I.E.S.-(Conv.)-1994

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) State and explain (i) Maximum Power Transfer Theorem, and (ii) Teliengen's Theorem Verify Tellengens theorem for the network shown in fig.1. It is given that

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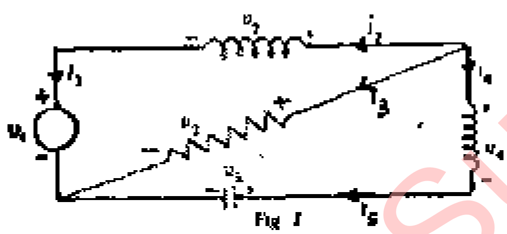
$v_1 = 4V$, $v_2 = -2V$, $v_3 = 2V$, $v_4 = 8V$, $v_5 = -6V$

$i_1 = 2A$, $i_2 = 2A$, $i_3 = -6A$, $i_4 = 4A$, $i_5 = 4A$



(b) In the network shown in fig. 2, switch K is in position until steady state is reached. Switch K is moved to position 2 at time t = 0. With switch in position 2, determine the transform of current through the inductor.

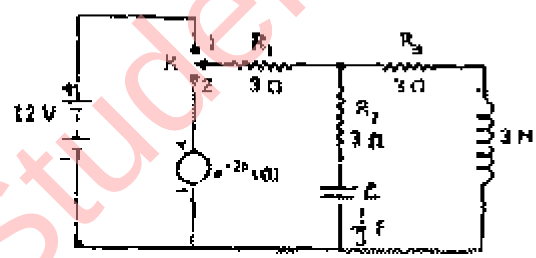


Fig 2.

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(c) The response of a network to an impulse is given by

$h(t) = 0.18(e^{-0.32t} - e^{-2.1t})$. Find, using convolution integral, the response of the network to a step function.

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2. (a) State initial and final value theorems. Find the initial and final value of i, where

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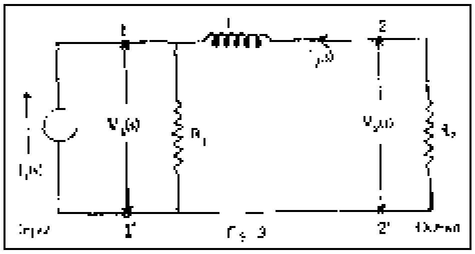
$$I(s) = 6.67\left[\frac{s = 250}{s(s+166.7)}\right]$$

(b) Define the terms driving point impedance, transfer impedance and transfer function of a network.



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The network show in Fig. 3 is driven by a current source and is terminated by resistor at port 2. For this terminated 2-port network, calculate (i) transfer functions $G_{21}(s)$, $\alpha_{21}(s)$, $Z_{21}(s)$ and $Y_{21}(s)$, and (ii) driving point impedance Z_{11}.

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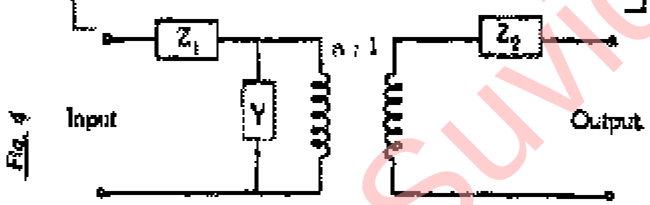
(c) Derive the transfer matrices of the various elements of the circuit illustrated in fig. 4, and then show that the transfer matrix for the whole arrangement is

$$[A] = \begin{bmatrix} n(1 + Z_1Y) & nZ_2\left(1 + Z_1Y + \frac{Z_1}{n}\right) \\ nY & nZ_2Y + \frac{1}{n} \end{bmatrix}$$



3. (a) (i) State the properties of the driving point impedance of (1) LC network, and (2) RC network.

(ii) Test the following Polynomial for 1 Hurwitz property:

$F(s) = s^4 + s^3 + 5s^2 + 3s + 4$

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(b) Realize the network function

$$Z(s) = \frac{s(s^2+4)}{2(s^2+1)(s^2+9)}$$

as first and second forms of Cauer networks

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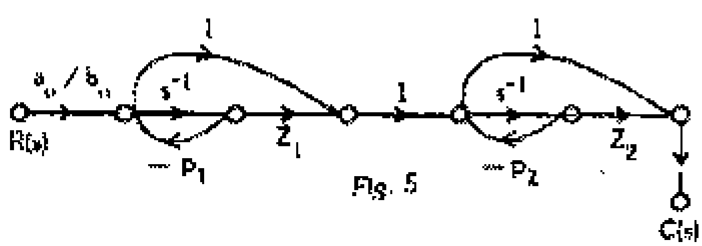
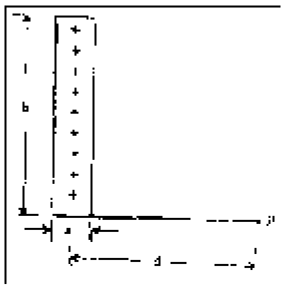
(c) State and explain Masons's Gain Formula. Hence find the transfer function $\frac{C(s)}{R(s)}$ the system whose signal flow graph is shown in Fig. 5



PART B

4. (a) Fig 6 shows a rectangular bus bar for distributing large currents. It is required to find magnetic field at the point 'P' located on x-axis, adjacent to the bus bar and directly opposite one edge of it. Show that the X and Y components of the resulting vector B are given by

$$B_X = \frac{\mu_0 I}{4\pi b} \ln \frac{d^2 + b^2}{d^2} \quad \text{and} \quad B_Y = \frac{\mu_0 I}{2\pi b} \tan^{-1}(b/d)$$



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(b) Two long parallel zinc plated iron pipes have a spacing of 6 m between centres. The pipes are half buried in the ground as shown in Fig 7. The diameter of the pipes is 60 cms. The conductivity of the ground is 10^{-4} mho/meter. Find the resistance between the two pipes per meter length.

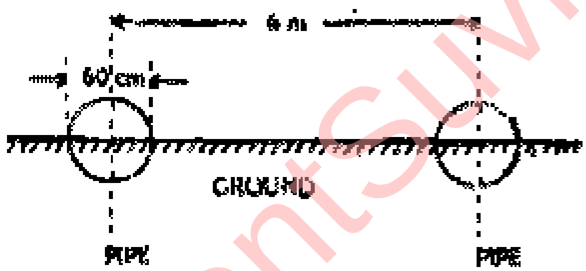

Fig.7.

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(c) A spherical charge density distribution is given by

$$\rho = \rho_0\left(1 - \frac{r^2}{a^2}\right) \qquad r \le a$$

$$= 0 \qquad ; r > a$$

Using Poisson's and Laplace's equations as applicable, find E everywhere for $0 \le r \infty$. Show that maximum value of E occurs at r = 0.45 a.

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5. (a) Obtain Maxwell's equation in the differential form as derived form Faraday Laws.

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(b) The electric field intensity of an electromagnetic wave in free space is given by

$$E_Y = 0, \qquad E_Y = 0, \qquad E_X = E_0 \, Cos \, \omega\left(t - \frac{Z}{\upsilon}\right)$$

Determine expression for the components of magnetic intensity $\overline{H}$.

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(c) A uniform plane electromagnetic wave is incident at an angle Θ_1, at the surface of discontinuity between two homogeneous isotropic dielectrics with permittivity, ε_1 and ε_2, ε_2 being the permittivity of the dielectric into which the wave gets refracted at an angle Θ_2. If E_1 E_r and E_t are the electric intensities respectively of the incident, reflected and transmitted waves, show that the reflection co-efficient for parallel polarization is given by

$$\frac{E_r}{E_i} = \frac{\tan(\theta_1 - \theta_2)}{\tan(\theta_1 + \theta_2)}$$

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PART C

6. (a) What do you understand by

(i) Polarization, and (ii) Polarizability?

The Centres of two identical atoms of polarizability $\alpha = 2 \times 10^{-40}$ Farads-m^2 are separated by a distance b. A homogeneous electric field is applied in a direction parallel to the line joining the centres of the two atoms. The ratio between the internal field E_i and E is 1.03 Find the distance 'b'.

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(b) Explain the phenomenon of

(i) Ferro electricity, and (ii) Piezo electricity

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(c) Explain what you understand by the following in relation to solid dielectrics:

(i) Intrinsic breakdown (ii) Thermal breakdown, and (iii) Discharge breakdown

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7. (a) Explain what you understand by the following:

(i) Magnetic dipole (ii) Magnetic dipole moment (iii) Magnetic susceptibility (vi) Magnetisation $\overline{M}$ and Magnetic field intensity $\overline{H}$

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(b) Write notes on

12

(i) Magnetic Anisolopy, and (ii) Magnetostriction

(c) What is Hall effect in Semiconductors ? The resistivity of a doped silicon material is 9×10^{-3} ohm-m. The Hall co-efficient is 3.6×10^{-4} m^3 coulomb^{-1}. Assuming single carrier conduction, find the mobility and density of charge carriers. $e = 1.6 \times 10^{-19}$ coulomb.

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PART D

8. (a) Give the meaning of the following terms:

(i) Precision (ii) Accuracy (iii) Standard deviation, and (iv) Probable error

Two resistors R_1 and R_2 are connected in series and in parallel. The values of resistances are

$R_1 = 100.0 \pm 0.1\ \Omega$, $R_2 = 50 \pm 0.05\Omega$.

Calculate die uncertainty in the combined resistance for the both series arid parallel arrangements.

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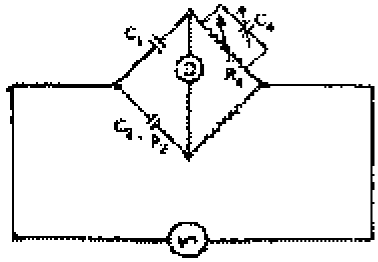
(b) Fig. 8, shows a Schering bridge circuit used for measuring the power loss in dielectrics. The specimens are in the form of discs 0.3 cm thick and have a dielectric constant of 2.3. The area of each electrode is 314 cm^2, and the loss angle is 9 for a frequency of 50Hz. $\varepsilon_0 = 8.855 \times 10^{-2}$ F/m. The fixed resistor of the network has a value of 1000Ω and the fixed capacitance is 50 μμF. Find the values of variable resistor and capacitor required at balance. Derive the expressions used, if any

Fig. 8



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(c) Describe, with the help of a block diagram, the operation of a spectrum analyzer.

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9. (a) Explain with the help of circuit diagram, the principle of working of a Q-meter.

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(b) Explain the principle of the following transducers for measuring linear displacements:

(i) Strain gauges (ii) Piezo electric transducers

12

(c) Explain how you would measure frequency of a signal on a C.R.O.

A Lissajous pattern on an oscilloscope is stationary and has 5 horizontal tangencies and 2 vertical tangencies. The frequency of horizontal input is 1000 Hz. Determine the frequency of vertical input.

10

10. (a) Distinguish between Analog Pulse Telemetery and Digital Telemetery (Pulse code Modulation). What do you understand by Pulse duration modulation (PDM) and Pulse position modulation (PPM) systems of telemetery? What is the advantage of PPM system?

12

(b) Explain, with the help of a basic block diagram, the working of a potentiometric DVM.

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(c) What are the properties of an ideal operational amplifier used in measurement and instrumentation system? Explain, with the help of circuit diagrams, how it is used as (i) Adder, (ii) Multiplier (iii) Integrator, and (iv) Differentiator.

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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) In so far as they relate to a digital computer, explain the following in about 5 lines for each:

(i) the advantage of using binary number system (ii) the function of a compiler (iii) the advantages of floating point representation of number

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(b) Explain how multitasking facilities are provided in a digital computer.

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(c) The marks scored by 56 students in a class in 8 subjects are available as shown.

Subject No. 1

SI. No.	1	2	3	…….	56
Mark	x	x	x	…….	x

Subject No. 8

SI. No.	1	2	3	…….	56
Mark	x	x	x	…….	x

For each subject it is required to find the maximum mark scored and the number of students who have scored the maximum mark. (Note that in any subject, more than one student could have scored the maximum mark.)

Write a complete FORTRAN program with proper output statements to display the results neatly. Use a subroutine subprogram to find the maximum mark in a subject and the number of students who have scored that maximum mark.

20

2. (a) State the rules related to the SUBROUTINE subprogram.

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(b) Write a FORTRAN expression corresponding to each mathematical expression.

(i) $4x^2y - 3xy + 7yz^3$ (ii) $\left(\frac{a+b}{c+d}\right)^3$ (iii) $x^5/5!$ (iv) $\left(3+\frac{a}{b}\right)^{m-1}$ (v) $\frac{\left(\frac{a}{b}+6\right)}{\left(x-\frac{y}{z}\right)}$

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(c) Draw a flowchart and writ a FORTRAN program which can calculate and print the value of $\frac{1}{1}+\frac{1}{3}+\frac{1}{5}.......+\frac{1}{21}$ with an accuracy of 5 decimal places.

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SECTION B

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

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(b) A 3.5 MVA, slow-speed, 3—phase synchronous generator rated at 6.6 kV has 32 poles. Its direct and quadrature axis synchronous reactances as measured by the slip test are 9.6 and 6Ω respectively. Neglecting armature resistance determine the regulation and the excitation emf needed to maintain 6.6 kV at the terminals when supplying a load of 2.5 MW a 0.8 pf lagging. What maximum power can the generator supply at the rated terminal voltage, if the filed becomes open-circuited?

18

(c) A 3-phase induction motor has a starting torque of 100% and a maximum torque of 200% of the full-load torque. Find slip at maximum torque.

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4. (a) A constant load of 300 MW is supplied by two 200 MW generators, 1 and 2 for which the respective incremental fuel costs are:

$$\frac{dF_1}{dP_1} = 0.10P_1 + 20Rs / MWh$$

$$\frac{dF_1}{dP_1} = 0.12P_2 + 15Rs / MWh$$

With powers P in MW and costs F in Rs/hr. Determine

(i) the most economical division of load between the generators, and (ii) the saving In Its/day thereby obtained compared to equal load sharing between generators.

15

(b) Discuss in detail various factors that affect power system transient stability.

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(c) Explain with a neat sketch the working of a nuclear power station. Discuss the merits and problems associated with nuclear power stations.

15

5. (a) The core-loss for a given specimen of magnetic material is found to be 2000 W at 50 Hz. Keeping the flux density constant, the frequency of the supply is raised to 75 Hz resulting in core-lose of 3200 W. Compute separately hysteresis and eddy current losses at both the frequencies.

12

(b) Explain the conditions in detail that must be fulfilled for the satisfactory parallel operation of two single phase transformers.

8

(c) Derive an expression for disruptive critical (corona) voltage of a single-phase overhead line. Show that this result can be extended to a 3-phase line. Explain how bundle conductors help to raise disruptive critical voltage of a transmission line.

20

SECTION C

6. (a) A servomechanism is used to control the angular position θ_0, of a mass through a command signal θ_i. The moment of inertia of moving parts referred to the load shaft is 200 kg-m^2 and the motor torque at the load is 6.88 x 10^4 N-m per rad. of error. The damping torque co-efficient referred to the load shaft is 5 x 10^3 N-m per rad/sec.

(i) Find the Lime response of the servomechanism to a step input of 1 rad and determine the frequency of transient oscillation, the time to rise to the peak overshoot and the value of the peak overshoot.

(ii) Determine the steady-state error when the command signal is a constant angular velocity of 1 revolution/minute.

(iii) Determine the steady-state error which exists when a steady torque of 1200 N-m is applied at load shaft.

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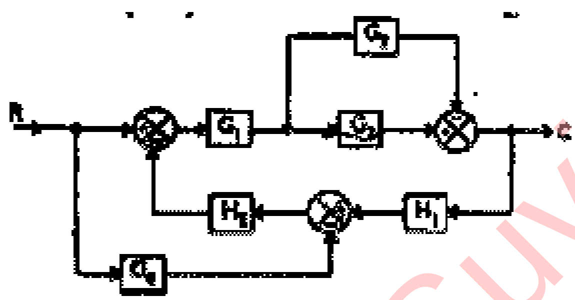
(b) Draw a signal flow graph and evaluate the closed- loop transfer function of a system whose block diagram is given below.



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7. (a) Explain the meaning and significance of phase and gain margins of a feedback control system. How will you obtain the values of these margins from (i) polar plot, and (ii) Bode plots?

Illustrate your answer by giving plots for stable and unstable systems separately.

20

(b) Consider a system with the state model.

$$x = \begin{bmatrix} 0 & 1 \\ -2 & -3 \end{bmatrix} x + \begin{bmatrix} 0 \\ 2 \end{bmatrix} u, \qquad x(0) = \begin{bmatrix} 0 \\ 1 \end{bmatrix}$$

Transform the state model into Jordan canonical form, and compute the state transition matrix.

12

(c) Explain the importance of root-locus diagrams in the design of feedback control systems.

8

SECTION D

8. (a) Distinguish the constructional and operational features of a WET and a MOSFET. Show bow a voltage follower circuit is made up by using a JFET.

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(b) Simplify the following logic function

$X = (B + C)(B + D)(C + D)$

and show that $X = BC + BD + CD$

Realize the function by 2-input NAND gates.

10

(c) Distinguish between 'voltage' feedback and 'current' feedback in amplifier circuits. State the merit of each and for each case derives the expression for the net output impedance of the amplifier showing the influence of feedback.

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(d) What are the specifications of an ideal OPAMP? Discuss the meaning of the following terms.

(i) Slew rate (ii) CMRR (iii) Virtual ground

Show how an OPAMP may be used as a summing integrator.

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9. (a) An inverting Op-Amp stage is designed with

$R_1 = 5\ k\Omega$, and feedback resistance $R_2 = 10\ k\Omega$ and

$R_L = 100\ \Omega$, the Op-Amp has $A_v = 5 \times 10^4$,

$R_0 = 500\ \Omega$ and $R_1 \infty$

(i) Determine the voltage across R_L for an rms input signal of 1.5 V.

(ii) Repeat (i) considering that the Op-Amp is ideal.

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(b) Taking the example of CE amplifier, explain the criterion for selection of a suitable operating point and factors affecting its stability. Hence define stability factor S.

10

(c) Draw the circuit diagram of a RC phase shift oscillator and obtain an expression for its frequency of oscillations.

15

(d) What do you understand by the dV/dt rating of a thyristor?

5

10. (a) Derive an expression for the signal-to-quantization noise ratio for a sinusoidal modulating signal in PCM system.

15

(b) What is the frequency range for the following bands? Mention a typical application for each.

(i) ME (ii) HF (iii) VHF (vi) UHF (v) Microwave (vi) Optical range

12

(c) Distinguish between a 'narrow-band' and a 'wide- band' frequency modulated signal. Show by means of block diagrams how a narrow-band FM signal is generated.

13