**Q2 (a) A battery has an internal resistance of $0.5\Omega$ and open circuit voltage of 12V. What is power lost in the battery and terminal voltage on full load if a resistance of $3\Omega$ 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= $3\Omega$

Terminal voltage $=IR_L=3.43\times3=10.3$v

Rint= $0.5\Omega$

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

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

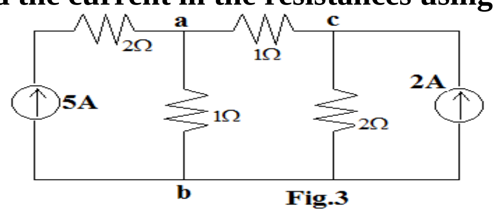



**Fig.3**

**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

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

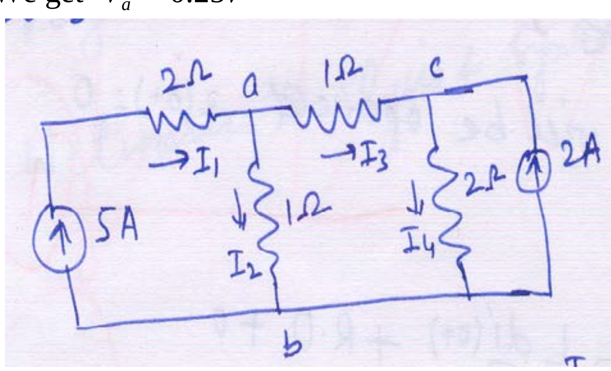
$$1.5V_b-V_a=-7$$

$$or3V_b-2V_a=-14----(2)$$

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

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

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



$\therefore I_1 = 5A$

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

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

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

**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 $v_s = 10V$.**

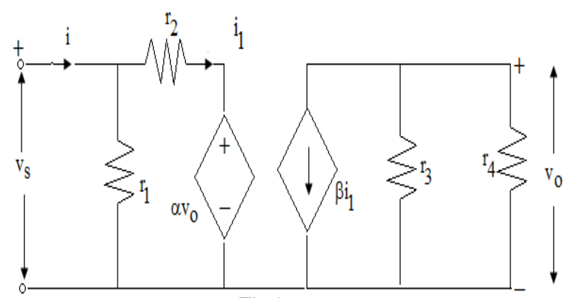



Fig.4

**Answer**

Applying KUL at output Loop

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

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

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

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

$or$

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

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

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

$V_0 = -183.48 mv$

**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 $t = 0^+$.**

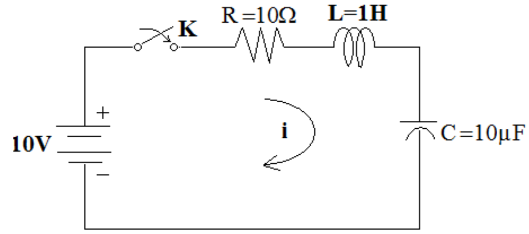



Fig.5

**Answer**
Apply KUL, we get

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

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

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

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

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

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

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

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 $\mathrm{i}_2$ at $\mathrm{t} = 0^+$ when switch k is closed at t = 0 in Fig.6.**

**Answer**

$$\mathrm{I}_1(8)(6+8) - \mathrm{I}_2(8) = 10/8....................(5)$$

$$-\mathrm{I}_1(8) + \mathrm{I}_2(8)(6+8) = 0....................(6)$$

$$Substitutinge.qin5....................weget$$

$$\mathrm{I}_2(8)(6+8)^2 - \mathrm{I}_2(8) = 10/8$$

$$\mathrm{I}_2(8)[(6+8)^2 - 1] = 10/8$$

$$\mathrm{I}_2(8)[36+8^2 + 128 - 1] = 10/8$$

*or*

$$\mathrm{I}_2(8) = 10/8(8^2 + 128 + 35)...........(7)$$

$u\sin g$ partial trantion , we get

$$\mathrm{I}_2(8) = 2/7/8 + 10/84/8 + 7 + 1/6/8 + 5............(8)$$

*Taking* inverse laplace transform

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

**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.**

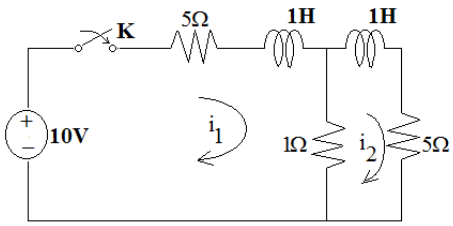



Fig.6

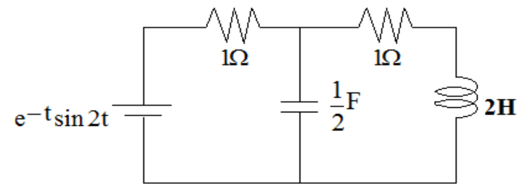



Fig.7

**Answer**

Apply KVL, to series
RC circuit

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

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

$$RCCRT$$

$$\textit{Taking}\ \text{laplace transform , we get}$$

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

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

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

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

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

$$\textit{Taking inverselaplacetransform}$$

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

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

**Answer** Page Number 254 of Text-Book-I

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

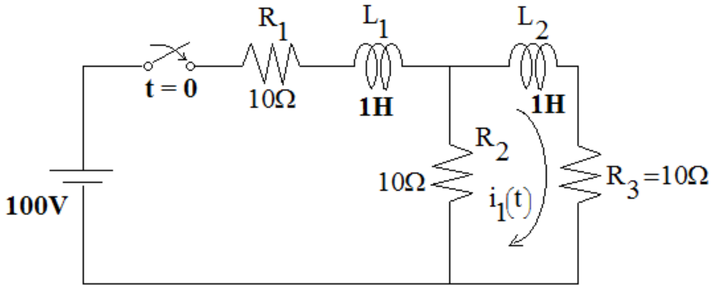


**Fig.8**

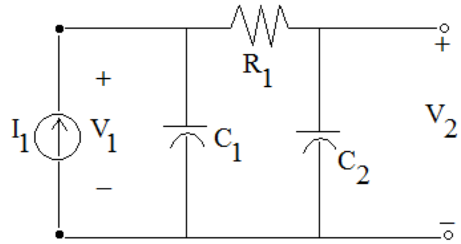


**Fig.9**

**Answer** Page Number 267 of Text-Book-I

**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

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

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

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

$$now$$

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

$$also$$

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

$$substitutingineq.(3)$$

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

$$now$$

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

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

$$Substituting \text{ the value of } C_1, C_2 \; \& \; R_1 ineq(4) \; \& \; (5),....weget$$

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

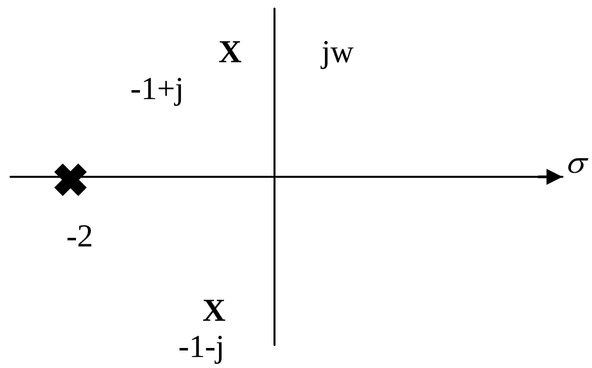
$$and \quad \mathrm{Z}_{12}(\&) = \frac{0.5}{\&(\& + 1.5)}$$

**Q6 (b) A network function is given by** $H(s)=\dfrac{2s}{(s+2)(s^2+2s+2)}$**. 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** $F(s)=\dfrac{s^2+10s+4}{s+2}$**.**

**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$\left[\dfrac{-w^2+10jw+4}{jw+2}\right]\left[\dfrac{-jw+2}{-jw+2}\right]$

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

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

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

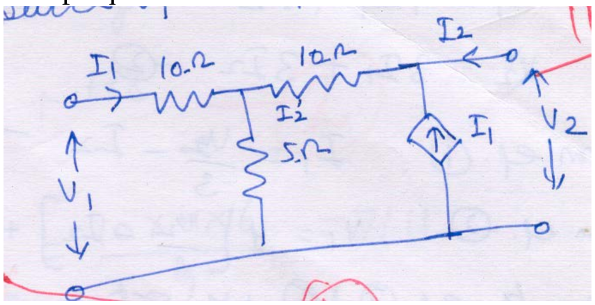
Since for all values of w, Re [(f(jw)] $\geq 0$

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




$$V_1 = I_1(10+5) - 5I_2^1 -------------(1)$$

*or*

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

$I_2 = 0, being$ output open circuit

$I_2^1 = I_1$

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

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

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

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

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

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

$Here\ I_2 = I_2^1$

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

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

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

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

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

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

**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

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

Recreate eq… (3)& (4) we get

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

**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=$\infty$.

Taking partial fraction of 2(s) we get

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

$$A = \left.\frac{10(s^2+4)(s^2+16)}{s(s-j3)}\right|_{s=0} = \frac{10\times4\times16}{9} = 71.11$$

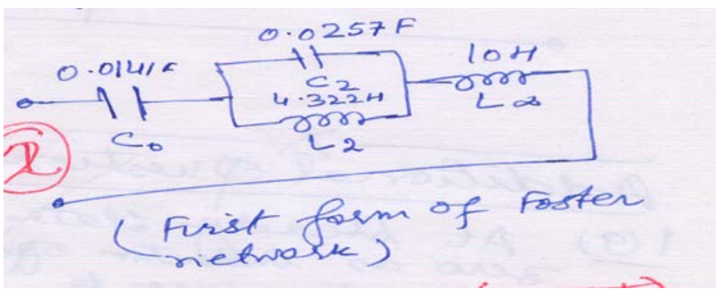
$$B = \left.\frac{10(s^2+4)(s^2+16)}{s(s-j3)}\right|_{s=-j3} = \frac{(10(-j3)^2+4)((-j3)^2+16)}{(-j3)(-j3-j3)} = \frac{350}{18} = 19.45$$

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

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

$$C_2 = 1/2B = \frac{1}{2\times19.45} = 0.0257F$$

$$L_2 = 2B/w^2n = \frac{2\times19.45}{32} = 4.322H.$$




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

**Answer** Page Number 366 & 368 of Text-Book-II

**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** $1\Omega$ **resistor.**

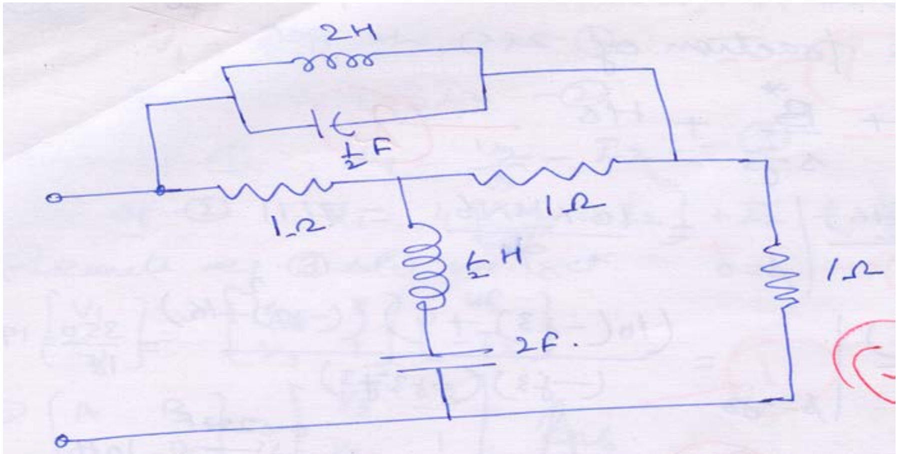
**Answer**

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

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

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

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




## Text Books

**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.**