

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. (a)
 - (a)(i) What are the difficulties associated with measurement of low resistances? 5
 - (a)(ii) Describe how low resistance is measured accurately by Kelvin's double bridge. Derive the formula. 15
 - (b) A 110-kV, 50-Hz, 3-phase, 200-km long line has resistance and reactance of 40 ohms and 80 ohms per phase respectively. The capacitance of each conductor to neutral is $1.68 \mu\text{F}$. If the receiving-end voltage is 110 kV at no load, compute– (i) the sending-end voltage at no load; (ii) the line charging current; (iii) the kVA supplied to the line; (iv) the open-circuit power loss in the line. Assume a nominal- π circuit for the line. 20
 - (c)
 - (c)(i) Explain the steps involved in interfacing a stepper motor to the 8255. Draw the interface schematic. 10
 - (c)(ii) Indicate the steps involved in designing an 8-bit output port using partial decoding such that the port maps to any address between 80 H and FF H. Show also the hardware schematic. 10
2. (a)

The diagram of a speed control system is given below: The generator e.m.f. e_g is 2000 volts per field ampere. The motor e.m.f. e_m is $1.5 \text{ volts rad}^{-1} \text{ sec}$. The motor torque K_T is $0.5 \text{ N m per armature ampere}$ and the inertia of motor and load is 10^{-4} kg m^2 . Assuming negligible friction, determine the transfer function $\omega(s)/V_{in}(s)$.

[Figure: Generator field circuit: input voltage V_{in} applied across a 100Ω resistor in series with a 1H field inductance. Armature loop: generator armature (e.m.f. e_g) connected through a 100Ω resistor to the motor armature (e.m.f. e_m), the lower terminals of the two machines joined directly. The motor shaft (speed ω) drives the load of inertia J]

20
 - (b) State and briefly explain the basic requirements (i.e., essential qualities) of protective relaying. 20
 - (c)
 - (c)(i) Discuss consideration of transmission losses in economic operation of thermal power plants. 10
 - (c)(ii) For a system consisting of two plants, the incremental costs are given by

$$dC_1/dP_1 = 0.01P_1 + 20 \text{ ₹/MW hr}$$

$$dC_2/dP_2 = 0.015P_2 + 22.5 \text{ ₹/MW hr}$$
10

The system is running under optimal schedule with $P_1 = P_2 = 100$ MW. If $\partial P_L / \partial P_2 = 0.2$, find the penalty factor of the plants.

3. (a) The output/error transfer function of a control system with unit feedback loop is

$$G(s) = K/(s^2(1+sT))$$
 Sketch the Nyquist locus and hence determine the stability of the system. (Note: The diagram is to be drawn on the answer-book itself.) 20
- (b)
- (b)(i) Explain what you understand by steady-state stability and steady-state stability limit. 6
- (b)(ii) Explain the methods to improve transient stability of power system. 14
- (c) Discuss in brief the physical, chemical and electrical properties of SF_6 gas with respect to its application in high-voltage circuit breakers. 20
4. (a)
- (a)(i) Briefly explain the working principle of a CRO with the help of a block diagram. 10
- (a)(ii) The voltage across horizontal deflection plates of a CRO is $V_1 \sin(\omega t + \theta_1)$, and that across vertical plates is $V_2 \sin(\omega t + \theta_2)$. Prove that the trace on the screen is an ellipse. Determine the equation and interpret its meaning. 10
- (b)
- (b)(i) How is error detection handled in data transfer, using checksums and cyclic redundancy characters (CRC)? Explain the concepts. 8
- (b)(ii) Suppose the following data bytes are received and the last byte is the checksum character: 10, 23, 45, 04, 84 Has the data been received correctly? 4
- (b)(iii) Calculate the data polynomial $M(X)$ for the 16-bit data stream 26F0 H. Write the generator polynomial $G(X)$ for bisync and SDLC protocols. 8
- (c)
- (c)(i) What is the theoretical bandwidth required to transmit a digital signal? Justify your answer. How can you relate bandwidth to bit rate? 8
- (c)(ii) What is Inter-Symbol Interference (ISI)? How can this be tackled? What is the importance of Eye diagram? How is it generated? 12

SECTION 'B'

5. (a)
- (a)(i) Using Routh-Hurwitz criteria, determine the maximum value of K for which the following control system is stable:
 [Figure: Block diagram: $R(s) \rightarrow$ summing junction (+ from $R(s)$, - from feedback) $\rightarrow$ block $K/((1+0.02s)) \rightarrow$ block $2/(s(s+2)) \rightarrow$ output (labelled $R(s)$ in the figure); unity negative feedback from the output to the summing junction] 10
- (a)(ii) For the following control system with sinusoidal input signal, determine the frequency at which the output magnitude is maximum:
 [Figure: Block diagram: input $R(s) = 0.5 \sin \omega t \rightarrow$ summing junction (+, - from feedback) $\rightarrow$ block $100/(s(s+10)) \rightarrow C(s)$; unity negative feedback from $C(s)$ to the summing junction] 10
- (b)
- (b)(i) Show the schematic diagram of a power line carrier protection scheme for a transmission line. 8
- (b)(ii) Which are the components you consider most vital in the scheme? 4
- (b)(iii) Using the principle of phase comparison, explain how the scheme works. 8

	(c)		
	(c)(i)	How is 'regeneration' in digital communication different from 'amplification' in analog communication? In what way regeneration is better?	5
	(c)(ii)	Draw the block diagram of a PCM receiver and show how a transmitted sinusoidal signal is reconstructed in the receiver.	5
	(c)(iii)	Distinguish between virtual circuit and datagram in data networks.	5
	(c)(iv)	What is the rationale behind error control coding? Distinguish between linear codes and non-linear codes.	5
6.	(a)		
	(a)(i)	Explain the carrier type a.c. signal conditioning system with the help of a block diagram.	10
	(a)(ii)	Describe the circuit of a 3-amplifier configuration of an instrumentation amplifier. Discuss how this offers a very high input impedance to the signal.	10
	(b)		
	(b)(i)	Draw the block diagram of a microprocessor-based process control system, making use of data acquisition systems, sensor inputs, outputs connected to relays, DACs. Explain the scheme briefly.	12
	(b)(ii)	Design an interface to a microcomputer port using the LM334 temperature sensor and LM393 analog comparator. A logic 1 i/p should indicate a temperature of greater than 100 °F. (Corresponding voltage for this sensor is 3.11 volts.)	8
	(c)		
	(c)(i)	The information in an analog signal voltage waveform is to be transmitted over a PCM system with an accuracy of $\pm 0.1\%$ (full scale). The analog voltage waveform has a bandwidth of 100 Hz and an amplitude range of -10 V to +10 V. (1) Determine the maximum sampling rate required. (2) Determine the number of bits in each PCM word. (3) Determine the minimum bit rate required in the PCM signal. (4) Determine the minimum absolute channel bandwidth required for the transmission.	12
	(c)(ii)	Why do we need a MODEM to access Internet over telephone line? How does it work? What is the role of a ROUTER in a data network?	8
7.	(a)		
	(a)(i)	What are capacitive transducers?	5
	(a)(ii)	What are the different uses of capacitive transducers?	5
	(a)(iii)	A pressure-measuring instrument uses a capacitive transducer having a spacing of 4 mm between its diaphragms. A pressure of 500 kN/m^2 produces an average deflection of 0.25 mm of the diaphragm of the transducer. The transducer had a capacitance of 300 pF before application of the pressure and was connected to an oscillator circuit having a frequency of 100 kHz. Determine the change in frequency of oscillator after the pressure is applied to the transducer.	10
	(b)		
	(b)(i)	What are the features of three sources of interrupts that 8086 has?	6
	(b)(ii)	What are the three operations possible in the 'string' group? What are the registers used by the instructions in this group?	6
	(b)(iii)	Write the block diagram indicating how 8255A PPI is interfaced to 8086 max mode CPU module, using two 8255As for 16-bit I/O operation.	8
	(c)		

	(c)(i)	Distinguish among the following terms: (1) Forward error correction and Error detection method (2) Random error and Burst error (3) Block codes and Convolutional codes	6
	(c)(ii)	If C is a valid code vector [$C=DG$], then prove that $CH^T=0$, where H^T is the transpose of the parity check matrix H .	10
	(c)(iii)	List the merits and demerits of delta modulation.	4
8.	(a)	A PID control system is shown below: For $K_I=0$, find the values of K_P and K_D so that the system has no steady-state error with step input, has a damping ratio of 0.9 and the dominant time constant of 1. [Figure: Block diagram: $R(s) \rightarrow$ summing junction (+ from $R(s)$, - from feedback) $\rightarrow$ PID block $K_P+K_I/s+K_Ds \rightarrow$ plant $1/(s(s+1)) \rightarrow C(s)$; unity negative feedback from $C(s)$ to the summing junction]	20
	(b)		
	(b)(i)	A line-to-ground fault occurs on phase 'a' of a three-phase synchronous generator, grounded through an impedance Z_n and operating without load. Derive sequence network representation for this fault and determine the current in phase 'a'.	12
	(b)(ii)	The positive, negative and zero sequence reactances of a 13.2-kV, 50-MVA synchronous generator are 0.3 pu, 0.2 pu and 0.1 pu respectively. A line-to-ground fault occurs on phase 'a'. Neglecting all resistances, determine the fault current.	8
	(c)	The figure below shows the single-line diagram of a part of a power system. It is provided with distance relays at A and B. C_1, C_2, C_3 and C_4 are circuit breakers. The impedances of the sections of the line are shown in ohms: [Figure: Single-line diagram: source bus A $\rightarrow$ circuit breaker $C_3 \rightarrow$ line section of 30 Ω (current $I_A = 500$ A flowing from A towards the junction) $\rightarrow$ junction J. Source bus B $\rightarrow$ circuit breaker $C_4 \rightarrow$ line section of 15 Ω (current $I_B = 200$ A flowing from B towards J) $\rightarrow$ J. From J a 75 Ω section to the point F_1 (fault to ground shown at F_1), then circuit breaker C_1 and, across an intermediate bus, circuit breaker C_2 , followed by a further 75 Ω section to the point F_2 (fault to ground shown at F_2)]	
	(c)(i)	A fault occurs at F_1 as shown in the figure. Calculate the impedance seen by the relay installed at A. Will this relay operate before the circuit breaker at B has tripped?	5
	(c)(ii)	Will the relay at B trip for a fault at F_1 before the circuit breaker at A has tripped?	5
	(c)(iii)	If the circuit breaker C_2 fails for a fault at F_2 , will the fault be cleared by the relays at A and B?	5
	(c)(iv)	How will the fault at F_2 be cleared?	5