Total No. of Questions :12] [Total No. of Pages : 4

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B.E. (Electronics)
ADVANCED POWER ELECTRONICS
(2003 Course)

Time : 3 Hours] *[Max. Marks : 100*

Instructions to the candidates:

1) *Answer Q1 or Q2, Q3 or Q4, Q5 or Q6 from section I and Q7 or Q8, Q9 or Q10, Q11 or Q12 from section II.*
2) *Answers to the two sections should be written in separate books.*
3) *Neat diagrams must be drawn wherever necessary.*
4) *Figures to the right indicate full marks.*
5) *Use of logarithmic tables, slide rule, Mollier charts, electronic pocket calculator and steam tables is allowed.*
6) *Assume suitable data, if necessary.*

SECTION - I

Q1) a) Draw the circuit diagram of a three-phase semi-converter feeding a highly inductive (level) active load and the following waveforms for firing angle $\alpha = 60^{\circ}$:

i) Supply phase voltages.

ii) Supply line voltages.

iii) Output voltage.

iv) Phase A line current. [8]

b) A three-phase semi-converter operates from the 415V, 50Hz mains and feeds a highly inductive (level) active load having $R = 20\Omega$. If the firing angle is 60°, calculate: [10]

i) Average (DC) load voltage.

ii) Average (DC) load current.

iii) RMS line current.

OR

Q2) a) With the help of a neat circuit diagram and relevant waveforms, explain the operation of a three-phase circulating-current type dual converter. Derive an expression for the peak circulating current in terms of the firing angle. **[10]**

b) A series-parallel bank of thyristors consists of 5 parallel strings, with each string containing 6 thyristors in series. The rating of all thyristors is identical with a voltage rating of 1600V and current rating of 1000A. During testing it was found that the maximum voltage withstand capability and maximum current carrying capacity of the bank was 8 KV and 4 KA, respectively. Calculate the series-string efficiency and parallel-string efficiency. **[8]**

Q3) a) With the help of a neat circuit diagram, relevant waveforms and mode equivalent circuits, explain the operation of a three-phase, 120° mode, voltage source inverter feeding a balanced, star-connected resistive load. Also derive an expression for the RMS phase output voltage and RMS SCR current. **[10]**

b) The above inverter operates from a 400V DC supply and feeds a balanced, star-connected resistive load of 25Ω per-phase. Calculate

i) RMS phase output voltage.

ii) RMS phase current.

iii) RMS SCR current. **[6]**

OR

Q4) a) What are the different output voltage control and harmonic reduction techniques in inverters? Explain any one technique in detail. **[10]**

b) Cross-conduction ('shoot-through') faults are likely to occur in a 180° mode three-phase VSI but unlikely when the same inverter is operated in 120° mode. Justify.

How would you modify the gate pulse waveforms of a 180° mode three-phase VSI so as to eliminate cross-conduction? **[6]**

Q5) a) With the help of a neat circuit diagram and relevant waveforms, explain the Symmetrical Angle Control (SAC) technique for power factor improvement in AC-DC converters. **[8]**

b) Explain how the following parameters are sensed in power electronic circuits: [8]

i) DC current.

ii) AC current.

OR

Q6) a) With the help of a power circuit diagram, control circuit block diagram and waveforms, explain the operation of a single-phase active wave-shaping circuit for power factor improvement. [10]

b) Compare ZVS & ZCS converters. [6]

SECTION - II

Q7) a) Compare servomotors with conventional DC motors and stepper motors. [8]

b) With the help of a neat circuit diagram and relevant waveforms, explain the operation of an unipolar-voltage chopper drive for PM & hybrid stepper motors. [10]

OR

Q8) a) With the help of a neat circuit diagram and relevant waveforms, explain the operation of a three-phase LCC based separately excited DC drive having a full converter in the armature circuit and a semi-converter in the field circuit. Also derive an expression for the motor speed in terms of armature converter firing angle, field converter firing angle, motor torque and supply voltage. [10]

b) A 400V, 1500rpm, 15A separately excited DC motor with $R_a = 0.2\Omega$, $R_f = 225\Omega$, $K_v = 3.97/\pi$ V/A-rad/sec, is fed from a three-phase full converter operating from the 415V, 50Hz mains. The field circuit is fed from a three-phase semi-converter. Speed variation below base speed is obtained by armature voltage control with the field converter set at $V_f = 450V$, whereas speed variation above base speed is obtained by field voltage control with the armature converter set at $V_a = 450V$. Calculate.

i) The armature converter firing angle for a motor speed of 900rpm if the motor torque is 30N/m.

ii) The field converter firing angle for a motor speed of 1800rpm if the motor current is 10A. [8]

Q9) a) With the help of a neat circuit diagram and appropriate torque-speed curves, explain the slip power recovery scheme for speed control of induction motors in both sub-synchronous and super-synchronous speed regions. **[8]**

b) Explain the operation of a three-phase brushless DC motor drive with the help of a neat circuit diagram and relevant waveforms. **[8]**

OR

Q10) a) Explain the operation (any two) of the following motor protections:

i) Field failure in DC motors.

ii) Soft start for DC motors.

iii) Phase failure for three-phase AC motors. **[8]**

b) A 6 pole, 380V, 60Hz, three-phase induction motor has a rated speed of 1160rpm. Calculate its speed, slip and slip frequency during electromagnetic braking under constant V/f control for a stator frequency of 45Hz, the braking torque (-ve) being equal to 75% of rated motor torque. **[8]**

Q11) a) What is meant by supply voltage waveform distortion in a power system? What are the causes and effects of harmonics and inter-harmonics in the power system? **[8]**

b) What are the different types of voltage transients present in a power system? List the mitigation techniques for these voltage transients. **[8]**

OR

Q12) a) Explain the terms 'Voltage sag (dip)' and 'Voltage swell (rise)'. What are the different sources / causes of voltage sags and swells? **[8]**

b) Explain how an Energy Audit helps in controlling energy losses in a typical production plant. **[8]**