CSM – 25/21

Electrical Engineering

Paper – II

Time : 3 hours

Full Marks : 300

The figures in the right-hand margin indicate marks.

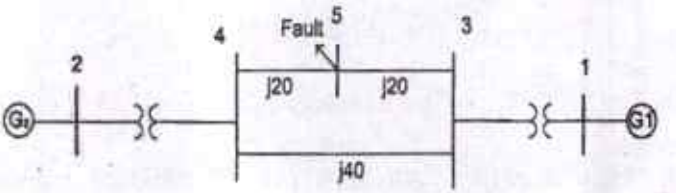
*Candidates should attempt Q. No. 1 from Section – A and Q. No. 5 from Section – B which are compulsory and any **three** of the remaining questions, selecting at least **one** from each Section.*

SECTION – A

1. Answer any **three** questions of the following :

   (a) Figure shows a power system network, each of the alternators G_1 and G_2 is rated at 125 MVA, 11 kV, and has a sub-transient reactance of 0.21 p.u. Each of the transformers is rated as 125 MVA,

11/132 kV and has a leakage reactance of 0.06 p.u. Find (i) Fault MVA and (ii) fault current for a fault at bus 5. 20

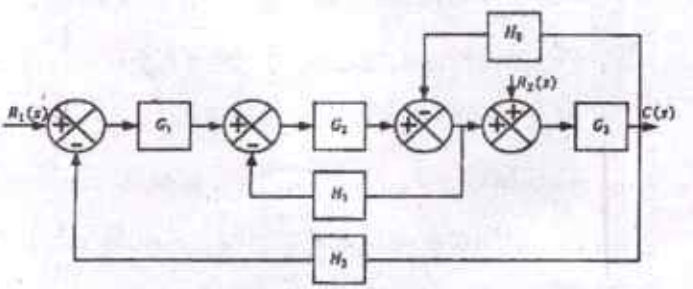


(b) Find the closed loop transfer function of the block diagram shown in Figure, when the input is : 20

(i) $R_1(S)$

(ii) $R_2(S)$

(iii) Draw the signal flow graph of this system.



(c) Design a PV water pumping system, which is required to draw 25000 lit. of water everyday from a depth of 10m. Take the following data during the design : 20

Operating factor = 0.75

Solar PV module used = $75W_p$

Pump efficiency = 30%

Mismatch factor = 0.85

(d) Explain what is meant by polarization interleaving. On a frequency axis, draw to scale the channel allocation for the 32 TV channels in the Ku band, showing how polarization interleaving is used in this. Why is it desirable to down-convert the satellite TV signal received at the antenna ? 20

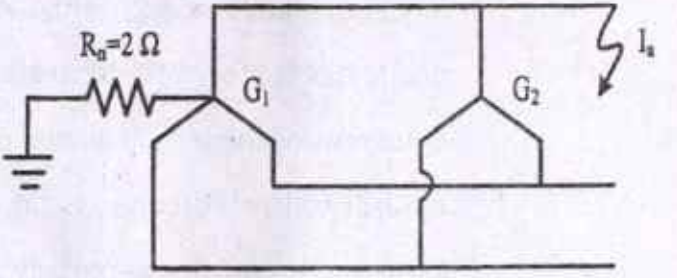
2. (a) (i) Explain hysteresis loop with required diagram. What is meant by hysteresis loss in a ferromagnetic metal and

discuss the factors that governs the magnitude of this loss. 15

(ii) Calculate the hysteresis loss in an iron core of volume 1500 cm^3 at a frequency of 30Hz and a maximum B of 0.8 Wb/m^2 if the hysteresis loss is 1.6W per kg at 50Hz and maximum B of 1Wb/m^2. Assume that over this range of flux densities the hysteresis loss per cycle is α (maximum flux density)$^{1.8}$. Take the specific gravity of iron as 7.8. 5

(b) Two 11kV, 20 MVA, 3ϕ star connected generators operate in parallel as shown in Figure. The +ve, –ve and zero sequence reactances of each being respectively, j0.18, j0.15, j0.1 p.u. The star point of one of the generators is isolated and that of the other is earthed through a 2Ω resistor. A single line to ground fault occurs at the terminals of one of the generators. Estimate (i) the fault current

(ii) the current in grounding resistor and (iii) the voltage across grounding resistor. 20



(c) Compare monolithic and hybrid ICs. Explain the difference between the two film deposition process CVD and LPCVD. 20

3. (a) Draw the timing diagram for following instructions : 20

(i) STA 9000H

(ii) MVI B, 3FH

(iii) MOV C, A

(b) (i) Explain with block diagram the various parts of a CRT. What extra components are needed to make it a CRO ? Explain how would you measure frequency using a CRO. 10

(ii) A capacitive transducer is made up of two concentric cylindrical electrodes. The length of electrode is 25 mm, the inner diameter of outer cyclindrical electrode is 4.2mm and the outer diameter of inner cylindrical electrode is 4.0mm. Determine : (a) the sensitivity of the transducer for air medium, (b) the change in capacitance for a displacement of the inner electrode of 2.5 mm, (c) the electric stress when a voltage of 230V is applied across the electrodes. 10

(c) A feedback system is having a closed loop transfer function as

$$G(s) = \frac{1000}{(s+22.5)\left(s^2+2.45s+44.4\right)}. \quad 20$$

(i) Determine the resonant frequency ω_r and resonance peak M_r of the system

by drawing the frequency response curve.

(ii) Find the values of damping ratio ζ and undamped natural frequency ω_n of an equivalent 2nd order system which will produce same ω_r and M_r as in (i).

(iii) Find the bandwidth of the equivalent second order system.

4. (a) The fuel inputs per hour of plants 1 and 2 are given as : 20

$F_1 = 0.2\ P_1^2 + 40P_1 + 120$ Rs./hr.

$F_2 = 0.2\ 5P_2^2 + 30P_2 + 150$ Rs./hr.

Determine the economic operating schedule and the corresponding cost of generation, if the maximum and minimum loading on each unit is 100 MW and 25 MW respectively, the demand is 180 MW and the transmission losses are neglected. If the load is equally shared by both the units, determine the saving

ontained by loading the units as per equal incremental production cost.

(b) (i) What is quality factor ? Draw the circuit diagram and explain the working principle of Q-meter. 5

(ii) Explain the measurement of low impedance components and high impedance components with proper diagram and derivations for Q-factor of the unknown components. 15

(c) In a 220 kV system, the reactance and capacitance up to the location of circuit breaker is 10 Ω and 0.02 μF respectively. A resistance of 600 Ω is connected across the contacts of the circuit breaker. Determine the following : 20

(i) Natural frequency of oscillation

(ii) Damped frequency of oscillation

(iii) Critical value of resistance which give no transient oscillation

The value of resistance which will give damped frequency of oscillation, one fourth of the natural frequency of osciallation.

SECTION – B

5. Answer any **three** questions of the following :

(a) A three phase, 415V, star connected, four-pole, 50Hz, slip ring induction motor runs at a speed of 1447 rpm when operating at its rated load. The motor equivalent circuit parameters referred to the stator are $R_m = 68\ \Omega$, $R_s = 0.075\ \Omega$, $R'_r = 0.063\ \Omega$, $X_m = 6.3\ \Omega$, $X_{\ell s} = 0.305\ \Omega$, and $X'_{lr} = 0.305\ \Omega$. The turns ratio of stator-to-rotor is 1.2. The machine is driven at supersynchronous speed and the power flow into the 415 V utility system is controlled by the Static Scherbius Scheme where a full-wave diode bridge rectifier constitutes converter I. Converter II is connected to the source

through a transformer with a turn ratio of 1.2. The resistance of the smoothing reactor of the dc link is 0.15 Ω. 20

(i) With the slip rings short circuited, how much power can be fed to the system for the same rated current and what should be the speed of the induction generator ? Determine the efficiency of the generator.

(ii) The induction machine is driven at 1800 rpm. Calculate the output power and the efficiency when harmonic currents and dc link resistances are (1) Neglected and (2) Considered.

(b) A subgrid has total rated capacity of 2500 MW. It encounters a load increase of 50 MW, if the normal operating load is 1000 MW. Assume the Inertia constant H to be

5 sec and regulation of the generator in the system as 2 Hz / p.u. MW. Find : 20

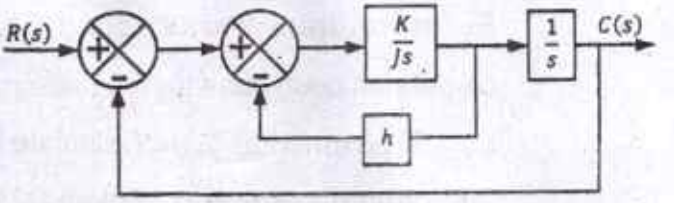
(i) ALFC Loop parameters

(ii) Static frequency drop

(iii) Transient response of ALFC loop

(iv) Assume load frequency dependency to be linear

(c) Find the values of K and h of the closed-loop system as shown in the Figure, so that the maximum overshoot in unit step response is 20% and the peak time is 1.2s. Assume that $J = 1kg - m^2$. 20



(d) (i) A satellite TV link is designed to provide a video signal-to-noise ratio of 62 dB. The peak deviation is 9.6 MHz, and the

highest video baseband frequency is 4.3 MHz. Calculate the carrier-to-noise ratio required at the input to the FM detector, given that the combined noise weighting, emphasis improvement and implementation margin is 11.8 dB. 5

(ii) A dispersion management map strategy to provide dispersion compensation for a DWDM single-mode fiber system operating in the wavelength region around 1.55 μm is displayed in the Figure. The two path lengths L_1 and L_2 are 160 km and 20 km, respectively. Furthermore, the second-order dispersion coefficient for the latter path L_2 is 17ps $nm^{-1}km^{-1}$. (a) Calculate the 2nd-order dispersion coeficient for the first path length L_1 in order to achieve zero mean chromatic dispersion. (b) If the dispersion slope for the first fibre path

L_1 is 0.075 ps nm^{-2} km^{-1}, then determine the dispersion slope for the 2nd fibre path L_2. (c) Verify that the periodic dispersion management map will provide sufficient confidence to facilitate reliable DWDM transmission.

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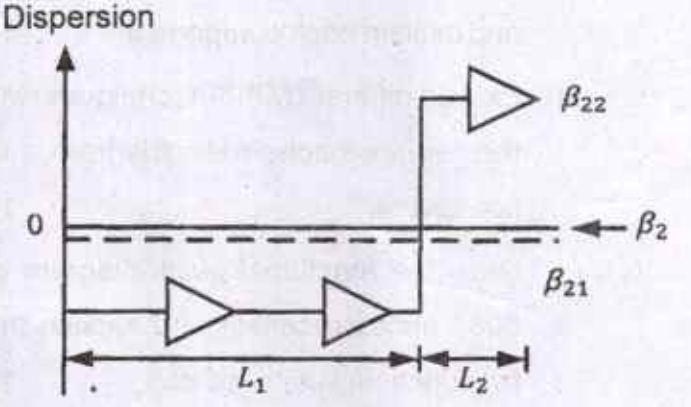


6. (a) A 3-phase, 20 MVA, 11 kV star connected alternator is protected by Merz-Price circulating current system. The star point is earthed through a resistance of 5 Ω. If the CTs have a ratio of 1000/5 and the relay is set to

operate, when there is an out of balance current of 1.5 A. Calculate : 20

(i) The percentage of each phase of stator winding, which is unprotected

(ii) Minimum value of the earthing resistance to protect 90% of the winding

(b) (i) Draw the basic components of a WECS and explain each component. 10

(ii) Explain different MPPT techniques with the required schematic diagram and flow charts. 10

(c) (i) Draw the functional block diagram of 8085 microprocessor and explain the five functional units in detail. 15

(ii) How does 8085 processor differentiate a memory access (read / write) signal from an I/O access (read / write) signal ? 5

7. (a) (i) A barium titanate piezoelectric pick-up has dimensions of 7mm × 7mm × 1.5mm

and voltage sensitivity of 0.012Vm/N. The relative permittivity of the barium titanate is $12 \times 10^{10} N/m^2$. Determine the output voltage, charge sensitivity, strain, charge generated and capacitance of the pick-up. The force applied to the pick-up is 10 N. 10

(ii) Determine the magnitude of resultant resistance and limiting errors in percentage and ohms, if the resistances R_1, R_2 and R_3 are connected in (a) series and (b) parallel. 5

$R_1 = 250\ \Omega \pm 5\%$, $R_2 = 150\ \Omega \pm 5\%$, $R_3 = 50\ \Omega \pm 5\%$.

(iii) A set of 10 observations were taken to determine the weight of a lead sheet. The weights in gramme were : 1.577, 1.570, 1.562, 1.597, 1.580, 1.575, 1.586, 1.564, 1.591 and 1.550. Determine the arithmetic mean, average deviation,

standard deviation, variance, probable error of one reading and probable error of the mean. 5

(b) Explain with neat diagrams the various steps involved in the fabrication of ICs. How the SiO_2 surface is formed ? Why the formation of SiO_2 layer is necessary ? 20

(c) (i) Derive the exact coordination equation including transmission loss. 10

(ii) Explain what is meant by "coherent detection" as used for the demodulation of PSK bandpass signals. An envelope detector is an example of a non-coherent detector. Can such a detector be used for BPSK ? Give reasons for your answer. 10

8. (a) (i) For satellite no. 14452 the NASA prediction bulletin for a certain epoch gives the eccentricity as 9.5981×10^{-3} and the mean anomaly as 204.9779°.

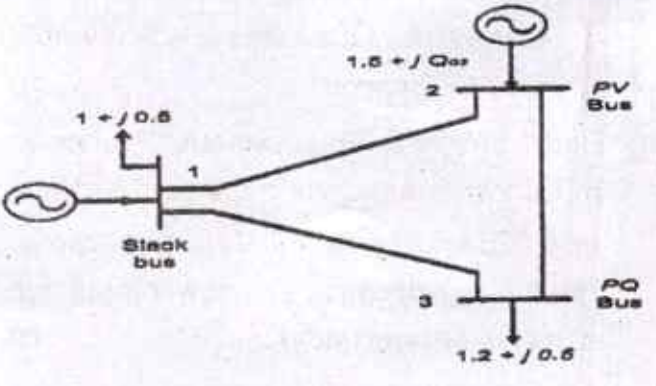
The mean motion is 14.2171404 rev/day. Calculate the true anomaly and magnitude of the radius vector 5s after epoch. The semi major axis is known to be 7194.9 km. Also, express r in vector form in the perifocal coordinate system. 10

(ii) A satellite is in a circular polar orbit at a height of 880 km, the orbital period being approximately 102 min. Assuming an average value of Earth's radius is 6371 km. (A) Determine approximately the maximum period the satellite is visible from a beacon at sea level. (B) The satellite orbit passes directly over a beacon at sea level. Determine approximately the fractional Doppler shift at the instant the satellite is first visible from the beacon. 10

(b) Figure shows a 3-bus system. The series impedance and shunt admittance of each line are 0.026 + j0.11 pu and j0.04 pu respectively. The bus specification and power input, etc at the buses is as under : 20

Bus	P_G	Q_G	P_L	Q_L	Bus voltage
1	Unspecified	Unspecified	1.0	0.5	1.03 + j0 (slack bus)
2	1.5	Unspecified	0	0	V = 1.03 (PV bus)
3	0	0	1.2	0.5	Unspecified (PQ bus)

For bus 2 the minimum and maximum reactive power limits are 0 and 0.8 pu. (i) Form $[Y_{bus}]$, (ii) Find P_2^0, Q_2^0, P_3^0, Q_3^0 (iii) Find $[J^0]$, and iv. Form the general equation for calculating the changes in variables by NR method. Write the equation for first iteration.



(c) (i) In the Fermi distribution function introduce a new variable $x = (W - W_F) / kT$; x measures the energy in units of kT relative to the Fermi energy W_F. Show that $\frac{-dF}{dx}$ is a symmetrical function with a maximum at x = 0. On the basis of the information so obtained, show that $\frac{\partial F}{\partial W}$ has an appreciable value only in an energy region of the order of kT on either side of the Fermi level. 10

(ii) The average power received in a binary polar transmission is 10 mW and the bit period is 100 μs. If the noise power spectral density is 0.1μJ and optimum filtering is used, determine the bit error. 5

(iii) Explain how a QPSK signal can be represented by two BPSK signals. Show that the bandwidth required for QPSK signal is one-half of that required for a BPSK signal operating at the same data rate. 5