UNIT-1

Power Electronics

Concept of power Electronics :-

* power Electronics is a Combination of power Engineering and Electronic Engineering & Control Engineering,
* power Engineering is mainly Concerned with generation, transmission, distribution & utilization of Electric Energy at high Efficiency.
* Electronic Engineering is mainly Concerned production, transmission & reception of data & Signals of very low power level, of the order of a few Watts (or) milli Watts.
* The main Concept of power Electronics is the Bulk amount of power Can be Converted & Controlling by (on) With Electronic devices.

Ex:- A Semi Conductor power Switches such as thyristor, GTOs etc., Work on the principle of Electronics (movement of holes & Electrons), but have the name power attached to them only as a description of their power Ratings.

Applications of power Electronics :-

* The area of Modern power electronics began with invention of SCR by Bell Laboratories in

1956. power Electronics System today incorporate power Semi Conductors as well as micro Electronic integrated ckt's

→ Conventional power Controllers based on thyratrons, mercury arc rectifiers, magnetic amplifiers, rheostatic Controllers have been replaced by power Electronic Controllers using Semi Conductor devices in all most all applications.

1. **AeroSpace**:- Space Shuttle, power Supplies, Satellite power Supplies.

* Advantages :-

1. High Efficiency due to low loss.
2. High reliability
3. long life & less maintainance due to absence of any moving parts.
4. Small Size and less weight result in less floor Space & there-fore lower installation Cost.

* Dis Advantages :-

1. power Electronic Controllers have low over load Capacity
2. Regulation of power is difficult.
3. Ac to D.C and A.c to A.c Converters operate at a low i/p power factor under Certain operating Conditions
4. power - Electronic Circuits have a tendency to generate harmonics in the Supply Systems as well as in load Circuit.

Types of power Converters:-

1. Diode Rectifiers
2. A.C to DC Converters
3. DC to DC Converters
4. DC to AC Converters
5. AC to AC Converters
6. Static Switches.

* Power Semi Conductor Diode:-

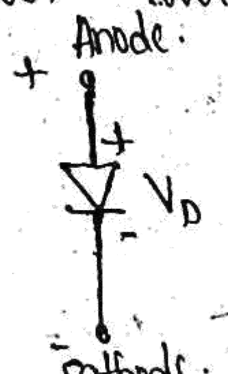


fig:- Symbol

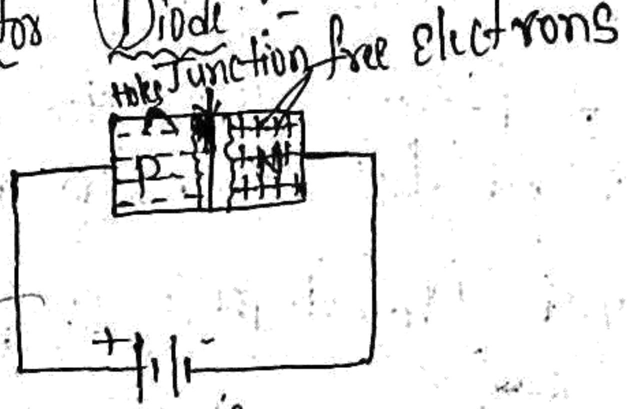


fig: Diode Construction

→ Diode is a uni directional & un Controlled device.

→ Diode is a Semi Conductor device with two terminals that Conducts Current in one direction only known as unidirectional.

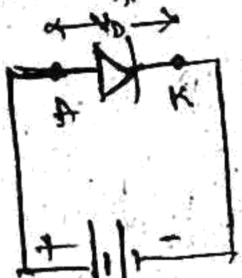
→ A P-N Junction is the simplest form of Semi-Conductor diode which in ideal Condition behaves as a Short Circuit when it is forward biased and in open Circuit when it is in Reverse biased.

Working:-

→ A diode working principle depends on the interaction of n-types and p-type Semi Conductor has plenty of free Electrons and a very few number of holes. In other words we can say that the Concentration of free electrons is high and that of holes is very low in an n-type Semi Conductor. free Electrons in the n-type Semi Conductor are referred as majority Charge Carriers, and holes in the n-type Semi Conductor are referred as minority charge Carriers.

→ A p-type Semi Conductor has a high Concentration of holes and low Concentration of free Electrons.

* V-I Characteristics Of Diode :-



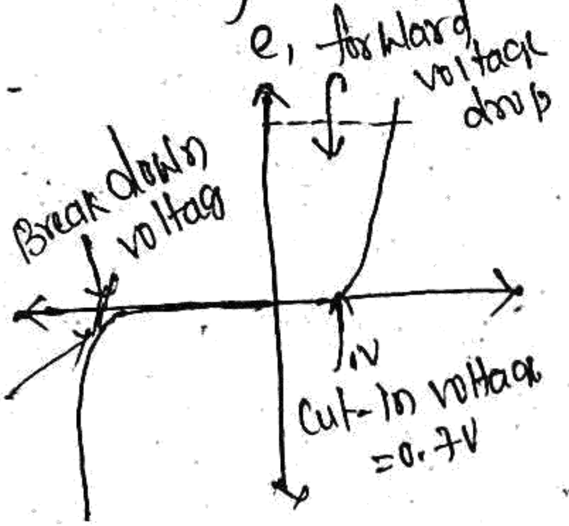
→ When anode is +ve w.r.t Cathode diode is said to be forward biased. With the increase of Source voltage "V_s" from zero value initially diode Current is zero, from, $V_s = 0$ to "Cut-in voltage", the forward diode Current is very small. Cut in voltage is also known as threshold voltage (or) turn-on voltage.

→ Cut in voltage around "0.7" V

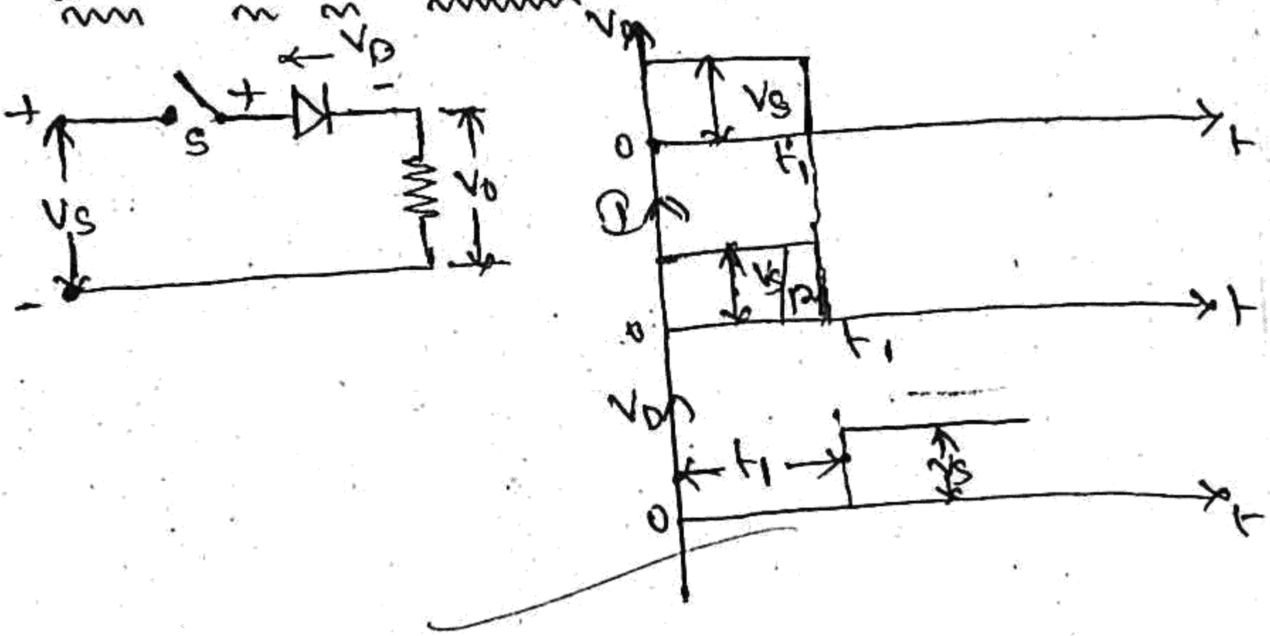
→ When diode Conducts, there is a forward voltage drop of order of "0.5 to 1V"

→ The diode is reverse biased. In this Condition, a small reverse Current Called leakage Current of the order of μA (or) mA purpose. The leakage current is almost independent of magnitude of reverse voltage until this voltage is reaches break down voltage.

→ A large Reverse break down voltage associated with high reverse Current, leads to excessive power loss that may destroy the diode.



* Diode As a Rectifier :-



→ In the Ckt, When Switch "S" is Closed, the Current rises instantaneously to V_S/R as shown in fig (b). Hence V_S is the DC Source voltage

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Applications of P.E :-

1. Aero Space :- (Air Craft power supplies)
2. Satellite power supply. Commercial purposes (TV, Refrigerators) etc.

   ↓ It has more advantages that why we use power Electronics in Commercial purpose

3. Residential purposes (Iron Box) → All Electronic devices.
4. Industrial purposes (fan, heaters etc.,) All industrial devices.
5. Tele-Communication (Battery charging, ups power supply)
6. Traction purpose (Rails).
7. Utility purpose (HVDC)

Power Conversions:-

(i) A.c to D.c Conversions:- (Phase Controlled Converters)

→ 90% of applications is used variable D.C (or) speed.

→ But we have a fixed D.C is com to double bridge rectifier. We have variable speed (or) voltage. That's why we used phase controlled converters.

(ii) D.C to D.C Converters:- (D.C Choppers).

→ It converts fixed D.C to variable D.C.

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(iii) D.C to A.c Converters:- (Inverter):-

D.C → fixed voltage

A.c → variable voltage (or) variable frequency.

(iv) A.c to A.c Converters:- (A.c Regulators).

A.c → fixed voltage.

A.c → variable voltage (or) variable frequency.

→ We need only "variable voltage" to fixed voltage is called A.c Regulator (or) AC voltage controller.

→ We need only variable frequency to fixed frequency is called Cyclo (converter).

* Thyristor is always similar to p-n Junction

Thyristor:-

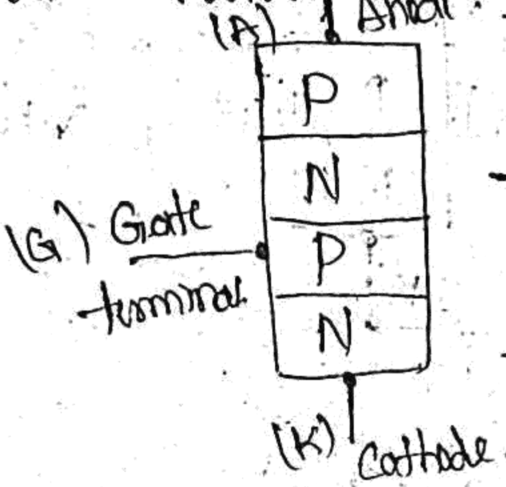
→ By using device we can convert and control.

In olden days THYRotran is used to convert and control.

→ Thyristor characteristics is similar to THYRotran tube. **THYRISTOR.**

→ Thyristor construction is similar to transISTOR

Thyristor Construction:-



→ It has 4 - layers. PN - PN layers.

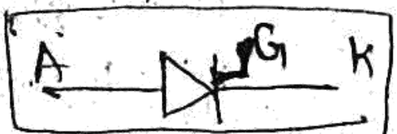
→ It has 3 - junctions.

→ 3 - terminals.

→ The terminal P layer connected is anode.

→ The terminal N layer connected is cathode.

→ Symbol of Thyristor



→ uni directional device just like diode

→ Thyristor is a control device (difference of thyristor & diode is) I
we can control current.

→ It always obtained controlled o/p.

→ Single chip available Rating is "10 KV."

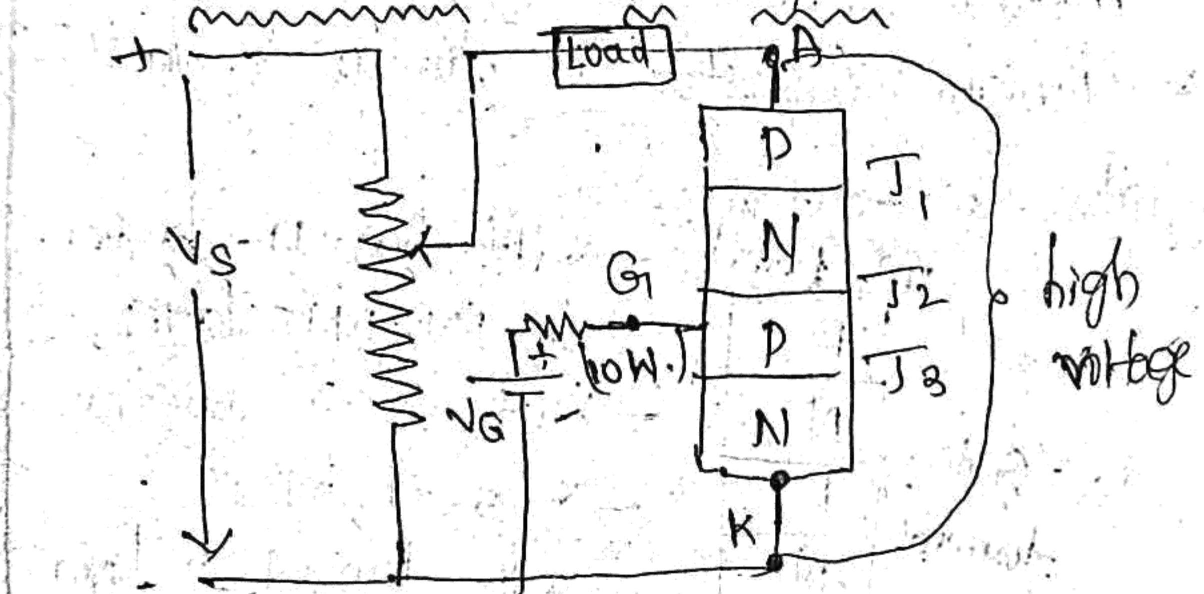
→ Single chip can handle 40 M[illegible] Power Watt $I = 4KA$

→ "J_1" is formed outer 'p' layer inner 'N' layer

→ "J_2" is formed inner 'p' & 'N' layers.

→ "J_3" is formed inner "p" & outer "N" layers.

* Characteristics of Thyristor:-



→ Diode is classified into
(i) forward bias Mode
(ii) Reverse Bias Mode.

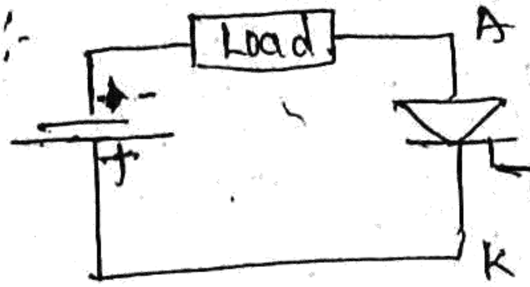
→ There are three types of Modes of operation

OFF switch.
1. Reverse Blocking Mode → (open)
2. Forward Blocking Mode. → (open)

3. Forward Conduction Mode → (close).
ON-State

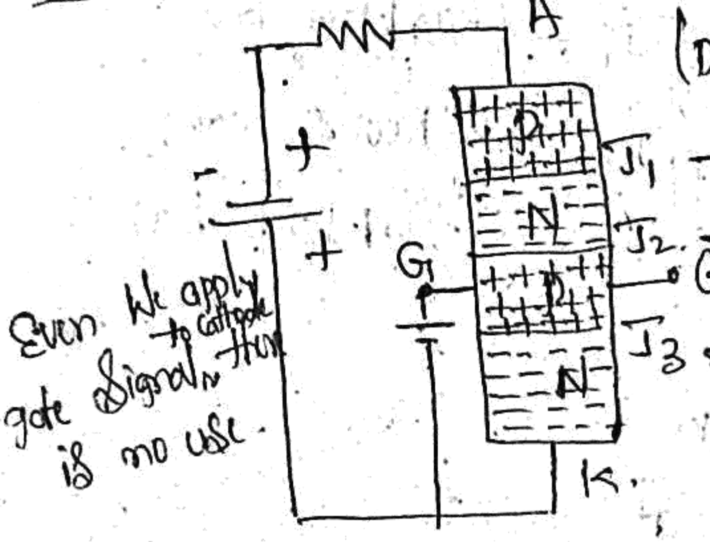
1. Reverse Blocking Mode (RBM) :-

Symbol :-



* Here voltage is Reversed.
* Reverse voltage is applied across the Thyristor.

Structure :-



J_1 → Reverse bias (Depreciation layer ↑, Resistance ↑) current "0"

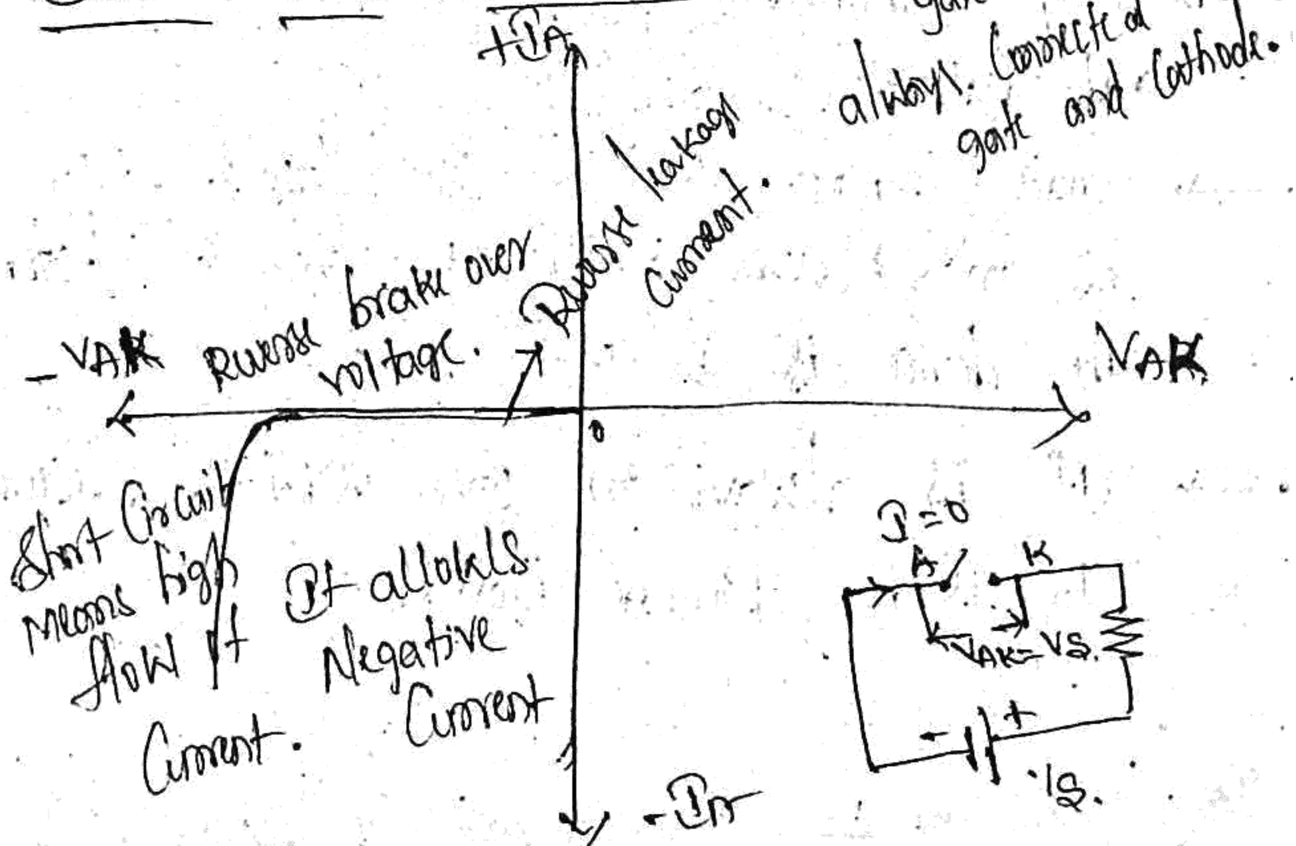
J_2 → Forward bias (Repel each other and goes to Junction) (Resistance ↓, Current ↑)

J_3 → Reverse bias.

→ Here, two Reverse bias, the device is not at all comes to conduction

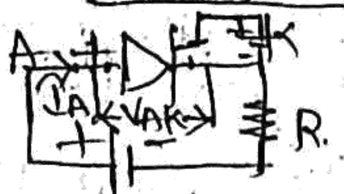
Static V-I Characteristics :-

gate terminal is always connected to gate and cathode.

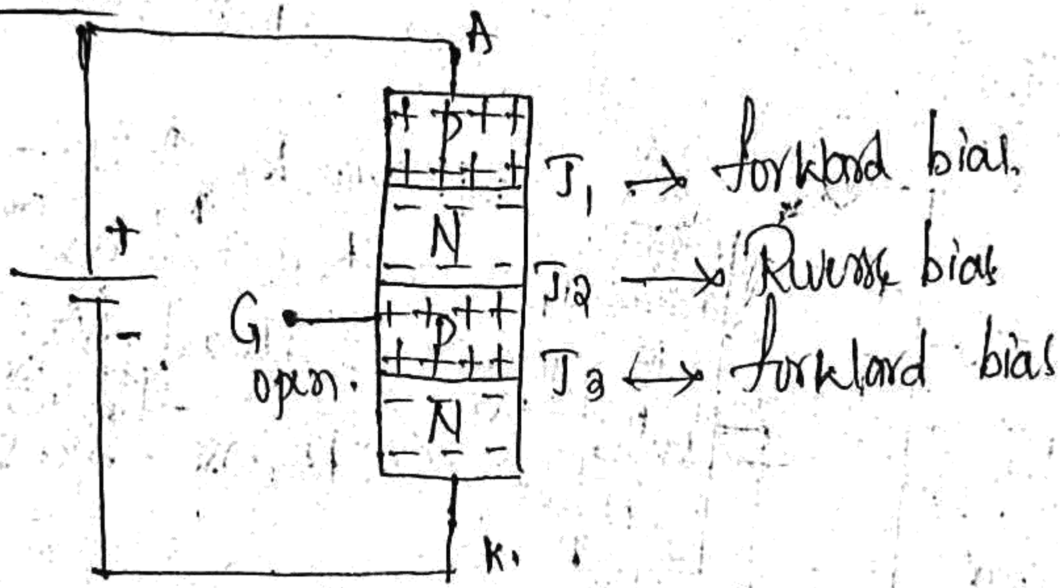


2. Forward Blocking Mode :- 05/07/19

Symbol :



Structure :-



→ J_2 is located at Centre

→ J_2 is not allow the flow of Electrons

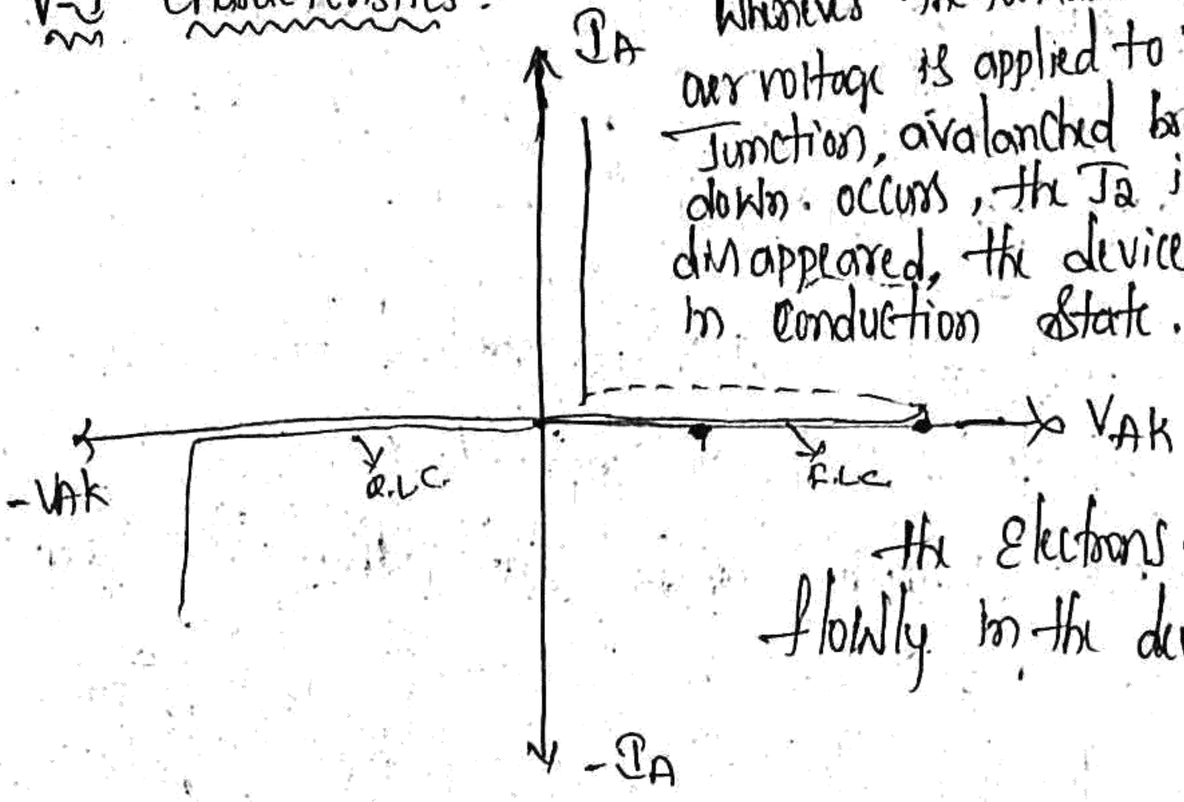
→ J_2 is block to flow of Electrons

→ only forward voltage is applied to anode and Cathode.

→ Gate signal is in open state, J_2 is in Reverse bias. no flow of Electrons the device is in off state.

→ It is always in open switch. because J_2 is in Reverse bias.

V-I Characteristics :-



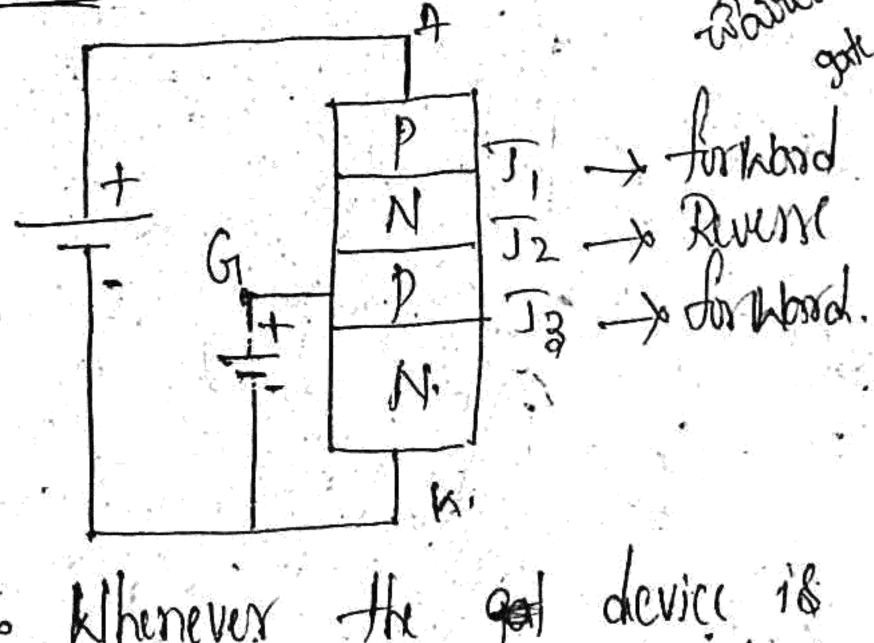
Whenever the forward break over voltage is applied to J_2 Junction, avalanched break down occurs, the J_2 is disappeared, the device is in conduction state.

the electrons free flowly in the device.

3. Forward Conduction Mode :-

[ఏ Time period వరకైతే on చేయాలనుకుంటామో అప్పుడు gate signal apply చేయాలి].

Structure :-



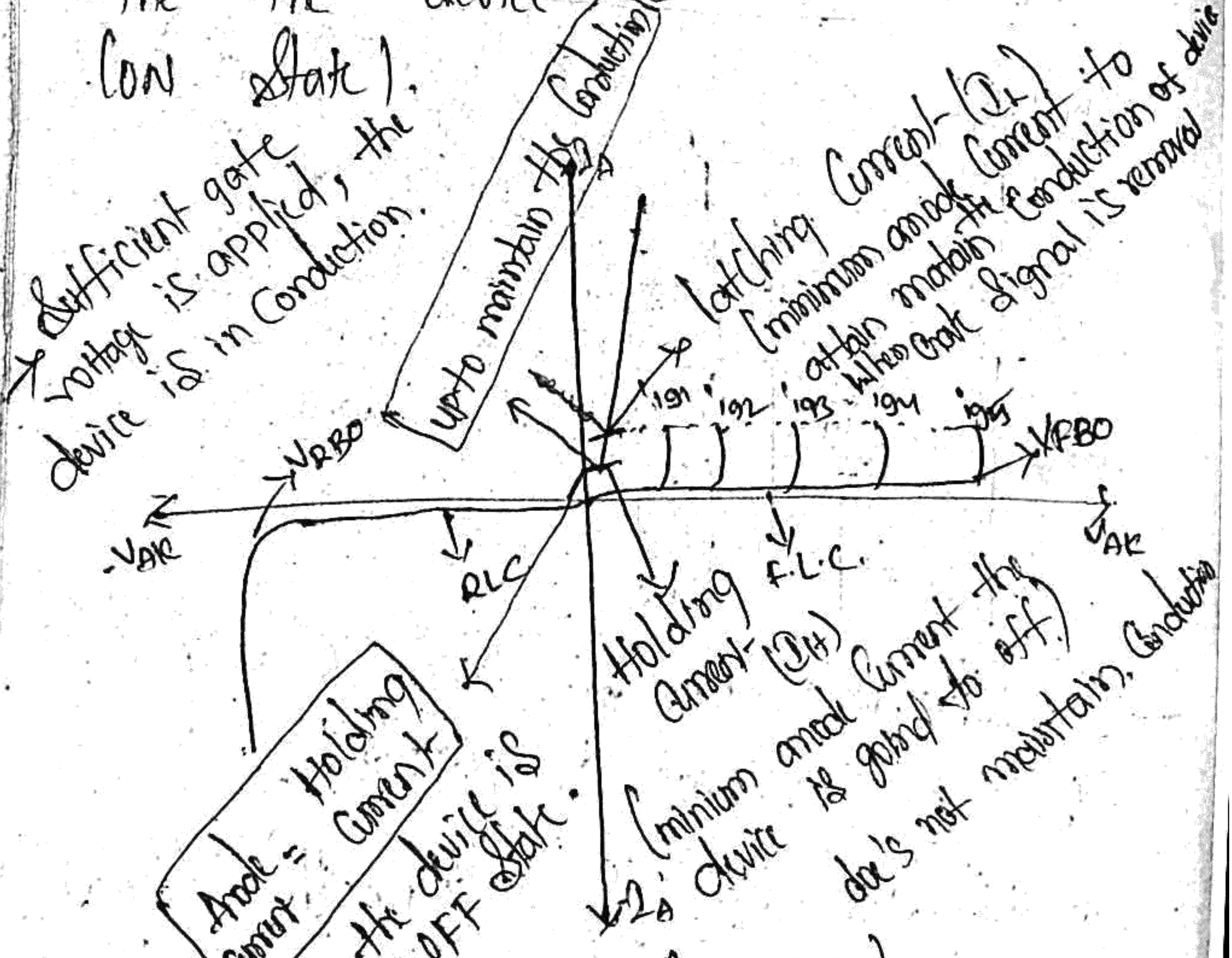
→ Whenever the ~~gat~~ device is in "on" state, the gate signal is applied.

→ Whenever Gate is applied, the external charges is injected to the inner "p" layer the Reverse bias changed to forward bias.

→ So, the J_1, J_2, J_3 are three are in forward bias, so the Electrons flows freely in the device.

→ forward voltage is applied to anode to Cathode at the same time Gate is applied b/w Cathode and Gate then the Conduction occurs.

→ Whenever the Conduction occurs, the electrons flows freely from the anode to Cathode, that the the device is in Closed switch (ON state).



→ Gate signal is applied to Continuous signal (A.C, D.C), Digital signal

→ Whenever the gate signal is removed, current flows continuously.

→ latching current is 2 to 3 times of holding current $I_L > I_H$ → the device is in on state.

* Turn-on and Turn-off Methods of SCR:-

(i) Turn-on :-

→ The device is F.B.M converts to F. Conduction state.

OFF → ON.

1. forward voltage turn on method (Not Efficient)

2. $\frac{dv}{dt}$ triggiring (Not Efficient Junction Capacitance more).

Rated voltage is across applied thyristor

3. gate triggiring → Most Efficient and economical.

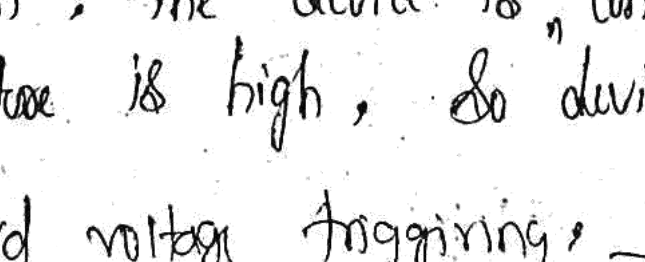
4. Thermal triggiring (or) Temperature (Not Efficient)

5. Light triggiring (Not Efficient)

→ When the Electrons move slowly to p to N Junction, the device is slowly conduction, but temperature is high, so device is Collapsed.

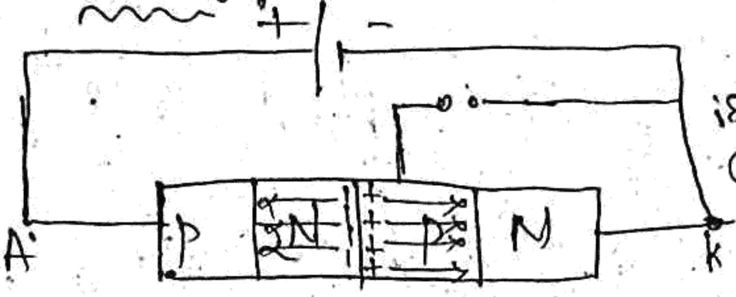
(i) forward voltage triggiring :- 8/07/19

→ forward voltage Applied across device.



forward voltage increased up to break over voltage (Rated voltage) then the Junction J_2 is disappeared and electrons flow from 'A to K'. The device may comes Conduction (Rated voltages are required).

2. $\frac{dv}{dt}$ triggering :-



Whenever the voltage is applied, the Junction Capacitances varies. Current increases

→ The rate of change of voltage

$$i_c = C_j \frac{dv}{dt}$$

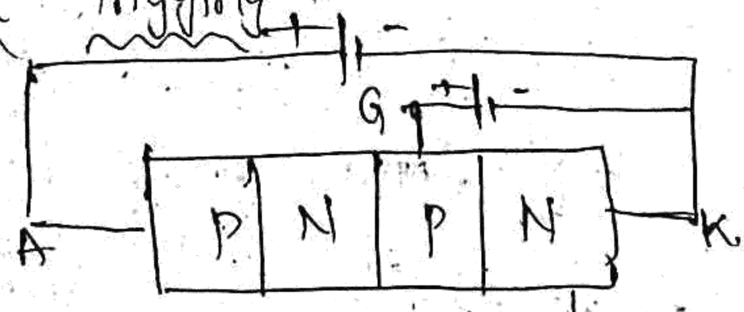
→ Whenever the device is in Conduction, ic values increases.

$$\frac{dQ}{dt} = \frac{d(C \cdot V)}{dt} \qquad Q = CV$$

$$\frac{dQ}{dt} = C_j \frac{dV}{dt} + V \frac{dC_j}{dt}$$

→ voltage increases, Conduction Current increases.

3. Gate triggering :-



Main purpose is to turn on device. once device is fully on, no need to gate signal, No change in conduction

→ The forward voltage is applied Anode to Cathode.

→ The forward Gate voltage is applied to Gate and Cathode

→ Whenever the Gate Signal is applied. The external Charges is applied to "J_2" Junction. The J_2 junction Changes from Reverse bias to forward bias

4. Thermal triggering :- (Temperature)

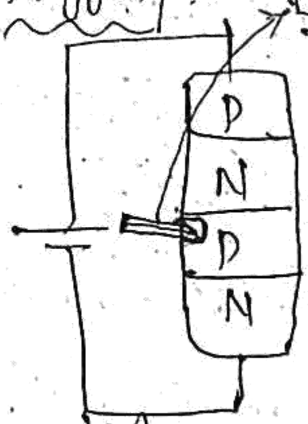
→ These are Electronic devices.

→ These devices are Sensitive at Small. temperature.

→ the Junction Current (leakage Currents) are present for a long period then the temperature increases, ~~Aut the~~ Junction break, Automatically the devices Comes to fail.

5. light Triggering :- LASCR

light Activate Silicon Control Rectifier.



only high light intensity

Symbol :-

Whenever the high light intensity fall in "LASCR" the External Energy Applied (injection) to Junction, then Junction Comes to Conduction (forward Conduction)

Turn- off :- (Turn-off process of SCR is called Commutation)

→ The device is Comes from f.C.M to f.B.M

ON → OFF State.

* Two types of Methods :-

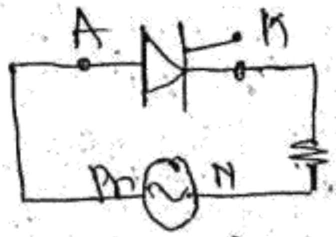
Class A, Class B — (i) line Commutation (or) Natural Commutation (When applied to A.C voltage supply)

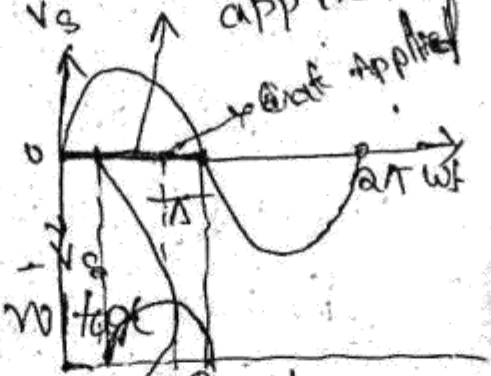
Class C, Class D, Class E — (ii) forced Commutation. (When applied mostly to D.C and sometimes to A.C supply)

By using these two methods, to turn - off the devices.

Suppose,

(i)





0-π → forward voltage

* At this instant forward gate signal is applied the device is 'ON' State. (Closed Switch)

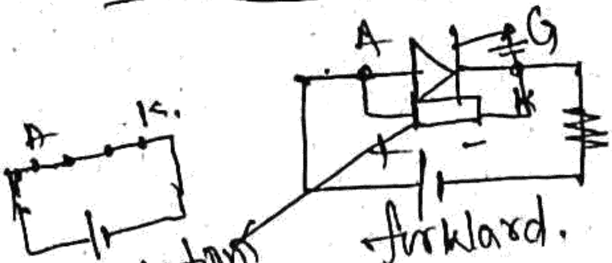
$V_0 = V_S$. Closed Switch.

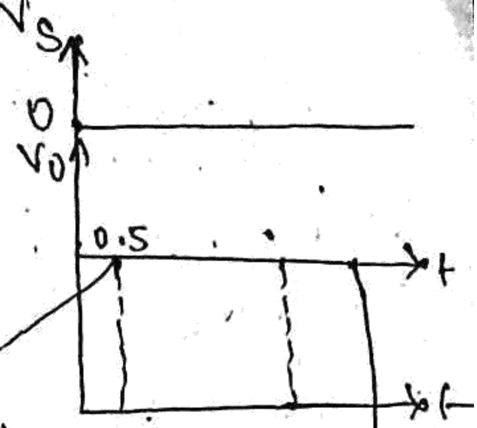
→ At 'π' - 2π , Reverse.

Wherever the anode voltage is "0" at "π", forward bias is "0", So the device gets Reverse

* Naturally the device is turn off due to line voltage that type is Called line Commutation (line voltage is zero).

2. Forced Commution :-





→ $V_0 = V_S$, the device is on.

This is constant forward voltage. We have whenever the Reverse bias. So we apply Commutation Circuit b/w "A and K".

→ Commutating elements is "L" and "C".

→ Impedence is low (Commutation CKT) Compared to the closed Circuit.

→ So, the Current is diverted to "L" and "C". the resistance is reduced.

→ Whenever Anode Current (below) less than holding Current, the Junction "J_2" gets reversed. So the device is comes to OFF-State.

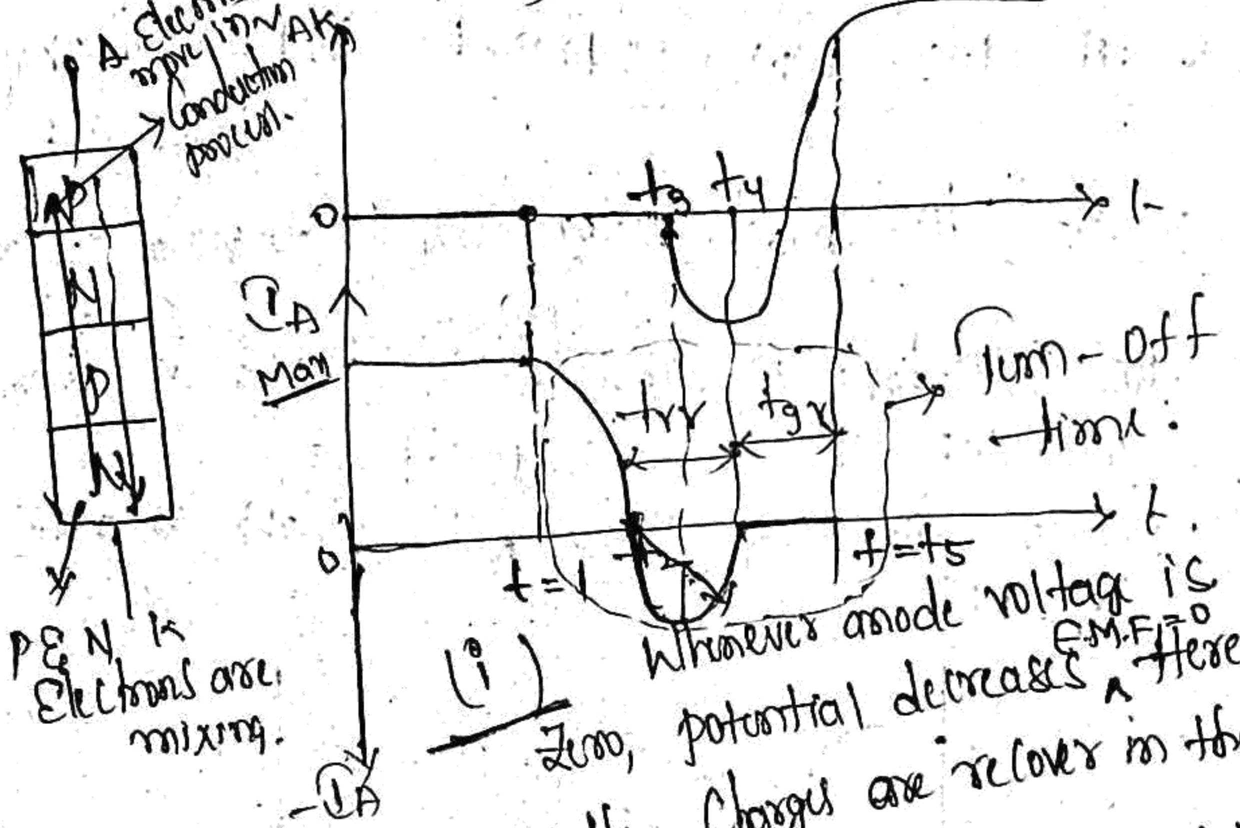
11/07/19 Time taken to Block the Current That type is Turn-off.

(ii) Turn-off time Characteristics:- (F.C.M - F.B.M) ON - OFF

→ Two times.

(ii) Gate Recovery time. (tgr):

(iii) Reverse Recovery time (trr):-



(i) Whenever anode voltage is Zero, potential decreases E.M.F=0 Here. The Charges are recover in the devices.

→ The device is not suddenly off

→ These Electrons are move in reverse direction to set in original State when the ... (for some period.)

→ But some moments the Electrons are slowly decreases and reaches to its original State.

(ii) Gate recovery time:-

→ But when the gate is applied to the device. Some Charges inject to the device.

So, some Electrons are recovery in the device (for time period).

→ This condition, the device is in Blocking State.

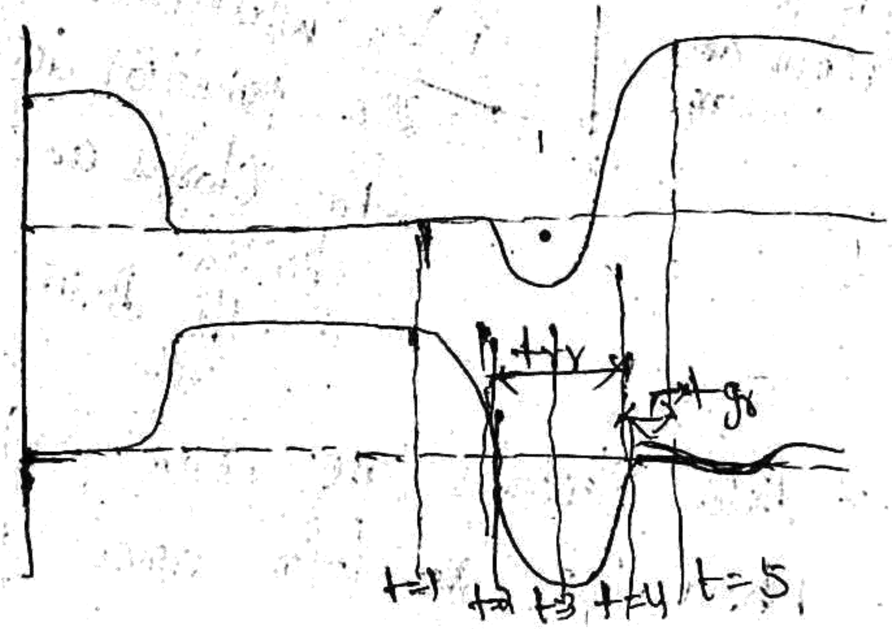
→ It is in m-sec (or) μ-sec

→ It lies b/w 50 μs to 100 μs (Converter Grade SCR.)

→ It lies b/w 0 to 50 μs (Inverter Grade SCR)

* Turn of time period is more is known as Converter Grade SCR.

* Turn of time period is small is known as inverter Grade SCR.



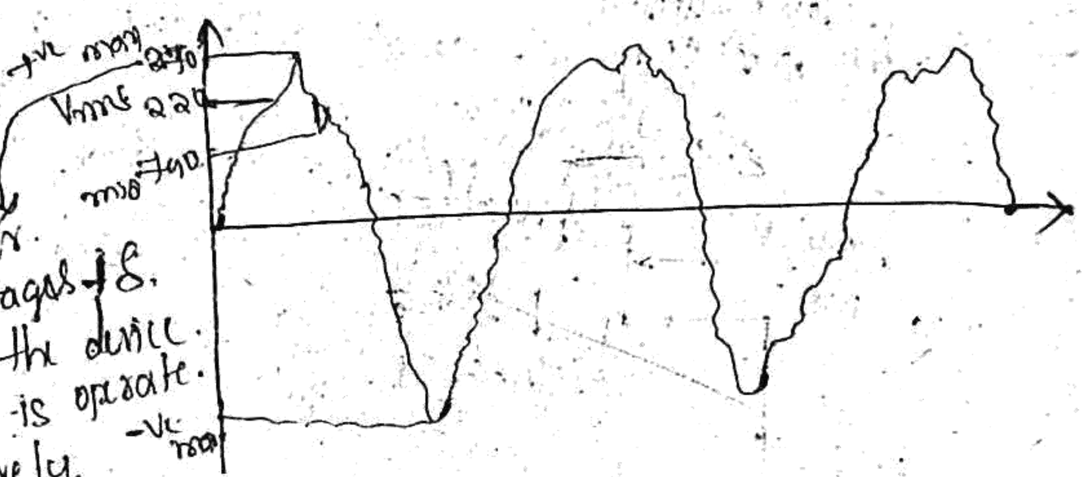
* Protection of SCR:-

1. Voltage protection.
2. Current protection
3. power protection →
4. Temp protection → Temperature increases, the Junction breakes for the device. So, we can control the device.
5. Gate protection.

1. Voltage protection :- $\left(\frac{dv}{dt}\right)$

(i) Internal voltage :- the rating devices.

(ii) External voltage



whenever this voltages is given to the device the device is operate effectively.

(2) Current protection :- $\frac{di}{dt}$ protection.

(i) internal Current

(ii) External Current

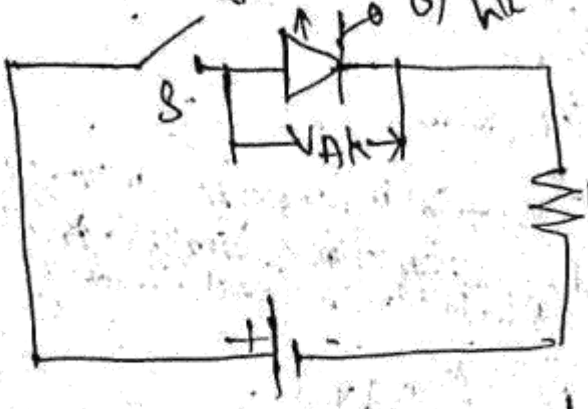
(iii) false Current

→ Whenever The defined SCR's Currents comes, the Electrons moves slowly & smoothly and spread.

→ Whenever the Sudden Currents comes to the devices the device is damaged.

1. $\frac{dv}{dt}$ protection :- (or) Snubber Circuit :-

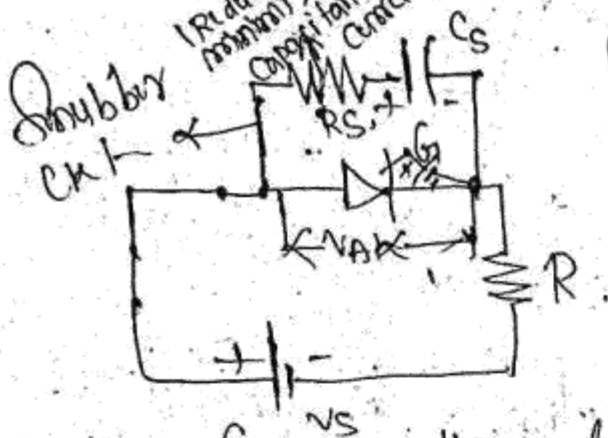
How much rating is G we take that type of snubber ckt



the voltage fluctuates due to falls so, we protect the device

→ When the switch is closed, the initial voltage is supplied; the voltage is b/w V_{AK} because Gate 'G' is Blocking state.

→ the device is applied supply a small voltages. (linear voltages)



Capacitor allows rate of change of voltage

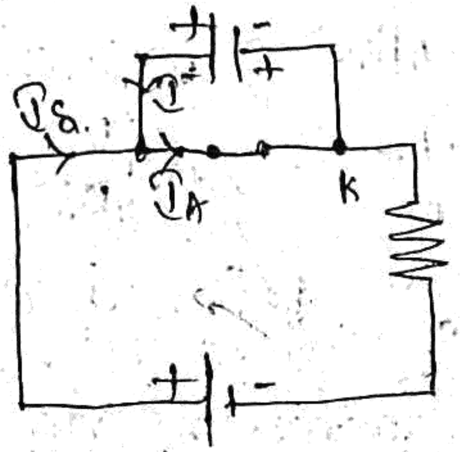
→ In this case, the sudden voltage is supplied to the circuit. The voltage is supplied to the capacitor.

→ The capacitor does not allow sudden current.

→ It allows smooth circuit.

→ for some period the voltage across capacitor is fully charged with Vs. $V_s = C_s$

→ Whenever the gate signal is applied, the device is in conduction.



$I_A = I_S + I_C$

→ For some time the fully charged capacitor is discharging. So capacitor currents is '0'.

→ It acts as open ckt.

→ No "Rs," the SCR is controlled $I_S + I_C$.

– No controlling $I_S + I_C$, the device will fail.

→ Snubber circuit is protected the SCR to $\frac{dv}{dt}$.

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1. A thyristor operating to a peak supply voltage 400 V has been following specifications, repetitive $I_p = 200$ A, $\frac{dI_m}{dt} = 50$ Amp/µs, $\left(\frac{dv}{dt}\right)_{max} = 200$ V/µs and $\left(\frac{dv}{dt}\right)_{max}$. Design a suitable snubber ckt. The minimum value of load resistances 10 Ω.

Sol:- Given data,

$V_s = 400$ V.

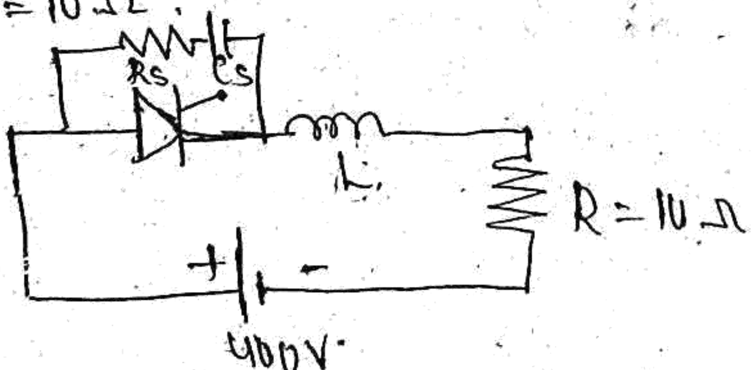
$I_p = 200$ A,

$\left(\frac{dI}{dt}\right)_{max} = 50$ A/µs.

$\left(\frac{dv}{dt}\right)_{max} = 200$ V/µs

Safety factor of 2, for I_p, $\left(\frac{dI}{dt}\right)_{max}$, $\left(\frac{dv}{dt}\right)_{max}$

$R_L = 10\ \Omega$.



$I_p = \frac{200}{2} = 100$ A, $\left(\frac{dI}{dt}\right)_{max} = \frac{50}{2} = 25$ A/µs

$\left(\frac{dv}{dt}\right)_{max} = \frac{200}{2} = 100$ V/µs.

$$L = \frac{V_s}{\left(\frac{di}{dt}\right)_{max}} = \frac{400}{25/10^{-6}} = 16\ \mu H.$$

$$R_s = \frac{L}{V_s}\left(\frac{dv}{dt}\right)_{max} = \frac{16 \times 10^{-6}}{400} \times \frac{100}{10^{-6}}$$

$$= 4\Omega .$$

When thyristor is turned on Current through the thyristor

$$I_A = I_s + I_C$$

$$= \frac{400}{10} + \frac{400}{4} = \boxed{140A}$$

→ The peak current to a SCR his more than the permissible peak current of 100 A. The magnitude of R_s must be increase taking 8Ω (R_s as)

Now the peak current SCR is

$$I_A = \frac{400}{10} + \frac{400}{8} = 90\ A$$

the resistance is negligible.

$$C_s = \left(\frac{2\zeta}{R_s}\right)^2 \cdot L \qquad (\zeta = 0.65)$$

$$= \left(\frac{2 \times 0.65}{8}\right)^2 \times 16 \times 10^{-6}$$

$$\boxed{C_s = 0.4\ \mu F}$$

→ The value C_s is also reduced the Energy Stored C_s is Small the Snubber discharge doesn't from SCR when it is a turn on.

→ At instant of Switch is Closed thyristor is open Circuited and Current through C_s is given by.

$$C_s \frac{dv}{dt} = \frac{V_s}{R_s + R_L}$$

$$0.3 \times 10^{-6} \frac{dv}{dt} = \frac{400}{8+10}$$

$$\frac{dv}{dt} = \frac{400}{18 \times 0.50 \times 10^{-6}} = 74.07 \ V/\mu s.$$

Since design value of $\frac{dv}{dt}$ is less than the Specified maximum of 100 V/μs. then the value of C_s Chossen as Correct.

$$\boxed{L = 10 \ \mu H, \ R_s = 8 \Omega, \ C_s = 0.3 \mu F}$$

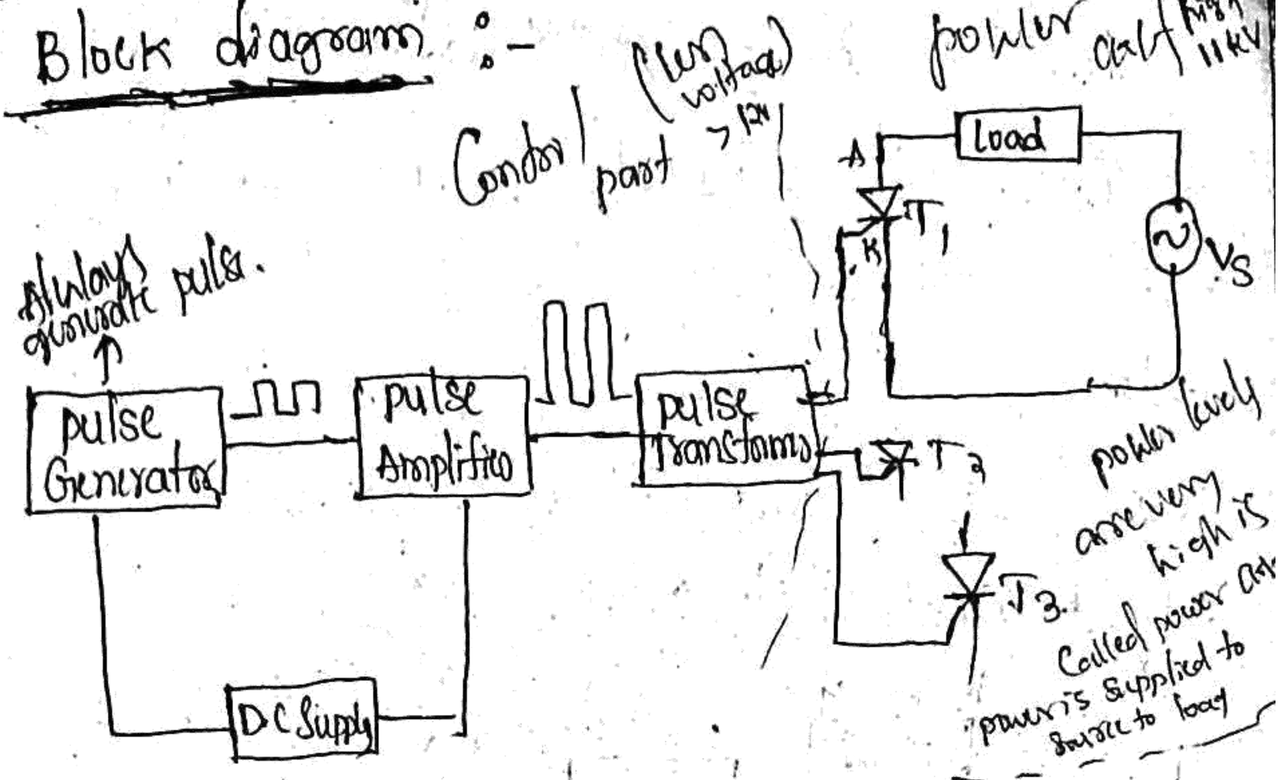
* Firing (or) triggering CKS :-

Means Controlling (less voltage)

→ F.B.M to F.C.M.

OF → ON State.

Block diagram :-



→ Generated pulses cannot turn on SCR i.e., cannot provide sufficient Gate currents (low currents).

→ To avoid the problem, we go pulse Amplifier
: It means the magnitude increases.
Pulse Generator Amplifier does not repeat the problem.

→ It gives greater currents.

→ pulse transformer works
(i) transfer pulses
(ii) isolation process.

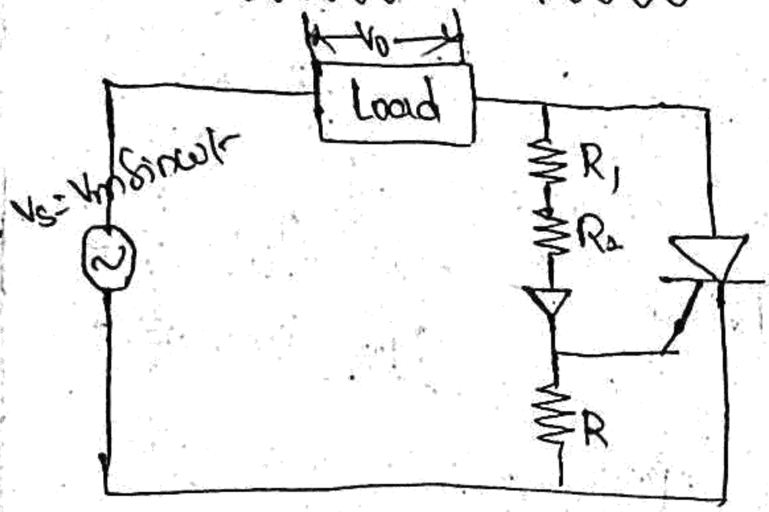
→ So, there is no isolation in the system any problem arise in the system, then the total System is damaged.

→ there is a isolation, the gate is on. the Current flows through system.

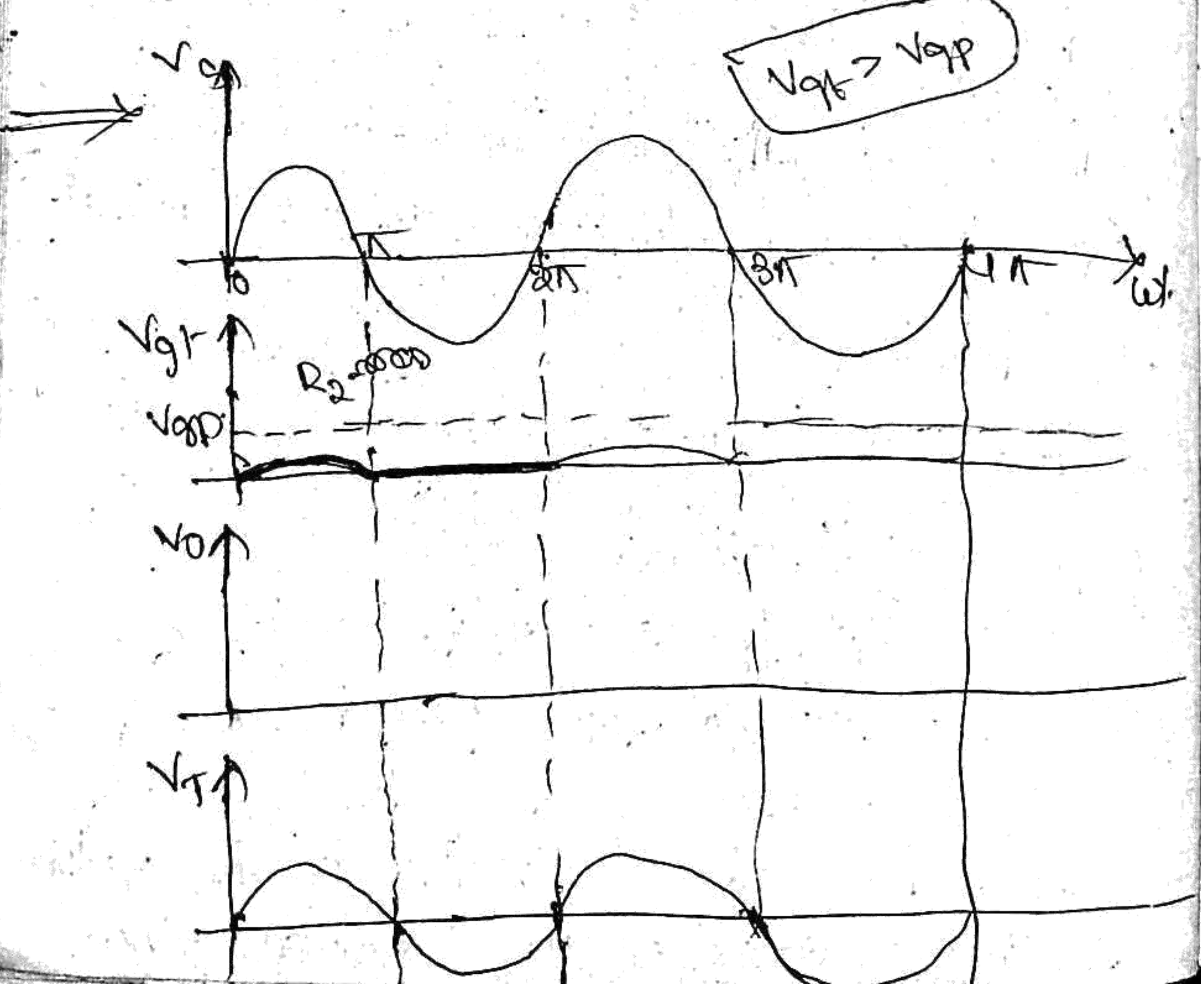
18/07/08

These are classified into three types:

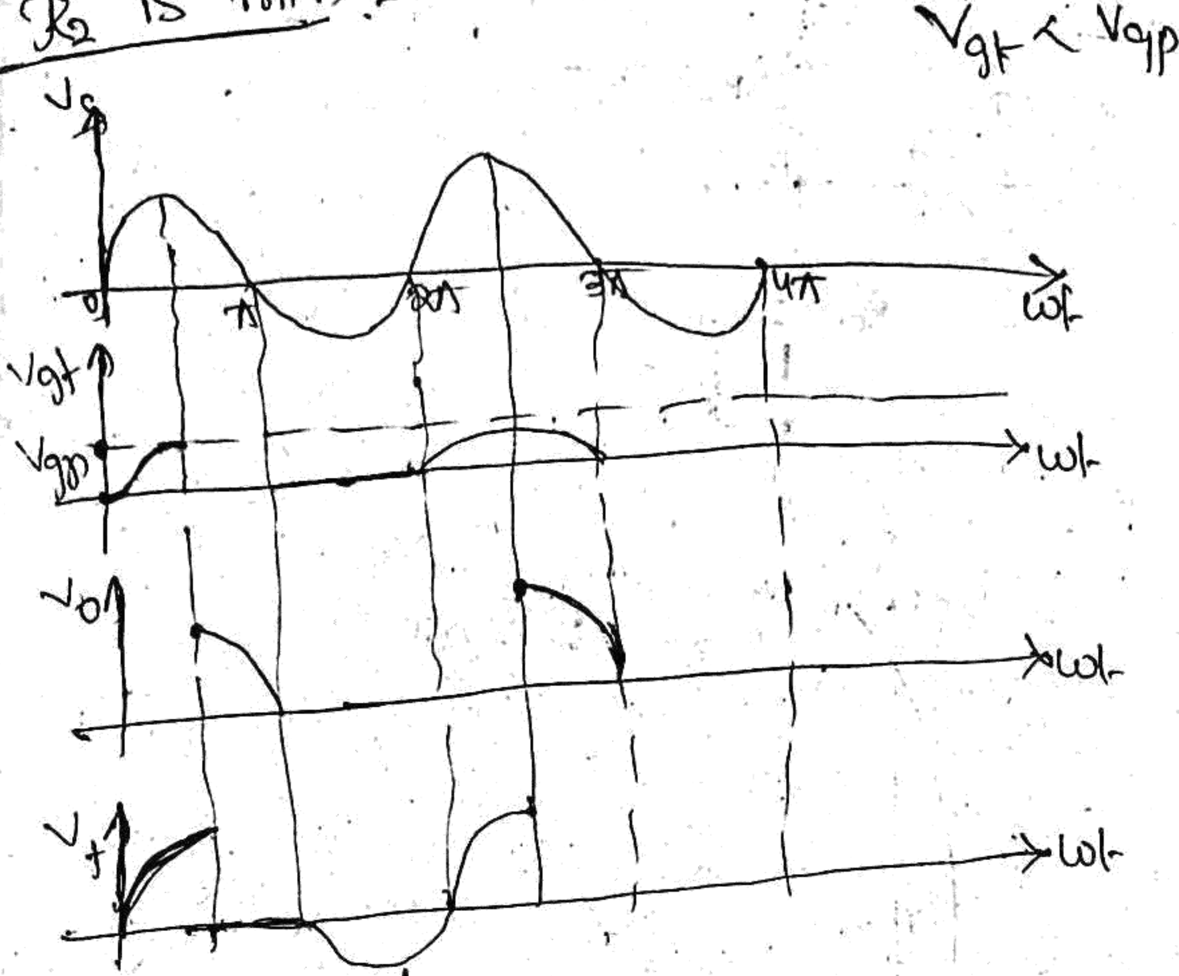
1. Resistance triggering.



R2 is max,



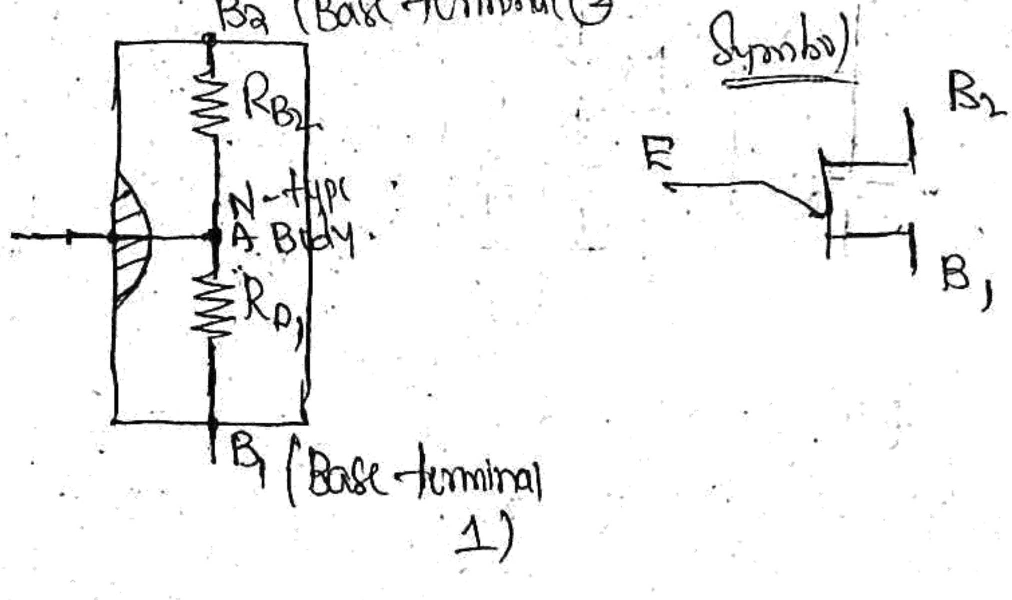
R_2 is min:-



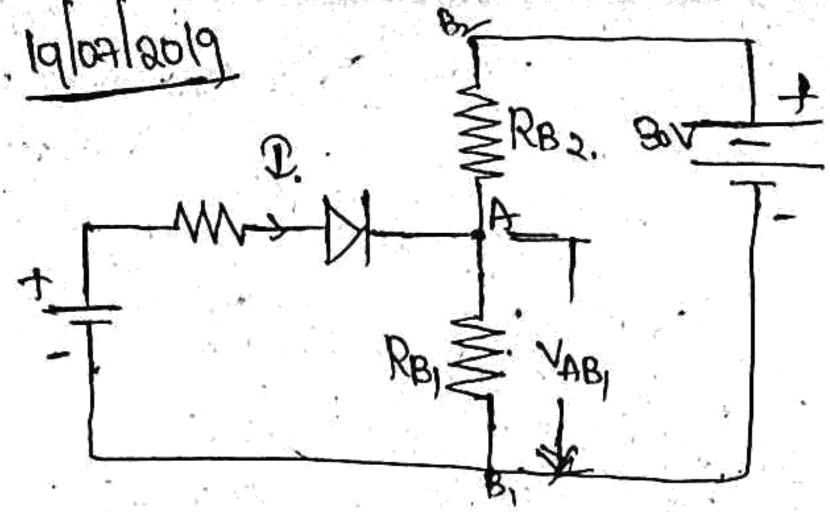
→ Main draw back is,

The Control voltage is possible is 0-90°
90°-180° this is not possible to Control

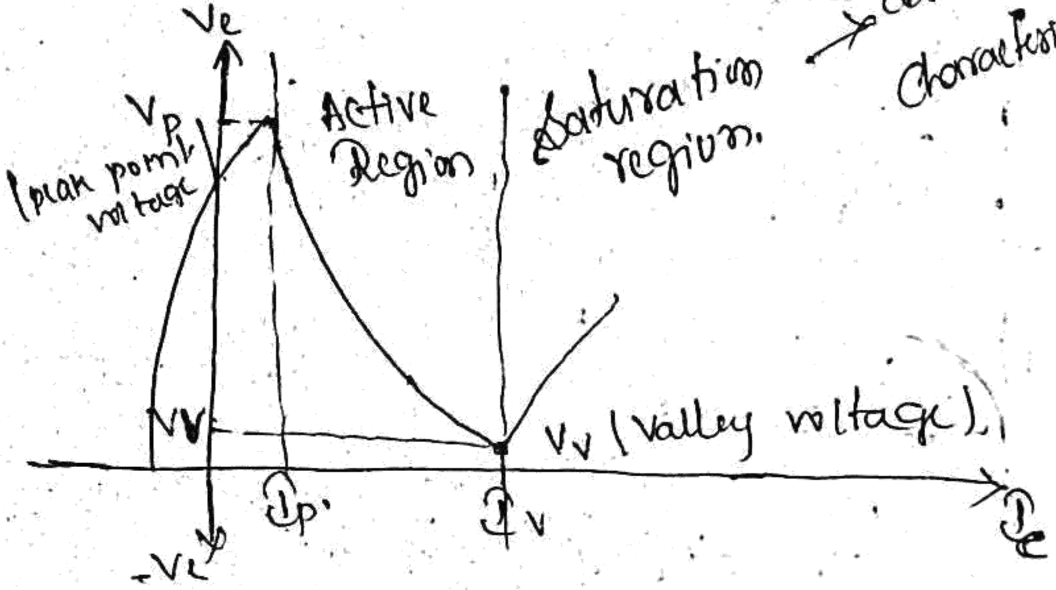
3. U.J.T triggiring:-



19/07/2019

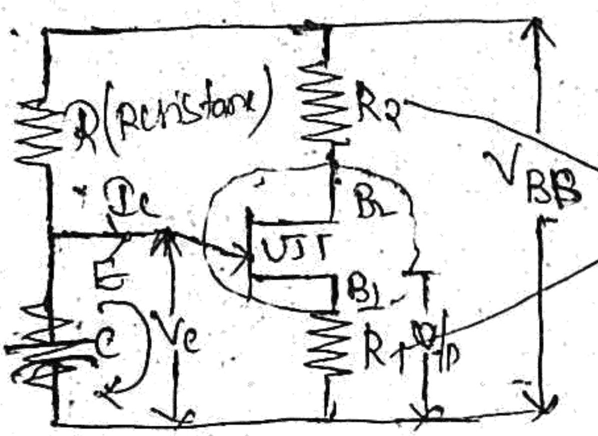


→ UJT is mainly used as oscillators
→ as a negative characteristic



* UJT oscillating Circuits :-

Sensitive device



External resistance always less than the internal resistance of UJT.

→ When VBB is applied to the R1 & R2 the UJT gets off, due to Reverse bias.

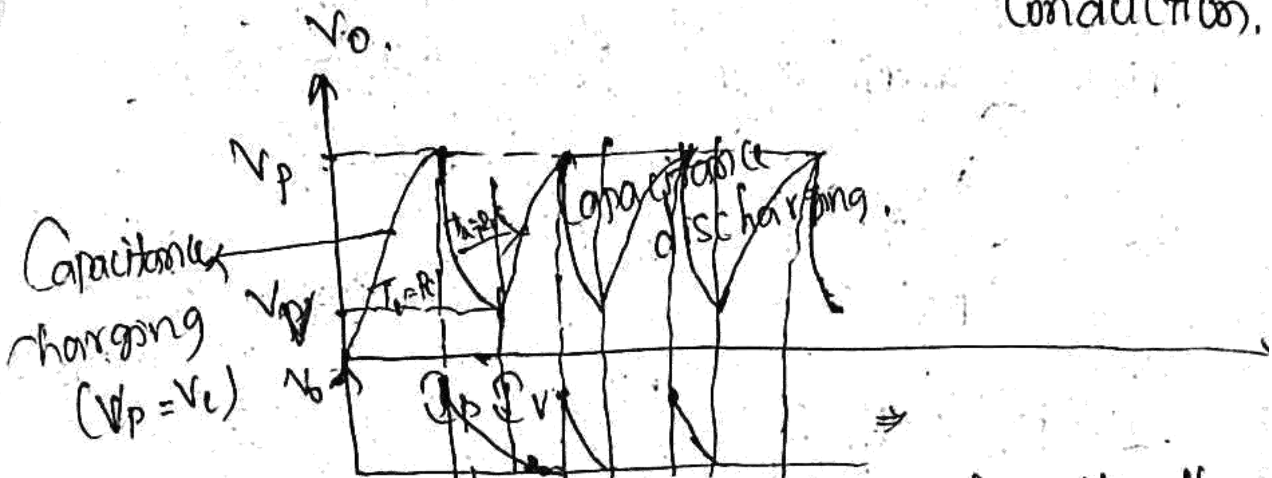
→ Current through UJT is "0". It is off state.

→ When voltage is applied to the Resistance and Capacitance, Capacitance gets Charged.

→ Capacitance voltage = Emitter voltage (or) V_p.

→ When $V_e = V_c = V_{BB}\left(1 - e^{-t/RC}\right)$

the device is acts as closed switch ← → gets start Conduction.



→ Again due to injection of volt the device is in Saturation and again the path gets off.

→ and Again Capacitance gets Charging.

Charging and discharging by changing the resistance values

$V_p = \eta V_{BB} + V_D$.

$= V_{BB}\left(1 - e^{-T/RC}\right) + V_V$

$V_D = V_V, \quad \eta = \left(1 - e^{-T/RC}\right)$.

$$T = 1/f = RC \ln\left(\frac{1}{1-\eta}\right)$$

$$\alpha = \omega T = \omega RC \ln\left(\frac{1}{1-\eta}\right)$$

→ R_2 is used to Control the temperature in device.

$$R_2 = \frac{10^4}{\eta V_{BB}}$$

→ R_1 is measure on triggering pulse, (How much time, How much time period).

$$\frac{V_{BB} \cdot R_1}{R_{BB} + R_1 + R_2} < \text{~~50%~~ SCR triggering voltage } (V_{gt})$$

$$R_{BB} = R_{B_1} + R_{B_2}$$

→ "R" is We can obtain peak point voltage, peak point Current by setting "R" Maximum value i.e., V_p and I_p

When voltages across "C" Reaches "V_p".

the voltage across "R" is $V_{BB} - V_p$.

and Corresponding $R_{max} = \frac{V_{BB} - V_p}{I_p}$

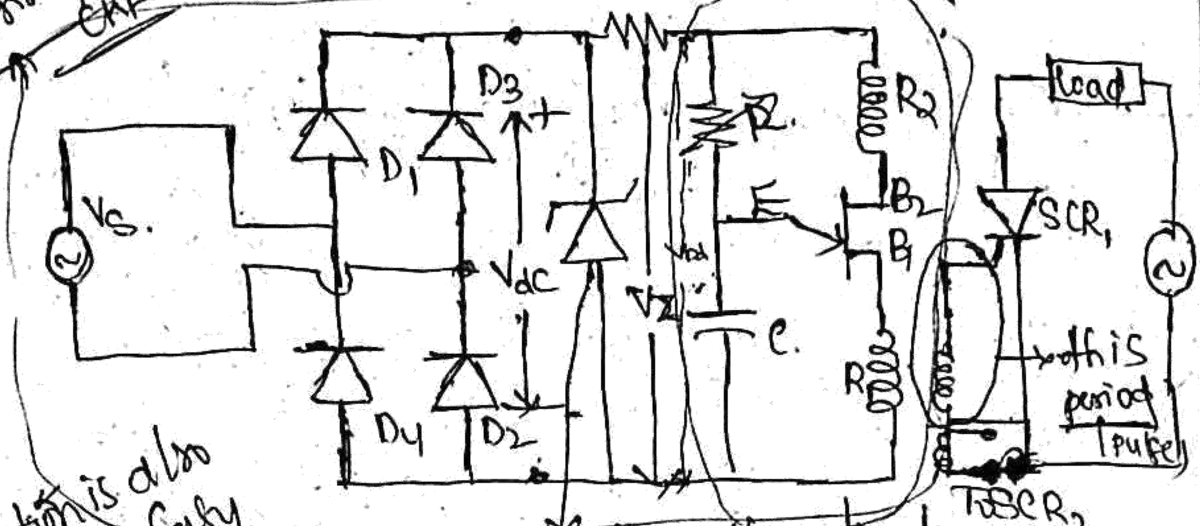
$$V_p = V_{BB}\eta + V_D$$

→ "~~R~~" minimum value of "R" governed by valley point values V_V and I_V is given by.

$$R_{min} = \frac{V_{BB} - V_v}{I_v}$$

* Synchronize UJT triggering (or) Ramp triggering :-

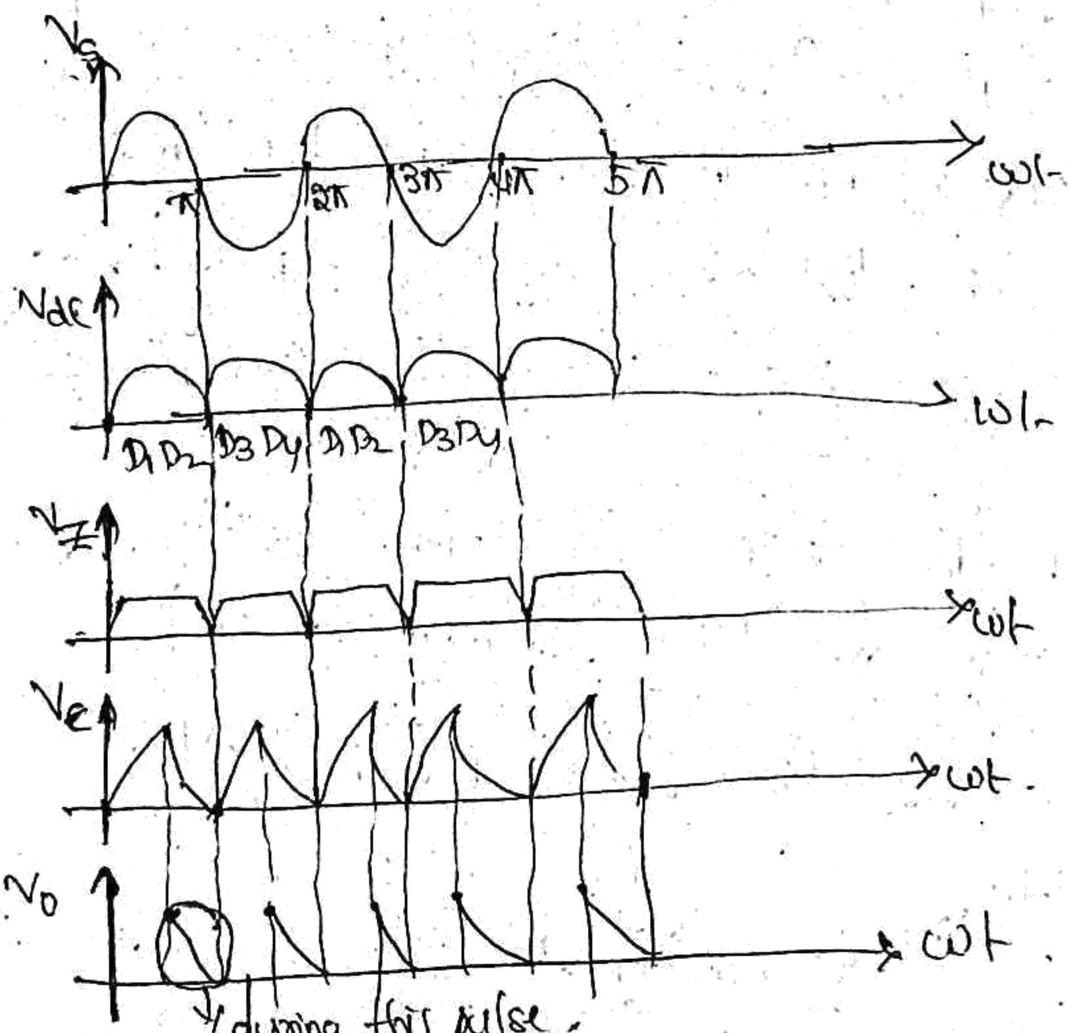
triggering ckt



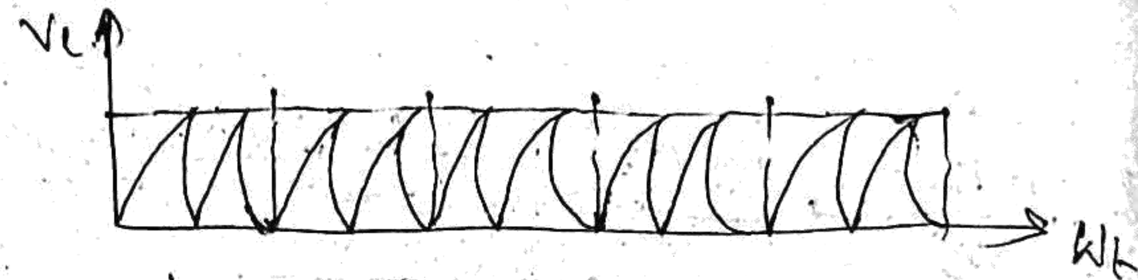
operation is also very Easy.

to stabilize the diode.

→ To Control load by using SCR



→ By Changing "R" and "C", We Can generate More pulses.



→ The o/p are generated during this period only (pulse)

20/08/19

* BJT :-

→ Due to majority charge Carries, the Current flows both Currents

→ B.J.T is a bi direction device 

→ It is a Current Control device.

→ ~~Whenever~~ i/p impedance is low "kΩ"

→ Due to low i/p impedance, Switching losses are more (During the process ON & Off).

→ once the device Comes to Conduction, the Conduction are low (Steady State)

→ The device Can operate Either Switch (or) Amplifier :- To Amplify the Signal.

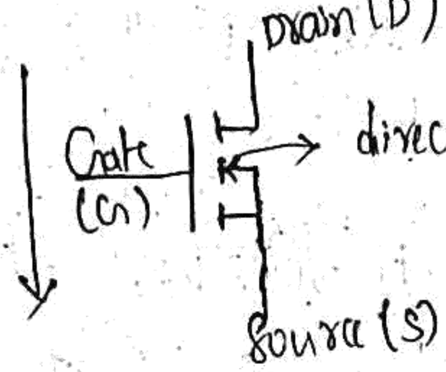
→ If small increase in Junction temperature the device fails that is called by second break over voltage.

→ These are avoided by MOSFET.

MOSFET :- (Metal oxide Semi Conductor field Effect transistor)

→ The device is operated by field Effect Technology.

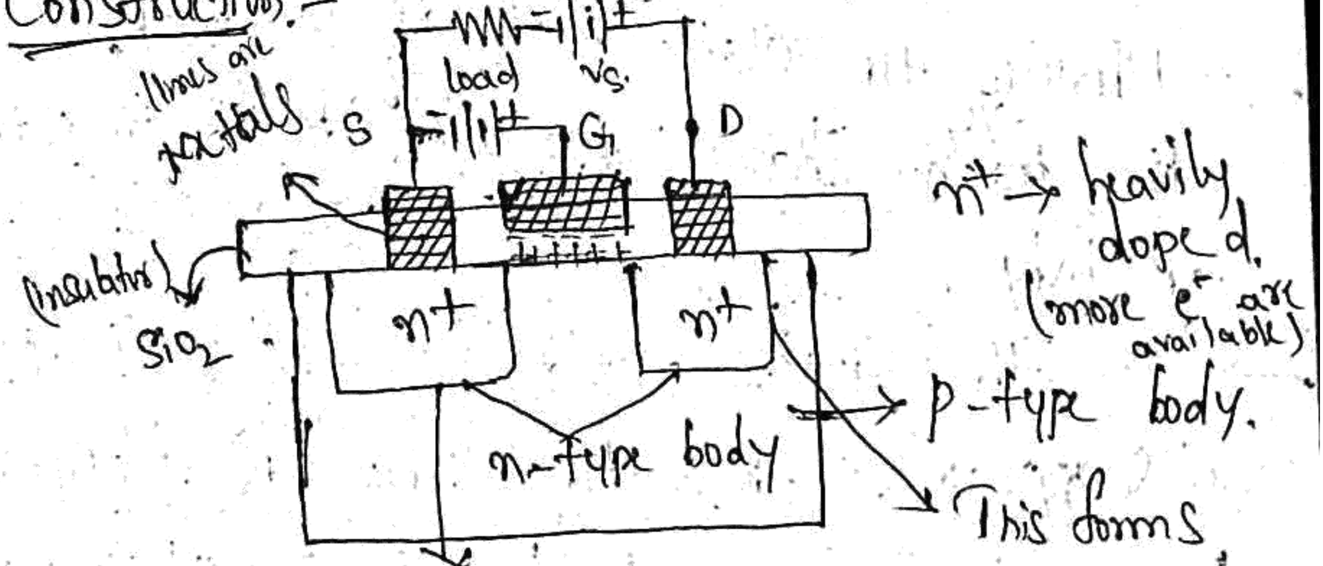
Symbol :-



→ uni directional device (Drain to Source)

→ It is a voltage Control device. ****

Construction :-



→ This metals are Connected to SiO_2 and n^+ layer material

→ The Drain also Connected to SiO_2 and n^+ layer materials.

→ Gate is not directly Connect to SiO_2 layer.

→ Whenever apply "S" and "D" the Junction becomes Reverse bias, there is no flow of Electrons.

→ To make it to turn on, the Gate terminal is applied to Gate and Source terminal)

→ Whenever Gate voltage is applied. Some Electric field beneith the SiO_2.

→ Whenever the electric field is Existed, the ~~positive~~ -ve Charge produces beneith in p-type body.

→ By the Electric field the Reverse bias disappear, then the Current is flowing Drain to Source and beneith the Electrons

→ Then the device comes to conduction. It acts as ON state, (closed switch)

→ Gate is ↑, Electric field ↑, flow of electrons ↑.

→ When ever gate is removed, Electric field disappear, there is no flow of electrons, then is not comes to conduction

→ i/p impedences are very high (MW)

→ Switching losses are low.

→ Conducting loss are more in MOSFET.

→ Generally low rating voltages, we desi design some changes in MOSFET.

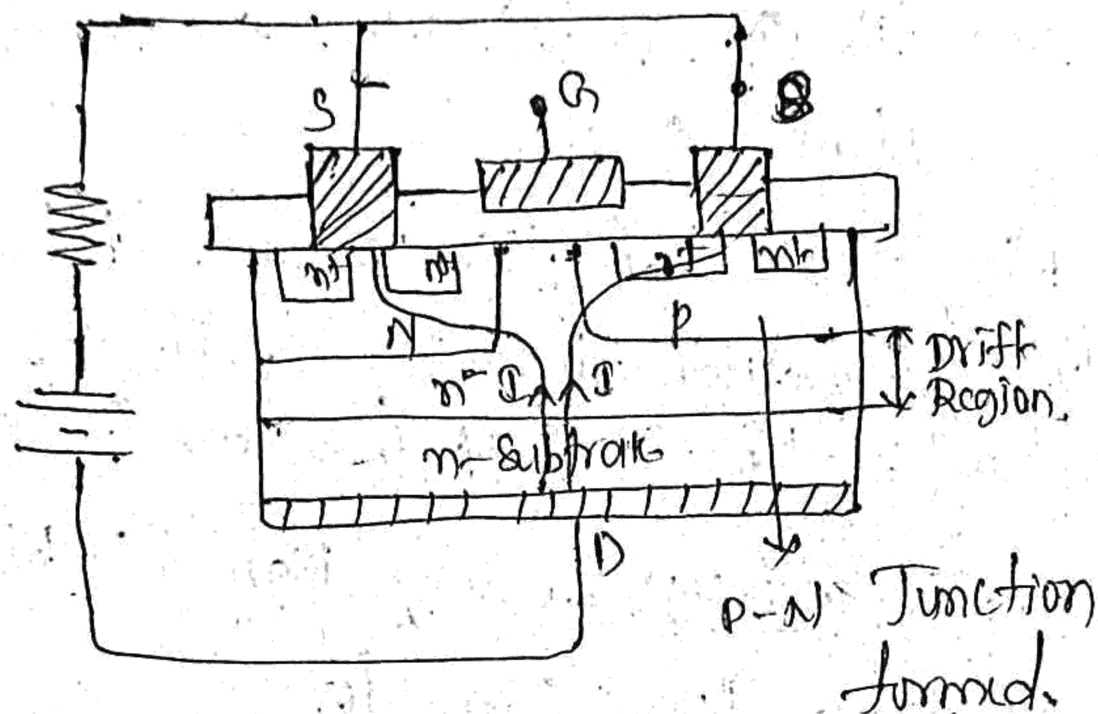
→ It can be classified into three types:

(i) P-FET
(ii) N-FET
(iii) D MOSFET.

(i) <u>D. MOSFET</u> :-

By considering we can increasing power rating.

⇒ Drift region ↑ blocking voltage Capability of b/w increases.



→ The junction gets Reverse bias, the devices is in Off State.

→ We can operate the device upto "2000 V" and "150 A".

→ used for low & medium power application.

→ To make Conduction, the gate voltage is applied b/w Gate and Source terminal.

* Characteristics:-

→ It always shown b/w V & I.

1. Static Characteristics (or) Steady State
2. Switching Characteristics.

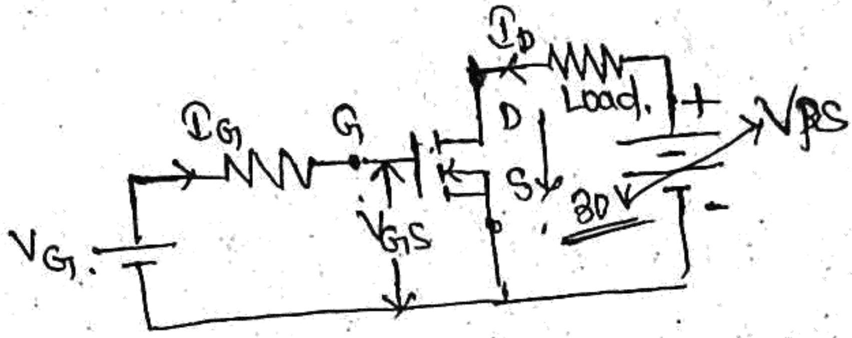
Switching Characteristics → Turn-off, Turn-on

Static (or) Steady State → transfer characteristics, o/p characteristics

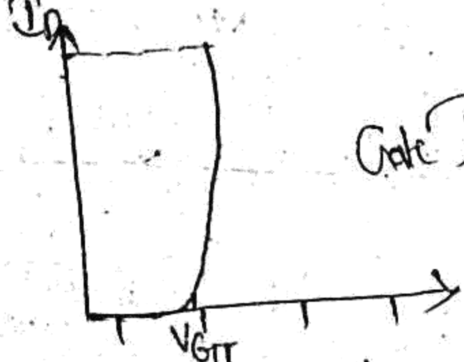
transfer characteristics → (i/p V and o/p I) → i/p V vs o/p I

o/p characteristics → o/p V vs o/p I

i/p Characteristics



* transfer Charac : (V_{GS} vs I_D).

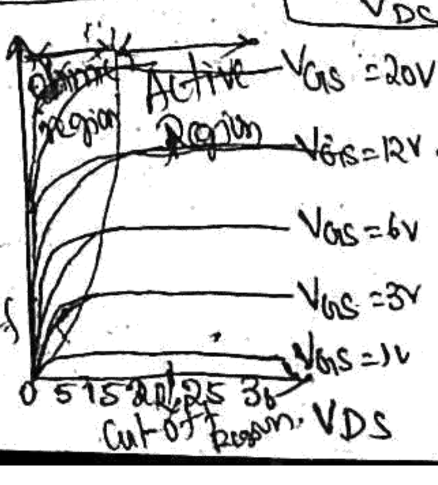


Gate Threshold voltage nearly = 2V

→ Gate Current is Slowly increasing.
→ Whenever Sufficient voltage is Applied
→ once the device is on the Current flows drain to Source

o/p Characteristics :- (o/p V (V_{DS}) Vs o/p I (I_D))

ohmic
Active
Cut-off



We have applied only '1V' basic. '2V' is the value device is not on that is cut-off region.

The voltage is kept constant (Vcc) '1V'
→ V_{GS} is increase from slowly.

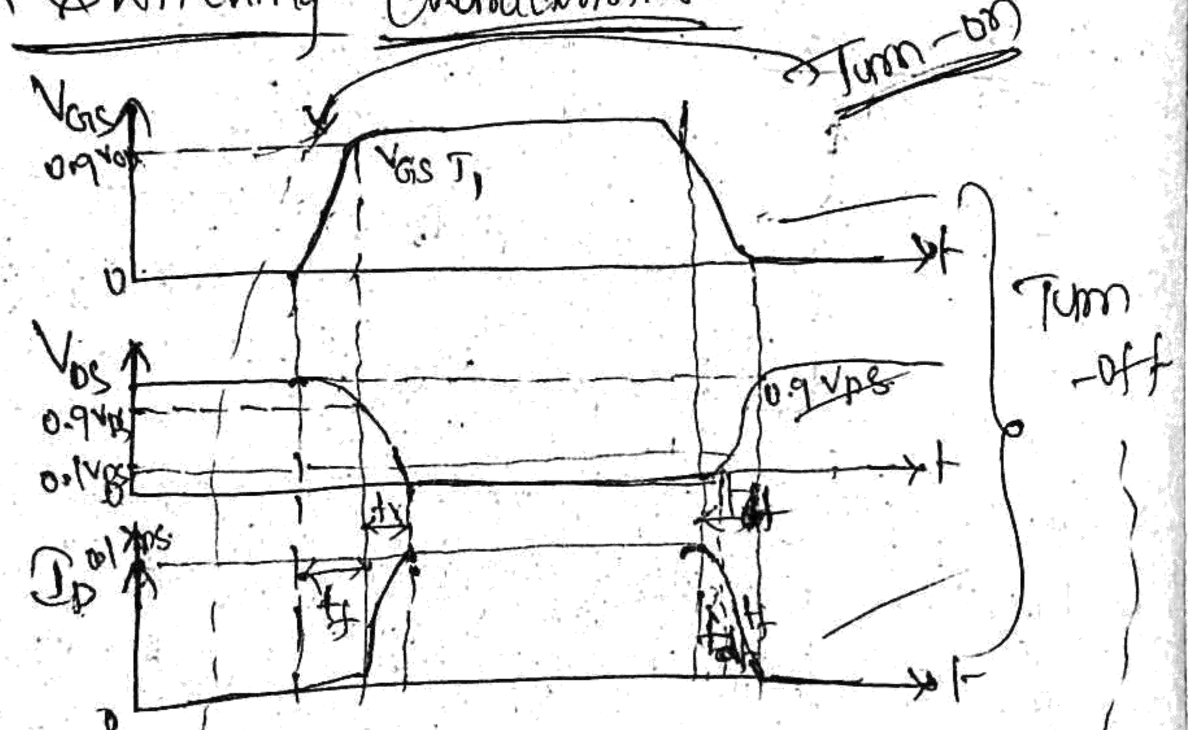
→ Gate voltage maintain "3V", VDS increases from 0 to "30V". It can turn on device.

→ VDS value ~~decreases~~ increases from 0 to "30V". Gate voltage maintain "6V".

→ ohmic Region acts as Switch in MOSFET.

→ Active Region Act as Amplifier.

* Switching Characteristics :-

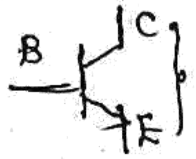
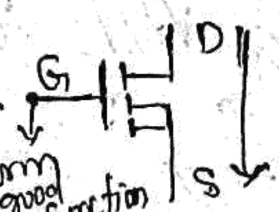


$$t_{off} = t_{df} + t_f$$

$$t_{on} = t_d + t_r$$

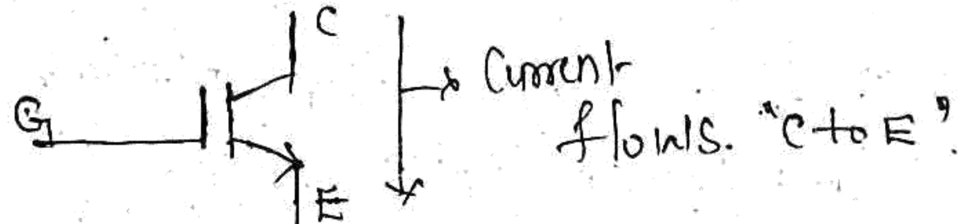
23/07/19

* IGBT :- (Insulated Gate Bipolar Transistor) :-

BJT	MOSFET.
1. Switching losses are More	1. Switching losses are low.
2. Conduction losses are low	2. Conduction losses are high.
3.  perform good function.	3.  perform good function
4. It is a bi-directional device	4. uni-directional device.
5. Second break down. Characteristics	5. No-break down characteristis
6. -ve temperature Co-efficient	6. +ve temperature Co-efficient (parallel operation is very Easy)
7. Current Control device.	7. voltage Control device.

→ By desinging IGBT. These two advantages are taken is given by.

Symbol

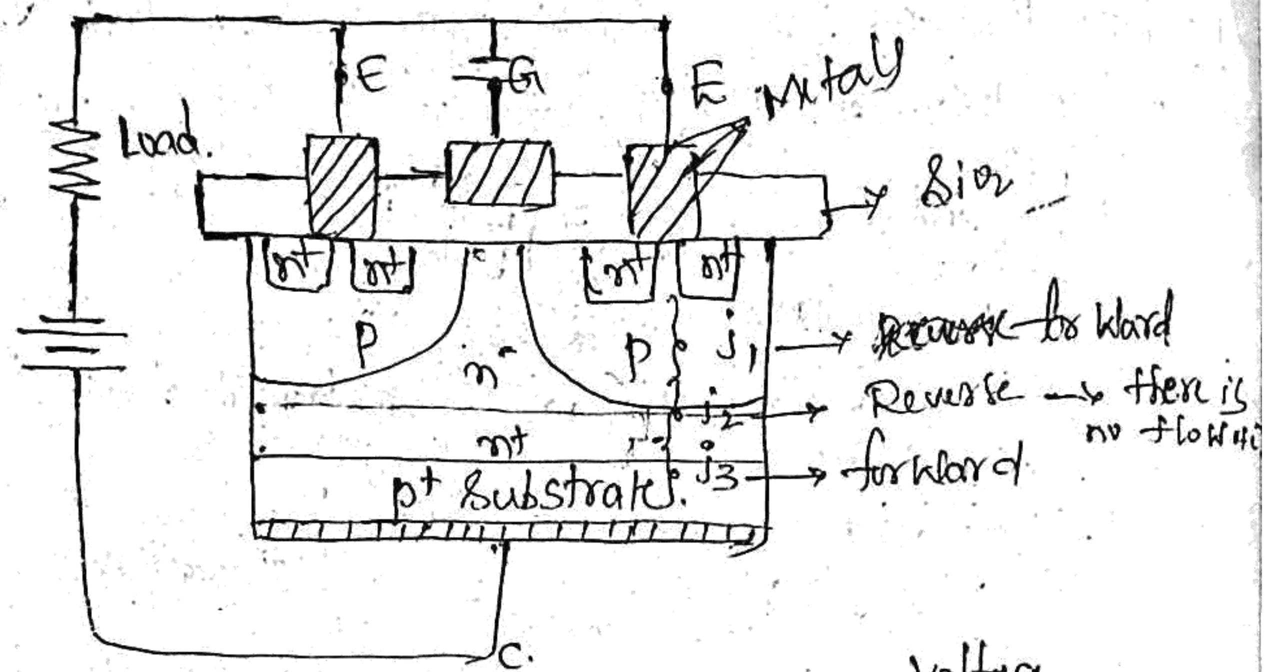


→ It is also voltage Control device.

→ It is also uni-direction device.

→ IGBT has less Conduction & less Switch-
-ing losses.

Structure of IGBT :-

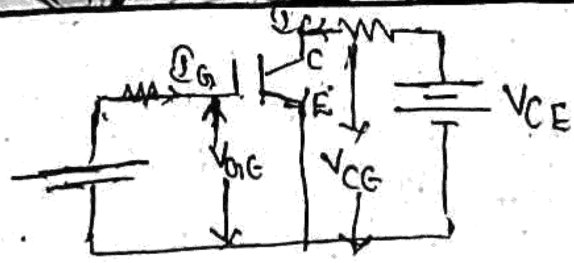


→ We must apply Gate voltag b/w Gate and Emitter then Electric field exists. (Acts as closed state).

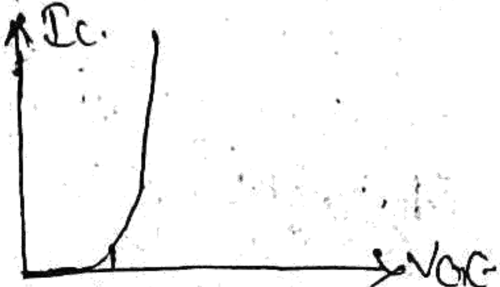
→ This device is also operate on field Effect technology.

Characteristics :-

1. Static characteristics < Transfer chara / o/p chara
2. Switching characteristics < Turn-off char / Turn-on char

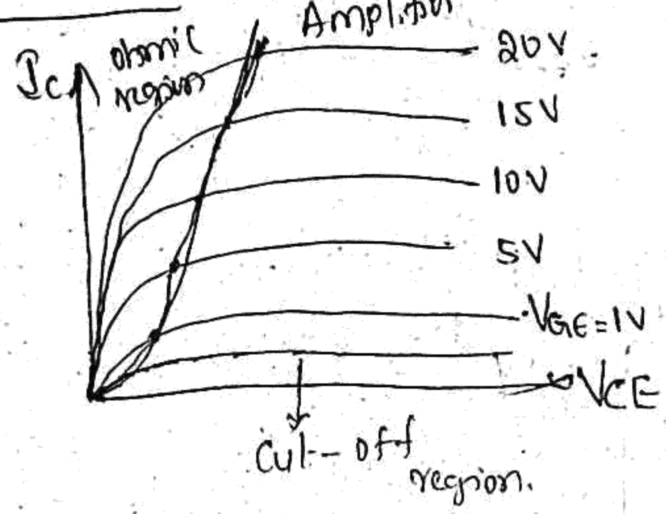


Transfer Chara :-



V_{GET} → Threshold gate voltage = 2V.

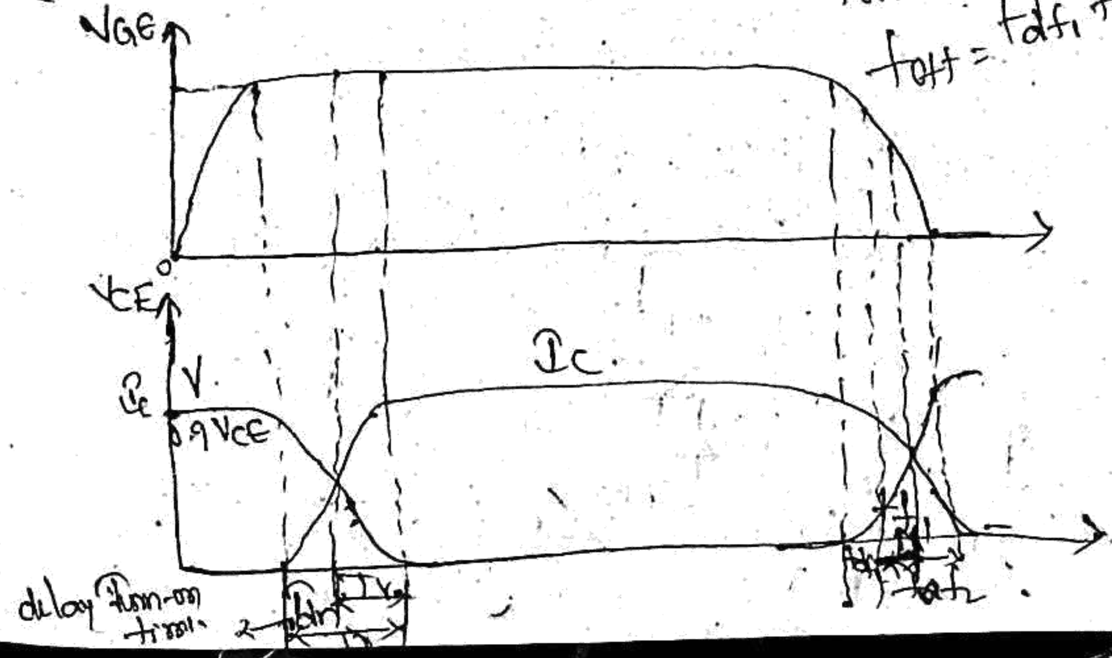
O/p Characteristics :-



Switching Characteristics :-

$t_{on} = t_{dn} + t_r$

$t_{off} = t_{df_1} + t_{f_1} + t_{f_2}$



Applications :-

1. Invertor Application.
2. Speed Control of A.C Motors.
3. Air Craft power supply Applications.
4. Induction furnances Applications

Insulator act as Conductor at high voltage

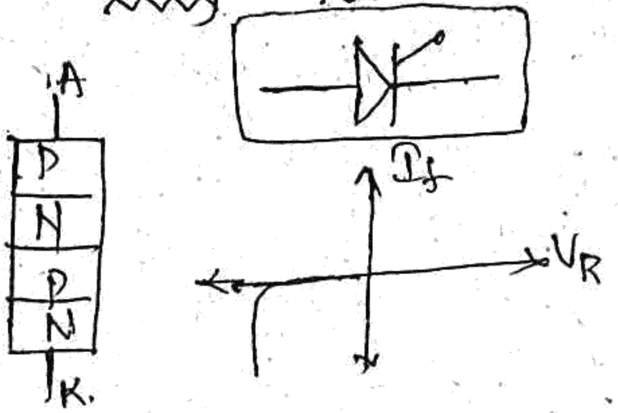
25/07/19

* Thyristor family devices :-

1. SCR :-

V = 10KV

A = 5KA.

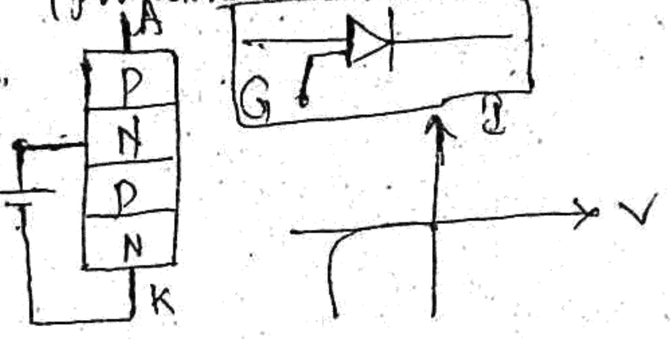


2. PUT :- (programmable uni-Junction transistor.

Voltage is "200V".

Current is "1A".

Anode voltage more than G Corres to 0.7V the divise Corre to Conduction.



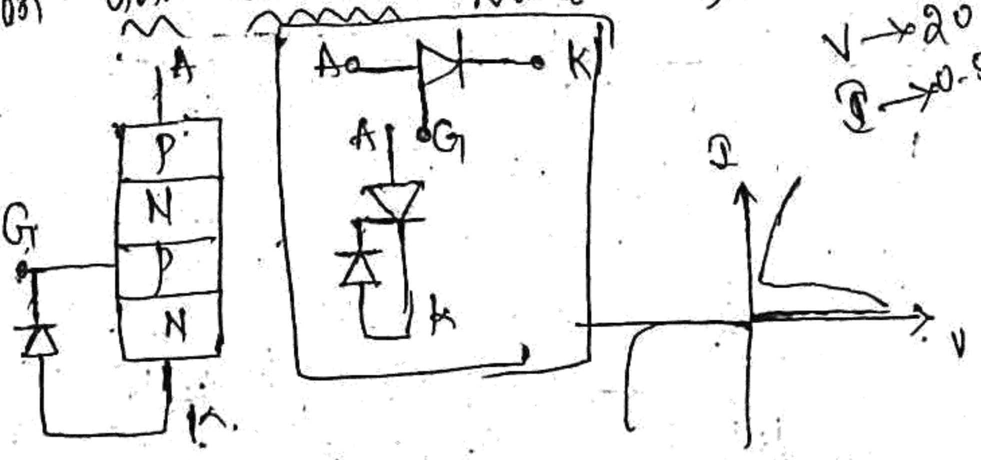
Applications:-

→ Timing, logic, Gate Circuits.

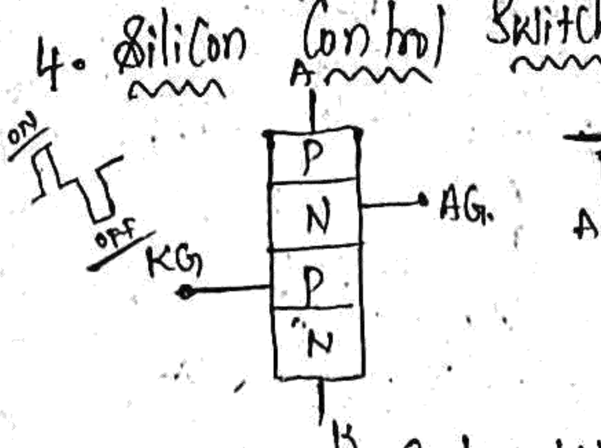
3. Silicon uni-direction Switch (SUS) :-

V → 20 V

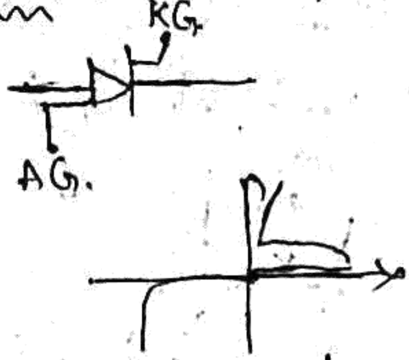
I → 0.5A



4. Silicon Control Switch :-

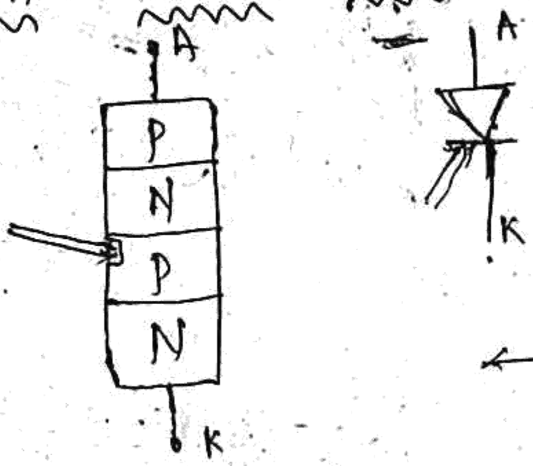


50V - V
100 MA - I

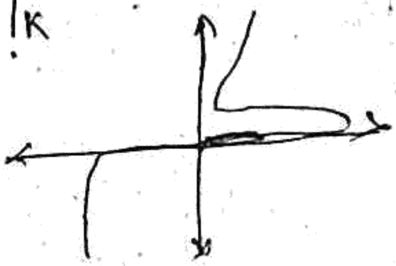


Whenever "+ve" Gate Voltage is applied the device is turn on, then -ve Gate voltage is applied the device is turn-off.

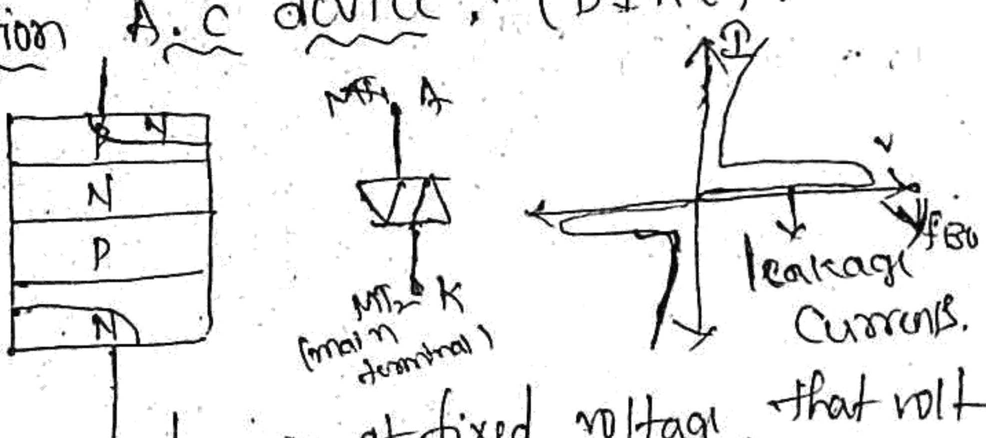
5. light Activate Silicon Control device (LASCD) :-



5 KV - V
3 kA - I



5. Direction A.C device :- (DIAC) :-



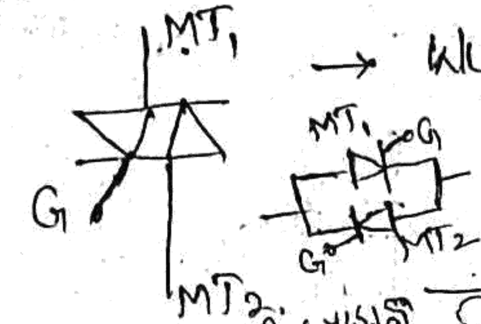
This device is turn on at fixed voltage, that volt -age is forward Break over voltage. the device is comes to conduction.

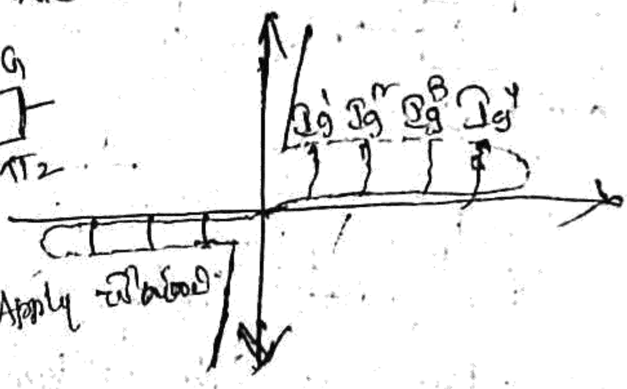
→ It is an uncontrol device.

→ We can't control the power and voltage

7. TRAIC :- (Tri direction A.C thyristor) :-

→ we can control the power



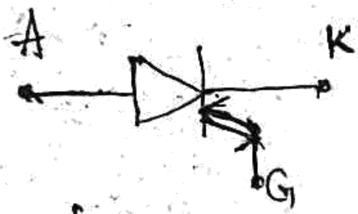


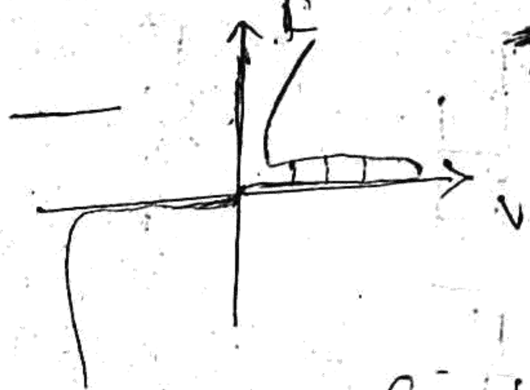
ఎక్కడైతే ON అవ్వాలనుకున్నామో అక్కడ కావాలసిన Gate voltage Apply చెయ్యాలి.

8. GTO (Gate Turn-off Thyristor) :-

V – 6 kV

I – 4 kA





Self Commutating device.

→ 1/3rd of Reverse Gate Current is Required to turn-off the device. (6A to 7A)