

8EE6  
**ELECTRICAL  
DRIVES AND  
CONTROL  
LAB**



## **EXPERIMENT LIST**

1. Study and test the firing circuit of three phase half controlled bridge converter.
  2. Study and obtain waveforms of 3 phase half controlled bridge converter with R and RL loads.
  3. Study and test the firing circuit of 3-phase full controlled bridge converter.
  4. Study and obtain waveforms of 3-phase full controlled bridge converter with R and RL loads.
  5. Study and test 3-phase AC voltage regulator.
  6. Control speed of dc motor using 3-phase half controlled bridge converter. Plot armature voltage versus speed characteristic.
  7. Control speed of dc motor using 3-phase full controlled bridge converter. Plot armature voltage versus speed characteristic.
  8. Control speed of a 3-phase induction motor in variable stator voltage mode using 3-phase AC voltage regulator.
  9. Control speed of universal motor using AC voltage regulator.
  10. Study 3-phase dual converter.
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## EXPERIMENT:1

**Object:** Study and test the firing circuit of three phase half controlled bridge converter..

### Apparatus Required:-

- 1 3 phase half controlled bridge converter
- 2: 3 phase A.C supply
- 3:-Connecting wires
- 4:-C.R.O
- 5:-C.R.O probes (1:10)

### Theory:-

The three phase half controlled bridge converters & fully controlled bridge converters are used extensively in industrial applications up to about 15kW of output power. The three phase controlled rectifiers provide a maximum dc output of

$$v_{dc(max)} = 2V_m / \pi$$

The output ripple frequency is equal to the twice the ac supply frequency.

The single phase controlled rectifiers provide two output pulses during every input supply cycle and hence are referred to as two pulse converters. Three phase converters are 3-phase controlled rectifiers which are used to convert ac input power supply into dc output power across the load.

Features of 3-phase controlled rectifiers are

1. Operate from 3 phase ac supply voltage.
  2. They provide higher dc output voltage and higher dc output power.
  3. Higher output voltage ripple frequency.
  4. Filtering requirements are simplified for smoothing out load voltage and load current
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Three phase controlled rectifiers are extensively used in high power variable speed industrial dc drives.

### 3-PHASE HALF WAVE CONVERTER

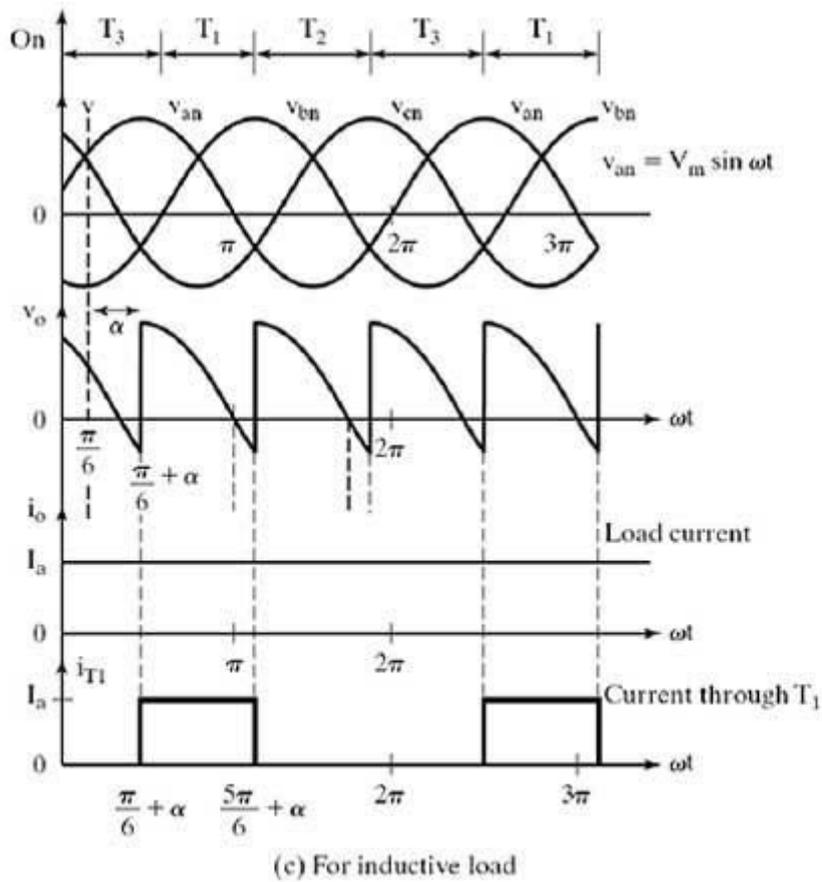
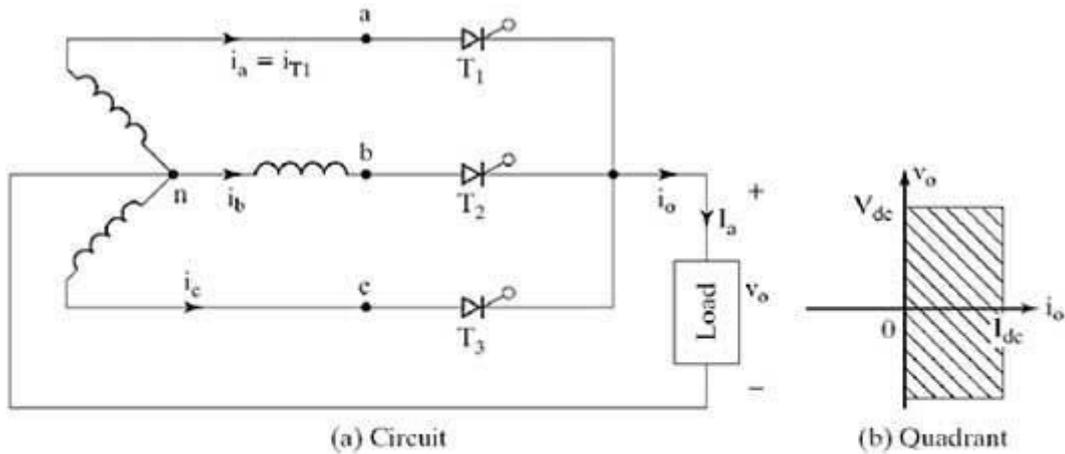
Three single phase half-wave converters are connected together to form a three phase half-wave converter as shown in the figure.

The 3-phase half wave converter combines three single phase half wave controlled rectifiers in one single circuit feeding a common load. The thyristor T1 in series with one of the supply phase windings 'a-n' acts as one half wave controlled rectifier. The second thyristor T2 in series with the supply phase winding 'b-n' acts as the second half wave controlled rectifier. The third thyristor T3 in series with the supply phase winding acts as the third half wave controlled rectifier.

The 3-phase input supply is applied through the star connected supply transformer as shown in the figure. The common neutral point of the supply is connected to one end of the load while the other end of the load connected to the common cathode point. When the thyristor T1 is triggered at  $\omega t = (\pi/6 + \alpha) = (30^\circ + \alpha)$ , the phase voltage  $V_{an}$  appears across the load when T1 conducts. The load current flows through the supply phase winding 'a-n' and through thyristor T1 as long as T1 conducts. When thyristor T2 is triggered at  $\omega t = (5\pi/6 + \alpha)$ , T1 becomes reverse biased and turns-off. The load current flows through the thyristor and through the supply phase winding 'b-n'. When T2 conducts the phase voltage  $v_{bn}$  appears across the load until the thyristor T3 is triggered. When the thyristor T3 is triggered at  $\omega t = (3\pi/2 + \alpha) = (270^\circ + \alpha)$ , T2 is reversed biased and hence T2 turns-off. The phase voltage  $V_{an}$  appears across the load when T3 conducts. When T1 is triggered again at the beginning of the next input cycle the thyristor T3 turns off as it is reverse biased naturally as soon as T1 is triggered. The figure shows the 3-phase input supply voltages, the output voltage which appears across the load, and the load current assuming a constant and ripple free load current for a highly inductive load and the current through the thyristor T1. For a purely resistive load where the load inductance 'L = 0' and the trigger angle  $\alpha > (\pi/6)$ , the load current appears as discontinuous load current and each thyristor is naturally commutated when the polarity of the corresponding phase supply voltage reverses. The frequency of output ripple frequency for a 3-phase half wave converter is  $3f_s$ , where  $f_s$  is the input supply frequency. 3 The 3-phase half wave converter is not normally used in practical converter systems because of the disadvantage that the supply current waveforms contain dc components (i.e., the supply current waveforms

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have an average or dc value).



**Precautions: -**

1. Some components are common to many expts. Hence perform only one expt. At one time .remove all other links.
2. Don't touch any connection in working condition.

3. Oscilloscope should be connecting in unearthed sockets.
4. Use double beam CRO for observing two wave forms simultaneously one when they have one end in common. Thus the driving and load wave form cannot be observed simultaneously but two driving (I/P) wave forms can be observed.

**Graph:-**Graph has been plotted for the firing circuit of three phase half controlled bridge converter.

**Result:-**We have Studied the firing circuit of 3phase half controlled bridge converter.

**Viva voice:-**

1. Describe the advantages of three phase half controlled bridge converter.
  2. What is an ideal thyristor switch.?
  3. Give at least two definitions of firing angle.
  4. Draw the proper connection of three phase half controlled bridge converter.
  5. *What is holding current in SCR?*
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## EXPERIMENT:2

**Object:** Study and obtain waveforms of 3 phase half controlled bridge converter with R and RL loads.

### Apparatus Required:-

- 1: 3 phase half controlled bridge converter kit
- 2: 3 phase A.C supply
- 3: Connecting wires
- 4: C.R.O
- 5: C.R.O probes (1:10)
- 6: R and RL load

### Theory :

For large power dc loads, 3-phase ac to dc converter are commonly used. The various types of three phase controlled converter are 3-phase half wave converter, 3-phase half wave converter is rarely used in industry because it introduces dc component in the supply circuit. If diodes are replaced by 3-thyristors, a semi converter bridge is obtained.

Free wheeling mode of operation of bridge connected rectifiers can be realized half of its thyristor with diodes.

Therefore, circuit of three phase half controlled bridge converter contains three thyristor in three arms and diodes in the other three arms.

For  $\alpha < 60^\circ$  the continuous conduction mode is possible. For firing angles  $\alpha > 60^\circ$  the discontinuous conduction mode occurs. It can be observed from the waveforms that the output voltage becomes zero during a part of the output voltage period, because of

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the free wheeling action. It is easily noted from the waveforms that the freewheeling period is  $\pi - \alpha$ . Therefore the supply current flows for the period  $(\pi - \alpha)$  in each half cycle. As  $\alpha$  increase the duration of the supply current pulse decreases. Therefore, the harmonic content in the source current increases as the firing angle increases. For large firing angle delays, commutation failure may take place due to the limited time available in symmetrical half controlled converter circuit configuration, if the current is assumed to be continuous. This may result in half weaving effect.

Procedure:

1. Make the connections as per the circuit diagram.
2. Verify the connections before switching on the supply
3. Keep the rheostat position and variac positions as the values given by the instructor.
4. Switch on power circuit and firing circuit.
5. Switch on the CRO and calibrate it with input voltage.
6. Observe output voltage waveform on CRO.
7. Note down readings of firing angle and output voltage.
8. Also calculate theoretical and practical values of output voltages and compare.
9. Repeat above steps for various firing angles.
10. For RL-load connect Inductance in series with resistance.

**Graph:-**Graph has been plotted for R and RL loads of 3-phase half controlled bridge converter

**Result:-** Study and obtain waveforms of 3-phase half controlled bridge converter has been done.

**Viva voice:-**

1. What is conduction angle?
  2. What is the maximum dc output in 3-phase half controlled bridge converter?
  3. Why 1-phase controlled rectifier is also called as 2-pulse converter?
  4. Features of 3-phase controlled rectifier.
  5. Uses of 3-phase controlled rectifier.
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### Experiment no. 3

**Object:-** Study and test the firing circuit of 3-phase full controlled bridge converter.

**Apparatus Required:-**

- 1:- 3 phase full controlled bridge converter kit.
- 2:-CRO-30 MHz And CRO probe (1:10)
- 3:- Connecting leads
- 4:- Power Supply

**Theory:-**

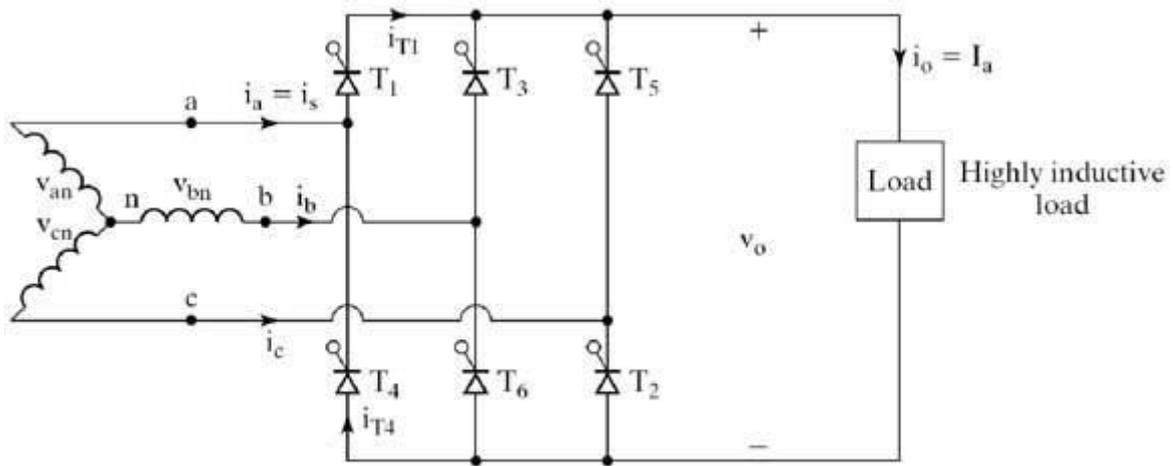
**THREE PHASE FULL CONVERTER**

Three phase full converter is a fully controlled bridge controlled rectifier using six thyristors connected in the form of a full wave bridge configuration. All the six thyristors are controlled switches which are turned on at appropriate times by applying suitable gate trigger signals.

The three phase full converter is extensively used in industrial power applications upto about 120kW output power level, where two quadrant operations is required. The figure shows a three phase full converter with highly inductive load. This circuit is also known as three phase full wave bridge or as a six pulse converter.

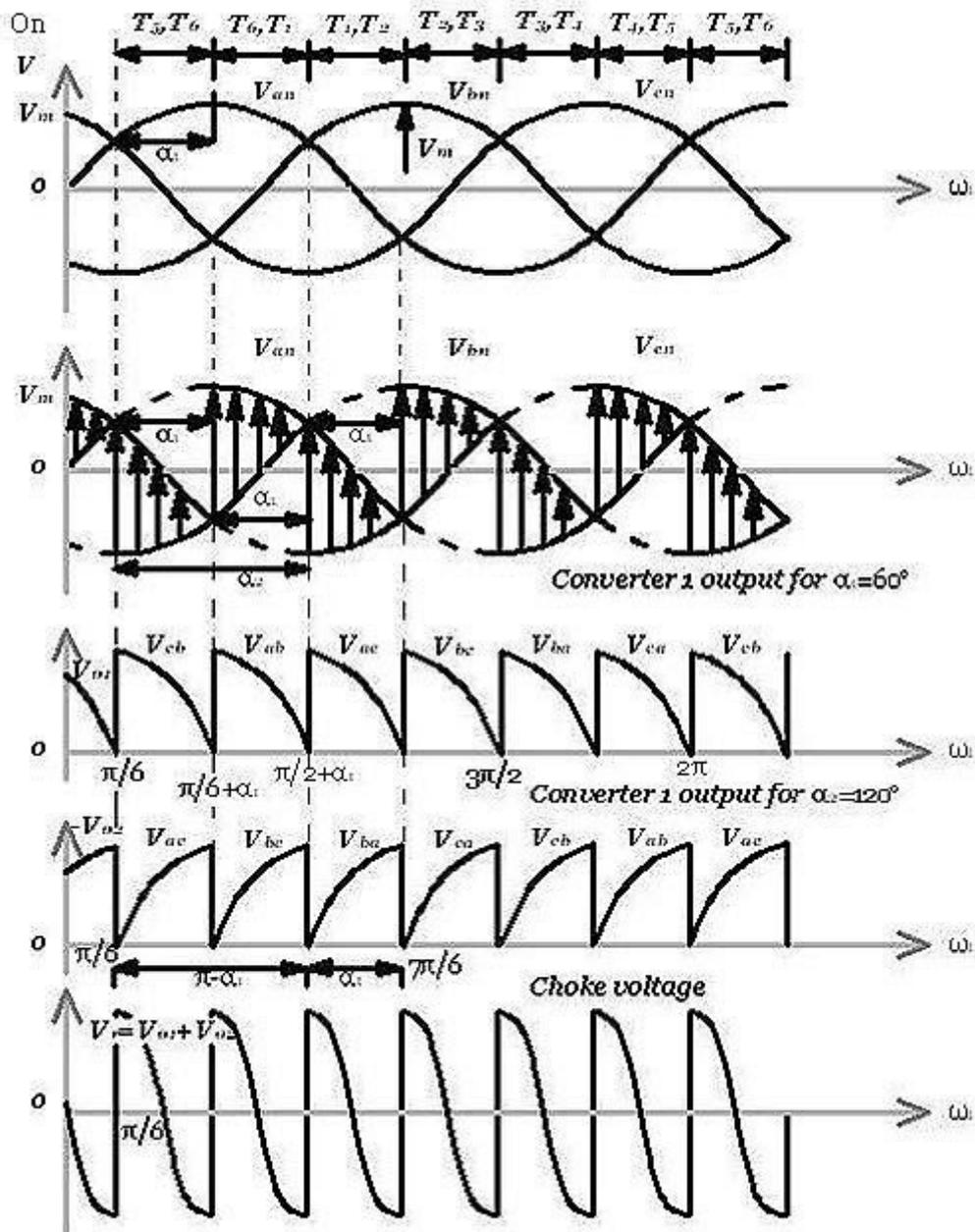
The thyristors are triggered at an interval of  $(\pi/3)$  radians (i.e. at an interval of  $30^\circ$ ). The frequency of output ripple voltage is  $6f_s$  and the filtering requirement is less than that of three phase semi and half wave converters.

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At  $\omega t = (\pi/6 + \alpha)$ , thyristor is already conducting when the thyristor is turned on by applying the gating signal to the gate of . During the time period  $\omega t = (\pi/6 + \alpha)$  to  $(\pi/2 + \alpha)$ , thyristors and conduct together and the line to line supply voltage appears across the load.

At  $\omega t = (\pi/2 + \alpha)$ , the thyristor  $T_2$  is triggered and  $T_6$  is reverse biased immediately and  $T_6$  turns off due to natural commutation. During the time period  $\omega t = (\pi/2 + \alpha)$  to  $(5\pi/6 + \alpha)$ , thyristor  $T_1$  and  $T_2$  conduct together and the line to line supply voltage appears across the load.



**Precautions: -**

1. Some components are common to many expts. Hence perform only one expt. At one time .remove all other links.
2. Don't touch any connection in working condition.
3. Oscilloscope should be connecting in unearthed sockets.
4. Use double beam CRO for observing two wave forms simultaneously one when they have one end in common. Thus the driving and load wave form cannot be observed simultaneously but two driving (I/P) wave forms can be observed.

**Graph:-**Graph has been plotted for the firing circuit of three phase full controlled bridge converter.

**Result:-** We have studied the firing circuit of 3-phase full controlled bridge converter.

Viva voce

1. How a semi converter bridge is obtained?
  2. When and why output voltage becomes zero in 3-phase half controlled converters?
  3. What is the effect of firing angle on current pulse?
  4. What does RLE load indicate?
  5. Types of connections in 3-phase converters.
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## EXPERIMENT:4

**Object:** Study and obtain waveforms of 3-phase full controlled bridge converter with R and RL loads.

**Apparatus Required:-**

- 1 :- 3 phase full controlled bridge converter kit.
- 2:-CRO-30 MHz And CRO probe (1:10)
- 3:- Connecting leads
- 4:- Power Supply

**Theory:-** The detailed circuit diagram is shown in which the six SCR's are connected in the bridge circuit configuration & are fed from 3phase output through the transient suppression circuit di/dt chokes the HRC fuses etc.

The mean load  $v/g$  ( $v_{max}$ ) is now seen to be controllable delaying the commutation of the thyristors by the firing delay angle. This converter typically exhibits starting problem. Hence, in order to start the circuit functioning, two thyristor must be fixed at the same time in order to commence current flow. The supply is connected when  $v_o$  is at its peak value, the next firing pulse will be to  $t_2$ . However, thyristor T2 will not conduct unless at the same time thyristors T1 is also pulsed.

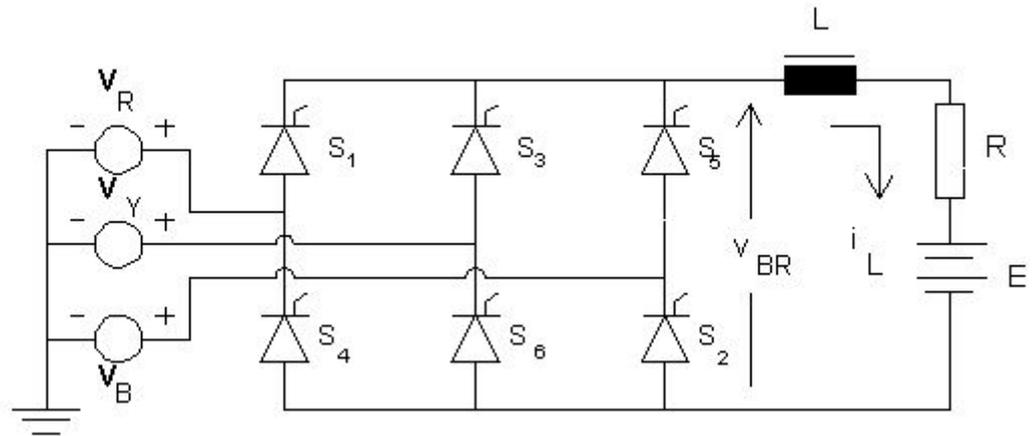
Once the circuit is running normally, the second pulse will have no effect, as the thyristor will already be in the 'ON' state.

When the firing delay is large with the load  $v/g$  having negative periods, it is difficult to visualize the load waveforms the two 3 phase picture the six line voltage,  $v_a-v_b, v_c-v_a, v_c-v_b$  gives a direct picture. The mean voltage is reduced when the firing angle delay is  $90^\circ$

The value of mean load voltage is given by,

$$V_{mean} = \frac{3}{\pi} V_{line(max)} (\cos \alpha)$$

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**Precautions: -**

1. Some components are common to many expts. Hence perform only one expt. At one time .remove all other links.
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3. Oscilloscope should be connecting in unearthed sockets.
4. Use double beam CRO for observing two wave forms simultaneously one when they have one end in common. Thus the driving and load wave form cannot be observed simultaneously but two driving (I/P) wave forms can be observed.

**Graph:-**Graph has been plotted for R and RL loads of 3-phase full controlled bridge converter

**Result:-** : Study and obtain waveforms of 3-phase full controlled bridge converter with R and RL loads.

Viva voce:-

1. What is a six pulse converter?
2. Why highly inductive load is used?
3. Operation of 3-phase full bridge converter.
4. How the speed of motor is to be controlled?
5. In a thyristor controlled rectifier the firing angle of thyristor is to be controlled in the range of?

## Experiment no. 5

**Object:-**Study and test of 3 phase a.c voltage Regulator.

### **Apparatus Required:-**

- 1:-3phase a.c voltage controller kit.
- 2: 3 phase A.C supply
- 3:-Connecting wires
- 4:-C.R.O
- 5:-C.R.O probes (1:10)

### **Theory:-**

A.C. voltage controllers are thyristor based devices which convert fixed alternating voltage directly to variable alternating voltage without a change in the frequency.

Single-phase A.C. voltage controllers are phase-controlled devices, the phase relationship between the start of load current and the supply voltage is controlled by varying the firing angle. The power circuit diagram of a single-phase full-wave A.C. voltage controller make with two SCRs connected in antiparallel.

When input of AC supply for the AC voltage controller is switch ON. For the positive half cycle SCR T1 in forward bias & SCR T2 in reverse bias. At this time a firing pulse is applied to T1, it will conduct and give output positive controlled half cycle. For the negative half cycle SCR T1 in reverse bias & SCR T2 in forward bias. At this time a firing pulse is applied to T2, it will conduct and give output negative controlled half cycle.

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For single-phase AC voltage controller, we use universal motor for low inductive value and single-phase capacitor start induction motor for increase inductive load.

For three-phase AC voltage controller, we use three-phase induction motor as high inductive load. And we study the output voltage waveform variation with load variation.

Full wave phase control can be obtained if a 2 thyristors is introduced into the half wave circuit. The thyristors are connected “back to back” and are triggered alternatively at identical point in their anode to cathode  $v/g$  cycles. A symmetrical a.c voltage is therefore applied across the loads.

For a pure resistive load the voltage and current waveform are shown with an inductive load current flow is again maintained by the induced emf for an internal after the supply  $v/g$  has reversed its polarity.

The current pulse decrease in amplitude as  $\alpha$  is increased and zero load current is obtained when  $\alpha=180$ . Variation of the thyristors delay angle  $\alpha$  controls the average power delivered to the load by the a.c supply.

A bidirectional thyristors OR triac may be used in place of the 2 back to back thyristors. These can be used as power regulators for heating or lightening loads.

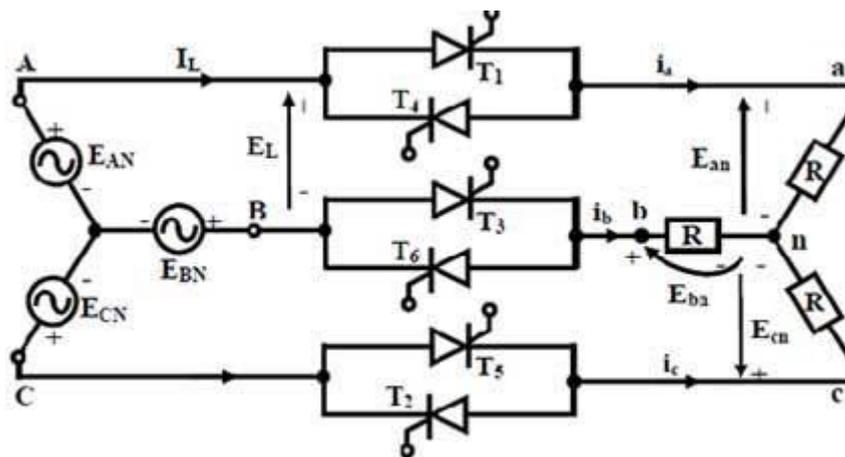


Fig: 1 Three-phase, three-wire Ac regulator

**Result:-** We have Studied 3 phase a.c voltage Regulator.

Viva voce:-

1. What happens in a thyristor controlled rectifier when firing angle control range exceeds?
  2. In a 3-phase full wave AC to DC converter the ratio of output ripple frequency to supply voltage frequency is?
  3. Which converter can operate both in 3-pulse and 6-pulse mode?
  4. What is space charge region?
  5. Which power electronics/semi conductor device is used in chopper and why?
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## EXPERIMENT:6

**Object:**Control speed of d.c motor with the help of three phase half controlled bridge converter. Plot armature voltage versus speed characteristic.

**Apparatus Required:-** 1 3 phase half controlled bridge converter

2: 3 phase A.C supply

3:-Connecting wires

4:-C.R.O

5:-C.R.O probes (1:10)

**Theory:-**

### INTRODUCTION

Three phase half controlled bridge converters & fully controlled bridge converters are used extensively in industrial applications up to about 15kW of output power. The three phase controlled rectifiers provide a maximum dc output of

$$v_{dc(max)} = 2v_m / \pi$$

The output ripple frequency is equal to the twice the ac supply frequency. The single phase full wave controlled rectifiers provide two output pulses during every input supply cycle and hence are referred to as two pulse converters. Three phase

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converters are 3-phase controlled rectifiers which are used to convert ac input power supply into dc output power across the load.

Features of 3-phase controlled rectifiers are

- Operate from 3 phase ac supply voltage.
- They provide higher dc output voltage and higher dc output power.
- Higher output voltage ripple frequency.
- Filtering requirements are simplified for smoothing out load voltage and load current

A 3 phase half controlled bridge controlled bridge converter is a 3 phase ,3 SCR , 3 Diode configuration of full wave converter capable of delivering 15A max,O/P current.

It houses 3 power diodes D2,D4,D6 in place of the SCR-2, SCR-4, SCR-6 and thus making it a half controlled converter.

It houses a free wheeling diode connected across the O/P as shown in the main circuit on lower horizontal plate.

The mean V/G can be considered as the addition of the half wave 3 phase,3 pulse v/g

$$V_{\text{mean}} = (3/2 * \pi) V_{\text{line(max)}} (1 + \cos \alpha)$$

Compared to the fully controlled circuit, the half controlled circuit is cheaper, has no starting problems, but has a higher harmonic content in its load v/g and supply current waveforms.

**:Precautions: -**

1. Some components are common to many expts. Hence perform only one expt. At one time .remove all other links.
  2. Don't touch any connection in working condition.
  3. Oscilloscope should be connecting in unearthed sockets.
  4. Use double beam CRO for observing two wave forms simultaneously one when they have one end in common. Thus the driving and load
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wave form cannot be observed simultaneously but two driving (I/P) wave forms can be observed.

**Graph:-**

**Result:-** Study and test of the firing circuit of 3phase half controlled bridge converter has been done.

Viva voce:-

1. Which device is used for switching in a switched mode power supply?
  2. What is the output frequency of AC voltage regulator?
  3. What is the difference between AC voltage regulator and amplifier?
  4. How the phase relationship between the start of load current and the supply voltage is controlled?
  5. When zero load current is obtained?
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### **Experiment no. 7**

**Object:** - Control speed of dc motor using 3-phase full controlled bridge converter. Plot armature voltage versus speed characteristic.

#### **Apparatus Required:-**

1. TPSF Trainer kit;
2. TPCON Trainer kit;
3. 3- phase auto transformer ( I/P-440V;O/P-0-440V; 2 KVA)
4. Separately excited DC motor:- - ( KW/HP-0.37 / 0.5; 2.3Amp;230V;1500rpm;Excitation 230V);
5. CRO-30 MHz And CRO probe (1:10);
6. Connecting leads.

#### **Brief Theory:-**

In three-phase fully controlled bridge converter, six thyristors are used to control both the cycle of AC input. The average output voltage (DC voltage) is varied by varying the firing angle. This converter is used for supplying the power to armature of the separately excited DC motor. The output of fully controlled converter is vary from 0-440 VDC 15A MAX.

The load voltage  $V$  mean is now seen to be controllable by delaying the commutation of the thyristors by the firing delay angle. The thyristors are to be fired in

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the correct sequence as indicated by their numbering T1 to T6. But if a single firing gate pulse is used, the circuit will not start and no current will flow, as the other thyristor in the current path will be in the off-state. Hence, in order to start the circuit functioning, two thyristors must be fired at the same time in order to commence current flow.

For supplying field of the separately excited DC motor a single-phase semi converter is used. The output of semi converter is vary from 100-200 VDC 2A level can be used.

Speed of DC motor is controlled by three methods as varying armature voltage control, field flux control and armature resistance control.

In over experiment we perform and study only two method, first armature voltage control for below rated speed and field control for above rated speed.

### **Procedure:-**

1. Put all the switches on the unit to off
  2. Connect the A.C mains to the unit.
  3. Keep all controls fully anticlockwise.
  4. Connect the external control input and feedback input between the respective potentiometer top terminal sockets and REF negative, if no such input is available, the 4.7 VDC internal signals may be used for this purpose.
  5. Connect Logic O inputs to L1 and L2, if no such signals are available connect these points to REF
  6. connect Logic O inputs to H1 and H2 ,if no such signals are available connect these points to 47VDC
  7. Connect current limit signal as specified in the handbook earlier between feed 75mVDC current limit and RFE sockets if no such signal is available connect this point to RFE
  8. Put the main switch to on position the three R Y B neon's shall light. for a fraction of the second and then turn off .this indicates the working of soft start action finally all leads shall be off if not take action to adjust the input as outline in the facilities section
  9. Put the Trigger on switches to on position now about .7 VDC signal shall be available between test and REF Sockets check that signal increases as the control potentiometer is moved clockwise while it decreases if the feedback
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potentiometer is moved clocked .the trigger pluses trains can be seen at the output terminals .

10. Now the unit is ready for use .switch off the mains supply .connect the trigger output to the respective SCR gate cathodes terminal of the converter also connect the A.C mains to the converter taking the precaution outlined on pages 1 now putting on the Mains supply shall put on the converter and its out put can be controlled by the control and feedback potentiometer

**Precautions: -**

1. Some components are common to many expts. Hence perform only one expt. At one time .remove all other links.
2. Don't touch any connection in working condition.
3. Oscilloscope should be connecting in unearthed sockets.
4. Use double beam CRO for observing two wave forms simultaneously one when they have one end in common. Thus the driving and load wave form cannot be observed simultaneously but two driving (I/P) wave forms can be observed.

viva voce:-

1. Which motor is used in traction system?
  2. What is the relation between current and flux in series shunt motor?
  3. Which motor can never be operated in no load condition and why?
  4. Types of braking.
  5. Back emf depends on which quantities?
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## Experiment no. 8

**Object:-** Control speed of a 3-phase induction motor in variable stator voltage mode using 3- phase AC voltage regulator.

### Apparatus Required:-

1. TCT Trainer kit
2. CRO-30 MHz And CRO probe (1:10)
3. Connecting leads
4. Universal motor (HP/KW=0.1/75,230V,50c/s,0.85A,6000RPM)
5. Three-phase induction motor (HP/KW=0.5/0.37,415/230 Volt, 50Hz, 1.4/2.0 Amp, Phase-three, Eff%=70, 1440RPM)
6. Single-phase induction motor-HP/KW=0.5/0.37, 240 Volt, 50 Hz, 2.6 Amp, 2800 RPM, Phase-I, CAP.-10 MFD 440VAC

### Brief theory:-

Full wave phase control can be obtained if a 2 thyristors is introduced into the half wave circuit. The thyristors are connected “back to back” and are triggered alternatively at identical point in their anode to cathode v/g cycles. A symmetrical a.c voltage is therefore applied across the loads.

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For a pure resistive load the voltage and current waveforms are shown with an inductive load current flow is again maintained by the induced emf for an interval after the supply voltage has reversed its polarity.

The current pulse decrease in amplitude as alpha is increased and zero load current is obtained when  $\alpha = 180^\circ$ . Variation of the thyristors delay angle alpha controls the average power delivered to the load by the a.c supply.

A bidirectional thyristors OR triac may be used in place of the 2 back to back thyristors. These can be used as power regulators for heating and lighting loads.

### **Procedure:-**

AC power control- Three phase – “0.5 H.P. Three phase induction Motor”

Load.

(1) Connect Shorting links as follows:

$G_1$  --  $G1 R$ ;      $K_1$  --  $K1R$ .

$G_2$  --  $G2 R$ ;      $K_2$  --  $K2R$ .

(2) Connect the two 4mm. red sockets marked “ $R_L$ ” together by shorting links. Similarly connect the two 4mm. red socket above them, marked “ $R$ ” 1 $\emptyset$  and “ $R$ ” 3 $\emptyset$  also together by another link.

(3) The voltage divider for 3 $\emptyset$  loads are all internally connected as shown. Hence the user will nowhere accidentally come in contact with the dangerously high phase – to – phase voltage of 440v.

(4) Connect the oscilloscope beams as shown. Turn the “DC CONTROL SIGNAL” potentiometer fully anticlockwise.

(5) Connect the three phase motor terminals in STAR as per the colours of wires in the right side terminals of the PUSHFIX.

(6) Turn the main switch ON and slowly advance the control potentiometer. Phase controlled outputs with phase differences of  $120^\circ$  shall be seen developed across the three phases initially. But since this

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load is highly inductive, the conduction angle rapidly goes far beyond  $180^\circ$  in every half cycle of all phases and the waveform cover the full cycle with motor reaching full speed. The effective control angle of the potentiometer is thus very small.

(7) Reversal of the direction of rotation is easily done here. Just exchange the sequence of any of the two phase wires out of R, Y, B and the direction of rotation shall be reversed.

**Precautions: -**

- 1 Some components are common to many expts. Hence perform only one expt. At one time .remove all other links.
- 2 Don't touch any connection in working condition.
- 4 Oscilloscope should be connecting in unearthed sockets.
- 5 Use double beam CRO for observing two wave forms simultaneously one when they have one end in common. Thus the driving and load wave form cannot be observed simultaneously but two driving (I/P) wave forms can be observed.

**Result:-** speed control of dc motor is successfully done.

Viva voce:-

1. What are the different method of speed control
  2. Explain field control method
  3. Explain armature resistance control method.
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## Experiment no. 9

**Object:-**Control speed of universal motor using AC voltage regulator.

### **Apparatus Required :-**

1. Universal motor
2. 3 Phase A.c. Voltage regulation kit
3. C.R.O. (30 MHZ)
4. C.R.O. Probes (1:10)
5. Connecting wires

### **Theory :-**

**A.C. Voltage Regulation :-** Thyristors These are based devices which converts fixed a.c. voltage directly to variable alternating voltage without the change in the

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frequency. Some of the main application of D.C. voltage regulator is speed control of single phase or 3 – phase A.C. drives & starting of induction motor.

A.C. voltage regulator are also adoptable for closed loop control system. Since, the A.C. voltage regulator are phase controlled device, thyristor & triacs are line commutated & as such nice complex communication circuitry is these controllers.

The main disadvantage of A.C. voltage regulation is the introduction fo objectionable harmonics in the supply current & load v/g waveforms, particularly of reduced o/p voltage levels.

For regulating the power flow in A.C. voltage regulator, control strategies are of two types :-

(a) Phase control

(b) Integral Cycle control

Fig shows a 1 – Phase voltage regulator feeding power to a universal motor. Two thyristor are connected in antiparallel. Thyristor  $T_1$  &  $T_2$  are forwarded biased during tve & -ve half cycles respectively.

During tve cycle  $T_1$  is triggered at a firing angle  $\alpha$   $T_1$  starts conducting phase source v/g is applied to load from  $\alpha$  to  $\pi$ , both voltage phase current is zero. During –ve half cycle  $T_2$  is triggered at  $(\pi + \alpha)$ .  $T_2$  conducts from  $\pi + \alpha$  to  $2\pi$

### **Universal Motor :**

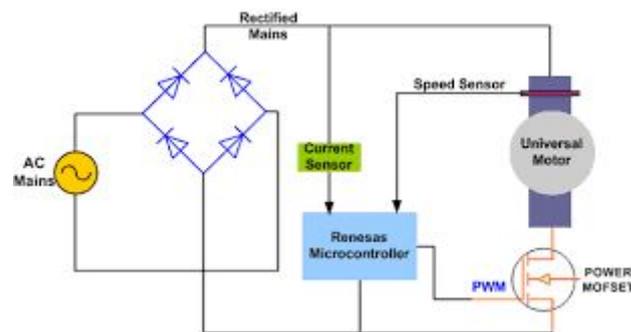
The **universal motor** is so named because it is a type of electric motor that can operate on both AC and DC power. It is a **commutated series-wound motor** where the stator's field coils are connected in series with the rotor windings through a commutator. It is often referred to as an AC series motor. The universal motor is very similar to a DC series motor in construction, but is modified slightly to allow the motor to operate properly on AC power. This type of electric motor can operate well on AC because the current in both the field coils and the armature (and the resultant magnetic fields) will alternate (reverse polarity) synchronously with the supply. Hence the resulting mechanical force will occur in a consistent direction of rotation, independent of the direction of applied voltage, but determined by the commutator and polarity of the field coils.

Universal motors have high starting torque, can run at high speed, and are lightweight and compact. They are commonly used in portable power tools and equipment, as well

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as many household appliances. They're also relatively easy to control, electromechanically using tapped coils, or electronically. However, the commutator has brushes that wear, so they are much less often used for equipment that is in continuous use. In addition, partly because of the commutator, universal motors are typically very noisy, both acoustically and electromagnetically.

In series motor, torque depends on the product of armature current & field flux. Reversal of the terminal voltage reverse both the armature current & field flux.



### Precautions :-

- i) All connections should be tight.
- ii) Do not touch any connection while supply is 'on'.

### Result :-

Testing of control speed universal motor using a.c. motor regulator has been done.

### Viva voce:-

1. Advantage of universal motor
  2. Speed control method of universal motor.
  3. Comparison between ac series motor and dc series motor.
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## **Experiment no. 10**

**Object:-** Study 3-phase dual converter.

**Theory:-**

The fully controlled converter can produce a reversible direct output voltage with output current in one direction, and in terms of a conventional voltage/ current be capable of operation in two quadrants, the first and fourth. Such a range of operation is useful for certain purposes, The control of a dc torque motor, i.e. a motor used to provide unidirectional torque with reversible rotation and a DC transmission link between two AC systems in which power can be transmitted in either direction according to the polarity of the voltage with current flows always in one direction. Equally a converter may be used under steady- stage conditions in the first quadrant only but transiently in the second quadrant in order to extract energy from the load quickly and thereby improve the response of the system to changing command signals.

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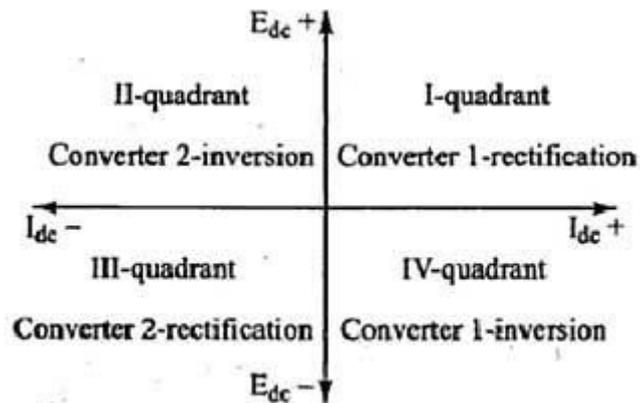


Fig.1: Voltage-Current diagram

If four-quadrant operation of a DC motor is required, i.e. reversible rotation and reversible torque, a single converter needs the addition of either a change-over contractor to reverse the armature connections or a means of reversing the field current in order to change the relationship between the converter voltage and the direction of rotation of the motor. Both of these are practicable in suitable phase and three-phase dual-converter using bridge type converter circuits. The output terminals of each converter having the same potential are connected together through a reactor. The four possible quadrants of converter operation thus resulting can be translated into four (steady-state) combinations of motor-torque and rotation as shown in diagram

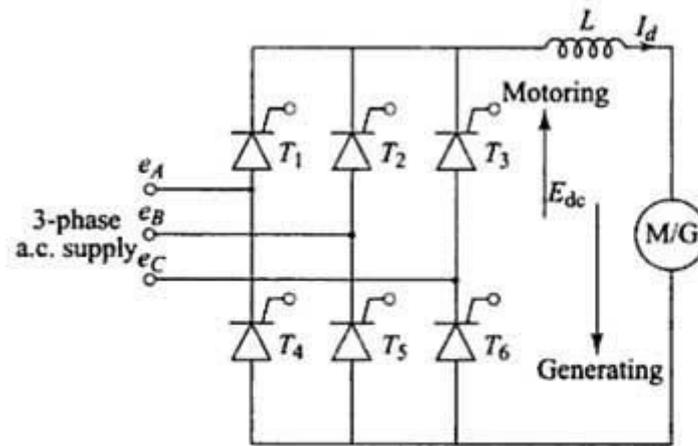


Fig.2

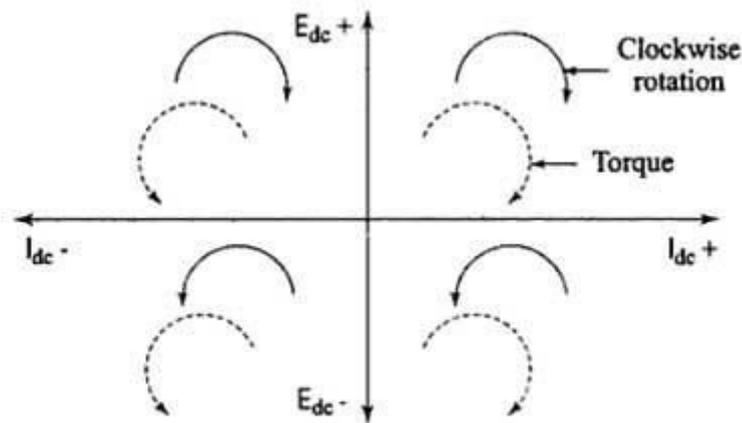


Fig.3: Torque-Rotation Diagram

## Principle of Dual Converter

The basic principle of operation of dual converter can be explained with reference to the simplified equivalent diagram of the DC circuit. In this simplified representation, assumption is made that the dual converters are ideal and they produce pure DC output terminals. Each two-quadrant converter is assumed to be a controllable direct voltage source, connected in series with a diode. Diode D1 and D2 represent the unidirectional current flow characteristics of the converters. The current in load circuit can, however, flow in either direction.

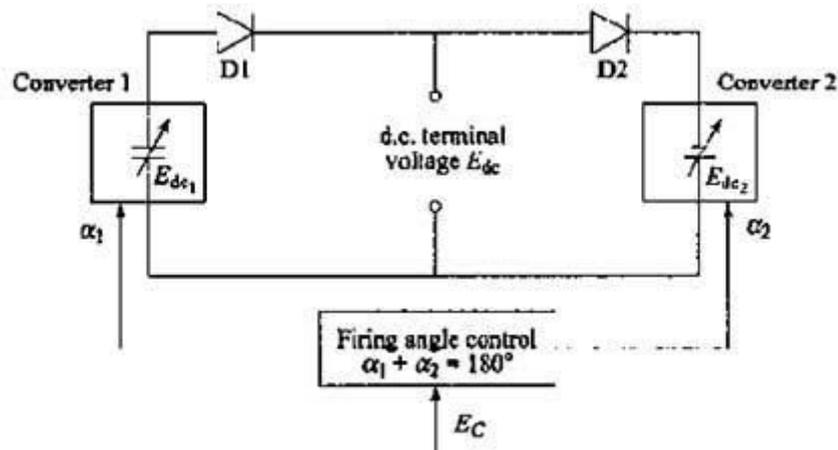


Fig.4: Ideal dual converter equivalent circuit

## Dual Converter without circulating current mode

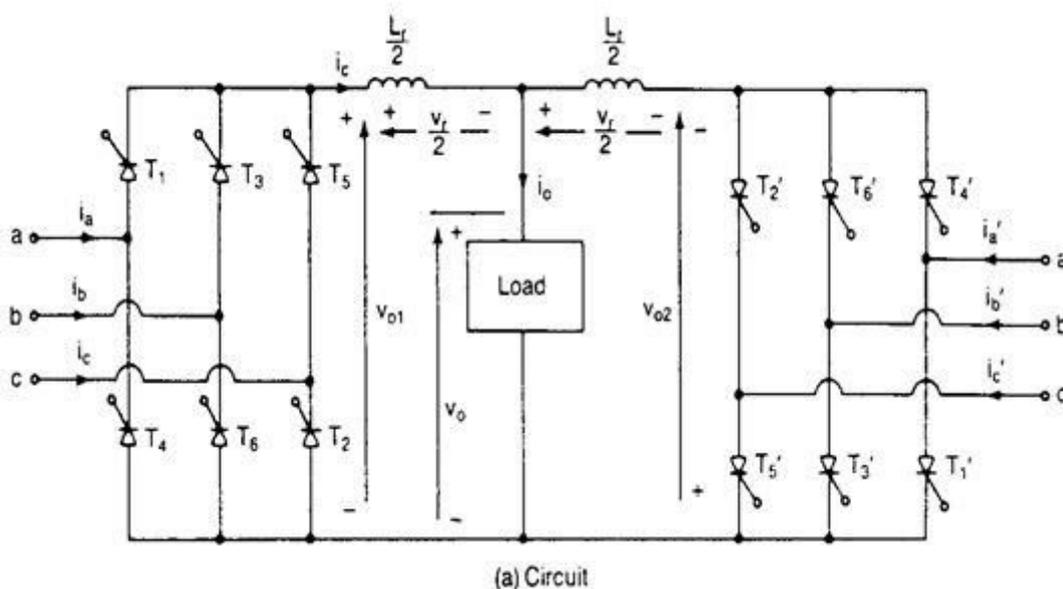
In a dual converter without circulating current operating mode, the flow of circulating current is completely inhibited through automatic control of the firing pulses, so that only that converter which carries the load current is in conduction and the other converter is temporarily blocked. Since only one converter operates at a time and the other is in blocking state, no reactor is required between the converters.

At a particular instant, suppose converter 1 is operating as a rectifier and is supplying the load current while pulses to second converter are blocked. For the inversion operation, converter 1 is first blocked by removing its firing pulses and load current is reduced to zero. Converter 2 is made to conduct by applying the firing pulses to it. The current in converter 2 would now build up through the load in the reverse direction. So long as converter 2 is in operation, converter 1 is in the blocking state since the firing pulses are withdrawn from it.

The pulses to converter 2 are applied after a delay time (current-free safety interval) of 10 to 20ms. This delay time ensures reliable commutation of thyristors in converter 1. If the converter 2 is triggered before the converter 1 has been completely turned-off, a large circulating current would flow between the two converters.

Irregular jumps in the level of the DC terminal voltage at the point of current reversal must be avoided in order to achieve a smooth change over of current from one converter to the other. Thus the firing pulse control should, ideally, be such that the mean DC terminal voltage of the converter 2, at the instant of current reversal, is the same as that of the converter 1.

From the above discussion, it becomes clear that such a mode of operation requires sophisticated control system which automatically blocks and unblocks the individual converters in accordance with the direction of load current suitably with a safety intervals.



**Result:-** We have Studied 3-phase dual converter.

Viva voce

1. Class E inverter operates in which quadrant?
  2. Different commutation techniques.
  3. Applications of dual converter.
  4. Which is the best commutation technique and why?
  5. Advantages of using dual converters.
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