Practical Manual

ELECTRONICS DEVICES LAB / POWER ELECTRONICS LAB

Electrical & Electronics Communication Engineering

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ELECTRONICS DEVICES LAB / POWER ELECTRONICS LAB

LIST OF EXPERIMENTS:

1. Study of characteristics of diode, thyristor and triac.
2. Study of characteristics of transistor and MOSFET.
3. Study of R and R-C firing circuits.
4. Study of UJT firing circuit.
5. Study of complementary voltage commutation using a lamp flasher.
6. Study of complementary voltage commutation using ring counter.
7. Study of thyristorised d-c circuit breaker.
8. Study of a.c. phase control.
9. Study of full wave converter.
10. Study of dc chopper.
11. Study of series inverter.
12. Study of bridge inverter.
13. Study of single phase cycloconverter.

EXPERIMENT – 1

AIM

To plot the forward and reverse bias characteristics of PN junction diode.

APPARATUS

1. DC power supply of 3V and 30V for forward and reverse bias respectively.
2. Voltmeter.
3. Ammeter.
4. Two PN junction diode.

THEORY

If a region of n – type semiconductor is in intimate contact with a region of p – type semiconductor, they form PN junction. A PN junction is formed at the interface between the Indium saturated
p – region and n – type semiconductor. The holes from p – zone cross over to n – zone and electrons from n – zone cross over to
p – zone. This flow continues until there are positive and negative layers on both sides to stop the flow. We call it the depletion layer or the potential barrier. It exists at the junction before any external field is applied.

Forward Biasing:

When the positive terminal of the battery is connected to p – type and negative is connected to n – type region of a PN junction as shown in fig. (1a). The PN junction is said to be forward biased.

The applied potential difference provides the necessary energy for the holes and electrons to diffuse through the junction or barrier. The holes in the p – region are pushed forward towards the n-region and electrons from the n – region because of negative applied potential is increased, there is gradual increase in the current but then shoots up. This happens because at this applied potential all the majority charge carriers (i.e. holes and electrons) cross over.

Reverse Biasing:

In this case the negative terminal of the battery is connected to p – region and positive terminal is connected to n – region. The holes of p – region move towards the negative terminal and electrons towards the positive terminal of the battery or the deflection layer becomes thick or we can say that the junction barrier gets strengthened. Practically there should be no flow of current but a very small amount of current flows which is called reverse current.

This current is due to the thermally generated electron – hole pairs within both p and n type materials. As the reverse bias is increased to sufficient high value, the covalent bonds near the junction breaks down and as a result of this large number of
electron – hole pairs are liberated.

Thus the current rises abruptly as shown in fig. (2b). The voltage at which the current rises abruptly is called breakdown voltage.

CIRCUIT DIAGRAM

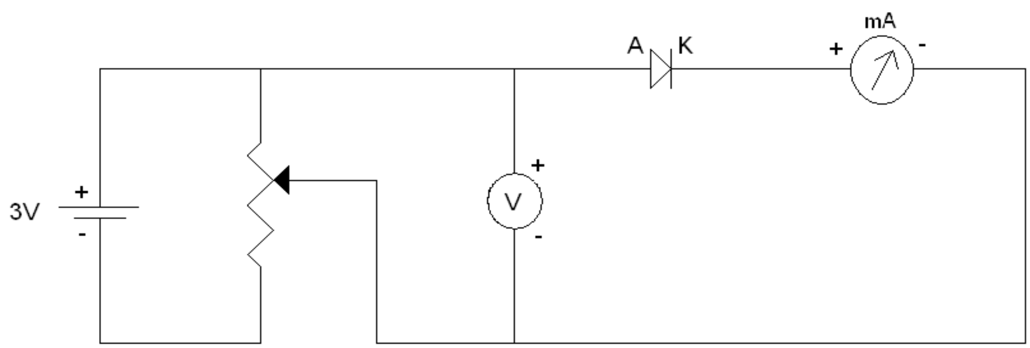


Fig. (1a)

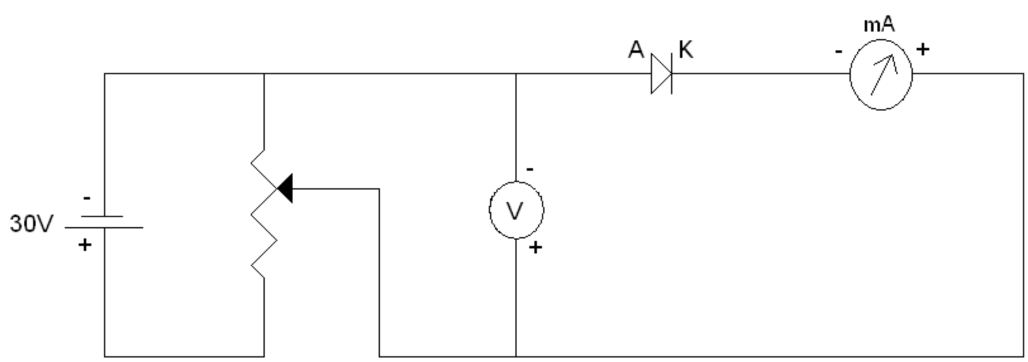


Fig. (2a)

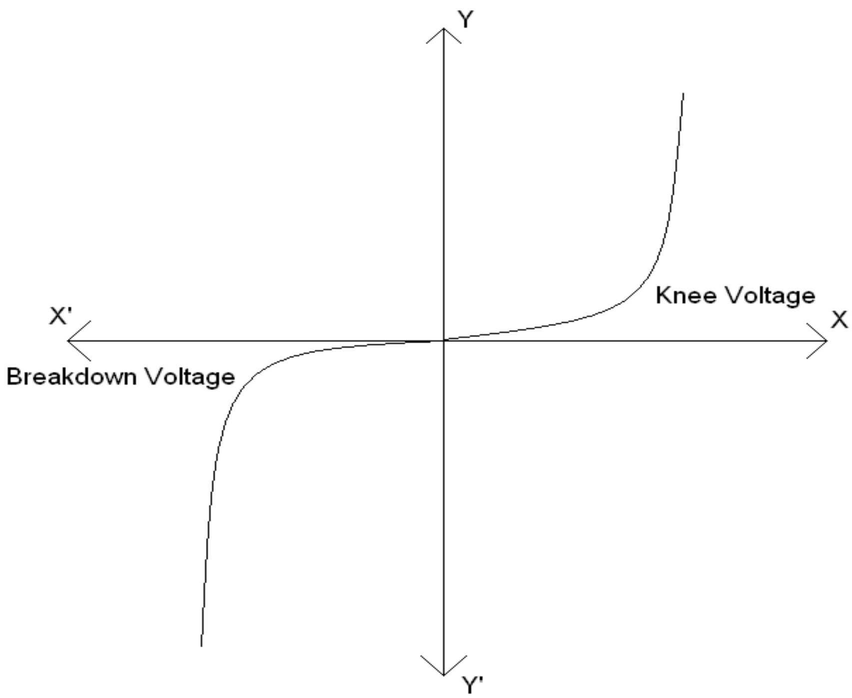


Fig. (2b)

PROCEDURE

For Forward Bias Characteristics:

1. Make all the connections as shown in fig. (1a).
2. Select the voltmeter to 3V range and ammeter to 10mA range using toggle switches.
3. Switch on the instrument and set voltage to 0 volts.
4. Increase the voltage slowly and note down the corresponding current.
5. Plot the graph between voltage and current as shown in fig. (2b).

For Reverse Bias Characteristics:

1. Make all connections as shown in fig. (2a).
2. Select the voltmeter to 30V range and ammeter to 100□A range using toggle switches.
3. Switch on the instrument and set the voltage to 0 volts.
4. Increase the voltage slowly and note down the corresponding current. When the current is approaching 100□A change the range of ammeter to 10mA.

5. Keep on increasing the voltage till current rising uniformly. At a particular voltage current rises abruptly. This is called Reverse Breakdown Voltage of PN junction diode.
6. Plot a graph between voltage and current for reverse characteristics.

PRECAUTIONS

1. Current should not be passed for a long time.
2. Reverse voltage applied should not exceed safety limit.
3. All connections should be neat and clean.

RESULT

The forward and reverse bias characteristics of PN junction diode are shown in graph.

EXPERIMENT – 2

AIM

To study the characteristic of a transistor in Common Base configuration.

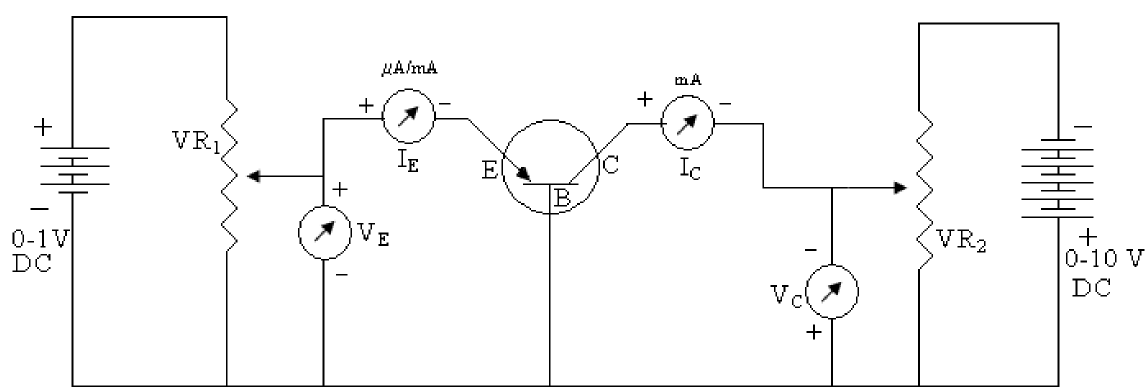
APPARATUS

1. Power Supply
2. Transistor
3. Characteristic Kit
4. Connecting Leads
5. Voltmeter
6. Ammeter.

THEORY

Transistor is a semiconductor device which consists of PN junction & has three terminals. To handle the input & output four terminals are needed therefore one terminals is made common. The common base circuit arrangement PNP transistor is shown in figure. In this circuit, the input is connected between the base & emitter. Thus the emitter of the transistor is common to both input & output circuit & hence the name is Common Base Configuration.

CIRCUIT DIAGRAM



(Fig. 2a)

PROCEDURE

Connect the electrical circuit as shown in fig. (2a). Keep the meter selector switch on mill ampere side. In the connections collector bias is –ve with respect to base & emitter bias is +ve with respect to base.

Input characteristics:

1. Adjust collector to base voltage V_{CB} (using VR2) at some suitable value (say at -2V) & keep it constant.
2. By adjusting input supply set the emitter current to a small but measurable value say 5mA, note down the corresponding emitter to base voltage V_{EB} in small steps & note down the corresponding emitter current I_E.
3. Repeat step no. 1 & 2 for other value collector voltage (say -6V, 8V etc).
4. Plot the graph by taking emitter-base voltage V_{EB} along X-axis & emitter current I_E along Y-axis as shown in figure (2b).
5. Draw a tangent to V_{EB}-I_E curve & determine its slope. The reciprocal of the slope gives the value of input resistance of transistor.

Output characteristics:

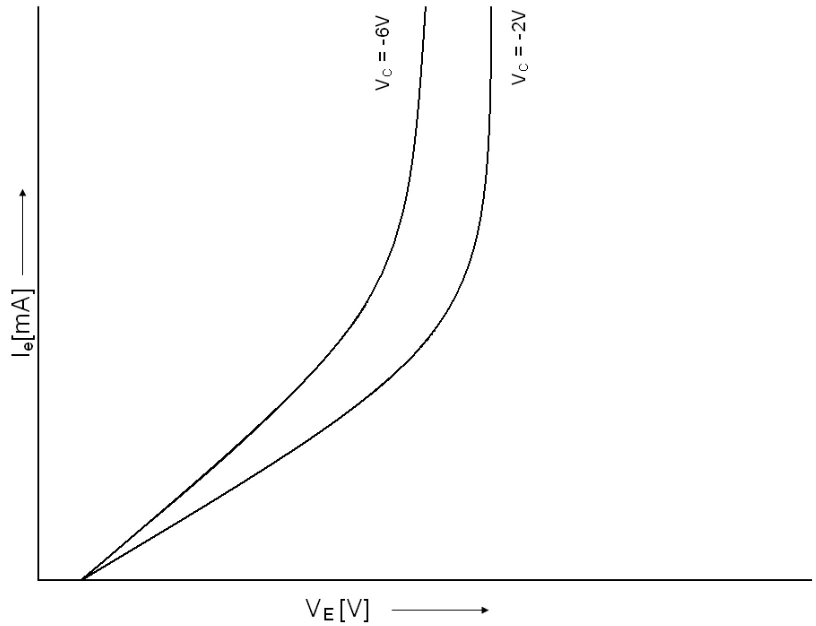
1. Adjust the emitter current I_E to a suitable value (say 10 mA).
2. Set collector voltage V_{CB} to 0.5V & note corresponding collector current I_C. Gradually increase the collector voltage in small steps (i.e. make it -2V, -2.5V, -3.0V…10V etc) & note down the corresponding values of collector current I_E constant.
3. Repeat steps 1 & 2 for other value of emitter current I_E (say 15mA, 20mA etc).
4. Plot graph by taking collector voltage V_{CB} along X-axis fig. (2c) & collector current I_C along Y-axis.
5. Draw a tangent on a V_{CB} -I_C curve & determine its slope, reciprocal of the slope gives the value of output resistance of transistor.

Transfer characteristics:

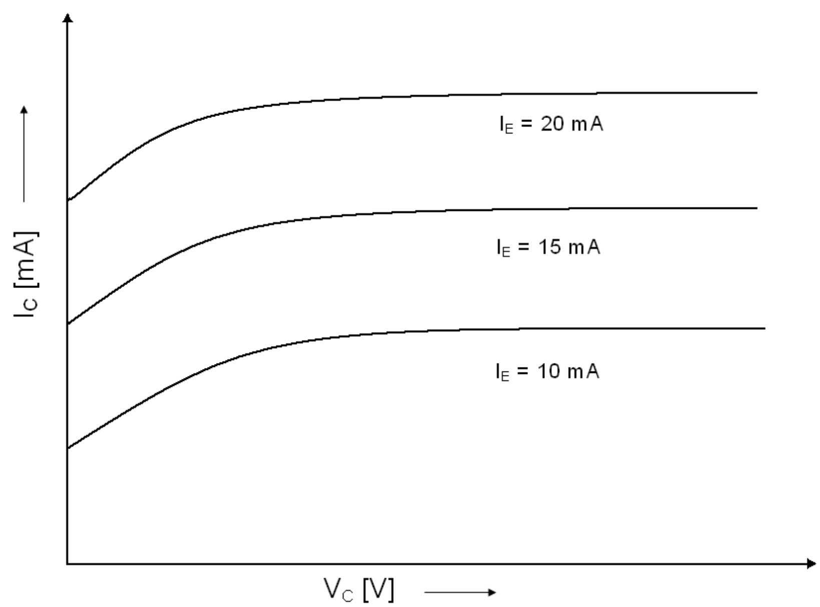
1. Adjust collector voltage at suitable value (say V_{CB}= -4V) & maintain it constant.
2. Adjust emitter current I_E to a suitable small but measurable value & note the corresponding collector current I_C. Increase I_E in small steps & note the collector current I_C each time.

3. Plot a graph by taking emitter current is along X-axis & collector I_C along Y-axis as shown in figure (2d).the slope of the graph give s the value of current gain B.

GRAPHS



INPUT CHARACTERISTIC
(Fig. 2b)



OUTPUT CHARACTERISTIC
(Fig.2c)

OBSERVATION TABLE

	Input Characteristics		Output Characteristics	
S. No.	V_{EB} (V)	I_E (μA)	V_{CB}(V)	I_C(mA)
1				
2				
3				
4				
5				
6				

PRECAUTIONS

1. Always connect voltmeter in parallel & ammeter in series.
2. Switch 'ON' the supply after completing the circuit.
3. Note the output & input waveform correctly.

EXPERIMENT - 3

AIM

To study the characteristics of transistor in Common emitter configuration.

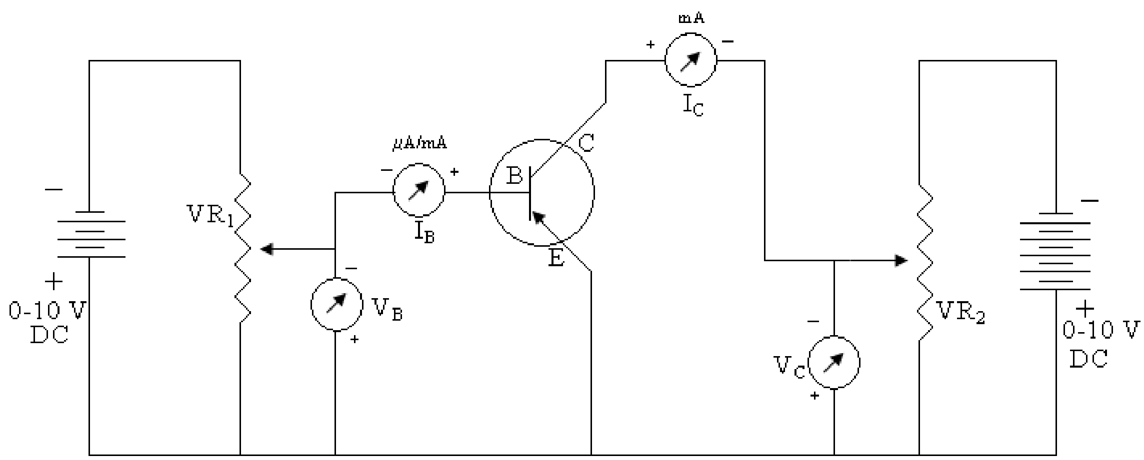
APPARATUS

7. Power Supply
8. Transistor
9. Characteristic Kit
10. Connecting Leads
11. Voltmeter
12. Ammeter.

THEORY

Transistor is a semiconductor device which consists of a P-N junction. It has three terminals to handle input & output four terminals are needed, therefore one terminal is made common. The common emitter circuit arrangement of PNP is shown in figure. In circuit the input is connected between collector & emitter. Thus emitter of transistor is common to both input & output circuit & hence the name is Common emitter configuration.

CIRCUIT DIAGRAM



(Fig.1 a)

PROCEDURE

Connect the electrical circuit as shown in figure (1a). Keep the meter selector switch on microampere side. In the connection collector bias as well as base bias is negative with respect to emitter.

Input Characteristics:

1. Adjust the collector to emitter voltage V_{CE} (using VR_2) at some suitable value (say at -2V) & keep it constant.
2. By adjusting input supply (using VR_1) set the base to emitter voltage, so that base current shows value say 20□A. note down base to emitter voltage V_{BE}, increase V_{BE} in small steps & note the corresponding base current I_B.
3. Repeat step no. 1 & 2 for other value of V_{CE} (say -6V, -8V etc).
4. Plot a graph by taking base voltage V_{BE} along X-axis & base current I_B along Y-axis as shown in figure (1b).
5. Draw a tangent to V_{BE}-I_B curve & determine its slope. The reciprocal of the slope gives the value of input resistance of transistor.

Output Characteristics:

1. Adjust the base current I_B to 50□A using VR_1.
2. Set collector voltage V_{CE} to 0.5V & note down the corresponding collector current I_C. Gradually increase the collector voltage in small steps (i.e. make it -2V, -2.5V,-3.0V... 10 V etc) & note down the corresponding value of collector current I_C keeping the base current I_B constant.
3. Repeat steps 1 & 2 for other value on base current I_B (say 75□A, 100□A etc).
4. Plot the graph by taking collector voltage V_{CE} along X-axis (fig.1c) & collector current along Y-axis.
5. Draw a tangent on a V_{CE}-I_C curve & determine its slope, reciprocal of the slope gives the value of output resistance of the transistor.

Transfer Characteristics:

1. Adjust collector voltage at suitable value (say V_C = -4V) & maintain it constant.
2. Adjust base current I_B to suitable small but measurable value & note down the corresponding collector current I_C. Increase I_B in small steps & note down the collector current I_C each time.

3. Plot a graph by taking base current I_B along X-axis & collector I_C along Y-axis as shown in figure (1d). The slope of the graph gives the value of current gain B.

OBSERVATION TABLE

	Input Characteristics		Output Characteristics	
S. No.	V_{EB} (V)	I_B (μA)	V_{CE}(V)	I_C(mA)
1				
2				
3				
4				
5				
6				

PRECAUTIONS

1. Always connect the voltmeter and ammeter in screw as shown in Fig.
2. Connections should be proper and light.
3. Switch 'ON' supply after computing the circuit.
4. DC supply should be measured slowly in steps. Recording of voltmeter and ammeter should be accurate.

EXPERIMENT – 4

AIM

To study and draw the transfer characteristics of MOSFET.

APPARATUS

1. MOSFET characteristics kit.
2. Multimeter.
3. Connecting leads.

THEORY

Metal oxide, semiconductor field, effect transistor (MOSFET) is an important semiconductor device and it is widely used in many circuit applications since it is constructed with terminal insulated from the channel, it is some times called insulated gate FET. MOSFET has lower capacitance and input impedance much more than that of JEET. MOSFET are of two types namely enhancement type MOSFET and deflection type enhancement MOSFET. In the deflection made construction a channel is physically constructed and a current between drain and source is due to voltage applied across the drain source terminal. The E – MOSFET structure has no channel found formed during its construction. Voltage is applied to the gate, in this case to develop a channel of charge carrier so that the current result when the voltage is applied across the drain – source terminal.

CIRCUIT DIAGRAM:

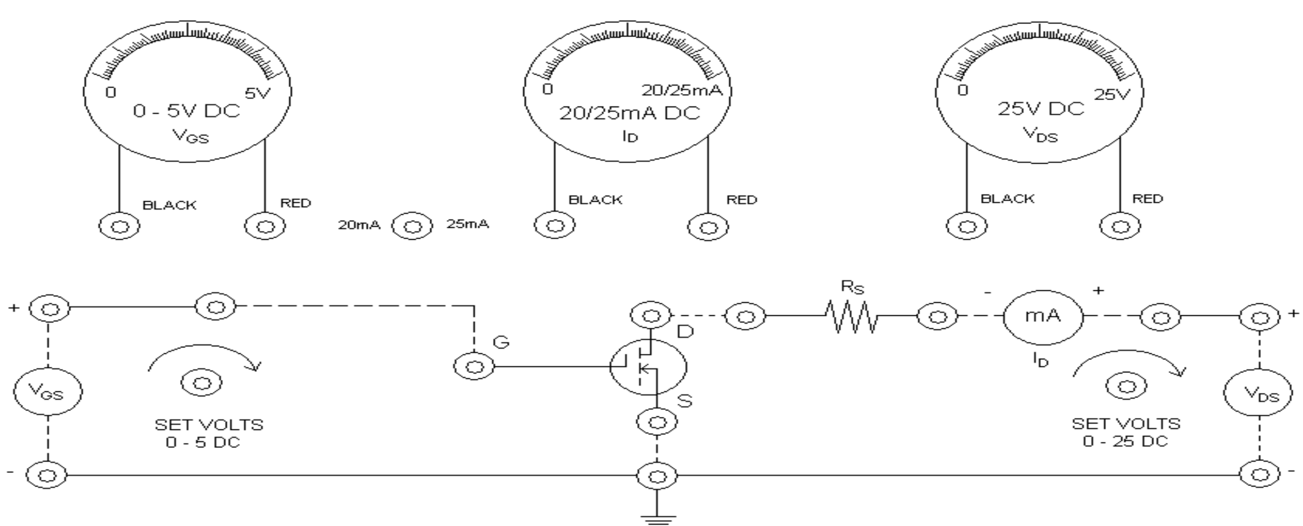


Fig. (1)

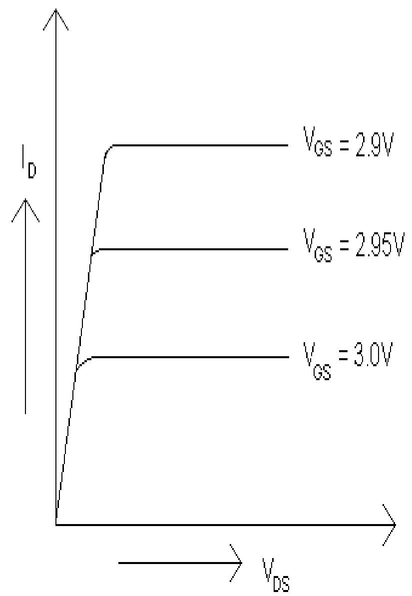


Fig. (2)

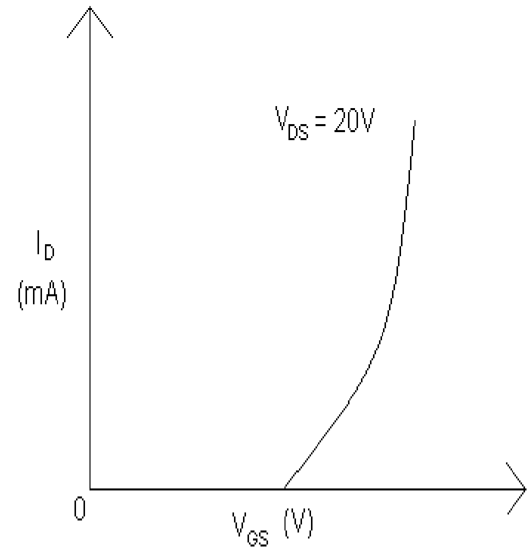


Fig. (3)

PROCEDURE

Drain Characteristics

1. Connect the circuit as shown in fig. (1).
2. Keep control knobs of both the power supplies anticlockwise and switch on the instrument by changing the position of toggle switch to ON side provided on the front panel. LED on the front panel will glow indicating that 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 and note down the corresponding Drain current.
5. Increase the drain – source voltage in the steps of 0.5V and note down the effect of that voltage on drain current I_D.
6. Now repeat the steps 4 & 5 for different Gate voltages say 2.95V, 3.0V etc and note down the observation in Table No. 3.
7. Plot the graph between Drain to source voltage (V_{DS}) and Drain Current I_D keeping V_{GS} (Gate to Source Voltage) constant as shown in Fig. (2).

Transfer Characteristics

1. Connect the circuit as shown in fig. (1).
2. Keep control knobs of both the power supplies anticlockwise and switch on the instrument by changing the position of toggle switch to ON side provided on the front panel. LED on the front panel will glow indicating that instrument is ready for use.
3. Keep V_{DS} (Drain to Source Voltage) constant at 20 volts.
4. Keep Gate to Source voltage at 0.5V and note down the drain current.
5. Increase the gate source voltage in steps and note down corresponding drain current in Observation Table No. (4).
6. Plot a graph between Gate – Source Voltage (V_{GS}) and Drain Current (I_D) as shown in fig. (3).

OBSERVATION TABLE

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

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

Table No. 4

PRECAUTIONS

1. Connections should be tight.
2. Handle the equipment carefully.

RESULT

Input and output characteristics of MOSFET are drawn on graph.

EXPERIMENT – 5

AIM

To study the characteristic of silicon controlled rectifier (SCR) or thyristor.

APPARTUS

1. Power Supply
2. SCR Circuit
3. Voltmeter
4. Ammeter
5. Connecting Leads.

THEORY

Silicon controlled rectifier is four layer, 3-D semiconductor device. The end ‘P’ from the anode & end ‘N’ form the cathode & gate terminals ‘G’ is form the ‘P’ layer next to the cathode. It is a unidirectional device. The device can exist upon either ‘ON’ or ‘OFF’ state depending upon the voltage is +ve with respect to cathode, the SCR starts conducting. If some small gate voltage is applied the SCR triggers at the low value of anode voltage but it causes its control on the SCR circuit after triggering.

Therefore in order to turn off the SCR, the anode voltage is reduced to zero.

CIRCUIT DIAGRAM

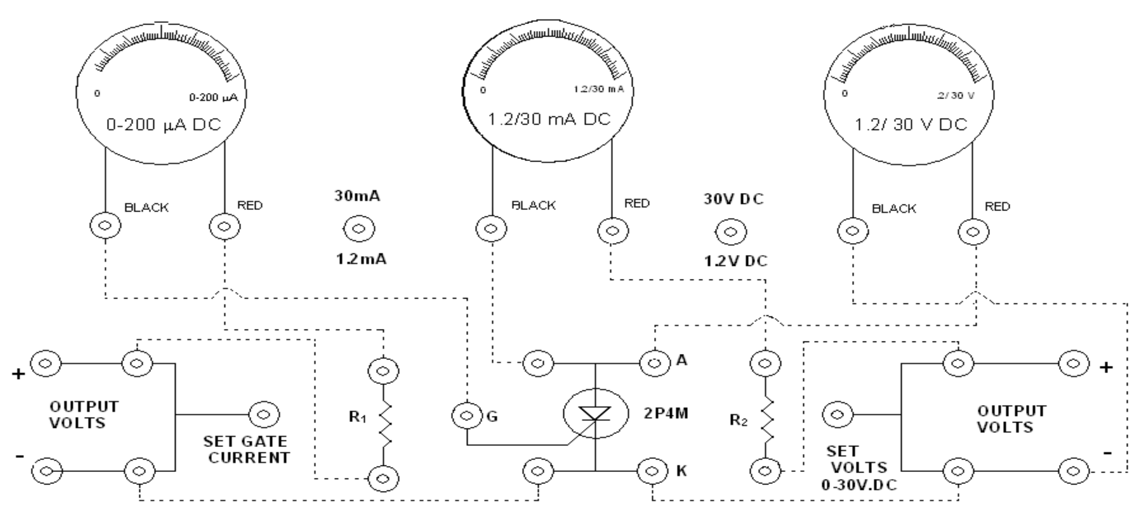


fig (2)

FORWARD CHARACTERISTICS

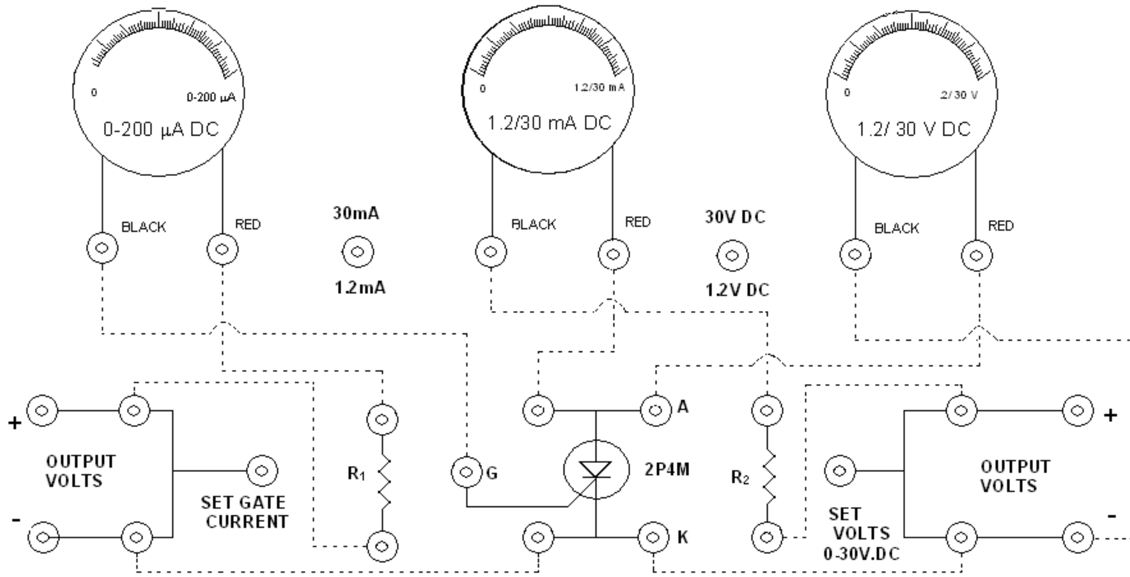


fig (3)

REVERSE CHARACTERISTIC

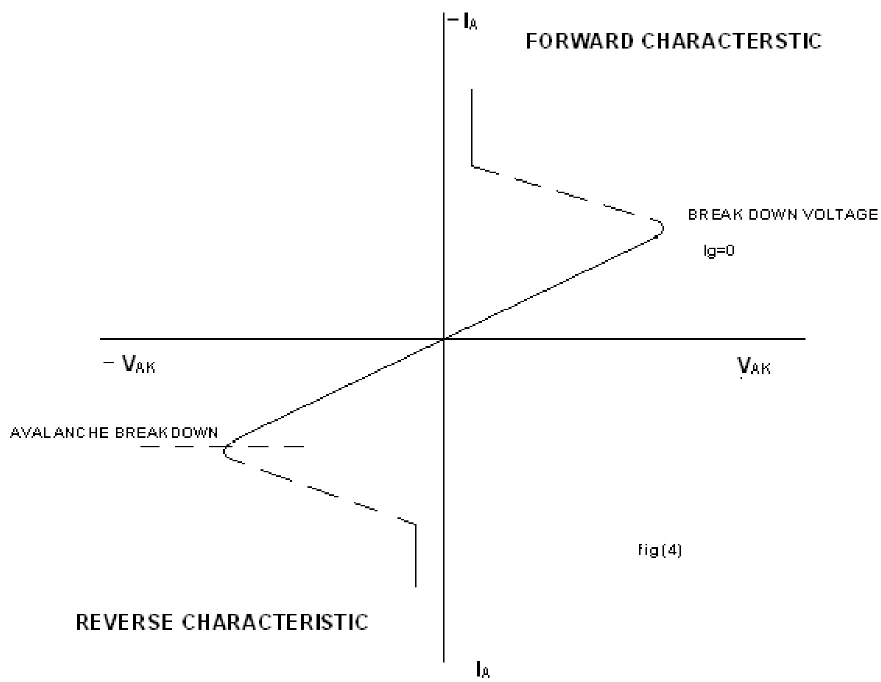


fig (4)

PROCEDURE

- **WITH OPEN GATE**

1. Connect the circuit as shown by dotted lines [in figure(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 1.2mA & voltmeter range to 30V.
4. Switch On the instruments using ON/OFF toggle switch provided on the front panel.
5. Increase anode (A-K) cathode power supply V_{AK} in small steps & note down corresponding anode current I_A. As I_A is small SCR is in 'OFF' state.

Note: break over of SCR with open gate will take place at higher voltages (say 100v), maximum permissible forward voltage. It is undesirable to apply this voltage as SCR has never used with open gate.

- **WHEN GATE IS POSITIVE W.R.T CATHODE**

1. Connect the circuit as shown in figure (2).
2. Repeat the steps (2) to (4) as given in case of open gate circuit.
3. Select milliammeter range to 30mA.
4. 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}).
5. Change the range of voltmeter to 1.2V after triggering of SCR record all possible value of I_A (say between 10mA to 30mA) & corresponding V_{AK} (may in the range of 0.8V to 1V).
6. Also note down the gate current (I_g) required for triggering the SCR at a given V_{AK}.
7. Plot a graph between V_{AK} & I_A by taking V_{AK} along X-axis & I_A along Y-axis.

TO RECORD HOLDING CURRENT (I_H)

When the SCR turns 'ON' decreases 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 remain in 'OFF' state. On the other hand I_H SCR remains in ON state.

TO RECORD HOLDING VLTAGE (V_H)

When the SCR turns 'ON' V_{AK} starts decreasing in small steps so that anode current (I_A) decreases to a holding current (I_H). Record the corresponding value of V_{AK}. This is the holding voltage V_H.

REVERSE CHARACTERISTICS

1. Connect the circuit as shown by dotted lines [in fig.3] though patch chords.
2. Repeat all the steps characteristic in case of forward characteristics procedure & plot a graph between V_{AK} & I_A as shown in figure 4.

NOTE: in reverse characteristics the SCR will never be turned ON at the application of gate current (I_g) 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 the case of SCR that it should not operate in the AVALANCHE BREAKDOWN region.

OBSERVATION TABLE

S.No.	I(mA)	V(Volts)
1		
2		
3		
4		
5		
6		

PRECAUTONS

1. Always connect the voltmeter in parallel & ammeter in series.
2. Connections should be proper & tight.
3. DC supply should be increased slowly.

EXPERIMENT – 6

AIM

To study characteristics of TRIAC.

APPARATUS

1. Power Supply.
2. TRIAC Characteristics Kit.
3. Ammeter.
4. Voltmeter.
5. Connecting Wires.

THEORY

The major drawback of an SCR is that it can conduct current only in one direction. Therefore, an SCR can only control DC power or forward biased half cycles of AC in a load. However, in an AC system, it is often desirable and necessary to exercise control over both positive and negative half cycles. For this purpose, a semiconductor device called TRIAC is used.

A TRIAC is a three terminals semiconductor switching device which can control alternating current in a load.

TRIAC is abbreviation for triode AC switch. ‘Tri’ indicates that the device is has three terminals and AC mean alternating current or can conduct current in either direction. Since a TRIAC can control conduction of both positive and negative half cycles of AC supply, it is sometimes called a bidirectional semiconductor triode switch. A TRIAC is a bidirectional switch with three terminals. It can be seen that even symbol of TRIAC indicates that it can conduct for either polarity of voltage across the main terminals. The gate provides control over conduction in either direction. TRIACs are commercially available to handle maximum r.m.s. currents from about 0.5A upto 25A, although special TRIACs upto about 1000A have been developed. As the current handling capacity increases so does the semiconductor element size containing package.

CIRCUIT DIAGRAM

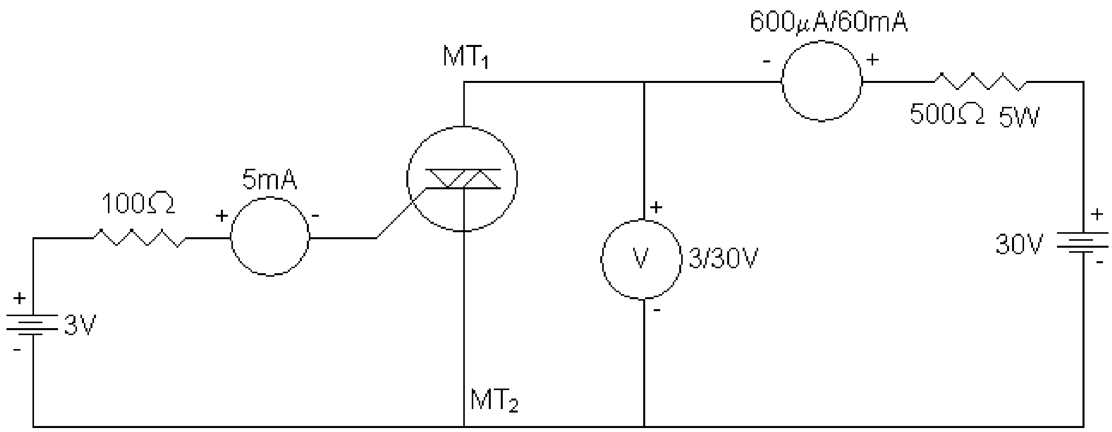


Fig No. (1a)

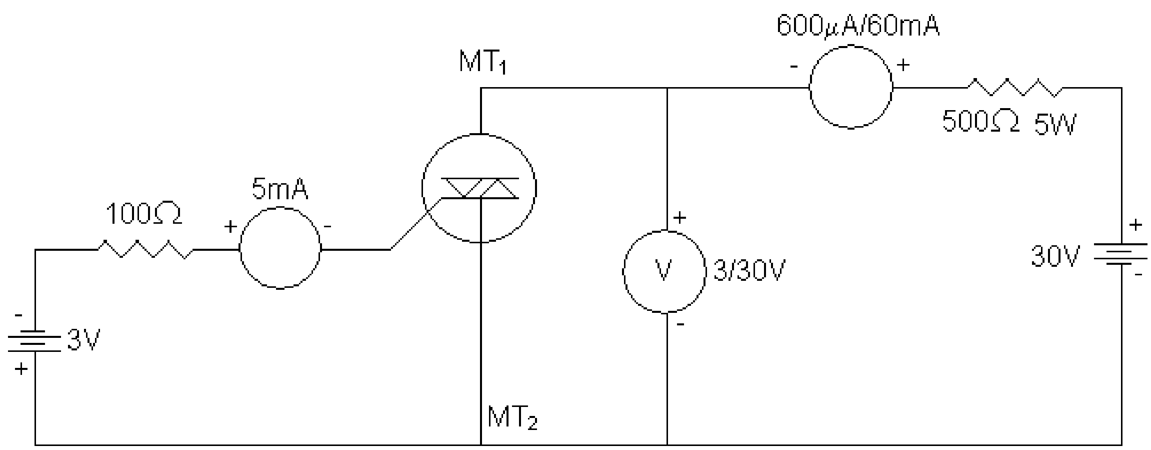


Fig No. (1b)

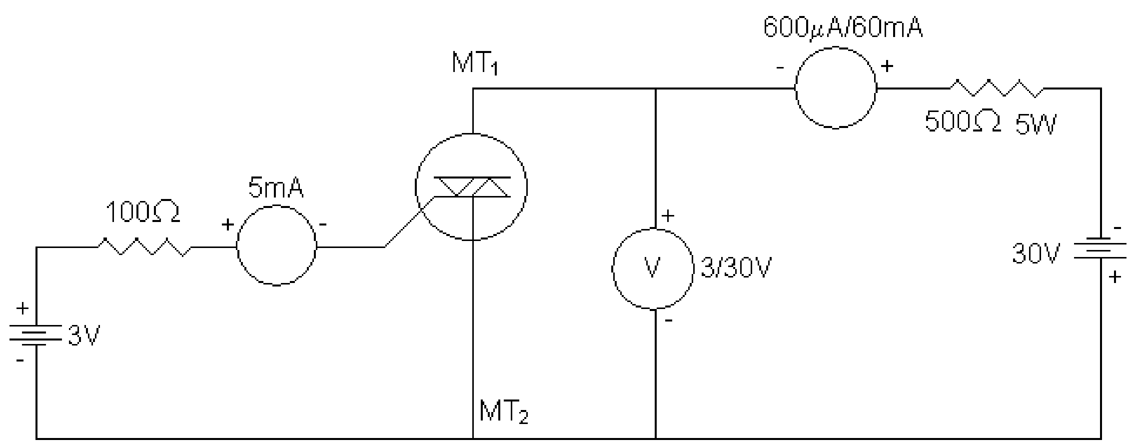


Fig No. 2

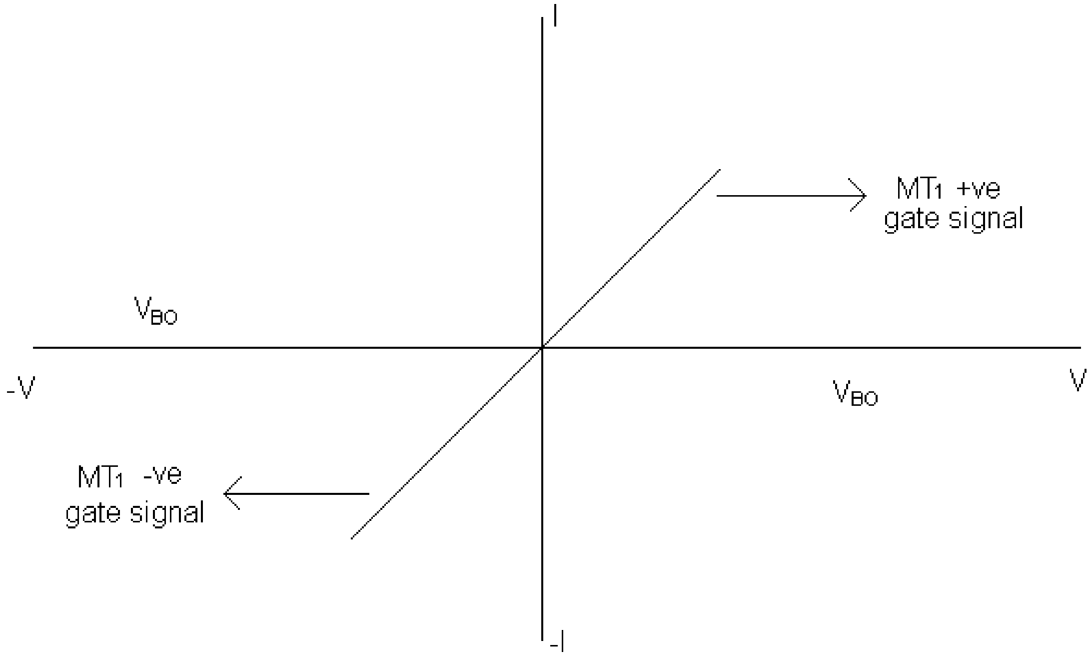


Fig No. 3

PROCEDURE

FOR FORWARD CHARACTERISTICS

- **WITH OPEN GATE**

1. Connect the circuit as shown in fig. (1a).
2. Keep gate supply control knob to minimum position so that gate current becomes zero.
3. Select milliammeter range to 600□A and voltmeter range to 30V.
4. Increase MT_1 – MT_2 supply in steps and note down the corresponding MT_1 current. As MT_1 current is small TRIAC is in OFF state.

- **WHEN GATE IS POSITIVE/ NEGATIVE W.R.T MT_2**

1. Connect the circuit as shown in fig (1b).
2. Repeat the steps 2 to 4 as given in case of open gate circuit.
3. Select milliammeter range to 60mA.

4. Increase gate current (I_g) in small steps, at a particular value of I_g, TRIAC will turn ON resulting in sudden increase in MT_1 current and decreases in $MT_1 – MT_2$ voltage.
5. Change the range of voltmeter to 3V after triggering of TRIAC.
6. Also note down the gate current I_g required for triggering the TRIAC at a given $V_{MT1 – MT2}$.
7. Record different breakover voltages and triggering gate currents. Plot the graph as shown in fig 3.

FOR REVERSE CHARACTERISTICS

1. Connect the circuit as shown in fig 2.
2. Repeat all steps as in case of forward characteristics procedure.
3. Record all possible results and plot the graph as shown in fig 3.

PRECAUTIONS

1. Always connect the voltmeter in parallel and ammeter in series.
2. Connections should be proper and tight.
3. Switch ON the supply connecting circuit.
4. DC supply should be increased slowly in steps.

EXPERIMENT – 7

AIM
Study of R and R-C firing circuits.

APPARATUS
R & RC Firing circuits training kit, 40W Lamp load, CRO.

THEORY
Thyristors are excellent devices for use in the control of AC power. In general, thyristors initially assume a blocking or high impedance state and remain in that state until triggered to ON or low impedance state. Once triggered, the thyristor remain ON until the current is reduced to zero. The thyristors then return to its blocking state. Because the current decreases to zero during every half cycle in an AC supply turn off is guaranteed in every half cycle. So, far an AC power control a trigger circuit is required to control thyristor turn ON. So that whole or partial cycles may be switched to load. In many power control applications of thyristors partial cycles of the applied AC voltage are switched to load. Because the power delivered to the load is controlled by variations of the phase angle at which the thyristor switching initiates current flow, this type of operation is usually referred to as phase angle control.
Power to an AC load can also b controlled by switching of complete half cycles or integral numbers of whole cycles of the AC power to the load. This type of control is usually referred to an integral cycle or zero voltage switching control.

R – FIRING CIRCUIT
In order that the peak gate current of the thyristor I_{gfm} is not exceeded, a limiting resistor R_{min} is placed between anode and gate. For the worst case, that is when the supply voltage has reached its peak E

$$R_{min} \geq E / I_{gfm}$$

The stabilizing resistor R_b is so chosen that the voltage across it does not exceed the forward gate voltage V_{gfm}. From the voltage distribution

$$R_b \leq (R + R_{min})\, V_{gfm} / E - V_{gfm}$$

The SCR will trigger when the instantaneous anode voltage e is

$$e = V_d + V_{gf} + I_{gf}\,(R + R_{min})$$

where V_d = voltage drop across diode D, I_{gt} = gate current to trigger the thyristor and V_{gt} = gate voltage to trigger corresponding to I_{gt}.

The minimum triggering angle is obtained with R equal to zero. The delay angle increases with an increase in R. Consequently, the power delivered to the load decreases. since the thyristor T_1 latches into conduction the first time I_{gt} is reached and because the anode voltage and the gate current are in phase the conduction of the thyristor T_1 cannot be delayed beyond 90^o with this simple triggering circuit. the circuit provides control from 100% of half wave output to 50% of full wave output.

RC FIRING CIRCUIT

The role of capacitor is to shift the phase of the anode voltage so that a positive gate current can be supplied even after the peak of the anode voltage. By varying the resistor R the firing angle can be controlled from 0^o to 90^o. The capacitor charges to negative peak of the AC voltage in every negative half cycle through diode D_2. During the positive half cycle it begins to charge through the resistance R. when the voltage across the capacitor reaches the required positive value, the thyristor T_1 is triggered and the capacitor voltage remains almost constant. The diode D_1 prevents breakdown of the gate to cathode junction during the negitive half – cycle.

For a typical thyristor in the range of power frequencies it may be empirically shown that RC for zero output must be chosen as follows:

$$RC \geq 1.3T/2 \approx 4/w, \ w = 2\pi f \quad \ldots\ldots\ldots\ldots\ldots \text{ eqn 1}$$

where T = 1/f = period of AC line frequency in seconds. When the capacitor voltage $e_c = V_{gt} + V_d$, where V_d is the voltage drop of the diode D_1, the thyristor will turn on provided the gate current I_{gt} is available. Hence, the maximum value of R is given by

$$e \geq I_{gt}R + e_c = I_{gt}R + V_{gt} + V_d \quad \ldots\ldots\ldots \text{ eqn 2}$$

or

$$R \leq \frac{e - V_{gt} + V_d}{I_{gt}}$$

where e is the instantaneous supply voltage at which the thyristor will turn on. Suitable value of R amd C can be obtained from eqns.

RC FULL WAVE CIRCUIT

There are many possible variations of the RC trigger circuit, all operating on the same basic principle. A simple circuit giving full wave output is shown in fig. In this circuit the initial voltage from which the capacitor C charges is essentially zero. The capacitor C is reset to this voltage by the clamping action of the thyristor gate. For this reason, the charging time constant RC must be chosen longer than for the half wave RC circuit in order to delay the triggering an equal amount for a given AC half – cycle of charging voltage. The RC value is chosen using the following empirical rule.

$$RC \geq \frac{50T}{2} \cong \frac{157}{w} \quad \text{............ Eqn 3}$$

The value of R is selected from eqn 4

$$R \leq \frac{e - V_{gt}}{I_{gt}} \quad \text{.............. Eqn 4}$$

PROCEDURE

R – FIRING CIRCUIT

1. Connect 230V, 40W to the 230V AC input terminals of the circuit.
2. Connect 40W lamp load.
3. Make sure that the phase control potentiometer is in its minimum position and switch ON the experimental kit.
4. By varying the phase control pot, firing / conduction angle of the SCR can be changed. Changing the intensity of the bulb indicates that. If resistance is less, gate current is more and than SCR conducts heavily.
5. Observe the waveforms at different stages on CRO.

RC – FIRING CIRCUIT (HALF WAVE)

1. Connect 230V, 40W to the 230V AC input terminals of the circuit.
2. Connect 40W lamp load.
3. Make sure that the phase control potentiometer is in its minimum position and switch ON the experimental kit.
4. By varying the phase control pot, firing / conduction angle of the SCR can be changed. Changing the intensity of the bulb indicates that. If resistance is less, gate current is more and than SCR conducts heavily.

5. Observe the waveforms at different stages on CRO.

RC – FIRING CIRCUIT (FULL WAVE)

1. Connect 230V, 40W to the 230V AC input terminals of the circuit.
2. Connect 40W lamp load.
3. Make sure that the phase control potentiometer is in its minimum position and switch ON the experimental kit.
4. By varying the phase control pot, firing / conduction angle of the SCR can be changed. Changing the intensity of the bulb indicates that. If resistance is less, gate current is more and than SCR conducts heavily.
5. observe the waveforms at different stages on CRO.

EXPERIMENT – 8

AIM

Study of SCR Communication Technique Class A-E.

APPARATUS

Commutation Circuits Trainer, 40W Lamp Load (2 nos.), CRO, Patch Chords.

THEORY

The SCR is turned off when its forward current is reduced below the level of the holding current. In AC circuits, when the current in the SCR goes through a natural zero, a reverse voltage automatically appears across the SCR. This is known as Natural Commutation. No external circuits are required to for turning off the SCR. In DC circuits the forward current has to be forced to zero by an external circuit to turn off the SCR. This is known as Forced Commutation. DC input is required for SCR controlled circuits used for DC to DC converters and DC to AC inverters.

CLASS A: RESONANT COMMUTATION

Here the commuting components L and C are connected to load as shown in fig, so that overall circuit becomes under damped and zero current is obtained. The commutation of SCR is however due to the resonant behavior of the overall circuit. In shunt type resonant commutation capacitor is connected in parallel to load. Whenever the SCR is triggered, bulb connected in place of load will glow and the capacitor starts charging. After some time depending on the LC time constant, voltage across capacitor equals the voltage at a mode terminal of the SCR that means the voltage at whole and cathode is equal as this makes the SCR off.

CLASS E: EXTERNAL PULSE COMMUTATION

Here a pulse of current obtained from and external voltage turns off the conducting SCR. The peak amplitude of the current pulse must be greater than that of the load current through the SCR, and the duration of the reverse voltage applied following the turn off of the SCR must be longer than that SCR turn off time.

A pulse forming network is shown in fig. When SCR 1 is fired a current pulse by peak value E/(C/L) will flow through SCR and charge all the capacitors to a voltage level 2E. The duration of the current pulse will be n/LC, where n is the number of LC sections. When SCR 2 is fired, the charged network will discharge through SCR 3 in the opposite direction and after SCR 3 is turn off, apply a reverse potential across for a period of about n/LC.

PROCEDURE

RESONANT COMMUTATION

1. Connect 250V power supply to the appropriate terminals of the circuit.
2. Connect C capacitor in place ‘C’ mentioned in circuit. (C = 40 – 60µF).
3. Connect 40W lamp load.
4. Now connect isolated firing pulses FP_1 to the SCR and put in low frequency position.
5. Now switch on the system and observe the waveform on the CRO with 10:1 resistive attenuator.
6. Repeat the same procedure for different frequencies by adjusting the firing pulses.

EXTERNAL PULSE COMMUTATION

1. Connect 250V power supply to the appropriate terminals of the circuit.
2. Now connect isolated firing pulses FP_1 to the SCR and put in low frequency position.
3. Connect 40W lamp load.
4. Now switch on the system and observe the waveform on the CRO with 10:1 resistive attenuator.
5. Repeat the same procedure for different frequencies by adjusting the firing pulses.

EXPERIMENT – 9

AIM

To study JONES and MORGAN's chopper.

APPARATUS

JONES and MORGAN's chopper circuit trainer kit, CRO, 40W load lamp.

THEORY

The chopper circuits are means of providing variable DC supply to loads by varying the turn on/off ratio of the switching voltages. Such chopper voltages are advantageous for traction purposes because of superior torque. As the name chopper implies a DC voltage is converted into AC voltage by switching through thyristor ON and OFF.

MORGAN'S CHOPPER

This circuit as shown in fig is characterized by class B commutation i.e. self commutation by a resonant circuit aided by a saturable reactor. Its major advantage is that it uses only one thyristor. Hence the one time ON is fixed by the LC parameters and the average voltage across the load is altered by adjusting T i.e. by varying the frequency of the gate firing pulses given to SCR's gate terminal.

When SCR (TYN 604) is fired, the capacitor C1 discharges around C, SCR and l circuit to acquire a reverse polarity. As the current again reverses the voltage across L is held for a certain time and then saturation occurs so that the whole of the capacitor voltage appears across the thyristor. The thyristor is reverse biased if the discharge current is greater than the load current, the thyristor turns off.

The capacitor continues to carry load current until it charges up the full positive again. The freewheeling diode will provide a path to dissipate further stored energy (1/2 Li2) and if that is dissipate before the thyristor is turned on, again the load will indicate. It is possible among a number of variations, to add a reverse diode across the thyristor to provide impulse commutation. Although the frequency of switching is under precise control of the oscillator, the time SCR is ON can be effected by fluctuations of load.

JONES CHOPPER

The circuit shown in fig. is characterized by class D commutation, i.e. a charged capacitor switched by an auxiliary thyristor. SCR_2 is to commute the main thyristor SCR_1. This circuit is more stable than the basic Morgan circuit and provides a more reliable commutation of the load thyristor. As the morgan chopper, when the thyristor SCR_1 is fired, the capacitor is charged positively, discharges around the loop C, SCR_1, L and D circuit and attains reverse biased and its current is reduced to zero. As the capacitor voltage swings negative, the reverse bias on diode D_2 decreases. This process will continue upto a time = L/S.

When SCR_2 is turned ON, the negative voltage on capacitor C is applied across SCR_1 is turned off after recovery current becomes zero. The load current, which is normally constant starts to flow in SCR_2 and capacitor C. the capacitor C is charged positively at first upto a voltage equal to the supply voltage C_{DC}. The freewheeling diode becomes forward biased and begins to pick up the load current and capacitor current reduces below the holding current of SCR_2 when it is turned off. The cycle repeats when SCR_1 is again turned ON.

PROCEDURE

MORGAN CHOPPER

1. Connect 250V, DC power supply to the appropriate terminals of the Morgan chopper circuit.
2. Connect isolated firing pulses (FP_1) to the SCR's gate and put in minimum frequency position.
3. Connect 40W lamp load and switch ON the system.
4. Observe the waveform across load using 10:1 attenuator probe on CRO by increasing the frequency.

JONES CHOPPER

1. Connect 250V, DC power supply to the appropriate terminals of the Jones chopper circuit.
2. Connect isolated firing pulses FP_1 and FP_2 to the main and auxiliary SCR's gate and put in maximum frequency position.
3. Connect 40W lamp load and switch ON the system.
4. Observe the waveform across main SCR, auxiliary SCR and load using 10:1 attenuator probe on CRO by varying the frequency.

EXPERIMENT – 10

AIM

To study Full wave and Half wave AC phase control using SCR.

APPARATUS

Half & Full wave phase control circuit Trainer kit, Cathode Ray Oscilloscope, 40W lamp load.

THEORY

Thyristors are excellent devices for use in the control of AC power. In general, Thyristors initially assume a blocking, or high impedance state and remain in that state until triggered to the ON or low impedance state. Once trigger, the Thyristors then returns to its blocking state. Because the current decreases to zero during every half cycle in an AC supply turn off is guaranteed in every half cycle. All that is necessary for AC power control therefore is a trigger circuit to control Thyristor turn ON. So that whole or partial cycles may be switched to the load. In many power control applications of Thyristors partial cycle of applied AC voltage are switched to the load. Because the power delivered to the load is controlled by variation of the phase angle at which the Thyristor switching initiates the current flow, this type of operation is usually referred as a phase angle control.

Power to an AC load can also be controlled by switching of complete half Cycle or integral numbers of whole cycles of the AC power to the load. This type of control is usually referred to the integral cycle or zero voltage switching control.

PHASE CONTROL

The electrical angle of the applied AC voltage waveform at which the Thyristor current is initiated is termed the Firing Angle (O_f). it is usually more important, to refer to the condition angle (O_c), which is the number of electrical degrees of the applied AC voltage waveform during which the Thyristor is in conductor.

1. HALF WAVE PHASE CONTROL USING SCR

Fig-1a shows the simple RC circuit for triggering SCRs by means of gate control. The magnitude of gate current can be changed by varying R since the SCR rigger only when there is sufficient gate current. A control on the firing angle can be easily attained when the applied voltage is AV. In Fig-1a capacitor C gets charged through diode D_2 to the negative peak value of the applied AC voltage during every negative half-cycle charging in the positive direction takes place in the following positive half cycle. The charging rate is controlled by resistance R when there is sufficient positive voltage across capacitor C, the SCR fires. Diode D_1 is used for preventing reverse breakdown of the gate to cathode junction in the negative half cycle. The circuit in Fig-2a provides phase control in every positive half cycle. Half wave control this RC circuit is a not-linear function with R as it depends upon RC charging rate which is exponential. Main draw back of this circuit is even thought it is half wave control, it having form $0\text{-}90^0$ only.

2. FULL WAVE PHASE CONTROL USING SCR

Fig-2a shows the UJT triggered SCR phase control circuit. Because of unidirectional characteristics of the SCR, we have control only on positive half cycles. But in full wave control, we have to control both positive and negative cycles. For this purpose a bridge circuit, we get only positive (full wave rectified) cycle, which are applied, to the anode of the SCR TYN 604. The gate current of the SCR is controlled by the pulses produced by the UJT 2N2646. The UJT 2N2646. The UJT is connected in relaxation oscillator mode. Occurrence of the pulses depend upon the values of R_1 (which is variable) and R_2 & capacitor C. the pulses developed at Base-1 of the UJT controls the gate current of SCR. Fig-2b shows the waveforms at different points in the circuit.

PROCEDURE

1. Connect the isolated AC circuit to the input terminals of the half wave phase control using SCR.
2. Connect lamp load.
3. Switch ‘ON’ the trainer kit.
4. Vary the phase control potentiometer to control the intensity of lamp.
5. Note down the waveforms at different point using 10.1 resistive attenuator & compare with the waveform given in fig.
6. Repeat the step 1 to 5 to perform the next experiment.