A device which converts input power at one frequency to output power at different frequency in a single stage is known as **cycloconverter.**

A cycloconverter is basically of two types.

1.Step-down cycloconverter

In this type of cycloconverter the output frequency f_o is less than the supply frequency f_s.

2.Step-up cycloconverter.

In this type of cycloconverter the output frequency f_o is greater than the supply frequency f_s.

3.1 Principle of operation of cycloconverter

3.1.1 Single phase to single phase step up cycloconverter

For simplicity load is assumed to be purely resistive. The basic principle is first described for mid-point type and then for bridge type.

3.1.1.1 Mid-point type cycloconverter. (Step up with R load)

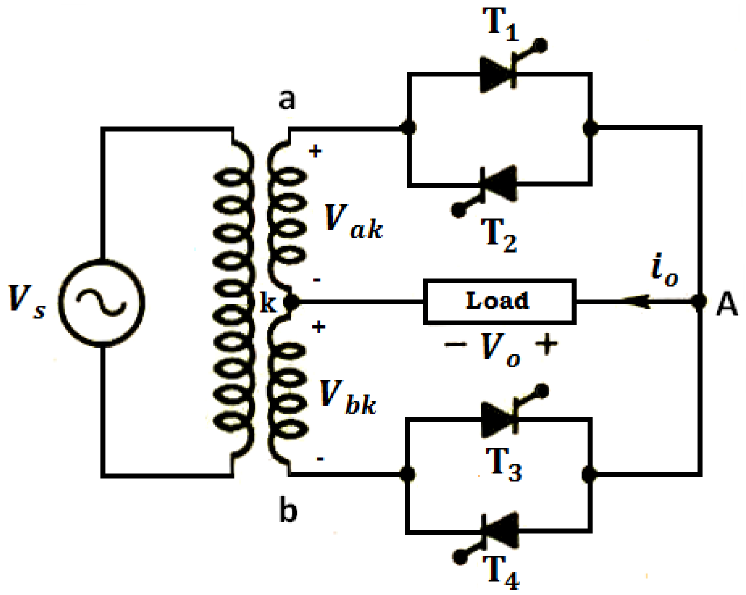

Figure 1 *Mid point type cycloconverter with R load.*

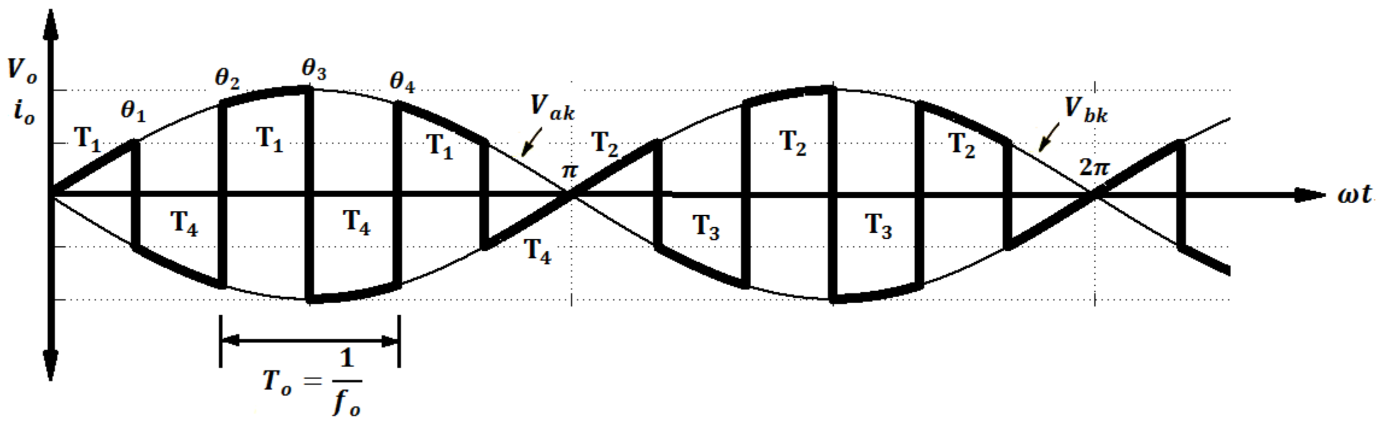

Figure 2 *Waveforms of step-up mid point type cycloconverter with R load.*

- It consists of a transformer with mid-point secondary and four thyristor as shown in figure 1.
- Two thyristor T_1, T_4 from positive group and T_2, T_3 from negative group.
- Positive direction of output voltage and current are marked in figure 1.
- During positive cycle of the supply voltage the terminal "a" is positive with respect to terminal "b". So, SCR T_1 and T_4 are forward bias from $\omega t = 0$ to $\omega t = \pi$ as shown in figure 1.
- As the thyristor T_1 is turned on at $\omega t = 0$, so that load voltage is positive and follows the supply voltage envelope as shown in figure2.
- At instant $\omega t = \theta_1$, T_1 is force commutated and forward biased thyristor T_4 is triggered so that load voltage is negative and follows negative envelope of supply voltage as shown in figure2.
- At $\omega t = \theta_2$, T_4 is force commutated and T_1 is turned on. The load voltage is now positive and follows positive envelope of the supply voltage.
- After $\omega t = \pi$, terminal "b" is positive with respect to "a". Both thyristor T_3 and T_2 are forward biased from $\omega t = \pi$ to $\omega t = 2\pi$. At $\omega t = \pi$, T_4 is force commutated and forward biased thyristor T_3 is turned on.
- At $\omega t = \frac{1}{2f_s} + \frac{1}{2f_o}$, T_3 is force commutated and forward biased thyristor T_2 is turned on. In this manner, thyristorT_4, T_4 for first half cycle; T_2, T_3 in the second half cycle and so on switched alternatively between positive and negative envelope at high frequency.
- As a result output frequency f_o is greater than the supply frequency f_s is obtained as shown in figure 2.

3.1.1.2 Bridge type cycloconverter (Step up with R load)

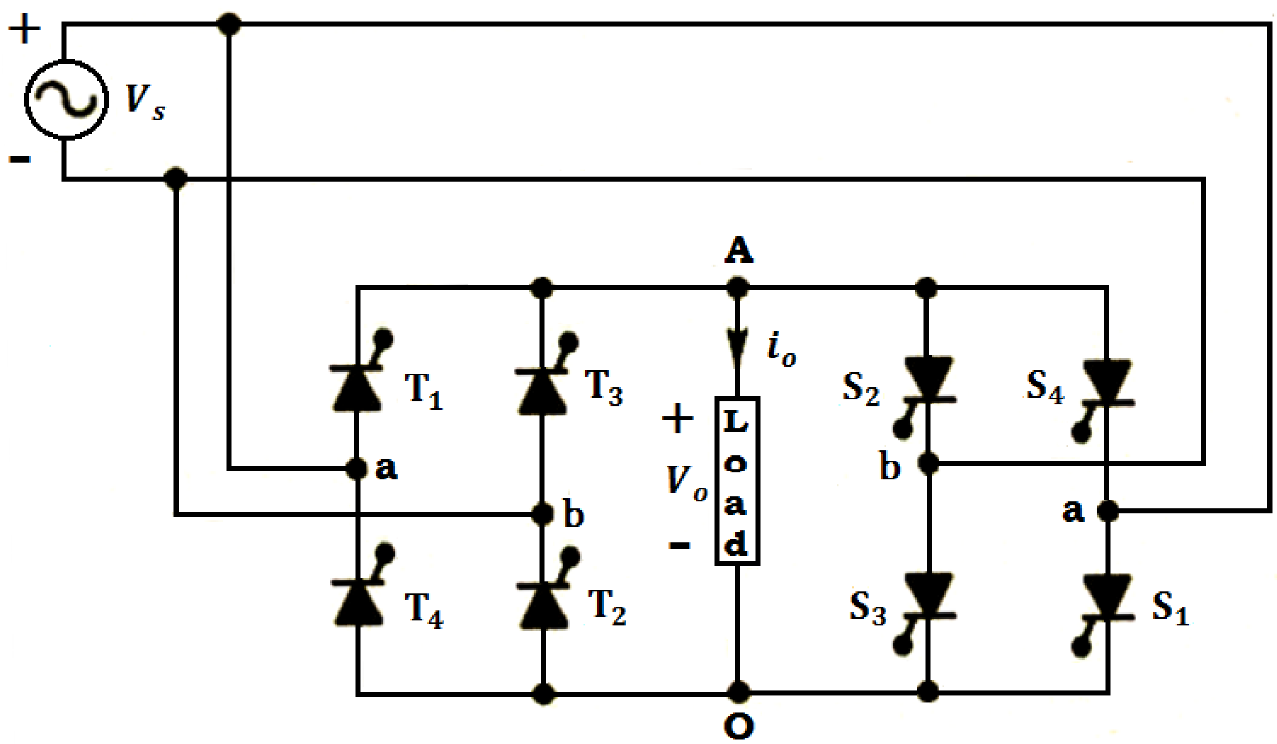

***Figure 3** Single phase Bridge type cycloconverter (R load)*

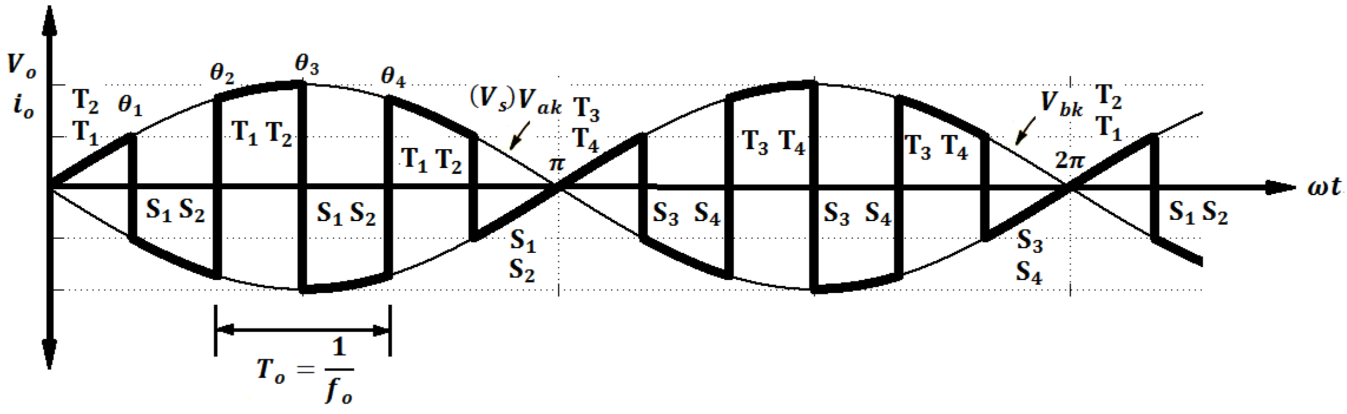

Figure 4 Waveform of single phase bridge type cycloconverter (R load)

- It consist of total eight thyristor T_1 to T_4; four from positive group and remaining S_1 to S_4 for negative group as shown in figure 3.
- When "a" is positive with respect to "b". during positive half cycle of the supply voltage, thyristor T_1, T_2 and S_1, S_2 are forward biased from $\omega t = 0$ to $\omega t = \pi$.
- When forward biased thyristor T_1 and T_2 are triggered at $\omega t = 0$. The load voltage terminal is positive and followed by positive envelope of supply as shown in figure 4.
- At $\omega t = \theta_1$, T_1 and T_2 are force commutated and S_1 and S_2 are triggered. With this load voltage will be negative and follows negative envelope of the supply voltage as shown in figure 4.
- At $\omega t = \theta_2$, S_1 and S_2 are force commutated and T_1 and T_2 are turned on. The load voltage is now positive and follows positive envelope of supply voltage.
- After $\omega t = \pi$, thyristor pair T_3, T_4 and S_3, S_4 are forward biased, these can therefore be turned on and force commutated from $\omega t = \pi$ to $\omega t = 2\pi$. In this way output frequency can be increased then the supply frequency.

3.1.1.3 Mid-point type cycloconverter. (Step down with R load)

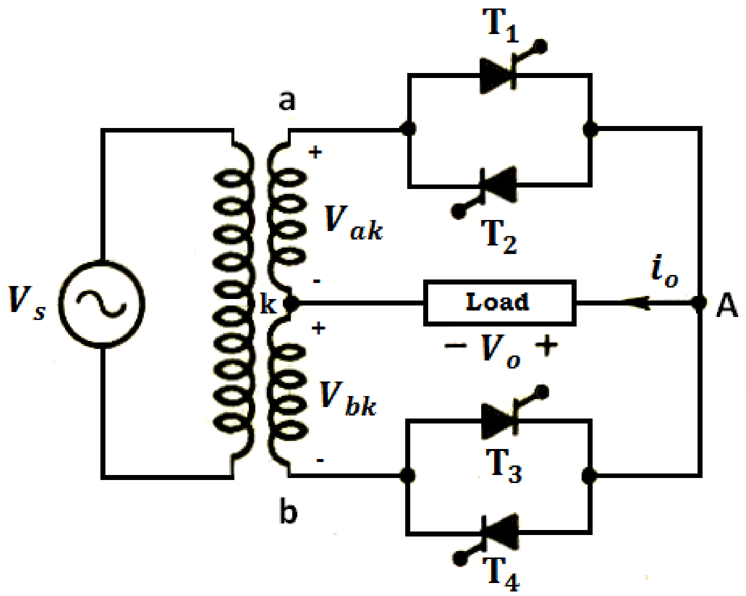

Figure 5 Single phase mid point type rectifier with R load

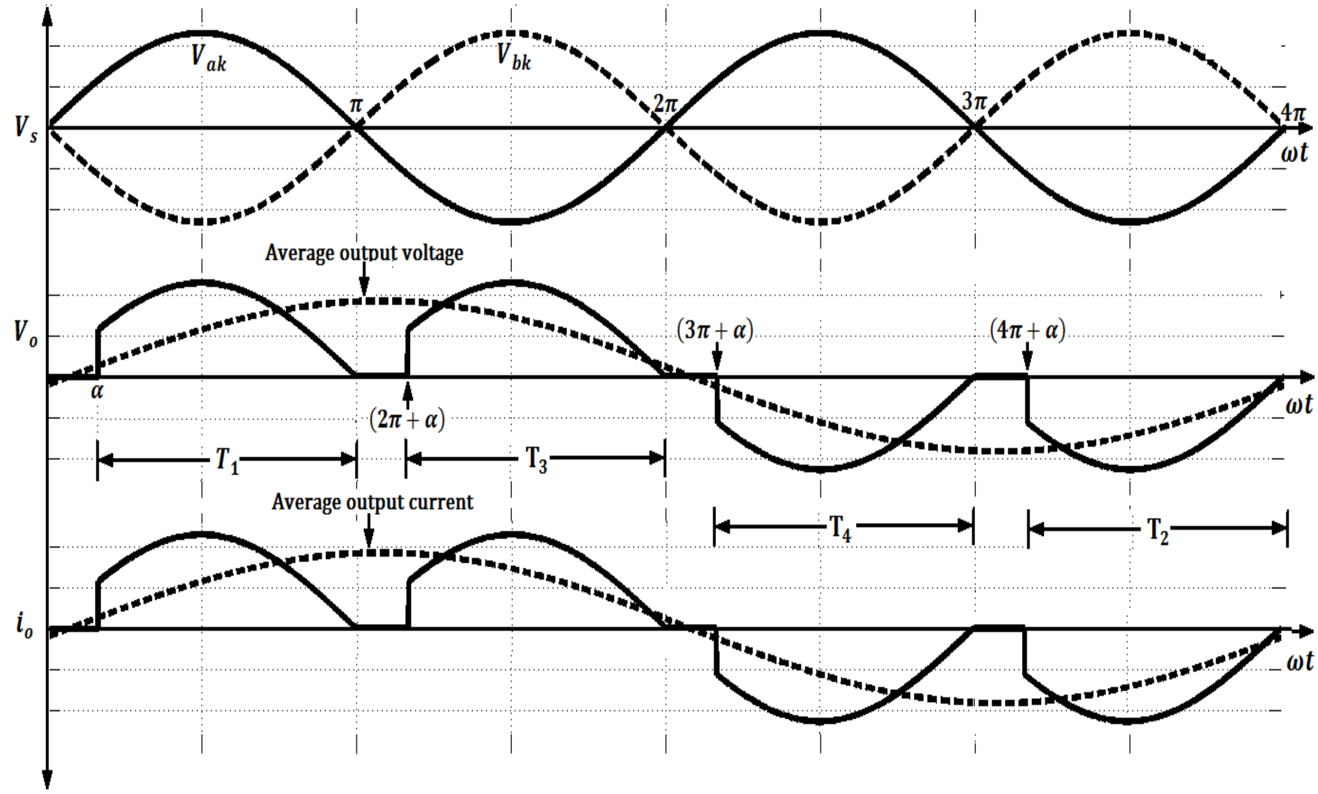

Figure 6 *Wave form of single mid point type step down cycloconverter with R load.*

- When "a" is positive with respect to "k" in figure 5 during positive half cycle of supply voltage forward biased thyristor T_1 is triggered at $\omega t = \alpha$.
- With this, load current i_o starts flowing in the positive direction from "A" to "k". Load current i_o is shown in figure 6.
- Thyristor is T_1 remains on till $\omega t = \pi$. At $\omega t = \pi$ the load current is zero as supply voltage falls to zero and hence T_1 is commutated at π.
- After π, negative cycle of supply starts hence "b" is positive with respect to "k" thereby forward biasing thyristor T_2. T_2 is triggered at $\omega t = \pi + \alpha$. Load voltage now follows V_{bk} as shown in figure 6. At $\omega t = 2\pi$ thyristor T_2 is commutated.
- After such two positive half cycles of load voltage and load current, thyristor T_4 is gated at $(3\pi + \alpha)$ when "k" is positive with respect to "b". As T_4 is forward biased, it starts conducting but load direction is reversed, i.e. it is now from "k" to "A".
- At $\omega t = 4\pi$, thyristor T_4 is naturally commutated and load current goes to zero as shown in figure 6.
- In a sequence at $\omega t = 4\pi + \alpha$, T_2 is triggered as "k" is positive with respect to "a" N_2 starts conducting and load voltage and current will be negative as shown in figure 6.
- In this manner, two negative half cycles of load voltage and current, equal to the two positive half cycle, are generated as shown in figure 6.
- It is seen from the figure 6 that frequency of output voltage and current is $f_o = \frac{1}{2} f_s$

3.1.1.4 Bridge type cycloconverter. (Step down with R load)

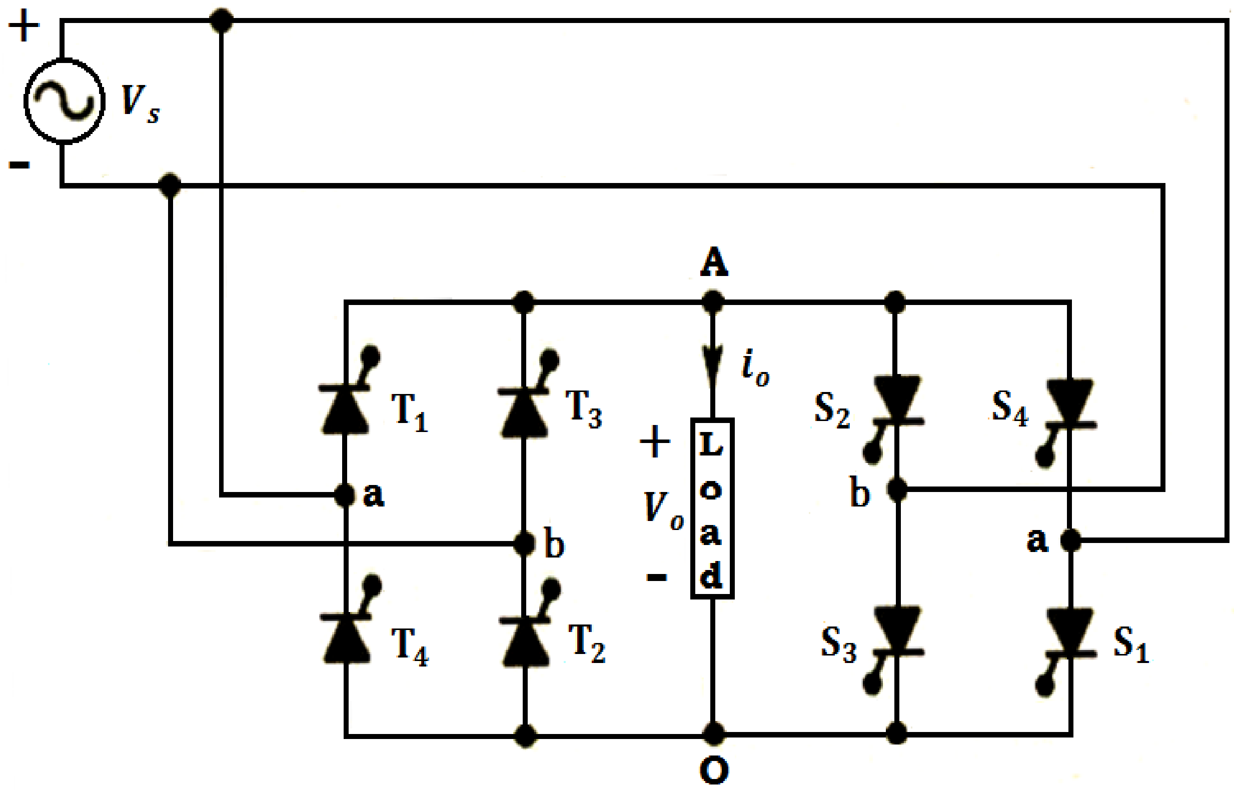

Figure 7 *Single phase to single phase bridge type step down cycloconverter with R load*

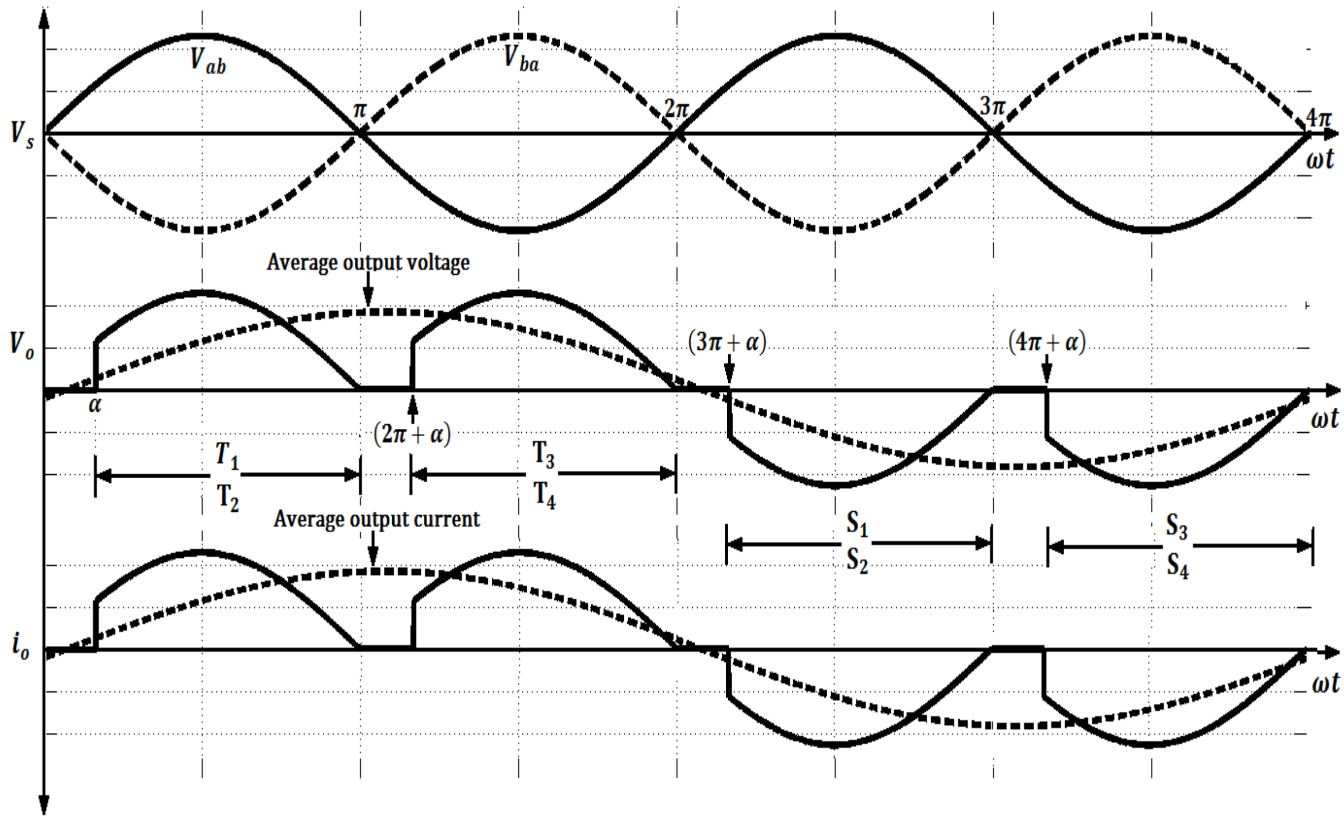

Figure 8 *Waveforms of single phase to single phase bridge type stepdown cycloconverter with R load*

- When "a" is positive with respect to "b" in fig 7 forward biased thyristor T_1T_2 is triggered at $\omega t = \alpha$ with this, load current i_o starts flowing in the positive direction from "A" to "O". Load current i_o is shown in figure 8.
- Thyristor is T_1 remains on till $\omega t = \pi$. At $\omega t = \pi$ the load current is zero as supply voltage falls to zero and hence T_1T_2 is commutated at π.
- After π, negative cycle of supply starts hence "b" is positive with respect to "a" thereby forward biasing thyristor T_3, T_4. T_3, T_4 is triggered at $\omega t = \pi + \alpha$. Load voltage V_o now is as shown in figure 7. At $\omega t = 2\pi$, thyristor T_3, T_4 is commutated.
- After such two positive half cycles of load voltage and load current, thyristor S_1, S_2 is gated at $(3\pi + \alpha)$ when "a" is positive with respect to "b". As S_1, S_2 is forward biased, it starts conducting but load direction is reversed, i.e. it is now from "O" to "A". At $\omega t = 4\pi$ thyristor S_1, S_2 is naturally commutated and load current goes to zero as shown in figure 8 .
- In a sequence at $\omega t = 4\pi + \alpha$, S_3S_4 is triggered as "b" is positive with respect to "a" S_3S_4 starts conducting and load voltage and current will be negative as shown in figure 7.
- In this manner, two negative half cycles of load voltage and current, equal to the two positive half cycle, are generated as shown in figure 8.
- It is seen from the figure 8 that frequency of output voltage and current is $f_o = \frac{1}{2} f_s$

3.2 Single phase to single phase mid-point type step down cycloconverter with RL load.

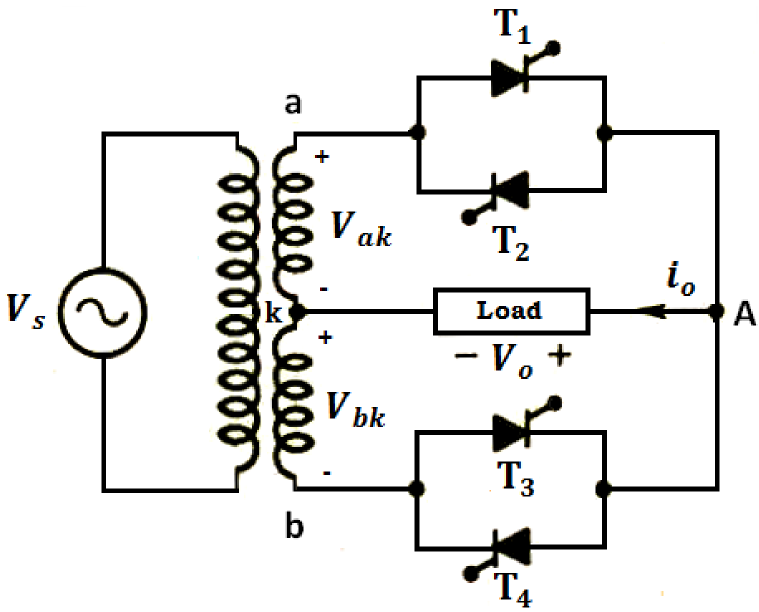

Figure 9 Single phase to single phase mid point type cycloconverter (RL load)

- Step down cycloconverter do not require any force commutation. It requires phase controlled converter as shown in the figure 9.
- It can be explained with discontinuous and continuous load current.

3.2.1 Discontinuous load current

- When "a" is positive with respect to "b" in figure 9 forward biased thyristor T_1 is triggered at $\omega t = \alpha$, with this, load current i_o starts building up in the positive direction from "A" to "k". Load current i_o becomes zero at $(\omega t = \beta) > \pi$ but less then $(\pi + \alpha)$ in figure 10.
- Thyristor T_1 is thus commutated at $\omega t = \beta$, which is already reversed biased after π. After a half cycle, "b" is positive with respect to "a". Now forward biased thyristor T_3 is triggered at $\omega t = \pi + \alpha$.

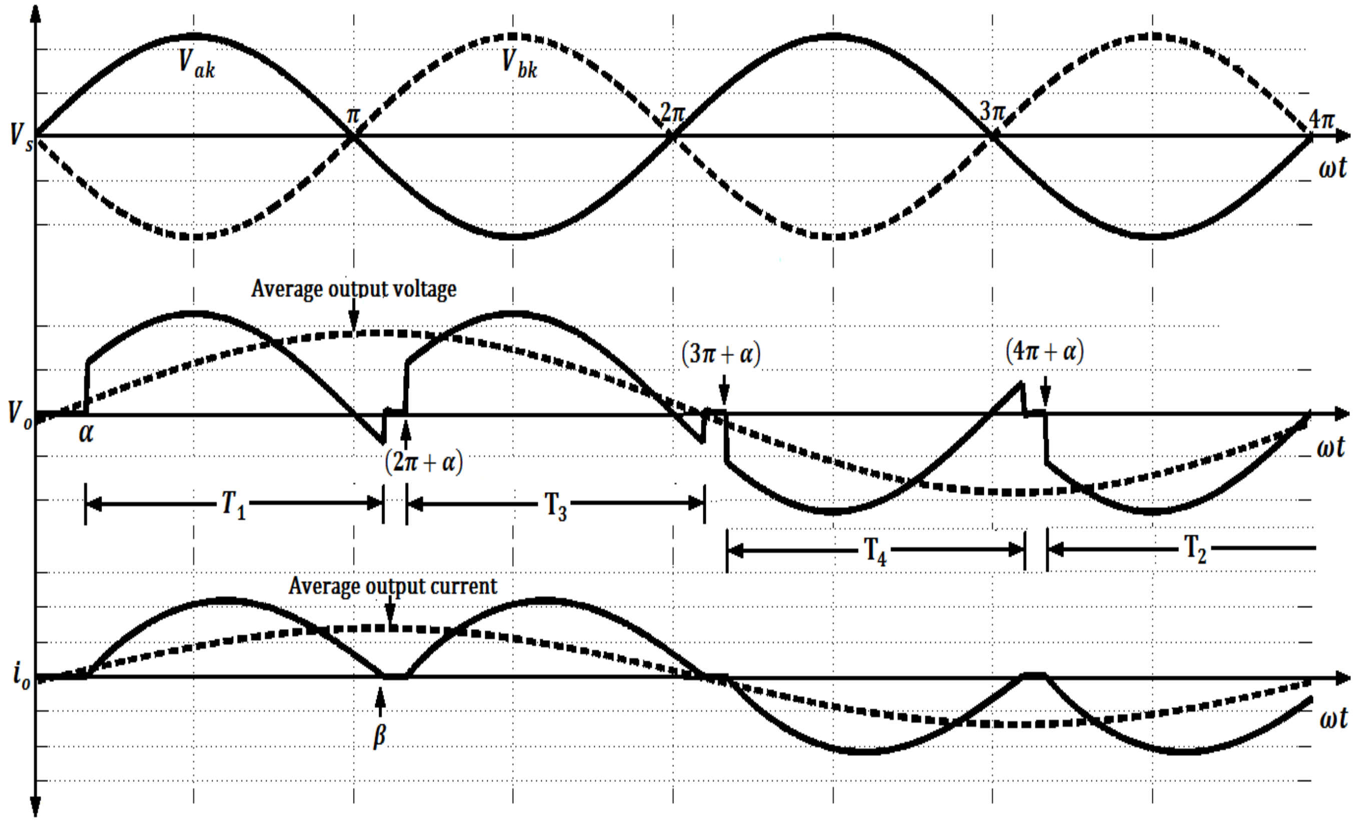

Figure 10 Waveforms of 1 phase mid point type cycloconverter with RL load (Discont. Current)

- Load current is again positive from "A" to "k" builds up from zero. At $\omega t = \pi + \beta$, i_o decays to zero and T_3 is naturally commutated. Load current is to be seen discontinuous.
- After two positive half cycles of load voltage and load current, thyristor T_4 is gated at $(3\pi + \alpha)$ when "a" is positive with respect to "b". As T_4 is forward biased, it starts conducting but load direction is reversed, i.e. it is now from "k" to "A".
- After T_4 is triggered, load current builds up in the negative direction as shown if figure 10. In the next half cycle , "b" is positive with respect to "a" but before T_2 is fired, i_o decays to zero and T_4 is naturally commutated.
- Now T_2 is gated at $4\pi + \alpha$, i_o again builds up and decays to zero before thyristor T_1 in sequence is again gated.
- In this manner, two negative half cycles of load voltage and current, equal to the two positive half cycle, are generated as shown in figure 10.
- It is seen from the figure 10 that frequency of output voltage and current is $f_o = \frac{1}{2} f_s$.

3.2.2 Continuous load current

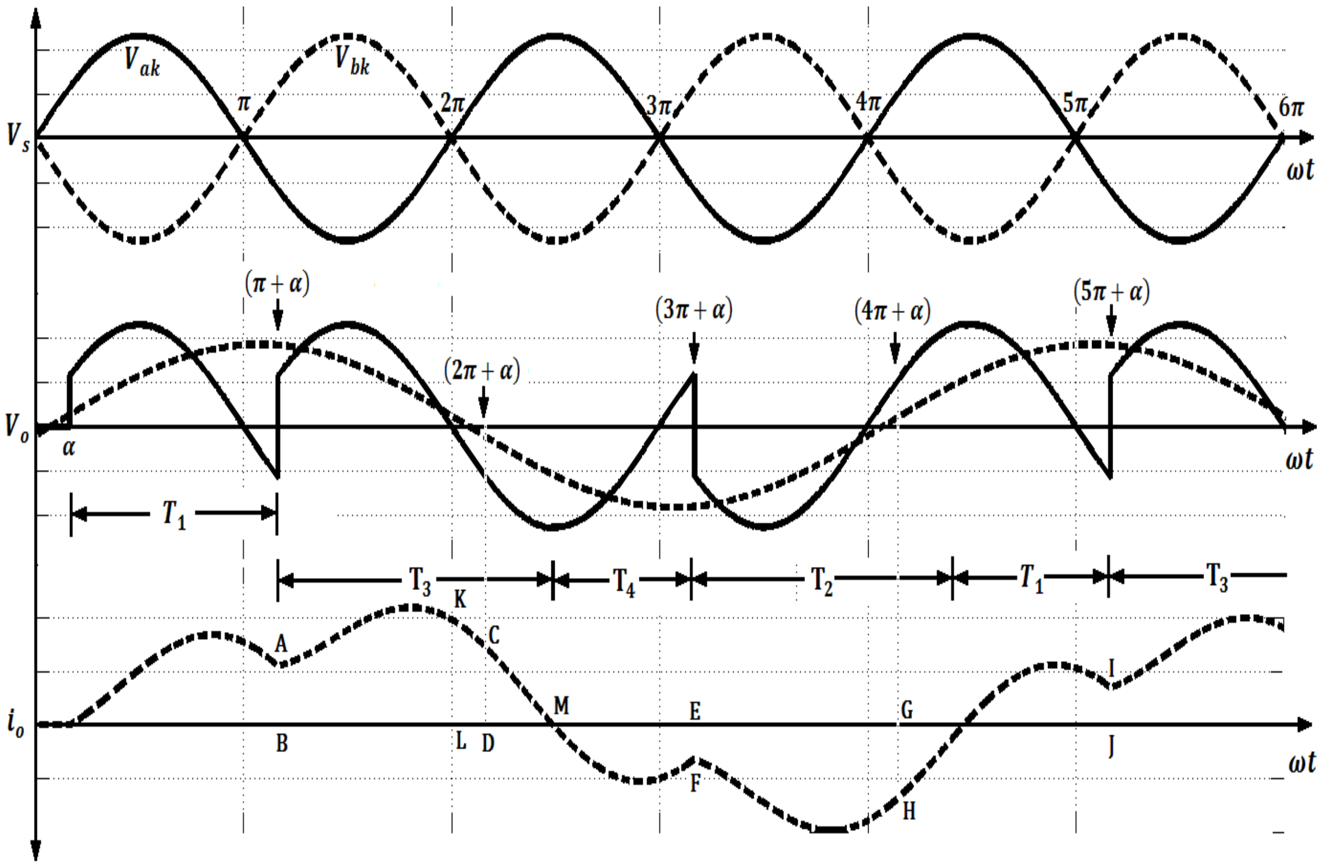

Figure 11 Waveforms of 1 phase mid point type cycloconverter with RL load (Conti. Current)

- When "a" is positive with respect to "b". T_1 is triggered at $\omega t = \alpha$, positive output voltage appears across the load and load current starts building up as shown in figure 11.
- At $\omega t = \pi$, load voltages are zero. After $\omega t = \pi$, T_1 is reversed biased. As load current is continuos, T_1 is not turned off at $\omega t = \pi$. When T_3 is triggered in a sequence at $\omega t = \pi + \alpha$, a reverse voltage appears across T_1, is therefore turned off by natural line commutation.
- When T_1 is commutated load current has built up to a value equal to AB as shown in figure 11 with turning on of T_3 at $\pi + \alpha$, output voltage is again positive as it was with T_1 on. As a consequence load current builds up further then AB as shown figure 11.
- At the end of two positive half cycle of output voltage, load current is beyond KL. After 2π, "k" is positive with respect to "b" but as due to inductive load T_3 will remain in conduction till the current reaches to zero. T_4 is already triggered at $2\pi + \alpha$ with prolonged pulse. When current goes to zero at point M, T_3 turns off and T_4 starts conducting when T_4 is now conducting after T_3 load is subjected to negative voltage and load current i_o increased from zero in negative direction as shown in figure 11.
- Now T_4 is commutated as T_2 is gated at $(3\pi + \alpha)$. Load current becomes more negative than EF at $(4\pi + \alpha)$, this is because with T_2 on, load voltage is negative.
- For two negative half cycles of output voltage, current i_o is shown in figure 11.

- It is seen from load current waveform that i_o is symmetrical about ωt axis in figure 11.
- The positive group of voltage group and current wave consist of two pulses and same is true for negative group wave.
- One positive group of pulses along with one negative group of identical pulses constitute one cycle for load voltage and load current.
- The supply voltage has, however, gone through four cycles. The output frequency is, therefore $f_o = \frac{1}{2} f_s$ in figure 11.

3.3 Single phase to singe phase step-down bridge type cycloconverter with RL load.

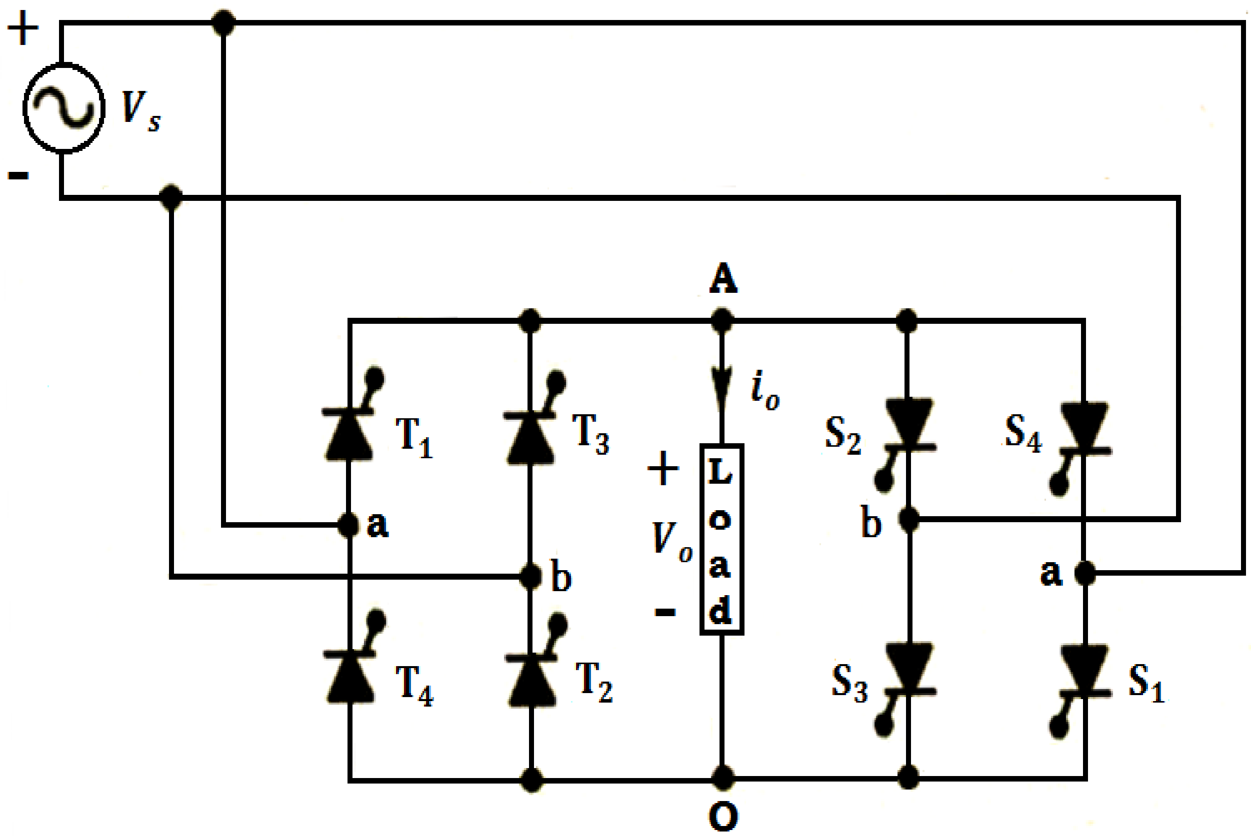

Figure 12 *Single phase bridge type cycoconverter with RL load*

3.3.1 Discontinuous load current.

- When "a" is positive with respect to "b" in figure 12 forward biased thyristor T_1 and T_2 is triggered at $\omega t = \alpha$ With this, load current i_o starts building up in the positive direction from A to O. Load current i_o becomes zero at $(\omega t = \beta) > \pi$ but less then $(\pi + \alpha)$ in figure 13.
- Thyristors T_1 and T_2 are thus commutated at $\omega t = \beta$, which is already reversed biased after π. After a half cycle, "a" is positive with respect to "b". Now forward biased thyristor T_3 and T_4 is triggered at $\omega t = \pi + \alpha$.

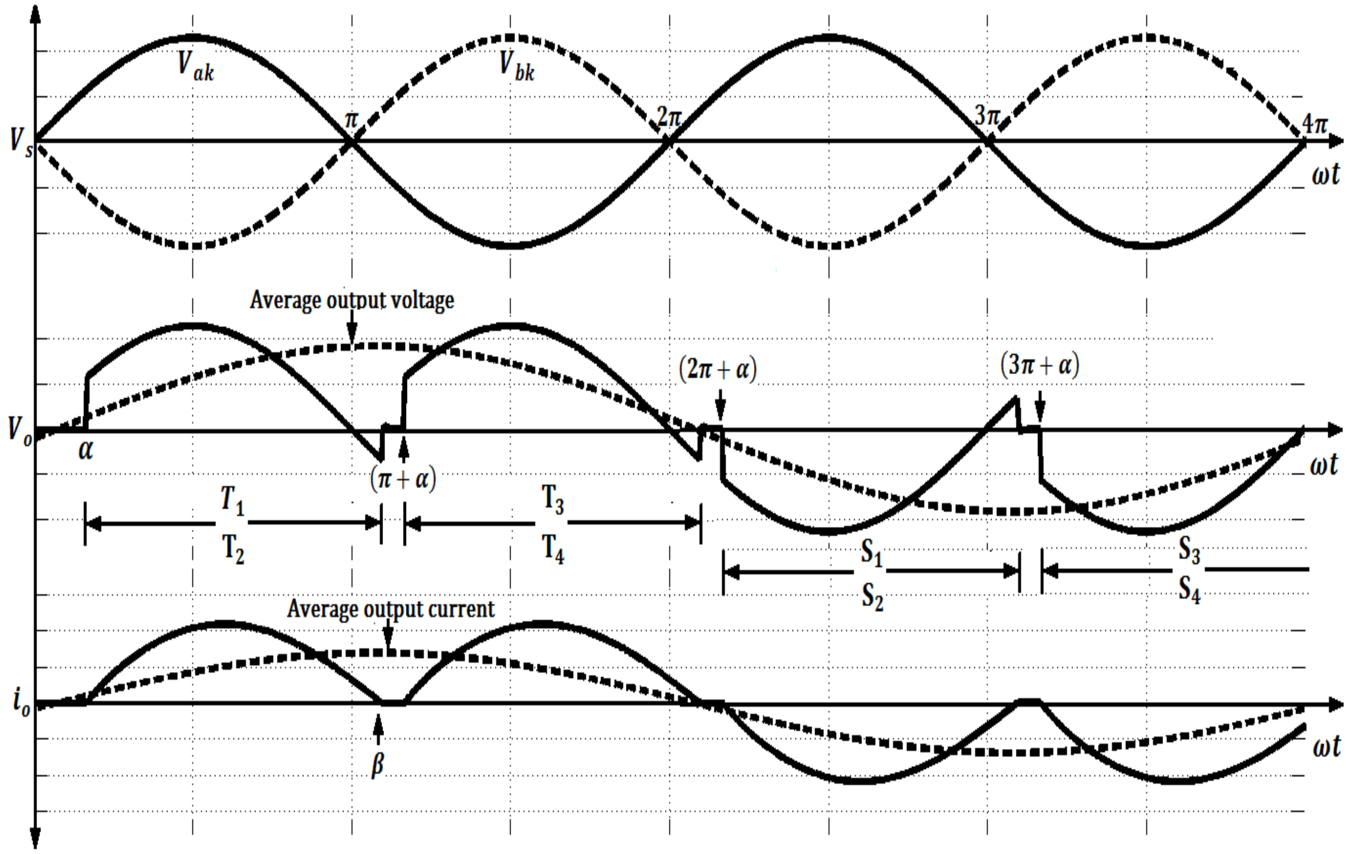

Figure 13 Waveforms of 1 phase bridge type cycloconverter with RL load (Discont. Current)

- Load current is again positive from "A" to "O" builds up from zero. At $\omega t = \pi + \beta$, i_o decays to zero and T_3 and T_4 is naturally commutated. Load current is to be seen discontinuous.
- After two positive half cycles of load voltage and load current, thyristor S_1 and S_2 is gated at $(3\pi + \alpha)$ when "a" is positive with respect to "b".
- As S_1 and S_2 are forward biased, it starts conducting but load direction is reversed, i.e. it is now from "O" to "A".
- After S_1 and S_2 are triggered, load current builds up in the negative direction as shown in figure 13.
- In the next half cycle , "b" is positive with respect to "a" but before S_3 and S_4 are fired, i_o decays to zero and S_1, S_2 is naturally commutated.
- Now S_3 and S_4 are gated at $5\pi + \alpha$, i_o again builds up and decays to zero before thyristor T_1 and T_2 in sequence is again gated.
- In this manner, two negative half cycles of load voltage and current, equal to the two positive half cycle, are generated.
- It is seen from the figure that frequency of output voltage and current is $f_o = \frac{1}{2} f_s$ as shown if figure 13.

3.3.2 Continuous load current

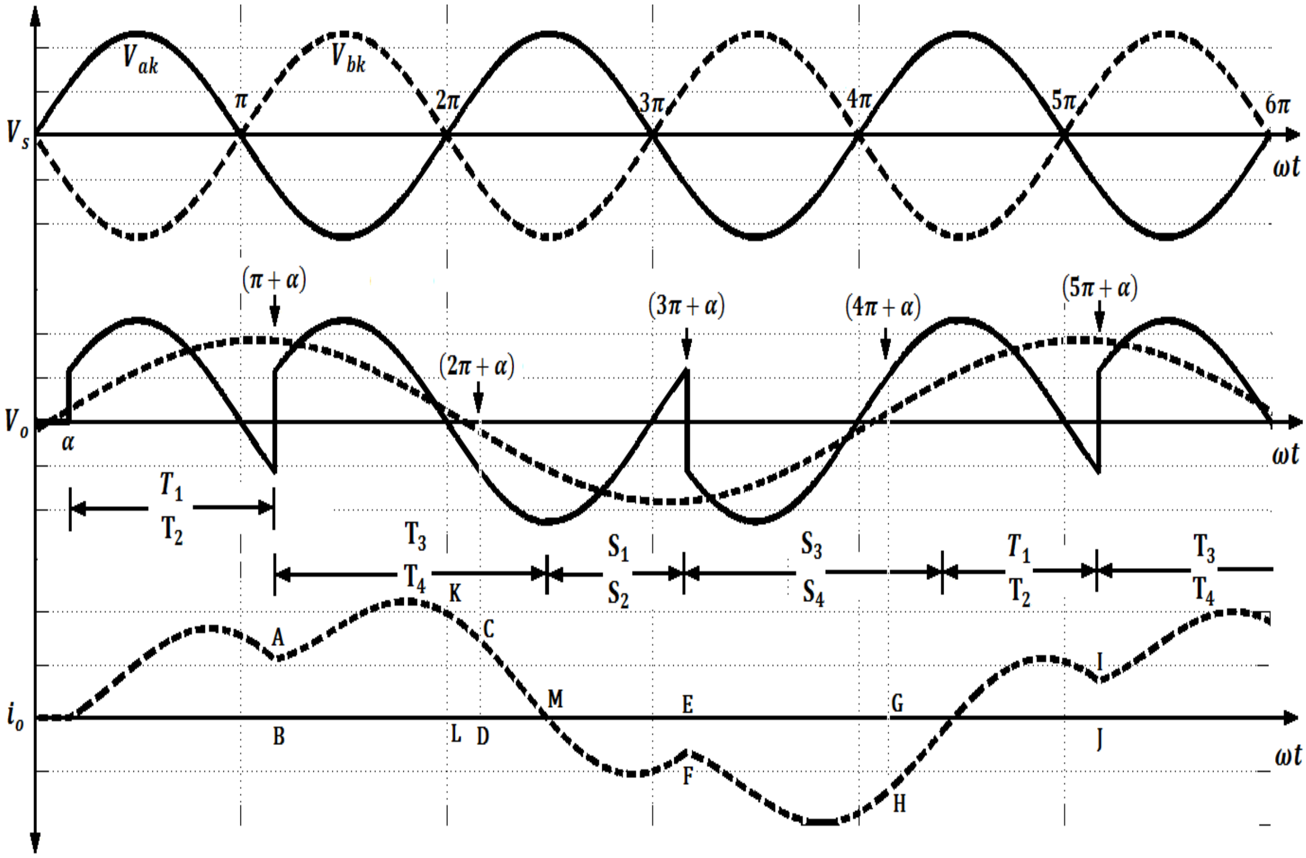

Figure 14 Waveforms of 1 phase bridge type cycloconverter with RL load (Conti. Current)

- When "a" is positive with respect to "b" in figure 12. T_1 and T_2 are triggered at $\omega t = \alpha$, positive output voltage appears across the load and load current starts building up as shown in figure 14.
- At $\omega t = \pi$, load voltages are zero. After $\omega t = \pi$, T_1 and T_2 are reversed biased. As load current is continuous, T_1 and T_2 are not turned off at $\omega t = \pi$. When T_3 and T_4 are triggered in a sequence at $\omega t = \pi + \alpha$, a reverse voltage appears across P_1 and P_2, are therefore turned off by natural line commutation.
- When T_1 and T_2 are commutated load current has built up to a value equal to AB as shown in figure 10. With turning on of T_3 and T_4 at $\pi + \alpha$, output voltage is again positive as it was with T_1 and T_2 on. As a consequence, load current builds up further then AB as shown figure 14.
- At $2\pi + \alpha$, when P_1 and P_2 are again turned on, P_3 and P_4 is naturally commutated and load current through P_1 and P_2 builds up beyond RS as shown.
- At the end of two positive half cycle of output voltage, load current is beyond KL. After 2π, "a" is positive with respect to "b" but as due to inductive load T_3 and T_4will remain in conduction till the current reaches to zero at M. S_1, S_2 is already triggered at $2\pi + \alpha$ with prolonged pulse. When current goes to zero at point M, T_3 and T_4 turns off and S_1, S_2 starts conducting when S_1, S_2 is now conducting after T_3, T_4 load is subjected to negative voltage and load current i_o increases from zero as shown in figure 14.

- Now S_1 and S_2 are commutated and S_3 and S_4 is gated at $(3\pi + \alpha)$. Load current becomes more negative than EF at $(4\pi + \alpha)$, this is because with S_3 and S_4 on, load voltage is negative.
- For two negative half cycles of output voltage, current i_o is shown in figure 14.
- It is seen from load current waveform that i_o is symmetrical about ωt axis in figure 14. The positive group of voltage group and current wave consist of four pulses and same is true for negative group wave.
- One positive group of pulses along with one negative group of identical pulses constitute one cycle for load voltage and load current.
- The supply voltage has, however, gone through two cycles. The output frequency is, therefore $f_o = \frac{1}{2} f_s$ in figure 14.

3.4 Three phase to singe phase half-wave step-down type cycloconverter with RL load.

3.4.1 Three phase to single phase half-wave step down cycloconverter.

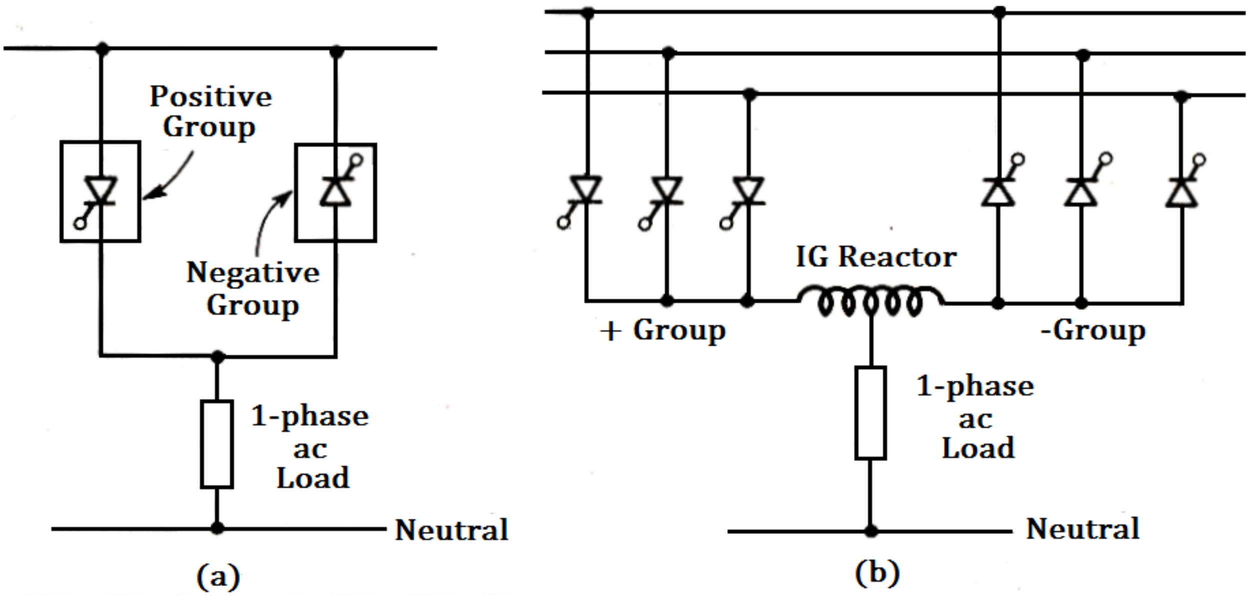

Figure 15 Three phase to single phase half wave cycloconverter with RL Load

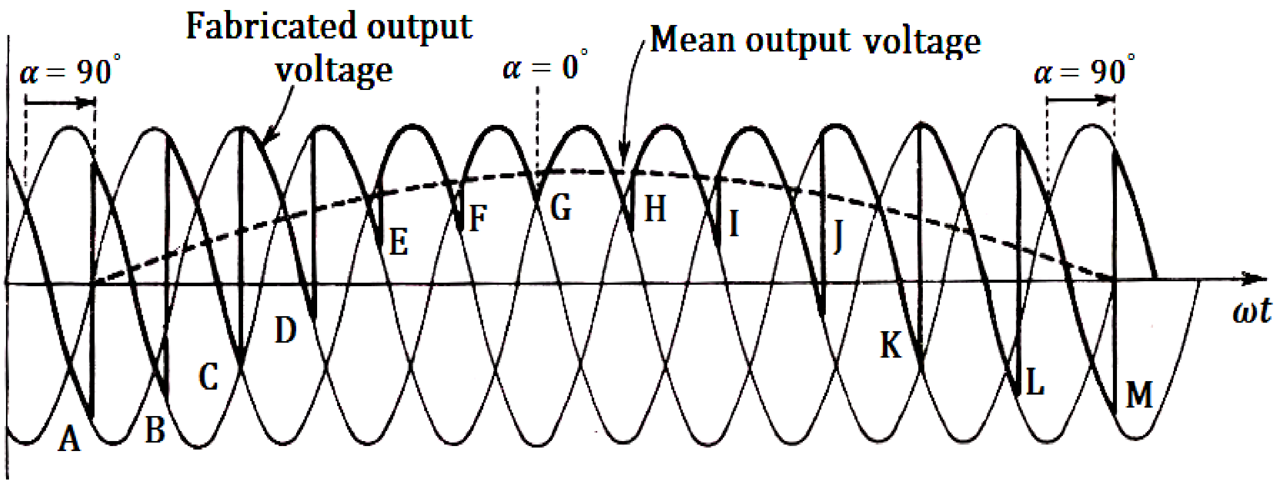

Figure 16 Fabricated and mean output voltage of 3 phase to single phase cycloconverter

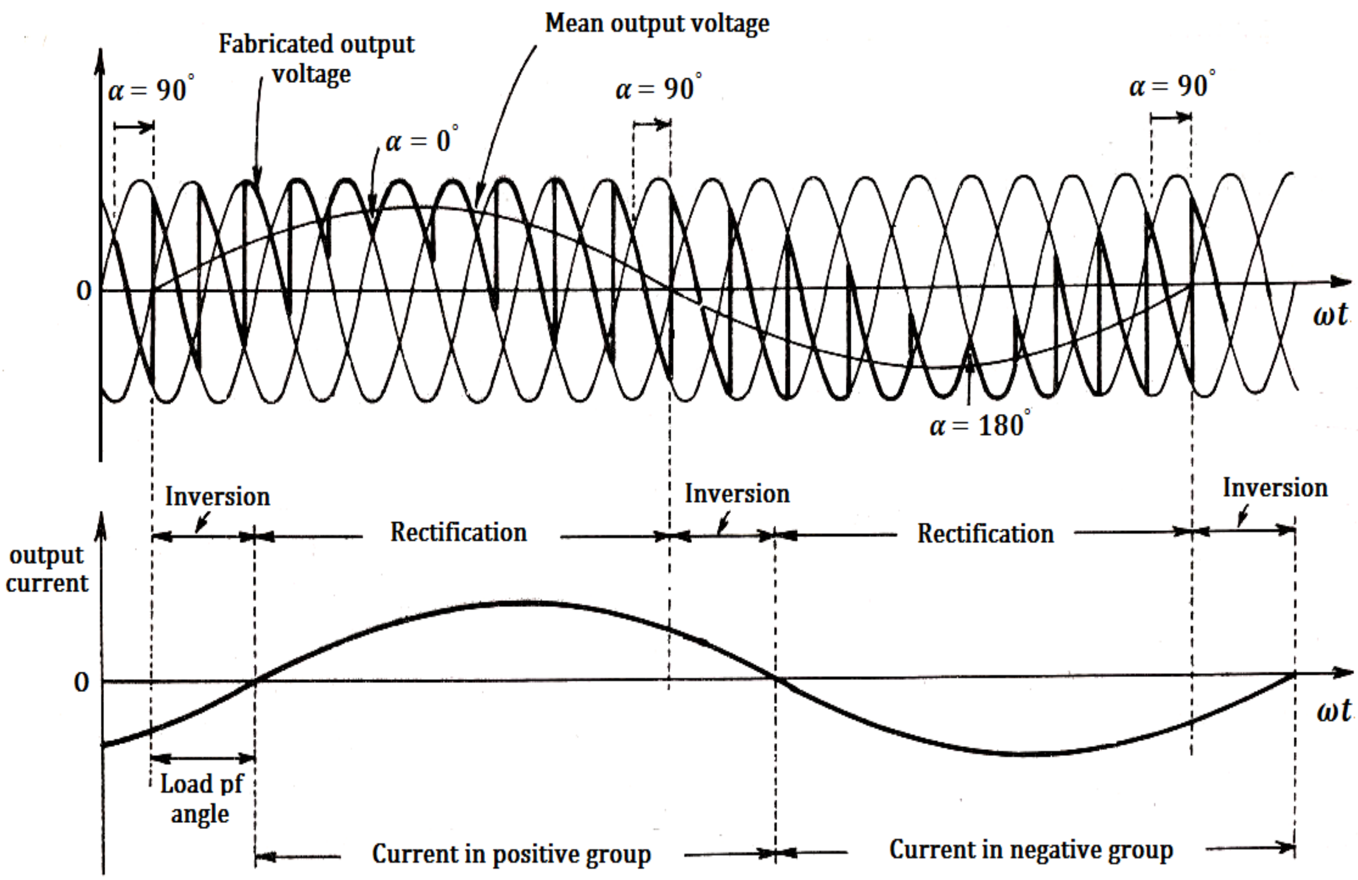

Figure 17 Voltage *and current waveforms of 3 phase to single phase halfwave cycloconverter*

- For converting three-phase supply at one frequency to single phase supply at lower frequency, the basic principle is to vary progressively the firing angle of three thyristor of three phase half-wave circuit.
- In figure 16, firing angle at A, α is 90°, At B, firing angle(α) is somewhat less then 90°, at C the firing angle is still further reduced than it is at B and so on.

- In this manner, a small delay in firing angle introduced at A,D,E,F and G. At G the firing angle is zero and the mean output voltage , given by $V_o = V_{do} \cos\alpha$, is maximum at G.
- At A, the mean output voltage is zero as $\alpha = 90^{\circ}$.
- After point G, a small delay in firing angle is further introduced progressively at points H,I,J,K,L and M. At M, the firing angle is again 90° and the value of mean output voltage is zero.
- In the fig 16, the single-phase output voltage, fabricated from 3 phase input voltage is shown by thick curve. Mean output voltage is obtained by joining point pertaining to average voltage values.
- For example, at A, $\alpha = 90^{\circ}$, $V_o = 0$; at G, $\alpha = 0^{\circ}$, therefore V_o has maximum mean output voltage so on.
- Figure 16 reveals that on half cycle of fundamental frequency output voltage, there are eight half cycles of supply frequency voltage. This shows that output frequency $f_o = \frac{1}{8} f_s$ where f_s is the supply frequency.
- In thyristor converter circuit, current can only flow in one direction, for allowing the current in both direction during one complete cycle of the load current, two three phase halfwave converter is must be connected in antiparallel as shown in figure 15(b).
- The converter circuit that allows the current during positive half cycle of load current is called positive converter group, group permitting flow of current during negative half cycle of load current is know as negative group converter.
- Examination of figure 17 reveals that when output current is positive, positive converter conducts.
- Under this condition, positive converter acts as rectifier when output voltage is positive and as an inverter when output voltage is negative.
- When output current is negative, the negative converter conducts.
- Figure 15(b) is almost similar to a dual converter where two phase-controlled converter are connected in anti parallel.
- As a dual converter also both component converter belonging to one phase can be phase controlled simultaneously to fabricate output voltage.
- Though the output voltage of two converters in the same phase have the same average value, their output voltage however functions of time are, however, different and as a result, there will be net potential difference across the two converter, this is similar to dual converter.
- The circulating current can be avoided by removing gating from idle converter or can be limited to a low value by inserting an inter-group reactor between positive and negative group converter.
- If α_p and α_n are the firing angle for positive and negative group converters respectively, then these firing angle should be controlled as to satisfy the relation $\alpha_p + \alpha_n = 180^{\circ}$

3.5 Three phase to three phase mid-point type step down cycloconverter with R-L load.

3.5.1 Three phase to three phase 3 pulse cycloconverter

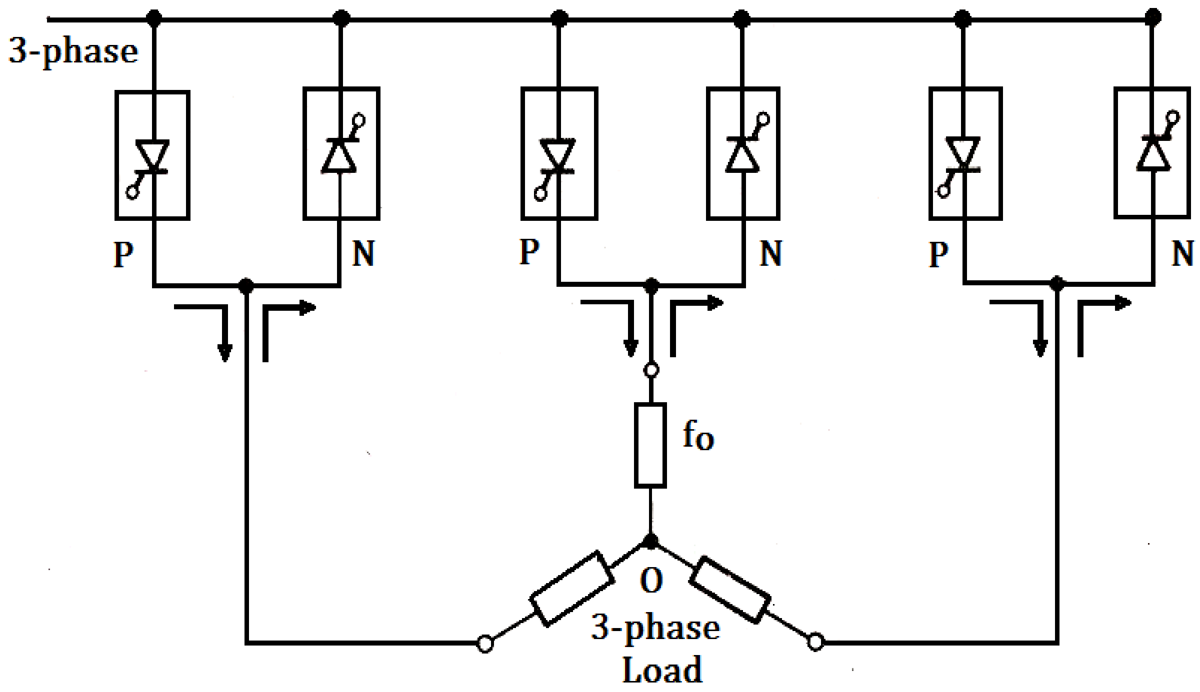

Figure 18 3 phase to 3 phase cycloconverter employing 3 phase halfwave circuit schematic diagram

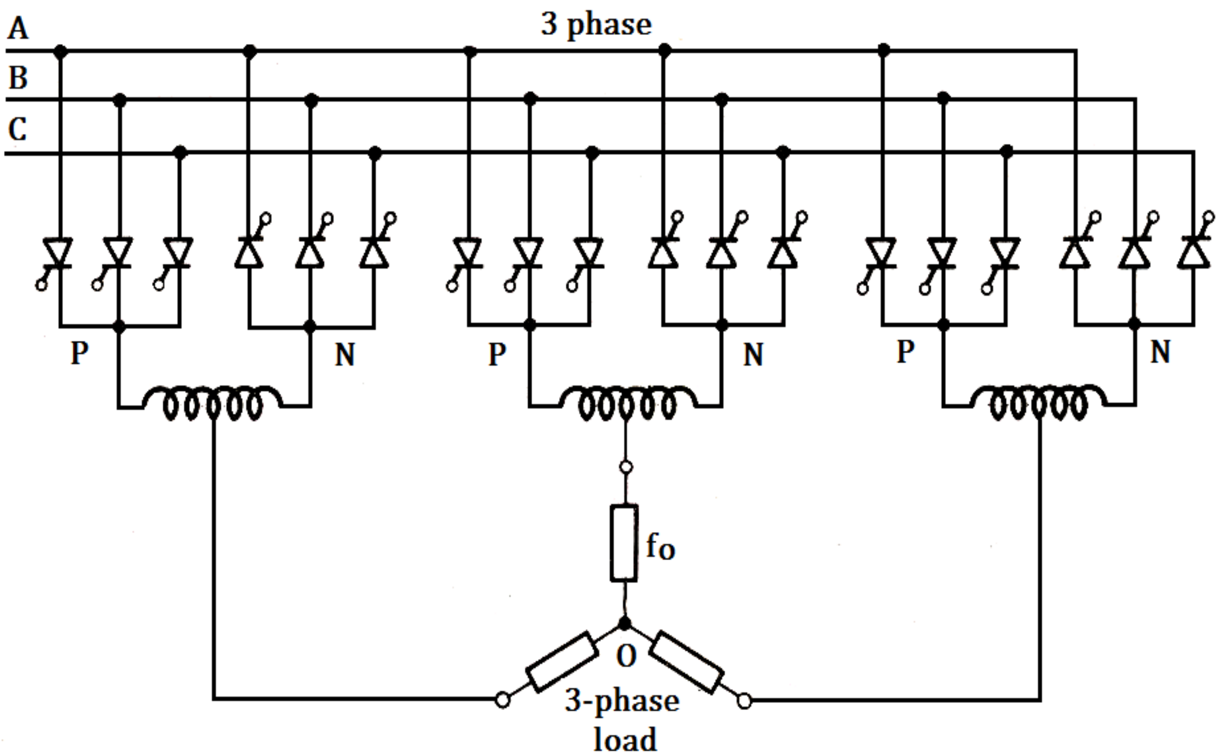

***Figure 19** 3 phase to 3 phase cycloconverter basic circuit arrangement employing halfwave circuit*

- When 3-phase low-frequency output is required, then three sets of phase controlled 3 phase to single-phase circuits are inter connected as shown in figure 18.
- Each phase of 3 phase output must have displacement of 120° figure 19 shows the circuit arrangement of 3 phase to 3 phase cycloconverter using three sets three phase half-wave circuit employing a total of 18 thyristors.
- The device is called three phase to 3 phase cycloconverter.

3.5.1 Three phase to three phase 6 pulse cycloconverter (Bridge circuit)

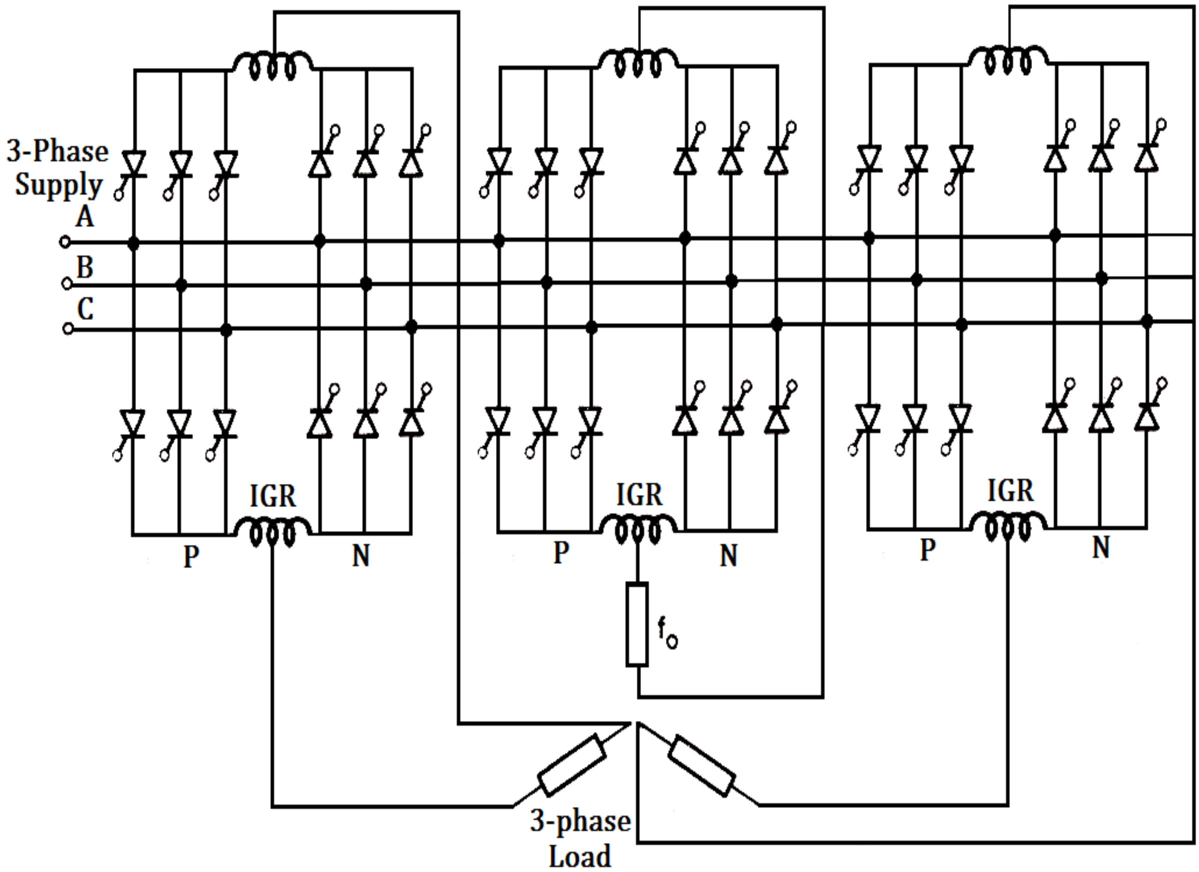

Figure 20 *Three phase to three phase 6 pulse cyccloconverter*

- Out of several configuration of 3 phase to 3 phase cycloconverter, this is the most important scheme, used for large industrial drive is presented.
- This scheme, shown in figure 20 employs 36 thyristor and is called 6 pulse, 3 phase to 3 phase cycloconverter.
- In this circuit, each phase group consist of 3 phase dual-converter with two IGR.
- The load phase, shown in star in figure 20 must not be interconnected. If it is done, then positive group of one output phase and negative group of other output phase would be joined together through IGR without load impedance which is undesirable.
- The magnitude of output voltage in 3 phase bridge circuit of figure 20 is doubled of that in the 18 thyristor circuit.
- Three phase bridge circuit gives a smooth variations of output voltage, but its control circuit is complex and expensive.

3.6 Output voltage Equation for a Cycloconverter

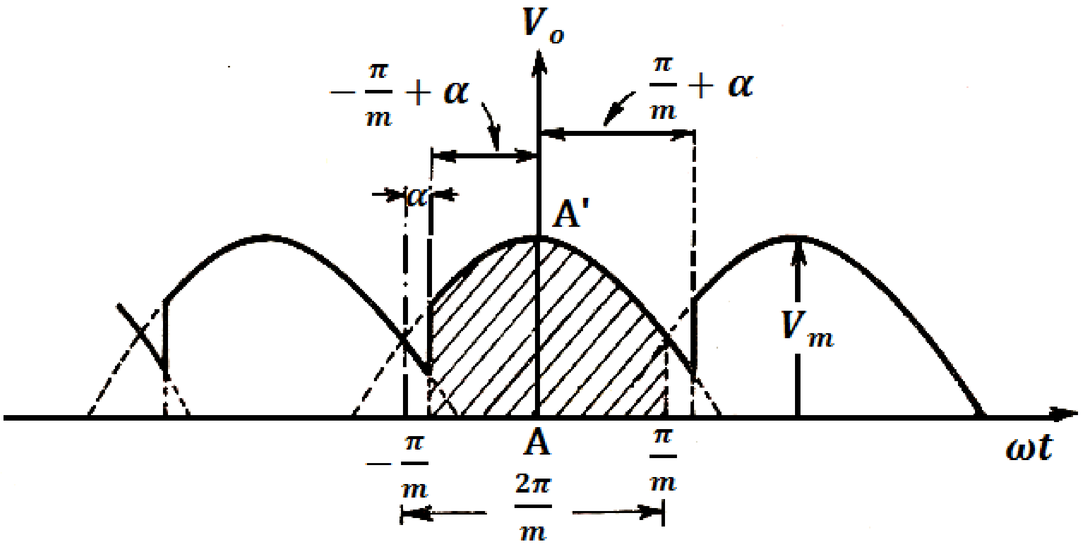

Figure 21 *Output voltage wavefrom for m phase halfwave converter.*

- In this section, emf expressions for the line commutated phase-controlled cycloconverter are discussed.
- A cycloconverter is essentially a dual converter but so operated as to produce an alternating output voltage. Each SCR in cycloconverter works as phase controlled converter with a varying firing angle.
- In three phase cycloconverter each phase conducts for $\frac{2\pi}{3}$ radians of a cycle of 2π radians. In general, for an m-phase half-wave converter, each phase conducts for $\frac{2\pi}{m}$ radians in one cycle of 2π radians. this is shown in figure. with time origin AA' taken at peak value of supply voltage, the instantaneous phase voltage is

$$v = V_m \cos \omega t = \sqrt{2}\, V_{ph} \cos \omega t$$

Where V_{ph} = rms value of per-phase supply voltage.

- It is seen from the figure that conduction takes place from $-\frac{\pi}{m}$ to $\frac{\pi}{m}$ for α=0°. For any firing angle α, the conduction is from $\left[-\frac{\pi}{m}+\alpha\right]$ to $\left[\frac{\pi}{m}+\alpha\right]$. Thus average value of output dc voltage V_d equal to the average height of shaded area in figure is

$$V_d = \frac{m}{2\pi}\int_{-\left[\frac{\pi}{m}+\alpha\right]}^{\left[\frac{\pi}{m}+\alpha\right]} V_m \cos \omega t \, d(\omega t) = V_m \left[\left(\frac{m}{x}\right)\sin\frac{\pi}{m}\right]\cos\alpha \; --- (3.1)$$

For 0 firing angle delay, the average value of V_{do} is given as

$$V_{do} = V_m \left[\frac{m}{\pi}\right]\sin\frac{\pi}{m} = \sqrt{2}V_{ph}\left(\frac{m}{\pi}\right)\sin\frac{m}{\pi}$$

- In actual cycloconverter, the firing angle is gradually varied. For any firing angle, the output phase voltage at any point of the low frequency voltage wave is equal to $V_{do}\cos\alpha$ on the assumption of continous conduction. Note that relation $V_{do}\cos\alpha$ neglects the voltage fluctuation superimposed on the average low frequency waveform.
- If V_{or} is the fundamental rms value of per phase output voltage of cycloconverter, the peak output voltage for zero firing angle is

$$\sqrt{2}V_{or} = V_{do} = \sqrt{2}V_{ph}\left(\frac{m}{x}\right)\sin\frac{\pi}{m}$$

or

$$V_{or} = V_{ph}\left(\frac{m}{x}\right)\sin\frac{\pi}{m} - -(3.2)$$

- In practice, the firing angle α_p of positive group cannot be reduced to zero, for this firing angle corresponds to $\alpha_n = 180 - \alpha_p = 180$ for negative group. Actually, inverter firing angle can never be equal to 180° because of commutation overlap and thyristor on time. As a result, firing angle for positive group can never be zero but must have some finite value. Let this minimum value of firing angle be α_{min} that is possible in practical cycloconverter. For this firing angle, maximum output voltage per phase is

$$V_{dmx} = V_{do}\cos\alpha_{min} = rV_{do} - - - (3.3)$$

or

where, $r = \cos\alpha_{min}$ and is called voltage reduction factor

- Thus the expression for the fundamental rms phase value of the output voltage of a cycloconverter is given by

$$V_{or} = r\left[V_{ph}\left[\frac{m}{\pi}\right]\sin\left[\frac{\pi}{m}\right]\right] - - - -(3.4)$$

- As α_{min} is always greater than zero, the voltage reduction factor, r, is always less than unity.

3.7 DC-link converter

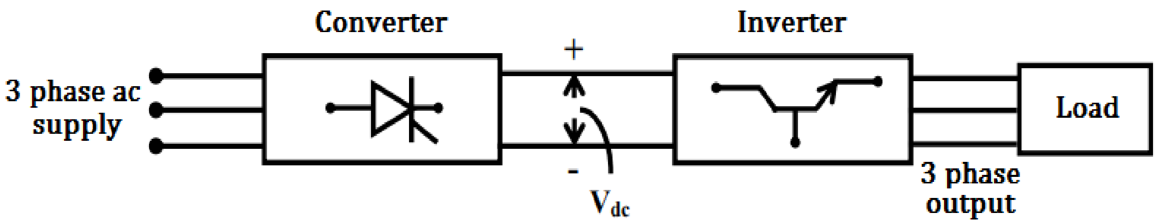

Figure 22 *DC-link converter*

- The cyclo-converter is normally compared with dc link converter , where two power controllers, first one for converting from ac input at line frequency to dc output, and the second one as inverter to obtain ac output at any frequency from the above dc input fed to it.
- The thyristors, or switching devices of transistor family, which are termed as self-commutated ones, usually the former, which in this case is naturally commutated, are used in controlled converters (rectifiers). The diodes, whose cost is low, are used in uncontrolled ones.
- But now-a-days, switching devices of transistor family are used in inverters, though thyristors using force commutation are also used. A diode, connected back to back with the switching device, may be a power transistor (BJT), is needed for each device.

- The number of switching devices in dc link converter depends upon the number of phases used at both input and output. The number of devices, such as thyristors, used in cyclo-converters depends on the types of connection, and also the number of phases at both input and output.
- It may be noted that all features of a cycloconverter may not be available in a dc link converter. Similarly, certain features, like Pulse Width Modulation (PWM) techniques as used in inverters and also converters, to reduce the harmonics in voltage waveforms, are not applied in cyclo-converters

3.7.1 Advantages and disadvantages of dc link converter

Advantages

- The output frequency can be varied from zero to rated value, with the upper frequency limit, being decided by the turn-off time of the switching devices, which is quite low due to the use of transistors in recent time.
- The control circuit here is simpler, as compared to that used in cyclo-converter.
- It has high input power factor, if diode rectifier is used in the first stage. If phase-controlled thyristor converter is used, power factor depends upon phase angle delay.
- It is suitable for higher frequencies.

Disadvantages

- The conversion is in two stages, using two power controllers – one as converter and other as inverter.
- Forced commutation is required for the inverter, if thyristors are used, even though phase control is used in converter, where natural commutation takes place.
- The feature of regeneration is somewhat difficult, and also is involved to incorporate in a dc link converter.
- The output waveform of the inverter is normally a stepped one, which may cause non-uniform rotation of an ac motor at very low frequencies (< 10 Hz). The distorted waveform also causes system instability at low frequencies. This can be reduced by using PWM technique.