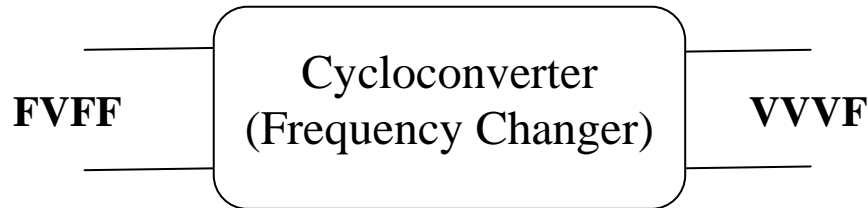


# Cycloconverter (Frequency Changer)

## 1-Main Idea:



**FVFF... Fixed Voltage Fixed Frequency**

**VVVF... Variable Voltage Variable Frequency**

## 2-Definition:

- is a power electronics circuit (a static frequency changer) that used to transfer power from an (ac) supply directly into an (ac) load of different frequency.

(The output voltage is less or equals the input voltage)

(The output frequency is less than the input frequency)

- The cycloconverter output is derived directly from the line-frequency input without an intermediate dc link.
- The basic principle of this converter to construct an alternating voltage wave of lower frequency from successive segment of voltage waves of higher frequency ac supply by a switching arrangement was conceived and patented in 1920s.
- Note that: The maximum output frequency is limited to about one-third of the input ac frequency to maintain an acceptable waveform with a low harmonic content.

### 3-Construction:

- Consists of an array of back-to-back or inverse-parallel connected switches, usually silicon controlled rectifiers (SCRs). By the controlled opening and closing of the switches it is possible to fabricate output voltage waveforms having a fundamental component of the desired output frequency (see Fig. 1).

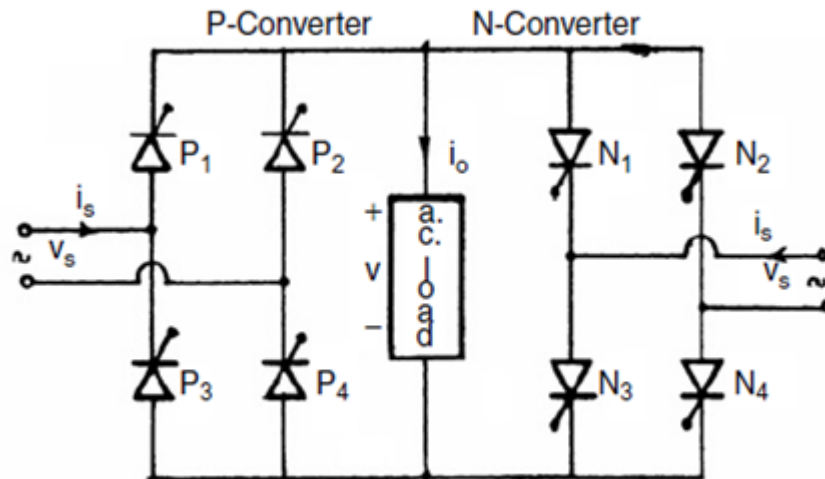
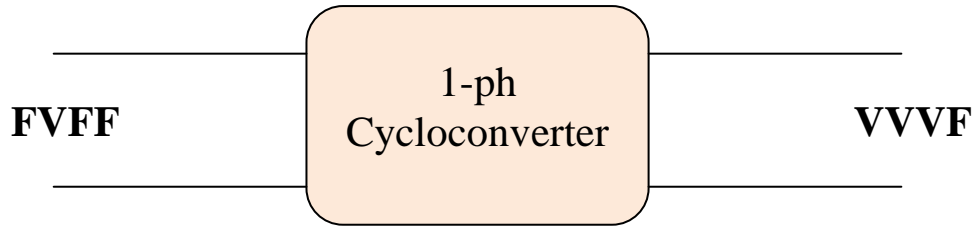


Fig. 1: Power circuit for a single-phase bridge cycloconverter  
(Named as Single Phase Dual Converter)

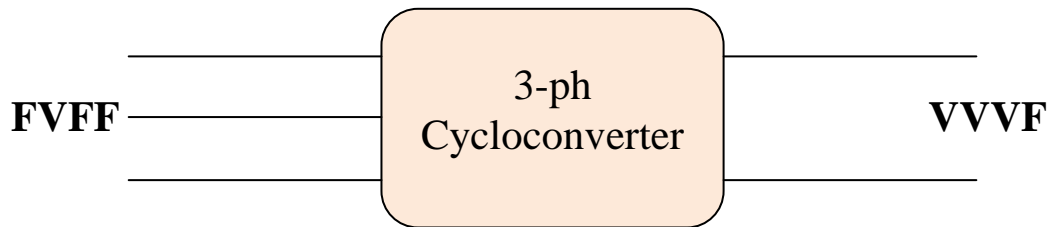
- According to the construction:
  - naturally commutated converter with inherent capability of bi-directional power flow (i.e., current flows from the source to the load and vice versa),
  - the switching losses are considerably low,
  - It is capable of operating even with blowing out of individual SCR fuse.
  - The main limitations of a naturally commutated cycloconverter are:
    - (i) Limited frequency range for sub-harmonic free and efficient operation, and
    - (ii) Poor input power factor, particularly at low-output voltages.

## 4- Basic Forms of Cycloconverters:

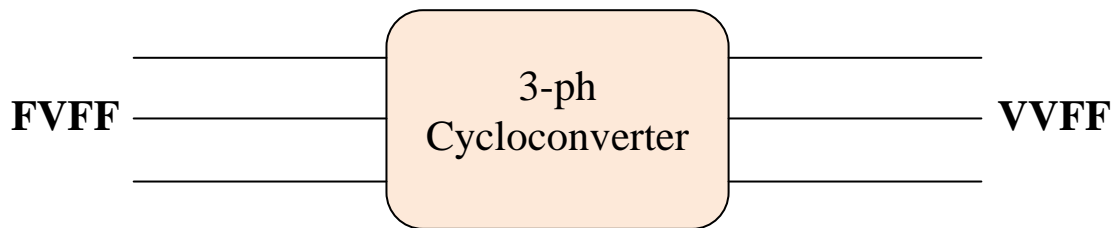
4-1 One phase to One phase.



4-2 Three Phase to One Phase.



4-3 Three Phase to Three Phase.



## 5-Applications:

- 1- In low-speed and very large horsepower applications, it is possible to use cycloconverters to control the speed of synchronous and induction motors.
- 2- Practical uses of the cycloconverter include the speed control of adjustable frequency ac induction motors and in aircraft variable-speed, constant-frequency (VSCF) supply systems.
- 3- 1930s in Germany: (using a type of switches known as Grid-controlled mercury-arc rectifiers) to obtain single-phase supply of  $16\frac{2}{3}$  Hz from a three-phase 50Hz system for driving ac series traction motors,
- 4- 1930s in USA: (using a type of switches known as thyratrons) a cycloconverter using 18 thyratrons supplying a 400 hp synchronous motor was in operation for some years as a power station auxiliary drive.
- 5- Types of switches in (3) & (4) are still used until SCRs became available in 1960s: practical converter for application in large power, low speed variable-voltage variable-frequency (VVVF) ac drives in cement and steel rolling mills as well as in variable-speed constant-frequency (VSCF) systems in air-crafts and naval ships.

In addition to severe output voltage distortion the input current to a cycloconverter is usually significantly distorted. Also, the fundamental component of the input current lags the supply voltage, resulting in poor input power factor, irrespective of whether the load current is lagging, leading, or of unity power factor. Very often both input and output filters may be needed.

## 6-Operation of One Phase to One Phase Cycloconverter:

- The firing angles of the individual two-pulse two-quadrant bridge converters are continuously modulated here, as will be illustrated here depending on Fig.2.
- Because of the unidirectional current carrying property of the individual converters, it is inherent that the positive half cycle of the current is carried by the P-converter and the negative half cycle of the current by the N-converter.

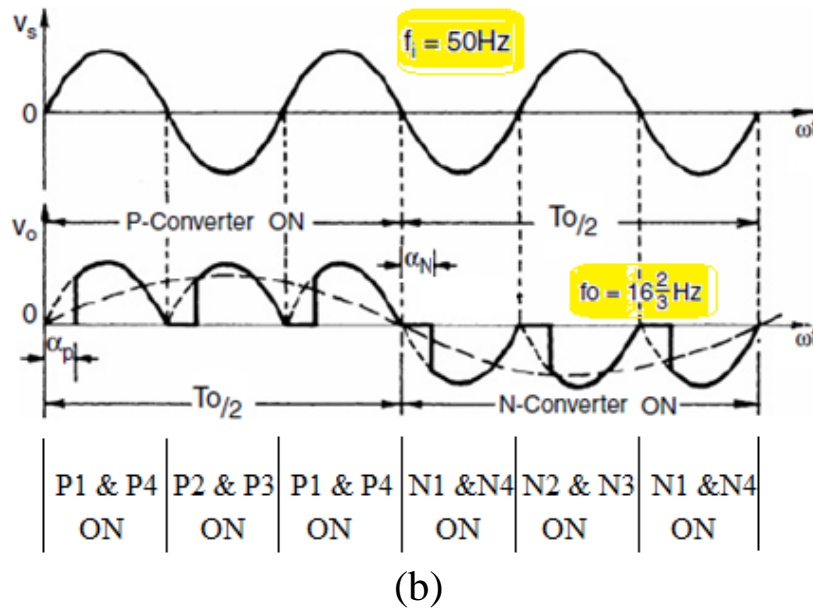
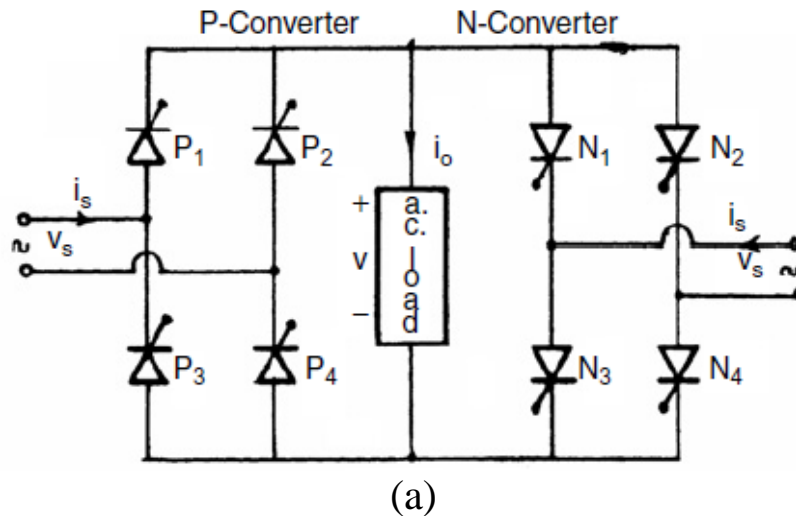


Fig. 2: (a) power circuit for a single-phase cycloconverter, (b) Input and output voltage waveforms of a 50–16<sup>2</sup>/<sub>3</sub>Hz cycloconverter with R load.

- The P- and N- converters operate for alternate  $T_o/2$  periods.
- The output frequency ( $1/T_o$ ) can be varied by varying  $T_o$  and the voltage magnitude by varying the firing angle ( $\alpha$ ) of the SCRs. As shown in the figure, three cycles of the ac input wave are combined to produce one cycle of the output frequency to reduce the supply frequency to one-third across the load.

$\alpha_P$  is the firing angle of SRCs in the P-converter

$\alpha_N$  is the firing angle of SRCs in the N-converter

- Fig.2(b) shows that the waveform with  $\alpha$  remaining fixed in each half cycle generates a square wave having a large low-order harmonic content.
- To obtain output voltage of frequency one-fifth (i.e,  $1/5$ ) the input frequency; see Fig. 3

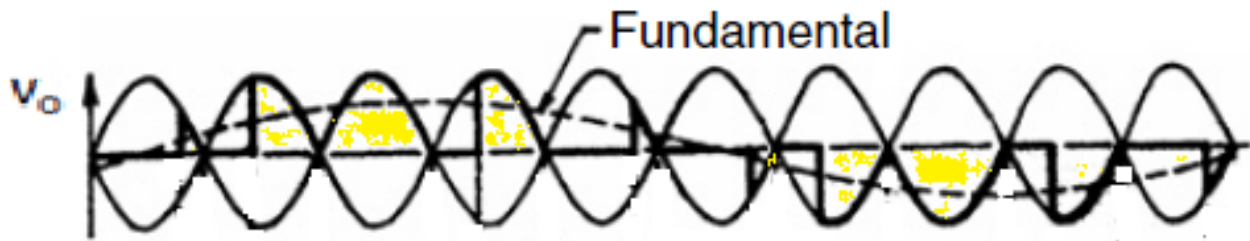


Fig. 3: output voltage waveform of a single-phase/single-phase cycloconverter (Input and output frequency is 50–10Hz) with R load