I.E.S.-(Conv.)-1997

ELECTRICAL ENGINEERING

PAPER - I

PART A

1. (a) (i) A voltage source $v(t) = V_0 \cos \omega$ is connected to a linear time varying capacitor $c(t) = C_0 (1 + \cos \omega t)$. Find the current.

(ii) Show that a linear time varying inductor behaves to a time varying source as a combination of a time invariant inductor and a linear time varying resistor.

10

(b) Given in figure 1 are two network configurations. Show that one can be transformed into the other. Obtain the values of Z_1 , Z_2 and Z_3 in terms of Z_A , Z_B and Z_C as also the values of Z_A, Z_B and Z_C in terms of Z_1, Z_2 and Z_3 if both the networks are equivalent to each other.

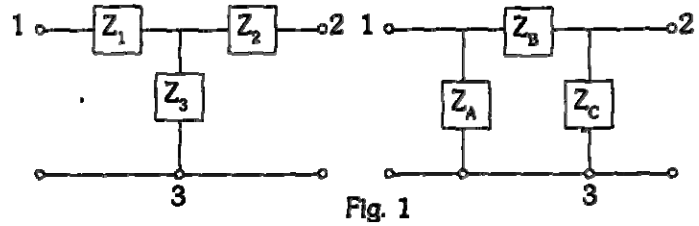

Fig. 1

10

(c) Realize the following impedance function using both first and second forms of Foster and Cauer canonical networks.

2. (a) What is convolution integral? Discuss its application to circuit theory.

The step input response of a network is given by

$$1-\frac{1}{2}\varepsilon^{-at}+\frac{3}{2}\varepsilon^{-bt}$$

Find impulse response of the network using convolution integral.

10

(b) For the m usually coupled circuit shown in fig. 2, show that the secondary current and voltage E_2 will have its largest value if the following relationship holds true

$$\frac{1}{\omega C_2} = \omega\left(\frac{R_2}{R_1}L_1 + L_2\right) \approx \omega L_2$$

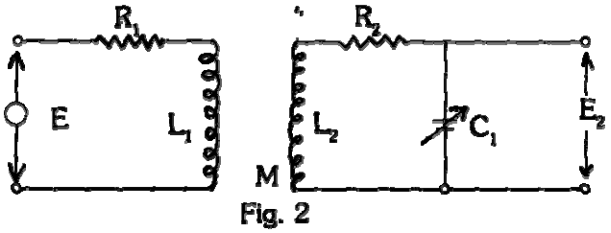

Fig. 2

Hence prove that the maximum value of E_2 is obtained when $\omega M = \sqrt{R_1 R_2}$

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(c) Distinguish between zero state response dnd zero input response of a linear time invariant network.

For the network of fig. 3, determine the input i_s over (0, 1) if the zero state response for $t \geq 1$ is $e_2(t) = \varepsilon^{P1t}$; P_1 being the pole nearest to origin

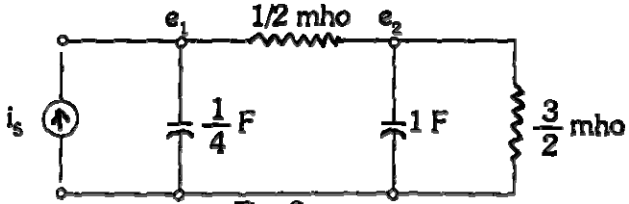

Fig. 3

3. (a) Apply Routh criterion to show that the system with the following characteristic equation is limitedly stable

$$s^6+2s^5+8s^4+12s^3+20s^2+16s+16=0$$

10

(b) What is the steady state error in a feedback system? Show that this error depends upon the input and forward transfer function. Hence deduce the values of position error, velocity error and acceleration error constants.

10

(c) (i) Develop state variable model for the arrangement of fig. 4 showing a dc motor lifting a hoist.

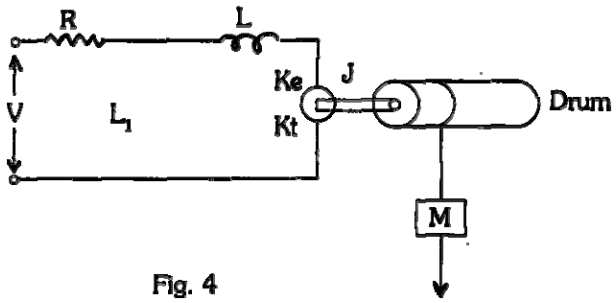

Fig. 4

k_e – motor emf constant

k_t – motor torque constant

J – rotating system inertia

6

(ii) Explain Z-transformation analysis of a sampled date system.

6

PART B

4. (a) (i) Show that the electromagnetic energy due to charged conductors in space is given by

$$\frac{1}{2}\int_v \bar{D}.\bar{E}dv$$

where fields $\bar{D}$ and $\bar{E}$ occupy whole of the space.

8

(ii) A square metal plate of 0.2 m side is suspended from one of the aims of a balance such that it is parallel to another fixed horizontal plate of same dimension 1.0 mm below it. What should be the mass placed in the other arm of the balance to maintain the separation on applying 100 V across plates?

4

(b) The plane X = 0 separates two isotropic linear homogeneous magnetic materials. If relative permittivity is 5 for x > 0 and 2 for x < 0 and

for x < 0, $\bar{B} / \mu_0 = -2\bar{i}_x + 2\bar{i}_y - \bar{i}_z$

find $\bar{H}$ and $\bar{m}$ for x > 0.

What will be these values if there is a surface current density

$J = 2i_y$ A/m

On the plane x = 0?

12

(c) The electric field intensity of an e.m. wave at the origin of the spherical co-ordinate system is given by

$$\bar{E} = \frac{E_0}{r} \sin\theta \cos(\omega t - \beta r) i_\phi; \quad \beta = \omega\sqrt{\mu_0 \varepsilon_0}$$

Find

(i) associated magnetic field

(ii) Poynting vector

(iii) power over a spherical surface of radius r around the origin.

12

5. (a) (i) A sheet charge of uniform density p_s extends in the entire X - Y plane. Show that Gauss's law in differential form for the entire sheet charge is given by

$\bar{\nabla}\bar{F} = \frac{1}{\varepsilon_0} \rho_s \delta(z); \delta(z)$ is dirac delta function.

4

(ii) Obtain Green's integral identities and state their significance. Apply first identity to show that the specifications of both divergence and curl of a vector with boundary conditions are sufficient to make the function unique.

8

(b) (i) A parallel plate capacitor has rectangular plates of area A, but plates are not exactly parallel. The separation at one edge is (d-a) while at the other is (d + a); a << d. Show that the capacitance is given approximately by

$$C = \frac{\varepsilon_0 A}{d}\left(1 + \frac{a^2}{3d^2}\right)$$

8

(ii) Show that the vector potential due to moving point charge q at a distance R is given by

$\bar{A}(r) = \frac{\mu_0}{4\pi} \frac{q\bar{v}}{R}$; $\bar{v}$ being velocity of charge.

(c) The electric field intensity associated with a plane e.m. wave along any direction in free space is given by

$$\bar{E}(r) = \frac{1}{2}\left[\left(-2\sqrt{3} - j\right)\bar{a}_x + \left(Zj\sqrt{3}\right)a_y + j2\sqrt{3}\bar{a}_z\right]\varepsilon^{-j-\frac{\pi}{5}\left(\sqrt{3}x+3y+2z\right)}$$

Find

(i) direction of wave propagation

(ii) frequency and wavelength

(iii) apparent wavelengths and phase velocities along three axes.

12

PART C

6. (a) Explain the origin of permanent magnetic dipoles in materials. Why is the proportion of electron spin system more important than others?

Hence deduce and discuss Curie law of paramagnetism.

12

(b) What is a complex dielectric constant? If it is represented as $\varepsilon_r^* = \varepsilon_1 + \varepsilon_2^*$ explain the origin and nature of ε_1 and ε_2.

Show that the conductive admittance per m^2 of a parallel plate capacitor having a lossy dielectric and plate separation of 1 m, is given by

$$Y^* = j\omega\varepsilon_0\left[\left(\varepsilon_r + 1\right) + \frac{\left(\varepsilon_2 + 1\right)}{1 + j\omega t}\right]$$

Where ω = angular frequency

ε_0 – permittivity of free space

τ – relaxation time

12

(c) What do you understand by electron scattering in conductors? How is the resistivity dependent on it? Hence explain debye temperature and Matthiessen's rule

12

7. (a) How does conduction take place in intrinsic semiconductors ? Explain with examples. What are limitations of intrinsic semiconductors and how are these taken care of by extrinsic semiconductors? Show that the minimum value of conductivity of a semiconductor with impurity is $\sigma_{\min} = 2n_e e\mu_e$ where

n_e – concentration of conduction electrons (m^{-3})

e – electronic charge (C)

μ_e – mobility of electrons ($m^2\ V^{-1}\ s^{-1}$)

(b) What is superconductivity? Is it possible to make a pure metal a superconductor? Why? Discuss the electric, magnetic and thermal properties of superconductors. Distinguish between Type I and Type II superconductors and give a brief account of oxide superconductors.

12

(c) Discuss the properties and applications of

(i) Ferrites (ii) ALNICO (iii) Ferro-electric ceramics

12

PART D

8. (a) What are the different types of errors ?

Describe their sources briefly.

Find the value of (R_1 + R_2), considering the errors in their values as (i) limiting error (ii) standard deviation when

R_1 = (100 ± 2%) ohm, R_2 = (200 ± 2.5%) ohm.

10

(b) The following test data pertains to an instrument transformer obtained with the help of a co-ordinate potentiometer.

(i) I_1 = 10A, 50Hz; V_1 = (–0.33 + j 0.42) V

E_2 = (–3.14 + j 2.5)V; I_2 = 0

(ii) I_1 = 10A, 50 Hz; V_1 = (–0.03 + j 0.42) V; E_2 = 0

Assuming phase of coil 1 current with respect to potentiometer current same in both cases, find resistance and self inductances of the two coils and mutual inductance between them.

10

(c) Explain the principle of operation of a staircase ramp digital voltmeter with the help of block diagram.

12

9. (a) What are the usual elements of an electronic multimeter ? Draw and explain the basic circuit of the instrument. The value of the current of a triangular wave shape indicated by the multimeter is 2.2 a. Find the rms value of the current.

10

(b) What is a wave analyser? Explain the working of

(i) Frequency selective (ii) Heterodyne wave analysers.

10

(c) Describe the arrangement of A/D converters based on the following:

(i) Successive approximation method

(ii) Slope integration method, and

(iii) Re-circulating remainder system

12

10. (a) What is a data acquisition system? Give the block diagram arrangement of a digital data acquisition system and describe the function of each component.

10

(b) How is pulse modulation used for data transmission? Explain different types of pulse modulators.

Compare PCM telemetry with PAM telemetry.

12

(c) Describe and compare different methods of digital tape recording.

10

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ELECTRICAL ENGINEERING

PAPER - II

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

SECTION A

1. (a) What is meant by similar polarity ends of the two windings of a single phase transformer ? How are these ends identified?

10

(b) A is 15 kVA, 2300/230 V, 50 Hz single phase transformer gave the following test data:

Open Circuit Test $V_0 = 2300$ V, $I_0 = 0.21$ A,

$W_0 = 50$ W

Short Circuit Test $V_S = 47$ V, $I_S = 6.0$ A,

$W_S = 160$ W

(i) Find the equivalent circuit referred to high voltage side.

(ii) Calculate the full load voltage regulation at 0.8 pf lagging when the load voltage is held at 220 volts.

(iii) What is the efficiency at half the rated load at unity of ?

(iv) Find the maximum efficiency and corresponding output power.

20

. (c) State reasons of using tertiary windings in a transformer.

10

2. (a) Explain with the help of suitable diagrams, how rotating magnetic field is produced in a 3-phase induction motor.

10

(b) A 25 hp, 400 V, 50 Hz four pole star connected induction motor has the following impedances per phase in ohms referred to the stator side:

$R_S = 0.641$, $R_r = 0.332$

$X_S = 1.106$, $X_r = 0.464$ and $X_{mag} = 26.30$

Rotational losses are assumed constant and are 1.1 kw and core losses are assumed negligible. If the slip is 2.2% at rated voltage and frequency, find:

(i) speed

(ii) Stator current

(iii) Power factor

(iv) Output and input power

(v) Efficiency of the motor

20

(c) Show that the starting torque of a single phase induction motor is zero.

10

3. (a) Sketch and explain the Open Circuit and Short Circuit characteristics of a synchronous machine.

10

(b) Two synchronous generators are supplying a common load. Generator 1 has a no load frequency of 51.5 Hz and regulation of 1 MW/Hz. The total load is 2.5 MW at 0.8 pf lagging.

(i) At what frequency, are the generators supplying this load and how much power is supplied by each generator?

(ii) An additional load of 1 MW is attached to this system. What will be the new frequency and power generation of each alternator?

(iii) How much is the governor set-point of generator 2 to be adjusted to bring the system frequency at 50 HZ for 3.5 MW system load?

20

(c) Compare the speed-current characteristics of various types of D.C. motors.

10

SECTION B

4. (a) With the help of a schematic diagram, explain the working of "Pumped-storage Plant". Discuss advantages and disadvantages of the plant

10

(b) Draw flow chart of Newton Raphson method for load-flow studies including PV buses. Explain each block of the chart.

20

(c) Discuss the advantages of using Y_{BUS} model of power system network for load-flow analysis.

10

5. (a) Explain the equal-area criterion for the stability of an alternator supplying infinite bus bar via an inductive inter-connector. Mention the limitations of the method.

15

(b) The ABCD constants of a nomial π network representing a three-phase transmission line are:

$A = D = 0.950 \angle 1.27^{o}$, $B = 92.4 \angle 76.87^{o}\ \Omega$ and $C = 0.0006 \angle 90^{o}$ S

Find steady state limit if both the sending end and the receiving end voltages are held at 138 kV, (i) with the given ABCD constants and (ii) with series resistance and shunt admittance neglected.

25

SECTION C

6. (a) Explain the difference between the enhancement mode and depletion mode MOSFETs.

5

(b) Draw h-parameter equivalent circuit of a loaded amplifier in common emitter configuration and derive the expressions for current gain, input impedance, output impedance, overall voltage gain and current gain.

15

(c) Discuss the operation of a generalized resonant circuit oscillator with impedances z_1, z_2 and z_3. Derive the conditions of oscillation and explain under what circumstances the configuration reduces to Hartley oscillator.

15

(d) What are the main purposes for which a common collector amplifier may be used?

5

7. (a) Draw the circuit diagram of a CMOS NAND gate and explain its operation. List main advantages of CMOS gates.

10

(b) What is the main advantage of a synchronous counter over a ripple counter? Draw the block diagram of a 5-bit synchronous counter and explain its operation. Show that a counter may be used for frequency measurement.

20

(c) Distinguish between a 'half adder' and a 'full adder. Give the truth table of a half adder and sketch a circuit which may be used to realize a half adder. Draw the block diagram of a 4-bit parallel binary adder using cascaded full adders.

10

8. (a) List advantages and disadvantages of isolated and memory mapped I/O.

10

(b) Write a program in assembly language to add four numbers available in the memory locations 2500 (H), 2501 (H), location 2501 (H). Also write the algorithm for solving the problem.

20

(c) Write three micro processor instruction used for the memory location called stack.

10

SECTION D

9. (a) In an AM system, the modulating signal is sinusoidal with frequency of f_m Hz. If 80% modulation is used, determine the ratio of the total side-band power to the total power in the modulated signal.

15

(b) A PCM system uses a uniform quantization followed by a 7 bit binary encoder. The bit rate of the system is equal to 50 Megabits per second.

(i) What is the maximum message bandwidth for which the system operates satisfactorily?

(ii) Determine the output signal-to-quantization noise ratio when a full load sinusoidal modulating frequency of 1 MHz is applied to the input.

15

(c) Explain what is meant by "quadrature null effect" in a coherent detector for DSB-SC signals.

10

10. (a) What is an IGBT? Sketch the cross section and equivalent circuit of an IGBT. Discuss its advantages and disadvantages.

10

(b) Explain the principle of operation of a 1-phase inverter. Name the commonly used techniques for controlling the gain and hence the output of the inverter. Explain the Multiple-pulse width modulation techniques.

20

(c) What is a resonant pulse converter? List different types of converters. Discuss the advantages and disadvantages of parallel resonant inverters.

10