Model Answers

SUMMER – 2019 Examinations

Subject & Code: FUNDAMENTALS OF POWER ELECTRONICS (22326)

Important Instructions to examiners:

1) The answers should be examined by key words and not as word-to-word as given in the model answer scheme.
2) The model answer and the answer written by candidate may vary but the examiner may try to assess the understanding level of the candidate.
3) The language errors such as grammatical, spelling errors should not be given more importance (Not applicable for subject English and Communication Skills).
4) While assessing figures, examiner may give credit for principal components indicated in the figure. The figures drawn by candidate and model answer may vary. The examiner may give credit for any equivalent figure drawn.
5) Credits may be given step wise for numerical problems. In some cases, the assumed constant values may vary and there may be some difference in the candidate's answers and model answer.
6) In case of some questions credit may be given by judgement on part of examiner of relevant answer based on candidate's understanding.
7) For programming language papers, credit may be given to any other program based on equivalent concept.

Model Answers

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Subject & Code: FUNDAMENTALS OF POWER ELECTRONICS (22326)

1	**Attempt any FIVE of the following:**	**10**

1 a) Give the applications of IGBT.

Ans:

1) AC and DC motor drives
2) SMPS
3) Inverters
4) Choppers
5) Solid-state Relays
6) solid-state Contactors

½ marks for each of any four applications = 2 marks

1 b) What is the need of UPS?

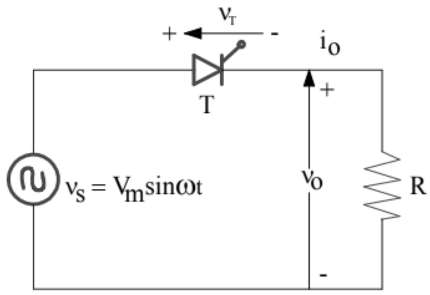
Ans:

1) An Uninterruptible Power Supply (UPS) is used to protect critical loads from mains supply problems including spikes, voltage dips, fluctuations and complete power failures using a dedicated battery.
2)A UPS system can also be used as standby system when AC mains is failed.

1 mark for each of any 2 points = 2 marks

1 c) Draw a neat circuit diagram of class F commutation

Ans:



2 marks for labeled diagram

1 marks for partially labeled diagram

1 d) Define: i) Firing angle ii) Conduction angle

Ans:

(i) Firing Angle(α):

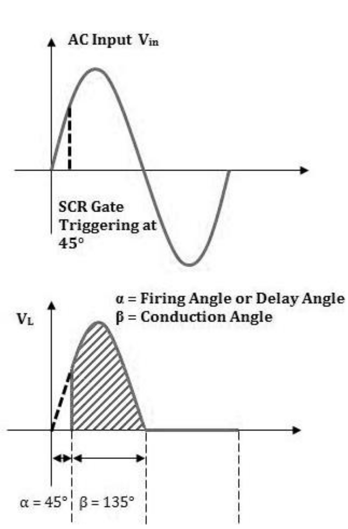
Firing angle is defined as the angle between the instant the SCR would conduct if it would be a diode and the instant it is triggered or fired.

Firing angle or delay angle can be defined as the angle measured from the angle that gives maximum average output voltage to the angle when the SCR is actually triggered or fired by gate pulse.

(ii) Conduction Angle (β):

Conduction angle is defined as the angle between the instant the SCR is triggered or turned on and the instant at which the SCR is turned off.

Assuming that the SCR is turned off naturally at



1 mark for each definition = 2 marks

the end of positive half cycle, the relation between the firing or delay angle (α) and conduction angle (β) can be expressed as:
$\alpha + \beta = \pi$ radian or 180°

1 e) How GTO is advantages over SCR

Ans:

i) It is turned-off by negative gate pulse.
ii) No commutation circuit required, reducing the cost, size, weight and volume of the circuit.
iii) As commutation choke is not used, the associated acoustic and electromagnetic noise (interference) is absent.
iv) Less turn off time permits high switching frequency.
v) It has higher di/dt rating at turn-off.

1 mark for each of any two points = 2 marks

1 f) State the main difference between PUT and UJT.

Ans:

Difference between PUT and UJT:

(i) The intrinsic stand-off ratio of a UJT is fixed hence operating characteristics cannot be alterd. The PUT, on the other hand has operating characteristics that can be altered. These include base-base resistance, intrinsic stand-off voltage, valley current and peak current and all these can be altered by setting the values of two external resistors.
(ii) The UJT is made up of a lightly doped n-region known as the base region onto which is joined a small heavily doped p-region called the emitter. The PUT on the other hand is a four layer device similar to an SCR except that the gate terminal of the PUT is connected to the n-region adjacent to the anode.
(iii) PUT has high forward conductance, so it can provide high peak current pulses, even with low value capacitor in relaxation oscillator circuit.
(iv) PUT has fast rise time, which allows faster rise in current and provides healthy output pulses as compared to UJT.

1 mark for each of any two points = 2 marks

1 g) Write the function of freewheeling diode.

Ans:

Function of Freewheeling Diode (FWD):

a) Freewheeling diode is used across inductive loads such as coils, dc motor armature etc. to prevent voltage spikes across these loads when the switching device is turned off.
b) It is used to bypass the stored energy in inductive elements when the switching device is turned off.
c) In absence of FWD, the stored energy in inductance will maintain forward current through the power semiconductor device and prevent it from being turned off.
d) When the power semiconductor device in series with load is turned off, the free-wheeling diode is forward biased and the current in load is bypassed through FWD. Since load current is shifted from switching device, it is turned off easily and regain its blocking ability.

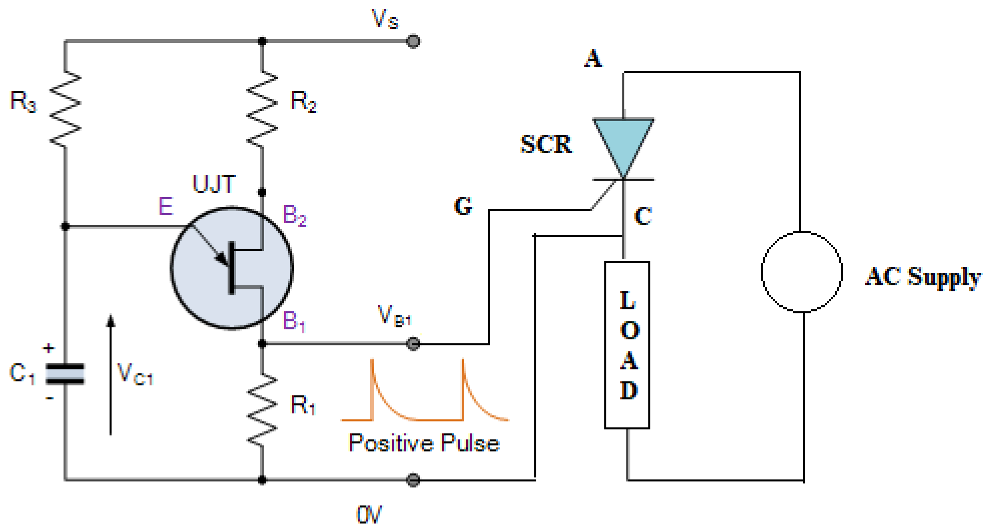
1 mark for each of two functions = 2 marks

2 Attempt any THREE of the following: 12

2 a) Describe triggering of SCR using UJT relaxation oscillator.

Ans:

Triggering of SCR using UJT relaxation oscillator:



1 mark for circuit diagram

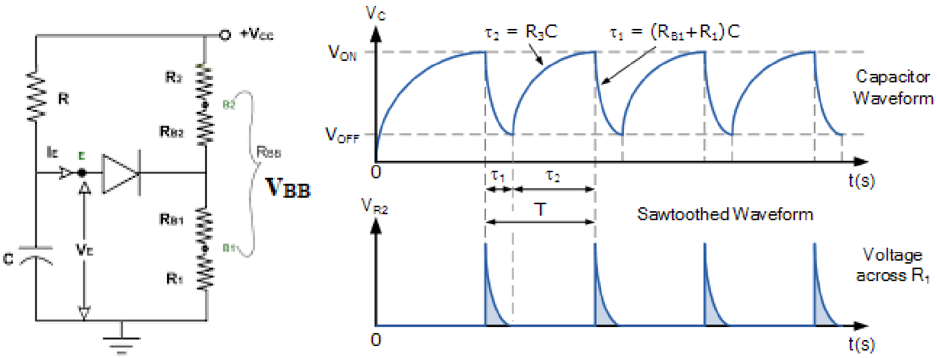
The circuit configuration of UJT relaxation oscillator is shown above. The output pulses are line synchronized with AC supply so that the pulse get applied to SCR during positive half cycles i.e when SCR is forward biased. When the supply is given, the capacitor C_1 starts charging through R_3 towards V_S. Therefore, the emitter voltage V_E exponentially rises with time constant $\tau_2 = R_3C_1$, as shown in the waveform. When the capacitor voltage (so also the emitter voltage) reaches to a level called Peak-point voltage V_P (=V_{ON}), the UJT is turned-on, the current flows from emitter to base B_1. Referring to the equivalent circuit of UJT, it is clear that the UJT can conduct only when the emitter voltage is at least equal to sum of forward volt-drop across diode and voltage across R_{B1}.

2 marks for explanation

$$V_P = V_D + V_{RB1} = 0.7 + \frac{R_{B1}}{R_{B1}+R_{B2}} V_{BB} = 0.7 + \eta V_{BB}$$

where, η is called intrinsic stand-off ratio.

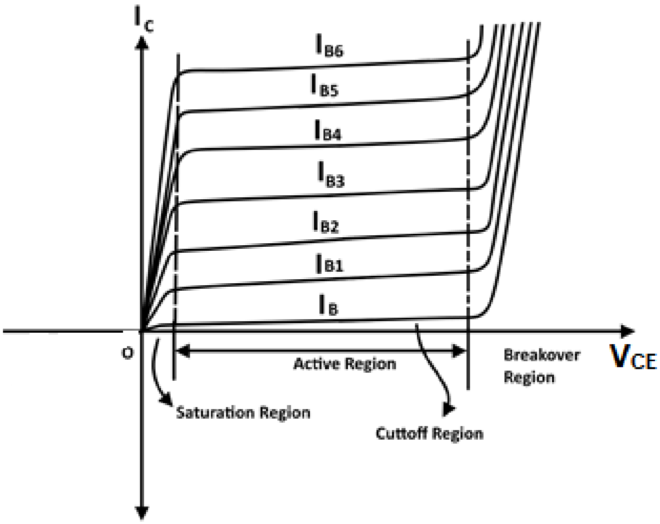
At this voltage, the emitter diode gets forward biased & it conducts. Due to this current, the carriers are injected in the lower base B_1 region of UJT structure and its resistance R_{B1} is considerably reduced. Due to this, the capacitor discharges through emitter diode D, base resistance R_{B1}, external resistance R_1. The discharging time-constant is thus $(R_{B1}+R_1)C_1$. The capacitor discharges and when its voltage reaches to a level called Valley-point voltage V_V (=V_{OFF}), the UJT is turned-off. The discharging current flowing through external resistance R_1 causes a pulse voltage across it, as shown in the waveform. This pulse is applied to gate-cathode junction of forward biased SCR to turn it on. As AC supply is applied in SCR circuit, the SCR is forward biased only during positive half cycles. Therefore, the pulses are synchronized with AC supply such that each pulse is produced only during positive half cycle. After receiving pulse, the SCR is turned-on and conducts the load current till the end of that half-cycle. At the end of that half-cycle, the voltage and hence the load current may fall to zero & SCR is naturally turned-off. In the next positive half cycle next pulse turns the SCR on again and the process repeats.



1 mark for waveforms

2 b) Draw the I-V characteristics of Power Transistor. Show all regions.

Ans:



4 marks for labeled diagram

3 marks for partially labeled diagram

2 marks for unlabeled diagram

2 c) With neat circuit diagram explain working of emergency light system.

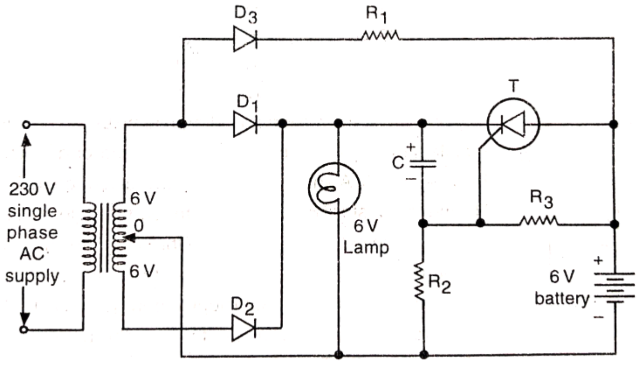
Ans:

Emergency lighting system:

In the residential, commercial and industrial areas, the illumination system work with available AC supply. In the event of AC supply failure, partial illumination can be obtained using emergency lighting system that works on DC supply. A very simple single source emergency lighting system which is most suitable for household application is shown in the figure. The input 230v AC supply is stepped down to 6-0-6V AC supply by centre-tapped transformer. The diodes D_1 and D_2 form full wave rectifier and comnvert 6-0-6V AC supply into 6V DC supply for 6V lamp. When AC supply is available, 6V DC supply appears across lamp & it glows. The pulsating current also flows through D_3, R_1 to trickle charge the battery. Thus battery charging is carried out when AC supply is availabl;e. The capacitor C get charged with upper plate positive to some voltage less than 6V. due to capacitor voltage, gate-cathode junction of thyristor T get

2 marks for circuit diagram and

reverse biased. The anode is at battery voltage and cathode is at rectifier output voltage, which is slightly higher, hence thyristor is reverse biased and can not conduct. The lamp glows due to rectifier output DC voltage. When AC supply fails, rectifier output DC voltage is reduced to zero. The capacitor C then discharges through lamp and R_2. After discharging, due to battery, it charges through R_3 and lamp with lower plate positive. Due to capacitor voltage, gate-cathode junction get forward biased and gate current flows. Since the anode is now at higher potential than cathode, thyristor T is turned-on. The lamp get connected across battery through thyristor and therefore, it glows. In rthis way, on failure of AC supply, light is obtained from DC supply.



Emergency lighting system

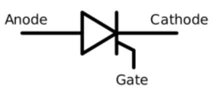
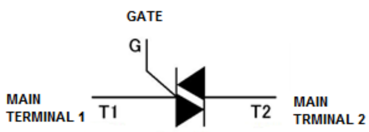
2 marks for explanation

OR

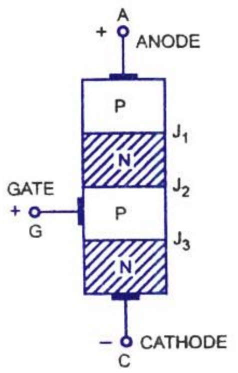
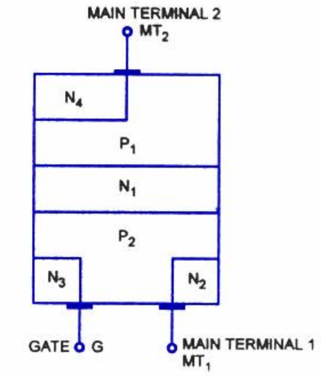
(Any other equivalent valid circuit and explanatiobn)

2 d) Compare SCR and TRIAC (any four)

Ans:

SCR	TRIAC
It is an unidirectional device.	It is a bidirectional device.
It is turned-on by only positive gate current.	It can be turned-on by either positive or negative gate current.
Operates only in the first quadrant	Operates in either 1st or 3rd quadrant.
Anti-parallel SCRs are used for bidirectional current flow.	TRIAC is equivalent to a pair of antiparallel connected SCRs.
It has better gate-current sensitivity.	It has poor gate-current sensitivity as compared to SCR.
It has lower turn-on & turn-off times as compared to TRIAC.	It has higher turn-on & turn-off times as compared to SCR.
For bidirectional current applications, two SCRs & two heat sinks require more space.	For bidirectional current applications, one TRIAC & one heat sink require less space.
Firing circuit design is simple.	More careful firing circuit design is required.
Higher voltage & current ratings as compared to TRIAC.	Lower voltage & current ratings as compared to SCR.
	

1 mark for each of any 4 correct points = 4 marks

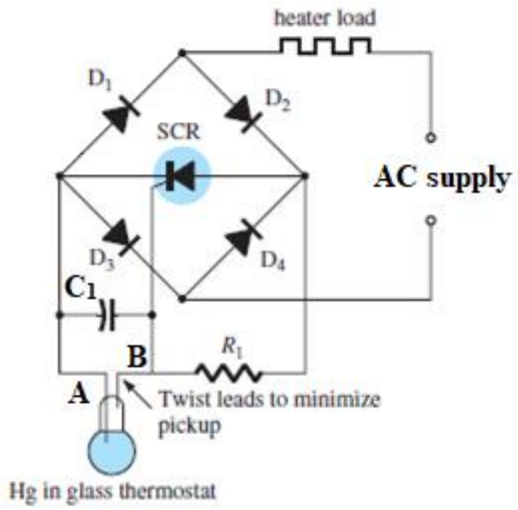
	
It is employed in large power applications including large power supplies, DC motor drives, lighting and heating, Static VAR compensators, Electronic circuit breakers etc.	It is employed in low and medium power applications including lamp dimmer, heating control, zero voltage switched AC relay, small AC motor control etc.

3 Attempt any THREE of the following: 12

3 a) Explain with neat circuit diagram operation of temperature controller using SCR.

Ans:

Temperature controller using SCR:



2 marks for diagram

The temperature control circuit is used to regulate the temperature. Figure shows the temperature control circuit using thermostat as temperature detector and SCR as a switching device. The mercury in glass thermostat is extremely sensitive temperature measuring instrument which is capable of sensing changes in temperature of the order of 0.1°C.

2 marks for explanation

Working:

Mode I: When the temperature is less than the desired value, the mercury in the glass thermostat is not able to short the electrodes A & B. Therefore the SCR receives the gate signal in both the half cycles & it will be triggered. Hence the heater will be connected to AC source in respective half-cycles. Thus heating is continued and temperature increases to desired level.

Mode II: As the temperature increases, the mercury level increases and when it reaches the desired value, the electrode A and B are short circuited through mercury. This will short circuit the gate to cathode, hence no trigger pulse can be received by SCR. Hence it is not turned-on in the next half-cycle & maintained off. Thus the heater gets disconnected and will remain disconnected from the circuit. The heating then stops and temperature is not allowed to rise beyond desired level. After some time when temperature falls to certain level and mercury switch gets opened, i.e the gate-cathode short-circuit is opened, the pulse is provided to SCR in each half-cycle and heater gets connected to source to produce heat and raise the temperature.

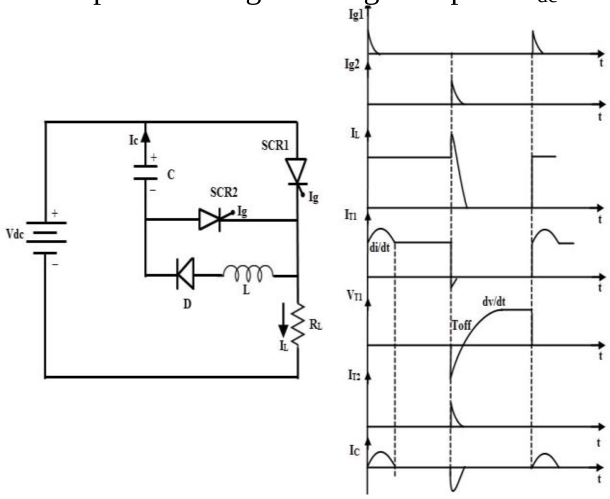
3 b) **Draw circuit diagram of class D commutation & explain its working.**

Ans:

<u>Class D commutation:</u>

This is also called as auxiliary commutation because it uses an auxiliary SCR to switch the charged capacitor across conducting SCR to turn it off. In this scheme, the main SCR is commutated by the auxiliary SCR. The main SCR with load resistance R_L forms the power circuit while the diode D, inductor L, capacitor C and SCR2 forms the commutation circuit.

When the supply voltage V_{dc} is applied, both SCRs are in OFF state and hence the capacitor voltage is zero. In order to charge the capacitor, SCR2 must be triggered first. So the capacitor charges through the path V_{dc}-C-SCR2-R_L-V_{dc}.



1 marks for circuit diagram

1 marks for waveform

When the capacitor is fully charged, the charging current becomes zero and the SCR2 is turned-off naturally.

The supply voltage V_{dc} as well as the charged capacitor C holds the SCR1 in forward bias condition. If the SCR1 is triggered, it is turned-on and two currents flow through it: one is the load current supplied by source, through path V_{dc}-SCR1 – R_L – V_{dc} and another one is capacitor discharge current through path C – SCR1 – L – D - C. The capacitor while discharging supplies its energy to the inductor L. When the capacitor fully discharges, its voltage becomes zero at peak discharge current instant. Then the inductor L utilizes its energy to maintain the current through the same path and the capacitor charges with reversed polarity. When the inductor gives out its energy to the capacitor, the current naturally falls to zero and the capacitor charges fully with reversed polarity. Due to the presence

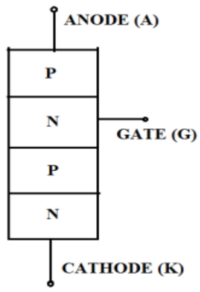
2 marks for explanation

of diode the reverse discharge is not possible. Thus after reverse charging of C, the SCR1 continues to carry only load current. The capacitor voltage maintains forward bias across SCR1, thereby it can be triggered at any instant.
Now when it is desired to turn-off SCR1 for load voltage control, the SCR2 is triggered. The charged capacitor (lower plate positive) then placed across conducting SCR1, applying reverse bias to SCR1. Also, the capacitor discharging starts through path C - SCR2- R_L- V_{dc} - C. The load current is shifted from SCR1 to C – SCR2 path. When this discharging current becomes more than the load current the SCR1 is turned OFF. After turning off of SCR1, the reverse bias is maintained across it by capacitor voltage, which ensures the proper turn-off.
The capacitor discharges fully first and then starts charging with polarity of upper plate positive, through the SCR2 – R_L to a supply voltage V_{dc}. When the capacitor fully charges, the charging current falls to zero and SCR2 is naturally turned off. The capacitor voltage as well as supply voltage make SCR1 forward biased and keep ready for next triggering. The above cyclic process is repeated.

3 c) With neat constructional diagram write operating principle of PUT.

Ans:

<u>Constructional diagram & Operating principle of PUT:</u>



The PUT is a PNPN device similar to SCR, but its operation is similar to the UJT. The PUT behave like a UJT whose trigger voltage V_P can be set by the circuit designer via an external voltage divider, so termed as "Programmable UJT (PUT)".

2 marks for construction

Fig. shows the PNPN structure and the circuit symbol for the PUT. The anode (A) and cathode (K) are the same as for any PNPN device. The gate (G) is connected to the N-region next to the anode. Thus, the anode and gate constitute a P-N junction. It is this P-N junction which controls the "on" and "off" states of the PUT. The gate is usually positively biased relative to the cathode by a certain amount, Vg. When the anode voltage is less than Vg" the anode-gate junction is reverse-biased and the PNPN device is in the "off" state, acting as an open-switch between anode and cathode. When the anode voltage exceeds Vg by about 0.7V, the anode gate junction conducts, causing carrier injection at the middle reverse biased junction J_2 and the PNPN device is turned-on. In the "on" state, the PUT acts like any PNPN device between anode and cathode (low resistance and $V_{AK} \approx 1V$). The PUT is also referred to as a complementary SCR (CSCR).

2 marks for explanation

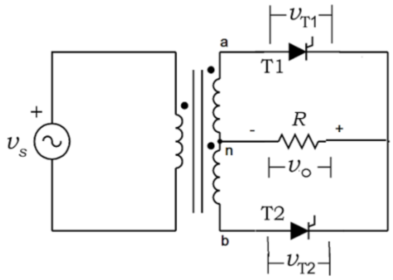
3 d) Explain with circuit diagram 1 ϕ mid-point controlled rectifier with R-load.

Ans:

Single-phase Midpoint controlled rectifier with Resistive load:

1) During positive half cycle of AC supply, "a" is positive with respect to "b", this makes T_1 forward biased and T_2 is reverse biased. But since no triggering pulse is applied, both are in off state. When SCR T_1 is triggered at firing angle α, current flows through load from "a", T_1 and back to

centre-tap "n" of the transformer. This current flow is continuous till angle π when the supply voltage reverses the polarity and T_1 is turned off.

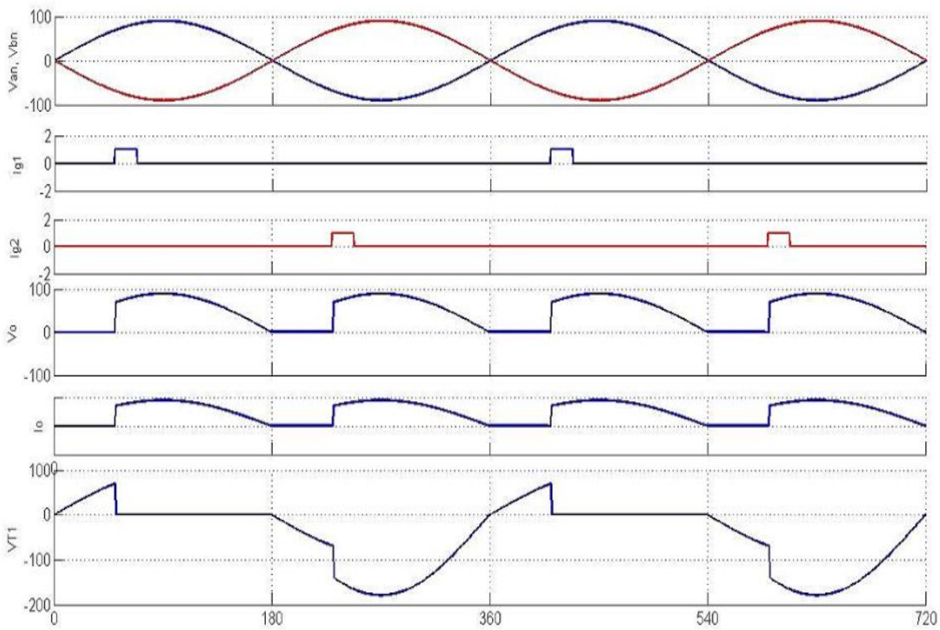


1 mark for circuit diagram

2)

2) During negative half cycle of AC supply, "b" is positive with respect to "a", this makes T_2 forward biased and T_1 is reverse biased. But since no triggering pulse is applied, both are in off state. When SCR T_2 is triggered at firing angle α+π, current flows through load from "b", T_2 and back to centre-tap "n" of the transformer. This current flow is continuous till angle 2π, when the supply voltage reverses the polarity and T_2 is turned off. The operation is as shown in waveforms.

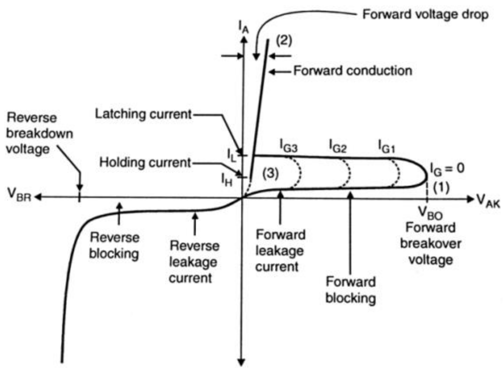
2 marks for explanation



1 mark for waveform

4 **Attempt any THREE of the following:** **12**

4 a) Draw a neat labelled I-V characteristics of SCR.
Define i)Latching current ii)holding current
Ans:
V-I characteristics of SCR:



V-I Characteristics of SCR

2 marks for I-V characteristics

1 mark for each correct definition

- **(i) Latching current:** It is the minimum anode current required to maintain the SCR in the conduction state just after turn-on and the gate signal has been removed.
- **(ii) Holding current:** It is the minimum anode current required to hold the conducting SCR in the ON state.

4 b) Differentiate between Natural and Forced commutation (any four).

Ans:

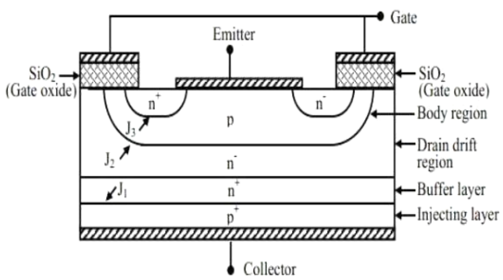
Sr. No.	Natural commutation	Forced commutation
1	Source is AC	Source is DC
2	External commutating componants are not required	External commutating componants are required
3	SCR turns off when its forward current goes below the holding current when the AC input changes	Conducting SCR turns off by applying a reverse voltage across it or a reverse current pulse is forced through conducting SCR
4	Cost of commutating circuit is less	Cost of commutating circuit is more
5	Used in controlled rectifiers, AC voltage controllers etc.	Used in choppers & inverters etc.

1 mark for each of any four points = 4 marks

4 c) Draw construction of IGBT. State any two applications of it.

Ans:

Construction & applications of IGBT



Construction of IGBT

2 marks for diagram

Applications of IGBT:

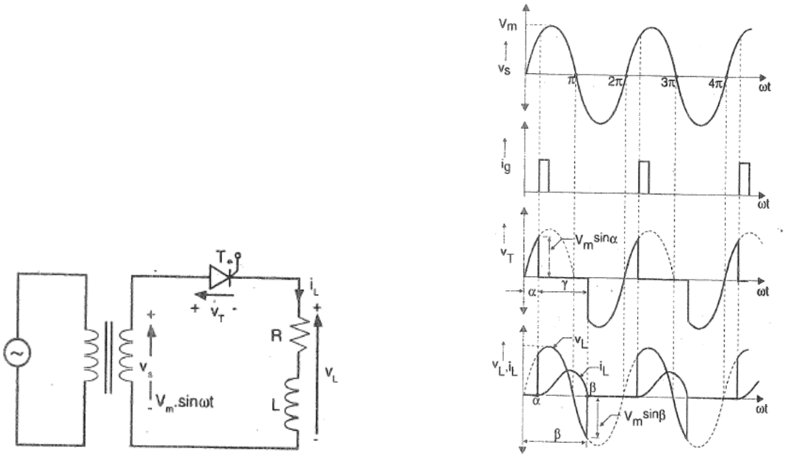
1) AC and DC motor drives
2) SMPS
3) Inverters
4) Choppers
5) Solid-state Relays
6) solid-state Contactors

2 marks for any 2 applications

4 d) Explain with circuit diagram the working of 1ϕ half wave controlled rectifier with R-L load

Ans:

<u>Single phase fully controlled half wave converter:</u>



(a) Circuit arrangement (b) Waveforms

1 mark for circuit diagram

1 mark for waveform

The circuit diagram of single-phase half-wave controlled rectifier with RL load and without freewheeling diode is shown in Fig. (a). The SCR T is forward biased only during positive half cycle whereas reverse biased during negative half cycle. Therefore, it is triggered in positive half cycles only. When the gate pulse is applied in positive half cycle with delay angle of α as shown in waveform diagram (b), the SCR conducts and starts to carry the load current. Since the load is inductive (RL), the current lags behind the voltage. The load inductance maintains the load current and keeps SCR on even if the supply voltage is reversed. Thus every positive half cycle of load voltage is followed by some negative voltage till the current drops to zero. The negative voltage appearing across load reduces the average load voltage. For some sensitive loads, the negative voltage is undesirable. In such cases freewheeling diode is used to prevent the negative voltage across the load. Thus the use of freewheeling diode helps to increase the average load voltage.

2 marks for explanation

Mode 1: (0 to α) (+ve half cycle)
SCR anode is positive w. r. t. cathode but gate pulse is not applied therefore SCR is in off state though it is forward biased. The load current is zero & load voltage is also zero.

Mode 2: (α to π) (+ve half cycle + gate signal is applied at α)
SCR is forward biased and gate signal is applied, therefore SCR turns on at α.

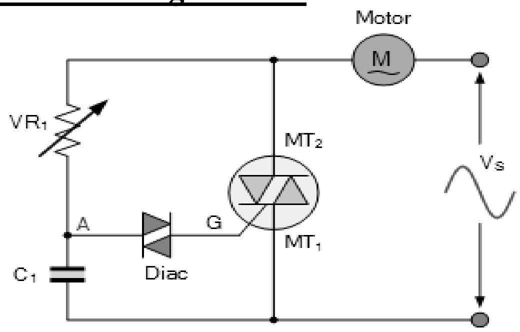
When SCR is triggered the load current will increase in a finite time through the inductive load. The supplied voltage from this instant appears across the load. Due to the inductive load the increase in current is gradual, energy is stored in inductor during α to π .

Mode3: **(**π to 2 π) (negative half cycle) During this part of negative half cycle, current continues to flow but falls and finally becomes zero when the energy stored in the inductance is dissipated in the load resistor and a part of the energy is feedback to the source, Hence due to energy stored in inductor, current continues to flow up to instant $\omega t = \beta$. Thus during interval from $\omega t = \pi$ to $\omega t = \beta$, the negative supply voltage appears across the load. When the load current becomes zero, due to negative supply voltage, the SCR is turnd off. At instant $\omega t = \pi + \alpha$, when again pulse is applied, the SCR is turned on & the above cycle is repeated.

4 e) Draw a suitable circuit to control the speed of the motor using TRIAC and also give its operation.

Ans:

Speed control of the motor using TRIAC:



2 marks for Circuit diagram

This basic phase triggering circuit uses the triac in series with the motor across an AC sinusoidal supply. The variable resistor, VR_1 is used to control the amount of phase shift on the gate of the triac, which in turn controls the amount of voltage applied to the motor by turning it ON at different instants during the AC cycle.

The triac's triggering voltage is derived from the $VR_1 - C_1$ combination via the **Diac** (The diac is a bidirectional semiconductor device that helps to provide a sharp trigger current pulse to fully turn-ON the triac).

At the start of each cycle, C_1 charges up via the variable resistor, VR_1. This continues until the voltage across C_1 is sufficient to trigger the diac into conduction which in turn allows capacitor, C_1 to discharge into the gate of the triac turning it "ON".

2 marks for explanation

Once the triac is triggered into conduction and saturates, it effectively shorts out the gate triggering phase control circuit connected in parallel across it. Therefore, there is no control over the conduction of triac for the remainder of the half-cycle. At the end of this half-cycle, the triac current falls to zero and triac is commutated naturally.

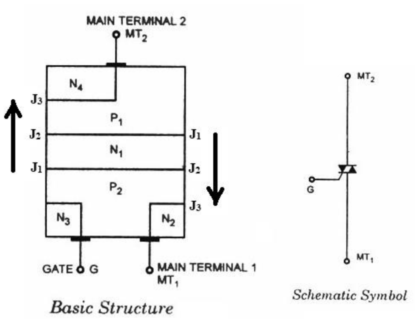
In the next half-cycle, the $VR_1 - C_1$ triggering process starts again. However, because the triac requires different amounts of gate current in each switching mode of operation, for example I+ and III–, a triac is therefore asymmetrical meaning that it may not trigger at the exact same point for each positive and negative half cycle.

5 Attempt any TWO of the following: **12**

5 a) Draw a structure of TRIAC with doping levels. Write operating principle and give applications of it.

Ans:

TRIAC Structure:



2 marks for structure

Operating Principle: A triac is a three terminal, five layer semiconductor device. It is equivalent to two separate SCRs connected in anti-parallel with gates common. It acts like a bidirectional switch i.e. it can conduct current in either direction regardless of polarities. It can be turned ON either with a positive or negative current pulse at the gate terminal. Once the triac is fired into conduction, the gate losses all control over the conduction and triac continues to conduct. It can be turned OFF by reducing the current to the value less than holding current.

With MT_2 terminal positive with respect to MT_1 terminal, the junctions J_1 and J_3 get forward biased but the junction J_2 get reverse biased. Due to this reverse biased junction J_2 the triac can not conduct. However, when the positive or negative gate current pulse is applied to gate, the carriers are injected at the reverse biased junction J_2. Due to this, the junction J_2 loses its identity as reverse biased junction, the carriers cross over the junction J_2 and the triac is turned on. The current then flows from MT_2 to MT_1, as shown in the figure.

With reversed polarities i.e MT_1 positive with respect to MT_2, the same phenomenon takes place when positive or negative gate current pulse is applied.

2 marks for principle

Applications:

i. A high power lamp switch.
ii. Electronics changeover of transformer taps.
iii. As light dimmers.
iv. Speed control for electric fans and other electric motors.
v. Heating control
vi. Zero voltage switched relay

Any two applications 1 mark each = 2 marks

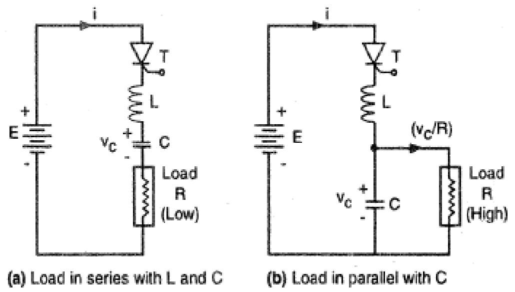
5 b) Draw the circuit diagram & waveforms of class A commutation. Explain its working.

Ans:

Class A: Load Commutation:

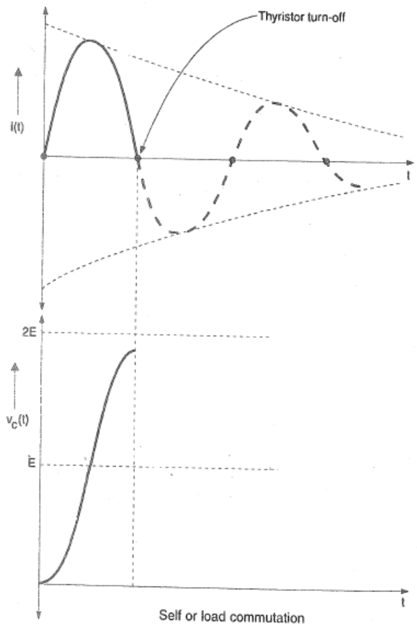
The class A or load commutation (also called self-commutation or resonant commutation) is employed in thyristor circuits supplied from DC source. The commutating components include inductor (L) and capacitor (C). The load resistance (R) and these commutating elements L and C are so chosen that there is a natural tendency for the load current that flows through the thyristor to become zero. When the load resistance (R) is very low, the elements L, C and R are connected in series. However, if load resistance (R) is high, then capacitor (C) is connected across it and then this parallel combination is connected in series with inductor (L) and thyristor as shown in the figure.

2 marks for explanation



(a) Load in series with L and C (b) Load in parallel with C

Class A - Load commutation



Self or load commutation

2 marks for diagram

2 marks for waveforms

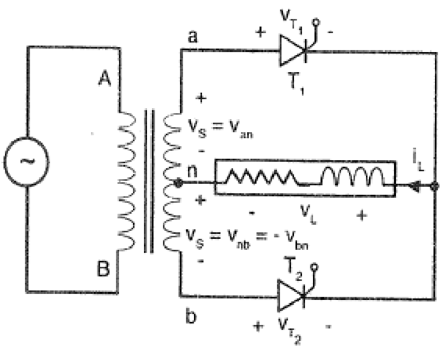
The load resistance R in series with L and C forms a series R-L-C circuit connected across DC source through the thyristor as shown. Initially the thyristor is off, hence entire supply voltage E appears across it and therefore it is forward biased. If a gate pulse is applied, the device can be turned on. Once turned on, it acts as short-circuit, thereby connecting series RLC circuit across DC source. When series RLC circuit (Load circuit) is underdamped, the current is oscillating having natural zero values even though the supply is DC voltage. Referring to waveform of current, when the thyristor is turned on at t = 0, the current starts to flow, then attains peak and finally falls to zero. During this, the capacitor voltage rises towards 2E. When current reaches to natural zero value, the capacitor voltage is higher than the supply voltage E and hence the thyristor gets reverse biased. Thus the zero-current and reverse-bias cause the thyristor to turn-off.

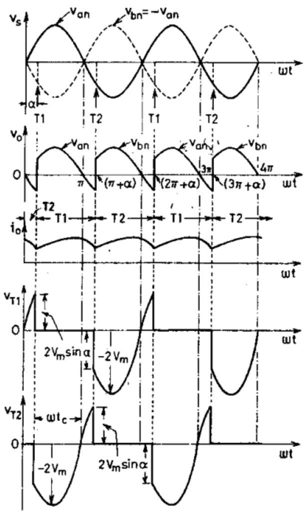
5 c) Draw & explain the working of 1ϕ mid-point controlled rectifier with RL load. Also draw input output waveforms of it.

Ans:

Circuit Diagram:

Single-phase mid-point controlled rectifier with RL load:





2 marks for circuit diagram

2 marks for waveforms

The circuit configuration of single-phase midpoint controlled rectifier is shown in the figure. During positive half-cycle of input supply voltage, terminal "a" is positive w.r.t. terminal "n" and "n" is positive w.r.t. terminal "b". Thyristor T_1 is therefore forward biased whereas the thyristor T_2 is reverse biased. Hence during positive half-cycle of input supply voltage, gate pulse is applied to T_1. When T_1 is fired, it acts as short-circuit and input voltage V_{an} appears across load. The thyristor T_1 conducts till its current falls to zero. Due to inductive load, current lags behind the voltage and falls to zero after reversal of voltage. Thus some part of next negative half-cycle of voltage can appear across load.

During negative half-cycle of input voltage, terminal "b" becomes positive w. r. t. terminal "n" and "n" becomes positive w.r.t. terminal "a". Thyristor T_1 is therefore reverse biased whereas the thyristor T_2 is forward biased. Hence during negative half-cycle of input supply voltage, gate pulse is applied to T_2. When T_2 is fired, it acts as short-circuit and input voltage V_{bn} appears across load. The thyristor T_2 conducts till its current falls to zero. Due to inductive load, current lags behind the voltage and falls to zero after reversal of voltage. Thus some part of next positive half-cycle of voltage with reversed polarity can appear across load.

2 marks for explanation

6 Attempt any TWO of the following: 12

6 a) Draw full bridge & half bridge configuration with common cathode.

Ans:

Half Bridge Configuration:

Model Answers
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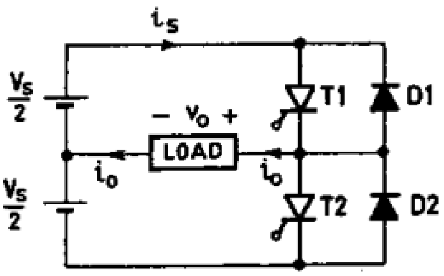
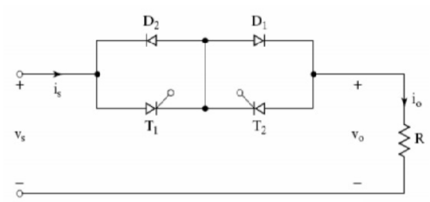
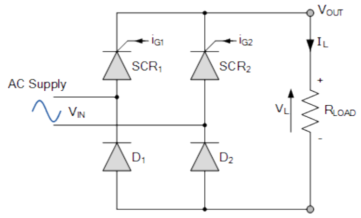




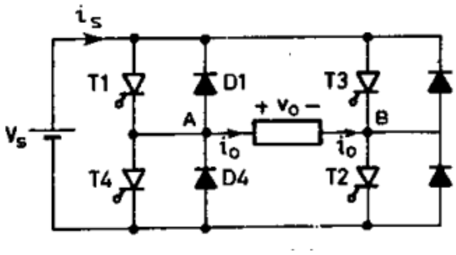
Half-bridge, Common-cathode configuration
AC voltage controller

OR

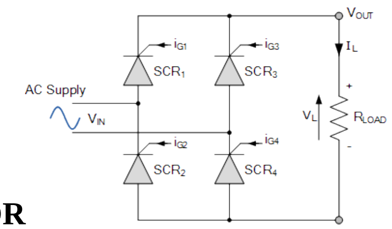
3 marks for each configuration



Full Bridge Configuration:



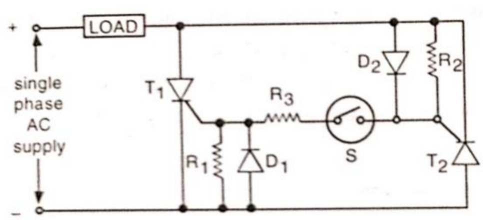
OR



6 b) Explain working of AC circuit breaker using SCR with circuit diagram.

Ans:

AC Circuit Breaker:



AC circuit breaker

3 marks for diagram

The circuit configuration of static AC circuit breaker using SCR is shown in the figure. When switch 'S' is closed, the SCRs T_1 and T_2 are fired in positive and negative half-cycles respectively. During positive half-cycle, T_1 receives gate current through D_2 || R_2, switch S and R_3 and it conducts. At the end of positive half-cycle, T_1 is turned off due to natural current zero. In the negative half-cycle, T_2 receives gate current through D_1 || R_1, R3andswitch S and it conducts. It is turned off at the end of this negative half cycle due to natural current zero value. When the load current is required to be interrupted, the switch S is opened. It results in blocking of gate currents of both SCRs and hence both SCRs are maintained off. When switch S is opened at any instant in a particular half-cycle, the load current continue to flow through conducting SCR till the end of this half-cycle, however in the next half-cycle the other SCR will not be fired due to non-availability of gate current. Thus the maximum time delay for

3 marks for description

Model Answers

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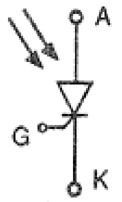
breaking the circuit is one half-cycle.

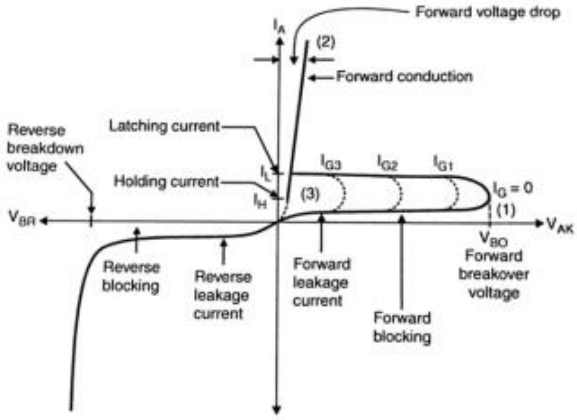
c) Draw symbol & V-I characteristics of
(i) LASCR (ii) DIAC (iii) TRIAC

Ans:

(i) LASCR:



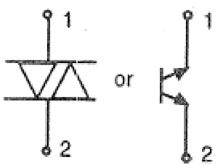
LASCR symbol



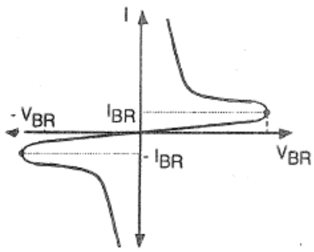
V-I Characteristics of SCR

1 mark for each symbol
1 mark for each V-I characteristic
= 6 marks

(ii) DIAC:

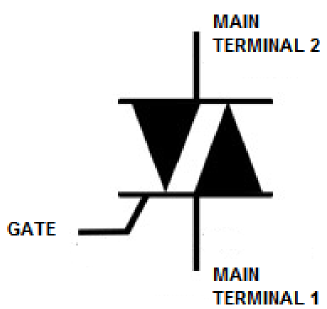


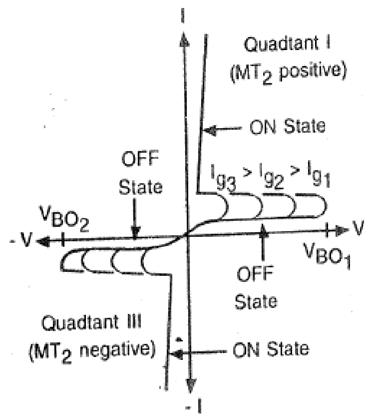
Symbol



V-I Characteristics of DIAC

(iii) TRIAC:





V-I Characteristics