ELECTRICAL ENGINEERING

PAPER - I

Time Allowed: Three Hours   **Maximum Marks: 200**

Candidates should attempt SIX questions, selecting TWO questions

from Part A, ONE from part B, ONE from Pair C, and

TWO from Part D.

PART A

1.   (a)   State and explain (i) Thevenin's theorem and (ii) Norton's theorem.

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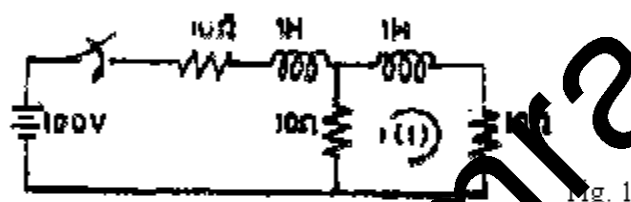   (b)   Determine the current i(t) in the circuit of Fig.1 using Thevenin's theorem.

Fig. 1

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   (c)   A voltage of pulse 10V magnitude and 1 μsec duration is applied to the RC network shown in Fig. 2 Determine the current i(t) and show its variation with time.

Fig.2

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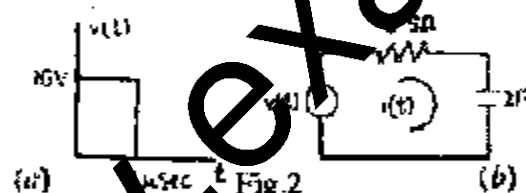
2.   (a)   State the necessary conditions for a network function to be a driving point function.

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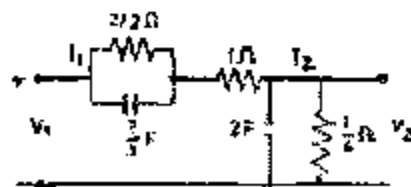   (b)   For the network shown in Fig. 3, determine the transfer admittance Y_{12}.

Fig. 3

                                                  12

   (c)   Two two-port networks having parameters A_1, B_1, C_1, D_1 and A_2, B_2, C_2, D_2 respectively are connected in cascade. Determine the parameters of the overall network.

                                                  12

3. (a) Explain clearly the following

    (i)   Poles and zeros of a network function

    (ii)   Frequency response of a network

                                                               6

(b) The driving point impedance function of a network is given as

$$z(s) = \frac{(s+1)(s+3)(s+5)}{s(s+2)(s+4)(s+6)}$$

Determine the Foster first form of realization of the network.

                                                          10

(c) State and explain Masons' gain formula for signal flow graphs. Fig.4 shows block diagram of a Feedback Control system. Obtain an expression for the closed loop transfer function of the system using signal flow graph of the system.
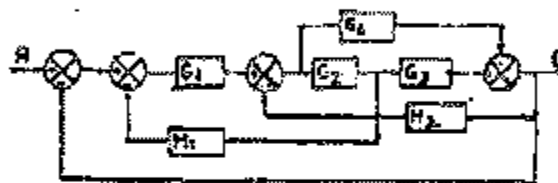

Fig.4

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PART B

4. (a) Find the work involved in moving a charge of 1 coulomb from (6, 8, −10) to (3, 4, −5) along a single straight line in the field

$$\bar{E} = -x\bar{a}_x + y\bar{a}_y - 3\bar{a}_z$$

                                                          10

(b) The volume charge density distribution in a device is given by $p = 2p_o$ sech x/a tanh x/a

Determine an expression for voltage using Poission's

Equation. Assume E = 0 as x±∞ and V = 0 at x = 0.

                                                           18

(c) Find the e.m.f. developed about the path r = 0.5, z = 0 at t = 0 if

                                                           8

$$\bar{B} = 0.1\bar{a}_c \sin 377t$$

5. (a) Starting from first principle, derive Maxwells equations in integral form. Write these equations in different form.

                                                           12

(b) Derive an expression for Poynting vector and explain its significance.

                                                           16

(c) Find the velocity at which a sinusoidal signal of 10^9 rad/sec travels down a line for which L = 0.4 µH/m and C = 40 pF/m. Assume the line to be lossless. Derive any formula used.

                                                           8

PART C

6. (a) Explain the phenomena of (i) Ferro-electricity and (ii) Piezo-electricity. Give examples of materials which exhibit these characteristics.

10

(b) Explain the basis on which solid materials are classified as conductors, insulators and semiconductors. Differentiate these materials with reference to Energy Band Theory.

0

(c) What are artificial dielectrics? Derive an expression for the relative permittivity of such a material.

16

7. (a) Differentiate between anti-ferromagnetism, ferromagnetism and ferrimagnetism.

12

(b) Explain what is Hall effect, Derive an expression for Hall voltage.

12

(c) Four micrograms of antimony are thoroughly mixed in molten form with 100 gm of pure germanium, and antimony atoms substitute for germanium atoms uniformly throughout the solid material. Find (i) the density of antimony atoms (ii) the density of donated electrons (iii) the conductivity if electron mobility is 3600 cm^2/volt-sec for the carriers. Assume density of Ge = 5.46 gm/cm^3, Atomic weight of antimony 121.76. The electron carries a charge of 1.6 $\times$ 10^{-19} Cb.

12

PART D

8. (a) Explain the nature of problems faced while measuring very low valued and very high valued resistors.

6

(b) In a test on bakelite sample at 20kv 50Hz by a Schering bridge having a standard capacitor of 106 pF, balance was obtained with a capacitance of 0.35 µF in parallel with a non-inductive resistance of 318 ohms, the non-inductive resistance in the remaining arm of the bridge being 130 ohms. Determine the capacitance, the p.f. and equivalent series resistance of the specimen. Derive any formula used. Indicate the precautions to be observed for avoiding errors.

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(c) Explain with the help of a basic diagram how you measure Q of a coil.

6

9. (a) Explain with the help of neat diagrams how you would mean-sure the frequency of a signal using CRO.

8

(b) Briefly describe the types of resistance strain gauges available while deriving the expression for the gauge factor. Show how a transducer can be designed by using them for the measurement of liquid level.

(c)   Describe with neat diagram the operation and application of a balanced bridge triode vacuum tube voltmeter.

8

10.   (a)   What is spectrum analysis? Describe with the help of neat diagram the operation of a spectrum analyzer.

8

(b)   Describe with the help of block diagram the principle of operation of a digital frequency meter.

8

(c)   Discuss the relative merits and demerits of telemetering a measured variable into a related (i) dc voltage. (ii) dc current and (iii) frequency. Draw simple schemes showing the arrangements.

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ELECTRICAL ENGINEERING

PAPER - II

Time Allowed: Three Hours   **Maximum Marks: 200**

Candidates should attempt FIVE questions in all, choosing at least ONE from each Section.

SECTION A

1. (a) A matrix

$$\begin{bmatrix} 3.8 & -1.7 & -1.2 \\ -0.6 & 4.2 & -1.1 \\ -1.5 & -0.9 & 4.1 \end{bmatrix}$$

is to be read by the following segment of the program. Show for each case how the data cards are to be prepared.

(i)   DO 15 I = 1, 3

         DO 15 J = 1, 3

15   READ 16,P(I,J)

16   FORMAT (3 F 5.2)

(ii)   DO 15 I = 1,3

15   READ 16,(P(I,J),J=1,3)

16   FORMAT (5F 5.2)

(iii)   READ 16,(P(I,J),J= 1, 3), I=1,3)

16   FORMAT (5 F 5.2)

(vi)   READ 16,(P(I,J),J=1,3),I=1,3,

16   FORMAT (2F 5.2)

12

(b) In an electric Circuit the resonance frequency is given by

$$f_0 = \frac{1}{2\pi\sqrt{LC}}\sqrt{\frac{R_L^2 - \dfrac{L}{C}}{R_C^2 - \dfrac{L}{C}}}$$

It is required to compute and print f_0 for inductance L=2, 2.5, 3 and 3.5 mH with capacitance C varying from 1 to 2 μF with an increment of 0.2 μF. Take R_L = 5 ohms and R_C = 15 ohms. Draw a neat flowchart and write a complete FORTRAN program.

14+14

2. (a) A and B are square matrices of order 6. Write a FORTRAN program to read these two matrices and to check whether they are inverse of each other or not. Note that if two matrices are inverse of each other, their product will be a unit matrix.

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(b)   Consider a currency system in which there are notes of 7 denominations, namely

        Re 1   Rs 2   Rs 5   Rs 10   Rs 20   Rs 50   Rs 100

Given a sum of Rs N, write a FORTRAN program to compute the smallest number of notes that will combine to give Rs N. Value of the sum and the number of notes in different denominations are to be printed out.

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SECTION B

3. (a)   With proper circuit diagram, explain the working of shaded pole single phase induction motor.

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(b)   Describe the star-delta method of starting a three-phase induction motor.

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(c)   A 100 HP induction motor is coupled to an industrial drive whose torque varies directly as the square of the speed. An e.m.f. of 100 V per phase is induced in the rotor winding of the induction motor at standstill. The full-load slip of the induction motor is 5 per cent. Calculate the resistance to be added in the rotor circuit to reduce the speed by 20 per cent. Neglect the mechanical losses and rotor reactance.

20

4. (a)   The maximum efficiency of a 100 kVA single phase transformer is 98 per cent and occurs at 80 per cent full load at 0.8 p.f. If the leakage impedance of the transformer is 5 per cent, find the voltage regulation at rated load at 0.75 p.f. lagging.

12

(b)   Draw the layout of a typical thermal electric power station and explain the functions of major components in it.

13

(c)   A synchronous motor is receiving 30 per cent of the power that is capable of receiving from an infinite bus. If the load on it is doubled, calculate the maximum value of the rotor angle during swinging of the motor around its new equilibrium position.

15

5. (a)   Develop the policy for optimal generation scheduling among N units in a thermal plant for a total load of P_D. Explain how the minimum and maximum power limits of the units can be accounted.

10

(b)   A power plant has three units with the following input-output characteristics:

$$Q_1 = 0.002\ P_1^2 + 0.86\ P_1 + 20 \text{ tons/hour}$$

$$Q_2 = 0.004\ P_2^2 + 1.08\ P_2 + 20 \text{ tons/hour}$$

$$Q_3 = 0.0028\ P_3^2 + 0.64\ P_3 + 36 \text{ tons/hour}$$

where P_1, P_2, and P_3 are the generating powers in MW. The fuel cost is Rs 25 per ton. The maximum and minimum possible generations from each unit are 120 MW and 39 MW respectively. Find the optimal scheduling for a total load of 200 MW.

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(c) Explain the differential protection scheme for protecting three- phase transformer against short circuits.

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SECTION C

6. (a) Consider a single control area with integral control. Draw its block diagram representation. There is a sudden increase in load of ΔP_D. Show that

(i) the system will be stable (ii) the final frequency error will be zero. Assume that the action of the speed governor plus the turbine generator is instantaneous and the product of their gain constant is equal to one.

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(b) A second order servo-system has poles at $-1 \pm j2$ and a zero at 1. Its steady state output for a unit step input is 3. Determine its transfer function. What is its peak over-shoot for a unit step input.

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7. (a) Consider the open-loop transfer function of a unity feedback system

$$G(s) = \frac{k}{(s+3)(s+5)(s^2+2s+2)}$$

In the root locus diagram for this system-

(i) Determine the number of branches of root loci. (ii) Determine at what locations these branches start. (iii) determine where the branches terminate. (iv) Find the angles of the asymptotes and the point at which the asymptotes intersect the real axis. (v) Find the breakaway point. (vi) Find the points where the root loci cross the imaginary axis.
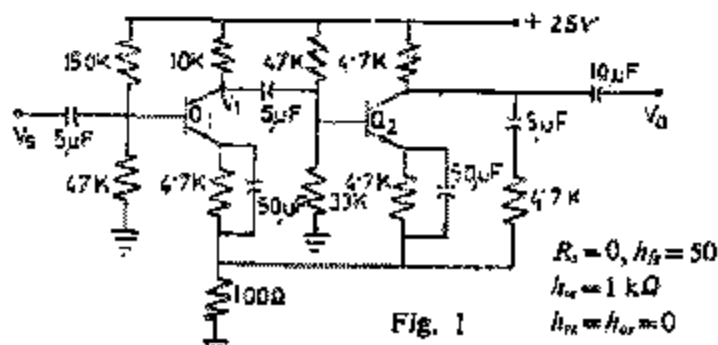
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(b) For the system described

$$\begin{bmatrix} x_1 \\ x_2 \end{bmatrix} = \begin{bmatrix} 0 & 1 \\ 0 & -2 \end{bmatrix}\begin{bmatrix} x_1 \\ x_2 \end{bmatrix}$$

determine the state transition matrix.

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SECTION D

8. Consider the circuit shown in Fig. 1.

Fig. 1

$R_s = 0$, $h_{fe} = 50$
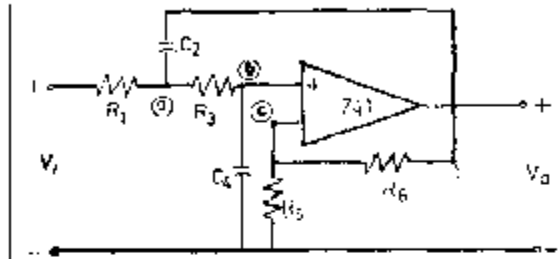$h_{ie} = 1\ k\Omega$
$h_{re} = h_{oe} = 0$

Determine the type of feedback and hence calculate the gain stabilized by this feedback. Also determine the input impedance with feedback and the output impedance with feedback.

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(b) Draw the necessary circuit diagram and explain the push-pull configuration. Mention its advantages.

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(c) Fig. 2

In terms of the admittances of the different parameters, show that the transfer function of the circuit shown in Fig. 2 is

$$\frac{V_o}{V_i} = \frac{Y_1 Y_8 \left(Y_5 + Y_6\right)}{Y_1 Y_6 \left(Y_3 + Y_4\right) + Y_4 Y_6 \left(Y_2 + Y_3\right) - Y_2 Y_3 Y_5}$$

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9. (a) Implement the following Boolean expression using minimum number of 3 input NAND gates:

$$f(A,B,C,D) = \sum (1, 2, 3, 4, 7, 9, 10, 12)$$

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(b) Design a 4 bit magnitude comparator.

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(c) Draw the schematic of the up-down ripple counter and briefly explain the principle of operation.

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(d) Explain the successive approximation A/D converter.

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10. (a) With the help of a diagram explain the generation of SSB wave.

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(b) Derive an expression for mean square quantization error in PCM.

14

(c) A 35 MHz carrier is modulated by a 700 Hz audio sine wave. If the carrier voltage is 5V and the maximum deviation is 14 kHz, write the equations of this modulated wave for FM and PM.

If the modulating frequency is now changed to 2.1 kHz, all others remaining unaltered, write the new equations for FM and PM.

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