CH-4-INVERTER

INVERTER:- Inverter is a device which converts D.C power to A.C power at certain o/p voltage & frequency or at a certain current level & frequency.

Application of Inverter:

(1) variable Speed A.C Motor drives.
(2) Adjustable a.c drives.
(3) Induction heating
(4) Uninterruptible power Supplies.
(5) HVDC transmission Line (±2000MW)

↳ It is well known fact that SCR is a device which produces d.c output from an a.c Source.

↳ But so many applications need of variable a.c voltage from a fixed d.c Supply.

↳ The Inverters that are discussed in this chapter are so designed to meet the requirement of a.c o/p from a d.c Source & can be defined as a device, which produces variable or fixed a.c voltage from a fixed or variable d.c Source.

CLASSIFICATION OF INVERTER:

Inverters are classified according to type of input applied as

(i) voltage Source inverter (VSI) or voltage driven or voltage fed inverter.
(ii) current Source inverter (CSI) or current fed inverters or current driven inverter
(iii) variable D.C Linked inverter.

(i) VSI → It is the one in which d.c Source has Small or negligible Impedance
or
In other word it has stiff d.c voltage Source at its input terminals.
Simply if i/p voltage of an inverter is maintained constant is called VSI or voltage fed Inverter.

(ii) CSI → CSI is the one in which d.c Source has high or Infinite Impedance.
In other word it has Stiff d.c Source at its i/p terminals which are adjustable

Supply of i/p current of an inverter is maintained constant is called current fed Inverter.

Variable- D.C Linked Inverter :

If the i/p voltage of an inverter is controllable it is called as variable-DC linked inverter.

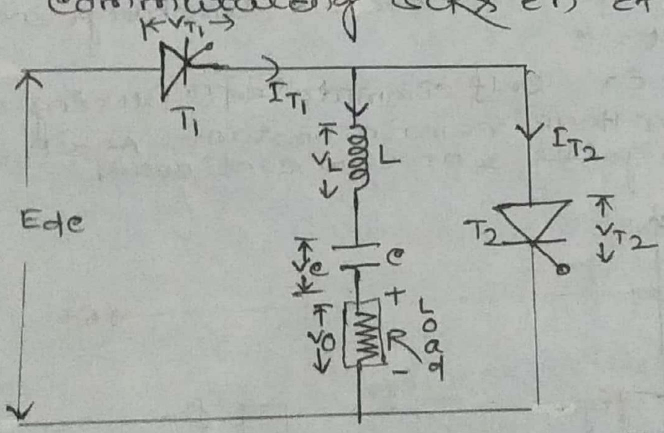
Inverters are also classified as follows depending upon the connection of commutating component with the main ckt

(a) Series Inverters
(b) parallel Inverters.
(c) Bridge Inverters.

VOLTAGE SOURCE SERIES INVERTER

↳ Inverters in which commutating elements are connected in series with the load are called Series Inverter.

↳ These inverters uses class A type commutating SCRs in its ckt.



In the ckt Edc is the d.c supply, T_1 is the main SCR, T_2 is supporting SCR, L&C are commutating elements, where v_0 is the Load voltage, V_c is the voltage across the capacitor.

- V_L → voltage across the Inductor.

I_{T_1}, I_{T_2} → current flowing through SCR-1, SCR-2

I_0 → Load current.

OPERATION

The operation of series inverter is explained with the help of wave form.

At t = 0,

T_1 is gated but T_2 is not gated

T_1 turns ON

T_2 is OFF

As the Nature of ckt is underdamped i_0 reached its peak value & then falls to zero, say at a, up to this point capacitor starts charging.

AT t=a.

T_1 is OFF due reverse direction of I_0 until t=b, T_2 is also OFF, Hence $i_0=0$

There fore the period ab is called Turn-off period (T_{off}) T_1 & T_2 are OFF the Load terminals are open ckted, capacitor charging voltage remains constant. &

Voltage across Inductor (V_L) = $-L\,di/dt$.

AT t=b

T_2 is gated & T_1 is OFF.

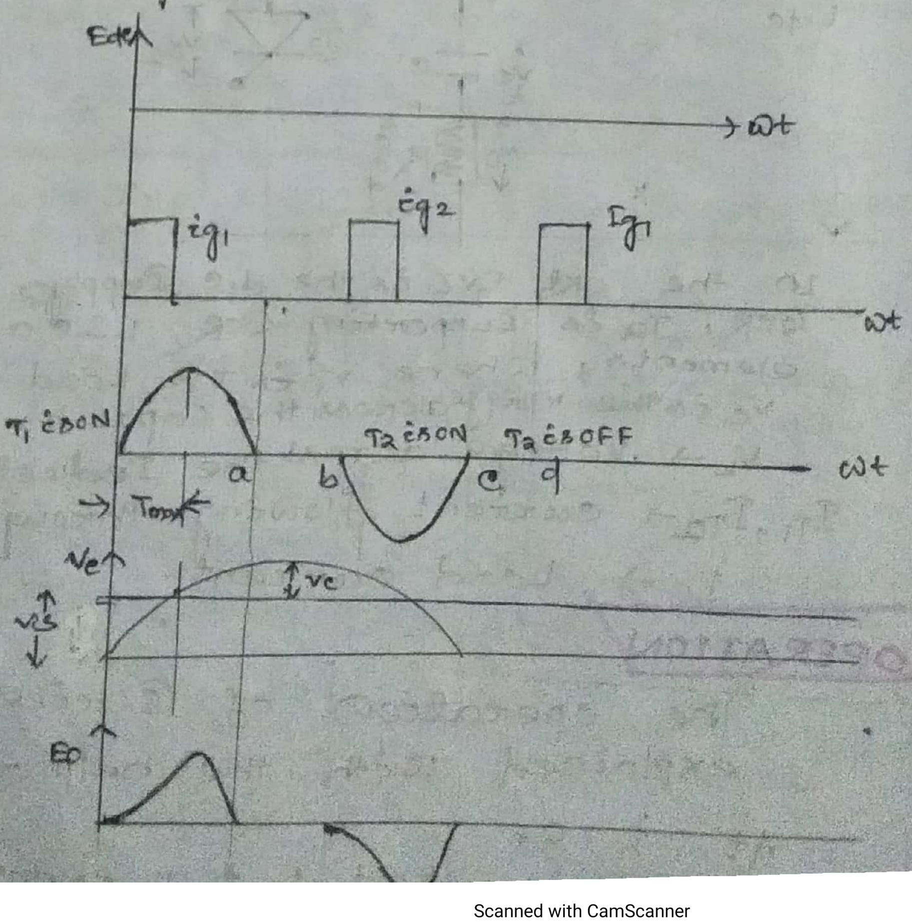
A Loop is formed through T_2, R-Load, C&L

$i_0 = -I_0$

Now capacitor starts discharging.

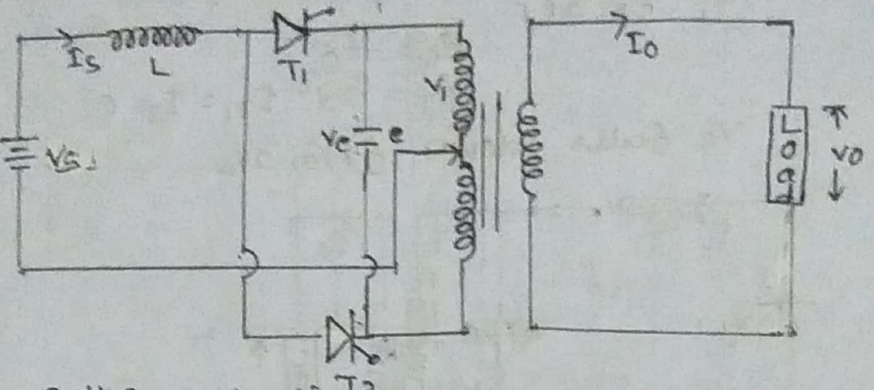
AT t=c

$i_0=0$, T_2 is self commutation. During cd capacitor voltage remain constant. Again at t=d, T_1 is gated & process continuous.



VOLTAGE SOURCE PARALLEL INVERTER

This ckt consist of two SCR T_1 & T_2, commutating capacitor C, Inductor L & output T/F with turns ratio $N_1 : N_2$



in the ckt diagram
V_s → Supply voltage or Source voltage.
V_o → Load voltage.
V_c → voltage across commutating Capacitor.
V_1 → Voltage across primary half of the T/F
I_{T1}, I_{T2} → current across SCR$_1$ & SCR$_2$.
I_s → Source current.
I_c → discharging current.

OPERATION

The operation of basic parallel inverter is explained with help of four modes.

Mode-01: at t=0,

↳ Source current (I_s) starts flowing through primary winding which according faraday's Law of Electromagnetic mutual Induction the self Induced emf V_1 ($\approx V_s$) across first half of the primary winding. Same is the case across second half also (According potential division rule)

↳ There fore total Induced voltage across primary winding equal to the sum of voltages across two halves of primary winding which is equal to twice the supply voltage. Now voltage across capacitor

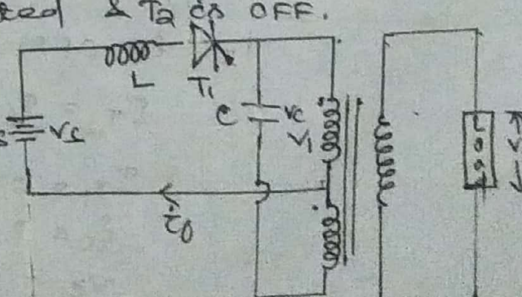
$V_c = 2V_1 \approx 2V_s$

T_1 is ON as it is gated & T_2 is OFF.

$I_{T1} = I_s = I_o$

$V_c = 2V_1 = 2V_s$

$V_o = V_s$



Mode-02:
at t=0

↳ From this Instant capacitor starts discharging its stores $2V_s$ amount of voltage across SCR T_1 there by Reverse biasing it.

L) Hence T_1 is Turned off. Also at the same time this capacitor discharging voltage appear across first half of the primary establishing discharge current in negative direction to flow until capacitor charges $+2V_s$ at $t = t_1$

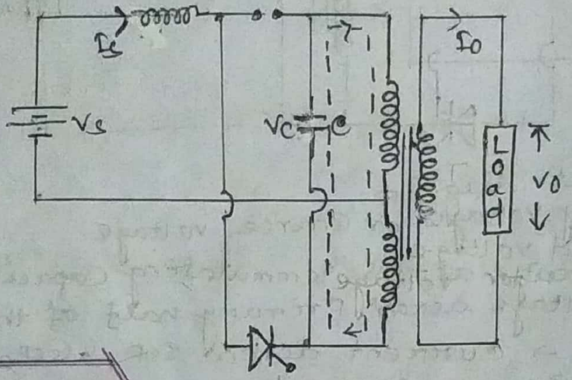
T_2 is ON as it gated it.

T_1 is OFF.

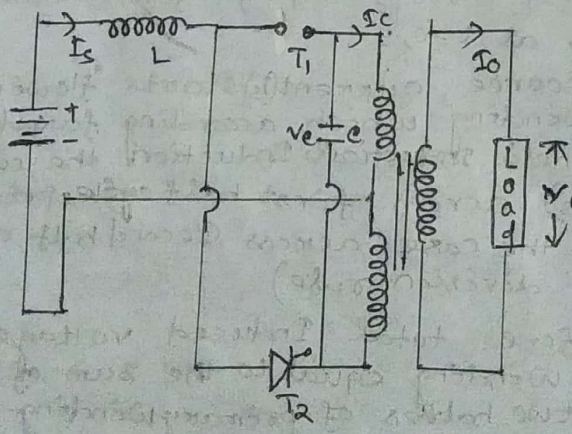
$i_C = -i_O$

$i_T = 0$, $I_{T_1} = I_S = 0$

V_C falls down from $2V_s$



Mode-03



at $t = t_1$

T_2 is ON as it is gated in

T_1 is OFF.

$I_{T_2} = I_S \approx I_O$

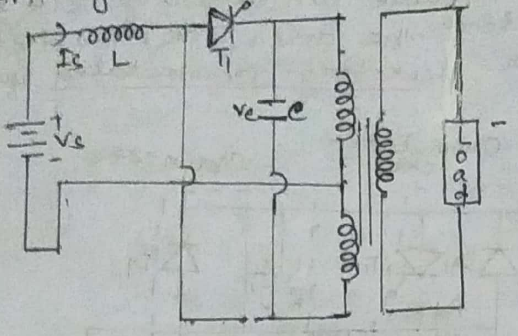
$I_{T_1} = 0$

$i_C = 0$

$V_C = -2V_S$

Mode-04 at $t = t_2$, At this Instant Capacitor charging voltage $V_C = -2V_S$ appear across T_2 & Reverse biased it there by turning it off.

↳ Also this charging voltage appears across T_1 & starts forward biasing it & aids the the gate signal to turn 'ON' it.



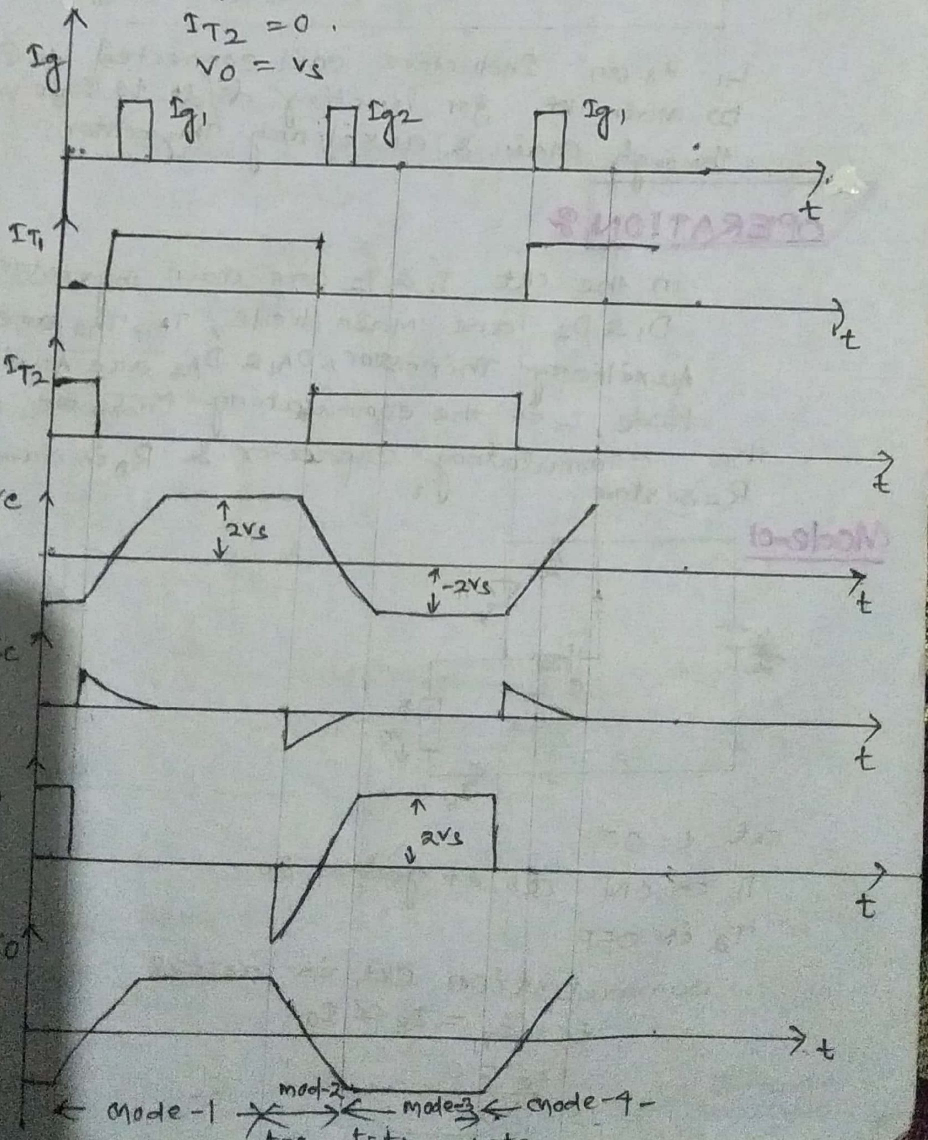
T_1 is ON as gated it.

T_2 is OFF.

$I_{T_1} = I_S = I_O$

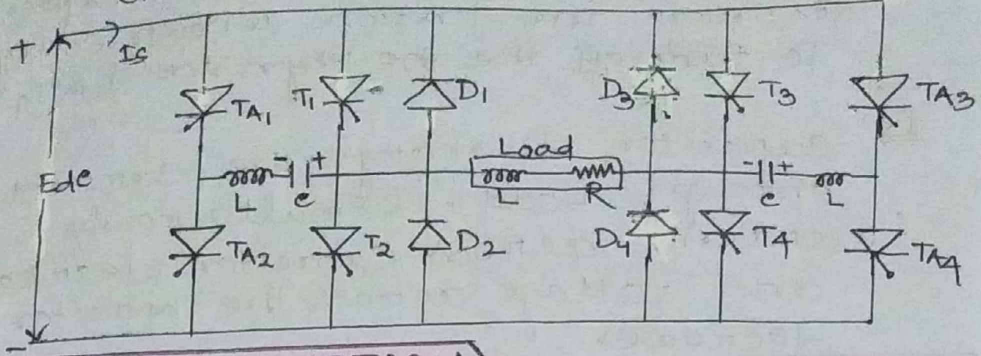
$I_{T_2} = 0$.

$V_O = V_S$



VOLTAGE SOURCE FULL BRIDGE INVERTER

MC Murray Impulse commutated 1-ϕ Bridge ckt.



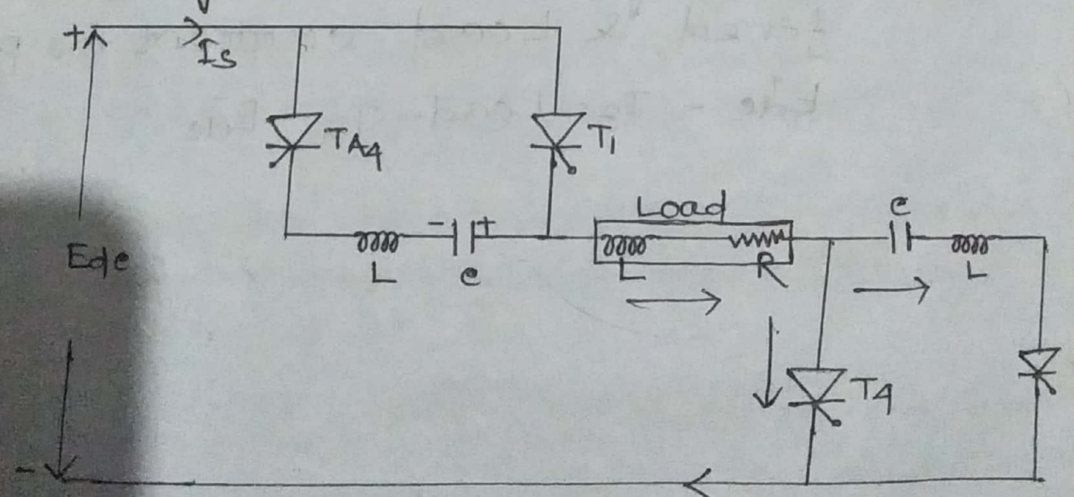
CKT DESCRIPTION

↳ It consist of four main Thyristore T_1, T_2, T_3 & T_4 Diodes D_1, D_2, D_3 & D_4 commutation ckt consist of four auxiliary Thyristore TA_1, TA_2, TA_3 & TA_4, Inductance & capacitance

It's operation may be explained in different four modes.

MODE - 01

Initially thyristore T_1, T_4, TA_1 & TA_4 are Triggered & Hence, they are made to conduct a load current I_o, whose direction is shown in fig. & capacitore is charged to a voltage V_c



Load current follow the path

$\overset{+}{E}_{dc}$ – T_1 – Load – T_4 – $\bar{E}_{dc}$

MODE-02

For commutation process capacitor discharge the charge shown in fig. To turn off the the thyristor T_1 & T_4

- capacitor discharge the current through Load. Simultaneously current across capacitor decrease and voltage across the capacitor decreases.

MODE-03

- When ever $I_c < I_0$, thyristor T_1 & T_4 Return to the forward blocking mode
- The Thyristor T_1 & T_4 return forward blocking mode.
- Again T_{A1} & T_{A4} followed the path.

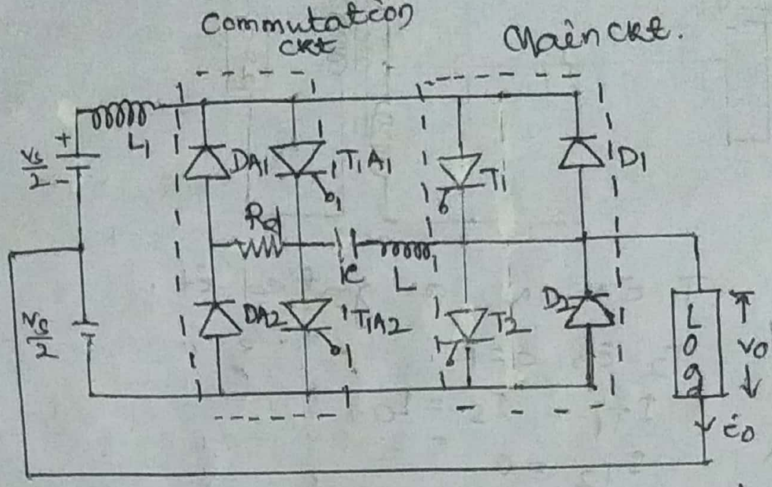
MODE-04

During this mode T_2 & T_3 are fired & Load current the path

$E_{dc}^{+} - T_3 - \text{Load} - T_2 - E_{dc}^{-}$

MC MURRAY VOLTAGE SOURCE HALF BRIDGE INVERTER

- 1-ϕ modified M.C. Murray Bridge Inverter basically a current commulated voltage source inverter.
- Its ckts include an auxilary SCR for commutating the main SCR. So it is named as auxilary commutated Inverter.

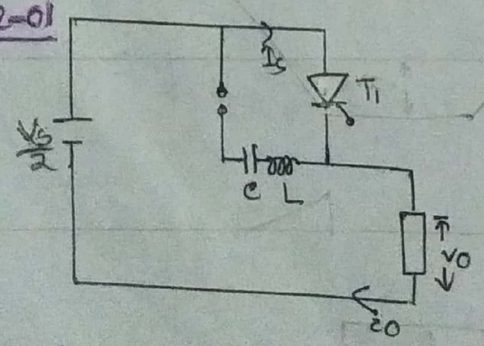


L_1 is an Inductive coil connected in series to main ckt. for limiting di/dt to safe value through main & auxiliary Thyristor.

OPERATION :-

In the ckt T_1 & T_2 are main Thyristor, D_1 & D_2 are Main diode, TA_1, TA_2 are Auxiliary Thiristor, D_{A1} & D_{A2} are Auxilary diode, L is the commutating Inductor, c is the commutating capacitor. & R_D is daming Resistor.

Mode-01



at $t=0^-$

T_1 is ON as it gated in.

T_2 is OFF

commutation ckt is passive

$$i_0 = i_{T_1} = I_S \simeq I_0$$

$$i_c = 0$$

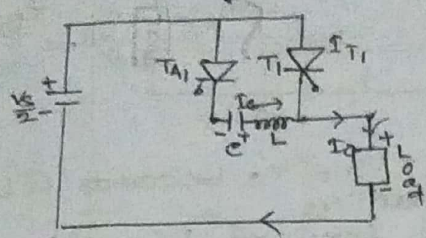
Mode-II

at t=0

T_{A1} is ON

capacitor starts charging

Since voltage drop across T_1 Reverse biased D_1



Here

$I_0 = I_{T_1} + I_{TA}$

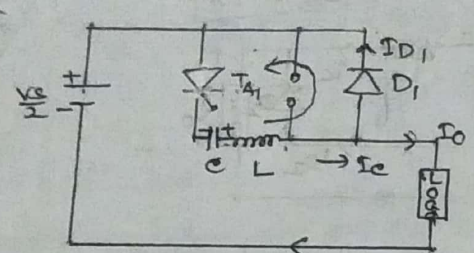
$I_c = I_0$

So $\boxed{i_0 = I_{T_1} + I_{TA}}$

Mode-3

AT $t = t_1$

T_1 is Turn off & diode (D_1) is ON



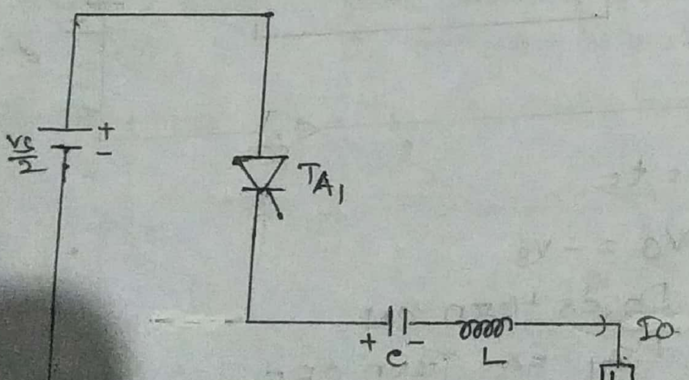
Capacitor starts discharging through D_1

$I_0 = i_c - I_{D1}$

$I_c = I_{D1} + I_0$

$\boxed{V_c = 0}$

Mode-4



at $t = t_2$

D_1 turn off

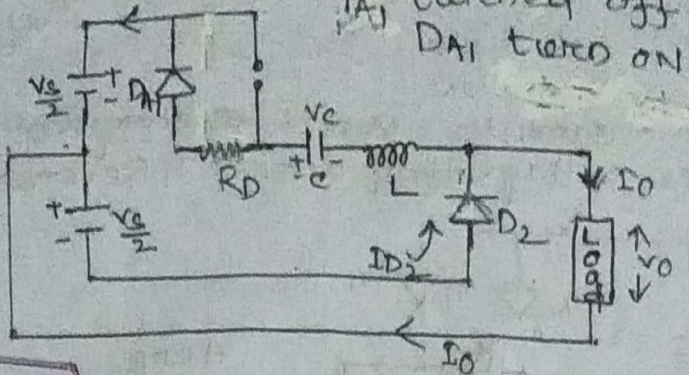
Here $I_{TA_1} = I_c = I_0$.

Mode-05

AT $t = t_4$

Here $V_C = V_m$ (The energy stored in Inductore is transfered to capacitor consequence capacitor is over charged to peak voltage V_m at t_4

T_{A1} turned off
D_{A1} turn ON



$i_o = i_{D2}$
$i_{D2} > i_o$

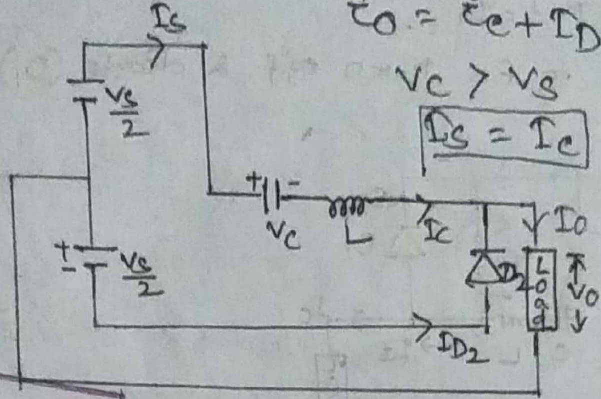
Mode-05

AT $t = t_3$, V_c becomes slightly more than V_s
D_2 get forward biased

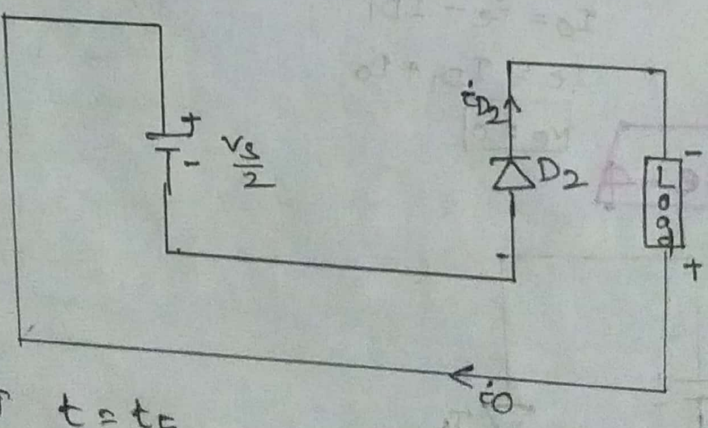
$i_o = i_c + I_{D2}$

$V_c > V_s$

$I_s = I_c$



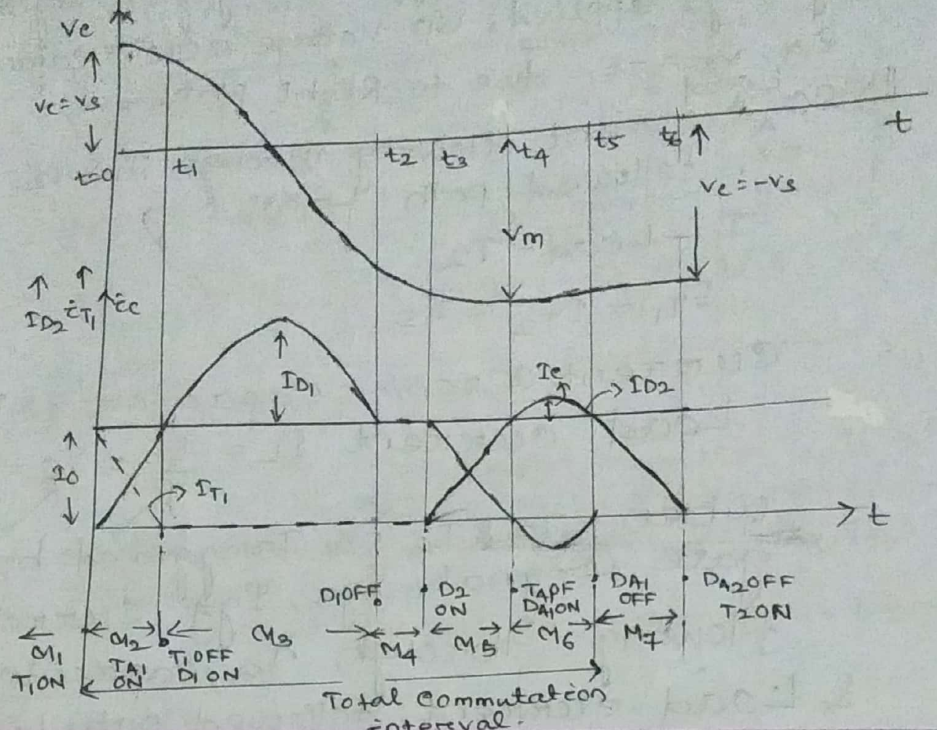
Mode-07



AT $t = t_5$

$V_o = -V_s$

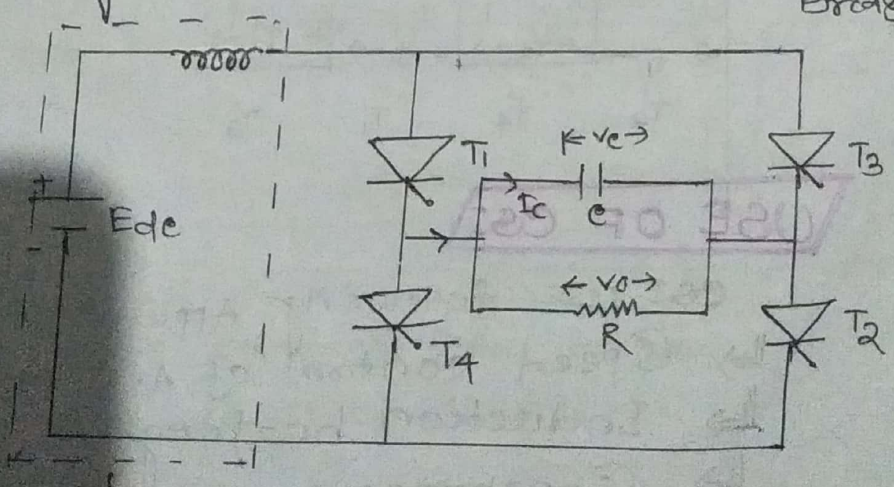
- D_2 is turn ON
- D_{A1} is Turn OFF.



SINGLE PHASE CAPACITOR COMMUTATED CURRENT SOURCE INVERTER WITH R-LOAD

↳ Single phase, current source bridge Inverter ckt with R-Load. capacitor (c) in parallel with Load is used for storing the charge for forced commutation of SCR.

↳ Thyristor T_1, T_2, T_3 & T_4 from the power Bridge.



↳ Constant Current Source 'L' is Large

↳ When T_1 & T_2 is Triggered by gate signal I_{g1}, I_{g2} applied, so voltage across capacitor is $V_c = -E_1$ due to Right plate +ve.

↳ So Load current flowing through T_1 & T_2 is followed path Like

T_1 - Load - T_2

$I_{T_1} = I_{T_2} = I_S$

Current across Capacitor is I_c

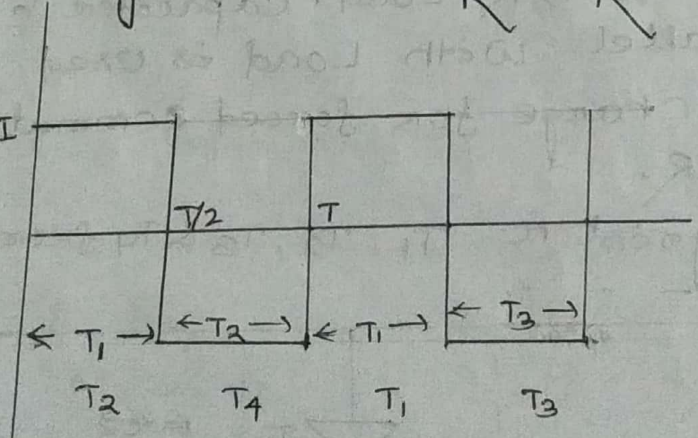
Load current $I_L = \frac{E_L}{R} = \frac{V_0}{R} = \frac{-V_c}{R}$

When T_3 & T_4 is Triggered by gate signal I_{g3}, I_{g4} current flowing through T_3, capacitor & Load current followed path Like

T_3 - Load - T_4, Here $V_C = E_1$

& $I_{T_3} = I_{T_4} = I_S$

again $I_L = \frac{E_L}{R} = \frac{V_0}{R} = \frac{V_C}{R}$



USE OF CSI

CSI use following Application.

↳ Speed control of A.C motor.

↳ Induction heating

↳ Synchronous motor starting

↳ Lagging VAR Compensation.