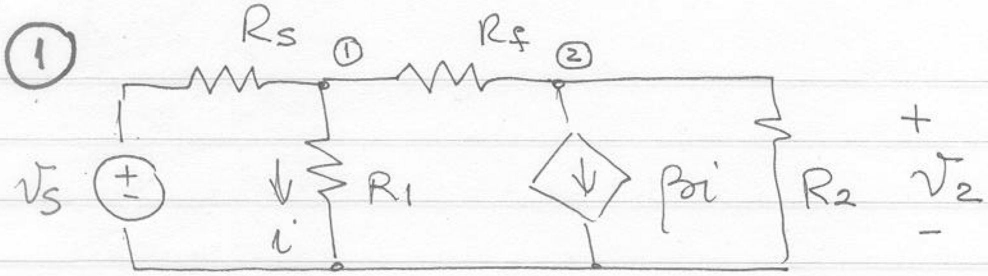
1



$R_s = 8\,\Omega$

$R_1 = 1\,\Omega$

$R_2 = 5\,\Omega$

$R_f = 30\,\Omega$

$$\frac{v_1 - V_s}{R_s} + \frac{v_1}{R_1} + \frac{V_1 - V_2}{R_f} = 0$$

$$\frac{V_2 - V_1}{R_f} + \beta i + \frac{v_2}{R_2} = 0$$

$$v_1 \cdot \left(\frac{1}{R_s} + \frac{1}{R_1} + \frac{1}{R_f} \right) - \frac{1}{R_f} \cdot V_2 = \frac{V_s}{R_s}$$

$$-\frac{v_1}{R_f} + V_2 \cdot \left(\frac{1}{R_f} + \frac{1}{R_2} \right) + \beta \cdot \frac{V_1}{R_1} = 0$$

Hence: $$v_1 \cdot \left(-\frac{\beta}{R_1} + \frac{1}{R_f} \right) = V_2 \cdot \left(\frac{1}{R_f} + \frac{1}{R_2} \right)$$

$$v_1 = V_2 \cdot \frac{\frac{1}{R_f} + \frac{1}{R_2}}{\frac{1}{R_f} - \beta / R_1}$$

②

$$\frac{v_1}{v_2} = \frac{\frac{1}{R_f} + \frac{1}{R_2}}{\frac{1}{R_f} - \beta/R_1}$$

$$v_2 \cdot \frac{\frac{1}{R_f} + \frac{1}{R_2}}{\frac{1}{R_f} - \beta/R_1} \cdot \left(\frac{1}{R_s} + \frac{1}{R_1} + \frac{1}{R_f}\right) - \frac{v_2}{R_f} = \frac{V_S}{R_S}$$

$$\frac{V_2}{V_S} = \frac{1}{\frac{G_f + G_2}{G_f - \beta G_1} \cdot (G_s + G_1 + G_f) - G_f} \cdot \frac{1}{R_S}$$

$$\frac{V_2}{V_S} = \frac{G_f - \beta G_1}{(G_f + G_2)(G_s + G_1 + G_f) - G_f\,(G_f - \beta G_1)} \cdot G_S$$

$$\frac{V_2}{V_S} = \frac{G_f - \beta G_1}{G_2(G_s + G_1 + G_f) + G_f(G_s + G_1) + \beta G_1 G_f} \times G_S$$

$G_s = 1/8$, $G_1 = 1$, $G_2 = 1/5$ $G_f = \frac{1}{30}$

$$\frac{V_2}{V_S} = \frac{1/30 - \beta}{\frac{1}{5} \cdot \left(\frac{1}{8} + 1 + \frac{1}{30}\right) + \frac{1}{30} \cdot \left(\frac{1}{8} + 1\right) + \beta \cdot 1 \cdot \frac{1}{30}} \times \frac{1}{8}$$

$$\frac{v_2}{v_S} = \frac{\frac{1}{30} - \beta}{\frac{1}{5} \cdot \frac{15 + 120 + 4}{120} + \frac{1}{30} \cdot \frac{9}{8} + \beta/30} \times \frac{1}{8}$$

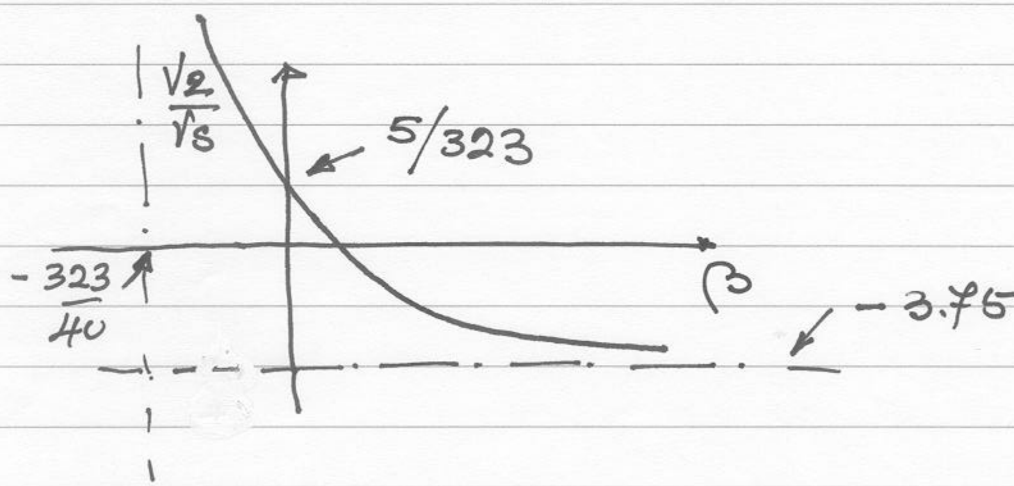
$$\frac{V_2}{V_s} = \frac{1/30 - \beta}{\frac{139}{600} + \frac{3}{80} + \frac{\beta}{30}} \cdot \frac{1}{8} \Big/ 30$$

$$= \frac{1 - 30\beta}{\frac{139}{20} + \frac{9}{8} + \beta}$$

$$= \frac{40}{8} \cdot \frac{1 - 30\beta}{323 + 40\beta}$$

$$\beta = 0 \Rightarrow \frac{V_2}{V_s} = \frac{5}{323}$$

$$\beta \to \infty \Rightarrow \frac{V_2}{V_s} = -\frac{3}{4} \times 5$$



$$\frac{V_2}{V_s} = \frac{G_f - \beta \cdot G_1}{G_2(G_s + G_1 + G_f) + G_f \cdot (G_s + G_1) + \beta G_1 \cdot G_f} \cdot G_s$$

$G_s = 1/8$
$G_1 = 1$
$G_2 = 1/5$

$$\frac{V_2}{V_s} = \frac{G_f - \beta}{\frac{1}{5} \cdot \left(\frac{1}{8} + 1 + G_f\right) + G_f \cdot \left(\frac{1}{8} + 1\right) + \beta \cdot G_f} \cdot \frac{1}{8}$$

Let $\frac{V_2}{V_s} = 5$

$$5 = \frac{G_f - \beta}{\frac{9}{5} + \frac{8}{5} G_f + 9 G_f + 400 \cdot G_f}$$

$$5 = \frac{G_f - \beta}{\frac{9}{5} + \frac{2053 G_f}{5}}$$

$$9 + 2053 \cdot G_f = G_f - \beta \; : \quad \beta = 50$$

Hence:

$$2052 \times G_f = -59$$

$$\Rightarrow G_f < 0$$

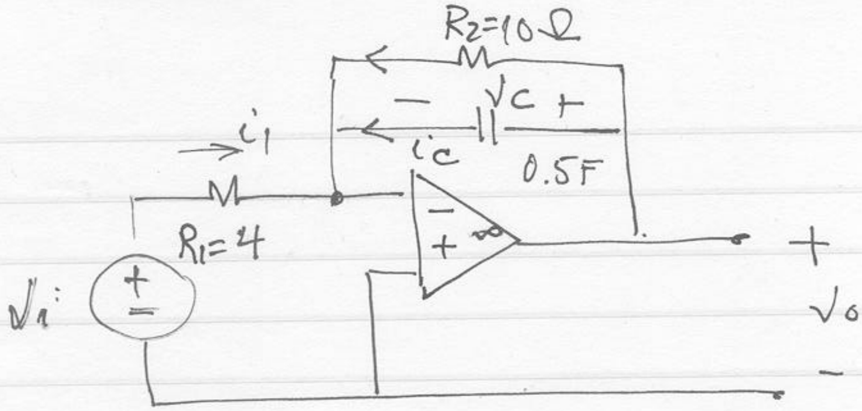
If: $\frac{V_2}{V_s} = -5$

then: $9 + 2053 G_f = \beta - G_f \quad ; \beta = 50$

$$2054 \times G_f = 41 \quad \Rightarrow G_f = \frac{41}{2054}$$

$$R_f = \frac{2054}{41}$$

2



$$i_1 = \frac{v_1}{R_1}$$

$$\frac{v_o}{R_2} + i_C + \frac{v_i}{R_1} = 0$$

$$i_C = C\frac{dv_C}{dt}$$

$$\frac{v_o}{R_2} + C \cdot \frac{dv_C}{dt} + \frac{v_i}{R_1} = 0$$

$$v_C = v_o$$

$$C \cdot \frac{dv_o}{dt} + \frac{v_o}{R_2} + \frac{v_i}{R_1} = 0 \qquad \text{Diff. eq.}$$

$$0.5 \cdot \frac{dv_o}{dt} + \frac{v_o}{10} + \frac{v_i}{4} = 0$$

$$\frac{dv_o}{dt} + \frac{v_o}{5} + \frac{v_1}{2} = 0 \qquad \frac{dv_o}{dt} + \frac{v_o}{5} = -\frac{v_1}{2}$$

$$v_{o_h} = K e^{-\frac{1}{5}t}$$

$$v_{op} = A \qquad \frac{A}{5} = -\frac{v_1}{2}$$

$$A = -\frac{5}{2} \cdot v_1$$

$V_1 = 6 \cdot u(t)$

$A = -15\, u(t)$

Hence:

$v_o = \left(K e^{-t/5} - 15\right) u(t)$

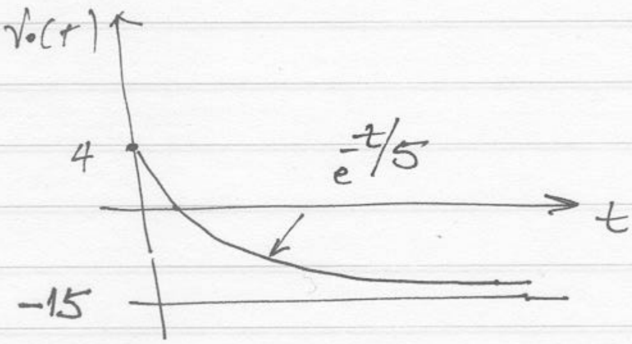
$v_o(0-) = 4$

$k e^{-0/5} - 15 = 4 \qquad k = 19$

$v_o = \left(19 e^{-t/5} - 15\right) u(t)$

leaky integrater.

as $t \to \infty$ $\underline{v_o = -15 \cdot u(t)}$



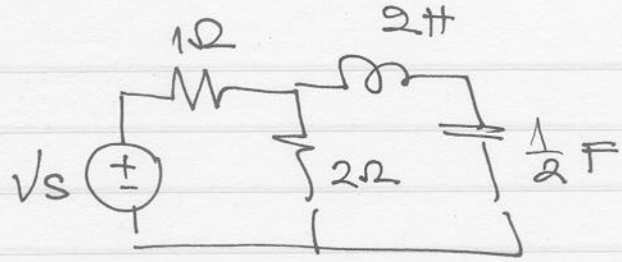
$19 e^{-t_1/5} = 15$

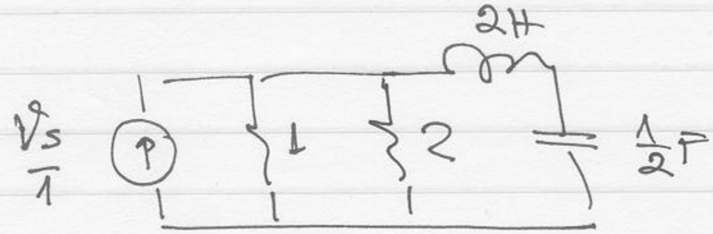
$e^{-t/5} = \frac{15}{19}$

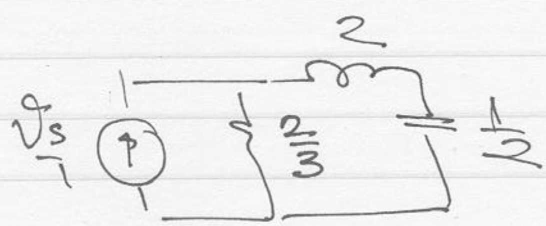
$-t/5 = \ln \frac{15}{19}$

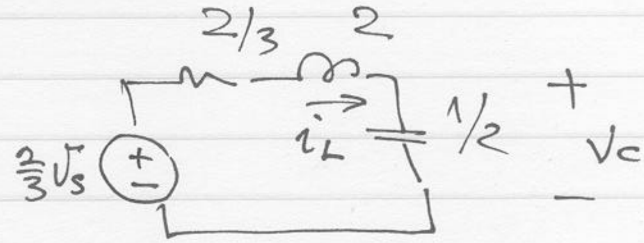
$\underline{t_1 = +5 \ln 19/15}$

3









$$\frac{2}{3}V_s - \frac{2}{3}\cdot i_L - \underset{\substack{\downarrow \\ 2}}{L}\frac{di_L}{dt} - V_C = 0$$

$$2\frac{di_L}{dt} + \frac{2}{3}\cdot i_L + V_C = \frac{2}{3}\cdot V_s$$

$$i_C = C\cdot\frac{dV_C}{dt}$$

$$\frac{1}{2}\cdot\frac{dV_C}{dt} = i_L$$

Hence: $$2\frac{di_L}{dt} + \frac{2}{3}i_L + V_C = \frac{2}{3}V_s$$

$$\frac{1}{2}\frac{dV_C}{dt} - i_L = 0$$

$$\frac{di_L}{dt} + \frac{1}{3}i_L + \frac{1}{2}V_C = \frac{1}{3}V_s$$

$$\frac{dV_C}{dt} - 2i_L = 0$$

$$\begin{pmatrix} \frac{di_L}{dt} \\ \frac{dv_c}{dt} \end{pmatrix} + \begin{pmatrix} \frac{1}{3} & \frac{1}{2} \\ -2 & 0 \end{pmatrix} \begin{pmatrix} i_L \\ v_c \end{pmatrix} = \begin{pmatrix} 1/3 \\ 0 \end{pmatrix} v_s$$

$$\begin{pmatrix} \frac{di_L}{dt} \\ \frac{dv_c}{dt} \end{pmatrix} = - \begin{pmatrix} 1/3 & 1/2 \\ -2 & 0 \end{pmatrix} \cdot \begin{pmatrix} i_L \\ v_c \end{pmatrix} + \begin{pmatrix} 1/3 \\ 0 \end{pmatrix} v_s$$

$$\dot{x} = A x + b . v_s$$

$$A = - \begin{pmatrix} 1/3 & 1/2 \\ -2 & 0 \end{pmatrix}$$

Then: $$sI - A = \begin{pmatrix} s & 0 \\ 0 & s \end{pmatrix} + \begin{pmatrix} 1/3 & 1/2 \\ -2 & 0 \end{pmatrix} = \begin{pmatrix} s+1/3 & 1/2 \\ -2 & s \end{pmatrix}$$

$$\det(sI - A) = (s + 1/3)s + 2 \cdot 1/2$$

$$s^2 + \frac{1}{3}s + 1 = 0$$

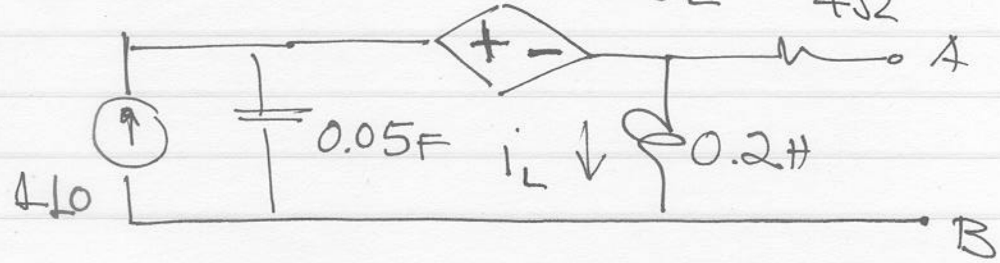
$$s_{1/2} = -\frac{1}{6} \pm \sqrt{\frac{1}{36} - 1}$$

$$= -\frac{1}{6} \pm \frac{\sqrt{-35}}{6}$$

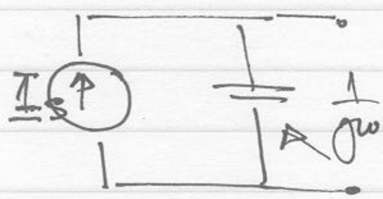
$$= \frac{-1 \pm j\sqrt{35}}{6}$$

under-damped system.

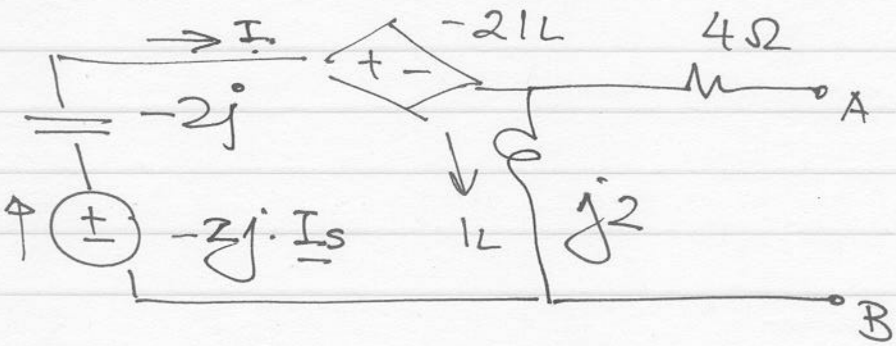
(4)



Thevenin's equivalent.



$\frac{1}{j\omega C} = \frac{1}{j\cdot 10\cdot 0.05} = \frac{1}{j0.5} = \frac{2}{j} = -2j$



Thevenin's voltage: $\underline{V}_{AB}$

a) $(-2j\,\underline{I_s}) - (-2j\cdot \underline{I}) - (-2\cdot \underline{I}) - j2\cdot \underline{I} = 0$

$\underline{I_L} = \underline{I}$

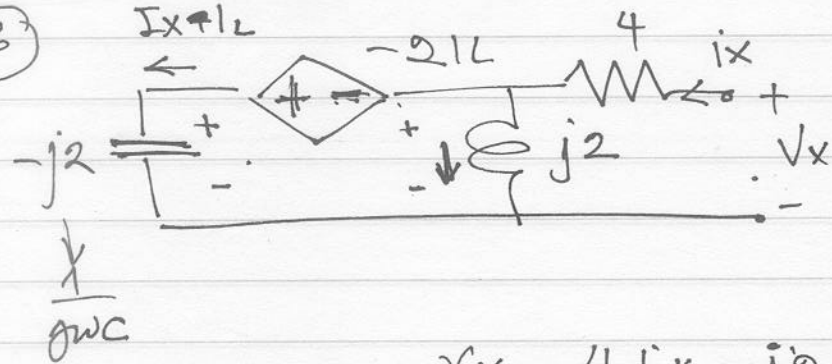
$-2j\cdot \underline{I_s} + \cancel{2j\cdot I} + 2\cdot I - \cancel{j2\cdot I} = 0$

$\underline{I} = j\,\underline{I_s} \qquad I = j$

$V_{th} = j2 \cdot I$

$V_{th} = -2V$

(6)



$\omega=10$
$C=0.05$

$V_x - 4 \cdot i_x - j2 \cdot i_L = 0$

$V_x = 4 \cdot i_x + j2 \cdot i_L$

$j2 \cdot i_L - 2 \cdot I_L - (-j2 \cdot)(i_x - i_L) = 0$

$j2 \cdot I_L - 2 \cdot I_L + j2 \cdot (i_x - I_L) = 0$

$-2I_L = -j2I_x$

$+jI_x = I_L$

$V_x = 4 \cdot i_x + j2 \cdot (+j \cdot I_x)$

$V_x = 2 \cdot i_x$ $\quad$ $Z_{th} = 2$