Conventional Paper-I-2012

Part A

1. (a) Define intrinsic wave impedance for a medium and derive the equation for intrinsic impedance for a lossy dielectric medium (consider $E_x = 0$, $E_y = 0$, $E_z = E_0 e^{-vy}$)

(b) A spherical volume density is given by,

$$\rho = \rho_0 \left[1 - \frac{r^2}{a^2}\right]; (r \le a)$$
$$= 0; (r > a)$$

(i) Calculate the total charge Q.

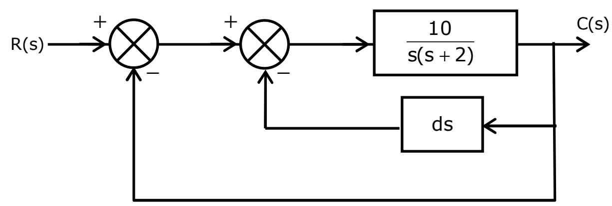
(ii) Find $\vec{E}$ everywhere for $0 < \gamma \le a$ and $\gamma > a$.

(c) Starting from Maxwell's equation

$$\nabla \times \vec{E} = -\frac{\partial \vec{B}}{\partial t} \text{ and } \nabla \times \vec{H} = \vec{J} + \frac{\partial D}{\partial t}$$

Show that $\nabla.\vec{B} = 0$ and $\nabla.\vec{D} = \rho$

2. (a)



A system is described in the above figure

(i) In the absence of derivative feedback (i.e. d=0) determine the damping ratio (δ), natural frequency (ω_n) and the steady state error resulting from a unit ramp input.

(ii) Determine the derivative feedback constant (d) of which will increase the damping ratio of the system to 0.8. What is the steady state error to unit-ramp input with this setting of the derivative feedback constant.

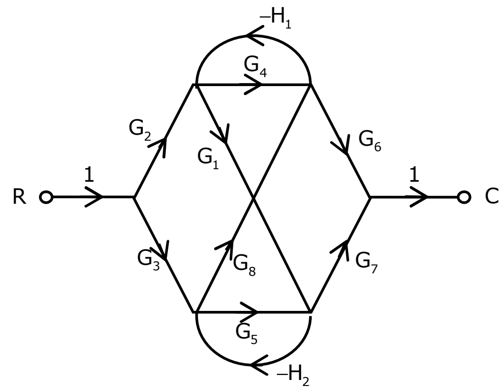
(iii) By changing the forward gain of the amplifier, the steady state error of the system with derivative feedback to unit-ramp input is reduced to same value as in part (i) while the damping ratio is maintained at 0.8. Determine the value of Amplifier gain K_A and the derivative feedback constant. You may use higher gain K_A in place of 10 (as given in the open loop transfer-function). Or you may use an additional amplifier of gain K_A between the two summing points without changing the value of 10 as given in the system.

(b) (i) The characteristic equation of a system is given by

$$s(s-1)(s^2 + 4s + 20) + K(s+1) = 0$$

Find the range of K for which the system is stable.

(ii)



Obtain $\frac{C}{R}$ from the signal flow graph shown in the above figure using Mason's Gain Formula.

(c) Given $G(s)H(s)=\frac{K}{s(s+1)(s+4)}$, sketch the root locus of the system.

(i) Determine the value of K for which the system is at the verge of instability

(ii) For the damping ratio (δ) 0.34, determine the value of K and gain margin (GM).

3. (a) A state variable description of a system is given by the matrix equation:

$$\dot{X}=\begin{bmatrix}-1 & 0\\ 1 & -2\end{bmatrix}X+\begin{bmatrix}1\\ 0\end{bmatrix}r(t),\ Y=\begin{bmatrix}1 & 1\end{bmatrix}X$$

Find:

(i) The transfer function $\frac{Y(s)}{R(s)}$

(ii) The Eigen values of the system

(iii) The state transition matrix

(iv) Prove the non-uniqueness of state variables in general

(b) (i) Derive the expression for c(t) (i.e. the output) for a second order system subject to a unit step input.

(ii) Derive the expressions for generalized error series and also the generalized error coefficients for unity feedback system.

(c) Sketch the complete Bode Plot of the unity feedback system whose open loop frequency function $G(j\omega)=\frac{10}{j\omega(0.1j\omega+1)(0.05j\omega+1)}$

(i) Determine the Gain Margin and Phase Margin.

(ii) Find the open loop gain K for a Gain Margin of 20 db

PART-B

4. (a) Differentiate between intrinsic and extrinsic semiconductors. Explain doping.

(b) The resistivity of pure germanium at room temperature is 0.47 ohms-m. Find out the carrier density of germanium at room temperature for the electron mobility of $0.42\ m^2/\text{volt}-\text{sec}$ and hole mobility of $0.20\ m^2/\text{volt}-\text{sec}$. (electron charge $e = 1.6\times10^{-19}\,C$)

(c) Give and explain the temperature classification of solid insulating materials. Name at least two materials in each class.

5. (a) Discuss classification of Magnetic materials. List properties of ferromagnetic materials. In a certain region, $\mu = 4.6\,\mu_0$ and $B = 10e^{-y}\vec{a}_z$.
Calculate the values (i) χ_m, (ii) H and (iii) M.

(b) (i) Prove with the help of electrons flow that W=VI. Where W is the power in watts, V voltage in volts and I current in amperes, in case of conductor materials.

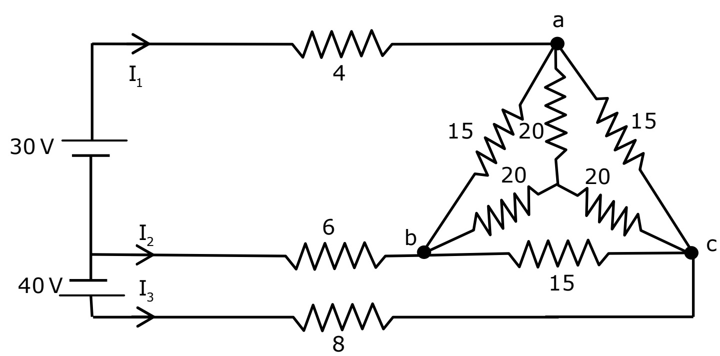
(ii) Find the mean velocity of electron flow in a conductor having a cross-sectional area of $2.1\times10^{-6}\,m^2$ when a current of 20 amperes flows through it. Assume that there are 8.5×10^{28} electrons / m^3 of the material. Charge on an electron is 1.6×10^{-19} coulombs.

(c) What is "magneto resistance effect"? Calculate the current produced in a small germanium plate of area $1\ cm^2$ and of thickness 0.3 mm when a potential difference of 2 V is applied across the faces. Given: concentration of free electrons in germanium is $2\times10^{19}/m^3$ and mobilities of electrons and holes are $0.36\ m^2/\text{volt}-\text{sec}$ and $0.17\ m^2/\text{volt}-\text{sec}$ respectively.

PART-C

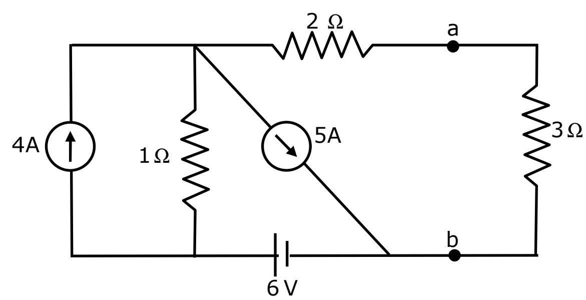
6. (a) Three single phase loads can be connected in either star or in delta to form three-phase load. Which of these connections results in higher current when connected to a three-phase supply? During the measurement of power by two-wattmeter method, the total input power to a 3-phase 440-V motor running at a power factor of 0.8 was found to be 25 kW. Find the readings of the two wattmeters.

(b)



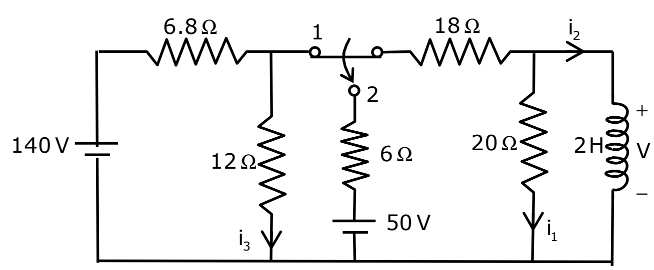
Using star-delta transformation, find the currents I_1, I_2 and I_3 for the above circuit. All the resistances are in ohm.

(c)



For the above circuit, determine the voltage across 3 ohm resistor applying Thevenin's theorem. State the maximum power theorem for an ac circuit.

7. (a)



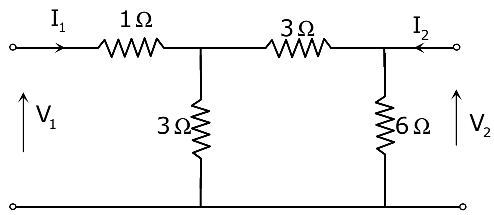
For the above circuit the switch has been in position 1 for a long time.

(i) Find the indicated currents

(ii) Find the indicated currents and voltage immediately after the switch has been thrown to position 2.

(b) Define bandwidth in a series RLC circuit. Show the bandwidth increases with the increase in the value of resistance. The voltage applied to a series RLC circuit is 8.5 V. The quality factor of the coil is 50 and the value of the capacitor is 320 pF. The resonance frequency of the circuit is 175 KHz. Find the value of the inductance, current flowing in the circuit during resonance and voltage across the capacitor under resonance. Draw phasor diagram.

(c)



Obtain z-parameters of a two-port network in terms ABCD parameters. Obtain z-parameters for the circuit shown in the above figure.

Part-D

8. (a) (i) Explain, with a histogram, the normal distribution of errors.
(ii) What is probable error and what is its significance?
(iii) Explain units, system of units, standard and standard for absolute ampere.

(b) Draw the phasor diagram for a two wattmeter method of measuring power in a 3 phase balanced star connected load and derive equations to show that the phase angle of the load

$$\phi = \tan^{-1}\sqrt{3}\frac{(P_1 - P_2)}{P_1 + P_2}$$

Where P_1 & P_2 are wattmeter readings.

(c) What are normal mode and common mode signals? How are they reduced?

9. (a) Explain the principle of operation and construction details of a Resistance Temperature device (RTD).

(b) Draw a sketch of a variable reluctance accelerometer and explain its working.

(c) Draw a circuit diagram of De Sauty Bridge for the measurement of capacitance and obtain an expression for the unknown capacitance. Where are the defects of this bridge?

10. (a) In a non-magnetic medium
$\vec{E} = 4\sin(2\pi\times 10^7 t - 0.8x)\vec{a}_z$ V/m. Find
(i) ε_r, η and
(ii) The time-average power carried by the wave.

(b) Discuss the force exerted on a current element due to a magnetic field $\vec{B}$ in another current element.

(c) A dielectric material contains 2×10^{19} polar molecules/m^3, each of dipole moment. 1.8×10^{-27} C/m. Assuming that all the dipoles are aligned in the direction of the electric field. $\vec{E} = 10^5\vec{a}_x$ V/m, Find $\vec{P}$ and ε_r.