Q2 (a) A battery has an internal resistance of 0.5Ω and open circuit voltage of 12V. What is power lost in the battery and terminal voltage on full load if a resistance of 3Ω is connected across the terminals of the battery?

Answer

The internal resistance is series with load. Hence the current is

I=12/3.5=3.43A

RL= 3Ω

Terminal voltage =IR_L=3.43×3=10.3v

Rint= 0.5Ω

Power loss =I^2Rint=$(3.43)^2\times0.5$=5.88 watt.

Q2 (b) In the Fig.3, find the current in the resistances using node analysis.

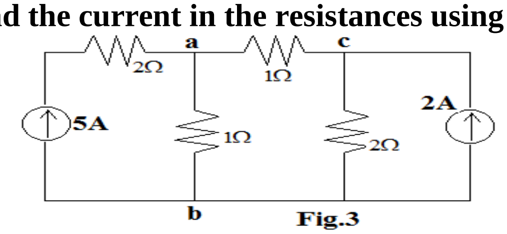


Fig.3

Answer

At node a of fig3, using node analysis

$$S = \frac{V_a - V_b}{1} + \frac{Va}{1}$$

$$\therefore 2V_a - V_b = 5 - - - - - - -(1)$$

Similarity, at node b, using node analysis

$$\frac{V_a - V_b}{1} + \frac{Va}{2} + 5 + 2 = 0$$

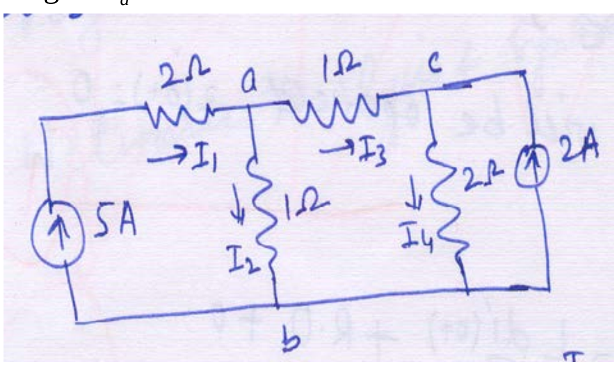
$$1.5V_b - V_a = -7$$

$$or 3V_b - 2V_a = -14 - - - -(2)$$

Adding eg.(1) &(2), we get

-Vb+3V_b =5-14 $\rightarrow 2V_b = -9 \Rightarrow V_b = -4.5U$

Substitute in eq.1, We get $V_a = 0.25V$



$\therefore I_1 = 5A$

$I_2 = \frac{V_a - V_b}{1} = 4.75A$

$I_3 = \frac{Va}{1} = 0.25A$

$I_4 = \frac{-V_b}{2} = -2.25A$

Q2 (c) Find v_0 using Kirchhoff's laws in the circuit as shown in Fig.4. Given that $r_1 = 1000\Omega$, $r_2 = 500\Omega$, $r_3 = 50\Omega$, $r_4 = 5\Omega$, $\alpha = 0.5, \beta = 2$ and $v_s = 10V$.

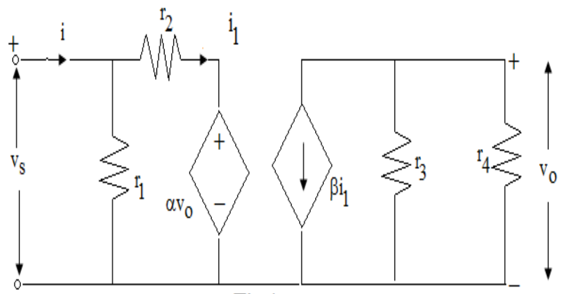


Fig.4

Answer

Applying KUL at output Loop

$V_0 = -\beta I_1 (fc_3 \| ru) = \frac{\beta r_3 r_4}{r_3 + r_4} i ---------(1)$

At input loop , $I_1 = \frac{V_5 - \alpha V_0}{r_2} ----------(2)$

$u \sin g(2) in\ eq..(1), we\ have$

$V_0 = \frac{\beta r_3 r_4}{r_3 + r_4}\left(\frac{V_5 - \alpha V_0}{r_2}\right)$

or

$V_0 = \left(1 - \frac{\beta r_3 r_4 \alpha}{r_2 (r_3 + r_4)}\right) = -\frac{\beta r_3 r_4 V_8}{r_2 (r_3 + r_4)}$

$$\therefore V_0 = \frac{\left(-\frac{\beta r_3 r_4 \alpha}{r_2 (r_3 + r_4)}\right)}{\left(1 - \frac{\beta r_3 r_4 \alpha}{r_2 (r_3 + r_4)}\right)}$$

substituting the values of $r_1, r_2, r_3, r_4, \alpha, \beta$ and V_5, we get

$V_0 = -183.48mv$

Q3 (a) For the circuit given in Fig.5, switch K is closed at t = 0. Find the i, $\frac{di}{dt}$ and $\frac{d^2i}{dt^2}$ at $t = 0^+$.

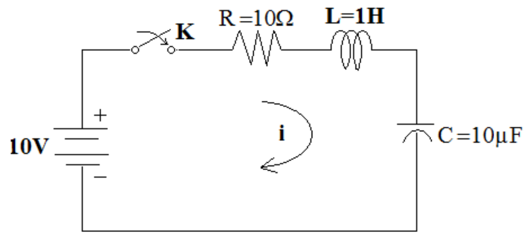


Fig.5

Answer

Apply KUL, we get

$$10 = L\frac{di}{dt} + Ri + \frac{1}{c}\int idt \text{.......................(1)}$$

for t=0, the circuit will be open click ,I(0+)=0

At t=0, $\frac{1}{c}\int idt = 0$

$$10 = L\frac{di}{dt}(0+) + R.O + 0$$

$\therefore$ eq (1) become

$$\therefore \frac{di(0+)}{dt} = \frac{10}{L} = \frac{10}{1} = 10amp/\sec$$

Differentiate eq.(1), we get

$$O = L\frac{d^2i}{dt^2} + R\frac{di}{dt} + \frac{1}{c}i \text{............................(2)}$$

Substitute values of di/dt and I at t=ot

$$1.\frac{a^2i(0+)}{dt^2} + 10.10 + \frac{1}{10MF} \times 0 = 0$$

or

$$\frac{d^2i(O+)}{dt^2} = -100amp/\sec^2$$

Q3 (b) Find the general solution of the equation $2\frac{di}{dt} + i(t) = 2i(t)$ with initial condition at t = 0, i = 5(A)

Answer

The given equation is

$$2\frac{\text{di(t)}}{\text{dt}} + i(t) = 2i(t)\text{.................}(1)$$

$$2\frac{di(t)}{dt} + 2i(t) - 2i(t) = 0$$

$$\frac{di(t)}{dt} + \frac{1}{2}i(t) = 0\text{...................}(2)$$

The general solution of thus equation is

I(t)= $ee^{1/2}t$ …………………….(3)

C=constant

Putting intial conditions, at t=0,I=5A

5=eC =C=5

The solution is

2(t)= $5e^{1/2t}$ *for* t=0

Q4 (a) Using Laplace transform technique, find i_2 at $t = 0^+$ when switch k is closed at t = 0 in Fig.6.

Answer

$$I_1(8)(6+8) - I_2(8) = 10/8\text{....................}(5)$$

$$-I_1(8) + I_2(8)(6+8) = 0\text{.....................}(6)$$

*Substitutinge.qin*5....................*weget*

$$I_2(8)(6+8)^2 - I_2(8) = 10/8$$

$$I_2(8)[(6+8)^2 - 1] = 10/8$$

$$I_2(8)[36 + 8^2 + 128 - 1] = 10/8$$

or

$$I_2(8) = 10/8(8^2 + 128 + 35)\text{...........}(7)$$

u sin *g* partial trantion , we get

$$I_2(8) = 2/7/8 + 10/84/8 + 7 + 1/6/8 + 5\text{.............}(8)$$

Taking inverse laplace transform

$$\text{i(t)} = 2/7 + \frac{10}{84}e^{-7t} + \frac{1}{6}e^{-5t}$$

4 (b) A unit impulse voltage is applied to a series RC circuit at t =0 with $R = 5\Omega$ **and C = 2F. Find i(t) using Laplace transform, assuming the initial charge stored in the capacitor is zero.**

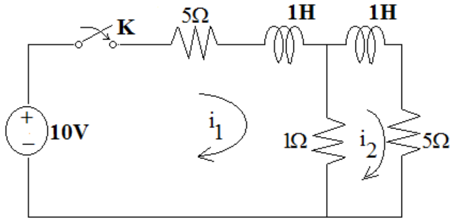


Fig.6

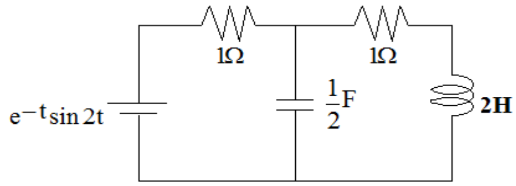


Fig.7

Answer
Apply KVL, to series
RC circuit

$$\int_{-\infty}^{t} i(t)dt = g(t)\dots\dots\dots\dots\dots\dots(1)$$

$$Ri(t) + 1/c\int_{-\infty}^{0} i(t)dt = 1/c\int_{0}^{t} i(t)dt = \&t$$

$$RCCRT$$

Taking laplace transform , we get

$$\mathrm{RI}(\&) + 1/\mathrm{c}\frac{\mathrm{q}(0+)}{\&} + 1/c\frac{I(\&)}{\&} = 1\dots\dots\dots\dots\dots\dots\dots\dots(3)$$

As initial change store in c is zero $\therefore$ q(0+) = 0

$$\therefore \mathrm{RI}(\&) + 1/\mathrm{c}\ \&\ \mathrm{I}(\&) = 1$$

$$\mathrm{I}(\&) = \frac{1}{\mathrm{R} + \frac{1}{\mathrm{c}\,\&}} = 1/R.\frac{\&}{\& + \frac{1}{Rc}} = 1/5.\frac{\&}{\& + 1/10}$$

$$= 0.2\,\&\,/\& + 0.1 = 0.2\left[1 - \frac{0.1}{\& + 0.1}\right]\dots\dots\dots\dots(4)$$

Taking inverselaplacetransform

$$i(t) = 0.2[8(t) - 0.1e^{-0.1t}]$$

Q5 (a) Determine Z(s) and I(s) for the network shown in Fig.7 using transform network.

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Q5 (b) Consider the network shown in Fig.8. Calculate $i_1(t)$ using Thevenin's theorem.

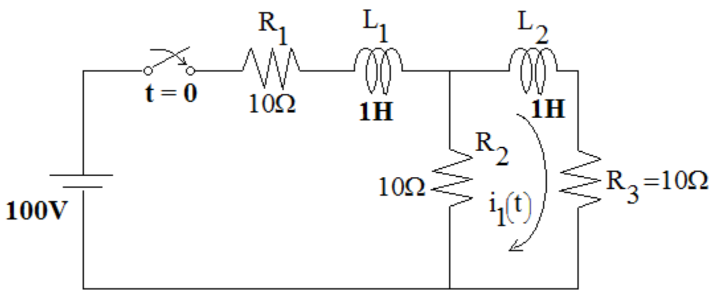

Fig.8

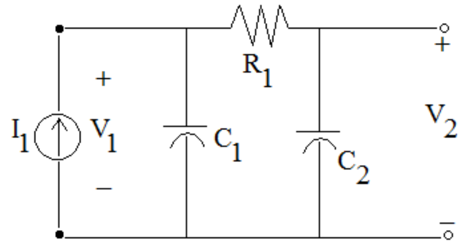

Fig.9

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Q6 (a) Compute the current gain $\alpha_{12}(s)$ and driving point impedance $Z_{12}(s)$ for the network shown in Fig.9 with $C_1 = 1F$, $R_1 = 1\Omega$ and $C_2 = 2F$.

Answer

In the current divider network of fig 9, we have

$$I_1(s) = I_{c_i}(s) + I_{R_i}(s) = V_1(s)\left[Y_{c1}^s + Y_{R1}^s\right]....................(1)$$

$$\sin ce \quad I_{R_i}(s) = \frac{Y_{R1}(s)}{V_1(s)}$$

$$\therefore I_{R_i}(s) = \frac{Y_{R1}(s)}{Y_{c1}^s + Y_{Ri}(s)} I_1(s)......................(2)$$

now

$$L_{12}(\&) = \frac{I_2(s)}{I1(s)} = \frac{y_2(s)}{y_{c_1}(s) + y_{R_1}(s)}........................(3)$$

also

$$y_{R_1}(s) = \& / R_1 / (\& + y_{R_1c1}) and y_{c_1} = c1/s$$

substitutingineq.(3)

$$L_{12}(\&) = 1/R1C1.\frac{1}{s + (c1 + c2)/R1C1C2.}....................(4)$$

now

$$V_2(\&) = \frac{1}{C_{23}}.I_2(\&) \inf ig9.$$

$$2_{12}(\&) = \frac{u_2(\beta)}{I_1(\&)} = \frac{1}{R_1C_1C_2}.\frac{1}{\&[\& + (1 + c2)/R_1C_1C_2}..............(5)$$

Substituting the value of C_1, C_2 & $R_1 ineq(4)$ & (5),....*weget*

$$L_{12}(\&) = \frac{1}{\& + 1.5}$$

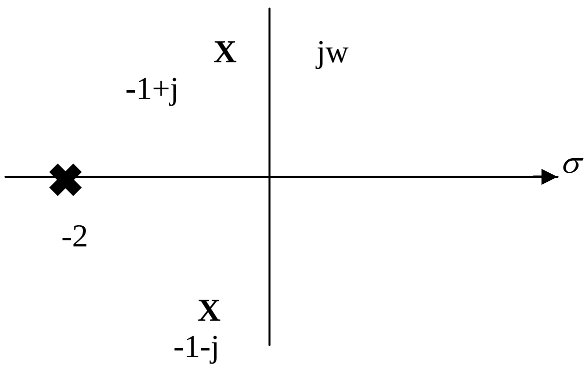
$$and \quad Z_{12}(\&) = \frac{0.5}{\&(\& + 1.5)}$$

Q6 (b) A network function is given by $H(s)=\frac{2s}{(s+2)(s^2+2s+2)}$. Obtain pole-zero diagram.

Answer

$$\therefore H(s)=\frac{2s}{(s+2)(s^2+2s+2)}\text{..............(1)}$$

The poles are located at &=-2, (-1+j), (-1-j) and zero is at &=0



Q6 (c) Check the positive realness of the function $F(s)=\frac{s^2+10s+4}{s+2}$.

Answer

Apply the test of positive realness

(i) Since all the coefficient of polynomials in the numerator and denominator are the hence f(s)is real if s is real.

(ii) The poles of the function lies on left half of the s-plane

(iii) Re[F(jw)=Re$\left[\frac{-w^2+10jw+4}{jw+2}\right]\left[\frac{-jw+2}{-jw+2}\right]$

$$\text{Re}=\left[\frac{-2w^2-20jw+8+jw^3+10w^2-4jw}{w^2+4}\right]$$

$$==\text{Re}\left[\frac{8w^2+16jw+jw^3+8}{w^2+4}\right]=\left[\frac{(8w^2+8)+j(w^3+16w)}{w^2+4}\right]$$

$$=\frac{8w^2+8}{w^2+4}$$

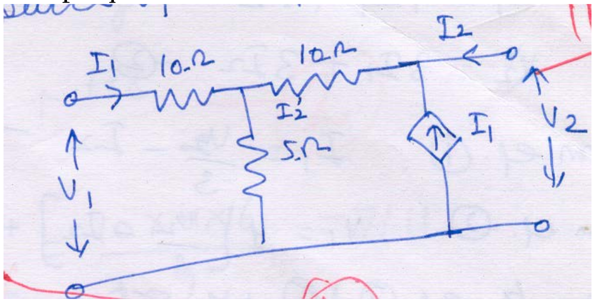
Since for all values of w, Re [(f(jw)] ≥ 0

Therefore f(s) is positive real function.

Q7 (a) Determine the Z-parameter of the network shown in Fig.10.

Answer

With open circuiting the output port C-D and applying a voltage place V_1 at input parts A-B, The loop equations are



$$V_1 = I_1(10+5) - 5I_2^1 \text{ ------------- } (1)$$

or

$$V_1 = 15I_1 - 15I_2^1$$

$I_2 = 0,$ *being* output open circuit

$I_2^1 = I_1$

eq....(1)*becomes* $V_1 = 15I_1 + 15I_1 = 20I_1$

$$\therefore \frac{V_1}{I_1} \left| I_2 = 0 = 2_{11} = 20\Omega \text{ ------ } (2)\right.$$

$$and\ I_2^1 = -I_1 = \frac{-V_1}{20} A \text{ ---------- } (3)$$

$$Again V_2 = (I_1 - I_2^1)5 - 10I_2^1 = (I_1 + I_1)5 + 10I_1 \,|\therefore I_1 = -I_2^1 = 20I_1$$

$$\therefore \frac{V_2}{I_1} \left| I_2 = 0 = 2_{21} = 20\Omega \text{ -------- } (4)\right.$$

Again V_2 *is* applyied at output part C.D. The input is open , $I_1 = 0$

Here $I_2 = I_2^1$

and $V_2 = I_2^1(10+5) = 15I_2^1 = 15I_2$

$$Z_{22} = \frac{V_2}{I_2}\Big|_{I_1=0} = 15\Omega \text{ -------- } (5)$$

Also $V_1 = I_2^1 \times 5 = 5I_2$

$$Z_{12} = \frac{V_1}{I_2}\Big|_{I_1=0} = 5\Omega \text{ -------- } (6)$$

$\therefore Z_{11} = 10 - \Omega, Z_{12} = 5\Omega$

$\therefore Z_{21} = 20 - \Omega, Z_{22} = 15\Omega$

Q7 (b) The Z-parameter of a circuit are given by $\begin{bmatrix} 4 & 1 \\ 3 & 3 \end{bmatrix}$. Obtain the transmission line ABCD parameters.

Answer

The Z Parameters equation is given by

$$V_1 = 4I_1 + I_2 ------(1)$$
$$V_2 = 3I_1 + 3I_2 ------(2)$$
$$From\, eq..(1) I_1 = \frac{V_2}{3} - I_2 ----(3)$$
$$From\, eq..(2) V_1 = 4\left[\ \frac{V_2}{3} - I_2 + \right] I_2 = \frac{4}{3}V_2 + 3(-I_2) ----(4)$$

Recreate eq… (3)& (4) we get

$$\begin{bmatrix} V_1 \\ I_1 \end{bmatrix} = \begin{bmatrix} 4/3 & 3 \\ 1/3 & 1 \end{bmatrix} \begin{bmatrix} V_2 \\ -I_2 \end{bmatrix}$$
$$= \begin{bmatrix} A & B \\ C & D \end{bmatrix} = \begin{bmatrix} 4/3 & 3 \\ 1/3 & 1 \end{bmatrix}$$

Q8 (a) Obtain the driving point impedance of the given network across A-B shown in Fig.11 using Transform network.

Answer

Transforming the given network into domain

$$Z_{AB}(s) = Z_{L_1}(s) + Z_{ep^{(s)}}$$

$$Z_{CD}(s) = \left[\left(\frac{s+1}{s}\right) 11 \frac{1}{s}\right]$$

$$= \frac{s(s+1/s)}{s+s+1/s} = \frac{s(s+1/s)}{2s+1/s} = \frac{s(s^2+1)}{2s^2+1}$$

Also,

$$Z_{L_1}(s) = s$$

$$\therefore Z_{AB}(s) = \Delta + \frac{s(s^2+1)}{2\Delta^2+1} = \frac{2s^3+s+s^3+s}{2s^2+1} = \frac{3s^2+2s}{2s^2+1}$$

$$\therefore Z_{AB}(s) = \frac{s(3s^2+2)}{2s^2+1}$$

Q8 (b) The driving point impedance of an LC network is

$$Z(s) = \frac{10(s^2+4)(s^2+16)}{s(s^2+9)}$$ **. Obtain Foster form of network.**

Answer

Two poles exit at W=0 and at W=∞.

Taking partial fraction of 2(s) we get

$$2(s) = \frac{A}{s} + \frac{B}{s+j3} + \frac{B^*}{s-j3} + Hs$$

$$A = \left.\frac{10(s^2+4)(s^2+16)}{s(s-j3)}\right|_{s=0} = \frac{10\times 4\times 16}{9} = 71.11$$

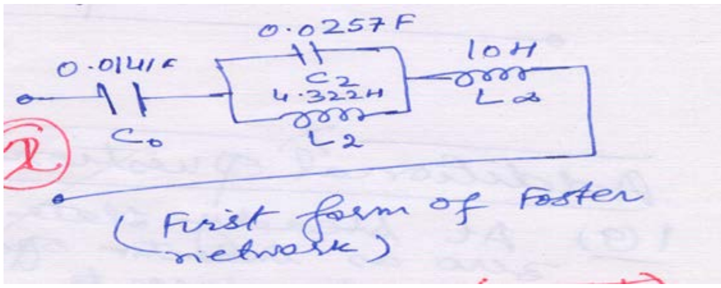
$$B = \left.\frac{10(s^2+4)(s^2+16)}{s(s-j3)}\right|_{s=-j3} = \frac{(10(-j3)^2+4)((-j3)^2+16)}{(-j3)(-j3-j3)} = \frac{350}{18} = 19.45$$

$$C_0 = \frac{1}{A} = \frac{1}{71.11} = 0.0141F$$

$$L_\infty = H = 10H$$

$$C_2 = 1/2B = \frac{1}{2\times 19.45} = 0.0257F$$

$$L_2 = 2B/w^2n = \frac{2\times 19.45}{32} = 4.322H.$$



Q9 (a) What are the error criteria in any approximation problem in network theory? Derive amplitude approximation for maximally flat low pass filter approximation.

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Q9 (b) Synthesize the voltage ratio $\frac{V_2}{V_1} = \frac{s^2+1}{s^2+2s+1}$ **as a constant resistance bridged-T network terminated in a** 1Ω **resistor.**

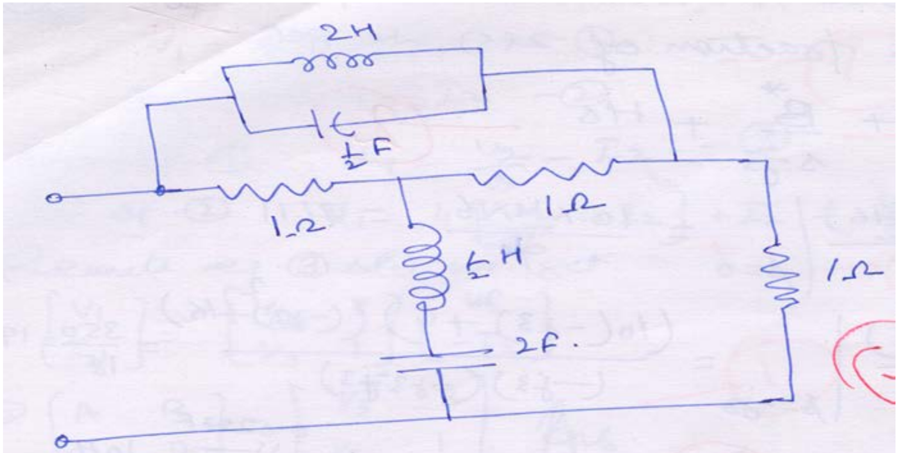
Answer

$$\frac{V_2}{V_1} = \frac{s^2+1}{s^2+2s+1} --------(1)$$

$$Z_a = \frac{2s}{s^2+1} --------(2)$$

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

Z_a , as parallel L_c to network circuit and Z_b as series L_c network circuit. The network is:



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1. Network Analysis, M.E.Van Valkenberg, 3rd Edition, Prentice-Hall India, EEE 2006.

2. Network Analysis and Synthesis, Franklin F Kuo, 2nd Edition, Wiley India Student Edition 2006.