5.4 AC VOLTAGE CONTROL STRATEGY

There are two different types of thyristor control used in practice to control the flow ac power

1. Phase control
2. On-Off control

PHASE CONTROL TECHNIQUE

In phase control, the Thyristors are used as switches to connect the load circuit to the input ac supply, for a part of every input cycle. That is the ac supply voltage is chopped using thyristors during a part of each input cycle. The thyristor switch is turned on for a part of every half cycle, so that input supply voltage appears across the load and then turned off during the remaining part of input half cycle to disconnect the ac supply from the load. By controlling the phase angle or the trigger angle 'α' (delay angle), the output RMS voltage across the load can be controlled.

INTEGRAL CYCLE CONTROL

Integral cycle control consists of switching on the supply to load for an integral number of cycles and then switching off the supply for a further number of integral cycles.

The principle of integral cycle control can be explained by referring to the above Figure for a single phase voltage controller with resistive load. Gate pulses ig1 turn on the thyristors Tl, T2 respectively at zero-voltage crossing of the supply voltage.

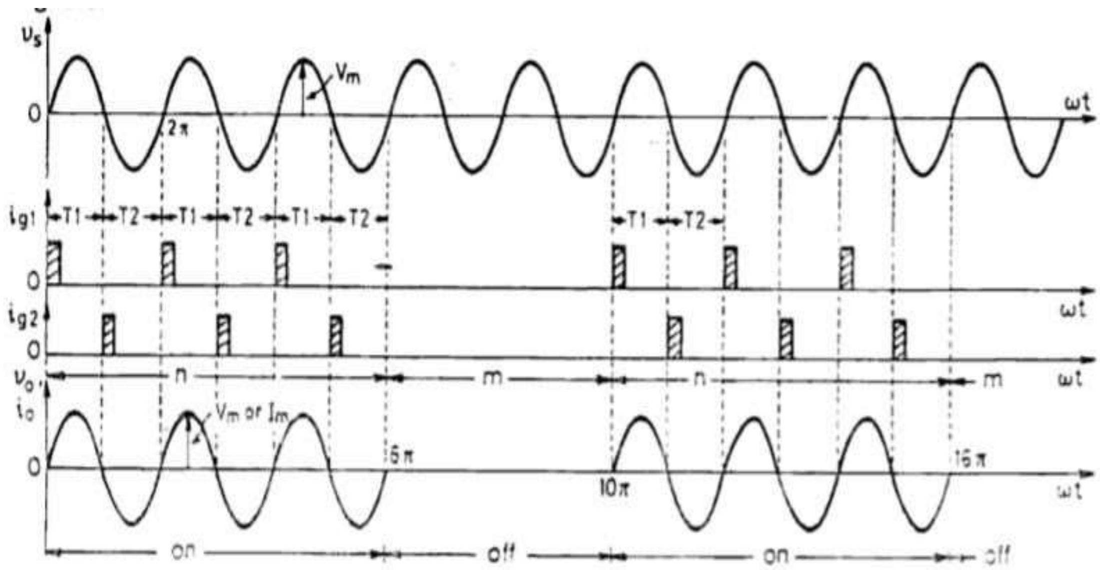


Figure 5.4.1 Integral cycle control

[Source: "Power Electronics" *by* P.S.Bimbra, Khanna Publishers *Page: 393]*

The source energises the load for n (= 3) cycles. When gate pulses are withdrawn, load remains off for m (= 2) cycles. In this manner, process of turn on and turn off is repeated for the control of load power. By varying the number of n and m cycles, power delivered to load can be regulated as desired.

For n = 3 and m = 2. Power is delivered to load for n cycles. No power is delivered to load for m cycles. It is the average power in the load that is controlledIntegral cycle control is also known as on-off control, burst firing, zero- voltage switching, cycle selection cycle syncopation.

5.7 CYCLO CONVERTERS

Cyclo converters are frequency changers that convert AC power of specific frequency and voltage to different frequency and voltage of AC power without any intermediate DC link. (usually lower frequency).

A cyclo converter is a naturally commutated converter in which the output frequency and voltage can be controlled independently and continuously using a control circuit. Therefore, unlike other converters, it is a single stage frequency converter.

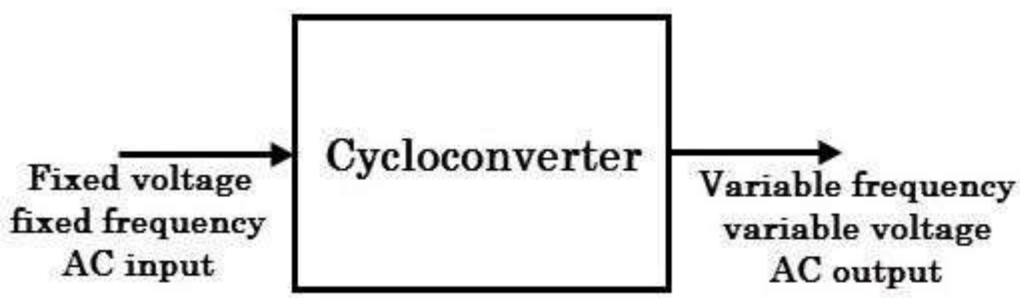


Figure 5.7.1 Block diagram of cyclo converter

[Source: "Power Electronics" *by* P.S.Bimbra*,* Khanna Publishers *Page: 414]*

Mainly there are two types according to the output frequency which are

(1) Step-up cyclo converters

(2) Step-down cyclo converters

Step Up cyclo converter − These types use natural commutation and give an output at higher frequency than that of the input.

Step Down cyclo converter − This type uses forced commutation and results in an output with a frequency lower than that of the input.

• Cyclo converters are further classified into three categories −

1. Single phase to single-phase − This type of cyclo converter has two full wave converters connected back to back. If one converter is operating the other one is disabled, no current passes through it.
2. Three-phase to single-phase − This cyclo converter operates in four quadrants that is (+V, +I) and (−V, −I) being the rectification modes and (+V, −I) and (−V,+I) being the inversion modes.
3. Three-phase to three-phase − This type of cyclo converter is majorly used in AC machine systems that are operating on three phase induction and synchronous machines.

- In case of step-down cyclo-converter, the output frequency is limited to a fraction of input frequency, typically it is below 20Hz in case 50Hz supply frequency. In this case, no separate commutation circuits are needed as SCRs are line commutated devices.

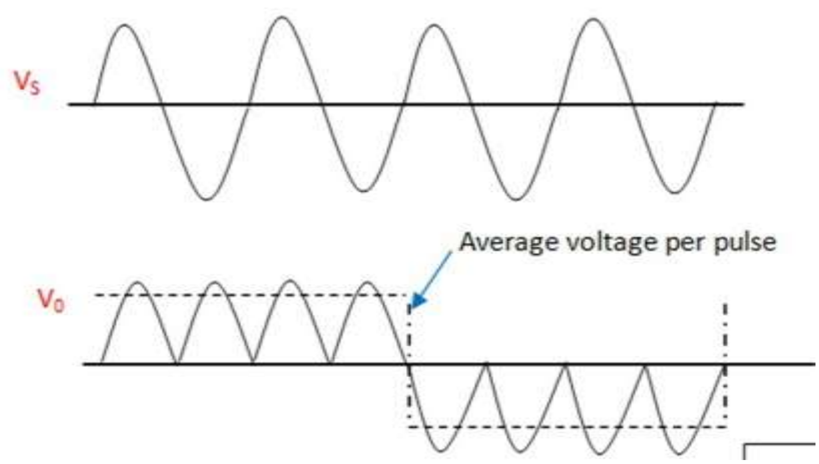


Figure 5.7.2 Voltage waveforms of step down cyclo converter

[Source: "Power Electronics" *by* P.S.Bimbra, Khanna Publishers *Page: 414]*

5.1 Introduction - AC voltage controllers

AC voltage controllers are thyristor based devices which convert fixed alternating voltage directly to variable alternating voltage without a change in the frequency. Some of the main applications of ac voltage controllers are for domestic and industrial heating, transformer tap changing, lighting control, speed control of single phase and three phase ac drives and starting of induction motors.

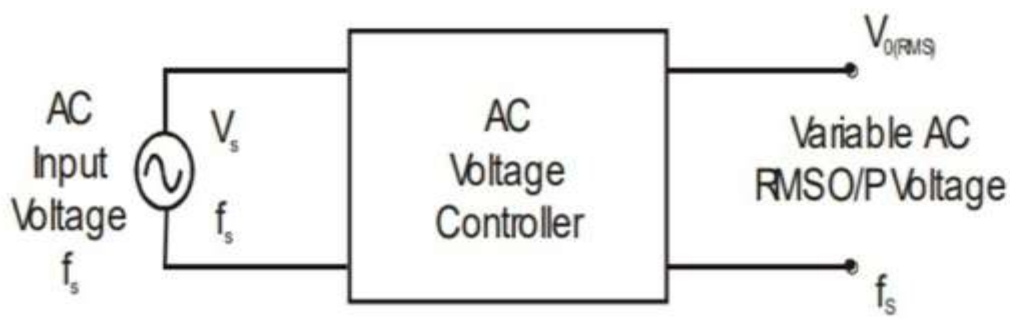


Figure 5.1.1 Block diagram of AC voltage controller

[Source: "Power Electronics" *by* P.S.Bimbra*,* Khanna Publishers *Page: 392]*

TYPE OF AC VOLTAGE CONTROLLERS

The ac voltage controllers are classified into two types based on the type of input ac supply applied to the circuit.

- Single Phase AC Controllers.
- Three Phase AC Controllers.

- Single phase ac controllers operate with single phase ac supply voltage of 230V RMS at 50Hz in our country.
- Three phase ac controllers operate with 3 phase ac supply of 400V RMS at 50Hz supply frequency.

APPLICATIONS OF AC VOLTAGE CONTROLLERS

- Lighting / Illumination control in ac
- power circuits. Induction heating.
- Industrial heating & Domestic heating.
- Transformers tap changing (on load transformer tap changing).
- Speed control of induction motors (single phase and poly phase ac induction motor control).

5.10 MATRIXCONVERTER

A matrix converter is defined as a converter with a single stage of conversion. It utilizes bidirectional controlled switch to achieve automatic conversion of power from AC to AC. It provides an alternative to PWM voltage rectifier double sided.

Features of MatrixConverter

- Direct AC / AC Conversion.
- No DC Link
- Less bulky (compact motor drives) – Safer (hostile environments: aircraft, submarine…)
- Bidirectional power flow. 4 quadrant converter
- No restriction on input and output frequency within limits imposed by switching frequency
- Sinusoidal input and output currents waveforms • 9 bidirectional switches.

Standard: – Wind/Water Force Machines (blowers, boilers, incinerators), pumps,and general IndustrialMachines.

- Specific Applications: – Compact or Integrated Motor Drives – Motor Drives for hostile environments (aircrafts, submarines) – AC/AC Power Conversions: wind energy, variable speed drives... AC / AC direct electrical power conversion
- MXN , inputs & outputs. Figure corresponds to the 3 X 3
- Variable frequency and variable voltage

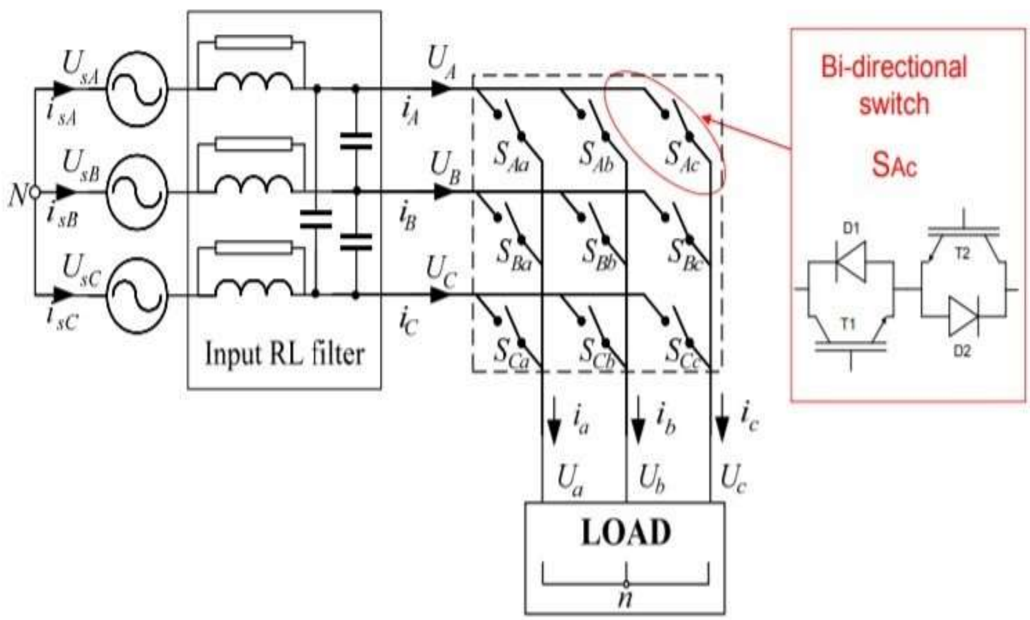


Figure 5.10.1 Matrix converter-circuit diagram

[Source: "Power Electronics" *by* P.S.Bimbra*,* Khanna Publishers *Page: 418]*

5.6 Multistage sequence control

- When two or more sequence control stages are connected, it is possible to have an improvement in power factor and further reduction in THD (total harmonic distortion). An n-stage sequence control converter has n windings in the transformer secondary part with each rated e_S/n (the source voltage).

Two stage sequence control of AC voltage regulators

- Sequence control of ac voltage regulators are used for reduction of harmonics and the improvement of system power factor in the input current & the output voltage. Sequence control of ac regulators means the use of two or more stages of voltage controllers in parallel for the regulation of output voltage. The sequence control of ac voltage controllers can be used as voltage controllers in supply systems & for the speed control of induction motors. These types of controllers are known as synchronous tap changers or transformer tap changers.

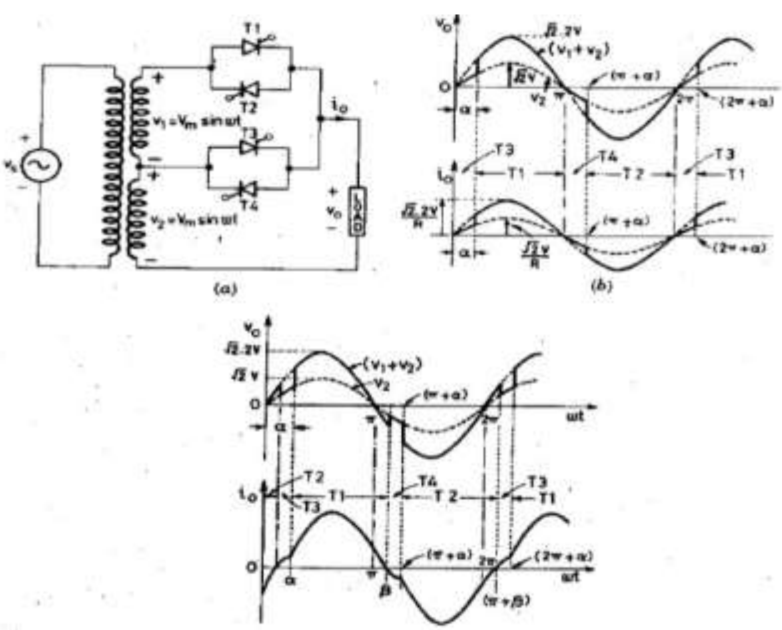


Figure 5.6.1 Two stage sequence controlled ac voltage controller

[Source: "Power Electronics" *by* P.S.Bimbra, Khanna Publishers *Page: 409]*

Thyristors are used as static switches for on load changing of transformer connections. Static connections changers have the advantage of very fast switching action the change over can be controlled to cope with the load condition & is smooth. When thyristors T3 & T4 are alternately fired with delay angle of α=0, the load voltage is Vo=V1. If full output voltage is required, thyristors T1 & T2 are alternately fired with delay angle of α=0 and full vltage I Vo=V1+V2. The gating pulse of thyristors can be controlled to vary the load voltage. The RMS value of load voltage Vo can be varied within three possible ranges 0 < Vo < V1, V1 < Vo < (V1+V2).

Case1: 0 < Vo < V1

To vary the RMS voltage within this range, T1 & T2 are turned off. T3 & T4 can be operated as a single phase ac voltage regulator. The RMS load voltage is given by, Vo=V1[1/π(π-α+(sin2α/2))]1/2 and the firing angle range is 0<α< Vo < (V1+V2) T3 & T4 are turned off. T1 & T2 operate as a single phase ac voltage regulator, the load voltage is Vo=(V1+V2)[1/π(π-α+(sin2α/2))]1/2 .

Case2: V1 < Vo < (V1+V2)

- T3 is turned on at ωt=0 and the secondary voltage V1 appears across the load. If T1 is turned on at ωt=α, T3 is reverse biased due to secondary voltage V2 & T3 is turned off. The voltage across the load is (V1+V2). At ωt=π, T1 is self commutated & T4 is turned on. The secondary voltage V1 appears across the load until T1 is fired ωt=π+α, t4 is turned off due to reverse voltage V2 and the load voltage is (V1+V2). At ωt=2π, T2 is self commutated, T3 is turned on again the cycle is repeated. This type of controller is also called as synchronous tap changer.

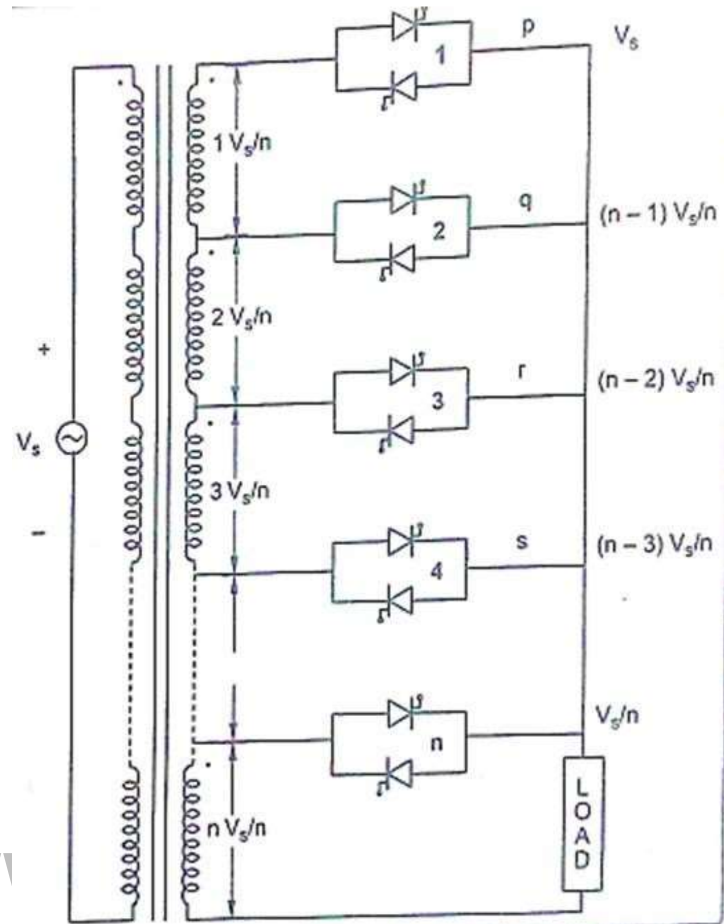


Figure 5.6.2 Multi stage sequence controlled ac voltage controller

[Source: "Power Electronics" *by* P.S.Bimbra*,* Khanna Publishers *Page: 409]*

The transformer has n secondary windings. Each secondary is rated for Vs/n, where Vs is the source voltage. The voltage of node p with respect to K is Vs.the load voltage at terminal Q is (n-1)V3/n and so on. If voltage control from Vsk=(n- 3)Vs/n to Vrk=(n-2)Vs/n is required, then SCR pair $ is triggerer at α=0 and firing angle of SCR pair3 is controlled from α= 0 to 180 and all other SCRs are kept off. Similarly for controlling the voltage from Vqk=(n-1)Vs/n to Vpk=Vs, SCR pair 2 is triggered at α=0, whereas for SCR pair 1, firing angle is varied from 0 to 180 keeping the remaining (n-2) SCR pairs off. Thus the load voltage can be varied from Vs/n to Vs by an appropriate control of triggering the adjacent SCR pairs. The presence of harmonics in the output voltage depends upon the voltage variation. If this voltage variation is a small fraction of the total output voltage, the harmonic content in the output voltage is also small.

5.5 POWER FACTOR CONTROL

Power factor control, also known as correction of power factor, is the process of reducing the amount of reactive power. The power electronic device used in this case is called a power factor controller (PFC). From the power triangle (which comprises reactive, true and apparent power), the reactive power is at right angle (90°) to the true power and is used to energize the magnetic field. Although reactive power does not have a real value in electronic equipment, the bill for electricity comprises real and reactive power costs. This makes it necessary to have power factor controllers in electronic devices.

Power factor (k) is defined as the ratio of the real power (in kW) to the reactive power (in kVAr). Its value ranges from 0 to 1. If a device has a power factor of 0.8 and above, it is said to be using power efficiently. Incorporating a PFC ensures the power factor ranges from 0.95 to 0.99.

Power factor controllers are mainly in industrial equipment to minimize reactive power generated by fluorescent lighting and electric motors. To ensure power factor is improved without causing harmonic distortion, the conventional capacitors should not be used. Instead, filters combination of capacitors and reactors) for harmonic suppression are used.

The figure below shows a harmonic filter.

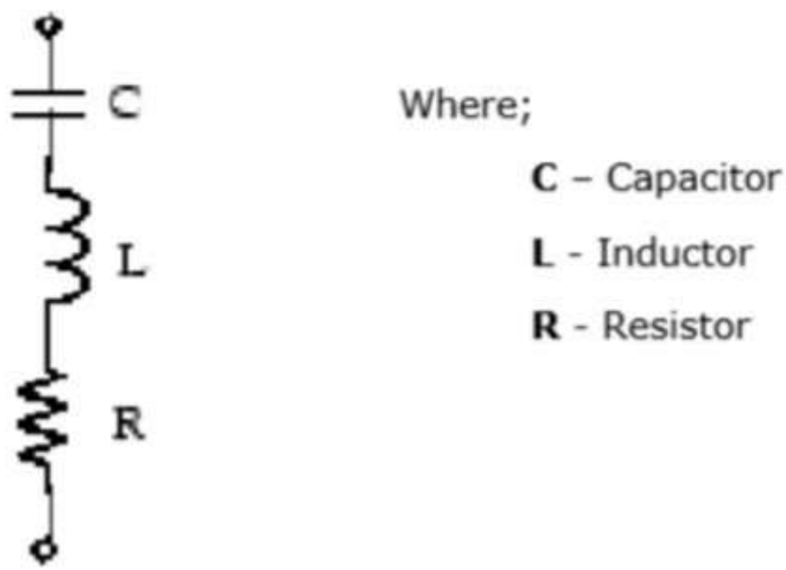


Figure 5.5.1Harmonic filter.

[Source: "Power Electronics" *by* P.S.Bimbra*,* Khanna Publishers *Page: 432]*

The above type of harmonic filter is referred to as a single tuned filter. A quality factor Q of this filter is defined as quality factor of its reactance (XL) at Q (tuning frequency) where Q is given by (nXL/R).

5.8 Single phase to Single phase Cyclo converter

It consists of back to back connected controlled rectifiers whose output voltage and frequency can be controlled by tuning firing angles of rectifiers. With respect to the connection of rectifiers, its structure can comprise of half-wave or full-wave bridge.

- It consists of two full-wave, fully controlled bridge thyristors, where each bridge has4 thyristors, and each bridge is connected in opposite direction (back to back) such that both positive and negative voltages can be obtained as shown in figure below. Both these bridges are excited by single phase, 50 Hz AC supply.

- Bridge 1-+ve group converter supplies load current in the +ve half of the output cycle and bridge 2 -ve group converter supplies load current in the negative half of the output cycle.

- The two bridges should not conduct together as this will produce a short circuit at the output.

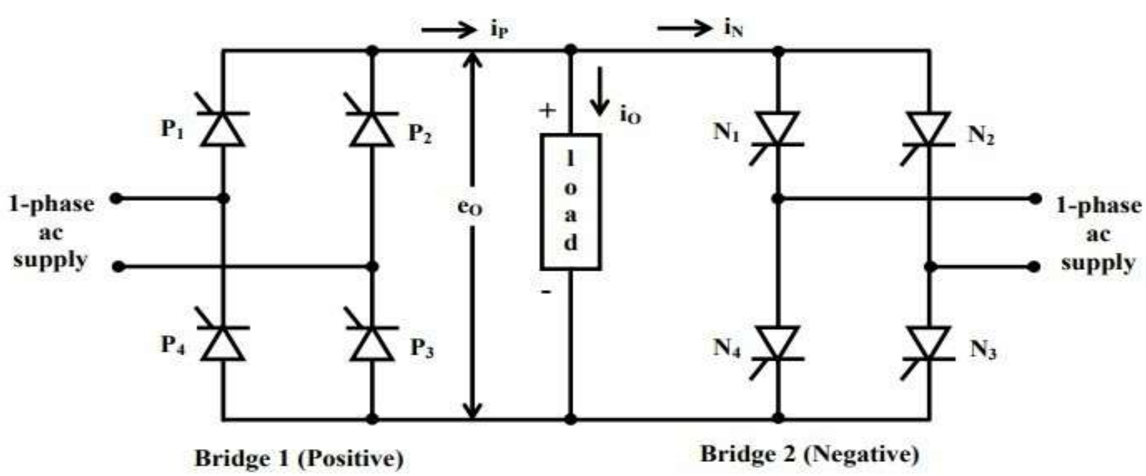


Figure 5.8.1 Single phase bridge type cyclo converter

[Source: "Power Electronics" *by* P.S.Bimbra*,* Khanna Publishers *Page: 415]*

OPERATION

MODE-1 : To get Positive half cycle of Output Voltage

- During positive half cycle of the input voltage, positive converter (bridge-1) is turned ON and it supplies the load current. During the +ve half cycle, 0 to π ,SCR P1 & P3 are forward biased and are triggered at ωt=α. Then P1 & P3 are on state & the output is positive. The current flows from V+-P1-R-P3-V-. at ωt=π, P1 & P2 are turned off. It rectifies the input voltage and produce unidirectional output voltage as we can observe four positive half cycles .

- During negative half cycle of the input, negative bridge is turned ON and it supplies load current. During –ve half of the cycle, π to 2π, SCR P3 & P4 are forward biased and is triggered at ωt=π+α. Then P2 & P4 are in on state. Again the output voltage & current is positive. Current flow is through V+-P3-R-P4-V-. at ωt=2π , SCR P2 & P4 are turned off due to natural commutation.

- Both converters should not conduct together that cause short circuit at the input.To avoid this, triggering to thyristors of bridge-2 is inhibited during positive half cycle of load current, while triggering is applied to the thyristors of bridge-1 at their gates. During negative half cycle of load current, triggering to positive bridge is inhibited while applying triggering to negative bridge.

- By controlling the switching period of thyristors, time periods of both positive and negative half cycles are changed and hence the frequency. This frequency of fundamental output voltage can be easily reduced in steps, i.e., 1/2, 1/3, 1/4 and so on.

MODE-2: To get Negative half cycle of Output Voltage

- Now bridge 2 can be operated and the output is negative. During +ve half cycle 2π to 3π, SCR N1 & N3 are forward biased. It is triggered at ωt=2π+ α. Then it comes to on state. The current flows through B-N1-R-N3-C. the output voltage & current is negative. At ωt=3π SCR N1 & N3 are turned off due to natural commutation.

- During negative half cycle 3π to 4π, SCR N2 & N4 are forward biased. It is triggered at ωt=3π+α. Then it comes to on state. The current flows through C-N3-R-N4-B. now negative voltage & current is got as the output. At ωt=4π, SCR N2 & N4 are turned off due to natural commutation.

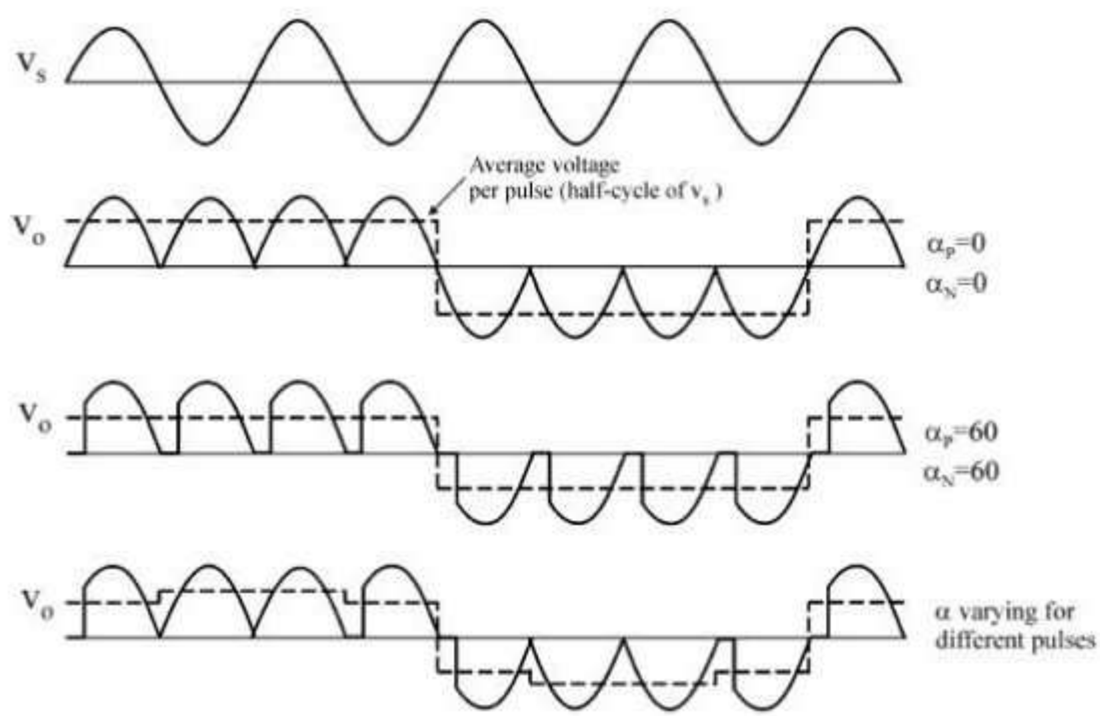


Figure 5.8.2 Wave forms of cyclo converter

[Source: "Power Electronics" *by* P.S.Bimbra*,* Khanna Publishers *Page: 416]*

5.2 SINGLE-PHASE HALF-WAVE AC VOLTAGE CONTROLLER

- It consists of one thyristor in antiparallel with one diode.
- Then SCR is forward biased during positive half cycle, it is turned on at firing angle α.
- Load voltage at once jumps to Vm sinωt, likewise load current becomes Vm sinα.
- Thyristor get turned off at ωt = ∏ for R load. After ωt = ∏, negative half cycle forward biases diode DI, therefore DI conducts from ωt = ∏ to 2∏.
- Only positive half cycle onduction can be controlled, by varying firing angle. negative half cycle cannot be controlled. So single-phase half wave voltage controller is also called single phase unidirectional voltage controller. From the Figure it is understood that positive half cycle is not identical with negative half-cycle for both voltage and current waveforms. As a result, dc component is introduced in the supply and load circuits which is undesirable.

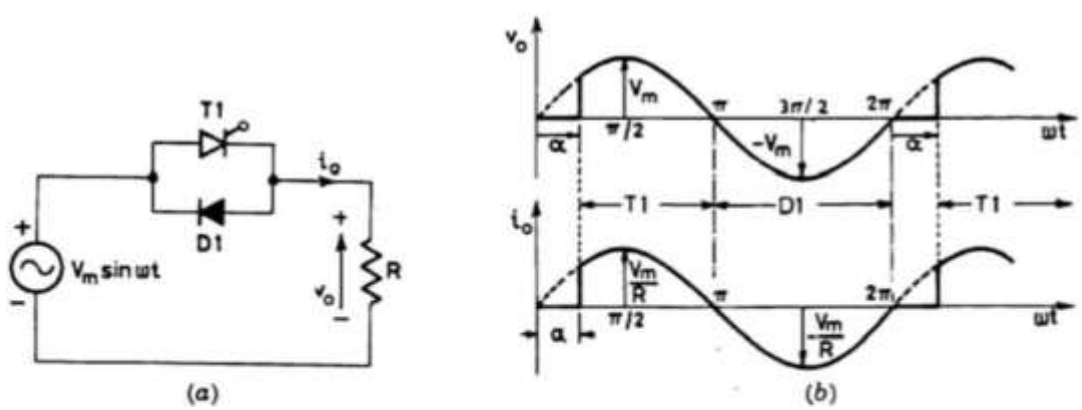


Figure 5.2.1 Single Phase AC voltage controller

[Source: "Power Electronics" *by* P.S.Bimbra*,* Khanna Publishers *Page: 396]*

RMS VALUE OF OUTPUT VOLTAGE OF SINGLE PHASE UNIDIRECTIONAL VOLTAGE CONTROLLER:

$$V_{or} = \pi \ \frac{1}{2x}\int_{\alpha}^{2\pi} V_m^2 \sin^2 \omega t d(\omega t) \Big|^{\frac{1}{2}}$$

$$V_{or}^2 = \frac{V_m^2}{4\pi}\int_{\alpha}^{2\pi}(1-\cos 2\omega t)d(\omega t)$$

$$V_{or}^2 = \frac{V_m^2}{4\pi} \ (2\pi-\alpha) + \frac{\sin 2\alpha}{2}$$

$$V \quad \frac{V}{2} \ \overset{*}{x} \quad 2\pi-\alpha) + \frac{\sin 2\alpha}{2}$$

$$I_{or} = \frac{V_{or}}{R}$$

AVERAGE VALUE OF OUTPUT VOLTAGE

$$V_o = \Big| \frac{1}{2\pi}\int_{\alpha}^{2\pi} V_m \sin \ \omega t d(\omega t)$$

$$'o \quad \frac{V_m}{2n}(-\cos \omega o)_{\alpha}^{2\pi}$$

$$V_{o*} - \frac{V^{\circ}}{2n}(\cos o - l)$$

SINGLE PHASE FULL WAVE AC VOLTAGE CONTROLLER

- It consists of two SCRs connected in antiparallel.
- During positive halfcycle T1 is triggered at firing angle , it conducts from wt = α to ∏ for R load.
- During negative half cycle,T2 is triggered at wt = ∏ + α, it conducts from rot = ∏

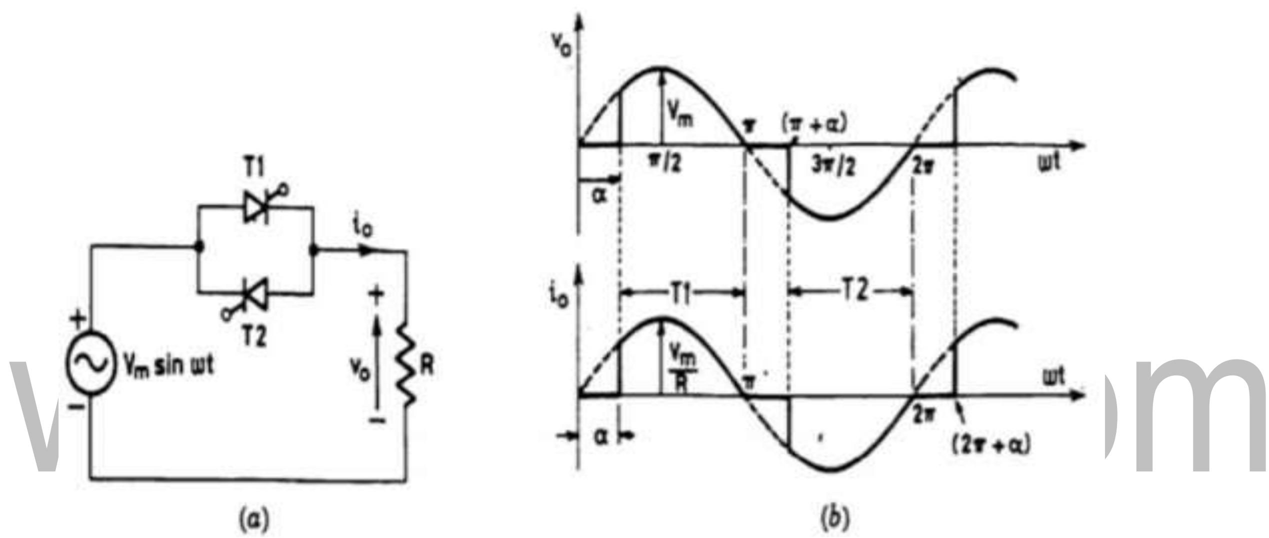


Figure 5.2.2 Single-phase full-wave ac voltage controller

[Source: "Power Electronics" *by* P.S.Bimbra, Khanna Publishers *Page: 397]*

- It has been stated above that ac voltage controllers are phase-controlled converters, the phase relationship between the start of load current and the supply voltage is controlled by varying the firing angle. These are called phase- controlled ac voltage controllers or ac voltage controllers. Single phase full-wave ac voltage controller is also called single phase bidirectional voltage-controller.

5.3 THREE PHASE AC VOLTAGE CONTROLLER

- To control the current and voltage of three phase loads, Three Phase AC Voltage Controller are required. The single phase controller described previously can be introduced singly in each phase or line, to form a three phase controller. There exist a variety of connections for Three Phase AC Voltage Controller.

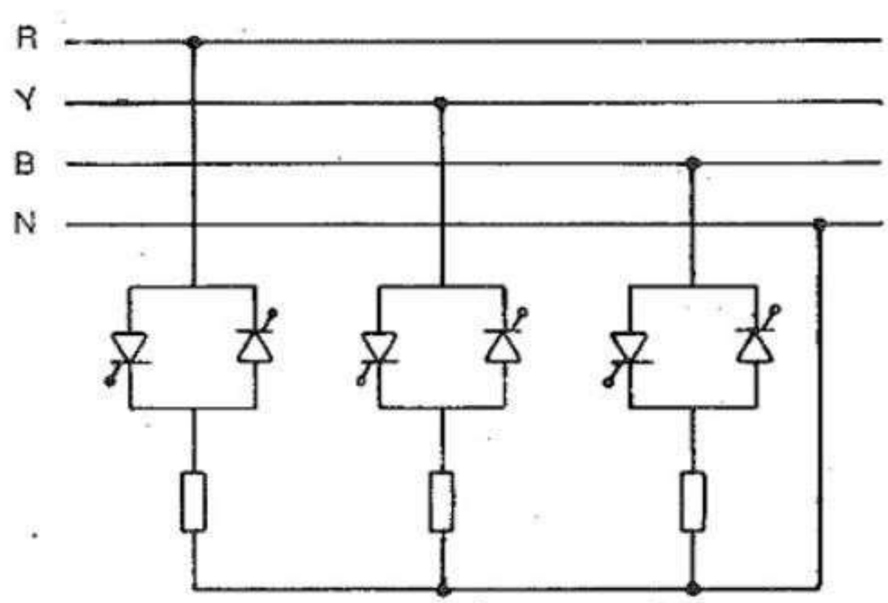


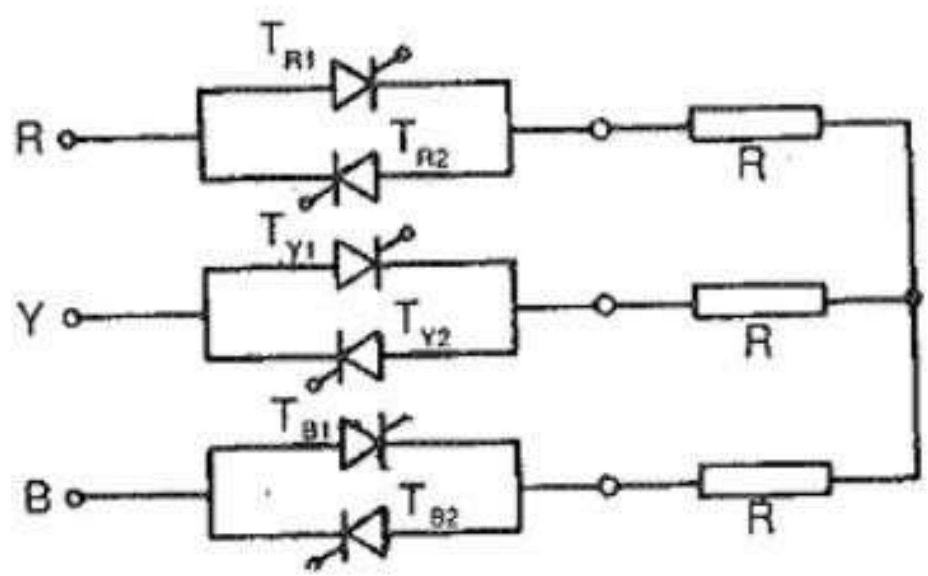
Figure 5.3.1 Block diagram of Three Phase AC voltage controller

[Source: "Power Electronics" *by* P.S.Bimbra*,* Khanna Publishers *Page: 398]*

- A three phase four wire controller is shown in Fig 5.6. The load neutral and supply neutral are connected together. Each of the three controllers can be independently controlled to feed the load impedance. Each phase has the same relations as a single phase controller. The neutral and line currents contain triplet harmonics along with other odd harmonics.

A Three Phase AC Voltage Controller has symmetrical control if both the back to back connected thyristors have the same firing angle. It has asymmetrical control if the firing angles differ or if one of the thyristors is replaced by a diode, or if the controllers are placed in only two of the three lines.

We now discuss the features of a symmetrically controlled three phase, three wire, star-connected controller for both ohmic and inductive loads.



5.3.2 Three phase ac voltage controller feeding a resistive load

[Source: "Power Electronics" *by* P.S.Bimbra*,* Khanna Publishers *Page: 399]*

The schematic of a three phase, three wire voltage controller feeding a three phase, star-connected balanced resistance is shown in Fig. 5.10. Phase control of the thyristors is employed. The phase and line voltages of the three phase system are shown in Fig. 5.10. For a controller, the control pulse is of a long duration, equal to the conduction period of the thyristor. This is to make sure that the firing pulse is available at the gate whenever the thyristor is forward biased, so that the thyristor can go into conduction.

It also ensures the firing of the thyristor whenever a forward current is expected. If, because of some circuit condition, the current goes to zero the thyristor turns off. A lengthy pulse can bring it into conduction. Further, slow building up of current in the load circuit when the thyristor is fired (to give maximum load voltage) may cause the thyristor to go to an off state if it is not fully turned on.

For current to flow it is necessary to trigger at least two thyristors at a time. If we define the instantaneous input phase voltages as:

$$v_{an} = V_m \sin\omega t$$

$$v_{bn} = V_m \sin(\omega t - 2\pi/3)$$

$$v_{cn} = V_m \sin(\omega t - 4\pi/3)$$

The instantaneous input line voltages are

$$v_{ab} = 3 v_{an} = 3 v_m \sin(\omega t + \pi/6)$$

$$v_{bc} = 3 v_{bn} = 3 v_m \sin(\omega t - \pi/2)$$

$$v_{ca} = 3 v_{cn} = 3 v_m \sin(\omega t - 7\pi/6)$$

5.9 Three-Phase to Single-Phase Cyclo converters

- A three-phase to single phase cyclo converter also consists of positive and negative group thyristors. Positive converters will provide positive current and negative converters will provide negative current to the load.
- .These cyclo-converters can be half-wave or full bridge converters as shown in figure. Like single phase cyclo-converters, these also produce a rectified voltage at the load terminals by each group of thyristors.
- At any time, one converter will operate. The circuit of half wave and full wave cycloconverters are shown below.

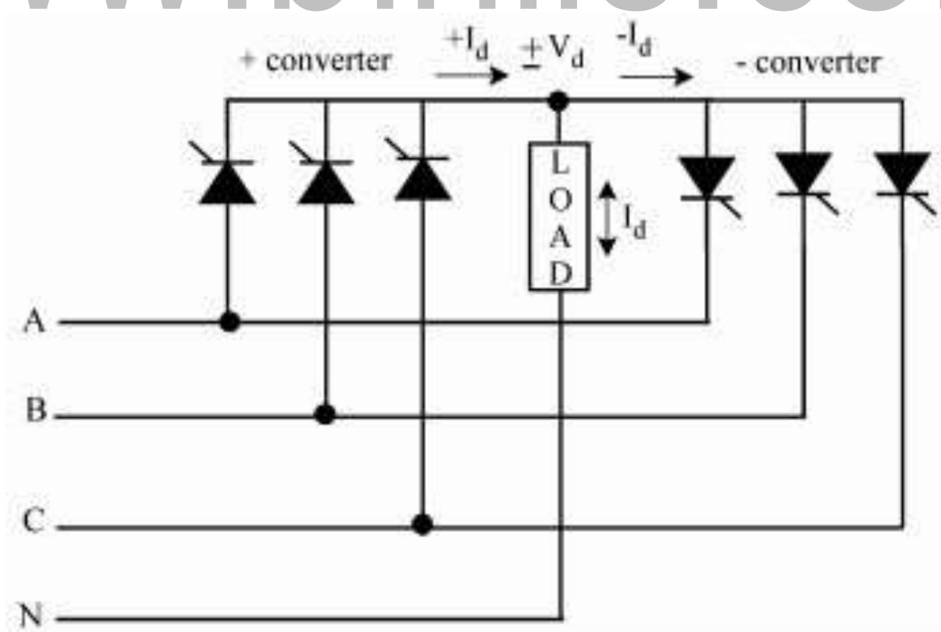


Figure 5.9.1 3phase cyclo converter

[Source: "Power Electronics" *by* P.S.Bimbra, Khanna Publishers *Page: 418]*

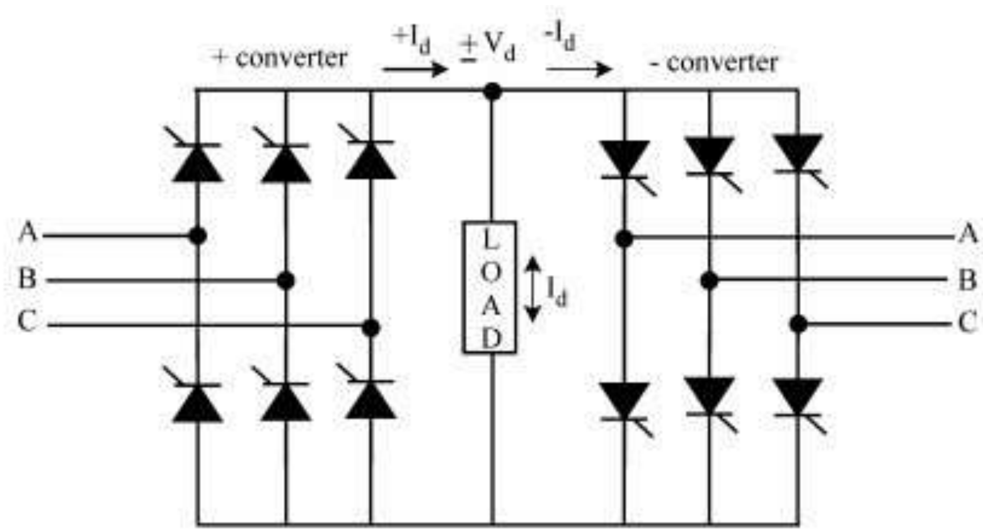


Figure 5.9.2 3phase to single phase cyclo converter

[Source: "Power Electronics" *by* P.S.Bimbra*,* Khanna Publishers *Page: 418]*

During positive half cycle of the input, conduction of the positive group thyristors is controlled and during negative half-cycle, conduction of negative group of thyristors is controlled in order to produce an output voltage at desired frequency.

OPERATION

The firing angle (α) of two converters is first decreased starting from the initial value of 90° to the final value of 0°, and then again increased to the final value of 90° , as shown in Fig. below Also, for positive half cycle of the output voltage waveforrn, bridge 1 is used, while bridge 2 is used for negative half cycle. The two half cycles are combined to form one complete cycle of the output voltage, the frequency being decided by the number of half cycles of input voltage waveform used for each half cycle of the output. As more no. of segments of near 60°(π/6} is used, the output voltage waveform becomes near sinusoidal, with its frequency also being reduced.

The initial value of firing angle delay is kept at $\alpha_1 \approx 90°$, such the average value (dc) of the output voltage in this interval of near 60° (π/6) [Vav= cos α_1 = cos 90°= 0, is zero. It may be noted that the next thyristor in sequence is triggered at $\alpha_2 < 90°$, as the firing angle is decreased for each segment, to obtain higher voltage Vavα cos α_2 = +ve , to form the sine waveat the output. This can beobserved from the points, M, N, O, P, Q, R & S, shown in Fig.From these segments, the first quarter cycle of the output voltage waveform from 0° to 90°, is obtained. The second quarter cycle of the above waveform from 90°to180° , is obtained, using the segments starting from the points, T, U, V, W, X &Y. It may be noted that the firing angle delay at the point, Y is α = 90° , and also the firing angle is increased from 0° (T) to 90° (Y) in this interval. When the firing angle delay is 0° , the average value of the segment is Vav α cos α= cos 0° = 1.0. The two quarter cycles form the positive half cycle of the output voltage waveform. In this region, the bridge I (positive) is used.

- To obtain the negative half cycle of the output voltage waveform (180° - 360°), the other bridge converter (#2) termed negative (B) is used in the same manner as given earlier, i.e. its firing angle delay ((1) is first decreased starting from the initial value of 90° to the final value of 0° , and then again increased to the finalvalue of 90°.the two half cycles together form the complete cycle of the output voltage waveform.
- In a bridge type of cyclo-converter, both positive and negative converters can generate voltages at either polarity, but negative converter only supplies negative current while positive converter supply positive current.

- Therefore, the cyclo-converter can operate in four quadrants, i.e., rectification modes of (+V, +i) and (-V, -i) and inversion modes of (+V, -i) and (-V, +i)

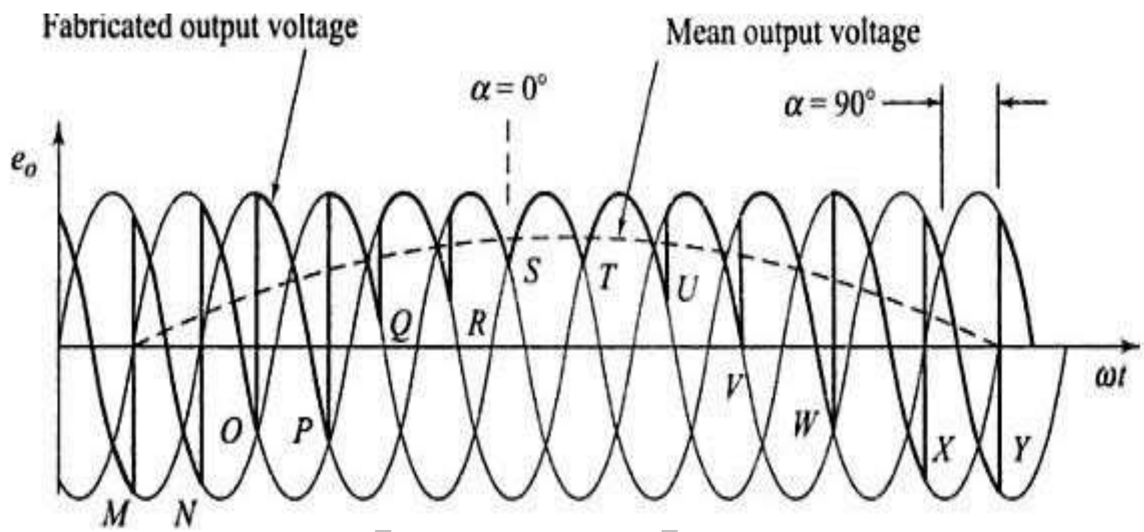


Figure 5.9.3 Output Voltage form

[Source: "Power Electronics" *by* P.S.Bimbra*,* Khanna Publishers *Page: 419]*

The above figure shows the conversion of three phase supply at one frequency to single phase supply of lower frequency. In this, the firing angle to a positive group of thyristors is varied progressively to produce single phase output voltage.

- At point M, the firing angle is 90 degrees and it is reduced till point S where it is zero. Again from point T to Y, the delay angle is progressively increased.

- This varied triggering signals to the thyristors, varies its conduction time periods and hence the frequency of the output voltage.

5.11 WELDING

- Power sources will require either a single or three phase supply at the voltage of the country in which it is intended to be used. Most equipment is provided with a series of voltage tappings and these may need to be adjusted to match the supply voltage. In the UK and the rest of Europe the supply voltages are now 230V AC single phase and 400V AC three phase. In other parts of the world, different supply voltages occur and may vary between regions. In some countries,220V AC three phase may be encountered. Three phase supplies may be limited to 30A, but higher power welding equipment may require a 45A or even a 60A supply.
- From 1999, equipment started to appear with an effective current rating on the rating plate. This value should be used to determine the cable size and fusing requirements. However, national wiring regulations should always be followed.
- Particular attention should be paid to the supply requirements for single phase equipment. In many parts of Europe the 230V supply is 16A, but in the UK the standard plug is only 13A. Therefore, the relatively low power output of this type of equipment is further reduced if a 13A plug is fitted, so a dedicated circuit may be required. In some parts of the world the single phase mains supply may be further limited in current, but generally in these countries, three phase supplies will be readily available. Another problem to be wary of is imbalance in the supply, if high powered equipment is connected between two phases of a three

phase supply. If more than one power source is installed they should be connected between different phases.

- Apart from the obvious hazards of overloading a supply, e.g. overheating and blowing fuses, problems with other equipment may be caused. If the supply has a high impedance (commonly known as soft) as may be the case in overhead cables, a high current draw may cause the voltage of the supply to fall below levels which may cause problems with other equipment.

AC-AC converter for Welding Application

- Welding is an integral and energy intensive part of the construction, manufacturing, and maintenance industries.To weld two plates ie work pieces, the melting energy is provided by establishing an arc between two electrodes, where one of them is the metallic workpiece being welded.

- There are several technologies for electric arc welding, each with their own unique power quality requirements.

- Welding technologies such as metal inert gas (MIG), Tungsten inert gas (TIG) and submerged arc welding (SAW) requires constant voltage power supply.

Power Supplies for Electric Arc Welding

➢ power supplies for electric arc welding provide a CC/CV constant current/constant voltage output that may be either AC or DC.

➢ They are particularly well adapted for submerged arc welding.

- Constant voltage (CV) DC sources were used for the constant speed wire electrode feeders.
- DC power supplies pose arc blow issues. Arc blow is less of a problem when using an AC power supply (because there is not a DC arc current). A sinusoidal output does not always perform well in sub arc welding processes because the sinusoidal wave exhibits a slow zero crossover which may result in arc rectification.
- For sub arc welding, an AC power source which receives a three phase input and provides a single phase AC output, having relatively fast zero crossings, at a frequency 1.5 times the input frequency. (step up CC)
- A welding power supply comprising a step-up cycloconverter having at least one control input and a controller coupled to the control input.