CSM – 25/19

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** of the following :

   (a) A 4-pole, 50 Hz turbo-generator is rated at 45 MW, 0.8 p. f. lag and has an inertia of 25,000 Kg-m^2. It is connected via a transmission system to another set whose corresponding data is 2-pole, 50 Hz, 60 MW, 0.75 p. f. lag, 9000 Kg-m^2. Calculate the

inertia constant of each set on its own rating and that of the single equivalent set connected to an infinite bus-bar and on a base rating of 100 MVA. 20

(b) A two-area system connected by a tie-line has the following parameters on a 1000 MVA common base.

Area	1	2
Speed regulation	$R_1 = 0.05$	$R_2 = 0.0625$
Frequency – sensitive load coefficients	$D_1 = 0.6$	$D_2 = 0.9$
Inertia constants	$H_1 = 5$	$H_2 = 4$
Base power	1000MVA	1000MVA
Governor time constant	$\tau_{g1} = 0.2$ sec	$\tau_{g2} = 0.3$ sec
Turbine time constant	$\tau_{T1} = 0.5$ sec	$\tau_{T2} = 0.6$ sec

The units are operating in parallel at the nominal frequency of 60 Hz. The synchronizing power coefficient is given to be $P_s = 2.0$ per unit. A load change of 187.5 MW occurs in area-1. Determine the new steady-state frequency and change in the tie-line flow. From where does this change in tie-line flow come ? 20

(c) The incremental cost characteristics of a two-plant system are $IC_1 = 1.0P_1 + 85$ Rs/MWh, $IC_2 = 1.2\,P_2 + 72$ Rs/MWh where, P_1 and P_2 are in MW. The loss coefficient matrix in MW^{-1} is given by : $\begin{bmatrix} 0.015 & -0.001 \\ -0.001 & 0.02 \end{bmatrix}$.

Compute the optimum scheduling with $\lambda = 150$ Rs/MWh. 20

(d) (i) Draw and explain the typical power versus speed characteristics of a wind turbine. 10

(ii) For a 1 MW land based wind turbine generator, the capital cost is Rs. 1,20,000 per KW. Its estimated operating and maintenance cost is Rs. 3,000,000 per year. It has a design life of 25 years and a capacity factor of 28%. Its construction time is very short and there are of course zero fuel costs. For a given competing bulk (fossil fuel) electricity price of Rs. 5 per KWh, find the payback time without considering O & M payments and any interest payments on the capital. 10

2. (a) Consider the unit-step response of a unity feedback control system whose open loop transfer function is $G(s)\ \frac{1}{s(s+1)}$. Obtain the rise time, peak time, maximum overshoot and settling time. 20

(b) A single-input single-output system is given as :

$$x(t) = \begin{bmatrix} -1 & 0 & 0 \\ 0 & -2 & 0 \\ 0 & 0 & -3 \end{bmatrix} x(t) + \begin{bmatrix} 1 \\ 1 \\ 0 \end{bmatrix} u,\ y = \begin{bmatrix} 1 & 0 & 2 \end{bmatrix} x(t).$$

Test for controllability and observability. 20

(c) The magnitude plot of the open loop transfer function G(s) of a certain system is shown in the following figure.

(i) Determine G(s) if it is known that the system is of minimum phase type. 10

(ii) Estimate the phase at each of the corner frequencies. 10

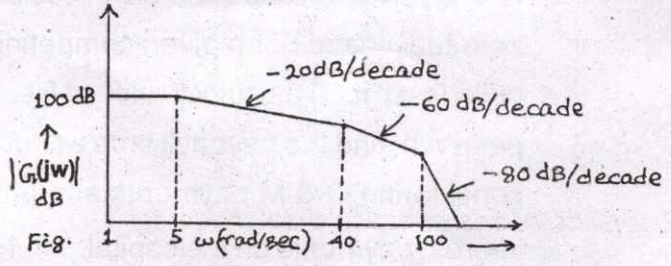

Fig.

3. (a) (i) A 100/1 A bar primary CT supplies an overcurrent relay set at 10% pickup and having a burden of 1 VA. It is required to cater for a current of 10 times the relay setting. Determine the knee point voltage and cross-section of the core, if the CT has 10 secondary turns. Assume the flux density in the CT core to be 1 Wb/m^2. Assume also the power frequency to be 50 Hz. 10

(ii) A Si bar of 0.1 cm long and 100 μm^2 in cross-sectional area is doped with $10^{17}\ cm^{-3}$ phosphorus. Find the current with 10 V applied. Assume that for this doping, $\mu_n = 700\ cm^2/V.s$. 10

(b) An alternator rated 10 KV protected by the balanced circulating current system has its neutral grounded through a resistance of 10 ohms. The protective relay is set to operate when there is an out-of-balance current of 1.8 ampere in the pilot wires,

which are connected to the secondary windings of 1000/5 ratio current transformers. Determine :

(i) The percentage winding which remains unprotected. 10

(ii) The minimum value of earthing resistance required to protect 80% of the winding. 10

(c) Draw and explain the generalized block diagram of a static distance relay. Draw also the typical distance characteristics. 20

4. (a) Explain the operating principle of a digital spectrum analyzer. Draw the basic block diagram for a digital spectrum analyzer and describe its operation. 20

(b) (i) The output of an LVDT is connected to a 5 V voltmeter through an amplifier whose amplification factor is 250. An output of 2 mV appears across the terminals of LVDT when the core moves through a distance of 0.5 mm. Calculate the sensitivity of the LVDT and that of whole

set-up. The milli-voltmeter scale has 100 divisions. The scale can be read to 1/5 of a division. Calculate the resolution of the instrument in mm. 10

(ii) In a piezo-electric transducer, a flat frequency response within 5% is required. Find the value of minimum frequency in terms of time constant for which it can be used. If the time constant of the transducer is 1.5 ms, find the value of minimum frequency. Find the phase shift at this frequency. 10

(c) A system oscillates with frequency ω, if it has poles at $s = \pm j\omega$ and no poles in the right half s-plane. Determine the values of 'K' and 'a' so that the system shown in figure below oscillates at a frequency of 2 rad/sec. 20

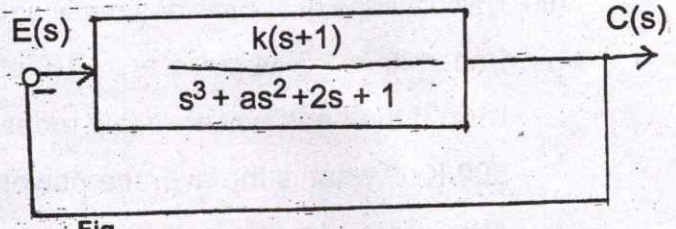

Fig.

SECTION – B

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

(a) Explain the working principle of a PCM system with the help of a block diagram. What are the advantages of PCM over analog modulation ? 20

(b) (i) Define Doppler Radar. What is meant by Doppler Effect ? What is the importance of Doppler Effect ? 10

(ii) If the maximum unambiguous range of radar system operates is 500 Km, the wavelength is 1 deci-meter, calculate Pulse Repetition Frequency (PRF) and the maximum unambiguous velocity in m/s. 5

(iii) Calculate the duty cycle of a radar which transmits a 1.5 μs pulse at a PRF of 8 KHz. If the peak power of this radar is 500 KW, what is the average power ? Also what is the resting time ? 5

(b) The e.m.f. developed by a photo-voltaic cell can be taken as proportional to the logarithm of the intensity of radiation impinging on it. For 10 W/m^2 radiation, a cell develops an e.m.f. of 0.33 V and drives a current of 2.2 mA into a 100 ohm load. Calculate (i) the open circuit voltage at 25 W/m^2 and (ii) the internal resistance of the cell. 20

(c) (i) Draw the block diagram of Intel 8086 microprocessor. How many segment registers, general purpose registers and index and pointer registers are there ? Name them. 10

(ii) How many flags are available in 8086 ? Name the status flags and control flags. 5

(iii) If the CS contains 124A H and IP contains 0728 H, calculate the physical address. 5

7. (a) 2 K bytes of ROM has to be interfaced to an 8085 microprocessor using one ROM chip.

(c) (i) A speech signal is sampled at a rate of 8 KHz, logarithmically compressed and encoded into a PCM format using 8 bits per sample. The PCM data is transmitted through an AWGN baseband channel via 4-level PAM signalling. Determine the required transmission bandwidth. Assume rectangular pulses and the zero-to-null definition of bandwidth. 10

(ii) Find the maximum amplitude of a 1 KHz sinusoidal signal input to a delta modulator that will prevent slope overload, when the sampling rate is 10,000 samples/sec and the step size is $\Delta = 0.1$. 10

(d) Explain two methods of improving contrast for the screen of TV picture tube. 20

6. (a) Describe the photoetching process with relevant diagrams. State and explain also the Diffusion Law. 20

The address space assigned to the ROM chipin hex is COOO H – C7FF H.

(i) Show how the address and data lines of the 8085 are to be connected to those of the ROM chip. 10

(ii) Design the address decoding circuit whose output is to be connected to the Chip Enable pin of ROM chip which is of active high signal using only AND and NOT gates. 10

(b) With the help of a suitable diagram starting from the principle of optical fibre showing the path of a light signal travelling inside an optical fibre, derive an expression for numerical aperture of the optical fibre in terms of refractive indices of core (n_1) and cladding (n_2). 20

(c) A step-index multimode fibre has a core of refractive index 1.5 and cladding of refractive index 1.485.

(i) What is the maximum allowable angle of acceptance for refraction on core-cladding surface ? 10

(ii) If the length of the fibre is 500 m, what is the difference of distance of travel between the longest and shortest signal path ? 10

8. (a) What are LEO, MEO and GEO satellites ? Draw a schematic block diagram of a C-band satellite transponder and explain its working. 20

(b) Explain the working principle of a Simple Radar System. What are the ranges of frequencies and their typical application areas of L-band, S-band, K-band and X-band raders ? 20

(c) State Kepler's Laws as applied to satellite communications. Briefly describe the orbital parameters with the help of suitable diagrams. 20