1.1 P-N JUNCTION DIODE CHARACTERISTICS

Objective:

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

Hardware Required:

S. No	Apparatus	Type	Range	Quantity
01	PN Junction Diode	IN4001		1
02	Resistance		1k ohm	1
03	Regulated power supply		(0 – 30V)	1
04	Ammeter	mC	(0-30)mA, (0-500)μA	1
05	Voltmeter	mC	(0 – 1)V, (0 – 30)V	1
06	Bread board and connecting wires			

Introduction:

Donor impurities (pentavalent) are introduced into one-side and acceptor impurities into the other side of a single crystal of an intrinsic semiconductor to form a p-n diode with a junction called depletion region (this region is depleted off the charge carriers). This region gives rise to a potential barrier $V\gamma$ called **Cut- in Voltage**. This is the voltage across the diode at which it starts conducting. The P-N junction can conduct beyond this Potential.

The P-N junction supports uni-directional current flow. If +ve terminal of the input supply is connected to anode (P-side) and –ve terminal of the input supply is connected to cathode (N- side), then diode is said to be forward biased. In this condition the height of the potential barrier at the junction is lowered by an amount equal to given forward biasing voltage. Both the holes from p-side and electrons from n-side cross the junction simultaneously and constitute a forward current (**injected minority current** – due to holes crossing the junction and entering N-side of the diode, due to electrons crossing the junction and entering P-side of the diode). Assuming current flowing through the diode to be very large, the diode can be approximated as short-circuited switch. If –ve terminal of the input supply is connected to anode (p-side) and +ve terminal of 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 thereby increasing the depleted region. However the process cannot continue indefinitely, thus a small current called **reverse saturation current** continues to flow in the diode. This small current is due to thermally generated carriers. Assuming current flowing through the diode to be negligible, the diode can be approximated as an open circuited switch.

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

$I = I_o(\mathrm{Exp}(V/\eta V_T)-1)$

I=current flowing in the diode

Io=reverse saturation current

V=voltage applied to the diode

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

η=1 (for Ge) and 2 (for Si)

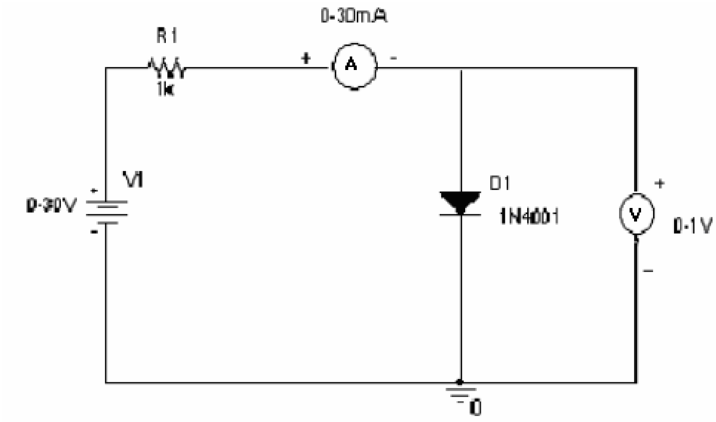
It is observed that Ge diode has smaller cut-in-voltage when compared to Si diode. The reverse saturation current in Ge diode is larger in magnitude when compared to silicon diode.

Prelab Questions:

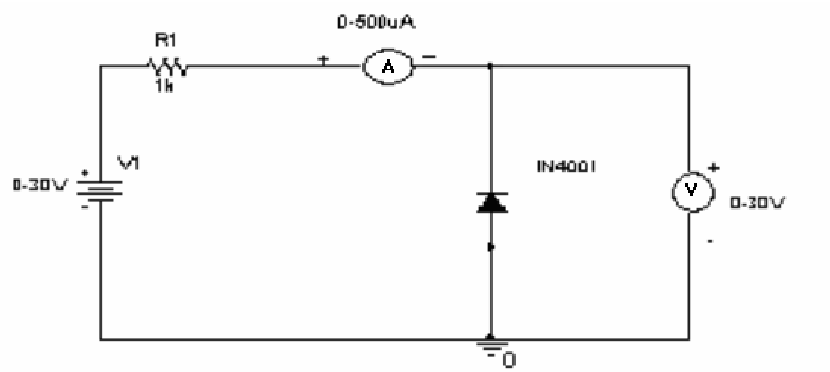
1. What is the need for doping?
2. How depletion region is formed in the PN junction?
3. What is leakage current?
4. What is break down voltage?
5. What is an ideal diode? How does it differ from a real diode?
6. What is the effect of temperature in the diode reverse characteristics?
7. What is cut-in or knee voltage? Specify its value in case of Ge or Si?
8. What are the difference between Ge and Si diode.
9. What is the capacitance formed at forward biasing?
10. What is the relationship between depletion width and the concentration of impurities?

Circuit diagram:

Forward Bias



Reverse Bias



Precautions:

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

Experiment:

Forward Biased Condition:

1. Connect the PN Junction diode in forward bias i.eAnode is connected to positive of the power supply and cathode is connected to negative of the power supply .

2. Use a Regulated power supply of range (0-30)V and a series resistance of 1kΩ.
3. For various values of forward voltage (V_f) note down the corresponding values of forward current(I_f) .

Reverse biased condition:

1. Connect the PN Junction diode in Reverse bias i.e; anode is connected to negative of the power supply and cathode is connected to positive of the power supply.
2. For various values of reverse voltage (Vr) note down the corresponding values of reverse current (Ir).

Tabular column:

Forward Bias:

S. No	V_f (volts)	I_f (mA)

Reverse Bias:

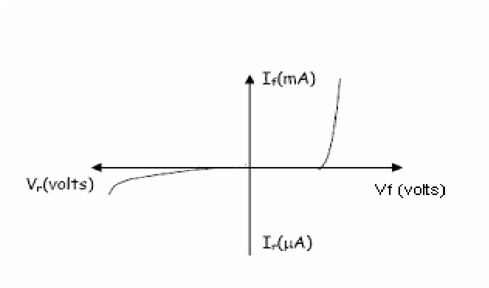
S. No	Vr (volts)	Ir (µA)

Graph (instructions)

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 Vr
   +ve y-axis as I_f
   -ve y-axis as Ir.

3. Mark the readings tabulated for diode forward biased condition in first Quadrant and diode reverse biased condition in third Quadrant.

Graph:



Calculations from Graph:

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

Dynamic forward Resistance $r_{ac} = \Delta V_f/\Delta I_f$ Ω

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

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

Result:

Thus the VI characteristics of PN junction diode is verified.

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

Post lab Questions:

1. Comment on diode operation under zero biasing condition
2. How does PN-junction diode acts as a switch?
3. What is peak inverse voltage?
4. What is the need for connecting Resistance Rs in series with PN diode.
5. What are the applications of PN junction diode?

Conclusion

Particulars	Max. Marks	Marks Obtained
Prelab	20	
Lab Check of and verification	40	
Report & post lab	40	
Total	100	

1.2 ZENER DIODE CHARACTERISTICS

Objective:

1. To plot Volt-Ampere characteristics of Zener diode.
2. To find Zener break down voltage in reverse biased condition.

Hardware Required:

S. No	Apparatus	Type	Range	Quantity
01	Zener Diode	IZ 6.2		1
02	Resistance		1k ohm	1
03	Regulated power supply		(0 – 30V)	1
04	Ammeter	mC	(0-30)mA, (0-500)µA	1
05	Voltmeter	mC	(0 – 1)V, (0 – 30)V	1
06	Bread board and connecting wires			

Introduction:

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

A **zener diode** when reverse biased can either undergo **avalanche break down** or **zener break down**.

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

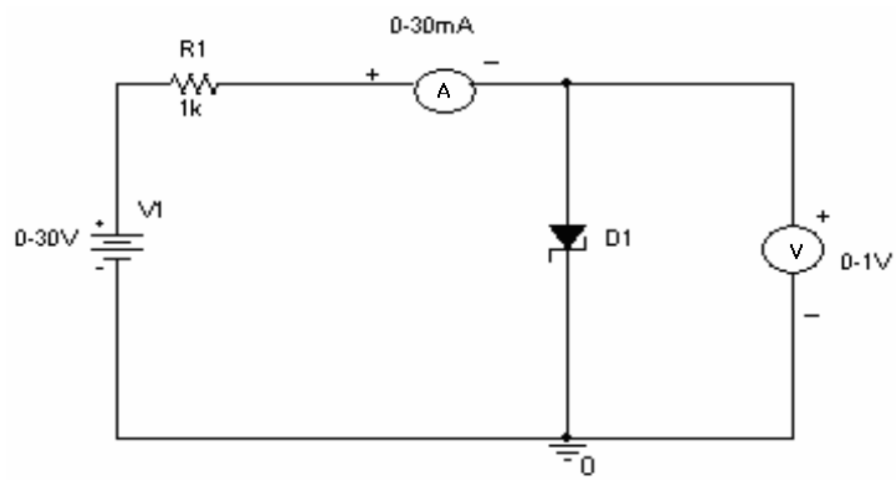
Zener break down:-If both p-side and n-side of the diode are heavily doped, depletion region at the junction reduces. Application of even a small voltage at the junction ruptures covalent bonding and generates large number of charge carriers. Such sudden increase in the number of charge carriers results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

Pre lab Questions:

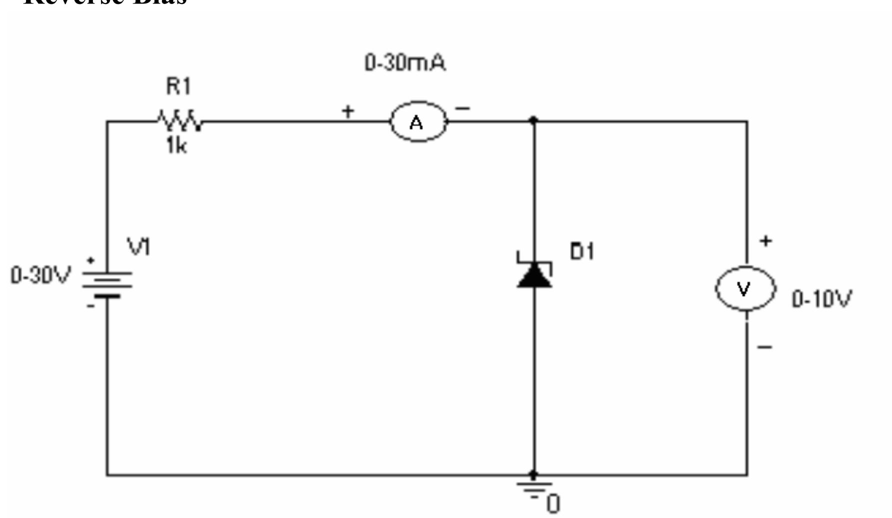
1. Explain the concept of zener breakdown?
2. How depletion region gets thin by increasing doping level in zener diode?
3. State the reason why an ordinary diode suffers avalanche breakdown rather than zener breakdown?
4. Give the reasons why zener diode acts as a reference element in the voltage regulator circuits.

Circuit diagram:

Forward Bias



Reverse Bias



Precautions:

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

Experiment:

Forward Biased Condition:

1. Connect the Zener diode in forward bias i.e; anode is connected to positive of the power supply and cathode is connected to negative of the power supply as in circuit
2. Use a Regulated power supply of range (0-30)V and a series resistance of 1kΩ.
3. For various values of forward voltage (V_f) note down the corresponding values of forward current(I_f) .

Reverse Biased condition:

1. Connect the Zener diode in Reverse bias i.e; anode is connected to negative of the power supply and cathode is connected to positive of the power supply as in circuit.
2. For various values of reverse voltage(Vr) note down the corresponding values of reverse current (Ir).

Tabular column:

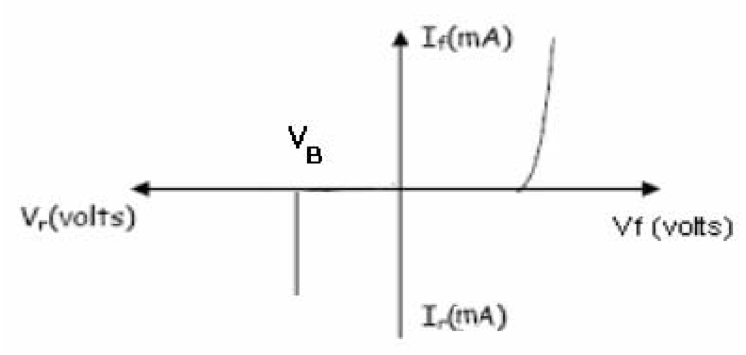
Forward Bias:

S. No	V_f (volts)	I_f (mA)

Reverse Bias:

S. No	Vr (volts)	Ir (mA)

Model Graph



Calculations from Graph:

Cut in voltage = ---------- (v)
Break down voltage = ------------(v)

Result:

The zener diode characteristics have been plotted.

1. Cut in voltage = ……… V

2 Break down voltage = ------------(v)

Post lab Questions:

1. Can we use Zener diode for rectification purpose?
2. What happens when the Zener diodes are connected in series?
3. What type of biasing must be used when a Zener diode is used as a regulator?
4. Current in a 1W – 10V Zener diode must be limited to a maximum of what value?
5. How will you differentiate the diodes whether it is Zener or avalanche when you are given two diodes of rating 6.2 v and 24V?
6. When current through a Zener diode increases by a factor of 2, by what factor the voltage of Zener diode increases.

Conclusion

Particulars	Max. Marks	Marks Obtained
Prelab	20	
Lab Check of and verification	40	
Report & post lab	40	
Total	100	

2. COMMON EMITTER CONFIGURATIONS

Objective:

To study the input and output characteristics of a bipolar junction transistor in common emitter configuration.

Hardware Required:

S. No	Apparatus	Type	Range	Quantity
01	Transistor	BC147		1
02	Resistance		1k ohm	2
03	Regulated power supply		(0 – 30V)	2
04	Ammeter	mC	(1-10)mA, (0-500)µA	1
05	Voltmeter	mC	(0 – 1)V, (0 – 30)V	1
06	Bread board and connecting wires			

Introduction:

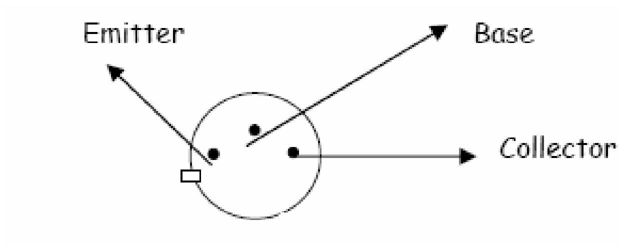
Bipolar junction transistor (BJT) is a 3 terminal (emitter, base, collector) semiconductor device. There are two types of transistors namely NPN and PNP. It consists of two P-N junctions namely emitter junction and collector junction.

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

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

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

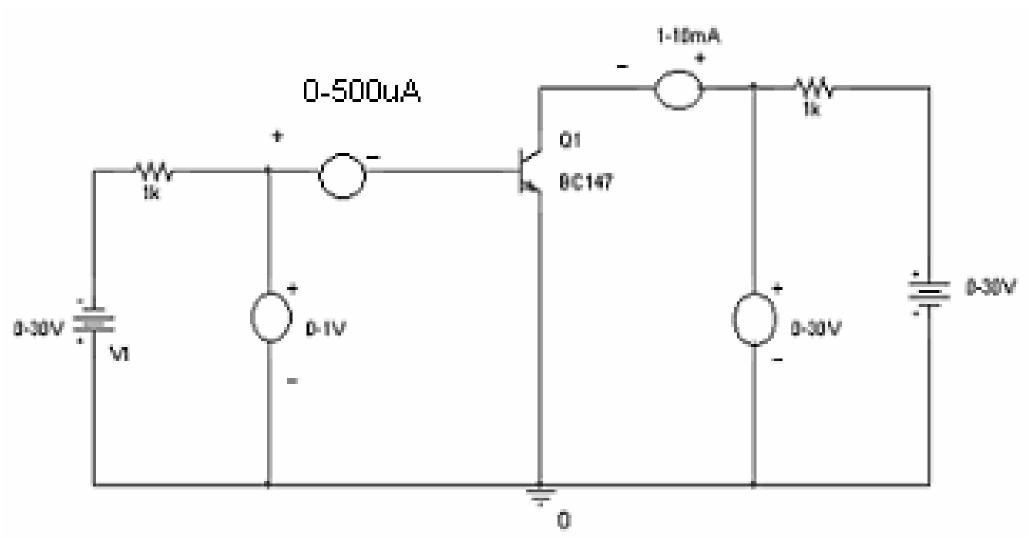
Pin Assignment:



Pre lab Questions

1. What is the significance of arrow in the transistor symbol?
2. Define current amplification factor?
3. What is the function of a transistor?
4. Give the doping levels and the width of the layers of BJT.
5. Two discrete diodes connected back-to-back can work as a transistor? Give comments.
6. For amplification, CE configuration is preferred, why?
7. To operate a transistor as amplifier, the emitter junction is forward biased and the collector junction is reversed biased, why?
8. With the rise in temperature, the leakage collector current increases, why?
9. Can a transistor base emitter junction be used as zener diode?

Circuit Diagram:



Precautions:

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

Experiment:

Input Characteristics

1. Connect the transistor in CE configuration as per circuit diagram
2. Keep output voltage V_{CE} = 0V by varying V_{CC}.
3. Varying V_{BB} gradually, note down both base current I_B and base - emitter voltage (V_{BE}).
4. Repeat above procedure (step 3) for various values of V_{CE}

Output Characteristics

1. Make the connections as per circuit diagram.
2. By varying V_{BB} keep the base current I_B = 20μA.
3. Varying V_{CC} gradually, note down the readings of collector-current (I_C) and collector- emitter voltage (V_{CE}).
4. Repeat above procedure (step 3) for different values of I_E

Tabular Column:

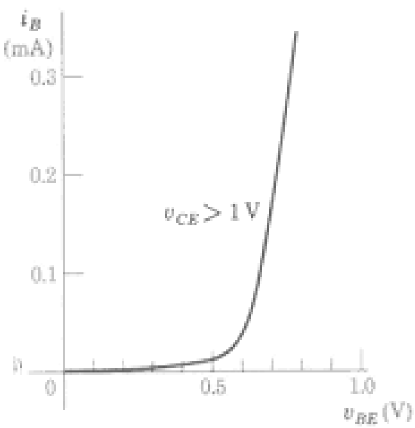
Input characteristics:

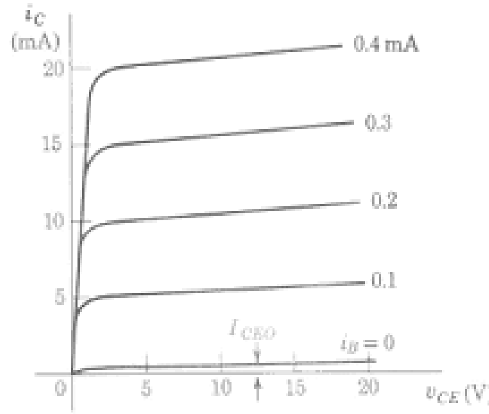
V_{CE} = 0 V		**V_{CE} = 4V**	
V_{BE} (volts)	**I_B (mA)**	**V_{BE} (volts)**	**I_B (mA)**

Output characterstics:

I_B = 30 µA		I_B = 60 µA	
V_{CE} (volts)	**Ic (mA)**	**V_{CE} (volts)**	**Ic (mA)**

Graph:





Input characteristics **Output characteristics**

1. Plot the input characteristics by taking V_{BE} on Y-axis and I_B on X-axis at constant V_{CE}.

2. Plot the output characteristics by taking V_{CE} on x-axis and I_C on y-axis by taking I_B as a constant parameter.

Calculations from graph:

1. Input resistance:

To obtain input resistance find ΔV_{BE} and ΔI_B at constant V_{CE} on one of the input characteristics.

Then $Ri = \Delta V_{BE} / \Delta I_B$ (V_{CE} constant)

2. Output resistance:

To obtain output resistance, find ΔI_C and ΔV_{CE} at constant I_B.

$$Ro = \Delta V_{CE} / \Delta I_C \ (I_B \text{ constant})$$

Calculations from graph:

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

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

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

d) Reverse voltage gain(h_{rc})= $\Delta V_{BE}/\Delta V_{EC}$, I_B constant

Inference:

1. Medium Input and Output resistances.
2. Smaller value of V_{CE} becomes earlier cut-in-voltage.
3. Increase in the value of I_B causes saturation of the transistor at an earlier voltage.

Result:

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

1. Input Resistance (Ri) = ……………Ω
2. Output Resistance (Ro) = ……………Ω

Post lab Questions

1. NPN transitors are more preferable for amplification purpose than PNP transistors. Why?
2. Explain the switching action of a transistor?
3. At what region of the output characteristics, a transistor can act as an amplifier?
4. What happens when we change the biasing condition of the transistors.
5. Why the output is phase shifted by 180 ◦ only in CE configuration.

Conclusion

Particulars	Max. Marks	Marks Obtained
Prelab	20	
Lab Check of and verification	40	
Report & post lab	40	
Total	100	

3. COMMON COLLECTOR CONFIGURATION

Objective:

To study the input and output characteristics of a transistor in common collector configuration and to determine its h parameters.

Hardware Required:

S. No	Apparatus	Type	Range	Quantity
01	Transistor	BC147		1
02	Resistance		68 k, 1k ohm	1
03	Regulated power supply		(0 – 30V)	2
04	Ammeter	mC	(1-10)mA, (0-500)µA	1
05	Voltmeter	mC	(0 – 1)V, (0 – 30)V	1
06	Bread board and connecting wires			

Introduction:

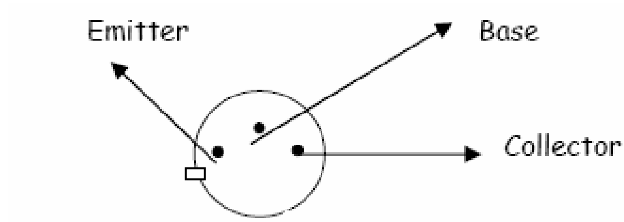
Bipolar junction transistor (BJT) is a 3 terminal (emitter, base, collector) semiconductor device. There are two types of transistors namely NPN and PNP. It consists of two P-N junctions namely emitter junction and collector junction.

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

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

Output characteristics are obtained between the output voltage and output current taking input current as parameter. It is plotted between VCE and IE at constant IB in CC configuration.

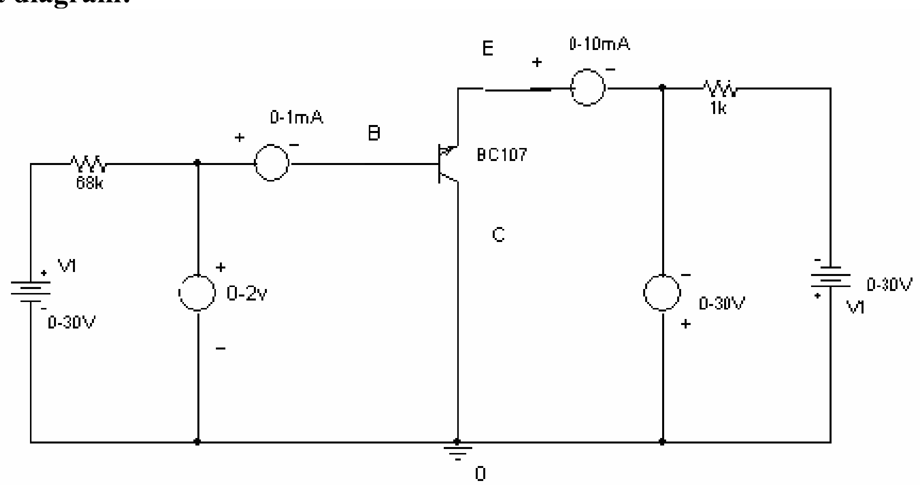
Pin Assignment:



Pre lab Questions

1. Why CC Configuration is called emitter follower?
2. Can we use CC configuration as an amplifier?
3. What is the need for analyzing the transistor circuits using different parameters?
4. What is the significance of hybrid model of a transistor?
5. Is there any phase shift between input and output in CC configuration.

Circuit diagram:



Precautions:

1. While doing the experiment do not exceed the ratings of the transistor. This may lead to damage the transistor.
2. Connect voltmeter and Ammeter in correct polarities as shown in the circuit diagram.

3. Do not switch **ON** the power supply unless you have checked the circuit connections as per the circuit diagram.
4. 4.Make sure while selecting the emitter, base and collector terminals of the transistor.

Experiment:

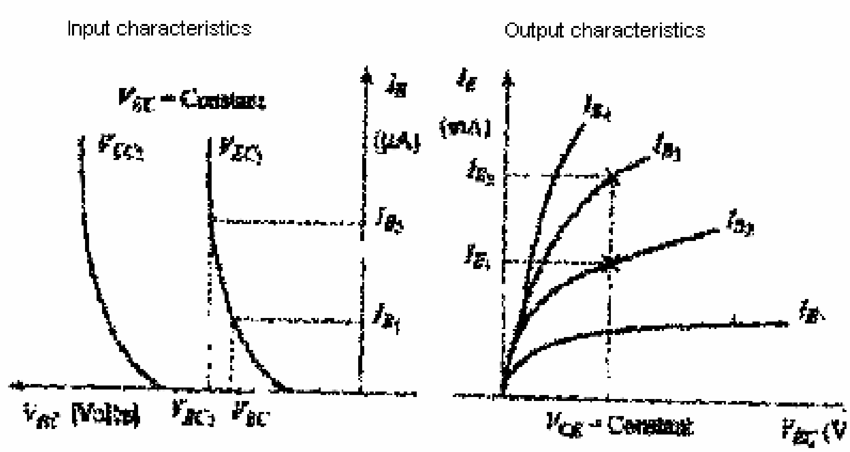
Input Characteristics:

1. Connect the transistor in CC configuration as per circuit diagram
2. Keep output voltage V_{CE} = 0V by varying V_{EE}.
3. Varying V_{BB} gradually, note down both base current I_B and base - collector voltage (V_{BC}).
4. Repeat above procedure (step 3) for various values of V_{CE}

Output Characteristics

1. Make the connections as per circuit diagram .
2. By varying V_{BB} keep the base current I_B = 20μA.
3. Varying V_{CC} gradually, note down the readings of emitter-current (I_E) and collector- Emitter voltage (V_{CE}).
4. Repeat above procedure (step 3) for different values of I_E

Graph:



Calculations from graph:

e) Input impedance(h_{ic})= = ΔV_{BC} / ΔI_B

f) Forward current gain(h_{fc})= = ΔI_E / ΔI_B

g) Output admittance(h_{oc})= = ΔI_E / Δ V_{EC}

h) Reverse voltage gain(h_{rc})= ΔV_{BC}/Δ V_{EC}

Result:

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

a) Input impedance(hic)=

b) Forward current gain(hfc)=

c) Output admittance(hoc)=

d) Reverse voltage gain(hrc)=

Post lab Questions:

1. What are the applications of CC configuration?
2. Compare the voltage gain and input and output impedances of CE and CC configurations.
3. BJT is a current controlled device. Justify.

Conclusion

Particulars	**Max. Marks**	**Marks Obtained**
Prelab	20	
Lab Check of and verification	40	
Report & post lab	40	
Total	100	

4. FET CHARACTERISTICS

Objective:

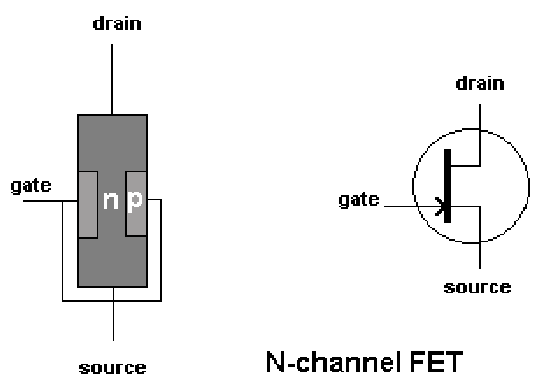
a) To study Drain Characteristics of a FET.

b) To study Transfer Characteristics of a FET.

Hardware Required:

S. No	Apparatus	Type	Range	Quantiy
01	JFET	BFW11		1
02	Resistance		1k ohm	1
03	Regulated power supply		(0 – 30V)	1
04	Ammeter	mC	(0-30)mA, (0-500)MA	1
05	Voltmeter	mC	(0 – 1)V, (0 – 30)V	1
06	Bread board and connecting wires			

Introduction:



N-channel FET

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

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

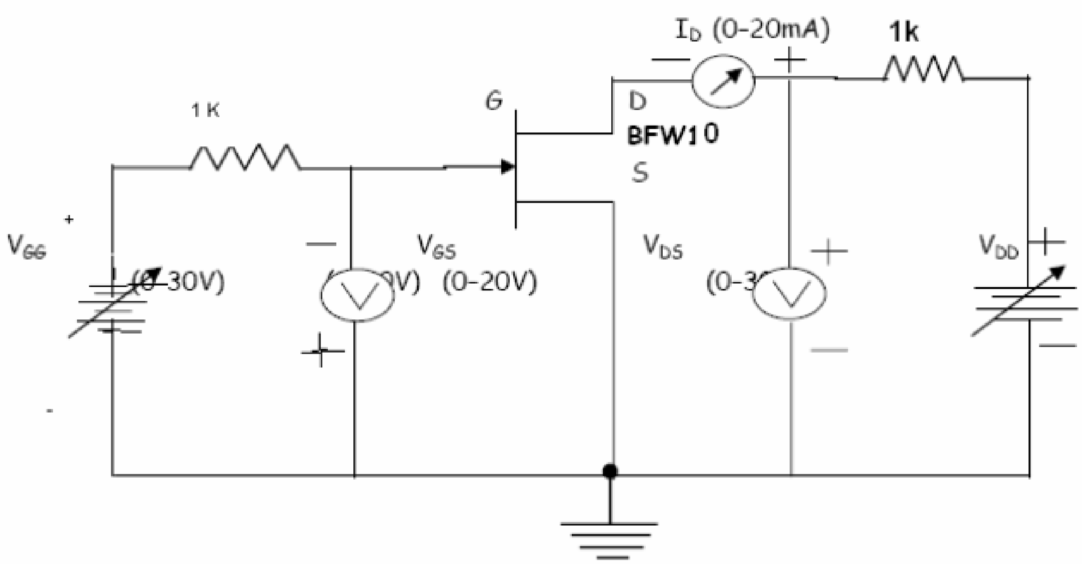
If the FET is accidentally forward biased, gate current will flow and the FET will be destroyed. To avoid this, an extremely thin insulating layer of silicon oxide is placed between the gate and the channel.

The device is then known as an insulated gate FET, or IGFET or metal oxide semiconductor FET(MOSTFET) Drain characteristics are obtained between the drain to source voltage (VDS) and drain current (ID) taking gate to source voltage (VGS) as the parameter. Transfer characteristics are obtained between the gate to source voltage (VGS) and Drain current (ID) taking drain to source voltage (VDS) as parameter

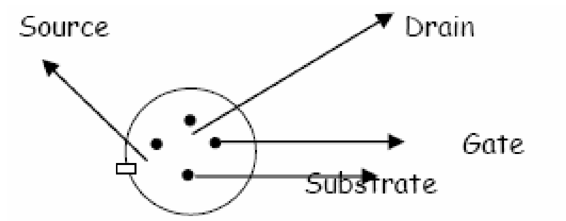
Prelab Questions:

1. Why FET is called as a unipolar transistor?
2. What are the advantages of FET over BJT?
3. State why FET is voltage controlled device?
4. Why thermal runaway does not occur in FET?
5. What is the difference between MOSFET and FET?

Circuit diagram:



Pin assignment of FET:



Precautions:

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

Experiment:

DRAIN CHARACTERISTICS

Determine the drain characteristics of FET by keeping $V_{GS} = 0$v.

Plot its characteristics with respect to V_{DS} versus I_D

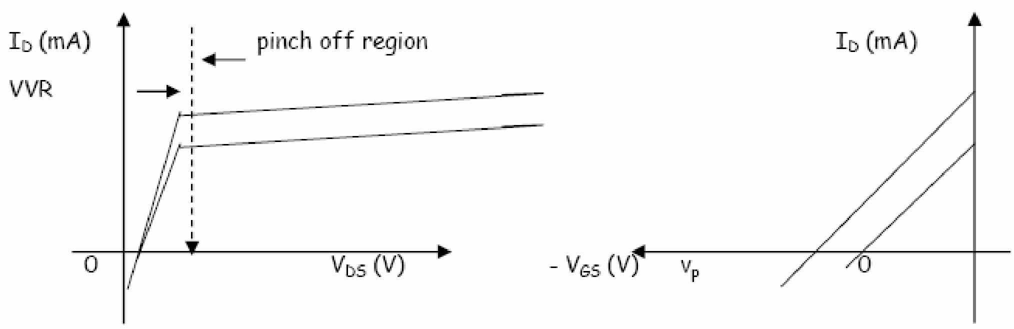
TRANSFER CHARACTERISTICS:

Determine the transfer characteristics of FET for constant value of V_{DS}.

Plot its characteristics with respect to V_{GS} versus I_D

Graph (Instructions):

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



DRAIN CHARACTERISTICS **TRANSFER CHARACTERISTICS**

Calculations from Graph:

Drain Resistance (rd) :

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

Trans-Conductance (gm) :

Ratio of small change in drain current (ΔI_D) to the corresponding change in gate to source voltage (ΔV_{GS}) for a constant V_{DS}. gm = $\Delta I_D / \Delta V_{GS}$ at constant V_{DS} . (from transfer characteristics) The value of gm is expressed in mho's or siemens (s).

Amplification Factor (μ) :

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

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

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

μ = rd X gm.

Inference:

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 =0 V
2. The value of drain to source voltage (VDS) is decreased as compared to that when VGS =0V

Result:

1. Drain Resistance (rd) = …………

2. Transconductance (gm) = …………

3. Amplification factor (μ) = ……………

Post lab Questions:

1. What is trans conductance?
2. Why current gain is important parameter in BJT where as conductance is important parameter in FET?
3. What is pinch off voltage
4. How can avalanche breakdown be avoided in FET
5. Why does FET produce less electrical noise than BJT.

Conclusion

Particulars	Max. Marks	Marks Obtained
Prelab	20	
Lab Check of and verification	40	
Report & post lab	40	
Total	100	

5. CHARACTERISTICS OF LDR,PHOTODIODE,PHOTOTRANSISTOR.

Objective:

1. To plot distance Vs Photocurrent Characteristics of LDR, Photodiode and Phototransistor.

.

Hardware Required:

S. No	Apparatus	Type	Range	Quantity
01	Photodiode			1
02	Phototransistor		1k ohm	1
03	Regulated power supply			1
04	Ammeter	mC	(0-30)mA;(0-30)microA	1
05	Voltmeter	mC	(0-10)V	1
06	Bread board and connecting wires			1
07	LDR			1

Introduction:

LDR

A photoresistor or light dependent resistor or cadmium sulfide (CdS) cell is a resistor hose resistance decreases with increasing incident light intensity. It can also be referred to as a photoconductor.

A photoresistor is made of a high resistance semiconductor. If light falling on the device is of high enough frequency, photons absorbed by the semiconductor give bound lectrons enough energy to jump into the conduction band. The resulting free electron (and its hole partner) conduct electricity, thereby lowering resistance

Photodiode

A silicon photodiode is a solid state light detector that consists of a shallow diffused P-N junction with connections provided to the out side world. When the top surface is illuminated, photons of light penetrate into the silicon to a depth determined by the photon energy and are absorbed by the silicon generating electron-hole pairs. The electron-hole pairs are free to diffuse (or wander) throughout the bulk of the photodiode until they recombine.

The average time before recombination is the “minority carrier lifetime”. At the P-N junction is a region of strong electric field called the depletion region. It is formed by the voltage potential that exists at the P-N junction. Those light generated carriers that wander into contact with this field are swept across the junction. If an external connection is made to both sides of the junction a photo induced current will flow as long as light falls upon the photodiode. In addition to the photocurrent, a voltage is produced across the diode. In effect, the photodiode functions exactly like a solar cell by generating a current and voltage when exposed to light.

Phototransistor:

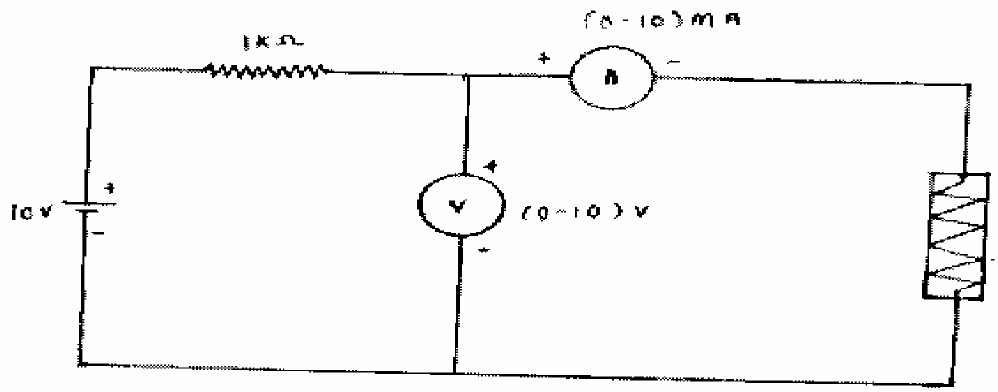
Photo-Transistor, is a bit like a Photo-Diode in the fact that it detects light waves, however photo-transistors, like transistor are designed to be like a fast switch and is used for light wave communications and as light or infrared sensors . The most common form of photo-transistor is the NPN collector and emitter transistor with no base lead. Light or photons entering the base (which is the inside of the photo-transistor) replace the base - emitter current of normal transistors.

Prelab Questions:

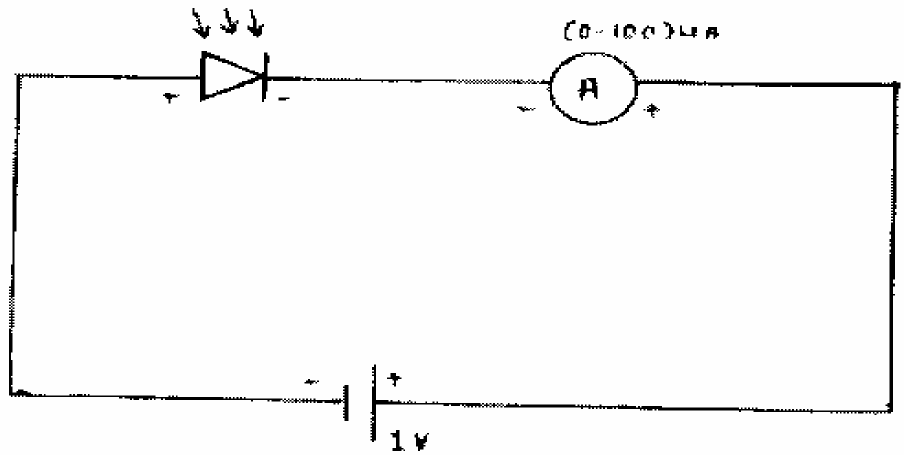
1. What is the principle of operation of LDR?
2. What is the principle of operation of Photodiodes?
3. What is the principle of operation of Phototransistors?
4. What is the difference between Photodiode and phototransistor?.
5. Give the applications of LDR?
6. Give the applications of Photodiodes?
7. Give the applications of Phototransistors?

Circuit diagram:

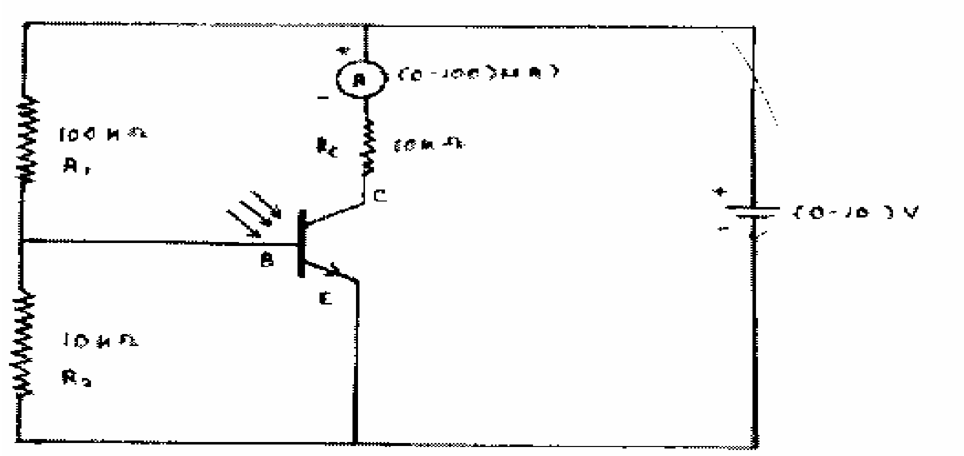
LDR:



Photodiode:



Phototransistor:



Precautions:

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

Experiment:

Procedure:

LDR:

Connect circuit as shown in figure

Keep light source at a distance and switch it ON,so that it falls on the LDR

Note down current and voltage in ammeter and voltmeter.

Vary the distance of the light source and note the V & I.

Sketch graph between R as calculated from observed V and I and distance of light source.

Photodiode:

Connect circuit as shown in figure

Maintain a known distance between the bulb and photodiode say 5cm

Set the voltage of the bulb,vary the voltage of the diode in steps of 1 volt and note down the diode current Ir.

Repeat above procedure for VL=4V,6V,etc.

Plot the graph :Vd Vs Ir for constant VL

Phototransistor:

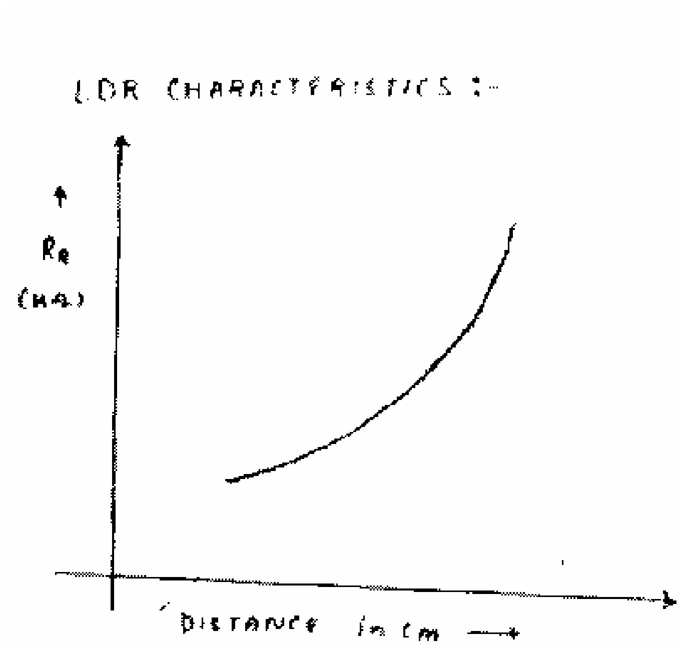
Connect circuit as shown in figure

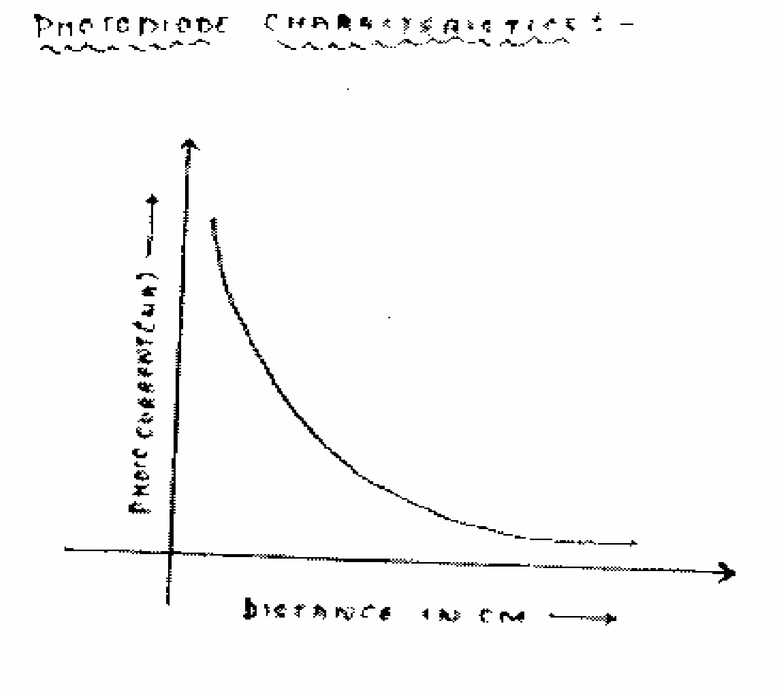
Repeat the procedure as that of the photodiode.

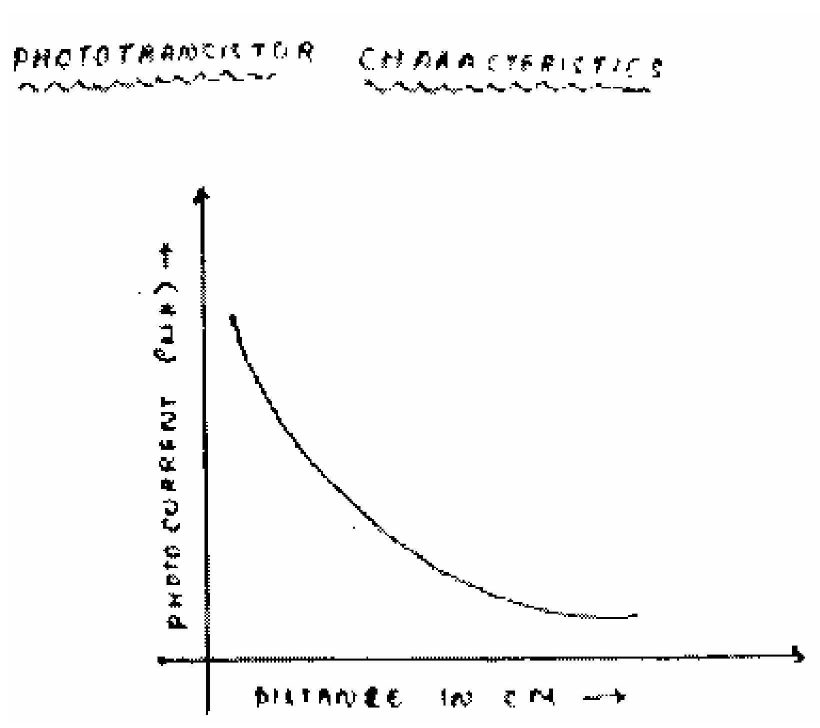
Graph (instructions)

1. Take a graph sheet. Mark origin at the left bottom of the graph sheet.
2. Now mark photocurrent in Y axis and distance in cm along X axis
3. Mark the readings tabulated.

Graph:







Calculations from Graph:

Resistance R = V/I Ω

Result:

1.The characteristics of LDR,Photodiode,Phototransistor is to be tabulated

2. Graph is to be drawn

Post lab Questions:

1. What happens when distance is increased in case of LDR, Photodiode and phototransistor?
2. Define dark current in photodiode?
3. Can we operate photodiode in forward bias condition? Justify the answer?
4. Why we are making light to fall on collector base junction in case of phototransistor?

Conclusion

Particulars	Max. Marks	Marks Obtained
Prelab	20	
Lab Check of and verification	40	
Report & post lab	40	
Total	100	

6.1 HALF WAVE RECTIFIER

OBJECTIVE:

1. To plot Output waveform of the Half Wave Rectifier.
2. To find ripple factor for Half Wave Rectifier using the formulae.
3. To find the efficiency, Vp(rect), Vdc for Half Wave Rectifier.

HARDWARE REQUIRED:

S. No	Apparatus	Type	Range	Quantity
01	Transformer		6-0-6 V	1
02	Resistance		470 ohm	1
03	Capacitor		470µF	1
04	Diode	IN4001		1
05	Bread board and connecting wires			

INTRODUCTION:

A device is capable of converting a sinusoidal input waveform into a nidirectional waveform with non zero average component is called a rectifier.

A practical half wave rectifier with a resistive load is shown in the circuit iagram. During the positive half cycle of the iniput the diode conducts and all the input voltage is dropped across RL. During the negative half cycle the diode is reverse biased and is in FF state and so the output voltage is zero.

The filter is simply a capacitor connected from the rectifier output to ground. The capacitor quickily charges at the beginning of a cycle and slowly discharges through RL after the positive peak of the input voltge. The variation in the capacitor voltage due to charging and discharging is called ripple voltage. Generally, ripple is undesirable, thus the smaller the ripple, the better the filtering action.

Ripple factor is an indication of the effectiveness of the filter and is defined as R=Vr(pp)/V DC

Where Vr(pp) = Ripple voltage

Vdc= Peak rectified voltage.

The ripple factor can be lowered by increasing the value of the filter capacitor or increasing the load capacitance.

MATHEMATICAL ANALYSIS (Neglecting Rf and Rs)

Let Vac = Vm sinωt is the input AC signal, the current Iac flows only for one half cycle i.e from ωt

= 0 to ωt = π , where as it is zero for the duration π ≤ ωt ≤ 2π
Therefore, Iac = = Im sinωt 0 ≤ ωt ≤ π
= 0 π ≤ ωt ≤ 2π

Where
Im = maximum value of current

Vm = maximum value of voltage

AVERAGE OR DC VALUE OF CURRENT

Vdc = Vm /π

The RMS VALUE OF CURRENT
Vrms = Vm/2

RECTIFICATION FACTOR:
The ratio of output DC power to the input AC power is defined as efficiency

Output power = I2dcR

Input power = I2rms(R+Rf)

Where Rf – forward resistance of the diode

η = Pdc/Pac = I2dcR/ I2rms (R+Rf)

PERCENTAGE OF REGULATION:
It is a measure of the variation of AC output voltage as a function of DC output Voltage
Percentage of regulation

$$\frac{V_{NL} - V_{FL}}{V_{FL}} \times 100\ \%$$

VNL = Voltage across load resistance, When minimum current flows though it.

VFL = Voltage across load resistance, When maximum current flows through.

For an ideal half-wave rectifier, the percentage regulation is 0 percent. For a practical half wave

$$V_{NL} = \frac{V_m}{\pi}$$

$$V_{FL} = \frac{V_m}{\pi} - I_{dc}(R+R_f)$$

Peak – inverse – voltage PIV:

It is the maximum voltage that has to be with stood by a diode when it is reverse biased

PIV = Vm

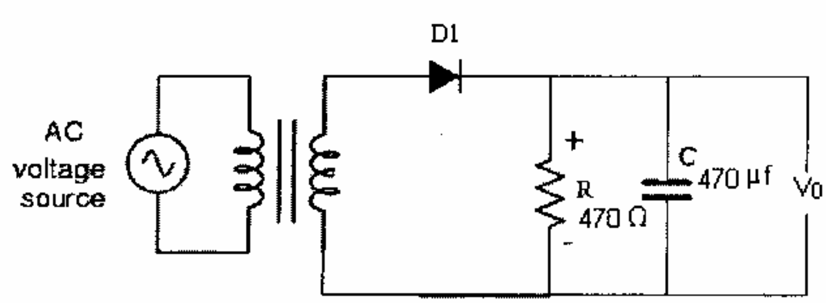
PRELAB QUESTIONS:

1. Why are rectifiers used with a filter at their output?
2. What is the voltage regulation of the rectifier?
3. What is the ideal value of regulation?
4. What does no load condition refer to?
5. What are the advantages of bridge rectifier?
6. What are the advantages and disadvantages of capacitor filter?
7. What are the applications of rectifiers?
8. What is the regulation for a

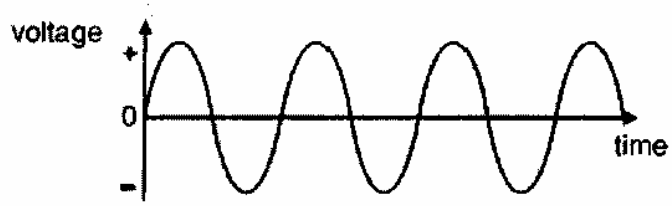
(i) Half - wave circuit (ii) Full-wave circuit

9. What is PIV? State it value in case of (i) Half wave (ii) Full wave (iii) Bridge rectifier.
10. What is the need for rectification ?

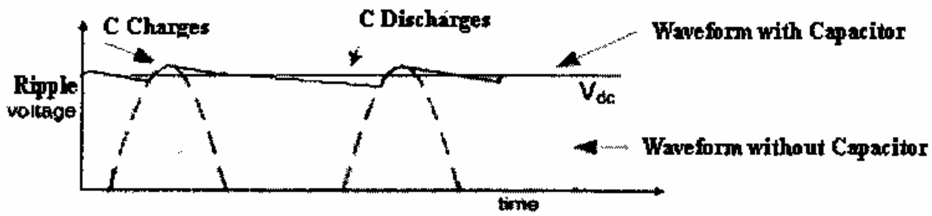
CIRCUIT DIAGRAM OF HALF – WAVE RECTIFIER WITH FILTER



MODEL GRAPH:



Input Waveform



Resultant Output Waveform

PRECAUTIONS:

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

EXPERIMENT:

1. Connections are given as per the circuit diagram without capacitor.
2. Apply AC main voltage to the primary of the transformer. Feed the rectified output voltage to the CRO and measure the time period and amplitude of the waveform.
3. Now connect the capacitor in parallel with load resistor and note down the amplitude and timeperiod of the waveform.
4. Measure the amplitude and timeperiod of the transformer secondary(input waveform) by connecting CRO.
5. Plot the input, output without filter and with filter waveform on a graph sheet.
6. Calculate the ripple factor.

GRAPH (instructions):

1. Take a graph sheet and divide it into 2 equal parts. Mark origin at the center of the graph sheet.
2. Now mark x-axis as Time
   y-axis as Voltage
3. Mark the readings tabulated for Amplitude as Voltage and Time in graph sheet.

FORMULAE:

Peak to Peak Ripple Voltage, Vr(pp)=(1/fRLC)Vp(rect)

Vp(rect) = Unfiltered Peak Rectified Voltage

Vdc=(1-1/(2fRLC))Vp(rect)

Ripple Factor = Vr(pp)/Vdc

OBSERVATIONS:

	Input Waveform	**Output Waveform**	**Ripple Voltage**
Amplitude			
Time Period			
Frequency			

RESULT:

The Rectified output Voltage of Half Wave Rectifier Circuit is observed and the calculated value of ripple factor is ________________

Conclusion

Particulars	**Max. Marks**	**Marks Obtained**
Prelab	20	
Lab Check of and verification	40	
Report & post lab	40	
Total	100	

6.2 FULL WAVE RECTIFIER

OBJECTIVE:

1. To plot Output waveform of the Full Wave Rectifier.
2. To find ripple factor for Full Wave Rectifier using the formulae.
3. To find the efficiency, Vp(rect), Vdc for Full Wave Rectifier.

HARDWARE REQUIRED:

S. No	Apparatus	Type	Range	Quantity
01	Transformer		6-0-6 V	1
02	Resistance		470 ohm	1
03	Capacitor		470µF	1
04	Diode	IN4001		2
05	Bread board and connecting wires			

INTRODUCTION:

A device is capable of converting a sinusoidal input waveform into a unidirectional waveform with non zero average component is called a rectifier.

A practical half wave rectifier with a resistive load is shown in the circuit diagram. It consists of two half wave rectifiers connected to a common load. One rectifies during positive half cycle of the input and the other rectifying the negative half cycle. The transformer supplies the two diodes (D1 and D2) with sinusoidal input voltages that are equal in magnitude but opposite in phase.

During input positive half cycle, diode D1 is ON and diode D2 is OFF. During negative half cycle D1 is OFF and diode D2 is ON.

Generally, ripple is undesirable, thus the smaller the ripple, the better the filtering action.

Ripple factor is an indication of the effectiveness of the filter and is defined as R=Vr(pp)/Vdc

Where Vr(pp) = Ripple voltage

Vdc= Peak rectified voltage.

The ripple factor can be lowered by increasing the value of the filter capacitor or increasing the load capacitance.

MATHEMATICAL ANALYSIS (Neglecting Rf and Rs)

The current through the load during both half cycles is in the same direction and hence it is the sum of the individual currents and is unidirectional Therefore, I = Id1 + Id2 The individual currents and voltages are combined in the load and there fore their average values are double that obtained in a half – wave rectifier circuit.

AVERAGE OR DC VALUE OF CURRENT Idc

$$I_{dc} = 1/2\pi \left[\int_0^{\pi} I_m(\sin\omega t)d\omega t \; - \; \int_{\pi}^{2\pi} I_m(\sin\omega t)d\omega t \right] = 2\, I_m / \pi$$

Similarly,

$$V_{dc} = 2V_m / \pi$$

The RMS VALUE OF CURRENT

$$= \sqrt{.\pi \int_0^{2\pi} I_m^2 \sin^2 \omega t \, d\omega t}$$

$$= \frac{I_m}{\sqrt{2\pi}}$$

Similarly $$V_{rms} = \frac{V_m}{\sqrt{2\pi}}$$

RECTIFICATION FACTOR

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

$$\eta = \frac{P_{dc}}{P_{ac}} = \frac{V_{dc} * I_{dc}}{V_{rms}\sqrt{I_{ac}^2 + I_{dc}^2}} * 100$$

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

PERCENTAGE OF REGULATION

It is a measure of the variation of AC output voltage as a function of DC output voltage.

$$\frac{V_{NL} - V_{FL}}{V_{FL}} \times 100\%$$

For an ideal Full-wave rectifier. The percentage regulation is 0 percent.

Peak – Inverse – Voltage (PIV)

It is the maximum voltage that has to be with stood by a diode when it is reverse biased

PIV = 2Vm

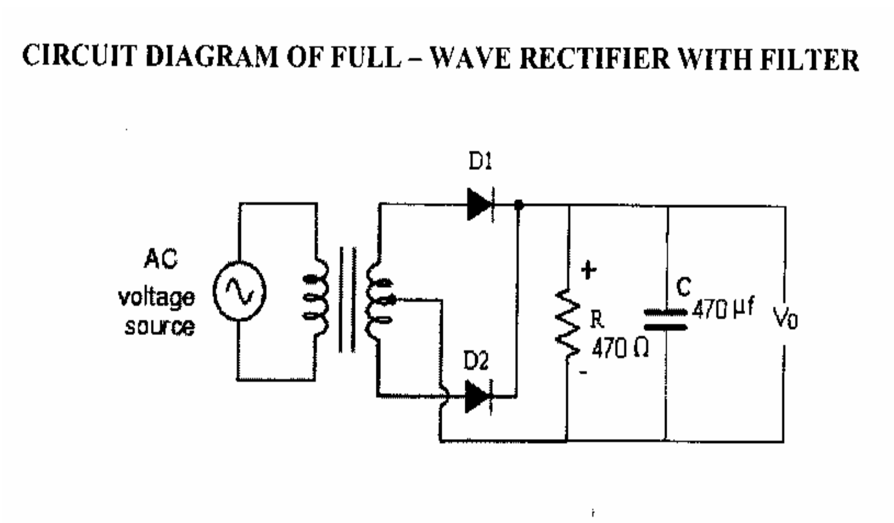
Advantages of Full wave Rectifier

1. γ is reduced
2. η is improved

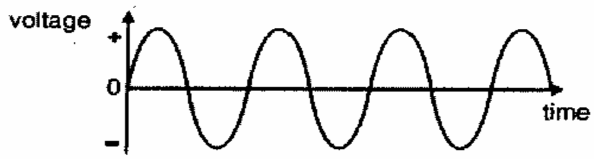
Disadvantages of Full wave Rectifier

1. Output voltage is half the secondary voltage
2. Diodes with high PIV rating are used

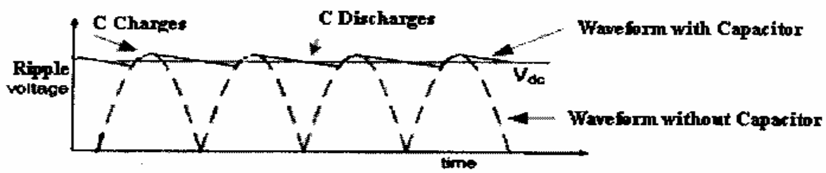
Manufacturing of center-taped transformer is quite expensive and so Full wave rectifier with



MODEL GRAPH:



Input Waveform



Resultant Output Waveform

PRECAUTIONS:

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

EXPERIMENT:

1. Connections are given as per the circuit diagram without capacitor.
2. Apply AC main voltage to the primary of the transformer. Feed the rectified output voltage to the CRO and measure the time period and amplitude of the waveform.
3. Now connect the capacitor in parallel with load resistor and note down the amplitude and time period of the waveform.
4. Measure the amplitude and time period of the transformer secondary(input waveform) by connecting CRO.
5. Plot the input, output without filter and with filter waveform on a graph sheet.
6. Calculate the ripple factor.

Graph (instructions)

1. Take a graph sheet and divide it into 2 equal parts. Mark origin at the center of the graph sheet.

2. Now mark x-axis as Time
   y-axis as Voltage

3. Mark the readings tabulated for Amplitude as Voltage and Time in graph sheet.

Formulae:

Peak to Peak Ripple Voltage, $V_{r(pp)}=(1/2fR_LC)V_{p(rect)}$

$V_{p(rect)}$ = Unfiltered Peak Rectified Voltage

$V_{dc}=(1-1/(4fR_LC))V_{p(rect)}$

Ripple Factor = $V_{r(pp)}/V_{dc}$

Observations:

	Input Waveform	Output Waveform	Ripple Voltage
Amplitude			
Time Period			
Frequency			

Result:

The Rectified output Voltage of Full Wave Rectifier Circuit is observed and the calculated value of ripple factor is ________________

Conclusion

Particulars	Max. Marks	Marks Obtained
Prelab	20	
Lab Check of and verification	40	
Report & post lab	40	
Total	100	

6.3 FULL WAVE BRIDGE RECTIFIER

Objective:

1. To plot Output waveform of the Full Wave Bridge Rectifier.
2. To find ripple factor for Full Wave Bridge Rectifier using the formulae.
3. To find the efficiency, Vp(rect), Vdc for Full Wave Bridge Rectifier.

Hardware Required:

S. No	Apparatus	Type	Range	Quantity
01	Transformer		6-0-6 V	1
02	Resistance		470 ohm	1
03	Capacitor		470µF	1
04	Diode	IN4001		4
05	Bread board and connecting wires			

Introduction:

A device is capable of converting a sinusoidal input waveform into a unidirectional waveform with non zero average component is called a rectifier.

The Bridege rectifier is a circuit, which converts an ac voltage to dc voltage using both half cycles of the input ac voltage. The Bridege rectifier has four diodes connected to form a Bridge. The load resistance is connected between the other two ends of the bridge.

For the positive half cycle of the input ac voltage, diode D1 and D3 conducts whereas diodes D2 and D4 remain in the OFF state. The conducting diodes will be in series with the load resistance RL and hence the load current flows through RL .

For the negative half cycle of the input ac voltage, diode D2 and D4 conducts whereas diodes D1 and D3 remain in the OFF state. The conducting diodes will be in series with the load resistance RL and hence the load current flows through RL in the same direction as in the previous half cycle. Thus a bidirectional wave is converted into a unidirectional wave.

Ripple factor is an indication of the effectiveness of the filter and is defined as

R=Vr(pp)/Vdc

Where Vr(pp) = Ripple voltage

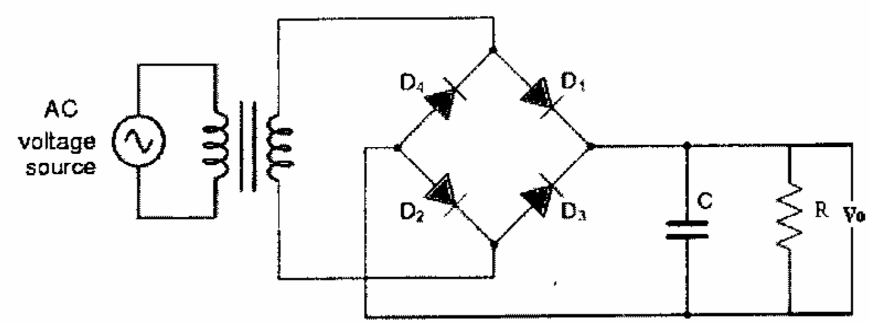
Vdc= Peak rectified voltage.

The ripple factor can be lowered by increasing the value of the filter capacitor or increasing the load capacitance.

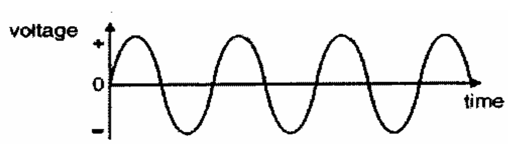
Prelab Questions:

1. What are the advantages of bridge rectifier over center tapped full wave rectifier?
2. What is the PIV rating of diode in bridge rectifier?
3. Can we use zener diode in case pn junction diode? Justify your answer.

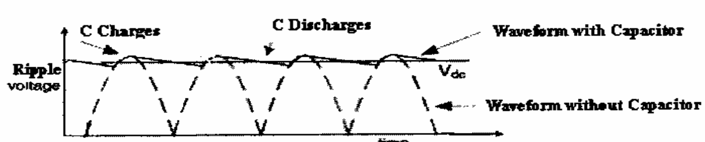
CIRCUIT DIAGRAM OF FULL – WAVE BRIDGE RECTIFIER WITH FILTER



MODEL GRAPH:



Input Waveform



Resultant Output Waveform

Precautions:

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

Experiment:

1. Connections are given as per the circuit diagram without capacitor.
2. Apply AC main voltage to the primary of the transformer. Feed the rectified output voltage to the CRO and measure the time period and amplitude of the waveform.
3. Now connect the capacitor in parallel with load resistor and note down the amplitude and time period of the waveform.
4. Measure the amplitude and time period of the transformer secondary(input waveform) by connecting CRO.
5. Plot the input, output without filter and with filter waveform on a graph sheet.
6. Calculate the ripple factor.

Graph (instructions)

1. Take a graph sheet and divide it into 2 equal parts. Mark origin at the center of the graph sheet.

2. Now mark x-axis as Time
   y-axis as Voltage
   .

3. Mark the readings tabulated for Amplitude as Voltage and Time in graph sheet.

Formulae:

Peak to Peak Ripple Voltage, $V_{r(pp)}=(1/2fR_LC)V_{p(rect)}$

$V_{p(rect)}$ = Unfiltered Peak Rectified Voltage

$V_{dc}=(1-1/(4fR_LC))V_{p(rect)}$

Ripple Factor = $V_{r(pp)}/V_{dc}$

Observations:

	Input Waveform	Output Waveform	Ripple Voltage
Amplitude			
Time Period			
Frequency			

Result:

The Rectified output Voltage of Full Wave Rectifier Circuit is observed and the calculated value of ripple factor is ________________

Post lab Questions:

1. A diode should not be employed in the circuits where it is to carry more than its maximum forward current, why?
2. While selecting a diode, the most important consideration is its PIV, why?
3. The rectifier diodes are never operated in the breakdown region, why?
4. How big should be the value of capacitor to reduce the ripple to 0.1?
5. What happens when we remove capacitor in the rectifier circuit?
6. If a transformer is removed from the rectifier circuit, what happens to the circuit?

Conclusion

Particulars	Max. Marks	Marks Obtained
Prelab	20	
Lab Check of and verification	40	
Report & post lab	40	
Total	100	

7. SERIES VOLTAGE REGULATOR

OBJECTIVE:

1. To design a series voltage regulator
2. To find load regulation
3. To find line regulation

HARDWARE REQUIRED:

S. No	Apparatus	Range	Type
1	Power transistor		2N3055
2	Transistor		
3	Zener diode		1Z6.2
4	Resistors	947Ω, 2.48KΩ, 2.2kΩ, 2.75KΩ, 49.6Ω	
5	Multimeter		
6	Bread board & wires		

INTRODUCTION:

The term regulation is the ability of the power supply source to maintain a constant output voltage in spite of line voltage fluctuations and changes in load current

The factors of poor regulation are

1. The line voltage changes which causes a dc output change and the ripple content of the dc input due to inadequate filtering.
2. The load current changes which causes a variable internal drop due to the internal resistance of the regulator and the consequent change in the output voltage and
3. The temperature coefficient of the device parameters which results in a change of the output voltage.

Voltage regulators can be classified by the method of achieving regulation as linear regulators and switching regulators. They are also classified by the way they are connected to the load as series regulators and shunt regulators. Standard regulator contains three basic elements namely a precision voltage reference, an error amplifier and a power control element.

In a series regulator, the switching control element is connected between the load and the unregulated supply. The series regulator is desirable when the load current varies from zero to fixed maximum. A shunt regulator is suitable when the load current varies from a finite minimum value to a finite maximum value.

In this circuit the transistor Q_2 Functions both as a voltage comparator and dc amplifier. Any increase in the output voltage V_o either due to the input-voltage variation or change of load results in increase of V_{BE} of the transistor Q_2. Hence the collector current IC_2 increase. Due to this the total current following through R_3 increases. Hence the collector voltage of Q_2 decreases.

Since the base of Q_1 is tied to the collector of T_2, the base voltage of $Q_{1.}$ with respect to ground decreases thereby decreasing the forward bias of the emitter junction of Q_2. Hence the collector emitter voltage of Q_1 has to increase in order to maintain the same emitter current. If the change in $V_{CE,}$ of Q_1 can be made equal to Vi then the output voltage will remain constant. Since $V_{CBI} = V_{CEI.}$ We can assume that if Vi dropped across R_3, then the output voltage will remain constant.

Line Regulation:

Line regulation is a measure of the ability of the power supply to maintain its output voltage given changes in the input line voltage. Line regulation is expressed as percent of change in the output voltage relative to the change in the input line voltage.

$$\text{Line regulation} = \frac{(\text{output voltage at High line input voltage} - \text{output voltage at low line input voltage}) \times 100}{(\text{High line input voltage} - \text{low line input voltage})}$$

Load Regulation

Load regulation is a measure of the ability of an output channel to remain constant given changes in the load. Depending on the control mode enabled on the output channel, the load regulation specification can be expressed in one of two ways In constant voltage mode, variations in the load result in changes in the output current. This variation is expressed as a percentage of range per amp of output load and is synonymous with a series resistance. In constant voltage mode, the load regulation specification defines how close the series resistance of the output is to 0 ohms - the series resistance of an ideal voltage source.

In constant current mode, variations in the load result in changes to the current through the load. This variation is expressed as a percentage of range change in current per volt of change in the output voltage and is synonymous with a resistance in parallel with the output channel terminals. In constant current mode, the load regulation specification defines how close the output shunt resistance is to infinity—the parallel resistance of an ideal current. In fact, when load regulation is specified in constant current mode, parallel resistance is expressed as 1/load regulation.

Load Regulation can be defined as a percentage by the equation:

$$\text{Percent of regulation} = \frac{(E_{nL} - E_{fL})}{E_{fL}} \times 100$$

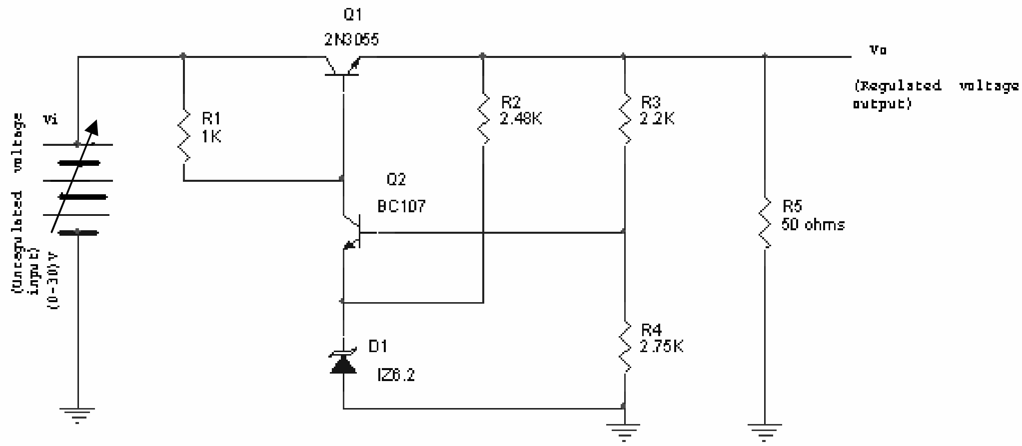
Where:

- FullLoad (E_{fL}) is the load that draws the greatest current (is the lowest specified load resistance - never short circuit)
- MinimumLoad (E_{nL}) is the load that draws the least current (is the highest specified load resistance - possibly open circuit for some types of linear supplies, usually limited by pass transistor minimum bias levels)
- NominalLoad (E_{fL}) is the typical specified operating load

Prelab Question:

1. What are the three basic elements inside a standard voltage regulator?
2. Compare series regulator with shunt regulator by principle.
3. What device is used as a control element? Why?
4. What are the performance measures of the regulator?
5. What is line regulation
6. what is load regulation
7. what is the efficiency of series voltage regulator

SERIES VOLTAGE REGULATOR – CIRCUIT DIAGRAM



DESIGN SPECIFICATIONS

Series pass Transistor 2N3055:

h_{fe} =20-70

I_{emax} =15 amperes

V_{ce} =70V

BC 170

I_e =2 mA

h_{fe} =125-500

ASSUMPTIONS

V_I =12.4 V

=250 mA

=2.5 mA

=10mA

β1 =28

β2 =188

DESIGN

$= V_L/2 = 12.4 / 2 = 6.2$ V

$= V_L/I_L = 12.4 / 250*10^{-3} = 49.6\Omega$

$= 0.01 * I_L = 12.4 / 250$ mA

$= V_L – V_Z / I_D = 12.4 – 6.2 / 2.5* 10\text{-}3 = 2.48\ K\Omega$

R1 $= \dfrac{V_L – (V_{BE2}+VZ)}{I_1} = \dfrac{(12.4-(0.7 + 6.2)}{2.5*10^{-3}} =5.5 / 2.5 * 10^3 = 2.2K\Omega$

$V_{R2} = V_{BE2} + V_Z * (R_2 / R_1+R_2)$

0.7 + 6.2	=	$12.4 * (R_2/ (2.2*10^{-3} + R_2))$
R2	=	2.75 KΩ
I2	=	$(V_2+V_{BE2}) / R_2 = 6.9 / 2.75 *103 = 2.5mA$
IE1	=	$(I_D+I_1 + I_L) = (2.5 + 2.5 + 250)$ mA = 255mA
IB1	=	$I_{E1} / \beta1 = 255 / 28 = 9.107$ mA
I3	=	$I_{B1} + I_{C2} = 9.107$ mA = 19.107 mA
R3	+	$[V_{INMX} - (V_{BE1} + V_2)] / I_3 = \frac{25-(0.7*6.2)}{19.107*10^{-3}} = 947\Omega$

Procedure:

Connect the circuit as per the circuit diagram.

1. For load regulation characteristics, keep the input voltage constant, find V_L for different values of R_L. Plot the graph by taking R_L in the axis and V_L in the Y axis.
2. For line regulation characteristics, keep R_L constant and for different values of input V_{in} find $V_{L.}$ Plot the graph by taking V_{in} in x axis and V_L in the y axis

Tabulation

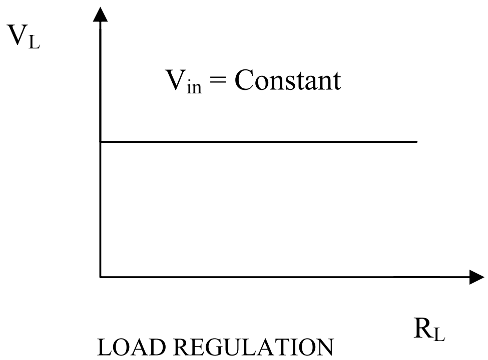
Line regulation RL = ------------ (Ω)

S. No	V_i (V)	V_o (V)
1. 2. 3. 4. 5.		

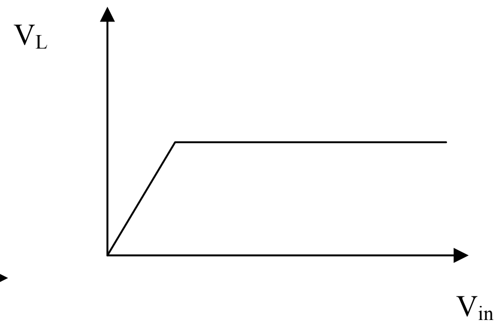
Load regulation V_i = ------------ (V)

S.No	$R_L(\Omega)$	$V_o(V)$
1. 2. 3. 4. 5.		

MODEL GRAPH



LOAD REGULATION



LINE REGULATION

Result:

The series voltage regulator was designed and constructed and the characteristics were plotted.

1. the regulated output voltage was found to be--------------V.
2. Line regulation was found to be ---------------------
3. Load regulation was found to be ----------------------.

Post Lab Question:

1. What will be the output voltage if reference voltage was short circuited
2. What will be the output voltage if reference voltage was open circuited
3. what will happen if potential divider was open circuited
4. what is the role of resistor R_1 in this circuit
5. what is the role of resistor R_2 in this circuit

Conclusion

Particulars	Max. Marks	Marks Obtained
Prelab	20	
Lab Check of and verification	40	
Report & post lab	40	
Total	100	

8. SHUNT VOLTAGE REGULATOR

OBJECTIVE:

1. To design a shunt voltage regulator
2. To find load regulation
3. To find line regulation

HARDWARE REQUIRED:

S.No	Apparatus	Range	Type
1	Regulated power supply	(0-30 V)	
2	Resistors	31.66 Ω,10 KΩ	
3	Zener diode		1z 5.1
4	Multimeter.		
5	Breadboard & wires		

INTRODUCTION:

The function of a voltage regulator is to provide a stable dc voltage to electronic circuits and capable of providing substantial output current. Since the lement or component used for voltage regulation is connected across the load, it is called as shunt voltage regulator. There are two types of shunt voltage regulator

1. Zener diode shunt voltage regulator
2. Transistor shunt voltage regulator

A zener diode is connected in parallel with the load; a resistance (R_2) is connected in series with the zener to limit the current in the circuit. Hence the resistance is called as series current limiting resistor. The output voltage (V_o) is taken across the load resistance (R_1). Since the reverse bias characteristics of sener diode are used in voltage regulation, the input voltage is always maintained greater than zener voltage (V_z).

Line Regulation:

Line regulation is a measure of the ability of the power supply to maintain its output voltage given changes in the input line voltage. Line regulation is expressed as percent of change in the output voltage relative to the change in the input line voltage.

Load Regulation

Load regulation is a measure of the ability of an output channel to remain constant given changes in the load. Depending on the control mode enabled on the output channel, the load regulation specification can be expressed in one of two ways:

In constant voltage mode, variations in the load result in changes in the output current. This variation is expressed as a percentage of range per amp of output load and is synonymous with a series resistance. In constant voltage mode, the load regulation specification defines how close the series resistance of the output is to 0 ohms - the series resistance of an ideal voltage source.

In constant current mode, variations in the load result in changes to the current through the load. This variation is expressed as a percentage of range change in current per volt of change in the output voltage and is synonymous with a resistance in parallel with the output channel terminals. In constant current mode, the load regulation specification defines how close the output shunt resistance is to infinity—the parallel resistance of an ideal current. In fact, when load regulation is specified in constant current mode, parallel resistance is expressed as 1/load regulation.

Load Regulation can be defined as a percentage by the equation:

$$\text{Percent of regulation} = \frac{(E_{nL} - E_{fL})}{E_{fL}} \times 100$$

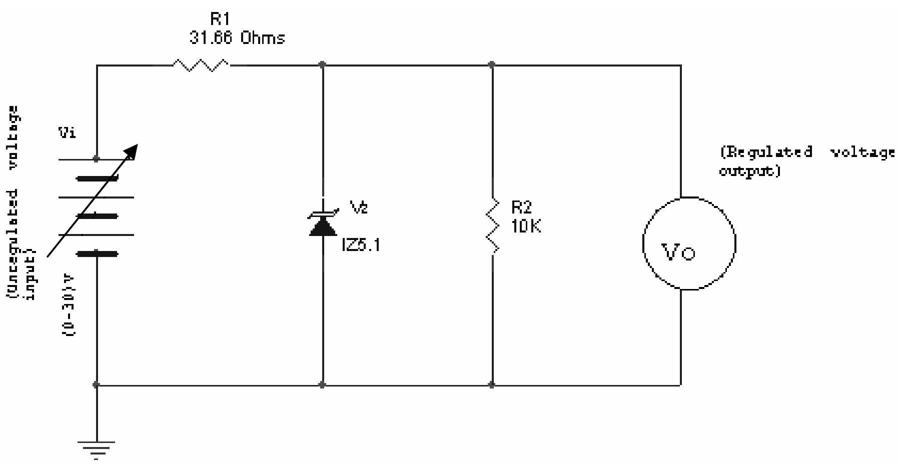
Where:

- FullLoad (E_{fL}) is the load that draws the greatest current (is the lowest specified load resistance - never short circuit)
- MinimumLoad (E_{nL}) is the load that draws the least current (is the highest specified load resistance - possibly open circuit for some types of linear supplies, usually limited by pass transistor minimum bias levels)
- NominalLoad (E_{fL}) is the typical specified operating load

Prelab Question:

1. Compare series regulator with shunt regulator by principle.
2. What device is used as a control element? Why?
3. What are the performance measures of the regulator?
4. What is line regulation
5. what is load regulation
6. what is the efficiency of shunt voltage regulator

SHUNT VOLTAGE REGULATOR – CIRCUIT DIAGRAM



DESIGN

Let I_z max = 10 mA, Vz = V_L = 5.1 V

Load current I_L = 50 mA.

Therefore $R_L = V_{L=} / I_L = 5.1\ V / 50 * 10^{-3}\ A = 120\ \Omega$

$R_L = 102\Omega$

RL should be greater than or equal to 102 Ω

$I_1 = I_Z + I_L$

= 10mA + 50 mA

I_1 = 60 mA

Rs = (Vi-Vz) / I_1 = (7-5.1) / (60*10^{-3} = 31.66Ω

Rs = 31.66Ω

PROCEDURE

Line regulation

1. Connections are made as per as the circuit diagram.
2. The load resistance (R_L) is kept constant and input voltage is varied and the corresponding output voltage (Vo) are noted.
3. A graph is drawn by taking input voltage (V_i) in x axiz and output voltage (Vo) in y axis.

Load regulation

1. The same circuit is used for finding load regulation. In the case, the input voltage (V_i) is kept constant.
2. The load resistance R_L is varied and the corresponding output voltage are noted.
3. A graph is plotted by having R_L in x axis and Vo in y axis.

TABULATION

Line regulation R_L = 10 K (Ω)

S.No	V_i (V)	V_o (V)
1.	2	2.07
2.	9	6.8
3.		
4.		
5.		

Load regulation

V_i = 7 (V)

S.No	R_L (Ω)	V_o(V)
1.	50	4.28
2.	700	6.51
3.		
4.		
5.		

Result:

The shunt voltage regulator was designed and constructed and the characteristics were plotted.

1. The regulated output voltage was found to be--------------V.
2. Line regulation was found to be ---------------------
3. Load regulation was found to be ----------------------

Post Lab Question:

1. What will be the output voltage if Zener diode was short circuited
2. What will be the output voltage if reference voltage was open circuited
3. What is the disadvantage of shunt regulator
4. What is the role of resistor R_1 in this circuit
5. What is the role of resistor R_2 in this circuit

Conclusion

Particulars	Max. Marks	Marks Obtained
Prelab	20	
Lab Check of and verification	40	
Report & post lab	40	
Total	100	

9. V-I CHARACTERISTICS OF LED

Objective :

To obtain the V-I Characteristics of LED

Hardware Required:

S. No	Apparatus	Range	Quantity
1.	Regulated power supply	(0 -5 V)	1
2.	Resistors	330Ω	1
3.	LED		1
4.	Voltmeter	(0 – 30V)	1
5.	Ammeter	(0 – 100 mA)	1
6.	Bread board and connecting wires		

Introduction:

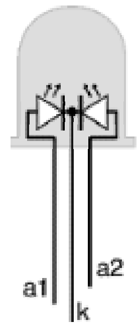
Function

LEDs emit light when an electric current passes through them.

LED is connected in the circuit as shown in figure. LED operates only in forward biased condition. Under forward bias condition the anode is connected to the positive terminal and the cathode is connected to the negative terminal of the battery. It is like a normal pn junction diode except the basic semiconductor material is GaAs or InP which is responsible for the color of the light. When it is forward biased the holes moves from p to n and electrons flow from n to p. In the junction the carriers recombine with each other and released the energy in the form of light. Thus LED emits light under forward biased condition. Under reverse biased condition, there is no recombination due to majority carriers, so there is no emission of light.

Connecting and soldering

LEDs must be connected the correct way round, the diagram may be labelled **a** or + for anode and **k** or **-** for cathode (yes, it really is k, not c, for cathode!). The cathode is the short lead and there may be a slight flat on the body of round LEDs. If you can see inside the LED the cathode is the larger electrode (but this is not an official identification method). LEDs can be damaged by heat when soldering, but the risk is small unless you are very slow. No special precautions are needed for soldering most LEDs.



Testing an LED

Never connect an LED directly to a battery or power supply!

It will be destroyed almost instantly because too much current will pass through and burn it out. LEDs must have a resistor in series to limit the current to a safe value, for quick testing purposes a 1kΩ resistor is suitable for most LEDs if your supply voltage is 12V or less. Remember to connect the LED the correct way round!

Colours of LEDs

LEDs are available in red, orange, amber, yellow, green, blue and white. Blue and white LEDs are much more expensive than the other colours. The colour of an LED is determined by the semiconductor material, not by the colouring of the 'package' (the plastic body). LEDs of all colours are available in uncoloured packages which may be diffused (milky) or clear (often described as 'water clear'). The coloured packages are also available as diffused (the standard type) or transparent.

As well as a variety of colours, sizes and shapes, LEDs also vary in their viewing angle. This tells you how much the beam of light spreads out. Standard LEDs have a viewing angle of 60° but others have a narrow beam of 30° or less.

Calculating an LED resistor value

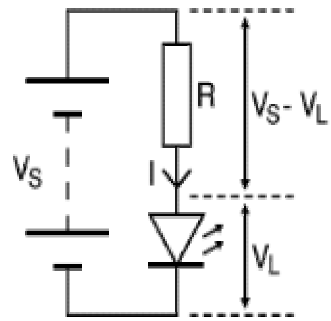
An LED must have a resistor connected in series to limit the current through the LED, otherwise it will burn out almost instantly. The resistor value, R is given by:

$$\boxed{\mathbf{R = (V_S - V_L) / I}}$$

V_S = supply voltage

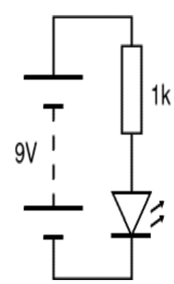
V_L = LED voltage (usually 2V, but 4V for blue and white LEDs)

I = LED current (e.g. 20mA), this must be less than the maximum permitted .

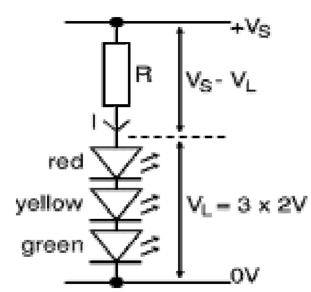


If the calculated value is not available choose the nearest standard resistor value which is **greater**, so that the current will be a little less than you chose. In fact you may wish to choose a greater resistor value to reduce the current (to increase battery life for example) but this will make the LED less bright.

For example
If the supply voltage V_S = 9V, and you have a red LED (V_L = 2V), requiring a current I = 20mA = 0.020A,
R = (9V - 2V) / 0.02A = 350Ω, so choose 390Ω (the nearest standard value which is greater).

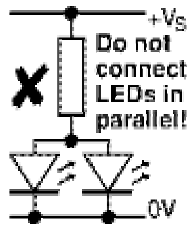


Connecting LEDs in series



If you wish to have several LEDs on at the same time it may be possible to connect them in series. This prolongs battery life by lighting several LEDs with the same current as just one LED.

All the LEDs connected in series pass the **same current** so it is best if they are all the same type. The power supply must have sufficient voltage to provide about 2V for each LED (4V for blue and white) plus at least another 2V for the resistor. To work out a value for the resistor you must add up all the LED voltages and use this for V_L.



Example calculations:

A red, a yellow and a green LED in series need a supply voltage of at least
$3 \times 2V + 2V = 8V$, so a **9V battery** would be ideal.
$V_L = 2V + 2V + 2V = 6V$ (the three LED voltages added up).
If the supply voltage V_S is 9V and the current I must be 15mA = 0.015A,
Resistor $R = (V_S - V_L) / I = (9 - 6) / 0.015 = 3 / 0.015 = 200\Omega$,
so choose $R = 220\Omega$ (the nearest standard value which is greater).

Avoid connecting LEDs in parallel. Connecting several LEDs in parallel with just one resistor shared between them is generally not a good idea. If the LEDs require slightly different voltages only the lowest voltage LED will light and it may be destroyed by the larger current flowing through it. Although identical LEDs can be successfully connected in parallel with one resistor this rarely offers any useful benefit because resistors are very cheap and the current used is the same as connecting the LEDs individually.

Advantages of LED:

1. Less complex circuitry
2. Can be fabricated less expensively with high yield

Desired characteristics:

1. Hard radiation
2. Fast emission response time
3. High quantum efficiency

Basic LED configuration:

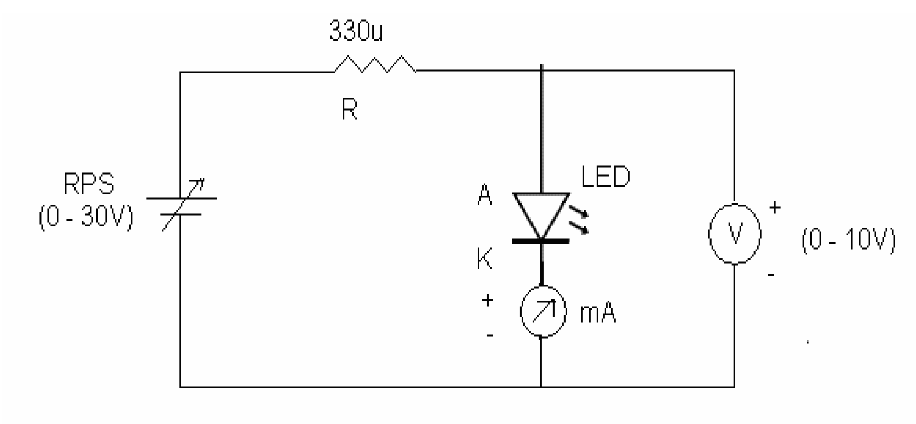
1. Surface emitter
2. Edge emitter

Pre Lab questions :

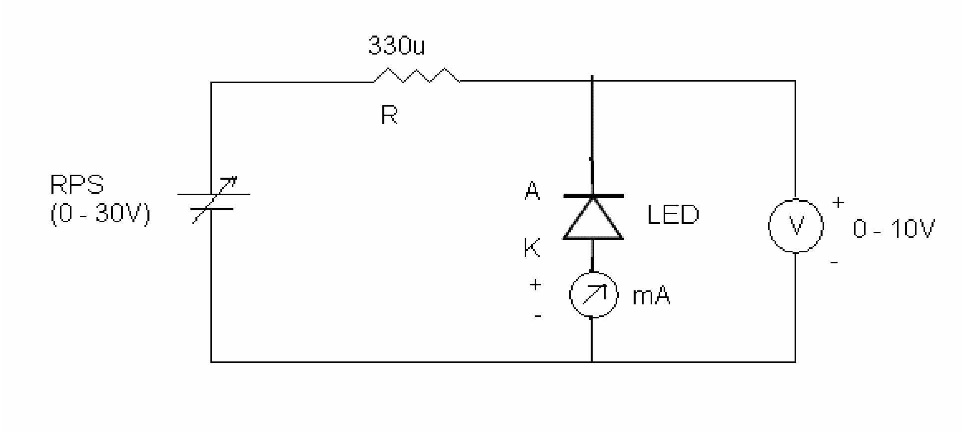
1. What are light sources?
2. What is a LED?
3. Differentiate LED from normal PN junction diode?
4. Define wavelength.
5. What are light materials?
6. What happens when LEDs connected in series and parallel?
7. What are the advantages of LED over laser diode?
8. What are the desired characteristics of LED?
9. What are the configurations of LED.

Circuit diagram:

Forward bias:



Reverse bias:



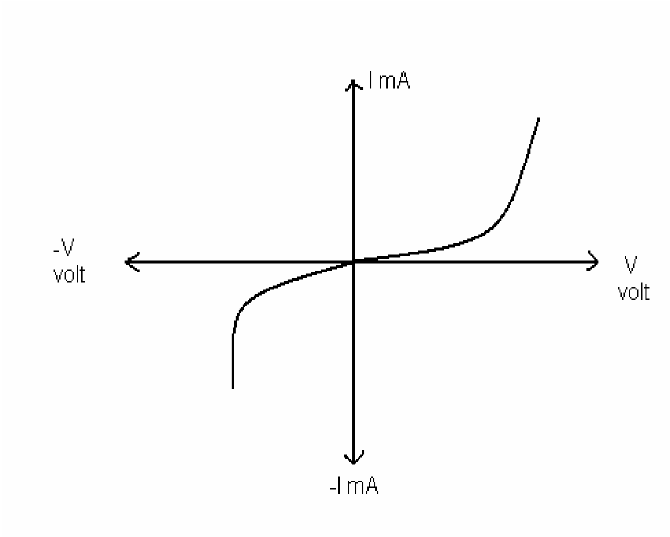
Experimental procedure:

1. Give the connection as per the circuit diagram.
2. Vary the input voltages at the RPS and note down the corresponding current for the voltages.
3. Repeat the procedure for reverse bias condition and tabulate the corresponding voltages and currents.
4. Plot the graph between voltage and current for forward bias and reverse bias.

Tabular column:

S. No	Voltages V	Currents mA
1.		
2.		
3.		
4.		
5.		

Model Graph:



Result:

Thus the VI characteristics of LED were studied.

Post Lab questions:

1. Explain the operation of LED under forward bias and reverse bias condition?
2. Why light is not emitted under reverse bias condition?
3. What is meant by recombination rate?
4. Give the applications of LED.

Conclusion

Particulars	Max. Marks	Marks Obtained
Prelab	20	
Lab Check of and verification	40	
Report & post lab	40	
Total	100	

10. CHARACTERISTICS OF THERMISTOR

Objective:

- To determine the physical characteristics of the given thermistor.
- Calculate the resistance of the thermistor and the temperature coefficient using the given formula for different temperatures

Hardware Required:

S. No	Apparatus	Quantity	Type
1.	Thermistor	1	
2.	Thermometer	1	
3.	Multimeter	1	Digital
4.	Heater	1	
5.	Connecting wires		

Introduction:

A **thermistor** is a type of resistor whose resistance varies with temperature.. The word **thermistor** is a combination of words"thermal" and "resistor". A thermistor is a temperature-sensing element composed of sintered semiconductor material which exhibits a large change in resistance proportional to a small change in temperature.Thermistors are widely used as inrush current limiters, temperature sensors, self-resetting over current protectors, and self-regulating heating elements.

Assuming, as a first-order approximation, that the relationship between resistance and temperature is linear, then:

$$\Delta R = k\Delta T$$

Where ΔR = change in resistance.

ΔT = change in temperature.

k = first-order temperature coefficient of resistance

Thermistors can be classified into two types depending on the sign of k. If k is positive, the resistance increases with increasing temperature, and the device is called a positive temperature coefficient (**PTC**) thermistor, or **posistor**. If k is negative, the resistance decreases with increasing temperature, and the device is called a negative temperature coefficient (**NTC**) thermistor. Resistors that are not thermistors are designed to have a *k* as close to zero as possible, so that their resistance remains nearly constant over a wide temperature range.PTC thermistors can be used as heating elements in small temperature controlled ovens. NTC thermistors are used as resistance thermometers in lowtemperature measurements of the order of 10 *K*. NTC thermistors can be used also as inrush-current limiting devices in power supply circuits. They present a higher resistance initially which prevents large currents from flowing at turn-on, and then heat up and become much lower resistance to allow higher current flow during normal operation. These thermistors are usually much larger than measuring type thermistors, and are purpose designed for this application. Thermistors are also commonly used in modern digital thermostats and to monitor the temperature of battery packs while charging.

They are most commonly made from the oxides of metals such as manganese, cobalt, nickel and copper. The metals are oxidized through a chemical reaction, ground to a fine powder, then compressed and subject to very high heat. Some NTC thermistors are crystallized from semiconducting material such as silicon and germanium.

Thermistors differ from resistance temperature detectors (RTD) in that the material used in a thermistor is generally a ceramic or polymer, while RTDs use pure metals. The temperature response is also different; RTDs are useful over larger temperature ranges, while thermistors typically achieve a higher precision within a limited temperature range [usually -90C to 130C].

Applications:

- NTC thermistors are used as resistance thermometers in low-temperature measurements of the order of 10 K.
- NTC thermistors can be used as inrush-current limiting devices in power supply circuits. They present a higher resistance initially which prevents large currents from flowing at turn-on, and then heat up and become much lower resistance to allow higher current flow during normal operation. These thermistors are usually

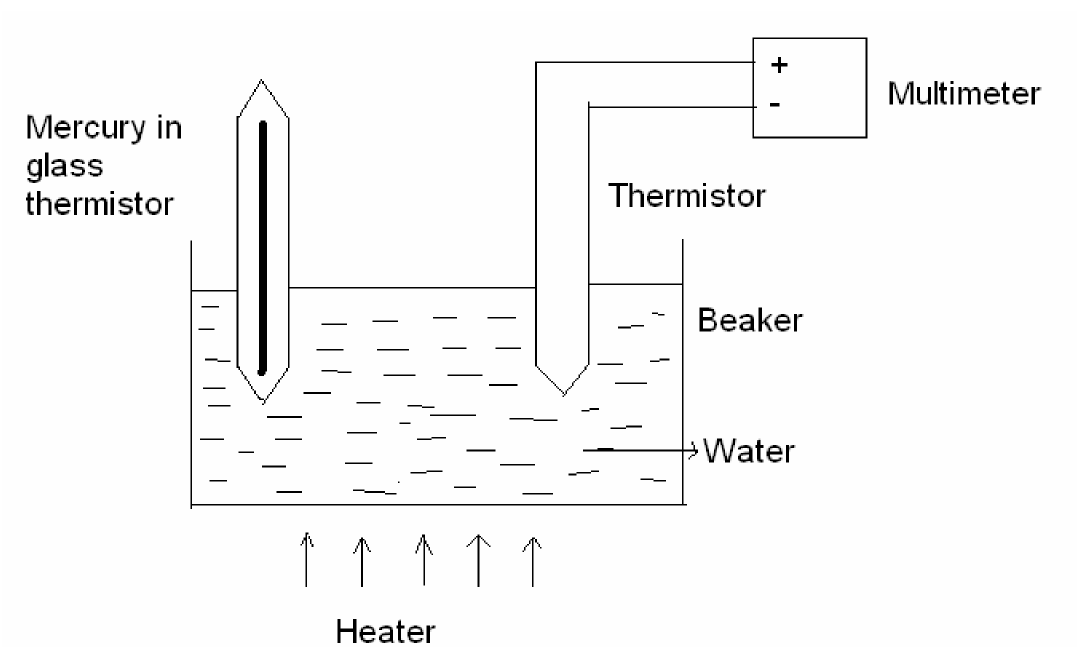
much larger than measuring type thermistors, and are purposely designed for this application.

- NTC thermistors are regularly used in automotive applications. For example, they monitor things like coolant temperature and/or oil temperature inside the engine and provide data to the ECU and, indirectly, to the dashboard.
- Thermistors are also commonly used in modern digital thermostats and to monitor the temperature of battery packs while charging.

Pre Lab questions:

1. What is meant by temperature sensor?
2. What are the types of temperature sensors?
3. What is meant by positive and negative temperature co- efficient of resistance?
4. Give the differences between active and passive transducers?
5. What is a thermistor?
6. How the thermistor is made up of?

Experimental Set up:



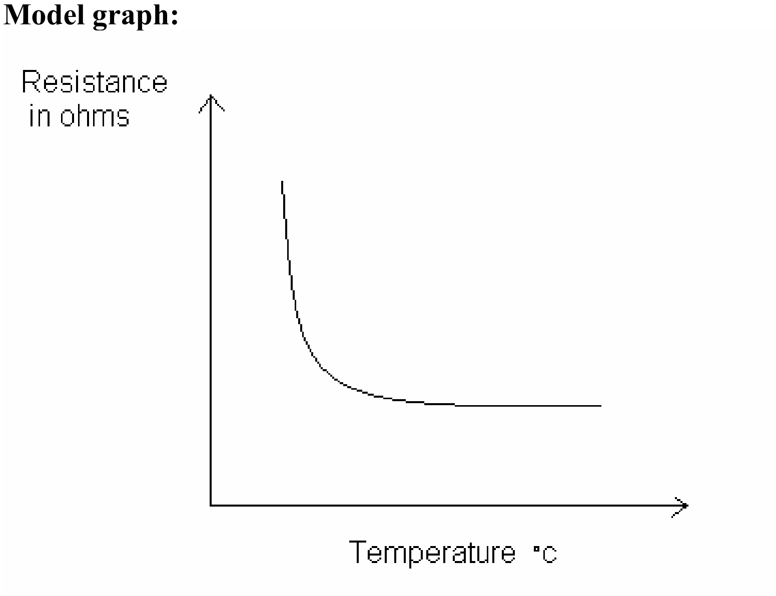
Experimental procedure:

1. The apparatus are placed as it is given in the experimental set up.
2. The thermistor is placed in a vessel containing water and using heater rise the temperature of the water.
3. Find the resistance of the given thermistor at room temperature using multimeter.
4. Repeat the experiment for different temperatures and calculate the temperature co-efficient for various temperatures.
5. A graph was plotted between temperature °C and resistance in ohms of the thermistor.

Tabular column:

S.No	Temperature °C	Resistance in ohms
1.		
2.		
3.		
4.		
5.		

Model graph:



Result:

Thus the given thermistor characteristics were measured and verified.

Post Lab Questions:

1. What are the applications of thermistors?
2. Compare thermistor with RTD and thermocouple.
3. Thermistor is a passive transducer? Justify.

Conclusion

Particulars	Max. Marks	Marks Obtained
Prelab	20	
Lab Check of and verification	40	
Report & post lab	40	
Total	100	

CONTENTS

EC0221 Laboratory Policies and Report Format

Reports are due at the beginning of the lab period. The reports are intended to be a complete documentation of the work done in preparation for and during the lab. The report should be complete so that someone else familiar with concepts of electron devices could use it to verify your work. The prelab and postlab report format is as follows:

1. A neat thorough prelab must be presented to your Staff Incharge at the beginning of your scheduled lab period. **Lab reports should be submitted on A4 paper.** Your report is a professional presentation of your work in the lab. Neatness, organization, and completeness will be rewarded. Points will be deducted for any part that is not clear.

2. In this laboratory students will work in teams of three. However, the lab reports will be written individually. Please use the following format for your lab reports.
    a. **Cover Page:** Include your name, Subject Code, Section No., Experiment No. and Date.
    b. **Objectives:** Enumerate 3 or 4 of the topics that you think the lab will teach you. DO NOT REPEAT the wording in the lab manual procedures. There should be one or two sentences per objective. Remember, you should write about what you will learn, not what you will do.
    c. **Design:** This part contains all the steps required to arrive at your final circuit. This should include circuit diagrams, tabular columns,formulae,graph etc. Be sure to reproduce any tables you completed for the lab. **This section should also include a clear written description of your design process.** Simply including a circuit schematic is not sufficient.
    d. Questions: Specific questions(Prelab and Postlab) asked in the lab should be answered here. **Retype the questions presented in the lab and then formally answer them.**

3. Your work must be original and prepared independently. However, if you need any guidance or have any questions or problems, please do not hesitate to approach your staff incharge during office hours. Copying any prelab/postlab will

result in a grade of 0. The incident will be formally reported to the University and the students should follow the dress code in the Lab session.

4. Each laboratory exercise (circuit) must be completed and demonstrated to your Staff Incharge in order to receive working circuit credit. This is the procedure to follow:
   a. Circuit works: If the circuit works during the lab period (3 hours), call your staff incharge, and he/she will sign and date it.. This is the end of this lab, and you will get a complete grade for this portion of the lab.
   b. Circuit does not work: If the circuit does not work, you must make use of the open times for the lab room to complete your circuit. When your circuit is ready, contact your staff incharge to set up a time when the two of you can meet to check your circuit.

5. Attendance at your regularly scheduled lab period is required. An unexpected absence will result in loss of credit for your lab. If for valid reason a student misses a lab, or makes a reasonable request in advance of the class meeting, it is permissible for the student to do the lab in a different section later in the week if approved by the staff incharge of both the sections. Habitually late students (i.e., students late more than 15 minutes more than once) will receive 10 point reductions in their grades for each occurrence following the first.

6. Final grade in this course will be based on laboratory assignments. All labs have an equal weight in the final grade. Grading will be based on pre-lab work, laboratory reports, post-lab and in-lab performance (i.e., completing lab, answering laboratory related questions, etc.,).The Staff Incharge will ask pertinent questions to individual members of a team at random.

7. Labs will be graded as per the following grading policy:

Pre-Lab Work	20.00%
In-Lab Performance	40.00%
Post Lab Work	20.00%
Laboratory Report	20.00%

Each student will receive up to 10 points for each lab session. Each lab will equally contribute to the final grade.

8. **Reports Due Dates**: Reports are due one week after completion of the corresponding lab. A late lab report will have 20% of the points deducted for being one day late. If a report is 2 days late, a grade of 0 will be assigned.

9. Systems of Tests: Regular laboratory class work over the full semester will carry a weightage of 75%. The remaining 25% weightage will be given by conducting an end semester practical examination for every individual student if possible or by conducting a 1 to 1 ½ hours duration common written test for all students, based on all the experiment carried out in the semester.

10. General Procedure:
    a. **Properly** place the all the components of the circuit in the Bread board, and give the Power supply connections as given .
    b. Test all the components before giving connection to the circuit.
    c. Check the connections before switch on the power supply.
    d. Any modification in the circuit connection should be done only after switching off the power supply .