

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) Identify the correctness of the following statements. Justify your answers:
- | | | |
|----------|---|----|
| (a)(i) | The root locus gives idea about system's transient behaviour. | 3 |
| (a)(ii) | For an inherently stable second-order system, all the coefficients of characteristic equation are of the same sign. | 4 |
| (a)(iii) | A critically damped system has sustained oscillations. | 3 |
| (b) | | |
| (b)(i) | In 8085 microprocessor, what is the advantage of multiplexing the address bus with a data bus? | 5 |
| (b)(ii) | Write an assembly level program of 8085 microprocessor to exchange the contents of DE register pair with that of HL register pair, using only PUSH-POP instructions. | 5 |
| (c) | | |
| (c)(i) | The transfer function of a thermocouple relating output voltage to temperature is given by
$(0.625 \times 10^{-4}) / (s + 0.125) \text{ V/ } ^\circ\text{C}$ <p>Put the transfer function in standard format and find the values of characterising parameters of the thermocouple. Determine the thermocouple output voltage at $t=8$ s, when the thermocouple kept at ambient temperature of 20°C at $t=0$ s is taken to a water bath kept at 80°C.</p> | 7 |
| (c)(ii) | Comment upon 'linearity' and 'sensitivity' of thermistors in comparison to thermocouples. | 2 |
| (c)(iii) | Why is 'lead wire compensation' not required for thermistors? | 1 |
| (d) | | |
| (d)(i) | What is the impedance of the ideal load connected to an HVAC transmission line? | 2 |
| (d)(ii) | What is the nature of the load of an HVAC transmission line by itself, capacitive or inductive? | 2 |
| (d)(iii) | Which electrical quantity measures the magnitude of electrical load in a system? What is generally the nature of the load current, capacitive or inductive, in the power system? | 2 |
| (d)(iv) | Under which condition is the receiving-end voltage higher than the sending-end voltage in a transmission line? Explain with the help of a phasor diagram. | 4 |
| (e) | Describe the essential features of protective relay. | 10 |

- (f)
- (f)(i) A binary PCM system uses a uniform quantizer and an 8-bit binary encoder. If the bit rate is 100 Mb/s, what is the maximum bandwidth for which the system operates satisfactorily? Determine the output signal to quantization ratio when full-load sinusoidal modulating wave of frequency 1 MHz is applied to the input. 5
- (f)(ii) A discrete memoryless source is described by the alphabet $X=\{x_1, x_2, \dots, x_8\}$ and the corresponding probability vector
- $$P=\{0.2, 0.12, 0.06, 0.15, 0.07, 0.1, 0.13, 0.17\}$$
- Design a Huffman code for this source; find $\bar{L}$, the average codeword length for the Huffman code; and determine the efficiency of the code. 5
2. (a) For the control system, shown in the following figure, determine the steady-state error for a unit step input in terms of K and K_1 , where $E(s)=R(s)-C(s)$. Determine the value of K_1 , when steady-state error is zero:
[Figure: Block diagram: $R(s) \rightarrow$ block $K_1 \rightarrow$ summing junction (+ from K_1 , - from feedback); its output $E(s) \rightarrow$ block $K/(s(s+10)(s+12)) \rightarrow C(s)$; unity negative feedback from $C(s)$ to the summing junction] 20
- (b) A three-phase, 66 kV/11 kV transformer is connected in star/delta. The transformer is protected by Merz-Price circulating current system. Protecting current transformers on the low-voltage side have a ratio of 250/5. Find the ratio of the current transformer on the high-voltage side. 20
- (c) For 8085 microprocessor, explain the CALL instruction, showing the details of main memory and stack. 20
3. (a)
- (a)(i) Draw power triangles showing the three types of power and their units for– (1) inductive loads; (2) capacitive loads. 10
- (a)(ii) A single-phase, 240 V a.c. voltage is applied to a series circuit whose impedance is $10 \angle 60^\circ \Omega$. Find R , X , P and Q , and also the power factor of the circuit. 10
- (b) The equivalent model of a piezoelectrical crystal is shown below:
[Figure: Current source i_{cr} (arrow upwards) in parallel with resistor R_{eq} and capacitor C_{eq} ; output voltage V_o taken across the parallel combination at two output terminals]
- (b)(i) Derive the transfer function relating output voltage (V_o) to input displacement (x_i). Arrange it in standard form and identify the expression for characterising parameters. The charge developed in piezoelectric crystal is related to x_i by a constant k_q . 10
- (b)(ii) “Piezoelectric transducers cannot be used to measure static displacement.” Comment upon the statement. State the reason based on the transfer function derived in Part (i). 2
- (b)(iii) If the lower range of frequency for displacement measurement is 5 kHz with 5% inaccuracy, what is the lower range of frequency for 2% inaccuracy? 8
- (c)
- (c)(i) Explain ASK, FSK and PSK modulation schemes used for transmitting the data. Draw clearly the block diagram for coherent detection and non-coherent detection of FSK modulation scheme. 10
- (c)(ii) A (6, 3) systematic linear block code encodes the information sequence $X=(x_1, x_2, x_3)$ into code word $C=(c_1, c_2, c_3, c_4, c_5, c_6)$ such that c_4 is a parity check on c_1 and c_2 , to make the overall parity even, i.e., $c_1 \oplus c_2 \oplus c_4 = 0$. Similarly c_5 is a parity check on c_2 and c_3 , and c_6 is a parity check on c_1 and c_3 . (1) Determine the generator matrix of this code. (2) Find the parity check matrix for this code. (3) Using the parity check matrix, determine the minimum distance of this code. (4) How many errors of this code are capable of correcting? 10
4. (a)

- (a)(i) Under which different conditions a generator or a number of generators together may lose synchronism or fall out of step in an interconnected power system? Explain in brief. **10**
- (a)(ii) Relating the torque angle and the rotor angular displacement (electrical) of a synchronous generator, derive the 'swing equation' taking into consideration the inertia constant of the machine. Make suitable assumptions. **10**
- (b) For an 8085 microprocessor, write an assembly level program to transfer the contents of the stack pointer register to the output ports A_0 and A_1 . Write comments with selected instructions. **20**
- (c)
- (c)(i) Some control systems have more than one inputs applied at different points in the system. How do we find the response of such systems, using block diagram algebra? Illustrate your answer with the help of a simple example. **10**
- (c)(ii) For the block diagram representation of the figure shown below, determine the system characteristic equation. Is the system represented by this block diagram stable?
[Figure: $R(s) \rightarrow$ summing junction (+) $\rightarrow$ forward block $(s+1)(s+3) \rightarrow C(s)$; feedback from $C(s)$ through block $1/((s+2)(s+4))$ to the (-) input of the summing junction] **10**

SECTION 'B'

5. (a)
- (a)(i) What are the limitations of Routh, Hurwitz and continued fraction stability criteria when used for determining system stability? What is Nyquist analysis? Where is this technique used? **6**
- (a)(ii) Why are integral and derivative controllers not used in practice? **4**
- (b) Can the 8085 microprocessor be interrupted before completion of existing Interrupt Service Subroutine (ISS)? Justify your answer. **10**
- (c)
- (c)(i) Draw the basic circuit of an analog series ohmmeter to measure an unknown resistance R_x . **3**
- (c)(ii) If the standard resistance and meter resistance add up to $20\text{ k}\Omega$, and the battery is of 2.0 V , determine the instrument indication, when $R_x = 0\text{ }\Omega$. **2**
- (c)(iii) What would be the resistance value marked for 0.5 FSD (full-scale deflection)? **2**
- (c)(iv) What component should be connected and in which way to take care of falling battery voltage? **1**
- (c)(v) When each time ohmmeter is used, what adjustment is recommended for accurate measurement? **2**
- (d)
- (d)(i) Define an electrical power grid in one sentence. How is it achieved? **2**
- (d)(ii) Write four main advantages of the electrical power grid system. **2**
- (d)(iii) What is the purpose of installing a 'reactor' at a suitable location on a long high-voltage a.c. transmission line? **2**
- (d)(iv) Write the full form of FACTS. **2**
- (d)(v) What are the advantages of 'reactive power control' installed on the transmission lines? **2**
- (e) What is circuit breaker rating? Explain the rated making capacity of a circuit breaker. **10**
- (f)

- (f)(i)** A convolutional encoder is given in the figure below: (1) Find the impulse response of the encoder. (2) Find the output code word if the input sequence is all 1's (111111...).
 [Figure: Convolutional encoder: input shifted into a 3-stage shift register S_1, S_2, S_3 . Upper modulo-2 adder takes inputs from S_1 and S_2 ; lower modulo-2 adder takes inputs from S_1 and S_3 . The outputs of the two adders go to the two contacts of a commutator switch (upper adder to the upper contact, lower adder to the lower contact) which forms the Output] 5
- (f)(ii)** Determine the channel capacity of band-limited waveform AWGN channel with an input power constraint. 5
- 6. (a)**
- (a)(i)** What are the basic elements of a static relay? Describe the function of each element. 12
- (a)(ii)** What are the advantages of static overcurrent relays over the electromagnetic form? 8
- (b)** Draw a block schematic of an 8255-programmable parallel I/O device, showing all elements and control word format. For mode 0 (simple input and output), determine the addresses of its ports and of the control register. Write a control word in the control register, when port A = output, port C_U = output, port B = input and port C_L = input. 20
- (c)** For the block diagram shown in the figure below, find the overall transfer function of the system. Verify the same, using signal-flow graph analysis:
 [Figure: $R(s) \rightarrow$ summing junction 1 (+ for $R(s)$, - for feedback) $\rightarrow G_1 \rightarrow$ summing junction 2 (+ from G_1 , - from feedback) $\rightarrow G_2 \rightarrow$ node 3 $\rightarrow G_3 \rightarrow$ node 4 $\rightarrow C(s)$. Feedback from node 3 through H_1 to the (-) input of junction 1; feedback from node 4 through H_2 to the (-) input of junction 2] 20
- 7. (a)**
- (a)(i)** Draw the circuit diagram for a single line to ground fault on an unloaded Y-connected generator with its neutral grounded through reactance. Also draw the connection for three symmetrical component sequence networks for this case showing the currents and voltages. 10
- (a)(ii)** A synchronous generator rated at 100 MVA, 20 kV has $X''=X_2=20\%$ and $X_0=5\%$. Its neutral is grounded through a reactor of 0.32Ω . The generator is operating at rated voltage without load and is disconnected from the system when a single phase to ground fault occurs at its terminals. Find the sub-transient current in the faulted phase. 10
- (b)**
- (b)(i)** Draw the neat sketch of OSI model. What is the significance of data link layer? Explain the flow-control and error-control mechanism. 10
- (b)(ii)** Compute the CRC-4 character for the following message, using a modified divisor constant of 10011: 1100 0110 1011 01 10
- (c)** The a.c. bridge circuit shown below is used to measure the excitation frequency of the source and the resistance R_x connected in arm CD of the bridge. Arm AB is parallel combination of R_1 and C_1 , arm BC is fixed resistor R_2 , arm AD is serial combination of R_4 and C_4 :
 [Figure: Bridge ABCD drawn as a diamond (B top, A left, C right, D bottom) with four arm impedances (unlabelled boxes) AB, BC, CD and DA; detector G connected between A and C; source V_s (a.c.) connected between B and D] 10
- (c)(i)** Find the expression for the unknown resistance R_x at balance. 5
- (c)(ii)** Find the expression for unknown excitation frequency (ω) at balance. 5
- (c)(iii)** If $R_1=200 \Omega$, $C_1=1 \mu F$, $R_2=400 \Omega$, $C_1/C_4=0.5$ and $R_4/R_1=2$, find the value of R_x in $k\Omega$ and frequency of excitation in kHz. 10
- 8. (a)** What is the importance of testing of a circuit breaker? Explain different tests carried out to prove the ability of a circuit breaker. 20
- (b)**

- (b)(i)** Bring out the salient points of relation between DM and DPCM. Draw the block diagram of delta modulator and demodulator. **8**
- (b)(ii)** Find the capacity of an additive white Gaussian noise channel with a bandwidth 1 MHz, power 10 W and noise power spectral density $N_0/2=10^{-9}$ W/Hz **6**
- (b)(iii)** Explain cyclic codes. **6**
- (c)** The circuit given below is made by three ideal operational amplifiers (op-amp):
 [Figure: Three op-amp circuit. Op-amp 1: V_1 to the non-inverting (+) input; output at point (c); resistor R from (c) to point (a); the inverting (-) input of op-amp 1 is connected to (a). Resistor R_g from (a) to point (b). Op-amp 2: V_2 to the (+) input; output at point (d); resistor R from (b) to (d); the (-) input of op-amp 2 is connected to (b). Op-amp 3 (difference amplifier): (c) through R_1 to its (-) input, feedback R_2 from its output (point (e)) to the (-) input; (d) through R_1 to its (+) input, with R_2 from the (+) input to ground]
- (c)(i)** Identify the name of the circuit. Comment upon its CMRR in comparison to op-amp. **2**
- (c)(ii)** Find the expressions for voltages at points (a), (b), (c), (d) and (e). **10**
- (c)(iii)** If $V_1=5$ V and $V_2=5.05$ V and V_e (voltage at point (e)) is 5 V, find the ratio of R/R_g and R_2/R_1 , when overall gain is divided in the ratio of 10:1 between first and second stage of the circuit. **8**