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. The number of marks carried by each question is indicated at the end of the question. Answer must be written in English.

Assume suitable data, if necessary and indicate the same clearly.

PART A

1. (a) Define unit step unit impulse unit ramp and shifted unit step functions and indicate their inter-relationship.

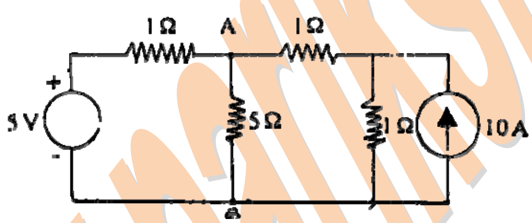
8

(b) Find the current i(t) in a series R–L–C circuit comprising R = 3Ω. L = 1 H and C = 0.5 F. when each of the following driving force voltage is applied:

(i) ramp voltage 12 r(t–2) (ii) step voltage 2u (t–3)

14

(c) Find using Thevenin's theorem, the current in the 5-ohm resistor connected across, 1B in the network shown in the figure below:



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2. (a) Explain what you understand by:

(i) Driving point impedance and transfer impedance of a network.

(ii) Poles and zeros of a network function. Discuss restrictions on the pole-zero location in the S-place for driving point impedance functions.

12

(b) A two-terminal network consists of a coil having an inductance L and resistance R shunted y a capacitance C. The poles and zeros of the driving point function Z(s) of this network are:

Poles at $-\frac{3}{2}\pm\frac{\sqrt{3}}{2}$

Zero at –3+jo

If Z (jo) = 1. determine the values of R, L and C.

8

(c) A 2-port network has:

(i) at port 1, driving point impedance 60Ω and 50Ω with port 2 open circuited and short circuited respectively.

(ii) at port 2, driving point impedance 80Ω and 70Ω with port 1 open circuited and short circuited respectively.

Find the image parameters of the network. Derive the expressions used.

12

3. (a) State clearly the conditions to be fulfilled for a function to be positive rea1

Test the following polynomial for Hurwit/properly

$$2S^0 + S^5 + 13S^1 + 6S^3 + 56S^2 + 255 + 25$$

10

(b) Explain the difference in the philosophy between Foster Caner forms of synthesis of a given driving point impedance.

Realize the network function

$$Y(S) = \frac{(S+2)(S+4)}{(S+1)(S+3)}$$

and a Cauer network.

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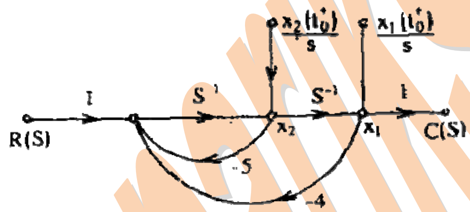
(c) What is a Silent-flow graph? Give its properties. For the signal-flow graph shown in the figure below find using Mason's gain formula, the Transfer function $\frac{C(S)}{R(S)}$.



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PART B

4. (a) Derive the expression for the expression for the electric field intensity at any point inside and outside of a sphere of radius a due to a uniform spherical distribution of charge of density ρ by applying Poission's equation or its equivalent Div. $\bar{D} = \rho$ both inside and outside the sphere. One constant is evaluated by matching solutions at the boundary of the sphere and the other is evaluated by nothing that $\bar{D}$ is zero at the centre of the sphere.

12

(b) Two isotropic dielectric media 1 and 2 with relative permittivities ε_{11} and ε_{12} are separated by a charge-free boundary. The conductivities of the two media are zero. The field lines in the two media made angles θ_1 and θ_2 with normal to the charge-free boundary. Prove that

$$\frac{\tan\theta_1}{\tan\theta_2} = \frac{\varepsilon_{r1}}{\varepsilon_{r2}}$$

Show that static electric fields line it a dielectric conductor boundary is always perpendicular to the conductor surface when no current is present)

12

(c) A fixed square 9-turn coil with lower left corner at the origin has sides of lengths x_1 and y_1. If $x_1 = y_1 = 1$m and if the magnetic flux density $\bar{B}$ is normal to the plane of the coil and has a space variation of amplitude

$$B_o = 5\sin\frac{\pi x}{x_1}\sin\frac{\pi y}{y_1}T$$

Find the r.m.s e.m.f. induced in the coil if $\bar{B}$ varies harmonically with time at 1000 cps.

12

5. (a) What do you understand by Magnetic Vector Potential?

Find the magnetic vector potential $\bar{A}$ of a lone wire of circular cross-section of radius b carrying a current of density $\bar{J}$. From the value of $\bar{A}$. deduce the expression for $\bar{B}$.

12

(b) Given the properties of a linearly polarized uniform plane wave. A uniform plane wave is specified by $H = 2e^{jo1/}\bar{a}y$ Ā/m. If the velocity of the wave is 2 x 10^8 m/s and the relative permeability is 1.6. Find the frequency. Relative permittivity wave-length and intrinsic impedance.

12

(c) Distinguish the linearly, elliptically and circularly polarized waves.

An elliptically polarized wave in air has x and y components.

$E_x = 4\sin(\omega t - \beta z)$ volts/metre

$Ey = 8\sin(\omega t - \beta z + 75^o)$ volts/metre)

Find the Poynting Vector. For air the intrinsic impedance is 376.7 ohms.

12

PART C

6. (a) Distinguish between soft and hard magnetic materials and classify them suitably. Indicate the properties sought in each case and suggest their applications.

12

(b) Explain what you understand by polarization of a dielectric.

An isotropic material has N elements/m^3 of polarizability α. The total electric field acting on each element is $E + E_1$ where E is the applied field and E_1 is the additional field caused by the presence of the polarized dipoles.

The simplest calculation for E_1 gives the value $P/3\varepsilon^o$. Show that the relative permittivity of material is then

$$\varepsilon_1 = \frac{1 + \frac{2}{3}\frac{N\alpha}{\varepsilon_0}}{1 - \frac{N\alpha}{3\varepsilon_0}}$$

12

(c) Explain the phenomenon of

(i) Magnetostriction, and

(ii) Hysteresis in ferromagnetic materials.

12

7. (a) Explain different types of electron emissions from metals and metallic compounds.

12

(b) Distinguish between intrinsic and extrinsic semiconductors. What do you mean by 'Zener' and 'Avalanche' breakdown in the barrier layer of a semiconductor?

12

(c) A specimen of germanium at 300^oK for which the density of Carriers is $2.5 \times 10^{13}/cm^3$, is doped with impurity atoms such that there is one impurity atom for 10^o germanium atoms. All the impurity atoms may be assumed ionized. The resistivity of doped material is 0.039 ohm-cm. Carrier mobility for germanium at 300^oK is 3600. For the doped material, find the electron and hole densities, $c = 1.602 \times 10^{-19}C$.

12

PART D

8. (a) What are the difficulties associated with measurement of low resistances ? Describe how low resistance is measured accurately by Kelvin's double bridge.

12

(b) An a.c. bridge ABCD has the following four arms taken in sequence.

Arm AB a capacitance c with series loss effect resistance R in series with the primary of a mutual inductance M.

Arm BC resistance R_2.

Arm CD resistance R_3.

Arm DA loss-less capacitance C_4.

The primary of mutual inductance has self-inductance L and negligible resistance. The secondary of mutual inductance is connected in series with detector across BD. The source of angular frequency ω is connected across IC. Determine the capacitance c and associated loss angle if the bridge is balanced with $\omega = 10^3$, M = 0.0015H, $R_2 = R_3 = 10^4\Omega$, L = 0.0045H and $C_4 = 0.15\ \mu F$. Derive the balance conditions and there from the expression used. Comment on the sources of error in measurement.

14

(c) Explain the working of any one type of phase sequence indicator.

6

9. (a) Briefly explain the principle of working of a C.R.O.

The voltage across horizontal deflector plates of C.R.O. is $V_1 \sin(\omega t + \theta_1)$ and the across the vertical plates is $V_2 \sin(\omega t + \theta_2)$. Prove that the trance on the screen is an ellipse. Determine its equation and interpret its meaning.

10

(b) What is an electrical transducer? Discuss its primary role and therefore its characteristics.

6

(c) Explain the principle of working of a Linear Variable Different Transformer (LVDT). Show how it can be used for the measurement of small mechanical-displacement.

8

(d) For a piezoelectric transducer a flat frequency response within 10% is required. Find the value of minimum frequency at which it can be use and the corresponding phase shift given that the time constant of the transducer is 1.8 ms.

8

10. (a) What is a digital Voltmeter (DVM)? What are its advantages?

List different types of DVMs. How can a DVM be used for the measurement of

(i) Current, and (ii) resistance ?

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(b) Explain, with the help of a functional block diagram, the principle of working of an x-y recorder

12

(c) Briefly discuss the use of LED and LCD as display devices in instrumentation. Comment on their relative merits and demerits

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I.E.S.-(Conv.)-1992

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. The number of marks carried by each question is indicated at the end of the question. Answers must be written in English. Assume suitable data, if necessary and indicate the same clearly.

PART A

1. (a) Explain the different control statements that are used in FORTRAN language

15

(b) Given an admittance matrix, node k can be eliminated and the remaining elements can be modified using the formula

$$Y'_{\eta} = Y'_{\eta} - \frac{Y_d Y_{k1}}{Y_{k1}}$$

where Y'_{η} are the modified elements corresponding to be elements Y'_{η}. Write a FORTRAN program to read an admittance matrix of order 10x10 to eliminate the last 4 nodes and to print the resultant matrix.

25

2. (a) Prepare a FORTRAN program

(i) to read 60 positive numbers $a_1, a_2, \ldots a_{60}$

(ii) to find $s_1 = a_1 + a_3 + a_5 + \ldots + a_{50}$

$s_2 = a_2 + a_1 + a_0 + \ldots + a_{60}$

(iii) to find n such that $\sum_{i=1}^{n} a_1 \leq 500$ and

$\sum_{i=1}^{n+1} a_1 > 500$ and

(iv) to output the number in the order a_{60}, a_{50} .... a_1

20

(b) Write a FORTRAN program to determine all the integer points that lie on or within the ellipse

$$\frac{x^2}{36} + \frac{y^2}{25} = 1$$

but not on or within the circle $x^2 + y^2 = 5$. Note that the ellipse has the major axis from (–6,0) to (6,0) and the minor axis from (0,–5) to (0,5) and the radius of the circle is $\sqrt{5}$.

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PART B

3. (a) Explain the speed-current torque-current and speed-torque characteristics of DC series motor. 12

(b) A three phase star connected synchronous generator is rated at 1.5 MVA, 11 KV. The armature effective resistance and synchronous reactance are 1.2ohm and 25 ohms respectively per phase. Calculate the percentage voltage regulation for a load of 1.4375 MVA at (i) 0.8 p.f. lagging and (ii) 0.8 p.f. leading. Also find out the p.f. at which the regulation becomes zero. 18

(c) In the case of three phase induction motor derive the ratio of maximum torque to full load torque as

$$\frac{T_m}{T_{F1}} = \frac{1}{2}\,\frac{\beta_2 + s_{FL}^2}{\beta_{SFL}} \qquad \text{where } \beta = \frac{y_2}{x_2}$$

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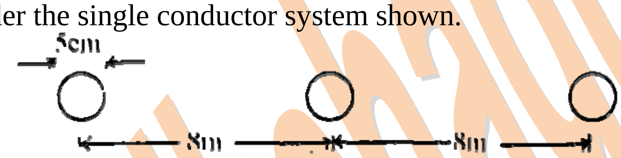
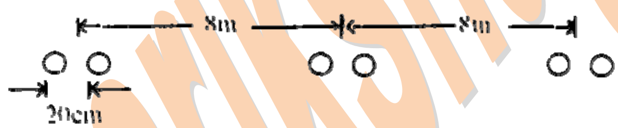
4. (a) With necessary circuit diagram briefly describe Sumpner's test. Explain how the test results are useful in determining equivalent circuit and efficiency of the transformer. 16

(b) Consider the single conductor system shown.



Calculate the inductance per phase per km. Compare for equal conductor area, the inductance of this system with that of bundle conductor system shown below



Assume that both the systems are transposed. 12

(c) Explain how inverse time over-current relay is different in operation from definite lime over-current relay. With neat circuit diagram explain the working of inverse time over-current static relay. 12

5. (a) The following two synchronous machines arc operating in parallel.

Machine A	50 MW	6% speed regulation
Machine B	50 MW	3% speed regulation

(i) Determine the load taken by each machine for a total load of 80 MW when the speed changers are set to give rated speed at 100% rated output.

(ii) The speed changers of machine A is so adjusted that 80 MW is equally shard. Find the output of machine A for rated speed and also its percentage speed at no load. 12

(b) The incremental cost characteristic of a two plant system are

$IC_1 = 1.0\ P_1 + 85$ Rs/MWh

$IC_2 = 1.2\ P_2 + 72$ Rs/MWh

where P_1 and P_2 are in MW. The loss coefficient matrix in MW^{-1} is given by

$$\begin{bmatrix} 0.015 & -0.001 \\ -0.001 & 0.02 \end{bmatrix}$$

Compute the optimal scheduling with λ = 150 Rs/MWh. The load on the system is 30 MW. For an improved value of λ with 10% change. Write the coordination equations.

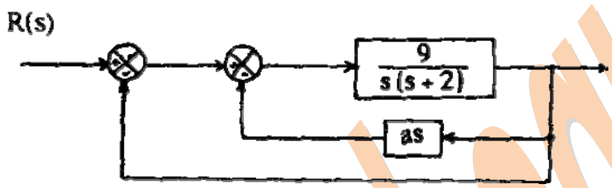
14

(c) Explain how transient stability analysis can be carried out using digital computer.

14

PART C

6. (a) Consider the system shown below:



(i) In the absence of derivative feedback (a=0) determine the damping factor and natural frequency. Also determine the steady state error resulting from a unit-input.

(ii) Determine the derivative feedback constant a which will Increase the damping factor of the system to 0.7 What is the steady state error to unit-ramp input with this setting of the derivative feedback constant?

(iii) Illustrate bow the steady state error of the system with the derivative feedback to unit-ramp can be reduced to the same value as in part (i) while the damping factor is maintained at 0.7.

28

(b) The open-loop transfer function of unity feedback system is given by

$$G(s) = \frac{K}{s(T_1 s+1)(T_2 s+1)}$$

Derive an expression for gain K in terms of T_1, T_2 and the specified gain margin G_m

12

7. (a) (i) What are compensators?

(ii) Explain clearly lag, lead and lag-lead compensators.

(iii) How do you proceed to design a lag compensator:

(iv) How do you proceed to design a lag-lead compensator?

16

(b) Obtain the response of the following system:

$$\begin{bmatrix} x_1 \\ x_2 \end{bmatrix} = \begin{bmatrix} 0 & 1 \\ -2 & -3 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \begin{bmatrix} 2 \\ 0 \end{bmatrix} [u]$$

where u (t) = 0 for t < 0

= ε^{-1} for $t \geq 0$

with $x_1(0) = x_2(0) = 0$

using (i) Cononical transformation method

(ii) Laplace transform method.

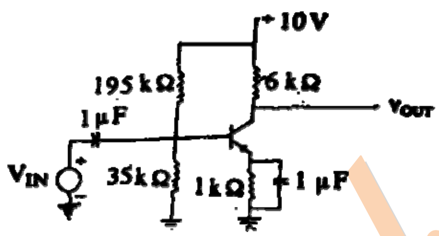
12 + 12

PART D

8. (a) Sketch the small signal high frequency circuit of a common source amplifier. Derive the expression for the voltage gain an Input admittance.

12

(b)



For the circuit shown above taking β = 200 and $V_{BE} = 0.6$ V

(i) Find I_{CQ} and V_{CEQ}.

(ii) Redraw the circuit in the small signal form using common emitter h-parameters and assuming that the capacitors are a.c. short circuits.

(iii) If $h_{je} = 11.4$ kΩ. $h_{re} = 1.0 \times 10^{-1}$, $h_{fe} = 200$ and $h_{oe} = 14.7 \times 10^{-6}$ S. Calculate the voltage gain A_5 in the frequency range where the capacitors are assumed to be a.c. short circuits.

12+4+12

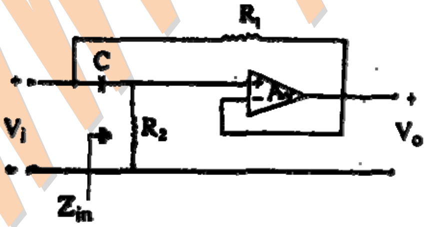
9. (a) What are the advantages of negative feedback in amplifiers ? Explain them.

12

(b) Show that the input impedance of the OP AMP shown below is given by $Z_m = R_e + J\omega L_e$

where $R_e = \dfrac{R_1\left(1 = \omega^2 C^2 R_1 R_2\right)}{1+\left(\omega C R_1\right)^2}$

and $L_e = \dfrac{R_1 C\left(R_2 - R_1\right)}{1+\left(\omega C R_1\right)^2}$



16

(c) A truth table has output Is for these inputs

A B C D = 001

A B C D = 0110

A B C D = 1000

A B C D = 1100

and 0s for other inputs.

Drawn the Karnaugh map and find the simplified Boolean equation for the truth table.

12

10. (a) Calculate the noise voltage at the input of a television-RF amplifier using a device that has 220 ohms equivalent noise resistance and a 300 ohms input resistance. The bandwidth of the amplifier is 6 MHz and the temperature is 18° C.

(b) A broadcast AM transmitter radiates 50 KW of carrier power. What will be the radiated power at 85% modulation?

8

(c) A cattier wave of amplitude 5V and frequency 90 MHz is frequency modulated by a sinusoidal voltage of amplitude 5V and frequency 10KHz. The frequency deviation constant is 1KHz/ V. Using the following table sketch the spectrum of the modulated wave.

Modulation Index m_1	Carrier J_0	Side Frequencies				
		1st J_1	2nd J_2	3rd J_3	4th J_4	5th J_5
0.25	0.98	0.12	0.01	-	-	-
0.50	0.94	0.24	0.03	-	-	-
1.00	0.77	0.44	-0.11	0.02	-	-
1.50	0.51	0.56	0.23	0.06	0.01	-
2.00	0.22	0.58	0.35	0.13	0.03	0.01

12

(d) Describe the digital filtering used in digital communication.

12