Lab Code:20ECL102
Hardware Lab Manual

Department of Electronics & Communication Engineering

Bapatla Engineering College :: Bapatla

(Autonomous)

G.B.C. Road, Mahatmajipuram, Bapatla-522102, Guntur (Dist.)
Andhra Pradesh, India.

E-Mail:bec.principal@becbapatla.ac.in
Web:www.becbapatla.ac.in

Contents

Bapatla Engineering College :: Bapatla
(Autonomous)

Vision

- To build centers of excellence, impart high quality education and instill high standards of ethics and professionalism through strategic efforts of our dedicated staff, which allows the college to effectively adapt to the ever changing aspects of education.
- To empower the faculty and students with the knowledge, skills and innovative thinking to facilitate discovery in numerous existing and yet to be discovered fields of engineering, technology and interdisciplinary endeavors.

Mission

- Our Mission is to impart the quality education at par with global standards to the students from all over India and in particular those from the local and rural areas.
- We continuously try to maintain high standards so as to make them technologically competent and ethically strong individuals who shall be able to improve the quality of life and economy of our country.

Bapatla Engineering College :: Bapatla

(Autonomous)

Department of Electronics and Communication Engineering

Vision

To produce globally competitive and socially responsible Electronics and Communication Engineering graduates to cater the ever changing needs of the society.

Mission

- To provide quality education in the domain of Electronics and Communication Engineering with advanced pedagogical methods.

- To provide self learning capabilities to enhance employability and entrepreneurial skills and to inculcate human values and ethics to make learners sensitive towards societal issues.

- To excel in the research and development activities related to Electronics and Communication Engineering.

Bapatla Engineering College :: Bapatla

(Autonomous)

Department of Electronics and Communication Engineering

Program Educational Objectives (PEO's)

PEO-I: Equip Graduates with a robust foundation in mathematics, science and Engineering Principles, enabling them to excel in research and higher education in Electronics and Communication Engineering and related fields.

PEO-II: Impart analytic and thinking skills in students to develop initiatives and innovative ideas for Start-ups, Industry and societal requirements.

PEO-III: Instill interpersonal skills, teamwork ability, communication skills, leadership, and a sense of social, ethical, and legal duties in order to promote lifelong learning and Professional growth of the students.

Program Outcomes (PO's)

Engineering Graduates will be able to:

PO1. Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

PO2. 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.

PO3. 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.

PO4. 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.

PO5. 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.

PO6. 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.

PO7.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.

PO8. Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

PO9. Individual and Teamwork: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

PO10. 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.

PO11. 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.

PO12. 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.

Bapatla Engineering College :: Bapatla

(Autonomous)

Department of Electronics and Communication Engineering

Program Specific Outcomes (PSO's)

PSO1: Develop and implement modern Electronic Technologies using analytical methods to meet current as well as future industrial and societal needs.

PSO2: Analyze and develop VLSI, IoT and Embedded Systems for desired specifications to solve real world complex problems.

PSO3: Apply machine learning and deep learning techniques in communication and signal processing.

Hardware Lab
I B.Tech – I Semester (Code: 20ECL102)

Lectures	0	Tutorial	0	Practical	3	Credits	1.5
Continuous Internal Assessment			30	Semester End Examination (3 Hours)			70

Prerequisites: None

Course Objectives: Students will

- Learn the identification and testing of various circuit elements.
- Know how to measure voltage, frequency and phase of any waveform using CRO.
- Learn how to calculate voltage & current using circuit theorems.
- Observe the characteristics of electronic devices.

Course Outcomes: After studying this course, the students will be able to

CO1	Identify and test various electronic circuit components.
CO2	Measure voltage, frequency and phase of different waveforms using CRO.
CO3	Plot the characteristics of P-N Junction and Zener diode and measure the performance characteristics.
CO4	Calculate the currents and voltages of a circuit using Thevenin's & Norton's theorems.

Mapping of Course Outcomes with Program Outcomes & Program Specific Outcomes

	PO's												PSO's		
CO	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1	2			3					3				3	1	
CO2		2		3					3				3	1	
CO3	2			3					3				3	1	
CO4		3		3					3				3	1	
AVG	2	2		3					3				3	1	

LIST OF LAB EXPERIMENTS

1. Identification and testing of various circuit elements.
2. Study of CRO and Function Generator.
3. Study of RPS and Multimeter.
4. Verification of KCL and KVL.
5. Testing of basic gates.
6. Realization of basic gates using discrete components.
7. V-I characteristics of Diode.
8. V-I characteristics of Zener Diode.

9. Verification of Thevenin’s Theorem.
10. Component Testing using CRO.
11. Verification of Norton’s Theorem.
12. Frequency and Phase Measurement using CRO.
13. Lissajious Figures in CRO.
14. Simulation Software Introduction.
15. Small Circuits Design using Simulation Software.

NOTE: A minimum of 10 (Ten) experiments have to be Performed and recorded by the candidate to attain eligibility for Semester End Examination.

1. Identification and Testing of Various Circuit Elements

(a) Resistors:

Aim:

To measure the resistance of a resistor using multimeter and compare it with colour code value.

Apparatus Required:

i. Resistors
ii. Digital Multimeter (DMM) and
iii. Connecting Probes

Theory:

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. In electronic circuits, resistors are used to limit current flow, to adjust signal levels, bias active elements, and terminate transmission lines. High power resistors that can dissipate many watts of electrical power as heat may be used as part of motor controls, in power distribution systems, or as test loads for generators. Fixed resistors have resistances that only change slightly with temperature, time or operating voltage. Variable resistors can be used to adjust circuit elements (such as a volume control or a lamp dimmer), or as sensing devices for heat, light, humidity, force, or chemical activity.

Resistors are common elements of electrical networks and electronic circuits and are ubiquitous in electronic equipment. Practical resistors as discrete components can be composed of various compounds and forms. Resistors are also implemented within integrated circuits. The electrical function of a resistor is specified by its resistance. Common commercial resistors are manufactured over a range of more than nine orders of magnitude. The nominal value of the resistance will fall within a manufacturing tolerance.

Resistor Values are always coded in Ohms (Ω) and they usually have 4 or 5 color bands printed on it. The first two bands represent the value of the resistor with each band giving the base number. The third and fourth band represents the multiplier and tolerance respectively. If the resistor has a 5th band, then it provides more precise value as the first three bands represent the base value, 4th the multiplier and the last one signifying the tolerance.

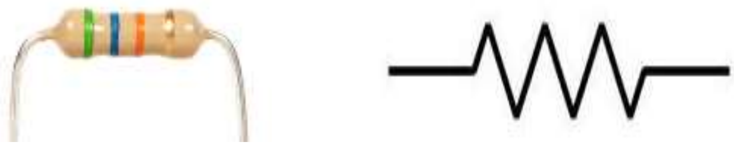
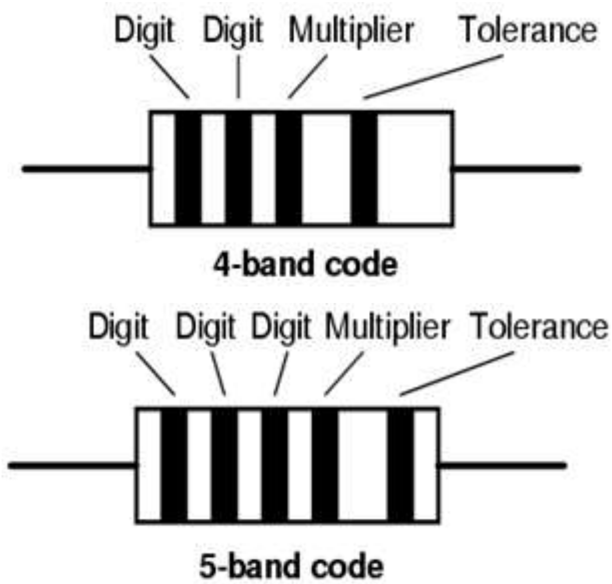


Fig 1: Resistor and its symbol.



Color	Color Name	1st digit 1st stripe	2nd digit 2nd stripe	Multiplier 3rd stripe	Tolerance 4th stripe
	Black	0	0	x1	-
	Brown	1	1	x10	1%
	Red	2	2	x100	2%
	Orange	3	3	x1,000	3%
	Yellow	4	4	x10,000	4%
	Green	5	5	x100,000	-
	Blue	6	6	x1,000,000	-
	Violet	7	7	-	-
	Grey	8	8	-	-
	White	9	9	-	-
	Gold	-	-	x0,1	5%
	Silver	-	-	x0,01	10%

Fig 2: Resistor Colour Coding.

Procedure:

1. Take different types of resistors and calculate the colour coded value.
2. Keep the multimeter in resistance mode.
3. Connect resistor to the multimeter using connecting probes, measure the resistance value and tabulate them.
4. Compare the colour coded value with the measured value.

Observations:

S. No	Colour Code Value	Multimeter Value

Precautions:

1. Readings should be taken carefully.

Result:

Resistance of various resistors is measured using colour coding and verified using multimeter.

(b) Inductors:

Aim:

To test the inductor by using multimeter.

Apparatus Required:

i. Inductors
ii. Digital multimeter and
iii. Connecting probes

Theory:

An inductor also called a coil, choke 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. According to Lenz's law the direction of induced emf is always such that it opposes the change in current that created it. As a result, inductors always oppose a change in current, in the same way that a fly wheel oppose a change in rotational velocity.

An inductor is characterized by its inductance, the ratio of the voltage to the rate of change of current, which has units of Henries (H). Inductors have values that typically range from 1 µH (10−6H) to 1 H. Many inductors have a magnetic core made of iron or ferrite inside the coil, which serves to increase the magnetic field and thus the inductance. Along with capacitors and resistors, inductors are one of the three passive linear circuit elements that make up electric circuits. Inductors are widely used in alternating current (AC) electronic equipment, particularly in radio equipment. They are used to block AC while allowing DC to pass; inductors designed for this purpose are called chokes. They are also used in electronic filters to separate signals of different frequencies and in combination with capacitors to make tuned circuits, used to tune radio and TV receivers.

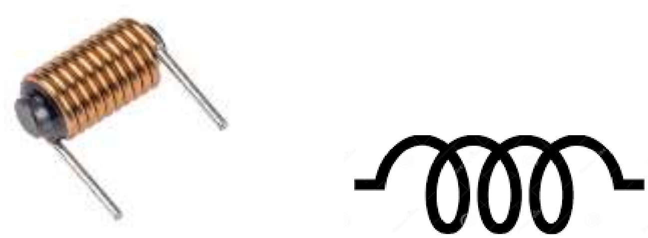


Fig 3: Inductor and its symbol.

Procedure:

1. Take different types of inductors.
2. Keep the multimeter in resistance mode.
3. Connect inductor to the multimeter using connecting probes.
4. Measure the resistance of the coil and check the continuity of the coil.

Observations:

S. No	Resistance of the coil (Ω)	Condition

Result: Various inductor models are observed, and their resistivity is measured using multimeter.

(c) Capacitors:

Aim:

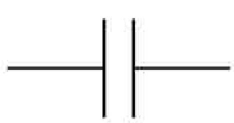
To measure the capacitance of a capacitor using multimeter and compare it with the actual value

Apparatus Required:

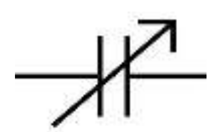
i. Different Capacitors
ii. Multimeter
iii. Connecting Probes

Electrolytic Capacitor

Disc Capacitor



Fixed Capacitor



Variable Capacitor

Fig. 4: Capacitor and its symbol.

Theory:

A capacitor, originally known as a condenser is a passive two terminal electrical component used to store electrical energy temporarily 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. an insulator that can store energy by becoming polarized). The conductors can be thin films, foils or sintered beads of metal or conductive electrolyte, etc. The non-conducting dielectric acts to increase the capacitor's charge capacity. A dielectric can be glass, ceramic, plastic film, air, vacuum, paper, mica, oxide layer etc. Capacitors are widely used as parts of electrical circuits in many common electrical devices. 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.

When there is a potential difference across the conductors i.e. when a capacitor is attached across a battery, an electric field develops across the dielectric, causing positive charge +Q to collect on one plate and negative charge –Q to collect on the other plate. If a battery has been attached to a capacitor for a sufficient amount of time, no current can flow through the capacitor. However, if a time varying voltage is applied across the leads of the capacitor, a displacement current can flow.

An ideal capacitor is characterized by a single constant value, its capacitance. Capacitance is defined as the ratio of the electric charge Q on each conductor to the potential difference V between them. The SI unit of capacitance is the farad (F), which is equal to one coulomb per volt (1 C/V). Typical capacitance values range from about 1 pF (10^{-12} F) to about 1 mF (10^{-3} F). The larger the surface area of the plates (conductors) and the narrower the gap between them, the greater the capacitance is. In practice, the dielectric between the plates passes a small amount of leakage current and also has an electric field strength limit, known as the breakdown voltage. The conductors and leads introduce an undesired inductance and resistance. Capacitors are widely used in electronic circuits for blocking direct current while allowing alternating current to pass. In analog filter networks, they smooth the output of power supplies. In resonant circuits they tune radios to particular frequencies. In electric power transmission systems, they stabilize voltage and power flow.

Observations:

S. No	Actual Value	Measured Value

Procedure:

1. Take different types of capacitors.
2. Note down the actual value of capacitor which is on the capacitor.
3. Keep multimeter in Farad's mode.
4. Place the capacitor in C mode provided in multimeter and measures the value. Also tabulate the value.
5. Compare both actual value and measured value of capacitors.

Result: Identified various types of capacitors and measured their capacitance and compared with multimeter reading.

(d) Diodes:

Aim:

To test the different types of diodes using multimeter.

Apparatus Required:

i. Different types of diodes
ii. Multimeter and
iii. Connecting probes

Theory:

A p-n junction diode conducts only in one direction. When P-type (Anode is connected to positive terminal and n- type (cathode) is connected to negative terminal of the supply voltage is known as forward bias. The potential barrier is reduced when diode is in the forward biased condition. At some forward voltage, the potential barrier altogether eliminated and current starts flowing through the diode and in the circuit. The diode is said to be in ON state. The current increases with increasing forward voltage. When N-type (cathode) is connected to positive terminal and P-type (Anode) is connected to the negative terminal of the supply voltage is known as reverse bias and the potential barrier across the junction increases. Therefore, the junction resistance becomes very high and a very small current (reverse saturation current) flows in the circuit. The diode is said to be in OFF state. The reverse bias current is due to minority charge carriers.

The most common function of a diode is to allow an electric current to pass in one direction called the diode's forward direction, while blocking current in the opposite direction (the reverse direction). Thus, the diode can be viewed as an electronic version of a check valve. This unidirectional behavior is called rectification, and is used to convert alternating current to direct current. A Zener diode is a diode which allows current to flow in the forward direction in the same manner as an ideal diode but also permits it to flow in the reverse direction when the voltage is above a certain value known as the breakdown voltage, zener knee voltage, zener voltage or peak inverse voltage. The device consists of a reverse biased, highly doped, p-n junction diode operating in the breakdown region. Conventional diodes and rectifiers never operate in the breakdown region, but the zener diode makes a virtue of it and can safely be operated at this point.

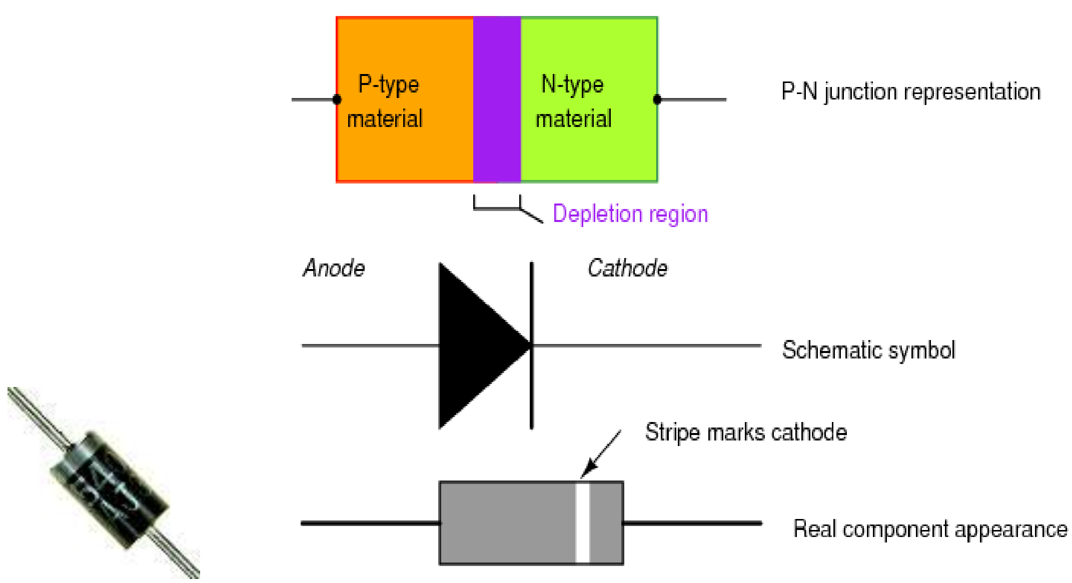


Fig. 5: PN Junction Diode & its symbol

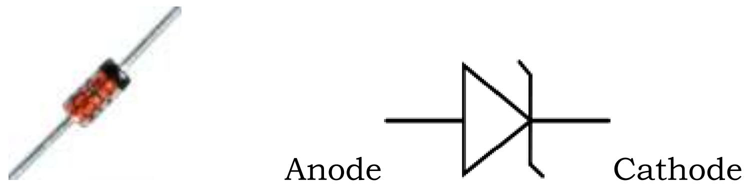


Fig. 6: Zener diode and its symbol.

Procedure:

1. Take different types of diodes and identify the anode and cathode terminals of diode
2. Keep the multimeter in diode mode.
3. Connect the anode of the diode to the positive terminal of the multimeter and cathode to the negative terminal and note down the cut in voltage.
4. Reverse the diode and see whether there is reading on the multi meter or not.
5. Finally check the condition of the given diode

Observations:

S. No	Diode Name	Component No.	Cut-in Voltage	Condition

Result: Various types of diodes are observed and their cut-in voltages are measured using multimeter.

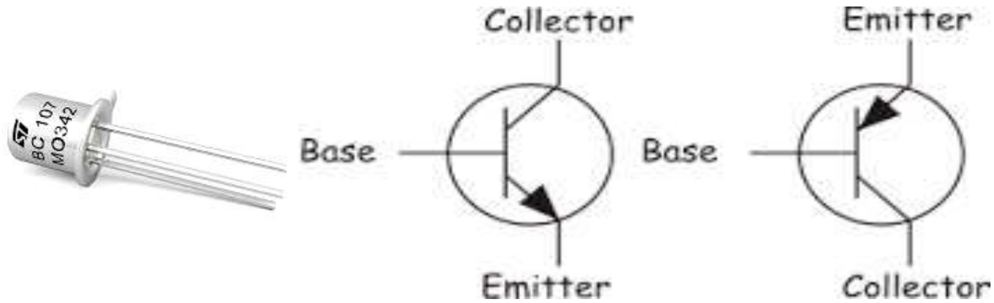
(e) Transistors:

Aim:

To identify the leads and test different types of transistors using multimeter

Apparatus Required:

i. Different types of transistors and
ii. Multimeter
iii. Connecting probes



(a) NPN (b) PNP

Fig. 7: Transistor & its symbols.

Theory:

Bipolar transistors are so named because they conduct by using both majority and minority carriers. The bipolar junction transistor, the first type of transistor to be mass produced, is a combination of two junction diodes, and is formed of either a thin layer of p-type semiconductor sandwiched between two n-type semiconductors (an n–p–n transistor), or a thin layer of n-type semiconductor sandwiched between two p-type semiconductors (a p–n–p transistor). This construction produces two p–n junctions. A base–emitter junction and a base–collector junction, separated by a thin region of semiconductor known as the base region (two junction diodes wired together without sharing an intervening semiconducting region will not make a transistor). BJTs have three terminals, corresponding to the three layers of semiconductor—an emitter, a base, and a collector. They are useful in amplifiers because the currents at the emitter and collector are controlled by relatively small base current. Transistors are active components and are found everywhere in electronic circuits. They are used as amplifiers and switching devices. As amplifiers, they are used in high and low frequency stages, oscillators, modulators, detectors and in any circuit needing to perform a function. In digital circuits they are used as switches.

Procedure:

1. Take different types of transistors and identify the leads of the transistor.
2. For NPN transistor, emitter and collector are of N-type and base is of P-type material, whereas for PNP transistor, emitter and collector are of P-type and base is of N-type material.

3. Keep the multimeter in h_{fe} mode.
4. Place the transistor leads in EBC part of the multimeter and note down the h_{fe} value of transistor.

Observations:

S. No	Type of Transistor	h_{fe} value

Result: Identified various types of transistors and their h_{fe} is measured using multimeter.

(f) Breadboard:

Aim:

Study of bread board.

Apparatus Required

i. Bread board.

Theory:

A bread board is a construction base for prototyping of electronics. The breadboard consists of two terminal strips and two bus strips (often broken in the centre). Each bus strip has two rows of contacts. Each of the two rows of contacts are a node. That is, each contact along a row on a bus strip is connected together (inside the breadboard). Bus strips are used primarily for power supply connections but are also used for any node requiring a large number of connections.

Each terminal strip has 60 rows and 5 columns of contacts on each side of the centre gap. Each row of 5 contacts is a node. Because the solderless breadboard does not require soldering, it is reusable. This makes it easy to use for creating temporary prototypes and experimenting with circuit design. For this reason, solderless breadboards are also extremely popular with students and in technological education. Older breadboard types did not have this property. A strip board and similar prototyping printed circuit boards, which are used to build semi-permanent soldered prototypes, cannot easily be reused. A variety of electronic systems may be prototyped by using breadboards, from small analog and digital circuits to complete central processing units (CPUs).

Terminal strips:

The main areas, to hold most of the electronic components. In the middle of a terminal strip of a breadboard, one typically finds a notch running in parallel to the long side. The notch is to mark the centreline of the terminal strip and provides limited airflow (cooling) to DIP ICs straddling the centreline. The clips on the right and left of the notch are each connected in a radial way; typically, five clips i.e., beneath five holes in a row on each side of the notch are electrically connected.

Bus strips:

To provide power to the electronic components, a bus strip usually contains two columns: one for ground and one for a supply voltage. However, some breadboards only provide a single column power distributions bus strip on each long side. Typically, the column intended for a supply voltage is marked in red, while the column for ground is marked in blue or black. Some manufacturers connect all terminals in a column. Others just connect groups of, for example, 25 consecutive terminals in a column. The latter design provides a circuit designer with some more control over crosstalk (inductively coupled noise) on the power supply bus. Often the groups in a bus strip are indicated by gaps in the color marking. Bus strips typically run down one or both sides of a terminal strip or between terminal strips. On large breadboards additional bus strips can often be found on the top and bottom of terminal strips.

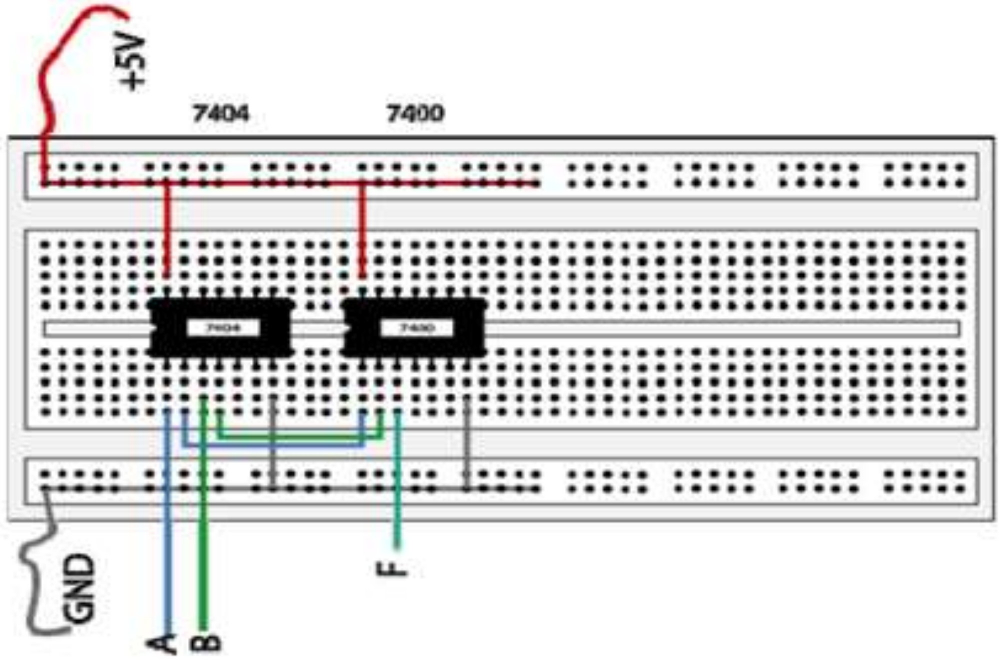


Fig. 8: Bread board representation.

Result: Observed the bread board connections.

2. Study of CRO and Function Generator

(a) Study of Cathode Ray Oscilloscope (CRO):

Aim: To observe front panel control knobs and to determine the amplitude, time period and frequency of waveform.

Apparatus Required:

i. Cathode Ray Oscilloscope (CRO)

Theory:

Cathode ray oscilloscopes an extremely useful and versatile laboratory instrument used for studying wave shapes of alternating currents and voltages as well as for measurement of voltage, current, power and frequency, in fact, almost any quantity that involves amplitude and waveform. It allows the user to see the amplitude of electrical signals as a function of time on the screen.

It is widely used for trouble shooting radio and TV receivers as well as laboratory work involving research and design. It can also be employed for studying the wave shape of a signal with respect to amplitude distortion and deviation from the normal. In true sense the cathode ray oscilloscope has been one of the most important tools in the design and development of modern electronic circuits.

The below figure shows the block diagram of a CRO. Cathode ray tube is a vacuum tube in which a beam of electrons is produced and focused onto a fluorescent screen. The electrons kinetic energy is converted into light energy as they collide with the screen. It is an essential component of television receivers, computer visual display units, and CRO. Between the electron gun and the screen are two pairs of metal plates: (i) Horizontal Deflection Plates and (ii) Vertical deflection plates. These are driven by Horizontal Deflection system and Vertical deflection system respectively.

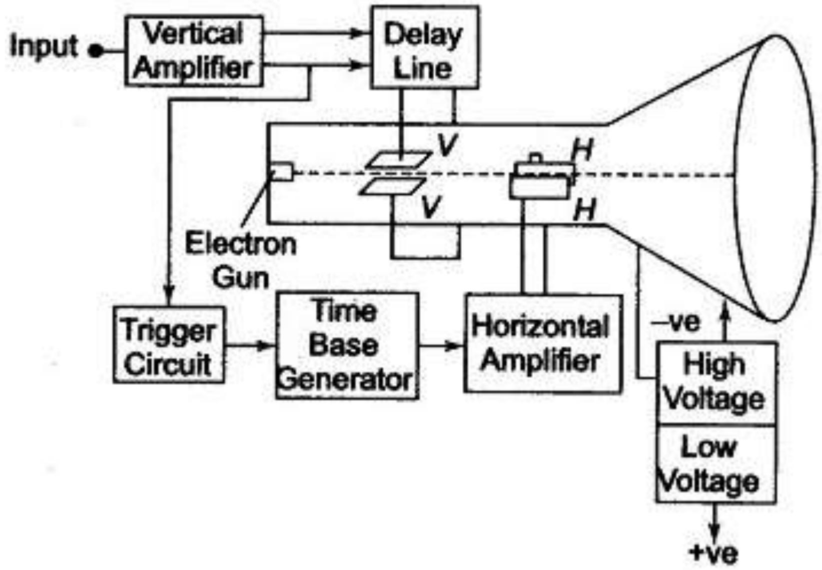


Fig. 9: Block diagram of CRO.

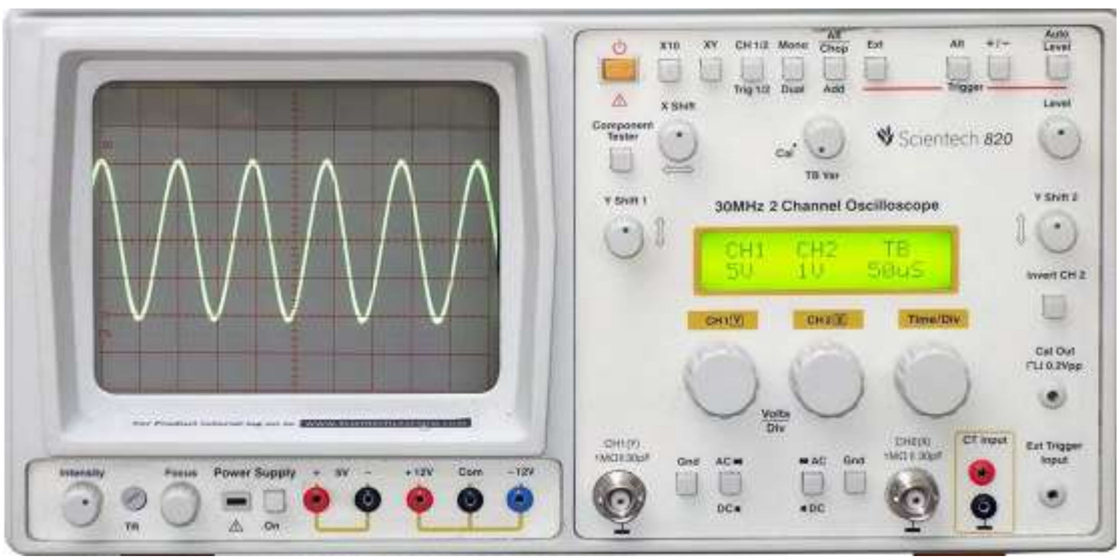


Fig. 10: Front Panel of CRO.

Description of Front Panel Controls of CRO:

1.	POWER ON	Put the instrument to main supply with LED indication.
2.	INTENSITY	Controls the brightness of the display.
3.	FOCUS	Controls the sharpness of the display
4.	TIME BASE	18 step switch to enable selection of 18 calibrated sweep from 0.5 micro sec/div to0.2s/div in 1,2, 5....sequence
5.	TIME BASE VARIABLE	In calibrated position (CAL) the selected sweep speed holds indicated calibration clockwise. It extends the sweep speed by 2.5

		times approx. with the LED indication.
6.	HOLD-OFF	Provides 4:1 Hold off to enhance HF &Complex Signal Triggering.
7.	⇔ POSITION/x5	Controls the horizontal position of the display. When this control is pulled, it magnifies the sweep 5 times with LED indication.
8.	LEVEL	Variable control, selects the trigger point on the displayed waveform.
9.	AUTO/NORM	In auto mode trace is displayed in absence of any input signal. The display is then automatically triggered for signals above 30 Hz depending upon correct setting of trigger LEVEL controls.
10.	INT/EXT	INT: Display triggers from signals derived from CH1, CH2 or line.EXT: triggering from any other external source fed through EXT TRIG BNC socket.
11.	LINE	Triggers from power line frequency.
12.	CH1/CH2	Select trigger signal in INT mode derived from either CH1 or CH2 inputs.
13.	⇳ Positions	Controls the vertical position of the display
14.	INPUT BNC CH1/Y (CH2/X)	Input terminals to CH1/Y, CH2/X inputs
15.	TRACE	Screwdriver control to adjust horizontal tilt of the trace.
16.	CH1/CH2 ATTENUATOR	12 steps compensated attenuator from 5 mv/div to 20 V/div in 1, 2, 5 sequence.
17.	VERTICAL MODES	
	a. ALT/CHOP	Selects switching mode for 2-channel while in DUAL operations
	b. DUAL/MONO (X-Y)	In DUAL, operates as a DUAL trace scope in ALT or CHOP mode as selected.
	c. CHANNEL ADDTION (CH1-CH2)	In DUAL mode, when ADD switch is pressed signals of CH1 and CH2 are algebraically added.
	d. CHANNEL SUBRACTION(CH1-CH2)	In DUAL mode, when ADD and CH2 INV switches are pressed CH2 signal is algebraically subtracted from CH1 signal.
	e. CH2 INV	When CH2 INV switch is pressed polarity of the signal to CH2 is inverted.

Procedure:

1. Understand the significance of each knob on the CRO.
2. From the given function generator feed in a sinusoidal wave and adjust the time base knob and the amplitude knob to observe the waveform as a function of time.
3. Measure the time period and amplitude (peak to peak) of the signal. Find the frequency and verify if the same frequency is given from the function generator.
4. Observe the waveforms displayed on CRO.
5. Repeat the above steps for pulse and triangular waveforms.
6. Report the readings and the waveforms taken.

Measurements:

Amplitude = no. of vertical divisions x Volts/div.

Time period = no. of horizontal divisions x Time/div.

Frequency= (1/T) Hz

Model Graph:

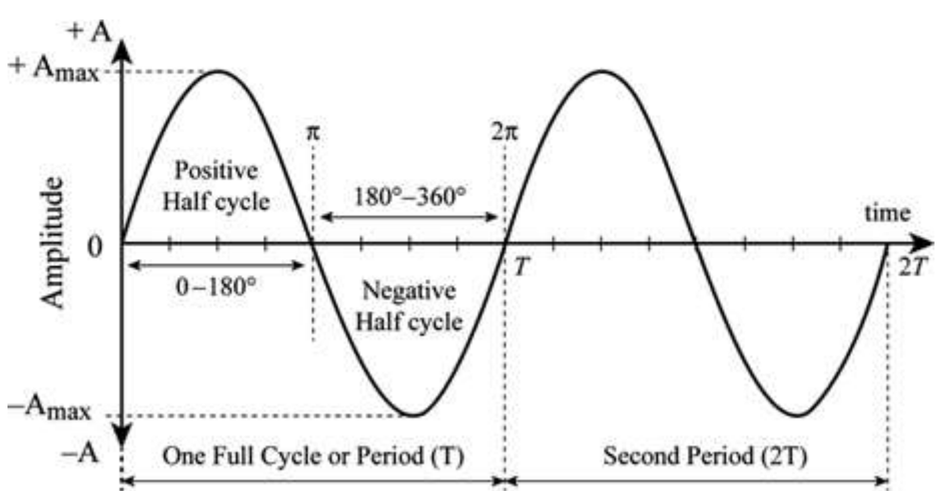


Fig. 11: Model graph to observed in CRO.

Result: Studied the front panel controls of cathode ray oscilloscope.

(b) Study of Function Generator

Aim: To study the operation of function generator.

Apparatus Required:

i. Function Generator

Theory:

Function Generators are instruments capable of generating an ac signal of any frequency approximately 100Hz to hundreds of KHz, voltage approximately 1 mV – 20V and various forms like sine wave, square pulse, saw tooth wave, triangular wave or noise waveform. They also provide a continuously variable dc offset, variable duty cycle.

Fig. 12: Front Panel of Function Generator.

Some of the front panel controls of a typical function generator are:

1. Power Switch: For switching on the power supply.
2. Digital Display: This is a 4-digit frequency meter.
3. DC OFFSET: This knob is for adding a dc voltage to the output signal.
4. Amplitude Variable: This does the continuous adjustment of output voltage.
5. Frequency Range: This knob is for selecting the frequency range from 0.3 Hz to 3MHz in decade steps.
6. Function selection switch: It is used to select the required sine or square or triangular wave signal.
7. BNC Output connector: This is a 50 Ω output BNC connector

8. Attenuation: A push button control for -20 to -40dB dB attenuation.

Procedure:

1. Study the front panel of function generator thoroughly and study each control of switch and its usage and how to connect to the external circuits to be tested.
2. Observe different waveforms in CRO which are giving from function generator.
3. Note down the value of amplitude, time period and frequency.
4. Tabulate the readings.

Observations:

S.No	**Type of Function**	**Amplitude (V)**	**Time Period, T (Sec)**	**Frequency, f (Hz)**	**Model Wave**

Result: The function and operation of function generator is observed.

3. Study of RPS and Multimeter

(a) Regulated Power Supply (RPS):

Aim: To study the regulated power supply.

Apparatus Required:

i. Regulated Power Supply

ii. Digital Multimeter

iii. Resistor

Theory:

Regulated power supplies are useful to get the DC voltage depending upon its range (0-30V) as most of electronic circuit's required DC voltages. These regulated power supplies are used to supply the required voltage. This DC voltage is obtained by AC mains converting the alternating current into direct current using the rectifier, filter and regulator, which produce a constant DC voltage.

Front Panel Controls:

ON/OFF switch	the switch is used to supply the external AC power to regulated power supply
Course and Fine control	the required voltage can be obtained by the use of coarse and fine control
Overload indicator	This bulb glows when there is any short circuit occurred between the output terminals
Output terminals	Through which we can get the output voltage from the RPS
Voltmeter	MC type portable voltmeter is placed in front panel of RPS for observing voltage values while giving to the output terminals

Ammeter	It is also potable type MC type meters which indicate how much current the circuit drawing

Fig. 13: Front Panel of RPS and sample circuit.

Observations:

S.No	Voltmeter reading(v)	Ammeter reading(A)	Resistance (ohms)

Procedure:

1.Connections are made as per the circuit shown in fig.

2.Apply different voltages from RPS unit and note down the voltmeter reading and ammeter readings.

3.Tabulate the readings.

Result: The function and operation of regulated power supply is observed.

(b) Multimeter:

Aim: To study the function and operation of multimeter.

Apparatus Required:

i. Multimeter

Theory:

A multimeter or a multitester, also known as a VOM (Volt-Ohm meter or Volt-Ohm-milliammeter), is an electronic measuring instrument that combines several measurement functions in one unit. A typical multimeter would include basic features such as the ability to measure voltage, current, and resistance. Analog multimeters use a microammeter whose pointer moves over a scale calibrated for all the different measurements that can be made. Digital multimeters (DMM, DVOM) display the measured value in numerals and may also display a bar of a length proportional to the quantity being measured. Digital multimeters are now far more common but analog multimeters are still preferable in some cases, for example when monitoring a rapidly varying value.

A multimeter can be a hand-held device useful for basic fault finding and field service work, or a bench instrument which can measure to a very high degree of accuracy. They can be used to troubleshoot electrical problems in a wide array of industrial and household devices such as electronic equipment, motor controls, domestic, power supplies, and wiring systems.

A multimeter is a combination of a multirange DC voltmeter, multirange AC voltmeter, multirange ammeter, and multi range ohmmeter. An un-amplified analog multimeter combines a meter movement, range resistors and switches. For an analog meter movement, DC voltage is measured with a series resistor connected between the meter movement and the circuit under test. A set of switches allows greater resistance to be inserted for higher voltage ranges. The product of the basic full-scale deflection current of the movement, and the sum of the series resistance and the movement's own resistance, gives the full-scale voltage of the range.

As an example, a meter movement that required 1 milliampere for full scale deflection, with an internal resistance of 500 ohms, would, on a 10volt range of the multimeter, have 9,500 ohms of series resistance. For analog current ranges, low-resistance shunts are connected in parallel with the meter movement to divert most of the current around the coil.

Front Panel:

Voltage, current, and resistance have units of volts, amps, and ohms, which are represented by V, A, and Ω respectively. Most multimeters use these abbreviations instead of spelling out words. Most multimeters also use metric prefixes. Metric prefixes work the same way with units of electricity as they do with other units you might be more familiar with, like distance and mass. Here are the common metric prefixes you will find on most multimeters.

Fig. 14: Front Panel of multimeter.

i. **µ** (micro): one millionth
ii. **m** (milli): one thousandth
iii. **k** (kilo): one thousand

iv. **M**: (mega): one million

These metric prefixes are used in the same way for volts, amps, and ohms. For example, 200kΩ is pronounced "two hundred kilo-ohms," and means two hundred thousand (200,000) ohms. Some multimeters are "auto-ranging," whereas others require you to manually select the range for your measurement. If you need to manually select the range, you should always pick a value that is slightly higher than the value you expect to measure. Think about it like using a ruler and a yardstick. If you need to measure something that is 18 inches long, a 12-inch ruler will be too short; you need to use the yardstick. The same applies to using a multimeter. Say you are going to measure the voltage of an AA battery, which you expect to be 1.5V.

The multimeter has options for 200mV, 2V, 20V, 200V, and 600V (for direct current). 200mV is too small, so you would pick the next highest value that works: 2V. All the other options are unnecessarily large and would result in a loss in accuracy. Multimeters will use the abbreviations AC and DC, which stand for alternating current and direct current, respectively. Note that some multimeters might have AC and DC after the V and A, instead of before.

Procedure:

1. Select the mode corresponding to the component which is to be tested.
2. Note down the values displayed on the multimeter

Result: The function and operation of multimeter is observed.

4. Verification of KCL and KVL

(a) KCL Verification for Simple Circuits

Aim: To Verify KCL theorem from the given circuit on bread board.

Apparatus Required:

S. NO.	Name of the Apparatus	Range	Quantity
1	Bread Board	-	1
2	Resistor	1KΩ	3
3	Ammeter	0-25mA	3
4	Voltmeter	0-30V	2
5	RPS	0-30V	1

Theory:

Kirchhoff's Current Law (KCL) states that the sum of the currents entering any node or point, or junction is equal to the sum of the currents leaving that node or point or junction.

$$I_1 = I_2 + I_3$$

Where I_1 is the current flowing through resistor R_1. Similarly, I_2 is the current flowing through resistor R_2 and I_3 is the current flowing through resistor R_3.

Procedure:

1. Give the connections as per the circuit shown in figure and consider R1=R2=R3=1KΩ.
2. Keep the supply voltage Vi as 5V and note down the currents I_1, I_2 & I_3 from the ammeter.
3. And verify the practical values with the theoretical values.
4. Then vary the supply voltage Vi from 5V to 10 V and note down the currents I_1, I_2 & I_3 from the ammeter.
5. And verify the practical values with the theoretical values.

Circuit Diagram:

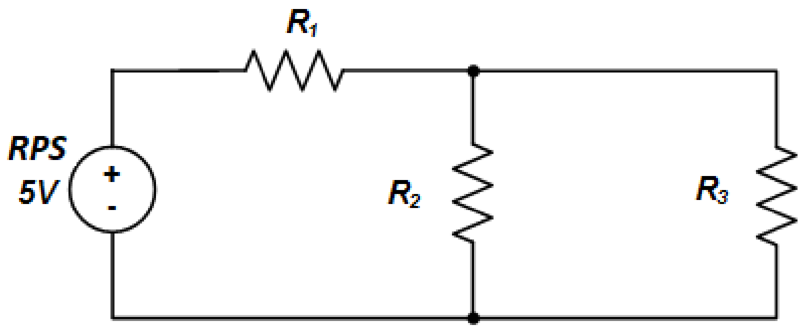


Fig. 15: KCL verification for simple circuit.

Observations:

V_i (v)	I_2(mA)		I_3(mA)		$I_1 = I_2 + I_3$ (mA)	
	Theoretical	Practical	Theoretical	Practical	Theoretical	Practical
5v						
10v						

Note: All theoretical values can be found by using either mesh analysis or nodal analysis and using voltage division rule and current division rule where it is applicable.

Result: The KCL is verified for the given circuit using bread board.

(b) KVL Verification for Simple Circuits

Aim: To Verify KVL from the given circuit using bread board

Apparatus Required:

S.NO.	Name of the Apparatus	Range	Quantity
1	Bread Board	-	1
2	Resistor	1KΩ	3
3	Ammeter	0-25mA	3
4	Voltmeter	0-30V	2
5	RPS	0-30V	1

Theory:

Kirchhoff's Voltage Law (KVL) states that the algebraic sum of all branch voltages around any closed path in a circuit is always zero at all instants of time. The algebraic sum of voltages around first loop which containing the elements V_s, R_1 and R_2 is given by:

$$V_s - V_1 - V_2 = 0 \text{ (or) } V_s = V_1 + V_2$$

Similarly, the algebraic sum of the voltages around second loop which containing the elements V_2, and V_3 is given by:

$$V_2 - V_3 = 0 \text{ or } V_2 = V_3$$

Where V_1 is the voltage across the resistor R_1. Similarly, V_2 is the voltage across the resistor R_2 and V_3 is the voltage across the resistor R_3.

Procedure:

1. Give the connections as per the circuit shown in figure and consider $R_1=R_2=R_3=1K\Omega$.
2. Keep the supply voltage Vi as 5V and note down the voltages V_1, V_2 & V_3 from the voltmeter.
3. And verify the practical values with the theoretical values.
4. Then vary the supply voltage Vi from 5V to 10 V and note down the voltages V_1, V_2 & V_3 from the voltmeter.
5. And verify the practical values with the theoretical values.

Circuit Diagram:

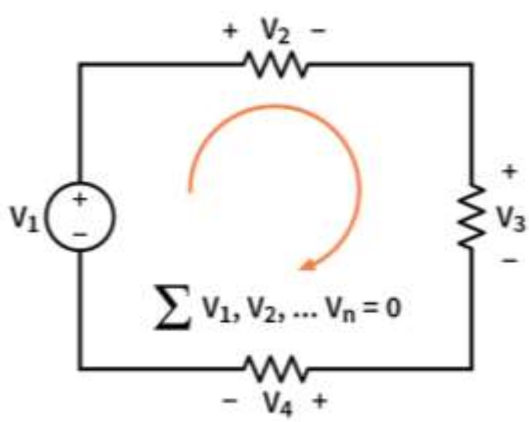


Fig. 16: KVL verification for simple circuit.

Observations:

$V_1(v)$	$V_2(v)$		$V_3(v)$		$V_4(v)$		$V_1 = V_2+V_3+V_4$ (v)	
	TV	PV	TV	PV	TV	PV	TV	PV

Note: TV denotes Theoretical Value and PV denotes Practical Value. All theoretical values can be found by using either mesh analysis or nodal analysis and using voltage division rule and current division rule where it is applicable.

Result: The KVL is verified for the given circuit using bread board.

5. Testing of Logic Gates

Aim: To test the given basic logic gates like AND, OR and NOT integrated circuits.

Apparatus Required:

S. No.	Apparatus	Quantity
1	IC-7408	1
2	IC-7432	1
3	IC-7404	1
4	Electronic Circuit Designer	1
5	Connecting Wires	

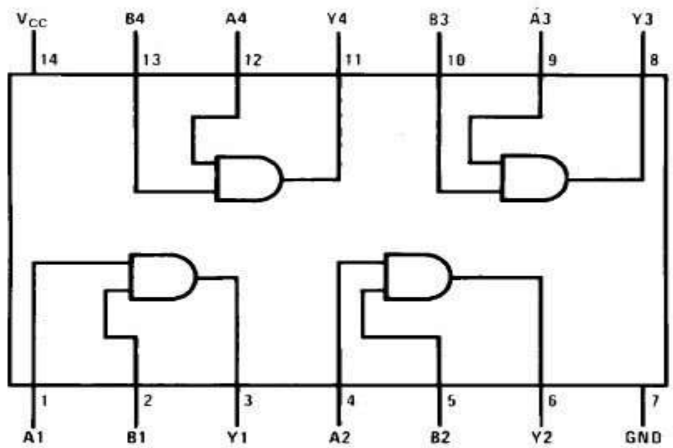
Theory:

An integrated circuit or monolithic integrated circuit also referred to as an IC, a chip, or a microchip is a set of electronic circuits on one small plate "chip" of semiconductor material, normally silicon. This can be made much smaller than a discrete circuit made from independent electronic components. ICs can be made very compact, having up to several billion transistors and other electronic components in an area the size of a fingernail. The width of each conducting line in a circuit can be made smaller and smaller as the technology advances. ICs were made possible by experimental discoveries showing that semiconductor devices could perform the functions of vacuum tubes and by mid-20th-century technology advancements in semiconductor device fabrication. The integration of large numbers of tiny transistors into a small chip was an enormous improvement over the manual assembly of circuits using discrete electronic components. The integrated circuits mass production capability, reliability and building-block approach to circuit design ensured the rapid adoption of standardized integrated circuits in place of designs using discrete transistors.

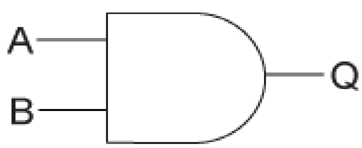
ICs have two main advantages over discrete circuits: cost and performance. Cost is low because the chips, with all their components, are printed as a unit by photolithography rather than being constructed one transistor at a time. Furthermore, packaged ICs use much less material than discrete circuits. Performance is high because the IC's components switch quickly and consume little power (compared to their discrete counterparts) as a result of the small size and proximity of the components.

(a) IC-7408 (AND Gate):

Pin Configuration



Symbol

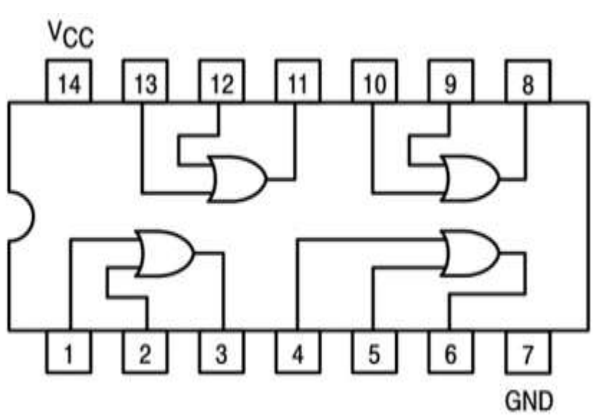


Truth Table

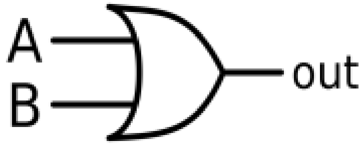
Inputs		Output
A	**B**	**Q**
0	0	0
0	1	0
1	0	0
1	1	1

(b) IC-7432 (OR Gate):

Pin Configuration



Symbol

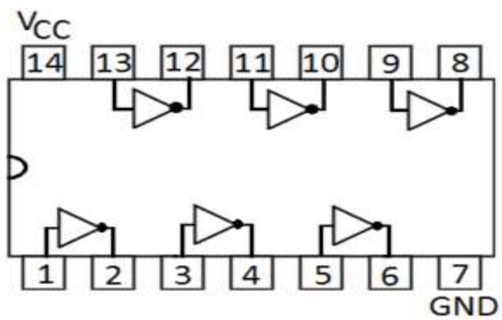


Truth Table

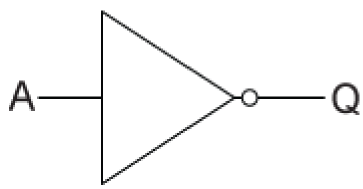
Inputs		Output
A	**B**	**Q**
0	0	0
0	1	1
1	0	1
1	1	1

(c) IC-7404 (NOT Gate):

Pin Configuration



Symbol



Truth Table

Input	Output
A	**Q**
0	1
1	0

Procedure:

1. Identify the pin numbers of the IC and make the connections as per the IC pin configuration.
2. Connect Pin (14) to +Vcc (5V) and Pin (7) to ground.
3. Apply inputs 0 or 1 from switches in different combinations.
4. Observe the output with the help of LED indicators.

Precautions:

1. All the connections should be made properly

Result: Tested basic gates and their truth tables are verified.

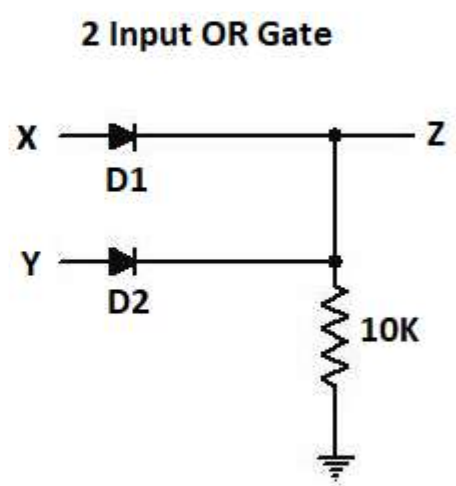
6. Realization of Logic Gates using Discrete Components

Aim: To construct the logic gates such as OR, AND, NOT, NOR and NAND gates using discrete components and verify their truth tables.

Apparatus Required:

S. No.	Apparatus	Range	Quantity
1.	Electronic circuit designer	--	1
2.	Resistors	1K (R_0),10K (R_1)	2
3.	Transistors	SL100/2N2222	1
4.	Diodes	IN4002	3
5.	Connecting wires		

Circuit Diagrams:



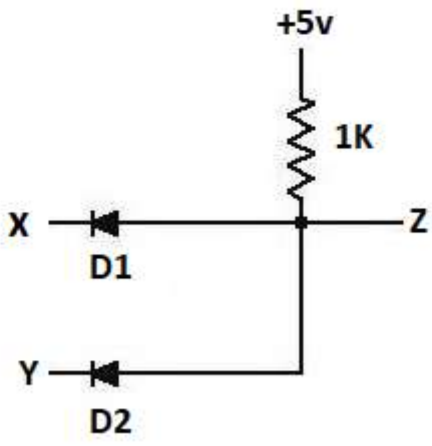
Truth Table

1 represents 5v

0 represents 0v/-5v

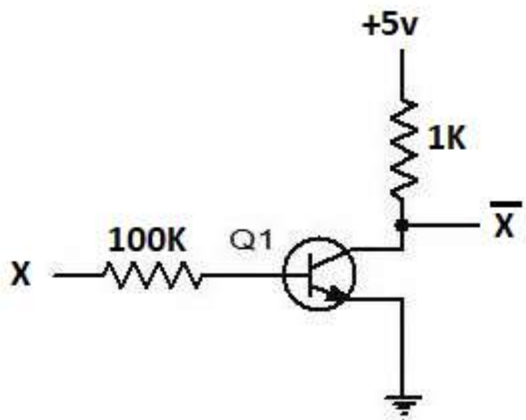
Inputs		Output
X	Y	Z
0	0	0
0	1	1
1	0	1
1	1	1

2 Input AND Gate



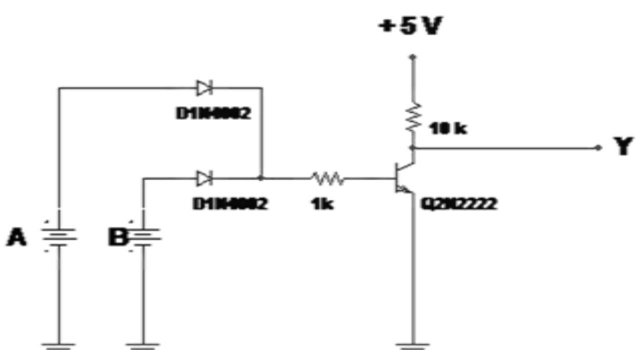
Inputs		Output
X	Y	Z
0	0	0
0	1	0
1	0	0
1	1	1

NOT Gate

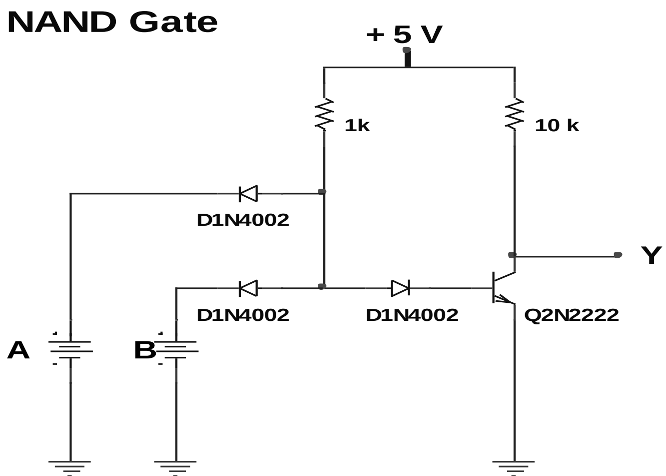


Input	Output
X	$\overline{X}$
0	1
1	0

NOR Gate



Inputs		Output
A	B	Y
0	0	1
0	1	0
1	0	0
1	1	0



Inputs		Output
A	**B**	**Y**
0	0	1
0	1	1
1	0	1
1	1	0

Fig. 17: Circuit diagrams of logic gates using discrete components.

Procedure:

1. Connect the circuit as per the circuit diagram.
2. Switch on the power supply.
3. Apply different combinations of inputs and observe the outputs.
4. Compare the outputs with the truth tables.

Precautions:

1. All the connections should be made properly.

Result: Different logic gates are constructed and their outputs are verified with truth tables.

7. V-I Characteristics of P-N Junction Diode

Aim: To verify the V-I characteristics of P-N junction diodes in forward and reverse bias configurations.

Apparatus Required:

S. No.	Apparatus	Range	Quantity
1.	P-N Diodes	BY126	1
2.	Regulated Power supply	0-30V	1
3.	Resistor	1KΩ	1
4.	Ammeters	200 mA, 0-200μA	1
5.	Voltmeter	0-20 V	1
6.	Bread board & Connecting wires		

Theory:

A p-n junction diode conducts only in one direction. The V-I characteristics of the diode are curve between voltage across the diode and current through the diode. When external voltage is zero, circuit is open and the potential barrier does not allow the current to flow. Therefore, the circuit current is zero.

When P-type (Anode is connected to +ve terminal and n- type (cathode) is connected to –ve terminal of the supply voltage, is known as forward bias. The potential barrier is reduced when diode is in the forward biased condition. At some forward voltage, the potential barrier altogether eliminated and current starts flowing through the diode and also in the circuit. The diode is said to be in ON state. The current increases with increasing forward voltage.

When N-type (cathode) is connected to +ve terminal and P-type (Anode) is connected to the–ve terminal of the supply voltage is known as reverse bias and the potential barrier across the junction increases. Therefore, the junction resistance becomes very high and a very small current (reverse saturation current) flows in the circuit. The diode is said to be in OFF state. The reverse bias current is due to minority charge carriers.

Circuit Diagram:

(a) Forward Bias:

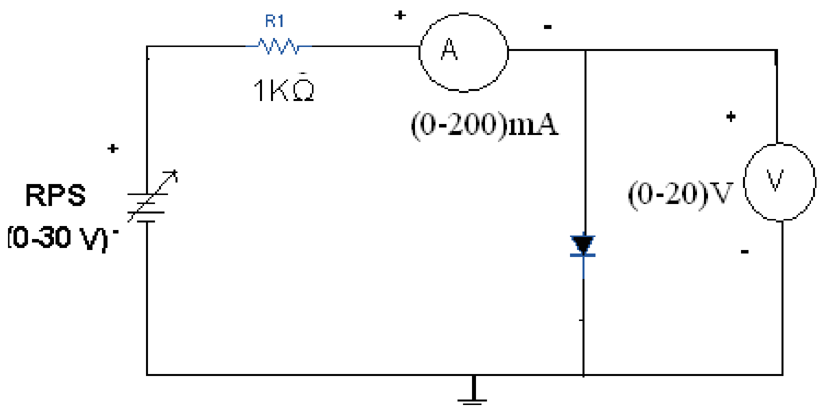


Fig. 18: PN junction diode under forward bias

(b) Reverse Bias:

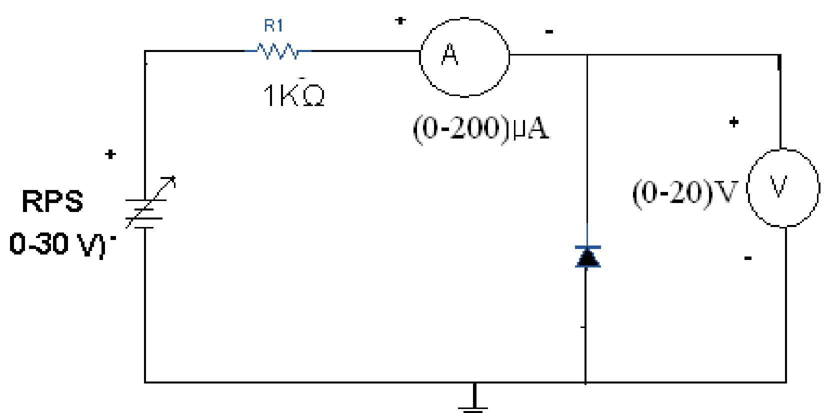


Fig. 19: PN junction diode under reserve bias

Observation:

(a) Forward Bias:

S. No	Applied Voltage (V)	Diode Voltage V_f (V)	Diode Current I_f (ma)

(b) Reverse Bias:

S. No	Applied Voltage (V)	Diode Voltage V_r (V)	Diode Current I_r (μA)

Model Waveform:

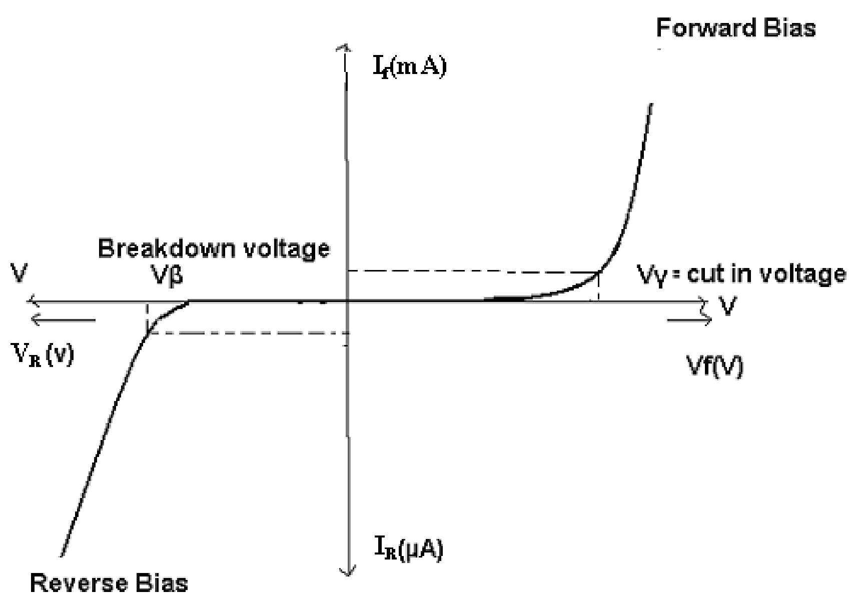


Fig. 20: Characteristics of PN junction diode

Procedure:

(a) Forward Bias:

1. Connections are made as per the circuit diagram.
2. For forward bias, the RPS +ve is connected to the anode of the silicon diode and RPS –ve is connected to the cathode of the diode.

3. Switch on the power supply and increases the input voltage (supply voltage) in steps.
4. Note down the corresponding current flowing through the diode and voltage across the diode for each and every step of the input voltage.
5. The readings of voltage and current are tabulated and a graph is plotted between voltage and current.

(b) Reverse Bias:

1. Connections are made as per the circuit diagram.
2. For reverse bias, the RPS +ve is connected to the cathode of the silicon diode and RPS –ve is connected to the anode of the diode.
3. Switch on the power supply and increase the input voltage (supply voltage) in steps.
4. Note down the corresponding current flowing through the diode voltage across the diode for each and every step of the input voltage.
5. The readings of voltage and current are tabulated and graph is plotted between voltage and current.

Precautions:

1. All the connections should be correct.
2. Parallax error should be avoided while taking the readings from the analog meters.

Result: V-I characteristics of PN junction diode in Forward and Reverse bias configurations are verified.

8. V-I Characteristics of Zener Diode

Aim: To verify the V-I characteristics of a Zener diode in forward bias and reverse bias.

Apparatus Required:

S. No.	Apparatus	Range	Quantity
1.	Zener diode	IZ5.1 or IZ9.1	1
2.	Regulated Power supply	0-30V	1
3.	Resistor	1KΩ	1
4.	Ammeters	0-100mA	1
5.	Voltmeter	0-20 V	1
6.	Bread board & Connecting wires		

Theory:

A zener diode is heavily doped p-n junction diode, specially made to operate in the break down region. A p-n junction diode normally does not conduct when reverse biased. But if the reverse bias is increased, at a particular voltage it starts conducting heavily. This voltage is called Break down Voltage. High current through the diode can permanently damage the device. To avoid high current, we connect a resistor in series with zener diode. Once the diode starts conducting it maintains almost constant voltage across the terminals whatever may be the current through it, i.e., it has very low dynamic resistance. It is used in voltage regulators.

Circuit Diagram:

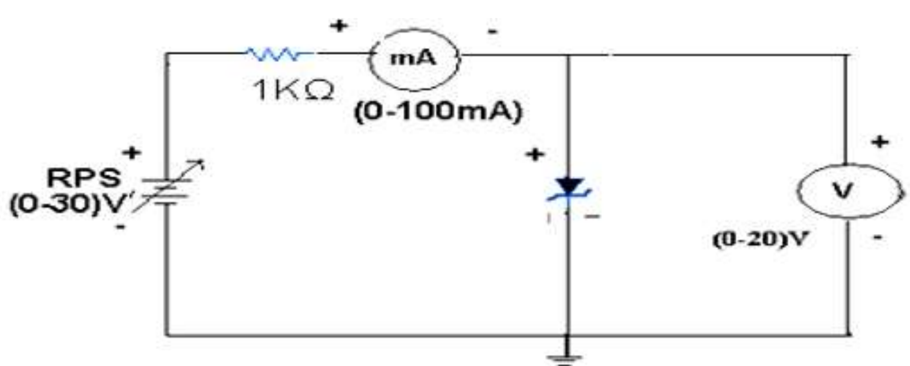


Fig. 21: Zener diode under forward bias

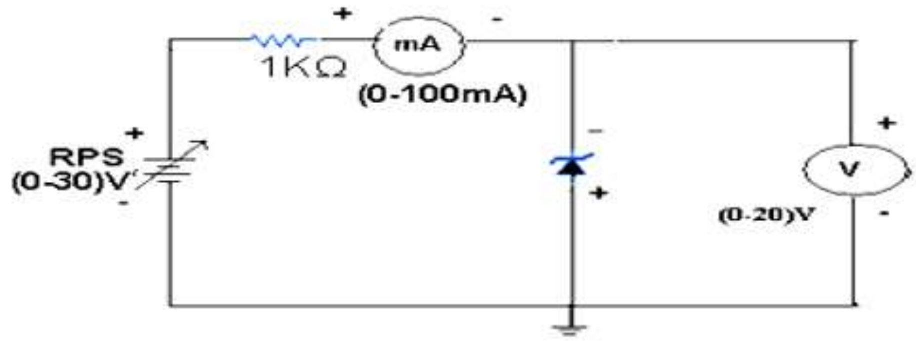


Fig. 22: Zener diode under reverse bias

Observations:

S. NO	Zener Voltage (V_Z)	Zener Current (I_Z)

Model Waveform:

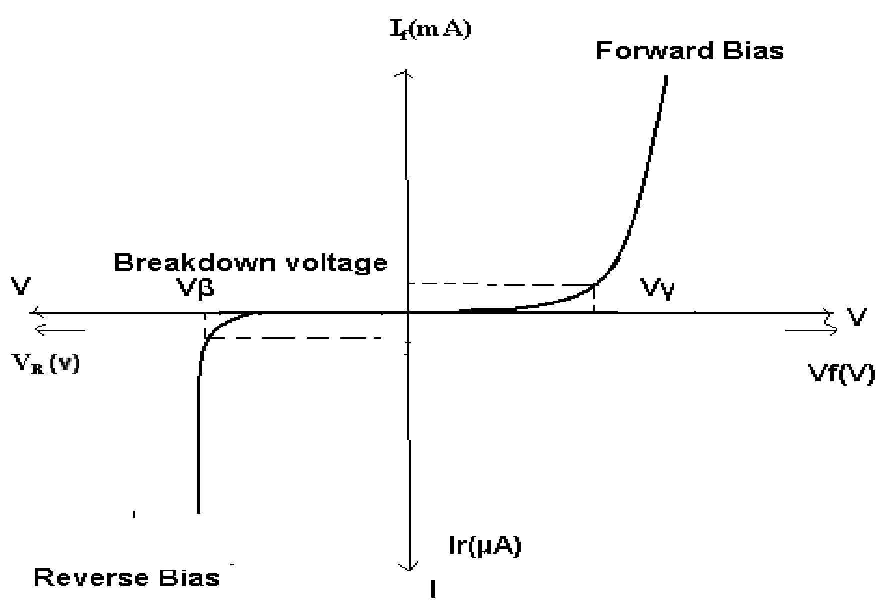


Fig. 23: Characteristics of Zener diode.

Procedure:

1. Connections are made as per the circuit diagram.
2. The Regulated power supply voltage is increased in steps.
3. The zener current (lz), and the zener voltage (Vz.) are observed and then noted in the tabular form.
4. A graph is plotted between zener current (Iz) and zener voltage (Vz). Do the above steps for forward as well as reverse bias connections as shown in the circuit diagrams

Precautions:

1. The terminals of the zener diode should be properly identified.
2. Should be ensured that the applied voltages & currents do not exceed the diode ratings

Result: The V-I characteristics of a given Zener diode are verified.

9. Verification of Thevenin's Theorem

Aim: To verify Thevenin's theorem for the given circuit.

Apparatus Required:

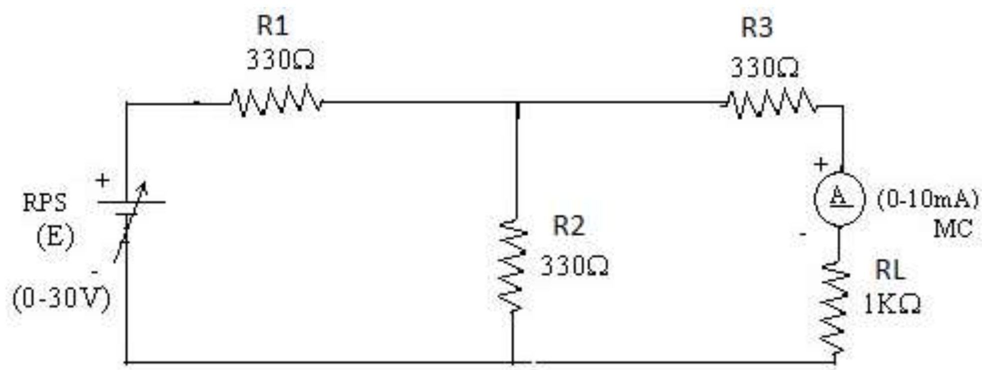
S. No.	Apparatus	Range	Quantity
1.	Regulated Power supply	0-30V	1
2.	Ammeter	(0-10mA)	1
3.	Resistor	1K, 330Ω	1, 3
4.	DRB		
5.	Bread board & Connecting wires		

Theory:

A linear or bilateral network consist of energy sources and resistances can be replaced by single equivalent circuit contains single voltage source (V_{TH}) in series with resistance (R_{TH}).

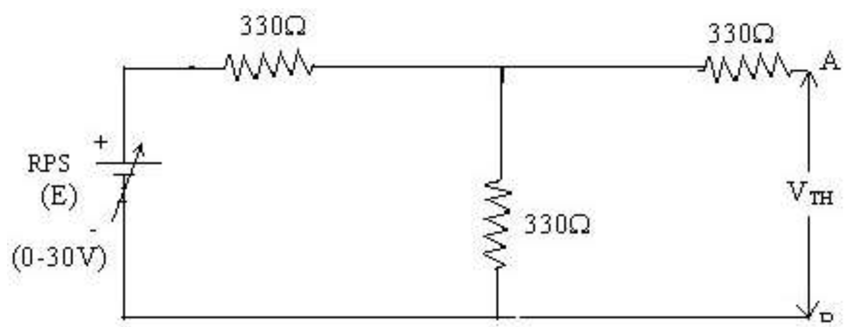
Circuit Diagrams:

(a) To find load current:

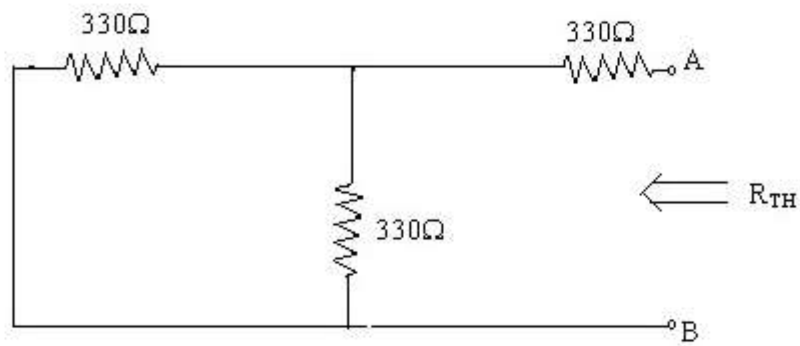


(a)

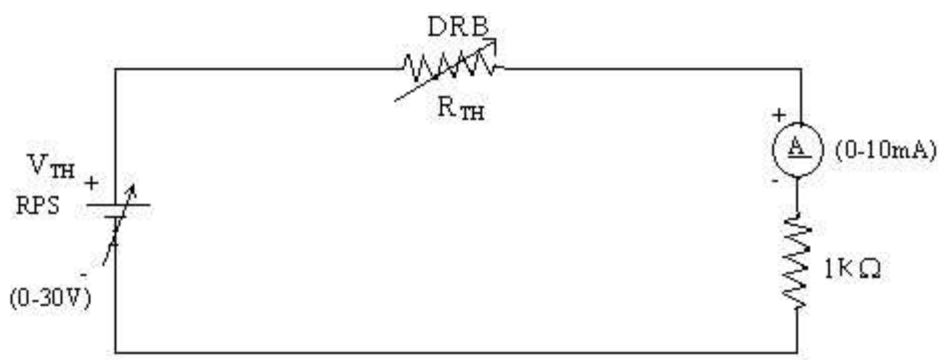
To find V_{TH}:



To find R_{TH}:



(b) Thevenin's Equivalent circuit:



(b)

Fig. 24: Verification of Thevenin's Theorem.

Procedure:

1. Connections are given as per Fig.(a).
2. Set a value of input voltage using RPS and note down the corresponding ammeter reading (Load current).
3. **To find V_{TH}:** Remove the load resistance and measure the open circuit voltage using multimeter (V_{TH}).
4. **To find R_{TH}**: To find the Thevenin's resistance, remove the RPS and short circuit it and find the R_{TH} using multimeter.
5. Give the connections for equivalent circuit as shown in Fig.(b) and note the corresponding ammeter reading.
6. Verify the Thevenin's theorem.

Observations:

	E (V)	V_{TH} (V)	R_{TH} (Ω)	I_L (mA)	
				Circuit	Equivalent Circuit
Theoretical					
Practical					

Model Calculations:

From Fig(a):

$$V_{TH} = I \times R_2$$

$$I = \frac{E}{R_1 + R_2}$$

$$R_{TH} = \frac{R_1 \times R_2}{R_1 + R_2} + R_3$$

Precautions:

1. Voltage control knob of RPS should be kept at minimum position.
2. Current control knob of RPS should be kept at maximum position.

Result: Hence the Thevenin’s theorem is verified both practically and theoretically.

10. Components Testing using CRO

Aim: To test various components like passive and active components such as resistor, capacitor, diodes, BJT using CRO.

Apparatus Required:

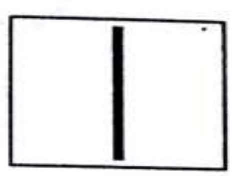
S. No.	Apparatus	Quantity
1.	Resistor	1
2.	Capacitor	1
3.	Diodes	1
4.	Zener diodes	1
5.	BJT	1

Procedure:

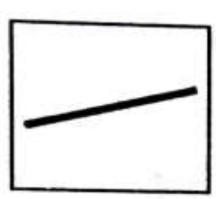
1. Press in COMP TEST push button to place oscilloscope in component test operating mode.
2. Disconnect CH1 and CH2 input connectors.
3. Insert components between COMP TEST socket and ground.
4. Verify the displayed waveforms are like the test patterns.

Test Patterns:

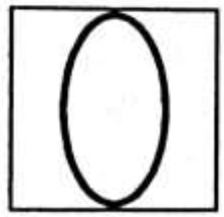
a) SHORT CIRCUIT:



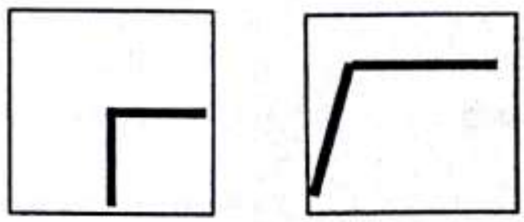
b) RESISTOR:



c) CAPACITOR:

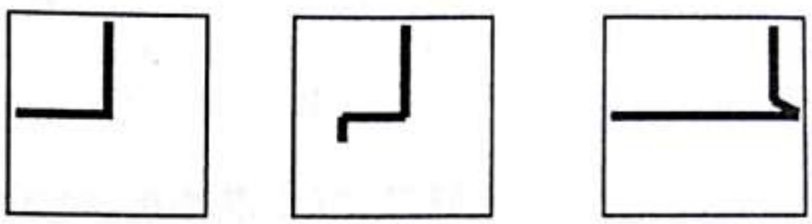


d) DIODE:



Silicon Diode   Germanium Diode

e) TRANSISTOR:



Junction B-C   Junction B-E   Junction E-C

Result: Various components such as resistor, capacitor, diodes, BJT are tested using CRO.

11. Verification of Norton's Theorem

Aim: To verify Norton's theorem for the given circuit.

Apparatus Required:

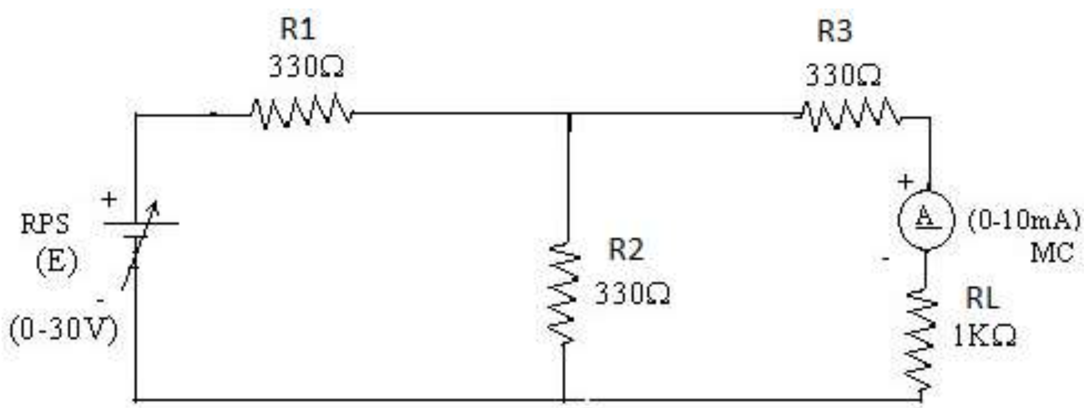
S. No.	Apparatus	Range	Quantity
1.	Regulated Power supply	0-30V	2
2.	Ammeter	(0-10mA)	1
3.	Resistor	1K, 330Ω	1, 3
4.	DRB		1
5.	Bread board and Connecting wires	-	1

Theory:

Any linear circuit containing several energy sources and resistances can be replaced by a single constant current generator in parallel with a single resistor.

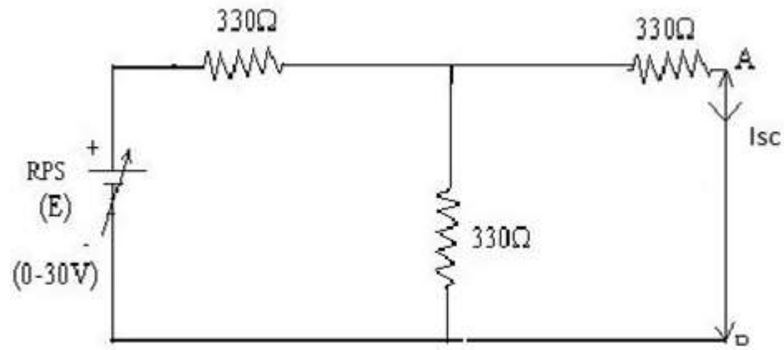
Circuit Diagrams:

(a) To find load current:

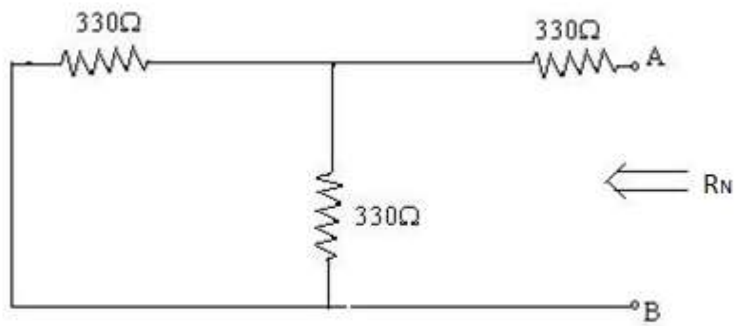


(a)

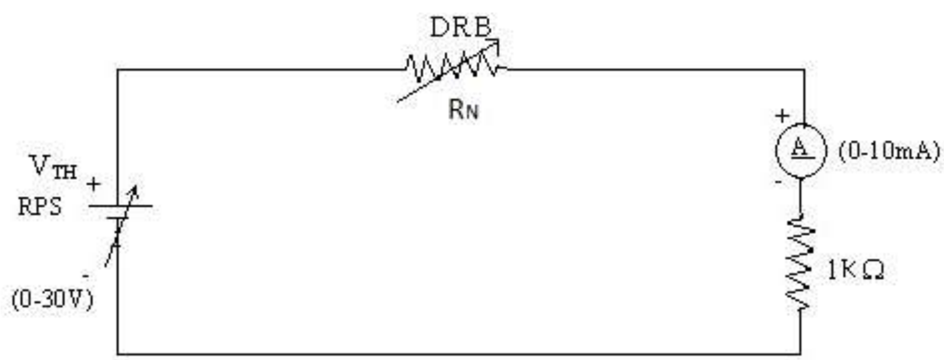
To find Isc:



To find R_N:



<u>(b) Norton's Equivalent circuit</u>:



(b)

Fig. 25: Verification of Norton's Theorem.

Observations:

	E (V)	V_{TH} (V)	R_N (Ω)	I_L (mA)	
				Circuit-I	Equivalent Circuit
Theoretical					
Practical					

Model Calculations:

$$I = \frac{E}{R_1 + R_2}$$

$$V_{TH} = I \times R_2$$

$$I_{sc} = I \frac{R_2}{R_2 + R_3}$$

$$R_N = R_{TH} = \frac{R_1 \times R_2}{R_1 + R_2} + R_3$$

$$I_L = \frac{V_{TH}}{R_{TH} + R_L}$$

Procedure:

1. Connections are given as per the circuit diagram.
2. Set a particular value of voltage using RPS and note down the corresponding ammeter readings.
3. To find I_{SC}: Remove the load resistance and measure the short circuit current using multimeter (I_{sc}).
4. To find R_{TH}: To find the Thevenin's resistance, remove the RPS and short circuit it and find the R_{TH} using multimeter.
5. Calculate Thevenin's voltage multiplying Isc with R_{TH}.
6. Give the connections for equivalent circuit and set V_{TH} and R_{TH} and note the corresponding ammeter reading.
7. Verify Norton's theorem.

Precautions:

1. Voltage control knob of RPS should be kept at minimum position.
2. Current control knob of RPS should be kept at maximum position.

Result: Hence the Norton's theorem is verified both practically and theoretically.

12. Generation of a Sinusoidal Signal having 4v Peak to Peak and 5KHz Frequency

Aim: To generate sinusoidal functions of given specifications using function generator and observe those waveforms using CRO.

Apparatus Required:

i. CRO
ii. Function Generator
iii. BNC-BNC connectors

Theory:

A sinusoidal signal is time varying physical quantity. All the oscillatory functions can be represented by a sinusoidal signal. Signal representation with respect to time is waveform. Sinusoidal signals have three parameters which describes it shape and structure they are amplitude, frequency and phase. The general representation of a sinusoidal signal is $x(t) = Asin(2\pi ft + \theta)$. Where A represents the amplitude of the waveform, f represents the frequency of the waveform theta represents the phase of the waveform and t is the variable time about which the waveform is generated.

Frequency of a signal is defined as the number of cycles per second which is inverse of the time period which is time taken by the signal for one complete cycle. A sinusoidal signal can be generated by using cosine signal also.

Procedure:

1. Connect the power supply to the CRO and Function generator.
2. Switch on the power for CRO and Function generator.
3. Connect the function generator output to a channel input of CRO using BNC-BNC cable connector.
4. Select sinusoidal function using function selecting knob.
5. Select the required frequency range and vary the frequency variable to the specified frequency.
6. Vary the amplitude variable to obtain specified amplitude.

7. Vary the volts/div and time/div for better view of sinusoidal waveform in CRO.
8. Measure the number of horizontal divisions for a cycle and multiply with time/div to measure time period.
9. Inverse the time period to find frequency of sinusoidal signal.
10. Measure the number of vertical division over which the waveform amplitude spread and multiply with volt/div to measure peak to peak amplitude of the sinusoidal signal.
11. Repeat the steps 5 to 10 for triangular function, square function, ramp function.
12. Tabulate the observations.

Model Graph:

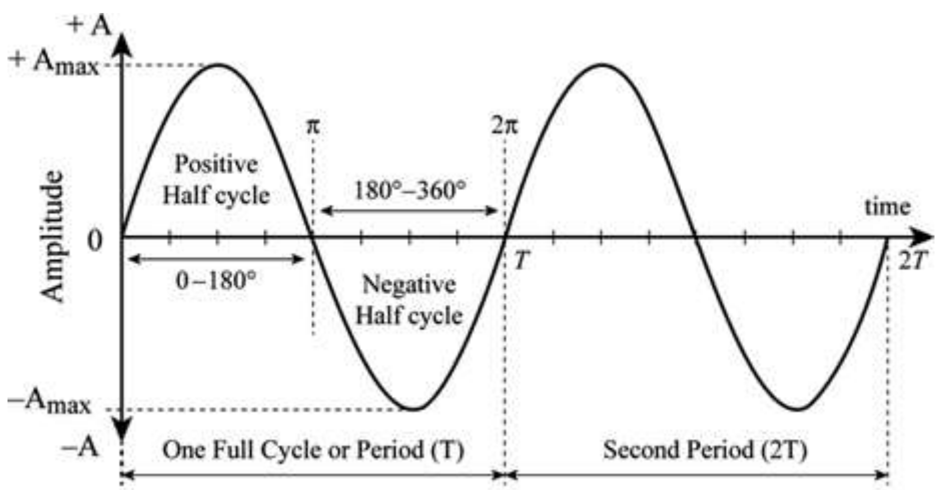


Fig. 26: Model waveform.

Precautions:

1. Ensure the cables are not damaged.
2. Avoid loose connections.

Result: 4V,5KHZ Sinusoidal signal is generated by function generator and measured using CRO.

APPENDIX – A

Diode

Type No	1N4007
Max. Peak Inverse Volts	50
Max RMS Supply Volts	35
Maximum Forward Voltage @ 1Ampere, DC @ 75^0 C	1.1 Volts, Peak
Maximum Reverse DC Current @PIV @ 25^0 C	10µA
Maximum Dynamic Reverse Current @PIV @75^0 C	30µA, Average