ANALOG AND DIGITAL ELECTRONICS LAB MANUAL

LABORATORY MANUAL

B.TECH II YEAR I SEM (2021-22)

PREPARED BY

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MALLA REDDY COLLEGE OF ENGINEERING & TECHNOLOGY
(Autonomous Institution – UGC, Govt. of India)
Sponsored by CMR Educational Society
(Affiliated to JNTU, Hyderabad, Approved by AICTE - Accredited by NBA & NAAC – 'A' Grade - ISO 9001:2015 Certified)
Maisammaguda, Dhulapally (Post Via. Kompally), Secunderabad – 500100, Telangana State, India.
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VISION

- To establish a pedestal for the integral innovation, team spirit, originality and competence in the students, expose them to face the global challenges and become technology leaders of Indian vision of modern society.

MISSION

- To become a model institution in the fields of Engineering, Technology and Management.
- To impart holistic education to the students to render them as industry ready engineers.
- To ensure synchronization of MRCET ideologies with challenging demands of International Pioneering Organizations.

QUALITY POLICY

- To implement best practices in Teaching and Learning process for both UG and PG courses meticulously.
- To provide state of art infrastructure and expertise to impart quality education.
- To groom the students to become intellectually creative and professionally competitive.
- To channelize the activities and tune them in heights of commitment and sincerity, the requisites to claim the never ending ladder of SUCCESS year after year.

PROGRAMME EDUCATIONAL OBJECTIVES

PEO 1. Excellence in Career To provide students with in-depth knowledge in the fundamental and advanced areas of electrical and electronics engineering and there by excel in professional career and higher education.
PEO 2. Development of Research and Industry Interaction To train students in the software/hardware design of electrical systems and promote the development of research activity as well as interaction with the industry.
PEO 3. Professional and Ethical Attitude To inculcate professional and ethical attitude in students and enhance the ability to relate engineering issues to broader social context.

PROGRAMME SPECIFIC OBJECTIVES

PSO1: To make students strong in core and advanced subjects of electrical and electronics engineering by which they can excel in their future endeavors.
PSO2: To make students exposed to latest simulation tools of electrical systems and provide a sense of direction towards research and industry interaction.
PSO3: To make the students handle social related engineering issues without deviating from professional and ethical values.

PROGRAM OUTCOMES (POs)

Engineering Graduates will be able to:

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

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.

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.

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.

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.

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.

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.

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

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

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.

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 multi-disciplinary environments.

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.

CODE OF CONDUCT FOR THE LABORATORIES

- All students must observe the Dress Code while inthe laboratory.
- Sandals or open-toed shoes are NOTallowed.
- Foods, drinks and smoking are NOTallowed.
- All bags must be left at the indicatedplace.
- Thelabtimetablemustbestrictlyfollowed.
- Be PUNCTUAL for your laboratorysession.
- Program must be executed within the giventime.
- Noise must be kept to aminimum.
- Workspace must be kept clean and tidy at alltime.
- Handle the systems and interfacing kits withcare.
- All students are liable for any damage to the accessories due to theirown negligence.
- AllinterfacingkitsconnectingcablesmustbeRETURNEDifyoutakenfromthelabsupervisor.
- Students are strictly PROHIBITED from taking out any items fromthelaboratory.
- StudentsareNOT allowedtoworkalonein thelaboratorywithouttheLabSupervisor
- USBPortshavebeendisabledifyouwanttouseUSBdriveconsultlabsupervisor.
- ReportimmediatelytotheLabSupervisorifanymalfunctionoftheaccessories,isthere.

Before leaving the lab

- Place the chairsproperly.
- Turn off the systemproperly
- Turn off themonitor.

- Please check the laboratory notice board regularly forupdates.

(R20A0466) ANALOG AND DIGITAL ELECTRONICS LAB

COURSE OBJECTIVES:

1. To identify and test R,L & C components, potentiometers, breadboards, Diodes, BJTs, Power Transistors, LEDs, Millimeters, RPS, CRO and Function Generators.
2. To conduct experiments and plot the characteristics PN diode, zener diode characteristics
3. To conduct experiment and plot input and output characteristics of BJT and FET in different configurations.
4. To study and verify Basic Gates (AND, OR & NOT), Universal Gates (NAND & NOR) and implement Boolean Functions using the gates.
5. To realize Digital Circuits and analyze Op-amp for various applications.

PART A:

Only For Viva- Voice Examination Electronic Work Shop Practice (In ONE Lab Session)

1. Identification, Specifications, Testing of R, L, C Components (Color Codes), Potentiometers, Bread Boards.
2. Identification, Specifications and Testing of Active Devices, Diodes, BJT's, Power Transistors, Led's.
3. Study and operation of
   i. Multi meters (Analog and Digital)
   ii. Function Generator
   iii. Regulated Power Supplies
   iv. CRO.

PART B:

(For Laboratory Examination – Minimum of 10 experiments)

1. P-N junction diode forward and reverse bias characteristics
2. Zener diode characteristics
3. Input and output characteristics of a BJT in CE configuration
4. Input and output characteristics of a BJT in CB configuration
5. FET Characteristics
6. Study and verification of Basic Gates(AND,OR &NOT)

7. Study and verification of Universal Gates (NAND &NOR)
8. Implementation of the given Boolean function using logic gates
9. Realization of Half Adder& Full Adder using Basic gates
10. Realization of Half subtractor& Full subtractor using Basic gates
11. Multiplexer andDe-multiplexer
12. Encoder andDecoder
13. Op-amps (using IC 747): Summer, Integrator and Differentiator

COURSE OUTCOMES:

1. Identifying and testing R,L& C components, potentiometers, breadboards, Diodes, BJTs, Power Transistors, LEDs, Multimeters, RPS, CRO and Function Generators.
2. Conducting experiments and plotting the characteristics PN diode, zener diode characteristics
3. Conducting experiment and plotting input and output characteristics of BJT and FET in different configurations.
4. Studying and verifying Basic Gates (AND, OR & NOT), Universal Gates (NAND & NOR) and implement Boolean Functions using the gates.
5. Realizing Digital Circuits and analyze Op-amp for various applications.

BASIC REQUIREMENT FOR EDCLAB

PART A: Only For Viva- Voice Examination Electronic Work ShopPractice

1) Identification,Specifications,TestingofR,L,CComponents(ColorCodes),Potentiometers, Bread Boards.

2) Identification, Specifications and Testing of Active Devices, Diodes, BJT's, Lowpower Transistors, LED's.

3) Study and operation of

   a) Multi meters (Analog and Digital)

   b) Function Generator

   c) Regulated Power Supplies

   d) CRO.

LIST OF EXPERIMENTS

PART B: (For Laboratory Examination – Minimum of 10 experiments)

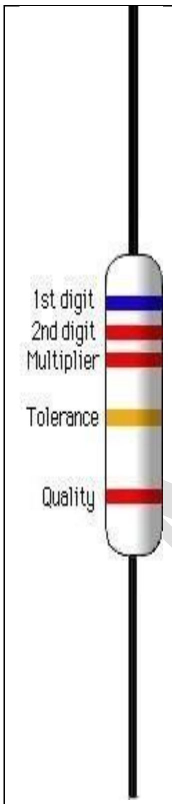
1. BASIC ELECTRONICCOMPONENTS

COLOUR CODING OF RESISTOR:

Colour Codes are used to identify the value of resistor. The numbers to the Colour are identified in the following sequence which is remembered as **BBROY GREAT BRITAN VERY GOOD WIFE (BBROYGBVGW)** and their assignment is listed in followingtable.

Black	Brown	Red	Orange	Yellow	Green	Blue	Violet	Grey	White
0	1	2	3	4	5	6	7	8	9

Table1: Colour codes of resistor



	First find the tolerance band, it will typically be gold (5%) and sometimes silver (10%).
	Starting from the other end, identify the first band - write down the number associated with that color
	Now read the next color, so write down a its value next to the first value.
	Now read the third or 'multiplier exponent' band and write down that as the number of zeros.
	If the 'multiplier exponent' band is Gold move the decimal point one to the left. If the 'multiplier exponent' band is Silver move the decimal point two places to the left. If the resistor has one more band past the tolerance band it is a quality band.
	Read the number as the '% Failure rate per 1000 hour' This is rated assuming full wattage being applied to the resistors. (To get better failure rates, resistors are typically specified to have twice the needed wattage dissipation that the circuit produces). Some resistors use this band for temco information. 1% resistors have three bands to read digits to the left of the multiplier. They have a different temperature coefficient in order to provide the 1% tolerance. At 1% the temperature coefficient starts to become an important factor. at +/-200 ppm a change in temperature of 25 Deg C causes a value change of up to 1%

Table2: Procedure to find the value of resistor using colour codes

COLOUR CODING OF CAPACITORS

An electrical device capable of storing electrical energy. In general, a capacitor consists of two metal plates insulated from each other by a dielectric. The capacitance of a capacitor depends primarily upon its shape and size and upon the relative permittivity ε_r of the medium between the plates. In vacuum, in air, and in most gases, ε_r ranges from one to severalhundred.

One classification of capacitors comes from the physical state of their dielectrics, which may be gas (or vacuum), liquid, solid, or a combination of these. Each of these classifications may be subdivided according to the specific dielectric used. Capacitors may be further classified by their ability to be used in alternating-current (ac) or direct- current (dc) circuits with various current levels.

- **Capacitor Identification Codes:** There are no international agreements in place to standardize capacitor identification. Most plastic film types (Figure1) have printed values and are normally in microfarads or if the symbol is n, Nanofarads. Working voltage is easily identified. Tolerances are upper case letters: M = 20%, K = 10%, J= 5%, H = 2.5% and F = ±1pF.

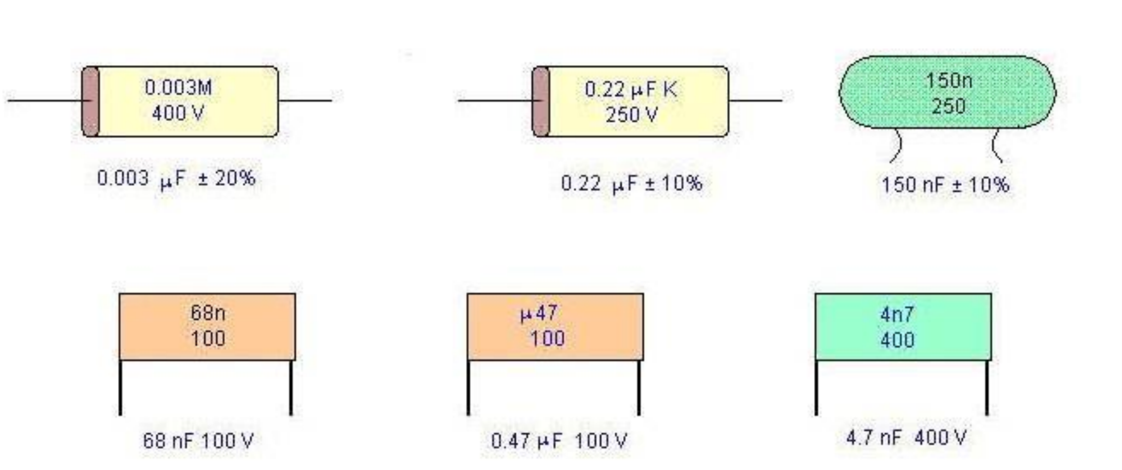


Figure 1: Plastic Film Types

A more difficult scheme is shown in Figure 2 where K is used for indicating Picofarads. The unit is picofarads and the third number is a multiplier. A capacitor coded 474K63 means 47 × 10000 pF which is equivalent to 470000 pF or 0.47 microfarads. K indicates 10% tolerance. 50, 63 and 100 are working volts.

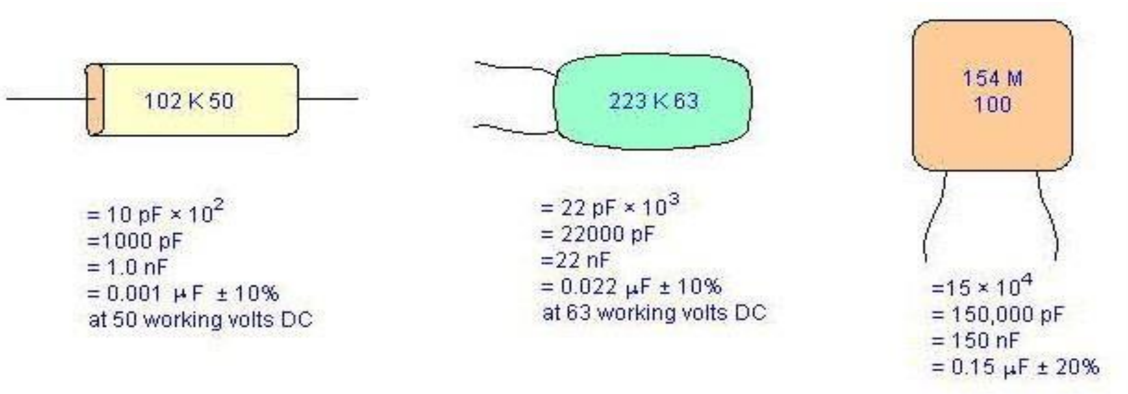


Figure 2: Picofarads Representation

Ceramic disk capacitors have many marking schemes. Capacitance, tolerance, working voltage and temperature coefficient may be found which is as shown in figure 3. Capacitance values are given as number without any identification as to units. (uF, nF, pF) Whole numbers usually indicate pF and decimal numbers such as 0.1 or 0.47 are microfarads. Odd looking numbers such as 473 is the previously explained system and means 47nf

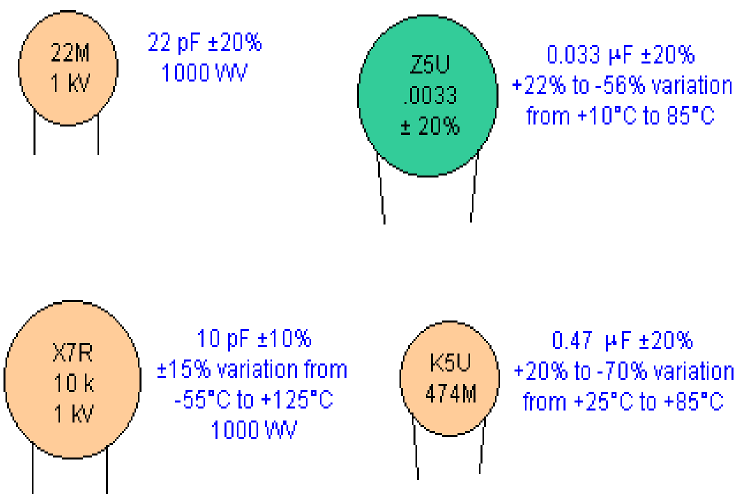


Figure3: Ceramic Disk Capacitor

Figure 4 shows some other miscellaneous schemes.

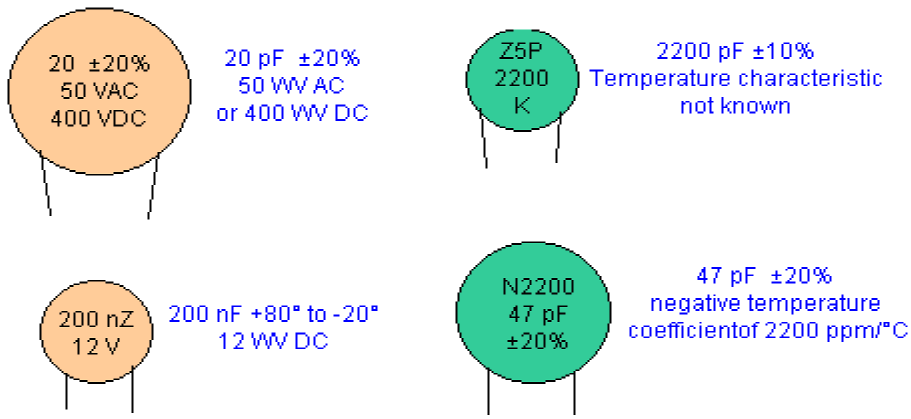


Figure 4: Miscellaneous Schemes.

Electrolytic capacitorproperties

There are a number of parameters of importance beyond the basic capacitance and capacitive reactance when using electrolytic capacitors. When designing circuits using electrolytic capacitors it is necessary to take these additional parameters into consideration for some designs, and to be aware of them when using electrolytic capacitors

- **ESR Equivalent series resistance:** Electrolytic capacitors are often used in circuits where current levels are relatively high. Also under some circumstances and current sourced from them needs to have low source impedance, for example when the capacitor is being used in a power supply circuit as a reservoir capacitor. Under these conditions it is necessary to consult the manufacturers' datasheets to discover whether the electrolytic capacitor chosen will meet the requirements for the circuit. If the ESR is high, then it will not be able to deliver the required amount of current in the circuit, without a voltage drop resulting from the ESR which will be seen as a source resistance.
- **Frequency response:** One of the problems with electrolytic capacitors is that they have a limited frequency response. It is found that their ESR rises with frequency and this generally limits their use to frequencies below about 100 kHz. This is particularly true for large capacitors, and even the smaller electrolytic capacitors should not be relied upon at high frequencies. To gain exact details it is necessary to consult the manufacturer's data for a givenpart.

- **Leakage:** Although electrolytic capacitors have much higher levels of capacitance for a given volume than most other capacitor technologies, they can also have a higher level of leakage. This is not a problem for most applications, such as when they are used in power supplies. However under some circumstances they are not suitable. For example they should not be used around the input circuitry of an operational amplifier. Here even a small amount of leakage can cause problems because of the high input impedance levels of the op-amp. It is also worth noting that the levels of leakage are considerably higher in the reverse direction.
- **Ripple current:** When using electrolytic capacitors in high current applications such as the reservoir capacitor of a power supply, it is necessary to consider the ripple current it is likely to experience. Capacitors have a maximum ripple current they can supply. Above this they can become too hot which will reduce their life. In extreme cases it can cause the capacitor to fail. Accordingly it is necessary to calculate the expected ripple current and check that it is within the manufacturer's maximum ratings.
- **Tolerance:** Electrolytic capacitors have a very wide tolerance. Typically this maybe -50% + 100%. This is not normally a problem in applications such as decoupling or power supply smoothing, etc. However they should not be used in circuits where the exact value is of importance.
- **Polarization:** Unlike many other types of capacitor, electrolytic capacitors are polarized and must be connected within a circuit so that they only see a voltage across them in a particular way.

The physical appearance of electrolytic capacitor is as shown in Figure 5.The capacitors themselves are marked so that polarity can easily be seen. In addition to this it is common for the can of the capacitor to be connected to the negative terminal.

Figure 5: Electrolytic Capacitor

It is absolutely necessary to ensure that any electrolytic capacitors are connected within a circuit with the correct polarity. A reverse bias voltage will cause the centre oxide layer forming the dielectric to be destroyed as a result of electrochemical reduction. If this occurs a short circuit will appear and excessive current can cause the capacitor to become very hot. If this occurs the component may leak the electrolyte, but under some circumstances they can explode. As this is not uncommon, it is very wise to take precautions and ensure the capacitor is fitted correctly, especially in applications where high current capability exists.

COLOUR CODING OF INDUCTORS

Inductor is just coil wound which provides more reactance for high frequencies and low reactance for low frequencies.

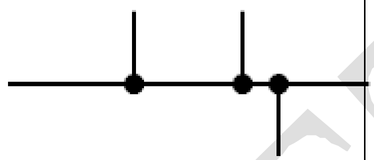
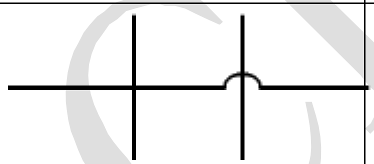
Molded inductors follow the same scheme except the units are usually micro henries. A brown-black-red inductor is most likely a 1000 uH. Sometimes a silver or gold band is used as a decimal point. So a red-gold-violet inductor would be a 2.7 uH. Also expect to see a wide silver or gold band before the first value band and a thin tolerance band at the end. The typical Colour codes and their values are shown in Figure 6.

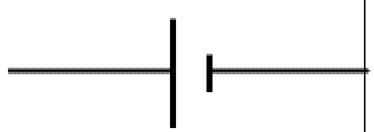
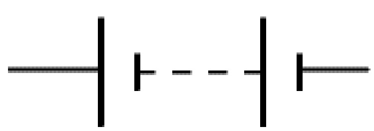
1000uH (1millihenry), 2%

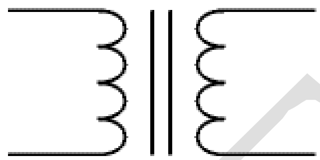
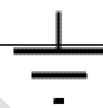
6.8 uH, 5%

Figure 6: Typical inductors colour coding and their values.

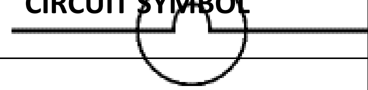
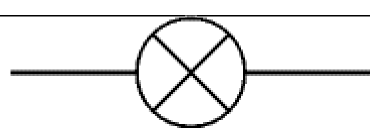
2. CIRCUITSYMBOLS

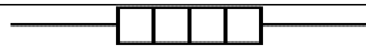
WIRES AND CONNECTIONS			
S.NO	**COMPONENT NAME**	**CIRCUIT SYMBOL**	**FUNCTION**
1	WIRE		To pass current very easily from one part of a circuit to another.
2	WIRES JOINED		A 'blob' should be drawn where wires are connected (joined), but it is sometimes omitted. Wires connected at 'crossroads' should be staggered slightly to form two T-junctions, as shown on the right.
3	WIRES NOT JOINED		In complex diagrams it is often necessary to draw wires crossing even though they are not connected. I prefer the 'bridge' symbol shown on the right because the simple crossing on the left may be misread as ajoin where you have forgotten to add a 'blob'.

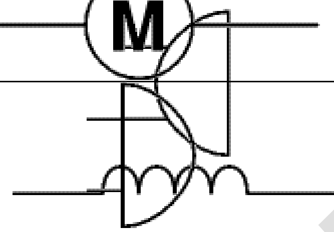
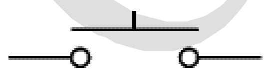
POWER SUPPLIES			
S.NO	**COMPONENT NAME**	**CIRCUIT SYMBOL**	**FUNCTION**
1	CELL		Supplies electrical energy. The larger terminal (on the left) is positive (+). A single cell is often called a battery, but strictly abattery is two or more cells joined together
2	BATTERY		Supplies electrical energy. A battery is more than one cell. The larger terminal (on the left) is positive (+).

3	DC SUPPLY		Supplies electrical energy. DC = Direct Current, always flowing in one direction.
4	AC SUPPLY		Supplies electrical energy. AC = Alternating Current, continually changing direction.
5	FUSE		A safety device which will 'blow' (melt) if the current flowing through it exceeds a specified value.
6	TRANSFORMER		Two coils of wire linked by an iron core. Transformers are used to step up (increase) and step down (decrease) AC voltages. Energy is transferred between the coils by the magnetic field inthe core. There is no electrical connection between thecoils.
7	EARTH(GROUND)		A connection to earth. For many electronic circuits this is the 0V (zero volts) of the power supply, but for mains electricity and some radio circuits it really means the earth. It is also known as ground.

Output Devices: Lamps, Heater, Motor, etc.

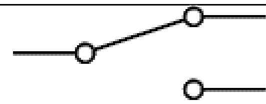
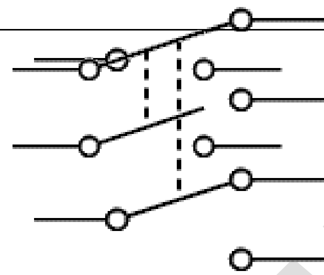
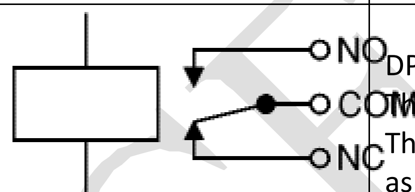
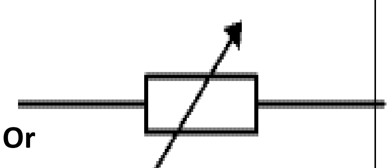
S.NO	COMPONENT NAME	CIRCUIT SYMBOL	FUNCTION
1	LAMP(LIGHTING)		A transducer which converts electrical energy to light. This symbol is used for a lamp providing illumination, for example a car headlamp or torch bulb
2	LAMP(INDICATOR)		A transducer which converts electrical energy to light. This symbol is used for a lamp which is an indicator, for example a warning light

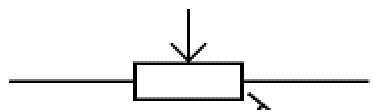
			on a car dashboard.
3	HEATER		A transducer which converts electrical energy to heat.

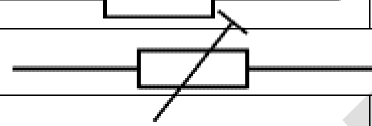
4	MOTOR		A transducer which converts electrical energy to kinetic energy (motion).
5	BELL		A transducer which converts electrical energy to sound.
6	BUZZER		A transducer which converts electrical energy to sound.
7	INDUCTOR(SOLIN OID,COIL)		A coil of wire which creates a magnetic field when current passes through it. It may have an iron core inside the coil. It can be used as a transducer converting electrical energy to mechanical energy by pulling on something.

Switches

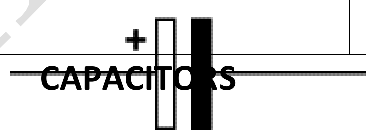
S.NO	COMPONENT NAME	CIRCUIT SYMBOL	FUNCTION
1	PUSH SWITCH(PUSH TO MAKE)		A push switch allows current to flow only when the button is pressed. This is the switch used to operate a doorbell.
2	PUSH TO BREAK SWITCH		This type of push switch is normally closed (on), it is open (off) only when the button is pressed.
3	ON/OFF SWITCH(SPST)		SPST = Single Pole, Single Throw. An on-off switch allows current to flow only when it is in the closed (on) position.

4	2 WAY SWITCH(SPDT)		SPDT = Single Pole, Double Throw. A 2-way changeover switch directs the flow of current to one of two routes according to its position. Some SPDT switches have a central off position and are described as 'on-off-on'.
5	DUAL ON-OFF SWITCH(DPST)		DPST = Double Pole, Single Throw. A dual on-off switch which is often used to switch mains electricity because it can isolate both the live and neutral connections.
6	REVERSING SWITCH(DPDT)		DPDT = Double Pole, Double Throw. This switch can be wired up as a reversing switch for a motor. Some DPDT switches have a central off position.
7	RELAY		An electrically operated switch, for example a 9V battery circuit connected to the coil can switch a 230V AC mains circuit. NO = Normally Open, COM = Common, NC = Normally Closed.
	RESISTORS		
S.NO	**COMPONENT NAME**	**CIRCUIT SYMBOL**	**FUNCTION**
1	RESISTOR	**Or** 	A resistor restricts the flow of current, for example to limit the current passing through an LED. A resistoris used with a capacitor in a timing circuit.

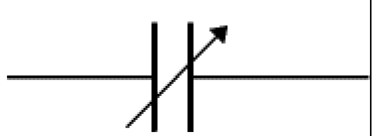
2	VARIABLE RESISTOR(RHEOSTAT)		This type of variable resistor with 2 contacts (a rheostat) is usually used to control current. Examples include: adjusting lamp brightness, adjusting motor speed, and adjusting the rate of flow of charge into a capacitor in a timing circuit.
3	VARIABLE RESISTOR(POTENTIOMETER)		This type of variable resistor with 3 contacts (a potentiometer) is usually



			used to control voltage. It can be used like this as a transducer converting position (angle of the control spindle) to an electrical signal
4	VARIABLE RESISTER(PRESET)		This type of variable resistor (a preset) is operated with a small screwdriver or similar tool. It is designed to be set when the circuit is made and then left without further adjustment. Presets are cheaper than normal variable resistors so they are often used in projects to reduce the cost



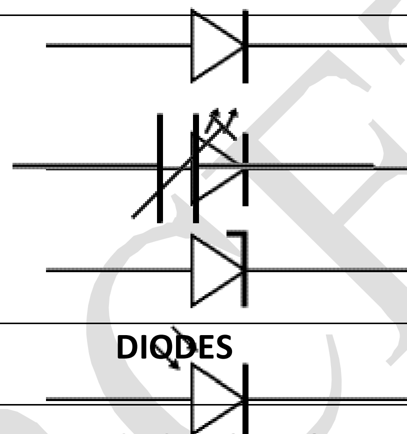
CAPACITORS

S.NO	NAME OF THE COMPONENT	CIRCUIT SYMBOL	FUNCTION OF THE COMPONENT
1	CAPACITOR		A capacitor stores electric charge. A capacitor is used with a resistor in a timing circuit. It can also be used as a filter, to block DC signals but pass AC signals.

2	CAPACITOR POLARISED		A capacitor stores electric charge. This type must be connected the correct way round. A capacitor is used with a resistor in a timing circuit. It can also be used as a filter, to block DC Signals but pass AC signals.
3	VARIABLE CAPACITOR		A variable capacitor is used in a radio tuner.
4	TRIMMER CAPACITOR		This type of variable capacitor (a trimmer) is operated with a small screwdriver or similar tool. It is designed to be set when the circuit is made and then left without further adjustment

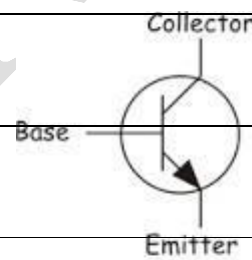
DIODES

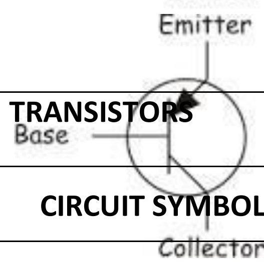
S.NO	NAME OF THE COMPONENT	CIRCUIT SYMBOL	FUNCTION OF THE COMPONENT
1	DIODE		A device which only allows current to flow in one direction
2	LED(LIGHT EMITTING DIODE)		A transducer which converts electrical energy to light.
3	ZENER DIODE		A special diode which is used to maintain a fixed voltage across its terminals
4	PHOTO DIODE		A light-sensitive diode.



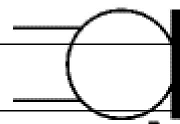
TRANSISTORS

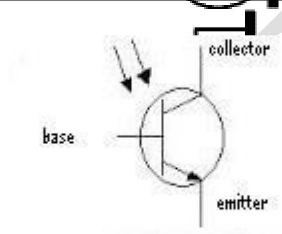
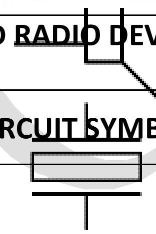
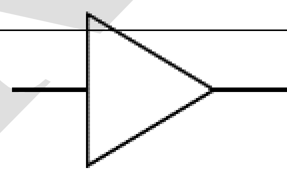
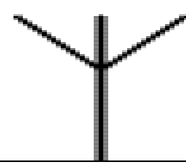
S.NO	NAME OF THE COMPONENT	CIRCUIT SYMBOL	FUNCTION OF THE COMPONENT





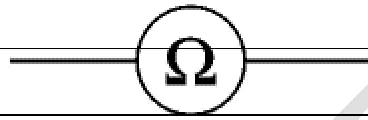
1	TRANSISTOR NPN		A transistor amplifies current. It can be used with other components to make an amplifier or switching circuit.
2	TRANSISTOR PNP		A transistor amplifies current. It can be used with other components to make an amplifier or switching circuit.

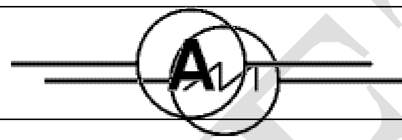
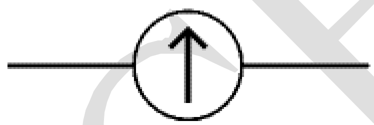
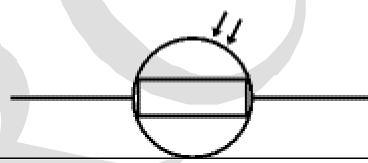
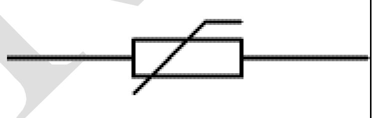


3	PHOTO TRANSISTOR		A light-sensitive transistor.
AUDIO AND RADIO DEVICES			
S.NO	**NAME OF THE COMPONENT**	**CIRCUIT SYMBOL**	**FUNCTION OF THE COMPONENT**
1	MICROPHONE		A transducer which converts sound to electrical energy.
2	EARPHONE		A transducer which converts electrical energy to sound.
3	LOUD SPEAKER		A transducer which converts electrical energy to sound.
4	PIEZO TRANSDUCER		A transducer which converts electrical energy to sound.
5	AMPLIFIER(GENER AL SYMBOL)		An amplifier circuit with one input. Really it is a block diagram symbol because it represents a circuit rather than just one component.

6	ARIEL (ANTENNA)		A device which is designed to receive or transmit radio signals. It is also known as an antenna

S.NO	NAME OF THE COMPONENT	CIRCUIT SYMBOL	FUNCTION OF THE COMPONENT
1	VOLTMETER		A voltmeter is used to measure voltage. The Proper name for voltage is 'potential difference', but most people prefer to say voltage.



2	AMMETTER		An ammeter is used to measure current
3	GALVANOMETER		A galvanometer is a very sensitive meter which is used to measure tiny currents, usually 1mA or less
4	OHMMETER		An ohmmeter is used to measure resistance. Most multimeters have an ohmmeter setting.
5	OSCILLOSCOPE		An oscilloscope is used to display the shape of electrical signals and it can be used to measuretheir voltage and timeperiod.

Sensors (input devices)

S.NO	NAME OF THE COMPONENT	CIRCUIT SYMBOL	FUNCTION OF THE COMPONENT
1	LDR		A transducer which converts brightness (light) to resistance (an electrical property). LDR = Light Dependent Resistor
2	THERMISTOR		A transducer which converts temperature (heat) to resistance (an electrical property).

3. STUDY OF CRO

An oscilloscope is a test instrument which allows us to look at the 'shape' of electrical signals by displaying a graph of voltage against time on its screen. It is like a voltmeter with the valuable extra function of showing how the voltage varies with time. A graticule with a 1cm grid enables us to take measurements of voltage and time from the screen.

The graph, usually called the trace, is drawn by a beam of electrons striking the phosphor coating of the screen making it emit light, usually green or blue. This is similar to the way a television picture is produced.

Oscilloscopes contain a vacuum tube with a cathode (negative electrode) at one end to emit electrons and an anode (positive electrode) to accelerate them so they move rapidly down the tube to the screen. This arrangement is called an electron gun. The tube also contains electrodes to deflect the electron beam up/down and left/right.

The electrons are called cathode rays because they are emitted by the cathode and this gives the oscilloscope its full name of cathode ray oscilloscope or CRO.

A dual trace oscilloscope can display two traces on the screen, allowing us to easily compare the input and output of an amplifier for example. It is well worth paying the modest extra cost to have this facility.

Figure1: Front Panel of CRO

- **BASIC OPERATION:**

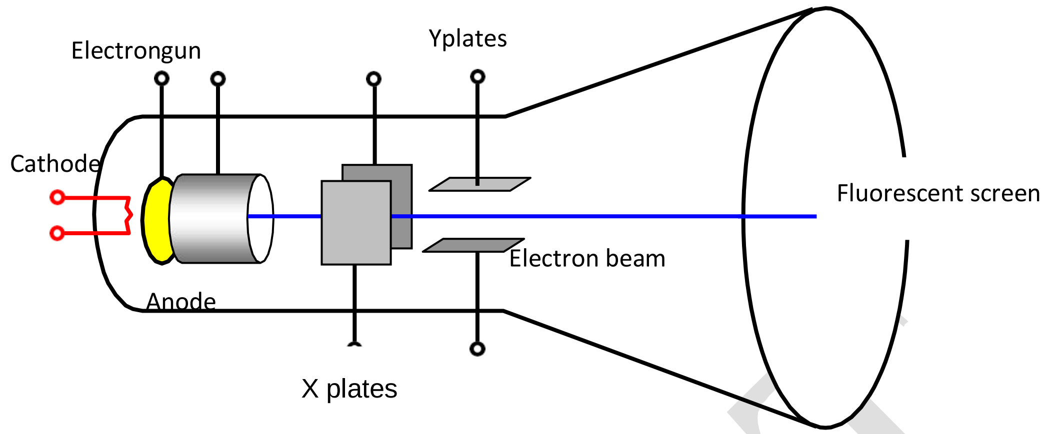


Figure2: Internal Blocks of CRO

- **Setting up an oscilloscope:**

Oscilloscopes are complex instruments with many controls and they require some careto set up and use successfully. It is quite easy to 'lose' the trace off the screen if controls are setwrongly.

There is some variation in the arrangement and labeling of the many controls so the following instructions may need to be adapted for this instrument.

1. Switch on the oscilloscope to warm up (it takes a minute or two).
2. Do not connect the input lead at this stage.
3. Set the AC/GND/DC switch (by the Y INPUT) toDC.
4. Set the SWP/X-Y switch to SWP(sweep).
5. Set Trigger Level to AUTO.
6. Set Trigger Source to INT (internal, the y input).
7. Set the Y AMPLIFIER to 5V/cm (a moderate value).
8. Set the TIMEBASE to 10ms/cm (a moderate speed).
9. Turn the time base VARIABLE control to 1 or CAL.
10. Adjust Y SHIFT (up/down) and X SHIFT (left/right) to give a trace across the middle of the screen, like the picture.
11. Adjust INTENSITY (brightness) and FOCUS to give a bright, sharp trace.

The following type of trace is observed on CRO after setting up, when there is no input signal connected.

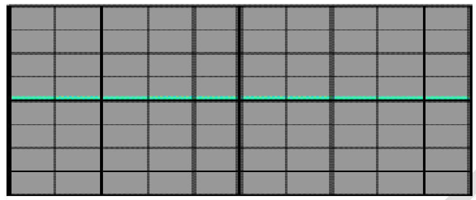


Figure 3: Absence of input signal

- **Connecting an oscilloscope :**

The Y INPUT lead to an oscilloscope should be a co-axial lead and the figure 4 shows its construction. The central wire carries the signal and the screen is connected to earth (0V) to shield the signal from electrical interference (usually called noise).

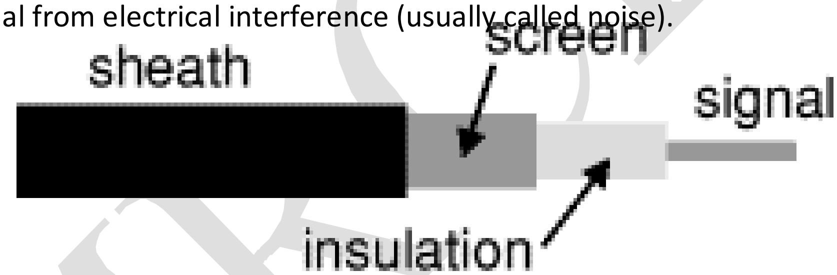


Figure 4: Construction of a co-axial lead

Most oscilloscopes have a BNC socket for the y input and the lead is connected with a push and twist action, to disconnect we need to twist and pull. Professionals use a specially designed lead and probes kit for best results with high frequency signals and when testing high resistance circuits, but this is not essential for simpler work at audio frequencies (up to 20 kHz).

Figure 5: Oscilloscope lead and probes kit

Obtaining a clear and stabletrace:

Once if we connect the oscilloscope to the circuit, it is necessary to adjust the controls to obtain a clear and stable trace on the screen in order to test it.

- The Y AMPLIFIER (VOLTS/CM) control determines the height of the trace. Choose asettings othetr aceoccupies at least half the screen height, but does not disappear off the screen.
- The TIMEBASE (TIME/CM) control determines the rate at which the dot sweeps across the screen. Choose a setting so the trace shows at least one cycle of the signal across the screen. Note that a steady DC input signal gives a horizontal line trace for which the time base setting is noncritical.
- The TRIGGER control is usually best left set to AUTO.

The trace of an AC signal with the oscilloscope controls correctly set is as shown in Figure 6.

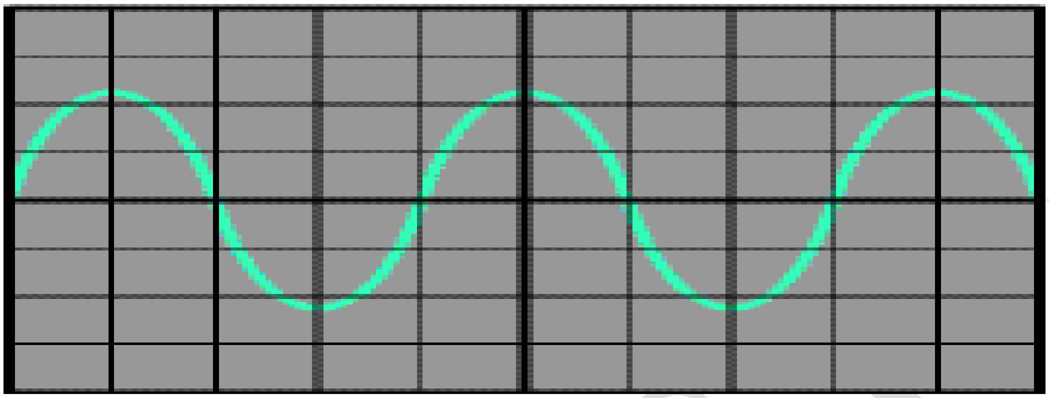


Figure 6 : Stable waveform

➤ Measuring voltage and timeperiod

The trace on an oscilloscope screen is a graph of voltage against time. The shape of this graph is determined by the nature of the input signal. In addition to the properties labeled on the graph, there is frequency which is the number of cycles per second. The diagram shows a sine wave but these properties apply to any signal with a constant shape

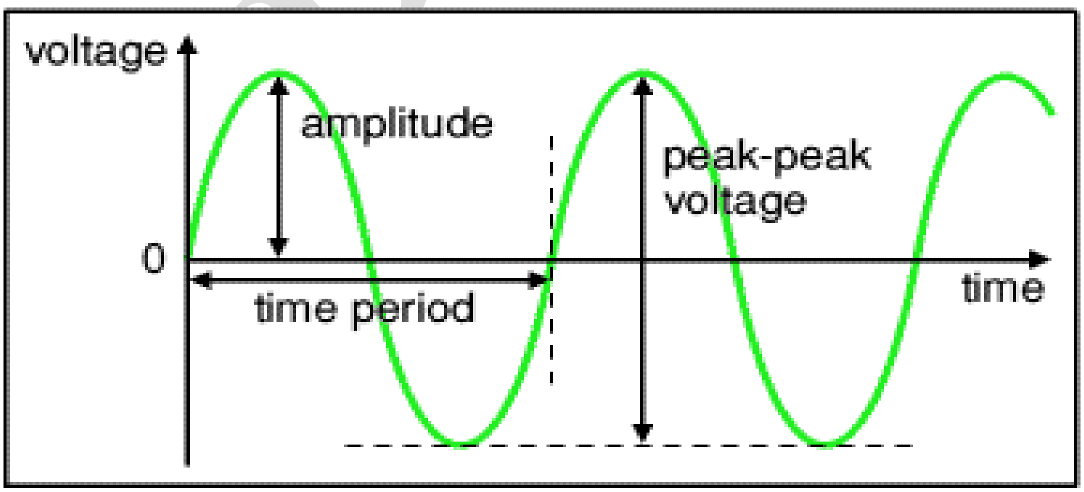


Figure7: Properties of trace

- **Amplitude** is the maximum voltage reached by the signal. It is measured in volts.
- **Peak voltage** is another name foramplitude.
- **Peak-peak voltage** is twice the peak voltage (amplitude). When reading an oscilloscope trace it is usual to measure peak-peak voltage.
- **Time period** is the time taken for the signal to complete one cycle.
  It is measured in seconds (s), but time periods tend to be short so milliseconds (ms) and microseconds (µs) are often used. 1ms = 0.001s and 1µs = 0.000001s.
- **Frequency** is the number of cycles per second. It is measured in hertz (Hz), but frequencies tend to be high so kilohertz (kHz) and megahertz (MHz) are often used.
  1kHz = 1000Hz and 1MHz =1000000Hz.

$$\text{Frequency} = \frac{1}{\text{Time period}}$$

$$\text{Time period} = \frac{1}{\text{Frequency}}$$

A) Voltage: Voltage is shown on the vertical y-axis and the scale is determined by the Y AMPLIFIER (VOLTS/CM) control. Usually peak-peak voltage is measured because it can be read correctly even if the position of 0V is not known. The amplitude is half the peak-peak voltage.

Voltage = distance in cm × volts/cm

B) Time period: Time is shown on the horizontal x-axis and the scale is determined by the TIMEBASE (TIME/CM) control. The time period (often just called period) is the time for one cycle of the signal. The frequency is the number of cycles per second, frequency = 1/timeperiod.

Time = distance in cm × time/cm

4. STUDY OF FUNCTIONGENERATOR

A function generator is a device that can produce various patterns of voltage at a variety of frequencies and amplitudes. It is used to test the response of circuits to common input signals. The electrical leads from the device are attached to the ground and signal input terminals of the device under test.

Figure 1: A typical low-cost function generator.

- **Features and controls:**

Most function generators allow the user to choose the shape of the output from a small number of options.

- Square wave - The signal goes directly from high to low voltage.

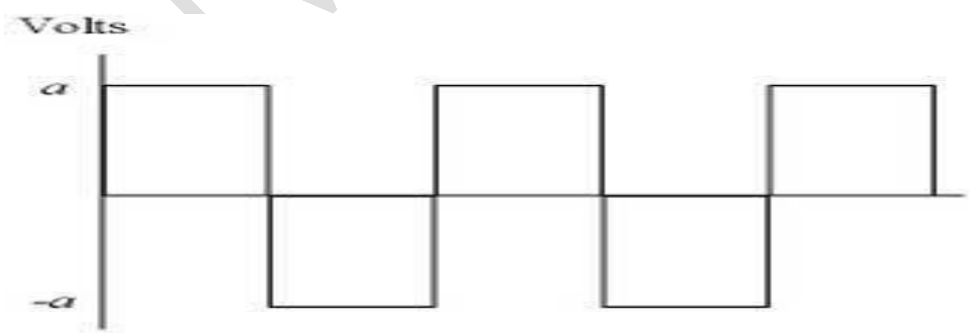


Figure 2: Square wave

The duty cycle of a signal refers to the ratio of high voltage to low voltage time in a square wave signal.

- Sine wave - The signal curves like a sinusoid from high to low voltage.

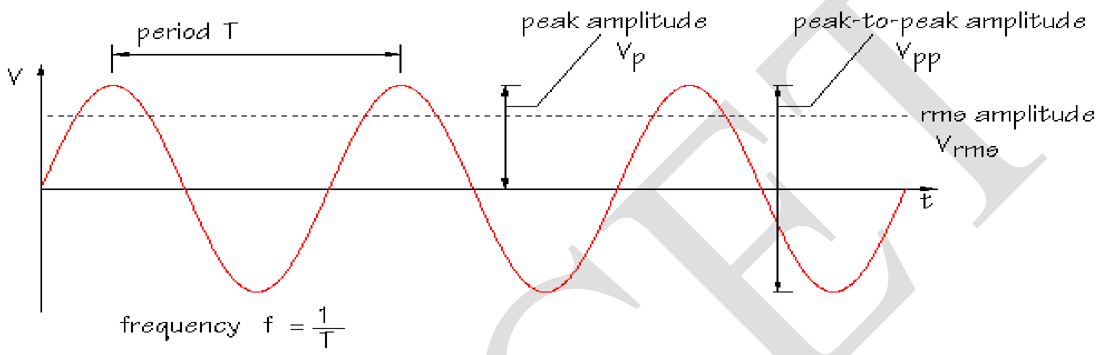


Figure3: Sine Wave

- Triangle wave - The signal goes from high to low voltage at a fixed rate.

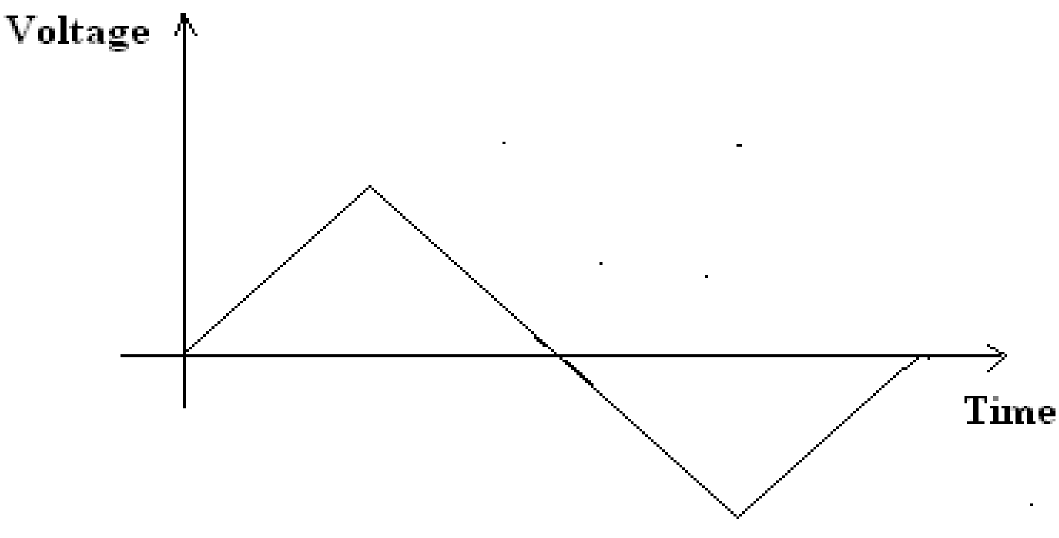


Figure 4: Triangular Wave

The amplitude control on a function generator varies the voltage difference between the high and low voltage of the output signal. The direct current (DC) offset control on a function generator varies the average voltage of a signal relative to the ground.

The frequency control of a function generator controls the rate at which output signal oscillates. On some function generators, the frequency control is a combination of different controls. One set of controls chooses the broad frequency range (order of magnitude) and the other selects the precise frequency. This allows the function generator to handle the enormous variation in frequency scale needed for signals.

- **How to use a function generator**

After powering on the function generator, the output signal needs to be configured to the desired shape. Typically, this means connecting the signal and ground leads to an oscilloscope to check the controls. Adjust the function generator until the output signal is correct, then attach the signal and ground leads from the function generator to the input and ground of the device under test. For some applications, the negative lead of the function generator should attach to a negative input of the device, but usually attaching to ground is sufficient.

5. STUDY OF REGULATED POWERSUPPLY

There are many types of power supply. Most are designed to convert high voltage AC mains electricity to a suitable low voltage supply for electronic circuits and other devices. A power supply can by broken down into a series of blocks, each of which performs a particular function. For example a 5V regulated supply:

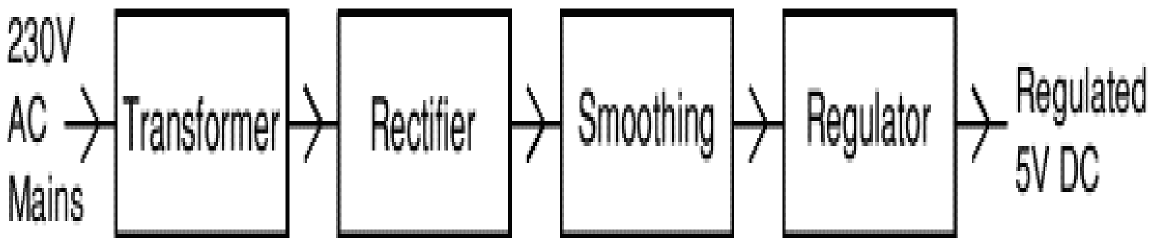


Figure1: Block Diagram Of Regulated Power Supply

Each of the blocks is described in more detail below:

- Transformer: Steps down high voltage AC mains to low voltage.
- Rectifier: Converts AC to DC, but the DC output is varying.
- Smoothing: Smooths the DC from varying greatly to a small ripple.
- Regulator: Eliminates ripple by setting DC output to a fixed voltage.

- **Dual Supplies:** Some electronic circuits require a power supply with positive and negative outputs as well as zero volts (0V). This is called a 'dual supply' because it is like two ordinary supplies connected together as shown in the diagram. Dual supplies have three outputs, for example a ±9Vsupply has +9V, 0V and -9V outputs.

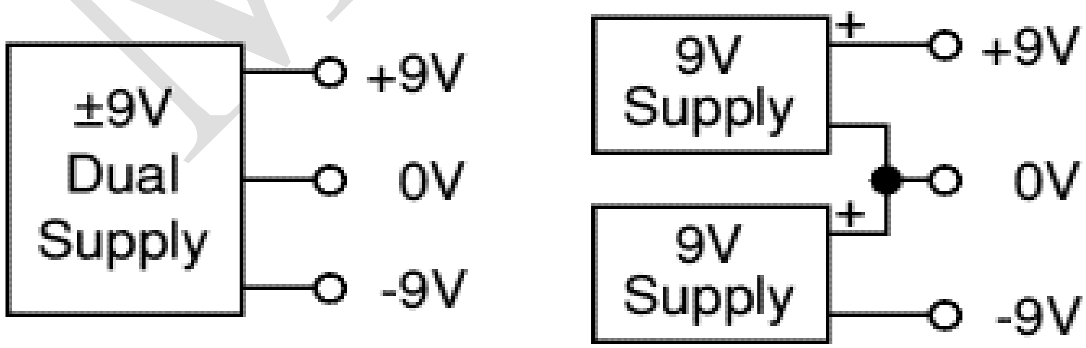


Figure 2: Dual Supply

6. TYPES OF CIRCUITBOARD

- **Breadboard:** This is a way of making a temporary circuit, for testing purposes or to try out an idea. No soldering is required and all the components can be re-used afterwards. It is easy to change connections and replace components. Almost all the Electronics Club projects started life on a breadboard to check that the circuit worked as intended. The following figure depicts the appearance of Bread board in which the holes in top and bottom stribes are connected horizontally that are used for power supply and ground connection conventionally and holes on middle stribes connected vertically. And that are used for circuit connections conventionally**.**

Figure 1: Breadboard

- **Stripboard:**

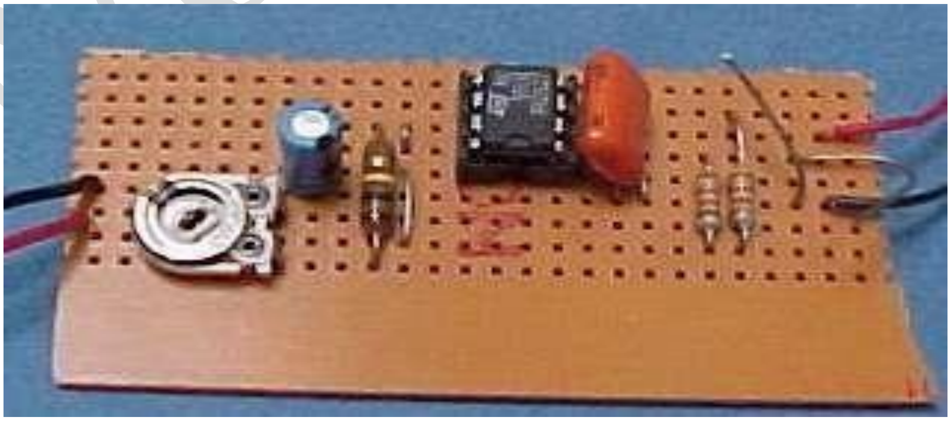


Figure 2: StripBoard

Stripboard has parallel strips of copper track on one side. The strips are 0.1" (2.54mm) apart and there are holes every 0.1" (2.54mm). Stripboard requires no special preparation other than cutting to size. It can be cut with a junior hacksaw, or simply snap it along the lines of holes by putting it over the edge of a bench or table and pushing hard.

Printed Circuit Board: A printed circuit board, or PCB, is used to mechanically support and electrically connect electronic components using conductive pathways, tracks or tracesetched from copper sheets laminated onto a non-conductive substrate. It is also referred to as printed wiring board (PWB) or etched wiring board. A PCB populated with electronic components is a printed circuit assembly (PCA), also known as a printed circuit board assembly(PCBA).

Printed circuit boards have copper tracks connecting the holes where the components are placed. They are designed especially for each circuit and make construction very easy. However, producing the PCB requires special equipment so this method is not recommended if you are a beginner unless the PCB is provided for you.

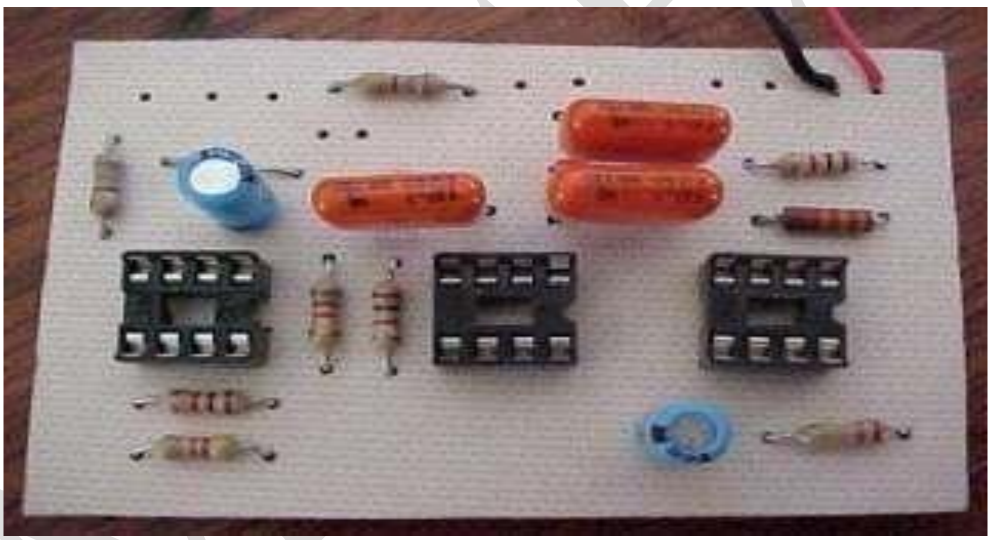


Figure 3: Printed circuit board

PCBs are inexpensive, and can be highly reliable. They require much more layout effort and higher initial cost than either wire-wrapped or point-to-point constructed circuits, but are much cheaper and faster for high-volume production. Much of the electronics industry's PCB design, assembly, and quality control needs are set by standards that are published by the IPC organization.

1. P-N junction diode forward and reverse bias characteristics.

Objective:

1. To plot Volt-Ampere Characteristics of Silicon P-N Junction Diode.
2. To find cut-in Voltage for Silicon P-N Junction diode.
3. To find static and dynamic resistances for P-N Junction diode.

Apparatus:

S.No	Apparatus	Type	Range	Quantity
01	PN Junction diode	1N4007		01
02	Resistance		470Ω,1KΩ	01
03	Regulated Power supply		(0-30V)	01
04	Ammeter		(0-200mA),(0-200μA)	01
05	Voltmeter		(0-20V)	01
06	Breadboard and Wires			

Introduction:

The semi conductor diode is created by simply joining an n-type and a p-type material together nothing more just the joining of one material with a majority carrier of electrons to one with a majority carrier of holes.

The P-N junction supports uni-directional current flow. If +ve terminal of the input supply is connected to anode (P-side) and –ve terminal of the input supply is connected to cathode (N-side), then diode is said to be forward biased. In this condition the height of the potential barrier at the junction is lowered by an amount equal to given forward biasing voltage. Both the holes from p-side and electrons from n-side cross the junction simultaneously and constitute a forward current(**injected minority current** – due to holes crossing the junction and entering N-side of the diode, due to electrons crossing the junction and entering P-side of thediode).

Assuming current flowing through the diode to be very large, the diode can be approximated as short- circuited switch. If –ve terminal of the input supply is connected to anode (p-side) and +ve terminal of theinputsupplyisconnectedtocathode(n-side)thenthediodeissaidtobereversebiased.Inthiscondition an amount equal to reverse biasing voltage increases the height of the potential barrier at the junction. Both the holes on p-side and electrons on n-side tend to move away from the junction thereby increasing the depleted region. However the process cannot continue indefinitely, thus a small current called **reverse saturation current** continues to flow in the diode. This small current is due to thermally generated carriers. Assuming current flowing through the diode to be negligible, the diode can be approximated as an open circuited switch. The volt-ampere characteristics of a diode explained by following equation:

$$I = I_0\left(e^{\frac{V}{\eta V_T}} - 1\right)$$

I=current flowing in the diode

I_o=reverse saturation current

V=voltage applied to the diode

V_T=volt-equivalent of temperature $\frac{KT}{q} = \frac{T}{11{,}600} = 26mA$ at room temp

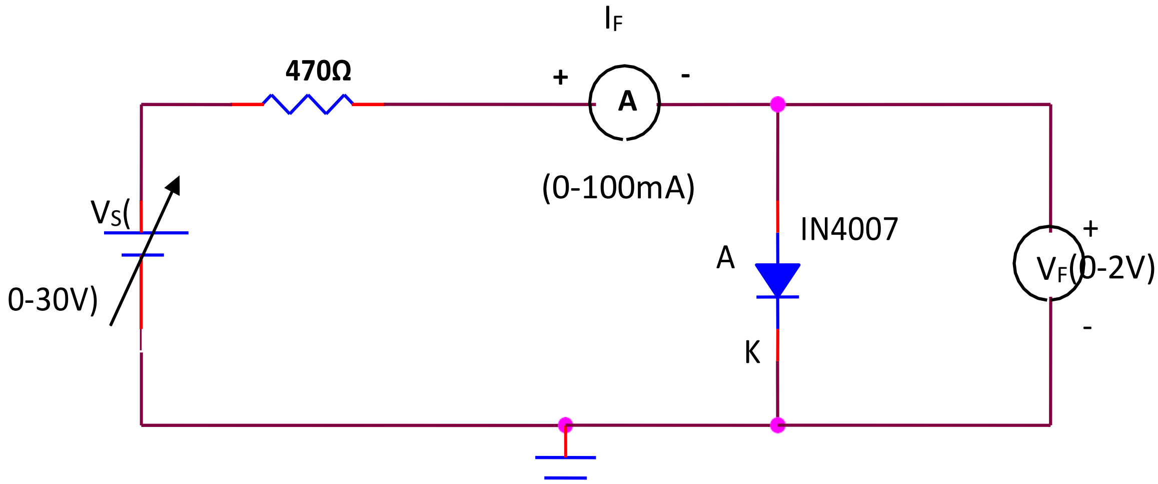
η = 1 (for Ge)

η = 2 (for Si)

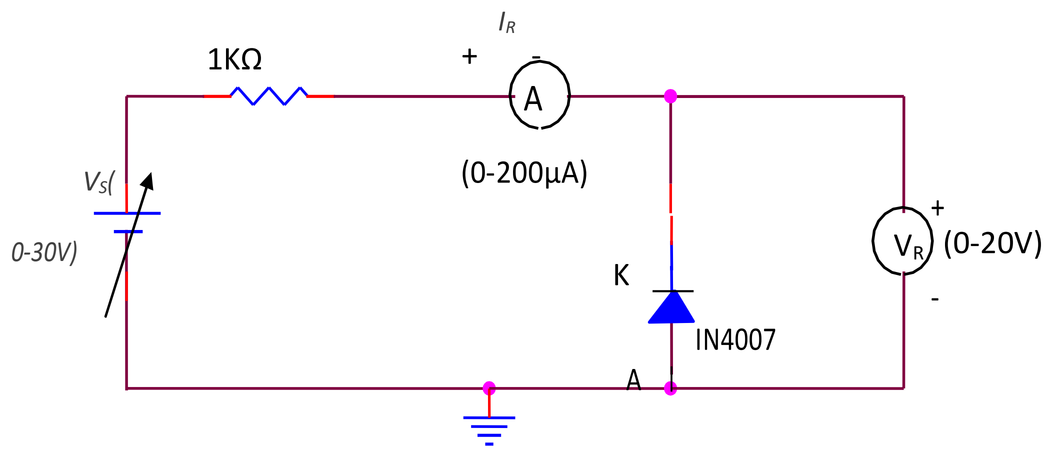
It is observed that Ge diode has smaller cut-in-voltage when compared to Si diode. The reverse saturation current in Ge diode is larger in magnitude when compared to silicon diode.

Circuit Diagram

Forward Bias



Reverse Bias:



Experiment procedure

Forward Biased condition

1. Connect the PN Junction diode in forward bias i.e Anode is connected to positive of the power supply and cathode is connected to negative of the power supply.
2. Use a Regulated power supply of range (0-30)V and a series resistance of470Ω
3. By varying the input voltage in steps of 0.1V, notedown corresponding Ammeter readings.(I_F) and voltmeter reading.
4. Plot the graph between forward voltage (V_F) and forward current(I_F).

Reverse Biased condition

1. Connect the PN Junction diode in Reverse bias i.e; anode is connected to negative of the power supply and cathode is connected to positive of the power supply.
2. Use a Regulated power supply of range (0-30)V and a series resistance of1KΩ
3. By varying the input voltage vary voltage (V_R) in steps of 1V and note down corresponding Ammeter readings.(I_R)
4. Plot the graph between Reverse voltage (V_R) and Reverse current(I_R).

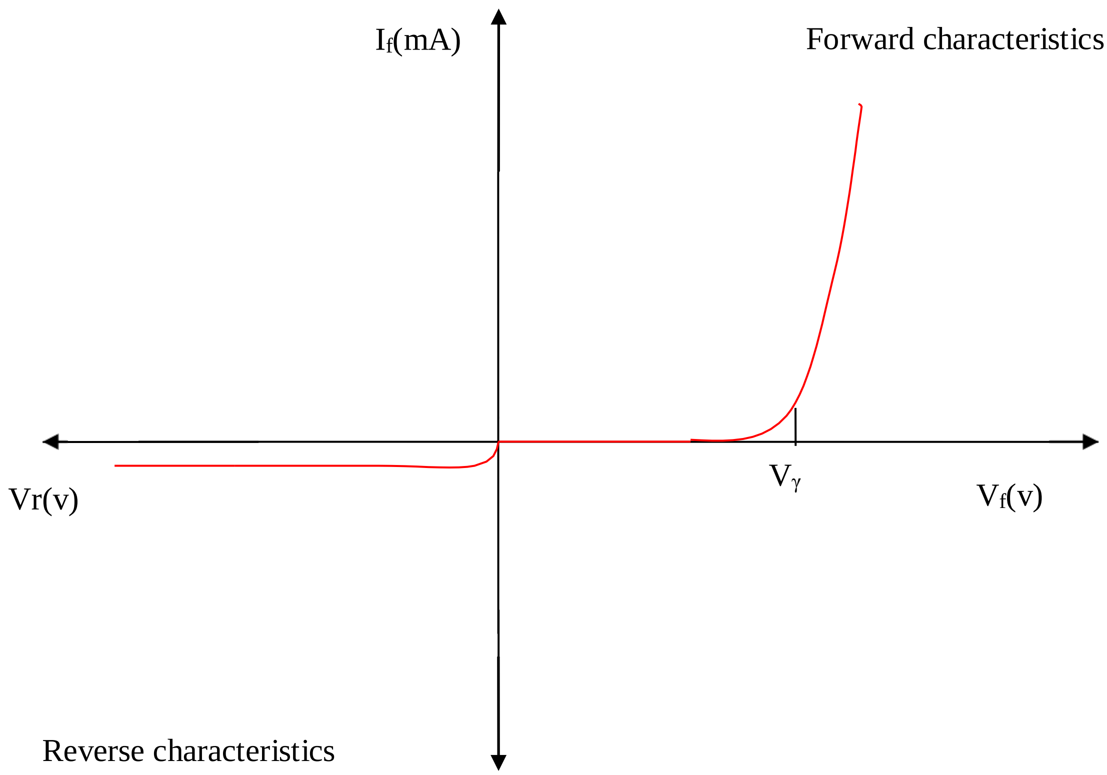
Tabular column

Forward Bias

S.No	V_S (Volts)	V_F (Volts)	I_F (mA)

Reverse Bias

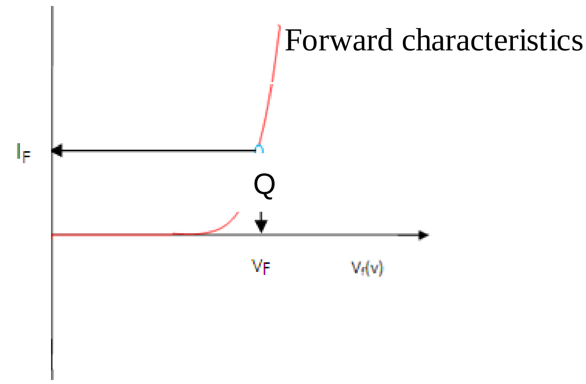
S.No	V_S (Volts)	V_R (Volts)	I_R (µA)



Model Graph

Calculations from the Graph

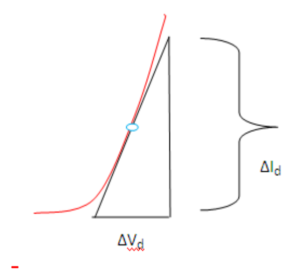
1. **Static Resistance:** To find the forward static resistance locate a point on characteristic curve obtained from the forward bias characteristics which is called operating point Q and draw a line onto the X-axis and Y-axis to obtain $V_F$and I_F Calculate static forward resistance



$R_F = V_F / I_F$

Dynamic Resistance: The dc resistance of a diode is independent of the shape of the characteristic in the region surrounding the point of interest. If a sinusoidal input is applied rather than a dc input ,the varying input will move the instantaneous operating point up and down a region of the characteristics and thus defines a specific change in current and voltage. To find the ac or dynamic resistance draw a straight line drawn tangent to the curve through the Q-point as shown in the figure will define a particular change in voltage and current that can be used to determine the ac or dynamic resistance for this region of the diode characteristics.

Dynamic Resistance r_d = —— Ω at Q-point



Precautions:

1. While doing the experiment do not exceed the ratings of the diode. This may lead to damage of thediode.
2. Connect voltmeter and Ammeter in correct polarities as shown in the circuitdiagram.
3. Do not switch **ON** the power supply unless you have checked the circuit connections as per the circuit diagram.

Result:

Thus the VI characteristic of PN junction diode is verified.

1. Cut in voltage = ………V
2. Static forward resistance= .... Ω
3. ac or Dynamic résistance= .... Ω

VIVA QUESTIONS:

1. When diode acts like ideal switch?
2. What is the cut in voltage? Give typical values for Ge andSi.
3. What is reverse saturation current?
4. What is Dynamic and static resistance?
5. What is V-I characteristicsequation?
6. Define potential barrier.
7. Define doping.
8. What is the effect of temperature onIco.
9. Define a Q point.
10. Explain how the diode can acts as a capacitor.

2. Zener diode characteristics

Objective:

1. To plot Volt-Ampere Characteristics of Zener Diode in reverse bias.
2. To find Zener Breakdown Voltage in reverse biased condition.

Apparatus:

S.No	Apparatus	Type	Range	Quantity
01	Zener diode	IMZ 5.1V		01
02	Resistance		470Ω	01
03	Regulated Power supply		(0-30V)	01
04	Ammeter		(0-200mA)	02
05	Voltmeter		(0-20V)	01
06	Decade Resistance Box		(0-10K)	01
07	Breadboard and Wires			

Introduction:

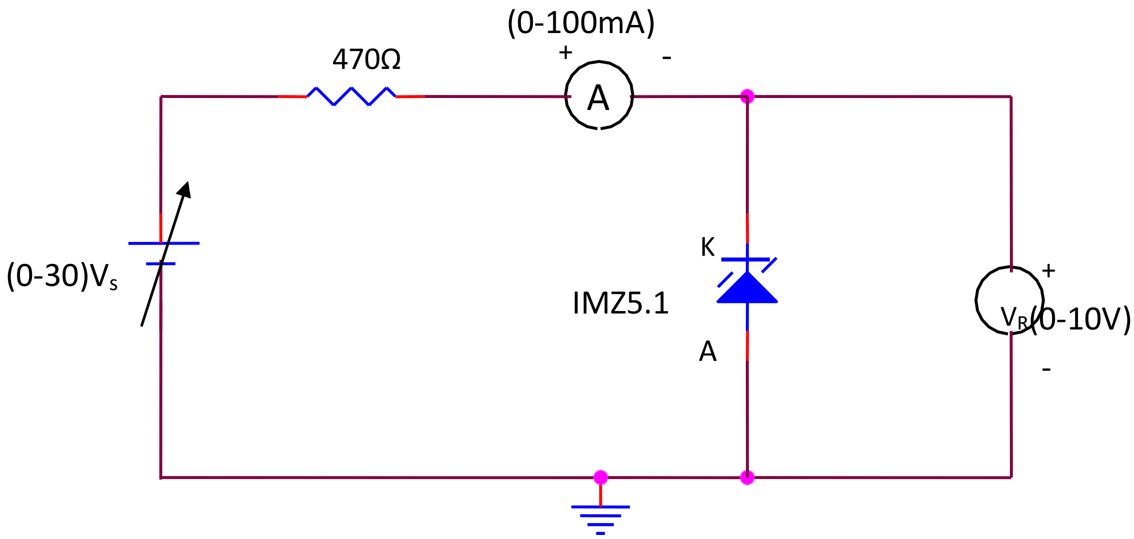
An ideal P-N Junction diode does not conduct in reverse biased condition. A **zener diode** conducts excellently even in reverse biased condition. These diodes operate at a precise value of voltage called break down voltage. A **zener diode** when forward biased behaves like an ordinary P-N junction diode.

A **zener diode** when reverse biased can either undergo **avalanche break down** or **zener break down**. **Avalanche break down**:-If both p-side and n-side of the diode are lightly doped, depletion region at the junction widens. Application of a very large electric field at the junction may rupture covalent bonding between electrons. Such rupture leads to the generation of a large number of charge carriers resulting in **avalanche multiplication**.

Zener break down:-If both p-side and n-side of the diode are heavily doped, depletion region at the junction reduces. Application of even a small voltage at the junction ruptures covalent bonding and generates large number of charge carriers. Such sudden increase in the number of charge carriers results in **zener mechanism**.

Circuit Diagram

Reverse Biased



Precautions:

1. While doing the experiment do not exceed the ratings of the diode. This may lead to damage of the diode.
2. Connect voltmeter and Ammeter in correct polarities as shown in the circuit diagram.
3. Do not switch **ON** the power supply unless you have checked the circuit connections as per the circuit diagram.

Experiment:

To plot V-I characteristics of Zener diode in reverse bias condition and to find Zener breakdown voltage

1. Connect the Zener diode in Reverse bias i.e; anode is connected to negative of the power supply and cathode is connected to positive of the power supply as in circuit.
2. Vary the input voltage in steps of 1V and note down reverse voltage(V_R) and the corresponding values of reverse current (I_R).
3. Plot the graph between reverse voltage (V_R) and the reverse current (I_R).

Tabular column

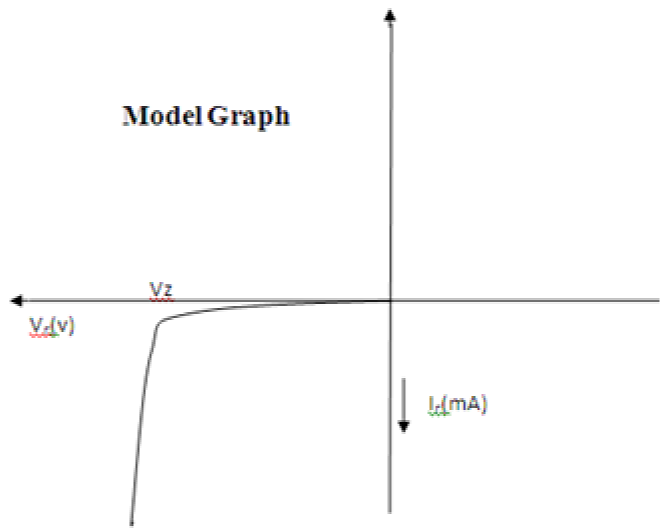
1. To plot V-I characteristics

S.No	V_s(V)	V_R(V)	I_R(mA)

Precautions:

Keeping the input voltage constant if the load resistance is increased zener current increases so as to make the load voltage to remain constant.

Model Graph:



Reverse characteristics

Calculations from Graph

To find Zener breakdown voltage

1. In the reverse characteristics of Zener diode observe the voltage at which the reverse current is abnormally increasing while the reverse voltage remain constant.
2. That particular reverse voltage is called the breakdown voltage of the Zener diode

Result

1. The V-I characteristics of Zener diode were plotted and the Zener breakdown voltage was determined and is given as ----- V
2. Load regulation characteristics were plotted.

VIVA QUESTIONS:

1. Difference between Zener and Avalanche breakdown.
2. What is the difference between zener and ordinary diode?
3. Draw equivalent circuit for Zener diode.
4. What is Breakdown voltage?
5. What are the applications of zener diode?
6. How zener acts as regulator?

3. Input and Output Characteristics of a BJT in CB Configuration

Objective:

To plot the input and output characteristics of a transistor in CB Configuration and to compute the h – parameters.

Apparatus

S.No	Apparatus	Type	Range	Quantity
01	Transistor	BC107		01
02	Resistance		1KΩ	02
03	Regulated Power supply		(0-30V)	02
04	Ammeter		(0-200mA)	02
05	Voltmeter		(0-20V)	02
06	Breadboard and Wires			

Introduction:

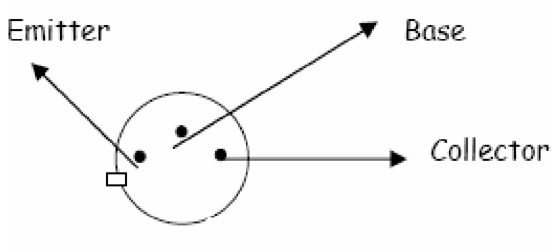
Bipolar junction transistor (BJT) is a 3 terminal (emitter, base, collector) semiconductor device. There are two types of transistors namely NPN and PNP. It consists of two P-N junctions namely emitter junction and collector junction.

In Common Base configuration the input is applied between emitter and base and the output is taken from collector and base. Here base is common to both input and output and hence the name common base configuration.

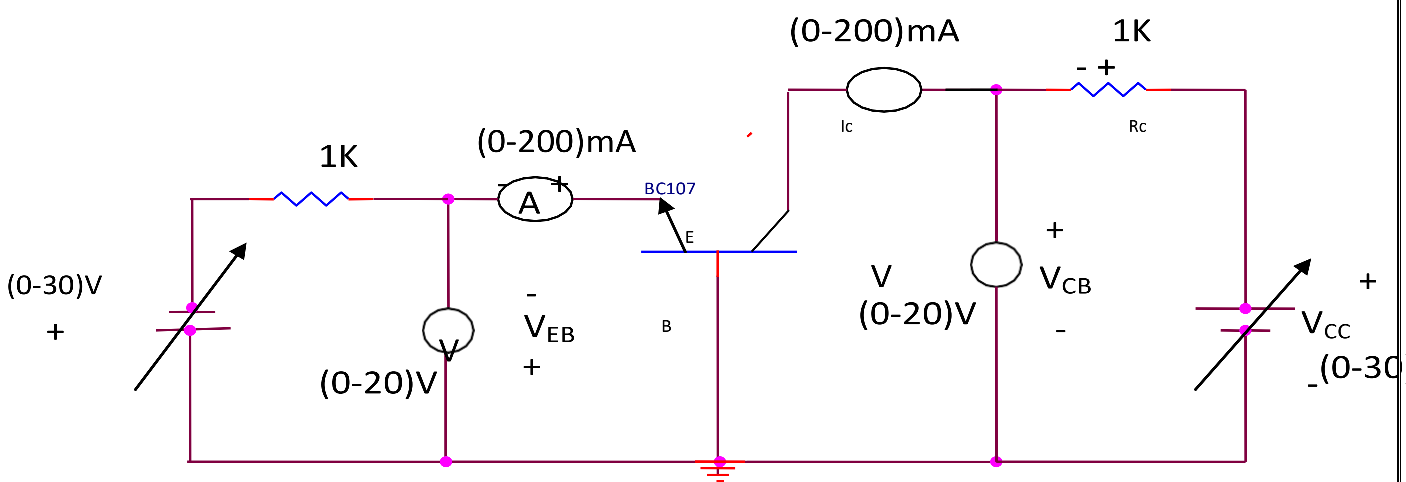
Input characteristics are obtained between the input current and input voltage taking output voltage as parameter. It is plotted between V_{EB} and I_E at constant V_{CB} in CB configuration.

Output characteristics are obtained between the output voltage and output current taking input current as parameter. It is plotted between V_{CB} and I_C at constant I_E in CB configuration.

PIN Assignment



Circuit Diagram



Precautions:

1. While doing the experiment do not exceed the ratings of the transistor. This may lead to damage the transistor.
2. Connect voltmeter and Ammeter in correct polarities as shown in the circuit diagram.
3. Do not switch **ON** the power supply unless you have checked the circuit connections as per the circuit diagram.
4. Make sure while selecting the emitter, base and collector terminals of the transistor.

Experiment Procedure

Input Characteristics

1. Connect the transistor in CB configuration as per circui tdiagram
2. Keep output voltage V_{CB} = 0V by varying V_{CC}.
3. By varying V_{EE} , vary V_{EB}in steps of 0.1V and note down emitter current I_E.
4. Repeat above procedure (step 3) for various values of V_{CB} (V_{CB}=5V and V_{CB}=10V)

Output Characteristics

1. Make the connections as per circuit diagram.
2. By varying V_{EE} keep the base current I_E=10mA.
3. By varying V_{CC} ,vary V_{CB}in steps of 1V and note down the readings of collector-current(I_C).
4. Repeat above procedure (step 3) for different values of I_E(I_E=15mA &I_E=20mA)

Tabular column

Input Characteristics

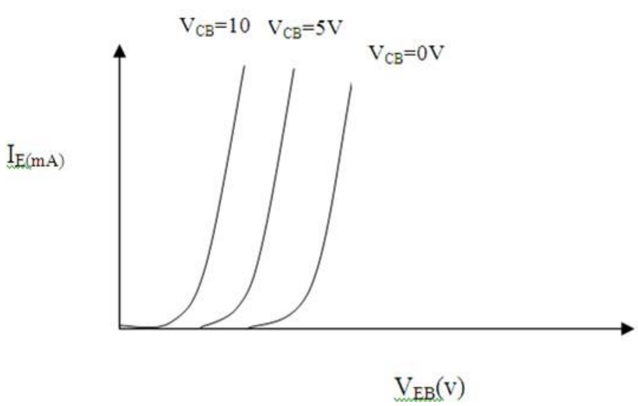
V_{CB}= 0 V		V_{CB}= 5V		V_{CB} = 10 V	
V_{EB} (V)	I_E(mA)	V_{EB} (V)	I_E (mA)	V_{EB} (V)	I_E (mA)

Output Characteristics

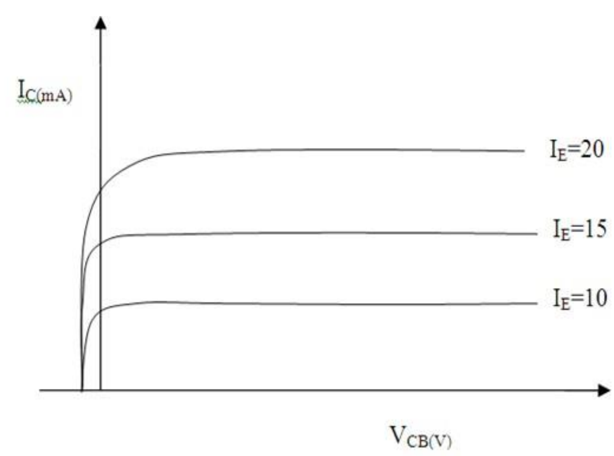
I_E = 10 mA		I_E = 15 mA		I_E = 20 mA	
V_{CB} (V)	I_C (mA)	V_{CB} (V)	I_C (mA)	V_{CB} (V)	I_C (mA)

Model Graph

Input characteristics



Output characteristics



Calculations from the Graph

Input characteristics

a) Input impedance(h_{ib})= ΔV_{EB} / ΔI_E , V_{CB} constant.

b) Reverse voltage gain(h_{rb})= ΔV_{EB}/Δ V_{CB} , I_E constant

Output characteristics

a) Output admittance(h_{ob})= ΔIc / Δ V_{CB} , I_E constant

b) Forward current gain(h_{fb})= ΔIc / ΔI_E , V_{CB} constant

Result:

Thus the input and output characteristics of CB configuration are plotted and h parameters are found.

a) Input impedance(h_{ib})=

b) Forward current gain(h_{fb})=

c) Output admittance(h_{ob})=

d) Reverse voltage gain(h_{rb})=

VIVA QUESTION:

1. What is Early effect?
2. Draw the small signal model of BJT Common Base Configuration.
3. What is Reach –Through effect?
4. What are the applications of Common Base.
5. What will be the parameters of CB.
6. Explain the Transistor operation?

4. Input and Output Characteristics of a BJT in CB Configuration

Objective :

To plot the input and output characteristics of a transistor in CE Configuration and to compute the h – parameters.

Apparatus

S.No	Apparatus	Type	Range	Quantity
01	Transistor	BC107		01
02	Resistance		100KΩ,1KΩ	01
03	Regulated Power supply		(0-30V)	01
04	Ammeter		(0-200mA),(0-200µA)	01
05	Voltmeter		(0-20V)	01
06	Breadboard and Wires			

Introduction:

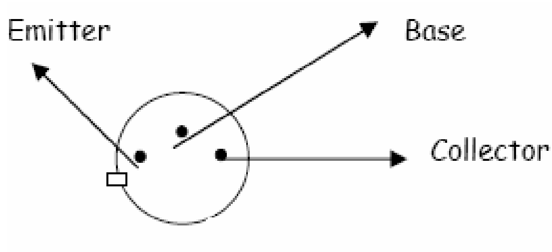
Bipolar junction transistor (BJT) is a 3 terminal (emitter, base, collector) semiconductor device. There are two types of transistors namely NPN and PNP. It consists of two P-N junctions namely emitter junction and collector junction.

In Common Emitter configuration the input is applied between base and emitter and the output is taken from collector and emitter. Here emitter is common to both input and output and hence the name common emitter configuration.

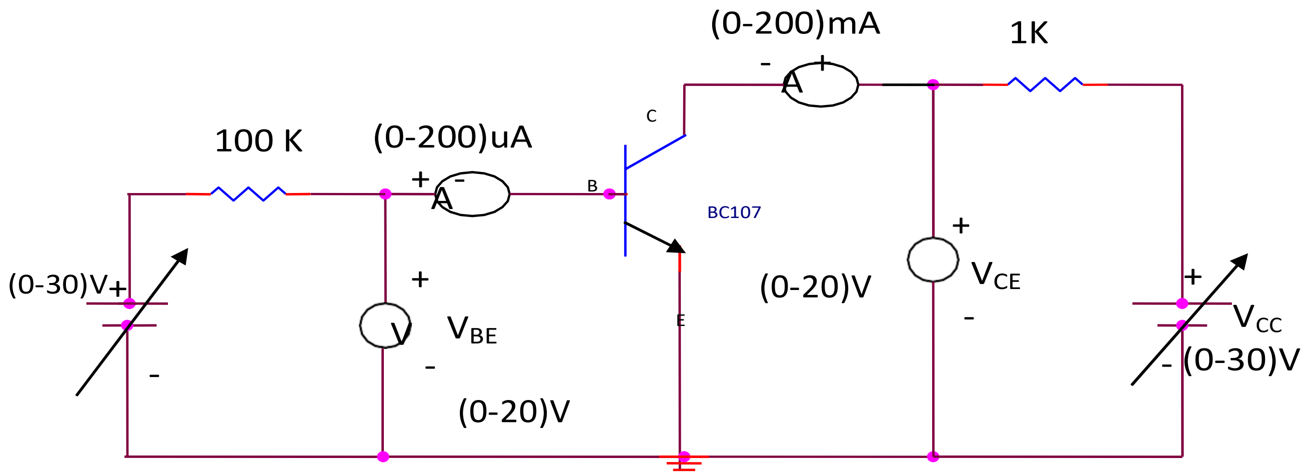
Input characteristics are obtained between the input current and input voltage taking output voltage as parameter. It is plotted between V_{BE} and I_B at constant V_{CE} in CE configuration.

Output characteristics are obtained between the output voltage and output current taking input current as parameter. It is plotted between V_{CE} and I_C at constant I_B in CE configuration.

PIN Assignment



Circuit Diagram



Precautions:

1. While doing the experiment do not exceed the ratings of the transistor. This may lead to damage the transistor.

2. Connect voltmeter and Ammeter in correct polarities as shown in the circuit diagram.

3. Do not switch **ON** the power supply unless you have checked the circuit connections as per the circuit diagram.

4. Make sure while selecting the emitter, base and collector terminals of the transistor.

Experiment procedure

Input Characteristics

1. Connect the transistor in CE configuration as per circuit diagram
2. Keep output voltage V_{CE} = 0V by varying V_{CC}.
3. By varying V_{BB} ,vary V_{BE}in steps of 0.1V and note down base current I_B.
4. Repeat above procedure (step 3) for various values of V_{CE}(V_{CE}=5V and V_{CE}=10V)
5. Plot the input characteristics by taking V_{BE} on X-axis and I_B on Y-axis at constant V_{CE}.

Output Characteristics

1. Make the connections as per circuit diagram.
2. By varying V_{BB} keep the base current I_B =0µA.
3. By varying V_{CC} , vary V_{CE}in steps of 1V and note down the readings of collector-current(I_C)
4. Repeat above procedure (step 3) for different values of I_B
5. Plot the output characteristics by taking V_{CE} on x-axis and I_C on y-axis by taking I_B as a constant parameter.

Tabular column

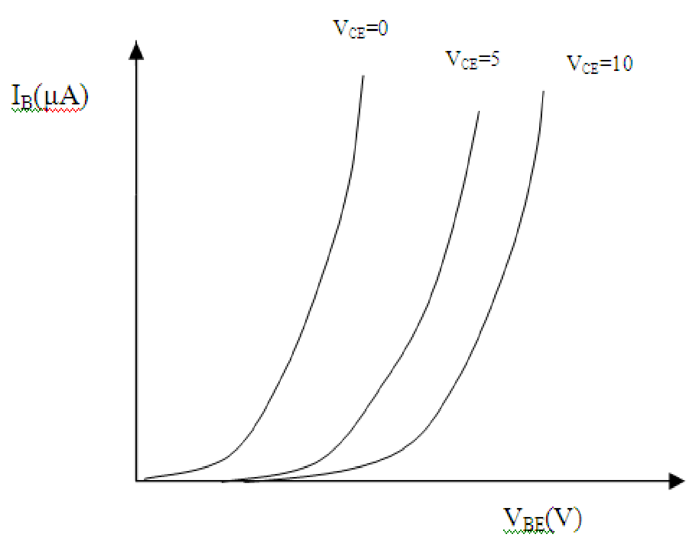
Input Characteristics

V_{CE}= 0 V		V_{CE}= 5 V		V_{CE} = 10 V	
V_{BE} (V)	I_B (µA)	V_{BE} (V)	I_B (µA)	V_{BE} (V)	I_B (µA)

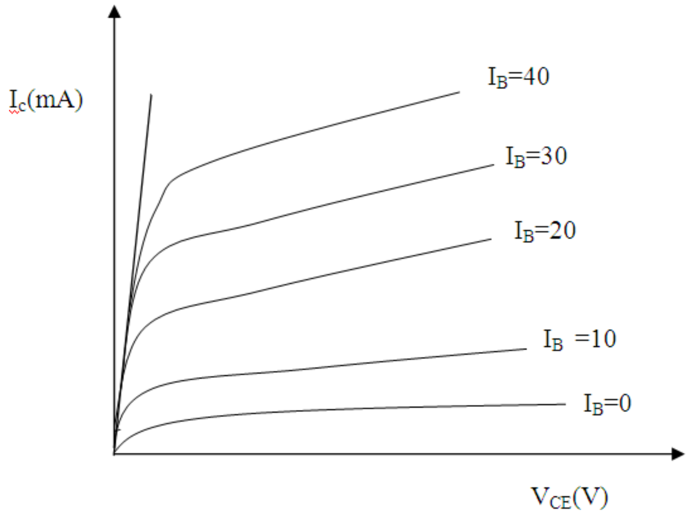
Output Characteristics

I_B = 0 µA		I_B = 10 µA		I_B = 20 µA	
V_{CE} (V)	I_C (mA)	V_{CE} (V)	I_C (mA)	V_{CE} (V)	I_C (mA)

Model Graph



Input characteristics



Output characteristics

Calculations from graph:

Input characteristics

a) Input impedance(h_{ie})= $\Delta V_{BE} / \Delta I_B$, V_{CE} constant.

b) Reverse voltage gain(h_{re})= $\Delta V_{BE}/\Delta V_{CE}$, I_B constant

Output characteristics

a) Output admittance(h_{oe})= $\Delta Ic / \Delta V_{CE}$, I_B constant

b) Forward current gain(h_{fe})= $\Delta Ic / \Delta I_B$, V_{CE} constant

Result:

Thus the input and output characteristics of CE configuration is plotted.

a) Input impedance(h_{ie})=

b) Forward current gain(h_{fe})=

c) Output admittance(h_{oe})=

d) Reverse voltage gain(h_{re})=

VIVA QUESTION:

1. Why CE configuration is most widely used?
2. Draw the equivalent Circuit ofC.E
3. What is the Current Gain,voltagegain,i/p and o/p impedance inCE?.
4. Relation between„α‟ and„β‟ andγ
5. Give the condition to operate the given Transistor in active, saturation &Cut-offRegions
6. What is Emitter Efficiency?

5. FET characteristics

Objective

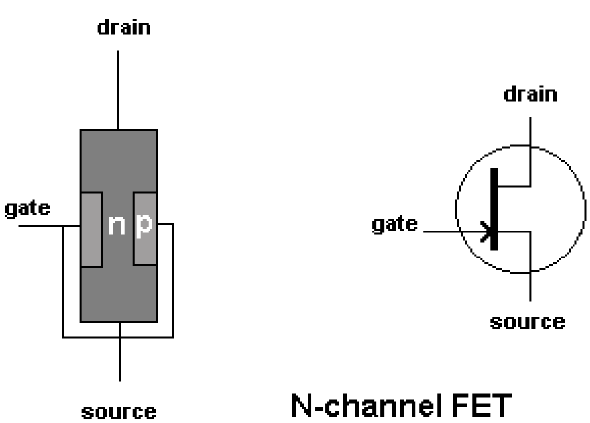
1.To study Drain characteristics and Transfer characteristics

2.To find the Transconductance ,Drain resistance and Amplification factor

Apparatus

S.No	Apparatus	Type	Range	Quantity
01	JFET	BFW10		01
02	Resistance		1KΩ	01
03	Regulated Power supply		(0-30V)	01
04	Ammeter		(0-200mA)	01
05	Voltmeter		(0-20V)	02
06	Breadboard and Wires			

Introduction:



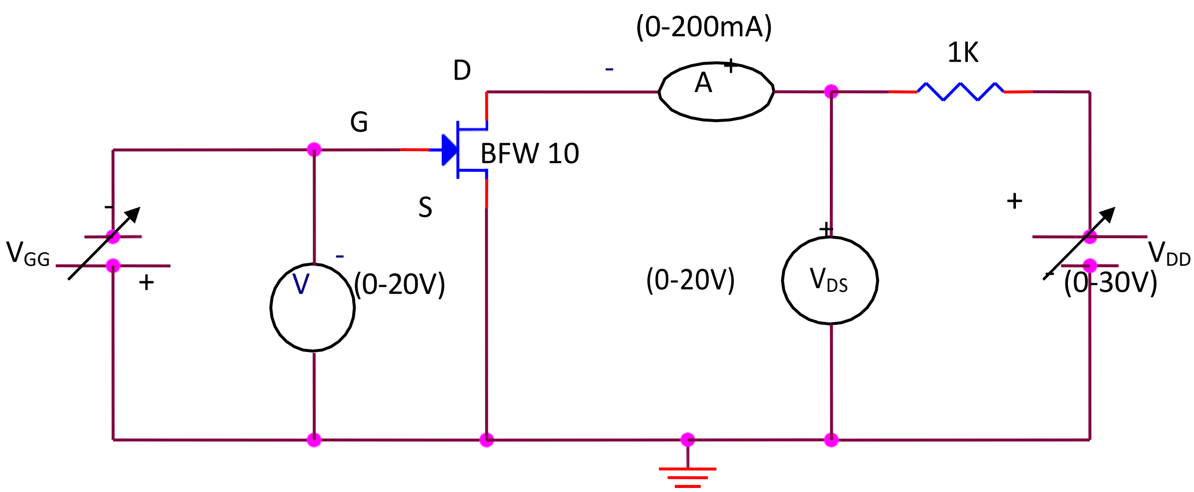
N-channel FET

The field effect transistor (FET) is made of a bar of N type material called the SUBSTRATE with a P type junction (the gate) diffused into it. With a positive voltage on the drain, with respect to the source, electron current flows from source to drain through theCHANNEL.

If the gate is made negative with respect to the source, an electrostatic field is created which squeezes the channel and reduces the current. If the gate voltage is high enough the channel will be "pinched off" and the current will be zero. The FET is voltage controlled, unlike the transistor which is current controlled. This device is sometimes called the junction FET or IGFET or JFET.

If the FET is accidentally forward biased, gate current will flow and the FET will be destroyed. To avoid this, an extremely thin insulating layer of silicon oxide is placed between the gate and the channel and the device is then known as an insulated gate FET, or IGFET or metal oxide semiconductor FET (MOSFET) Drain characteristics are obtained between the drain to source voltage (V_{DS}) and drain current (I_D) taking gate to source voltage (V_{GS}) as the parameter. Transfer characteristics are obtained between the gate to source voltage (V_{GS}) and Drain current (I_D) taking drain to source voltage (V_{DS}) as parameter

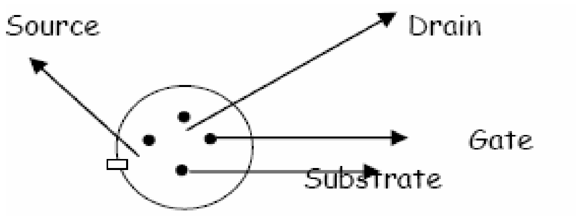
Circuit Diagram



(0-30V) GS

\+ -

Pin assignment of FET:



Precautions:

1. While doing the experiment do not exceed the ratings of the FET. This may lead to damage the FET.
2. Connect voltmeter and Ammeter in correct polarities as shown in the Circuit diagram.
3. Do not switch ON the power supply unless you have checked the Circuit connections as per the circuit diagram.
4. Make sure terminals of the FET.

Experiment:

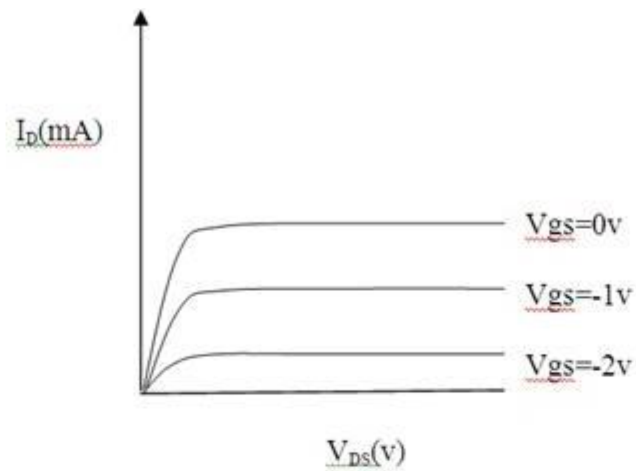
Drain characteristics

1. By Varying V_{GG} keep V_{GS} = 0v.
2. By varying V_{DD} , vary V_{DS} in steps of 0.5V and note down corresponding I_D
3. Repeat the above procedure for different values of V_{GS} (i.e. V_{GS}=-1V & V_{GS}=-2V)
4. Plot its characteristics with respect to V_{DS} versus I_D

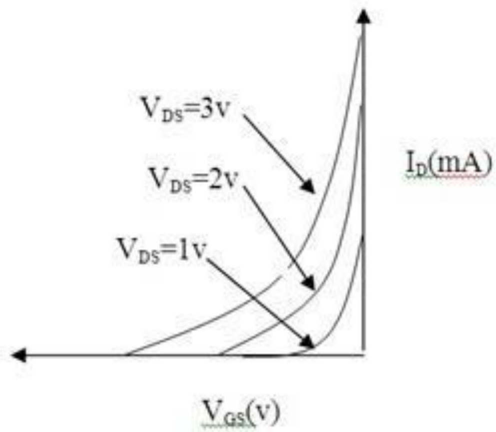
Transfer characteristics:

1. By Varying V_{DD} keep V_{DS} = 1v.
2. By varying V_{GG} , vary V_{GS} in steps of 0.5V and note down corresponding I_D
3. Repeat the above procedure for different values of V_{DS} (i.e. V_{DS}=2V & V_{DS}=3V)
4. Plot its characteristics with respect to V_{GS} versus I_D

Model Graph



Drain characteristics



Transfer Characteristics

Tabular column

Drain Characteristics

V_{GS} = 0V		V_{GS} = -1V		V_{GS} = -2V	
V_{DS}(V)	I_D (mA)	V_{DS} (V)	I_D (mA)	V_{DS} (V)	I_D (mA)

Transfer Characteristics

V_{DS} = 1V		V_{DS} = 3V		V_{DS} = 5V	
V_{GS}(V)	I_D (mA)	V_{GS} (V)	I_D (mA)	V_{GS} (V)	I_D (mA)

Graph (Instructions):

1. Plot the drain characteristics by taking V_{DS} on X-axis and I_D on Y-axis at constant V_{GS}.
2. Plot the Transfer characteristics by taking V_{GS} on X-axis and I_D on Y-axis at constant V_{DS}.

Calculations from graph:

Drain characteristics

Drain resistance is given by the ration of small change in drain to source voltage (ΔV_{DS}) to the corresponding change in Drain current (ΔI_D) for a constant gate to source voltage (V_{GS}), when the JFET is operating in pinch-off or saturation region.

Drain resistance (r_d) =

Amplification Factor (μ) :

It is given by the ratio of small change in drain to source voltage (ΔV_{DS}) to the corresponding change in gate to source voltage (ΔV_{GS}) for a constant drain current.

$\mu = \Delta V_{DS} / \Delta V_{GS}$.

$\mu = (\Delta V_{DS} / \Delta I_D) X (\Delta I_D / \Delta V_{GS})$

$\mu = r_d X g_m$.

Result

Drain resistance (r_d) =

Mutual conductance

(g_m) = Amplification

factor(μ)=

Viva Questions:

1 .What is meant by Field Effect Transistor?

2. What is meant by Uniploar and bipolar?

3. What is the difference between BJT and FET?

4. What are the characteristics of FET

5. What is Pinch Off Voltage?

6. Why FET is called Voltage controlled Device?

7. Draw Small Signal model of FET.

8. What are the advantages of FET?

6.Study and verification of Basic Gates(AND,OR &NOT)

Aim: To study and verify the Truth Tables of AND, OR, NOT logic gates

Components: IC 7408,7432,7404
Apparatus: Prototyping board (breadboard), DC Power Supply, Connecting Wires

Theory:

AND, OR and NOT gates are **basic gates**. NAND and NOR are **universal gates**. Basically logic gates are electronic circuits because they are made up of number of electronic devices and components. Inputs and outputs of logic gates can occur only in two levels. These two levels are term HIGH and LOW, or TRUE and FALSE, or ON AND off, OR SIMPLY 1 AND 0. A table which lists all possible combinations of input variables and the corresponding outputs is called a „truth table‟. It shows how the logic circuit‟s output responds to various combinations of logic levels at the inputs.

AND GATE:-

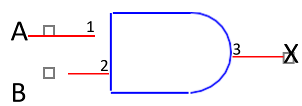
An AND gate has two or more inputs but only one output. The output assumes the logic 1 state only when each one of its inputs is at logic 1 state. The output assumes logic 0 state even if one of its input is at logic 0 state. AND gate is also called an „all or nothing‟ gate.

The logic symbol & truth table of two input AND gate are shown in figure 1.a & 1.b respectively. The symbol for AND operation is „.‟.

With input variables A & B the Boolean expression for output can be written as;

$$X = A.B$$

Logicsymbol:

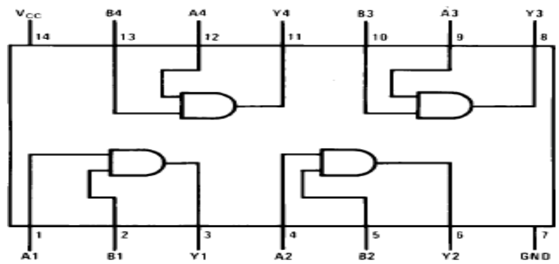


X =AB

Truthtable:

Input		Output
A	B	X
0	0	0
0	1	0
1	0	0
1	1	1

Pin diagram of IC**74LS08**:



OR GATE

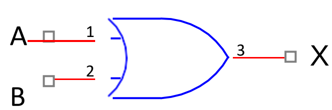
Like an AND gate, an OR gate may have two or more inputs but only one output. The output assumes the logic 1 state, even if one of its inputs is in logic 1 state. Its output assumes logic 0 state, only when each one of its inputs is in logic 0 state. OR gate is also called an „any or all" gate. It can also be called an inclusive OR gate because it includes the condition „both the input can be present".

The logic symbol & truth table of two input OR gate are shown in figure 1.c & 1.d respectively. The symbol for OR operation is „+".

With input variables A & B the Boolean expression for output can be written as;

$$X = A + B$$

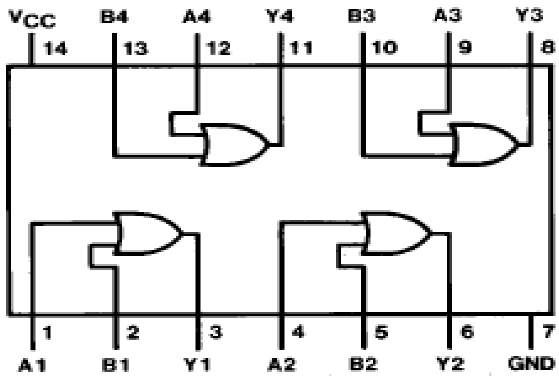
Logicsymbol:



Truthtable:

Input		Output
A	**B**	**X**
0	0	0
0	1	1
1	0	1
1	1	1

Pin diagram of IC**74LS32**:



NOT GATE

A NOT gate is also known an inverter, has only one input and only one output. It is a device whose output is always the complement of its input. That is the output of a not gate assumes the logic 1 state when its input is in logic 0 state and assumes the logic 0 state when its input is in logic 1 state.

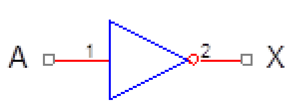
The logic symbol & truth table of NOT gate are shown in figure 1.e & 1.f respectively. The symbol for NOT operationis „-„-‟(bar).

With input variable A the Boolean expression for output can be written as;

–

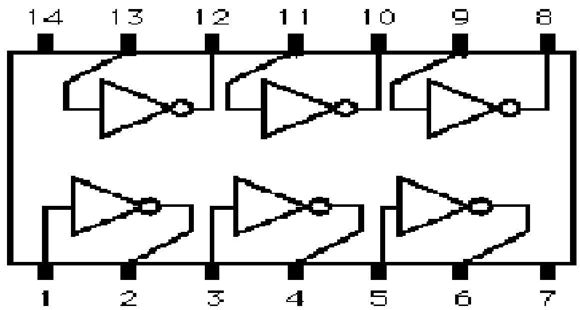
This is read as “X is equal to a bar”.

Logic symbol: Truth table:



Input	Output
A	**X**
0	1
1	0

Pin diagram for IC**74LS04**:



Results and Analysis:

NOT Gate: When logic 1 is applied to one of NOT gate of 7404 IC, then output becomes zero. When input LED is ON (RED), the output LED become OFF (Green) vice versa.

OR Gate: The output of an OR gate is a 1 if one or the other or both of the inputs are 1, but a 0 if both inputs are 0. When One or the other or Both of the input LEDS are ON (RED Light), then output LED is ON(RED) otherwise Output LED is OFF(Green Light)

AND Gate: The output of an AND gate is only 1 if both its inputs are 1. For all other possible inputs the output is 0.When both the LEDS are On, then output LED is ON (RED Light) otherwise Output LED is OFF.

Conclusion: Any Boolean expression can be realized using NOT, AND, ORgates.

7. Study and verification of Universal Gates (NAND &NOR)

Aim: To study and verify the Truth Tables of AND, OR, NOT, NAND, NOR, EXOR logic gates

Components: IC 7400, 7402

Apparatus: Prototyping board (breadboard), DC Power Supply, Connecting Wires

Theory:

AND, OR and NOT gates are **basic gates**. NAND and NOR are **universal gates**. Basically logic gates are electronic circuits because they are made up of number of electronic devices and components. Inputs and outputs of logic gates can occur only in two levels. These two levels are term HIGH and LOW, or TRUE and FALSE, or ON AND off, OR SIMPLY 1 AND 0. A table which lists all possible combinations of input variables and the corresponding outputs is called a „truth table‟. It shows how the logic circuit‟s output responds to various combinations of logic levels at the inputs.

NAND GATE

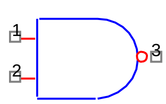
NAND gate is universal gate. It can perform all the basic logic function. NAND means NOT AND that is, AND output is NOTed.so NAND gate is combination of an AND gate and a NOT gate. The output is logic 0 level, only when each of its inputs assumes a logic 1 level. For any other combination of inputs, the output is logic 1 level. NAND gate is equivalent to a bubbled OR gate.

The logic symbol & truth table of two input NAND gate are shown in figure

With input variables A & B the Boolean expression for

output can be written as;

Logic symbol:



A

X

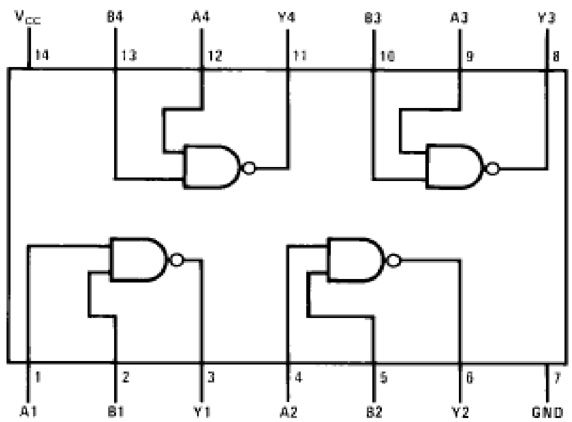
B

$X = \overline{AB}$

Truthtable:

Input		Output
A	B	X
0	0	1
0	1	1
1	0	1
1	1	0

Pin diagram for IC**74LS00**:

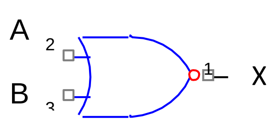


NOR GATE

NOR gate is universal gate. It can perform all the basic logic function. NOR means NOT OR that is, OR output is NOTed.so NOR gate is combination of an OR gate and a NOT gate. The output is logic 1 level, only when each of its inputs assumes a logic 0 level. For any other combination of inputs, the output is logic 0 level. NOR gate is equivalent to a bubbled AND gate. The logic symbol & truth table of two inputs NOR gate are shown in figure . With input variables A & B the Boolean expression for output can be written as;

–

Logic symbol:

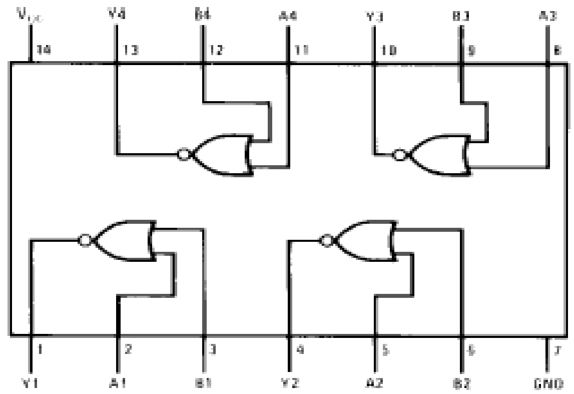


$X = \overline{A + B}$

Truth table:

Input		Output
A	**B**	**X**
0	0	1
0	1	0
1	0	0
1	1	0

Pin diagram for IC**74LS02**:



Results and Analysis:
NOR Gate: The output of the NOR gate is a 1 if both inputs are 0 but a 0 if one or the other or both the inputs are 1.
NAND Gate: The output of the NAND gate is a 0 if both inputs are 1 but a 1 if one or the other or both the inputs are0.

Conclusion: Any Boolean expression can be realized using NAND,NOR, gates.

8.Implementation of the given Boolean function using logic gates

AIM: To Realize the Given Function Using Basic Gates

F(w,x,y,z)=∑(0,1,2,3,4,5,6,9,10,11,12,13)

APPARATUS:

i) IC74LS04(NOT Gate)
ii) IC74LS08 (two input AND gate)
iii) IC74LS32 (two input OR gate)
iv) Connecting Wires

MINIMIZATION

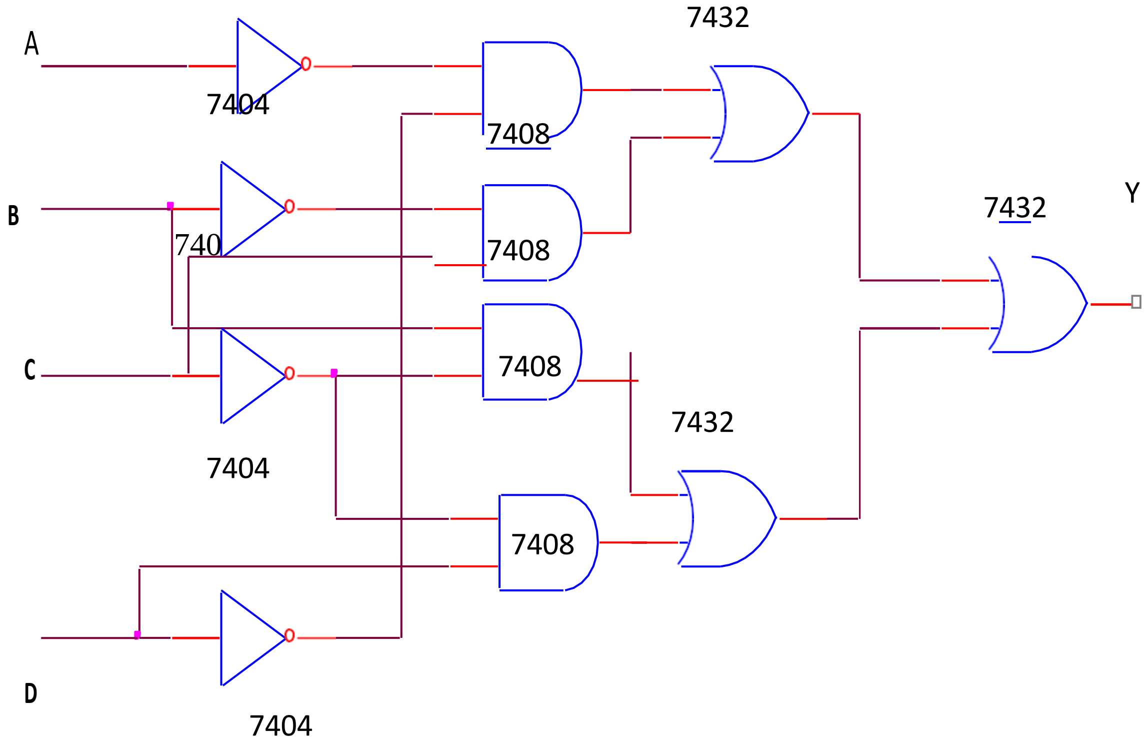
AB/CD	C'D'	C'D	CD	CD'
A'B'	1	1	1	1
A'B	1	1	0	1
AB	1	1	0	0
AB'	0	1	1	1

$$Y = C^{I} D + C^{I} B + B^{I} C + A^{I} D^{1}$$

PROCEDURE:

1. The given function minimized using karnaugh maps.
2. Implement the logic diagram with truth table
3. Verify the Boolean function experimentally basic gates.
4. The truthtables are to be verified.

LOGICCIRCUIT



Viva Questions:

.What is SOP?

The logical sum of the several product variables is called sum of product. It is basically an OR operation of AND operated variables.

Y=AB+BC+CA

2. What is POS?

The logical product of the several sum variables is called product of sum. It is basically an AND operation o f OR operated variables.

Y=(A+B)(B+C)(C+A)

3. State DeMorgan's theorem?

The first theorem states that the complement of a product/sum is equal to the sum/product of the complements.

4. What is Minterm?

Product term containing allthepossiblevariablesofthefunctionineithercomplementoruncomplimentaryformis called Minterm.

5. What is Maxterm?

Sum term containing all the possible variables of the function in either complement o un complimentary form is called Maxterm

9. Realization of Half Adder& Full Adder using Basic gates

Aim: - To realize half/full adder **Using X-OR and basicgates**

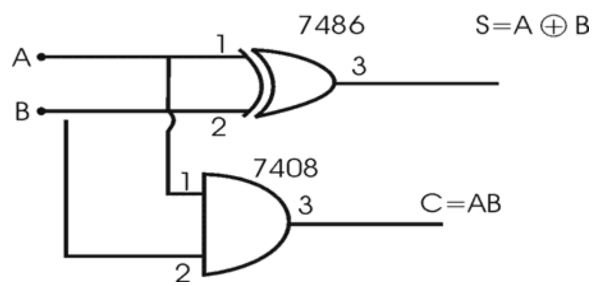
Apparatus Required: -

IC 7486, IC 7432, IC 74 08, IC 7400, etc.

Procedure: -

1. **Verify the gates.**
2. **Make the connections as per the circuit diagram.**
3. **Switch on V_{CC} and apply various combinations of input according to the truthtable.**
4. **Note down the output readings for r half/full adder and half/full sum and the carry bit for different combinations of inputs.**

Half Adder using basic gates:-

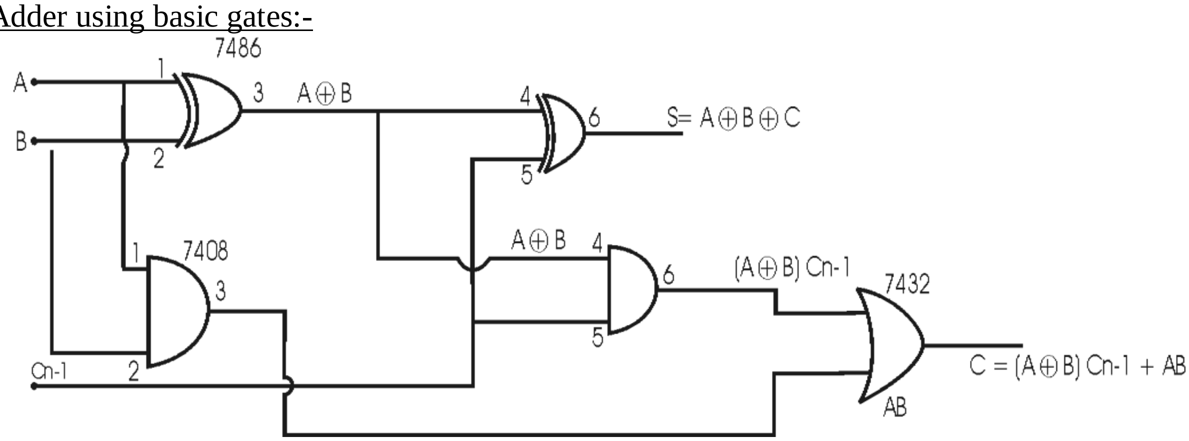


$$S = \bar{A}B + A\bar{B}$$

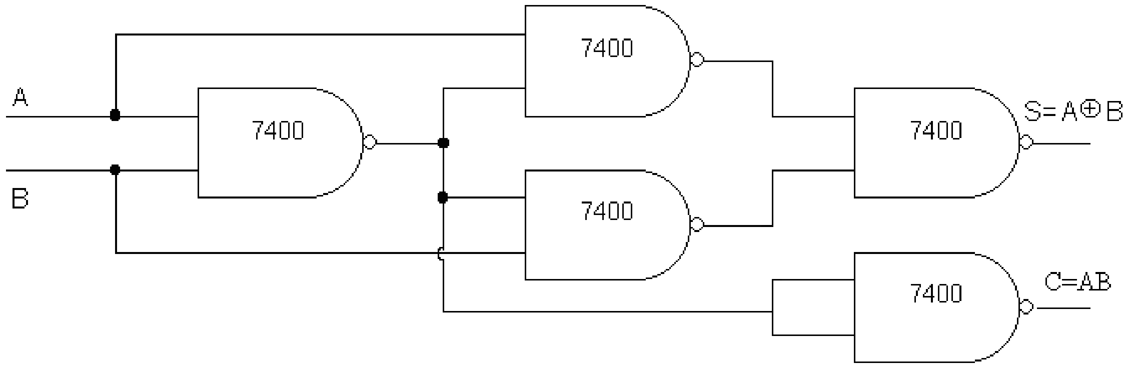
$$S = A \oplus B$$

$$C = AB$$

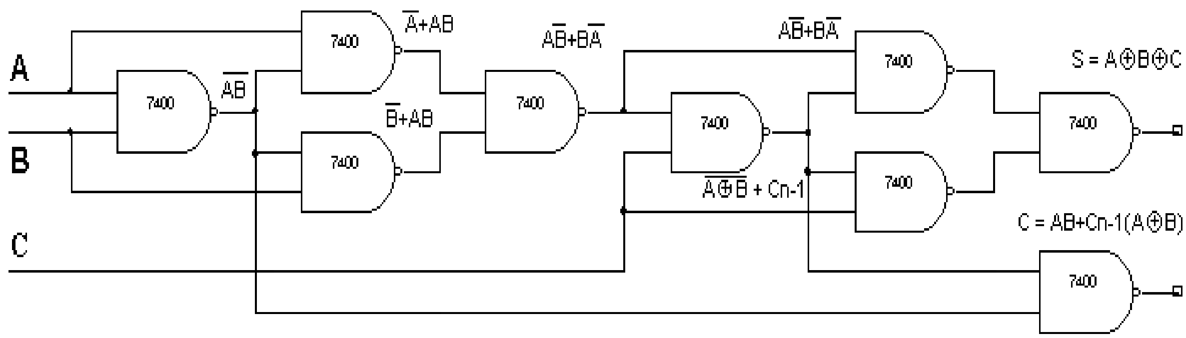
Full Adder using basic gates:-



HalfAdderusingNANDgatesonly:-



FullAdderusingNANDgatesonly:-



Half Adder

A	B	Sum	Carry
0	0		
0	1		
1	0		
1	1		

Full Adder

A	B	C_{in}	Sum	C_{out}
0	0	0		
0	0	1		
0	1	0		
0	1	1		
1	0	0		
1	0	1		
1	1	0		
1	1	1		

Result:

Half adder and Full Adder using basic gates truthtable verified.

10.Realization of Half subtractor& Full subtractor using Basic gates

<u>Aim</u>: - To realize half/full subtractor **Using X-OR and basic gates**

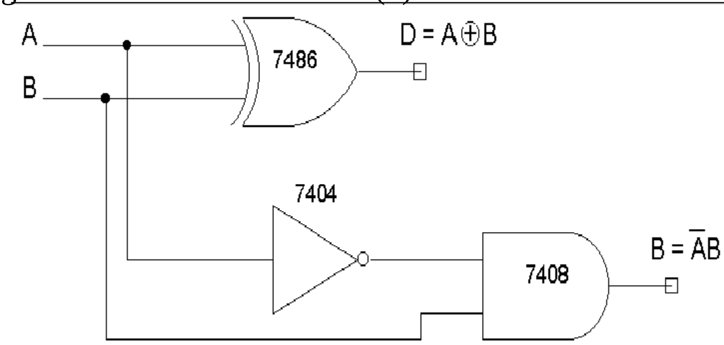
<u>Apparatus Required: -</u>

IC 7486, IC 7432, IC 74 08, IC 7400, etc.

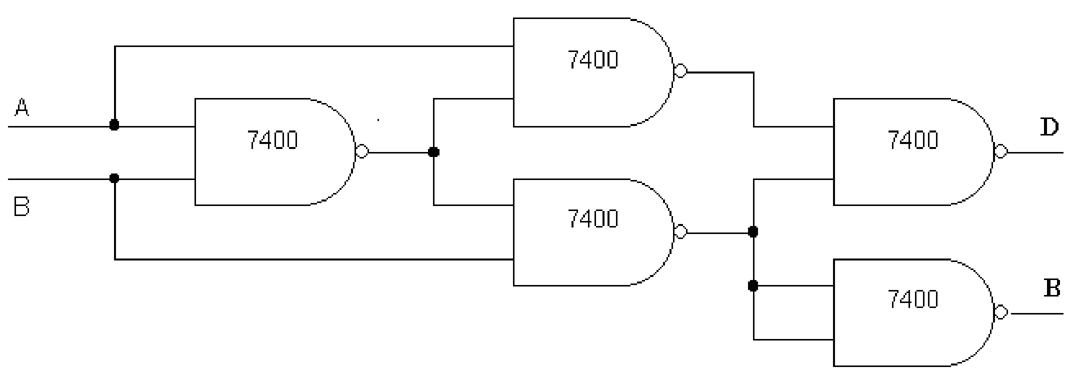
<u>Procedure: -</u>

5. **Verify thegates.**
6. **Make the connections as per the circuit diagram.**
7. **Switch on V_{CC} and apply various combinations of input according to the truthtable.**
8. **Note down the output readings for half/full subtractor difference and the borrow bit for different combinations of inputs.**

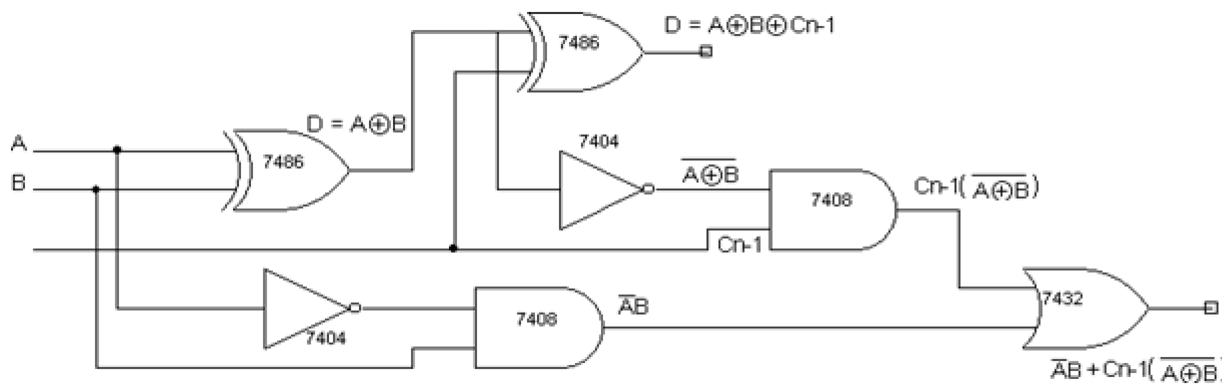
Using X – OR and Basic Gates (a)HalfSubtractor



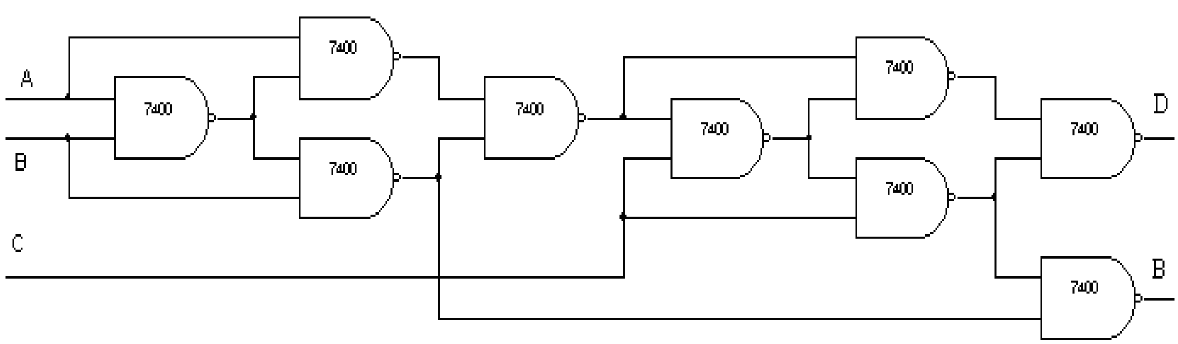
<u>Using only NANDgates (a) Halfsubtractor</u>



Full Subtractor



Using only NANDgates: Fullsubtractor



Half Subtractor

A	B	D	Barow
0	0		
0	1		
1	0		
1	1		

Full Subtractor

A	B	B_{in}	Difference	B_{out}
0	0	0		
0	0	1		
0	1	0		
0	1	1		
1	0	0		
1	0	1		
1	1	0		
1	1	1		

Result:

Half Subtractor and Full Subtractor using basic gates truthtable verified.

11.Multiplexer and Demultiplexer

Aim: To construct the circuit of multiplexer and to study their working

Componentsrequiredandtheirpurpose

Component	Specification	Quantity
NOT gate	74LS04/74HCT04	1
3-inputANDgate	74LS11/74HCT11	1
2-inputORgate	74LS32/74HCT32	1
Digital IC trainerkit		1

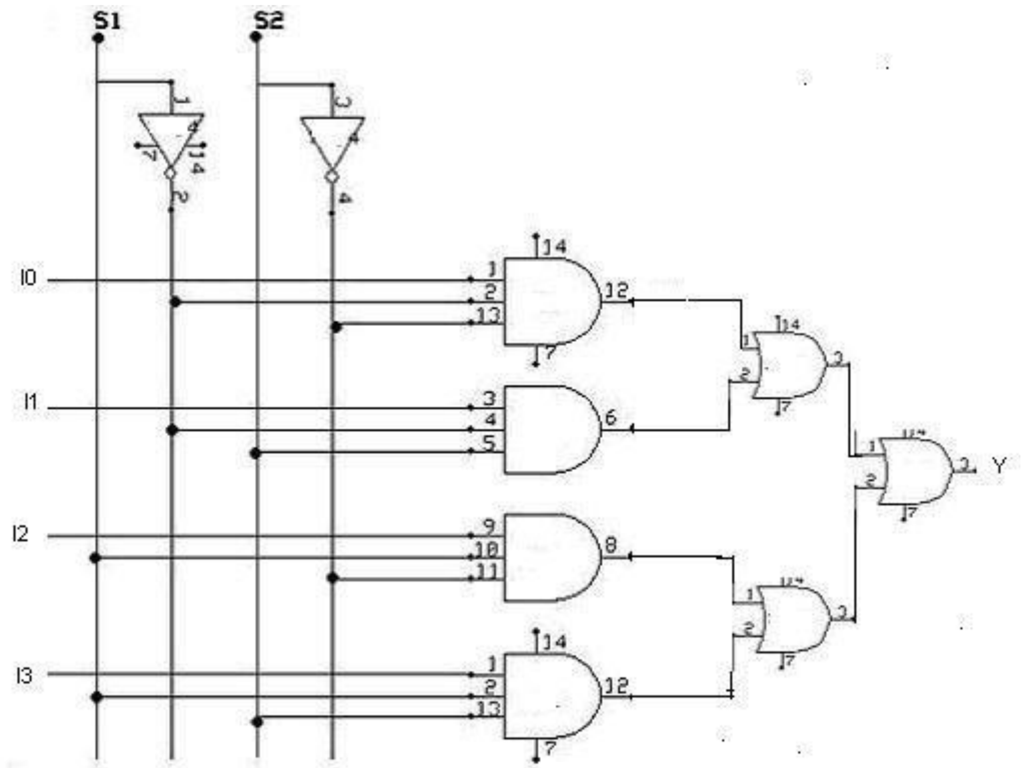
Theory:

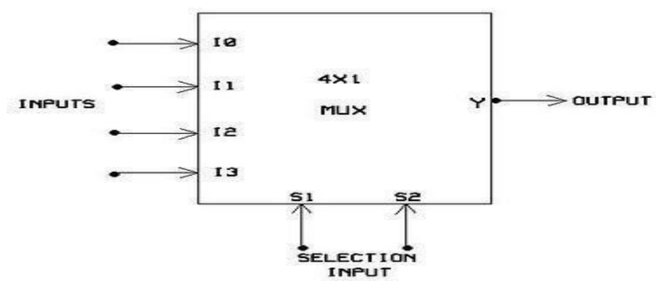
- Multiplexerhasmanyinputsand onlyoneoutput.
- Theselectionofaparticularinputlineiscontrolledbyselectlines.
- Fourinputsrequire2selectlines(n=4,x=$\log_2 n$=2selectlines).
- 4: 1or8:1or16:1multiplexersareavailableasstandard ICs.

Procedure:

1. Constructthecircuitasshowninfigure
2. SelecttheswitchesA,B,CandDtoprovide inputbitcombinations.
3. SelecttheswitchesXandYtoprovide‘select’signals
4. ObservetheoutputLEDforeachselectinputcombinationandverifythetruthtable.

LogicDiagram:





TruthTable:

Selectlines		Inputs				OUTPUT	Data linesenttooutput
S_1	S_2	I_O	I_1	I_2	I_3		
0	0	1	X	X	X	1	I_O
0	1	X	1	X	X	1	I_1
1	0	X	X	1	X	1	I_2
1	1	X	X	X	1	1	I_3

De-Multiplexer

AIM: To construct the circuit of Demultiplexer and to study their working

ComponentsRequired:

Component	Specification	Quantity
NOTgate	74LS04/74HCT04	1
3-input ANDgate	74LS11/74HCT11	1
DigitalICtrainerkit		1

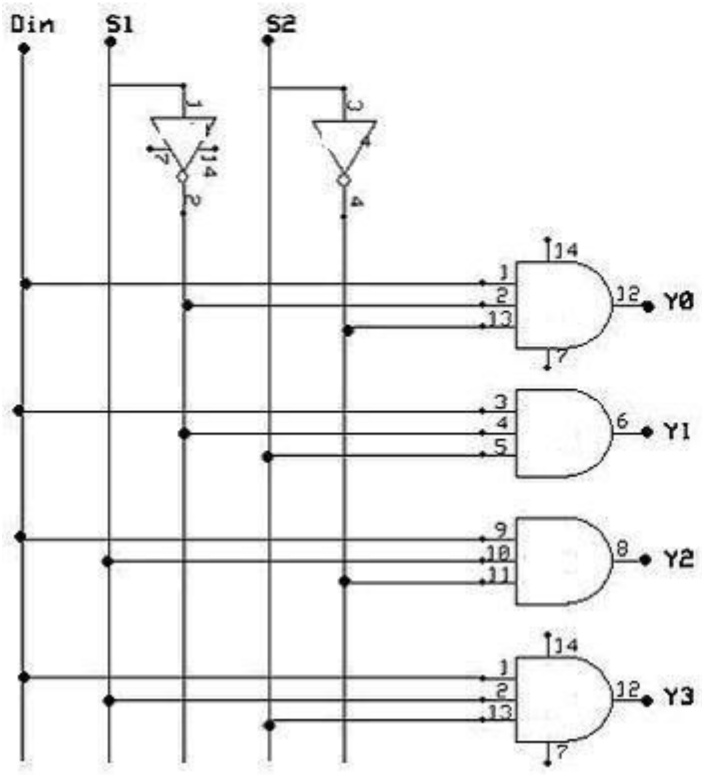
Theory:

- Demutiplexer has one input and many outputs.
- The selection of the particular output line is controlled by a set of control inputs called select lines.
- For1:*n*demultiplexer,the number of select lines required is $S=\log_2 n$or $N=2^S$.
- Four outputs require 2 selectlines (n=4,$S=\log_2 n$ =2selectlines).

Procedure:

1. Construct the circuit as shown in figure
2. Select the switches A and Bt o provide input bit combinations.
3. Observe the output LEDs for each select input combinations and verify the truth table.

Logic Diagram:



TruthTable:

Datainput='1'

Selectinput		**Output**			
S_1	**S_2**	**Y_O**	**Y_1**	**Y_2**	**Y_3**
0	0	1	0	0	0
0	1	0	1	0	0
1	0	0	0	1	0
1	1	0	0	0	1

RESULT:

Multiplexer and demultiplexer circuits were constructed and their operations were verified

12.Encoder and Decoder

AIM: To design and implement encoder and decoder using logic gates.

Sl.No.	COMPONENT	SPECIFICATION	QTY.
1.	3 I/P NAND GATE	IC 7410	2
2.	OR GATE	IC 7432	3
3.	NOT GATE	IC 7404	1
2.	IC TRAINER KIT	-	1
3.	PATCH CORDS	-	27

THEORY:

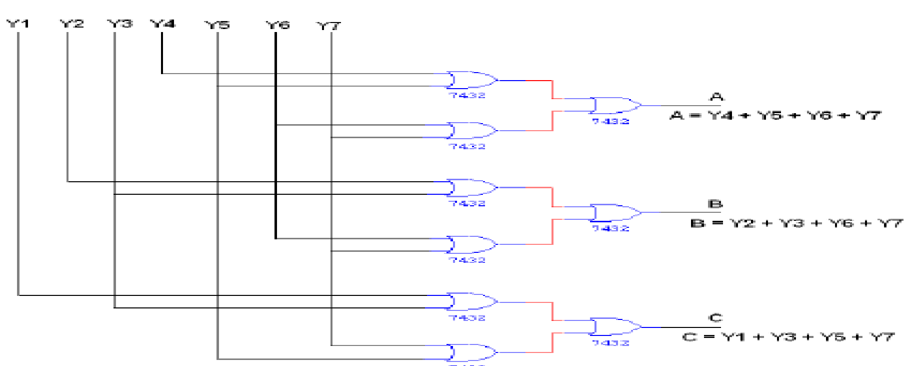
ENCODER:

An encoder is a digital circuit that performs inverse operation of a decoder. An encoder has 2^n input lines and n output lines. In encoder the output lines generates the binary code corresponding to the input value. In octal to binary encoder it has eight inputs, one for each octal digit and three output that generate the corresponding binary code. In encoder it is assumed that only one input has a value of one at any given time otherwise the circuit is meaningless. It has an ambiguila that when all inputs are zero the outputs are zero. The zero outputs can also be generated when D0 =1.

DECODER:

A decoder is a multiple input multiple output logic circuit which converts coded input into coded output where input and output codes are different. The input code generally has fewer bits than the output code. Each input code word produces a different output code word i.e there is one to one mapping can be expressed in truth table. In the block diagram of decoder circuit the encoded 2n information is present as n input producing 2 through output 2n-1

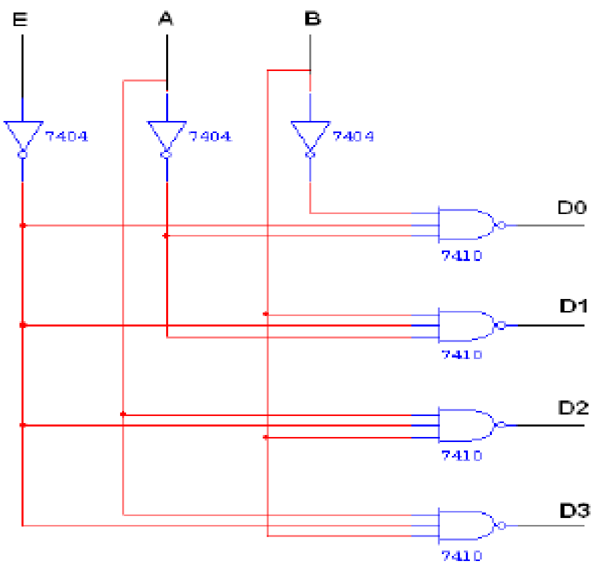
LOGIC DIAGRAM FOR ENCODER



TRUTH TABLE

INPUT							OUTPUT		
Y1	Y2	Y3	Y4	Y5	Y6	Y7	A	B	C
1	0	0	0	0	0	0	0	0	1
0	1	0	0	0	0	0	0	1	0
0	0	1	0	0	0	0	0	1	1
0	0	0	1	0	0	0	1	0	0
0	0	0	0	1	0	0	1	0	1
0	0	0	0	0	1	0	1	1	0
0	0	0	0	0	0	1	1	1	1

LOGIC DIAGRAM FOR DECODER:



TRUTH TABLE

INPUT			OUTPUT			
E	A	B	D0	D1	D2	D3
1	0	0	1	1	1	1
0	0	0	0	1	1	1
0	0	1	1	0	1	1
0	1	0	1	1	0	1
0	1	1	1	1	1	0

PROCEDURE:

(i) Connections are given as per circuit diagram.
(ii) Logical inputs are given as per circuit diagram.
(iii) Observe the output and verify the truth table.

RESULT:

Thus the design and implementation of encoder and decoder using logic gates were done.

13.Op-amps (using IC 747): Summer, Integrator and Differentiator

AIM: To study Adder, circuit using OP-AMP IC741 and verify their theoretical and practical output.

To study the operation of the Integrator & differentiator using op-amp and trace the output wave forms for sine and square wave inputs.

APPARATUS:

- Bread Board
- IC741, Resistors
- DC Supply
- Function Generator
- Multimeter
- CRO
- Probes, Connecting Wires

THEORY:

ADDER: Op-amp can be used to design a circuit whose output is the sum of several input signals. Such a circuit is called a summing amplifier or an adder. Summing amplifier can be classified as inverting & non-inverting summer depending on the input applied to inverting & non-inverting terminals respectively. Circuit Diagram shows a non-inverting adder with n inputs. Here the output will be the linear summation of input voltages. The circuit can be used either as summing amplifier, scaling amplifier, or as averaging amplifier.

From the circuit of adder, it can be noted that at pin3

$$I_1+I_2+I_3+ \ldots\ldots\ldots\ldots\ldots\ldots_n=0$$

$$\frac{Va-V1}{R}+\frac{Va-V2}{R}+\frac{Va-V3}{R}+\ldots\ldots\ldots\ldots\frac{Va-Vn}{R}=0$$

$$\frac{nVa-(V1+V2+V3}{R}+\ldots+Vn)=0$$

$$V_a=\frac{V1+V2+V3+\cdots+Vn}{n}$$

$$V_o=(1+\frac{Rf}{R1})Va$$

$$V_o=(1+\frac{Rf}{R1})(\frac{V1}{n}+V2+V3+\ldots Vn)$$

$$V_o=(1+\frac{(n-1)R1}{R1})(\frac{V1}{n}+V2+V3+\ldots Vn)$$

$$= (1+(n-1))\left(\frac{V1}{n}+V2+V3=\cdots Vn\right)$$

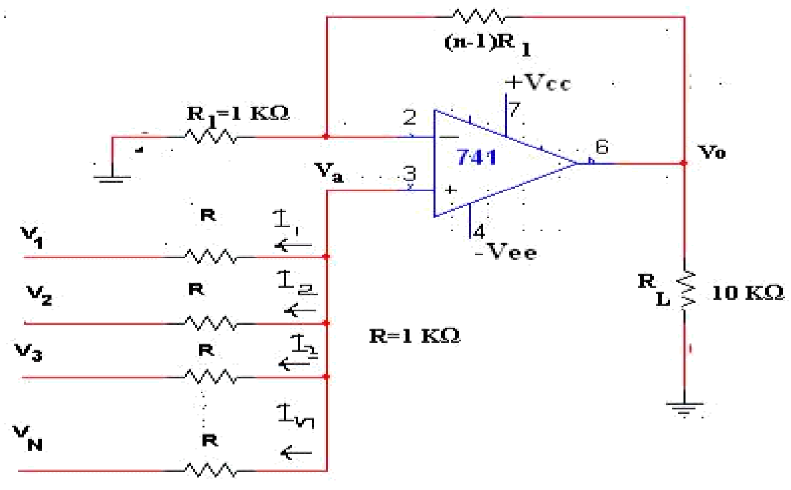
$$=n\left(\frac{V1}{n}+V2+v3+\ldots+Vn\right)$$

$$V_0= V_1+V_2+V_3+\ldots+V_n$$

This means that the output voltage is equal to the sum of all the input voltages.

CIRCUIT DIAGRAM:

ADDER:



PROCEDURE:

ADDER:

1. Connect the components/equipment as shown in the circuit diagram.
2. Switch ON the power supply.
3. Apply dc voltages at each input terminal for V_1 and V_2 from the dc supply and check the output voltage $V_o$at the output terminal.
4. Tabulate 3 different sets of readings by repeating the abovestep.
5. Compare practical $V_o$with the theoretical output voltage $V_o=V_1+V_2$.

TABLE:

ADDER:

S.No.	V_1 Volts	V_2 Volts	Theoretical $V_o=V_1+V_2$	Practical V_o Volts

THEORY:

INTEGRATOR:

A circuit in which the output voltage is the integration of the input voltage is called an integrator.

$$V_o = -\frac{1}{R_1 C_f} \int V_{in}\, dt \qquad \text{——} \qquad (1)$$

In the practical integrator to reduce the error voltage at the output, a resistor R_F is connected across the feedback capacitor C_F. Thus, R_F limits the low-frequency gain and hence minimizes the variations in the output voltage.

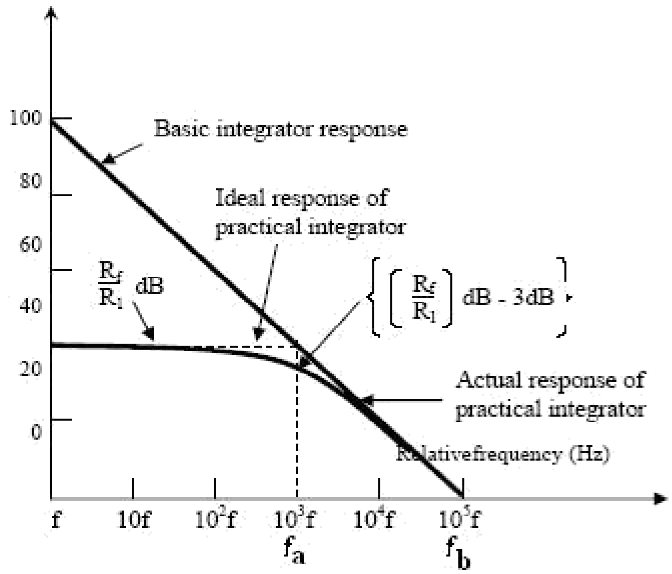


Fig 2.1 Frequency Response of Integrator

The frequency response of the integrator is shown in the fig. 2.1. f_b is the frequency at which the gain is 0 dB and is given by

$$f_b = 1/2\,\pi R_1 C_f.$$

In this fig. there is some relative operating frequency, and for frequencies from f to f_a the gain R_F/R_1 is constant. However, after f_a the gain decreases at a rate of 20 dB/decade. In other words, between f_a and f_b the circuit of fig. 2.1 acts as an integrator. The gain-limiting frequency f_a is given by

$$f_a = 1/2\pi R_f C_f.$$

Normally $f_a < f_b$. From the above equation, we can calculate R_f by assuming f_a & C_f. This is very important frequency. It tells us where the useful integration range starts.

If $f_{in} < f_a$ If $f_{in} = f_a$ If $f_{in} = 10 f_a$ - circuit acts like a simple inverting amplifier and no integration results, - integration takes place with only 50% accuracy results, - integration takes place with 99% accuracy results.

In the circuit diagram of Integrator, the values are calculated by assuming f_a as 50 Hz. Hence the input frequency is to be taken as 500Hz to get 99% accuracy results.

Integrator has wide applications in

1. Analog computers used for solving differential equations in simulation arrangements.
2. A/Converters
3. Signal wave shaping
4. Function Generators.

DIFFERENTIATOR:

As the name suggests, the circuit performs the mathematical operation of differentiation, i.e. the output voltage is the derivative of the input voltage.

$$V_o = -R_f C_1 \frac{dV_{in}}{dt}$$

Both the stability and the high-frequency noise problems can be corrected by the addition of two components: R_1 and C_f, as shown in the circuit diagram. This circuit is a practical differentiator.

The input signal will be differentiated properly if the time period T of the input signal is larger than or equal to $R_f C_1$. That is, $T >= R_f C_1$

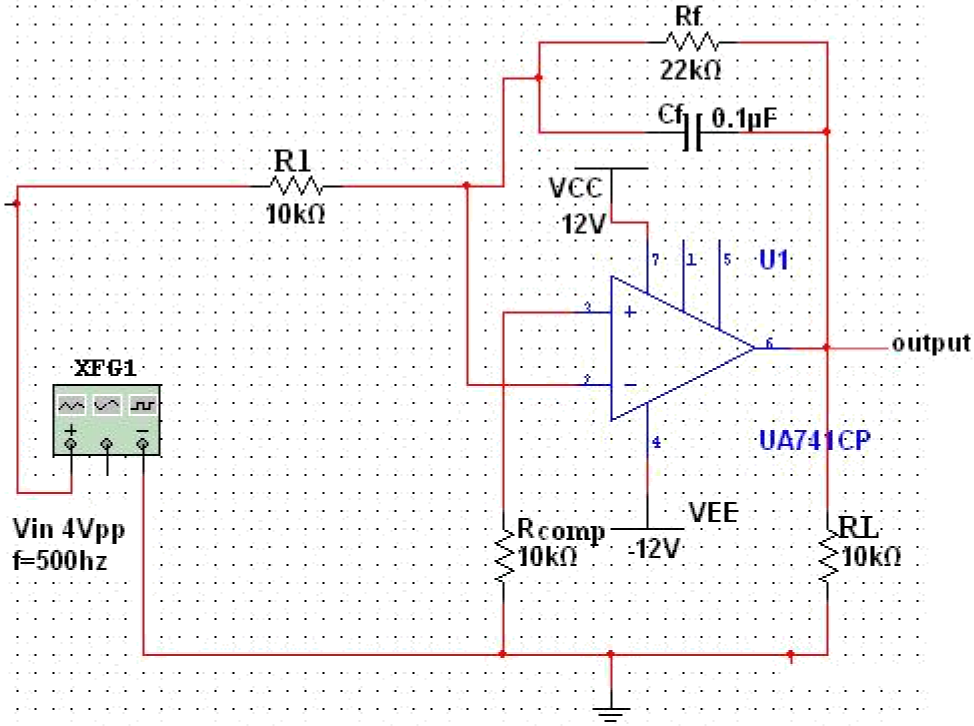
Differentiator can be designed by implementing the following steps.

1. Select f_a equal to the highest frequency of the input signal to be differentiated. Then, assuming a value of $C_1 < 1\ \mu F$, calculate the value of R_f
2. Calculate the values of R_1 and C_f so that $R_1 C_1 = R_f C_f$.

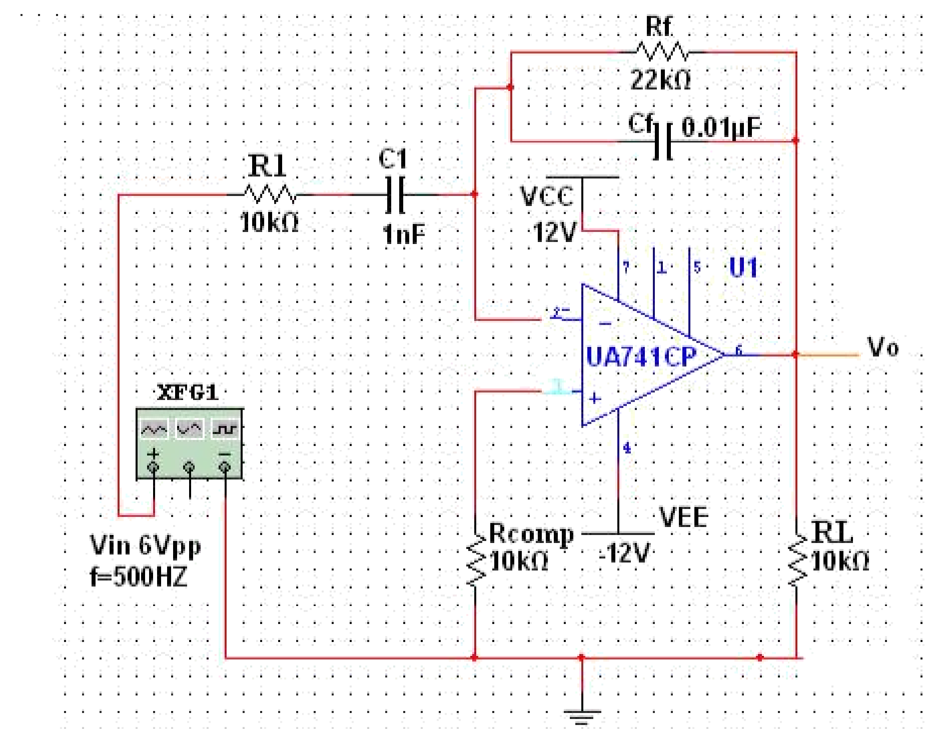
Differentiator has wide applications in

1. Monostable Multivibrator
2. Signal wave shaping
3. Function Generators.

CIRCUIT DIAGRAM:
INTEGRATOR:



DIFFERENTIATOR:



PROCEDURE:

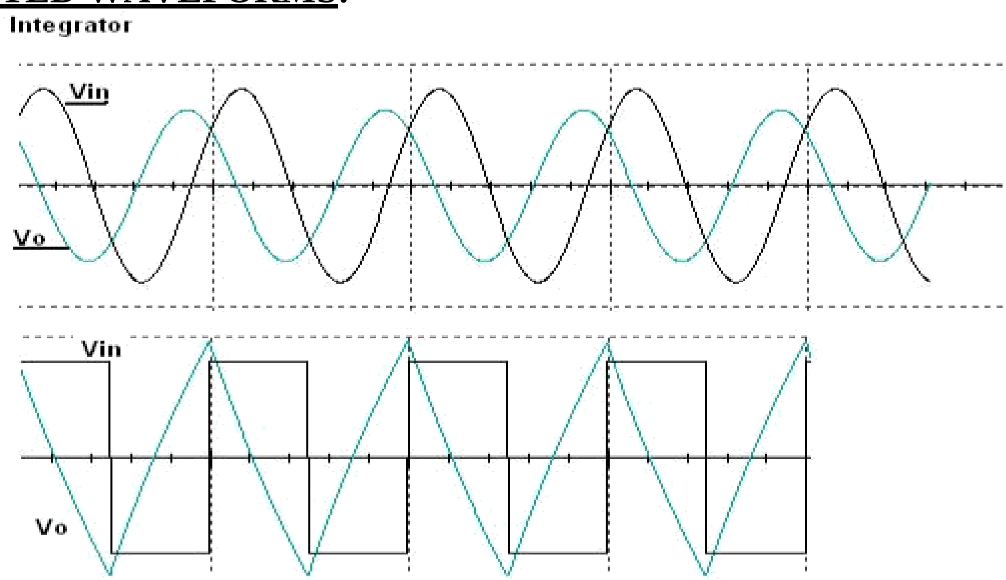
INTEGRATOR:

1. Connect the components/equipment as shown in the circuit diagram.
2. Switch ON the power supply.
3. Apply sine wave at the input terminals of the circuit using function Generator.
4. Connect channel-1 of CRO at the input terminals and channel-2 at the output terminals.
5. Observe the output of the circuit on the CRO which is a cosine wave (90^o phase shifted from the sine wave input) and note down the position, the amplitude and the time period of V_{in} & V_o.
6. Now apply the square wave as input signal.
7. Observe the output of the circuit on the CRO which is a triangular wave and note down the position, the amplitude and the time period of V_{in} &V_o.
8. Plot the output voltages corresponding to sine and square wave inputs.

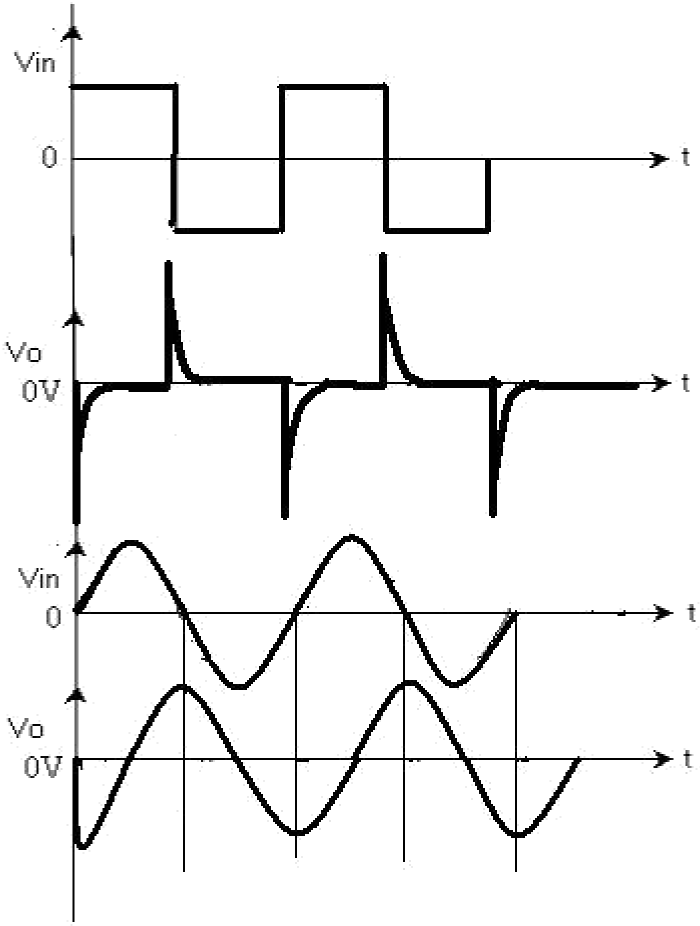
DIFFERENTIATOR:

1. Connect the components/equipment as shown in the circuit diagram.
2. Switch ON the power supply.
3. Apply sine wave at the input terminals of the circuit using function Generator.
4. Connect channel-1 of CRO at the input terminals and channel-2 at the output terminals.
5. Observe the output of the circuit on the CRO which is a cosine wave (90^o phase shifted from the sine wave input) and note down the position, the amplitude and the time period of V_{in} & V_o.
6. Now apply the square wave as input signal.
7. Observe the output of the circuit on the CRO which is a spike wave and note down the position, the amplitude and the time period of V_{in} &V_o.
8. Plot the output voltages corresponding to sine and square wave inputs.

EXPECTED WAVEFORMS:



DIFFERENTIATOR:



RESULT:

QUESTIONS:

1. What is an Integrator?
2. Draw the circuit of the Integrator using op-ampIC741.
3. Write down the expression for $V_o$of an Integrator.
4. Draw the frequency response of the Integrator and explain.
5. Draw the output waveform of the Integrator when the input is a Square wave.
6. What is the purpose behind the connection of Rf in the feedback path of Integrator?
7. What are the applications of Integrator?
8. Why R_{comp} is used in both Integrator and Differentiator circuits?
9. What is differentiator?
10. Draw the circuit of the Differentiator using op-ampIC741.
11. Write down the expression for $V_o$of a Differentiator.
12. Draw the output waveform of the Differentiator when the input is a Sine wave.
13. Why R1 and Cf are connected in the circuit of the Differentiator?
14. What are the applications of Differentiator?