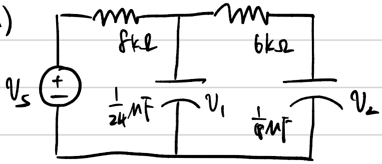
EEC HW5 2021-16988 Jaewan Park.

Exercise 12.2

(a)



$$\frac{v_1}{8} + \frac{v_1 - v_2}{6} + \frac{1}{24}\frac{dv_1}{dt} = 0$$

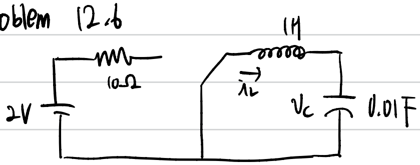
$$\frac{v_1 - v_2}{6} = \frac{1}{18}\frac{dv_2}{dt}$$

$$\Rightarrow \frac{d^2v_2}{dt^2} + 10\frac{dv_2}{dt} + 9v_2 = 0$$

$$\Rightarrow v_2 = A_1e^{-9t} + A_2e^{-t}, \quad A_1 = -\frac{3}{8}, \; A_2 = \frac{3}{8}$$

$$\therefore v_2(t) = -\frac{3}{8}e^{-9t} + \frac{3}{8}e^{-t}$$

Problem 12.6



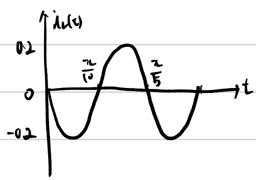
$$v_c(0-) = v_c(0+) = 2, \quad i_L(0-) = i_L(0+) = 0$$

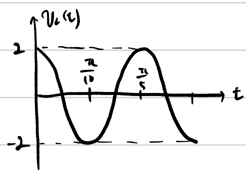
$$\Rightarrow i_L = 0.01\frac{dv_c}{dt}, \quad v_c + 1\cdot\frac{di_L}{dt} = 0$$

$$\therefore \frac{d^2i_L}{dt^2} + 100i_L = 0. \quad i_L = A_1e^{10jt} + A_2e^{-10jt}$$

$$\Rightarrow A_1 = -0.1j, \; A_2 = 0.1j$$

$$\therefore i_L(t) = -0.2\sin 10t, \quad v_c(t) = 2\cos 10t$$





Exercise 13.13

(a) Using impedance,

$$\frac{V_{OUT}}{V_{IN}} = \frac{\frac{1}{j\omega C_2}}{R + \frac{1}{j\omega C_1} + \frac{1}{j\omega C_2}} = \frac{\frac{1}{20j\omega}}{1 + \frac{1}{20j\omega} + \frac{1}{20j\omega}} = \frac{1}{2 + 20j\omega}$$

$$\therefore \text{magnitude} = \frac{1}{2\sqrt{1+100\omega^2}}$$

$$\text{phase} = \tan^{-1}(-10\omega)$$

(b) $v_o(t) = \dfrac{1}{2\sqrt{1+100w^2}} \cos(10^3 w t + \phi)$ $\quad (\tan\phi = -10w)$

Use super position

① $\cos(100t)$, $w = 100 \times 10^{-3} = 0.1$ (w : rad/s)

$\Rightarrow \phi = \tan^{-1}(-1) = -\frac{\pi}{4}$. $v_o(t) = \frac{1}{2\sqrt{2}} \cos(100t - \frac{\pi}{4})$

② $\cos(10000t)$, $w = 10000 \times 10^{-3} = 10$

$\Rightarrow \phi = \tan^{-1}(-100)$. $v_o(t) = \dfrac{1}{2\sqrt{10001}} \cos(10000t - \tan^{-1}(100))$

$\therefore v_o(t) = \dfrac{1}{2\sqrt{2}} \cos(100t - \frac{\pi}{4}) + \dfrac{1}{2\sqrt{10001}} \cos(10000t - \tan^{-1}(100))$

Problem 13.4

(a) $\dfrac{v_1}{v_0} = \dfrac{R_1 + jwL_1}{R + jwL + R_1 + jwL_1}$

(b) DC : $w = 0$

$\therefore \dfrac{R_1}{R+R_1} = \dfrac{1}{10}$. $\therefore R = 9\,k\Omega$.

(c) High Frequency : $w \to \infty$

$\therefore \dfrac{L_1}{L+L_1} = \dfrac{1}{10}$ $\therefore L = 90\ mH$

Problem 15.12

① V_{TH}

$\Rightarrow V_{TH} = R_1 \cdot g V_{TH}$.

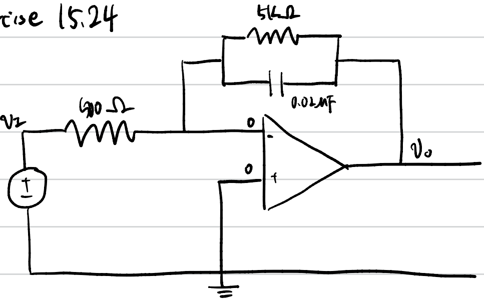
$\Rightarrow V_{TH}$ should be 0

② R_{TH}

$\Rightarrow i = gv + \dfrac{v}{R_1} = v\left(g + \dfrac{1}{R_1}\right)$

$\therefore R_{TH} = \dfrac{v}{i} = \dfrac{1}{g + \frac{1}{R_1}} = \dfrac{R_1}{1 + R_1 g}$

Exercise 15.24



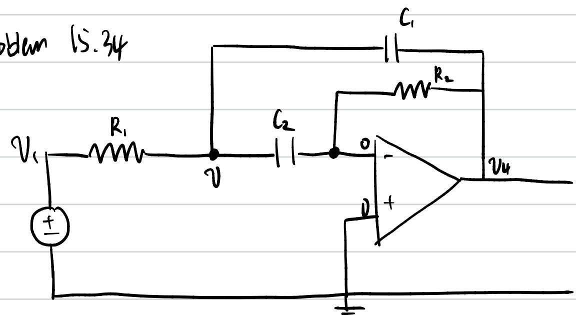
(a) $$\frac{v_I}{0.5} = \frac{0-v_o}{5} + \frac{0-v_o}{\frac{1}{j\omega\cdot 0.02}} = -\left(\frac{1}{5} + 0.02\,\omega j\right) v_o$$

$$\therefore \frac{v_o}{v_I} = -\frac{5}{0.5\,(1+0.1\,\omega j)}$$

$$\omega = 0 \rightarrow \frac{v_o}{v_I} = -10$$

(b) $$\frac{v_o}{v_I} = -\frac{10}{1+0.1\,\omega j}$$

Problem 15.34



(a) $$\frac{V_1 - v}{R_1} = \frac{v - v_4}{\frac{1}{j\omega C_1}} + \frac{v}{\frac{1}{j\omega C_2}}$$

$$\frac{v}{\frac{1}{j\omega C_2}} = \frac{-v_4}{R_2}$$

$$\Rightarrow \frac{v_4}{V_1} = -\frac{1}{\frac{R_1(C_1+C_2)}{R_2 C_2} + j\left(R_1 C_1 \omega - \frac{1}{\omega R_2 C_2}\right)}$$

(c) $$\left|\frac{v_4}{v_1}\right| = \frac{1}{\sqrt{\left(\frac{R_1(C_1+C_2)}{R_2C_2}\right)^2 + \left(\omega R_1C_1 - \frac{1}{\omega R_2C_2}\right)^2}}$$

$\omega \to 0: \left|\frac{v_4}{v_1}\right| \to 0$, $\omega \to \infty: \left|\frac{v_4}{v_1}\right| \to 0$ ∴ Band Pass Filter.

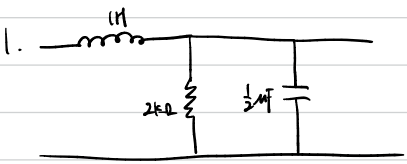
∴ Bandwidth

$$\Rightarrow \omega R_1C_1 - \frac{1}{\omega R_2C_2} = \pm \frac{R_1(C_1+C_2)}{R_2C_2}$$

$$\omega^2 \pm \frac{C_1+C_2}{R_2C_1C_2}\omega - \frac{1}{R_1R_2C_1C_2} = 0$$

$$\Rightarrow \therefore |\omega_2-\omega_1| = \frac{C_1+C_2}{R_2C_1C_2}$$

1.



(a) $$Z(j\omega) = j\omega\cdot 1 + 2 \,//\, \frac{1}{j\omega\cdot\frac{1}{2}}$$

$$= \frac{2}{1+\omega^2} + \left(\omega - \frac{2\omega}{1+\omega^2}\right)j$$

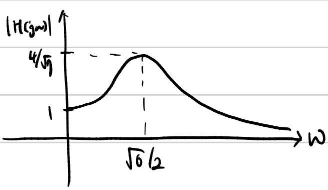
$$\therefore \omega - \frac{2\omega}{1+\omega^2} = 0, \quad \omega = 1$$

(b) $$H(j\omega) = \frac{2 \,//\, \frac{1}{j\omega\cdot\frac{1}{2}}}{Z(j\omega)} = \frac{2}{(2-\omega^2)+j\omega}$$

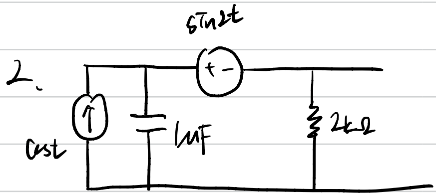
$$\therefore |H(j\omega)| = \frac{2}{\sqrt{(2-\omega^2)^2+\omega^2}}$$

$\omega \to 0: |H(j\omega)| \to 1$ max: $\omega = \frac{\sqrt{6}}{2}$, $|H(j\omega)| = \frac{4}{\sqrt{7}}$

$\omega \to \infty: |H(j\omega)| \to 0$



2.



Use superposition

① $\cos t \leftarrow e^{jt}$ $(\omega=1)$

$$|H(j\omega)| = \left(\frac{1}{j} \,//\, 2\right)\cdot 1 = \frac{2}{1+j2}$$

$$\therefore V_o(t) = \frac{2}{\sqrt{5}}\cos(t-\theta_1), \quad \tan\theta_1 = 2$$

② $\sin 2t \leftarrow -j\cdot e^{2jt}$ $(\omega=2)$

$$|H(j\omega)| = \frac{2}{2+\frac{1}{2j}}\cdot j = \frac{4}{-1-4j}$$

$$\therefore V_o(t) = \frac{4}{\sqrt{17}}\cos(2t-\theta_2), \quad \tan\theta_2 = 4$$

$$\therefore V_o(t) = \frac{2}{\sqrt{5}}\cos(t-\theta_1) + \frac{4}{\sqrt{17}}\cos(2t-\theta_2)$$