POWER ELECTRONICS LAB MANUAL

(NEE-551)

DEPARTMENT OF ELECTRICAL & ELECTRONICS ENGINEERING

27, Knowledge Park-III, Greater Noida, (U.P.)
Phone : 0120-2323854-58
website :- www.dronacharya.info

CONTENTS

SYLLABUS

NEE-551: POWER ELECTRONICS LAB **L T P**
0 0 3

Note: Minimum of nine experiments from the following:

1. To study V-I characteristics of SCR and measure latching and holding currents.
2. To study UJT trigger circuit for half wave and full wave control.
3. To study single-phase half wave controlled rectified with (i) resistive load (ii) inductive load with and without freewheeling diode.
4. To study single phase (i) fully controlled (ii) half controlled bridge rectifiers with resistive and inductive loads.
5. To study three-phase fully/half controlled bridge rectifier with resistive and inductive loads.
6. To study single-phase ac voltage regulator with resistive and inductive loads.
7. To study single phase cyclo-converter
8. To study triggering of (i) IGBT (ii) MOSFET (iii) power transistor
9. To study operation of IGBT/MOSFET chopper circuit
10. To study MOSFET/IGBT based single-phase series-resonant inverter.
11. To study MOSFET/IGBT based single-phase bridge inverter.

STUDY AND EVALUATION SCHEME

SESSIONAL EVALUATION:-

CLASS TEST	**:**	**10 MARKS**
TEACHER'S ASSESMENT	**:**	**10 MARKS**
EXTERNAL EXAM	**:**	**30 MARKS**
TOTAL	**:**	**50 MARKS**

LIST OF EXPERIMENTS

1. To study V-I characteristics of SCR and measure latching and holding currents.
2. To study UJT trigger circuit for half wave and full wave control.
3. To study single-phase half wave controlled rectified with (i) resistive load (ii) inductive load with and without freewheeling diode.
4. To study single phase (i) fully controlled (ii) half controlled bridge rectifiers with resistive and inductive loads.
5. To study three-phase fully/half controlled bridge rectifier with resistive and inductive loads.
6. To study single-phase ac voltage regulator with resistive and inductive loads.
7. To study single phase cyclo-converter
8. To study triggering of (i) IGBT (ii) MOSFET (iii) power transistor
9. To study operation of IGBT/MOSFET chopper circuit
10. To study MOSFET/IGBT based single-phase series-resonant inverter.
11. To study MOSFET/IGBT based single-phase bridge inverter.

INDEX

S.NO.	NAME OF EXPERIMENT	SIGNATURE OF FACULTY/ DATE OF EVALUATION	GRADE

EXPERIMENT NO. 01

1. AIM: Characteristic of silicon-controlled rectifier.

2. APPARATUS REQUIRED:

S.No.	Apparatus / Software Used	Specification	Quantity
1.	SCR Kit		1
2.	Multimeter		2
3.	Patch cards		

3. THEORY:

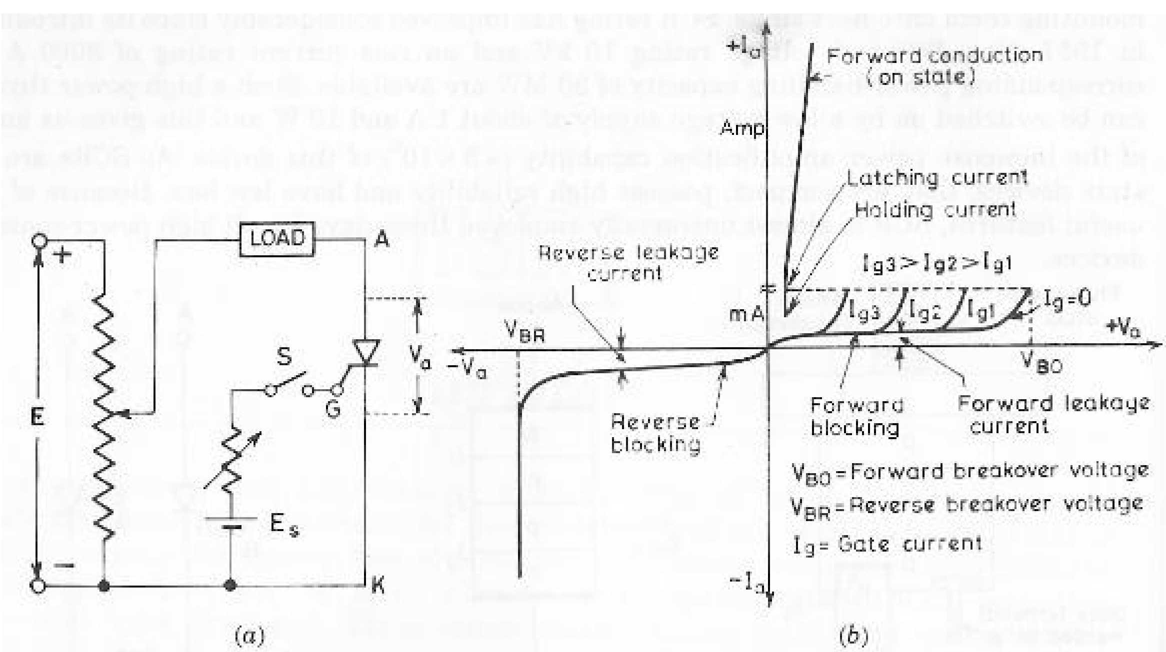


Fig. 4.2. (a) Elementary circuit for obtaining thyristor V-I characteristics
(b) Static V-I characteristics of a thyristor.

An elementary circuit diagram for obtaining static V-I characteristics of a thyristor is shown in Fig. 4.2 (a). The anode and cathode are connected to main source through the load. The gate and cathode are fed from a source E_s which provides positive gate current from gate to cathode.

Fig. 4.2 (b) shows static V-I characteristics of a thyristor. Here V_a is the anode voltage across thyristor terminals A, K and I_a is the anode current. Typical SCR V-I characteristic shown in Fig. 4.2 (b) reveals that a thyristor has three basic modes of operation; namely, reverse blocking mode, forward blocking (off-state) mode and forward conduction (on-state) mode. These three modes of operation are now discussed below:

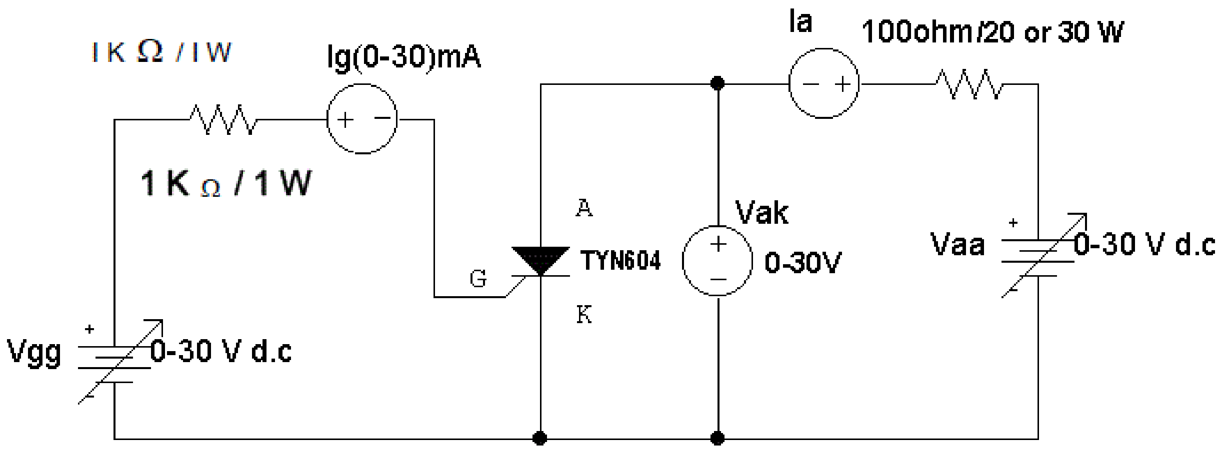
Reverse Blocking Mode: When cathode is made positive with respect to anode with switch S open, Fig. 4.2 (a), thyristor is reverse biased as shown in Fig. 4.3 (a). Junctions J1 J_3 are seen to be reverse biased whereas junction J_2 is forward biased. The device behaves as if two diodes are connected in series with reverse voltage applied across them. A small leakage current of the order of a few milliamperes (or a few microamperes depending upon the SCR rating) flows. This is reverse blocking mode, called the off-state, of the thyristor. If the reverse voltage is increased, then at a critical breakdown level, called reverse breakdown voltage VBR, an avalanche occurs at J1 and J3 and the reverse current increases rapidly. A large current associated with VBR gives rise to more losses in the SCR. This may lead to thyristor damage as the junction temperature may exceed its permissible temperature rise. It should, therefore, be ensured that maximum working reverse voltage across a thyristor does not exceed VBR. When reverse voltage applied across a thyristor is less than VBR, the device offers a high impedance in the reverse direction. The SCR in the reverse blocking mode may therefore be treated as an open switch.

Note that V-I characteristic after avalanche breakdown during reverse blocking mode is applicable only when load resistance is zero, Fig. 4.2 (b). In case load resistance is present, a large anode current associated with avalanche breakdown at V_{BR} would cause substantial voltage drop across load and as a result, V-I characteristic in third quadrant would bend to the right of vertical line drawn at V_{BR}.

Forward Blocking Mode: When anode is positive with respect to the cathode, with gate circuit open, thyristor is said to be forward biased as shown in Fig. 4.3 (b). It is seen from this figure that junctions J1, J_3 are forward biased but junction J_2 is reverse biased. In this mode, a small current, called forward leakage current, flows as shown in Figs. 4.2 (b) and 4.3 (b). In case the forward voltage is increased, then the reverse biased junction J_2 will have an avalanche breakdown at a voltage called forward break over voltage VB0. When forward voltage is less than VBO, SCR offers high impedance. Therefore, a thyristor can be treated as an open switch even in the forward blocking mode.

Forward Conduction Mode: In this mode, thyristor conducts currents from anode to cathode with a very small voltage drop across it. A thyristor is brought from forward blocking mode to forward conduction mode by turning it on by exceeding the forward breakover voltage or by applying a gate pulse between gate and cathode. In this mode, thyristor is in on-state and behaves like a closed switch. Voltage drop across thyristor in the on state is of the order of 1 to 2 V depending on the rating of SCR. It may be seen from Fig. 4.2 (b) that this voltage drop increases slightly with an increase in anode current. In conduction mode, anode current is limited by load impedance alone as voltage drop across SCR is quite small. This small voltage drop v_T across the device is due to ohmic drop in the four layers.

4. CIRCUIT DIAGRAM:



5. PROCEDURE:

1. Connections are made as shown in the circuit diagram.

2. The value of gate current $I_{G,}$ is set to convenient value by adjusting $V_{GG.}$

3. By varying the anode cathode voltage V_{AA} gradually in step by step, note down the corresponding values of V_{AK} and I_{A} . Note down V_{AK} and I_A at the instant of firing of SCR

and after firing (by reducing the voltmeter ranges and ammeter ranges) then increase the supply voltage V_{AA} . Note down corresponding values of V_{AK} and I_A.

4. The point at which SCR fires, gives the value of break over voltage V_{BO}.

5. A graph of V_{AK} V/S I_A is to be plotted.

6. The on state resistance can be calculated from the graph by using a formula.

7. The gate supply voltage V_{GG} is to be switched off.

8. Observe the ammeter reading by reducing the anode cathode supply voltage V_{AA} .The point at which ammeter reading suddenly goes to zero gives the value of holding current I_H

9. Steps no.2, 3, 4, 5, 6, 7, 8 are repeated for another value of gate current I_G .

6. OBSERVATION:

For forward bias **For reverse bias**

S.No.	Voltage (V)	Current (mA)	S.No.	Voltage (V)	Current (µA)

7. RESULTS AND DISCUSSION:

The V-I characteristics of silicon controlled rectifier is plotted on the graph which is true according to theory.

8. PRE EXPERIMENT Q.B:

Q1. What is SCR?

Ans. A silicon-controlled rectifier (or semiconductor-controlled rectifier) is a four-layer solid state current. The name "silicon controlled rectifier" or SCR is General Electric's trade name for a type of thyristor. SCRs are mainly used in devices where the control of high power, possibly coupled with high voltage, is demanded. Their operation makes them suitable for use in medium to high-voltage AC power control applications, such as lamp dimming, regulators and motor control.

9. POST EXPERIMENT Q.B:

Q1. What are various turn on method for thyristor?

Ans. i) Forward voltage triggering.

ii) gate triggering

iii) dv/dt triggering

iv) temperature triggering

v) light triggering

10. PRECAUTIONS:

1. Keep your hand away from main supply.

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

EXPERIMENT NO. 02

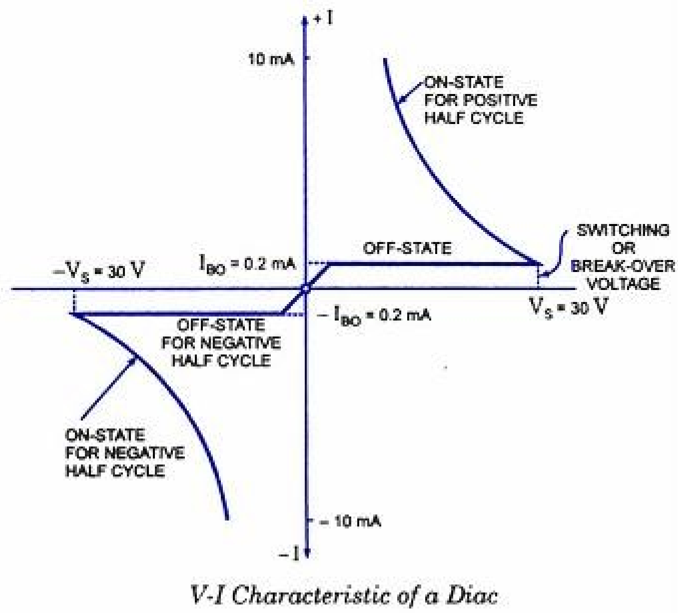
1. AIM: **To plot** V-I Characteristics of DIAC.

2. APPARATUS REQUIRED:

S.No.	Apparatus / Software Used	Specification	Quantity
1. 2. 3.	DIAC Kit Multimeter Connecting Leads		1 2

3. THEORY:

A diac is an important member of the thyristor family and is usually employed for triggering triacs. A diac is a two-electrode bidirectional avalanche diode which can be switched from off-state to the on-state for either polarity of the applied voltage. This is just like **a triac** without gate terminal, as shown in figure. Its equivalent circuit is a pair of inverted four layer diodes. Two schematic symbols are shown in figure. Again the terminal designations are arbitrary since the diac, like triac, is also a bilateral device. The switching from off-state to on-state is achieved by simply exceeding the avalanche break down voltage in either direction.

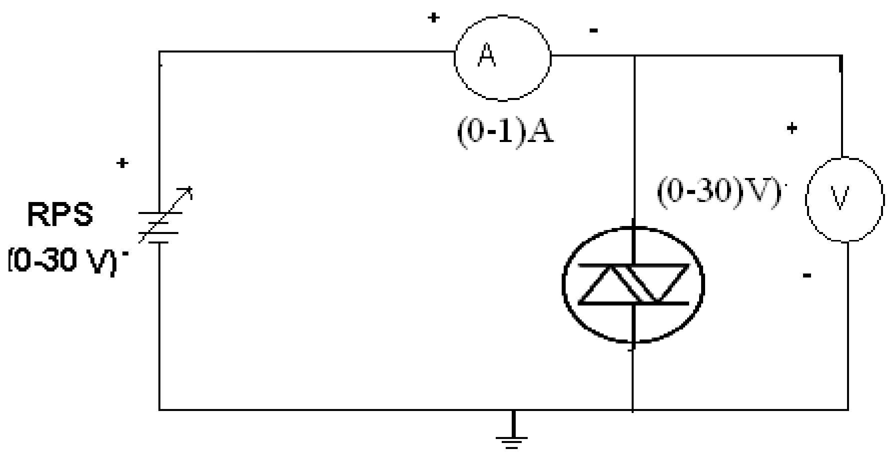


V-I Characteristic of a Diac

Volt-ampere characteristic of a diac is shown in figure. It resembles the English letter Z because of the symmetrical switching characteristics for either polarity of the applied voltage.

The diac acts like an open-circuit until its switching or breakover voltage is exceeded. At that point the diac conducts until its current reduces toward zero (below the level of the holding current of the device). The diac, because of its peculiar construction, does not switch sharply into a low voltage condition at a low current level like the SCR or triac. Instead, once it goes into conduction, the diac maintains an almost continuous negative resistance characteristic, that is, voltage decreases with the increase in current. This means that, unlike the SCR and the triac, the diac cannot be expected to maintain a low (on) voltage drop until its current falls below a holding current level.

4. CIRCUIT DIAGRAM:



5. PROCEDURE:

1. Connect the millimetre, DIAC, Voltmeter to the circuit.
2. Switch on the power supply.
3. Increase the supply voltage in steps; note the corresponding currents and voltages for each step.
4. Plot the graph of VI characteristics.

5. Reverse the terminal of DIAC. Increase the supply voltage in steps, note the corresponding currents and voltages for each step

6. Plot the graph of VI characteristics.

6. OBSERVATION:

For forward bias **For reverse bias**

S.No.	Voltage (V)	Current (mA)	S.No.	Voltage (V)	Current (µA)

7. RESULTS AND DISCUSSION:

The V-I characteristics of DIAC is plotted on the graph which is true according to theory.

8. PRE EXPERIMENT Q.B:

Q1. What is DIAC?

Ans. DIAC is a three layer; two terminal semiconductor devices.MT1 and MT2 are the two main terminals which are interchangeable .It acts as a bidirectional avalanche diode. It does not have any control terminal. It has two junctions J1 and J2 resembles a bipolar transistor, the central layer is free from any connection with the terminals. It acts as a switch in both directions.

9. POST EXPERIMENT Q.B:

Q1. What are the applications of DIAC?

Ans. DIACS are widely used in AC applications and it is found that the device is "reset" to its non-conducting state, each time the voltage on the cycle falls so that the current falls below the holding current. As the behaviour of the device is approximately equal in both directions, it can provide a method of providing equal switching for both halves of an AC cycle, e.g for triacs.

10. PRECAUTIONS:

1. Keep your hand away from the main supply.

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

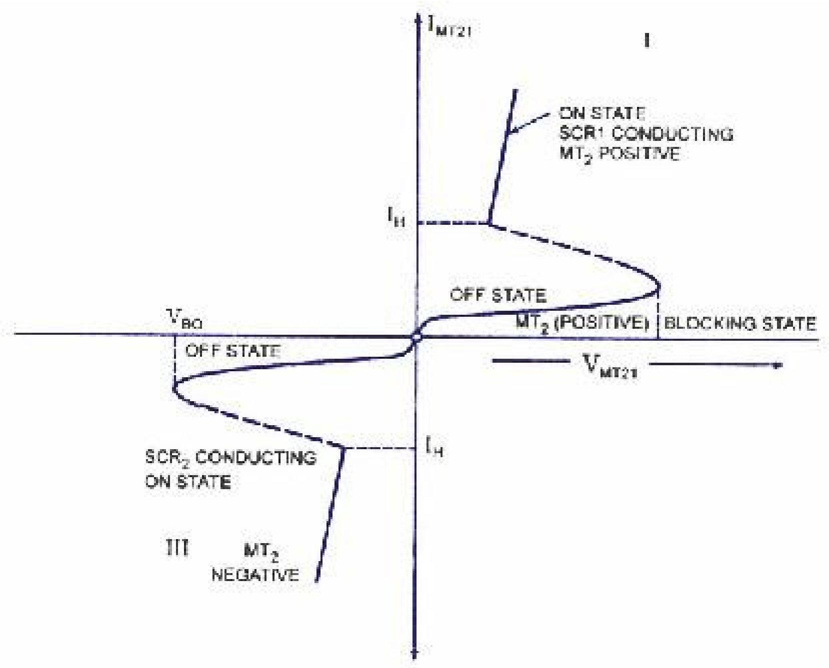
EXPERIMENT NO. 03

1. AIM: **To draw** V-I characteristics of TRIAC for different values of Gate Currents.

2. APPARATUS REQUIRED:

S.No.	Apparatus / Software Used	Specification	Quantity
1. 2. 3.	TRIAC Kit Multimeter Connecting Leads		1 2

3. THEORY:



V-I Characteristic of a Triac

Typical V-I characteristics of a **triac** are shown in figure. The triac has on and off state characteristics similar to SCR but now the char acteristic is applicable to both positive and negative voltages. This is expected because triac consists of two SCRs connected in parallel but opposite in direc tions.

MT_2 is positive with respect to MT_X in the first quadrant and it is negative in the third quad rant. As already said in previous blog posts, the gate triggering may occur in any of the following four modes.

Quadrant I operation : V_{MT2}, positive; V_{Gl} positive

Quadrant II operation : V_{MT21} positive; V_{Gl} negative

Quadrant III operation : V_{MT21} negative; V_{Gl} negative

Quadrant IV operation : V_{MT21} negative; V_{G1} positive

where V_{MT21} and V_{Gl} are the voltages of terminal MT_2 and gate with respect to terminal MT_1.

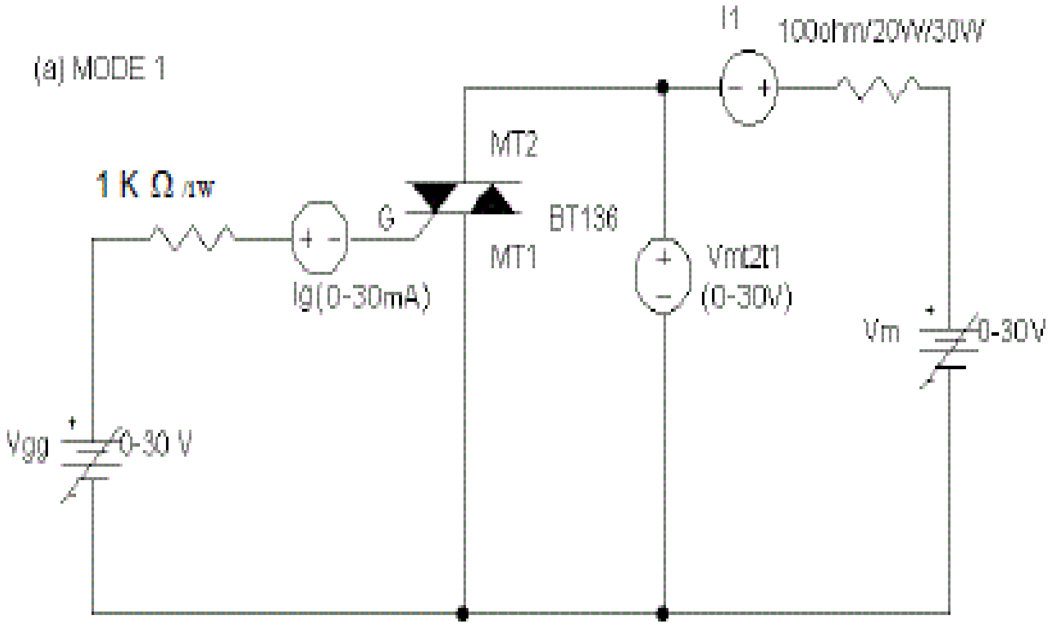
The device, when starts conduction permits a very heavy amount of current to flow through it. This large inrush of current must be restricted by employing external resist ance, otherwise the device may get damaged.

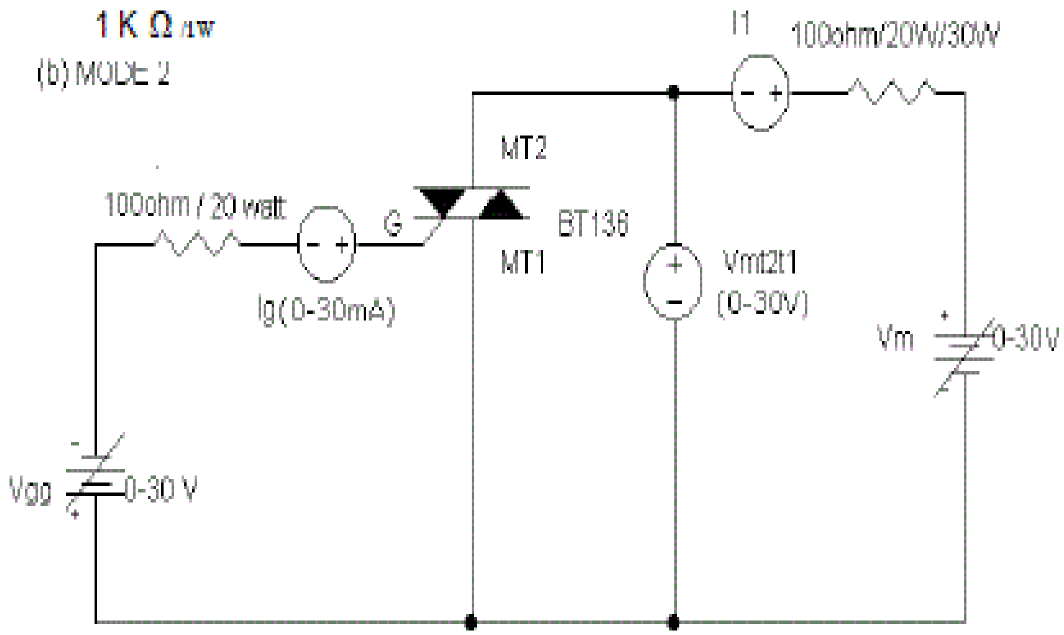
The gate is the control terminal of the device. By applying proper signal to the gate, the firing angle of the device can be controlled. The circuits used in the gate for triggering the device are called the gate-triggering circuits. The gate-triggering circuits for the triac are almost same like those used for SCRs. These triggering circuits usually generate trigger pulses for firing the device. The trigger pulse should be of sufficient magnitude and duration so that firing of the device is assured. Usually, a duration of 35 us is sufficient for sustaining the firing of the device.

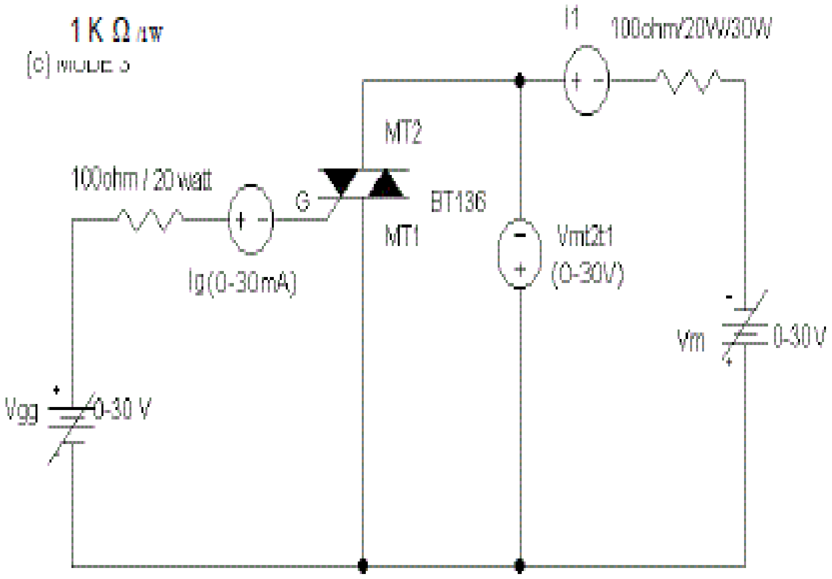
A typical triac has the following voltage/current values:

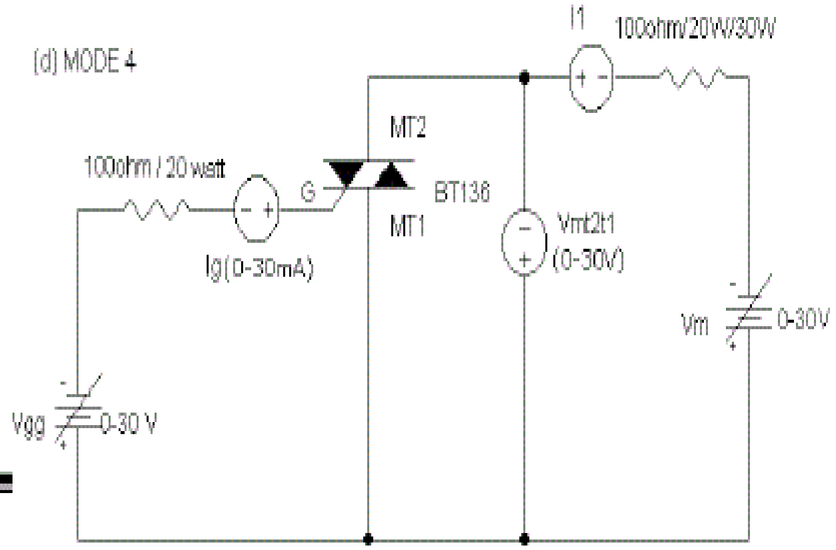
- Instantaneous on-state voltage – 1.5 Volts
- On-state current – 25 Amperes
- Holding current, I_H - 75 Milli Amperes
- Average triggering current, I_G – 5 Milli Amperes

4. CIRCUIT DIAGRAM:






1 K Ω /1w
(c) MODE 3
I1
100ohm/20W/30W
MT2
100ohm / 20 watt
G
BT136
MT1
Vmt2t1
(0-30V)
Ig(0-30mA)
Vm
0-30 V
Vgg
0-30 V


(d) MODE 4
I1
100ohm/20W/30W
MT2
100ohm / 20 watt
G
BT136
MT1
Vmt2t1
(0-30V)
Ig(0-30mA)
Vm
0-30V
Vgg
0-30 V

5. PROCEDURE:

1. Connections are made as shown in the circuit diagram
2. Adjust the value of I_g to zero or some minimum value
3. By varying the voltage V_{mt2mt1} from 0 to 10 volts with a step of 2 volts, note down corresponding values of I_1
4. Now apply the gate voltage gradually, until SCR fires, then note down the values of I_g and also the values of I_1 and V_{mt2mt1}.
5. Increase V_m to some value and note down I_1 and V_{mt2mt1}.
6. Reduce gate voltage to zero, observe ammeter reading by reducing V_m which gives the values of I_h (holding current) at the point at which, current suddenly drops to zero
7. Repeat the steps 2, 3, 4, 5 & 6 for different values of break over voltages
8. Plot a graph of V_{mt1mt2} v/s I_1
9. Repeat the steps 1, 2, 3, 4, 5, 6 & 7 for different modes
10. Compare sensitivity of TRIAC and comment on sensitivities.
11. Refer same design procedure for selection of R_L and R_g as that of SCR.
12. Follow the same procedure as that of SCR experiment to find latching current.

6. OBSERVATION:

For forward bias **For reverse bias**

S.No.	Voltage (V)	Current (mA)	S.No.	Voltage (V)	Current (µA)

7. RESULTS AND DISCUSSION:

The V-I characteristics of TRIAC is plotted on the graph which is true according to theory.

8. PRE EXPERIMENT Q.B:

Q1. What is TRIAC?

Ans. TRIAC, from Triode for Alternating Current, is a generalized trade name for an electronic component that can conduct current in either direction when it is triggered (turned on), and is formally called a bidirectional triode thyristor or bilateral triode thyristor. TRIACs belong to the thyristor family and are closely related to Silicon-controlled rectifiers (SCR). However, unlike SCRs, which are unidirectional devices (i.e. can conduct current only in one direction), TRIACs are bidirectional and so current can flow through them in either direction.

9. POST EXPERIMENT Q.B:

Q1. What do you mean by gate threshold current?

Ans. A TRIAC starts conducting when a current flowing into or out of its gate is sufficient to turn on the relevant junctions in the quadrant of operation. The minimum current able to do this is called gate threshold current and is generally indicated by I_{GT}

Q2. What are the applications of TRIAC?

Ans. Low power TRIACs are used in many applications such as light dimmers, speed controls for electric fans and other electric motors, and in the modern computerized control circuits of many household small and major appliances.

10. PRECAUTIONS:

1. Keep your hand away from main supply.

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

EXPERIMENT NO. 04

1) **OBJECTIVE: Triggering of IGBT, MOSFET & Power Transistor**

2) **APPARATUS REQUIRED:**

S. no.	Name of equipments/components	Specification	Range/Rating	Qty.
1.				
2.				
3.				
4.				
5.				

3) **THEORY & FORMULAE USED:** The meaning of IGBT, MOSFET & Power Transistor is to switch on the concerning components. Switch on means in the case of IGBT collector to emitter should fully internally shorted i.e. voltage between emitter and collector should be almost zero or few milli volts and in the case of non triggering conditions emitter to collector internally totally open circuit. In the field the requirement is to operate many or atleast two IGBTs at a time. To make proper electrically isolation in between triggering pulses is required here we will be discussed the same. Such type of triggering circuit is use for Mosfet and for power transistor more current is required so driver amplifier is used to drive the power transistor.

Gate Frequency Generation: The Gate frequency generation circuit is given in Fig-'1'. To operate Gate wave circuit +5 V DC is developed through diode D1, D2, D3, D4, C3, C4 and IC 5. IC_1 is a stable multi vibrator VR1 to control its frequency. It will give the output from pin no. 3 and fed to IC2 that is JK flip-flop and its output will come through pin no. 14 & pin no. 15.The frequency at 14 and 15 will half the a stable multivibrator frequency. The output from pin no. 15 will feed to opto coupler IC3 and output of opto coupler is fed to driver transistor T1. The output of T1 will fed to the base of power transistor T2, the process will same as IC3 and T1. The difference between them pin no 15 of IC2 will at 0^o and pin no 14 of IC 2 will at 180^o.

For electric isolation every opto coupler is required separate isolated 12 V supply, so it also given in diagram.

Triggering of IGBT:

To triggering of IGBT, its required emitter to gate voltage approximates 10 V DC. To operate at a time many IGBTs, electrically isolation is required. So its necessary to use opto coupler for triggering of IGBTs at a time with perfect electrically isolation. IGBT is voltage operated device so voltage with current is not required the gate current almost negligible. The output voltage from opto coupler is sufficient to trigger IGBT.

The gate of IGBT should never hang in air. Because due to available voltage in air the IGBT may partially ON and may heat & damage so its Gate to emitter a high ohmic resistance approximate 10K is hard coupled. The IGBTs is the combination of MOSFET & power transistor to use at high voltage switching.

Triggering of MOSFET:

All features to trigger the MOSFET is same as IGBT, only difference is MOSFET is used for low voltage switching. Safety measures 10 K resistance is also required. Source to gate voltage approximate 10 V DC is required. Same electrically isolation is required which is operate by opto coupler.

Triggering of Power Transistor:
Transistor is current operated device to switching it the requirement is low voltage but few milli amps current also. The output of opto coupler is fed to a driver transistor and transistor will provide sufficient power to a drive a power transistor. Power transistor mostly used for high voltage and high frequency switching.

4) CIRCUIT DIAGRAM:

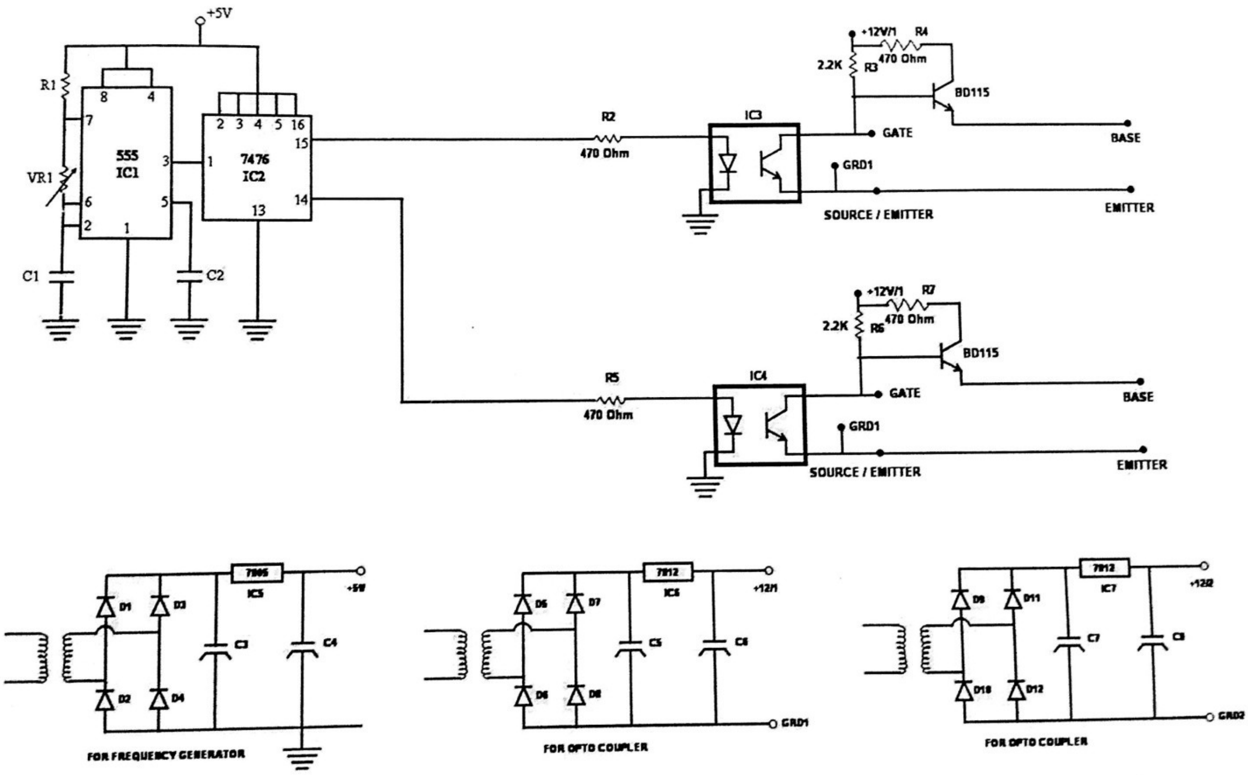


FIG-'1' : TRIGGERING CIRCUIT DIAGRAM FOR IGBT, MOSFET & POWER TRANSISTOR

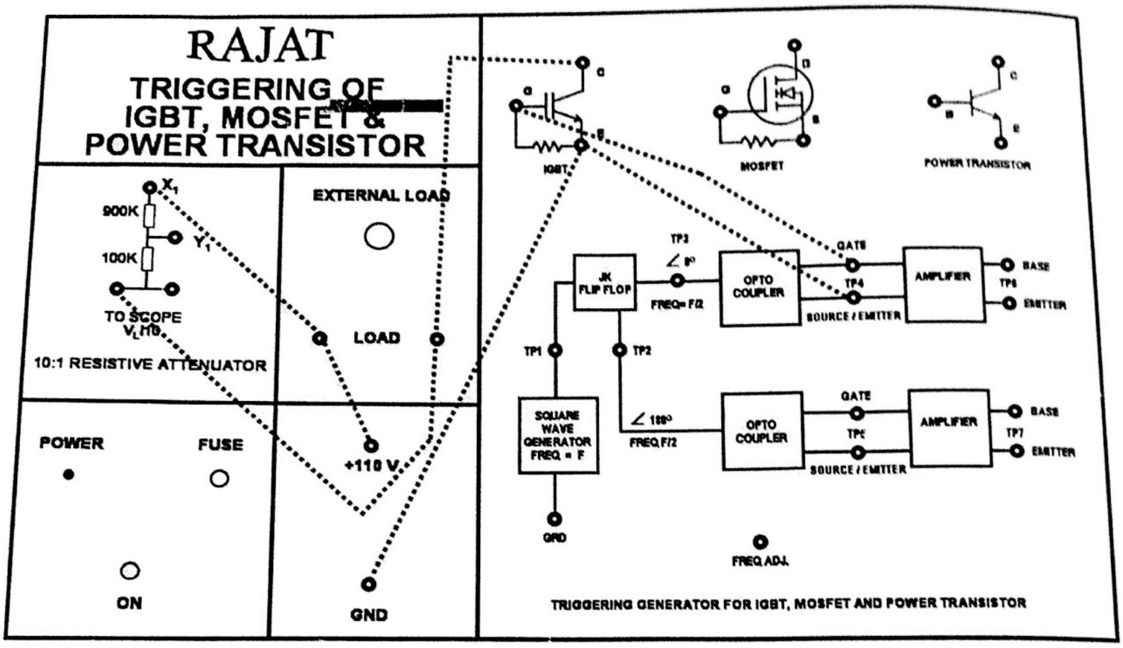

RAJAT
TRIGGERING OF
IGBT, MOSFET &
POWER TRANSISTOR
X_1
900K
Y_1
100K
TO SCOPE
10:1 RESISTIVE ATTENUATOR
EXTERNAL LOAD
LOAD
POWER
FUSE
+110 V
ON
GND
IGBT
MOSFET
POWER TRANSISTOR
TP3
JK FLIP FLOP
FREQ= F/2
OPTO COUPLER
GATE
TP4
SOURCE / EMITTER
AMPLIFIER
BASE
EMITTER
TP1
TP2
SQUARE WAVE GENERATOR FREQ = F
FREQ F/2
OPTO COUPLER
GATE
SOURCE / EMITTER
AMPLIFIER
TP7
BASE
EMITTER
GRD
FREQ ADJ.
TRIGGERING GENERATOR FOR IGBT, MOSFET AND POWER TRANSISTOR

FIG – '3'

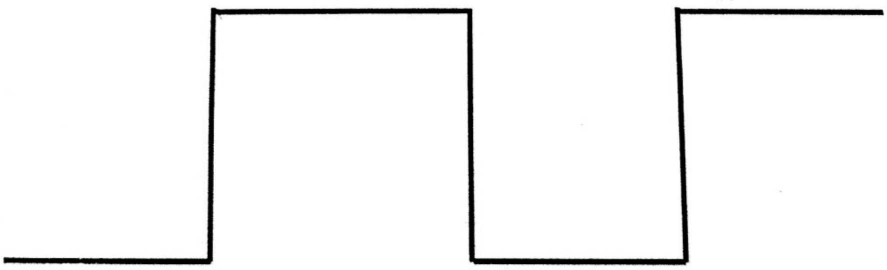


FIG – '4'

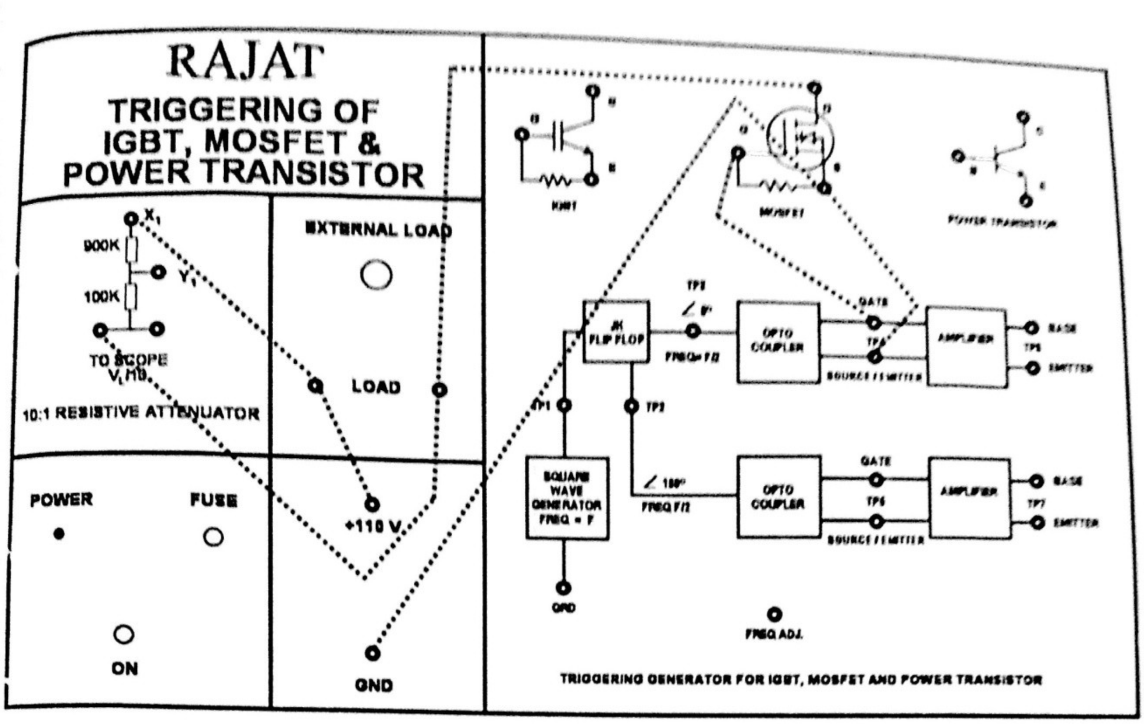

RAJAT
TRIGGERING OF
IGBT, MOSFET &
POWER TRANSISTOR
EXTERNAL LOAD
900K
100K
TO SCOPE
10:1 RESISTIVE ATTENUATOR
LOAD
POWER
FUSE
+110 V
ON
GND
JK FLIP FLOP
OPTO COUPLER
AMPLIFIER
SQUARE WAVE GENERATOR
GATE
BASE
EMITTER
GND
FREQ ADJ.
TRIGGERING GENERATOR FOR IGBT, MOSFET AND POWER TRANSISTOR

FIG – '5'

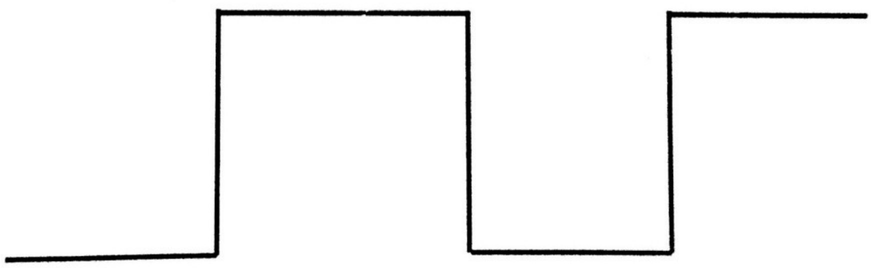


FIG – '6'

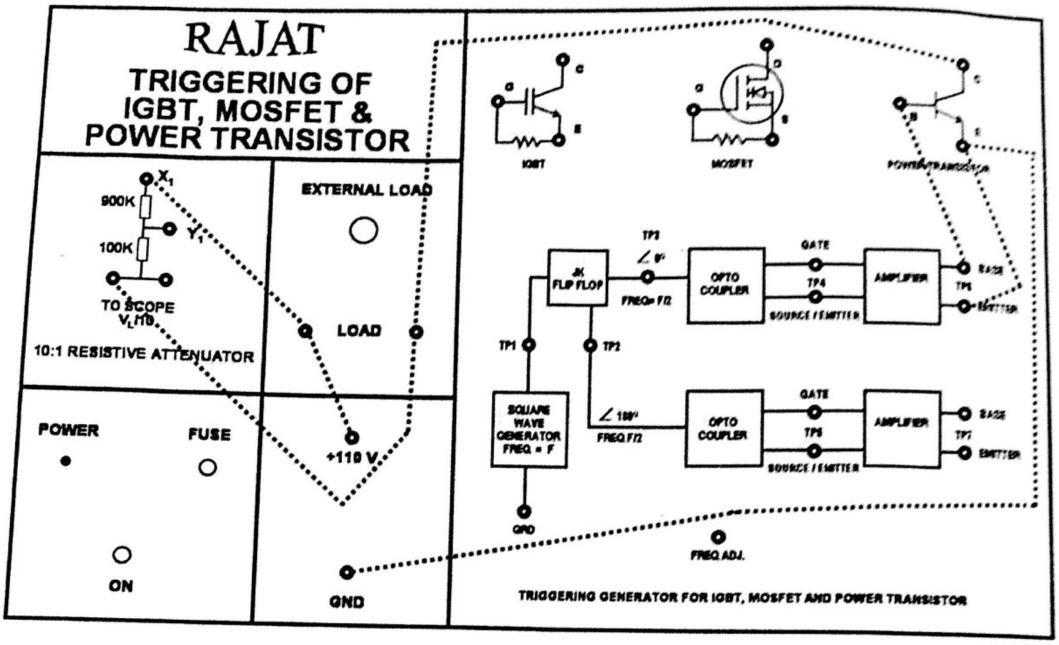


FIG – '7'

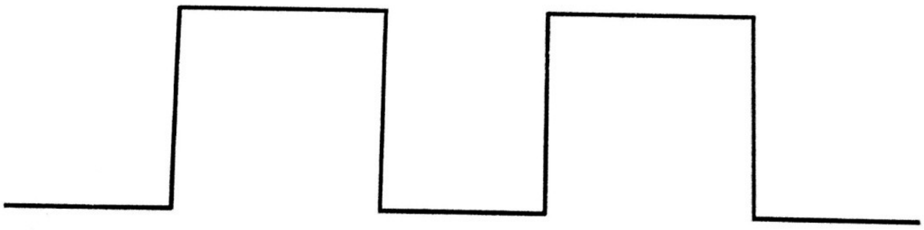


FIG – '8'

5) **PROCEDURE**:

6) **OBSERVATIONS**:

7) **CALCULATIONS**:

8) **RESULTS & DISCUSSION**:

9) **PRECAUTIONS**:

10) **PRE-EXPERIMENT QUESTIONS**:

11) **POST-EXPERIMENT QUESTIONS**:

EXPERIMENT NO. 05

1) **OBJECTIVE: To study Bridge inverter using IGBT.**
2) **APPARATUS REQUIRED:**

S. no.	Name of equipments/components	Specification	Range/Rating	Quantity
1.				
2.				
3.				
4.				
5.				

3) **THEORY & FORMULAE USED:**

Inverter is a unit to change DC supply to AC. There are several methods to achieve the same. Selection is depending upon our required AC data and DC availability. One question arrives that oscillator is also used for the same purpose. What is the difference between Oscillator and inverter? The oscillator is used to generate few milli watts and KH Hz AC. The circuit efficiency is non considerable factor and frequency accuracy is most important. But by inverter AC generated in several watts and KHz AC. The circuit efficiency is inconsiderable factor and frequency accuracy is most important. But by inverter AC generated in several watts or KWs at 50 Hz or nearby frequency. Here efficiency is most considerable factor. The bridge inverter has higher efficiency to generate AC wave. Generating frequency can vary by the potentiometer. Generated wave can be observed at CRO. The circuit is operated at 110 V DC. At short circuit condition or protective resistance 200 W lamp is given. The circuit along with power supply is capable to tolerate the short circuiting by IGBT of two one or two minute along with protective resistance.

Gate Frequency Generation:

The gate frequency generation circuit is given in fig. '1'. To operate gate wave circuit +5 V DC is developed through diode D10, D11, D 12, D 13 , C 7, C8 and IC7.

IC_1 is astable multi-vibrator VR1 to control its frequency. It will give the output from pin no. 3 and fed to IC2 that is JK flip flop and its output will come through pin No. 3 and fed to IC2 that is JK flip flop and its output will come through pin no. 14 & pin no. 15. The frequency at 14 & 15 will half the astable multivibrator frequency. The output from pin no 15 will feed to pulse generator using IC3. Here IC3 is monostable mult ivibrator and gives the pulse to diode side of opto coupler IC4. The opto coupler is given for electrically isolation between gate frequency to Mosfet 1 & 2.

The output of IC2 (JK FLIP FLOP) pin no. 14 is also fed to another monostable multivibrator using IC 5. The output of IC 5 from pin no. 3 is fed to opto coupler IC6.

4) **CIRCUIT DIAGRAM:**

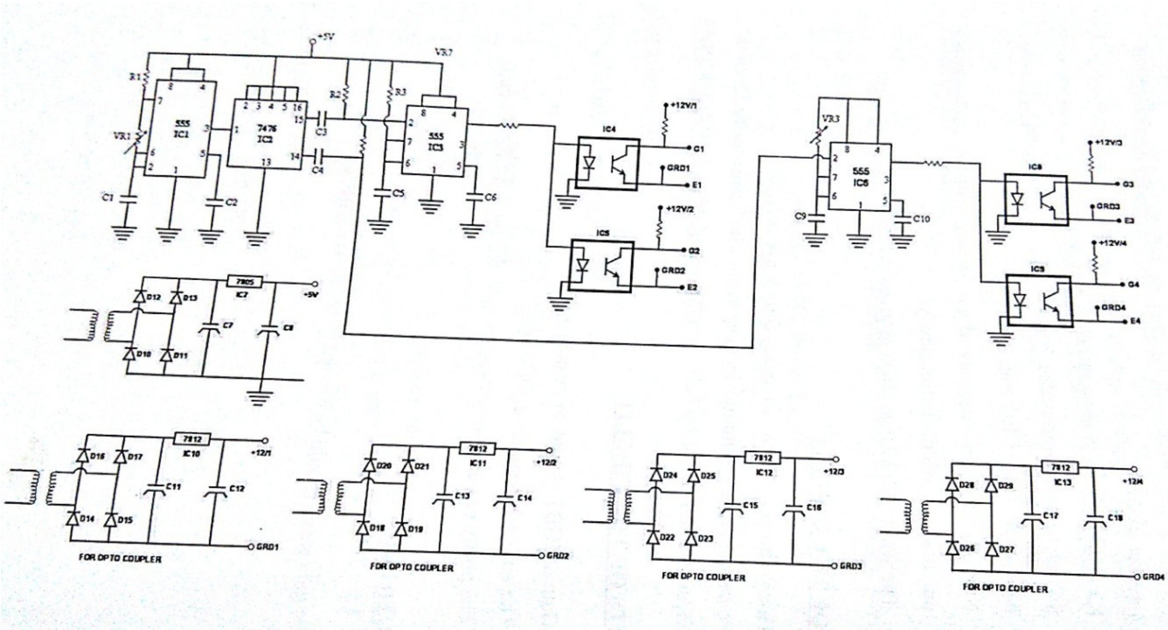


FIG-'1' : FIRING CIRCUIT DIAGRAM FOR BRIDGE INVERTER USING IGBT

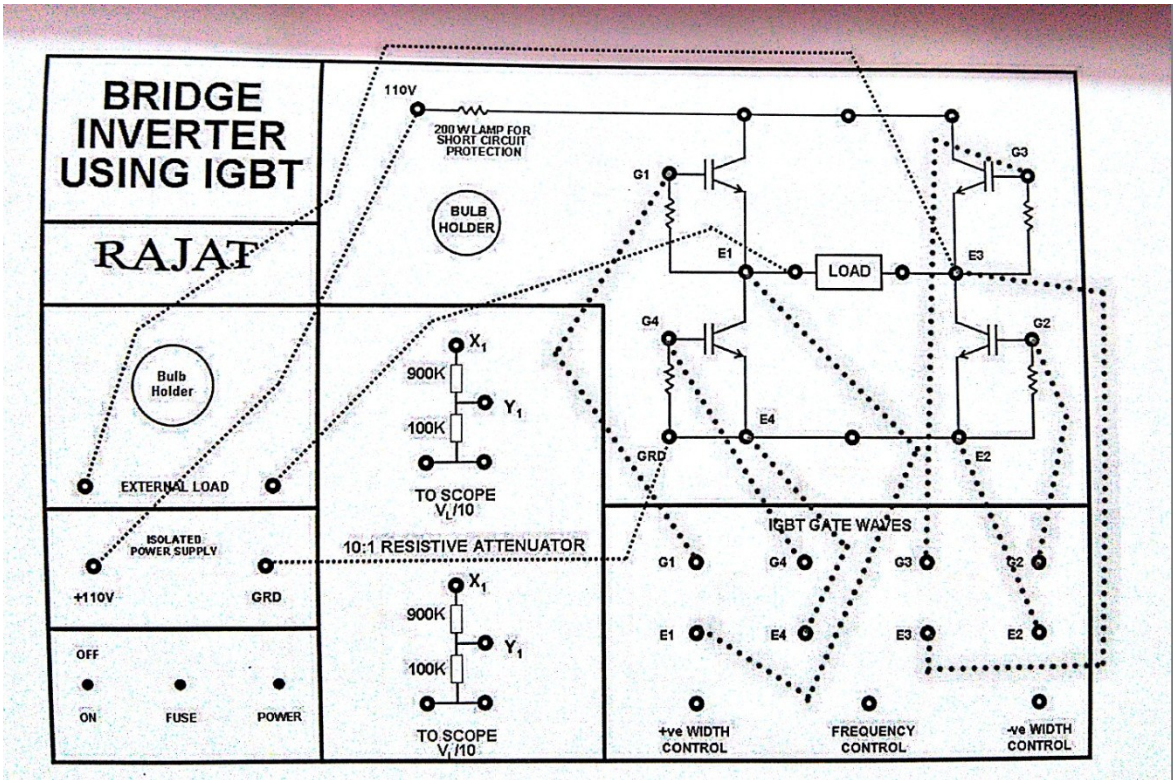


Fig. 2 Connection Diagram

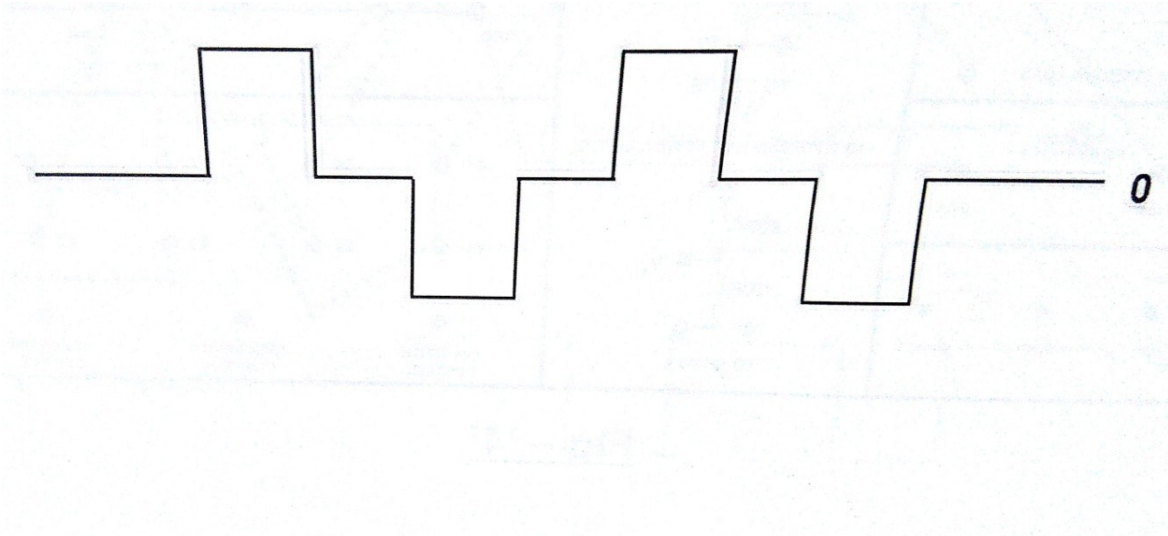


Fig.3 Output Waveform of Inverter

5) **PROCEDURE:**

6) **OBSERVATIONS:**

7) **CALCULATIONS:**

8) **RESULTS & DISCUSSION:**

9) **PRECAUTIONS:**

1. Respective Gate wave should be connected respective MOSFET.

10) **PRE-EXPERIMENT QUESTIONS:**

11) **POST-EXPERIMENT QUESTIONS:**

EXPERIMENT NO. 06

1) **OBJECTIVE: To study Series Inverter using MOSFET.**

2) **APPARATUS REQUIRED:**

S. no.	Name of equipments/components	Specification	Range/Rating	Quantity
1.				
2.				
3.				
4.				
5.				

3) **THEORY & FORMULAE USED:** The Gate frequency generation circuit is given in Fig-'1'. To operate gate wave circuit +5 DC is developed through diode D10, D11, D12, D13, C7,C8 and IC7.

IC_1 is stable vibrator VR1 to control its frequency. It will give the output from pin No.3 and fed to IC2 that is JK flip flop and its output will come through pin no.14 & pin No. 15. The frequency at 14 and 15 will half the astable multivibrator frequency. The output from pin no. 15 will feed to pulse generator using IC3. Here IC3 is monostable multivibrator and gives the pulse to diode side of opto coupler IC4. The opto coupler is given for electrically isolation between gate frequency to Mosfet 1& 2.

The output of IC2 (JK flip-flop) pin no. 14 is also fed to another monostable multivibrator using IC5. The output of IC5 from pin no. 3 is fed to optocoupler IC6.

For electric isolation every gate pulses generation is required separate isolated +12 V supply, so it's also given in diagram.

Explanation of series Inverter Diagram using MOSFET:

Consider the fig. '2', the first gate wave will appear at Mosfet-1. So this MOSFET will fire and current will flow from 110V DC to MOSFET 1, inductor, load & capacitor C2. At the time of appearing the gate wave at MOSFET-2 will remain zero. The current will flow upto the charging of C2 only.

Now after disappearing/zeroing the gate wave at Mosfet-1, the gate wave at Mosfet-2 in opposite direction with respect to previous case. Along with discharging the C2 & C1 charging current will also flow. This path will be 110 V DC, C1, load, inductor and Mosfet-2. The process will repeat.

4) **CIRCUIT DIAGRAM:**

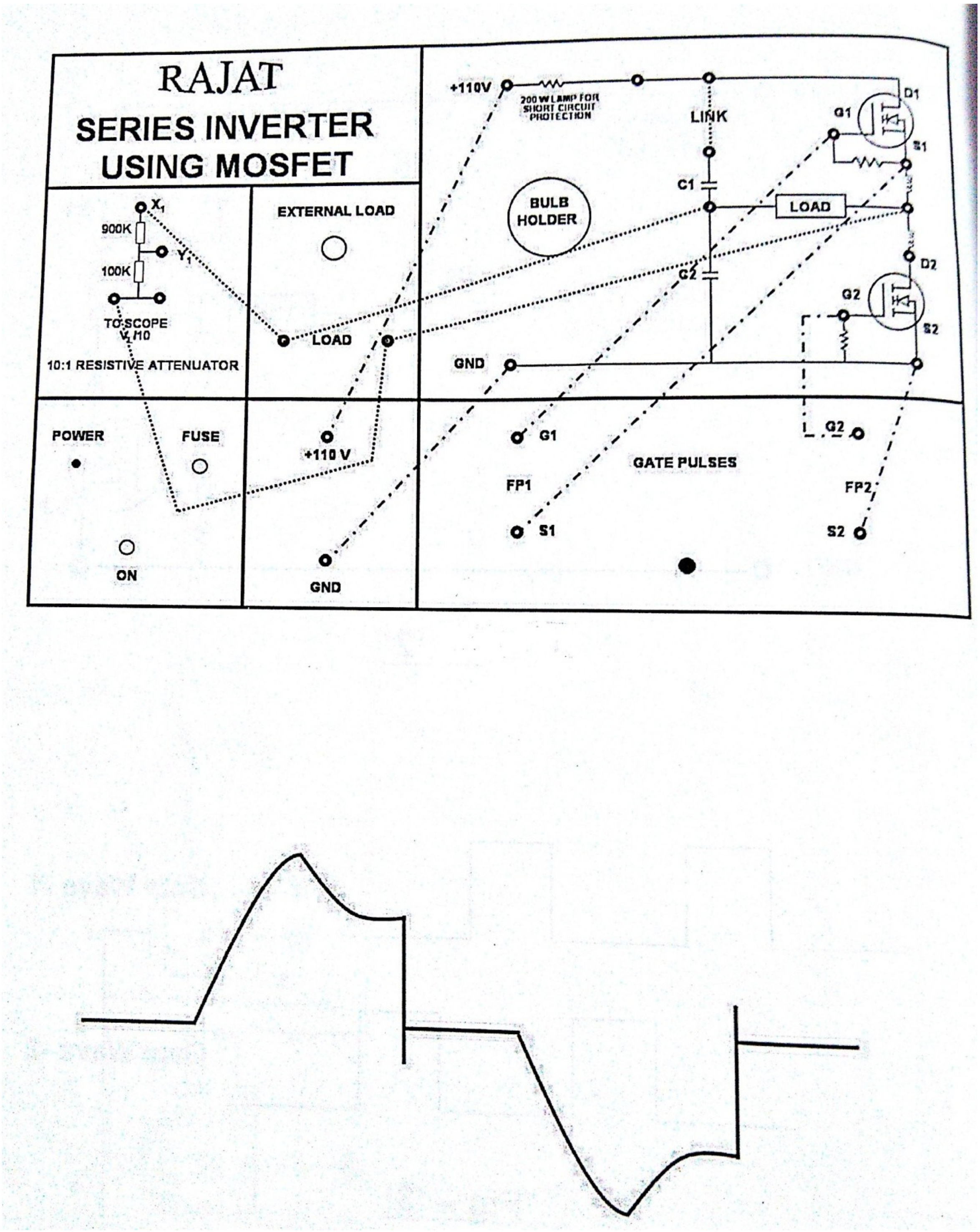


Fig. Circuit Connection & Output Waveform

5) **PROCEDURE**:

6) **OBSERVATIONS**:

7) **CALCULATIONS**:

8) **RESULTS & DISCUSSION**:

9) **PRECAUTIONS**:

10) **PRE-EXPERIMENT QUESTIONS**:

11) **POST-EXPERIMENT QUESTIONS**:

EXPERIMENT NO. 07

1) **OBJECTIVE: Microcontroller based Single Phase Bridge Configuration Cycloconverter.**

2) **APPARATUS REQUIRED:**

S. no.	Name of equipments/components	Specification	Range/Rating	Qty.
1.				
2.				
3.				
4.				
5.				

3) **THEORY & FORMULAE USED:**

The basic control principle of an ideal cycloconverter is to continuously modulate the firing angles of individual converter, so that each produces the same sinusoidal ac voltage at its output terminal. Thus the voltages of the two generators in fig. 1 have the same amplitude, frequency and phase and the the voltage at the output terminals of the cycloconverter is equal to the voltage of either of these generators. It is possible for the mean power to flow either "to" or "from" the output terminals and the cycloconverter is inherently capable of operation with loads of any phase angle within a complete spectrum of 360.

Bridge Configuration:

Two Single phase fully controlled bridges are connected in opposite direction. Bridge 1supplies load current in the positive half of the output cycle and bridge 2 supplies load current in the negative half of the output cycle. The two bridges should not conduct together as this will produce a short circuit at the input. Instead of one thyristor in the centre tap transformer configuration, two thyristor come in series with the each voltage source in bridge configuration. For resistive loads the SCR undergo natural commutation and produce discontinuous current operation as shown in figure.

For inductive load , the load current may be continuous or discontinuous depending upon the firing angle and load power factor. The load voltage and current waveforms for continuous and discontinuous load current are shown in figure.

4) **CIRCUIT DIAGRAM**:

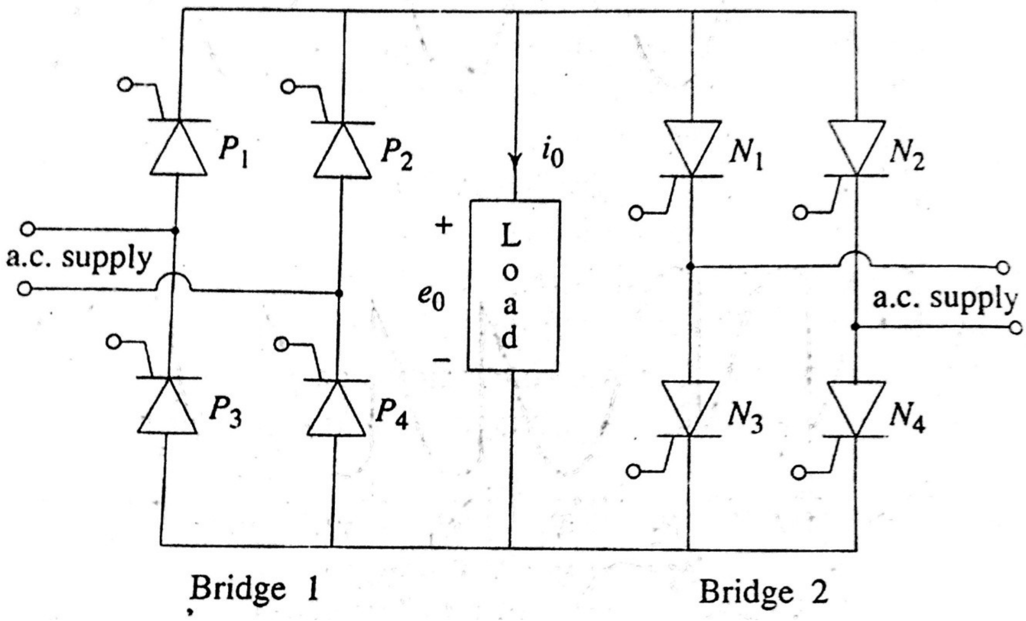


Fig.1 Bridge Configuration Single Phase Cycloconverter

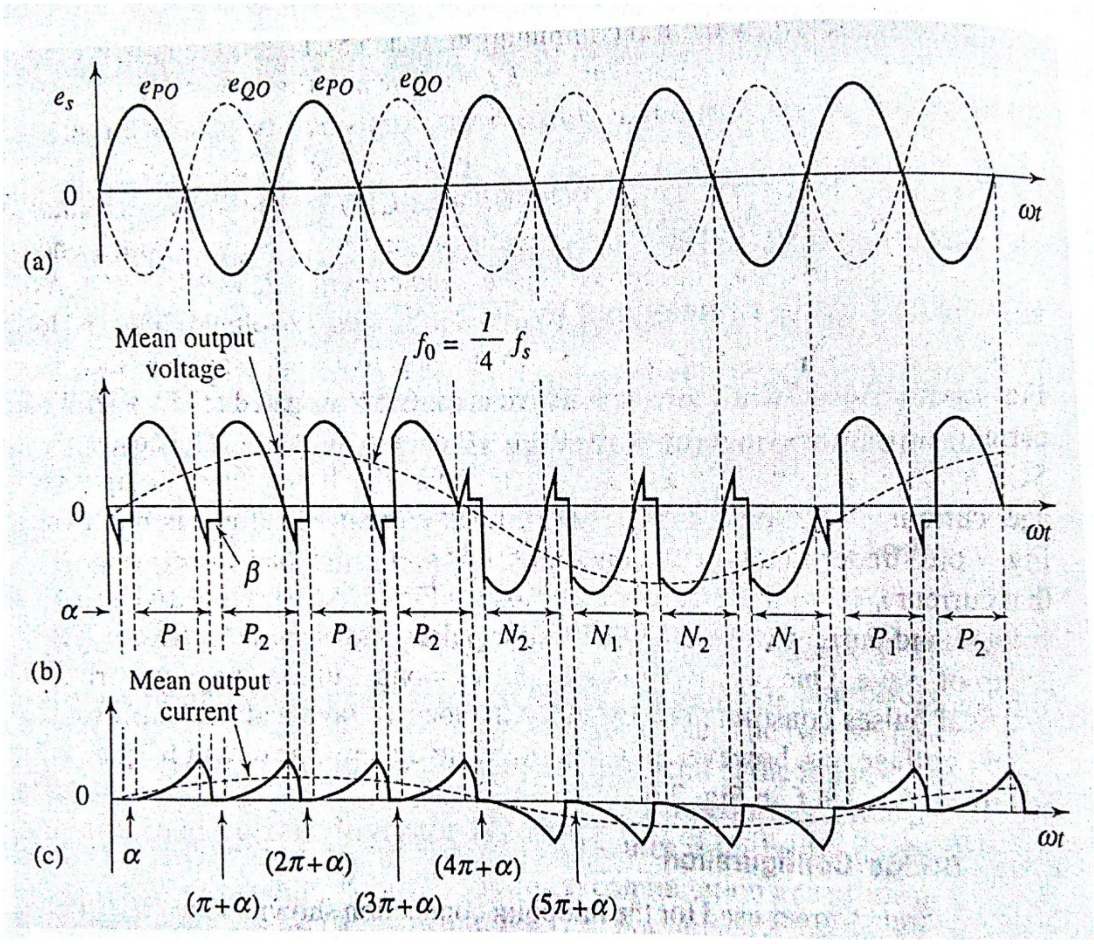


Fig.2 Voltage & Current waveform for a 1-ϕ to 1-ϕ cycloconverter with discontinuous load current

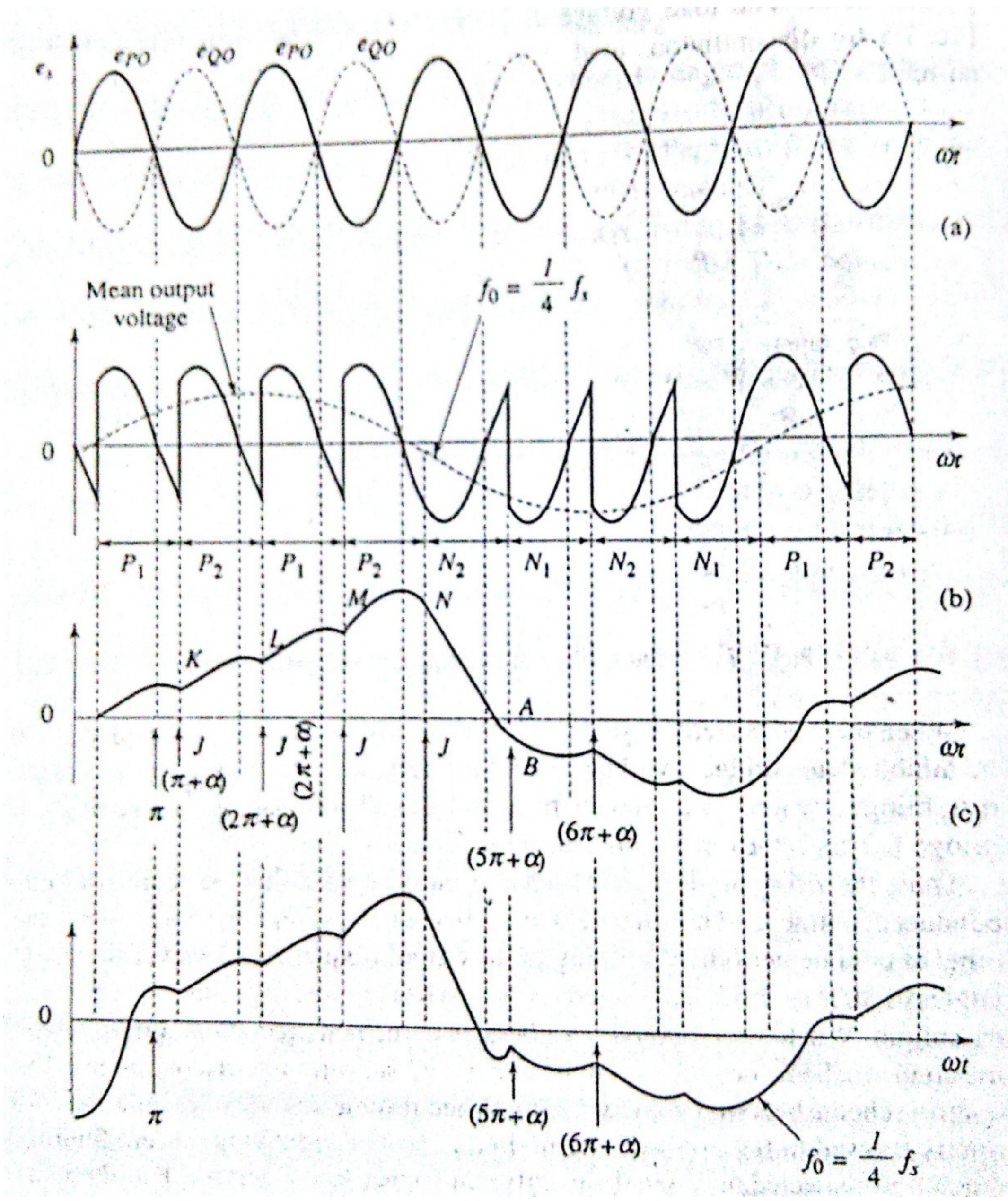


Fig.3 Voltage & Current waveform for a 1-ϕ to 1-ϕ cycloconverter with continuous load current

5) **PROCEDURE**:
6) **OBSERVATIONS**:
7) **CALCULATIONS**:

8) **RESULTS & DISCUSSION**:

9) **PRECAUTIONS**:
10) **PRE-EXPERIMENT QUESTIONS**:
11) **POST-EXPERIMENT QUESTIONS**:

EXPERIMENT NO. 08

1) **OBJECTIVE: To Study Three Phase Fully Controlled Bridge Converter.**
2) **APPARATUS REQUIRED:**

S. No.	Name of equipments/components	Specification	Range/Rating	Qty.
1.				
2.				
3.				
4.				
5.				

3) **THEORY & FORMULAE USED:**

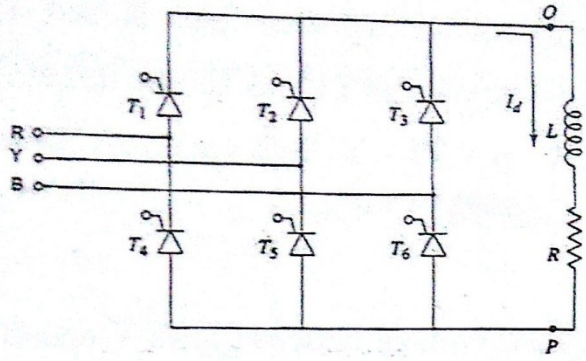
The figure '1' shows the power circuit of three phase fully controlled converter. The load is fed via a three phase half wave connection to one of the three supply lines, no neutral being required. Hence transformer connection is optional. However, for isolation of output from supply source, or for higher output requirement, the transformer is to be connected.

If transformer is used, then one winding is connected in delta because the delta connection gives the circulating path for third harmonic current. This circuit consists of two groups of SCRs, positive group and negative group. Here, Scr T_1, T_2, T_3 forms a positive group. Whereas SCR T_4, T_5, T_6 forms a negative group. The positive group SCRs are turned on when the supply voltages are poisitive and negative group SCRs are turned on when the supply voltage are negative.

Continuous Conduction Mode:

The firing angle of each phasor is varied through a range of 60^0 to 180^0. The minimum firing angle is 60^o and is taken as α=0, at 60^0. When the phasor R-Y is allowed to conduct at α between zero to $\pi/3$, it continues to conduct by 60^0 when the phasor R-B is fired. The condition is shifted from SCR T5 to SCR T6. T5 is commutated off by reverse voltage of phase Y and Y across it. The Phasor R-B conducts after another 60^0 after which it is replaced by phasor (Y-B) when phase Y voltage assumes greater value than B or R. Hence load current is continuous for between 0 to $\pi/3$. The waveforms are shown in figure.

4) CIRCUIT DIAGRAM:



3-Phase Fully Controlled Bridge with R-L Load

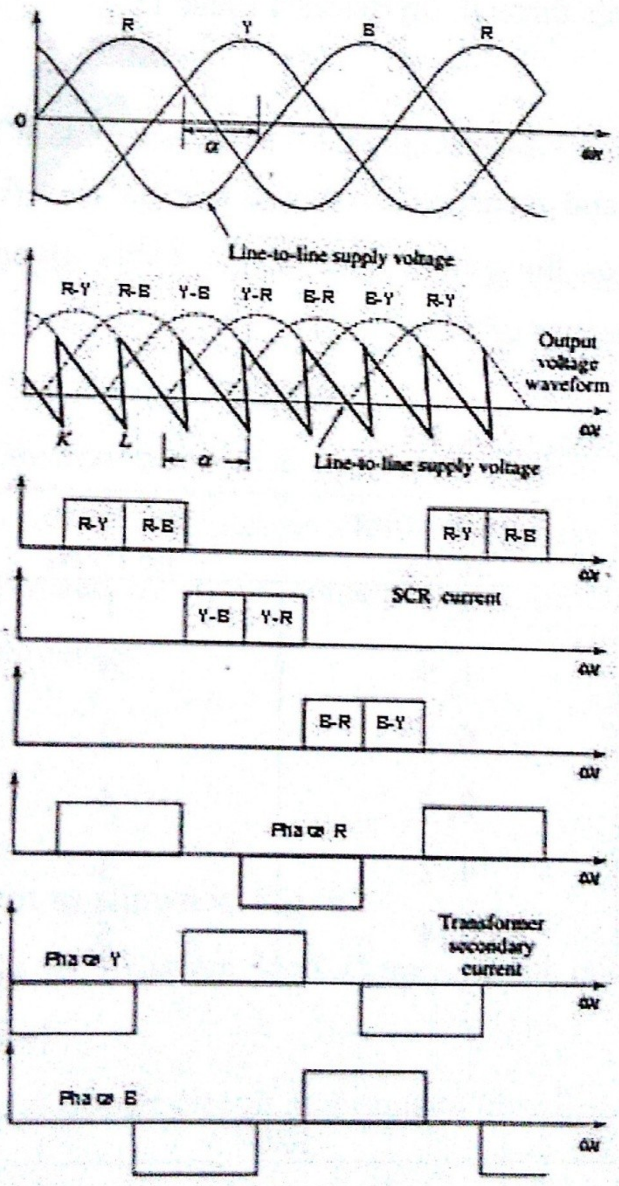


Fig.1 Circuit Diagram, Voltage & Current waveforms

5) **PROCEDURE**:

6) **OBSERVATIONS**:

7) **CALCULATIONS**:

8) **RESULTS & DISCUSSION**:

9) **PRECAUTIONS**:

10) **PRE-EXPERIMENT QUESTIONS**:

11) **POST-EXPERIMENT QUESTIONS**:

EXPERIMENT NO. 09

1) **OBJECTIVE: AC Regulators using Triac, Anti parallel thyristor and Triac & Diac**

2) **APPARATUS REQUIRED:**

S. no.	Name of equipments/components	Specification	Range/Rating	Quantity
1.				
2.				
3.				
4.				
5.				

3) **THEORY & FORMULAE USED:**

Diac and Triac are used AC Power control circuit. The firing of a triac can be phase controlled. Since the exercised in both directions the power in the load can be varied from full value to almost zero. Fig. shows a RC phase shift circuit applied as control signal to the gate. The Diac in the circuit gives a wide range of summetrical firing of the Triac. The resistance R1 control the Gate current by controlling the voltage across C.

Here the voltage across C first turns on the diac which in turns applies enough voltage to the Gate to turn on the triac. By property matching the diac to the triac symmetrical triggering of the triac in both the positive and negative alternations is accomplished.

Morever, the range of firing control is much wider so that a turn on delay of almost 180^0 is possible in each alternation. The circuit however shows some hystersis i.e. the power applied to the load does not vary in the same manner when the direction of rotation of R1 is reversed.

AC Phase Control by RC Triggering:

In above figure we control circuit in series with load it is meant for comfortable commutation of Triac and save the extra transformer cost.Initially the triac is in commuted position, so 230 V will reach at resistance R1, VR1and charged the capacitor C1. Capacitor C2 will charged through resistance through Resistance R2. The circuit will allow passing both the AC power cycles. By varying the variable resistance VR1 we can change the fire angle of AC power. We can use this circuit to control AC power from 0 to 100 %.

Diac is a device which gives minimum resistance after certain value of potential difference so it helps us smooth changing of AC phase control.

4) <u>CIRCUIT DIAGRAM</u>:

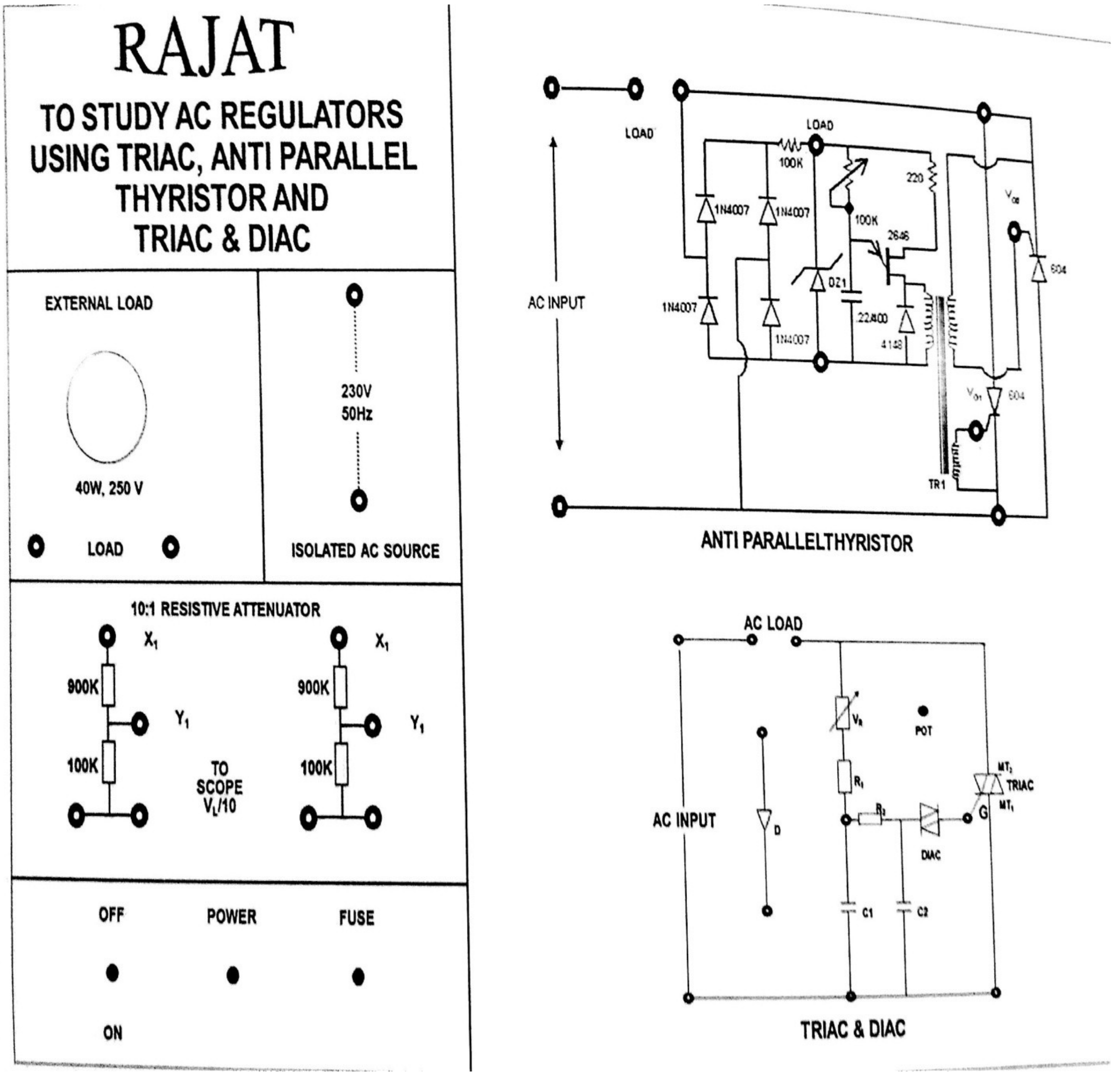


Fig.1 Circuit diagram

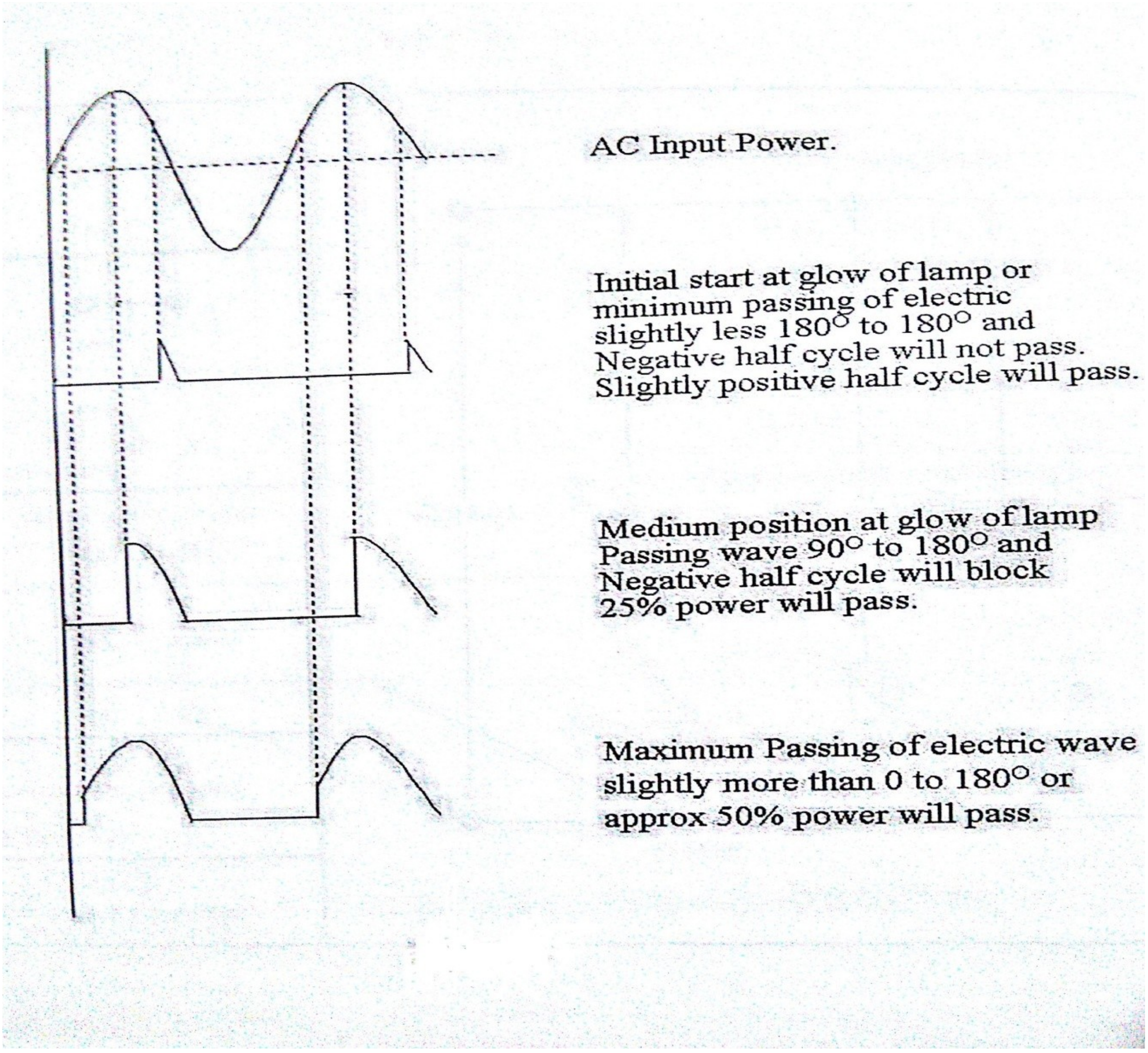


Fig.2 Output Waveforms

5) PROCEDURE:

6) OBSERVATIONS:

7) CALCULATIONS:

8) RESULTS & DISCUSSION:

9) PRECAUTIONS:

10) PRE-EXPERIMENT QUESTIONS:

11) POST-EXPERIMENT QUESTIONS: