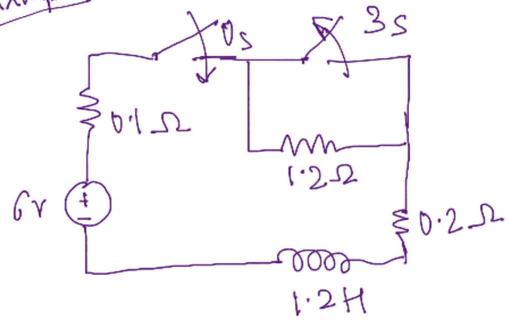
Example



Find current through the switches for $t \geq 0$

Sol $t<0$ No current flows (o.c.)

At $t=0$ & $t<3s$

$$\tau = 1.2/(.1+.2) = 4$$

$$i_{n_1} = A e^{-t/\tau}$$

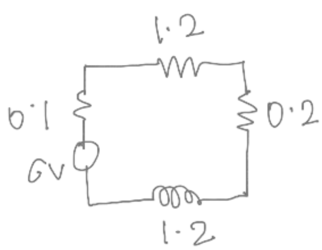
$$i_{f_1} = \frac{6}{.1+.2} = 20\,A$$

$$i_1 = 20 + A e^{-t/\tau}$$

$t=0$ $i=0$, $\therefore$ $A=-20$ $\Rightarrow$ $\boxed{i_1 = 20\left(1-e^{-t/4}\right)}$

At $t=3\,sec$ $i_1 = 20\left(1-e^{-3/4}\right) = 10.55\,A$

$t=3s$



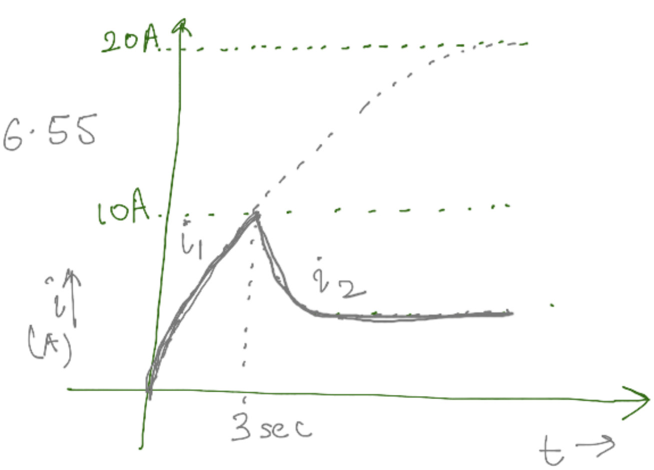
$$\tau_2 = \frac{1.2}{1.2+.3} = \frac{1.2}{1.5} = 4/5 = 0.8\,sec$$

$$i_{f_2} = \frac{6}{1.5} = 4\,A$$

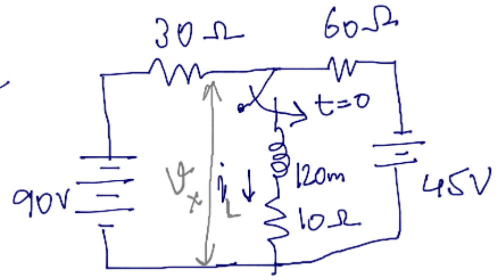
$$i = 4 + A_2 e^{-t/0.8}$$

($t=3$, $t=0$ for this ckt) $10.55 = 4 + A_2 \Rightarrow A_2 = 6.55$

$$\boxed{i_2 = 4 + 6.55\, e^{-t/0.8}}$$



Ex

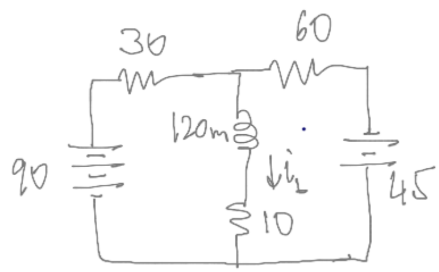


Find i

Sol $t<0$ $\quad i_L = 0$ $\quad i = \dfrac{90-45}{30+60} = \dfrac{45}{90} = 0.5\,A$ (through resistors)

$\therefore \; v_x = 90 - 30 * i = 90 - 15 = \underline{\underline{75V}}$

At $t=0$



R_{th} (across L) $\quad (30 \| 60) + 10 = \dfrac{\cancel{30} \times \cancel{60}^{\,20}}{\cancel{90}_{\,3}} + 10 = 30\,\Omega$

$\tau = \dfrac{120m}{30} = 4\,msec$

$i_{n_L} = A\, e^{-t/4m}$

$i_{f_L} = \left\{ 90 \Big/ \left[\dfrac{60 * 10}{60+10} + 30 \right] \right\} * \dfrac{60}{70} - \dfrac{45}{\dfrac{30*10}{30+10} + 60} * \dfrac{30}{40}$

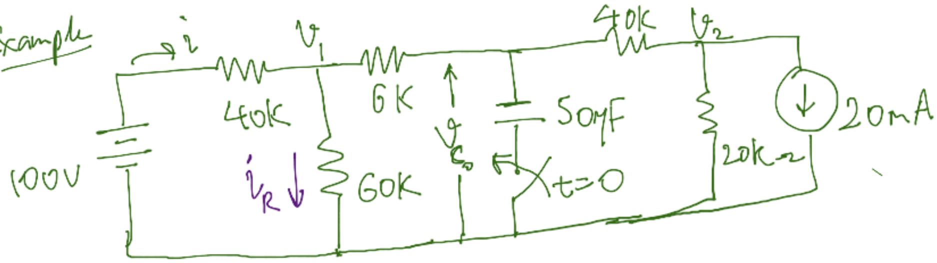
$= \dfrac{90}{38.57} * \dfrac{6}{7} - \dfrac{45}{67.5} * \dfrac{3}{4} = 2.00 - 0.5 = 1.5\ A$

$i_L = 1.5 + A e^{-t/4m}$

$i_L = 0$ at $t=0 \Rightarrow A = -1.5$

$$\boxed{i_L = 1.5\left(1 - e^{-t/4m}\right)}$$

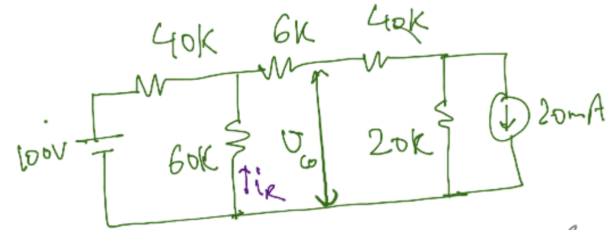
Example

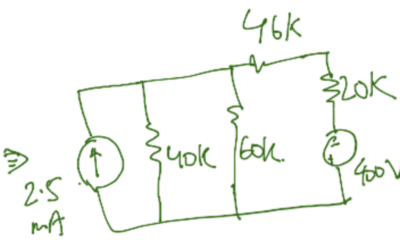


Given $v_c(t=0) = 0$

Find i_R through 60KΩ

$t \to \infty \Rightarrow (C \to O.C)$





Source Transformation

$$i = \frac{400+60}{(24+66)K} = \frac{460}{90K} = \frac{46}{9} mA$$

$$v_{c\infty} = 60 - (24K + 6K) * \frac{46}{9} m$$
$$= -93.3V$$

$$v_1 = 60 - 24 \times \frac{46}{9} = 62.66V$$

$R_{th} = (24+6)k \,||\, 60K = \frac{30*60}{90}k = 20k.$ (across cap)

$$\tau = R_{th} * C = 20k * 50\mu = 1000 \times 10^{-3} = 1 sec.$$

At $t=0$ $(C \to S.C)$ $\quad i_{R(0)} = \frac{6}{66} * \frac{100}{40k + \frac{6*60}{66}k} = \frac{6*100}{3000k} = 0.2mA$

$$i_{Rn} = A e^{-t}$$

$$i_{Rf} = \frac{100 - 40k * \frac{46}{9}m}{60k} = -1.74mA$$

$$i_R = -1.74m + A e^{-t}$$

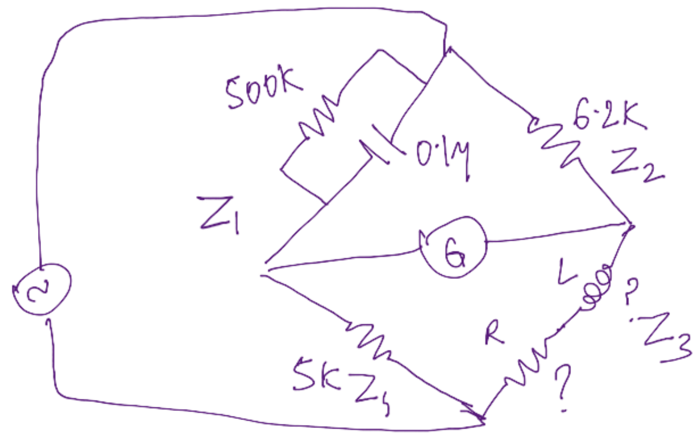
$t=0$ $\quad 0.2 = -1.74m + Am \Rightarrow A = +1.94mA$

$$\Rightarrow i_R = -1.74m + 1.94 \times 10^{-3} e^{-t}$$

$$v_c = -93.3 + A e^{-t}$$

$v_c = 0$ at $t=0$ $\therefore A = 93.3$ $\quad v_c = 93.3(-1 + e^{-t})$

Example



The given Wheatstone Bridge (Maxwell's) is balanced.
Find values of L & R

Sol Balanced Bridge.

$$Z_1 Z_3 = Z_2 Z_4$$

$$\left(\frac{R_1 \frac{1}{j\omega C}}{R_1 + \frac{1}{j\omega C}}\right)(R_3 + j\omega L) = R_2 * R_4$$

$\Rightarrow$

$$LHS = \left(\frac{-R_1 \frac{j}{\omega C}}{R_1 - \frac{j}{\omega C}}\right)(R_3 + j\omega L) = \left(\frac{-jR_1}{\omega R_1 C_1 - j}\right)(R_3 + j\omega L)$$

$$\Rightarrow \quad -jR_1R_3 + R_1\omega L = R_2R_4(\omega R_1 C_1 - j)$$

Re $\quad \cancel{R_1}\cancel{\omega} L = R_2 R_4 \cancel{\omega}\cancel{R_1} C_1$

$$\boxed{L = R_4 R_2 C_1} \qquad L = 5k * 6.2k * 0.1\mu = 3.10\ H$$

Im $\quad +R_1R_3 = +R_2R_4$

$$\boxed{R_3 = \frac{R_2 R_4}{R_1}} \qquad R_3 = \frac{6.2k * 5k}{500k} = 62\,\Omega$$

Such Bridges are used for measuring value of R & L. by keeping R_1 & R_2 variable.

Example $20\mu F$ cap and parallel 200Ω draw 4A at 60Hz. What are the W, VAR.

Sol 60Hz $= f$ $2\pi f = \omega = 2*3.14*60$ rad/s $= 376.8$ rad/s

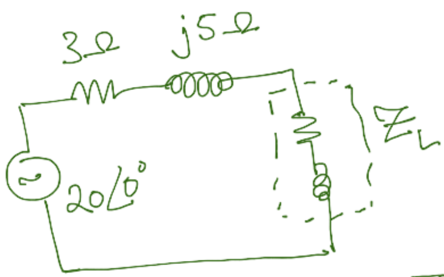
$$X_c = \frac{-j}{\omega * C} = \frac{-j}{376.8 * 20\mu F} = -j0.1327\, m\Omega = -j\, 132.7\,\Omega$$

$$\text{Power} = S = I^2 * Z$$

$$S = 4^2 * \frac{200 * (-j132.7)}{200 - j132.7} = -1769.2 \angle 123^\circ$$

$$= \underset{W}{+978.136} - j\underset{VAR}{1474.206}$$

Example



Given: Load impedance p.f $= 0.8$
What is the value of Z_L at max power trasfr.

$$Z_L = Z_s^*$$

$$Z_L = 3 - j5 = 5.83 \angle -59^\circ$$

$$\cos\phi = 0.8 \Rightarrow \phi = 36.87$$

$$\Rightarrow \sin\phi = 0.6$$

$$R = 5.8 \cos\phi = 4.64\,\Omega$$

$$X_L = 5.8 \sin\phi = 3.498\,\Omega$$