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Question Paper Code : 91003

B.E./B.Tech. DEGREE EXAMINATIONS, APRIL/MAY 2025.

Fifth/Sixth/Seventh Semester

Electrical and Electronics Engineering

EE 3012 — ELECTRICAL DRIVES

(Regulations 2021)

Time : Three hours | Maximum : 100 marks

Answer ALL questions.

PART A — (10 × 2 = 20 marks)

1. Write is steady state stability in an electric drive system? Define the condition for steady state stability.

2. Write the differential equation governing the motion of a motor-load system. Signify its importance.

3. A chopper-fed DC motor operates with 60% duty cycle and input voltage of 100 V. What is the average armature voltage?

4. A single-phase full converter operates at 230 V AC with a firing angle of 60° feeding a resistive load. Calculate the average output voltage.

5. An induction motor is designed to operate at 400 V and 50 Hz. What should be the voltage applied to the motor if the frequency is reduced to 25 Hz, assuming constant V/f control?

6. Draw the speed-torque characteristics of an induction motor drive operated under the stator voltage control method of speed control.

7. What is meant by self-control of a synchronous motor?

8. A 6-pole Permanent Magnet Synchronous Motor rotates at 1000 rpm. Find the electrical frequency of the stator.

9. A separately excited DC motor has an armature resistance $R_a = 1\ \Omega$, armature inductance $L_a = 0.5$ H, back EMF constant $K_e = 0.1$ V/rad/s, and torque constant $K_t = 0.1$ Nm/A. Calculate the electrical time constant of the armature circuit.

10. A current controller for a DC motor has a proportional gain $K_p = 10$ and integral gain $K_i = 100$. Write the transfer function $G_c(S)$ of the PI controller.

PART B — (5 × 13 = 65 marks)

11. (a) With speed-torque sign conventions, explain the multi-quadrant dynamics of an electric drive system by considering the following modes of operation

(i) acceleration (4)

(ii) deceleration (3)

(iii) starting (3)

(iv) stopping (3)

Or

(b) Classify the selection of motor based on drive duty cycles and explain the same. Signify the importance of heating and cooling curves in the selection of motor.

12. (a) With power schematics and waveforms, explain the working principle of 4-quadrant chopper fed separately excited DC motor drive. Draw the speed-torque characteristics of the drive system and infer the same.

Or

(b) A 230 V, 960 rpm and 200 A separately excited DC motor has an armature resistance of 0.02 Ω. The motor is fed from a chopper which provides both motoring and braking operations. The source has a voltage of 230 V. Assuming continuous conduction,

(i) Calculate duty ratio of chopper for motoring operation at rated torque and 350 rpm. (4)

(ii) Calculate duty ratio of chopper for braking operation at rated torque and 350 rpm. (4)

(iii) If maximum duty ratio of chopper is limited to 0.95 and maximum permissible. Motor current is twice the rated, calculate maximum permissible motor speed obtainable without field weakening and power fed to the source. (5)

13. (a) Discuss in detail about the significance of V/f control in induction motor drives. Illustrate the V/f control strategy using appropriate block diagram and waveforms and explain the speed-torque characteristics of the system, highlighting the key inferences.

Or

(b) Draw a speed control and torque control loops necessary in the closed loop control of electric drives. Explain the key features to be considered in the design of these loops.

14. (a) With relevant block diagram and waveforms, explain the concept of margin angle control of synchronous motor drives. Hence, list the key benefits of margin angle control.

Or

(b) Discuss how the choice of permanent magnet material affects the power and torque density of Permanent Magnet Synchronous Motors (PMSM). Hence, describe the possible rotor configuration of PMSMs.

15. (a) Discuss the performance metrics to be considered in the design of current controller and describe the methodology to derive the gain of the current controller.

Or

(b) Explain the design procedure of a speed controller for a DC motor drive and the key considerations in tuning the controller parameters. Also, discuss how load disturbances affect the motor speed arid the controller mitigates these effects.

PART C — ($1 \times 15 = 15$ marks)

16. (a) From the fundamentals, derive the transfer function of DC motor with load and converter for the required closed loop control With current and speed feedback. Hence, describe the system model under the armature voltage control and field weakening mode of operations.

Or

(b) A 3-phase, 415 V, 50 Hz supply is used to feed a separately excited DC motor through a controlled converter. The motor requires a rated voltage of 220 V and rated current of 30 A.

(i) Select a suitable type of converter for speed control and justify your choice considering the motor requirements. (3)

(ii) For the selected converter, calculate the average output voltage when the firing angle $\alpha = 30°$. (3)

(iii) Explain the effect of varying the firing angle on the output voltage, power factor, and the operating mode of the converter. (4)

(iv) Discuss the key characteristics of the selected converter and how they influence motor performance. (5)