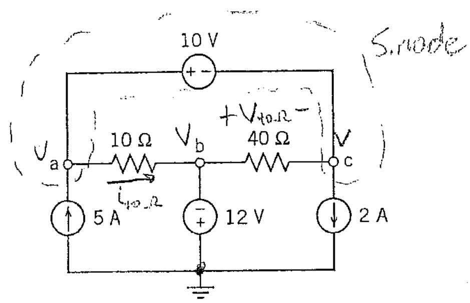
ECE 083

Sample Final Exam

Problem #1 : For the Given Circuit Find :

(15)

$V_{40\Omega}$ and $i_{10\Omega}$



$V_B = -12V$

V_a, V_c : $\frac{V_a - V_b}{10} + \frac{V_c - V_b}{40} + 2 - 5 = 0, \quad V_a = V_c + 10$

$\frac{V_a}{10} + \frac{12}{10} + \frac{V_c}{40} + \frac{12}{40} = 3$

$\frac{V_c}{10} + \frac{10}{10} + \frac{V_c}{40} = 1.5$

$\frac{V_c}{8} = 0.5$

$V_c = 4V$

$V_a = V_c + 10 = 14V$

15

$V_{40\Omega} = V_b - V_c$

$= -12V - 4V$

$= \boxed{-16V}$

$i_{10\Omega} = \frac{V_a - V_b}{10}$

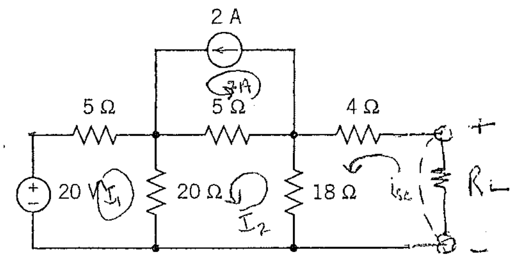
$= \frac{14 + 12}{10}$

$= \boxed{2.6A}$

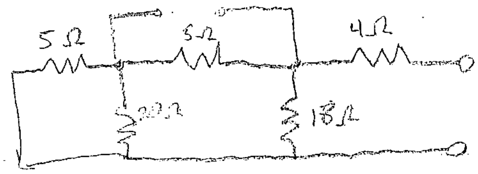
PROBLEM #2 : FIND THE NORTON-THEVENIN SUBCIRCUITS FOR THE GIVEN CIRCUIT

10

NOTE: LOOK THROUGH R_L



R_{TH}:



$$(5 \| 20 + 5) \| 18 + 4$$

$$\frac{1}{\frac{1}{5}+\frac{1}{20}} = 4 \Rightarrow 5+4 = 9 \Rightarrow \frac{1}{\frac{1}{9}+\frac{1}{18}} = 6 \Rightarrow 6+4 = 10$$

I_1: $5I_1 + 20I_1 + 20I_2 - 20 = 0$

$$25I_1 = 20 - 20I_2$$

$$I_1 = \frac{4}{5} - \frac{4}{5}I_2$$

I_2: $18I_2 + 5I_2 + 20I_2 + 20I_1 - 5(2) - 18i_{sc} = 0$

$$43I_2 + 20\left(\frac{4}{5} - \frac{4}{5}I_2\right) = 18i_{sc} + 10$$

$$43I_2 + 16 - 16I_2 = 18i_{sc} + 10$$

$$27I_2 = 18i_{sc} - 6$$

$$I_2 = \frac{2}{3}i_{sc} - \frac{2}{9}$$

10

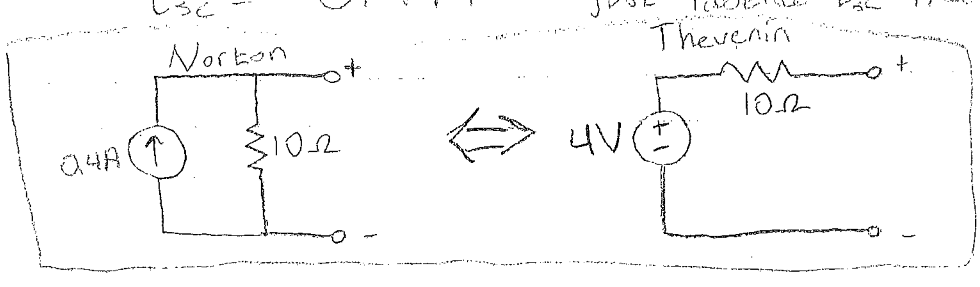
i_{sc}: $4 \cdot i_{sc} + 18i_{sc} - 18I_2 = 0$

$$22i_{sc} - 18\left(\frac{2}{3}i_{sc} - \frac{2}{9}\right) = 0$$

$$22i_{sc} - 12i_{sc} + 4 = 0$$

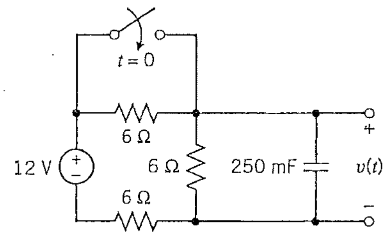
$$10i_{sc} = -4$$

$$i_{sc} = -0.4\text{ A}$$ (actually in the correct orientation, I just labelled i_{sc} incorrectly)

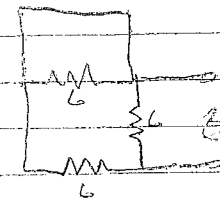


Problem #3 : For the Given Circuit Find $v(t)$ For All Time.

15



R_{Th}:



$V(0^+) = \frac{6}{6+6+6} \cdot 12V = 4V$

$6 \| 6 = 3\Omega$

$\tau = R_{Th} \cdot C$

$= (3\Omega)(250 \times 10^{-3} F)$

$= 0.75 s$

$V(\infty) = \frac{6}{6+6} \cdot 12V = 6V$

$V(t) = V(\infty) + [V(0^+) - V(\infty)] \cdot e^{-t/\tau}$

$= 6 + [4 - 6] \cdot e^{-\frac{t}{0.75}}$ V

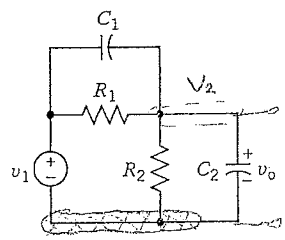
$= \boxed{6 - 2 \cdot e^{-\frac{4t}{3}}}$

15

Problem # 4 : For the Given Circuit Find the Transfer Function

(15)

If $H(f) = \frac{V_o}{V_i}$



Voltage divider:

$$Z_{C_2} = \frac{-j}{\omega C_2} \qquad Z_{C_1} = \frac{-j}{\omega C_1}$$

$$R_2 \| Z_{C_2} = \frac{1}{\frac{1}{R_2} + j\omega C_2} \qquad R_1 \| Z_{C_1} = \frac{1}{\frac{1}{R_2} + j\omega C_1}$$

$$V_o = V_{in} \cdot \frac{R_2 \| Z_{C_2}}{R_1 \| Z_{C_1} + R_2 \| Z_{C_2}} = V_{in} \cdot H(f)$$

$$H(f) = \frac{\frac{1}{\frac{1}{R_2} + j\omega C_2}}{\frac{1}{\frac{1}{R_1} + j\omega C_1} + \frac{1}{\frac{1}{R_2} + j\omega C_2}} \cdot \frac{(\frac{1}{R_2} + j\omega C_2)(\frac{1}{R_1} + j\omega C_1)}{(\frac{1}{R_2} + j\omega C_2)(\frac{1}{R_1} + j\omega C_1)}$$

$$= \frac{\frac{1}{R_1} + j\omega C_1}{\frac{1}{R_2} + j\omega C_2 + \frac{1}{R_1} + j\omega C_1} \cdot \frac{R_1 \cdot R_2}{R_1 \cdot R_2}$$

15

$$= \frac{R_2 + j\omega C_1 \cdot R_1 \cdot R_2}{R_1 + R_2 + j\omega (C_1 + C_2) \cdot R_1 \cdot R_2}$$

$$= \frac{R_2 (1 + j\omega R_1 C_1)}{R_1 + R_2 + j\omega (C_1 + C_2) \cdot R_1 R_2}, \qquad \omega = 2\pi f$$

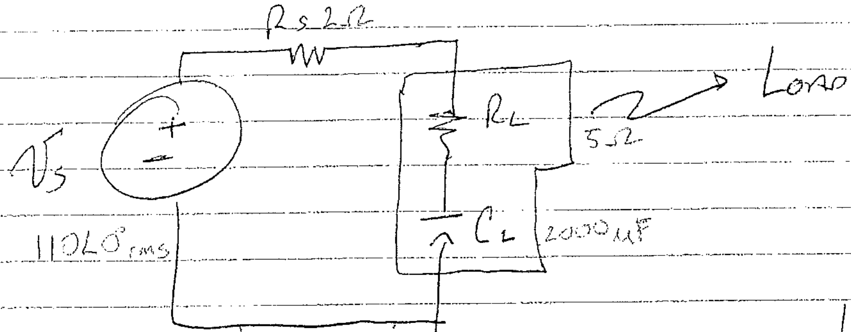
$H(0) \Rightarrow C$ is oc,

$V_o = \frac{R_2}{R_1 + R_2} \cdot V_{in}$ ✓

$$\boxed{H(f) = \frac{R_2 (1 + jf \cdot 2\pi R_1 C_1)}{R_1 + R_2 + jf \cdot 2\pi (C_1 + C_2) R_1 R_2}}$$

Problem #5 : Find the Complex Power and the Power Factor Associated With the Load.

(15)



$V_s = 110\angle 0°$ rms

$R_s = 2\,\Omega$

$R_L = 5\,\Omega$

$C_L = 2000\,\mu F$

Let's suppose $\omega = 500$

$Z_c = \frac{-j}{\omega C_L} = -\frac{j}{2000\times10^{-6}\times 500} = -j$

$Z_{eff} = R_s + R_L + Z_c$

$= 2+5+(-j)$

$= 7-j$

$I_{rms} = \frac{110\angle 0°}{7-j} = \frac{110\angle 0°}{5\sqrt{2}\angle -8.13°} = 11\sqrt{2}\cdot\angle 8.13°$

$V_L = \frac{R_L+Z_c}{R_L+R_s+Z_c}\cdot V_{rms} = \frac{5-j}{7-j}\cdot 110 = 79.2 - j4.4 = 22\sqrt{13}\ \angle -3.18°$

$S = V_{rms}\cdot I_{rms}^{*} = (22\sqrt{13}\ \angle -8.13°)(11\sqrt{2}\ \angle -3.18°)$

$= 242\sqrt{26}\ \angle -11.3°$

$= \boxed{1210 - j242}$

10

$pf = \cos(\theta_v - \theta_i)$

$= \cos(-3.18° - 8.13°)$

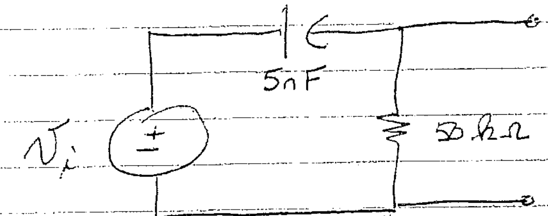
$= \cos(-11.3°) = \boxed{0.98}$

Problem #6 : For the Following Circuit, Given :

15

$v_i = 5 + 15\cos(200\pi t) + 30\cos(1000\pi t)$

Find An Expression For v_o. Explain Your Results !



H.P.F. : $H(f) = \dfrac{j\left(\frac{f}{f_B}\right)}{1 + j\left(\frac{f}{f_B}\right)}$

$f_B = \dfrac{1}{2\pi RC} = \dfrac{1}{2\pi(5\times10^{-9}\,F)(50000\,\Omega)} = \dfrac{2000}{\pi}\ Hz.$

$V_{out} = V_{in} \cdot H$

$\omega = 0,\ V_{out}(0) = V_{in}(0) \cdot H(0)$
$= 5 \cdot \left(\frac{j\frac{0}{f_B}}{1 + j\frac{0}{f_B}}\right)$
$= 5 \cdot 0 = 0$

15

$\omega = 200\pi,\ V_{out}(100) = V_{in}(100) \cdot H(100)$
$= 15 \cdot \dfrac{j\frac{100\pi}{2000}}{1 + j\frac{100\pi}{2000}}$
$= 0.361 + j2.299$
$= 2.33 \angle 81.1°$
$= 2.33 \cdot \cos(200\pi t + 81.1°)$

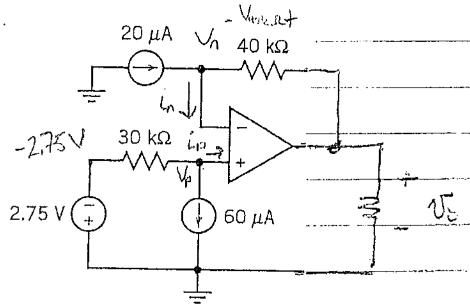
$\omega = 1000\pi,\ V_{out}(500) = V_{in}(500) \cdot H(500)$
$= 30 \cdot \dfrac{j\frac{500\pi}{2000}}{1 + j\frac{500\pi}{2000}}$
$= 11.445 + j14.573$
$= 18.53 \angle 51.9°$
$= 18.53 \cdot \cos(1000\pi t + 51.9°)$

$$\boxed{V_{out}(t) = 2.33 \cdot \cos(200\pi t + 81.1°) + 18.53 \cdot \cos(1000\pi t + 51.9°)}$$

The D.C. voltage of 5V is completely filtered out because this is a high pass filter. All A.C. voltages are conditioned, with the magnitude of lower frequency signals being reduced more drastically than those with higher frequencies as we expect of a high pass filter.

PROBLEM # 7 : For the OP-AMP CIRCUIT Given Find v_o

20



$V_o = V_{40k\Omega} + V_n = V_{40k\Omega} + V_p$ (negative feedback)

$V_n = V_p$

$V_p: \frac{V_p + 2.75}{30000} + 60 \times 10^{-6} = 0$

$V_p + 2.75 = -1.8$

$V_p = -4.55\text{ V}$

(infinite input impedance)

$i_n = 0A$, so $V_{40k\Omega} = (-20 \times 10^{-6})(40000)$

$= -0.8\text{ V}$

20

$V_o = (-0.8\text{ V}) + (-4.55\text{ V})$

$= \boxed{-5.35\text{ V}}$