as required in Table 5. Calculate & record Ai and Av of the amplifier observe and record the Input/Output waveforms available on the CRO.

**Note:**

- **In this circuit note that the base of the transistor is biased by voltage divider network made up of $R_1$ & $R_2$.**
- **Q point of this circuit lies half way along the transistor's load line.**
- **$V_{CE} = V_{CC} - I_C (R_C+R_E)$ and $I_C = \beta x I_B$**
- **RB << $(\beta+1) R_E$ and $R_B = R_1 // R_2$.**

**Table 5**

| Signal Condition | Base current $I_B$ | Collector current $I_C$ | $\beta_{dc}$ | Voltage drop Across | | | | $V_{BE}$ | $V_{CE}$ | Voltage gain $A V = \frac{V_{Load}}{V_{in}}$ |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | $R_1$ | $R_2$ | $R_C$ | $R_E$ | | | |
| **Without signal** | | | | | | | | | | |
| **With signal** | | | | | | | | | | |

7 Get the work checked by the Instructor.

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# Construct and test a CE amplifier with and without emitter bypass capacitors

**Objectives:** At the end of this exercise you shall be able to
- **construction and find the effect of emitter bypass capacitor on amplifier gain and input impedance**
- **plot the frequency response of CE amplifier with by pass capacitor.**

## Requirements

**Tools/Equipments/Instruments**

| | |
|---|---|
| • Trainees tool kit | - 1 Set |
| • CRO, 20 MHz Dual trace | - 1 No |
| • AF Signal generator | - 1 No |
| • Regulated DC power supply, 30V/2A | - 1 No |
| • Digital multimeter with probes | - 1 No |

**Materials/Components**

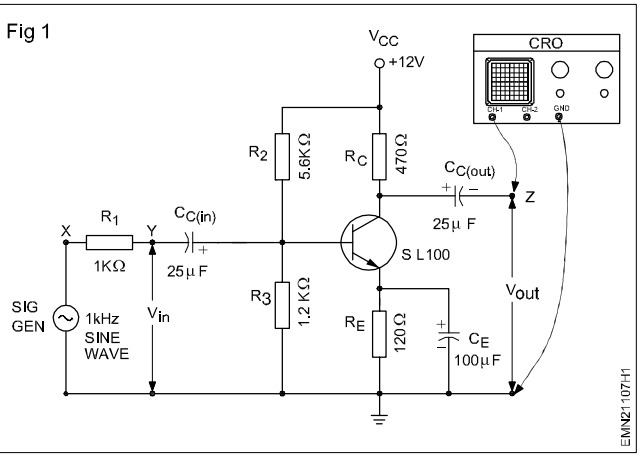
| | |
|---|---|
| • Hook-up wires | - as reqd |
| • Breadboard | - as reqd |
| • Resistor/¼W/CR25 | |
| 1kΩ,1.2 kΩ, 5.6 kΩ | |
| 120Ω, 470Ω | - 1 No each |
| • Capacitors | |
| 25 μF/25V | - 2 Nos |
| 4.7 μF/25V | - 1 No |
| 100 μF/25V | - 1 No |
| 470 μF/25V | - 1 No |

## PROCEDURE

TASK 1 : **Construction and testing of the effect of bypass capacitor in CE amplifier**

1 Collect all the components, test them assemble the circuit as shown in Fig 1 on breadboard. Capacitor $C_E$ is the emitter by pass capacitor.

Fig 1




2 Get the circuit connections checked by the Instructor.

3 Preapare the CRO for measurements and switch 'ON' 12V DC supply to the circuit, adjust the output of the signal generator at 1kHz such that $V_{out}$ is large enough and undistorted.

4 Record the peak to peak values of input $V_{in}$ and output $V_{out}$ in Table 1; Calculate and record the voltage gain $A_v$ of the amplifer.

5 Find the input impedance $Z_{in}$ and output impedance $Z_{out}$ of the amplifier using the same procedure as followed for Task 2 of Ex. 2.1.106; Record values in Table 1.

6 Measure and record the AC and DC voltages at various points of the amplifier in Fig 2 and Fig 3.

7 Switch off DC supply to the circuit. Disconnect 100 μF capacitor connected across the 120Ω emitter resistor.

**Now the input $V_{in}$ may show higher value due to increased $Z_{in}$ without the bypass capacitor. Do not alter the output level / frequency of the signal generator.**

8 Switch 'ON' DC supply to the circuit, repeat steps 4 and record readings in Table 1.

9 Measure and record the AC and DC levels at various points of the amplifier without the bypass capacitor in Fig 3.

10 Switch-OFF DC supply to the circuit and from the recorded readings, complete the sentences given in record sheet.

11 Get the work checked by the Instructor.

**Table - 1**

| Condition | $V_{in(peak-to-peak)}$ | $V_{out(peak-to-peak)}$ | $A_v$ | $Z_{in}$ | $Z_{out}$ |
|---|---|---|---|---|---|
| **With bypass capacitor $C_E$ connected across $R_E$** | | | | | |
| **Without bypass capacitor $C_E$** | | | | | |

Fig 2

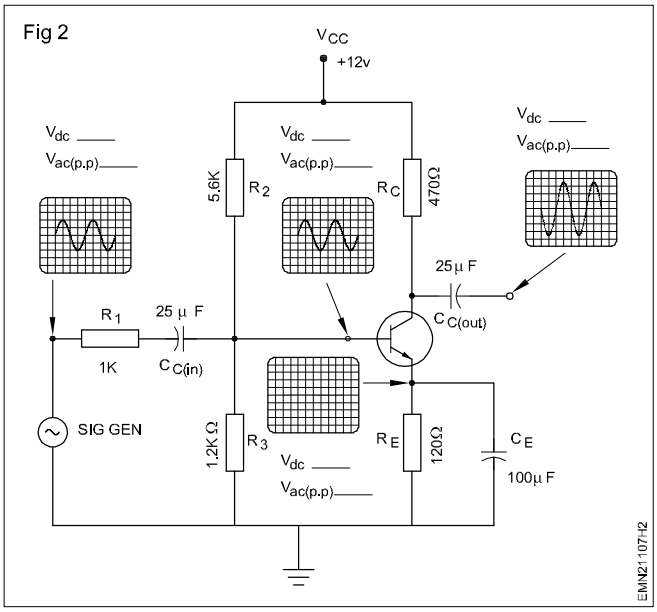
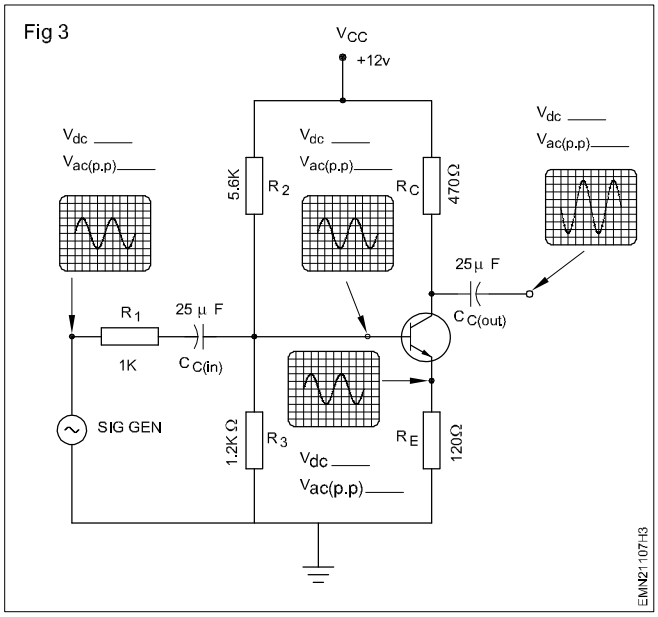



Fig 3




**12 Complete the sentences given below with the readings recorded in Table 1.**

When the emitter bypass capacitor was removed

a)the voltage gain of the amplifier decreased by _____%.

b)the input impedance of the amplifier _____ by _____%.

– – – – – – –

TASK 2 : **Plotting the frequency response of CE amplifier**

1 Modify the circuit to confirm to the schematic diagram as given in Fig 4.

2 Set the output of the signal generator to sine wave, 1 KHz. Adjust the input voltage to the transistor $V_{in}$ = 200mV.

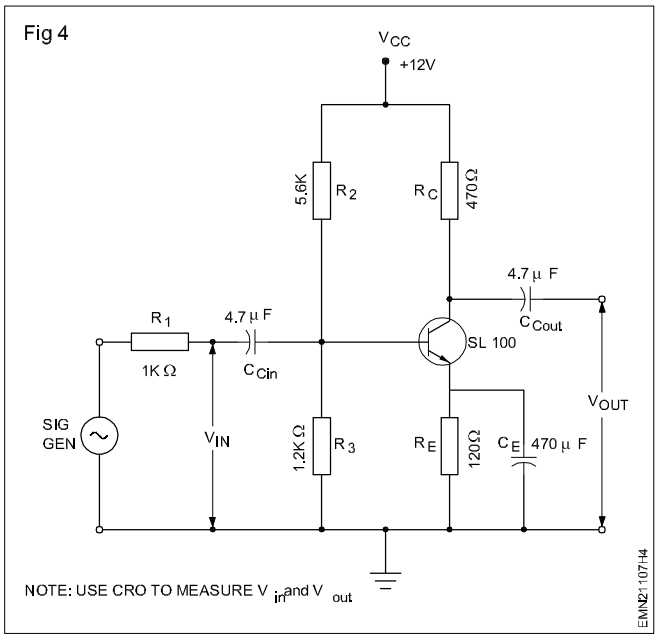
3 Record the set input level $V_{in}$ and corresponding value of output $V_{out}$ of the amplifier in the appropriate row of the Table 2.

4 Vary the output frequency of the signal generator above and below the set frequency of 1 kHz in steps as given in Table 2. At each step record the output of amplifier, $V_{out}$.

5 Calculate and record the voltage gain $A_V$ of the amplifier at different frequencies.

6 Change the value of $C_{C(in)}$ to 4.7µF and repeat steps 2 to 5.

Fig 4



7 Plot the graph of frequency ($f_{in}$) versus voltage gain $A_V$ for the readings taken with the capacitor values of 0.047 and 4.7 µF in Table 2. Find and mark the low frequency cut off/half power point on the graph.

**The cut off/half power point is 0.707 $A_V$ at the mid-band gain.**

8 Switch OFF DC supply to the circuit; change the value of the input coupling capacitor $C_{C(in)}$ to 100 µF.

**$C_{C(in)}$ is made 100µF to eliminate the effect of the coupling capacitor while finding the effect of $C_E$ on the frequency response.**

9 Change value of the bypass capacitor $C_E$ to 0.47µF and repeat steps 2 to 5, record readings in Table 3.

10 Change the value of the bypass capacitor $C_E$ back to 470µF and repeat steps 2 to 5.

11 Find the dominant lower cut off frequency of the amplifier with $C_{C(in)}$ = 4.7µF and $C_E$ = 470µF.

**The effect of $C_{C(out)}$ on the amplifier frequency response is not given in the procedure as the effect of $C_{C(out)}$ is almost same as that of $C_{C(in)}$.**

**Table - 2**

**Frequency response for different $C_{cin}$**

| Set value of $V_{in}$ = _____ at $f_{in}$ = 1 kHz $C_E$ = 470 µF $C_{Cout}$ = 4.7 µF | | | | |
|---|---|---|---|---|
| frequency $f_{in}$ $H_Z$ | $C_{Cin}$ = 0.047 µF | | $C_{Cin}$ = 4.7 µF | |
| | $V_{out}$ | $A_V$ | $V_{out}$ | $A_V$ |
| 10 | | | | |
| 20 | | | | |
| 30 | | | | |
| 100 | | | | |
| 200 | | | | |
| 400 | | | | |
| 800 | | | | |
| 1000 | | | | |
| 1200 | | | | |
| 1400 | | | | |
| 1600 | | | | |
| 2000 | | | | |
| 3000 | | | | |

**Table - 3**

**Frequency response for different $C_E$**

| Set value of $V_{in}$ = _____ at $f_{in}$ = 1 kHz $C_{Cin}$ = 100 µF $C_{Cout}$ = 4.7 µF | | | | |
|---|---|---|---|---|
| frequency $f_{in}$ $H_Z$ | $C_E$ = 0.47 µF | | $C_E$ = 470 µF | |
| | $V_{out}$ | $A_V$ | $V_{out}$ | $A_V$ |
| 10 | | | | |
| 20 | | | | |
| 30 | | | | |
| 100 | | | | |
| 200 | | | | |
| 400 | | | | |
| 800 | | | | |
| 1000 | | | | |
| 1200 | | | | |
| 1400 | | | | |
| 1600 | | | | |
| 2000 | | | | |
| 3000 | | | | |

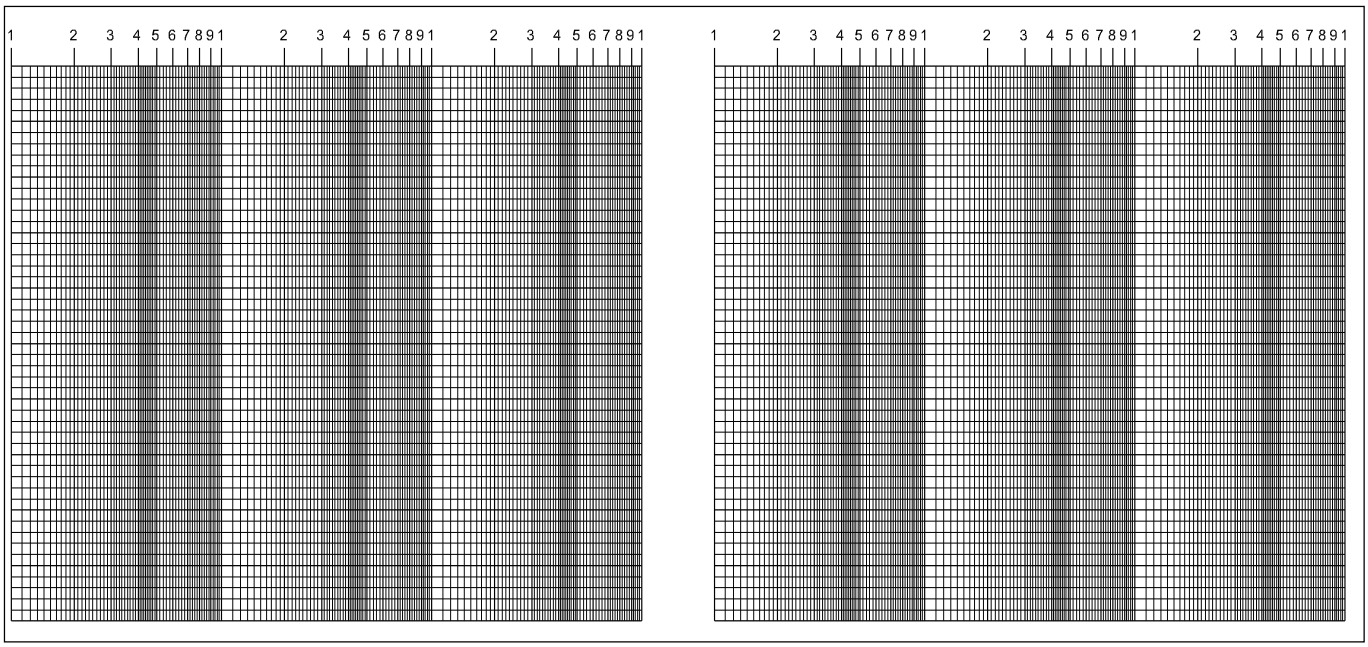
12 Get the work checked by the Instructor.

**Graph 1**

**Frequency response with $C_{cin}$ = 0.047capacitor**

**Graph 2**

**Frequency response with $C_{cin}$ = 4.7µ F**

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# Construct and test a Common Base amplifier

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

- **construct a common base amplifier and measure,**
  - **– current gain, of the amplifier**
  - **– voltage gain of the amplifier**
  - **– input-impedance of the amplifier**
  - **– output-impedance of the amplifier**
  - **– power gain of the amplifier**
- **compare the phase relationship between Input and Output of common base amplifier.**

## Requirements

**Tools/Equipments/Components**

| | |
|---|---|
| • Trainees tool kit | - 1 Set |
| • DC milliammeter, 0-10mA | - 1 No |
| • Regulated DC power supply 0-30V/2A | - 1 No |
| • CRO, 20 MHz Dual trace | - 1 No |
| • AF signal generator | - 1 No |
| • Multimeter /DMM with probes | - 1 No |

**Materials/Components**

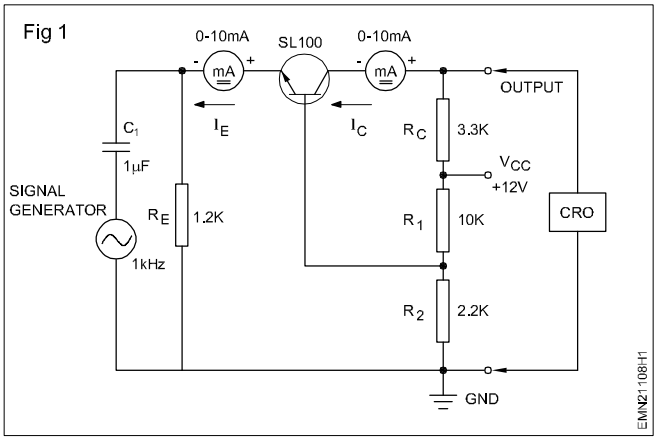
| | |
|---|---|
| • Breadboard | - 1 No |
| • Transistor, SL 100 | - 1 No |
| • Resistors/¼ W/CR25 | |
| 1kΩ | - 1 No |
| 1.2kΩ | - 1 No |
| 2.2kΩ | - 1 No |
| 3.3kΩ | - 1 No |
| 6.8kΩ | - 1 No |
| 10kΩ | - 1 No |
| • Capacitors | |
| 25 µF/25V | - 2 Nos |
| 100 µF/25V | - 1 No |

## PROCEDURE

TASK 1: **Construction and measurement of Ai, $A_v$, $Z_{in}$ and $Z_{out}$ in CB amplifier**

1 Collect all the required components, test and assemble the common base amplifier as shown in Fig 1.

Fig 1




2 Get the assembled circuit checked by the Instructor.

3 Switch ON 12V DC supply to the circuit, measure and record the dc voltage levels of $V_{RE}$, $V_{BE}$, $V_{CB}$ and $V_{CE}$;

**From the readings, conclude whether the transistor is working or not.**

Record the values of input current $I_E$ and output current $I_C$. Calculate and record the current gain Ai of the common base amplifier in Table 1 using the formula

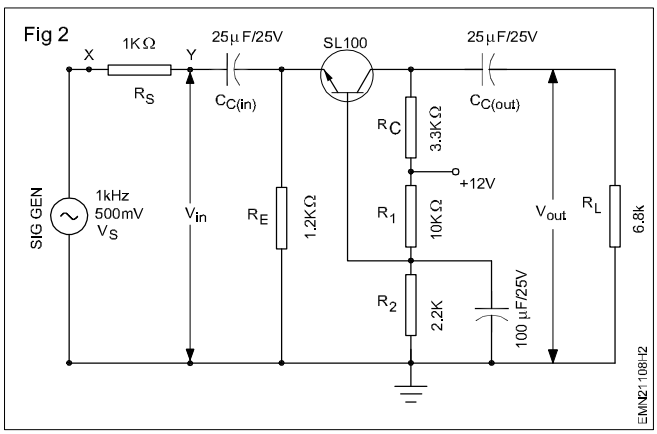
$$A_i = \frac{I_c}{I_E}$$

4 Calculate and record values of, input impedance $Z_{in}$, output impedance $Z_{out}$, voltage gain $A_v$ in Table 2.

**Use the value of Ai found in step 3. Find the value of $r'_e$ using the formula, $r'_e = 25mV/I_E$.**

5 Modify the circuit as shown in Fig 2 and prepare the CRO for measurements.

Fig 2



6 Set the output of the Signal generator to Sine wave, 1kHz at 500mV. Measure and record $V_{in}$ and $V_{out}$ of the amplifier. Calculate and record the voltage gain $A_V$ of the amplifier in Table 3; draw the input and output waveforms in the graph sheets.

7 Measure and record the input impedance $Z_{in}$ and output indepence Zout of the common base amplifier in the same way as found in common emitter amplifiers Ex.No. 2.1.107.

8 Calculate and record the power gain of the common base amplifier using the above readings.

9 Compare the calculated readings at step 4 and the actual values measured.

10 Get the work checked by the Instructor.

**Table 1**
**Current gain $A_i$ of CB amplifier**

| $V_{BG}$ | $V_{BE}$ | $V_{CB}$ | $V_{CE}$ | Condition of transistor | $I_E$ | $I_C$ | Current gain $A_i$ (or) a |
|---|---|---|---|---|---|---|---|
| | | | | | | | |

**Table 2**

**Calculated values using given circuit component values**

| $r'_e$ | $Z_{in}$ | $Z_{out}$ | $A_v$ | $A_p$ |
|---|---|---|---|---|
| | | | | |

**Table 3**

**Frequency set to 1 kHz , sine wave**

| $V_{in}$ | $V_{out}$ | Voltage gain $A_V$ | Input impedance $Z_{in}$ | Output Impedance $Z_{out}$ | Power gain $A_P$ |
|---|---|---|---|---|---|
| | | | | | |

**Graph of Input/output phase relationship**

Note: ***Make rough sketches of wave-forms using pencil.***

| Amplifiers input waveform | Amplifiers output waveform | Remarks on input-output phase relationship |
|---|---|---|
| | | |

– – – – – – –

TASK 2: **Comparison of phase relationship between input and output**

1 Adjust the signal generator output for maximum undistorted $V_{out}$.

2 Prepare the CRO for measurement and connect Ch-1 of CRO at input point (across signal generator) and Ch-2 at the output point (across $R_L$).

3 Switch 'ON' 12V DC supply to the circuit, observe and sketch the waveform in graph sheet as in Table 4.

4 Record the remarks on the phase relationship between input and output waveforms. (Inphase/out of phase)

5 Get the work checked by the Instructor.

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# Construct and test a Common Collector/Emitter Follower amplifier

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

- **construct a common collector/Emitter Follower amplifier and measure current gain, voltage gain of Emitter Follower amplifier**
- **Compare input - output phase relationship of Emitter Follower amplifier**
- **measure input impedance $Z_{in}$ ,output impedance Zout and power gain of Emitter Follower amplifier.**

## Requirements

**Tools/Equipments/Instruments**

- Trainees tool kit - 1 Set
- DC microammeter 0-500 µA - 1 No
- DC milliammeter 0-1 mA - 1 No
- Regulated DC power supply 0-30V/2A - 1 No
- A.F Signal generator - 1 No
- CRO, 20MHz-Dual trace - 1 No
- Multimeter / DMM with probes - 1 No

**Materials/Components**

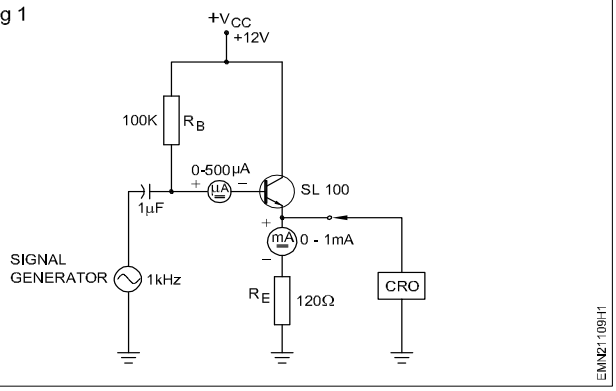
- Breadboard
- Transistor, SL100 or equivalent - 1 No
- Resistors/¼ W/CR25
  - 120Ω - 1 No
  - 100kΩ - 1 No
  - 1kΩ - 1 No
- Preset, 470Ω - 1 No
- Capacitors, 0.47 µF/25V - 2 Nos

## PROCEDURE

TASK 1: **Construction and measurement of current gain and voltage gain of emitter follower**

1 Collect all the components, test and assemble the emitter follower circuit as shown in Fig 1, on breadboard.

Fig 1




2 Get the assembled circuit checked by the Instructor.

3 Measure and record the values of $I_B$ and $I_E$, in Table 1. Assuming $I_C \approx I_E$, calculate and record the β of the transistor using the formula in Table 1.

$$\beta \approx \frac{I_E}{I_B} \approx \frac{I_C}{I_B}$$

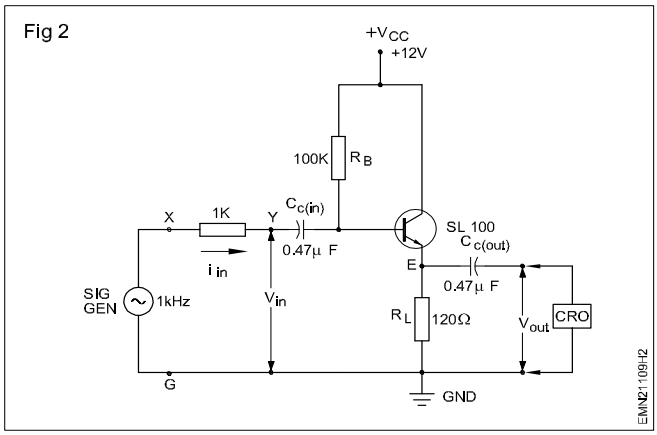
4 Calculate and record the theoretical values of voltage gain $A_v$, input impedance $Z_{in}$, output impedance $Z_{out}$ and current gain $A_i$ of the amplifier in Table 2.

[ To calculate the value of $r'_e$ use the formula,

$$r_e' = \frac{25mV}{I_E} \ ]$$

5 Modify the assembled circuit as shown in Fig 2. Get the correctness of the assembled circuit checked by the Instructor.

Fig 2




6 Connect the signal generator to the input of the emitter follower amplifier. Set the signal generator output to sine wave, 1 kHz.

7 Adjust the signal generator output level such that the AC input $V_{in(p-p)}$ = 500 mV. Measure and record the corresponding output $V_{out(p-p)}$ of amplifier in record sheet Table 3.

8 From the measured values of $V_{in}$ and $V_{out}$, calculate and record the voltage gain $A_V$ of the circuit.

9 Compare the values of calculated voltage gain $A_v$ of the amplifier in step 4 and that found in step 8. Record the difference in Table 3.

**Table - 1**

| $I_B$ | $I_E$ | Current gain $A_i = I_E/I_B \approx \beta$ |
|---|---|---|
| | | |

**Table - 2**

**Values calculated using circuit component values**

| $A_v$ | $Z_{in}$ | $Z_{out}$ | $A_i$ | $r'_e$ |
|---|---|---|---|---|
| | | | | |

**Table 3**

**(a) Measured value of $A_v$**

**Frequency set to 1 KHz**

| $V_{in(p-p)}$ | $V_{out(p-p)}$ | $A_V$ |
|---|---|---|
| **500 mv** | | |
| | | |

10 Get the work checked by the Instructor.

(b) Difference between calculated (at step-4) and measured value of $A_v$ (at step-8):-

– – – – – – –

TASK 2: **Measure input and output impedance of emitter follower**

1 Set the output of the signal generator to sine wave, 1 kHz, 500 m $V_{(p-p)}$ in Fig. 2 and record $V_{in}$ and $V_{out}$ levels in Table 4.

2 Measure voltages $V_{XG}$ and $V_{YG}$ on either side of the 1KΩ resistor. Record readings in the record sheet at Table 4.

3 From the recorded values of $V_{XG}$ and $V_{YG}$, calculate the input signal current $I_{in}$ to the amplifier using Ohms law as given below,

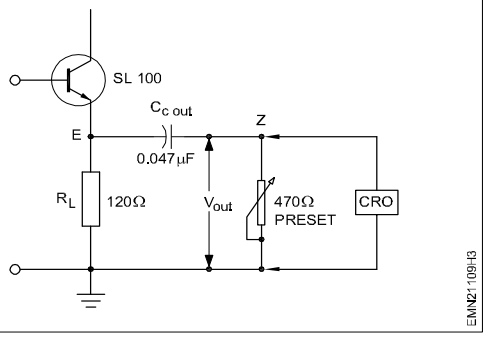
$$I_{in} = \frac{V_{XG} - V_{YG}}{1k\Omega}$$

4 From the values $V_{in}$ and $I_{in}$, calculate and record the input impedance $Z_{in}$ using the formula

$$Z_{in} = \frac{V_{in}}{I_{in}}$$

5 Connect a 470Ω preset across the output of the amplifier as shown in Fig 3. Keep the preset in the maximum resistance position before switching ON DC supply to the circuit.

Fig 3




**Precaution: Since there is no limiting resistor in the collector, if the preset is set at zero or low resistance heavy current may damage the transistor.**

6 Adjust the preset until $V_{out}$ is half the value measured at Step 1 and record the input & output waveforms in graph sheet

**Do not adjust the output level of signal generator set at step 1 of this task.**

7 Switch OFF DC supply to the circuit. Take out the preset from the circuit without disturbing its adjusted position.

8 Measure the adjusted resistance value of the preset and record it as the amplifier's output impedance $Z_{out}$ in Table 4.

9 From the values recorded, calculate and record, current gain $A_i$, and power gain $A_P$ of the amplifier, using the formulae

$$A_i = A_V \frac{Z_{in}}{R_E}$$

$$P_{in} = \frac{V_{in}^2}{Z_{in}}$$

$$P_{out} = \frac{V_{out}^2}{R_{out}}.$$

$$\text{Power gain of amplifier } A_P = \frac{P_{out}}{P_{in}}$$

$$\text{Power gain } A_P \text{ in decibel} = 10 \log \frac{P_{out}}{P_{in}}$$

**Table - 4**

**Frequency set to 1kHz**

| $V_{in(p-p)}$ | $V_{out(p-p)}$ | $V_{XG}$ | $V_{YG}$ | $I_{in}$ | Input impedance $Z_{in}$ of amplifier | Output impedance $Z_{out}$ of amplifier |
|---|---|---|---|---|---|---|
| **500 mV** | | | | | | |

**2 Current gain $A_i$ using the formula $A_i = A_v(Z_{in}/R_E)$ : _____**

**3 Power gain $A_e$ of emitter follower/CC amplifier : _____**

**4 Power gain $A_p$ of emitter follower/CC amplifier in dB : _____**

10 Get the work checked by the Instructor.

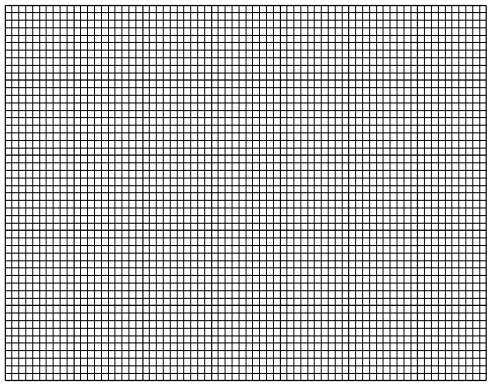
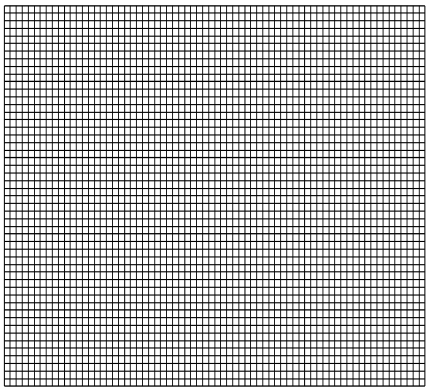
– – – – – – –

TASK 3: **Comparison of phase relationship between the input and output of emitter follower amplifier.**

1 Find the phase relationship between the input and output of the emitter follower in the same way as done for common emitter amplifier in Exercise 2.1.107 or Ex. No. 2.1.108

**Graph of Input and output phase relationship.**

2 Get the work done by the Instructor.

| Amplifiers input wave-form | Amplifiers output wave-form | Remarks on input-output phase relationship |
|---|---|---|
|  |  | |

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# Construct and test a Darlington amplifier

**Objectives:** At the end of this exercise you shall be able to
- **construct Darlington amplifier and measure current gain and voltage gain**
- **Compare the input - output phase relationship**
- **measure input and output impedance and calculate power gain of darlington amplifier**
- **compare the phse relationship.**

## Requirements

**Tools/Equipments/Instruments**

- Trainees tool kit - 1 Set
- DC microammeter 0-100µA - 1 No
- DC milliammeter 0-1mA - 1 No
- Regulated DC power supply, 0-30V/2A - 1 No
- AF Signal generator - 1 No./batch
- CRO, 20 MHz- Dual trace - 1 No./batch
- Multimeter/DMM with probes - 1 No

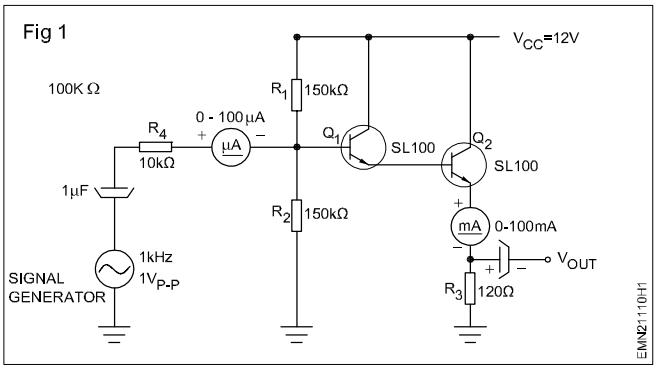
**Materials/Components**

- Breadboard - 1 No
- Transistor, SL100 or equivalent - 2 Nos
- Resistors/¼ W/CR25
  - 120Ω - 1 No
  - 150kΩ , 10kΩ , - 2 Nos
  - 1kΩ - 1 No
- POT, 470Ω, 1/2W - 1 No
- Capacitors, 0.47 µF/25V - 2 Nos
- 1µF/25V - 1 No

TASK 1(a): **Measurement of current gain and voltage gain**

1 Collect all the components, test them and assemble the Darlington amplifier circuit as shown in Fig 1.

Fig 1




2 Get the assembled circuit checked by the Instructor.

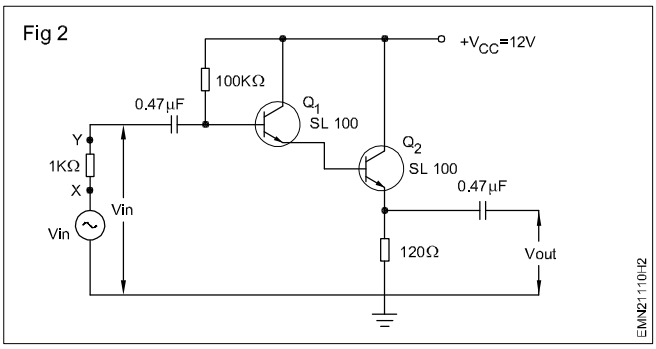
3 Measure and record the values of $I_B$ at base and $I_E$ at Emitter of transistor-Q1 and $I_E$, at emitter of transistor-Q2 in Table 1. Assuming $I_C \approx I_E$, calculate and record the current gain of the transistor using the formula,

$$\text{current gain} = \frac{\beta dc \quad I_{E2}}{I_{B1}}$$

4 Using the value of $I_E$ and current gain from step 3, calculate and record the theoretical values of voltage gain $A_v$, input impedance $Z_{in}$, output impedance $Z_{out}$ and current gain $A_i$ of the amplifier in Table 2.

5 Modify the assembled circuit as shown in Fig 2. Get the correctness of the wired circuit checked by the instructor.

Fig 2




6 Connect the signal generator to the input of transistor Q1 and set the signal generator output to sine wave, 1kHz.

7 Adjust the signal generator output level such that the AC input $V_{in(p-p)}$ = 500 $mV_{p-p}$. Measure and record the corresponding output $V_{out(p-p)}$ of amplifier in Table 3.

8 From the measured values of $V_{in}$ and $V_{out}$, calculate and record the voltage gain $A_V$ of the circuit in Table 3.

9 Compare the values of calculated voltage gain $A_v$ of the amplifier in step 3 and that found in step 8. Record the difference in the space provided.

1 **Table - 1**

| $Q_1$ $I_{B1}$ | $Q_1$ $I_{E1}$ | $Q_2$ $I_{E2}$ | Current gain $A_i = I_{E2}/I_B \approx \beta$ |
|---|---|---|---|
| | | | |

**a) Observation to obtain $A_v$ the darlington amplifier practically**

**Frequency set to 1 KHz**

| $V_{in(p-p)}$ | $V_{out(p-p)}$ | $A_V$ |
|---|---|---|
| **500 mv** | | |

(b) Difference between calculated (at step-3) and measured value of $A_v$ (at step-7):

**Table - 2**

**Values calculated using circuit component values**

| $A_v$ | $Z_{in}$ | $Z_{out}$ | $A_i$ | $r'_e$ |
|---|---|---|---|---|
| | | | | |

10 Get the work checked by the Instructor.

– – – – – – –

TASK 1(b) : **Measurement of input and output impedance and calculation of power gain for darlington amplifier**

1 Set the output of the signal generator to sine wave, 1 kHz, 500 m $V_{in(p-p)}$ in Fig. 2 and record $V_{in}$ and $V_{out}$ levels in Table 4.

2 Measure voltages $V_{XG}$ and $V_{YG}$ on either side of the 1K resistor. Record readings in Table 4.

3 From the recorded values of $V_{XG}$ and $V_{YG}$, calculate the input signal current $I_{in}$ to the amplifier using Ohms law as given below,

$$I_{in} = \frac{V_{XG} - V_{YG}}{1k\Omega}$$

4 From the values $V_{in}$ and $i_{in}$, calculate and record the input impedance $Z_{in}$ using the formula

$$Z_{in} = \frac{V_{in}}{I_{in}}$$

5 Connect a 470Ω preset across the output of the amplifier as shown in Fig 3. Keep the preset in the maximum resistance position before switching ON DC supply to the circuit.

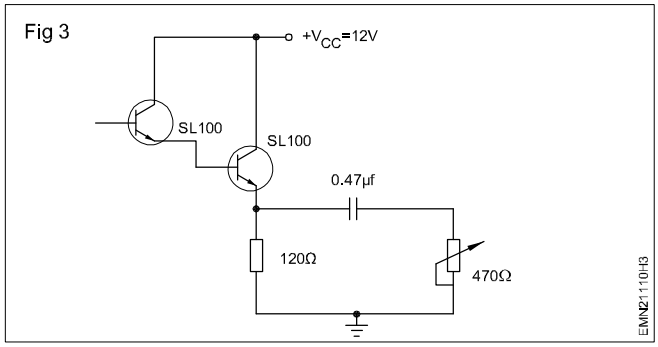
**Since there is no limiting resistor in the collector, if the preset is set at zero or low resistance heavy current may damage the transistor.**

6 Adjust the preset until $V_{out}$ is half the value measured at Step 1.

**Do not adjust the output level of sig. gen. set at step 1 of this task.**

7 Switch OFF DC supply to the circuit. Take out the preset from the circuit without disturbing its adjusted value.

Fig 3




8 Measure the adjusted value of the preset and record it as the amplifier's output impedance $Z_{out}$ in Table 4.

9 From the values recorded calculate and record, current gain $A_i$, and power gain $A_p$ of the amplifier, using the formulae

$$A_I = A_V \frac{Z_{in}}{R_E}$$

$$P_{in} = \frac{V_{in}^2}{Z_{in}}$$

$$P_{out} = \frac{V_{out}^2}{R_{out}}.$$

$$\text{Power gain of amplifier } A_p = \frac{P_{out}}{P_{in}}$$

$$\text{Power gain } A_p \text{ in decibel} = 10 \log \frac{P_{out}}{P_{in}}$$

**Table - 4**

**Frequency set to 1 kHz**

| $V_{in(p-p)}$ | $V_{out(p-p)}$ | $V_{XG}$ | $V_{YG}$ | $I_{in}$ | Input impedance $Z_{in}$ of amplifier | Output impedance $Z_{out}$ of amplifier |
|---|---|---|---|---|---|---|
| **500 mV** | | | | | | |

10 Get the work checked by the Instructor.

– – – – – – –

TASK 2 : **Compare the phase relationship between input and output of darlington amplifier**

1 Draw the sketch of input & output waveform on graoh sheet.

2 Find the phase relationship between the input and output of the emitter follower in the same way as done for common emitter amplifier in Exercise 2.1.106.

3 Write remark on input and output phase relationship.

| Amplifiers input wave-form | Amplifiers output wave-form | Remarks on input-output phase relationship |
|---|---|---|
| | | |

4 Get the work checked by the Instructor.

– – – – – – –

# Construct and a two stage test RC-coupled Amplifier

**Objectives:** At the end of this exercise you shall be able to
- **construct and test two stage amplifier using RC coupling**
- **observe the frequency response of RC coupled amplifier.**

## Requirements

**Tools/Equipments/Instruments**

| | |
|---|---|
| • Trainees tool kit | - 1 Set |
| • CRO, 20 MHz Dual trace | - 1 No |
| • AF Signal generator | - 1 No |
| • Regulated DC power supply 0-30V/2A | - 1 No |
| • Semiconductor data manual | - as reqd |

**Materials/Components**

| | |
|---|---|
| • Breadboard | - 1 No |
| • Transistor SL 100 | - 2 Nos |
| • Resistor ¼ W/CR25 | |
| 5.6 kΩ | - 2 Nos |
| 1kΩ | - 2 Nos |
| 3.3 kΩ, 22 kΩ | - 1 No each |
| 15 kΩ, 2.5 kΩ | - 1 No each |
| • Capacitor | |
| 1 μF/25V | - 3 Nos |
| 100 μF/25V | - 2 Nos |
| • Hook up wire | - as reqd |
| • Patch cords | - as reqd |

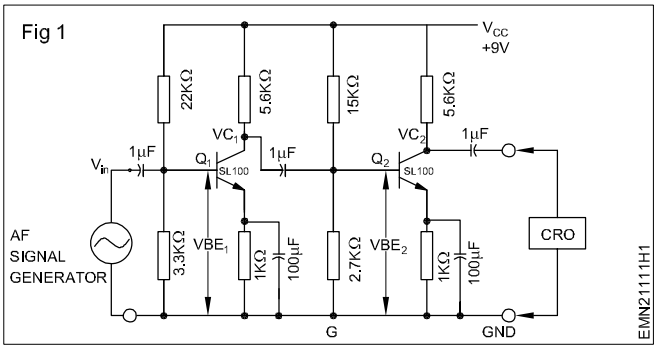
## PROCEDURE

TASK 1: **Construction and testing of 2 stage RC coupled amplifier**

1 Collect all the components, identify the base, emitter and collector pins of given transistors and test for their good working condition.

2 Assemble the RC coupled amplifier on breadboard as shown in Fig 1.

Fig 1




3 Get the assembled circuit checked by the Instructor.

4 Switch ON 9 VDC supply to the assembled circuit, measure the DC levels at different test points $V_{BE}$, $V_{CE}$, $V_{BE2}$, $V_{CE2}$ (of both transistors) shown in Fig 1; record the measured voltages in Table 1.

5 Connect the A.F. signal generator at the input of the assembled amplifier; set the output of the signal generator at 20 mV, 1 kHz, sinewave.

6 Preapre the CRO for measurements, measure and record the output of each stage in Table 2.

7 From the recorded readings find and record the gain of each stage and the overall voltage gain of the cascaded amplifier.

8 Vary the output frequency of the signal generator between 20 Hz to 20 kHz in steps as given in Table 3 and record overall gain of the amplifier at different frequency settings in Table 3.

9 Plot the graph of frequency versus voltage gain and mark the low frequency cut-off ($f_{LC}$) and high frequency cut-off ($f_{HC}$) points on the graph.

**Table 1**

**Vin = 9V DC**

| Transistor $Q_1$ (DC levels) | | Transistor $Q_2$ (DC levels) | | Transistor Condition |
|---|---|---|---|---|
| $V_{BE1}$ | $V_{CE1}$ | $V_{BE2}$ | $V_{CE2}$ | ON/OFF |
| | | | | |

**Table 2**

**$V_{in}$ = 20 mV, F = 1kHz, sinewave**

| Amplifier-1 stage output Voltage | Amplifier-2 stage output Voltage | Amplifier output waveform on CRO |
|---|---|---|
| $V_{C1}$ - Gnd | $V_{C2}$ - Gnd | |
| | | |

**Table 3**

**$V_{in}$ = 20mV Oberservation of frequency response of RC coupled amplifier**

| Sl No. | Input frequency | $V_o$ | Voltage Gain $= \frac{V_o}{V_{in}} = A_V$ |
|---|---|---|---|
| 1 | 10Hz | | |
| 2 | 50Hz | | |
| 3 | 100Hz | | |
| 4 | 200kHz | | |
| 5 | 500kHz | | |
| 6 | 1kHz | | |
| 7 | 2kHz | | |
| 8 | 5kHz | | |
| 9 | 10kHz | | |
| 10 | 15kHz | | |
| 11 | 20MHz | | |

10 Get the working of the circuit and the recorded readings checked by the Instructor.

– – – – – – –

# Construct and test class-B complementary push-pull amplifier

**Objectives:** At the end of this exercise you shall be able to
- **construct and test a Class B complementary-symmetry push-pull amplifier circuit**
- **test the amplifier with AF signal input and loudspeaker output.**

## Requirements

**Tools/Equipments/Instruments**

- Trainees tool kit - 1 Set
- CRO, 20 MHz - Dual trace - 1 No
- AF signal generator - 1 No
- Regulated DC power supply 0-30V/2A - 1 No
- Multimeter /DMM with probes - 1 No
- Ammeter 0-500 mA MC panel type - 1 No
- Soldering iron 25W/230V - 1 No

**Materials/Components**

- Transistors 100N or 100P or equivalent - 1 No each
- BC 148B - 1 No
- Transistor data sheet - as reqd
- General purpose PCB - 1 No
- Capacitors 25VDC wkg
  - 1000 µF - 1 No
  - 22 KpF - 1 No
  - 1µF - 1 No
- Resistors ¼ W/CR25
  - 100 kΩ - 1 No
  - 1kΩ - 1 No
  - 120Ω - 1 No
- Potentiometer 10kΩ,LOG - 1 No
  - 8.2 kΩ - 1 No
- Loudspeaker - 8Ω/5W - 1 No
- Rosin cored solder - as reqd
- Hook up wire/connecting wires - as reqd

## PROCEDURE

TASK 1 : **Construction and testing of a class-B complementary symmetry push-pull audio amplifier**

1 Collect all the components, identify the base emitter and collector leads of given transistors and test them.

2 Plan the layout of components and assemble the complementary push pull amplifier as shown in Fig 1 on the general purpose PCB.

3 Connect a 0-500mA DC current meter in series with the 9 V regulated DC supply to the assembled circuit as shown in Fig 1. Switch ON DC supply to the circuit.

**If current meter shows more than 50mA, switch-off DC supply and consult your instructor.**

4 Measure the current drawn and the dc voltage levels at different test points of the circuit in Table 2.

5 From the recorded readings, calculate the DC current drawn by each stage. Get it checked by Instructor.

6 Feed a 100 mV, 1 kHz sine wave from AF signal generator to the input of the amplifier.

**If the output of speaker is feeble, increase the input signal level suitably by adjusting the volume control.**

7 Prepare the CRO for measurements and verify the input and output at each transistor to confirm amplification.

8 Measure and record the ac voltage levels (peak-to-peak) at the output of each stage using CRO in Table 3.

9 From the recorded readings calculate the overall voltage gain, efficiency of the amplifier and output power.

10 Vary the output frequency of the signal generator between 20 Hz and 20kHz and record the 3dB low frequency cut off($f_{Lc}$) and high frequency cut-off($f_{Hc}$) on a graph sheet.

Check the audiability of loud speaker.

11 Get the working of the amplifier and the recorded readings checked by the Instructor.

Fig 1

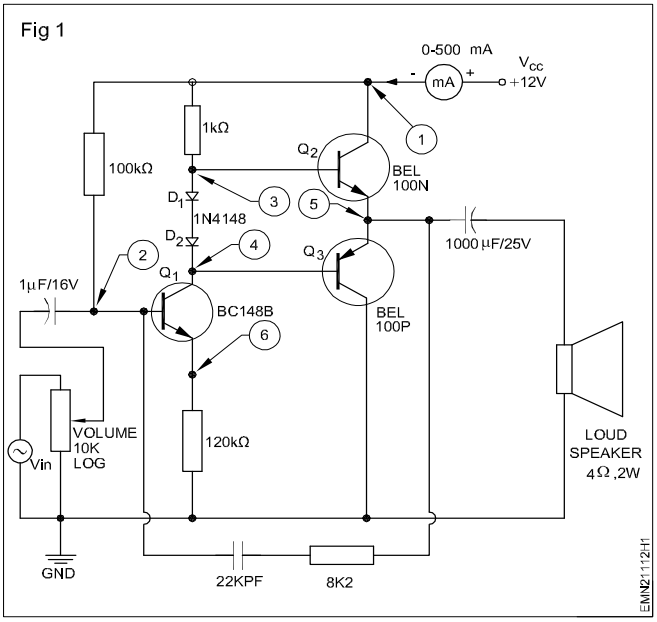



**Table 1 Transistor specifications**

| Transistor type number | NPN or PNP | Package type | Leads diagram | $\beta_{dc}$ Typ | $V_{dc}$ Max | $I_c$ Max | $P_D$ | Application |
|---|---|---|---|---|---|---|---|---|
| BC 100P | | | | | | | | |
| BC 100N | | | | | | | | |
| BC 148B | | | | | | | | |

**Table 2**

| Current drawn by the circuit | | DC voltage levels at test points | | | | | |
|---|---|---|---|---|---|---|---|
| Without signal | With max signal | Supply $V_{cc}$ | $V_{B1}$ | $V_{B2}$ | $V_{B3}$ | $V_{E1}$ | $V_{E2}$ |
| | | | | | | | |

**Table 3 Total circuit current drawn by the cascaded amplifiers with input ac signal: _____**

| AC voltage levels (p-p) at, | | | | | Overall voltage gain $A_V = \frac{V_{out}}{V_{in}}$ |
|---|---|---|---|---|---|
| Input | Collector of $Q_1$ | Emitter of $Q_2$ | Emitter of $Q_3$ | Speaker | |
| | | | | | |

**Efficiency calculation :-**

Input current ($I_1$)= _____

DC power ($P_o$)=Vcc x $I_1$ =_____

Voltage across speacker ($V_o$) = _____

Resistance of speaker ($R_L$) = _____

Output power ($P_o$)= $\frac{V_o^2}{R_L}$

Efficiency = $\frac{P_o}{P_{DC}} \times 100$

# Construct and test Calss C Tuned Amplifier

**Objectives:** At the end of this exercise you shall be able to
- **construct and test a Tuned Amplifier and plot the frequency response.**

## Requirements

**Tools/Equipments/Instruments**

- Function generator (1Hz to 1 MHz) - 1 No
- CRO 0-20 MHz Dual channel - 1 No
- Trainees tool kit - 1 Set
- Multimeter / DMM with probes - 1 No
- Regulated DC power supply 0-30V/2A - 1 No

**Materials/Components**

- Transistor BF 494 - 1 No
- Resistors ¼ W/CR25 10kΩ,12kΩ,1kΩ - 1 No each
- Inductor, 1mH - 1 No
- Capacitor 0.1µF/25V - 4s Nos
- Capacitor 1 nF - 1 No
- Breadboard - 1 No
- Hookup wires - as reqd

## PROCEDURE

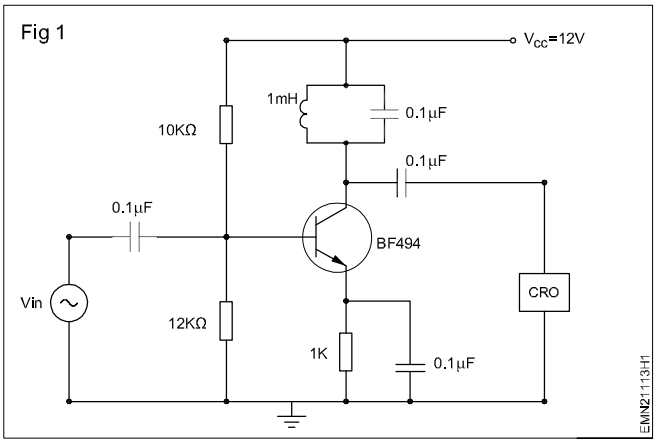
1 Collect the required components , check them and assemble the components on breadboard as shown in Figure 1.

2 Measure $V_B$,$V_C$,$V_E$ of the transistor and record in Table 1.

3 Connect the FG at the input terminals and CRO in the output terminals.

4 Prepare CRO for measurements, connect one channel to FG/AF generator and other channel to O/P of amplifier a shown in Fig 1.

Fig 1




5 Apply 1 kHz -20 mV, sinewave to the input of the circuit and measure the output voltage (P-P) and record in Table 2.

6 Vary the frequency in steps and keep the input voltage constant and record the readings in Table 2.

7 Repeat the above steps till the output amplitude increases and falls below the 70.7% of the maximum value.

8 Plot the graph by taking frequency in X axis & gain in Y axis as shown in Fig 2.

9 Mark the 3 dB lower and higher cut-off frequences on the graph.

**Table 1**

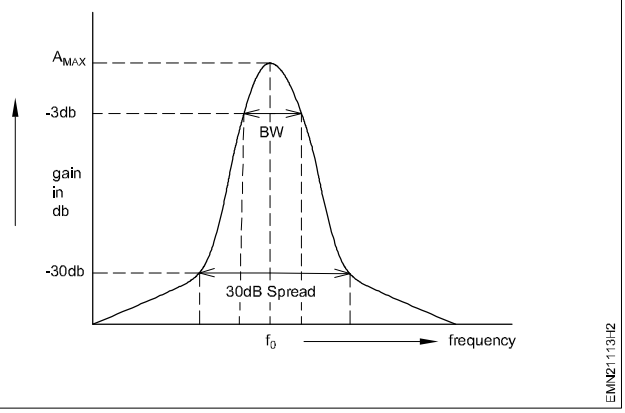
**DC voltage levels**

| $V_B$ | $V_C$ | $V_E$ |
|---|---|---|
| | | |

**Table 2**

| Sl.No | Freq in kHz | $V_{out}$ | $V_{in}$ | $Gain = \frac{V_{out}}{V_{in}}$ |
|---|---|---|---|---|
| | | | | |

Fig 2




10 Get the work checked by the Instructor.

3dB Lower cut-off frequency = ---------- kHz

3dB Higher cut-off frequency = ---------- kHz

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# Demonstrate Colpitt's oscillator, Hartley oscillator circuits and compare the output frequency of the oscillator by CRO

**Objectives :** At the end of this exercise you shall be able to
- **construct and test a Colpitts oscillator**
- **construct and test a Hartley oscillator**
- **compare the measured output frequency with calculated frequency.**

## Requirements

**Tools/Equipments/Instruments**

- Trainees tool kit - 1 Set
- CRO 20 MHz -Dual trace - 1 No
- Regulated DC power supply 0-30V/2A - 1 No
- Digital multimeter with probes - 1 No
- Soldering iron 25W/230V - 1 No
- Soldering iron stand - 1 No

**Materials/Components**

- Transistor BF 195 - 1 No
- MW oscillator coil - 1 No
- Breadboard - 1 No
- Resistor ¼ W/CR25
  18kΩ, 390Ω, 82kΩ, 3K9 - 2 Nos each
- Capacitor
  0.1 μF - 1 No
  0.01 μF - 2 Nos
- 2J gang capacitor - 1 No
- Hook up wires - as reqd
- Rosin cored solder - as reqd

## PROCEDURE

TASK 1 : **Construction and testing of a Colpitts oscillator**

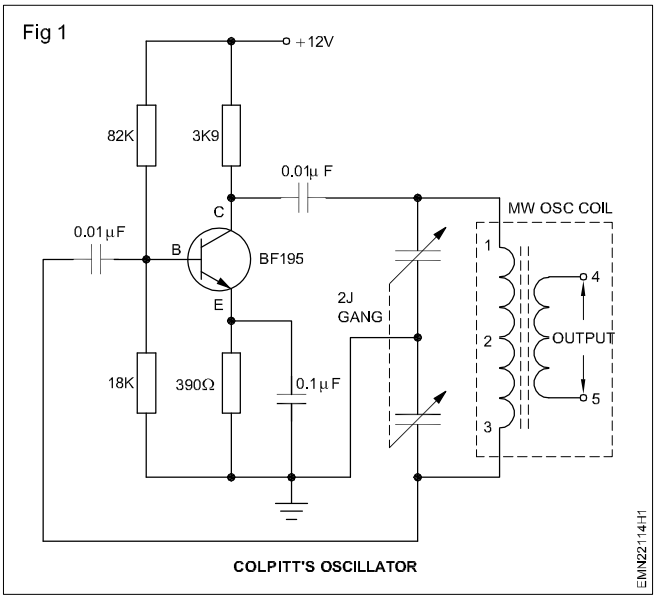
1 Collect all the required components for assembling/ collect trainer kit & test the component for working condition.

2 Plan the layout and assemble the circuit on the bread-board as shown in Fig 1.

**Note: If the trainer kit on oscillator is not available, the instructor can use assembled oscillator for demonstration.**

3 Get the assembled circuit checked by the Instructor.

Fig 1




COLPITT'S OSCILLATOR

4 Prepare the CRO for measuring the output of oscillator.

5 Switch ON the 12VDC supply to the circuit connect the CRO at the output terminal of the oscillator circuit and measure the waveform.

6 Adjust the gang capacitor to get the desired frequencyo on CRO.

**Note: The operating range of Colpitts oscilator using medium wave oscillator coil is from 1000 kHz to 2055 kHz Frequency of Colpitts oscillator can be determined therotically by using Formula:**

$$F = \frac{1}{2\pi\sqrt{LC}}$$

**Where 'C' is the capacitance of 2J gang and L is the inductance of the oscillator coil in the tank circuit.**

7 Repeat the above step, by changing the position of the gang capacitor and record the readings in Table 1.

8 Draw waveform observed at 3 positions of gang capacitor and note down the frequencies.

9 Compare the calculated value with observed value of frequencies.

Table 1

**Colpitts oscillator Observation**

| | Conventional circuit | | |
|---|---|---|---|
| Position of gang capacitor | Amplitude in volts | Frequency in Hz | |
| | | Calculated | Observed |
| Gang capacitor at one extreme end | | | |
| Gang capacitor at other extreme end | | | |
| Gang capacitor at approximately mid-position | | | |

10 Get the work checked by the Instructor.

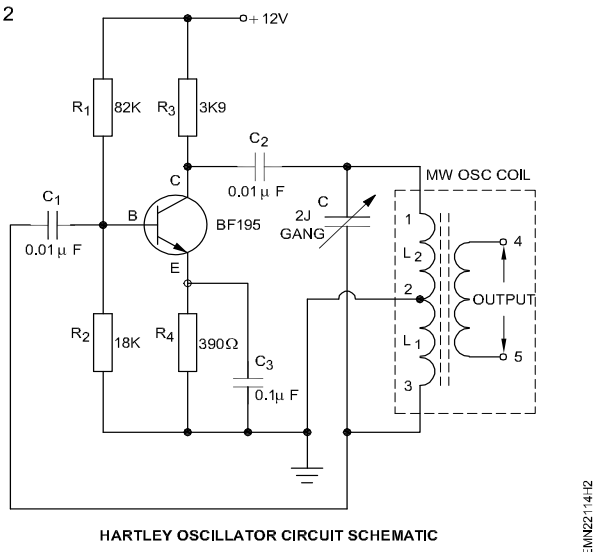
– – – – – – –

TASK 2 : **Construction and testing of a Hartley oscillator**

1 Use trainer kit (or) assemble the components as shown in Fig 2 on breadboard.

2 Connect the DC supply and set for 12V

Fig 2




HARTLEY OSCILLATOR CIRCUIT SCHEMATIC

3 Switch on the supply

4 Switch on the CRO and adjust to get horizontal trace.

5 Connect the CRO in the O/P terminal of the circuit.

6 Observe the output of the circuit in the CRO, adjust the time/div, V/div knobs to get stable wave form.

7 Measure the time period & calculate the frequency of oscillator using the formula $F = \frac{1}{T}$ practically.

**Note: Frequency of Hartley oscillator can be determined theoritically by using formula**

$$F = \frac{1}{2\pi\sqrt{LC}}$$

**, Where 'C' is the capacitance of the capacitor C1 in tank circuit and L = L1 + L2 the effective series inductances of tank circuit.**

8 Repeat the above steps by changing the position of the gang capacitor and record the readings in Table 2.

9 Draw waveform observed at different settings of gauged capacitor and note down the frequencies as given in Table 2.

Table 2

| | Conventional circuit | |
|---|---|---|
| Position of gang capacitor | Amplitude in volts | Frequency in Hz |
| Gang capacitor at one extreme end | | |
| Gang capacitor at other extreme end | | |
| Gang capacitor at approximately mid-position | | |

10 Get the work checked by the Instructor.

– – – – – – –

# Construct and test RC phase-shift oscillator circuits

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

- **construct and test RC phase shift oscillator circuit using transistor and vary the output frequency of the oscillator.**

## Requirements

**Tools/Equipments/Instruments**

- Trainees tool kit - 1 Set
- Regulated DC power supply, 0-30V/2A - 1 No
- CRO, 20 MHz - Dual channel - 1 No
- Digital frequency counter - 1 No
- Soldering Iron 25W/230V with stand - 1 No
- Digital multimeter with probes - 1 No

**Materials/Components**

- Breadboard - 1 No
- Resistor ¼ W/CR25
  10kΩ, 2k2, 680Ω, 47kΩ - 1 No each
- Resistor 4.7kΩ/¼ W/CR25 - 2 Nos
- Capacitor 25VDC working
  0.01 μF - 3 Nos
  1μF, 22μF - 1 No each
- Transistor BC 107 - 1 No
- POT 4.7kΩ - 1 No
- Hookup wire - as reqd

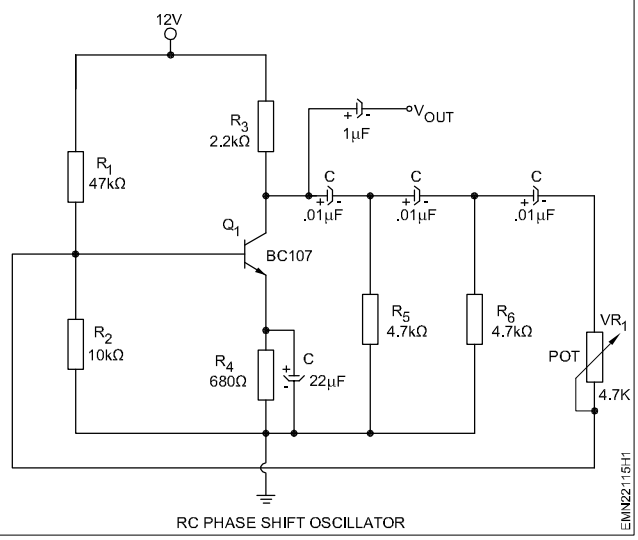
## PROCEDURE

TASK 1 : **Construction and testing of RC phase shift oscillator circuit using transistor**

1 Collect all the components from instructor and test them.

2 Assemble the RC phase-shift oscillator as shown in Fig 1 on the breadboard.

Fig 1




RC PHASE SHIFT OSCILLATOR

3 Get the assembled circuit checked by the Instructor.

4 Preapre the CRO for measurements and connect it across the output terminals.

5 Switch ON the 12VDC supply to the RC phase shift oscillator circuit and measure the output waveform using CRO.

**If there is no output, adjust the value of POT to get the output; even after adjusting the POT no output is available consult the instructor.**

6 Keep the preset $VR_1$ at maximum resistance position adjust the preset pot and observe the change in frequency/waveform on CRO.

7 Measure and record the oscillator output frequency in Table1.

8 Measure the output using frequency counter also and record the readings in Table 1.

9 Adjust POT suitably and find the minimum and maximum frequency of oscillations of the circuit. Record the observations in Table.

10 Compare the calculated and measured frequency of the oscillator.

11 Get the work checked by the Instructor.

**Table 1**

**Output frequency at different positions of $R_3$ preset  Calculated frequency _____ Hz**

| Sl. No. | Position of preset $VR_1$ | Frquency measured using CRO | Frequency measured using freq counter | $\left.\begin{matrix}Calculated\\Frequency\end{matrix}\right\} F = \frac{1}{2\pi RC\sqrt{6}}$ |
|---|---|---|---|---|
| 1 | Minimum | | | |
| 2 | Middle | | | |
| 3 | Maximum | | | |

– – – – – – –

# Construct and test a crystal oscillator circuit

**Objectives** : At the end of this exercise you shall be able to
- **construct and test a Crystal oscillator using transistor.**

## Requirements

**Tools/Equipments/Instruments**

- Trainees tool kit - 1 Set
- Oscilloscope, 20 MHz Dual trace - 1 No
- Regulated DC power supply 0-30V/2A - 1 No
- Digital multimeter with probes - 1 No

**Materials/Components**

- Breadboard - 1 No
- Hook up wires - as reqd
- 8.44 MHz Crystal with holder - 1 No
- Capacitors - 25V DC wkg
  - 680pF - 1 No
  - 330pF - 1 No
- Capacitor 0.1μF - 2 Nos
- Transistor BF195 - 1 No
- Resistors ¼ W/CR25 82kΩ,18kΩ, 3.9kΩ, 390Ω - 1 No each

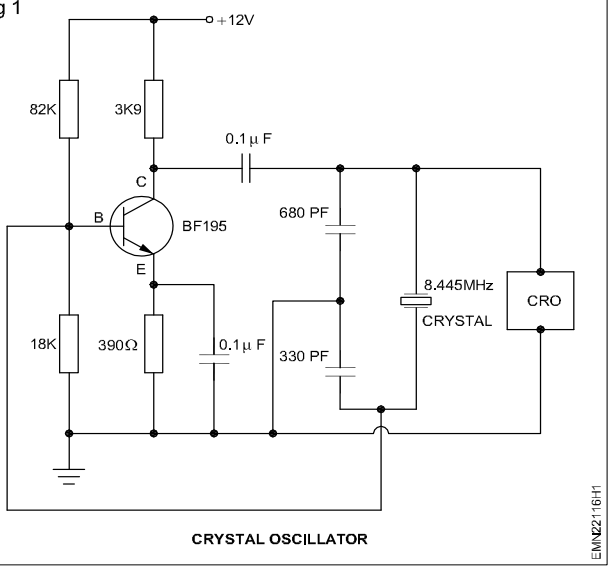
## PROCEDURE

TASK 1 : **Construction and testing of crystal controlled Pierce oscillator**

1 Record the frequency marked on the crystal.

2 Collect all the required components, test and assemble pierce crystal controlled oscillator circuit on breadboard as shown in Fig 1.

Fig 1




CRYSTAL OSCILLATOR

3 Connect 12V DC supply to the oscillator circuit.

4 Prepare the CRO for measurement and connect it cross the output of the oscillator.

5 Adjust the CRO time-base to get a clear sinusoidal waveform on the screen. Measure and record the amplitude and frequency of oscillations.

**If oscillations are not seen, the crystal may be bad. Consult your instructor.**

6 Decrease the supply voltage to find and record the minimum $V_{CC}$ voltage at which the crystal oscillator oscillates satisfactorily.

7 Get the working of the circuit and the recorded readings checked by the instructor.

TASK 2 : **Construct and test a Pierce Crystal oscillator**

1 Frequency marked on crystal :_____

2 (a) Amplitude of oscillations :_____

(b) Frequency of oscillations :_____

3 (a) Minimum $V_{CC}$ at which crystal oscillator work satisfactorily :_____

(b) Output frequency :_____

(c) Output amplitude :_____

# Demonstrate Astable, Monostable and Bistable multivibrator circuits using transistors

**Objectives :** At the end of this exercise you shall be able to
- **construct and test an astable multivibrator using transistors**
- **construct and test a monostable multivibrator using transistors**
- **construct and test a bistable multivibrator using transistors.**

## Requirements

**Tools/Equipments/Instruments**

- Trainees tool kit - 1 Set
- Oscilloscope 20 MHz Dual trace - 1 No
- Digital multimeter with probes - 1 No
- Regulated DC power supply 0-30V/2A - 1 No

**Materials/Components**

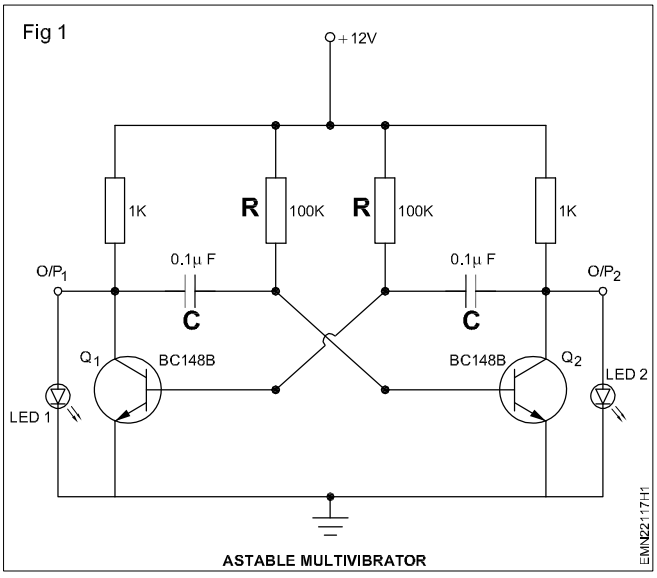
- Breadboard - 1 No
- Transistor BC 148 B - 2 Nos
- LED 5mm, Red and Green - 1 No each
- Resistors/¼ W/CR25
  - 100 kΩ - 2 Nos
  - 1kΩ - 4 Nos
  - 10 kΩ - 2 Nos
  - 33 kΩ - 1 Nos
  - 150 kΩ - 1 No
- Capacitors 25 V DC wkg
  - 0.1 µF - 2 Nos
- Diode- 1N4001 - 2 Nos
- Push button Switch (push-to-ON) - 2 Nos
- Hook up wires - as reqd

## PROCEDURE

TASK 1 : **Construction and testing of astable multivibrator using transistors**

1 Collect the required components, test and assemble the astable multivibrator on breadboard as shown in Fig 1.

Fig 1




ASTABLE MULTIVIBRATOR

2 Connect 12 V DC supply and switch ON the circuit.

**1** (a) Calculated ON-time ($t_{ON}$) : (0.69 RC): _____

(b) Calculated OFF-time ($t_{OFF}$) : (0.69 RC) : _____

**2** (a) Measured ON-time ($t_{ON}$) : _____

(b) Measured OFF-time ($t_{OFF}$) : _____

3 Prepare the CRO for measurements and connect it across any one of the collector of the transistor and ground.

4 Observe the waveform, measure the frequency of oscillation and record it in Table 1.

5 Calculate the ON time OFF time, PRF and record the values.

6 Observe the of LEDs and record in Table 1.

**Table 1**

| Value of | | Wave form at | | Calculated frequency (PRF) | Measured frequency (PRF) | Status of LEDs | Remarks |
|---|---|---|---|---|---|---|---|
| R | C | Base | Collector | | | | |
| | | | | | | | |

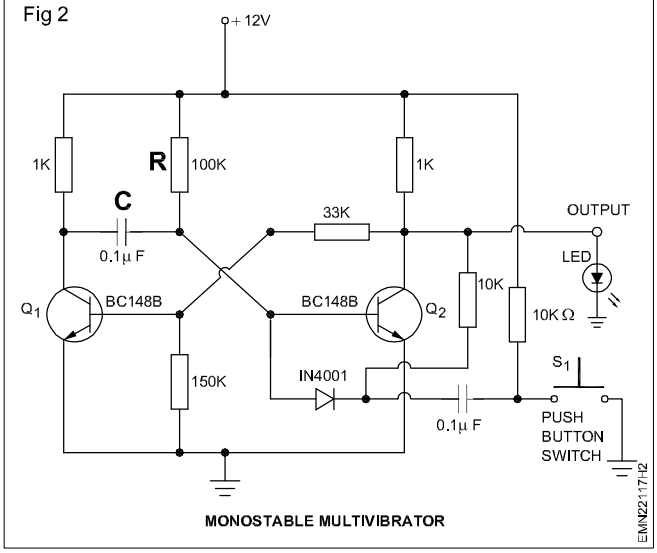
7 Get the work checked by the Instructor.

– – – – – – –

TASK 2 : **Construction and testing of monostable / One shot multivibrator using transistors**

1 Assemble the monostable multivibrator as shown in Fig 2.

Fig 2




2 Calculate and record the ON time of the monostable multivibrator.

3 Get the circuit and calculated values checked by the Instructor.

4 Switch ON 12 VDC supply to the circuit, connect the CRO probe at the collector of $Q_1$ with reference to ground.

1 Calculated ON time : _____

2 Measured ON time of the output pulse ($t_{ON}$) with C = 100µF : _____

3 Calculated ON time : _____

Measured ON time : _____

5 Press switch $S_1$ and observe the LED and one single pulse output on CRO. Repeat this step for adjusting the CRO controls such that the pulse can be clearly seen on CRO.

6 Press $S_1$ repeatedly such that the pulse keep appearing on the screen repeatedly. Measure and record the ON time of the pulse.

**If the CRO used has storage option, use this option to measure the ON time more conveniently. Take the help of the instructor to use the storage option on the DSO.**

7 Change the value of the capacitor C from 0.1µF to 100µF. Calculate and record the new ON-time of the pulse.

8 Switch ON DC supply to the circuit. Press switch $S_1$ and observe the LED glowing. Try to find the approximate glow time using a stop watch record the glowing time of the LED.

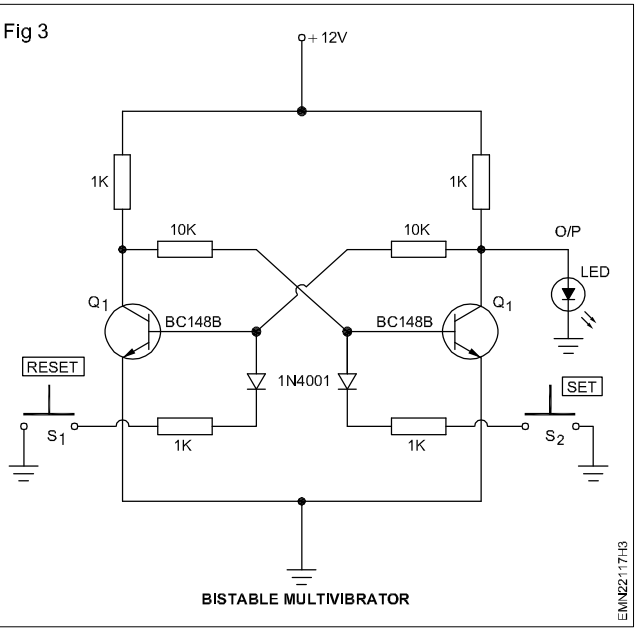
9 Get the working of the circuit checked by the Instructor.

– – – – – – –

TASK 3 : **Construction and testing of Bistable multivibrator using transistors**

1 Assemble the bistable multivibrator as shown in Fig 3.

Fig 3




2 Connect the 12VDC supply to the circuit and switch ON.

3 Press switch $S_1$, observe the condition of LED.

4 Press switch $S_2$, observe the condition of LED.

5 Record the observations in Table 1.

Table 1

| Sl. No. | Switch to press | Output condition | |
|---|---|---|---|
| | | (HIGH/LOW) | (Glow / No Glow) |
| | Set | | |
| | Reset | | |

6 Get the work checked by the Instructor.

– – – – – – –

# Construct and test shunt clipper

**Objectives :** At the end of this exercise you shall be able to
- **construct and test the positive shunt clipper circuit using descrete components**
- **construct and test the shunt negative clipper circuit.**

## Requirements

**Tools/Equipments/Instruments**

- Trainees tool kit - 1 Set
- Function Generator - 1 No
- Oscilloscope 20 MHz - Dual trace - 1 No
- Regulated DC power supply 0-30V/2A - 1 No
- Digital multimeter with probe - 1 No

**Materials/Components**

- Diode 1N 4007 - 1 No
- Resistor 10 kΩ/¼ W/CR25 - 1 No
- Breadboard - 1 No
- Hook up wires - as reqd

## PROCEDURE

TASK 1 : **Construction and testing of positive shunt clipper circuit using discrete components**

1 Collect the components identify the diode number and cathode terminal.

2 Carry out quick test to confirm good working condition of the given diode using multimeter

3 Construct the positive shunt clipper circuit as shown in Fig 1 and verify the circuit connection by the Instructor.

4 Switch on the 5 VDC power supply to the shunt clipper circuit.

5 Set the function generator to sinewave output with 1kHz 10 $V_{P-P}$.

6 Prepare the CRO for meaurements.

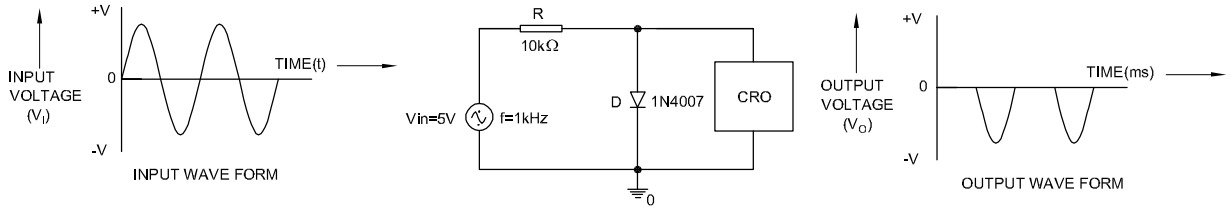
7 Observe the input waveform, output clipped waveform and record them in Table 1.

8 Use DMM measure the input, output voltages and record the radings in Table 1.

Table - 1

| Sl. No. | Voltage | Waveform | Voltage as per CRO | Voltage as per DMM | Remarks |
|---|---|---|---|---|---|
| 1 | Input voltage | | | | |
| 2 | Output voltage | | | | |

Fig 1




9 Get the work checked by the Instructor.

– – – – – – –

TASK 2 : **Construction and testing of negative shunt clipper**

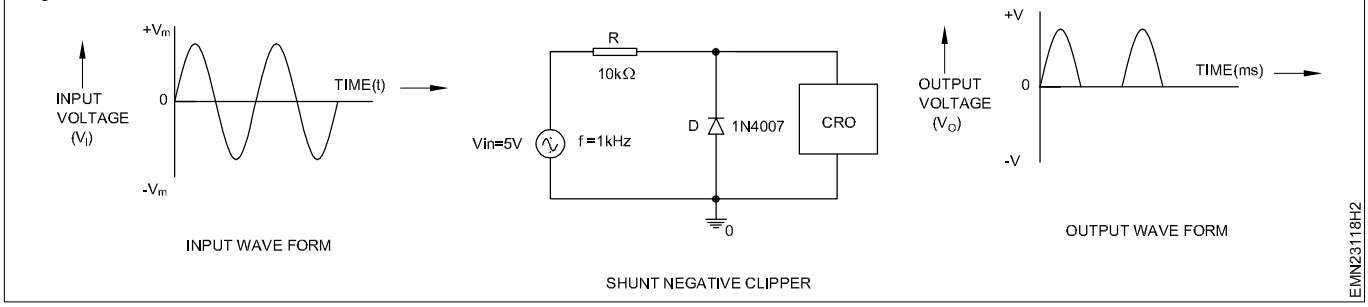
1 Modify the polarities of the diode as shown in Fig 2 for negative shunt clipper circuit.

2 Repeat steps 4 to 8 of Task 1 and record the readings in Table 2

Table - 2

| Sl. No. | Voltage | Waveform | Voltage as per CRO | Voltage as per DMM | Remarks |
|---|---|---|---|---|---|
| 1 | Input | | | | |
| 2 | Output | | | | |

Fig 2




3 Ge the work checked by the Instructor.

– – – – – – –

# Construct and test series and dual clipper circuit using diodes

**Objectives :** At the end of this exercise you shall be able to
- **construct and test series negative clipper circuit using diode**
- **construct and test series positive clipper circuit using diode**
- **construct and test dual clipper circuit using diode.**

## Requirements

**Tools/Equipments/Instruments**

- Trainees tool kit - 1 Set
- Function Generator - 1 No
- CRO 20 MHz - Dual trace - 1 No
- Regulated DC power supply 0-30V/2A - 1 No
- Digital multimeter with probes - 1 No

**Materials/Components**

- Diode 1N 4007 - 1 No
- Resistor 10 kΩ /¼ W/CR25 - 1 No
- Breadboard - 1 No
- Hook up wires - as reqd

## PROCEDURE

TASK 1 : **Construction and testing of series negative clipper circuit using discrete components**

1 Collect the components, identify the diode number and cathode terminal.

2 Carry out quick test to confirm good working condition of the given diode using multimeter.

3 Construct the series negative clipper circuit as shown in Fig 1 on breadboard and verify the circuit connection by the Instructor.

4 Switch ON the 5 VDC power supply to the series negative clipper circuit.

5 Set the function generator to sinewave output with 1kHz 10 $V_{P-P}$.

6 Prepare the CRO for meaurements.

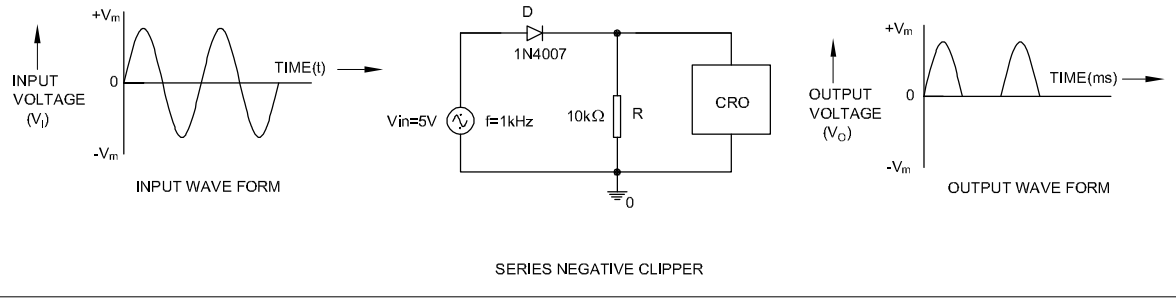
7 Observe the input waveform, output clipped waveform and record them in Table 1.

8 Use DMM measure the input, output voltages and record the readings in Table 1.

Table - 1

| Sl. No. | Voltage | Waveform | Voltage as per CRO | Voltage as per DMM | Remarks |
|---|---|---|---|---|---|
| 1 | Input | | | | |
| 2 | Output | | | | |

Fig 1




9 Get the work checked by the Instructor.

– – – – – – –

TASK 2 : **Construction and testing of series positive clipper**

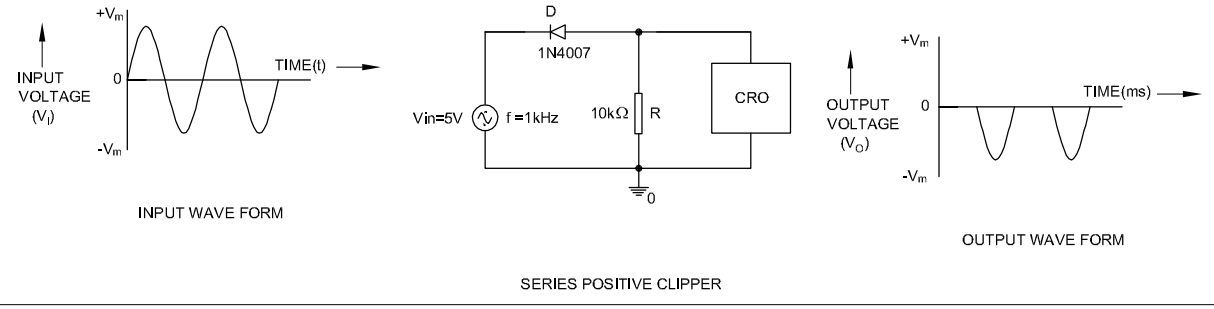
1 Modify the polarities of the diode as shown in Fig 2 for series positive clipper circuit.

2 Repeat steps 4 to 8 of Table 1 and record the readings in Table 2.

Table - 2

| Sl. No. | Voltage | Waveform | Voltage as per CRO | Voltage as per DMM | Remarks |
|---|---|---|---|---|---|
| 1 | Input | | | | |
| 2 | Output | | | | |

Fig 2




3 Get the work checked by the Instructor.

– – – – – – –

TASK 3 : **Construction and testing of dual Clipper Circuit using discrete components**

1 Collect the components, check them and assemble the dual clipper circuit on breadboard as shown in Fig 1.

2 Set 2V DC on both the sections of dual DC power supply and connect as V1 AND V2 as shown in the circuit.

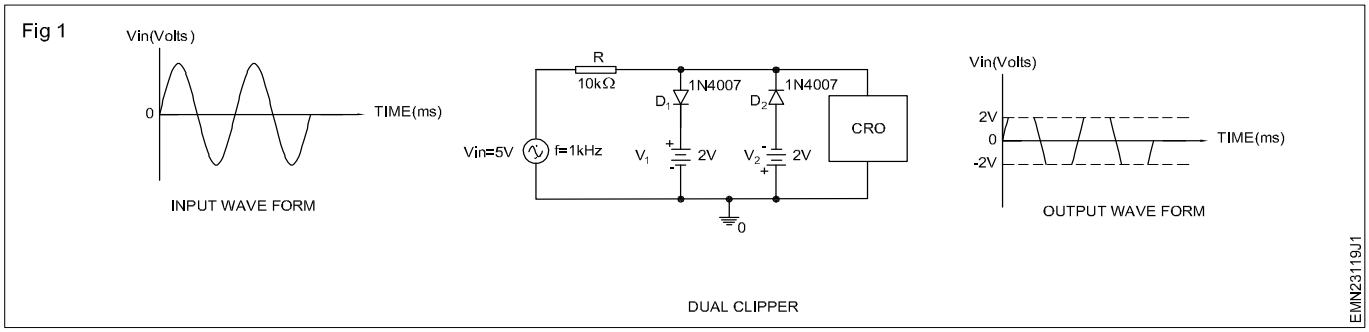
3 Check and verify the circuit connection by the linstructor.

4 Repeat steps 4 to 8 of Task 1 and record the readings in Table 3.

Table - 3

| Sl. No. | Voltage | Waveform | Voltage as per CRO | Voltage as per DMM | Remarks |
|---|---|---|---|---|---|
| 1 | Input | | | | |
| 2 | Output | | | | |

Fig 1




5 Ge the work checked by the Instructor.

– – – – – – –

# Construct and test clamper circuit using diodes

**Objectives :** At the end of this exercise you shall be able to
- **construct and test a positive clamper circuit using diode**
- **construct and test a negative clamper circuit using diode.**

## Requirements

**Tools/Equipments/Instruments**

- Trainees tool kit - 1 Set
- Function Generator 0-1 MHz - 1 No
- Oscilloscope 20 MHz - Dual trace - 1 No
- Regulated DC power supply 0-30V/2A - 1 No
- Digital multimeter with probes - 1 No

**Materials/Components**

- Diode 1N 4007 - 1 No
- Resistor 10 kΩ /¼ W/CR25 - 1 No
- Capacitor 0.1 µF/25VDC - 1 Nos
- Breadboard - 1 No
- Connecting wires/Hook up wires - as reqd

## PROCEDURE

TASK 1 : **Construction and testing of positive clamper circuit using discrete components**

1 Collect all the components required identify the diode number and cathode terminal.

2 Carryout quick test to confirm good working condition of the given diode using multimeter.

3 Construct the positive clamper circuit as shown in Fig 1 on breadboard.

4 Check and verify the circuit connection by the Instructor.

5 Switch ON the 5 VDC power supply to clamper circuit.

**Safety precautions: Ensure the variable DC power supply control zero volt position.**

6 Set the Sinewave generator frequency to 1kHz and its output amplitude to 10 $V_{p-p}$.

7 Prepare the CRO for measurements.

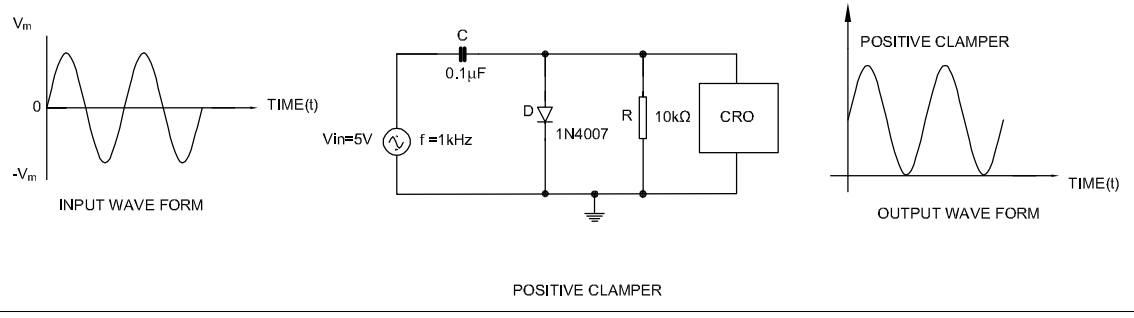
8 Observe the output waveform on the CRO, and record the amplitude and time period from the waveforms in Table 1.

9 Measure the clamped voltage verify with the input voltage using DMM and record the observations in Table 1.

Table - 1

| Sl. No. | Voltage | Waveform | Voltage as per CRO | Voltage as per DMM | Remarks |
|---|---|---|---|---|---|
| 1 | Input | | | | |
| 2 | Output | | | | |

Fig 1




10 Get the work checked by the Instructor.

– – – – – – –

TASK 2 : **Construction and testing of negative clamper circuit using discrete components**

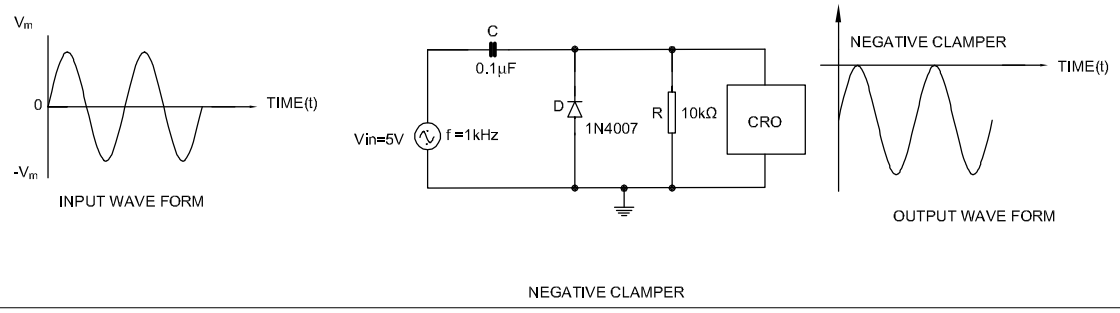
1 Modify the polarities of the diode as shown in Fig 2 for negative clamper circuit.

2 Repeat stpes 4 to 9 of Task 1 and record the observations in Table 2.

Table - 2

| Sl. No. | Voltage | Waveform | Voltage as per CRO | Voltage as per DMM | Remarks |
|---|---|---|---|---|---|
| 1 | Input | | | | |
| 2 | Output | | | | |

Fig 2




3 Get the work checked by the Instructor.

– – – – – – –

# Construct and test zener diode as a peak clipper

**Objectives :** At the end of this exercise you shall be able to
- **construct zener diode circuit as peak clipper**
- **test zener diode circuit.**

## Requirements

**Tools/Equipments/Instruments**

- Trainees tool kit - 1 Set
- Function Generator 0-1MHz - 1 No
- Oscilloscope 20 MHz - Dual trace - 1 No
- Regulated DC power supply 0-30V/2A - 1 No
- Digital multimeter with probes - 1 No

**Materials/Components**

- Zener Diode BZX55 or equivalent - 1 No
- Resistor 1kΩ /¼ W/CR25 - 1 No
- Breadboard - 1 No
- Connecting wires/Hook up wires - as reqd

**Aids:** Semiconductor data manual - as reqd

## PROCEDURE

TASK 1 : **Construction of peak clipper Circuit using Zener Diode**

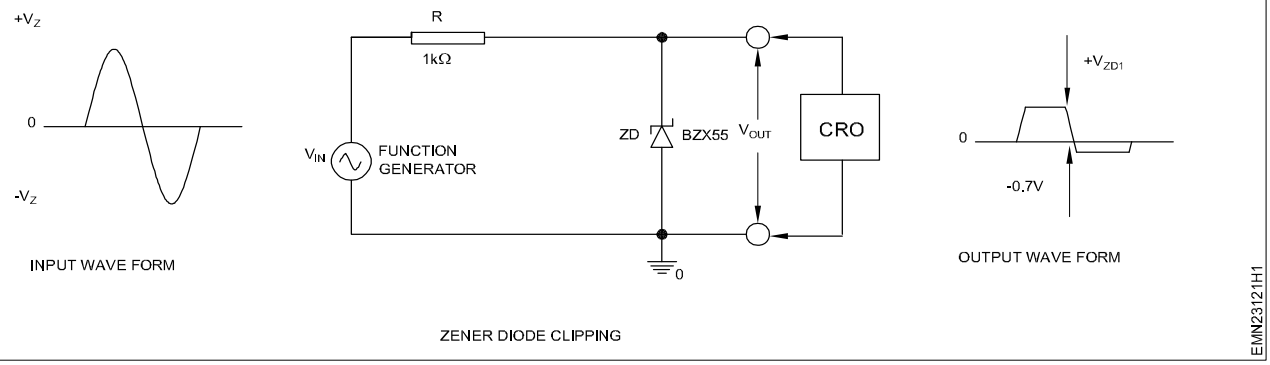
1 Collect the components and identify the Zener diode number and cathode terminal.

2 Carry out quick test to confirm good working condition of the given diode using multimeter.

3 Construct the peak clipper circuit as shown in Figure 1.

4 Check and verify the circuit connection by the Instructor.

Fig 1

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TASK 2 : **Test the clipper circuit**

1 Switch ON the 5 VDC power supply to the peak clipper circuit.

2 Switch ON the signal generator, apply Sinewave input amplitude greater than the clipping level of the zener diode.

3 Prepare the CRO for measurements.

4 Observe the output waveform on the CRO, record the amplitude and time period from the waveform in Table 1.

5 Measure the clipped voltage, verify with the input voltage using DMM and record the observations in Table 1.

Table - 1

| Sl. No. | Voltage | Waveform | Voltage as per CRO | Voltage as per DMM | Remarks |
|---|---|---|---|---|---|
| 1 | Input | | | | |
| 2 | Output | | | | |

6 Get the work checked by the Instructor.

– – – – – – –

# Identify different power electronic components, their specification and terminals

**Objectives :** At the end of this exercise you shall be able to
- **identity the terminals of FET, UJT and its specification using data manual**
- **identify the terminals of SCR, TRIAC, DIAC and its specification using data manual.**

## Requirements

**Tools/Equipments/Instruments**

- Trainees tool kit - 1 Set
- Semiconductor data manual for the active devices used for this exercise - as reqd
- Digital multimeter with probes - 1 No

  Aids: Chart showing the pin out diagram of active devices used for this exercise - as reqd

**Material/Components**

- Assorted types of N-Channel FET - 3 Nos
- Assorted types of SCR - 3 Nos
- Assorted types of UJT - 2 Nos
- Assorted types of TRIAC - 2 Nos
- Assorted types of DIAC - 2 Nos
- Plastic sleeves (2mm dia)-Red, Green, Yellow, Black - 1 M each

**Note: The instructor has to label the active devices used for this exercise**

## PROCEDURE

TASK 1 : **Identification of leads of given FETs and its specifications using Data manual**

1 Collect the components and pick a labelled FET from the assorted lot record the code number of the FET and enter against its label number in Table 1.

2 Draw the pinout package diagram, refer to the chart/ data manual/identify and record the following important specification of the FET based on its type Number, package type,
- Polarity of the device (N-type/P-type)
- Maximum drain-source Voltage, $V_{DS}$
- Maximum gate-source Voltage, $V_{GS}$
- Maximum drain current, $I_D$.
- Maximum forward gate current, $I_G$.
- Pinch-off Voltage (at $I_D$ =0), $V_P$.
- Maximum power dissipation, $P_{max}$

3 Put sleeves of suitable length to the leads following the colour scheme given below.

Drain - Red

Source - Green

Gate - Yellow

Shield - Black

4 Repeat steps 1 to 3 for the remaining labelled FETs.

Table 1

| Sl. No. | Label | FET No. | Type | $V_{DS}$ | $V_{GS}$ | $I_D$ | $I_G$ | $V_P$ | $P_{max}$ | Package/ diagram pintout |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | | | | | | | | | | |
| 2 | | | | | | | | | | |
| 3 | | | | | | | | | | |

5 Get the work checked by the Instructor.

– – – – – – –

TASK 2 : **Identifications of UJT by its code number**

1 Pick a labelled UJT, record the code number, refer to the data manual find and record the specification of the given UJTs in Table 2.

2 Draw the pinout/package diagram and mark the terminal.

Table 2

| Sl.No | Type Label No. | Device code number | $I_P$ | $I_V$ | $R_{BB}$ | h | Package pinout diagram |
|---|---|---|---|---|---|---|---|
| 1 | | | | | | | |
| 2 | | | | | | | |

3 Get the work checked by the Instructor.

– – – – – – –

TASK 3 : **Identification and specifications of SCR by its code number**

1 Collect the components from the instructor and pick one of the labelled SCR from the assorted lot, note down the SCR label number and its Code number printed on the SCRI in Table 3.

2 Draw the package/pinout diagram of SCR identify the terminals of SCR referring to the data manual, and record the specifications in Table 3.

**In some power SCRs, the metal case itself will act as anode. Mark "A' on the case using a pencil or put a RED colour dot using colour marker pen.**

3 Repeat above steps for remaining labelled SCRs from the assorted lot.

Table 3

| Sl. No. | Label No | Code number of SCR | $V_{RRM-}$ | $I_{T(RMS)-}$ | $I_{TSM}$ | $I_{GT}$ | $V_{GT}$ | $I_H$ | Package/ pinout diagram |
|---|---|---|---|---|---|---|---|---|---|
| 1<br>2<br>3 | | | | | | | | | |

4 Get the work checked by the Instructor.

– – – – – – –

TASK 4 : **Identification of leads of given TRIAC and its specifications using data manual**

1 Pick a labelled TRIAC from the given lot, record the code number of the TRIAC against its label number in Table 4.

2 Draw the pinout/package diagram, refer to the chart/ data manual, identify and record the important specifications used on the code number in Table 4.

3 Repeat above steps for the remaining labelled TRIAC and record the observations in Table 4.

Table 4

| Sl. No. | Label No. | Code number | Votage off state | Current on-state ($I_t$) | Voltage gate trigger ($V_{gt}$) | Current gate trigger ($I_{gt}$) | Package pinout diagram |
|---|---|---|---|---|---|---|---|
| 1 | | | | | | | |
| 2 | | | | | | | |

4 Get the work checked by the Instructor.

– – – – – – –

TASK 5 : **Identification of leads of given DIAC and its specifications using data manual**

1 Pick a labelled DIAC from the given lot, record the code number against its label number in Table 5.

2 Draw the package/terminal diagram, refer to the datasheet, identify and record the important specifications of the DIAC in Table 5.

3 Repeat above steps for the remaining labelled DIACs and record the observations in Table 5.

Table 5

| Sl.No | Label No. | Code number | $V_{BO}$ | $I_{TRM}$ | $T_j$ | Package pinout diagram |
|---|---|---|---|---|---|---|
| 1 | | | | | | |
| 2 | | | | | | |

4 Get the work checked by the Instructor.

– – – – – – –

# Construct and test a FET Amplifier

**Objectives :** At the end of this exercise you shall be able to
- **construct a voltage amplifier using a JFET**
- **measure the gain of JFET amplifier with different input voltages**
- **calculate the gain of the amplifier at different frequencies.**

## Requirements

**Tools/Equipments/Instruments**

- Trainees tool kit - 1 Set
- Regulated DC power supply 0-30V/2A - 1 No
- Function generator - 1 No
- Soldering iron 25W/240VAC - 1 No
- Oscilloscope 0-20 MHz Dual trace - 1 No
- Digital multimeter with probes - 1 No

**Materials/Components**

- Assorted types of N-channel JFET - 4 Nos
- Plastic sleeves Red, Green, Yellow, Black (each of 10mm length) - 4 Nos

**Aids:** Semiconductor data manual/ data sheet of the FET - as reqd

- Capacitors
  - 5.6 nF/25V DC - 1 No
  - 270 nF/25V DC - 1 No
  - 6.8 µF/25V - 1 No
- Resistors, ¼ W/CR25
  - 10 kΩ - 1 No
  - 12 kΩ - 1 No
  - 47 kΩ - 1 No
  - 1 MΩ - 1 No
- Solder, flux - as reqd
- Hook up wires - as reqd

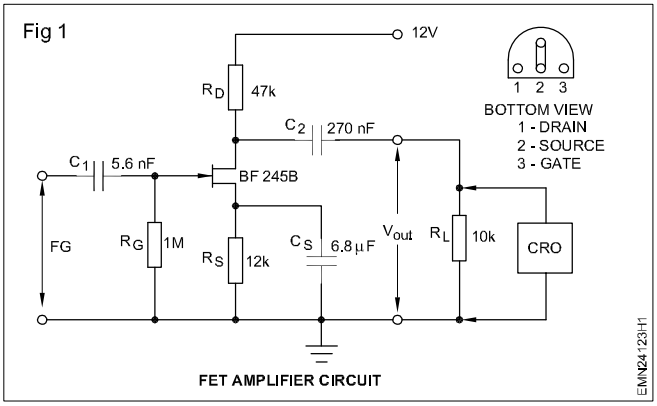
**One of the given JFET should be a BF 245B or BFW 10 or equivalent.**

TASK 1 : **Construction and testing of FET amplifier**

1 Collect the required components, test and assemble the FET amplifier as shown in Fig 1.

**Construct the circuit on a bread board or on a GPCB.**

Fig 1




FET AMPLIFIER CIRCUIT

2 Get the assembled circuit checked by the instructor.

3 Switch ON the 12 VDC to the circuit.

4 Set the function generator output with sinewave at 10 kHz, 100 $mV_{p-p}$ as the input to the FET amplifier.

5 Prepare the CRO for measurements and observe the output across the $R_L$.

6 Record the output reading in Table 1.

**Table 1**

| Input frequency : 10 kHz | | | |
|---|---|---|---|
| Sl. No. | Input voltage (mV) | O/P voltage | Gain= Output voltage / Input voltage |
| 1 | 100 | | |
| 2 | 200 | | |
| 3 | 300 | | |
| 4 | 400 | | |
| 5 | 500 | | |
| 6 | 600 | | |
| 7 | 700 | | |
| 8 | 800 | | |
| 9 | 900 | | |
| 10 | 1000 | | |

7 Increase the input voltage in steps of 100 mV upto 1V, record the observation in Table 1.

8 Calculate gain for each setting of input and record them.

9 Get the work checked by the Instructor.

– – – – – – –

TASK 2 : **Measurement of gain of FET amplifier at different frequencies**

1 Set the function generator output with sinewave at 20 kHz- 400 mV, switch ON the FET amplifier

2 Measure the output across $R_L$ using CRO and record the readings in Table 2.

**Table 2**

| Input volt 400mV | | |
|---|---|---|
| Frequency kHz | O/P Voltage | Gain = $\frac{\text{Output voltage}}{\text{Input voltage}}$ |
| 40<br>80<br>100<br>120<br>150 | | |

3 Increase the signal frquency from 20 kHz in steps of 20 kHz, measure the output voltage and record the readings in Table 2.

4 Calculate the gain for each setting of input and record them.

5 Get the work checked by the Instructor.

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# Construct and test a circuit of SCR using UJT triggering

**Objectives :** At the end of this exercise you shall be able to
- **construct and test of SCR using UJT triggering.**

## Requirements

**Tools/Equipments/Instruments**

- Digital multimeter with probes - 1 No
- Trainees tool kit - 1 Set
- AC Power supply (0-250V) - 1 No
- CRO, 0-20MHz-Dual channel - 1 No

**Materials/ Components**

- Stepdown transformer 230V/0-12V/500mA - 1 No
- Diode 1N4007 - 2 Nos
- Zener diode 12V/1W - 1 No
- LED-5mm/Red - 1 No
- UJT 2N2646 - 1 No

  **Aids:** Semiconductor data manual data sheet of the LOT and SCR - as reqd
- Miniature toggle switch SPST - 2 Nos
- SCR.Ty 6004 - 1 No
- Variable Resistor pot 100 K - 1 No
- Lamp 12V/5W with holder - 1 Set
- Capacitor 100 μF/25V, 10 μF/25V - 1 No each
- Resistor
  - 100 Ω - 2 Nos
  - 12 Ω - 1 No
  - 4.7 kΩ - 1 No
  - 3.3 kΩ - 1 No
  - 560 Ω - 1 No
  - 1 kΩ - 1 No
- Gen purpose PCB - 1 No
- Rosin cored solder - as reqd
- Hook up wire - as reqd

## PROCEDURE

TASK 1 :

1 Collect all the components required, test them and confirm their working condition.

2 Plan the layout of components on the General purpose PCB, assemble the circuit as shown in Fig 1.

3 Verify the connections and get the assembled circuit checked by the Instructor.

4 Keep switch S2 open, switch ON mains supply to transformer, observe the LED is ON.

5 Measure the DC voltage at cathode of zener diode, B1 & B2 terminals of UJT and record the readings in Table 1.

**Table 1**

| Voltage across | | | Waveform across | |
|---|---|---|---|---|
| Zener diode | UJT B1 | B2 | B2 | Lamp |
| | | | | |

6 Prepare CRO for measurements and observe the Pulse waveform at B2 terminal of UJT.

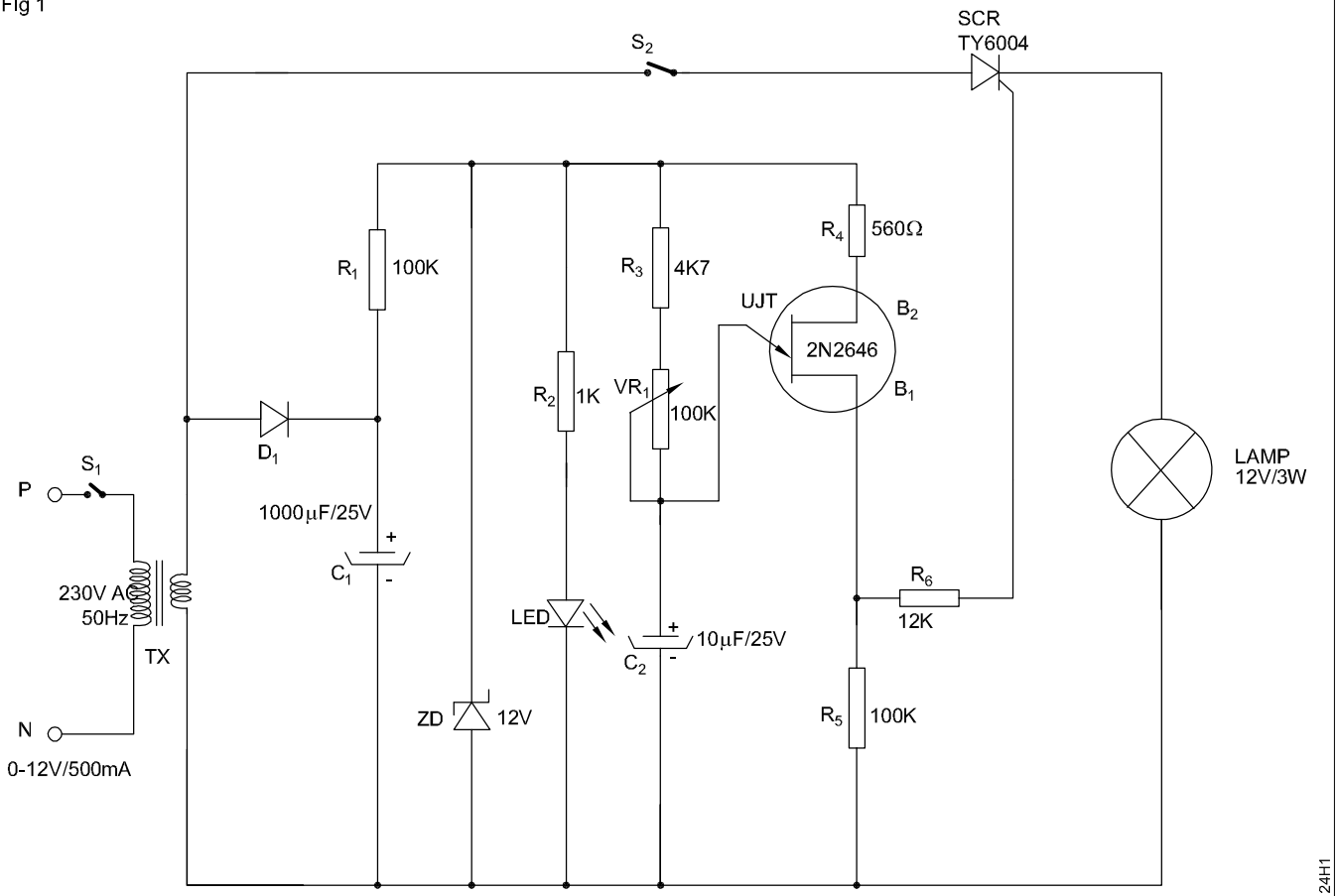
7 Close the switch S2 to allow AC supply to SCR, observe the Lamp is ON.

8 Measure the waveform across the Lamp and record the observations in Table 1.

9 Get the work checked by the Instructor.

**Note: The Instructor has to adjust the preset slightly and observe the pulse frequency waveform, explain the reasons to trainees.**

Fig 1




UJT TRIGGERED SCR CIRCUIT

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# Identify different heatsinks used in SCRs

**Objective :** At the end of this exercise you shall be able to
- **to identify different shapes and sizes of heatsinks used for SCRs.**

## Requirements

**Tools/Equipments/Instruments**

- Trainees tool kit - 1 Set
- International SCR data book - 1 No
- Data sheets of SCRs - as reqd
- Chart showing all types of heatsinks used for SCRs - 1 No

**Materials /Components**

- SCR with assorted rating (T0-3, T0-3P, T0-92, T0-220, T0-220AB, T0-126, T0-208AC, T0-247, T0-65, T0-32) - 10 Nos
- Heat sinks for given SCR packages - 10 Nos

**Note:**

**1 The Instructor has to provide minimum one SCR in each package type with label for all ratings of voltage/current and physical sizes.**

**2 Label all the heatsinks provided for this exercise with different method of coding.**

## PROCEDURE

1 Pick one of the labelled SCR, refer to data book identify the ratings package type etc., record those parameters in Table 1.

2 Repeat the above steps for all the labelled SCRs.

3 Identify the heat sink required for given SCR according to SCR current rating/Junction temperature with reference to the Chart 1.

4 Repeat the above step for the labelled items.

Table 1

| Sl.No | SCR Label | Code number on SCR | Package type | Voltage rating | Current rating | $V_{GT}$ | $I_{GT}$ | $T_J$ Junction temperature | Remarks |
|---|---|---|---|---|---|---|---|---|---|
| 1 | | | | | | | | | |
| 2 | | | | | | | | | |
| 3 | | | | | | | | | |
| 4 | | | | | | | | | |
| 5 | | | | | | | | | |
| 6 | | | | | | | | | |
| 7 | | | | | | | | | |
| 8 | | | | | | | | | |
| 9 | | | | | | | | | |
| 10 | | | | | | | | | |

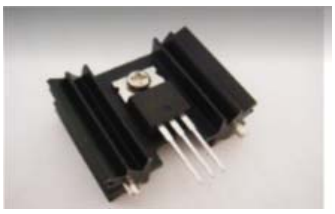
Table 2

| Sl. No. | Heatsink Label No. | Suitable for SCR type Package No. | Remarks |
|---|---|---|---|
| | | | |

5 Get the work checked by the Instructor.

**Chart 1**

1



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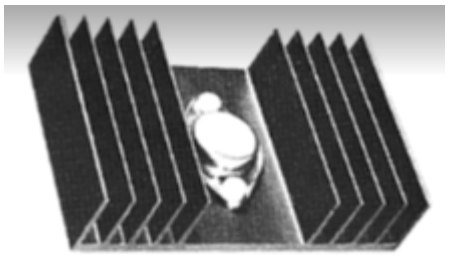

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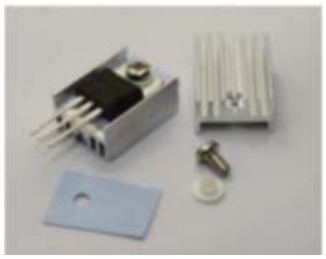
6



7

8

50 W

9

100 W

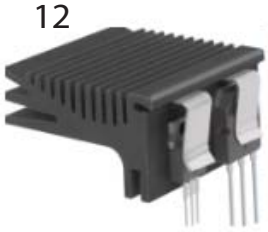
10

200W

11

300W

12



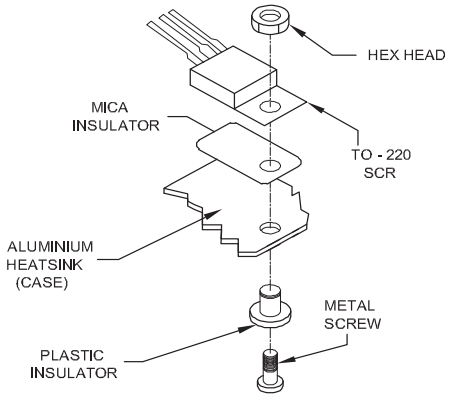
13

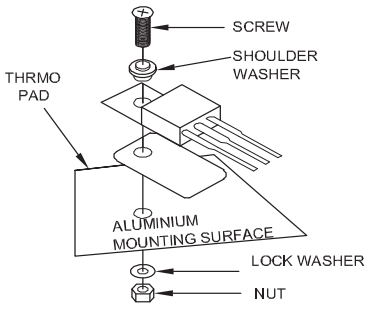
14

500W

15

1000W




MOUNTING METHODS OF MOSFET ON HEATSINK

# Construct a snubber circuit for protecting SCR use freewheeling diode to reduce back emf

**Objective :** At the end of this exercise you shall be able to
- **construct a snubber circuit for protecting SCR and use free wheeling diode to reduce back emf.**
- **measure the waveform of gate trigger pulse and across the load.**

## Requirements

**Tools/Equipments/Instruments**

- Trainees tool kit - 1 Set
- Variac (0-260 VAC/5A) - 1 No
- Digital multimeter with probes - 1 No
- CRO, 0-20MHz Dual channel - 1 No
- Pulse generator/Function generator - 1 No

**Materials/Components**

- General purpose printed circuit Board - 1 No
- Resistors
  120Ω, 100Ω/1W - 1 No each
  30 VDC motor/2A - 1 No
  SCR TY6004 - 2 Nos
  Capacitor 680pF/1KV - 1 No
  DPST Switch - 1 No

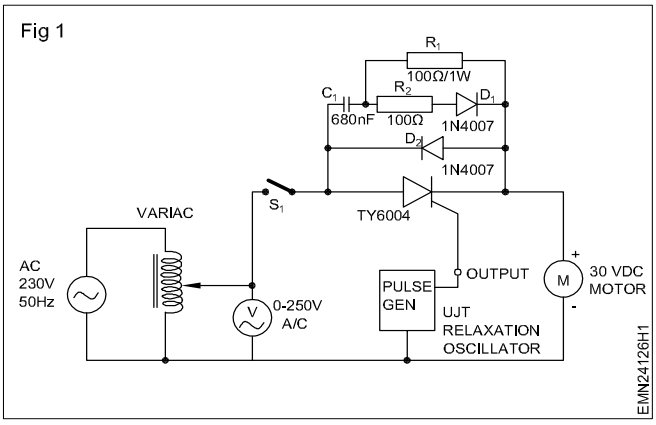
**Note: The instructor may use the assembled circuit of previous Ex.No.2.4.124 for this task with necessary additional components for snubber circuit across the SCR.**

## PROCEDURE

TASK 1 : **Construction snubber circuit for protecting SCR with free wheeling diode**

1 Collect all the components, check them plan the lay-out of the circuit shown in Fig 1 on the general purpose PCB.

Fig 1




2 Fix the component as per the layout assemble the snubber circuit for SCR.

3 Get the assembled snubber circuit checked by the Instructor.

4 Connect the load (DC motor) and the pulse generator to the SCR circuit.

5 Keep the variac in zero volt position and connect to the AC mains supply.

6 Switch ON and adjust prepare the CRO for measurements.

7 Switch ON the AC mains supply, adjust /set the ouput of variac at 30 VAC to the circuit.

8 Switch ON the pulse generator and apply the gate triggering pulse to the SCR.

9 Measure the waveform at gate terminal across the load, and across the SCR.

10 Record the observation in Table 1.

Table 1

| Sl. No | Test point | Waveform measured | Remarks |
|---|---|---|---|
| 1 | Gate terminal | | |
| 2 | Across load | | |
| 3 | Across SCR | | |

11 Get the work checked by the Instructor.

– – – – – – –

# Construct a jig circuit to test DIAC

**Objectives :** At the end of this exercise you shall be able to
- **construct the test jig circuit for DIAC**
- **test the DIAC in both directions.**

## Requirements

**Tools/Equipments/Instruments**

- Trainees tool kit - 1 Set
- Regulated DC power supply 0-30V/2A - 1 No
- Ammeter 0-5 mA (MC) - 1 No
- Voltmeter 0-50V DC (MC) - 1 No
- Digital multimeter with probes - 1 No
  **Aids:** Semiconductor data manual /data sheet of the DIAC - as reqd

**Materials/Components**

- DIAC DB3 or equivalent - 1 No
- Resistor 5kΩ/5W - 1 No
- Breadboard - 1 No
- Hook up wires - as reqd

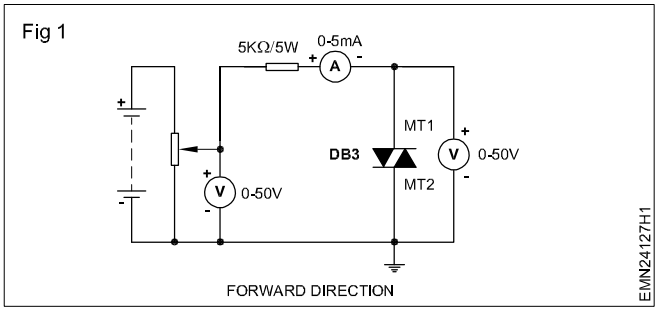
## PROCEDURE

TASK 1 : **Testing the DIAC in one direction**

1 Collect the DIAC and identify the terminals with reference to the Data sheet, note down the rating of the DIAC $V_{BO}$ - $I_{BO}$.

2 Assemble the circuit on breadboard as shown in Fig 1.

Fig 1




3 Switch ON the DC power supply unit, increase the voltage to 5V.

4 Observe the ammeter, measure the voltage across DIAC and record the readings in Table 1.

5 Increace the DC voltage in steps of 5V upto 25V, record the readings.

**Note: After reached 25V DC, carefully increase the voltage and observe the breakover of the DIAC.**

6 Slowly increase the voltage in steps of 2V upto 30V and record the readings.

Table 1

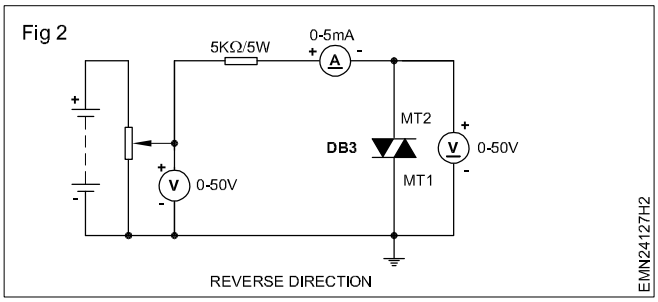
| Sl. No. | Applied Voltage | Current | Voltage across DIAC | Remarks |
|---|---|---|---|---|
| 1 | 5V | | | |
| 2 | 10V | | | |
| 3 | 15V | | | |
| 4 | 20V | | | |
| 5 | 25V | | | |
| 6 | 27V | | | |
| 7 | 29V | | | |
| 8 | 30V | | | |

7 Get the work checked by the Instructor.

TASK 2: **Testing the DIAC in opposite direction**

1 Reserve the polarity of the DIAC and connect the circuit as shown in Fig 2.

Fig 2




2 Repeat steps 3 to 6 and recosrd the readings in Table 2.

Table 2

| Sl. No. | Applied Voltage | Current | Voltage across DIAC | Remarks |
|---|---|---|---|---|
| 1 | 5V | | | |
| 2 | 10V | | | |
| 3 | 15V | | | |
| 4 | 20V | | | |
| 5 | 25V | | | |
| 6 | 27V | | | |
| 7 | 29V | | | |
| 8 | 30V | | | |

3 Get the work checked by the Instructor.

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# Construct a simple dimmer circuit using TRIAC

**Objectives:** At the end of this exercise you shall be able to
- **assemble and test a lamp dimmer circuit using TRIAC and DIAC**
- **test the lamp dimmer circuit using domestic fan.**

## Requirements

**Tools/Equipments/Instruments**

- Soldering iron 25W/230V - 1 No
- Trainees tool kit - 1 Set
- Lamp load (60 watts 230V) with holder - 1 No
- Digital multimeter with probes - 1 No

**Materials/Components**

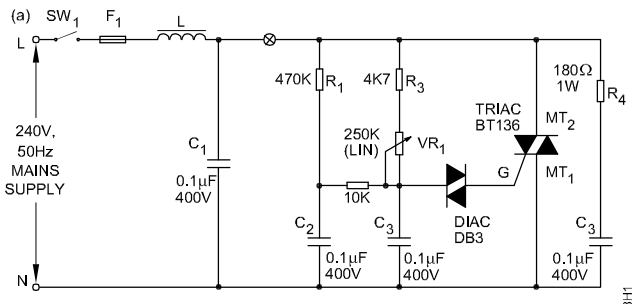
- Printed circuit Board, (as Fig 2) - 1 No
- Resistors 180 ohms 1W, carbon film - 1 No
  4.7 kΩ, ½ W - 1 No
  470 kΩ, ½ W - 1 No
- Potentiometer 250kΩ, 16 mm plastic shaft - 1 No
- Capacitor 0.1 μF 400 volts - 3 Nos
- TRAIC BT136 or equivalent - 1 No
- DIAC D3202 or equivalent - 1 No
- Inductor / Choke - 1 No
  (25 SWG,40 turns on 10mm ferrite rod with former made of leatheroid paper)
- SPST switch flush type, 5 amps, 240V - 1 No
- Knob (for potentiometer) - 1 No
- 2 core mains cord, 240V/5 amps - 1 No
- Solder and Flux - as reqd
- Fuse 500 mA - 1 No
- Connecting wires - as reqd
- 2 core twisted pair flexible wire - 1 No

## PROCEDURE

TASK 1: **Construction and testing of lamp dimmer using TRIAC and DIAC**

1 Collect all the required components to assemble the circuit as shown in Fig 1

Fig 1

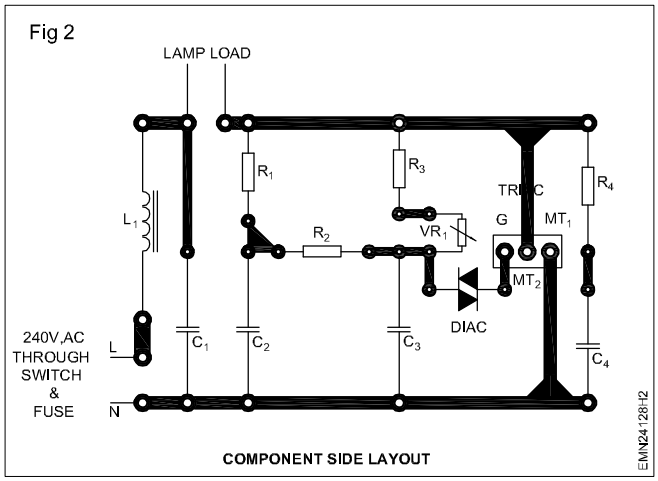



2 Plan the layout of components on the Gen.purpose PCB.

**Use the dimmer circuit PCB if available as shown**

3 Assemble the lamp dimmer circuit reference to the schematic diagram shown in Fig 1 & PCB layout diagram shown in Fig 2.

Fig 2




4 Get the wired circuit checked by the Instructor.

5 Connect the load and keeep the lamp on a safe place to avoid heatung nearby items.

6 Switch ON AC mains supply to the circuit, observe the lamp and increase the potentiometer position to the maximum brightness

7 Gradually decrease lamp brightness, and record the observations in Table - 2 (as dim, bright,very bright).

8 Get the work checked by the Instructor.

– – – – – – –

TASK 2 : **Testing the lamp dimmer circuit to control the speed of domestic Fan**

1 Remove the lamp load and connect the domestic fan across the terminals.

2 Keep the potentiometer at minimum position, switch ON AC mains supply to the circuit, gradually increase to maximum observing the rotation of fan speed.

3 Gradually decrease the speed and record the observations in Table 2 (as slow, medium, or fast).

4 Get the work checked by the instructor.

Table 1

| Sl. No. | Potentiometer position | Fan speed | Remarks |
|---|---|---|---|
| 1 | Minimum | | |
| 2 | Middle | | |
| 3 | Maximum | | |

– – – – – – –

# Construct UJT based free running oscillator and change its frequency

**Objectives:** At the end of this exercise you shall be able to
- **construct and test free running oscillator**
- **measure time period and frequency.**

## Requirements

**Tools/Equipments/Instruments**

- Trainees tool kit - 1 Set
- CRO dual trace 20MHz - 1 No
- Regulated DC power supply 0-30V/2A - 1 No
- Digital multimeter with probes - 1 No

**Materials/Components**

- UJT 2646 - 1 No
- Resistor 47 ohm 1/4W - 1 No
- 10Ω/¼ W - 1 No
- Resistor 330 Ohm/¼ W - 1 No
- Preset 47kΩ - 1 No
- Capacitor 0.1μF - 2 Nos
- Hookup wires - 1 No
- Breadboard - 1 No
- Miniature toggle switch SPST - 1 No

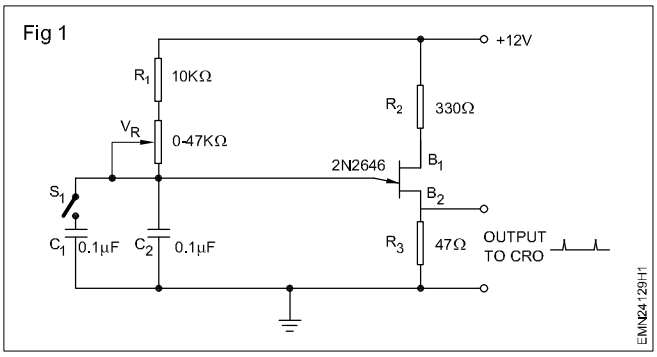
## PROCEDURE

1 Collect all the components, test them to confirm their working condition.

2 Assemble the circuit on the breadboard as shown in Fig 1

3 Get the assembled circuit checked by the instructor.

Fig 1




4 Switch ON 12VDC power supply to the circuit

5 Prepare CRO for measurements, observe keeping preset value maximum

6 Observe the waveform across resistor R3 and record them in Table - 1

7 Measure time period & frequency of waveform compare with calculated values and record it.

8 Adjust the preset, change the value of VR measure the resistance value and record in Table - 1.

9 Repeat steps 6&7

10 Close switch $S_1$ to increase the value of 'c' and repeat steps 6&7

**Table 1**

| Sl. No | Value of R | Value of C | Calculated frequency | Mesured frequency |
|---|---|---|---|---|
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |

Wave form

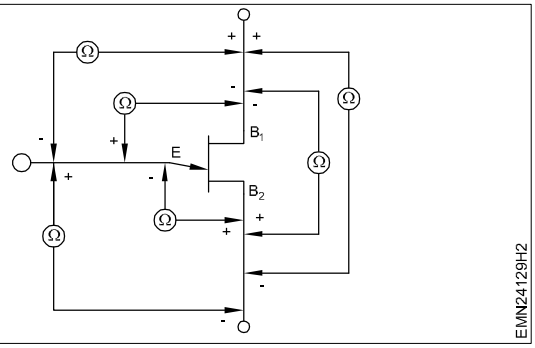
Across $R_1$

Across C

**Table 2**

| UJT No. | Resistance | | | | | | Conclusion |
|---|---|---|---|---|---|---|---|
| | $B_1$ & $B_2$ | | $B_1$ & G | | $B_2$&G | | |
| | Forward | Reverse | Forward | Reverse | Forward | Reverse | |
| | | | | | | | |

Fig 2




11 Get the work checked by the Instructor.

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# Identify various power MOSFETs by its number and test by using multimeter

**Objectives:** At the end of this exercise you shall be able to
- **identify given MOSFET type by its number and test MOSFET using multimeter.**

## Requirements

**Tools/Equipments/Instruments**

- Trainees tool kit - 1 Set
- Digital multimeter with probes - 1 No
- MOSFET Data book - 1 No

**Materials/Components**

- MOSFET IRF 540 - 1 No
  IRF Z44 - 1 No
  IRF 840 - 1 No

## PROCEDURE

TASK 1: **Identification of the given MOSFET by its number and testing with a multimeter**

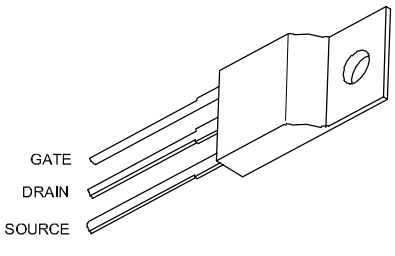
**MOSFET is easily destroyed with static electricity, always ground yourself before working with one.**

1 Note down the number, specification & type of given MOSFET by using MOSFET data book.

2 Identify which pins of the MOSFET are its source, gate and drain leads. Look up the device's part number in the MOSFET data book to verify its leads layout.

3 For testing the MOSFET using multimeter, hold the MOSFET by the case or the tab but don't touch the metal parts of the test probes with any of the other MOSFET'S terminals until needed. Do not allow a MOSFET to come in contact with your clothes, plastic or plastic products, etc. because of the high static voltages it can generate.

Fig 1




4 First, touch the multimeter positive lead onto the MOSFET'S 'Gate' and negative lead onto the source.

**This testing procedure is for use with a digital multimeter in the diode test-range with a minimum of 3.3 volt over diode-under-test. If your multi-meter battery is less than that it will not do the test. Check your meter for the specification.**

**Table 1**

| Sl. No. | MOSFET No. | $V_{GD}$ | $V_{DS}$ | $V_{GS}$ | Condition of MOSFET |
|---|---|---|---|---|---|
| | | | | | |

5 Now move the positve probe to the 'Drain'. You should get a 'low' reading. The MOSFET'S internal capacitance on the gate has now been charged up by the meter and the device is 'turned-ON'.

6 With the meter positive still connected to the drain, touch a finger between source and gate (and drain if you like, it does not matter at this stage). The gate will be discharged through your finger and the meter reading should go high, indicating a non-conductive device/high resistance condition.

**The above test means that, actually testing the cut-off voltage, which is basically the highest voltage put on the gate without making it conduct.**

7 If the meter reading is low on both sides of VGS (or) VDS, then MOSFET is short circuted/defective.

8 Get the work checked by the Instructor.

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# Identify different heatsinks used with various power MOSFET devices

**Objective:** At the end of this exercise you shall be able to
- **identify different shapes and sizes of heatsinks used for power MOSFETs.**

## Requirements

**Tools/Equipments/Instruments**

- Trainees tool kit - 1 Set
- Semiconductor data manual - 1 No

**Materials/Components**

- MOSFET with assorted rating (T0-3P, T0-220, T0-220AB, T0-247, T0-247 plus) - 5 Nos
- Heat sinks for given MOSFET - 5 Nos
- MOSFET Data book - 1 No

**Note:**

**1 The Instructor has to provide minimum on MOSFET in each package type with label for each one.**

**2 Label all the heat sinks provided with label numbers.**

## PROCEDURE

1 Pick one of the labelled MOSFET, identify the rating current capacity & junction to case thermal resistance of given MOSFET from data sheet record the parameters in Table 1.

2 Identify the heat sink required for given MOSFET according to current capacity of MOSFET with reference to the chart 1.

3 Draw the pictorial diagram & note down the specification of heat sink selected in Table 2.

4 Repeat the above steps for all the labelled items in Table 1 & 2.

**Typically an aluminum heatsink, with fins to increase the surface area, is used to dissipate this energy to air. Higher current capacity controllers use a fan to force the air to pass through the fins in order to increase heat dissipation.Water cooled heatsinks are used on MOSFET with very high current ratings.**

**Table 1**

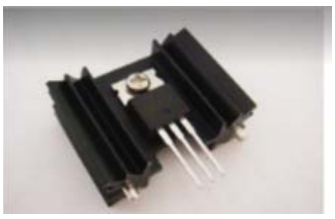
| Sl. No. | Label No. | Code no on MOSFET | package type | Voltage rating | Current rating | Junction temperature | Remarks |
|---|---|---|---|---|---|---|---|
| 1 | | | | | | | |
| 2 | | | | | | | |
| 3 | | | | | | | |
| 4 | | | | | | | |
| 5 | | | | | | | |

Table 2

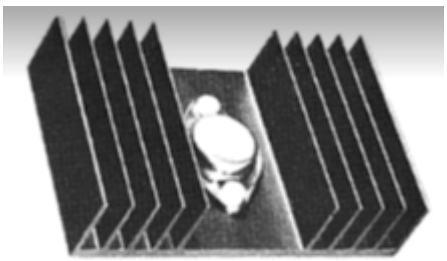
| Sl. No. | Heatsink label no. | Suitable for MOSFET number | Package type number | Heatsink outline diagram |
|---|---|---|---|---|
| 1 | | | | |
| 2 | | | | |
| 3 | | | | |
| 4 | | | | |
| 5 | | | | |

5 Get the work checked by the Instructor.

1



2

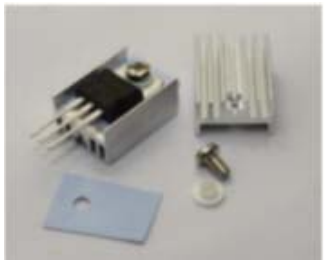


3

4

5

6



7

8

50 W

9

100 W

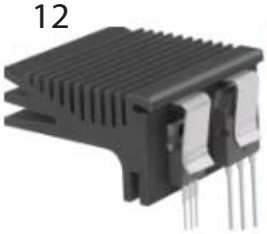
10

200W

11

300W

12



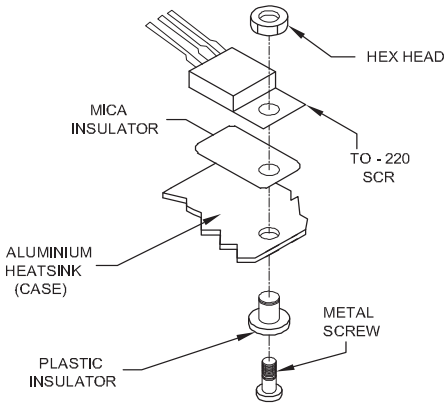
13

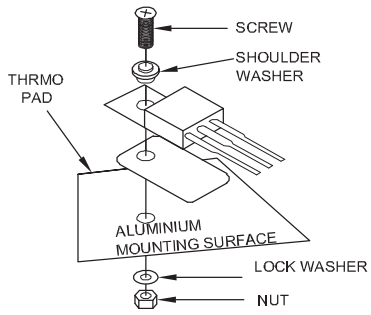
14

500W

15

1000W




MOUNTING METHODS OF MOSFET ON HEATSINK

# Construct MOSFET test circuit with a small load

**Objectives:** At the end of this exercise you shall be able to
- **to construct MOSFET test circuit with a small load.**

## Requirements

**Tools/Equipments/Instruments**

- Trainees tool kit - 1 Set
- Regulated DC power supply 0-30V/2A - 1 No
- Multimeter with probes - 1 No

**Materials/Components**

- MOSFET (assorted number) - 5 Nos
- Resistor 1kΩ, ¼ W/CR25 - 1 No
- Resistor 100 Ohm/ ¼ W/CR25 - 1 No
- Resistor 68kΩ/¼ W/CR25 - 1 No
- ON/OFF Switch - 2 Nos
- Socket for MOSFET - 1 No
- 12V lamp - 1 No
- Hook up wires - as reqd
- Solder flux - as reqd
- Connecting wires - as reqd
- PCB/Bread board - 1 No

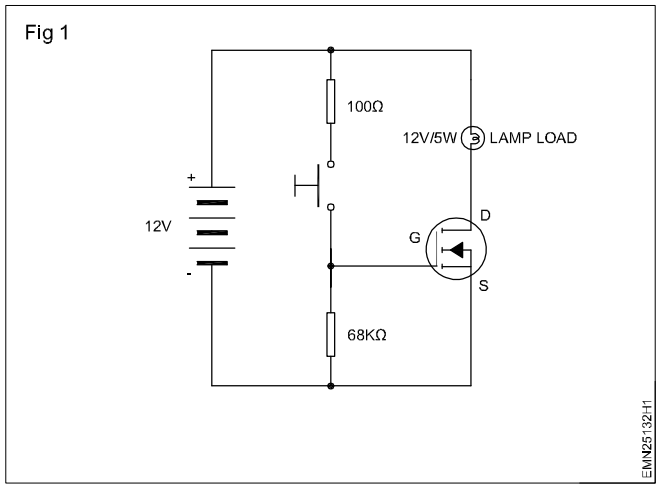
## PROCEDURE

TASK 1 :

1 Check the working condition of all given components with multimeter.

2 Assemble the circuit on bread board as shown in the circuit Fig 1.

Fig 1




3 Insert MOSFET (to be checked) in socket.

4 Power on the supply, Press switch S and observe that lamp glows. This means MOSFET is turned ON. Note down the status of lamp in Table 1.

5 Thus MOSFET act as open switch if gate voltage is zero. If gate voltage is applied then the MOSFET will act as closed switch then the working condition of MOSFET is good/ON.

6 If the MOSFET is P-channel then reverse the polarity of power supply and lamp load then check the condition of lamp load.

**Table 1**

| Sl. No. | MOSFET No. | Type | Status of lamp ON/OFF | MOSFET Condition |
|---|---|---|---|---|
| | | | | |

7 Get the work checked by the Instructor.

– – – – – – –

# Identify IGBTs by their numbers and test by using multimeter

**Objectives:** At the end of this exercise you shall be able to
- **identify IGBT by its number, specification, pin configuration type and application**
- **test IGBT by using multimeter.**

## Requirements

**Tools/Equipments/Instruments**

- Trainees tool kit - 1 Set
- Multimeter with probes - 1 No

**Materials/Components**

- IGBT with assorted rating - 5 Nos
- IGBT data book - 1 No

## PROCEDURE

TASK 1 : **Identification of IGBTs by their number, pin configuration of type**

1 Note down the number printed on given device.

2 Identify the number in data book and note IGBT type.

3 Record the specification like voltage & current rating of given IGBT in Table 1.

4 Identify the terminals gate, emitter & collector with the help of the data book.

**Table**

| Sl.No. | IGBT No. | Specifications | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | VR (Voltage Rating) | CR (Current Rating) | ID (Gate Input Drive) | II (Input Impedence) | OI (Output Impedence) | SS (Switching Speed) | Pin confi-guration | Application |
| | | | | | | | | | |

– – – – – – –

TASK 2 : **Testing of IGBT using multimeter**

1 To test IGBT with multimeter use meter in diode checking mode with battery voltage of less than 20 V.

2 To test collector emitter junction remove the conductive foam and short the gate to the emitter

3 As the multimeter is in diode check mode, the collector to emitter should give a normal diode reading with positive on the collector and negative on the emitter.

4 The multimeter should read open or infinite with collector negative and emitter positive.

5 If IGBT is damaged it may test as shorted in both positive and negative directions, open in both directions, or low resistive in both directions.

6 For gate oxide test keep the meter in resistance mode, where the resistance from gate to collector and gate to emitter should be infinite on a good device

7 If it is a damaged device it appears shorted or have leakage resistance from gate to collector and/ or emitter.

**Note: The input section of IGBT junctions like a MOSFET and the output section of IGBT functions like a bipolar juntion transistor.**

8 Get the work checked by the Instructor.

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# Construct IGBT test circuit with a small load

**Objectives:** At the end of this exercise you shall be able to
- **to determine the working condition of IGBT by using test circuit.**

## Requirements

**Tools/Equipments/Instruments**

- Trainees tool kit - 1 Set
- Regulated DC power supply 0-30V/2A - 1 No
- Multimeter with probes - 1 No

**Materials/Components**

- IGBT (5SMV 86M1731) - 5 Nos
- Resistor 1kΩ/¼ W - 1 No
- Resistor 2.2kΩ/¼ W - 2 Nos
- ON/OFF Switch - 2 Nos
- Socket for IGBT - 1 No
- Breadboard - 1 No
- 12V lamp - 1 No

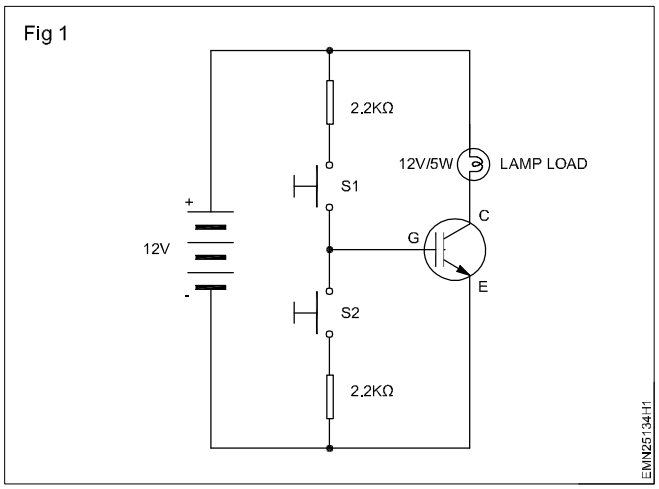
## PROCEDURE

TASK 1 : **Construction and testing of IGBT test circuit**

1 Collect and check the working condition of all the given components by multimeter.

2 Assemble the circuit on breadboard as shown in Fig 1.

Fig 1




3 Insert IGBT (to be checked) in socket.

4 Power ON the supply & Press switch $S_1$ and observe that lamp load will glow this means IGBT is turned ON.

5 Switch OFF $S_1$ and press switch $S_2$ observe that lamp will turn OFF this means IGBT is turned OFF.

**Thus IGBT act as open switch if gate voltage is not provided. If positive gate voltage is applied then the IGBT will act as closed switch then the working condition of IGBT is good.**

7 Test all given IGBT by using above procedure.

8 Note down the readings on Table 1.

**Table 1**

| Sl. No. | IGBT No. | $S_1$ Position | $S_2$ Position | Lamp ON/OFF | IGBT Condition |
|---|---|---|---|---|---|
| 1 | | Closed | Open | | |
| | | Open | Closed | | |
| 2 | | Closed | Open | | |
| | | Open | Closed | | |
| 3 | | Closed | Open | | |
| | | Open | Closed | | |

9 Get the work checked by the Instructor.

– – – – – – –

# Test LEDs with DC supply and measure voltage drop and current using multimeter

**Objectives:** At the end of this exercise you shall be able to
- **measure voltage drop and current using multimeter by testing LED.**

## Requirements

**Tools/Equipments/Instruments**

- Trainees tool kit - 1 Set
- Digital multimeter with probes - 1 No
- Ammeter (0-50) mA - 1 No

**Materials/Components**

- LED (assorted colour, Type & size) - 10 Nos

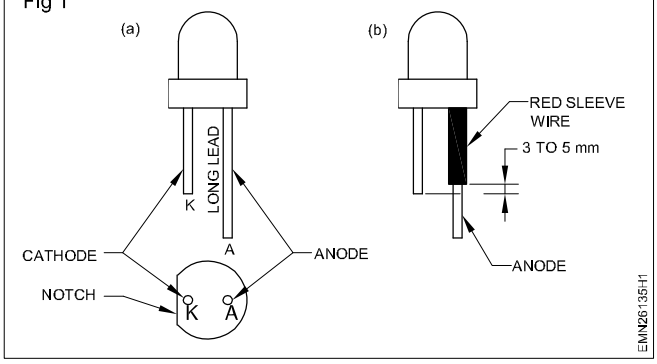
## PROCEDURE

1 Note down the type of LED by physical identification. (ie. Single colour 5mm LED, Miniature, flashing LED, Bi-colour or tri-colour) and for details look-into the data sheet.

2 Determine the Anode and Cathode terminaols of the LED.

**If it is a new LED, the long leg should be the anode(+) and the short leg is the cathode(-). You can also look inside the LED and the larger electrode is cathode and the smaller electrode is the anode (+).**

Fig 1




3 Turn digital multimeter ON and set it to diode mode testing position will be marked by a diode symbol.

**Note: In diode mode and resistance mode of testing using multimeter, the battery of the multimeter is engaged for providing DC bias (or) DC supply voltage required for testing.**

4 Clip the positive(+) of meter to the predetermined anode(+) of the LED and the negative(-) to the cathode (-). The LED should glow and shows bias in display.

5 If the connection is correct and the LED does not light up then LED is bad.

6 Connect ammeter in series with the LED and measure current.

**Note: Man forward voltage that can be applied to a smm LED can draw is only20 ma.SO always use a current limiting resistor in series with an LED (for using in the circuits)**

7 Record it in Table 1.

8 Repeat the procedure for testing other LEDs.

**Table 1**

| Sl. No. | Type of LED | LED ON/OFF | Voltage drop | I when LED is ON |
|---|---|---|---|---|
| | | | | |

9 Get the work checked by the Instructor.

– – – – – – –

# Construct a circuit to test photo voltaic cell

**Objectives:** At the end of this exercise you shall be able to
- **construct a simple photovoltaic (PV) system, using a PV cell(s) and a DC ammeter**
- **learn how the amount and wavelength of light affect the generation of electricity.**

## Requirements

**Tools/Equipments/Instruments**

- Trainees tool kit - 1 Set
- DC ammeter 0-500 mA - 1 No
- DC volt meter 0-24V - 1 No
- Multimeter/DMM with probes - 1 No

**Materials/Components**

- Small PV cells
- Sheets of colored transparency film in different colors - as reqd
- Two electrical leads with crocodile clips
- Source of bright light or access to direct sunlight (desklamp or flashlight could be substituted)
- Goggles/gloves - 1 Set

## PROCEDURE

TASK 1: **Constructing the Photovoltaic Energy System for Light Source Changes**

1 If your PV cell mini panel does not have wires already attached to it, you should attach 15 cm of wire to each node of the PV cell. The cell should have either clips or hooks around which you can manually twist the wire.

2 Follow the Instructor safety instructions and attach the red wire from the PV cell to the red lead of the volt meter and ammeter (either clip or connect the wires together).

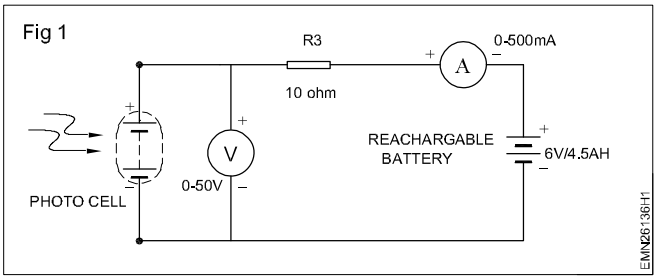
3 Similarly, connect the black wires from the PV cell to the negative terminal black lead of the voltmeter.

4 Connect the 6V/4.5Ah battery between negative terminal of Ammeter and negative terminal of solar panel.

4 Use the direct light/other source on the PV cell to see if you are getting a current reading. If the ammeter shows no current, check the wire connections.

5 Check DC voltage across battery.

Fig 1

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TASK 2: **Performing the Activity for Light**

1 Keeping the sunlight constant (or the light source at constant distance), cover the PV cell(s) with a piece of coloured transparency film. Repeat with the other colours of transparency film and then use just direct sunlight alone (or light substitute). Record the current generated for all colours tested and for direct light in Data Table 1.

**Note that different colours (wave lengths) of light on the solar panel produces different voltage. It is concluded that the wave length of light affects the electricity.**

**Table 1 Effect of Colour (Wavelength) on Cell Current**

| Color of Filter | Current | Remarks |
|---|---|---|
| Red | | |
| Green | | |
| Blue | | |
| Yellow | | |
| No filter | | |

2 With just 1 PV cell in the circuit, shade 1/4 of the PV cell with a piece of cardboard or paper and take a reading. Shade 1/2, 3/4 and then all of the photovoltaic cell. Record the readings in Data Table 2.

**Table 2 Effect of Shading on Cell Current**

| Amount of Shade Current | Current |
|---|---|
| No shade | |
| 1/4 covered | |
| 1/2 covered | |
| 3/4 covered | |
| All covered | |

**Note:-**

**Safety Precautions to be followed while handling photo-roltaic cells.**

**1 Do not press (or) apply pressure on PV cell (a) panel, they may break (or) cause injury or damage to the solar panel.**

**2 Make sure you entire PV system is properly and safely earth grounded to prevent electrical shock and injury.**

**3 When the solar panel is exposed to sunlight, do not touch any electrical lubricant (or) wiring with bare hands. Wear goggles to protect eyes form bright-light.**

3 Get the work checked by the Instructor.

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# Construct a circuit to switch a lamp load using photo diode

**Objectives:** At the end of this exercise you shall be able to
- **construct a circuit to switch a lamp using photo diode and test the working of photo diode.**

## Requirements

**Tools/Equipments/Instruments**

- Trainees tool kit - 1 Set
- DC Power Supply 0-30V/2A - 1 No
- Multimeter with probes - 1 No

**Materials/Components**

- Photo diode BPW 34 - 1 No
- POT 4.7kΩ/1W, linear - 1 No
- Relay (SPST) 12V - 1 No
- Transistor BC548 - 1 No
- Lamp 12V - 1 No
- Diode 1N4007 - 1 No
- Bread board - 1 No

## PROCEDURE

1 Check all given component using multimeter for good working condition.

2 Assemble the circuit on bread board as shown in diagram, connect a lamp to relay contact.

3 Switch on DC power supply, cover photo diode with card board. & observe the position of relay & load lamp. At this position relay will be activated and the lamp will produce light as shown in Fig 1.

4 Expose the photo diode with a light (gran IR LED or with trorch light) & note down the position of relay and lamp condition. Lamp will not produce output.

5 Record the observation in the Table 1.

Fig 1

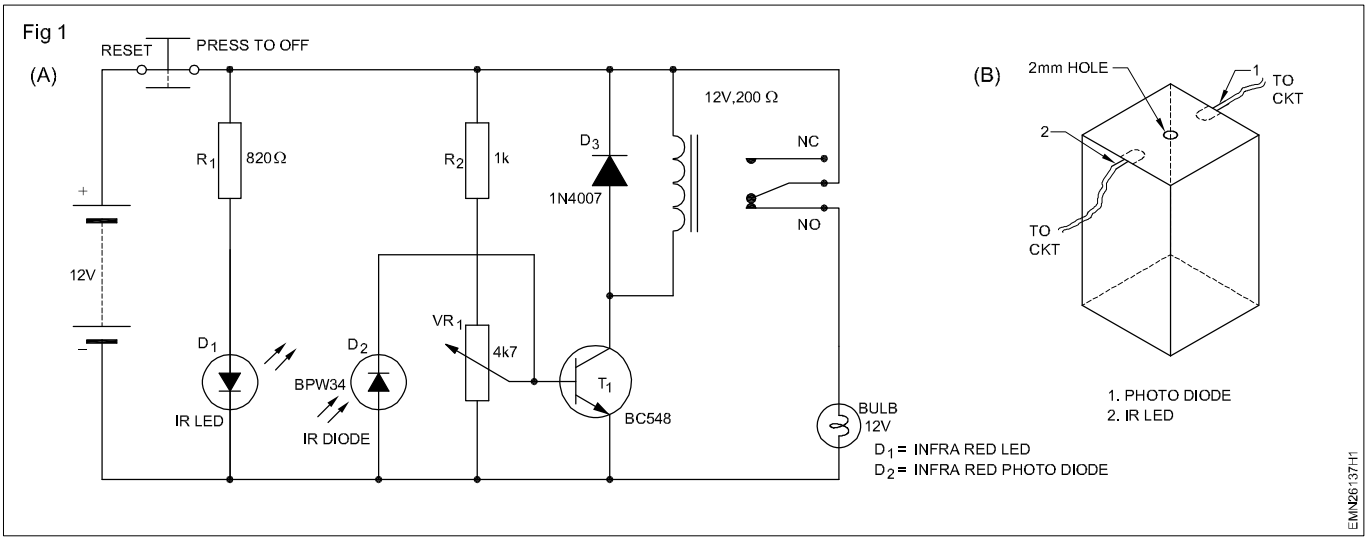


**Table 1**

| Sl. No | Light falling on photo diode | Relay position | Lamp condition |
|---|---|---|---|
| 1 | Darkness | | |
| 2 | Exposed to Lamp light | | |

6 Get the work checked by the Instructor.

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# Construct a circuit to switch a lamp load using photo transistor

**Objectives:** At the end of this exercise you shall be able to
- **construct a circuit to switch a lamp using photo transistor and test the working of photo transistor.**

## Requirements

**Tools/Equipments/Instruments**

- Trainees tool kit - 1 Set
- DC Power Supply, 0-30V/2A - 1 No
- Multimeter DMM with probes - 1 No

**Materials/Components**

- Photo transistor PT 1504-6B - 1 No
- POT 100kΩ/1W, linear - 1 No
- Transistor 2N2222 - 1 No
- Relay 6 V - 1 No
- Lamp - Green, Red 12V/5W - 1 No each
- Breadboard - 1 No

## PROCEDURE

TASK 1: **Construction and testing of photo transistor using a switch and lamp load**

1 Test all given component on multimeter for good working condition.

2 Assemble the circuit on bread board as shown in fig 1.

3 Cover photo transistor with card board & switch on the DC & AC power supply.

4 Relay will be OFF hence lamp $L_2$ will turn ON & $L_1$ will remain OFF.

5 Now remove card board & expose phototransistor to light Lamp of 10W & again observe position of relay. Now relay will be activated & Lamp $L_1$ will turn ON & Lamp $L_2$ will turn OFF.

6 Note down position of phototransistor, Relay & Lamp in observation Table 1.

Fig 1

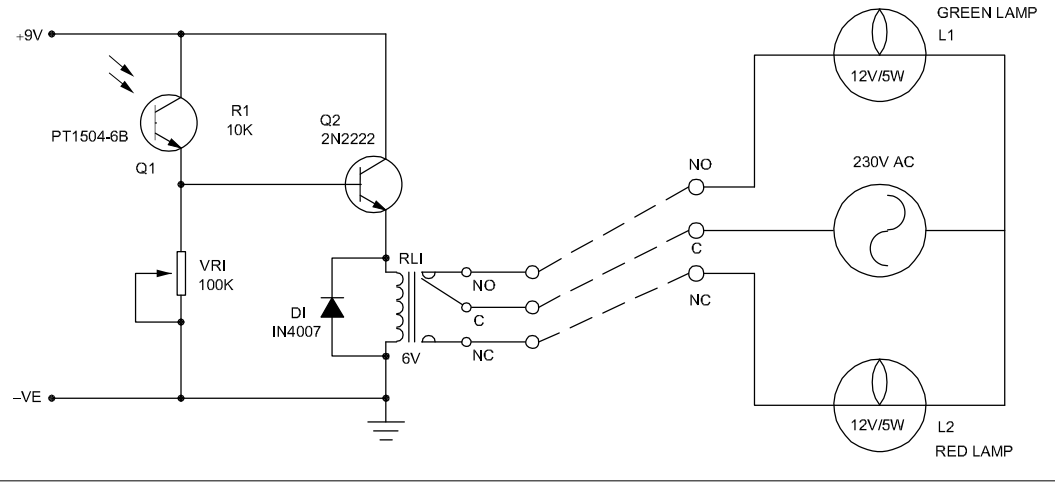


**Table 1**

| Sl . No | Light falling on photo transistor | Relay position | Lamp $L_1$ | Lamp $L_2$ |
|---|---|---|---|---|
| 1 | Darkness | | | |
| 2 | Exposed to Lamp light | | | |

7 Get the work checked by the Instructor.

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# Identify Opto coupler input and output terminals and measure the quantum of Isolation between input/output terminals and operate a relay by connecting a switch

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

- **identify the input & output terminal by referring data manual and measure the quantum of isolation between I/O terminals**
- **operate a relay by using opto-coupler.**

## Requirements

**Tools/Equipments/Instruments**

- Trainees tool kit - 1 Set
- DC Power Supply 0-30V/2A - 1 No
- DC Power Supply 0-5V/2A - 1 No

**Materials/Components**

- Opto coupler IC - 4N25 (opto transistor) - 1 No
- Opto-TRIAC IC - MOC3011 - 1 No
- Opto-SCR -H11C4 - 1 No
- Relay 12 V - 1 No
- Diode 1N 4007 - 1 No
- Lamp 40W - 1 No

## PROCEDURE

TASK 1: **Identification of the terminals of Opto-coupler**

1 Collect the components and note down the number & type of opto-coupler from data book.

2 Identify the terminal 1 by Index mark on IC.

3 Identify other terminals by using data book & note down the observation in Table 1 for all given opto-coupler ICs.

Fig 1

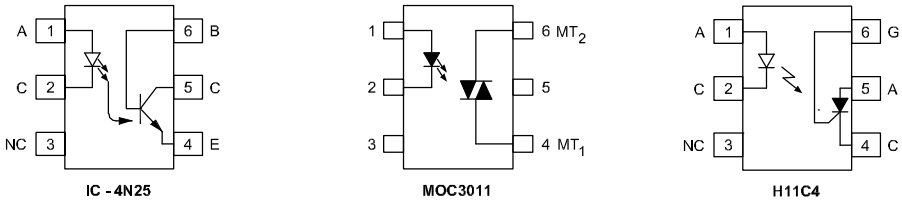


**Table 1**

| Sl. No | Opto coupler type No. | Input Voltage to Opto-coupler | O/P resistance/Bias across terminal | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | B | C | E | G | A | K |
| | | | | | | | | |

– – – – – – –

TASK 2: **Operation of a relay by using opto-coupler**

1 Assemble the circuit on bread board as shown in Fig 2.

2 Switch ON 12V DC supply and AC mains.

3 Note down the position of relay & load lamp.

4 Now apply 5V DC supply at the input terminal of opto-coupler & observe the position of relay & load lamp.

5 Note down the observation in Table-2.

6 Get the work checked by the Instructor.

Fig 2

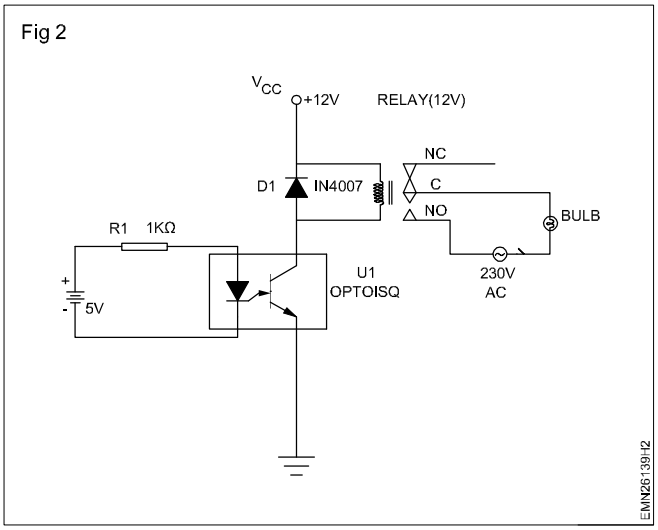


**Table 2**

**When Input 5V is applied to the Opto-coupler**

| Sl. No | Opto coupler type No. | Position of relay | | Condition of load lamp | |
|---|---|---|---|---|---|
| | | NO | NC | ON | OFF |
| | | | | | |

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# Identify different logic gates (AND, OR, NAND, NOR, EX-OR, EX- NOR, NOT ICs) by the number printed on them

**Objectives:** At the end of this exercise you shall be able to
- **identify different logic gates by the IC number printed on them**
- **identify various ICs and their specifications using data sheet/semiconductor data manual.**

## Requirements

**Tools/Equipments/Instruments**

- Trainees tool kit - 1 Set
- Logic Gates (IC) trainer Kit - 1 No
- Digital multimeter with probes - 1 No
- Data sheet of ICs used - as reqd

**Materials/Components**

- Breadboard - 1 No
- Connecting Patch Cords - as reqd
- IC 7400, IC 7408, IC 7432 IC 74266, IC 7402, IC 7404 IC 7486 - 1 No each

PROCEDURE

**Note: The Instructor has to provide/ensure ICs with their number printed on them is clearly visible and all the ICs are inserted on a bread board safely.**

**Safety precaution: Do not touch the pins of the ICs with fingers.**

1 Pick one of the ICs note down the number in Table -1

2 Refer to the data sheet/semiconductor data manual,find the logic gate function,draw the pin out diagram, mark the input, output and supply pin numbers.

3 Repeat the steps for remaining ICs and record the observations in Table-1.

Table 1

| Sl.No. | IC number | Logic gate | Symbol | Pin out diagram |
|---|---|---|---|---|
| 1 | IC 7408 | | | |
| 2 | IC 7432 | | | |
| 3 | IC 7404 | | | |
| 4 | IC 7400 | | | |
| 5 | IC 7402 | | | |
| 6 | IC 7486 | | | |
| 7 | IC 74266 | | | |

4 Get the work checked by the Instructor.

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# Verify the truth tables of all logic gate ICs by connecting switches and LEDs

**Objectives:** At the end of this exercise you shall be able to
- **construct AND, OR, NOT, NAND, NOR and EX-OR gates using ICs**
- **verify truth tables of AND, OR, NOT, NAND, NOR and EX-OR gates using switches and LEDs.**

## Requirements

**Tools/Equipments/Instruments**

- Trainees tool kit - 1 Set
- Regulated DC power supply 0-30V/2A - 1 No
- Digital multimeter with probes - 1 No

**Materials/Components**

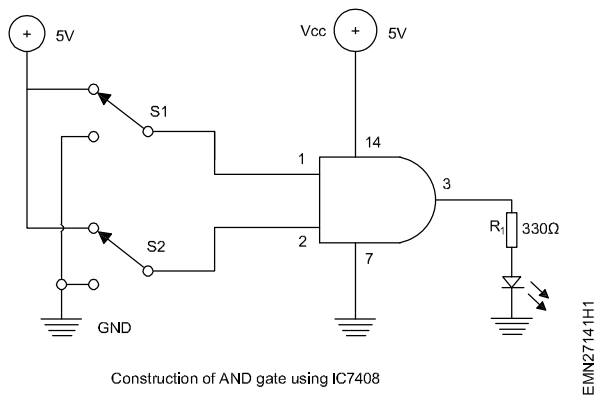
- Breadboard - 1 No
- IC 7408 - 1 No
- IC - 7432 - 1 No
- IC-7486 - 1 No
- IC-7400 - 1 No
- SPDT Switches (Miniature Toggle) - 2 Nos
- IC 7404 - 1 No
- Hook up wire, red and black - as reqd
- Flexible wires - as reqd
- Resistor/¼ W/CR25 - 1 No
- 330Ω - 1 No
- LED 5mm, Red - 1 No
- Data sheets of ICs used - as reqd

## PROCEDURE

TASK 1 : **Construction and AND gate using IC 7408 and verification of its truth table**

1 Collect all the components, check them, refer to the data sheet of the IC 7408, assemble the AND gate as shown in Fig 1 on the bread board.

Fig 1




Construction of AND gate using IC7408

2 Use toggle switches $S_1$ as input A and switch $S_2$ as input B.

3 Get the assemble circuit checked by the Instructor.

4 Switch ON 5VDC supply and operate switches $S_1$ & $S_2$ for different levels either in 5V position or zero volt (GND) position as shown in Table 1.

5 Observe the status of LED for each step of combinations, record the observations in Table 1.

Table 1

| Sl.No. | Input | | Output LED status |
|---|---|---|---|
| | A | B | |
| 1 | | | |
| 2 | | | |
| 3 | | | |
| 4 | | | |

**AND gate Truth table**

| Sl.No. | Input | | Output Y=A.B |
|---|---|---|---|
| | A | B | |
| 1 | 0 | 0 | 0 |
| 2 | 0 | 1 | 0 |
| 3 | 1 | 0 | 0 |
| 4 | 1 | 1 | 1 |

6 Verify the readings with the truth table of AND gate.

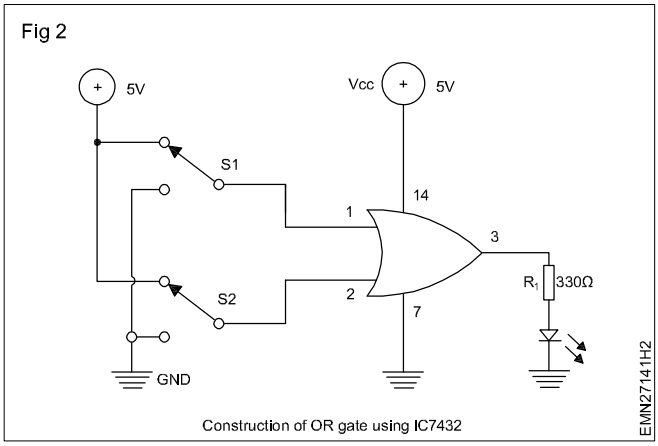
7 Get the work checked by the Instructor.

– – – – – – –

TASK 2 : **Construction of OR gate using IC 7432 and verification of its Truth table**

1 Collect all the components, check them, refer to the data sheet of the IC 7432, assemble the OR gate as shown in Fig 2 on the bread board.

Fig 2




Construction of OR gate using IC7432

2 Repeat steps 2 to 5 of Task 1 and record the observations in Table 2.

3 Verify the readings with the truth table of OR gate.

4 Get the work checked by the Instructor.

Table 2

| Sl.No. | Input | | Output LED status |
|---|---|---|---|
| | A | B | |
| 1 | | | |
| 2 | | | |
| 3 | | | |
| 4 | | | |

**OR gate Truth table**

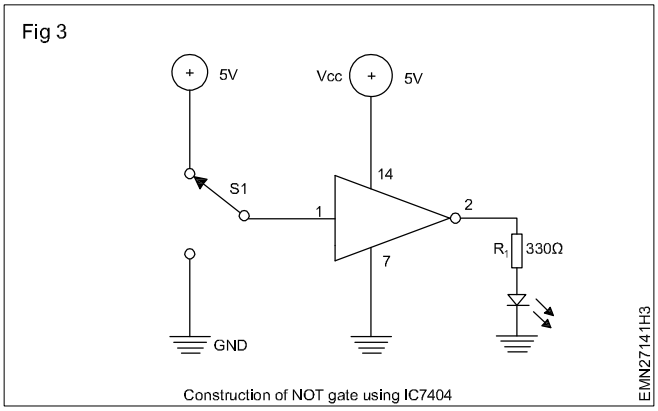
| Sl.No. | Input | | Output Y=A+B |
|---|---|---|---|
| | A | B | |
| 1 | 0 | 0 | 0 |
| 2 | 0 | 1 | 1 |
| 3 | 1 | 0 | 1 |
| 4 | 1 | 1 | 1 |

– – – – – – –

TASK 3 : **Construction of NOT gate using IC 7404 and verification of its Truth table**

1 Collect all the components, check them, refer to the data sheet of the IC 7404, assemble the NOT gate as shown in Fig 3 on the bread board.

Fig 3




Construction of NOT gate using IC7404

2 Use toggle switches $S_1$ as input A.

3 Repeat steps 3 to 5 of Task 1 and record the observations in Table 3.

4 Verify the readings with the truth table of NOT gate.

5 Get the work checked by the Instructor.

Table 3

| Sl.No. | Input | Output LED status |
|---|---|---|
| | A | |
| 1 | | |
| 2 | | |

**NOT gate Truth table**

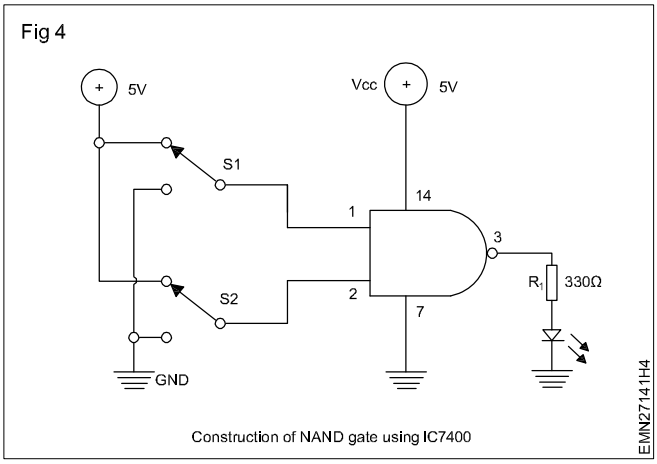
| Sl.No. | Input | Output $\bar{Y}=A$ |
|---|---|---|
| | A | |
| 1 | 0 | 1 |
| 2 | 1 | 0 |

– – – – – – –

TASK 4 : **Construction of NAND gate using IC 7400 and verification of its Truth table**

1 Collect all the components, check them, refer to the data sheet of the IC 7400, assemble the AND gate as shown in Fig 4 on the bread board.

Fig 4




Construction of NAND gate using IC7400

2 Repeat steps 2 to 5 of Task 1 and record the observations in Table 4.

3 Verify the readings with the truth table of NAND gate.

4 Get the work checked by the Instructor.

Table 4

| Sl.No. | Input | | Output LED status |
|---|---|---|---|
| | A | B | |
| 1 | | | |
| 2 | | | |
| 3 | | | |
| 4 | | | |

**NAND gate Truth table**

| Sl.No. | Input | | Output $Y=\overline{A.B}$ |
|---|---|---|---|
| | A | B | |
| 1 | 0 | 0 | 1 |
| 2 | 0 | 1 | 1 |
| 3 | 1 | 0 | 1 |
| 4 | 1 | 1 | 0 |

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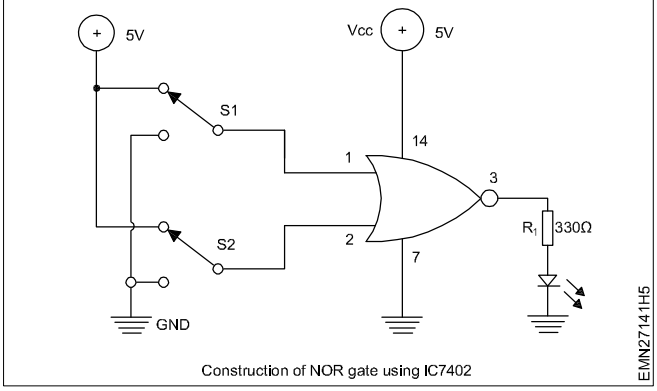
TASK 5 : **Construction of NOR gate using IC 7402 and verification of its Truth table**

1 Collect all the components, check them, refer to the data sheet of the IC 7402, assemble the NOR gate as shown in Fig 5 on the bread board.

Fig 5




Construction of NOR gate using IC7402

2 Repeat steps 2 to 5 of Task 1 and record the observations in Table 5.

3 Verify the readings with the truth table of NOR gate.

4 Get the work checked by the Instructor.

Table 5

| Sl.No. | Input | | Output LED status |
|---|---|---|---|
| | A | B | |
| 1 | | | |
| 2 | | | |
| 3 | | | |
| 4 | | | |

**NOR gate Truth table**

| Sl.No. | Input | | Output $Y=\overline{A+B}$ |
|---|---|---|---|
| | A | B | |
| 1 | 0 | 0 | 1 |
| 2 | 0 | 1 | 0 |
| 3 | 1 | 0 | 0 |
| 4 | 1 | 1 | 0 |

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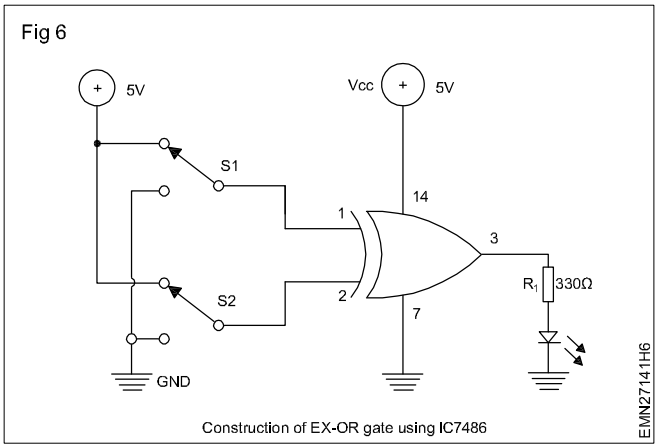
TASK 5 : **Construction of EX-OR gate using IC 7486 and verification of its Truth table**

1 Collect all the components, check them, refer to the data sheet of the IC 7486, assemble the EX-OR gate as shown in Fig 6 on the bread board.

Fig 6




Construction of EX-OR gate using IC7486

2 Repeat steps 2 to 5 of Task 1 and record the observations in Table 6.

3 Verify the readings with the truth table of EX-OR gate.

4 Get the work checked by the Instructor.

Table 6

| Sl.No. | Input | | Output LED status |
|---|---|---|---|
| | A | B | |
| 1 | | | |
| 2 | | | |
| 3 | | | |
| 4 | | | |

**EX-OR gate Truth table**

| Sl.No. | Input | | Output Y=A⊕B |
|---|---|---|---|
| | A | B | |
| 1 | 0 | 0 | 0 |
| 2 | 0 | 1 | 1 |
| 3 | 1 | 0 | 1 |
| 4 | 1 | 1 | 0 |

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# Construct and verify the truth table of all the gates using NAND and NOR gates

**Objectives :** At the end of this exercise you shall be able to
- **construct AND, OR, NOT, NOR, EX-OR and EX-NOR gates using NAND gate**
- **construct AND, OR, NOT, NAND, EX-OR and EX-NOR gates using NOR gates.**

## Requirements

**Tools/Equipments/Instruments/Data Manuals**

- Logic probe - 1 No
- Trainees tool kit - 1 Set
- Regulated DC power supply 0-30V/2A - 1 No
- Digital multimeter with probes - 1 No

**Materials/Components**

- Digital IC data manual - 1 No
- IC 7400 - 2 Nos
- IC 7402 - 2 Nos
- Hook up wires - as reqd
- 14 pin IC base - 4 Nos
- Toggle switches miniature type SPDT - 2 Nos
- Bread board - 1 No
- LED 5mm, Red - 1 No
- Resistor - 330Ω/1/4W - 1 No

**Note:**

1 **The Instructor has to guide the trainees to record 5VDC given to gate input as logic high (1) and GND (zero volt) as logic low (0)**

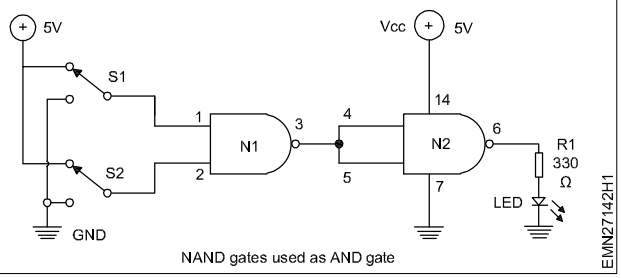
2 **The condition of LED ON as Logic '1' and OFF as logic '0'.**

## PROCEDURE

TASK 1 : **Construction of AND gate circuit using NAND gate IC 7400 and verification of its truth table**

1 Collect all the components, check them, refer to the data sheet of the IC 7400, assemble the AND gate as shown in Fig 1 on the bread board.

Fig 1




NAND gates used as AND gate

2 Use toggle switches $S_1$ as input A and switch $S_2$ as input B.

3 Get the assembled circuit checked by the Instructor.

4 Switch ON 5VDC supply and operate switches $S_1$ & $S_2$ for different logic levels either in 5V position or zero volt position as shown in Table 1.

5 Observe the LED for each step of combinations, record the observations in Table 1.

**AND gate Truth table**

| Sl.No. | Input | | Output Y=A.B |
|---|---|---|---|
| | A $S_1$ | B $S_2$ | |
| 1 | 0 | 0 | 0 |
| 2 | 0 | 1 | 0 |
| 3 | 1 | 0 | 0 |
| 4 | 1 | 1 | 1 |

Table 1

| Sl.No. | Input | | Output LED Condition |
|---|---|---|---|
| | A $S_1$ | B $S_2$ | |
| 1 | | | |
| 2 | | | |
| 3 | | | |
| 4 | | | |

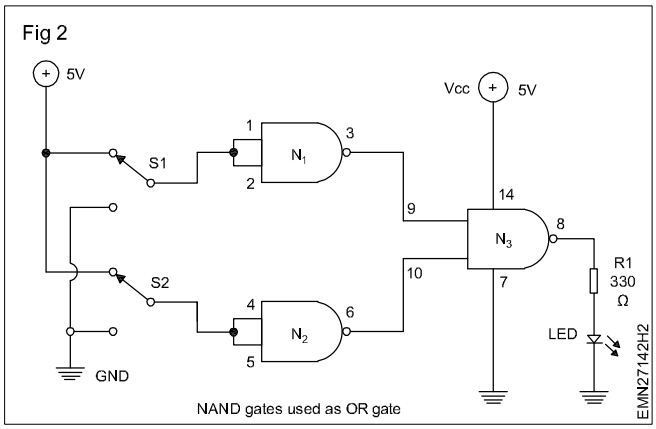
6 Get the work checked by the Instructor.

– – – – – – –

TASK 2 : **Construction of OR gate circuit using NAND gate and verification of its truth table**

1 Rearrange the connections and assemble the OR gate circuit using NAND gates as shown in Fig 2 on bread board.

Fig 2




NAND gates used as OR gate

2 Repeat steps 2 to 5 of Task 1 and record the observations in Table 2.

3 Verify the readings with the truth table of OR gate.

4 Get the work checked by the Instructor.

**Note: Use logic probe to check the status of each pin to confirm the functioning of each gate.**

**OR gate Truth table**

| Sl.No. | Input | | Output Y=A+B |
|---|---|---|---|
| | A | B | |
| 1 | 0 | 0 | 0 |
| 2 | 0 | 1 | 1 |
| 3 | 1 | 0 | 1 |
| 4 | 1 | 1 | 1 |

Table 2

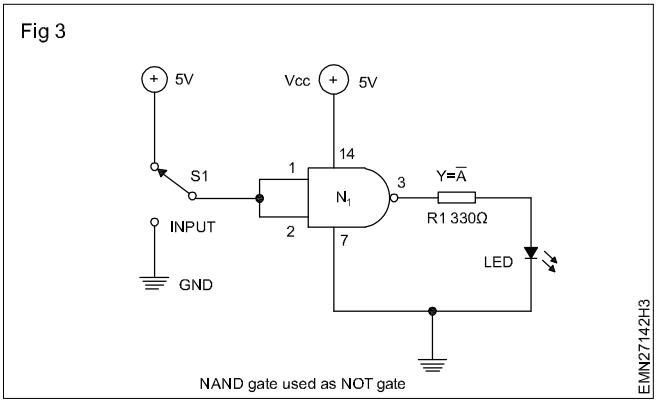
| Sl.No. | Input | | Output LED |
|---|---|---|---|
| | A | B | |
| 1 | | | |
| 2 | | | |
| 3 | | | |
| 4 | | | |

– – – – – – –

TASK 3: **Construction of NOT gate circuit using NAND gate and verification of its truth table**

1 Rearrange the connections and assemble the NOT gate circuit using NAND gates as shown in Fig 3 on bread board.

Fig 3




NAND gate used as NOT gate

2 Use toggle switch $S_1$ as input A.

3 Repeat steps 3 to 5 of Task 1 and record the observations in Table 3.

4 Get the work checked by the Instructor.

**NOT gate Truth table**

| Sl.No. | Input | Output |
|---|---|---|
| | A | $Y=\overline{A}$ |
| 1 | 0 | 1 |
| 2 | 1 | 0 |

Table 3

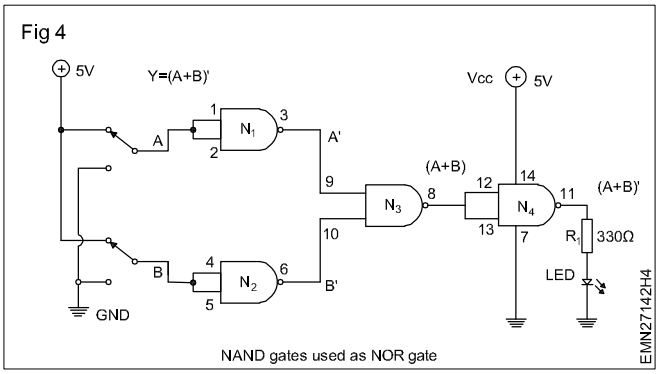
| Sl.No. | Input | Output LED |
|---|---|---|
| | A | |
| 1 | 0 | |
| 2 | 1 | |

– – – – – – –

TASK 4 : **Construction of NOR gate circuit using NAND gate and verification of its truth table**

1 Rearrange the connections and assemble the NOR gate circuit using NAND gates as shown in Fig 4 on bread board.

Fig 4




NAND gates used as NOR gate

2 Repeat steps 2 to 5 of Task 1, and record the observations in Table 4.

3 Verify the readings with the truth table of NOR gate.

4 Get the work checked by the Instructor.

**Note: Use logic probe to check the status of each pin to confirm the functioning of each gate.**

**NOR gate Truth table**

| Sl.No. | Input | | Output |
|---|---|---|---|
| | A | B | $Y=\overline{A+B}$ |
| 1 | 0 | 0 | 1 |
| 2 | 0 | 1 | 0 |
| 3 | 1 | 0 | 0 |
| 4 | 1 | 1 | 0 |

Table 4

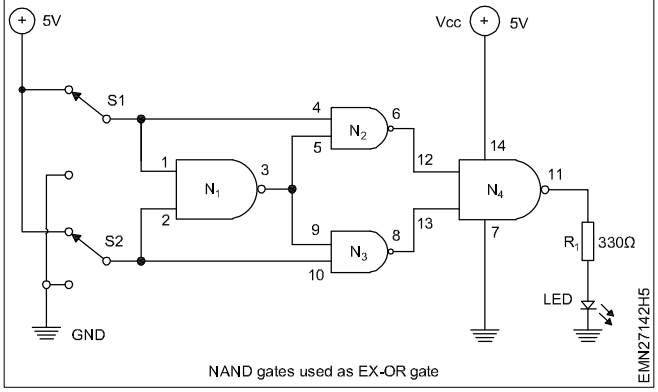
| Sl.No. | Input | | Output LED |
|---|---|---|---|
| | A | B | |
| 1 | | | |
| 2 | | | |
| 3 | | | |
| 4 | | | |

– – – – – – –

TASK 5 : **Construction of EX-OR gate circuit using NAND gate and verification of its truth table**

1 Rearrange the connections and assemble the EX-OR gate circuit using NAND gates as shown in Fig 5 on bread board.

Fig 5




NAND gates used as EX-OR gate

2 Repeat steps 2 to 5 of Task 1, and record the observations in Table 5.

3 Verify the readings with the truth table of EX-OR gate.

4 Get the work checked by the Instructor.

**Note: Use logic probe to check the status of each pin to confirm the functioning of each gate.**

**EX-OR gate Truth table**

| Sl.No. | Input | | Output $Y=A\oplus B$ |
|---|---|---|---|
| | A | B | |
| 1 | 0 | 0 | 0 |
| 2 | 0 | 1 | 1 |
| 3 | 1 | 0 | 1 |
| 4 | 1 | 1 | 0 |

Table 5

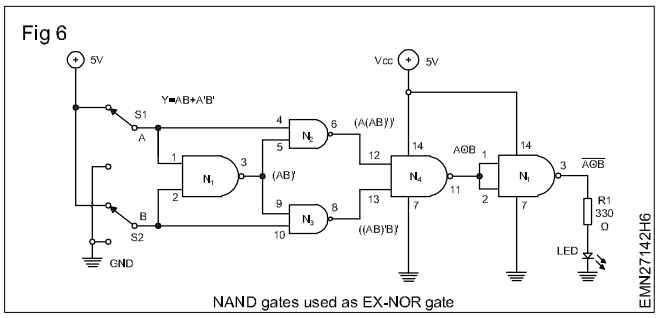
| Sl.No. | Input | | Output LED |
|---|---|---|---|
| | A | B | |
| 1 | | | |
| 2 | | | |
| 3 | | | |
| 4 | | | |

– – – – – – –

TASK 6 : **Construction of EX-NOR gate circuit using NAND gate and verification of its truth table**

1 Rearrange the connections and assemble the EX-NOR gate circuit using NAND gates as shown in Fig 6 on bread board.

Fig 6




NAND gates used as EX-NOR gate

2 Repeat steps 2 to 5 of Task 1, and record the observations in Table 6.

3 Verify the readings with the truth table of EX-NOR gate.

4 Get the work checked by the Instructor.

**Note: Use logic probe to check the status of each pin to confirm the functioning of each gate.**

**EX-NOR gate Truth table**

| Sl.No. | Input | | Output $Y=\overline{A \oplus B}$ |
|---|---|---|---|
| | A | B | |
| 1 | 0 | 0 | |
| 2 | 0 | 1 | |
| 3 | 1 | 0 | |
| 4 | 1 | 1 | |

Table 6

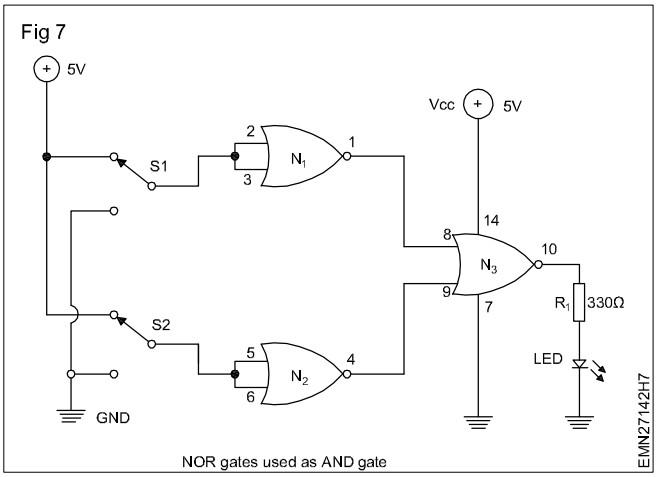
| Sl.No. | Input | | Output LED |
|---|---|---|---|
| | A | B | |
| 1 | | | |
| 2 | | | |
| 3 | | | |
| 4 | | | |

– – – – – – –

TASK 7 : **Construction of AND gate using NOR gate IC 7402 and verification of its truth table**

1 Collect all the components, check them, refer to the data sheet of the IC 7402, assemble the AND gate as shown in Fig 7 on the bread board.

Fig 7




NOR gates used as AND gate

2 Repeat steps 2 to 5 of Task 1, and record the observations in Table 7.

3 Verify the readings with the truth table of AND gate.

4 Get the work checked by the Instructor.

**Note: Use logic probe to check the status of each pin to confirm the functioning of each gate.**

**AND gate Truth table**

| Sl.No. | Input | | Output Y=A.B |
|---|---|---|---|
| | A | B | |
| 1 | 0 | 0 | 0 |
| 2 | 0 | 1 | 0 |
| 3 | 1 | 0 | 0 |
| 4 | 1 | 1 | 1 |

Table 7

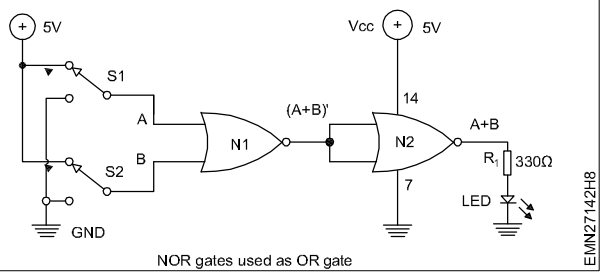
| Sl.No. | Input | | Output LED |
|---|---|---|---|
| | A | B | |
| 1 | | | |
| 2 | | | |
| 3 | | | |
| 4 | | | |

– – – – – – –

TASK 8 : **Construction of OR gate using NOR gate IC 7402 and verification of its truth table**

1 Collect all the components, check them, refer to the data sheet of the IC 7402, assemble the OR gate as shown in Fig 8 on the bread board.

Fig 8




NOR gates used as OR gate

2 Repeat steps 2 to 5 of Task 1, and record the observations in Table 8.

3 Verify the readings with the truth table of OR gate.

4 Get the work checked by the Instructor.

**Note: Use logic probe to check the status of each pin to confirm the functioning of each gate.**

**OR gate Truth table**

| Sl.No. | Input | | Output Y=A+B |
|---|---|---|---|
| | A | B | |
| 1 | 0 | 0 | 0 |
| 2 | 0 | 1 | 1 |
| 3 | 1 | 0 | 1 |
| 4 | 1 | 1 | 1 |

Table 8

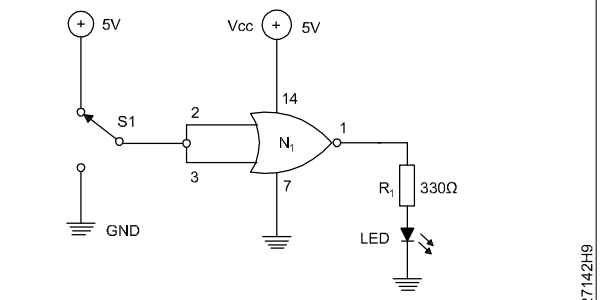
| Sl.No. | Input | | Output LED |
|---|---|---|---|
| | A | B | |
| 1 | | | |
| 2 | | | |
| 3 | | | |
| 4 | | | |

– – – – – – –

TASK 9 : **Construction of NOT gate using NOR gate IC 7402 and verification of its truth table**

1 Collect all the components, check them, refer to the data sheet of the IC 7402, assemble the NOT gate as shown in Fig 9 on the bread board.

Fig 9




2 Repeat steps 2 to 5 of Task 9, and record the observations in Table 9.

3 Verify the readings with the truth table of NOT gate.

4 Get the work checked by the Instructor.

**NOT gate Truth table**

| Sl.No. | Input | Output $Y=\overline{A}$ |
|---|---|---|
| | A | |
| 1 | 0 | 1 |
| 2 | 1 | 0 |

Table 9

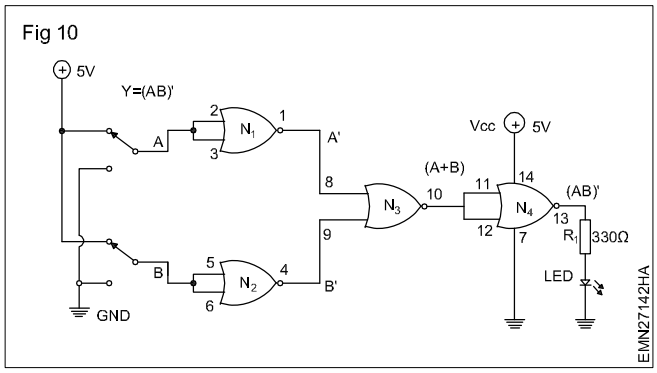
| Sl.No. | Input | Output LED |
|---|---|---|
| | A | |
| 1 | | |
| 2 | | |

– – – – – – –

TASK 10 : **Construction of NAND gate using NOR gate IC 7402 and verification of its truth table**

1 Collect all the components, check them, refer to the data sheet of the IC 7402, assemble the NAND gate as shown in Fig 10 on the bread board.

Fig 10




2 Repeat steps 2 to 5 of Task 9, and record the observations in Table 10.

3 Verify the readings with the truth table of NAND gate.

4 Get the work checked by the Instructor.

**Note: Use logic probe to check the status of each pin to confirm the functioning of each gate.**

**NAND gate Truth table**

| Sl.No. | Input | | Output $Y=\overline{A.B}$ |
|---|---|---|---|
| | A | B | |
| 1 | 0 | 0 | 1 |
| 2 | 0 | 1 | 1 |
| 3 | 1 | 0 | 1 |
| 4 | 1 | 1 | 0 |

Table 10

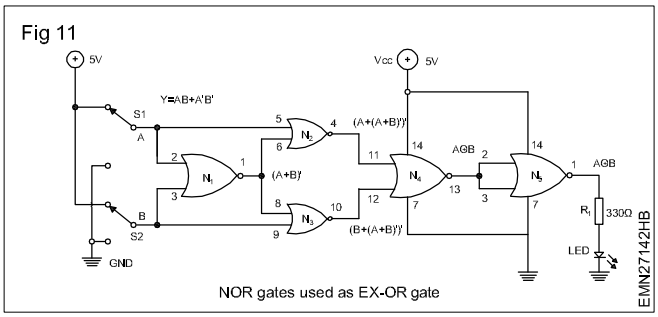
| Sl.No. | Input | | Output LED |
|---|---|---|---|
| | A | B | |
| 1 | | | |
| 2 | | | |
| 3 | | | |
| 4 | | | |

– – – – – – –

TASK 11 : **Construction of EX-OR gate using NOR gate IC 7402 and verification of its truth table**

1 Collect all the components, check them, refer to the data sheet of the IC 7402, assemble the EX-OR gate as shown in Fig 11 on the bread board.

Fig 11




NOR gates used as EX-OR gate

2 Repeat steps 2 to 5 of Task 9, and record the observations in Table 11.

3 Verify the readings with the truth table of EX-OR gate.

4 Get the work checked by the Instructor.

**Note: Use logic probe to check the status of each pin to confirm the functioning of each gate.**

**EX-OR gate Truth table**

| Sl.No. | Input | | Output $Y=A \oplus B$ |
|---|---|---|---|
| | A | B | |
| 1 | 0 | 0 | 0 |
| 2 | 0 | 1 | 1 |
| 3 | 1 | 0 | 1 |
| 4 | 1 | 1 | 0 |

Table 11

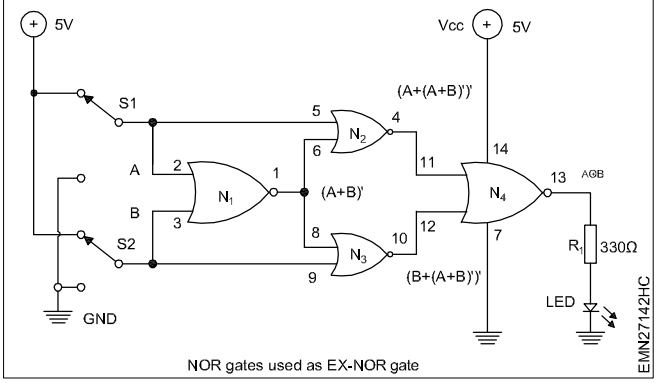
| Sl.No. | Input | | Output LED |
|---|---|---|---|
| | A | B | |
| 1 | | | |
| 2 | | | |
| 3 | | | |
| 4 | | | |

– – – – – – –

TASK 12 : **Construction of EX-NOR gate using NOR gate IC 7402 and verification of its truth table**

1 Collect all the components, check them, refer to the data sheet of the IC 7402, assemble the EX-NOR gate as shown in Fig 12 on the bread board.

Fig 12




NOR gates used as EX-NOR gate

2 Repeat steps 2 to 5 of Task 9, and record the observations in Table 12.

3 Verify the readings with the truth table of EX-NOR gate.

4 Get the work checked by the Instructor.

**Note: Use logic probe to check the status of each pin to confirm the functioning of each gate.**

**EX-NOR gate Truth table**

| Sl.No. | Input | | Output |
|---|---|---|---|
| | A | B | $Y=\overline{A \oplus B}$ |
| 1 | 0 | 0 | 1 |
| 2 | 0 | 1 | 0 |
| 3 | 1 | 0 | 0 |
| 4 | 1 | 1 | 1 |

Table 12

| Sl.No. | Input | | Output LED |
|---|---|---|---|
| | A | B | |
| 1 | | | |
| 2 | | | |
| 3 | | | |
| 4 | | | |

– – – – – – –

# Use digital IC tester to test various digital ICs (TTL and CMOS)

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

- **identify the IC manufacturers' names from the logo given on the IC and manufacturers data**
- **identify IC code number printed on the given digital IC**
- **identify the type of package of the given digital IC (TTL and CMOS)**
- **identify the logic family of the given digital IC referring databook**
- **identify the pin numbers of the given Digital IC referring data book**
- **test the given IC using digital IC tester.**

## Requirements

**Tools/Equipments/Instruments/Data manual**

- Digital IC databook - 1 No
- Digital IC tester with manual - 1 No
- DMM with probes - 1 No

**Materials/Components**

- Assorted Digital ICs (both TTL and CMOS types) - 10 Nos
- Breadboard - 1 No
- Hook up wires - as reqd

**Note: The Instructor has to label all the ICs serially**

**Keep a minimum of 20 numbers of assorted labeled TTL and CMOS ICs for thtis exercise. Instruct the trainees to pick one IC at a time and carryout the exercise.**

**Demonstrate setting the controls and testing ICs using digital IC tester. No detailed procedure for using IC tester is given as different IC testers used in different institures may have different operating procedures and specification.**

## PROCEDURE

1 Identify operator controls, switches and IC socket on the digital IC tester as shown in Fig 1 with reference to the manual.

2 Pick one of the labeled IC from the assorted lot and record its label number.

3 Refer to the data manual interpret the manufacturer's logo given on the IC or alphabets used for the IC type identify and record the details in Table 1.

4 Identify and record the logic family supply voltage and function of the IC referring the data manual.

5 Count and record the number of pins on the IC.

6 As demonstrated by the instructor, test and record the condition of the IC using digital IC tester for atleast 10 different ICs both in TTL and CMOS types.

**Note: Follow the procedure demonstrated by the instructor for setting the controls on digital IC tester while testing the IC.**

7 Get the recorded information checked by the instructor for 10 different ICs.

– – – – – – –

**TABLE 1**

| Sl. No. | Label No. IC | Code No. of IC | No.of pins | Logic family | Function | Package type | Maximum $V_{cc}$ voltage | Condion of IC tested |
|---|---|---|---|---|---|---|---|---|
| 1 | | | | | | | | |
| 2 | | | | | | | | |
| 3 | | | | | | | | |
| 4 | | | | | | | | |
| 5 | | | | | | | | |
| 6 | | | | | | | | |
| 7 | | | | | | | | |
| 8 | | | | | | | | |
| 9 | | | | | | | | |
| 10 | | | | | | | | |
| 11 | | | | | | | | |
| 12 | | | | | | | | |
| 13 | | | | | | | | |
| 14 | | | | | | | | |
| 15 | | | | | | | | |
| 16 | | | | | | | | |
| 17 | | | | | | | | |
| 18 | | | | | | | | |
| 19 | | | | | | | | |
| 20 | | | | | | | | |


**DIGITAL IC TESTER**

– – – – – – –

# Construct Half Adder circuit using ICs and verify the truth table

**Objectives:** At the end of this exercrise you shall be able to
- **construct the half adder circuit and verify the truth table.**

## Requirements

**Tools/Equipments/Instruments**

- Soldering iron 25W/230V - 1 No
- Logic probe - 1 No
- Trainees tool kit - 1 Set
- Regulated DC power supply 0-30V/2A - 1 No
- Digital multimeter with probes - 1 No

**Materials/Components**

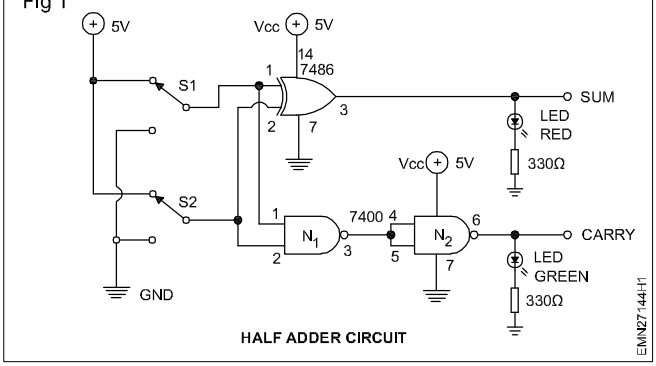
- IC-7486 with base - 1 No
- IC-7400 with base - 1 No
- Data sheet of ICs used - 1 No each
- LED 5mm Red, Green - 2 Nos
- Resistor 330Ω/¼ W/CR25 - 2 Nos
- Miniature toggle switch SPDT - 3 Nos
- Breadboard - 1 No
- Solder, flux - as reqd
- Hook up wires - as reqd

## PROCEDURE

TASK 1: **Construction of Half Adder circuit and verification of truth table**

1 Collect all the components, check them and assemble the Half adder circuit as shown in Fig 1on breadboard.

Fig 1




**Use 14 pin IC base on the bread board for this task.**

2 Use toggle switch $S_1$ as input A and switch $S_2$ as input B.

3 Get the assembled circuit checked by the Instructor.

4 Switch ON 5VDC supply and operate switches S1 & S2 for different logic levels either in 5V position for zero volt (GND) position as shown in Table 1.

5 Observe the LEDs for each step of combinations, record your observations in Table 1.

6 Verify readings with truth table of Half Adder.

**Use logic probe to check the status of each pin to confirm the functioning of the gate.**

**Truth Table of Half Adder**

| Sl. No. | Input | | Output | |
|---|---|---|---|---|
| | A | B | Sum | Carry |
| 1 | 0 | 0 | 0 | 0 |
| 2 | 0 | 1 | 1 | 0 |
| 3 | 1 | 0 | 1 | 0 |
| 4 | 1 | 1 | 0 | 1 |

**Table 1**

| Sl. No. | Input | | Output LED | |
|---|---|---|---|---|
| | A | B | Red (Sum) | Green (carry) |
| 1 | | | | |
| 2 | | | | |
| 3 | | | | |
| 4 | | | | |

7 Get the work checked by the instructor.

– – – – – – –

# Construct Full adder with two Half adder circuit using ICs and verify the truth table

**Objectives:** At the end of this exercrise you shall be able to
- **construct and test full adder using half adder circuits.**

## Requirements

**Tools/Equipments/Instruments**

- Soldering iron 25W/230V - 1 No
- Logic probe - 1 No
- Trainees tool kit - 1 Set
- Regulated DC power supply 0-30V/2A - 1 No
- Digital multimeter with probes - 1 No

**Materials/Components**

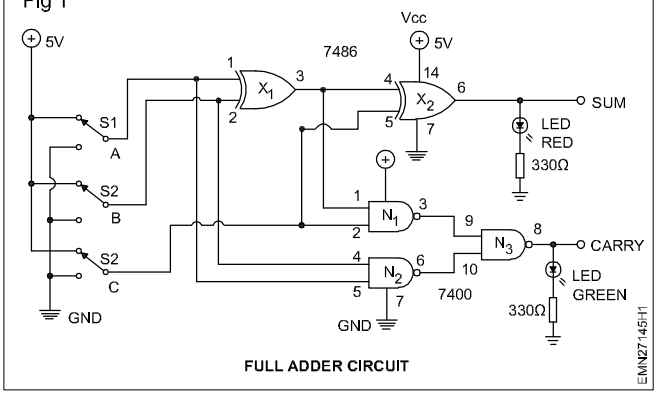
- IC-7486 with base - 1 No
- IC-7400 with base - 1 No
- Data sheet of ICs used - as reqd
- LED 5mm Red, Green - 1 No each
- Resistor 330Ω/¼ W/CR25 - 2 Nos
- Miniature toggle switch SPDT - 3 Nos
- Breadboard - 1 No
- Solder, flux - as reqd
- Hook up wires - as reqd

## PROCEDURE

TASK 1 : **Construction of Full Adder using two Half Adder circuits and verification of truth table**

1 Collect all the components, check them and assemble the Full adder circuit as shown in Fig 1on breadboard.

Fig 1




FULL ADDER CIRCUIT

2 Use toggle switch $S_1$ as input A and switch $S_2$ as input B and switch $S_3$ as inpuct C.

3 Get the assembled circuit checked by the Instructor.

4 Switch ON 5VDC supply and operate all the switches for different logic levels either in 5V position for zero volt (GND) position as shown in Table 1.

5 Observe the LEDs for each step of combinations, record the observations in Table 1.

6 Verify readings with truth table of Half Adder.

**Note: Use logic probe to check the status of each pin to confirm the functioning of the gate.**

**Truth table of Full Adder**

| Sl. No. | Input | | | Output | |
|---|---|---|---|---|---|
| | A | B | C | Sum | Carry |
| 1 | 0 | 0 | 0 | | |
| 2 | 0 | 0 | 1 | | |
| 3 | 0 | 1 | 0 | | |
| 4 | 0 | 1 | 1 | | |
| 5 | 1 | 0 | 0 | | |
| 6 | 1 | 0 | 1 | | |
| 7 | 1 | 1 | 0 | | |
| 8 | 1 | 1 | 1 | | |

**Table 1**

| Sl. No. | Input | | | Output | |
|---|---|---|---|---|---|
| | A | B | C | Sum | Carry |
| 1 | | | | | |
| 2 | | | | | |
| 3 | | | | | |
| 4 | | | | | |
| 5 | | | | | |
| 6 | | | | | |
| 7 | | | | | |
| 8 | | | | | |

7 Get the work checked by the instructor.

– – – – – – –

# Construct the adder cum subtractor circuit and verify the result

**Objectives:** At the end of this exercise you shall be able to
- **construct a 4 bit binary adder circuit using IC 7483, IC7486 and verify the result**
- **construct a 4 bit binary subtractor circuit using IC7483, IC7486 and verify the result.**

## Requirements

**Tools/Equipments/Instruments**

- Soldering iron 25W/230V - 1 No
- Trainees tool kit - 1 Set
- Regulated DC power supply 0-30V/2A - 1 No
- Digital multimeter with probes - 1 No
- Logic probe - 1 No
- Data sheet of ICs used - as reqd

**Materials/Components**

- Miniature toggle switch SPDT - 3 Nos
- IC-7486 with base (14 pin) - 1 No
- IC-7483 with base (16 pin) - 1 No
- Breadboard - 1 No
- Solder, flux - as reqd
- Connecting wires - as reqd
- Resistor 330Ω ¼ W/CR25 - 2 Nos
- Hook up wires - as reqd
- LED 5mm, Red - 4 Nos
- LED 5mm, Green - 1 No
- Resistor 330Ω/¼ W/CR25 - 5 Nos

## PROCEDURE

TASK 1: **Construction and testing of 4 bit binary adder circuit**

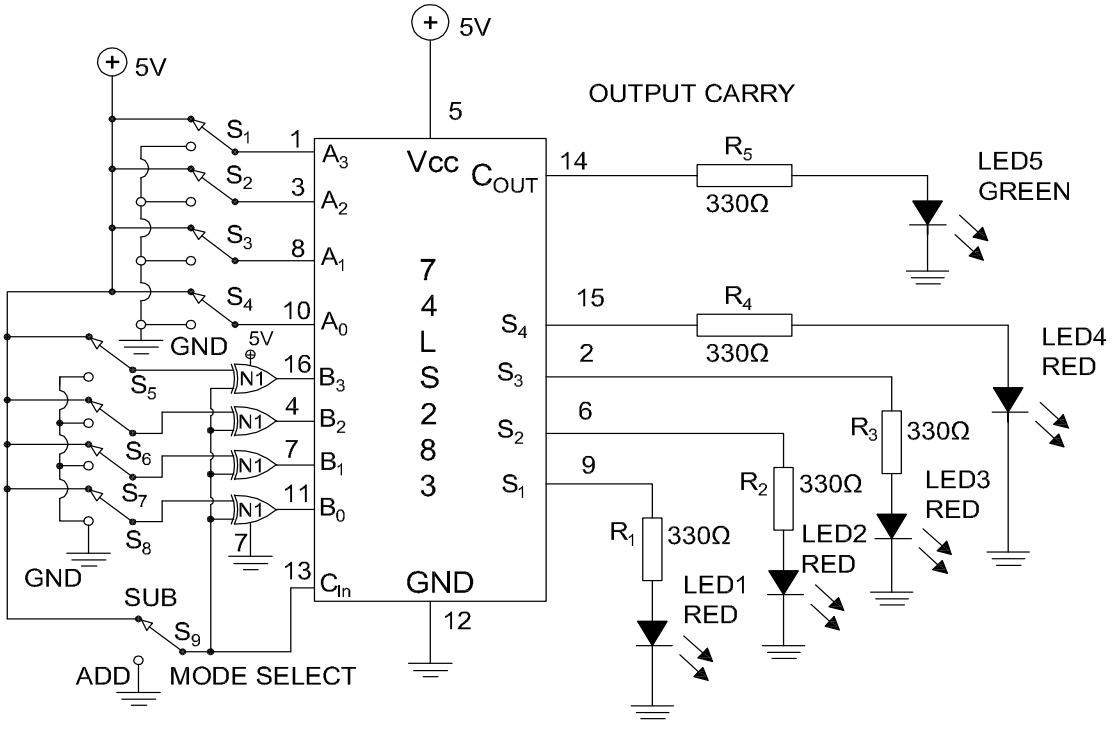
1 Collect all the components required, test them refer to the data sheet of ICs, asssemble the 4 bit binary adder circuit as shown in Fig 1 on bread board.

2 Use toggle switch $S_1$ as data input $A_0$, switch $S_2$ as data input $A_1$, and switch $S_3$ as data input $A_2$, and switch $S_4$ as data input $A_3$ as shown in Fig 1.

3 Use toogle switch $S_5$ as data input $B_0$, switch $S_6$ as data input $B_1$, and switch $S_7$ as data input $B_2$, and switch $S_8$ as data input $B_3$ and switch $S_9$ as mode select switch as shown in Fig 1.

4 Get the assembled circuit checked by the Instructor.

Fig 1




4 BIT BINARY ADDER CUM SUBTRACTOR CIRCUIT

EMN27146H1

5 Switch ON 5VDC supply and operate switches $S_1$ to $S_8$ for different logic levels either in 5V position or zero volt (GND) position keeping the switch $S_9$ at END positon to operate the circuit as 4 bit binary adder as shown in Table 1.

6 Observe the status of all the five LEDs for each step of combinations record them in Table 1.

**Table 1**

| Sl.No | Inputs | | | | Inputs | | | | | Mode switch=OV | | | | | Mode switch=5V | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | Status of LEDs | | | | | Status of LED | | | | |
| | $A_3$ | $A_2$ | $A_1$ | $A_0$ | $B_3$ | $B_2$ | $B_1$ | $B_0$ | $Carry_{out}$ | $Q_3$ | $Q_2$ | $Q_1$ | $Q_0$ | $C_{out}$ | $Q_3$ | $Q_2$ | $Q_1$ | $Q_0$ | $Carry_{out}$ |
| 1 | | | | | | | | | | | | | | | | | | | |
| 2 | | | | | | | | | | | | | | | | | | | |
| 3 | | | | | | | | | | | | | | | | | | | |
| 4 | | | | | | | | | | | | | | | | | | | |
| 5 | | | | | | | | | | | | | | | | | | | |
| 6 | | | | | | | | | | | | | | | | | | | |
| 7 | | | | | | | | | | | | | | | | | | | |
| 8 | | | | | | | | | | | | | | | | | | | |
| 9 | | | | | | | | | | | | | | | | | | | |
| 10 | | | | | | | | | | | | | | | | | | | |
| 11 | | | | | | | | | | | | | | | | | | | |
| 12 | | | | | | | | | | | | | | | | | | | |
| 13 | | | | | | | | | | | | | | | | | | | |
| 14 | | | | | | | | | | | | | | | | | | | |
| 15 | | | | | | | | | | | | | | | | | | | |
| 16 | | | | | | | | | | | | | | | | | | | |

7 Get the work checked by the Instructor.

– – – – – – –

TASK 2: **Construction and testing of 4 bit binary subtractor circuit**

Use the assembled circuit for 4 bit binary subtractor function/operation with following steps.

1 Set/toggle the mode select switch $S_9$ to 5VDC position (Logic '1')

2 Switch ON 5VDC supply and operate switches S1 to S8 for different logic levels either in 5V position or zero volt (GND) position as shown in Table 1.

3 Observe the status of all the five LEDs for each step of combinations and record them in Table 1.

4 Get the work checked by the Instructor.

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# Construct and test a 2 to 4 Decoder

**Objectives :** At the end of this exercise you shall be able to
- **construct a 2 to 4 decoder using AND, NOT gates and verify the truth table.**

## Requirements

**Tools/Equipments/Instruments**

- Logic probe - 1 No
- Trainees tool kit - 1 Set
- Regulated DC power supply 0-30V/2A - 1 No
- Soldering iron 25W/230V - 1 No
- Digital multimeter with probes - 1 No
- Data sheet of ICs used - as reqd

**Materials/Components**

- Rosin cored solder - as reqd
- Miniature toggles - 2 Nos
- 14 pin IC Base Switch SPDT - 2 Nos
- Breadboard - 1 No
- IC-7404 - 1 No
- IC-7408 - 1 No
- LED 5mm, Red - 4 Nos
- Resistor 330Ω/¼ W/CR25 - 4 Nos

**Note:**

**1 The Instructor has to guide the trainees to record 5VDC given to gate input as Logic High (1) and GND as Logic Low (0).**

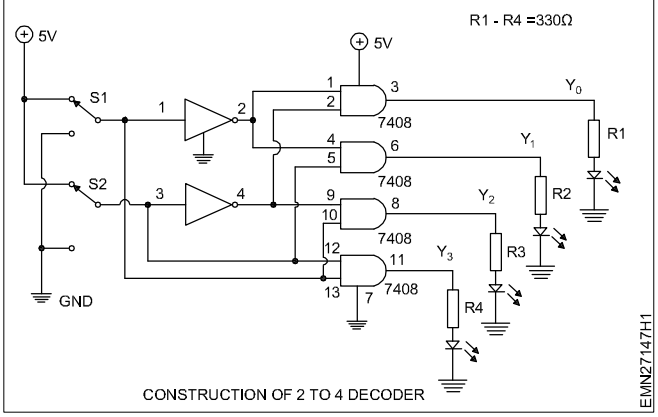
**2 The status of LED ON as Logic '1' and 'OFF' as Logic '0'.**

## PROCEDURE

TASK 1 : **Construction of 2 to 4 decoder circuit and verification of truth table**

1 Collect all the components, check them, refer to the data sheet of the ICs assemble the 2 to 4 decoder circuit as shown in Fig 1 on breadboard.

Fig 1




2 Use toggle switch $S_1$ as input A and switch $S_2$ as input B.

3 Get the assembled circuit checked by the Instructor.

4 Switch ON 5VDC supply and operate switches $S_1$ & $S_2$ for different logic levels either in 5V position or zero volt (GND) position as shown in Table - 1.

5 Observe the status of LEDs for each step of combinations and record the observations in Table - 1.

**Table 1**

| Sl. No | INPUT | | OUTPUT LED Status | | | |
|---|---|---|---|---|---|---|
| | A | B | Y0 | Y1 | Y2 | Y3 |
| 1 | 0 | 0 | | | | |
| 2 | 0 | 1 | | | | |
| 3 | 1 | 0 | | | | |
| 4 | 1 | 1 | | | | |

**2 to 4 Decoder TRUTH TABLE:**

| Sl. No | INPUT | | OUTPUT LED Status | | | |
|---|---|---|---|---|---|---|
| | A | B | Y0 | Y1 | Y2 | Y3 |
| 1 | 0 | 0 | 1 | 0 | 0 | 0 |
| 2 | 0 | 1 | 0 | 1 | 0 | 1 |
| 3 | 1 | 0 | 0 | 0 | 1 | 0 |
| 4 | 1 | 1 | 0 | 0 | 0 | 1 |

6 Verify the readings on the Table with the Truth table of 2 to 4 Decoder Truth table given.

7 Get the work checked by the Instructor.

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# Construct and test a 4 to 2 Encoder

**Objectives :** At the end of this exercise you shall be able to
- **construct and test 4 to 2 Encoder.**

## Requirements

**Tools/Equipments/Instruments**

- Soldering iron 25W/230V - 1 No
- Trainees tool kit - 1 Set
- DC power supply 0-30V/2A - 1 No
- Digital multimeter with probes - 1 No
- Data sheet of ICs used - as reqd

**Materials/Components**

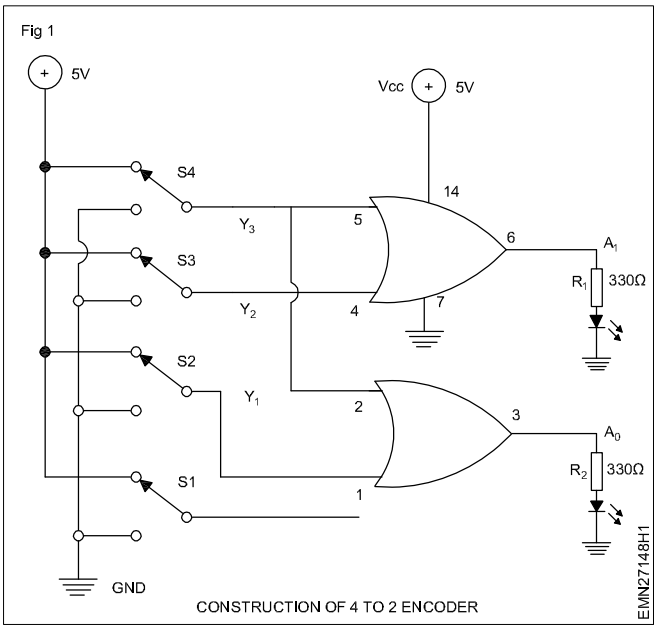
- Miniature toggles Switch SPDT - 4 Nos
- Breadboard - 1 No
- IC-7432 - 1 No
- LED 5mm, Red, Green - 1 No each
- Hook up wires - as reqd
- Rosin cored solder - as reqd
- Resistor 330Ω/¼ W/CR25 - 2 Nos

## PROCEDURE

TASK 1: **Construction of 4 to 2 Encoder circuit and verification of its truth table**

1 Collect all the components, check them and assemble the 4 to 2 Encoder circuit as shown in Fig 1 on bread board.

Fig 1




CONSTRUCTION OF 4 TO 2 ENCODER

2 Use toggle switch $S_1$ as input $Y_0$, switch $S_2$ as input $Y_1$, switch $S_3$ as input $Y_2$ and switch $S_4$ as input $Y_3$.

**In the 4 to 2 Encoder using OR gates note that the switch $S_1$ is kept unconnected to the input, as neither of the outputs depend on it.**

3 Get the assembled circuit checked by the Instructor.

4 Switch ON 5VDC supply, and operate switches $S_2$, $S_3$ and $S_4$ only for different logic levels either in 5V position or zero volt (GND) position as shown in Table - 1.

**Table 1**

| Sl. No | INPUT | | | | OUTPUT | |
|---|---|---|---|---|---|---|
| | Y3 | Y2 | Y1 | Y0 | A1 | A0 |
| 1 | 0 | 0 | 0 | 1 | | |
| 2 | 0 | 0 | 1 | 0 | | |
| 3 | 0 | 1 | 0 | 0 | | |
| 4 | 1 | 0 | 0 | 0 | | |

**2 to 4 Decoder TRUTH TABLE:**

| Sl. No | INPUT | | | | OUTPUT | |
|---|---|---|---|---|---|---|
| | Y3 | Y2 | Y1 | Y0 | A1 | A0 |
| 1 | 0 | 0 | 0 | 1 | 0 | 0 |
| 2 | 0 | 0 | 1 | 0 | 0 | 1 |
| 3 | 0 | 1 | 0 | 0 | 1 | 0 |
| 4 | 1 | 0 | 0 | 0 | 1 | 1 |

5 Observe the status of LEDs for each step of combinations and record your observations in Table - 1.

6 Verify the readings on the Table with the Truth table of 4 to 2 Encoder given.

7 Get the work checked by the Instructor.

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# Construct and test a 4 to 1 Multiplexer

**Objectives :** At the end of this exercise you shall be able to
- **construct and test 4 to 1 multiplexer circuit using IC74LS151.**

## Requirements

**Tools/Equipments/Instruments**

- Soldering iron 25W/230V - 1 No
- Trainees tool kit - 1 Set
- Regulated DC power supply 0-30V/2A - 1 No
- Digital multimeter with probes - 1 No

**Materials/Components**

- Rosin cored solder - as reqd
- IC-74LS151 - 1 No
- IC 7432 IC base - 1 No
- Digital IC trainer kit with instruction manual - 1 No
- Resistor 330Ω/¼ W/CR25 - 2 Nos
- Bread board - 1 No
- LED 5mm, Red - 1 No
- Hook up wires - as reqd
- Miniature SPDT toggle switch - 6 Nos
- Data sheet of IC 74LS151 - 1 No

**Safety Precaution: Ensure that the IC pins are not bent while inserting into the bread board IC Base.**

## PROCEDURE

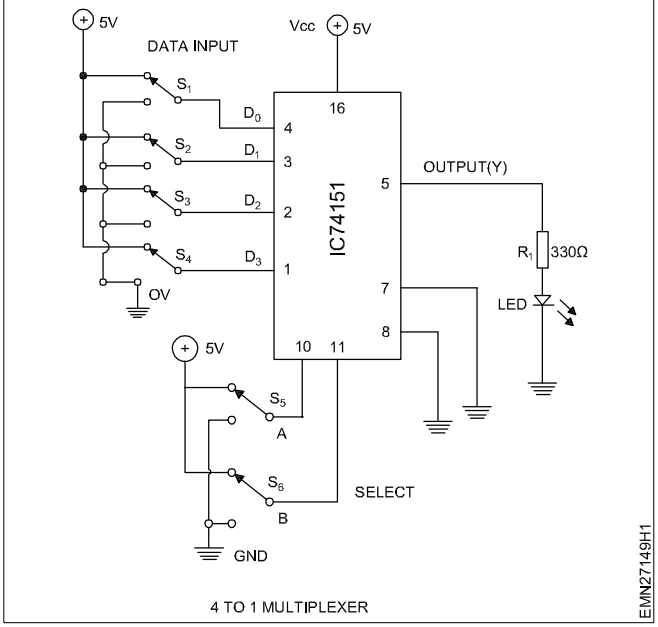
**Note: If the digital IC trainer kit is not available in the lab,follow the steps given for this exercise** .

TASK 1 : **Construction and testing of 4 to 1 multiplexer circuit using IC 74LS151**

1 Collect the components required, check them and assemble the multimeter circuit as shown in Fig 1 on breadborad.

**Use the 16 pin IC base for IC74LS151.**

Fig 1




4 TO 1 MULTIPLEXER

2 Use toggle switches either in 5V position or in Zero Volt position for different logic levels as shown in Table-1.

3 Get the assembled multiplexer circuit checked by the Instructor.

4 Switch ON the 5VDC supply to the circuit and operate switches S1 to S4 for Data inputs and S5 & S6 for selection Sequence.

5 Observe the LED for each setting and record it in Table 1.

**Note: When data input is not available, multiplexer does not produce output for the select condition.**

6 Verify the output by keeping data input switches S1 to S4 in 5VDC position and select S5 & S6 randomly.

7 Observe the LED and change Data input switches one at a time for theLED to go OFF.

**It confirms that input is selected and goes to the output.**

8 Repeat steps 6 & 7 with different combinations of S5 & S6 and confirm the Data selected.

**Table 1**

| Sl. No. | DATA INPUTS (LOGIC LEVELS) | | | | SELECT SEQUENCE | | LED OUTPUT (Y) |
|---|---|---|---|---|---|---|---|
| | D3 | D2 | D1 | D0 | B | A | |
| 1 | 0 | 0 | 0 | 1 | 0 | 0 | D0-LED ON |
| 2 | 0 | 0 | 1 | 0 | 0 | 1 | D1-LED ON |
| 3 | 0 | 1 | 0 | 0 | 1 | 0 | D2-LED ON |
| 4 | 1 | 0 | 0 | 0 | 1 | 1 | D3-LED ON |
| 5 | 1 | 1 | 1 | 1 | | | |

9 Get the work checked by the Instructor.

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# Construct and test a 1 to 4 Demultiplexer

**Objectives :** At the end of this exercise you shall be able to
- **construct and test a 1 to 4 demultiplexer circuit using IC 74LS138.**

## Requirements

**Tools/Equipments/Instruments**

- Trainees tool kit - 1 Set
- Regulated DC power supply 0-30V/2A - 1 No
- Digital multimeter with probes - 1 No
- Soldering iron 25W/230V - 1 No
- Digital IC trainer kit with instruction manual - 1 Set

**Materials/Components**

- IC-74LS138 with data sheet - 1 No
- 16 pin IC Base - 1 No
- LED 5mm, Red, Green - 4 Nos
- Resistors 330Ω/¼W/CR25 - 4 Nos
- Hook up wires - as reqd
- Breadboard - 1 No
- Rosin cored solder - as reqd

**Note: If the digital IC trainer hit is not available in the lab, follow the steps given for this exercise.**

## PROCEDURE

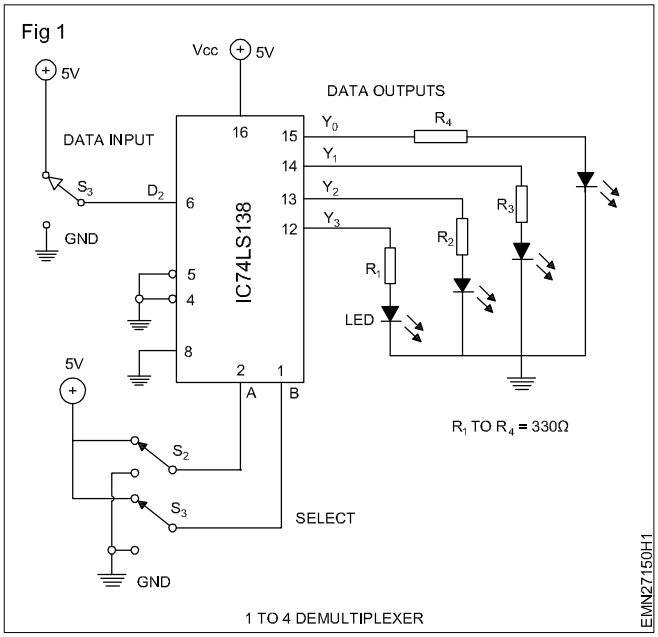
TASK 1 : **Construction and testing of 1 to 4 Demultiplexer circuit using IC74LS138**

1 Collect all the components check them and assemble the demultiplexer as shown in Fig 1 on breadboard.

**Use the 16 pin base for IC74LS138.**

2 Connect the toggle switch at input as shown in the circuit

Fig 1




3 Get the assembled circuit checked by the Instructor.

4 Switch ON the 5VDC supply to the circuit, Keep S1 at + 5VDC for the data input high. Change the settings of switches S2 and S3 for different combination of Data select sequence as shown in Table -1.

5 Observe the LEDs for each setting and record the status in Table -1

**Note: When data input is not available, Demultiplexer does not produce output for that condition in any of the Data output pins.**

6 Verify the output by keeping the Data input switch S1 to ground, Select Switch S2 & S3 randomly.

7 Observe the LED, Change switches S2 & S3 to other three combinations, for whether any of the LEDs to glow.

8 Repeat steps 6 and 7 by keeping the switch S1 at +5VDC and confirm the LEDs are glowing independently as per the selection sequence in Table -1

Table 1

| Sl. No. | Selection Sequence | | Output channels(Pin Nos.) LED ON =1 LED OFF = 0 | | | | | | | | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | A | B | Y0 pin 15 | Y1 pin 14 | Y2 pin 13 | Y3 pin 12 | Y0 LED | Y1 LED | Y2 LED | Y3 LED | |
| 1 | | | | | | | | | | | |
| 2 | | | | | | | | | | | |
| 3 | | | | | | | | | | | |
| 4 | | | | | | | | | | | |
| 5 | | | | | | | | | | | |

9 Get the work checked by the Instructor.

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# Identify different Flip-Flop ICs by the number printed on them

**Objectives :** At the end of this exercise you shall be able to
- **identify different Flip Flop by the number printed on the ICs.**

## Requirements

**Tools/Equipments/Instruments**

- Trainees tool kit - 1 Set

**Aids:** Data sheet of ICs used for this exercise

**Materials/Components**

- 74 LS 73
  74 LS 74
  74 LS 76
  74 LS 107
  74 LS 109

  - 1 No each

**Note: Instructor has to label the different types of logic gates ICs.**

## PROCEDURE

1 Collect the labelled flipflop ICs from the Instructor

2 Pick one of the IC from the lot, and identify the code number printed on the IC and noted in Table -1

3 Refer to the data sheet of the IC, draw the pinout diagram and mark the details in Table 1.

4 Repeat the steps 2 and 3 for remaining labelled logic gates.

**Note:**

**1 The Instructor has to provide/ensure the Flipflop ICs with their number printed on them is clearly visible.**

**2 Insert all the ICs on the breadboard.**

**Safety Precaution: Do not touch the pins of ICs with fingers.**

Table 1

| Sl.No. | IC Number | Logic gates function | Symbol | Pinout diagram |
|---|---|---|---|---|
| 1 | | 74LS73 | | |
| 2 | | 74LS74 | | |
| 3 | | 74LS76 | | |
| 4 | | 74LS107 | | |
| 5 | | 74LS109 | | |

5 Get the work checked by the Instructor.

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# Construct and test four bit latch using 7475

**Objectives :** At the end of this exercise you shall be able to
- **Construct and test four bit latch using IC 7475**

## Requirements

**Tools/Equipments/Instruments**

- Trainees tool kit - 1 Set
- Regulated DC power supply 0-30V/2A - 1 No
- Digital multimeter with probes - 1 No
- Data sheet of IC7475 - 1 No

**Materials/Components**

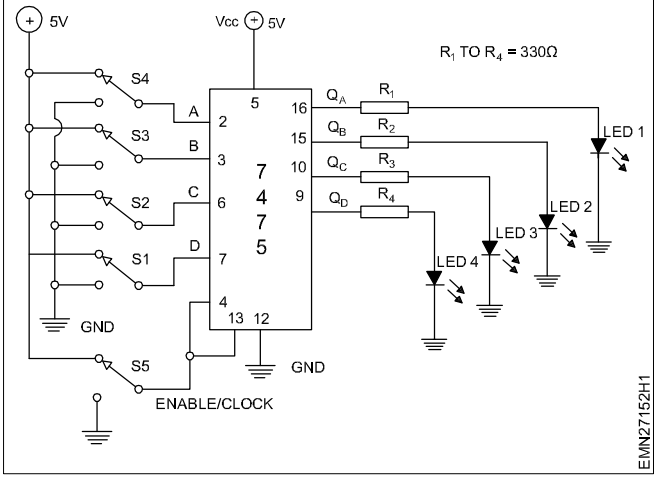
- Breadboard - 1 No
- IC-7475 (D-Latch) with base - 1 No
- LED 5mm, Red - 4 Nos
- Resistors 330Ω/¼ W/CR25 - 4 Nos
- Miniature toggle Switch SPDT - 5 Nos
- Hook up wires - as reqd

## PROCEDURE

TASK 1 : **Construction and testing of fourbit batch circuit using IC7475**

1 Collect all the components, check them refer to the data sheet of the IC, assemble the 4 bit latch circuit as shown in Fig 1 on breadboard.

Fig 1




**Use the 16 pin IC base on the breadboard for this exercise.**

2 Use toggle switch $S_1$ as data input A, switch $S_2$ as data input B, switch $S_3$ as data input C, switch $S_4$ as data input D and switch $S_5$ as Enable/clock input.

3 Get the assembled circuit checked by the Instructor.

4 Switch ON 5VDC supply and operate switches $S_1$ to $S_5$ for different logic levels either in 5V position or zero volt (GND) position as shown in Table - 1.

5 Observe the LEDs for each step of combinations, record them in Table 1.

**Table 1**

| Sl.No | Inputs | | | | Enable/clock =1 | | | | Enable/clock =0 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Output LEDs | | | | Output LEDs | | | |
| | A | B | C | D | $Q_A$ | $Q_B$ | $Q_C$ | $Q_D$ | $Q_A$ | $Q_B$ | $Q_C$ | $Q_D$ |
| 1 | 0 | 0 | 0 | 0 | | | | | | | | |
| 2 | 0 | 0 | 0 | 1 | | | | | | | | |
| 3 | 0 | 0 | 1 | 0 | | | | | | | | |
| 4 | 0 | 0 | 1 | 1 | | | | | | | | |
| 5 | 0 | 1 | 0 | 0 | | | | | | | | |
| 6 | 0 | 1 | 0 | 1 | | | | | | | | |
| 7 | 0 | 1 | 1 | 0 | | | | | | | | |
| 8 | 0 | 1 | 1 | 1 | | | | | | | | |
| 9 | 1 | 0 | 0 | 0 | | | | | | | | |
| 10 | 1 | 0 | 0 | 1 | | | | | | | | |
| 11 | 1 | 0 | 1 | 0 | | | | | | | | |
| 12 | 1 | 0 | 1 | 1 | | | | | | | | |
| 13 | 1 | 1 | 0 | 0 | | | | | | | | |
| 14 | 1 | 1 | 0 | 1 | | | | | | | | |
| 15 | 1 | 1 | 1 | 0 | | | | | | | | |
| 16 | 1 | 1 | 1 | 1 | | | | | | | | |

6 Get the work checked by the Instructor.

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# Construct and test R-S Flip-flop using IC 7400 with clock and without clock pulse

**Objectives:** At the end of this exercise you shall be able tos
- **construct and test R-S flip-flop using IC 7400 without clock pulse**
- **construct and test RD flip-flop with clock pulse.**

## Requirements

**Tools/Equipments/Instruments**

- Trainees tool kit - 1 Set
- DC power supply 0-30VDC/2A - 1 No
- Digital multimeter with probes - 1 No

**Materials/Components**

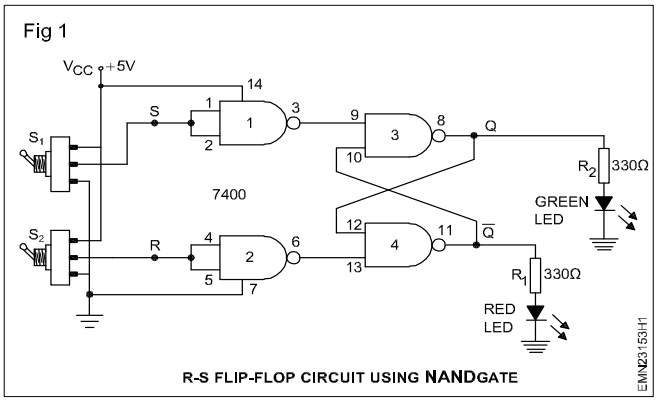
- Breadboard - 1 No
- IC-7400 NAND gate with data sheet - 1 No
- Miniature toggles switch - 2 Nos
- Hook up wires - as reqd
- LED 5mm, Red, Green - 1 No each
- Resistor 330Ω/¼ W/CR25 - 2 Nos

## PROCEDURE

TASK 1: **Construction and testing of R-S Flip-Flop without clock pulse using IC 7400**

1 Collect all the components required, check them and assemble the RS flipflop circuit on the breadboard as shown in Fig 1

Fig 1




R-S FLIP-FLOP CIRCUIT USING NANDGATE

2 Get the assembled RS flipflop circuit checed by the Instructor.

3 Switch ON 5DVC supply to the circuit, use switches $S_1$ and $S_2$ for setting input logic levels as shown in Fig 1.

4 Operate the switches to apply different logic levels and observe corresponding output.

5 Record the status of LEDs for each step of logic levels.

**Table 1**

**RS flip-flop using NAND gate**

| Input | | Output | | | | |
|---|---|---|---|---|---|---|
| **S** | **R** | **Q** | **Q - LED Status (ON/OFF)** | **Q** | **Q - LED Status (ON/OFF)** | **Operating Mode** |
| **0** | **1** | | | | | **Set** |
| **1** | **1** | | | | | **No Change** |
| **1** | **0** | | | | | **Reset** |
| **1** | **1** | | | | | **No Change** |
| **0** | **0** | | | | | **Forbidden** |

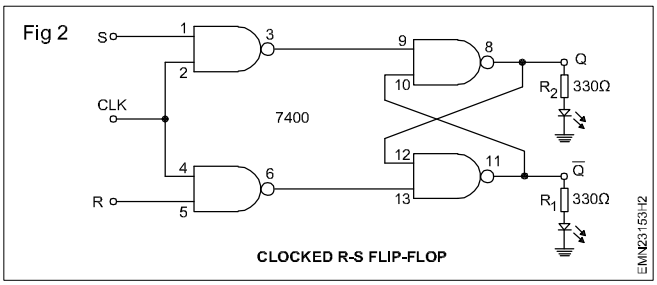
6 Get the work checked by the Instructor.

– – – – – – –

TASK 2 : **Construction and testing of RS flipflop with clock pulse using IC 7400**

1 Modify the RS flipflop circuit into clocked RS flipflop circuit as shown in Fig 2.

Fig 2




CLOCKED R-S FLIP-FLOP

2 Connect switches S1 and S2 at R and S inputs respectively.

3 Switch ON 5VDC supply to the circuit, operate switches S1,S2 apply differnt logic levels to the input keeping clock input at ground/negative.

4 Observe the status of LEDs for the above four steps and record in Table 2.

5 Connect the clock input to +5VDC and repeat steps 3 and 4 and record the obsevations for next four steps.

**Table 2**

| Clock Input | Input | | Output | | | |
|---|---|---|---|---|---|---|
| | S | R | Q | Q-LED Status (ON/OFF) | Q | Q-LED Status (ON/OFF) |
| 0 | 0 | 1 | | | | |
| 0 | 1 | 0 | | | | |
| 0 | 1 | 1 | | | | |
| 0 | 0 | 0 | | | | |
| 1 | 0 | 1 | | | | |
| 1 | 0 | 0 | | | | |
| 1 | 1 | 0 | | | | |
| 1 | 0 | 0 | | | | |
| 1 | 1 | 1 | | | | |

6 Get the work checked by the Instructor.

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# Verify the truth tables of Flipflop ICs (RS, D, T, JK, MSJK) by connecting switches and LEDs

**Objectives:** At the end of this exercise you shall be able to
- **construct and verify the truth table of RS flip flop by connecting switches and LEDs**
- **construct and verify the truth table of D flip flop by connecting switches and LEDs**
- **construct and verify the truth table of T.flip flop by connecting switches and LEDs**
- **construct and verify the truth table of JK flop by connecting switches and LEDs**
- **construct and verify the truth table of JK flip flop by connecting switches and LEDs.**

## Requirements

**Tools/Equipments/Instruments**

- Trainees tool kit - 1Set
- DC power supply - 0-30V/2A - 2 Nos
- DMM with probes - 1 No

**Materials/Components**

- Breadboard - 1 No
- IC 74 HC00 (Quad Nand Gate) - 2 Nos
- IC 74LS10 (3 Input NAND) - 1 No
- IC MC74HC 73 (Dual/JKFlip-Flop) - 1 No
- IC 74LS76 (JK-FF) - 1 No
- Resistors 330Ω/¼ W/CR25 - 4 Nos each
- LED (Red,Green) - 1 No each
- Toggle switch - 4 Nos
- Connecting wire - as reqd
- Battery (9V) - as reqd

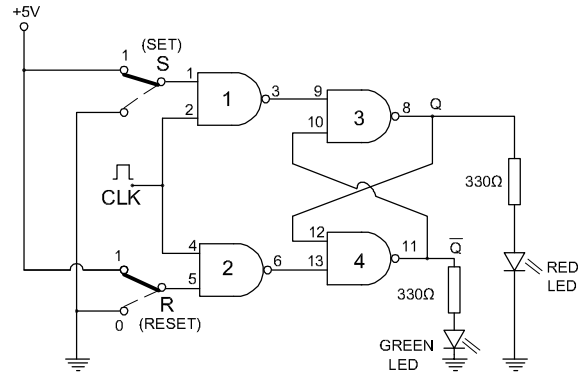
**Aids:** • Semicondutor digital IC-Data manual
• charts

## PROCEDURE

TASK 1: **Construction of RS flipflop circuit and verification of the truth table.**

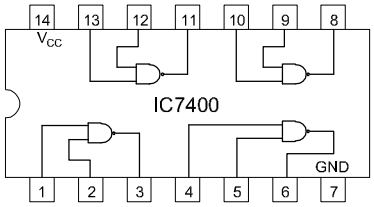
- Collect the materials, check them and assemble RS flipflop circuit on a breadboard as shown in Fig 1a.

Fig 1a




CLOCKED SR FLIP-FLOP

Fig 1b




PINOUT DIAGRAM OF IC7400

EMN23154H1

- Get the circuit checked by the Instructor.
- Apply different Inputs to S and R as given in truth table 1 and record the corresponding output levels and the status of the LED.
- Thus for different inputs at S and R the corresponding output can be seen through LED Q and $\overline{Q}$.

**Table 1**

**Truth table of clocked SR Flip-flop**

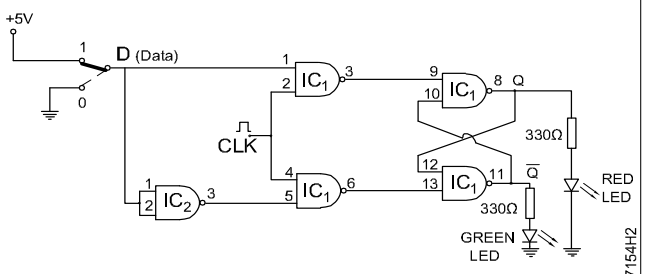
| CLK | INPUT | | OUTPUT | | State of Flip flop |
|---|---|---|---|---|---|
| Clock | S | R | Q | $\overline{Q}$ | |
| LOW | x | x | 0 | 1 | Previous state |
| HIGH | 0 | 0 | 0 | 1 | No state |
| HIGH | 0 | 1 | 0 | 1 | Reset |
| HIGH | 1 | 0 | 1 | 0 | High |
| HIGH | 1 | 1 | x | x | In terminate |

- Get the work checked by the Instructor.

TASK 2 : **Construction of D flipflop circuit and verfication of the truth table**

- Assemble a D flipflop circuit by referring to Fig 2 on a bread board
- Get the circuit checked by the instructor.
- Apply different input to D Flip Flop as given in the truth table and verify the corresponding output level and the status of LEDs at Q and $\overline{Q}$ of the FF.

Fig 2




D FLIP-FLOP

**Table 2**

**Truth table of D Flip-Flop - clocked**

| Clock | INPUT | OUTPUT | |
|---|---|---|---|
| | D | Q | $\overline{Q}$ |
| LOW | x | 0 | 1 |
| HIGH | 0 | 0 | 1 |
| HIGH | 1 | 1 | 0 |

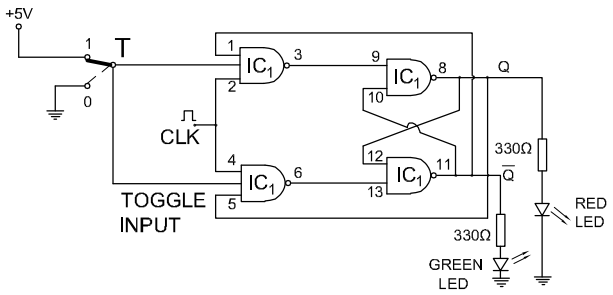
- Get the work checked by the Instructor.

– – – – – – –

TASK 3: **Construction of T.flip flop circuit and verification of the truth table**

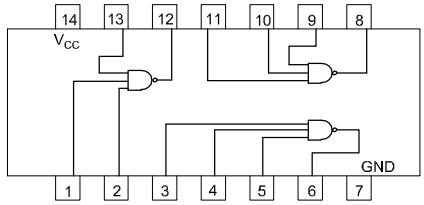
- Assemble a T.flipflop on a breadboard as shown in Fig 3a.

Fig 3a




T FLIP-FLOP

Fig 3b




PIN DIAGRAM OF IC74LS10

EMN27154H3

- Get the circuit checked by the Instructor
- Apply different inputs to toggle FF as given in the truth table at table and verify the corresponding output level and the status of LED
- Thus for different inputs at T.flip flop corresponding outputs can be seen through LEDs Q and Q'.

**Table 3**

| Clock | INPUT | OUTPUT | | Status of output |
|---|---|---|---|---|
| High/Low | T | Q | $\overline{Q}$ | |
| Low | x | 0 | 1 | Previos |
| High | 0 | 0 | 1 | No change |
| High | 1 | 1 | 0 | Output-toggles |

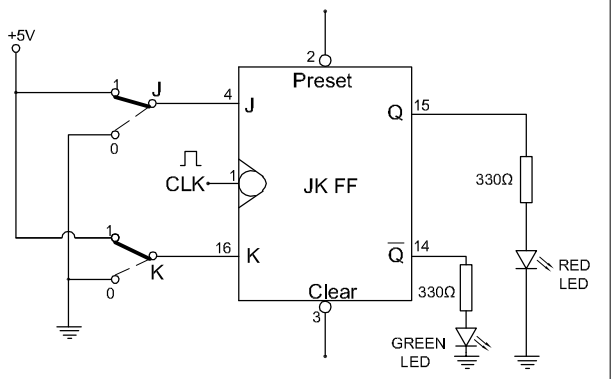
- Get the work checked by the Instructor.

– – – – – – –

TASK 4 : **Construction of JK flip-flop circuit and verification of the truth table**

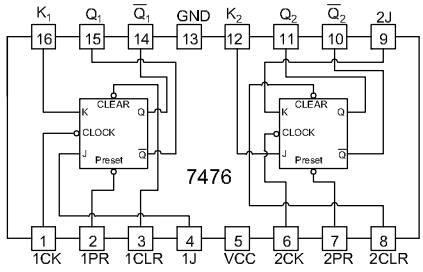
- Assemble a Jk flip-flop circuit by referring to Fig 4 on a bread board

Fig 4a




JK FLIP FLOP

Fig 4b




PINOUT DIAGRAM OF IC7476

EMN23154H4

- Get the circuit checked by the Instructor.
- Apply different inputs J and K, as given in the truth table 4 and verify the corresponding output levels and the status of LEDs.
- Thus for different inputs of JK flip-flop corresponding outputs can be seen through LEDs Q and $\overline{Q}$.

**Table 4**

**Truth table of JK Flip Flop**

| Clock Input H/L | INPUTS | | | | OUTPUTS | |
|---|---|---|---|---|---|---|
| | Preset | Clear | J | K | Q | $\overline{Q}$ |
| X | 0 | 0 | X | X | 1 | 1 |
| X | 0 | 1 | X | X | 1 | 0 |
| X | 1 | 0 | X | X | 0 | 1 |
| L | 1 | 1 | 0 | 0 | 0 | Q |
| L | 1 | 1 | 1 | 0 | 1 | 0 |
| L | 1 | 1 | 0 | 1 | 0 | 1 |
| L | 1 | 1 | 1 | 1 | Toggles | Toggles |
| L | 1 | 1 | X | X | Q | $\overline{Q}$ |

- Get the work checked by the Instructor.

– – – – – – –

TASK 5 : **Construction of a master -slave JK flip-flop circuit and verification of the truthtable**

- Assemble a MSJK flip-flop circuit by referring to Fig 5 on a breadboard
- Get the circuit checked by the Instructor
- Apply different Inputs J and K, MSJK as given in the truth table 5 and verify the corresponding output levels and status of LEDs.
- Thus for different Inputs of MSJK flip-flop corresponding outputs can be seen through LEDs Q and Q'

**Note: MS JK FF.**

**It may be noted that in the Fig 5. the output of the master J-K FF is led to the input of slave FF. the outputs of slave - FF is used as leedback inputs to master J-k FF. The clk pulse is inverted and applied to slave FF. So the inputs are received by the slave FF only during trailing edge of clock pulse [logic-level-0]. Hence the Master - slave Jk Flip-Flop is a "Synchronons' device as it a passes data with the timing of the clock signal.**

**When Master receives Input during positive clock signal, slave FF outputs are said to be in latched condition (means no change).**

**In the truth table, $M_1$ and $M_2$ are outputs of Master FF and Q & $\overline{Q}$ are the outputs of slave FF.**

Fig 5a

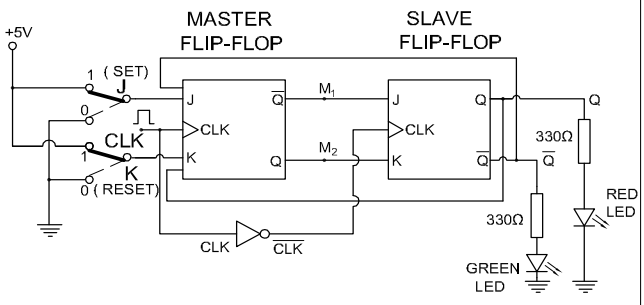
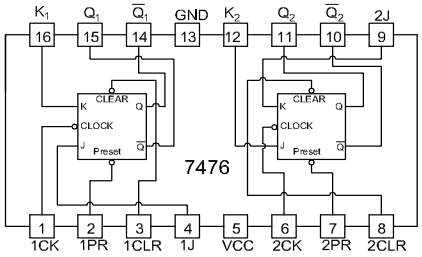



Fig 5b




PINOUT DIAGRAM OF IC7476

EMN23154H5

**Table 5**

**Truth table of master slave JK Flip Flop**

| Trigger | Inputs | | Output | | | | | | Inference |
|---|---|---|---|---|---|---|---|---|---|
| | | | Present state | | Intermediate | | Next state | | |
| CLK | J | K | Q | Q | M1 | M2 | Q | $\overline{Q}$ | |
| ↑ | 0 | 0 | 0 | 1 | 0 | 1 | Latched | | No Change |
| ↓ | | | 0 | 1 | Latched | | 0 | 1 | |
| ↑ | | | 1 | 0 | 1 | 0 | Latched | | |
| ↓ | | | 1 | 0 | Latched | | 1 | 0 | |
| ↑ | 0 | 1 | 0 | 1 | 0 | 1 | Latched | | Reset |
| ↓ | | | 0 | 1 | Latched | | 0 | 1 | |
| ↑ | | | 1 | 0 | 0 | 1 | Latched | | |
| ↓ | | | 1 | 0 | Latched | | 0 | 1 | |
| ↑ | 1 | 0 | 0 | 1 | 1 | 0 | Latched | | Set |
| ↓ | | | 0 | 1 | Latched | | 1 | 0 | |
| ↑ | | | 1 | 0 | 1 | 0 | Latched | | |
| ↓ | | | 1 | 0 | Latched | | 1 | 0 | |
| ↑ | 1 | 1 | 0 | 1 | 1 | 0 | Latched | | Toggles |
| ↓ | | | 0 | 1 | Latched | | 1 | 0 | |
| ↑ | | | 1 | 0 | 0 | 1 | Latched | | |
| ↓ | | | 1 | 0 | Latched | | 0 | 1 | |

- Get the work checked by the Instructor.

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# Prepare simple digital and electronic circuits using the software

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

- **construct EX-OR gate using IC7404, 7408 and 7432 by the simulation software**
- **construct a positive shunt clipper circuit using discrete components by simulation software.**

## Requirements

**Tools/Equipments/Instruments**

- Personal computer installed with simulation software like TINA/Multisim or similar software - 1 No
- Printer - 1 No

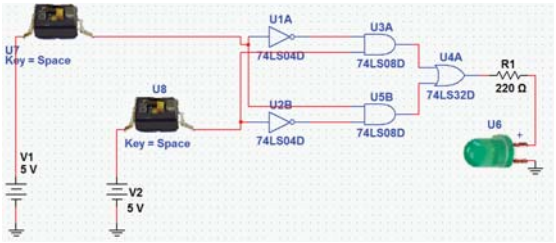
**Note: This exercise has been developed using the multisim simulatiom software. The instructor has to follow/guide the trainees as per the steps/sequence with reference to the software available in the Lab/ computer.**

## PROCEDURE

TASK 1 : **Construction of EX-OR gate using simulation software**

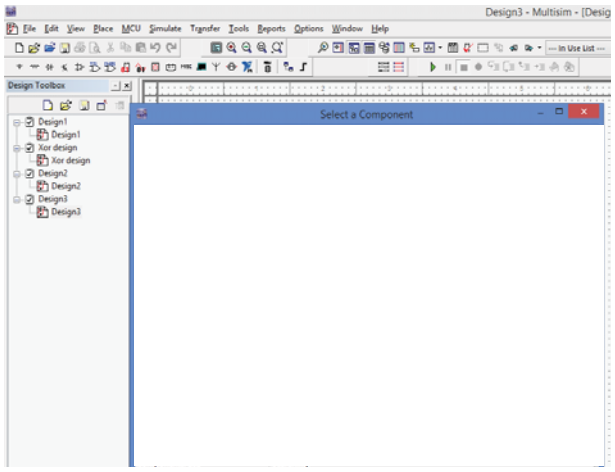
1 Select the circuit diagram to construct using simulation software. (For example the XOR gate is selected for this exercise) as shown in Fig 1.

Fig 1



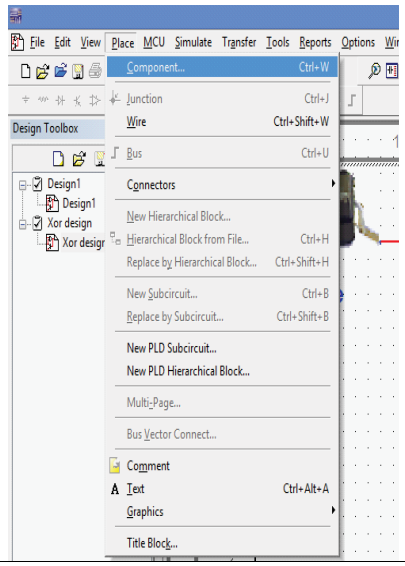

2 Switch ON computer, open the simulation software through the windows start menu or click on the simulator icon on your desktop and get the first screen as shown in Fig 2.

Fig 2




3 Click on **Place** menu and pull down the options as shown in Fig 3.

Fig 3




4 Click on component group, select **TTL** and scroll to **74LS** and select the required IC (**74LS04D**) and click **OK** as shown in the Fig 4.

Fig 4

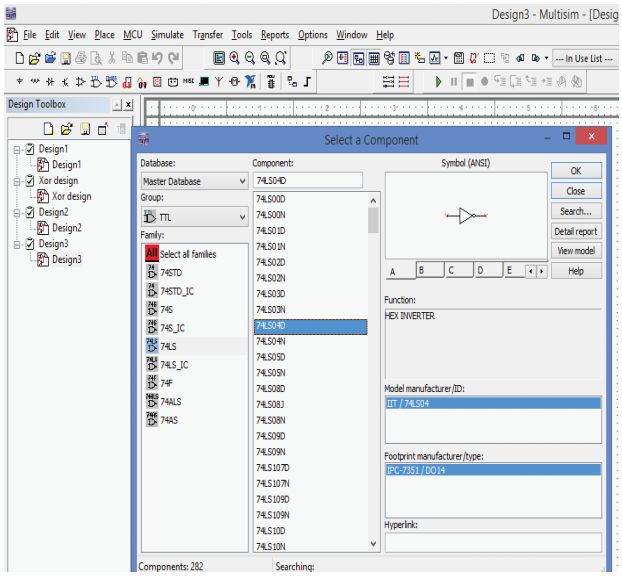



Fig 5

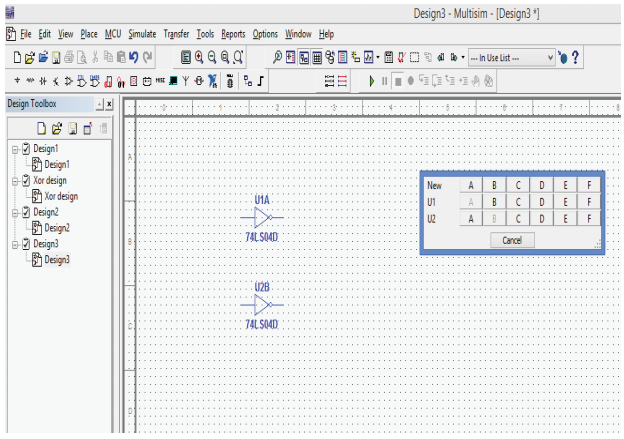
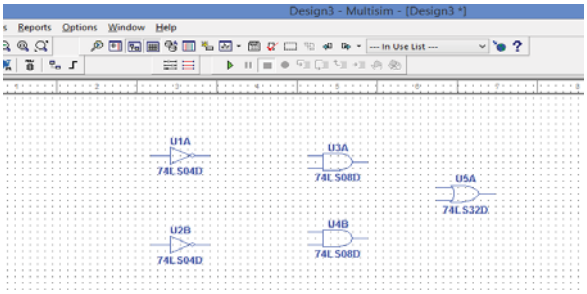



Fig 6

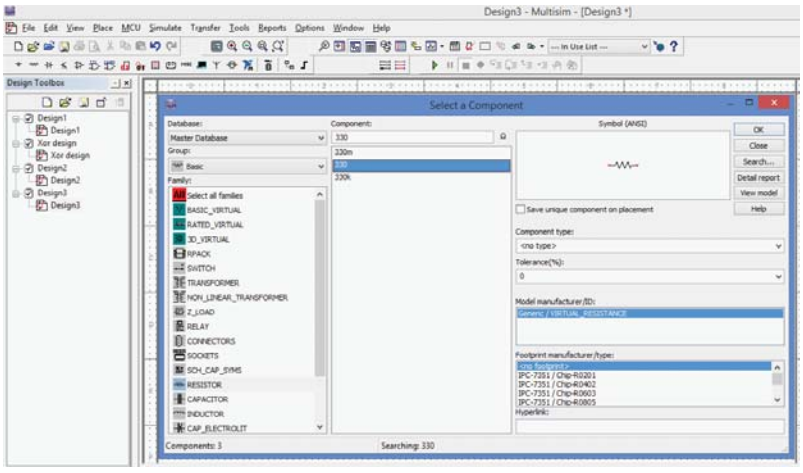



5 Click on A and OK, if more than one gate is required click on A and B, etc. as shown in the Fig 5.

6 Follow the step 4&5 to select the other logic gates 7408 and 7432 as shown in Fig 6.

7 Select the required resistor by referring the figure given in Fig 7 and click **OK.**

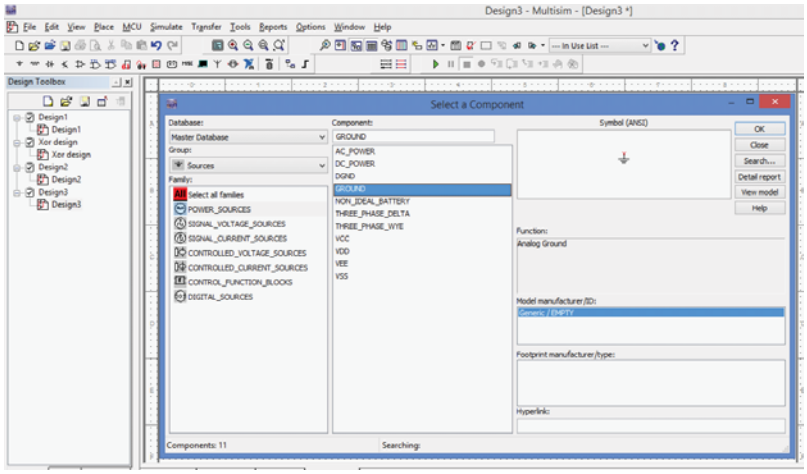
Fig 7




8 Select the required LED and click OK.

9 Add the power supply and ground to the circuit as shown in Fig 8.

Fig 8

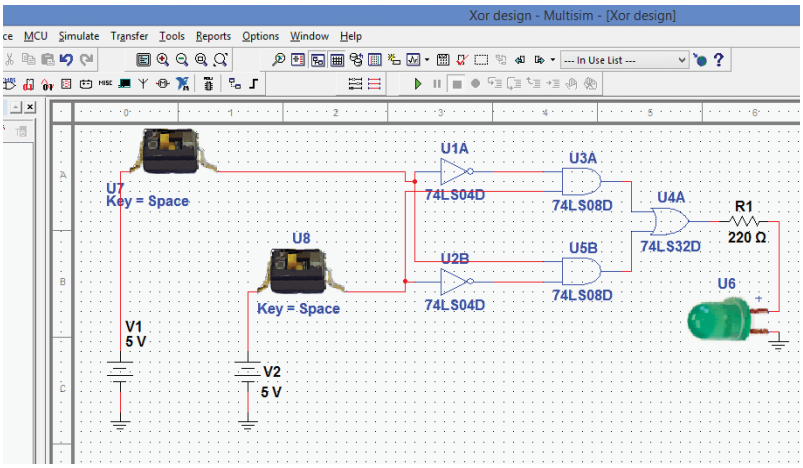



10 Make the wiring of the circuit by following Fig 1. Keep the cursor at one node of the component a dot will appear, move the cursor to the place of wiring the dot will appear at that node, now click the mouse to finish the wiring.

11 Double click on the power supply and change the label as A and B and set the voltages to 0.

12 Double click on the LED and change the label as C as shown in Fig 9 and save it.

Fig 9




13 Get the work checked by the Instructor.

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TASK 2 : **Construction of positive shunt clipper circuit using simulation software**

1 Select the positive shunt clipper circuit by referreing to the circuit as shown in in Fig 10.

2 Switch ON the computer, double click on the simulator icon on the desktop.

3 Click on semiconductor and then click on diode, drag the diode into the user area as shown in Fig 11

4 Double click on the diode in the user area and click on the TYPE.

Fig 10

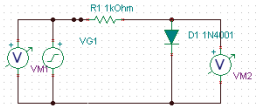
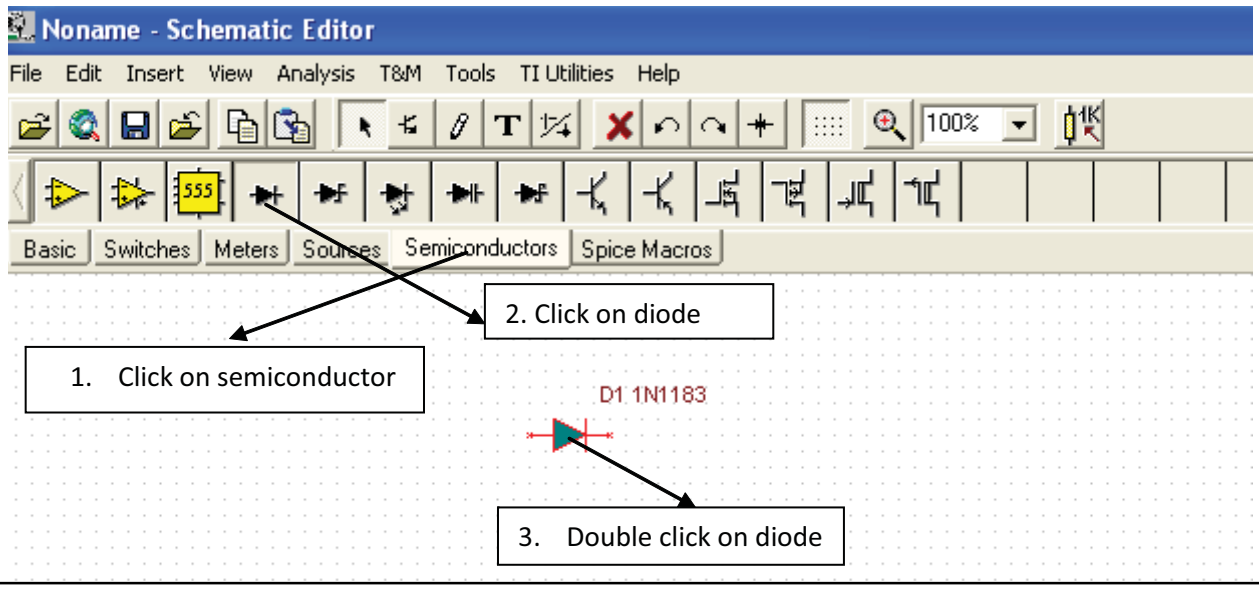


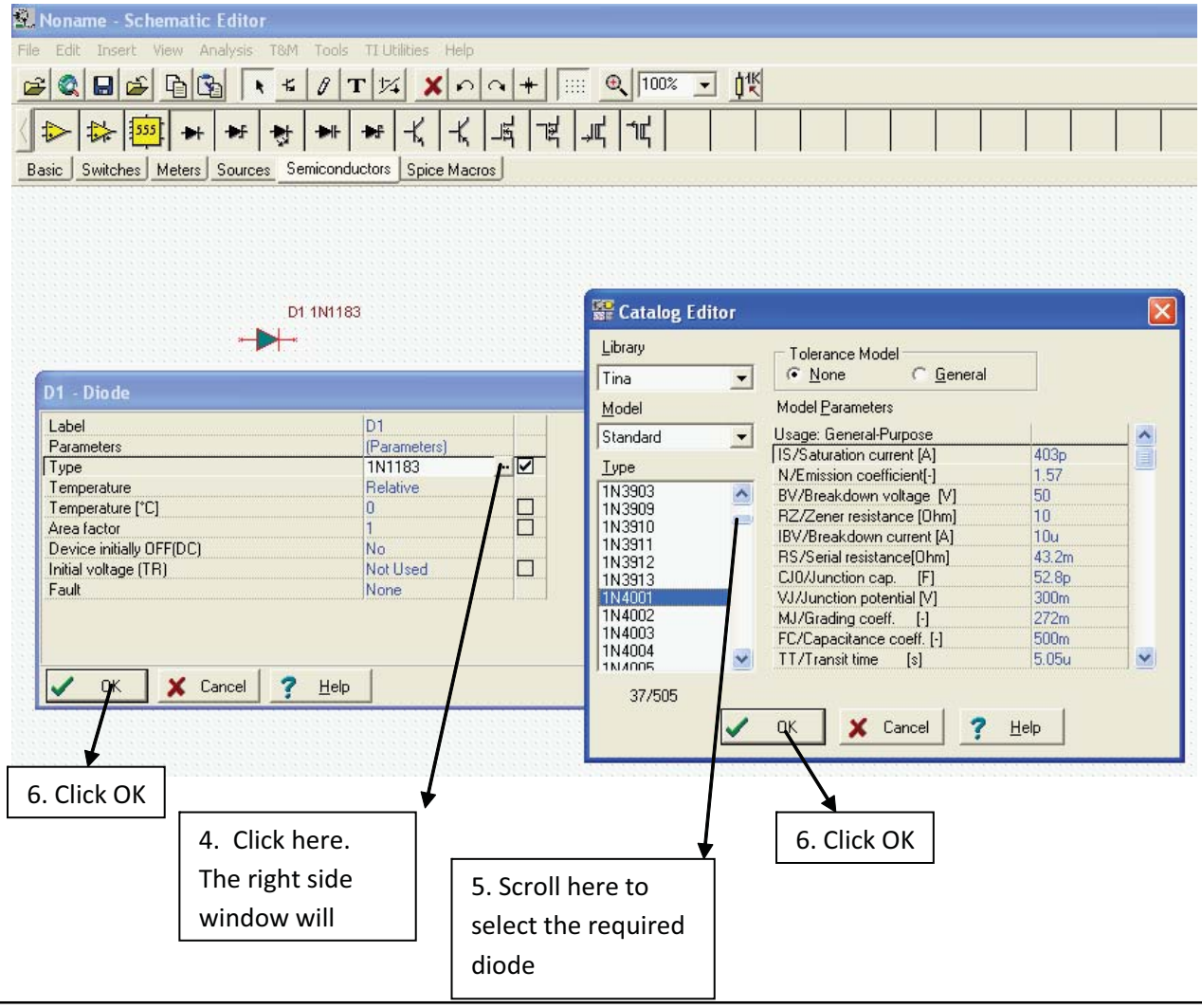
Fig 11




5 Select the suitable diode as shown in Fig 12 and Click **on OK** tab.

6 Ensure that the selected diode type number is displayed near the diode symbol.

Fig 12



7 Right click on the diode select **Rotate Right** if you want to place the diode in the vertical position as shown in Figs 13 & 14.

Fig 13

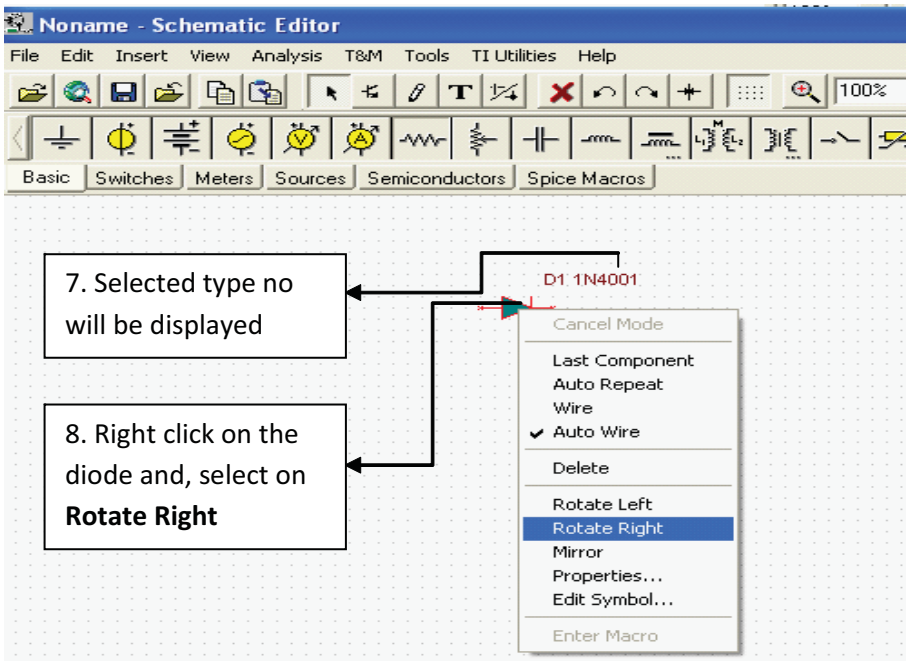
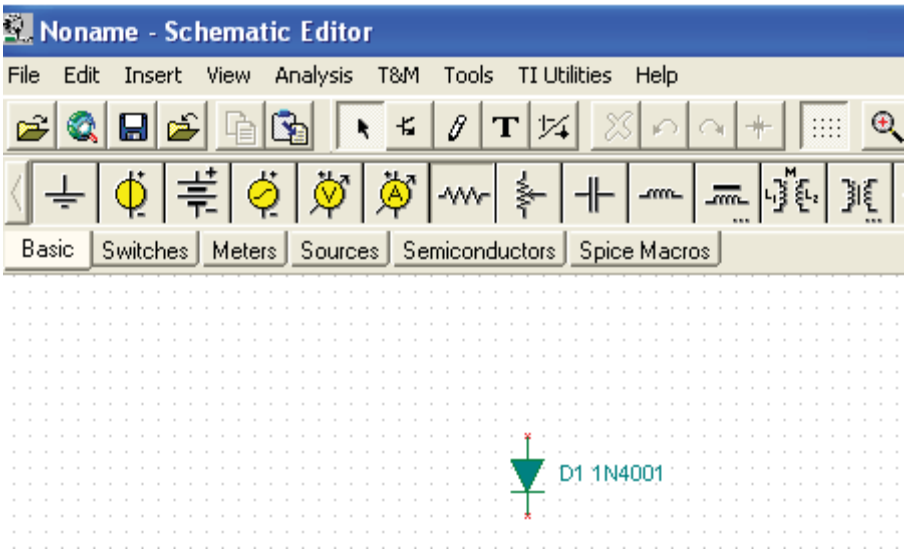



Fig 14

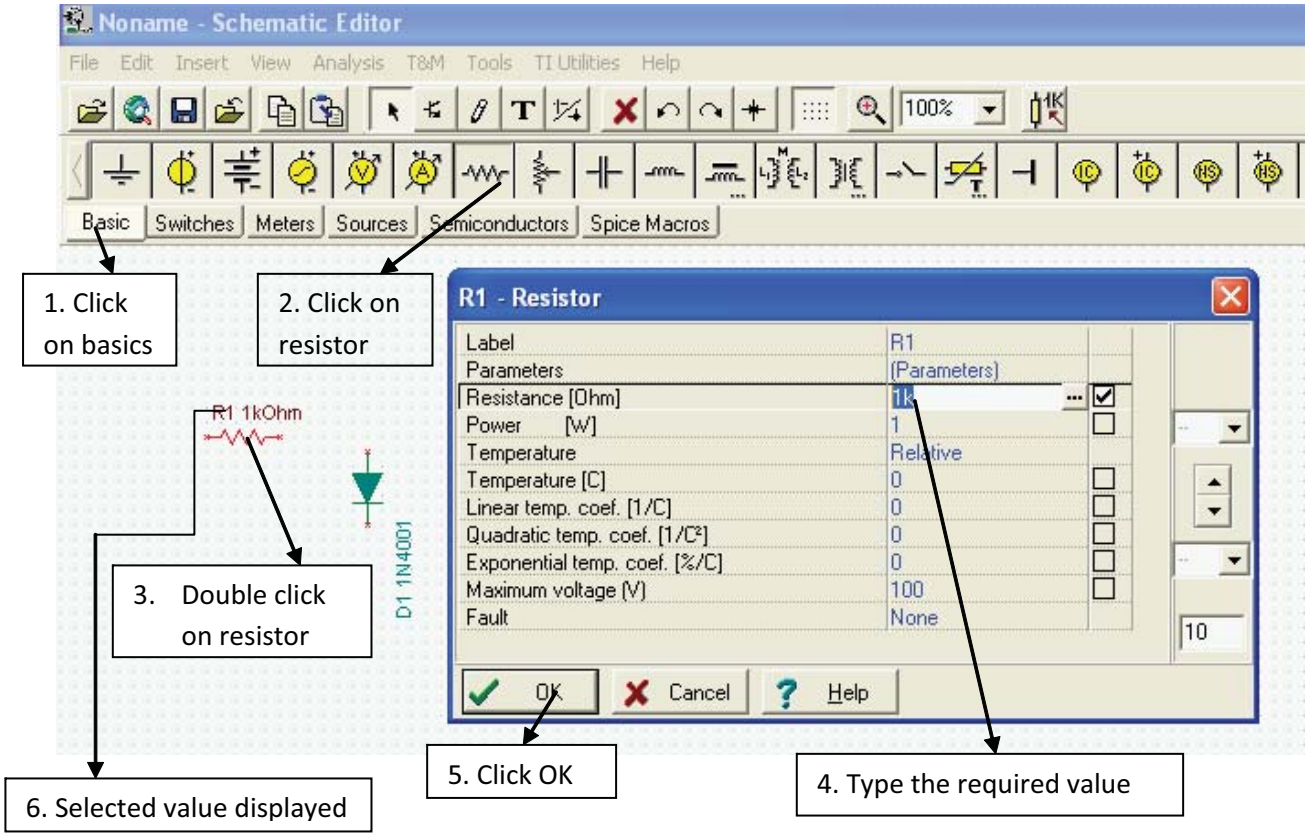



8 Click on **Basic menu to select a resistor and** click on resistor, drag the resistor into the user area.

9 Double click on selected resistor, type the value of resistor and click OK as shown in Fig 15.

**Ensure that the selected resistor value is displayed near the resistor symbol.**

Fig 15




10 Keep the cursor at one of the resistor terminal and drag the mouse towards the terminals of the diode make the wiring.

**Refer the circuit in figure 10 for making other connections.**

1. **Keep the cursor at the red dot of one of the terminal and then drag the mouse, till the red dot of the other device where you want to make the wiring.**
2. **If any component/device is edited by double clicking on it, the symbol will appear red, otherwise it appear in green colour.**
3. **Press ESC on the keyboard if you have clicked on any symbol which you donot want to use in the circuit**.

11 Click on the **Sources** menu to connect a voltage generator and voltmeters.

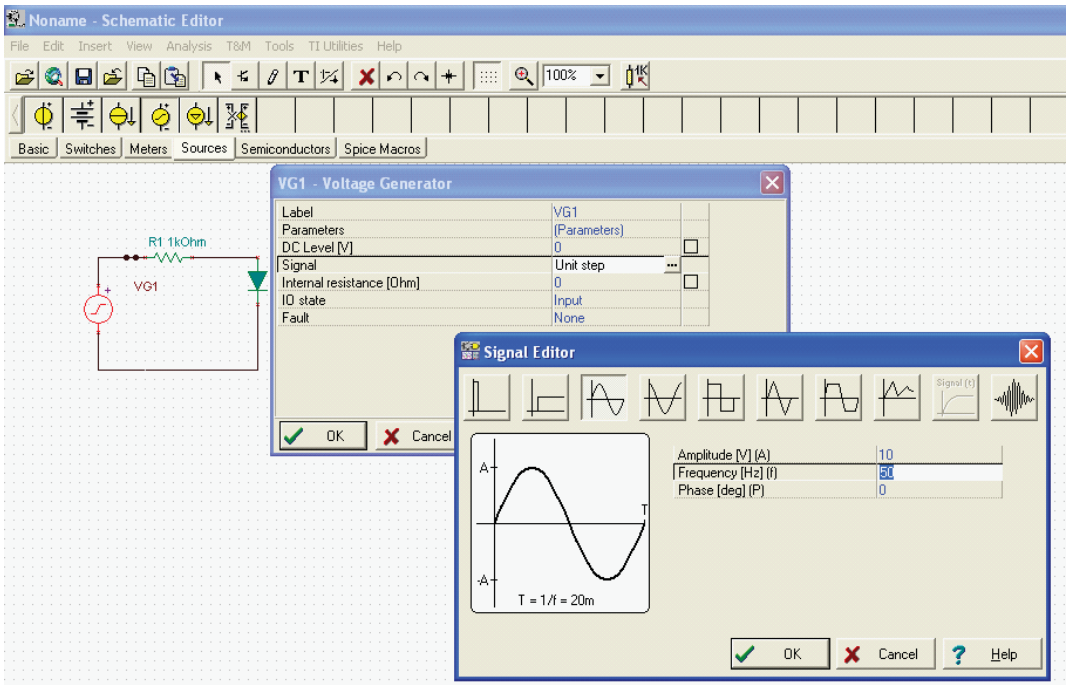
12 Click on the **voltage generator** dialog box and double click on the generator symbol.

13 Click on **Signal** and then **Unit step** dialog box.

14 Click on the required waveform appearing in the pop up window as shown in Fig 16.

15 Click on amplitude, frequency and phase to select the required value respectively and click OK and save the circuit.

Fig 16




16 Get the work checked by the Instructor.

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# Simulate and test the prepared digital and analog circuits

**Objectives:** At the end of this exercise you shall be able to
- **test the prepared digital circuits using simulation software**
- **test the prepared analog circuits using simulation software.**

## Requirements

**Tools/Equipments/Instruments**

- Desk top computer with simulation software installed - No

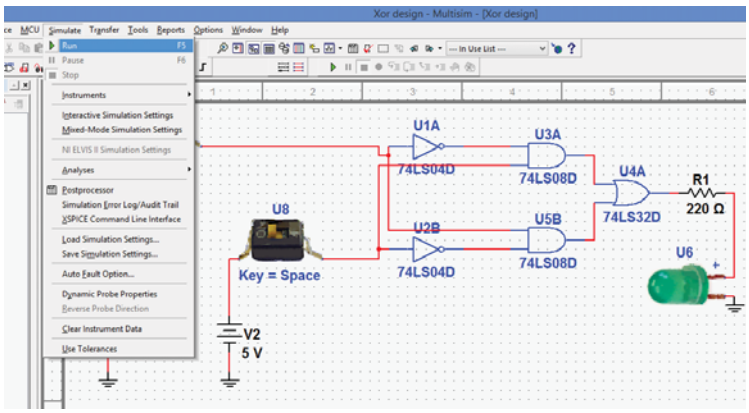
## PROCEDURE

TASK 1 : Testing the constructed digital circuit (OR gate) using simulation software

1 Switch ON the computer, open the simulation software and open the saved OR gate circuit.

2 Click on simulate menu to run the circuit as shown in Fig 1.

Fig 1

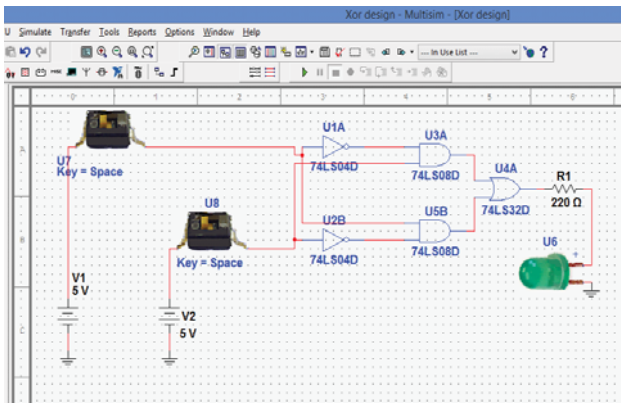



3 Modify the supply voltages as shown in the truth table and verify the truth table (If the output is one, the arrow in the LED will become RED (if red LED is selected; otherwise respective colour as shown in Fig 2, if the output is zero the arrow will be no glow).

**Truth table of OR gate**

| $S_1$ | $S_2$ | LED condition |
|---|---|---|
| Open | Open | |
| Open | Close | |
| Close | Open | |
| Close | Close | |

Fig 2




4 Get the work checked by the Instructor.

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TASK 2 : **Testing the prepared analog circuit positive shunt clipper using simulation software**

1 Open the saved positive shunt clipper circuit.

2 Click on **meters** on the menubar.

3 Click and drag **volt meter** and connect across the voltage generator.

4 Once again Click and drag **volt meter** and connect across the diode ( output terminal) as shown in Fig 3.

5 Click on **T&M** on the menubar, Select **oscilloscope** and click on it.

6 On pop up window Click on **Run** and observe the wave form displayed in the CRO.

7 Adjust **Time/div** and **Volt/div positions** to the suitable value as shown in Fig 4.

8 So that the waveform clearly seen select second channel by the probe in the CRO and click on the output terminal get both the waveforms visible on the CRO.

Fig 3

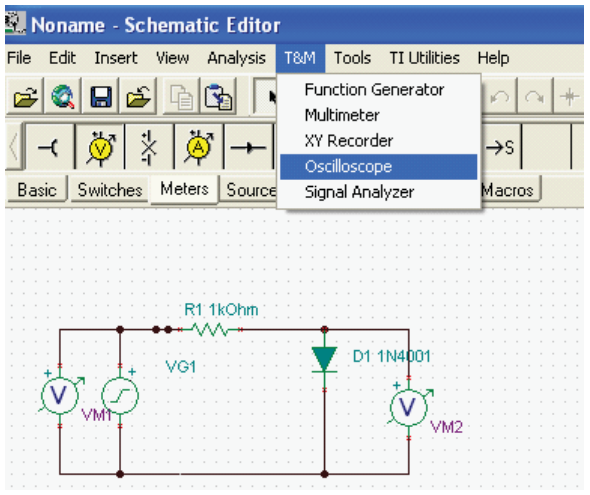
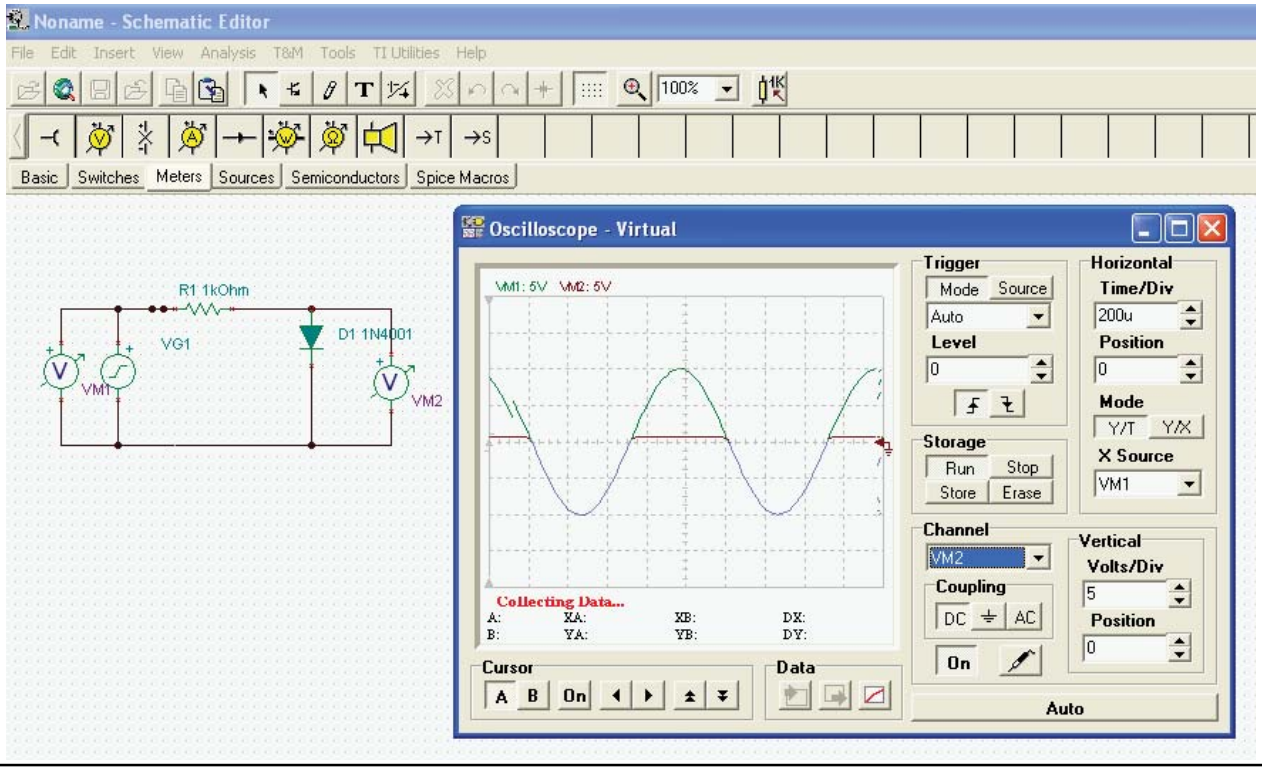



Fig 4




9 Click on stop , trace the waveforms and save it.

**Save the circuit, so same circuit may be used later for revision.**

10 Get the result checked by the Instructor.

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# Convert the prepared circuit into a layout diagram

**Objectives:** At the end of this exercise you shall be able to
- **construct a single stage transistor amplifier using simulation software**
- **construct the prepared circuit into a layout diagram using simulation software.**

## Requirements

**Tools/Equipments/Instruments**

- Personal computer installed with simulation software - 1 No

## PROCEDURE

TASK 1 : **Construction of a single stage transistor amplifier circuit using simulation software**

1 Switch ON the computer, double click the icon on the desktop, open the software and pick the required components from the transistor amplifier circuit.

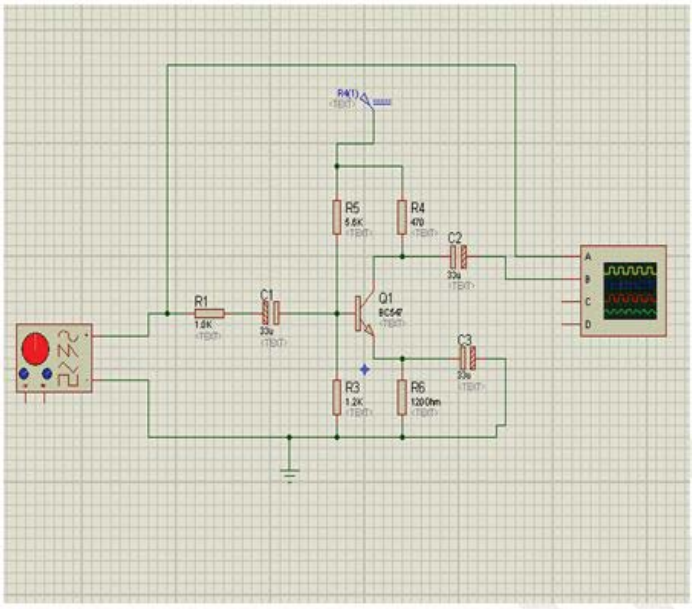
2 Place the required components, assemble the circuit in the work sheet area as shown in Fig 1.

3 Select required junction dot, terminal lead place in circuit for coupling required to construct wiring.

4 Connect the necessary equipments and instruments to the circuit as shown and save it.

5 Get the work checked by the Instructor.

Fig 1

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TASK 2 : **Conversion of the prepared circuit into a layout diagram.**

1 Open the circuit for conversion in the user area.

2 Click file menu, select convert PCB option and open PCB layout.

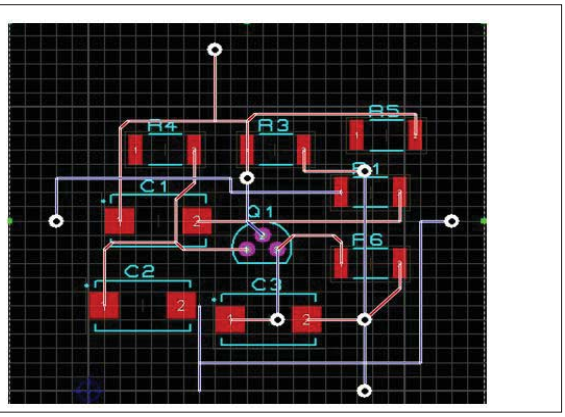
3 Click view menu, select grid size, and board outline.

4 Click and drag the components into the created layout.

5 Click for auto routing and save the lay out diagram as shown in Fig 2.

6 Get the work checked by the Instructor.

Fig 2

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# Prepare simple, power electronic and domestic electronic circuit using simulation software

**Objectives :** At the end of this exercise you shall be able to
- **prepare a simple power electronic circuit (half wave rectifier) using simulation software.**
- **construct a domestic electronic circuit using simulation software.**

## Requirements

**Tools/Equipments/Instruments**

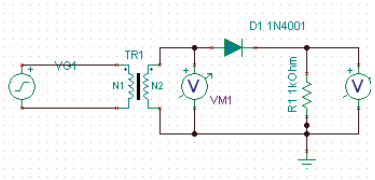
- Desk top computer installed with simulation software

## PROCEDURE

TASK 1 : **Construction of simple power electronic circuit (half wave rectifier) using simulation software**

1 Select the components required for constructing the half wave rectifier as shown in Fig 1.

Fig 1




2. Switch ON the computer and double click on the simulator icon available in the desk top.

3 Refer to the Ex No. 2.8.155, Task 2, follow steps and select the required resistor, diode and voltmeter by clicking on them.

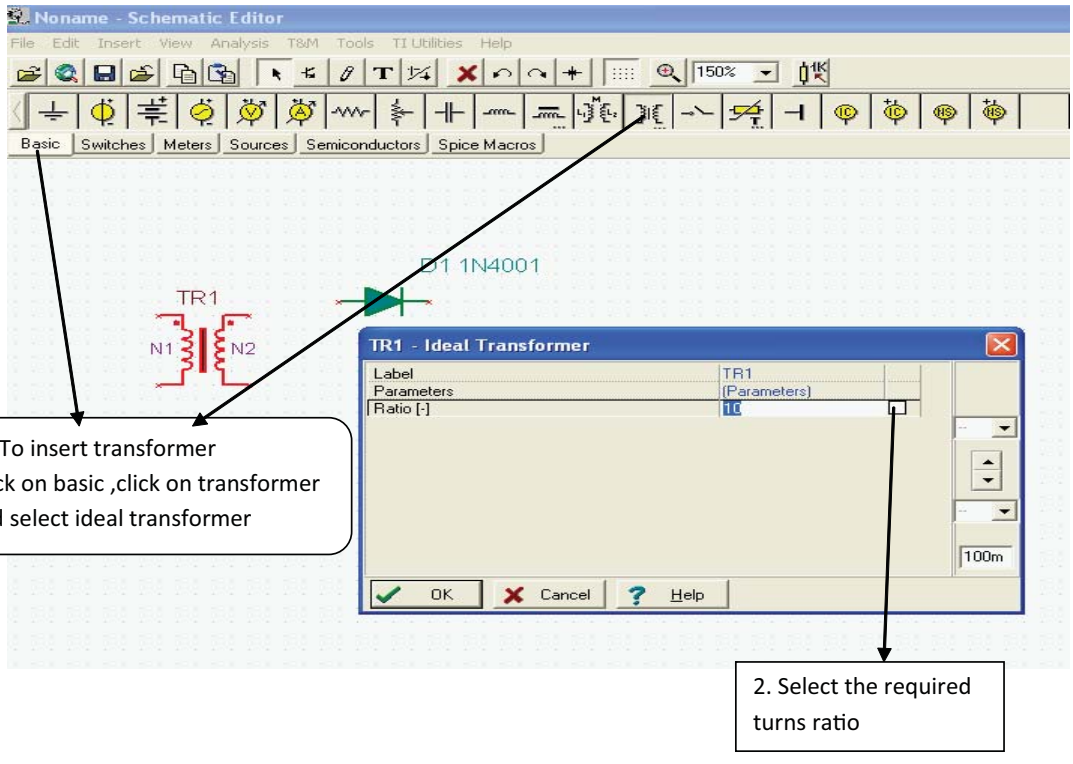
**1 If you need to change the type of diode double click on diode & change its type.**

**2 To rotate the diode right click on it & select rotate option.**

4 Click on Basics menu and on transformer, select ideal transformer.

5 Double click on the transformer, select the required turns ratio as shown in Fig 2.

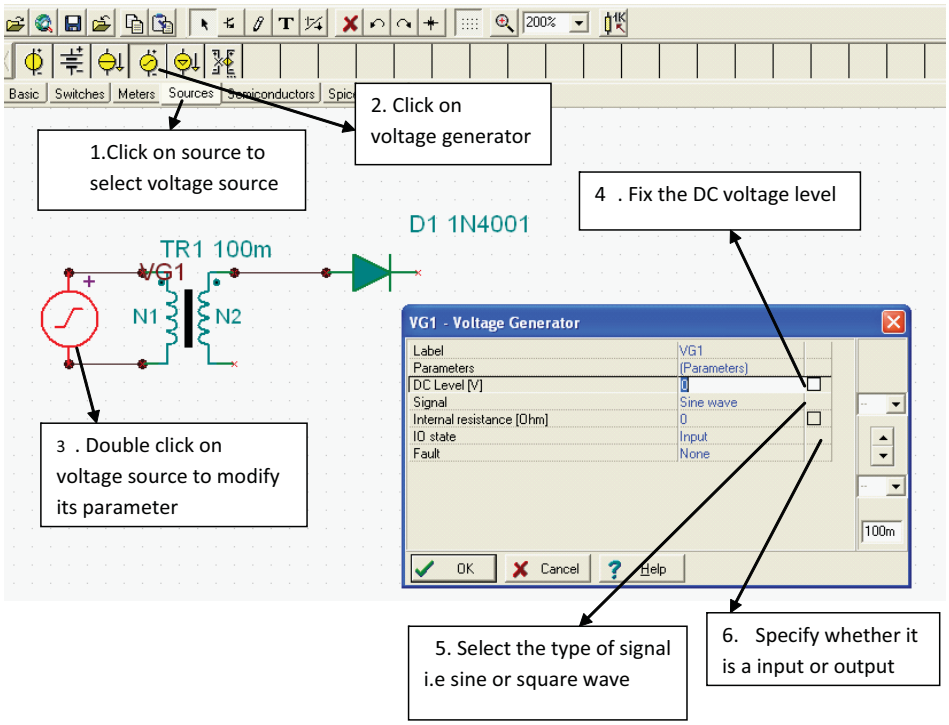
Fig 2



6 Click on **source** menu and insert the voltage source.

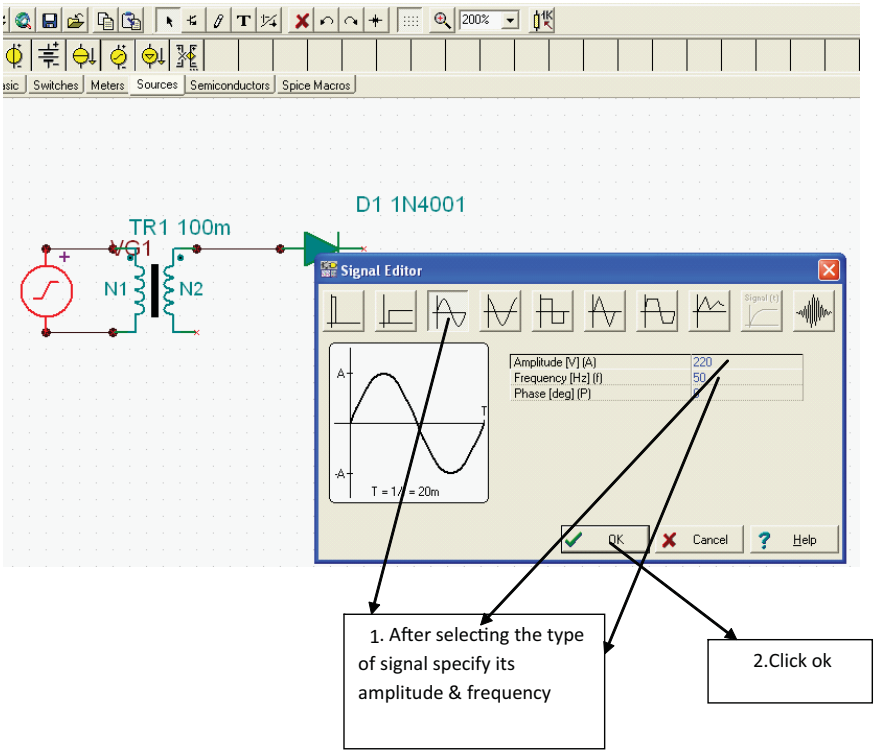
7 Click on **voltage generator** and double click on voltage generator to fix the parameters as shown in Fig 3.

Fig 3




8 Click on signal dialogue box, set the type of waveform, amplitude, frequency & phase as shown in Fig 4.

Fig 4

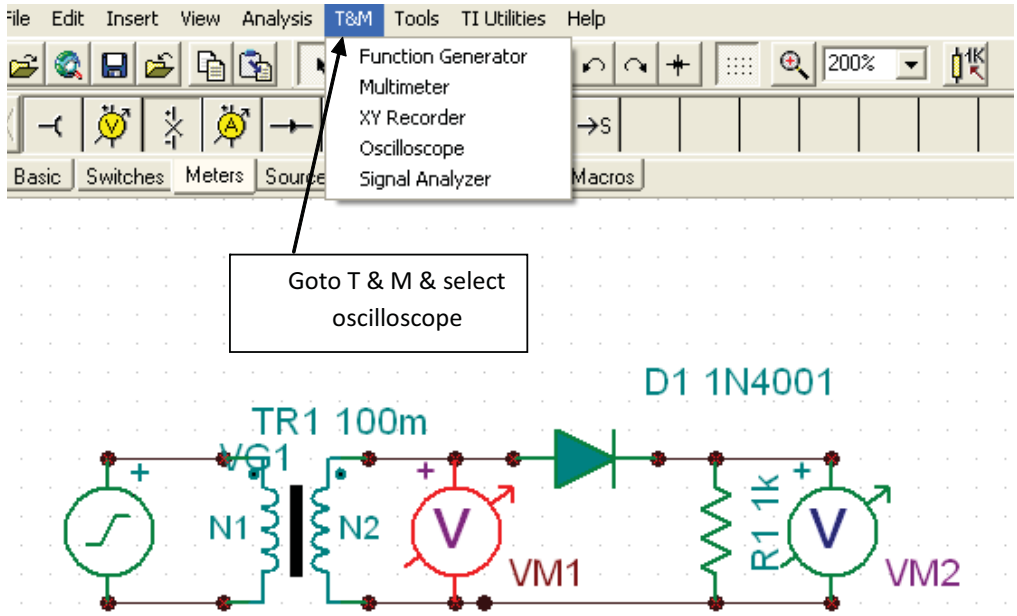


9 Make the connections by referring to the circuit diagram in Fig 1; Keep the cursor on the x mark on the component and drag the mouse wherever it need to be connected.

10 Go to menu bar & click T&M, select CRO as shown in Fig 5, click on it to use CRO.

11 Get the work checked by the Instructor.

Fig 5




TASK 2 : **Construction of electronic lamp dimmer circuit using simulation software**

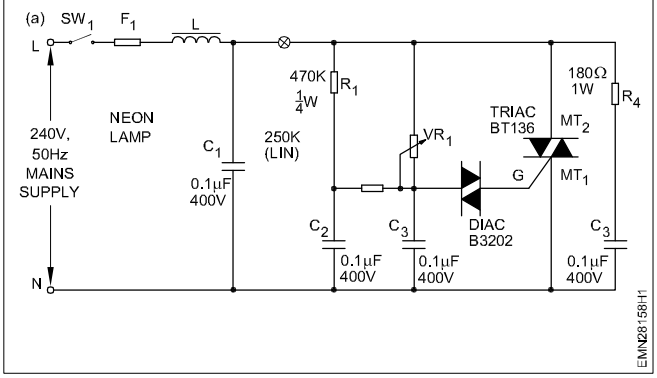
**Note:**

**This exercise /Task has been developed using proteus - ISIS free simulation software.**

**The Instructor has to guide the trainees to follow each and every critical steps to select the components their values and placement / position, printing their numbers etc to complete the task as per the simulation software available in the lab.**

1 Select the circuit for construction of electronic dimmer circuit as shown in Fig 1.

Fig 1




2 Switch ON the computer, double click the simulator icon on the desktop.

3 Open a new project the schematic and go to the schematic capture option.

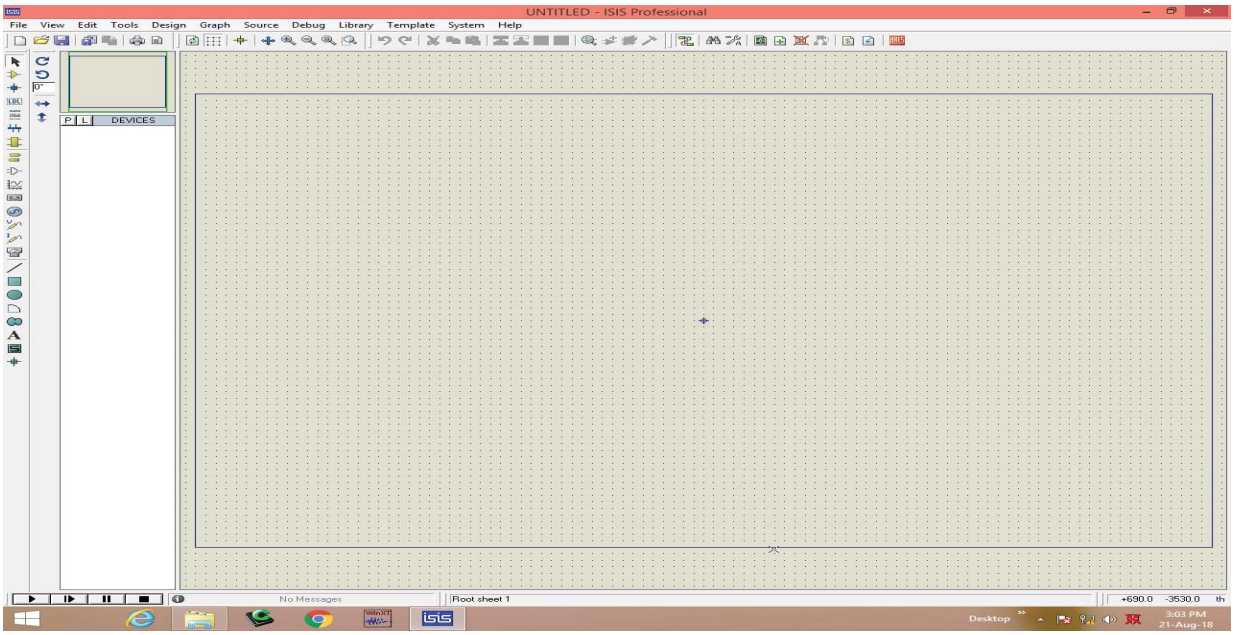
4 Click and select all the parts required from resistors, capacitor to diac and triac into the library as shown in Fig 2.

5 Move the cursor, select the triac, left click drag and place it on the user area place and position it on the user area.

6 Similarly select and place all the components, voltage source etc as per the diagram of the dimmer circuit.

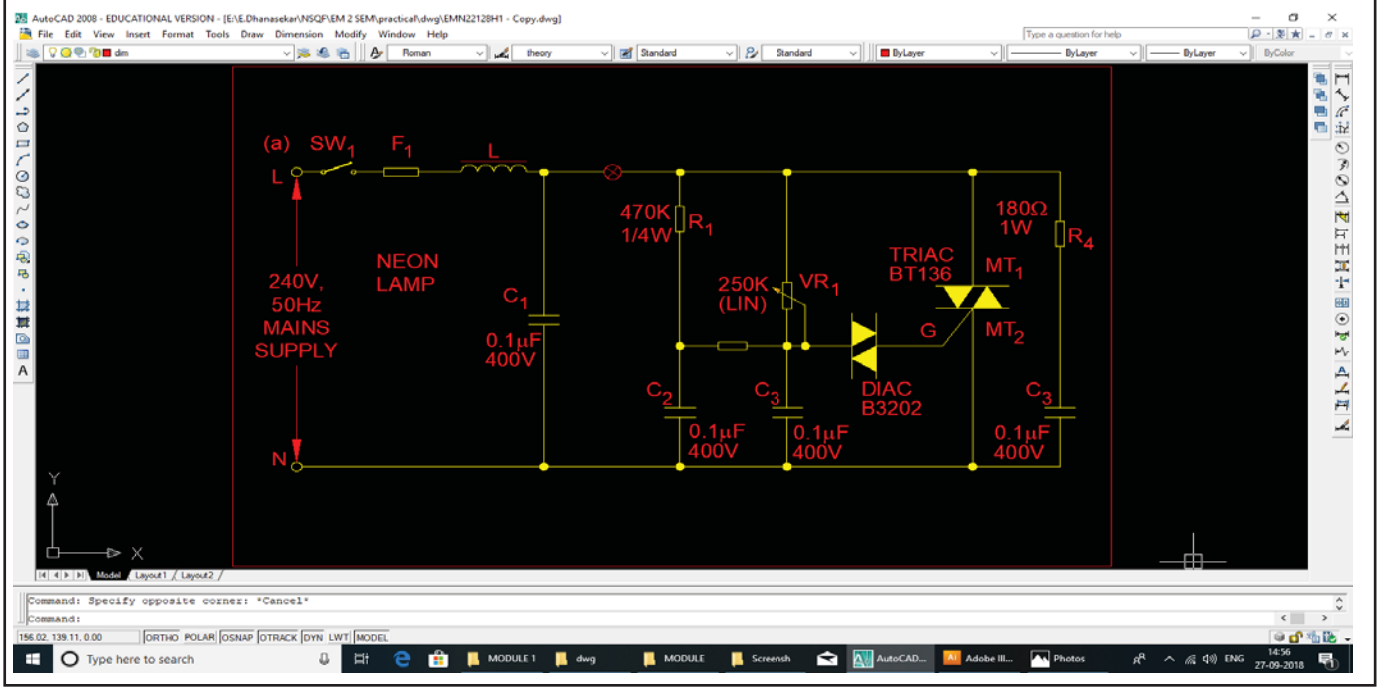
7 Click the cursor to wire the connection on the component tip a red square dot appears move the cursor click again complete the wiring.

Fig 2




8 Close the switch S1 and observe the bulb is ON and adjust the a rheostat VR1 the brightness is reduced as shown in Fig 3.

Fig 3




9 Get the work checked by the Instructor.

# Construct and test a four bit asynchronous binary counter using IC 7493

**Objective:** At the end of this exercise you shall be able to
- **construct and test trace bit asynchronous binary counter using IC 7493. (4 bit ripple counter).**

## Requirements

**Tools/Equipments/Instruments**

- Digital multimeter with test probes - 1 No
- DC power supply, 0-30V/2A - 1 No
- Function Generator - 1 No
- Dual trace CRO 0-20 MHz - 1 No

**Materials/Components**

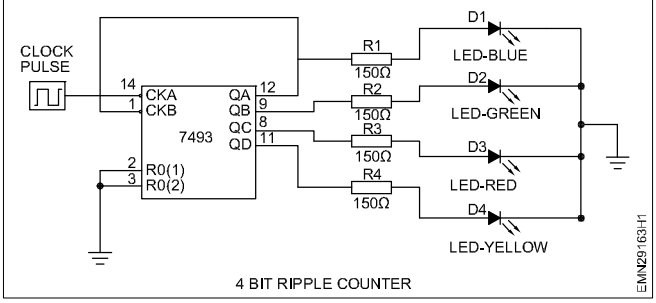
- Breadboard - 1 No
- 74LS47 (BCD-to-7 segment decoder chip) - 1 No
- IC 74LS93 (Asynchronous binary counter) - 1 No
- LED 5mm, Red - 4 Nos
- Resistor 330Ω/¼ W/CR25 - 4 Nos
- Connecting Hook up wire - as reqd
- 7 Segment display (CA) - 1 No

## PROCEDURE

TASK 1: **Construction and testing of asynchronous binary counter using IC7493 (4 bit ripple counter)**

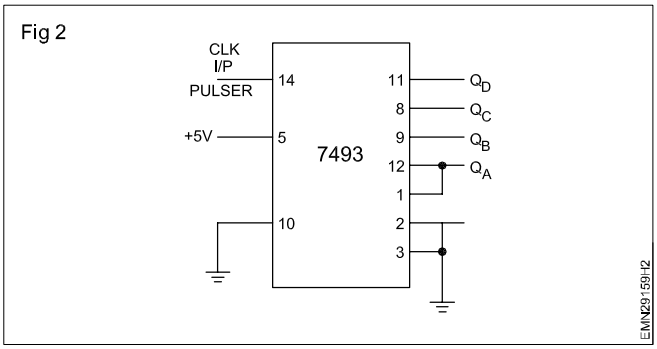
1 Assemble the 4-bit ripple counter shown in Fig 1. Internal diagram of IC 7493 shown in Fig 2.

Fig 1




4 BIT RIPPLE COUNTER

Fig 2



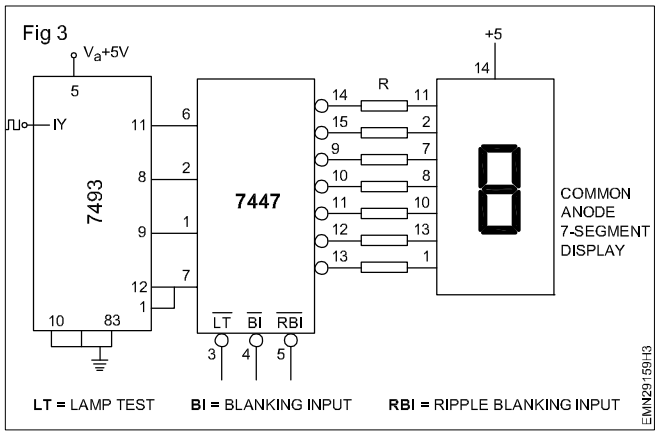

2 Operate the pulser to verify that the count goes from zero (0000) to fifteen (1111).

3 Connect the Clock pulse at Pin No. 14 of IC and use a dual trace oscilloscope to observe the waveforms at the clock and the counter outputs.

4 Alternately connect seven segment driver IC 7447 to display on seven segment LED as shown in Fig 3.

5 Get the work checked by the Instructor.

Fig 3



# Construct and test 7493 as a modulus - 12 counter

**Objectives:** At the end of this exercise you shall be able to
- **construct and test modulus 12 counter using TTL IC-7493.**

## Requirements

**Tools/Equipments/Instruments**

- Trainees tool kit - 1 Set
- DC power supply 0-30V/2A - 1 No
- DMM with probes - 1 No
- Clock pulse generator - 1 No
- Dual trace CRO-20 MHz - 1 No

**Materials/Components**

- Breadboard - 1 No
- IC 7493 - 1 No
- LED 5mm, Red - 5 Nos
- Resistor 330Ω/¼ W/CR25 - 5 Nos
- Connecting wire (hook - up) - as reqd
- IC 7447 & 7 segment display - 1 Set

**The 7493 is a four - bit ripple type binary counter. It consists of four flip-flops which are connected as shown in Figure below. In order to function as a four-bit counter, CP1 must be externally connected to QA. If both the master reset pins MR1 and MR2 are raised high, the four-bit flip-flops are reset to zero.**

## PROCEDURE

1 Connect the modulus 12 counter using 7493 on bread board referring to circuit shown in Fig 1 & 2.

2 Connect $Q_C$ & $Q_D$ (pins 8 & 11) to $MR_1$ & $MR_2$ (pins 2 &3) respectively.

3 Get the assembled circuit checked by the instructor

4 Switch on +5V regulated DC power supply.

5 Press CLEAR-A & CLEAR-B push buttons switch once, to clear the outputs of all flip flops.

Fig 1

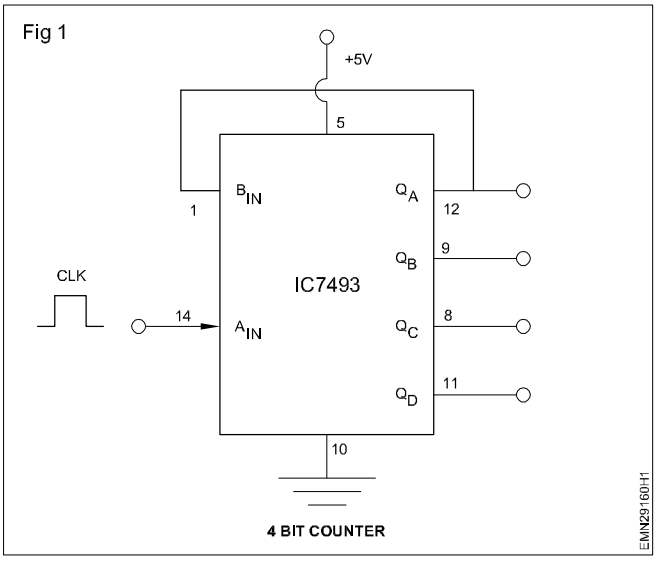
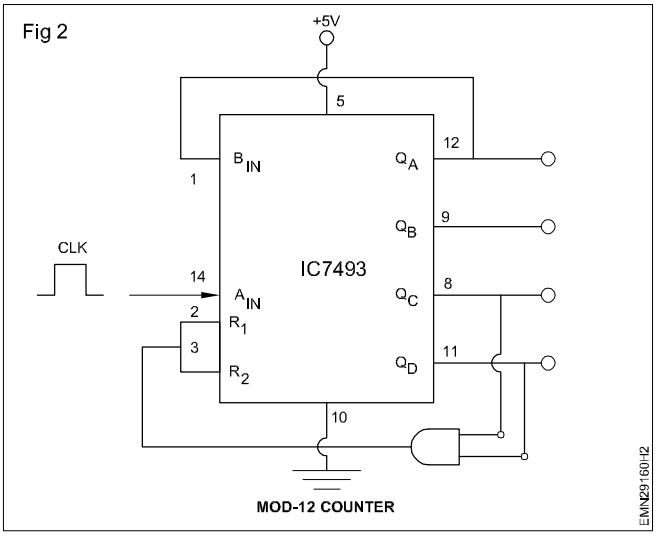



Fig 2




6 Record the Q-outputs ($Q_A$ to $Q_D$) of all the 4-flip flops based on the LEDs status.

7 Apply one clock pulse at the input (first PIN of IC-7493 i.e $Cp_1$) using the single shot pulser.

8 Record the output logic levels and the status of LEDs A,B,C,D in Table 1.

9 Repeat the steps with 7-segment driver IC 7447 & 7seg display as shown in Fig 3 of Ex 2.9.159.

**Table 1**

| Input | Four bit mod-12 counter | | | |
|---|---|---|---|---|
| Count | QD | QC | QB | QA |
| 1 | | | | |
| 2 | | | | |
| 3 | | | | |
| 4 | | | | |
| 5 | | | | |
| 6 | | | | |
| 7 | | | | |
| 8 | | | | |
| 9 | | | | |
| 10 | | | | |
| 11 | | | | |

10 Get the recorded reading checked by the Instructor.

– – – – – – –

# Construct and test a four bit synchronous binary counter using IC 74163

**Objectives:** At the end of this exercise you shall be able to
- **construct and test synchronous binary counter using IC 74163.**

## Requirements

**Tools/Equipments/Instruments**

- Mulitmeter with probes - 1 No
- DC power supply, 0-30V/2A - 1 No
- Clock pulse generator 1 Hz - 1 No
- Dual trace CRO, 0-20 MHz - 1 No

**Materials/Components**

- Breadboard - 1 No
- I.C 74LS47 - 1 No
  (BCD-to-7 segment decoder chip)
- IC 74LS163 (synchronous binary counter) - 1 No
- IC 7404 - 1 No
- LED 5mm, Red - 4 Nos
- Resistor 270Ω/¼ W/CR25 - 4 Nos
- Lengths of jumper wire/connecting wire (hook-up) - as reqd

**Inside the IC74163**

**There are two separate enable inputs, ENT and ENP, setting either of these inputs to logic 0 stops counting asynchronously. Ripple Carry Output (RCO) is normally at logic 0 and goes to logic 1 when counter reaches its highest count i.e., '1111'. It is used in cascading multiple 74163 ICs. Load is an active, low input which allows the count on 'ABCD' to reflect on '$Q_AQ_BQ_CQ_D$' at active clock edges. CLR is also an active low input which clears counter as asynchronously to '0000'.**

## PROCEDURE

TASK 1 : **Construction and testing of synchronous binary counter**

1 Collect all the components, check them and assemble the circuit on the breadboard as shown in Fig 1. The Pin details of IC 74163 is shown in Fig 2.

2 Get the assembled circuit checked by the Instructor.

3 Apply clock pulses using pulse Generator and observe the counter outputs in LEDs and noted in Table 1.

4 Make CLR input to logic-0 and reset the counter.

Fig 1

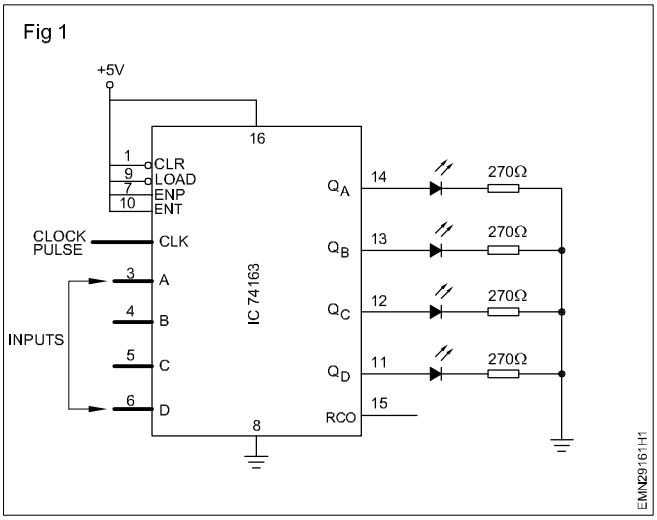
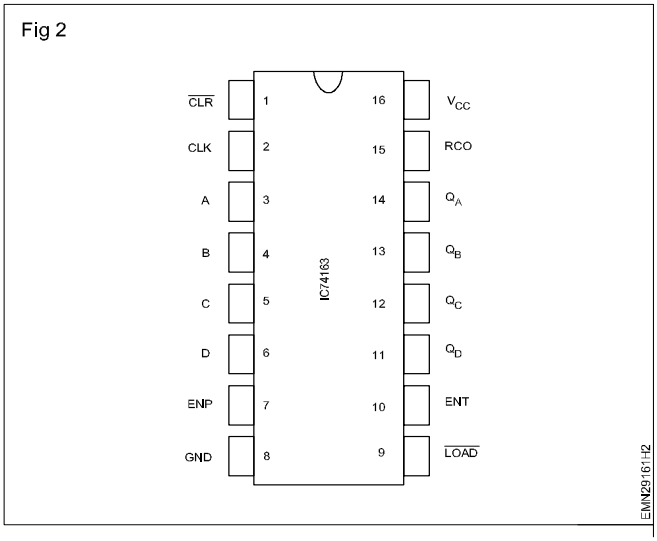



Fig 2




5 Repeat counting by making CLR input to logic - 1.

6 Use IC 74LS47 and 7 - segment LED as shown in previous exercise 2.9.159 to obtain & view a decimal - counted value on display.

7 Record the readings in Table 1.

**Table 1**

| S.No. | Pulse count | $Q_D$ | $Q_C$ | $Q_B$ | $Q_A$ | 7-Seg display reading |
|---|---|---|---|---|---|---|
| | | | | | | |

8 Get the work checked by the Instructor.

– – – – – – –

# Construct and test synchronous Decade counter

**Objectives:** At the end of this exercise you shall be able to
- **construct and test synchronous decade counter.**

## Requirements

**Tools/Equipments/Instruments**

- Trainees tool kit - 1 Set
- DC power supply, 0-30V/2A - 1 No
- Logic with probes - 1 No

**Materials/Components**

- IC 74LS90 (Decade counter) - 1 No
- IC 7447 (7-seg driver) - 1 No
- 7-seg display - 1 No
- Resistor 330Ω/¼ W/CR25 - 8 Nos
- LED Red, Green - 4 Nos

1 Assemble a ripple binary counter on a breadboard referring to the circuit shown in Fig 1.

2 Get the assembled circuit checked by the instructor.

3 Switch on +5V regulated DC power supply. Press CLEAR push button switch once, to clear the outputs. Observe the Q-outputs ($Q_0$ to $Q_3$) based on the LEDs status (ON/OFF) in Table 1 of record sheet.

4 Apply one clock pulse at the input at pin 14 and record the output logic levels. Observe outputs of IC 7490 using logic probe.

5 Repeat step 4 and verify the output logic levels for successive clock pulse input and observe the status of output QA, QB, QC and QD after giving each clock pulse at the input as shown in Table 1.

6 Repeat step 3 to clear the output of all flip-flops.

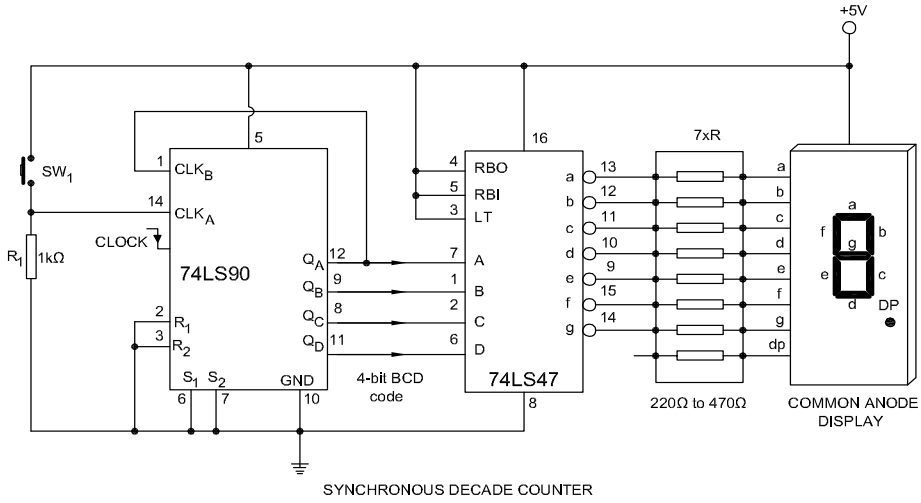
7 Use IC 74LS47 and 7-seg display to observe the count value in decimal.

8 Get the work checked by the Instructor and observe counter output on 7 seg display.

Table 1

| Clock Pulse | QD | QC | QB | QA |
|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 |
| 1 | 0 | 0 | 0 | 1 |
| 2 | 0 | 0 | 1 | 0 |
| 3 | 0 | 0 | 1 | 1 |
| 4 | 0 | 1 | 0 | 0 |
| 5 | 0 | 1 | 0 | 1 |
| 6 | 0 | 1 | 1 | 0 |
| 7 | 0 | 1 | 1 | 1 |
| 8 | 1 | 0 | 0 | 0 |
| 9 | 1 | 0 | 0 | 1 |

Fig 1



# Construct and test an UP/DOWN synchronous decade counter using 74190 and monitor the output on LEDs

**Objectives:** At the end of this exercise you shall be able to
- **construct an up/down counter using IC 74LS190**
- **test the counter for counting UP and counting DOWN.**

## Requirements

**Tools/Equipments/Instruments**

- Trainees tool kit - 1 Set
- Regulated power supply 0-30V/2A - 1 No
- Logic probe - 1 No
- Single shot pulser - 1 No

**Materials/Components**

- Breadboard - 1 No
- IC74LS190 (Up/down decade counter) - 1 No
- LED 5mm (Red, Green, Amber, Yellow) - 1 No each
- Resistors 220Ω, ¼ W/CR25 - 4 Nos
- Switches SPDT - 2 Nos
- Connecting wires/ Hook up wires - as reqd

## PROCEDURE

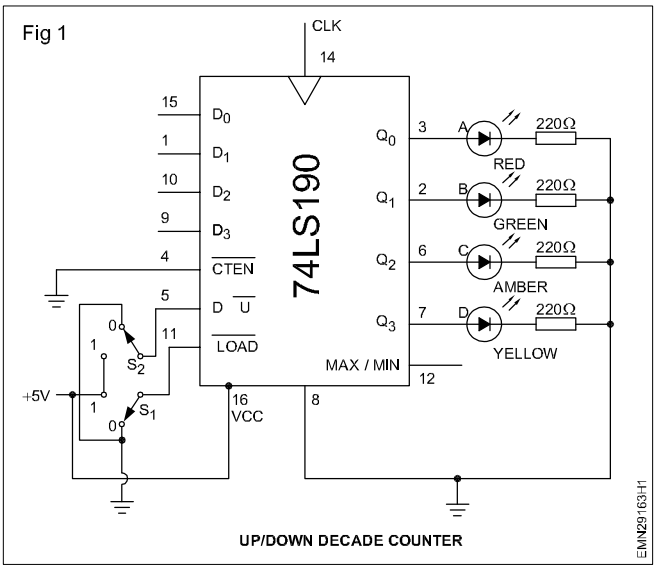
TASK 1: **Construction of synchronous UP/DOWN decade counter using 74 LS190**

1 Collect all the components, check them and assemble the circuit of a up/down decade counter on a breadboard using IC74LS190 as shown in Fig 1.

2 Get the assembled circuit checked by the instructor.

**Note:**
- **Up/Down decade counter counts from 0 to 9 and then recycles to '0' again.**
- **Pin-5 determines the direction of count when this input is high the counter counts down, when it is low, the counter counts up.**
- **MAX/MIN - The output at this pins counts high when the counter is reached at NINE (1001).**

Fig 1




UP/DOWN DECADE COUNTER

– – – – – – –

TASK 2: **Setting the decade counter to count-up mode and test**

1 Switch ON the supply and apply +5V regulated DC supply to the circuit.

2 Apply logic-0 to the control pin D/ to make the counter count-up through a toggle switch.

3 Apply logic 0 to the pins $D_0$ to $D_3$. Apply logic-0 to the control pin load momentarily and raise it back to Logic-1 state with a toggle switch.

**This sets output $Q_3$, $Q_2$, $Q_1$, $Q_0$ to logic-0 levels.**

4 Refer Table 1 of record sheet and feed clock pulses at clock input (pin 14) using single shot pulser. Record the status of LED(s) at outputs $Q_3$, $Q_2$, $Q_1$ and $Q_0$.

5 Record the logic levels at $Q_3$, $Q_2$, $Q_1$, and $Q_0$ using the logic probe in Table 1.

6 From the recorded readings at steps 4 and 5 conclude whether the counter is counting-up or down.

7 Get the recorded output and your conclusion checked by the Instructor.

8 Repeat steps 3, 4, 5 and 6 to recheck satisfactory working of the counter.

**Table 1 Up counter**

| D/$\overline{U}$ Pin No.5 | Clock input Pin No.14 | $\overline{LOAD}$ Pin No.11 | Status of LEDs | | | |
|---|---|---|---|---|---|---|
| | | | $D_0$ | $D_1$ | $D_2$ | $D_3$ |
| 0 | x | | 0 | 0 | 0 | 0 |
| 0 | ↑ | 1 | x | x | x | x |
| 0 | ↑ | 1 | x | x | x | x |
| 0 | ↑ | 1 | x | x | x | x |
| 0 | ↑ | 1 | x | x | x | x |
| 0 | ↑ | 1 | x | x | x | x |
| 0 | ↑ | 1 | x | x | x | x |
| 0 | ↑ | 1 | x | x | x | x |
| 0 | ↑ | 1 | x | x | x | x |
| 0 | ↑ | 1 | x | x | x | x |

Conclusion: _____

9 Get the work checked by the Instructor.

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TASK 3: **Setting the decade counter to count-down mode and test**

1 Feed $D_3$, $D_2$, $D_1$ and $D_0$ with 1001 (binary 9) by applying suitable voltage levels (logic-1=+5V and logic-0=0V).

2 Apply logic-0 to $\overline{LOAD}$ input (pin-11) momentarily and raise it back to logic-1 level.

**This sets the outputs $Q_3$, $Q_2$, $Q_1$ and $Q_0$ to 1001 such that this becomes the starting value for the down counter.**

3 Apply logic-1 to D/U (Down/Up, pin 5) such that the counter is prepared for count-down operation.

4 Refer Table 2 and feed clock pulses at clock input (Pin 14). On feeding each clock pulse record the output $Q_3$, $Q_2$, $Q_1$ and $Q_0$.

5 From the recorded readings at step 4, conclude whether the counter is counting-up or counting-down.

6 Repeat steps 1 to 5 to recheck satisfactory working of the down-counter.

7 Get the working of the circuit and the recorded output checked by the Instructor.

**Table 2-Down Counter**

| D/$\overline{U}$ Pin No.5 | Clock input Pin No.14 | $\overline{LOAD}$ Pin No.11 | Status of LED(S) | | | |
|---|---|---|---|---|---|---|
| | | | $D_0$ | $D_1$ | $D_2$ | $D_3$ |
| x | x | | 1 | 0 | 0 | 1 |
| 1 | ↑ | 1 | | | | |
| 1 | ↑ | 1 | | | | |
| 1 | ↑ | 1 | | | | |
| 1 | ↑ | 1 | | | | |
| 1 | ↑ | 1 | | | | |
| 1 | ↑ | 1 | | | | |
| 1 | ↑ | 1 | | | | |
| 1 | ↑ | 1 | | | | |

Conclusion: _____

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# Identify and test common anode and common cathode seven segment LED display using multimeter

**Objectives:** At the end of this exercise you shall be able to
- **test the common anode and common cathode by using multimeter.**

## Requirements

**Tools/Equipments/Instruments**

- Multimeter with probes - 1 No

**Materials/Components**

- Seven segment LED (common anode) - 1 No
- Seven segment LED (comon cathede) - 1 No

## PROCEDURE

TASK 1 : **Testing the seven segment - LED display and identify the type**

1 Collect the components from Instructor. Check the 7-seg display units by using multimeter.

2 Identify the given display whether it is common anode (or) common cathode using data book.

3 Check each segment using multimeter in diode mode as shown in Fig 1. (Each segment is an LED inside when forward biased LED slows when reverse biased LED does no glow). Refer to Fig 3 to know the common terminal.

Fig 1

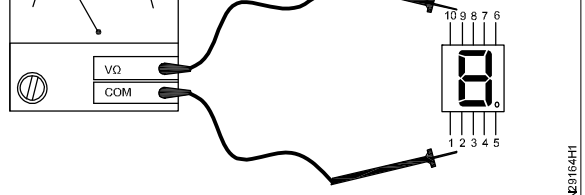



Fig 2

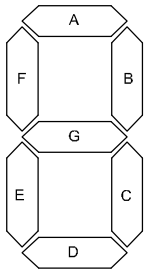
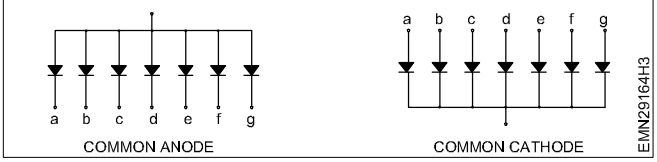



Fig 3




4 Multimeter +ve terminal is connected to common pin and -ve tenimal is connected to all pins.

5 7 Segment pins are 10 numbers and 2 pins are common. 1 pin is dot (Details of Pin).

6 Repeat the checking procedure for the other type of display.

7 Get the work checked by the Instructor.

– – – – – – –

# Display the two digit count value on seven segment display using decoder/driver ICs

**Objectives :** At the end of this exercise you shall be able to
- **construct and test a decade counter using IC No.7490 with a BCD to seven segment decoder/driver and 7-segment display**
- **construct a 2 digit counter & display count value.**

## Requirements

**Tools/Equipments/Instruments**

- Trainees tool kit - 1 Set
- DC power supply, 0-30V/2A - 1 No
- Logic probe - 1 No

**Materials/Components**

- IC-7490 - 2 Nos
- IC-7447 - 2 Nos
- IC base 14 pin - 2 Nos
- IC base 16 pin - 2 Nos
- 7-segment LED display FND507 - 2 Nos
- Resistors 330Ω/¼W/CR25 - 7 Nos
- Logic probe - 1 No
- Single shot logic pulser - 1 No
- General purpose IC TB/Bread board - 1 No
- Solder, flux - as reqd
- Connecting wires - as reqd

## PROCEDURE

TASK 1: **Construction and testing of a decade counter using IC7490**

1 Collect all the components, check them and assemble the decade counter using IC 7490 on the bread board as shown in Fig 1.

**Make use of IC base to connect IC7490**

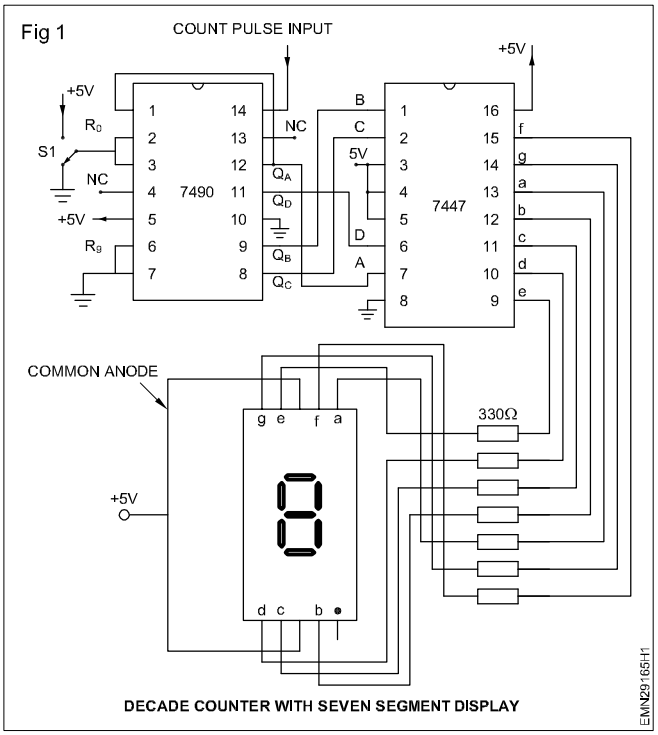
2 Reset the counter output by applying logical 1 input momentarily to reset input pins 2 & 3.

3 Test and record the output logic levels in Table 1 using logic probe.

4 Apply a clock pulse at Pin no.14 using single shot logic pulser and note down the output logic levels in Table 1 at QA, QB, QC & QD using logic probe.

5 Repeat step 4 for different clock pulses and record the observations in the table.

Fig 1




DECADE COUNTER WITH SEVEN SEGMENT DISPLAY

**Table 1 Testing of decade counter IC7490**

| Clock input | Output | | | | Decimal number displayed |
|---|---|---|---|---|---|
| | $Q_D$ | $Q_C$ | $Q_B$ | $Q_A$ | |
| 0 (reset) | | | | | |
| 1 | | | | | |
| 2 | | | | | |
| 3 | | | | | |
| 4 | | | | | |
| 5 | | | | | |
| 6 | | | | | |
| 7 | | | | | |
| 8 | | | | | |
| 9 | | | | | |
| 10 | | | | | |

6 Get the work checked by the Instructor.

– – – – – – –

TASK 2: **Construction and testing of decoder/driver with seven segment display for two digit count value**

1 Assemble the circuit shown in Fig 2 with decoder/driver 7-segment display refer Fig 1 and construct the remaining part of the circuit using decoder/driver IC7447 on the same bread board used in the previous task.

2 Connect the seven segment display module to the decoder/driver by referring to Fig 1.

3 Get the assembled circuit checked by the instructor.

4 Reset the counter output by applying logical 1 input momentarily to reset input pins 2 & 3 and record the 7-segment output of 7447 and the number displayed on seven segment display in Table 2.

5 Apply a clock pulse at Pin no.14 using single shot logic pulser and note down the number displayed on seven segment display in Table 2.

6 Repeat step 5 for different clock pulses and record the observations.

**Compare and relate the output levels of IC7490 and the corresponding displayed values on the seven segment display for each of the clock pulse applied at Pin no.14.**

Fig 2

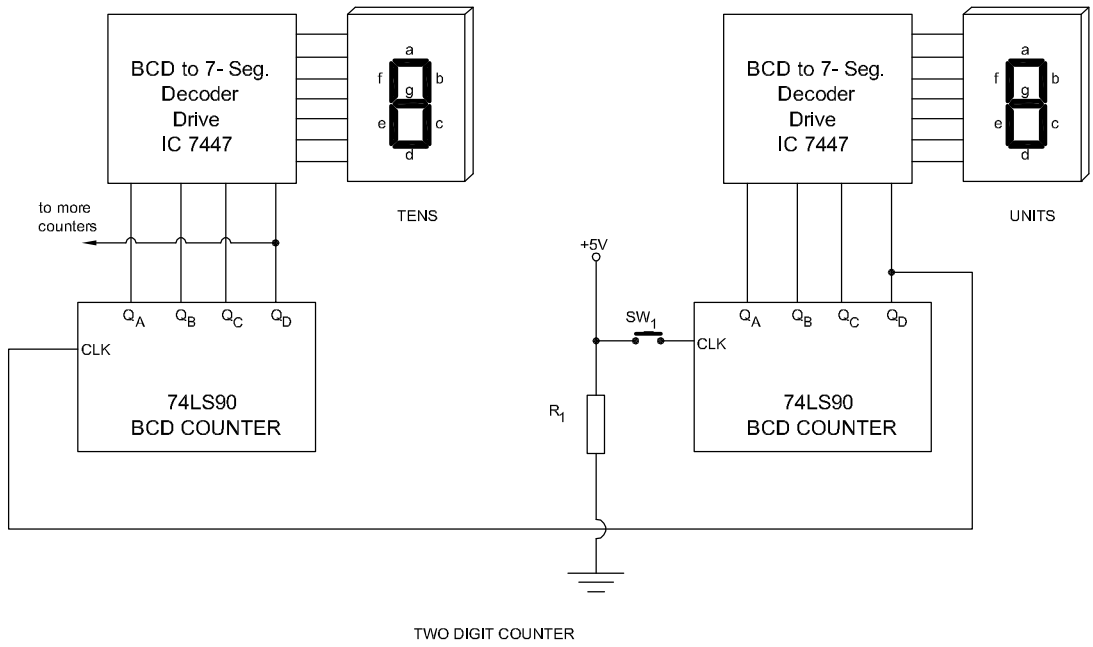



**Table 2**

| Clock input | Output of 7490 | | | | 7-segment display reading | Output of 7447 | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $Q_D$ | $Q_C$ | $Q_B$ | $Q_A$ | | a | b | c | d | e | f | g |
| Reset | | | | | | | | | | | | |
| 1 | | | | | | | | | | | | |
| 2 | | | | | | | | | | | | |
| 3 | | | | | | | | | | | | |
| 4 | | | | | | | | | | | | |
| 5 | | | | | | | | | | | | |
| 6 | | | | | | | | | | | | |
| 7 | | | | | | | | | | | | |
| 8 | | | | | | | | | | | | |
| 9 | | | | | | | | | | | | |
| 10 | | | | | | | | | | | | |

7 Get the work checked by the Instructor.

– – – – – – –

# Construct a shift register using RS/D/JK Flip- Flop and verify the result

**Objectives:** At the end of this exercise you shall be able to
- **construct a shift register RS flip-flop**
- **construct a shift register D flip-flop**
- **construct a shift register JK flip-flop.**

## Requirements

**Tools/Equipments/Instruments**

- Trainees tool kit - 1 Set
- DC power supply, 0-30V/2A - 1 No
- Data sheet of the IC used - as reqd
- Digital multimeter with probes - 1 No

**Materials/Components**

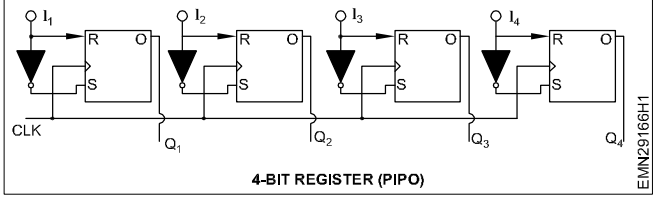
- Hook up wire/connecting wires - as reqd
- Bread board - 1 No
- IC 74279, IC 74379 - 1 No each
- Miniature toggle switch SPDT - 2 Nos
- LED 5mm, Red - 4 Nos
- Resistor 330Ω/1/4W/CR25 - 4 Nos
- IC 7476 - 4 Nos

## PROCEDURE

TASK 1: **Construction of a shift registers using RS Flip-Flop IC 74279**

1 Collect the components check them and assemble the circuit of a shift register on a breadboard as shown in Fig 1.

Fig 1




4-BIT REGISTER (PIPO)

2 Get the assembled circuit checked by the Instructor.

3 Apply logic o to clear input (cr), measue and record the output logic level in Table 1.

4 Apply logic-1 to clear input (cr). Apply data input of the FF. Input set $I_1$, $I_2$, $I_3$ and $I_4$ at

5 Give one clock pulse at the clock input. Record the output logic level in the Table 1.

6 Apply logic 0 to serial input. Repeat steps 5.

7 Apply logic 1 to serial input and Repeat step 5.

**Table 1**

| Clock | Clear Input | Serial Input | Parallel O/P | | | |
|---|---|---|---|---|---|---|
| | | | $Q_4$ MSB | $Q_3$ | $Q_2$ | $Q_1$ LSB |
| X | 0 | x | | | | |
| ↓ | 1 | 1 | | | | |
| ↓ | 1 | 0 | | | | |
| ↓ | 1 | 0 | | | | |
| ↓ | 1 | 1 | | | | |

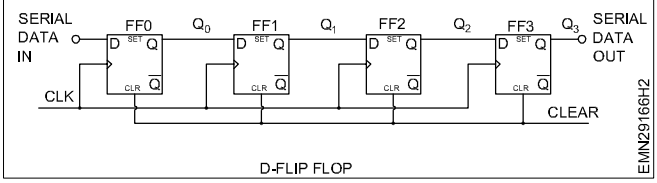
8 Get the record verified by the Instructor.

– – – – – – –

TASK 2: **Construct a Shift registers using D flip-flop IC 74379**

1 Refer Fig 2 and assemble the circuit of a shift register on a bread board using IC 74379.

Fig 2




2 Get the assembled circuit checked by the Instructor.

3 Apply logic-0 to clear input (cr) measure and record the output logic levels in Table 2.

4 Give one clock pulse at the clock input. Record the out logic level in the Table 2.

**Table 2**

| CLOCK PULSE | Q3 | Q2 | Q1 | Q0 |
|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 |
| 1 | 0 | 0 | 0 | 1 |
| 2 | 0 | 0 | 1 | 1 |
| 3 | 0 | 1 | 1 | 1 |
| 4 | 1 | 1 | 1 | 1 |
| 5 | 1 | 1 | 1 | 0 |
| 6 | 1 | 1 | 0 | 0 |
| 7 | 1 | 0 | 0 | 0 |

EMN25166H2a

5 Apply logic 0 to serial input. Repeat step 4.

6 Apply logic 1 to serial input and Repeat step 4 and similarly apply the serial data $(1111)_2$

7 Get the recorded readings verified by the Instructor.

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TASK 3: **Construction of a shift register using JK-Flip-Flop IC-7476**

1 Refer Fig 3 and wire the circuit of a shift register on a circuit bread board using IC-7476.

2 Get the assembled circuit checked by the Instructor.

3 Apply logic-0 to clear input(C).Measure and record the output logic levels $Q_A$, $Q_B$, $Q_C$ and $Q_D$ in Table 3.

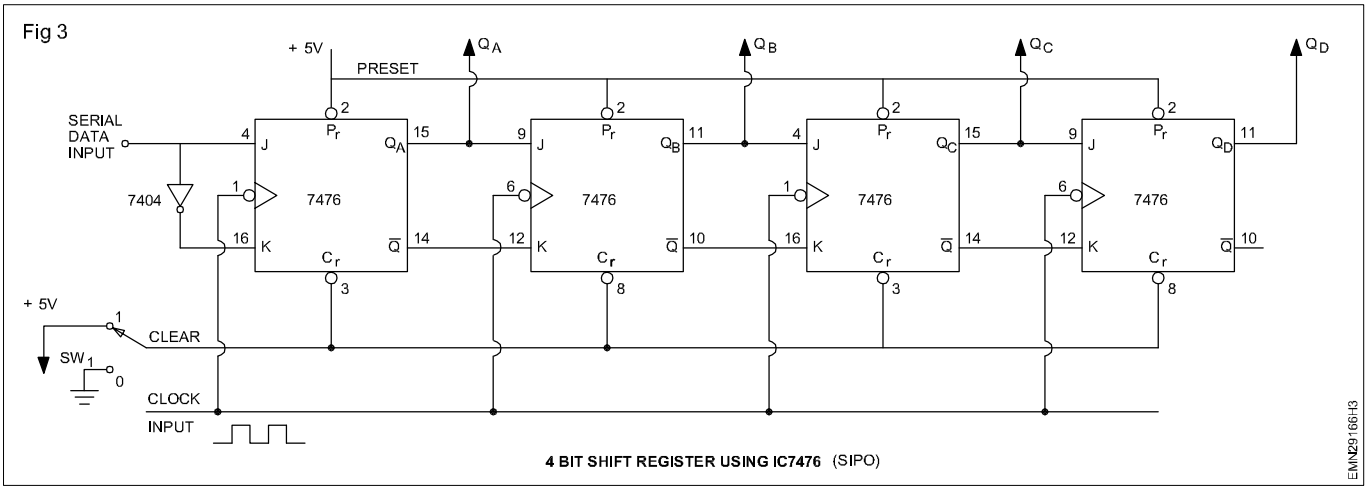
4 Apply logic-1 to Clear input (Cr), Apply serial/data input to the circuit.

5 Give one clock pulse at the clock input. Record the output logic levels in the Table 3.

6 Apply logic-0 to serial input. Repeat step 5 and give the second and third clock pulses.

7 Apply $(1001)_2$ as serial input to SIPO register in steps of one bit at time and repeat step-5.

Fig 3




**4 BIT SHIFT REGISTER USING IC7476** (SIPO)

**Table 3**

**4 BIT SHIFT REGISTER USING IC7476**

**4-bit shift left register using 7476 JK-Flip-Flop**

| Clock | Clear Input | Serial Input | Parallel O/P | | | |
|---|---|---|---|---|---|---|
| | | | $Q_D$ MSB | $Q_C$ | $Q_B$ | $Q_A$ LSB |
| X | 0 | x | | | | |
| ↓ | 1 | 1 | | | | |
| ↓ | 1 | 0 | | | | |
| ↓ | 1 | 0 | | | | |
| ↓ | 1 | 1 | | | | |

8 Get the recorded readings verified by the Instructor.

– – – – – – –

# Construct a test four bit SIPO register

**Objectives:** At the end of this exercise you shall be able to
- **construct and test 4 bit SIPO register using IC 7495.**

## Requirements

**Tools/Equipments/Instruments**

- Multimeter with probes - 1 No
- DC power supply, 0-30VDC/2A - 1 No
- Logic probe - 1 No
- Single Shot Pulser - 1 No
- Trainees tool kit - 1 Set

**Materials/Components**

- Breadboard - 1 No
- IC 7495 miniature toggle - 1 No
- Switch SPDT - 1 No
- Solder Flux - as reqd
- Hookup wires - as reqd
- LED 5mm, Red - 4 Nos
- Resistors 330Ω/¼ W/CR25 - 4 Nos

## PROCEDURE

TASK 1 : **Construction and testing of 4 bit serial in, parallel out (shift right)**

1 Collect all the components, check them and assemble the circuit to a serial in, parallel out (SIPO) (shift right) shift register as shown in Fig 1.

2 Get the assembled circuit checked by the Instructor.

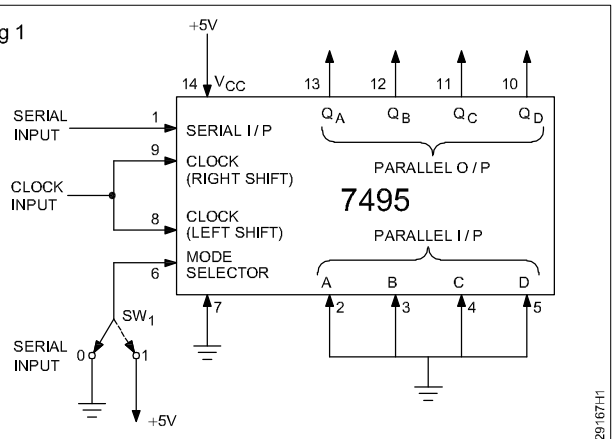
3 Power 'ON' circuit. Apply logic-1 to mode control input and also apply a clock pulse to clock input and record the parallel output logic levels $Q_A$, $Q_B$, $Q_C$ and $Q_D$ (should be 0000).

**With mode control input at logic '1', parallel inputs A=B=C=D=0, results in $Q_A$ $Q_B$ $Q_C$ and $Q_D$ equal to 0000.**

**During shift right, parallel inputs are in don't care condition i.e not necessary to be kept in 0.**

4 Apply logic-o to mode control. Apply clock pulse to clock input and serial inputs to circuit as in Table 1. Record the corresponding outpur logic levels.

Fig 1




SERIAL IN PARALLEL OUT (SHIFT RIGHT) CIRCUIT

5 Get the working of the circuit and recorded readings checked by the Instructor.

6 Switch OFF the DC supply.

**Table 1**
**Serial in, parallel out (Shift right)**

| Mode control | Clock Input | Parallel Input | | | | Parallel Output | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | $Q_A$ | $Q_B$ | $Q_C$ | $Q_D$ | $Q_A$ | $Q_B$ | $Q_C$ | $Q_D$ |
| 1 | ↓ | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | Serial Input | | | | | | | |
| 0 | ↓ | 1 | | | | | | | |
| 0 | ↓ | 1 | | | | | | | |
| 0 | ↓ | 1 | | | | | | | |
| 0 | ↓ | 1 | | | | | | | |

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# Construct and test four bit PIPO register

**Objectives:** At the end of this exercise you shall be able to
- **construct and test a 4 bit shift register using IC 7495.**

## Requirements

**Tools/Equipments/Instruments**

| | |
|---|---|
| • Trainees tool kit | - 1 Set |
| • DC power supply, 0-30V/2A | - 1 No |
| • Logic probe | - 1 No |
| • Single Shot Pulser | - 1 No |

**Materials/Components**

| | |
|---|---|
| • Breadboard | - 1 No |
| • IC 7495 (4 bit shift register) | - 1 No |
| • Miniature toggle switch SPDT | - 5 Nos |
| • Connecting wires/Hook up wires | - as reqd |
| • LED 5mm, Red | - 4 Nos |
| • Resistor 330Ω/¼ W/CR25 | - 1 Nos |

## PROCEDURE

TASK 1: **Construction and testing of a 4-bit shift register using IC-7495 (PIPO)**

1 Collect the components, check them and assemble the circuit of a 4 bit shift register on a bread board using IC-7495 as shown in Fig 1.

2 Get the assembled circuit checked by the Instructor.

3 Switch ON main supply and connect RPS. Apply +5V DC to IC-7495.

4 Apply logic-1 to mode control input through switch $SW_1$.

5 Apply 1011 as a parallel input data through switches $SW_2$ $SW_3$, $SW_4$ and $SW_5$. Give clock pulse to clock input by using single shot pulser. Record the output logic levels $Q_A$,$Q_B$,$Q_C$ and $Q_D$ in Table 1.

6 Repeat step 4 and 5 for different parallel inputs and record corresponding output logic levels in Table 1.

7 Get the working of the circuit & recorded readings checked by the Instructor.

8 Switch-off the DC supply to the circuit.

Fig 1

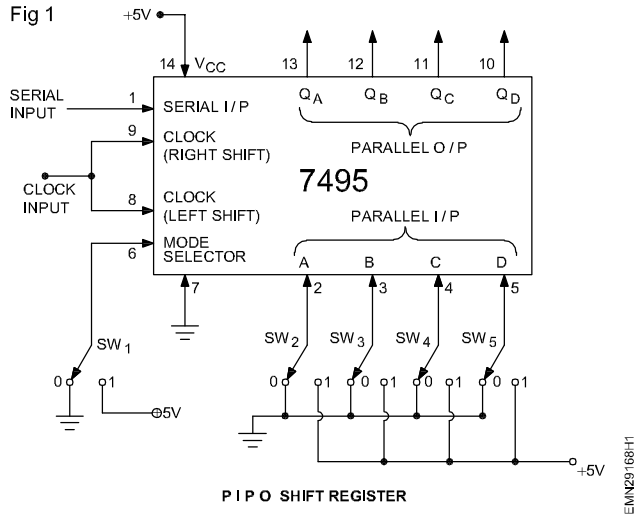


**Table 1**

**4-bit shift register using IC-7495**

| Mode control | Clock Input | Parallel Input | | | | Parallel Output | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | D | C | B | A | $Q_D$ | $Q_C$ | $Q_B$ | $Q_A$ |
| 1 | ↓ | 1 | 0 | 0 | 1 | | | | |
| 1 | ↓ | 1 | 0 | 1 | 1 | | | | |
| 1 | ↓ | 1 | 1 | 0 | 1 | | | | |
| 1 | ↓ | 1 | 1 | 1 | 1 | | | | |

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# Construct and test bidirectional shift register

**Objectives:** At the end of this exercise you shall be able to
- **construct and test bidirectional shift register using IC 74194.**

## Requirements

**Tools/Equipments/Instruments**

- Trainees tool kit - 1 Set
- Digital mulitmeter with probes - 1 No
- Regulated DC power supply, 0-30VDC/2A - 1 No
- Clock pulse generator 1 Hz - 1 No
- CRO Dual trace 20 MHz - 1 No
- Data sheet of the IC - as reqd

**Materials/Components**

- Miniature toggle switch SPST - 9 Nos
- Breadboard - 1 No
- I.C 74LS194(bidirectional shift register) - 1 No
- LED 5mm, Red - 4 Nos
- Resistor 330Ω/¼ W/CR25 - 4 Nos
- Connecting Hook up wires - as reqd

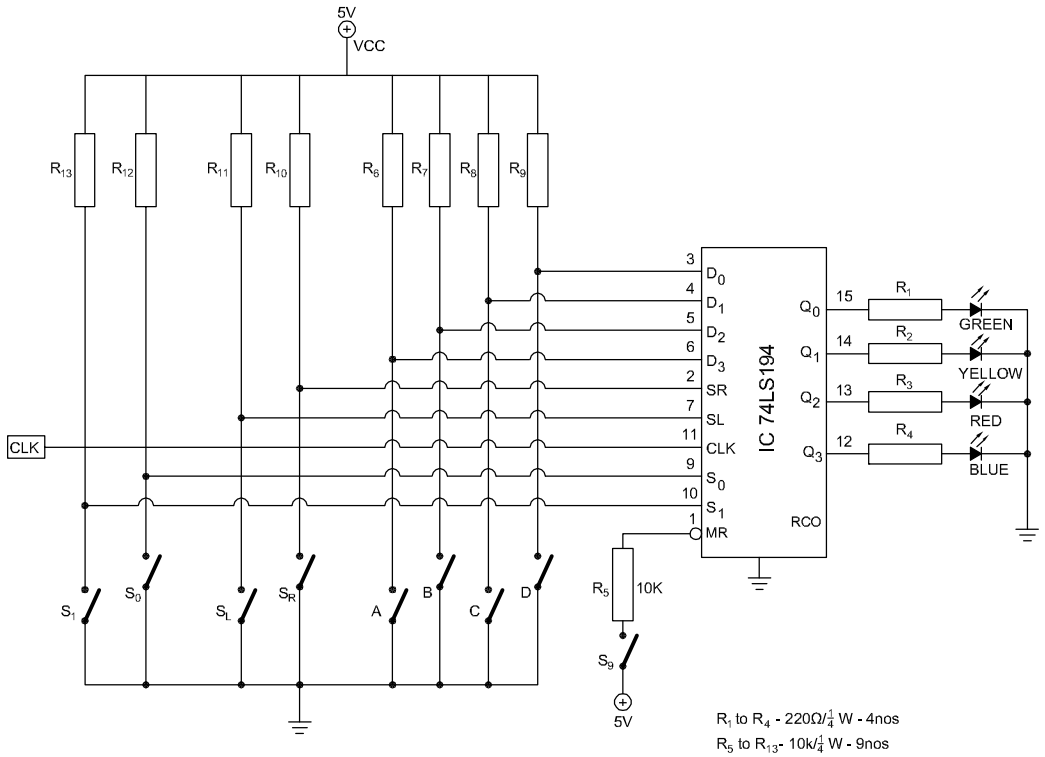
## PROCEDURE

TASK 1 : **Construction and testing of bidirectional shift register using IC74LS194**

1 Collect all the components required, test them, refer to the pin out diagram on the data sheet of the IC, assemble the bidirectional shift register circuit as shown in Fig 1 on broad board.

2 Use toggle switches for data input pins for A, B, C and D, and also for $S_1$, $S_0$, Data Shift Left (DSL), Data Shift Right (DSR) and for Master Reset/Clear pins as shown in Fig 1.

Fig 1




CIRCUIT DIAGRAM OF BIDIRECTIONAL SHIFT REGISTER

3 Get the assembled circuit checked by the Instructor.

4 Switch ON 5VDC supply and operate all the switches as per the Truth tables given below for different logic levels either in 5V position or in zero volt (GND) position as shown in the Tables.

5 Observe the status of all the LEDs for each step of combinations, record them in the respective tables given.

6 Set the switches as per the Truth Table - 1 and observe the LEDs and record in Table - 1

**Truth Table 1**

| MR | $S_1$ | $S_0$ | DSR | DSL | CP | $D_0$ | $D_1$ | $D_2$ | $D_3$ | $Q_0$ | $Q_1$ | $Q_2$ | $Q_3$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | x | x | x | x | x | x | x | x | x | x | x | x | x |

7 Repeat the steps parallel data loading operation as shown in truth table -2 below and verify the output with clock pulse.

**Truth Table 2**

| MR | $S_1$ | $S_0$ | DSR | DSL | CP | $D_0$ | $D_1$ | $D_2$ | $D_3$ | $Q_0$ | $Q_1$ | $Q_2$ | $Q_3$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1 | 1 | x | x | CLK | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |

8 Switch DSL input to logic '1' as shown in truth table -3 and observe the shifting of logic '1' to the LEFT, truth table 3.

**Truth Table 3**

| n clock pulses | $Q_0$ | $Q_1$ | $Q_2$ | $Q_3$ |
|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 |
| 1 | 0 | 0 | 0 | 1 |
| 2 | 0 | 0 | 1 | 1 |
| 3 | 0 | 1 | 1 | 1 |
| 4 | 1 | 1 | 1 | 1 |

9 Observe the output with each clock pulse and verify. Change the logic inout to DSL as logic '0' follow the condition MR=1, $S_0$=0, $S_1$=1, DSL=0, DSR=X, observe the outputs as shown in truth table -4 for each clock pulse and verify the shift left logic '0'.

**Truth Table 4**

| n clock pulses | $Q_0$ | $Q_1$ | $Q_2$ | $Q_3$ |
|---|---|---|---|---|
| 0 | 1 | 1 | 1 | 1 |
| 1 | 1 | 1 | 1 | 0 |
| 2 | 1 | 1 | 0 | 0 |
| 3 | 1 | 0 | 0 | 0 |
| 4 | 0 | 0 | 0 | 0 |

10 Switch DSR input to logic '1'as shown in truth table -5, follow the condition MR=1, $S_0$=1, $S_1$=0, DSL=X, DSR=1, observe the outputs for each clock pulse and verify the shift right logic '1'.

**Truth Table 5**

| n clock pulses | $Q_0$ | $Q_1$ | $Q_2$ | $Q_3$ |
|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 |
| 1 | 1 | 0 | 0 | 0 |
| 2 | 1 | 1 | 0 | 0 |
| 3 | 1 | 1 | 1 | 0 |
| 4 | 1 | 1 | 1 | 1 |

11 Change the input to DSR as logic '0' and follow the condition MR=1, $S_0$=1, $S_1$=0, DSL=X, DSR=0, as per the truth table -6; observe the outputs for each clock pulse and verify the shift right of logic '0'.

**Truth Table 6**

| n clock pulses | $Q_0$ | $Q_1$ | $Q_2$ | $Q_3$ |
|---|---|---|---|---|
| 0 | 1 | 1 | 1 | 1 |
| 1 | 0 | 1 | 1 | 1 |
| 2 | 0 | 0 | 1 | 1 |
| 3 | 0 | 0 | 0 | 1 |
| 4 | 0 | 0 | 0 | 0 |

12 Switch $S_0$ & $S_1$ to logic '0' follow the condition MR=1,DSL=0, DSR=0, $S_0$=X, $S_1$=X, observe the outputs formeach clock pulse as per the truth table -7 for HOLD operation, and verify the output truth table 7.

13 Get the work checked by the instructor.

**Truth Table 7**

| n clock pulses | $Q_0$ | $Q_1$ | $Q_2$ | $Q_3$ |
|---|---|---|---|---|
| 0 | Previous data just before $S_0$ & $S_1$ both switched to logic '0' | | | |
| 1 | | | | |
| 2 | | | | |
| 3 | | | | |
| 4 | | | | |

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# Use analog IC tester to test various analog ICs

**Objectives:** At the end of this exercise you shall be able to
- **identify various analog ICs with their specifications**
- **test the anolog ICs using anolog IC tester.**

## Requirements

**Tools/Equipments/Instruments**

- Analog/IC Tester with operating manual - 1 No
- Semiconductor Data book/manual - as reqd

**Materials/Components**

- Assorted analog ICs such as Op-Amp and timer ICs (IC 74, LM 324 IC 555) - Minimum 3 Nos each

**Keep a minimum of 10 nos of assorted labeled ICs on a table at two places and instruct the trainees to pick one IC at a time to carry out the testing work.**
**Instructor should demonstrate the operation of IC tester available in the laboratary. A typical IC tester is shown in Fig 1.**

## PROCEDURE

TASK 1 : **Identification of various Analog ICs with their specifications and pin diagram**

1 Pick one of the labeled IC from the assorted lot and record its product code /label number printed on the body.

2 Refer to the data sheet semiconductor international data book for Op-Amp / Timer (which ever applicable) and record the following specifications of the given IC;
   - Type of package
   - Manufacturers name
   - Number of OP-Amps/timers in the IC
   - Rated maximum DC supply voltage
   - Open-loop gain $A_{VOL}$
   - Minimum output current $I_{out(min)}$
   - Slew rate of the IC
   - Any other parameter applicable to this IC
   - Typical applications.

3 Count the number of pins in the given IC. Make a rough sketch of the IC. Identify and record the pin numbers.

4 Repeat the steps for atleast four different ICs having different product code.

**Table 1**

| Sl.No. | Label No. | IC Number | Manufacturer name | $V_{cc}$ max | $A_{VOL}$ | $I_{OUT}$ (min) | Application | Pin diagram |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | | |

5 Get the work checked by the Instructor.

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TASK 2 : **Testing of the given Op- Amp and Timer IC with Analog IC Tester**

**IC Tester has self test button. On pressing it, The IC tester performs self Diagnostic test its own hardware. It has two modes of operations**

**1 Quick test - To test and give result immediately.**

**2 Stepwise test - To know which portion of hardware in IC has failed.In this method, even if one AMP in a dual Op- Amp IC is GOOD that IC can be used.**

1 Refer to the instruction operation manual of IC tester, familiar with operation of analog/universal IC tester available in laboratory.

**Use operator manual note down the library of analog ICs of the tester to know which ICs may be tested with the tester as shown in Fig 1.**

Fig 1

Analog IC Tester

2 Pick one of the labelled IC, identify the pin no. 1, orient it/as per the ZIF socket position.

3 Open the level of the ZIF socket and insert the IC into position carefully.

**Note: ZIF socket refers to Zero Insertion Force.It is a type of socket for mounting electronic devices that is designed not to stress ordamage them during Insertion.**

4 Switch on the power switch of IC tester enter the IC number on the keypad of the IC tester and press TEST key and see the result.

**Note: The IC tester comprises of programs /set of testing procedure to test every analog IC available in its library. it checks the procedures of various steps and produces the result as GOOD or BAD on the display provided in it.**

5 Find out whether the given IC is GOOD (or) BAD by observing the display of the IC tester and record the result in Table 2.

6 Repeat the exercise for at least 3 Op-Amps and 3 Timer IC to show the difference between good and defective and record in Table 2.

**Table 2**

| Sl.No. | IC No. test | Mode | Condition of IC |
|---|---|---|---|
| | | | |

7 Get the work checked by the Instructor.

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# Construct and test various Op-Amp circuits Inverting, Non-inverting, Summing Amplifiers

**Objectives :** At the end of this exercise you shall be able to
- **construct and test Inverting amplifier using LM 324**
- **construct and test Non-Inverting amplifier using LM 324**
- **construct and test summing amplifier and differential amplifier using LM 324.**

## Requirements

**Tools/Equipments/Instruments**

- Analog/Universal IC Tester with instruction manual - 1 No
- CRO, 20 MHz Dual trace - 2 Nos
- Semiconductor Data book - 1 No
- Analog/Digital multimeter with probes - 1 No
- Dual regulated DC power supply 0-30V/2A - 1 No
- Function generator - 1 No
- Trainees tool kit - 1 Set

**Materials/Components**

- Op-Amp ICs LM324, UA741 - 2 Nos each
- Breadboard - 2 Nos each
- Resistors 10 kΩ,¼ W/CR25 - 7 Nos
  100 kΩ,¼ W/CR25 - 1 No
- Hook up wires/connecting wires - as reqd
- IC base (8 pin), DIP - 2 Nos
- Diodes 1N4001 - 4 Nos

## PROCEDURE

TASK 1 : **Construction and testing of an inverting amplifier**

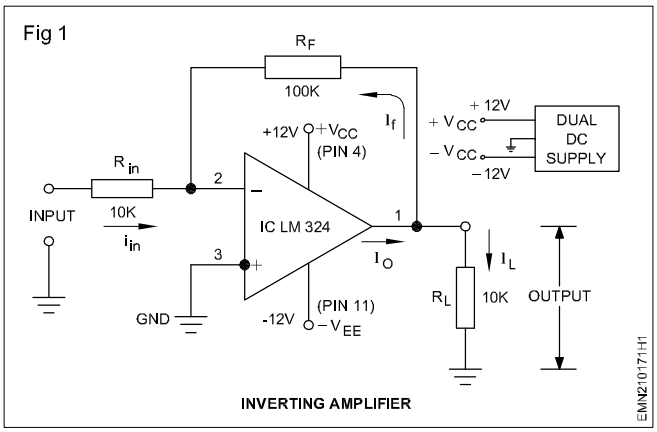
1 Collect all the required components from the instructor and check them with multimeter; use IC tester for checking ICs.

2 Identify the type of package and pins of the given Op-Amp using Data book.

3 Refer to circuit diagram shown in Fig 1 and assemble the inverting amplifier circuit on bread board.

4 Get the assembled circuit checked by the Instructor.

Fig 1




INVERTING AMPLIFIER

**Always keep an IC base fixed on the breadboard for inserting the Op-Amp IC.**

5 Connect +12V, -12V and GND of dual DC power supply to pin 4, pin 11 and GND respectively.

6 Prepare the CRO for measurements and apply $0.2V_{p\text{-}p}$ at the input.

7 Meaure the output using DMM and CRO.

8 Vary the input voltage and observe the output variations using multimeter and oscilloscope; record the observation in Table 1.

9 Change the value of feedback resistor $R_F$ and $R_{in}$ observe the variation in gain and record them in Table.

8 Get the completed work checked by the Instructor.

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TASK 2 : **Construction and testing of a non-inverting amplifier using IC LM324**

1 Refer to the circuit diagram shown in Fig 2 and modify the assemblled circuit on Bread board.

2 Get the assembled circuit checked by the Instructor.

3 Repeat steps 5 to 8 of Task 1 and record the observations.

4 Repeat the steps 9, record the observations and calculate the gain and record them.

Fig 2

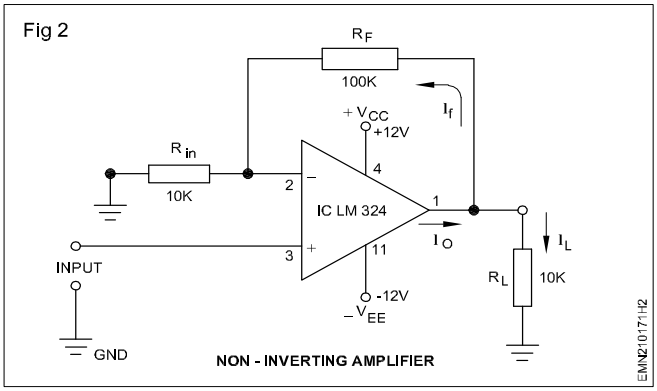


**Table 1**

| S.No. | Input voltage applied ($V_i$) | Output voltage | | Gain normal observed values $V_{out}$ / $V_{in}$ | | Gain x Vin= Volt Calculate values | |
|---|---|---|---|---|---|---|---|
| | | Inverting amplifier | Non inverting amplifier | Inverting amplifier | Non inverting amplifier | Inverting amplifer ($R_f/R_{in}$) x Vin | Non inverting ($1+(R_f/R_1)$xVin |
| 1 | 0.2V | | | | | | |
| 2 | 0.4V | | | | | | |
| 3 | 0.6V | | | | | | |

5 Get the work checked by the Instructor.

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TASK 3 : **Construction and testing of a summing amplifier using IC LM324**

**Carry out the experiment on a Bread board. The suitable values for input voltage are kept such that.**

$$\frac{R_F}{R_1} = \frac{R_F}{R_2} = \frac{R_F}{R_3} = \frac{R_f}{R_{in}}$$

1 Collect all the required items, check the components and assemble the circuit according to the amplifier circuit shown in Fig 3.

**Note the inputs have been applied to inverting terminal.**

2 Get the assembled circuit checked by the instructor.

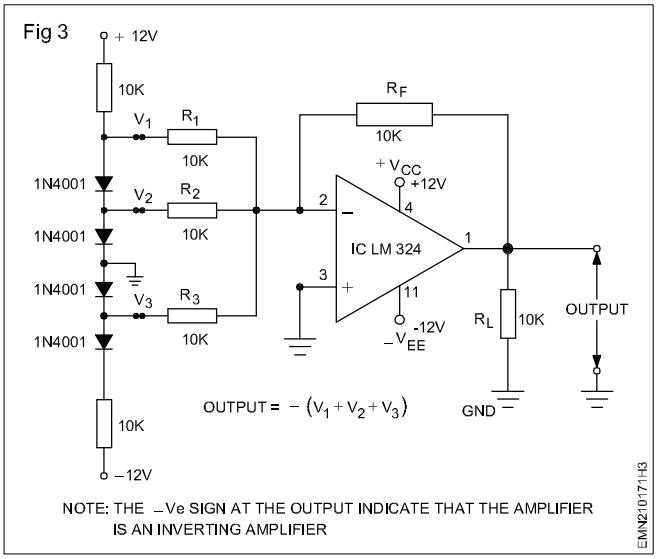
3 Switch ON the dual DC power supply measure the output using multimeter and CRO.

**Use the given formula to calculate the output voltage for summing amplifier.**

4 Verify the results obtained & compare with the calculated values.

**To apply inputs to noninverting terminal exchange the inputs applied on inverting and non inverting terminals.**

Fig 3



**Observation table**

**Table 2**

| S.No. | Configuration | Output voltage | Result |
|---|---|---|---|
| 1 | When inputs $V_1$, $V_2$ & $V_3$ have been applied on -Ve terminal | Vo= | Is O/P proportional to sum of inputs? (Yes / No) |
| 2 | When input $V_1$, $V_2$ & $V_3$ have been applied on +Ve terminal | Vo= | Is output proportional to sum of inputs? (Yes / No) |

**Formula to calculate output voltage of summing amplifier**

**i For Inverting Amplifier**

$$V_o = -\left(\left(\frac{R_f}{R_{in}} \times V_1\right) + \left(\frac{R_f}{R_{in}} \times V_2\right) + \left(\frac{R_f}{R_{in}} \times V_3\right)\right) = \frac{R_f}{R_{in}}\left(V_1 + V_2 + V_3\right)$$

**ii For Non-Inserting Amplifier**

$$V_o = \left(\left(1 + \frac{R_f}{R_{in}}\right)V_1 + \left(1 + \frac{R_f}{R_{in}}\right)V_2 + \left(1 + \frac{R_f}{R_{in}}\right)V_3\right) = \left(1 + \frac{R_f}{R_{in}}\right)\left(V_1 + V_2 + V_3\right)$$

If $R_f = R_1$

$V_o = 2\ (V_1 + V_2 + V_3)$

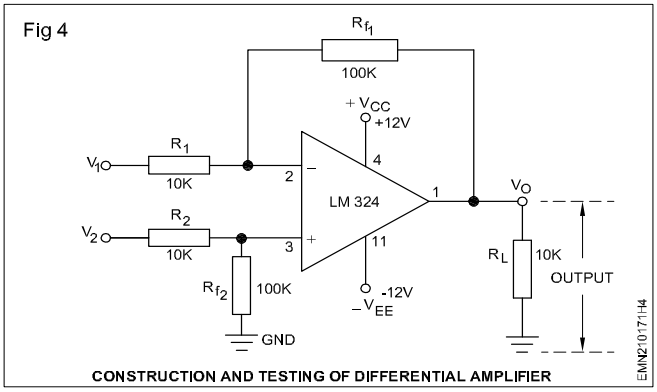
– – – – – – –

TASK 4 : **Construction and testing of Differential Amplifier using LM324**

1 Modify the components values and assemble the circuit shown in Fig 4.

2 Get the assembled circuit checked by the instructor.

Fig 4




3 Repeat step 5 of Task 1.

4 Apply the DC inputs to the differntial amplifier circuit at pin 2 and pin 3 through 10k resistors as per the Table 3.

4 Measure the output using Multimeter and record in given table.

5 Change the input values at V1 and V2 and record the output readings in Table 3.

6 Compare the calculated value with observed.

7 Get the work checked by the Instructor.

**Note: A $R_{f1} = R_{f2} = R_f$ and $R_1 = R_2 - R_{in}$**

**$V_o$ Output = $(V_2 - V_1)\ \frac{R_f}{R_{in}}$**

**Oberservation table**

Table 3

| Input to Differential Amplfier | | Output to ($V_O$) calculated | Output Observed ($V_O$) |
|---|---|---|---|
| $V_1$ | $V_2$ | | |
| 0.5V | 1V | | |
| +1V | -2V | | |
| -2V | +2.5V | | |

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# Construct and test Differentiator and integrator

**Objectives :** At the end of this exercise you shall be able to
- **construct and test differentiator circuit using Op-Amp IC 741**
- **construct and test integrator circuit using Op-Amp IC 741.**

## Requirement

**Tools/Equipments/Instruments / Data Book**

- Trainees tool kit - 1 Set
- CRO 20MHz dual trace - 1 No
- Digital multimeter with probes - 1 No
- Voltmeter 0-10V - 1 No
- Regulated dual DC power supply 0-30V/2A - 1 No
- Function generator - 1 No

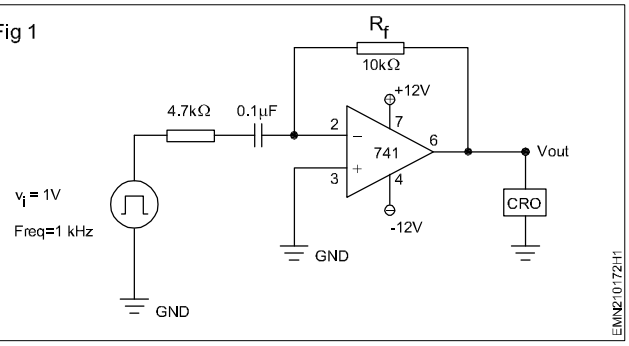
**Materials/Components**

- Resistors 1kΩ, 10kΩ, 4.7kΩ ¼ W/CR25 - each 1 No
- IC 741 Op-Amp - 1 No
- Capacitor 0.1 μF/25V - 1 No
- Hook up wire - as reqd
- Breadboard - 1 No
- Graph sheet (Linear) - 1 No

TASK 1 : **Construction and testing of a differentiator circuit**

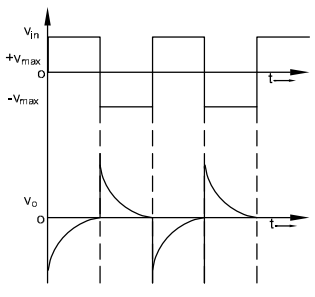
1 Collect and check the components for the good working condition and assemble the circuit on the bread board as shown in Fig 1.

Fig 1




2 Get the assembled circuit checked by the Instructor Calculate RC time constant($T=R_fC$).

Fig 2




3 Give a square wave input of 1 $V_{p-p}$ to the inverting terminal and set the frequency to 1/T in the function generator.

4 Switch ON the dual power supply and set it to +12V and -12V and GND as shown in Fig 1.

**Note: For a differentiator,**

$$VO = R_fC \frac{d(V_{in}(t))}{dt}$$

5 Prepare the CRO for measurement and observe the output waveform on the CRO.

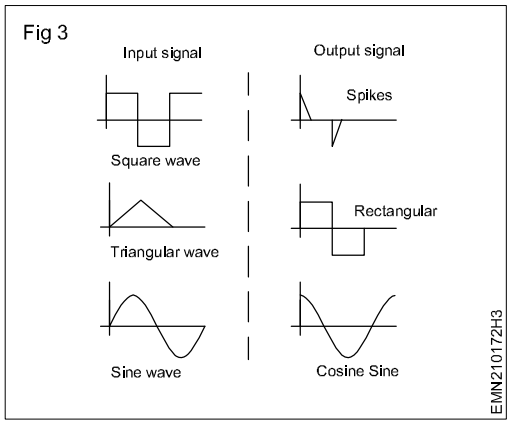
6 Vary the frequency to 1/10T and observe the waveform.

7 Vary the frequency to 1/0.1T and observe the waveform.

8 Draw output and input waveform of the circuit as shown in 2 on a graph sheet for all the 3 steps.

9 Repeat the above procedure for different input signals viz. triangular waveform and sinwave waveform as shown in Fig 3.

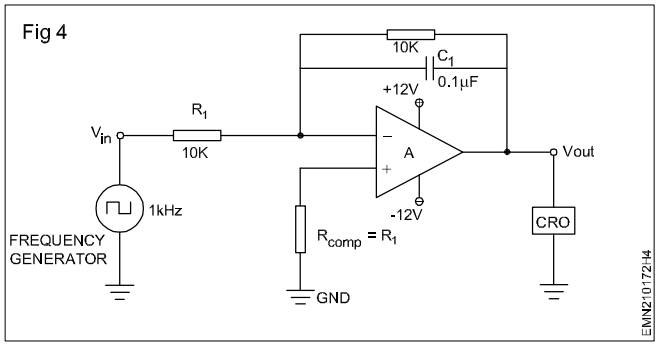
Fig 3



TASK 2 : **Construction and testing of a integrator circuit**

1 Check the components for their good working condition and connect the circuit on the bread board as shown in the Fig 4.

Fig 4




2 Calculate RC time constant($T=R_1C$).

3 Apply a non sinusoidal input of 1 $V_{p-p}$ to the inverting terminal and set the frequency to 1/T in the function generator.

**Note: For a Integrator:**

$$VO = -\frac{1}{R_1C_1}\int V_{in}\,dt$$

4 Switch ON the dual power supply and set it to +12V, -12V and GND connections.

5 Observe the output waveform on the CRO.

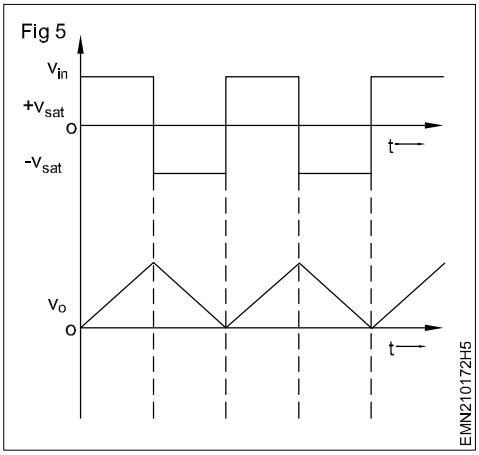
6 Vary the frequency to 1/10T and observe the waveform.

7 Vary the frequency to 1/0.1T and observe the waveform.

8 Draw output and input waveform of the circuit as shown in Fig 5, on a graph sheet for all the 3 steps.

9 Repeat the same procedure for different input signals viz. square wave, triangular waveform.

Fig 5




10 Get the result checked by the Instructor.

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# Construct and test a zero crossing detector

**Objectives :** At the end of this exercise you shall be able to
- **verify the operation of a zero crossing detector circuit using Op-Amp IC741.**

## Requirement

**Tools/Equipments/Instruments / Data Book**

- CRO Dual trace 0-20 MHz - 1 No
- Signal Generator - 1 No
- Regulated dual DC power supply 0-30V/2A - 1 No
- Trainees tool kit - 1 Set

**Materials/Components**

- Breadboard - 1 No
- IC 741 - 1 No
- Diode 1N4007 - 2 Nos
- Resistor 1kΩ, ¼ W/CR25 - 3 Nos

## PROCEDURE

TASK 1: **Construction and testing of Zero crossing detectors using Op-Amp IC741**

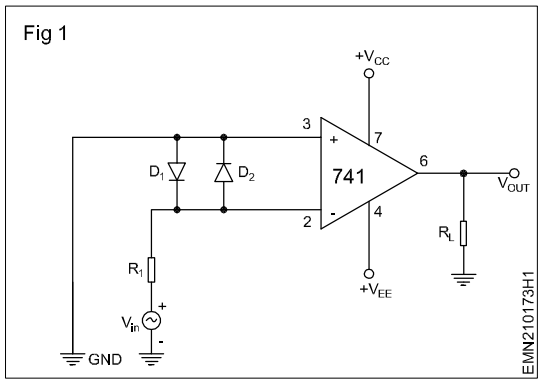
1 Collect all the materials check the working condition using the multimeter and assemble the circuit as shown in Fig 1 on bread board.

**Check the IC using the IC tester.**

2 Connect the reference Input to zero crossing detector, pin no 3 to GND.

3 Get the assembled circuit checked by the Instructor.

Fig 1




4 Connect the input sinewave signal, obtained from a Function generator, at 1 kHz/1 $V_{p-p.}$

5 Prepare the CRO for measurements and connect the input and output to dual channel CRO, and compare the input and output wave forms with Fig 2 and record the observations in Table 1.

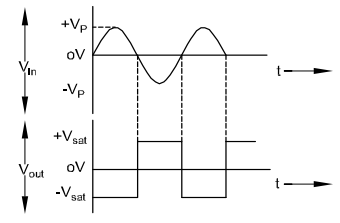
6 Get the work checked by the Instructor.

**Observation Table**

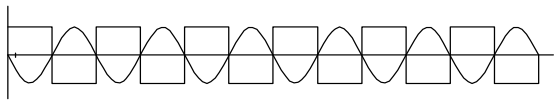
**Table 1**

| Parameter | Waveform | Time |
|---|---|---|
| Input - Voltage ($V_{in}$) = _____ | | |
| Output - Voltage ($V^{out}$) = _____ | | |

Fig 2




INPUT AND OUTPUT WAVEFORM



Zero Crossing Detector waveforms

EMN210173H2

**Note: Instructor may guide the trainees to note that output waveform changes state, whenever the input sinewave signal crosses the zero level. The circuit works as an Inverting Comparator.**

– – – – – – –

# Construct and test instrumentation amplifier

**Objectives :** At the end of this exercise you shall be able to
- **construct and test Instrumentation amplifier circuit using IC LM324.**

## Requirement

**Tools/Equipments/Instruments/Data Book**

- Function generator - 1 No
- CRO dual trace 20MHz - 1 No
- Dual regulated DC power supply 0-30V/2A - 1 No
- Trainees tool kit - 1Set
- Digital multimeter with probes - 1 No
- Data sheet of the IC LM324 - as reqd

**Materials/Components**

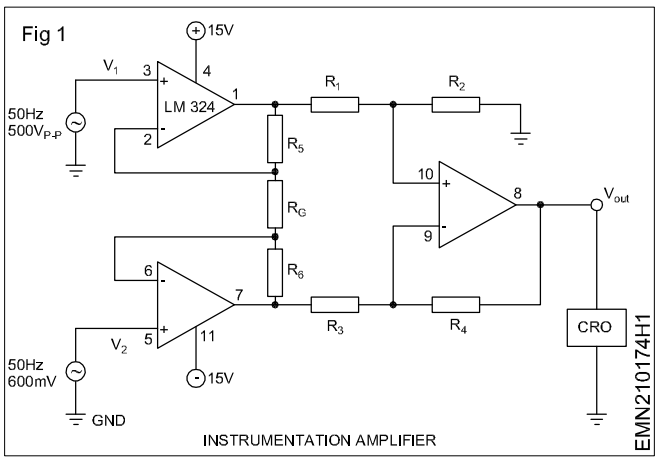
- Resistors ¼ W/CR25
  - 1kΩ - 4 Nos
  - 100kΩ - 4 Nos
  - 1kΩ POT - 1 No
- IC LM324 - 1 No
- Breadboard - 1 set

## PROCEUDRE

TASK 1 : **Construction and testing of an Instrumentation amplifier circuit**

1 Collect all the components, test them and refer to the pin out diagram of the IC and assemble the circuit as per the circuit diagram shown in Fig 1.

Fig 1




2 Get the assembled circuit checked by the Instructor.

3 Set the inputs $V_1$ and $V_2$ at different values but at the same frequency.

4 Switch ON the dual power supply and set the voltage + 15V, -15V and GND.

5 Prepare the CRO for measurements and measure the output at the output pin.

6 Calculate the theoretical gain from the given formula and verify the practical values.

*Formula*

$$Voltage gain A_V = \frac{V_0}{V_2 - V_1} = \left(1 + \frac{2R_1}{R_{gain}}\right) \times \left(\frac{R_3}{R_2}\right)$$

**Table**

| Sl.No. | Applied input voltage | Voltage gain AV | Output voltage calculated ($V_o$) | Result Observed Output '$V_o$' |
|---|---|---|---|---|
| 1 | $V_1$=<br>$V_2$= | $V_o$= | | |

7 Get the work checked by the Instructor.

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# Construct and test a Binary weighted and R-2R Ladder type Digital- to- Analog converters

**Objectives:** At the end of this exercise you shall be able to
- **assemble and test a digital to analog converter using R-2R ladder network using Op-Amp.**

## Requirements

**Tools/Equipments/Instruments**

- Trainees tool kit - 1 Set
- Regulated dual DC power supply 0-30V/2A - 1 No
- DC power supply 15V/500 mA - 1 No
- Digital multimeter with probe - 1 No

**Materials/Components**

- IC LM741 - 1 No
- Data sheet of the ICs used - as reqd
- Resistor, carbon film 10 kΩ/¼ W/CR25 - 16 Nos
- Breadboard - 1 No
- IC Base 8 pin - 1 No
- Hook up wire - as reqd
- Miniature toggle switch SPDT - 4 Nos

## PROCEDURE

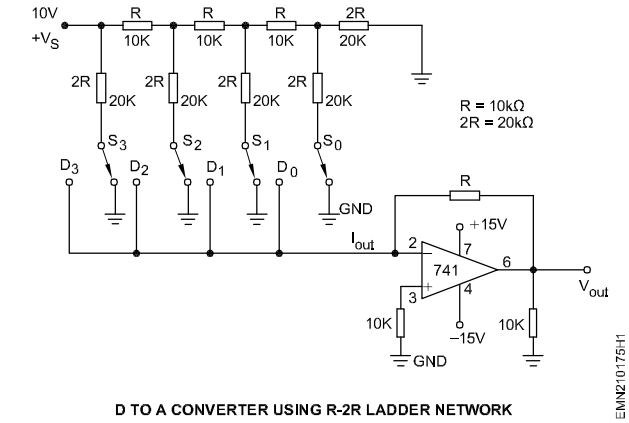
TASK 1: **Construct and test D to A converter using R-2R ladder network**

1 Collect all the components, check them; Refer Fig 1 and assemble the op-amp circuit using IC741 with 8 pin IC base on bread board.

2 Get the assembled circuit checked by the Instructor.

3 Connect the dual DC power supply +15, -15V and GND terminals to the IC741 referring to Fig 1.

Fig 1




D TO A CONVERTER USING R-2R LADDER NETWORK

4 Assemble the remaining part of R-2R ladder network on bread board ensuring four terminal connections $D_0$ to $D_3$ which are digital inputs.

5 Use the toggle switches $S_0$ to $S_3$ and operate them to provide logic levels low (GND) and thigh (1) as per the Table 1.

6 Get the work checked by the Instructor.

7 Apply binary logic inputs at $D_0$ to $D_3$ as per Table 1, measure voltage at the output of the Op-Amp and record them in Table.

8 Repeat step 7 for different binary input combinations.

9 Calculate the theoretical $V_o$ by using the formula for different binary input combinations and record the same in Table 1.

Formula for theoretical output $V_0$

$$V_0 = \frac{D_0.2^o+D_1.2^1+D_2.2^2+D_3.2^3}{2^3}$$

Digital Input = logic 0/logic 1

**Note: For (eg) If the 4 bit binary inuts are [D0 D1 D2 D3 - Decimal values = 7.**

The equivalent analog value of the D to A converter can be calculated as follows:

As logic - 2 refer to 5V, $V_{ref}$ = 5V in the circuit.

For the binary inputs 1110, the input voltage x at pin 2 of Op - Amps, is

$$V_x = [(2^0 \times 1)+(2^1 \times 1) + (2^2 \times 1) + (2^3 \times 0)]$$

$$\text{Analog} = \frac{1}{16}(7) = \left(\frac{7}{16}\right)$$

$$\text{O/P } V_o = \frac{7}{16} \times 5V$$

For binary Input $(-1111)_2$

Analog output will = -5V

(-1 is the inverting amplifier gain).

**Table 1**

| Decimal Value of Input | 4-bit Digital Input | | | | $V_o$ Calculated | $V_o$ Measured |
|---|---|---|---|---|---|---|
| | $D_3$ | $D_2$ | $D_1$ | $D_0$ | | |
| 0 | 0 | 0 | 0 | 0 | | |
| 1 | 0 | 0 | 0 | 1 | | |
| 2 | 0 | 0 | 1 | 0 | | |
| 3 | 0 | 0 | 1 | 1 | | |
| 4 | 0 | 1 | 0 | 0 | | |
| 5 | 0 | 1 | 0 | 1 | | |
| 6 | 0 | 1 | 1 | 0 | | |
| 7 | 0 | 1 | 1 | 1 | | |
| 8 | 1 | 0 | 0 | 0 | | |

10 Get the work checked by the Instructor.

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# Construct and test Astable multivibrator circuit using IC 555

**Objectives:** At the end of this exercise you shall be able to
- **assemble and test an astable multivibrator circuit using IC 555**
- **measure pulse repetition frequency (PRF), rise time and fall time of the pulses.**

## Requirements

**Tools/Equipments/Instruments**

- Regulated DC power supply 0-30/2A - 1 No
- Trainees tool kit - 1 Set
- CRO 20MHz, Dual trace - 1 No
- Digital multimeter with probes - 1 No

**Materials/Components**

- Bread board - 1 No
- IC base, 8 pin DIL - 1 No
- IC 555 - 1 No
- Carbon resistors, ¼ W/CR25
  1kΩ - 1 No
  10k preset - 1 No
- Preset, 10kΩ - 1 No
- Capacitors
  0.01 µF/25V - 1 No
  0.1 µF/25V - 1 No
  4.7 µF/25V - 1 No
- Speaker, 8Ω, 2" or any small speaker (used in pocket radios) - 1 No
- LED 5mm, Red - 1 No
- Hook up wires -as reqd

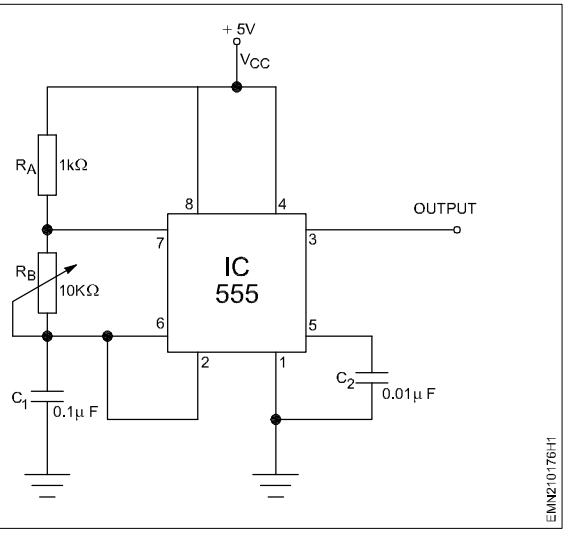
## PROCEDURE

TASK 1 : **Construction and testing of an astable Multivibrator using IC 555**

1 Collect all the required components, check them and assemble the astable multivibrator circuit on breadboard as shown in Fig 1.

2 Get the assembled circuit checked by the Instructor.

Fig 1




**Place and fix the IC in the IC socket ensuring that the IC pins do not get bent or come out of the IC base.**

3 From the values of the circuit components, calculate and record the ON-time($t_{ON}$), OFF-time($t_{OFF}$) and the pulse repetition frequency(PRF) of output.

4 Get the calculated values checked by the instructor.

5 Prepare the CRO for measurements.

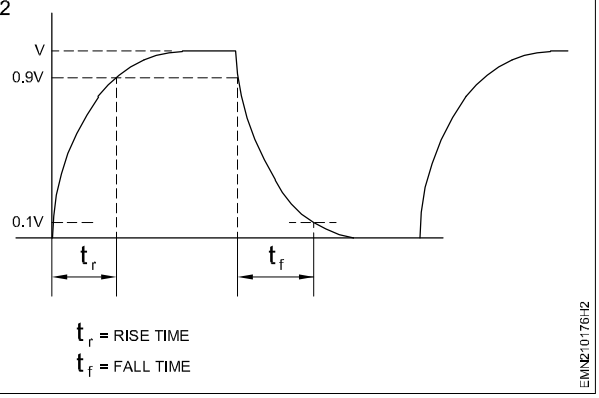
6 Switch ON DC voltage to the circuit and check for continuous rectangular pulses at the output of the circuit using the CRO.

**If there is no output, switch off the voltage to the circuit and check the circuit connections. Take the help of the Instructor, if necessary.**

7 Measure and record the ON-time, OFF-time and PRF (pulse repetition frquency) of the output pulses.

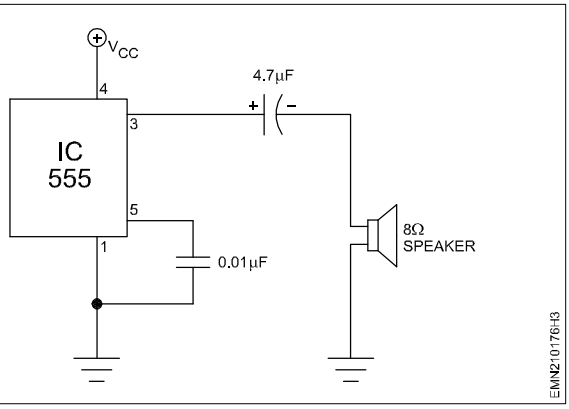
8 Measure and record the rise-time and fall-time of the pulses as shown in Fig 2.

Fig 2



9 Connect a capacitor 4.7μF and a 8Ω, 2 inch speaker at the output in series with a capacitor as shown in Fig 3.

Fig 3




10 Switch ON the DC supply and listen to the audible sound from the speaker. Change the position of the preset 'RB' and check for changed frequency output from the speaker.

11 Measure and record output frequencies and duty cycle at four different positions of preset.

12 Get the working of astable multivibrator circuit and the recorded readings checked by the Instructor.

**Note:**

**The frequency (or) PRF of Astable multivibrator is:**

- **f = =** $\frac{1.44}{(R + 2RB)C}$
- **t OFF = 0.693 x RB x C**
- **t ON = 0.693 (RA + RB) C**
- **D = Duty Cycle =** $\frac{(RA + RB)}{(RA + 2RB)}$

**1** (a) Measured ON-time ($t_{ON}$) : _____

(b) Measured OFF-time ($t_{OFF}$) : _____

(c) Measured pulse repetition frequency (PRF) : _____

(d) Duty cycle : _____

**2 Rise time of pulse (Observed) :** _____

**3 Fall time of pulse (Observed) :** _____

**4** (a) Audible output heard from speaker : YES/NO

(b) Frequency/pitch of audible output from speaker varies with position of preset : YES/NO

Table 1

| Resistance of preset RB | Output Frequency | Waveform on CRO |
|---|---|---|
| | | |

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# Construct and test Monostable multivibrator circuit using IC 555

**Objective :** At the end of this exercise you shall be able to
- **assemble and test a monostable multivibrator using IC 555.**
- **use the monostable multivibrator as a touch switch.**

## Requirements

**Tools/Equipments/Instruments**

- Digital multimeter with probes - 1 No
- Trainees tool kit - 1 Set
- Storage oscilloscope/CRO-0-20 MHz dual trace - 1 No
- Regulated DC power supply 0-30V/2A - 1 No

**Materials/Components**

- Breadboard - 1 No
- 8-pin IC base - 1 No
- IC 555 - 1 No
- Carbon resistors, 1/4 watt
  10 MΩ - 1 No
  33 kΩ 330Ω, 1MΩ - 1 No
- Capacitors 25VDC - 1 No each
  0.01μF - 2 Nos
  4.7μF - 1 No
- LED 5mm, Red - 1 No
- Push-button switch (Push-to-ON) - 1 No
- Hook up wires - as reqd

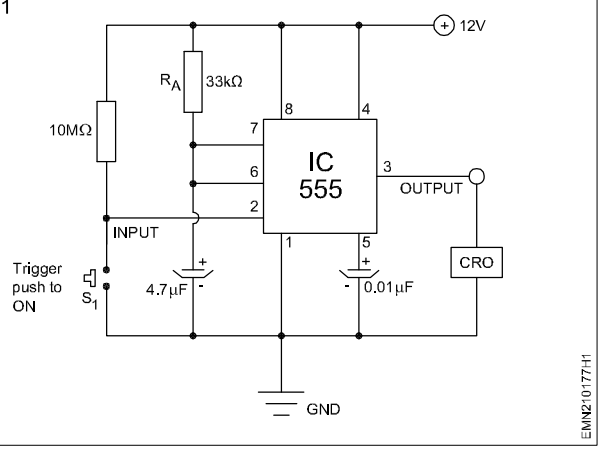
## PROCEDURE

TASK 1 : **Construction and testing of Monostable multivibrator circuit using IC 555**

1 Collect all the materials required and check them.

2 Assemble the monostable multivibrator on breadboard referring to the circuit diagram shown in Fig 1.

Fig 1




3 Get the assembled circuit checked by the instructor.

4 Switch ON the 12VDC supply to the circuit.

5 Prepare the CRO for measurements and connect the CRO at the output of the monostable multivibrator.

6 Press the push-button(trigger signal) and observe the output pulse on the CRO.

7 Keep pressing and releasing the trigger button and measure the ON-time($t_{ON}$) of the output pulse. Record the reading in Table 1&2.

**If the CRO has a storage option, use it to measure the pulse width conveniently. Take the help of the instructor to use the storage option.**

8 Connect the CRO probe at pin No. 2 of the IC; keep pressing and releasing the trigger button and observe the trigger input waveform on the CRO. Sketch the observed waveform in the space provided in the Table 2.

9 Change the value $R_A$ from 33 KΩ to 1 MΩ. Connect the LED with a 330 Ω resistor in series at the output pin 3 to GND.

10 Switch ON DC supply to the circuit; press the push-button (trigger) and observe the LED glow for a few seconds and turn OFF again. Record your observation.

**Table 1**

| S.No. | $R_A$ | C | Time | |
|---|---|---|---|---|
| | | | Calculated $T=1.11 \times R_A C$ | Measured |
| 1 | 33kΩ | 4.7µF | | |
| 2 | 1MΩ | 4.7µF | | |

**Table 2**

| Wave form at Trigger Input Pin -2 | Wave form at Output Pin-3 |
|---|---|
| | |
| | |

11 Get the work checked by the Instructor.

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TASK 2 : **Construction and testing of Monostable multivibrator as a touch switch**

1 Remove the push-button switch connected at pin No.2 of the IC. Connect a wire of about 0.5 metres skinned at both ends at pin No. 2 of IC.

2 Switch ON DC supply to the circuit. Touch once, the free end of the wire by your fingers and observe the LED glow. Repeat this step a few more times and record your observation.

**The circuit is now working as a touch-switch.**

3 Get the working of the touch-switch checked by the Instructor.

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# Construct and test VCO (V to F converter) using IC 555

**Objectives :** At the end of this exercise you shall be able to
**• construct and test VCO circuit using IC 555.**

## Requirements

**Tools/Equipments/Instruments**

- Trainees tool kit - 1 Set
- Digital multimeter with probes - 1 No
- Regulated DC power supply 0-30V/2A - 1 No

**Materials/Components**

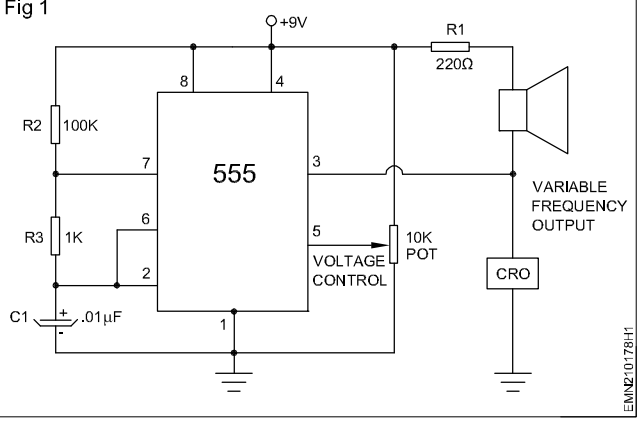
- Bread board - 1 No
- Resistor 100kΩ, 1kΩ, 220Ω ¼ W/CR25 - 1 No each
- IC 555 - 1 No
- Capacitor 0.01µF/25V - 1 No
- Loud speaker 8Ω/1W - 1 No
- Hookup wire - as reqd
- 10k Linear potentiometer - 1 No

## PROCEDURE

TASK 1 : **Construction and testing of VCO circuit using IC 555**

1 Collect all the materials required for the circuit diagram shown in the Fig 1 and check them for their working condition using multimeter.

Fig 1




2 Assemble the components on breadboard according to the circuit shown in Fig 1.

3 Get the assembled circuit checked by the Instructor.

4 Switch ON 9V DC supply to the circuit from the Regulated DC power supply.

5 Preapare the CRO for measurement, and observe the waveform at pin no.3.

6 Adjust the DC control voltage at pin no. 5 and observe the sound and measure the effect on the output of the circuit.

**This observation, conclude that the output of the circuit (i.e the frequency of astable multivibrator) varies on varying the control voltage at pin no. 5 then the circuit behaves as voltage controlled oscillator.**

7 Change the DC control voltage settings as per the table and record the readings in Table 1.

**Table 1**

| Sl.No. | Input Voltage | CRO readings |
|---|---|---|
| 1 | 1.5V | |
| 2 | 3V | |
| 3 | 4.5V | |
| 4 | 7.5V | |

8 Get the work checked by the Instructor.

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# Construct and test 555 timers as pulse width modulator

**Objective:** At the end of this exercise you shall be able to
**• construct and test a PWM circuit using IC555 to generate pulse width modulated output.**

## Requirements

**Tools/Equipments/Instruments/Data Book**

- Trainees tool kit - 1 Set
- Digital multimeter with probes - 1 No
- Regulated DC power supply 0-30V/2A - 1 No
- Function generator - 1 No
- AF signal generator - 1 No

**Materials/Components**

- Breadboard - 1 No
- IC 555 - 1 No
- IC Base-8 pin - 1 No
- Diode 1N4001 - 1 No
- Resistor
  15kΩ, carbon, ¼ W - 1 No
  10kΩ, carbon, ¼ W - 1 No
  5.6kΩ, carbon, ¼ W - 1 No
- Capacitors 25V DC
  0.1µF, ceramic disc - 2 Nos
  10 µF - 1 No
- LED 5mm, Red - 1 No
- Push-button switch (Push-to-ON) - 1 No
- Hook up wires - as reqd

## PROCEDURE

TASK 1 : **Construction and testing of PWM circuit using IC 555**

1 Collect all the materials required identify the components as per the circuit diagram. Ensure working condition of the components by using multimeter and IC tester.

2 Assemble the PWM control circuit using IC 555 as shown in Fig 1.

3 Switch ON 12V DC power supply.

4 Connect the square wave input as carrier, from function generator. Set the waveform to the required duty cycle and AF signal as message.

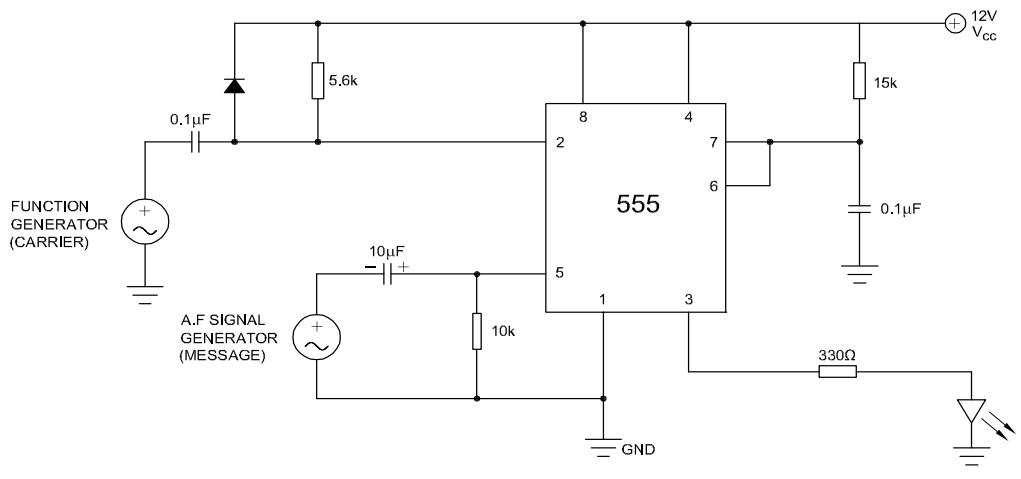
5 Observe the output LED at pin 3 and the brightness of the LED.

6 Prepare the CRO for measurement and observe the out waveform verify PWM frequency and duty cycle; record the waveform in Table 1.

**Table 1**

| Function Generator frequency | A.F. Generator frequency | Output waveform | Remarks |
|---|---|---|---|
| | | | |

Fig 1




7 Get the result checked by the Instructor.

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