EXPERIMENT NO. 1

OBJECT: To study and test the firing circuit of three phase half controlled bridge converter.

APPARATUS:

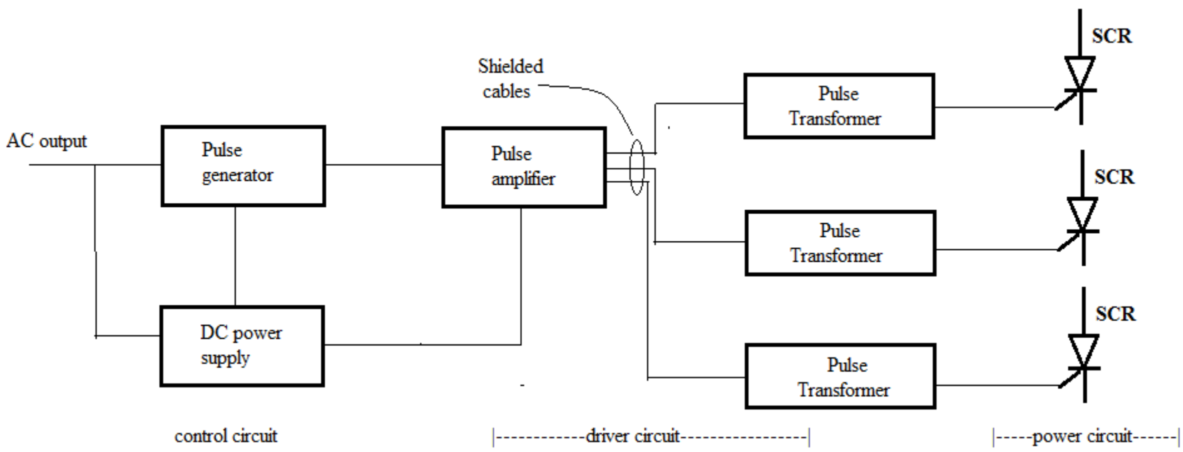
S.NO.	EQUIPMENT	RATING	QUANTITY
1.	Three Phase SCR Module kit	PEC14HV5P	1.
2	SCR	1600 Volt, 90Amp	
3	Connecting Leads		A.P.R
4	Load	R….. , RL…….	
5	Triggering Module	PEC16HV2B	1

THEORY: The most common method for controlling the onset of conduction in a SCR is by means of gate voltage controlling .The gate voltage circuit also called as firing circuit.

A firing circuit should fulfil following two functions.

(i) If power circuit has more than one SCR, the firing circuit should produce gating pulses for each SCR at the desired instance for proper operation of the power circuit.

(ii) The control signal generated by a firing circuit mar not be able to turn on an SCR. It is therefore common to feed the voltage pulses to driver circuit and then to gate cathode circuit.

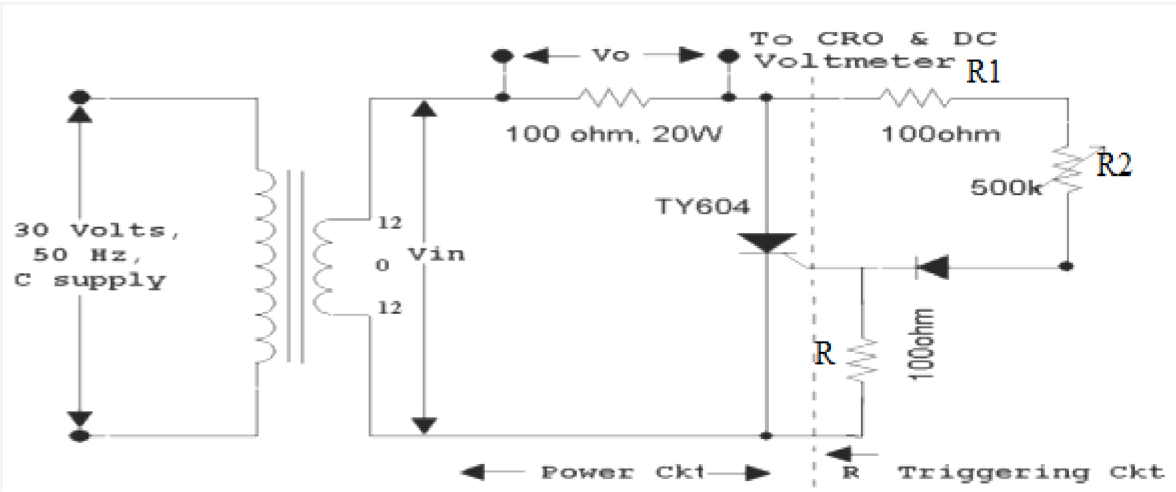


A General layout of the firing circuit scheme of SCRs

Some firing circuit schemes are described in this section.

I. Resistance triggering
II. RC firing circuit
III. UJT firing circuit.

1-Resistance Triggering: Resistance trigger circuits are the simplest & most economical method. During the positive half cycle of the input voltage, SCR become forward biased but it will not conduct until its gate current exceeds Igmin . Diode D allows the flow of current during positive half cycle only. R2 is the variable resistance & R is the stabilizing resistance .R1 is used to limit the gate current. During the positive half cycle current Ig flows. Ig increases and when Ig= Igmin the SCR turns ON .The firing angle can be varied from 0 — 90° by varying the resistance R



Here R_1 can be found from relation,

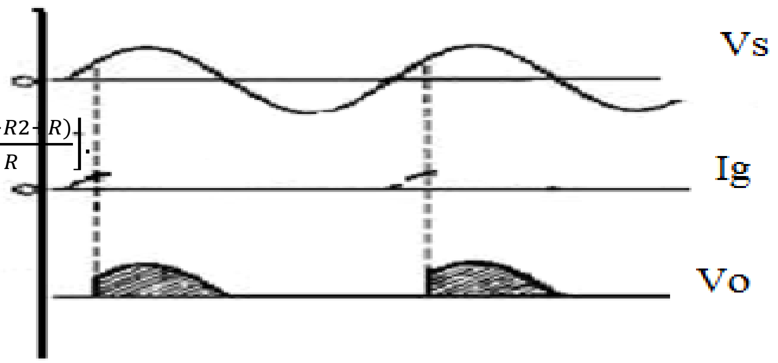
$$R_1 \geq \frac{V_m}{I_{gm}}$$

where V_m = maximum value of source. Value resistance R such that maximum value across it does not exceed maximum possible gate voltage V_{gm} . R is given by

$$R \leq \frac{V_{gm} \cdot R_1}{V_m - V_{gm}}$$

Firing angle relation is given by α = $\sin^{-1}\left[\frac{Vgt(R1+R2+R)}{Vm\ R}\right]$.

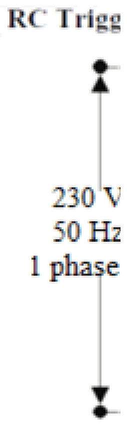
But as V_{gt} ,R_1, R and



Resistance firing circuit waveforms

V_m are fixed for a circuitry then $\alpha \propto \sin^{-1} R_2$ or $\alpha \propto R_2$.

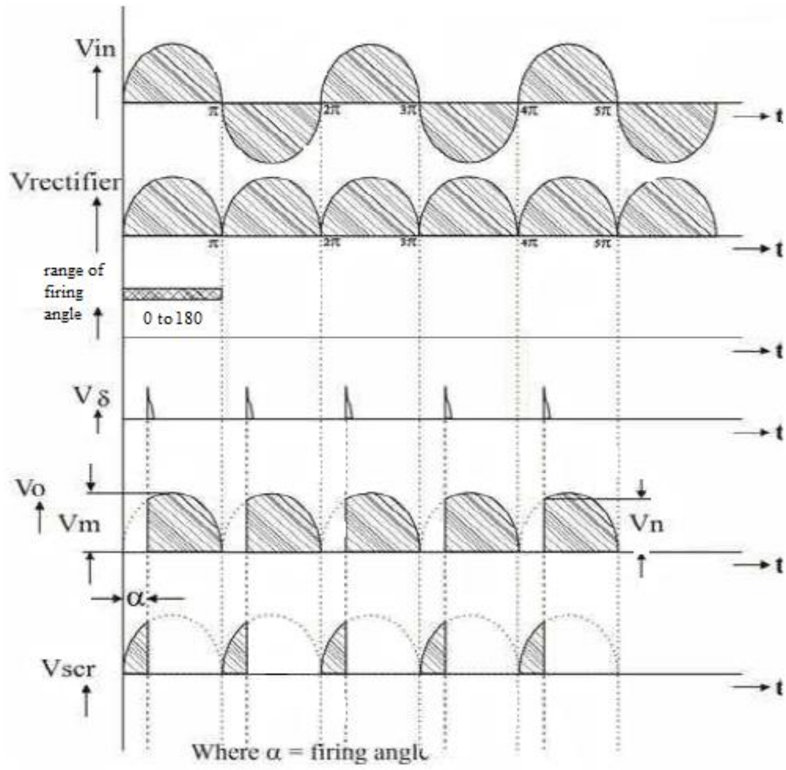
2. R -C Triggering: By varying the variable resistance R, the firing angle can be varied from 0 —180° .In the negative half cycle the capacitance C charges through the diode D_2 with lower plate positive to, the peak supply voltage E_{max} .This Capacitor voltage remains constant at until supply voltage attains zero value. During the positive half cycle of the input voltage, C begins to charge through R. When the capacitor voltage reaches the minimum gate trigger voltage SCR will turn on.



Maximum value of R is given by:-

$$R \leq \frac{Vs - Vgt - vd}{Igt}$$

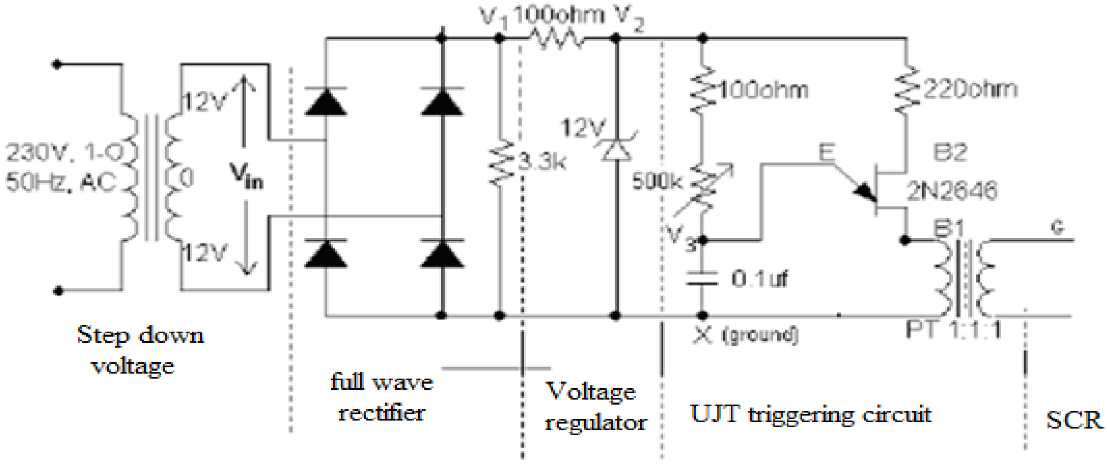
Where V_s source voltage at which thyristor turns on. Waveforms are shown below:-



3.UJT : Resistance and RC triggering circuits described above give prolonged pulse. As a result, power dissipation in the gate circuit is large. At the same time R and RC triggering circuits cann't be used for automatic and feedback systems. These difficulties can be overcome by the use of UJT triggering circuits.

A synchronized UJT triggered circuit using an UJT is shown in the figure. Diodes 'D1' to 'D4' rectify ac to dc. Resistor R1 lowers V_{dc} to a suitable value for the zener diode and UJT. Zener diode 'Z' functions to clip the rectified voltage to a standard level, 'V_z' which remains constant except near the V_{dc} zero. The voltage Vz is applied to the charging circuit RC. Current 'I', charges capacitor 'c' at a rate determined by 'R' voltage across capacitor is marked by 'V_c' as shown. When 'V_c' reaches the uni junction threshold voltage Vz, the t-B1 junction of UJT breaks down and the capacitor 'c' discharges through the primary of pulse transformer sending a current 'C_2' as shown.

As the current 'i_2' is in the form of pulse, windings of the pulse transformer have pulse voltages at their secondary terminals. Pulse at the two secondary windings feeds the same in phase pulse to two SCRs of a half wave circuits. SCR with positive anode voltage would turn ON. As soon as the capacitor discharges, it starts to recharge as shown. Rate of rise of capacitor voltage can be controlled by varying 'R'. The firing angle can be controlled up to above 1500.



Circuit Diagram: UJT Triggering Circuit

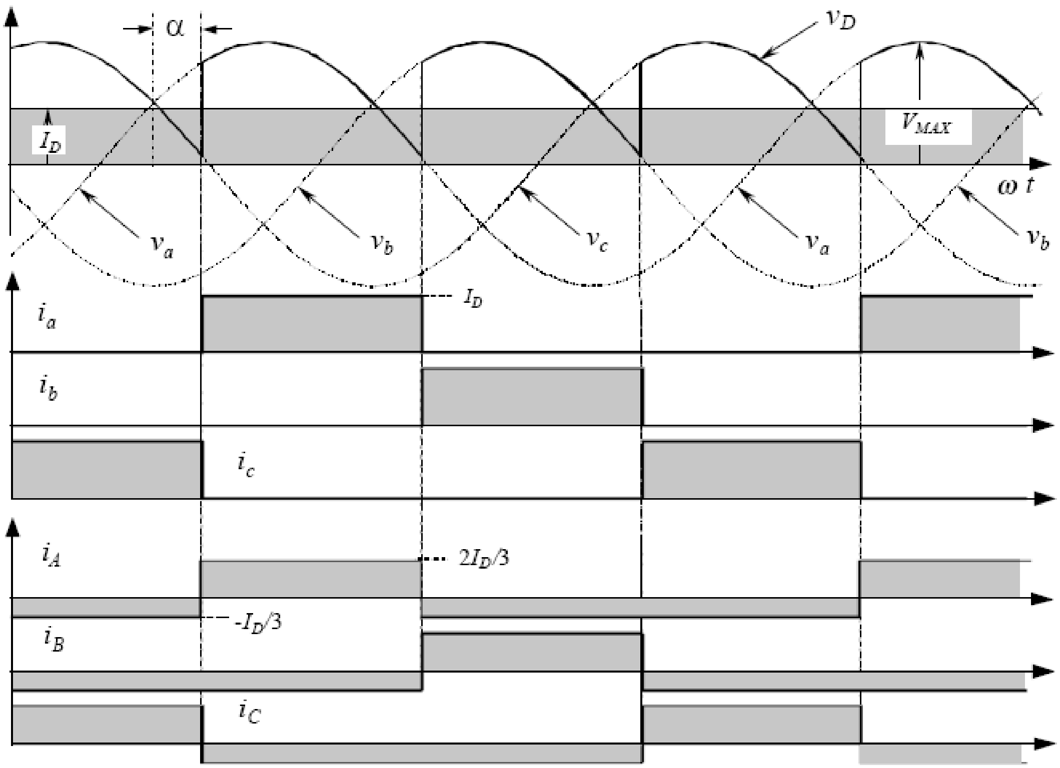
We have intrinsic stand off ratio. Typical values of $\acute{\eta}$ are 0.51 to 0.82

$$\acute{\eta} = \frac{R_{B1}}{R_{B1} + R_{B2}}$$

The time required for capacitor C to charge

$$T = \frac{1}{f} = RC\ ln\left(\frac{1}{1-\acute{\eta}}\right)$$

Wave form of UJT



Now the above firing circuits can be used in 3 phase half controlled converter and we can have desired output voltage.

Theoretical value is given by the equation:-

$$V_{dc} = {}^{2v}/_{\pi}$$

Observation for different firing circuit can be noted down in below table…

CONCLUSION: Thus study and test the firing circuit of three phase half controlled bridge converter is done.

EXPERIMENT NO. 2

OBJECT- Study and obtain waveform of three phase half controlled bridge convertor with R-load and RL-load

APPRATUS REQUIRED-

S.NO.	EQUIPMENT	RATING	QUANTITY
1.	Three Phase SCR Module kit	PEC14HV5P	01
2	SCR	1600 Volt, 90Amp	
3	Connecting Leads		A.P.R
4	Load	R….. , RL…….	
5	Triggering module	PEC14HV5P	01

THEORY- Three-phase controlled rectifiers have a wide range of applications, from small rectifiers to large High Voltage Direct Current (HVDC) transmission systems. They are used for electro-chemical process, many kinds of motor drives, traction equipment, controlled power supplies, and many other applications. From the point of view of the commutation process, they can be classified in two important categories: Line Commutated Controlled Rectifiers (Thyristor Rectifiers), and Force Commutated PWM Rectifiers.

RATING- 440 Volt, Three phase 50 Hz AC Supply
With 5Amp. Fuse

Half controlled bridge converter-

The fully controlled three-phase bridge converter shown in figure has six thyristors. this circuit operates as a rectifier when each thyristor has a firing angle, a, which is less than 90 degrees, and functions as an inverter for a greater than 90 degrees. If inverter operation is not required, the circuit may be simplified by replacing three controlled rectifiers with power diodes, as in figure 12.15 a). This simplification is economically attractive because diodes are considerably less expensive than thyristors, and they do not require firing angle control electronics.

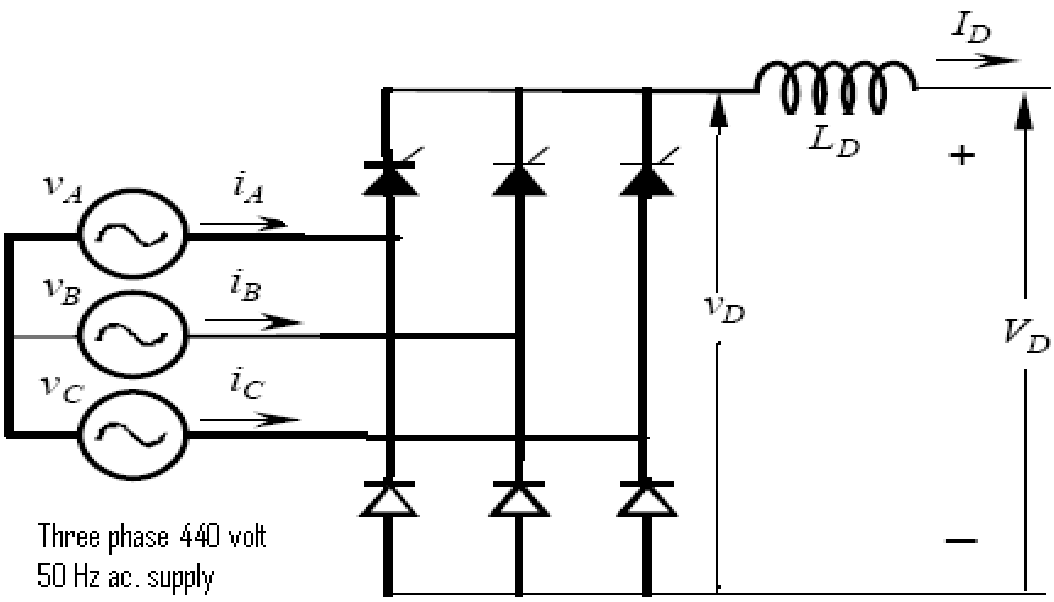
The half controlled bridge, or “semiconverter”, is analyzed by considering it as a phasecontrolled half-wave circuit in series with an uncontrolled half wave rectifier. The average *dc* voltage is given by the following equation:

$$V_{dc} = \frac{3}{2\pi}\left[\int_{\pi/3}^{(2\pi/3)+\alpha} v_{RY}\, d(\acute{\omega}t) + \int_{(2\pi/3)+\alpha}^{\pi} vv_{RB}\, d(\acute{\omega}t)\right]$$

$$= \frac{3}{2\pi}\left[\int_{\pi/3}^{((2\pi/3)+\alpha))}(\sqrt{3}_{V_m}) \sin \acute{\omega}t\, (d\acute{\omega}t) - \int_{(2\pi/3)+\alpha}^{(\pi)}(\sqrt{3}V_m) \sin(\acute{\omega}t - 240)\, (d((\acute{\omega}t))\right]$$

$$V_{dc} = \frac{3\sqrt{3}}{\pi} Vm \left(\frac{1+\cos\alpha}{2}\right)$$

CIRCUIT DIAGRAM=

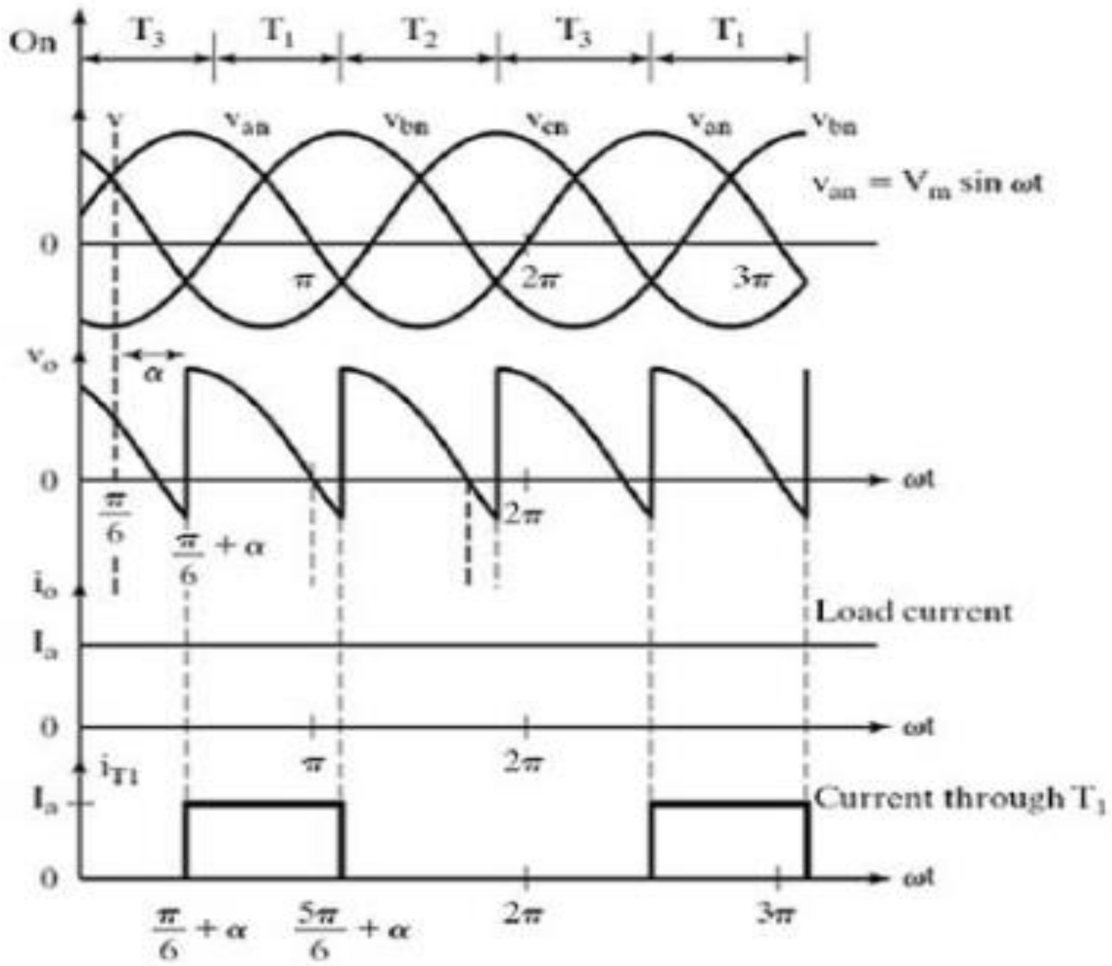


One-quadrant bridge converter circuits

half-controlled bridge

Then, the average voltage *VD* never reaches negative values. The output voltage waveforms of half-controlled bridge are similar to those of a fully controlled bridge with a free-wheeling diode. The advantage of the free-wheeling diode connection, shown in figure is that there is always a path for the *dc* current, independent of the status of the *ac* line and of the converter. This can be important if the load is inductive-resistive with a large time constant, and there is a interruption in one or more of the line phases. In such a case, the load current could commutate to the free-wheeling diode

WAVEFORM-



OBSERVATION TABLE-

S.NO	INPUT VOLTAGE	FIRING ANGLE	OUTPUT VOLTAGE

RESULT- Studied and obtained waveform of three phase full controlled bridge convertor with R-load and RL-load

PRECAUTIONS:

1. Make connection carefully.
2. Give an appropriate value of "*a*" and obtain waveforms.
3. Error free measuring instruments should be used.

EXPERIMENT NO. 3

OBJECT: To study and test the firing circuit of three phase fully controlled bridge converter.

APPARATUS:

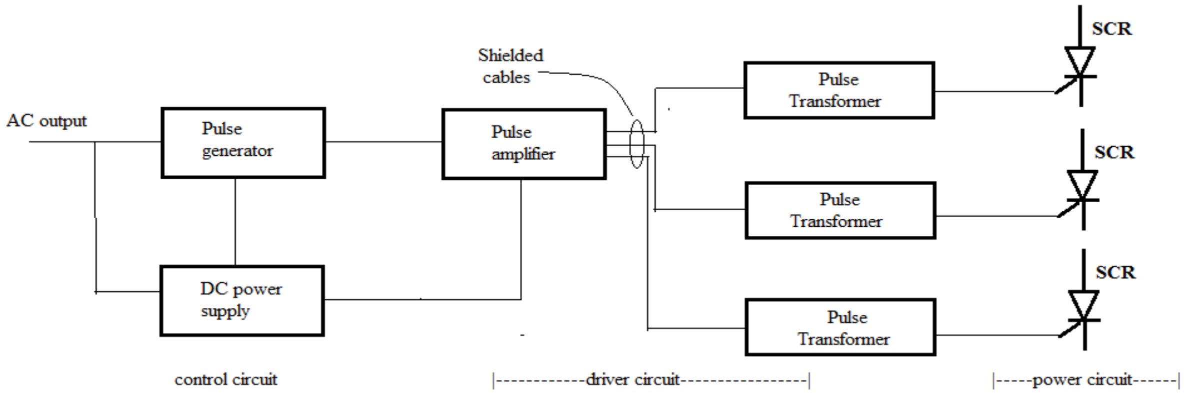
S.NO.	EQUIPMENT	RATING	QUANTITY
1.	Three Phase SCR Module kit	PEC14HV5P	1.
2	SCR	1600 Volt, 90Amp	
3	Connecting Leads		A.P.R
4	Load	R….. , RL…….	

THEORY: The most common method for controlling the onset of conduction in a SCR is by means of gate voltage controlling .The gate voltage circuit also called as firing circuit.

A firing circuit should fulfil following two functions.

(iii) If power circuit has more than one SCR, the firing circuit should produce gating pulses for each SCR at the desired instance for proper operation of the power circuit.

(iv) The control signal generated by a firing circuit mar not be able to turn on an SCR. It is therefore common to feed the voltage pulses to driver circuit and then to gate cathode circuit.



A General layout of the firing circuit scheme of SCRs

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IV. Resistance triggering
V. RC firing circuit
VI. UJT firing circuit.

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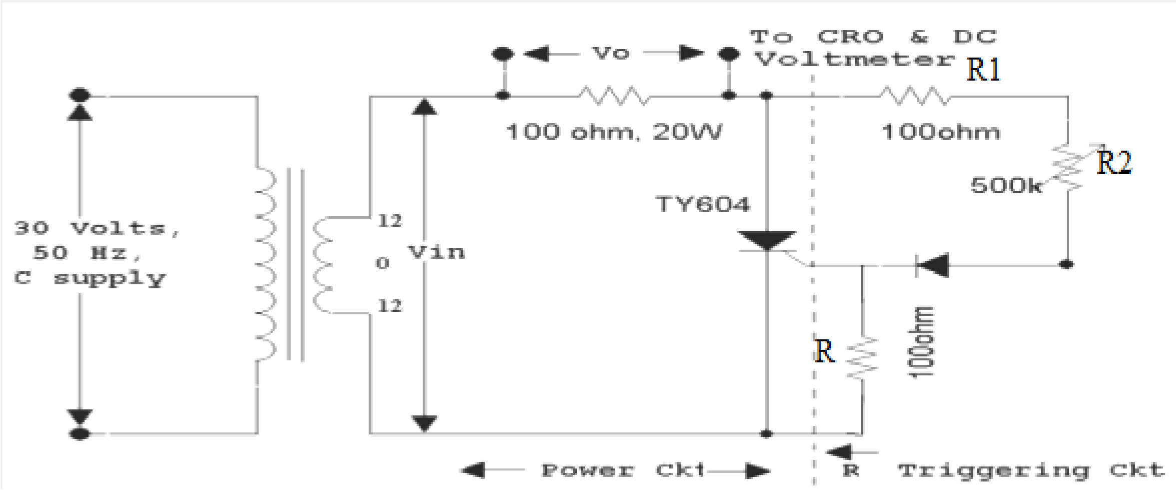


Here R_1 can be found from relation,

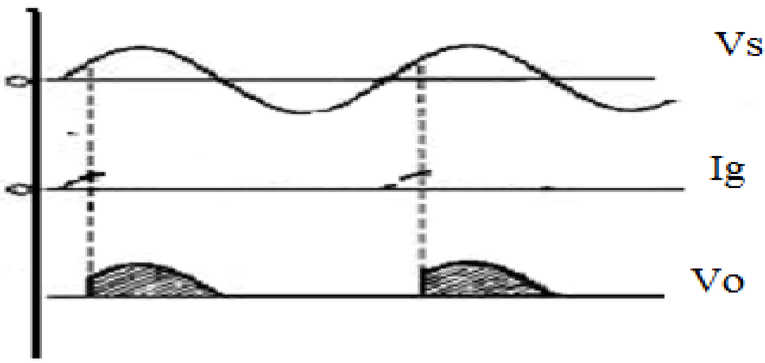
$$R_1 \geq \frac{V_m}{I_{gm}}$$

where V_m = maximum value of source. Value resistance R such that maximum value across it does not exceed maximum possible gate voltage V_{gm} . R is given by

$$R \leq \frac{V_{gm} \cdot R_1}{V_m - V_{gm}}$$

Firing angle relation is given by $\alpha = \sin^{-1}\left[\frac{Vgt(R1+R2+R)}{Vm\ R}\right]$.

But as V_{gt} ,$R_{1,}$ R and V_m are fixed for a circuitry then $\alpha \propto \sin^{-1} R_2$ or $\alpha \propto R_2$.

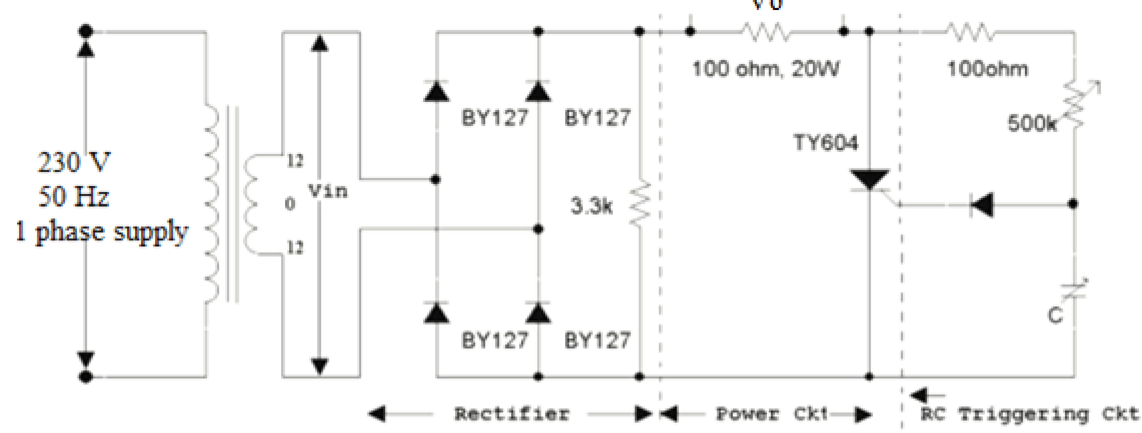


Resistance firing circuit waveforms

2-R —C Triggering:

By varying the variable resistance R, the firing angle can be varied from 0 —180° .In the negative half cycle the capacitance C charges through the diode D_2 with lower plate positive to, the peak supply voltage E_{max} .This Capacitor voltage remains constant at until supply voltage attains zero value. During the positive half cycle of the input voltage, C begins to charge through R. When the capacitor voltage reaches the minimum gate trigger voltage SCR will turn on.

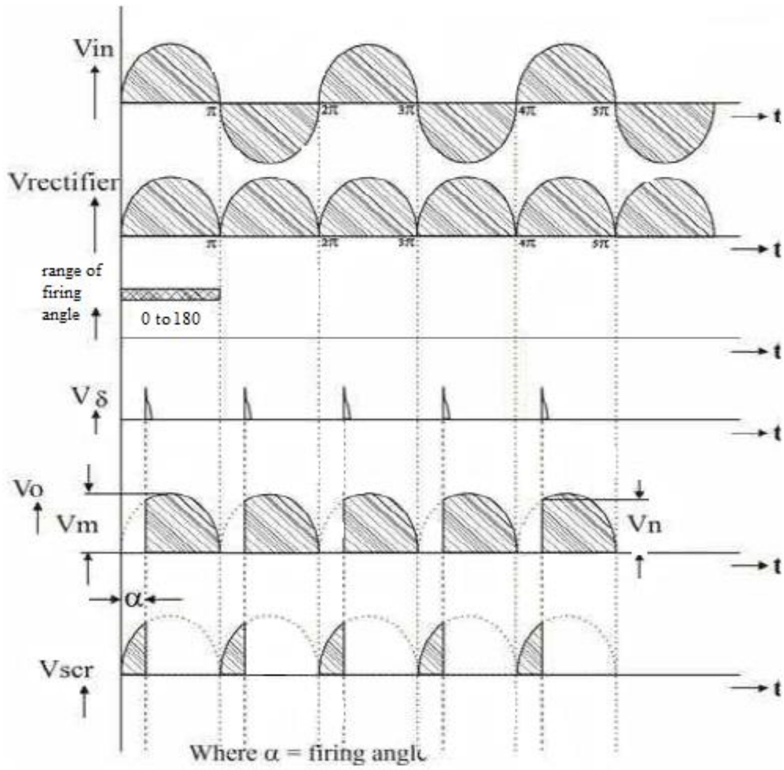
RC Triggering Circuit:



Maximum value of R is given by:-

$$R \le \frac{Vs - Vgt - vd}{Igt}$$

Where V_s source voltage at which thyristor turns on. Waveforms are shown below:-

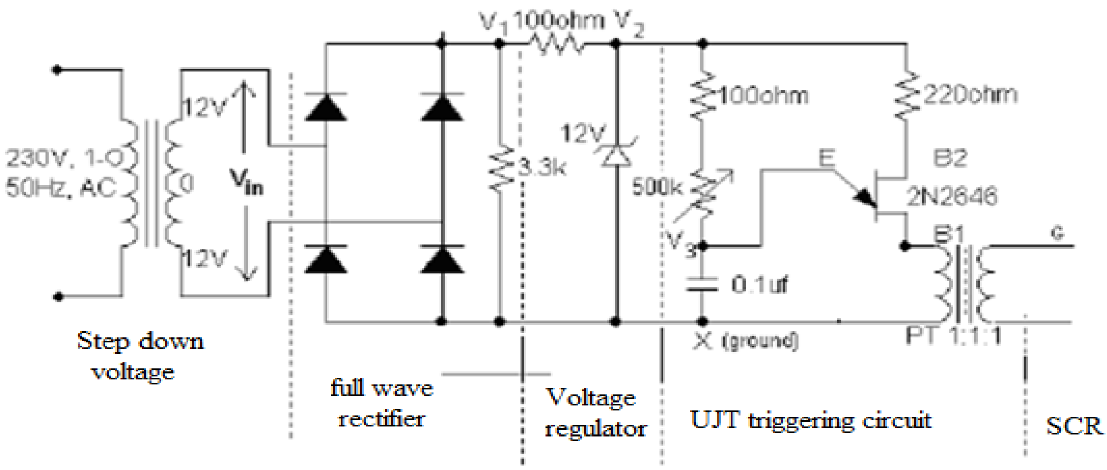


3-UJT

Resistance and RC triggering circuits described above give prolonged pulse. As a result, power dissipation in the gate circuit is large. At the same time R and RC triggering circuits can not be used for automatic and feedback systems. These difficulties can be overcome by the use of UJT triggering circuits.

A synchronized UJT triggered circuit using an UJT is shown in the figure. Diodes 'D1' to 'D4' rectify ac to dc. Resistor R1 lowers V_{dc} to a suitable value for the zener diode and UJT. Zener diode 'Z' functions to clip the rectified voltage to a standard level, 'V_z' which remains constant except near the V_{dc} zero. The voltage Vz is applied to the charging circuit RC. Current 'I', charges capacitor 'c' at a rate determined by 'R' voltage across capacitor is marked by 'V_c' as shown. When 'V_c' reaches the uni junction threshold voltage Vz, the t-B1 junction of UJT breaks down and the capacitor 'c' discharges through the primary of pulse transformer sending a current 'C_2' as shown.

As the current 'i_2' is in the form of pulse, windings of the pulse transformer have pulse voltages at their secondary terminals. Pulse at the two secondary windings feeds the same in phase pulse to two SCRs of a full wave circuits. SCR with positive anode voltage would turn ON. As soon as the capacitor discharges, it starts to recharge as shown. Rate of rise of capacitor voltage can be controlled by varying 'R'. The firing angle can be controlled up to above 1500.



Circuit Diagram: UJT Triggering Circuit

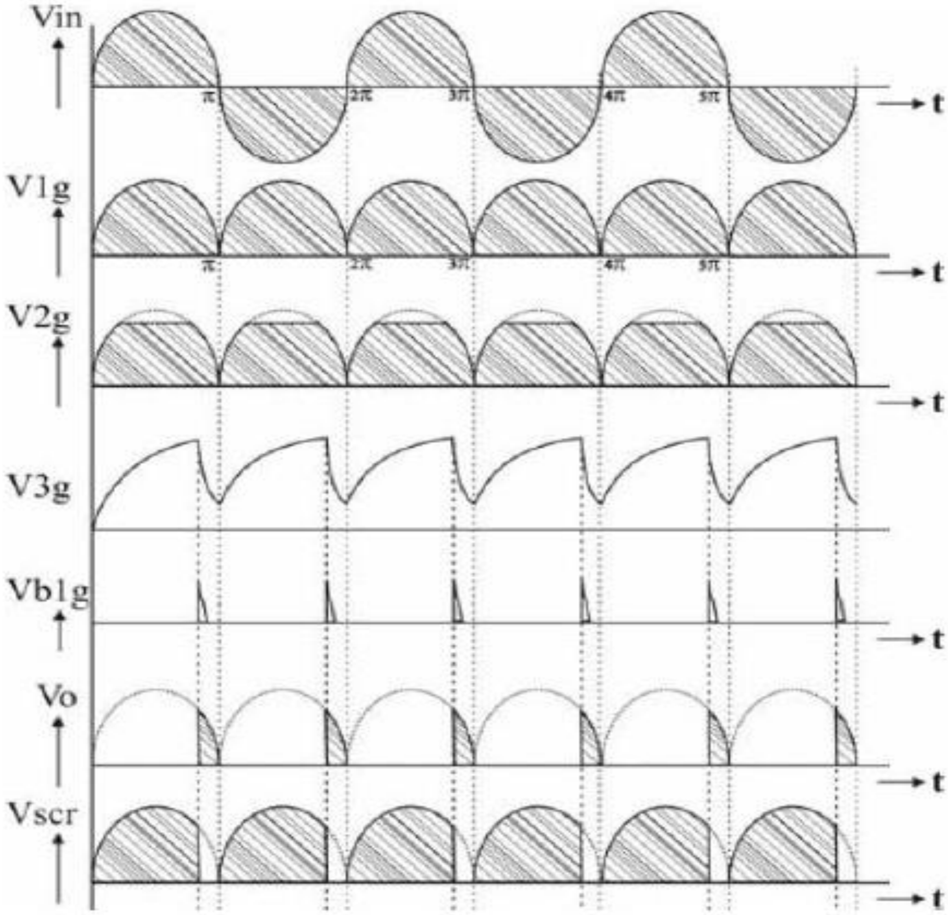
We have intrinsic stand off ratio. Typical values of ή are 0.51 to 0.82

$$ή = \frac{R_{B1}}{R_{B1} + R_{B2}}$$

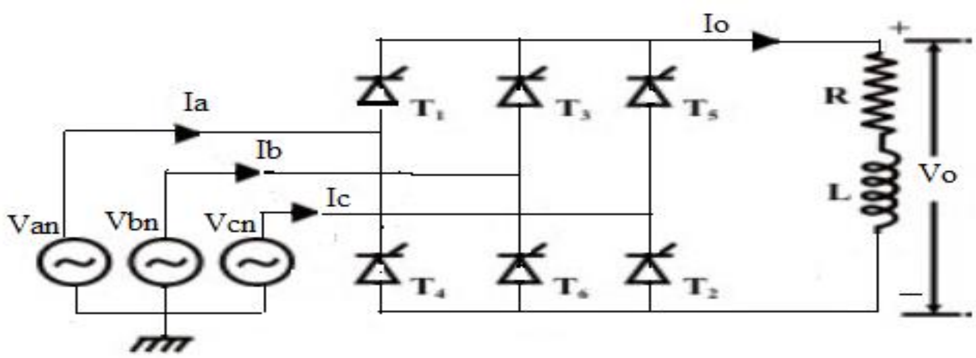
The time required for capacitor C to charge

$$T = \frac{1}{f} = RC\ ln\left(\frac{1}{1-ή}\right)$$

Wave form of UJT



Now the above firing circuits can be used in 3 phase full controlled converter and we can have desired output voltage.



Theoretical value is given by the equation:-

$$V_{dc} = {\sqrt{2V}}/{2\pi} \ (1 + \cos\alpha)$$

Observation for different firing circuit can be noted down in below table…

OBSERVATION TABLE

S.No	Time Period	Firing Angle	$V_{dc\ theoretical}$ (volts)	$V_{dc\ pract}$(volts)

RESULT: Thus study and test the firing circuit of three phase fully controlled bridge converter is done.

EXPERIMENT NO.-4

OBJECT- Study and obtain waveform of three phase half controlled bridge convertor with R-load and RL-load.

APPRATUS REQUIRED:-

S.NO.	EQUIPMENT	RATING	QUANTITY
1.	Three Phase SCR Module kit	PEC14HV5P	1
2	SCR	1600 Volt, 90Amp	
3	Patch chords		A.P.R
4	Load	R….. , RL…….	
5	Tigring model	PEC14HV5P	1

Theory: Single phase ac-to-dc converters are generally limited to a few kilowatts, and for higher levels of d.c. power output three-phase line commuted converters are used owing to restrictions on unbalanced loading, line harmonics, current surge and voltage dips. Increase in ripple frequency also reduces the filter size. Converter which can be operated both in rectifying and inverter modes are called fully controlled converters. When power flow can only occur from ac-to-dc, the converter is known as semi converter, or half controlled converter. fully controlled three-phase converters find applications in high voltage dc power(HVDC) transmission, d.c. and a.c. motor drives with regenerative breaking capabilities.

CIRCUIT DESCRIPTIONS AND PRINCIPLES: Circuit shows the power circuit configuration of a three –phase fully controlled converter in which all the rectifying elements are thyristors. Waveforms shows supply voltages, converter output voltage under continuous load current condition, firing instants for controlling the output voltage and sequence of firing. Thyristors are gated on at an interval of 60˚ in the sequence in which they are numbered. Triggering angle α,also called firing delay angle, is defined with respect to the cross over points of the phase voltages at which an equivalent diode would start to conduct. In the positive group of thyristors, viz.T_{h1}, T_{h2} and T_{h3}, turning on of one thyristor turns off a conducting thyristors in the group. So is the case with negative group of thyristors, viz. T_{h2},

T_{h4} and T_{h6}. As a result with highly inductive load , carrying continuous current, each thyristor would conduct for a period of 120˚in a cycle with commutation occurring every 60˚ .

Since at any instant two thyristors should be in the conducting state no current would flow if at start a single thyristor is given a pulse. This means that each thyristor should always be supplied with gate pulses 60˚ apart so that at start two thyristors can be triggered simultaneously.

Reference to Fig.1b shows that the ideal d.c. average output voltage (average height of the full line wave) of the converter under continuous load current is

$$E_o = \frac{3\sqrt{2}}{\pi} E_{L-L} \cos\alpha$$

Where E_{L-L} is the line to line rms voltage, and α is the delay angle.

If thyristor drops and supply side inductances are taken into account, Average load voltage is quite closely given by

$$E_{ovg} - E_o - 2V_{th} - \frac{3wL_o}{\pi} I_L$$

For delay angle greater than 60˚ ,the instantaneous output voltage will have a negative part in its periodicity for continuous load current (Fig.2a) with a resistive load current is always in phase with voltage. As current through a thyristor can not be negative, the output voltage cannot take any negative value. The range of control for delay angle α ,with resistive load, is from 0˚to 120˚. For $\alpha < 60^\circ$, the ideal output voltage, with resistive load, is the same as in Fig.5.5.1b for continous load current whereas for $\alpha > 60^\circ$, the output voltage waveform will be as shown in Fig.2b. The ideal average of the converter output voltage, with resistive load, is given by

$$Eo = \frac{3\sqrt{2}}{\pi} EL\text{-}L \; [1+ \cos(\alpha+\pi/3)] \qquad \text{For } \pi/3 < \alpha < 2\pi/3$$

$$Eo = \frac{3\sqrt{2}}{\pi} EL\text{-}L \cos\alpha \qquad \text{For } 0 < \alpha < \pi/3$$

Circuit Diagram:

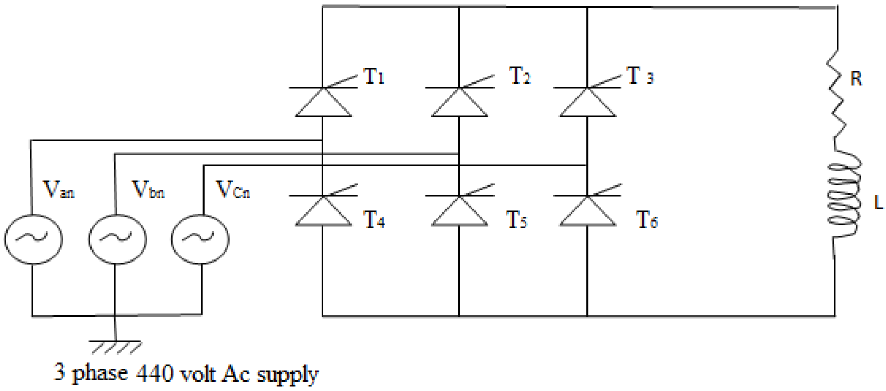


Fig. Circuit of Full wave Control Converter

Waveform:

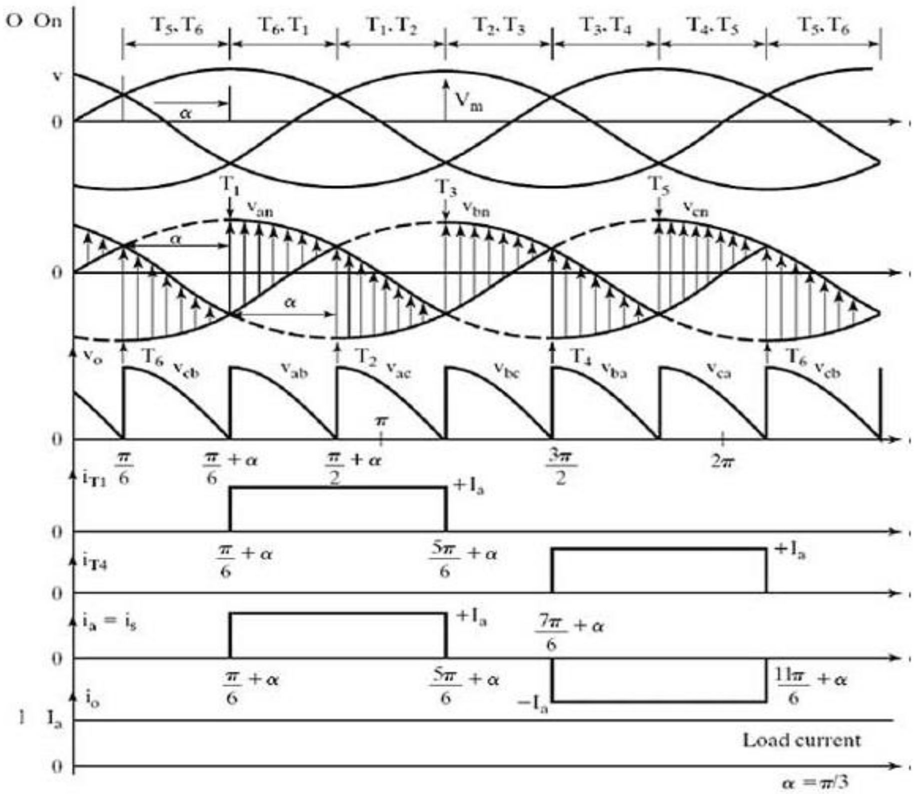


Fig. Waveform of three phase full controlled bridge converter

A fully controlled converter can be made a semi- converter by placing a freewheel diode across the load as shown in Fig.3. This circuit has the same output voltage characteristic as that of the full converter with resistive load since the output voltage can never go negative because of the freewheel diode. Another configuration of a three phase semi converter is a half controlled Converter bridge, shown in Fig.4a, where half the devices are thyristors, the Remainder being diodes. Thyristors get turned off either on the firing of another thyristor or by the action of the freewheeling diode. The circuit function will be the same with or without freewheeling diode. However, in order to avoid half waving effect in the case of trigger failure of the thyristors a freewheeling diode is a necessity. Fig.5.5.4b and 4c show the output voltage waveforms. For delay angle $\alpha < \pi/3$ output voltage wave is discontinuous. The average output voltage is given by

$$E_o = \frac{3\sqrt{2}}{\pi} E_{L-L} [1 + \cos\alpha] \qquad \text{For } 0 < \alpha < \pi$$

OBSERVATION TABLE:

S.No.	Input Voltage	Firing Angle	utput voltage	Speed

RESULT- Studied and obtained waveform of three phase full controlled bridge convertor with R-load and RL-load

PRECAUTIONS:

1. Make connection carefully.
2. Give an appropriate value of "*a*" and obtain waveforms.
3. Error free measuring instruments should be used.

EXPERIMENT 5

OBJECT: Study and test three phase ac voltage regulator.

APPARATUS:

S. no.	Name of apparatus	Rating	Quantity
1	SCR module	PEC14HV5P	1
2	Triggering module	PEC16HV2B	1
3	Power supply	440 v, ac 50Hz	1
4	Fuse	5 amp.	1
5	SCR	1600 v, 95 amp.	1
6	Three phase auto transformer	415 v,8 amp. 50 Hz	1
7	Inductive load	415 v, 15 amp. 3 phase	1

THEORY A voltage controller, also called an AC voltage controller or AC regulator is an electronic module based on either thyristors, TRIACs, SCRs or IGBTs, which converts a fixed voltage, fixed frequency alternating current (AC) electrical input supply to obtain variable voltage in output delivered to a resistive load. This varied voltage output is used for dimming street lights, varying heating temperatures in homes or industry, speed control of fans and winding machines and many other applications, in a similar fashion to an autotransformer. Voltage controller modules come under the purview of power electronics. Because they are low-maintenance and very efficient, voltage controllers have largely replaced such modules as magnetic amplifiers and saturable reactors in industrial use.

Working: Thyristors are used to halve the voltage cycle during input. By controlling the phase angle or trigger angle, the output RMS voltage of the load can be varied. The thyristor is turned on for every half-cycle and switched off for each remaining half-cycle. The phase angle is the position at which the thyristor is switched on. TRIACs are often used instead of thyristors to perform the same function for better efficiency. If the load is a combination of resistance and inductance, the current cycle lags the voltage cycle, decreasing overall power output.

The current flow to load is controlled by thyristors T1, T3, T5 ; and the diodes provides the return current path. The firing sequence of thyristors is T1, T3, T5.for the current to flow through the power controller at least one thyristor must conduct. thyristor will conduct if its anode voltage is higher than that of its cathode and it is fired. Once a thyristor start conducting it would be turned off only when its current falls to zero. if V_S is rms value of input phase voltage and we define the instantaneous input phase voltage as:

$V_{an} = \sqrt{2}Vs \sin wt$

$V_{bn} = \sqrt{2}Vs \sin (wt-\frac{2\pi}{3})$

$V_{cn} = \sqrt{2}Vs \sin (wt-\frac{4\pi}{3})$

Where V_{an}, V_{bn}, V_{cn} are instantaneous input phase voltage.

And V_S is rms value of input phase voltage.

Then input line voltages are

$V_{ab} = \sqrt{6}Vs \sin (wt+\frac{\pi}{6})$

$V_{bc} = \sqrt{6}Vs \sin (wt-\frac{\pi}{2})$

$V_{ca} = \sqrt{6}Vs \sin (wt-\frac{7\pi}{6})$

Where V_{ab}, V_{bc}, V_{ca} are instantaneous input line voltages.

For $0 \leq \alpha < 60^0$ either two or three devices can conduct at the same time and the possible combinations are (1) two thyristors and one diode (2) one thyristors and one diode. (3) one thyristors and two diodes. If three devices conduct output voltage is same as input voltage . If two devices conduct at the same time the current flow only through two lines .the line to line voltage would appear across two terminals of load. And the output voltage would be one half of the line voltage .

For $60^0 \leq \alpha < 120^o$ at any time only one thyristor is conducting and the return path is shared by one or two diodes . for $\alpha=60^o$ the extinction angle β is delayed to 180^o. this is due to the fact that an output phase voltage may depend on the input line to line voltage .When V_{ab} becomes zero at $wt=150^o$,the current of thyristor T1 can continue to flow until V_{ca} becomes zero at wt=210 and a delay angle of a 210^0 gives zero output voltage .

In practice the gate pulses consists of two parts. The first pulse of T1 starts anywhere between 0 and 150^0 and ends at $wt=150^0$, the second pulse which can start at $wt =150^0$, always ends at $wt=210^0$. This allows the current to flow through thyristor during the period $150^0 \leq wt \leq 210^0$.

The expression for the rms output phase voltage(V_o)depends on the range of delay angle. the rms output voltage for a wye connected load can be found as follows:

For 0≤ α<90⁰ : (α = firing angle of thyristor)

Now rms output phase voltage (V_o)

$$V_o = \sqrt{\left[\frac{1}{2\pi}\int_0^{2\pi} v_{an}^2 \; d(wt)\right]}$$

$$V_o = \sqrt{6}Vs\ \{ \frac{1}{2\pi}[\frac{1}{3}\int_a^{2\pi/3} sin^2wt\ \ d(wt) + \frac{1}{4}\int_{\pi/2}^{\frac{\pi}{2}+a} sin^2wt\ \ d(wt)$$

$$+ \frac{1}{3}\int_{\frac{2\pi}{3}+a}^{4\pi/3} sin^2wt\ \ d(wt) + \frac{1}{4}\int_{3\pi/2}^{\frac{3\pi}{2}+a} sin^2wt\ \ d(wt) + \frac{1}{3}\int_{\frac{4\pi}{3}+a}^{2\pi} sin^2wt\ \ d(wt)\ \}^{1/2}$$

$$V_o = \sqrt{3}Vs[(\frac{1}{\pi} - \frac{a}{4} + \frac{\sin 2a}{8})]^{1/2}$$

For 90⁰≤ α<120⁰ :

$$V_o = \sqrt{6}Vs\{ \frac{1}{2\pi}[\frac{1}{3}\int_a^{2\pi/3} sin^2wt\ \ d(wt) + \frac{1}{4}\int_{\pi/2}^{\frac{\pi}{2}} sin^2wt\ \ d(wt)$$

$$+ \frac{1}{3}\int_{\frac{2\pi}{3}+a}^{4\pi/3} sin^2wt\ \ d(wt) + \frac{1}{4}\int_{3\pi/2}^{2\pi} sin^2wt\ \ d(wt) + \frac{1}{3}\int_{\frac{4\pi}{3}+a}^{2\pi} sin^2wt\ \ d(wt)\ \}^{1/2}$$

$$V_o = \sqrt{3}Vs[\frac{1}{\pi}(\frac{11\pi}{24} + \frac{a}{2})]^{1/2}$$

Observation Table:

Sno.	**Input voltage**	**Firing angle**	**Output voltage**

RESULT:

The particle of study and test three phase ac voltage regulator has successfully performed.

PRECAUTION:

Circuit connections should be tight and right.

The initial reading of all the equipment should be zero.

APPLICATION:

- Light dimming circuits for street lights
- Industrial & domestic heating
- Induction heating
- transformer tap changing
- Speed control of Motors (variable torque)
- speed control of winding machines,fans
- AC magnet controls

EXPERIMENT NO. 6

OBJECT: Control speed of DC Motor using 3-phase half controlled bridge converter And Plot armature voltage versus speed characteristics.

APPARATUS REQUIRED:

S.No.	EQUIPMENT	SPECIFICATION	QUANTITY
1.	3 Phase SCR Module	PEC14HVSP	01
2.	DC Motor	220V, 5.1Amp, 1 HP,1500 RPM	01

3.	3 Phase Auto Transformer	415V, 8 Amp, 50 Hz	01
4.	Power Supply	440V AC, 50Hz	01
5.	Chopper/ Inverter PWD control Module	PEC16HV2B	01
6.	CRO	...	01
7.	Patch chords	...	As per required

THEORY: The commonly used dc separately excited motor shown in fig. In a separately excited motor, the field and armature voltages can be controlled independent of such other. Basic equations applicable to all dc motors are

$$E = Ke\phi\, Wm \quad (1)$$
$$V = E + Ra * Ia \quad (2)$$
$$T = Ke\phi\, Ia \quad (3)$$

Where ϕ = flux per pole, webers;

Ia = the armature current, Amp.

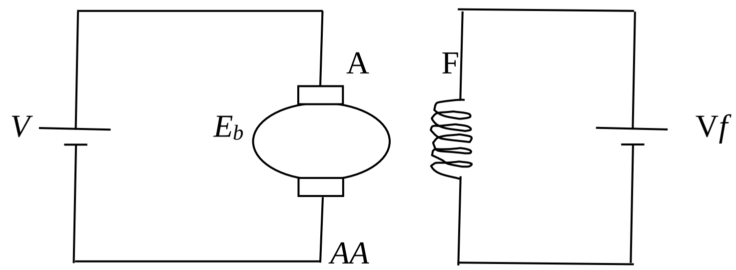
V = the armature voltage, Volts

Ra = the resistance of the armature circuit, ohms

Wm = the speed of the armature, rad./sec.

T = the torque developed by the motor, N-m

Ke=the motor constant.



Fig(a) : separately excited dc motor

From eqs (1) to (3)

$$Wm = \frac{V}{Ke\phi} - \frac{Ra}{Ke\phi} Ia \quad (4)$$

$$Wm = \frac{V}{Ke\phi} - \frac{Ra}{(Ke\phi)^2}T \qquad (5)$$

In case of separately excited motors, with a constant field current, the flux can be assumed to be constant. Let $Ke\phi = K(constant)$ (6)

Then from eqs. (1), (3), and (4) to (6)

$$T = K*Ia \qquad (7)$$

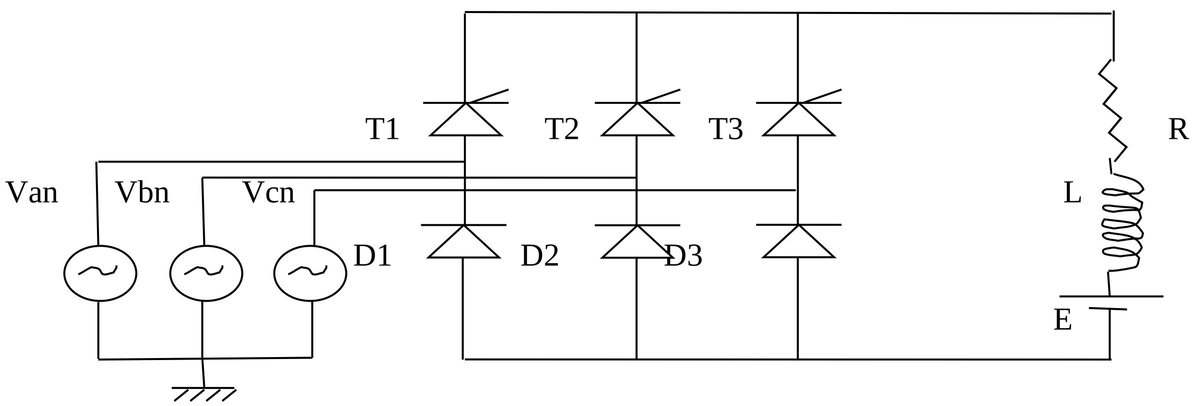
$$E = K*w_m \qquad (8)$$

$$Wm = \frac{V}{K} - \frac{Ra}{K}Ia \qquad (9)$$

$$Wm = \frac{V}{K} - \frac{Ra}{K^2}T \qquad (10)$$

CIRCUIT DESCRIPTION:

Three phase fully controlled (6 pulse) rectifier fed separately excited DC motor drive is shown in fig (b). Thyristors are fired in the sequence of their numbers with a phase difference of 60 degree by gate pulses of 120 degree duration. Each thyristor conducts for 120 and one thyristors conduct at a time-one from upper group (odd numbered thyristor) and the other from lower group (even numbered thyristors) applying respective line voltages to the motor.



Fig(b) circuit diagram of three phase half controlled converter.

Transfer of current from an outgoing to incoming thyristor can take place when the respective line voltage is of such a polarity that only if forward biases the incoming thyristor, but if leads to reverse biasing of the outgoing when incoming turn-off. Thus, firing angle for a thyristor is measured from the instant when respective line voltage is zero and increasing. For example, the transfer of current from the thyristor D1 to thyristor T1 can occur as long as the If line voltage Vab is taken as reference voltage, then

$$V_{ab} = V_m \sin wt$$

And $$a = wt - \pi/3$$

Where, Vm is the peak of line voltage.

Motor terminal voltage and current waveforms for continuous conduction are shown in figs (b) and (c) For motoring and braking operations, respectively. Devices under conduction are also shown in the figure. The discontinuous conduction is neglected here because it o curs is a narrow region of its operation. For the motor terminal voltage cycle from $(a+\pi/3)$ to $(a+2\pi/3)$ (from figs (b) and (c)).

$$V = \frac{3}{2\pi}\{\int_{(a+\pi/3)}^{(a+2\pi/3)} Vm \sin wt \; d(wt) + \int_{\pi/3}^{2\pi/3} Vm \sin wt \; d(wt)\}$$

$$= 3/2\pi \; Vm\,(1 + \cos a)$$

OBSERVATION TABLE:

S.No.	Input Voltage	Firing Angle	utput voltage	Speed

RESULT:

We have successfully studied and obtain the waveform of 3-phase half controlled bridge converter.

PRECAUTIONS:

1. Make connection carefully.
2. Give an appropriate value of "*a*" and obtain waveforms.
3. Error free measuring instruments should be used.

EXPERIMENT NO. 7

OBJECT: Control speed of DC Motor using 3-phase full controlled bridge converter
And Plot armature voltage versus speed characteristics.

APPARATUS REQUIRED:

S.No.	EQUIPMENT	SPECIFICATION	QUANTITY
1.	3 Phase SCR Module	PEC14HVSP	01
2.	DC Motor	220V, 5.1Amp, 1 HP,1500 RPM	01
3.	3 Phase Auto Transformer	415V, 8 Amp, 50 Hz	01
4.	Power Supply	440V AC, 50Hz	01

5.	Chopper/ Inverter PWD control Module	PEC16HV2B	01
6.	CRO	...	01
7.	Patch chords	...	As per required

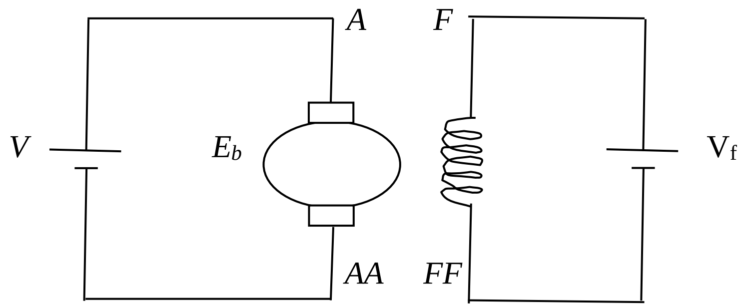
THEORY: The commonly used dc separately excited motor shown in fig. In a separately excited motor, the field and armature voltages can be controlled independent of such other. Basic equations applicable to all dc motors are

$$V = E + Ra * Ia \qquad .(1)$$

$$T = Ke\phi\, Ia \qquad (2)$$

Where ϕ = flux per pole, webers;

a. Ia = the armature current, Amp.
b. V = the armature voltage, Volts
c. Ra = the resistance of the armature circuit, ohms
d. T = the torque developed by the motor, N-m
e. K*e*=the motor constant.



Fig(a) : separately excited dc motor

From eqs (1) to (3)

$$Wm = \frac{V}{Ke\phi} - \frac{Ra}{Ke\phi} Ia \qquad (4)$$

$$\mathrm{Wm} = \frac{\mathrm{V}}{\mathrm{Ke\phi}} - \frac{\mathrm{Ra}}{(\mathrm{Ke\phi})^2}\mathrm{T} \qquad (5)$$

In case of separately excited motors, with a constant field current, the flux can be assumed to be constant. Let $K e\phi = K(constant)$ (6)

Then from eqs. (1), (3), and (4) to (6)

$$T = K*Ia \quad (7)$$

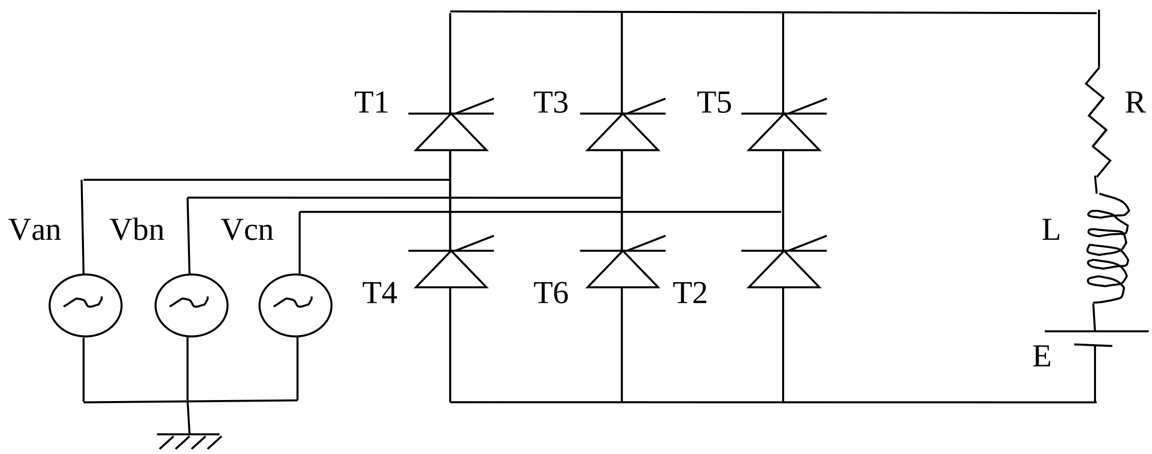
$$E = K*w_m \quad (8)$$

$$Wm = \frac{V}{K} - \frac{Ra}{K} Ia \quad (9)$$

$$Wm = \frac{V}{K} - \frac{Ra}{K^2} T \quad (10)$$

CIRCUIT DESCRIPTION:

Three phase fully controlled (6 pulse) rectifier fed separately excited DC motor drive is shown in fig (b). Thyristors are fired in the sequence of their numbers with a phase difference of 60 degree by gate pulses of 120 degree duration. Each thyristor conducts for 120 and two thyristors conduct at a time-one from upper group (odd numbered thyristor) and the other from lower group (even numbered thyristors) applying respective line voltages to the motor.



Fig(b). circuit diagram of three phase full controlled converter.

Transfer of current from an outgoing to incoming thyristor can take place when the respective line voltage is of such a polarity that not only if forward biases the incoming thyristor, but also leads to reverse biasing of the outgoing when incoming turn-on. Thus, firing angle for a thyristor is measured from the instant when respective line voltage is zero and increasing. For example, the transfer of current from the thyristor T_5 to thyristor T_1 can occur as long as the If line voltage Vab is taken as reference voltage, then

$$Vab = Vm \sin wt$$

And $$a = wt - \pi/3$$

Where, Vm is the peak of line voltage.

Motor terminal voltage and current waveforms for continuous conduction are shown in figs (b) and (c) For motoring and braking operations, respectively. Devices under conduction are also shown in the figure. The discontinuous conduction is neglected here because it o curs is a narrow region of its operation.For the motor terminal voltage cycle from ($a+\pi/3$) to ($a+2\pi/3$) (from figs (b) and (c)).

$$Va = \frac{3}{\pi}\int_{(a+\pi/3)}^{(a+2\pi/3)} Vm \sin wt \, d(wt)$$

$$= 3/\pi \, Vm \cos a$$

From eqs. (1), (2), (3) and (4)

$$Wm = \frac{3Vm}{\pi K}\cos a - \frac{Ra}{K^2}T$$

OBSERVATION TABLE:

S.No.	Input Voltage	Firing Angle	Output voltage	Speed

RESULT:

We have successfully studied and obtain the waveform of 3-phase full controlled bridge converter.

PRECAUTIONS:

1. Make connection carefully.
2. Give an appropriate value of "*a*" and obtain waveforms.
3. Error free measuring instruments should be used.