Inverter:

It Converts DC in AC.

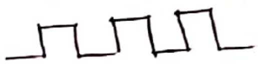
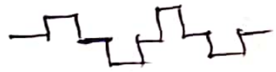
⇒ Classification based on input source.

- VSI (Voltage Source Inverter)
- CSI (Current Source Inverter)

⇒ Classification based on circuit configuration

- Series Inverter
- parallel Inverter
- Bridge Inverter.

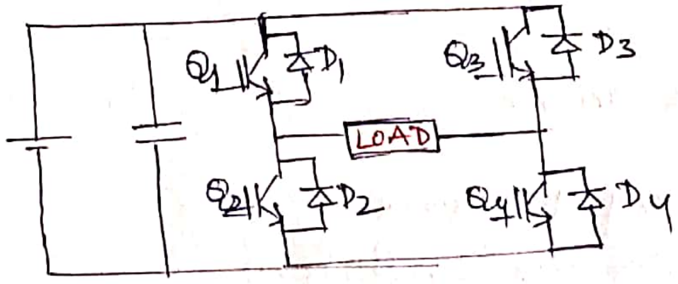
⇒ Classification based on type of output.

- Square wave inverter 
- Quasi square wave inverter 
- PWM Inverter 

VSI:

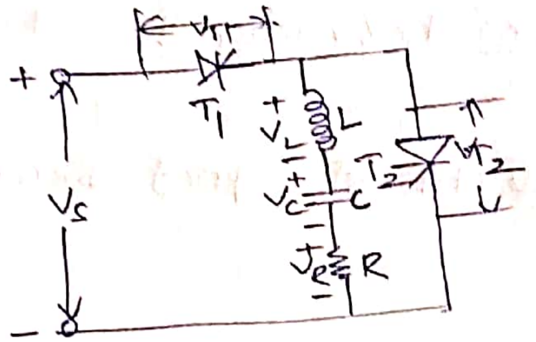
Voltage source inverter (VSI) consists of one DC voltage source, transistors for switching, and one large dc link capacitor.

- DC Source may be a battery, Dynamos or solar cell.
- Transistor may be IGBT, BJT, MOSFET or GTO.
- For Direct current the large DC link capacitor acts like open circuit and for high frequency AC the capacitive impedance is low.
- VSI may be single phase bridge circuit or three phase bridge circuit.
- 1ϕ bridge circuit consist of two legs of switches each leg consists of upper and lower switch.
- Antiparallel diode is use to allow non-unity power factor load at output.



1-ϕ VSI.

Series Inverter : Load Commutated Inverter.
self commutated



this inverter is called as self commutated inverter or Load Commutated Inverter.

This inverter is used for high frequency applications.

Working :

power circuit Diagram :

⇒ the power circuit diagram of the series inverter is shown in the figure the SCR(T_1) and SCR(T_2) are turned on at regular interval in order to achieve desirable output voltage and output frequency.

⇒ The SCR T_2 is kept off at starting condition and polarity of voltage across capacitor is shown in figure A.

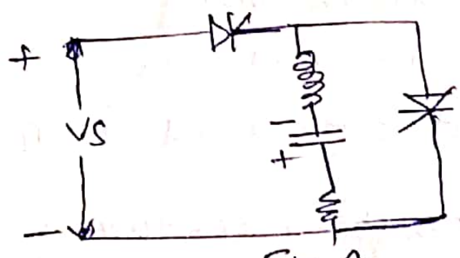
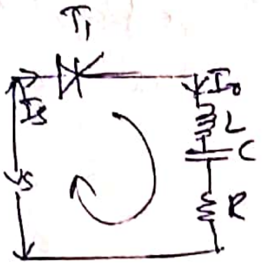


FIG A

Operation :

Mode 1: SCR T_1 is turned ON



- The voltage Vdc directly applies to RLC series circuit as soon as the SCR T_1 is turned on.
- The capacitor polarity charging is shown in fig B.
- the nature of the load current is alternating as there is under damped circuit of the commutating components.

⇒ the voltage across capacitor becomes $+V_{dc}$ when the load current becomes maximum.

⇒ the voltage across capacitor becomes $+2V_{dc}$ when the load current becomes zero at point.

⇒ then the SCR (T_1) automatically turns OFF at a point because the load current becomes zero.

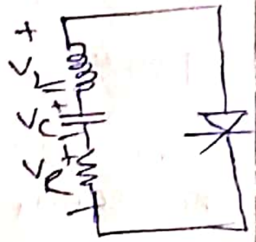
Mode 2: T_1 and T_2 both OFF.

⇒ the load current becomes zero from point a to b as the SCR T_1 turns OFF in this time period.

⇒ The SCR (T_1) and SCR (T_2) are turned OFF in this time duration and voltage across capacitor becomes equal to $+2V_{dc}$.

Mode 3: T_2 is turned ON.

= the SCR (T_2) is turned ON at point b due to it reverses positive capacitor voltage.



= the discharging of capacitor is done through SCR T_2 and RLC circuit.

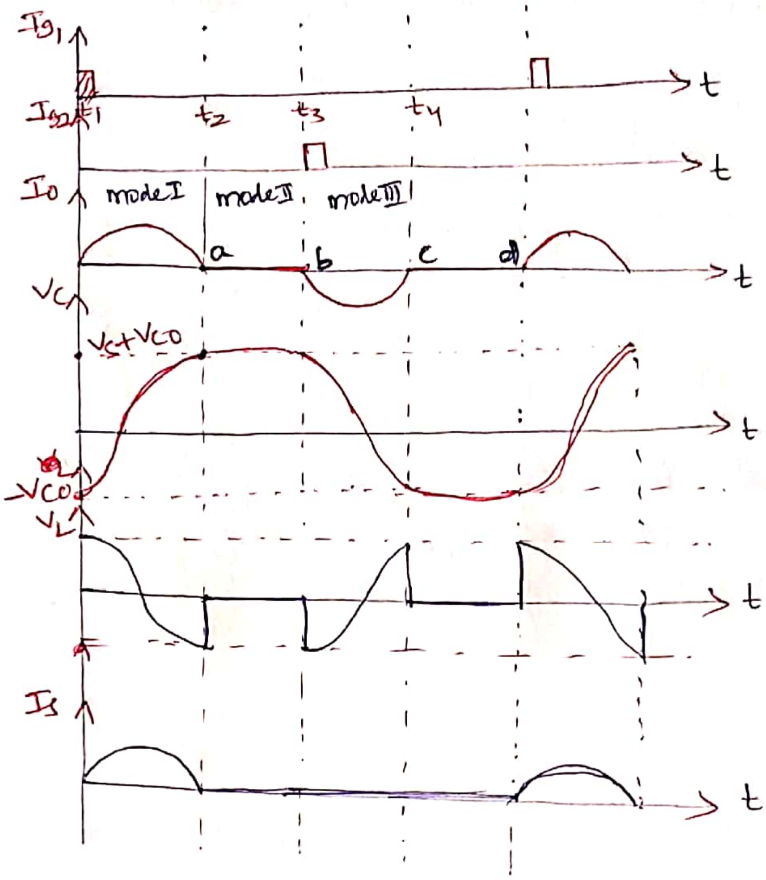
= the load current becomes zero after it becomes maximum in the negative direction.

= The capacitor discharges from $+2V_{dc}$ to $-V_{dc}$ during this time and SCR T_2 turns OFF automatically at point c due to load current becomes zero.

= the SCR T_2 turns OFF during point c to D and SCR T_1 again turns ON.

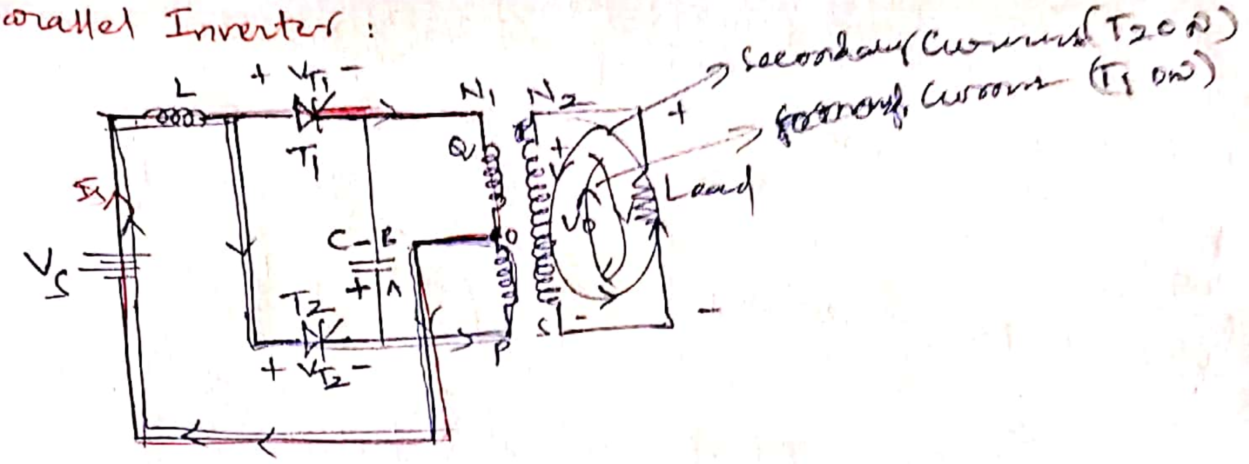
⇒ this way cycle repeat after it complete one turns.

⇒ the positive AC output voltage half cycle generates due to dc voltage source whereas ~~negative~~ negative half cycle generates due to capacitor.



I_{g1}
I_{g2}
t_1
t_2
t_3
t_4
I_0
mode I
mode II
mode III
a
b
c
d
V_C
V_s+V_{C0}
$-V_{C0}$
V_L
I_s
t

Parallel Inverter :



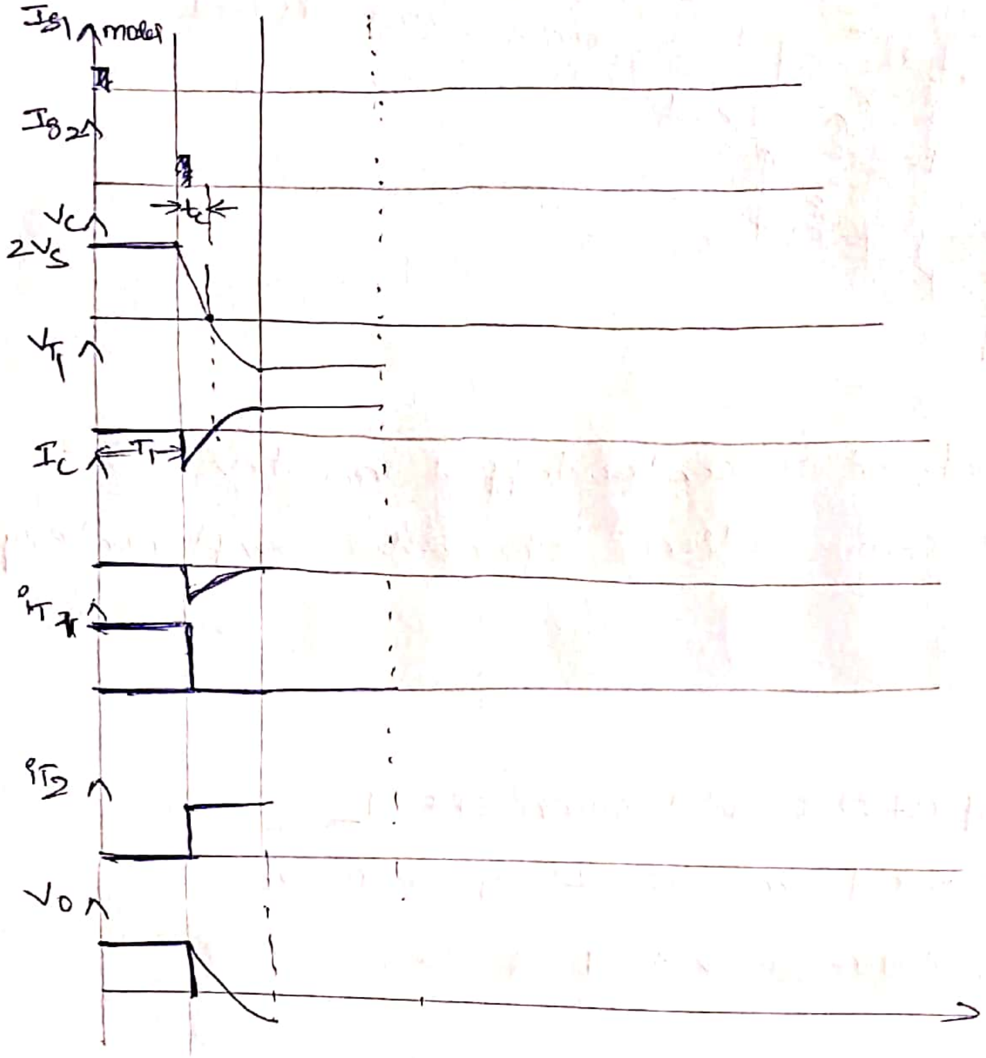
- This inverter even referred as center tapped inverter
- Capacitor is used for commutation, "C provides Complementary Commutation

Mode I : T_1 – ON

- By triggering T_1, Capacitor C will turn OFF T_2
- primary current flows from $V_s - L - T_1 - Q - O - V_s$.
- Capacitor voltage A (+ve) w.r.t (B) plate.
- output is +ve.

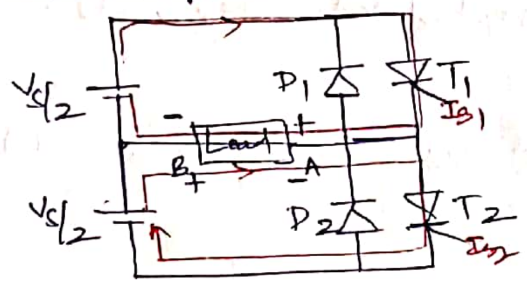
Mode II : T_2 – ON.

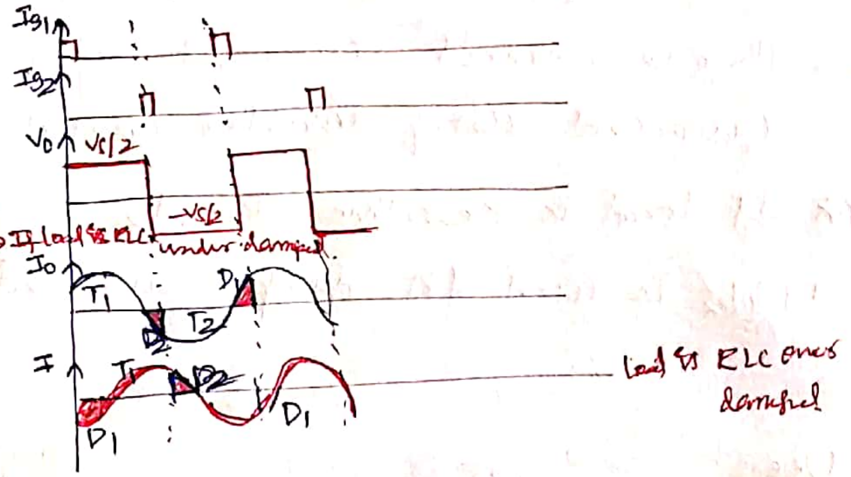
- By triggering T_2, Capacitor C will be turn OFF T_1.
- primary Current flows from $V_s - L - T_2 - P - O - V_s$
- Capacitor voltage B (+ve) w.r.t (A) plate
- output is –ve.


I_{g1}
mode
I_{g2}
t_c
V_C
$2V_S$
V_{T1}
I_C
T_1
i_{T1}
i_{T2}
V_o

Single phase Half bridge Inverter: (Square wave inverter)

Circuit diagram:





Construction of circuit:

Basically, for single phase half bridge inverter as shown in fig. the following components are required.

1. two Thyristors 2. Load 3. one voltage source (Divided into two sources)
4. Two Diodes.

Operation:

- A single DC source is divided into two DC sources (Vs/2).
- Initially, two thyristors are not triggered to turn ON. so zero current flows through the device.

Mode I:

- The Thyristor (T_1) is turned 'ON' by giving a gate pulse to it and thyristor T_2 is kept OFF and no gate signal is given to it.
- Thus, the thyristor T_1 starts conducting and the current starts to flow from Vs/2 (+ve terminal of 1st source) – T_1 – Load – negative terminal of 1st source.
- Thus, a positive cycle similar to that of ac cycle is obtained.

Mode II:

- Now, the thyristor T_1 is made 'OFF' and T_2 is made 'ON' by giving a gate signal to it. then the thyristor T_2 starts to conduct and the current starts to flow from Vs/2 (+ve terminal of 2nd source) – Load – T_2 – negative terminal of 2nd source
- thus, a negative cycle is obtined.
- Two SCRs are triggered alternatively so that the load conducts current in both directions.

⇛ Thus, a square ac wave is generated.

— Hence, direct current is converted into alternating current using inverter circuit.

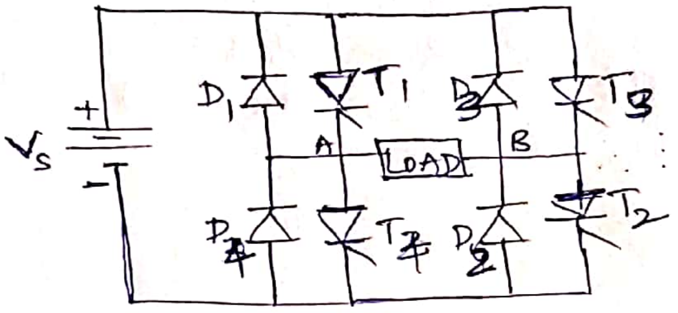
** If load is Resistive D_1 & D_2 is not used. If load is RL load D_1 & D_2 is used for damped current.

Use:

- DC power source usage
- UPS
- In refrigeration compressor

Single phase Full bridge Inverter:

Circuit Diagram:



Construction of Circuit:

- In a full bridge inverter, four thyristors and fours feedback/diodes used. one DC source applied to the circuit.
- In full bridge inverter, two switches are in conduction at a time.

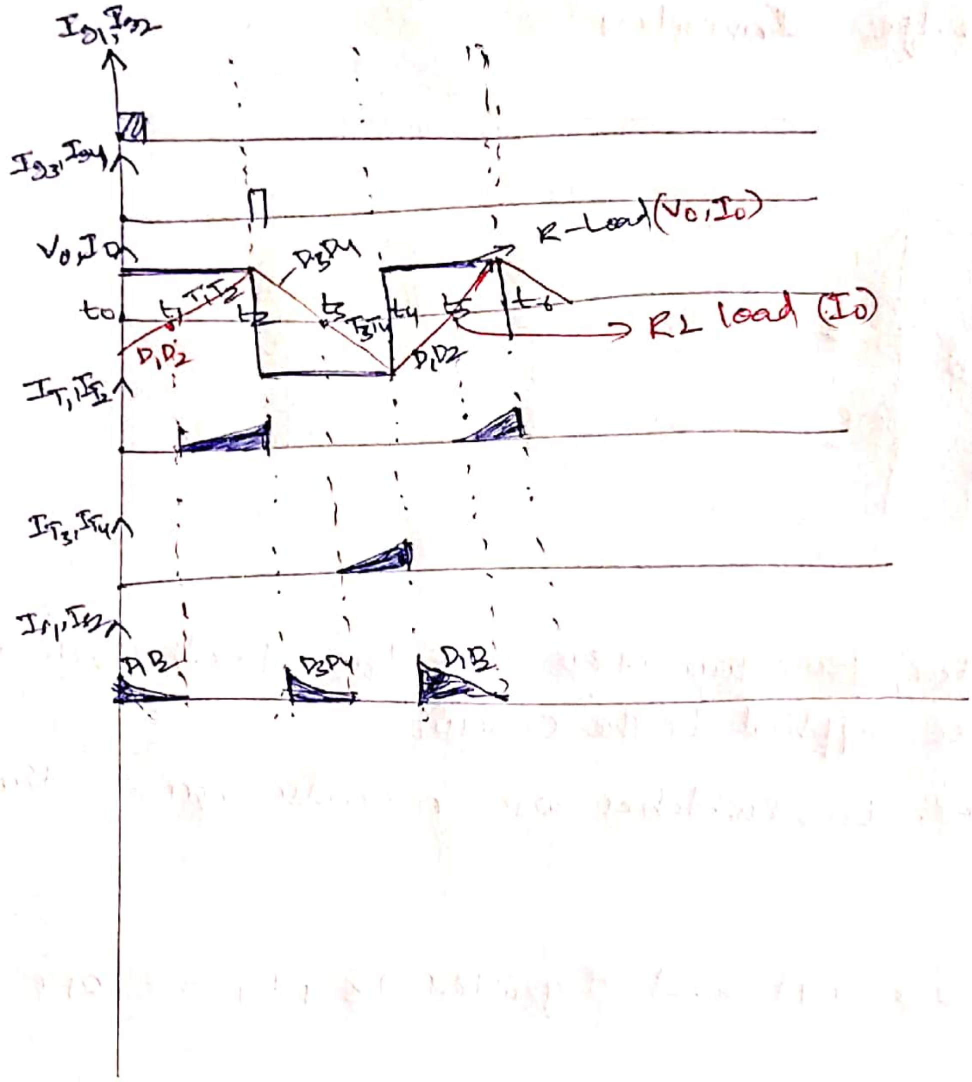
Operation:

Mode I:

- Thyristor T_1 & T_2 are ON and thyristors T_3 & T_4 are OFF during this mode.
- The current flowing path is $V_s(+) - T_1 - A - Load - B - T_2 - V_s(-)$
- The current flowing through the load is from A to B makes a positive half cycle.

Mode-II:

- Thyristor T_3 & T_4 are ON and thyristor T_1 & T_2 OFF
- The current flowing through the path is $V_s(+) - T_3 - B - load - A - T_4 - V_s(-)$
- The current flowing through the load is from B to A and make a negative half cycle of output.



For RL load:

$t_0 - t_1 \Rightarrow D_1 D_2$ conducts = load current

$t_1 - t_2 \Rightarrow T_1 \& T_2$ = supply current

$t_2 - t_3$ - $D_3 \& T_4$ = load current

$t_3 - t_4$ - $T_3 \& T_4$ = supply current.

Three - phase Inverter:

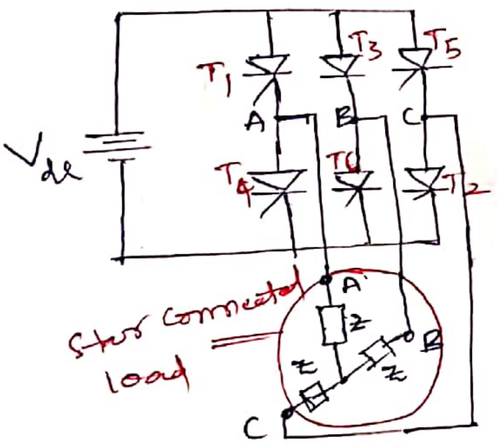
Generally, 3-ϕ Ac supply used in industries and the load is 3-ϕ. In this case, a 3-ϕ inverter used to run this load.

Construction of Circuit:

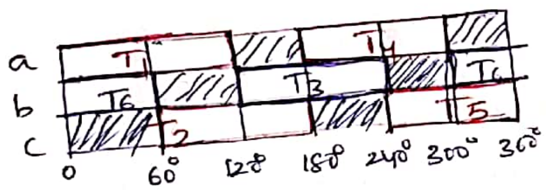
- In three - phase inverter, six diodes & six thyristors used.
- According to the conduction time of thyristors, this inverter divided into two types.

1. 120 degree mode of operation
2. 180 degree mode of operation.

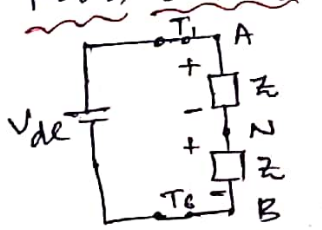
Circuit diagram :



120 - degree Mode of operation: (Quasi square wave)



From 0° to 60° $[T_1, T_6]$ conducts ⇒

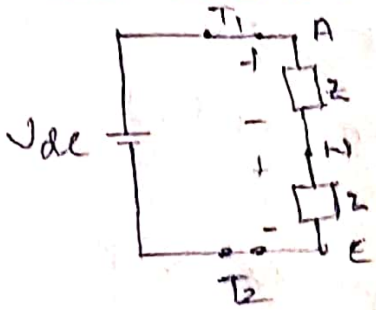


$$V_{AN} = \frac{V_{dc}(Z)}{Z+Z} = \frac{V_{dc}}{2}$$

$$V_{BN} = \frac{-V_{dc}(Z)}{Z+Z} = \frac{-V_{dc}}{2}$$

$$V_{CN} = 0$$

- From 60° to 120° [T_1, T_2 Conducts]

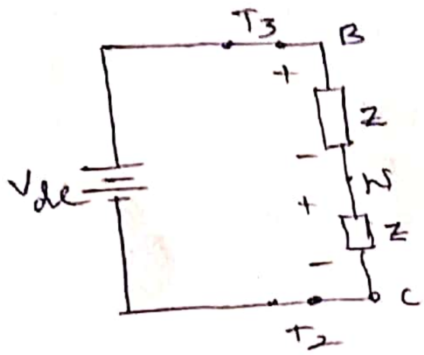


$$V_{AN} = \frac{V_{dc}(Z)}{Z+Z} = \frac{V_{dc}}{2}$$

$$V_{BN} = 0$$

$$V_{CN} = -\frac{V_{dc}(Z)}{Z+Z} = -\frac{V_{dc}}{2}$$

- From 120° to 180° [T_3, T_2 Conducts]

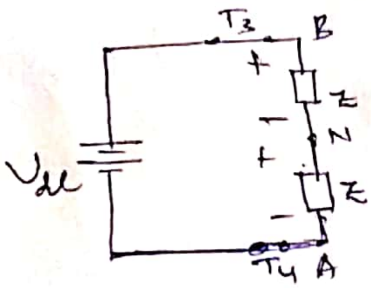


$$V_{AN} = 0$$

$$V_{BN} = \frac{V_{dc}(Z)}{Z+Z} = \frac{V_{dc}}{2}$$

$$V_{CN} = \frac{-V_{dc}(Z)}{Z+Z} = -\frac{V_{dc}}{2}$$

- From 180° to 240° [T_3, T_4 Conducts]

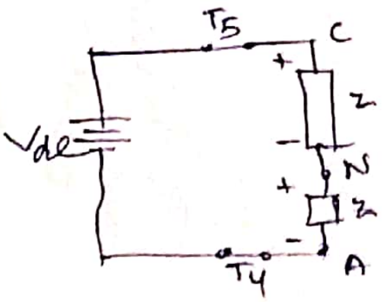


$$V_{AN} = \frac{-V_{dc}(Z)}{Z+Z} = -\frac{V_{dc}}{2}$$

$$V_{BN} = \frac{V_{dc}}{2}$$

$$V_{CN} = 0.$$

- From 240° to 300° (T_4, T_5 Conducts)

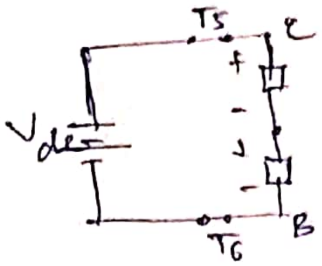


$$V_{AN} = \frac{-V_{dc}}{2}$$

$$V_{BN} = 0$$

$$V_{CN} = \frac{V_{dc}}{2}$$

- From 300° to 360° (T_5, T_6 Conducts)



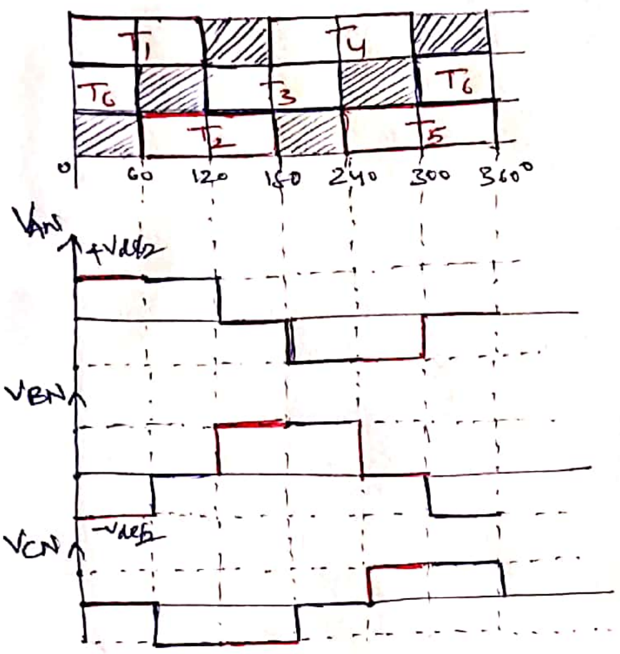
$$V_{AN} = 0$$

$$V_{CN} = \frac{V_{dc}}{2}$$

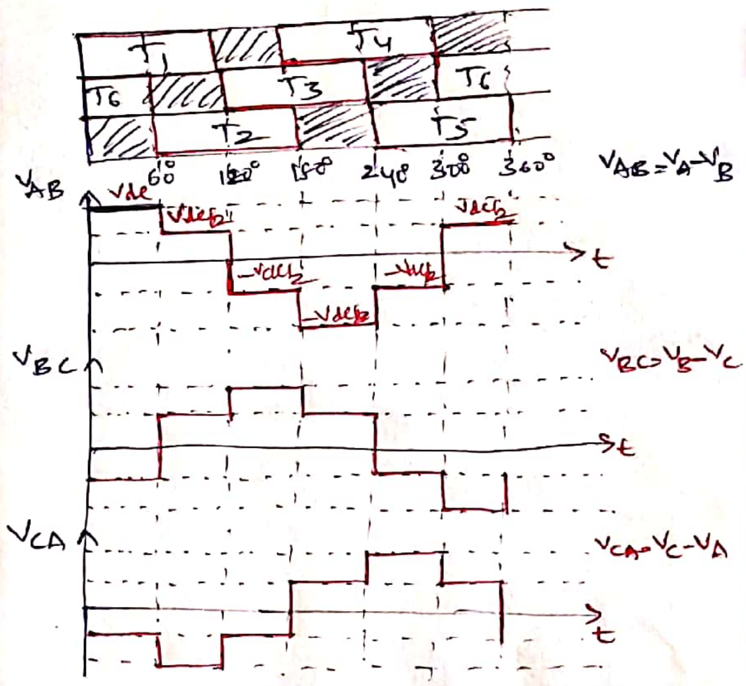
$$V_{BN} = \frac{-V_{dc}}{2}$$

Output wave forms

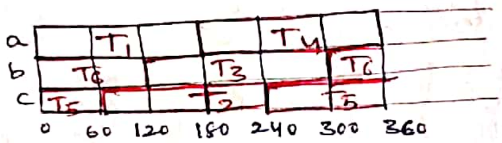
(a) phase voltage



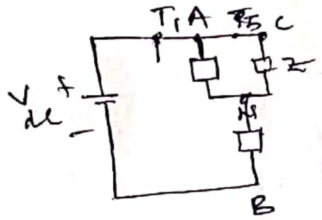
(b) Line Voltage



3-ϕ Inverter with 180° mode of operation:



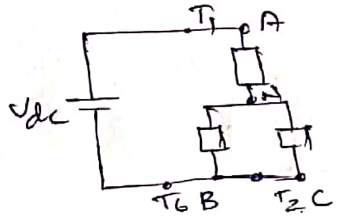
- From 0 to 60° (T_1, T_6, T_5 conducts)



$$V_{AN} = V_{CN} = \frac{V_{dc}(Z/2)}{Z/2 + Z} = V_{dc}/3$$

$$V_{BN} = \frac{-V_{dc}(Z)}{Z/2 + Z} = -2V_{dc}/3$$

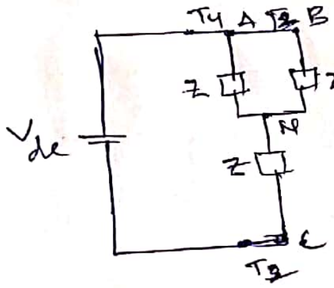
- From 60° to 120° (T_1, T_6, T_2 conducts)



$$V_{AN} = \frac{V_{dc}(Z)}{Z + Z/2} = 2V_{dc}/3$$

$$V_{BN} = V_{CN} = -V_{dc}/3$$

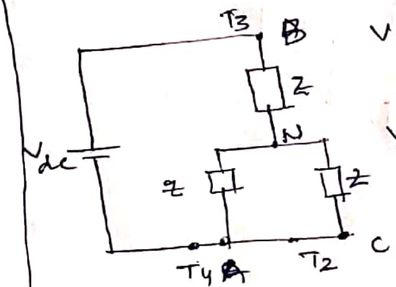
- From 120° to 180° (T_1, T_3, T_2 conducts)



$$V_{AN} = V_{BN} = V_{dc}/3$$

$$V_{CN} = -2V_{dc}/3$$

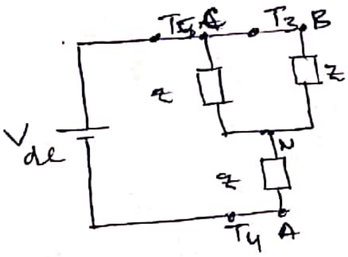
- From 180° to 240 (T_4, T_3, T_2 conducts)



$$V_{BN} = 2V_{dc}/3$$

$$V_{BN} = V_{CN} = -V_{dc}/3$$

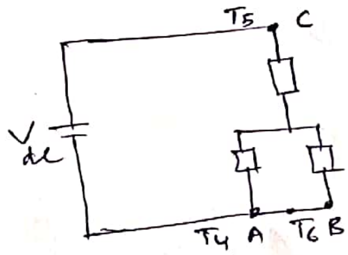
- From 240° to 300° (T_4, T_3, T_5 conducts)



$$V_{CN} = V_{BN} = V_{dc}/3$$

$$V_{AN} = -2V_{dc}/3$$

- From 300° to 360° (T_4, T_6, T_5 conducts)

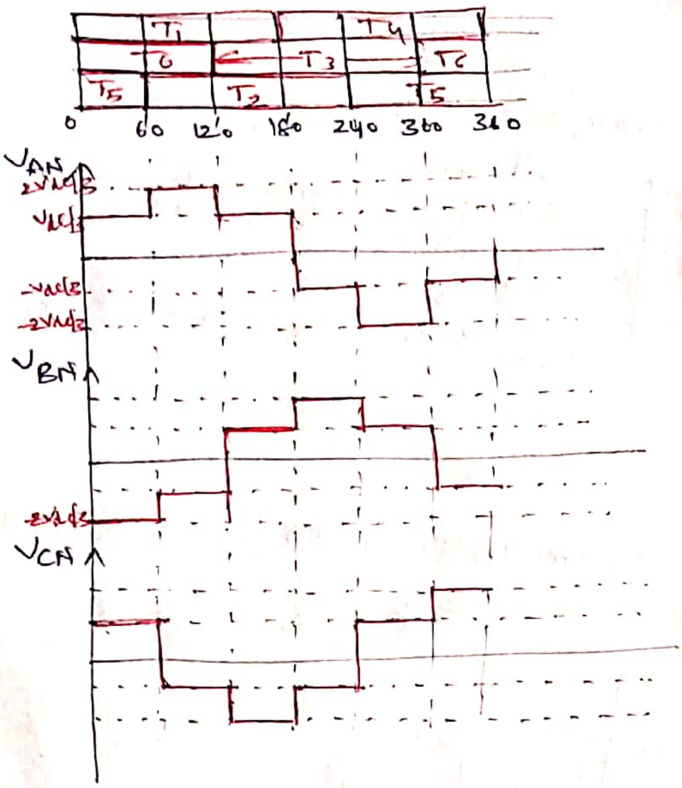


$$V_{CN} = 2V_{dc}/3$$

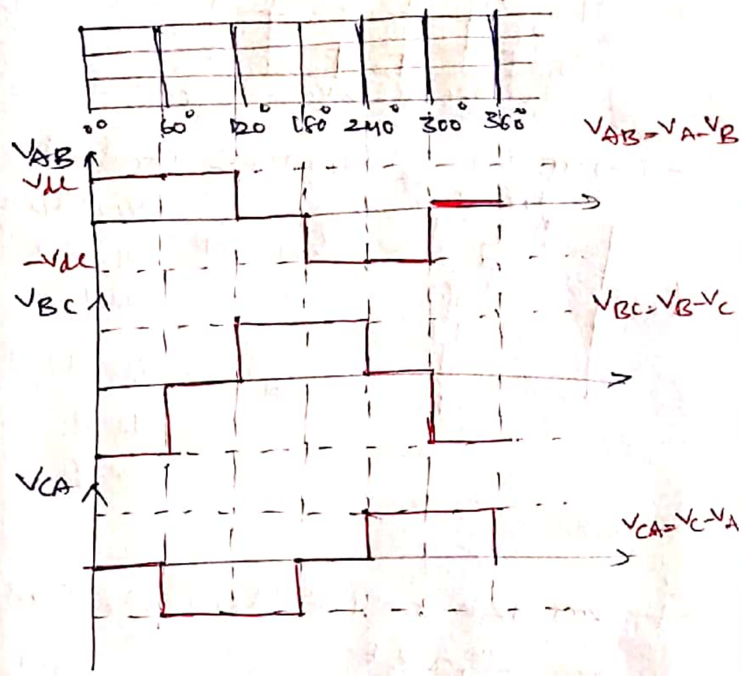
$$V_{AN} = V_{BN} = -V_{dc}/3$$

Output wave forms

1. phase wave form



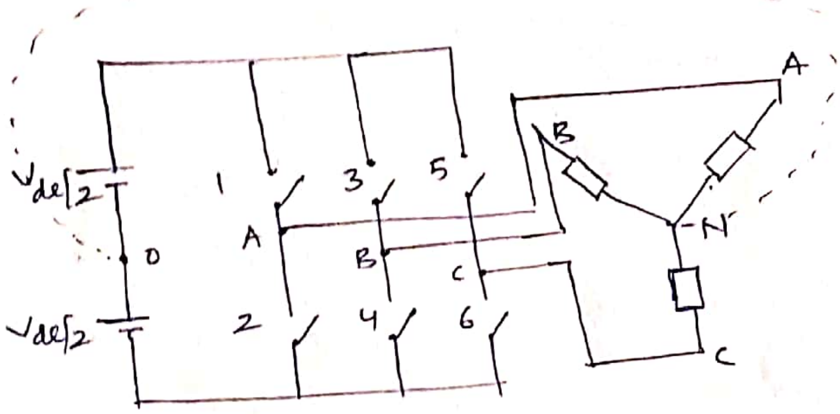
2. Line wave form.



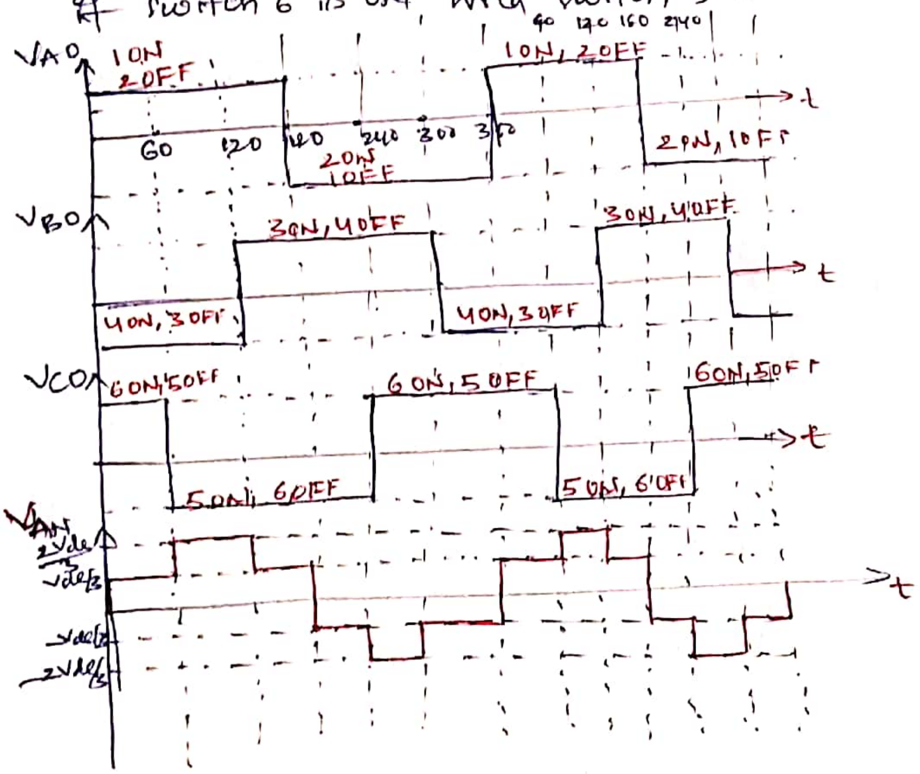
PWM Inverter:

Pulse Width Modulation Inverter:

3-ϕ Inverter as PWM Inverter:



- For phase A: output(OA) if switch 1 is ON and switch 2 is OFF output is $V_{dc}/2$ and if switch 2 is ON and switch 1 is OFF then output is $-V_{dc}/2$.
- For phase B: if switch 3 is ON & switch 4 is OFF output is $V_{dc}/2$ and if switch 4 is ON and switch 3 is OFF then output is $-V_{dc}/2$
- For phase C: if switch 5 is ON & switch 6 is OFF output is $V_{dc}/2$ and if switch 6 is ON and switch 5 is OFF then output is $-V_{dc}/2$



$$V_{AO} = V_{AN} + V_{NO}$$
$$V_{BO} = V_{BN} + V_{NO}$$
$$V_{CO} = V_{CN} + V_{NO}$$

$$(V_{AO} + V_{BO} + V_{CO}) = 3V_{NO} + 0$$

$$V_{NO} = \frac{V_{AO} + V_{BO} + V_{CO}}{3}$$

$$V_{AN} = V_{AO} - V_{NO}$$
$$= V_{AO} - \frac{V_{AO} + V_{BO} + V_{CO}}{3}$$

$$\boxed{V_{AN} = \frac{2}{3} V_{AO} - \frac{1}{3}(V_{BO} + V_{CO})}$$

If Sine > Triangle S_1 ON, S_2 OFF

If Sine < Triangle S_1 OFF, S_2 ON.