

ELECTRICAL ENGINEERING (Paper II)

Time Allowed : Three Hours

Maximum Marks : 300

QUESTION PAPER SPECIFIC INSTRUCTIONS

(Please read each of the following instructions carefully before attempting questions)

There are EIGHT questions divided in two Sections.

Candidate has to attempt FIVE questions in all.

Question Nos. 1 and 5 are compulsory and out of the remaining, any THREE are to be attempted choosing at least ONE question from each Section.

The number of marks carried by a question/part is indicated against it.

Wherever any assumptions are made for answering a question, they must be clearly indicated.

Word limit in questions, wherever specified, should be adhered to.

SECTION 'A'

1. Answer any THREE of the following:

3×20=60

- (a) Hicks clinical thermometer measures human body temperature. The instruction is to wait for half-a-minute before taking the reading. Is it because the measuring system is a: (i) zero order system with a pure time delay of half-a-minute? (ii) first order system with a time constant greater than half-a-minute? (iii) first order system with a time constant equal to half-a-minute? (iv) first order system with a time constant less than half-a-minute? Justify your answer.
- (b) Enumerate the different kinds of head type flow meters used in the industry. What kinds of restrictions are placed in the flow path for flow measurement? Develop the relationship between flow and pressure differential from physical principles. Why is it that a rotameter is considered a standard in flow measurement?
- (c) Give a brief account of application of computers in the study, analysis and control of power systems.
- (d) Colour sub-carrier (3.58 MHz for FCC standard and 4.43 MHz for CCIR standard) is chosen as some odd multiple of one-half of line frequency. Justify the statement.

2. (a) What is the difference between a microcomputer and a micro-process? What type of data is stored in the memory of a microcomputer? How much memories can a typical 8-bit micro-process access? What are the condition flags and why are they important? Write the advantage of the indexed address mode compared to the direct addressing mode. Draw the time diagram of out instruction for 8085 micro-process. **20**

- (b) A constant load of 330 MW is supplied by two 250 MW generators, 1 and 2, for which the respective incremental fuel costs are:

$$dF_1/dP_1 = 0.12P_1 + 22, \text{ and } dF_2/dP_2 = 0.10P_2 + 16$$

with powers P in MW and costs F in Rs./hr. Determine: (i) most economic operating schedule of the generators, and (ii) the saving in Rs./hr. thereby obtained compared to equal load sharing between them. **20**

- (c) Explain the sea waves phenomena and vortex motion of waves. Discuss the principles of two possible devices used for generating electrical energy from the wave energy. Draw the block diagram from wave energy device to utility grid. Write the relation for the potential power in terms of height of wave and its time period. If the time period of a wave is 10 secs having height 7 meters, estimate the power that can be generated. **20**

3. (a) How is the surface layer of silicon dioxide formed? How thick is this layer? What are the reasons for forming the silicon dioxide layer? **20**
- (b) A 25 MVA, 11 kV generator has $\bar{Z}_1 = \bar{Z}_2 = j0.2 \text{ pu}$ and $\bar{Z}_0 = j0.05 \text{ pu}$. For a line-to-ground fault on the generator terminals, find: (i) the fault current and (ii) the line-to-line voltages during the fault condition. Assume that the generator neutral is solidly grounded and that the generator is operating at no load and at rated voltage at the time of occurrence of fault. Compare this fault current with the line current for a three-phase fault at the terminals. **20**
- (c) (i) A power transformer is connected in Δ/Δ fashion. Draw the arrangement of the current transformers (CTs) on either side of the transformer for Merz-Price circulating current protection. (ii) A distribution transformer is to be protected by over-current relays against all kinds of fault. List the different kinds of fault and suggest the minimum number of over-current relays required. How would those over-current relays be placed in the circuit? (iii) How would one protect a direct-on-line (DOL) start induction motor against overload? Explain your choice. **20**
4. (a) Discuss the physics of piezo-electric phenomena. Draw the equivalent circuit of a piezo-electric transducer and derive the output voltage, V_{out} of transducer with applied force F . Point out the four materials which exhibit the piezo-electric phenomena. Also write its applications. A piezo-electric pressure transducer having a charge sensitivity of $2 \times 10^{-12} \text{ C/N}$ is connected to a charge amplifier, the gain being set to 5 mV/pC . The amplifier output is connected to an ultraviolet chart recorder whose sensitivity is set to 25 mm/volt . Determine the overall sensitivity. **20**
- (b) With the aid of a block schematic, describe the functioning of the receiving unit of a DBS TV/FM receiving system intended for home reception. **20**
- (c) Consider an optical fiber with refractive index of the core 1.8 and of cladding 1.7; calculate: (i) Critical angle (ii) Acceptance angle (iii) Brewster angle (iv) Numerical aperture. **20**

SECTION 'B'

5. Answer any THREE of the following: **3×20=60**
- (a) What do you understand by dielectric films? State any two dielectric film material and point out their important properties and applications. Explain (i) the orientation polarization, (ii) electronic polarization; and (iii) ionic polarization referred to polyatomic gas. Discuss the effect of frequency on electronic polarization and ionic polarization. What is electronegative gases? State the important features of SF₆ and its applications.
- (b) Find the gain and approximate input impedance of the accompanying circuit. What is its bandwidth? What is this circuit called and for what purpose it is used as instrumentation? Analyze the following three Op-Amp based instrumentations amplifier and find its gain. What is its approximate input impedance? Assume that the Op-Amps are ideal.
 [Figure 1 (after "... used as instrumentation?"): Op-amp voltage follower: input V_{in} to the non-inverting (+) input; output connected directly back to the inverting (-) input; output V_o]
 [Figure 2 (after "... input impedance?"): Three op-amp instrumentation amplifier: input V_{in} applied between the + input of OA I (top) and the + input of OA II (bottom); a variable resistor R_1 [?] connected between the - inputs of OA I and OA II; feedback resistor R_f [?] from the output of OA I to its - input and an equal resistor R_f [?] from the output of OA II to its - input; the output of OA I goes through R_1 to the - input of OA III, and the output of OA II goes through R_1 to the + input of OA III; R_2 from the output of OA III to its - input and R_2 from its + input to ground; output terminal at the output of OA III]
- (c) Explain why it is more difficult to interrupt short-circuit current in an HVDC circuit than that in an HVAC circuit.
- (d) In a certain communication system, the message is coded into binary digits 0 and 1. After coding, the probability of a 0 being sent is 0.45, while the probability of a 1 being sent is 0.55. In the communication channel, the probability of a transmitted 0 being converted into

a 1 at the receiver is 0.1, while the probability of a 1 being distorted into a 0 is 0.2. Find: (i) the probability that a received 0 was transmitted as a 0, and (ii) the probability that a received 1 was transmitted as a 1.

6. (a) $\underline{x}=[[-1 \ 0 \ -0.375; 0 \ -1 \ -0.375; 1 \ 1 \ 1]]\underline{x}+[[0; 0; -1]]u$
 Given that the above is a linear time-invariant (LTI) system, how would you check the stability of the system? If there is an unstable mode in the system, is it controllable? If the unstable mode is controllable shift it to a stable position, say $\lambda=-0.5$, by state feedback. 20
- (b) What are the design considerations for layering in data networks? Discuss a seven-layer network architecture with a diagram. 23
- (c) Why and to what degree do optical signals get degraded as they propagate along a fiber? Discuss in detail. 23
7. (a) Which I/O technique provides the highest data transfer rate? Explain the function of DMA. Draw the block diagram of a DMA controller with memory interfacing. What is meant by simultaneous DMA? List three different DMA modes for transferring data. How is the DMA controller is programmed? Are special buffers required when interfaces a DMA controller? 20
- (b) A radar receiver has a low noise RF amplifier of noise figure 6 dB and gain 20 dB followed by a mixer of noise figure 6 dB and conversion loss of 6 dB. If the noise figure of IF pre-amplifier is 3 dB with a gain of 26 dB and that of IF main amplifier is 10 dB, obtain the noise figure of the receiver and its noise temperature. 20
- (c) Draw the waveform at the end of one of the vertical fields, showing a horizontal and a vertical blanking pulse. Indicate the duration and relative amplitudes of two pulses and explain their functions. Where are synchronizing pulses placed? Does it matter that there are no horizontal blanking pulses during vertical blanking period? 23
8. (a) A Wheatstone bridge has resistances R_1 , R_2 , R_3 , and R_4 in its four arms. The bridge is excited by E volts dc. Assuming that the ratio of arms R_1 and R_2 are equal, the bridge is initially balanced with R_3 equal to R_4 . A slight unbalance ($R_3 \pm \Delta R_3$) is created by R_3 . Show that the unbalance voltage, V_o , is directly proportional to $(\Delta R_3/R_3)$ as long $(\Delta R_3/R_3) \ll 1$. What is the condition for maximizing the sensitivity? 20
- (b) The figure below shows a generator-transformer unit feeding 1.0 pu power to the infinite bus through a double-circuit transmission line with the generator terminal voltage of $V_1=1.0$ pu. Compute the generator e.m.f. behind transient reactance. Also find the maximum power that can be transferred when (i) the system is operating under healthy condition, (ii) one line is shorted (three-phase) in the middle, and (iii) one line is open.
 [Figure: Single-line diagram: generator G with transient reactance $X_d'=0.2$, terminal voltage $\bar{V}_t$ [?] at its terminals; step-up transformer of reactance $j0.1$; two parallel transmission lines each of reactance $j0.4$ from the transformer bus to the infinite bus; infinite-bus voltage $\bar{V}=1.0 \angle 0^\circ$ pu] 20
- (c) What do you understand by energy conservation? What is the economics of energy conservation? Point out the strategic measures for energy conservation. Show that for a given load current I, if power factor is improved from 0.7 to 0.9, the useful power can be enhanced by 28.6% of the existing system. Comment on the losses due to power factor improvement. 20