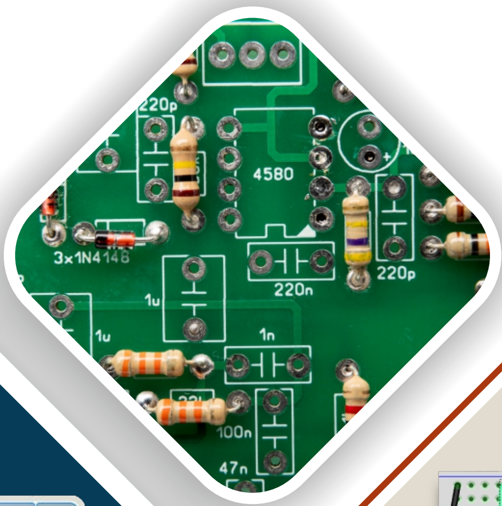
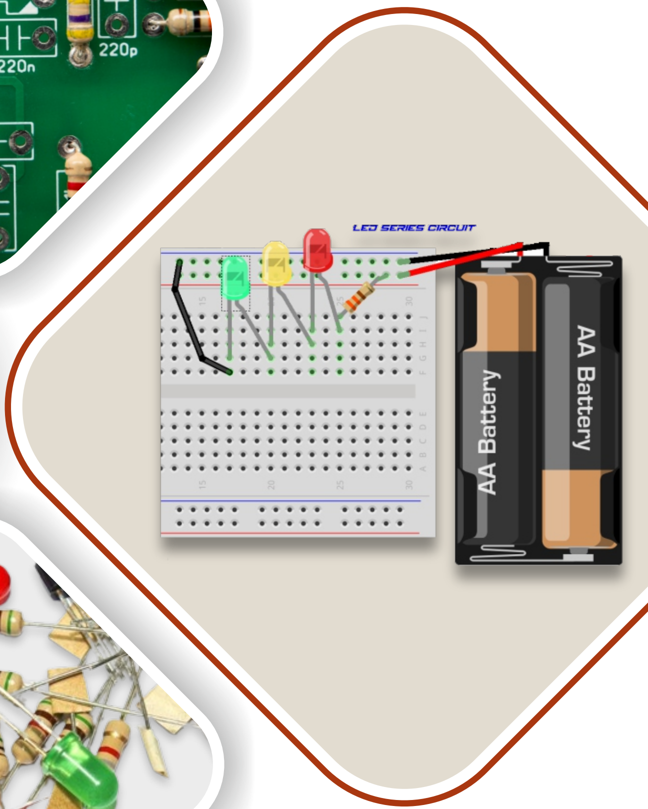
SCHEME : K

Name : ____________________________________
Roll No. : ________________ Year : 20___ 20___
Exam Seat No. : ____________________________

LABORATORY MANUAL FOR
ELEMENTS OF ELECTRONICS
(312309)





ELECTRICAL ENGINEERING GROUP

MAHARASHTRA STATE BOARD OF TECHNICAL EDUCATION, MUMBAI
(Autonomous) (ISO 9001: 2015) (ISO/IEC 27001:2013)

A Laboratory Manual for

Elements of Electronics

(312309)

Semester-II

(EE/EP)

Maharashtra State

Board of Technical Education, Mumbai

(Autonomous) (ISO 9001:2015) (ISO/IEC 27001:2013)

Maharashtra State Board of Technical Education,
(Autonomous) (ISO 9001 : 2015) (ISO/IEC 27001 : 2013)
4th Floor, Government Polytechnic Building, 49, Kherwadi,
Bandra (East), Mumbai - 400051.
(Printed on December, 2017)

MAHARASHTRA STATE

BOARD OF TECHNICAL EDUCATION

Certificate

This is to certify that Mr. / Ms. ....Roll No. ………., of Second Semester of Diploma in………………… ……………………..………… of Institute,……………..……………………… ……………… (Code: …………...) has completed the term work satisfactorily in Subject **Elements of Electronics (312309)** for the academic year 20…….. to 20… as prescribed in the curriculum.

Place: …………… Enrollment No: …………….

Date: …………… Exam. Seat No: ……………

Subject Teacher **Head of the Department** **Principal**

Seal of Institution

Preface

The primary focus of any engineering laboratory/field work in the technical education system is to develop the much needed industry relevant competencies and skills. With this in view, MSBTE embarked on this innovative ‘K’ Scheme curricula for engineering diploma programmes with outcome-based education as the focus and accordingly, relatively large amount of time is allotted for the practical work. This displays the great importance of laboratory work making each teacher; instructor and student to realize that every minute of the laboratory time need to be effectively utilized to develop these outcomes, rather than doing other mundane activities. Therefore, for the successful implementation of this outcome-based curriculum, every practical has been designed to serve as a ‘vehicle’ to develop this industry identified competency in every student. The practical skills are difficult to develop through ‘chalk and duster’ activity in the classroom situation. Accordingly, the ‘K’ scheme laboratory manual development team designed the practical to focus on the outcomes, rather than the traditional age old practice of conducting practical to ‘verify the theory’ (which may become a byproduct along the way).

This laboratory manual is designed to help all stakeholders, especially the students, teachers and instructors to develop in the student the pre-determined outcomes. It is expected from each student that at least a day in advance, they have to thoroughly read through the concerned practical procedure that they will do the next day and understand the minimum theoretical background associated with the practical. Every practical in this manual begins by identifying the competency, industry relevant skills, course outcomes and practical outcomes which serve as a key focal point for doing the practical. The students will then become aware about the skills they will achieve through procedure shown there and necessary precautions to be taken, which will help them to apply in solving real-world problems in their professional life.

This manual also provides guidelines to teachers and instructors to effectively facilitate student-centered lab activities through each practical exercise by arranging and managing necessary resources in order that the students follow the procedures and precautions systematically ensuring the achievement of outcomes in the students.

Elements of Electronics course provides a platform for students to understand working of active components such as Diode, BJT, MOSFET, JFET and circuits likerectifier, oscillator, regulators and digital electronics circuits. It is one of the foundation course, which is required for students to understand working of complex electronic circuits and systems suitable in electrical engineering applications. It also gives information about rectifiers, filters, different oscillator circuits, voltage regulator and digital circuits with their applications for effective functioning in the field of electrical engineering.

Although best possible care has been taken to check for errors (if any) in this laboratory manual, perfection may elude us as this is the first edition of this manual. Any errors and suggestions for improvement are solicited and highly welcome.

Programme Outcomes (POs) to be achieved through Practical

Following programme outcomes are expected to be achieved through the practical of the course:

PO1. **Basic and Discipline specific knowledge:** Apply knowledge of basic mathematics, science and engineering fundamentals and engineering specialization to solve the engineering problems.

PO2. **Problem analysis:** Identify and analyse well-defined engineering problems using codified standard methods.

PO3. **Design/ development of solutions:** Design solutions for well-defined technical problems and assist with the design of systems components or processes to meet specified needs.

PO4. **Engineering Tools, Experimentation and Testing:** Apply modern engineering tools and appropriate technique to conduct standard tests and measurements.

PO5. **Engineering practices for society, sustainability and environment:** Apply appropriate technology in context of society, sustainability, environment and ethical practices.

PO6. **Project Management:** Use engineering management principles individually, as a team member or a leader to manage projects and effectively communicate about well-defined engineering activities.

PO7. **Life-long learning:** Ability to analyse individual needs and engage in updating in the context of technological changes.

List Relevant Skills

The following industry relevant skill of the competency "**Use electronic components and circuits in electrical equipment and systems**" are expected to be developed in the student byundertaking the practical of this laboratory manual.

1. Identify the electronic component.
2. Test electronic component
3. Select the electronic component of proper value as per the requirement.
4. Mount the electronic component on breadboard as per circuit diagram.
5. Test the circuit for the given application.
6. Compare the observed output with the expected output.
7. Find faults and trouble shoot the given circuit.

Practical- Course Outcome matrix

	Course Outcomes (COs): CO1 - Identify various electronic components CO2 - Use semiconductor diodes in different applications. CO3 - Use semiconductor transistors in different applications. CO4 - Use different types of Oscillators as per requirement CO5 - Test operation of regulated power supply.					
S. No.	**Practical Outcome**	**CO 1.**	**CO 2.**	**CO 3.**	**CO 4.**	**CO 5.**
1.	Identification of Active and Passive Components and DMM handling	√	-	-	-	-
2.	Measurement of amplitude, time period and frequency of given signal on CRO	√	-	-	-	-
3.	Check the performance of PN Junction diode	-	√	-	-	-
4.	Check performance of Zener diode	-	√	-	-	-
5.	Test the performance of photo diode by varying the light intensity as well as the distance of the light source	-	√	-	-	-
6.	Construct and Test the half wave rectifier	-	√	-	-	-
7.	Prepare and Test the half wave rectifier with LC filter/ π filter.	-	√	-	-	-
8.	Build and Test the full wave rectifier using two diodes	-	√	-	-	-
9.	Construct and Test the full wave Bridge rectifier on bread board using four diodes	-	√	-	-	-
10.	Use LC/ π filter with full wave rectifier to measure ripple factor	-	√	-	-	-
11.	Prepare and Test the full wave rectifier on bread board using IC KBU 808 with filter.	-	√	-	-	-
12.	Build clipper circuit and observe the waveforms.	-	√	-	-	-
13.	Construct clamper circuit and observe waveforms	-	√	-	-	-
14.	Identify and select transistors for given application using datasheets	-	-	√	-	-
15.	Build and Test the performance of BJT in CB mode	-	-	√	-	-

16.	Construct and test the circuit for BJT in common emitter configuration	-	-	√	-	-
17.	Test the performance parameters of BJT as Switch	-	-	√	-	-
18.	Check the performance of FET drain Characteristics	-	-	√	-	-
19.	Test the performance of FET transfer characteristics and calculate transconductance	-	-	√	-	-
20.	Measure the frequency of given Oscillator Circuit	-	-	-	√	-
21.	Find out faults at different stages of regulated DC power supply	-	-	-	-	√
22.	Trouble shoot given DC regulated power Supply	-	-	-	-	√
23.	Build and Test the performance of Zener voltage regulator for given voltage	-	-	-	-	√
24.	Construct and Test the performance of Positive voltage regulator using 78XX , three terminal IC for given voltage.	-	-	-	-	√
25.	Prepare and Test the performance of Dual voltage regulator using 78XX and 79XX ,three terminal IC for given voltage.	-	-	-	-	√
26.	Test the performance of IC 723 as Regulator.	-	-	-	-	√

Guidelines to Teachers

1. Teacher should provide the guideline with demonstration of practical to the students with all features.
2. Teacher shall explain prior concepts to the students before starting of each practical
3. Involve students in performance of each experiment.
4. Teacher should ensure that the respective skills and competencies are developed in the students after the completion of the practical exercise.
5. Teachers should give opportunity to students for hands on experience after the demonstration.
6. Teacher is expected to share the skills and competencies to be developed in the students.
7. Teacher may provide additional knowledge and skills to the students even though not covered in the manual but are expected the students by the industry.
8. Finally give practical assignment and assess the performance of students based on task assigned to check whether it is as per the instructions.
9. If practical is in two parts -Part I and Part II it should be conducted in two weeks.
10. Teacher is expected to refer complete curriculum document and follow guidelines for implementation.

Instructions for Students

1. Listen carefully the lecture given by teacher about course, curriculum, learning structure, skills to be developed.
2. Organize the work in the group and make record of all observations.
3. Students shall develop maintenance skill as expected by industries.
4. Student shall attempt to develop related hand-on skills and gain confidence.
5. Student shall develop the habits of evolving more ideas, innovations, skills etc. those included in scope of manual
6. Student shall refer technical magazines, IS codes and data books.
7. Student should develop habit to submit the practical on date and time.
8. Student should well prepare while submitting write-up of exercise

Content Page

List of Practical's and Formative Assessment Sheet

Sr. No	Practical Outcome	PageNo.	Date of performance	Date of submission	Assessment marks(25)	Dated sign. of teacher	Remarks (if any)
1.	Identification of Active and Passive components and DMM handling.	1					
2.	Measurement of amplitude, time period and frequency of given signal on CRO	7					
3.	Check the performance of PN Junction diode.	15					
4.	Check performance of Zener diode.	24					
5.	Test the performance of photo diode by varying the light intensity as well as the distance of the light source.	34					
6.	Construct and Test the half wave rectifier.	44					
7.	Prepare and Test the half wave rectifier with LC filter/ π filter	52					
8.	Build and Test the full wave rectifier using two diodes	60					
9.	Construct and Test the full wave Bridge rectifier on bread board using four diodes	68					
10.	Use LC/ π filter with full wave rectifier to measure ripple factor.	75					
11.	Prepare and Test the full wave rectifier on bread board using IC KBU 808 with filter.	83					
12.	Build clipper circuit and observe the waveforms.	88					
13.	Construct clamper circuit and observe waveforms.	95					
14.	Identify and select transistors for given application using datasheets	103					
15.	Build and Test the performance of BJT in CB mode	110					
16.	Construct and test the circuit for BJT in common emitter configuration.	119					
17.	Test the performance parameters of BJT as Switch	127					
18.	Check the performance of FET drain Characteristics	135					

19.	Test the performance of FET transfer characteristics and calculate transconductance	144					
20.	Measure the frequency of given Oscillator circuit	152					
21.	Find out faults at different stages of regulated DC power supply	161					
22.	Trouble shoot given DC regulated power supply	166					
23.	Build and Test the performance of Zener voltage regulator for given voltage	172					
24.	Construct and Test the performance of Positive voltage regulator using 78XX , three terminal IC for given voltage	181					
25.	Prepare and Test the performance of Dual voltage regulator using 78XX and 79XX ,three terminal IC for given voltage	189					
26.	Test the performance of IC 723 as Regulator	198					
Total							

- To be transferred to Proforma of CIAAN-2022

Practical No.1: Identification of Active and Passive components and DMM handling

I Practical Significance

In industries, to build any hardware, it is necessary to identify electronic component, their terminals, ratings and packaging. Depending on application appropriate components need to be selected for better performance. In this practical student will identify active and passive electronic components on the basis of physical verification and basic knowledge about the components. Multimeter is used to verify the component ratings.

II Industry / Employer Expected Outcome

This practical is expected to develop the following skill: '**Use electronic components and circuits in electrical equipment and systems**'.

III Course Level Learning Outcome

Identify electronic components used electronic circuits.

IV Laboratory Learning Outcomes

To identify active and passive electronic components in a given circuit

1. Identify active and passive components in given circuit.
2. Measure the rating of given resistors on Digital Multimeter (DMM).
3. Test Diode and LED on Digital Multimeter.

V Relevant Affective Domain related Outcomes

1. Handle components and instruments with care.
2. Work in team.

VI Minimum Theoretical Background

Passive Component: The device or component which do not require external source for their operation are called Passive Component. A passive component does not provide any power gain to a circuit.

Example: Resistor, Capacitor and Inductor.

Active Component: The device or components which required external source for their operation are called Active Component. An active component may provide power gain to a circuit.

Example: Diode, Transistor and Integrated Circuit (IC).

VII Practical setup in Laboratory

(a) Sample

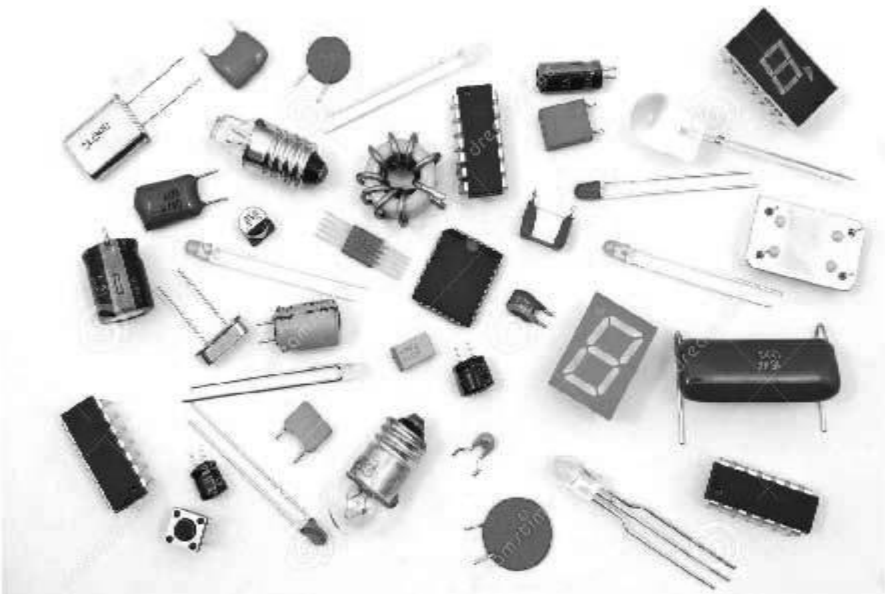


Figure 1.1: Active Components and Passive Components

Figure 1.2: Digital Multimeter (DMM) for component testing

(b) Actual setup used in Laboratory

VIII Required Resources/apparatus/equipment with specifications

Sr. No	Instruments/Components	Specification	Quantity
1	Multimeter	3 ½ -digit display with AC and DC voltage measurement and Current measurement facility and Diode testing facility.	1
2	Electronic Components	Resistor, Capacitor, Inductor, PN junction diode, Zener diode, LED, BJT, FET, Integrated circuit.	Asp per requirement

IX Precautions to be followed

1. Care should be taken while handling terminals of components.
2. Select proper range and mode of ammeter and voltmeter.
3. Connect probes of measuring instrument tightly to terminals of a component.

X Procedure

A) Component Identification:

1. Identify each terminal of the given component.
2. Select the proper range and position of various knobs of multimeter to test the given component.
3. Observe the value of the given component on the multimeter meter.
4. Compare the obtained value with its theoretical value.

B) Resistance measurement:

1. Set DMM range switch to Ω meter.
2. Connect the probes to the two leads of the resistor.
3. The value indicated on the display is measured as the value of resistor.
4. Compare the value with colour code value of resistor.

C) Capacitance measurement:

1. Set DMM on correct range of capacitance.
2. Measure the value of capacitor inserting capacitor in appropriate volt provided on meter.

D) Diode testing:

1. Set DMM range switch to Ω meter.
2. Connect the positive lead to the anode and negative lead to cathode. Note forward resistance of diode.
3. Reverse the polarity of diode and note down reverse resistance of diode.

E) Transistor testing:

1. Set DMM range switch to hfe range.
2. Identify the lead of transistor in hfe socket which labeled as E.B.C.
3. Note the value indicated on display.

XI Observation Table

Table 1: Measure Value of Passive component

Component	Measured Value	Theoretical Value
1) Resistor	**1)** **2)** **3)**	
2) Inductor	**1)** **2)** **3)**	
3) Capacitor	**1)** **2)** **3)**	

Table 2: Measure Value of Active component

Diode Type	Forward Resistance	Reverse Resistance
1N4001		
By126		
Transistor Type	**Maximum DC power gain (hfe)**	
BC148 (NPN)		
BC157 (PNP)		

XII Result

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XIII Interpretation of results

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XIV Conclusions and recommendation

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XV Practical related Questions

1. Sketch the given components and label them.
2. Specify the multimeter range suitable for measuring a 10KΩ resistor.
3. Give stepwise procedure to test continuity of wire with the help of multimeter.

[Space for answers]

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XVI References / Suggestions for further Reading

1. https://www.youtube.com/watch?v=81o8OYPK5TQ
2. https://www.youtube.com/watch?v=fEP6fgy_Cio
3. https://www.youtube.com/watch?v=9hE6Ua68XdE

XVII Assessment Scheme

	Performance Indicators	Weightage
Process related (15 Marks)		**60%**
1	Handling of the components	10%
2	Identification of component	20%
3	Measuring value using suitable instrument	20%
4	Working in team	10%
Product related (10 Marks)		**40%**
1	Calculate theoretical values of given component	10%
2	Interpretation of result	05 %
3	Conclusions	05 %
4	Practical related questions	15 %
5	Submitting the journal in time	05%
	Total (25 Marks)	**100%**

Names of Student Team Members

1. ....
2. ....
3. ....
4. ....

Marks Obtained			Dated Signature of Teacher
Process Related(15)	**Product Related(10)**	**Total (25)**	

Practical No.2: Measurement of amplitude, time period and frequency of given signal on CRO

I Practical Significance

In industries, for manufacture and maintenance of electronic circuits, measurement / testing are a prime requirement. The various parameters are to be tested with utmost accuracy and precision. For this purpose, testing instruments like CRO are used. Through this practical, student will be able to handle CRO efficiently for measuring amplitude, time period and frequency of a given input

II Industry / Employer Expected Outcome

This practical is expected to develop the following skill for the industry: '**Use electronic components and circuits in electrical equipment'.**

III Course Level Learning Outcome

This practical is a prerequisite to achieve various course outcomes.

IV Laboratory Learning Outcome

Measure amplitude, time period and frequency of given signal on CRO

V Relevant Affective Domain related Outcomes

1. Handle equipment carefully.
2. Follow safety practices.

VI Minimum Theoretical Background

CRO: A Cathode Ray Oscilloscope is a type of electronic and measuring instrument that allows observation of constantly varying signal voltages, usually as a two-dimensional plot of one or more signals as a function of time. Other signals (such as Temperature/sound or vibration) can be converted to voltages and displayed.

A graticule with a 1 cm grid enables one to take measurements of voltage and time from the screen. The graph, usually called the trace, is drawn by a beam of electrons striking the phosphor coating of the screen making it emit light, usually green or blue.

Oscilloscopes use high voltages to create the electron beam and these remain same time after switching off. For your own safety do not attempt to examine the inside of an oscilloscope, An Oscilloscope is a test instrument which allows observing the shape of the electrical signals by displaying the graph of voltage against time on its screen.

Signal generator:

A Signal generator is electronic test equipment used to generate different types of waveforms over a wide range of frequencies. Signal generators are capable of producing the following types of repetitive waveforms as shown in figure 2.1 and 2.2

Sine wave:

A Signal generator will normally have the capability to produce a standard Sine wave output. This is the standard waveform that oscillates between two levels with a standard sinusoidal shape.

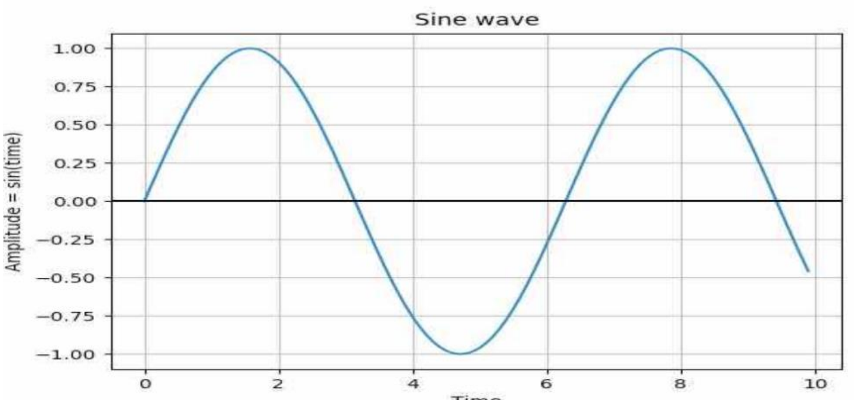

Figure 2.1: Sine Wave

Square wave:

A square wave consists of a high and low level.

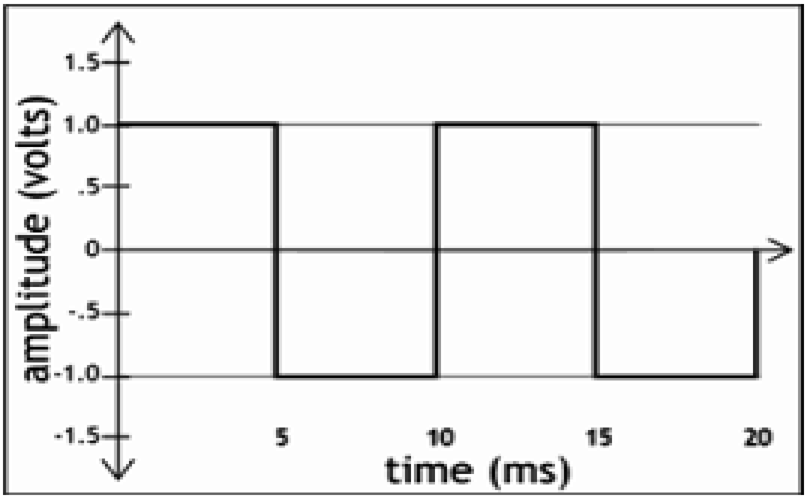

Figure 2.2: Square Wave

VII Practical setup in Laboratory

(a)Sample

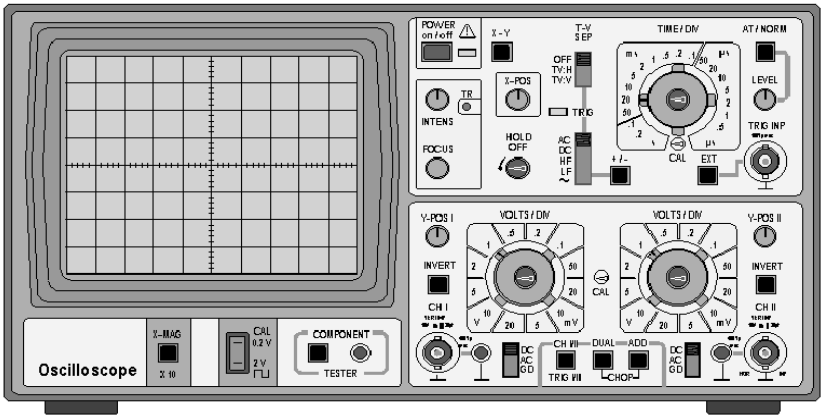

Figure 2.3: Front Panel of CRO

Figure 2.4: Front Panel of Function Generator

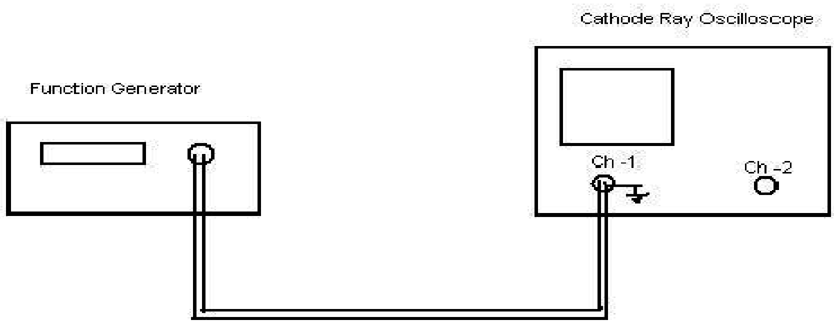

Figure 2.5: Connecting Function Generator to CRO

(b) Actual setup used in Laboratory

VIII Required Resources/apparatus/equipment with specifications

Sr. No	Instruments/Components	Specification	Quantity
1	CRO	0-20MHz, Dual trace	1
2	Function Generator	0-1 MHz	1
3	Connecting wires	Banana plugs	4

IX Precautions to be followed

1. An Oscilloscope should be handled gently to protect its fragile vacuum tube.
2. Never advance the Intensity control so far that an excessively bright spot appears. Bright spots imply burning of the screen. A sharp focused spot of high intensity (great brightness) should never be allowed to remain fixed in one position on the screen for any length of time. It may cause damage to the screen.

X Procedure

Sine Wave

A) Measurement of Amplitude:

1. Make the connections as per the figure 2.5
2. Put the CRO on a single channel mode and bring the CRO into operation by adjusting the trace of the beam to a normal brightness and into a thin line.
3. Now apply the sinusoidal wave of different amplitudes by using signal generator.
4. Note down the vertical division scale.

B) Measurement of Frequency:

1. Make the connections as per the figure 2.5
2. Put the CRO on a single channel mode and bring the CRO into operation by adjusting the trace of the beam to a normal brightness and into a thin line.
3. Now apply the sinusoidal wave of different frequencies by using signal generator.
4. Note down the horizontal division scale by observing difference between the two successive peaks of the waveform.

Square Wave:

A) Measurement of Amplitude:

1. Make the connections as per the figure 2.5
2. Put the CRO on a single channel mode and bring the CRO into operation by adjusting the trace of the beam to a normal brightness and into a thin line.
3. Now apply the square wave of different amplitudes by using signal generator.
4. Note down the vertical division scale.

B) Measurement of Frequency

1. Make the connections as per the figure 2.5
2. Put the CRO on a single channel mode and bring the CRO into operation by adjusting the trace of the beam to a normal brightness and into a thin line.
3. Now apply the square wave of different frequencies by using signal generator.
4. Note down the horizontal division scale by observing difference between the positive transitions of two successive waveforms.

XI Observation Table

Table 1: Measure Value Sine and Square Waveform

Signal	Vertical Division (cm)	Volts/div (v)	Amplitude (v)	Horizontal division (cm)	Time / div (s)	Time period (s)	Frequency (1/T) (Hz)
Sine Waveform							
Square Waveform							

XII Result

1. Amplitude of Sine Wave is…………………………………….
2. Amplitude of Square Wave is ………………………………
3. Frequency of Sine Wave is…………………………………….
4. Frequency of Square Wave is ………………………………

XIII Interpretation of results

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XIV Conclusions and recommendation

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XV Practical related Questions

1. State maximum frequency and voltage measurement capacities of the oscilloscope in your laboratory.
2. State procedure to measure voltage exceeding the voltage limit of the CRO.
3. Write the function of AC/DC input coupling push-button switch on CRO.
4. If time period of sine wave is 1*m*S, calculate the frequency.

[Space for answers]

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XVI References / Suggestions for further Reading

1. https://www.youtube.com/watch?v=Lanpw4Ry8xc
2. https://www.youtube.com/watch?v=kh-oIlf4e3Y
3. https://www.youtube.com/watch?v=yQiYDGVUHgA

XVII Assessment Scheme

Performance Indicators		Weightage
Process related (15 Marks)		**60%**
1	Proper connection of electrical circuit and Handling of instrument	20%
2	Taking proper readings	20%
3	Calculation of amplitude and frequency.	20%
Product related (10 Marks)		**40%**
1	Interpretation of Result & conclusion	20%
2	Practical related questions	10%
3	Completion and submission of experiment in time	10%
	Total (25 Marks)	**100%**

Names of Student Team Members

1. ....
2. ....
3. ....
4. ....

Marks Obtained			**Dated Signature of Teacher**
Process Related(15)	**Product Related(l0)**	**Total (25)**	

Practical No.3: Check the performance of PN Junction diode

I Practical Significance

PN Junction diode is used in industries as well as in domestic applications such as current protection circuits, wave shaping circuits and in rectifier of DC Power Supplies. For these applications diode selection plays a vital role. In this practical, students will draw V-1 characteristics of the given diode to understand diode behavior with respect to change in applied voltage.

II Industry / Employer Expected Outcome

This practical is expected to develop the following skill: **'Use electronics components and circuits in electrical equipment.'**

III Course Level Learning Outcome

Use semiconductor diodes in different applications.

IV Laboratory Learning Outcomes

Test V-I characteristics of PN Junction diode to:

1. Check PN junction Diode in forward bias.
2. Plot the V-I characteristics of PN junction diode and determine cut-in voltage.

V Relevant Affective Domain related Outcome

Handle components and equipment carefully.

VI Minimum Theoretical Background

A PN Junction Diode is one of the simplest semiconductor devices, and it has the characteristic of passing current in one direction only. If a suitable positive voltage (forward bias) is applied between the two ends of the PN junction, it can supply free electrons and holes with the extra energy they require to cross the junction, as the width of the depletion layer around the PN junction is decreased.

Static resistance (R_S) of a PN junction diode is a ratio of forward voltage (V_F) to the forward current (I_F).

$R_s = V_F/I_F$ Where, R_S =Static resistance of the component

Dynamic resistance (R_d) of a PN junction diode is a ratio of small change in forward voltage ($\blacktriangle V_F$) to small change in forward current ($\blacktriangle I_F$).

$R_d = (\blacktriangle V_F) / (\blacktriangle I_F)$ Where, R_d =Static resistance of the component

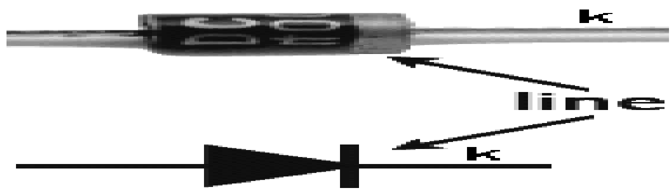

Figure 3.1: Diode and its symbol

VII Practical setup in Laboratory

(a) Sample

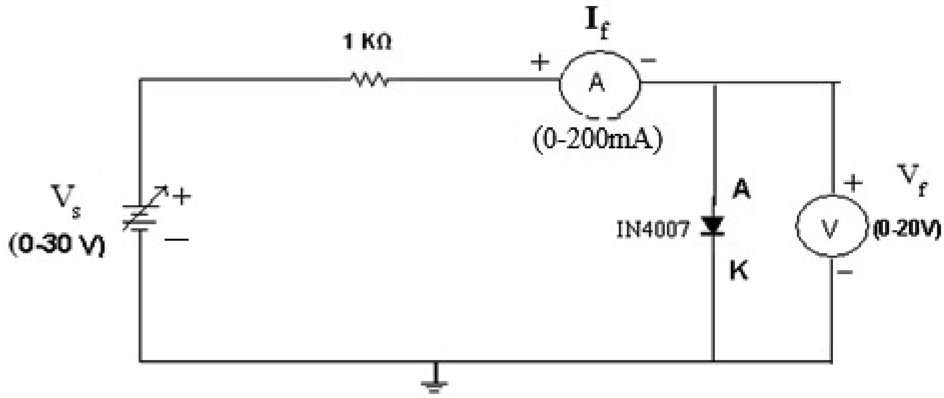

Figure 3.2: Circuit diagram of diode in forward

(b) Actual circuit diagram used in Laboratory

(c) Actual practical set up used in Laboratory

VIII Required Resources/apparatus/equipment with specifications

Sr. No	Instruments/Components	Specification	Quantity
1.	Multimeter	3 ½ -digit display with AC and DC voltage measurement and Current measurement facility and Diode testing facility.	1
2.	DC Regulated power supply	Variable DC power supply 0- 30V, 2A, SC protection, display for voltage and current.	1
3.	DC Voltmeter	0-20 V	1
4.	DC Ammeter	0 - 200 mA	1
5..	Diode	IN4007(or any another equivalent diode)	1
6.	Resistor	1KΩ(0.5watts/0.25watts)	1
7.	Bread board	5.5 CMX 17CM	1
8.	Connecting wires	Single strand Teflon coating (0.6mm diameter)	As per requirement

IX Precautions to be followed

1. Do not switch ON the power supply unless you have checked the circuit connections as per the circuit diagram.
2. Connect voltmeter and ammeter with correct polarities as shown in the circuit diagram.
3. Connect voltmeter and ammeter with correct polarities as shown in the circuit diagram

X Procedure

1. Connect the circuit as shown in figure 3.2
2. Switch ON the power supply.
3. Record the voltage V_F and current I_F in the observation table
4. Increase the input voltage in step of 0.l V
5. Again, record the voltage V_F and current I_F in the observation table.
6. Repeat steps 4 to 5 till input voltage is reached to 1V.
7. Plot the graph for the forward bias characteristics of diode by taking V_F on X-axis and I_F on Y- axis.
8. Calculate the static resistance at a particular point, on the characteristics.
9. Considering two points on the plotted graph, calculate dynamic resistance.

XI Observation Table

Table 1: Measurement of V_F and I_F

Sr. No.	V_F (volts)	I_F (mA)
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		

Calculations:

Calculate static resistance at particular point

$R_S = V_F \; / \; I_F$ where, R_S =Static resistance of the component

Calculate dynamic resistance

$R_d = \Delta V_F \; / \; \Delta I$ where, Rd =Dynamic resistance of the component

XII Results

1. Static resistance of given diode= ....
2. Dynamic Resistance of given diode =.......................
3. Knee Voltage of given diode=...................................

XIII Interpretation of results

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XIV Conclusions and Recommendation

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XV Practical related Questions

1. List important specification of diode.
2. Find out the voltage across silicon diode at knee voltage.
3. Find out the voltage across germanium diode at knee voltage.
4. If in reverse biased condition input voltage across the diode in increases then what is the effect on electric field of diode?

[Space for answers]

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XVI References / Suggestions for further Reading

1. https://www.youtube.com/watch?v=Fwj_d3uO5g8
2. https://www.youtube.com/watch?v=qu9reCzzrco
3. https://www.youtube.com/watch?v=Nds6Qrd6k40

XVII Assessment Scheme

Performance Indicators		Weightage
Process related (15 Marks)		**60%**
1	Proper connection of electrical circuit	20%
2	Handling of instrument	10%
3	Taking proper readings	20%
4	Working in team.	10%
Product related (10 Marks)		**40%**
1	Calculate theoretical value of given component.	10%
2	Interpretation of Result & conclusion	05%
3	Practical related questions	15%
4	Completion and submission of experiment in time	10%
	Total (25 Marks)	**100%**

Names of Student Team Members

1. ....
2. ....
3. ....
4. ....

Marks Obtained			**Dated Signature of Teacher**
Process Related(15)	**Product Related(l0)**	**Total (25)**	

1N4001, 1N4002, 1N4003, 1N4004, 1N4005, 1N4006, 1N4007

www.vishay.com

Vishay General Semiconductor

General Purpose Plastic Rectifier

DO-41 (DO-204AL)

FEATURES

- Low forward voltage drop
- Low leakage current
- High forward surge capability
- Solder dip 275 °C max. 10 s, per JESD 22-B106
- Material categorization: for definitions of compliance please see www.vishay.com/doc?99912

RoHS COMPLIANT

PRIMARY CHARACTERISTICS	
$I_{F(AV)}$	1.0 A
V_{RRM}	50 V, 100 V, 200 V, 400 V, 600 V, 800 V, 1000 V
I_{FSM} (8.3 ms sine-wave)	30 A
I_{FSM} (square wave t_p = 1 ms)	45 A
V_F	1.1 V
I_R	5.0 μA
T_J max.	150 °C
Package	DO-41 (DO-204AL)
Circuit configuration	Single

TYPICAL APPLICATIONS

For use in general purpose rectification of power supplies, inverters, converters, and freewheeling diodes application.

MECHANICAL DATA

Case: DO-41 (DO-204AL), molded epoxy body
Molding compound meets UL 94 V-0 flammability rating
Base P/N-E3 - RoHS-compliant, commercial grade

Terminals: matte tin plated leads, solderable per J-STD-002 and JESD 22-B102
E3 suffix meets JESD 201 class 1A whisker test

Polarity: color band denotes cathode end

MAXIMUM RATINGS (T_A = 25 °C unless otherwise noted)

PARAMETER	SYMBOL	1N4001	1N4002	1N4003	1N4004	1N4005	1N4006	1N4007	UNIT
Maximum repetitive peak reverse voltage	V_{RRM}	50	100	200	400	600	800	1000	V
Maximum RMS voltage	V_{RMS}	35	70	140	280	420	560	700	V
Maximum DC blocking voltage	V_{DC}	50	100	200	400	600	800	1000	V
Maximum average forward rectified current 0.375" (9.5 mm) lead length at T_A = 75 °C	$I_{F(AV)}$	1.0							A
Peak forward surge current 8.3 ms single half sine-wave superimposed on rated load	I_{FSM}	30							A
Non-repetitive peak forward surge current square waveform T_A = 25 °C (fig. 3), t_p = 1 ms	I_{FSM}	45							A
t_p = 2 ms		35							
t_p = 5 ms		30							
Maximum full load reverse current, full cycle average 0.375" (9.5 mm) lead length T_L = 75 °C	$I_{R(AV)}$	30							μA
Rating for fusing (t < 8.3 ms)	I^2t (1)	3.7							A^2s
Operating junction and storage temperature range	T_J, T_{STG}	-50 to +150							°C

Note

(1) For device using on bridge rectifier application

1N4001, 1N4002, 1N4003, 1N4004, 1N4005, 1N4006, 1N4007

VISHAY www.vishay.com

Vishay General Semiconductor

ELECTRICAL CHARACTERISTICS (T_A = 25 °C unless otherwise noted)											
PARAMETER	TEST CONDITIONS		SYMBOL	1N4001	1N4002	1N4003	1N4004	1N4005	1N4006	1N4007	UNIT
Maximum instantaneous forward voltage	1.0 A		V_F	1.1							V
Maximum DC reverse current at rated DC blocking voltage		T_A = 25 °C	I_R	5.0							μA
		T_A = 125 °C		50							
Typical junction capacitance	4.0 V, 1 MHz		C_J	15							pF

THERMAL CHARACTERISTICS (T_A = 25 °C unless otherwise noted)									
PARAMETER	SYMBOL	1N4001	1N4002	1N4003	1N4004	1N4005	1N4006	1N4007	UNIT
Typical thermal resistance	$R_{\theta JA}$ [(1)]	50							°C/W
	$R_{\theta JL}$ [(1)]	25							

Note

(1) Thermal resistance from junction to ambient at 0.375" (9.5 mm) lead length, PCB mounted

ORDERING INFORMATION (Example)				
PREFERRED P/N	UNIT WEIGHT (g)	PREFERRED PACKAGE CODE	BASE QUANTITY	DELIVERY MODE
1N4004-E3/54	0.33	54	5500	13" diameter paper tape and reel
1N4004-E3/73	0.33	73	3000	Ammo pack packaging

RATINGS AND CHARACTERISTICS CURVES (T_A = 25 °C unless otherwise noted)

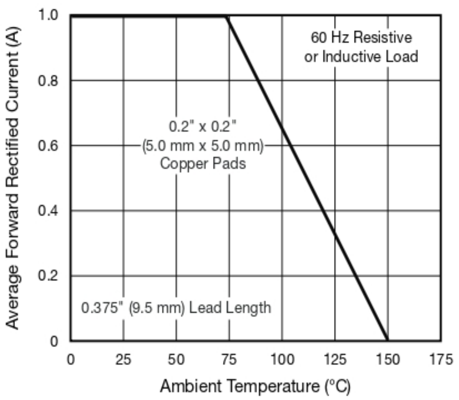

Fig. 1 - Forward Current Derating Curve

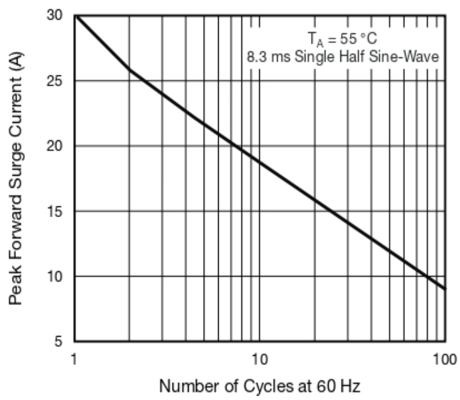

Fig. 2 - Maximum Non-repetitive Peak Forward Surge Current

Scale
X-axis

Y-axis

Practical No.4: Check performance of Zener diode

I Practical Significance

In industries, Zener diode is widely used as voltage references and as shunt regulators to regulate the voltage across circuits. Zener diodes are also used in over voltage protection circuits and switching applications. Zener diode is suitable for surge suppression circuits, for device protection, for clipping, clamping circuits and especially as peak clippers.

II Industry / Employer Expected Outcome

This practical is expected to develop the following skill: **'Use electronics components and circuits in electrical equipment'.**

III Course Level Learning Outcome

Use relevant diode in different electronic circuits.

IV Laboratory Learning Outcome

Check the performance of Zener diode in forward and reverse biasing.

V Relevant Affective Domain related Outcomes

Handle components and equipment carefully.

VI Minimum Theoretical Background

Zener diode is formed by combining highly doped P and N semiconductor materials. It works on the principle of Zener breakdown and is normally operated in reverse breakdown region. In reverse breakdown region, high current flow through the diode leading to high power dissipation.

The Zener breakdown occurs when the electric field across the junction produced due to the reverse voltage is sufficiently high, this breaks covalent bonds. Thus, large numbers of carriers are generated which causes a more current to flow. This mechanism is called as Zener breakdown. After Zener breakdown the reverse current increases sharply. Zener resistance of a Zener diode is a ratio of reverse Zener voltage to the reverse Zener current.

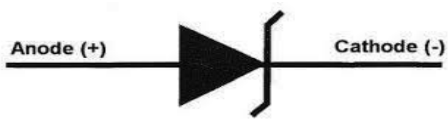

Figure 4.1: Symbol of Zener diode

VII Practical setup in Laboratory

(a) Sample

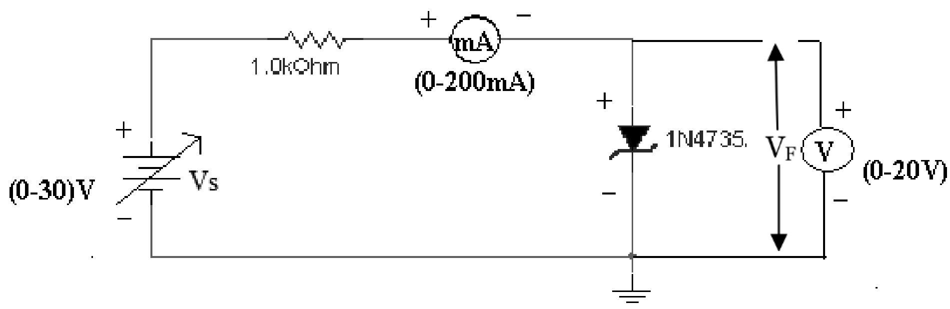

Figure 4.2: Zener diode in forward bias

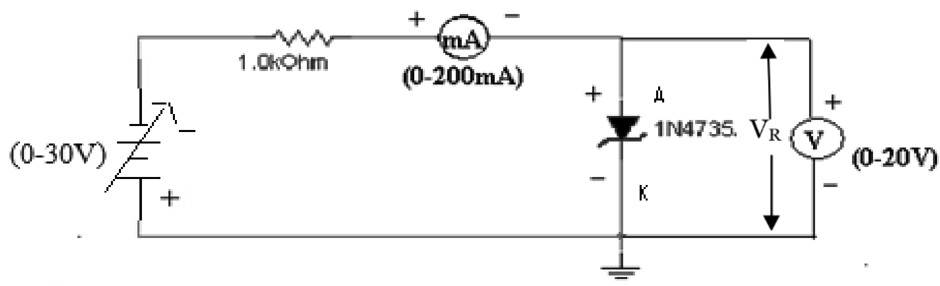

Figure 4.3: Zener diode in reverse bias

(b) Actual Circuit Diagram used in Laboratory

(c) Actual Experimental set up used in Laboratory

VIII Required Resources/apparatus/equipment with specifications

Sr. No	**Instruments/Components**	**Specification**	**Quantity**
1.	Multimeter	3 ½ -digit display with AC and DC voltage measurement and Current measurement facility and Diode testing facility.	1
2.	DC Regulated power supply	Variable DC power supply 0- 30V, 2A, SC protection, display for voltage and current.	1
3.	DC Voltmeter	0-20 V	1
4.	DC Ammeter	0 - 200 mA	1
5.	Bread board	5.5CM X 17CM	1
6.	Diode	1N4735 (or any another equivalent diode)	1
7.	Resistor	1KΩ (0.5watts/0.25watts)	1
8.	Connecting wires	Single strand Teflon coating (0.6mm diameter)	As per requirement

IX Precautions to be followed

1. Do not switch ON the power supply unless you have checked circuit connections as in figure 4.2
2. While doing the practical do not exceed the input voltage of the diode beyond the rated voltage of diode as given in datasheet. This may lead to damaging of the diode Connect the circuit as in figure 4.2
3. Connect voltmeter and ammeter with correct polarities as shown in the circuit diagram

X Procedure

1. Connect the circuit as in figure 4.2
2. Switch ON the power supply.
3. Record the voltage V_F and current I_F in the observation table
4. Increase the input voltage in step of 0.l V
5. Again, record the voltage V_F and current I_F in the table 1.
6. Repeat steps 4 to 5 till input voltage is reached to 1 V.
7. Plot the graph for the forward bias characteristics of diode by taking V_F on X-axis and I_F on Y- axis.
8. Connect the circuit as shown in figure 4.3
9. Vary input voltage gradually in steps of 1V up to 12V.
10. Record the corresponding readings of V_R and I_R.in the observation table 2.
11. Plot the graph for the reverse bias characteristics of Zener diode by taking V_R on X-axis and I_R on Y-axis.

XI Observation Table

Table 1: Measurement of V_F and I_F

Sr. No.	V_F (volts)	I_F (mA)
1.		
2.		
3.		
4.		
5.		
6.		
7.		
8.		
9.		
10.		

Table 2: Measurement of V_R and I_R

Sr. No.	V_R (volts)	I_R (mA)
1.		
2.		
3.		
4.		
5.		
6.		
7.		
8.		
9.		
10.		

Calculations:

$$R_Z = V_F/I_F$$

$$R_Z = V_R/I_R$$

XII Results

1. Zener breakdown voltage= ....
2. Forward resistance of zener diode =..................

XIII Interpretation of results

....

....

XIV Conclusions and Recommendation

....

....

XV Practical related Questions

1. Determine maximum and minimum value of Zener current if value of series resistance is 1K, load resistance is 2K and input varies from 10V to 30V. Zener voltage is 5 V.
2. Is it possible to operate normal PN junction diode in breakdown region? Justify your answer Give reason.

3. State the effect on voltage across zener diode and current flowing through it, when reverse voltage across it is more than breakdown voltage.
4. Identify the portion of Zener diode characteristics suitable for voltage regulation applications.

[Space for answers]

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XVI References / Suggestions for further Reading

1. https://www.youtube.com/watch?v=itzPT3UClI
2. https://www.youtube.com/watch?v=XhQqtdTlRus
3. https://www.youtube.com/watch?v=mtjnStAF8Yg

XVII Assessment Scheme

Performance Indicators		**Weightage**
Process related (15 Marks)		**60%**
1	Proper connection of electrical circuit	20%
2	Handling of instrument	10%
3	Taking proper readings	20%
4	Working in team.	10%
	Product related (10 Marks)	**40%**
1	Interpretation of Result	10%
2	Conclusions	05%
3	Practical related questions	15%
4	Completion and submission of experiment in time	10%
	Total (25 Marks)	**100%**

Names of Student Team Members

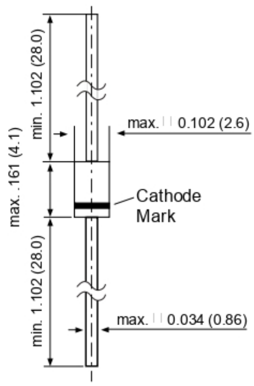
1. ....
2. ....
3. ....
4. ....

Marks Obtained			**Dated Signature of Teacher**
Process Related(15)	**Product Related(l0)**	**Total (25)**	

1N4728 THRU 1N4764

ZENER DIODES

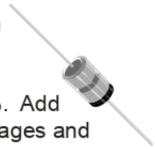
DO-41 Glass



Dimensions in inches and (millimeters)

FEATURES

- Silicon Planar Power Zener Diodes
- For use in stabilizing and clipping circuits with high power rating.
- Standard Zener voltage tolerance is ±10%. Add suffix “A” for ±5% tolerance. Other Zener voltages and tolerances are available upon request.
- These diodes are also available in the MELF case with type designation ZM4728 thru ZM4764



MECHANICAL DATA

Case: DO-41 Glass Case
Weight: approx. 0.35 g

MAXIMUM RATINGS

Ratings at 25°C ambient temperature unless otherwise specified.

	SYMBOL	VALUE	UNIT
Zener Current (see Table “Characteristics”)			
Power Dissipation at T_{amb} = 25°C	P_{tot}	1.0(1)	Watts
Junction Temperature	T_j	175	°C
Storage Temperature Range	T_S	– 65 to +175	°C

Characteristics at Tamb = 25 °C

	SYMBOL	MIN.	TYP.	MAX.	UNIT
Thermal Resistance Junction to Ambient Air	R_{thJA}	–	–	170(1)	°C/W
Forward Voltage at I_F = 200 mA	V_F	–	–	1.2	Volts

NOTES:
(1) Valid provided that electrodes at a distance of 10mm from case are kept at ambient temperature

1N4728 THRU 1N4764

ELECTRICAL CHARACTERISTICS

Ratings at 25°C ambient temperature unless otherwise specified.

Type	Nominal Zener voltage(3) at I_{ZT} V_Z V	Test current I_{ZT} mA	Maximum Zener impedance(1) Z_{ZT} at I_{ZT} Ω	Z_{ZK} Ω	at I_{ZK} mA	Maximum reverse leakage current I_R µA	at V_R V	Surge current at T_A = 25°C I_R mA	Maximum regulator current(2) I_{ZM} mA
1N4728	3.3	76	10	400	1.0	100	1	1380	276
1N4729	3.6	69	10	400	1.0	100	1	1260	252
1N4730	3.9	64	9	400	1.0	50	1	1190	234
1N4731	4.3	58	9	400	1.0	10	1	1070	217
1N4732	4.7	53	8	500	1.0	10	1	970	193
1N4733	5.1	49	7	550	1.0	10	1	890	178
1N4734	5.6	45	5	600	1.0	10	2	810	162
1N4735	6.2	41	2	700	1.0	10	3	730	146
1N4736	6.8	37	3.5	700	1.0	10	4	660	133
1N4737	7.5	34	4.0	700	0.5	10	5	605	121
1N4738	8.2	31	4.5	700	0.5	10	6	550	110
1N4739	9.1	28	5.0	700	0.5	10	7	500	100
1N4740	10	25	7	700	0.25	10	7.6	454	91
1N4741	11	23	8	700	0.25	5	8.4	414	83
1N4742	12	21	9	700	0.25	5	9.1	380	76
1N4743	13	19	10	700	0.25	5	9.9	344	69
1N4744	15	17	14	700	0.25	5	11.4	304	61
1N4745	16	15.5	16	700	0.25	5	12.2	285	57
1N4746	18	14	20	750	0.25	5	13.7	250	50
1N4747	20	12.5	22	750	0.25	5	15.2	225	45
1N4748	22	11.5	23	750	0.25	5	16.7	205	41
1N4749	24	10.5	25	750	0.25	5	18.2	190	38
1N4750	27	9.5	35	750	0.25	5	20.6	170	34
1N4751	30	8.5	40	1000	0.25	5	22.8	150	30
1N4752	33	7.5	45	1000	0.25	5	25.1	135	27
1N4753	36	7.0	50	1000	0.25	5	27.4	125	25
1N4754	39	6.5	60	1000	0.25	5	29.7	115	23
1N4755	43	6.0	70	1500	0.25	5	32.7	110	22
1N4756	47	5.5	80	1500	0.25	5	35.8	95	19
1N4757	51	5.0	95	1500	0.25	5	38.8	90	18
1N4758	56	4.5	110	2000	0.25	5	42.6	80	16
1N4759	62	4.0	125	2000	0.25	5	47.1	70	14
1N4760	68	3.7	150	2000	0.25	5	51.7	65	13
1N4761	75	3.3	175	2000	0.25	5	56.0	60	12
1N4762	82	3.0	200	3000	0.25	5	62.2	55	11
1N4763	91	2.8	250	3000	0.25	5	69.2	50	10
1N4764	100	2.5	350	3000	0.25	5	76.0	45	9

NOTES:

(1) The Zener impedance is derived from the 1KHz AC voltage which results when an AC current having an RMS value equal to 10% of the Zener current (I_{ZT} or I_{ZK}) is superimposed on I_{ZT} or I_{ZK}. Zener impedance is measured at two points to insure a sharp knee on the breakdown curve and to eliminate unstable units

(2) Valid provided that electrodes at a distance of 10mm from case are kept at ambient temperature

(3) Measured under thermal equilibrium and DC test conditions

Scale
X-axis

Y-axis

Practical No.5: Test the performance of photo diode by varying the light intensity as well as the distance of the light source

I Practical Significance

In industry and domestic applications, photodiode is used in applications of photo detectors like charge-coupled devices, photoconductors, and photomultiplier tubes. These diodes are used in consumer electronics applications like smoke detectors, compact disc players, and televisions remote controls. Photodiodes are frequently used for exact measurement of the intensity of light in industry applications. These diodes are much faster and more complex than normal PN junction diodes and hence are frequently used for lighting regulation and in optical communications.

II Industry / Employer Expected Outcome

This practical is expected to develop the following skill: **'Use electronics components and circuits in electrical equipment'.**

III Course Level Learning Outcome

Use relevant diode in different electronic circuits.

IV Laboratory Learning Outcome

Build the circuit for Photodiode and observe the change in current with change in light intensity of the source.

V Relevant Affective Domain related Outcome

Handle components and equipment carefully.

VI Minimum Theoretical Background

A photodiode is a two terminal PN-junction diode that is operated in reverse biasing the junction and then illuminating it by light energy to produce electric current. It is also called as photo-detector/light detector/photo-sensor. These diodes are designed to work in reverse bias condition, it means that the P-side of the photodiode is connected with the negative terminal of the battery and N-side is connected to the positive terminal of the battery. This diode is very sensitive to light, so when light falls on the diode it changes light into electric current.

Figure 5.1: Symbol of Photo Diode

Figure 5.2: Photo Diode

Photo Current (I_{λ}): It is the reverse current produced due to thermally generated electron-hole pairs in depletion region due to incident light. Photo current is proportional to light intensity as light intensity increases photocurrent increases.

Dark Current: A reverse current flows when no light is incident on the device.

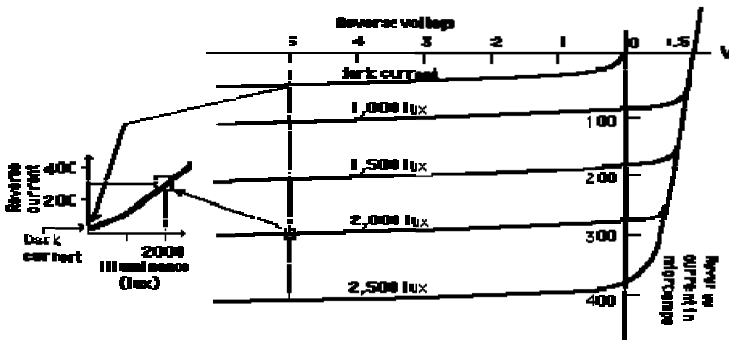


Figure 5.3: Plot of V_R verses V_F

VII Practical setup in Laboratory

(a) Sample

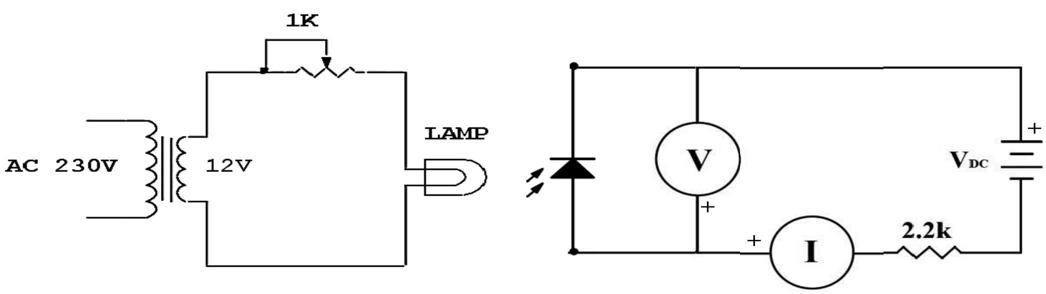


Figure 5.4: Photodiode practical setup

(b) Actual Circuit Diagram used in Laboratory

(c) Actual practical set up used in Laboratory

VIII Required Resources/apparatus/equipment with specifications

Sr. No	Instruments/Components	Specification	Quantity
1	DC Regulated power supply	Variable DC power supply 0- 30V, 2A, SC protection, display for voltage and current.	1
2.	Multimeter	3 ½ -digit display with AC and DC voltage measurement and Current measurement facility and Diode testing facility.	1
3.	Transformer	Step down 9-0-9 V, 500mA	1
4.	DC Voltmeter	0-20V	1
5.	DC Ammeter	0-200mA	1
6.	Photodiode	BPW 34 or equivalent any other photodiode	1
7.	Lux meter/ Optical power meter	3000 Lumens, Battery-operated hand-held type	1
8.	Light Source	Portable lamp mounted on stand	1
9.	Breadboard	5.5CM X 17CM	1
10.	Resistor	2.2KΩ,1.1 KΩ (0.5watts)	1 each
11.	Connecting wires	Single strand Teflon coating (0.6mm diameter)	As per requirement

IX Precautions to be followed

1. Do not switch ON the power supply unless you have checked the circuit connections as per the circuit diagram.
2. While doing the practical do not exceed the input voltage of the diode beyond the rated voltage of diode as given in datasheet. This may lead to damaging of the diode.
3. Connect voltmeter and ammeter with correct polarities as shown in the circuit diagram.

X Procedure

Test performance of photo diode by varying the light intensity.

1. Select the component as per circuit diagram.
2. Make the connections as per circuit diagram.
3. Apply the reverse voltage, and measure the current when light is not incident.
4. Increase the reverse voltage and light intensity in step and note down the photocurrent.
5. Change the light intensity and repeat the steps.
6. Plot the graph of reverse voltage (negative X-Axis) Vs reverse photo current (negative Y-Axis) for various light intensity.

Test performance of photo diode by varying distance of the light source.

1. Select the component as per circuit diagram.
2. Make the connections as per circuit diagram.
3. Apply the reverse voltage, and measure the current when light is not incident.
4. Keep the input voltage constant at which we get sufficient light intensity and vary the distance of light source from photo diode in step and note down the photocurrent.
5. Plot the graph of reverse voltage (negative X-Axis) Vs reverse photo current (negative Y-Axis) for various light intensity.

XI Observation Table

Table 1: Measurement of Photodiode current when light intensity is varied

Light Intensity	No Light Condition (Lux meter reading ---)		Low Light Condition (Lux meter reading ---)		High Light Condition (Lux meter reading ---)	
Sr. No.	V_R (Volts)	I_P (uA)	V_R (Volts)	I_P (uA)	V_R (Volts)	I_P (uA)
1.	2					
2.	4					
3.	6					
4.	8					
5.	10					
6.	12					
7.	14					
8.	16					

Table 2: Measurement of Photodiode current when distance is varied

Light Intensity	Position I No Light Condition (Distance of light source in cm ---)		Position II Low Light Condition (Distance of light source in cm ---)		Position III High Light Condition (Distance of light source in cm ---)	
Sr. No.	V_R (Volts)	I_P (uA)	V_R (Volts)	I_P (uA)	V_R (Volts)	I_P (uA)
1.	2					
2.	4					
3.	6					
4.	8					
5.	10					
6.	12					
7.	14					
8.	16					

Calculations:

XII Results

Dark Current: -..

XIII Interpretation of results

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XIV Conclusions and Recommendation

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XV Practical related Questions

1. State the working principle of photodiode.
2. Write specification of photodiode used in above experiment.
3. Is photocurrent in photodiode, depends on wavelength of incident light?

[Space for answers]

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XVI References / Suggestions for further Reading

1. https://www.youtube.com/watch?v=SFc673lEyQA
2. https://www.idconline.com/technical_references/pdfs/electronic_engineering/Photo_Diode.pdf
3. https://www.youtube.com/watch?v=rNoHLOumplk

XVII Assessment Scheme

Performance Indicators		Weightage
Process related (15 Marks)		**60%**
1	Proper connection of electrical circuit	20%
2	Handling of instrument	10%
3	Taking proper readings	20%
4	Working in team.	10%
Product related (10 Marks)		**40%**
1	Interpretation of Result	10%
2	Conclusions	05%
3	Practical related questions	15%
4	Completion and submission of experiment in time	10%
	Total (25 Marks)	**100%**

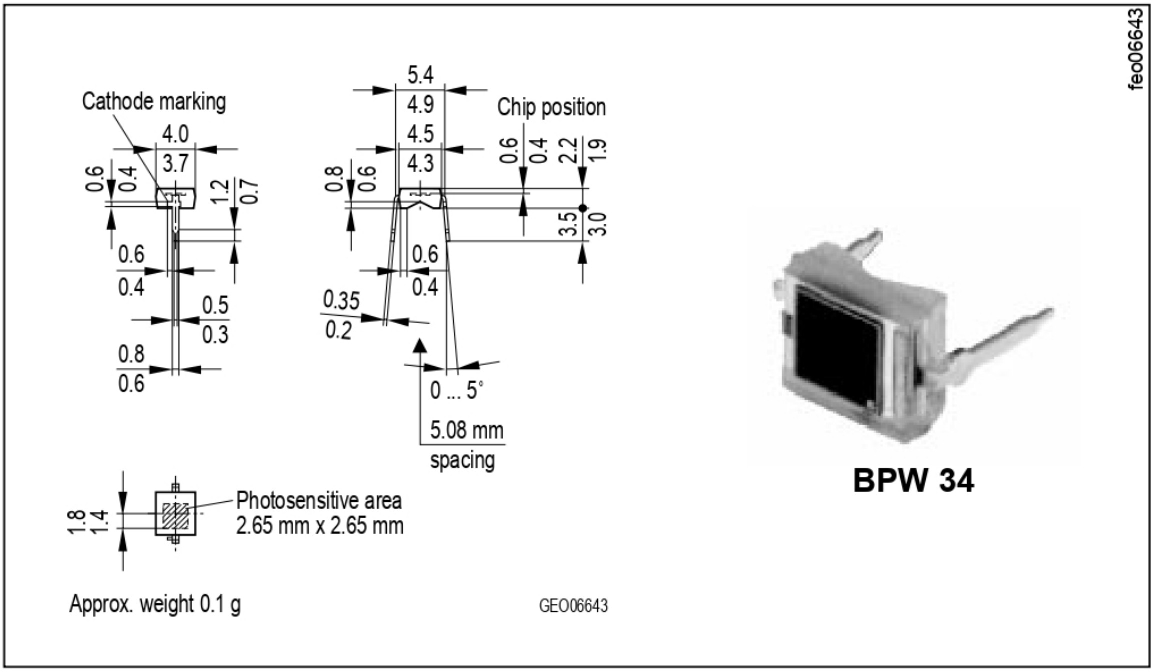
Names of Student Team Members

1. ....
2. ....
3. ....
4. ....

Marks Obtained			**Dated Signature of Teacher**
Process Related(15)	**Product Related(l0)**	**Total (25)**	

SIEMENS

Silizium-PIN-Fotodiode **BPW 34**
NEU: in SMT und als Reverse Gullwing **BPW 34 S**
Silicon PIN Photodiode **BPW 34 S (E9087)**
NEW: in SMT and as Reverse Gullwing



Maße in mm, wenn nicht anders angegeben/Dimensions in mm, unless otherwise specified.

Wesentliche Merkmale
- Speziell geeignet für Anwendungen im Bereich von 400 nm bis 1100 nm
- Kurze Schaltzeit (typ. 20 ns)
- DIL-Plastikbauform mit hoher Packungsdichte
- BPW 34 S/(E9087): geeignet für Vapor-Phase Löten und IR-Reflow Löten (JEDEC level 4)

Features
- Especially suitable for applications from 400 nm to 1100 nm
- Short switching time (typ. 20 ns)
- DIL plastic package with high packing density
- BPW 34 S/(E9087): suitable for vapor-phase and IR-reflow soldering (JEDEC level 4)

Anwendungen
- Lichtschranken für Gleich- und Wechsellichtbetrieb
- IR-Fernsteuerungen
- Industrieelektronik
- "Messen/Steuern/Regeln"

Applications
- Photointerrupters
- IR remote controls
- Industrial electronics
- For control and drive circuits

Scale
X-axis

Y-axis

Practical No.6: Construct and Test the half wave rectifier

I Practical Significance

AC power is more efficiently and economically transmitted. The majority of electrical equipment, devices work on DC power. It becomes necessary to convert AC power into DC power. In half wave rectifier single diode is used. The current flows in only one direction through diode. So, it is unidirectional device.

II Industry / Employer Expected Outcome

This practical is expected to develop the following skill: **'Use electronics components and circuits in electrical equipment'.**

III Course Level Learning Outcome

Use diode in different rectifier and filter.

IV Laboratory Learning Outcome

Construct and test half wave rectifier on breadboard.

V Relevant Affective Domain related Outcome

Handle components and equipment carefully.

VI Minimum Theoretical Background

Rectifier: - It is a circuit, which converts AC supply into the Pulsating DC supply.

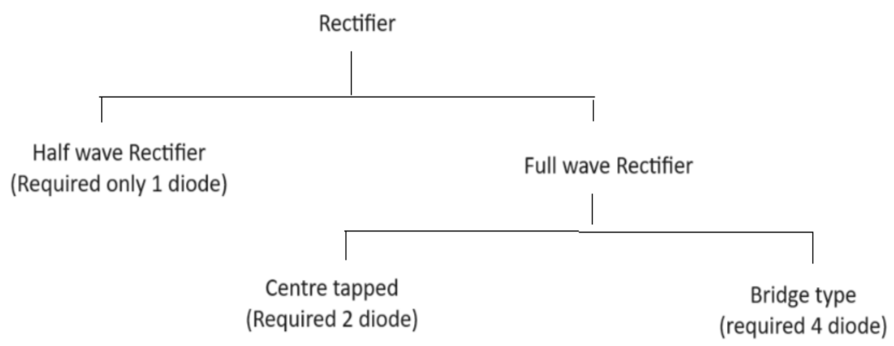


Figure 6.1: Classification of Rectifier

Half wave Rectifier: DC or average output voltage of half wave rectifier is Vm/π as the output current flows only for half the cycle of input signal.

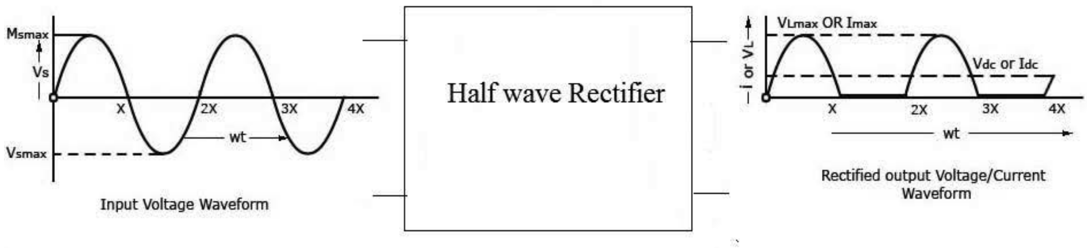


Figure 6.2: Half wave Rectifier

VII Practical setup in Laboratory

(a) Sample

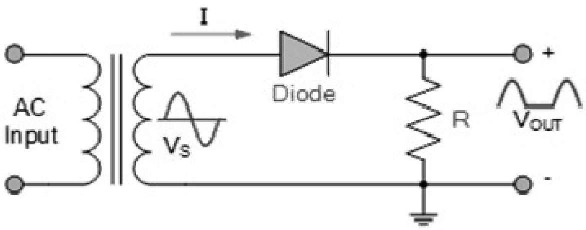


Figure 6.3: Circuit diagram of Half wave rectifier

(b) Actual Circuit Diagram used in Laboratory

(c) Actual Practical set up used in Laboratory

VIII Required Resources/apparatus/equipment with specifications

Sr. No	Instruments/Components	Specification	Quantity
1	Transformer	Step down 9-0-9 V, 500mA	1
2.	Digital Multimeter	3 ½ -digit display with AC and DC voltage measurement and Current measurement facility and Diode testing facility.	1
3.	CRO	25 MHz, dual trace, 15 MΩ input impedance	1
4.	Bread board	5.5 CM X 17CM	1
5.	Diode	1N4007 (or any other equivalent diode)	1
6.	Resistor	1KΩ/10KΩ(0.5watts/0.25watts)	1
7.	Connecting wires	Single strand Teflon coating (0.6mm diameter)	As per requirement

IX Precautions to be followed

1. Do not switch ON the power supply unless you have checked the circuit connections as per the circuit diagram.
2. While doing the practical do not exceed the input voltage of the diode beyond the rated voltage of diode as given in datasheet. This may lead to damaging of the diode.

X Procedure

1. Make the connection as per the circuit diagram shown in figure 6.3
2. Connect the CRO probe across the Secondary and measure the Vp-p appearing across the diodes.
3. Now connect the CRO probes across the resistance R_L and measure the peak value of output voltage (Vm).
4. Observe the waveform on CRO and draw it on graph paper.
5. From the measured peak value of output voltage (Vm), calculate the average or dc value of output voltage (Vdc).
6. Connect the DMM across the R_L and measure the de voltage.
7. Compare the value calculated in step 5 with the value measured in step 6.
8. Tabulate the readings in Table1.

XI Observation Table

Table 1

Type of Rectifier	Rectifier output on CRO (Vm)	Vdc Calculated (using formula Vdc = (Vm / π)	Vdc measured (using DMM)	Comment

Calculations:

Calculate Vdc using Formula:

$$V_{dc} = (V_m / \pi)$$

XII Results

DC output voltage of Half wave rectifier

1. Calculated V_{dc} (CRO)=..V
2. Measured V_{dc} (DMM)=..V

XIII Interpretation of results

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....

XIV Conclusions and Recommendation

....

....

XV Practical related Questions

1. Repeat the experiment for silicon diode of different specification.
2. Draw and explain the operation of half wave rectifier.
3. If V_{dc} =2 V, what will be the value of V_{m}.

[Space for answers]

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XVI References / Suggestions for further Reading

1. https://www.electrical4u.com/half-wave-rectifiers/
2. https://www.youtube.com/watch?v=3pw40e-W4eI
3. https://www.youtube.com/watch?v=9xoByZ9qyPo

XVII Assessment Scheme

Performance Indicators		Weightage
Process related (15 Marks)		**60%**
1	Proper connection of electrical circuit	20%
2	Handling of instrument	10%
3	Taking proper readings	20%
4	Working in team.	10%
Product related (10 Marks)		**40%**
1	Calculation of theoretical value	10%
2	Interpretation of Result and Conclusions	10%
3	Practical related questions	15%
4	Completion and submission of experiment in time	05%
	Total (25 Marks)	**100%**

Names of Student Team Members

1. ....
2. ....
3. ....
4. ....

Marks Obtained			**Dated Signature of Teacher**
Process Related (15)	**Product Related (10)**	**Total (25)**	

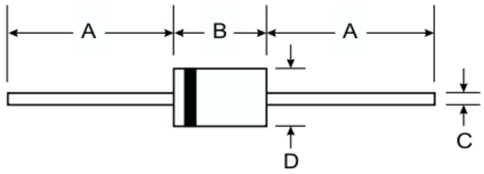
DIODES INCORPORATED

1N4001G/L - 1N4007G/L

1.0A GLASS PASSIVATED RECTIFIER

Features

- Glass Passivated Die Construction
- Diffused Junction
- High Current Capability and Low Forward Voltage Drop
- Surge Overload Rating to 30A Peak
- Plastic Material - UL Flammability Classification 94V-0



Mechanical Data

- Case: Molded Plastic
- Terminals: Plated Leads Solderable per MIL-STD-202, Method 208
- Polarity: Cathode Band
- Weight: DO-41 0.30 grams (approx)
  A-405 0.20 grams (approx)
- Mounting Position: Any
- Marking: Type Number

	DO-41 Plastic		A-405	
Dim	**Min**	**Max**	**Min**	**Max**
A	25.40	—	25.40	—
B	4.06	5.21	4.10	5.20
C	0.71	0.864	0.53	0.64
D	2.00	2.72	2.00	2.70
All Dimensions in mm				

"L" Suffix Designates A-405 Package
No Suffix Designates DO-41 Package

Maximum Ratings and Electrical Characteristics @ T_A = 25°C unless otherwise specified

Single phase, half wave, 60Hz, resistive or inductive load.
For capacitive load, derate current by 20%.

Characteristic	Symbol	1N4001 G/GL	1N4002 G/GL	1N4003 G/GL	1N4004 G/GL	1N4005 G/GL	1N4006 G/GL	1N4007 G/GL	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	V_{RRM} V_{RWM} V_R	50	100	200	400	600	800	1000	V
RMS Reverse Voltage	$V_{R(RMS)}$	35	70	140	280	420	560	700	V
Average Rectified Output Current (Note 1) @ T_A = 75°C	I_O	1.0							A
Non-Repetitive Peak Forward Surge Current 8.3ms single half sine-wave superimposed on rated load (JEDEC Method)	I_{FSM}	30							A
Forward Voltage @ I_F = 1.0A	V_{FM}	1.0							V
Peak Reverse Current @T_A = 25°C at Rated DC Blocking Voltage @ T_A = 125°C	I_{RM}	5.0 50							µA
Reverse Recovery Time (Note 3)	t_{rr}	2.0							µs
Typical Junction Capacitance (Note 2)	C_j	8.0							pF
Typical Thermal Resistance Junction to Ambient	$R_{\theta JA}$	100							K/W
Operating and Storage Temperature Range	T_j, T_{STG}	-65 to +175							°C

Notes:
1. Leads maintained at ambient temperature at a distance of 9.5mm from the case.
2. Measured at 1.0 MHz and applied reverse voltage of 4.0V DC.
3. Measured with I_F = 0.5A, I_R = -1A, I_{rr} = 0.25A.

Scale
X-axis

Y-axis

Practical No.7: Prepare and Test the half wave rectifier with LC filter/ π filter

I Practical Significance

The filter converts the pulsating DC into pure DC. The electronic reactive elements like capacitor and inductor are used for filtering.

II Industry / Employer Expected Outcome

This practical is expected to develop the following skill: **'Use electronic components and circuits in electrical equipment and systems'.**

III Course Level Learning Outcome

Use semiconductor diodes in different rectifier and filter.

IV Laboratory Learning Outcomes

Test half wave rectifier with LC/ π filter on Breadboard:

1. Prepare the circuit for Half Wave Rectifier with LC filter/ pi (π) filter using PN junction Diode.
2. Observe and draw input-output waveforms for sinusoidal wave.

V Relevant Affective Domain related Outcomes

1. Handle components and equipment carefully.
2. Follow all safety precautions

VI Minimum Theoretical Background

The capacitor used in "C" filter reduces the ripple voltage, but causes the diode current to increase. This large current may damage the diode and will further cause heating problem and decrease the efficiency of the filter. On the other hand, a simple series inductor reduces both the peak and effective values of the output current and output voltage. So, the combination of both the filter (Land C), forms a new filter called the L-C filter which will have a good efficiency, with controlled diode current and enough ripple removal factor. The voltage stabilizing action of shunt capacitor and the current smoothing action of series inductor filter can be combined to form a perfect practical filter circuit.

Half wave rectifier without filter capacitor converts AC voltage into pulsating DC voltage. Filter capacitor is used to obtain smooth DC voltage.

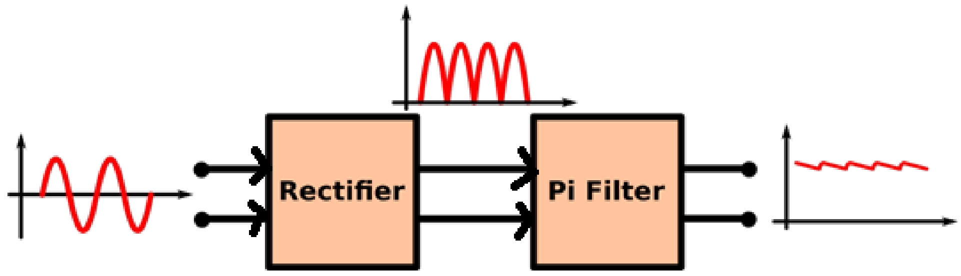


Figure 7.1: Concept of filter

VII Practical setup in Laboratory

(a) Sample

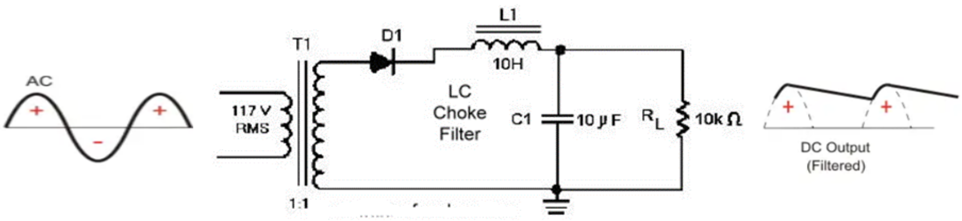


Figure 7.2: Half wave rectifier (HWR) with LC filter

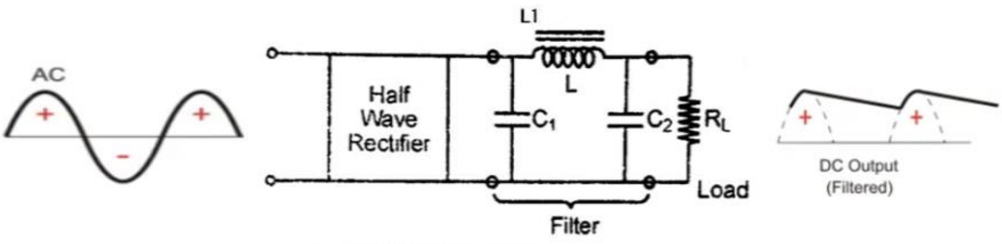


Figure 7.3: Half wave rectifier (HWR) with π filter

(b) Actual Circuit Diagram used in Laboratory

(c) Actual practical set up used in Laboratory

VIII Required Resources/apparatus/equipment with specifications

Sr. No	Instruments/Components	Specification	Quantity
1	Transformer	12-0-12V AC, 500 mA	1
2.	Multimeter	3 ½ -digit display with AC and DC voltage measurement and Current measurement facility and Diode testing facility.	1
3.	C.R.O.	25MHz, Dual trace, 15MΩ input impedance	1
4.	Resistor	10KΩ, 0.5 Watt.	1
5.	Diode	Silicon 1N4007	1
6.	Capacitor	10µF (Electrolytic)	2
7.	Inductor	10H	1
8.	Bread board	5.5 CM X 17CM	1
9.	Connecting wires	Single strand Teflon coating (0.6 mm diameter)	As per requirement

IX Precautions to be followed

1. Do not switch ON the power supply unless you have checked the circuit connections as per the circuit diagram.
2. While doing the practical do not exceed the input voltage of the diode beyond the rated voltage of diode as given in datasheet. This may lead to damaging of the diode.

X Procedure

1. Connect the circuit of rectifier with LC / π Filter on bread board as shown in figure 7.2
2. Connect the primary side of the transformer to AC mains and the secondary side to rectifier input.
3. Before switching ON power supply, check the connection.
4. Record peak voltage across load resistor using CRO.
5. Calculate the DC output voltage and peak to peak ripple voltage.
6. Calculate the ripple factor.
7. Repeat the steps 1 to 6 for figure 7.3
8. Observe and draw the waveforms across LC/ π filter on graph paper.

XI Observation Table

Table 1

Type of Rectifier	Peak Voltage V_m (volts)	$V_{dc} = V_m / \pi$ (volts)	Peak to peak ripple voltage Vr (volts)	Ripple factor= Vr/Vdc
Full wave rectifier with LC filter				
Full wave rectifier with π filter				

Calculations:

XII Results

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XIII Interpretation of results

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XIV Conclusions and Recommendation

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XV Practical related Questions

1. State the required PIV rating of diode if transformer voltage of 24V.
2. Give the mathematical relationship between rms input AC voltage and DC output voltage in half wave rectifier with and without filter capacitor.

[Space for answers]

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XVI References / Suggestions for further Reading

1. https://www.elprocus.com/half-wave-rectifier-circuit-working-principle-and-characteristics-2/
2. https://www.youtube.com/watch?v=QGawHsg4NpQ

XVII Assessment Scheme

Performance Indicators		Weightage
Process related (15 Marks)		**60%**
1	Proper connection of electrical circuit	20%
2	Handling of instrument	10%
3	Taking proper readings	20%
4	Working in team.	10%
Product related (10 Marks)		**40%**
1	Calculation of theoretical value	10%
2	Interpretation of Result	05%
3	Conclusions	05%
4	Practical related questions	15%
5	Completion and submission of experiment in time	05%
	Total (25 Marks)	**100%**

Names of Student Team Members

1. ....
2. ....
3. ....
4. ....

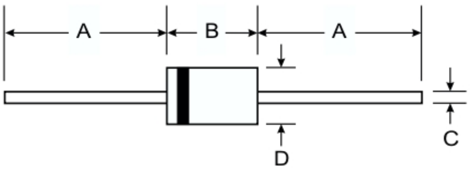
Marks Obtained			**Dated Signature of Teacher**
Process Related (15)	**Product Related (10)**	**Total (25)**	

1N4001G/L - 1N4007G/L

1.0A GLASS PASSIVATED RECTIFIER

Features

- Glass Passivated Die Construction
- Diffused Junction
- High Current Capability and Low Forward Voltage Drop
- Surge Overload Rating to 30A Peak
- Plastic Material - UL Flammability Classification 94V-0



Mechanical Data

- Case: Molded Plastic
- Terminals: Plated Leads Solderable per MIL-STD-202, Method 208
- Polarity: Cathode Band
- Weight: DO-41 0.30 grams (approx)
  A-405 0.20 grams (approx)
- Mounting Position: Any
- Marking: Type Number

	DO-41 Plastic		A-405	
Dim	Min	Max	Min	Max
A	25.40	—	25.40	—
B	4.06	5.21	4.10	5.20
C	0.71	0.864	0.53	0.64
D	2.00	2.72	2.00	2.70
All Dimensions in mm				

"L" Suffix Designates A-405 Package
No Suffix Designates DO-41 Package

Maximum Ratings and Electrical Characteristics

@ $T_A = 25°C$ unless otherwise specified

Single phase, half wave, 60Hz, resistive or inductive load.
For capacitive load, derate current by 20%.

Characteristic	Symbol	1N4001 G/GL	1N4002 G/GL	1N4003 G/GL	1N4004 G/GL	1N4005 G/GL	1N4006 G/GL	1N4007 G/GL	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	V_{RRM} V_{RWM} V_R	50	100	200	400	600	800	1000	V
RMS Reverse Voltage	$V_{R(RMS)}$	35	70	140	280	420	560	700	V
Average Rectified Output Current (Note 1) @ $T_A = 75°C$	I_O	1.0							A
Non-Repetitive Peak Forward Surge Current 8.3ms single half sine-wave superimposed on rated load (JEDEC Method)	I_{FSM}	30							A
Forward Voltage @ $I_F = 1.0A$	V_{FM}	1.0							V
Peak Reverse Current @ $T_A = 25°C$ at Rated DC Blocking Voltage @ $T_A = 125°C$	I_{RM}	5.0 50							µA
Reverse Recovery Time (Note 3)	t_{rr}	2.0							µs
Typical Junction Capacitance (Note 2)	C_j	8.0							pF
Typical Thermal Resistance Junction to Ambient	$R_{\theta JA}$	100							K/W
Operating and Storage Temperature Range	T_j, T_{STG}	-65 to +175							°C

Notes:
1. Leads maintained at ambient temperature at a distance of 9.5mm from the case.
2. Measured at 1.0 MHz and applied reverse voltage of 4.0V DC.
3. Measured with $I_F = 0.5A$, $I_R = -1A$, $I_{rr} = 0.25A$.

Scale
X-axis

Y-axis

Practical No.8: Build and Test the full wave rectifier Using two diodes

I Practical Significance

Electric power is usually transmitted in AC form. However certain application needs DC power supply such as electronic appliances. A rectifier is an electronic device that converts an alternating current into a direct current by using one or more P-N junction diodes. Hence, AC mains need to be rectified using rectifier when DC power is required.

II Industry / Employer Expected Outcome

This practical is expected to develop the following skill: **'Use electronic components and circuits in electrical equipment and systems'.**

III Course Level Learning Outcome

Use semiconductor diodes in different rectifier and filter.

IV Laboratory Learning Outcomes

Test full wave rectifier using wo diodes on Breadboard:

1. Build the circuit for Full Wave Centre Tapped Rectifier using PN junction Diode.
2. Observe and draw input-output waveforms for sinusoidal wave.

V Relevant Affective Domain related Outcomes

1. Handle components and equipment carefully.
2. Follow all safety precautions

VI Minimum Theoretical Background

Rectifier is an electronic device used for converting AC into pulsating DC and this process is known as Rectification. Like the half wave circuit, a full wave rectifier circuit produces an output voltage or current which is pulsating DC Full wave rectifier utilizes both the cycle of input AC voltage. Two diodes are used in full wave center tapped rectifier. A center-tapped full wave rectifier circuit consists of a center-tapped transformer, two diodes, and a resistive load. The center-tapped transformer has a wire connected at the center of its secondary winding, which divides the input AC voltage into two halves. The diodes are connected in parallel to each other, with the load connected at the center tap of the transformer. During the positive half of the input cycle, one diode conducts (forward bias) while the other diode is non-conducting (reverse bias).

This allows current to flow through the load. In the negative part of the cycle, the diodes change their job. The one that was allowing electricity to flow now stops, and the one that was blocking it begins to allow it through. This is unlike a half-wave rectifier that uses only one part of the cycle. Using both parts in a full wave rectifier improves its performance and ensures more efficient conversion of the wavy input into a smooth output.

VII Practical setup in Laboratory

(a) Sample

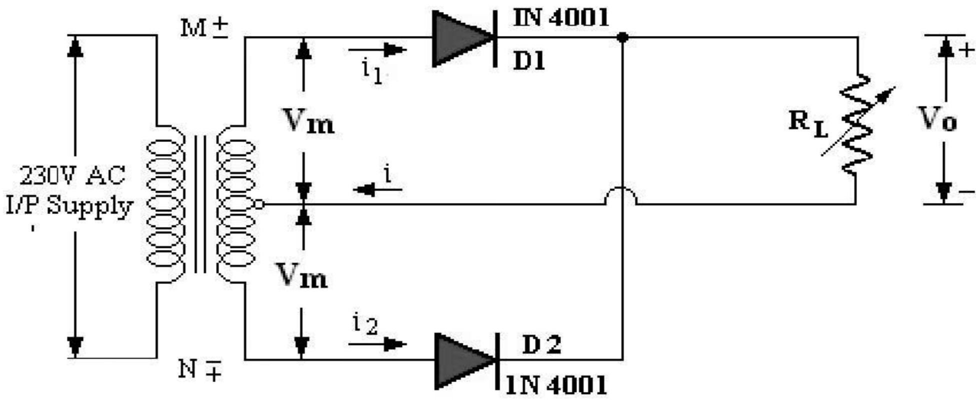


Figure 8.1: Full wave rectifier (FWR) without filter

(b) Actual Circuit Diagram used in Laboratory

(c) Actual practical set up used in Laboratory

VIII Required Resources/apparatus/equipment with specifications

Sr. No	Instruments/Components	Specification	Quantity
1	Transformer	12-0-12V AC, 500 mA	1
2.	Multimeter	3 ½ -digit display with AC and DC voltage measurement and Current measurement facility and Diode testing facility.	1
3.	C.R.O.	25MHz, Dual trace, 15MΩ input impedance	1
4.	Resistor	10KΩ, 0.5 Watt.	1
5.	Diode	Silicon 1N4007	1
6.	Bread board	5.5 CM X 17CM	1
7.	Connecting wires	Single strand Teflon coating (0.6 mm diameter)	As per requirement

IX Precautions to be followed

1. Do not switch ON the power supply unless you have checked the circuit connections as per the circuit diagram.
2. While doing the practical do not exceed the input voltage of the diode beyond the rated voltage of diode as given in datasheet. This may lead to damaging of the diode.

X Procedure

1. Connect the circuit for Center Tapped Full wave rectifier on breadboard as shown in Figure 8.1
2. Connect the primary side of the transformer to AC mains. Connect the CRO probe across the secondary and measure the Vs_{p-p} appearing across diode.
3. Measure the peak value of output voltage (V_m) across the resistance.
4. Draw input and output waveforms of full wave rectifier.
5. Calculate the average or dc value of output voltage.
6. Using DMM measure the DC voltage at the load resistance R_L.
7. Compare the value calculated instep5with the value measured in step 6.
8. Tabulate the readings in Table1.

XI Observation Table

Table 1

Type of rectifier	**Rectifier Output On CRO(V_m)**	**V_{dc} Calculated (using Formula $V_{dc}=(2V_m/\pi)$)**	**V_{dc} Measured (using DMM)**	**Comment**

Calculations:

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

XII Results

1. V_{dc} calculated=………………….. V

XIII Interpretation of results

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XIV Conclusions and Recommendation

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XV Practical related Questions

1. Calculate frequency of waveform obtained at the output of full wave rectifier
2. Compare half wave and Full wave rectifier based on output waveforms obtained in Laboratory.
3. State need of rectifier

[Space for answers]

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XVI References / Suggestions for further Reading

1. http://nptel.ac.in/courses/
2. www.electronics-tutorials.ws › Diodes

XVII Assessment Scheme

Performance Indicators		Weightage
Process related (15 Marks)		**60%**
1	Proper connection of electrical circuit	20%
2	Handling of instrument	10%
3	Taking proper readings	20%
4	Working in team.	10%
Product related (10 Marks)		**40%**
1	Calculation of theoretical value	10%
2	Interpretation of Result	05%
3	Conclusions	05%
4	Practical related questions	15%
5	Completion and submission of experiment in time	05%
	Total (25 Marks)	**100%**

Names of Student Team Members

1. ....
2. ....
3. ....
4. ....

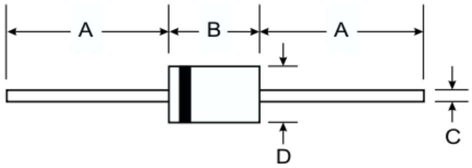
Marks Obtained			**Dated Signature of Teacher**
Process Related (15)	**Product Related (10)**	**Total (25)**	

1N4001G/L - 1N4007G/L

1.0A GLASS PASSIVATED RECTIFIER

Features

- Glass Passivated Die Construction
- Diffused Junction
- High Current Capability and Low Forward Voltage Drop
- Surge Overload Rating to 30A Peak
- Plastic Material - UL Flammability Classification 94V-0



Mechanical Data

- Case: Molded Plastic
- Terminals: Plated Leads Solderable per MIL-STD-202, Method 208
- Polarity: Cathode Band
- Weight: DO-41 0.30 grams (approx)
  A-405 0.20 grams (approx)
- Mounting Position: Any
- Marking: Type Number

	DO-41 Plastic		A-405	
Dim	**Min**	**Max**	**Min**	**Max**
A	25.40	—	25.40	—
B	4.06	5.21	4.10	5.20
C	0.71	0.864	0.53	0.64
D	2.00	2.72	2.00	2.70
All Dimensions in mm				

"L" Suffix Designates A-405 Package
No Suffix Designates DO-41 Package

Maximum Ratings and Electrical Characteristics

@ $T_A = 25°C$ unless otherwise specified

Single phase, half wave, 60Hz, resistive or inductive load.
For capacitive load, derate current by 20%.

Characteristic	Symbol	1N4001 G/GL	1N4002 G/GL	1N4003 G/GL	1N4004 G/GL	1N4005 G/GL	1N4006 G/GL	1N4007 G/GL	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	V_{RRM} V_{RWM} V_R	50	100	200	400	600	800	1000	V
RMS Reverse Voltage	$V_{R(RMS)}$	35	70	140	280	420	560	700	V
Average Rectified Output Current (Note 1) @ $T_A = 75°C$	I_O	1.0							A
Non-Repetitive Peak Forward Surge Current 8.3ms single half sine-wave superimposed on rated load (JEDEC Method)	I_{FSM}	30							A
Forward Voltage @ $I_F = 1.0A$	V_{FM}	1.0							V
Peak Reverse Current @$T_A = 25°C$ at Rated DC Blocking Voltage @ $T_A = 125°C$	I_{RM}	5.0 50							µA
Reverse Recovery Time (Note 3)	t_{rr}	2.0							µs
Typical Junction Capacitance (Note 2)	C_j	8.0							pF
Typical Thermal Resistance Junction to Ambient	$R_{\theta JA}$	100							K/W
Operating and Storage Temperature Range	T_j, T_{STG}	-65 to +175							°C

Notes:
1. Leads maintained at ambient temperature at a distance of 9.5mm from the case.
2. Measured at 1.0 MHz and applied reverse voltage of 4.0V DC.
3. Measured with $I_F = 0.5A$, $I_R = -1A$, $I_{rr} = 0.25A$.

Scale
X-axis

Y-axis

Practical No.9: Construct and Test the full wave Bridge rectifier on bread board using four diodes

I Practical Significance

Bridge Rectifier is a type of Full Wave Rectifier that uses four diodes to form a close-loop bridge. The diodes conduct in pairs through each positive and negative half cycle, leading to no wastage of power. It is used for converting an alternating current (AC) input into a direct current (DC) output. Bridge rectifier is widely used in power supply circuit.

II Industry / Employer Expected Outcome

This practical is expected to develop the following skill: **'Use electronic components and circuits in electrical equipment and systems'.**

III Course Level Learning Outcome

Use semiconductor transistors in different applications.

IV Laboratory Learning Outcomes

Test full wave bridge rectifier on Breadboard:

1. Construct the circuit for Full Wave Bridge Rectifier using PN junction Diodes.
2. Observe and draw input-output waveforms for sinusoidal wave.

V Relevant Affective Domain related Outcomes

1. Handle components and equipment with care.
2. Work in team.

VI Minimum Theoretical Background

A single-Phase Bridge Rectifier is constructed using four Diodes D1, D2, D3, and D4, connected in a closed loop configuration that forms a bridge. The four diodes labeled D1 to D4 are arranged in "series pairs" with only two diodes conducting current during each half cycle.

During the positive half cycle of the supply, diodes D1 and D2 conduct in series while diodes D3 and D4 are reverse biased and the current flows through the load as shown below.

During the negative half cycle of the supply, diodes D3 and D4 conduct in series, but diodes D1 and D2 switch "OFF" as they are now reverse biased. The current flowing through the load is the same direction as before.

As the current flowing through the load is unidirectional, so the voltage developed across the load is also unidirectional the same as for the previous two diode full-wave rectifier, therefore the average DC voltage across the load is 0.637 Vmax.

VII Practical setup in Laboratory

(a) Sample

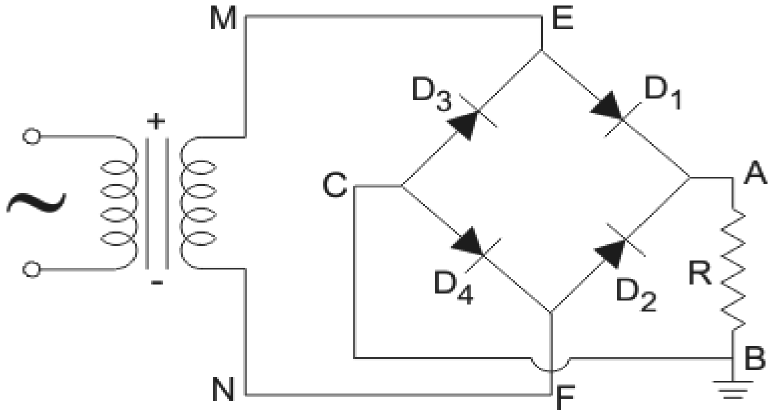


Figure 9.1: Full wave bridge rectifier

(b) Actual Circuit Diagram used in Laboratory

(c) Actual practical set up used in Laboratory

VIII Required Resources/apparatus/equipment with specifications

Sr. No	Instruments/Components	Specification	Quantity
1	Transformer	12-0-12V AC, 500 mA	1
2.	Multimeter	3 ½ -digit display with AC and DC voltage measurement and Current measurement facility and Diode testing facility.	1
3.	C.R.O.	25MHz, Dual trace, 15MΩ input impedance	1
4.	Function Generator	0-2 MHz with Sine, square and triangular output with variable frequency and amplitude.	1
5.	Resistor	10KΩ, 0.5 Watt.	1
6.	Diode	Silicon 1N4007	4
7.	Bread board	5.5 CM X 17CM	1
8.	Connecting wires	Single strand Teflon coating (0.6 mm diameter)	As per requirement

IX Precautions to be followed

1. Do not switch ON the power supply unless you have checked the circuit connections as per the circuit diagram.
2. While doing the practical do not exceed the input voltage of the diode beyond the rated voltage of diode as given in datasheet. This may lead to damaging of the diode.

X Procedure

1. Connect the circuit for Full wave bridge rectifier on breadboard as shown in Figure 9.1
2. Connect the primary side of the transformer to AC mains and the secondary side to rectifier input.
3. Before switching ON power supply, check the connection.
4. Switch ON the power supply and connect the CRO to the load resistor.
5. Measure the peak voltage Vm (peak voltage) across load resistor.

XI Observation Table

Table 1

Sr. No.	Rectified output across R (V_m)
1.	
2.	

Calculations:

XII Results

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XIII Interpretation of results

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XIV Conclusions and Recommendation

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XV Practical related Questions

1. Write the formula of peak inverse voltage for center tapped full wave rectifier and bridge rectifier.
2. In a bridge rectifier circuit what happens if one of the diodes is shorted?
3. Compare between half wave rectifier, full wave rectifier and bridge rectifier on the basis of output waveform

[Space for answers]

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XVI References / Suggestions for further Reading

1. http://nptel.ac.in/courses/
2. http://www.circuitstoday.com/full-wave-bridge-rectifier.
3. https://www.electrical4u.com/bridge-rectifiers/

XVII Assessment Scheme

Performance Indicators		Weightage
Process related (15 Marks)		**60%**
1	Proper connection of electrical circuit	20%
2	Handling of instrument	10%
3	Taking proper readings	20%
4	Working in team.	10%
Product related (10 Marks)		**40%**
1	Calculation of theoretical value	10%
2	Interpretation of Result	05%
3	Conclusions	05%
4	Practical related questions	15%
5	Completion and submission of experiment in time	05%
	Total (25 Marks)	**100%**

Names of Student Team Members

1. ....
2. ....
3. ....
4. ....

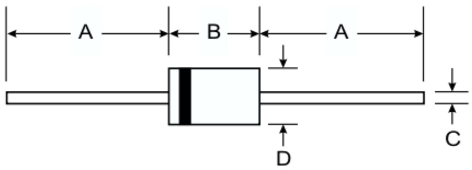
Marks Obtained			Dated Signature of Teacher
Process Related (15)	**Product Related (10)**	**Total (25)**	

1N4001G/L - 1N4007G/L

1.0A GLASS PASSIVATED RECTIFIER

Features

- Glass Passivated Die Construction
- Diffused Junction
- High Current Capability and Low Forward Voltage Drop
- Surge Overload Rating to 30A Peak
- Plastic Material - UL Flammability Classification 94V-0



Mechanical Data

- Case: Molded Plastic
- Terminals: Plated Leads Solderable per MIL-STD-202, Method 208
- Polarity: Cathode Band
- Weight: DO-41 0.30 grams (approx)
  A-405 0.20 grams (approx)
- Mounting Position: Any
- Marking: Type Number

	DO-41 Plastic		A-405	
Dim	**Min**	**Max**	**Min**	**Max**
A	25.40	—	25.40	—
B	4.06	5.21	4.10	5.20
C	0.71	0.864	0.53	0.64
D	2.00	2.72	2.00	2.70
All Dimensions in mm				

"L" Suffix Designates A-405 Package
No Suffix Designates DO-41 Package

Maximum Ratings and Electrical Characteristics

@ $T_A = 25°C$ unless otherwise specified

Single phase, half wave, 60Hz, resistive or inductive load.
For capacitive load, derate current by 20%.

Characteristic	Symbol	1N4001 G/GL	1N4002 G/GL	1N4003 G/GL	1N4004 G/GL	1N4005 G/GL	1N4006 G/GL	1N4007 G/GL	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	V_{RRM} V_{RWM} V_R	50	100	200	400	600	800	1000	V
RMS Reverse Voltage	$V_{R(RMS)}$	35	70	140	280	420	560	700	V
Average Rectified Output Current (Note 1) @ $T_A = 75°C$	I_O	1.0							A
Non-Repetitive Peak Forward Surge Current 8.3ms single half sine-wave superimposed on rated load (JEDEC Method)	I_{FSM}	30							A
Forward Voltage @ $I_F = 1.0A$	V_{FM}	1.0							V
Peak Reverse Current @$T_A = 25°C$ at Rated DC Blocking Voltage @ $T_A = 125°C$	I_{RM}	5.0 50							μA
Reverse Recovery Time (Note 3)	t_{rr}	2.0							μs
Typical Junction Capacitance (Note 2)	C_j	8.0							pF
Typical Thermal Resistance Junction to Ambient	$R_{\theta JA}$	100							K/W
Operating and Storage Temperature Range	T_j, T_{STG}	-65 to +175							°C

Notes:
1. Leads maintained at ambient temperature at a distance of 9.5mm from the case.
2. Measured at 1.0 MHz and applied reverse voltage of 4.0V DC.
3. Measured with $I_F = 0.5A$, $I_R = -1A$, $I_{rr} = 0.25A$.

Scale
X-axis

Y-axis

Practical No.10: Use LC/ π filter with full wave rectifier to measure ripple factor

I Practical Significance

A filter circuit is one which removes the AC component present in the rectified output and allows the DC component to reach the load. The electronic reactive elements like capacitor and inductors are used for filtering.

II Industry / Employer Expected Outcome

This practical is expected to develop the following skill: **'Use electronic components and circuits in electrical equipment and systems.**

III Course Level Learning Outcome

Use semiconductor transistors in different applications.

IV Laboratory Learning Outcomes

1. Build the circuit for Full Wave Rectifier using PN junction Diode with LC/Pi filter Measure dynamic resistance of a given diode.
2. Calculate ripple factor for given set up.

V Relevant Affective Domain related Outcomes

1. Handle components and equipment with care.
2. Work in team.

VI Minimum Theoretical Background

A filter circuit consists of passive circuit elements i.e., inductors, capacitors, resistors, and their combination. The filter action depends upon the electrical properties of passive circuit elements. For example, an inductor allows the D.C. to pass through it. But it blocks A.C. On the other hand, a capacitor allows the AC to pass through it. But it blocks the D.C.

In the inductor filter, the ripple factor is directly proportional to the load resistance. On the other hand, in a capacitor filter, it varies inversely with the load resistance. Hence if we combine the inductor filter with the capacitor the ripple factor will become almost independent of the load filter. It is also known as inductor input filter, choke input filter, L input, or LC-section.

In this circuit, a choke is connected in series with the load. It offers high resistance to the AC components and allows the DC component to flow through the load. The capacitor across the load is connected in parallel which filters out any AC component flowing through the choke. In this way, the ripples are rectified and a smooth DC is provided through the load.

Inductive reactance formula:

XL = 2πfL, where f is the frequency and L is the inductance.

VII Practical setup in Laboratory

(a) Sample

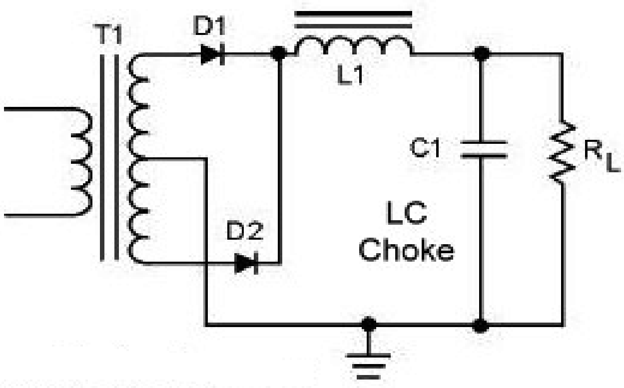


Figure 10.1: Full wave rectifier with LC filter

(b) Actual Circuit Diagram used in Laboratory

(c) Actual practical set up used in Laboratory

VIII Required Resources/apparatus/equipment with specifications

Sr. No	Instruments/Components	Specification	Quantity
1	Transformer (centre tapped)	12-0-12V AC, 500 mA	1
2.	Multimeter	3 ½ -digit display with AC and DC voltage measurement and Current measurement facility and Diode testing facility.	1
3.	C.R.O.	25MHz, Dual trace, 15MΩ input impedance	1
4.	Function Generator	0-2 MHz with Sine, square and triangular output with variable frequency and amplitude.	1
5.	Resistor	10KΩ, 0.5 Watt.	1
6.	Capacitor	1.00mF(electrolytic capacitors)	1
7.	Inductor	1nH	1
8.	Diode	Silicon 1N4007	2
9.	Bread board	5.5 CM X 17CM	1
10.	Connecting wires	Single strand Teflon coating (0.6 mm diameter)	As per requirement

IX Precautions to be followed

1. Do not switch ON the power supply unless you have checked the circuit connections as per the circuit diagram.
2. While doing the practical do not exceed the input voltage of the diode beyond the rated voltage of diode as given in datasheet. This may lead to damaging of the diode.

X Procedure

1. Connect the circuit for Full wave bridge rectifier on breadboard as shown in Figure 10.1
2. Connect the primary side of the transformer to AC mains and the secondary side to rectifier input.
3. Record peak voltage across load resistor using CRO.
4. Calculate the DC output voltage and peak to peak ripple voltage.
5. Calculate the ripple factor.
6. Observe and draw the waveforms across LC filter on graph paper.

XI Observation Table

Table 1

Type of Rectifier	Peak Voltage Vm (volts)	Vdc=2V m/π (volts)	Peak to peak ripple voltage Vr(volts)	Ripple factor=Vr/Vdc
Full wave rectifier				

Calculations:

XII Results

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XIII Interpretation of results

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XIV Conclusions and Recommendation

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XV Practical related Questions

1. Repeat the above experiment using L filter and comment on ripple factor.
2. Write the formula for calculating capacitive reactance.
3. Calculate the inductive reactance of a 3.00 mH inductor when 60.0 Hz and 10.0 kHz AC voltages are applied

[Space for answers]

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XVI References / Suggestions for further Reading

1. https://www.elprocus.com/half-wave-rectifier-circuit-working-principle-and-characteristics-2/
2. http://nptel.ac .in/courses /117103063/4

XVII Assessment Scheme

Performance Indicators		Weightage
Process related (15 Marks)		**60%**
1	Proper connection of electrical circuit	20%
2	Handling of instrument	10%
3	Taking proper readings	20%
4	Working in team.	10%
Product related (10 Marks)		**40%**
1	Calculation of theoretical value	10%
2	Interpretation of Result	05%
3	Conclusions	05%
4	Practical related questions	15%
5	Completion and submission of experiment in time	05%
	Total (25 Marks)	**100%**

Names of Student Team Members

1. ………………………….
2. ………………………..
3. ………………………….
4. ………………………….

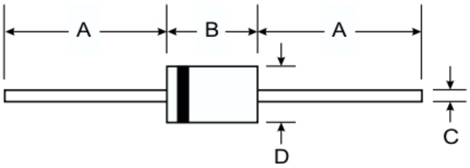
Marks Obtained			Dated Signature of Teacher
Process Related (15)	Product Related (10)	Total (25)	

1N4001G/L - 1N4007G/L

1.0A GLASS PASSIVATED RECTIFIER

Features

- Glass Passivated Die Construction
- Diffused Junction
- High Current Capability and Low Forward Voltage Drop
- Surge Overload Rating to 30A Peak
- Plastic Material - UL Flammability Classification 94V-0



	DO-41 Plastic		A-405	
Dim	Min	Max	Min	Max
A	25.40	—	25.40	—
B	4.06	5.21	4.10	5.20
C	0.71	0.864	0.53	0.64
D	2.00	2.72	2.00	2.70
All Dimensions in mm				

"L" Suffix Designates A-405 Package
No Suffix Designates DO-41 Package

Mechanical Data

- Case: Molded Plastic
- Terminals: Plated Leads Solderable per MIL-STD-202, Method 208
- Polarity: Cathode Band
- Weight: DO-41 0.30 grams (approx)
  A-405 0.20 grams (approx)
- Mounting Position: Any
- Marking: Type Number

Maximum Ratings and Electrical Characteristics

@ T_A = 25°C unless otherwise specified

Single phase, half wave, 60Hz, resistive or inductive load.
For capacitive load, derate current by 20%.

Characteristic	Symbol	1N4001 G/GL	1N4002 G/GL	1N4003 G/GL	1N4004 G/GL	1N4005 G/GL	1N4006 G/GL	1N4007 G/GL	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	V_{RRM} V_{RWM} V_R	50	100	200	400	600	800	1000	V
RMS Reverse Voltage	$V_{R(RMS)}$	35	70	140	280	420	560	700	V
Average Rectified Output Current (Note 1) @ T_A = 75°C	I_O	1.0							A
Non-Repetitive Peak Forward Surge Current 8.3ms single half sine-wave superimposed on rated load (JEDEC Method)	I_{FSM}	30							A
Forward Voltage @ I_F = 1.0A	V_{FM}	1.0							V
Peak Reverse Current @T_A = 25°C at Rated DC Blocking Voltage @ T_A = 125°C	I_{RM}	5.0 50							µA
Reverse Recovery Time (Note 3)	t_{rr}	2.0							µs
Typical Junction Capacitance (Note 2)	C_j	8.0							pF
Typical Thermal Resistance Junction to Ambient	$R_{\theta JA}$	100							K/W
Operating and Storage Temperature Range	T_j, T_{STG}	-65 to +175							°C

Notes:
1. Leads maintained at ambient temperature at a distance of 9.5mm from the case.
2. Measured at 1.0 MHz and applied reverse voltage of 4.0V DC.
3. Measured with I_F = 0.5A, I_R = -1A, I_{rr} = 0.25A.

Scale
X-axis

Y-axis

Practical No.11: Prepare and Test the full wave rectifier on bread board using IC KBU808 with filter

I Practical Significance

The filter converts the pulsating DC into pure DC. The electronic reactive elements like capacitor and inductors are used for filtering. KBU 808 are a single-phase bridge rectifier IC.

II Industry / Employer Expected Outcome

This practical is expected to develop the following skill: **'Use electronic components and circuits in electrical equipment and systems.**

III Course Level Learning Outcome

Use semiconductor transistors in different applications.

IV Laboratory Learning Outcomes

Prepare the circuit for full wave rectifier using IC KBU 808 with filter.

V Relevant Affective Domain related Outcomes

1. Handle components and equipment with care.
2. Work in team.

VI Minimum Theoretical Background

The KBU808 is a bridge rectifier integrated circuit that is commonly used in power supply applications to convert alternating current (AC) into direct current (DC)

Features of KBU808

- Surge overload rating 200 amperes peak.
- Ideal for printed circuit board.
- Reliable low-cost construction utilizing molded plastic technique.
- Plastic Passivated chip junctions.
- Lead-free parts meet RoHS requirements.
- UL recognized file # E321971.
- Suffix "-H" indicates Halogen-free part, ex.KBU8005-H.

VII Practical setup in Laboratory

(a) Sample

Figure 11.1: IC KBU808

(b) Actual Circuit Diagram used in Laboratory

(c) Actual practical set up used in Laboratory

VIII Required Resources/apparatus/equipment with specifications

Sr. No	Instruments/Components	Specification	Quantity
1.	Variable DC power supply	0-30V, 2A, SC protection, display for voltage and current	1
2.	Transformer	9-0-9VAC,500mA	1
3.	Digital Multimeter	3 ½ -digit display with AC and DC voltage measurement and Current measurement facility and Diode testing facility.	1
4.	IC KBU 808	IF=8A, VF=1V	1
5.	Bread board	5.5 CM X 17CM	1
6.	Connecting wires	Single strand Teflon coating (0.6 mm diameter)	As per requirement

IX Precautions to be followed

1. Do not switch ON the power supply unless you have checked the circuit connections as per the circuit diagram.
2. While doing the practical do not exceed the input voltage of the diode beyond the rated voltage of diode as given in datasheet. This may lead to damaging of the diode.

X Procedure

1. Keep DMM on diode test mode.
2. Connect the positive terminal of DMM to pin no.4 and the negative terminal of DMM to pin no.3 of IC 808 observe the drop on DMM of IC 808 observe the drop on DMM.
3. Connect the negative terminal of DMM to pin no.4 of IC 808 DMM and connect the positive terminal of DMM to pin no.3 of IC 808 observe OL(no drop) on DMM
4. Repeat above steps for pin no.1 and Pin no.2 of IC 808 note down the drop and no drop on DMM.
5. Connect the positive terminal of DMM to pin no.4 of IC and connect negative terminal of DMM to pin no.1 of IC note down the double diode drop on DMM

XI Observation Table

Table 1

Sr. No.	Pin connection	Output on DMM
1.	Drop between pin no.3 and 4	
2.	Reverse drop between pin no.4 and pin no.3	
3.	Drop between pin no.2 and pin no.1	
4.	Reverse drop between pin no.1 and pin no.2	
5.	Drop between pin no.1 and 4	
6.	Reverse drop between pin no.4 and pin no.1	

XII Results

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XIII Interpretation of results

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XIV Conclusions and Recommendation

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XV Practical related Questions

1. Repeat the above experiment for Schottky diode and comment on voltage drop.
2. List features of IC KBU 808.
3. List the applications of IC KBU 808

[Space for answers]

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XVI References / Suggestions for further Reading

1. http://nptel.ac.in/courses/
2. www.electronics-tutorials.ws › Diodes

XVII Assessment Scheme

Performance Indicators		Weightage
Process related (15 Marks)		**60%**
1	Proper connection of electrical circuit	20%
2	Handling of instrument	10%
3	Taking proper readings	20%
4	Working in team.	10%
Product related (10 Marks)		**40%**
1	Calculation of theoretical value	10%
2	Interpretation of Result	05%
3	Conclusions	05%
4	Practical related questions	15%
5	Completion and submission of experiment in time	05%
	Total (25 Marks)	**100%**

Names of Student Team Members

1. ....
2. ....
3. ....
4. ....

Marks Obtained			**Dated Signature of Teacher**
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No.12: Build clipper circuit and observe the Wave forms

I Practical Significance

A clipper is a device that limits, removes, or prevents some portion of the waveform (input signal voltage) above or below a certain level. In other words, the circuit which limits positive or negative amplitude, or both is called a clipping circuit.

II Industry / Employer Expected Outcome

This practical is expected to develop the following skill: **'Use electronic components and circuits in electrical equipment and systems.**

III Course Level Learning Outcome

Use semiconductor transistors in different applications.

IV Laboratory Learning Outcomes

1. Build/Test positive Clipper circuit.
2. Build/Test negative Clipper circuit.

V Relevant Affective Domain related Outcomes

1. Handle components and equipment with care.
2. Work in team.

VI Minimum Theoretical Background

A clipping circuit consists of linear elements like resistors and non-linear elements like junction diodes or transistors, but it does not contain energy-storage elements like capacitors. Clipping circuits are used to select for purposes of transmission, that part of a signal wave form which appears above or below a certain reference voltage level. Thus, a clipper circuit can remove certain portions of an arbitrary wave form near the positive or negative peaks. Clipping may be achieved either at one level or two levels.

Clipper has two types:

1. Series Clipper: In this configuration the diode is connected in series with the load.
2. Parallel Clipper: In this configuration the diode is connected in parallel with the load.

In a series positive clipper, a diode is connected in series with the output, as shown in Fig 12.1. During the positive half of the input voltage, terminal A is positive with respect to B. These reverse biases the diode and it acts as an open switch Therefore all the applied voltage drops across the diode and none across the resistor.

As a result of this there is no output voltage during the positive half cycle of the input voltage. In a series negative clipper, a diode is connected in a direction appositive to that of a positive clipper Fig 12.2 shows the circuit of a negative clipper. During the positive half cycle of the voltage, terminal A is positive with respect to terminal B There for the diode is forward biased and it acts it as a closed switch. As a result, all the input voltage appears across the resistor as shown in Fig12.2 During the negative half cycle of the input voltage, terminal B is positive with respect to the terminal A. Therefore, the diode is reverse biased and it acts as an open switch, thus there is no voltage drop across the resistor during the negative half cycle as shown in the output waveform.

VII Practical setup in Laboratory

(a) Sample

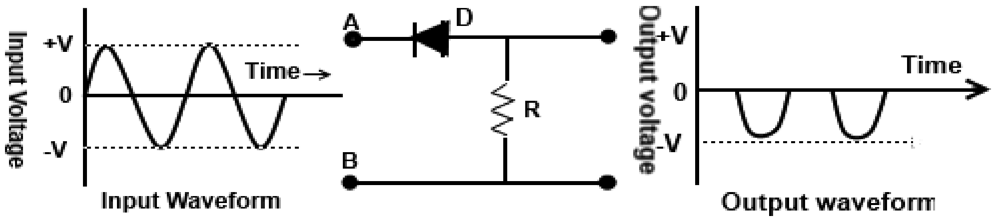

Figure 12.1: Circuit diagram of Positive Clipper.

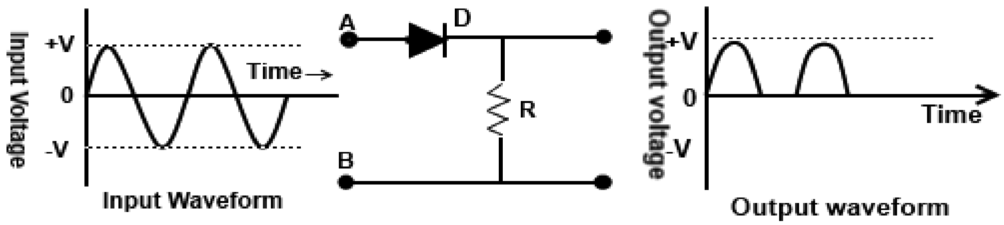

Figure 12.2: Circuit diagram of Negative Clipper.

(b) Actual Circuit Diagram used in Laboratory

(c) Actual practical set up used in Laboratory

VIII Required Resources/apparatus/equipment with specifications

Sr. No	Instruments/Components	Specification	Quantity
1	Digital Multimeter	3 ½ -digit display with AC and DC voltage measurement and Current measurement facility and Diode testing facility.	2
2.	DC Regulated power supply	Variable DC power supply 0- 30V, 2A, SC protection, display for voltage and current.	1
3.	Cathode Ray Oscilloscope	Dual Trace 20Mhz. 1 5Mega ohm Input impedance	1
4.	Function Generator	0-2 MHz with Sine, square and triangular output with variable frequency and amplitude.	1
5.	Diode	IN4007 (or any other Equivalent diode)	1
6.	Resistor	1KΩ (0.5watts/0.25watts)	1
7.	Bread board	5.5 CM X 17CM	1
8.	Connecting wires	Single strand Teflon coating (0.6mm)	As per requirement

IX Precautions to be followed

1. Care should be taken while handling the terminals of components.
2. Select proper range and mode of Ammeter and voltmeter.
3. Connect wire tightly while building circuits.
4. Do not switch ON the power supply unless you have checked the circuit connections as per the circuit diagram

X Procedure

1. Make the connections on bread board as per circuit diagram as shown in figureno.12.1 and 12.2
2. Connect the function generator at the input and apply sine wave to the input of circuit (8Vp-p).
3. Observe the input and output waveforms on CRO and draw it on the graph paper.

XI Observation Table

Table 1: Measurement of Positive clipper

Sr. No.	Input Voltage Vin(V)	Output Voltage Vout (V)	Comments
1.			

Table 2: Measurement of Negative clipper

Sr. No.	Input Voltage Vin(V)	Output Voltage Vout (V)	Comments
1.			

XII Results

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XIII Interpretation of results

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XIV Conclusions and Recommendation

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XV Practical related Questions

1. Draw the input and output waveforms. (For positive Clipper circuit)
2. Draw the input and output waveforms and find out the difference between input and output voltage. (For negative Clipper circuit)
3. List the different types of clipper circuit.

[Space for answers]

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XVI References / Suggestions for further Reading

1. http://www.expertsmind.com/learning/combination-clipper-assignment-help-
2. 7342873667.aspx
3. https://www.youtube.com/watch?v=Mvmfqg28ZnY

XVII Assessment Scheme

Performance Indicators		Weightage
Process related (15 Marks)		**60%**
1	Proper connection of electrical circuit	20%
2	Handling of instrument	10%
3	Taking proper readings	20%
4	Working in team.	10%
Product related (10 Marks)		**40%**
1	Calculation of theoretical value	10%
2	Interpretation of Result	05%
3	Conclusions	05%
4	Practical related questions	15%
5	Completion and submission of experiment in time	05%
	Total (25 Marks)	**100%**

Names of Student Team Members

1. ....
2. ....
3. ....
4. ....

Marks Obtained			Dated Signature of Teacher
Process Related (15)	**Product Related (10)**	**Total (25)**	

Scale
X-axis

Y-axis

Practical No.13: Construct clamper circuit and observe waveforms

I Practical Significance

A Clamper circuit can be defined as the circuit that consists of a diode, a resistor and a capacitor that shifts the waveform to a desired DC level without changing the actual appearance of the applied signal. Clampers can be constructed in both positive and negative polarities. Clamper essentially adds a DC level to the AC output signal; clampers are commonly used in analog TV receivers.

II Industry / Employer Expected Outcome

This practical is expected to develop the following skill: **'Use electronic components and circuits in electrical equipment and systems'.**

III Course Level Learning Outcome

Use semiconductor transistors in different applications.

IV Laboratory Learning Outcomes

1. Construct and Test Positive Clamper Circuit
2. Construct and Test negative Clamper Circuit

V Relevant Affective Domain related Outcomes

1. Handle components and equipment with care.
2. Work in team.

VI Minimum Theoretical Background

A clamper is an electronic circuit that changes the DC level of a signal to the desired level without changing the shape of the applied signal. In other words, the clamper circuit ADDS positive or negative DC level. The DC component is simply added to the input signal or subtracted from the input signal. A clamper circuit adds the positive dc component to the input signal to push it to the positive side. Similarly, a clamper circuit adds the negative dc component to the input signal to push it to the negative side.

Positive clamper

If the circuit pushes the signal upwards then the circuit is said to be a positive clamper. When the signal is pushed upwards, the negative peak of the signal meets the zero level. The positive clamper is made up of a voltage source Vi, capacitor C, diode D, and load resistor RL. In the Figure 13.1 diagram, the diode is connected in parallel with the output load. So the positive clamper passes the input signal to the output load when the diode is reverse biased and blocks the input signal when the diode is forward biased

During negative half cycle:

During the negative half cycle of the input AC signal, the diode is forward biased and hence no signal appears at the output. In forward biased condition, the diode allows electric current through it. This current will flows to the capacitor and charges it to the peak value of input voltage Vm. The capacitor charged in inverse polarity (positive) with the input voltage. As input current or voltage decreases after attaining its maximum value -Vm, the capacitor holds the charge until the diode remains forward biased.

During positive half cycle:

During the positive half cycle of the input AC signal, the diode is reverse biased and hence the signal appears at the output. In reverse biased condition, the diode does not allow electric current through it. So, the input current directly flows towards the output.

Negative clamper

During positive half cycle:

During the positive half cycle of the input AC signal, the diode is forward biased and hence no signal appears at the output. In forward biased condition, the diode allows electric current through it. This current will flow to the capacitor and charges it to the peak value of input voltage in inverse polarity -Vm. As input current or voltage decreases after attaining its maximum value Vm, the capacitor holds the charge until the diode remains forward biased.

During negative half cycle:

During the negative half cycle of the input AC signal, the diode is reverse biased and hence the signal appears at the output. In reverse biased condition, the diode does not allow electric current through it. So, the input current directly flows towards the output.

VII Practical setup in Laboratory

(a) Sample

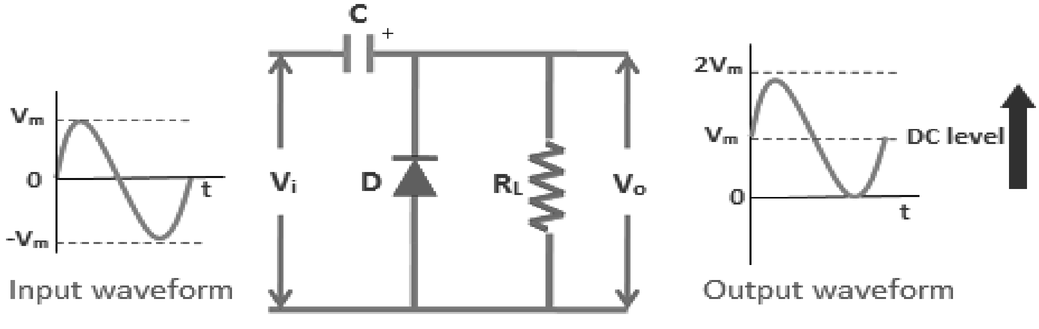

Figure 13.1: Circuit diagram of Positive clamper.

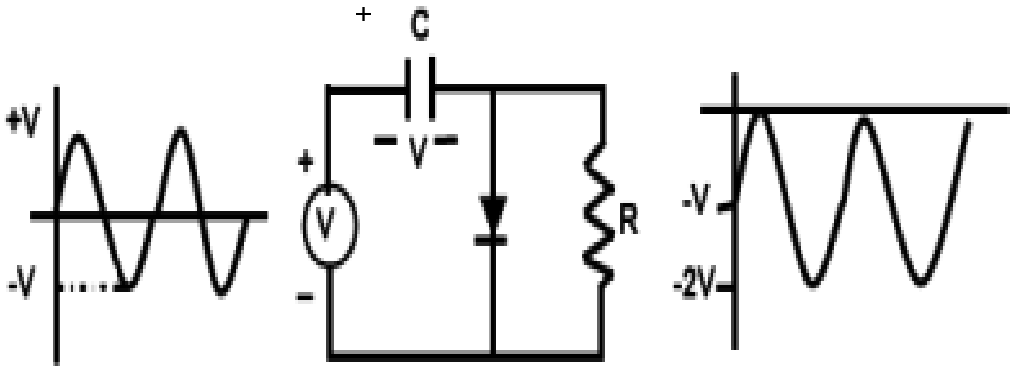

Figure 13.2: Circuit diagram of Negative clamper.

(b) Actual Circuit Diagram used in Laboratory

(c) Actual practical set up used in Laboratory

VIII Required Resources/apparatus/equipment with specifications

Sr. No	Instruments/Components	Specification	Quantity
1	Digital Multimeter	3 ½ -digit display with AC and DC voltage measurement and Current measurement facility and Diode testing facility.	1
2.	Cathode Ray Oscilloscope	Dual Trace 20Mhz. 1 5Mega ohm Input impedance.	1
3.	Function Generator	0-2 MHz with Sine, square and triangular output with variable frequency and amplitude.1MHz, Multi waveform output	1
4.	Diode	IN4007(or any other equivalent diode)	1
5.	Resistors	l KΩ (0.5watts/0.25watts	1
6.	Capacitor	1µf (or any other capacitor value)	1
7.	Bread board	5.5 CM X 17CM	1
8.	Connecting wires	Single strand Teflon coating (0.6mm)	As per requirement

IX Precautions to be followed

1. Care should be taken while handling the terminals of components.
2. Connect wire tightly while building circuits.
3. Do not switch ON the power supply unless you have checked the circuit connections as per the circuit diagram.

X Procedure

1. Make the connections on breadboard as per circuit diagram as shown in figure 13.1 and 13.2
2. Apply sine wave as input of 8V peak to peak to the circuit.
3. Observe and draw the input and output waveforms from CRO.

XI Observation Table

Table 1: Positive clamper circuit

Sr. No.	Vin(volts)	Vout (Volts)	Output Waveform	Comment
1.				

Table 2: Negative clamper circuit

Sr. No.	Vin(volts)	Vout (Volts)	Output Waveform	Comment
1.				

XII Results

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XIII Interpretation of results

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XIV Conclusions and Recommendation

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XV Practical related Questions

1. Repeat the above experiment for input voltage 6 volt peak to peak and 2 volt peak to peak.
2. Repeat the above experiment for 4 volt peak to peak and observe output and input.
3. Compare between clipper and clamper circuit

[Space for answers]

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XVI References / Suggestions for further Reading

1. http://www.expertsmind.com/learning/combination-clipper-assignment-help-7342873667.aspx
2. https://www.youtube.com/watch?v=Mvmfqg28ZnY
3. https://www.youtube.com/watch?v=VMquoQBbjFQ

XVII Assessment Scheme

Performance Indicators		Weightage
Process related (15 Marks)		**60%**
1	Proper connection of electrical circuit	20%
2	Handling of instrument	10%
3	Taking proper readings	20%
4	Working in team.	10%
Product related (10 Marks)		**40%**
1	Calculation of theoretical value	10%
2	Interpretation of Result	05%
3	Conclusions	05%
4	Practical related questions	15%
5	Completion and submission of experiment in time	05%
	Total (25 Marks)	**100%**

Names of Student Team Members

1. ....
2. ....
3. ....
4. ....

Marks Obtained			**Dated Signature of Teacher**
Process Related (15)	**Product Related (10)**	**Total (25)**	

Scale
X-axis

Y-axis

Practical No.14: Identify and select transistors for given application using datasheets

I Practical Significance

In industry, transistor has wide range of applications. Transistors are semiconductor devices used for applications like amplification of voltages, current and are also used in oscillator circuits and switches. In digital circuits they are used as switches. It is used in electronic equipment, computers, televisions, mobile phones, audio amplifiers, industrial control, and radio transmitters.

II Industry / Employer Expected Outcome

This practical is expected to develop the following skill: **'Use electronic components and circuits in electrical equipment and systems.**

III Course Level Learning Outcome

Use semiconductor transistors in different applications.

IV Laboratory Learning Outcomes

1. Identify the terminals of the PNP and NPN transistor for TO-5, TO-220, TO-66.
2. Selection of transistor for different parameters as maximum voltage, current and switching speed.

V Relevant Affective Domain related Outcomes

1. Handle components and equipment with care.
2. Work in team.

VI Minimum Theoretical Background

A transistor has two PN junctions (a combination of two diodes connected back-to-back), one junction is forward biased and the other is reverse biased. The forward biased junction has a low resistance path where as a reverse biased junction has a high resistance path. The weak signal is introduced in the low resistance circuit and output is taken from the high resistance circuit. Transistor has two junctions and 3 terminals, made of three layers of N and P type materials. The three regions are emitter, base and collector. There are 2 types of BJT (i) PNP and (ii) NPN.

An NPN transistor is composed of two N-type semiconductors separated by a thin section of P type. However, a PNP transistor is formed by two P-sections separated by a thin section of N-type as shown in Figure 14.1.

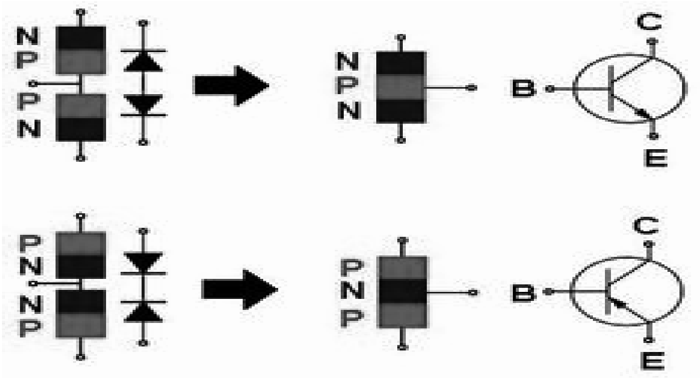
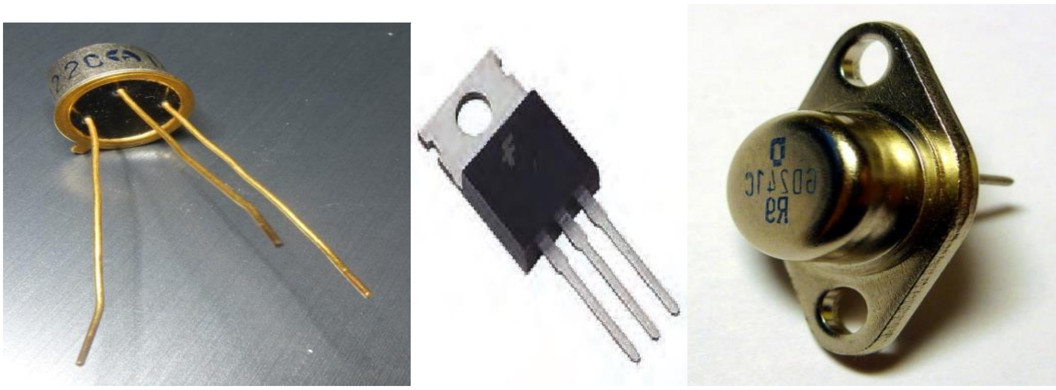


Figure 14.1: Symbol and construction of NPN and PNP transistor

Identifying Transistor Terminals:

The transistors are available with various packages in the market. Consider about the T0-5, TO-220& TO-66 package. Keep the transistor such that the flat surface is facing towards you as shown in the figure 14.2(a),(b),(c).



(a) (b) (c)

Figure 14.2: (a) TO5, (b) TO220, (c)TO66

Remember the following points:

1. The transistor internally has two diodes (NPN=N-P-N=NP Junction +PN Junction and PNP= P-N-P= PN Junction +NP Junction) i.e. Emitter to base is one PN Junction (diode) and Base to collector another PN junction (diode).
2. In the diode mode, the multimeter will show the voltage when we connect the positive probe of the multimeter to the anode of the diode and negative probe to the cathode.
3. If the multimeter positive probe is connected to the cathode of the diode and the negative probe to the anode, then it will not give any voltage (showing zero).

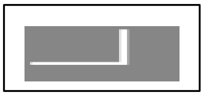
Steps to identify the PNP type transistor using DMM

1. Keep the DMM in the resistance mode.
2. Keep the positive probe to the pin-1(Emitter) of the transistor and connect the negative probe to the center pin (Base).You will see some resistance in the DMM.

3. Similarly connect the negative probe to the center pin (Base) with respect to the pin-3 (collector). You will see some resistance in the DMM.
4. It will ensure that it is a PNP transistor. The logic behind this is in PNP transistor Emitter(E) P type material Equivalent to anode of diode.
5. The diode Base(B) N-type material-Equivalent to cathode of the Diode Collector(C) - P type material - Equivalent to anode of the diode
6. If the multimeter positive probe is connected to anode and negative probe is connected to cathode, then it will show resistance. If the connections are interchanged it will not show any value.

Steps to identify the PNP type transistor using CRO

1. By operating CRO in component testing mode.
2. Keep the knob on xy mode of CRO and observe the patterns on CRO screen.
3. If the pattern is as given in text box The transistor terminals are in



Forward bias (low resistance)

4. If the pattern is as given in text box The transistor terminals are in

Reverse bias (high resistance)

VII Practical setup in Laboratory

(a) Sample

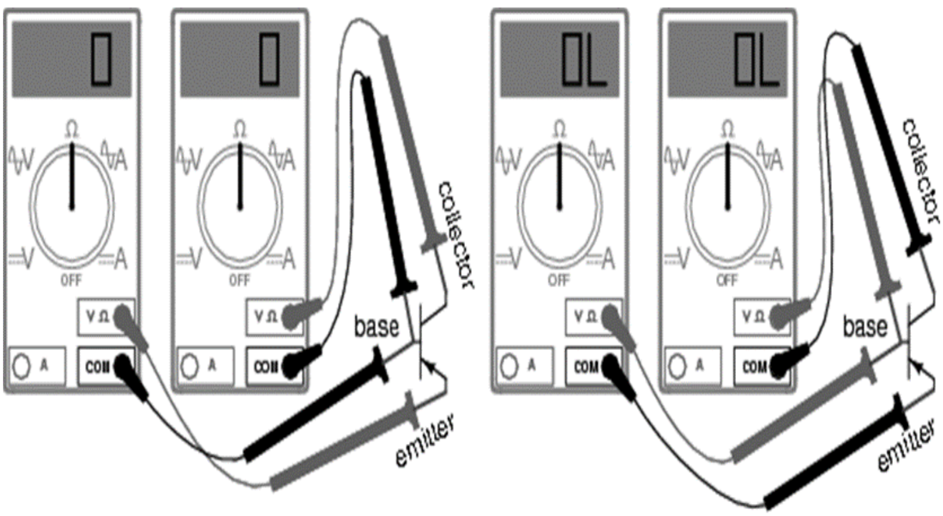


Figure 14.3: Connection of transistor testing using DMM

(b) Actual practical setup used in Laboratory

VIII Required Resources/apparatus/equipment with specifications

Sr. No	Instruments/Components	Specification	Quantity
1	Digital Multimeter	3 ½ -digit display with AC and DC voltage measurement and Current measurement facility and Diode testing facility.	1
2.	Cathode Ray Oscilloscope	Dual Trace 20Mhz. 1 5Mega ohm Input impedance	1
3.	Transistors	Power Transistors 2N2955(NPN) 2N3055(PNP),TO-5,TO-220,TO-66.	1
4.	Bread board	5.5 CM X 17CM	1
5.	Connecting wires	Single strand Teflon coating (0.6mm)	As per requirement

IX Precautions to be followed

1. Care should be taken while handling the terminals of components.
2. Select proper range in Digital Multimeter.

X Procedure

1. Set the multimeter to its ohms range.
2. Measured the resistance between base and emitter.
3. Measured the resistance between base and collector.
4. Measured the resistance between emitter and collector.

XI Observation Table

1. Testing of PNP terminal resistance using Multimeter

a) Resistance between emitter and base RBE =

b) Resistance between Collector and base RCB=

c) Resistance between Collector and Emitter RCE=

2. Testing of NPN terminal resistance using Multimeter

a) Resistance between emitter and base RBE=

b) Resistance between Collector and base RCB=

c) Resistance between Collector and Emitter RCE=

XII Results

1. From the values of RBE, RCB and RCE on DMM the transistor is identified as...............
2. From CRO pattern the transistor is identified as...............

XIII Interpretation of results

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XIV Conclusions and Recommendation

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XV Practical related Questions

1. List the specification of transistor.
2. Name five different types of transistors.
3. Draw the symbol of NPN & PNP transistor.

[Space for answers]

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XVI References / Suggestions for further Reading

1. https://www.allaboutcircuits.com/textbook/semiconductors/chpt-4/meter-check-transistor-bjt/
2. http://www.electricalbasicprojects.com/how-to-identify-npn-and-pnp-transistor-using-multimeter/

XVII Assessment Scheme

Performance Indicators		Weightage
Process related (15 Marks)		**60%**
1	Handling of the components	20%
2	Identification of component	10%
3	Measuring value using suitable instrument	20%
4	Working in team.	10%
Product related (10 Marks)		**40%**
1	Interpretation of Result	10%
2	Conclusions	05%
3	Practical related questions	10%
4	Completion and submission of experiment in time	15%
	Total (25 Marks)	**100%**

Names of Student Team Members

1. ……………………………
2. ……………………………..
3. …………………………….
4. …………………………..

Marks Obtained			**Dated Signature of Teacher**
Process Related (15)	**Product Related (10)**	**Total (25)**	

2N3055(NPN), MJ2955(PNP)

Preferred Device

Complementary Silicon Power Transistors

Complementary silicon power transistors are designed for general−purpose switching and amplifier applications.

Features

- DC Current Gain − h_{FE} = 20−70 @ I_C = 4 Adc
- Collector−Emitter Saturation Voltage − $V_{CE(sat)}$ = 1.1 Vdc (Max) @ I_C = 4 Adc
- Excellent Safe Operating Area
- Pb−Free Packages are Available*

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector−Emitter Voltage	V_{CEO}	60	Vdc
Collector−Emitter Voltage	V_{CER}	70	Vdc
Collector−Base Voltage	V_{CB}	100	Vdc
Emitter−Base Voltage	V_{EB}	7	Vdc
Collector Current − Continuous	I_C	15	Adc
Base Current	I_B	7	Adc
Total Power Dissipation @ T_C = 25°C Derate Above 25°C	P_D	115 0.657	W W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200	°C

Maximum ratings are those values beyond which device damage can occur. Maximum ratings applied to the device are individual stress limit values (not normal operating conditions) and are not valid simultaneously. If these limits are exceeded, device functional operation is not implied, damage may occur and reliability may be affected.

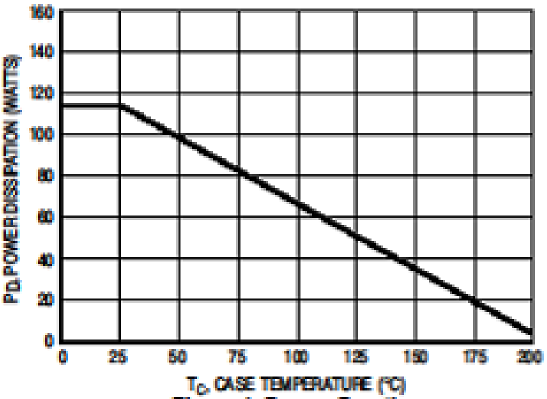

Figure 1. Power Derating

*For additional information on our Pb−Free strategy and soldering details, please download the ON Semiconductor Soldering and Mounting Techniques Reference Manual, SOLDERRM/D.

ON Semiconductor™

http://onsemi.com

15 AMPERE POWER TRANSISTORS COMPLEMENTARY SILICON 60 VOLTS, 115 WATTS

TO−204AA (TO−3)
CASE 1−07
STYLE 1

MARKING DIAGRAM

xxxx55	=	Device Code xxxx = 2N30 or MJ20
G	=	Pb−Free Package
A	=	Location Code
YY	=	Year
WW	=	Work Week
MEX	=	Country of Orgin

ORDERING INFORMATION

Device	Package	Shipping
2N3055	TO−204AA	100 Units / Tray
2N3055G	TO−204AA (Pb−Free)	100 Units / Tray
MJ2955	TO−204AA	100 Units / Tray
MJ2955G	TO−204AA (Pb−Free)	100 Units / Tray

Preferred devices are recommended choices for future use and best overall value.

Practical No.15: Build and Test the performance of BJT in CB mode

I Practical Significance

Transistor is a basic building block of modern electronic circuits. Nearly every electronic circuit contains at least one or more types of transistors. A transistor is a semiconductor device used to amplify or switch electronic signals and electrical power. In this practical student will plot the characteristics of NPN transistor in input and output mode for CB configuration and calculate current amplification factorα.

II Industry / Employer Expected Outcome

This practical is expected to develop the following skill: **'Use electronic components and circuits in electrical equipment and systems'.**

III Course Level Learning Outcome

Use semiconductor transistors in different applications.

IV Laboratory Learning Outcomes

Test the performance of BJT in CB mode:

1. Build the circuit for BJT in common base configuration.
2. Plot input and output characteristics of common base configuration

V Relevant Affective Domain related Outcomes

1. Handle components and equipment with care.
2. Work in team.

VI Minimum Theoretical Background

Input Characteristics:

In common base configuration, Emitter is the input terminal and collector is the output terminal and base connected as a common terminal for both input and output. The CB configuration is used in applications where low input impedance is required.

This curve gives the relationship between input current (I_E) and input voltage (V_{EB}) for constant output voltage (V_{CB}) by varying V_{EB} for constant V_{CB} it may be noted that below knee voltage current is very small. Beyond the knee voltage, the emitter current (I_E) increases with small increase in emitter to base voltage V_{EB} for constant V_{CB}. As the collector to Base voltage is increased above 1V, the curve shifts upwards.

Input characteristics may be used to determine the value of common base transistor AC input resistance ri. It is the ratio of change in emitter to base voltage ($\blacktriangle V_{EB}$) to resulting change in emitter current (I_E) at a constant collector to base voltage (V_{CB}).

$$r_i = \frac{\blacktriangle V_{EB}}{\blacktriangle I_E} \quad V_{CB} = \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots$$

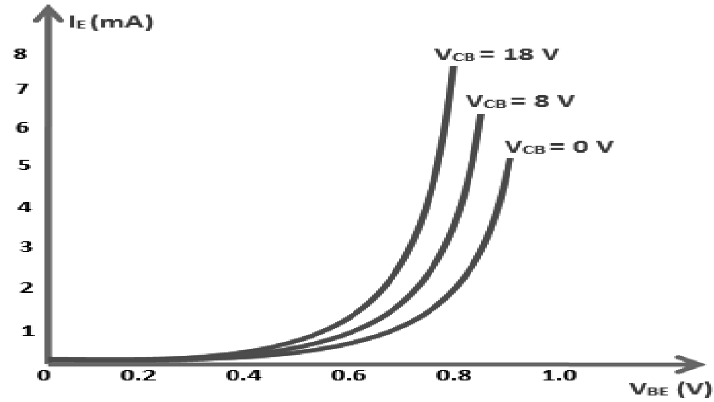

Figure 15.1: Input characteristics in CB

Output Characteristics:

This curve gives the relationship between output current (I_E) it and output voltage (V_{CB}) for a constant emitter current (I_E).

The output characteristics are divided into three regions:

Cut off region: Transistor act as OFF State switch

Saturation Region: Transistor act as ON State switch

Active Region: Transistor acts as amplifier.

Output characteristics may be used to determine the value of common base transistor a.c. output resistance r. It is the ratio of change in collector to base voltage ($\blacktriangle V_{CB}$) to resulting change in collector current ($\blacktriangle I_c$) at a constant emitter current (I_E).

$$r_o = \frac{\blacktriangle V_{CB}}{\blacktriangle I_c} \quad I_E = \ldots\ldots\ldots\ldots\ldots\ldots$$

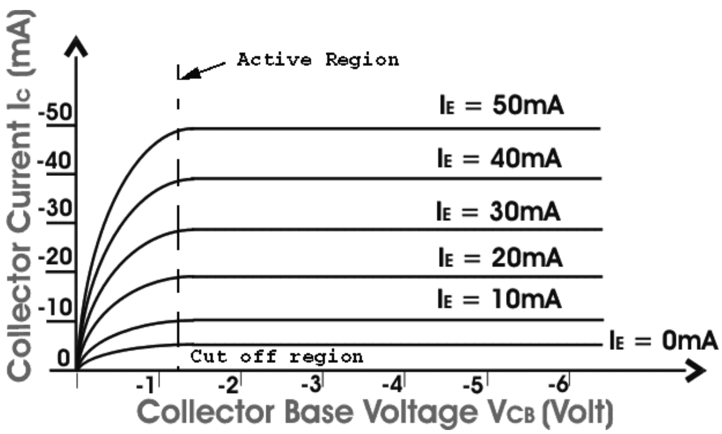

Figure 15.2: Output characteristics in CB

VII Practical setup in Laboratory

(a) Sample

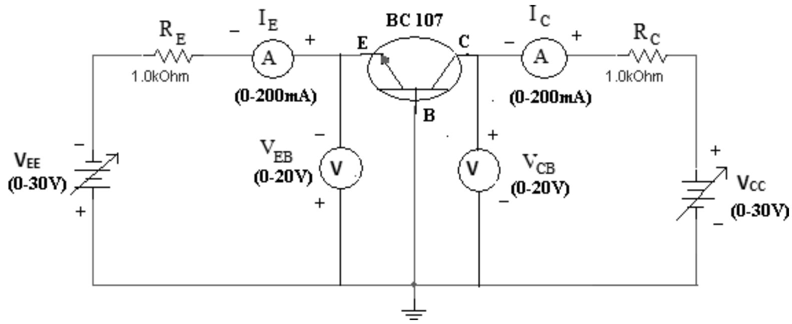

Figure 15.3: Circuit diagram of BJT in CB mode.

(b) Actual Circuit Diagram used in Laboratory

(c) Actual practical set up used in Laboratory

VIII Required Resources/apparatus/equipment with specifications

Sr. No	Instruments/Components	Specification	Quantity
1	Digital Multimeter	3 ½ -digit display with AC and DC voltage measurement and Current measurement facility and Diode testing facility.	1
2.	DC Regulated power supply	Variable DC power supply 0- 30V, 2A, SC protection, display for voltage and current.	2
3.	DC Voltmeter	0-20 V	2
4.	DC Ammeter	0 - 200 mA	2
5.	Transistor	BC107 or any other equivalent	1
6.	Resistor	1KΩ (0.5watts/0.25watts)	2
7.	Bread board	5.5 CM X 17CM	1
8.	Connecting wires	Single strand Teflon coating (0.6mm)	As per requirement

IX Precautions to be followed

1. Care should be taken while handling the terminals of components.
2. Select proper range and mode of Ammeter and voltmeter.
3. Connect wire tightly while building circuits.
4. Do not switch ON the power supply unless you have checked the circuit connections as per the circuit diagram

X Procedure

Part I

Input characteristics:

1. Connect the circuit as shown in figure 15.3
2. Keep output voltage V_{CB}= 0V by varying Vcc.
3. Vary V_{EB} in step of 0.1V from Oto 1Vand note down the corresponding emitter current I_E.
4. Repeat above procedure (step 3) for V_{CB}= 4V.

Part II

Output characteristics:

1. Connect the circuit as shown in figure 15.3
2. Keep input current I_E = 0 mA by varying V_{EE}.
3. Vary VCB in step of 1V from 1 to 10 V and note down the corresponding collector current Ic.
4. Repeat above procedure (step 3) for I_E= 10 mA

XI Observation Table

Table 1: Input Characteristics

Sr. No.	V_{CB} =OV		V_{CB} =4V	
	V_{EB} (V)	I_E (mA)	V_{EB} (V)	I_E (mA)
1.				
2.				
3.				
4.				
5.				
6.				

Table 2: Output Characteristics

Sr. No.	I_E (mA)=O		I_E (mA)=10mA	
	V_{CB}(Volts)	Ic(mA)	V_{CB} (Volts)	Ic(mA)
1.				
2.				
3.				
4.				
5.				
6.				

Calculations*: (from graph)*

1. Input resistance ri:
2. Output resistance ro:
3. Current amplification factor α. :

XII Results

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XIII Interpretation of results

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XIV Conclusions and Recommendation

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XV Practical related Questions

1. Repeat the same experiment using PNP transistor.
2. State the early effect. Have you observed early effect in your experiment?

[Space for answers]

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XVI References / Suggestions for further Reading

1. https://www.electrical4u.com/transistor-characteristics/
2. https://www.youtube.com/watch?v=NMD4KECE-7I
3. https://www.electronicshub.org/common-base-amplifier/

XVII Assessment Scheme

Performance Indicators		Weightage
Process related (15 Marks)		**60%**
1	Proper connection of electrical circuit	20%
2	Handling of instrument	10%
3	Taking proper readings	20%
4	Working in team.	10%
Product related (10 Marks)		**40%**
1	Calculation of theoretical value	10%
2	Interpretation of Result	05%
3	Conclusions	05%
4	Practical related questions	15%
5	Completion and submission of experiment in time	05%
	Total (25 Marks)	**100%**

Names of Student Team Members

1. ....
2. ....
3. ....
4. ....

Marks Obtained			**Dated Signature of Teacher**
Process Related (15)	**Product Related (10)**	**Total (25)**	

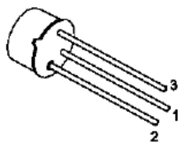
SGS-THOMSON MICROELECTRONICS

BC107 BC108

LOW NOISE GENERAL PURPOSE AUDIO AMPLIFIERS

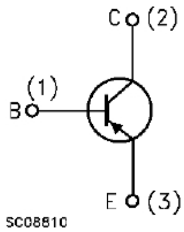
DESCRIPTION

The BC107 and BC108 are silicon planar epitaxial NPN transistors in TO-18 metal case. They are suitable for use in driver stages, low noise input stages and signal processing circuits of television reveivers. The PNP complemet for BC107 is BC177.



TO-18

INTERNAL SCHEMATIC DIAGRAM



ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Value		Unit
		BC107	BC108	
V_{CBO}	Collector-Base Voltage (I_E = 0)	50	30	V
V_{CEO}	Collector-Emitter Voltage (I_B = 0)	45	20	V
V_{EBO}	Emitter-Base Voltage (I_C = 0)	6	5	V
I_C	Collector Current	100		mA
P_{tot}	Total Dissipation at $T_{amb} \leq 25\ ^oC$ at $T_{case} \leq 25\ ^oC$	0.3 0.75		W W
T_{stg}	Storage Temperature	-55 to 175		^oC
T_j	Max. Operating Junction Temperature	175		^oC

Scale
X-axis

Y-axis

Practical No.16: Construct and test the circuit for BJT in common emitter configuration

I Practical Significance:

A BJT is commonly used as an amplifier. Common Emitter (CE) mode is the universal mode of operation for a BJT. All types of amplifications can be performed using CE mode with suitable biasing. Common-emitter amplifiers are also used in radio frequency circuits.

II Industry / Employer Expected Outcome

This practical is expected to develop the following skill: **'Use electronic components and circuits in electrical equipment and systems'.**

III Course Level Learning Outcome

Use semiconductor transistors in different applications.

IV Laboratory Learning Outcomes

Test the performance of BJT in CE mode:

1. Construct the circuit for BJT in common emitter configuration.
2. Plot input and output characteristics of common emitter configuration

V Relevant Affective Domain related Outcomes

1. Handle components and equipment with care.
2. Work in team.

VI Minimum Theoretical Background

CE is the most frequently used configuration in practical amplifier circuits, since it provides good voltage, current, and power gain. The input is applied across the base- emitter circuit and the output is taken from the collector-emitter circuit, making the emitter "common" to both input and output. CE configuration provides a phase reversal between input and output signals.

VII Practical setup in Laboratory

(a) Sample

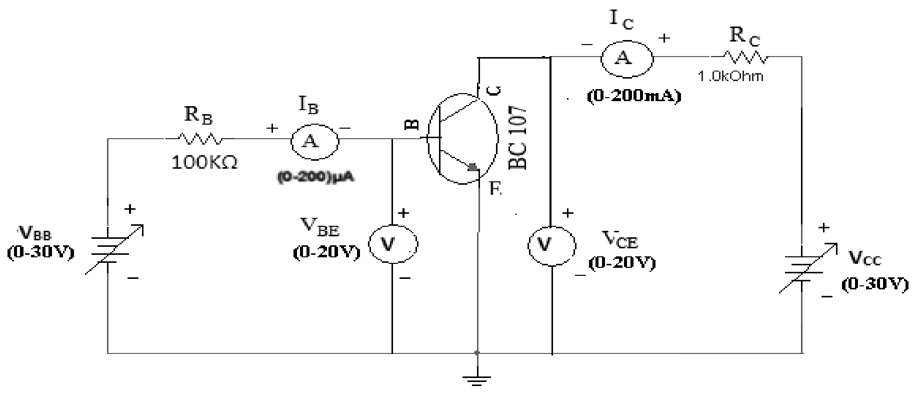


Figure 16.1: Circuit diagram of BJT in CE mode.

(b) Actual Circuit Diagram used in Laboratory

(c)Actual practical set up used in Laboratory

VIII Required Resources/apparatus/equipment with specifications

Sr. No	Instruments/Components	Specification	Quantity
1	Digital Multimeter	3 ½ -digit display with AC and DC voltage measurement and Current measurement facility and Diode testing facility.	1
2.	DC Regulated power supply	Variable DC power supply 0-30V, 2A, SC protection, display for voltage and current.	2
3.	DC Voltmeter	0-20V	2
4.	DC Ammeter	0-200 mA, 0-200 µA	1 each
5.	Transistor	BC107 or any other equivalent	1
6.	Resistor	1KΩ,100KΩ (0.5watts/0.25watts)	1 each
7.	Bread board	5.5 CM X 17CM	1
8.	Connecting wires	Single strand Teflon coating (0.6mm)	As per requirement

IX Precautions to be followed

1. Care should be taken while handling the terminals of components.
2. Select proper range and mode of Ammeter and voltmeter.
3. Connect wire tightly while building circuits.
4. Do not switch ON the power supply unless you have checked the circuit connections as per the circuit diagram.

X Procedure

Input characteristics:

1. Connect the circuit as shown in Figure 16.1
2. Set V_{CE} at constant voltage (2V) by varying Vcc.
3. Vary the input voltage V_{BE} in steps of 0.1V from 0V up to 1V and record the corresponding value of I_B in observation table.
4. Repeat the above steps 2 and 3 by keeping V_{CE} at 5V, and l0V.
5. Sketch the characteristics from the recorded readings.
6. At suitable operating point calculate input resistance (Ri).

Output characteristics:

1. Connect the circuit as shown in Figure 16.1
2. Set I_B constant at 10µA by varying V_{BB}.
3. Vary the output voltage Vcc in steps of 1V from 0V upto 10V and record the corresponding value of V_{CE} and I_c in observation table.

4. Repeat the above steps 2 and 3 by keeping I_B at 20µA and 30µA.
5. Sketch the characteristics from the recorded readings and calculate output resistance (Ro).

XI Observation Table

Table 1: Input Characteristics

Sr. No.	V_{CE}=2V		V_{CE}=5V		V_{CE}=10V	
	V_{BE} (V)	I_B (µA)	V_{BE} (V)	I_B (µA)	V_{BE} (V)	I_B (µA)
1.						
2.						
3.						
4.						
5.						
6.						
7.						
8.						
9.						
10.						

Table 2: Output Characteristics

Sr. No.	I_B=10µA		I_B=20µA		I_B=30µA	
	V_{CE}(V)	Ic(mA)	V_{CE}(V)	Ic(mA)	V_{CE}(V)	Ic(mA)
1.						
2.						
3.						
4.						
5.						
6.						
7.						
8.						
9.						
10.						

Calculations*: (from graph)*

1. Input resistance Ri: ……………
2. Output resistance Ro: …………..
3. Current amplification factor α. : ……………

XII Results

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XIII Interpretation of results

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XIV Conclusions and Recommendation

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XV Practical related Questions

1. Repeat the same experiment using PNP transistor.
2. State current gain of the transistor in CE configuration. Find out DC current gain you obtain in this practical?

[Space for answers]

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XVI References / Suggestions for further Reading

1. https://www.electrical4u.com/transistor-characteristics/
2. https://www.eeeguide.com/ce-transistor-characteristics/
3. https://www.youtube.com/watch?v=KynKHr2cXgk

XVII Assessment Scheme

Performance Indicators		Weightage
Process related (15 Marks)		**60%**
1	Proper connection of electrical circuit	20%
2	Handling of instrument	10%
3	Taking proper readings	20%
4	Working in team.	10%
Product related (10 Marks)		**40%**
1	Calculation of theoretical value	10%
2	Interpretation of Result	05%
3	Conclusions	05%
4	Practical related questions	15%
5	Completion and submission of experiment in time	05%
	Total (25 Marks)	**100%**

Names of Student Team Members

1. ....
2. ....
3. ....
4. ....

Marks Obtained			Dated Signature of Teacher
Process Related (15)	**Product Related (10)**	**Total (25)**	

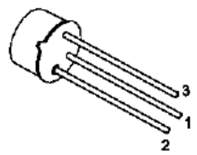
SGS-THOMSON MICROELECTRONICS

BC107
BC108

LOW NOISE GENERAL PURPOSE AUDIO AMPLIFIERS

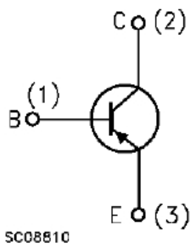
DESCRIPTION

The BC107 and BC108 are silicon planar epitaxial NPN transistors in TO-18 metal case. They are suitable for use in driver stages, low noise input stages and signal processing circuits of television reveivers. The PNP complemet for BC107 is BC177.



TO-18

INTERNAL SCHEMATIC DIAGRAM



ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Value		Unit
		BC107	BC108	
V_{CBO}	Collector-Base Voltage ($I_E = 0$)	50	30	V
V_{CEO}	Collector-Emitter Voltage ($I_B = 0$)	45	20	V
V_{EBO}	Emitter-Base Voltage ($I_C = 0$)	6	5	V
I_C	Collector Current	100		mA
P_{tot}	Total Dissipation at $T_{amb} \leq 25\ ^oC$ at $T_{case} \leq 25\ ^oC$	0.3 0.75		W W
T_{stg}	Storage Temperature	-55 to 175		^oC
T_j	Max. Operating Junction Temperature	175		^oC

Scale
X-axis

Y-axis

Practical No.17: Test the performance parameters of BJT as Switch

I Practical Significance

BJT can be operated in three regions: cut-off region, active region and saturation region. When BJT is used as a switch, only two regions cut- off and saturation are used. In saturation region transistor acts as ON state switch. In cut-off region, transistor acts as OFF state switch. In this practical only two points of DC load line while using BJT as a switch.

II Industry / Employer Expected Outcome

This practical is expected to develop the following skill: **'Use electronic components and circuits in electrical equipment and systems'.**

III Course Level Learning Outcome

Use semiconductor transistors in different applications.

IV Laboratory Learning Outcomes

Test BJT as switch on Breadboard:

1. Test the performance parameters of BJT as Switch.
2. Identify Cutoff and saturation regions.

V Relevant Affective Domain related Outcomes

1. Handle components and equipment carefully.
2. Follow all safety precautions

VI Minimum Theoretical Background

If the circuit uses the BJT transistor as a switch, then the biasing of the transistor, NPN or PNP is arranged to operate the transistor at the both sides of the V-I characteristics curves shown in figure 17.1

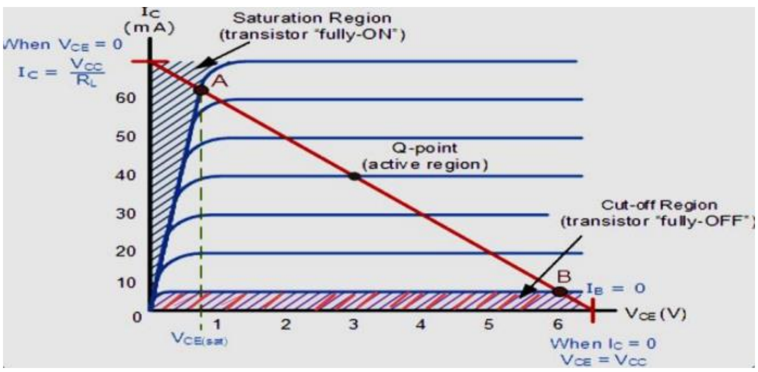


Figure 17.1: Output characteristics of BJT

From the above characteristics it is found that, the shaded area at the bottom of the curves represents the Cut-off region and the shaded area to the left represent the Saturation region of the transistor.

Cut-off Region: The operating conditions of the transistor are zero input base current (I_B=0), zero output collector current (I_C=0), and maximum collector voltage (V_{CE}) which results in a large depletion layer and no current flowing through the device. Therefore, the transistor is switched to "Fully-OFF State".

Saturation Region: In this region, the transistor will be biased so that the maximum amount of base current (I_B) is applied, resulting in maximum collector current (I_C=V_{CC}/R_L) and then resulting in the minimum collector-emitter voltage (V_{CE} ~ 0) drop. At this condition, the depletion layer becomes as small as the possible and maximum current flowing through the transistor. Therefore, the transistor is switched "Fully-ON State".

VII Practical setup in Laboratory

(a) Sample

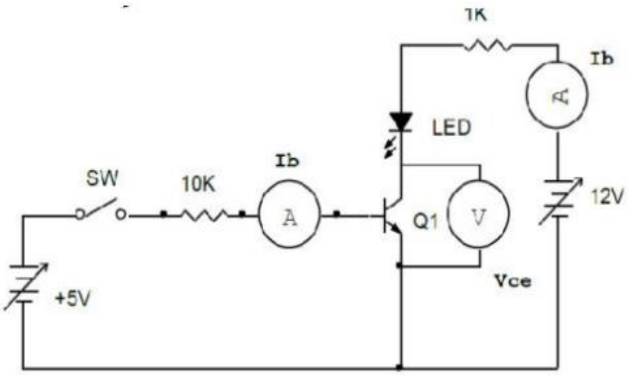


Figure 17.2: Circuit diagram of BJT as a switch

(b) Actual Circuit Diagram used in Laboratory

(c) Actual practical set up used in Laboratory

VIII Required Resources/apparatus/equipment with specifications

Sr. No	Instruments/Components	Specification	Quantity
1	Digital Multimeter	3 ½ -digit display with AC and DC voltage measurement and Current measurement facility and Diode testing facility.	1
2.	DC Regulated power supply	Variable DC power supply 0- 30V, 2A, SC protection, display for voltage and current.	2
3.	DC Voltmeter	0-20 V	1
4.	DC Ammeter	0 - 200 mA, 0 - 200 μA	1 each
5.	Transistor	BC107 or any other equivalent	1
6.	Resistor	1KΩ and 10KΩ (0.5watts/0.25watts)	1 each
7.	Bread board	5.5 CM X 17CM	1
8.	Connecting wires	Single strand Teflon coating (0.6mm)	As per requirement

IX Precautions to be followed

1. Care should be taken while handling the terminals of components.
2. Select proper range and mode of Ammeter and voltmeter.
3. Connect wire tightly while building circuits.
4. Do not switch ON the power supply unless you have checked the circuit connections as per the circuit diagram.

X Procedure

1. Connect circuit as shown in figure 17.2
2. Adjust collector supply Vcc = +12V and base supply V_{BB}=+5V.
3. Use base voltage supply switch instead of switch shown in the circuit diagram.
4. Measure I_B, I_C and V_{CE} when switch is OFF (It will be zero).
5. Now apply base voltage +5V.
6. Measure I_B, I_C and V_{CE}.

XI Observation Table

Table 1

Switch Condition	**V_{BB}**	**I_B**	**V_{CE}**	**I_C**
Switch OFF	V_{BB}= 0V			
Switch ON	$V_{BB=}$ +5V			

XII Results

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XIII Interpretation of results

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XIV Conclusions and Recommendation

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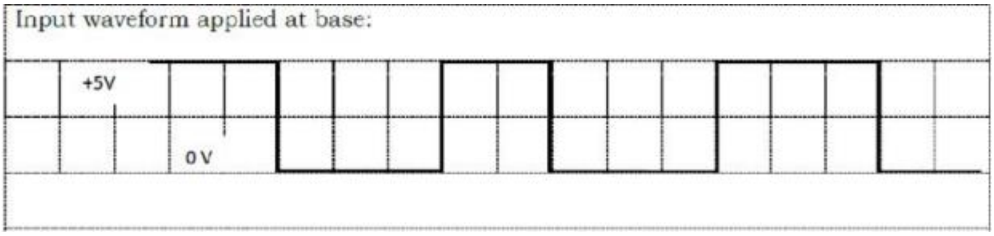
XV Practical related Questions

1. List types of BJT available in your laboratory.
2. Find out the ratio of collector resistance to base resistance while designing transistor switch. State the effect of saturation on transistor operation.
3. Draw output waveform when following waveform is applied at the base circuit.



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XVII References / Suggestions for further Reading

1. https://www.electronics-tutorials.ws/transistor/tran_4.html
2. https://www.build-electronic-circuits.com/transistor-as-a-switch/
3. https://www.youtube.com/watch?v=oXY9zUSulkg

XVII Assessment Scheme

Performance Indicators		Weightage
Process related (15 Marks)		**60%**
1	Proper connection of electrical circuit	20%
2	Handling of instrument	10%
3	Taking proper readings	20%
4	Working in team.	10%
Product related (10 Marks)		**40%**
1	Calculation of theoretical value	10%
2	Interpretation of Result	05%
3	Conclusions	05%
4	Practical related questions	15%
5	Completion and submission of experiment in time	05%
	Total (25 Marks)	**100%**

Names of Student Team Members

1. ....
2. ....
3. ....
4. ....

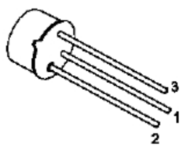
Marks Obtained			**Dated Signature of Teacher**
Process Related (15)	**Product Related (10)**	**Total (25)**	

SGS-THOMSON MICROELECTRONICS

BC107
BC108

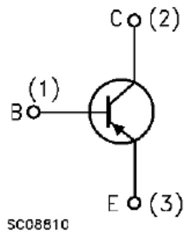
LOW NOISE GENERAL PURPOSE AUDIO AMPLIFIERS

DESCRIPTION
The BC107 and BC108 are silicon planar epitaxial NPN transistors in TO-18 metal case. They are suitable for use in driver stages, low noise input stages and signal processing circuits of television reveivers. The PNP complemet for BC107 is BC177.



TO-18

INTERNAL SCHEMATIC DIAGRAM



ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Value		Unit
		BC107	BC108	
V_{CBO}	Collector-Base Voltage ($I_E = 0$)	50	30	V
V_{CEO}	Collector-Emitter Voltage ($I_B = 0$)	45	20	V
V_{EBO}	Emitter-Base Voltage ($I_C = 0$)	6	5	V
I_C	Collector Current	100		mA
P_{tot}	Total Dissipation at $T_{amb} \leq 25\ ^oC$ at $T_{case} \leq 25\ ^oC$	0.3 0.75		W W
T_{stg}	Storage Temperature	-55 to 175		^oC
T_j	Max. Operating Junction Temperature	175		^oC

Scale
X-axis

Y-axis

Practical No.18: Check the performance of FET drain Characteristics

I Practical Significance

The field-effect transistor (FET) is a transistor that uses an electric field to control the electrical behavior of the circuit. JFETs are known as unipolar transistors since they involve single-carrier-type operation. Field effect transistors have very high input impedance at low frequencies.

II Industry / Employer Expected Outcome

This practical is expected to develop the following skill: **'Use electronic components and circuits in electrical equipment and systems'.**

III Course Level Learning Outcome

Use semiconductor transistors in different applications.

IV Laboratory Learning Outcomes

Test the performance of FET in common source mode:

1. Build the circuit for FET in common source configuration.
2. Plot characteristics for drain to source voltage V_{DS} verses drain current I_D for different Values of V_{GS}

V Relevant Affective Domain related Outcome

Handle components and equipment carefully.

VI Minimum Theoretical Background

Junction Field Effect Transistors are a type of FETs (high input impedance devices) which have three terminals namely Source (S), Gate (G) and Drain (D). These devices are also called voltage-controlled devices as the voltage applied at the gate terminal determines the amount of current flowing in-between the drain and the source terminals.

N-channel JFET

N-channel JFET has its major portion made of N-type semiconductor. The mutually- opposite two faces of this bulk material form the source and the drain terminals. There are two relatively-small P-regions embedded into this substrate which are internally joined together to form the gate terminal. Thus, here, the source and the drain terminals are of N-type and the gate is of P-type.

P-channel JFET

P-channel JFET has its major portion made of P-type semiconductor. The mutually- opposite two faces of this bulk material form the source and drain terminals. There are two relatively-small-regions embedded into this substrate which are internally joined together to form the gate terminal. Thus, here, the source and the drain terminals are of p-type while the gate is of n-type.

Figure 18.1: Symbol of JFET

Drain Characteristics:

The curve is divided into following regions:

Ohmic Region: In this region drain current increases linearly with the increase in drain to source voltage, obeying ohm's law.

Curve AB: In this region drain current increases at the inverse square law rate with the increase in drain to source voltage. It is because of fact that with increase in drain to source voltage, drain current increases. This in tum increases reverse bias voltage across gate to source junction. As a result, width of depletion region increases reducing effective width of channel.

Pinch off Region: This is also called saturation region. In this region drain current remains almost constant and at its maximum value

Breakdown Region: In this region drain current increases rapidly as the drain to source voltage is also increased. It happens because of breakdown of gate to source junction due to avalanche effect.

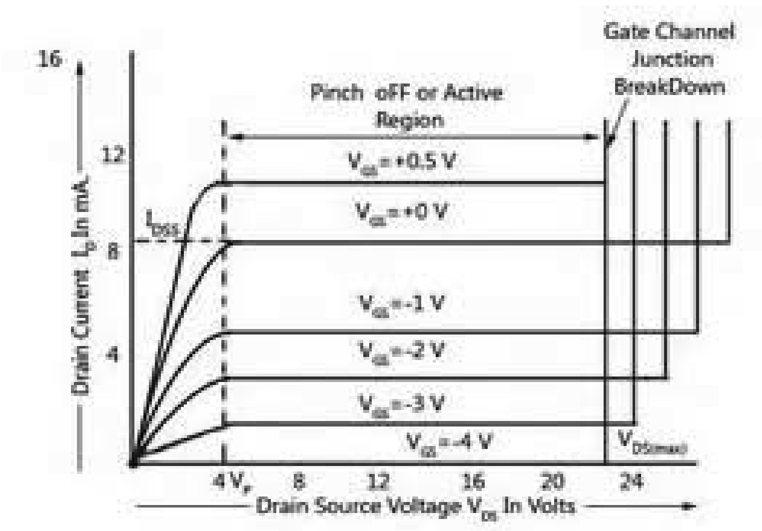


Figure 18.2: Drain characteristics

VII Practical setup in Laboratory

(a) Sample

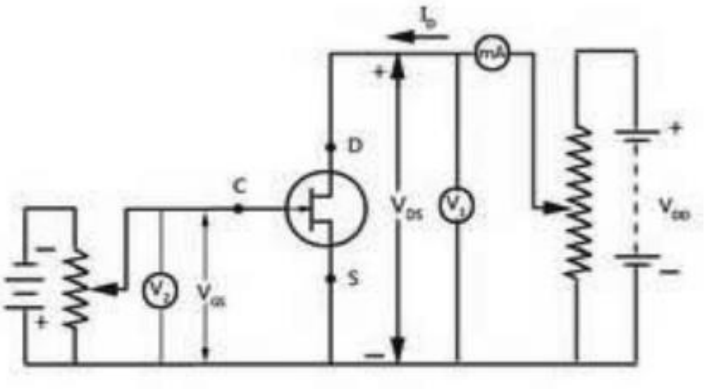


Figure 18.3: Circuit diagram of common source JFET

(b) Actual Circuit Diagram used in Laboratory

(c) Actual practical set up used in Laboratory

VIII Required Resources/apparatus/equipment with specifications

Sr. No	Instruments/Components	Specification	Quantity
1.	Variable DC Power Supply	0-30V, 2A, SC protection, display for voltage and current	1
2.	DC Voltmeter	0-20V	2
3.	DC Ammeter	0-200mA	1
4.	JFET	BFW10, BFW15 or equivalent JFET	1
5.	Connecting wires/ probes	Single strand 0.6mm Teflon coating	As per requirement
6.	Bread Board	5.5 CM X 17CM	1

IX Precautions to be followed

1. Care should be taken while handling terminals of components.
2. Select proper range and mode of ammeter and voltmeter.
3. Connect wires tightly while building circuit.
4. Show the connections to course faculty and then switch ON the power supply.

X Procedure

1. Connect the circuit as shown in figure 18.3
2. Fix gate to source voltage (V_{GS}) at 0V.
3. Increase drain to source power supply and note down drain to source voltage (V_{DS}) and drain current (I_D).
4. Increase gate to source de power supply so that voltmeter connected to gate and source terminal show 1V.
5. Now repeat above procedure and note down drain to source voltage and drain current by increasing drain power supply.
6. Take readings for 3 to 4 gate voltage values and tabulate it.
7. Plot a graph of V_{DS} verses I_D for various values of V_{GS}.

XI Observation Table

Table 1

Sr. No.	V_{GS}= V		V_{GS}= V		V_{GS}= V	
	V_{DS} (V)	I_D (mA)	V_{DS} (V)	I_D (mA)	V_{DS} (V)	I_D (mA)
1.						
2.						
3.						
4.						
5.						
6.						

Calculations:

Drain dynamic Resistance:

$$rd = \frac{\Delta VDS}{\Delta ID}$$

XII Result

1. Drain dynamic Resistance (rd)= ....

XIII Interpretation of result

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XIV Conclusions and Recommendation

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XV Practical related Questions

1. Justify ‘Field effect transistor called as unipolar transistor’.
2. Write the Part number and manufacturer of given JFET.
3. Write the steps to identify terminals of given JFET.

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[Space for answers]

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XVI References / Suggestions for further Reading

1. https://www.youtube.com/watch?v=2I_8YNVgbEw
2. https://www.electronicshub.org/junction-field-effect-transistor/
3. https://www.analog.com/en/resources/glossary/jfet.html

XVII Assessment Scheme

Performance Indicators		Weightage
Process related (15 Marks)		**60%**
1	Proper connection of electrical circuit	20%
2	Handling of instrument	10%
3	Taking proper readings	20%
4	Working in team.	10%
Product related (10 Marks)		**40%**
1	Calculation of theoretical value	10%
2	Interpretation of Result	05%
3	Conclusions	05%
4	Practical related questions	15%
5	Completion and submission of experiment in time	05%
	Total (25 Marks)	**100%**

Names of Student Team Members

1. ....
2. ....
3. ....
4. ....

Marks Obtained			**Dated Signature of Teacher**
Process Related (15)	**Product Related (10)**	**Total (25)**	

New Jersey Semi-Conductor Products, Inc.

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SPRINGFIELD, NEW JERSEY 07081
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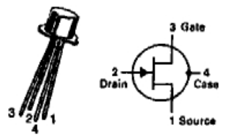
TELEPHONE: (973) 376-292
(212) 227-600
FAX: (973) 376-896

BFW10
BFW11

TO-72 (TO-206A)



JFET
VHF/UHF AMPLIFIER

N-CHANNEL — DEPLETION

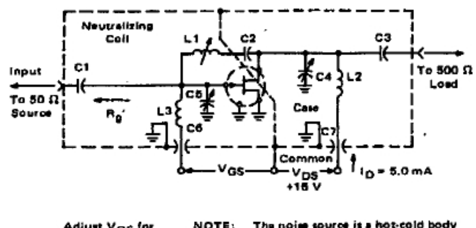
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	30	Vdc
Drain-Gate Voltage	V_{DG}	30	Vdc
Reverse Gate-Source Voltage	V_{GSR}	−30	Vdc
Forward Gate Current	I_{GF}	10	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	300 1.71	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +150	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Gate-Source Breakdown Voltage (I_G = 10 μAdc, V_{DS} = 0)		$V_{(BR)GSS}$	30	—	—	Vdc
Gate-Source Cutoff Voltage (V_{DS} = 15 Vdc, I_D = 0.5 nAdc)	BFW10 BFW11	$V_{GS(off)}$	—	—	8 6	Vdc
Gate Reverse Current (V_{GS} = 20 Vdc, V_{DS} = 0)		I_{GSS}	—	—	0.1	nAdc
Gate-Source Voltage (V_{DS} = 15 Vdc, I_D = 400 μAdc)	BFW10	V_{GS}	2	—	7.5	Vdc
Gate-Source Voltage (V_{DS} = 15 Vdc, I_D = 50 μAdc)	BFW11	V_{GS}	1.25	—	4	Vdc
ON CHARACTERISTICS						
Zero-Gate Voltage Drain Current (V_{DS} = 15 Vdc, V_{GS} = 0)	BFW10 BFW11	I_{DSS}	8 4	— —	20 10	mAdc
SMALL-SIGNAL CHARACTERISTICS						
Forward Transadmittance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1 kHz)	BFW10 BFW11	Y_{fs}	3.5 3.0	— —	6.5 6.5	mmhos
Output Admittance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 kHz)	BFW10 BFW11	Y_{os}	— —	— —	85 50	μmhos
Input Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0 Vdc, f = 1.0 MHz)		C_{iss}	—	—	5.0	pF
Reverse Transfer Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0 Vdc, f = 1.0 MHz)		C_{rss}	—	—	0.8	pF
Forward Transadmittance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 200 MHz)		Y_{fs}	3.2	—	—	mmhos
Equivalent Noise Voltage (V_{DS} = 15 Vdc, V_{GS} = 0, f = 25 Hz)		e_n	—	—	75	$nV/\sqrt{Hz}$
Noise Figure (V_{DS} = 15 Vdc, V_{GS} = 0 V, see Figures 1, 2, 3)		NF	—	—	2.5	dB

FIGURE 1 — 100 MHz and 400 MHz NEUTRALIZED TEST CIRCUIT



Adjust V_{GS} for
I_D = 50 mA
V_{GS} < 0 Volts

NOTE: The noise source is a hot-cold body (AIL type 70 or equivalent) with a test receiver (AIL type 136 or equivalent).

Reference Designation	VALUE	
	100 MHz	400 MHz
C1	7.0 pF	1.8 pF
C2	1000 pF	17 pF
C3	3.0 pF	1.0 pF
C4	1-12 pF	0.8-8.0 pF
C5	1-12 pF	0.8-8.0 pF
C6	0.0015 μF	0.001 μF
C7	0.0015 μF	0.001 μF
L1	3.0 μH*	0.2 μH**
L2	0.15 μH*	0.03 μH**
L3	0.14 μH*	0.022 μH**

*L1 17 turns, (approx. — depends upon circuit layout) AWG #28 enameled copper wire, close wound on 9/32" ceramic coil form. Tuning provided by a powdered iron slug.

L2 4-1/2 turns, AWG #18 enameled copper wire, 5/16" long, 3/8" I.D. (AIR CORE).

L3 3-1/2 turns, AWG #18 enameled copper wire, 1/4" long, 3/8" I.D. (AIR CORE).

**L1 6 turns, (approx. — depends upon circuit layout) AWG #24 enameled copper wire, close wound on 7/32" ceramic coil form. Tuning provided by an aluminum slug.

L2 1 turn, AWG #16 enameled copper wire, 3/8" I.D. (AIR CORE).

L3 1/2 turn, AWG #16 enameled copper wire, 1/4" I.D. (AIR CORE).

Scale
X-axis

Y-axis

Practical No.19: Test the performance of FET transfer characteristics and calculate Transconductance

I Practical Significance

The field-effect transistor (FET) is a transistor that uses an electric field to control the electrical behavior of the circuit. JFETs are known as unipolar transistors since they involve single-carrier-type operation. Field effect transistors have very high input impedance at low frequencies.

II Industry / Employer Expected Outcome

This practical is expected to develop the following skill: **'Use electronic components and circuits in electrical equipment and systems'.**

III Course Level Learning Outcome

Use semiconductor transistors in different applications.

IV Laboratory Learning Outcomes

Test the performance of FET in common source mode:

1. Build the circuit for FET in common source configuration.
2. Plot characteristics for Gate to source voltage V_{GS} verses drain current I_D and calculate transconductance.

V Relevant Affective Domain related Outcome

Handle components and equipment carefully.

VI Minimum Theoretical Background

Junction Field Effect Transistors are a type of FETs (high input impedance devices) which have three terminals namely Source (S), Gate (G) and Drain (D). These devices are also called voltage-controlled devices as the voltage applied at the gate terminal determines the amount of current flowing in-between the drain and the source terminals.

Gate/ Transfer Characteristics:

It gives relationship between drain current (I_D) and gate to source voltage (V_{GS}) for a constant value of drain to source voltage (V_{DS}).

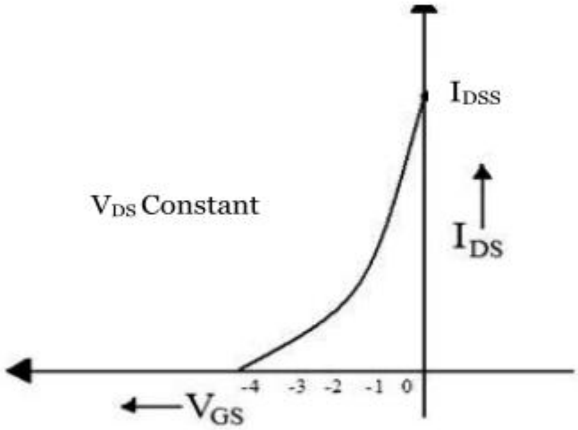


Figure 19.1: Transfer characteristics

VII Practical setup in Laboratory

(a) Sample

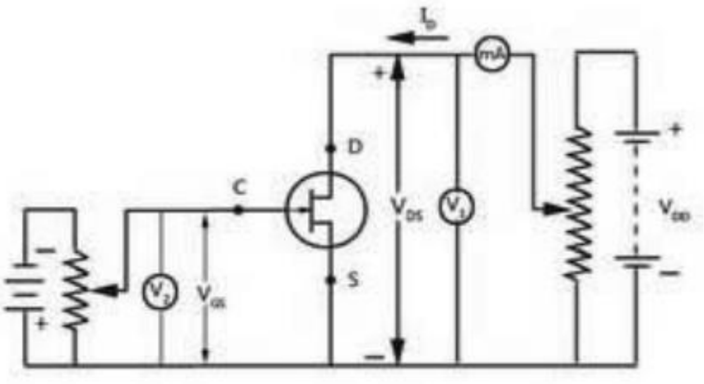


Figure 19.2: Circuit diagram of common source JFET

(b) Actual Circuit Diagram used in Laboratory

(c) Actual practical set up used in Laboratory

VIII Required Resources/apparatus/equipment with specifications

Sr. No	Instruments/Components	Specification	Quantity
1.	DC Power Supply	0-30V, 2A, SC protection, display for voltage and current.	2
2.	DC Voltmeter	0-20V	2
3.	DC Ammeter	0-50mA	1
4.	JFET	BFW10, BFW15 or equivalent JFET	1
5.	Bread Board	5.5 CM X 17CM	1
6.	Connecting wires/ probes	Single strand 0.6mm Teflon coating	As per requirement

IX Precautions to be followed

1. Care should be taken while handling terminals of components.
2. Select proper range and mode of ammeter and voltmeter.
3. Connect wires tightly while building circuit.
4. Show the connections to course faculty and then switch ON the power supply.

X Procedure

1. Connect the circuit as shown in figure 19.2
2. Set drain to source voltage to 1V, vary gate to source voltage (V_{GS}) in steps and note down corresponding drain current (I_D).
3. Repeat the procedure for different set values of drain voltage and keep the record of gate to source voltage and drain current.
4. Plot a graph of gate to source voltage verses drain current for different set values of drain to source voltage.
5. A graph will be in second quadrant as gate to source voltage is negative.

XI Observation Table

Table 1

Sr. No.	V_{DS}= V		V_{DS}= V		V_{DS}= V	
	V_{GS} (V)	I_D (mA)	V_{GS} (V)	I_D (mA)	V_{GS} (V)	I_D (mA)
1						
2						
3						
4						
5						
6						

Calculations:

Transconductance:

$$gm = \frac{\blacktriangle I_D}{\blacktriangle V_{GS}}$$

XII Result

1. Transconductance (gm)= ....

XIII Interpretation of results

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XIV Conclusions and Recommendation

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XV Practical related Questions

1. Is FET a unipolar or bipolar device? Give reason.
2. Explain the term Drain in FET.
3. Give advantages of FET over BJT.
4. List any two JFET available in your laboratory and give its specifications.

[Space for answers]

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XVI References / Suggestions for further Reading

1. http://www.electronics-tutorials.ws/transistor/tran5.html
2. http://www.circuitstoday.com/characteristics-of-jfets
3. https://www.youtube.com/watch?v=h9WlHNVHZ84

XVII Assessment Scheme

Performance Indicators		Weightage
Process related (15 Marks)		**60%**
1	Proper connection of electrical circuit	20%
2	Handling of instrument	10%
3	Taking proper readings	20%
4	Working in team.	10%
Product related (10 Marks)		**40%**
1	Calculation of theoretical value	10%
2	Interpretation of Result	05%
3	Conclusions	05%
4	Practical related questions	15%
5	Completion and submission of experiment in time	05%
	Total (25 Marks)	**100%**

Names of Student Team Members

1. ....
2. ....
3. ....
4. ....

Marks Obtained			**Dated Signature of Teacher**
Process Related (15)	**Product Related (10)**	**Total (25)**	

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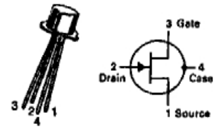
BFW10
BFW11

TO-72 (TO-206A)



JFET
VHF/UHF AMPLIFIER

N-CHANNEL — DEPLETION

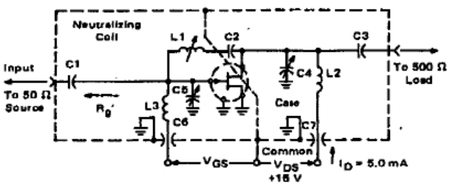
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	30	Vdc
Drain-Gate Voltage	V_{DG}	30	Vdc
Reverse Gate-Source Voltage	V_{GSR}	−30	Vdc
Forward Gate Current	I_{GF}	10	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	300 1.71	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +150	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted.)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Gate-Source Breakdown Voltage (I_G = 10 μAdc, V_{DS} = 0)		$V_{(BR)GSS}$	30	—	—	Vdc
Gate-Source Cutoff Voltage (V_{DS} = 15 Vdc, I_D = 0.5 nAdc)	BFW10 BFW11	$V_{GS(off)}$	—	—	8 6	Vdc
Gate Reverse Current (V_{GS} = 20 Vdc, V_{DS} = 0)		I_{GSS}	—	—	0.1	nAdc
Gate-Source Voltage (V_{DS} = 15 Vdc, I_D = 400 μAdc)	BFW10	V_{GS}	2	—	7.5	Vdc
Gate-Source Voltage (V_{DS} = 15 Vdc, I_D = 50 μAdc)	BFW11	V_{GS}	1.25	—	4	Vdc
ON CHARACTERISTICS						
Zero-Gate Voltage Drain Current (V_{DS} = 15 Vdc, V_{GS} = 0)	BFW10 BFW11	I_{DSS}	8 4	— —	20 10	mAdc
SMALL-SIGNAL CHARACTERISTICS						
Forward Transadmittance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1 kHz)	BFW10 BFW11	Y_{fs}	3.5 3.0	— —	6.5 6.5	mmhos
Output Admittance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 kHz)	BFW10 BFW11	Y_{os}	— —	— —	85 50	μmhos
Input Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0 Vdc, f = 1.0 MHz)		C_{iss}	—	—	5.0	pF
Reverse Transfer Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0 Vdc, f = 1.0 MHz)		C_{rss}	—	—	0.8	pF
Forward Transadmittance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 200 MHz)		Y_{fs}	3.2	—	—	mmhos
Equivalent Noise Voltage (V_{DS} = 15 Vdc, V_{GS} = 0, f = 25 Hz)		e_n	—	—	75	$nV/\sqrt{Hz}$
Noise Figure (V_{DS} = 15 Vdc, V_{GS} = 0 V, see Figures 1, 2, 3)		NF	—	—	2.5	dB

FIGURE 1 — 100 MHz and 400 MHz NEUTRALIZED TEST CIRCUIT



Reference Designation	VALUE	
	100 MHz	400 MHz
C1	7.0 pF	1.8 pF
C2	1000 pF	17 pF
C3	3.0 pF	1.0 pF
C4	1-12 pF	0.8-8.0 pF
C5	1-12 pF	0.8-8.0 pF
C6	0.0015 μF	0.001 μF
C7	0.0015 μF	0.001 μF
L1	3.0 μH*	0.2 μH**
L2	0.15 μH*	0.03 μH**
L3	0.14 μH*	0.022 μH**

Adjust V_{GS} for
I_D = 50 mA
V_{GS} < 0 Volts

NOTE: The noise source is a hot-cold body (AIL type 70 or equivalent) with a test receiver (AIL type 136 or equivalent).

*L1 17 turns, (approx. — depends upon circuit layout) AWG #28 enameled copper wire, close wound on 9/32" ceramic coil form. Tuning provided by a powdered iron slug.

L2 4-1/2 turns, AWG #18 enameled copper wire, 5/16" long, 3/8" I.D. (AIR CORE).

L3 3-1/2 turns, AWG #18 enameled copper wire, 1/4" long, 3/8" I.D. (AIR CORE).

**L1 6 turns, (approx. — depends upon circuit layout) AWG #24 enameled copper wire, close wound on 7/32" ceramic coil form. Tuning provided by an aluminum slug.

L2 1 turn, AWG #16 enameled copper wire, 3/8" I.D. (AIR CORE).

L3 1/2 turn, AWG #16 enameled copper wire, 1/4" I.D. (AIR CORE).

Scale
X-axis

Y-axis

Practical No. 20: Measure the frequency of given Oscillator circuit

I Practical Significance

An oscillator is an electronic circuit for generating AC signal voltage with a DC supply as the only biasing requirement. The frequency of the generated signal is decided by the circuit elements. An oscillator requires an amplifier a frequency selective network and positive feedback from the output to the input. The Barkhausen criteria for sustained oscillator is $A\beta = 1$, where A is gain of the amplifier and β is the feedback factor.

II Industry / Employer Expected Outcome

This practical is expected to develop the following skill: **'Use electronic components and circuits in electrical equipment and systems'.**

III Course Level Learning Outcome

Use different types of Oscillators as per requirement.

IV Laboratory Learning Outcomes

1. Build the circuit and measure the frequency of given LC Oscillator circuit.
2. Build the circuit and measure the frequency of given RC Oscillator circuit.

V Relevant Affective Domain related Outcomes

Handle components and equipment carefully.

VI Minimum Theoretical Background

In the RC phase shift oscillator, the required phase shift of 180˚ in the feedback loop from the output to input is obtained by using R and C components, instead of tank circuit. Here a common emitter amplifier is used in forward path followed by three sections of RC phase network in the reverse path with the output of the last section being returned to the input of the amplifier. The phase shift Φ is given by each RC section $\Phi = \tan^{-1}(1/\omega rc)$. In practice R-value is adjusted such that Φ becomes 60˚. If the value of R and C are chosen such that the given frequency for the phase shift of each RC section is 60˚. Therefore, at a specific frequency the total phase shift from base to transistors around circuit and back to base is exactly 360˚ or 0˚. Thus, the Barkhausen criterion for oscillation is satisfied. The three section RC network offers 180^0 phase shift and the β of $\frac{1}{29}$. Hence for unity gain feedback, the gain of the amplifier should be 29. The phase shift oscillator is particularly useful as audio frequency generator.

The frequency of oscillation is given by $f = \frac{1}{2\pi\sqrt{6}\,RC}$.

Hartley oscillator is an LC oscillator. It has LC tank circuit for frequency selection. LC oscillators are preferred for higher frequencies. Voltage divider bias is used for the amplifier in CE configuration. Amplifier section provides 180^0 phase shift. The tank circuit provides another 180^0 phase shift to satisfy Barkhausen criteria. R_E is bypassed by C_{BP} to prevent AC signal feedback and thus to improve the gain of the amplifier. Frequency of oscillation is determined by the resonant circuit consisting of capacitor C and inductors L1 and L2.

It is given by $f = \frac{1}{2\pi\sqrt{Leq.C}}$ Hz.

Where Leq = L1+L2. The output voltage appears across L1 and feedback voltage appears across L2. So, the feedback factor of the oscillator is given by $\beta = \frac{L2}{L1}$ This means that the gain of the amplifier section is $A = \frac{L1}{L2}$.

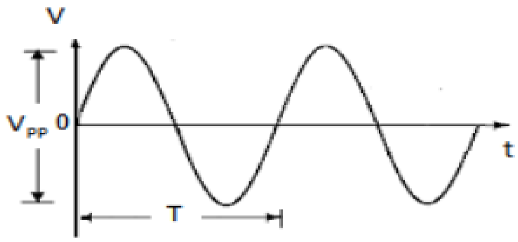


Figure 20.1: Sinusoidal output

VII Practical setup in Laboratory

(a) Sample

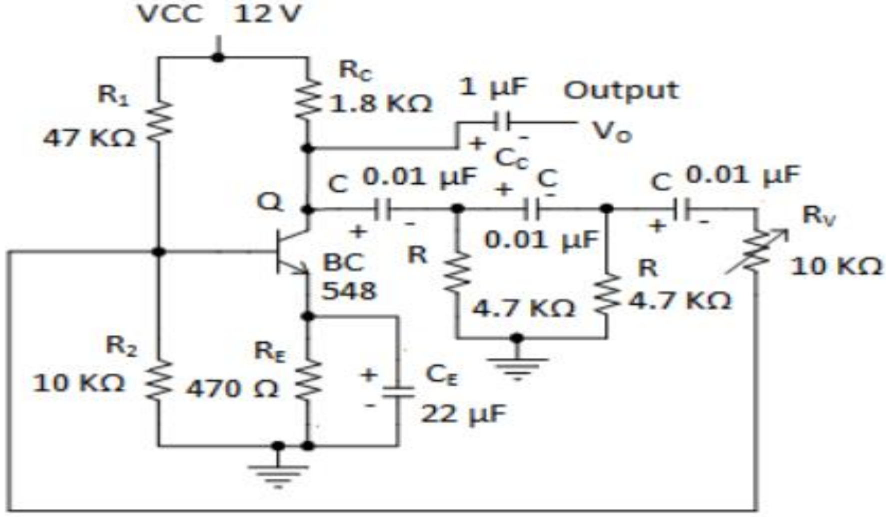


Figure 20.2: Circuit diagram of RC Phase Shift Oscillator

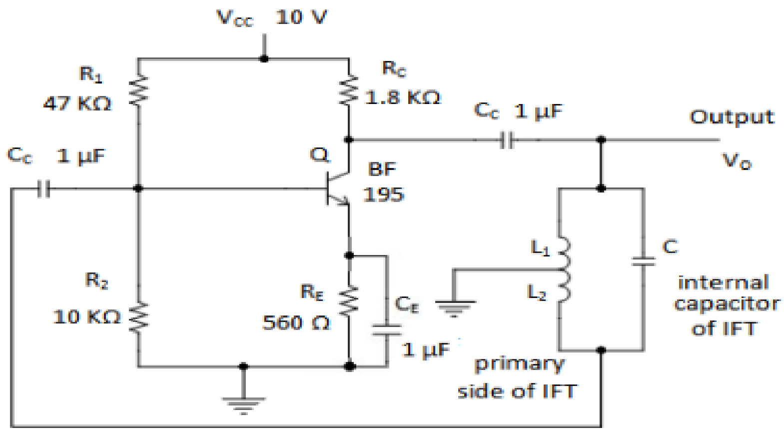


Figure 20.3: Circuit diagram of LC (Hartley) Phase Shift Oscillator

(b) Actual Circuit Diagram used in Laboratory

(c) Actual practical set up used in Laboratory

VIII Required Resources/apparatus/equipment with specifications

Sr. No	Instruments/Components	Specification	Quantity
1.	Multimeter	3 ½ -digit display with AC and DC voltage measurement and Current measurement facility and Diode testing facility.	1
2.	CRO	0-25MHz, Dual Trace	1
3.	DC Power supply	0-12 V	1
4.	Resistor	470 Ω, 47 Ω, 560Ω	1 each
5.	Resistor	4.7 KΩ, 10 KΩ, 1.8 KΩ	2 each
6.	Capacitor	0.01µF,1µF, 22µF (Electrolytic)	1 each
7.	Variable resistor – Potentiometer	10 KΩ	1
8.	Transistor	BC 548, BF 195	1 each
9.	Bread Board	5.5 CM X 17CM	1
10.	IFT	-	1
11.	Connecting wires	Single strand Teflon coating (0.6mm diameter)	As per requirement

IX Precautions to be followed

1. Care should be taken while handling terminals of components.
2. Connect wires tightly while building circuit.
3. Show the connections to course faculty and then switch ON the power supply.

X Procedure

Part I

RC Phase Shift Oscillator

1. Test the components and assemble the circuit on a breadboard as shown in figure 20.2
2. Connect the output of the circuit to an oscilloscope.
3. Adjust the 10 KΩ pot and observe the output.
4. Measure the frequency and amplitude of the output.
5. Sketch the output waveform on graph paper.

Part II

LC (Hartley) Oscillator

1. Test the components and assemble the circuit on bread board as shown in figure 20.3
2. Measure and verify the DC biasing conditions of the transistor.
3. Connect the output to oscilloscope

4. Observe and measure the amplitude and time period of the output.
5. Calculate the frequency of oscillation.
6. Adjust the core of IFT to get a desired frequency if necessary.
7. Sketch the output waveform on graph paper.

XI Observation Table

Table 1- RC Phase Shift Oscillator

Sr. No.	Amplitude (V)	Time (ms)	Frequency (KHz)
1.			

Table 2- LC (Hartley) Oscillator

Sr. No.	Amplitude (V)	Time (ms)	Frequency (KHz)
1.			

Calculations:

XII Results

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XIII Interpretation of results

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XIV Conclusions and Recommendation

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XV Practical related Questions

1. Give the conditions for oscillation.
2. Difference between RC oscillator and LC oscillator?
3. Write down the application of RC phase shift oscillator.

[Space for answers]

XVI References / Suggestions for further Reading

1. https://circuitdigest.com/tutorial/rc-phase-shift-oscillator
2. https://www.electronics-tutorials.ws/oscillator/hartley.html
3. https://www.youtube.com/watch?v=akqoYmkaiSc

XVII Assessment Scheme

Performance Indicators		Weightage
Process related (15 Marks)		**60%**
1	Proper connection of electrical circuit	20%
2	Handling of instrument	10%
3	Taking proper readings	20%
4	Working in team.	10%
Product related (10 Marks)		**40%**
1	Interpretation of Result & Conclusion	15%
2	Practical related questions	15%
3	Completion and submission of experiment in time	10%
	Total (25 Marks)	**100%**

Names of Student Team Members

1. ....
2. ....
3. ....
4. ....

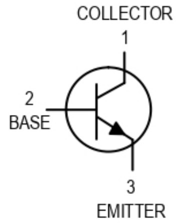
Marks Obtained			Dated Signature of Teacher
Process Related (15)	Product Related (10)	Total (25)	

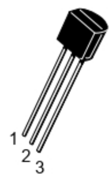
MOTOROLA
SEMICONDUCTOR TECHNICAL DATA

Order this document
by BC546/D

Amplifier Transistors
NPN Silicon

BC546, B
BC547, A, B, C
BC548, A, B, C





CASE 29–04, STYLE 17
TO–92 (TO–226AA)

MAXIMUM RATINGS

Rating	Symbol	BC 546	BC 547	BC 548	Unit
Collector–Emitter Voltage	V_{CEO}	65	45	30	Vdc
Collector–Base Voltage	V_{CBO}	80	50	30	Vdc
Emitter–Base Voltage	V_{EBO}	6.0			Vdc
Collector Current — Continuous	I_C	100			mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	625 5.0			mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.5 12			Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	–55 to +150			°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	200	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	83.3	°C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector–Emitter Breakdown Voltage (I_C = 1.0 mA, I_B = 0)	BC546 BC547 BC548	$V_{(BR)CEO}$	65 45 30	— — —	— — —	V
Collector–Base Breakdown Voltage (I_C = 100 µAdc)	BC546 BC547 BC548	$V_{(BR)CBO}$	80 50 30	— — —	— — —	V
Emitter–Base Breakdown Voltage (I_E = 10 µA, I_C = 0)	BC546 BC547 BC548	$V_{(BR)EBO}$	6.0 6.0 6.0	— — —	— — —	V
Collector Cutoff Current (V_{CE} = 70 V, V_{BE} = 0) (V_{CE} = 50 V, V_{BE} = 0) (V_{CE} = 35 V, V_{BE} = 0) (V_{CE} = 30 V, T_A = 125°C)	 BC546 BC547 BC548 BC546/547/548	I_{CES}	 — — — —	 0.2 0.2 0.2 —	 15 15 15 4.0	 nA µA

Scale
X-axis

Y-axis

Practical No. 21: Find out faults at different stages of regulated DC power supply

I Practical Significance

Today almost every electronic device needs a DC supply for its smooth operation and they need to be operated within certain power supply limits. This required DC voltage or DC supply is derived from single phase AC mains. A regulated power supply can convert unregulated an AC (alternating current or voltage) to a constant DC (direct current or voltage). A regulated power supply is used to ensure that the output remains constant even if the input changes. A regulated DC power supply is also called as a linear power supply; it is an embedded circuit and consists of various blocks.

II Industry / Employer Expected Outcome

This practical is expected to develop the following skill: **'Use electronic components and circuits in electrical equipment and systems'.**

III Course Level Learning Outcome

Test operation of regulated power supply.

IV Laboratory Learning Outcomes

1. Test the voltages &waveforms at various Test points of regulated dc power supply.
2. Identify the various faults in the Regulated DC power supply

V Relevant Affective Domain related Outcomes

1. Handle components and equipment carefully.
2. Follow safety practices.
3. Maintain tools and equipment.
4. Follow ethical practices.

VI Minimum Theoretical Background

Testing of regulated DC power supply is used to troubleshoot the power supply. Testing is use to solve and eliminate the causes of fault. These faults cause voltage and current instability. Which can have a significant impact on equipment? The aim of a DC power supply is to provide the required level of DC power to the load using an AC supply at the input. The DC power supply consists of following major components/circuits:

i. Input transformer: The input transformer is a step down transformer.
ii. Rectifier: The rectifier converts AC to pulsating DC.

iii. Filter: It removes ripples.
iv. Voltage Regulator: It provides a constant output voltage irrespective of change in line and load voltage.

VII Practical setup in Laboratory

(a) Sample

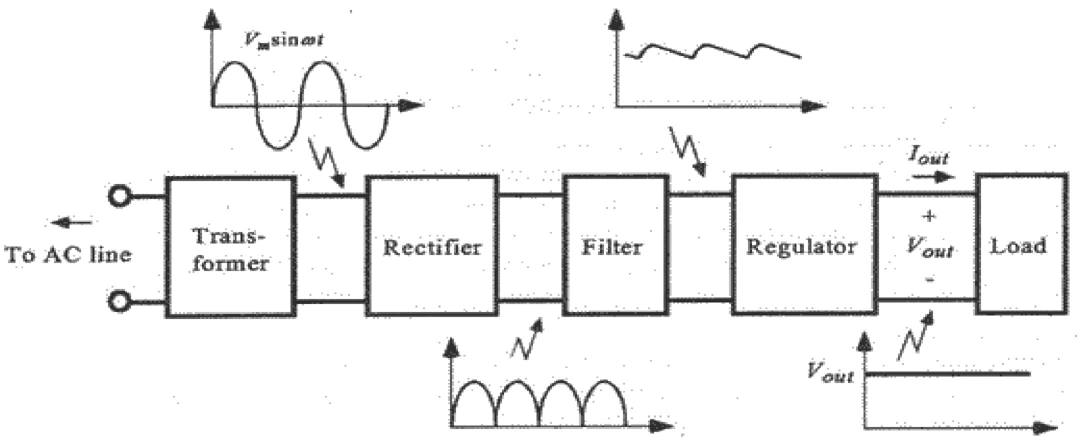


Figure 21.1: Block diagram of Regulated power supply

(b) Actual Circuit Diagram used in Laboratory

(c) Actual practical set up used in Laboratory

VIII Required Resources/apparatus/equipment with specifications

Sr. No	Instruments/Components	Specification	Quantity
1.	Multimeter	3 ½ -digit display with AC and DC voltage measurement and Current measurement facility and Diode testing facility.	2
2.	CRO	0-25MHz, Dual Trace	1
3.	DC Power supply	0-30V, 2A, SC protection, display for voltage and current.	2
4.	Bread Board/Trainer kit	5.5 CM X 17CM	1

IX Precautions to be followed

1. Before connecting the plug to the mains check, the insulation of wires.

X Procedure

1. Use trainer kit of regulated DC power supply.
2. ON the AC supply.
3. Create faults at different stages, compare the observed output voltage with the expected output voltage at that stage and comment on the values

XI Observation Table

Table 1- Observe output voltage and fault

Sr. No.	Create fault at Stage	Expected Output Voltage	Observed Output Voltage	Comment Related to Observed fault
1.				
2.				
3.				
4.				
5.				

XII Results

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XIII Interpretation of results

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XIV Conclusions and Recommendation

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XV Practical related Questions

1. Measure the voltages at given different stages given in observation table using DMM.
2. List the different blocks of a regulated DC power supply.

[Space for answers]

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XVI References / Suggestions for further Reading

1. https://www.electrical4u.com/regulated-power-supply/
2. https://commons.wikimedia.org/wiki/File:Practical_Regulated_Power_Supply_Components.

XVII Assessment Scheme

Performance Indicators		Weightage
Process related (15 Marks)		**60%**
1	Proper connection of electrical circuit	20%
2	Handling of instrument	10%
3	Taking proper readings	20%
4	Working in team.	10%
Product related (10 Marks)		**40%**
1	Interpretation of Result & Conclusion	15%
2	Practical related questions	15%
3	Completion and submission of experiment in time	10%
	Total (25 Marks)	**100%**

Names of Student Team Members

1. ……………………………
2. ……………………………
3. ……………………………
4. ……………………………

Marks Obtained			**Dated Signature of Teacher**
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No. 22: Trouble shoot given DC regulated power supply

I Practical Significance

Troubleshooting of an electronic circuit is a process of having a special outlook on components that comes out with remedies to repair it. The unexpected behavior exhibited by the circuit is due to improper locating or soldering of components, component damage due to aging, faults, over heat, and so on.

II Industry / Employer Expected Outcome

This practical is expected to develop the following skill: **'Use electronic components and circuits in electrical equipment and systems'.**

III Course Level Learning Outcome

Test operation of regulated power supply.

IV Laboratory Learning Outcomes

Rectify the various faults in the Regulated DC power supply.

V Relevant Affective Domain related Outcomes

1. Handle components and equipment carefully.
2. Follow safety precautions.
3. Follow ethical practices

VI Minimum Theoretical Background

Troubleshooting is a form of problem solving, often applied to repair failed products or processes on a machine or a system. It is a logical, systematic search for the source of a problem in order to solve it, and make the product or process operational again.

Troubleshooting approach consists of the following:

Step1- Physical Observation (Locating different electronic component in different section)

Step2- Define Problem Area

Step3- Identify Possible Causes

Step4- Determine Most Probable Cause

Step5- Test and Repair.

VII Practical setup in Laboratory

(a) Sample

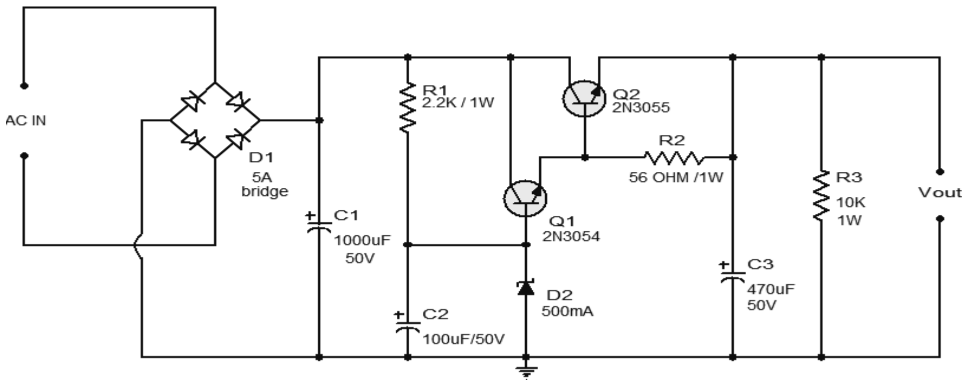


Figure 22.1: Regulated power supply

(b) Actual Circuit Diagram used in Laboratory

(c) Actual practical set up used in Laboratory

VIII Required Resources/apparatus/equipment with specifications

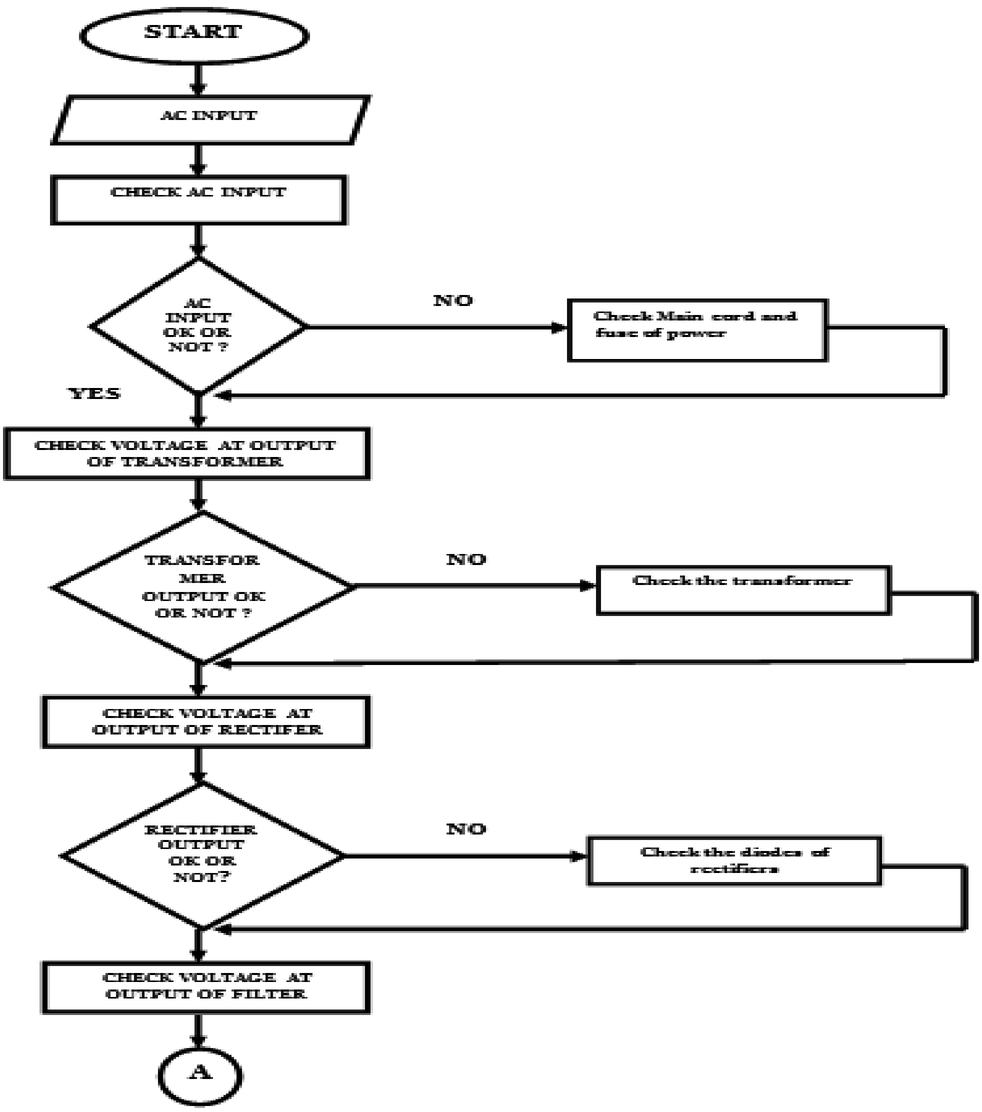
Sr. No	Instruments/Components	Specification	Quantity
1.	Multimeter	3 ½ -digit display with AC and DC voltage measurement and Current measurement facility and Diode testing facility.	1
2.	CRO	0-25MHz, Dual Trace	1
3.	DC Power supply	0-30V, 2A, SC protection, display for voltage and current	1
4.	Bread Board	5.5 CM X 17CM	1

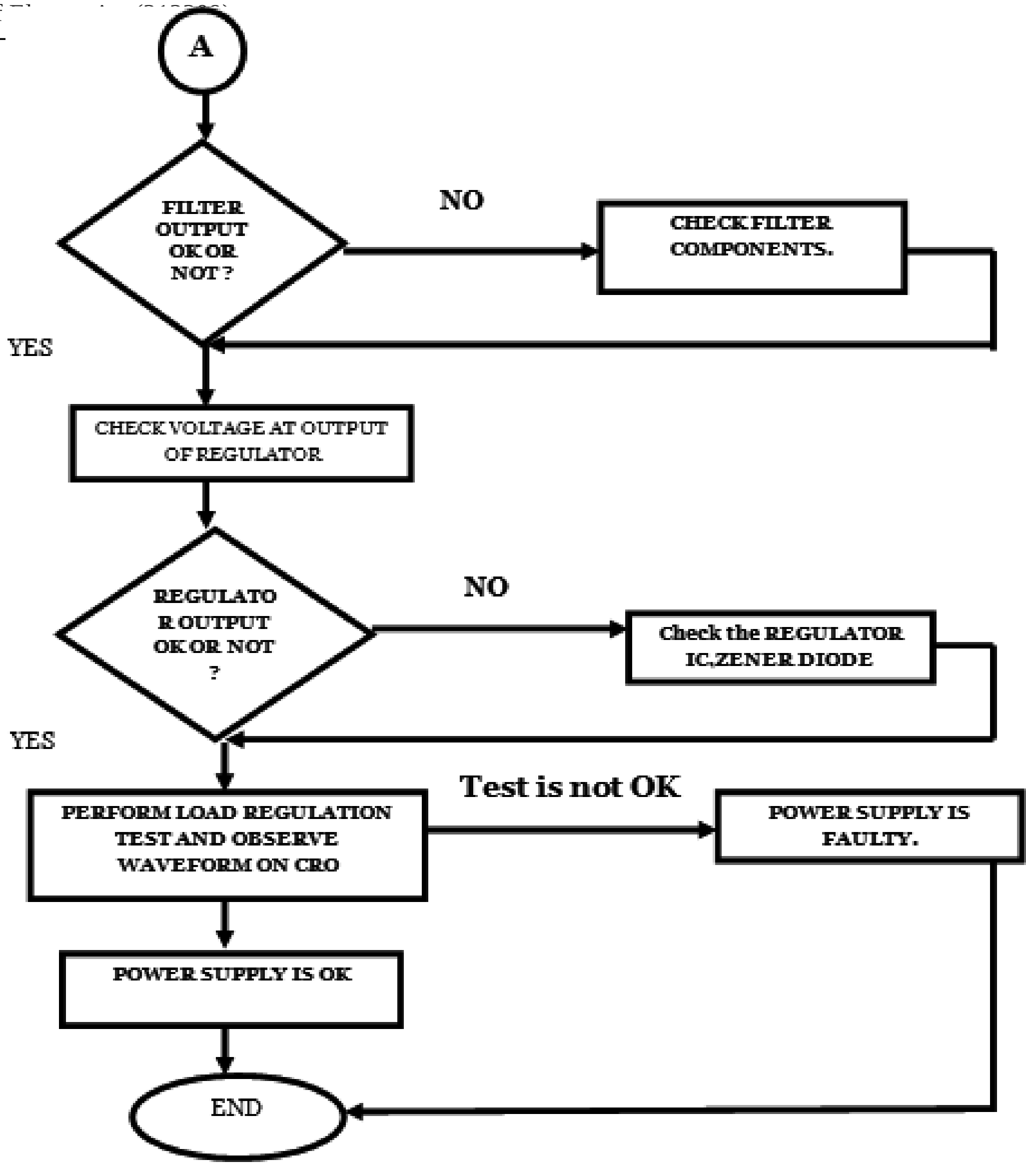
IX Precautions to be followed

Before connecting the plug to the mains check, the wires are properly insulated.

X Procedure

1. For trouble shooting of given power supply follow the given flow chart: Follow the given flowchart for troubling shooting the given power supply.
2. Do the physical observations of different section of the given power supply.
3. Draw the circuit diagram of the given power supply and mark test point as per the flowchart.
4. Go on testing each section of given circuit from input side to output side and test output. Record the voltage and sketch waveforms at all check points in the table.
5. Compare the voltage value at given point with expected value, check wave form at given point and then identify the fault in given supply.





XI Observation Table

Table 1- Observed Waveform

Sr. No.	Test Points	Standard value	Measured value	Observed waveform
1.				
2.				
3.				
4.				
5.				
6.				

XII Results

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XIII Interpretation of results

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XIV Conclusions and Recommendation

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XV Practical related Questions

1. Repeat the experiment with different faults.
2. List the different steps to trouble shoot DC regulated power supply.
3. State the need of DC regulated power supply.

[Space for answers]

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XVI References / Suggestions for further Reading

1. https://www.electrical4u.com/regulated-power-supply/
5. http://www.circuitstoday.com/regulated-power-supply

XVII Assessment Scheme

Performance Indicators		Weightage
Process related (15 Marks)		**60%**
1	Proper connection of electrical circuit	20%
2	Handling of instrument	10%
3	Taking proper readings	20%
4	Working in team.	10%
Product related (10 Marks)		**40%**
1	Interpretation of Result & Conclusion	15%
2	Practical related questions	15%
3	Completion and submission of experiment in time	10%
	Total (25 Marks)	**100%**

Names of Student Team Members

1. ....
2. ....
3. ....
4. ....

Marks Obtained			Dated Signature of Teacher
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No. 23: Build and Test the performance of Zener voltage regulator for given voltage

I Practical Significance

Zener diode is a silicon semiconductor with a p-n junction that is specifically designed to work in the reverse biased condition. When forward biased, it behaves like a normal signal diode, but when the reverse voltage is applied to it, the voltage remains constant for a wide range of currents. Due to this feature, it is used as a voltage regulator in D.C. circuit.

Zener Breakdown: There is a limit for the reverse biasing voltage. Reverse biasing voltage can increase until the diode breakdown voltage reaches. This reverse biased voltage is called Zener Breakdown voltage. At this stage, maximum current will flow through the Zener diode.

II Industry / Employer Expected Outcome

This practical is expected to develop the following skill: **'Use electronic components and circuits in electrical equipment and systems'.**

III Course Level Learning Outcome

Test operation of regulated power supply.

IV Laboratory Learning Outcomes

1. Build Zener voltage regulator for given voltage.
2. Calculate load and line regulation.

V Relevant Affective Domain related Outcomes

1. Handle components and equipment carefully.
2. Follow safety precautions.
3. Follow ethical practices

VI Minimum Theoretical Background

The function of a regulator is to provide a constant output voltage to a load connected in parallel with it in spite of the ripples in the supply voltage or the variation in the load current and the zener diode will continue to regulate the voltage until the diodes current falls below the minimum IZ (min) value in the reverse breakdown region. It permits current to flow in the forward direction as normal, but will also allow it to flow in the reverse direction when the voltage is above a certain value - the breakdown voltage known as the Zener voltage. The Zener diode specially made to have a reverse voltage breakdown at a specific voltage.

Its characteristics are otherwise very similar to common diodes. In breakdown the voltage across the Zener diode is close to constant over a wide range of currents thus useful as a shunt voltage regulator. The purpose of a voltage regulator is to maintain a constant voltage across a load regardless of variations in the applied input voltage and variations in the load current. A typical Zener diode shunt regulator is shown in Figure 23.1. The resistor is selected so that when the input voltage is at VIN (min) and the load current is at IL (max) that the current through the Zener diode is at least Iz (min). Then for all other combinations of input voltage and load current the Zener diode conducts the excess current thus maintaining a constant voltage across the load. The Zener conducts the least current when the load current is the highest and it conducts the most current when the load current is the lowest.

a) Line Regulation

In line regulation, series resistance and load resistance are fixed, only input voltage is changing. Output voltage remains the same as long as the input voltage is maintained above a minimum value.

Line regulation is the ability of a power supply to maintain a constant output voltage despite changes to the input voltage, with the output current drawn from the power supply remaining constant. It is desirable for a power supply to maintain a stable output regardless of changes in the input voltage. The line regulation is important when the input voltage source is unstable or unregulated and this would result in significant variations in the output voltage. Percentage of line regulation can be calculated by

$$\text{Line Regulation} = \frac{\Delta V_o}{\Delta V_i} \cdot 100\%$$

b) Load Regulation

Load regulation is the measure of the ability of a power supply to maintain a constant output voltage despite changes in output current or load. A good load regulation ensures that the power supply will deliver a required and stable voltage to the circuit or system. Ideally the load regulation should be zero meaning that the supply's output voltage is independent of the load and remains the same throughout.

When choosing a power supply, it is important to pay attention to the load regulation as specified in the data sheets. The power supply should be able to supply a constant and reliable power to within the specified load current range. The load regulation is not a fixed number but rather presented as a percentage.

$$\text{Load regulation} = \frac{V_{NL} - V_{FL}}{V_{FL}} 100\%$$

VII Practical setup in Laboratory

(a) Sample

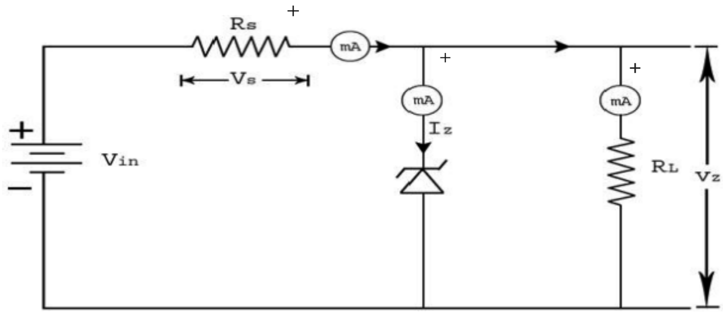

Figure 23.1: Zener diode Shunt Regulator

(b) Actual Circuit Diagram used in Laboratory

(c) Actual practical set up used in Laboratory

VIII Required Resources/apparatus/equipment with specifications

Sr. No	Instruments/Components	Specification	Quantity
1.	Digital Multimeter	3 ½ -digit display with AC and DC voltage measurement and Current measurement facility and Diode testing facility.	1
2.	Variable DC power supply	0-30V, 2A, SC protection, display for voltage and current.	1
3.	DC Voltmeter	0-20V	1
4.	Diode	1N4733(or any other Equivalent Zener diode)	1
5.	Variable Load Resistor	0 -10KΩ(Rheostats/potentiometers)	1
6.	Resistor	1KΩ(0.5watts/0.25watts)	1
7.	Bread Board	5.5 CM X 17CM	1

IX Precautions to be followed

1. Do not switch ON the power supply unless you have checked the circuit connections as per the circuit diagram.
2. While doing the experiment do not exceed the input voltage of the diode beyond the rated voltage of diode. This may lead to damaging of the diode.
3. Connect voltmeter and ammeter in correct polarities as shown in the circuit diagram.

X Procedure

Part I

Line Regulation:

1. Connect the circuit as in figure 23.1.
2. Keep load resistance fixed value; vary DC input voltage from 5Vto 15V.
3. Record the output voltage as a load voltage with high line voltage 'V HL 'and as a load voltage with low line voltage 'VLL' in the observation table.

Part II

Load Regulation:

1. Keep input voltage constant say 1OV, vary load resistance value.
2. Record no load voltage 'VNL' for maximum load resistance value and full load voltage 'VFL' for minimum load resistance value.
3. Calculate load regulation as per formula.
4. Sketch the graph for recorded readings.

XI Observation Table

Table 1- Measurement of Vin and Vz

Sr. No.	Line Regulation (RL constant) IL=lO (mA)		Load Regulation (Vin constant) Vin=lO (V)	
	Input voltage Vin(VOLTS)	Output voltage Vz(VOLTS)	Load current IL(mA)	Output voltage Vz(VOLTS)
1.				
2.				
3.				
4.				
5.				
6.				

Calculations:

Percentage of line regulation=

Percentage of load regulation=

XII Results

Load Resistance	Output voltage Vz(VOLTS)	Load current IL(mA)
RL minimum		
RL maximum		

XIII Interpretation of results

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XIV Conclusions and Recommendation

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XV Practical related Questions

1. Repeat the above experiment different Zener diode.
2. Differentiate between PN junction & Zener diode.
3. Draw Zener diode as a voltage regulator.

[Space for answers]

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XVI References / Suggestions for further Reading

1. https://www.youtube.com/watch?v=n56b6-j0r4
2. https://www.youtube.com/watch?v=jG2YAtTWxv
3. https://www.youtube.com/watch?v=mfGEODPzTmc

XVII Assessment Scheme

Performance Indicators		Weightage
Process related (15 Marks)		**60%**
1	Proper connection of electrical circuit	20%
2	Handling of instrument	10%
3	Taking proper readings	20%
4	Working in team.	10%
Product related (10 Marks)		**40%**
1	Interpretation of Result & Conclusion	15%
2	Practical related questions	15%
3	Completion and submission of experiment in time	10%
	Total (25 Marks)	**100%**

Names of Student Team Members

1. ....
2. ....
3. ....
4. ....

Marks Obtained			**Dated Signature of Teacher**
Process Related (15)	**Product Related (10)**	**Total (25)**	

CDZFH6.2B

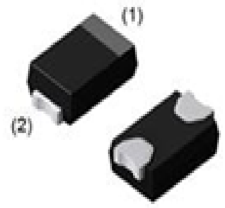
Zener Diode (AEC-Q101 qualified)

Data sheet

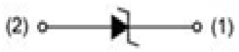
P_D	100	mW

Outline

VMN2 SOD923



Inner Circuit



(1)Cathode
(2)Anode

Feature

High reliability
Small mold type

Application

Voltage regulation

Structure

Silicon Epitaxial Planar

Packaging Specification

Packing	Embossed Tape
Reel Size(mm)	180
Taping Width(mm)	8
Basic Ordering Unit(pcs)	8000
Taping Code	T2RA
Marking	C

Absolute Maximum Rating (T_a = 25 °C)

Parameter	Symbol	Limits	Unit
Power dissipation	P_D	100	mW
Junction temperature	T_j	150	°C
Storage temperature	T_{stg}	-55 ~ 150	°C

Scale
X-axis

Y-axis

Practical No. 24: Construct and Test the performance of Positive voltage regulator using 78XX, three terminals IC for given voltage

I Practical Significance

In industry and domestic appliances three terminal regulators are used. They give fixed output voltage making these useful in a wide range of applications. One of these on-board regulations, eliminating the distribution problems associated with single point regulation. Use of 78xx will help students to acquire necessary practical skills related to regulators.

II Industry / Employer Expected Outcome

This practical is expected to develop the following skill: **'Use electronic components and circuits in electrical equipment and systems'.**

III Course Level Learning Outcome

Test operation of regulated power supply.

IV Laboratory Learning Outcomes

1. Construct the circuit for Positive voltage regulator using 78XX IC.
2. Calculate load and line regulation.

V Relevant Affective Domain related Outcomes

1. Handle components and equipment carefully.
2. Follow safety precautions.
3. Follow ethical practices

VI Minimum Theoretical Background

IC78XX is positive series of regulators. For ICs with in the78xx family, the xx is replaced with two digits, indicating the output voltage for example; the 7805 has a 5-volt output, while the 7812 produces12 volts. The LM78XX series of three terminal regulators is available with several fixed output voltages making them useful in a wide range of will allow over 1. 0A load current if adequate heat sinking is provided. Current limiting is included to limit the peak output current to a safe value. Safe area protection for the output transistor is provided to limit internal power dissipation. If internal power dissipation becomes too high for the heat sinking provided, the thermal shutdown circuit takes over preventing the IC from overheating.

Voltage Range are LM7805C 5V; LM7812C 12V; LM7815C 15V.The LM79XX series of 3-terminal regulators is available with fixed output voltages of 5V,8V,12V, and15V. These devices need only one external component, i.e. compensation capacitor at the output. The LM79XX series is packaged in the TO-220 power package and is capable of supplying 1.5A of output current. In LM78xx LM indicate the manufacturer name.

VII Practical setup in Laboratory

(a) Sample

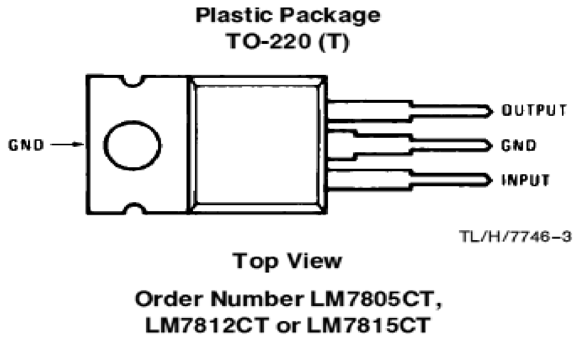


Figure 24.1: Pin diagram of IC78XX

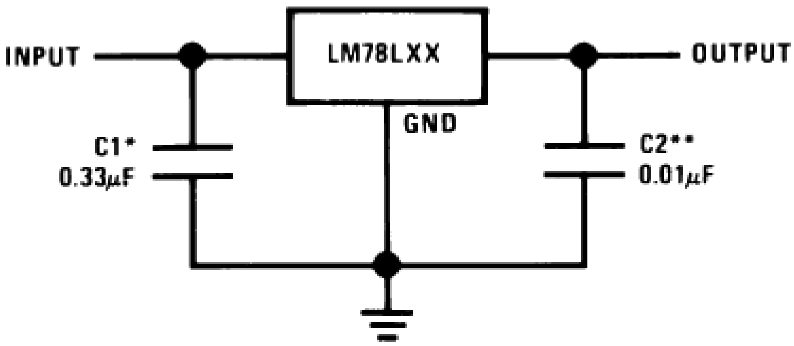


Figure 24.2: IC78XX as positive voltage regulator

(b) Actual Circuit Diagram used in Laboratory

(c) Actual practical set up used in Laboratory

VIII Required Resources/apparatus/equipment with specifications

Sr. No	Instruments/Components	Specification	Quantity
1.	Digital Multimeter	3 ½ -digit display with AC and DC voltage measurement and Current measurement facility and Diode testing facility.	1
2.	DC Voltmeter	0-20V	1
3.	IC7805,7812,7815	LM78L05 with tolerances of ±5% over the temperature range.	1 each
4.	Variable Load Resistor	0 -10KΩ(Rheostats/potentiometers)	1
5.	Capacitors	0.01µF,0.33µF,2.2µF,1µF(ceramic capacitor)	1 each
6.	Bread Board	5.5 CM X 17CM	1

IX Precautions to be followed

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

X Procedure

1. Connect circuit on General Purpose Bread boards.
2. Apply unregulated DC power supply.
3. Measure input voltage with voltmeter or Multimeter.
4. Measure output voltage with voltmeter or Multimeter.

Part I
Line Regulation:

1. Connect the circuit as in figure 24.2
2. Keep load resistance fixed value; vary DC input voltage from 5Vto 15V.
3. Record the output voltage as a load voltage with high line voltage 'V HL 'and as a load voltage with low line voltage 'VIN' in the observation table.

Part II
Load Regulation:

1. Keep input voltage constant say 1OV, vary load resistance value.
2. Record no load voltage 'VNL' for maximum load resistance value and full load voltage 'VFL' for minimum load resistance value.
3. Calculate load regulation as per formula.
4. Sketch the graph for recorded readings.

XI Observation Table

Table 1- Positive voltage regulator using IC78XX

Sr. No	IC Used	Input DC Voltage	Output DC Voltage
1.	7805		
2.	7812		
3.	7815		

Table 2- Measurement of Vin and Vz

Sr. No.	Line Regulation (RL constant) IL=10 (mA)		Load Regulation (Vin constant) Vin=10(V)	
	Input voltage Vin(VOLTS)	Output voltage Vz(VOLTS)	Load current IL(mA)	Output voltage Vz(VOLTS)
1.				
2.				
3.				
4.				
5.				
6.				

Calculations:

Percentage of line regulation=

Percentage of load regulation=

XII Results

Load Resistance	Output voltage Vz(VOLTS)	Load current IL(mA)
RL minimum		
RL maximum		

XIII Interpretation of results

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XIV Conclusions and Recommendation

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XV Practical related Questions

Note: Below given are few sample questions for reference. Course faculty must design more such questions so as to ensure the achievement of identified CO.

1. List the three terminal of IC 78xx voltage regulator.
2. List voltage options are available in 78xx voltage regulator.
3. List any two advantages of IC 78xx

[Space for answers]

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XVI References / Suggestions for further Reading

1. www.alldatasheet.com/datasheet-pdf/pdf/9037/NSC/LM78XX.html
2. www.cedmagic.com/tech-info/data/lm78xx.pdf

XVII Assessment Scheme

Performance Indicators		Weightage
Process related (15 Marks)		**60%**
1	Proper connection of electrical circuit	20%
2	Handling of instrument	10%
3	Taking proper readings	20%
4	Working in team.	10%
Product related (10 Marks)		**40%**
1	Interpretation of Result & Conclusion	15%
2	Practical related questions	15%
3	Completion and submission of experiment in time	10%
	Total (25 Marks)	**100%**

Names of Student Team Members

1. ....
2. ....
3. ....
4. ....

Marks Obtained			**Dated Signature of Teacher**
Process Related (15)	**Product Related (10)**	**Total (25)**	

LM78XX

THINKI SEMICONDUCTOR ®

Pb Free Plating Product

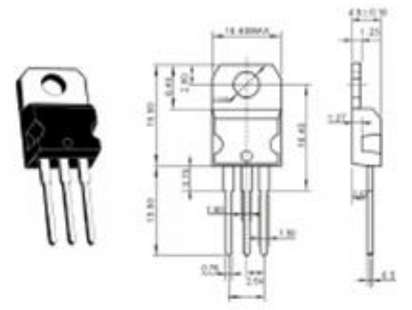
LM78XX

RoHS Pb

3-Terminal 1 A Positive Voltage Regulator

Features

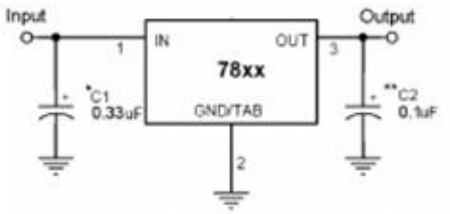
- Output Voltage Range 5 to 24V
- Output current up to 1A
- No external components required
- Internal thermal overload protection
- Internal short-circuit current limiting
- Output transistor safe-area compensation
- Output voltage offered in 4% tolerance



TO-220M-1

Unit : (mm)

Standard Application Circuit



A common ground is required between the input and the output voltages. The input voltage must remain typically 2.0V above the output voltage even during the low point on the Input ripple voltage.

XX = these two digits of the type number indicate voltage.

* = Cin is required if regulator is located an appreciable distance from power supply filter.

** = Co is not needed for stability; however, it does improve transient response.

Absolute Maximum Rating (Ta = 25°C unless otherwise noted)

Parameter		Symbol	Limit	Unit
Input Voltage	V_{OUT}=5~18V	V_{IN}	35	V
	V_{OUT}=24V		40	
Output Current		I_{OUT}	Internal Limited	
Power Dissipation		P_D	Internal Limited	
Operating Junction Temperature		T_J	0~+125	°C
Storage Temperature Range		T_{STG}	-65~+150	°C
Thermal Resistance - Junction to Case	TO-220	$R\Theta_{JC}$	5	°C/W
	ITO-220		5	
Thermal Resistance - Junction to Ambient	TO-220	$R\Theta_{JA}$	50	°C/W
	ITO-220		60	

Note: Absolute maximum ratings are those values beyond which damage to the device may occur. Functional operation under these condition is not implied.

Scale
X-axis

Y-axis

Practical No. 25: Prepare and Test the performance of Dual voltage regulator using 78XX and 79XX, three terminal IC for given voltage

I Practical Significance

In industry and domestic appliances three terminal regulators are used. They give fixed output voltage making these useful in a wide range of applications. One of these is on board regulation, eliminating the distribution problems associated with single point regulation. 78xx series of voltage regulators are most commonly used to provide a stable output voltage from a slightly higher input voltage. And 79xx series of voltage regulators perform in pretty much the same way but they are intended to output a negative voltage.

II Industry / Employer Expected Outcome

This practical is expected to develop the following skill: **'Use electronic components and circuits in electrical equipment and systems'.**

III Course Level Learning Outcome

Test operation of regulated power supply.

IV Laboratory Learning Outcomes

1. Prepare the circuit for Dual voltage regulator using 78XX and 79XX IC.
2. Calculate load and Line regulation.

V Relevant Affective Domain related Outcomes

1. Handle components and equipment carefully.
2. Follow safety precautions.
3. Follow ethical practices

VI Minimum Theoretical Background

IC78XX is positive series of regulators. For ICs with in the78xx family, the xx is replaced with two digits, indicating the output voltage for example; the7805 has a 5-volt output, while the 7812 produces12 volts. The LM78XX series of three terminal regulators is available with several fixed output voltages making them useful in a wide range of will allow over 1.0A load current if adequate heat sinking is provided. Current limiting is included to limit the peak output current to a safe value. Safe area protection for the output transistor is provided to limit internal power dissipation. If internal power dissipation becomes too high for the heat sinking provided, the thermal shutdown circuit takes over preventing the IC from overheating. Voltage Range are LM7805C 5V; LM7812C 12V; LM7815C 15V.where LM indicate the manufacturer name.

The LM79XX series of 3-terminal regulators is available with fixed output voltages of 5V, 8V, 12V, and 15V.These devices need only one external component, i.e. compensation capacitor at the output. The LM79XX series is packaged in the TO-220 power package and is capable of supplying 1.5A of output current. The third pin is ground. The purpose of the first and second pins of these two types of ICs is different:

I. The first and second pins of 78xx voltage regulator ICs are used for connecting the input and ground respectively.

II. The first and second pins of 79xx voltage regulator ICs are used for connecting the ground and input respectively.

Examples

7805 voltage regulator IC produces a DC voltage of +5 volts.

7905 voltage regulator IC produces a DC voltage of -5 volts.

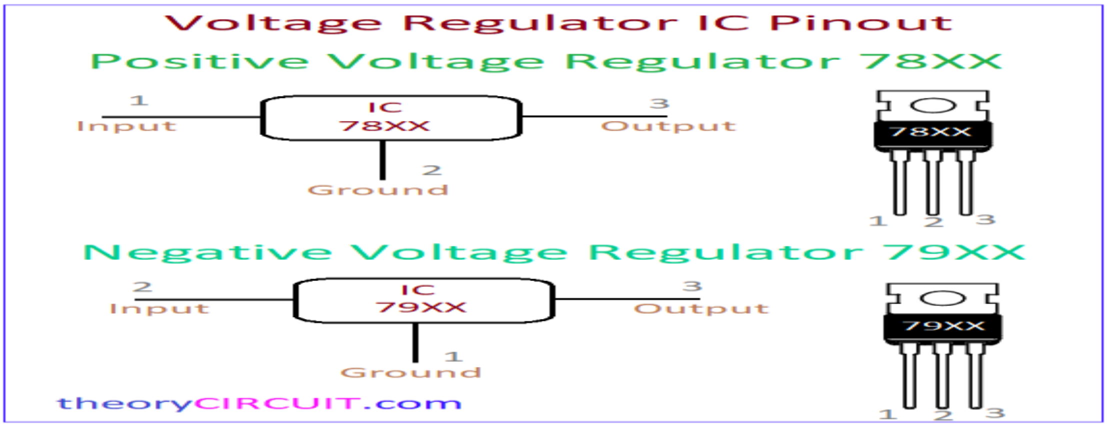


Figure 25.1: Pin diagram of IC78XX and 79XX

VII Practical setup in Laboratory

(a) Sample

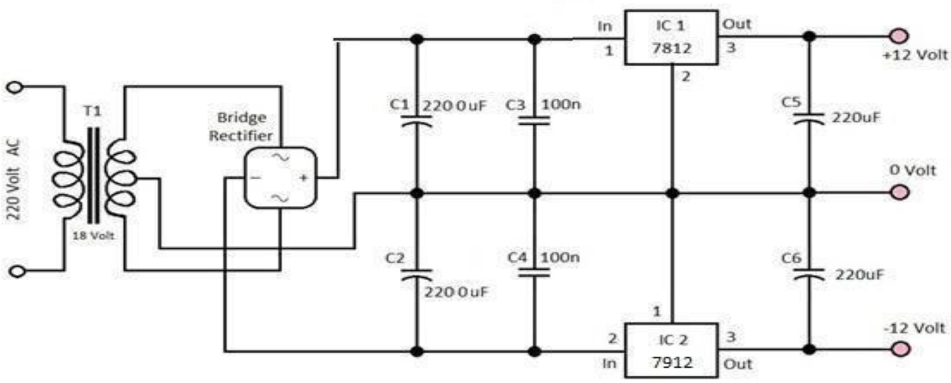


Figure 25.2: Dual voltage regulator

(b) Actual Circuit Diagram used in Laboratory

(c)Actual practical set up used in Laboratory

VIII Required Resources/apparatus/equipment with specifications

Sr. No	Instruments/Components	Specification	Quantity
1.	Digital Multimeter	3 ½ -digit display with AC and DC voltage measurement and Current measurement facility and Diode testing facility.	1
2.	DC Voltmeter	0-20V	1
3.	IC7805,7812,7815	LM78L05 input voltage tolerances of ±5% over the temperature range and Output current of 100mA.	1 each
4.	IC7905,7912,7915	Thermal, short circuit and safe are a protection, High ripple rejection,1.5A output current, 4% tolerance on preset Output voltage.	1 each
5.	Capacitors	2200µF,220µF (Ceramic capacitor)	4
6.	Transformer	9-0-9VAC,500mA	1
7.	Bridge rectifier	100V,2A	1
8.	Bread Board	5.5 CM X 17CM	1

IX Precautions to be followed

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

X Procedure

Select components and test it with multimeter.

1. Mount components on bread board as per circuit diagram.
2. Connect dc power supply at the input.
3. Connect multimeter at the output.
4. Vary input voltage by varying DC supply till constant output voltage is obtained.
5. Note down the corresponding output voltage.
6. Tabulate input and output voltage in observation table.
7. Plot a graph of input dc voltage versus output voltage.
8. Measure output voltage with voltmeter or Multimeter

Part I

Line Regulation:

1.Connect the circuit as in figure 25.2

2. Keep load resistance fixed value; vary DC input voltage from 5Vto 15V.

3.Record the output voltage as a load voltage with high line voltage 'V HL 'and as a load voltage with low line voltage 'VIN' in the observation table.

Part II

Load Regulation:

1. Keep input voltage constant say 10V, vary load resistance value.

2.Record no load voltage 'VNL' for maximum load resistance value and full load voltage 'VFL' for minimum load resistance value.

3.Calculate load regulation as per formula.

4. Sketch the graph for recorded readings.

XI Observation Table

Table 1- Positive voltage regulator using IC78XX

Sr. No	IC Used	Output at positive DC Voltage	Output at negative DC Voltage
1.	7805		
2.	7812		
3.	7815		

Table 2- Negative voltage regulator using IC79XX

Sr. No.	IC Used	Output at positive DC Voltage	Output at negative DC Voltage
1.	7905		
2.	7912		
3.	7915		

Table 3- Measurement of Vin and Vz

Sr. No.	Line Regulation (RL constant) IL=lO (mA)		Load Regulation (Vin constant) Vin=lO (V)	
	Input voltage Vin(VOLTS)	Output voltage Vz(VOLTS)	Load current IL(mA)	Output voltage Vz(VOLTS)
1.				
2.				
3.				
4.				
5.				

Calculations:

Percentage of line regulation=

Percentage of load regulation=

XII Results

Load Resistance	Output voltage Vz(VOLTS)	Load current IL(mA)
RL minimum		
RL maximum		

XIII Interpretation of results

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……………………………………………………………………………………

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XIV Conclusions and Recommendation

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XV Practical related Questions

Note: Below given are few sample questions for reference. Course faculty must design more such questions so as to ensure the achievement of identified CO.

1. Draw the pin configuration of IC 78xx & 79xx.
2. List the different applications of voltage regulator IC 78xx family.
3. List features of IC 78xx and 79xx.

[Space for answers]

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XVI References / Suggestions for further Reading

1. www.alldatasheet.com/datasheet-pdf/pdf/9037/NSC/LM78XX.html
2. www.cedmagic.com/tech-info/data/lm78xx.pdf

XVII Assessment Scheme

Performance Indicators		Weightage
Process related (15 Marks)		**60%**
1	Proper connection of electrical circuit	20%
2	Handling of instrument	10%
3	Taking proper readings	20%
4	Working in team.	10%
Product related (10 Marks)		**40%**
1	Interpretation of Result & Conclusion	15%
2	Practical related questions	15%
3	Completion and submission of experiment in time	10%
	Total (25 Marks)	**100%**

Names of Student Team Members

1. ....
2. ....
3. ....
4. ....

Marks Obtained			Dated Signature of Teacher
Process Related (15)	**Product Related (10)**	**Total (25)**	

LM78XX

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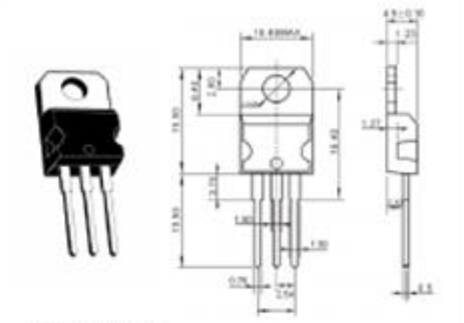
LM78XX

3-Terminal 1 A Positive Voltage Regulator

Features

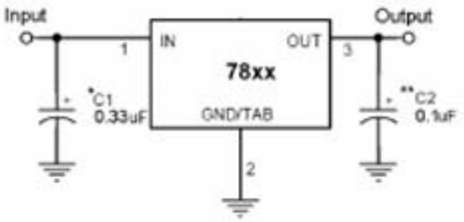
- Output Voltage Range 5 to 24V
- Output current up to 1A
- No external components required
- Internal thermal overload protection
- Internal short-circuit current limiting
- Output transistor safe-area compensation
- Output voltage offered in 4% tolerance



TO-220M-1

Unit : (mm)

Standard Application Circuit



A common ground is required between the input and the output voltages. The input voltage must remain typically 2.0V above the output voltage even during the low point on the Input ripple voltage.

XX = these two digits of the type number indicate voltage.

* = Cin is required if regulator is located an appreciable distance from power supply filter.

** = Co is not needed for stability; however, it does improve transient response.

Absolute Maximum Rating (Ta = 25°C unless otherwise noted)

Parameter		Symbol	Limit	Unit
Input Voltage	V_{OUT}=5~18V	V_{IN}	35	V
	V_{OUT}=24V		40	
Output Current		I_{OUT}	Internal Limited	
Power Dissipation		P_D	Internal Limited	
Operating Junction Temperature		T_J	0~+125	°C
Storage Temperature Range		T_{STG}	-65~+150	°C
Thermal Resistance - Junction to Case	TO-220	$R\Theta_{JC}$	5	°C/W
	ITO-220		5	
Thermal Resistance - Junction to Ambient	TO-220	$R\Theta_{JA}$	50	°C/W
	ITO-220		60	

Note: Absolute maximum ratings are those values beyond which damage to the device may occur. Functional operation under these condition is not implied.

Scale
X-axis

Y-axis

Practical No. 26: Test the performance of IC 723 as Regulator

I Practical Significance

Voltage regulators are used to compensate for voltage fluctuation in main power as well as load current variation. Voltage regulators are used in industries as well as in domestic applications such as Air Condition, TV, and Refrigerators in order to protect them from fluctuating input voltage. IC 723 is a general purpose, extremely versatile voltage regulator IC, which can be used for making various types of regulated power supply.

II Industry / Employer Expected Outcome

This practical is expected to develop the following skill: **'Use electronic components and circuits in electrical equipment and systems'.**

III Course Level Learning Outcome

Test operation of regulated power supply.

IV Laboratory Learning Outcomes

1. Build LOW/High voltage regulator circuit using IC LM723.
2. Calculate load and Line regulation.

V Relevant Affective Domain related Outcomes

1. Handle components and equipment carefully.
2. Follow safety precautions.
3. Follow ethical practices

VI Minimum Theoretical Background

The723 voltage regulator is commonly used for series voltage regulator applications. It can be used as both positive and negative voltage regulator. LM723 IC can also be used as a temperature controller, current regulator or shunt regulator and it is available in both Dual-In-Line and Metal Can packages.

The IC 723 is a general purpose, extremely versatile voltage regulator IC, which can be used for making various types of regulated power supplies such as:

a. Positive Voltage Regulator
b. Negative Voltage Regulator
c. Switching Regulator
d. Foldback Current Limiter

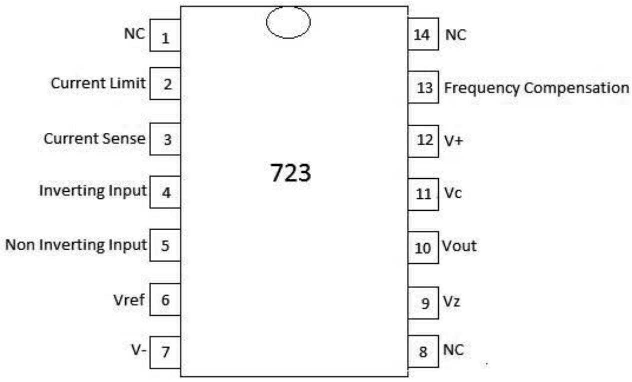


Figure 26.1: Pin diagram of IC LM723

Block diagram of IC 723

Includes, voltage reference source, error amplifier, a series pass transistor and a current limit transistor all are include din14pin DIP package. It has temperature compensated 6.2V Zener, which is biased with constant current source. A reference voltage amplifier generates the precise reference voltage in between 6.8 to 7.5 V. The output of error amplifier drives the series pass transistor Q1 to give output voltage. Transistor Q2 is connected internally to provide short circuit current limiting.

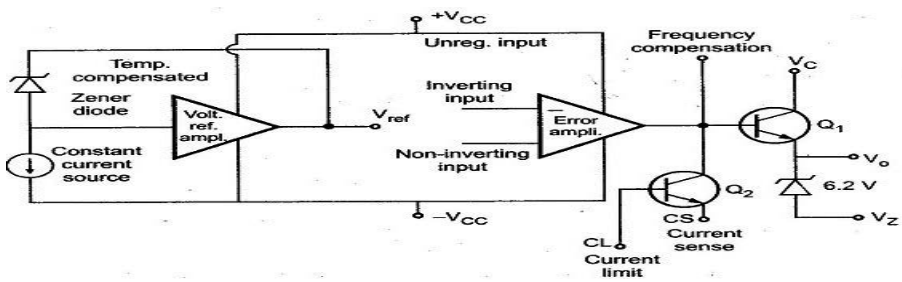


Figure 26.2: Block diagram of IC LM723

VII Practical setup in Laboratory

(a) Sample

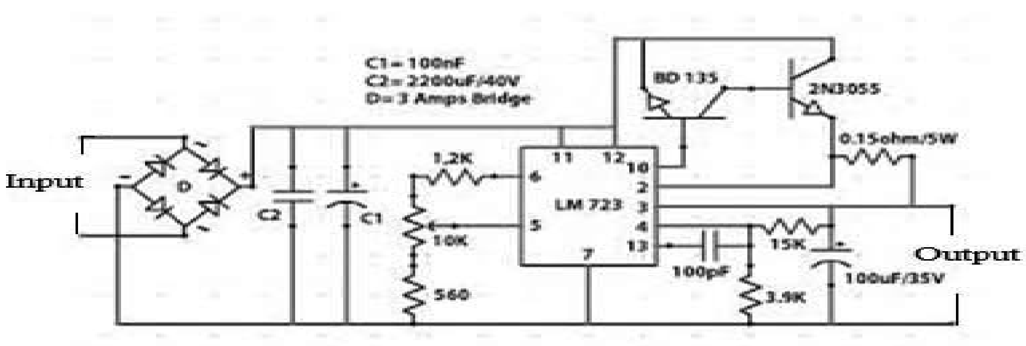


Figure 26.3: Circuit diagram of IC723

(b) Actual Circuit Diagram used in Laboratory

(b) Actual practical set up used in Laboratory

VIII Required Resources/apparatus/equipment with specifications

Sr. No	Instruments/Components	Specification	Quantity
1.	Digital Multimeter	3 ½ -digit display with AC and DC voltage measurement and Current measurement facility and Diode testing facility.	1
2.	Variable DC power supply	0-30V, 2A, SC protection, display for voltage and current.	1
3.	IC723	LM723	1
4.	Resistor	1.2KΩ, 560 Ω,3.9 KΩ, 15 KΩ,0.15Ω/5W,10KΩ Variable resistor	6
5.	Capacitor	100pF,100Nf,100µF,2200µF. (Ceramic capacitor)	4
6.	Transistor	2N3055, BD135	2
7.	Bread Board	5.5 CM X 17CM	1

IX Precautions to be followed

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

X Procedure

Select components and test it with multimeter.

1. Mount components on bread board as per circuit diagram.
2. Connect dc power supply at the input.
3. Connect multimeter at the output.
4. Vary input voltage by varying DC supply till constant output voltage is obtained.
5. Note down the corresponding output voltage.
6. Tabulate input and output voltage in observation table.
7. Plot a graph of input dc voltage versus output voltage.
8. Measure output voltage with voltmeter or Multimeter

Part I

Line Regulation:

1.Connect the circuit as in figure 26.3

2**.** Keep load resistance fixed value; vary DC input voltage from 5Vto 15V.

3.Record the output voltage as a load voltage with high line voltage 'V HL 'and as a load voltage with low line voltage 'VIN' in the observation table.

Part II

Load Regulation:

1. Keep input voltage constant say 10V, vary load resistance value.
2. Record no load voltage 'VNL' for maximum load resistance value and full load voltage 'VFL' for minimum load resistance value.
3. Calculate load regulation as per formula.
4. Sketch the graph for recorded readings.

XI Observation Table

Table 1- Measurement of Vin and Vz

Sr. No.	Line Regulation (RL constant) IL=10(mA)		Load Regulation (Vin constant) Vin=10 (V)	
	Input voltage Vin(VOLTS)	Output voltage Vz(VOLTS)	Load current IL(mA)	Output voltage Vz(VOLTS)
1.				
2.				
3.				
4.				
5.				

Calculations:

Percentage of line regulation=

Percentage of load regulation=

XII Results

……………………………………………………………………………………

……………………………………………………………………………………

XIII Interpretation of results

……………………………………………………………………………………

……………………………………………………………………………………

……………………………………………………………………………………

XIV Conclusions and Recommendation

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XV Practical related Questions

Note: Below given are few sample questions for reference. Course faculty must design more such questions so as to ensure the achievement of identified CO.

1. State the difference between low voltage and high voltage regulator?
2. List the various protection circuits used in voltage regulator?
3. Sate the function of current limiting in IC 723?

[Space for answers]

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XVI References / Suggestions for further Reading

1. https://www.youtube.com/watch?v=veXShWaCliA
2. https://www.youtube.com/watch?v=tNqT7vCDswk

XVII Assessment Scheme

Performance Indicators		Weightage
Process related (15 Marks)		**60%**
1	Proper connection of electrical circuit	20%
2	Handling of instrument	10%
3	Taking proper readings	20%
4	Working in team.	10%
Product related (10 Marks)		**40%**
1	Interpretation of Result & Conclusion	15%
2	Practical related questions	15%
3	Completion and submission of experiment in time	10%
	Total (25 Marks)	**100%**

Names of Student Team Members

1. ....
2. ....
3. ....
4. ....

Marks Obtained			Dated Signature of Teacher
Process Related (15)	**Product Related (10)**	**Total (25)**	

Scale
X-axis

Y-axis