EC1009 ELECTRON DEVICES LAB

LABORATORY MANUAL

SEMESTER III

DEAPRTMENT OF

ELECTRONICS AND COMMUNICATION ENGINEERING

SRM UNIVERISTY

(Under SECTION 3 of the UGC Act, 1956)

S.R.M. NAGAR, KATTANKULATHUR – 603203. KANCHEEPURAM DISTRICT

DEPARTMENT OF

ELECTRONICS AND COMMUNICATION

ENGINEERING

EC1009 Electron Devices Lab

Laboratory Manual

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JUNE 2015

Course Number and Title
EC1009 ELECTRON DEVICES LAB
Credits / Contact Hours
2 / 45
Instructor Name
Mrs.S.Latha
Textbooks, References
• LAB MANUAL", Department of ECE, SRM University • Paul B Zbar and Alber P Malvino, Michael A Miller, "Basic Electronics: A Text Lab Manual", 7th edition, Tata McGraw Hill, 2009. • David A Bell, "Laboratory Manual for Electronic Devices and Circuits", 4th edition, PHI, 2001. • Muhammed H Rashid, "SPICE for circuits and electronics using PSPICE", 2nd edition, PHI, 1995. • Mithal. G.K, "Practicals in Basic Electronics", G K Publishers Private Limited, 1997. • Maheswari. L.K and Anand.M.M.S, "Laboratory Manual for Introductory Electronic Experiments", New Age, 2010. • PoornachandraRao.S and Sasikala.B, "Handbook of Experiments in Electronics and Communication Engineering", Vikas publishers, 2003
Purpose
To reinforce learning in the accompanying EC1004 course through hands-on experience by examining the electrical characteristics of various semiconductor devices, such as diodes, BJTs and FETs. To provide the student with the capability to use simulation tools for performing various analysis of semiconductor devices.

Prerequisites	Co-requisites
EC1004	EC1006

Required, Elective or Selected Elective (as per Table 5.1a)
Required

Instructional Objectives
1. To study experimentally the characteristics of diodes, BJT's and FET's. 2. To verify practically the response of various special purpose electron devices. 3. To construct and simulate various semiconductor devices using tools such as PSPICE/multisim..

Student Outcomes from Criterion 3 covered by this Course

	a	b	c	d	e	f	g	h	i	j	k
Student outcome		X	X	X		X					X
Mapping of instructional objectives with student outcome		1-3	1-3	1-3		1-3					3

List of Topics Covered
LIST OF RECOMMENDED EXPERIMENTS 1. Characteristics of PN junction and Zener diode. 2. Input, Output and Transfer characteristics of CE and CC Amplifier. 3. Characteristics of LDR, Photo-diode and Photo transistor. 4. Transfer characteristics of JFET. 5. Transfer characteristics of MOSFET (with depletion and enhancement mode) 6. Characteristics of LED with three different wavelengths. 7. Half wave rectifier. 8. Full wave rectifier with 2 diodes. 9. Full wave rectifier with 4 diodes (Bridge rectifier). 10. Series voltage Regulator. 11. Shunt voltage Regulator. 12. Characteristics of Thermistor. 13. Simulation experiments using PSPICE or Multisim.

S.R.M University

Faculty of Engineering and Technology

Department of Electronics and Communication Engineering

Sub Code : EC1009 Year/Semester: II / III

Sub Title : Electron Devices Lab Course Time: Jul–Dec'15

Pre-requisites: EC1004 - Electric Circuits Lab

Co-requisites: EC1006 - Electron Devices

Student Outcome

(b) an ability to design and conduct experiments, as well as to analyze and interpret data

Experiment 1 & 2: To verify the VI Characteristics of PN junction diode and Zener diode

Experiment 3: To analyze the Input and Output characteristics and to measure the h-parameter ofCommon Emitter Configuration.

Experiment 4: To analyze the drain and transfer characteristics of a JFET.

(c) an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability

Experiment 5 : To verify the distance versus photocurrent characteristics of LDR, Photodiode andPhototransistor

Experiment 6, 7 & 8: To verify the working of a Half wave rectifier, Full wave rectifier and fullwave bridge rectifier and to measure the ripple factor.

Experiment 9 & 10: To design Series and Shunt Voltage regulator **Experiment 11:** To verify the VI Characteristics of LED **Experiment 12:** To verify the physical characteristics of Thermistor.

(d) an ability to function on multidisciplinary teams

Experiment 6, 7 & 8: To verify the working of a Half wave rectifier, Full wave rectifier and fullwave bridge rectifier and to measure the ripple factor.

Experiment 9 & 10: To design Series and Shunt Voltage regulator

(f) an understanding of professional and ethical responsibility Experiment 9 &

10: To design Series and Shunt Voltage regulator

(k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

Experiment 12: To analyze the input and output characteristics of a transistor in Common CollectorConfiguration using Pspice Capture Lite Software.

Experiment 13: To analyze the drain characteristics and transfer characteristics of MOSFET usingPspice Capture Lite Software.

S.R.M University

Faculty of Engineering and Technology

Department of Electronics and Communication Engineering

Sub Code : EC1009   Year/Semester: II / III

Sub Title : Electron Devices Lab   Course Time: Jul–Dec'15

Pre-requisites: EC1004 - Electric Circuits Lab

Co-requisites: EC1006 - Electron Devices

Program Education Objective versus Student Outcome

Program Educational Objective → / Student Outcomes ↓	PEO1: Graduates will perform as a successful Professional engineer in related fields of Electronics and Communication Engineering.	PEO2: Graduates will pursue higher education and/or engage themselves in continuous professional development to meet global standards.	PEO3: Graduates will work as a team in diverse fields and gradually move into leadership positions.	PEO4: Graduates will understand current professional issues, apply latest technologies and come out with innovative solutions for the betterment of the nation and society.
B	√	√		
C	√			√
D	√		√	√
F	√	√	√	√
K	√	√		√

S.R.M University

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Department of Electronics and Communication Engineering

Sub Code : EC1009   Year/Semester: II / III

Sub Title : Electron Devices Lab   Course Time: Jul–Dec'15

Pre-requisites: EC1004 - Electric Circuits Lab

Co-requisites: EC1006 - Electron Devices

Instructional Objective versus Student Outcome

S.No	Instructional Objective	Student Outcome	Experiment Details
1.	To study experimentally the characteristics of diodes, BJT's and FET's.	(b) an ability to design and conduct experiments, as well as to analyze and interpret data (c) an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability.	**Experiment 1 & 2:** To verify the VI Characteristics of PN junction diode and Zener diode **Experiment 3:** To analyze the Input and Output characteristics and to measure the h-parameter of Common Emitter Configuration. **Experiment 4:** To analyze the drain and transfer characteristics of a JFET **Experiment 5 :** To verify the distance versus photocurrent characteristics of LDR, Photodiode and Phototransistor **Experiment 6, 7 & 8:** To verify the working of a Half wave rectifier, Full wave rectifier and full wave bridge rectifier and to measure the ripple factor. **Experiment 9 & 10:** To design Series and Shunt Voltage regulator **Experiment 11:** To verify the VICharacteristics of LED
2.	To verify practically the response of various special purpose electron devices.	(c)an ability to design a system,component, or process to meet desired needs within realistic constraints such	**Experiment 8:**To verify the working of a Full wave bridge rectifier and to measure the ripple factor.

		aseconomic, environmental,social, political, ethical, health and safety, manufacturability, and sustainability	**Experiment 9 & 10:** To design Series and Shunt Voltage regulator
			Experiment 14: To verify the physical characteristics of Thermistor.
		(d) an ability to function on multidisciplinary teams	
		(f) an understanding of professional and ethical responsibility	
3.	To construct and simulate	(k) an ability to use the techniques, skills, and modern engineering tools	**Experiment 12:** analyze the input various semiconductor and output characteristics of a transistor devices using tools such necessary for engineering practice in Common Collector Configuration as PSPICE/multisim.usingPspice Capture Lite Software.
			Experiment 13: To analyze the drain characteristics and transfer characteristics of MOSFETusing Pspice Capture Lite Software.

S.R.M University

Faculty of Engineering and Technology

Department of Electronics and Communication Engineering

Sub Code : EC1009   Year/Semester: II / III

Sub Title : Electron Devices Lab   Course Time: Jul–Dec'15

Pre-requisites: EC1004 - Electric Circuits Lab

Co-requisites: EC1006 - Electron Devices

Experiment Details

S.No	Experiment Details	Equipment Required	Components Required
1	P-N Junction Diode Characteristics	1.Ammeter: (0-30mA), (0-500μA) 2. Voltmeter : (0-1V) (0-30V) 3.Regulated Power Supply:(0-30V)	PN Junction diode(IN4001), Resistor (1KΩ)
2	Zener Diode Characteristics	1.Ammeter: (0-30mA), (0-500μA) 2. Voltmeter : (0-1V) (0-30V) 3.Regulated Power Supply:(0-30V)	Zener diode(IZ6.2) , Resistor (1KΩ)
3	Common Emitter Configurations	1.Ammeter: (0-30mA), (0-500μA) 2. Voltmeter : (0-1V) (0-30V) 3.Regulated Power Supply:(0-30V)	BJT(BC147), Resistor(1KΩ)
4	JFET Characteristics	1.Ammeter: (0-30mA), (0-500mA) 2. Voltmeter : (0-1V) (0-30V) 3.Regulated Power Supply:(0-30V)	FET(BFW11) , Resistor(1 KΩ)
5	Characteristics of LDR, Photodiode, Phototransistor	1.Ammeter: (0-30mA), (0-500mA) 2. Voltmeter : (0-1V) (0-30V) 3.Regulated Power Supply:(0-30V)	Photodiode, Phototransistor and LDR

6	Half Wave Rectifier	CRO	Diode(IN4001) , Resistor 470Ω, Capacitance 470 µF, Transformar(6-0-6)
7	Full Wave Rectifier	CRO	Diode(IN4001) , Resistor 470Ω, Capacitance 470 µF, Transformar(6-0-6)
8	Full Wave Bridge Rectifier	CRO	Diode(IN4001) , Resistor 470Ω, Capacitance 470 µF, Transformar(6-0-6)
9	Series Voltage Regulator	Multimeter	Power transistor(2N3055), Zener diode(IZ6.2), BJT(BC107) , Resistor(947 Ω, 2.48 K Ω, 2.2 K Ω, 2.75K Ω, 49.6 Ω)
10	Shunt Voltage Regulator	1.Regulated Power Supply:(0-30V) 2.Multimeter	Zener diode(IZ5.1) , Resistor(31.66 Ω, 10K Ω)
11	V-I Characteristics Of LED	1.Ammeter: (0-100mA) 2.Voltmeter : (0-30V) 3.Regulated Power Supply:(0-30V)	LED, Resistor (330 Ω)
12	Common Collector Configuration Using Pspice	System with Pspice Capture Lite Software.	BJT(BC147), Resistor(1KΩ , 68 KΩ)
13	Characteristics MOSFET Using Pspice	System with Pspice Capture Lite Software	IRF150
14	Characteristics of Thermistor	Mulimeter	Thermistor, Thermometer

EC1009 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 digital design could use it to verify your work. The pre-lab and post-lab report format is as follows:

1.   A neat thorough pre-lab must be presented to your course teacher In-charge 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, timeliness, 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. andDate.

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. Thisshould include diagrams, tables, equations, theoretical calculation etc. Be sure to reproduce any tables you completed for the lab. **This section should also include aclear written description of your design process.** Simply including a circuitschematic is not sufficient.

d.   **Questions:** Specific questions(Pre-lab and Post-lab) asked in the lab should beanswered in the observation notebook. **Retype the questions presented in the laband 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 course teacher in-charge during office hours. The students should follow the dress code in the Lab session.

4.   Each laboratory exercise (circuit) must be completed and demonstrated to your course teacher In-charge 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 course teacher in-charge 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 in-charge 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 course teacher in-charge 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.

7. **Reports Due Dates**: Reports are due one week after completion of the corresponding lab.

8. **Systems of Tests:** Regular laboratory class work over the full semester will carry aweightage of 60%. The remaining 40% weightage will be given by conducting an end semester practical examination for every individual student if possible or by conducting a 2 hours duration common written test for all students, based on all the experiment carried out in the semester.

9. General Procedure

a.   Properly place the components in the general purpose breadboard and identify the positive and negative terminals of the power supply, before making connection.

b.   Keep the required supply voltage in Power supply and connect power supply voltage and ground terminals to the respective node points in the breadboard.

c.   Connect the components as per the circuit diagram, after verifying connection switch on the supply and note down the required parameter values

d.   After completion of the experiments, switch off the power supply and return the components.

SRM University

Department of Electronics and Communication Engineering

EC1009 - Electron Devices Lab

Laboratory Report Cover sheet

ODD Semester – 2015

Name   :

Register Number   :

Semester / Section   :

Batch   :

Venue   :

Title of the Experiment   :

Date of Performance   :

Date of Submission   :

Particulars	Max. Marks	Marks Obtained
Pre Lab	05	
Lab Performance	10	
Post Lab	5	
Lab Report	05	
Total	25	

Report Verification

Staff Name   :

Staff Signature   :

Contents

EXP 1 P-N JUNCTION DIODE CHARACTERISTICS

1.1 Objective:

To study the Volt-Ampere Characteristics of Silicon P-N Junction Diode and to find cut-in voltage, static and dynamic resistances.

1.2 Hardware Required:

S. No	Apparatus	Type	Range	Quantity
01	PN Junction Diode	1N4001		1
02	Resistance		1k ohm, 10% tolerance, 1/2 watt rating	1
03	Regulated power supply		(0 – 30V), 2A Rating	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			

1.3 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 Vγ 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:

$I = I_o(\exp(V/\eta V_T)-1)$ 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)

Germanium diode has smaller cut-in-voltage than Silicon diode. The reverse saturation current in Ge diode is larger in magnitude when compared to silicon diode.

1.4 Circuit diagram: 1.4.1 Forward Bias
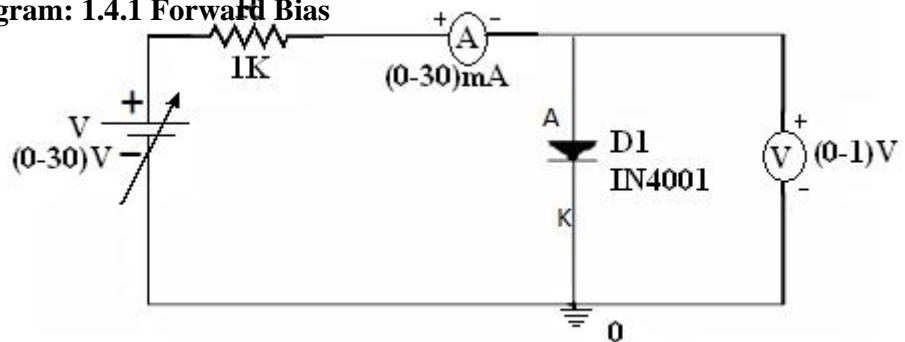
1.4.2 Reverse Bias
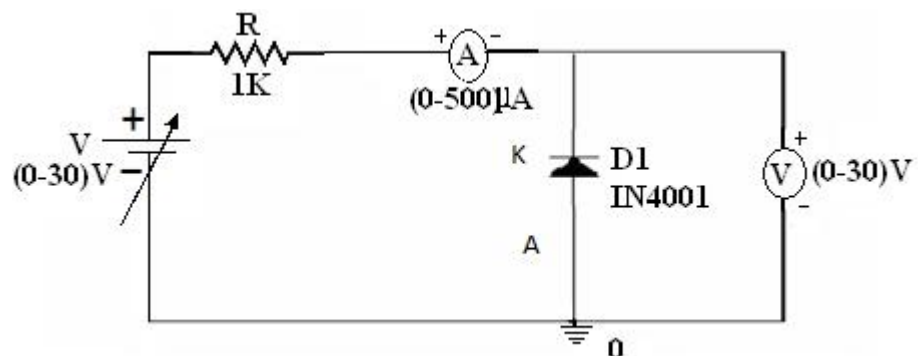
1.5 Precautions:

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.

1.6 Characteristics of PN junction diode:

1. Breakdown voltage can be traded with switching speed. A reduction in recombination lifetime through addition of suitable impurities will increase leakage current. This can be countered by decreasing diode area which however will lead to reduced forward current rating unless doping is increased. This will lead to a reduced breakdown voltage.

2. The breakdown voltage and reverse recovery are also related together in more direct manner. Regions which have higher doping also have a lower recombination lifetime so that a lower breakdown voltage diode is likely to have lower lifetime and better switching speeds. So a **single diode** cannot meet the diverse applications.

1.7 Procedure:

1.7.1Forward 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).

1.7.2Reverse biased condition:

4. 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.

5. For various values of (V_r) note down the corresponding values of reverse current (Ir).

1.8 Tabular column:

1.8.1 Forward Bias:

S. No	V_f (volts)	I_f (mA)

1.8.2 Reverse Bias:

S. No	Vr (volts)	Ir (µA)

1.9 Model Graph:
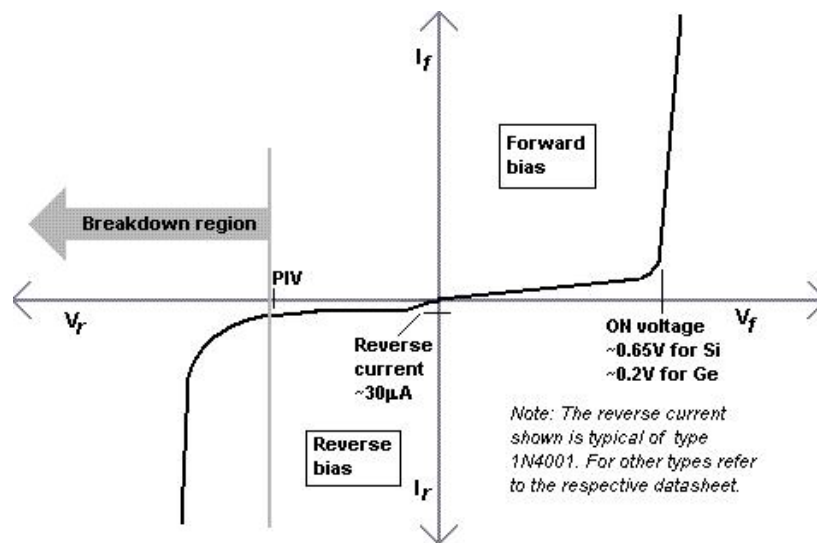
1.10 Result:

Thus the VI characteristic of PN junction diode was verified.

i.   Cut in voltage   = ……… V

ii. Static forward Resistance R_{dc} = (V_f/I_f) Ω

iii. Dynamic forward Resistance r_{ac} = $(\Delta V_f/\Delta I_f)$ Ω

iv. Static Reverse Resistance R_{dc} = (V_r/I_r) Ω

v.   Dynamic Reverse Resistance r_{ac} = $(\Delta V_r/\Delta I_r)$ Ω

1.11 Prelab Questions:

1.   What is the need for doping?

2.   How depletion region is formed in the PN junction?

3.   What is break down voltage?

4.   What is cut-in or knee voltage? Specify its value in case of Ge or Si?

5.   What are the differences between Ge and Si diode?

6.   What is the relationship between depletion width and the concentration of impurities?

1.12 Post lab Questions:

1. Generate input and output characteristics in PN Junction diode using PSPICE and compare with the obtained output.

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

3. Comment on diode operation under zero biasing condition.

4. For a uniformly doped silicon PN junction diode with an N-type doping of 10^{16} cm^{-3} and a P-type doping of 2 x 10^{16} cm^{-3}, Sketch the potential within the space charge region at equilibrium. What fraction of the built-in voltage is dropped in the N-region? Where will most of the built-in voltage be dropped if the P type doping is much larger than the N-type doping?

5. The depletion capacitance/Area measured for a symmetrical Silicon PN junction at different bias voltages is given below:

Bias	Capacitance (F/cm²)
0.25	3x10^{-8}
0.0	2.44x10^{-8}
-0.5	1.86x10^{-8}
-0.7	1.72x10^{-8}

    (a)   Determine   the   doping   of   N   and   P-regions
    (b)   Determine   the   built-in   voltage
    (c) Determine the depletion width at zero bias

6. Design circuits to get the following outputs.

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D is not in conduction

D is conducting and capacitor changes to 5 V
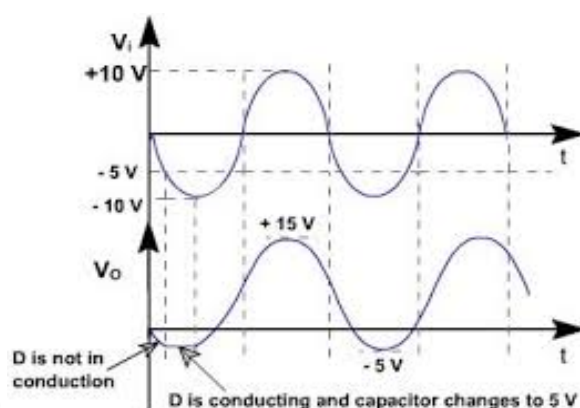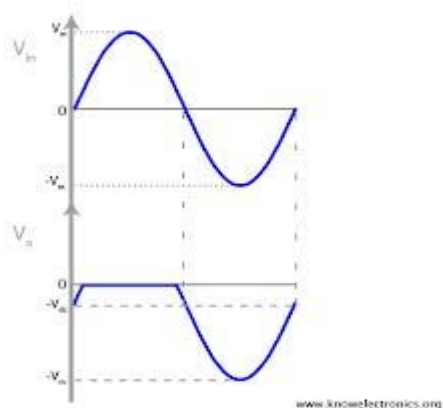
EXP 2: ZENER DIODE CHARACTERISTICS

2.1 Objective:

To study the Volt-Ampere characteristics of Zener diode and to measure the Zener break down voltage.

2.2 Hardware Required:

S. No	Apparatus	Type	Range	Quantity
01	Zener Diode	IZ 6.2		1
02	Resistance		1k ohm, 10% tolerance, 1/2 watt rating	1
03	Regulated power supply		(0 – 30V), 2A rating	1
04	Ammeter	mC	(0-30)mA	1
05	Voltmeter	mC	(0 – 1)V, (0 – 10)V	1
06	Bread board and connecting wires			

2.3 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 breakdown** or **Zener breakdown**.

Avalanche breakdown:-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 breakdown:-If both p-side and n-side of the diode are heavily doped, depletion region at thejunction 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**.

2.4 Circuit diagram: 2.4.1 Forward Bias
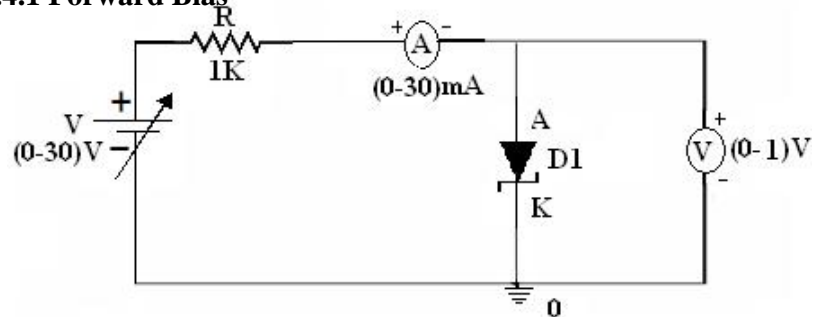
2.4.2 Reverse Bias
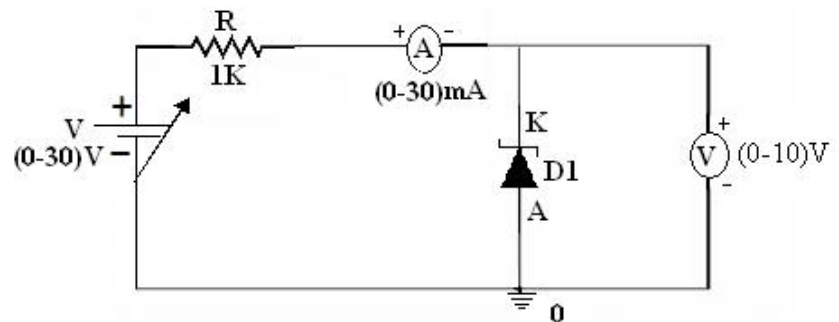
2.4.3 Zener Diode Symbol:
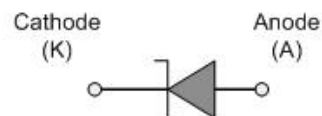
2.5 Precautions:

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.

2.6 Characteristics of Zener Diode:

For IZ6.2 Zener diode,

Forward Bias:

At a given (constant) diode current, V exhibits an approximately linear shift in the VI -characteristic due to the combined effect of the temperature dependences of both I_S and V_T

Typically, the VI -characteristic shifts approximately -2 mV/°C.

Reverse Bias:

The temperature dependence of the reverse current is that of IS alone, which changes exponentially as a function of temperature. Typically, I_S approx. doubles for every 10 °C increase in Temperature. These variations may lead to significant changes in the operation of a circuit over a large temperature range and, in many applications, requires compensation strategies to be implemented in the design of some circuits.

2.7 Procedure:

2.7.1 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).

2.7.2 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 (V_r) note down the corresponding values of reverse current (I_r).

2.8 Tabular column: 2.8.1 Forward Bias:

S. No	V_f (volts)	I_f (mA)

2.8.2 Reverse Bias:

S. No	V_r (volts)	I_r (mA)

2.9 Model Graph:
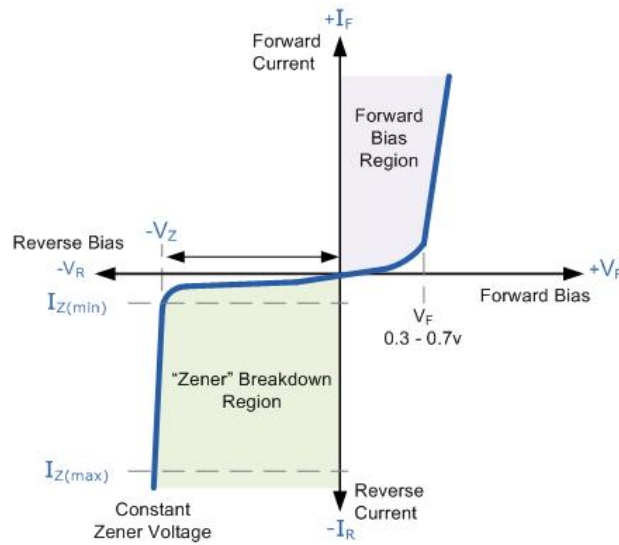
2.10 Result:

The Zener diode characteristics have been verified and the following parameters were calculated

i)   Cut in voltage   = ……… V
ii)   Break down voltage =………. V

2.11 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.
5. What type of biasing must be used when a Zener diode is used as a regulator?

2.12 Post lab Questions:

1. Generate input and output characteristics in Zener diode using PSPICE and compare with the obtained output .
2. Design a DC power supply network using Zener diode.

3.   What happens when the Zener diodes are connected in series ?
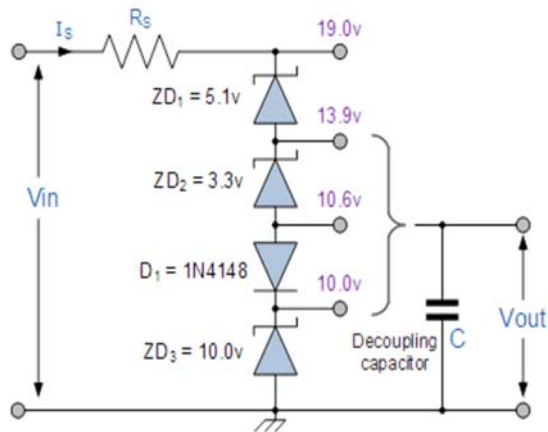
4.   Justify the use of zener diode in a stabilization circuit?

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.   How does a zener diode protect meters from excess voltage that is applied accidentally?

EXP 3: COMMON EMITTER CONFIGURATIONS

3.1 Objective:

To study the input and output characteristics of a bipolar junction transistor in Common Emitter configuration and to measure h-parameters

3.2 Hardware Required:

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

3.3 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.

3.4 Pin Assignment:
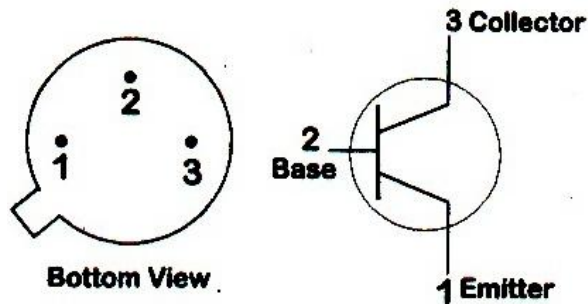
3.5 Circuit Diagram:
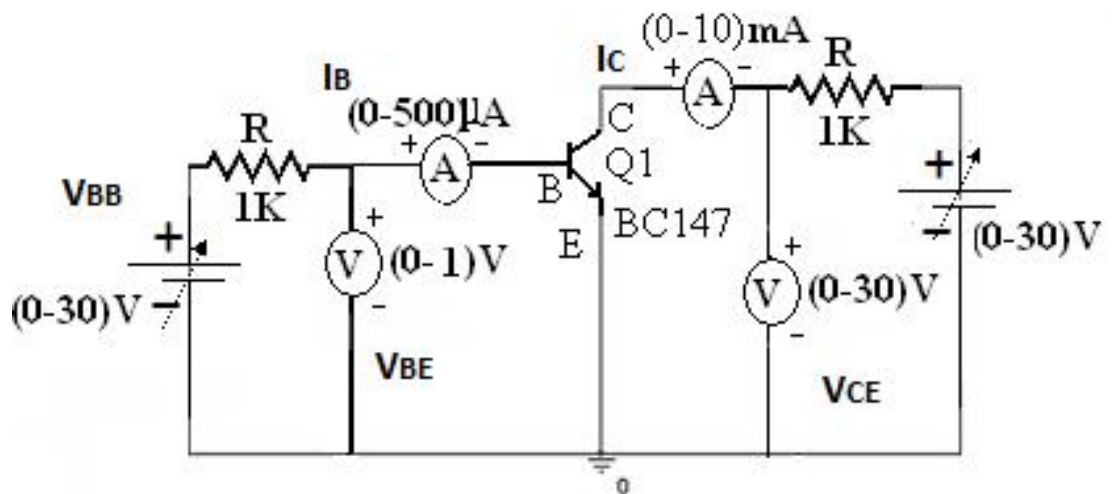
3.6 Precautions:

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.

3.7 Procedure:

3.7.1 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}

3.7.2 Output Characteristics

1. Make the connections as per circuit diagram.

2. By varying V_{BB} keep the base current $I_B = 20\mu A$.

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

3.8 Tabular Column:

3.8.1 Input Characteristics:

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

3.8.2 Output Characteristics:

$I_B = 30\ \mu A$		$I_B = 60\ \mu A$	
V_{CE} (volts)	Ic (mA)	V_{CE} (volts)	Ic (mA)

3.9 Model Graph:
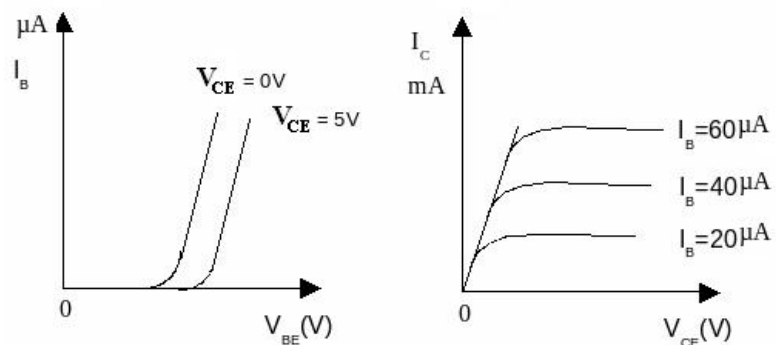
Input characteristics   **Output characteristics**

3.10 Result

Thus the input and output characteristics of BJT in CE configuration was verified and the graph was plotted.

a)   Impedance (h_{ie}) = ΔV_{BE} / ΔI_B, V_{CE} constant.   =

b)   Output admittance (h_{oe})= ΔIc / ΔV_{EC} , I_B constant=

3.11 Prelab Questions

1. Why is base width small?
2. Why is Silicon transistor more commonly used compared to Germanium transistor?
3. What is base width modulation?
4. The junction capacitance across collector to base junction is much lower than that across base to emitter junction. Why?
5. What is the difference between diffusion capacitance and transition capacitance?
6. What is the voltage across the collector to emitter terminal when the transistor is in (i) saturation (ii) cut-off (iii) active region?

3.12 Post lab Questions

1. Design a circuit to sketch the input and output characteristics of common emitter configuration using PSPICE and compare the output with the obtained result .
2. From the above observation find forward current gain and reverse voltage gain.
3. Explain the switching action of a transistor?
4. At what region of the output characteristics, a transistor can act as an amplifier?
5. Design an NPN common emitter transistor to work as a current source. It is in which region of the transistor?
6. Based on which parameters do we choose a transistor for a particular application?

EXP 4 : JFET CHARACTERISTICS

4.1 Objective:

To study drain and transfer characteristics of a FET and measure the parameters

4.2 Hardware Required:

S. No	Apparatus	Type	Range	Quantiy
01	JFET	BFW10		1
02	Resistance		1k ohm, 10% tolerance, ½ watt rating	1
03	Regulated power supply		(0 – 30V), 2A Rating	1
04	Ammeter	MC	(0-30)mA	1
05	Voltmeter	MC	(0 – 30)V	2
06	Bread board and connecting wires			

4.3 Introduction:

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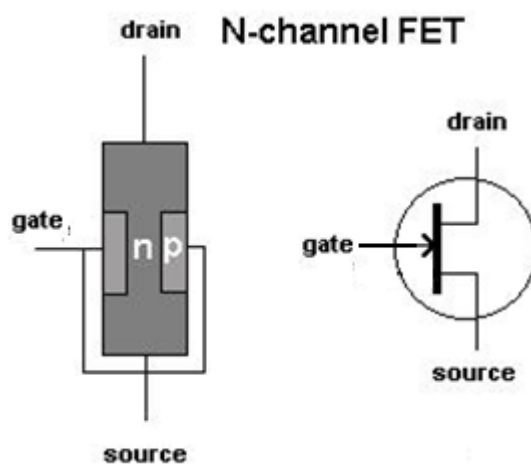
If the gate voltage is high enough the channel will be "pinched off" and the current will be zero. The FET is voltage controlled, unlike the transistor which is current controlled. This device is sometimes called the junction FET or IGFET or JFET.

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

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.

4.4 Circuit diagram:
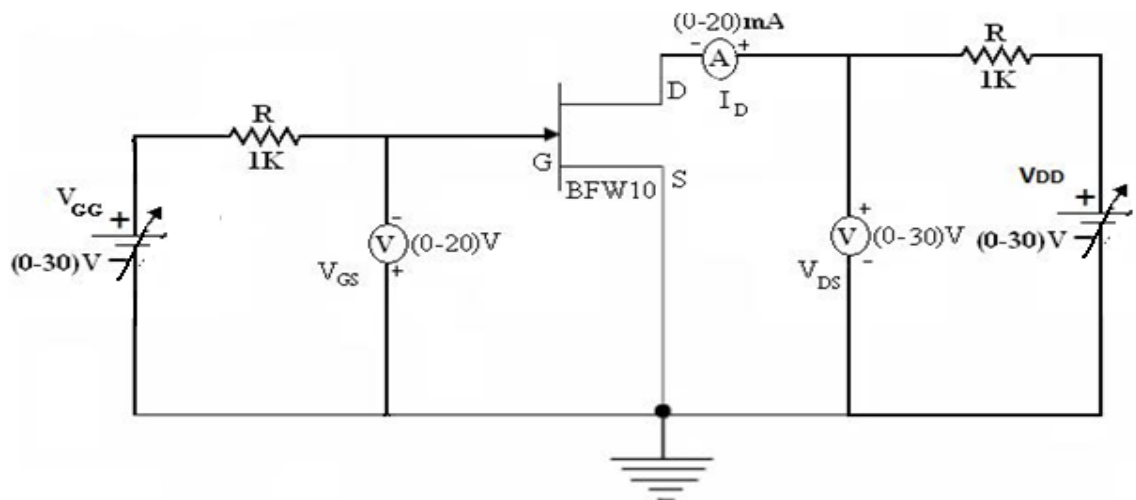
4.5 Pin assignment of JFET (BFW10):
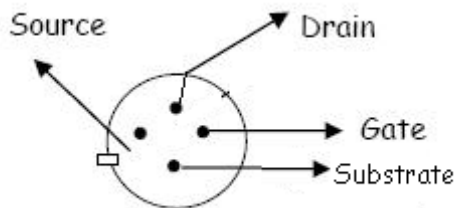
BFW10 – Silicon- N channel Depletion mode FET manufactured by MOTOROLA.

4.6 Characteristics of JFET:

In BFW10 JFET,

1. The transconductance g_m of JFET at zero gate –source voltage is in the range of 0.1 to 10mA/V. (Since drain current is proportional to g_m, for more transconductance MOSFETs can be preferred).

2. Gate leakage current of JFET is in the range of 100μA to 10nA, which consumes power (whereas MOSFET has 100nA to 10pA).

3. Greater susceptibility to damage in its handling.

4.7 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.

4.8 Tabular Column:

Drain Characteristics				Transfer Characteristics			
$V_{GS} =$		$V_{GS} =$		$V_{DS} =$		$V_{DS} =$	
$V_{DS}(V)$	$I_D(mA)$	$V_{DS}(V)$	$I_D(mA)$	V_{GS} (V)	$I_D(mA)$	V_{GS} (V)	$I_D(mA)$

4.9 Model Graph:

Drain Characteristics   **Transfer Characteristics:**
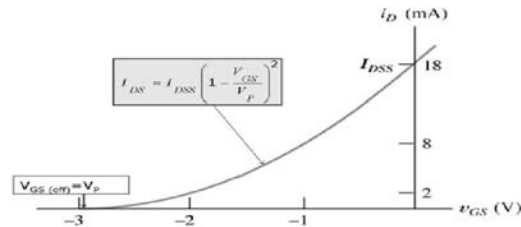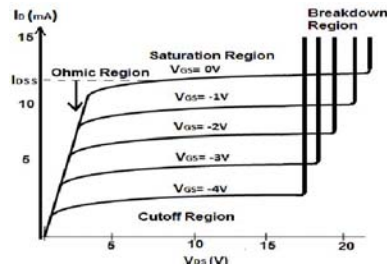
4.9.1 Graph (Instructions):

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}.

4.10 Calculations from Graph:

4.10.1 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.

4.10.2 Trans-Conductance (gm):

The 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 = ΔI_D / ΔV_{GS} at constant V_{DS} (from transfer characteristics)}.The value of gm is expressed in mhos or Siemens (s).

4.10.3 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.

μ = ΔV_{DS} / ΔV_{GS}.

μ = (ΔV_{DS} / ΔI_D) X (ΔI_D / ΔV_{GS})

μ = rd X gm.

4.11 Result:

    Thus the drain and transfer characteristics of a JFET was studied and verified, the following parameters were calculated

i.   Drain Resistance (rd) = ………….
ii.   Transconductance (gm) = ………….
iii.   Amplification factor (μ) = ……………

4.12 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.   JFET operates in either Enhancement mode or Depletion mode or both. Why?
5.   How electron flows through P-channel JFET?

Post lab Questions:

1.   Simulate using PSPICE and compare the Drain and Transfer characteristics of JFET with the obtained result.
2.   Why current gain is an important parameter in BJT where as conductance is important parameter in FET?
3.   Why does drain current remains physically constant above pinch off voltage?
4.   What are the conditions to be satisfied for the JFET to work in pinch off or active region?
5.   State the reason for non symmetrical nature of depletion region around gate to source junction.
6.   Interpret transfer characteristics curve from the following drain characteristics.
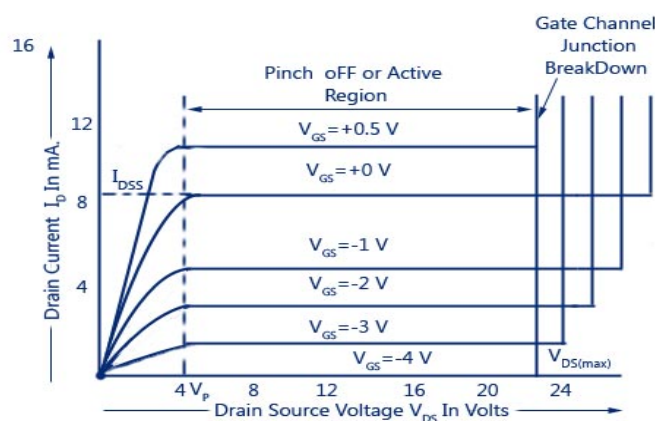
EXP 5: CHARACTERISTICS OF LDR, PHOTODIODE, PHOTOTRANSISTOR

5.1 Objective:

To study and verify the characteristics of LDR, Photodiode and Phototransistor

5.2 Hardware Required:

S. No	Apparatus	Type	Range	Quantity
01	Resistors		1KΩ,10KΩ,100KΩ, 10% tolerance,1/2 watt rating	1
02	Photodiode		QSD 2030F	1
03	Phototransistor		BPW77NA	1
04	Regulated power supply		(0-30V), 2A Rating	1
05	Ammeter	MC	(0-30)mA;(0-30)microA	1
06	Voltmeter	MC	(0-10)V	1
07	Bread board and connecting wires			1
08	LDR			1

5.3 Introduction

5.3.1 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 electrons enough energy to jump into the conduction band. The resulting free electron (and its hole partner) conduct electricity, thereby lowering resistance

5.3.2 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.

5.3.3 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.

5.4 Circuit diagram:
5.4.1 LDR   5.4.2 Photodiode
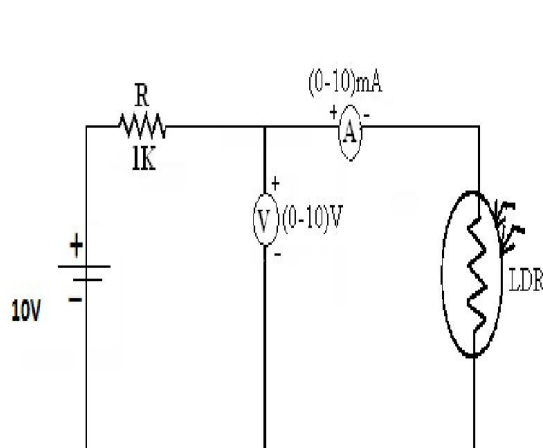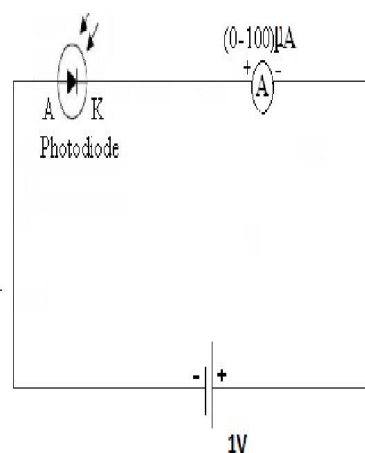
5.4.3 Phototransistor:
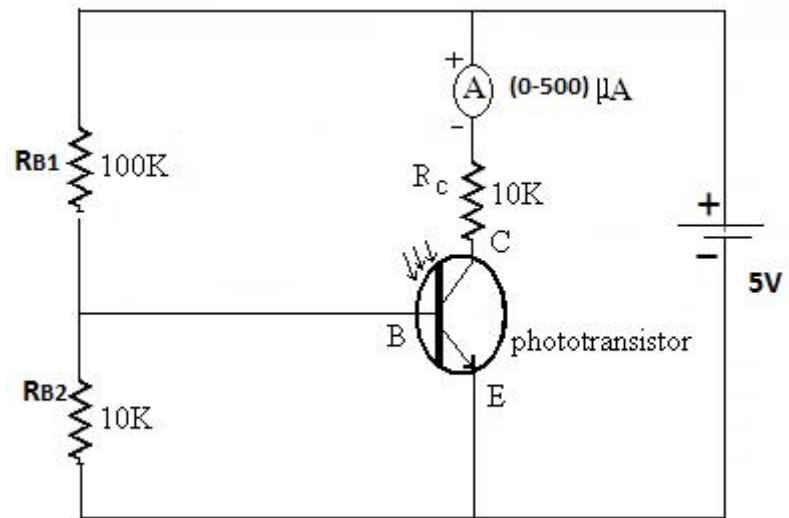
5.5 Tabular Column :

5.5.1 LDR

Distance (cm)	Voltage (V)	Current (mA)	Resistance(KΩ)

5.5.2 Photodiode

Distance (cm)	Current (µS)

5.5.3 Photo Transistor

Distance (cm)	Current (µS)

5.6 Characteristics of LDR, Photodiode, Phototransistor:

1. The dark resistance of an LDR is quite less compared with the reverse bias resistance offered by photo diodes because of which it may consume comparatively more power than its semiconductor counterparts.

2. Phototransistors made of silicon are not capable of handling voltages over 1,000 Volts.

3. Phototransistors are also more vulnerable to surges and spikes of electricity as well as electromagnetic energy.

4. Phototransistors also do not allow electrons to move as freely as other devices do, such as electron tubes.

5. The phototransistor has maximum sensitivity in the infrared (around a wavelength of 940nm), which is typical for silicon photodiodes and phototransistors.

6. Photoresistors are less light-sensitive devices than photodiodes or phototransistors: the two latter components are true semiconductor devices, while a photoresistor is a passive component and does not have a PN-junction. The photoresistivity of any photoresistor may vary widely depending on ambient temperature, making them unsuitable for applications requiring precise measurement of or sensitivity to light.

7. Photoresistors also exhibit a certain degree of latency between exposure to light and the subsequent decrease in resistance, usually around 10 milliseconds. The lag time when going from lit to dark environments is even greater, often as long as one second.

5.7 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.

5.8 Procedure:

5.8.1 LDR:

1. Connect circuit as shown in figure 5.4.1

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

3. Note down current and voltage in ammeter and voltmeter.

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

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

5.8.2 Photodiode:

1. Connect circuit as shown in figure 5.4.2

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

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

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

5. Plot the graph: V_d Vs Ir for constant VL

5.8.3 Phototransistor:

1. Connect circuit as shown in figure 5.4.3

2. Repeat the procedure as that of the photodiode.

5.9 Model Graph:

LDR   **Photodiode**

                                                  Phototransistor

28
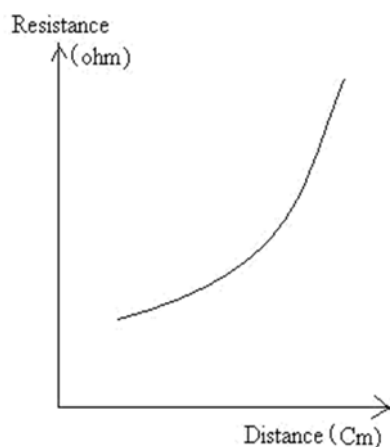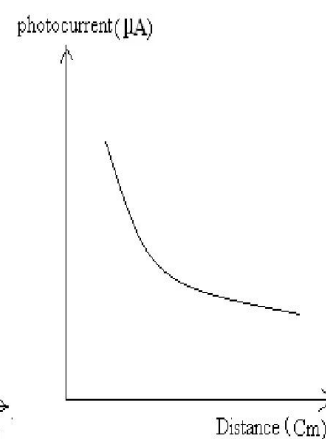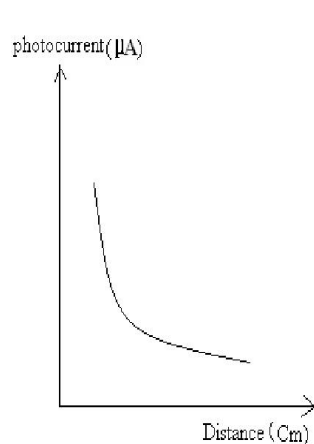
5.10 Result:

Thus the characteristics of LDR, Photodiode, Phototransistor were studied and verified

5.11 Prelab Questions:

1. Give the principle of operation of LDR, Photodiode and Phototransistor?
2. What is the difference between Photodiode and phototransistor?
3. Give the applications of LDR, Photodiode and Phototransistor?
4. Differentiate Direct and Indirect Semiconductor. Which is used as Optoelectronic Device? Why?
5. What is Photogeneration and Radiative Recombination?

5.12 Post lab Questions:

1. Simulate using PSPICE to get the characteristics of LDR, Photodiode and phototransistor.
2. What happens when distance is increased in case of LDR, Photodiode and phototransistor?
3. Define dark current in photodiode?
4. Can we operate photodiode in forward bias condition? Justify the answer?
5. Why we are making light to fall on collector base junction in case of phototransistor?
6. For applications requiring wavelength from 400 to 1700 nm, which material must be used to manufacture phototransistor.

6 HALF WAVE RECTIFIER

6.1 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, Vr(pp), Vdc for Half Wave Rectifier.

6.2 Hardware Required:

S. No	Apparatus	Type	Range	Quantity
01	Transformer		6-0-6 V, 500mA, 1A Rating	1
02	Resistance		470 ohm, 10% tolerance, 1/2 watt rating	1
03	Capacitor		470µF	1
04	Diode	IN4001		1
05	Bread board and connecting wires			

6.3 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. In positive half cycle, Diode D is forward biased and conducts. Thus the output voltage is same as the input voltage. In the negative half cycle, Diode D is reverse biased, and therefore output voltage is zero. A smoothing filter is induced between the rectifier and load in order to attenuate the ripple component. The filter is simply a capacitor connected from the rectifier output to ground. The capacitor quickly charges at the beginning of a cycle and slowly discharges through R_L after the positive peak of the input voltage. 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 a measure of effectiveness of a rectifier circuit and defined as a ratio of RMS value of ac component to the dc component in the rectifier output.

Theoretical calculations for Ripple Factor:

Without Filter:

$V_{rms} = V_m / 2$

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

Ripple factor (Theoretical) $= \sqrt{(\frac{V_{rms}}{V_{dc}})^2 - 1} = 1.21$

Ripple Factor(practical) $\gamma = \frac{V_{ac}}{V_{dc}}$ where $V_{ac} = \sqrt{(V_{rms}^2 - V_{dc}^2)}$

With Filter:

Ripple Factor (Theoretical) $r = \frac{1}{2\sqrt{3}fCR}$

Where f = 50Hz, R = 1KΩ, C = 1000μF

$$V_{ac} = \frac{V_{r(p-p)}}{2\sqrt{3}}$$

$$V_{dc} = V_m - \frac{V_{r(p-p)}}{2}$$

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

Percentage Regulation $= \frac{V_{NL} - V_{FL}}{V_{FL}} * 100$ %

V_{NL} = DC voltage at the load without connecting the load (Minimum current).

V_{FL} = DC voltage at the load with load connected.

Efficiency $\eta = \frac{P_{DC}}{P_{AC}}$

$P_{AC} = V_{2rms} / R_L$

$P_{DC} = V_{dc} / R_L$

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

6.4 Circuit Diagram of Half Wave Rectifier

AC Input Waveform

Resultant Output Waveform
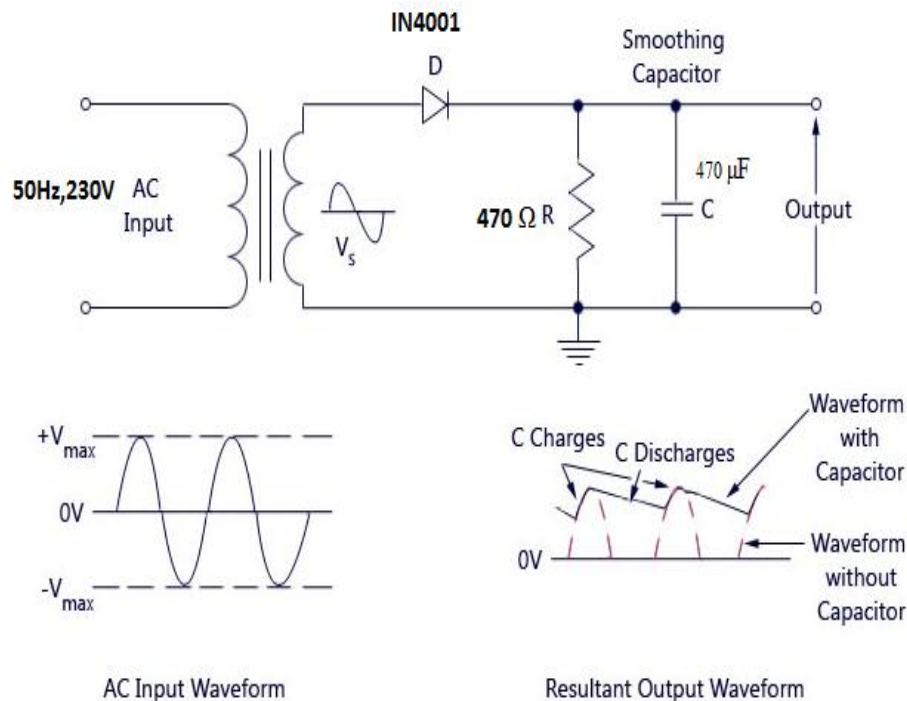
6.5 Characteristics of Half Wave Rectifier:

1. The output current in the load contains, in addition to dc component, ac components of basic frequency equal to that of the input voltage frequency. Ripple factor is high and an elaborate filtering is, therefore, required to give steady dc output.

2. The power output and, therefore, rectification efficiency is quite low. This is due to the fact that power is delivered only during one half cycle of the input alternating voltage.

3. Transformer utilization factor is low.

4. DC saturation of transformer core resulting in magnetizing current and hysteresis losses and generation of harmonics.

6.6 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.

6.7 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.

6.8 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 and y-axis as Voltage
3. Mark the readings tabulated for Amplitude as Voltage and Time in graph sheet.

6.9 Observations:

	Input Waveform	Output Waveform (without filter)	Ripple Voltage (with filter)
Amplitude			
Time Period			
Frequency			

6.10 Result:

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

6.11 Pre Lab

1. What is the purpose of a rectifier?

2. Why filter is used in a rectifier?

3. What are the advantages of half wave rectifier?

4. Define Ripple factor and Efficiency. State the ideal values.

5. Define PIV. Give the PIV of Half wave rectifier.

6.13 Post Lab

1. Simulate Half wave rectifier with the given specifications for with and without filter using Pspice. Compare the output with the theoretical value.

2. If the input supply is 60Hz, what will be the output ripple frequency in half wave rectifier?

3. Find the ripple factor for a half wave rectifier circuit with resistor 470 Ω and capacitor 47µF .

4. Silicon diode in a half-wave rectifier has a barrier potential of 0.7V. This has the effect of reducing the peak output voltage by 0.7 V. increasing the peak output voltage by 0.7 V. reducing the peak input voltage by 0.7 V. no effectt.

5. For an ideal power supply, the output voltage should be of load current and the percentage regulation should be.

7. FULL WAVE RECTIFIER

7.1 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.

7.2 Hardware Required:

S. No	Apparatus	Type	Range	Quantity
01	Transformer		6-0-6 V	1
02	Resistance		470 ohm, 10% tolerance, 1/2 watt	1
03	Capacitor		470μF	1
04	Diode	IN4001		2
05	Bread board and connecting wires			

7.3 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. Peak Inverse Voltage (PIV) is the maximum voltage that has to be withstand by a diode when it is reverse biased. Peak inverse voltage for Full Wave Rectifier is $2V_m$ because the entire secondary voltage appears across the non-conducting diode **.**

The output of the Full Wave Rectifier contains both ac and dc components. A majority of the applications, which cannot tolerate a high value ripple, necessitates further processing of the rectified output. The undesirable ac components i.e. the ripple, can be minimized using filters.

7.3.1 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'.

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

7.3.2 Efficiency:

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).

The maximum efficiency of a Full Wave Rectifier is 81.2%.

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 = $2V_m$

7.3.3 Transformer Utilization Factor

Transformer utilization factor (TUF), which is defined as the ratio of power delivered to the load and ac rating of the transformer secondary, So

TUF = dc power delivered to the load/ac rating of transformer secondary

Transformer Utilization Factor, TUF can be used to determine the rating of a transformer secondary. It is determined by considering the primary and the secondary winding separately and it gives a value of 0.693.

7.4 Theoretical 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) = $\sqrt{(\frac{V_{rms}}{V_{dc}})^2 - 1} = 0.48$

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

With filter:

Ripple factor (Theoretical) $\gamma = \frac{1}{4\sqrt{3}fCR}$

Where f = 50Hz, R =1KΩ, C = 1000μF.

$$V_{ac} = \frac{V_{r(p-p)}}{2\sqrt{3}}$$

$$V_{dc} = V_m - \frac{V_{r(p-p)}}{2}$$

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

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

V_{NL} = DC voltage at the load without connecting the load (Minimum current).

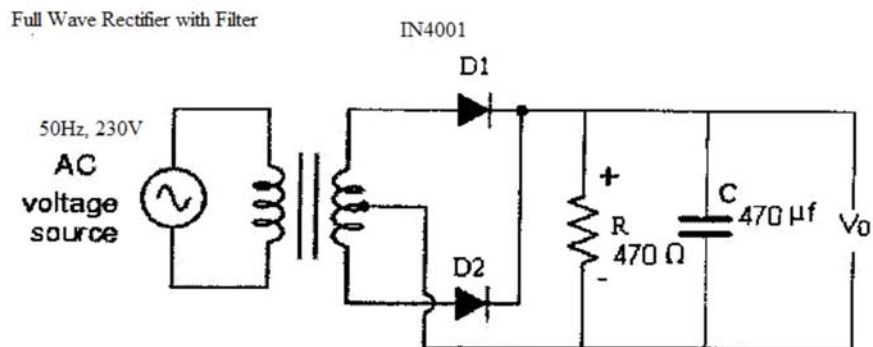V_{FL} = DC voltage at the load with load connected.

Efficiency $\eta = \frac{P_{DC}}{P_{AC}}$%u200B

P_{AC} = V_{2rms} / R_L

P_{DC} = V_{dc} / R_L

7.5 Circuit Diagram:

Full Wave Rectifier with Filter

7.6 MODEL GRAPH:

Input Waveform
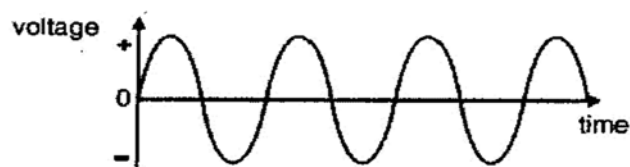
Resultant Output Waveform
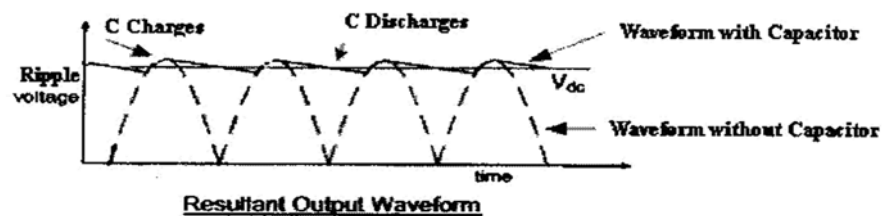
7.7 Characteristics of Full Wave Rectifier:

1.	The peak voltage in the full-wave rectifier is only half the peak voltage in the half-wave rectifier. This is because the secondary of the power transformer in the full-wave rectifier is center tapped; therefore, only half the source voltage goes to each diode.

2.	A larger transformer for a given power output is required with two separate but identical secondary windings making this type of full wave rectifying circuit costly compared to the "Full Wave Bridge Rectifier" circuit equivalent.

7.8 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.

7.9 Procedure:

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.

7.10 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.

7.11 Observations:

|	**Input Waveform**	**Output Waveform** (without filter)	**Ripple Voltage** (with filter)
Amplitude			
Time Period			
Frequency			

7.12 Result:

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

7.13 Prelab Questions

1. Each diode in a centre-tapped full-wave rectifier is _____ -biased and conducts for _____ of the input cycle.

    a) Forward, 90^0

    b) Reverse, 180^0

    c) Forward, 180^0

    d) Reverse, 90^0

2. What is the V_{RRM} (PIV rating) for the 1N4001 rectifier diode? Give the PIV of Full Wave Rectifier.

3. Define Efficiency of rectifier. Compare the efficiency of Full Wave and Half Wave rectifier.

7.14 Postlab Questions

1. Simulate Full wave rectifier with the given specifications for with and without filter using Pspice. Compare the output with the theoretical value.

2. Calculate the ripple voltage of a full-wave rectifier with a 75- μ F filter capacitor connected to a load drawing 40 mA.

    a. 1.20V

    b. 1.28V

    c. 1.32V

    d. 1.41V

3. The output frequency of a full-wave rectifier is _____ the input frequency

4. In the full-wave rectifier circuit,(fig 7.5) what will happen to the circuit if 1) D1 is disconnected, 2) D1's polarity is reversed.

5. In this rectifier circuit, the output voltage is less than half of the secondary winding's rated voltage (12 volts). Why is this?

117 V / 12 V CT

To 117 VAC power source

Load
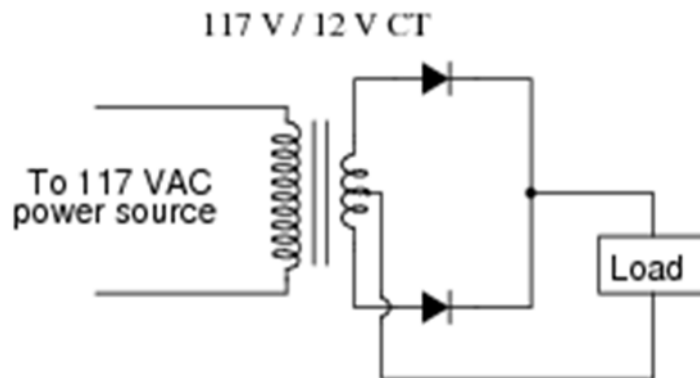
Also, interpret whether this is a half-wave or a full-wave rectifier circuit, and explain.

6.   Compare the ripple factors of half wave and full wave rectifier.

EXP 8: FULL WAVE BRIDGE RECTIFIER

8.1 Objective:

To study and verify the working of a full wave bridge rectifier with and without filter and to measure its parameters

8.2 Hardware Required:

S. No	Apparatus	Type	Range	Quantity
01	Transformer		6-0-6 V	1
02	Resistance		470 ohm, 10% tolerance, 1/2 watt	1
03	Capacitor		470μF	1
04	Diode	IN4001		4
05	Bread Board and connecting wires			

8.3 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 Bridge rectifier is a circuit, which converts an ac voltage to dc voltage using both half cycles of the input ac voltage. The Bridge 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 a measure of effectiveness of a rectifier circuit and defined as a ratio of RMS value of ac component to the dc component in the rectifier output.

8.4 Theoretical calculations: 8.4.1 Ripple Factor

The ripple factor for a Full Wave Rectifier is given by

$$\gamma = \sqrt{\left(\frac{V_{rms}}{V_{dc}}\right)^2 - 1}$$

The average voltage ofr the DC voltage available across the load resistance is $Vdc = 2V_m/\pi$

The RMS value of the voltage at the load resistance is $Vrms = V_m$

Ripple factor

$$\therefore \gamma = \sqrt{\left(\frac{V_m/2}{2V_m/\pi}\right)^2 - 1} = \sqrt{\left(\frac{\pi}{8}\right)^2 - 1} = 0.482$$

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

8.4.2 Efficiency

Efficiency, η is the ratio of dc output power to ac input power

$$\eta = \frac{dc\,output\,power}{ac\,input\,power} = \frac{P_{dc}}{P_{ac}}$$

$$\frac{V_{dc}^2/R_L}{V_{rms}^2/R_L} = \frac{\left[2V_m/\pi\right]^2}{\left[V_m/\sqrt{2}\right]^2} = 8/\pi^2 = 0.812 = \underline{81.2\%}$$

The maximum efficiency of a Full Wave Rectifier is 81.2%.

8.4.3 Transformer Utilization Factor

Transformer utilization factor (TUF), which is defined as the ratio of power delivered to the load and ac rating of the transformer secondary, So

TUF = dc power delivered to the load/ac rating of transformer secondary

Transformer Utilization Factor, TUF can be used to determine the rating of a transformer secondary. It is determined by considering the primary and the secondary winding separately and it gives a value of 0.812.

8.5 Circuit Diagram:

8.6 Model Graph:
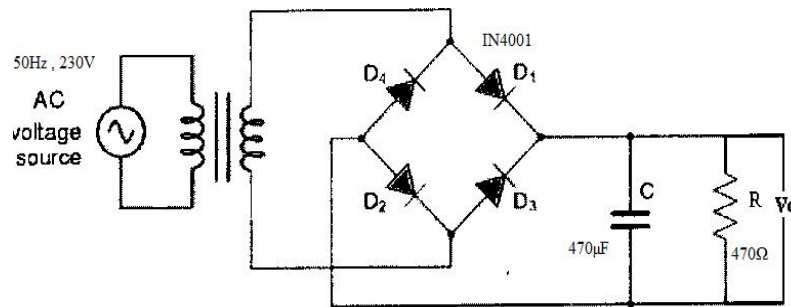
Input Waveform

Resultant Output Waveform

8.7 Precautions:
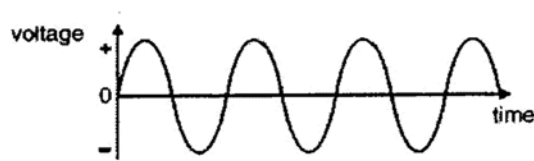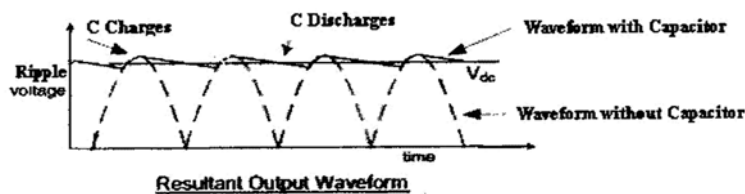
1. While doing the experiment do not exceed the ratings of the diode. This may lead to damage the diode.

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.

8.8 Procedure:

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.

44

5. Plot the input, output without filter and with filter waveform on a graph sheet.

6. Calculate the ripple factor.

8.9 Formulae:

Peak to Peak Ripple Voltage, $Vr_{(pp)} = \dfrac{Vp(rect)}{2 fR_L C}$

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

Peak rectified voltage, $Vdc = (1 - \dfrac{1}{4 fR_L C}) Vp(rect)$

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

8.10 Observations:

	Input Waveform	Output Waveform (without filter)	Ripple Voltage (with filter)
Amplitude			
Time Period			
Frequency			

8.11 Result:

The rectified output voltage of full wave bridge rectifier circuit is observed and the calculated value of **ripple factor** is _____

8.12 Prelab Questions:

1. What is the PIV of a diode full wave bridge rectifier circuit?

2. A bridge rectifier is preferable to a full-wave rectifier using center-tap transformer as

(a)   It uses four diodes

(b)   Its transformer does not require center-tap

(c)It requires much smaller transformer for the same output

(d)   All of these

3. In a full-wave bridge rectifier, the current in each diode flows for

(a)   Complete cycle of the input signal

(b)   Half-cycle of the input signal

(c)   Less than half-cycle of the input signal

(d)   More than half-cycle of the input signal

4. What is the purpose of a filter in dc power supply?

5. What is TUF? Give the TUF of half wave, full wave-center tapped and bridge rectifier.

8.13 Post lab Questions:

1.   Simulate Fullwave Bridge rectifier with the given specifications for with and without filter using PSPICE. Compare the output with the theoretical value

2.   When a 50Hz ac signal is fed to a rectifier, the ripple frequency of the output voltage waveform for full bridge rectifier is

(a) 25 Hz   (b) 50 Hz

(c) 100 Hz   (c)150 Hz
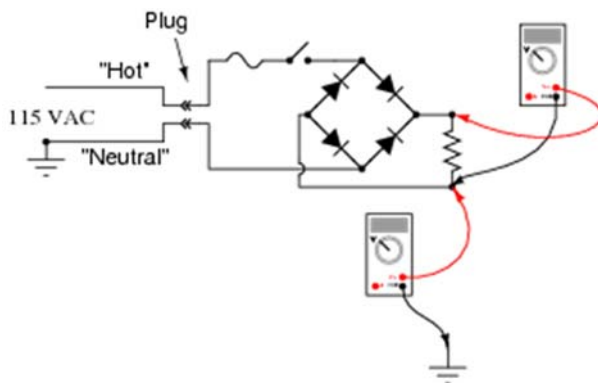
3. Trace the current through this rectifier circuit at a moment in time when the AC source's polarity is positive on right and negative on left as shown. Be sure to designate the convention you use for current direction (conventional or electron flow):
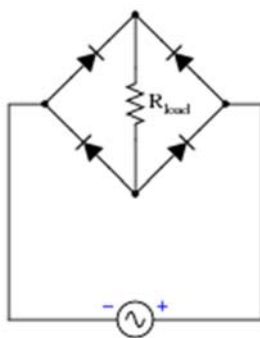
Also, mark the polarity of the voltage drop across R_{load}.

4.For the figure shown below. Determine (a) the DC output voltage, (b) DC load current, (c) the RMS value of the load current, (d) the DC power, (e)the AC power, (f) efficiency of rectifier, (g) peak inverse voltage of each diode, and (h) output frequency. Assume all diodes are ideal.
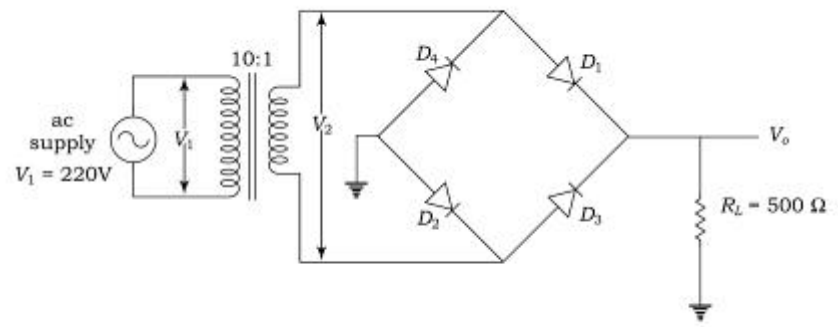
9. SERIES VOLTAGE REGULATOR

9.1 Objective:

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

9.2 Hardware Required:

S. No	Apparatus	Type	Range	Quantity
1	Power transistor	2N3055		1
2	Transistor		BC147	1
3	Zener diode	1Z6.2		1
4	Resistors		947Ω, 2.48KΩ, 2.2kΩ, 2.75KΩ, 49.6Ω, 10% tolerance, ½ watt	1
5	Voltmeter	MC	(0 – 30)V	1
6	Bread board & wires			
7.	Decade Resistance Box		50Ω	1

9.3 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 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 I_{C2} 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.

9.3.1 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.

Line regulation = (output voltage at High line input voltage - output voltage at low line input voltage) x100 (High line input voltage - low line input voltage)

9.3.2 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

9.4 Circuit Diagram - Series Voltage Regulator
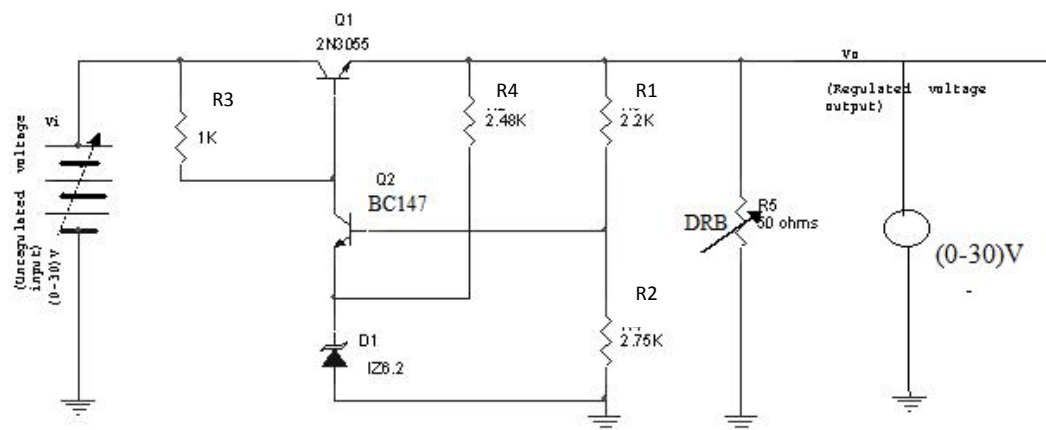
9.4.1 Design Specifications Series pass Transistor 2N3055:

h_{fe} =20-70

I_{emax} =15 amperes

V_{ce} =70V

BC   170

$$I_e \quad = 2 \text{ mA}$$

$$h_{fe} \quad = 125\text{-}500$$

ASSUMPTIONS

$$V_I \quad = 12.4 \text{ V}$$

$$= 250 \text{ mA}$$

$$= 2.5 \text{ mA}$$

$$= 10 \text{mA}$$

$$\beta_1 = 28$$

$$\beta_2 = 188$$

DESIGN

$$= \quad V_L/2 = 12.4 / 2 = 6.2 \text{ V}$$

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

$$= \quad 0.01 * I_L = 12.4 / 250 \text{ mA}$$

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

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

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

$$0.7 + 6.2 \quad = \quad 12.4 * (R_2/ (2.2*10^{-3} +R_2))$$

$$R2 \quad = \quad 2.75 \text{ K}\Omega$$

$$I2 \quad = \quad (V_2+V_{BE2}) / R_2 = 6.9 / 2.75 *10^3 = 2.5 \text{mA}$$

$$IE1 \quad = \quad (I_D+I_1 + I_L) = (2.5 + 2.5 + 250) \text{ mA} = 255 \text{mA}$$

$$IB1 \quad = \quad I_{E1} / \beta_1 = 255 / 28 = 9.107 \text{ mA}$$

$$I3 \quad = \quad I_{B1} + I_{C2} = 9.107 \text{ mA} = 19.107 \text{ mA}$$

$$R3 \quad + \quad [V_{INMX} - (V_{BE1} + V_2)] / I_3 = \frac{25-(0.7*6.2)}{19.107*10\text{-}^3} = 947\Omega$$

9.5 Characteristics of Series Voltage Regulator:

This series voltage regulator is suitable only for low output voltages because of the following reasons

1. With the increase in room temperature, the values of Vbe and Vzener tend to decrease. Thus the output voltage cannot be maintained a constant. This will

further increase the transistor base emitter voltage and thus the load.

2. There is no option to change the output voltage in the circuit.

3. Due to small amplification process provided by only one transistor(BC147), the circuit cannot provide good regulation at high currents.

4. The power dissipation of a pass transistor is large because it is equal to VccIc and almost all variation appears at Vce and the load current is approximately equal to collector current. Thus for heavy load currents pass transistor has to dissipate a lot of power and, therefore, circuit becomes hot. So some heat sink is required.

9.6 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
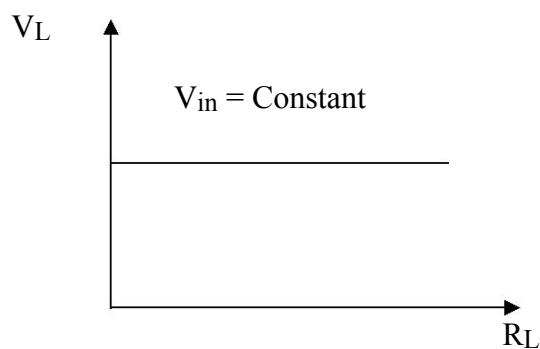
9.7 Tabulation

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

S. No	V_i (V)	V_o (V)
1.		
2.		
3.		
4.		
5.		
6.		
7.		
8.		
9.		
10		
11		
12		

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

S.No	$R_L(\Omega)$	$V_o(V)$
1.		
2.		
3.		
4.		
5.		
6.		

9.8 Model Graph
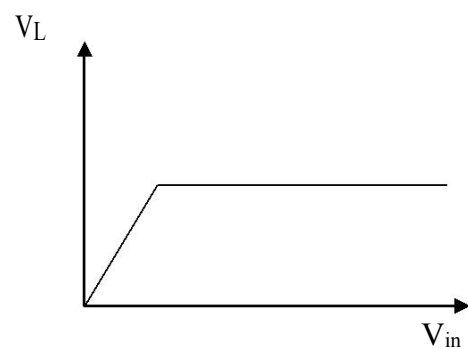
          LOAD REGULATION   LINE REGULATION

9.9 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 ----------------------

9.10 Prelab Question:

1. What are the three basic elements inside a standard voltage regulator?

2. What device is used as a control element? Why?

3. What are the performance measures of the regulator?

4. What is line regulation and Load regulation What is the efficiency of series voltage regulator

9.11 Post Lab Question:

1. Design series voltage Regulator in PSPICE and compare with obtaind line and load regulation curves.

2. With reference to the above circuit (fig 9.4), What will be the output voltage if reference voltage was short circuited?

3. The 7812 regulator IC provides _____.

   a) 5V

   b) -5V

   c) 12V

   d) -12V

4. what will happen if potential divider was open circuited

5. what is the role of resistor R_1 and R2 in the circuit

10.SHUNT VOLTAGE REGULATOR

10.1 Objective:

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

10.2 Hardware Required:

S.No	Apparatus	Type	Range	Quantity
1	Regulated power supply	MC	(0-30 V), 2 A rating	1
2	Resistors		1K Ω, 10% tolerance, ½ watt	1
3	Zener diode	1z 5.1		1
4	Voltmeter		(0-30)V	1
5	Breadboard & wires			
6	Decade Resistance Box	1	10K Ω	1

10.3 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).

10.3.1 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.

10.3.2 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 Ω

10.4 Circuit Diagram – Shunt Voltage Regulator
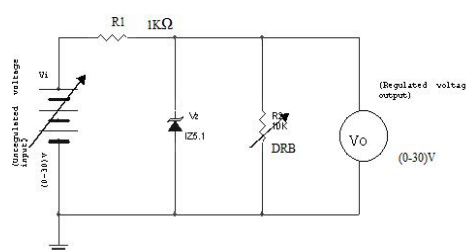
10.5 Design

Let l_z max = 10 mA, $V_z = V_L$ = 5.1 V Load current l_L = 50 mA.

Therefore $R_L = V_{L=} / l_L$ = 5.1 V/ 50 * 10^{-3} A = 120 Ω R_L = 102Ω

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

10.6 Characteristics of Shunt Voltage Regulator:

The series resistor causes a huge amount of power loss.

1. The circuit may have problems regarding over voltage mishaps.

10.7. Procedure:

10.7.1 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.

10.7.2 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.

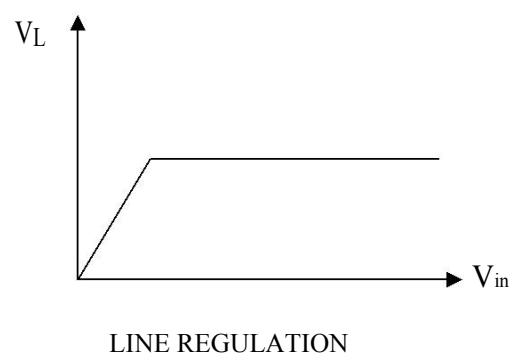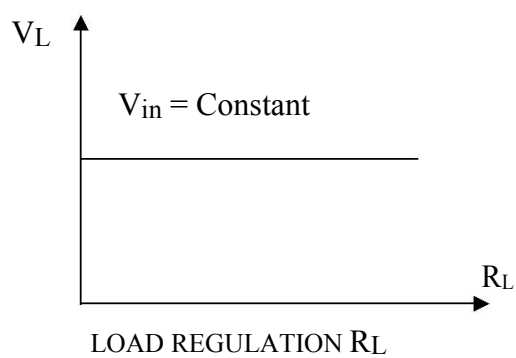3. A graph is plotted by having R_L in x axis and Vo in y axis.

10.8 Tabulation

10.8.1 Line regulationRL = ------------ (Ω)

S. No	V_i (V)	V_o (V)
1.		
2.		
3.		
4.		
5.		
6.		
7.		
8.		
9.		
10.		
11.		
12.		

10.8.2Load regulation V_i = ------------ (V)

S.No	$R_L(Ω)$	$V_o(V)$
1.		
2.		
3.		
4.		
5.		
6.		

10.9 Model Graph

LOAD REGULATION R_L LINE REGULATION

10.10 Result

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

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

10.11 Pre Lab Question:

1. List the difference between Series and Shunt Voltage Regulator
2. Give the application of shunt regulator
3. In the circuit of shunt voltage regulator which element is considered control element and explain its function.

10.12 Post Lab Questions

1. Design Shunt Voltage regulator in PSPICE and analyse the circuit.
2. What will be the output voltage if Zener diode was short circuited?
3. What will be the output voltage if reference voltage was open circuited?
4. What is the role of resistor R1 and R2 in the circuit ?
5. The transistor shunt regulator shown in figure has a regulated output voltage of 10 volts, when input varies from 20 volts to 30 volts. The relevant parameters for the zener diode and the transistor are: $V_Z = 9.5$ volts, $V_{BE} = 0.3$ votls, $\beta = 99$. Neglect the current throught R_B. Then the maximum power dissipated in the zener diode (P_Z) and the transistor (P_T) are
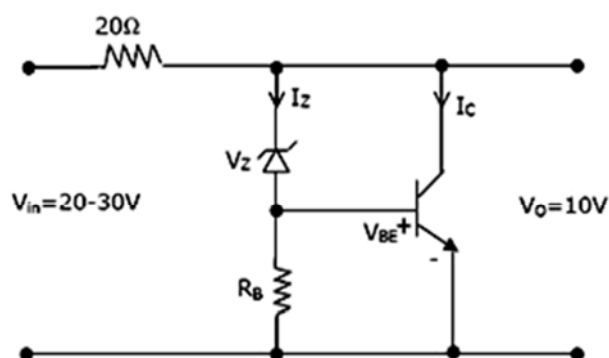
(a) $P_Z=75mW$, $P_T=7.9W$

(b) $P_Z=85mW$, $P_T=8.9W$

(c) $P_Z=95mW$, $P_T=9.9W$

(d) $P_Z=115mW$, $P_T=11.9W$

11 V-I CHARACTERISTICS OF LED

11.1 Objective:

To study and verify the V-I Characteristics of LED

11.2 Hardware Required:

S. No	Apparatus	Range	Quantity
1.	Regulated power supply	(0 -5) V	1
2.	Resistors	330Ω, 10% tolerance, ½ watt	1
3.	LED	Red, Green, Yellow colours; 3mm size	1
4.	Voltmeter	(0 – 30)V	1
5.	Ammeter	(0 – 100) mA	1
6.	Bread board and connecting wires		

11.3 Introduction:

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.

11.3.1 Connecting and soldering

LEDs must be connected the correct way round, the diagram may be labeled **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.

11.3.2 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!

11.3.3 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.
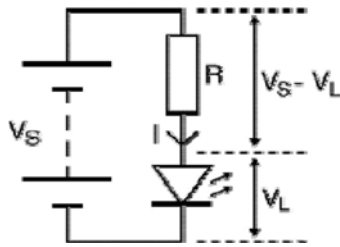
11.3.4 Calculating an LED resistor value

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:

$$R = (V_S - V_L) / I$$

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 agreater 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).
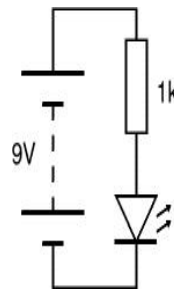

11.3.5 Connecting LEDs in series
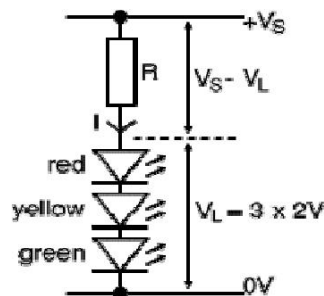
If you wish to have several LEDs on at the same time it may be possible to connect them in series. This prolongs battery life by lighting several LEDs with the same current as just one LED.

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.
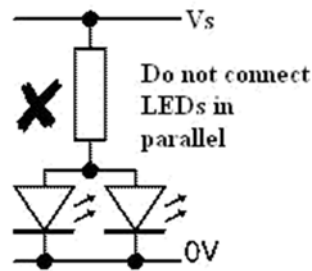
For Example a red, a yellow and a green LED in series need a supply voltage of at least $3 \times 2V + 2V = 8V$, so a **9V battery** would be ideal.

$V_L = 2V + 2V + 2V = 6V$ (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 = 220Ω (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.

11.3.6 Advantages of LED:
1.   Less complex circuitry
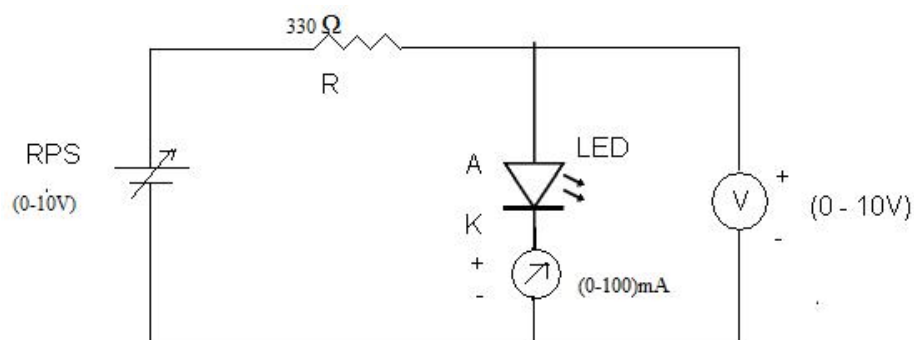2.   Can be fabricated less expensively with high yield

11.3.7 Desired characteristics:
1.   Hard radiation
2.   Fast emission response time
3.   High quantum efficiency

11.3.8 Basic LED configuration:
1.   Surface emitter
2.   Edge emitter

11.4 Circuit diagram: Forward bias

11.5 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.
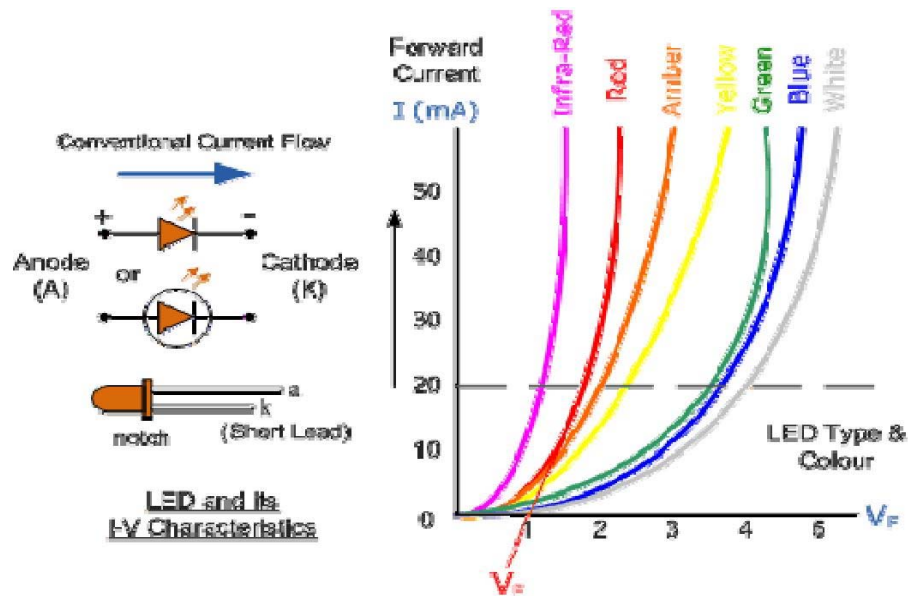
11.6 Tabular column:

LED Colour: Red   **LED Colour: Green**   **LED Colour: Yellow**

S. No	Voltage(V)	Current(mA)	S. No	Voltage(V)	Current(mA)	S. No	Voltage(V)	Current(mA)

1.7 Model Graph:

11.8 Result:

Thus the VI characteristics of LED were studied.

11.9 Pre Lab questions:

1. Differentiate LED from normal PN junction diode?

2. Define wavelength.

3. What happens when LEDs connected in series and parallel?

4. What are the advantages of LED over laser diode?

5. What are the desired characteristics of LED?

11.10 Post Lab questions:

1. Simulate using PSPICE the characteristics of Red, Green and Yellow LED's.

2. Explain the operation of LED under forward bias and reverse bias condition?

3. Why light is not emitted under reverse bias condition?

4. Why is it important to control the current through an LED?

5. Can LEDs be dimmed? Does dimming LEDs cause color shifts?

EXP 12: COMMON COLLECTOR CONFIGURATION USING PSPICE

12.1 Objective:

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

12.2 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			

12.3 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 CC configuration.

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.
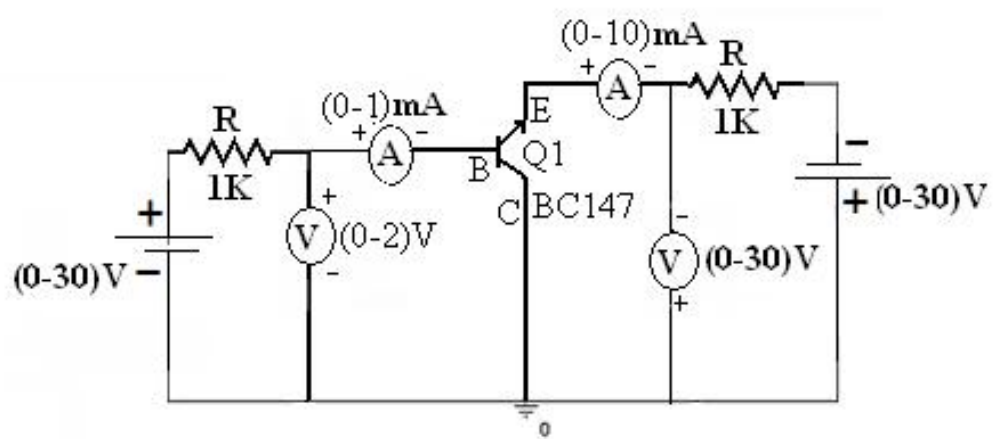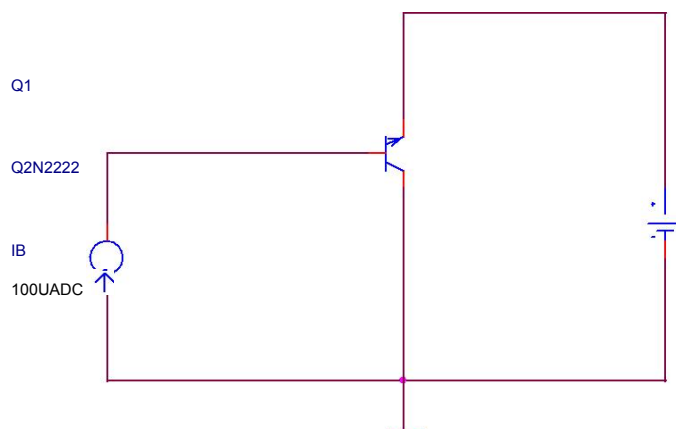
12.4 Pin Assignment:
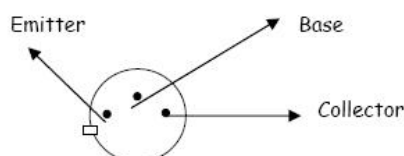
12.5 Circuit diagram:
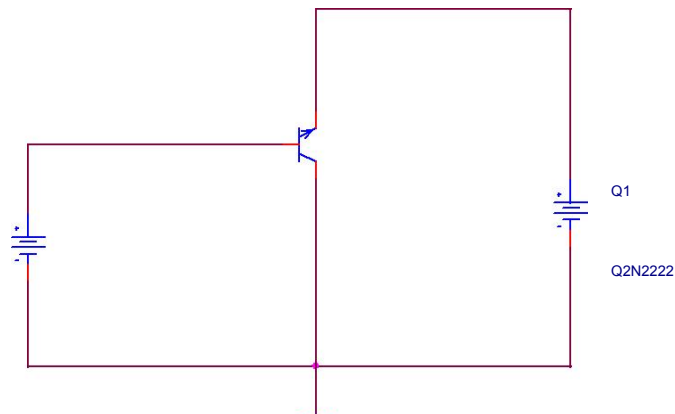
12. 6 Schematic Diagram

12.6.1 Input Characteristics

12.6.2 Output Characteristics

12.7 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.

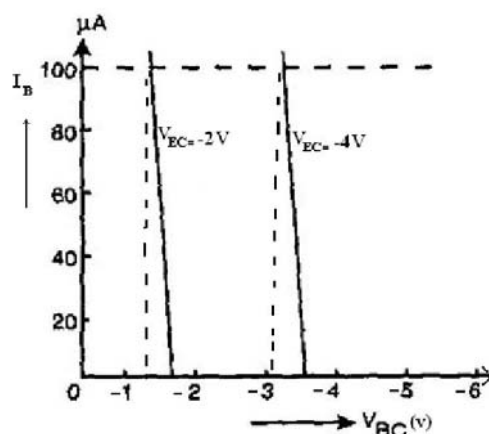**12.8 Procedure:**

12.8.1 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}

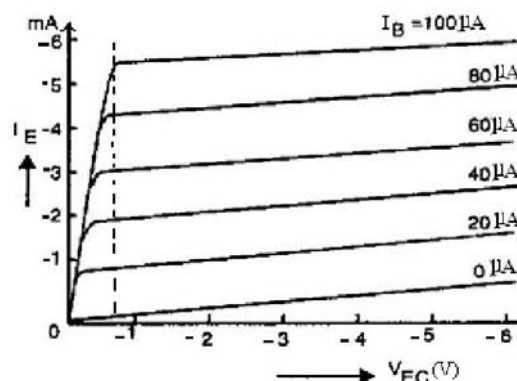**12.8.2 Output Characteristics:**

1. Make the connections as per circuit diagram.

2. By varying V_{BB} keep the base current $I_B = 20\mu A$.

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

12.9 Model Graph:

12.9.1 Input characteristics   **12.9.2 Output Characteristics**

68

12.10 Result:

Thus the input and output characteristics of BJT in CC configuration was verified and the graph was plotted.

i.   Input impedance(h_{ic})$= = \Delta V_{BC} / \Delta I_B = $ _____

ii.   Forward current gain(h_{fc})$= = \Delta I_E / \Delta I_B = $ _____

iii. Output admittance(h_{oc})$= = \Delta I_E / \Delta V_{EC} = $ _____

iv.   Reverse voltage gain(h_{rc})$= \Delta V_{BC}/\Delta V_{EC} = $ _____

12.11 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?

12.12 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. BJT is a current controlled device. Justify.

13. CHARACTERISTICS OF METAL OXIDE SEMICONDUCTOR FIELD EFFECT TRANSISTORS (MOSFETS) USING PSPICE

13.1 Objective:

To perform drain characteristics and transfer characteristics of MOSFET using Pspice Capture Lite Software.

13.2. Theory:

In a MOSFET, current flows from the drain terminal to the source terminal through a semiconductor channel. The resistance of the channel, and therefore its ability toconduct current, is controlled by a voltage applied to a third terminal denoted as the gate.MOSFETs can be either an n-channel type or a p-channel type. In a n-channel MOSFET a positive voltage is applied to the drain terminal for operation while in a p-channel MOSFET a negative voltage is applied to the drain terminal for operation. An n-channel and p-channel type MOSFET may be one of two modes; enhancement mode or depletion mode. The enhancement mode MOSFET is normally "off" (in cutoff and conducting no current) when no voltage is applied to the gate and is "on" (in saturation and conducting current) when a voltage greater than the gate-to-source threshold is applied to the gate. The depletion mode MOSFET is normally "on" (in saturation and conducting current) when no voltage is applied to the gate and is "off" (in cutoff and not conducting current) when a voltage more negative than the gate-to-source threshold is applied to the gate.
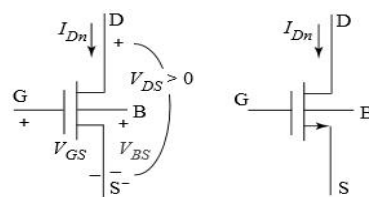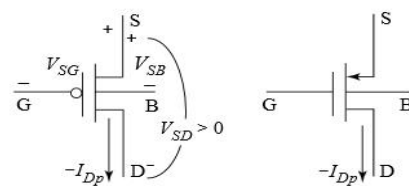
(a) n-channel MOSFET   (b) p-channel MOSFET
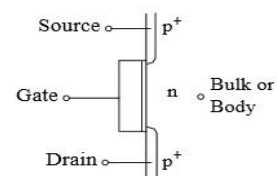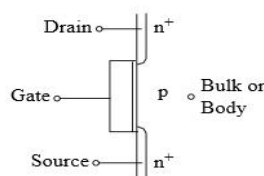
13.2.1 Transfer Characteristics:

In most MOSFET applications, an input signal is the gate voltage V_G and the output is the drain current I_D. The ability of MOSFET to amplify the signal is given by the output/input ratio: the transconductance, $g_m = dI_D/dV_{GS}$ with V_{DS} constant

13.2.2 Drain Characteristics:

MOSFET operates in three operation mode, Cut-off when $V_{GS} < V_t$,

Linear mode when $V_{GS} > V_{th}$ and $V_{DS} < (V_{GS} - V_{th})$ and Saturation when $V_{GS} > V_{th}$ and $V_{DS} \geq (V_{GS} - V_{th})$. Pinch off occurs when $V_{DS} = V_{Sat} = V_{GS} - V_t$. The drain resistance , $R_d = dV_{DS}/dI_D$ with V_{GS} constant
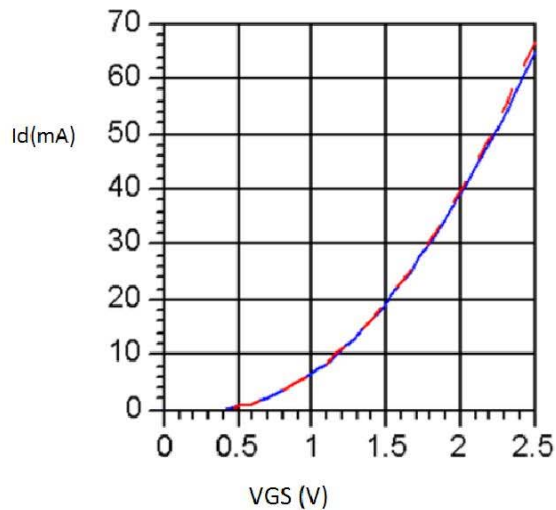
13.3 Circuit Diagram :
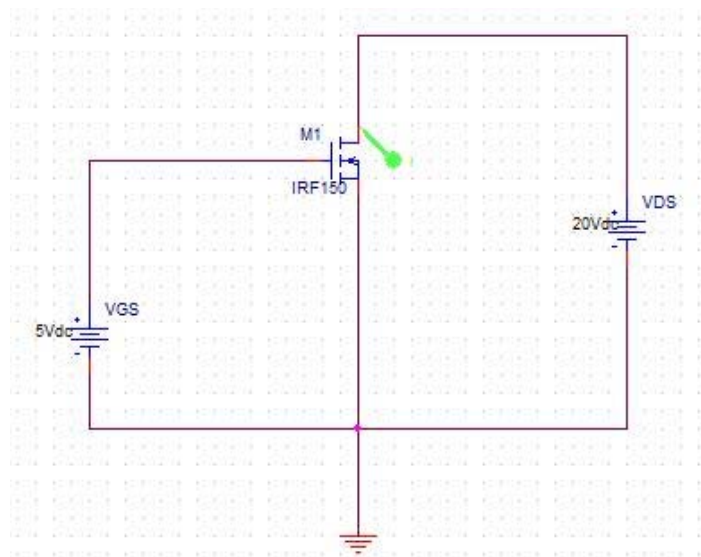
13.4 Handling Precautions:

1. When handling power MOS FETs, the man should be ground. And Power MOS FETs, should be handled by the package, not by the leads.
2. When handling or installing Power MOS FETs into circuits, use metal plates that it grounded on Work Stations.
3. When testing Power MOS FETs, Test Circuit (Curve tracer, etc.) should be grounded.
4. When using soldering irons, soldering irons should be grounded. (It's better to use battery operated soldering irons.)
5. When shipping in circuit boards, they should be placed in antistatic bags, unless the gate and the source are connected by resistors or inductors.
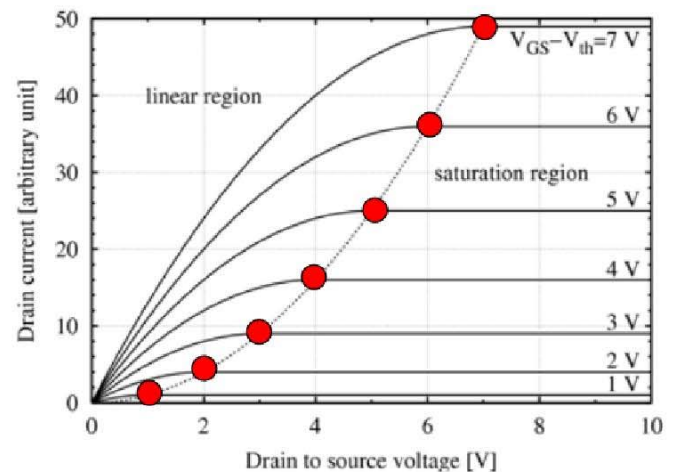
6. Power MOS FETs should be placed not in plastic casesor bags, but in antistatic bags, conductive foam, or aluminum foil.

13.5 Model Graph :

13.5.1 Transfer Characteristics:	13.5.2 Drain Characteristics:

13. 6 Result:

The drain Characteristics and Transfer Characteristics of MOSFET was simulated using Pspice , the transconductance = _____ and drain resistance = -------------- was found.

13.7 PreLab Questions:

1. With the E-MOSFET, when gate input voltage is zero, what is the drain current?
2. When is a vertical channel E-MOSFET used?
3. Compare the input impedance of MOSFET with that of BJT and FET.
4. In MOSFET devices the N-channel type is better the P-channel type. How?

13.8Post lab:

1. In a MOSFET, the polarity of the inversion layer is the same as that of _____

2. What is the difference between depletion MOSFET and JFET.

Input impedance of MOSFET is

◻ less than of FET but more than BJT.

◻ more than that of FET and BJT.

◻ more than that of FET but less than BJT.

◻ less than that of FET and BJT.

3.   What are the three regions of operation in MOSFET?

4.   Interpret transfer characteristics from the given drain characteristics for MOSFET.

Drain Charecteristics
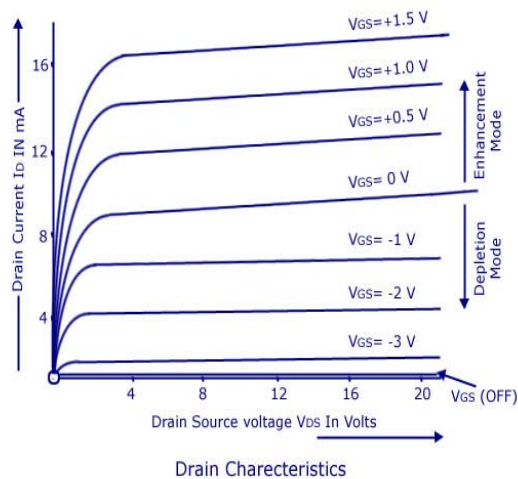
www.circuitsToday.com

<h1>EXP 14: CHARACTERISTICS OF THERMISTOR</h1>

14.1 OBJECTIVE:

To study and verify the physical characteristics of the given thermistor and ccalculate the resistance of the thermistor and the temperature coefficient using the given formula for different temperatures

14.2 HARDWARE REQUIRED:

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

14.3 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:

$$R = k\,T$$

Where R = change in resistance.

T = 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 low temperature 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 andcopper. The metals are oxidized through a chemical reaction, ground to a fine powder, thencompressed 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.

14.4 Experimental Set up:
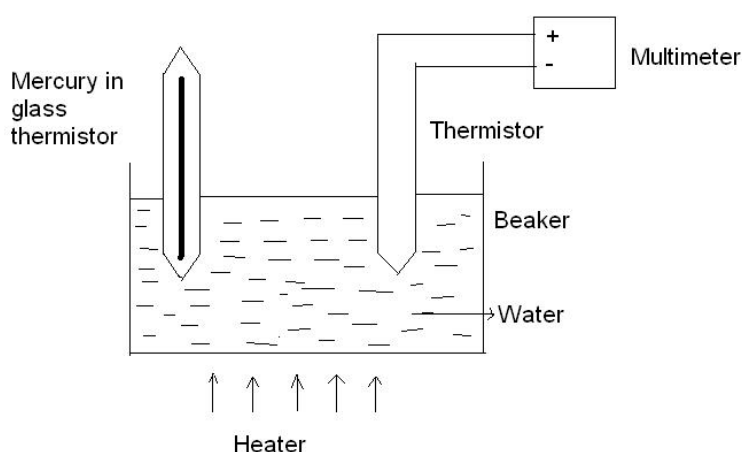
14.5 Procedure:

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.

14.6 Tabular column:

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

14.7 Model graph:
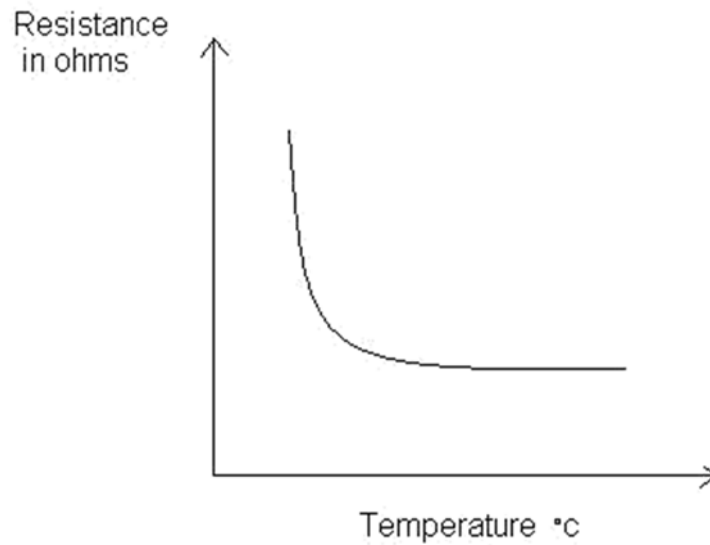
14.8 Result:

Thus the given thermistor characteristics were measured and verified.

14.9 Pre Lab questions:

1. What is meant by temperature sensor and what are the types of temperature sensors

2. What is meant by positive and negative temperature co- efficient of resistance?

3. Give the differences between active and passive transducers?

4. What is a thermistor and how it is made?

14.10 Post Lab Questions:

1.   List the applications of thermistors?

2.   Compare thermistor with RTD and thermocouple.

3.   Thermistor is a passive transducer? Justify.