Varuvan Vadivelan Institute of Technology

Dharmapuri – 636 703

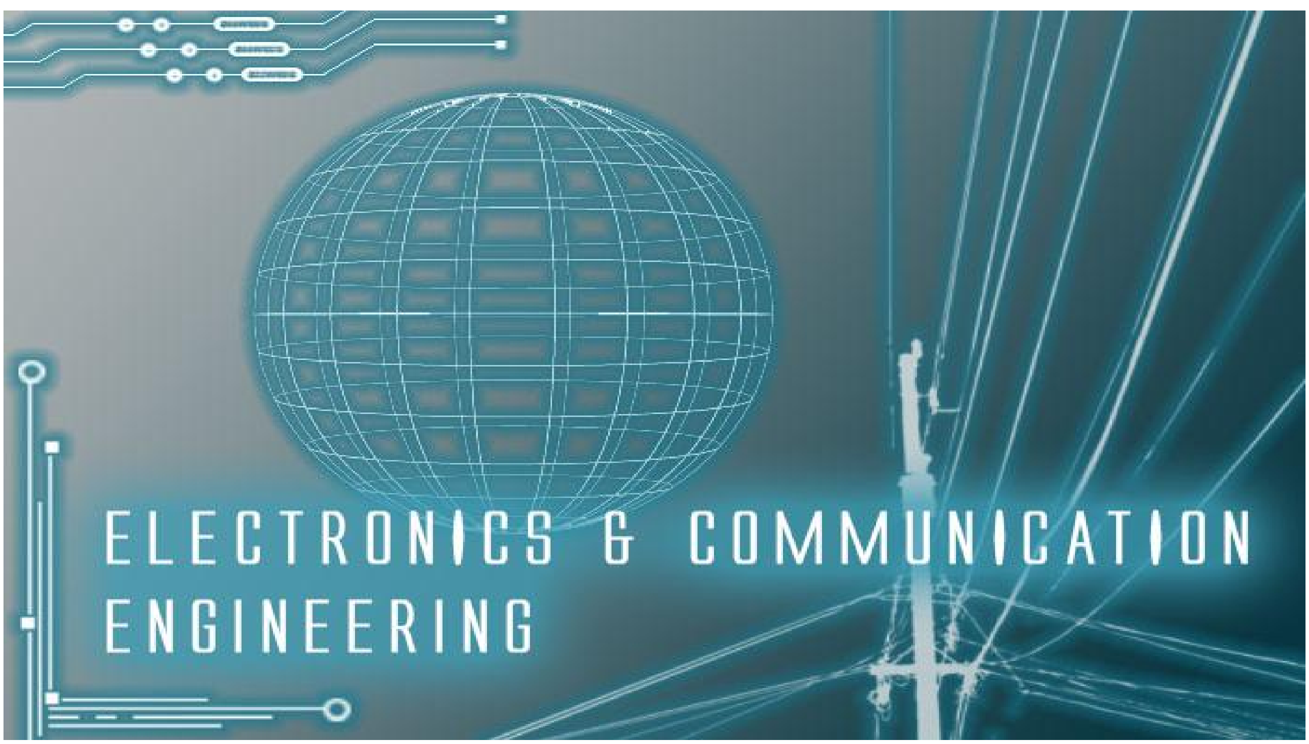
LAB MANUAL

Regulation : 2013

Branch : *B.E.* - ECE

Year & Semester: I Year / II Semester

EC6211 - CIRCUITS AND DEVICES LABORATORY



ANNA UNIVERSITY: CHENNAI
REGULATION 2013

EC6211 - CIRCUITS AND DEVICES LABORATORY

OBJECTIVES:

The student should be made to:

- Be exposed to the characteristics of basic electronic devices
- Be exposed to RL and RC circuits
- Be familiar with Thevinin & Norton theorem KVL & KCL, and Super Position Theorems

LIST OF EXPERIMENTS:

1. Characteristics of PN Junction Diode
2. Zener diode Characteristics & Regulator using Zener diode
3. Common Emitter input-output Characteristics
4. Common Base input-output Characteristics
5. FET Characteristics
6. SCR Characteristics
7. Clipper and Clamper & FWR
8. Verifications Of Thevinin & Norton theorem
9. Verifications Of KVL & KCL
10. Verifications Of Super Position Theorem
11. verifications of maximum power transfer & reciprocity theorem
12. Determination Of Resonance Frequency of Series & Parallel RLC Circuits
13. Transient analysis of RL and RC circuits

TOTAL: 45 PERIODS

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Sl.No	Date	Name Of The Experiments	Staff Signature	Remarks
1		Characteristics of PN Junction Diode		
2		Zener diode Characteristics & Regulator using Zener diode		
3		Common Base input-output Characteristics		
4		Common Emitter input-output Characteristics		
5		FET Characteristics		
6		SCR Characteristics		
7		Full Wave Rectifier With and Without Filters		
8		Clipper and Clamper circuit		
9		Kirchoff's Voltage Law		
10		Kirchoff's Current Law		
11		Thevenin's Theorem		
12		Norton's theorem		
13		Superposition Theorem		
14		Maximum power Transfer Theorem		
15		Reciprocity Theorem		
16		Time Domain Transient response of RL circuit		
17		Time Domain Transient Response of RC circuit		
18		Resonance Frequency of Series & Parallel RLC Circuits		

BASIC ELECTRONIC COMPONENTS

1.1. RESISTOR

A Resistor is a passive two-terminal electrical component that implements electrical resistance as a circuit element. The current through a resistor is in direct proportion to the voltage across the resistor's terminals. This relationship is represented by Ohm's law:

—

Where

- I is the current through the conductor in units of amperes,
- V is the potential difference measured across the conductor in units of volts, and
- R is the resistance of the conductor in units of ohms.

The ratio of the voltage applied across a resistor's terminals to the intensity of current in the circuit is called its resistance, and this can be assumed to be a constant (independent
of the voltage) for ordinary resistors working within their ratings.

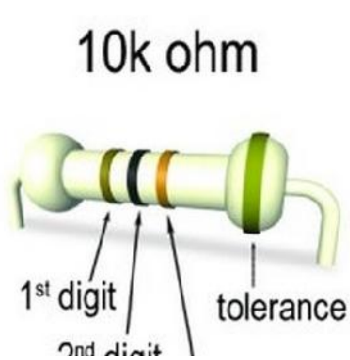
1.2. COLOUR CODING OF RESISTOR

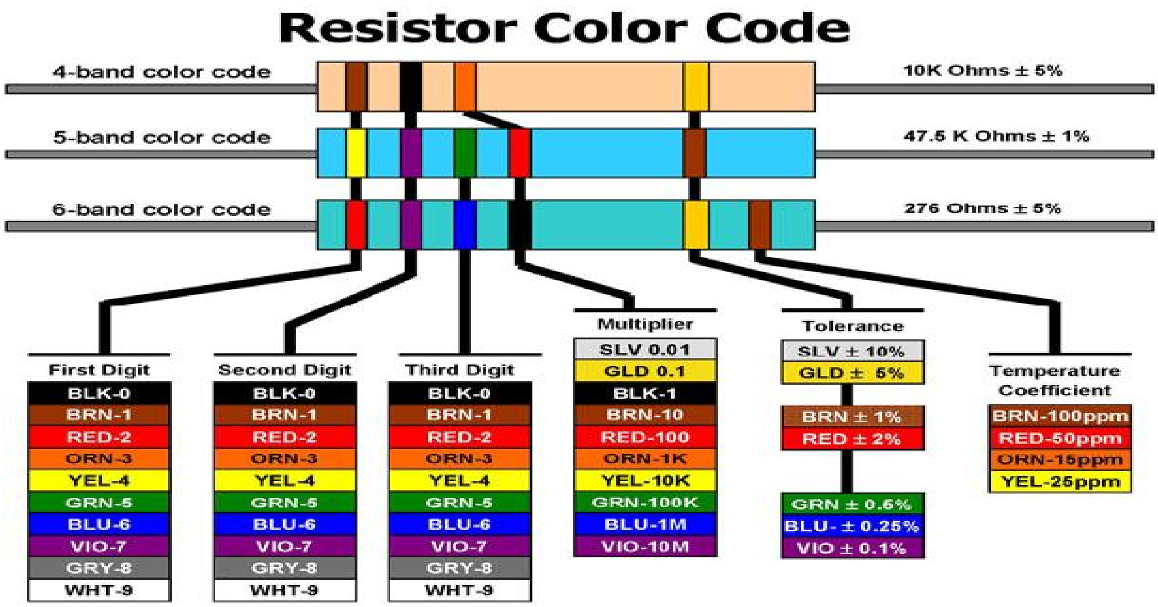
Colour Codes are used to identify the value of resistor. The numbers to the Colour are identified in the following sequence which is remembered as BBROY GREAT BRITAN VERY GOOD WIFE (BBROYGBVGW) and their assignment is listed in following table.

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

Table 1: Colour codes of resistor

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





Resistor Color Codes: Resistors are devices that limit current flow and provide a voltage drop in electrical circuits. Because carbon resistors are physically small, they are color-coded to identify their resistance value in Ohms. The use of color bands on the body of a resistor is the most common system for indicating the value of a resistor. Color-coding is standardized by the Electronic Industries Association (EIA).

Use the Resistor Color Code Chart (above) to understand how to use the color code system. When looking at the chart, note the illustration of three round resistors with numerous color code bands. The first resistor in the chart (with 4 bands) tells you the minimum information you can learn from a resistor. The next (a 5-band code) provides a little more information about the resistor. The third resistor (a 6-band) provides even more information. Each color band is associated with a numerical value.

How to read a typical 4-band, 5-band and 6-band resistor: 4-Band: Reading the resistor from left to right, the first two color bands represent significant digits , the third band represents the decimal multiplier, and the fourth band represents the tolerance. 5-Band: The first three color bands represent significant digits, the fourth band represents the decimal multiplier, and the fifth band represents the tolerance. 6-Band: The first three color bands represent significant digits, the fourth band represents the decimal multiplier, the fifth band represents the tolerance, and the sixth band represents the temperature coefficient.

Definitions of color bands: The color of the multiplier band represents multiples of 10, or the placement of the decimal point. For example: ORANGE (3) represents 10 to the third power or 1,000. The tolerance indicates, in a percentage, how much a resistor can vary above or below its value. A gold band stands for +/- 5%, a silver band stands for +/- 10%, and if there is no fourth band it is assumed to be +/- 20%. For example: A 100-Ohm 5% resistor can vary from 95 to 105 Ohms and still be considered within the manufactured tolerance. The temperature coefficient band specifies the maximum change in resistance with change in temperature, measured in parts per million per degree Centigrade (ppm/°C).

Example (from chart): Lets look at the first resistor on the chart. In this case, the first color band is BROWN. Following the line down the chart you can see that BROWN represents the number 1. This becomes our first significant digit. Next, look at the second band and you will see it is BLACK. Once again, follow the line down to the bar scale; it holds a value of 0, our second significant digit. Next, look at the third band, the multiplier, and you will see it is ORANGE. Once again, follow the line down to the bar scale; it holds a value of 3. This represents 3 multiples of 10 or 1000. With this information, the resistance is determined by taking the first two digits, 1 and 0 (10) and multiplying by 1,000.

Example: 10 X 1000 = 10,000 or 10,000 Ohms. Using the chart, the fourth band (GOLD), indicates that this resistor has a tolerance of +/- 5%. Thus, the permissible range is: 10,000 X .05 = +/- 500 Ohms, or 9,500 to 10,500 Ohms.

1.3. TYPES OF RESISTORS

- Carbon Resistors
- Wire wound Resistors

Carbon Resistors

There are many types of resistors, both fixed and variable. The most common type for electronics use is the carbon resistor. They are made in different physical sizes with power dissipation limits commonly from 1 watt down to 1/8 watt. The resistance value and tolerance can be determined from the standard resistor color code.

A variation on the color code is used for precision resistors which may have five colored bands. In that case the first three bands indicate the first three digits of the resistance value and the fourth band indicates the number of zeros. In the five band code the fifth band is gold for 1% resistors and silver for 2%.

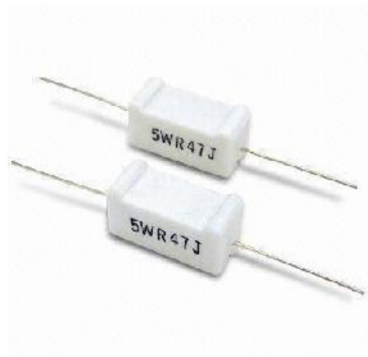
Figure 2: Images of Carbon Resistors

Wire wound Resistors

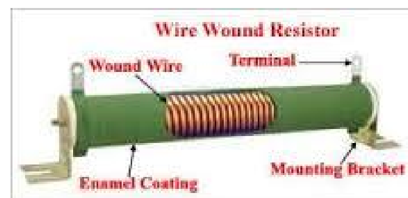
A wire wound resistor is an electrical passive component that limits current. The resistive element exists out of an insulated metallic wire that is winded around a core of non-conductive material. The wire material has a high resistivity, and is usually made of an alloy such as Nickel-chromium (Nichrome) or a copper-nickel-manganese alloy called Manganin. Common core materials include ceramic, plastic and glass. Wire wound resistors are the oldest type of resistors that are still manufactured today. They can be produced very accurate, and have excellent properties for low resistance values and high powerratings. Read more http://www.resistorguide.com/wirewound-resistor/

Applications of wire wound resistors are similar to those of composition resistors with the exception of the high frequency. The high frequency response of wire wound resistors is substantially worse than that of a composition resistor.

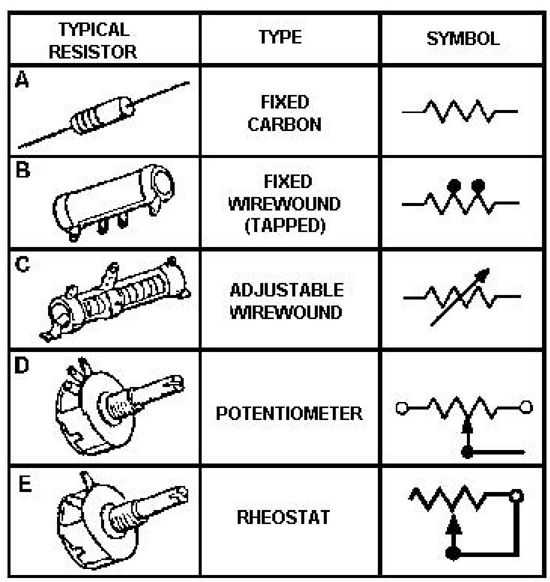
Fixed-Wire-Wound-Resistor



Fixed-Wire wound-Resistor



Adjustable-Wire Wound-Resistor



Resistor-Symbols

1.4. CAPACITOR

A capacitor (originally known as a condenser) is a passive two-terminal electrical component used to store energy electro statically in an electric field. By contrast, batteries store energy via chemical reactions. The forms of practical capacitors vary widely, but all contain at least two electrical conductors separated by a dielectric (insulator); for example, one common construction consists of metal foils separated by a thin layer of insulating film. Capacitors are widely used as parts of electrical circuits in many common electrical devices.

When there is a potential difference (voltage) across the conductors, a static electric field develops across the dielectric, causing positive charge to collect on one plate and negative charge on the other plate. Energy is stored in the electrostatic field. An ideal capacitor is characterized by a single constant value, capacitance. This is the ratio of the electric charge on each conductor to the potential difference between them. The SI unit of capacitance is the farad, which is equal to one coulomb per volt.

Electrolytic capacitors of different voltages and capacitance

Solid-body, resin-dipped 10 μF 35 V Tantalum capacitors.

Type ⊕ = polarized	Pic	Cap Range	ESR	Leakage	Voltage Rating	Temp Range	Gen Notes
Ceramic		pF - μF	low	med	high	-55° to +125°C	Multipurpose Cheap
Mica (silver mica)		pF - nF	low 0.01-0.1Ω	low	high	-55° to +125°C	For RF filters Expensive Very stable
Plastic Film (polyethylene polystyrene)		few μFs	med	med	high	varies	For low freq Cheap
Tantalum ⊕		μFs	high 0.5-5.0Ω	low	lowest	-55° to +125°C	Expensive Nonlinear (bad for audio)
OSCON ⊕		μFs	low 0.01-0.5Ω	low	low	-55° to +105°C	Best quality Highest price
Aluminum Electrolytic ⊕		high μFs	high 0.05-2.0Ω	med	low	-40° to +85°C	For low-med frequencies Cheap Hold charge for long time – not for production test

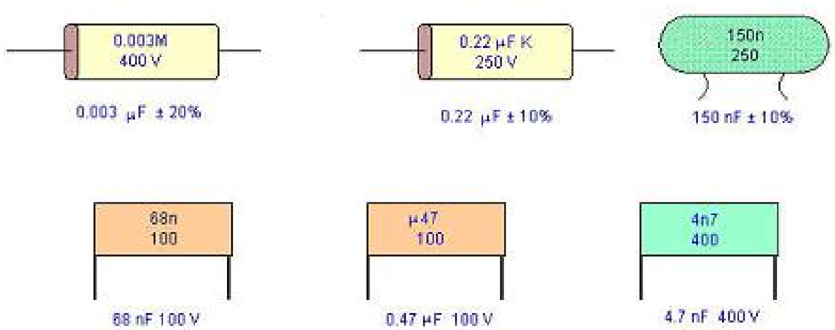
1.5. COLOUR CODING OF CAPACITORS

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 εr of the medium between the plates. In vacuum, in air, and in most gases, εr ranges from one to several hundred.

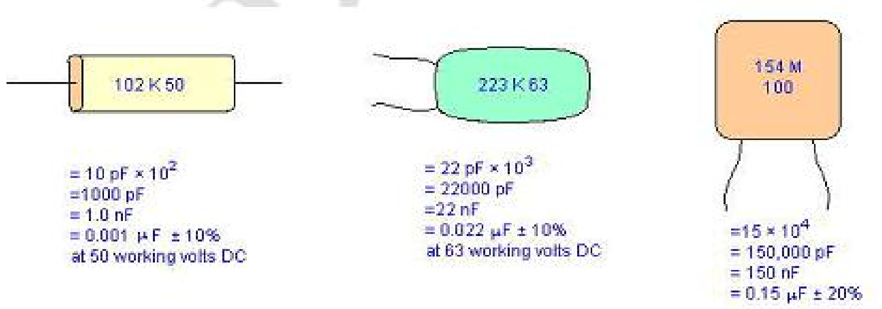
One classification of capacitors comes from the physical state of their dielectrics, which may be gas (or vacuum), liquid, solid, or a combination of these. Each of these classifications may be subdivided according to the specific dielectric used. Capacitors may be further classified by their ability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

- Capacitor Identification Codes:

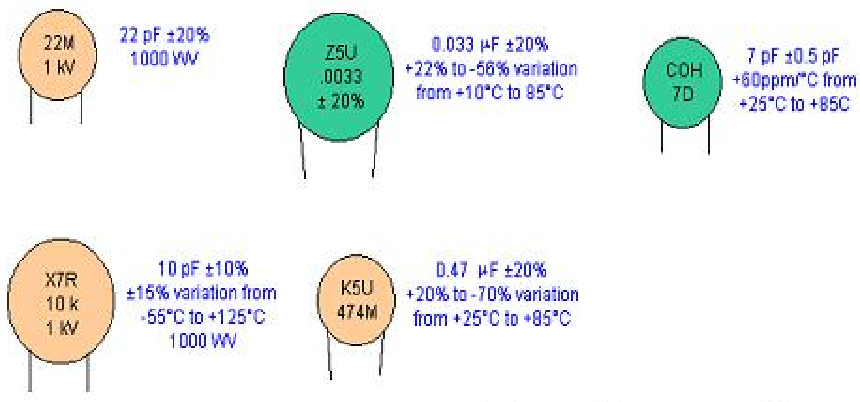
There are no international agreements in place to standardize capacitor identification. Most plastic film types (Figure1) have printed values and are normally in microfarads or if the symbol is n, Nanofarads. Working voltage is easily identified. Tolerances are upper case letters: M = 20%, K = 10%, J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



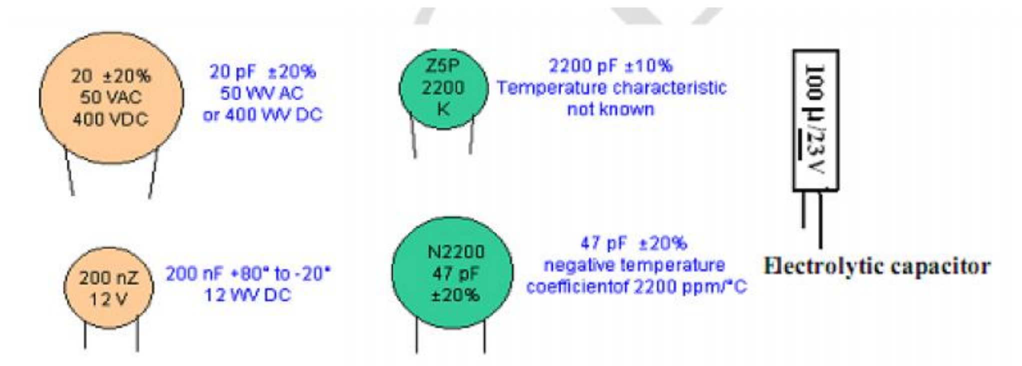
Plastic Film Types



Pico Farads Representation



Ceramic Disk Capacitor

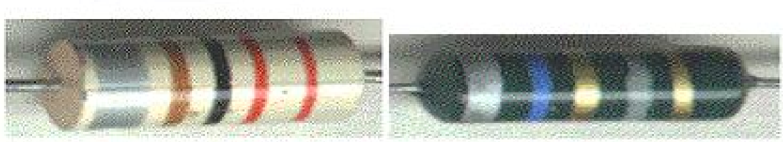


Miscellaneous Capacitors

COLOUR CODING OF INDUCTORS

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

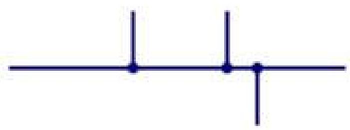
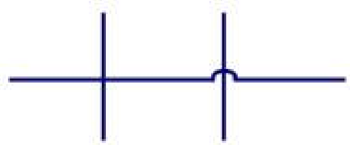
Molded inductors follow the same scheme except the units are usually micro henries. A brown-black-red inductor is most likely a 1000 uH. Sometimes a silver or gold band is used as a decimal point. So a red-gold-violet inductor would be a 2.7 uH. Also expect to see a wide silver or gold band before the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



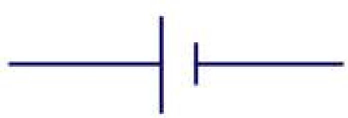
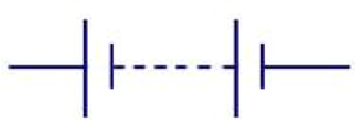
Typical inductors Colour coding and their values.

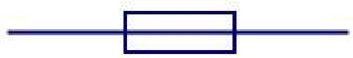
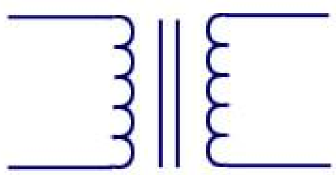
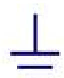
CIRCUIT SYMBOLS

WIRE

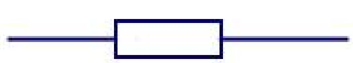
Electronic Component	**Circuit Symbol**	**Description**
Wire	*Wire Circuit Symbol*	Used to connect one component to another
Wires Joined	 *Wires Joined Circuit Symbol*	One device may be connected to another through wires. This is represented by drawing "blobs" on the point where they are shorted.
Unjoined Wires	 *Wires Not Joined Circuit Symbol*	When circuits are drawn some wires may not touch others. This can only be shown by bridging them or by drawing them without blobs. But bridging is commonly practised as there will not arise any confusion.

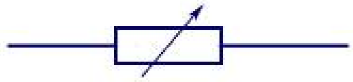
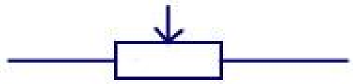
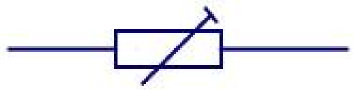
POWER SUPPLY

Electronic Component	**Circuit Symbol**	**Description**
Cell	 *Cell Circuit Symbol*	Used to provide a supply for a circuit.
Battery	 *Battery Circuit Symbol*	A battery has more than a cell and is used for the same purpose. The smaller terminal is negative and the larger one is positive. Abbreviated as 'B'.

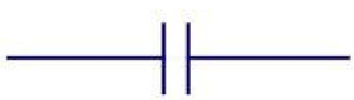
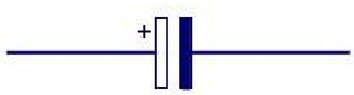
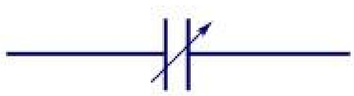
DC Supply	 *DC Supply Circuit Symbol*	Used as a DC power supply, that is, the current will always flow in one direction.
AC Supply	 *AC Supply Circuit Symbol*	Used as AC power supply, that is, the current will keep alternating directions.
Fuse	 *Fuse Circuit Symbol*	Used in circuits where a probability of excessive current flows. The fuse will break the circuit if excessive current flows and saves the other devices from damage.
Transformer	 *Transformer Circuit Symbol*	Used as an ac power supply. Consists of two coils, the primary and secondary that are linked together through an iron core. There is no physical connection between the two coils. The principle of mutual inductance is used to obtain power. Abbreviated as ‘T’.
Earth/Ground	 *Earth Circuit Symbol*	Used in electronic circuits to represent the 0 volts of the power supply. It can also be defined as the real earth , when it is applied in radio circuits and power circuits.

RESISTOR

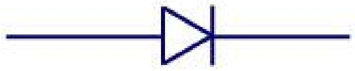
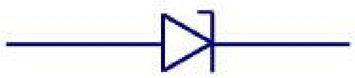
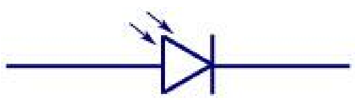
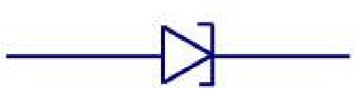
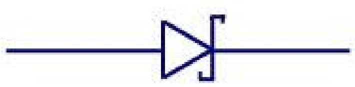
Electronic Component	**Circuit Symbol**	**Description**
Resistor	 *Resistor Circuit Symbol*	A **resistor** is used to restrict the amount of current flow through a device. Abbreviated as ‘R’.

Rheostat	 *Rheostat Circuit Symbol*	A **rheostat** is used to control the current flow with two contacts. Applicable in controlling lamp brightness, capacitor charge rate, etc.
Potentiometer	 *Potentiometer Circuit Symbol*	A **potentiometer** is used to control the voltage flow and has three contacts. Have applications in changing a mechanical angle change to an electrical parameter. Abbreviated as 'POT'.
Preset	 *Preset Circuit Symbol*	**Presets** are low cost variable resistors that are used to control the charge flow with the help of a screw driver. Applications where the resistance is determined only at the end of the circuit design.

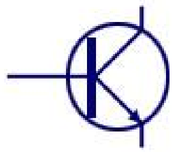
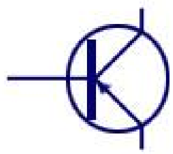
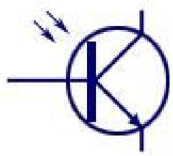
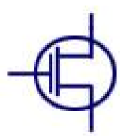
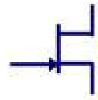
Capacitor

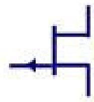
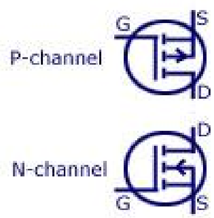
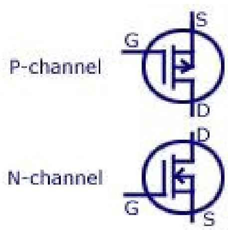
Electronic Component	**Circuit Symbol**	**Description**
Capacitor	 *Capacitor Circuit Symbol*	**Capacitor** is a device that is used to store electrical energy. It consists of two metals plates that are separated by a dielectric. It is applicable as a filter, that is, to block DC signals and allow AC signals. Abbreviated with the letter 'C'.
Capacitor – Polarized	 *Capacitor-Polarised Circuit Symbol*	Capacitor can be used in a timer circuit by adding a resistor.
Variable Capacitor	 *Variable Capacitor Circuit Symbol*	Used to vary the capacitance by turning the knob. A type of variable capacitor is the trimmer capacitor that is small in size. The notations are all the same.

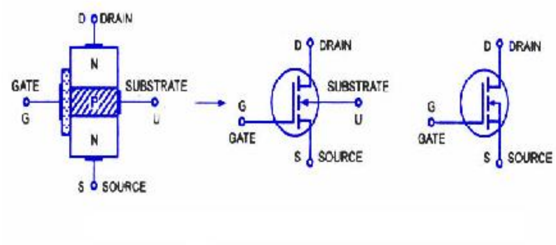
DIODE

Electronic Component	Circuit Symbol	Description
Diode	 *Diode Circuit Symbol*	A diode is used to allow electric current to flow in only one direction. Abbreviated as 'D'.
Light Emitting Diode (LED)	 *LED Circuit Symbol*	**LED** is used to emit light when a current is passed through the device. It is abbreviated as LED.
Zener Diode	 *Zener Diode Circuit Symbol*	After a breakdown voltage, the device allows current to flow in the reverse direction as well. It is abbreviated as 'Z'.
Photo Diode	 *Photo Diode Circuit Symbol*	**Photodiode** works as a photo-detector and converts light into its corresponding voltage or current.
Tunnel Diode	 *Tunnel Diode Circuit Symbol*	**Tunnel Diode** is known for its high-speed operation due to its application in quantum mechanical effects.
Schottky Diode	 *Schottky Diode Circuit Symbol*	The **Schottky Diode** is known for its large forward voltage drop and hence has great applications in switching circuits.

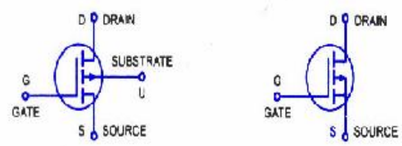
TRANSISTOR

Electronic Component	Circuit Symbol	Description
NPN Transistor	 *Transistor NPN Circuit Symbol*	This is a transistor with a layer of P-doped semiconductor fixed between two layers of N-doped semiconductors that act as the emitter and collector. Abbreviated as 'Q'.
PNP Transistor	 *Transistor PNP Circuit Symbol*	This is a transistor with a layer of N-doped semiconductor fixed between two layers of P-doped semiconductors that act as the emitter and collector. Abbreviated as 'Q'.
Phototransistor	 *Phototransistor Circuit Symbol*	The working of a **phototransistor**is similar to that of a bipolar transistor with a difference that it converts light into its corresponding current. The phototransistor can also act as a photodiode if the emitter is not connected.
Field Effect Transistor	 *Field Effect Transistor Circuit Symbol*	Like a transistor, a **FET** has three terminals, the Gate, Source and Drain. The device has an electric field that controls the conductivity of a channel of one type charge carrier in a semiconductor substance.
N-Channel Junction FET	 *n-channel Junction Field Effect Transistor (JFET) Circuit Symbol*	The Junction Field Effect Transistor (JFET) is the simplest type of FET with applications in Switching and voltage variable resistor. In an N-channel JFET an N-type silicon bar has two smaller pieces of P-type silicon material diffused on each sides of its middle part, forming P-N junctions.

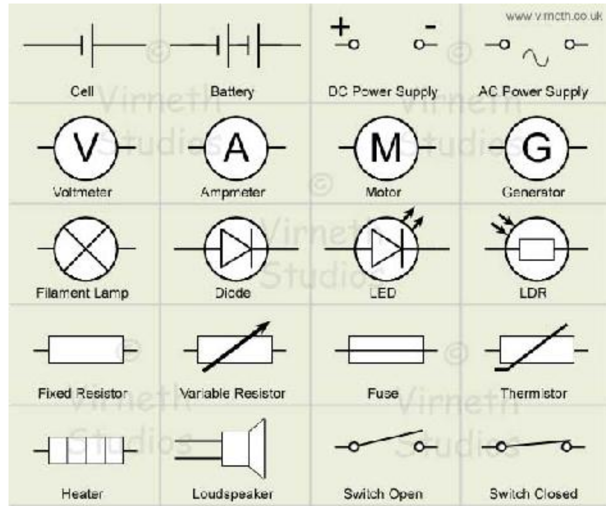
P-Channel Junction FET	 *p-channel Junction Field Effect Transistor (FET) Circuit Symbol*	P-channel JFET is similar in construction to N-channel JFET except that P-type semiconductor base is sandwiched between two N-type junctions. In this case majority carriers are holes.
Metal Oxide Semiconductor FET	Given Below	Abbreviated as MOSFET. MOSFET is a three terminal device and is controlled by a gate bias. It is known for its low capacitance and low input impedance.
Enhancement MOSFET	 *e-MOSFET Circuit Symbol*	The enhancement MOSFET structure has no channel formed during its construction. Voltage is applied to the gate, so as to develop a channel of charge carriers so that a current results when a voltage is applied across the drain-source terminals. Abbreviated as e-MOSFET.
Depletion MOSFET	 *d-MOSFET Circuit Symbol*	In the depletion-mode construction a channel is physically constructed and a current between drain and source is due to voltage applied across the drain-source terminals. Abbreviated as d-MOSFET.

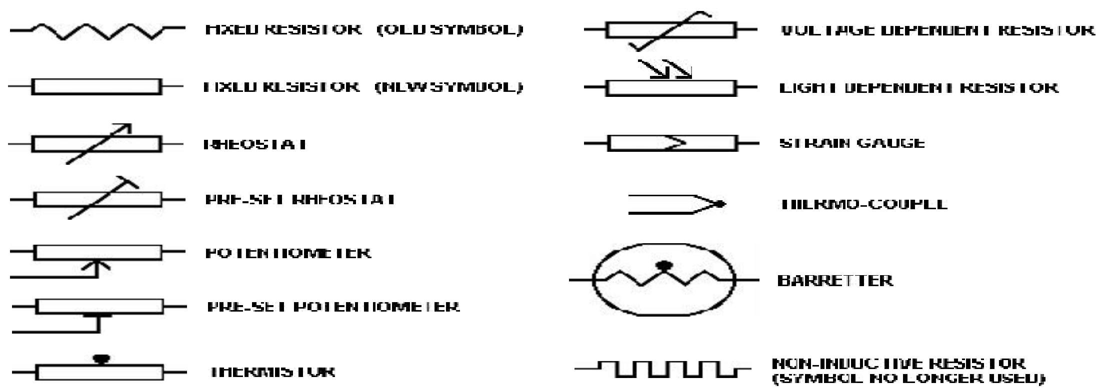


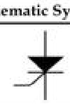
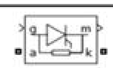
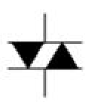
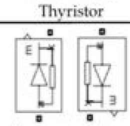
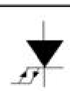
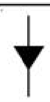
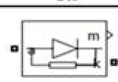
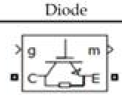
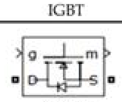
N-Channel E-MOSFET

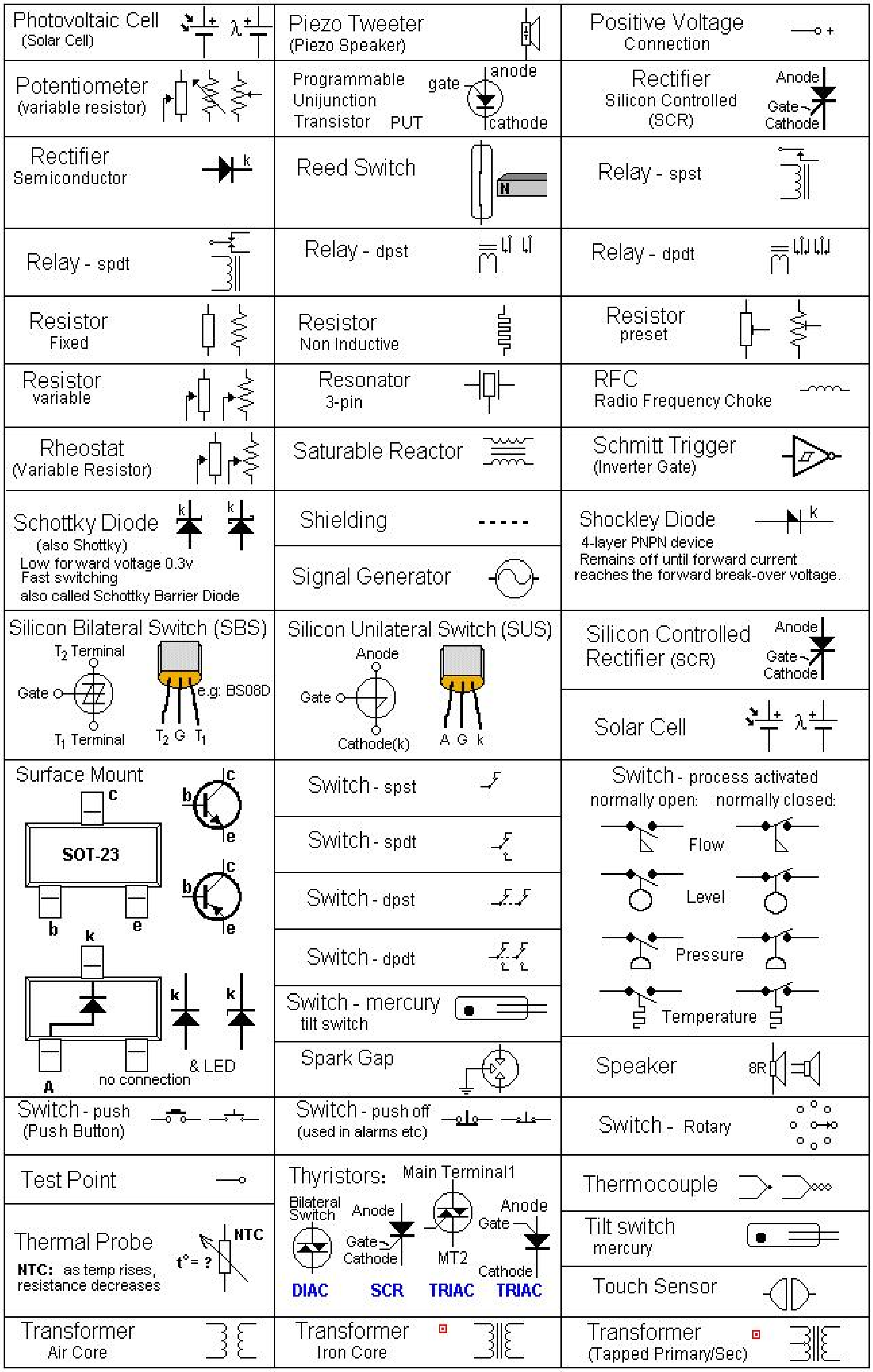


P-Channel E-MOSFET
Schematic Symbols For E-MOSFETs





Type	Schematic Symbol	SimPower Device	Commutation	Characteristics	Typ. Application
SCR		 Thyristor	Line	Pass current in one direction, active control	Simple power control circuits, overcurrent protection circuits (crowbar)
DIAC		 Opposing Diodes	Line	Pass current in both directions, A/C waveforms, passive control (forward voltage)	Light dimmer, symmetrical firing of TRIACs
GTO		 Gto	Forced	High power applications, active control, extended switch-off time (tail-time)	HVDC Systems, applications with low switching frequencies
Diode		 Diode	Line	Pass current in one direction, passive control (forward voltage)	Rectifier, protection circuitry (free-wheel)
IGBT		 IGBT	Forced	Fast switching, medium or high power applications	Electric Heater, audio amplifier
MOSFET		 Mosfet	Forced	Low power capablities	Signal amplifier, electronic switching


Photovoltaic Cell (Solar Cell)
Piezo Tweeter (Piezo Speaker)
Positive Voltage Connection
Potentiometer (variable resistor)
Programmable Unijunction Transistor PUT
gate
anode
cathode
Rectifier Silicon Controlled (SCR)
Anode
Gate
Cathode
Rectifier Semiconductor
k
Reed Switch
N
Relay - spst
Relay - spdt
Relay - dpst
Relay - dpdt
Resistor Fixed
Resistor Non Inductive
Resistor preset
Resistor variable
Resonator 3-pin
RFC Radio Frequency Choke
Rheostat (Variable Resistor)
Saturable Reactor
Schmitt Trigger (Inverter Gate)
Schottky Diode (also Shottky)
Low forward voltage 0.3v
Fast switching
also called Schottky Barrier Diode
Shielding
Signal Generator
Shockley Diode
4-layer PNPN device
Remains off until forward current reaches the forward break-over voltage.
Silicon Bilateral Switch (SBS)
T2 Terminal
Gate
T1 Terminal
e.g: BS08D
T2 G T1
Silicon Unilateral Switch (SUS)
Anode
Gate
Cathode(k)
A G k
Silicon Controlled Rectifier (SCR)
Solar Cell
Surface Mount
SOT-23
b c e
k
A
no connection
& LED
Switch - spst
Switch - spdt
Switch - dpst
Switch - dpdt
Switch - mercury tilt switch
Spark Gap
Switch - process activated
normally open:
normally closed:
Flow
Level
Pressure
Temperature
Speaker
8R
Switch - push (Push Button)
Switch - push off (used in alarms etc)
Switch - Rotary
Test Point
Thyristors:
Main Terminal1
Bilateral Switch
Anode
Gate
Cathode
MT2
DIAC
SCR
TRIAC
TRIAC
Thermocouple
Thermal Probe
NTC
t° = ?
NTC: as temp rises, resistance decreases
Tilt switch mercury
Touch Sensor
Transformer Air Core
Transformer Iron Core
Transformer (Tapped Primary/Sec)

EX.NO : 01

DATE :

Characteristics of PN Junction Diode

AIM:

To study and verify the functionality of **PN junction** diode in forward bias and reverse bias and to

1. Plot Volt-Ampere Characteristics of P-N Diode.
2. Plot Volt-Ampere Characteristics of P-N Diode in XY mode.
3. Find cut-in voltage for P-N Junction diode.
4. Find static and dynamic resistances in both forward and reverse biased conditions.

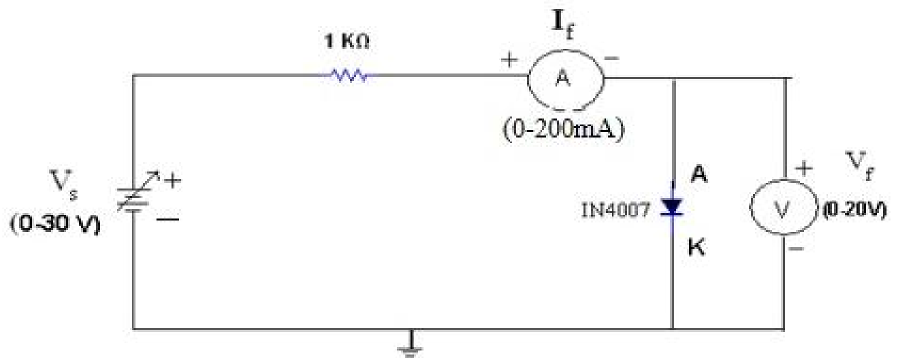
COMPONENTS:

S.No.	Name	Quantity
1	Diode (1N4007)	1(One) No.
2	Resistor (1KΩ)	1(One) No.
3	Bread board	1(One) No.

EQUIPMENT:

S.No.	Name	Quantity
1	Dual DC Regulated Power supply (0 - 30 V)	1(One) No.
2	Digital Ammeters (0 - 200 mA, 0 - 200 µA)	1(One) No. Each
3	Digital Voltmeter (0 - 20V)	1(One) No.
4	Bread board	1(One) No.
5	Connecting wires (Single Strand)	

Circuit Diagram:



:

Fig. (1) - Forward Bias Condition:

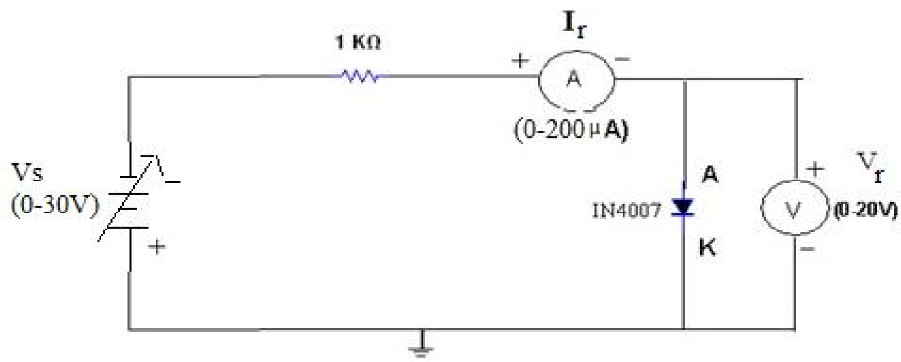


Fig. (2) - Reverse Bias Condition

<u>Observations:</u>

<u>Forward Bias Condition:</u>

Sl.No	RPS Voltage Vs **(volts)**	Forward Voltage across the diode V*f* **(volts)**	Forward Current through the diode I*f* **(mA)**
1			
2			
3			
4			
5			
6			
7			

Specifications:

List of Parameters	SILION DIODE (1N4007)
Maximum Forward Current	1A
Maximum Reverse Current	5.0µA
Maximum Forward Voltage	0.8V
Maximum Reverse Voltage	1000V
Maximum Power Dissipation	30mW
Temperature	-65 to 200° C

Operation:

A PN junction diode is formed when a single crystal of semiconductor is doped with acceptors impurities (Pentavalent) on one side and donor impurities (Trivalent) on the other side. It has two terminals called electrodes, one each from P-region and N-region. Due to two electrodes it is called (i.e., Di-electrode) Diode.

Biasing of PN junction Diode

Applying external D.C. voltage to any electronic device is called biasing. There is no current in the unbiased PN junction at equilibrium.

Depending upon the polarity of the D.C. voltage externally applied to diode ,the biasing is classified as Forward biasing and Reverse biasing.

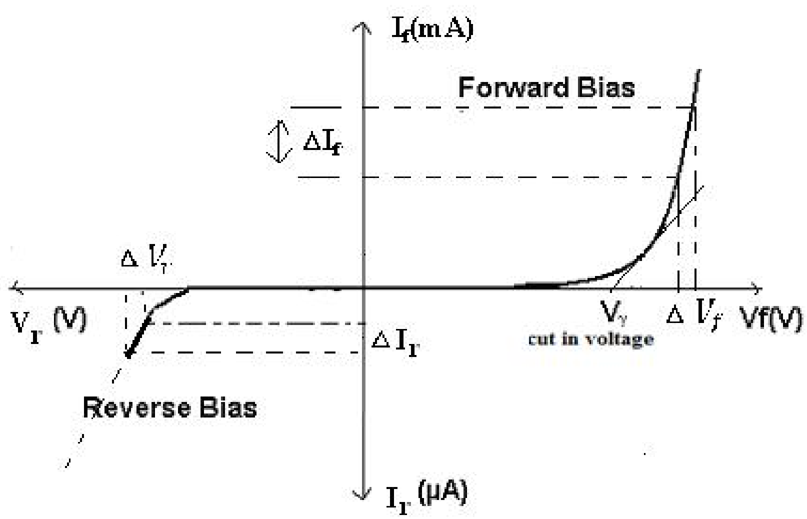
Forward bias operation

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 the cathode. 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 from n-side cross the junction simultaneously and constitute a forward current (injected minority current – due to holes crossing the junction and entering P- side of the diode). Assuming current flowing through the diode to be very large, the diode can be approximated as short- circuited switch

Reverse Bias Condition:

Sl.No	RPS Voltage Vs **(volts)**	Reverse Voltage across the diode V_r **(volts)**	Reverse Current through the diode I_r **(µA)**
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			

Model graph



Reverse bias operation

If negative 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 the diode is said to be reverse biased. In this condition 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 there by 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 current is negligible; the diode can be approximated as an open circuited switch.

Diode current equation

The volt-ampere characteristics of a diode explained by the following equations:

$I = I_0(e^{V/\eta V_T} \quad 1) where$

I = current flowing in the diode, I_0 = reverse saturation current

V = Voltage applied to the diode

V_T = volt- equivalent of temperature = k T/q = T/ 11,600 = 26mV (@ room temp)

η =1 (for Ge) and 2 (for Si)

It is observed that Ge diodes 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.

Procedure:

Forward Bias Condition:

1. Connect the circuit as shown in figure (1) using PN Junction diode.
2. Initially vary Regulated Power Supply (RPS) voltage $\mathbf{V_s}$ in steps of **0.1 V**. Once the current starts increasing vary $\mathbf{V_s}$ from **1V** to **12V** in steps of **1V** and note down the corresponding readings $\mathbf{V_f}$ and $\mathbf{I_f}$.
3. Tabulate different forward currents obtained for different forward voltages.

Reverse Bias Condition:

1. Connect the circuit as shown in figure (2) using PN Junction diode.
2. Vary $\mathbf{V_s}$ in the Regulated Power Supply (RPS) gradually in steps of **1V** from **0V** to **12V** and note down the corresponding readings $\mathbf{V_r}$ and $\mathbf{I_r}$.
3. Tabulate different reverse currents obtained for different reverse voltages.

4. To get the graph in reverse region (theoretically), remove voltmeter and with reference to the supply voltage note down the reverse current readings in Ammeter because current always selects low reactance path.(Diode have infinite resistance in reverse bias ideally).To get the graph in reverse region (theoretically), replace voltmeter with nano ammeter. Voltmeter has less load resistance when compared to diode. Current conducts in low resistance path.

Graph:

1. Take a graph sheet and divide it into 4 equal parts. Mark origin at the center of the graph sheet.
2. Now mark +ve X-axis as V_f, -ve X-axis as V_r, +ve Y-axis as I_f and –ve Y-axis as I_r.
3. Mark the readings tabulated for Si forward biased condition in first Quadrant and Si reverse biased condition in third Quadrant.

Fig: V- I Characteristics of PN Junction Diode under Forward Precautions:

1. While doing the experiment do not exceed the readings of the diode. This may lead to damaging 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.

RESULT : Volt-Ampere Characteristics of P-N Diode are studied.

a) Forward Bias of PN Junction Diode:

1. The Cut in Voltage or Knee Voltage **(Vγ)** of **1N4007** is ______________**Volts.**
2. The Dynamic Forward resistance of **1N4007** is ___________________ **Ω .**
3. The Static Forward resistance of **1N4007** is ___________________ **Ω** .

b) Reverse Bias of PN Junction Diode:

1. The Dynamic Reverse resistance of **1N4007** is __________________ **Ω** _ .
2. The Static Reverse resistance of **1N4007** is __________________ **Ω** .

Outcomes: Students are able to

1. analyze the characteristics of PN diode
2. calculate the dynamic and static resistance in forward bias and reverse bias.

Calculations from Graph:

Cutin Voltage V γ

Static forward Resistance $R_{dc} = V_f / I_f \Omega$

Dynamic Forward Resistance $r_{ac} = \Delta V_f / \Delta I_f \Omega$

Static Reverse Resistance $R_{dc} = V_r / I_r \Omega$

Dynamic Reverse Resistance $r_{ac} = \Delta V_r / \Delta I_r \Omega$

Viva Questions:

1. What are trivalent and penatavalent impurities?

Ans: Doping is the process of adding impurity atoms to intrinsic silicon or germanium to improve the conductivity of the semiconductor.

Commonly used doping elements

- Trivalent Impurities to make p-Type: Aluminum (Al), Gallium (Ga), Boron(B) and Indium (In).
- Pentavalent Impurities to make n-type: Phosphorus (P), Arsenic (As), Antimony (Sb) and Bismuth (Bi).

2. How PN junction diode does acts as a switch?

Ans: Apply voltage in one direction; it acts like an open circuit. Reverse the polarity of the voltage and it acts like a short circuit.

3. What is diode current equation?

Ans: $I = I_S(e^{V_D/(\eta V_T))} - 1)$

4. What is the value of V_t at room temperature?

Ans: 25mV

5. Dynamic resistance expression?

Ans: $r_d = \Delta V / \Delta I$

EX.NO : 02

DATE :

Zener diode Characteristics & Regulator using Zener diode

AIM:

To study and verify the functionality of Zener diode in forward bias and reverse bias and to

1. Plot Volt-Ampere Characteristics of Zener Diode.
2. Find Zener Breakdown Voltage in Reverse Biased conditions.
3. Calculate static and dynamic resistance of the Zener diode in both forward and reverse biased conditions (before, after break down voltages).

Components:

S.No.	Name	Quantity
1	Zener Diodes (1N4735A)	1(One) No.
2	Resistors (1KΩ, 3.3Ω)	1(One) No. Each
3	Bread board	1(One) No.

Equipment:

S.No.	Name	Quantity
1	Dual DC Regulated power supply (0 - 30V)	1(One) No.
2	Digital Ammeter (0 - 200 mA)	2(Two) No.
3	Digital Voltmeter (0 - 20V)	1(One) No.
4	Decade Resistance Box (DRB)	1(One) No.
5	Connecting wires (Single Strand)	FEW

Specificationsof 1N 4735A Zener diode:

- Breakdown Voltage = 5.1V
- Power dissipation = 0.75W
- Max Forward Current = 1A

CIRCUIT DIAGRAM:

Fig (1) - Forward Bias Condition:

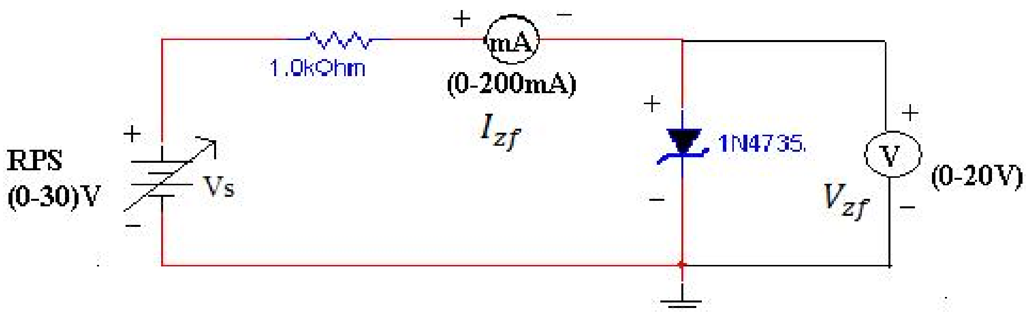


Fig (2) - Reverse Bias Condition:

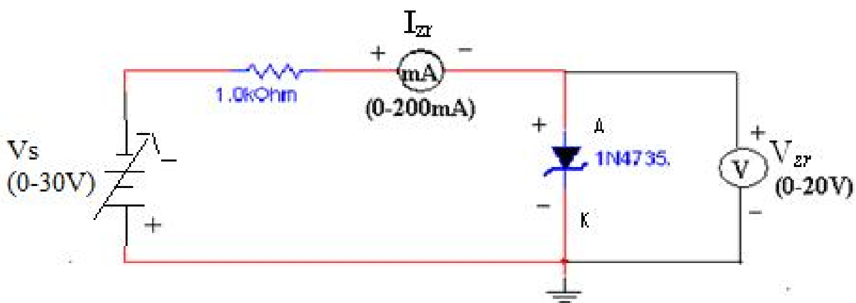


Fig (3) - Circuit Diagram of Zener Diode as Line Regulator:

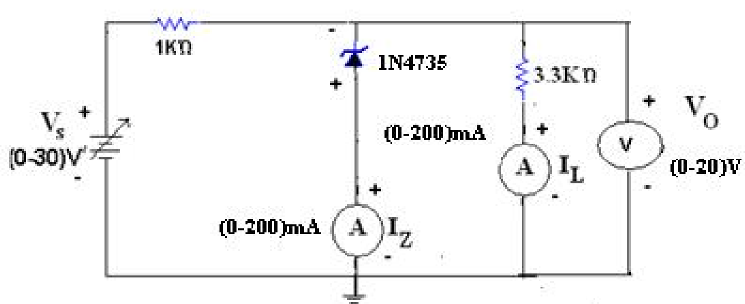
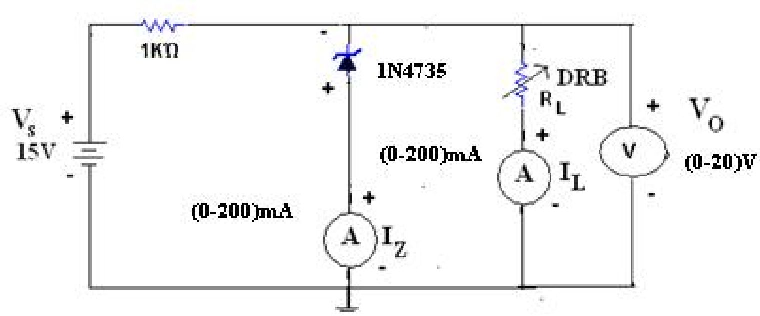


Fig (4) - Circuit Diagram of Zener Diode as Load Regulator:



Operation:

Zener diodes are a special kind of diode which permits current to flow in the forward direction. What makes them different from other diodes is that Zener diodes will also allow current to flow in the reverse direction when the voltage is above a certain value. This breakdown voltage is known as the Zener voltage. In a standard diode, the Zener voltage is high, and the diode is permanently damaged if a reverse current above that value is allowed to pass through it. Zener diodes are designed in a way where the Zener voltage is a much lower value. There is a controlled breakdown which does not damage the diode when a reverse current above the Zener voltage passes through a Zener diode.

The most common values for nominal working voltage are 5.1 V, 5.6 V, 6.2 V, 12 V and 15 V. We also carry Zener diodes with nominal working voltage up to 1 kV. Forward (drive) current can have a range from 200 uA to 200 A, with the most common forward (drive) current being 10 mA or 200 mA.

- In the forward bias direction, the zener diode behaves like an ordinary silicon diode.

In the reverse bias direction, there is practically no reverse current flow until the breakdown voltage is reached. When this occurs there is a sharp increase in reverse current. Varying amount of reverse current can pass through the diode without damaging it. The breakdown voltage or zener voltage (V_Z) across the diode remains relatively constant. The maximum reverse current is limited, however, by the wattage rating of the diode**.**

Avalanche Break down:

When the diode is in the reverse bias condition, the width of the depletion region is more. If both p-side and n-side of the diode are lightly doped, depletion region at the junction widens. In reverse bias, the minority charge carrier current flows through junction. As the applied reverse voltage increases the minority carriers acquire sufficient energy to collide with the carriers in the covalent bonds inside the depletion region. As a result, the bond breaks and electron hole pairs are generated. The process becomes cumulative and leads to the generation of a large number of charge carriers resulting in Avalanche Breakdown.

Observations:

Table: 1 Forward Bias Condition:

Sl.No	RPS Voltage Vs **(volts)**	Forward Voltage across the diode V_{zf} (volts)	Forward Current through the diode I_{zf} (mA)
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			

Table: 2 Reverse Bias Condition:

Sl.No	RPS Voltage Vs **(volts)**	**Reverse Voltage across the diode V_{zr} (volts)**	**Reverse Current through the diode I_{zr} (mA)**
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			

Zener Break down:

If both p-side and n-side of the diode are heavily doped, depletion region at the junction reduces compared to the width in normal doping. Applying a reverse bias causes a strong electric field get applied across the device. As the reverse bias is increased, the Electric field becomes strong enough to rupture covalent bonds and generate large number of charge carriers. Such sudden increase in the number of charge carriers due to rupture of covalent bonds under the influence of strong electric field is termed as Zener breakdown.

Zener Diode as Voltage Regulator:

The function of a regulator is to provide a constant output voltage to a load connected in parallel with it in spite of the ripples in the supply voltage or the variation in the load current and the zener diode will continue to regulate the voltage until the diodes current falls below the minimum I_Z(min) value in the reverse breakdown region. It permits current to flow in the forward direction as normal, but will also allow it to flow in the reverse direction when the voltage is above a certain value - the breakdown voltage known as the Zener voltage. The Zener diode specially made to have a reverse voltage breakdown at a specific voltage. Its characteristics are otherwise very similar to common diodes. In breakdown the voltage across the Zener diode is close to constant over a wide range of currents thus making it useful as a shunt voltage regulator.

The purpose of a voltage regulator is to maintain a constant voltage across a load regardless of variations in the applied input voltage and variations in the load current. A typical Zener diode shunt regulator is shown in Figure 3. The resistor is selected so that when the input voltage is at V_{IN}(min) and the load current is at I_L(max) that the current through the Zener diode is at least I_z(min). Then for all other combinations of input voltage and load current the Zener diode conducts the excess current thus maintaining a constant voltage across the load. The Zener conducts the least current when the load current is the highest and it conducts the most current when the load current is the lowest.

If there is no load resistance, shunt regulators can be used to dissipate total power through the series resistance and the Zener diode. Shunt regulators have an inherent current limiting advantage under load fault conditions because the series resistor limits excess current.

A Zener diode of break down voltage V_z is reverse connected to an input voltage source V_i across a load resistance R_L and a series resistor R_S. The voltage across the zener will remain steady at its break down voltage V_Z for all the values of zener current I_Z as

Table: 3 Line Regulation:

Load Resistance R_L = ____________ (KΩ)

Sl.No	Unregulated Power Supply V_s (V)	Zener Current I_z (mA)	Load Current I_L (mA)	Regulated Output Voltage V_o (V)
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				

Table: 4 Load Regulation:

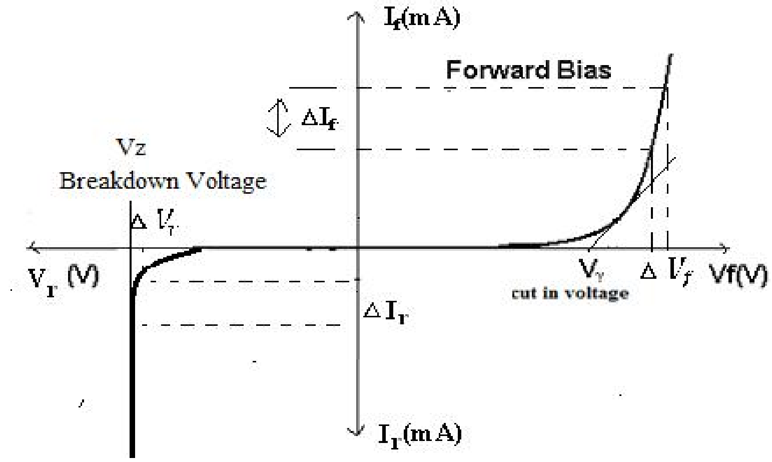
Input Supply Voltage **V_s** = _________ Volts

No-load **DC** Voltage, **V_{NL}** = _________ Volts

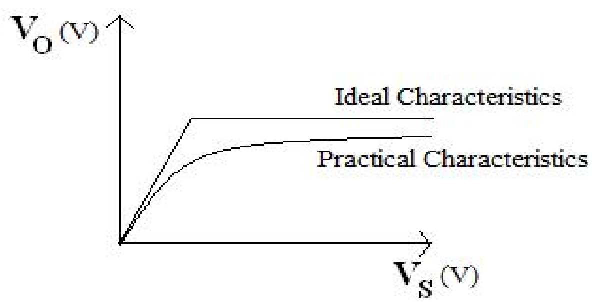
Sl.No	Load Resistance R_L (KΩ)	Zener Current I_z (mA))	Load Current I_L (mA)	Regulated Output Voltage V_o (V)	% Voltage Regulation
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					

Expected Graph:

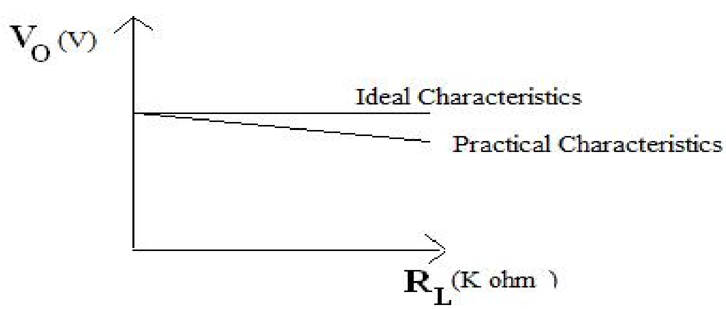
Fig: V- I Characteristics of Zener Diode under Forward & Reverse Bias Conditions



Line Regulation



Load Regulation:



long as the current remains in the break down region. Hence a regulated DC output voltage $V_0 = V_Z$ is obtained across R_L, whenever the input voltage remains within a minimum and maximum voltage.

Basically there are two types of regulations such as:

a. **Line Regulation:** In this type of regulation, series resistance and load resistance are fixed, only input voltage is changing. Output voltage remains the same as long as the input voltage is maintained above a minimum value.
b. **Load Regulation:** In this type of regulation, input voltage is fixed and the load resistance is varying. Output volt remains same, as long as the load resistance is maintained above a minimum value.

Procedure:

a) Forward Bias Condition:

1. Connect the circuit as shown in figure (1).
2. Initially vary V_s in steps of 0.1V. Once the current starts increasing vary V_s in steps of 1V up to 12V. Note down the corresponding readings of V_{zf} and I_{zf}.

b) Reverse Bias Condition:

1. Connect the circuit as shown in figure (2).
2. Vary V_s gradually in steps of 1V up to 12V and note down the corresponding readings of V_{zr} and I_{zr}.
3. Tabulate different reverse currents obtained for different reverse voltages.

c) Zener Diode as Line Regulator (for variations in supply voltage):

Connect the circuit for Line regulation as shown in figure (3). Vary supply voltage (V_s) in in steps of **1volt** from 0 **- 15 volts** and note the corresponding Zener Current (I_Z), Load Current (I_L) and Output Voltage (V_O). Plot the graph between V_S and V_O taking V_S on X-axis and V_O on Y-axis.

d) Zener Diode as Load Regulator (for variations in load connected):

1. Connect the circuit for Load regulation as shown in figure (4).
2. Now fix the power supply voltage, V_s at **10V**.
3. Without connecting the load R_L, note down the No-Load Voltage (V_{NL}).
4. Now connect the load (R_L) using Decade Resistance Box (DRB) and vary the resistance in steps 1KΩ from 1KΩ to10KΩ / in steps of 10 KΩ from10KΩ to

100KΩ and note the corresponding Zener Current (I_Z), Load Current (I_L) and Output Voltage (V_O) for 10 readings and calculate the percentage regulation.

5. Plot the graph between R_L and V_O taking R_L on X-axis and V_O on Y-axis.

Zener Diode Characteristics in X-Y mode:

1. Adjust CRO TIME/DIV knob in X-Y mode.
2. Give the input as triangular voltage waveform from Function Generator (both positive and negative peaks).
3. Connect the CRO CH1 across the input and CH2 across resistor.
4. Zener diode characteristics can be observed.

Precautions:

1. While doing the experiment do not exceed the readings of the diode. This may lead to damaging 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.

RESULT : The characteristics and Voltage Regulation of Zener diode are studied.

a) Forward Bias Zener Diode:

1. The Knee voltage or Cut-in Voltage (V_y) is __________________ **Volts.**
2. The Dynamic Forward resistance is __________________ **Ω**.
3. The Static Forward resistance is __________________ **Ω**..

b) Reverse Bias of Zener Diode:

1. Zener Breakdown Voltage (V_Z) is ____________________ **Volts.**
2. The Dynamic Reverse resistance is __________________ **Ω**..
3. The Static Reverse resistance is __________________ **Ω**. .

Outcomes: Students are able to

1. analyze the forward and reverse bias characteristics of Zener diode.
2. calculate static and dynamic resistance in both forward and reverse bias condition.
3. analyze the working of Zener diode as a voltage regulator for line regulation and load regulation.

Viva Questions:

1. What is the difference between p-n Junction diode and zener diode?

Ans: A zener is designed to operate stably in reverse breakdown, which is designed to be at a low voltage, between 3 volts and 200 volts. The breakdown voltage is specified as a voltage with a tolerance, such as 10 volts ±5%, which means the breakdown voltage (or operating voltage) will be between 9.5 volts and 10.5 volts.
A signal diode or rectifier will have a high reverse breakdown, from 50 to 2000 volts, and is NOT designed to operate in the breakdown region. So exceeding the reverse voltage may result in the device being damaged. In addition, the breakdown voltage is specified as a minimum only.

Forward characteristics are similar to both, although the zener's forward characteristics is usually not specified, as the zener will never be used in that region. A signal diode or rectifier has the forward voltage specified as a max voltage at one or more current levels.

2. What is break down voltage?

Ans: The breakdown voltage of a diode is the minimum reverse voltage to make the diode conduct in reverse.

3. What are the applications of Zener diode?

Ans: Zener diodes are widely used as voltage references and as shunt regulators to regulate the voltage across small circuits.

4. What is cut-in-voltage ?

Ans: The forward voltage at which the current through the junction starts increasing rapidly, is called the knee voltage or cut-in voltage. It is generally 0.6v for a Silicon diode.

5. What is voltage regulator?

Ans: A voltage regulator is an electronic circuit that provides a stable dc voltage independent of the load current, temperature and ac line voltage variations.

EX.NO : 03

DATE :

Common Base input-output Characteristics

AIM:

To study the input and output characteristics of a transistor in Common Base Configuration

Components:

S.No.	Name	Quantity
1	Transistor BC 107	1(One) No.
2	Resistors (1KΩ)	2(Two) No.
3	Bread board	1(One) No.

Equipment:

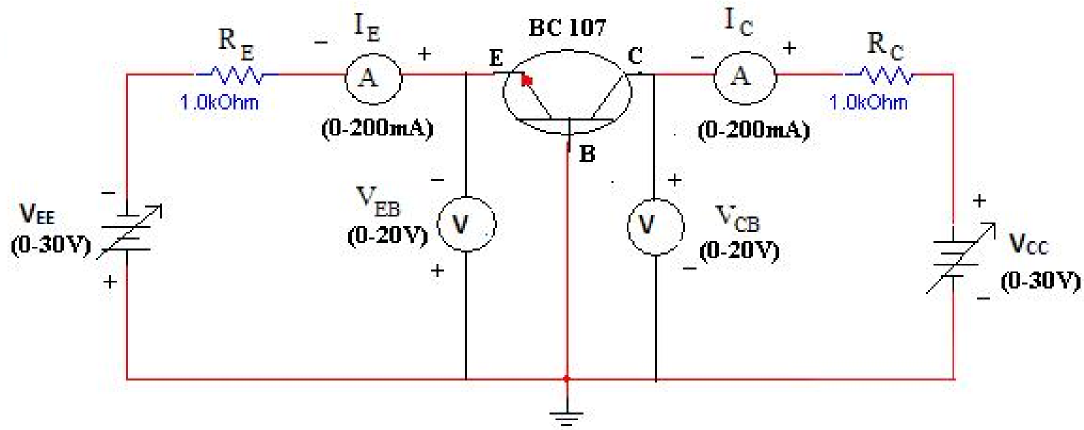
S.No.	Name	Quantity
1	Dual DC Regulated Power supply (0 – 30 V)	1(One) No.
2	Digital Ammeters (0 – 200 mA)	2(Two) No.
3	Digital Voltmeter (0-20V)	2(Two) No.
4	Connecting wires (Single Strand)	FEW

Specifications:

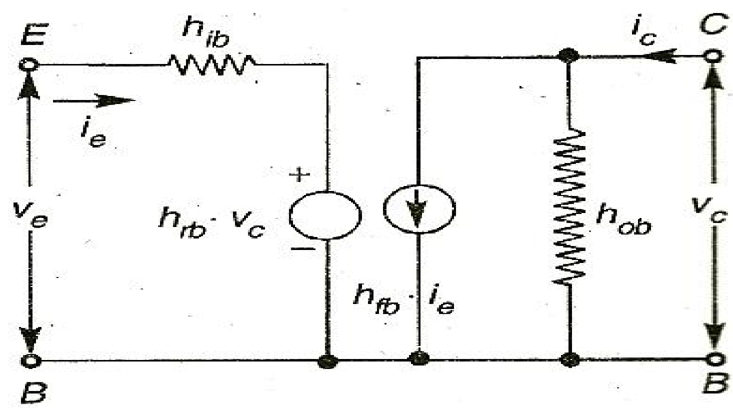
For Transistor BC 107:

- Max Collector Current = 0.1A
- V_{ceo} max = 50V

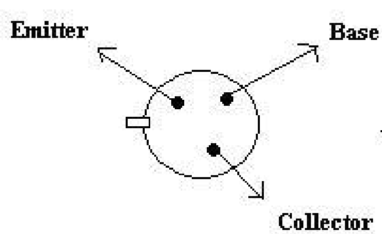
Circuit Diagram:

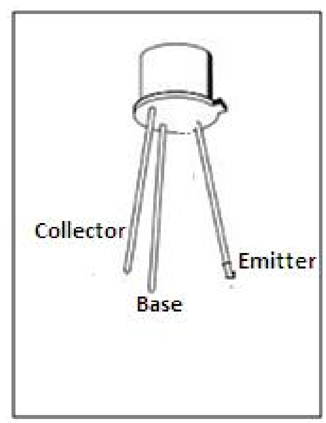


h – Parameter model of CB transistor:



Pin assignment of Transistor:





View from side of pins

View from top of casing

- **Operation:**

Bipolar Junction Transistor (BJT) is a three terminal (emitter, base, collector) semiconductor device. There are two types of BJTs, namely NPN and PNP. It consists of two PN junctions, namely emitter junction and collector junction.

The basic circuit diagram for studying input characteristics is shown in the circuit diagram. The input is applied between emitter and base, the output is taken between collector and base. Here base of the transistor is common to both input and output and hence the name is Common Base Configuration.

Input characteristics are obtained between the input current and input voltage at constant output voltage. It is plotted between $\mathbf{V_{EE}}$ and $\mathbf{I_E}$ at constant $\mathbf{V_{CB}}$ in CB configuration.

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

Procedure:

Input Characteristics:

1. Connect the circuit as shown in the circuit diagram.
2. Keep output voltage V_{CB} = 0V by varying V_{CC}.
3. Varying V_{EE} gradually, note down emitter current I_E and emitter-base voltage(V_{EE}).
4. Step size is not fixed because of nonlinear curve. Initially vary V_{EE} in steps of 0.1 V. Once the current starts increasing vary V_{EE} in steps of 1V up to 12V.
5. Repeat above procedure (step 3) for V_{CB} = 4V.

Output Characteristics:

1. Connect the circuit as shown in the circuit diagram.
2. Keep emitter current I_E = 5mA by varying V_{EE}.
3. Varying V_{CC} gradually in steps of 1V up to 12V and note down collector current I_C and collector-base voltage(V_{CB}).
4. Repeat above procedure (step 3) for I_E = 10mA.

Repeat above procedure (step 3) for I_E = 10mA.

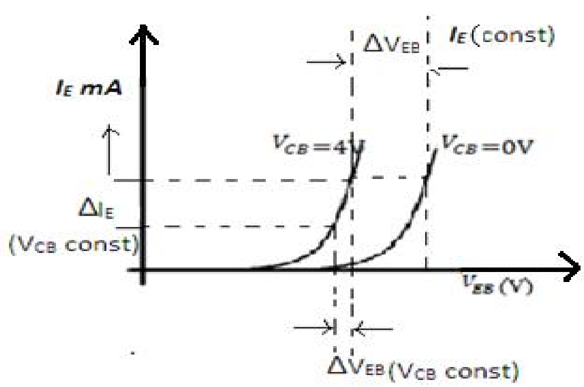
1. Plot the input characteristics for different values of $\mathbf{V_{CB}}$ by taking $\mathbf{V_{EE}}$ on X-axis and $\mathbf{I_E}$ on Y-axis taking $\mathbf{V_{CB}}$ as constant parameter.

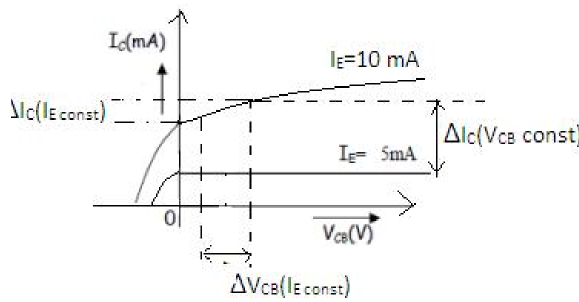
Observations:

Input Characteristics				
VEE (Volts)	VCB = 0V		VCB = 4V	
	VEB (Volts)	IE (mA)	VEB (Volts)	IE (mA)

Output Characteristics						
VCC (Volts)	IE = 0mA		IE = 5V		IE = 10mA	
	VCB (Volts)	IC (mA)	VCB (Volts)	IC (mA)	VCB (Volts)	IC (mA)

Graph:





Plot the output characteristics by taking $\mathbf{V_{CB}}$ on X-axis and taking $\mathbf{I_C}$ on Y-axis taking $\mathbf{I_E}$ as a constant parameter.

Calculations from Graph:

The h-parameters are to be calculated from the following formula:

1. **Input Characteristics:** To obtain input resistance, find ΔV_{EE} and ΔI_E for a constant V_{CB} on one of the input characteristics.
   Input impedance = $h_{ib} = R_i = \Delta V_{EE} / \Delta I_E$ (V_{CB} = constant)
   Reverse voltage gain = hrb = $\Delta V_{EB} / \Delta V_{CB}$ (I_E = constant)

2. **Output Characteristics:** To obtain output resistance, find ΔI_C and ΔV_{CB} at a constant I_E.
   Output admitance = $h_{ob} = 1/Ro = \Delta I_C / \Delta V_{CB}$ (I_E = constant)
   Forward current gain = $h_{fb} = \Delta I_C / \Delta I_E$ (V_{CB} = constant)

Inference:

1. Input resistance is in the order of tens of ohms since Emitter-Base Junction is forward biased.
2. Output resistance is in order of hundreds of kilo-ohms since Collector-Base Junction is reverse biased.
3. Higher is the value of V_{CB}, smaller is the cut in voltage.
4. Increase in the value of I_B causes saturation of transistor at small voltages.

Precautions:

1. While performing 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.

RESULT :

Input and Output characteristics of a Transistor in Common Base Configuration are studied.

The h-parameters for a transistor in CB configuration are:

a. The Input resistance (h_{ib}) ___________________ **Ω**

b. The Reverse Voltage Transfer Ratio (h_{rb}) ___________________.

c. The Output Admittance (h_{ob}) ___________________ **Mhos**.

d. The Forward Current gain (h_{fb}) ___________________.

<u>Outcomes:</u> Students are able to

1. analyze the characteristics of BJT in Common Base Configuration.
2. calculate h-parameters from the characteristics obtained.

<u>Discussion/Viva Questions:</u>

1. What is transistor?

Ans: A transistor is a semiconductor device used to amplify and switch electronic signals and electrical power. It is composed of semiconductor material with at least three terminals for connection to an external circuit. The term transistor was coined by John R. Pierce as a portmanteau of the term "transfer resistor".

2. Write the relation between α and β ?

$$\beta_F = \frac{\alpha_F}{1-\alpha_F} \Leftrightarrow \alpha_F = \frac{\beta_F}{\beta_F + 1}$$

Ans: $\boldsymbol{\beta_f = \frac{\alpha_f}{1-\alpha_f}}$ $\boldsymbol{\alpha_f = \frac{\beta_f}{1-\beta_f}}$

3. Define α (alpha)? What is the range of α?

Ans: The important parameter is the common-base current gain, α. The common-base current gain is approximately the gain of current from emitter to collector in the forward-active region. This ratio usually has a value close to unity; between 0.98 and 0.998.

4. Why α is less than unity?

Ans: It is less than unity due to recombination of charge carriers as they cross the base region.

5. Input and output impedance equations for CB configuration?

Ans: $\boldsymbol{h_{ib} = \frac{V_{BE}}{I_E}}$ $\boldsymbol{h_{oe} = \frac{V_{CE}}{I_C}}$

EX.NO : 04

DATE :

Common Emitter input-output Characteristics

AIM:

To study the input and output characteristics of a transistor in Common Emitter configuration.

Components:

S.No.	Name	Quantity
1	Transistor BC 107	1(One) No.
2	Resistors (1K, 100K)	1(One) No. Each
3	Bread board	1(One) No.

Equipment:

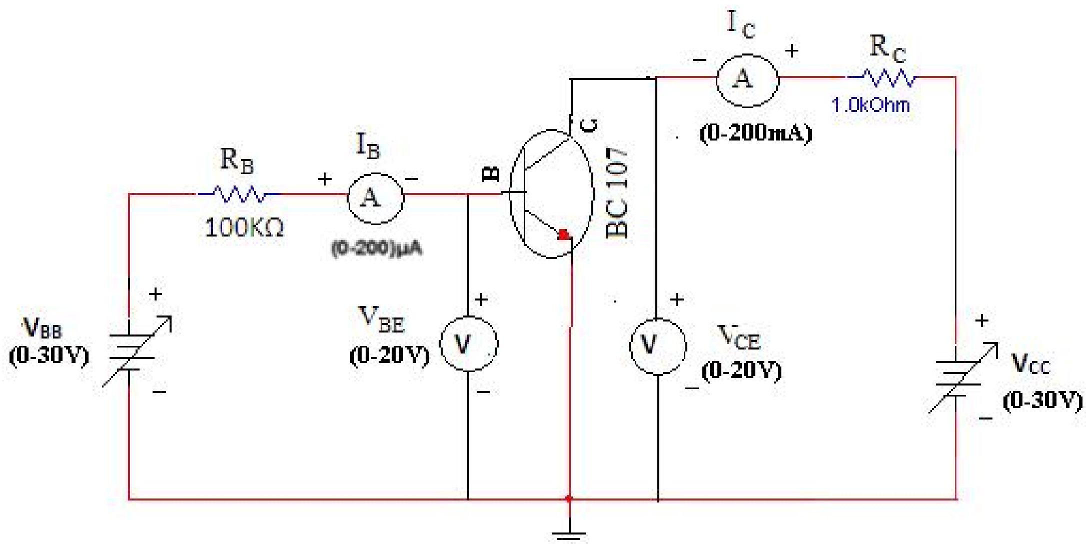
S.No.	Name	Quantity
1	Dual DC Regulated Power supply (0 - 30 V)	1(One) No.
2	Digital Ammeters (0 - 200 mA, 0-200 A)	1(One) No. Each
3	Digital Voltmeter (0 - 20V)	2(Two) No.
4	Connecting wires (Single Strand)	Few

Specifications:

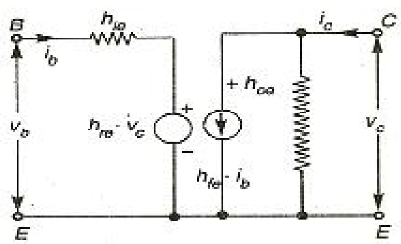
For Transistor BC 107:

- Max Collector Current = 0.1A
- V_{CEO} max = 50V

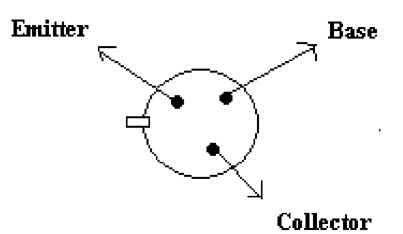
Circuit Diagram:



h – Parameter model of CE transistor:



Pin assignment of Transistor:



Operation:

The basic circuit diagram for studying input characteristics is shown in the circuit diagram. The input is applied between base and emitter, the output is taken between collector and emitter. Here emitter of the transistor 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 at constant output voltage. 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 at constant input current. It is plotted between V_{CE} andI_C at constant I_B in CE configuration.

Procedure:

Input Characteristics:

1. Connect the circuit as shown in the circuit diagram.
2. Keep output voltage V_{CE} = 0V by varying V_{CC}.
3. Varying V_{BB} gradually, note down base current I_B and base-emitter voltage V_{BE}.
4. Step size is not fixed because of non linear curve. Initially vary V_{BB} in steps of 0.1V. Once the current starts increasing vary V_{BB} in steps of 1V up to 12V.
5. Repeat above procedure (step 3) for V_{CE} = 5V.

Output Characteristics:

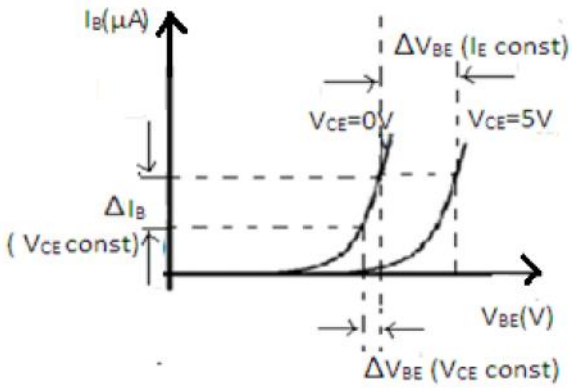
1. Connect the circuit as shown in the circuit diagram.
2. Keep emitter current I_B = 20μA by varying V_{BB}.
3. Varying V_{CC} gradually in steps of 1V up to 12V and note down collector current I_C and Collector-Emitter Voltage(V_{CE}).
4. Repeat above procedure (step 3) for I_B = 60µA, 0µA.

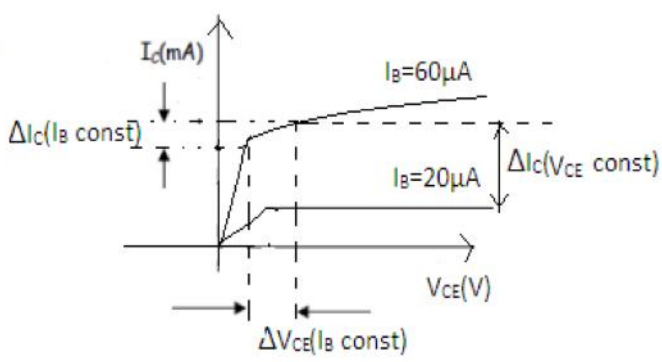
Observations:

Input Characteristics				
V_{EE} (Volts)	V_{CB} = 0V		V_{CB} = 4V	
	V_{EB} (Volts)	I_E (mA)	V_{EB} (Volts)	I_E (mA)

Output Characteristics						
V_{CC} (Volts)	I_E = 0mA		I_E = 5V		IE = 10mA	
	V_{CB} (Volts)	I_C (mA)	V_{CB} (Volts)	I_C (mA)	V_{CB} (Volts)	I_C (mA)

Graph:





Input Characteristics *Output Characteristics*

1. Plot the input characteristics by taking $\mathbf{V_{BE}}$ on X-axis and $\mathbf{I_B}$ on Y-axis at a constant $\mathbf{V_{CE}}$ as a constant parameter.
2. Plot the output characteristics by taking $\mathbf{V_{CE}}$ on X-axis and taking $\mathbf{I_C}$ on Y-axis taking $\mathbf{I_B}$ as a constant parameter.

Calculations from Graph:

1. **Input Characteristics:** To obtain input resistance find ΔV_{BE} and ΔI_B for a constant $\mathbf{V_{CE}}$ on one of the input characteristics.

   Input impedance = $\mathbf{h_{ie} = R_i} = \Delta \mathbf{V_{BE}} / \Delta \mathbf{I_B}$ ($\mathbf{V_{CE}}$ is constant)

   Reverse voltage gain = $\mathbf{h_{re}} = \Delta \mathbf{V_{EB}} / \Delta \mathbf{V_{CE}}$ ($\mathbf{I_B}$ = constant)

2. **Output Characteristics:** To obtain output resistance find $\Delta \mathbf{I_C}$ and $\Delta \mathbf{V_{CB}}$ at a constant $\mathbf{I_B}$.

   Output admittance **1/hoe** = $\mathbf{R_o} = \Delta \mathbf{I_C} / \Delta \mathbf{V_{CE}}$ (I_B is constant)

   Forward current gain = $\mathbf{h_{fe}} = \Delta \mathbf{I_C} / \Delta \mathbf{I_B}$ ($\mathbf{V_{CE}}$ = constant)

Inference:

1. Medium input and output resistances.
2. Smaller values if $\mathbf{V_{CE}}$, lower the cut-in-voltage.
3. Increase in the value of $\mathbf{I_E}$ causes saturation of the transistor of an earlier voltage.

Precautions:

1. While performing 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.

RESULT :

Input and Output characteristics of a Transistor in Common Emitter Configuration are studied.

The h-parameters for a transistor in CE configuration are:

a. The Input Resistance (**h_{ie}**) ________________**Ohms.**

b. The Reverse Voltage Gain (**h_{re}**) ________________.

c. The Output Conductance (**h_{oe}**) ________________ **Mhos.**

d. The Forward Current Gain (**h_{fe}**) ________________.

Outcomes: Students are able to

1. Analyze the characteristics of BJT in Common Emitter and configuration.
2. Calculate h-parameters from the characteristics obtained.

Viva Questions:

1. Can transistor be replaced by two back to back connected diodes?

Ans: No, because the doping levels of emitter(heavily doped), base(lightly doped) and collector(doping level greater than base and less than emitter) terminals are different from p and n terminals in diode.

2. For amplification CE is preferred, why?

Ans: Because amplification **factor beta is usually ranges from 20-500 hence this configuration gives appreciable current gain as well** as voltage gain at its output on the other hand in the Common Collector configuration has very high input resistance(~750K Ω) & very low output resistance(~25Ω) so the voltage gain is always less than one & its most important application is for impedance matching for driving from low impedance load to high impedance source.

3. To operate a transistor as amplifier, emitter junction is forward biased and collector junction is reverse biased. Why?

Ans: Voltage is directly proportional to Resistance. Forward bias resistance is very less compared to reverse bias. In amplifier input forward biased and output reverse biased so voltage at output increases with reverse bias resistance.

4. Which transistor configuration provides a phase reversal between the input and output signals? **Ans:** Common emitter configuration.

5. What is the range β of a BJT? **Ans:** Beta is usually ranges from 20 - 500.

EX.NO : 05

DATE :

FET Characteristics

AIM:

To study Drain Characteristics and Transfer Characteristics of a Field Effect Transistor (FET).

Components:

S.No.	Name	Quantity
1	JFET (BFW11/ BFW10)	1(One) No.
2	Resistor (1K ,100K)	1(One) No. Each
3	Bread board	1(One) No.

Equipment:

S.No.	Name	Quantity
1	Dual DC Regulated Power supply (0 - 30 V)	1(One) No.
2	Digital Ammeters (0 - 200 mA)	1(One) No.
3	Digital Voltmeter (0 - 20V)	2(Two) No.
4	Connecting wires (Single Strand)	

Specifications:

For FET BFW11:

- Gate Source Voltage VGS = -30V
- Forward Gain Current IGF = 10mA
- Maximum Power Dissipation PD = 300mW

Circuit Diagram:

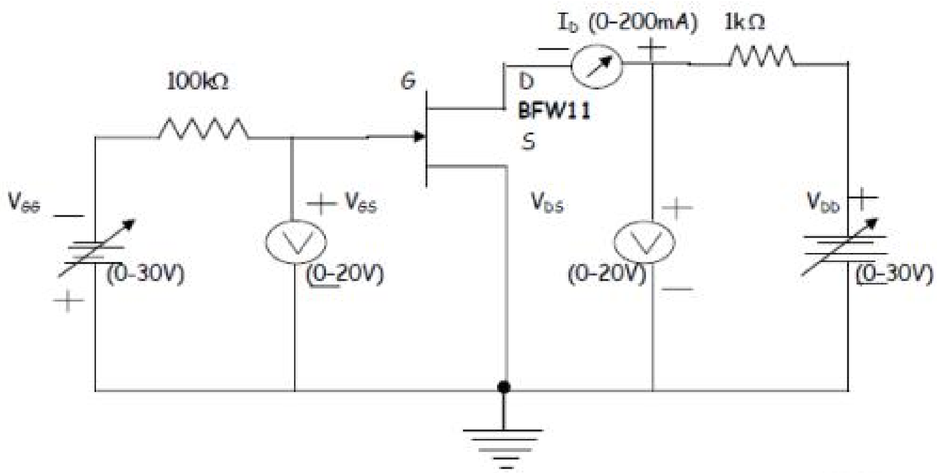
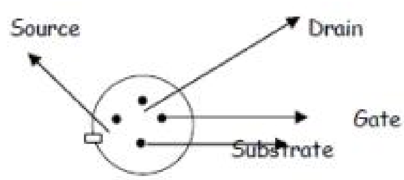
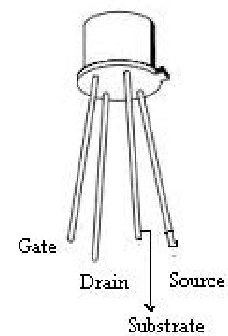


Figure 1.

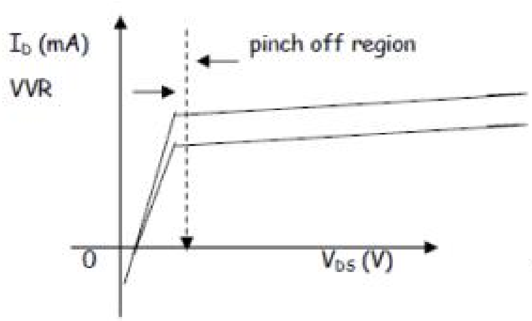
Pin assignment of FET:

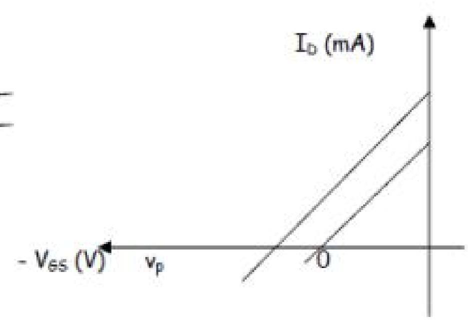




Top View Bottom View

Graph:





DRAIN CHARACTERISTICS **TRANSFER CHARACTERISTICS**

1. Plot the drain characteristics by taking **VDS** on X-axis and **ID** on Y-axis at a constant **VGS**.
2. Plot the transfer characteristics by taking **VGS** on X-axis and taking **ID** on Y-axis at constant **VDS**.

Operation:

The circuit diagram for studying drain and transfer characteristics is shown in the figure1.

1. Drain characteristics are obtained between the drain to source voltage (**VDS**) and drain current (**ID**) taking gate to source voltage (**VGS**) as the constant parameter.
2. Transfer characteristics are obtained between the gate to source voltage (**VGS**) and drain current (**ID**) taking drain to source voltage (**VDS**) as the constant parameter.

Procedure:

Drain Characteristics:

1. Connect the circuit as shown in the figure1.
2. Keep **VGS = 0V** by varying **VGG**.
3. Varying **VDD** gradually in steps of **1V** up to **10V** note down drain current **ID** and drain to source voltage (**VDS**).
4. Repeat above procedure for **VGS = -1V**.

Transfer Characteristics:

1. Connect the circuit as shown in the figure1.
2. Set voltage **VDS = 2V/5V** (BFW10/ BFW11).
3. Varying **VDD** in steps of 0.5V until the current **ID** reduces to minimum value.
4. Varying **VGG** gradually, note down both drain current **ID** and gate-source voltage(**VGS**).
5. Repeat above procedure (step 3) for **VDS** = 4V/ 8V (BFW10/ BFW11).

Calculations from Graph:

1. **Drain Resistance (rd):** It is given by the relation of small change in drain to source voltage(∆VDS) to the corresponding change in Drain Current(∆ID) for a constant gate to source voltage (∆VGS), when the JFET is operating in pinch-off region. $r_d = \frac{\Delta V_{DS}}{\Delta I_D}$ at a constant **VGS** (from drain characteristics)
2. **Trans Conductance (gm):** Ratio of small change in drain current(∆ID) to the corresponding change in gate to source voltage (∆VGS) for a constant **VDS**. $gm = \frac{\Delta I_D}{\Delta V_{GS}}$ at constant **VDS** (from transfer characteristics).

Tabulation:

Drain Characteristics				
VDD (Volts)	VGS = 0V		VGS = -1V	
	VDS(Volts)	ID(mA)	VDS(Volts)	ID(mA)

Transfer Characteristics				
VGG (Volts)	VDS = 2V/5V		VDS = 4V/8V	
	VGS(Volts)	ID(mA)	VGS(Volts)	ID(mA)

The value of **gm** is expressed in mho's (℧) or Siemens (**s**).

3. **Amplification factor (μ):** It is given by the ratio of small change in drain to source voltage (ΔVDS) to the corresponding change in gate to source voltage (Δ VGS) for a constant drain current (ID).

$$\mu = \frac{\Delta V_{DS}}{\Delta I_D} * \frac{\Delta I_D}{\Delta V_{GS}} = \frac{\Delta V_{DS}}{\Delta V_{GS}} = r_d * gm$$

$$\mu = \left(\frac{\Delta V_{DS}}{\Delta I_D}\right) * \left(\frac{\Delta I_D}{\Delta V_{GS}}\right) = \frac{\Delta V_{DS}}{\Delta V_{GS}} = r_d * gm$$

<u>Inference:</u>

1. As the gate to source voltage (**VGS**) is increased above zero, pinch off voltage is increased at a smaller value of drain current as compared to that when **VGS = 0V**.
2. The value of drain to source voltage (**VDS**) is decreased as compared to that when **VGS = 0V**.

<u>Precautions:</u>

1. While performing the experiment do not exceed the ratings of the FET. This may lead to damage of FET.
2. Connect voltmeter and ammeter with correct polarities as shown in the circuit diagram.
3. Do not switch ON the power supply unless the circuit connections are checked as per the circuit diagram.
4. Properly identify the Source, Drain and Gate terminals of the transistor.

<u>RESULT :</u>

Drain and Transfer characteristics of a FET are studied.

<u>Outcomes:</u> Students are able to

1. analyze the Drain and transfer characteristics of FET in Common Source configuration.
2. calculate the parameters transconductance (**gm**), drain resistance (**rd**) and amplification factor(**μ**).

Viva Questions:

1. Why FET is called a Unipolar device?

Ans: FETs are unipolar transistors as they involve single-carrier-type operation.

2. What are the advantages of FET?

Ans: The main advantage of the FET is its high input resistance, on the order of 100 MΩ or more. Thus, it is a voltage-controlled device, and shows a high degree of isolation between input and output. It is a unipolar device, depending only upon majority current flow. It is less noisy. and is thus found in FM tuners and in low-noise amplifiers for VHF and satellite receivers. It is relatively immune to radiation. It exhibits no offset voltage at zero drain current and hence makes an excellent signal chopper. It typically has better thermal stability than a bipolar junction transistor (BJT)

3. What is transconductance?

Ans: Trasconductance is an expression of the performance of a bipolar transistor or field-effect transistor (FET). In general, the larger the transconductance figure for a device, the greater the gain(amplification) it is capable of delivering, when all other factors are held constant. The symbol for transconductance is gm. The unit is thesiemens, the same unit that is used for direct-current (DC) conductance.

4. What are the disadvantages of FET?

Ans: It has a relatively low gain-bandwidth product compared to a BJT. The MOSFET has a drawback of being very susceptible to overload voltages, thus requiring special handling during installation.The fragile insulating layer of the MOSFET between the gate and channel makes it vulnerable to electrostatic damage during handling. This is not usually a problem after the device has been installed in a properly designed circuit.

5. Relation between μ, gm and rd? Ans: μ = gm * rd

EX.NO : 06

DATE :

SCR CHARACTERISTICS

AIM:

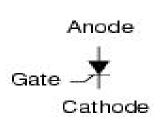
To draw the V-I Characteristics of Silicon controlled rectifier.

Apparatus:

- SCR (TYN616)
- Regulated Power Supply (0-30V)
- Resistors 10kΩ, 1kΩ
- Ammeter (0-50)mA
- Voltmeter (0-20V)
- Breadboard
- Connecting Wires.

Theory:

It is a four layer semiconductor device being alternate of P-type and N-type silicon. It consists as 3 junctions J1, J2, J3 the J1 and J3 operate in forward direction and J2 operates in reverse direction and three terminals called anode A, cathode K , and a gate G. The operation of SCR can be studied when the gate is open and when the gate is positive with respect to cathode.

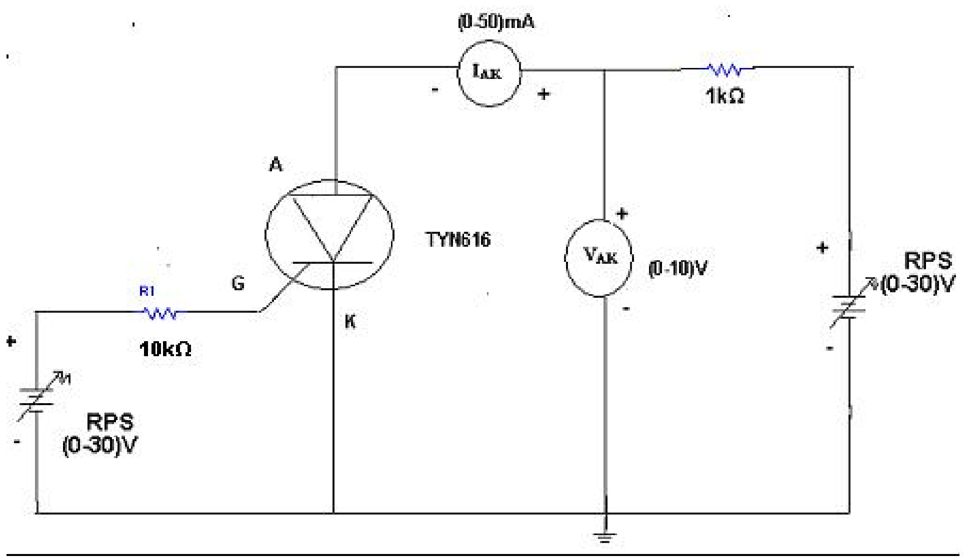


Schematic symbol

When gate is open, no voltage is applied at the gate due to reverse bias of the junction J2 no current flows through R2 and hence SCR is at cutt off. When anode voltage is increased J2 tends to breakdown.

When the gate positive,with respect to cathode J3 junction is forward biased and J2 is reverse biased .Electrons from N-type material move across junction J3 towards gate while holes from P-type material moves across junction J3 towards cathode. So gate

Circuit Diagram:

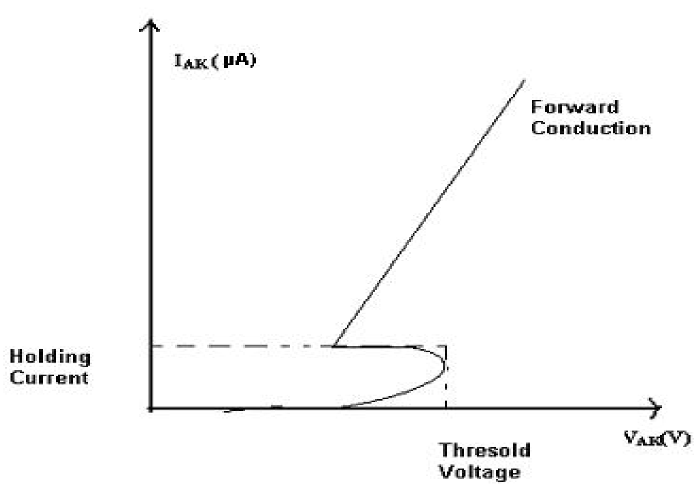


1.

Observation:

SL.No	VAK(V)	IAK (µA)

GRAPH



current starts flowing ,anode current increase is in extremely small current junction J2 break down and SCR conducts heavily.

When gate is open thee break over voltage is determined on the minimum forward voltage at which SCR conducts heavily. Now most of the supply voltage appears across the load resistance. The holding current is the maximum anode current gate being open , when break over occurs.

Procedure:

1. Connections are made as per circuit diagram.
2. Keep the gate supply voltage at some constant value
3. Vary the anode to cathode supply voltage and note down the readings of voltmeter and ammeter. Keep the gate voltage at standard value.

A graph is drawn between VAK and IAK.

RESULT : SCR Characteristics are observed.

Viva questions:

1. What is an SCR?

Ans: Silicon-controlled rectifier (or semiconductor-controlled rectifier) is a four-layer solid state current controlling device. The name "silicon controlled rectifier" or SCR is General Electric's trade name for a type of thyristor

2. What is the difference between SCR and TRIAC?

Ans: SCRs are unidirectional devices (i.e. can conduct current only in one direction) as opposed to TRIACs which are bidirectional (i.e. current can flow through them in either direction). SCRs can be triggered normally only by currents going into the gate as opposed to TRIACs which can be triggered normally by either a positive or a negative current applied to its gate electrode.

3. What are the applications of SCR?

Ans: SCRs are mainly used in devices where the control of high power, possibly coupled with high voltage, is demanded. Their operation makes them suitable for use in medium to high-voltage AC power control applications, such as lamp dimming, regulators and motor control.

SCRs and similar devices are used for rectification of high power AC in high-voltage direct current power transmission. They are also used in the control of welding machines, mainly MTAW and GTAW processes.

4. Why is Peak Reverse Voltage Important?

Ans: When an SCR is used for rectification, during the negative half cycle of given ac supply, reverse voltage is applied across the SCR. If Peak Reverse Voltage is exceeded, there may be an avalanche breakdown and the SCR will be damaged (unless the external circuit limits the current).Commercial SCRs have a PRV up to 2.5kV.

5. What is asymmetrical SCR?

Ans: SCR incapable of blocking reverse voltage are known as asymmetrical SCR, abbreviated ASCR. They typically have a reverse breakdown rating in the 10's of volts. ASCR are used where either a reverse conducting diode is applied in parallel (for example, in voltage source inverters) or where reverse voltage would never occur (for example, in switching power supplies or DC traction choppers).

Asymmetrical SCR can be fabricated with a reverse conducting diode in the same package. These are known as RCT, for reverse conducting thyristor.

EX.NO : 06

DATE :

FULL WAVE RECTIFIER WITH AND WITHOUT FILTERS

AIM:

To study the operation of Full- Wave Rectifier with and without filter and to find its:

a. Percentage Regulation
b. Ripple Factor
c. Efficiency

Components:

S.No.	Name	Quantity
1	Bread board	1 (One) No.
2	Diodes (1N4007)	2 (Two) No.
3	Resistor (1K Ω)	1 (One) No.
4	Capacitor (1000µf)	1 (One) No.

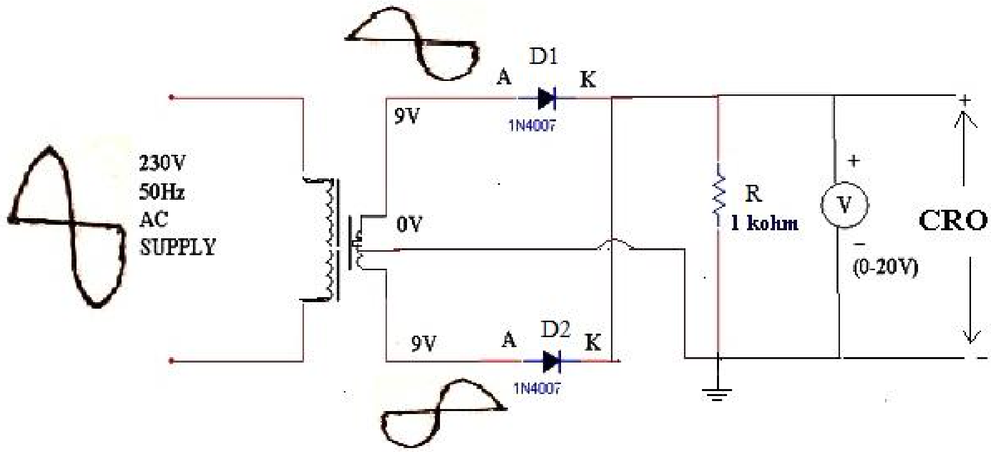
Equipment:

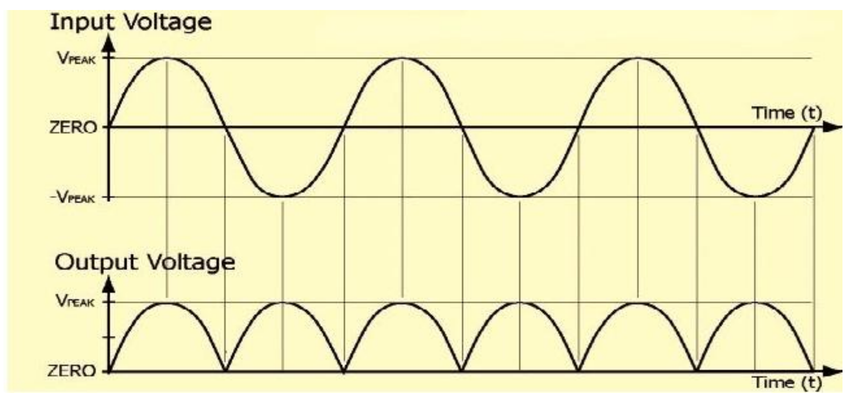
S.No.	Name	Quantity
1	Transformer with Center Tapped Secondary (9 - 0 - 9)V	1 (One) No.
2	Digital Multimeter	1 (One) No.
3	Cathode Ray Oscilloscope (CRO) (0-20MHz)	1 (One) No.
4	Connecting wires (Single Strand)	few

Operation:

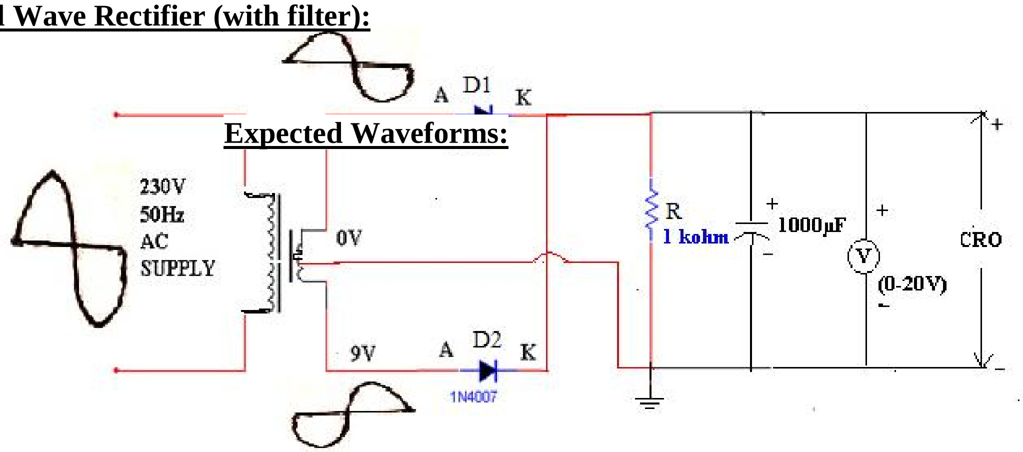
The conversion of AC into pulsating DC is called Rectification. Electronic Devices can convert AC power into DC power with high efficiency.

Full Wave Rectifier (without filter):

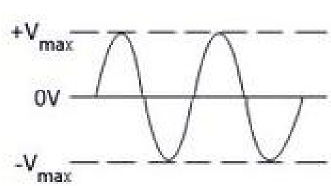




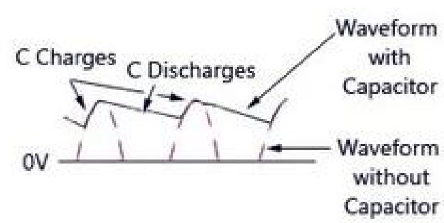
Full Wave Rectifier (with filter):



Expected Waveforms:



AC Input Waveform



Resultant Output Waveform

The full-wave rectifier consists of a center-tapped transformer, which results in equal voltages above and below the center-tap. During the positive half cycle, a positive voltage appears at the anode of D1 while a negative voltage appears at the anode of D2. Due to this diode D1 is forward biased. It results a current Id1 through the load R

Ripple Factor:

Ripple factor is defined as the ratio of the effective value of AC components to the average DC value. It is denoted by the symbol 'γ'.

$$\gamma = \frac{V_{ac}}{V_{dc}}, (\gamma = 0.48)$$

Rectification Factor:

The ratio of output DC power to input AC power is defined as efficiency.

$$\eta = \frac{(V_{dc})^2}{(V_{ac})^2}$$

η = 81% (if R >> R_f, then R_f can be neglected).

Percentage of Regulation:

It is a measure of the variation of DC output voltage as a function of DC output current (i.e., variation in load).

Percentage of regulation = $(\frac{V_{NL} - V_{FL}}{V_{FL}}) * 100$ %

V_{NL} = Voltage across load resistance, when minimum current flows through it.

V_{FL} = Voltage across load resistance, when maximum current flows through.

For an ideal Full-wave rectifier, the percentage regulation is 0 percent. The percentage of regulation is very small for a practical full wave rectifier.

Peak- Inverse - Voltage (PIV):

It is the maximum voltage that the diode has to withstand when it is reverse biased.

PIV = $2V_m$

Tabulation

Type of Rectifier	Ripple factor		Efficiency	% Regulation
	Theoretical	Practical		
FWR without filter				
FWR with filter				

Calculations:

Without filter: $V_{rms} = \frac{V_m}{\sqrt{2}}$ $V_{ac} = \sqrt{V_{rms}^2 - V_{dc}^2}$ $V_{dc} = \frac{2V_m}{\pi}$

Ripple factor (Theoretical) = $\sqrt{\left(\frac{V_{rms}}{V_{dc}}\right)^2 - 1} = 0.48$

Ripple Factor (Practical) $\gamma = \frac{V_{ac}}{V_{dc}}$

With filter: $\gamma = \frac{1}{4\sqrt{3}fCR}$

Ripple factor (Theoretical)

Where f = 50Hz, R =1KΩ, C = 1000μF.

$V_{ac} = \frac{V_{r(ptoP)}}{2\sqrt{3}}$ $V_{dc} = V_m - \frac{V_{r(ptoP)}}{2\sqrt{3}}$

Ripple Factor $\gamma = \frac{V_{ac}}{V_{dc}}$

Advantages of Full wave Rectifier:

1. γ is reduced.
2. η is improved.

Disadvantages of Full wave Rectifier:

1. Output voltage is half of the full secondary voltage.
2. Diodes with high PIV rating are to be used.
3. Manufacturing of the center-tapped transformer is quite expensive and so Full wave rectifier with center-tapped transformer is costly.

Procedure:

1. Connect the circuit as shown in the circuit diagram.
2. Connect the primary side of the transformer to AC mains and the secondary side to rectifier input.
3. Using a CRO, measure the maximum voltage V_m of the AC input voltage of the rectifier and AC voltage at the output of the rectifier.
4. Using a DC voltmeter, measure the DC voltage at the load resistance.
5. Observe the Waveforms at the secondary windings of transformer and across load resistance for a load of 1KΩ.
6. Calculate the ripple factor (γ), percentage of regulation and efficiency (η) as per the below given formulae.

Observations:

1. Peak Voltage, $\mathbf{V_m}$ = (From CRO for HWR with and without filter)
2. DC Voltage, $\mathbf{V_{DC(full\ load)}}$ = (From Voltmeter/ Multimeter for HWR with and without filter)
3. No Load DC Voltage, $\mathbf{V_{DC(No\ load)}}$ = (From Voltmeter/ Multimeter for HWR with and without filter)
4. Ripple Voltage, $\mathbf{V_r}$ = (From CRO for HWR with filter)
5. Percentage Regulation %$= \frac{V_{NL}-V_{FL}}{V_{FL}} * 100$
6. V_{NL} = DC voltage at the load without connecting the load (Minimum current).
7. V_{FL} = DC voltage at the load with load connected.
8. Efficiency $\eta = \frac{P_{DC}}{P_{AC}}$ %u200B
9. $P_{AC} = V_{rms} / R_L$
   $P_{DC} = V_{dc} / R_L$

RESULT :

The operation of Full Wave rectifier is studied .

Viva Questions:

1. What is filter?

Ans: Electronic filters are electronic circuits which perform signal processing functions, specifically to remove unwanted frequency components from the signal.

2. Give some rectifications technologies?

Ans: Synchronous rectifier, Vibrator, Motor-generator set , Electrolytic ,Mercury arc, and Argon gas electron tube.

3. What is the efficiency of bridge rectifier?

Ans: % $\boldsymbol{\eta} = \frac{81.2}{1+\frac{2r_d}{R_L}}$

4. What is the value of PIV of a center tapped FWR?

Ans: $2V_{m.}$

5. In filters capacitor is always connected in parallel, why?

Ans: Capacitor allows AC and blocks DC signal.in rectifier for converting AC to DC, capacitor placed in parallel with output, where output is capacitor blocked voltage.If capacitance value increases its capacity also increases which increases efficiency of rectifier.

Clipper and Clamper circuit

objective

To construct the biased positive & negative Clipper circuits using diodes.

APPARATUS REQUIRED:

S. NO.	APPARATUS REQUIRED	RANGE	QUANTITY
1	RPS	(0 – 30) V	1
2	Diode	1N4001	1
3	Resistor	10 K	1
4	CRO	0-20 MHZ-	1
5	FGR	--	1
6	Bread Board	--	1
7	Connecting Wires	--	1 Set
7	Connecting Wires	--	1 Set

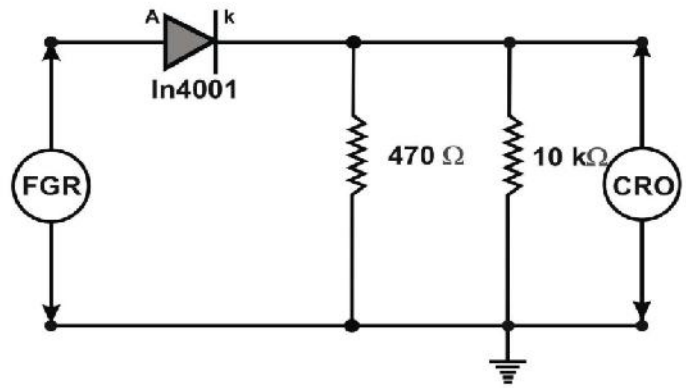
PROCEDURE:

1. Connections are made as shown in fig. Power supply is switched ON.
2. Using Function Generator we can vary the frequency and fixed at particular frequency.
3. Now the corresponding input and output waveforms are drawn. Amplitude and time, input & output waveforms are drawn. And graph is drawn for input and output waveform.

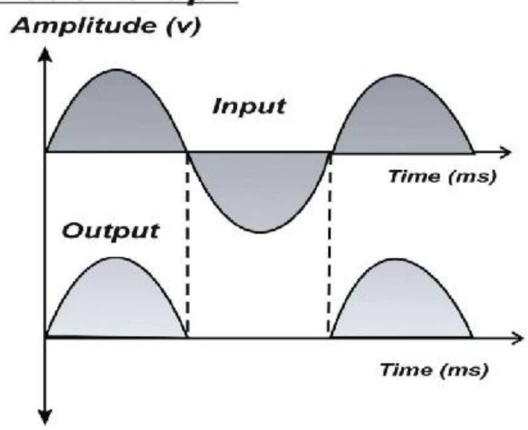
Power supply is switched OFF

Negative Clipper

Circuit Diagram



Model Graph



S. NO.	**Input**		**output**	
	Amplitude (v)	Timeperiod(t)	Amplitude (v)	Timeperiod(t)
1				
2				
3				
4				
5				
6				

PROCEDURE:

1. Connections are made as shown in fig. Power supply is switched ON.
2. Using Function Generator we can vary the frequency and fixed at particular frequency.
3. Now the corresponding input and output waveforms are drawn. Amplitude and time, input & output waveforms are drawn. And graph is drawn for input and output waveform.
4. Power supply is switched OFF

1. Negative Clamper

The Negative Clamping circuit consists of a diode connected in parallel with the load. The capacitor used in the clamping circuit can be chosen such that it must charge very quickly and it should not discharge very drastically. The anode of the diode is connected to the capacitor and cathode to the ground. During the positive half cycle of the input, the diode is in forward bias and as the diode conducts the capacitor charges very quickly.

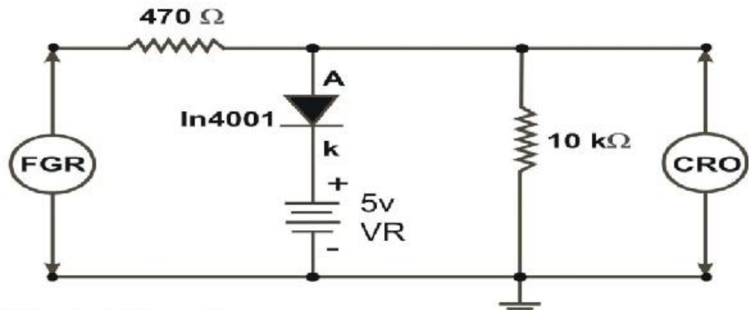
During the negative half cycle of the input, the diode will be in reverse bias and the diode will not conduct, the output voltage will be equal to the sum of the applied input voltage and the charge stored in the capacitor during reverse bias. The output waveform is same as input waveform, but shifted below 0 volts.

4. Positive Clamper

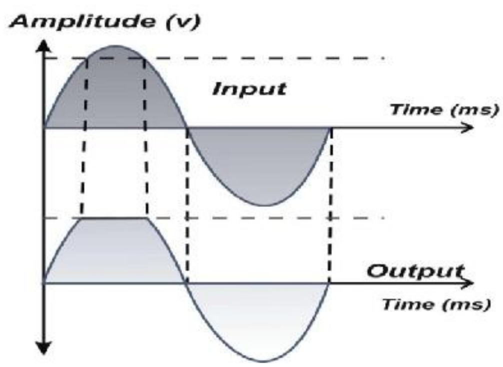
The circuit of the positive clamper is similar to the negative clamper but the direction of the diode is inverted in such a way that the cathode of the diode is connected to the capacitor. During the positive half wave cycle, output voltage of the circuit will be the sum of applied input voltage and the charge stored at capacitor. During the negative half wave cycle, the diode starts to conduct and charges the capacitor very quickly to its maximum value. The output waveform of the positive clamper shifts towards the positive direction above the 0 volts.

Positive Biased Clipper

Circuit Diagram

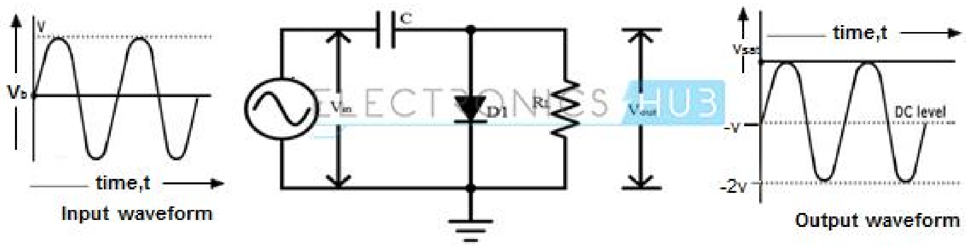


Model Graph

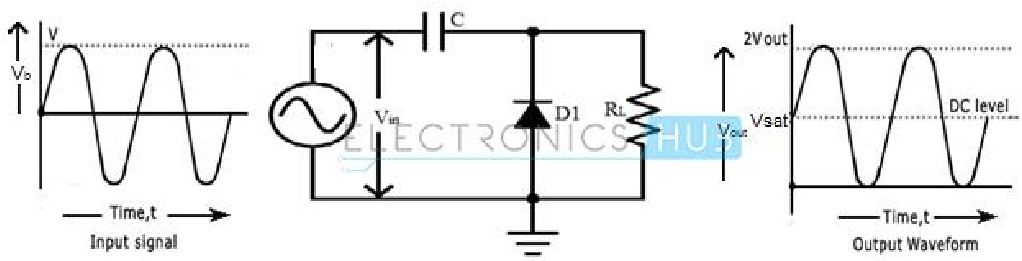


S. NO.	Input		output	
	Amplitude (v)	Timeperiod(t)	Amplitude (v)	Timeperiod(t)
1				
2				
3				
4				
5				
6				

Negative Clamper



Positive Clamper



S. NO.	Input		output	
	Amplitude (v)	Timeperiod(t)	Amplitude (v)	Timeperiod(t)
Negative Clamper				
1				
2				
Positive Clamper				
1				
2				

RESULT :

Thus the Positive and Negative Clipper and clampers Circuits were studied and constructed and its input and output waveforms were drawn.

KIRCHOFF'S VOLTAGE LAW

AIM: To verify the Kirchoff's Voltage Law (KVL) for the given circuit.

APPARATUS REQUIRED:

S.NO	APPARATUS	TYPE	RANGE	QUANTITY
1	RPS	DC	(0-30)V	1
2	Resistor	-	1KΩ	3
3	Voltmeter	DC	(0-10)V	3
4	Bread board	-	-	1
5	Connecting wires	-	-	Few

FORMULA USED:

1. CURRENT DIVISION RULE:

I = (TOTAL CURRENT X OPPOSITE RESISTANCE / TOTAL RESISTANCE)

2. OHM'S LAW:

V=IR

Where, V = Voltage in Volts

I = Current in Amperes

R = Resister in Ohms

THEORY:

KIRCHOFF'S VOLTAGE LAW:

It states that the algebraic sum of all the voltages in a closed loop is equal to zero.

$\Sigma V = 0$

PROCEDURE:

KIRCHOFF'S VOLTAGE LAW:

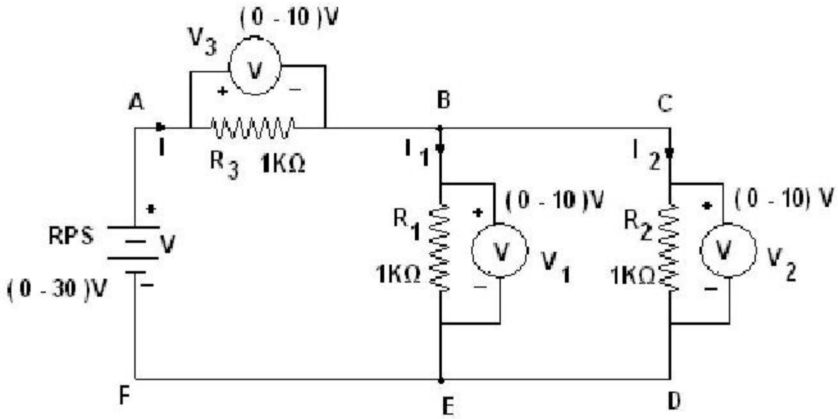
1. The circuit connections are given as per the circuit diagram.
2. Switch ON the power supply.
3. Initially set 5V as input voltage from RPS.
4. The voltmeter readings are noted and the values are tabulated.

The same procedure is repeated for various values

In the loop ABEFA,

Circuit Diagram

$$V = V_3 + V_1$$



CALCULATION:

R_1 **= 1KΩ ;** R_2 **= 1K Ω;** R_3 **= 1KΩ**

$$R_T = R_3 + R_P \qquad R_T = R_3 + \frac{R_1 R_2}{R_1 + R_2} \qquad I = \frac{V}{R_T}$$

Let V = 5V, $I_1 = \frac{I * R_2}{R_1 + R_2}$, $V_1 = I_1 * R_1$

Table:

Let V = 5V

	Resistance in Ohms				Voltage in Volts			$V = V_1 + V_3$
	R_1	R_2	R_3	R_T	V_1	V_2	V_3	$= V_2 + V_3$ (V)
Theoretical								
Practical								

RESULT : Thus the Kirchoff's Voltage Law (KVL) for the given circuit is verified

KIRCHOFF'S CURRENT LAW

AIM:

To verify the Kirchoff's Current Law (KCL) for the given circuit.

APPARATUS REQUIRED:

S.NO	APPARATUS	TYPE	RANGE	QUANTITY
1	RPS	DC	(0-30)V	1
2	Resistor	-	1KΩ	3
3	Ammeter	DC	(0-30)mA	3
4	Bread board	-	-	1
5	Connecting wires	-	-	Few

FORMULA USED:

1. CURRENT DIVISION RULE:

I = (TOTAL CURRENT X OPPOSITE RESISTANCE / TOTAL RESISTANCE)

2. OHM'S LAW:

V=IR

Where, V = Voltage in Volts
I = Current in Amperes
R = Resister in Ohms

THEORY:

KIRCHOFF'S CURRENT LAW:

It states that the algebraic sum of the currents meeting at a node is equal to zero.

$$\sum Current\ flow\ towards\ the\ node = \sum Current\ flow\ away\ from\ the\ node$$

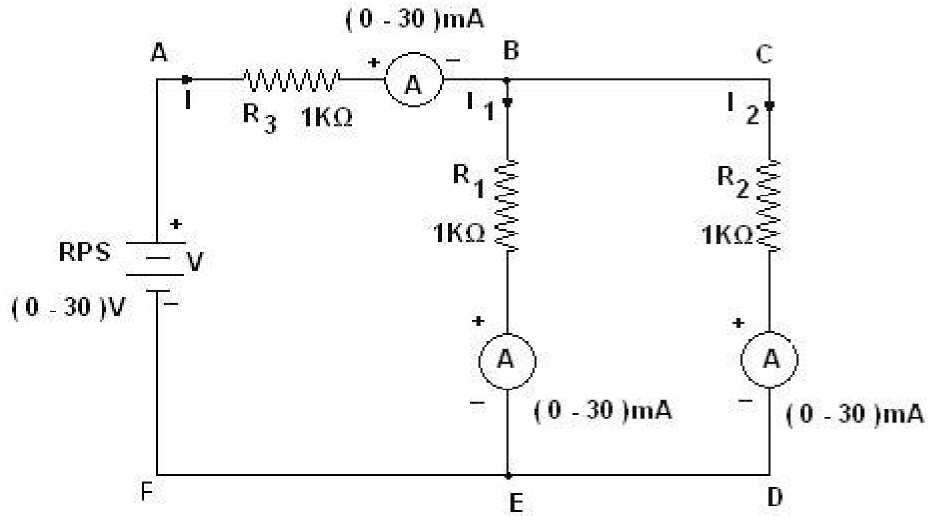


Table:

Let V = 5V , So I = 3.3 mA

Circuit Diagram for Kirchoff's Current Law

	Resistance in Ohms				Current in mA		
	R_1	R_2	R_3	R_T	I_1	I_2	$I = I_1+I_2$
Theoritical							
Practical							

CALCULATION:

R_1 **= 1KΩ** ; R_2 **= 1KΩ ;** R_3 **= 1KΩ**

$$R_T = R_3 + R_P \qquad R_T = R_3 + \frac{R_1 R_2}{R_1+R_2} \qquad I = \frac{V}{R_T}$$

Let V = 5V, $I_1 = \frac{I*R_2}{R_1+R_2}$, $V_1 = I_1 * R_1$

At node B the current = $I=I_1+I_2$

PROCEDURE:

KIRCHOFF'S CURRENT LAW:

1. The circuit connections are given as per the circuit diagram.
2. Switch ON the power supply.
3. Initially set 5V as input voltage from RPS.
4. The ammeter readings are noted and the values are tabulated.
5. The same procedure is repeated for various values.

RESULT :

Thus the Kirchoff's Current Law (KCL) for the given circuit is verified.

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THEVENIN'S THEOREM

AIM:

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

APPARATUS REQUIRED:

S.NO	APPARATUS	TYPE	RANGE	QUANTITY
1	RPS	DC	(0-30)V	1
2	Resistor	-	1KΩ	3
3	Ammeter	DC	(0-10)mA	1
4	Bread board	-	-	1
5	Connecting wires	-	-	Few

THEORY:

THEVENIN'S THEOREM:

Any linear active network with output terminals C and D can be replaced by a single voltage source ($V_{Th} = V_{Oc}$) in series with a single impedance ($Z_{Th} = Z_i$).

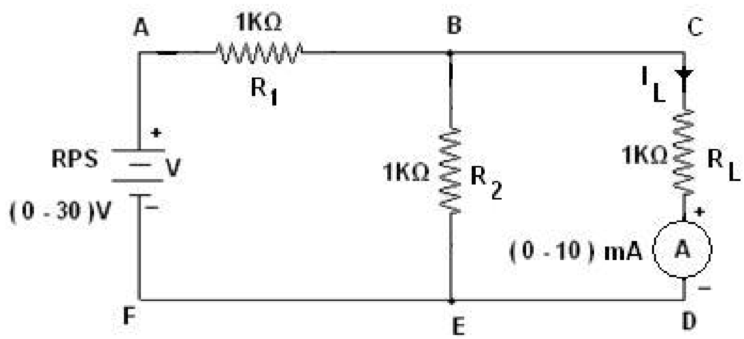
V_{Th} is the Thevenin's voltage. It is the voltage between the terminals C and D on open circuit condition. Hence it is called open circuit voltage denoted by V_{Oc}.

Z_{Th} is called Thevenin's impedance. It is the driving point impedance at the terminals C and D when all the internal sources are set to zero. In case of DC Z_{Th} is replaced by R_{Th}.

PROCEDURE:

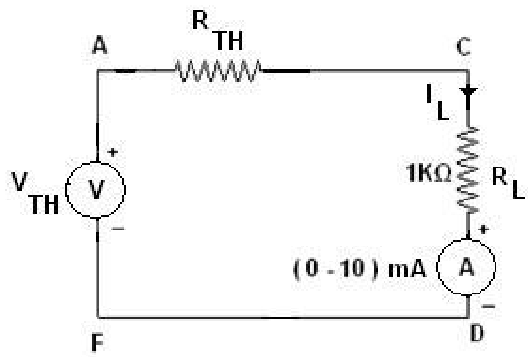
1. The circuit connections are given as per the circuit diagram.
2. Switch ON the power supply.
3. Initially set 5V as input voltage from RPS.
4. The ammeter reading is noted and the value is tabulated.

Circuit Diagram for Thevenin's Theorem

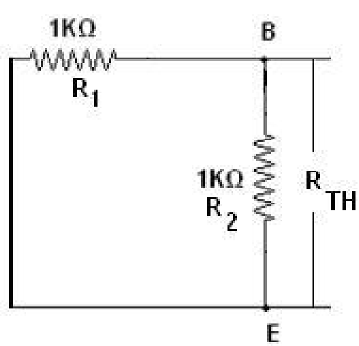


CALCULATION:

The Thevenin's equivalent circuit is,

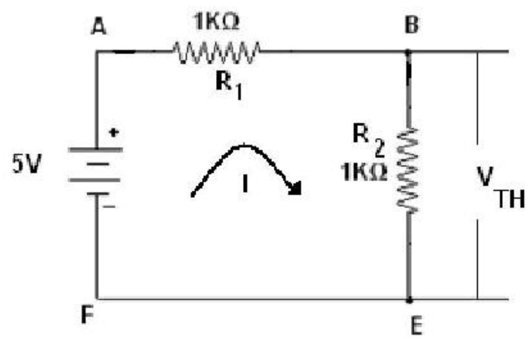


To Find RTH: $\boldsymbol{I_L = \frac{V_{TH}}{R_{TH}+R_L}}$ $I_L = \frac{V_{TH}}{R_{TH} + R_L}$



R_1 = **1K**Ω ; R_2 = **1K**Ω**;** $\mathbf{R_{TH} = \frac{R_1 * R_2}{R_1 + R_2}}$

To Find V_{TH}:



$$I = \frac{V}{R_T}$$

Let V = 5V,

V_{TH}=V_{BE}

Table:

Let V = 5V

S.No	**Voltage in Volts**	**Load Current in Amps**	
		Theoretical Value	**Practical Value**
1			

RESULT :

Thus the Thevenin’s theorem for the given circuit is verified successfully.

NORTON'S THEOREM

AIM:

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

APPARATUS REQUIRED:

S.NO	APPARATUS	TYPE	RANGE	QUANTITY
1	RPS	DC	(0-30)V	1
2	Resistor	-	1KΩ	3
3	Ammeter	DC	(0-10)mA	1
4	Bread board	-	-	1
5	Connecting wires	-	-	Few

THEORY:

NORTON'S THEOREM:

Any linear active network with output terminals C and D can be replaced by a single current source ISC(IN) in parallel with a single impedance (ZTh = Zn).

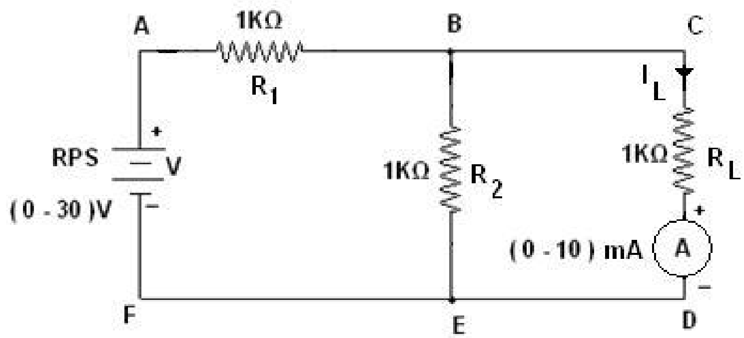
ISC is the current through the terminals C and D on short circuit condition. ZTh is called Thevenin's impedance. In case of DC ZTh is replaced by RTh.

The current through impedance connected to the terminals of the Norton's equivalent circuit must have the same direction as the current through the same impedance connected to the original active network.

PROCEDURE:

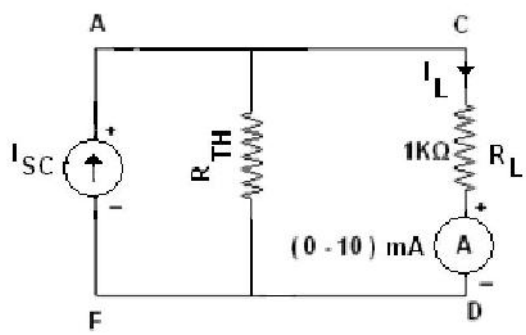
1. The circuit connections are given as per the circuit diagram.
2. Switch ON the power supply.
3. Initially set 5V as input voltage from RPS.
4. The ammeter reading is noted and the value is tabulated.

<u>Circuit Diagram for Norton's Theorem</u>



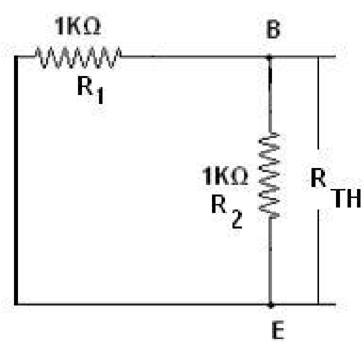
<u>CALCULATION:</u>

The Norton's equivalent circuit is,



$$I_L = \frac{I_{SC} R_{TH}}{R_{TH} + R_L}$$

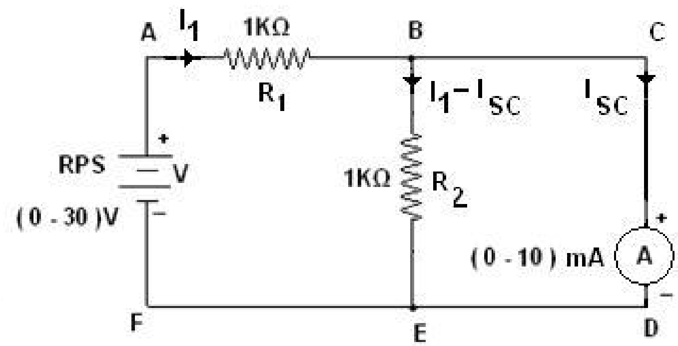
To Find RTH:



$R_1 = 1K\Omega$; $R_2 = 1K\Omega$;

RTH= <u>R1*R2</u>
R1+R2

To Find ISC:



Let V=5V

In the loop ABEFA by applying KVL,

$I_1R_1 + (I_1 - I_{SC})R_2 = V$

$I_1 X 1 + (I_1 - I_{SC}) X 1 = 5$

$2I_1 - I_{SC} = 5 - - - - - - - - - - - - - (1)$

In the loop BCDEB by applying KVL,

$(I_1 - I_{SC})R_2 = V$

$(I_1 - I_{SC}) X 1 = 0$

$I_1 - I_{SC} = 0 - - - - - - - - - - - - - (2)$

From the equation (I) and (2),

$I_{SC} = 5\ mA$ $I_1 = 5\ mA$

$I_L = \frac{I_{SC} * R_{TH}}{R_{TH} + R_L}$

Table:

Let V = 5V

	I_{SC}	I_L
Theoretical		
Practical		

RESULT :

Thus the Norton's theorem for the given circuit is verified successfully.

SUPERPOSITION THEOREM

AIM:

To verify the superposition theorem for the given circuit.

APPARATUS REQUIRED:

S.NO	APPARATUS	TYPE	RANGE	QUANTITY
1	RPS	DC	(0-30)V	2
2	Resistor	-	1KΩ	3
3	Ammeter	DC	(0-10)mA	1
4	Bread board	-	-	1
5	Connecting wires	-	-	Few

THEORY:

SUPERPOSITION THEOREM:

The superposition theorem for electrical circuits states that the total current in any branch of a bilateral linear circuit equals the algebraic sum of the currents produced by each source acting separately throughout the circuit.To ascertain the contribution of each individual source, all of the other sources first must be "killed" (set to zero) by:

1. replacing all other voltage sources with a short circuit (thereby eliminating difference of potential. i.e. V=0)
2. replacing all other current sources with an open circuit (thereby eliminating current. i.e. I=0)

This procedure is followed for each source in turn, and then the resultant currents are added to determine the true operation of the circuit. The resultant circuit operation is the superposition of the various voltage and current sources.

Circuit Diagram for Superposition Theorem

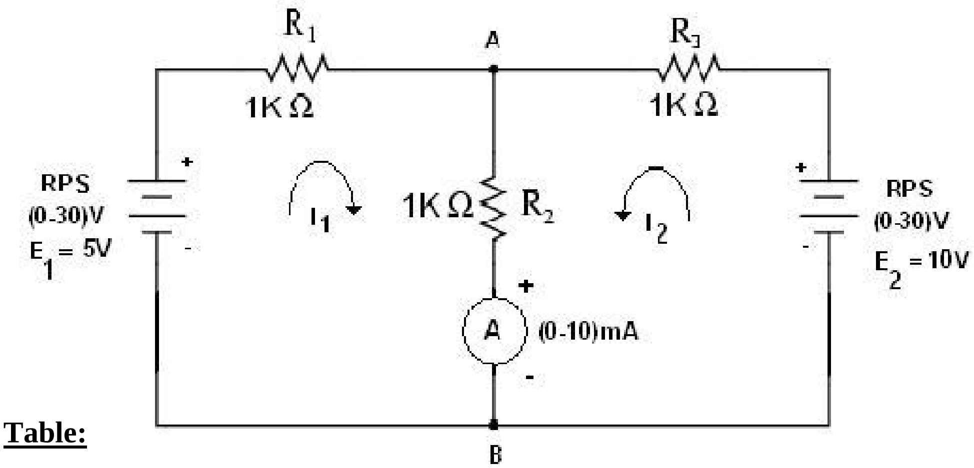
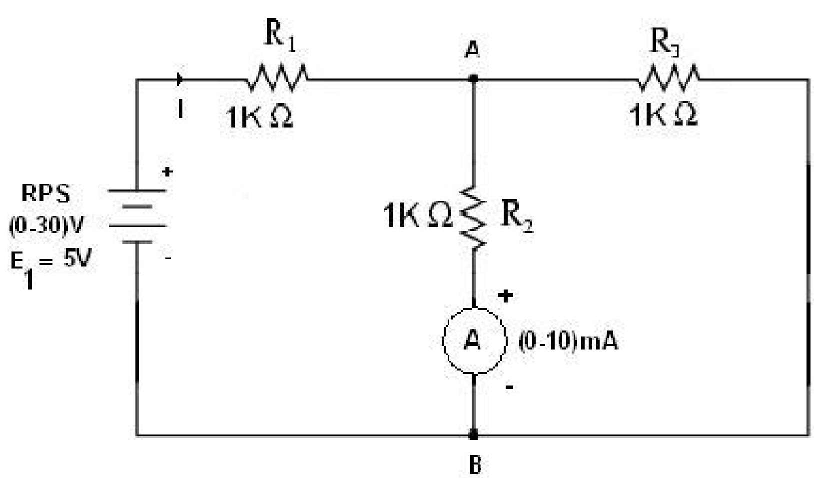


Table:

S.No	E_1 voltage(Volts)	E_2 voltage(Volts)	Load current across the branch AB (mA)	
			Theoritical	Practical
1				

E_1 SOURCE IS



CALCULATION:

R_1 = 1K = 1K ; = 1K

$$R_T = R_1 + R_P$$

$$= R_1 + \frac{R_2 R_3}{R_2 + R_3}$$

Let V = 5V,

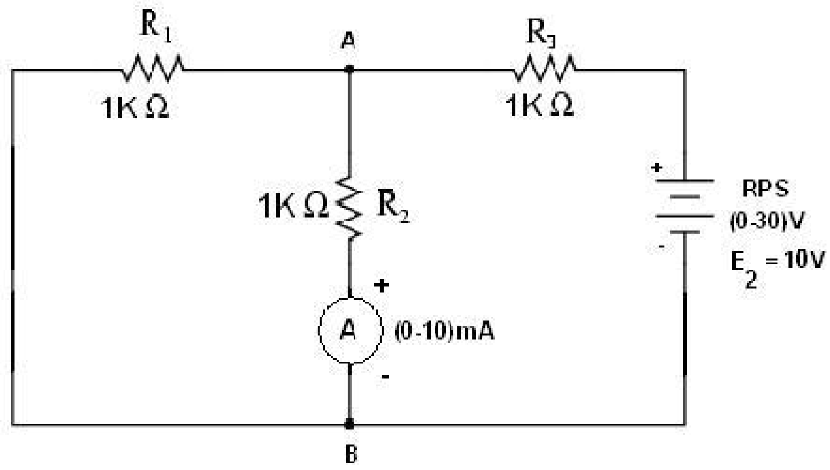
$$I = \frac{V}{R_T}$$

$$I_{AB1} = I \; X \; \frac{R_3}{R_2 + R_3} = 3.3 \; X \; 10^{-3} \; X \; \frac{1000}{1000+1000}$$

Table:

S.No	E1 voltage(Volts)	Load current across the branch AB (mA)	
		Theoritical	Practical
1			

E2 SOURCE IS ACTING:



RESULT :

Thus the superposition theorem for the given circuit is verified.

MAXIMUM POWER TRANSFER THEOREM

AIM:

To verify the maximum power (transfer) theorem for the given circuit.

APPARATUS REQUIRED:

S.NO	APPARATUS	TYPE	RANGE	QUANTITY
1	RPS	DC	(0-30)V	1
2	Resistor	-	1KΩ	2
3	Variable Resistor		1KΩ	1
4	Ammeter	DC	(0-10)mA	1
5	Bread board	-	-	1
6	Connecting wires	-	-	Few

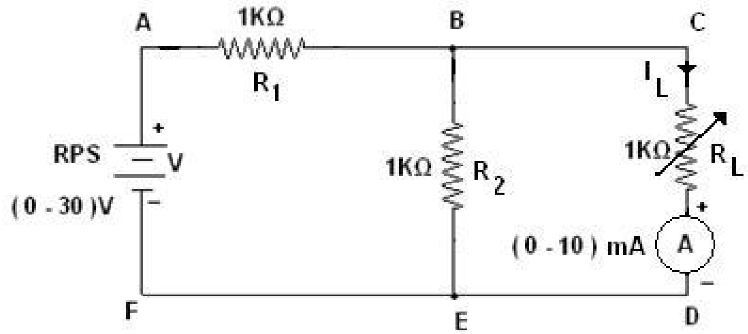
THEORY:

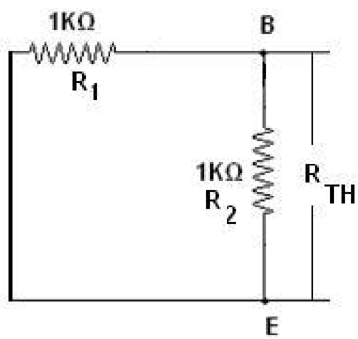
MAXIMUM POWER TRANSFER THEOREM:

In electrical engineering, the **maximum power (transfer) theorem** states that, to obtain maximum external power from a source to a load with a finite internal resistance, the resistance of the load must be made the same as that of the source.

The theorem applies to maximum power, and not maximum efficiency. If the resistance of the load is made larger than the resistance of the source, then efficiency is higher, since most of the power is generated in the load, but the overall power is lower since the total circuit resistance goes up.

If the internal impedance is made larger than the load then most of the power ends up being dissipated in the source, and although the total power dissipated is higher, due to a lower circuit resistance, it turns out that the amount dissipated in the load is reduced.



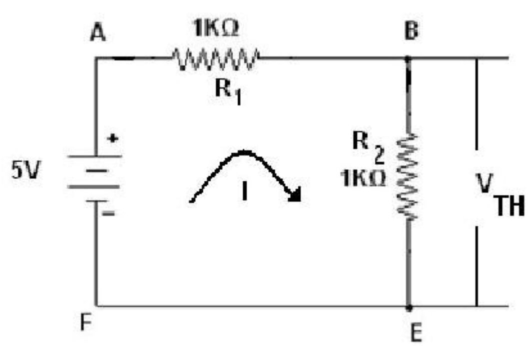


Circuit Diagram for Maximum Power Transfer

Theorem <u>CALCULATION:</u>

To Find R_{TH}:

$$R_{TH} = \frac{R_1 R_2}{R_1 + R_2} = \frac{1000\ X\ 1000}{1000 + 1000}$$



$$I = \frac{V}{R_T}$$

PROCEDURE:

1. The circuit connections are given as per the circuit diagram.
2. Switch ON the power supply.
3. Initially set 5V as input voltage from RPS.
4. The ammeter reading is noted for various values of load resistance and the values are tabulated.
5. The load resistance for the maximum power is obtained from the table.

Let V = 5V,

$$V_{TH} = V_{BE} = 5 - 1K\ X\ I$$

$$\therefore I_L = \frac{V_{TH}}{2\ X\ R_{TH}} = \frac{2.5}{2\ X\ 500} = 2.5mA$$

$$\therefore P_{max} = I_L^2\ X\ R_{TH} = 2.5\ X\ 10^{-3}\ X\ 2.5\ X\ 10^{-3}\ X\ 500$$

$$\therefore Load\ Resistance\ R_L =$$

Table:

Let V = 5V

S.No	**Resistance(R_L) in Ohms**	**Current(I_L) in mA**	**Power ($I_L^2 R_L$) in mW**
1	100		
2	200		
3	300		
4	400		
5	500		
6	700		
7	900		

RESULT :

Thus the maximum power transfer theorem for the given circuit is verified successfully.

RECIPROCITY THEOREM

AIM:

To verify the reciprocity theorem for the given circuit.

APPARATUS REQUIRED:

S.NO	APPARATUS	TYPE	RANGE	QUANTITY
1	RPS	DC	(0-30)V	1
2	Resistor	-	1KΩ	2
3	Ammeter	DC	(0-10)mA	1
4	Bread board	-	-	1
5	Connecting wires	-	-	Few

THEORY:

RECIPROCITY THEOREM:

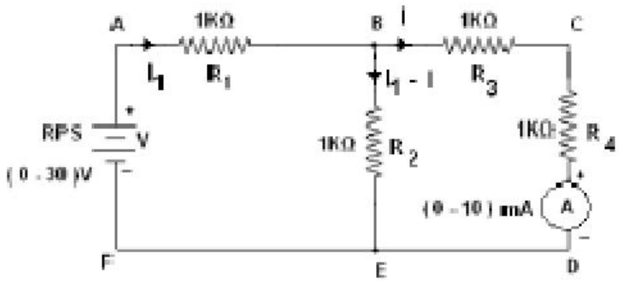
The reciprocity theorem states that if an emf ‘E’ in one branch of a reciprocal network produces a current I in another, then if the emf ‘E’ is moved from the first to the second branch, it will cause the same current in the first branch, where the emf has been replaced by a short circuit. We shall see that any network composed of linear, bilateral elements (such as R, L and C) is reciprocal.

PROCEDURE:

1. The circuit connections are given as per the circuit diagram.
2. Switch ON the power supply.
3. Initially set 5V as input voltage from RPS.

The ammeter reading is noted and tabulated

Before interchanging:



Circuit Diagram for Reciprocity Theorem

CALCULATION:

Let V=5V

In the loop ABEF by applying KVL,

$$I_1R_1 + (I_1 - I)R_2 = V$$
$$I_1 \, X \, 1 + (I_1 - I) \, X \, 1 = 5$$
$$2I_1 - I = 5 -------------(1)$$

In the loop BCDE by applying KVL,

$$IR_3 + IR_4 - (I_1 - I)R_2 = V$$
$$I \, X \, 1 + I \, X \, 1 - (I_1 - I) \, X \, 1 = 0$$
$$-I_1 + 3I = 0 -------------(2)$$

D = $\begin{vmatrix} 2K & -1K \\ -1K & 3K \end{vmatrix} = 6K^2 - 1K^2 = 5K^2 = 5 \, X \, 10^6$

$$D_2 = \begin{vmatrix} 2K & 5 \\ -1K & 0 \end{vmatrix} = 5K = 5 \, X \, 10^3$$
$$I = \frac{D_2}{D} = \frac{5 \, X \, 10^3}{5 \, X \, 10^6} = 1mA$$

attainment of steady state is called transient state. The time duration from the instant of switching till the steady state is called transient period. The current & voltage of circuit elements during transient period is called transient response.

FORMULA:

Time constant of RC circuit = RC

PROCEDURE:

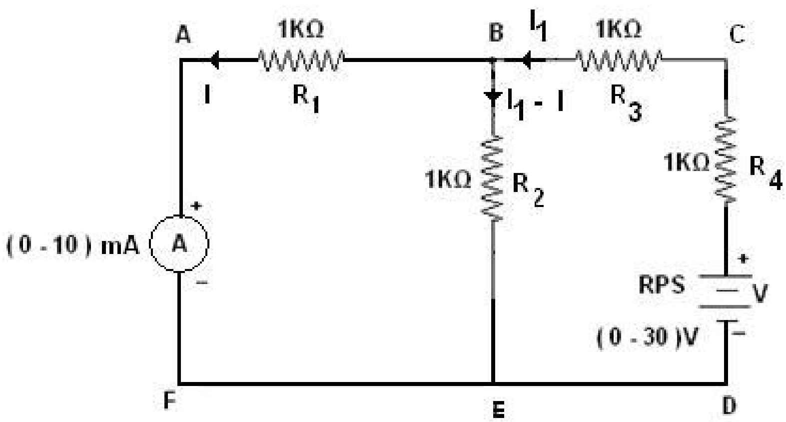
1. Connections are made as per the circuit diagram.
2. Before switching ON the power supply the switch S should be in off position

Now switch ON the power supply and change the switch to ON position

Table for before interchanging:

Sl.No	V (Volts)	Current (mA)	
		Theoretical	Practical

After interchanging:



CALCULATION: Let V=5V.

In the loop ABEFA by applying KVL,

$IR_1 - (I_1 - I)R_2 = V$ $\quad I\ X\ 1 - (I_1 - I)\ X\ 1 = 0$

$IR_1 - (I_1 - I)R_2 = V$ $\quad -I_1 + 2I = 0 - - - - - - - - - - - - - (1)$

$I\ X\ 1 - (I_1 - I)\ X\ 1 = 0$ $\quad -I_1 + 2I = 0 - - - - - - - - - - - - - (1)$

In the loop BCDE B by applying KVL,

$$I_1R_4 + I_1R_3 + (I_1 - I)R_2 = V$$

$$I_1\ X\ 1 + I_1\ X\ 1 + (I_1 - I)\ X\ 1 = 5$$

$$3I_1 - I = 5 - - - - - - - - - - - - - (2)$$

$$D_2 = \begin{vmatrix} -1K & 0 \\ 3K & 5 \end{vmatrix} = -5K - 0 = -5\ X\ 10^3$$

$$I = \frac{D_2}{D} = \frac{-5\ X\ 10^3}{-5\ X\ 10^6} = 1mA$$

PROCEDURE:

1. The circuit connections are given as per the circuit diagram.
2. Switch ON the power supply.
3. Initially set 5V as input voltage from RPS.

The ammeter reading is noted and tabulated

Table for after interchanging:

Sl.No	V (Volts)	Current (mA)	
		Theoretical	Practical

RESULT :

Thus the reciprocity theorem for the given circuit is verified successfully.

TIME DOMAIN TRANSIENT RESPONSE OF RL CIRCUIT

AIM:

(a) To study the transient response of RL circuit.
(b) To determine the time constant of the circuit theoretically and practically.

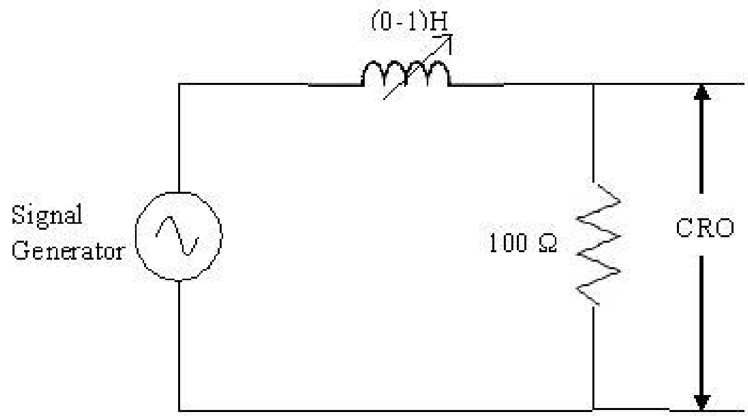
Theory:

When a RL circuit is suddenly energized or de-energized a transient phenomenon which dies out as the circuit approaches its steady state. This is because of the way in which inductor store energy and resistor dissipate it. The exact nature of the transient depends on R and L as well as how they are connected in the circuit. The time constant τ represent the time for the system to make significant change in charge V or current I.

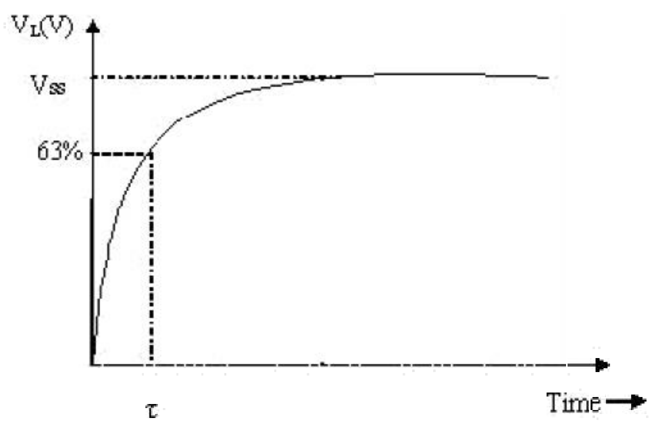
Apparatus Required:

S.NO.	**Name of the apparatus**	RANGE	**Quantity**
1	Function generator	(0-3) MHZ	1
2	CRO	(0-30)MhZ	1
3	Decade Inductance Box		1
4	Resistor	100Ω	1
5	Bread board	-	1
6	Connecting wires	-	As required

CIRCUIT DIAGRAM



Model Graph:



where, Vss = Steady State Voltage

Procedure:

1. Connections are given as per the circuit diagram and set the input voltage as 2V.
2. Calculate the time constant theoretically ($\tau = L/R$).
3. Choose the frequency such that $1/(2f) > 2\tau$ i.e., $f < 1 / (4\tau)$
4. 4 Select square wave mode in function generator and set frequency lesser than the calculated frequency.
5. Connect the CRO probe across the resistor and observe the waveform.
6. Find the time taken to reach 63.2% of the final value τ_{pr} and compare it

   with the time constant calculated in step 2.

Theoretical Calculation:

Let R=100Ω L=50mH

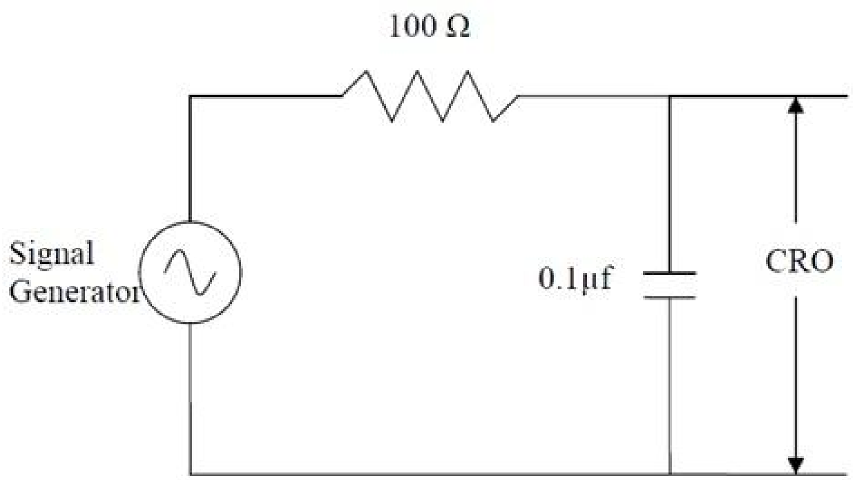
Time constant $\tau = L/R = 0.5$msec.

Input frequency $f < 10^3 / (4 * 0.5) = f < 500$ Hz.

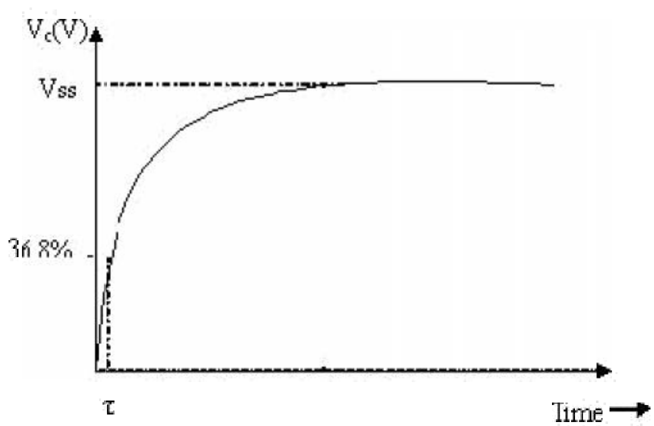
RESULT :

Transient response of RL circuit was studied and the time constant was calculated both theoretically and practically.

CIRCUIT DIAGRAM:



MODEL GRAPH



where, Vss = Steady State Voltage

EX.NO: DATE :

Time Domain Transient Response of RC circuit

Aim:

To study the transient response of RC circuit

To determine the time constant of the circuit theoretically and practically.

Apparatus Required:

S.NO.	**Name of the apparatus**	RANGE	**Quantity**
1	Function generator	(0-3) MHZ	1
2	CRO	(0-30)MhZ	1
3	Capacitor	0.1µf	1
4	Resistor	100Ω	1
5	Bread board	-	1
6	Connecting wires	-	As required

Theory:

When a RC circuit is suddenly energized or de-energized a transient phenomenon which dies out as the circuit approaches its steady state. This is because of the way in which capacitor store energy and resistor dissipate it. The exact nature of the transient depends on R and C as well as how they are connected in the circuit. The time constant τ represent the time for the system to make significant change in charge V or current I whenever a capacitor is charging or discharging.

Theoretical Calculation:

Let R=100Ω C = 0.1 µf

Time constant τ = R*C = 10^{-5} s = 0.1 µs.

Input frequency f < 1 / (4 *10^{-5}) = f < 25000 Hz.

Procedure:

1. Connections are given as per the circuit diagram and set the input voltage as 2V.
2. Calculate the time constant theoretically (τ = R*C).
3. Choose the frequency such that 1/(2f) > 2τ i.e., f < 1 / (4f).
4. Select square wave mode in function generator and set frequency lesser than the calculate frequency.
5. Connect the CRO probe across the resistor and observe the waveform.
6. Find the time taken to reach 36.8% of the final value τ_{pr} and compare it with the time constant calculated in step 2.

Result

Transient response of RC circuit was studied and the time constant was calculated both theoretically and practically.

Resonance Frequency of Series & Parallel RLC Circuits

Aim:

a) To Study and plot the curve of Resonance for a Series resonance circuits.

Apparatus Required:

S.No	Apparatus Required	Range	Quantity
1	Signal Generator	(0-1) MHz	1
2	Ammeter (MC)	(0-10) mA	1
3	Voltmeter (MC)	(0-10) V	3
	Resistors	1KΩ,	
2	Capacitor	1μF	1
3	Bread Board		1
4	Decade Inductance Box		1
5	Wires		

Theory:

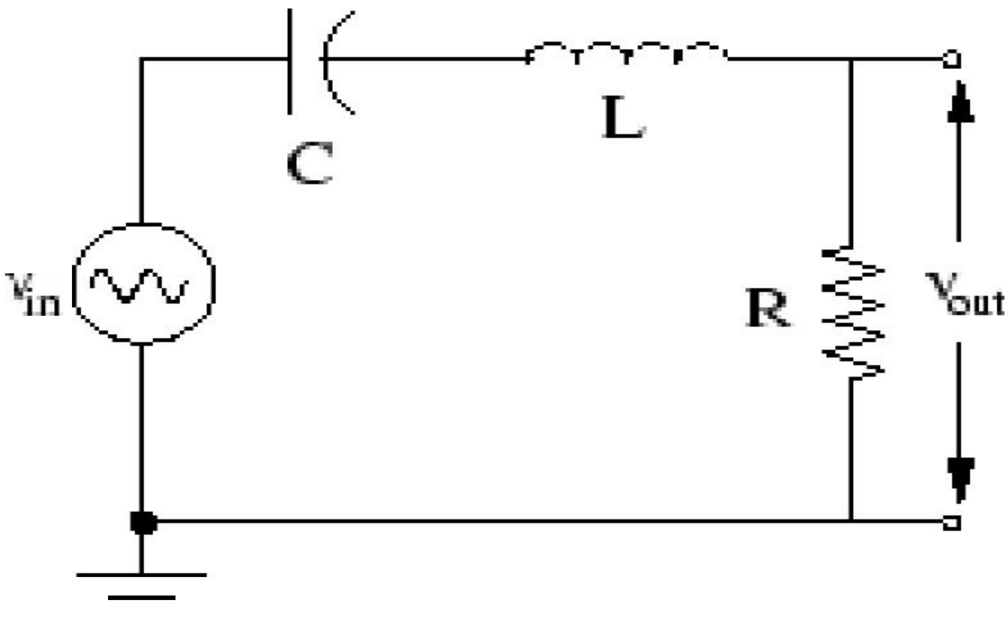
An ac circuit is said to be in resonance when the applied voltage and the resulting current are in phase. In an RLC circuits at resonance, Z = R & X_L = Xc where X_L is inductive reactance and Xc is capacitive reactance.

The frequency at which the voltage in RLC circuit is maximum is known as resonant frequency (f_o). At f_o I_C and I_L are equal in magnitude and opposite in phase.

Band width:

The distance between the lower half power frequency f1 and the upper half frequency f2 is called band width of the circuit.

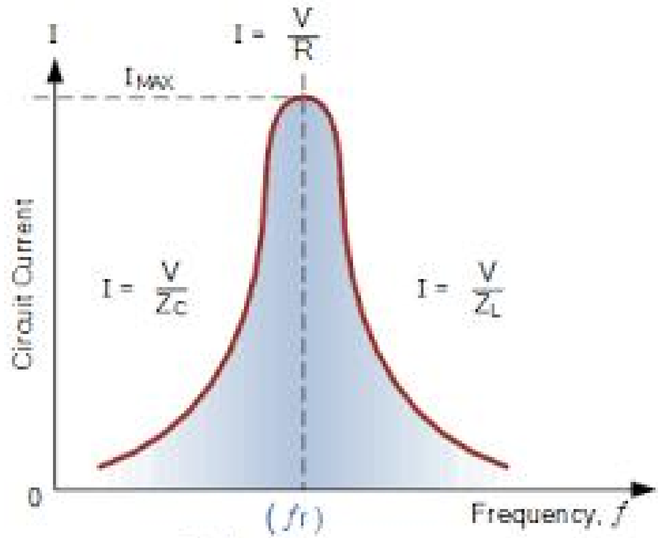
CIRCUIT DIAGRAM



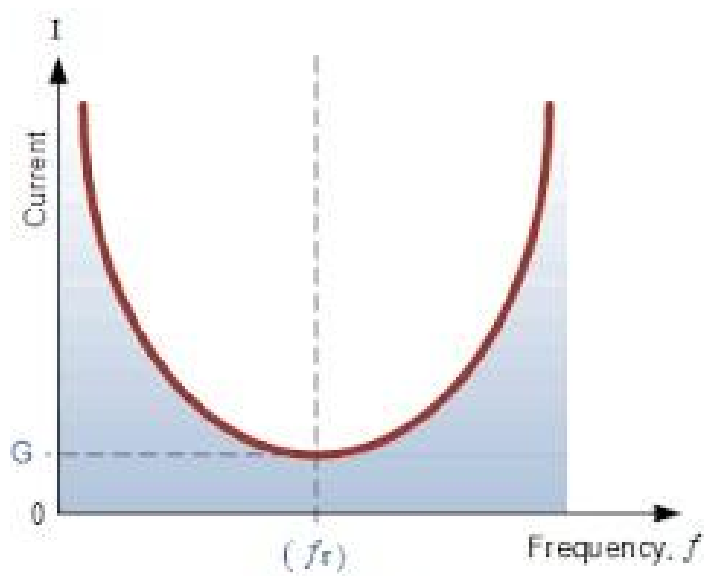
S.NO.	FREQUENCY (IN Hz)	V_R IN VOLTS

TABULATION :

MODEL GRAPH:



Series Resonance



Parallel Resonance

PROCEDURE :

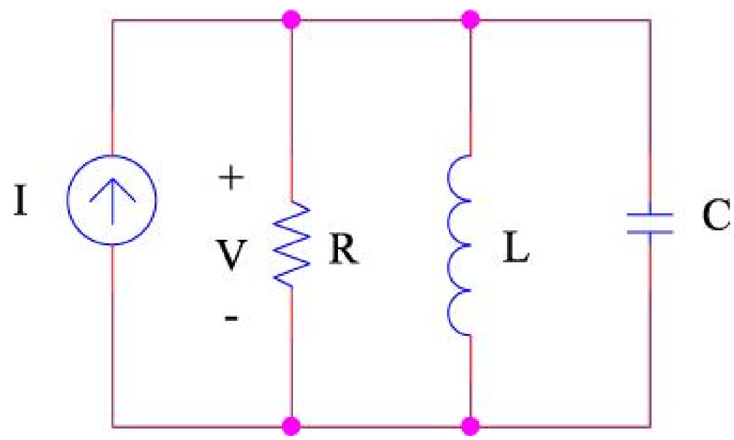
1. Connection are made as per the circuit diagram
2. Vary the frequency of function generator .
3. Measure the corresponding Values of Voltage across R1 resister for series RLC and Parallel Circuit.
4. Repeat the same procedure for different values of frequency
5. Tabulate the reading.
6. Note Down the resonance frequency from the table

Theoretical calculations:

Series and Parallel resonance frequency:

$$f_0 = \frac{1}{2\pi\sqrt{LC}}$$

CIRCUIT DIAGRAM:



TABULATION :

S.NO.	FREQUENCY (IN Hz)	V_R IN VOLTS

Result :

The resonance frequency of the electrical network is obtained