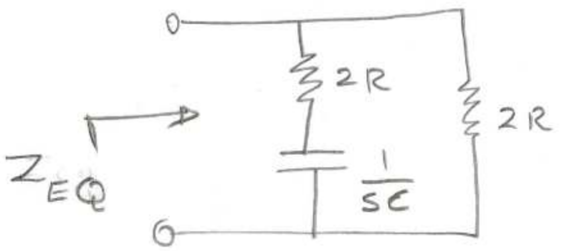
10.3

Let us consider in s-domain



$$Z_{EQ} = \left(2R + \frac{1}{sC}\right) \| 2R$$

$$= \left(\frac{2RCs + 1}{sC}\right) \| 2R$$

$$Z_{EQ} = \frac{\frac{2RCs+1}{sC} \times 2R}{\frac{2RCs+1}{sC} + 2R} = \frac{(2RCs + 1)\, 2R}{2RCs + 1 + 2RCs} = \frac{(2RCs+1)\, 2R}{4RCs + 1}$$

Zeros : $2RCs + 1 = 0 \longrightarrow s = \frac{-1}{2RC}$ (zero)

Poles : $4RCs + 1 = 0 \longrightarrow s = \frac{-1}{4RC}$ (Pole)

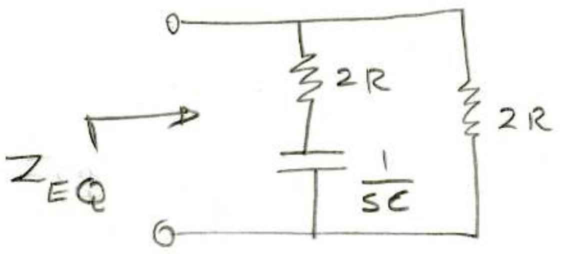
(b) $\frac{-1}{4RC} = -22 \Longrightarrow RC = \frac{1}{88}$

Let $R = 2\,K\Omega \longrightarrow C = 5.6\ \mu F$

zero $\Rightarrow$ $s = \frac{-1}{2\left(\frac{1}{88}\right)} = -44$ rad/s

10.3

Let us consider in s-domain



$$Z_{EQ} = \left(2R + \frac{1}{sC}\right) \parallel 2R$$

$$= \left(\frac{2RCs + 1}{sC}\right) \parallel 2R$$

$$Z_{EQ} = \frac{\frac{2RCs+1}{sC} \times 2R}{\frac{2RCs+1}{sC} + 2R} = \frac{(2RCs + 1)\,2R}{2RCs + 1 + 2RCs} = \frac{(2RCs+1)\,2R}{4RCs + 1}$$

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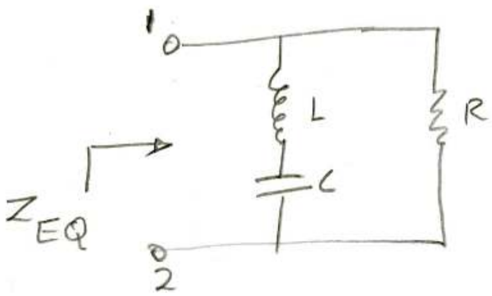
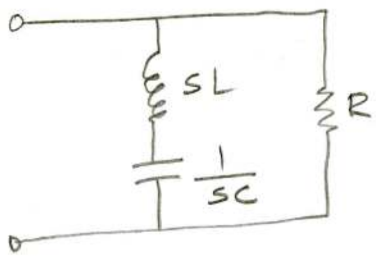
zero $\Rightarrow$ $s = \frac{-1}{2\left(\frac{1}{88}\right)} = -44$ rad/s

10.7



s-domain $\longrightarrow$



(a) $$Z_{EQ} = \left(sL + \frac{1}{sC}\right) \| R = \left(\frac{s^2LC + 1}{sC}\right) \| R$$

$$Z_{EQ} = \frac{R + s^2 LCR}{1 + sRC + s^2 LC}$$

Zeroes : $R + s^2 LCR = 0 \longrightarrow s = \pm j\sqrt{\frac{1}{LC}}$ (zeros)

Poles : $1 + sRC + s^2 LC = 0 \longrightarrow s = \dfrac{-RC \pm \sqrt{R^2C^2 - 4LC}}{2LC}$ (Poles)

$\boxed{b}$ $R = 1\,k\Omega$, $C = 0.1\,\mu F$

if zeroes at $\pm j10$ k rad/s $= \pm 10^4$ rad/s

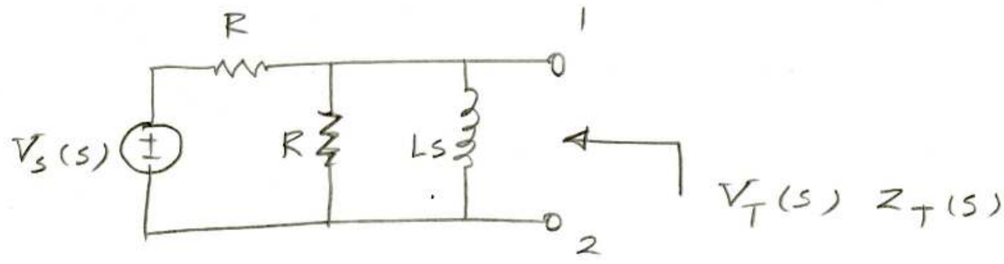
$$\sqrt{\frac{1}{LC}} = 10^4 \longrightarrow L = \frac{1}{C(10^4)^2} = \frac{1}{0.1\times10^{-6}\ 10^8} = \frac{1}{10}$$

$$\longrightarrow \boxed{L = 0.1\ H}$$

$\boxed{c}$ $$s = \frac{-R}{2L} \pm \sqrt{\frac{R^2}{4L^2} - \frac{1}{LC}} = \frac{-1000}{2\times0.1} \pm \sqrt{\frac{10^6}{4(0.01)} - 10^8}$$

$s = -5000 \pm j\,8660$ rad/s

10.21

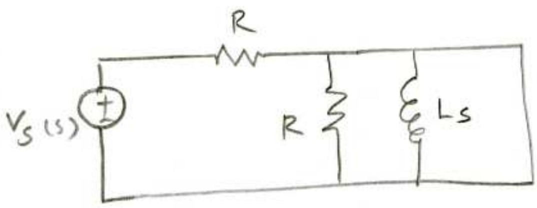


$V_T(s)$ = Voltage across $R \parallel Ls$

$$V_T(s) = \frac{(R \parallel Ls)}{(R + R \parallel Ls)} V_s(s) = \frac{\frac{RLs}{R+Ls}}{\frac{RLs}{R+Ls} + R} \times V_s(s)$$

$$V_T(s) = \frac{Ls}{R + 2Ls} V_s(s)$$

By short circuiting 1, 2 we get,



$$I_{sc}(s) = \frac{V_s(s)}{R}$$

$$Z_T(s) = \frac{V_T(s)}{I_{sc}(s)} = \frac{RLs}{R + 2Ls}$$

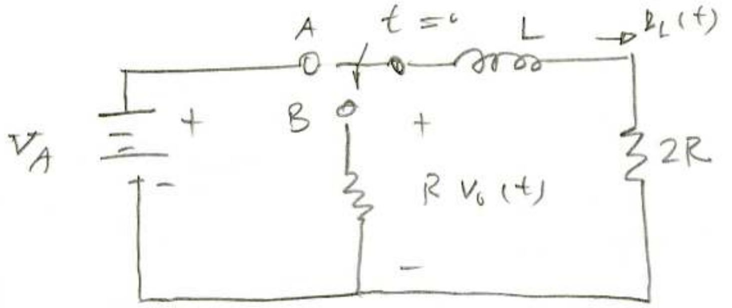
Pole at $s = \frac{-R}{2L} = -24$ krad/s $\rightarrow$

Choose $R = 6\ k\Omega \rightarrow L = 125$ mH

X 10.25

solve for $I_L(s)$, $i_L(t)$, $V_o(s)$, $V_o(t)$

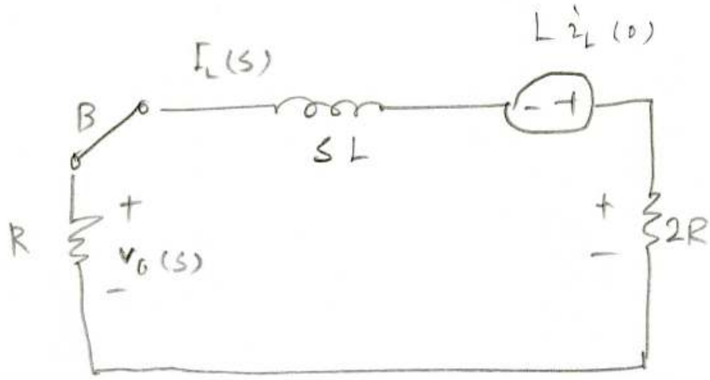
Let move switch to position B at $t=0$



initial condition:

For $t<0$ circuit is in a DC steady state condition acts like a short circuit

So $i_L(t) = \frac{V_A}{2R}$



① using KVL we get

$$SL\, I_L(s) - L\, i_L(0) + 2R\, I_L(s) + R\, I_L(s) = 0$$

$$(SL + 3R)\, I_L(s) = L\, i_L(0) = L \frac{V_A}{R}$$

$$I_L(s) = \frac{L \frac{V_A}{R}}{SL+3R} = \frac{1/R}{s + 3\frac{R}{L}} V_A$$

② $$\boxed{V_o(s) = -R\, I_L(s) = -\frac{V_A}{s + \frac{3R}{L}}}$$

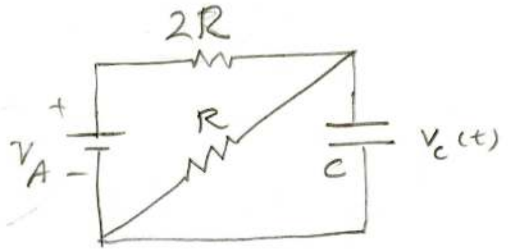
$$\boxed{V_o(t) = \left\{ -V_A\, e^{-\frac{3R}{L}t} \right\} u(t)}$$

$$I_L(s) = \frac{1/R}{s + \frac{3R}{L}} V_A$$

$$i_L(t) = \left\{ \frac{V_A}{R} e^{-\frac{3R}{L}t} \right\} u(t)$$

problem 27

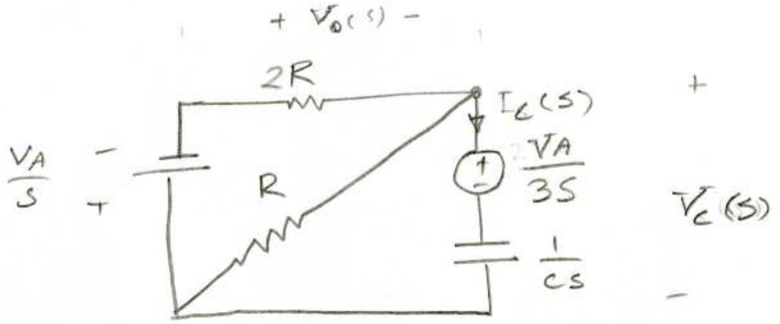
Determine initial condition by analysing circuit in position



- voltage divider, capacitor acts as open circuit as $t \to \infty$

$$\frac{V_c(0)}{R} = \frac{V_A}{3R} \to V_c(0) = \frac{V_A}{3}$$

Now we look at the s-domain circuit in position B.



So we have $$\frac{V_c(s) + \frac{V_A}{s}}{2R} + \frac{V_c(s)}{R} + \frac{V_c(s) - \frac{V_A}{3s}}{1/cs} = 0$$

$$\left(\frac{3}{2R} + cs\right) V_c(s) = \left(\frac{c}{3} - \frac{1}{2Rs}\right) V_A \Rightarrow V_c(s) = \frac{2R}{3+2RCs} \times \frac{2RCs-3}{6Rs} V_A$$

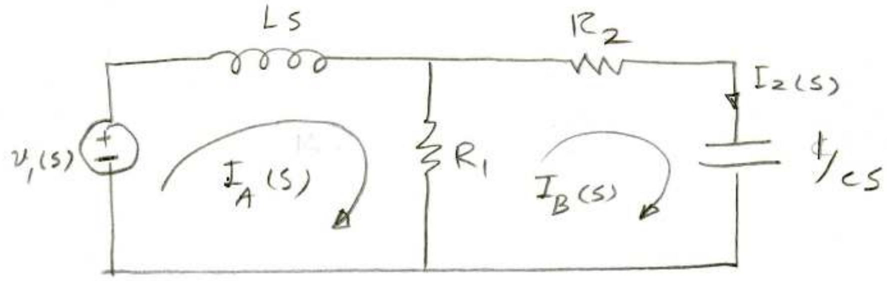
$$\boxed{V_c(s) = \frac{V_A}{3s}\left(\frac{2RCs-3}{3+2RCs}\right)}, \quad I_c(s) = \frac{v_c(s) - \frac{V_A}{3s}}{\frac{1}{cs}} = cs\, v_c(s) - \frac{c}{3} V_A$$

$$I_c(s) = \frac{cV_A}{3}\left(\frac{2RCs-3}{3+2RCs}\right) - \frac{c}{3} V_A = \frac{cV_A}{3} \, \frac{2RCs-3-3-2RCs}{3+2RCs}$$

$$I_c(s) = \frac{-6}{3+2RCs} \, \frac{cV_A}{3} = -\frac{2CV_A}{3+2RCs} \Rightarrow \boxed{I_c(s) = -\frac{2CV_A}{3+2RCs}}$$

S-domain

Q.51



Let us formulate the mesh current equation:

(1) $-v_1(s) + I_A(s)\,Ls + R_1\,(I_A(s) - I_B(s)) = 0$

$$v_1(s) = I_A(s)\,(Ls + R_1) - I_B(s)\,R_1$$

(2) $0 = (R_1 + R_2 + \frac{1}{cs})\,I_B(s) - R_1\,I_A(s) = 0$

from (1) $I_A(s) = \dfrac{v_1(s) + I_B(s)R_1}{Ls + R_1}$

$$I_B = \frac{R_1 I_A(s)}{\frac{cs(R_1+R_2)+1}{cs}} = \frac{R_1 cs}{cs(R_1+R_2)+1}\left[\frac{v_1(s) + I_B(s)R_1}{Ls + R_1}\right]$$

$$I_2(s) = I_B(s) = \frac{R_1\,v_1(s)\;Cs}{(R_1+R_2)LCs^2 + (R_1R_2C + L)s + R_1}$$

(c) Single zero of system located at $s=0$

Poles: $s^2(R_1+R_2)LC + (R_1R_2C + L)s + R_1 = 0$

$$P = \frac{-(R_1R_2C + L) \pm \sqrt{(R_1R_2C + L)^2 - 4(R_1+R_2)LCR_1}}{2(R_1+R_2)LC}$$

10.51

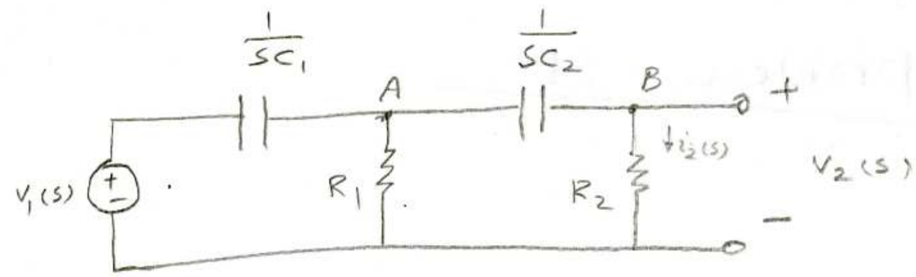
(d) $v_1(t) = 20\, u(t)$. $R_1 = 2\,k\Omega$ $R_2 = 1\,k\Omega$

$L = 1\ Hz$ $C = 0.5\ \mu F$

$$I_2(s) = \frac{2\ (20)\ 0.5\,\mu F\ s}{(2+1)\,1\,(0.5\,\mu F)\,s^2 + (2\times 0.5+1) + 2}$$

*prob.

10.53



Let consider the node voltage equations at A, B are

$$A: \left(\frac{1}{1/sC_1} + \frac{1}{1/sC_2} + \frac{1}{R_1}\right) V_A - \left(\frac{1}{1/sC_2}\right) V_B = \frac{1}{1/sC_1} V_1(s)$$

$$\Rightarrow \left(sC_1 + sC_2 + \frac{1}{R_1}\right) V_A - sC_2 V_B = sC_1 V_1(s) \qquad (i)$$

$$B: \left(-\frac{1}{1/sC_2}\right) V_A + \left(\frac{1}{1/sC_2} + \frac{1}{R_2}\right) V_B = 0 \quad \Rightarrow$$

$$-sC_2 V_A + \left(sC_2 + \frac{1}{R_2}\right) V_B = 0 \qquad (ii)$$

Solving $V_2(s)$ $\left(V_2(s) = V(B)\right)$

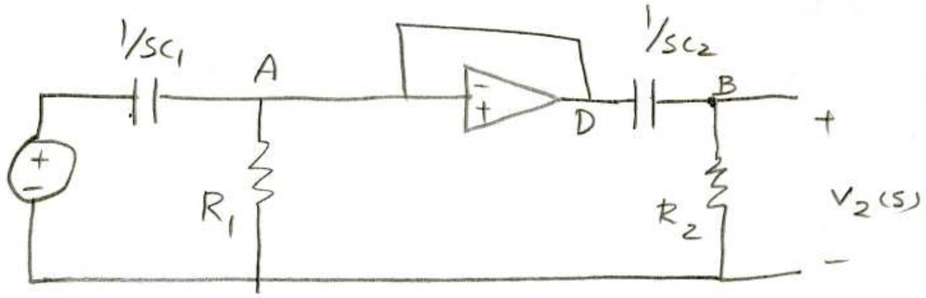
$$V_A = \frac{sC_1 V_1(s) + sC_2 V_2(s)}{sC_1 + sC_2 + \frac{1}{R_1}}$$ Substituting in (ii) we

get $$-sC_2 \frac{sC_1 V_1(s) + sC_2 V_2(s)}{sC_1 + sC_2 + \frac{1}{R_1}} + \left(sC_2 + \frac{1}{R_2}\right) V_2(s) = 0 \longrightarrow$$

$$V_2(s) = \frac{s^2 C_1 C_2 R_1 R_2 V_1(s)}{s^2 R_1 R_2 C_1 C_2 + s(R_1C_1 + R_2C_2 + R_1C_2) + 1}$$

10.53

c)



as the output impedence of op amp is very low

$V_A = V_D$

at Node A: $\left(\frac{1}{R_1} + sC_1\right) V_A = V_1(s) \times sC_1$

at Node B: $(-sC_2) V_A + \left(sC_2 + \frac{1}{R_2}\right) V_2(s) = 0$

$$(-sC_2)\left(\frac{V_1(s)\, sC_1}{sC_1 + \frac{1}{R_1}}\right) + \left(sC_2 + \frac{1}{R_2}\right) V_2(s) = 0 \implies$$

$$V_2(s) = \frac{s^2 C_1 C_2 R_1 R_2 V_1(s)}{(sC_1R_1 + 1)(sC_2R_2 + 1)} = \frac{s^2 V_1(s)}{\left(s + \frac{1}{C_1R_1}\right)\left(s + \frac{1}{C_2R_2}\right)}$$

(d) Poles are $s = \frac{-1}{C_1R_1}$ $\quad s = \frac{-1}{C_2R_2}$

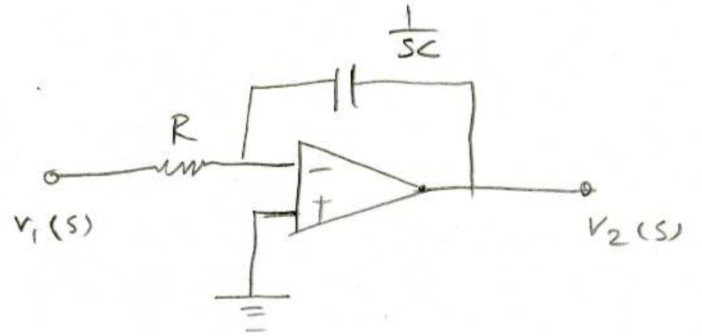
$\begin{cases} \text{if } R_1 = 1\,k\Omega \\ \frac{1}{C_1R_1} = 10^4 \end{cases}$ $\longrightarrow C_1 = 0.01\,\mu F$

$\begin{cases} \text{if } R_2 = 1\,k\Omega \\ \frac{1}{C_R R_2} = 10^5 \end{cases}$ $\longrightarrow C_2 = 0.1\,\mu F$

10.72

$v_1(t) = \cos 2000t$ $\qquad V_1(S) = \dfrac{S}{S^2 + (2000)^2}$

desired output $\; v_2(t) = -\sin 2000t$ $\qquad V_2(S) = \dfrac{-2000}{S^2 + (2000)^2}$



this is an inverting amplifier and know that

$$V_2(S) = K V_1(S) = \frac{-\frac{1}{SC}}{R} V_1(S) = -\frac{1}{SCR} V_1(S) \qquad \text{So}$$

$$V_2(S) = -\frac{1}{SCR} V_1(S)$$

$$-\frac{2000}{S^2 + (2000)^2} = -\frac{1}{SCR}\,\frac{S}{S^2 + (2000)^2} \rightarrow \quad \frac{1}{CR} = 2000 \rightarrow$$

$$C = \frac{1}{2000R} \qquad \text{Let select } R = 0.5\,K\Omega \rightarrow C = 1\,\mu F$$

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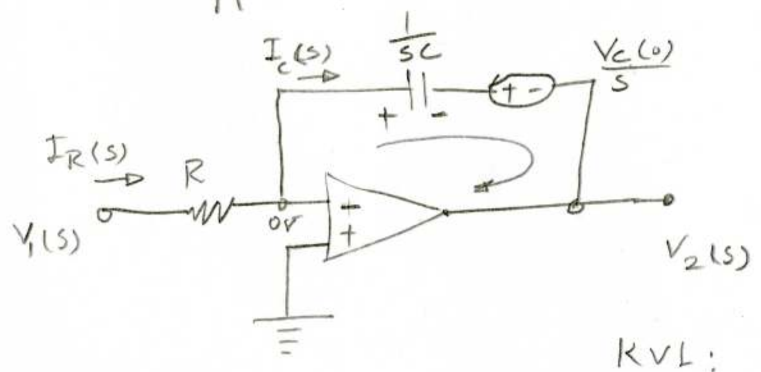
what happens if $V_c(0) = 5V$



we know that

$i_N = i_p = 0$ so

$I_c(S) = I_R(S) = I(S)$

$V^+ = V^- = 0$

KVL: $\; -V_2(S) = \frac{1}{SC} I(S) + \frac{V_c(0)}{S}, \qquad I(S) = \frac{V_1(S)}{R}$

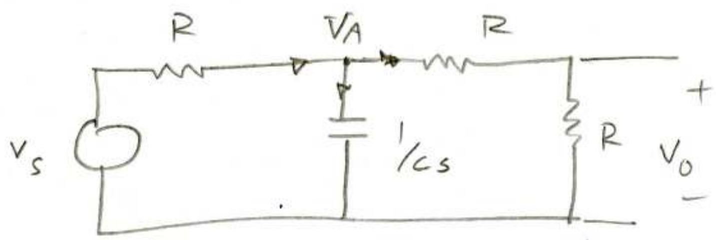
$$-V_2(S) = \frac{1}{SC}\,\frac{V_1(S)}{R} + \frac{V_c(0)}{S}$$

$$V_2(S) = -\frac{V_1(S)}{SCR} - \underbrace{\frac{V_c(0)}{S}}$$

→ step function in time domain

output is shifted by $V_c(0) = 5\,V$

10-18



node Analysis at (A)

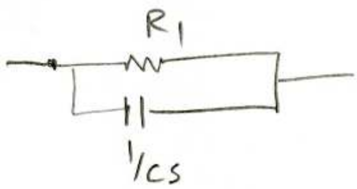
$$\frac{V_s - V_A}{R} = \frac{V_A}{\frac{1}{sc}} + \frac{V_A}{2R} \rightarrow \frac{V_s}{R} = \frac{3V_A}{2R} + scV_A = \left(\frac{3+2Rsc}{2R}\right)V_A$$

voltage diviviser $\quad \frac{V_o}{R} = \frac{V_A}{2R} \rightarrow V_o = \frac{V_A}{2}$

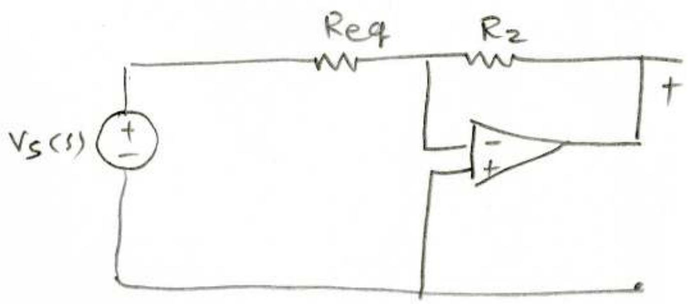
$$V_s = \frac{3+2Rsc}{2} V_A$$

$$V_o = \frac{V_A}{2} \longrightarrow \frac{V_o}{V_s} = \frac{1}{3+2RSC}$$

10-83



$$Req = \frac{R_1 \frac{1}{cs}}{R_1 + \frac{1}{cs}} = \frac{R_1}{R_1cs+1}$$



inverting Amp

$$K = -\frac{R_2}{R_1} = -\frac{R_2}{Req}$$

$$\frac{V_o}{V_s} = -\frac{R_2}{\frac{R_1}{R_1CS+1}} = -\frac{R_2(R_1CS+1)}{R_2}$$

zero at

$R_1Cs + 1 = 0$

$\rightarrow s = \frac{-1}{R_1CS}$

if a pole get and cancel zero $s = \frac{-1}{R_1C}$ then