Unit 5: Converters

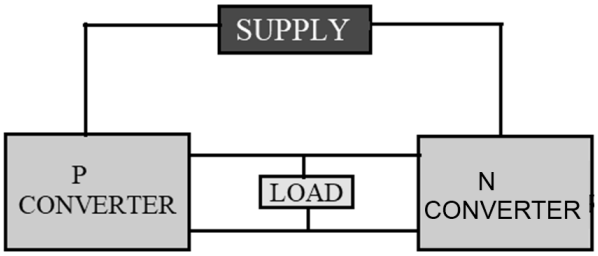
Module 17: DC link variable converter; Dual Converter without circulating current

Introduction:

DUAL-CONVERTERS

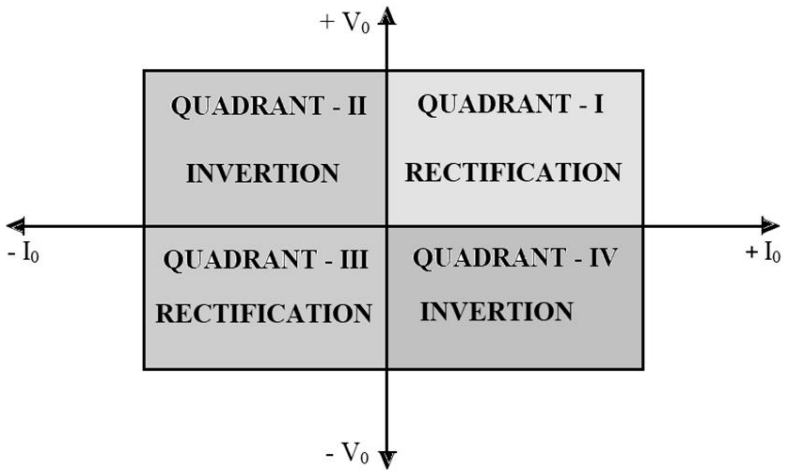
Dual converter, the name itself says two converters. It is an electronic circuit which comprises of two converters. One will perform as a rectifier and the other will perform as an inverter. Therefore, we can say that double processes will occur at a moment. Here, two full converters are arranged in anti-parallel pattern and linked to the same dc load. These converters can provide four quadrant operations. It is mostly found in variable speed drives.

The basic block diagram is shown below.



Quadrants of operation of a Dual Converter

A Dual Converter is able to work in all four Quadrants to get either positive or negative polarity DC from AC rectification by the forward converter and reverse converter. In a dual converter, two converters are connected together back to back. One of the bridge works as a rectifier (converts AC to DC), another half bridge works as an inverter (converts DC to AC) and connected commonly to a DC load. Here two conversion processes take place simultaneously, so it is called as a dual converter. The dual converter can provide four quadrant operations. The four quadrant operation is shown below.

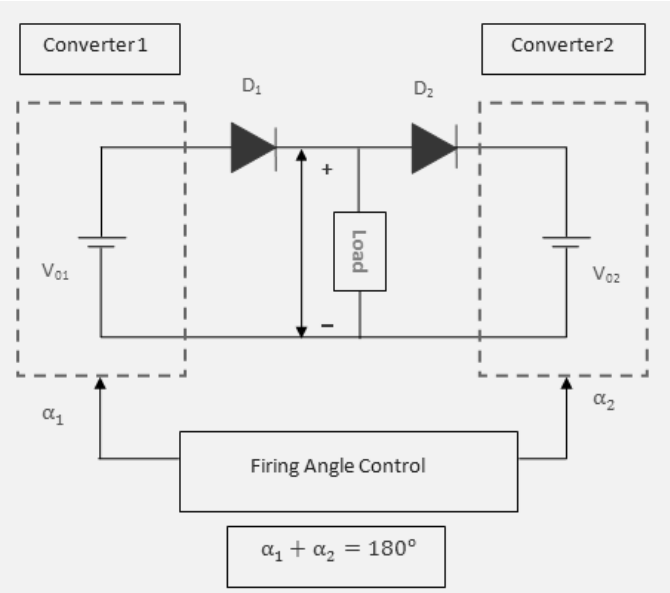


Principle of Dual Converter

The dual converter basic principle of operation can be explained with reference to the simplified equivalent diagram of the DC circuit shown in the figure below. In this simplified representation, two assumptions are made.

- Dual converters are ideal that means they produce pure DC output terminals without containing any ripples.
- Each two-quadrant converter is assumed to be a controllable direct voltage source, connected in series with a diode.

Here Diode D1 and D2 represent the unidirectional current flow characteristics of the converters. However, the direction of current can be in any way. Let us assume, the average output voltage of the converter 1 is V01 and converter 2 is V02. To make the output voltage of the two converters in same polarity and magnitude, the firing angles of the thyristors have to be controlled.



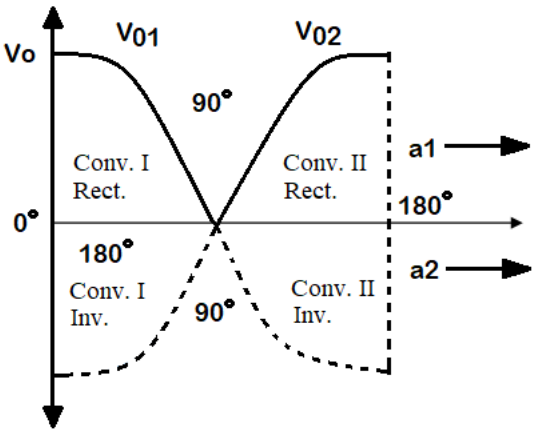
Ideal Dual Converter Simplified Representation

Average output voltage of Single-phase converter = $2V_m$ COSα/ π
Average output voltage of Three-phase converter = $3V_m$ COSα/ π
For converter 1, the average output voltage, $V_{01}= V_{max}$ COSα_1
For converter 2, the average output voltage, $V_{02}= V_{max}$ COSα_2

The Output voltage is given by,

$$V_0 = V_{01} = -V_{02}$$
$$V_{max}Cos\alpha_1 = -V_{max}Cos\alpha_2$$
$$Cos\alpha_1 = Cos(180^o - \alpha_2) \; or \; Cos\alpha_2 = Cos(180^o + \alpha_2)$$
$$\alpha_1 + \alpha_2 = 180^o \; And \; \alpha_1 - \alpha_2 = 180^o$$

The firing angle can never be greater than 180. So, $\alpha_1+ \alpha_2 = 180^0$



Modes of Operation of Dual Converter

There are two functional modes: Non-circulating current mode and circulating mode.

Non-Circulating Current Mode

One converter will perform at a time. There is no circulating current between the converters.

- During the converter 1 operation, the firing angle (α1) will be 0<α1< 900 (Vdc and Idc are positive)
- During the converter 2 operation, firing angle (α2) will be 0<α2< 900 (Vdc and Idc are negative)

Circulating Current Mode

In this mode, both converters will be in the ON condition at the same time. So, circulating current is present.

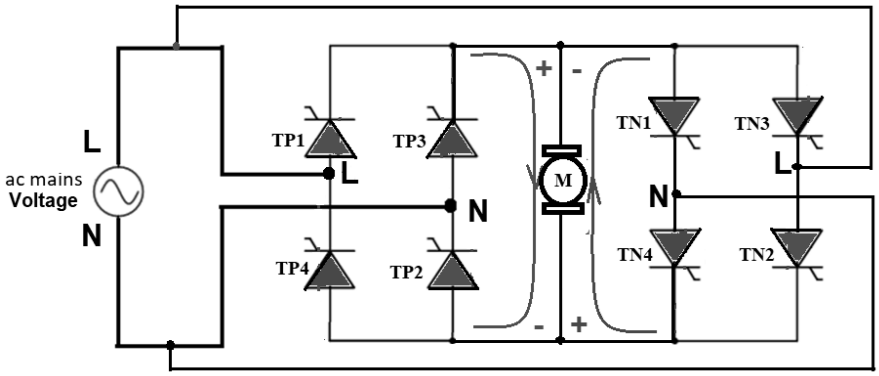
- The firing angles are adjusted such that $\alpha_1 + \alpha_2 = 180^0$. Firing angle of converter 1 is α1 and firing angle of converter 2 is α_2.
- In this mode, the Converter 1 works as a controlled rectifier when the firing angle is $0 < \alpha_1 < 90^0$ and Converter 2 works as an inverter when the firing angle is $90^0 < \alpha_2 < 180^0$. In this condition, V_{dc} and I_{dc} are positive.
- Converter 1 works as an inverter when firing angle be $90^0 < \alpha_1 < 180^0$ and Converter 2 works as a controlled rectifier when the firing angle is $0 < \alpha_2 < 90^0$ in this condition, V_{dc} and I_{dc} are negative.

Single Phase Dual Converter

The blow shown figure shows single phase dual converter using thyristors. As explained above, in single phase dual converter we use single phase rectifier circuit for converting single phase AC into steady DC.

The Converter 1 consists of Rectifier. Then the rectified DC fed to a filter which removes pulses from rectified DC and converts it to a pure DC by filtering.

After that, this pure DC is fed to load and from the load, it is given to inverter circuit which converts this DC to AC and finally this AC of inverter taken as the output.

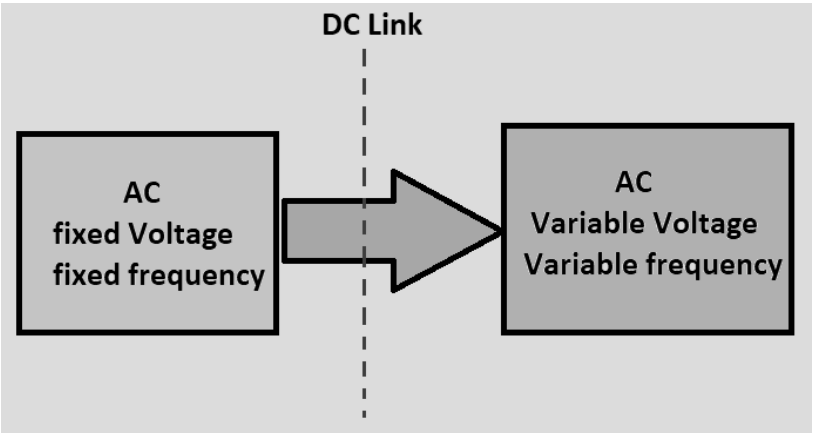


Applications of Dual Converter

- Direction and Speed control of DC motors.
- Applicable wherever, the reversible DC is required.
- Industrial variable speed DC drives.

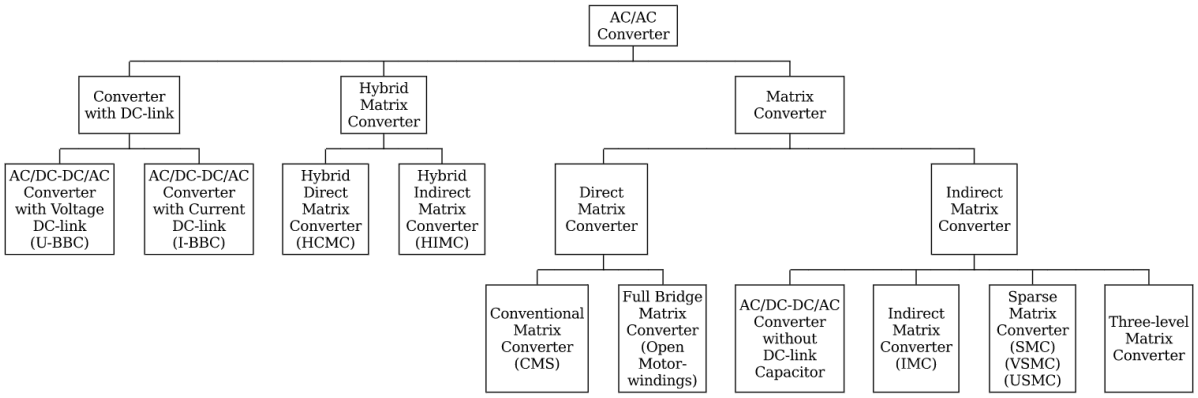
DC Link Variable Converter

- Is a two stage frequency converter
- Converts AC voltage at one frequency to AC voltage at another frequency

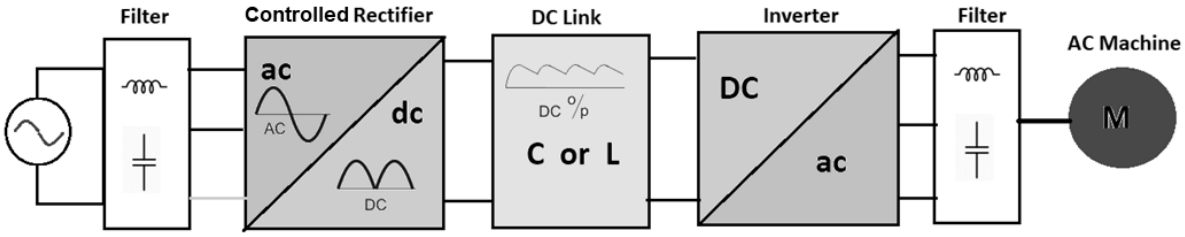


Mainly used for Speed Control of a AC (Synchronous) Motor

Classification of DC Link Converters



Block diagram of DC link Variable Converter



- An ac supply voltage is first rectified to controlled dc by means of controlled rectifiers.
- An Inductor/Capacitor filter is used for filtering the ripples in the output of rectifier.
- The dc is then inverted to ac of the required frequency by means of a forced commutated inverter.

DC Link Variable Converter

There are two types of converters with DC link:

- Voltage-source inverter (VSI) converters and
- Current-source inverter (CSI) converters

Voltage-source inverter (VSI) converters

In VSI converters, the rectifier consists of a diode-bridge and the DC link consists of a shunt capacitor.

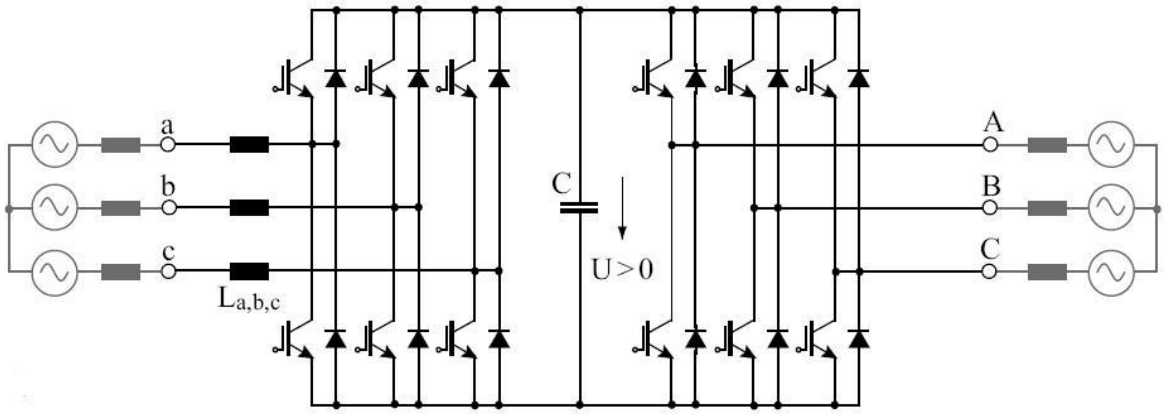


Figure: 3 phase Voltage-source inverter (VSI) converters

Current-source inverter (CSI) converters

In CSI converters, the rectifier consists of a phase-controlled switching device bridge and the DC link consists of 1 or 2 series inductors between one or both legs of the connection between rectifier and inverter.

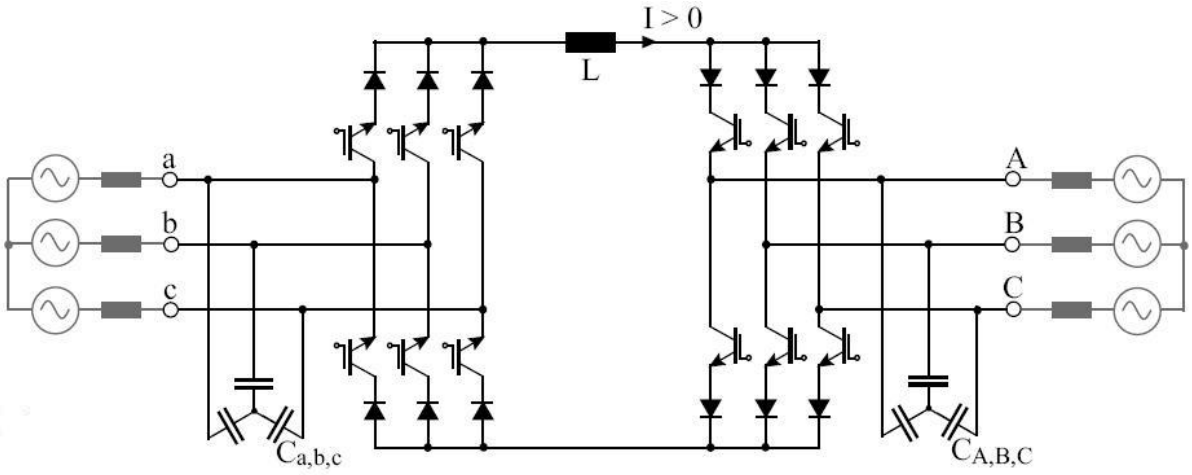


Figure: 3 phase Current-source inverter (CSI) converter

Features of DC Link Converter

- It is more suitable for high frequency applications.
- It generates a stepped wave voltage that causes higher harmonic content.