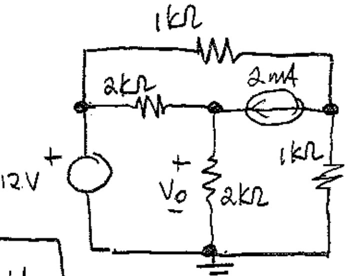
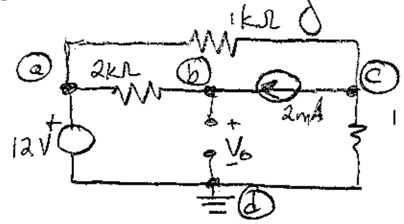
Irwin 4.36, 6.67, 7.55, 11.55, 11.62

Engineering 72
Electronic Circuit Applications
Assignment 1 Solutions

LAM
9.5.05

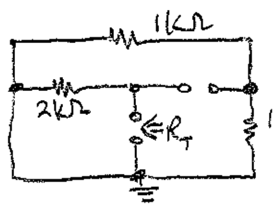


(1.) Find V_o using Thevenin's Theorem

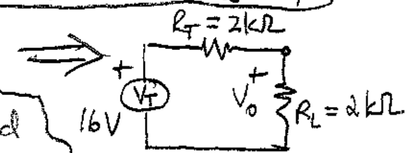


By inspection, the 2 mA source forces 2 mA through the 2kΩ resistor.

$v_a = 12V \Rightarrow v_b = 12 + (2k)(2m) = 16V = V_{oc} = V_T$



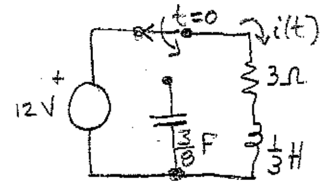
The 2 1kΩ resistors are shorted by removing the 12V source ⇒ S.C.
Thus $R_T = 2k\Omega$

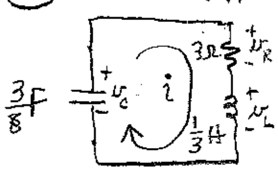


& by voltage divider, $V_o = \frac{R_L}{R_T + R_L} V_T$

$\Rightarrow \boxed{V_o = \frac{2}{2+2}(16) = 8\ V}$

(2.) Find $i(t)$.





$Z(s) = sL + R + \frac{1}{sC} = \frac{s^2LC + sRC + 1}{sC}$; for natural current, use zeros of $Z(s) = 0$.

$Z(s) = 0 \Rightarrow s^2 + s\frac{R}{L} + \frac{1}{LC} = 0 \Rightarrow s^2 + s\left(\frac{3}{1/3}\right) + \frac{1}{(1/3)(3/8)} = 0$

$s^2 + 9s + 8 = 0 \Rightarrow (s+1)(s+8) = 0$ or $s = -1, -8$

$i(t) = A_1 e^{-t} + A_2 e^{-8t}$ need ICs to find A_1, A_2.

$v_C(0^+) = v_C(0^-) = 0$

$i(0^+) = i_L(0^+) = i_L(0^-) = V/R = 12/3 = 4A$; $\left.\frac{di}{dt}\right|_{t=0^+} = \frac{v_L(0^+)}{L}$ $\quad v_L(0^+) = -v_R(0^+) - v_C(0^+)$

$v_R(0^+) = i(0^+)R = i(0^-)R$ since $i = i_L$ can't change instantaneously

so $v_L(0^+) = -12 - 0 = -12V$

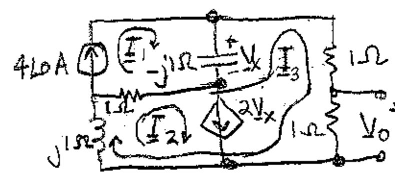
$i(0^+) = A_1 + A_2 = 4$

$\left.\frac{di}{dt}\right|_{t=0^+} = -A_1 - 8A_2 = \frac{-12}{1/3} = -36$ $\Big\} \Rightarrow A_1 = -4/7,\ A_2 = 32/7$

$\therefore \boxed{i(t) = \frac{1}{7}\left(-4e^{-t} + 32e^{-8t}\right) u(t)\ A}$

$\left(u(t) = \begin{cases} 1 & t>0 \\ 0 & t<0 \end{cases} \Rightarrow \text{true for } t>0\right)$

(3.) Find V_o. Use loop current method. (a) $I_1 = 4$, (b) $I_2 = 2V_x$



(1) $1I_3 + 1I_3 + j1(I_2 + I_3) + 1(I_3 + I_2 - I_1) - j1(I_3 - I_1) = 0$

(2) $V_x = -j1(I_1 - I_3) = -j1(4 - I_3)$; sub in (a),(b) to (1),(2) ⇒

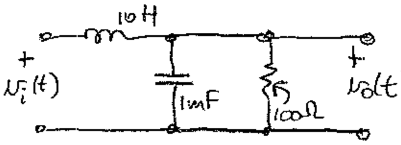
(1) $I_3(3) + 2V_x(1+j1) + 4(-1+j1) = 0$

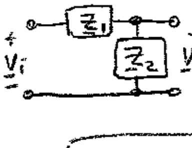
(2) $V_x = -j1(4 - I_3)$

} solve simultaneously ⇒ $I_3 = \frac{4+j12}{5}$

& $\boxed{V_o = \frac{4}{5} + j\frac{12}{5}}$

(4.) Sketch magnitude of transfer function $G_v(j\omega) = \frac{V_o}{V_i}(j\omega)$
Identify type of filter. By voltage divider,

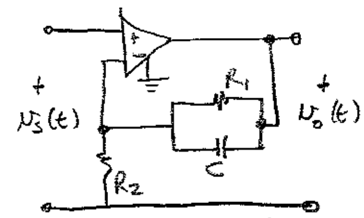




$\frac{V_o}{V_i} = \frac{Z_2}{Z_1 + Z_2}$, where $Z_1 = j\omega L$, $Z_2 = \frac{R/j\omega C}{R + 1/j\omega C} = \frac{R}{1 + j\omega RC}$

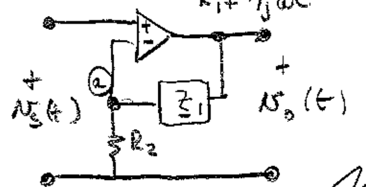
so $\frac{V_o}{V_i} = \frac{\frac{R}{1+j\omega RC}}{j\omega L + \frac{R}{1+j\omega RC}} = \frac{R}{R + j\omega L - \omega^2 RLC} = \frac{100}{100 + j\omega 10 - \omega^2} = \boxed{\frac{1}{1 + j\,\omega/10 + (j\,\omega/10)^2} = \frac{V_o}{V_i}}$ LPF

Engineering 72
Electronic Circuit Applications
Assignment 1 Solutions Continued



(5) Sketch magnitude of transfer function $\underline{G}_V(j\omega) = \frac{V_o}{V_i}(j\omega)$. Identify the type of filter.

$Z_1 = R_1 \| C = \frac{R_1/j\omega C}{R_1 + 1/j\omega C}$



$$\sum_a i = 0 = \frac{\underline{V}_o - \underline{V}_s}{\underline{Z}_1} - \frac{\underline{V}_s}{R_2} \Rightarrow \underline{V}_o = \left(1 + \frac{\underline{Z}_1}{R_2}\right)\underline{V}_s$$

so $Z_1 = \frac{R_1}{1 + j\omega R_1 C}$

$$\text{so } \underline{G}_V = \frac{\underline{V}_o}{\underline{V}_s} = \frac{R_2 + R_1/(1 + j\omega R_1 C)}{R_2} = \frac{R_1 + R_2 + j\omega R_1 R_2 C}{R_2 + j\omega R_1 R_2 C}$$

Ck: $\omega \to 0$ (dc) : $C \to$ o.c. $\Rightarrow$ non-inverting op amp configuration ✓
$\omega \to \infty$ (high freq) : $C \to$ s.c. ; R_1 short circuited $\Rightarrow$ buffer configuration ✓

∴ All-pass filter