Chapter 9 Power Electronics and its applications

One mark questions (knowledge)

- 1. What is power electronics?
- 2. What is a power diode?
- 3. Name any one power semiconductor device.
- 4. Draw the circuit symbol of a power diode.
- 5. Name the lightly doped layer in power diode.
- 6. What is the magnitude of impurity atom density in drift layer?
- 7. What is the magnitude of impurity atom density in heavily doped regions?
- 8. What is the significance of drift region in power diode?
- 9. What is meant by 'double injection' in a power diode?
- 10.What is power BJT?
- 11.Expand PBJT.
- 12.Name the three terminals of a SCR.
- 13. What is the other name for SCR?
- 14. Write an expression for SCR anode current when gate current is zero.
- 15. Write an expression for SCR anode current when positive gate current is applied.
- 16. What is holding current in SCR?
- 17. What is latching current in SCR?
- 18.Expand MOSFET.
- 19.Name the terminals of MOSFET.
- 20.Expand IGBT.

One mark questions (understanding)

- 1. Which layer is called as 'drift layer' in power diode?
- 2. Which are the two heavily doped layers in power diode?
- 3. How do you designate heavily doped n layer?
- 4. Write an expression for the voltage drop across forward conducting power diode.
- 5. In which region of the power diode the conductivity modulation takes place?
- 6. Which region of the power transistor is lightly doped?
- 7. How many PN junctions are there in SCR?
- 8. How many regions are there in SCR?
- 9. Mention one application of TRIAC.
- 10. In what respect a TRIAC is better than SCR?
- 11. Which power semiconductor device is categorized as bidirectional current controlled?
- 12. Power MOSFET is a voltage controlled device. Why?
- 13. Mention one application of MOSFET.
- 14. Which semiconductor device combines the features of both MOSFET and BJT?
- 15. What is an IGBT?
- 16. IGBT is a voltage controlled device. Why?
- 17. Mention one application of IGBT.

One mark questions (skill)

- 1. Draw the circuit symbol of npn PBJT.
- 2. Draw the circuit symbol of pnp PBJT.
- 3. Draw the circuit symbol for SCR.
- 4. Draw the circuit symbol for TRIAC.
- 5. Draw the circuit symbol for n-channel enhancement type MOSFET.
- 6. Draw the circuit symbol for p-channel enhancement type MOSFET.
- 7. Draw the circuit symbol for n channel IGBT.

Two marks questions (knowledge)

- 1. What are the main areas of application of power electronics?
- 2. What is meant by conductivity modulation?
- 3. What is meant by double injection?
- 4. What is the significance of material designated p^+ and n^- in a power diode?
- 5. What is meant by a punch through p-n power diode?
- 6. What is meant by a non-punch through p-n power diode?
- 7. What are the conditions under which a transistor operates as a switch?
- 8. What is a Silicon Controlled Rectifier? Why is it so called?
- 9. What is TRIAC? How is different from a SCR?
- 10.Name some applications of TRIAC.
- 11. What is TRIAC? Give the circuit symbol of TRIAC.
- 12. Mention the four operating modes of TRIAC.
- 13. What is MOSFET? Explain its principle of operation.
- 14. What is MOSFET? What are the types of MOSFETs?
- 15. What are the different types of power MOSFET?
- 16.Name the different operating regions of MOSFET.

Two marks questions (understanding)

- 1. In what way a power diode is different from signal diode?
- 2. Derive an expression for the voltage drop across a forward biased p-n junction power diode.
- 3. List the applications of SCR.
- 4. Mention any two features of SCR.
- 5. Is it possible to turn ON the SCR with the gate open circuited? Explain.
- 6. Distinguish between holding current and latching current of a SCR.
- 7. Distinguish between SCR and TRIAC.

Two marks questions (skill)

- 1. Draw the cross sectional view of a typical pn junction power diode. Indicate typical dimensions and doping levels.
- 2. Draw the I-V characteristics of forward biased power diode.
- 3. Draw the circuit diagram of a power BJT in CE configuration.

- 4. Draw the equivalent circuit of two transistor analogy of a SCR.
- 5. Draw the V-I characteristics of SCR.
- 6. Sketch the typical V-I characteristics of an SCR. Indicate all the regions of the characteristics.
- 7. Draw the I-V characteristics for TRIAC.
- 8. Sketch the output characteristics of MOSFET.
- 9. Draw the circuit diagram of MOSFET to plot its output characteristics.
- 10.Draw the circuit symbol of IGBT and name its terminals.
- 11.Draw the circuit diagram of n channel IGBT to plot its output characteristics.

Three marks questions (knowledge)

- 1. What is meant by a punch through pn power diode? Draw the diagram giving electric field profile of this diode.
- 2. What is meant by a non-punch through pn power diode? Draw the diagram giving electric field profile of this diode.
- 3. What are the regions of operation of a power BJT? In which regions the BJT operates while acting as a switch?
- 4. Explain the construction of SCR. Give its circuit symbol.
- 5. What is meant by triggering of SCR? Describe the method to trigger an SCR.
- 6. List the modes of operation of TRIAC and mention the preferred modes.

Three marks questions (understanding)

- 1. With a diagram explain constructional features of a power BJT.
- 2. With a diagram explain P+ n– junction under thermal equilibrium.
- 3. Distinguish between punch through and non-punch through power diodes?
- 4. Explain the construction of SCR. Give its circuit symbol.
- 5. Compare TRIAC with SCR.

Three marks questions (skill)

- 1. What are the regions of operation of a power BJT? In which regions the BJT operates while acting as a switch?
- 2. Sketch I-V characteristics of SCR for different gate currents and indicate there upon holding current, latching current and break over voltage.

Five mark questions (knowledge)

- 1. What is a power diode? In what way a power diode is different from signal diode? With a diagram explain constructional features of a power BJT.
- 2. What is SCR? Draw the equivalent circuit of two transistor analogy of a SCR. Define latching current and how it is different from holding current?

Five mark questions (understanding)

- 1. Explain with a circuit diagram working of power diode under forward bias. What is meant by conductivity modulation?
- 2. Draw the circuit diagram of a power BJT in CE configuration to draw output characteristics. Explain different operating regions of BJT.
- 3. What is SCR? Explain its construction. Distinguish between holding current and latching current of a SCR.
- 4. With a circuit diagram explain the two transistor model of SCR. Derive an equation for anode current for zero gate current.
- 5. Draw the circuit diagram of IGBT to draw output characteristics. Explain different operating regions of V-I characteristics.

Five mark questions (skill)

- Draw the structure of a power diode showing impurity atom and densities. What is the significance of material designated p⁺, n⁻? Draw the diagram giving electric field profile of punch through pn junction diode.
- 2. Draw the circuit diagram of IGBT to draw output characteristics. Sketch different operating regions of V-I characteristics. Mention one application of IGBT.

Problems:

- A silicon diode has a saturation current of 0.1X10⁻¹²A at 20° C. Find its current when it is forward biased by 0.55V. (Ans: 0.283mA)
- For silicon diode with reverse saturation current of 2.5μA at 300K, find the forward voltage at a forward current of 10mA. (Ans: 0.43V)
- 3. A p-n junction diode has a reverse saturation current rating of 100 nA at 50°C. What should be the value of the forward current for a forward voltage drop of 0.6 V? (Ans:223.72A)
- 4. Determine cathode current I_K of SCR when $I_G = 0$. Given $(\alpha_1 + \alpha_2) = 0.99$ and $(I_{CO1} + I_{CO2}) = 3$ mA.

(Ans: 0.3A)

5. Determine anode current I_A of SCR when gate current I_G =50mA, α_1 = 0.495, α_2 = 0.495 and I_{CO1} = 1 mA and I_{CO2} = 1 mA. (Ans: 2.675A)

APPLICATIONS OF POWER ELECTRONICS

One mark questions (knowledge)

- 1. What is meant by uncontrolled rectifier?
- 2. What is meant by phase controlled rectifier?
- 3. Give an expression for average voltage of single phase half wave rectifier.
- 4. Give an expression for average voltage of single phase full wave rectifier.
- 5. Name the device used in phase controlled rectifier.
- 6. Define the conduction angle for a SCR.
- 7. Define the firing angle for a SCR.
- 8. What does ac voltage controller mean?
- 9. Name the converter which converts AC to unipolar DC current.
- 10.What is a DC chopper?
- 11.Define duty cycle.
- 12. Mention an application of DC to AC converter.

- 13. What is an inverter related to power electronics?
- 14. Mention the use of pulse transformer isolator circuit.
- 15.What is opto-coupler?
- 16. What is pulse transformer?
- 17. Mention the use of Opto-coupler isolator circuit.
- 18. What is snubber circuit?
- 19. Mention how power devices can be protected from excessive temperature.

One mark questions (Understanding)

- 1. How can you control the output voltage of a rectifier?
- 2. Which power semiconducting device is used in the construction of single phase AC voltage controller?
- 3. Write an expression for the average voltage of a DC chopper.
- 4. Why the protection is required for SCR?
- 5. Why snubber circuits are used?

One mark questions (skill)

- 1. Draw the symbol of rectifier.
- 2. Draw the symbol of AC voltage controller.
- 3. Draw the symbol of DC chopper.
- 4. Draw the symbol of Inverter.

Two marks questions (knowledge)

- 1. Name the types of power converters and draw their symbol.
- 2. Define firing angle and conduction angle of SCR.
- 3. Mention some of the applications of phase controlled rectifiers.
- 4. What is a chopper? Name some applications.
- 5. What is an inverter? How does it differ from a converter?
- 6. Name any two types of isolator circuit.

Two marks questions (understanding)

- 1. Why the power semiconductor devices are used in power controls?
- 2. What is the difference between half-wave controlled rectifier and full-wave controlled rectifier?
- 3. In a DC chopper how can the output voltage be varied?

Two marks questions (skill)

- 1. Draw the circuit of pulse transformer isolator to drive SCR.
- 2. Draw the schematic diagram of IGBT based single phase inverter.
- 3. Draw the circuit of Opto-coupler isolator.

Three mark questions (Knowledge)

- 1. What is a chopper? Mention any two applications of choppers.
- 2. What is an inverter? Name any two types of isolator circuit.

Three mark questions (understanding)

- 1. With circuit diagram explain the working of Opto-coupler isolator circuit.
- 2. With circuit diagram explain the working of pulse transformer isolator circuit to drive SCR.

Three mark questions (skill)

- 1. Draw the circuit diagram of single phase SCR half wave rectifier with RC triggering. Sketch its input and output waveform.
- 2. Draw the circuit diagram of single phase SCR full wave rectifier with RC triggering. Sketch its input and output waveform.
- 3. Draw the circuit diagram of TRIAC AC voltage controller with RC triggering. Sketch its input and output waveform.
- 4. Draw the circuit diagram of DC to DC chopper. Sketch input and output waveform.
- 5. Draw the schematic diagram of IGBT based single phase inverter and output waveforms

Five mark questions (understanding)

- 1. With circuit diagram explain the working of single phase SCR half wave rectifier with RC triggering.
- 2. With circuit diagram explain the working of single phase SCR full wave rectifier with RC triggering.
- 3. With circuit diagram explain the working of TRIAC AC voltage controller with RC triggering.
- 4. With circuit diagram explain the working of DC to DC chopper. Sketch input and output waveform.

Five mark questions (skill)

- 1. Draw the circuit diagram of single phase SCR full wave rectifier with RC triggering. Sketch its input and output waveform. Draw the circuit of pulse transformer isolator to drive SCR.
- 4. Draw the schematic diagram of IGBT based single phase inverter and output waveforms. Draw the circuit of pulse transformer isolator to drive SCR.

Problems:

 A thyristor is connected in series with a load resistance 50 Ω. The supply voltage is 230 V, 50 Hz. The thyristor is triggered at an angle of 30° during every positive half cycle. Compute the (a) average value of load voltage and (b) average value of load current.

(Ans: 96.60 V,1.93A)

2. A transformer with secondary voltage of 230V, 50Hz, delivers power to 10 Ω load through a half wave controlled rectifier circuit. Determine (i) average output voltage (ii) average load current.

(Ans: 77.64 V, 7.764 A)

3. A half wave rectifier feeds a 15 ohm resistance. The supply voltage is 230 V. The firing angle is ☑/2. Find
(a) average value of load voltage and (b) average value of load current (c) power delivered to the load.

(Ans: 51.76 V, 3.45 A, 178.57W)

4. A single phase half wave rectifier circuit using a thyristor is fed by a transformer whose secondary voltage is 400 sinωt. Find the average load voltage and average load current if the thyristor is fired at 30° in each positive half cycle.

(Ans: 118.8 V,2.376 A)

5. A single phase full controlled converter is supplied from a 230V, 50Hz ac supply for a firing angle of 30°, determine the average load voltage consider load as purely resistive.

(Ans: 193.20V)

6. A single phase full wave rectifier has an input voltage of 200 V rms. The load resistance is 100 Ω and firing angle is 30°. Find average load voltage and average load current.

(Ans: 167.98 V,1.68 A)

7. A full wave controlled rectifier rectifies 230 V, 50Hz a.c mains and give an output of 150V to a resistive load of 10 Ω . Find the firing angle.

(Ans: 63.33°)

8. A basic chopper is supplied from a 220V dc source. The load is pure resistance. If the duration of the ON and OFF time are 0.3 ms and 0.5 ms respectively, determine average load voltage.

(Ans: 82.5 V)

9. For a basic feeding a resistive load, the average load voltage is 132V and the input voltage is 220V. If the time for which the semiconductor ON is 0.24 ms, find the OFF period.

(Ans: 0.16ms)