ENGINEERING & MANAGEMENT EXAMINATIONS, DECEMBER – 2006

CIRCUIT THEORY AND NETWORKS

SEMESTER – 3

Time : 3 Hours] [Full Marks : 70

GROUP – A

(Multiple Choice Questions)

1. Choose the most appropriate answers for any *ten* of the following : $10 \times 1 = 10$

i) A capacitor of 0·01 farad has a leakage resistance 100 ohms across it terminals. The quality factor of it at 10 rad/sec should be

a) $\frac{1}{10}$ b) 1

c) 10 d) 100. ☐

ii) An R-L-C series circuit consists of a resistance of 1 kilo-ohm, an inductance of 0·1 H and capacitance of 10 micro-micro-farad. The Q-factor of the circuit will be

a) 100 b) 50

c) 10 d) $\frac{1}{100}$. ☐

iii) The superposition theorem is applicable to

a) linear responses only

b) linear and non-linear responses

c) linear, non-linear and time variant responses. ☐

iv) A circuit having neither an e.m.f. source or any energy source is

a) active circuit b) passive circuit

c) unilateral circuit d) bilateral circuit. ☐

v) What should be the internal impedance of an ideal current source ?

a) Zero b) Infinite

c) Both (a) and (b) d) None of these.

vi) A two-port network is reciprocal if and only if

a) $Z_{11} = Z_{22}$ b) $BC - AD = -1$

c) $Y_{12} = Y_{21}$ d) $h_{12} = h_{21}$

vii) A series RLC circuit is overdamped when

a) $\left[\frac{R^2}{(4L^2)}\right] > \left[\frac{1}{(LC)}\right]$

b) $\left[\frac{R^2}{(4L^2)}\right] = \left[\frac{1}{(LC)}\right]$

c) $\left[\frac{R^2}{(4L^2)}\right] < \left[\frac{1}{(LC)}\right]$

d) none of these.

viii) Laplace transform analysis gives

a) time domain response only

b) frequency domain response only

c) both (a) and (b)

d) none of these.

ix) The value of ramp function $t.u(t)$ at $t = -\infty$ is

a) 0 b) ∞

c) $-\infty$ d) 1.

x) The Fourier series expansion of a periodic function having half-wave symmetry contains only

a) cosine terms b) sine terms

c) even harmonics d) odd harmonics.

xi) The number of links for a graph having n nodes and b branches is

a) $b - n + 1$ b) $n - b + 1$

c) $b + n - 1$ d) $b + n$. ☐

xii) The d.c. gain of a system having the transfer function

$$H(S) = \frac{12}{[(S+2)(S+3)]}$$ is

a) 2 b) 1

c) 12 d) 3

e) 0. ☐

xiii) An R-C series circuit has a time constant given by

a) R/C b) C/R

c) $1/(RC)$ d) RC. ☐

xiv) If a function $f(t)$ is shifted by a then it is correctly represented as

a) $f(t-a)\,u(t)$ b) $f(t)\,u(t-a)$

c) $f(t-a)\,u(t-a)$ d) $f(t-a)(t-a)$. ☐

xv) In a four terminal network containing linear bilateral passive circuit elements which one of the following conditions for Z-parameters generally holds ?

a) $Z_{11} = Z_{22}$ b) $Z_{12} = Z_{21}$

c) $Z_{12} Z_{21} = Z_{11} Z_{22}$ d) $Z_{11}^2 = Z_{21} Z_{22}$. ☐

xvi) Two networks can be dual when

a) their nodal equations are the same

b) the loop equations of one network are the nodal equations of the other

c) their loop equations are the same

d) none of these. ☐

GROUP – B

Answer any *three* questions. $3 \times 5 = 15$

2. a) What is compensation theorem ? $2\frac{1}{2}$

   b) Convert a voltage source V with internal resistance R to a corresponding current source. Can you convert a voltage source V with zero internal resistance to a corresponding current source ? $2\frac{1}{2}$

3. Find the Laplace transform of the square wave shown in **Fig. 1**. 5

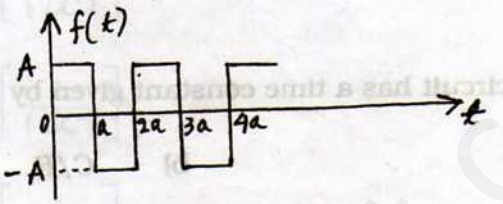

Fig. 1

4. Define tie-set. With the help of a suitable example, explain the term 'tie-set matrix' used in network analysis. 5

5. Explain under what condition, an *RC* series circuit behaves as

   i) low-pass filter

   ii) integrator. 5

6. Write the input file in SPICE to find the node voltages in the circuit in **Fig. 2**. 5

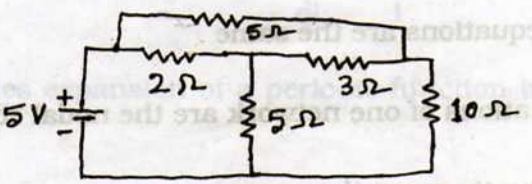

Fig. 2

GROUP – C

Answer any *three* questions. $3 \times 15 = 45$

7. a) State maximum power transfer theorem. 2

b) Find the Thevenin's equivalent between the points *a* and *b* for the circuit given in **Fig. 3**. What should be the value of impedance connected between *a* and *b* for maximum power to be transferred from the sources ? Obtain the amount of the maximum power. 8

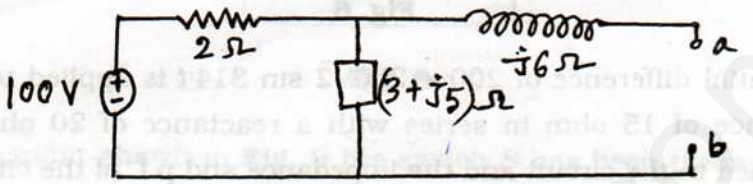

Fig. 3

c) Determine the voltage *v* in the network in **Fig. 4** using nodal analysis. 5

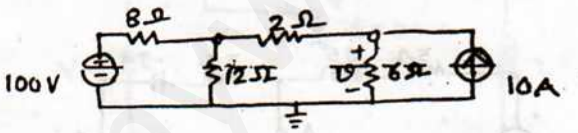

Fig. 4

8. a) State and explain Millman's theorem. Calculate the load current *I* in the circuit in **Fig. 5** by Millman's theorem. 2 + 6

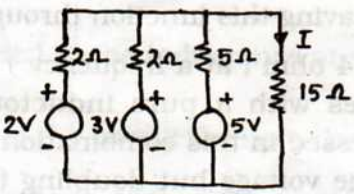

Fig. 5

b) Using Superposition theorem determine V_1, the voltage across the 3 ohm resistor in **Fig. 6.** 7

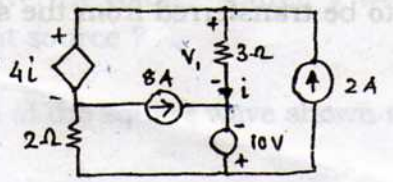

Fig. 6

9. a) A potential difference of $200 + 200\sqrt{2} \sin 314t$ is applied to a circuit having a resistance of 15 ohm in series with a reactance of 20 ohm. Find the power consumed in the circuit and the impedance and p.f. of the circuit. 8

b) In the network shown in the **Fig. 7** two voltage sources act on the load impedance connected to the terminals *A* and *B*. If the load is variable in both reactance and resistance, for what load, Z_L will receive max. power ? What is the value of max. power ? 7

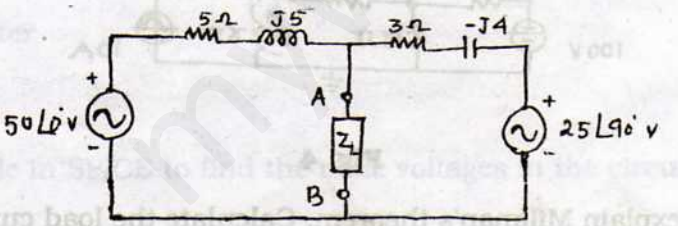

Fig. 7

10. a) 4 wires are joined at a node. The current entering this node through 3 of them are $5 \cos \omega t$, $6 \sin\left(\frac{\omega t + \pi}{6}\right)$ and $2 \cos\left(\frac{\omega t + \pi}{3}\right)$. Using the phasor method determine the current leaving this junction through the 4 wire. 8

b) A 3 ohm resistor and a 4 ohm (at a frequency f) capacitor are in parallel. This combination is in series with a pure inductor. An alternating voltage at a frequency f when impressed in this combination delivers current at unity power factor. Keeping the same voltage but doubling the frequency, what will be the percentage change in the current drawn by the circuit based on the current at lower frequency ? 7

11. a) Determine the voltage V using source transformation and simplification in **Fig. 8**. 6

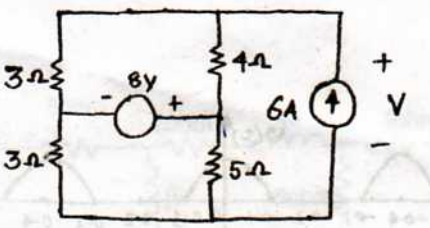

Fig. 8

b) In the circuit shown in **Fig. 9** the switch S has been thrown to position 1 for a long period of time. Find the complete expression for the current after throwing the switch S to 2 which removes R_1 from the circuit. 5

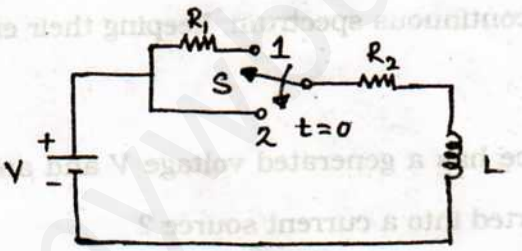

Fig. 9

c) If the values of V, R_1, R_2 and L be 10 V, 1 ohm, 2 ohm and 1 H respectively, calculate

i) steady state current

ii) the energy stored in the inductance at steady state period and

iii) time constant of the circuit for both the positions of the switch S.

Also calculate the voltage across the resistor R_2 and inductor L, at 0·05 sec after the switch S has been thrown to position 2. 4

12. a) Find the Fourier series of the voltage response at the output of a half-wave rectifier shown in **Fig. 10**. Plot the descrete spectrum of the waveform. 7

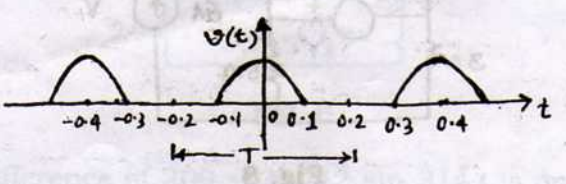

Fig. 10

b) Define Fourier transform of an aperiodic function $f(t)$. Obtain the Fourier transform of a single pulse of magnitude V and duration τ. Show that as $f(t)$ changes from periodic to aperiodic, the amplitude spectrum changes from a line spectrum to a continuous spectrum, keeping their envelopes of the same shape. 8

13. a) A voltage source has a generated voltage V and an internal resistance R. How can it be converted into a current source ? 3

b) Convert the current sources into the equivalent voltage sources given in **Fig. 11** and hence find the voltage V_0. 4

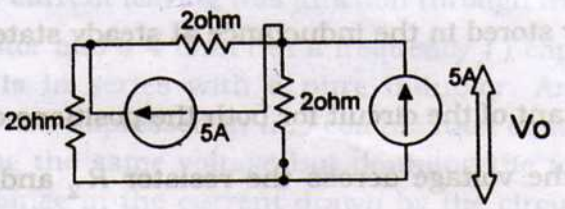

Fig. 11

c) In the network shown in **Fig. 12** determine the voltage V_b which results in a zero current through the $(2 + j3)\ \Omega$ impedance in a b branch. 8

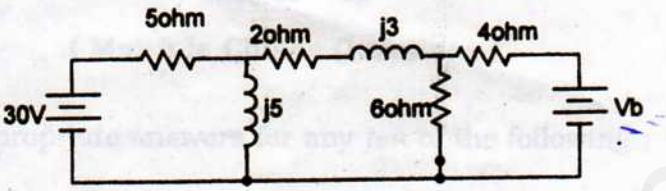

Fig. 12