INDIAN INSTITUTE OF TECHNOLOGY
Department of Electrical Engineering
END AUTUMN SEMESTER EXAMINATION-2010

Date: 22.11.10 **Time:** 3 hours **Full Marks:** 100 **No. of Students:** 206
Sub. Name: Signals & Networks **Sub. No.** EE21101

Instructions: *Answer any five questions.*

1. (a) State Tellegen's theorem. **(2)**

(b) Obtain the Norton's equivalent at terminals a and b for the network shown in Fig. Q1(b). **(6)**

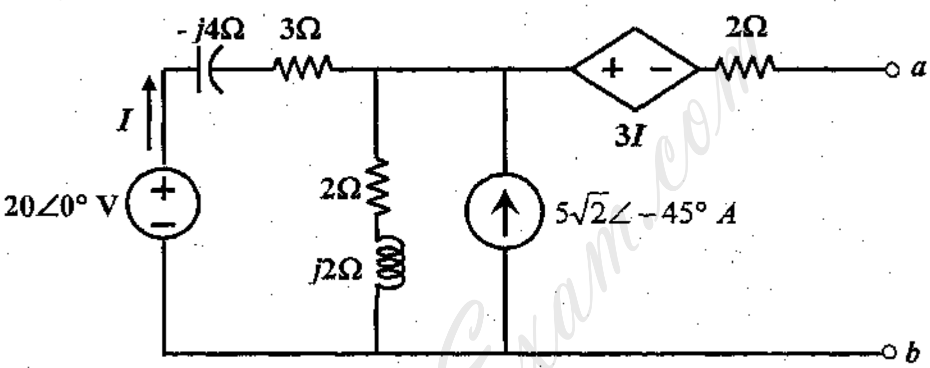


Fig. Q1(b)

(c) Prove that a network having n nodes and b branches can have exactly (b-n) number of linearly independent loop equations. **(6)**

(d) Express transmission parameters (A_a, B_a, C_a, D_a) of a 2-port network (network A) in terms of its admittance parameters (y_{11a}, y_{12a}, y_{21a}, y_{22a}). Now another 2-port network (network B) with admittance parameters (y_{11b}, y_{12b}, y_{21b}, y_{22b}) is connected in cascade with network A. Find out the expressions of admittance parameters of the composite network in terms of the individual admittance parameters. **(2+4)**

2. (a) Design a Sallen-Key low-pass filter having the parameters: $f_c = 3.2\text{kHz}, Q = 1.0$ and dc gain = 4dB. **(4)**

(b) Draw the oriented graph of the network shown in Fig. Q2(b). Find the fundamental tie-set matrix and the loop impedance matrix. Write the network equilibrium equation. **(1+2+2+1)**

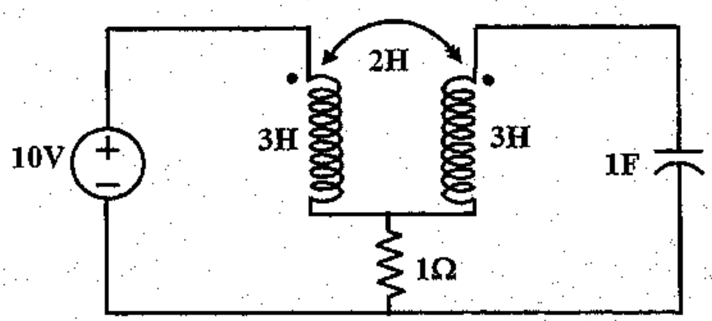
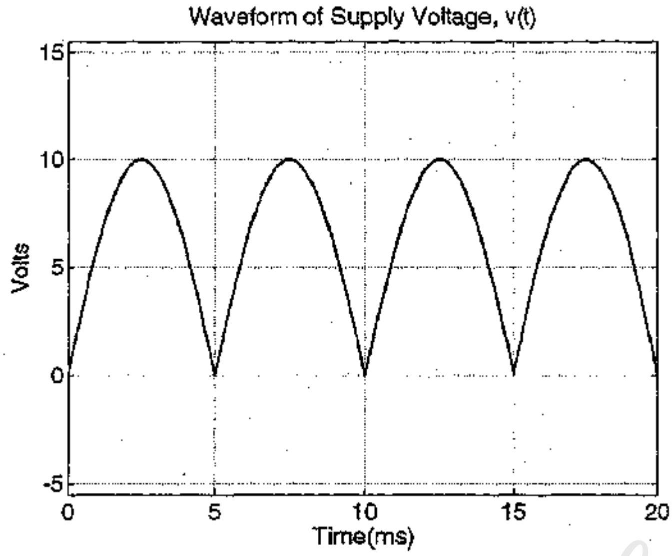


Fig. Q2(b)

2. (c) In the circuit shown in Fig. Q2(c), the switch K is closed on position 1 from time $t = -\infty$ and then moved to position 2 at time $t = 0$ to supply the series R-C circuit with a voltage source, $v(t)$. The voltage of the source is a periodic rectified sinusoid (the waveform is shown in the associated figure) having peak value of 10V. Find the initial charge on the capacitor (at $t = 0-$) and the expression for the voltage across the capacitor, $v_c(t)$ after the switch is moved to position 2. Also plot the waveform of $v_c(t)$ under steady-state condition (for $t \rightarrow \infty$). **(1+7+2)**



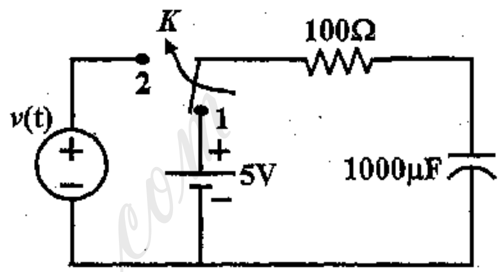


Fig. Q2(c)

3. (a) In the circuit shown in Fig. Q3(a), the switch K is closed at time $t_1 = \frac{\pi}{180}(\phi/\omega)$, where $\phi = 30°$. The nature of the switch K is such that it opens automatically when the current flowing through it becomes zero. Find out the time instant t_2 when the switch will open and the corresponding instantaneous value of voltage across the switch (V_{ab}). **(7+1)**

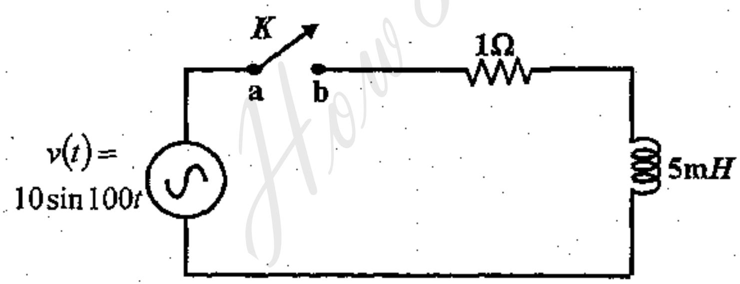


Fig. Q3(a)

3. (b) The incidence matrix of a network is given below. Using this matrix, (i) draw the oriented graph and write the complete incidence matrix A, (ii) considering branches 2, 3, 4 to constitute twigs of a tree, find the sub matrices A_t and A_l, (iii) find the fundamental cut-set matrix and the fundamental tie-set matrix using the values of A_t and A_l. **(2+2+4)**

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

3. (c) Find the admittance parameter of the 2-port network shown in Fig. Q3(c). **(4)**

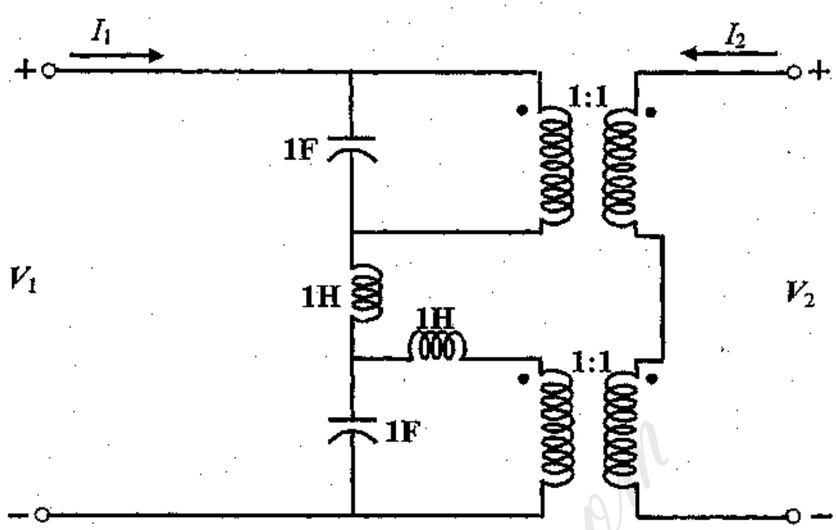


Fig. Q3(c)

4. (a) Determine the h-parameters of the network shown in Fig. Q4(a). Comment on the reciprocity and symmetry of the network. **(4+1)**

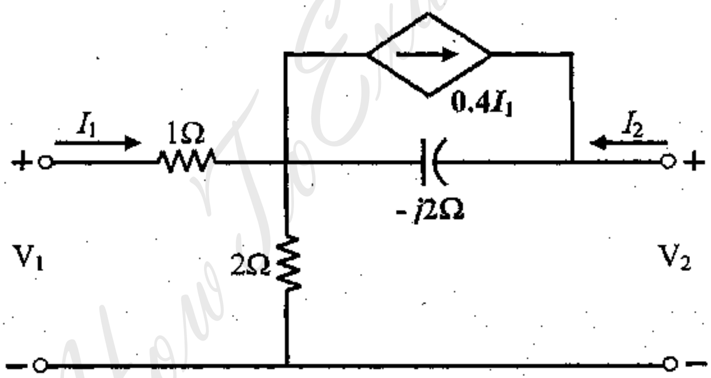


Fig. Q4(a)

(b) A filter is composed of a T-section. The inductance in each series arm is 16mH, while the shunt arm consists of a capacitance of 90nF in series with an inductance of 24mH. Calculate the cut-off frequency and the frequency of infinite attenuation of this filter. Also find the value of impedance at which the filter should be terminated. **(2+2+1)**

(c) A series R, L, C circuit is excited by a dc voltage $u(t)$. When do you say it is under-damped? Obtain the voltage across the capacitor for a typical under-damped situation. **(2+8)**

5. (a) Obtain the Fourier Transforms of (i) an unit impulse, and (ii) $\cos\omega_0 t$. **(4)**

(b) Obtain the Fourier Transform of the impulse response of a system governed by the differential equation $y^{(n)} + a_{n-1}y^{(n-1)} + a_{n-2}y^{(n-2)} + \cdots + a_0 y = b_m x^{(m)} + b_{m-1}x^{(m-1)} + \cdots + b_0 x$ where $x = x(t)$ is the input to and $y = y(t)$ is the output of the system, and $x^{(k)} = d^k x / dt^k$. **(4)**

(c) Obtain the response of the system in (b) for $x(t) = \cos\omega_0 t$. **(4)**

(d) What is meant by *frequency response* of a system? Obtain the same for a stable 2nd order $(n = 2)$ system of the form of (b) with $a_1 = 2\zeta\omega_n, b_0 = a_0 = \omega_n^2, b_1 = b_2 = 0$. **(8)**

6. (a) Define *Laplace Transform* (LT) of a signal $x(t)$ along with *Region of Convergence* (ROC). Obtain the same for $x(t) = e^{-4t}u(t) + e^{-5t}(\sin 5t)u(t)$. **(2+5)**

(b) The LT of the unit step response of a system is $\frac{(s-1)}{s(s+1)(s-2)}$. Obtain its transfer function $H(s)$ and hence the possible impulse responses $h(t)$. **(5)**

(c) What is the condition for BIBO stability of a system? How can the same ascertained from the LT of a system? Is any of the responses obtained in (b) stable? **(3)**

(d) The *unilateral* LT for a $x(t)$ is $\frac{(s^2+2s+3)}{(s+1)(s^2+s+1)}$. Find the initial and the final values of $x(t)$. Prove any one of these results. **(2+3)**

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