EE6503 – POWER ELECTRONICS

2 Marks - Question Bank

Unit 1- INTRODUCTION

Two marks

1. What is power electronics?

Power electronics is a subject that concerns the applications electronics principles into situations that are rated at power level rather than signal level. It may be defined as a subject deals with the apparatus and equipment working on the principle of electronics but at rated power level.

2. Give the applications of power electronics.

- Aerospace
- Commercial
- Industrial
- Telecommunications

3. Classify power semiconductor devices give examples.

- Diodes: power diodes
- Thyristors: SCR
- Control switches: BJT, MOSFET and IGBT

4. Define latching current of SCR. [Nov/Dec 2012] May/June 2014

The latching current is defined as the minimum value of anode current which it must attain during turn on process to maintain conduction when gate signal is removed.

5. What are the factors that influence the turn-off time of thyristor? [Nov/Dec 2010]

1. Recovery Process 2. Recombination Process

6. **What are the parameters involved in switching loss of power device? [April/May 2011]**

- Forward conduction loss
- Loss due to leakage current during forward and reverse blocking
- Switching losses at turn-on and turn-off.
- Gate triggering loss.

7. What are the advantages of MOSFET?

- Lower switching losses.
- No Secondary breakdown.
- Switching frequency high.
- It has positive temperature coefficient for resistance.

8. Define the term pinch off voltage of MOSFET. [May/June 2012]

If the gate source voltage is made negative enough, the channel will be completely depleted, offering a high value of drain to source resistance and there will be no current flow from drain to source. The value of gate source voltage is called pinch off voltage.

9. **In TRIAC which of the modes the sensitivity of gate is high**.

The more sensitive of the triac is greatest in the first quadrant when turned on with positive gate current and also in the third quadrant when turned on with negative gate current.

10. What are the types of power transistors?

- Bipolar Junction Transistor (BJT)
- Metal Oxide Semiconductor Field Effect Transistor (MOSFET)

- Insulated Gate Bipolar Transistor (IGBT)

11. Why are IGBT becoming popular in their application to controlled converters? May/June2012

- Lower hate requirements
- Lower switching losses
- Smaller snubber circuit requirements

12. Power BJT is a current controlled device. Why?

Because the output (collector) current can be controlled by base current.

13. What are the different types of power MOSFET?

i)N-channel MOSFET ii)P-channel MOSFET

14. How can a thyristor turned off?

A thyristor can be turned off by making the current flowing through it to a level below the holding current.

15. Define holding current.

The holding current is defined as the minimum value of anode current below which it must fall to for turning off the thyristor.

16. What is the use of snubber circuit? [May/June 2013]

It consists of a series combination of a resistor and a capacitor in parallel with the thyristors. It is mainly used for dv / dt protection.

17. What losses occur in a thyristor during working conditions?

- Forward conduction losses
- Loss due to leakage current during forward and reverse blocking.
- Switching losses at turn-on and turn-off. Gate triggering loss.

18. Define circuit turn off time of SCR. [Nov/Dec 2011]

It is defined as the time during which a reverse voltage is applied across the thyristor during its commutation process.

19. Why circuit turn off time should be greater than the thyristor turn-off time?

Circuit turn off time should be greater than the thyristor turn-off time for reliable turn-off, otherwise the device may turn-on at an undesired instant, a process called commutation failure.

20. What is meant by commutation? (Nov/Dec 2014)

It is the process of changing the direction of current flow in a particular path of the circuit. This process is used in thyristors for turning it off.

21. What are the types of commutation?

a. Natural commutation
b. Forced commutation

22. What is the turn-off time for converter grade SCRs and inverter grade SCRs?

Turn-off time for converter grade SCRs is 50 – 100 ms turn-off time for converter grade SCRs and inverter grade SCRs and for inverter grade SCRs is 3 – 50 ms.

23. Define hard-driving or over-driving.

When gate current is several times higher than the minimum gate current required, a thyristors is said to be hard-fired or over-driven. Hard-firing of a thyristor reduces its turn-on time and enhances its di/dt capability.

24. Write down the applications of IGBT?

- AC and DC motor drives
- UPS systems
- Power supplies
- Relays and Contactors

25. What are the advantages of GTO over SCR?

a. Elimination of commutation of commutating components in forced commutation, resulting in reduction in cost, weight and volume.

b. Reduction in acoustic noise and electromagnetic noise due to elimination of commutation chokes.

c. Faster turn-off, permitting high switching frequencies.

d. Improved efficiency of the converters

26. What are the draw backs of GTO? [Nov/Dec 2012]

1. Magnitude of latching and holding currents is more.
2. On state voltage drop and the associated loss is more
3. Due to multi cathode structure of GTO, triggering gate current is higher than the required for a conventional thyristor.

27. What are the different methods to turn on the thyristor? [April/May 2011]

Forward voltage triggering, Gate triggering, dv/dt triggering, temperature triggering & light triggering

28. Define forward break over voltage.

When anode is positive w.r.to cathode with gate current open, the junction J1 & J3 are forward biased but J2 is reverse biased. When the forward voltage is increased junction J2 will have an avalanche breakdown at a voltage. This voltage is called forward break over voltage.

29. Define reverse break over voltage.

When cathode is positive w.r.to anode with gate current open, the junction J1 & J3 are reverse biased but J2 is forward biased. When the reverse voltage is increased junctions J1 & J3 will have an avalanche breakdown at a voltage. This voltage is called as critical breakdown voltage Vbr.

30. IGBT is a voltage controlled device. Why?

IGBT is a voltage controlled device because the controlling parameter is gate emitter voltage VGE

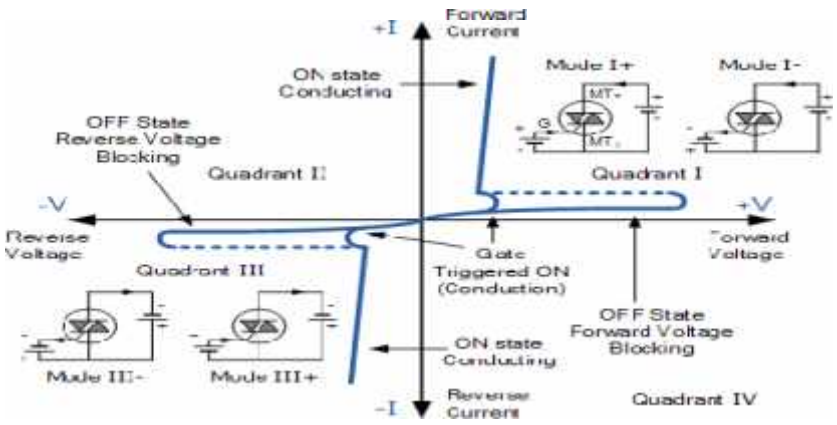
31. Power MOSFET is a voltage controlled device. Why?

Power MOSFET is a voltage controlled device because the output current can controlled by gate source voltage VGS.

32. What is meant by over drive factor?

It is defined as the ratio of IB & IBS ODF = IB / IBS

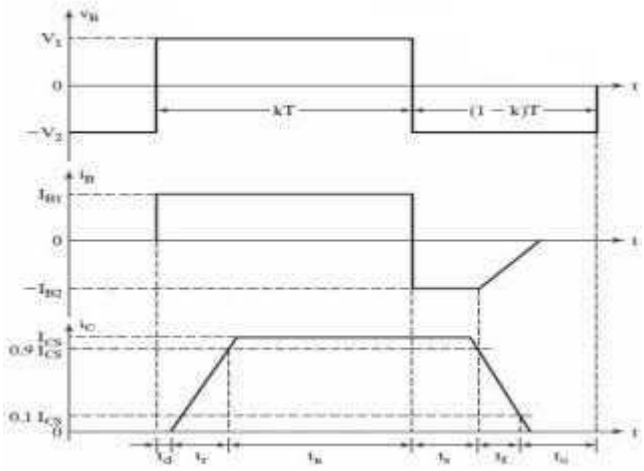
33. Draw the turn on characteristics of TRIAC and mark the t_d, t_r and t_{on}. [Nov/Dec 2010] [April/May 2015]



34. What is the limitation of high frequency operation of a power electronic device? May/June 2013

1. Higher Switching losses

35. Draw Switching Time characteristics of BJT? [April/May 2015]



36. Distinguish between SCR and TRIAC? (Nov/Dec 2014)

SCR is unidirectional device, gate current is positive, one VI characteristics

Triac is bidirectional device; gate current is positive or negative, two VI characteristics

37. Compare MOSFET and BJT? May/June 2014

MOSFET Voltage controlled device, unipolar device

BJT current controlled device, bipolar device

EE 6503 - Power Electronics

UNIT - 1 Introduction - Power Semiconductor Devices

(1) Describe the various types of commutation circuit for SCR

(1) line commutation (or) natural commutation

(2) Forced commutation

Natural commutation: If the source voltage is ac, the thyristor current passes through natural zero and reverse voltage will simultaneously appear on the thyristor. The thyristor is automatically turned off due to the natural behaviour of the input voltage. This commutation is known as Natural commutation.

↳ diagram & Explanation

Forced commutation:

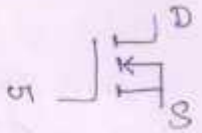
→ In case of dc circuits, for switching off thyristors, the forward current of the thyristor is forced to zero by an additional circuit called commutation circuit. This commutation is called forced commutation.

Types of forced commutation:

- capacitor commutation → diagram & explanation
- commutation by resonance → diagram & Explanation
- commutation by external source → diagram & explanation

② Explain the construction and switches characteristics of Power MOSFET.

→ A Power MOSFET is a voltage controlled device because the output current can be controlled by gate source voltage (V_{GS}). The Power MOSFET has three terminals called drain (D), source S and gate (G).



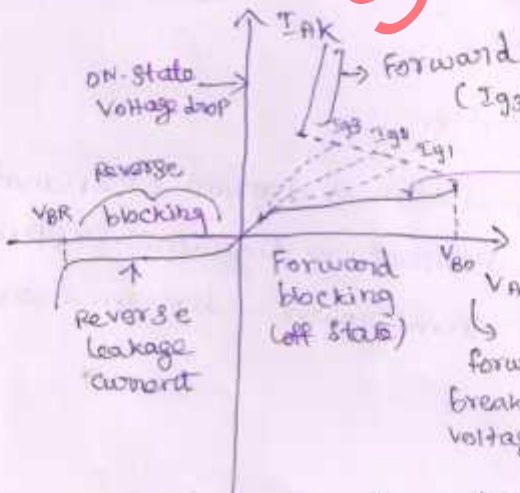
Types of Power MOSFET

1) Deplation MOSFET
2) Enhancement MOSFET

→ Construction of Power MOSFET - Diagram & Explanation
→ Switching characteristics of MOSFET Diagram & Explanation

③ Explain the various types of triggering methods of SCR.

→ There are three types of triggering methods



(i) Turn on
↳ Diagram & Explanation

(ii) Turn-off
↳ Natural & forced commutation

(1) Reverse blocking mode → diagram & Explanation
(2) Forward blocking mode → diagram & explanation
(3) Forward conduction mode → Explanation

(4) Discuss the circuit arrangements that are necessary for Proper operation of Parallel connected thyristors.

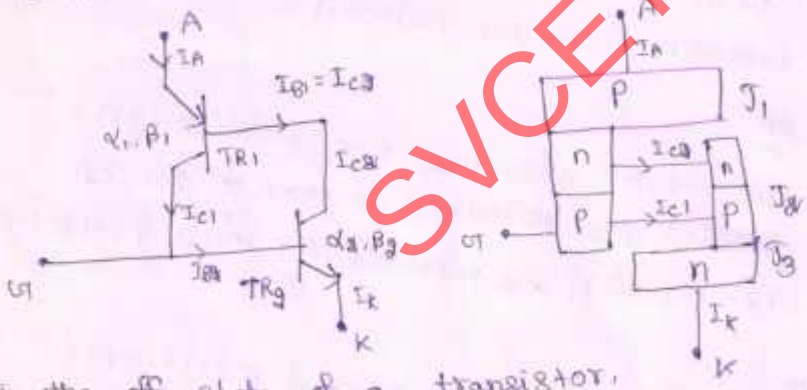
→ when SCRs are connected in parallel, the load current is not shared equally due to difference in their characteristics

→ If SCR carries more current than that of the others, its power dissipation increases, thereby increasing the junction temp and decreasing the internal resistance.

↳ Two SCRs connected in parallel for Static current Sharing → Diagram and Explanation

→ Two SCRs connected in parallel for Dynamic condition → Diagram and Explanation.

(5) Explain the operation of two transistor analogy?

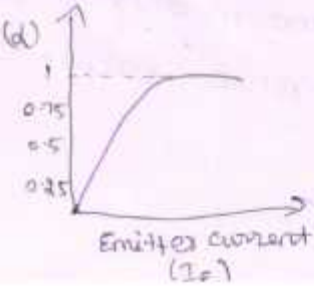


→ In the off-state of a transistor, collector current I_c is related to emitter current I_E

$I_c = \alpha I_E + I_{CBO}$. I_{CBO} - common base leakage current & collector base junction

$$I_a = \frac{\alpha_2 I_g + I_{CB01} + I_{CBO}(\alpha_1 + \alpha_2)}{1 - (\alpha_1 + \alpha_2)}$$

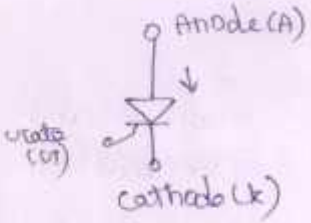
α - current gain.



(6) Explain the construction details of an SCR

→ SCR is a four layer device. It has three terminals Anode (A), cathode (K), Gate (G).

→ A small positive voltage between gate and cathode turns on the SCR.



Structure of SCR
- → Diagram
- → Explanation

Merits of SCR:

→ very small amount of gate drive is required since SCR is a regenerative device.

→ SCRs with high voltage & current ratings are available.

→ on-state losses in SCRs are reduced.

Demerits of SCR:

→ Gate has no control once the SCR is turned on

→ External circuits are required to turn off the SCR

→ Snubbers (RC circuits) are required for dv/dt protection.

Applications of SCR:

→ SCRs are best suitable for controlled rectifiers

→ AC regulators, lighting and heating applications

→ DC motor drives, large power supplies and Electronic circuit breakers.

(7) Describe the construction of TRIAC with aid of diagram and explain its characteristics.

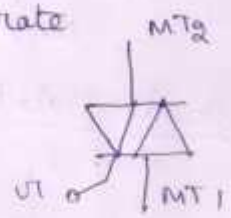
→ TRIAC is also called as "Bidirectional Triode thyristor"

→ Two thyristors may be connected in inverse-parallel, but at moderate power levels the two antiparallel thyristors can be integrated into a single device structure. This device is commonly name as TRIAC.

→ It has a three terminals, MT_1, MT_2 and gate

MT_1 → ref pt of measurement of voltage

MT_2 - currents & the gate terminal.



Structure of TRIAC → Diagram & Explanation

Characteristics of TRIAC → Diagram & Explanation.

Advantages of TRIAC:

→ TRIACs can be triggered with positive or negative polarity voltages.

→ A TRIAC needs a single fuse for protection, which also simplifies the construction.

→ A TRIAC needs a single heat sink of slightly larger size, where as antiparallel thyristor pair needs two heat sinks.

Disadvantages of TRIAC:

→ TRIAC have low dv/dt rating compared to SCRs.

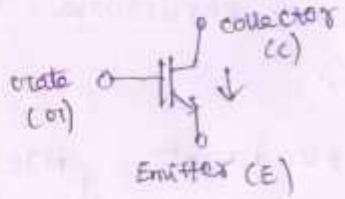
→ Since a TRIAC can be triggered in either direction, a trigger circuit with Triac needs careful consideration.

→ SCRs are available in larger rating compared to TRIAC.

(8) Explain the turn-on and turn-off characteristics of IGBT with neat waveforms.

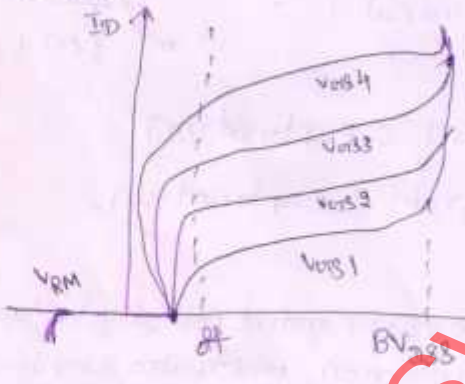
→ The insulated gate Bipolar transistor (IGBT).

→ The IGBT has three terminals : gate (G), collector (C) and Emitter (E), current flows from collector to emitter whenever a voltage between gate and Emitter is applied.



→ Structure of IGBT → Diagram & Explanation

Steady state (V-I) characteristics of IGBT



(9) Explain the switching performance of BJT with relevant waveforms indicating clearly the turn-on, turn-off times & their components.

→ Switching waveforms of BJT → Diagram and Explanation

Merits of BJT

→ BJTs have small turn-on and turn off times hence their switching frequency are higher.

→ BJTs have small turn-on losses.

Demerits of BJT

→ Drive circuit of BJT is complex

→ negative temp coefficient creates problems in Paralleling of BJT

(9) ~~What are the~~

(10) Briefly discuss the R-C triggering of SCR.

Rc firing circuit → Diagram and Explanation

Rc firing circuit → Diagram and Explanation
waveform