This question paper contains 9 printed pages]

Code No. : 09(II) *Roll No. .....*

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ELECTRICAL ENGINEERING

Paper : II

Time Allowed : 3 hours] *[Maximum Marks : 300*

Note : (i) Answers must be written in ***English.***

(ii) *Number of marks carried by each question are indicated at the end of the question.*

(iii) *Part/Parts of the same question must be answered together and should not be interposed between answers to other questions.*

(iv) ***The answer to each question or part thereof should begin on a fresh page.***

(v) ***Your answers should be precise and coherent.***

(vi) *Candidates should attempt* ***Section-A*** *and* ***B*** *OR* ***A*** *and* ***C.*** *Question* ***No. 1*** *of* ***Section-A*** *is* ***compulsory*** *and all* ***four*** *parts of it are to be answered. Candidates are required to attempt* ***one*** *more question from* ***Section-A*** *and any* ***three*** *questions from* ***Section-B*** *or* ***C.***

P. T. O.

SECTION – A

1. (a) A system is represented by the following equations :

$$x = x_1 + 3u$$

$$\frac{dx_1}{dt} = -3x_1 + x_2 + 2u$$

$$\frac{dx_2}{dt} = -2x_1 + u$$

Find the transfer function $X(s)/U(s)$ by the signal flow graph technique. 24

(b) Discuss various triggering circuits of an SCR giving merits and demerits of each circuit. How feedback signal can be used to control α in a TTL-based triggering control circuit ? 24

(c) For the unity feedback system : $G(s) = \frac{K}{s(s+1)(s+3)}$, plot the root locus showing all details on it. Comment on the stability of the system. 24

(d) Compare the bipolar and unipolar switching schemes of a sinusoidal PWM inverter. A three-phase inverter is fed from a 600 V dc source. The inverter is operated in 1500 conduction mode and it is supplying a purely resistive, star-connected

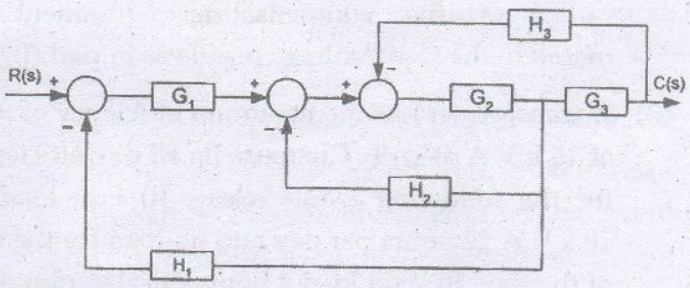
load with R = 15 ohm per phase. Determine (i) the rms value of load current, (ii) the rms value of switch current, and (iii) the power delivered to the load. 20

2. (a) A servomechanism having inertia of 20×10^{-6} kg-m^2; an external viscous friction of 100×10^{-6} Nm/rad/sec, and a damping ratio of 0.3 is required to have an steady state error of 0.5 degrees at an input speed of 10 rev/minute. Find (i) the required controller gain and (ii) the proportion of error-rate damping to secure this result. 20

(b) Discuss the stability by Routh's criterion of the system whose characteristic equation is : $s^6 + 2s^5 + 8s^4 + 12s^3 + 20s^2 + 16s + 16 = 0$ 16

(c) With the help of suitable circuit diagram and waveforms, describe single phase, full-bridge inverters. 16

3. (a) Determine the closed loop transfer function for the system shown in the following figure : 20



(b) A three-phase, six pulse, full converter is connected to three phase, 50 Hz, 220 V, star-connected supply. The load resistance and inductance are 10 ohm and 1 henry respectively. For $\alpha = 30°$, find (i) the average output voltage V_0, (ii) the average and rms output currents I_0 & $I_{0(rms)}$, (iii) the output power, and (iv) the voltage rating of thyristors. 16

(c) What are the merits of dc-dc converters ? A chopper based thyristor operates at 10 kHz in TRC mode. The turn off time of the inverter grade SCR is 12 μs. Find the maximum possible duty ratio of the chopper. 16

SECTION – B

4. (a) A 275 kV transmission line the following line constants : A = 0.85 ∠ 5°, B = 200 ∠ 75° ohm. (i) Determine the power at UPF that can be received if the voltage profile at each end is to be maintained at 275 kV, (ii) If the load at receiving end is increased to 150 MW at UPF, determine rating of the compensating equipment to maintain the same voltage profile as in part (i). 20

(b) A transformer has its maximum efficiency of 98% at 15 k V A at UPF. Compare its all day efficiency for the following load cycles : (i) Full load of 20 k V A 12 hours per day and no-load for the rest of the day. (ii) Full load 4 hours per day plus 40%

of full load rest of the day. Assume the load to operate at UPF in both the cases. 16

(c) Explain why negative sequence impedance of an alternator is less than positive sequence impedance, while they are equal in case of other components of power system. Also prove that in case of isolated neutral, zero sequence current is absent. 16

5. (a) A 3-phase, 400 V, 6-pole, 19 kW induction motor has the following parameters of its approximate equivalent circuit : $R_1 = 1.4\ \Omega$, $R_2 = 0.6\ \Omega$, $X_1 = 2\Omega$, $X_2 = 1\Omega$, and $X_m = 50\ \Omega$. The rotational loss is 275 W. For a slip of 0.03 and –0.03, calculate : (i) The line current, power factor and power input, (ii) Mechanical output and the shaft torque, and (iii) The efficiency. 20

(b) Discuss merits and demerits of Air blast circuit breaker over other type of circuit breakers. 16

(c) Derive the expression for fault current when a single line-to-ground fault is developed on a transmission line of a loaded power system. Give the connection diagram of three sequence networks. 16

6. (a) A 4-pole series-wound fan motor draws an armature current of 50 amp, when running at 2000 rpm on a 230 V dc supply with four field

coils connected in series. The four field coils are now are connected in two parallel groups of two coils in series. Assuming the flux per pole to be proportional to the exciting current and load torque proportional to the square of the speed, find the new speed and armature current. Neglect losses. Armature resistance = 0.2 ohm and resistance of each field coil is 0.05 ohm. 20

(b) A 1000 kW, 3-phase, 24-pole, star-connected, 3.3 kV, 50 Hz synchronous motor has a synchronous reactance of 3.24 Ω and negligible resistance. The motor is fed from infinite bus-bars at 3.3 kV. Its field excitation is adjusted to result in unity power factor operation at rated load. Calculate the maximum power and torque that the motor can deliver with its excitation remaining constant at this value. 16

(c) Discuss methods of preventing operation of relays on inrush current in a transformer. With the help of suitable diagram, give differential protection scheme of a star-delta transformer. 16

7. (a) Explain one of the numerical techniques for the solution of swing equation. Justify the assumptions made. Discuss methods for the improvement of transient stability. 20

(b) Three 6.6 kV alternators each of 10% transient reactance and MVA ratings 40, 50, and 25

respectively are connected to a common tie bar through current limiting reactors of 12% based upon their rating. A three-phase feeder with impedance of 0.06 + j0.12 ohm is connected to the terminals of 40 MVA alternator. Calculate the short-circuit MVA for a symmetrical 3-phase fault at the far end of the feeder. 16

(c) Compare Gauss-Siedel and Newton-Raphson techniques used for load-flow analysis. Give the π-representation of off-nominal turns ration transformer for load-flow studies. 16

SECTION – C

8. (a) A rectangular waveguide is filled with polyethylene ($\varepsilon = 2.5\ \varepsilon_0$) and operates at 24 GHz. If the cut-off frequency of a certain TE mode is 16 GHz, find the group velocity and intrinsic impedance of the mode. 20

(b) A transmission line operating at $\omega = 10^6$ rad/s has $\alpha = 8$ dB/m, $\beta = 1$ rad/m and $Z_0 = 60 + j\,40$ ohm, and is 2 m long. If the line is connected to a source of $10 \angle 0°$ V, $Z_g = 40$ ohm and terminated by a load of $20 + j\,50$ ohm, determine :

(i) The input impedance, and

(ii) The sending end current. 16

(c) The attenuation constant of a TM mode is given by :

$$\alpha = \frac{2}{\eta_0}\sqrt{\frac{\pi f \mu \sigma}{1-\left(\frac{f_c}{f}\right)}}$$

At what frequency will α be maximum. 16

9. (a) In a rectangular cavity resonator has dimensions a = 3 cm, b = 6 cm, and c = 9 cm. If it is filled with polyethylene ($\varepsilon = 2.5\ \varepsilon_0$), find the resonant frequencies of the first five lower order mode. 20

(b) A 100-turn loop antenna of radius 20 cm operating at 10 MHz in air to give a 50 m V per meter field strength at a distance 3 m from the loop. Determine : (i) The current that must be fed to the antenna, and (ii) The average power radiated by the antenna. 16

(c) At 10 GHz, a micro-strip line has the following parameters : h = 1 mm, w = 0.8 mm, $\varepsilon_r = 6.6$, $\tan\theta = 10\text{-}4$ and $\sigma_c = 5.8 \times 107$ S/m. Calculate the attenuation due to conduction loss and dielectric loss. 16

10. (a) A magnetic field strength of 5 μ A/m is required at a point on $\theta = \pi$ 2, 2 km from an antenna in air. Neglecting ohmic loss, how much power must the antenna transmit if it is (i) a half wave diapole, (ii) a quarter wave diapole, and (iii) a turn loop antenna of radius $\rho_0 = \lambda/20$. 20

(b) The transmitting and receiving antennas are separated by a distance of 200 λ and have directive gains of 25 and 18 dB respectively. If 5 mW power is to be received, calculate the minimum transmitted power. 16

(c) Discuss the technique used for controlling electro-magnetic interference. 16

11. (a) A 30 m long lossless transmission line with Z_0 = 50 ohm operating at 2 MHz is terminated with a load Z_L = 60 + j 40 ohm. If $u = 0.6c$ on the line, find : (i) The reflection coefficient Γ, (ii) The standing wave ratio, and (iii) The input impedance. 20

(b) A distortion less line has Z0 = 60 ohm, α = 20 mNp/m, $u = 0.6c$, where c is the speed of light in a vacuum. Find R, L, G, C, and λ at 100 MHz. 16

(c) In connection with optical-fibre, derive equation for numerical aperture. 16
