DEPARTMENT OF ELECTRONICS & COMMUNICATION ENGINEERING

NETWORK THEORY LABORATORY

STUDENT LABORATORY MANUAL

(As per 2023-2024 Academic Regulations)

B.E III SEMISTER E&CE

SUBJECT CODE: PC352 EC

Name:_____

Roll No.:_____

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Prepared by

Mr. P. Ramesh Babu, Assistant Professor

METHODIST

COLLEGE OF ENGINEERING & TECHNOLOGY

(An Autonomous Institution)

Approved by AICTE, New Delhi & Affiliated to Osmania University

Accredited by NBA and NAAC with A+ Grade

Estd : 2008

DEPARTMENT OF ELECTRONICS & COMMUNICATION ENGINEERING

Vision of the Institute:

To produce ethical, socially conscious and innovative professionals who would contribute to sustainable technological development of the society.

Mission of the Institute:

To impart quality engineering education with latest technological developments and interdisciplinary skills to make students succeed in professional practice

To encourage research culture among faculty and students by establishing state of art laboratories and exposing them to modern industrial and organizational practices

To inculcate humane qualities like environmental consciousness, leadership, social values, professional ethics and engage in independent and lifelong learning for sustainable contribution to the society.

DEPARTMENT OF ELECTRONICS & COMMUNICATION ENGINEERING

Vision of the Department:

To strive to become centre of excellence in Education, Research with moral, ethical values and serve society

Mission of the Department:

M1: To provide Electronics & Communication Engineering knowledge for successful career either in industry or research

M2: To develop Industry-Interaction for innovation, product oriented research and development.

M3: To facilitate value added education combined with hands-on trainings.

DEPARTMENT OF ELECTRONICS & COMMUNICATION ENGINEERING

Program Educational Objectives:

PEO 1: Apply the knowledge of Basic sciences and Engineering in designing and implementing the solutions in emerging areas of Electronics and Communication Engineering.

PEO 2: Pursue the research or higher education and practise profession.

PEO 3: Adapt to the technological advancements for providing the sustainable Engineering solutions to meet organisation/society needs

PEO 4: Work as an individual or in a team with professional ethics and values.

Program Outcomes:

1. Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

2. Problem analysis: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

3. Design/development of solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

4. Conduct investigations of complex problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

5. Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

6. The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

7. Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

8. Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

9. Individual and team work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

10. Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

11. Project management and finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

12. Life-long learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Program Specific Outcomes (PSOs):

PSO1: Professional Competence: Apply the knowledge of Electronics & Communication Engineering principles in different domains like VLSI, Signal processing, Communication, Embedded system & Control Engineering.

PSO2: Technical Skills: Able to design and implement products using the cutting- edge software and hardware tools and hence provide simple solutions to complex problems.

PSO3: Social consciousness: Graduates will be able to demonstrate the leadership qualities and strive for the betterment of organization, environment and society

METHODIST

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DEPARTMENT OF ELECTRONICS & COMMUNICATION ENGINEERING
Laboratory Code of Conduct

1. Students should report to the concerned labs as per the time table schedule.
2. Students who turn up late to the labs will in no case be permitted to perform the experiment scheduled for the day.
3. Students should bring a note book of about 100 pages and should enter the readings/observations into the note book while performing the experiment.
4. After completion of the experiment, certification of the concerned staff in-charge in the observation book is necessary.
5. Staff member in-charge shall award 25 marks for each experiment based on continuous evaluation and will be entered in the continuous internal evaluation sheet.
6. The record of observations along with the detailed experimental procedure of the experiment performed in the immediate last session should be submitted and certified by the staff member in-charge.
7. Not more than three students in a group are permitted to perform the experiment on a set-up for equipment-based labs. Only one student is permitted per computer system for computer-based labs.
8. The group-wise division made in the beginning should be adhered to, and no student is allowed to mix up with different groups later.
9. The components required pertaining to the experiment should be collected from the stores in-charge, only after duly filling in the requisition form/log register.
10. When the experiment is completed, students should disconnect the setup made by them, and should return all the components/instruments taken for the purpose.
11. Any damage of the equipment or burn-out of components will be viewed seriously by either charging penalty or dismissing the total group of students from the lab for the semester/year.
12. Students should be present in the labs for the total scheduled duration.
13. Students are required to prepare thoroughly to perform the experiment before coming to Laboratory.
14. Procedure sheets/data sheets provided to the students, if any, should be maintained neatly and returned after the completion of the experiment.

Course Code	Course Title						Core/Elective
PC352EC	**Network Theorem Lab**						**Core**
Prerequisite	**Contact Hours per Week**				**CIE**	**SEE**	**Credits**
Nil	**L**	**T**	**D**	**P**			
	-	-	-	2	25	50	1

Course Objectives:
  ➢ To learn the usage of basic electronic components, equipment and meters used in electronic laboratories.
  ➢ To learn practical electric AC & DC circuits.
  ➢ To learn about PCB making
  ➢ To learn various filters.

Course Outcomes:
  ➢ Use the basic electronic components and design circuits.
  ➢ Verify various parameters of the circuits by applying theorems.
  ➢ Understand the making of PCB.
  ➢ Design various filters.

List of Experiments
Part A

1. Study of all types of discrete Active & passive devices, display devices, integrated components, electro mechanical components (switches, sockets, connectors etc.,) electromagnetic components (relays). Study and use of different meters (volt/ammeter, AVO/Multi meter) for the measurement of electrical parameters. Measurement of RLC components using LCR Meter.
2. Study of CRO and its applications.
3. Verification of Superposition and Tellegan's theorem
4. Verification of of Thevenin's and Maximum Power Transfer Theorem.
5. Measurement of two-port network parameters.
6. Measurement of Image impedance and Characteristics impedance.
7. Design of T-section constant K Low Pass Filter.
8. Design of m-derive High Pass Filter.
9. Verification of Reciprocity theorem.
10. Verification of Norton's theorem.
11. Soldering and De-soldering.
12. PCB Making.

Suggesting Reading:

1. Paul B. Zbar, Albert P. Malvino, *Michael A. Miller, Basic Electronics, A Text - Lab Manual,* 7th Edition, TMH 2001.
2. Paul Tobin, *PSPICE for Circuit Theory and Electronic Devices,* Morgan & Claypool publishers, 1st ed., 2007.

Note: A minimum of 10 experiments should be performed. The students may use any commercial / open source SPICE programs available like MULTISIM,PSPICE, TINA, LAB VIEW for simulation.

PART A

EXPERIMENTS

EXPERIMENT NO: 1(A)

STUDY OF ELECTRONIC COMPONENTS & DEVICES

Aim: Study and identification of passive components.

Components required: - Resistors, capacitors inductors and Transformers

Theory:

Resistors:

A **resistor** is a passive two-terminal electrical component that implements electrical resistance as a circuit element. Resistors act to reduce current flow, and, at the same time, act to lower voltage levels within circuits The behavior of an ideal resistor is dictated by the relationship specified by Ohm's law:

$$V = I \cdot R.$$

Ohm's law states that the voltage (V) across a resistor is proportional to the current (I), where the constant of proportionality is the resistance (R). The ohm (symbol: Ω) is the SI unit of electrical resistance.

Symbols:

Fig 1: Resistors

Applications:

1. By placing a resistor in series with another component such as LED (Light emitting diodes) the current through that component is reduced.

2. A series resistor can be used for speed regulation of DC motors such as used in locomotives.

3. An attenuator is a network of two or more resistors used to reduce the voltage of a signal.

4. A line terminator is a resistor at the end of a transmission line designed to match the impedance for maximum power transfer and hence minimize the reflection of the signal. All resistors dissipate voltage into heat. This is the principle behind electric heaters and irons.

Color coding for fixed resistors
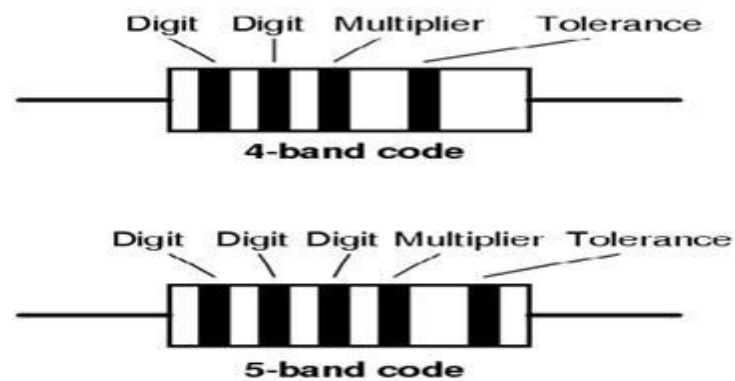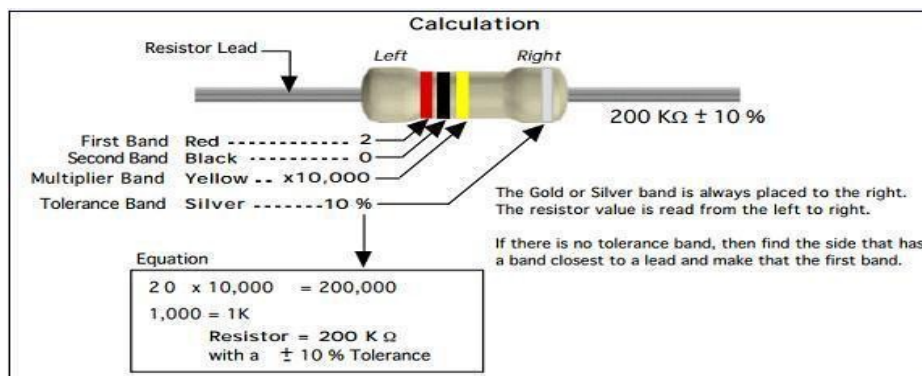
Fig 2: Resistor Bands

Fig 3: Description of Resistor bands

Table 1: Resistor color code table

The standard resistor color code table:							
Color	**Digit 1**	**Digit 2**	**Digit 3***	**Multiplier**	**Tolerance**	**Temp. Coef.**	**Fail Rate**
Black	0	0	0	$\times 10^0$			
Brown	1	1	1	$\times 10^1$	±1% (F)	100 ppm/K	1%
Red	2	2	2	$\times 10^2$	±2% (G)	50 ppm/K	0.1%
Orange	3	3	3	$\times 10^3$		15 ppm/K	0.01%
Yellow	4	4	4	$\times 10^4$		25 ppm/K	0.001%
Green	5	5	5	$\times 10^5$	±0.5% (D)		
Blue	6	6	6	$\times 10^6$	±0.25% (C)		
Violet	7	7	7	$\times 10^7$	±0.1% (B)		
Gray	8	8	8	$\times 10^8$	±0.05% (A)		
White	9	9	9	$\times 10^9$			
Gold				×0.1	±5% (J)		
Silver				×0.01	±10% (K)		
None					±20% (M)		

* 3rd digit - only for 5-band resistors

Specifications:-

1. Resistance 1 Ω to several mega Ω.

2. Power Rating: - 1/10 watt to 100 watt.

3. Temperature Coefficient – it is a parameter indicating the rate of change of nominal resistance value as a function of temperature. It is expressed as ppm/°C or % per °C

4. Voltage Rating or the rated continuous working voltage of a resistor is given by √ (W*R) Where W is the wattage rating in watts and R is the resistance value in ohms.

5. Noise, Frequency Response, Temperature Rating, Physical Size, Reliability etc**.**

All practical resistors also introduce small amount of inductance and capacitance which change the dynamic behavior of the resistor from the ideal.

Real Standard resistor values - E6 and E12 series:

Resistors are not available with every possible value, for example 22k and 47k are readily available, but 25k and 50k are not!. Electronic engineers and manufacturers have

Adopted a standard for resistors values. These are intended to keep the cost down and make it easier for to buy them from any supplier.

E6 series: Resistors with 20% tolerance 10, 15, 22, 33, 47, 68 ... then it continues 100, 150, 220, 330, 470, 680, 1000 etc.

E12 series: Resistors with 10% tolerance 10, 12, 15, 18, 22, 27, 33, 39, 47, 56, 68, 82... Then it continues 100, 120, 150 etc.

Capacitor:

A **capacitor** (originally known as a **condenser**) is a passive two-terminal electrical component used to store energy electro-statically in an electric field. The forms of practical capacitors vary widely, but all contain at least two electrical conductors (plates) separated by a dielectric (i.e. insulator). Unlike a resistor, an ideal capacitor does not dissipate energy. Instead, a capacitor stores energy in the form of an electrostatic field between its plates.

An ideal capacitor is wholly characterized by a constant capacitance C, defined as the ratio of charge $\pm Q$ on each conductor to the voltage V between them, The unit of capacitance is farad , mathematically defines a $Q = C/V$
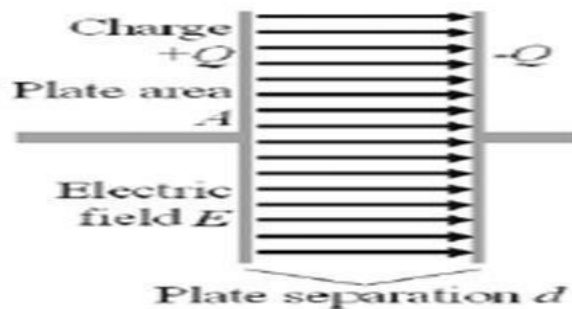

Fig 4: Parallel plate capacitor

Applications of capacitors:

Capacitors have very many uses in electronic and electrical systems:

- Energy storage devices.

- Used in power supplies to smooth the output of a full wave or half wave rectifier.

- Capacitors are connected in parallel with the power circuits of most electronic devices to shunt away the current fluctuations.

- Capacitors are used in power factor correction.

- Capacitors pass AC but block DC signals (when charged up to the applied dc voltage), they are often used to separate the AC and DC components of a signal. This method is known as *AC coupling*.

- Capacitors are also used in parallel to interrupt units of a high-voltage circuit breaker in order to equally distribute the voltage between these units. In this case they are called grading capacitors.

- The energy stored in a capacitor can be used to represent information, either in binary form, as in computers.

- Capacitors and inductors are applied together in tuned circuits to select information in particular frequency bands. For example, radio receivers rely on variable capacitors to tune the station frequency.

Specifications:

- They are specified by type (tantalum, electrolytic, etc.)
- They are specified by package (axial, radial, as discussed above).
- They are specified by how to connect to them, their connection type (such as "snap in" or leaded or threaded scrNT holes, or surface mount).
- They are specified by capacitance value, e.g. in microfarads (µF).
- They are specified by voltage rating (i.e., 30 V). This indicates the maximum voltage under which it is safe to use the referenced capacitor.
- Some types, such as electrolytic capacitors, are specified by operating temperature (usually 80 or 120 °C), which reflects the maximum temperature that the capacitor

  Can reach before failing. Note- common practice is to use capacitors well below their maximum operating voltage and temperature in order to ensure longevity.

☐ They can be specified by other parameters, including ESR or "equivalent series resistance" (explained above). Also, some capacitors can be specified by UL or other safety rating. A "X" type capacitor indicates that the capacitor meets certain standards one of which is that it is appropriate to be used with line-level voltages (such as 117 or 220 V) typically found from the wall outlet, as well as that it can withstand surges typically found in power distribution systems.

☐ They are specified in percentage accuracy, i.e., how much they are likely to deviate from their rated capacitance. Common ratings are + or - 20%.

Symbols:

| Normal | Normal | Electrolytic | Variable |
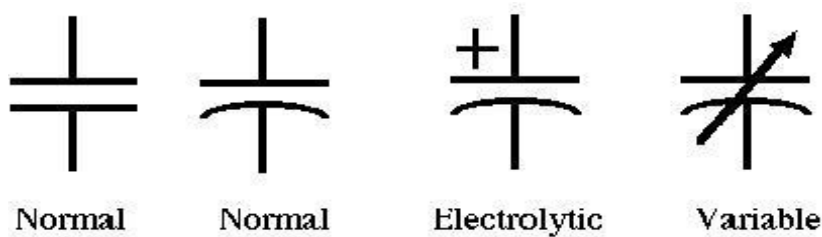
Fig 5: Capacitor symbols

Energy stored in a capacitor is given by

$$W = \int_0^Q V(q)\mathrm{d}q = \int_0^Q \frac{q}{C}\mathrm{d}q = \frac{1}{2}\frac{Q^2}{C} = \frac{1}{2}CV^2 = \frac{1}{2}VQ$$

Identification of capacitors:

Capacitors are labeled in different ways.

• Capacitor Labeled with number

scheme Ex:- "223" = 22 000 pF ,

"104" = 10 0000 pF ,

"393" = 39 000 pF

• Some capacitors are labeled implicitly

Ex: 4700pF, *250 V*
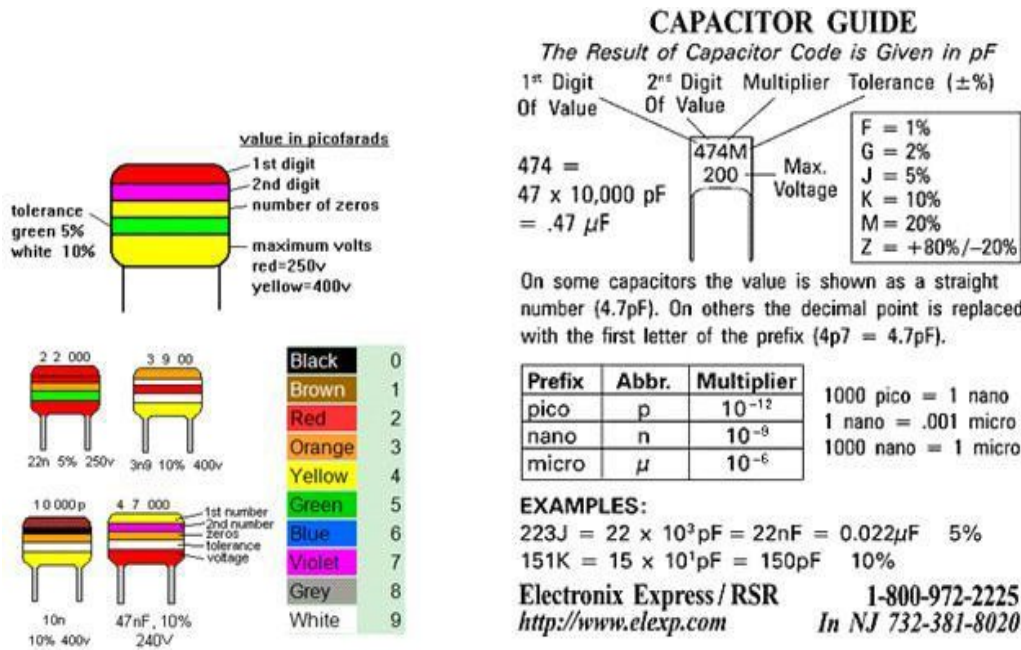
Color coded and labeled capacitors:

Fig 6: Color coded capacitors and labeled capacitors

Inductors:

An **inductor**, also called a **coil** or **reactor**, is a passive two-terminal electrical component which resists changes in electric current passing through it. It consists of a conductor such as a wire, usually wound into a coil. When a current flows through it, energy is stored temporarily in a magnetic field in the coil. When the current flowing through an inductor changes, the time-varying magnetic field induces a voltage in the conductor, according to Faraday's law of electromagnetic induction, which opposes the change in current that created it. As a result, inductors always oppose a change in current.

Inductance (L) results from the magnetic field around a current-carrying conductor; the electric current through the conductor creates a magnetic flux. Mathematically speaking, inductance is determined by how much magnetic flux φ through the circuit is created by a given current i .The voltage –current relation in an inductor is given as

$$v = \frac{d}{dt}(Li) = L\frac{di}{dt}$$

The unit of Inductance is „Henry". Basic inductance formula for a cylindrical coil:

$$L = \frac{\mu_0 \mu_r N^2 A}{l}$$

Where

L = Inductance in henries (H)

μ_0 = permeability of free space $=4\pi \times 10^{-7}$H/m

μ_r = relative permeability of core material N =
number of turns

A = area of cross-section of the coil in square meters (m^2)

l = length of coil in meters (m).

The energy stored by an inductor is

$$E_{stored} = \frac{1}{2}LI^2$$

Applications:

Inductors are used in electronic and electrical systems. Some of the applications are:

☐ Inductors along with capacitors are used in tuned circuits.

☐ Two (or more) inductors which have coupled magnetic flux form a transformer.

☐ Used as chokes in power supplies to remove residual hum or other fluctuations from the direct current output.

☐ An inductor is used as the energy storage device in a switched-mode power supply.

Table 2: Inductor color coding

Band	1	2	3	4
Meaning	1st Digit	2nd Digit	Multiplier (No. of zeros)	Tolerance %
Gold			x 0.1 (divide by 10)	+/-5%
Silver			x 0.01 (divide by 100)	+/-10%
Black	0	0	x1 (No Zeros)	+/-20%
Brown	1	1	x10 (0)	
Red	2	2	x100 (00)	
Orange	3	3	x1000 (000)	
Yellow	4	4	x10000 (0,000)	
Green	5	5		
Blue	6	6		
Violet	7	7		
Grey	8	8		
White	9	9		

Example: An inductor with color red violet brown and black , Therefore value is 27 x10 = µH with tolerance 20%
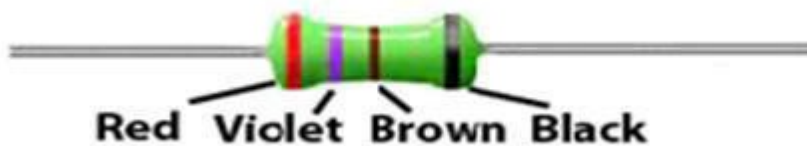
Fig 7: Color coded inductor

Symbols:
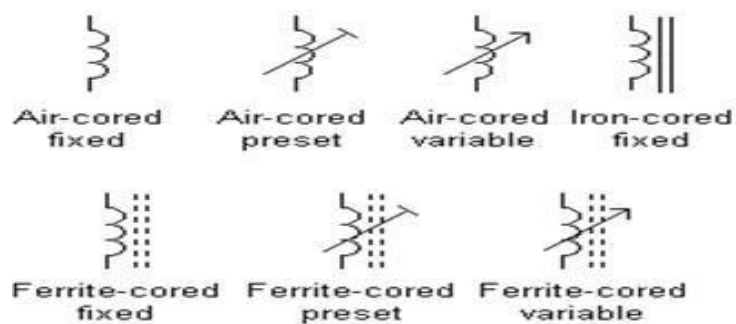
Transformer:

A transformer can be defined as a static device which helps in the transformation of electric power in one circuit to electric power of the same frequency in another circuit. The voltage can be raised or lowered in a circuit, but with a proportional increase or decrease in the current ratings.

The main principle of operation of a transformer is mutual inductance between two circuits which is linked by a common magnetic flux. A basic transformer consists of two coils that are electrically separate and inductive, but are magnetically linked through a path of reluctance. The working principle of the transformer can be understood from the figure below.
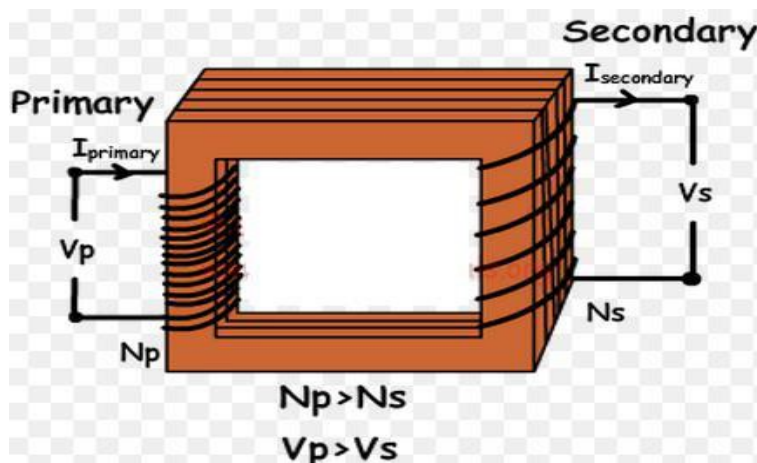
Fig 8: step-down transformer showing magnetizing flux in the core

In an ideal transformer: Vp/Vs = Np/Ns

In above equation Vp = voltage across primary

Vs = voltage across secondary

Np = numbers of turns in primary

Ns= numbers of turns in primary

As shown above the transformer has primary and secondary windings. The core laminations are joined in the form of strips in between the strips you can see that there are some narrow gaps right through the cross-section of the core. These staggered joints are said to be imbricated". Both the coils have high mutual inductance. A mutual electro-motive force is induced in the transformer from the alternating flux that is set up in the laminated core, due to the coil that is connected to a source of alternating voltage. Most of the

Alternating flux developed by this coil is linked with the other coil and thus produces the mutual induced electro-motive force. The so produced electro-motive force can be explained with the help of Faraday's laws of Electromagnetic Induction as

$$e = M * di/dt$$

If the second coil circuit is closed, a current flows in it and thus electrical energy is transferred magnetically from the first to the second coil.

The alternating current supply is given to the first coil and hence it can be called as the primary winding. The energy is drawn out from the second coil and thus can be called as the secondary winding.

Types of Transformers:

The types of transformers differ in the manner in which the primary and secondary coils are provided around the laminated steel core. According to the design, transformers can be classified into two:

1. Core- Type Transformer

In core-type transformer, the windings are given to a considerable part of the core. The coils used for this transformer are form-wound and are of cylindrical type. Such a type of transformer can be applicable for small sized and large sized transformers. In the small sized type, the core will be rectangular in shape and the coils used are cylindrical. The figure below shows the large sized type. You can see that the round or cylindrical coils are wound in such a way as to fit over a cruciform core section. In the case of circular cylindrical coils, they have a fair advantage of having good mechanical strength. The cylindrical coils will have different layers and each layer will be insulated from the other with the help of materials like paper, cloth, micarta board and so on. The general arrangement of the core-type transformer with respect to the core is shown below. Both low-voltage (LV) and high voltage (HV) windings are shown.
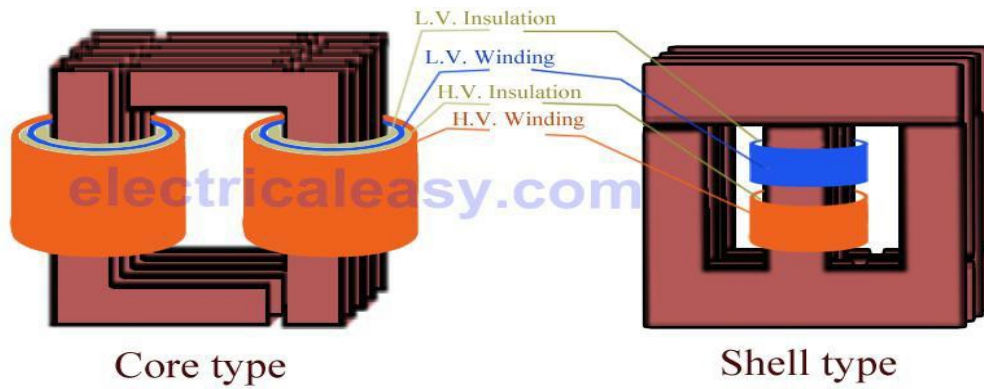
Fig 9: Core and shell type transformers

The low voltage windings are placed nearer to the core as it is the easiest to insulate. The effective core area of the transformer can be reduced with the use of laminations and insulation.

2. Shell-Type Transformer

In shell-type transformers the core surrounds a considerable portion of the windings. The comparison is shown in the figure below.
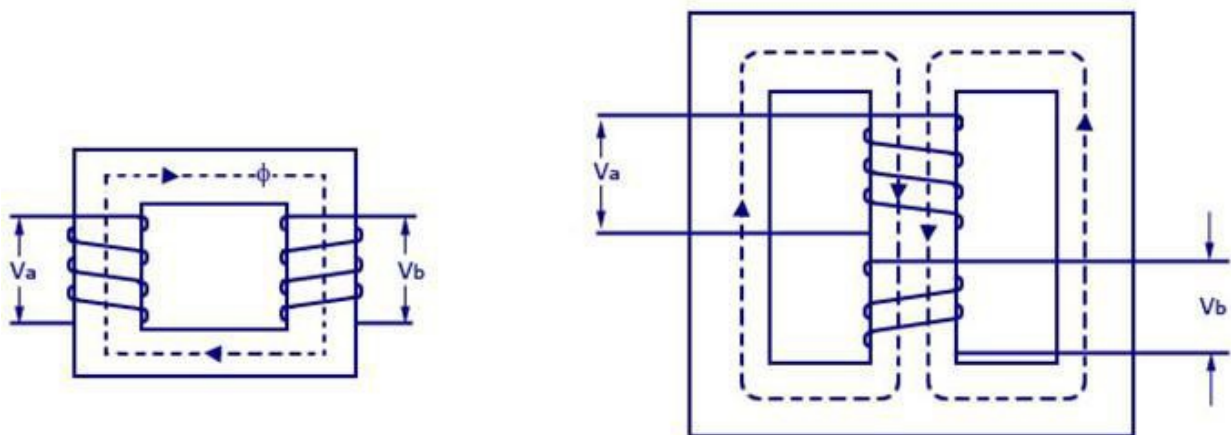

Fig 10: Core and shell type transformer winding

The coils are form-wound but are multi layer disc type usually wound in the form of pancakes. Paper is used to insulate the different layers of the multi-layer discs. The whole winding consists of discs stacked with insulation spaces between the coils. These insulation spaces form the horizontal cooling and insulating ducts. Such a transformer may have the shape of a simple rectangle or may also have a distributed form.

Observation table:

S.No	Resistor Colors	Measured value by Using Color Coding
1		
2		
3		
	Capacitor (Color coded/ Labeled value)	
4		
5		
6		
	Inductor(Color coded/ Labeled)	
7		
8		
9		

Display Boards – R , L and C:

Study of Transformer & Coil
Model : SE-713
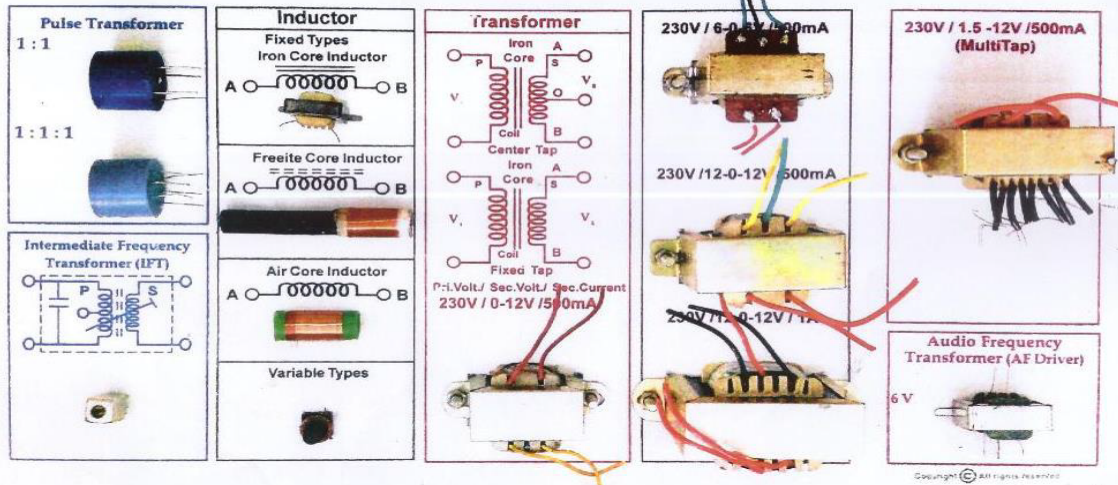
1.4 Results:

1. Basic electronics components resister, capacitor, inductor and transformer have been studied.

2. The values of basic components have been calculated using color coding method.

EXPERIMENT NO: 1(B)

STUDY OF ELECTRONIC COMPONETS AND DEVICES -II

Aim: Study and identification of active components, electromagnetic, electro-mechanical components and devices.

Components Required:- Diodes, Transistor, Integrated Circuits (ICs), electromagnetic, electro-mechanical components and devices.

Theory: Active Components are electronic components that require a Source of Energy to perform their intended functions. Active components increase the power of a signal and must be supplied with the signal and a source of power. Examples are Diodes. Simple p n junction that conducts current in one direction only, unless the reverse voltage is high enough to create a reverse current. Bipolar transistors, field effect transistors etc.

Diodes

In electronics, a **diode** is a component that restricts the direction of movement of charge carriers. It allows an electric current to flow in one direction, but essentially blocks it in the opposite direction. In a p-n diode, conventional current can flow from the p-type side (the anode) to the n-type side (the cathode), but not in the opposite direction.
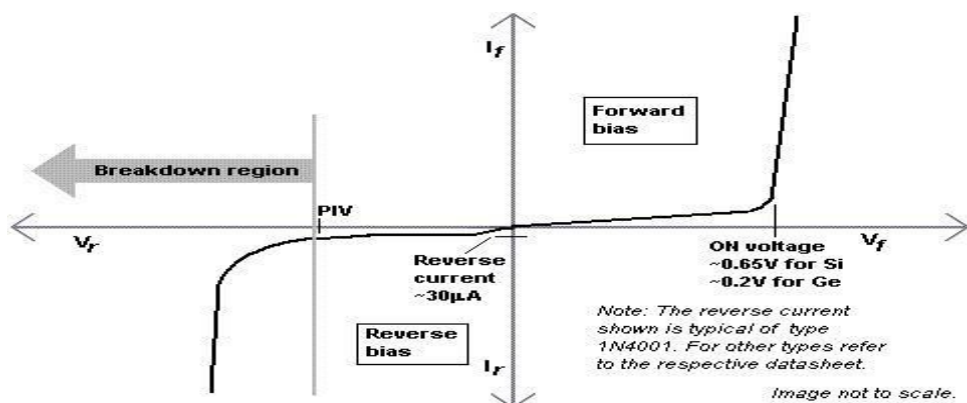
.

Fig 1: Ideal diode VI Characteristics

The current through an ideal diode is given by equation

,

Where I is the diode current,

I_S is a scale factor called the saturation current,

V_D is the voltage across the diode

V_T is the thermal voltage and n is the emission coefficient. n=1 for Ge & n = 2 for Si.

Table 1: Schematic Symbols of different Diodes

Name	Symbol	Name	Symbol
PN Diode		Zener Diode	
Light Emitting Diode		Photo Diode	
Varicap Diode		Silicon Control Rectifier (SCR)	

Transistors

The transistor is one of the greatest inventions in modern history. It is the key active component in practically all modern electronics. On 22 December 1947 William Shockley, John Bardeen and Walter Brattain invented the first practical transistor at Bell Labs. The transistor is a three terminal solid state semiconductor device that can be used for amplification, switching, voltage stabilization, signal modulation and many other functions.

Bipolar junction transistor:

Bipolar transistors are so named because they conduct by using both majority and minority carriers. The three terminals are named emitter, base and collector. Two p-n junctions exist inside a BJT: the base/collector junction and base/emitter junction. The BJT is commonly described as a current-operated device because the emitter/collector current is controlled by the current flowing between base and emitter terminals. Unlike the FET, the

BJT is a low input-impedance device. The BJT has a higher transconductance than the FET. Two types of BJT are common: PNP and NPN.

Fig 2: NPN and PNP Transistor

Field effect transistor:

The field-effect transistor (FET) is also called as unipolar transistor. It uses either electrons (N-channel FET) or holes (P-channel FET) for conduction. The three main terminals of the FET are named source, gate and drain. On some FETs a fourth connection to the body (substrate) is provided, but normally the body is connected internally to the source.

A voltage applied between the gate and source controls the current flowing between the source and drain. In FETs the source/drain current flows through a conducting channel near the gate. This channel connects the source region to the drain region. The channel conductivity is varied by the electric field generated by the voltage applied between the gate/source terminals. In this way the current flowing between the source and drain is controlled. Therefore FETs are also called as Voltage Controlled devices. Two types of
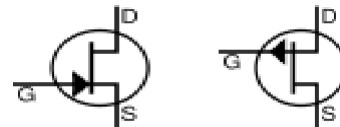
JFETs are commonly used: N-Channel JFET and P-

Fig 3: N-channel and P-channel JFET
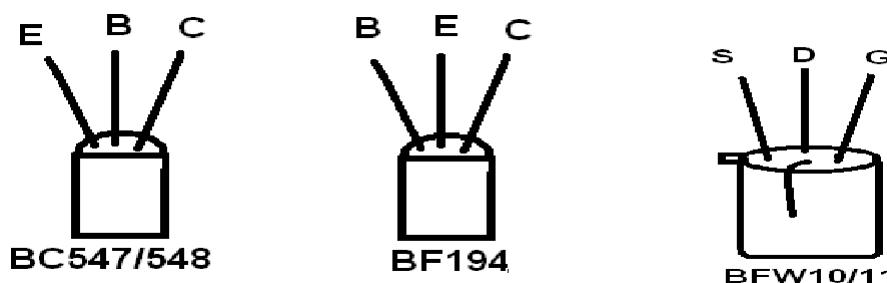
Fig 4: Terminal Identification of BJT and FET

Integrated Circuits (ICs)

Integrated circuits play very important part in many electronic devices of today. Integrated circuits are specially crafted electronic circuits, which could contain tens, hundreds, thousands or even tens of thousands of transistors, diodes and resistors. They are all interconnected by manufacturer in such a way that they form different purpose circuits like audio-amplifiers, voltage stabilizers, different logic circuits, certain parts of TV-receivers, a whole audio receiver or transceiver, etc.

Classification of Integrated Circuits

There are three methods of packaging ICs in containers the glass metal can, the ceramic flat pack, and the dual-in-line ceramic or plastic flat packs known as dual-in-line packages (DIPs). The popular, less expensive plastic (DIP packages can have 14,16,18,24 or 40 connecting pins. A minimum of two pins is required for connecting the IC to the power supply. The remaining connections are available for use as terminals for input and output signals.

Electromechanical components:

Switches:

In electronics, an electronic switch is an electronic component or device that can switch an electrical circuit, interrupting the current or diverting it from one conductor to another. Typically, electronic switches use solid state devices such as transistors. An electrical switch is any device used to interrupt the flow of electrons in a circuit.

Switches are essentially binary devices: they are either completely on ("closed") or completely off ("open"). There are many different types of switches. The simplest type of switch is one where two electrical conductors are brought in contact with each other by the motion of an actuating mechanism. Other switches are more complex, containing electronic circuits able to turn on or off depending on some physical stimulus (such as light or magnetic field) sensed. In any case, the final output of any switch will be (at least) a pair of wire-connection terminals that will either be connected together by the switch's internal contact mechanism ("closed"), or not connected together ("open").Any switch designed to be

Operated by a person is generally called a hand switch. Toggle switches are classified in to three types

SPST: A Single Pole Single Throw toggle switch Schematic Symbol.

Fig 5: Switch symbol

SPST

A Single Pole Single Throw toggle switch connects or disconnects one terminal either to or from another. It is the simplest switch.

Bat UP = ON (terminals connected)
Bat DOWN = OFF (terminals disconnected)

ON

OFF
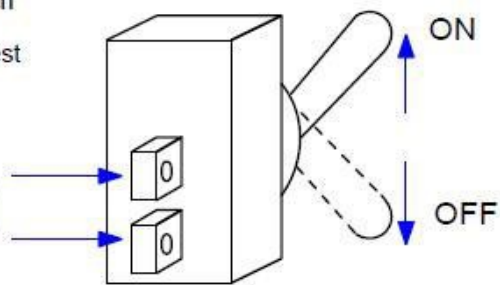
Fig 6: SPST switch

SPDT: A Single Pole Double Throw toggle switch connects a common terminal to one or the other of two terminals. It is always connected to one or the other. The two outside terminals are never connected by the switch.

A Single Pole Double Throw toggle switch Schematic Symbol and operation shown below

Bat DOWN = (C connected to A)
Common terminal
Bat UP = (C connected to B)

B connected to C
A disconnected from C

A connected to C
B disconnected from C
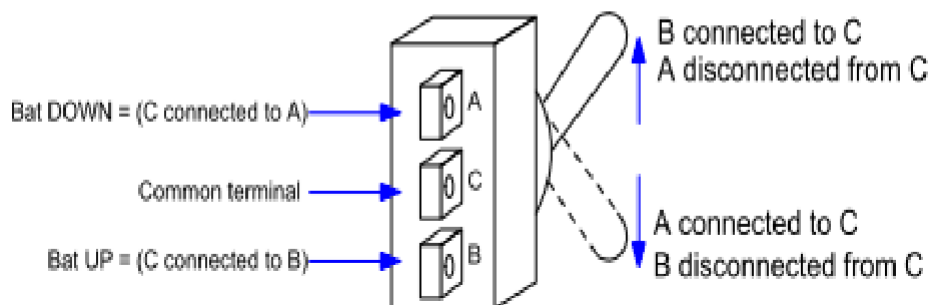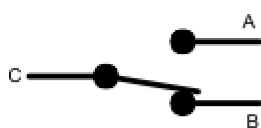
Fig 8: SPDT switch

DPDT: A Double Pole Double Throw toggle switch acts exactly like two separate SPDT switches connected to the same switch bat. It has two separate common terminals and each of those is connected to one or the other of the other two terminals on the same side of the switch. The dotted line in the picture is to illustrate that the switch is actually two SPDT switches in one package with one switch bat. A Double Pole Double Throw toggle switch Schematic Symbol and operation shown below
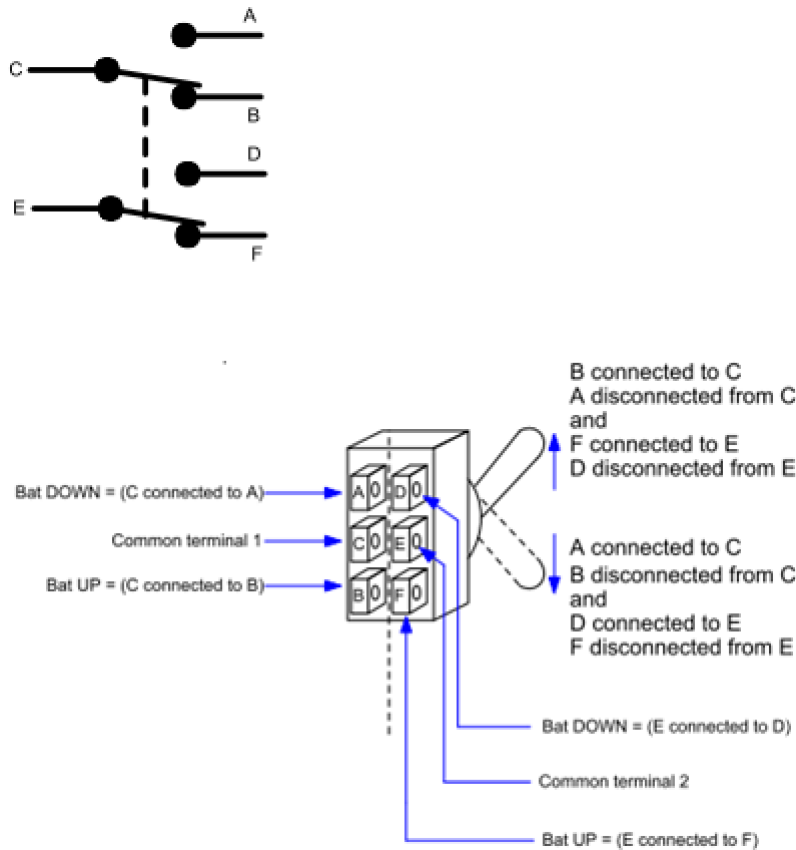
Fig 9: DPDT switch

Sockets:

It is device which allows electrically operated equipment to be connected to the primary alternative current (AC) power supply. Electrical plugs and sockets differ in voltage and current rating, shape, size and type of connectors Application of socket is to reduce the risk of electrical shocks and fire. Plugs and socket figures shown below

Fig 10: Plugs and Sockets

Connectors:

An electrical connector is an electro-mechanical device for joining electrical circuits as an interface using a mechanical assembly. Connectors consist of plugs and jacks. The connection may be temporary, as for portable equipment, require a tool for assembly and removal, or serve as a permanent electrical joint between two wires or devices. An adapter can be used to effectively bring together dissimilar connectors. Connectors may join two lengths of flexible copper wire or cable, or connect a wire or cable to an electrical terminal.

In computing, an electrical connector can also be known as a physical interface (compare physical layer in OSI model of networking). Cable glands, known as cable connectors. connectors shown below.

Fig 11: VGA connector, Serial port connector and USB Connector

Electromagnetic components – Relays

A relay is an electrically operated switch. Many relays use an electromagnet to mechanically operate switch, where it is necessary to control a circuit by a low-power signal or where several circuits must be controlled by one signal. The first relays were used in long distance telegraph circuits as amplifiers: they repeated the signal coming in from one circuit and re-transmitted it on another circuit. Relays were used extensively in telephone exchanges and early computers to perform logical operations.

Operation:

The electromagnetic relay consists of a multi-turn coil, wound on an iron core, to form an electromagnet. When the coil is energized, by passing current through it, the core becomes temporarily magnetized.
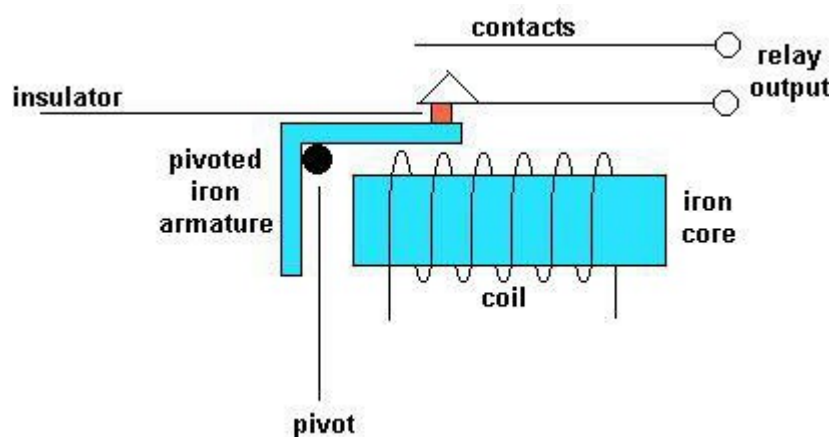
Fig: Relay

The magnetized core attracts the iron armature. The armature is pivoted which causes it to operate one or more sets of contacts. When the coil is de-energized the armature and contacts are released.

The coil can be energized from a low power source such as a transistor while the contacts can switch high powers such as the mains supply. The relay can also be situated remotely from the control source. Relays can generate a very high voltage across the coil when switched off. This can damage other components in the circuit. To prevent this diode is connected across the coil. The cathode of the diode is connected to the most positive end of the coil.

Relays are switches, the terminology applied to switches is also applied to relays; a relay switches one or more *poles*, each of contacts can be *thrown* by energizing the coil.
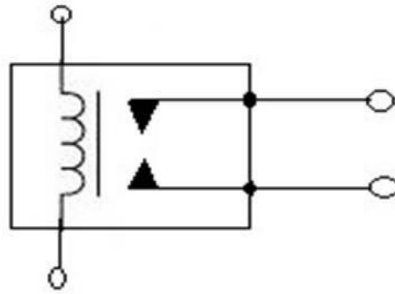
Fig 13: Relay symbol

Display Boards

Study of Transistors

Model : SE-705

SINCOM

VIEWS

BC 547 / 147
AF Transistors

BC 548 / 148

BC 157 / 557

BC 158 / 558

SYMBOLS

NPN PNP
BJT

BC 107
AF Transistors

BC 108

CL/SL 100

CK/SK 100

N-Channel **JFET** P-Channel

BF 194 / 494
HF / RF Transistors

BF 195 / 495

2N3055

2N 2646

N-Channel **MOSFET** P-Channel
E-Type

BFW 10
Field Effect Transistors (FET)

IRF 540
MOSFET

Power Type BJT

UJT

Photo Transistor

UJT

Study of Relays

Model : SE-712

SINCOM

Symbol

SPDT Relay

DPDT Relay

General Purpose Type

6V SPDT
(200Ω/2A)

12V SPDT
(200Ω/2A)

18V SPDT
(200Ω/5A)

General Purpose Type

12V DPDT
(200Ω/5A)

18V DPDT
(500Ω/5A)

24V DPDT
(500Ω/5A)

PCB MOUNTING Type

12V SPDT
(200Ω/5A)

5V SPDT
(400Ω/1A)

Dry Reed Type

Telephone Type

5V

Study of Band Switches
Model : SE-711

SCR, DIAC, TRIAC, UJT.
Model: SE-706

Results: Diodes, Transistor, Integrated circuits, electrometrical and electromagnetic components have been studied.

EXPERIMENT NO: 1(C)

STUDY AND USE OF DIFFERENT METERS

Aim: To Familiar with different meters and to measure inductance, capacitance and resistance, diodes and transistor using meters.

Components and Equipments Required:

1. Multimeter, LCR Meter 1 No

2. Resistors, Capacitors (ceramic and electrolytic) and Inductor

3. Diodes and Transistors

4. Bread board and connecting wires

Theory:

A multimeter is an electronic measuring instrument that combines several measurement functions in one unit also known as a VOM (Volt-Ohm meter or Volt-Ohm-milliammeter). A typical multimeter would include basic features such as the ability to measure voltage, current, and resistance. Digital multimeters (DMM, DVOM) display the measured value in numerals.
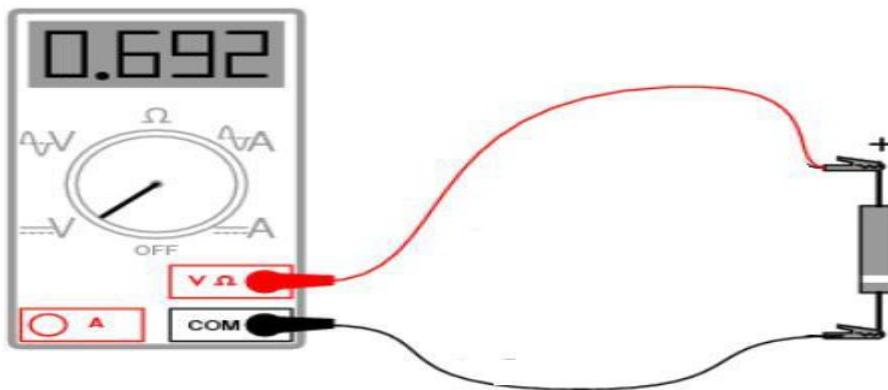
Fig 1: Multimeter

Procedure:

A) Voltage Measurements

- ☐ Connect the red test lead to the "V " jack and black test lead to the "COM" jack
- ☐ Set the function/Range switch to the desired voltage range and slide the "AC/DC" select switch to the desired voltage type . If magnitude of voltage is not known, set switch to the range and reduce until a satisfactory reading is obtained.
- ☐ Connect the test leads to the device or circuit being measured.

B) Current Measurements

- ☐ Set the function/Range switch to the desired current range and slide the "AC/DC" select switch to the desired current type .
- ☐ For current measurement less than 200 mA connect the red test lead to micro amp/mA jack and black test lead to COM jack.
- ☐ For current measurement of 200mA or greater, connect the red test lead to 10A jack and black test lead to COM jack.

C) Resistance Measurements

- ☐ Set the function/Range switch to the desired resistance range or continuity position.
- ☐ Remove power from the equipment under test.
- ☐ Connect the red test lead to "VOhms" jack and black test lead to COM jack.

D) Diode Tests

- ☐ Touch the probes to the test points. In ohms, the resistance value indicated in display.
- ☐ Connect the red test lead to "VOhms" jack and black test lead to COM jack.
- ☐ Set the function/Range switch to the "diode" position.
- ☐ Turn off power to the circuit under test.
- ☐ Touch probes to the diode. A forward – voltage drop is about 0.6 for Si and 0.3 for Ge
- ☐ Reverse probes, if the diode is good, "1" is displayed. If the diode is shorted "000". If diode is open "1" is displayed in both directions.

E) Transistor Gain Measurements

- ☐ Set the function/range switch to the desired hFE range (PNP or NPN type transistor).
- ☐ Plug the transistor directly into the hFE sockets. The sockets are labeled E,B and C for emitter base and collector.
- ☐ Read the transistor hFE directly from the display.

F) Capacitance Measurements

- ☐ Set the function/range switch to the desired Cx socket

Insert the capacitor lead directly into the Cx sockets.
 Read the capacitance directly from the display

Observations Tables:

Take set of components and use above procedure to measure value using LCR and multimeter.

Table 1: diode and transistor measurement

S.No	Components	Marked value	Components value using Multimeter
1.	Diodes (Si)		
2.	Diodes (Ge)		
3.	Transistor (Gain measurement)		

Table 2: Resistor

S.No	Resistance color Code	Resistance value using color code(Ω)	Resistance value using LCR meter /Multimeter(Ω)
1			
2			
3			

Table 3: Capacitor

S.No	Code marked on Capacitor	Capacitance using LCR meter	Capacitance using Multimeter
1.			
2.			
3.			

Table 4: Electrolytic Capacitor

S.No	Capacitance Marked Value	Capacitance using LCR meter
1		
2		

Table 5: Inductor Measurement

S.No	Marked Value of Inductor	Inductance using LCR meter
1		
2		

Results: The given components have been measured with LCR meter and multimeter successfully.

EXPERIMENT NO: 2(A)

STUDY OF CRO, MEASUREMENT OF AMPLITUDE & FREQUENCY

Aim: Study of CRO and to find the Amplitude and Frequency using CRO.

Components and Equipments Required: Cathode-ray oscilloscope, Function Generator, CRO Probes and Bread Board

Theory:

An outline explanation of how an oscilloscope works can be given using the block diagram shown below:
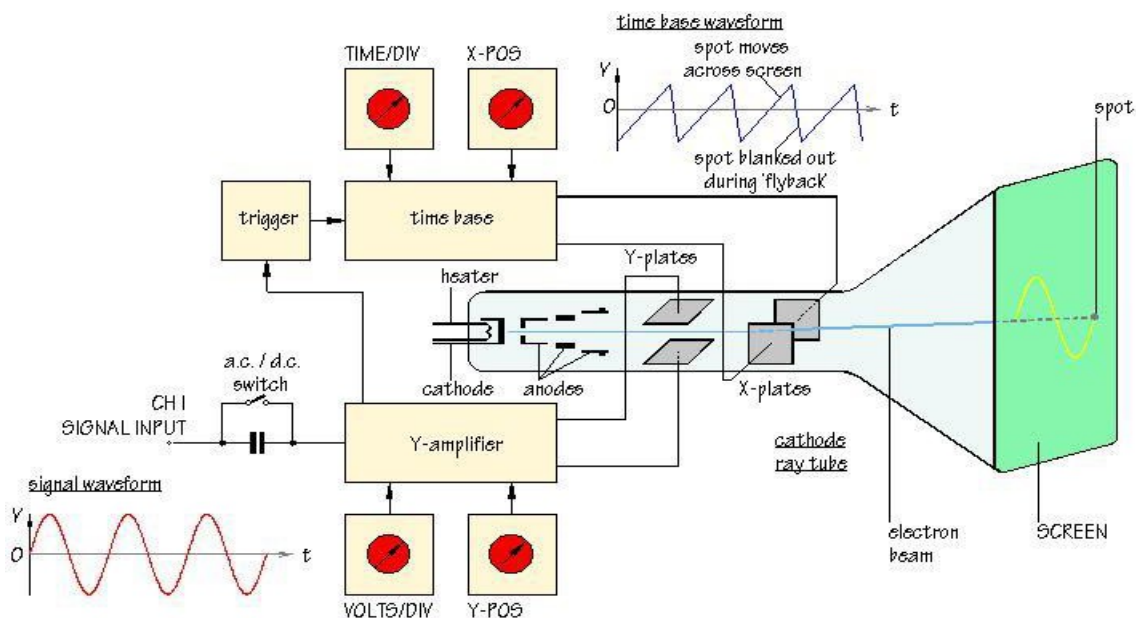
Fig 1: Cathode Ray Oscilloscope

Like a television screen, the screen of an oscilloscope consists of a **cathode ray tube**. Although the size and shape are different, the operating principle is the same. Inside the tube is a vacuum. The electron beam emitted by the heated cathode at the rear end of the tube is accelerated and focused by one or more anodes, and strikes the front of the tube, producing a bright spot on the phosphorescent screen.

The electron beam is bent, or deflected, by voltages applied to two sets of plates fixed in the tube. The horizontal deflection plates or **X-plates** produce side to side movement. As

You can see, they are linked to a system block called the **time base**. This produces a saw tooth waveform. During the rising phase of the saw tooth, the spot is driven at a uniform rate from left to right across the front of the screen. During the falling phase, the electron beam returns rapidly from right ot left, but the spot is 'blanked out' so that nothing appears on the screen. In this way, the time base generates the X-axis of the *V*/*t* graph.

The slope of the rising phase varies with the frequency of the saw tooth and can be adjusted, using the TIME/DIV control, to change the scale of the X-axis. Dividing the oscilloscope screen into squares allows the horizontal scale to be expressed in seconds, milliseconds or microseconds per division (s/DIV, ms/DIV, µs/DIV). Alternatively, if the squares are 1 cm apart, the scale may be given as s/cm, ms/cm or µs/cm.

The signal to be displayed is connected to the **input**. The AC/DC switch is usually kept in the DC position (switch closed) so that there is a direct connection to the **Y-amplifier**. In the AC position (switch open) a capacitor is placed in the signal path. The capacitor blocks DC signals but allows AC signals to pass.

The Y-amplifier is linked in turn to a pair of **Y-plates** so that it provides the Y-axis of the the *V*/*t* graph. The overall gain of the Y-amplifier can be adjusted, using the VOLTS/DIV control, so that the resulting display is neither too small or too large, but fits the screen and can be seen clearly. The vertical scale is usually given in V/DIV or mV/DIV.

The **trigger** circuit is used to delay the time base waveform so that the same section of the input signal is displayed on the screen each time the spot moves across. The effect of this is to give a stable picture on the oscilloscope screen, making it easier to measure and interpret the signal.

Changing the scales of the X-axis and Y-axis allows many different signals to be displayed. Sometimes, it is also useful to be able to change the *positions* of the axes. This is possible using the **X-POS** and **Y-POS** controls. For example, with no signal applied, the normal trace is a straight line across the centre of the screen. Adjusting Y-POS allows the zero level on the Y-axis to be changed, moving the whole trace up or down on the screen to give an effective display of signals like pulse waveforms which do not alternate between positive and negative values.
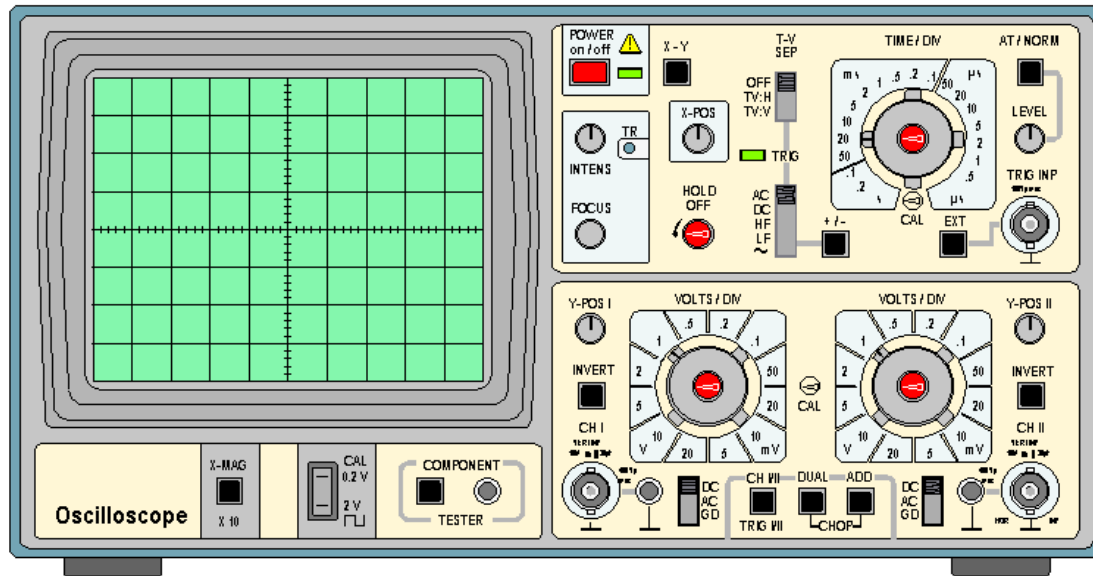
Fig 2: Front ViNT of Oscilloscope

Screen: Usually displays a *V/t* graph, with voltage *V* on the vertical axis and time *t* on the horizontal axis. The scales of both axes can be changed to display a huge variety of signals.
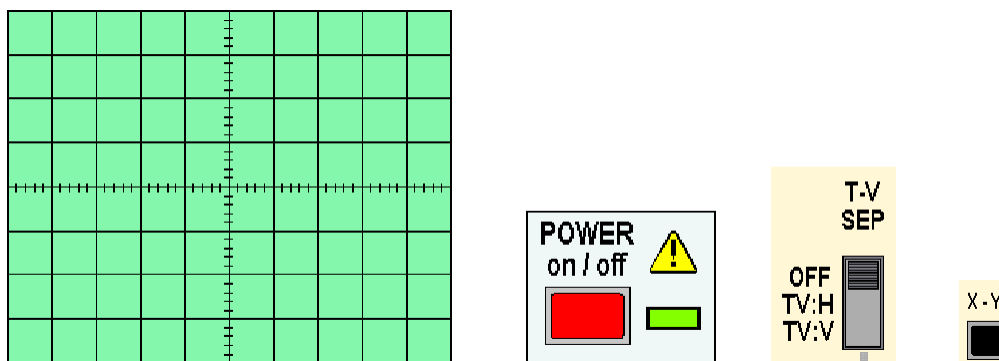
Fig 3: Screen display of Oscilloscope

On/Off Switch: Pushed in to switch the oscilloscope on. The green LED illuminates.

X-Y Control: Normally in the OUT position.

When the X-Y button is pressed IN, the oscilloscope does not display a *V/t* graph. Instead, the vertical axis is controlled by the input signal to CH II. This allows the oscilloscope to be used to display a *V/V* voltage/voltage graph.

The X-Y control is used when you want to display component characteristic curves, or Lissajous figures. (Links to these topics will be added later.)

TV-Separation: Oscilloscopes are often used to investigate waveforms inside television systems. This control allows the display to be synchronized with the television system so that the signals from different points can be compared.

Time / Div: Allows the horizontal scale of the *V*/*t* graph to be changed.
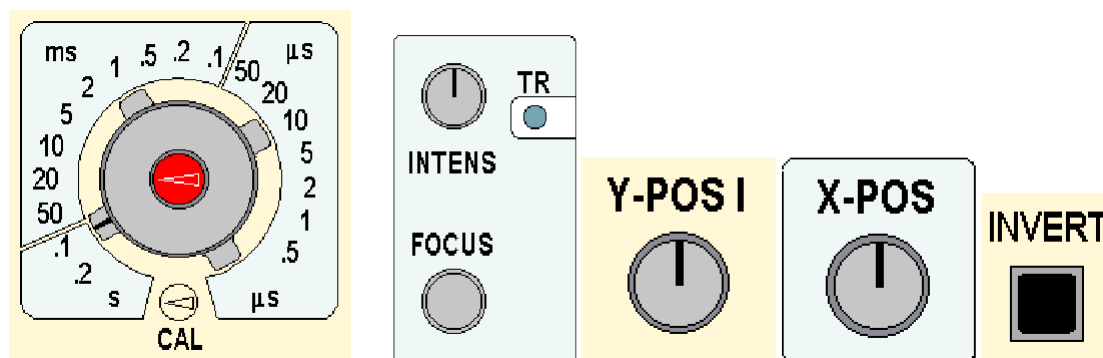
Fig 4: Time division, Intensity, focus, X-Y mode knobs

With more experience of using the oscilloscope, you will develop a clear understanding of the functions of the important trigger controls and be able to use them effectively.

Intensity and Focus: Adjusting the INTENSITY control changes the brightness of the oscilloscope display. The FOCUS should be set to produce a bright clear trace.

If required, TR can be adjusted using a small scrNTdriver so that the oscilloscope trace is exactly horizontal when no signal is connected.

X-POS: Allows the whole *V*/*t* graph to be moved from side to side on the oscilloscope screen.

This is useful when you want to use the grid in front of the screen to make measurements, for example, to measure the period of a waveform.

Y-POS I and Y-POS II: These controls allow the corresponding trace to be moved up or down, changing the position representing 0 V on the oscilloscope screen.

To investigate an alternating signal, you adjust Y-POS so that the 0 V level is close to the centre of the screen. For a pulse waveform, it is more useful to have 0 V close to the bottom of the screen. Y-POS I and Y-POS II allow the 0 V levels of the two traces to be adjusted independently.

Invert: When the INVERT button is pressed IN, the corresponding signal is turned upside down, or inverted; on the oscilloscope screen. This feature is sometimes useful when comparing signals.

CH I And CH II Inputs: Signals are connected to the BNC input sockets using BNC plugs.
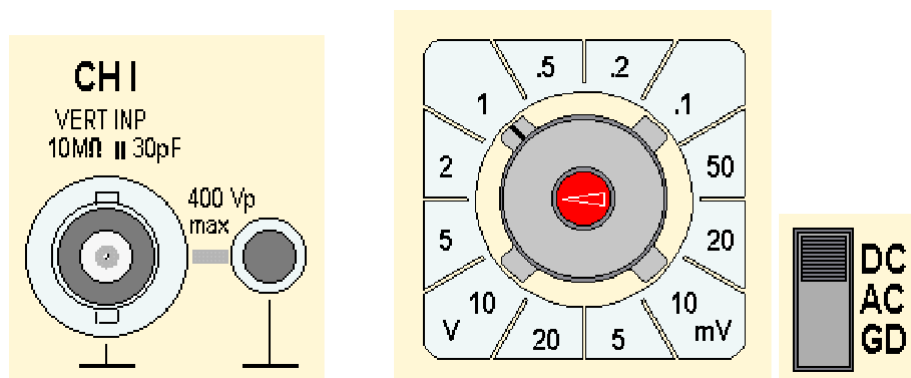
Fig 5: Voltage division, Channels, AC, DC and GD knobs

The smaller socket next to the BNC input socket provides an additional 0 V, GROUND or EARTH connection.

Volts / Div: Adjust the vertical scale of the *V/t* graph. The vertical scales for CH I and CH II can be adjusted independently.

DC/AC/GND Slide Switches: In the DC position, the signal input is connected directly to the Y-amplifier of the corresponding channel, CH I or CH II. In the AC position, a

Capacitor is connected into the signal pathway so that DC voltages are blocked and only changing AC signals are displayed.

In the GND position, the input of the Y-amplifier is connected to 0 V. This allows you to check the position of 0 V on the oscilloscope screen. The DC position of these switches is correct for most signals.

Trace Selection Switches: The settings of these switches control which traces appear on the oscilloscope screen.

Measurement of Amplitude & Frequency:
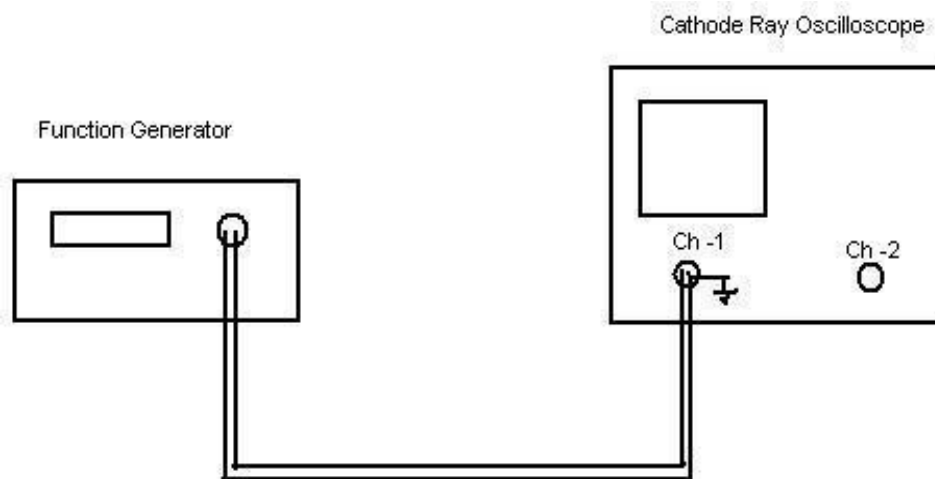
Fig 6: Block Diagram

Model waveforms:
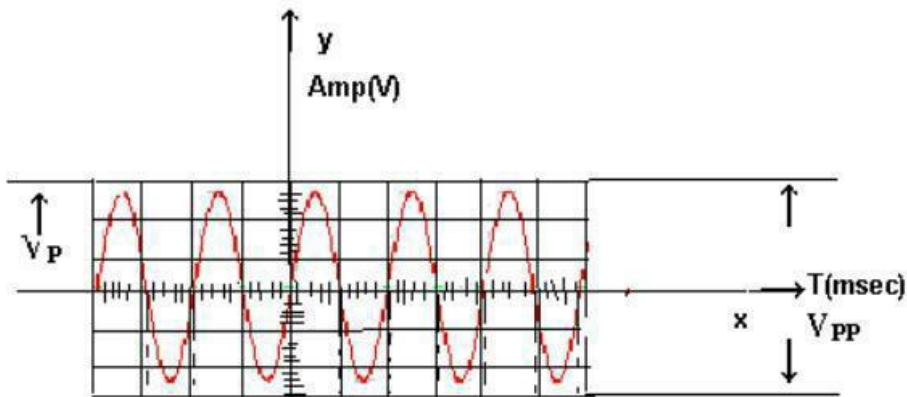
Fig 7: Sinusoidal waveform

A) Measurement of Amplitude:

Procedure:

1. Make the connections as per the diagram shown above.

2. Put the CRO on a single channel mode and bring the CRO into operation by adjusting the trace of the beam to a normal brightness and into a thin line.

3. Now apply the sinusoidal wave of different amplitudes by using the LEVEL and COARSE buttons of the function generator.

4. Note on the vertical scale the peak to peak amplitude (Vpp) .

Observations:

S.NO	No. of Vertical Divisions(X)	Voltage/ Division (Y)	Vp-p=X*Y	Vm=Vp-p/2

B) Measurement of

 Frequency: Procedure:

- ☐ Make the connections as per the diagram shown above.

- ☐ Put the CRO on a single channel mode and bring the CRO into operation by adjusting the trace of the beam to a normal brightness and into a thin line.

- ☐ Now apply the sinusoidal wave of different frequencies by using the LEVEL and COARSE buttons of the function generator.

- ☐ Note on the an horizontal scale period (T) in second by observing difference between the two successive peaks of the waveform.

Observations:

S.NO	No. Of Horizontal Divisions(X)	Time/Division= (Y)	X*Y	f=1/T

C) Component Testing:

Procedure

1. Switch on the CRO, Insert component terminals in Component Tester (CT) sockets

2. Press x-y mode and CT switches

3. Note down the Pattern from display.

Observations:

S.NO	Component	Signature or Pattern

Results:

1. Voltage amplitude and frequency have been measured.

2. Components have been tested using CRO

EXPERIMENT NO: 2(B)

MEASUREMENT OF UNKNOWN FREQUENCY & PHASE DIFFERENCE

Aim: To find the unknown Frequency with reference to known frequency and phase difference using CRO.

Components Required: Cathode-ray oscilloscope, Function Generators(2), CRO Probes(4).

Theory:

Measurement of unknown frequency:

Sine-wave signals of different frequencies are input given to the horizontal and vertical amplifiers a stationary pattern is formed on the CRT when the ratio of the two frequencies is an integral fraction such as 1/2, 2/3, 4/3, 1/5, etc. These stationary patterns are known as Lissajous figures and can be used for comparison measurement of frequencies. Using two oscillators to generate some simple Lissajous figures like shown in Fig 1 where Fv is number of loops cut by horizontal line and Fh is number of loops cut by vertical line. To maintain the Lissajous figures in a fixed configuration, the two oscillators are not phase and frequency locked their frequencies and phase drift slowly causing the two different signals to change slightly with respect to each other.

fv=fh   2fv=fh

fv=2fh   3fv=fh
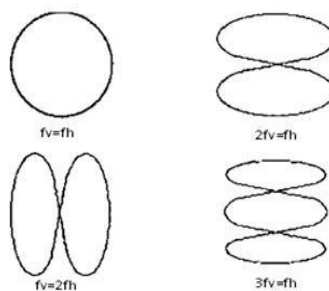
Fig 1: Lissajous pattern
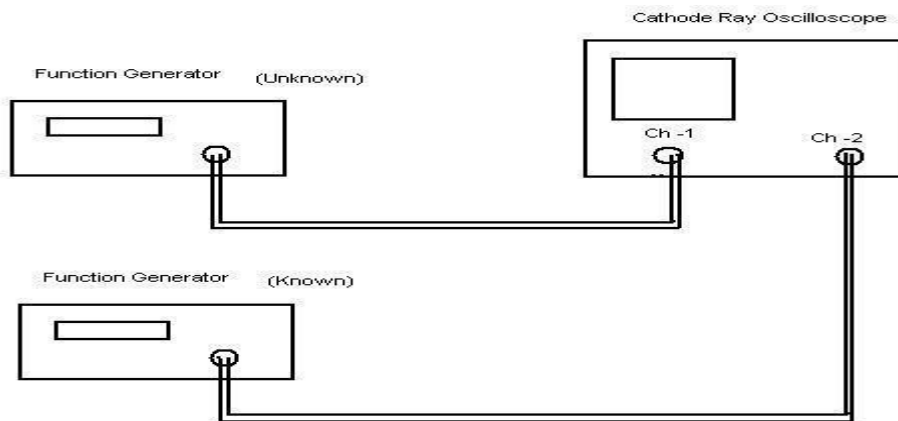
Fig 2: Block Diagram

Procedure:

1. Connect the unknown frequency to the vertical (Y) deflection plates (CH -1) and the known frequency to the horizontal (X) deflection plates (Ch-2) from two function generators as shown in the figure.

2. Press X- Y mode button on the CRO and obtain the LISSAJOUS PATTERN. The lissajous pattern is obtained when two sinusoidal signals of different frequencies are applied to the X and Y deflection plates of the CRO. If the two frequencies are equal, we get a circle or ellipse.

3. Note down Nx (Number of touching points on X- axis), Ny (Number of touching points on Y – axis), Fx (Frequency of known signal)

4. If the LISSAJOUS pattern obtained is not clear to note the readings, Vary the known frequency such that a clear lissajous pattern is obtained.

5. The unknown frequency Fy is given by Fy = (Nx * Fx) / (Ny)

Observation Table 1:

S. No.	Fx (Known frequency)	Nx	Ny	Fy (Unknwn frequency) = (Nx*Fx)/Ny
1				
2				
3				
4				

Measurement of phase difference:

If two sine wave signals of same frequency but having some angle difference is applied to CH1 and CH2, a ellipse will display on CRO screen as a Lissajous pattern as shown in fig 3, phase difference calculated by using formula $\varnothing = \sin^{-1}(b/a)$ where $\varnothing$ is phase difference between two signals.
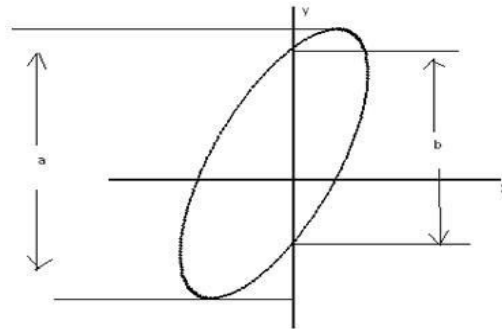
Fig 3: Lissajous pattern
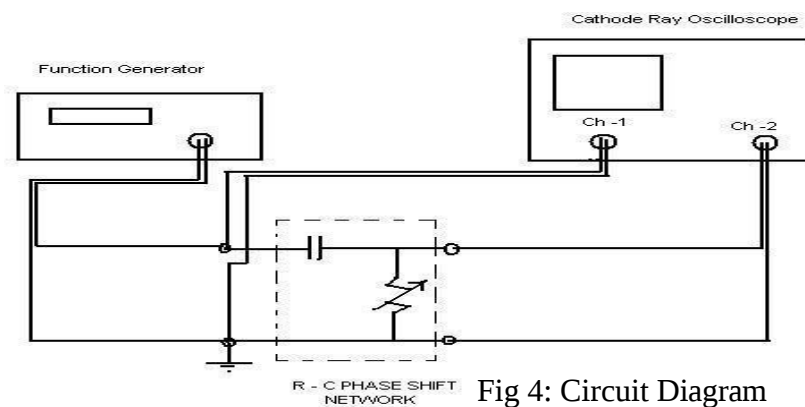
R - C PHASE SHIFT NETWORK   Fig 4: Circuit Diagram

Procedure:

1. Connect the RC phase shift network as shown above in the circuit diagram.
2. Obtain a sinusoidal signal of 5V (Pk- Pk) at 1 KHz from the function generator.
3. Connect the signal from the function generator to the input of the RC phase shift network and the same signal to the CH-1 of the CRO.
4. Connect the output of the Phase shift network to the CH-2 of the CRO.
5. Press X- Y mode button.
6. The pattern obtained on the screen will be an ellipse.
7. The phase difference between the two signals (θ) is given by $\theta = \sin^{-1}(b/a)$.
8. By varying the different values of the resistances from DRB, frequencies, note the values of b and a and hence find θ.

Observation table 2:

S.No.	R	C	a	b	$\Theta = \sin^{-1}(b/a)$
1					
2					
3					
4					
5					

Result: Measured unknown frequency of signal and phase angle difference using CRO successfully

.

<p style="text-align: center">EXPERIMENT NO: 3</p>

SOLDERING AND DESOLDERING TECHNIQUE

Aim: To perform soldering and Desoldering of electronic components on PCB

Theory

Soldering is a process for the joining of metal parts with the aid of a molten metal (SOLDER) where the melting temperature is situated below that of the material joined. Solder is an alloy of tin and lead used for fusing metals at relatively low temperatures of about 500 to 600 F. The joint where two metal conductors are to be fused is heated and then solder is applied so that it can melt and cover the connection. The reason for soldering connections is that it makes a good bond between the joint metal, covering the joint completely to prevent oxidation. The coating of solder provides protection for practically an indefinite period of time .

Mechanisms of Soldering:

The trick in soldering is to heat the joint, not the solder. When the joint is hot enough to melt the solder, the solder flows smoothly to fill the cracks forming a shiny cover without any air spaces. Do not move the joint until the solder has set, which takes only a fNT seconds. The small pencil soldering iron of 25W to 40W is helpful for soldering small connections where excessive heat can cause damage. This precaution is particularly important when working on PCB‟s where too much heat can soften the plastic form and loosen the printed wiring. A soldering iron for FET devices should have the tip grounded to eliminate the static charge.

Grades of Solder:

The three grades of solder generally used for electronic work are 40-60, 50-50, and 60-40 solder. The first figure is the percentage of tin while the other is the percentage of led. The 60-40 solder costs more but it melts at the lowest temperature, flows more freely, takes less time to harden and generally makes it easier to do a good soldering job.

In addition to the solder, there must be flux to remove any oxide film on the metals being joined. Otherwise they cannot fuse. The flux enables the molten solder to wet the metals so that the solder can stick. The two types are ACIDFLUX and ROSINFLUX. The acid flux is more active in cleaning metals but it is corrosive. The rosin flux is always used for light soldering works in making wire connections. Generally the rosin is in the hollow core of solder intended for electronic work so that a separate flux in unnecessary. Such rosin core solder is the type which is generally used. It should be noted, though, that the flux is not a substitute for cleaning the metals to be fused. They must be shiny cleaned for the solder to stick.

De-soldering Technique:

On PCB"s, de soldering is done to remove a defective components. De soldering is more important than the soldering. There are different methods of de soldering.

1. Using solder sucker: The solder sucker (de soldering pump) is first cocked and then the joint is heated in the same way as during soldering, and when the solder melts, the release button is pushed to disengage the pump. The method is repeated two to three times until the soldered components can be comfortably removed using long nose pliers.

2. Using wet de soldering wick: The wet de soldering wick is nothing but a fine copper braid used as a shield in co-axial cables. The de soldering wick is wet is using soldering flux and then it is pressed using the tip of the hot iron against the joint to be de soldered. The iron melts the solder, and it is drawn into the braid.

Precautions:

1. Mount the components at the appropriate places before soldering. Follow the circuit description and the component details, leads identification etc. Do not start soldering before making it confirmed that all the components are mounted at the right place.

2. Do not use a spread solder on the board, it may cause short circuit.

3. Do not under the fan while soldering.
4. Position the board so that gravity tends to keep the solder where you want it.
5. Do not over heat the components at the board. Excess heat may damage the components or the board.
6. The board should not vibrate while soldering, otherwise you will have a dry or a cold joint.
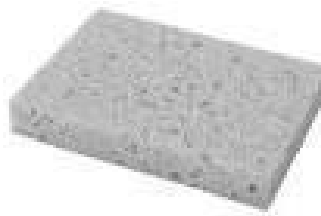
Figures:

Fig 1: Soldering iron

Fig 2: Sponge

Fig 3: Solder

Fig 4: Solder reel iron stand

Fig 5: Flux.

Fig 5: De-solder

Fig 6: De-soldering Sucker

Results: Soldering and De-soldering of electronic components have been done on the copper clad board.

EXPERIMENT NO: 4

PRINTED CIRCUIT BOARD MAKING

Aim: To design PCB of electronic circuit using PCB Fabrication flow.

Equipment and Components Required:

We will need the following items for making PCB design in PCB lab

1. Sprint-Layout tool to create layouts
2. Computer system with printer and application software for designing layout(Art work)
3. Photo Etch Machine
4. DIP Coating Machine
5. Photo Developer Machine
6. Photo UV Exposure Machine
7. Drilling Machine
8. Roller Tinning Machine
9. Dark room for chemical process facility
10. Plastic Tray
11. developer powder
12. fixer
13. Ferric chloride(Fecl$_3$)
14. Copper Clad Board
15. Thinner

PCB Fabrication – Theory:

A number of methods are available for making a PCB, the simplest being that of drawing the pattern on a copper clad board with etchant resistant ink or paint, etching the board and drilling the holes. This method is suitable where there is no need for precision and the quantity required is only are or two pieces. But with the use of ICs and crowding of the components on the board, this method becomes unsuitable as one has to have a very steady hand in drawing the lines of required thickness with paint and brush.

Printed Circuit Boards (PCB) form the very basis for the construction of almost every electronic equipment. PCBs have many advantages compared to conventional electronic circuit boards. PCB are small in size and have a reliable performance. In the wires are replaced by conductor paths avoiding the problem of loose wires. Problem of cross connection can be overcome easily. It has a possibility of mass production and thus cost is less. Testing & repairs are facilitated as all the points on the PCB are easily accessible. PCBs

.

consist basically of a board of insulating material covered with a thin layer of copper – a very good conductor. The insulating material generally used is epoxy or bakelite. For eg, it two resistors have to be mounted in series, then it is only necessary to drill four holes for their leads with a copper strip connecting the desired leads. When the leads are soldered, the component is fixed securely in places and an electrical contact is made between the lead and the copper coating of the PCB. Before mounting components, copper has to be removed or itched off by means of chemicals.

Fig 1: PCB laboratory ViNT

Procedure:

Step 1: Film making with photo-contact

- Take a plain paper , and cut it to the size of your PCB design artwork
- Cut the Lith film to this paper size
- Put the artwork on the glass of the photo contact. Place the cut lith film on the artwork and then close photo contact lid
- Expose the Film for approx 10 sec in the photo contact.
- Remove the film and put in Tray-1 with developer solution for approx 2 minutes and wash the film
- Remove the film and put in Tray-2 with fixer solution for approx 5 minutes to get clear negative
- Remove the film and put in Tray-3 with plain water and wash the film.
- Cut the copper clad of required size and clean the surface thoroughly.

Fig 2: Photo Etching machine

Step 2: DIP coating

Dip coating is the best method of photoresist coating; Stainless steel tank is used for storing the photoresist coating material

- Dip or immerse the copper clad in the tank and withdraw it slowly.
- After coating the copper clad is made to dry in the oven with the temperature of 30° - 45° for about 10 min

Fig 3: DIP coating machine

Step 3: Expose to Photo UV

- Fix the film exactly on the laminated board and the light is exposed by ultraviolet; it is double-sided drawer exposure unit with a vacuum system shown in Fig 4.
- After the UV exposure the part which is not protected by the layout film becomes etch-resistant.

Fig 4: Photo UV exposure Machine

Step 4: Preparation of Developer

Developer machine has two chambers, one with developer solution and other with dye solution
- The exposed copper clad in first immersed in developer chamber for about 60 -90 sec. This will remove unexposed areas of the photoresist and will show a colorless image.
- Immediately after development is over, wash it in running water and dry it.
- Immerse the copper clad in dye chamber and wash it in running water
- Now immerse the copper clad in etching machine for 9 min and wash the copper clad

Fig 5: Photo Developer Machine

Step 5:   Tinning

Roller Tinning Unit is used for solder coating of PCB"s to provide an effective protection against corrosion and ensuring along storage life and improve soldering properties
- After cleaning and fluxing, the PCB to be solder coated is passed between two rotating rollers, the one at the bottom being a tinned roller which partially dips into a solder bath and the top silicon rubber covered idler roller.
- The hot solder on the tinned roller transfers on to the copper patterns of the PCB
- The solder and roller temperature maintain up to $270^{o}C$

Fig 6: Roller Tinning Machine

Step 6:   Drilling

- The drilling of PCB is done for making holes on the conductor pattern for inserting the component leads to the solder side of the PCB

Fig 7: Drilling Machine

Results: PCB of Electronic Circuits have done successfully

VERIFICATION OF SUPERPOSITION THEOREM

Aim: To verify super position theorem

Components and Equipments Required:

1. DC Dual power supply 0-30V 1No

2. Resistor 1K**Ω**, ¼ watt (3)

3. Multimeters (2),

4. Bread board, connecting wires

Theory:

The superposition theorem for <u>electrical circuits</u> states that for a linear system the response (<u>voltage</u> or <u>current</u>) in any branch of a bilateral linear circuit having more than one independent source equals the algebraic sum of the responses caused by each independent source acting alone, where all the other independent sources are replaced by their internal <u>impedances</u>.

Circuit Diagram:
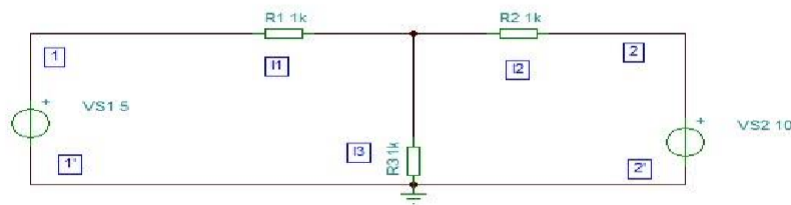
Fig 1: Circuit Diagram

Procedure:

1. Connect 10 V supply and 5 V supply ,note down the ammeter reading I1.

2. Connect only 10 V supply and reduce 5 V supply to zero, note down the ammeterreading I'$_1$.

3. Connect only 5 V supply and reduce 10 V supply to zero, note down the ammeterreading I''$_1$.

4. Verify I1 = I'$_1$ +I''$_1$

5. Compare the practical values with theoretical values.

<u>Verification using Simulation Tool:</u>

$I'_1=$ $I''_1=$ $I1=$

<u>Result:</u>

   The superposition theorem is verified

VERIFICATION OF THEVENIN'S and NORTON'S THEOREM

Aim: To Verify Thevenin's and Norton's Theorem

Components and Equipments Required:

1. D.C. dual power supply 0 – 30 V 1 No

2. Resistors:-1KΩ 1/4watt (4),

3. Multimeter 1 No.

4. Decade Resistance Box, Bread board and connecting wires

Theory:

In electrical circuit theory, Thevenin's theorem for linear electrical networks states that any combination of voltage sources, current sources and resistors with two terminals is electrically equivalent to a single voltage source V and a single series resistor R.

In electrical circuit theory, Norton's theorem for linear electrical networks states that any combination of voltage sources, current sources and resistors with two terminals is electrically equivalent to a single current source I and parallel with a single resistor R.
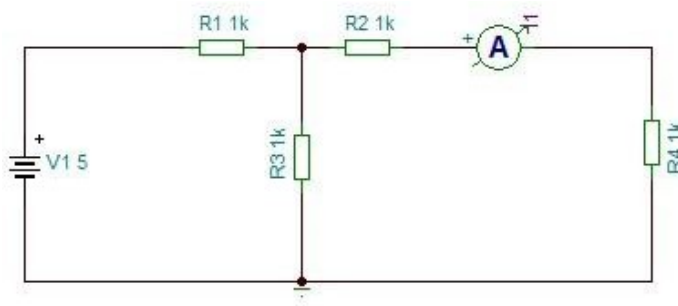
Circuit Diagram:

Fig 1: Circuit Diagram
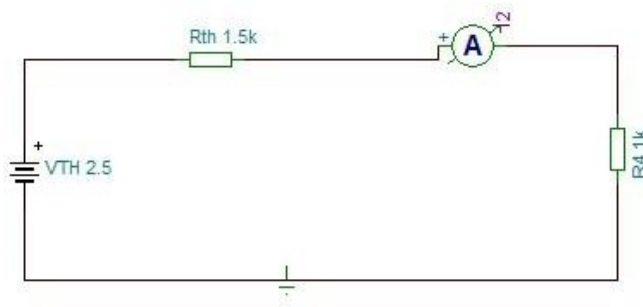
Fig 2: Thevenin"s Equivalent Circuit with load
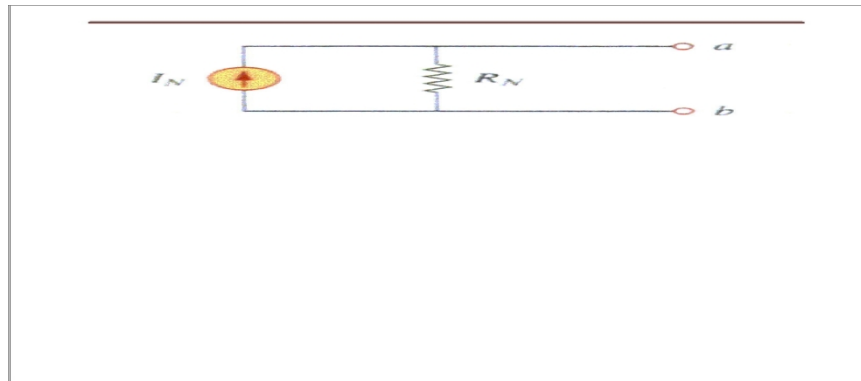
Fig 3: Norton's Equivalent Circuit

Procedure:

1. Connect the circuit as shown in figure 1.

2. Adjust power supply to 5V and measure I_1, using ammeter.

3. Remove AB branch, connect multimeter, and calculate I_{SC} and V_{OC}.

4. Find Rn and $R_{th} = V_{OC}/I_{SC}$.

5. Rig up the circuit as shown in figure 2. Set power supply as V_{th} and adjust DRB

   as R_{th} .

6. Find I_2 using ammeter.

7. Verify I_1 and I_2.

8. Compare practical values with theoretical values.

Observations:

Values	Theoretical	Practical
Rth		
Rn		
Isc		
Voc		
I_1=		
I_2=		

Verification using Simulation Tool:

Rth=

Rn=

Isc =

Voc=

I_1=

I_2=

Results: Thevenin's and Norton's Theorem are proved.

EXPERIMENT NO: 3

VERIFICATION OF MAXIMUM POWER TRANSFER THEOREM

Aim: To Verify Maximum Power Transfer Theorem.

Components and Equipments Required:

1. D.C. dual power supply 0 – 30 V 1 No

2. Resistors:-1KΩ 1/4watt (2),

3. Multimeter 1 No.

4. Decade Resistance Box, Bread board and connecting wires

Theory:

In electrical circuit theory, Maximum Power Transfer theorem for linear electrical networks states that Maximum power can be transferred to the load when load resistance is equal to the thevenin resistance.
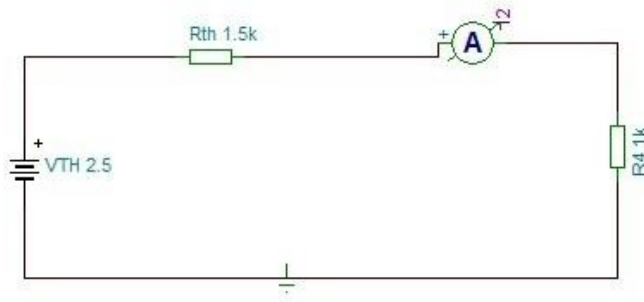
Results: Maximum Power Transfer Theorem is proved.

EXPERIMENT NO: 4

VERIFICATION RECIPROCITY THEOREM

AIM: To verify Reciprocity Theorem.

Components and Equipments Required: 1

Theory: Reciprocity theorem can be stated as in any bilateral linear network if a source of emf E in any branch produces a current I in any other branch then the same emf E acting in the second branch will produce the same current I in the first branch.

Circuit diagram:1KΩ ¼ watt (4), ammeter(1), Power Supply(1)
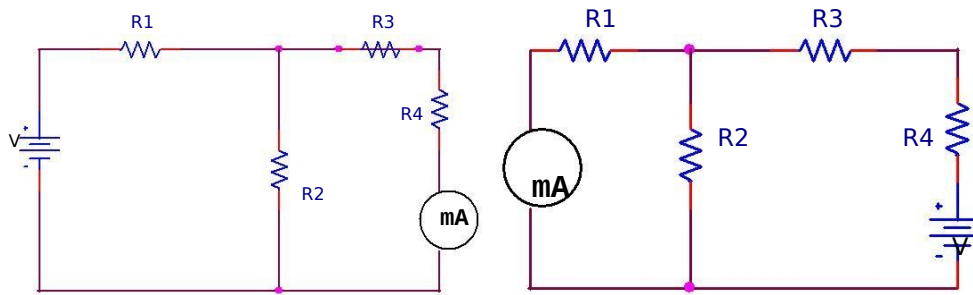
PROCEDURE:

1. Make the connection according to the circuit diagram
2. Measure the value of current by ammeter
3. Interchange the position of the ammeter and the voltage source
4. Now again measure the value of current
5. Verify that $I_1 = I_2$.

OBSERVATION TABLE:

SR.NO	APLIED VOLTAGE (volts)	I$_1$ (mA)	I$_2$ (mA)	ERROR I$_1$-I$_2$

RESULT : Reciprocity theorem has been verified

EXPERIMENT NO: 5

VERIFICATION OF TELLEGEN'S THEOREM

Aim: To verify Tellegen"s theorem

Components and Equipments Required:

1. D.C Dual power supply 0-30 V 1 No.
2. Resistors 1K**Ω** ¼ watt (5),
3. Bread board and connecting wires.
4. Multimeter 1 No.

Theory:

Tellegen's theorem is one of the most powerful theorems in network theory. Most of the energy distribution theorems and principles in network theory can be derived from it. It was published in 1952 by Bernard Tellegen. Fundamentally, Tellegen's theorem gives a simple relation between magnitudes that satisfy the Kirchhoff's laws of electrical circuit theory. Tellegen's theorem is based on the fundamental law of conservation of energy and is a logical outcome of Kirchoff's laws. It is a general and useful theorem. It states that the algebraic sum of power absorbed by all elements in a circuit is zero at any instant. This theorem is about the power balance in a circuit. Power absorbed by a resistor is always positive, whereas a source may deliver power then in this case the power associated with the

source is negative. Tellegens theorem gives $\sum V_k I_k = 0$, for k=0 to 6. Where V is branch

voltage, I is branch current and k is number of branches.
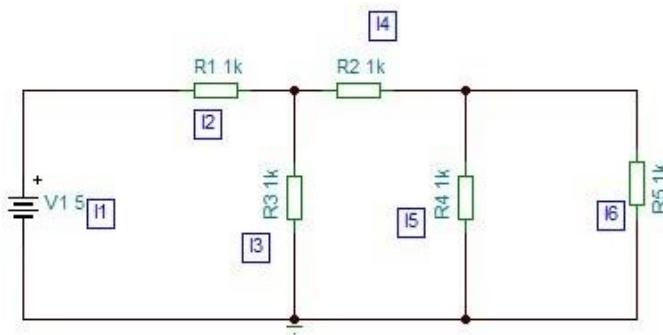
Circuit Diagram:

Fig 1: Circuit Diagram

Procedure:

1. Rig up the circuit as shown in figure. Adjust power supply voltage 5 V at channel 1 respectively.

2. Measure all branch voltages by connecting voltmeter parallel to the components.

3. Measure all branch currents by connecting ammeter in series with component.

4. Find algebraic summation of $\sum V_k I_k$ **= ....**for k=0 to 6.

5. Compare practical values with theoretical values.

Observations:-

Table 1: Branch Currents and voltages

Currents	Voltages
I_1=	V_1=
I_2=	V_2=
I_3=	V_3=
I_4=	V_4=
I_5=	V_5=
I_6=	V_6=

Table 2: Theoretical and practical Power comparison

Values	Theoretical	Practical
P_1		
P_2		
P_3		
P_4		
P_5		
P_6		

Result : $\sum V_k I_k = 0$, Hence Tellegen"s theorem is proved.

TWO PORT NETWORK PARAMETERS

Aim: To find two-port network parameters and verify reciprocity and symmetrical conditions for a given netwok.

Components and Equipments Required:

1. D.C Dual powers supply 0-30 V 1 No.
2. Resistors 2.7K**Ω**, ¼ watt (3), 1K**Ω** ¼ watt (2),
3. Bread board and connecting wires.
4. Multimeter 1 No

Theory:

A pair of terminals at which a signal (voltage or current) may enter or leave is called a port.A network having only one such pair of terminals is called a one port network.

A two-port network (or four-terminal network, or quadripole) is an electrical circuit or device with two pairs of terminals. Examples include transistors, filters and matching networks. The analysis of two-port networks was pioneered in the 1920s by Franz Breisig, a German mathematician.

A two-port network basically consists in isolating either a complete circuit or part of it and finding its characteristic parameters. Once this is done, the isolated part of the circuit becomes a "black box" with a set of distinctive properties, enabling us to abstract away its specific physical buildup, thus simplifying analysis. Any circuit can be transformed into a two-port network provided that it does not contain an independent source.

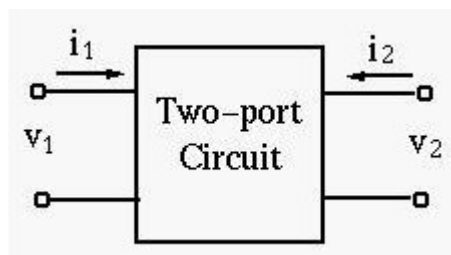A two-port network is represented by four external variables: voltage and

Fig 1: Two port model

In above figure the input port parameters are current i1 and voltage v1, output port parameters are current i2 and voltage v2.

The two-port network can be treated as a black box modeled by the the relationships between the four variables. There exist six different ways to describe the relationships between these variables.

Z-model: In the Z-model or impedance model, the two currents $I1$ and $I2$ are assumed to be known, and the voltages $V1$ and $V2$ can be found by:

$$V_1 = Z_{11}I_1 + Z_{12}I_2$$
$$V_2 = Z_{21}I_1 + Z_{22}I_2$$

$$\begin{bmatrix} V_1 \\ V_2 \end{bmatrix} = \begin{bmatrix} Z_{11} & Z_{12} \\ Z_{21} & Z_{22} \end{bmatrix} \begin{bmatrix} I_1 \\ I_2 \end{bmatrix}$$

where

$$Z_{11} = \left.\frac{V_1}{I_1}\right|_{I_2=0} \qquad Z_{12} = \left.\frac{V_1}{I_2}\right|_{I_1=0} \qquad Z_{21} = \left.\frac{V_2}{I_1}\right|_{I_2=0} \qquad Z_{22} = \left.\frac{V_2}{I_2}\right|_{I_1=0}$$

Here all four parameters $Z11$, $Z12$, $Z21$, and $Z22$ represent impedance. In particular, $Z21$ and $Z12$ are transfer impedances.

Y-model: In the Y-model or admittance model, the two voltages $V1$ and $V2$ are assumed to be known, and the currents $I1$ and $I2$ can be found by:

$$I_1 = Y_{11}V_1 + Y_{12}V_2$$
$$I_2 = Y_{21}V_1 + Y_{22}V_2$$

$$\begin{bmatrix} I_1 \\ I_2 \end{bmatrix} = \begin{bmatrix} Y_{11} & Y_{12} \\ Y_{21} & Y_{22} \end{bmatrix} \begin{bmatrix} V_1 \\ V_2 \end{bmatrix}$$

where

$$Y_{11} = \left.\frac{I_1}{V_1}\right|_{V_2=0} \qquad Y_{12} = \left.\frac{I_1}{V_2}\right|_{V_1=0} \qquad Y_{21} = \left.\frac{I_2}{V_1}\right|_{V_2=0} \qquad Y_{22} = \left.\frac{I_2}{V_2}\right|_{V_1=0}$$

Here all four parameters $Y11, Y12, Y21$, and $Y22$ represent admittance. In particular, $Y21$ and $Y12$ are transfer admittances. **Y** is the corresponding parameter matrix.

ABCD -model: In the A-model or transmission model, we assume $V2$ and $I2$ are known, and find $V1$ and $I1$ by:

$$\begin{bmatrix} V_1 \\ I_1 \end{bmatrix} = \begin{bmatrix} A & B \\ C & D \end{bmatrix} \begin{bmatrix} V_2 \\ -I_2 \end{bmatrix}$$

where

$$A = \left.\frac{V_1}{V_2}\right|_{-I_2=0} \qquad C = \left.\frac{I_1}{V_2}\right|_{-I_2=0} \qquad D = \left.\frac{I_1}{-I_2}\right|_{V_2=0} \qquad B = \left.\frac{V_1}{-I_2}\right|_{V_2=0}$$

Here A and D are dimensionless coefficients, B is impedance and C is admittance. A negative sign is added to the output current $I2$ in the model, so that the direction of the current is out-ward, for easy analysis of a cascade of multiple network models.

H-model: In the H-model or hybrid model, we assume $V2$ and $I1$ are known, and find $V1$ and $I2$ by:

$$V_1 = h_{11} I_1 + h_{12} V_2 \qquad\qquad \begin{bmatrix} V_1 \\ I_2 \end{bmatrix} = \begin{bmatrix} h_{11} & h_{12} \\ h_{21} & h_{22} \end{bmatrix} \begin{bmatrix} I_1 \\ V_2 \end{bmatrix}$$
$$I_2 = h_{21} I_1 + h_{22} V_2$$

where

$$h_{11} = \left.\frac{V_1}{I_1}\right|_{V_2=0} \qquad h_{12} = \left.\frac{V_1}{V_2}\right|_{I_1=0}$$
$$h_{21} = \left.\frac{I_2}{I_1}\right|_{V_2=0} \qquad h_{22} = \left.\frac{I_2}{V_2}\right|_{I_1=0}$$

Here $h12$ and $h21$ are dimensionless coefficients, $h11$ is impedance and $h22$ is admittance.

Circuit Diagram

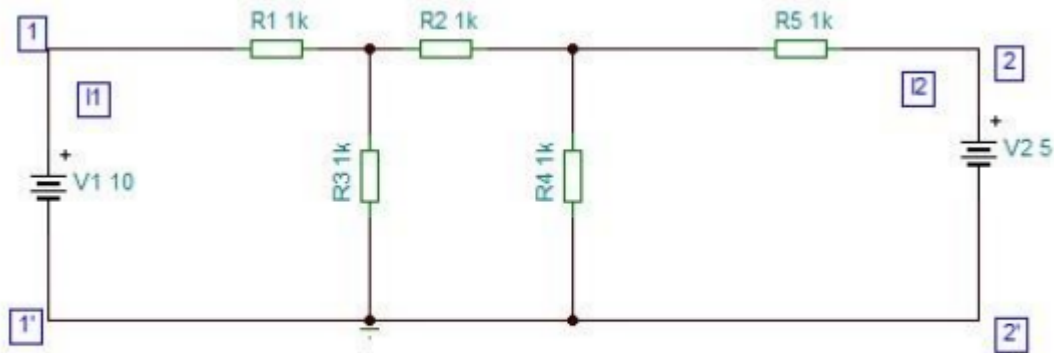
Fig 2: Circuit Diagram

Procedure:

1. Connect the circuit diagram as shown in figure and apply $V^1=10$ V and $V^{11}=10$ V.
2. Open –Circuit the port -2 (i.e. $I_2=0$) and measure the V_1, I_1 and V_2 values from thatcalculate the parameters Z_{11}, Z_{21}, A and C.
3. Open–Circuit the port -1 (i.e. $I_1=0$) and measure the V_1, I_2 and V_2 values from thatcalculate the parameters Z_{12}, Z_{22}, h_{12} and h_{22}.
4. Short–Circuit the port -2 (i.e. $V_2=0$) and measure the V_1, I_1 and I_2 values from thatcalculate the parameters Y_{11}, Y_{21}, h_{11} , h_{21}, B and D.
5. Short–Circuit the port -1 (i.e. $V_1=0$) and measure the I_1, I_2 and V_2 values from thatcalculate the parameters Y_{12}, Y_{22}.
6. Compare practical and theoretical values and verify conditions.

Reciprocity and Symmetrical Conditions:

The following symmetrical and reciprocity conditions to be satisfied by two port networkparameters

Parameter	Condition of Reciprocity	Condition of Symmetry
Z	$Z_{12}=Z_{21}$	$Z_{11}=Z_{22}$
Y	$Y_{12}=Y_{21}$	$Y_{11}=Y_{22}$
T(ABCD)	AD - BC=1	A=D
h	$h_{12}= -h_{21}$	$h_{11}h_{22} - h_{12}h_{21}=1$

Observations:

Values	Practical	Theoretical

Results: Measured two port network parameters and verified Reciprocity and Symmetrical Conditions successfully.

<div align="center">**Experiment no: 8**</div>

<div align="center">**Constant K Low Pass Filter.**</div>

8.1 Aim:-

1) To design a T-section constant K Low Pass Filter with a cut-off frequency of 2 KHz and a characteristic load impedance of 600Ω.

2) To obtain the output characteristics of the above filter.

8.2 Components:

Name	Quantity
Resistor 600 Ω	1
Capacitance box	1
Inductance box	2

Equipment:

Name	Range	Quantity
Bread Board		1
Function Generator	(0-2)MHz	1
Digital Ammeter, Voltmeter	[0-200µA/200mA], [0-20V]	1
CRO	(0-20)MHz	1
CRO probes, Connecting Wires		

8.3 Theory:-

Low pass filter is a circuit which passes low frequency signals and attenuates high frequency signals,

The frequency at which the gain is 70% of the maximum value is called as cut off frequency.

Design:-

We know that the cut off frequency is given by,

$$f_C = \frac{1}{\pi\sqrt{LC}}$$

and the characteristic load impedance is,
$$R_K = \sqrt{\frac{L}{C}}$$

then the design equations for L and C will be

$$L = \frac{\quad}{R_K} = \frac{600}{\pi \times 2000} = 48mH$$

$$\pi f C$$

$$C = \frac{1}{\pi R_K f C} = \frac{1}{\pi \times 600 \times 2000} = 0.26 \ \mu F$$
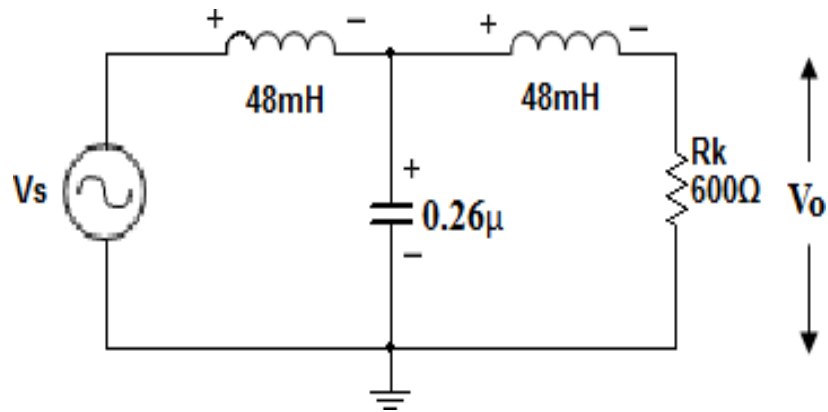
8.4Circuit Diagram:-

Fig (1): Low pass filter

8.5Procedure:-

1) Connect the components as shown in the circuit diagram.

2) Adjust $V_i = 4V$ (peak-to-peak) and keep it constant throughout the experiment.

3) Vary the input frequency from 100 Hz to 20 Khz in steps of 200 Hz and note down the peak-to-peak voltage across R_L i.e., V_O.

Note: Take more readings between 1.8KHz and 2.2KHz.

4) Plot the variation of Gain Versus frequency

5) From the graph find out f_C .

Observations:-
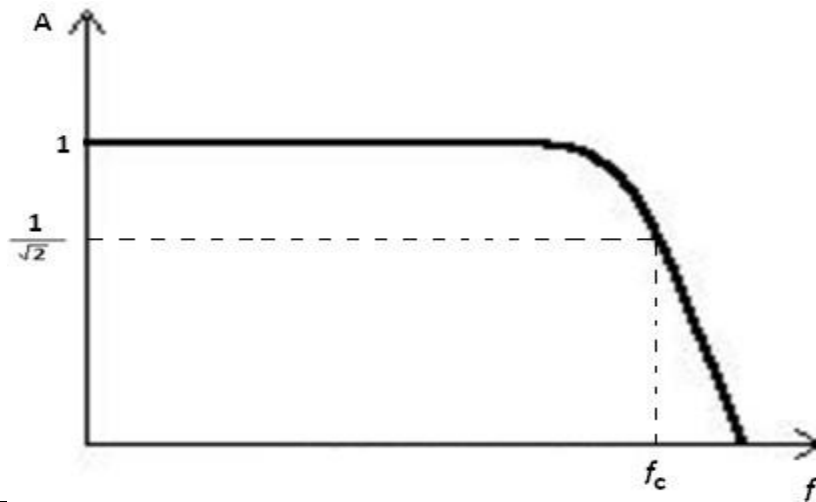
Sl. No.	Frequency (Hz)	V_i (Volt)	V_o (Volt)	$\alpha = \ln\left(\dfrac{V_i}{V_O}\right)$

8.7 Results:-

From the attenuation characteristics curve,

$$f_C = \square Hz$$

M-DERIVED HIGH PASSFILTER

9.1 Aim   1)To design an m-derived high pass T-section filter with a cut-off frequency of 1.2 KHz,
characteristic load impedance of 600 Ω and $f_\infty = 1.1KHz$

2)To obtain output characteristics of the above filter.

9.2Components:

Name	Quantity
Resistor 600 Ω	1
Capacitance box	3
Inductance box	1

Equipment:

Name	Range	Quantity
Bread Board		1
Function Generator	(0-2)MHz	1
Digital Ammeter, Voltmeter	[0-200µA/200mA], [0-20V]	1
CRO	(0-20)MHz	1
CRO probes, Connecting Wires		

9.3 Theory:-

High pass filter is a circuit which passes high frequency signals and attenuates low frequency signals,

The frequency at which the gain is 70% of the maximum value is called as cut off frequency. m-

derived filters have a very sharp cut off frequency

Design:-

a)   Design of prototype High Pass T-section

$$L = \frac{R_O}{4\pi fc} = \frac{600}{4\pi \times 1200} = 39.78mH$$

$$C = \frac{1}{4\pi R_O \, f_C} = \frac{1}{4\pi \times 600 \times 1200} = 0.8 \ \mu F$$

Value of m for m-derived section to give infinite attenuation at 800 Hz is given by,

$$m = \sqrt{1 - \left(\frac{|f_\infty|}{f_C}\right)^2} = \sqrt{1 - \left(\frac{800}{1200}\right)^2} = 0.4$$

b) for the m-derived T-section

Each series arm $= \dfrac{2C}{m} = \dfrac{0.22}{0.4} = 0.55\,\mu F$

Shunt arm $= \dfrac{L}{m} = \dfrac{39.78}{0.4} = 99.45 mH \ m$

And, $\dfrac{4mC}{1 - m^2} = \dfrac{4 \times 0.4 \times 0.8}{1 - (0.4)^2} = 0.21\,\mu F$
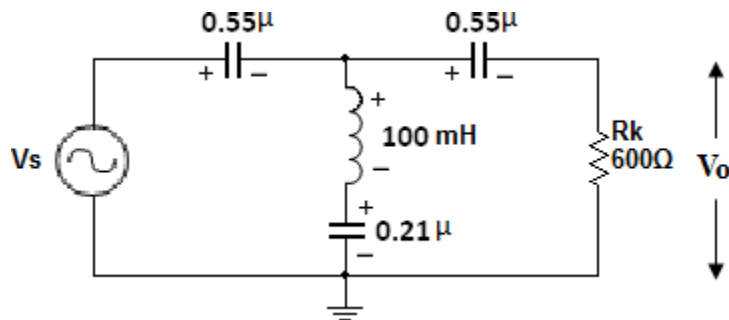
9.4 Circuit Diagram:-

Fig (1): High pass filter

9.5 Procedure:-

1) Connect the components as shown in the circuit diagram.

2) Adjust $V_i = 4V$ (peak-to-peak) and keep it constant throughout the experiment.

3) Vary the input frequency from 100 Hz to 20 Khz in steps of 200 Hz and note down the peak-to-peak voltage across R_L i.e., V_O.

4) Plot the variation of Gain Versus frequency

Sl. No.	Frequency (Hz)	V_i (Volt)	V_o (Volt)	$\alpha = \ln\left(\dfrac{V_i}{V_O}\right)$

9.6 Expected Graphs:-
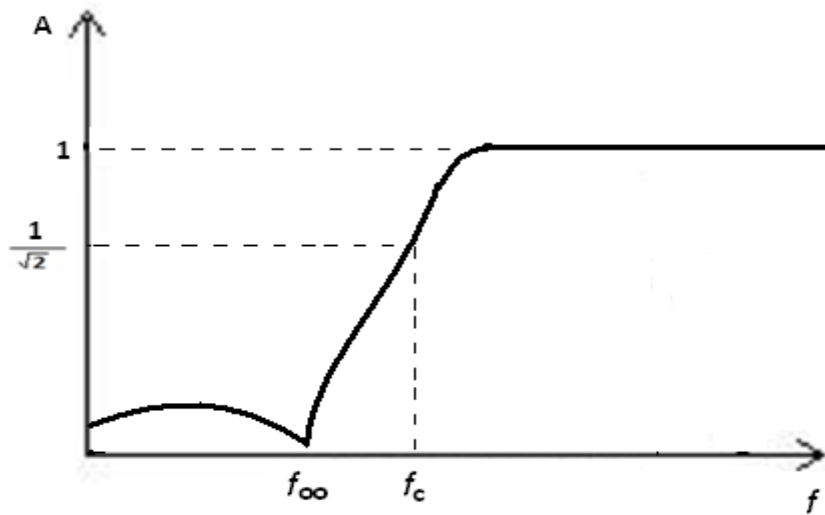
Fig(2): Frequency response of high pass filter

9.7 Results:-

From the attenuation characteristics curve,

f_C =☐Hz

f_∞ =☐Hz