MODULE 4
DUAL CONVERTERS & AC VOLTAGE CONTROLLERS

One converter at a time will operate. Consequently, there isn't any current flowing between the converters.
• Vdc and Idc are positive during converter 1 operation, and the firing angle (α1) will be 0<α1< 90.
• Vdc and Idc are negative during converter 2 operation, and the firing angle (α2) will be 0<α2< 90.

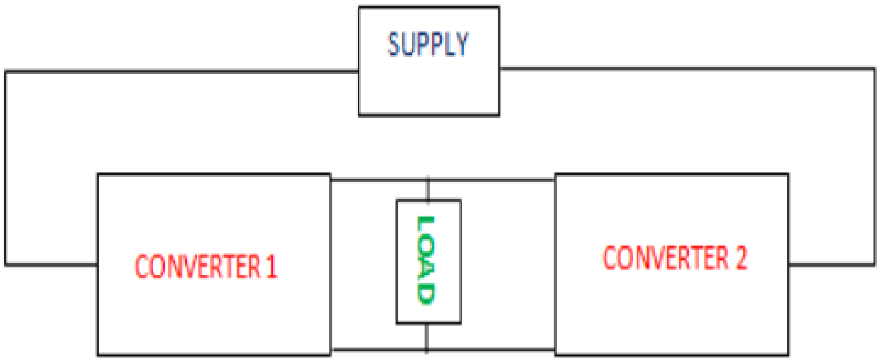

Figure: 2.28 Block diagram of dual converter

Mode of Circulating Current

At the same moment, two converters will be in the ON state. Thus, there is circulating current.
• By adjusting the firing angles, the firing angle of converter 1 (α1) plus the firing angle of converter 2 (α2) equals 180.
• When the firing angle is 0<α1< 90o, Converter 1 operates as a controlled rectifier; when the firing angle is 90<α2< 180, Converter 2 operates as an inverter. Vdc and Idc are both positive in this situation.
• When the firing angle is 90o<α1< 180o, Converter 1 functions as an inverter, and when the firing angle is 0<α2< 90, Converter 2 functions as a controlled rectifier. Vdc and Idc are both negative in this situation.
• Below is a display of the four quadrant operation.

Dual-phase, three-phase converter

In this case, a three-phase inverter and rectifier are used. Similar procedures apply to single-phase dual converters. The three-phase AC supply will be converted to DC by the three-phase rectifier. After filtering, this DC is sent into the second converter's input. Three-phase AC will be the output when it completes the DC to AC conversion. applications with a maximum output of two megawatts. The circuit is shown below.

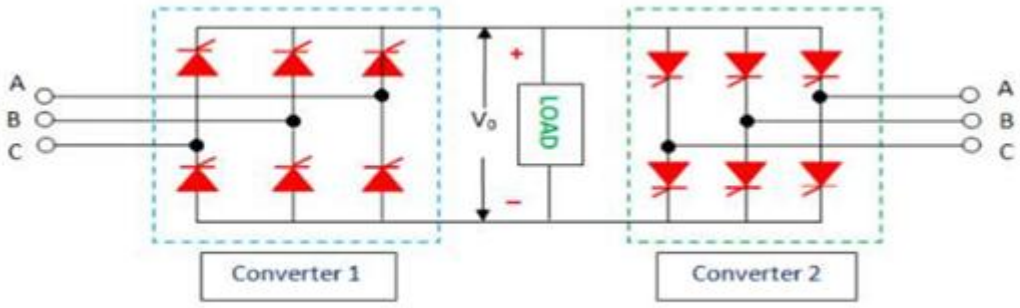

Figure: 2.33 Three phase dual converter

Using a Dual Converter
• DC motor direction and speed control.
• Useful whenever reversible DC is needed.
• DC drives with variable speeds for industry.

AC voltage Controllers

Overview of AC voltage controllers By placing thyristors between the load and a constant voltage ac source, AC voltage controllers, also known as ac line voltage controllers, are used to change the RMS value of the alternating voltage provided to a load circuit. By adjusting the triggering angle of the thyristors in the AC Voltage Controller circuits, the RMS value of the alternating voltage provided to a load circuit may be managed. To put it simply, an AC voltage controller is a kind of thyristor power converter that creates a variable voltage ac output from a fixed voltage, fixed frequency ac input supply. By altering the trigger angle "α," the RMS value of the ac output voltage and the ac power flow to the load are managed. • AC controllers with a single phase • AC controllers with three phases In our nation, single phase AC controllers run on a single phase ac supply voltage of 230V RMS @ 50Hz. Three-phase AC controllers run on a 400V RMS, three-phase AC supply with a frequency of 50 Hz. AC voltage controller performance parameters

AC voltage controller applications
• Control of lighting and illumination in circuits using ac power.
• Heating via induction.
• Heating for homes and businesses.
• The tap of transformers changes while they are under load.
• Induction motor speed control (both single- and multi-phase ac induction motor control).
• Controls for AC magnets.

Figure: 3.1 Block diagram of AC voltage controller

The primary function of a single phase AC voltage controller with R load AC to AC voltage converters is to manage the output voltage by means of the AC mains. At the load, certain parts of the supply sinusoid show up, while the rest parts are blocked by the semiconductor switches. Numerous topologies and techniques for regulating voltage have surfaced, the majority of which are connected to the advancement of semiconductor devices.

Factor of Power A nonlinear's power factor merits particular attention. The non-sinusoidal load current and supply voltage are shown in Fig. 2.35. The φ1 'Fundamental Power Factor' angle is the difference between the fundamental load/supply current and the supply voltage. The 'Displacement Factor' is another name for Cosφ1. This does not, however, take into consideration the system's overall reactive power consumption. Even if the real load is resistive, this power factor still exists! The trigger-angle dependent harmonics are also used to pull the reactive power.

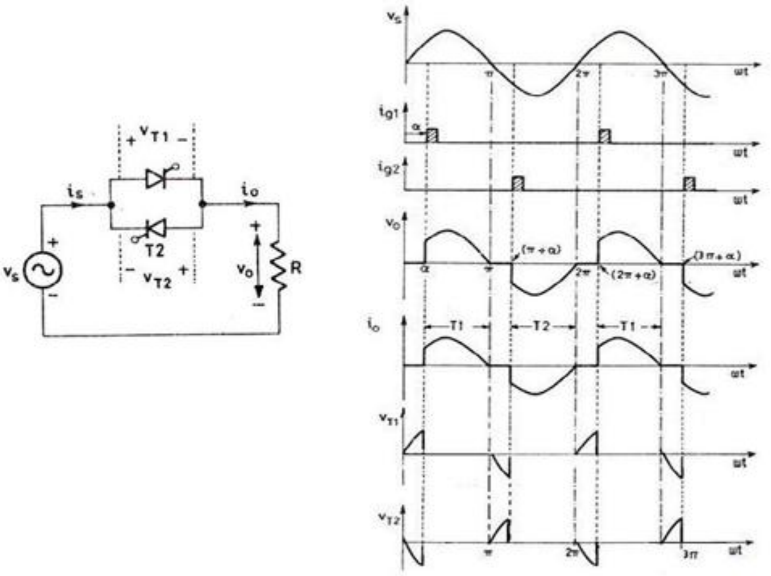

Figure: 3.2 Circuit diagram and output waveforms of AC voltage controller with R load

The rms voltage Vrms decides the power supplied to the load. It can be computed as

$$V_{rms} = \sqrt{\frac{1}{\pi}\int_{\alpha}^{\pi} 2V^2 \sin^2 \omega t \quad d\omega t}$$

$$= V\sqrt{1 - \frac{\alpha}{\pi} + \frac{\sin 2\alpha}{2\pi}}$$

RL load with a single phase AC voltage controller

Figure 2.36 shows how the PAC operates with inductive loads. In every cycle, the current increases from zero. Unlike a resistive load, it quenches after that moment rather than at the applied voltage's zero crossing. As a result, the supply voltage keeps applying pressure on the load until the load current drops to zero. If the TRIAC (or the anti-parallel device) is already conducting in the opposite way, a single-pulse trigger for it or the anti-parallel SCR has no impact on the devices. Since the devices are not forward biassed by the supply voltage when the trigger pulse occurs, they would not conduct as planned. A single pulse trigger will function until the trigger angle α > φ, where φ is the inductive load's power factor angle. Here, a train of pulses is needed. The only range in which the output voltage may be controlled is between φ and 180o. Fig. 26.6 provides further information on the load current waveform. There are two parts to the current. There would be no 99 | P a g e transients in the load current if the devices were activated at the load's power factor angle. The first component of the load current is the steady state component, and the second is the transient component. In such scenario, the load current is completely sinusoidal.

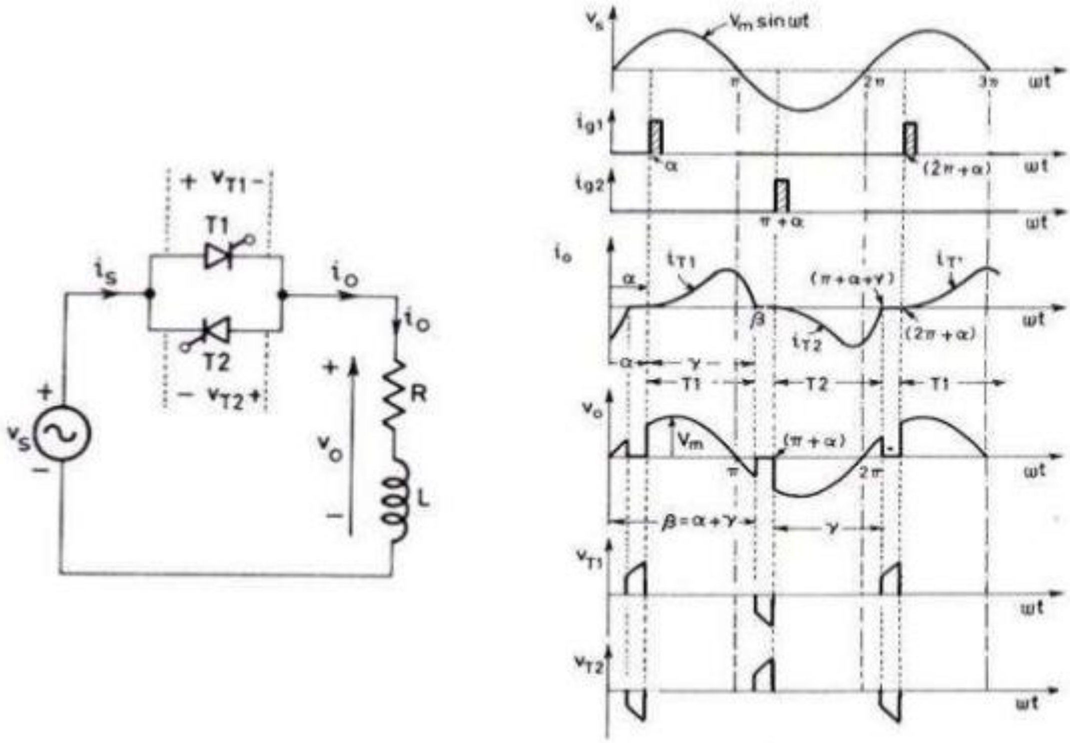

Figure: 3.3 Circuit diagram and output waveforms of AC voltage controller with RL load

$$L\,{di}/{dt} + Ri = v_s$$

$$i_{load} = \frac{\sqrt{2}V}{Z}\left[\ \sin(\omega t - \phi) + \sin(\alpha - \phi)e^{-\frac{R}{L}\left(\alpha/\omega - t\right)}\ \right]$$

Overview of Cyclo Converters

Historically, the cycloconverter has only been used in drives with very high power—typically more than one megawatt—where no other kind of drive is suitable. Examples include ship propulsion drives, reversible rolling mill drives, the 13 MW German-Dutch wind tunnel fan drive, and cement tube mill drives larger than 5 MW. The traditional Cycloconverter has several performance limitations, the worst of which is an output frequency that is only around one-third of the input frequency. It also requires a large number of thyristors—at least 36 and typically more—for good motor performance, in addition to a very complicated control circuit.

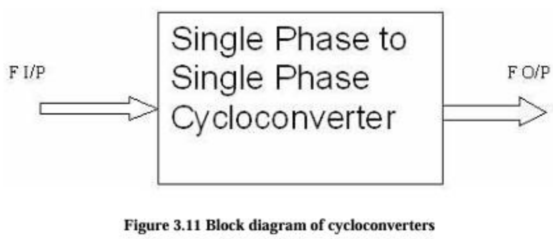

Figure 3.11 Block diagram of cycloconverters

Two thyristors each make up the positive and negative banks of the Cycloconverter's four thyristors. Phase control of the two positive bank thyristors regulates the output voltage when the load is receiving positive current while keeping the negative bank thyristors off, and vice versa when the load is receiving negative current. Figure 3.11 displays an idealised output waveform for a 45 degree load phase angle and a sinusoidal load current. In order to prevent the mains from being shorted via the two thyristor banks, which might lead to waveform distortion and device failure from the shorting current, it is crucial to always keep the non-conducting thyristor bank off. One of the Cycloconverter's main control issues is how to switch between banks as quickly as feasible to prevent distortion and make sure the two banks don't operate simultaneously. Placing a center-tapped inductor, also known as a circulating current inductor, between the outputs of the two banks is a popular modification to the power circuit that eliminates the need to keep one bank off. Without shorting the mains, both banks may now do business jointly. Additionally, both banks are continuously operated by the circulating current in the inductor, which produces better output waveforms. However, this method is seldom used since the circulating current lowers the input power factor and the circulating current inductor is often costly and large.

The output frequency of a 1-φ cycloconverter is lower than the supply frequency. The AC supply provides the natural commutation that these converters need. The forward bias of Thyristors P1 and N2 occurs during the positive half cycle of supply. P1 receives the first triggering pulse, which causes it to begin conducting. P1 turns off when the supply becomes negative, while P2 and N1 are forward biassed during the negative half cycle of the supply. P2 conducts because it is activated. N1 in the negative half cycle and N2 in the positive half cycle are activated in the subsequent supply cycle. As a result, we can see that the output frequency in this case is half of the source frequency.

Principles of Operation

Starting with the most basic single-phase to single-phase (1f-1f) cycloconverter, the next sections will explain the fundamentals of its functioning.

From one phase to another (1 Φ-1 Φ) The cycloconverter

The single-phase to single-phase cycloconverter (Fig. 3.12) should be examined first in order to comprehend the fundamentals of cycloconverter functioning. This converter is made up of two full-wave rectifier circuits connected back-to-back. The operational waveforms for this converter with a resistive load are shown in Fig. 3.13.

Thyristors function similarly to diodes when the firing angle is zero. Keep in mind that the firing angles for the positive and negative converters are designated as αP and αN, respectively. As shown in Fig. 3.13, the input voltage, vs, is an ac voltage at a frequency, fi. Assume for simplicity's sake that every thyristor is fired at α=0°.

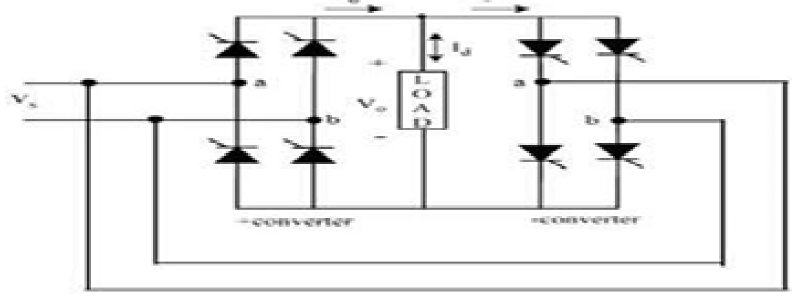

Figure 3.12 circuit diagram of cycloconverter

Examine how the cycloconverter works to get a quarter of the input frequency at the output. The positive converter runs by giving the load current for the first two versus cycles. As seen in Fig. 3.13, it rectifies the input voltage, causing the load to experience four positive half cycles. The negative converter runs for the following two cycles, delivering current to the load in the opposite direction. Since the resistive load current will have the same waveform as the voltage, only scaled by the resistance, the current waveforms are not shown in the figures. Keep in mind that the second converter is turned off while the first one is operating, preventing any current from flowing between the two rectifiers.

However, in order to switch off SCRs at the appropriate frequency in the case of a step-up cyclo-converter, forced commutation circuits are required. These circuits are comparatively quite intricate. As a result, step-down cyclo-converters, which reduce the frequency below the input frequency, make up the majority.

Both the positive and negative half cycle times, and hence the frequency, may be altered by adjusting the thyristors' switching period. It is simple to lower this basic output voltage frequency in increments of 1/2, 1/3, 1/4, and so on.

The output waveforms of a cyclo-converter that generates one-fourth of the input frequency are seen in the above graphic. In this case, the positive converter runs and provides the load with current for the first two cycles.

Four positive half cycles are seen in the graphic, indicating that it rectifies the input voltage and produces a unidirectional output voltage. The negative converter then runs and provides load current for the next two cycles.

Since this is a resistive load, where current (although of a smaller magnitude) precisely matches voltage, current waveforms are not shown here.

In this case, there is no circulating current between the two converters since one is turned off if the other is operating. The majority of cyclo-converters work in circulating current mode, which permits continuous current to flow between the converters and a reactor, due to the complexity of the discontinuous mode of control system.

Both purely resistive (R) and inductive (R-L) loads may be used with this cyclo-converter of the circulating current type.

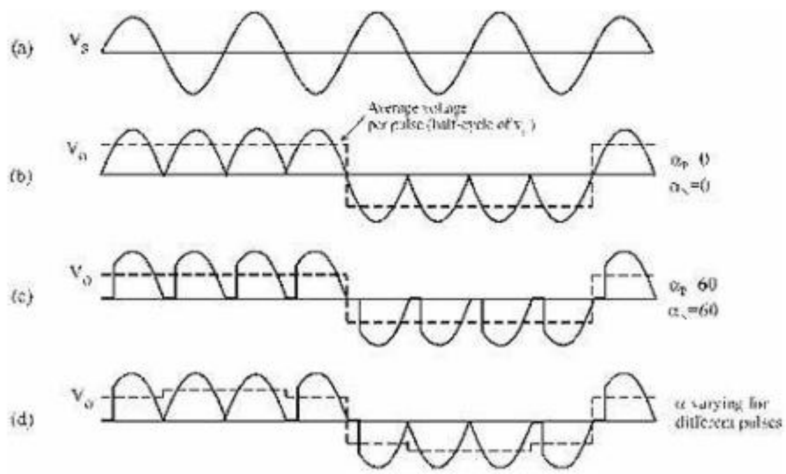

Figure 3.13 Input and output waveforms of cycloconverter