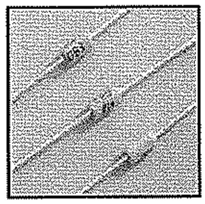
EXPERIMENT No. 5

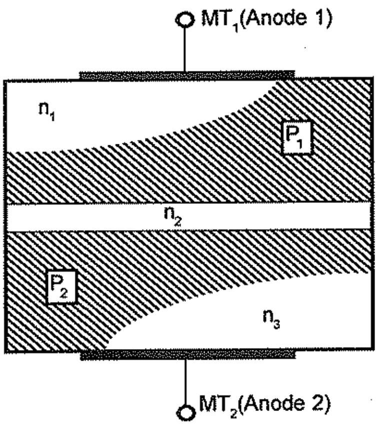


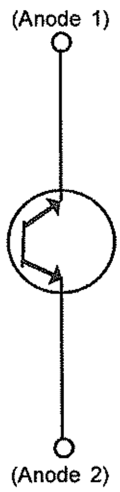
1.0 Title :

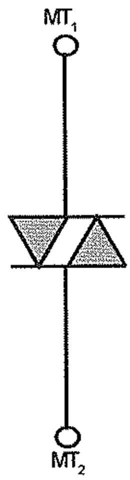
To plot V-I characteristics of DIAC (Diode AC Switch).

2.0 Prior Concepts :

- Diode - It is a PN junction device having two layers, two terminals and one junction.
- Comparison between AC and DC signalling.
- Diac - The diac is a two terminal device. It is a parallel inverse combination of seminconductor layers that permits triggering in either direction.





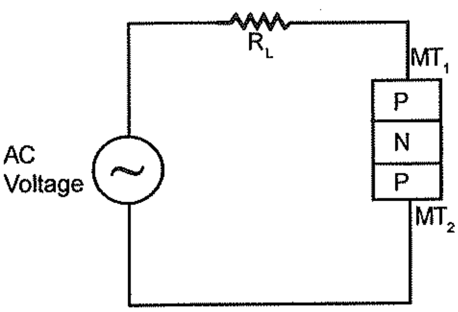


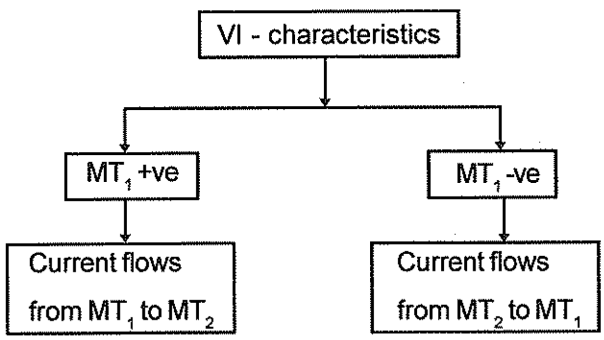
3.0 New Concepts :

Proposition 1 : VI characteristics

It is the curve drawn between voltage applied between MT_1, MT_2 and current.

Concept structure:





Proposition 2 :

Regions in characteristics

The VI characteristics in forward and reverse is divided into two regions.

A. Blocking state (Off state) :

For applied positive voltage less than $+V_{B0}$ and negative voltage less than $-V_{B0}$, a small leakage current ($+ I_{BO}$) flows through the device.

Under such conditions, the diac blocks the flow of current and effectively behaves as an open circuit, $+V_{B0}$ and $-V_{B0}$ are breakdown voltage.

B. Conduction state (ON state) :

When the positive or negative applied voltage is equal to or greater than the breakdown voltage, diac begins to conduct and the voltage drop across it becomes a few volts called as 'break back' voltage.

At this point, avalanche breakdown of the reversed biased junction occurs and the device exhibits -ve resistance i.e. current through the device increases with decreasing values of applied voltage.

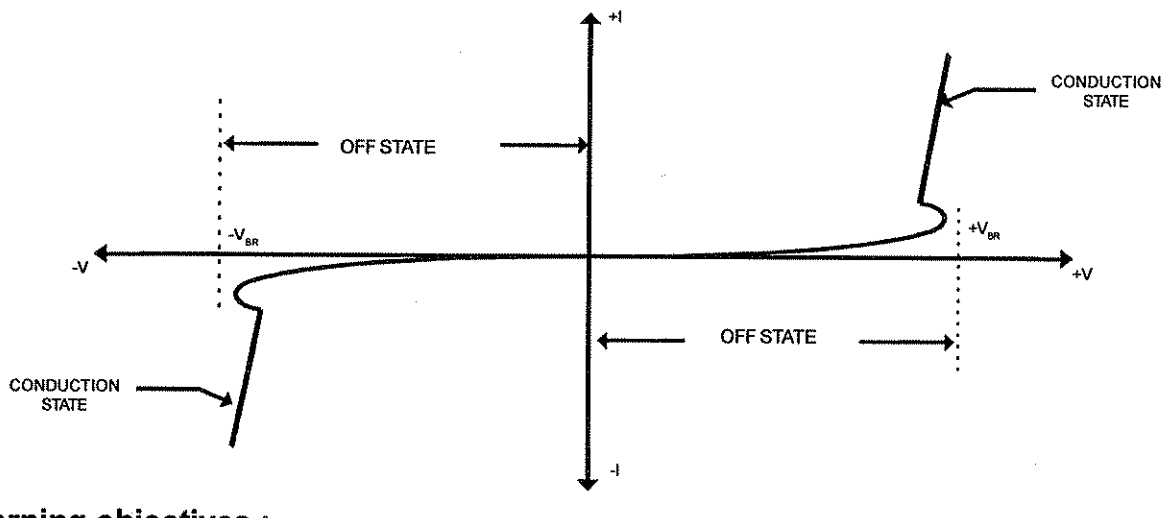
Concept Structure :

Regions of VI characeristics

- OFF state (blocking state)
- ON state (Conduction state)

Proposition 3 : DIAC characteristics

It is the curve drawn between voltage across terminal MT_1 and MT_2 & current. -



4.0 Learning objectives :

Intellectual Skills :

- To understand the effect of changing the polarity of I/P signal on conduction of Diac.
- To identify different regions in VI characteristics.

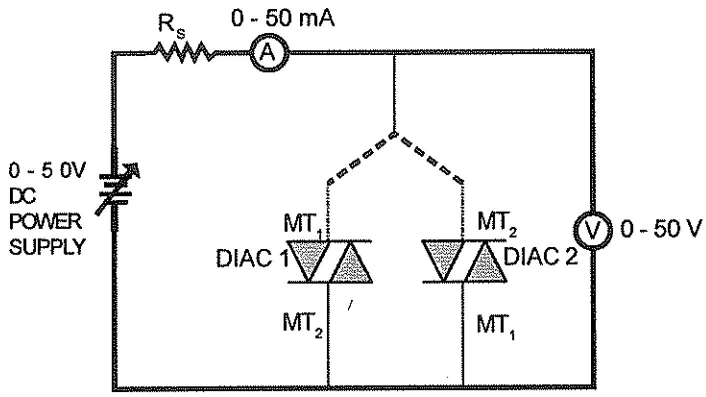
Motor Skills:

- Ability to make the connections.
- Ability to interpret different regions on graph.
- Ability to confirm that diac is a bidirectional device.
- Ability to observe and note the voltages and current and record them.

5.0 Apparatus :

- 0 - 50V DC power supply.
- 0 - 50 mA ammeter.
- 0 - 50 V voltmeter.

6.0 Circuit diagram :



7.0 Stepwise procedure :

1. Connect the milliammeter, DIAC, Voltmeter to the circuit.
2. Switch ON the power supply.
3. Increase supply voltage in steps, note the corresponding currents and voltages for each step.
4. Plot graph of VI characteristics.
5. Reverse the Terminal of Diac. Increase supply voltage in steps, note the corresponding currents and voltages for each step.
6. Plot graph of VI characteristics.

8.0 Observations :

For DIAC 1

Reading for voltage and current MT_1 is +ve and MT_2 is –ve	
O/P voltage (V)	Current (mA)

For DIAC 2

Reading for voltage and current MT_2 is +ve and MT_1 is –ve	
O/P voltage (V)	Current (mA)

9.0 Conclusion :

- In the VI characteristics of DIAC, when voltage increases current .... (increases / decreases / remains) in conduction state.
- Diac is a .... (unidirectional / bidirectional) device.
- Student to write conclusion on the behaviour of DIAC as a switch under guidance of teacher

....

....

10.0 Questions :

Write answers to Q..... Q..... Q..... Q..... Teacher shall allot the questions.

1. Diac resembles a Bipolar transistor with no base connection. Justify the statement.
2. Write three specifications of Diac.
3. DIAC is not a controlling device. Give reason.
4. Write two applications of Diac.
5. Name the device D in the following fig. 1

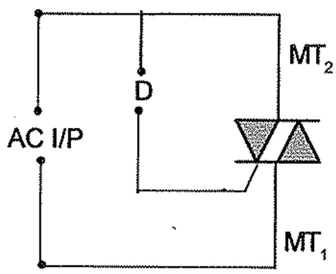


fig. 1

6. Refering above fig. 1 state whether the device D is used for A.C. or D.C.
7. Write the fulform of DIAC.
8. Write two difference between DIAC and SBS.
9. Can DIAC control AC power. Justify statement by giving reason
10. Draw DIAC from SBS.
11. Write two differences between SCR and DIAC.
12. Give the names of two bidirectional triggering devices.

Note : Teacher shall add few questions.

13...

....

14 ....

....

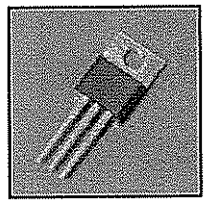
15...

....

(Space for answers)

Signatue of teacher

EXPERIMENT No. 6



1.0 Title :

To draw V-I characteristics of TRIAC for different values of gate currents

2.0 Prior Concepts :

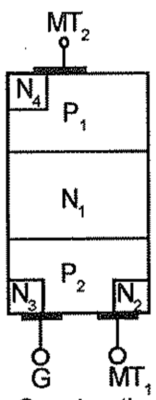
- SCR
- PN Junction
- Characteristics of SCR

3.0 New Concepts :

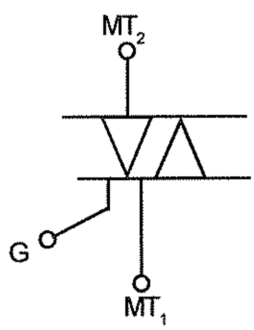
Proposition 1 : TRIAC

It is a three terminal device which can conduct in either direction when triggered either by a positive or a negative pulse irrespective of the polarity of the voltage across its main terminals. It is a bidirectional device. The three terminals are named as main terminal1 (MT_1), main terminal 2 (MT_2) and gate. Gate is a control terminal. Since the triac conducts in both directions, the two terminals are desigated by numbers instead of anode and cathode as in SCR.

Concept structure:



Construction

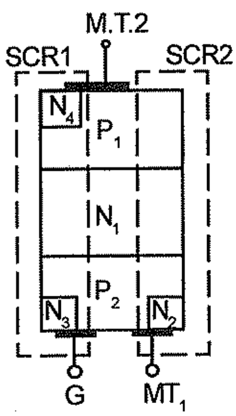


Symbol

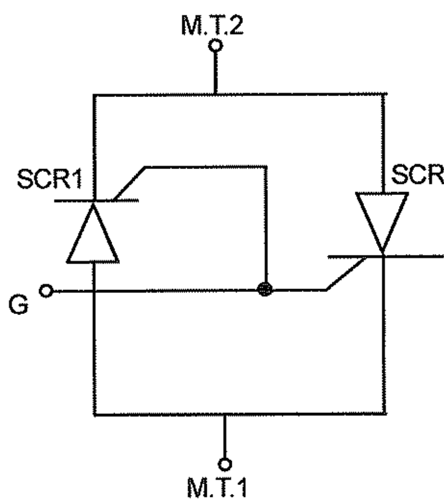
Proposition 2 : Two SCR version of TRIAC.

Triac is equivalent to two SCRs connected in parallel but in reverse direction with common gate terminal.

Concept Structure :



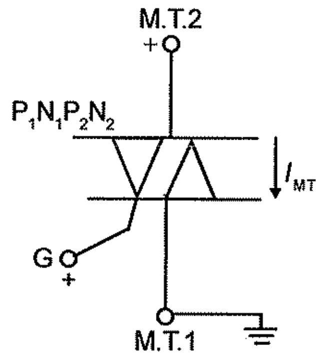
Construction



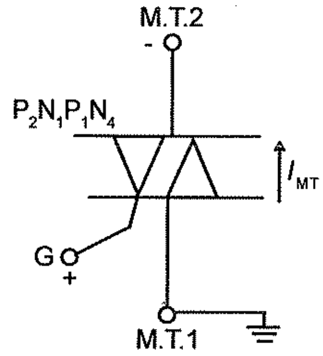
Proposition 3 : Operation of TRIAC

There are four modes of triac operation, depending upon the polarity of voltage across its main terminals and gate terminal. These modes are described as below:

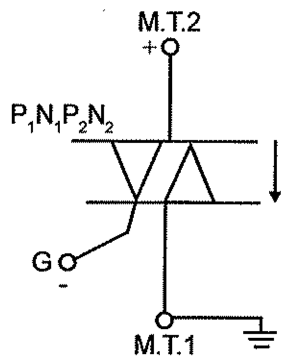
Concept Structure :



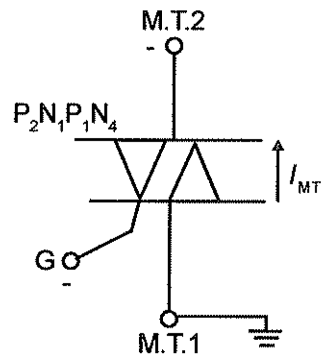
(a) Mode 1



(b) Mode 2



(c) Mode 3



(d) Mode 4

1. M. T. 2 is positive and G is positive. In this mode, the operation of the triac is identical to SCR. The current flows through the switch $P_1N_1P_2N_2$ from M.T.2 to M.T.1 as shown in fig. (a)
2. M. T. 2 is negative and G is positive. In this mode, the current flows through the switch $P_2N_1P_1N_4$ from M.T. $_1$ to M.T.$_2$ as shown in fig. (b). This is an inefficient mode and must be avoided.
3. M. T. 2 is positive and G is negative. In this mode, the current flows through the switch $P_1N_1P_2N_2$ from M.T. 2 to M.T.1 as shown in fig. (c). This mode is less efficient than mode 1 but not as poor as mode 2.
4. M. T. 2 is negative and G is negative. In this mode, the current flows through the switch $P_2N_1P_1N_4$ from M.T. 1 to M.T. 2 as shown in fig. (d). This mode is slightly less efficient than mode 1

The mode 1 and mode 4 are efficient modes in triac operation. Therefore these two modes are called normal modes of triac operation.

Proposition 4 : VI Characteristics of TRIAC.

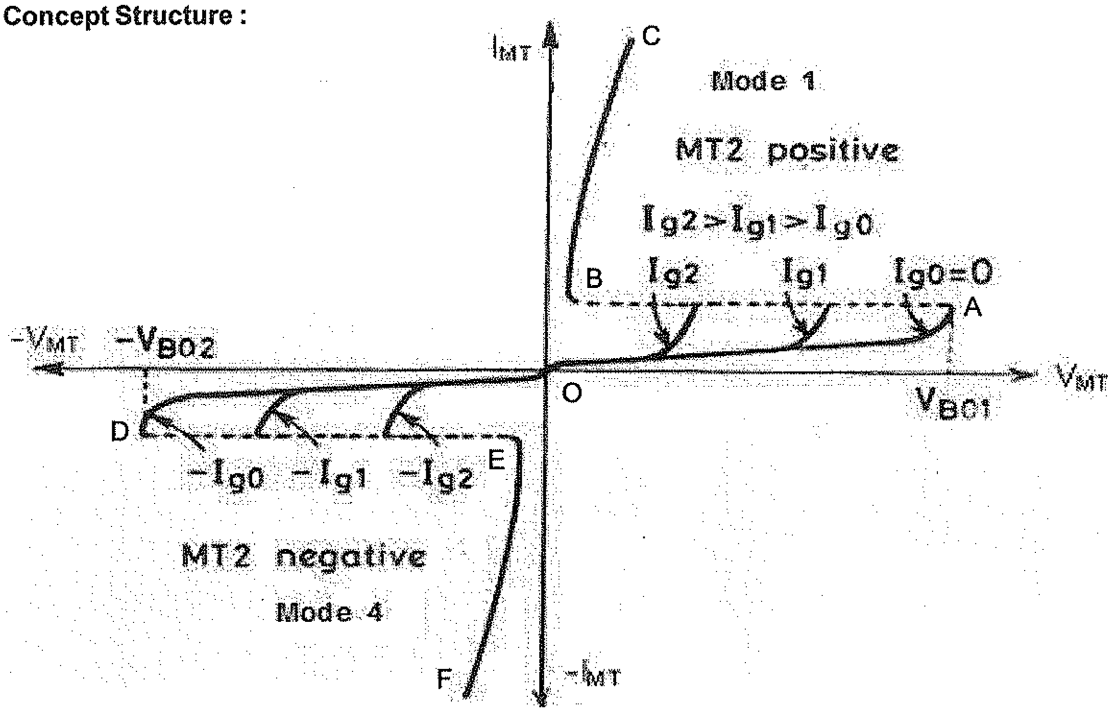
It gives the relationship between the TRIAC current and the voltage applied across its two main terminals. As discussed in proposition 3, triac is operated in two ways.

a) M.T. 2 and gate both positive w.r.t. M.T.1(Curve OABC)

b) M.T.2 and gate both negative w.r.t. M.T.1 (Curve ODEF)

In first case current flows from MT2 to MT1. and in the second case current flows from MT1 to MT2.

Concept Structure :



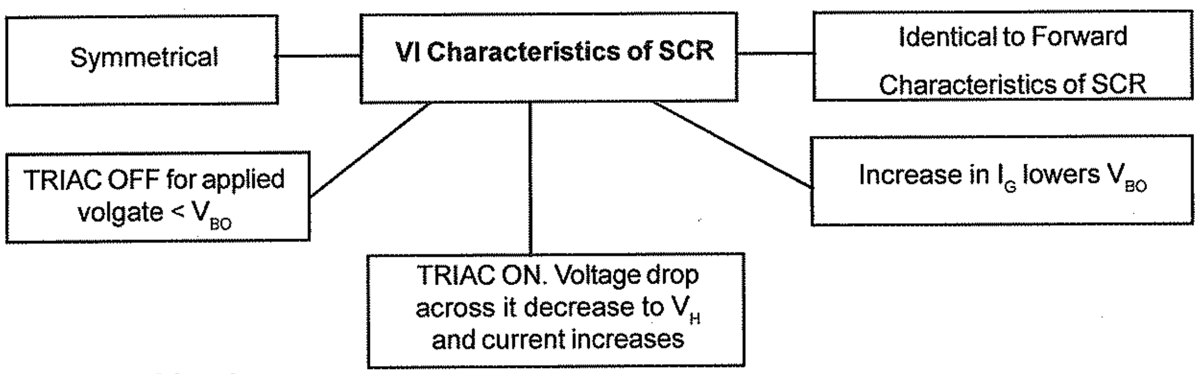
Note :

V_{MT} = Voltage across main terminal of TRIAC

I_{MT}= Current through TRIAC.

V_{BO1} ,V_{BO2} = Break over voltage.

I_G = Gate current.



4.0 : Learning objectives.

Intellectual Skills :

- To identify the components and equipment.
- To understand the behaviour of TRIAC by observing variations in current with respect to voltage across MT_1 and MT_2.
- To predict the effect of gate current on the characteristics.
- To identify differnet regions on the characteristics

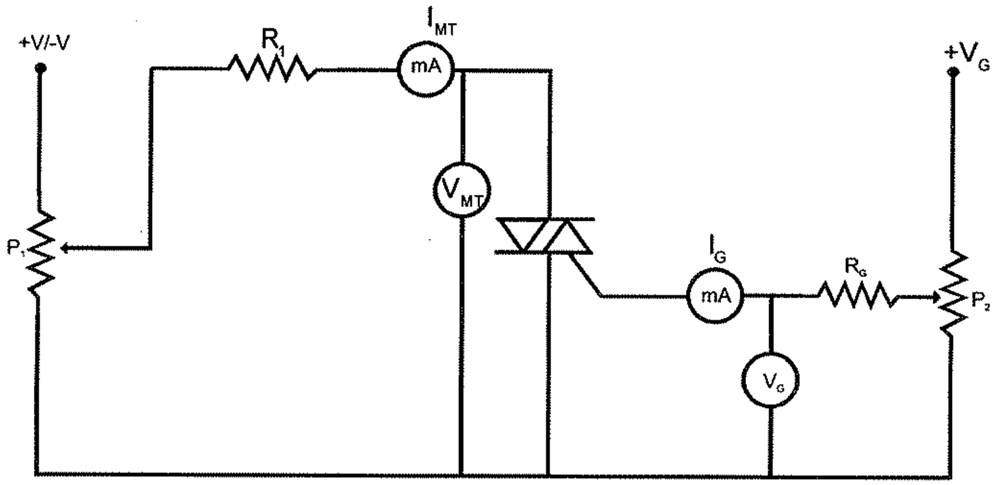
Motor Skills:

- Ability to make the connections as per circuit diagram.
- Ability to measure voltage and currents using meters.
- Ability to plot charactristics using observations.

5.0 : Apparatus :

Experimental Kit, Multimeters (2), Milliammeters (2) Regulated Power Supply (2)

6.0 : Circuit diagram :



7.0 Stepwise procedure :

1) Make connections as per the circuit diagarm.
2) Rotate potentiometers P_1 and P_2 for minimum resistance.
3) Switch on the power supply.
4) Put the switch towards +V.
5) Vary potentiometer P_2 to set gate current I_G to a lower value.
6) Increase voltage V_{MT} gradually by varying potentiometer P_1.
7) Observe the current in ammeter 1. It will show zero current in initial stage.
8) Try various values of gate current. Vary voltage by P_1 and note down current I_{MT}.
9) Note down voltage V_{MT} and corresponding current I_{MT} after firing of TRIAC
10) Note down readings in table 1
11) Rotate potentiometer P_1 fully counterclockwise
12) Put the switch towards -V and repeat from step 3 and note down the readings in observation table 2.
13) Plot the graph of V_{MT} versus I_{MT} for the reading in both tables.

8.0 Observations :

Table 1

Sr. No.	Voltage V_{MT}	Current I_{MT} at constant value of Gate current when switch is towards +V	
		I_G = ------------mA	I_G = ------------mA
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			

Table 2

Sr. No.	Voltage V_{MT}	Current I_{MT} at constant value of Gate current when switch is towards - V	
		I_G = ------------mA	I_G = ------------mA
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			

9.0 Result :

V_{BO} = ... V for I_G = ... mA

V_{BO} = ... V for I_G = ... mA

V_{BO} = - .... V for I_G = ... mA

V_{BO} = - .... V for I_G = ... mA

10.0 Conclusions :

- The characteristics has .... (same / different) shape in I and III quadrant
- As I_G increases, V_{BO} .... (increases / decreases)
- Students to write conclusion on the basis of ON and OFF condition of TRIAC by observing characteristics.

....

....

11.0 Questions :

Write answers to questions Q. ...... Q...... Q...... Q...... (Teacher shall allot questions)

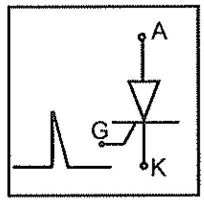
1) Why TRIAC is called bidirectional controlled device?
2) What is meant by holding current? State its significance.
3) What is meant by latching current?
4) What are the diffrent modes of operation of TRIAC?
5) If the gate voltage is same, will the V_{BO} change with MT_1 positive and MT_1 negative?
6) Justify the name TRIAC?
7) What is the effect of gate voltage once TRIAC comes in ON condition?
8) Is TRIAC a switch? Explain.
9) What is advantage of TRIAC over SCR?
10) What is limitation of TRIAC in comparison to SCR related to power handling capacity?
11) How will you get the function of TRIAC using SCRs?
12) How does a traic differ from DIAC?
13) Usually triac is triggerd by a diac Why?
14) Why the terms anode and cathode are not applicable for terminals of TRIAC ?
15) Name the device which is used to switch large power thyristor circuitry or a low power controlling device

(Space for answers)

(Space for answers)

Signatue of teacher

EXPERIMENT No. 7



1.0 Title :

To understand working of pulse triggering circuit using UJT

2.0 Prior Concepts :

- SCR (Silicon Controlled Rectifier).
- Unijunction transistor as relaxation oscillator.

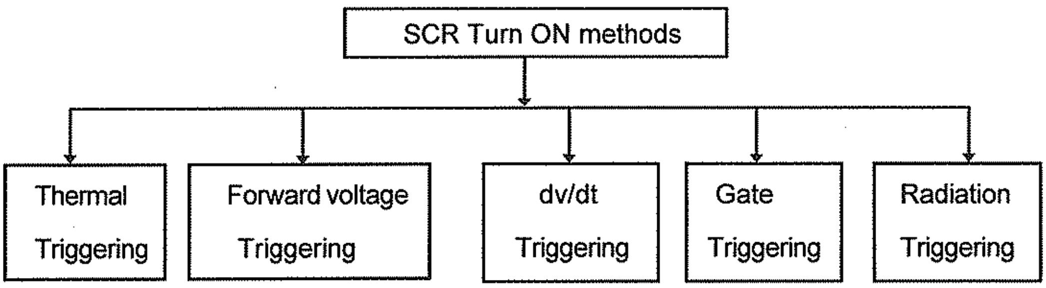
3.0 New Concepts :

Proposition 1 : Gate triggering of SCR

The SCR can be switched into conduction either by increasing the forward voltage beyond V_{BO} or by applying a positive gate signal when the device is forward biased. This second method is called the gate triggering of SCR.

It is more efficient and easy to implement for power control.

Concept structure :

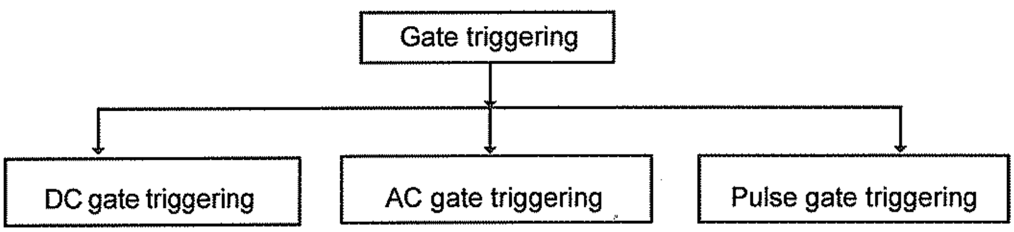


Proposition 2 : Methods of gate triggering

There are methods for gate triggering namely triggering by DC gate signal , AC gate signal or pulsed gate signal.

For gate triggering, signal is applied between gate and cathode.

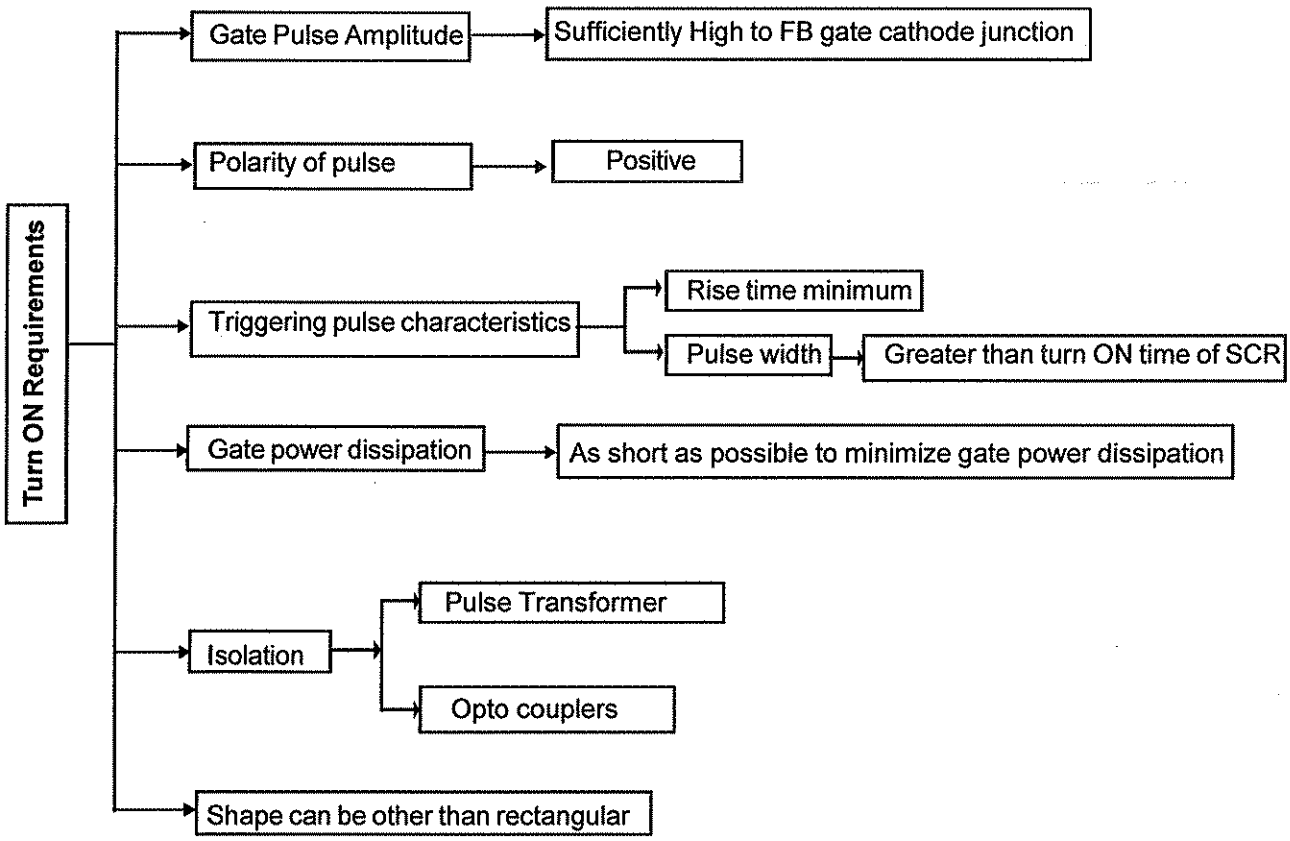
Concept structure :



Proposition 3 : Turn ON requirements

To turn ON SCR successfully using the pulse triggering techniques, various points must be carefully considered.

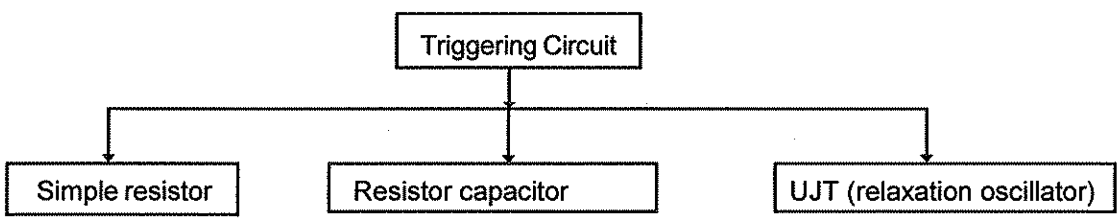
Concept structure :



Proposition 4 : Gate triggering circuits

The triggering circuits are designed by considering the gate pulse amplitude, polarity, characteristics etc. (Refer proposition 3)

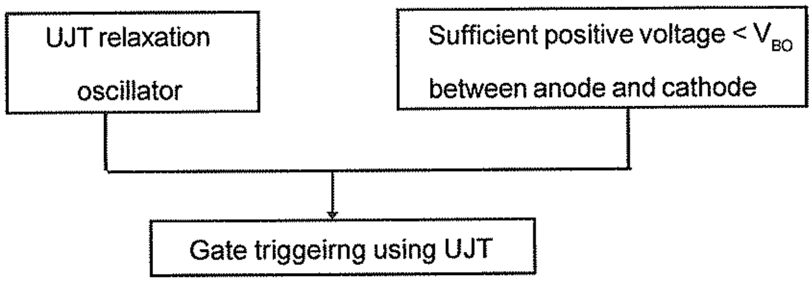
Concept structure :



Proposition 5 : Gate triggering of SCR using UJT

The UJT relaxation oscillator produces positive pulses at point B at a rate determined by the resistor (R) and capcitor (C). These pulses are applied to the gate of SCR to turn it ON. A fixed voltage is applied between anode and cathode and a triggering pulse of sufficient amplitude triggers the SCR.

Concept structure :



4.0 Learning objectives.

Intellectual Skills :

- To identify components on the experimental kit.
- To understand specifications of SCR related to experiment eg. V_{BO}, I_A etc.
- To understand values of components used in the circuit.
- To understand the concept of finding out triggering voltage of SCR.

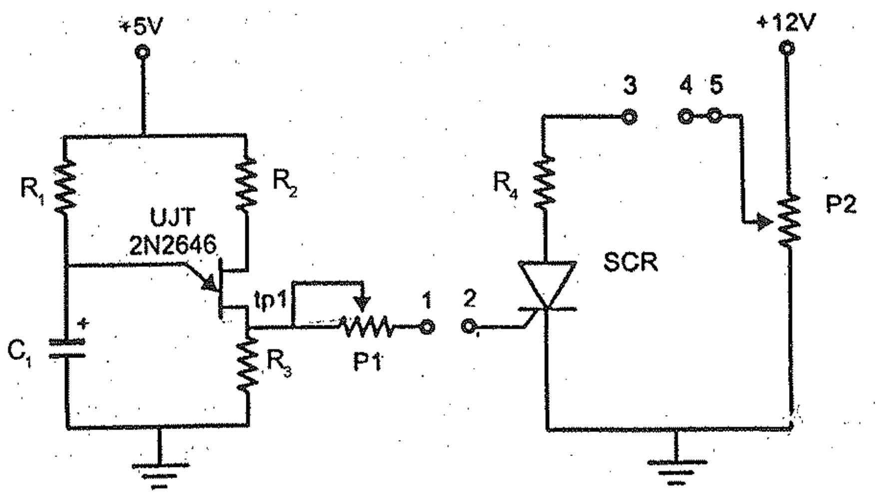
Motor Skills:

- Ability to make the connections as per the circuit diagram.
- Ability to measure and note down the currents and voltages.

5.0 Equipments :

- Experimental kit
- Variable DC regulated power supply (0 - 30v) - 2 Nos.
- Milliammeters - 2 Nos.

6.0 Circuit diagram :



7.0 Stepwise Procedure :

1. Make connections as shown in circuit diagram
2. Connect ammeter between points '3' and '4' to measure Anode cathode current $I_{AK(mA)}$
3. Connect ammeter between points '1' and '2' to measure gate current $I_{G(mA)}$

4. Connect voltmeter between points '5' and ground to measure the anode cathode voltage $V_{AK.}$
5. Rotate the potentiometer P1 fully in clockwise direction and P2 fully in the counterclockwise direction.
6. Switch on the power supply.
7. Vary the potentiometer P2 in clockwise direction so as to increase the anode to cathode voltage. Set this voltage to 11 V.
8. Vary the potentiometer P1 in counterclockwise direction so as to increase the value of gate current in step and measure the corresponding values of anode to cathode current $I_{AK.}$.
9. Initially there will not be any current flow across the SCR, while varying the gate current, the current in the ammeter connected at point '3' and '4' suddenly increases and the voltmeter connected at point '5' and ground will suddenly decrease.This shows that SCR is triggered
10. Now vary the P1, there will not be any effect in the anode-cathode voltage and current of SCR.
11. Follow the procedure from step 6 to repeat the procedure for different $V_{AK.}$

8.0 Observations :

Reading for Anode to Cathode Current , Anode to Cathode Voltage and gate current.

Set V_{AK} = 11V

S.NO.	Gate Current I_G(mA)	Anode to cathode current I_{AK} (mA)	Anode to cathode Voltage V_{AK}.(V)
1			
2			
3			
4			
5			

Set V_{AK} = 9V

S.NO.	Gate Current I_G(mA)	Anode to cathode current I_{AK} (mA)	Anode to cathode Voltage V_{AK}.(V)
1			
2			
3			
4			
5			

9.0 Conclusion :

1. Anode current suddenly .... (increases / decreases) when SCR is triggered.
2. Once SCR is triggered, there will be .... (increase in, decrease in, no effect on) anode to cathode voltage and anode current.
3. Students to write conclusion on the basis of effect of V_{AK} on triggering of SCR.

....

....

10.0 Questions :

Write answer to Q. ...., Q........., Q........, Q.......... Teacher shall allot the questions.

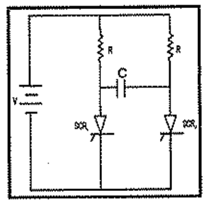
1. What is the method of triggering used in this circuit?
2. What is the limit on forward anode to cathode voltage to trigger it by gate triggering method?
3. What type of pulses are available at the base 1 of relaxation oscillator?
4. How will you change the amplitude of the pulses at the B1 of UJT?
5. What is the need for triggering of SCR?
6. What is the advantage of using UJT as a triggering device for SCR?
7. What other devices or components can be used to trigger SCR?
8. How does the negative resistance characteristics of UJT help us to use it as a triggering device?
9. State the meaning of firing angle of SCR?
10. State the situation to change the firing angle using this experiment.
11. List any four requiremnts of pulse to turn ON SCR.
12. Which method is preferred to turn ON SCR?
13. What are the limitations on the triggering pulse characteristics related to its width and amplitude ?
14. What is the function of UJT relaxation oscillator in this circuit?
15. What are the advantages of pulse triggering over R and RC triggering circuits?

(Space for answers)

(Space for answers)

Signatue of teacher

EXPERIMENT No. 8



1.0 Title :

To turn OFF SCR using Class C commutation Method and observe the waveforms at different points.

2.0 Prior Concepts :

- SCR
- Triggering of SCR

3.0 New Concepts :

Proposition 1 : Commutation of SCR

It is the process to turn OFF conducting SCR. There are two ways of commutating an SCR.

- By reducing the forward current through the SCR below its holding current called as current commutation.
- By applying a large reverse voltage across the SCR called as voltage cummutation.

Concept structure:

Commutation of Thyristor

(Ways)

Current commutation | **Voltage Commutation**

Proposition 2 : Types of commutation:

The two types of commutation

- Natural Commutation : When the thyristor is turned off due to its forward current going below holding current it is said to be natually commutated. Natural commutation takes place in the circuits powered by an altenating supply.
- Forced commulation : When the thyristors operate on a pure DC input voltage, the forward current can not be reduced below holding current naturally. therefore the thyristors must be commutated 'forcibly' by using additional commutation circuit. This is called forced commutation. This external commutation circuit will turn off the SCR by either current or voltage commutation.

Concept Structure :

Types of commutation

- Natural Commutation → Used in circuits powered by AC
- Forced commutation → Used in SCR inverters and Choppers

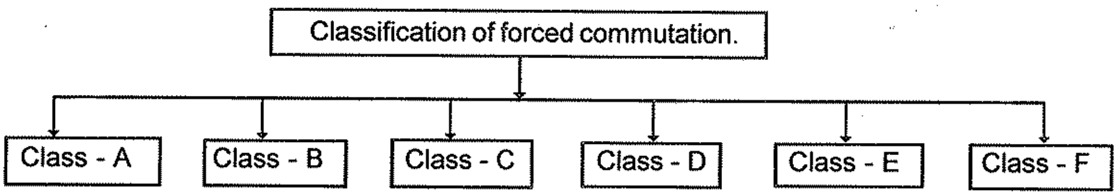
Proposition 3 : Classification of forced commutation methods

There are six different methods of forced commutation.

- Class - A : Self commutated by resonating load

- Class - B : Self commulated by LC circuit.
- Class - C : C or LC switched by another Load carrying SCR.
- Class - D : C or LC switched by an auxilliary SCR.
- Class - E : An external pulse source for commutation.
- Class - F : AC line commutation.

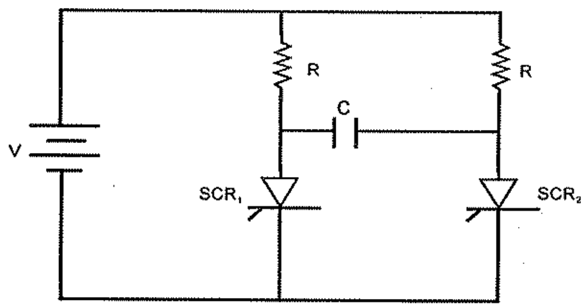
Concept Structure :



Proposition 4 : Class C circuit

SCR_1 and SCR_2 are capable of handling the load. C is the commutating capacitor and voltage across it is used to commutate the conducting SCR. Hence class C commutation is voltage commutation. R is load resistance

Concept Structure:



Proposition 5 : Modes of operation:

Before SCR_1 is triggerd and SCR_2 is conducting

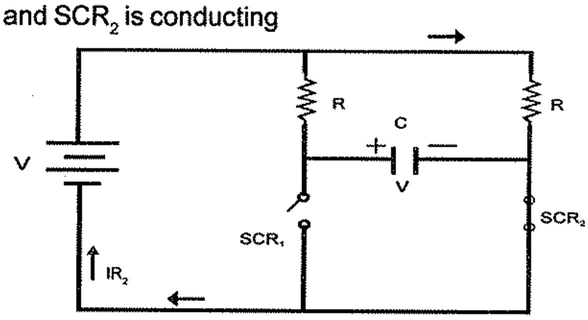


Fig. (a)

Mode I (t_0 to t_1)

At t_0 SCR_1 is triggered. Voltage across C reverse biases SCR_2 and it is turned off I_{R1} = V/R flows through SCR_1.

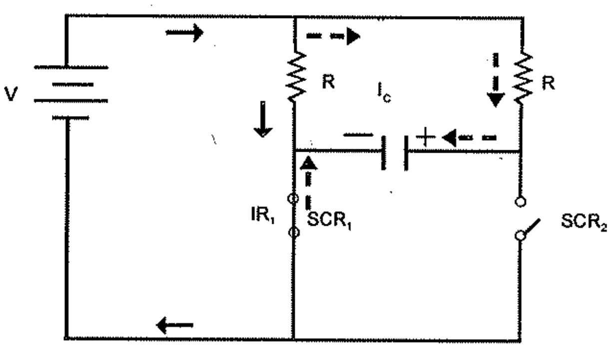


Fig. (b)

Mode II (t_1 to t_2)

At t_1 , I_C = O voltage acros C = V with potarities as shown in Fig. (C) SCR_1 continous to conduct load current I_{R1} = V/R.

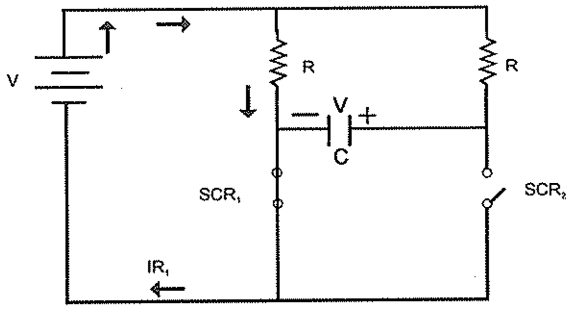


Fig. (c)

Mode III (t_2 to t_3)

At t = t_2, SCR_2 is turned ON. Commutating capacitor C applies reverse voltage across SCR_1 and turn it OFF. Current through SCR_2 = I_{R2} + I_C. At t_3, capacitor is fully charged.

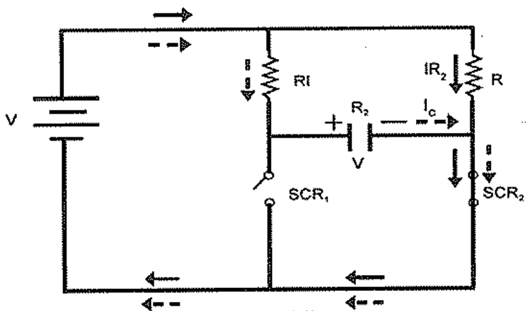


Fig. (d)

Mode IV (t_3 to t_4)

A t = t_3 , SCR_1 capacitor is fully charged, I_C = 0 and V_{SCR2} = V. Voltage across C is constant with polarities as shown in Fig (e)

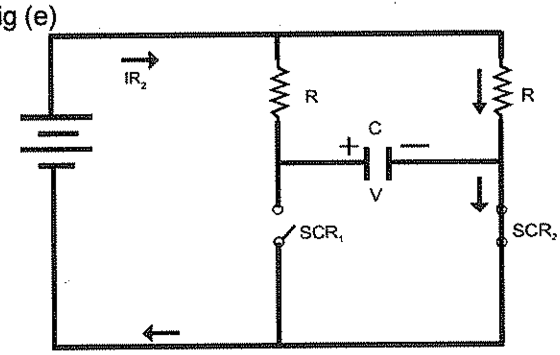
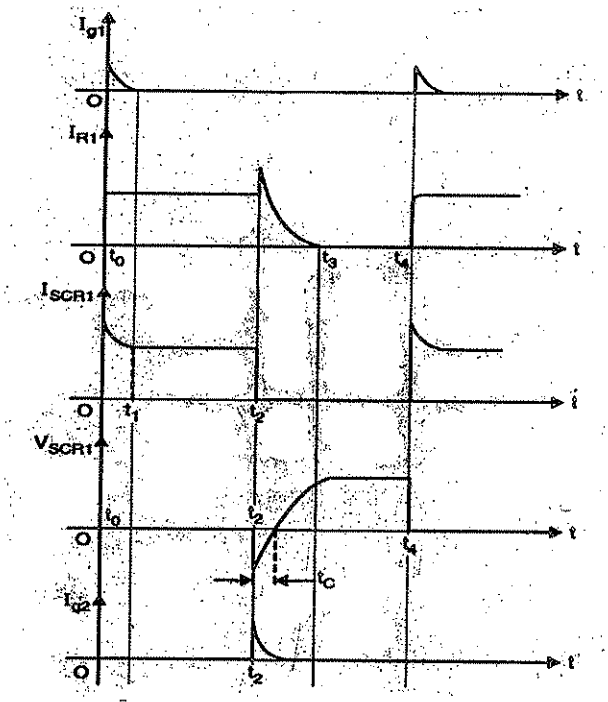


Fig. (e)

At t = t_4, SCR_1 is triggered again to turn OFF SCR_2 and the cycle of operation repeats itself

Concept Structure:



4.0 Learning objectives :

Intellectual Skills :

- To identify the components.
- To understand the ways of turning off SCR.
- To understand the concept of commutation.
- To analyse the waveforms of currents and voltages.

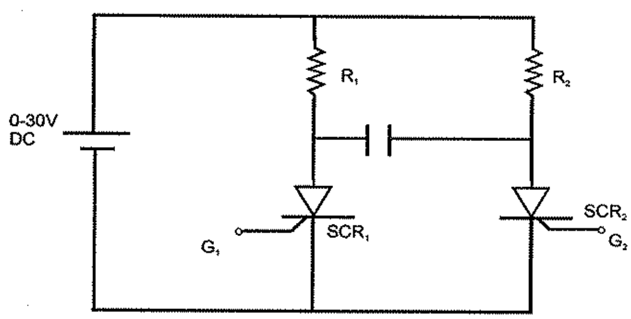
Motor Skills:

- Ability to make connections as per circuit diagram.
- Ability to observe waveforms of voltages and currents using CRO.
- Ability to plot the waveforms on graph paper.

5.0 Apparatus :

- Experimental Kit
- Variable DC regulated power supply (0 - 30V)
- CRO

6.0 Circuit diagram :



Note : At G_1 and G_2, the signals are to be supplied from a proper triggering circuit.

7.0 Stepwise procedure :

- Connect the circuit as shown in Figure.
- Connect G1 and G2 signals to gate of SCR.
- Switch ON the power supply.
- Connect oscilloscope across load resistance and observe waveforms.
- Draw the waveforms on graph paper.

8.0 Conclusion:

- When SCR_1 is triggered, the voltage across commutating capacitor .... (reverse biases / Forward Biases) the conducting SCR_2.
- The SCR turns off in this method due to .... (voltage / current) commutation.
- Students to write conclusion on the basis of variation of voltage by observing voltage waveform across SCR.

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9.0 Questions :

Write answer to Q. ...., Q........., Q........, Q.......... Teacher shall allot the questions.

1. What are the different ways of turning Off an SCR?
2. What is meant by natural commutation ?
3. Define forced commutation.
4. What should be the value of thyristor forward current to turn it off?
5. In which method of commutation, LC circuit is used in series of SCR?
6. What are the six basic methods of forced commutation?
7. In DC application, which commutation method is preferred?
8. What is the limitation of circuit recovery time in class C commutation?
9. State advantages of class C commutation.
10. What are the devices used for commutation of thyristor ?
11. What is another name for class C commutation ?
12 Compare Class B and Class C commutation in context to their circuit.
13. State two applications of class C commutation.

Note : Teacher shall add few questions as numbered below.

14..

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15..

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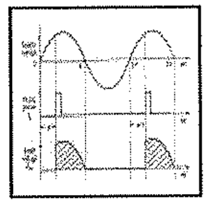
Signature of teacher

EXPERIMENT No. 9

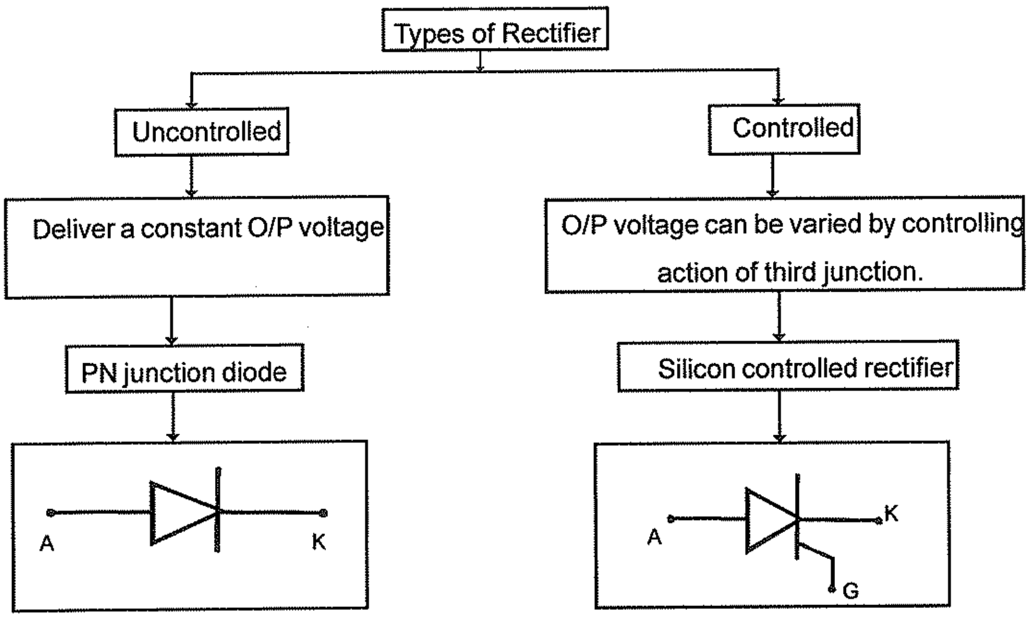


1.0 Title :

To understand operation and draw waveforms of single phase half wave controlled rectifier with R load.

2.0 Prior Concepts :

- Rectifier (uncontrolled) : A circuit which converts AC to DC.
- Types : Two types of rectifier
    - Controlled rectifier
    - Uncontrolled rectifier



- Phase controlled rectifier : A circuit which converts AC input voltage to a controllable DC output voltage.
- SCR : A silicon controlled rectifier is a three terminal, four layer, three junction device.

3.0 New Concepts :

Proposition 1 : Types of single phase controlled rectifiers

Different types of single phase controlled rectifiers are

- Half wave controlled rectifier
- Full wave controlled rectifier
- Half controlled bridge rectifier
- Full controlled bridge rectifier

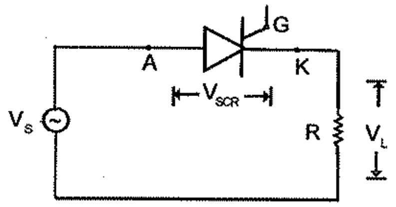
Proposition 2 : Basic principle of single phase controlled rectifier

The basic principle of phase -controlled rectifier is to control the point in time at which the SCRs are allowed to conduct during each AC cycle.

Thus it is possible to select the time segments of the AC voltage waves which appear at the DC terminals and the mean output voltage is controlled continuously.

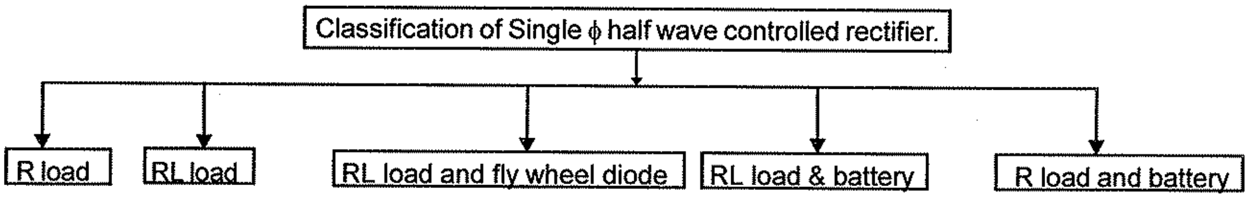
When the voltage across SCR is negative, they are turned off.

Concept Structure :



Proposition 3 : Single phase half wave controlled rectifier with load classification

In Single phase half wave controlled rectifier circuit there is only one SCR used.

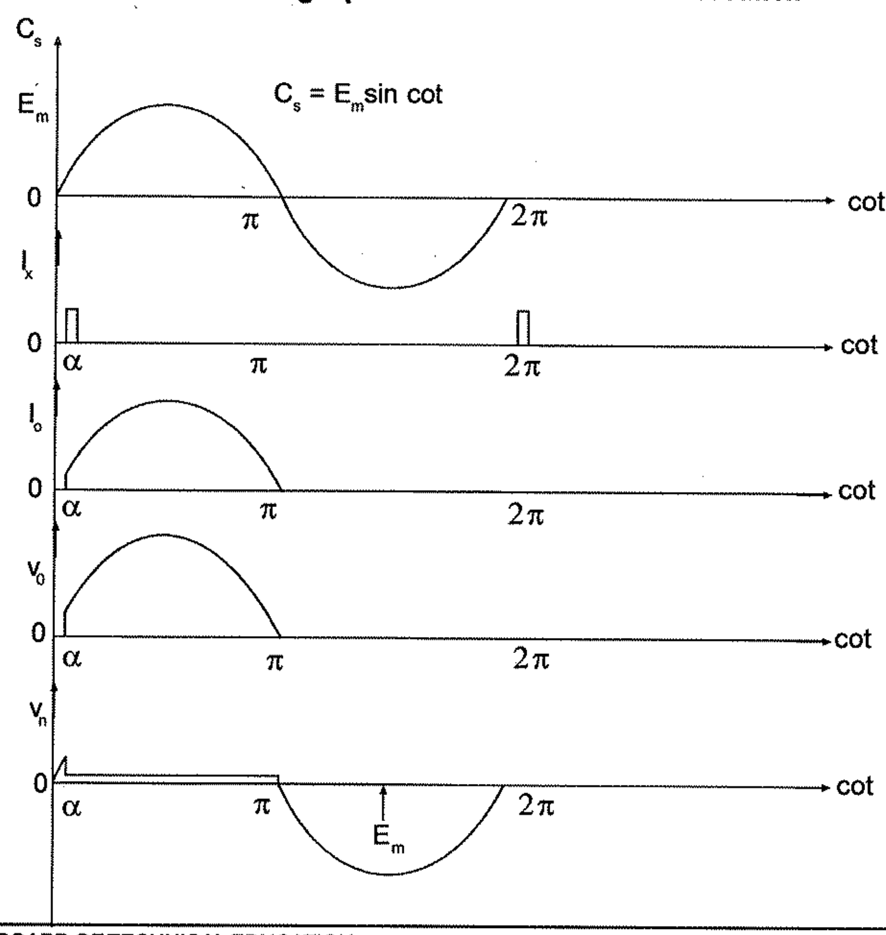


Proposition 4 : Working principle of single phase half wave controlled rectifier

The working principle of single phase half wave controlled rectifier is as follows :

- During positive half cycle of supply voltage, i.e. when the anode of SCR is positive with respect to cathode and the SCR is fired, power is delivered to the load.
- During negative half cycle, the SCR is reverse biased and blocks the line voltage and no current can flow through the load.

Proposition 5 : O/P waveforms of single phase half wave controlled rectifier.



4.0 Learning objectives.

Intellectual Skills :

- To understand SCR as a controlled rectifier.
- To discriminate between half wave controlled rectifier and half wave uncontrolled rectifier.
- To interpret different waveforms.

Motor Skills:

- Ability to observe waveforms and interpret.
- Ability to change firing angle and observe waveforms.

5.0 Apparatus :

- Trainer kit
- Power Supply
- Connecting wires
- CRO (Cathode Ray Oscilloscope)

6.0 Circuit diagram : (Student shall draw)

7.0 Stepwise procedure :

1. Make the connections as per circuit diagram.
2. Switch ON power supply.
3. Apply gate triggering voltage at firing angle α_1 and observe the waveform at load R.
4. Repeat step 3 by changing firing angle as α_2 and α_3
5. Draw graph for different firing angles.

8.0 Observations:

Readings for variation of load voltage with supply voltage at different values of α

For α = 30

V_S (V)	V_L (V)

For α = 45

V_S (V)	V_L (V)

For α = 60

V_S (V)	V_L (V)

9.0 Conclusion :

- As firing angle is increased, the voltage across load .... (increases/decreases/remains constant)
- Phase controlled rectifier circuits convert AC input voltage to a .... (controllable / uncontrollable) DC voltage.
- Student to write conclusion on the basis of output waveform at R load under guidance of teacher.

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9.0 Questions :

Write answer to Q. ...., Q........., Q........, Q.......... Teacher shall allot the questions.

1. Write two differences between SCR and diode.
2. Write two differences between controlled rectifier and uncontrolled rectifier.
3. State two applications of controlled rectifiers.
4. Define the following terms
   1. Form factor
   2. Ripple factor
   3. Utility factor
5. Half wave controlled rectifier have high percentage of ripple (say true or false) . What is the remedy?
6. Define:
   1. Direct current
   2. Alternating current.
7. Silicon diodes are preferred over germanium diode in rectifiers. State reasons.
8. Define an ideal rectifying element.
9. Why semiconductor diodes are preferred over gas tubes? Give reason.
10. Does type of load affect the behaviour of rectifier?
11. Write differences between half wave controlled rectifier with R load and RL load.

Note : Teacher shall add few questions.

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13...

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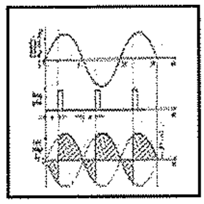
Signature of Teacher

EXPERIMENT No. 10

1.0 Title :



To draw waveforms of single phase fully controlled bridge rectifier with RL load

2.0 Prior Concepts :

- Controlled rectifiers : Rectifier circuit using SCR is a controlled rectifier.
- Single phase half wave controlled rectifier.
- Different types of load : R load, RL load.

3.0 New Concepts :

Proposition 1 : Types of single phase fully controlled rectifier

The circuit having four SCR's connected in bridge configuration with transformer primary as input is a single phase fully controlled rectifier.

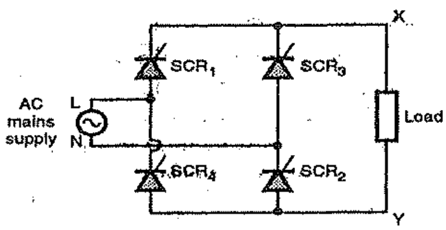
- Single phase fully controlled bridge with RL load.
- Single phase fully controlled bridge with R load.

Concept Structure :

Types of 1ϕ fully controlled rectifier

With R load

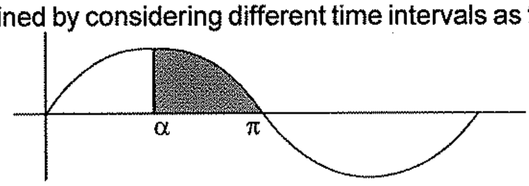
With RL load



Proposition 2 : Working principle of single phase fully controlled rectifier .

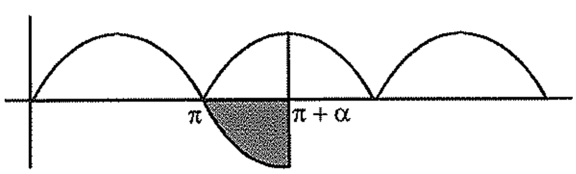
The working principle is explained by considering different time intervals as follows.

MODE - I ($\alpha \leq \omega t \leq \pi$)



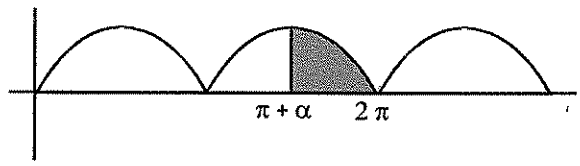
- In positive half cycle of input ac supply, L is positive with respect to neutral N, therefore SCRs 1 and 2 are forward biased and can be turned on at the desired value of α .
- At instant α SCRs 1 and 2 are triggered and load voltage is equal to instantaneous supply voltage.
- SCRs 3 and 4 are commuted that are already conducting as they are reversed biased.
- As polarity of load voltage and load current both is positive, the load inductance will store the energy.

MODE - II ($\pi \leq \omega t \leq \pi + \alpha$)



- At instant π the input AC supply voltage passes through zero, and after π radians it becomes negative. The inductive load will try to oppose any change in current through it and a self induced voltage appears across the load.
- This self induced voltage maintains SCRs 1 and 2 forward biased even if supply voltage is negative.
- The load voltage is negative and equal to instantaneous AC supply voltage whereas load current continues to be positive.

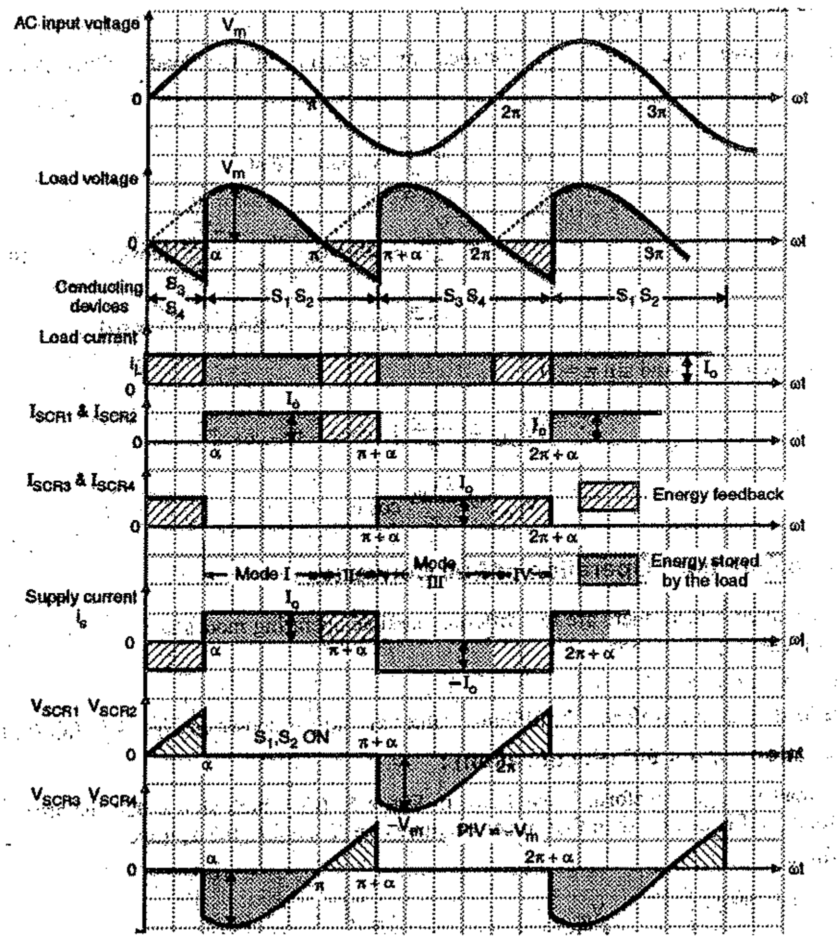
MODE - III $[(\pi + \alpha) \le \omega t \le 2\pi]$



- At instant π + α, SCRs 3 & 4 are turned on and negative input voltage appears across SCRs 1 and 2 and they are commuted.
- The load voltage becomes positive and load current also positive. So load will store energy in this mode.

Proposition 3 : Waveforms

Waveforms of voltages and currents.



Proposition 4 : Different configurations of single phase fully controlled rectifier.

The following are the configurations of 1ϕ fully controlled rectifier

- Midpoint configuration (M_2)
- Bridge configuration (P_2)

4.0 Learning objectives :

Intellectual Skills :

- To identify components and equipments required for the experiment.
- To discriminate the functioning of single phase halfwave controlled rectifier and single phase fully controlled bridge rectifier
- To interpret different waveforms.

Motor Skills:

- Ability to observe and draw the waveforms.
- Ability to compare the output of single phase fully controlled bridge circuit with that of single phase halfwave controlled bridge.

5.0 Apparatus :

- Experimental Kit.
- Power Supply (AC).
- Connecting wires.
- CRO

6.0 Circuit diagram :(Student to draw)

7.0 Stepwise procedure :

1. Rotate the firing control Potentiometer in full clockwise direction.
2. Switch ON the power.
3. Measure the ac voltage (Vrms) by voltmeter and calculate Em by Em = 1.414 x Vrms.
4. Switch OFF the power.
5. Connect the circuit of fully-controlled bridge rectifier .
6. Switch ON the power.
7. Connect the oscilloscope and voltmeter across the load.
8. Vary the firing control pot and set on 30^0, 60^0, 90^0, 120^0 and 150^0 firing angles using $T = (\alpha \times 10\ ms)/180$
9. Observe the output waveforms and note the readings of voltage across load on different firing angle.
10. Connect the oscilloscope one by one across SCR1, SCR2 and SCR3 and SCR4 and observe the waveforms.

8.0 Observations :

Readings for Input and Load Voltage

Sr. No.	Input AC Voltage		Firing Angle		Average Output Voltage Across Load		Average Load current (Idc)	
	In (V_{RMS})	In (V_M)	In (Deg.)	In Time (ms)	Measured Voltage (Vo)	Calculated Voltage (Vdc)	Measured (Io) Vo/R_L	Calculated (Idc) Vdc/R_L

9.0 Conclusion :

- In single phase fully controlled bridge the average output voltage becomes ....

  (Zero / Positive Maximum / Negative Maximum) at $\alpha = \frac{\pi}{2}$
- The load voltage has a .... (negative value / positive value) from π to $\alpha + \pi$ in single phase fully controlled bridge rectifier.
- Student to write conclusion on the basis of load current in the waveform under the guidance of teacher.

  ....

  ....

10.0 Questions :

Write answer to Q. .... Q.......... Q........ Q......... Teacher shall allot the questions.

1. Compare half and full controlled bridge on the basis of following points.
   - Average load voltage (RL load)
   - Quadrant of operation.
2. Define the following
   - Regeneration
   - Free wheeling.
3. Why semiconverter is preferred over full converter where regenerative braking is not required.
4. State the principle of phase control.
5. Compare phase control using SCR and phase control using UJT.
6. Sketch the output load voltage and load current waveforms for resistive load of single phase fully controlled bridge rectifier.

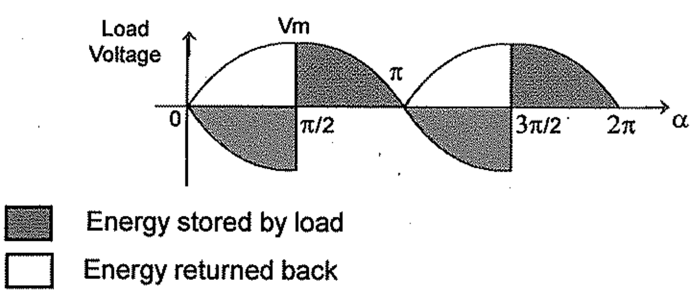
7. For 1ϕ full controlled bridge with resistive load, the table shows average load voltage for different values of α .

α Degrees	0	30	60	90	120	150	180
Average load voltage R Load	0.63Vm	0.59 Vm	0.47 Vm	0.31 Vm	0.16 Vm	0.04 Vm	0

Show graphically the variation of average load voltage with α . From this graph state whether resistive load increases or decreases.

8. Observe the waveforms of single phase full controlled bridge rectifier and state whether the power flow is bidirectional or unidirectional.
9. Which converter is used in Unidirectional DC motor ? (Semiconverter / Full converter /. Half wave converter)
10. Name the converter used in reversible regenerative DC motor controllers.
11. Name the operating mode for $\alpha \leq 90^0$.
12. Which of the following two operating mode is for $\alpha > 90^0$.
   - Rectification
   - Inversion.
13. Draw the circuit diagram of single phase fully controlled rectifier in mode (IV) ($\omega t = 0$ to α or 2π to $2\pi + \alpha$)

   Showing the situation of SCRs 1, 2, 3, 4 as on/off (close / open)
14. In half controlled bridge the average output voltage is zero only at $\alpha = \pi$ .State when average output voltage is zero in case of full controlled bridge.
15. The figure below shows load voltage waveform.



Observe the above waveform and state the value of α for which the above load voltage waveform is drawn.

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Signature of Teacher