《Fundamentals of Electric Circuits》 homework CH.14

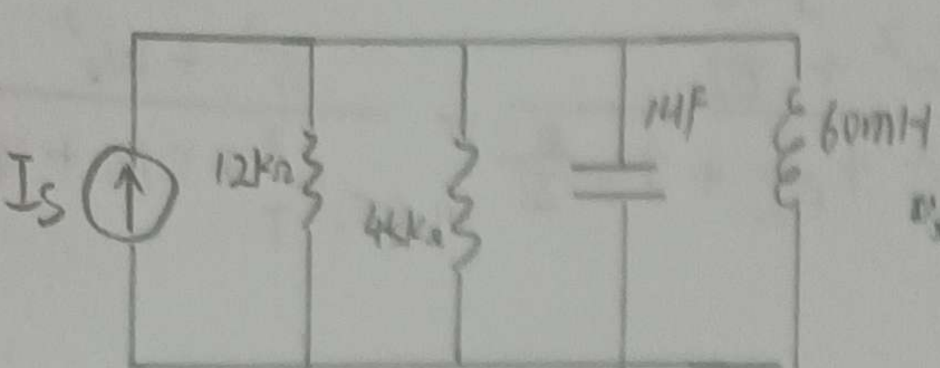
$w = a$

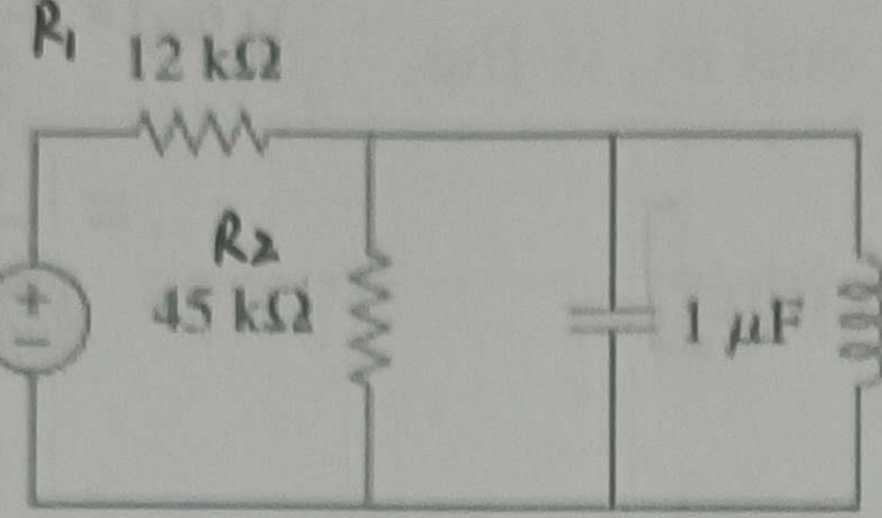
14.29 Let $v_s = 20\cos(at)$ V in the circuit of Fig. 14.77. Find w_o, Q, and B, as seen by the capacitor. (10')

解: $w_0 = \frac{1}{\sqrt{LC}} = \frac{1}{\sqrt{60\times10^{-3}\times1\times10^{-6}}} = 4082$ rad/s

$Q = \frac{R}{w_0 L} = \frac{12\|45\times10^{3}}{4082\times60\times10^{-3}} = 38.68$

$B = \frac{w_0}{Q} = \frac{4082}{38.68} = 105.5$ rad/s





$I_s = \frac{20\cos at}{12000}$ A

Figure 14.77

14.34 A parallel RLC circuit is resonant at 5.6 MHz, has a Q of 80, and has a resistive branch of 40 kΩ. Determine the values of L and C in the other two branches. (10')

解: $w_0 = 2\pi\times5.6\times10^6 = 3.519\times10^7$ rad/s $L = \frac{R}{Qw_0} = \frac{40\times10^3}{80\times3.519\times10^7} = 1.42\times10^{-5}$ H, $C = \frac{Q}{w_0R} = \frac{80}{3.519\times10^7\times40} = 5.6834\times10^{-8}$ F

14.42 For the circuits in Fig.14.81, find the resonant frequency w_o, the quality factor Q, and the bandwidth B. (10')

解: a) $w_0 = \frac{1}{\sqrt{LC}} = \frac{1}{\sqrt{1\times0.4}} = 1.581$ rad/s

$Q = \frac{w_0 L}{R} = \frac{1.581\times1}{8} = 0.1976$

$B = \frac{R}{L} = \frac{8}{1} = 8$ rad/s

b) $C = \frac{18}{3+6} = 2\mu F$

$w_0 = \frac{1}{\sqrt{LC}} = \frac{1}{\sqrt{20\times10^{-3}\times2\times10^{-6}}} = 5000$ rad/s

$Q = w_0RC = 5000\times2000\times2\times10^{-6} = 20$

$B = \frac{1}{RC} = \frac{1}{2000\times2\times10^{-6}} = 250$ rad/s

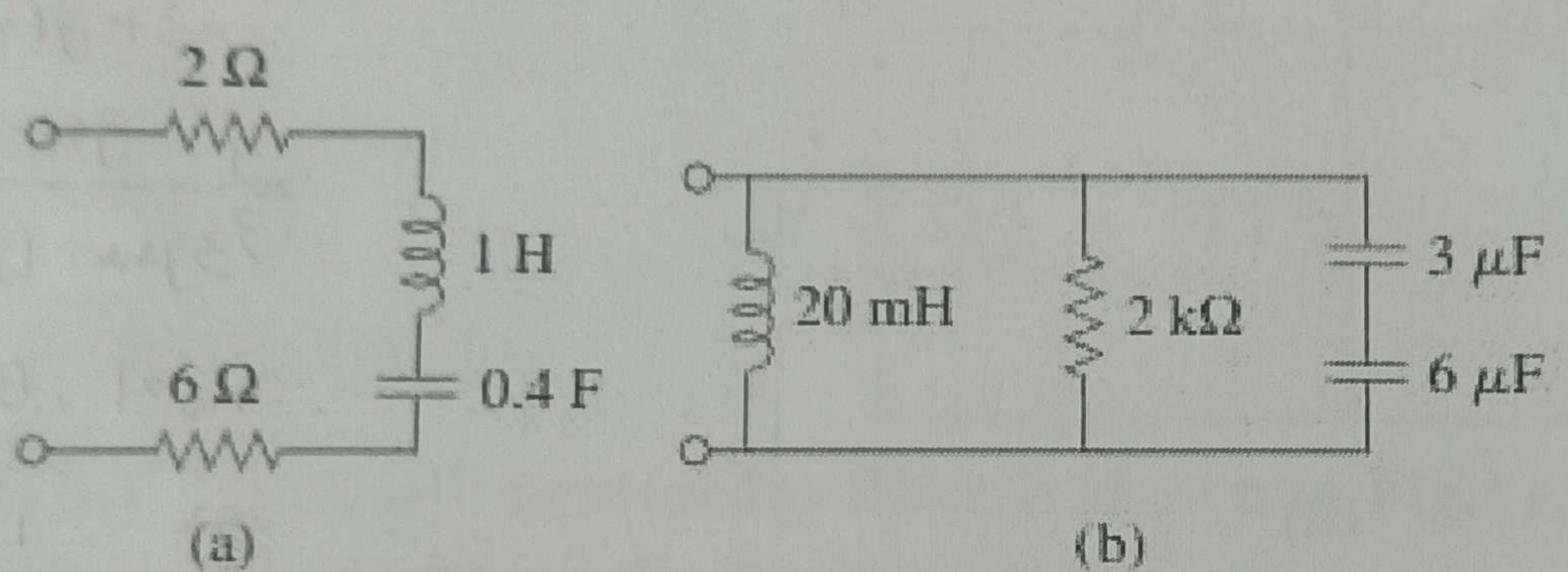


Figure 14.81

14.46 For the network illustrated in Fig. 14.85, find
(a) the transfer function $H(w) = V_o(w)/I(w)$,
(b) the magnitude of H at $w_o = 1$ rad/s. (10')

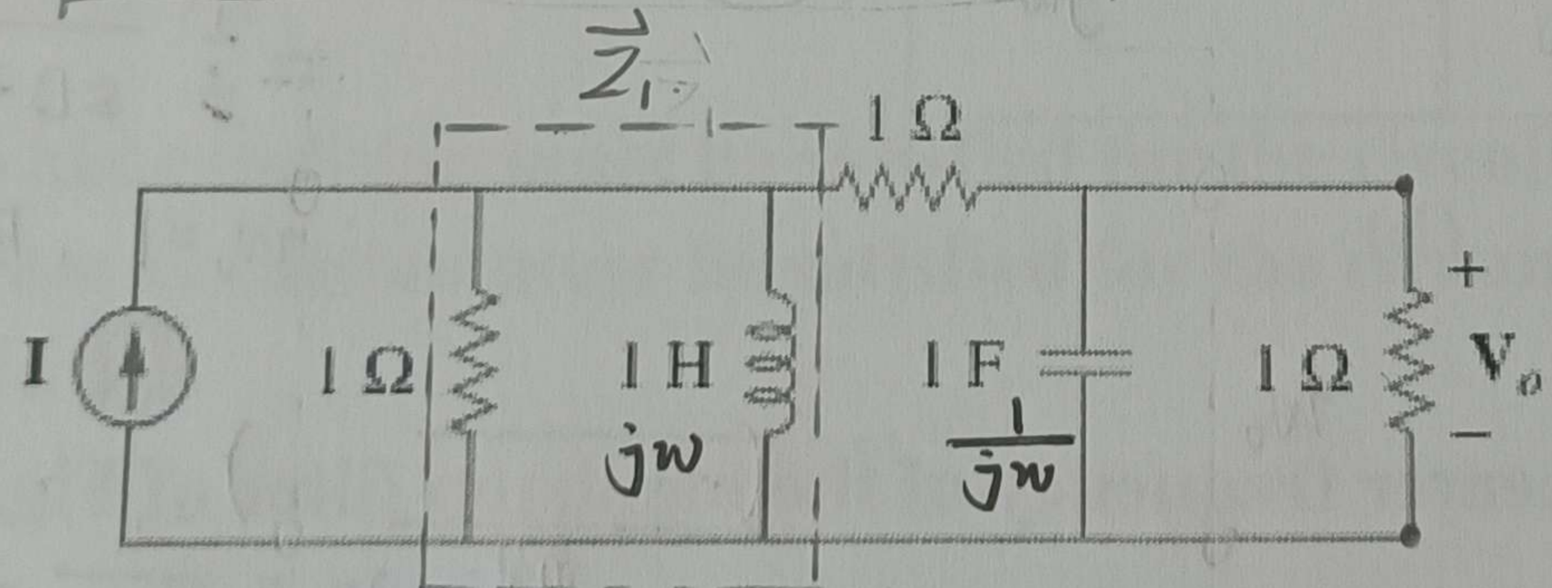
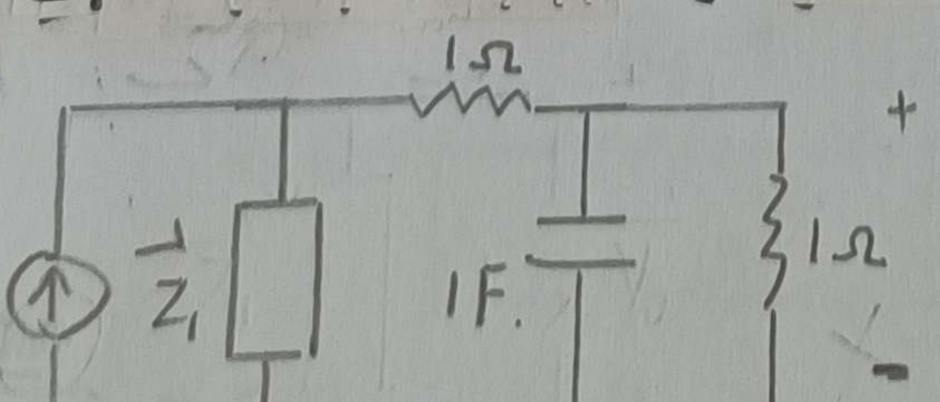


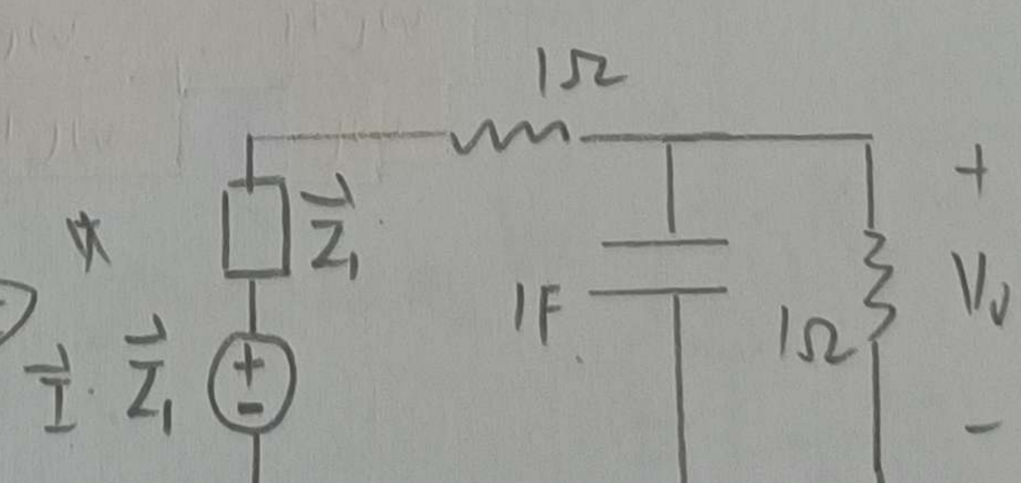
Figure 14.85

14.56

14.46 解: a) $\vec Z_1 = 1\|jw = \frac{jw}{1+jw}$



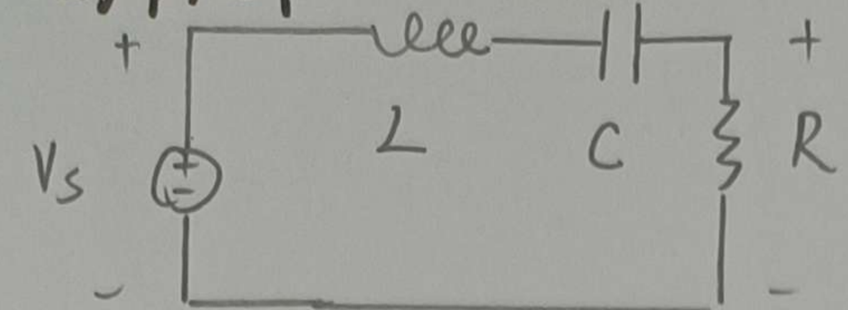
$\Rightarrow$



$\frac{\vec I\cdot\vec Z_1}{\vec Z_1 + 1 + \frac{1}{jw}\|1}\cdot\left(\frac{1}{jw}\|1\right) = \vec V_0 \Rightarrow \vec H(w) = \frac{\vec V_0(w)}{\vec I(w)} = \frac{\vec Z_1\cdot\left(\frac{1}{jw}\|1\right)}{\vec Z_1+1+\frac{1}{jw}\|1} = \frac{jw}{2(1+jw)^2}$

b) $\vec H(w_0) = \frac{j}{2(1+j)^2} = \frac{j}{2[1+(-1)+2j]} = 0.25$

14.56 解: a) proof



$\vec{V_o} = \vec{V_s} \cdot \frac{R}{j\omega L + \frac{1}{j\omega C} + R}$ $\omega_0 = \frac{1}{\sqrt{LC}}$, $B = \frac{R}{L}$

$\vec{H}(\omega) = \frac{R}{j\omega L + \frac{1}{j\omega C} + R} = \frac{j\omega R}{-\omega^2 L + \frac{1}{C} + j\omega R} = \frac{j\omega \frac{R}{L}}{-\omega^2 + \frac{1}{CL} + j\omega\frac{R}{L}}$

$= \frac{sB}{s^2 + sB + \omega_0^2}$

(a) Show that for a $\boxed{\text{bandpass filter}}$

$$\mathbf{H}(s) = \frac{sB}{s^2 + sB + \omega_0^2}, \qquad s = j\omega$$

where B = bandwidth of the filter and ω_0 is the center frequency.

b) proof:

$\vec{H}(\omega) = \frac{j\omega L + \frac{1}{j\omega C}}{j\omega L + \frac{1}{j\omega C} + R} = \frac{-\omega^2 L + \frac{1}{C}}{-\omega^2 L + \frac{1}{C} + j\omega R}$

$= \frac{-\omega^2 + \frac{1}{CL}}{-\omega^2 + \frac{1}{CL} + j\omega\frac{R}{L}} = \frac{s^2 + \omega_0^2}{s^2 + sB + \omega_0^2}$

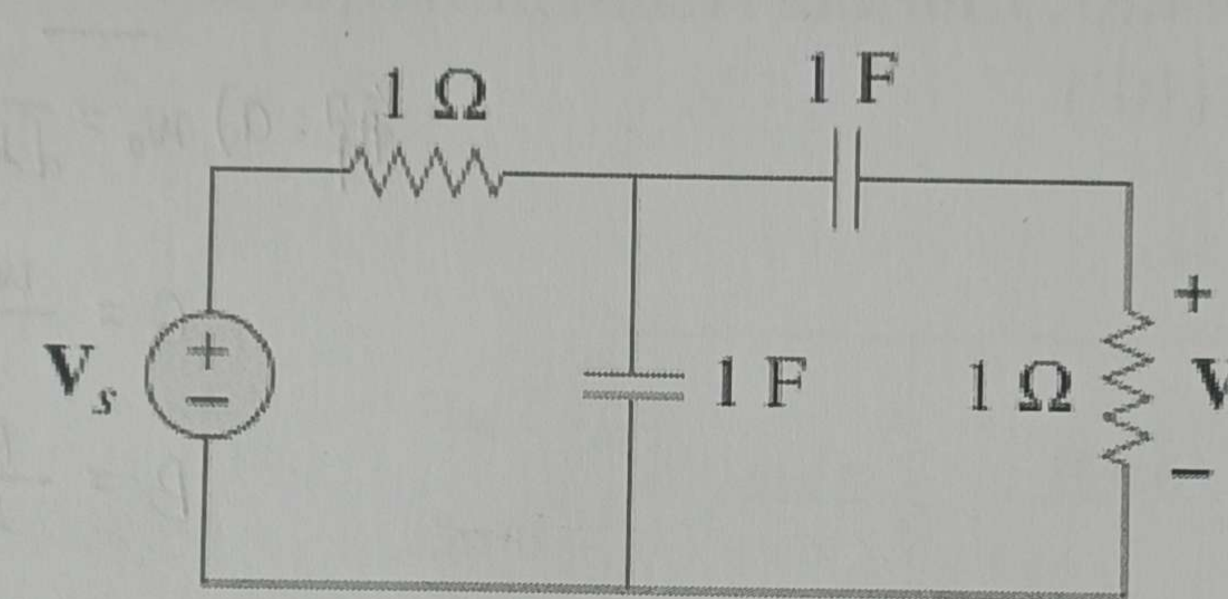
(b) Similarly, show that for a $\boxed{\text{bandstop filter}}$,

$$\mathbf{H}(s) = \frac{s^2 + \omega_0^2}{s^2 + sB + \omega_0^2}, \qquad s = j\omega$$

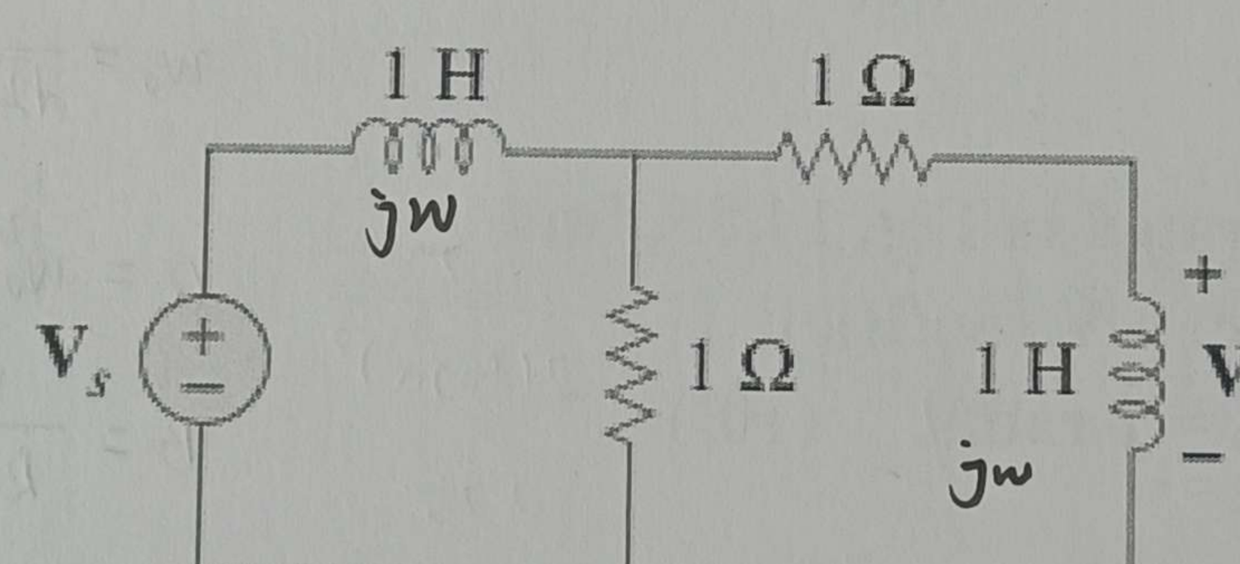
(10')

$\omega_0 = \frac{1}{\sqrt{LC}}$ 不可用.

14.57 Determine the center frequency and bandwidth of the $\boxed{\text{bandpass}}$ filters in Fig.14.88. (10')



(a)



(b)

Figure 14.88

解: a) $\vec{H}(\omega) = \frac{\vec{V_o}}{\vec{V_s}} = \frac{\frac{1}{j\omega}\|\left(\frac{1}{j\omega}+1\right) \times \left(\frac{1}{\frac{1}{j\omega}+1}\right)}{1 + \frac{1}{j\omega}\|\left(\frac{1}{j\omega}+1\right)}$

$= \frac{1}{3 + j(\omega - \frac{1}{\omega})} = \frac{1}{3 + j\omega - \frac{1}{\omega}j}$

$= \frac{1}{3}\frac{j\omega \cdot 3}{3j\omega + (j\omega)^2 + 1} = \frac{1}{3}\frac{s \cdot B}{sB + s^2 + \omega_0^2}$

$\therefore \omega_0 = 1$, $B = 3$

b) $\vec{H}(\omega) = \frac{\vec{V_o}}{\vec{V_s}} = \frac{1\|(1+j\omega) \cdot \frac{j\omega}{1+j\omega}}{j\omega + 1\|(1+j\omega)}$

$= \frac{1}{3}\frac{3j\omega}{3j\omega + (j\omega)^2 + 1}$

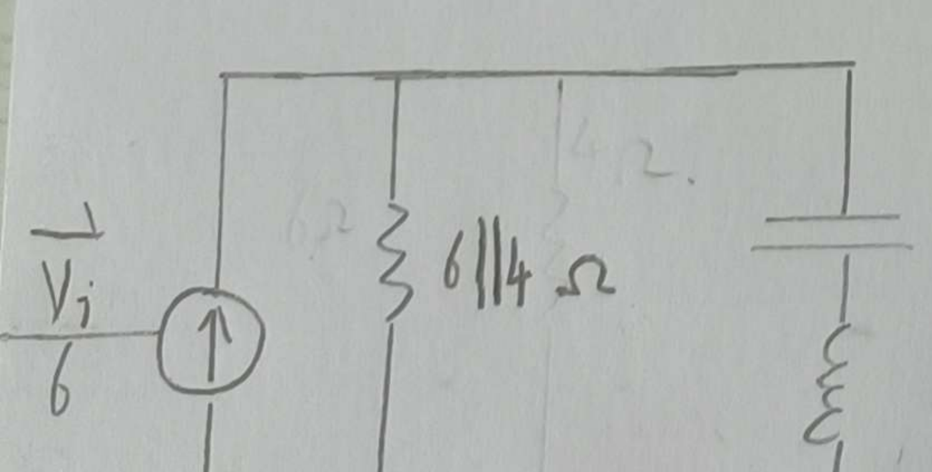
$= \frac{1}{3}\frac{sB}{sB + s^2 + \omega_0^2}$

$\therefore \omega_0 = 1$, $B = 3$

14.59 Find the bandwidth and center frequency of the $\boxed{\text{bandstop}}$ filter of Fig.14.89. (10')

B ω_0

2种方法.



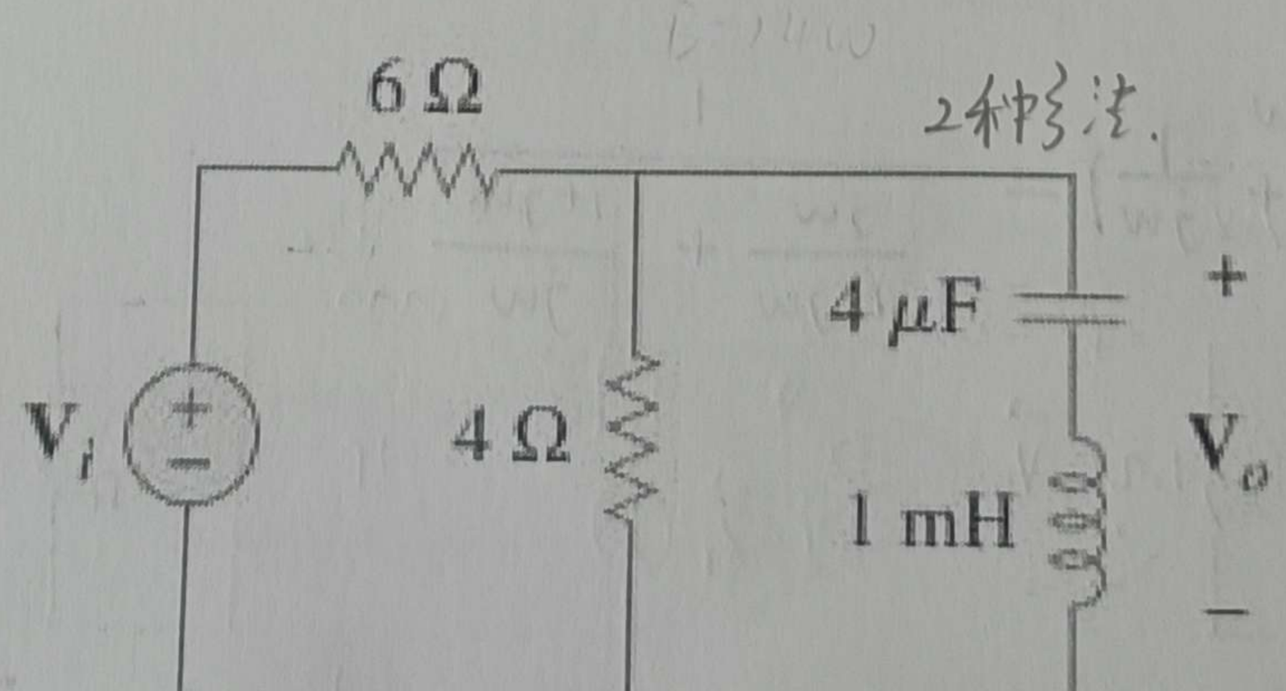


Figure 14.89

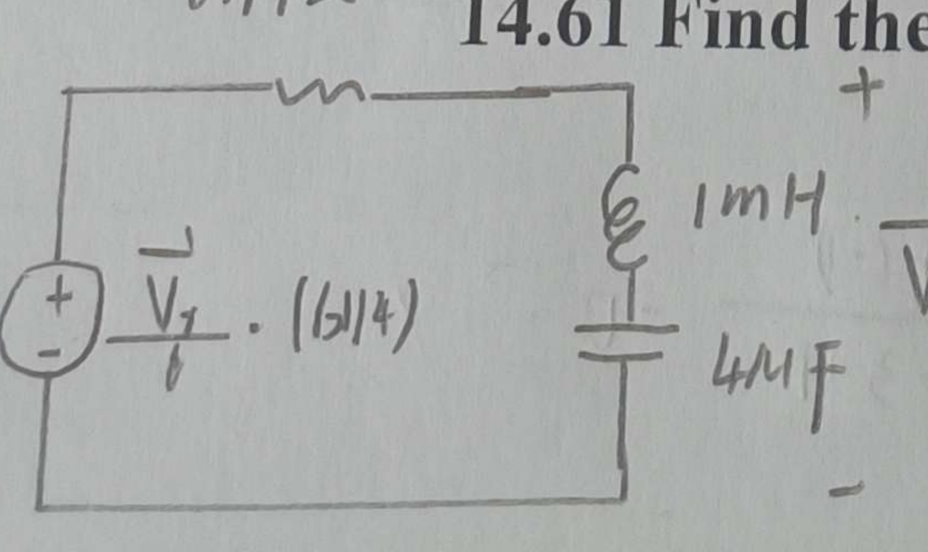
解: $\omega_0 = \frac{1}{\sqrt{LC}} = \frac{1}{\sqrt{10^{-3} \times 4 \times 10^{-6}}} = 15811$ rad/s

~~$Q = \frac{\omega_0 L}{R} = \frac{15811 \times 1 \times 10^{-3}}{6114}$~~

~~$= 6.588$~~

$B = \frac{\omega_0}{Q} = \frac{R}{L} = \frac{6114}{1 \times 10^{-3}} = 2400$ rad/s

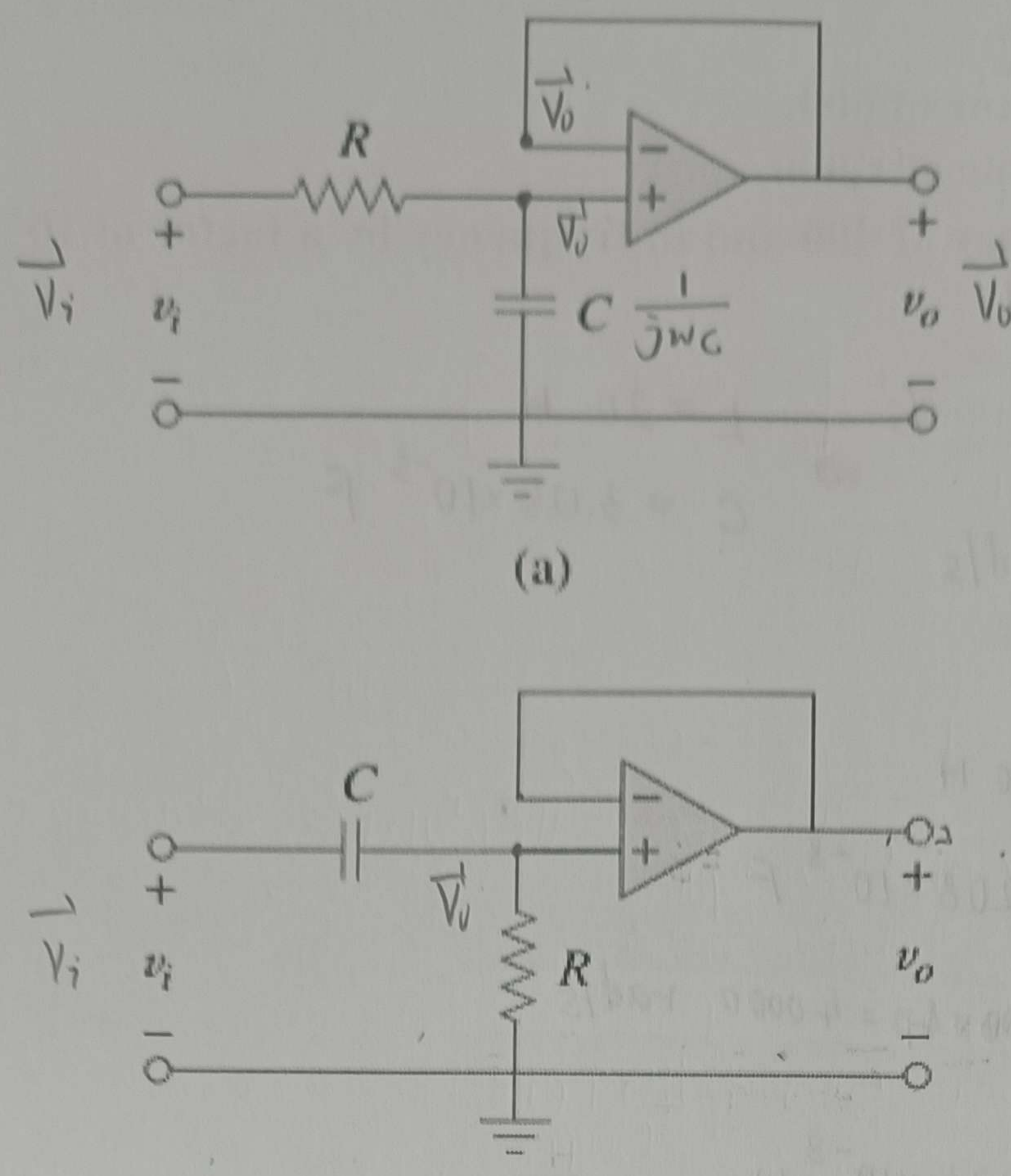
14.61 Find the transfer function for each of the active filters in Fig.14.90. (10')



14.61解:

a) $\vec{H}(w) = \frac{\vec{V_0}}{\vec{V_i}} = \frac{\frac{1}{jwC}}{R+\frac{1}{jwC}}$

$= \frac{1}{jwCR+1}$



b) $\vec{H}(w) = \frac{\vec{V_0}}{\vec{V_i}} = \frac{R}{\frac{1}{jwC}+R}$

$= \frac{jwCR}{1+jwCR}$

Figure 14.90

14.66 A "general" first-order filter is shown in Fig.14.93.
(a) Show that the transfer function is

$$H(s) = \frac{R_4}{R_3+R_4} \times \frac{s + (1/R_1C)[R_1/R_2 - R_3/R_4]}{s + 1/R_2C},$$

$s = j\omega$

(b) What condition must be satisfied for the circuit to operate as a highpass filter?
(c) What condition must be satisfied for the circuit to operate as a lowpass filter?
(10')

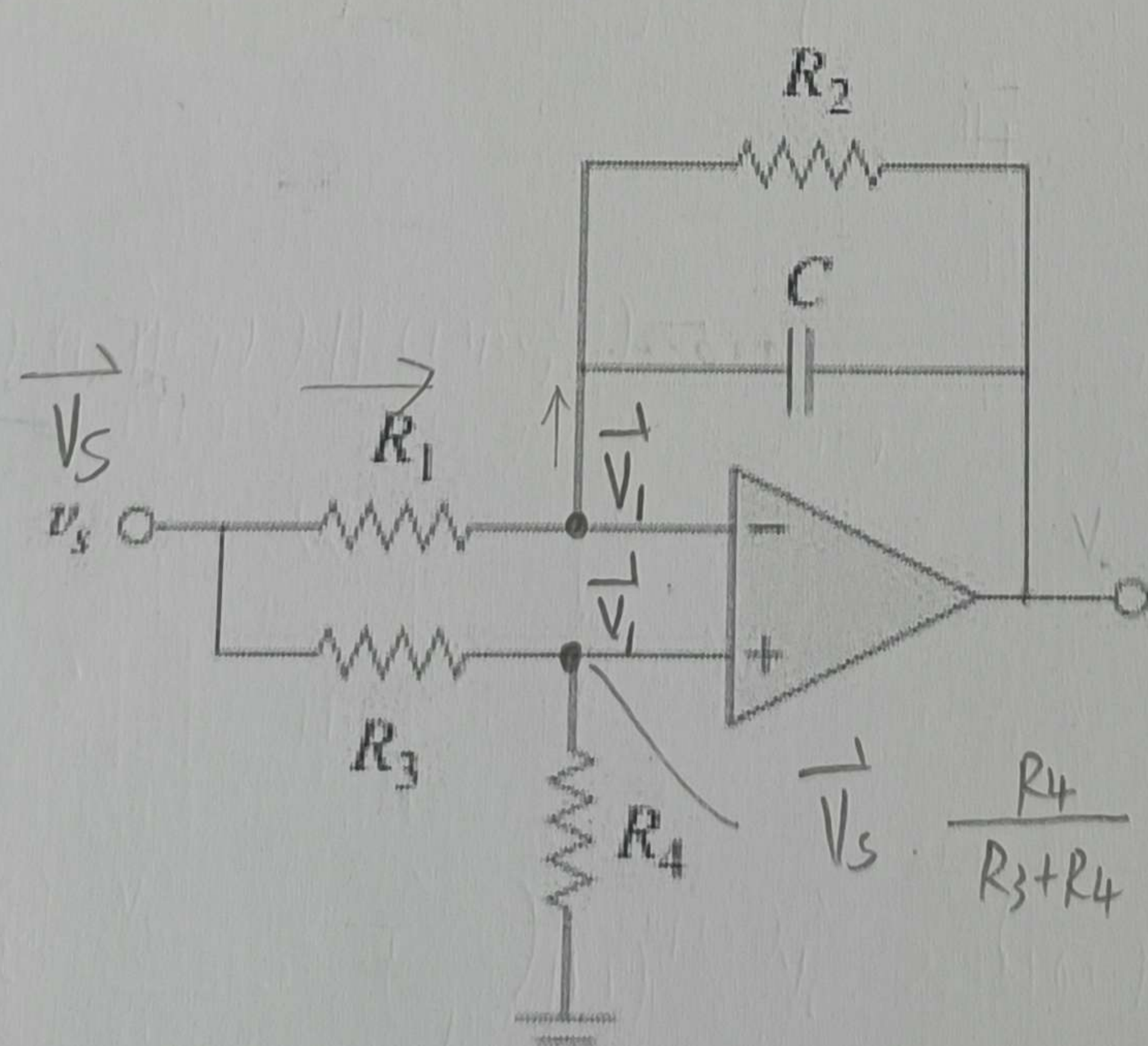


Figure 14.93

14.66解:

a) proof:

$$\begin{cases} \vec{V_1} = \vec{V_s} \cdot \frac{R_4}{R_3+R_4} \\ \frac{\vec{V_s}-\vec{V_1}}{R_1} = \frac{\vec{V_1}-\vec{V_0}}{R_2 \| \frac{1}{jwC}} \end{cases}$$

$\Rightarrow \vec{H}(w) = \frac{\vec{V_0}}{\vec{V_s}} = \frac{R_4}{R_3+R_4} - \frac{R_3}{(R_3+R_4)R_1}\left(R_2 \| \frac{1}{jwC}\right)$

$= \frac{R_4}{R_3+R_4} \cdot \left[1 - \frac{R_3}{R_1 R_4}\left(R_2 \| \frac{1}{jwC}\right)\right]$

$= \frac{R_4}{R_3+R_4} \cdot \frac{R_1R_4 - R_3 \cdot \frac{R_2}{1+jwCR_2}}{R_1 \cdot R_4}$

$= \frac{R_4}{R_3+R_4} \cdot \frac{1+jwCR_2 - \frac{R_2R_3}{R_1R_4}}{1+jwCR_2}$

$= \frac{R_4}{R_3+R_4} \cdot \frac{\frac{1}{CR_2} + jw - \frac{R_3}{R_1R_4C}}{jw + \frac{1}{CR_2}}$

$= \frac{R_4}{R_3+R_4} \cdot \frac{s + \frac{1}{CR_1}\left(\frac{R_1}{R_2} - \frac{R_3}{R_4}\right)}{s + 1/CR_2}$

b) high pass filter.

$w \to 0,\ H \to 0$

$\therefore \frac{R_1}{R_2} = \frac{R_3}{R_4}$

c) lowpass filter

$w \to \infty,\ H \to 0$

$\lim_{w\to\infty} \vec{H}(s) = \frac{R_4}{R_3+R_4} \to 0$

$R_3 \gg R_4,\ (R_3 \to \infty)$

$\frac{R_3}{R_4} \to \infty$

14.77 A series RLC circuit has $R = 100$, $w_o = 40$ rad/s, and $B = 5$ rad/s. Find L and C when the circuit is scaled:

(a) in magnitude by a factor of 600,

(b) in frequency by a factor of 1,000,

(c) in magnitude by a factor of 400 and in frequency by a factor of 10^5. (10')

解: a) without scaled.

$$w_0 = \frac{1}{\sqrt{LC}} = 40 \text{ rad/s}$$

$$B = \frac{R}{L} = 5 \text{ rad/s}$$

$$\Rightarrow \quad L = 20 \text{ H}, \quad C = 3.125\times10^{-5} \text{ F}$$

$k_m = 600$

$$L' = k_m L = 12000 \text{ H}$$

$$C' = \frac{C}{k_m} = 5.208\times10^{-8} \text{ F}$$

b) $$L' = \frac{L}{k_f} = 0.02 \text{ H}$$

$$C' = \frac{C}{k_f} = 3.125\times10^{-8} \text{ H}$$

c) $$L' = \frac{k_m L}{k_f} = \frac{400\times20}{10^5} = 0.08 \text{ H}$$

$$C' = \frac{C}{k_f k_m} = \frac{3.125\times10^{-5}}{10^5\times400} = 7.8125\times10^{-13} \text{ F}$$