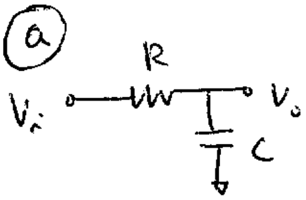
2000년 1학기 계측회로 II 중간고사

1. ⓐ

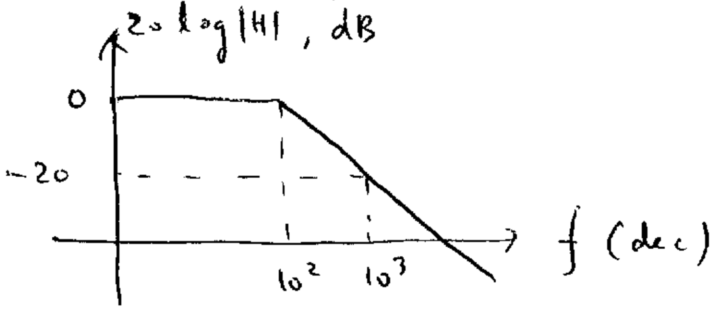


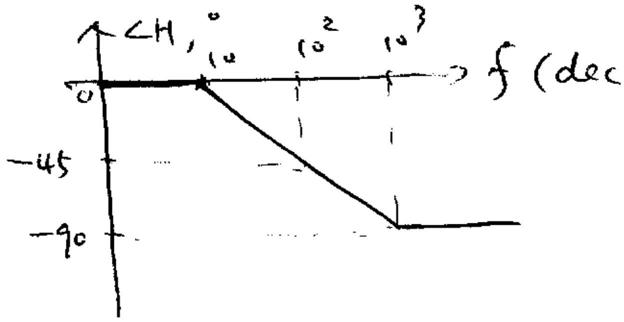
$$V_o = \frac{\frac{1}{sC}}{R + \frac{1}{sC}} V_i = \frac{1}{1 + sRC} V_i$$

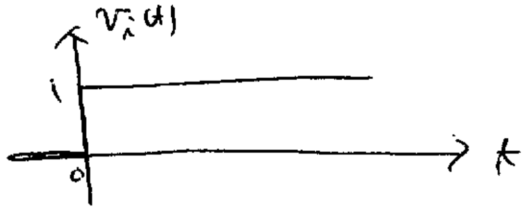
$$H(s) = \frac{V_o}{V_i} = \frac{1}{1 + sRC}$$

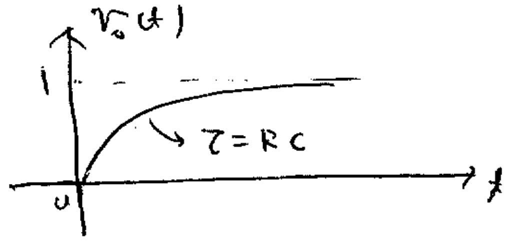
$$H(j\omega) = \frac{1}{1 + j\omega RC} = \frac{1}{1 + j\omega/\omega_o}$$

$$\omega_o = \frac{1}{RC}, \quad f_o = \frac{1}{2\pi RC} \doteqdot 100\ Hz$$



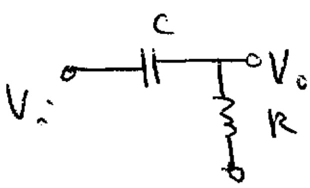






$$\text{at } f = f_o, \quad \angle H = \angle\left(\frac{1}{1+j}\right) = -45^\circ$$

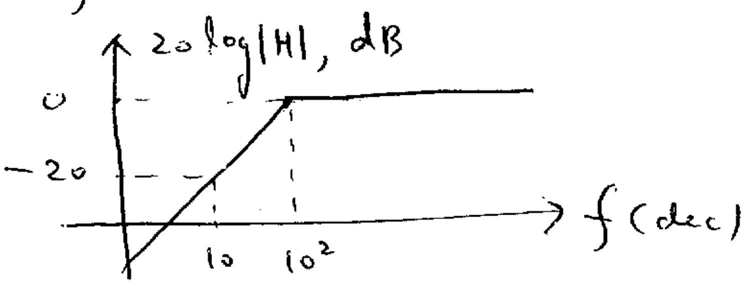
ⓑ

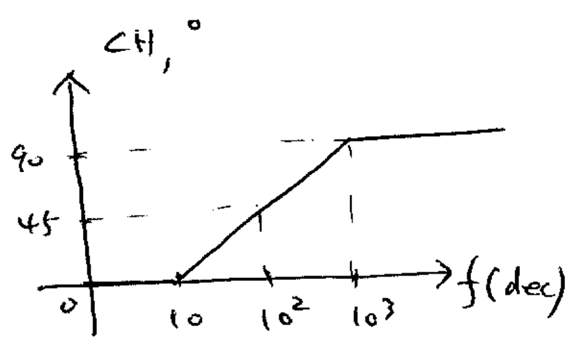


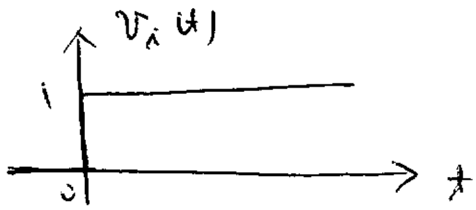
$$V_o = \frac{R}{\frac{1}{sC} + R} V_i = \frac{sRC}{1 + sRC} V_i$$

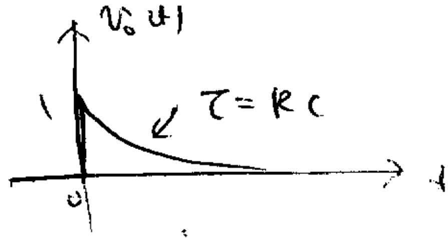
$$H(j\omega) = \frac{j\omega RC}{1 + j\omega RC} = \frac{j\omega/\omega_o}{1 + j\omega/\omega_o}, \quad \omega_o = \frac{1}{RC},$$

$$f_o = \frac{1}{2\pi RC} \doteqdot 100\ Hz$$



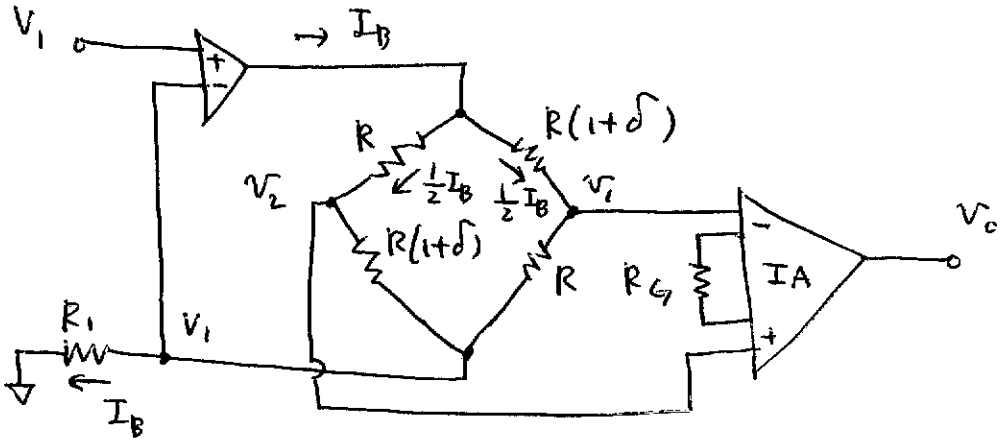






at $f = f_0$, $\angle H = \angle\left(\frac{j}{1+j}\right) = 45^\circ$.

2.



$$\delta = \alpha \Delta T = 0.00392\, \Delta T$$

$P_{RTD} = \left(\frac{1}{2} I_B\right)^2 R = \frac{R}{4} I_B^2 = 0.2 \times 10^{-3}$ 에서

$R = 100\,\Omega$ 이므로 $I_B = 2.83\ mA$.

따라서, $I_B = 2.5\ mA$ 로 선택. 그러면, $I_B = \frac{V_1}{R_1}$ 에서

$V_1 = 5\ V$, $R_1 = 2\ k\Omega$ 으로 선택.

$$v_2 = V_1 + R(1+\delta)\frac{1}{2} I_B, \quad v_1 = V_1 + R\frac{1}{2} I_B$$

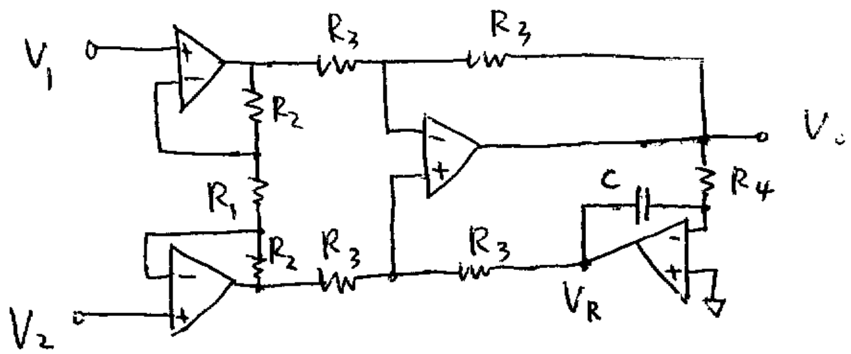
$$V_o = A_{DM}(v_2 - v_1) = A_{DM} R \delta \frac{1}{2} I_B$$

$$= A_{DM} \times 100 \times 0.00392\, \Delta T \times \frac{1}{2} \times 2.5 \times 10^{-3}$$

$V_o / \Delta T = 0.1$ 에서 $A_{DM} = 204.08$

$A_{DM} = \frac{49400}{R_G} + 1$ 에서 $R_G = 243.3\,\Omega$.

3.



$$V_R = -\frac{\frac{1}{sC}}{R_4} V_o = -\frac{1}{sR_4C} V_o$$

중첩의 원리에 의해

① $V_R = 0$ 일 때, $V_o = \left(1 + 2\frac{R_2}{R_1}\right)(V_2 - V_1)$

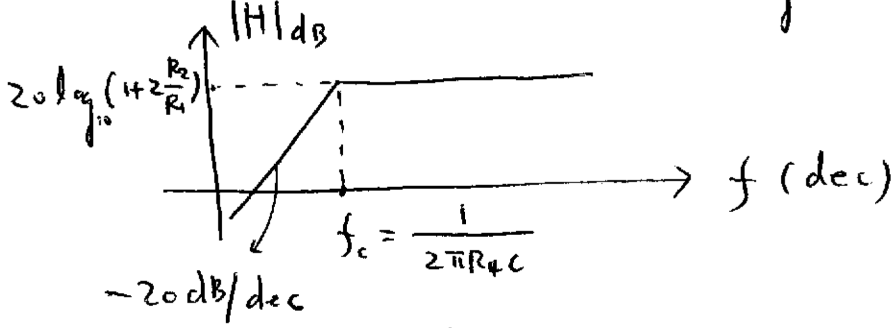
② $V_2 = V_1 = 0$ 일 때, $V_o = \frac{1}{2} V_R \times 2 = V_R$

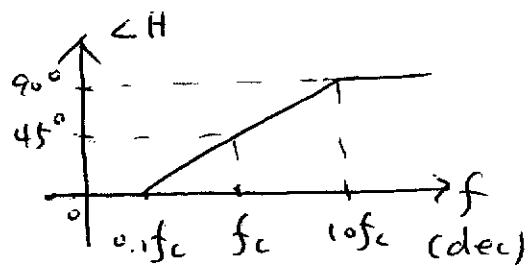
$$V_o = \left(1 + 2\frac{R_2}{R_1}\right)(V_2 - V_1) - \frac{1}{sR_4C} V_o$$

$$\frac{1 + sR_4C}{sR_4C} V_o = \left(1 + 2\frac{R_2}{R_1}\right)(V_2 - V_1)$$

$$H(s) = \frac{V_o}{V_2 - V_1} = \left(1 + 2\frac{R_2}{R_1}\right)\frac{sR_4C}{1 + sR_4C}$$

$$H(j\omega) = \left(1 + 2\frac{R_2}{R_1}\right)\frac{j\omega R_4 C}{1 + j\omega R_4 C}$$





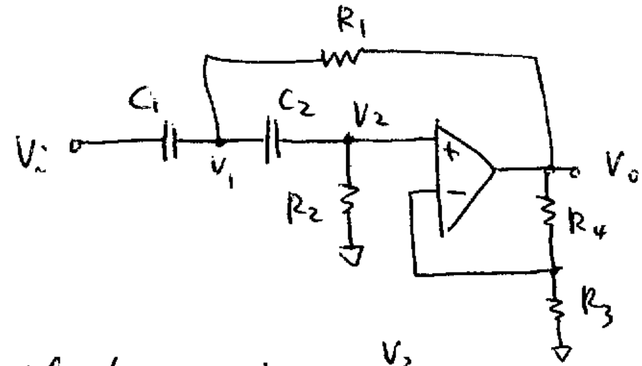
$A_{DM} = 1 + 2\frac{R_2}{R_1} = 100$ 에서 $R_2 = 49.5\,k\Omega$, $R_1 = 1\,k\Omega$

$f_c = \frac{1}{2\pi R_4 C} = 0.5$ 에서 $C = 1\,\mu F$, $R_4 = 318.3\,k\Omega$

$R_3 = 10\,k\Omega$ 이용

A_{CM}의 측정 : v_1과 v_2 모두에 $5\,V_{pp}$, $60\,Hz$ 정현파를 입력하고, V_o의 $60\,Hz$ 성분 정현파의 p-p 전압을 측정한다. 그러면, $A_{CM} = \dfrac{V_{o,pp}}{5}$ 이다.

4.



$$K = 1 + \frac{R_4}{R_3}$$

$$V_2 = \frac{V_o}{K}$$

$$sC_2(V_1 - V_2) = \frac{V_2}{R_2} \Longrightarrow sC_2R_2V_1 = (1 + sC_2R_2)V_2$$

$$V_1 = \frac{1 + sC_2R_2}{sC_2R_2} \cdot \frac{V_o}{K}$$

$$sC_1(V_i - V_1) = sC_2(V_1 - V_2) + \frac{V_1 - V_o}{R_1}$$

$$sC_1R_1V_i = (sC_1R_1 + sC_2R_1 + 1)V_1 - sC_2R_1V_2 - V_o$$

$$= \frac{[s(C_1R_1 + C_2R_1) + 1](sC_2R_2 + 1)}{sC_2R_2} \cdot \frac{V_o}{K} - sC_2R_1\frac{V_o}{K} - V_o$$

$$= \frac{V_o}{K} \cdot \frac{s^2C_1C_2R_1R_2 + s[(1-K)C_2R_2 + C_1R_1 + C_2R_1] + 1}{sC_2R_2}$$

$$H(s) = \frac{V_o}{V_i} = K\frac{s^2C_1C_2R_1R_2}{1 + s[(1-K)C_2R_2 + C_1R_1 + C_2R_1] + s^2C_1C_2R_1R_2}$$

$$H(j\omega) = K\frac{-\omega^2C_1C_2R_1R_2}{1 + j\omega[(1-K)C_2R_2 + C_1R_1 + C_2R_1] - \omega^2C_1C_2R_1R_2}$$

표준형 $H(j\omega)$와 비교하면,

$$\omega_o = \frac{1}{\sqrt{C_1C_2R_1R_2}}, \qquad H_{oHP} = K = 1 + \frac{R_4}{R_3}$$

$$Q = \frac{1}{(1-K)\sqrt{R_2C_2/R_1C_1} + \sqrt{R_1C_2/R_2C_1} + \sqrt{R_1C_1/R_2C_2}}$$

Equal component design 에 따르면,

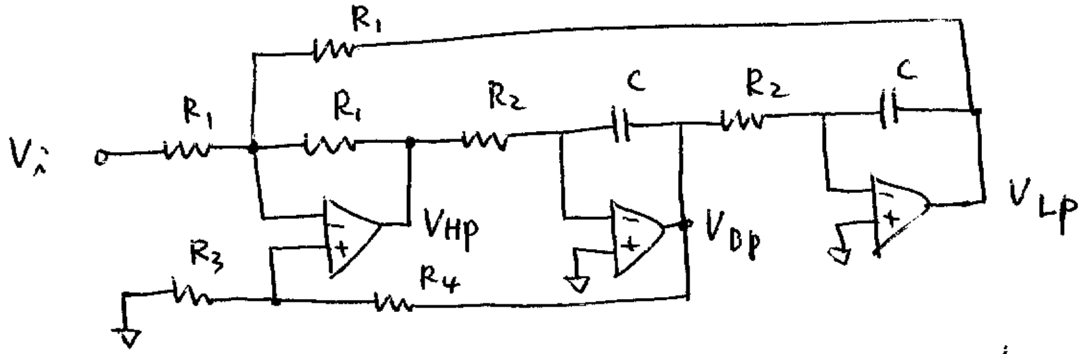
$C_1 = C_2 = C$, $R_1 = R_2 = R$

$$f_0 = \frac{1}{2\pi RC} = 100 \quad , \quad Q = \frac{1}{3-K} = 0.707$$

$$RC = \frac{1}{200\pi} \quad , \quad K = 1 + \frac{R_4}{R_3} = 1.5856$$

$C = 100nF$, $R = 16k\Omega$, $R_3 = 1k\Omega$, $R_4 = 585.6\Omega$

5.



$$V_{BP} = -\frac{1}{sR_2C} V_{HP} \quad , \quad V_{LP} = -\frac{1}{sR_2C} V_{BP}$$

$$V_{HP} = -V_i - V_{LP} + (1+2)\frac{R_3}{R_3+R_4} V_{BP}$$

$$= -V_i - V_{LP} + \frac{3}{1+\frac{R_4}{R_3}} V_{BP}$$

$$K = \frac{3}{1+\frac{R_4}{R_3}}$$ 라 놓음.

① $$V_i = K V_{BP} + \frac{1}{sR_2C} V_{BP} + sR_2C V_{BP}$$

$$= \frac{1 + sKR_2C + s^2R_2^2C^2}{sR_2C} V_{BP}$$

$$H_{BP}(j\omega) = \frac{j\omega R_2C}{1 + j\omega KR_2C - \omega^2R_2^2C^2}$$ 에서

$$\omega_0 = \frac{1}{R_2C} \quad , \quad Q = \frac{1}{K} = \frac{1}{3}\left(1+\frac{R_4}{R_3}\right) \quad , \quad H_{0BP} = Q$$

② $V_i = -K s R_2 C V_{LP} - V_{LP} - s^2 R_2^2 C^2 V_{LP}$

$= -\left[s K R_2 C + 1 + s^2 R_2^2 C^2 \right] V_{LP}$

$$H_{LP}(j\omega) = \frac{-1}{1 + j\omega K R_2 C - \omega^2 R_2^2 C^2}$$

$\omega_0 = \frac{1}{R_2 C}$, $Q = \frac{1}{3}\left(1 + \frac{R_4}{R_3}\right)$, $H_{0LP} = -1$

③ $V_i = -K \frac{1}{s R_2 C} V_{HP} - \frac{1}{s^2 R_2^2 C^2} V_{HP} - V_{HP}$

$= -\frac{1 + s K R_2 C + s^2 R_2^2 C^2}{s^2 R_2^2 C^2} V_{HP}$

$$H_{HP}(j\omega) = \frac{-\omega^2 R_2^2 C^2}{1 + j\omega K R_2 C - \omega^2 R_2^2 C^2}$$

$\omega_0 = \frac{1}{R_2 C}$, $Q = \frac{1}{3}\left(1 + \frac{R_4}{R_3}\right)$, $H_{0HP} = -1$

④ BPF 설계

$f_0 = \frac{1}{2\pi R_2 C} = 10^4 \Rightarrow R_2 C = 1.592 \times 10^{-5}$

$Q = \frac{f_0}{BW} = 100 = \frac{1}{3}\left(1 + \frac{R_4}{R_3}\right) \Rightarrow \frac{R_4}{R_3} = 299$

$C = 10nF$, $R_2 = 1.592k\Omega$, $R_3 = 1k\Omega$

$R_4 = 299k\Omega$, $R_1 = 10k\Omega$