B. Sc. Electronics (Hon's) VIth Semester

Photonic Devices & Power Electronics Lab

List of Experiments

1. Half Wave, Full Wave & Fully Controlled Bridge Rectifier using SCR's has been designed to measure the Average Voltage, Average Current & Ripple Factor by changing the firing angle of an SCR.
2. To study the Forward and Reverse characteristics of a Silicon Controlled Rectifier (SCR).
3. To determine slit width of single slit by using semiconductor Laser.
4. Study the characteristics of optoelectronic devices, light dependent Resistor (LDR) and light Emitting Diode (LED).
5. Study the characteristics of optoelectronic devices, Phototransistor and Photo diode.
6. To determine the numerical aperture of the PMMA FIBER cables included with this FO - 1.
7. To determine experimentally the static drain characteristics of a Metal oxide Semiconductor Field Effect Transistor (MOSFET).

EXPERIMENT NO. 1

OBJECTIVE: Half Wave, Full Wave & Fully Controlled Bridge Rectifier using SCR's has been designed to measure the Average Voltage, Average Current & Ripple Factor by changing the firing angle of an SCR.

The instrument comprises of the following built in parts:-

1 One stepdown transformer of 10-0-10VAC with output on sockets.

2. Four SCR's 2P4M are provided on the front panel with built in gate triggering circuits.

3 Built in load resistances from 50 Ω to 1KΩ with output on sockets.

4 Three analog meters are provided on the front panel to measure average voltage, average current & AC ripples.

THEORY

One important application of an SCR is the controlled half-wave rectification. The AC supply to be rectified is supplied at the anode. Let the peak inverse voltage appearing across secondary is less than the reverse breakdown voltage of the SCR. This ensures that SCR will not breakdown during negative half cycles of AC supply. The circuit action can be explained as follows:-

1. During the negative half cycles of AC voltage appearing across secondary, the SCR doesn't conduct irrespective of the gate voltage. In this condition anode is negative w. r .t. cathode and also PIV is less than the reverse breakdown voltage.
2. The SCR will conduct during positive half cycles provided proper gate current is made to flow. The larger the gate current, the lesser the supply voltage at which SCR is turned ON.

The SCR half-wave rectifier can be compared with the ordinary half-wave rectifier. The ordinary half-wave rectifier will conduct full positive half-cycle whereas an SCR half-wave rectifier can be made to conduct full or part of a positive half-cycle by adjusting the gate current. Therefore, an SCR can control power fed to the load and hence the name controlled rectifier.

The SCR full wave rectifier, in all respects resembles the ordinary centre-tap circuit except that the two diodes have been replaced by two SCR's. The gates of both SCR's get their supply from two gate controls. One SCR conducts during the positive half cycle and the other during the negative half-cycle. Thus, full wave rectified output is obtained across the load. During the positive half cycle of AC across secondary, the upper end of secondary is positive and lower end negative SCR1 will conduct. During the negative half-cycle of AC input the upper end of secondary becomes negative and the lower end positive. Now SCR2 will conduct. It may be noted that current through the load is in the same direction on both half cycles of input AC. The advantage of the circuit over ordinary full-wave rectifier circuit is that by adjusting the gate currents the conduction angle and so the output voltage can be changed.

PROCEDURE

For Half Wave Rectifier

1. Connect the circuit as shown in Fig. (1) by connecting the dotted lines through patch chords.
2. To observe the change in phase angle connect CRO across voltmeter points. Connect load resistance (R_L) in the circuit by connecting dotted line through patch chord. Also connect voltmeter, milliammeter & AC voltmeter in the circuit through patch chords.
3. Set the load Resistance R_L to 1KΩ and switch ON the instrument as well as CRO.
4. Now set the R_2 Potentiometer to get complete half wave rectified signal on CRO. Note down average DC voltage, DC current & AC ripples. Calculate the value of Ripple factor by using formula

Ripple Factor =AC Ripples (Voltage) / DC Voltage

(Standard value of ripple factor =1.21)

5. Now change the firing angle of SCR by varying potentiometer R_2 and every time note down observations of average DC voltage, current & AC Ripples. Also note down firing angle from CRO.
6. Also note down the observations of voltage, current & AC Ripples by varying the load Resistances (R_L).

For Full Wave Rectifier

1. Connect the circuit as shown in Fig. (2) by connecting the dotted lines through patch chords.
2. To observe the change in phase angle connect CRO across voltmeter points. Connect load resistance (R_L) in the circuit by connecting dotted line through patch chord. Also connect voltmeter, milliammeter & AC voltmeter in the circuit through patch chords.
3. Set the load Resistance RL to 1KΩ and switch ON the instrument as well as CRO.
4. Now set the R_2 & R_4 Potentiometer to get complete full wave rectified signal on CRO. Note down average DC voltage, DC current & AC ripples. Calculate the value of Ripple factor by using formula

Ripple Factor =AC Ripples (Voltage) / DC Voltage

(Standard value of ripple factor = 0.48)

5. Now change the firing angle of SCR by varying potentiometer R_2 and R_4 and every time note down observations of average DC voltage, current & AC Ripples. Also note down firing angle from CRO.
6. Also note down the observations of voltage, current & AC Ripples by varying the load Resistances.

For Fully Controlled Bridge Rectifier

1. Connect the circuit as shown in Fig. (3) by connecting the dotted lines through patch chords.

2. To observe the change in phase angle connect CRO across voltmeter points. Connect load resistance (R_L) in the circuit by connecting dotted line through patch chord. Also connect voltmeter, milliammeter & AC voltmeter in the circuit through patch chords.

3. Set the load Resistance R_L to 1KΩ and switch ON the instrument as well as CRO.

4. Now settle R_2, R_4, R_6 & R_8 Potentiometers to get complete full wave rectified (through Bridge circuit) signal on CRO. Note down average DC voltage, DC current & AC ripples. Calculate the value of Ripple factor by using formula

Ripple Factor =AC Ripples (Voltage) / DC Voltage

(Standard value of ripple factor = 0.48).

5. Now change the firing angle of SCR by varying potentiometers R_2, R_4, R_6 & R_8 every time note down the observations of average DC voltage, current & AC Ripples. Also note down firing angle from CRO.

6. Also note down the observations of voltage, current & AC Ripples by varying the load Resistances (R_L).

STANDARD ACCESSORIES

1. Eleven single point & Four interconnectable patch chords for Interconnections.
2. Instruction Manual.

For Half Wave Rectifier

Firing Angle	DC Voltage	DC Current	Load Resistance	Ripples (AC Voltage)	Ripple Factor = AC Volts/DC Volts

For Full Wave Rectifier

Firing Angle	DC Voltage	DC Current	Load Resistance	Ripples (AC Voltage)	Ripple Factor = AC Volts/DC Volts

For Bridge Rectifier

Firing Angle	DC Voltage	DC Current	Load Resistance	Ripples (AC Voltage)	Ripple Factor = AC Volts/DC Volts

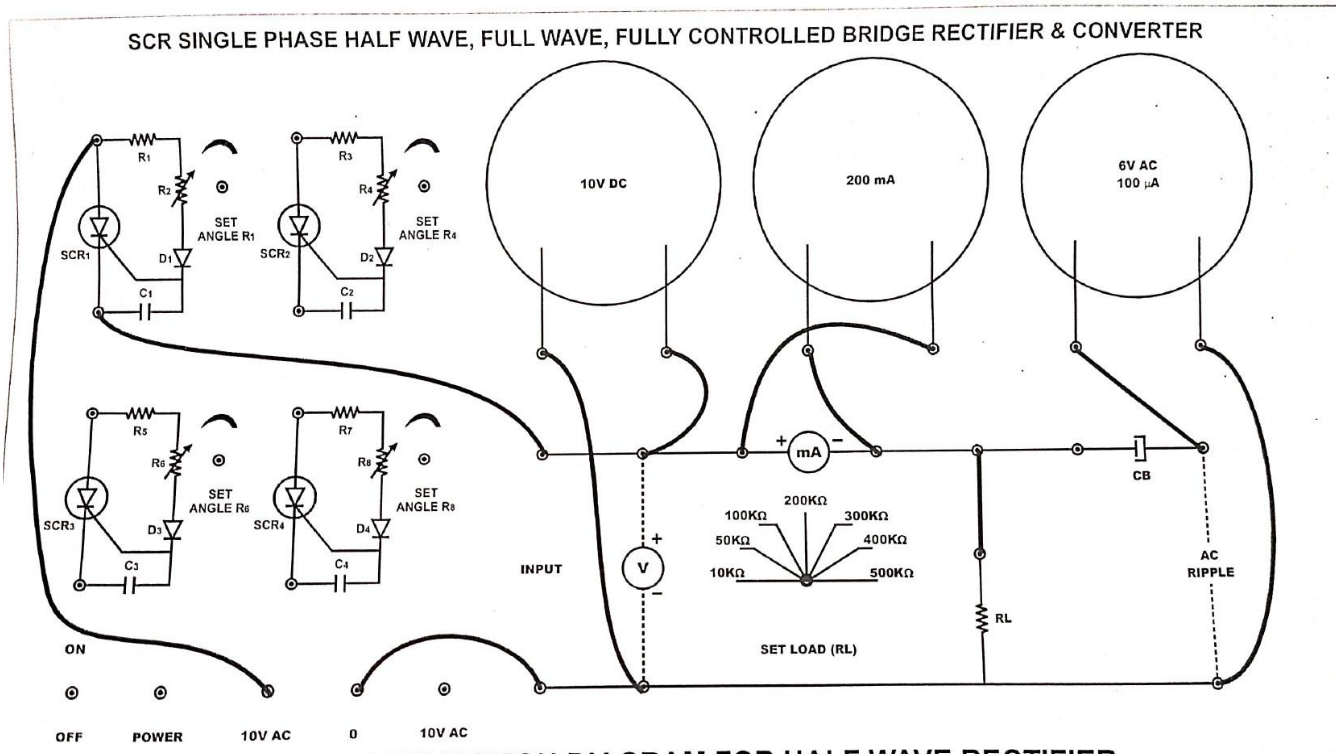


FIG. (1) CONNECTION DIAGRAM FOR HALF WAVE RECTIFIER

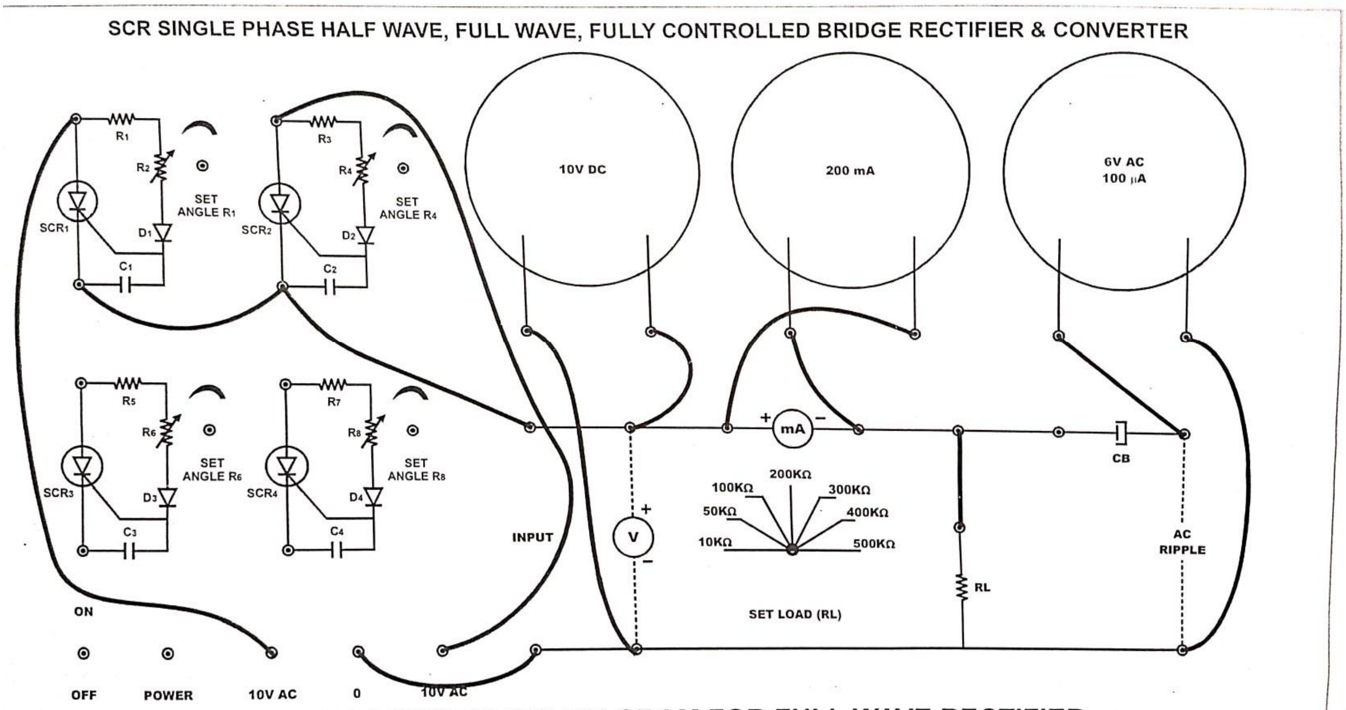


FIG. (2) CONNECTION DIAGRAM FOR FULL WAVE RECTIFIER

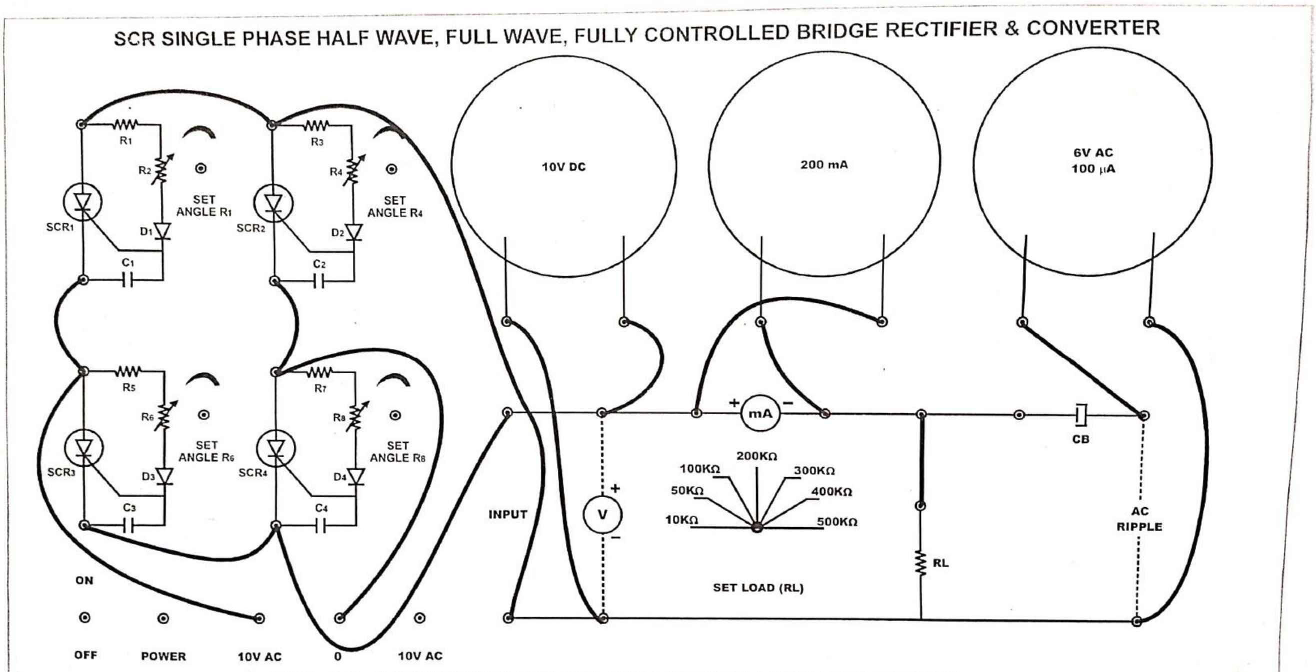


FIG. (3) CONNECTION DIAGRAM FOR BRIDGE RECTIFIER

EXPERIMENT NO. 2

OBJECTIVE: To study the Forward and Reverse characteristics of a Silicon Controlled Rectifier (SCR).

The instrument comprises of the following built in parts:

1. Two continuously variable DC regulated power supplies of 0-1V and 0-30V are provided.
2. Three meters to measure voltage & current are mounted on front panel & connections brought out on 4mm Sockets.
3. SCR (2P4M) placed inside the cabinet and connections are brought out at sockets.

THEORY

The Silicon Controlled Rectifier (abbreviated as SCR) is a three terminal semiconductor switching device which is probably the most important circuit element after the diode and the transistor. SCR are used as a controlled switch to perform various functions such as rectification, inversion and regulation of power flow. The SCR has assumed paramount importance in electronics because it can be produced inversions to handle currents upto several thousand amperes and voltages upto more than 1KV. It is a unidirectional power switch and is being extensively used in switching DC and AC, rectifying AC to give controlled DC output, converting DC into AC etc. In a silicon controlled rectifier, load is connected in series with anode. The anode is always kept at positive potential w.r.t. cathode. The working of SCR can be studied under the following two steps.

1. WHEN GATE IS OPEN:-

Fig (1a) shows the SCR circuit with gate open i.e. no voltage applied to the gate. Under this condition, junction J_2 is reverse biased with junctions J_1 and J_3 are forward biased. Hence the situations in the junctions J_1 and J_3 is just as in a npn transistor with base open. Consequently, no current flows through the load R_L and the SCR is cut off. However, if the applied voltage is gradually increased, a stage is reached when reverse biased junction J_2 breaks down. The SCR now conducts heavily and is said to be in the ON state. The applied voltage at which SCR conducts heavily without gate voltage is called Breakover voltage.

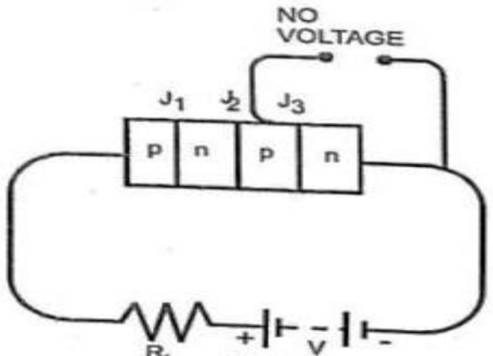


FIG. (1a)

2. WHEN GATE IS POSITIVE W.R.T. CATHODE

The SCR can be made to conduct heavily at smaller applied voltage by applying a small positive potential to the gate as shown in fig. (1b). Now junction J_3 is forward biased and junction J_2 is reverse biased. The electron from N type material start moving across junction J_3 towards left whereas holes from P type toward the right. Consequently, the electrons from junction J_3 are attached across junction J_2 and gate current starts flowing. As soon as the gate current flows, anode current increases. The increased anode current in turn makes more electrons available at junction J_2. This process continues and in an extremely small time, junction J_2 breaks down and the SCR starts conducting heavily. Once SCR starts conducting, the gate loses all controls. Even if gate voltage is removed, the anode current does not decreased at all. The only way to stop conduction (i.e. bring SCR is off condition) is to reduce the applied voltage to zero.

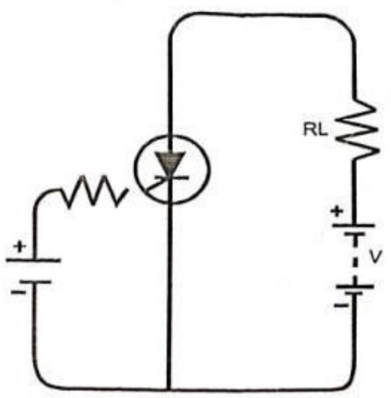


FIG. (1b)

BreakoverVoltage:-
It is the minimum forward voltage, gate being open, at which SCR starts conducting heavily i.e turned ON.

Peak Reverse Voltage:-
It is the maximum reverse voltage (cathode positive w.r.t anode) that can be applied to an SCR without conducting in the reverse direction.

Holding Current:-
It is the maximum anode current, gate being open, at which SCR is turned off from ON conditions.

PROCEDURE

FORWARD CHARACTERISTICS:

A.WITH OPEN GATE:-

1. Connect the circuit as shown by dotted lines [in Fig (2)] through patch chords.
2. Keep gate power supply control knob (Set Gate Current) to minimum position so that gate current becomes zero.
3. Select milliammeter range to 3mA and voltmeter range to 30V.
4. Switch ON the instrument using ON/OFF toggle switch provided on the front panel.
5. Increase Anode (A - K) Cathode power supply V_{AK} in small steps and note down corresponding Anode Current I_A. As I_A is small SCR is in "OFF" state.

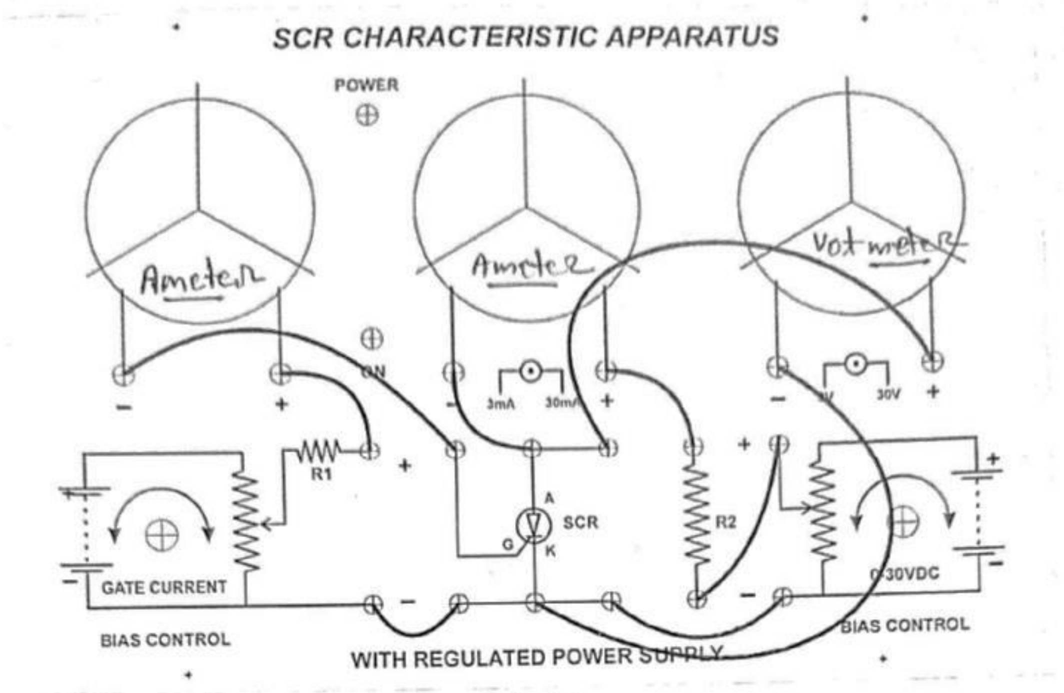


FIG. (2)

B. WHEN GATE IS POSITIVE W.R.T. CATHODE:-

6. Connect the circuit as shown in Fig. (2).
7. Repeat step (2) to (4) as given in the case of open gate circuit.
8. Select milliammeter range to 30 mA.
9. Increase gate current (I_g) in small steps, at a particular value of I_g, SCR will turn ON resulting sudden increase in anode current I_A with decrease in Anode-Cathode voltage (V_{AK}).
10. Change the range of voltmeter to 3V after triggering of SCR record all the possible value of I_A (say between 10mA to 30 mA) and corresponding V_{AK} (may in the range of 0.8V to 1V).
11. Also note down the Gate current (I_g) required for triggering the SCR at a given V_{AK}.
12. Repeat the experiment for different Anode-Cathode Voltages (V_{AK}).
13. Plot graph between V_{AK} and I_A by taking V_{AK} along X-axis & I_A along Y-axis.

TO RECORD HOLDING CURRENT I_H

14. When the SCR turns 'ON" decrease I_A by decreasing Anode - Cathode (V_{AK}) power supply in small steps. At certain value of V_{AK}, I_A drops suddenly towards zero. This value of anode current (I_A) is the holding current (I_H). Below (I_H) SCR will remains in 'OFF ' state. On the other hand above 1, SCR remains in ON state.

TO RECORD HOLDING VOLTAGE (V_H)

15. When the SCR turns 'ON' start decreasing V_{AK}, in small steps so that Anode Current (I_A) decreases to Holding Current (I_H). Record the corresponding value of V_{AK}. This is the holding voltage V_H.

REVERSE CHARACTERISTICS

16. Connect the circuit as shown by dotted lines [in Fig (3)] through patch chords.

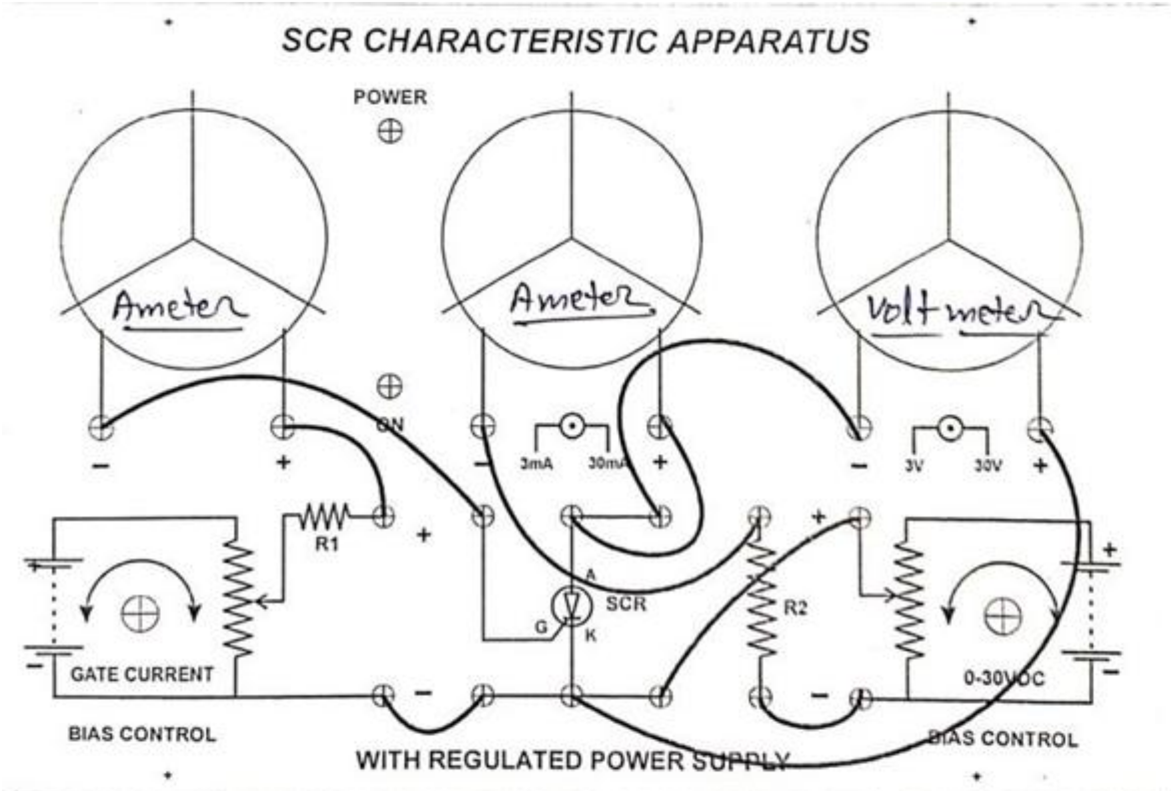


FIG. (3)

17. Repeat all the steps as in the case of forward characteristics procedure and plot a graph between V_{AK} & I_A as shown in Fig. (4).

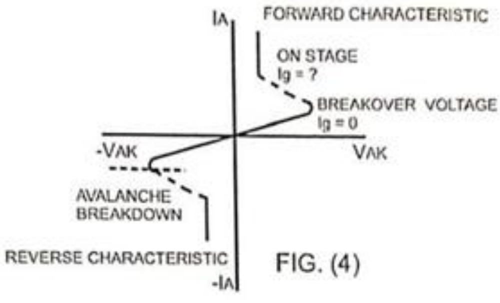


FIG. (4)

In reverse characteristics the SCR will never be turn ‘ON’ at the application of Gate Current (Ig) because it is harmful to operate the SCR in reverse direction. It may damage the SCR because SCR is a unidirectional device. So it is required in case of SCR that it should not operate in the AVALANCHE BREAKDOWN region.

STANDARD ACCESSORIES

1. Nine Single Point Patch cords for interconnections.
2. Instruction Manual.

EXPERIMENT NO. 3

OBJECTIVE: To determine slit width of single slit by using semiconductor Laser.

Apparatus: Semiconductor laser, Single Shit, Double Slit, Screen, Scale, tape etc.

Theory: If the waves have the same sign (are in phase), then the two waves constructively interfere, the net amplitude is large and the light intensity is strong at that point. If they have opposite signs, however, they are out of phase and the two waves-destructively interfere: the net amplitude is small and the light intensity is weak. It is these areas of strong and weak intensity, which make up the interference patterns we will observe in this experiment. Interference can be seen when light from a single source arrives at a point on a viewing screen by more than one path. Because the number of oscillations of the electric field (wavelengths) differs for paths of different lengths, the electromagnetic waves can arrive at the viewing screen with a phase difference between their electromagnetic fields. If the Electric fields have the same sign then they add constructively and increase the intensity of light, if the Electric fields have opposite signs they add destructively and the light intensity decreases.

Diffraction at single slit can be observed when light travels through a hole (in the lab it is usually a vertical slit) whose width, a, is small. Light from different points across the width of the slit will take paths of different lengths to arrive at a viewing screen (Figure 1). When the light interferes destructively, intensity minima appear on the 1 screen. Figure 1 shows such a diffraction pattern, where the intensity of light is shown as a graph placed along the screen. For a rectangular slit it can be shown that the minima in the intensity pattern fit the formula

$a\sin\theta = m\lambda$ (a=0.2 mm to 0.02 mm)

where m is an integer (±1, ±2, ±3……), a is the width of the slit, λ is the wavelength of the light and θ is the angle to the position on the screen. The m^{th} spot on the screen is called the m^{th} order minimum. Diffraction patterns for other shapes of holes are more complex but also result from the same principles of interference.

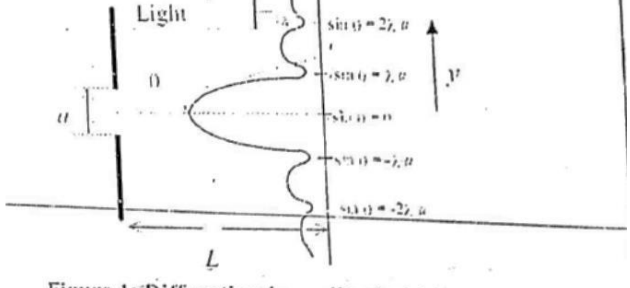


Figure 1: Diffraction by a slit of width a. Graph shows intensity of light on a screen.

Procedure:

Diffraction at single slit

The diffraction plate has slits etched on it of different widths and separations. For this part use the area where here is only a single slit. For two sizes of slits, examine the patterns formed by single slits. Set up the slit in front of the laser. Record the distance from the slit to the screen, L. For each of the slits, measure and record a value for y on the viewing screen corresponding to the center of a dark region. Record as many distances, y, for different values of m as you can. Use the largest two or three values for m which you are able to observe to find a value for a. The semiconductor laser has a wavelength of 670 nm.

Observations:

Table 1: Single slit

L = ... λ = ...6700 Å

Diffraction Order, m	Distance, y	y/L	Angle θ = ~~in radians~~ $\left(y/L \times \frac{180}{\pi}\right)$	$\sin\theta$	$a \left(= \frac{m\lambda}{\sin\theta}\right)$

Result: Slit width = ...

Precautions

Look through the slit (holding it very close to your eye). See if you can see the effects of diffraction. Set the laser on the table and aim it at the viewing screen.

DO NOT LOOK DIRECTLY INTO THE LASER OR AIM IT AT ANYONE! DO NOT LET REFLECTIONS BOUNCE AROUND THE ROOM.

Pull a hair from your head. Mount it vertically in front of the laser using a piece of tape. Place the hair in front of the laser and observe the diffraction around the hair. Use the formula above to estimate the thickness of the hair, a. (The hair is not a slit but light diffracts around its edges in a similar fashion.) Repeat with observation your lab partners' hair.

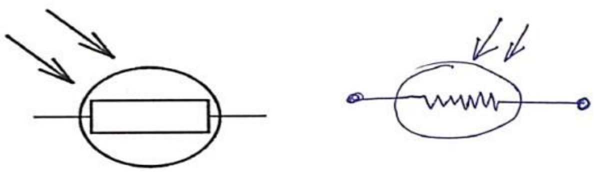
EXPERIMENT NO. 4

OBJECTIVE: Study the characteristics of optoelectronic devices, light dependent Resistor (LDR) and light Emitting Diode (LED).

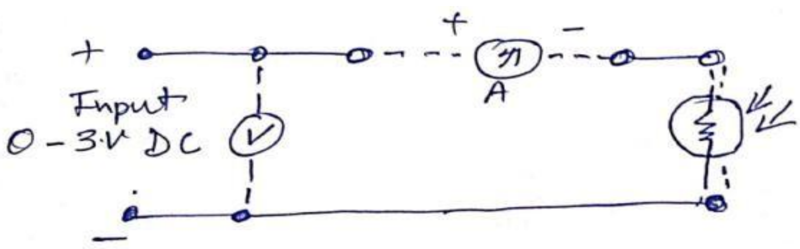
Apparatus:-one DC regulated power supply of 0-3 volts, light dependent resistor (LDR) and Light Emitting Diode (LED). Voltmeter 0-3 volt DC, DC miliammiter, and one lamp with standard connection wires etc.

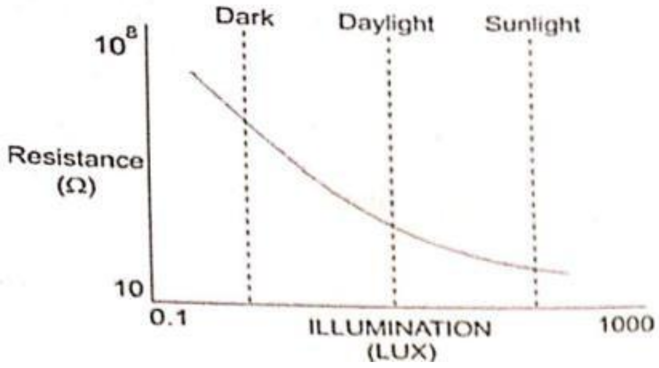
Theory:-

1. A **Light Dependent Resistor (LDR)** or a photo resistor is a device whose resistivity is a function of the incident electromagnetic radiation. Hence, they are light sensitive devices. They are also called as photo conductors, Photo conductive cells or simply photocells. They are made up o semiconductor materials having high resistance. There are many different symbols used to indicate a LDR. One of the most commonly used symbol is shown in the figure below. The arrow indicates light falling on it.



A light dependent resistor works on the principle of photo conductivity. Photo conductivity is an optical phenomenon in which the materials conductivity is increased when light is absorbed by the material. When light falls i.e. when the photons fall on the device, the electrons in the valence band of the semiconductor material are excited to the conduction band. These photons in the incident light should have energy greater than the band gap of the semiconductor material to make the electrons jump from the valence band to the conduction band. Hence when light having enough energy strikes on the device, more and more electrons are excited to the conduction band which results in large number of charge carriers. The result of this process is more and more current starts flowing through the device when the circuit is closed and hence it is said that the resistance of the device the most common **working principle of LDR**.





Procedure:-

1. Connect the output of DC power supply (0-3VDC) to the input of the LDR circuit. Also connect voltmeter, current meter and LDR in the circuit through patch cords shown by doted lines.
2. Place the lamp holder and LDR on a graduated wooden stand opposite to each other. Connect the lamp to AC mains and focus the light on LDR. Select the range of current meter to 5mA.
3. Switch on the instrument (power supply unit) using ON/OFF toggle switch provided on the front panel.
4. Now increase the power supply voltage in small step and every time note down the voltage & current in observation table. Calculate the resistance value of LDR by using formula R = V/I.
5. Vary the distance (d) between LDR & light source and repeat the experiment again.
6. Plot a graph between resistance (R) vs Distance (d2, SQURE).
7. Also note down the current (mA) for different distances between LDR & light source for fixed voltage.

Observation table for LDR

S,no.	Distance of lamp from LDR d cm	Voltmeter reading v volt	Milliammeter reading (I) mA	Resitance of LDR R = V/I	D2 cm2
1					
2					
3					

2. **Light Emitting Diode (LED)**

They are the most visible type of diode that emit a fairly narrow bandwidth of either visible light at different colored wavelengths, invisible infra-red light for remote controls or laser type li when a forward current is passed through them. The "Light Emitting Diode" or LED as it is more commonly called, is basically just a specialized type of diode as they have very similar electrical characteristics to a PN junction diode. This means that an LED will pass current in its forward direction but block the flow of current in the reverse direction.

Light emitting diodes are made from a very thin layer of fairly heavily doped semiconductor material and depending on the semiconductor material used and the amount of doping, when forward biased an LED will emit a colored light at a particular spectral wavelength.

When the diode is forward biased, electrons from the semiconductors conduction recombine with holes from the valence band releasing sufficient energy to produce photons which emit a monochromatic (single color) of light. Because of this thin layer a reasonable number of these photons can leave the junction and radiate away producing a colored light output.

Light emitting diode construction

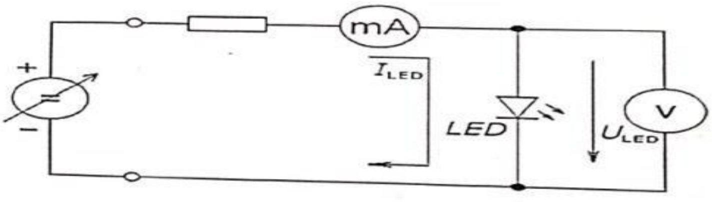
The construction of LED is very simple because it is designed through the deposition of three semiconductor material layers over a substrate. These three layers are arranged one by one where the top region is a P-type region, the middle region is active and finally, the bottom region is N-type. The three regions of semiconductor material can be observed in the construction. In the construction, the P-type region includes the holes; the N-type region includes electrons whereas the active region includes both holes and electrons.

When the voltage is not applied to the LED, then there is no flow of electrons and holes so they are stable. Once the voltage is applied then the LED will forward biased, so the electrons in the N-region and holes from P-region will move to the active region. This region is also known as the depletion region. Because the charge carriers like holes include a positive charge whereas electrons have a negative charge so the light can be generated through the recombination of polarity charges.

Light Emitting Diode Colours

So how does a light emitting diode get its colour. Unlike normal signal diodes which are made for detection or power rectification, and which are made from either Germanium or Silicon semiconductor materials, Light Emitting Diodes are made from exotic semiconductor compounds such as Gallium Arsenide (GaAs), Gallium Phosphide (GaP), Gallium Arsenide Phosphide (GaAsP), Silicon Carbide (SiC) or Gallium Indium Nitride (GaInN) all mixed together at different ratios to produce a distinct wavelength of colour.

Different LED compounds emit light in specific regions of the visible light spectrum and therefore produce different intensity levels. The exact choice of the semiconductor material used will determine the overall wavelength of the photon light emissions and therefore the resulting colour of the light emitted.

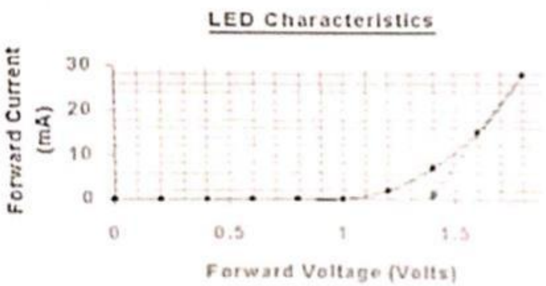


Procedure:-

1. Connect the output of DC power supply (0-3VDC) to the input of the LED circuit. Also connect voltmeter, current meter in the circuit through patch cords shown by doted lines.
2. Switch on the instrument (power supply unit) using ON/OFF toggle switch provided on the front panel.
3. Now increase the power supply voltage in small step and every time note down the voltage & current in observation table.
4. Plot a graph between voltage and current by taking voltage along X axis and current along Y axis.

Observation table for LED:-

s.no.	Forward voltage (V)	Forward current (I)
1		
2		
3		
4		
5		



Result:- 1. forward resistance of LDR is ……………and forward resistance of LED is……..
2 Voltage …… & current ………. LED start Glow, Voltage …… & current …….
LED fully Glow.

Precautions:-

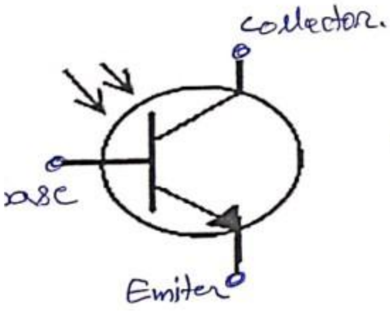
1. Firstly read about complete experiment then perform.
2. Connect circuit properly according to diagram.
3. Check connecting wires before use.
4. Connect current meter in series only.

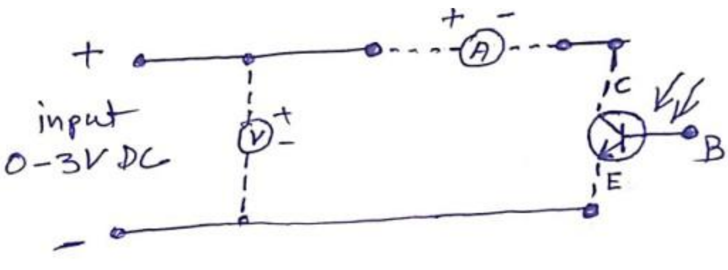
EXPERIMENT NO. 5

OBJECTIVE: Study the characteristics of optoelectronic devices, Phototransistor and Photo diode.

Apparatus:-One DC regulated power supply of 0- 3 volts, phototransistor (red terminal for collector and black terminal for emitter), voltmeter 0-3 volt DC, DC miliammiter, and one lamp with stand.

Theory:- figure 1. Shows the standard symbol of a phototransistor which can be regarded as a conventional transistor housed in a case that enable its semiconductor functions to be exposed to external light. The device is normally used with it, base open circuit. The collector junction of the transistor is effectively reverse biased and thus acts as a photo diode the photo generated current of the base-collector junction feed directly in to the base of the diode and normal current amplifying transistor action causes the output current to appear (greatly amplified form) as collector current in practice the collector and emitter current of the transistor are virtually identical and since base is open circuit, the device is not subjected to significant negative feedback. The sensitivity of a phototransistor is typically one hundred times greater than that of a photodiode, but its useful maximum operating frequency (a few hundred kilo hertz) is proportionally lower than that of a photodiode (ten of megahertz).A phototransistor can be converted into a photodiode by using only its base and collector terminal and ignore the emitter.





Phototransistor:-

A transistor, usually bipolar, in which minority carriers are injected on the basis of an internal photoelectric effect. Phototransistors are used to convert light signals into amplified electric signals. A phototransistor consists of a single crystal Ge or Si semiconductor wafer in which three region are produced by means of special technological processes. As in a conventional transistor, the regions are called the emitter, collector, and base; as a rule, the base has no lead. The crystal is placed in a housing with a transparent window. A phototransistor is connected to an external circuit in the same way as a bipolar transistor with a common-emitter connection and a zero base current. When light is incident on the base or collector, charge- carrier pairs (electrons and holes) are generated in that region; the carrier pairs are separated by the electric field in the collector junction. As a result, the carriers accumulate in the base region, causing a reduction of the potential barrier in the emitter junction and an increase, or amplification, of the current across the phototransistor in comparison with the current that is due only to the migration of carriers generated directly by the action of the light.

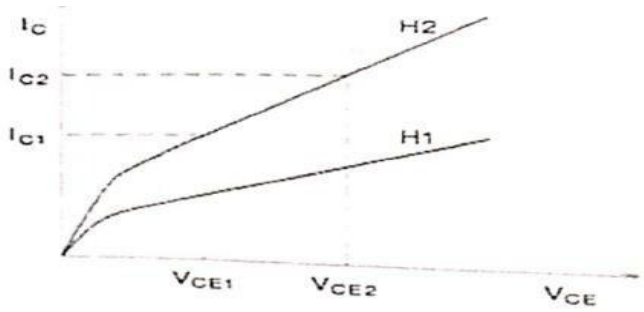
As with other photoelectric devices, such as photocells and photodiodes, the main parameters and characteristics of phototransistors are the luminous sensitivity, spectral response, and time constant. The luminous sensitivity is the ratio of the photoelectric current to the luminous flux. For the best specimens of phototransistors-for example, diffused planar devices luminous sensitivity may be as high as 10 amperes per lumen. The spectral response, which is the sensitivity to monochromatic radiation as a function of wavelength, defines the long-wavelength limit for the use of a particular phototransistor, this limit, which depends primarily on the width of the forbidden band of the semiconductor material is 1.7 micrometers for germanium and 1.1 micrometers for silicon. The time constant characterizes the inertia of a phototransistor and does not exceed several hundred microseconds. In addition, a phototransistor is characterized by the photoelectric gain, which may be as high as 10^2-10^3.

Procedure:-

1. Connect the output of DC power supply (0-3 V DC) to the input of the photo transistor circuit. Also connect voltmeter, current meter and phototransistor in the circuit through patch cords. Also connect volt meter, current meter and photo transistor in the circuit shown by circuit diagram.
2. Place the lamp holder and phototransistor on a graduated wooden stand opposite to each other. Connect the lamp to AC mains and focus the light on photo transistor.
3. Switch ON the instrument (power supply Unit) using ON/OFF toggle switch provide on the front panel.
4. Now increase the power supply voltage in small step and every time note down the voltage and current in table no. 1.
5. Plot a graph between voltage and current by taking voltage along X axis & current along Y axis.
6. Repeat the same procedure for different distances between phototransistor and lamp when circuit is in reverse bias.
7. Plot a graph between distance and current by taking distance along X axis & current along Y axis.

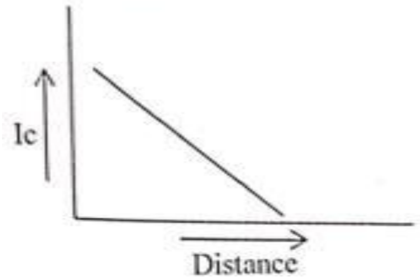
Observation table 1 (If circuit is forward bias).

s.no.	Collector voltage (Vc)	Collector current (Ic)
1		
2		
3		
4		
5		



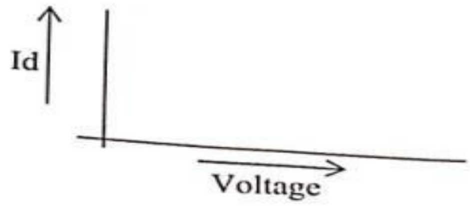
Observation table 2 (If circuit is reverse bias voltage constant).

s.no.	Distance(d) or intensity of light	Collector current (Ic)
1		
2		
3		
4		
5		



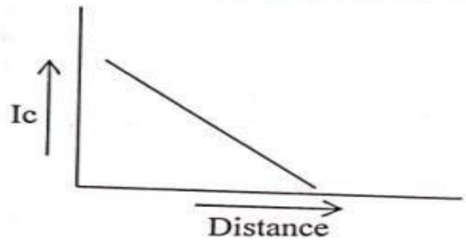
Photodiode:-

The semiconductor photodiode is a light detector device which detects presence of light. It is used to convert optical power into electrical current. PN junction Photodiode have P type and N type semiconductor forms junction. Thin P type layer is deposited on N type substrate. P-N junction has a space charge region at the interface of the P and N type 'material. Light enters through P-layer as shown in the following figure. This diode has relatively thin depletion region around the junction. It is reverse biased to increase width of the depletion region. Photons of light entering in P-layer ionize electron-hole pair. Photon generates electron-hole pair in the depletion region that moves rapidly with the drift velocity by the electric field. Responsivity is important technical term related to the photodiode. It is ratio of photocurrent to incident optical power. Responsivity of the photodiode is proportional to width of the junction. Photo diode is used in fibe optic communication at receiver side. It detects incoming light from the fiber end and convert sit info electrical signal. It can be also used in remote Control receiver.

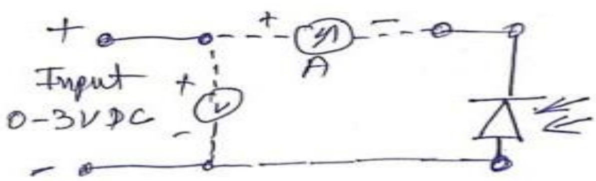


Observation table 2 (If circuit is reverse bias voltage constant).

s.no.	Distance(d) or intensity of light	Current (Id)
1		
2		
3		
4		
5		



Photodiode symbol



Observation table 1 (If circuit is forward bias).

s.no.	voltage (V)	Collector current (Id)
1		
2		
3		
4		
5		

Result:-1.The forward resistance of phototransistor is………and found the reverse current (decreases when the intensity of light decreases, distance between lamp and transistor increases.

2. The forward resistance of photodiodes………intensity of light decreases, distance between lamp and found the reverse current Idr (decreases when the intensity of light decreases, distance between lamp and transistor increases.

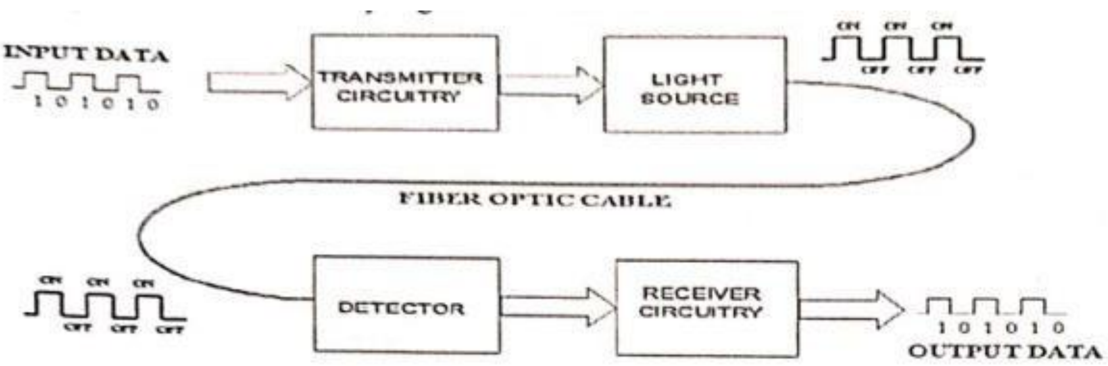
Precautions:-

1. Firstly read about complete experiment then perform.
2. Connect circuit properly according to diagram.
3. Check connecting wires before use.
4. Connect current meter in series only.

EXPERIMENT NO. 6

Optical communication system:-

Optical communication is any type of communication in which light is used to carry the signal to the remote end, instead of electrical current. Optical communication relies on optical fibers to carry signals to their destinations.



How can optical fiber be used for communication?

Fiber optics (optical fibers) are long, thin strands of very pure glass about the size of a human hair. They are arranged in bundles called optical cables and used to transmit signals over long distances. Fiber optic data transmission systems send information over fiber by turning electronic signals into light.

What is optical transmitter and receiver?

A fiber optic transmitter is a device which includes a LED or laser source and signal conditioning Electronics that is used to inject a signal into fiber. Fiber optic receivers capture the light from a fiber optic cable, decode the binary data it is sending and then convert into an electrical signal.

What is the optical source?

Optical source: 1. In optical communications, a device that converts an electrical signal into an optical signal. Note: The two most commonly used optical sources are light-emitting diodes (LEDs) and laser diodes.

What is the line width of a laser?

The linewidth (or line width) of a laser, typically a single-frequency laser, is the width (typically the full width at half-maximum, FWHM) of its optical spectrum. More precisely, it is the width of the power spectral density of the emitted electric field in terms of frequency, wavenumber or wavelength.

Numerical aperture of an optical fibre:

The Numerical Aperture (NA) is a measure of how much light can be collected by an optical system such as an optical fibre or a microscope lens. The NA is related to the) acceptance angle θa, which indicates the size of a cone of light that can be accepted by the fibre. Numerical aperture is thus considered as a light gathering capacity of an optical fibre. Numerical Aperture is defined as the Sine of half of the angle of fibre's light acceptance cone.i.e.NA=Sinθ_a, where θ_a is called acceptance cone angle.

Acceptance Angle:

The acceptance angle of an optical fiber is defined based on a purely geometrical consideration (ray optics): it is the maximum angle of a ray (against the fiber axis) hitting the fiber core which allows the incident light to be guided by the core.

Therefore, the fiber-optic critical angle = (90 degrees-physics critical angle). In an optical fiber, the light travels through the core (m1, high index of refraction) by constantly reflecting from the cladding (m2, lower index of refraction) because the angle of the light is always greater than the critical angle.

What is the cladding in fiber optics?

Cladding in optical fibers is one or more layers of materials of lower refractive index, in intimate contact with a core material of higher refractive index. The cladding causes light to be confined to the core of the fiber by total internal reflection at the boundary between the two.

Why refractive index of core and cladding is different?

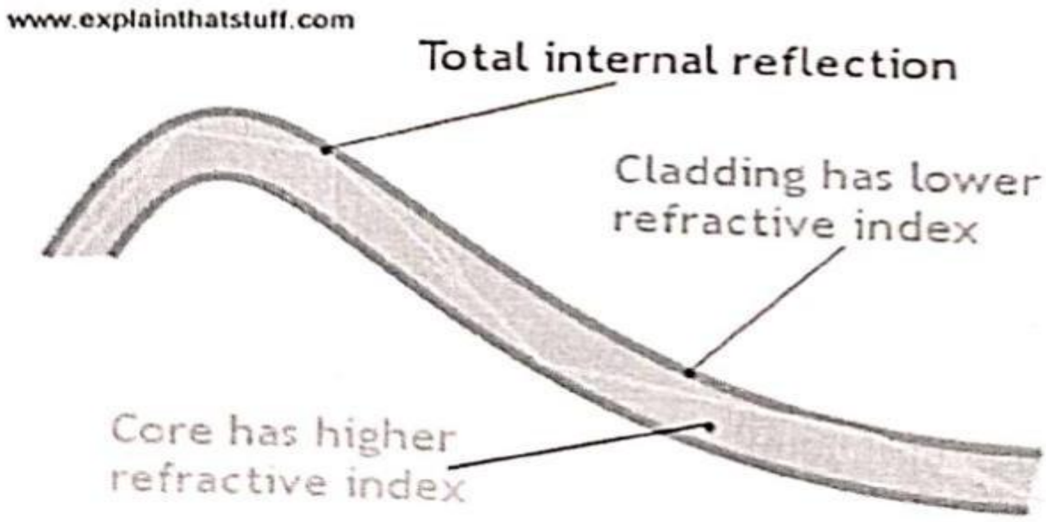
The refractive index of the core, n1, is always greater than the index of the cladding n2. Light is guided through the core, and the fiber acts as an optical waveguide….. As illustrated, light ray is injected into the fiber-optic cable on the left.

What is the purpose of the cladding in a fiber optic cable?

The larger the core, the more light that will be transmitted into the fiber. **Cladding**: The function of the cladding is to provide a lower refractive index at the core interface in order to cause reflection within the core so that light waves are transmitted through the fiber.

What is a fiber core?

The core of a conventional optical fiber is a cylinder of glass or plastic that runs along the fiber's length. The core is surrounded by a medium with a lower index of refraction, typically a cladding of a different glass, or plastic.



OBJECTIVE: To determine the numerical aperture of the PMMA FIBER cables included with this FO - 1.

BASIC DEFINITIONS:

Numerical aperture of any optical system is a measure of how much light can be collected by the optical system. It is the product of the refractive index of the incident medium and the sine of the maximum ray angle.

$$\mathbf{NA = ni.sin\theta_{max}}; \quad \mathbf{ni} \text{ for air is 1, hence } \mathbf{NA = sin\theta_{max}}$$

For a step-index fiber, as in the present case, the numerical aperture is given by

$$\mathbf{N = (N_{core}^2 - n_{cladding}^2)^{1/2}}$$

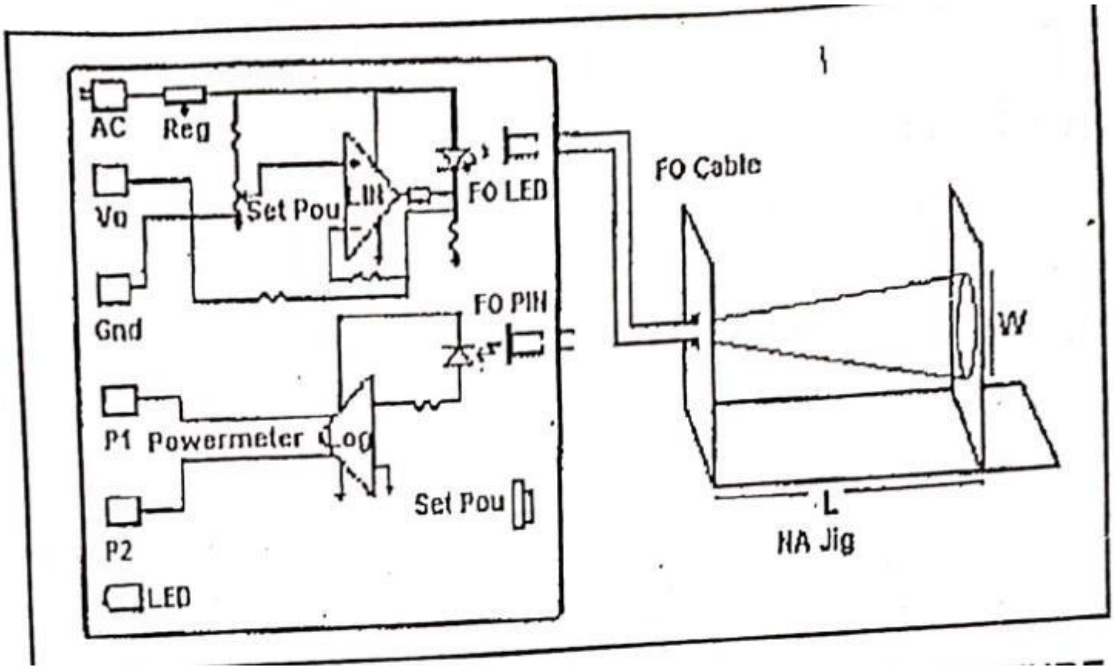
For very small differences in refractive indices the equation reduces to

$$\mathbf{NA = n_{core}(2\Delta)^{1/2}},$$

Where Δ is the fractional difference in refractive indices.

The fiber may refer to the specifications of the PMMA FIBER given in appendix – 1 and record the manufacture's NA, $n_{cladding}$, n_{core} and θ.

SCHEMATICBLOCK DIAGRAM: -

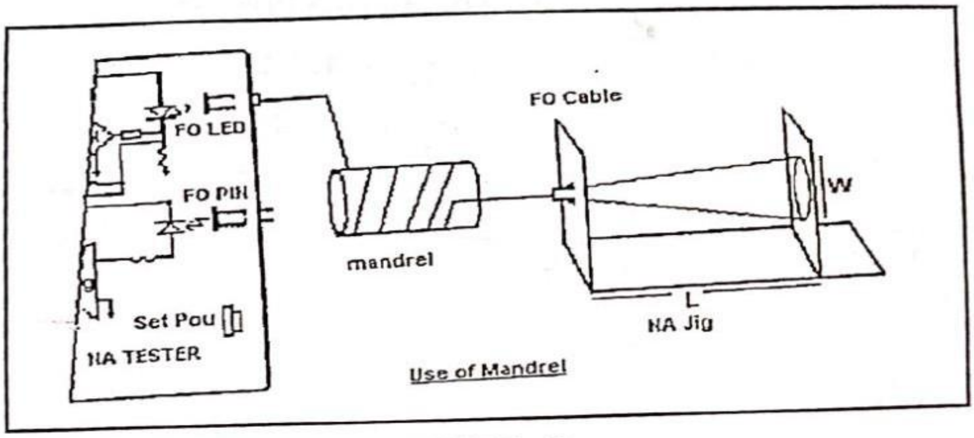


PROCEDURE:

1. Connect on end of the Cable1 (1-meter FO cable) to FO LED in the FIBER Optic LED driver section of FO-1 and the other end to the NA Jig, as shown in figure - 2.
2. Switch On the trainer. Light should appear at the end of the FIBER on the NA Jig. Turn the Set P_{out} knob clockwise to set to maximum Po. The light intensity should increase.
3. Hold the white screen with the concentric circles (5, 10, 15, 20 and 25mm diameter) vertically at a suitable distance to make the red spot from the emitting FIBER coincide with the 10 mm circle. Note that the circumference of the spot (outermost) must coincide with the circle. A dark room will facilitate good contrast. Record “L" the distance of the screen from the FIBER end and note the diameter) of the spot. You may measure the diameter of the circle accurately with a suitable scale.
4. Compute NA from the formula;

$$NA = \sin\theta_{max} = W/\,(4L^2+W^2)^{1/2}$$

Tabulate the reading and repeat the procedure for 15mm, 20mm and 25mm diameters too.



5. In case the FIBER is under filled, the intensity within the spot may not be evenly distributed. To ensure even distribution of light in the FIBER, first remove twists on the FIBER and then wind 5 turns of the FIBER on to the mandrel as shown in figure 3. Use an adhesive tape to hold the windings in position. Now view the spot. The intensity will be more evenly distributed within the core.

OBSERVATION TABLE: -

TABLE-1

S. No.	L (mm)	W (mm)	NA	Θ (degrees)
1	10	10	0.447	26.5
2	15	14	0.423	25.0
3	20	20	0.447	26.5
4	25	24	0.432	25.64
5	30	-	-	-

RESULT AND DISCUSSION: -

1. The numerical aperture as recorded in the manufacturer's data sheet is **0.5** typically the value measured here is ……….The lower reading recorded is mainly due to the FIBER being under filled.

2. The acceptance angle is given by $\mathbf{2\theta_{max}}$. The value of ………..degrees recorded in this is close to the range of **55-60°**. The lower reading is again due to FIBER being under filled.

PRECAUTIONS: -

1. You should take reading carefully.
2. Mounting and coupling should be carefully done.
3. Glass optical fibers are thin, delicate and should be handled carefully.
4. Care should be taken so that laser light should not directly fall into the eye.
5. As far as possible, experiment should be conducted in dark room environment

EXPERIMENT NO. 7

OBJECTIVE: To determine experimentally the static drain characteristics of a Metal oxide Semiconductor Field Effect Transistor (MOSFET).

THEORY:

The structure of an N-channel MOSFET is shown in Fig.1. On to a lightly doped P-type substrate two heavily doped N-regions, separated by, about 25 µm, are diffused. These N regions will act as the source and the drain. A thin layer of insulating silicon dioxide (SiO) is then grown over this surface and holes are cut into the oxide layer through which metal (aluminum) contacts for the source and drain are made. A conducting layer of aluminum which will act as gate, is overlaid on SIO, over the entire channel region. Because of the presence of the insulating layer of silicon dioxide this device is called the insulated-gate field effect transistor (IGFET or MOSFET or simply MOS).The semiconductor channel, the insulating dielectric SiO layer and the metal layer of the gate, forms a parallel plate capacitor. The insulating layer between the gate and the channel results in an extremely high input resistance (1010. to, 1025 2) for this device. There are two types of MOSFET: namely, (1) The enhancement type MOSFET and (2) The depletion type MOSFET.

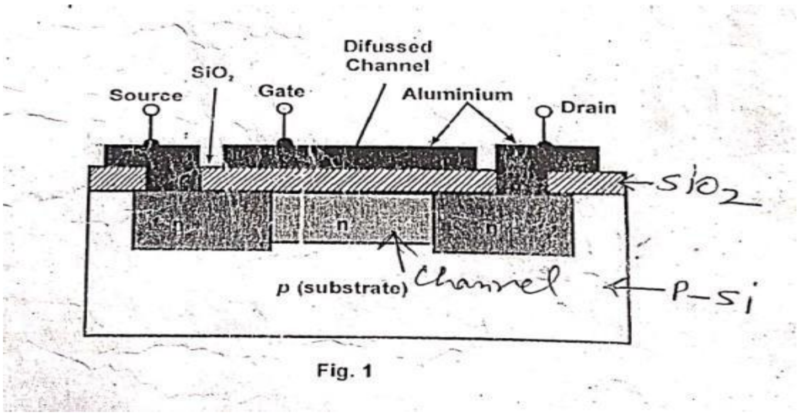


Fig.1. Basic structure of MOSFET

Fig. 3 shows the drain characteristics of N-channel type MOSFET. It may be noted that the current I_D for $V_{GS} \leq 0$ is very small, of the order of a few nanoamperes. As the voltage VGS is made more positive, the current ID increases slowly at first and then at much more rapid rate.

PROCEDURE:-

1. The circuit of MOSFET characteristics is rigged as shown in Fig. (2) with the help of Patch Cards provided. Patch Cards are checked for continuity with the help of multimeter to make that there is no leakage in the lead wire.
2. The training board is switched on.
3. The millimeter is set at 1.5 mAmps per second. Range with the help of range selector switch provided by the side of mA meter.
4. It will be noted that I_D is very small of the order of a few nanoamperes (very difficult to measure) for $V_{GS} \leq 0$. As the voltage V_{GS} is made more positive (around 3 volts) the Current I_D increases slowly at first and then at much more rapid rate as shown in fig. (3). The range selector switch is shifted to 15 mAmps range for taking the readings.
5. The source to Gate voltage V_{GS} set at 3 volts.
6. V_{GS} is changed in step of 0.2 or 0.5 volts and corresponding values of I_D are noted keeping V_{GS} constant.
7. The whole procedure is repeated for different values of V_{GS} i.e. 3.1V, 3.2V, 3.3V (Up to 3.3 VOLTS ONLY)
8. A graph is plotted keeping V_{DS} on X-axis and on I_D Y-axis.

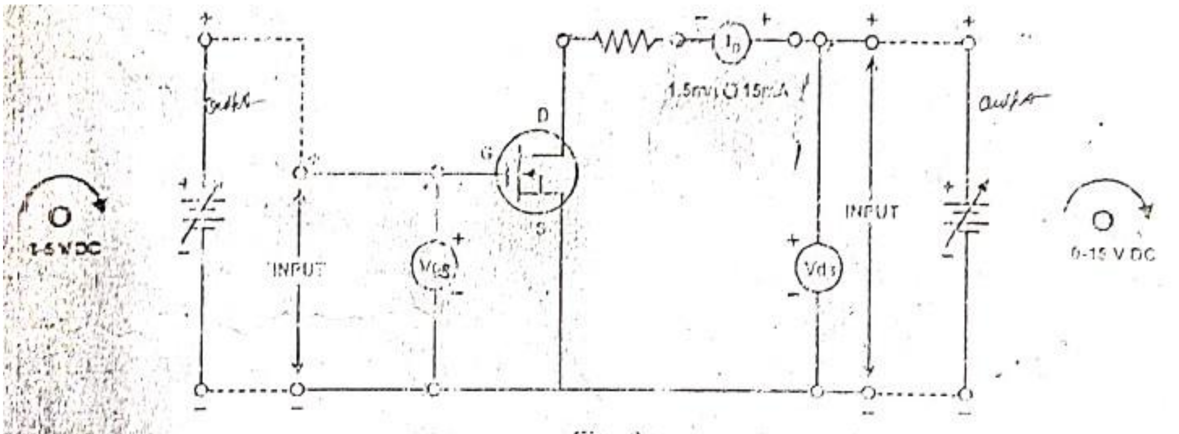


Fig - 2

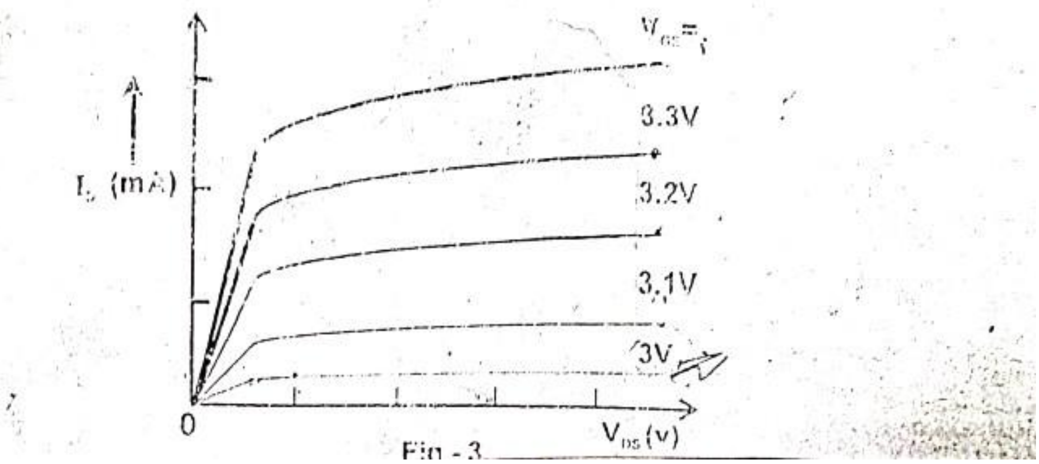


Fig - 3

PROCEDURE

Drain Characteristics:

1. Connect the circuit as shown in Fig. (1).
2. Keep control knobs of both the Power supplies anticlockwise & switch on the instrument by changing the position of the toggle switch to the ON side provided on the front panel.LED provided on the front panel will glow indicating that the instrument is ready for use.
3. Keep V_{GS} (Gate to Source Voltage) constant at 2.9V.
4. Keep Drain to Source voltage at 0.5 V & note down the corresponding Drain current.
5. Increase the drain-source voltage in small steps (0.5V) and note the effect of that voltage on the drain current I_D.
6. Now repeat steps 4 & 5 for different Gate voltages say 2.95V and 3.0V etc and note down the observations in Table 3.
7. Plot a graph between Gate sources volt (V_{GS}) and Drain current I_D keeping V_{GS} (Gate to Source Voltage) constant as shown in Fig. (2).

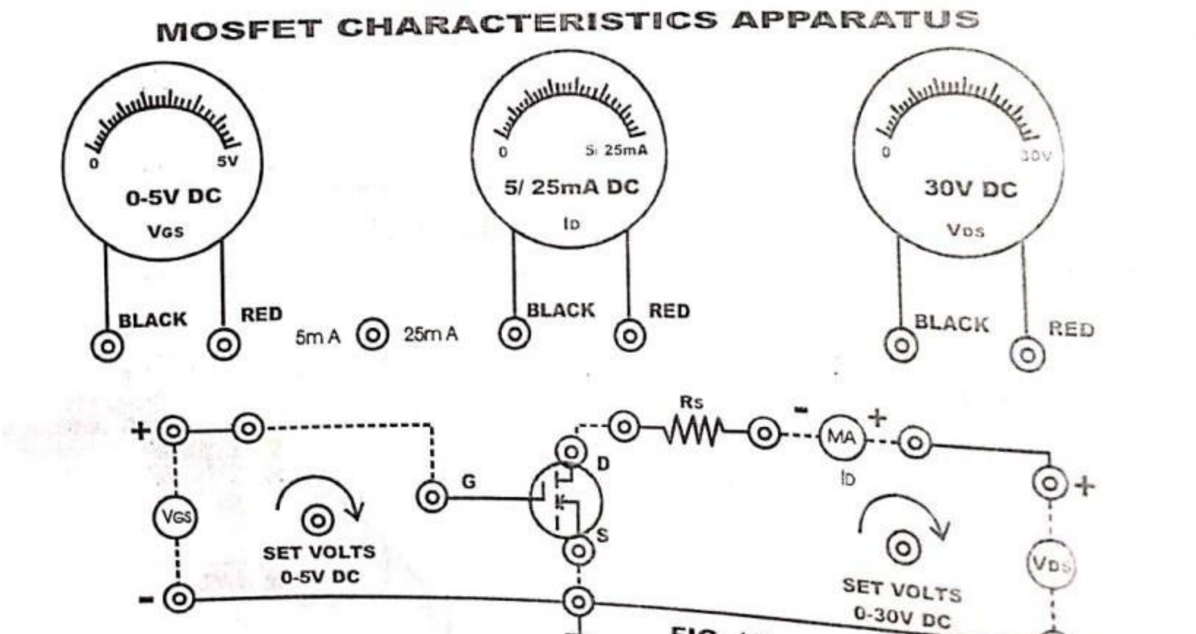


FIG. (1)

For Transfer Characteristics:

1) Connect the circuit as shown in Fig. (1).
2) Keep control knobs of both the Power supplies anticlockwise & switch on the instrument by changing the position of the toggle switch to ON side provided on the front panel. LED provided on the front panel will glow indicating that the instrument is ready for use.
3) Keep V_{DS} constant at 20 Volts.
4) Keep Gate Source Voltage (V_{GS}) at 0.5V and note down the drain current I_D.
5) Increase the gate-source voltage (V_{GS}) in forward bias and note down I_D in Table 4.
6) Plot a graph between V_{GS} and I_D.

6 Plot a graph between Gate- Source Voltage (V_{GS}) and Drain Current (I_D) as shown in Fig (3).

S. No.	$V_{GS} = 2.9V$		$V_{GS} = 2.95V$		$V_{GS} = 3.0V$	
	V_{DS}	I_D	V_{DS}	I_D	V_{DS}	I_D
1						
2						
3						
4						
5						
6						

TABLE NO. (3)

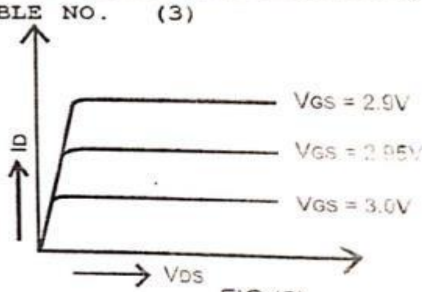


FIG (2)

S. No.	$V_{DS} = 20V$	
	V_{GS} (V)	I_{DS} (mA)
1		
2		
3		
4		
5		
6		

TABLE NO. (4)

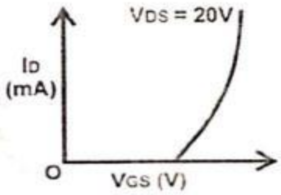


FIG. (3)

PRECATIONS:

1. Take reading carefully.
2. Check all the connection wires.
3. Never insert or remove MOSFET from a circuit with the power ON.
4. Never apply input signal when the dc power supply is off.
5. Wear a grounding strap on your wrist when handling the MOSFET device.