LAB MANUAL

ANALOG
ELECTRONICS - I
(EC – 201)

III SEMESTER

Electronics & Communication Engineering
Department

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LIST OF EXPERIMENT

1. To become familiar with the operation of basic laboratory instruments
    i. Digital storage oscilloscope
    ii. Waveform generator
    iii. DC power supply
    iv. Digital multimeter

2. Testing of different electronic components using a multimeter and determining their values.

3. To plot forward and reverse bias characteristics for PN Junction diode and determine its cut-in voltage, forward resistance and reverse resistance.

4. To plot forward and reverse biased characteristics for ZENER diode.

5. To design and study of Half Wave Rectifier circuit and find ripple factor with different capacitor filters.

6. To design and study of Full Wave Center Tapped Rectifier circuit and find ripple factor with different capacitor filters.

7. To design and study of Bridge Rectifier circuit and find ripple factor with different capacitor filters.

8. To analyze the Performance of different Clipping Circuits using diode and plot their respective output waveforms.

9. To analyze the Performance of different Clamping Circuits using diode and plot their respective output waveforms.

10. To design and plot the input and output characteristics of the given transistor in CB (common base) configuration.

11. To design and plot the input and output characteristics of the given transistor in CE (common-emitter) configuration.

12. To design and plot drain characteristics and transfer characteristics of JFET.

13. To design and plot drain characteristics and transfer characteristics of N-Channel metal oxide semiconductor junction field-effect transistor (MOSFET).

14. To design and analyze the Performance of MOSFET as a switch.

EXPERIMENT - 1

OBJECTIVE - To become familiar with the operation of basic laboratory instruments:

i. DC power supply
ii. Wave form generator
iii. Digital storage oscilloscope
iv. Digital multimeter

APPARATUS REQUIRED –

1.	DC power supply	01 No.
2.	Wave form generator	01 No.
3.	Digital Storage Oscilloscope	01 No.
4.	Digital multimeter	01 No.
5.	Connecting Wires	04 No.

THEORY -

- **DC Power supply**

A DC power supplies uses AC mains electricity as an energy source and therefore employ a transformer to convert input voltage to a lower or higher AC voltage. A rectifier is then used to convert the transformer output voltage to a varying DC voltage, which in turn is passed through an electronic filter to convert it to an unregulated DC voltage. The utility of the filter is to removes AC voltage variations; the remaining AC voltage is known as ripple.

Fig. 1.1 Pictorial view of DC power supply

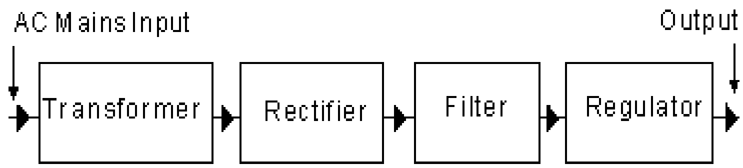


Fig. 1.2 Block diagram of regulated DC power supply

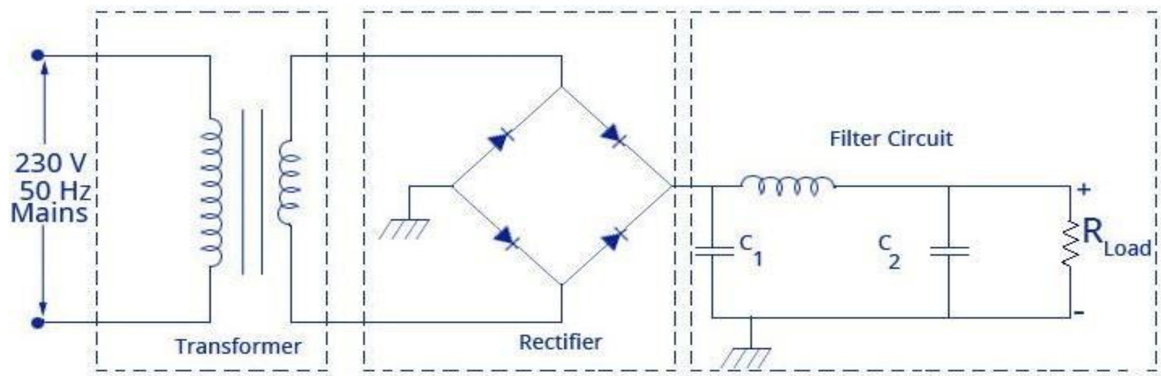


Fig. 1.3 Circuit diagram of regulated DC power supply.

Working principal of DC power supply

When designing a DC power supply, the aim is to get an output voltage with good stability.

A DC supply consists of the following parts:

- A transformer to change the voltage as required and to isolate the DC circuit from the line.
- A rectifier consisting of one or more diodes, to change AC to DC.
- A smoothing circuit using inductors and capacitors.
- An electronic stabilizer which improves the stability of the output voltage and/or current.

- **Digital Storage Oscilloscope (DSO)**

A digital storage oscilloscope (DSO) is a device that stores and analyses the signal digitally. It is now the most common type of oscilloscope in use because of the advanced trigger, storage, display, and measurement features which it typically provides.

Working principal

The input signal is applied to the amplifier and attenuator section

1. The attenuated signal is then applied to the vertical amplifier.
2. To digitize the analog signal, analog to digital (A/D) converter is used.

3. The output of the vertical amplifier is applied to the A/D converter section.
4. The successive approximation type of A/D converter is most often used in the digital storage oscilloscopes.
5. The sampling rate and memory size are selected depending upon the duration & the waveform to be recorded.
6. Once the input signal is sampled, the A/D converter digitizes it.
7. The signal is then captured in the memory.
8. Once it is stored in the memory, many manipulations are possible as memory can be readout
9. Without being erased.

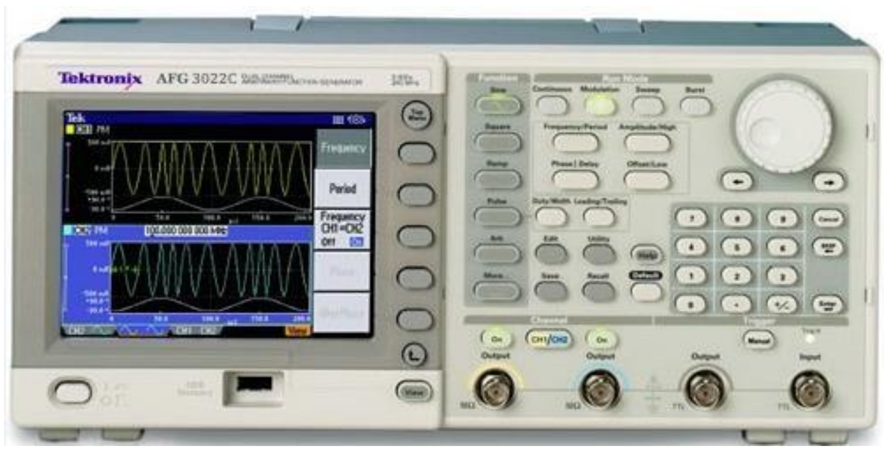


Fig. 1.4 Pictorial view of digital storage oscilloscope

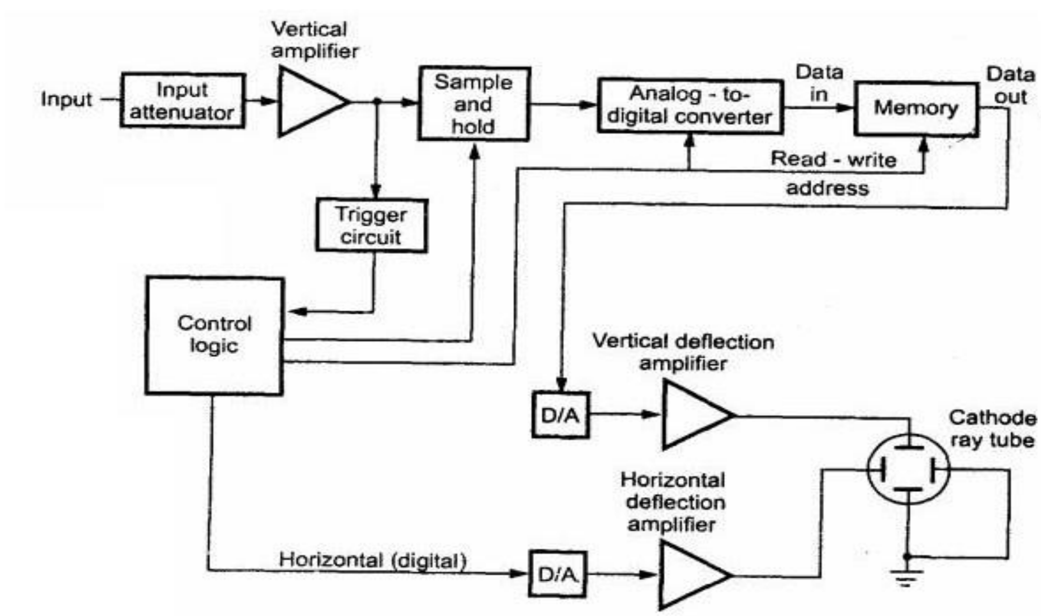


Fig. 1.5 Block diagram of digital storage oscilloscope

- **Waveform Generator**

A waveform generator is a piece of electronic test equipment used to generate electrical waveforms. These waveforms can be either repetitive or single-shot (once only) in which case some kind of triggering source is required (internal or external). The resulting waveforms can be injected into a device under test and analyzed as they progress through it, confirming the proper operation of the device, or pinpointing a fault in it. It contains an attenuator, various means of modulating the output waveform, and often contain the ability to automatically and repetitively "sweep" the frequency of the output waveform between two operator-determined limits. This capability makes it very easy to evaluate the frequency response of a given electronic circuit. They have the capability to produce standard waveforms such as sine, square, ramp, triangle, noise, and pulse. Some units include additional built-in waveforms such as exponential rise and fall times, sinx/x, and cardiac.

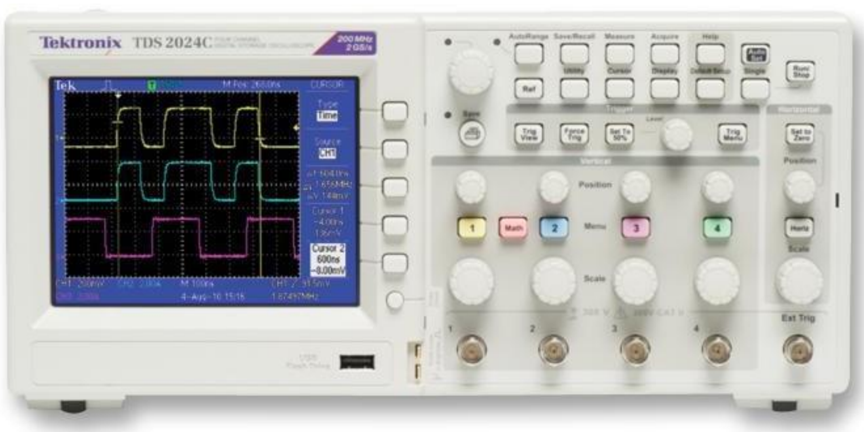


Fig. 1.6 Pictorial view of Wave form generator

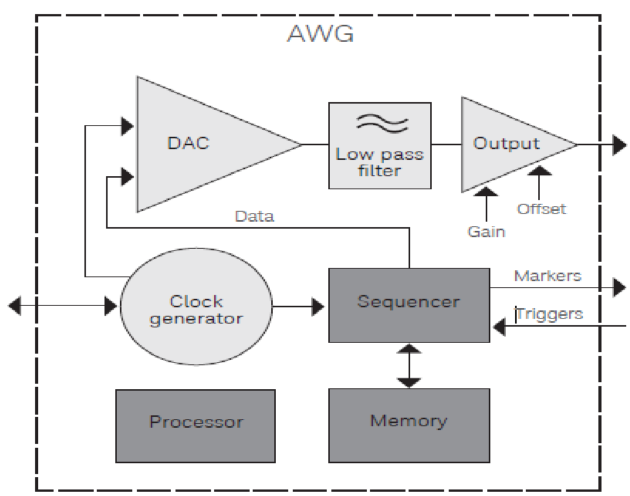


Fig 1.7 Block diagram of a waveform generator

- **Multimeter**

Digital multimeter is a test equipment which offers several electronic measurement task in one tool. It is also known as the voltmeter or Ohm meter or Volt Ohm meter. The standard and basic measurements performed by multimeter are the measurements of amps, volts, and ohms. The new improved digital multimeters are more efficient, faster and work with a large accuracy as compared to an analogue multimeter.

(a) (b)

Fig.1.8 (a) Analog multimeter and (b) Digital multimeter

<u>PROCEDURE</u> -

1. Power on the generator and select the desired output signal: square wave, sine wave or triangle wave.
2. Attach the output leads of the function generator to the input of the multimeter to verify the amplitude of the generated signal.
3. Connect the output leads to the DSO to visualize the output signal and set its parameters using the amplitude and frequency controls.

<u>RESULTS</u> -

The working of the four devices (DSO, function generator, DC power supply, and Multimeter) was understood and verified.

<u>PRECAUTIONS</u> -

1. Ensure correct connections of the leads for the multimeter for current and voltage measurements.
2. Check the mains connection of the DSO and ensure that the rating matches the power supply.

EXPERIMENT – 2

OBJECTIVE – Testing of different electronic components using a multimeter and determining their values.

APPRATUS REQUIRED –

1. Resistors
2. Diodes
3. Capacitors
4. Transistors
5. Inductors
6. Multimeter
7. Connecting Wires

THEORY -

An electronic component is a basic physical entity in an electronic system used to affect electrons or their associated fields. Electronic components are mostly industrial products, available in a singular form**.** A component may be classified as passive, active, or electron mechanic.

Resistor

Resistor can be made to control the flow of current. It works as voltage divider and it can shape electrical waves when used in combination of other components. Basic unit of resistance is ohm (Ω). They can be classified as fixed, semi-variable and variable resistors.

Fig. 2.1 Block diagram representation of a resistor

Capacitor

Capacitor stores the charge across its two plates. It opposes the change of voltage across its plates; the electric field developed across the plate opposes the rapid change in voltages. It produces phase difference between voltage applied to it and the current that passes through it. Capacitance of a capacitor holds the unit of farad (F).

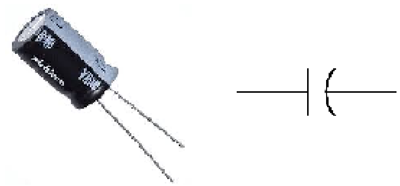


Fig. 2.2 Pictorial and symbolic representation of a capacitor

Table 2.1 Color code for resistance calculation

Color	Significant figures	Multiplier	Tolerance		Temp. Coefficient (ppm/K)	
Black	0	$\times 10^0$	–		250	U
Brown	1	$\times 10^1$	±1%	F	100	S
Red	2	$\times 10^2$	±2%	G	50	R
Orange	3	$\times 10^3$	–		15	P
Yellow	4	$\times 10^4$	(±5%)	–	25	Q
Green	5	$\times 10^5$	±0.5%	D	20	Z
Blue	6	$\times 10^6$	±0.25%	C	10	Z
Violet	7	$\times 10^7$	±0.1%	B	5	M
Gray	8	$\times 10^8$	±0.05% (±10%)	A	1	K
White	9	$\times 10^9$	–		–	
Gold	–	$\times 10^{-1}$	±5%	J	–	
Silver	–	$\times 10^{-2}$				

Inductor

Like capacitors, inductors also store energy in one part of AC cycle and return it during the next part of the cycle. Inductance is the property of a device that reacts against a change in current through the device. Measuring unit of inductance is hennery (H).

Fig. 2.3 Pictorial and symbolic representation of a inductor

Semiconducting devices

A semiconductor is defined on the basis of electrical conductivity mentioned as follows –

PN junction diode

A diode is a specialized electronic component with two electrodes called the anode and the cathode. Most diodes are made with semiconducting materials such as silicon, germanium, or selenium. It restricts current flow chiefly to one direction. Diodes can be used as rectifiers, signal limiters, voltage regulators and switches.

Fig. 2.4 Pictorial and symbolic representation of a diode

Zener diode

A Zener diode is a diode that allows current to flow in the forward direction in the same manner as an ideal diode, but will also permit it to flow in the reverse direction when the voltage is above a certain value known as the breakdown voltage or zener voltage. Until this voltage device exhibits a very high resistance and after that current suddenly increases keeping a constant voltage across it.

Fig. 2.5 Pictorial and symbolic representation of a Zener diode

Transistor

A transistor is a bipolar semiconductor device used to amplify and switch electronic signals and power. It is composed of semiconductor material with at least three terminals named emitter, base and collector for connection to an external circuit. A voltage or current applied to one pair of the transistor's terminals enhances through another pair of terminals and thus it works as a amplifier.

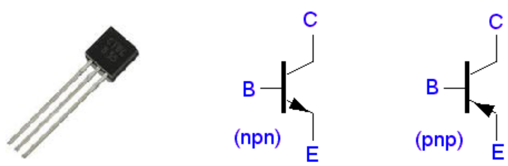


Fig. 2.6 Pictorial and symbolic representation of a transistor

Other symbols

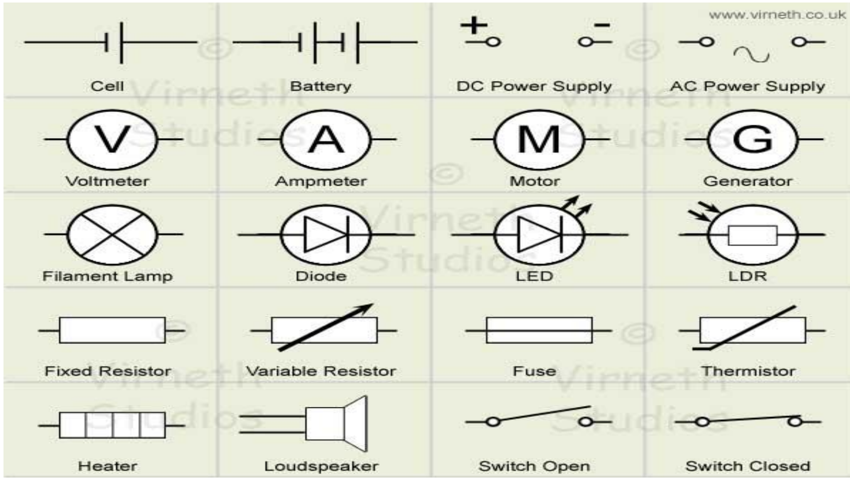


Fig. 2.7 Symbols to represent other symbols

<u>OBSERVATION</u> -

CALCULATION OF RESISTANCE

COLOR CODE	THEORETICAL VALUE OF RESISTANCE	RESISTANCE MEASURED BY MULTIMETER

CALCULATION OF CAPACITANCE

TYPE OF CAPACITOR	CODE MENTIONED ON CAPACITOR	THEORETICAL VALUE OF CAPACITANCE	CAPACITANCE MEASURED BY MULTIMETER
CERAMIC			
ELECTROLYTIC			

<u>RESULT</u> –

Thus we have studied various electronic components invariably using in electronic circuits. Moreover the values of different resistors and capacitors are also verified through multimeter, which are found close to the theoretical calculated values.

PRECAUTIONS -

1. Handle the components carefully.
2. Take the readings properly.
3. Avoid holding the components by hand while measuring through multimeter.

EXPERIMENT – 3

OBJECTIVE - To plot forward and reverse bias characteristics for PN Junction diode and determine its cut-in voltage, forward resistance and reverse resistance.

APPARATUS REQUIRED -

1.	Bread Board	01 No.
2.	P-N Junction Diode	01 No.
3.	Resistance- 1KΩ	01 No.
4.	Multimeter	02 Nos.
5.	Variable DC Power Supply	01 No.
6.	Connecting Wires	

THEORY -

The diode is a device formed from a junction of n-type and p-type semiconductor material. The lead connected to the p-type material is called the anode and the lead connected to the n-type material is the cathode. In general, the cathode of a diode is marked by a solid line on the diode. The primary function of the diode is rectification. When it is forward biased (the higher potential is connected to the anode lead), it will pass current. When it is reversed biased (the higher potential is connected to the cathode lead), current flow is blocked. In the simplest form, the diode is modeled by a switch. The switch is closed when the diode if forward biased and open when the diode is reversed biased. Immediately after the diodeis switched to reverse bias, the depletion region is still full of carriers. Therefore, a large negative current will flow until all of the excess carriers are washed out. As the carriers are removed, the reverse current decays exponentially to approximately zero. The volt-ampere characteristic of p-n junction diode is given by

$$I_D = I_R \left(e^{\frac{V_D}{nV_T}} - 1 \right) \qquad (3.1)$$

Where I_R is saturation current, V_D is diode voltage and V_T is thermal voltage, n is aconstant whose value is 1 for silicon and 2 for germanium.

- **Forward Biasing -**

The circuit diagram for the forward bias has been shown in fig. 3.1. The forward bias region is entered when terminal voltage v is positive. In this case V_D is several times of V_T due to which $e^{\frac{V_D}{nV_T}} >> 1$. Hence, diode current in forward bias is given as

$$I_D = I_R e^{\frac{V_D}{nV_T}} \tag{3.2}$$

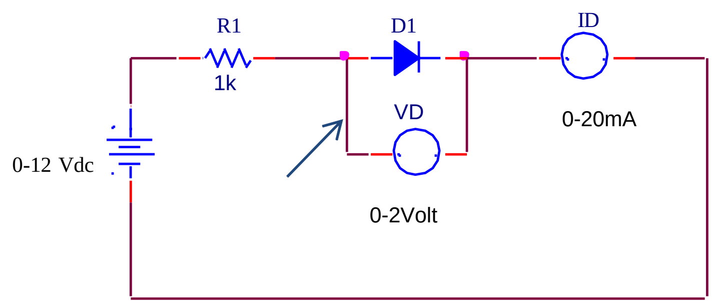


Fig. 3.1 Circuit diagram for forward bias condition of diode

- **Reverse Biasing -**

The circuit diagram for the reverse has been shown in fig. 3.2. The reverse bias region of operation is entered when the diode voltage v is made negative. If v is negative then the exponential term becomes negligibly small compared to unity and current becomes as

$$I_D \approx -I_R \tag{3.3}$$

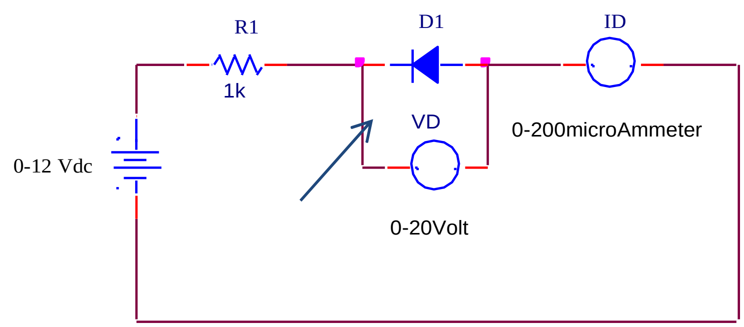


Fig. 3.2 Circuit diagram for reverse bias condition of diode

The forward and reverse bias characteristic for p-n junction diode has been given in Fig. 3.3.

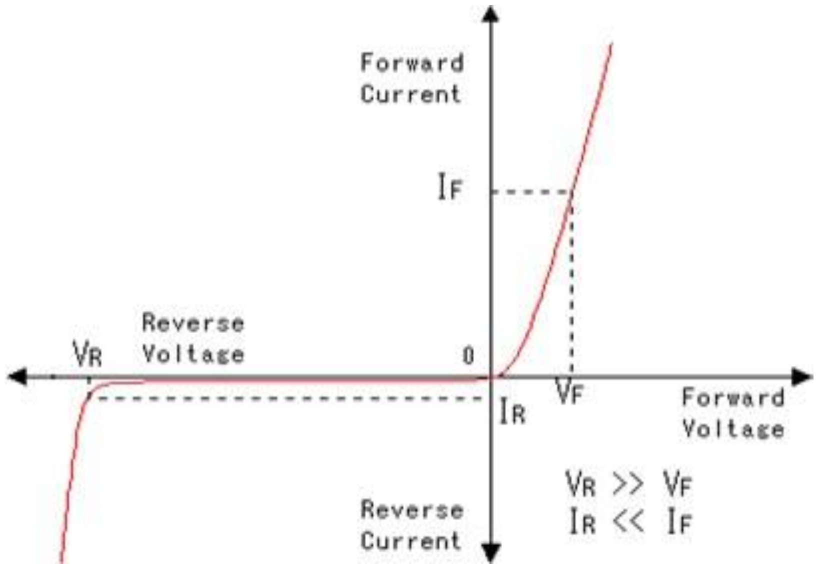


Fig. 3.3 Forward and reverse bias V-I characteristics of a PN junction diode

- **Static Resistance -**

For the calculation of static resistance, first fix the supply voltage at some constant values, then measure the value of voltage across diode V_{DQ} and value of current I_{DQ} across the circuit. The ratio of the diode voltage to the current will give the value of static resistance which is given as

$$R_D = V_{DQ}/I_{DQ} \tag{3.4}$$

- **Dynamic Resistance -**

For calculation of dynamic resistance, make the supply variable. Plot the I-V curve of PN junction diode, and then select two points on the curve which are making tangent on it. The ratio of voltage difference to current difference respective to those two points will give the value of dynamic resistance which is given as

$$R_d = \Delta V_D / \Delta I_D \tag{3.5}$$

<u>PROCEDURE</u> -

1. Using suitable patch cords make connection as shown in Fig. 3.1 for forward characteristics
2. In order to plot forward bias characteristics, perform the following steps: vary the diode voltage (V_D) in step of 0.1V starting from zero and observe the corresponding value of diode current (I_D) in milli- ampere (mA).
3. Record your reading in the observation table

4. Finally plot graph for forward bias characteristics.
5. Using suitable patch cords make connection as shown in Fig. 3.2 for reverse characteristics.
6. In order to plot Reverse bias characteristics, perform the following steps: vary the diode voltage (V_D) in step of 1V starting from zero and observe the corresponding value of diode current (I_D) in micro- ampere (μA).
7. Record your reading in the observation table
8. Finally plot the graph for reverse bias characteristics.
9. The typical forward and reverse characteristics are shown in Fig. 3.3.

OBSERVATION -

Forward Bias		**Reverse Bias**	
V_D (Volt)	**I_D(mA)**	**V_D(Volt)**	**I_D(μA)**
0		0	
0.1		1	
0.2		2	
0.3		3	
0.4		4	
0.45		5	
0.50		6	
0.55		7	
0.60		8	
0.65		9	
0.70		10	
0.75			

CALCULATION -

1. R_D = ……………….
2. R_d = ………………..

RESULT -

To forward and reverse bias characteristics for PN Junction diode were plotted to determine its cut-in voltage, forward resistance and reverse resistance.

PRECAUTIONS -

1. Keep variable power supply in anti-clock wise before the starting the experiment.
2. Do not exceed diode current beyond the limit i.e. 10 mA.

EXPERIMENT – 4

OBJECTIVE – To plot forward and reverse bias characteristics of Zener diode and calculate the Zener voltage.

APPARATUS REQUIRED -

1.	Bread Board	01 No.
2.	Zener Diode	01 No.
3.	Resistance- 1KΩ	01 No.
4.	Multimeter	02 Nos.
5.	Variable DC Power Supply	01 No.
6.	Connecting Wires	

THEORY -

A Zener Diode, also known as a breakdown diode, is a heavily doped semiconductor device that is designed to operate in the reverse direction. When the voltage across the terminals of a Zener diode is reversed and the potential reaches the Zener Voltage (knee voltage), the junction breaks down and the current flows in the reverse direction. This effect is known as the Zener Effect. There are two types of breakdowns, one is Zener breakdown and the other is the Avalanche breakdown. Zener diodes are used for regulating output voltage.

- **Forward Bias:**

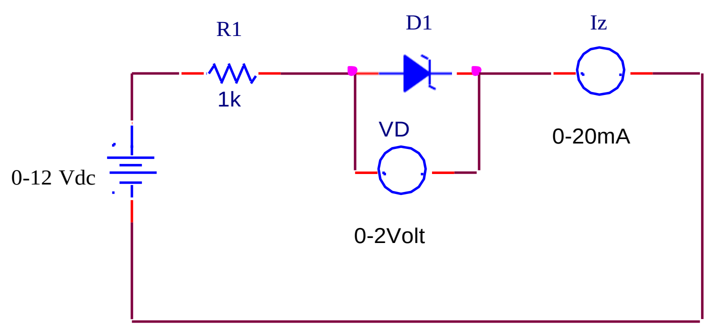


Fig 4.1 Circuit diagram for forward bias condition of diode

- **Reverse Bias –**

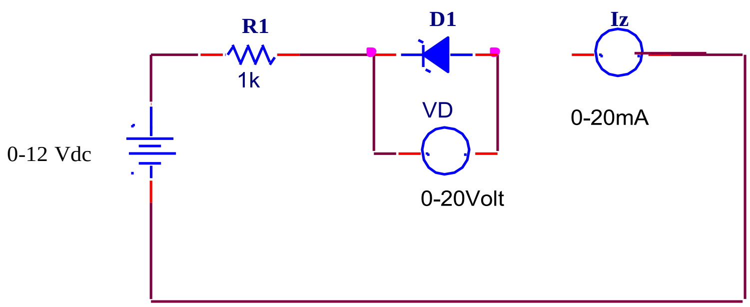


Fig 4.2 Circuit diagram for reverse bias condition of diode

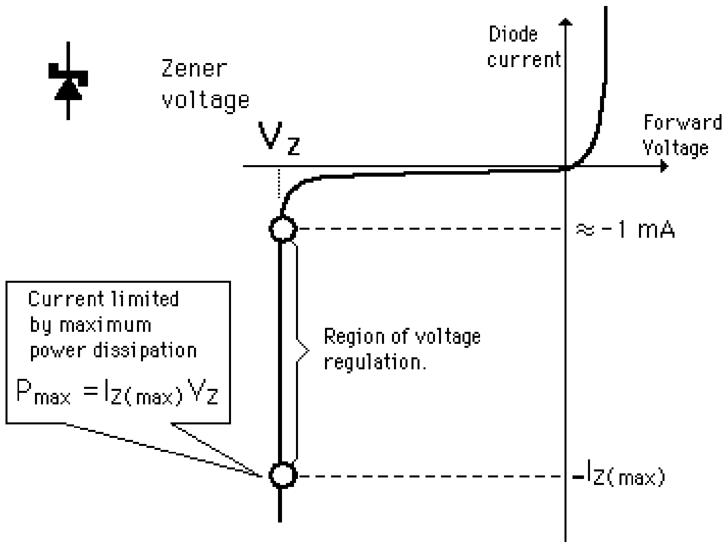


Fig. 4.3 Forward and reverse bias V-I characteristics of a PN junction diode

PROCEDURE -

1. Using suitable patch cords make connection as shown in Fig. 4.1 for forward characteristics
2. In order to plot forward bias characteristics, perform the following steps: vary the diode voltage (V_D) in step of 0.1V starting from zero and observe the corresponding value of diode current (I_D) in milli- ampere (mA).
3. Record your reading in the observation table
4. Finally plot graph for forward bias characteristics.
5. Using suitable patch cords make connection as shown in Fig. 4.2 for reverse characteristics.
6. In order to plot the reverse bias characteristics, perform the following steps: Vary the Diode voltage (V_Z) in steps of 1V starting from zero and observe the

corresponding value of Zener Diode Current (I_Z) in miliampere (mA) and observe the point where small change of zener voltage shows the great change in Zener Diode current (I_Z) that is breakdown zener voltage.

7. Record your reading in the observation table
8. Finally plot the graph for reverse bias characteristics.
9. The typical forward and reverse characteristics are shown in Fig. 4.3.

OBSERVATION -

Forward Bias		**Reverse Bias**	
V_Z (Volt)	**I_D (mA)**	**V_Z(Volt)**	**I_D(µA)**
0		0	
0.1		1	
0.2		2	
0.3		3	
0.4		4	
0.5		5	
0.6		6	
0.7		7	
0.8		8	
0.9		9	
1.0		10	

RESULT -

Observe the point where small change of Zener voltage shows the great change in Zener Diode current (I_Z) that is breakdown Zener voltage.

PRECAUTIONS -

1. Keep variable power supply in anti-clock wise before the starting the experiment.
2. Do not exceed Diode current beyond the limit i.e. 10 mA.

EXPERIMENT – 5

OBJECTIVE – To design and study of Half Wave Rectifier circuit and find ripple factor with different capacitor filters.

APPARATUS REQUIRED –

1.	Bread Board	01 No.
2.	P-N Junction Diode	01 No.
3.	Resistance 1kΩ	01 No.
4.	Transformer (9-0-9)	01 No.
5.	CRO with Probes	01 No.
6.	Electrolytic Capacitor	01 No.
7.	Connecting Wires	

THEORY -

In a half wave rectification an AC supply is applied at the input and only positive half cycle appears across the load whereas, the negative half cycle is suppressed.
During positive half-cycle of the input voltage, the diode D1 is in forward bias and conducts through the load resistor R_L. Hence the current produces an output voltage across the load resistor R_L, which has the same shape as the +ve half cycle of the input voltage.
During the negative half-cycle of the input voltage, the diode is reverse biased and there is no current through the circuit. i.e., the voltage across R_L is zero. The net result is that only the +ve half cycle of the input voltage appears across the load. The average value of the half wave rectified o/p voltage is the value measured on dc voltmeter.

For practical circuits, transformer coupling is usually provided for two reasons.

1. The voltage can be stepped-up or stepped-down, as needed.
2. The ac source is electrically isolated from the rectifier. Thus preventingshock hazards in the secondary circuit.

The efficiency of the Half Wave Rectifier is 40.6%

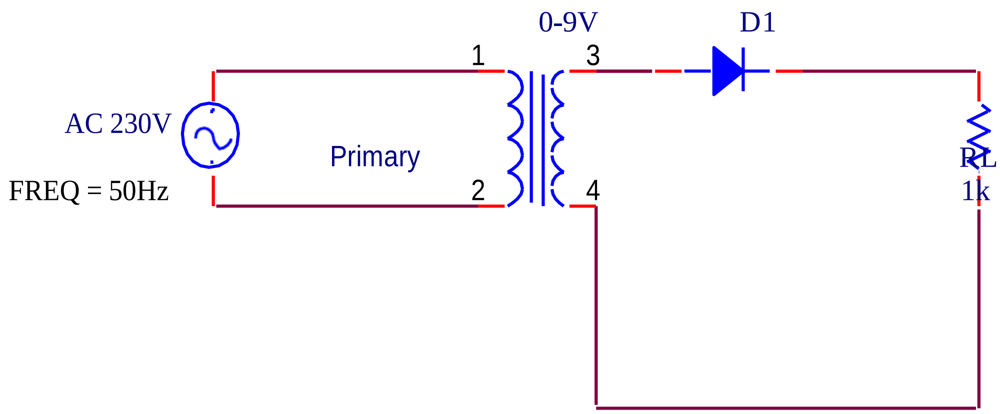


Fig. 5.1 Circuit diagram for a half wave rectifier

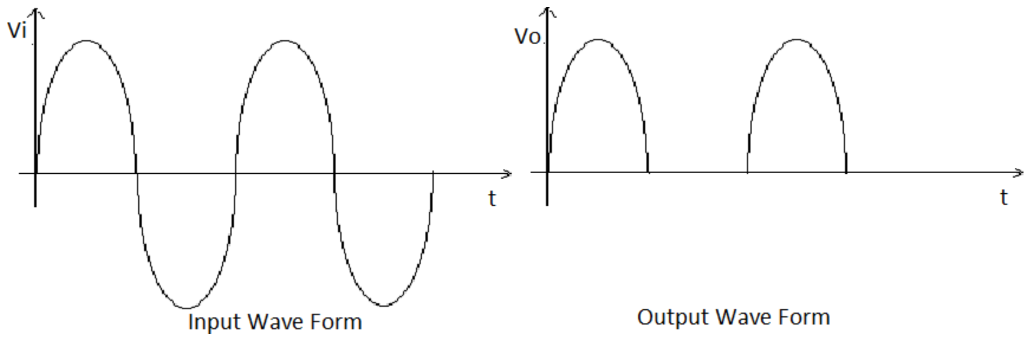


Fig. 5.2 Input and output waveform corresponding to a half wave rectifier

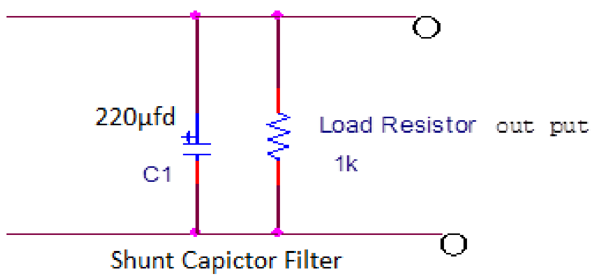


Fig. 5.3 Circuit diagram for the shunt capacitor circuit used after half wave rectifier

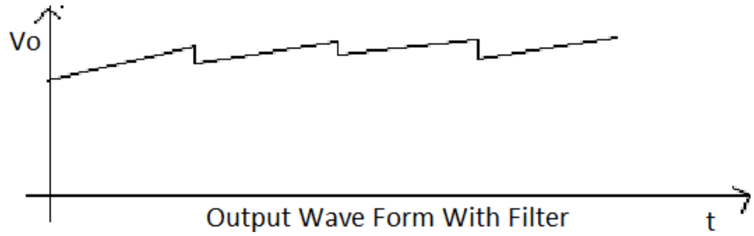


Fig. 5.4 Output waveform for the filter circuit

PROCEDURE -

1. Make connections for half wave rectifier as shown in figure.
2. Observe the input wave from on oscilloscope(Transformer Secondary Voltage i.e 9-0-9 Volt)
3. Observe the output wave form on oscilloscope.
4. Measure the DC voltage V_{DC} across the load.
5. Draw output waveform.
6. Measure r.m.s. value and ripple factor of output voltage.

OBSERVATION -

	V_{pp}	$V_m = \frac{V_{pp}}{2}$		$V_{rms} = \frac{V_m}{\sqrt{2}}$		$V_{dc} = \frac{V_m}{\Pi}$		$r = \sqrt{(V_{rms}^2/V_{dc}^2)} - 1$	
		T	P	T	P	T	P	T	P
Without Filter									

CALCULATIONS -

$$V_m = \frac{V_{pp}}{2} \tag{5.1}$$

$$V_{rms} = \frac{V_m}{\sqrt{2}} \tag{5.2}$$

$$V_{dc} = \frac{V_m}{\Pi} \tag{5.3}$$

Without Filter Ripple Factor

$$r = \sqrt{\frac{V_{rms}^2}{V_{dc}^2}} - 1 = 1.21 \tag{5.4}$$

With Filter Ripple Factor

$$r = \frac{1}{(2\sqrt{3fCR})} \tag{5.5}$$

RESULT –

The ripple factors for half wave Rectifier with Filter and without filterhave been calculated.

EXPERIMENT – 6

OBJECTIVE – To design and study of Full Wave Center Tapped Rectifier circuit and find ripple factor with different capacitor filters.

APPARATUS REQUIRED -

1.	Bread Board	01 No.
2.	P-N Junction Diode	02 No.
3.	Resistance 1kΩ	01 No.
4.	Transformer (9-0-9)	01 No.
5.	CRO with Probes	01 No.
6.	Electrolytic Capacitor	01 No.
7.	Connecting Wires	

THEORY -

The circuit of a center-tapped full wave rectifier uses two diodes D_1 and D_2. During positive half cycle of secondary voltage (input voltage), the diode D_1 is forward biased and D_2 is reverse biased. So, the diode D_1 conducts and current flowsthrough load resistor R_L.

During negative half cycle, diode D_2 becomes forward biased and D_1 reverse biased. Now, D_2 conducts and current flows through the load resistor R_L in the same direction. There is a continuous current flow through the load resistor R_L, during both the half cycles and will get unidirectional current as show in the model graph. The difference between full wave and half wave rectification is that a full wave rectifier allows unidirectional (one way) current to the load during the entire 360 degrees of the input signal and half-wave rectifier allows this only during one half cycle (180 degree).

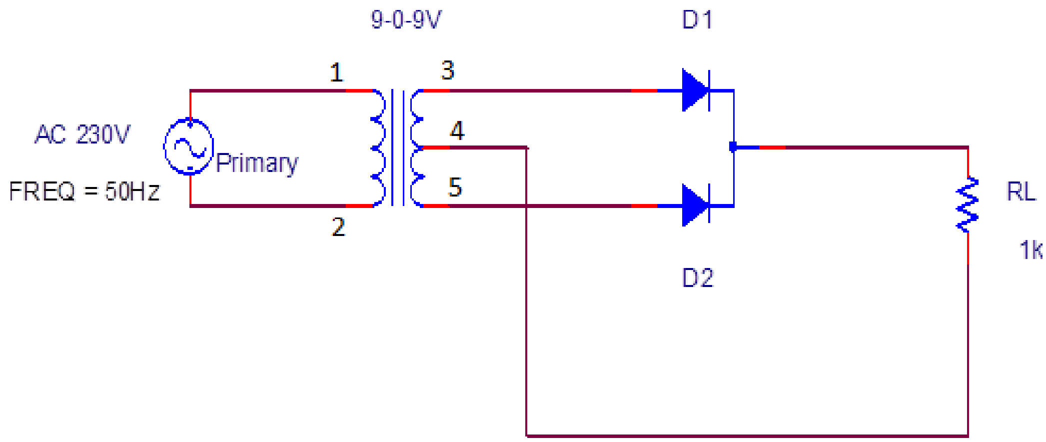


Fig. 6. 1 Circuit diagram for a center tapped full wave rectifier

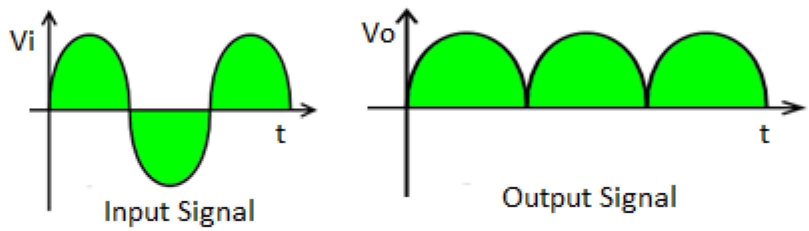


Fig. 6 2. Input and output waveform for a full wave rectifier

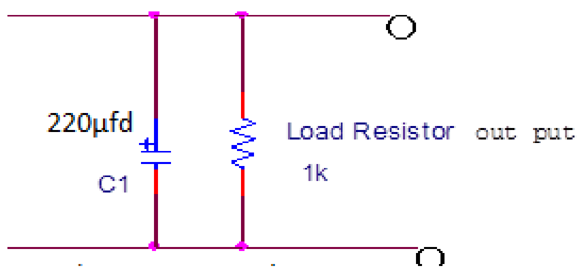


Fig 6.3 Circuit diagram for a shunt capacitor filter

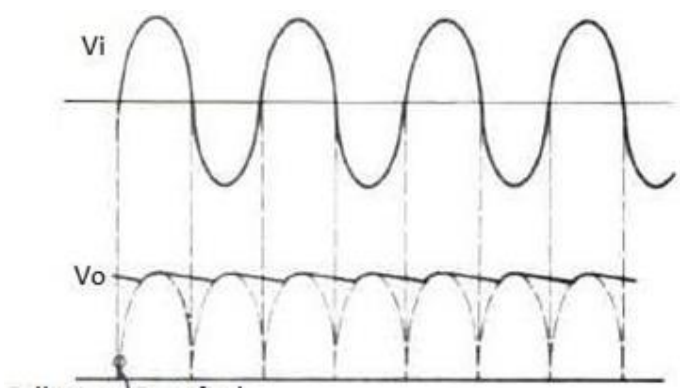


Fig. 6.4 The input and output waveform for full wave rectifier with shunt filter

PROCEDURE -

1. Make connections for full wave rectifier as shown in figure.
2. Observe the input wave from on oscilloscope.
   (Transformer Secondary Voltage i.e 9-0-9 Volt)
3. Observe the output wave form on oscilloscope.
4. Measure the DC voltage V_{DC} across the load.
5. Draw output waveform.
6. Measure r.m.s. value and ripple factor of output voltage.

OBSERVATION -

	V_{pp}	$V_m = \frac{V_{pp}}{2}$		$V_{rms} = \frac{V_m}{\sqrt{2}}$		$V_{dc} = \frac{2V_m}{\Pi}$		$r = \sqrt{(V_{rms}^2/V_{dc}^2)} - 1$	
		T	P	T	P	T	P	T	P
Without Filter									

CALCULATIONS -

$$V_m = \frac{V_{pp}}{2} \tag{6.1}$$

$$V_{rms} = \frac{V_m}{\sqrt{2}} \tag{6.2}$$

$$V_{dc} = \frac{V_m}{\Pi} \tag{6.3}$$

Without Filter Ripple Factor

$$r = \sqrt{\frac{V_{rms}^2}{V_{dc}^2}} - 1 = 0.482 \tag{6.4}$$

With Filter Ripple Factor

$$r = \frac{1}{(4\sqrt{3fCR})} \tag{6.5}$$

RESULT –

The ripple factors for Full wave Rectifier with Filter and without filterhave been calculated.

EXPERIMENT – 7

OBJECTIVE – To design and study of Bridge Rectifier circuit and find ripple factor with different capacitor filters.

APPARATUS REQUIRED -

1.	Bread Board	01 No.
2.	P-N Junction Diode	01 No.
3.	Resistance 1kΩ	01 No.
4.	Transformer (9-0-9)	01 No.
5.	CRO with Probes	01 No.
6.	Electrolytic Capacitor	01 No.
7.	Connecting Wires	

THEORY -

Another type of circuit that produces the same output waveform as the full wave rectifier circuit above is that of the Full Wave Bridge Rectifier. This type of single phase rectifier uses four individual rectifying diodes connected in a closed loop "bridge" configuration to produce the desired output. The main advantage of this bridge circuit is that it does not require a special center tapped transformer, thereby reducing its size and cost. The single secondary winding is connected to one side of the diode bridge network and the load to the other side as shown below.

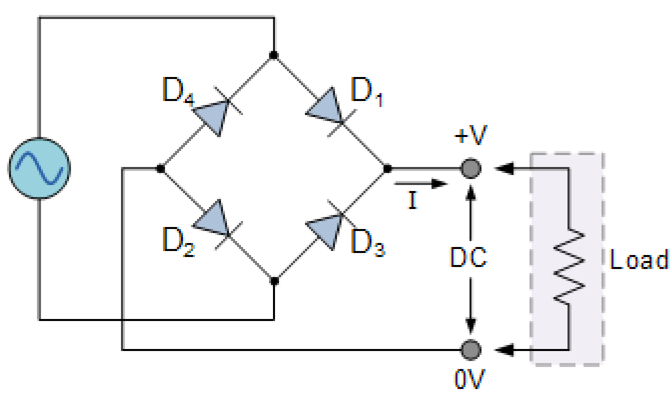


Fig. 7.1 Circuit diagram for bridge rectifier

The four diodes labeled D_1 to D_4 are arranged in "series pairs" with only two diodes conducting current during each half cycle. During the positive half cycle of the supply, diodes D_1 and D_2 conduct in series while diodes D_3 and D_4 are reverse biased and the current flows through the load as shown below.

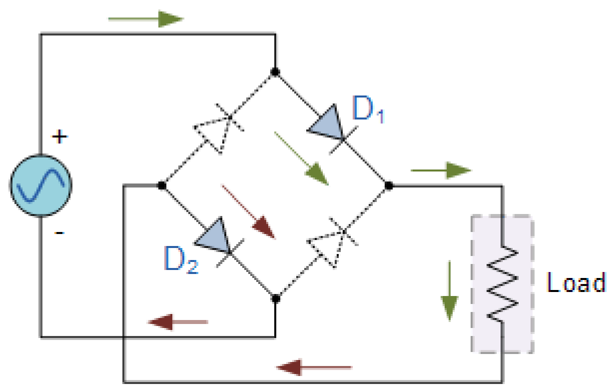


Fig. 7.2 Functional circuit during the positive half cycle for the bridge rectifier

During the negative half cycle of the supply, diodes D_3 and D_4 conduct in series, but diodes D1 andD2 switch "OFF" as they are now reverse biased. The current flowing through the load is the same direction as before.

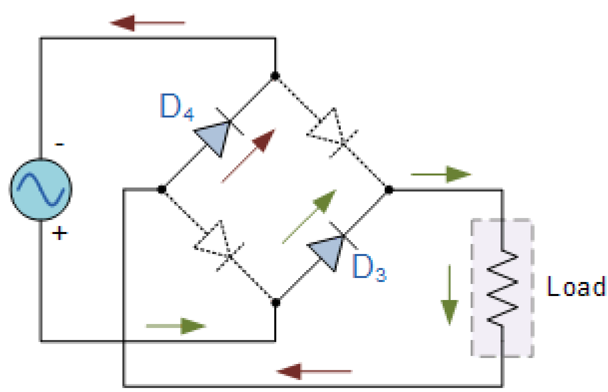


Fig. 7. 3 Functional circuit during the positive half cycle for the bridge rectifier

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 loadis $0.637V_{max}$

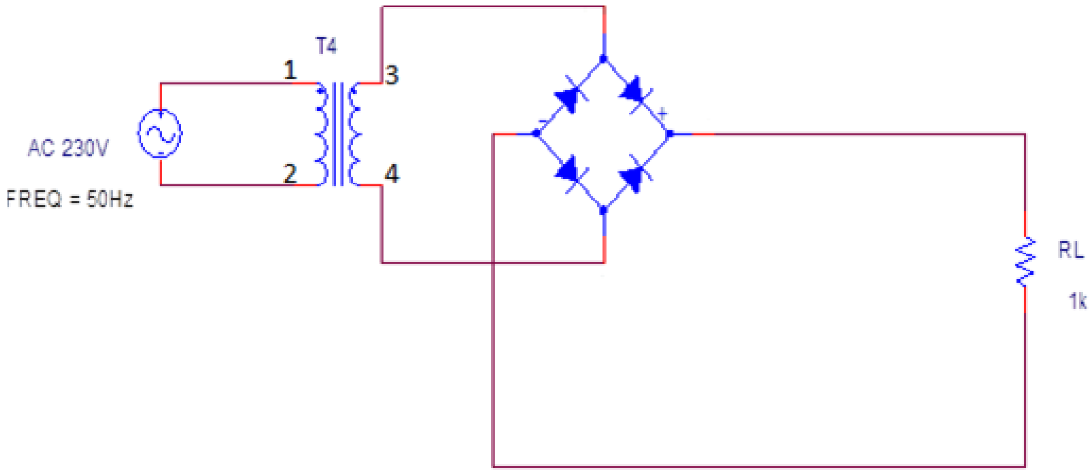


Fig. 7. 4 Complete circuit diagram for bridge rectifier along with transformer

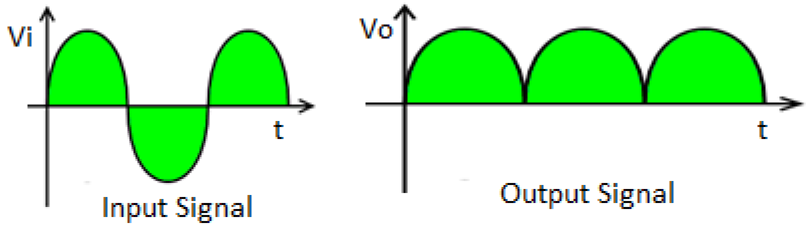


Fig. 7.5 Input and output waveform for a bridge rectifier

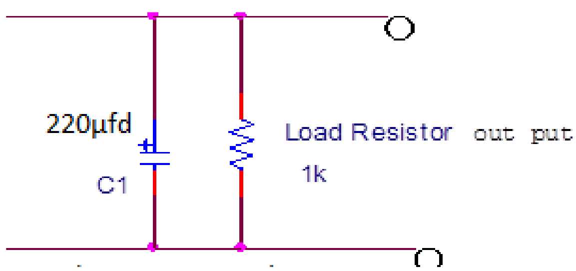


Fig 7.6 Circuit diagram for a shunt capacitor filter

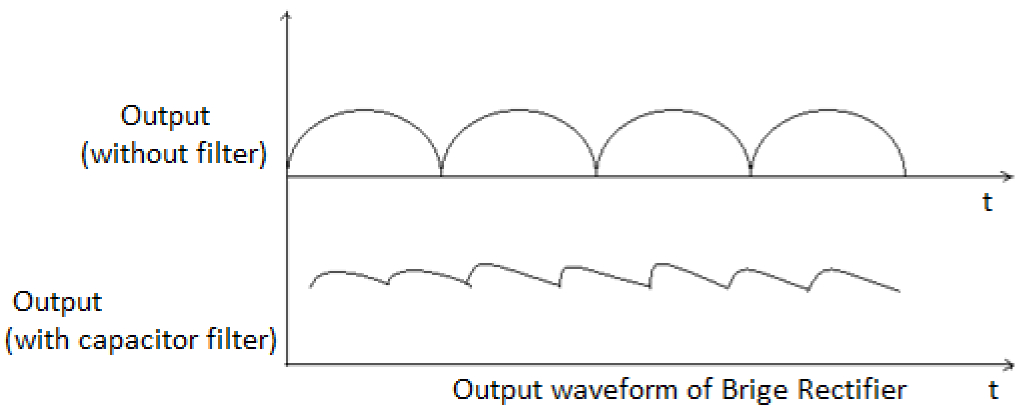


Fig. 7.7 Output waveform for a bridge rectifier

PROCEDURE -

1. Make connections for full wave rectifier as shown in figure.
2. Observe the input wave from an oscilloscope.
   (Transformer Secondary Voltage i.e., 9-0-9Volt)
3. Observe the output waveform on an oscilloscope.
4. Measure the DC voltage V_{DC} across the load.
5. Draw output waveform.
6. Measure r.m.s. value and ripple factor of output voltage.

OBSERVATION –

	V_{pp}	$V_m = \frac{V_{pp}}{2}$		$V_{rms} = \frac{V_m}{\sqrt{2}}$		$V_{dc} = \frac{2V_m}{\Pi}$		$r = \sqrt{(V_{rms}^2/V_{dc}^2)} - 1$	
		T	P	T	P	T	P	T	P
Without Filter									

CALCULATIONS -

$$V_m = \frac{V_{pp}}{2} \tag{7.1}$$

$$V_{rms} = \frac{V_m}{\sqrt{2}} \tag{7.2}$$

$$V_{dc} = \frac{V_m}{\Pi} \tag{7.3}$$

Without Filter Ripple Factor $$r = \sqrt{\frac{V_{rms}^2}{V_{dc}^2}} - 1 = 0.482 \tag{7.4}$$

With Filter Ripple Factor $$r = \frac{1}{(4\sqrt{3fCR})} \tag{7.5}$$

RESULT –

The ripple factors for Full wave Bridge Rectifier with Filter and withoutfilter have been calculated.

EXPERIMENT – 8

OBJECTIVE – To analyze the performance of different clipping circuits using diode and plot their respective output waveforms.

APPARATUS REQUIRED –

1.	Bread Board	01 No.
2.	P-N Junction Diode	02 No.
3.	Resistance – 10k**Ω**	01 No.
4.	Function Generator	01 No.
5.	CRO and Probes	01 No.
6.	Ceramic Capacitors (0.01uF)	01 No.
7.	Power Supply	
8.	Connecting Wires	

THEORY -

Clippers

Clipping circuits (also known as limiters, amplitude selectors, or slicers), are used to remove the part of a signal that is above or below some defined reference level. We've already seen an example of a clipper in the half-wave rectifier – that circuit basically cut off everything at the reference level of zero and let only the positive-going (or negative-going) portion of the input waveform through.

To clip to a reference level other than zero, a dc source is put in series with the diode. Depending on the direction of the diode and the polarity of the battery, the circuit will either clip the input waveform above or below the reference level (the battery voltage for an ideal diode; i.e., for V_{on}=0).

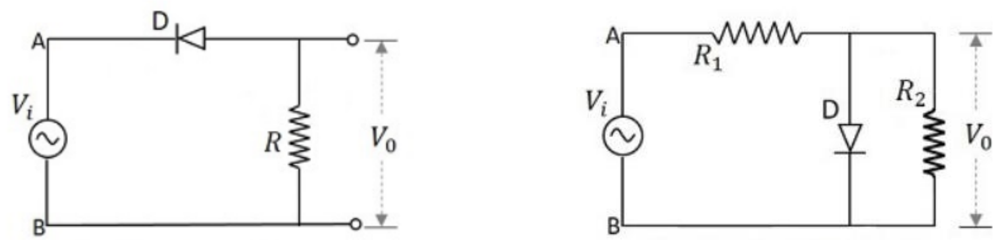
Clipping circuit is of various types:

1. Series Clipper

2. Parallel Clipper

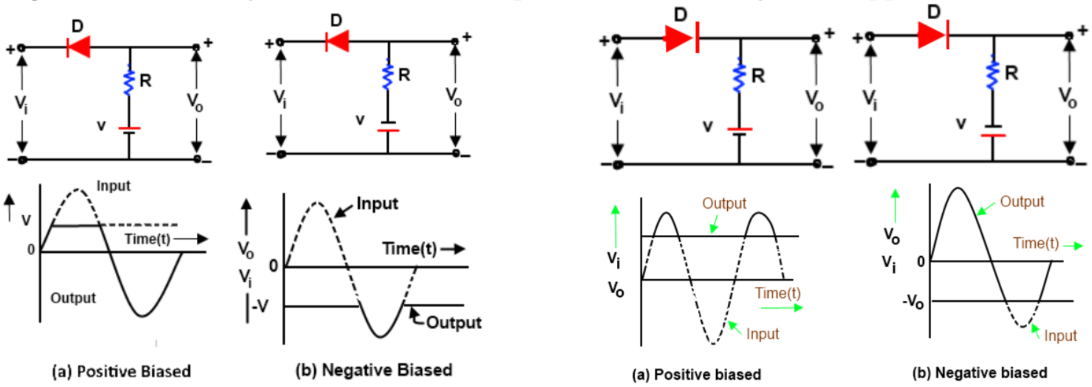
3. Series bias clipper

4. Parallel bias clipper



(a) (b)

Fig. 8.1 Circuit diagram for a series (a) positive, and (b) negative clipper circuit



(a) (b)

Fig. 8.2 Circuit diagram for a series (a) positive, and (b) negative clipper with DC bias

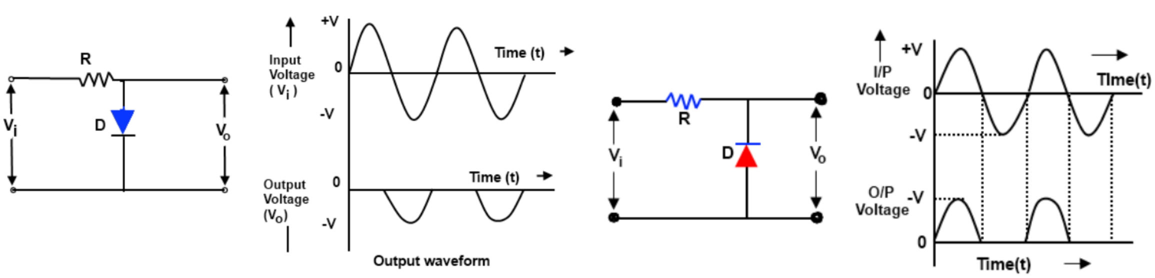


Fig. 8.3 Circuit diagram for a parallel (a) positive, and (b) negative clipper circuit

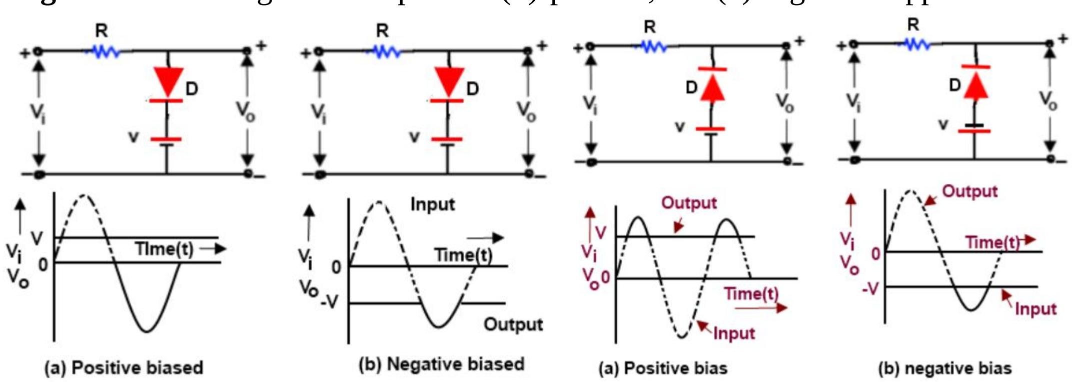


Fig. 8.4 Circuit diagram for a parallel (a) positive, and (b) negative clipper with DC bias

PROCEDURE -

1. Connect the circuit using suitable patch cord as shown in circuitdiagram.
2. Apply a Sinusoidal input of 5 volt and 1 kHz. (Use signal Generator for Sinusoidal input).
3. Observe the input signal on channel 1 on CRO and output signal from circuit on channel 2 on CRO.
4. Repeat the experiment for different clipping circuits.

RESULT -

1. Sketch the wave shape and label the amplitudes.
2. Indicate the type of clipping in each case.
3. Draw transfer characteristics for different clipping circuits.

EXPERIMENT – 9

OBJECTIVE – To analyze the performance of different clamping circuits using diode and plot their respective output waveforms.

APPARATUS REQUIRED –

1. Bread Board 01 No.
2. P-N Junction Diode 02 No.
3. Resistance – 10k**Ω** 01 No.
4. Function Generator 01 No.
5. CRO and Probes 01 No.
6. Ceramic Capacitors (0.01uF) 01 No.
7. Power Supply
8. Connecting Wires

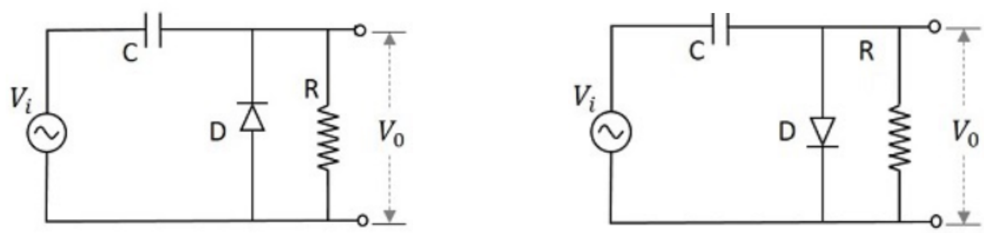
THEORY -

Clampers:

Clamping circuits, also known as dc restorers or clamped capacitors, shift an input signal by an amount defined by an independent voltage source. While clippers limit the part of the input signal that reaches the output according to some reference level(s), the entire input reaches the output in a clamping circuit – it is just shifted so that the maximum (or minimum) value of the input is "clamped" to the independent source.

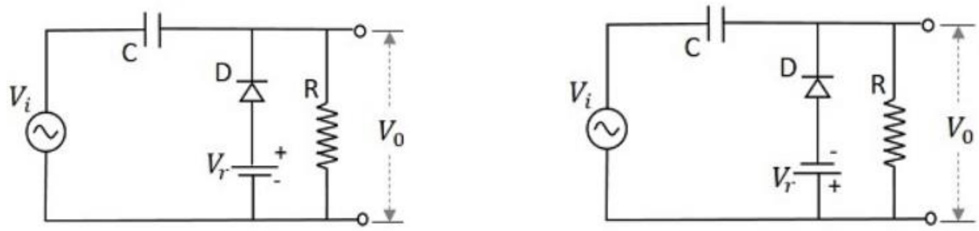
Clamping circuit is of various types:

1. Positive Clamper
2. Negative Clamper



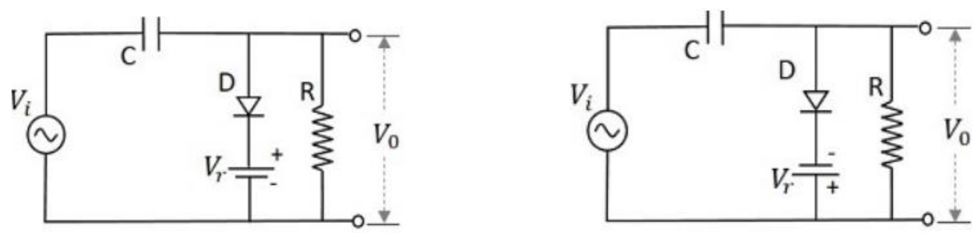
(a) (b)

Fig. 9.1 Circuit diagram for a parallel (a) positive, and (b) negative clamper circuit



(a) (b)

Fig. 9.2 Circuit diagram for a parallel positive clamper circuit with (a) positive, and (b) negative DC bias



(a) (b)

Fig. 9.3 Circuit diagram for a parallel negative clamper circuit with (a) positive, and (b) negative DC bias

<u>PROCEDURE</u> -

1. Connect the circuit using suitable patch cord as shown in circuitdiagram.
2. Apply a Sinusoidal input of 5 volt and 1 kHz. (Use signal Generator for Sinusoidal input).
3. Observe the input signal on channel 1 on CRO and output signal from circuit on channel 2 on CRO.
4. Repeat the experiment for different clipping and clamping circuits.

<u>RESULT</u> -

1. Sketch the wave shape and label the Amplitudes.
2. Indicate the type of clipping in each case.
3. Draw transfer characteristics for different clamping circuits.

EXPERIMENT – 10

OBJECTIVE – To study and plot the input and output Characteristics of the giventransistor in CB (common base) configuration.

APPARATUS REQUIRED –

1.	Bread Board	01 No.
2.	Transistor (BJT)	01 No.
3.	Resistance- 1KΩ	02 Nos.
4.	Multi-Meter	04 Nos.
5.	Dual Power Supply	01 No.
6.	Connecting Wires	

THEORY -

A transistor is a three terminal active device. The terminals are emitter, base, collector. In CB configuration, the base is common to both input (emitter) and output (collector). For normal operation, the E-B junction is forward biased and C-B junction is reverse biased. In CB configuration, I_E is +ve, I_C is –ve and I_B is –ve. So,V_{EB} = F1 ($V_{CB,}$ I_E) and I_C = F_2 ($V_{EB,}I_B$)

With an increasing the reverse collector voltage, the space-charge width at the output junction increases and the effective base width „W" decreases. This phenomenon is known as "Early effect". Then, there will be less chance for recombination within the base region. With increase of charge gradient with in the base region, the current of minority carriers injected across the emitter junction increases.

The current amplification factor of CB configuration is given by,

$$\alpha = \Delta I_C / \Delta I_E$$

Input Resistance, $r_i = \Delta V_{BE} / \Delta I_E$ at Constant V_{CB}
Output Résistance, $r_o = \Delta V_{CB} / \Delta I_C$ at Constant I_E

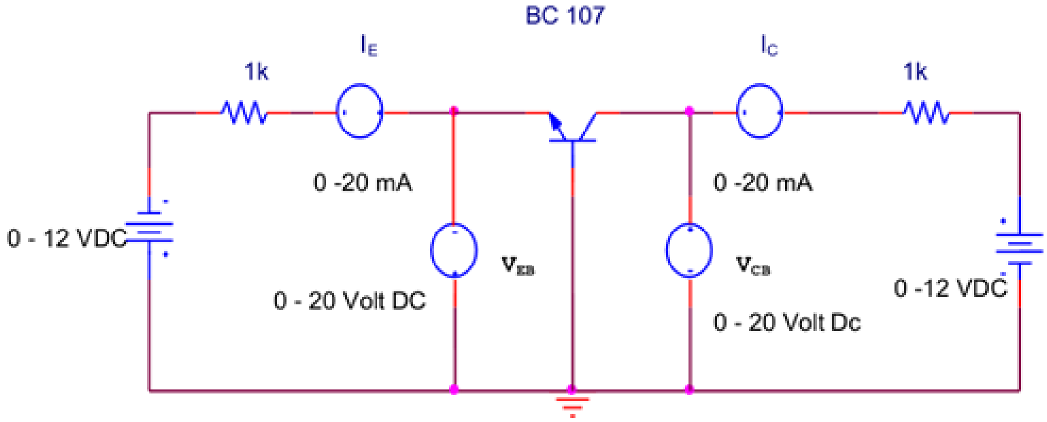


Fig. 10.1 Circuit diagram for CB configuration for an NPN transistor

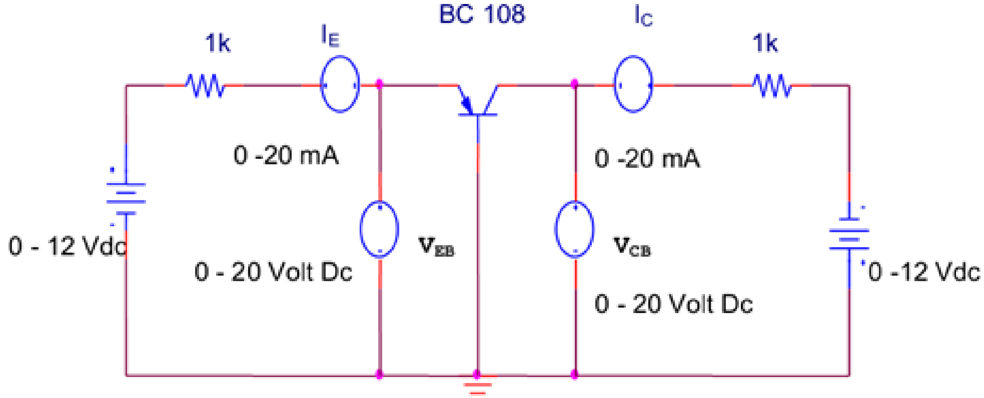
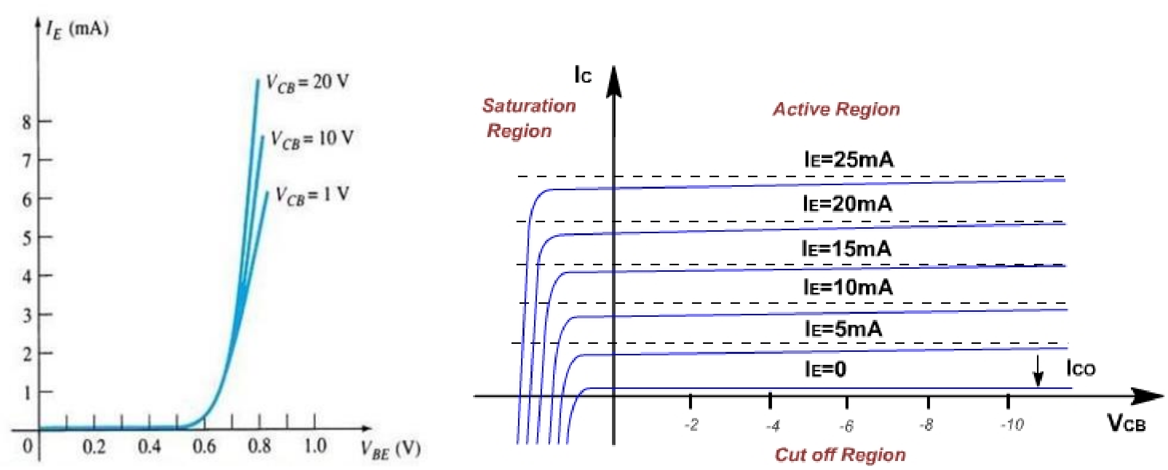


Fig. 10.2 Circuit diagram for CB configuration for an PNP transistor



(a) (b)

Fig. 10.3 (a) Input, and (b) Output characteristics for CB configuration

PROCEDURE -

To Plot the Input Characteristics perform the following steps:

1. Set the collector voltage, V_{CB} to a certain value, say 1 volt.
2. Now, vary the emitter base voltage, V_{EB} in steps of say 0.1volt starting from zero and observe the corresponding values of emitter current (I_E) .
3. Repeat step (ii) for different values of collector voltages, V_{CB}) : 2V, 5V, collector open.
4. Plot the input characteristics.

To plot Output characteristics, perform the following steps:

1. Set the emitter current to a certain value, say 1mA.
2. Now Vary the collector base voltage(V_{CB}) in steps of 1volt starting from zero and observe the corresponding collector currents (Ic)
3. Ensure that the emitter current remains constant, when collector voltage is being raised, by minor adjustment in the emitter-base voltage.
4. Repeat (ii) for different values of emitter currents, say, 2mA, 4mA, 8mA.
5. Plot the output characteristics.

OBSERVATION -

INPUT CHARACTERISTICS

Output voltage Constant (V_{CB}=0 volt)		**Output voltage constant (V_{CB}=2 volt)**	
Input voltage V_{EB}(Volt)	**Input current I_E(mA)**	**Input voltage V_{EB}(Volt)**	**Input current I_E(mA)**
0		0	
0.1		0.1	
0.2		0.2	
0.3		0.3	
0.4		0.4	
0.5		0.5	
0.6		0.6	
0.7		0.7	
0.8		0.8	
0.9		0.9	
1		1	

OUTPUT CHARACTERISTICS

Input Current Constant (I_E=1 mA)		Input Current constant (I_E=2 mA)	
output voltage V_{CB}(Volt)	**output current I_C(mA)**	**output voltage V_{CB}(Volt)**	**output current I_C(mA)**
0		0	
1		1	
2		2	
3		3	
4		4	
5		5	
6		6	
7		7	
8		8	
9		9	
10		10	

CALCULATION -

1. Input resistance, $R_{in}= V_{EB}/I_E$ for a certain value of $V_{CB.}$
2. Output resistance, $R_o=V_{CB}/I_C$ for a certain value of I_E.
3. Current gain, $\alpha= I_C/I_E$ for a certain value of V_{CB}.

RESULT -

R_{in} =................................ R_O = ...

α = ...

PRECAUTIONS -

1. The cut-in voltage, V_x is approximately 0.2V for Ge transistor and approx.0.6V for a Si transistor.
2. The collector current, I_C should be less than emitter current, I_E.
3. The value for current gain α_F is always less than 1.

EXPERIMENT – 11

OBJECTIVE – To study and plot the input and output characteristics of the giventransistor in C.E. (Common Emitter) Configuration

APPARATUS REQUIRED –

1.	Bread Board	01 No.
2.	Transistor (BJT)	01 No.
3.	Resistance- 1KΩ	01 Nos.
4.	Resistance- 100KΩ	01 Nos.
5.	Multi-Meter	04 Nos.
6.	Dual Power Supply	01 No.
7.	Connecting Wires	

THEORY -

In common emitter configuration, input voltage is applied between base and emitter terminals and output is taken across the collector and emitter terminals. Therefore, the emitter terminal is common to both input and output.
The input characteristics resemble that of a forward biased diode curve. This is expected since the Base-Emitter junction of the transistor is forward biased. As compared to CB arrangement I_B increases less rapidly with $V_{BE.}$ Therefore, input resistance of CE circuit is higher than that of CB circuit.
The output characteristics are drawn between I_c and V_{CE} at constant $I_{B.}$ the collector current varies with V_{CE} upto few volts only. After this the collector current becomes almost constant, and independent of $V_{CE.}$ The value of V_{CE} up to which the collector current changes with V_{CE} is known as Knee voltage. The transistor always operated in the region above Knee voltage, I_C is always constant and is approximately equal to $I_{B.}$ The current amplification factor of CE configuration is given by

$$\beta = \Delta I_C/\Delta I_B$$

Input Resistance, $r_i = \Delta \mathbf{V_{BE}} / \Delta \mathbf{I_B}$ (μA) at Constant V_{CE}
Output Resistance, $r_o = \Delta \mathbf{V_{CE}} / \Delta \mathbf{I_C}$ at Constant I_B (μA)

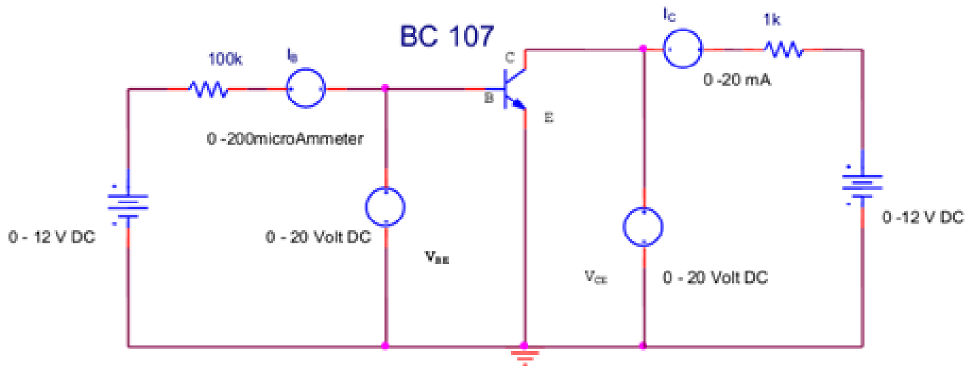


Fig. 11.1 Circuit diagram for CE configuration for an NPN transistor

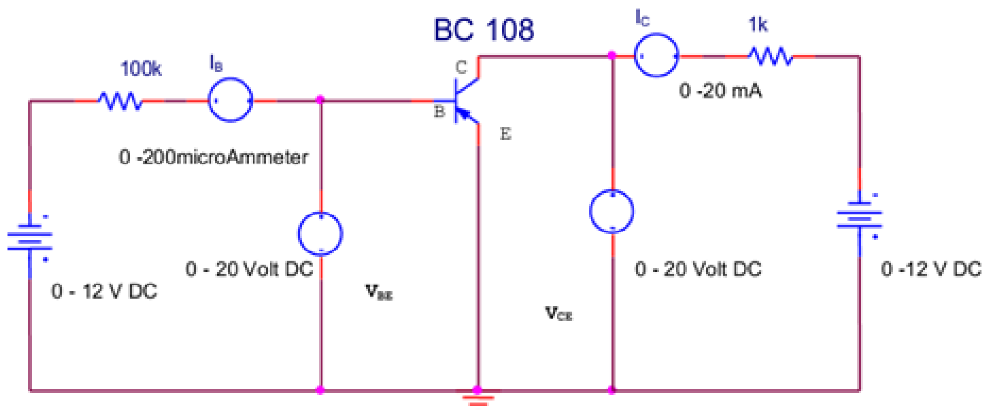


Fig. 11.2 Circuit diagram for CE configuration for an PNP transistor

PROCEDURE -

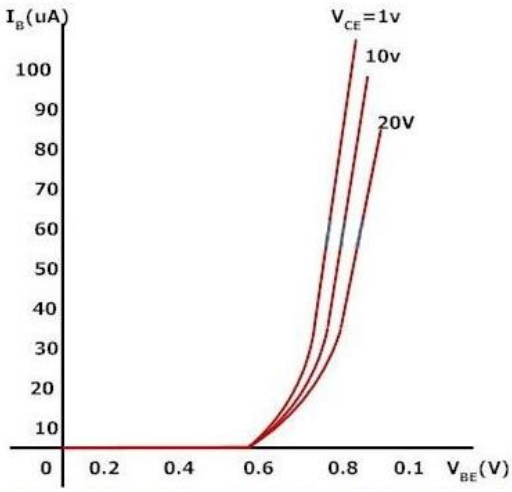
To plot Input characteristics, perform the following steps:

1. Set the collector voltage V_{CE} to a constant voltage of 1Volt.
2. Now vary the base voltage V_{BE} in steps of 0.1V and observe the corresponding base current (I_B). Do not exceed the base current from200µA. (The maximum base current varies from transistor totransistor.)
3. Repeat step (ii) for different values of collector voltages, $V_{CE:}$ 2V, 5V, and Open collector.
4. Plot the input characteristics.

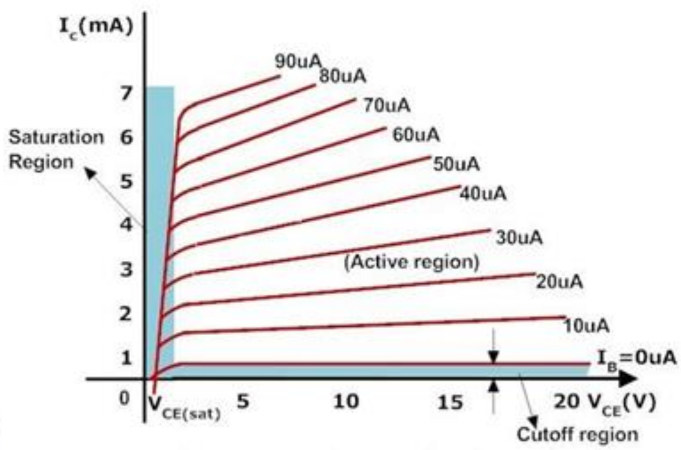
To plot Input characteristics, perform the following steps:

1. Set the base current (I_B) to say 25µA with the help of 0-12V variable supply in the input circuit.
2. Now vary the collector voltage (V_{CE}) from 0 to 12 Volts in steps of say 1

Volt and observe the corresponding values of collector current (I_C).
3. Repeat step (ii) for different values of base current, say 35µA, 50µA,
4. Plot the output characteristics.



(a)



(b)

Fig. 11.3 (a) Input and (b) Output characteristics for CB configuration

<u>OBSERVATION</u> –

INPUT CHARACTERISTICS

Output voltage Constant (V_{CE}=0 volt)		Output voltage constant (V_{CE}=2 volt)	
Input voltage V_{BE} (Volt)	**Input current I_B (µA)**	**Input voltage V_{BE} (Volt)**	**Input current I_B (µA)**
0		0	
0.1		0.1	
0.2		0.2	
0.3		0.3	
0.4		0.4	
0.5		0.5	
0.6		0.6	
0.7		0.7	
0.8		0.8	
0.9		0.9	
1		1	

OUTPUT CHARACTERISTICS

Input Current Constant (I_B=25μA)		Input Current constant (I_B=35μA)	
output voltage V_{CE} (Volt)	**output current I_C (mA)**	**output voltage V_{CE} (Volt)**	**output current I_C (mA)**
0		0	
1		1	
2		2	
3		3	
4		4	
5		5	
6		6	
7		7	
8		8	
9		9	
10		10	

CALCULATION -

1. Input resistance, $R_{IN} = V_{BE} / I_B$ at certain value of V_{CE}.
2. Output resistance $R_o = V_{CE}/I_C$ at certain value of I_B
3. DC forward current gain $\beta_F = I_C/I_B$

RESULT -

Input resistance, R_{IN} = -------------
Output resistance R_O = ------------------
DC forward current gain β_F =-------

PRECAUTIONS -

1. The cut-in voltage for a Ge transistor is about 0.2 Volt and about 0.6 volt fora Si transistor.
2. Observe the ‘saturation’ and ‘active’ and cut-off regions in the output characteristics.
3. The transistor gives current gain β_F in the range of 100 to 300 generalpurpose transistors.
4. Keep the knobs of both the 0-10 V D.C. supplies to fully anticlockwise position before switching on the mains supply.

EXPERIMENT – 12

OBJECTIVE - To draw the Drain characteristics and Transfer characteristics of N- channel junction field effect transistor

APPARATUS REQUIRED -

1.	Bread Board	01 No.
2.	Transistor (FET)	01 No.
3.	Resistance- 1KΩ	02 No.
4.	Multi-Meter	03 Nos.
5.	Dual Power Supply	01 No.
6.	Connecting Wires	

THEORY -

A FET is a three terminal device, in which current conduction is by majority carriers only. The flow of current is controlled by means of an Electric field. The three terminals of FET are Gate, Drain and Source. It is having the characteristics of high input impedance and less noise, the Gate to Source junction of the FETs always reverse biased. In response to small applied voltage from drain to source, the n-type bar acts as sample resistor, and the drain current increases linearly with $V_{DS.}$ With increase in I_D the ohmic voltage drop between the source and the channel region reverse biases the junction and the conducting position of the channel begins to remain constant. The V_{DS} at this instant is called "pinch of voltage". If the gate to source voltage (V_{GS}) is applied in the direction to provide additional reverse bias, the pinch off voltage ill is decreased.

In amplifier application, the FET is always used in the region beyond the pinch-off FET parameters:

AC Drain Resistance,

$r_d = \Delta V_{DS} / \Delta I_D$ at constant V_{GS}Trans conductance,

$g_m = \Delta I_D / \Delta V_{GS}$ at constant V_{DS}Amplification,

$\mu = \Delta V_{DS} / \Delta V_{GS}$ at constant I_D

Relation between above parameters

$\mu = r_d * g_m$

The drain current is given by

$I_D = I_{DSS} (1 - V_{GS}/V_P)^2$

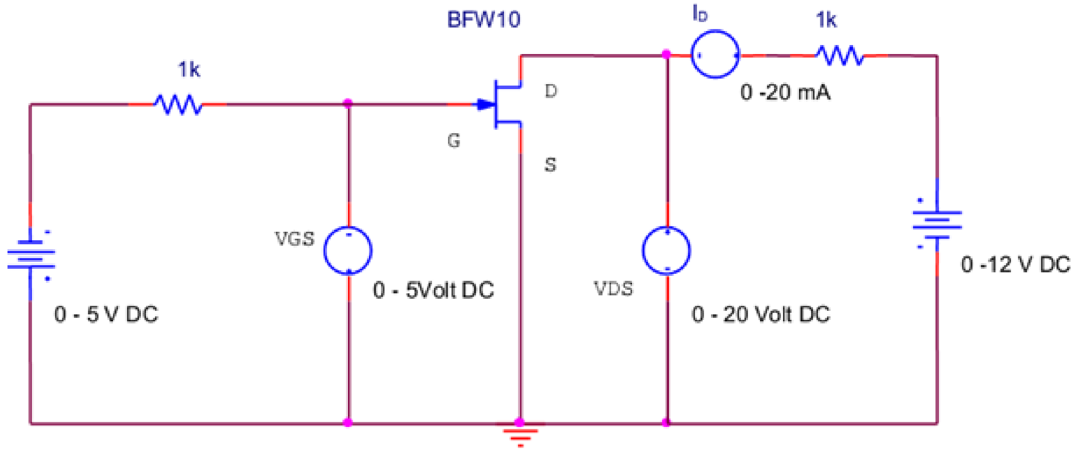


Fig.12.1 Circuit diagram for a JFET

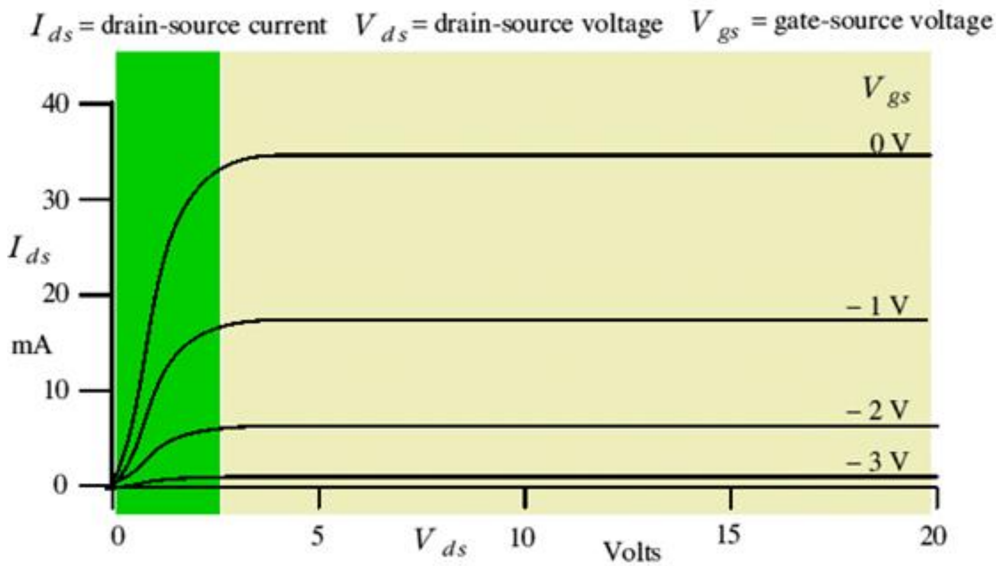


Fig. 12.2 The typical Drain characteristics for JFET

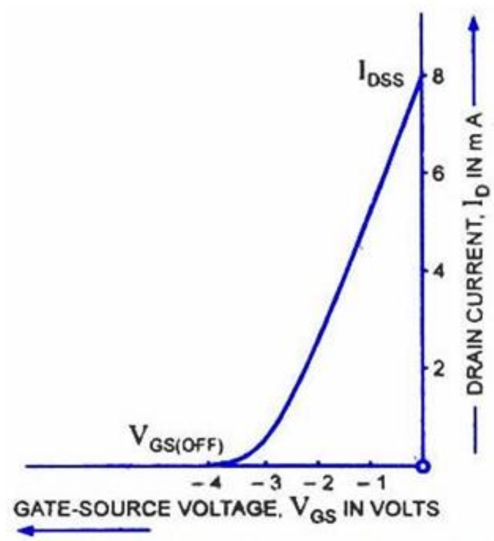


Fig. 12.3 The transfer characteristics for JFET

PROCEDURE –

In order to draw drain characteristics, perform following steps:

1. Connect the circuit as shown in fig. 1.
2. Set V_{GS} = 0Volt. Keep 0-5Volt variable power supply at anti-clock wise direction for making V_{GS} = 0Volt.
3. Now increase the V_{DS} in step say 1volt starting from zero and observe the corresponding Drain Current (I_D) in milli-ammeter.
4. Repeat step 2 for different V_{GS} value say -0.5V,-1V, -1.5, -2V
5. Plot the graph between V_{DS} vs I_D

In order to draw transfer characteristics perform following steps:

1. The circuit will be same for obtain the transfer characteristics.
2. Set the V_{DS} = 3V. by varying the 0 -12Volt variable power supply.
3. Now increases the V_{GS} in step say -0.5Volt starting from zero and observethe corresponding drain current I_D until I_D become zero.
4. Repeat step 2 for different value of V_{DS}.
5. Plot the graph between V_{GS} vs I_D.

OBSERVATION -

DRAIN CHARACTERISTICS

V_{GS} = 0Volt		V_{GS} = 0.5Volt		V_{GS} =-1Volt		V_{GS} = -2Volt	
V_{DS}(Volt)	I_D (mA)	V_{DS}(Volt	I_D (mA)	V_{DS}(Volt	I_D (mA)	V_{DS}(Volt	I_D (mA)
0		0		0		0	
0.5		0.5		0.5		0.5	
1		1		1		1	
1.5		1.5		1.5		1.5	
2		2		2		2	
2.5		2.5		2.5		2.5	
3		3		3		3	
3.5		3.5		3.5		3.5	
4		4		4		4	
4.5		4.5		4.5		4.5	
5		5		5		5	
6		6		6		6	
7		7		7		7	
8		8		8		8	

TRANSFER CHARACTERISTICS

V_{DS} = 3Volt		**V_{DS} = 5Volt**	
V_{GS} (Volt)	**I_D (mA)**	**V_{GS} (Volt)**	**I_D (mA**
0		0	
-0.5		-0.5	
-1		-1	
-1.5		-1.5	
-2		-2	
-2.5		-2.5	
-3		-3	
-3.5		-3.5	
-4		-4	
-5		-5	

CALCULATION -

The various parameters of a JFET are:

1. AC drain resistance, r_d: It is the resistance between drain and source terminals when JFET is in the Pinch-off region.

   r_d = change in V_{DS} / change in I_D.
2. Transconductance (g_m): Slope of transfer characteristic.

   g_m = change in I_D/ change in V_{GS}
3. Amplification factor: It is given by

   A.F. = Change in V_{DS} / Change in V_{GS}.
4. DC drain resistance, rds: it is given by –

   $R_{DS} = V_{DS}/I_{DS}$

RESULT -

1. AC drain resistance =---------------------
2. Transconductance (g_m) =---------------------
3. Amplification factor =------------------------
4. DC drain resistance, r =------------------------

PRECAUTIONS -

1. Do not exceed the I_D drain current 10mA.
2. Take proper care of terminates of JFET while fixing in the board.

EXPERIMENT - 13

OBJECTIVE – To draw the Drain characteristics and Transfer characteristics of N-channel Metal oxide field effect transistor (MOSFET)

APPARATUS REQUIRED -

1.	Bread Board	01 No.
2.	Transistor (MOSFET)	01 No.
3.	Resistance- 1KΩ	02 No.
4.	Multi-Meter	03 Nos.
5.	Dual Power Supply	01 No.
6.	Connecting Wires	

THEORY -

MOSFET is an abbreviation for metal oxide semiconductor filed transistor. Like JFET, it has a source (S), drain (D) and gate (G). However, unlike JFET, the gate of MOSFET is insulated from channel. Because of this, MOSFET is sometimes known as IGFET (insulated gate FET).
Basically, MOSFET are of two types
Depletion type MOSFET and
Enhancement type MOSFET.
Enhancement MOSFET has no depletion mode and only operates in enhancement mode. It differs in construction from depletion type MOSFET in the sense that it has no physical channel. The min gate-source voltage (V_{GS}), which producesinversion layer, called as threshold voltage.
Drain characteristics for enhancement MOSFET: -
When V_{GS}< (V_{GS}) the no drain current flows. However, in actual practice and extremely small value of drain current does flow through MOSFET. This current flow is generally due to presence of thermally generated electron in P-type substrate when value of V_{GS} is kept above (V_{GS}) significant drain current flow. Transfer characteristics of MOSFET: - When V_{GS}=0 there is no drain current, however if V_{GS} is increased rapidly as shown in fig. The relation gives the drain current at any instant along the curve.
I_D=k [(V_{GS}-V_{GS})]

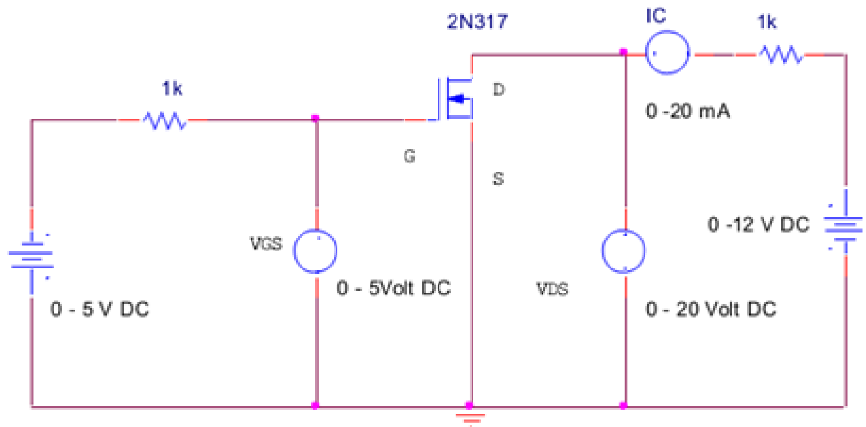


Fig. 13.1 Circuit diagram for an N-channel MOSFET (Depletion Mode)

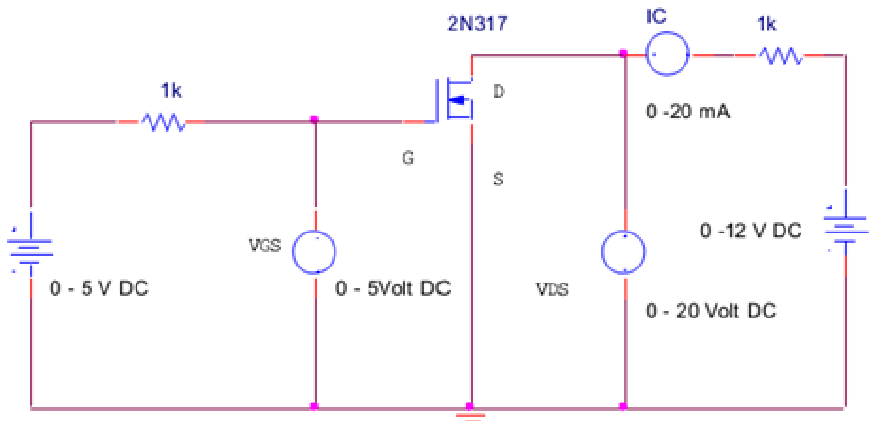


Fig. 13.2 Circuit diagram for an N-channel MOSFET (Enhancement Mode)

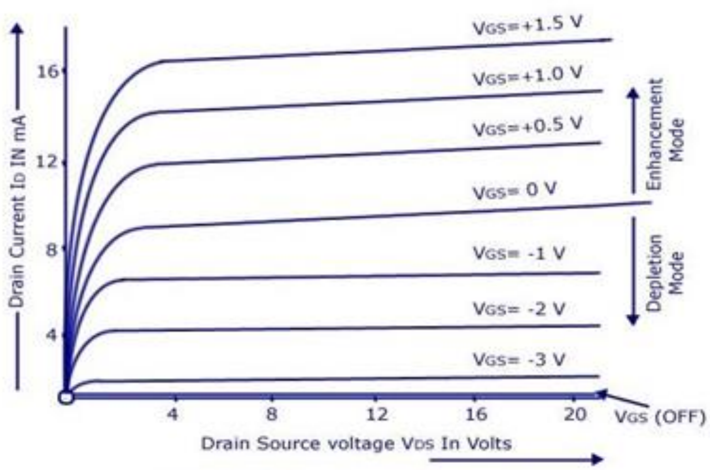


Fig. 13.3 Drain characteristics for a MOSFET

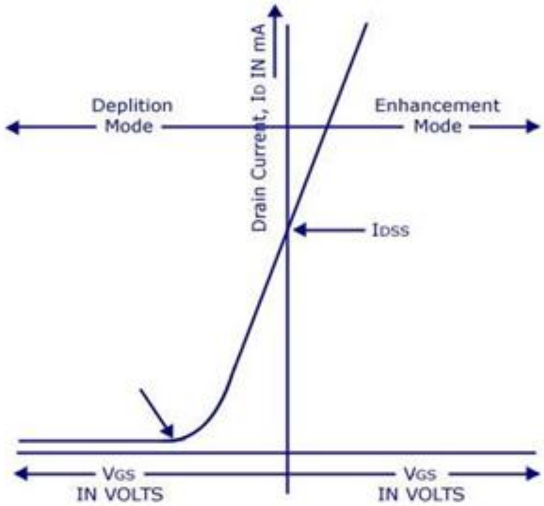


Fig. 13.4 Transfer characteristics for an MOSFET

PROCEDURE -

In order to draw the drain Characteristics perform following steps:

1. Connect the circuit as shown in figure.
2. Set V_{GS} = 0Volt. Keep 0-5Volt variable power supply at anti-clock wisedirection for making V_{GS} = 0Volt.
3. Now increase the V_{DS} in step say 1volt starting from zero and observethe corresponding Drain Current (I_D) in milli ammeter.
4. Repeat step 2 for different V_{GS} value say -0.5V,-1V, -1.5, -2V
5. Plot the graph between V_{DS} vs I_D

In order to draw the transfer characteristics perform following steps:

1. The circuit will be same for obtain the transfer characteristics.
2. Set the V_{DS} = 3V by varying the 0 -12Volt variable power supply.
3. Now increases the V_{GS} in step say -0.5Volt starting from zero and observe the corresponding drain current I_D until I_D become zero.
4. Repeat step 2 for different value of V_{DS}.
5. Plot the graph between V_{GS} vs I_D.

OBSERVATION -

DRAIN CHARACTERISTICS

V_{GS} = 0Volt		V_{GS} = 0.5Volt		V_{GS} =-1Volt		V_{GS} = -2Volt	
V_{DS}(Volt)	I_D (mA)	V_{DS}(Volt	I_D (mA)	V_{DS}(Volt	I_D (mA)	V_{DS}(Volt)	I_D (mA)
0		0		0		0	
0.5		0.5		0.5		0.5	
1		1		1		1	
1.5		1.5		1.5		1.5	
2		2		2		2	
2.5		2.5		2.5		2.5	
3		3		3		3	
3.5		3.5		3.5		3.5	
4		4		4		4	
4.5		4.5		4.5		4.5	
5		5		5		5	
6		6		6		6	
7		7		7		7	
8		8		8		8	

TRANSFER CHARACTERSTICS

V_{DS} = 3Volt		V_{DS} = 5Volt	
V_{GS} (Volt)	I_D (mA)	V_{GS} (Volt)	I_D (mA)
0		0	
-0.5		-0.5	
-1		-1	
-1.5		-1.5	
-2		-2	
-2.5		-2.5	
-3		-3	
-3.5		-3.5	
-4		-4	
-5		-5	

CALCULATION -

The various parameters of a MOSFET are:

1. AC drain resistance, r_d: it is the resistance between drain and source terminals when mosfet is in the pinch-off region.

   $$R_d = \text{change in } v_{ds} \text{ / change in } i_d.$$

2. Transconductance (g_m): slope of transfer characteristic.

   $$g_m = \text{change in } i_d\text{/ change in } v_{gs}$$

3. Amplification factor: it is given by

   $$\text{A.F.} = \text{change in } v_{ds} \text{ / change in } v_{gs}.$$

4. DC drain resistance, rds: it is given by

   $$R_{ds} = v_{ds}/i_{ds}$$

RESULT -

1. AC drain resistance =---------------------
2. Transconductance (g_m) =---------------------
3. Amplification factor =------------------------
4. DC drain resistance, R =------------------------

PRECAUTION -

1. Do not exceed the I_D drain current 10mA.
2. Take proper care of terminates of MOSFET while fixing in the board.

EXPERIMENT – 14

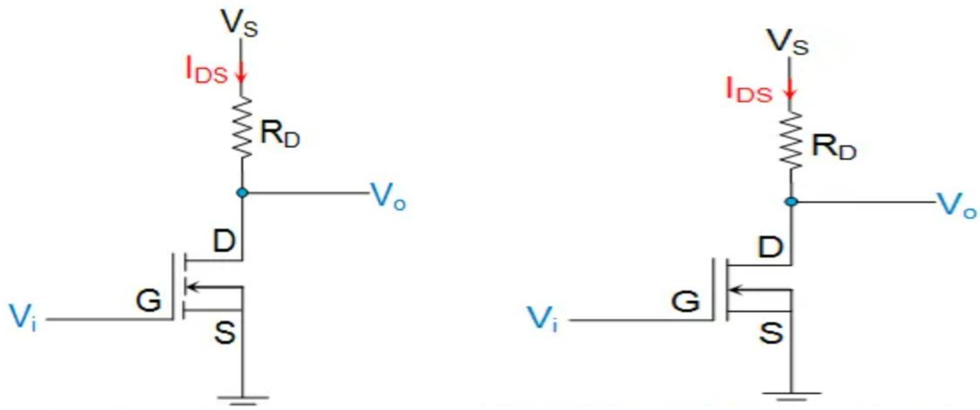
OBJECTIVE – To design and analyze the Performance of MOSFET as a switch.

APPARATUS REQUIRED -

1.	Bread Board	01 No.
2.	Transistor (MOSFET)	01 No.
3.	Resistance Rd- 1KΩ	02 No.
4.	Multi-Meter	03 Nos.
5.	Dual Power Supply	01 No.
6.	Connecting Wires	

THEORY -

MOSFET is an abbreviation for metal oxide semiconductor field transistor. Like JFET, it has a source (S), drain (D) and gate (G). However, unlike JFET, the gate of MOSFET is insulated from channel. Because of this, MOSFET is sometimes known as IGFET (insulated gate FET).
Basically, MOSFET are of two types
Depletion type MOSFET and Enhancement type MOSFET.
MOSFETs exhibit three regions of operation viz., Cut-off, Linear or Ohmic and Saturation. Among these, when MOSFETs are to be used as amplifiers, they are required to be operated in their ohmic region wherein the current through the device increases with an increase in the applied voltage. On the other hand, when the MOSFETs are required to function as switches, they should be biased in such a way that they alter between cut-off and saturation states. This is because, in cut-off region, there is no current flow through the device while in saturation region there will be a constant amount of current flowing through the device, just mimicking the behaviour of an open and closed switch, respectively. This functionality of MOSFETs is exploited in many electronic circuits as they offer higher switching rates when compared to BJTs.



(a) (b)

Fig 14.1 N Channel (a) Enhancement type, and (b) Depletion type, MOSFET as a switch

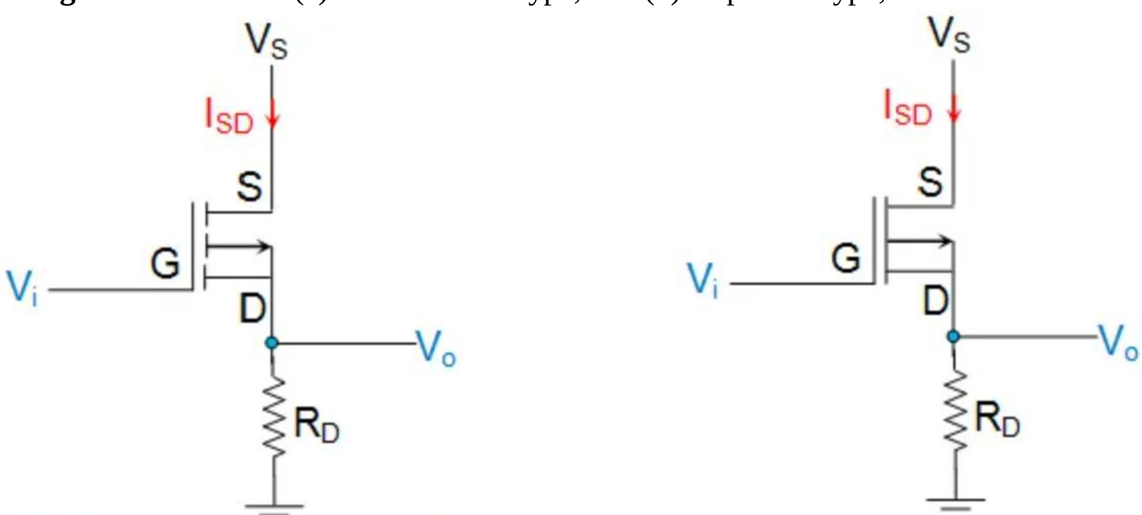


Fig 14.2 P Channel (a) Enhancement type, and (b) Depletion type, MOSFET as a switch

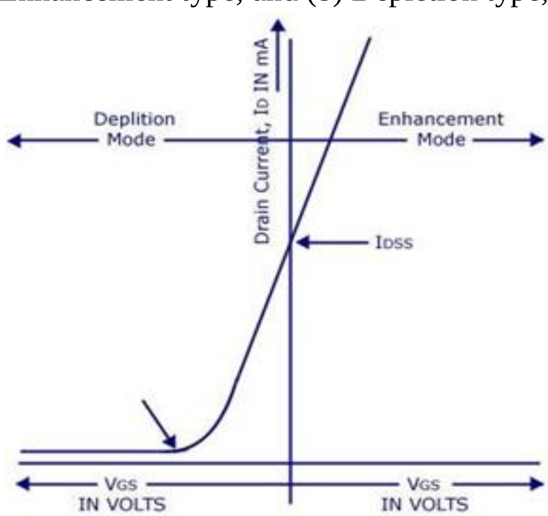


Fig. 14.3 Transfer characteristic for a MOSFET

Table 14.1 Different states of the device in keeping with the input and threshold voltage of MOSFET

MOSFET type	**State of the device**	
	ON	**OFF**
***n*-Channel Enhancement-type**	$V_i > V_T$	$V_i < V_T$
***n*-Channel Depletion-type**	$V_i > -V_T$	$V_i < -V_T$
***p*-Channel Enhancement-type**	$V_i < -V_T$	$V_i > -V_T$
***p*-Channel Depletion-type**	$V_i < V_T$	$V_i > V_T$

PROCEDURE -

In order to draw the above characteristics, perform the following steps:

1. Set the V_{DS} = 3V by varying the 0 -12Volt variable power supply.
2. Now increase the V_{GS} in step say -0.5Volt starting from zero and observe the corresponding drain current I_D until I_D becomes zero.
3. Repeat step 2 for different values of V_{DS}.
4. Plot the graph between V_{GS} vs I_D.

OBSERVATION –

TRANSFER CHARACTERISTICS

V_{DS} = 3Volt		**V_{DS} = 5Volt**	
V_{GS}(Volt)	**I_D (mA)**	**V_{GS} (Volt)**	**I_D(mA)**
0		0	
-0.5		-0.5	
-1		-1	
-1.5		-1.5	
-2		-2	
-2.5		-2.5	
-3		-3	
-3.5		-3.5	
-4		-4	
-5		-5	

CALCULATION -

The various parameters of a MOSFET are:

1. Transconductance (g_m): Slope of transfer characteristic.

   $g_{m =}$ Change in I_D/Change in V_{GS}

2. Amplification factor: It is given by

   A.F. = Change in V_{DS}/Change in V_{GS}.

3. DC drain resistance, Rds: It is given by

   $R_{DS} = V_{DS}/I_{DS}$

RESULT -

1. Transconductance (g_m) =---------------------
2. Amplification factor =------------------------
3. DC drain resistance, R =------------------------

PRECAUTION -

1. Do not exceed the I_D drain current 10mA.
2. Take proper care of terminals of MOSFET while fixing.