INVERTER

Inverter is a circuit which converts DC power into AC Power at the desired Voltage, Frequency and Waveform. The dc power input to the inverter is obtained from an existing power supply network or from a rotating alternator through a rectifier or a battery fuel cell, photo voltaic cell etc..,

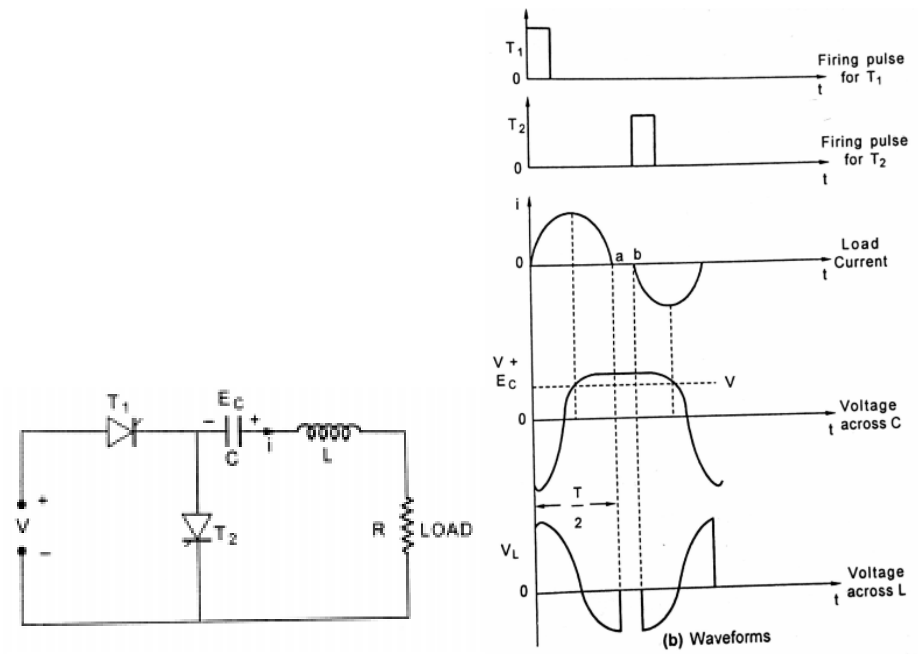
CLASSIFICATION OF INVERTERS:

Inverters can be broadly classified into following types:

1) Based on source
   a) Voltage source inverter (VSI)
   b) Current source inverter (CSI)
2) Based on connections of semiconductor devices
   a) Bridge inverters
   b) Series inverters
   c) Parallel inverters
3) Based on number of phases
   a) Single phase inverters
   b) Three phase inverters
4) Based on the communication methods of thyristors
   a) Load commutation inverters
   b) Forced commutation inverters
   c) Self-commutation inverters
5) Based on circuit configuration
   a) Half bridge inverter
   b) Full bridge inverter
6) Based on the nature of output voltage
   a) Square wave
   b) Quasi-square wave
   c) Sine wave

SERIES INVERTER:

- Inverters in which commutating components are permanently connected in series with the load are called series inverters.
- It consists of load resistance R in series with commutating components L and C.
- Two thyristors T1 and T2 are turned on appropriately so that output voltage of desired frequency can be obtained.



Working:

Mode 1:

- Initially the capacitor charged to negative E_c. This begins thyristor T1 is turned ON by an external triggering firing pulse. Hence, i – is passed to load through T1, C and L.
- After reaching the current maximum, the current starts decreasing but the voltage across the capacitor continues to increase.
- The left plate of the capacitor is positive at point a, hence the thyristor T1- turned OFF.

Mode 2:

- In this mode, the thyristor T2 is not be triggered, after successful T1 is commutated.
- If T2 is triggered without time delay, the battery gets shorted through T1 and T2.

Mode 3:

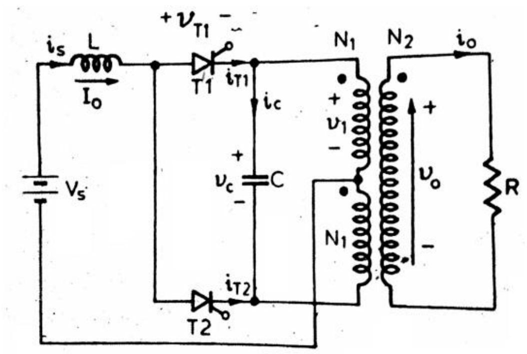
- In this mode, the thyristor T2 is turn ON by applying an external triggering pulse.
- Since the anode of T2 is positive due to charge on the capacitor. Hence, the T2 will starts conducting.
- The current increases in negative direction and after reaching negative peak vale then it will decreases to zero at point C.
- At point C, the thyristor T2 is turned-off.

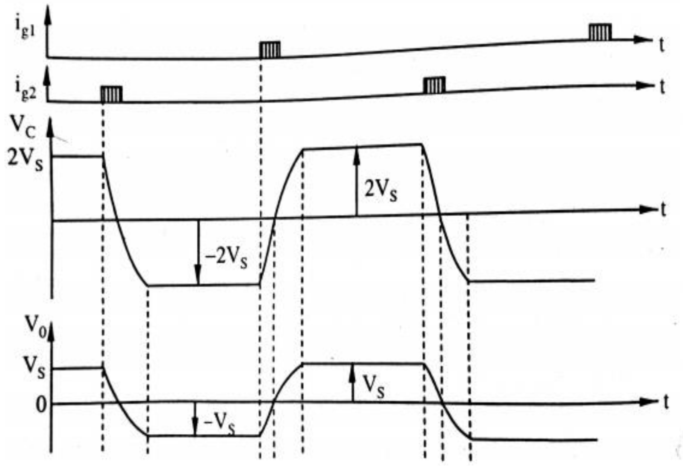
$$T_0 = T_r + 2\ T_d)$$
$$f_0 = 1/\ T_0 = 1/\ (\ T_r + 22\ T_d)$$

T_d - is the time delay
T_r – is the turn- ON time.

PARALLEL INVERTER:

The basic inverter circuit for parallel inverter is shown in fig. It consists of two thyristors T1 and T2, and inductor L, an output transformer and commutating capacitor C. The transformer turns ratio from each primary half to secondary winding is assumed unity. The output voltage and current are V_0 and I_0 respectively.





Working:

During the working of this inverter, capacitor C comes in parallel with the load via the transformer. That is why it is called a parallel inverter.

- When T1 is turned ON and T2 is OFF, current i_s flows in the upper half of primary winding. The current i_s Produces an EMF $2V_S$ at the total primary windings.
- This voltage charges the commutating capacitor C to a voltage of $2V_S$.
- Output voltage is positive.
- The capacitor voltage $2V_S$ appears revers bias across T1, Therefore T1 is turned OFF.
- When T2 is turned ON and T1 is OFF, the capacitor charges in reverse direction as lower plate and upper plate is negative and output voltage V_O reverses.
- The capacitor has charged to -$2V_S$ thyristor and makes T1is turned ON and T2 is turned OFF and the process repeats.

VOLTAGE SOURCE INVERTER:

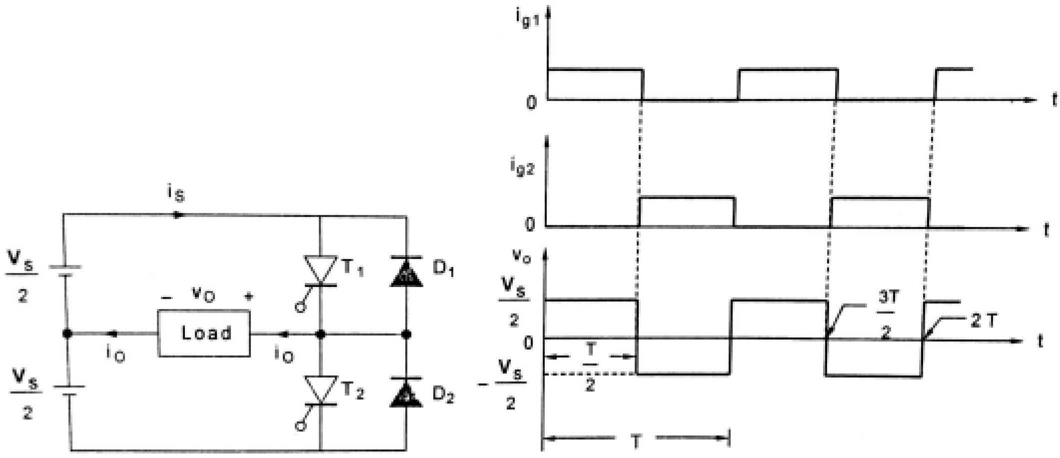
Voltage source inverter is one in which the DC source has small or negligible impedance. VSI's are two types:

(i) Single phase VSI
(ii) Three phase VSI

Single Phase voltage source inverters are of two types, namely (i) Single phase half – bridge inverters (ii) Single phase full – bridge inverters.

(i) Single phase half – bridge inverters

It consists of two thyristors (T1 and T2), two diodes (D1 and D2) and three wire D.C. supply. The firing pulse are given for each thyristor and resulting output voltage waveforms are shown in fig.



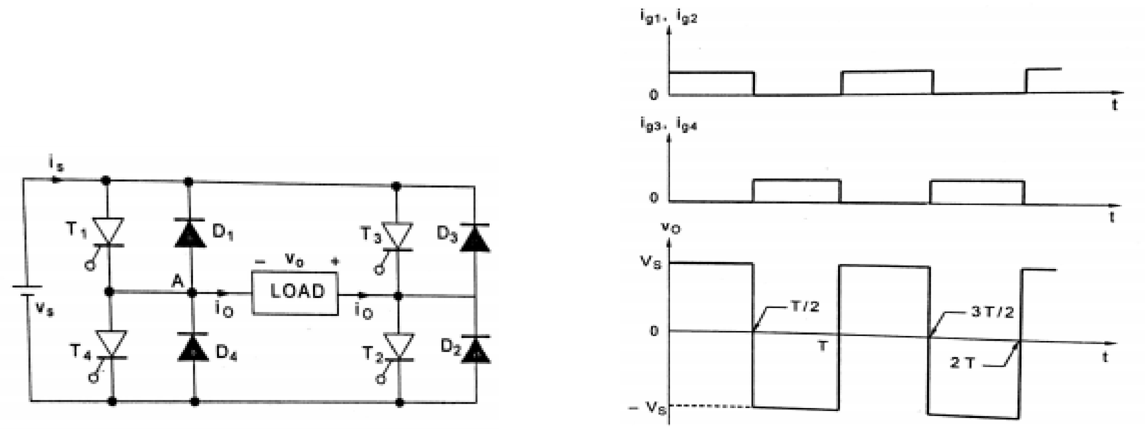
During the period $0< t \leq \frac{T}{2}$, T1 is triggered, hence it will conduct causes the current flows through the load from positive to negative terminal and we get positive half of output wave i.e.…, $\frac{Vs}{2}$.

During the period $\frac{T}{2}< t < T$, the thyristor T1 is turn off and T2- is triggered, hence T2 will conducts causes the current flows through the load from negative and positive terminal and we get negative half of output wave i.e.., $\frac{-Vs}{2}$.

From the above it is observed that the load voltage is alternating voltage waveform of amplitude $\frac{Vs}{2}$ with a frequency of $\frac{1}{T}$ Hertz.

(ii) Single phase Full bridge inverter:

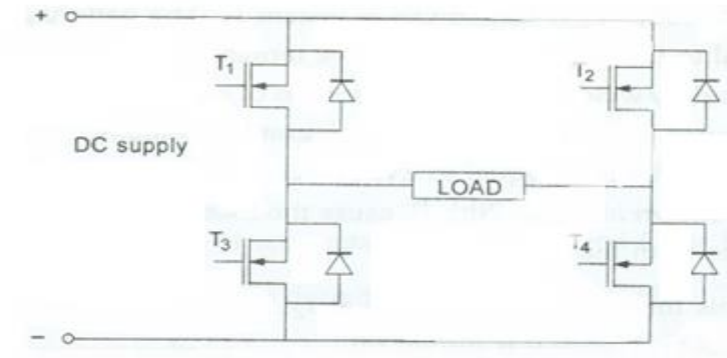
It consists of four thyristors [T1 to T4], four diodes [D1 to D4] and two wire D.C. supply.



During the period $0< t \leq \frac{T}{2}$, the thyristors T1 and T2 are triggered, hence these thyristors will conduct and the current flows through the load from positive to negative terminal and we get positive output voltage i.e.…, V_S.

During the period $\frac{T}{2}< t < T$, the thyristors T3 and T4 are triggered, hence these thyristors will conduct and the current flows through the load from negative to positive terminal and we get negative output voltage i.e.…, $-V_S$.

SINGLE PHASE BRIDGE INVERTER CIRCUIT DIAGRAM:



- 4 MOSFETs T_1 to T_4, of n – channel type
- A parallel combination of MOSFET & reverse biased diode in each arm of bridge.
- Load is connected across the bridge.

PULSE WIDTH MODULATION INVERTER (PWM):

In this method, a fixed DC input voltage is given to the inverter and a controlled AC output voltage is obtained by adjusting the ON and OFF periods of the inverter elements.

Type of pulse-width modulated inverters:

Depending on the type of controlling the output voltage and harmonic content, these are mainly of following types, namely

(i) Single – pulse modulation
(ii) Multiple – pulse modulation
(iii) Sinusoidal – pulse modulation

Single pulse modulation:

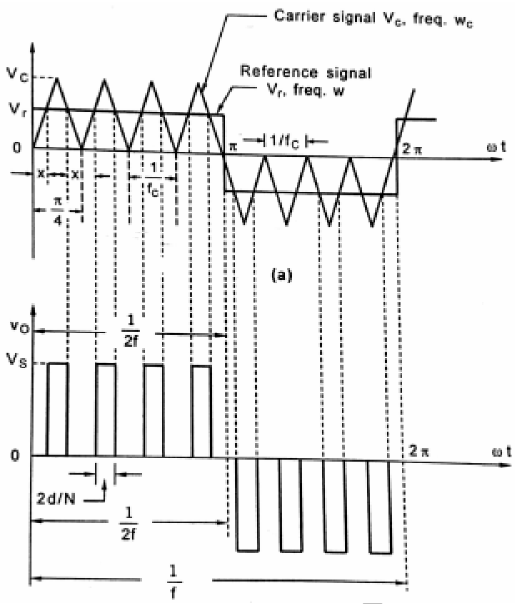
In this method, only pulse in each cycle is used and the width of the pulse is varied to control the output voltage.

The output voltage from single phase full bridge inverter is shown in when this waveform is modulated, the output voltage is of the form shown in fig. It consists of a pulse of width **2d** located symmetrically $\frac{\pi}{2}$ and another pulse located symmetrically about $\frac{3\pi}{2}$. The range of pulse **2d** varies from 0 to π. The output voltage is controlled by varying the pulse width **2d.**

Multiple – pulse modulation:

In this method, several equidistant pulse per half cycle are used and the width of the pulse is varied to control the output voltage.

When the square wave V_r of frequency w_r is compared with a triangular wave V_c at a frequency of w_c. The firing pulses generated to turn-ON the thyristors so that output voltage V_o.



Let

f_C - be the carrier signal frequency (Hz)

f_r - be the reference signal frequency (Hz)

From the Fig 3.6 (a) & (b)

$\frac{1}{f_c} = \frac{\pi}{4}$ and $\frac{1}{2f_r} = \pi$

For triangular carrier wave, pulse width $= \frac{1}{f_c}$

For reference square wave, width of Half–cycle $= \frac{1}{2f_r}$

$\therefore$ Number of pulse per half–cycle

$$= \frac{\text{Width of Half – Cycle of reference Square Wave}}{\text{Width of One – Cycle of triangular carrier Wave}}$$

$$N = \frac{1/2f_r}{1/f_r} = \frac{f_c}{2f_r} = \frac{w_C}{2w_r}$$

Pulse width,

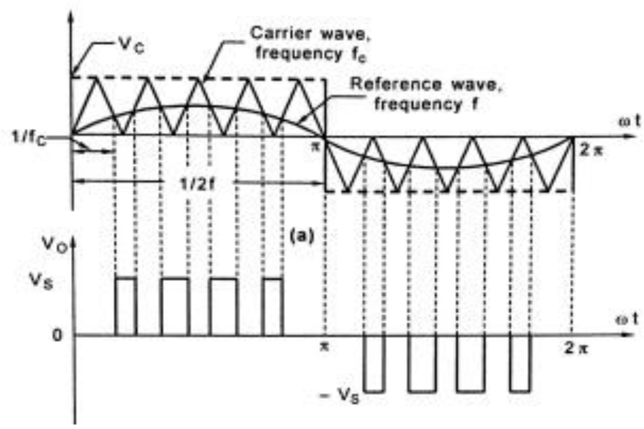
$$\frac{2d}{N} = \left[\frac{\pi}{N} - \frac{\pi}{N}\cdot\frac{V_r}{V_c}\right] = \left[1 - \frac{V_r}{V_c}\right]\frac{\pi}{N}$$

$\therefore$ **The rms value of output voltage,** $V_{o(rms)} = V_S\left[\frac{2d}{\pi}\right]^{1/2}$

Sinusoidal Modulation:

In this method of modulation, the five pulses per half cycle with reference sinusoidal wave V_r of desired frequency is compared with a triangular wave V_c at a frequency w_c. The triggering to the pulse thyristors are given at the intersection of the carrier and reference signal wave. The firing pulse are so generated to turn- ON so that the output voltage is available during the interval of triangular voltage wave with in the sinusoidal modulating wave and is as shown in fig.

Number of pulse per half cycle, $N = \frac{f_c}{2f_r}$



CYCLOCONVERTER

CycloConverter converts AC Power of a certain frequency to AC Power of much lower frequency without the help of an intermediate DC link. A cycloconverter is thus a one – stage frequency changer. Basically, cycloconverters are of two types. They are:

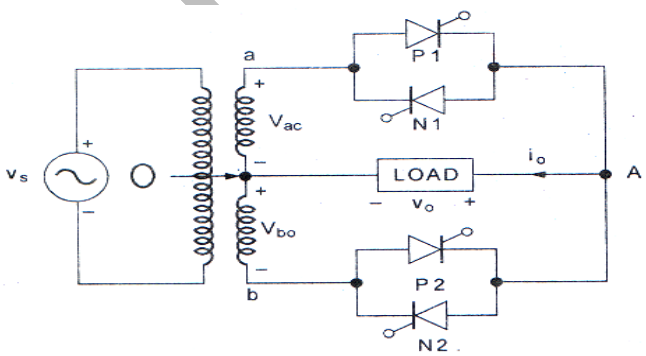
i) Step – down cycloconverters
ii) Step – up cycloconverters

In Step – down cycloconverters, the output frequency f_0 is lower than the supply frequency f_S. In Step – up cycloconverters, the output frequency f_0 is greater than the supply frequency f_S.

SINGLE PHASE CENTRE TAPPED CYCLOCONVERTER:

The single centre tapped cycloconverter using step – up transformer. In this type, the secondary winding of the transformer is provided with centre tapings. It consists of four thyristor, two of these thyristors P_1, P_2 are formed as positive group and the other two N_1 and N_2 are formed as negative group. The load is connected between secondary winding mid-point O and terminal A.

- During the positive half cycle of supply voltage, terminal a- is positive with respect to terminal b. therefore, the thyristors P1 and N_2 are forward biased from wt = 0 at wt = π.
- If the thyristor P1 is turned on at ωt = 0° so that the load voltage is +ve with terminal and O negative.
- The load voltage now follows the +ve envelope of the supply voltage.
- At ωt1, P1 is forced commutated and the other forward biased thyristor N2 is turned ON so that load voltage is –ve with terminal 'O' +ve and 'A' –ve.



(a) Single Phase Centre Tapped Cycle Converter

- So output voltage wave now traces the –ve envelop of the supply voltage.
- At ωt2, N2 is forced commutated and thyristor P1 is turned ON causes the load voltage is now traces the +ve envelope.
- After ωt = π, terminal **'b'** is +ve with respect to terminal **'a'**. Both Thyristors P2 and N1 are forward biased from ωt = π to 2π.
- At ωt = π, the Thyristor N2 is forced commutated and forward biased Thyristor P2 is turned on.

- At ωt =1/2fs + 1/2f0, P2 is Switched off (commutated) and forward biased Thyristor N1 is turned ON.
- Thyristor P1,N2 are switched on alternatively during +ve half cycle
- Thyristors P2, N1 are switched on alternatively during –ve half cycle. The frequency fo > fs.
- The output frequency is 1/3 the input frequency