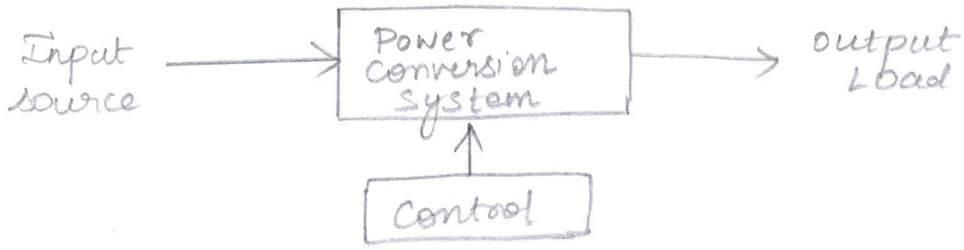
Q 1a) What is power Electronics? Draw a neat block diagram of generalised power converter system. (5M)

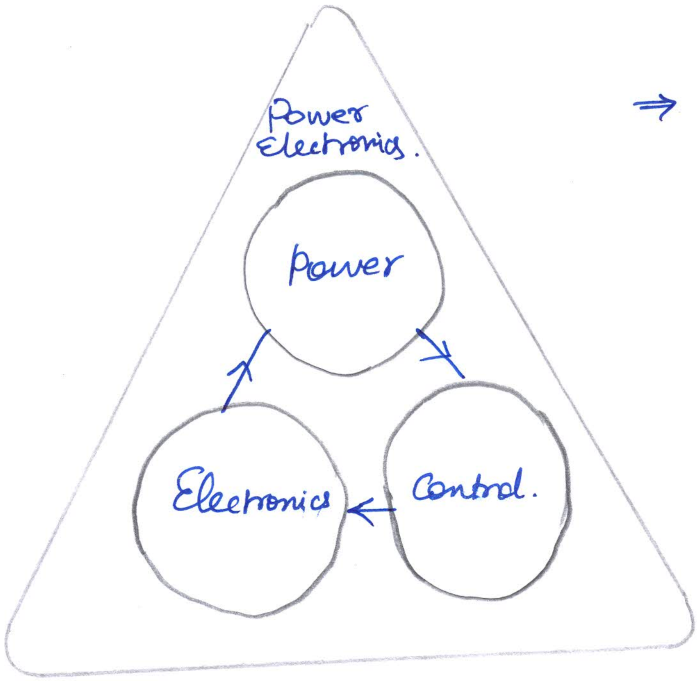


→ 2M

Power Electronics is the control & conversion of Electrical power from Source to load with the help of power semiconductor devices. → 2M

(Elaborate on each part of the diagram) → 1M

Q 1 b) Explain how power, electronics and control are related to power Electronics.

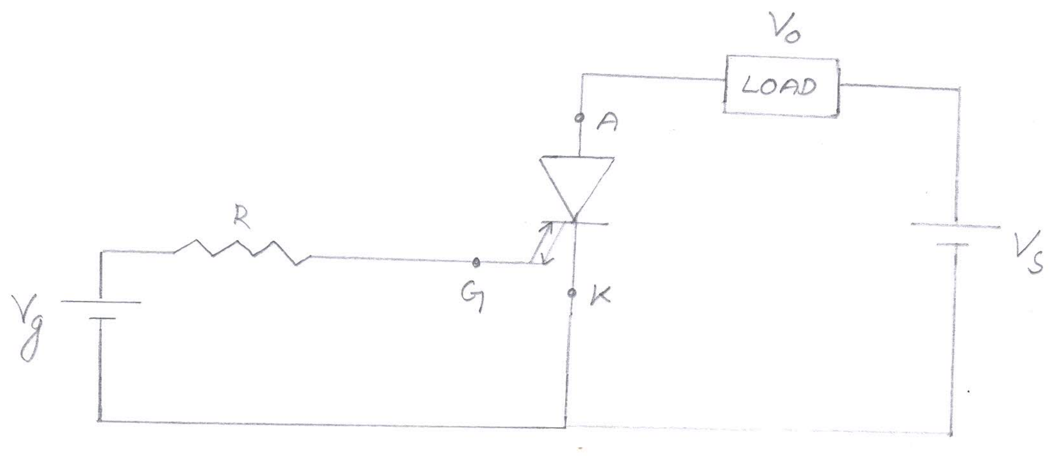


↓
2M

⇒ Explain the Diagram //
↓
3M

Q2. a) With the circuit diagram, input and output waveform Explain the control characteristics of GTO and SCR.

Ans :- GTO :- ($2\frac{1}{2}$ M)

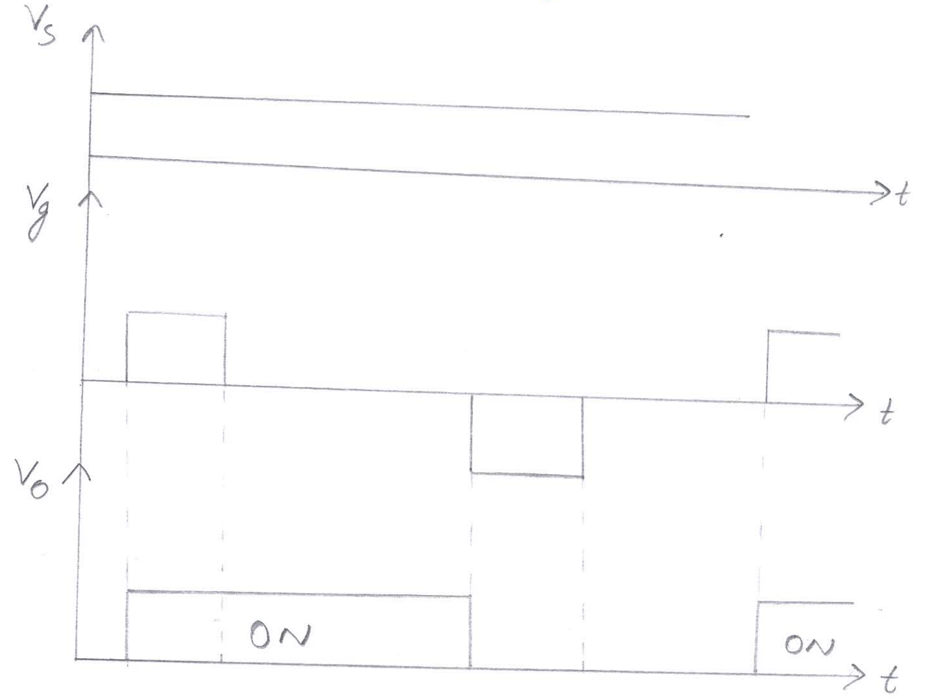


CIRCUIT DIAGRAM

→ GTO is a fully controlled device i.e

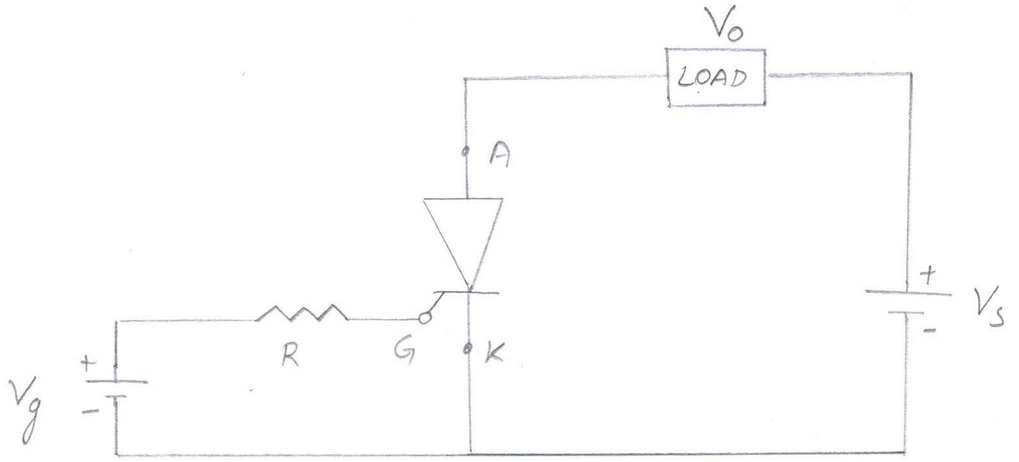
turns ON - +ve gate pulse

turns OFF - -ve gate pulse.



INPUT AND OUTPUT WAVEFORM

SCR :- (2½ m)

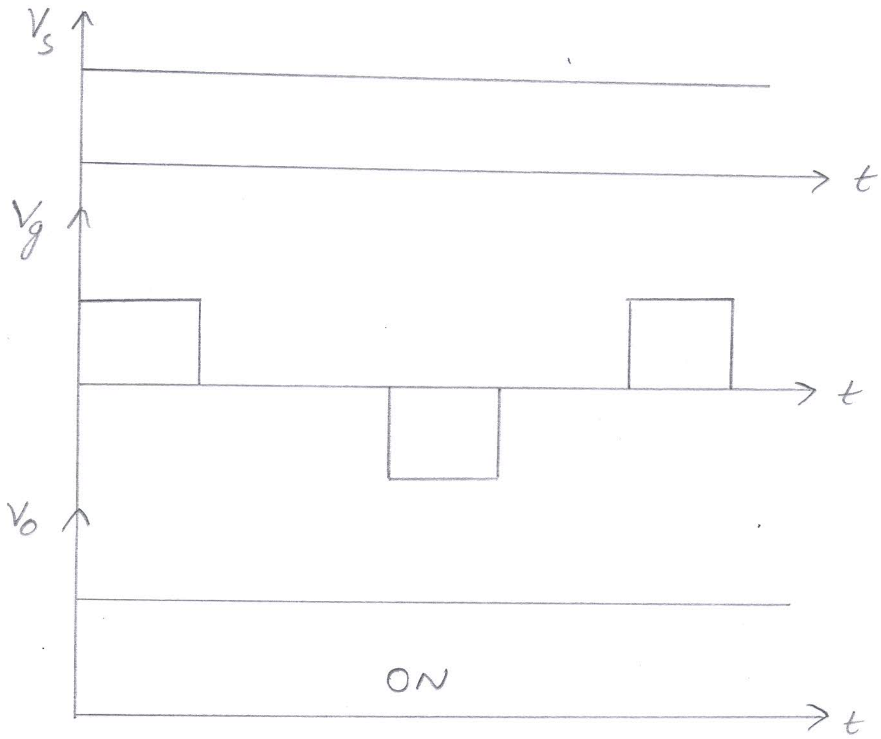


CIRCUIT DIAGRAM

→ SCR is a Semi Controlled device i.e

turn ON - +ve gate pulse.

turn OFF - gate looses control.

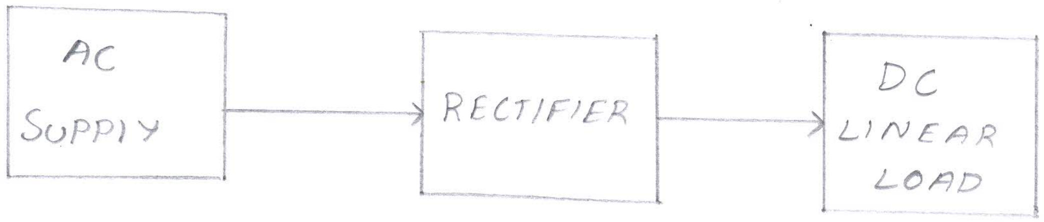


INPUT & OUTPUT WAVEFORM.

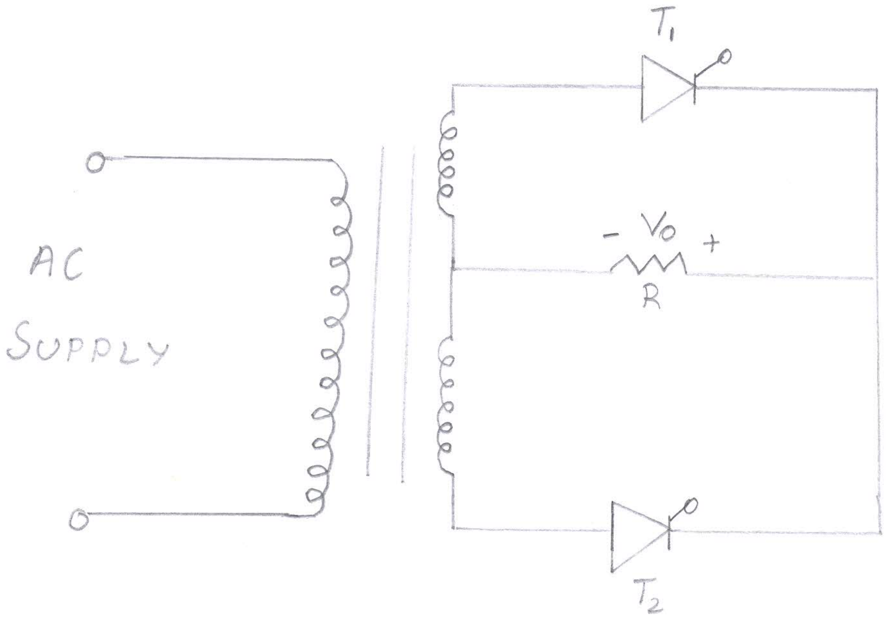
List out the diff power Electronic ckts.

Q2.b) Consider that AC Supply is given to a Circuit which Supplies a DC linear load. What is the Circuit that Can be used for this Operation? Draw the Circuit and explain the input and output waveforms.

Ans :- Types of circuits : → 1M



→ The Circuit required to Convert AC into DC as per the specified application is "Rectifier".



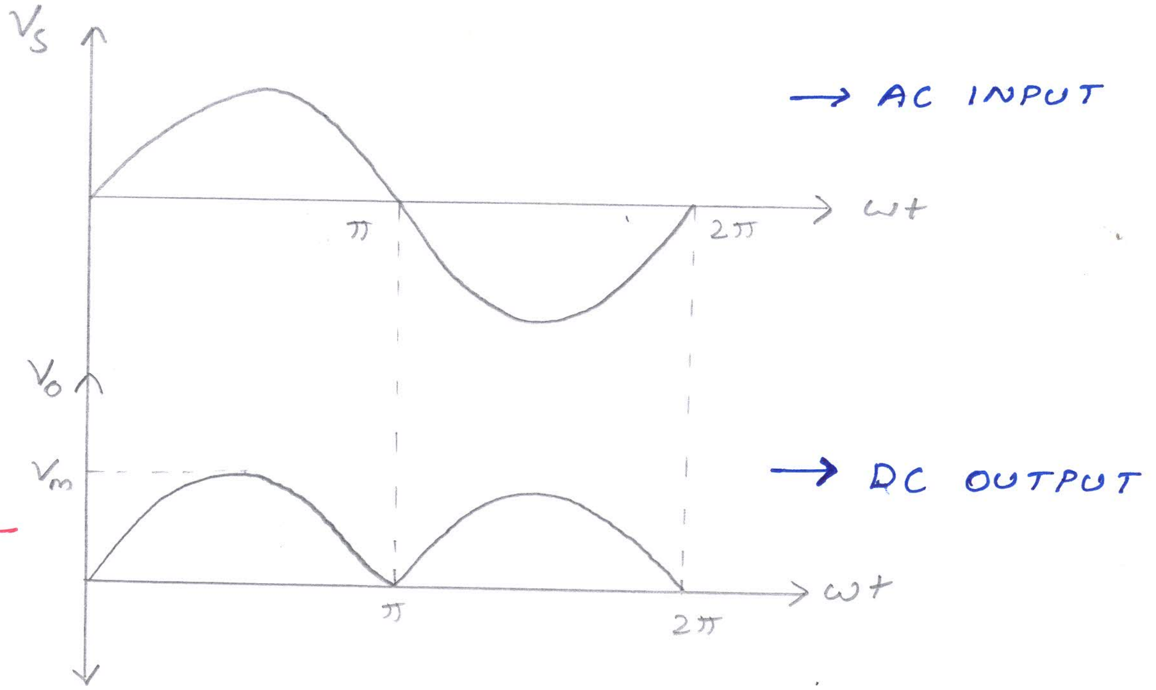
→ 2M

CIRCUIT :- CONTROLLED RECTIFIER.

→ During +ve half cycle of AC supply T_1 is triggered and +ve voltage appears across the load.

→ During -ve half cycle of AC T_2 is triggered ∴ again +ve voltage appears across the load.

→ By varying firing angle (α) of the thyristors the o/p voltage can be controlled.



2M ←

INPUT AND OUTPUT WAVEFORM.

Q3. a) The BJT is specified to have β in the range of 8 to 40. The load resistance $R_C = 11\,\Omega$. The DC supply voltage is $V_{CC} = 200V$ and the input voltage to the base circuit is $V_B = 10V$. If $V_{CE(sat)} = 1V$ & $V_{BE(sat)} = 1.5V$. FIND :-

a. The value of R_B that results in saturation with a ODF of 5.

b. The Forced β_F

c. The power loss P_T in the transistor.

Ans :-

a) $$I_{CS} = \frac{V_{CC} - V_{CE(sat)}}{R_C} = 18.1A.$$

$$I_{BS} = \frac{I_{CS}}{\beta_{min}} = 2.26\,A$$

$$I_B = ODF \times I_{BS} = 11.31\,A$$

$$R_B = \frac{V_B - V_{BE(sat)}}{I_B} = \boxed{0.715\,\Omega}$$ — 2M

b) $$\beta_F = \frac{I_{CS}}{I_B} = \boxed{1.6}$$ — 1M

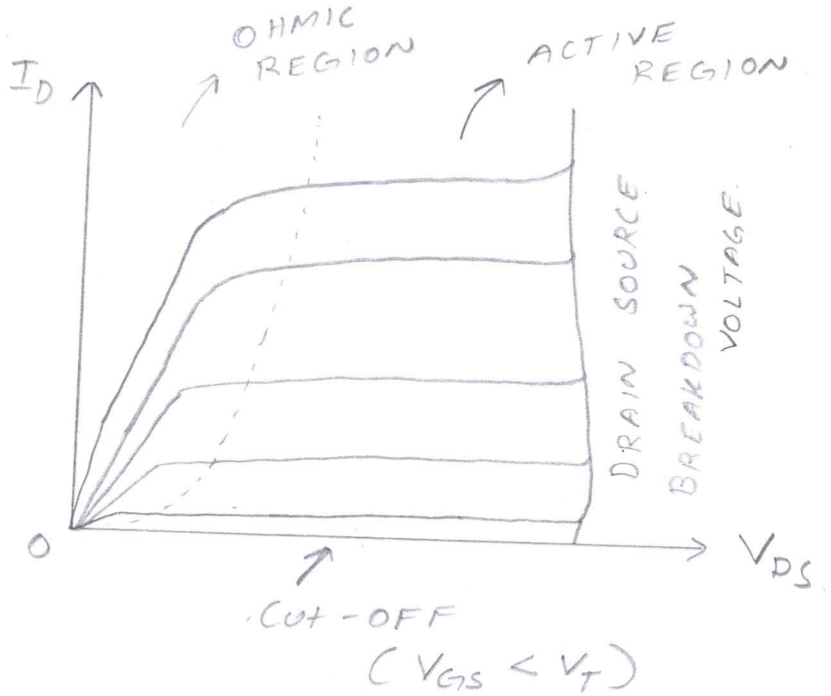
c) $$P_T = V_{BE} I_B + V_{CE} I_C$$

$$= \boxed{35.07\,W}$$ — 1M

Q3.b) Discuss the steady state characteristics of Power MOSFET. Compare this with the characteristics of power BJT.

Ans :-

2M ←



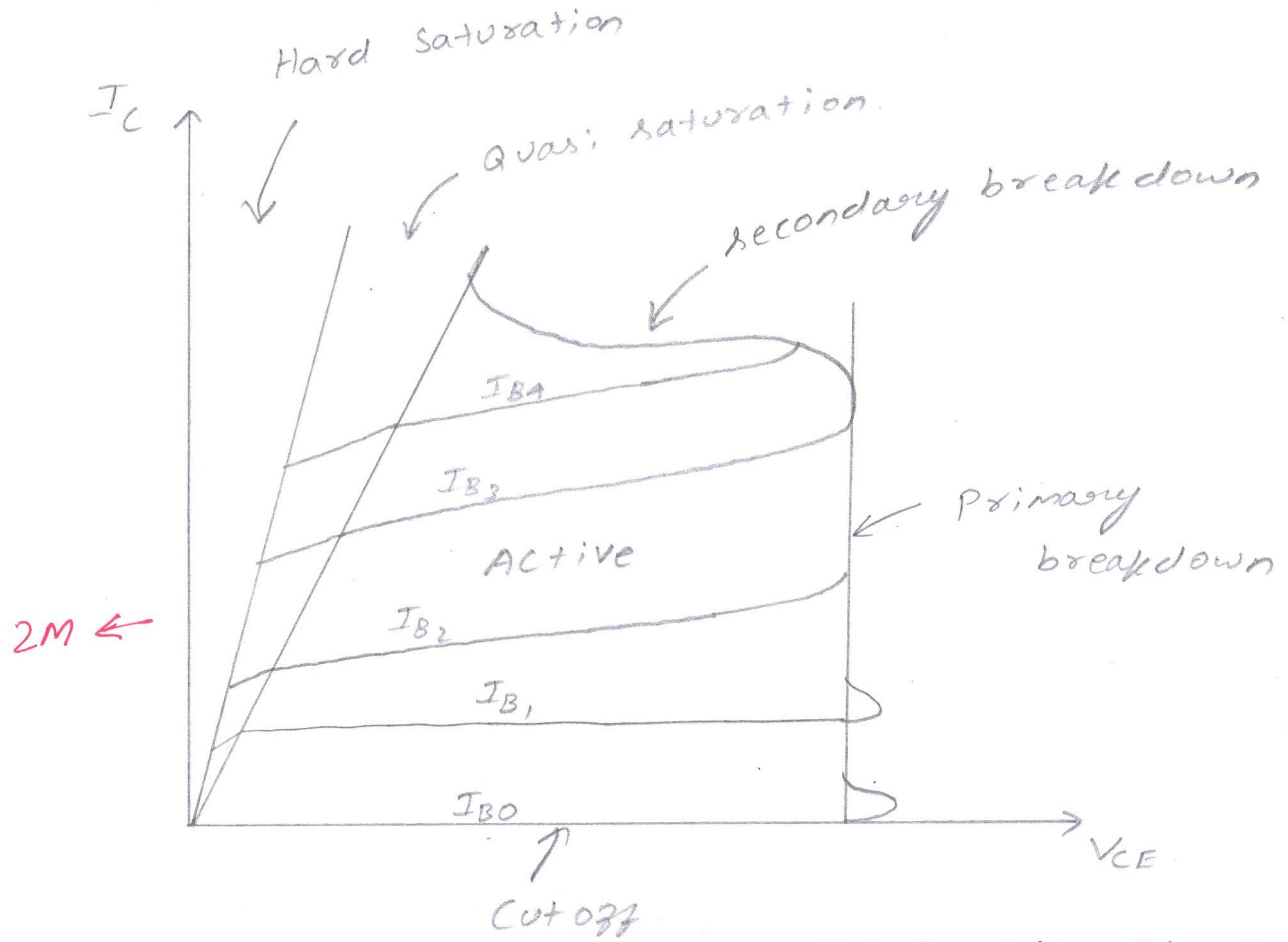
→ Power Mosfet operates in three regions :-

* Ohmic region
* Active Region
* Cut off Region.

→ As a switch we operate mosfet in Cut-OFF (OFF) and Ohmic region (ON).

→ Device remains in off state when the gate source voltage is lesser than threshold voltage.

→ For lower values of V_{DS} the graph is almost linear.



BJT o/p Characteristic

→ Now if we Compare Characteristics of BJT with mosfet we can observe :-

2M

* There is no secondary breakdown phenomenon in Mosfet like BJT.
∴ MOSFET is +ve temperature Coefficient device.

* There is an extra quasi-saturation region of operation in BJT which is absent in MOSFET.

Q4. a) What is the need for isolation of drive circuits from power circuits? Explain the gate and base drive isolation circuits with a neat diagram.

Ans :-

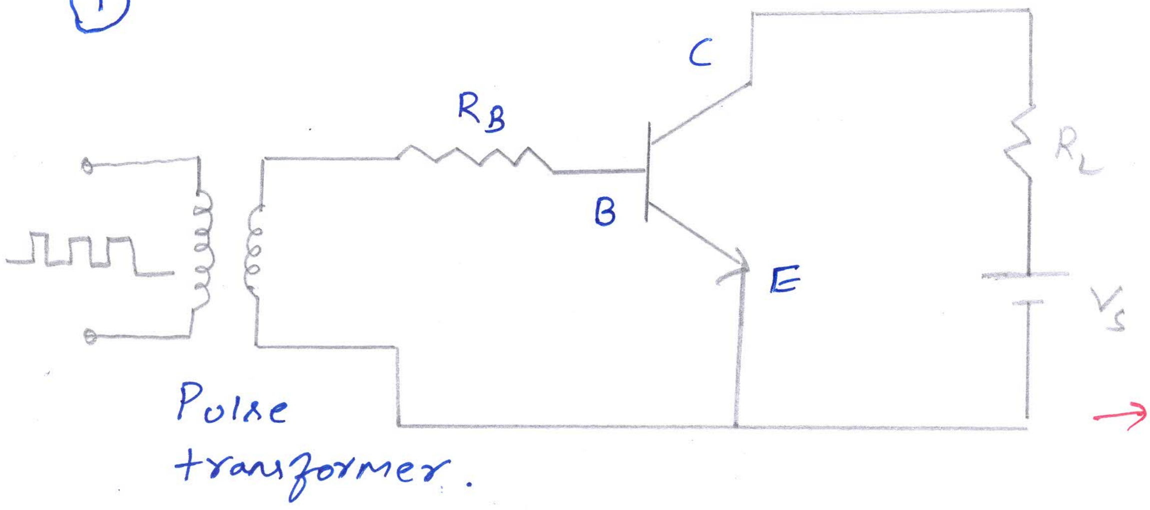
2M ← Need for isolation of drive circuits from Power circuits :-

* Isolation will prevent damaging of trigger circuit in case BJT is damaged. i.e Short ckt of collector-base.

* To avoid the damage of 2nd switch in case 1st switch gets damage. (when we have common ground).

Isolation circuits :-

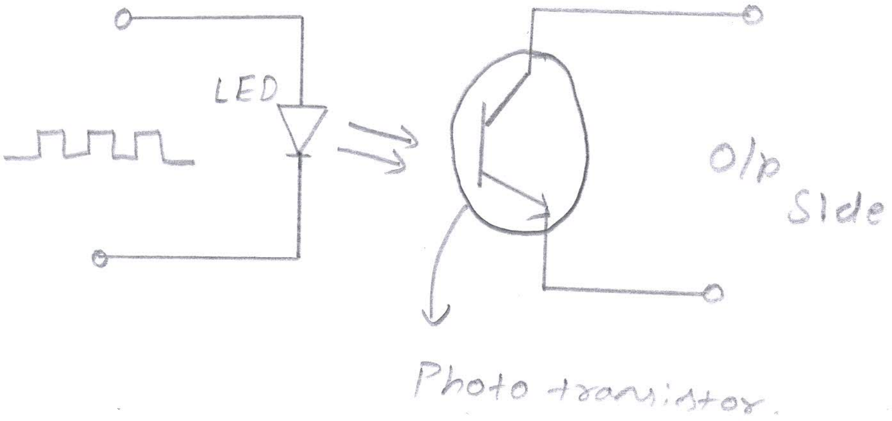
(1)



explain.

→ 3M

(2)



OptoCoupler.

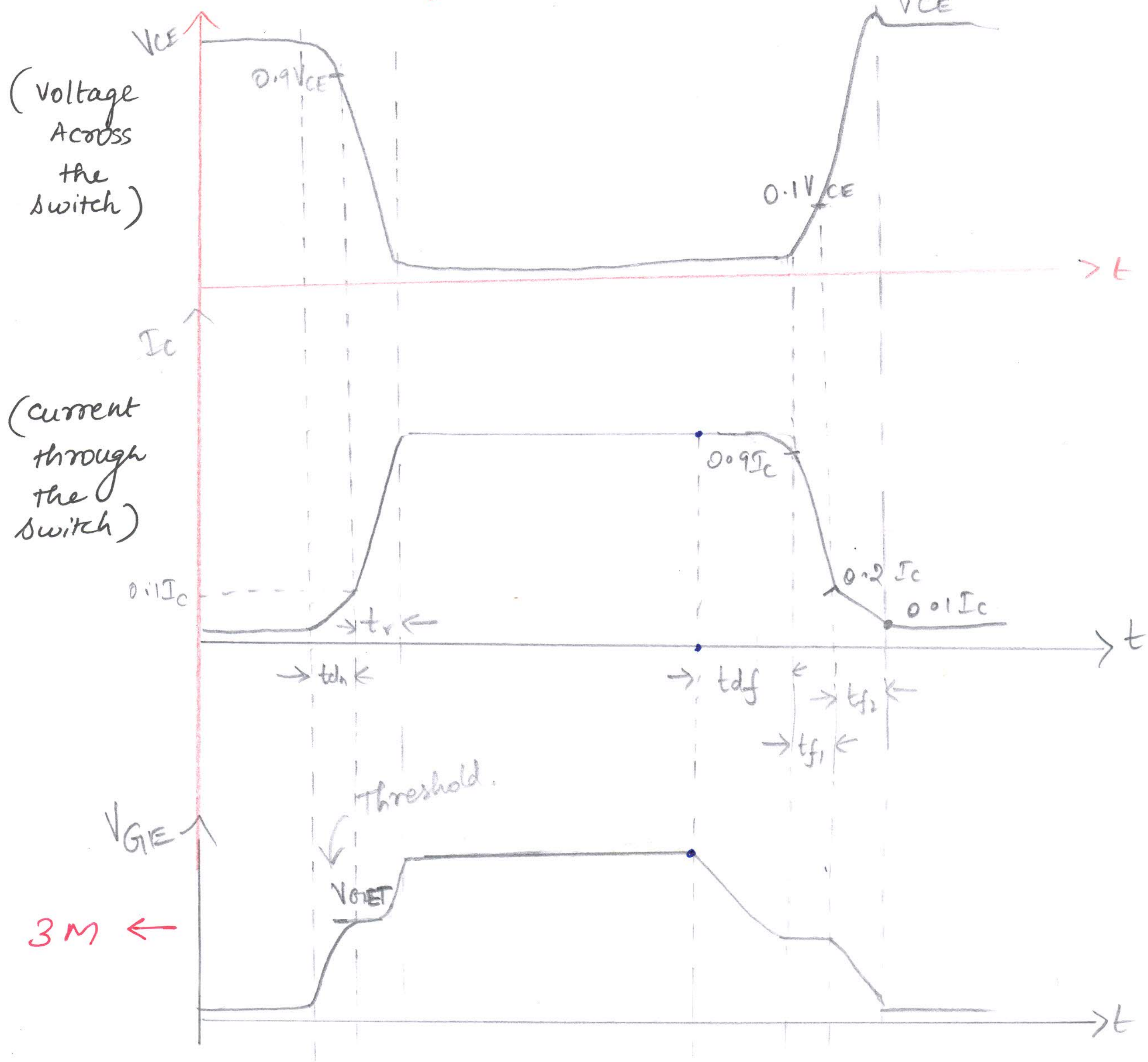
Explain.
↓
3M.

b) Compare IGBT and MOSFET on the basis of frequency and Conduction losses.

Ans :-

	IGBT	MOSFET
1M ←	→ Switching freq is lower Compared to MOSFET.	→ Higher Compared to IGBT.
1M ←	→ Conduction loss is low compared to MOSFET	→ Conduction loss is higher than IGBT.

Q5 a) With a neat diagram explain the switching characteristics of an IGBT.



3M ←

Turn ON:

$t_{ON} = t_{dn} + t_r$ → Delay time + Rise time.

(Ic rises to 0.1 Ic from 0) (Ic rises from 0.1 Ic to Ic)

↓ 1 M

$t_{off} = t_{df} + t_{f_1} + t_{f2}$

- t_{df} → Delay time during fall
- t_{f_1} → Initial fall time
- t_{f2} → Final fall time.

→ 1M

* The turn ON time of IGBT consists of Delay time and Rise time.

when $V_{GE} \geq V_{Th}$, Collector current starts to rise. when I_c increases, V_{CE} starts to decrease.

So, turn ON time is the sum of, t_{dn} & t_r

- $t_{dn} \rightarrow$ delay time V_{CE} falls from peak to $0.9 V_{CE}$ I_c increases from 0 to $0.1 I_c$.

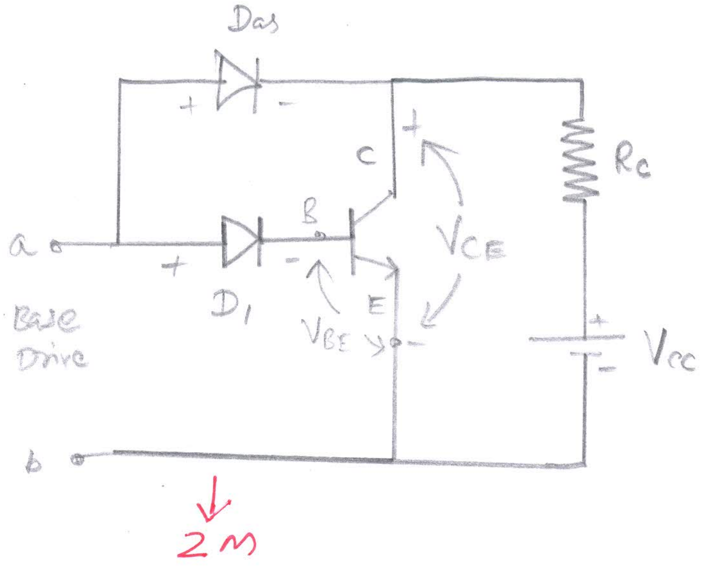
* Turn off $\rightarrow$ when Gate voltage is Reduced, I_c doesn't decrease fast.

$t_{df} \rightarrow$ Delay time during fall. I_c decreases from peak to $0.9 I_c$.

$t_{f1} \rightarrow$ Fall time of MOSFET current

$t_{f2} \rightarrow$ Fall time of BJT current.

Q 5b) Explain the Baker's clamping circuit used for anti-saturation base drive control of BJT.



$V_{ab} = V_{D1} + V_{BE} \rightarrow$ ①

$V_{ab} = V_{Das} + V_{CE} \rightarrow$ ②

① = ②

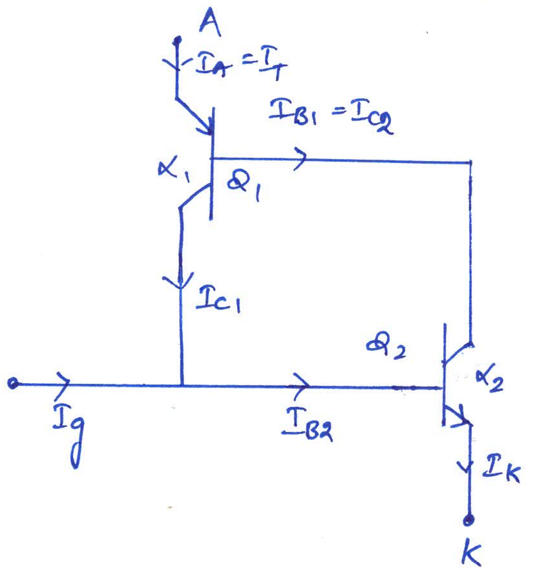
$V_{D1} + V_{BE} = V_{Das} + V_{CE}$

$\boxed{V_{BE} = V_{CE}}$ → 2M

→ Anti saturation control (Quasi-Sat Rgn) (Key)

Explain → 1M

Q6 (a) Draw the two transistor model of a thyristor and derive an expression for the anode current in terms of common base current gain α_1 and α_2 of transistors.



→ 1M

$$I_{C1} = \alpha_1 I_{E1} + I_{CBO1} \rightarrow (1)$$

$$I_{C1} = \alpha_1 I_A + I_{CBO1} \rightarrow (2)$$

$$I_{C2} = \alpha_2 I_{E2} + I_{CBO2} \rightarrow (3)$$

$$I_{C2} = \alpha_2 I_K + I_{CBO2} \rightarrow (4)$$

$$I_A = I_{C1} + I_{C2}$$

$$I_A = \alpha_1 I_A + I_{CBO1} + \alpha_2 I_K + I_{CBO2}.$$

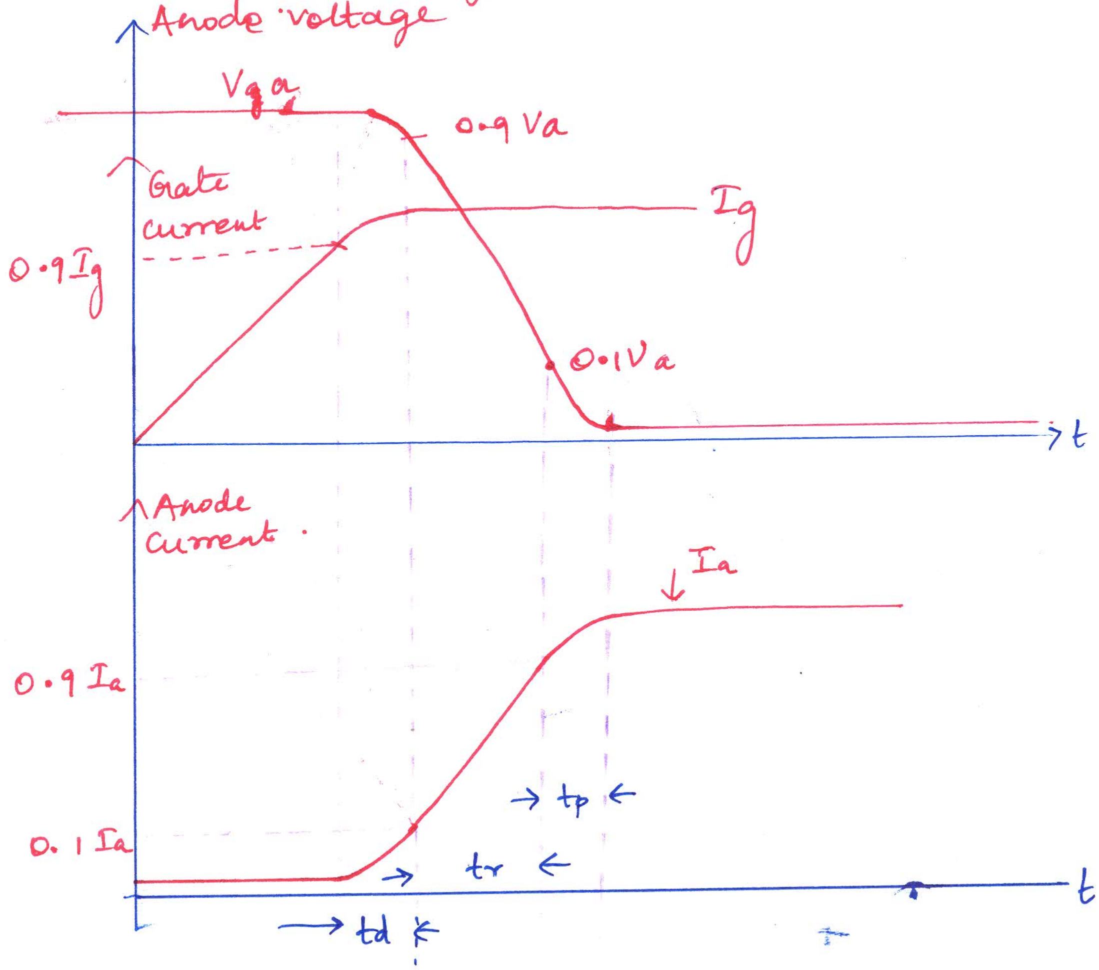
$$= \alpha_1 I_A + I_{CBO1} + I_{CBO2} + \alpha_2 (I_g + I_A)$$

$$I_A = (\alpha_1 + \alpha_2) I_A + \alpha_2 I_g + I_{CBO1} + I_{CBO2}$$

$$I_A (1 - (\alpha_1 + \alpha_2)) = \alpha_2 I_g + I_{CBO1} + I_{CBO2}$$

$$I_A = \frac{\alpha_2 I_g + I_{CBO1} + I_{CBO2}}{(1 - (\alpha_1 + \alpha_2))} \rightarrow 4M.$$

Q6 b) Draw and explain the dynamic turn ON characteristics of SCR.



→ (3M)

⇒ when positive Gate signal is applied to an SCR (Forward biased), SCR changes from blocking to conducting state → This is turn ON Mechanism.

$t_{ON} = t_d + t_r + t_p$ ⟶ ① → (2M)

t_d → delay time, t_r = rise time, t_p = peak time (or) spread time

Delay time → when Gate current reaches $0.9 I_g$, Anode current rises and reaches $0.1 I_a$ when V_a reaches $0.9 V_a$.

Rise time → ~~when~~ time during which Anode current rises from $0.1 I_a$ to $0.9 I_a$.

(or) time taken for Anode voltage to fall from $0.9 V_a$ to $0.1 V_a$.

Spread time (or) Peak time: time taken for Anode current to rise from ($0.9 I_a$ to I_a) (or) time taken for Anode voltage to fall from $0.1 V_a$ to ON state voltage drop.

Q 7 a) With Reference to SCR explain the following terms:

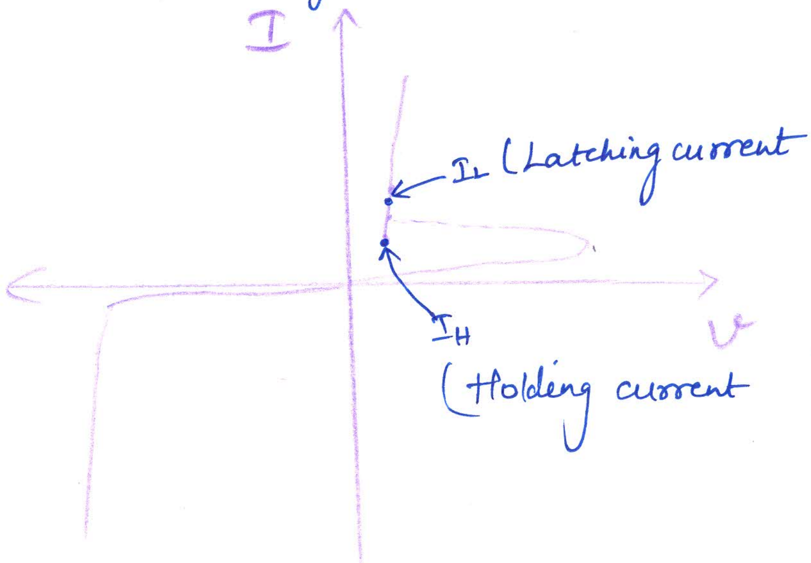
(a) Latching current

(b) Holding current

[5]

(a) Latching current is the minimum current required to turn ON the SCR and maintain it in conduction state even when the Gate is removed. — 2M

(b) Holding current is the minimum current required to maintain the SCR in ON-State. If SCR current falls below Holding current, SCR will change from ON state to OFF State immediately. 2M

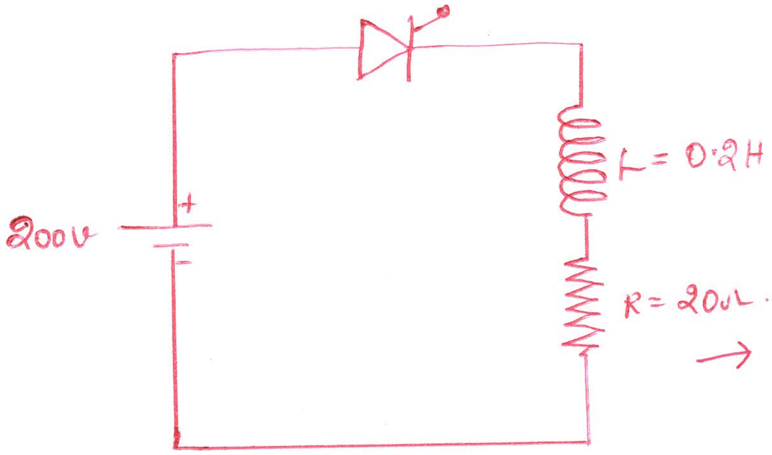


→ 1M.

I - V characteristics of SCR

Q 7 (b) The Latching current for SCR inserted between a dc voltage source of 200V and load is 100mA. Calculate the minimum width of gate pulse current required to turn on this SCR incase the load Consist of i) L = 0.2 (ii) R = 20 Ω in Series with L = 20H.

[5]



→ 1M.

Circuit will only close when SCR turns ON with Latching current, and current will flow.

$$i(t) = \frac{V_s}{R}\left(1 - e^{-tR/L}\right) \qquad \left(\because \tau = L/R\right)$$

↳ Instantaneous current through an RL circuit.

when $i(t) = I_L$ (SCR turns ON)

$$I_L = \frac{V_s}{R}\left(1 - e^{-tR/L}\right)$$

$$100 \times 10^{-3} = \frac{200}{20}\left(1 - e^{-t\times\frac{20}{0.2}}\right)$$

$$10^{-2} = \left(1 - e^{-t\frac{20}{0.2}}\right)$$

$$e^{-t20/0.2} = 1 - 10^{-2}$$

$$\frac{-20t}{0.2} = \ln\left(1 - 10^{-2}\right)$$

$$\frac{+20t}{0.2} = +0.01$$

$$t = \frac{0.01 \times 0.2}{20} = 1 \times 10^{-4}$$

$= \underline{0.1\ ms}$ → 4M