

# 15. THREE-PHASE INVERTERS

15.1 Three-phase inverters are normally used for high-power applications. Three single-phase parallel, inverters can be connected in parallel as shown in Fig.15.1 to form the configuration of a three-phase inverter.

The gating signals of single-phase inverters should be advanced or delayed by  $120^\circ$  with respect to each other in order to obtain three-phase balanced (fundamental) voltages. The transformer primary windings must be isolated from each other, while the secondary winding may be connected in wye or delta. The transformer secondary is normally connected in wye to eliminate triple harmonics ( $n = 3, 6, 9\dots$ ) appearing on the output voltages.

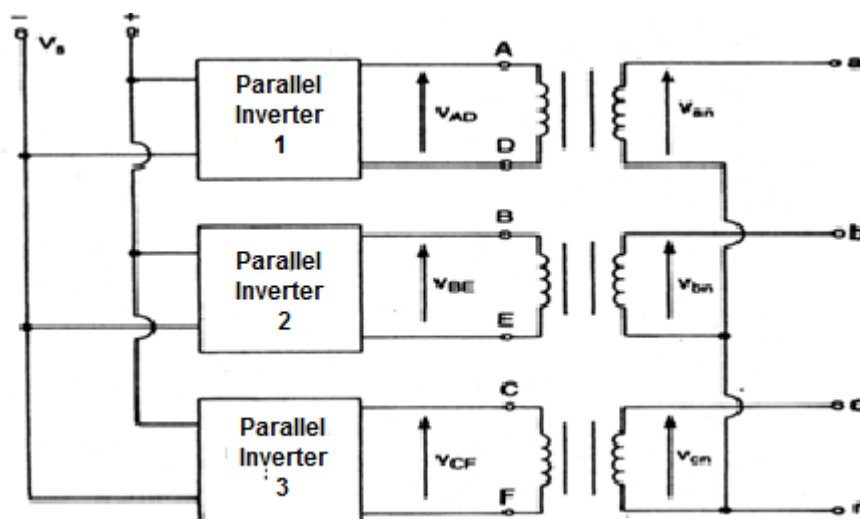


Fig. 15.1 Schematic diagram of a three-phase inverter constructed from three single-phase parallel inverters.

## 15.2. Three-phase Bridge inverter:

Three single-phase half- bridge inverters can be connected as shown in Fig.15.2 to form a configuration of three-phase inverter.

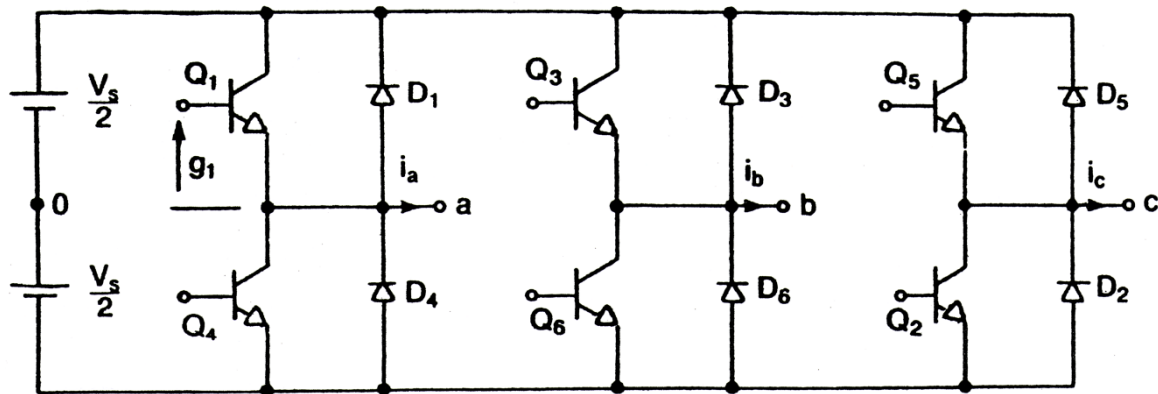


Fig.15.2

When transistor Q1 is switched on, terminal  $a$  is connected to the positive terminal of the dc input voltage. When transistor Q4 is switched on, terminal  $a$  is brought to the negative terminal of the dc source. There are two types of conduction depending on the control signal used:

1.  $120^\circ$  conduction.
2.  $180^\circ$  conduction.

In this context we shall consider  $120^\circ$  conduction mode only for clarity.

120 – Degree conduction:

In this type of control, each thyristor (or Transistor) conducts for  $120^\circ$ . Only two thyristors remain “ON” at any instant of time. The per phase and line- to- line voltage waveforms are shown in Figs.15.3 and 15.4 respectively.

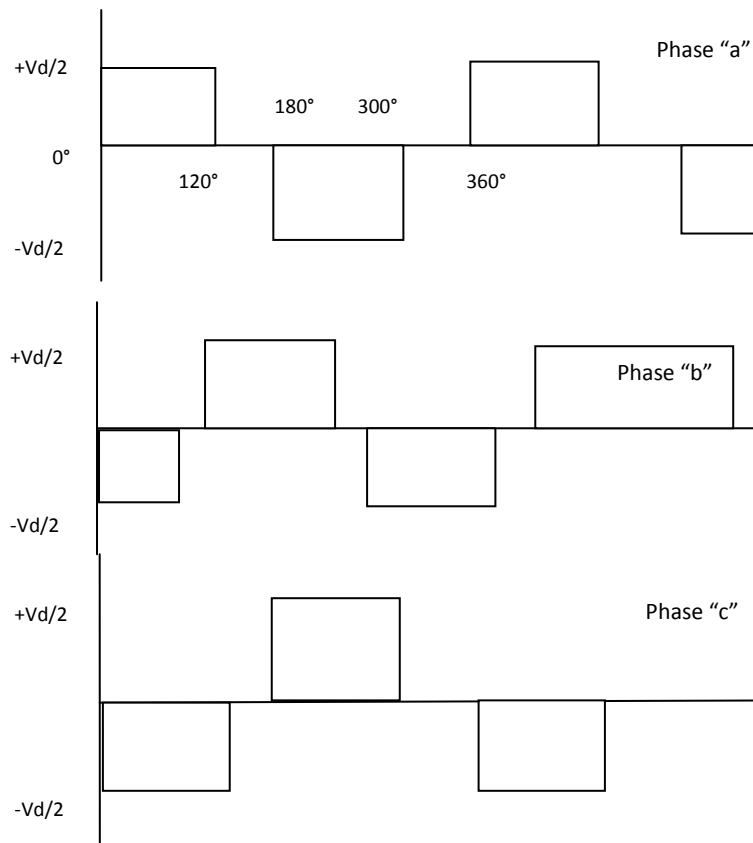


Fig.15.3 Per phase output voltage for three-phase bridge inverter

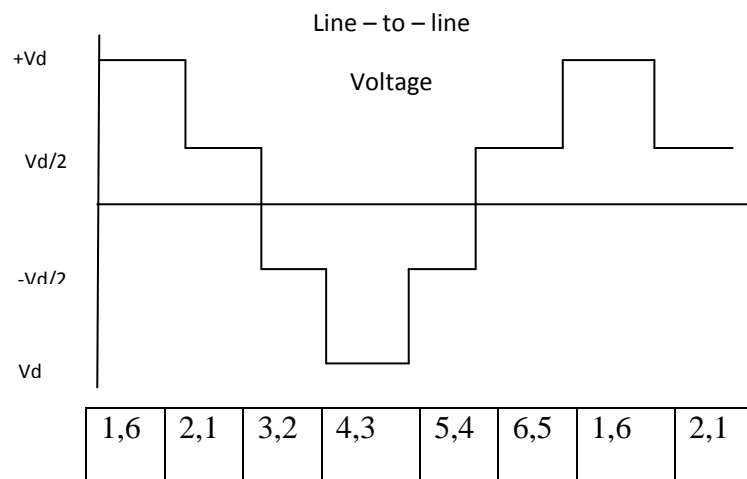


Fig.15.4 line to line voltage for three-phase Bridge inverter.

For star connected load, three modes for three-phase bridge inverter operation exist. In each case, the effective resistance across the source is  $2R$  as shown 15.5.

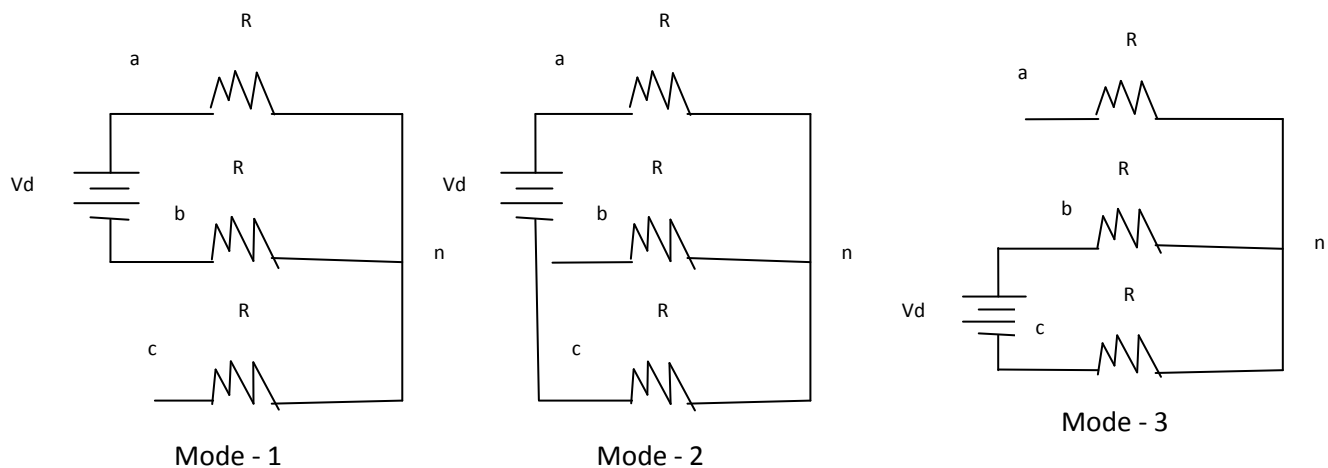


Fig.15.5 Modes for the three-phase bridge inverter.

For these three modes of operation:

Mode 1: Thyristors 1 & 6 conduct  $0 \leq \omega t \leq 60^\circ$

$$V_{an} = \frac{V_d}{2}, \quad V_{bn} = -\frac{V_d}{2}, \quad V_{cn} = 0$$

Mode 2: Thyristors 1 & 2 conduct  $60^\circ \leq \omega t \leq 120^\circ$

$$V_{an} = +\frac{V_d}{2}, \quad V_{bn} = 0, \quad V_{cn} = -\frac{V_d}{2}$$

Mode 3: Thyristors 2 & 3 conduct  $120^\circ \leq \omega t \leq 180^\circ$

$$V_{an} = 0, \quad V_{bn} = \frac{V_d}{2}, \quad V_{cn} = \frac{-V_d}{2}$$

- The line – to – neutral voltages can be expressed in Fourier series as:

$$V_{an}(\omega t) = \sum_{n=1,3,5}^{\infty} \frac{2Vd}{n\pi} \cos \frac{n\pi}{6} \sin n \left( \omega t + \frac{\pi}{6} \right)$$

$$V_{bn}(\omega t) = \sum_{n=1,3,5}^{\infty} \frac{2Vd}{n\pi} \cos \frac{n\pi}{6} \sin n \left( \omega t - \frac{\pi}{2} \right)$$

$$V_{cn}(\omega t) = \sum_{n=1,3,5}^{\infty} \frac{2Vd}{n\pi} \cos \frac{n\pi}{6} \sin n \left( \omega t - \frac{7\pi}{6} \right)$$

The peak amplitude of the fundamental component (n=1): for phase a, b or c is:

$$V_{1P} = \frac{2Vd}{\pi} \cos \frac{\pi}{6} = \frac{Vd}{\pi} \sqrt{3}$$

The r.m.s value of the fundamental component is

$$V_{1r.m.s} = \frac{V_{1P}}{\sqrt{2}} = \frac{Vd\sqrt{3}}{\sqrt{2}\pi}$$

- Note: line – to – line voltages for star – connected load can be found as:

$$V_{L-L} = \sqrt{3} V_{phase}$$