

4 장 $\frac{1}{s}$ 제 $\frac{1}{s}$ 제 $\frac{1}{s}$ 제

4-6 (a) $H(s) = \frac{1}{(s^2 + s\sqrt{2-\sqrt{2}} + 1)(s^2 + s\sqrt{2+\sqrt{2}} + 1)}$

$H(j\omega) = \frac{1}{(1 - \omega^2 + j\omega\sqrt{2-\sqrt{2}})(1 - \omega^2 + j\omega\sqrt{2+\sqrt{2}})}$

$|H(j\omega)| = \frac{1}{\left[\left\{ (1 - \omega^2) + \omega^2(2 - \sqrt{2}) \right\} \left\{ (1 - \omega^2)^2 + \omega^2(2 + \sqrt{2}) \right\} \right]^{1/2}}$

$= \frac{1}{\left[(\omega^4 - \sqrt{2}\omega^2 + 1)(\omega^4 + \sqrt{2}\omega^2 + 1) \right]^{1/2}}$

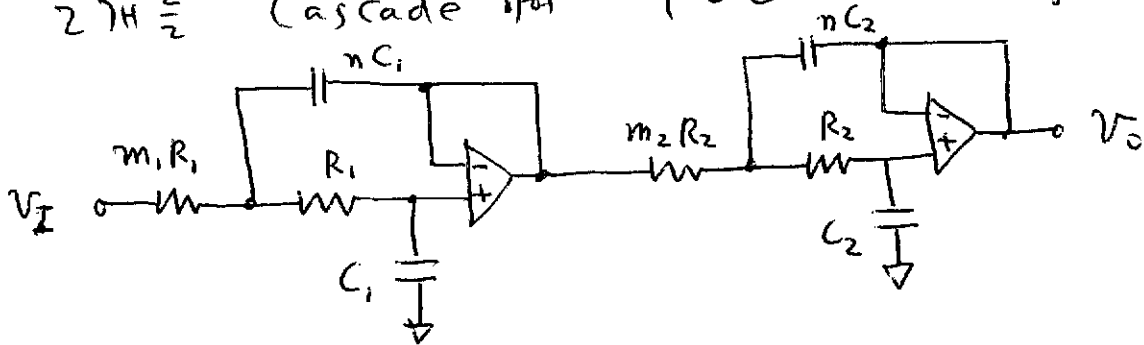
$= \frac{1}{\sqrt{1 + \omega^8}}$

(b) 4 장 Butterworth LPF, $f_c = 880 \text{ Hz}$, $H_0 = 0 \text{ dB}$

Table 11.1 $\left\{ \begin{array}{l} f_{01} = 1, \theta_1 = 0.541 \\ f_{02} = 1, \theta_2 = 1.306 \end{array} \right\}$ 이므로 $\frac{1}{s}$ $\frac{1}{s}$

$f_{01} = 880 \text{ Hz}, \theta_1 = 0.541$ } 이 KRC 2 장 LPF
 $f_{02} = 880 \text{ Hz}, \theta_2 = 1.306$

2 장 Cascade 이다. $\frac{1}{s}$ $\frac{1}{s}$ Unity gain 설계하면



$$\omega_0 = \frac{1}{\sqrt{m_1 n_1 R_1 C_1}} = \frac{1}{\sqrt{m_2 n_2 R_2 C_2}} = 2\pi \times f_{co}$$

$$\theta_1 = \frac{\sqrt{m_1 n_1}}{m_1 + 1} = 0.541$$

$$\theta_2 = \frac{\sqrt{m_2 n_2}}{m_2 + 1} = 1.306$$

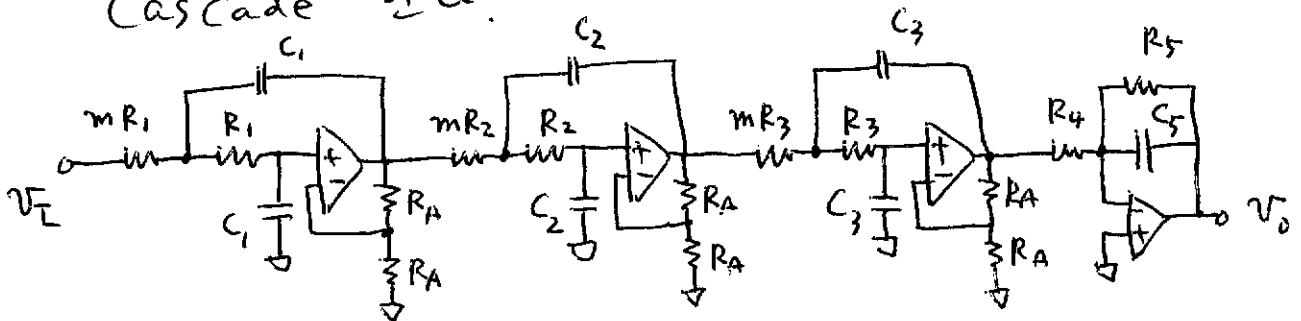
위의 관계식은 $\frac{1}{T}$ 이 m_1, n_1, m_2, n_2 의
 R_1, C_1, R_2, C_2 의 $\frac{R}{C}$ = $\frac{1}{\omega}$ 결정한다.

4-10 7차 Butterworth LPF, $f_c = 1 \text{ kHz}$, $H_0 = 20 \text{ dB}$
 (KRC filter $n=1$ 이고 $R_A = R_B$)

Table $n=1$

$$\left\{ \begin{array}{l} f_{01} = 1, \quad \theta_1 = 0.555 \\ f_{02} = 1, \quad \theta_2 = 0.802 \\ f_{03} = 1, \quad \theta_3 = 2.247 \\ f_{04} = 1 \end{array} \right.$$

2차 KRC filter 3단과 1차 LPF 1단 $\frac{2}{2}$
 Cascade 한다.



$$f_{01} = f_{02} = f_{03} = f_{04} = 1 \text{ kHz}$$

(i) $\frac{1}{s}$ 가 2 차 KRC LPF 단의 설계

$$R_B = R_A \text{ 이므로 } |K| = 1 + \frac{R_A}{R_B} = 2 = H_0$$

$$\frac{1}{s} \text{ (3.60b) 에서 } \omega_0 = \frac{1}{\sqrt{R_i C_i m R_i C_i}} = \frac{1}{\sqrt{m R_i C_i}} \quad \text{--- (1)}$$

($i = 1, 2, 3$)

$\frac{1}{s}$ (3.60c) 에서

$$Q = \frac{1}{(1-K) \sqrt{R_i C_i / m R_i C_i} + \sqrt{R_i C_i / m R_i C_i} + \sqrt{m R_i C_i / R_i C_i}}$$

$$= \sqrt{m} \quad \text{--- (2)}$$

①과 ② 식에서 $\frac{1}{s}$ 가 2 차 KRC LPF 단의 m_i, R_i, C_i 를 결정한다.

(ii) 1 차 LPF 단의 설계

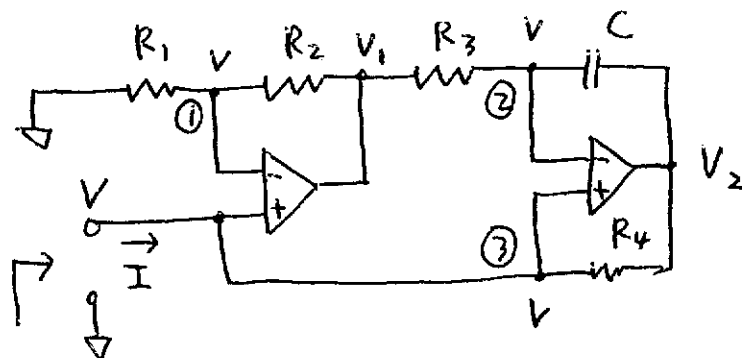
1 차 LPF 단의 $\frac{R_5}{R_4}$ 대역 이득은 $-\frac{R_5}{R_4}$ 이다.

$$\text{따라서, } \frac{R_5}{R_4} \times 2 \times 2 \times 2 = 10 \quad \frac{R_5}{R_4} = 1.25 \quad \text{--- (3)}$$

$$f_{04} = \frac{1}{2\pi R_5 C_5} = 1000 \quad \text{--- (4)}$$

③과 ④에서 R_4, R_5, C_5 를 결정한다.

4-18



$$\text{KCL ① 에서 } \frac{V}{R_1} = \frac{V_1 - V}{R_2} \Rightarrow V_1 = \left(1 + \frac{R_2}{R_1}\right) V \quad \text{--- (a)}$$

$$\text{KCL ② 에서 } \frac{V - V_1}{R_3} = j\omega C (V_2 - V) \quad \text{--- (b)}$$

$$\text{KCL ③ 에서 } I = \frac{V - V_2}{R_4} \Rightarrow V_2 = V - R_4 I \quad \text{--- (c)}$$

$$\text{(b) 식에서 } V - V_1 = j\omega R_3 C (V_2 - V)$$

(a) 식의 V_1 을 대입하면,

$$- \frac{R_2}{R_1} V = j\omega R_3 C V_2 - j\omega R_3 C V$$

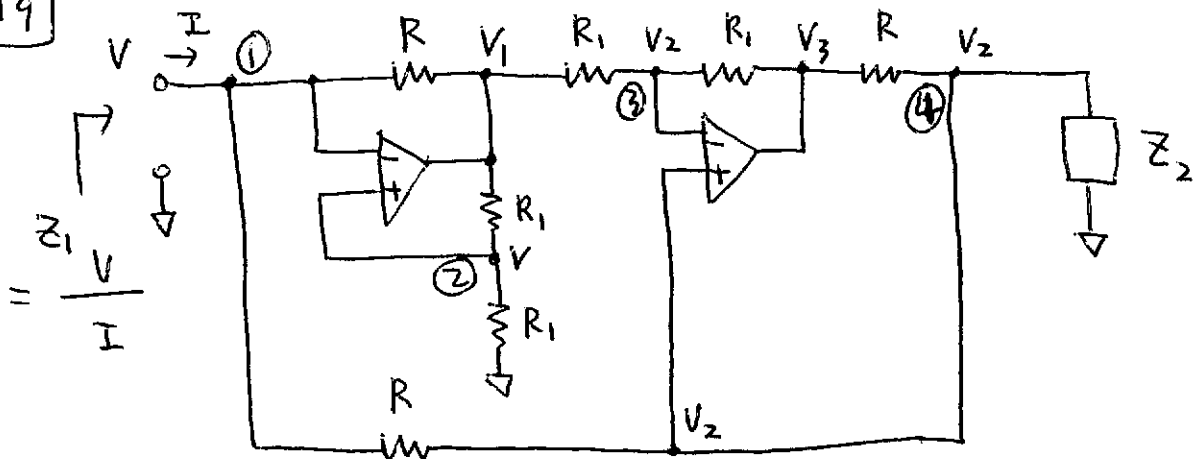
(c) 식의 V_2 을 대입하면,

$$- \frac{R_2}{R_1} V = j\omega R_3 C V - j\omega R_3 R_4 C I - j\omega R_3 C V$$

$$V = j\omega \frac{R_1 R_3 R_4}{R_2} C I$$

$$\therefore C_{eq} = \frac{R_1 R_3 R_4}{R_2} C$$

4-19



$$\text{KCL ① 에서 } I = \frac{V - V_2}{R} + \frac{V - V_1}{R}$$

$$\text{KCL ② 에서 } \frac{V_1 - V}{R_1} = \frac{V}{R_1} \Rightarrow V_1 = 2V$$

$$\text{LC ③ 时} \quad \frac{V_1 - V_2}{R_1} = \frac{V_2 - V_3}{R_1} \Rightarrow V_1 = 2V_2 - V_3$$

$$\text{LC ④ 时} \quad \frac{V_3 - V_2}{R} + \frac{V - V_2}{R} = \frac{V_2}{Z_2}$$

$$IR = 2V - V_2 - V_1 = -V_2 \quad (\because V_1 = 2V)$$

$$V_3 + V - 2V_2 = \frac{R}{Z_2} V_2 \quad \text{时}$$

$$V_3 + V = -\left(\frac{R}{Z_2} + 2\right) IR$$

$$2V = -2IR - V_3 \quad \text{时} \quad V_3 = -2(IR + V)$$

$$-2IR - 2V + V = -\left(\frac{R}{Z_2} + 2\right) IR \quad \text{时}$$

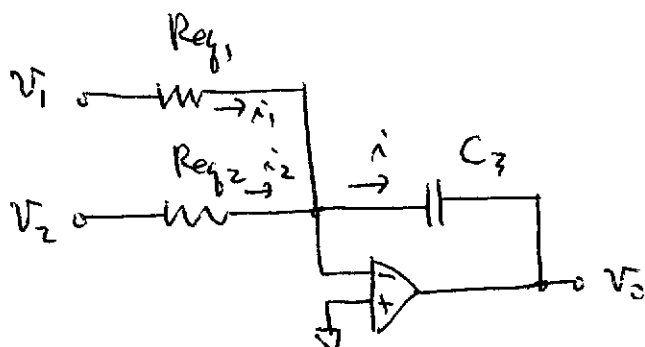
$$2IR + V = \left(\frac{R}{Z_2} + 2\right) IR$$

$$V = \frac{R}{Z_2} IR = \frac{R^2}{Z_2} I$$

$$\therefore Z_1 = \frac{V}{I} = \frac{R^2}{Z_2}$$

4-22

$$(a) \quad \text{Req}_1 = \frac{1}{C_1 f_{ck}}, \quad \text{Req}_2 = \frac{1}{C_2 f_{ck}}$$



$$\dot{i} = \dot{i}_1 + \dot{i}_2 = \frac{V_1}{\text{Req}_1} + \frac{V_2}{\text{Req}_2} = C_1 f_{ck} V_1 + C_2 f_{ck} V_2$$

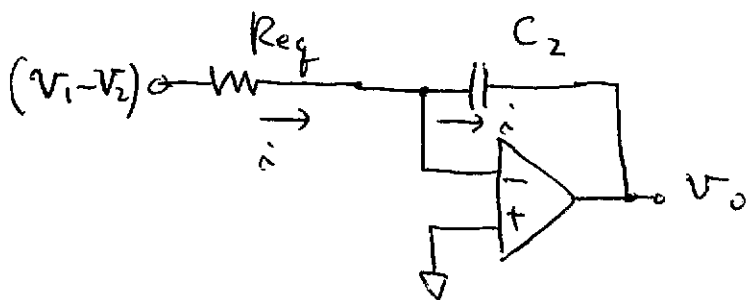
$$v_o = -\frac{1}{C_3} \int i \, dt$$

$$= -\frac{f_{ck}}{C_3} \int [C_1 v_1 + C_2 v_2] \, dt$$

⇒ Adding integrator

(b)

$$R_{eq} = \frac{1}{C_1 f_{ck}}$$



$$i = \frac{v_1 - v_2}{R_{eq}} = C_1 f_{ck} (v_1 - v_2)$$

$$v_o = -\frac{1}{C_2} \int i \, dt$$

$$= -\frac{C_1}{C_2} f_{ck} \int [v_1 - v_2] \, dt$$

⇒ Differential integrator