# 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 Part C and TWO from Part D.***

## PART A

1. (a) By the iterated use of Thevenin's theorem reduce the circuit shown in Fig 1 to a single e.m.f. acting in series with a single resistor. Hence calculate the current in the 1.0 ohm resistor XY.

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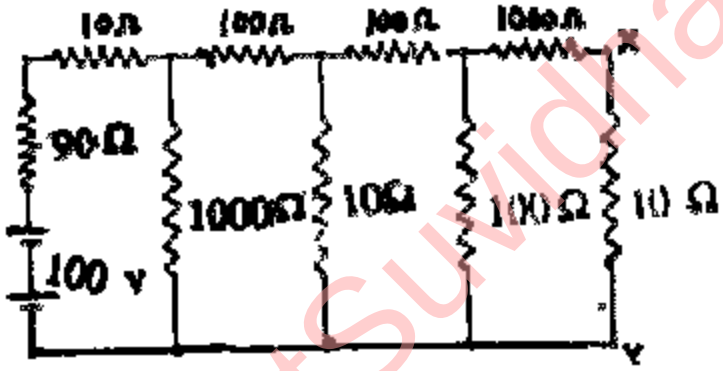


Fig. 1.

(b) Fig 2 shows a staircase voltage wave-form. Assuming that the staircase is not repeated, express its equation in terms of step functions. If this voltage is applied to a series R – L circuit with R = 2 ohms and L = 1 H, find an expression for the resulting current i(t). $(0^+) = 0$.

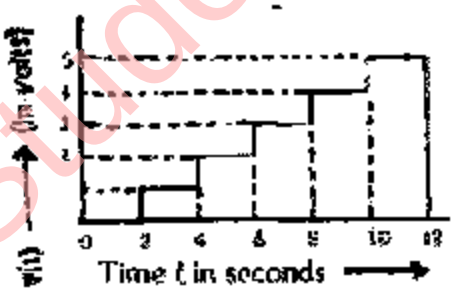


Fig. 2.

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(c) What do you understand by (i) Y-parameters. and (ii) h-parameters of a 2-port network ? Find the Y-parameters for the network shown in Fig 3.

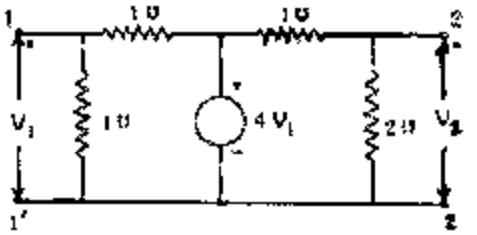


Fig. 3

2. (a) Define the following network functions with reference to a 2-pan network:

(i) Driving point impedance

(ii) Transfer admittance

Obtain $\frac{V_{ab}(s)}{V(s)}$ for the network shown in Fig. 4.

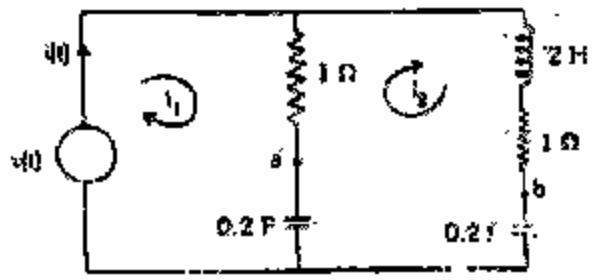


Fig. 4

(b) A voltage of 100 V at a frequency of $\left(\frac{10^6}{2\pi}\right) Hz$ is applied to the primary of the coupled circuit shown in Fig 5. Calculate the total resistance and reactance referred to the primary. Determine also the primary and secondary currents.

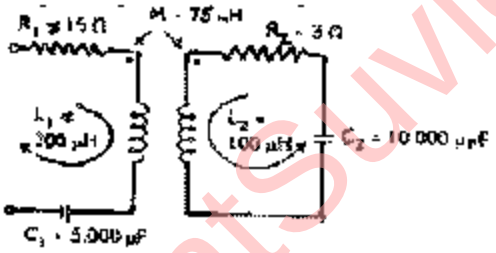

Fig. 5

(c) What do you understand by

(i) Zeros of a function (ii) Zeros of transmission ?

What information do poles and zeros provide in respect of a network to which they relate? Draw poles and zeros for $V(s) = \frac{s^2+3s+2}{s^2+7s+12}$ and evaluate v(t) either analytically or by making use of pole-zero diagram.

10

3. (a) Show that the locus of the poles of the driving point impedance of a series RLC circuit in the complex s-plane is a circle of radius $\omega_n$ the natural angular frequency and that the locus is formed by varying damping ratio $\zeta$ from 0 to 1.

Draw the frequency response plots of the voltage ratio transfer function of the 2-port RC network shown in Fig 6.

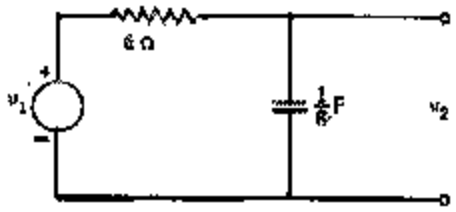


Fig. 6

(b) An impedance function is given by

(i) Show that Z(s) satisfies the conditions of minimum function.

(ii) Obtain the Brune's network realization for the function.

(c) State mason's Gain Formula. Hence or otherwise, find I and $E_C$ in terms of the input variables $E_1$, i(0) and $e_c$ (0) of the network whose signal flow-graph is shown in Fig 7.

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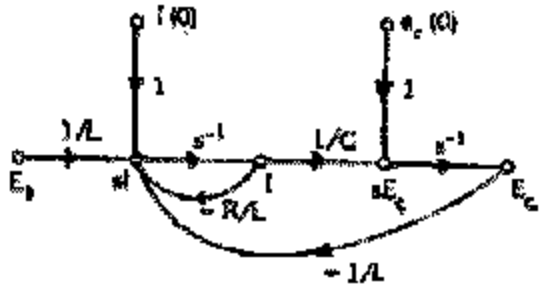


$R = 1\Omega, 1 = 1H, C = 1/4\ F$

## PART B

4. (a) (i) State Maxwell's equation in differential form corresponding to Gauss's Law for electric fields. Starting from the Maxwell's equation in differential form, obtain the Poisson's equation for the general situation in which the permittivity of the medium is not constant and is a function of position.

(ii) Starting from the equation of continuity, show for a conducting medium obeying Ohm's law, J = γ E, and using Gauss's law, that

$$\frac{\partial \rho}{\partial t} + \frac{\gamma}{\varepsilon_0}\rho = 0$$

where ρ is the charge density.

6, 6

(b) An infinite cylinder of radius p has a charge distribution of the form $\rho v = \rho_0 e^{-\rho/\rho 1}$

Derive expressions for electric field and electrostatic potential produced by this charge distribution. The potential is zero at the radius $\rho_1$.

12

(c) State Biot-Savart Law in its integral form. Find the magnetic induction at any point on the line through the center, and perpendicular to the plane circular current loop.

5. (a) Obtain Maxwell's equations in integral and differential forms as derived from Faraday's Laws.

12

(b) What do you understand by

(i) uniform plane wave

(ii) linearly polarized wave, and

(iii) elliptically polarized wave ?

The electric field intensity associated with a plane wave travelling in a perfect dielectric medium having $\mu = \mu_0$ is given by

$E = 10 \cos (6 \pi 10^7 t - 0.4 \pi Z)\ i_x$ V/m

Find the phase velocity, the permittivity of the medium and associated magnetic field vector H. Velocity in free space = $3 \times 10^8$ m/sec.

12

(c) Define, in relation to travelling waves, the following:

(i) Reflection co-efficient

(ii) Transmission co-efficient, and

(iii) Standing wave ratio

An electric field wave travelling in air is incident normally on a boundary between air and dielectric having permeability ç and relative permittivity $\varepsilon_r = 4$. Prove that one-ninth of the incident power is reflected and eight ninth of it transmitted into the second medium.

12

## PART C

6. (a) What do you understand by Dipolar relaxation? Show that dipolar relaxation leads to a complex dielectric constant of the material and deduce an expression for the same.

12

(b) What are piezo-electric materials? Give their applications. A pick up made from a piezo-electric material has the dimensions of 5 mm x 5mm x 1.25 mm. The force acting on it is 3N. The charge sensitivity of the material is 150 pC/N, its voltage sensitivity is $12 \times 10^{-3}$ Vm/N and its permittivity is $12.5 \times 10^{-9}$ F/m, Calculate the charge and the capacitance.

12

(c) What are Ferrites and Ferromagnetic materials ? Give their properties and applications.

12

7. (a) What is meant by relaxation time, collision time and mean free path as applied to conduction phenomenon ?

The following data is known for copper:

Resistivity = $1.73 \times 10^{-8}$ ohm-m Average time of collision of electrons = $2.42 \times 10^{-14}$ sec

Find (i) the valence electrons per unit volume, and (ii) Mobility of electrons,

e = $1.6 \times 10^{-19}$ C; m = $9.1 \times 10^{-31}$ kg.

12

(b) What are Ferro-electric materials? Explain the phenomenon of spontaneous polarization in ferro-electric materials.

12

(c) What are n-type and p-type semiconductors? Explain Zener and Avalanche breakdown in semiconductors.

12

## PART D

8. (a) List the factors that may lead to inaccuracies in measurements by AC. bridges.

The four arms of a bridge are:

arm ab : an imperfect capacitor $C_1$ with an equivalent series resistance of $r_1$

arm bc : a non-inductive resistance $R_3$

arm cd : a non-inductive resistance $R_4$

arm da : an imperfect capacitor $C_2$ with an equivalent resistance $r_2$ in series with a resistance $R_4$ .

A supply of 450Hz is given between terminals a and c and detector is connected between b and d. At balance = 5Ω, $R_3$ = 2000Ω , $R_4$ = 2950 ohms, $C_2$ = 0.5 μF and $r_2$ = 0.4Ω. Calculate the values of $C_1$ and $r_1$ and also of the dissipating factor for this capacitor. Derive the relations used, if any.

12

(b) Give the basic principle of working of an electrostatic voltmeter. Explain how you would increase (i) the operating forces, and (ii) voltage range of the voltmeter.

10

(c) Give the constructional features arid principle of working of a synchroscope.

10

9. (a) Explain the principle of electrostatic focusing of an electron beam in a C.R.O.

Calculate the maximum velocity of the beam of electrons in a CRT having a cathode anode voltage of 1000 V.

Assume the electrons to leave the cathode with zero velocity. Charge of electron = $1.6 \times 10^{-19}$ C and mass of electron = $9.1 \times 10^{-31}$ kg.

10

(b) What are capacitive transducers? What are their advantages and disadvantages? Explain the use of capacitive transducers for the measurement of liquid level.

12

(c) Explain the basic constructional features and principle of working of a strip chart recorder.

10

10. (a) Explain with the help of block diagram the principle of operation of a ramp type Digital Voltmeter .

10

(b) What is multiplexing in Telemetering system? Explain the principle of Time Division Multiplexing.

10

(c) Explain Segmental Displays and Dot matrices for numeric and alphanumeric displays. Draw circuits for a seven segment display and a 5 x 7 dot matrix using LEDs.

12

# ELECTRICAL ENGINEERING

## PAPER - II

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

**Candidates should attempt FIVE questions in all, choosing at least ONE front each section.**

## SECTION A

1. (a) State the rules related to the FUNCTION SUBPROGRAM.

   (b) Discuss, in brief, the general architecture of a modern digital computer system and indicate the advances which have taken place in recent years in input/output devices.

   (c) A set of 150 data representing the three sides of the triangle are available in real mode. Some of them are invalid since the sum of any two sides is not greater than the third side. Write a FORTRAN program that can do the following for the given data.

   (i) Read the three sides

   (ii) Check whether it is a valid set; give proper print out.

   (iii) For each valid set compute and print the area using the formula

   $$\text{Area} = \left[s(s-a)(s-b)(s-c)\right]^{1/2}$$

   where $s = (a+b+c)/2$

   15

2. (a) Draw a flow chart and write a FORTRAN program to read an integer N > 2 and determine if N is a prime number. N will be a prime number if it is not divisible by any number except 1 and N.

   15

   (b) Explain the function of a ALU.

   5

   (c) Write a SUBROUTINE subprogram to multiply a matrix R of order (L, M) with a matrix S of order (M, N) and store the product as T matrix.

   Write a main program that will use the above subroutine to compute the matrix polynomial

   $$C = 5X - 9Y^2 - 7Z^2$$

   The input to the program will be the elements of matrices X, Y and Z of order less than or equal to 15.

   20

## SECTION B

3. (a) Describe a series (universal) motor. Give its cross-sectional view when connected to ac supply. Describe its performance characteristics

   10

(b) A squirrel-cage induction motor has a slip of 4% at full load. Its starting current is five times the full-load current. The stator impedance and magnetising current may be neglected; the rotor resistance is assumed constant.

(i) Calculate the maximum torque and the slip at which it would occur.

(ii) Calculate the starting torque.

Express torques in pu of the full-load torque.

20

(c) What do you understand by a synchronous condenser? Explain with the help of phasor diagrams its operation and application.

10

4. (a) Explain with a neat sketch the working of a thermal-electric power station and explain the functions of major components in it.

15

(b) A 100 MVA synchronous generator operates on full load at a frequency of 50 Hz. The load is suddenly reduced to 50 MW. Due to time lag in governor system, the steam valve begins to close after 0.4 seconds. Determine the change in frequency that occurs in this time.

Given: H = 5 kW-s/kVA of generator capacity.

10

(c) Distinguish between the "transient" and "dynamic" stability of a power system. Discuss any three recent means of improving transient stability of a power system.

5. (a) Consider the following three incremental cost (IC) curves:

$P_{G1} = -100 + 50\ IC_1 - 2\ (IC_1)^2$

$P_{G2} = -150 + 60\ IC_2 - 2.5\ (IC_2)^2$

$P_{G3} = -80 + 40\ IC_3 - 1.8\ (IC_3)^2$

where ICs are in Rs/MWh and $P_G$'s are in MW. The total load at a certain hour of the day is 400 MW. Neglect transmission loss and find optimum values of generations i.e. $P_{G1}$, $P_{G2}$ and $P_{G3}$.

10

(b) Draw the block diagram representation of single area with proportional plus integral controller. Show that the system is stable and isochronous.

10

(c) The emf per turn of a 1-phase 2200/220 V, 50 Hz transformer is approximately 12 V. Calculate

(i) the number of primary and secondary turns, and

(ii) the net cross-sectional area of core for a maximum flux density of 1.5 T.

12

(d) Find the resistance of the load which takes a power of 5 kW from a dc shunt generator whose external characteristic is given by the equation $V = 250 - 0.5\ I_L$ .

8

## SECTION C

6. (a) Explain what is meant by the relative stability of a system. How do we specify relative stability in terms of (i) closed-loop pole locations, (ii) gain margin and phase margin?

15

(b) Obtain the root locus diagram for a unity feedback system with open-loop transfer function

$$G(s) = \frac{k}{s\left(s^2 + 6s + 10\right)}$$

15

(c) Explain how stability analysis is carried out using

(i) transfer function model (ii) state variable model. Which of the two models gives complete information on system stability?

7. (a) Discuss in brief three different canonical state models to study the controllability and observability properties of a system.

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(b) Consider the closed-loop feedback system shown in Fig 1. Determine the range of k for which the system is stable.

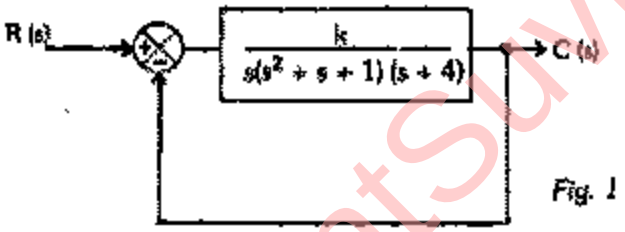


Fig. 1

(c) Examine the observability of the system given below

$$\begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ 0 & -2 & -3 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} + \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix} y = \begin{bmatrix} 3 & 4 & 1 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix}$$

## SECTION D

8. (a) Explain the working of a zener diode and its use as a reference voltage device.

8

(b) Show that the gain-bandwidth product of an amplifier with negative feedback -is the same as that of an amplifier without feedback.

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(c) For the combinational logic circuit shown in Fig 2 obtain simplified Boolean expressions for the output variables V, W. X, Y and Z in terms of the input variables A, B and C.

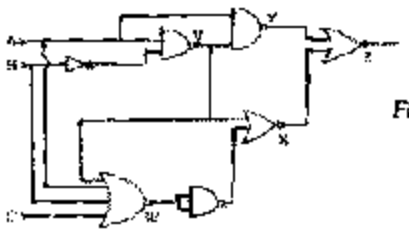

Fig. 2

(d) How does a UJT differ from a Junction Field Effect Transistor ? 7

9. (a) Draw the circuit diagram of aRC phase-shift oscillator and obtain an expression for its frequency of oscillation. 24

(b) Distinguish between JEFF and MOSFET. 8

(c) Explain how a JEET can be used as a square-law modulator 8

10. (a) Explain the principle and advantages of P.C.M. 15

(b) Draw the circuit diagram of an FM detector and describe its operation. 10

(c) Compare the average transmitter power and channel bandwidth requirements of USE, 558, and AM schemes for transmitting an audio signal with a bandwidth of 10 kHz with a destination signal-to-noise ratio of 50 dB. Assume that channel introduces a 50 dB power loss and that the noise power spectral density at the receiver input is $10^{-12}$ W/Hz. Assume the ratio of total sideband power to the carrier power (i.e. $m^2 S_x$) for AM as 0.5.