POWER ELECTRONICS LAB MANUAL

FOR

IV SEMESTER B.E (EC / TC / ML)

(For private circulation only)

VISVESVARAYA TECHNOLOGICAL UNIVERSITY

Name :……………………………………………

Reg no :……………………………………………

DEPARTMENT OF ELECTRONICS & COMMUNICATION

SRI SIDDHARTHA INSTITUTE OF TECHNOLOGY

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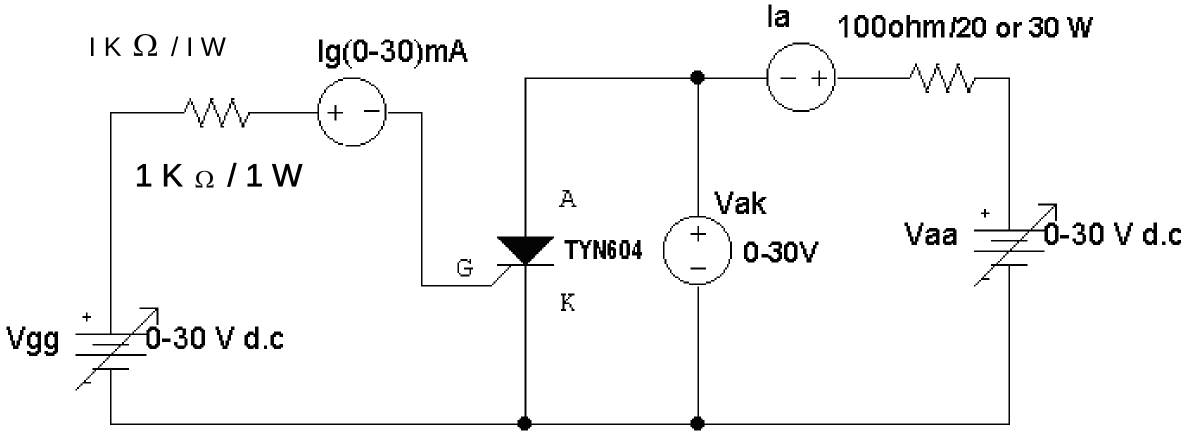
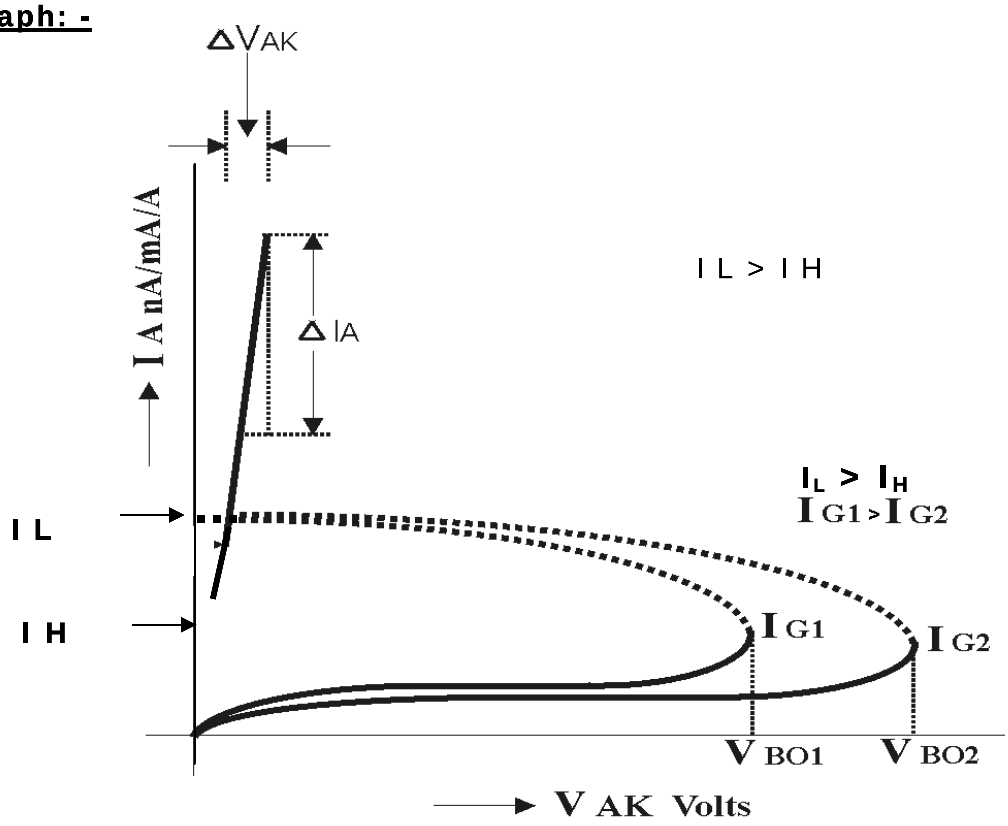
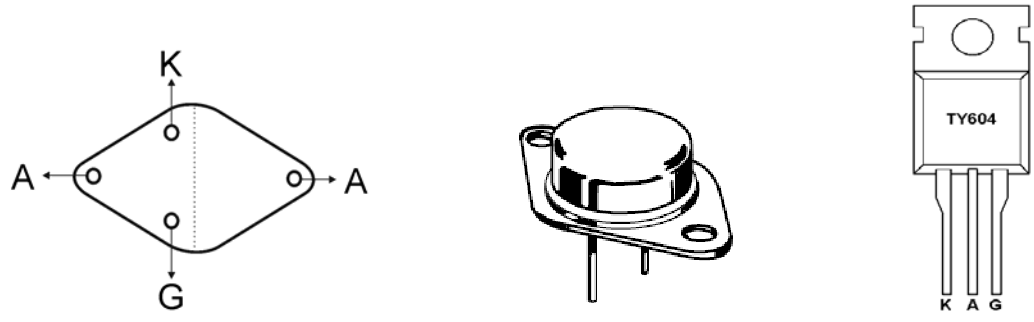
Circuit Diagram: -



Ideal Graph: -



Base Diagrams of 2N3669/70 & TY604: -



Experiment No: 1 **DATE: __ / __ / ____**

S.C.R. Characteristics

Aim: -

To study the V-I characteristics of S.C.R. and determine the Break over voltage, on state resistance Holding current. & Latching current

Apparatus required: -

SCR – TY604, Power Supplies, Wattage Resistors, Ammeter, Voltmeter, etc.,

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 supply voltage V_{AA} gradually in step-by-step, note down the corresponding values of V_{AK} & I_A. Note down V_{AK} & I_A at the instant of firing of SCR and after firing (by reducing the voltmeter ranges and in creasing the ammeter ranges) then increase the supply voltage V_{AA}. Note down corresponding values of V_{AK} & $I_{A.}$
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 the 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 the gate current I_G.

Designing Equations:-

Wkt,

$$V_{aa} = I_a R_L + V_{scr}$$

Let Ia = 300mA
Vscr = 1v
Vaa = 30v

$$R_L = \frac{V_{aa} - V_{scr}}{I_a}$$

$$R_L = \frac{30-1}{300\times10^{-3}} = 96.66\Omega \cong 100\Omega$$

Wattage:-

Power in watts = I^2R_L = $(300x10^{-3})^2x100$ = 9 watts (select 20 watts)

$\therefore$Load resistor = R_L = 100Ω, 20watts

Gate Resistance (Rg):-

Wkt,

$$V_{gg} = I_g R_g + V_{gt}$$

Let Ig = 15mA
Vgt = 1v
Vgg = 15v

$$R_g = \frac{V_{gg} - V_{gt}}{I_g}$$

$$R_g = \frac{15-1}{15\times10^{-3}} = 933\Omega \cong 1X\ \Omega$$

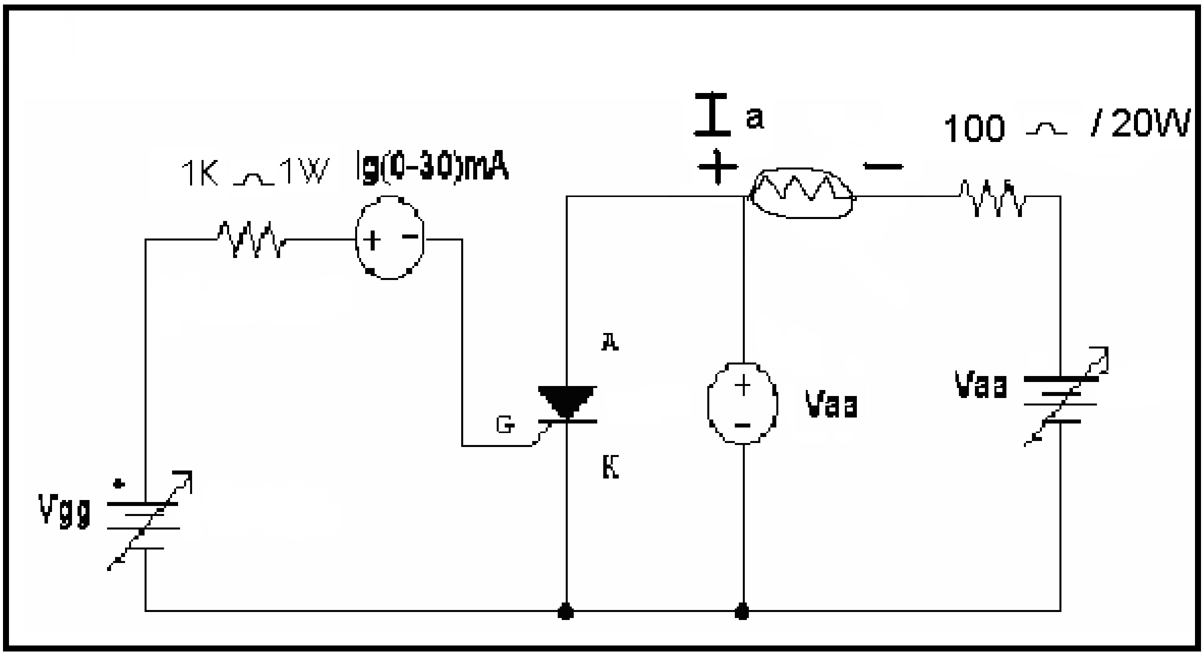
Wattage:-

Power in watts = I^2Rg = $(15x10^{-3})^2x10^3$ = 0.225w (select 1 watt)

$\therefore$Gate resistor = Rg = 1KΩ, 1 watts

Note: - Follow the same design procedure for TRIAC connection sting

Latching Current



Alternate Method: -

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_{ak} from 0 to 10 volts with a step of 2 volts, note down corresponding values of I_a
4. Now apply the gate voltage gradually, until SCR fires, then note down the values of I_g and also the values of I_a and V_{ak}
5. Increase V_{aa} to some value and note down I_a and V_{ak}
6. Reduce gate voltage to zero, observe ammeter reading by reducing V_{aa} 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 voltage
8. Plot a graph of V_{ak} v/s I_a
9. The on state resistance can be calculated from the graph by using formula,

$$R_{ON\text{ - }STATE} = \frac{\Delta V_{AK}}{\Delta I_A}\,\Omega$$

Tabular column: -

I_g = ____________mA

Sl.No	V_{AK} Volts	I_A µA/mA/A

I_g = ____________mA

Sl.No	V_{AK} Volts	I_A µA/mA/A

Procedure (Latching current)

1. connections one made as shown in the circuit diagram
2. Set Vgg at 7 volts
3. Set V_{aa} at particular value, observe I_a, by operating the switch (on & off). if in goes to zero after opening of the switch, indicates $I_a < I_L$
4. Repeat step 3 such that the current I_a should not go to zero after opening of the switch. Then I_a gives the value of I_L.

Viva questions: -

1. Explain the working operation of VI characteristics of S.C.R.
2. Define Holding current, Latching current on state resistance, Break down voltage
3. Explain the working operation of S.C.R. characteristics by using two transistor analogy
4. Write an expression for anode current
5. Mention the applications of S.C.R.?

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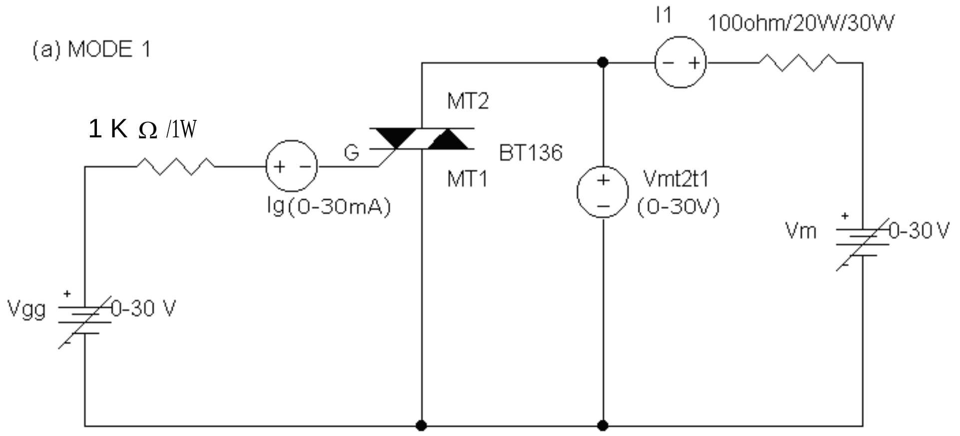
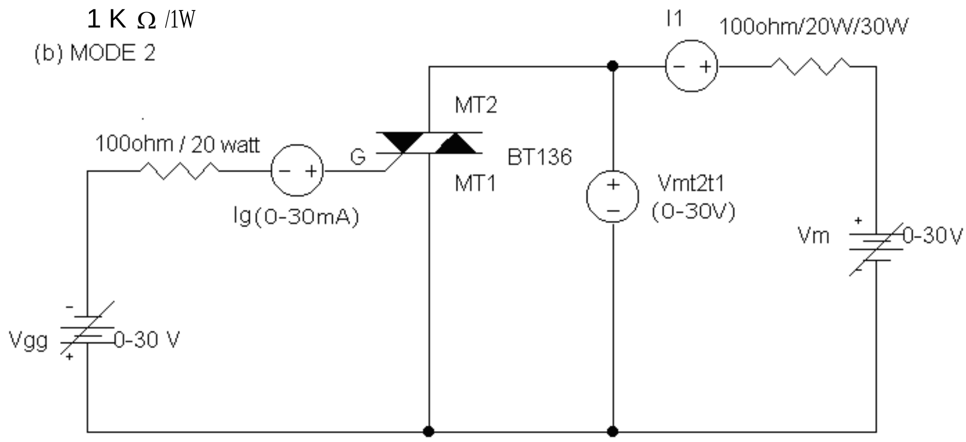
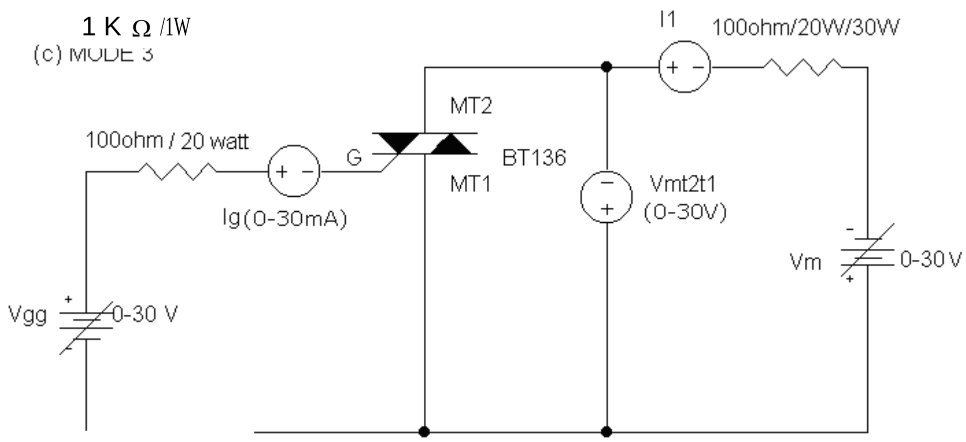
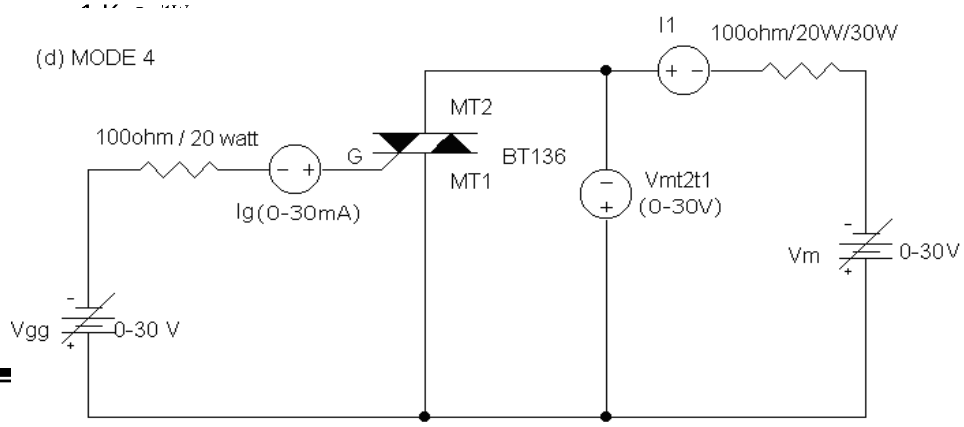
Signature of the staff with date

CIRCUIT DIAGRAM: -









Experiment No: 2 **DATE: __ / __ / ____**

TRIAC Characteristics

Aim: -

To study the v-1 characteristics of a TRIAC in both directions and also in different (1, 2, 3 & 4) modes op operation and determine break over voltages, holding current, latching current and comment on sensitivities.

Apparatus required: -

TRIAC – BT 136, power supplies, wattage resistors, ammeter, voltmeter, etc.,

Procedure: -

I mode

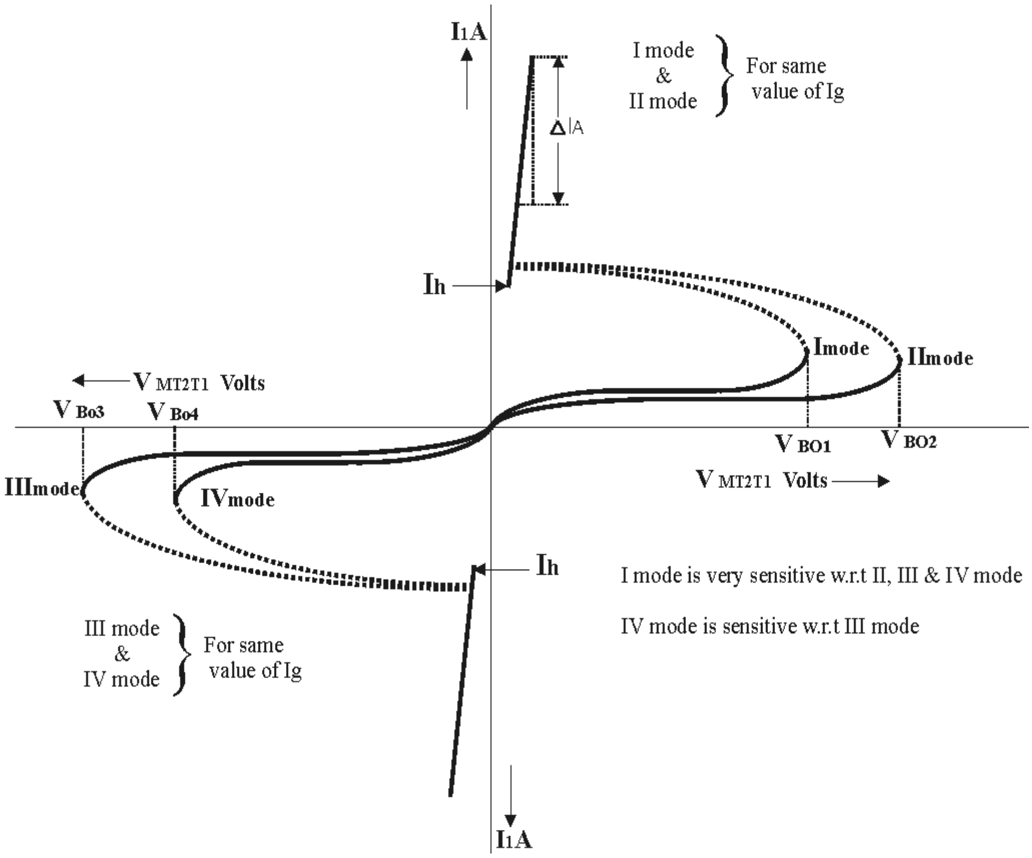
1. Connections are made as shown in the circuit diagram (a)
2. The value of gate current i_g is set to convenient value by adjusting v_{gg}.
3. By varying the supply voltage V_m gradually in step-by-step, note down the corresponding values of V_{mt2t1} and i_1. Note down V_{mt2t1} and i_1 at the instant of firing of TRIAC and after firing (by reducing the voltmeter ranges and increasing the ammeter ranges) then increase the supply voltage V_{mt2mt1} and i_1.
4. The point at which TRIAC fires gives the value of break over voltage v_{bo1}
5. A graph of v_{mt2t1} v/s i_1 is to be plotted.
6. The gates supply voltage. V_{gg} is to be switched off
7. Observe the am meter reading by reducing the supply voltage v_{mt}. The point at which the ammeter reading suddenly goes to zero gives the value of holding current $i_{h.}$

II mode: -

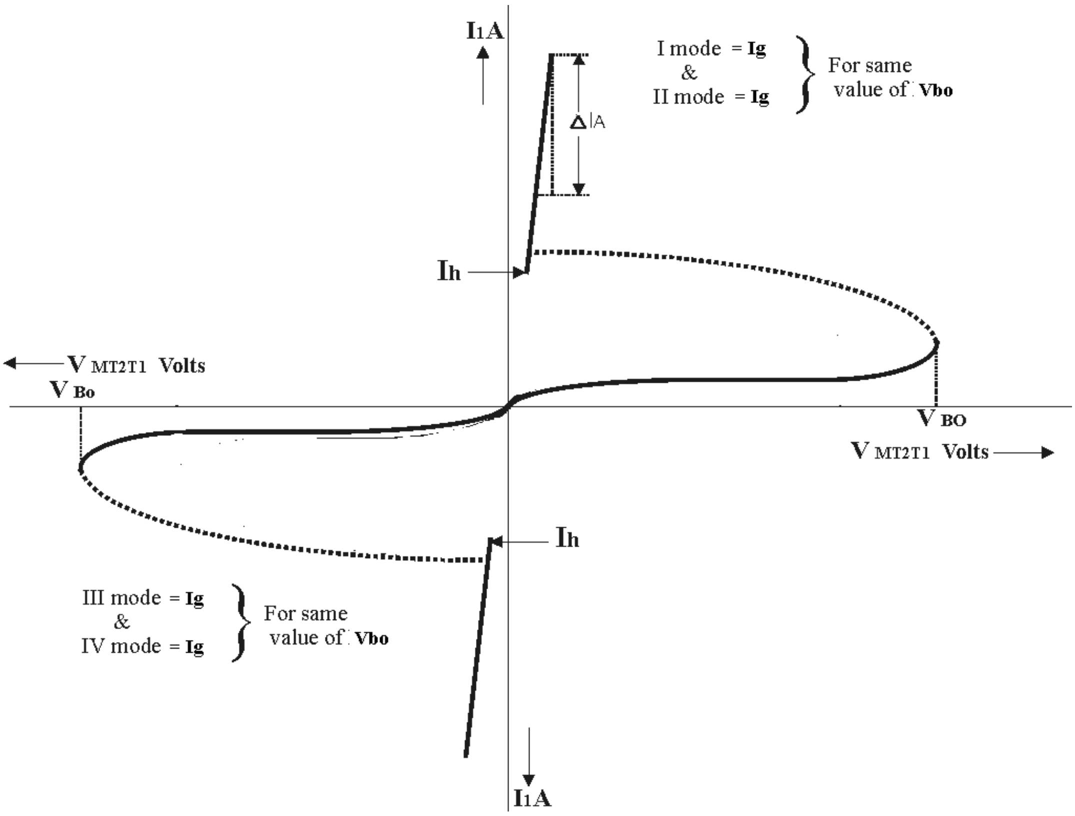
1. Connections are made as shown in the circuit diagram (b)
2. The gate current is set as same value as in i-mode
3. Repeat the step no. s 3, 4, 5, 6, & 7 of I-mode

Characteristic curve: -

Normal Method



Alternate Method



III mode

1. Connections are mode as shown in the circuit diagram (c).
2. Step no. s 2, 3, 4, 5, 6, & 7 are to be repeated as in i-mode.

IV mode

1. Connections are mode as shown in the circuit diagram (d)
2. Repeat the step no. s 2, 3, 4, 5, 6, & 7 of i-mode.

Alternate Method: -

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.

Tabular column: -

I-mode

i g = ma

Sl.no	V_{TRIAC} volts	I_{TRIAC} ma

II-mode

I g = ma

Sl.no	V_{TRIAC} volts	I_{TRIAC} ma

III-mode

i g = ma

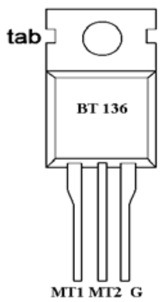
Sl.no	V_{TRIAC} volts	I_{TRIAC} ma

IV-mode

I g = ma

Sl.no	V_{TRIAC} volts	I_{TRIAC} ma

Base diagram of BT136:



Viva questions: -

1. Explain the different working modes of operations of a TRIAC?
2. Why i-mode is more sensitive among all modes?
3. What are the applications of TRIAC
4. Compare SCR, TRIAC & DIAC
5. Why I & II modes are operating in Ist quadrant and III & IV modes are operating in IIIrd quadrant?

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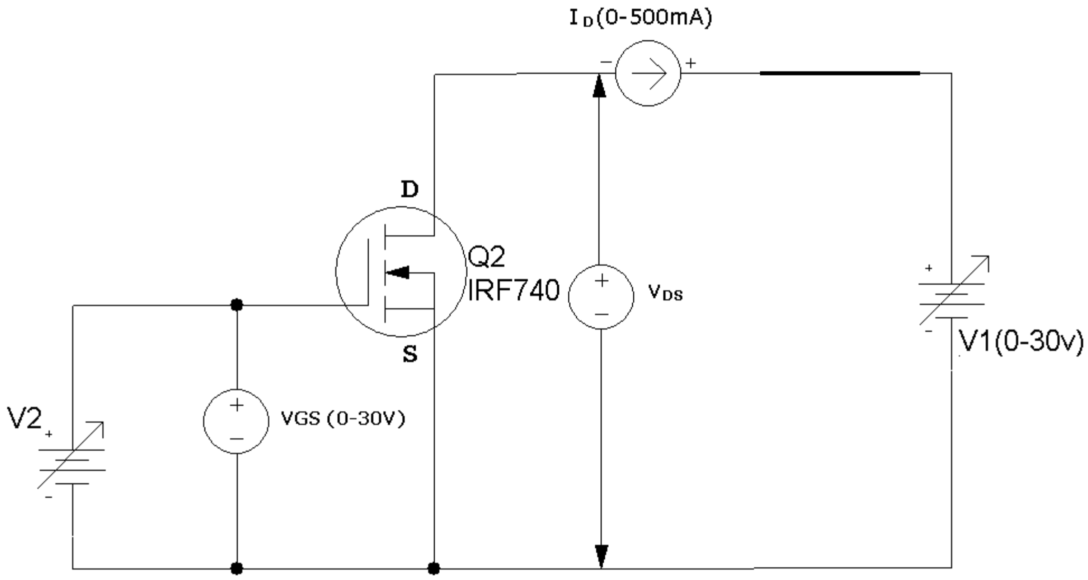
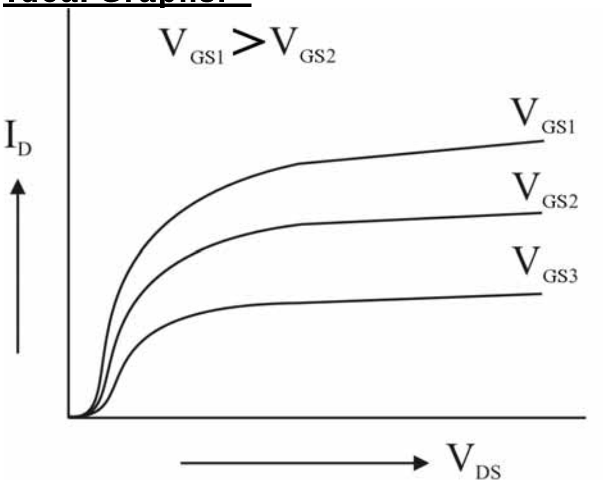
Signature of the staff with date

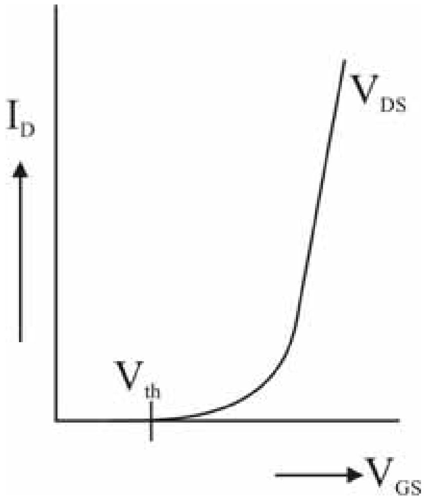
Circuit Diagram: -



Ideal Graphs: -



Drain Characteristics



Transconductance Characteristics

Tabular Column

V_{GS} =	
V_{DS}(V)	I_D(mA)

V_{GS} =	
V_{DS}(V)	I_D(mA)

V_{DS} =	
V_{GS}(V)	I_D(mA)

V_{DS} =	
V_{GS}(V)	I_D(mA)

Experiment No: 3 **DATE: __ / __ / ____**

MOSFET Characteristics

Aim: -

To study the characteristics of MOSFET

Apparatus required: -

MOSFET-IRF740, Power Supplies, Wattage Resistors, Ammeter, Voltmeter, etc.,

Procedure: -

Drain Characteristics

1. Connections are made as shown in the circuit diagram.
2. Adjust the value of V_{GS} slightly more than threshold voltage V_{th}
3. By varying V1, note down I_D & V_{DS} and are tabulated in the tabular column
4. Repeat the experiment for different values of V_{GS} and note down I_D v/s V_{DS}
5. Draw the graph of I_D v/s V_{DS} for different values of V_{GS}.

Transconductance Characteristics

1. Connections are made as shown in the circuit diagram.
2. Initially keep V1 and V2 zero.
3. Set V_{DS} = say 0.6 V
4. Slowly vary V2 (V_{GE}) with a step of 0.5 volts, note down corresponding I_D and V_{DS} readings for every 0.5v and are tabulated in the tabular column

5. Repeat the experiment for different values of V_{DS} & draw the graph of I_D v/s V_{GS}
6. Plot the graph of V_{GS} v/s I_D

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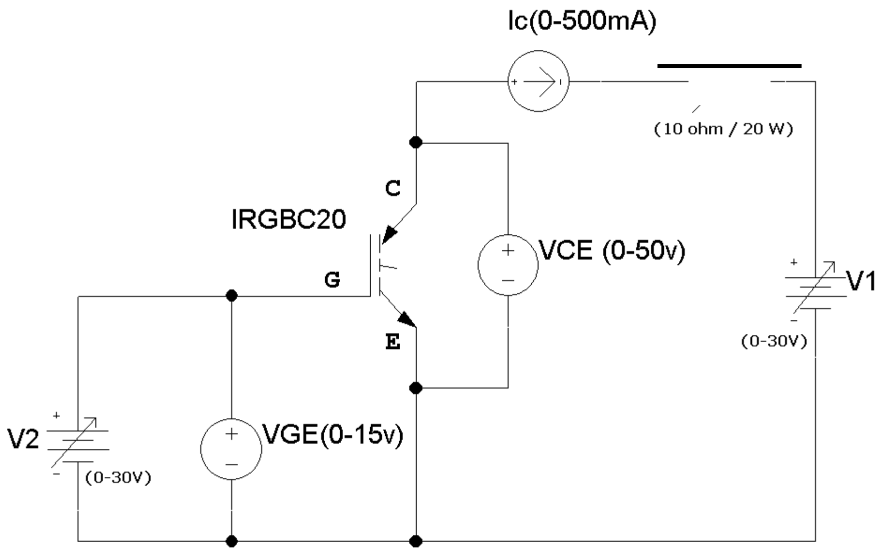
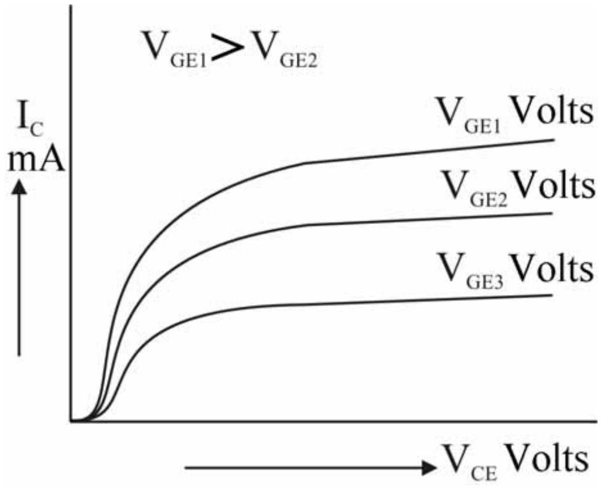
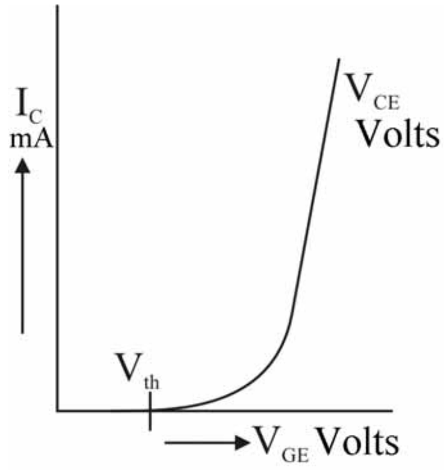
Circuit Diagram: -



Ideal Graphs: -



Collector Characteristics



Transconductance Characteristics

Tabular Column

V_{GE} =	
V_{CE}(V)	I_C(mA)

V_{GE} =	
V_{CE}(V)	I_C(mA)

V_{CE} =	
V_{GE}(V)	I_C(mA)

V_{CE} =	
V_{GE}(V)	I_C(mA)

Experiment No: 4 **DATE: __ / __ / ____**

IGBT Characteristics

Aim: -

To study the characteristics of IGBT

Apparatus required: -

IGBT-IRGBC 20S, Power Supplies, Wattage Resistors, Ammeter, Voltmeter, etc.,

Procedure: -

Collector Characteristics

1. Connections are mode as shown in the circuit diagram.
2. Initially set V2 to V_{GE1} = 5v (slightly more than threshold voltage)
3. Slowly vary V1 and note down I_C and V_{CE}
4. For particular value of V_{GE} there is pinch off voltage (V_P) between collector and emitter
5. Repeat the experiment for different values of V_{GE} and note down I_C v/s V_{CE}
6. Draw the graph of I_C v/s V_{CE} for different values of V_{GE}.

Transconductance Characteristics

1. Connections are mode as shown in the circuit diagram.
2. Initially keep V1 and V2 at zero.
3. Set V_{CE1} = say 0.8 v

4. Slowly vary V2 (V_{GE}) and note down I_C and V_{GE} readings for every 0.5v and enter tabular column

5. Repeat the experiment for different values of V_{CE} and draw the graph of

   I_C v/s V_{GE}

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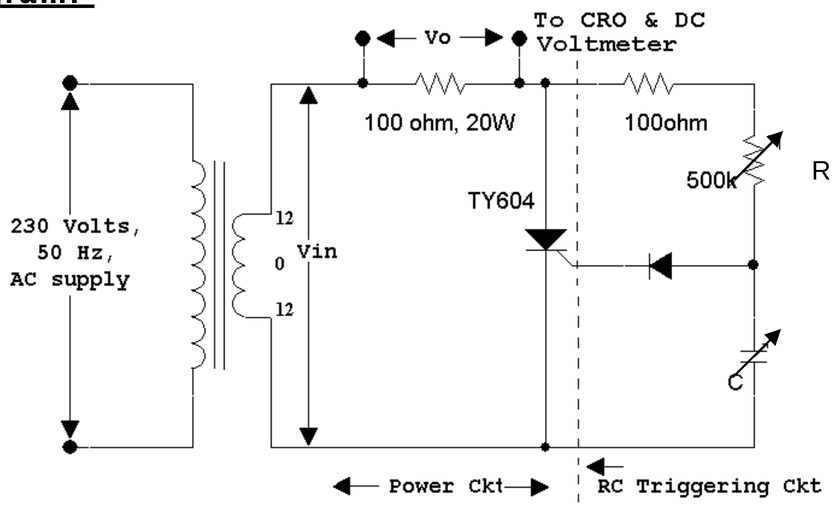
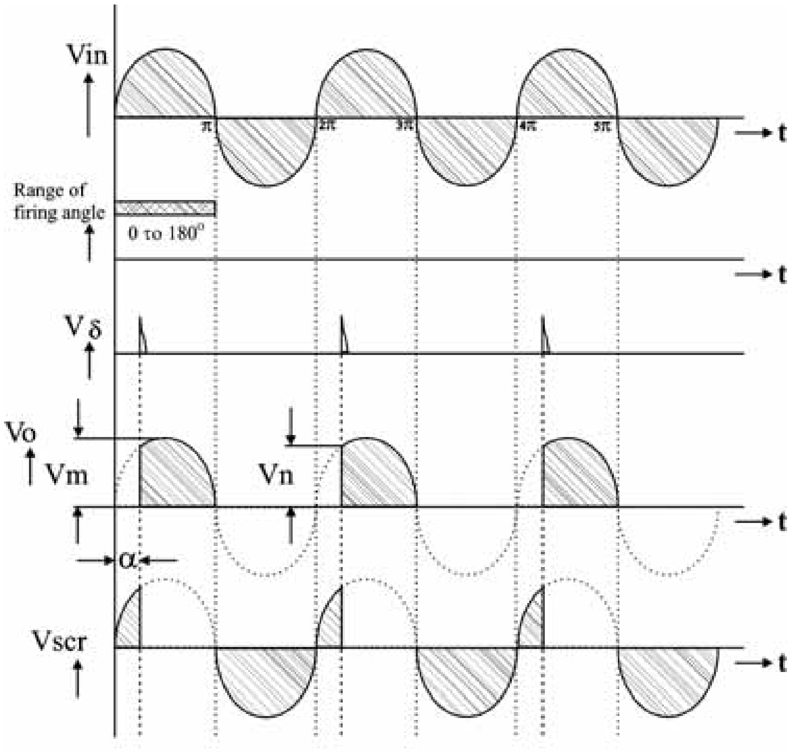
Half Wave Rectifier using RC Triggering

Circuit diagram:-

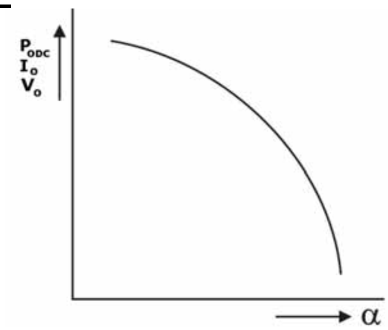


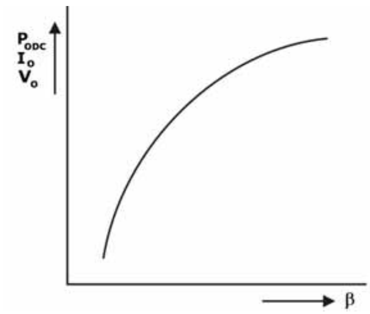
Waveforms:-



Where α = firing angle

Graph: -





Experiment No: 5 **DATE: __/__/____**

RC Triggering Circuit – HWR & FWR

AIM: -

To study the performance & waveforms of HWR & FWR by using RC triggering Circuit

APPARATUS REQUIRED: -

Transformer, SCR – TY604, BY127, Resistor, Capacitor, Ammeter, Voltmeter

PROCEDURE: -

Half Wave Rectifier

1. Connections are made as shown in the circuit diagram
2. By varying a resistance R gradually in step by step, note down the corresponding values of V_n & V_m from CRO and V_{odc} from the DC voltmeter. The readings are tabulated in the tabular column.
3. If the firing angle ranges from 0 to 90^O, then the firing angle α is calculated by using a formula $\alpha = \sin^{-1}\left(\frac{V_n}{V_m}\right)$ in degrees.
4. The conduction angle β is calculated by using a formula, $\beta = 180 - \alpha$.
5. The current and power is calculated by

   $I_{odc} = \frac{V_{odc}}{R}$ A & $P_{odc} = \frac{V_{odc}^2}{R}$ Watts respectively.
6. A graph of Vo v/s α, Vo v/s β, Io v/s α, Io v/s β, Podc v/s α, Podc v/s β are to be plotted.
7. Compare practical output voltage with theoretical output voltage,

$$V_{oth} = \frac{V_m}{2\pi}(1 + \cos\alpha)\text{ volts} \qquad \text{where } Vm = \sqrt{2}V_{rms}$$

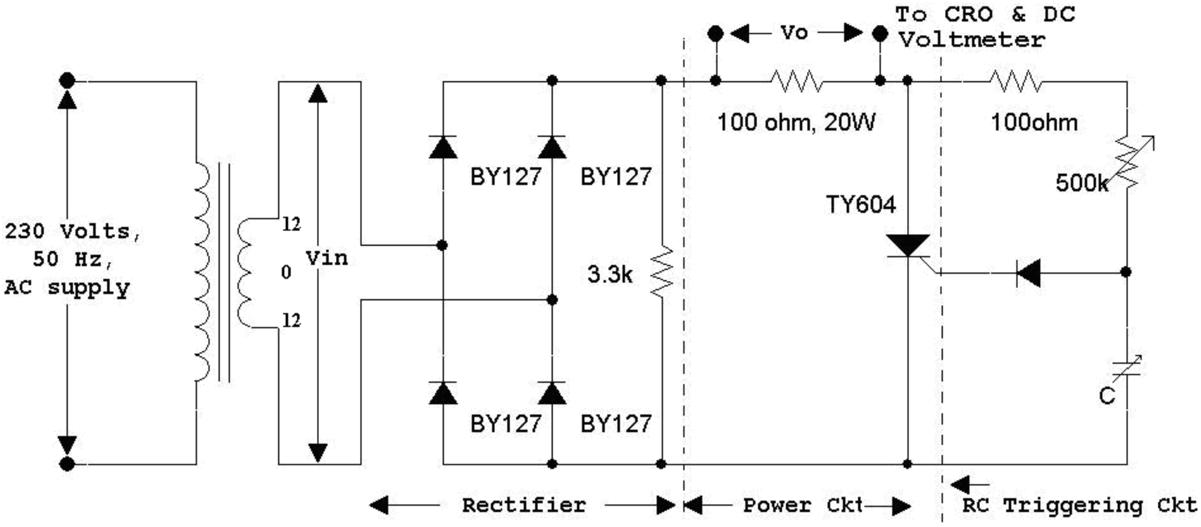
Full Wave Rectifier

1. Repeat the above said procedure for full wave rectifier.

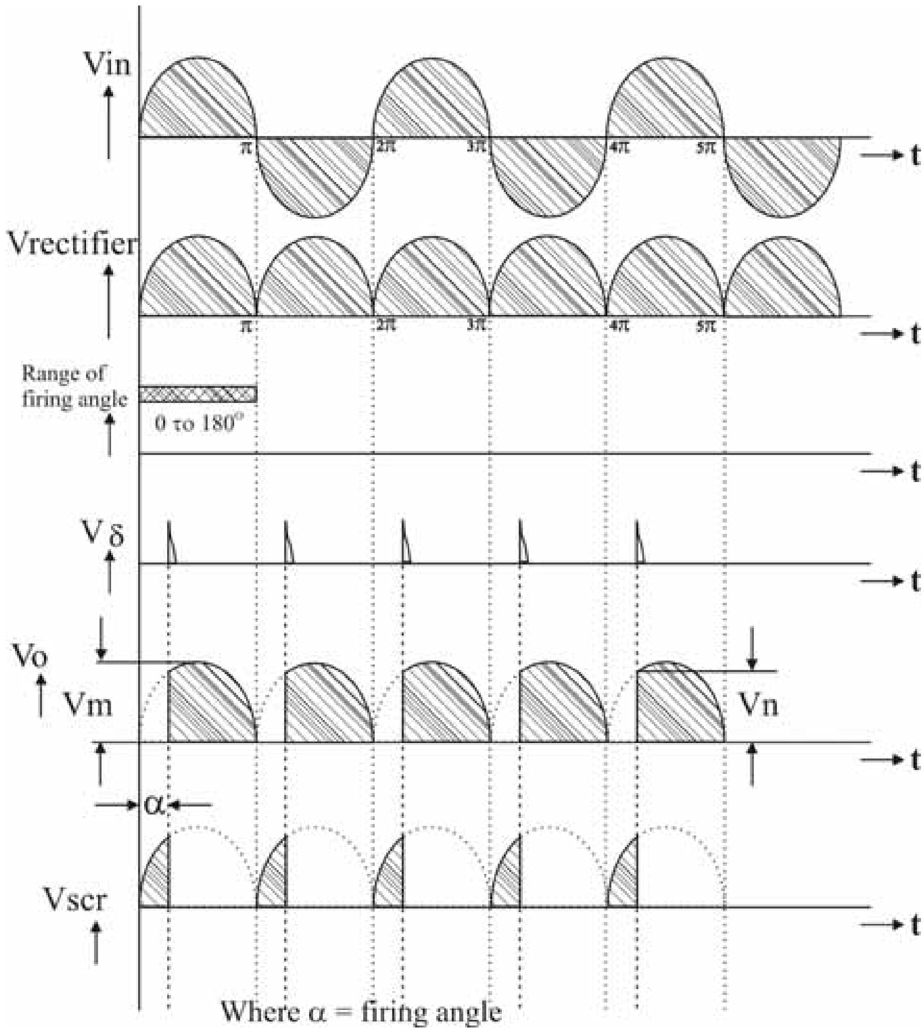
$$V_{oth} = \frac{V_m}{\pi}(1 + \cos\alpha)\text{ volts} \qquad \text{where } Vm = \sqrt{2}V_{rms}$$

Full Wave Rectifier using RC Triggering

Circuit diagram:-



Waveforms:-



Tabular Columns:-

Half Wave Rectifier

Sl. No.	Vn	Vm	($\alpha<90^{O}$)	($\alpha>90^{O}$)	Vodc	V_{oth}

			$\alpha = \sin^{-1}\left(\frac{V_n}{V_m}\right)$	$\alpha = 180 - \sin^{-1}\left(\frac{V_n}{V_m}\right)$		

Full Wave Rectifier

Sl. No.	Vn	Vm	$(\alpha<90^O)$ $\alpha = \sin^{-1}\left(\frac{V_n}{V_m}\right)$	$(\alpha>90^O)$ $\alpha = 180 - \sin^{-1}\left(\frac{V_n}{V_m}\right)$	Vodc	V_{oth}

Viva Questions: -

1. Explain the working operation of the circuit?
2. What are the limitations of R triggering circuit?
3. What are the limitations of RC triggering circuit?
4. Mention different methods of triggering SCR?
5. Why gate triggering is preferred?

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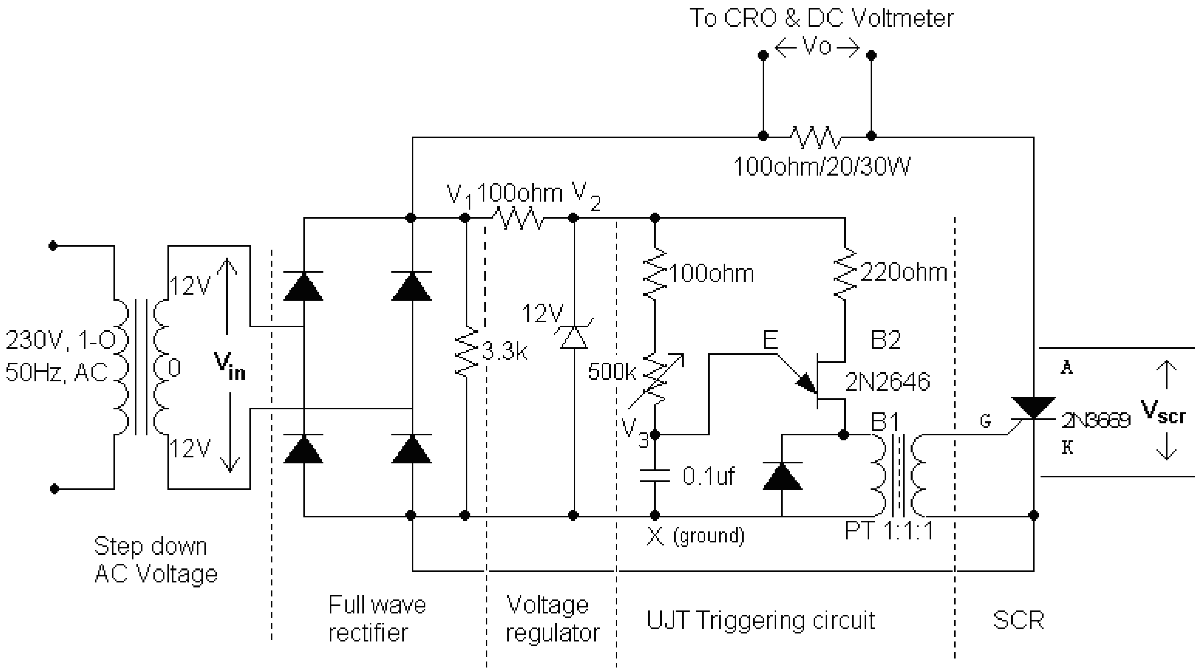
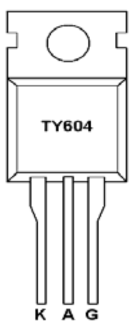
Signature of the staff-in-charge

CIRCUIT DIAGRAM: -

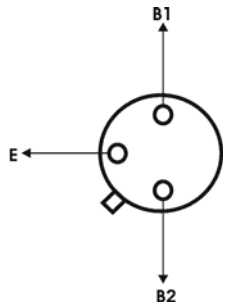


Base Diagrams: -

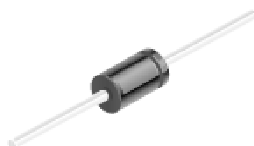
SCR-TY604



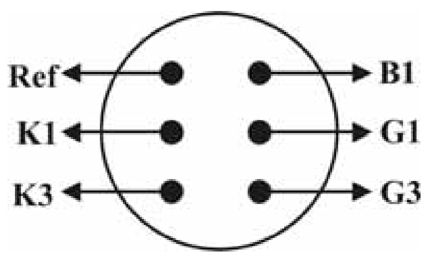
UJT: -2N2646



Diode: - BY127



Pulse Transformer



Experiment No: 6 **DATE: __ / __ / ____**

U. J. T. Triggering of S. C. R

AIM: - To study the performance & waveforms of U.J.T triggering of S.C.R.

APPARATUS REQUIRED: -

SCR-TY604, Power supplies, Wattage Resistors, Ammeter, Voltmeter, UJT-2N2646, Pulse Transformer, etc.,

PROCEDURE: -

1. Connections are mode as shown in the circuit diagram
2. By varying a resistance R gradually in step by step, note down the corresponding values of V_n & V_m from CRO and V_{Odc} from D.C voltmeter. The readings are tabulated in the tabular column.
3. If firing angle ranges from 0 to 90^0, then firing angle can be calculated from

$$\alpha = Sin^{-1}\left(\frac{V_n}{V_m}\right) \quad \text{in degrees}$$

   If firing angle ranges from 90^0 to 180^0, then firing angle can be calculated by using a formula,

$$\alpha = 180 - Sin^{-1}\left(\frac{V_n}{V_m}\right) \quad in \quad \text{degrees}$$

4. The conduction angle β can be calculated by using a formula,

$$\beta = 180 - \alpha$$

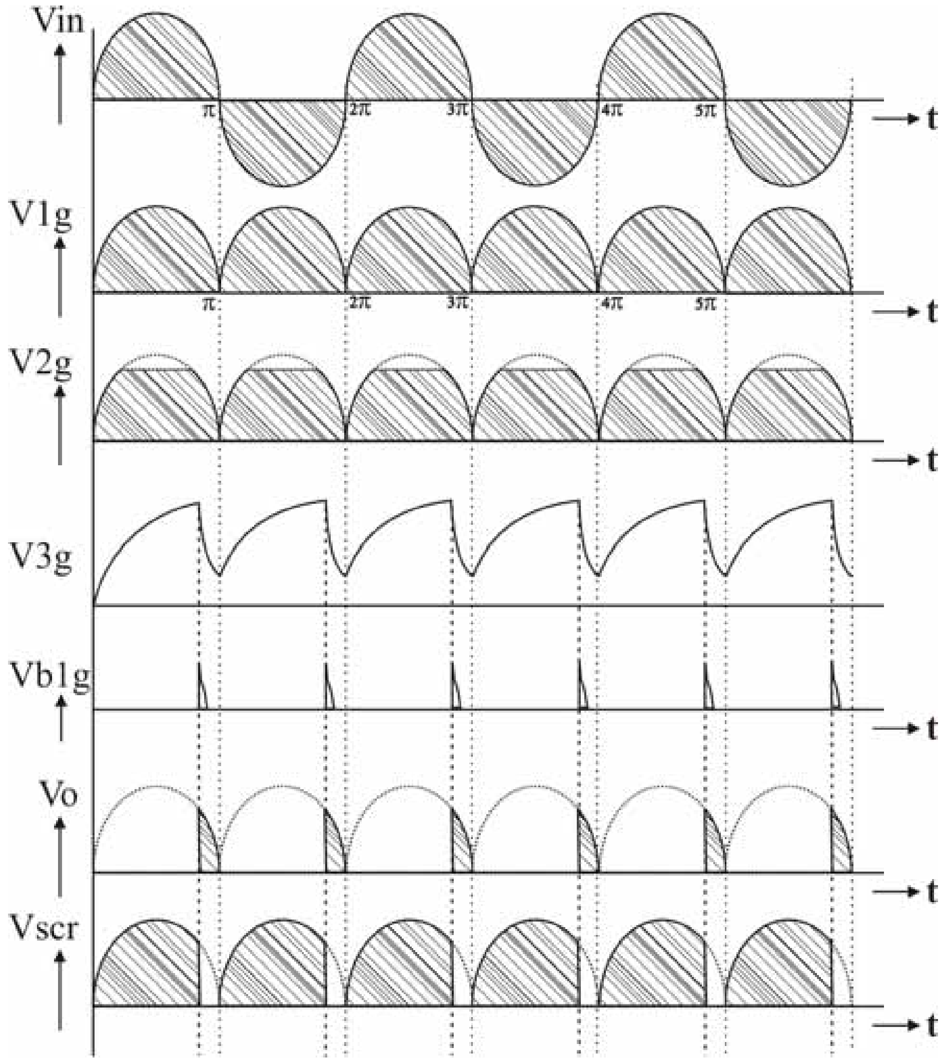
5. The current & power is calculated by

$$I_{dc} = \frac{V_{dc}}{R} \text{ Amps}$$

$$P_{dc} = \frac{V_{dc}^2}{R} \text{ Watts respectively}$$

6. A graph of V_{dc} v/s α, V_{dc} v/s β, I_{dc} v/s α, I_{dc} v/s β, P_{dc} v/s α , and P_{dc} v/s β are to be plotted on a graph sheet.

IDEAL WAVEFORMS: -



Tabular Column: -

Sl. No	FROM C.R.O								V_{DC} (V_{load}) volts	I_{dc} = V_{dc}/R A	P_{dc} = V_{dc}^2/R Watts	V_{oth}
	0 TO 90^0				90^0 TO 180^0							
	V_n volts	V_m volts	$\alpha = Sin^{-1}\left(\frac{V_n}{V_m}\right)^o$	β=180-α	V_n volts	V_m volts	$\alpha = 180 - Sin^{-1}\left(\frac{V_n}{V_m}\right)^o$	β= 180-α				

7. For given frequency, the value of R can be calculated by using a formula,

$$T = 2.303RC.\log_{10}\frac{1}{1-\eta}$$

$$R = \frac{T}{2.303C.\log_{10}\frac{1}{1-\eta}}\Omega$$

When C = 0.1 mF & N = Intrinsic stand off ratio = 0.67

8. This value of R is set in the circuit, Step No S 3. 4. 5. & 6. are repeated and waveforms are observed at different points as shown.

9. Compare V_{oth} with $V_{oPractical}$ where $V_{oth} = \frac{V_m}{\pi}[1+\cos\alpha]$

VIVA QUESTIONS: -

1. Explain the working operation of U.J.T. triggering circuit waveforms?
2. Why U.J.T. Triggering circuit is superior when compared to R & RC triggering circuit?
3. What is the use of pulse transformer?
4. Explain the design part of UJT?
5. Write equivalent circuit of UJT and show that $V_{peak} = V_{emitter} = V_{\gamma}+\eta V_{BB}$.
6. Why do we require turn-on circuits for thyristors?
7. Why do we require turn-off circuits for thyristors?
8. Comment on Forced & Natural Commutation techniques.

……………………………………………….

Signature of the staff-in-charge

Designing of zener voltage regulator

O/p of diode rectifier = $\frac{2vm}{\Pi} = \frac{2\sqrt{Z}}{\Pi} Vrms = \frac{(2\sqrt{Z})24}{\Pi} = 21.6volts$

Vo = 21.6 volts

Take (assume) V = 21.6 $\pm$ 2

V_{min} = 19.6 Volts and V_{max} = 23.6 volts

Vz = 12 V, I_L = 10 ma, P_z = 400 mw = 0.4w

V_{min} = 19.6 volts, V_{max} = 23.6 volts,

1) $R_L = \frac{V_Z}{I_L} = \frac{12}{0.01} = 1.2K\Omega$

2) $I_z = \frac{P_Z}{V_Z} = \frac{0.4}{12} 33.33mA$

Is = Iz + I_L = $(33.33X\ 10^{-3}) + (10X10^{-3}) = 43.33X10^{-3}$ A

Is = 43.33ma

When V = Vmax = 23.6 volts,

Rs = $\frac{V_{max} - V_o}{I_s} = \frac{23.6 - 12}{0.04333} = 267.72\Omega$

whenV = Vmin = 19.6 volts,

Rs= $\frac{V_{min} - V_o}{I_s} = \frac{19.6 - 12}{0.04333} = 175.4\Omega$

.: 175.4^{Ω} < Rs < 267.22 Ω

select Rs = 300Ω

wattage = Is^2 Rs = $(43.33\ X\ 10^{-3})^2$ X 300 = 0.563 w

.: Select Rs = 300Ω, 1w

Design of UJT

We have Vp = $nV_{bb} + V_{diode}$ = (0.63) (12) + 0.7 = 8.26 volts

Select V_p = 8.26 volts, V_V = 1 volt

I_V = 10 ma I_P = 5 micro amps

I. WKT, Rmax = $\frac{V_{bb}-V_p}{I_p}=\frac{12-8.26}{0.000005}=748k\Omega$

II. Rmin = $\frac{V_{bb}-V_V}{I_V}=\frac{12-1}{0.01}$ = 1.1k Ω

. : Rmin < R < Rmax

. : R varies from 1.1kΩ to 748KΩ

III. R2 = 10000/n V_B = 1000/(0.63)(12) = 1.32 KΩ

Select R2 = 220Ω

Designing of fuming pulses

Let F = 1 kHz, C = 0.01micro farads

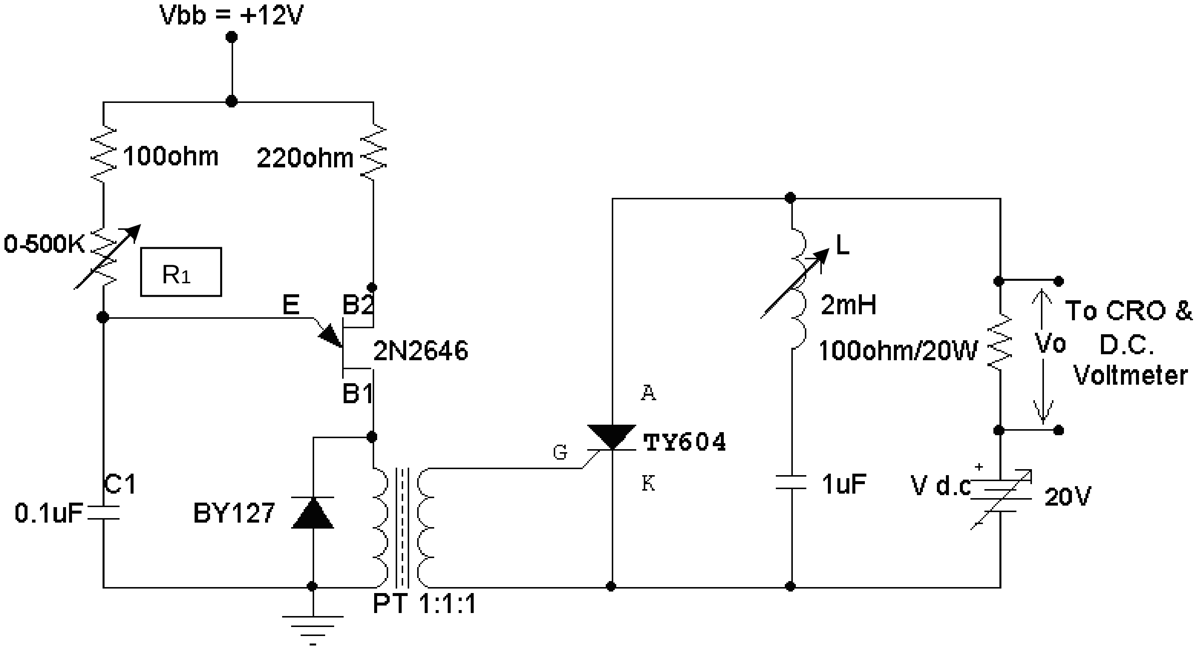
T = 1/f = 1/1k = 1 ms

. : WKT , T = 2.303 RC log 10 $\frac{1}{1-n}$

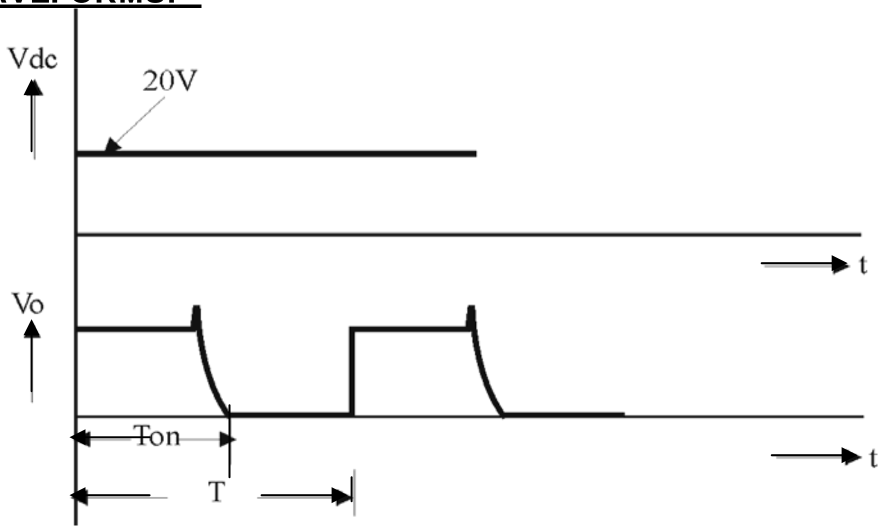
. : R = $\frac{T}{2.303C\log_{10}\frac{1}{1-n}}=\frac{0.011}{2.303X0.00000001X\log_{10}\frac{1}{1-0.63}}=18.75k\Omega$

R = 18.75 K Ω

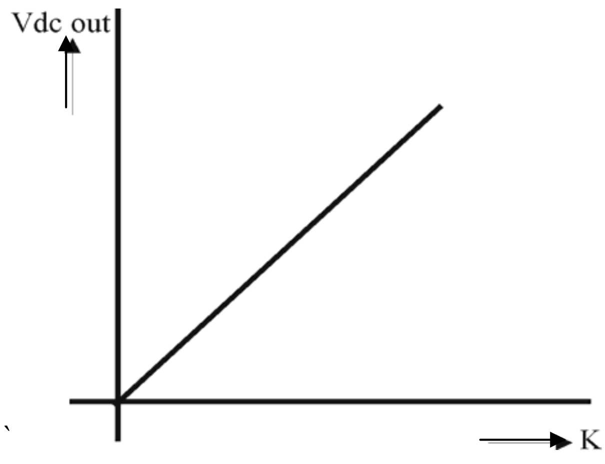
CIRCUIT DIAGRAM: -



IDEAL WAVEFORMS: -



IDEAL GRAPH: -



Experiment No: 7 **DATE: __ / __ / ____**

Oscillation Chopper Circuit

AIM: -

a) To convert variable D.C. voltage from a fixed D.C. input voltage.

b) Plot a graph of V_{DCOUT} v/s Duty cycle (K)

APPARATUS REQUIRED: -

SCR-TY604, UJT-242646, Pulse Transformer, Power supplies, Wattage resistor, Ammeter, Voltmeter, etc.,

PROCEDURE: -

A. Variable Frequency Operation

1. Connections are mode as shown in the circuit diagram.
2. The input D.C. voltage V_{DC} is set as convenient value say 20 V
3. Select proper values of L, for a given duty cycle C is calculated so that T_{ON} is constant.
4. By varying the variable resistor R_1 in step-by-step gradually, note down T_{ON} and T from CRO and V_O or V_{DCout} from D.C voltmeter.
5. The theoretical Ton and theoretical T are to be calculated by using a formula.

$$T_{ON_{th}} = \Pi\sqrt{LC} \qquad T_{th} = 2.303R_1C_1.\log_{10}\frac{1}{1-\eta}$$

Where η = Intrinsic stand off ratio = 0.67

6. The theoretical output voltage V_O or $V_{DCOUT\text{-}th}$ are to be calculated using formula,

$$V_{O_{th}} = V_{DCout_{th}} = \frac{T_{ON_{th}}}{T_{th}} \times V_{DC} \qquad V_{O_{CRO}} = V_{DCout_{CRO}} = \frac{T_{ON_{CRO}}}{T_{CRO}} \times V_{DC}$$

7. All observations and calculations are tabulated in a tabular column.
8. Compare V_{oth}, V_{oCRO} & V_O d.c.voltmeter
9. Plot a graph of V_{odc} v/s duty cycle (k)

Turn-off Circuit Design: -

$$I_{peak} = V\sqrt{\frac{C}{L}} \qquad \text{Where } I_{peak} = 2I_O$$

$$T_{off} = \frac{\pi\sqrt{LC}}{2} \qquad T_{off} = \text{Device turn off time}$$

Tabular Column:- (A)

Sl.No	V_{DC} Volts	R_1 Ω	C_1 μF	L H	C μF	$T_{ON_{th}} = \Pi\sqrt{LC}$	$T_{th} = 2.303\ RC.\log_{10}\frac{1}{1-\eta}$	$T_{ON_{CRO}}$	T_{CRO}	$V_{O_{th}} = \frac{T_{ON_{th}}}{T_{th}} \times V_{DC}$	$V_{O_{CRO}} = \frac{T_{ON_{CRO}}}{T_{CRO}} \times V_{DC}$	V_O D.C.Voltmeter

Tabular Column:- (B)

Sl.No	V_{DC} Volts	R_1 Ω	C_1 μF	L H	C μF	$T_{ON_{th}} = \Pi\sqrt{LC}$	$T_{th} = 2.303\ RC.\log_{10}\frac{1}{1-\eta}$	Duty cycle $K = \frac{T_{ON}}{T}$	$V_O = \frac{T_{ON}}{T} \times V_{DC}$

$$Let\ I_O = 100\ mA \qquad I_{peak} = V\sqrt{\frac{C}{L}}$$

$$I_{peak} = 200\ mA \qquad \sqrt{\frac{C}{L}} = \frac{I_{peak}}{V}\ \frac{200 \times 10\ /-3}{20}\ \frac{c}{l} = \{1 \times 10\ /-\ 4\}$$

$$V = 20\ volts \qquad C = \left(1 \times 10^{-4}\right)L - - - - (1)$$

$$T_{off} = 50\ \mu s$$

$$T_{off} = \frac{\pi\sqrt{LC}}{2} \qquad \therefore LC = \left(\frac{2T_{off}}{\pi}\right)^2 = \left(\frac{2\times 50\times 10^{-6}}{\pi}\right)^2 = 1\times 10^{-9}$$

$$solving\ 1\ \&\ 2\ we\ get$$

$$We\ \text{know that}\ C = \left(1\times 10^{-4}\right)L \qquad \therefore L = \sqrt{\frac{1\times 10^{-9}}{1\times 10^{-4}}} = 3.16\ mH$$

$$\therefore C = \left(1\times 10^{-4}\right)L = \left(1\times 10^{-4}\right)\left(3.16\times 10^{-3}\right) = 3.16\times 10^{-7} = 0.316\ \mu F$$

For successful commutation, turn off time of the circuit should be greater than turn off time of the device.

Select C = 1μF and L = 3mH.

$\therefore$Circuit turn off time = $\frac{\pi\sqrt{LC}}{2} = \frac{\pi}{2}\sqrt{1\times10^{-6}\times3\times10^{-3}} = 86\mu s$

$\therefore$Circuit turn off time > turn off time of the device

i.e., 86μs > 50μs

B. Fixed Frequency Operation

1. The value of variable resistor R1 is set at some value is T is fixed
2. By varying L at different values, calculate the duty cycle $K = \frac{T_{ON}}{T}$ Where

$$T_{ON_{th}} = \Pi\sqrt{LC} \quad \text{and} \quad T = 2.303RC.\log_{10}\frac{1}{1-\eta}$$

3. Note down the corresponding o/p D.C. Voltage V_{DCOUT} from D.C.Voltmeter

$$V_{O_{th}} = V_{DCout_{th}} = \frac{T_{ON_{th}}}{T_{th}} \times V_{DC} \qquad V_{O_{CRO}} = V_{DCout_{CRO}} = \frac{T_{ON_{CRO}}}{T_{CRO}} \times V_{DC}$$

4. Plot a graph of V_{DCOUT} v/s Duty cycle (K)

VIVA QUESTIONS: -

1. Explain the working operation of oscillation chopper circuit?
2. What type of commutation circuit is employed in this circuit? Why it is necessary?
3. Why UJT triggering is preferred?
4. Explain the working function of each component?
5. Explain the different types of commutation circuit

Note:- for T = 10 ms, K = 30% means T_{ON} = 0.3 T

$T = T_{ON} + T_{OFF}$ K = 50% means T_{ON} = 0.5 T

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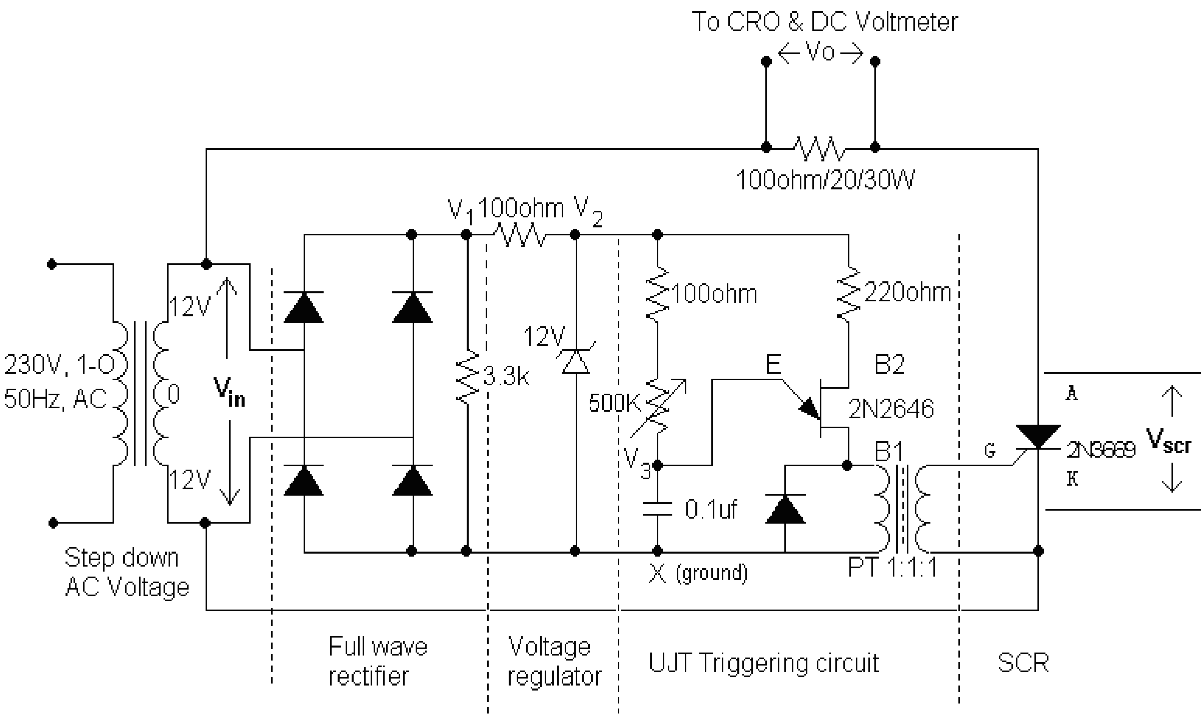
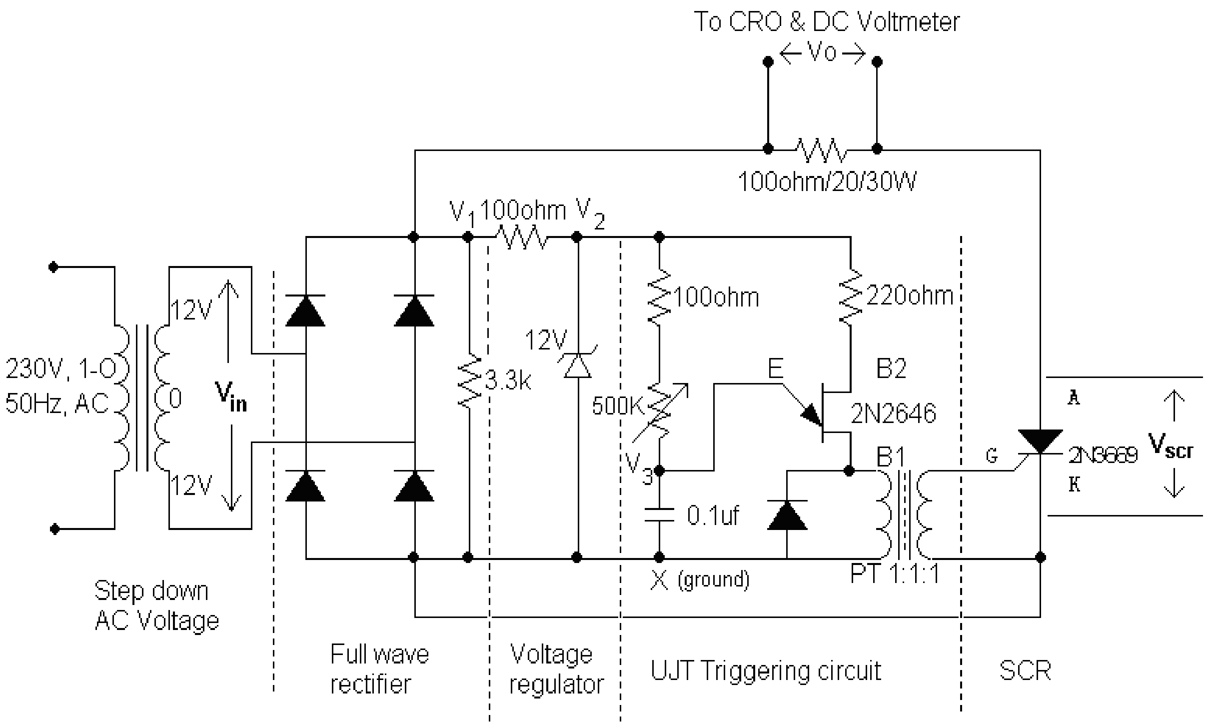
CIRCUIT DIAGRAM: -

Half Wave Rectifier



Full Wave Rectifier



Experiment No: 8 **DATE: __ / __ / ____**

U. J. T. Triggering for HWR & FWR

AIM: - To study the performance & waveforms of U.J.T triggering of S.C.R.

APPARATUS REQUIRED: -

SCR-TY604, Power supplies, Wattage Resistors, Ammeter, Voltmeter, UJT-2N2646, Pulse Transformer, etc.,

PROCEDURE: -

1. Connections are mode as shown in the circuit diagram
2. By varying a resistance R gradually in step by step, note down the corresponding values of V_n & V_m from CRO and V_{dc} from D.C voltmeter. The readings are tabulated in the tabular column.
3. If firing angle ranges from 0 to 90^0, then firing angle can be calculated from

   $\alpha = Sin^{-1}\left(\frac{V_n}{V_m}\right)$ in degrees. If firing angle ranges from 90^0 to 180^0, then firing angle can be calculated by using a formula,

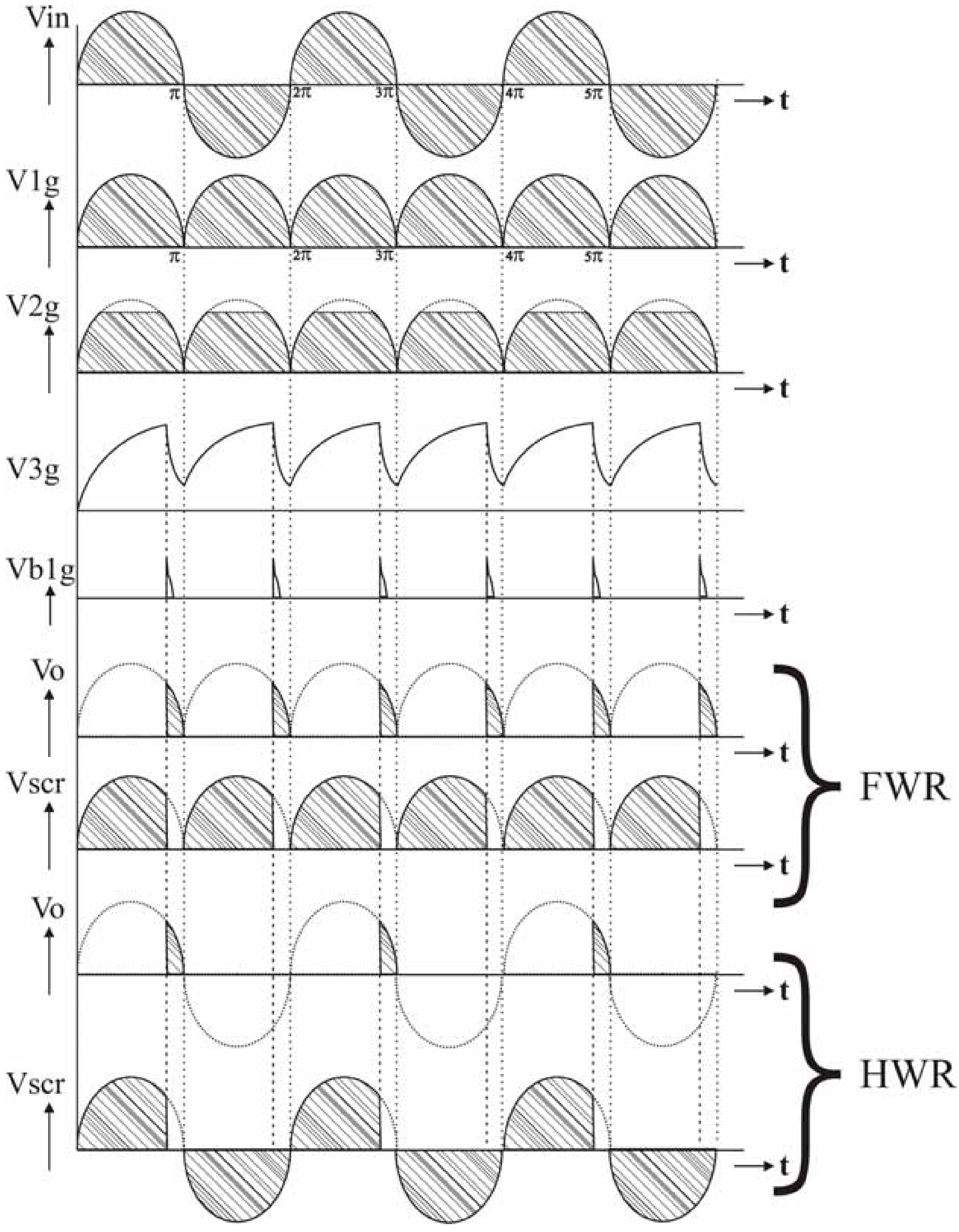
   $$\alpha = 180 - Sin^{-1}\left(\frac{V_n}{V_m}\right) \quad \text{in degrees}$$

4. The conduction angle β can be calculated by using a formula, $\beta = 180 - \alpha$
5. The current & power is calculated by

   $$I_{dc} = \frac{V_{dc}}{R} \text{ Amps} \qquad P_{dc} = \frac{V_{dc}^2}{R} \text{ Watts} \quad \text{respectively}$$

6. A graph of V_{dc} v/s α, V_{dc} v/s β, I_{dc} v/s α, I_{dc} v/s β, P_{dc} v/s α , and P_{dc} v/s β are to be plotted on a graph sheet.

IDEAL WAVEFORMS: -



7. For given frequency, the value of R can be calculated by using a formula,

$$T = 2.303RC.\log_{10}\frac{1}{1-\eta}$$

$$R = \frac{T}{2.303C.\log_{10}\frac{1}{1-\eta}}\Omega$$

When C = 0.1 mF & N = Intrinsic stand off ratio = 0.67

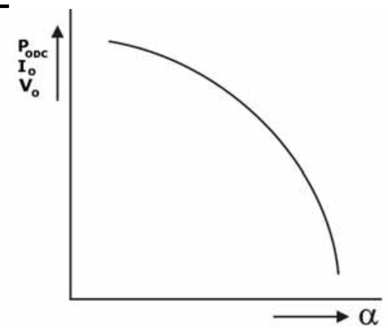
8. This value of R is set in the circuit, Step No S 3. 4. 5. & 6. are repeated and waveforms are observed at different points as shown.

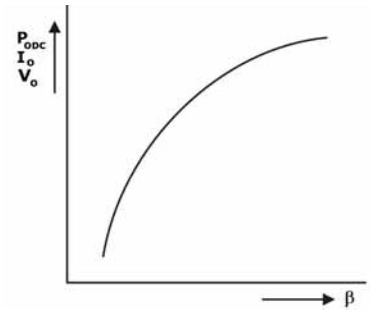
9. The practical o/p voltage ($V_{o\ meter}$) is compared with V_{oth}

$$For\ HWR, V_{oth} = \frac{V_m}{2\pi}(1+\cos\alpha)\ volts\ where\ V_m = \sqrt{2}V_{in\,rms}$$

$$For\ FWR, V_{oth} = \frac{V_m}{\pi}(1+\cos\alpha)\ volts$$

Graph: -





Tabular Column:- a) Half wave switches

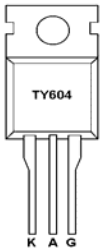
Sl.No	FROM C.R.O								V_{DC} (V_{load}) volts	I_{dc} = V_{dc}/R A	P_{dc} = V_{dc}^2/R Watts
	0 TO 90^0				90^0 TO 180^0						
	V_n volts	V_m volts	$\alpha = Sin^{-1}\left(\frac{V_n}{V_m}\right)^o$	β=180-α	V_n volts	V_m volts	$\alpha = 180 - Sin^{-1}\left(\frac{V_n}{V_m}\right)^o$	β=180-α			

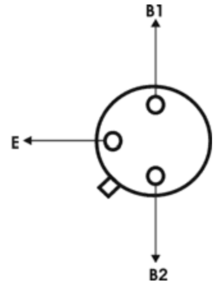
Full wave switches

Sl. No	FROM C.R.O								V_{DC} (V_{load}) volts	I_{dc} = V_{dc}/R A	P_{dc} = V_{dc}^2/R Watts
	0 TO 90^0				90^0 TO 180^0						
	V_n volts	V_m volts	$\alpha = Sin^{-1}\left(\frac{V_n}{V_m}\right)^o$	β=180-α	V_n volts	V_m volts	$\alpha = 180 - Sin^{-1}\left(\frac{V_n}{V_m}\right)^o$	β=180-α			

Base Diagrams: -

SCR-TY604 **UJT: -2N2646** **Diode: - BY127**





VIVA QUESTIONS: -

1. Explain the working operation of U.J.T. triggering circuit waveforms?
2. Why U.J.T. Triggering circuit is superior when compared to R & RC triggering circuit?
3. What is the use of pulse transformer?
4. Explain the design part of UJT?
5. Write equivalent circuit of UJT and show that $V_{peak} = V_{emitter} = V_{\gamma} + \eta V_{BB}$.
6. Why do we require turn-on circuits for thyristors?
7. Why do we require turn-off circuits for thyristors?
8. Comment on Forced & Natural Commutation techniques.

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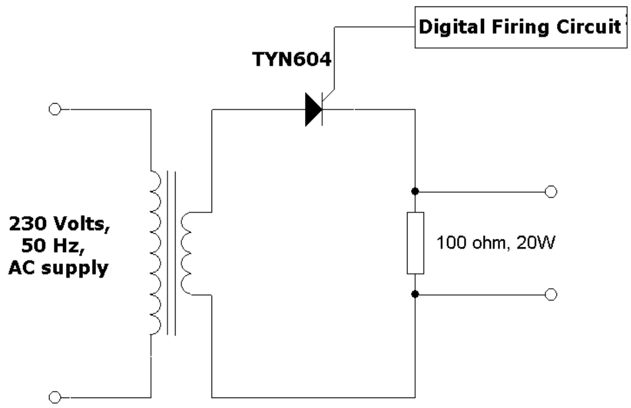
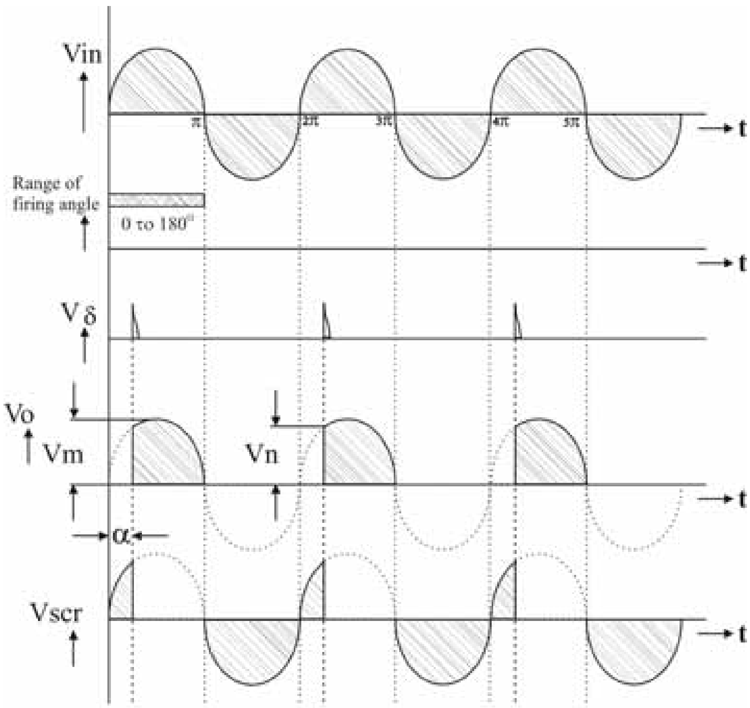
Signature of the staff-in-charge

Circuit Diagram:

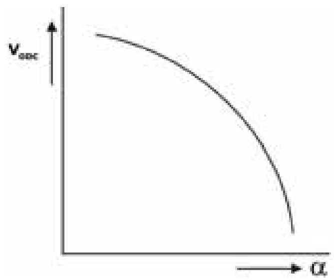


Wave form:-



Where α = firing angle

Graph:-



Tabular Column:-

Sl. No.	Firing Angle (α)	V_{ODC}

Experiment No: 9 **DATE: __ / __ / ____**

Digital Firing Circuit

Aim: -

To demonstrate digital firing circuit to turn on SCR (HW) for R-Load and to plot V_{ODC} v/s α.

Apparatus required: -

Digital Firing Module, SCR-TYN604, Resistor, etc.,

Procedure: -

1. Connections are made as shown in the circuit diagram.
2. Firing angle α is varied in steps gradually, note down corresponding values of V_{ODC} (DC voltmeter reading) and tabulate.
3. A graph of α v/s V_{ODC} is plotted.

Result: -

Digital Firing Circuit to turn on SCR is studied and a graph of α v/s V_{ODC} is plotted.

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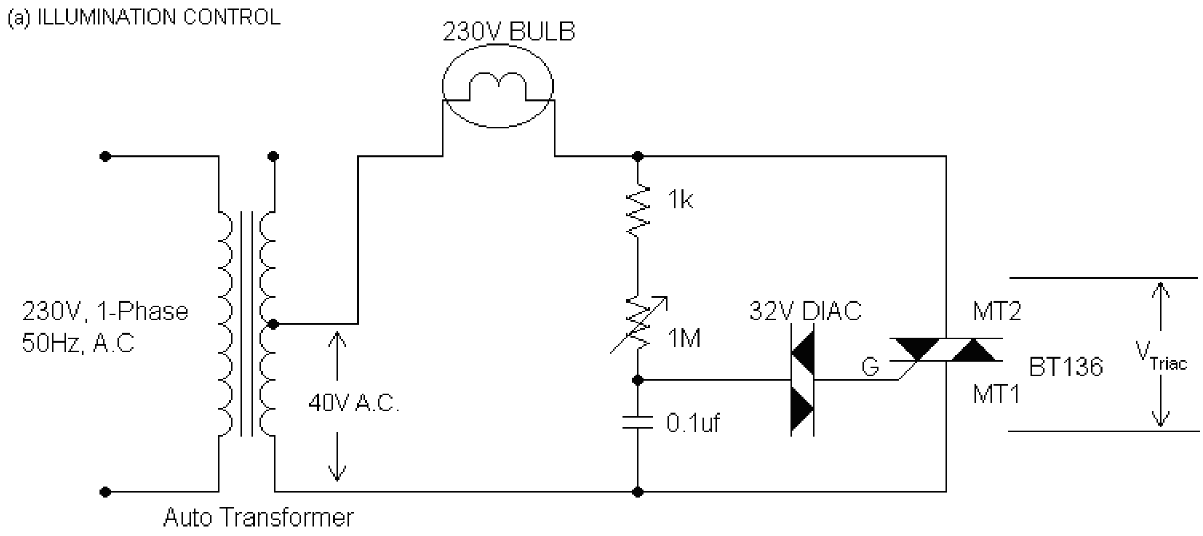
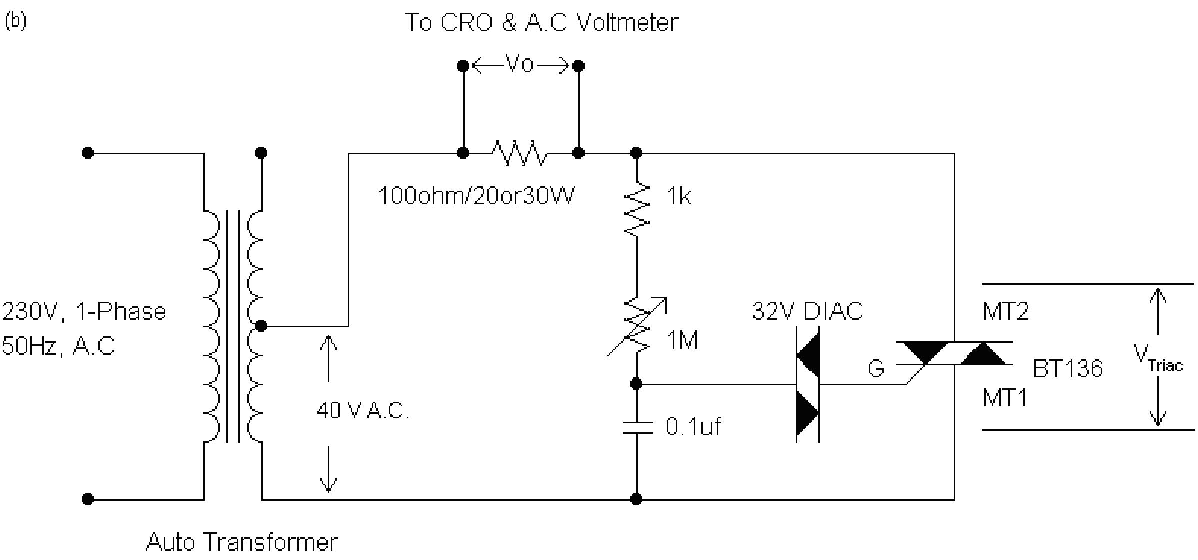
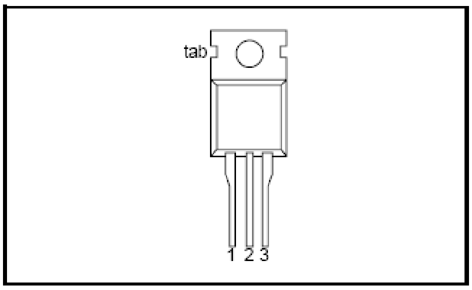
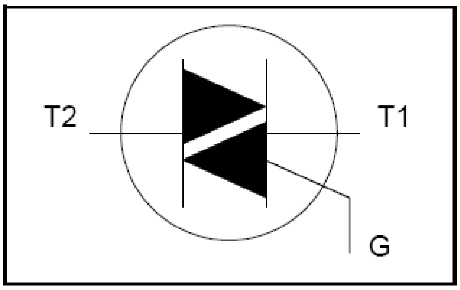
Signature of the staff with date

CIRCUIT DIAGRAM: -









PIN	DESCRIPTION
1	main terminal 1
2	main terminal 2
3	gate
tab	main terminal 2

Experiment No: 10 **DATE: __ / __ / ____**

AC Voltage Control by using TRIAC-DIAC Combination

AIM: -

1. To study the AC voltage control by using TRIAC-DIAC combination

APPARATUS REQUIRED: -

TRIAC, DIAC, supply voltage, wattage resistors, Ammeter, Voltmeter, etc,.

PROCEDURE: -

A.

1. Connections are mode as shown in the circuit diagram (a)
2. By varying the variable resistance R_1 in step by step, observe the variation of intensity of light.

B.

1. Connections are mode as shown in the circuit diagram (b)
2. By varying the resistance R, in step-by-step note down the corresponding vales of V_n & V_m from C.R.O. and $V_{a.c}$ from A.C. voltmeter the readings are tabulated in the tabular column

3. If delay angle ranges from 0 To 90^0, then firing angle can be calculated from $\alpha = Sin^{-1}\left(\frac{V_n}{V_m}\right)$ in degrees. If firing angle ranges from 90^0 To 180^0 then can be calculated by using a formula, $\alpha = 180 - Sin^{-1}\left(\frac{V_n}{V_m}\right)$ in degrees

4. The conduction angle B can be calculated by using a formula,

$$\beta = 180 - \alpha \text{ in degrees}$$

5. The current can be calculated by $I_{ac} = \frac{V_{ac}}{R}$

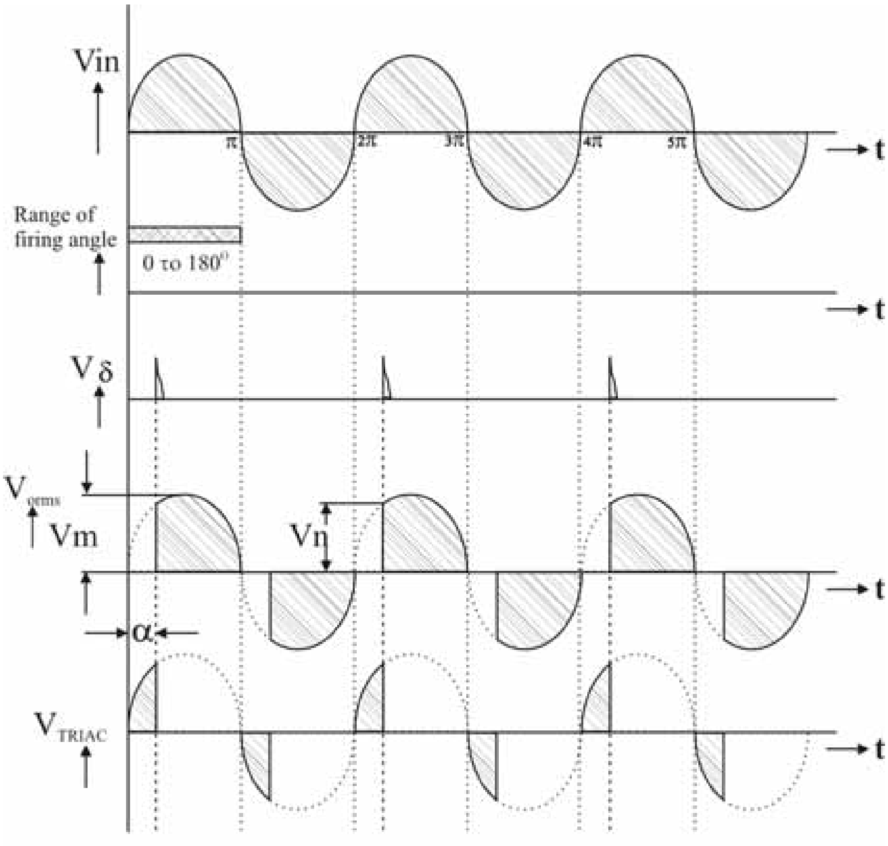
6. A graph of I_{ac} v/s α, V_{ac} or load voltage v/s α are to be plotted

7. Compare V_{oeter} with V_{oth} where $V_{oth} = V_{in\,rms}\sqrt{\frac{1}{\pi}\left(\pi - \alpha + \frac{\sin 2\alpha}{2}\right)}$

Tabular Column: -

Sl. No	FROM C.R.O								V_{DC} (V_{load}) volts	I_{dc} = V_{dc}/R A	V_{in} Volts	Speed rpm
	0 TO 90^0				90^0 TO 180^0							
	V_n volts	V_m volts	$\alpha = Sin^{-1}\left(\frac{V_n}{V_m}\right)^o$	β=180-α	V_n volts	V_m volts	L = 180 - $Sin^{-1}\left(\frac{V_n}{V_m}\right)^o$	β=180-α				

Waveforms:-



Where α = firing angle

VIVA QUESTIONS: -

1. Explain the features of TRIAC?
2. Explain the working operation of illumination control & various voltage output waveforms by using TRIAC?
3. Compare S.C.R, DIAC & TRIAC?
4. What is universal motor?
5. Comment on the different graphs of this experiment?
6. Mention the applications of TRIAC?

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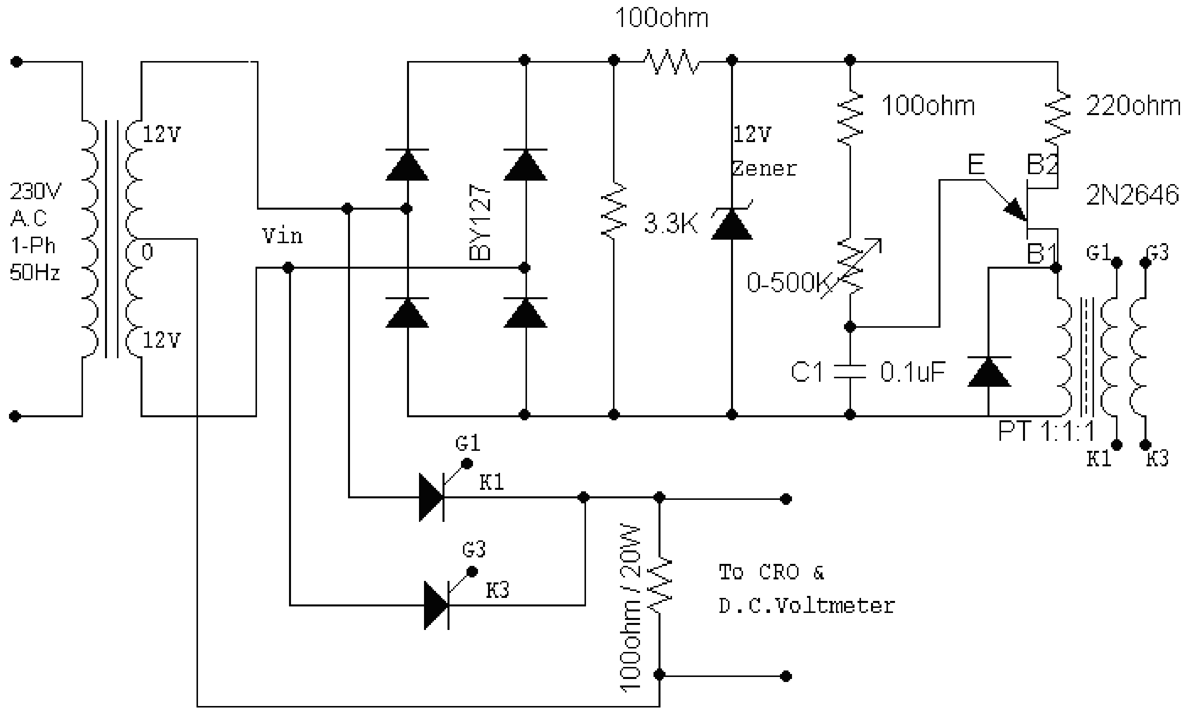
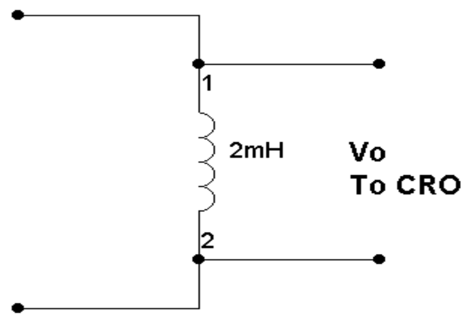
Signature of the staff with date

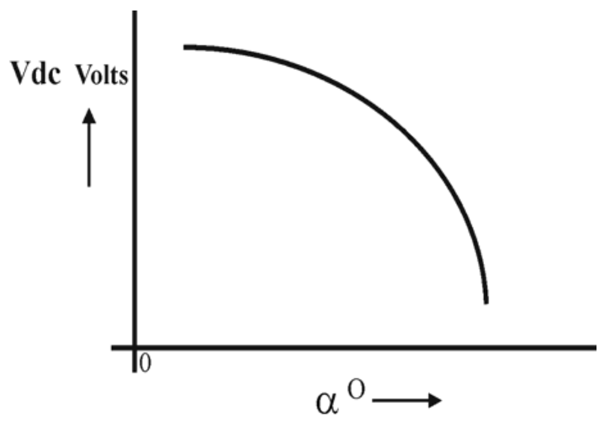
<u>CIRCUIT DIAGRAM: -</u> (a) With R-load (Resistive load)



(b) WITH L LOAD (Inductive load)



GRAPHS: -



Experiment No: 11 **DATE: __/__/____**

Single Phase Full Wave Controlled Rectifier

AIM: -

1. To study the performance and waveforms of full wave controlled rectifier with Resistance load and Inductive load
2. Plot a graph of V_O v/s for R-load

APPARATUS REQUIRED: -

SCR-TY604, Power supplies, Wattage Resistors, Ammeter, Voltmeter, UJT-2N2646, BY127, Inductor, Pulse Transformer, etc.,

PROCEDURE: -

1. Connections are made as shown in the circuit diagram for resistive load.

2. By varying a variable resistor R in step-by-step gradually. Note down corresponding values of V_N, V_M, from C.R.O. and V_O or V_{load} or V_{DC} from d.c.voltmeter for resistive load, the readings are tabulated in the tabular column
3. If α varies from 0 To 90^0, then firing angle can be calculated from

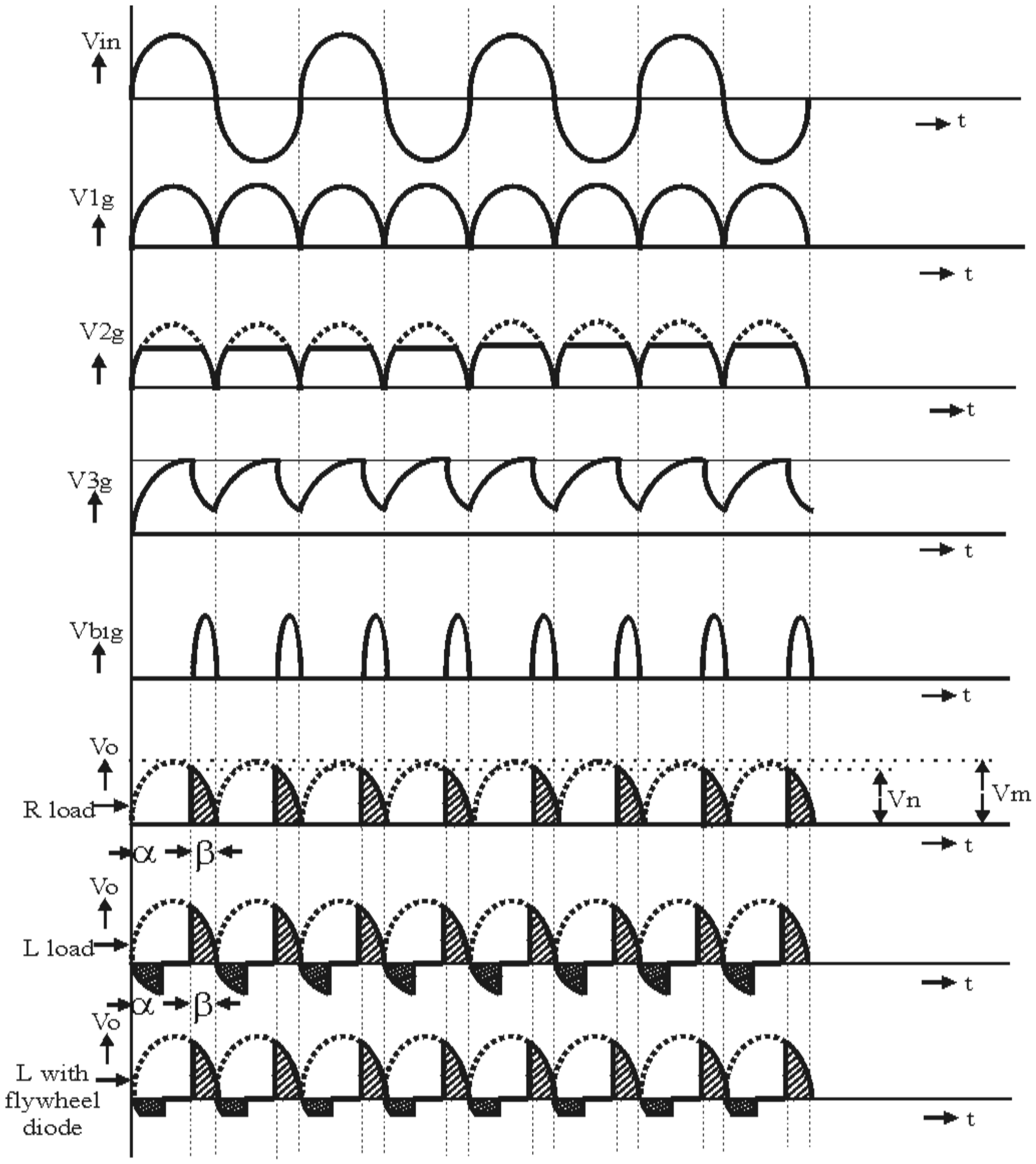
$$\alpha = Sin^{-1}\left(\frac{V_n}{V_m}\right) \quad \text{in degrees}$$

If α varies from 90^0 to 180^0 then α is

$$\alpha = 180 - Sin^{-1}\left(\frac{V_n}{V_m}\right) \quad \text{in degrees}$$

4. The conduction angle β= 180 - α in degrees is calculated for each value of α
5. Plot a graph of V_{DC} or V_{load} or V_O v/s firing angle α
6. Observe the waveforms at different points as shown and waveforms are traced on tracing paper.
7. For Inductance load repeat step no. s 1,2,3,4,5 & 6.

WAVEFORMS: -



TABULAR COLUMN: -

(a) For Resistive load

Sl.No	From CRO								V_O or V_{DC} or V_{LOAD} volts
	$0^0 - 90^0$				$90^0 - 180^0$				
	V_N volts	V_M volts	$\alpha = Sin^{-1}\left(\frac{V_n}{V_m}\right)^O$	β=180 - α	V_N volts	V_M volts	$\alpha = 180 - Sin^{-1}\left(\frac{V_n}{V_m}\right)^O$	β=180 - α	

b) Inductive load:

Sl.No	From CRO								V_O or V_{DC} or V_{LOAD} volts
	$0^0 - 90^0$				$90^0 - 180^0$				
	V_N volts	V_M volts	$\alpha = Sin^{-1}\left(\frac{V_n}{V_m}\right)^O$	β=180 - α	V_N volts	V_M volts	$\alpha = 180 - Sin^{-1}\left(\frac{V_n}{V_m}\right)^O$	β=180 - α	

C) R L with Free wheeling diode

Sl.No	From CRO								V_O or V_{DC} or V_{LOAD} volts
	$0^0 - 90^0$				$90^0 - 180^0$				
	V_N volts	V_M volts	$\alpha = Sin^{-1}\left(\frac{V_n}{V_m}\right)^O$	β=180 - α	V_N volts	V_M volts	$\alpha = 180 - Sin^{-1}\left(\frac{V_n}{V_m}\right)^O$	β=180 - α	

VIVA QUESTIONS: -

1. Explain the performance and working operation of single-phase full controlled rectifier with relevant waveforms for Resistive load, Inductive load.
2. Compare H.C.R with F.C.R
3. In cyclo-converter, why H.C.R with Inductive load cannot be implemented

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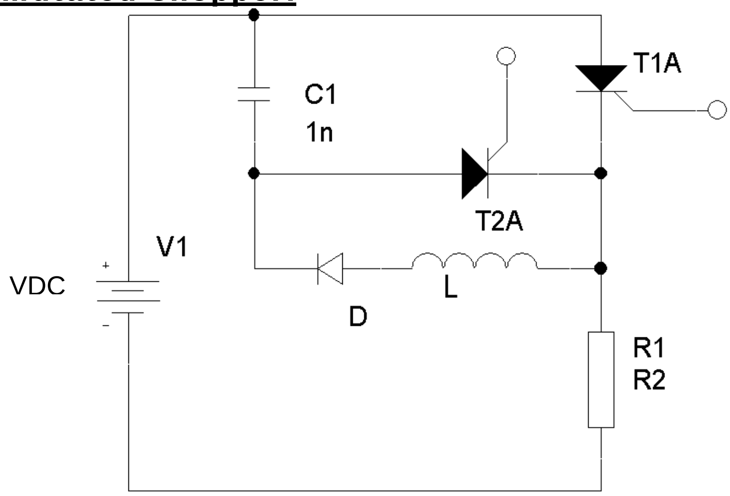
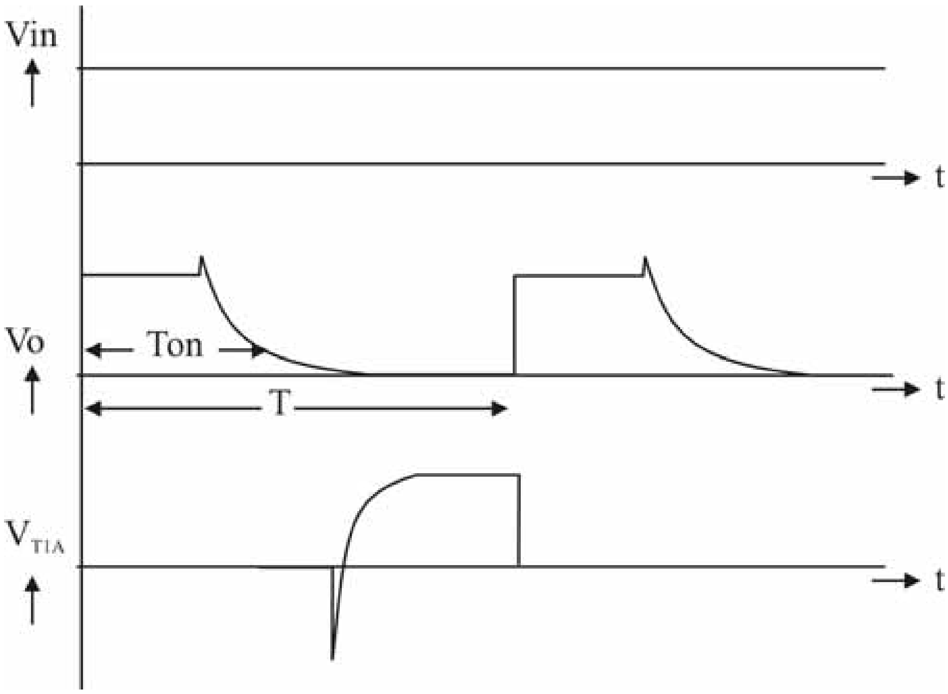
Signature of the staff with date

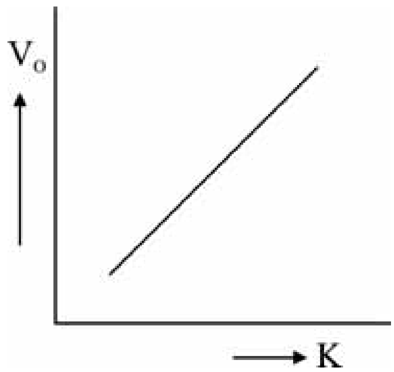
Impulse Commutated Chopper:



Wave forms:-



Graph:-



Experiment No: 12 **DATE: __ / __ / ____**

Impulse Commutated Chopper

Aim: -

To study the performance of voltage commutated chopper for constant frequency operations.

Apparatus required: -

Module, SCRs, Diodes, inductor, capacitors, etc.,

Procedure: -

1. Connections are made as shown in the circuit diagram.
2. Input DC voltage is set to convenient value (10v to 25v).
3. By varying duty cycle knob of triggering circuit module step by step gradually note down corresponding T_{on} and T from the CRO and V_O from DC voltmeter and tabulate.
4. Duty cycle 'K' is calculated by using $K = \frac{T_{on}}{T}$.
5. A graph of V_O v/s K is plotted.
6. Observe load and device voltage waveforms.

Tabular Column: -

Sl. No.	Duty Cycle knobs	$T_{ON\ cro}$	T_{CRO}	$K = \frac{T_{ON}}{T}$	Vo (V)

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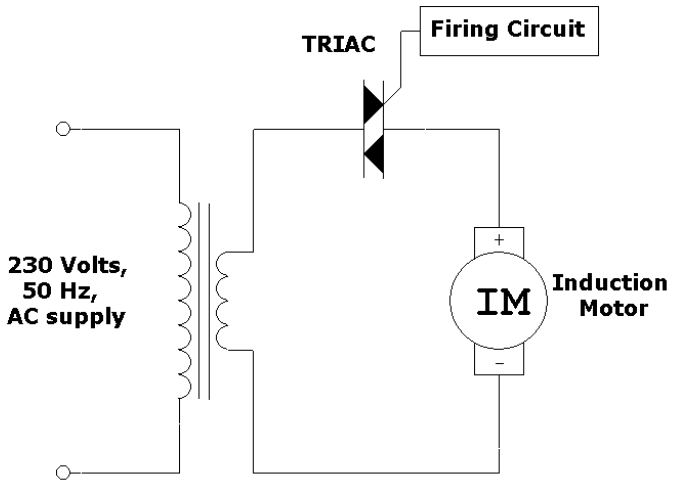
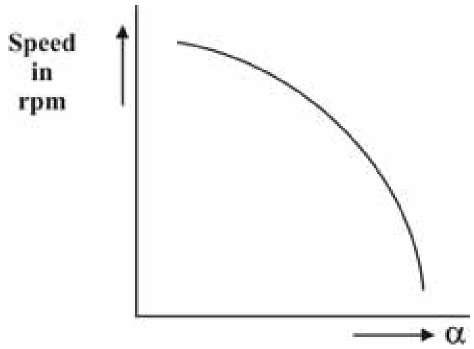
Signature of the staff with date

Single Phase Induction Motor:



Graph:-



Tabular Column:-

Sl. No.	Firing Angle (α)	Speed in RPM

Experiment No: 13 **DATE: __ / __ / ____**

Speed Control of Single Phase Induction Motor

Aim: -

To study speed control of Induction motor and plot speed v/s α.

Apparatus required: -

Module, TRIAC, Induction Motor, etc.,

Procedure: -

1. Connections are made as shown in the circuit diagram.
2. Firing angle α is varied in steps gradually, note down corresponding speed of the induction motor using Tachometer and tabulate.
3. A graph of α v/s speed is plotted.

Result: -

Speed control of Induction Motor is studied and a graph of α v/s speed is plotted.

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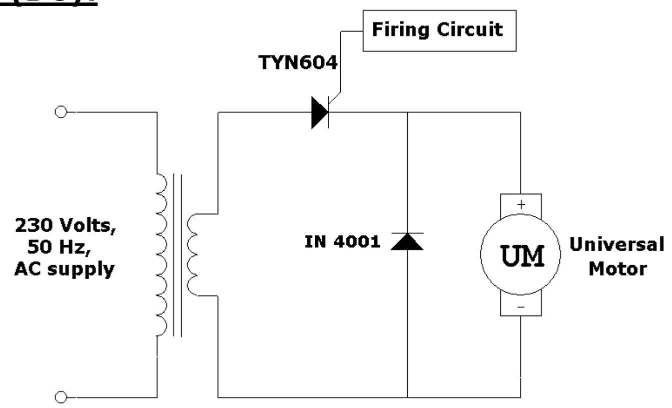
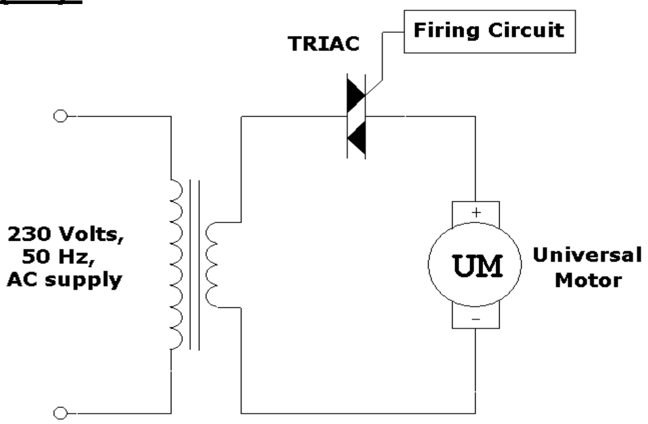
Signature of the staff with date

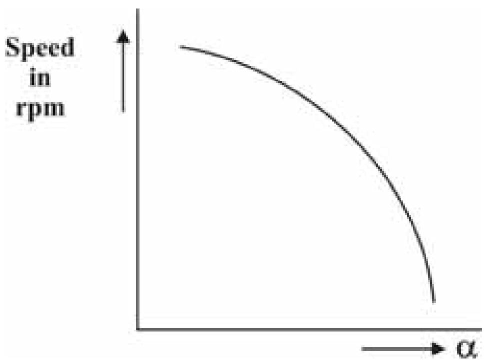
Universal Motor (DC):



Universal Motor (AC):



Graph:-



Tabular Column:-

AC Motor			DC Motor		
Sl. No.	Firing Angle (α)	Speed in RPM	Sl. No.	Firing Angle (α)	Speed in RPM

Experiment No: 14 **DATE: __ / __ / ____**

Speed Control of Universal Motor

Aim: -

To study speed control of Universal motor and plot speed v/s α.

Apparatus required: -

Module, TRIAC-BT136, Universal Motor, Diode-IN4001 etc.,

Procedure: -

DC Motor: -

1. Connections are made as shown in the circuit diagram.
2. Firing angle α is varied in steps gradually, note down corresponding speed of the induction motor using Tachometer and tabulate.
3. A graph of α v/s speed is plotted.

AC Motor: -

1. Above procedure is repeated for AC Motor.

Result: -

Speed control of Universal Motor is studied and a graph of α v/s speed is plotted.

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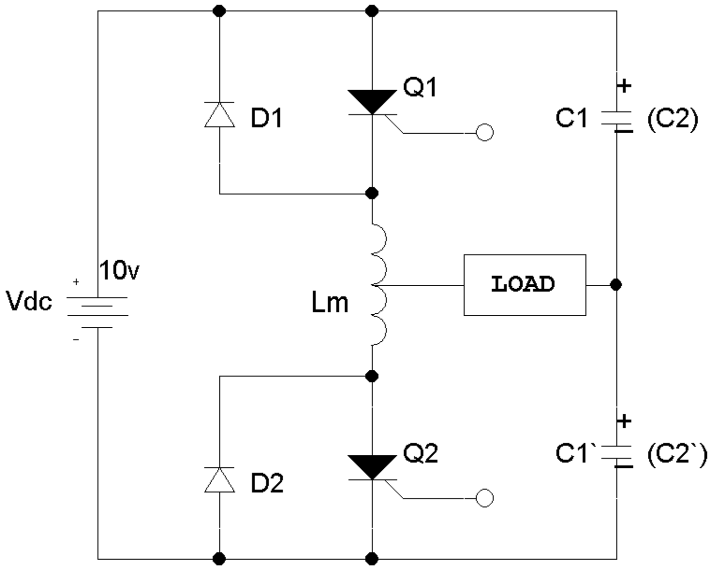
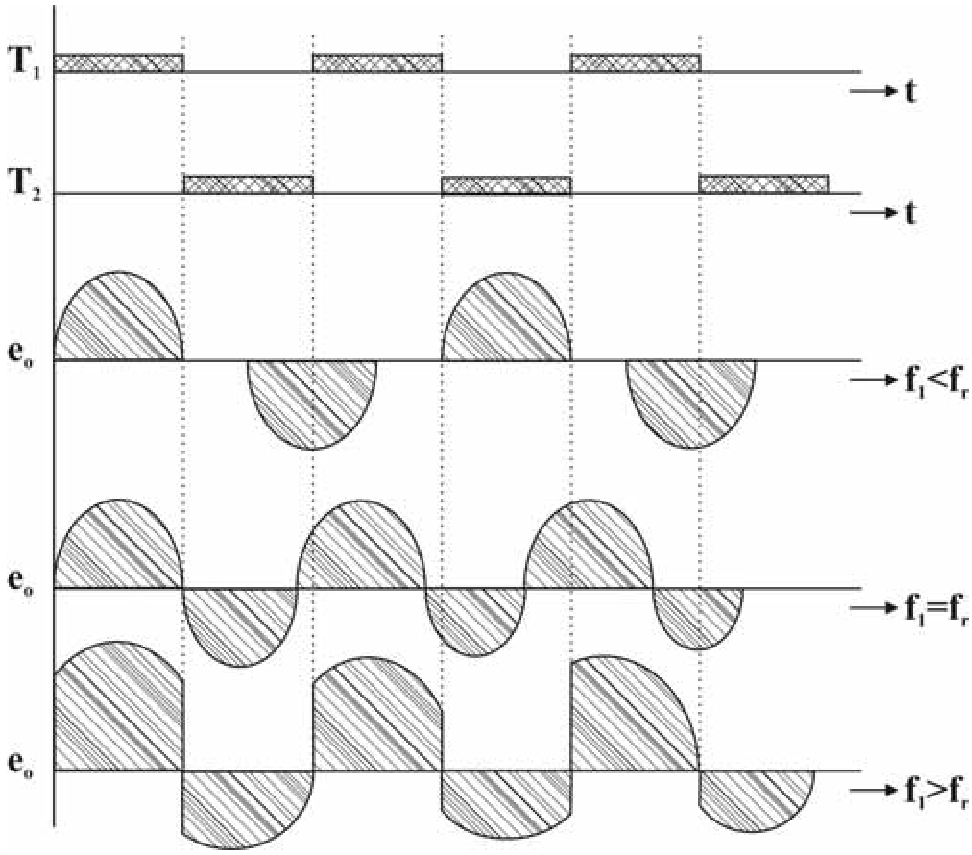
Signature of the staff with date

Series Inverter



Wave forms:-



Experiment No: 15 **DATE: __ / __ / ____**

Series Inverter

Aim: -

To obtain variable AC from DC ripple input.

Apparatus required: -

Module, SCRs, Diodes, inductor, capacitors, etc.,

Procedure: -

1. To begin with switch on the power supply to the firing circuit check that trigger pulses by varying the frequency.
2. Connections are made as shown in the circuit diagram.
3. Now connect trigger outputs from the firing circuits to gate and cathode of SCRs T1 & T2.
4. Connect DC input from a 30v/2A regulated power supply and switch on the input DC supply.
5. Now apply trigger pulses to SCRs and observe voltage waveform across the load.
6. Measure V_{orms} & frequency of o/p voltage waveform.

Resonance frequency: -

$$fr = \frac{1}{2\pi}\sqrt{\frac{1}{LC} - \frac{R^2}{4L^2}}$$

L=10mH, C = 10μF, R = 20Ω, f_{th}=477Hz, f_p=250KHz

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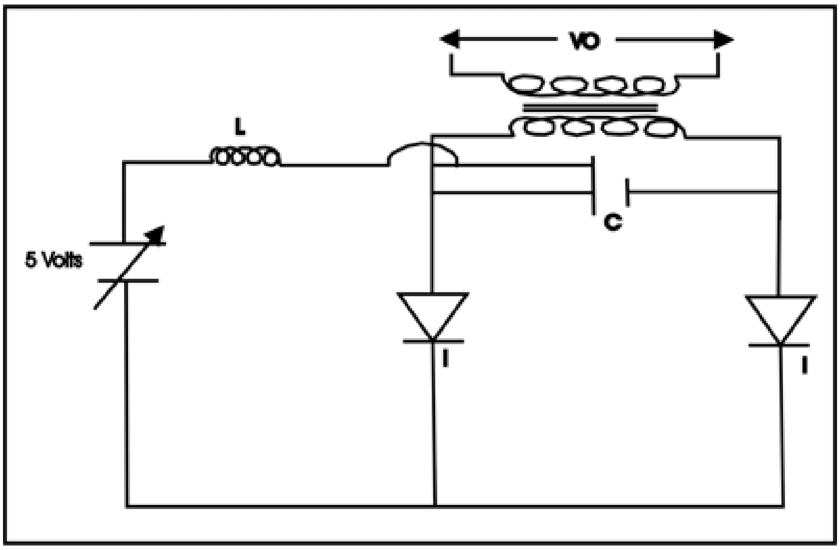
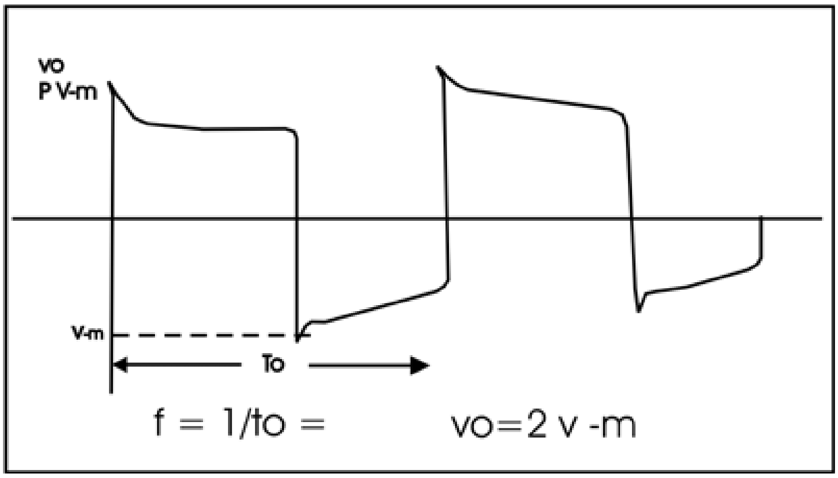
Signature of the staff with date

Experiment No: 16 **DATE: __ / __ / ____**

Parallel Inverter





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Signature of the staff with date

Parallel Inverter

Aim :-

To obtain variable AC from DC ripple input.

Apparatus required:-

Module, SCRs, Diodes, inductor, capacitors, etc,,

Procedure:-

1. Connecting are made as shown in the circuit diagram
2. Select values of c =   , L =
3. Set input voltage to 5 volts
4. Apply trigger voltage, observe corresponding output voltage (ac voltage and wave forms) at load terminal
5. Note down the voltage & frequency of out put wave form
6. The o/p ac voltage is almost equal to the two times of the dc i/p voltage.

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Signature of the staff with date

QUESTION BANK

4TH Semester EC/TC/ML

1. Obtain the VI characteristics of the SCR by conducting a suitable current and hence determine the holding current, forward ON state resistance & break over voltage.
2. Conduct a suitable experiment to obtain VI characteristics of the given three layer bi-directional switch experimentally. Determine the holding current and break over voltage in I and III quadrants and comment on its sensitivity.
3. Conduct a suitable experiment to obtain collector and transfer characteristics of IGBT.
4. Conduct a suitable experiment to obtain drain and transfer characteristics of MOSFET.
5. Conduct an experiment to obtain synchronized triggering pulses to turn ON SCR in full wave rectifier with resistive load. Show load voltage and triggering pulse waveform. Plot average DC voltage v/s delay angle.
6. Conduct an experiment to obtain synchronized triggering pulses to turn ON SCR in full wave rectifier with resistive and inductive load. Show load voltage and triggering pulse waveform. Plot average DC voltage v/s delay angle.
7. Conduct an experiment on controlled half wave rectifier to vary the DC power fed to load by using RC triggering. Plot o/p voltage v/s firing angle.
8. Conduct an experiment on controlled full wave rectifier to vary the DC power fed to load by using RC triggering. Plot o/p voltage v/s firing angle.
9. Conduct an experiment to control the illumination of incandescent lamp using TRIAC, DIAC combination. Plot the graph of V_{ORMS} v/s α.
10. Conduct an experiment to produce variable DC o/p voltage (chopper), plot o/p voltage v/s duty cycle for Variable frequency & Fixed Frequency.
11. Conduct an experiment to produce variable DC o/p voltage using voltage commutated chopper, plot o/p voltage v/s duty cycle for Fixed frequency operation.
12. Conduct a suitable experiment to control the speed of Induction motor. Plot speed v/s α.
13. Conduct a suitable experiment to control the speed of Universal motor. Plot speed v/s α.
14. Conduct a suitable experiment to obtain AC o/p using Series Inverter.
15. Demonstrate the digital firing circuit to turn ON SCR (HW) for R load. Plot V_{ODC} v/s α

VIVA QUESTIONS

OF

POWR ELECTRONICS LAB

Viva Questions Power Electronics Lab

1. What is power electronics?
2. Mention the different methods of varying the power?
3. What are the advantages of silicon over germanium?
4. What is power device?
5. Mention different types power devices?
6. What is SCR?
7. What are the features of SCR?
8. What are the features of Diac?
9. What is Diac?
10. What are the features of diac?
11. What are the applications of diac?
12. What is Triac?
13. What are the applications of Triac?
14. What are the applications of Triac?
15. What is power MOSFET?
16. What is power IGBT?
17. What are the applications of MOSFET & IGBT?
18. Compare SCR, Diac & Triac?
19. Compare MOSFET, BJT & IGBT?
20. What is turn of time?
21. What is turn off time?
22. What is static characteristics?
23. What is dynamic Characteristics?
24. What are the differences between static & dynamic Characteristics?
25. Explain gate characteristics & turn off characteristics of SCR?
26. Explain gate characteristics of SCR?
27. What is current controlled device?
28. What is voltage controlled device?
29. Explain o/p & transfer characteristics of MOSFET & IGBT?
30. What is the intention of using power device in power control circuit?
31. What is power control?
32. Why SCR is called as bidirectional an controlled device?
33. Why Diac is called as bidirectional an controlled Device?
34. Why Triac is called as bidirectional controlled device?
35. What is rectifier?
36. What is an inverter?
37. What is steep down chopper? What is its o/p voltage equation?
38. What is step up chopper? What is its o/p voltage equation?
39. What is buck boost regulator? What is its o/p voltage equation?

40. What is cuck regulator? What is its/ o/p voltage equation?
41. Explain the working operation of single phase controlled half wave rectifier with
 (a) R load
 (b) RL load
 (c) RL load with freewheeling diode
42. What is an intention of using freewheeling across inductive load in rectifier circuit?
43. What is pulse width?
44. Why turn off time of the circuit should be greater than turn off time of the device?
45. Explain the working operation of single phase Full wave controlled rectifier with
 a) R load
 b) RL load
 c) RL load with freewheeling diode?
46. Explain the working operation of single phase Half controlled bridge rectifier with
 a) R load
 b) RL load
 c) RL load with freewheeling diode?
47. Explain the working operation of single phase full controlled bridge rectifier with
 a) R load
 b) RL load
 c) RL load with freewheeling diode?
48. Define average output voltage, Rms Voltage, peak or maximum voltage?
49. Derive an expression of average output voltage, Rms out voltage of any wave form concerned to rectifier, ac voltage controller, chopper?
50. What is cyclo converter?
51. What is cyclo inverter?
52. Why forced commutation circuit is employed in case of cycle inverter?
53. What are the advantages of three phase circuit over single phase circuit?
54. What is firing angle or delay angle?
55. What is conduction period?
56. What is the meaning of triggering?
57. What are the different types of triggering methods (Can be used to trigger SCR)?
58. What is anode triggering, dv/dt triggering, temperature triggering, light triggering & gate triggering?
59. Why gate triggering is preferred than other types?
60. Mention the different types of gate triggering circuits?
61. Explain the working operation of R- triggering circuit?
62. Why firing angle in case of R- triggering circuit is limited to 90 degrees?
63. Explain the working operation of RC triggering circuit?
64. Explain how firing angle will be extended to more than 90^0 by using RC triggering circuit?
65. What is Uni-junction transistor (UJT)?
66. Write equivalent circuit of UJT?
67. Show that Vpeak = Vp= nV_{BB}+ V diode Where n = intrinsic standoff ratio, V_{BB} = applied or base voltage

68. Why UJT triggering circuit is superior than R & RC triggering circuit?
69. What is UJT relaxation oscillator?
70. What is line synchronized UJT triggering circuit?
71. Explain the working operation of UJT relaxation oscillator?
72. Explain the working operation of line synchronized UJT triggering circuit with wave forms at different points?
73. Design of UJT triggering circuit.
74. When UJT will conduct?
75. How UJT exhibits negative resistance property?
76. Why SCR, DIAC, TRIAC are called negative resistance devices?
77. Derive an expression of of frequency of UJT triggering pulse?
78. What is the function of pulse Transformer?
79. What are the different types of voltage ratings, current ratings & power ratings? Explain each term
80. Why do we require protection circuits for power devices?
81. What is dv/dt rating? How do you protect SCR against high dv/dt rating? Explain
82. What is dv/dt rating? How do you protect SCR against high dv/dt rating? Explain
83. What is over current? How do you project SCR against over current? Explain
84. What is over voltage? How do you lprotect SCR against over voltage? Explain
85. How device will be protected against heavy power dissipation?
86. Why Triac has 4 modes of operations?
87. Why 1^{st} & 2^{nd} mode of operations are operating in 1^{st} quadrant and 3^{rd} & 4^{th} mode of operations are operating 3^{rd} quadrant?
88. Why mode (1) is most sensitive among all modes?
89. What is commutation? What is commutation circuit?
90. Mention the different types of forced commutation circuit?
91. Explain the working operation of each forced commutation circuit with wave forms & derivation of designed equations
    (class A, Class B, class C, Class D, Class E & Class F commutation circuit)
92. What is Latching current? What is its significance?
93. What is Holding current? What is its significance?
94. What is dv/dt Rating? What is its significance?
95. What is dual converter?
96. Why full wave bridge controlled bridge rectifier with RL load (not with freewheeling diode) is preferred in dual converter than half wave bridge controlled rectifier with RL load (not with freewheeling diode).?
97. Why dual converter is called as four quadrant operator?
98. What is semi converter?
99. What is full converter?
100. Why gate is preferred at base of NPN transistor & not at the base of PNP transistor in SCR?
101. Derive an expression of anode current (SCR current)?
102. Explain the working operation of SCR with two transistor analogy?

103. Explain the working operation of each practical power electronics experiments with circuit diagram, wave forms & designed equations?
104. Why output voltage is more at lesser value of firing angle?
105. What are the differences between uncontrolled output & controlled output?
106. How do you design zener voltage regulator?
107. How do you select (design) the value of gate resistor and load resistor concerned to SCR experiment?
108. How do you check SCR, Triac, Diac, Diode, Zener diode, wires by using ohm meter?
109. How do you check an ammeter, voltmeter & power supply?
110. Why load resistor has higher wattage?
111. What is series inverter? Mention the advantages, disadvantages & applications of series inverter? Explain its working operation?
112. What is parallel inverter? Explain its working operation?
113. What is continuous mode & discontinuous mode of operations concerned to rectifier with (a). RL load (b) RL load with freewheeling diode.
114. Input voltage = device voltage + output voltage.
     Prove above words
115. What is blocking state or region?
116. What is forward blocking & reverse blocking?
117. What is reverse recovery time?
118. What is gate pulse?
119. Why gate pulses are preferred than continuous gate voltage?
120. S.T. turn on time =td + tr+ ts
121. S.T. turn off time = trr + tgr
122. How do you design gate pulse width?
123. What is snubber circuit? How do you design snubber?
124. What is heat sink? Its purpose is what?
125. What is circuit breaker & fuse? Why these are used in power circuit?
126. What is ac voltage controller? Mention different types? What are its applications?
127. Explain the working operation of
     (a). on & off AC voltage controller
     (b). uni directional or Half wave controller
     (c) . Bidirectional or Full wave AC voltage controller
     with R load & RL load with wave forms, with equations?
128. Why continuous gate pulses are applied to full wave ac voltage controller with RL load circuit?
129. Explain the working operation of static on load tap changer?
130. Why negative gate voltage should not be applied to gate of SCR?
131. Write symbols, static characteristics of all power devices concerned to syllabus?
132. Name different current controlled power devices?
133. Name different voltage controlled power devices?
134. What is I^2t rating?

Data Sheets

GOOD-ARK

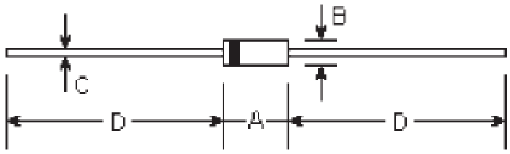
BY127, BY133, EM513, EM516

GENERAL PURPOSE PLASTIC RECTIFIER
Reverse Voltage - 1250 to 1800 Volts
Forward Current - 1.0 Ampere

Features

- The plastic package carries Underwriters Laboratory Flammability Classification 94V-0
- Construction utilizes void-free molded plastic technique
- Low reverse leakage
- Low forward voltage drop
- High current capability
- High reliability
- High surge current capability

DO-41



DIMENSIONS					
DIM	inches		mm		Note
	Min.	Max.	Min.	Max.	
A	0.165	0.205	4.2	5.2	
B	0.079	0.106	2.0	2.7	ф
C	0.028	0.034	0.71	0.86	ф
D	1.000	-	25.40	-	

Mechanical Data

- **Case:** Molded plastic, DO-41
- **Lead:** Axial leads, solderable per MIL-STD-202, method 208 guaranteed
- **Polarity:** Color band denotes cathode end
- **Mounting Position:** Any
- **Weight:** 0.012 ounce, 0.33 gram

Maximum Ratings and Electrical Characteristics

Ratings at 25℃ ambient temperature unless otherwise specified.
Single phase, half wave, 60Hz, resistive or inductive load.
For capacitive load, derate current by 20%.

	Symbols	BY127	BY133	EM513	EM516	Units
Maximum repetitive peak reverse voltage	V_{RRM}	1250	1300	1600	1800	Volts
Maximum RMS voltage	V_{RMS}	875	910	1120	1270	Volts
Maximum DC blocking voltage	V_{DC}	1250	1300	1600	1800	Volts
Maximum average forward rectified current 0.375" (9.5mm) lead length at T_A=75℃	$I_{(AV)}$	1.0				Amp
Peak forward surge current 8.3mS single half sine-wave superimposed on rated load (MIL-STD-750D 4066 method)	I_{FSM}	30.0				Amps
Maximum forward voltage at 1.0A DC and 25℃	V_F	1.1				Volts
Maximum full load reverse current at rated DC blocking voltage T_A=25℃ / T_A=100℃	I_R	5.0 / 200.0				μA
Typical junction capacitance (Note 1)	C_J	15.0				pF
Typical thermal resistance (Note 2)	$R_{\theta JA}$ / $R_{\theta JL}$	50.0 / 25.0				℃/W
Operating and storage temperature range	T_J, T_{STG}	-55 to +150				℃

Notes:

(1) Measured at 1.0MHz and applied reverse voltage of 4.0 VDC

(2) Thermal resistance junction to ambient and from junction to lead at 0.375" (9.5mm) lead length, P.C.B. mounted

DC COMPONENTS CO., LTD.

RECTIFIER SPECIALISTS

1N 4001A / RL 101
THRU
1N 4007A / RL 107

TECHNICAL SPECIFICATIONS OF SILICON RECTIFIER

VOLTAGE RANGE - 50 to 1000 Volts CURRENT - 1.0 Ampere

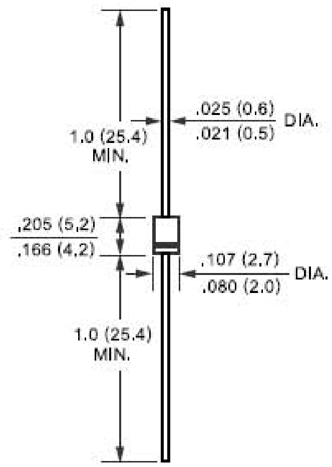
FEATURES

* High reliability
* Low leakage
* Low forward voltage drop
* High current capability

MECHANICAL DATA

* Case: Molded plastic
* Epoxy: UL 94V-0 rate flame retardant
* Lead: MIL-STD-202E, Method 208 guaranteed
* Polarity: Color band denotes cathode end
* Mounting position: Any
* Weight: 0.22 gram

A-405



Dimensions in inches and (millimeters)

MAXIMUM RATINGS AND ELECTRICAL CHARACTERISTICS

Ratings at 25 °C ambient temperature unless otherwise specified.
Single phase, half wave, 60 Hz, resistive or inductive load.
For capacitive load, derate current by 20%.

		1N4001A	1N4002A	1N4003A	1N4004A	1N4005A	1N4006A	1N4007A	
	SYMBOL	RL101	RL102	RL103	RL104	RL105	RL106	RL107	UNITS
Maximum Recurrent Peak Reverse Voltage	V_{RRM}	50	100	200	400	600	800	1000	Volts
Maximum RMS Voltage	V_{RMS}	35	70	140	280	420	560	700	Volts
Maximum DC Blocking Voltage	V_{DC}	50	100	200	400	600	800	1000	Volts
Maximum Average Forward Rectified Current at T_A = 55°C	Io	1.0							Amps
Peak Forward Surge Current, 8.3 ms single half sine-wave superimposed on rated load (JEDEC Method)	I_{FSM}	30							Amps
Maximum Instantaneous Forward Voltage at 1.0A DC	V_F	1.1							Volts
Maximum DC Reverse Current at Rated DC Blocking Voltage @T_A = 25°C	I_R	5.0							uAmps
Maximum DC Reverse Current at Rated DC Blocking Voltage @T_A = 100°C	I_R	500							uAmps
Maximum Full Load Reverse Current Average, Full Cycle .375"(9.5mm) lead length at T_L = 75°C	I_R	30							uAmps
Typical Junction Capacitance (Note)	C_J	15							pF
Typical Thermal Resistance	$R_{\theta JA}$	50							°C/W
Operating and Storage Temperature Range	T_J, T_{STG}	-65 to + 175							°C

NOTES : Measured at 1 MHz and applied reverse voltage of 4.0 volts

2N2646

SILICON PN UNIJUNCTION TRANSISTOR

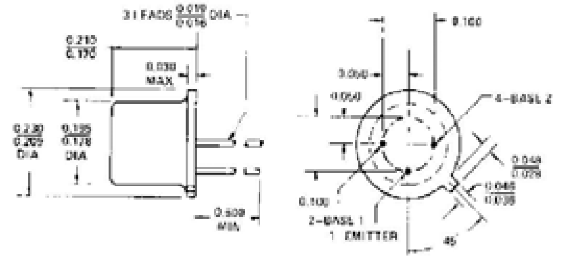
DESCRIPTION:

The **2N2646** is a Unijunction Transistor Used in General Purpose Pulse, Timing, Sense and Trigger Applications.

MAXIMUM RATINGS

I_C	2.0 A (PULSED)
V_{CE}	30 V
P_{DISS}	300 mW @ T_C = 25 °C
T_J	-65 °C to +125 °C
T_{STG}	-65 °C to +150 °C
θ_{JC}	33 °C/W

PACKAGE STYLE TO-18 (MOD)



CHARACTERISTICS $T_C = 25\,^{\circ}C$

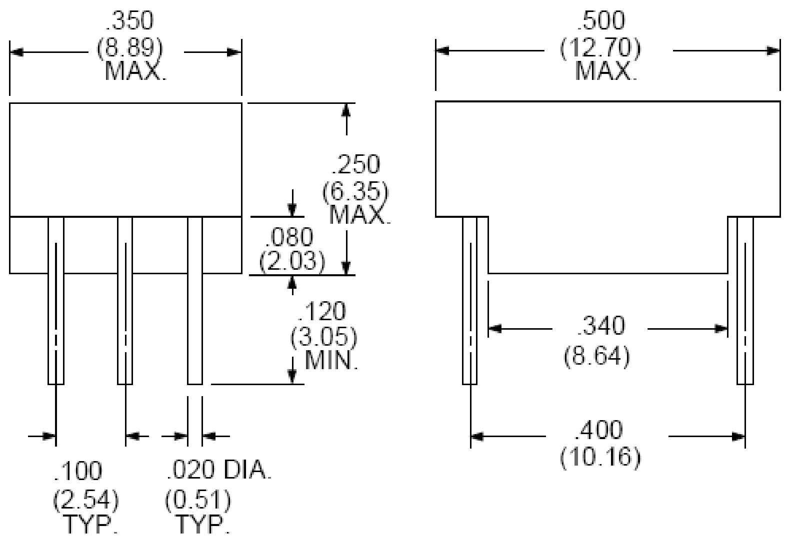
SYMBOL	TEST CONDITIONS	MINIMUM	TYPICAL	MAXIMUM	UNITS
η	V_{B2B1} = 10 V	0.56		0.75	--
r_{BB}	V_{B2B1} = 3.0 V	4.7		9.1	KΩ
α_{rBB}	V_{B2B1} = 3.0 V T_A = -55 to 125°C	0.1		0.9	%/°C
$V_{EB1(SAT)}$	V_{B2B1} = 10 V I_E = 50 mA		3.0		V
$I_{B2(MOD)}$	V_{B2B1} = 10 V I_E = 50 mA		20		mA
I_{B2EO}	V_{B2E} = 30 V I_{B1} = 0			12	µA
I_P	V_{B2B1} = 25 V			5.0	µA
I_V	V_{B2B1} = 20 V R_{B2} = 100 Ω	4.0			mA
V_{OB1}	V_{B2B1} = 20 V R_{B1} = 20 Ω	3.0	5.0		V

SCR TRIGGER PULSE TRANSFORMER

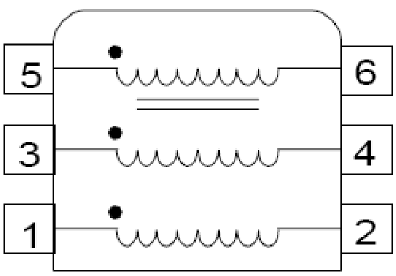
Turns Ratio 1 : 1 : 1

PARAMETER @25°C	MIN.	TYP.	MAX.	UNITS
Inductance		200		μH
Leakage Inductance		1.5		μH
DCR Each Winding		47.7		mΩ
Interwinding Capacitance		8.5		Pf
Hipot	2000			VRMS

PHYSICAL DIMENSIONS All dimensions in inches (mm):



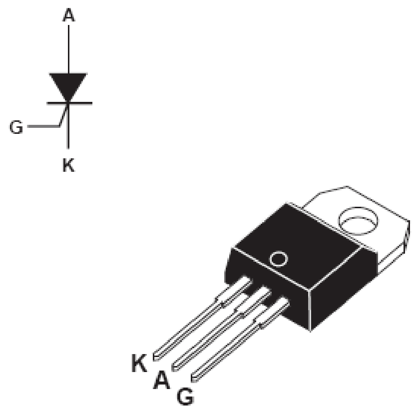
SCHEMATIC DIAGRAM:



RHOMBUS P/N: **T-1214**

TYN606
TYN1006

SCR



TO-220AB

FEATURES

- High surge capability
- High on-state current
- High stability and reliability

DESCRIPTION

The TYN606 and TYN1006 Family of Silicon Controlled Rectifiers are high performance glass passivated technology.

This general purpose Family of Silicon Controlled Rectifiers is designed for power supply up to 400Hz on resistive or inductive load.

ABSOLUTE RATINGS (limiting values)

Symbol	Parameter		Value	Unit
$I_{T(RMS)}$	RMS on-state current (180° conduction angle)	Tc = 110°C	6	A
$I_{T(AV)}$	Average on-state current (180° conduction angle, single phase circuit)	Tc = 110°C	3.8	A
I_{TSM}	Non repetitive surge peak on-state current (Tj initial = 25°C)	tp = 8.3ms	73	A
		tp = 10ms	70	
I^2t	I^2t value	tp = 10ms	24.5	A^2s
dI/dt	Critical rate of rise of on-state current Gate supply: I_G = 100mA dI_G/dt = 1A/µs		50	A/µs
Tstg Tj	Storage and operating junction temperature range		-40 to +150 -40 to +125	°C
Tl	Maximum lead soldering temperature during 10s at 4.5mm from case		260	°C

Symbol	Parameter	TYN		Unit
		606	1006	
V_{DRM} V_{RRM}	Repetitive peak off-state voltage Tj = 125°C	600	1000	V

TYN606 TYN1006

THERMAL RESISTANCE

Symbol	Parameter	Value	Unit
Rth (j-a)	Junction to ambient	60	°C/W
Rth (j-c) DC	Junction to case for DC	2.5	°C/W

GATE CHARACTERISTICS (maximum values)

$P_{G(AV)}$ = 1W P_{GM} = 10W (tp = 20µs) I_{FGM} = 4A (tp = 20µs) V_{RGM} = 5V

ELECTRICAL CHARACTERISTICS

Symbol	Test conditions			Value	Unit
I_{GT}	V_D = 12V (DC) R_L = 33Ω	Tj = 25°C	MAX.	15	mA
V_{GT}	V_D = 12V (DC) R_L = 33Ω	Tj = 25°C	MAX.	1.5	V
V_{GD}	V_D = V_{DRM} R_L = 3.3kΩ	Tj =110°C	MIN.	0.2	V
tgt	V_D = V_{DRM} I_G = 40mA dI_G/dt = 0.5A/µs	Tj = 25°C	TYP.	2	µs
I_L	I_G = 1.2I_{GT}	Tj = 25°C	TYP.	50	mA
I_H	I_T = 100mA Gate open	Tj = 25°C	MAX.	30	mA
V_{TM}	I_{TM} = 12A tp = 380µs	Tj = 25°C	MAX.	1.6	V
I_{DRM} I_{RRM}	V_{DRM} rated V_{RRM} rated	Tj = 25°C	MAX.	0.01	mA
		Tj = 110°C	MAX.	2	
dV/dt	Linear slope up to V_D = 67% V_{DRM} gate open	Tj = 110°C	MIN.	200	V/µs
tq	V_D=67%V_{DRM} I_{TM}= 12A V_R= 25V dI_{TM}/dt=30 A/µs dV_D/dt= 50V/µs	Tj = 110°C	TYP.	70	µs

Fig. 1: Maximum average power dissipation versus average on-state current.

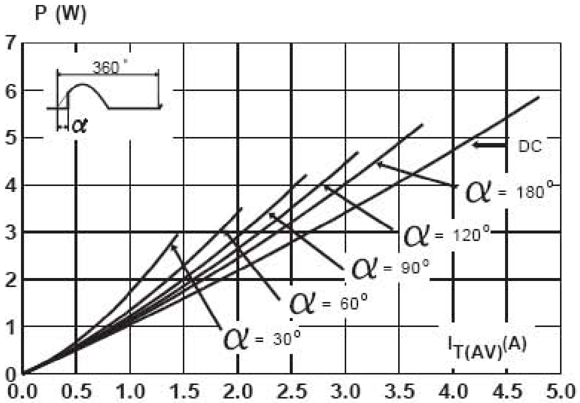
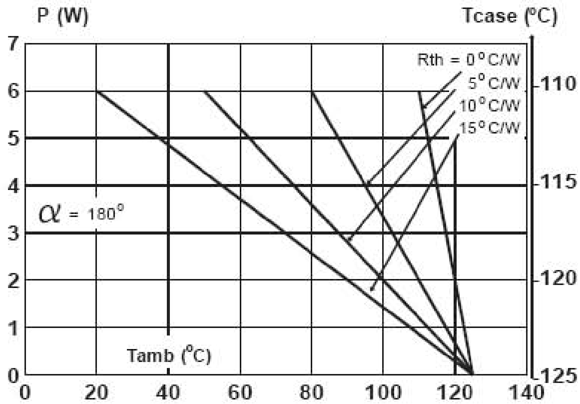


Fig. 2: Correlation between maximum average power dissipation and maximum allowable temperatures (Tamb and Tcase) for different thermal resistances heatsink + contact.



Philips Semiconductors Product specification

Triacs BT136 series

GENERAL DESCRIPTION

Glass passivated triacs in a plastic envelope, intended for use in applications requiring high bidirectional transient and blocking voltage capability and high thermal cycling performance. Typical applications include motor control, industrial and domestic lighting, heating and static switching.

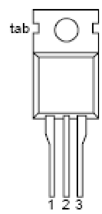
QUICK REFERENCE DATA

SYMBOL	PARAMETER	MAX.	MAX.	MAX.	UNIT
	BT136-	500	600	800	
	BT136-	500F	600F	800F	
	BT136-	500G	600G	800G	
V_{DRM}	Repetitive peak off-state voltages	500	600	800	V
$I_{T(RMS)}$	RMS on-state current	4	4	4	A
I_{TSM}	Non-repetitive peak on-state current	25	25	25	A

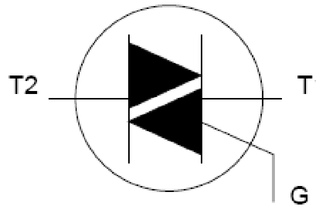
PINNING - TO220AB

PIN	DESCRIPTION
1	main terminal 1
2	main terminal 2
3	gate
tab	main terminal 2

PIN CONFIGURATION



SYMBOL



LIMITING VALUES

Limiting values in accordance with the Absolute Maximum System (IEC 134).

SYMBOL	PARAMETER	CONDITIONS	MIN.	MAX. -500	MAX. -600	MAX. -800	UNIT
V_{DRM}	Repetitive peak off-state voltages		-	500[1]	600[1]	800	V
$I_{T(RMS)}$	RMS on-state current	full sine wave; $T_{mb} \leq 107$ ˚C	-	4			A
I_{TSM}	Non-repetitive peak on-state current	full sine wave; $T_j = 25$ ˚C prior to surge					
		t = 20 ms	-	25			A
		t = 16.7 ms	-	27			A
I^2t	I^2t for fusing	t = 10 ms	-	3.1			A^2s
dI_T/dt	Repetitive rate of rise of on-state current after triggering	$I_{TM} = 6$ A; $I_G = 0.2$ A; $dI_G/dt = 0.2$ A/µs					
		T2+ G+	-	50			A/µs
		T2+ G-	-	50			A/µs
		T2- G-	-	50			A/µs
		T2- G+	-	10			A/µs
I_{GM}	Peak gate current		-	2			A
V_{GM}	Peak gate voltage		-	5			V
P_{GM}	Peak gate power		-	5			W
$P_{G(AV)}$	Average gate power	over any 20 ms period	-	0.5			W
T_{stg}	Storage temperature		-40	150			˚C
T_j	Operating junction temperature		-	125			˚C

1 Although not recommended, off-state voltages up to 800V may be applied without damage, but the triac may switch to the on-state. The rate of rise of current should not exceed 3 A/µs.

THERMAL RESISTANCES

SYMBOL	PARAMETER	CONDITIONS	MIN.	TYP.	MAX.	UNIT
$R_{th\ j\text{-}mb}$	Thermal resistance junction to mounting base	full cycle	-	-	3.0	K/W
		half cycle	-	-	3.7	K/W
$R_{th\ j\text{-}a}$	Thermal resistance junction to ambient	in free air	-	60	-	K/W

STATIC CHARACTERISTICS

T_j = 25 ˚C unless otherwise stated

SYMBOL	PARAMETER	CONDITIONS	MIN.	TYP.	MAX.			UNIT
		BT136-			...	...F	...G	
I_{GT}	Gate trigger current	V_D = 12 V; I_T = 0.1 A						
		T2+ G+	-	5	35	25	50	mA
		T2+ G-	-	8	35	25	50	mA
		T2- G-	-	11	35	25	50	mA
		T2- G+	-	30	70	70	100	mA
I_L	Latching current	V_D = 12 V; I_{GT} = 0.1 A						
		T2+ G+	-	7	20	20	30	mA
		T2+ G-	-	16	30	30	45	mA
		T2- G-	-	5	20	20	30	mA
		T2- G+	-	7	30	30	45	mA
I_H	Holding current	V_D = 12 V; I_{GT} = 0.1 A	-	5	15	15	30	mA
V_T	On-state voltage	I_T = 5 A	-	1.4	1.70			V
V_{GT}	Gate trigger voltage	V_D = 12 V; I_T = 0.1 A	-	0.7	1.5			V
		V_D = 400 V; I_T = 0.1 A; T_j = 125 ˚C	0.25	0.4	-			V
I_D	Off-state leakage current	$V_D = V_{DRM(max)}$; T_j = 125 ˚C	-	0.1	0.5			mA

DYNAMIC CHARACTERISTICS

T_j = 25 ˚C unless otherwise stated

SYMBOL	PARAMETER	CONDITIONS	MIN.			TYP.	MAX.	UNIT
		BT136-	...	...F	...G			
dV_D/dt	Critical rate of rise of off-state voltage	V_{DM} = 67% $V_{DRM(max)}$; T_j = 125 ˚C; exponential waveform; gate open circuit	100	50	200	250	-	V/μs
dV_{com}/dt	Critical rate of change of commutating voltage	V_{DM} = 400 V; T_j = 95 ˚C; $I_{T(RMS)}$ = 4 A; dI_{com}/dt = 1.8 A/ms; gate open circuit	-	-	10	50	-	V/μs
t_{gt}	Gate controlled turn-on time	I_{TM} = 6 A; $V_D = V_{DRM(max)}$; I_G = 0.1 A; dI_G/dt = 5 A/μs	-	-	-	2	-	μs

SGS-THOMSON MICROELECTRONICS

DB3 /DB4 / DC34

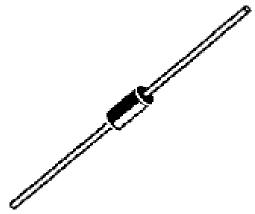
TRIGGER DIODES

FEATURES

- V_{BO} : 32V / 34V / 40V VERSIONS
- LOW BREAKOVER CURRENT

DESCRIPTION

High reliability glass passivation insuring parameter stability and protection against junction contamination.



DO 35
(Glass)

ABSOLUTE RATINGS (limiting values)

Symbol	Parameter		Value	Unit
P	Power dissipation on printed circuit (L = 10 mm)	Ta = 65 °C	150	mW
I_{TRM}	Repetitive peak on-state current	tp = 20 µs F= 100 Hz	2	A
Tstg Tj	Storage and operating junction temperature range		- 40 to + 125 - 40 to + 125	°C °C

THERMAL RESISTANCES

Symbol	Parameter	Value	Unit
$R_{th\ (j\text{-}a)}$	Junction to ambient	400	°C/W
$R_{th\ (j\text{-}l)}$	Junction-leads	150	°C/W

DB3 / DB4 / DC34

ELECTRICAL CHARACTERISTICS (Tj = 25°C)

Symbol	Parameter	Test Conditions		Value			Unit
				DB3	DC34	DB4	
V_{BO}	Breakover voltage *	C = 22nF ** see diagram 1	MIN	28	30	35	V
			TYP	32	34	40	
			MAX	36	38	45	
$[\lvert +V_{BO}\rvert - \lvert -V_{BO}\rvert]$	Breakover voltage symmetry	C = 22nF ** see diagram 1	MAX	± 3			V
$\lvert \Delta V \pm \rvert$	Dynamic breakover voltage *	$\Delta I = [I_{BO}$ to $I_F = 10mA]$ see diagram 1	MIN	5			V
V_O	Output voltage *	see diagram 2	MIN	5			V
I_{BO}	Breakover current *	C = 22nF **	MAX	100	50	100	µA
tr	Rise time *	see diagram 3	TYP	1.5			µs
I_B	Leakage current *	$V_B = 0.5\ V_{BO}$ max see diagram 1	MAX	10			µA

* Electrical characteristic applicable in both forward and reverse directions.

** Connected in parallel with the devices.

DIAGRAM 1 : Current-voltage characteristics

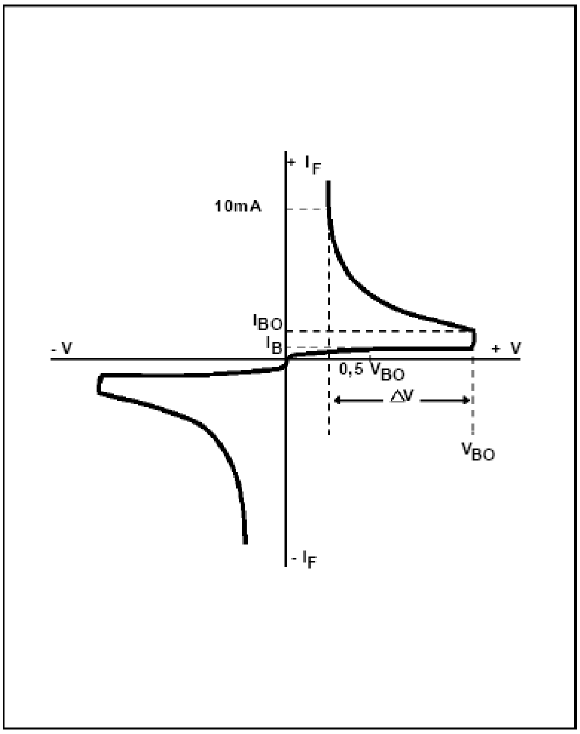


DIAGRAM 2 : Test circuit for output voltage

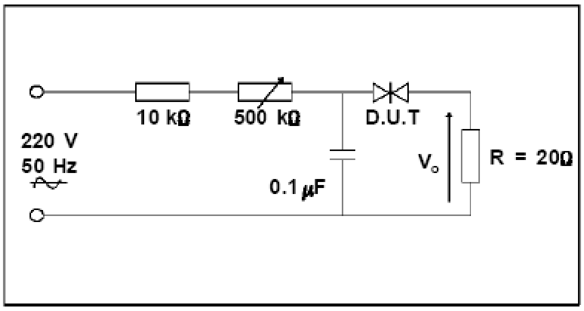
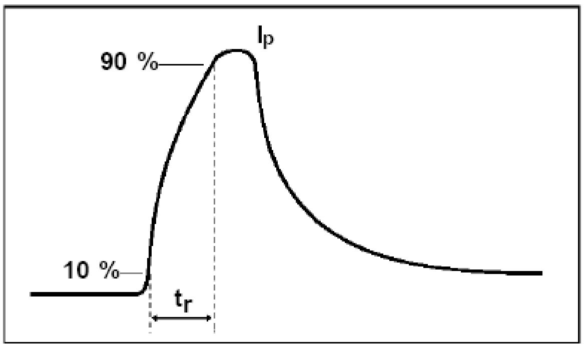


DIAGRAM 3 : Test circuit see diagram 2.
Adjust R for Ip=0.5A

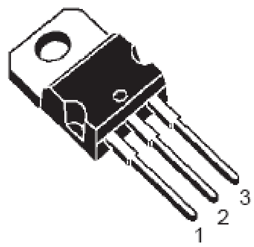


IRF740

N - CHANNEL 400V - 0.48 Ω - 10 A - TO-220 PowerMESH™ MOSFET

TYPE	V_{DSS}	$R_{DS(on)}$	I_D
IRF740	400 V	< 0.55 Ω	10 A

- TYPICAL $R_{DS(on)}$ = 0.48 Ω
- EXTREMELY HIGH dv/dt CAPABILITY
- 100% AVALANCHE TESTED
- VERY LOW INTRINSIC CAPACITANCES
- GATE CHARGE MINIMIZED



TO-220

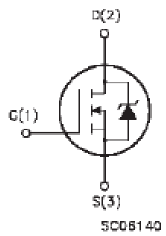
DESCRIPTION

This power MOSFET is designed using the company's consolidated strip layout-based MESH OVERLAY™ process. This technology matches and improves the performances compared with standard parts from various sources.

APPLICATIONS

- HIGH CURRENT SWITCHING
- UNINTERRUPTIBLE POWER SUPPLY (UPS)
- DC/DC COVERTERS FOR TELECOM, INDUSTRIAL, AND LIGHTING EQUIPMENT.

INTERNAL SCHEMATIC DIAGRAM



ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Value	Unit
V_{DS}	Drain-source Voltage (V_{GS} = 0)	400	V
V_{DGR}	Drain- gate Voltage (R_{GS} = 20 kΩ)	400	V
V_{GS}	Gate-source Voltage	± 20	V
I_D	Drain Current (continuous) at T_c = 25 °C	10	A
I_D	Drain Current (continuous) at T_c = 100 °C	6.3	A
I_{DM}(•)	Drain Current (pulsed)	40	A
P_{tot}	Total Dissipation at T_c = 25 °C	125	W
	Derating Factor	1.0	W/°C
dv/dt(1)	Peak Diode Recovery voltage slope	4.0	V/ns
T_{stg}	Storage Temperature	-65 to 150	°C
T_j	Max. Operating Junction Temperature	150	°C

(•) Pulse width limited by safe operating area (1) $I_{SD} \leq 10$ A, di/dt ≤ 120 A/µs, $V_{DD} \leq V_{(BR)DSS}$, $T_j \leq T_{JMAX}$

First Digit of the Datecode Being Z or K Identifies Silicon Characterized in this Datasheet

IRF740

THERMAL DATA

$R_{thj-case}$	Thermal Resistance Junction-case Max	1.0	°C/W
$R_{thj-amb}$	Thermal Resistance Junction-ambient Max	62.5	oC/W
$R_{thc-sink}$	Thermal Resistance Case-sink Typ	0.5	°C/W
T_l	Maximum Lead Temperature For Soldering Purpose	300	°C

AVALANCHE CHARACTERISTICS

Symbol	Parameter	Max Value	Unit
I_{AR}	Avalanche Current, Repetitive or Not-Repetitive (pulse width limited by T_j max)	10	A
E_{AS}	Single Pulse Avalanche Energy (starting T_j = 25 °C, $I_D = I_{AR}$, V_{DD} = 50 V)	520	mJ

ELECTRICAL CHARACTERISTICS (T_{case} = 25 °C unless otherwise specified)

OFF

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
$V_{(BR)DSS}$	Drain-source Breakdown Voltage	I_D = 250 µA V_{GS} = 0	400			V
I_{DSS}	Zero Gate Voltage Drain Current (V_{GS} = 0)	V_{DS} = Max Rating V_{DS} = Max Rating T_c = 125 °C			1 50	µA µA
I_{GSS}	Gate-body Leakage Current (V_{DS} = 0)	V_{GS} = ± 20 V			± 100	nA

ON (*)

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
$V_{GS(th)}$	Gate Threshold Voltage	$V_{DS} = V_{GS}$ I_D = 250 µA	2	3	4	V
$R_{DS(on)}$	Static Drain-source On Resistance	V_{GS} = 10V I_D = 5.3 A		0.48	0.55	Ω
$I_{D(on)}$	On State Drain Current	$V_{DS} > I_{D(on)} \times R_{DS(on)max}$ V_{GS} = 10 V	10			A

DYNAMIC

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
g_{fs} (*)	Forward Transconductance	$V_{DS} > I_{D(on)} \times R_{DS(on)max}$ I_D = 6 A	5.8			S
C_{iss} C_{oss} C_{rss}	Input Capacitance Output Capacitance Reverse Transfer Capacitance	V_{DS} = 25 V f = 1 MHz V_{GS} = 0		1400 220 27		pF pF pF

International IOR Rectifier

PD - 9.686A

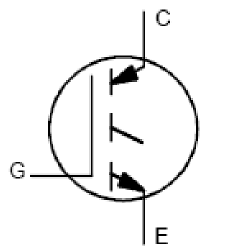
IRGBC20F

INSULATED GATE BIPOLAR TRANSISTOR

Fast Speed IGBT

Features

- Switching-loss rating includes all "tail" losses
- Optimized for medium operating frequency (1 to 10kHz) See Fig. 1 for Current vs. Frequency curve



n-channel

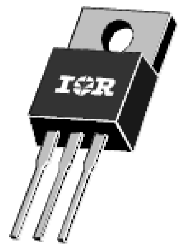
V_{CES} = 600V

$V_{CE(sat)} \leq 2.8V$

@V_{GE} = 15V, I_C = 9.0A

Description

Insulated Gate Bipolar Transistors (IGBTs) from International Rectifier have higher usable current densities than comparable bipolar transistors, while at the same time having simpler gate-drive requirements of the familiar power MOSFET. They provide substantial benefits to a host of high-voltage, high-current applications.



TO-220AB

Absolute Maximum Ratings

	Parameter	Max.	Units
V_{CES}	Collector-to-Emitter Voltage	600	V
I_C @ T_C = 25°C	Continuous Collector Current	16	
I_C @ T_C = 100°C	Continuous Collector Current	9.0	A
I_{CM}	Pulsed Collector Current ①	64	
I_{LM}	Clamped Inductive Load Current ②	64	
V_{GE}	Gate-to-Emitter Voltage	±20	V
E_{ARV}	Reverse Voltage Avalanche Energy ③	5.0	mJ
P_D @ T_C = 25°C	Maximum Power Dissipation	60	W
P_D @ T_C = 100°C	Maximum Power Dissipation	24	
T_J T_{STG}	Operating Junction and Storage Temperature Range	-55 to +150	°C
	Soldering Temperature, for 10 sec.	300 (0.063 in. (1.6mm) from case)	
	Mounting torque, 6-32 or M3 screw.	10 lbf•in (1.1N•m)	

Thermal Resistance

	Parameter	Min.	Typ.	Max.	Units
$R_{\theta JC}$	Junction-to-Case	—	—	2.1	
$R_{\theta CS}$	Case-to-Sink, flat, greased surface	—	0.50	—	°C/W
$R_{\theta JA}$	Junction-to-Ambient, typical socket mount	—	—	80	
Wt	Weight	—	2.0 (0.07)	—	g (oz)

FAIRCHILD
SEMICONDUCTOR™

1N4728A - 1N4752A Series

1N4728A - 1N4752A Series One Watt Zeners

Absolute Maximum Ratings*

T_A = 25°C unless otherwise noted

Tolerance: A = 5%

Parameter	Value	Units
Storage Temperature Range	-65 to +200	°C
Maximum Junction Operating Temperature	+ 200	°C
Lead Temperature (1/16" from case for 10 seconds)	+ 230	°C
Total Device Dissipation Derate above 50°C	1.0 6.67	W mW/°C
Thermal resistance Junction to Lead	53.5	°C/W
Thermal resistance Junction to Ambient	100	°C/W
Surge Power**	10	W

*These ratings are limiting values above which the serviceability of the diode may be impaired.
**Non-recurrent square wave PW= 8.3 ms, TA= 55 degrees C.

DO-41

NOTES:
1) These ratings are based on a maximum junction temperature of 200 degrees C.
2) These are steady state limits. The factory should be consulted on applications involving pulsed or low duty cycle operations.

Electrical Characteristics

T_A = 25°C unless otherwise noted

Device	V_Z (V)	Z_Z (Ω) @	I_{ZT} (mA)	Z_{ZK} (Ω) @	I_{ZK} (mA)	V_R (V) @	I_R (µA)	I_{SURGE} (mA)	I_{ZM} (mA)
1N4728A	3.3	10	76	400	1.0	1.0	100	1,380	276
1N4729A	3.6	10	69	400	1.0	1.0	100	1,260	252
1N4730A	3.9	9.0	64	400	1.0	1.0	50	1,190	234
1N4731A	4.3	9.0	58	400	1.0	1.0	10	1,070	217
1N4732A	4.7	8.0	53	500	1.0	1.0	10	970	193
1N4733A	5.1	7.0	49	550	1.0	1.0	10	890	178
1N4734A	5.6	5.0	45	600	1.0	2.0	10	810	162
1N4735A	6.2	2.0	41	700	1.0	3.0	10	730	146
1N4736A	6.8	3.5	37	700	1.0	4.0	10	660	133
1N4737A	7.5	4.0	34	700	0.5	5.0	10	605	121
1N4738A	8.2	4.5	31	700	0.5	6.0	10	550	110
1N4739A	9.1	5.0	28	700	0.5	7.0	10	500	100
1N4740A	10	7.0	25	700	0.25	7.6	10	454	91
1N4741A	11	8.0	23	700	0.25	8.4	5.0	414	83
1N4742A	12	9.0	21	700	0.25	9.1	5.0	380	76
1N4743A	13	10	19	700	0.25	9.9	5.0	344	69
1N4744A	15	14	17	700	0.25	11.4	5.0	304	61
1N4745A	16	16	15.5	700	0.25	12.2	5.0	285	57
1N4746A	18	20	14	750	0.25	13.7	5.0	250	50
1N4747A	20	22	12.5	750	0.25	15.2	5.0	225	45
1N4748A	22	23	11.5	750	0.25	16.7	5.0	205	41
1N4749A	24	25	10.5	750	0.25	18.2	5.0	190	38
1N4750A	27	35	9.5	750	0.25	20.6	5.0	170	34
1N4751A	30	40	8.5	1,000	0.25	22.8	5.0	150	30
1N4752A	33	45	7.5	1,000	0.25	25.1	5.0	135	27

V_F Foward Voltage = 1.2 V Maximum @ I_F = 200 mA for all 1N4700 series

 1N4700A Rev. B

IRGBC20F

Electrical Characteristics @ T_J = 25°C (unless otherwise specified)

	Parameter	Min.	Typ.	Max.	Units	Conditions	
$V_{(BR)CES}$	Collector-to-Emitter Breakdown Voltage	600	—	—	V	V_{GE} = 0V, I_C = 250μA	
$V_{(BR)ECS}$	Emitter-to-Collector Breakdown Voltage ④	20	—	—	V	V_{GE} = 0V, I_C = 1.0A	
$\Delta V_{(BR)CES}/\Delta T_J$	Temp. Coeff. of Breakdown Voltage	—	0.72	—	V/°C	V_{GE} = 0V, I_C = 1.0mA	
$V_{CE(on)}$	Collector-to-Emitter Saturation Voltage	—	2.0	2.8	V	I_C = 9.0A	V_{GE} = 15V
		—	2.6	—		I_C = 16A	See Fig. 2, 5
		—	2.3	—		I_C = 9.0A, T_J = 150°C	
$V_{GE(th)}$	Gate Threshold Voltage	3.0	—	5.5		V_{CE} = V_{GE}, I_C = 250μA	
$\Delta V_{GE(th)}/\Delta T_J$	Temp. Coeff. of Threshold Voltage	—	-11	—	mV/°C	V_{CE} = V_{GE}, I_C = 250μA	
g_{fe}	Forward Transconductance ⑤	2.9	5.1	—	S	V_{CE} = 100V, I_C = 9.0A	
I_{CES}	Zero Gate Voltage Collector Current	—	—	250	μA	V_{GE} = 0V, V_{CE} = 600V	
		—	—	1000		V_{GE} = 0V, V_{CE} = 600V, T_J = 150°C	
I_{GES}	Gate-to-Emitter Leakage Current	—	—	±100	nA	V_{GE} = ±20V	

Switching Characteristics @ T_J = 25°C (unless otherwise specified)

	Parameter	Min.	Typ.	Max.	Units	Conditions
Q_g	Total Gate Charge (turn-on)	—	16	21	nC	I_C = 9.0A
Q_{ge}	Gate - Emitter Charge (turn-on)	—	2.4	3.4		V_{CC} = 400V See Fig. 8
Q_{gc}	Gate - Collector Charge (turn-on)	—	7.8	10		V_{GE} = 15V
$t_{d(on)}$	Turn-On Delay Time	—	24	—	ns	T_J = 25°C
t_r	Rise Time	—	13	—		I_C = 9.0A, V_{CC} = 480V
$t_{d(off)}$	Turn-Off Delay Time	—	160	270		V_{GE} = 15V, R_G = 50Ω
t_f	Fall Time	—	310	600		Energy losses include "tail"
E_{on}	Turn-On Switching Loss	—	0.18	—	mJ	
E_{off}	Turn-Off Switching Loss	—	0.90	—		See Fig. 9, 10, 11, 14
E_{ts}	Total Switching Loss	—	1.08	2.0		
$t_{d(on)}$	Turn-On Delay Time	—	25	—	ns	T_J = 150°C,
t_r	Rise Time	—	18	—		I_C = 9.0A, V_{CC} = 480V
$t_{d(off)}$	Turn-Off Delay Time	—	210	—		V_{GE} = 15V, R_G = 50Ω
t_f	Fall Time	—	600	—		Energy losses include "tail"
E_{ts}	Total Switching Loss	—	1.65	—	mJ	See Fig. 10, 14
L_E	Internal Emitter Inductance	—	7.5	—	nH	Measured 5mm from package
C_{ies}	Input Capacitance	—	340	—	pF	V_{GE} = 0V
C_{oes}	Output Capacitance	—	63	—		V_{CC} = 30V See Fig. 7
C_{res}	Reverse Transfer Capacitance	—	5.9	—		f = 1.0MHz

Notes:

① Repetitive rating; V_{GE}=20V, pulse width limited by max. junction temperature. (See fig. 13b)

② V_{CC}=80%(V_{CES}), V_{GE}=20V, L=10μH, R_G= 50Ω, (See fig. 13a)

③ Repetitive rating; pulse width limited by maximum junction temperature.

④ Pulse width ≤ 80μs; duty factor ≤ 0.1%.

⑤ Pulse width 5.0μs, single shot.

Philips Semiconductors

Data sheet	
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2N2646
Silicon unijunction transistor

QUICK REFERENCE DATA

SYMBOL	PARAMETER	CONDITIONS	MIN.	TYP.	MAX.	UNIT
$-V_{EB2}$	emitter-base 2 voltage		–	–	30	V
I_{EM}	emitter current	peak value	–	–	2	A
P_{tot}	total power dissipation		–	–	300	mW
T_j	junction temperature		–	–	125	°C
R_{BB}	static inter-base resistance	$V_{B2B1} = 3$ V $I_E = 0$	–	7	–	kΩ
V_{EB1sat}	emitter-base 1 saturation voltage	$V_{B2B1} = 10$ V $I_E = 50$ mA	–	3.5	–	V
$I_{E(V)}$	emitter valley point current		4	6	–	mA
$I_{E(P)}$	emitter peak point current		–	1	5	µA

PINNING - TO-18

Base 2 connected to case.

PIN	DESCRIPTION
1	emitter
2	base 1
3	base 2

PIN CONFIGURATION

Fig.1 Simplified outline and symbol.

Silicon unijunction transistor 2N2646

CHARACTERISTICS

T_{amb} = 25 °C unless otherwise specified.

SYMBOL	PARAMETER	CONDITIONS	MIN.	TYP.	MAX.	UNIT
R_{BB}	static inter-base resistance	V_{B2B1} = 3 V I_E = 0	4.7	7	9.1	kΩ
TC_{RBB}	inter-base resistance temperature coefficient	V_{B2B1} = 3 V I_E = 0 T_{amb} = −55 to 125 °C	0.1	–	0.9	%/K
$-I_{EB2O}$	emitter cut-off current	$-V_{EB2}$ = 30 V I_{B1} = 0	–	–	12	V
V_{EB1sat}	emitter-base 1 saturation voltage	V_{B2B1} = 10 V I_E = 50 mA	–	3.5	–	V
I_{B2mod}	inter-base current modulation	V_{B2B1} = 10 V I_E = 50 mA	–	15	–	mA
η	input/output ratio (note 1)	V_{B2B1} = 10 V	0.56	–	0.75	
$I_{E(V)}$	emitter valley point current	V_{B2B1} = 20 V R_{B2} = 100 Ω	4	6	–	mA
$I_{E(P)}$	emitter peak point current	V_{B2B1} = 25 V	–	1	5	µA
V_{OB1M}	base 1 impulse/output voltage		3	5	–	V

Note

1. $\eta = \frac{(V_{E(P)} - V_{EB1})}{V_{B2B1}}$, when $V_{E(P)}$ = emitter peak point voltage, V_{EB1} = emitter-base 1 breakdown voltage, (approximately 0.5 V at 10 µA), and V_{B2B1} = inter-base voltage.

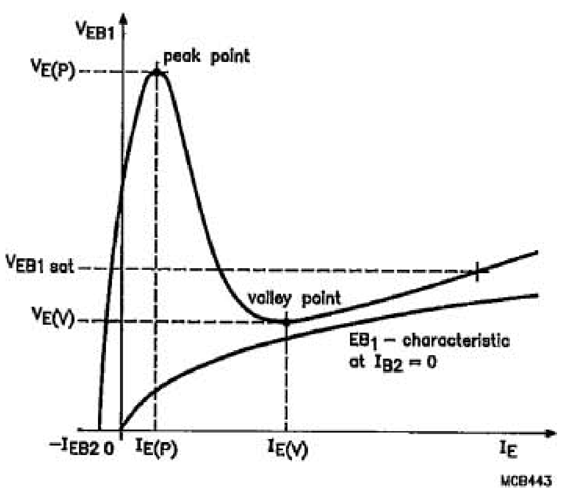

Fig.3 Impulse as a function of output voltage.

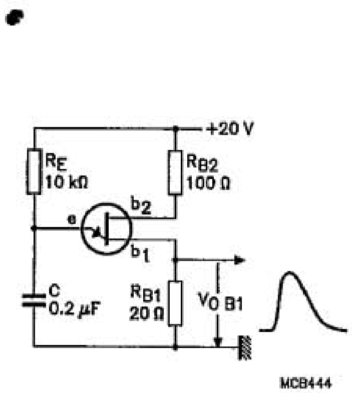

Fig.4 Impulse output circuit.

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