S'06 : 4 AN : EL 404 (1465)

CIRCUIT AND FIELD THEORY

Time : Three hours

Maximum Marks : 100

Answer FIVE *questions, taking* ANY TWO *from* **Group A**, ANY TWO *from* **Group B** *and* ALL *from* **Group C**.

All parts of a question (a, b, etc.) should be answered at one place.

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Group A

1. (*a*) Define the following terms : 6

(*i*) Rank of a Graph

(*ii*) Tie Set

(*iii*) Cut Set.

(*b*) Explain the following : 6

(*i*) Tie Set Matrix

(*Turn Over*)

(*ii*) Cut Set Matrix

(*iii*) Incidence Matrix.

(*c*) In the network of *Fig.* 1, the switch S is closed and a steady state is attained. At $t = 0$, the switch is opened. Determine the current through the inductor. 8

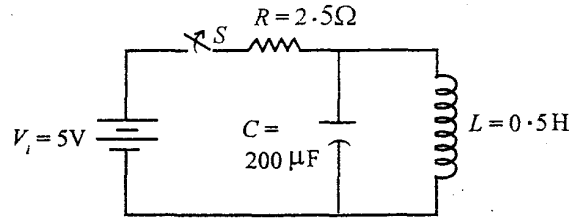


*Fig.*1

2. (*a*) Compare Fourier and Laplace Transforms.

(*b*) Name any three properties of Fourier Transforms.

(*c*) In the circuit of *Fig.* 2, $i(t) = 10e^{-t}\,u(t)\,A$ where $u(t)$ is a unit step function. Calculate the voltage $v(t)$ applying the Fourier Transform method. 20

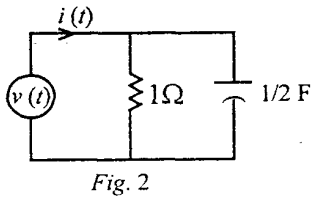


Fig. 2

3. (*a*) State Thévenin's theorem. Using Thévenin's theorem, determine the current in the branch AB of the circuit of *Fig.* 3. 2 + 4

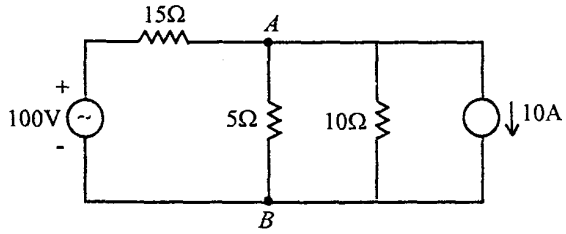


Fig. 3

(*b*) Define driving point impedance of a two-terminal network. What are the properties of the RL driving point impedance functions ? 2 + 6

(*c*) Determine the Z-parameter and Y-parameters of the network shown in *Fig.* 4. 6

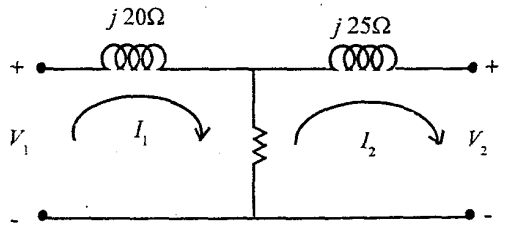
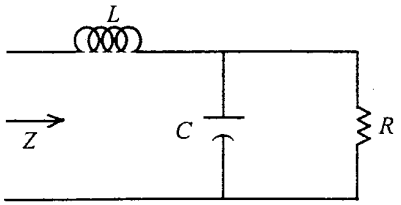


Fig. 4

4. (*a*) What is resonance ? Define Q factor of a resonant circuit. 6

(*b*) Find the resonant frequency for the circuit. Also find the quality factor Q. 6



(*c*) Derive an expression for the characteristic impedance and the propagation function of a symmetrical lattice network in terms of its series arm and diagonal arm impedances. 8

Group B

5. (*a*) Define Divergence. What is divergence of F. 2 + 6

(*b*) Write the Laplace equation for divergence. 2

(*c*) State and prove Stoke's theorem. 2 + 1 + 2 + 5

6. (*a*) Find an expression for H (field intensity) at the centre of a circular wire carrying a current I in the anti-clockwise direction. The radius of the circle is a and the wire is in XY-plane. 10

(*b*) Derive the boundary conditions related to B and H. 4 + 4

(*c*) Determine the flux density at a distance of 0·2 m in air from a N pole of strength 1200 Amp–metres. 2

7. (*a*) Explain Maxwell's equation. 2

(*b*) Derive the differential form of Maxwell's equation from Faraday's law. 2 + 8

(*c*) Define a Wave. Derive the electromagnetic wave equations using Maxwell's equations. 2 + 6

8. (*a*) What is characteristic impedance? 2

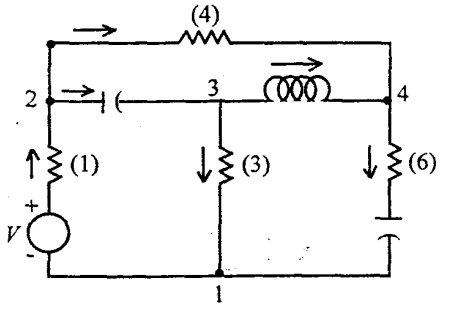
(*b*) Derive the wave equation for a conducting medium. 2 + 8

(*c*) A 2000 MHz standing wave pattern exists in a non-magnetic dielectric. What is the value of ε_r if the distance between a maximum and its adjacent minimum is 1·5 cm? 8

Group C

9. Answer the following: 2 x 10

(*i*) Draw the directed or an oriented graph of the given network.



(*ii*) What are driving point impedance and transfer impedance?

(*iii*) State superposition theorem.

(*iv*) Write the equation for the variation of current for a series RC circuit subjected to a step input voltage.

(*v*) What is called bandwidth in a resonance?

(*vi*) Give the mathematical statement of Helmholtz's theorem.

(*vii*) Define capacitance between two conductors.

(*viii*) Give the equation of Biot-Savart's law.

(*ix*) Write any one condition to be satisfied for a linearly, polarized, uniform plane wave.

(*x*) State the simple mathematical relation of Faraday's law of electromagnetic induction.

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Group A

1. (*a*) Define the open circuit impedance parameters. Why are the parameters called open circuit impedance parameters ? 4 + 1

(*b*) Draw the variation of inductive reactance, capacitive reactance, net reactance, impedance and current of a series RLC resonant circuit with frequency around the resonance frequency. 5

(c) A series RLC circuit consists of a resistance $R = 10\,\Omega$, inductance $L = 0{\cdot}2$ H and capacitance $C = 0{\cdot}2\,\mu$F. Calculate the frequency of resonance. A 10 volts sinusoidal voltage at the frequency of resonance is applied across the circuit. Draw the phasor diagram showing the value of each phasor.
Also calculate the value of current when 10 volt 850 Hz voltage is applied to the circuit. 10

2. (a) Define *ABCD* parameters. Prove that the *ABCD* parameter matrix for the overall network is simply the matrix product of the transmission parameter matrices of each of the two-port networks in cascade. 4 + 8

(b) In the given network (*Fig.* 2 (*b*)) making use of superposition theorem, determine the currents in the resistor R_1, R_2 and R_3 and also the current in the voltage source E. 8

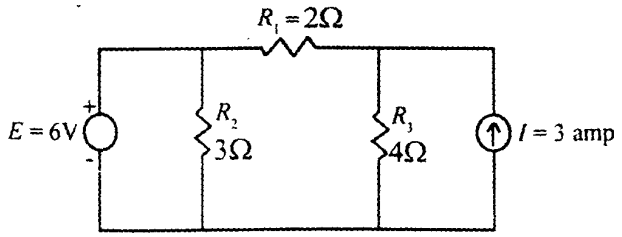

Fig. 2 (*b*)

3. (a) Distinguish between the transient state and steady state with the help of diagrams. 4

(b) Prove that the Laplace transform of any time function $f(t)$ delayed by time a is e^{-as} times the transform of the function $F(s)$. 8

(c) A staircase voltage $v(t)$ shown in *Fig.* 3 (*c*) is applied to an R-L network consisting of $L = 1$ *H* and $R = 2\,\Omega$. Write the equation for the staircase voltage in terms of step function. Find the Laplace transform of $v(t)$. Find the current $i(t)$ in the circuit. Draw the waveform of current $i(t)$. Assume zero current through the inductor L before applying the voltage. 8

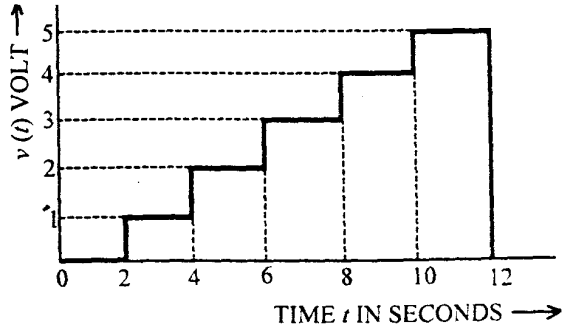

Fig. 3 (*c*)

4. (a) Explain with the help of any graph the connected graph and unconnected graph. 4

(b) For the given resistive network (*Fig.* 4 (*b*)), draw the graph and five possible trees. 1 + 5

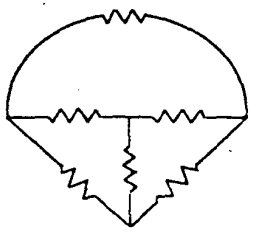

Fig. 4 (*b*)

(*c*) In the given network (*Fig*. 4 (*c*)), switch K is opened at time $t=0$, the steady-state having established previously. With switch K open, draw the transform network representing all elements and all initial conditions. Write the transform equation for current in the loop. Also find the current $i(t)$ in the loop. 10

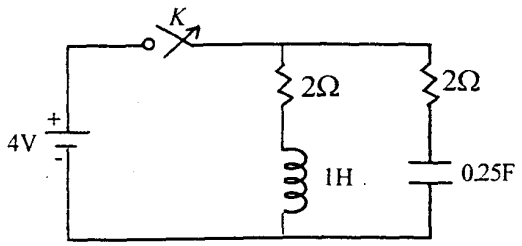

Fig. 4 (*c*)

Group B

5. (*a*) Define Gauss's law in electrostatics. Derive the Poisson's equation from it. 2 + 2

(*b*) Draw the E-field lines in the vicinity of an isolated negative point charge. Also draw a map of the field lines and equipotential contours around two equal negative point charges separated by a distance. 1 + 2 + 2

(*c*) The potential function if given by,

$$V=\frac{10}{x^2+y^2}$$

where V is in volts and x, y are in cm. Find:

(*i*) the expression for the gradient of the potential,

(*ii*) the value of gradient at the point (2, 1) cm,

(*iii*) the electric field intensity at this point. 6

(*d*) Two parallel planes of infinite-extent in the x and y directions and separated by a distance d in the z direction have a potential difference applied between them. The upper plane has a potential V_1 and the lower one has a potential V_0 ($V_1 > V_0$). By using Laplace's equation find the potential distribution and electric field strength in the region between the planes. $2\frac{1}{2}+2\frac{1}{2}$

6. (*a*) Define the Ampere's circuital law. What is the inconsistence of Ampere's law? How does Maxwell remove this inconsistency? Give necessary derivation. 2 + 2 + 3

(*b*) State the two magnetic boundary conditions. Prove them. 3 + 6

(*c*) Two long parallel wires separated by 2 cm in air carry current of 100 amp each. Find the force on one meter length of a conductor. 4

7. (*a*) Starting from the Maxwell's equations show that in free space wave equations are: 9

$$\nabla^2 \vec{E} = \mu\varepsilon \frac{\partial^2 \vec{E}}{\partial t^2}$$

and $$\nabla^2 \vec{H} = \mu\varepsilon \frac{\partial^2 \vec{H}}{\partial t^2}.$$

(*b*) Establish $\nabla \times \vec{B} = \mu_0 \vec{J}$. What is the physical significance of $\nabla \cdot \vec{B} = 0$? 3 + 2

(*c*) Consider the fixed rectangular loop of area A shown in *Fig.* 7 (*c*). The flux density $\vec{B}$ is normal to the plane of the loop (outward in figure) and is uniform over the area of the loop. However the magnitude of $\vec{B}$ varies harmonically with respect to time as given by

$$B = B_0 \cos \omega t$$

where B_0 = maximum amplitude, ω = radian frequency, t = time.

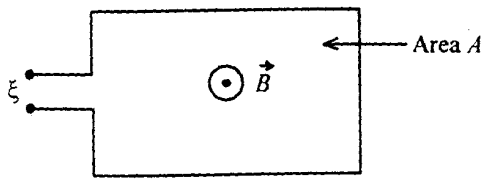

Fig. 7 (*c*)

Find the total emf induced in the loop. 3

(*d*) A one meter long wire carries a current of 10 amperes and makes an angle of 30° with a uniform magnetic field $B = 1.5$ weber/m^2. What is the magnitude and direction of the force acting on the wire? 2 + 1

8. (*a*) Define a uniform plane wave. Distinguish it with transverse wave. Find that a uniform plane wave propagating in the x-direction has no x component of field. 2 + 1 + 6

(*b*) Define perpendicular polarization with diagram. When both medium 1 and medium 2 are perfect non-magnetic dielectrics, prove that for perpendicular polarization the reflection coefficient

$$\Gamma = \frac{\sqrt{\varepsilon_1}\cos\theta_1 - \sqrt{\varepsilon_2 - \varepsilon_1 \sin^2\theta_1}}{\sqrt{\varepsilon_1}\cos\theta_1 + \sqrt{\varepsilon_2 - \varepsilon_1 \sin^2\theta_1}}$$

where, θ_1 is the incident angle in medium 1, ε_1 and ε_2 are the dielectric constants in media 1 and 2, respectively. 2 + 2 + 7

Group C

9. Answer the following: 2 x 10

(*i*) Distinguish between bilateral and unilateral elements with examples.

(*ii*) Why the voltage of a capacitor cannot change instantaneously?

(*iii*) Draw the pole-zero diagram of the network function:

$$N(s) = \frac{(s+1)^2 (s+5)}{(s+2)(s^2+6s+13)}.$$

(*iv*) What do you mean by the bandwidth of a resonant circuit? Why is it called 3-dB bandwidth?

(*v*) State the initial value theorem.

(*vi*) Write the expression of $\nabla\nabla$ in spherical co-ordinate system.

(*vii*) Give the physical interpretation of the equation $\nabla \cdot \vec{D} = \varrho$.

(*viii*) What is Brewster angle ?

(*ix*) Write the four Maxwell's equations.

(*x*)

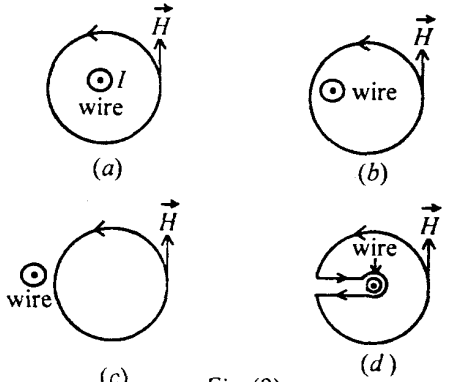

Fig. (9)

Find the line integral of $\vec{H}$ around each of the above closed paths Fig. (9)

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Group A

1. (*a*) Explain the following terms with example : (*i*) Tree, and (*ii*) Cotree of a graph. 8

(*b*) Find out currents and voltages across all branches of the network shown in *Fig.* 1, using current variables methods of Graph theory. 12

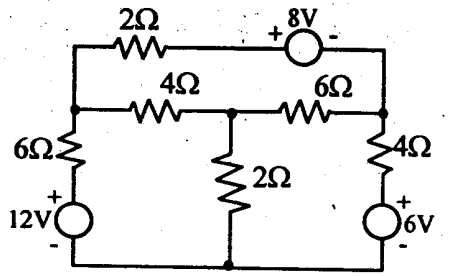

Fig. 1

2. (*a*) Find the Fourier series for the waveform as shown in *Fig.* 2. Also, draw the magnitude spectrum. 10

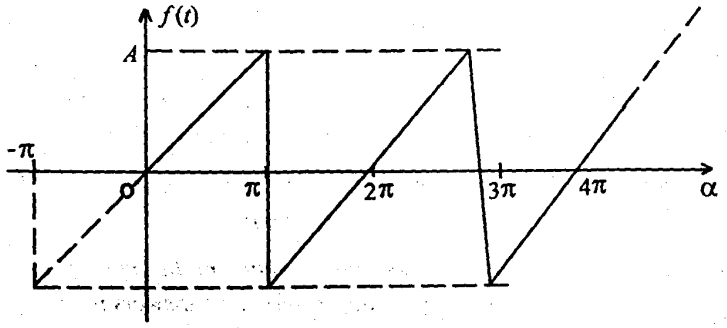

Fig. 2

(*b*) For the circuit shown in *Fig.* 3, find the current flowing in the circuit if the capacitor is initially charged to voltage V_0 as indicated in the figure. 10

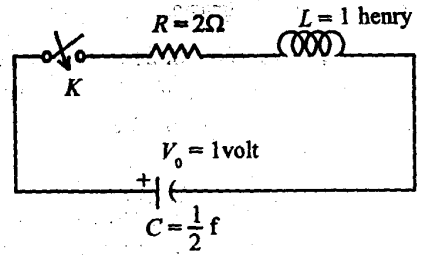

Fig. 3

3. (*a*) State and explain the steps involved in Norton's theorem. 4

(*b*) Find the current, which flows through R_3, by using Norton's theorem in the network as shown in *Fig.* 4. 10

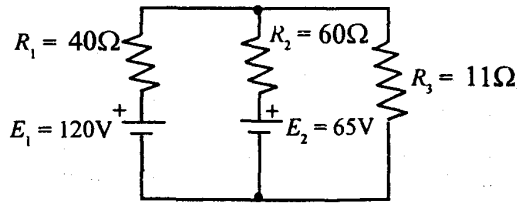

Fig. 4

(*c*) State and explain the maximum power transfer theorem. 6

4. (*a*) Find the transmission parameters for the network shown in *Fig.* 5. 10

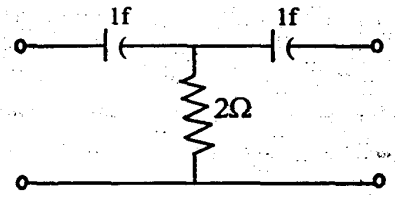

Fig. 5

(*b*) A series RLC circuit has for its driving point admittance pole zero diagram as shown in *Fig.* 6. Find the values of R, L and C. 10

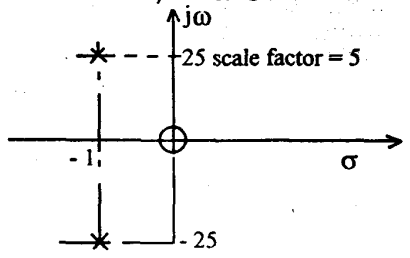

*Fig.*6

Group B

5. (*a*) Prove that electric field $\bar{E}$ and potential Φ are related by the following equation:

$$\bar{E} = -\text{grad}\ \phi .$$ 4

(*b*) Derive Laplace's and Poisson's equations. Using Laplace's equation, find the electric field between two large parallel plates which are closely spaced, ignoring fringing. 6

(*c*) State and explain Biot-Savart's law. Using Biot-Savart's law, find the magnetic induction at a point on the axis of a circular loop of radius R carrying a current I. 10

6. (*a*) Explain the term magnetic vector potential. Explain the steps to calculate it with a suitable example. 10

(*b*) Derive wave equation for conducting media, assuming harmonic variation of $\bar{E}$ with time. 10

7. Starting with Ampere's law, derive Maxwell's equation in integral form. Also, obtain the corresponding differential or point relation by applying Stoke's theorem. 20

8. (*a*) Write a short note on standing waves and determine an expression for the standing wave ratio. 8

(*b*) Explain the term depth of penetration of electromagnetic wave. Also, deduce suitable expression for the same. 6

(*c*) State and prove Poynting's theorem. 6

Group C

9. Answer the following in brief: 2 x 10

(*i*) Write the conditions to be fulfilled by a periodic function, $f(t)$, to be expanded into a Fourier series.

(*ii*) State final value theorem using Laplace transform method.

(*iii*) Write the Laplace transform of a periodic waveform.

(*iv*) Write the Laplace transform of (*a*) $e^{at} f(t)$, and (*b*) unit impulse function.

(*v*) Write divergence theorem in point form.

(*vi*) What do you mean by solenoidal and irrotational fields?

(*vii*) Derive an equation for the field produced by a line distribution of charge, ϱ_L (C/m), on a straight infinitely long conductor at a distance γ from it.

(*viii*) State Tellegen's theorem.

(*ix*) Write equations to transform a delta-connected circuit to a star-connected one.

(*x*) Comment on the use of methods of circuit analysis.

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Group A

1. (*a*) In a two-port input/output network, define the $[Z]$ parameters. How can $[Z]$ parameters be experimentally determined? 2 + 3

(*b*) Define quality factor and bandwidth of a series RLC resonant circuit. 5

(*c*) A series RLC circuit, which consists of a resistance $R = 15\,\Omega$, inductance $L = 0{\cdot}2\,\text{H}$ and capacitance $C = 0{\cdot}3\,\mu\text{F}$, is at resonance and is being supplied by a 15 V source having frequency equal to resonance frequency. The circuit is being used for detection of metal. In proximity to a metallic object, the inductance of the coil changes to $0{\cdot}3\,\text{H}$.

If the source voltage and frequency remain unaltered, calculate the initial resonance frequency, initial and final values of current. 10

2. (*a*) In the given network shown in *Fig.* 1, express the Thevinin's equivalent across load resistance R_L :

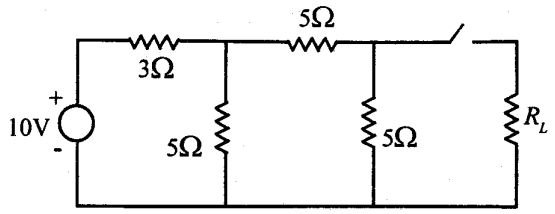

Fig. 1

Also, obtain the value of load resistance R_L for maximum power transfer. 5 + 5

(*b*) Using a suitable example, explain the superposition theorem. 5

(*c*) Explain transfer impedances in brief. 5

3. (*a*) In *Fig.* 2, obtain the expression of transient current using Laplace's transform, when the switch is suddenly closed at time $t = 0$. Also, plot $I(t)$ *vs.* t. 8

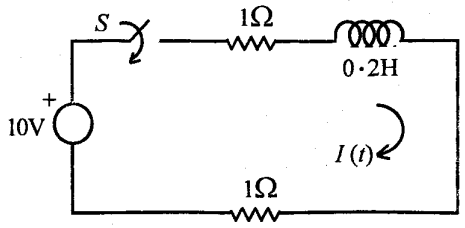

Fig. 2

(*b*) In *Fig.* 3, the circuit is connected to voltage source at $t = 0+$. After 0·1 sec, resistance R_1 is suddenly short-circuited. Using Laplace's transform, obtain the expressions of current for time $t = 0+$ to $t = 0{\cdot}1$ sec and $t = 0{\cdot}1$ sec to $t = \infty$ sec. 12

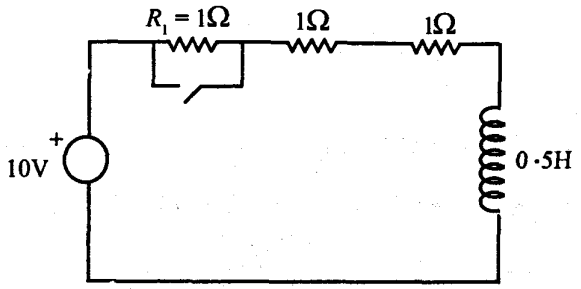

Fig. 3

4. Write short notes on any *two* of the following: 10 x 2

(*i*) Tie set and tie set matrices;

(*ii*) Convolution integral;

(*iii*) Initial and final value theorem;

(*iv*) Application of Laplace transform for solving differential equations.

Group B

5. (*a*) Write and discuss Maxwell's equations in point form. 6

(*b*) Draw a map of the field lines and equipotential contours for a transmission line shown in *Fig.* 4:

Fig. 4

Choose your own dimensions. 6

(*c*) In a two-dimensional problem, the potential function is given by

$$V(x, y) = 5/(x + y)$$

where V is in volts and x, y are in cm. Find the (*i*) expression for the gradient of the potential; and (*ii*) electric field intensity at a point (1, 1) cm. 8

6. (*a*) In *Fig.* 5, a point charge of + 1 μC is present at a point (5, 5) between two orthogonal conducting planes using method of images. Calculate (*i*) image charges and their ordinates; and (*ii*) electric potential at point (6,6).

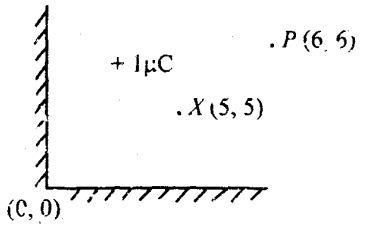

Fig. 5

Choose CGS system of units. 10

(*b*) Discuss boundary conditions in an electromagnetic field problems. 5

(*c*) Describe briefly (*i*) electric scalar potential, and (*ii*) magnetic vector potential. 5

7. (*a*) Explain briefly (*i*) transformer induced emf, and (*ii*) speed induced emf. 5

(*b*) In square trough, shown in *Fig.* 6, compute potential at point X using method of first iteration only. 15

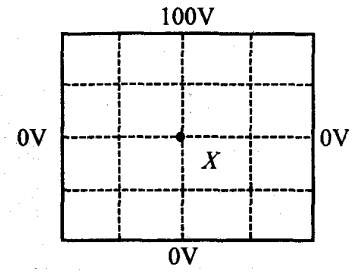

Fig. 6

8. (*a*) A 5 GHz plane wave is propagating in a material having $\epsilon_r = 2{\cdot}53$, $\mu_r = 1$ and $\sigma = 0$. Assuming that the electric field is given by

$$\bar{E} = 10 \cos (10\pi \times 10^9 t - \beta z) . \hat{a}_x \text{ V/m}$$

determine v, λ and β. 10

(*b*) Graph the fields $\bar{E}$ and $\bar{H}$ of a uniform plane wave at time $t = 0$, assuming free space. 5

(*c*) Define standing wave ratio. 5

Group C

9. Answer the following: 2 x 10

(*i*) Distinguish between *ABCD* parameters and *Z* parameters of a two-port network.

(*ii*) Define Lenz's law.

(*iii*) Draw the pole zero diagram of the network function:

$$H(s) = (s+5) / (s+3)\ (s+7s+14).$$

(*iv*) Write Laplace's equation in three-dimensional electrostatic problem.

(*v*) Calculate skin depth at 100 Hz in a material having $\mu_r = 1{\cdot}0$ and $\sigma = 3{\cdot}60 \times 10^7$ S/m.

(*vi*) A ferromagnetic plunger is attracted to a solenoid coil carrying 10 Amp d. c. current by 0·001 m when the inductance of solenoid changes by 0·02 H. Calculate the force on the plunger.

(*vii*) State and explain Biot-Savart law.

(*viii*) Can we apply superposition theorem to an electric circuit with a non-linear resistance?

(*ix*) Why is the disk plate inside the microwave oven rotated at low speed?

(*x*) State and explain Poynting theorem.

(*b*) Explain Gram-Schmidt procedure to obtain orthogonal basis of signals. 10

(*c*) State and explain Nyquist criterion. 4

3. (*a*) What is thermal noise? Find out the expression for available signal power in presence of thermal noise. 10

(*b*) What are shot noise and partition noise? 6

(*c*) What is noise equivalent bandwidth? 4

4. (*a*) A frequency-modulated signal which is modulated by a 3 kHz sine wave reaches a maximum frequency of 100·02 MHz and minimum frequency of 99·98 MHz. Determine (*i*) carrier swing, (*ii*) carrier frequency, (*iii*) frequency deviation, of the signal, and (*iv*) modulation index of the signal. 12

(*b*) Explain the principle of FDM and TDM? What is TDD? 8

Group B

5. (*a*) What is entropy of a source? How can you find maximum entropy of several alphabets? Define code efficiency and redundancy of codes. 8

(*b*) Define channel capacity and channel efficiency for a discrete noisy channel. Describe the properties of binary symmetric channel and binary erase channel. Derive an expression for channel capacity in terms of sampling conditioning. 12

6. (*a*) What are the differences between DPCM and ADPCM from quantization error point of view? 10

(*b*) Describe the method of optimum detection of signal using matched filters. Derive an expression for impulse response of a matched filter. 10

7. (*a*) What is intersymbol interference (ISI)? Describe the principle of a receiver which can be used to compensate or to reduce ISI in the received signal. 10

(*b*) What is the technique for digital RF modulation? Describe the principle and construction of a Modem. Derive an expression for bit error probability in terms of bit energy. 10

8. (*a*) Explain Schwarz's inequality for two power signals. Define cross-correlation and auto-correlation of two power signals. Find out spectral density function for a given power signal. 12

(*b*) What is envelope detector? How can you estimate SNR of an envelope detector? Describe the design constraint for envelope detector. 8

Group C

9. Choose the *correct* answer for the following: 2 x 10

(*i*) Maxwell's equation

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

is actually

(*a*) Gauss's law

W'08 : 4 AN : EL 404 (1465)

CIRCUIT AND FIELD THEORY

Time : Three hours

Maximum Marks : 100

Answer FIVE *questions, taking* ANY TWO *from* **Group A**, ANY TWO *from* **Group B** *and* ALL *from* **Group C**.

All parts of a question (a, b, etc.) should be answered at one place.

Answer should be brief and to-the-point and be supplemented with neat sketches. Unnecessary long answers may result in loss of marks.

Any missing or wrong data may be assumed suitably giving proper justification.

Figures on the right-hand side margin indicate full marks.

Group A

1. (*a*) Define the following terms in terms of network graph theory: 2 x 4

(*i*) Branch

(*ii*) Twig

(*iii*) Link

(*iv*) Cut-set.

(*b*) What is the relation between links and branches in terms of nodes? What are the properties of a tree in a graph? 5

(*c*) For a network shown in *Fig.*1, draw the oriented graph and obtain the cut-set matrix. Assume branch *b*-e to be the tree in the graph. Also, find number of twigs and links. 7

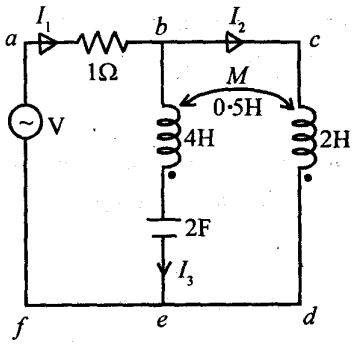

Fig. 1

2. (*a*) State and explain the initial and final value theorem. 5

(*b*) A function, in Laplace domain, is given by

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

Obtain its value by final value theorem in time domain. 3

(*c*) If $f_1(t) = 2u(t)$ and $f_2(t) = e^{-3t}u(t)$, determine the convolution between $f_1(t)$ and $f_2(t)$. 5

(*d*) A 10 V step voltage is applied across a *R*- *C* series circuit at $t = 0$. Find $i(t)$ at $t = 0+$ and obtain the value of $[di/dt]_{t=0+}$. Assume $R = 100\ \Omega$ and $C = 100\ \mu F$. 7

3. (*a*) Find the Fourier series of the function, shown in *Fig.*2, represented by 12

$$f(t) = \begin{cases} 0 \text{ for } & 0 < t < T/2 \\ A \text{ for } & T/2 < t < T \end{cases}$$

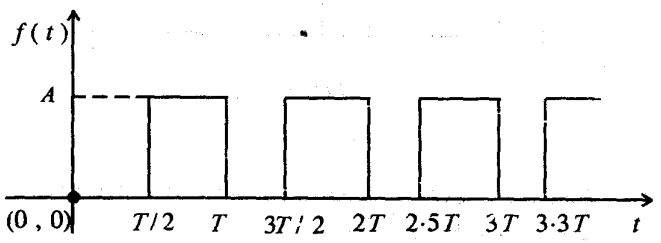

Fig. 2

(*b*) In the network shown in *Fig.*3, find the pole zero plot. 8

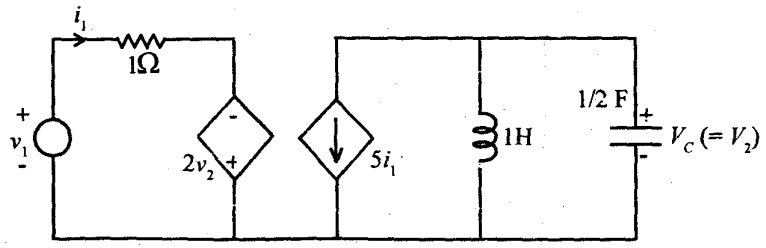

Fig. 3

4. (*a*) What is the Z parameter model of a two port network? How can you express Z parameters in terms of ABCD parameters? 4

(*b*) Find the open circuit parameter of the two port network shown in *Fig.* 4: 6

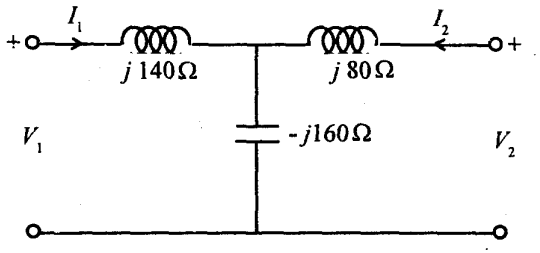

Fig. 4

(*c*) Find the Thevenin's equivalent network of the circuit across $X - Y$ (*Fig.* 5): 10

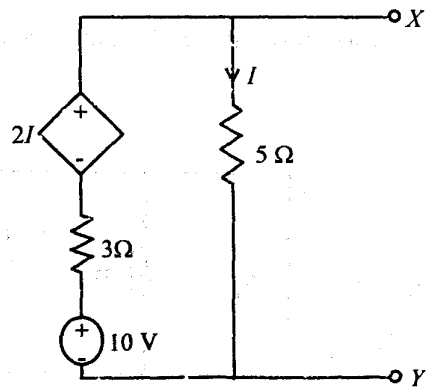

Fig. 5

Group B

5. (*a*) Explain the divergence and curl of a vector. What do you mean by solenoidal vector? 12

(*b*) State Stokes' theorem. 3

(*c*) Using Stokes and Divergence theorems, show that for a vector field A,

$$\nabla \cdot \nabla \times A = 0.$$ 5

6. (*a*) Using Gauss's theorem in electrostatics, develop Poisson's equations. How can you find Laplace equation from this? 10

(*b*) Considering a parallel plate capacitor, explain the concept of energy density. 10

7. (*a*) Explain the concept of (*i*) scalar magnetic potential, and (*ii*) magnetic vector potential. 5

(*b*) State and explain Ampere's law, both in integral and differential form, as used in magnetic fields. 7

(*c*) Show that the magnetostatic field can be described in terms of vector potential which satisfies the vector Poisson's equation. 8

8. (*a*) Write and explain differential and integral forms of Maxwell equations. Are all four Maxwell equations independent? Explain. 10

(*b*) State and prove Poynting theorem. Explain the terms : instantaneous , average and complex Poynting vectors. 10

Group C

9. Answer the following in brief: 2 x 10

(*i*) Duality of network.

(*ii*) Hurwitz properties of a polynomial.

(*iii*) Symmetry and reciprocity of a two port network.

(*iv*) Transfer function of a system.

(*v*) Dependent sources in an electrical network.

(*vi*) Time constant in an electric circuit.

(*vii*) Irrotational vector.

(*viii*) Magnetic dipole moment.

(*ix*) Differential form of Faraday's law.

(*x*) Propagation constant.

S'08 : 4 AN : EL 404 (1465)

CIRCUIT AND FIELD THEORY

Time : Three hours

Maximum Marks : 100

Answer FIVE *questions, taking* ANY TWO *from* **Group A**, ANY TWO *from* **Group B** *and* ALL *from* **Group C**.

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Answer should be brief and to-the-point and be supplemented with neat sketches. Unnecessary long answer may result in loss of marks.

Any missing or wrong data may be assumed suitably giving proper justification.

Figures on the right-hand side margin indicate full marks.

Group A

1. (*a*) Show that the resonant frequency, f_0, of a series RLC circuit is related to the half power frequencies f_1 and f_2 by the expression

$$f_0 = \sqrt{f_1 \; f_2}.$$

(*b*) For the a.c. voltage network shown in *Fig.*1, analyse by loop current method to determine the conditions for no current through the detector arm. 7

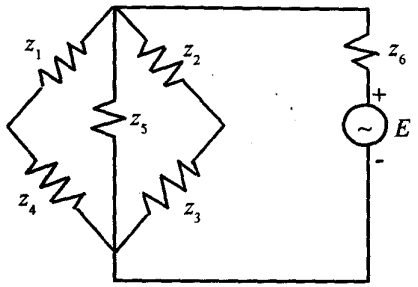

Fig. 1

(*c*) For symmetrical *T* network, shown in *Fig.*2, find *ABCD* constants. Hence or otherwise, find the image impedance of this two terminal pair network : 7

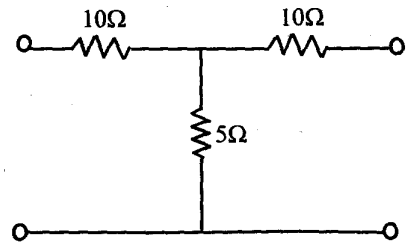

Fig. 2

2. : and explain Thevenin's theorem. 4

the current through R_3 using Norton's theorem
e network shown in *Fig*.3 : 10

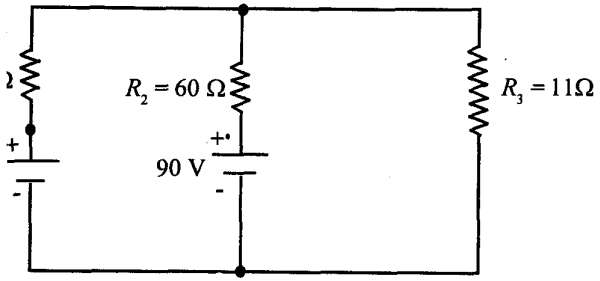

Fig. 3

: and prove the initial and final value theorems
ıplace transform. 6

3. (the inverse Laplace transforms of the wing : 6x2

(*i*) $F(s) = \dfrac{s+1}{s^3 + s^2 - 6s}$

(*ii*) $F(s) = \dfrac{s+2}{s^5 - 2s^4 + s^3}$

(*b*) For the circuit shown in *Fig.*4, find the current $i(t)$ using Laplace transform method. Given that $i(0+) = 2\,A$, and $v_c(0+) = 4\,V$. 8

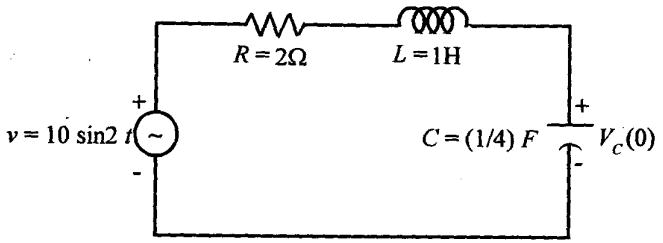

Fig. 4

5. (*a*) State and prove (*i*) convolution theorem, and (*ii*) complex translation theorem of Laplace transform. 10

(*b*) Find an expression for the value of current at any instant after a sinusoidal voltage of amplitude 600 V at 50 Hz is applied to a series circuit of resistance 10 ohms and inductance 0·1 henry, assuming that the voltage is zero at the instant of switching ($t = 0$). Also, find the value of transient current at $t = 0{\cdot}02$ sec. 10

Group B

3. (*a*) Write and discuss Maxwell's equations in point and integral forms. 7

(*b*) Show that the following field vectors in free space satisfy all Maxwell's equations : 7

$$\bar{E} = E_0 \cos(\omega t - \beta z)\,\bar{a}_x$$

$$\bar{H} = \frac{E_0}{\eta} \cos(\omega t - \beta z)\,\bar{a}_y$$

(*c*) Define magnetic scalar and vector potentials. 6

6. (*a*) Find the magnetic field and its curl at radius r within a conductor of radius $R > r$ carrying current I, uniformly distributed over the cross-section. 8

(*b*) Explain and derive boundary conditions for perfect dielectric materials. 8

(*c*) State and prove Ampere's law. 4

7. (*a*) Establish the relation between field and circuit theory. Illustrate equivalence of the two to a series circuit with resistance, inductance and capacitance connected across an a.c. generator. 10

(*b*) A pair of conducting planes meet at an angle of 60°. A point charge $+Q$ is located at a distance a from both the planes. Find the electric field intensity at the foot of a perpendicular. 10

8. (*a*) Verify whether the vector field

$$\bar{F} = y^2 z\,\bar{a}_x + z^2 x\,\bar{a}_y + x^2 y\,\bar{a}_z$$

is irrotational, solenoidal or general. 6

(*b*) State and explain Poynting theorem. 7

(*c*) Find the a.c. resistance and reactance of a rectangular conductor using Maxwell's equations. 7

Group C

9. Answer the following in brief : 2 x 10

(*i*) Define the term 'transfer function' of a system.

(*ii*) Write Poisson's equation for electrostatic potential in three-dimensional cartesian coordinate system.

(*iii*) Prove that the divergence of curl of a vector is zero.

(*iv*) Explain Lenz's law.

(*v*) What is meant by phase velocity and group velocity of an electromagnetic wave ?

(*vi*) What is a TEM wave ?

(*vii*) What is meant by depth of penetration of an electromagnetic wave in a conductor.

(*viii*) What do you understand by dual networks ?

(*ix*) Give a comparison of different methods of analysis of electric networks.

(*x*) What are standing wave and standing wave ratio ?

S'09 : 4 AN : EL 404 (1465)

CIRCUIT AND FIELD THEORY

Time : Three hours

Maximum Marks : 100

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Answer should be brief and to-the-point and be supplemented with neat sketches. Unnecessary long answers may result in loss of marks.

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Figures on the right-hand side margin indicate full marks.

Group A

1. (*a*) Define the following terms of network graph theory : 2 x 4

(*i*) Directed graph

(*ii*) Subgraph

(*iii*) Cut-set

(*iv*) Isomorphism.

(*Turn Over*)

(*b*) What is incidence matrix? Write the properties of incidence matrix. Draw the graph corresponding to the incidence matrix given below : 5

$$[A_i] = \begin{bmatrix} 1 & 0 & 0 & 1 \\ -1 & 1 & 1 & 0 \\ 0 & -1 & -1 & -1 \end{bmatrix}.$$

(*c*) For a resistive network shown in *Fig*.1, determine the number of branches, number of nodes, and number of links. Also, write the network equilibrium equation. 7

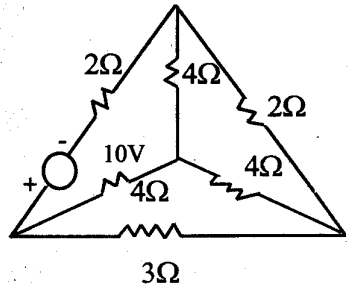

Fig. 1

2. (*a*) State and explain the initial and final value theorem. 5

(*b*) A function in Laplace domain is given by

$$I(s) = (s+1)/[s(s^2+4s+4)].$$

Obtain its inverse form. 5

(*c*) A pulse waveform is shown in *Fig*.2. Obtain its Laplace transform. 5

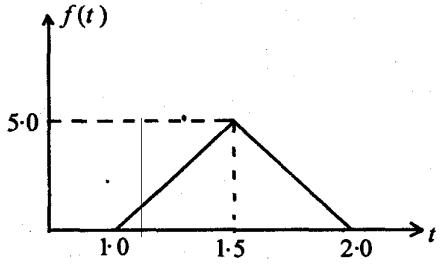

Fig. 2

(*d*) In *Fig*.3, switch S_1 is closed at $t=0$. Switch S_2 is opened at $t=4$ ms. Obtain i for $t>0$. 5

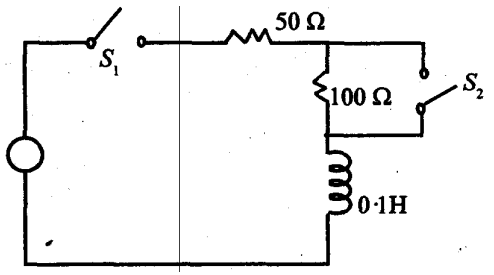

Fig. 3

3. (*a*) Find the Fourier series of the waveform shown in *Fig*. 4. 12

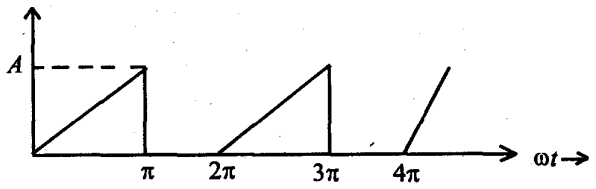

Fig. 4

(*b*) In the network, shown in *Fig*. 5, find V_c / V. Also, find pole zero locations. 8

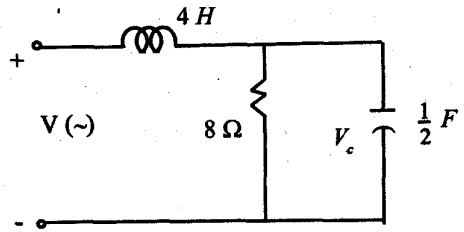

Fig. 5

4. (*a*) What is the *ABCD* parameter model of a two-port network? How can you express *z* parameters in terms of *ABCD* parameters? 5

(*b*) Find the *z*-parameter for the circuit model shown in *Fig*. 6. 5

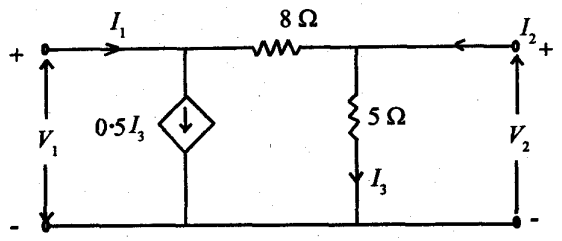

Fig. 6

(*c*) What should be the value of R_L so that the maximum power can be transferred from the source to R_L as shown in *Fig*. 7. Also, calculate the maximum power which can be transferred to R_L. 10

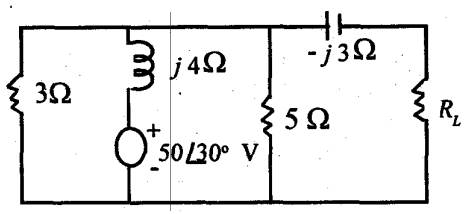

Fig. 7

Group B

5. (*a*) State and explain the following : 3 x 4

(*i*) The gradient of a scalar field

(*ii*) The divergence of a vector field

(*iii*) The curl of a vector field

(*iv*) Solenoidal vector.

(*b*) State and explain the (*i*) divergence theorem, and (*ii*) Stokes theorem. 2 + 2

(*c*) A vector field is given by

$$E = y\,a_x - 2{\cdot}5x\,a_y + 3a_z$$

at a point $P(4, 5, 2)$. Calculate the divergence of E at point P. 4

6. (*a*) State and explain the Gauss's law in differential form. Also, develop Poisson's and Laplace equations. 10

(*b*) A finite sheet of charge density $\rho_s = 2x(x^2 + y^2 + 4)^{3/2}$ c/m^2 lies in $z = 0$ plane for $0 \leq x \leq 2$m and $0 \leq y \leq 2$m. Determine the electric field intensity at point (0, 0, 2) m. 10

7. (*a*) State and explain Biot-Sevart's law for static magnetic fields as applied to different types of current distributions. 10

(*b*) Derive the expression curl $H = J$. 4

(*c*) Explain the following terms : 3 + 3

(*i*) Magnetic vector potential

(*ii*) Scalar magnetic potential.

8. (*a*) State and prove Poynting theorem. Also, calculate the average power density. 10

(*b*) Write and explain differential and integral forms of Maxwell equations. 10

Group C

9. Explain the following in brief : 2 x 10

(*i*) Norton theorem

(*ii*) Properties of Hurwitz polynomial

(*iii*) Q-factor

(*iv*) Transient response of R- L series circuit having d.c. excitation.

(*v*) Convolution

(*vi*) Coulomb's law

(*vii*) Irrotational vector

(*viii*) Differential form of Faraday's law

(*ix*) Energy density in magnetic field

(*x*) Polarization of electromagnetic wave.

W'09 : 4 AN : EL 404 (1465)

CIRCUIT AND FIELD THEORY

Time : Three hours

Maximum Marks : 100

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Answer should be brief and to-the-point and be supplemented with neat sketches. Unnecessary long answers may result in loss of marks.

Any missing or wrong data may be assumed suitably giving proper justification.

Figures on the right-hand side margin indicate full marks .

Group A

1. (*a*) What is reduced incidence matrix ? Develop the reduced incidence matrix of the graph shown in *Fig.* 1. 7

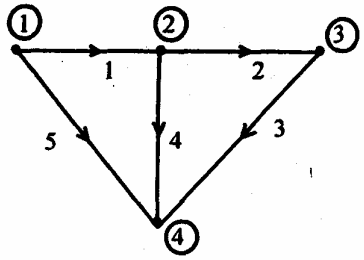


Fig. 1

(*b*) What do you mean by twig matrix and link matrix? With reference to *Fig.* 2, draw the graph and write the tie-set matrix. 8

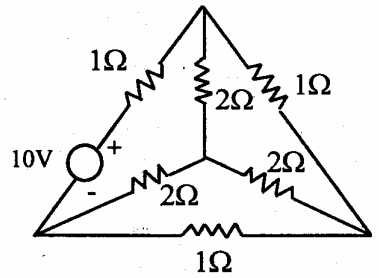


Fig. 2

(*c*) Define the following terms of network graph theory: (*i*) Incidence matrix, (*ii*) oriented graph, and (*iii*) loop. 5

2. (*a*) What is the difference between even function symmetry and odd function symmetry? 4

(*b*) Obtain the Fourier analysis of the waveform shown in *Fig.* 3: 12

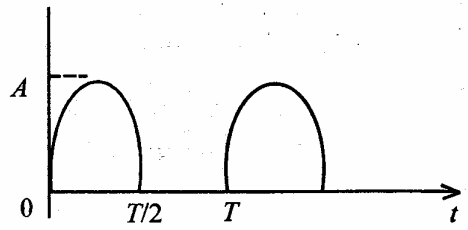


Fig. 3

(*c*) Find out the expression of power with non-sinusoidal voltage and current. 4

3. (*a*) State and explain the time displacement theorem. 5

(*b*) In the Laplace domain, a function is given by

$$F(S) = M\left[\frac{(s+\alpha)\sin\theta}{(s+\alpha)^2+\beta^2} + \frac{\beta\cos\theta}{(s+\alpha)^2+\beta^2}\right]$$

Show, by initial value theorem,

$$\lim_{t\to 0} f(t) = M\sin\theta.$$ 8

(*c*) Obtain inverse Laplace transform of $I(s)$ when 7

$$I(s) = \frac{250}{(s^2+625)(s+2)}.$$

4. (*a*) Find out the condition of reciprocity and symmetry in *z* parameter representation. 5

(*b*) Obtain the *z* parameter for *Fig.* 4 as shown below: 10

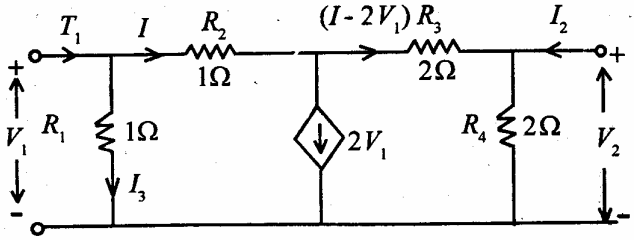


Fig. 4

(*c*) How can you express the *y* parameters in terms of *ABCD* parameters? 5

Group B

5. (*a*) Write the conditions for non-solenoidal and rotational field. 2

(*b*) Find the nature of following fields by determining divergence and curl: 4 + 4

(*i*) $F_1 = 30\ \hat{1}_x + 2xy\ \hat{1}_y + 5xz^2\ \hat{1}_z$

(*ii*) $F_2 = (150/r^2)\ \hat{1}_r + 10\ \hat{1}_\phi$.

(*c*) A vector field $\vec{D} = (5r^2/4)\ \hat{1}_r$ is given in spherical co-ordinates. Evaluate both sides of divergence theorem for the volume enclosed between $r = 1$ and $r = 2$. 10

6. (*a*) State and explain Ampere's law both in integral and differential form as used in magnetic fields. 7

(*b*) Derive the expression $\text{curl}\ \vec{H} = \vec{J}$. 5

(*c*) Show that the magnetostatic field can be described in terms of vector potential which satisfies the Vector-Poisson's equation. 8

7. (*a*) Write and explain differential and integral forms of Maxwell's equations. 5 + 5

(*b*) Explain the significance of displacement current. 5

(*c*) An a.c voltage source $v = V_0 \sin \omega t$ is connected across a parallel plate capacitor C. Verify that displacement current in capacitor is the same as the conduction current in wires. 5

8. (*a*) Derive the equation of uniform plane wave for the medium having constant μ, ϵ, σ. Find the solution of the wave equation for sinusoidal variation, if $\vec{E} = E_x\ \hat{1}_x$ and the wave is propagating in the $+z$ direction. 12

(*b*) For a lossy dielectric material having $\mu_r = 1$, $\epsilon_r = 48$, $\sigma = 20$ s/m, calculate the attenuation constant, phase constant and intrinsic impedance at a frequency of 16 GHz. 8

Group C

9. Explain the following in brief: 2 × 10

(*i*) Biot-Savart's law

(*ii*) Thevenin's theorem

(*iii*) Sinusoidal response of series RC circuit

(*iv*) Maximum power transfer theorem in a.c. circuit

(*v*) Millman's theorem

(*vi*) Initial and final value theorem

(*vii*) Rotational vector

(*viii*) Equipotential surface

(*ix*) Point form of Gauss's law

(*x*) Polarization.

Group B

5. (*a*) Write the conditions for non-solenoidal and rotational field. 2

(*b*) Find the nature of following fields by determining divergence and curl: 4 + 4

(*i*) $F_1 = 30\ \hat{1}_x + 2xy\ \hat{1}_y + 5xz^2\ \hat{1}_z$

(*ii*) $F_2 = (150/r^2)\ \hat{1}_r + 10\ \hat{1}_\phi$.

(*c*) A vector field $\vec{D} = (5r^2/4)\ \hat{1}_r$ is given in spherical co-ordinates. Evaluate both sides of divergence theorem for the volume enclosed between $r = 1$ and $r = 2$. 10

6. (*a*) State and explain Ampere's law both in integral and differential form as used in magnetic fields. 7

(*b*) Derive the expression curl $\vec{H} = \vec{J}$. 5

(*c*) Show that the magnetostatic field can be described in terms of vector potential which satisfies the Vector-Poisson's equation. 8

7. (*a*) Write and explain differential and integral forms of Maxwell's equations. 5 + 5

(*b*) Explain the significance of displacement current. 5

(*c*) An a.c voltage source $v = V_0 \sin \omega t$ is connected across a parallel plate capacitor C. Verify that displacement current in capacitor is the same as the conduction current in wires. 5

8. (*a*) Derive the equation of uniform plane wave for the medium having constant μ, ϵ, σ. Find the solution of the wave equation for sinusoidal variation, if $\vec{E} = E_x\ \hat{1}_x$ and the wave is propagating in the $+z$ direction. 12

(*b*) For a lossy dielectric material having $\mu_r = 1$, $\epsilon_r = 48$, $\sigma = 20$ s/m, calculate the attenuation constant, phase constant and intrinsic impedance at a frequency of 16 GHz. 8

Group C

9. Explain the following in brief: 2 × 10

(*i*) Biot-Savart's law

(*ii*) Thevenin's theorem

(*iii*) Sinusoidal response of series RC circuit

(*iv*) Maximum power transfer theorem in a.c. circuit

(*v*) Millman's theorem

(*vi*) Initial and final value theorem

(*vii*) Rotational vector

(*viii*) Equipotential surface

(*ix*) Point form of Gauss's law

(*x*) Polarization.

S'10:4AN:EL404 (1465)

CIRCUIT AND FIELD THEORY

Time : Three hours

Maximum Marks : 100

Answer FIVE *questions, taking* ANY TWO *from* **Group A,** ANY TWO *from* **Group B** *and* ALL *from* **Group C.**

All parts of a question (a,b,etc.) should be answered at one place.

Answer should be brief and to-the-point and be supplemented with neat sketches. Unnecessary long answers may result in loss of marks.

Any missing or wrong data may be assumed suitably giving proper justification.

Figures on the right-hand side margin indicate full marks.

Group A

1. (*a*) What is convolution ? State and prove convolution theorem. 6

(*b*) Obtain inverse Laplace transform of $I(s)$, when 6

$$I(s) = 250/(s^2 + 625)(s + 2)$$

(*c*) A step voltage of $100\, t\, u(t)$ volts is applied across a series RC circuit where $R = 5$ K-ohm and $C = 4$ μF. Find the voltage drop across the resistor R and show that it is approximately equal to 2V. 8

2. (*a*) Briefly explain what do you mean by 'symmetry' in Fourier series. 5

(*b*) Obtain the expression of the RMS value of a periodic complex wave. 8

(*c*) How do you obtain the expression of power with non-sinusoidal voltage and current ? 7

3. (*a*) For the network, shown in *Fig.* 1, draw (*i*) the oriented graph, (*ii*) select a tree using the LC branch of the original network, (*iii*) obtain the cut set matrix, and (*iv*) find number of twigs and links. 10

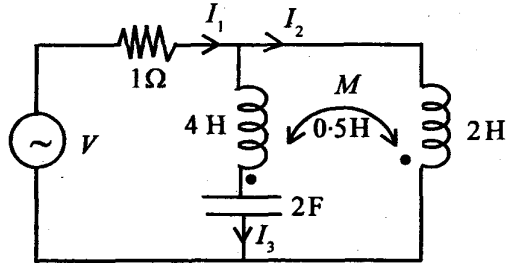


Fig. 1

(*b*) Find Thevenin's equivalent network of the circuit across *XY* terminal (*Fig.* 2): 10

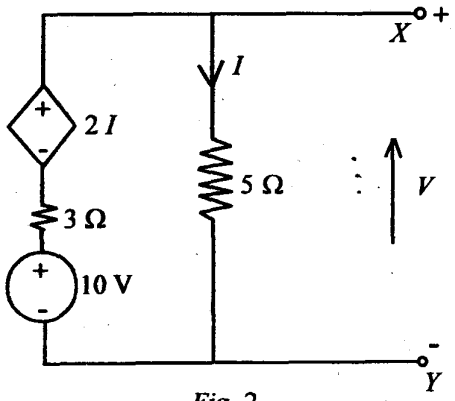


Fig. 2

4. (*a*) In a tank circuit (*Fig.* 3), show that the circulating current at resonance is given by

$$I = V\left[\frac{C}{L}\right]^{1/2}$$

for an a.c. supply voltage of V volt. Neglect any resistance of the circuit. 10

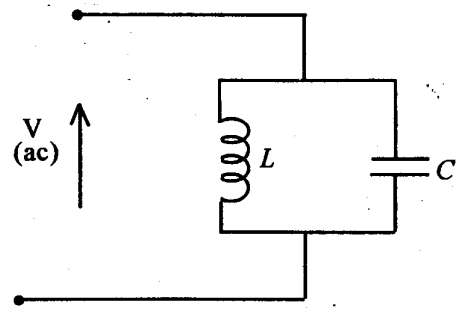


Fig. 3

(*b*) Find the pole zero locations of the current transfer ratio (I_2/I_1) in *s*-domain for the circuit shown in *Fig.* 4: 10

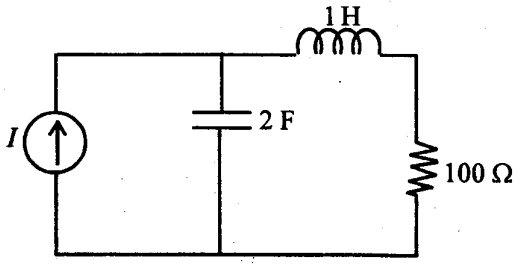


Fig. 4

Group B

5. (*a*) Obtain an expression of the gradient of a scalar field and find its magnitude. 10

(*b*) Why is the gradient zero on an equipotential surface ? 4

(*c*) Explain what do you mean by the curl and divergence of a vector field ? 6

6. (*a*) From Gauss's theorem, develop the Poisson's equation. 12

(*b*) Find the potential and electric field intensity for the region between two concentric right circular cylinders, where $V = 0$ at $r_a = 1$ mm and $V = 100$ V at $r_b = 20$ mm. Neglect fringing. 8

7. (*a*) State and explain Ampere's law both in integral and differential form as used in magnetic fields. 12

(*b*) How are the unit vectors defined in (*i*) cylindrical, and (*ii*) spherical co-ordinate systems ? 8

8. (*a*) State and prove Poynting theorem. Explain the terms instantaneous, average and complex Poynting vectors. 5 + 5

(*b*) Derive general expressions for reflection coefficient and transmission coefficient for *E* and *H* fields, when an electromagnetic wave is incident normally on the boundary separating two different (*i*) conducting media, and (*ii*) perfectly dielectric media. 5 + 5

Group C

9. Explain the following in brief : 2 × 10

(*i*) Dependent sources

(*ii*) Initial and final value theorem

(*iii*) Irrotational fields

(*iv*) Non-solenoidal field

(*v*) Superposition theorem applied to a.c. circuits

(*vi*) Fundamental tie set matrix

(*vii*) Implication of waveform symmetry in Fourier analysis

(*viii*) Driving point impedance

(*ix*) Series resonance in RLC circuit

(*x*) Difference between Fourier and Laplace transformation.

W'10 : 4AN : EL 404 (1465)

CIRCUIT AND FIELD THEORY

Time : Three hours

Maximum Marks : 100

Answer FIVE *questions, taking* ANY TWO *from* **Group A,** ANY TWO *from* **Group B** *and* ALL *from* **Group C.**

All parts of a question (a, b, etc.) should be answered at one place.

Answer should be brief and to-the-point and be supplemented with neat sketches. Unnecessary long answers may result in loss of marks.

Any missing or wrong data may be assumed suitably giving proper justification.

Figures on the right-hand side margin indicate full marks.

Group A

1. (*a*) Show that functions in exponential Fourier series of the periodic function, $f(t)$, are orthogonal. 5

   (*b*) Determine the current in 5Ω resistor for the circuit shown in Fig. 1 by using supernode analysis. 7

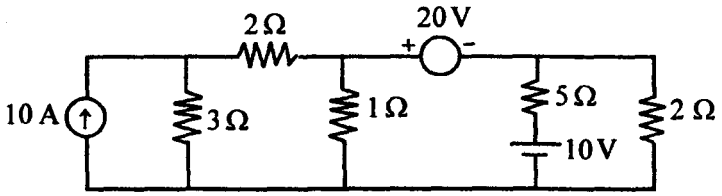


Fig. 1

(*c*) In the given network (Fig. 2), while switch, *K*, is closed before time $t = 0$, the steady-state is established. With switch *K* open at time $t = 0$, draw the transform network representing all elements and all initial conditions. Write the transform equation for current in the loop. Also, find the current, $i(t)$, in the loop. 3 + 2 + 3

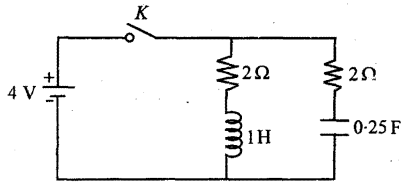


Fig. 2

(*a*) A coil of inductance *L* and resistance *R* is in parallel with a capacitor of capacitance *C*. Show that the resonant frequency is 6

$$f_0 = \frac{1}{2\pi}\sqrt{\frac{1}{LC} - \frac{R^2}{L^2}}$$

(*b*) Write two-port *z*-parameter and *ABCD* parameter equations. From *z*-parameter equations, derive expressions for *ABCD* parameters in terms of *z*-parameters. 4 + 4

(*c*) The *z*-parameters for a two-port network are: $z_{11} = 40\ \Omega$, $z_{22} = 30\ \Omega$, $z_{12} = z_{21} = 20\ \Omega$. Compute the transmission parameters for the network. Also, write network equations using these two types of parameters. 4 + 2

4. (*a*) The voltage across an inductor is given by $v(t) = te^{-t}$ volt at $t \geq 0$. Obtain the expression for the current through the inductor. Assume the value of the inductance of the inductor to be 10 mH. 4

(*b*) Prove that the Laplace transform of any time function, $f(t)$, delayed by time *a* is e^{-as} times the transform of the function $F(s)$. 5

(*c*) A staircase voltage, $v(t)$, shown in Fig. 5, is applied to an *R-L* network consisting of $L = 1H$ and $R = 2\ \Omega$. Write the equation for the staircase voltage in terms of step function. Find the Laplace transform of $v(t)$. Find the current $i(t)$ in the circuit. Draw the waveform of current $i(t)$. Assume zero current through the inductor, *L*, before applying the voltage. 3 + 2 + 5 + 1

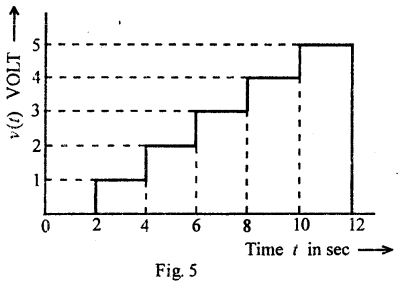


Fig. 5

Group B

5. (*a*) Define the Ampere's circuital law. What is the inconsistence of Ampere's law ? How does Maxwell remove this inconsistency ? Give necessary derivation. 2 + 2 + 6

3. (*a*) A two port network is shown in Fig. 3, where the block represents a network of resistors. A resistor, *R*, is connected at the output as shown in the figure. the given conditions of the network are :
(*i*) When $R = \infty$, V = 10 V
(*ii*) When $R = 0$, $I = 5$ A.
Find the value of V when $R = 8\ \Omega$ using the concept of Thevenin's theorem. 5

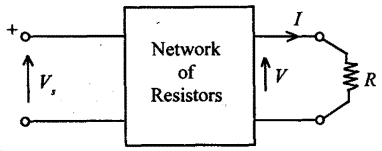


Fig. 3

(*b*) For the two-port network shown in Fig. 4, determine the driving point impedance, $Z_{11}(s)$, and driving point admittance, $Y_{11}(s)$. Also, find the transfer impedance, $Z_{21}(s)$. 4

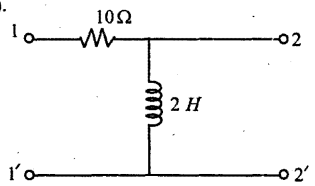


Fig. 4

(*c*) Define poles and zeros and their importance. 2 + 2

(*d*) Draw the pole zero diagram for the given network function, $I(s)$, and hence find the time domain behaviour from this pole and zero plots. 2 + 3

$$I(s) = \frac{20s}{(s+5)(s+2)}$$

(*b*) Give the statement and proof of the electric boundary condition involving normal component of displacement density vector. What would be the statement of this boundary condition when one of the two media is a metal conductor ? 2 + 3 + 1

(*c*) A 1 m long wire carries a current of 10 A and makes an angle of 30° with a uniform magnetic field $B = 1{\cdot}5$ weber/m². What is the magnitude and direction of the force acting on the wire ? 3 + 1

6. (*a*) State Faraday's laws of electromagnetic induction. 3

(*b*) What is the conservation of charge rule ? From this principle, prove that 2 + 4

$$\nabla.\vec{j} + \partial\rho/\partial t = 0$$

(*c*) Two parallel planes of infinite-extent in *x* and *y* directions and separated by a distance *d* in *z* direction have a potential difference applied between them. The upper plane has a potential V_1 and the lower one has a potential V_0 ($V_1 > V_0$). By using Laplace's equation, find the potential distribution and electric field strength in the region between the planes. 7

(*d*) Determine the divergence of the vector field : 4

$$\vec{P} = x^2\, yz\hat{a}_x + xz\hat{a}_z$$

7. (*a*) What do you mean by potential energy of a system ? Prove that the potential energy of a system of *N* charges is given by

$$U = \frac{1}{2}\sum_{i=1}^{N} q_i V_i = \frac{1}{2}\sum_{i=1}^{N} \frac{1}{4\pi\varepsilon}\sum_{j\neq 1}\frac{q_i q_j}{r_{ij}}$$

where symbols have their usual meanings. 10

(*b*) A square of side 1 m in air has a point charge $q_1 = 10^{-12}$ Coulomb at the upper-left corner, a point charge $q_2 = -10^{-11}$ Coulomb at the lower-left corner, and a line distribution of charge of uniform density $\rho_L = 10^{-11}$ Coul/m along the right edge. Calculate the potential at the point P at the centre of the square as shown in Fig. 6. 7

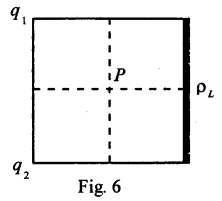


Fig. 6

(*c*) The capacitance of a parallel plate capacitor is 400 picofarad. What will be the energy when it is charged to 1500 V ? 3

8. (*a*) Define uniform plane wave. Distinguish it with the plane wave. 2 + 1

(*b*) Write the time-harmonic Maxwell's equations in differential and integral forms (indicating vector sign). 2 + 2

(*c*) Define perpendicular polarization with a neat diagram. When both medium 1 and medium 2 are perfect non-magnetic dielectrics, prove that, for perpendicular polarization, the reflection coefficient

$$\Gamma = \frac{\sqrt{\varepsilon_1}\cos\theta_1 - \sqrt{\varepsilon_2 - \varepsilon_1 \sin^2\theta_1}}{\sqrt{\varepsilon_1}\cos\theta_1 + \sqrt{\varepsilon_2 - \varepsilon_1 \sin^2\theta_1}}$$

where θ_1 is the incident angle in medium 1; ε_1 and ε_2, the dielectric constants in media 1 and 2, respectively. (2 + 2) + 9

Group C

9. Answer the following in brief : 10 × 2

(*i*) What is the usage of learning convolution integral ?

(*ii*) Define time constant of a circuit.

(*iii*) Why cannot the voltage of a capacitor change instantaneously ?

(*iv*) What do you mean by polarization of dielectric ?

(*v*) What do you mean by the bandwidth of a resonant circuit ? Why is it called 3 db bandwidth ?

(*vi*) State the final value theorem.

(*vii*) Give the physical interpretation of the equation $\nabla.\vec{D} = \rho$.

(*viii*) What is Brewster angle ?

(*ix*) Write the Laplace's and Poisson's equations.

(*x*) State uniqueness theorem.

S'11 : 4 AN : EL 404 (1465)

CIRCUIT AND FIELD THEORY

Time : Three hours

Maximum Marks : 100

Answer FIVE *questions, taking* ANY TWO *from* **Group A**, ANY TWO *from* **Group B** *and* ALL *from* **Group C**.

All parts of a question (a, b, etc.) should be answered at one place.

Answer should be brief and to-the-point and be supplemented with neat sketches. Unnecessary long answers may result in loss of marks.

Any missing or wrong data may be assumed suitably giving proper justification.

Figures on the right-hand side margin indicate full marks .

Group A

1. (*a*) Find the Thevenin's equivalent of the circuit across *X*- *Y* of the circuit shown in Fig. 1 : 6

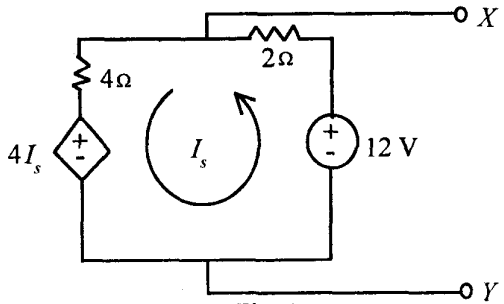


Fig. 1

(*b*) Determine the voltage ratio transfer function ($G_{12} = V_2/V_1$) for the network shown in Fig. 2 : 8

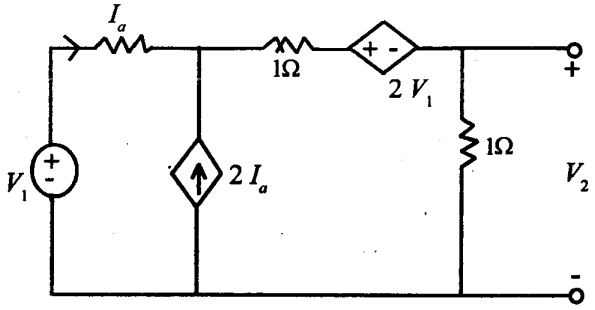


Fig. 2

(*c*) (*i*) Write the necessary condition for deriving point impedance. 3

(*ii*) Write the condition of reciprocity and symmetry in two port parameters. 3

2. (*a*) Determine the Z and Y parameters for the circuit shown in Fig. 3 : 10

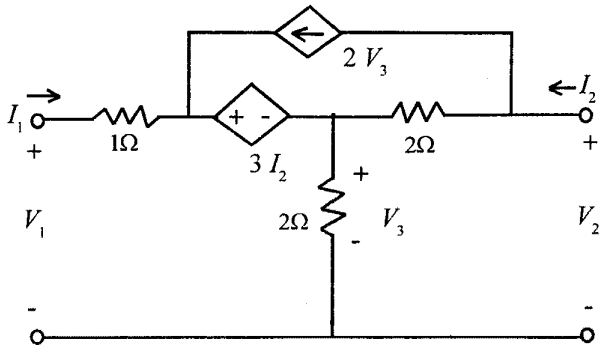


Fig. 3

(*b*) For the circuit shown in Fig. 4, determine (*i*) resonant frequency, (*ii*) total impedance of the circuit at resonance, (*iii*) bandwidth, (*iv*) quality factor, and (*v*) show the graph of capacitive and inductive susceptance with frequency. 5x2

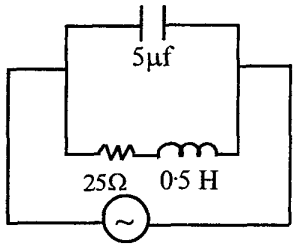


Fig. 4

3. (*a*) (*i*) Current and voltage profile of an element *vs.* time are given in Fig. 5 :

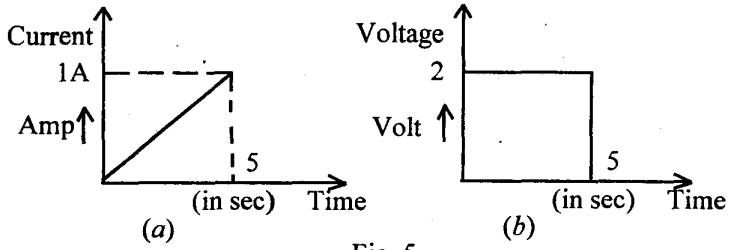


Fig. 5

Determine the element, s, and find its value. 3

(*ii*) In the circuit shown in Fig. 6, find V_x ? 3

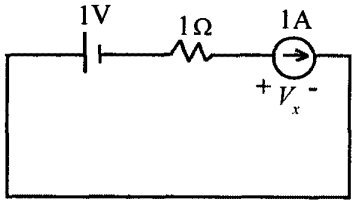


Fig. 6

(*b*) The reduced incidence matrix is given by 8

$$[A] = \begin{array}{c} \\ 1 \\ 2 \\ 3 \end{array} \begin{array}{c} \begin{array}{cccccc} 1 & 2 & 3 & 4 & 5 & 6 \end{array} \\ \begin{bmatrix} 1 & 1 & 0 & 0 & 0 & 1 \\ 0 & -1 & 1 & -1 & 0 & 0 \\ -1 & 0 & -1 & 0 & -1 & 0 \end{bmatrix} \end{array}$$

(*i*) Draw the graph corresponding to this matrix ?

(*ii*) Determine number of KCL equation.

(*iii*) Determine number of KVL equation.

(*iv*) Determine rank of the graph.

(*c*) In the network, shown in Fig. 7, the switch K is in position A for a long period of time. At $t=0$, the switch is moved from A to B. Find $V_2(t)$ using Laplace transformation method. Assume that the initial current in the 2-H inductor is zero. 6

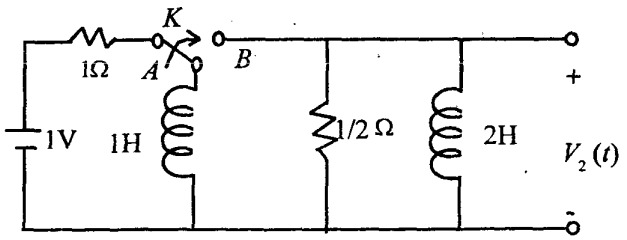


Fig. 7

4. (*a*) Determine Laplace transform of the periodic, rectified half-sine wave as shown in Fig. 8 : 8

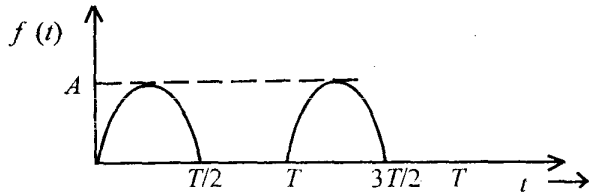


Fig. 8

(*b*) Find the Fourier series of single rectangular pulse shown in Fig. 9 : 8

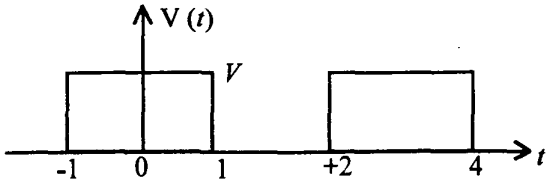


Fig. 9

(*c*) Determine the RMS value of $f(t)$: 4

$$f(t) = 3 + 4\sin(\omega t) + 5\cos(2\omega t)$$

Group B

5. (*a*) (*i*) State Gauss's law and develop its mathematical form. 5

(*ii*) Show that the expression for divergence of D, div $D = \varrho_v$. 5

(*b*) Derive Laplace's and Poisson's equation in cartesian, cylindrical and spherical co-ordinate systems. 10

6. (*a*) Show that the energy density in electrostatic field is $1/2\,(|\bar{D}|^2/\epsilon)$. 4

(*b*) A dipole having a moment $\bar{P} = 10\,\bar{a}_x - 3\,\bar{a}_y + 5\,\bar{a}_z$ $n\,(-m)$ is located at $Q\,(2, 4, 1)$ in free space. Find V at (*i*) $P(x, y, z)$, and (*ii*) $(5, 1, 0)$. 12

(*c*) Define the type of dielectrics polarisations. 4

7. (*a*) State and explain Stokes's theorem and Poynting theorem. 5 + 5

(*b*) If $\bar{B} = 0{\cdot}05\ x\ \bar{a}_y\ T$ in a material for which $x_m = 2{\cdot}5$, find (*i*) μ_r, (*ii*) μ, (*iii*) $\bar{\mu}$, (*iv*) $\bar{M}$, (*v*) $\bar{J}$. 5 x 2

8. (*a*) The electric field intensity of 300 MHz uniform plane wave in free space is given as

$$E_s = (20 + j50)\ (\bar{a}_x + 2\bar{a}_y)\ e^{-j\beta z}\ \text{V/m}$$

Find (*i*) ω, (*ii*) λ, (*iii*) ν, and (*iv*) β. 8

(*b*) Write the equation of Faraday's law, Ampere's circuital law, Gauss's law (magnetic) in differential form and integral form for time varying fields. 12

Group C

9. Choose the *correct* answer for the following : 10 x 2

(*i*) The superposition theorem is essentially based on the concept of

(*a*) reciprocity.

(*b*) linearity.

(*c*) duality.

(*d*) non-linearity.

(*ii*) If $z = 3 + 4j$, then the conductance is

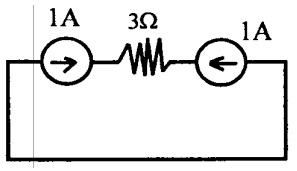
(*a*) 3

(*b*) 1/3

(*c*) 3/2*s*

(*d*) 4/2*s*

(*iii*) For the given circuit, find the power loss in 3Ω resistance :



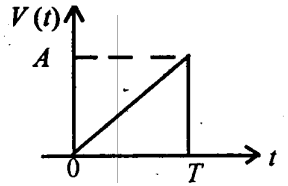
(*a*) 27 W

(*b*) 12 W

(*c*) 0 W

(*d*) 6 W

(*iv*) The voltage waveform shown in the given figure, the equation for $V(t)$ is



(*a*) $(A/T) + [u(t) - u(t-T)]$

(*b*) $(T/A) + [u(t) - u(t-T)]$

(*c*) $(A/T)(t-1)\ [u(t) - u(t-T)]$

(*d*) $(A/T)\ t\ u(t)$

(*v*) In the series RLC circuit, frequency less than the resonant frequency,

(*a*) circuit is capacitive.

(*b*) circuit is inductive.

(*c*) circuit is resistive.

(*d*) no effect.

(*vi*) The electric field lines and equipotential lines

(*a*) are parallel to each other.

(*b*) are one and the same.

(*c*) cut each other orthogonally.

(*d*) can be inclined to each other at any angle.

(*vii*) Maxwell's divergence equation for the magnetic field is given by

(*a*) $\nabla \times B = 0$

(*b*) $\nabla \cdot B = 0.$

(*c*) $\nabla \times B = \varrho$

(*d*) $\nabla \cdot B = \varrho$

(*viii*) Velocity of the plane wave $e^{\sin 2(\omega t - \beta x)}$ is

(*a*) $2\omega/\beta$

(*b*) $\omega/2\beta$

(*c*) ω^2/β^2

(*d*) ω/β

(*ix*) $\bar{E}$ and $\bar{H}$ are related as

(*a*) $\bar{E}/\bar{H} = \sqrt{\mu_0 \epsilon_0}$

(*b*) $\bar{E}/\bar{H} = \sqrt{\mu_0/\epsilon_0}$

(*c*) $\bar{H}/\bar{E} = \sqrt{\mu_0 \epsilon_0}$

(*d*) $\bar{H}/\bar{E} = \sqrt{\mu_0/\epsilon_0}$

(*x*) The boundary conditions at the interface between two dielectrics are

(*a*) $D_N = 0 : E_N = 0$

(*b*) $D_n = 0 : E_t = 0$

(*c*) $D_t = 0 : E_t = 0$

(*d*) None of the above.

W'11:4AN:EL404 (1465)

CIRCUIT AND FIELD THEORY

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Answer FIVE *questions, taking* ANY TWO *from* **Group A,** ANY TWO *from* **Group B** *and* ALL *from* **Group C.**

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Answer should be brief and to-the-point and be supplemented with neat sketches. Unnecessary long answers may result in loss of marks.

Any missing or wrong data may be assumed suitably giving proper justification.

Figures on the right-hand side margin indicate full marks.

Group A

1. (*a*) In the circuit, shown in Fig. 1, find Norton's equivalent circuit across (r_L) : 10

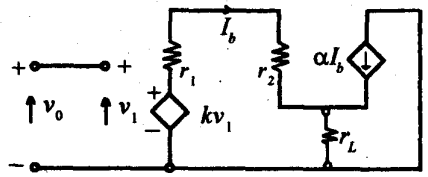

Fig. 1

(*b*) In Figs. 2 and 3, obtain V_0 and establish reciprocity theorem : 10

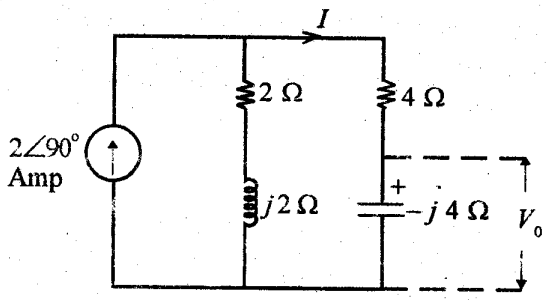

Fig. 2

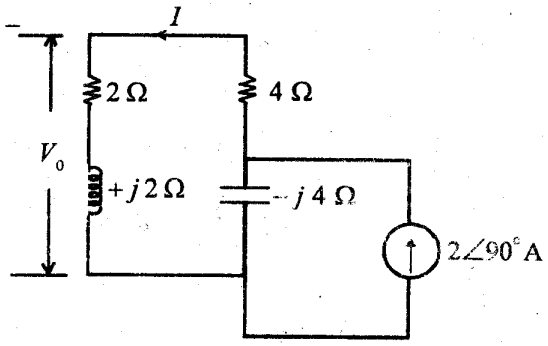

Fig. 3

2. (*a*) Find the value of R_1 in Fig. 4 such that the given circuit is resonant. 10

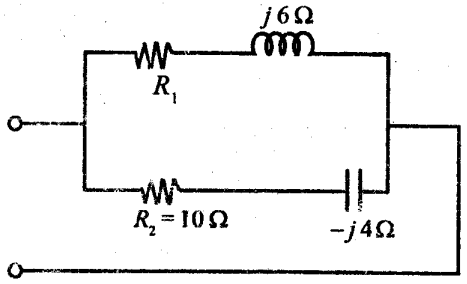

Fig. 4

(*b*) Write the equations for *Y*-parameter representation of a two-port netwrok and develop the conditions of reciprocity and symmetry in *Y*-parameter network. 10

3. (*a*) Establish analytically the concept of convolution using Laplace transformation of two functions. 10

(*b*) In a LC circuit, shown in Fig. 5, the initial current through the inductor being 2 A, the initial voltage is 10 V. Assume $L = 1$ H and $C = 0{\cdot}5$ F. Find the voltage across the capacitor at $t = (0+)$ using Laplace transformation technique. 10

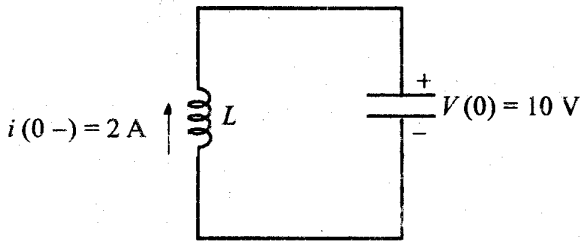

Fig. 5

4. (*a*) Find the pole zero locations of the current transfer ratio (I_2/I_1) in the *s*-domain for circuit shown in Fig. 6. 10

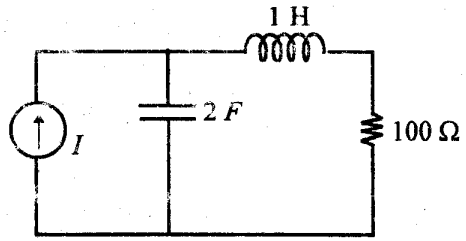

Fig. 6

(*b*) What are tie-set and cut-set matrices ? Establish the orthogonal relationship between these two matrices. 10

Group B

5. (*a*) State and prove Poynting theorem. Explain the terms instantaneous, average and complex Poynting vectors. 10

(*b*) Derive general expressions for reflection coefficient and transmission coefficient for E and H fields when an electromagnetic wave is incident normally on the boundary separating two different (*i*) conducting median, and (*ii*) perfectly dielectric median. 10

6. (*a*) State Gauss's law and establish the divergence theorem for a static electric field. 10

(*b*) What happens when a solid conductor is placed in an electric field ? Derive the boundary relations at the boundary between a conductor and a dielectric. 10

7. (*a*) Write and explain differential and integral forms of Maxwell's equations. Are all four Maxwell's equations independent ? Explain. 10

(*b*) What do you understand by skin effect ? Define skin depth. Show that in case of a semi-infinite solid conductor, the skin depth δ is given by

$$\delta = \sqrt{2/\omega\mu\sigma}$$

Symbols have their usual meanings. 10

8. (*a*) Find the skin depth, δ, at a frequency of 1.6 MHz in aluminium, where σ =38·2 MS/m and $\mu_r = 1$. Also, find the propagation constant and wave velocity. 10

(*b*) Keeping in view the field concepts, explain KVL (Kirchhoff's voltage law) and KCL (Kirchhoff's current law). 10

Group C

9. Answer the following in brief : 10 × 2

(*i*) Give the limitations of Gauss's law.

(*ii*) What is the concept of energy density in a parallel plate capacitor ?

(*iii*) Why the net impedance of a series LCR circuit at resonance is only R ?

(*iv*) What is the limitation of superposition theorem ?

(*v*) How do you validify the conservation of power in an electric network using Tellegen's theorem ?

(*vi*) What is a gate function and what is its Laplace transform ?

(*vii*) What is coefficient of coupling in a coupled circuit and when is its value zero ?

(*viii*) What is open circuit natural frequency (OCNF) ?

(*ix*) What are the salient properties of incidence matrix ?

(*x*) What is the mathematical relation between twigs and links in graph theory of network ?

S'12:4 AN : EL 404 (1465)

CIRCUIT AND FIELD THEORY

Time : Three hours

Maximum Marks : 100

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All parts of a question (a, b, etc.) should be answered at one place.

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Figures on the right-hand side margin indicate full marks.

Group A

1. (*a*) Differentiate between even function geometry and odd function geometry. 4

(*b*) Obtain the Fourier analysis of the waveform shown in Fig. 1 : 12

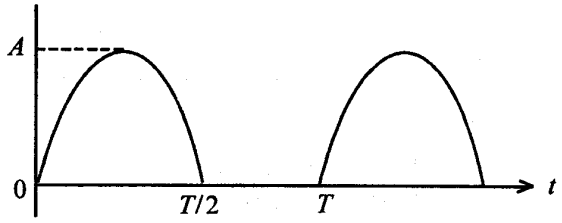

Fig. 1

(*c*) Find the expression of power with non-sinusoidal voltage and current. 4

(Turn Over)

2. (*a*) What is reduced incidence matrix ? Develop the reduced incidence matrix of the graph shown in Fig. 2 : 6

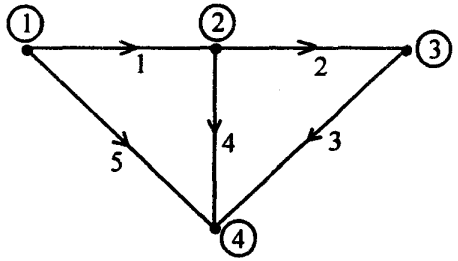

Fig. 2

(*b*) Define the following terms of network graph theory : (*i*) Incidence matrix, (*ii*) oriented graph, and (*iii*) loop. 3 × 2

(*c*) What do you understand by twig matrix and link matrix ? Draw the graph and write the tie-set matrix with reference to Fig. 3 : 8

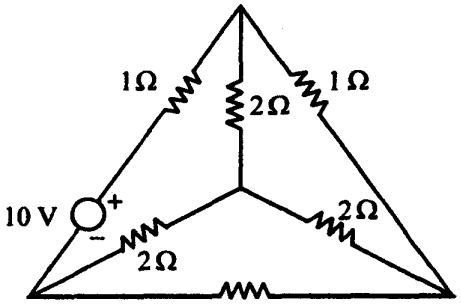

Fig. 3

3. (*a*) State and prove (*i*) convolution theorem, and (*ii*) complex translation theorem of Laplace transform. 10

(*b*) Find an expression for the value of current at any instant after a sinusoidal voltage of amplitude 600 V at 50 Hz applied to a series circuit of resistance 10 ohm and inductance 0·1 henry, assuming that the voltage is zero at the instant of switching ($t = 0$). Also, find the value of transient current at $t = 0{\cdot}02$ sec. 10

4. (*a*) Find the inverse Laplace transform of the following : 2 × 6

(*i*) $F(s) = \dfrac{s+1}{s^3 + s^2 - 6s}$

(*ii*) $F(s) = \dfrac{s+2}{s^5 - 2s^4 + s^3}$.

(*b*) Find the current $i(t)$, using Laplace transform method, for the circuit shown in Fig. 4. Given : $i(O^+) = 2A$ and $V_c(O^+) = 4$ V. 8

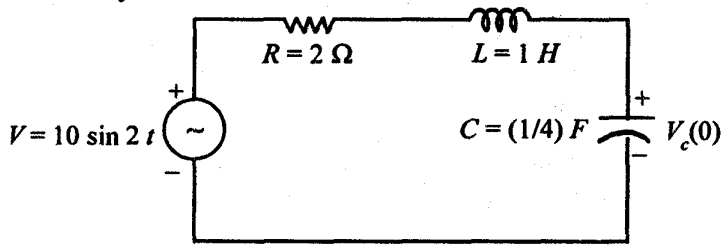

Fig. 4

Group B

5. (*a*) Find the magnetic field and its curl at radius r within a conductor of radius $R > r$ carrying current I, uniformly distributed over the cross-section. 8

(*b*) Explain and derive boundary conditions for perfect dielectric materials. 8

(*c*) State and prove Ampere's law. 4

6. (*a*) Write and discuss Maxwell's equations in point and integral forms. 7

(*b*) Show that the following field vectors in free space satisfy all Maxwell's equations : 7

$$\overline{E} = E_0 \cos(wt - \beta z)\,\ddot{a}_x$$

$$\overline{H} = (E_0/n) \cos(wt - \beta z)\,\ddot{a}_y$$

(*c*) Define magnetic scalar and vector potentials. 6

7. (*a*) Derive the equation of uniform plane wave for the medium having constants μ, $\in$, σ. Find the solution of the wave equation for sinusoidal variation, if $\vec{E} = E_x \hat{1}_x$ and the wave is propagating in $+z$ direction. 12

(*b*) For a lossy dielectric material having $\mu_r = 1$, $\in_r = 48$, $\sigma = 20$ s/m, calculate the attenuation constant, phase constant, and intrinsic impedance at a frequency of 16 GHz. 8

8. (*a*) State and explain the Ampere's law in both integral and differential forms as used in magnetic fields. 7

(*b*) Derive the expression, curl $\vec{H} = \vec{J}$. 5

(*c*) Show that the magnetostatic field can be described in terms of vector potential which satisfies the Vector-Poisson's equation. 8

Group C

9. Answer the following in brief : 10×2

(*i*) State Thevenin's theorem.

(*ii*) Define transfer function of a system.

(*iii*) What is a TEM wave ?

(*iv*) Explain Lenz's law.

(*v*) What is a rotational vector ?

(*vi*) State Millman's theorem.

(*vii*) Define equipotential surface.

(*viii*) What is polarisation ?

(*ix*) Prove that the divergence of curl of a vector is zero.

(*x*) What do you understand by dual networks ?

W'12: 4AN: EL404 (1465)

CIRCUIT AND FIELD THEORY

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Group A

1. (*a*) By loop current analysis, find the voltage, V_2, which results in zero current through the ohm resistance (branch *AB*) in the network shown in Fig. 1. 10

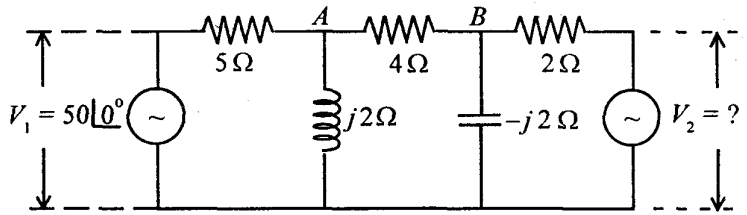

Fig. 1

(*b*) For the network shown in Fig. 2, draw the graph, a tree, tie-set schedule and find the loop currents. 10

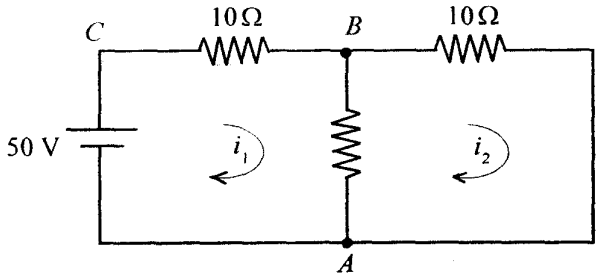

Fig. 2

2. (*a*) State and briefly explain the initial and final value theorem in Laplace domain. A function in Laplace domain is given by

$$F(s) = \frac{2(s+4)}{(s+3)(s+8)}.$$

Find the initial and final values. 10

(*b*) A series RL circuit is energized by a d.c. voltage of 1·0 V by switching it at $t = 0$. If $R = 1.0$ ohm; $L = 1{\cdot}0$ H, find the expression of the current using convolution integral. 10

3. (*a*) Find the values of V_1 and V_2 in Fig. 3. 10

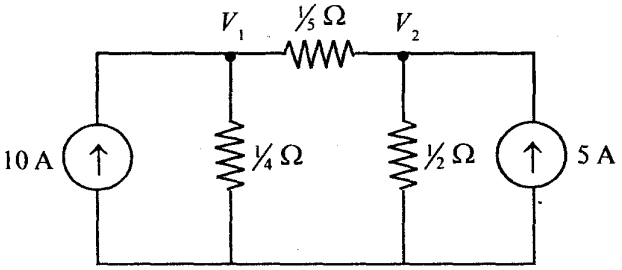

Fig. 3

(*b*) Using Thevenin's theorem, find the current in the 1 Ω resistor in the network shown in Fig. 4. 10

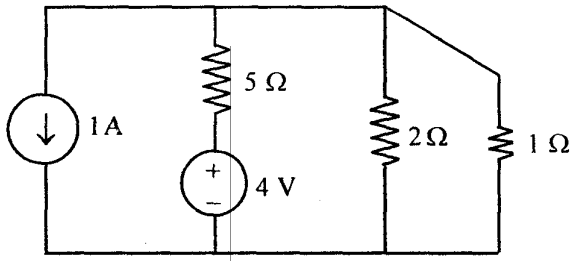

Fig. 4

4. (*a*) A RLC series circuit of 8 Ω resistance should be designed to charge bandwidth of 50 Hz. Determine the values of L and C so that the circuit resonates at 250 Hz. 10

(*b*) A series RLC circuit consists of 50 Ω resistance, 0·2 H inductance and 10 μF capacitance with applied voltage of 20 V. Determine resonant frequency. Find Q-factor of the circuit. Compute the lower and upper frequency limits and the bandwidth of the circuit. 10

Group B

5. (*a*) State and prove Stokes' theorem. 10

(*b*) State and prove uniqueness theorem. 10

6. (*a*) Obtain an expression for the magnetic field intensity due to infinitely long current carrying conductor. 10

(*b*) Derive the expression for the boundary condition at dielectric. 10

7. (*a*) State and explain Faraday's law. 10

(*b*) Derive an expression for the energy stored in magnetic field. 10

8. (*a*) Derive the wave equation for magnetic field. 10

(*b*) What are the properties of uniform plane wave ? 5

(*c*) A plane wave travelling air is normally incident on a block of paraffin with $\varepsilon_r = 2{\cdot}2$. Find the reflection coefficient. 5

Group C

9. Answer the following : 10×2

(*i*) In the circuit shown in Fig. 5, find the number of loops.

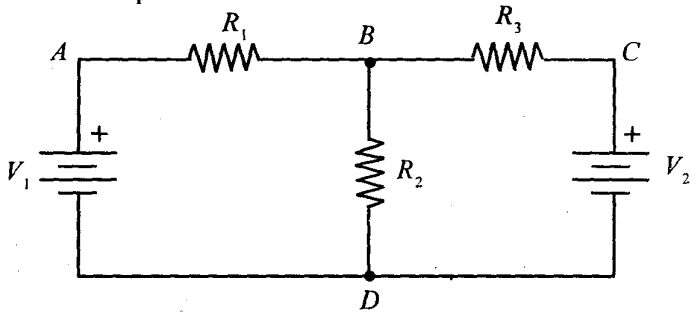

Fig. 5

(*ii*) How is reference node chosen in nodal analysis ?

(*iii*) State Thevenin's theorem.

(*iv*) Draw a neat sketch of general two-port network.

(*v*) What is called symmetrical lattice ?

(*vi*) Define curl of a vector.

(*vii*) What is meant by displacement current ?

(*viii*) Define permanence.

(*ix*) What is a wave ?

(*x*) What are two different cases considered in a reflection by a perfect dielectric ?

W'13: 4 AN: EL 404 (1465)

CIRCUIT AND FIELD THEORY

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Group A

1. (*a*) A voltage source, $v(t)$, is connected across a capacitor of $2F$. Find the energy stored in the capacitor from $t = 0$ to 10 sec, if $v(t) = t^2e^{-2t}$. 8

(*b*) Initially, k is at x. At $t = 0$, the switch is shifted to y. Find the voltage at $t > 0$ across ab. Assume zero initial condition for L_2 (Fig. 1). 12

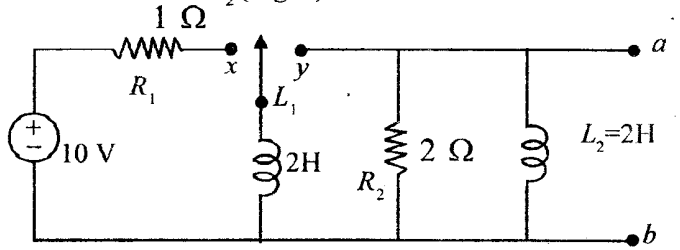

Fig. 1

2. (*a*) Define the terms : (*i*) Graph, (*ii*) tree, and (*iii*) link. 3 × 2

(*b*) A resistive network is shown in Fig. 2. Obtain the cut set matrix. **8**

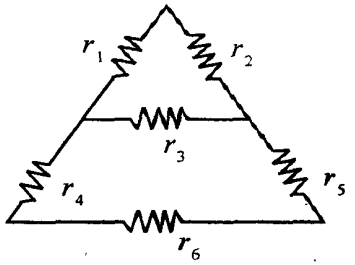

Fig. 2

(*c*) A reduced incidence matrix of a graph is given by

$$[A]=\begin{bmatrix} 1 & 1 & 0 & 0 & 0 & 1 \\ 0 & -1 & 1 & -1 & 0 & 0 \\ -1 & 0 & -1 & 0 & -1 & 0 \end{bmatrix}$$

Obtain the number of possible trees. **6**

3. (*a*) Find the Thevenin's equivalent across $x-y$ in the network shown in Fig. 3 : **10**

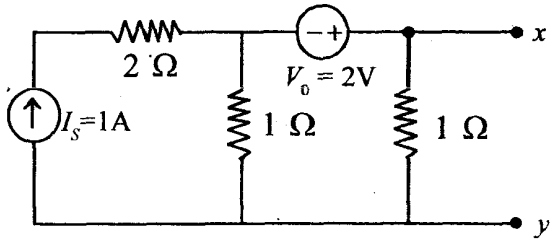

Fig. 3

(*b*) Show that the transmission parameter matrix for the entire network is simply the matrix product of the transmission parameter matrices of each of the two-port networks connected in tandem. **10**

4. (*a*) Define poles and zeros of a network function. Explain the procedure of finding the time-domain response from pole and zero plots. **10**

(*b*) A *R-L* series circuit is in parallel with a pure resistance R_2 as shown in Fig. 4. The combination is connected across a 10 Hz source (a.c.). The power delivered to do the resistance is 100 W. Find the value of the inductance. Assume $V = 50\angle 0^\circ$V; $R_1 = 10\ \Omega$; $R_2 = 50\ \Omega$ and $f = 10$ Hz. **10**

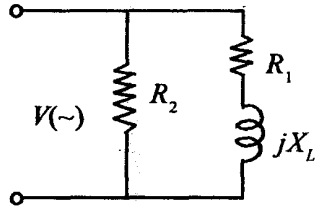

Fig. 4

Group B

5. (*a*) Write the statements of two electric boundary conditions. Prove them. **12**

(*b*) Determine the divergence of the vector field $\boldsymbol{P} = x^2yz\hat{x} + xz\hat{z}$. Give the physical interpretation of the equation $\nabla \cdot \boldsymbol{B} = 0$. **8**

6. (*a*) Define Ampere's law. Prove that it is not consistent with time varying current. Explain how Maxwell removed this inconsistency. Describe the consistency of modified Ampere's law when applied to a capacitor. **12**

(*b*) Write short notes on scalar and vector magnetic potentials. **8**

7. (*a*) State and prove uniqueness theorem. **10**

(*b*) If a bar magnet moves normally towards or away

from a closed wire loop, explain, with a neat diagram, how current is generated and flow in the loop (with direction). 10

8. (*a*) A plane wave is incident normally upon the boundary surface between two media having intrinsic impedances η_1 and η_2. Prove that the reflection coefficient is $\Gamma = (\eta_2 - \eta_1) / (\eta_2 + \eta_1)$. 10

(*b*) Write the Maxwell's equations in differential form. By using these equations, derive the wave equation for E-field in a conducting medium. What will be its phasor form ? State the rule in obtaining this phasor form from the general time domain form. 10

Group C

9. Answer the following in brief : 10×2

(*i*) Define final value theorem.

(*ii*) State the necessity of convolution integral. Explain.

(*iii*) What is a symmetrical network ? What are the *z*-parameter conditions for a network to be symmetrical ?

(*iv*) Define Telegen theorem.

(*v*) What is Q factor and explain its importance ?

(*vi*) Define curl. Write its espression in rectangular co-ordinate system.

(*vii*) What is uniform plane wave ?

(*viii*) What do you mean by potential and potential difference ?

(*ix*) Define magnetic dipole moment.

(*x*) What are the causes of eddy current ?