PNS School of Engineering & Technology

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Internal Assessment Examination-2022(5th Semester)

Subject : Th-5 -Power Electroncs & PLC

Branch : Electrical & ETC Engineering

Time : $1\frac{1}{2}$ Hours F.M. : 20

1. Answer the following questions(any Five) . [2 x 5]

(a) Define latching current.

(b) What is $\frac{dv}{dt}$ triggering of an SCR ?

(c) State delay time.

(d) Define snubber circuit.

(e) What is phase angle in converter ?

(f) What is chopper ?

(g) What do you mean by duty cycle ?

2. Answer the following questions. (any Two) [5 x 2]

(a) Explain the coustmetion of TRIAC with layer diagram.

(b) Explain the operation of step up chopper.

(c) Describe the operation of single phase full wave bridge converter with R-L load.

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ANSWER

1(a) Latching current - It is the minimum value of anode Current which it must attain during turn-on process to maintain conduction when gate signal is removed.

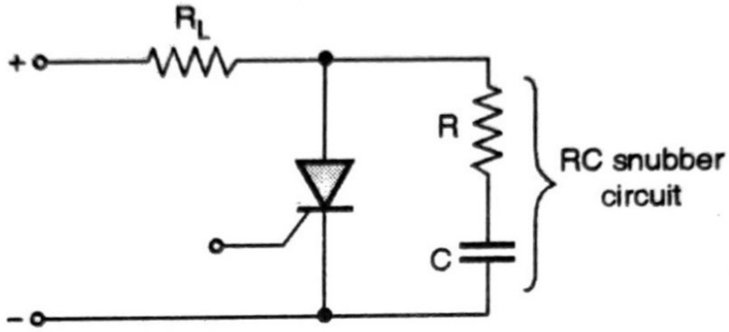
1(b) $\frac{dV}{dt}$ Triggering - With forward voltage across the anode and cathode of an SCR, the two outer junctions J_1 and J_3 are forward biased, but inner junction J_2 is reversed bias. This reverse biased function J_2 has the characteristic of a capacitor due to charges existing across the junction. If forward voltage is suddenly applied, a charging current through junction capacitance C_J, may turn on the SCR. Charging current

$$I_C = \frac{dQ}{dt} = \frac{dC_J V_a}{dt} = C_J \frac{dV_a}{dt}$$

Therefore, if the rise of the forward voltage is high, the charging current I_C would be more.

1(c) Delay Time (t_d) - The delay time t_d is the time interval between the instant at which the gate current reaches $0.9I_g$ and the instant at which anode current reaches $0.1I_a$. The delay time may also be defined as time during which anode voltage from V_a to $0.9\ V_a$.

1(d) Snubber circuit - A snubber circuit basically consists of a series - connected resistor and capacitor placed in shunt with an SCR.



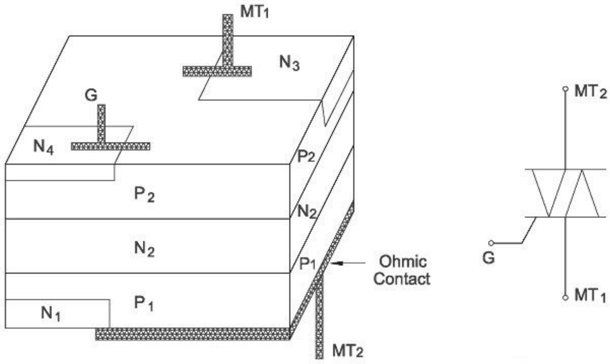
1(e) Phase angle is the time interval between the instant the SCR is forward biased and the instant gate pulse is given to turn ON the SCR.

1(f) A chopper is a static device (or switch) used to obtain variable DC voltage from a source of constant DC voltage. Therefore, chopper may be thought of as DC equivalent of an AC transformer, since they behave is an identical manner

1(g) Duty cycle – It is the ratio of turn ON time to toal time . It is denoted by α

$$\alpha = \frac{T_{ON}}{T} = \text{Duty cycle}$$

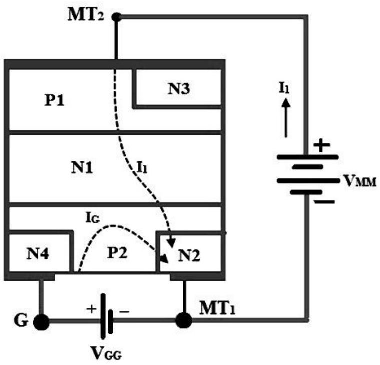
2(a) TRIAC - TRIAC is a four layer, six doped region and a three terminal device. Gate terminal is connected to both N_3 and P_2 so that gate triggers the device when both positive and negative voltage is applied. In the Same way MT_1 is also connected to N_2 and P_2 regions and MT_2 is connected to the P_1 and N_4 regions. So the polarity between the terminals decides the direction of the current through the layers.



Working of TRIAC:

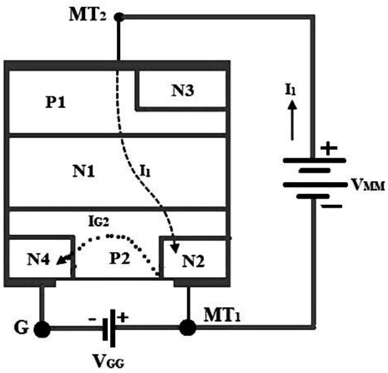
There are four possible combinations of the potentials applied to the terminals.

Mode1: MT_2 is positive and gate terminal is positive:



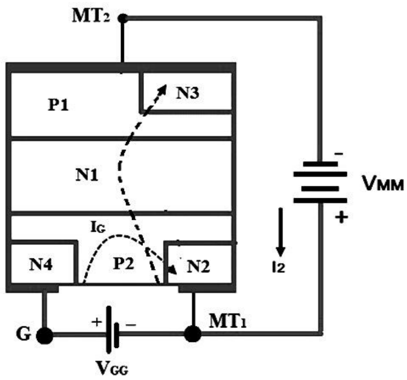
When the MT_2 terminal is made positive with respect to the terminal MT_1 and when positive voltage is applied at the gate terminal the path of the current flow from MT_2 to MT_1 will be P_1-N_1-P_2-N_2. The junction between P_1N_1 and P_2N_2 are forward biased and junction between N_1P_2 is reverse biased and breakdown occurs at this junction.

Mode2: MT_2 is positive and gate terminal is negative:



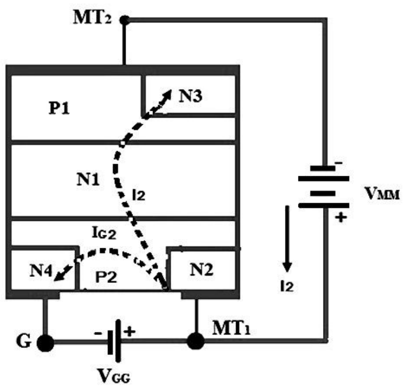
When the MT_2 terminal is made positive with respect to the terminal MT_1 and when negative voltage is applied at the gate terminal, initially the path of the current flow from MT_2 to MT_1 will be P_1-N_1-P_2-N_3. When the voltage applied at the MT_2 terminal is further increased the junction P_2N_2 is forward biased and the path of the current flow will be P_1-N_1-P_2-N_2. More Gate current is needed to turn the TRIAC.

Mode3: MT_2 is negative and gate terminal is positive:



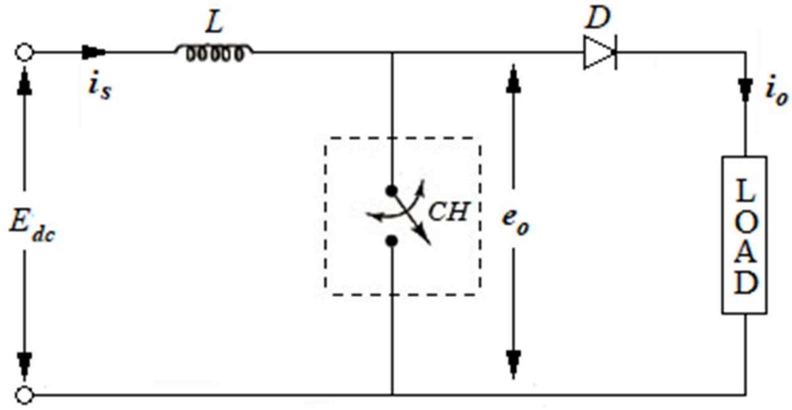
When the MT_2 terminal is made positive with respect to the terminal MT_1 and when negative voltage is applied at the gate terminal the path of the current flow from MT_2 to MT_1 will be $P_2N_1P_1$. The Junctions P_2N_1 and P_1N_4 are forward biased and the junction N_1P_1 is reverse biased. So in this mode, TRIAC work in a negative biased region.

Mode4: MT_2 is negative and gate terminal is negative:



When the MT_2 terminal is made negative with respect to the terminal MT_1 and when negative voltage is applied at the gate terminal the path of the current flow from MT_2 to MT_1 will be $P_2N_1P_1N_4$.

2(b) Working principle of step-up CHOPPER:



When the chopper is ON, the inductor L is connected to the supply and stores energy during on period T_{ON}. When the chopper is made OFF, the inductor stored energy as well as Source E_{DC} supply the load. Hence the load voltage becomes

$$E_O = E_{DC} + L\frac{dI_{DC}}{dt}$$

During the time T_{ON} when chopper is ON, the energy input to the inductor from the source is given by $W_I = E_{DC}\, I_{DC}\, T_{ON}$

During the time T_{OFF} when chopper is OFF, energy released by the inductor to the load is given by

$$W_O = (E_O - E_{DC})\, I_{DC}\, T_{OFF}$$

Considering the system to be lossless, the above two energies will be equal.

Hence WI = WO

Or $E_{DC}\, I_{DC}\, T_{ON} = (E_O - E_{DC})\, I_{DC}\, T_{OFF}$

Or $E_{DC}\, T_{ON} + E_{DC}\, T_{OFF} = E_O\, T_{OFF}$

Or $E_O = E_{DC}\,\frac{T_{ON}+T_{OFF}}{T_{ON}}$

Or $E_O = E_{DC}\,\frac{T}{T_{OFF}}$

Or $E_O = E_{DC}\,\frac{1}{1 - \frac{T_{ON}}{T}}$

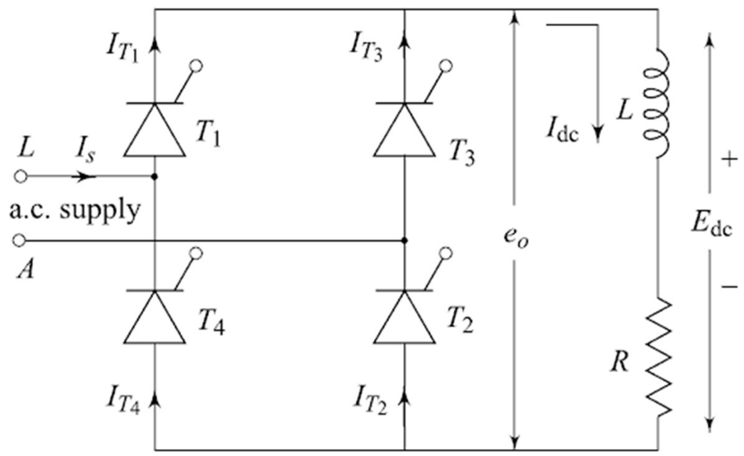
Or $E_O = \frac{E_{DC}}{1 - \alpha}$

Hence the output voltage E_O will vary in the range $E_{DC} < E_O < \infty$ for the variation of duty cycle α in the range $0 < \alpha < 1$.

2(c) Opereation of single phase full wave bridge converter with RL load:

During first positive half cycle, SCRs T_1 and T_2 are fired at fining angle α. So the current flows through the path L-T_1-L-R-T_2-N. Supply voltage from this instant appears across output load terminal. At instant π, voltage reverses, however the current is maintained in the same direction which keeps the SCRs T_1 and T_2 conducting and hence the negative supply voltage appears across load terminals.

At an angle $\pi + \alpha$, SCRs T_3 and T_4 are fired. With this, the negative line voltage reverse-biases SCRs T_1 and T_2 to commutate. Now the current flows through the path N-T_3-L-R-T_4-L. This continues in every half cycle and we get the output voltage across load.



The average load voltage is

$$E_{DC} = \frac{1}{\pi}\int_{\alpha}^{\pi+\alpha} E_m \text{Sin}\omega t d(\omega t)$$

Or $$E_{DC} = \frac{E_m}{\pi}[-\text{Cos } \omega t]_{\pi}^{\pi+\alpha}$$

Or $$E_{DC} = \frac{2E_m}{\pi}\text{Cos } \alpha$$