ELECTRICAL ENGINEERING

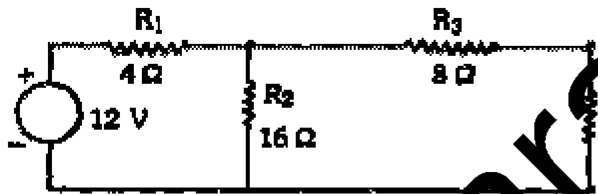
PAPER – I

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 aid TWO from Part D. The number of marks carried by tack 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) State and explain Reciprocity and Compensation theorems. Find the current flowing in the resistor R_4 of the network shown in Fig 1. If a resistance of [illegible].5 ohms is inserted in series with R_4, find, using compensation theorem, the current that will flow through R_4.



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(b) Fig. 2 shows a phase shifting network, V_1 being input supply voltage. R and C are always adjusted so that the magnitude of their total impedance is 2500 ohms. The supply frequency is 5,000 Hz. Determine the values of R and C which will produce a phase shift of 30° between V_1 and V_0 Does V_0 lag or lead with respect to V_1?

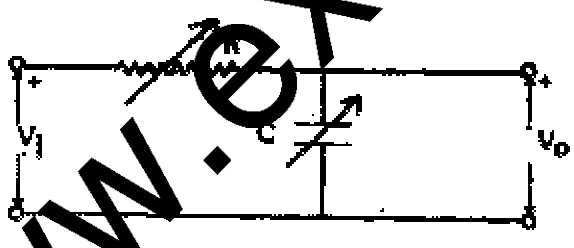

Fig. 2

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(c) A voltage with a truncated-ramp waveform as shown in Fig. 3 is applied to circuit, comprising R=1 Ω and C = 0.2 F in series.

The rise time t_0 = 2 sec. The initial charge on the capacitor is zero. Find the current (t) in the circuit.

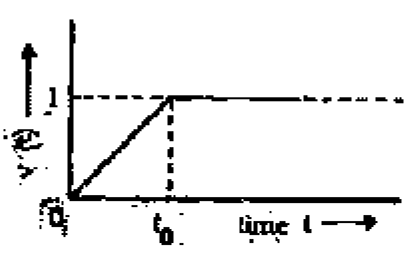

Fig.3

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2. (a) (i) What do you understand by 'Complex Frequency' Give its physical significance.

(ii) Define Transform impedance and Transform admittance for a 2-terminal element Obtain their expressions for (1) an inductor, and (2) a capacitor

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(b) Find the Driving point impedance Z(S) for the network shown in Fig. 4.

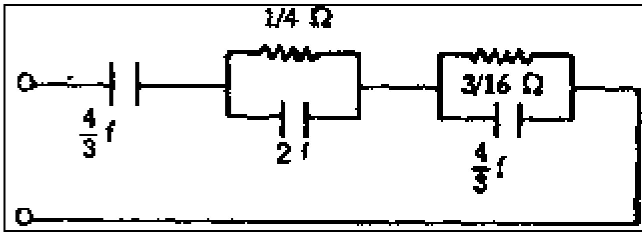

Fig. 4

(c) Derive expressions for the Y-Parameters in terms of A, B, C, D parameters of a 2-terminal pair (4-terminal) network. Two network have general A, B, C, D parameters as follows:

Parameter	Network 1	Network 2
A	1.50	[illegible]/3
B	11Ω	4Ω
C	0.25 siemens	[illegible] siemens
D	2.5	[illegible].0

If two networks are connected with their inputs and outputs in parallels, obtain the admittance matrix of the resulting network.

3. (a) (i) State properties of Hurwitz polynomial.

(ii) What do you mean by a Zero of Transmission?

Give an example to explain the concept.

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(b) Find the first and second Cauer forms of LC networks realizing the impedance function.

$$Z(S) = \frac{S^4 + 10S^2 + 9}{S^3 + 4S}$$

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(c) For a two wingding transformer (mutually coupled circuit), equations relating the terminal voltages and branch currents are given by

$$v_1 = (R_1 + L_1 p) i_1 - Mpi_2$$

$$v_2 = (R_2 + L_2 p) i_2 - Mpi_1$$

where p ix the differential operator. Re-arrange the above equations in appropriate cause-effect form to obtain the single-flow graph as shown in Fig. 5.

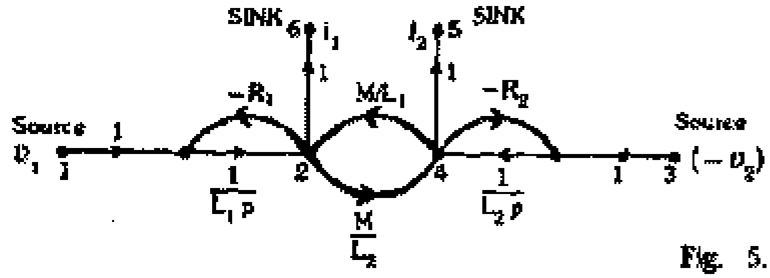

Fig. 5.

Using Mason's Gain-Formula, prove that i_1 is given by

$$i_1 = \frac{(R_2 + L_2 p)v_1 - Mpv_2}{p^2(L_1L_2 - M^2) + (R_1L_2 + R_2L_1)p + R_1R_2}$$

PART B

4. (a) A small, isolated conducting sphere of radius 'a' is charged with +Q coulombs. Surrounding this sphere and concentric with it is a conducting shell which possesses no net charge. The inner radius of the shell is 'b' and outer radius is 'c'. All non-conducting space is air. Using Gauss' Law, find and plot $\overline{E}$ and potential 'V' everywhere for $0 \le r \le \infty$, where r is the radial distance from the centre of sphere.

(12)

(b) Derive the equation of continuity for current

$$\overline{\nabla} \cdot j + \frac{\partial \rho}{\partial t} = 0$$

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where ρ is the charge density.

(c) (i) Determine if the vector

$$\overline{F} = y\bar{i}_x - x\bar{i}_y$$

can represent a magnetic field $\overline{B}$.

(ii) Find the skin depth of penetration in copper at 10,000 MHz. resistivity of copper is [illegible] $\times 10^{-6}$ ohm-cm.

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5. (a) Starting from Faraday's law of induction, show, with usual notations, that for time varying fields:

$$\overline{\nabla} \times \overline{E} = \frac{\partial B}{\partial t}$$

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Obtain the three dimensional wave equations for an absorbing medium assumed to be both magnetically and electrically homogeneous and isotropic. The charge density in the field may be assumed to be zero.

Hence determine the wave-equation if the field is varying harmonically with time.

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(c) The electric field of a uniform plane wave propagating in the positive Z-direction is given by

$$\overline{E} = E_0 \cos(\omega t - \beta z) i_z + E_0 \sin(\omega t - \beta z) i_y$$

where E is a constant Find

(i) the corresponding magnetic field H, and

(ii) the Poynting Vector

Evaluate the Poynting Vector if $E_0 = 10$ V/m.

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PART C

6. (a) What do you understand by Electronic Polarization, Ioin Polarization, and Orientational Polarization of dielectrics ? What is electric susceptibility of a dielectric? How is it related to relative permittivity?

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(b) Differentiate between Ferromagnetism and Ferrimagnetism. Give characteristics and applications of Ferromagnetic and Ferri-magnetic materials.

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(c) Explain the phenomenon of Piezo-electricity. Name three piezo-electric materials and give their properties.

A piezo-electric crystal having a thickness of 2 mm and voltage sensitivity of 0.055 V-m/N is subjected to a pressure of 1.25 MN/m^2. Calculate the voltage output. If the permittivity of the material is 40.6 x 10^{12} F/m, calculate its charge sensitivity.

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7. (a) Explain, with reference to Energy band theory, the difference between conductors, insulators and semi conductors.

The following data is known for a conductor:

Fermi energy = 5.5 eV

Mobility of electrons 7.04 x 10^{-3} m^2 $volt^{-1}$ set^{-1}

Number of conduction electrons per m^3 = 5.8 x 10^{28}

Calculate

(i) Relaxation time

(ii) Resistivity of conductor

(iii) Velocity of electron with the Fermi energy.

e = 1.6 x 10^{-19} C, and m = 9.1 x 10^{-31} kg

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(b) What is super conductivity? How is it affected by (i) Frequency, (ii) Magnetic field? Give some applications of super conductivity.

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(c) What are n-type and p-type semi conductors? Explain the behaviour of a p-n junction under forward and reverse bias conditions.

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PART D

8. (a) Explain the different types of errors that may occur in measurements. The resistance of an unknown resistor is determined by a Wheat-stone bridge. The solution for the unknown resistance is stated as

$$R_4 = \frac{R_1 R_2}{R_3}$$

The limiting values of various resistances are

$R_1 = 5000\Omega \pm 1\%$, $R_2 = 615\Omega \pm 1\%$, $R_3 = 100 \pm 0.5\%$.

Calculate (i) the nominal value of the unknown resistance, (ii) its limiting error in percent, and (iii) its limiting error in ohms.

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(b) The ants of an Anderson's bridge are as follows:

Arm AB : an unknown impedance (R_1, L_1) in series with a non-inductive resistor r_1.

Arm BC : A non-inductive resistor $R_3 = 100\ \Omega$

Arm CD : A non-inductive resistor $R_4 = 150\ \Omega$

Arm DA : A non-inductive resistor R_2 200 Ω

Arm DE : A variable non-inductive resistor

Arm EC : A lossless capacitor C = [illegible]F.

AC supply is connected across A and C, and the detector is connected between B and E.

Deduce conditions of balance and calculate R_1 and L_1 under balance conditions when r

$r_1 = 40\ \Omega$ and $r = 220\ \Omega$

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(c) Describe the Wien-bridge method for measuring unknown frequencies in the audio range. What are the other applications of this bridge?

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9. (a) (i) Give the principle of electrostatic focussing in a CRO.

(ii) Explain how from the Lissajous patterns appearing on the screen of a C.R.O., the phase and frequency of an unknown signal can be determined.

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(b) Explain the principle of action of a capacitive displacement transducer having linear characteristic. What are the disadvantages and uses of capacitive transducers?

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(c) A strain gauge having a resistance of 120 Ω and a gauge factor of 2 is connected in series with a ballast resistance of 120 Ω across a 12 V supply. Calculate the difference between the output voltage (voltage across the strain gauge) with no stress applied and with a stress of 140 MN/m^2. The modulus of elasticity of the member undergoing strain is 200 GN/m^2.

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10. (a) What is telemetry? Explain the principle of Position Telemetering systems.

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(b) Explain the principle of working of a Magnetic Tape Recorder. What are its basic components and their functions.

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(c) Explain with the help of a functional block diagram, the principle of operation of a Digital frequency meter.

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

SECTION A

1. (a) Distinguish between the rules related to function sub-programs and subroutine subprograms. 14

(b) Write a statement function defining

$$\text{DIVIDE}(x, y) = \frac{x+y}{x-y}$$

and use this function to compute

$$a = \frac{\sqrt{p}+5}{\sqrt{p}-5}$$

$$b = \left(\frac{p+q+r}{p+q-r}\right)^3$$

$$c = 3\tan^{-1}\left(\frac{1-s}{1+s}\right)$$

$$d = \frac{p+q}{p-q}\cdot\frac{r-s}{r+s}$$

$$e = \frac{\cos\theta+\sin\theta}{\cos\theta-\sin\theta}$$

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(c) Write a FORTRAN program to read a four digit positive integer number and to find the sum of the four digits. For example, for the number 7035, the sum is 7 + 0 + 3 + 5 = 15 14

2. (a) Write a complete FORTRAN program to solve the following equations using Gauss Seidel iterative procedure.

$$5x_1 - 3x_2 + 6x_3 = 2$$

$$3x_1 + 8x_2 + 2x_3 = 28$$

$$6x_1 + 2x_2 + 4x_3 = 4$$

(b) The percentage efficiency of a transformer is given by

$$\eta = \frac{xs\cos\theta}{xs\cos\theta + W_1 + x^2 W_c} \times 100$$

for a 5 KVA transformer, W_i = 60 watts and W_c = 50 watts. Write a FORTRAN program by which transformer efficiency can be obtained for x = 0 to 1.2 in step of 0.1 when cos Θ varies from 0.7 to 0.9 in step of 0.05. The results are to be printed neatly using proper formats.

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SECTION B

3. (a) A 220 V D.C. shunt motor takes 22 A at rated voltage and runs at 1000 rpm. Its field resistance is 100Ω and armature circuit resistance is 0.1Ω. Compute the value of additional resistance required in the armature circuit to reduce the speed to 800 rpm when

(i) the load torque is proportional to speed

(ii) the load torque varies as the square of the speed

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(b) Two identical D.C. machines when tested by Hopkinson method gave following test results:

Field currents are 2.5 A and 2 A. Line voltage is 220 V. Line current including both the field currents is 10 A. Motor armature current is 73 A. The armature resistance of each machine is 0.05Ω.

Calculate the efficiency of both the machines.

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(c) Explain the working of a transformer at no load and loaded conditions.

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4. (a) A 10 KVA, 440 V, 50 Hz, 3 phase alternator has the following O.C.C.

Field current (amp.)	1.5	3.0	5.0	8.0	11.0	15.0
Terminal voltage (volts)	150	300	440	560	600	635

With full load zero p1 load applied, an excitation of 14 A produced a terminal voltage of 500 V. On short circuit, 4A excitation was required to circulate full load current. Using MMF method determine the full load percentage regulation for 0.8 p.f. lagging and 0.8 p.f. leading.

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(b) When a three phase supply is given to a three phase winding a rotating magnetic field of constant amplitude will be produced. Justify the above statement.

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(c) Explain how the parameters of 3 phase induction motor can be obtained from the test results.

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5. (a) A hydro electric station has to operate with a mean head of 50 m. It makes use of water collected over a catchment area of 200 km^2 over which the average annual rainfall is 420 cm with a 30% loss due to evaporation. Assuming the turbine efficiency as 85% and the alternator efficiency as 80% calculate the average power that can be generated.

(b) With a neat diagram explain the working of induction type directional over-current relay.

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(c) For a power system consisting of N thermal power plants; including transmission lass, derive economic dispatch policy.

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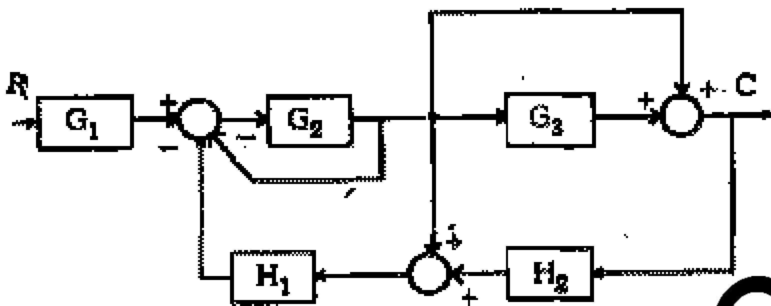
SECTION C

6. (a) Use block diagram reduction methods to obtain the equivalent transfer function from R to C.



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(b) Sketch the under-damped time response of second order control system to a step input. Define delay time, rise tune, peak time, peak overshoot, settling time and steady state error.

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(c) An open loop transfer function of unity feedback system is given by.

$$G(s) = \frac{25}{s(s+2)}s$$

Determine damping factor, undamped natural frequency, damped natural frequency and time response for a unit step input.

14

7. (a) By means of Routh criterion, determine the stability of the systems represented by the following characteristic equations. Wherever necessary find the number of roots in the right half of splane and on the imaginary axis.

(i) $s^5 + s^4 + 3s^3 + 9s^2 + 16s + 10 = 0$

(ii) $s^6 + 3s^5 + 5s^4 + 9s^4 + 8s^2 + 6s + 4 = 0$

(b) State Nyquist stability criteria and investigate the stability of the closed-loop system with the following open-loop transfer function

$$G(s)H(s) = \frac{2(s+3)}{s(s-1)}$$

by drawing Nyquist plot Wherever the Nyquist plot crosses the real or imaginary axis, determine the frequency and the intercept value.

24

SECTION D

8. (a) Draw the V-I characteristic of Tunnel diode. Briefly describe the mechanism of junction break down.

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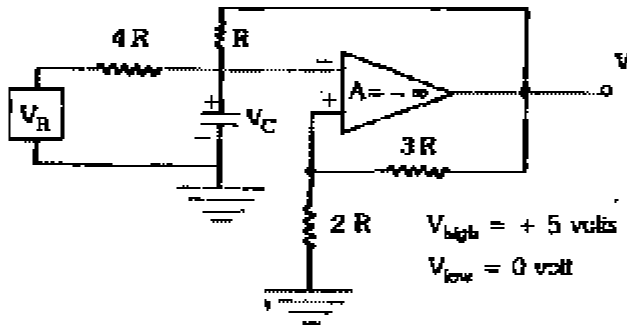
(b) In the Schmitt trigger circuit shown assume that at t = 0, V_c = 0 volt and V_0 = 5 volts.



For this circuit to operate as a square wave generator. Find the d.c. voltage V_R with proper sign.

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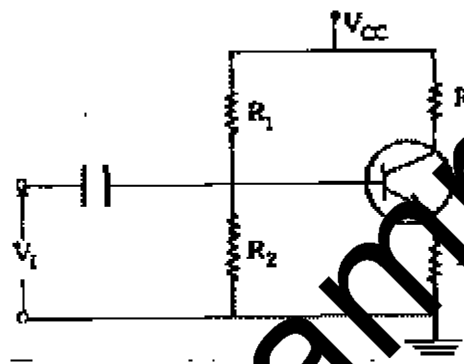
(c) In the self bias circuit shown, a silicon transistor is used with β = 50, V_{BE} = 0.6 V, V_{cc} = 18 V and R_C = 4.3 kΩ. It is desired to establish a quiescent point at I_C = 1.5 mA, V_{CE} = 10 V and a stability factor of S ≤ 4. Find R_c, R_1 and R_2.



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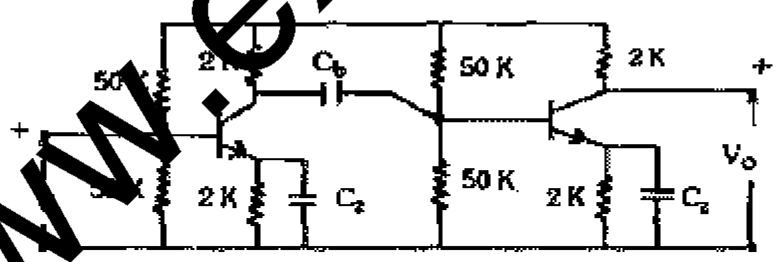
9. (a) The parameters of the transistor in the circuit shown h_{fe} = 50, h_{ie} = 1.1KΩ, h_{re} = h_{oe} = 0.



Find (i) mid-band gain (ii) the value of C_b necessary to give a lower 3 dB frequency of 20 Hz (iii) the value of C_b necessary to ensure less than 10% tilt for a 100 Hz square wave input.

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(b) A two stage FET oscillator uses the phase shifting network as shown below.

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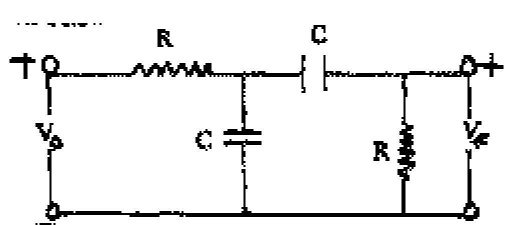

$$\frac{V_f}{V_o} = \frac{1}{3 + j\left(WRC - \frac{1}{WRC}\right)}$$

Briefly describe R.S., J-K, D-type and T-type flip-flops.

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10. (a) Defining selectivity, sensitivity and fidelity of the receiver describe briefly the operation of an A.M. super-heterodyne receiver with relevant block diagram. In what essential details would an F.M. receiver differ from the above?

(b) Explain how SSB signals are detected.

(c) Explain the principle of multiplexing Compare time division multiplexing and frequency division multiplexing.

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