232004

COMBINED COMPETITIVE EXAMINATION (MAIN)

ELECTRICAL ENGINEERING

Paper–II

Time : 3 Hours *Full Marks* : 200

Note : *(1) The figures in the right-hand margin indicate full marks for the questions.*

*(2) Attempt **five** questions in all.*

(3) Question No. **1** *is compulsory.*

1. Answer any ***ten*** questions from the following : 4×10=40

(a) List the elements of closed-loop control system.

(b) For the unit step input $r(t) = 1,\ t \geq 0$, the steady state response of a unity feedback system with open-loop transfer function

$$G(s) = \frac{K}{(s+1)(s+2)}$$ is 0.75.

Find the value of K.

(c) For a first order system, find out the output of the system when the input applied to the system is a unit ramp.

(d) Differentiate between the operation of a controlled rectifier with resistance load and *R-L* load.

(e) Name the quadrants of operation of full converter, dual converter and semiconverter.

(f) What are the characteristics of the load in a series inverter? What should be the condition of such series circuit load?

(g) What is chopper? Describe the principle of operation of a chopper.

(h) With the help of a block diagram, explain briefly an electromechanical energy conversion device.

(i) Write four differences between transformer and 3-phase induction motor.

(j) Why is rotating field system preferred over the stationary field system in synchronous genereator? Name the two types of synchronous generators depending on the rotor construction.

(k) Explain how arc is initiated and sustained in a circuit breaker when the circuit breaker contacts separate.

(l) A lighting stroke discharges impulse current of 12 kA (peak) on a 400-kV transmission line having surge impedance of 200 Ω. Assuming equal distribution of charge from the point of lighting stroke, find the magnitude of transient over-voltage travelling waves in either direction.

2. Answer any ***eight*** questions from the following : 5×8=40

(a) A mass spring system under equilibrium condition is shown in the figure. Assuming frictionless wheels derive the system equation.

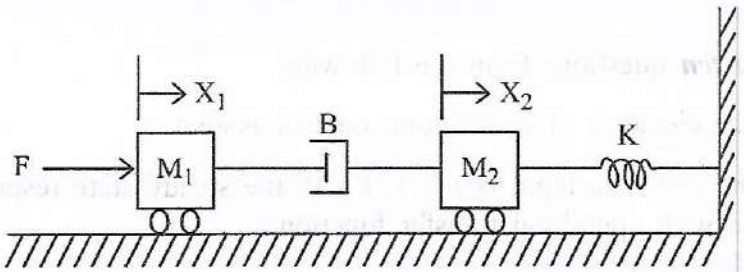

Fig. 1

(b) Distinguish between induction heating and dielectric heating.

(c) Write the relative merits and demerits of single-cage and double-cage 3-phase induction motors.

(d) Explain the synchronous impedance method of finding the voltage regulation of a three-phase alternator.

(e) What is phase fault compensation as applied to distance protection? Why is it necessary and how can it be achieved?

(f) How is a pumped storage plant different from a conventional hydroelectric plant? How do pumped storage hydro plants work?

(g) Explain the procedure of forming Routh array. How are stability conclusions drawn from it?

(h) A bridge-connected rectifier used in high voltage d.c. transmission system operates with delay angle 30° and commutation angle 15°. Determine the secondary line voltage of the rectifier transformer rated at 220 kV/110 kV to obtain d.c. output voltage of 100 kV.

(i) Explain the principle of operation of stepper motor. What are their applications?

(j) The open loop-transfer function of a unity feedback system is given by

$$G(s) = \frac{50}{(1+0.1s)(s+10)}$$

Determine the static error coefficients.

3. Answer any ***five*** questions from the following : 8×5=40

(a) What is a single flow graph? Draw the single flow graph for the following equations :

$$x_2 + 5x_3 - 2x_1 = 0$$

$$x_3 + 2x_4 - 4x_2 = 0$$

$$x_4 - 8x_3 = 0$$

(b) Sketch the polar plots of the following :

(i) $G(s) = \frac{1}{s+1}$

(ii) $G(s) = \frac{1}{s^2}$

(c) Explain various voltage and current ratings of a thyristor.

(d) Draw the circuit of a shunt regulator and explain the functions of different components.

(e) Explain the pole-changing technique adopted for the speed control of 3-phase induction motor. Also draw the torque-speed characteristics obtained by pole changing technique.

(f) Classify various types of overcurrent relay and give their applications along with approximate characteristics.

(g) Compare the performance and characteristics of air blast circuit breaker and bulk oil circuit breaker.

4. Answer any ***four*** questions from the following : 10×4=40

(a) A 3-phase, 10-kW, 400-volts, 4-pole, 50-Hz, star-connected induction motor draws 20 amp on full load. Its no load and blocked rotor test data are given below :

No Load Test	1002 W	400 V	6 amp
Blocked Rotor Test	762 W	90 V	15 amp

Neglecting copper loss in no load test and core loss in blocked rotor test, determine the full load efficiency of the motor.

(b) A unity feedback control system is characterized by open-loop transfer function

$$G(s) = \frac{K(s+1)}{s(1+Ts)(1+2s)} \; ; \; K, \; T > 0$$

Show that the closed-loop system will be stable, if

$$0 < K < \frac{T+2}{T-2}$$

(c) A string of suspension insulators consists of 6 units. If the maximum peak voltage per unit is 33 kV, calculate *(i)* the maximum voltage for which this string can be used and *(ii)* the string efficiency. Assume capacitance between each link pin and earth as 15 percent of the self-capacitance of each unit.

(d) With a neat circuit diagram, explain the working of chopper control separately excited d.c. motor drive operated in regenerative braking mode.

(e) Explain the operation and working of amplidyne. Give two applications of amplidyne.

5. Answer any ***two*** questions from the following : 20×2=40

(a) Obtain the state space representation of the following transfer function :

$$\frac{C(s)}{R(s)} = \frac{s+6}{s^2+5s+6}$$

(b) A 20-MVA, 11-kV star-connected alternator has positive, negative and zero phase sequence reactances of 25%, 35% and 10% respectively. The neutral is earthed through reactance of 8%. When the alternator is unloaded, a short circuit occurs between the two lines. Calculate the fault currents in all the phases and the line voltages. Assume that the fault point is not grounded.

(c) Describe various methods used for enhancing the power transmission in a long EHV transmission line. Which one is the most perferred method? Give reason.

6. Answer any ***four*** questions from the following : 10×4=40

(a) The A, B, C, D constants of a 220-kV line are

$$A = D = 0.94 < 1°$$

$$B = 130 < 73°$$

$$C = 0.001 < 90°$$

If the sending end voltage of the line for a given load delivered at nominal voltage is 240 kV, find the percentage voltage regulation of the line.

(b) The open-loop transfer function with unity feedback system is given by

$$G(s) = \frac{25}{s(s+1)(s+10)}$$

Determine analytically the phase margin and gain margin.

(c) Write the advantages of nuclear power station. State the factors affecting the site selection of nuclear power plants.

(d) Draw the circuit arrangements for a dual converter and explain its operation.

(e) Draw the phasor diagram of a synchronous motor. Also derive an expression for power developed in a synchronous motor.

7. Answer any ***two*** questions from the following : 20×2=40

(a) In a power system, the fuel inputs per hour of plants 1 and 2 are given as

$$F_1 = 0.20\ P_1^2 + 30P_1 + 100 \text{ Rs per hour}$$

$$F_2 = 0.25\ P_2^2 + 40P_2 + 150 \text{ Rs per hour}$$

The limits of generators are

$$20 \le P_1 \le 80 \text{ MW}$$

$$40 \le P_2 \le 200 \text{ MW}$$

Find the economic operating schedule of generation if the load demand is 130 MW. Neglect transmission losses.

(b) The open-loop transfer function of a unity feedback system is given by

$$G(s) = \frac{K(s+5)}{s(s+2)};\ K \ge 0$$

Draw a rough sketch of the root locus plot; given that the complex roots of the characteristic equation move along a circle. As K increases, does the relative stability decrease? Justify your answer.

(c) Explain with a flow-chart the computational procedure for load flow solution using Gauss-Seidel method when the system contains all types of buses.

8. What is compensation as applied to control system stability? Discuss various types of compensation technique. Compare the characteristics of phase lead and phase lag networks used for control system compensation. 40

9. Differentiate between steady state stability and transient stability of a power system. Derive swing equation and discuss its application in the study of power system stability. What is equal area criterion? 40

10. Deduce and discuss the equivalent circuit of 3-phase induction motor. Give the procedure of conducting no-load and blocked rotor tests on 3-phase induction motor. How are the parameters of the equivalent circuit determined from the test results? How would you construct the circle diagram of 3-phase induction motor from these tests data? 40

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