Ch 11 problems

11.2

$$a(\omega) = \frac{25\sqrt{\omega^2+16}}{\omega^2+100} \qquad \theta(\omega) = \tan^{-1}\left(\frac{\omega}{4}\right) - 2\tan^{-1}\left(\frac{\omega}{10}\right)$$

$\Rightarrow$

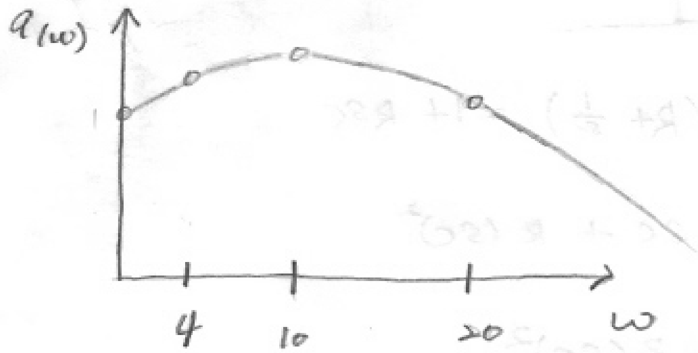
ω	2	10	50
$a(\omega)$	1.075	1.346	0.482
$\theta(\omega)$	3.9°	−21.8°	−71.9°

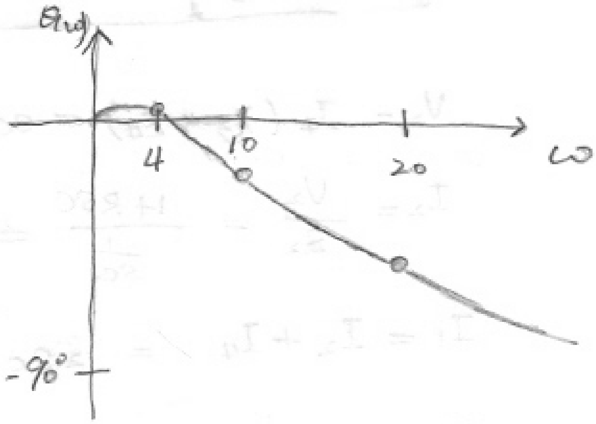
$$y(t) = 1.075\cos(2t + 3.9^\circ) + 1.346\cos(10t - 21.8^\circ) + 0.482\cos(50t - 71.9^\circ)$$

11.6

$$H(s) = \frac{25\,[s-(-4)]}{[s-(-10)]^2} \quad \Rightarrow \quad K = 25 \quad z_1 = -4 \quad P_1 = P_2 = -10$$

ω	0^+	4	10	20	∞
$s - z_1$	$4\angle 0^\circ$	$5.66\angle 45^\circ$	$10.8\angle 68.2^\circ$	$20.4\angle 78.7^\circ$	
$s-P_1 = s-P_2$	$10\angle 0^\circ$	$10.8\angle 21.8^\circ$	$14.1\angle 45^\circ$	$22.4\angle 63.4^\circ$	
$a(\omega)$	1	1.21	1.36	1.02	0
$\theta(\omega)$	0°	1.4°	−21.8°	−48.1°	−90°





11.19

Let $R_a = 1/\omega_1 C = 1/2\pi f_1 C$ and $R_b = 1/\omega_2 C = 1/2\pi f_2 C$

$$a_{lp}(0.6\omega_1) = \left[1 + \left(\frac{0.6\omega_1}{\omega_1}\right)^2\right]^{-\frac{1}{2}} = (1+0.6^2)^{-\frac{1}{2}} = 0.857$$

$$\theta_{lp}(0.6\omega_1) = -\tan^{-1}\left(\frac{0.6\omega_1}{\omega_1}\right) = -\tan^{-1} 0.6 = -31^\circ$$

$$a_{lp}(1.2\omega_2) = \left[1 + \left(\frac{1.2\omega_2}{\omega_1}\right)^2\right]^{-\frac{1}{2}} = (1+12^2)^{-\frac{1}{2}} = 0.083$$

$\theta_{lp}(1.2\omega_2) = -\tan^{-1}\left(\frac{1.2\omega_2}{\omega_1}\right) = -\tan^{-1}(12) = -85°$

$a_{hp}(0.6\omega_1) = \left[1+\left(\frac{\omega_2}{0.6\omega_1}\right)^2\right]^{-\frac{1}{2}} = \left[1+\left(\frac{10}{0.6}\right)^2\right]^{-\frac{1}{2}} = 0.06$

$\theta_{hp}(0.6\omega_1) = \tan^{-1}\left(\frac{\omega_2}{0.6\omega_1}\right) = \tan^{-1}\left(\frac{10}{0.6}\right) = 87°$

$a_{hp}(1.2\omega_2) = \left[1+\left(\frac{\omega_2}{1.2\omega_2}\right)^2\right]^{-\frac{1}{2}} = (1+1.2^{-2})^{-\frac{1}{2}} = 0.768$

$\theta_{hp}(1.2\omega_2) = \tan^{-1}\left(\frac{\omega_2}{1.2\omega_2}\right) = \tan^{-1}\left(\frac{1}{1.2}\right) = 40°$

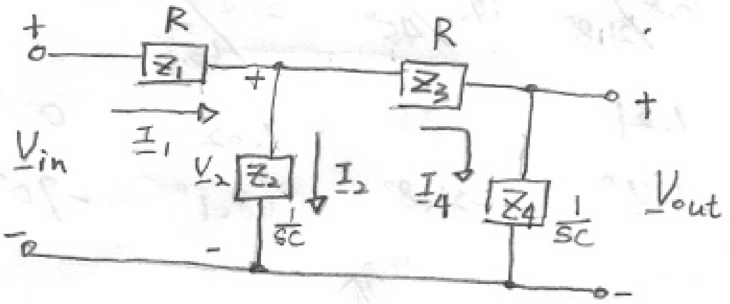
$\Rightarrow V_a(t) = 10\times 0.857\cos(0.6\omega_1 t - 31°) + 10\times 0.083\cos(1.2\omega_2 t - 85°)$

$= 8.57\cos(0.6\omega_1 t - 31°) + 0.83\cos(1.2\omega_2 t - 85°)$ #

$V_b(t) = 10\times 0.06\cos(0.6\omega_1 t + 87°) + 10\times 0.768\cos(1.2\omega_2 t + 40°)$

$= 0.6\cos(0.6\omega_1 t + 87°) + 7.68\cos(1.2\omega_2 t + 40°)$ #

11.22



$V_{out} = 1 = I_4 \times \frac{1}{sC}$

$\Rightarrow I_4 = sC$

$V_2 = I_4(Z_3 + Z_4) = sC\left(R + \frac{1}{sC}\right) = 1 + RsC$

$I_2 = \frac{V_2}{Z_2} = \frac{1+RsC}{\frac{1}{sC}} = sC + R(sC)^2$

$I_1 = I_2 + I_4 = 2sC + R(sC)^2$

$V_{in} = I_1 Z_1 + V_2 = [2sC + R(sC)^2]R + 1 + RsC$

$= (RsC)^2 + 3RsC + 1$

$H(s) = \frac{V_{out}}{V_{in}} = 1/(R^2C^2s^2 + 3RCs + 1)$ #

$H(j\omega_{co}) = 1/(1 - R^2C^2\omega_{co}^2 + j3RC\omega_{co})$

$$a^2(\omega_{co}) = 1 \Big/ \left[(1-R^2C^2\omega_{co}^2)^2 + (3RC\omega_{co})^2 \right]$$

$$= 1 \Big/ \left[(1-x)^2 + 9x \right] = \frac{1}{2}$$

$$(1-x)^2 + 9x = 2 \Rightarrow x^2 + 7x - 1 = 0 \Rightarrow x = \frac{-7 \pm \sqrt{7^2+4}}{2} \text{ (負不合)}$$

$$x = 0.14 \ , \ \omega_{co} = x^{\frac{1}{2}} \big/ RC = 0.374 \big/ RC \ \#$$

11.30

(a)

$$C = 1/\omega_0^2 L = 0.4\,\mu F \ , \ Q_{par} = \omega_0 / B = 20$$

$$R \,//\, R_{par} = \omega_0 L Q_{par} = 100\,\Omega$$

$$R_{par} = L / C R_w = 50\,\Omega$$

$$\frac{R \times 50}{R + 50} = 100 \Rightarrow R = \frac{50 \times 100}{50 - 100} = -100\,\Omega \ \#$$

(b) Replace R with negative-resistance converter with $R_L = 100\,\Omega$. So $R = \frac{V_{in}}{i_{in}} = -100\,\Omega$ #

11.35

$$H_{no}(s) = \frac{K(s^2 + 2Bs + \omega_0^2)}{s^2 + (\omega_0/Q)s + \omega_0^2} \quad (11.24)$$

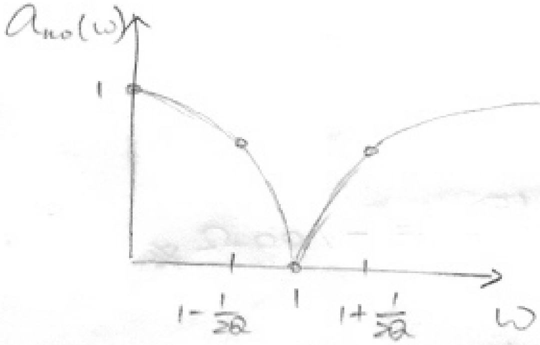
when $K = \omega_0 = 1$ $B = 0$ $Q >> 1$

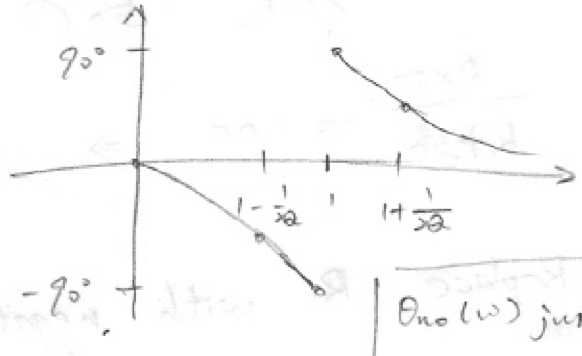
$$H_{no}(s) = \frac{(s^2+1)}{(s^2 + \frac{s}{Q} + 1)} = \frac{(s-j)(s+j)}{(s + \frac{1}{2Q} - j)(s + \frac{1}{2Q} + j) - \cancel{\frac{1}{4Q^2}}}$$

$\because Q >> 1$

$$\therefore Z_1, Z_2 = \pm j \quad P_1, P_2 = -\frac{1}{2Q} \pm j$$

ω	0^+	$1-1/2Q$	1^-	1^+	$1+1/2Q$	∞
$j\omega-z_1$	$1\angle -90^\circ$	$1/2Q\ \angle -90^\circ$	$0\angle -90^\circ$	$0\angle 90^\circ$	$1/2Q\ \angle 90^\circ$	
$j\omega-z_2$	$1\angle 90^\circ$	$2\angle 90^\circ$	$2\angle 90^\circ$	$2\angle 90^\circ$	$2\angle 90^\circ$	
$j\omega-p_1$	$1\angle -90^\circ$	$\sqrt{5}/2Q\ \angle -45^\circ$	$1/2Q\ \angle 0^\circ$	$1/2Q\ \angle 0^\circ$	$\sqrt{5}/2Q\ \angle 45^\circ$	
$j\omega-p_2$	$1\angle 90^\circ$	$2\angle 90^\circ$	$2\angle 90^\circ$	$2\angle 90^\circ$	$2\angle 90^\circ$	
$a_{no}(\omega)$	1	0.707	0	0	0.707	1
$\theta_{no}(\omega)$	0°	-45°	-90°	90°	45°	0°



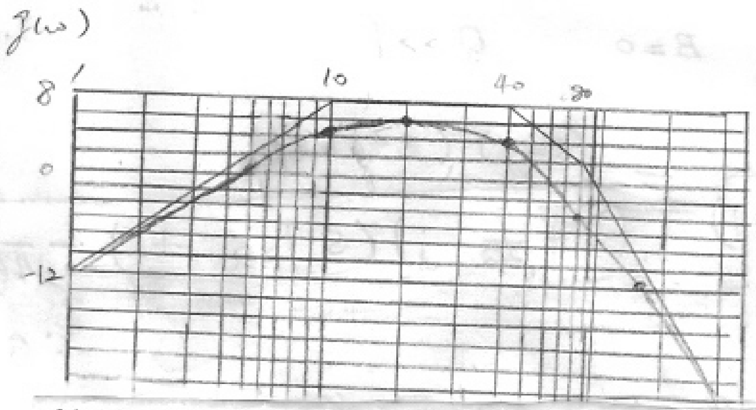


$\theta_{no}(\omega)$ jumps 180° at $\omega_0 = 1$

11.52

$$H(s) = \frac{8000}{40\times 80}\ \frac{s}{s+10}\ \frac{40}{s+40}\ \frac{80}{s+80} = 2.5\, H_{hp}(s;10)\, H_{lp}(s;40)\, H_{lp}(s;80)$$

$K_{dB} = 8 \qquad \angle K = 0^\circ$

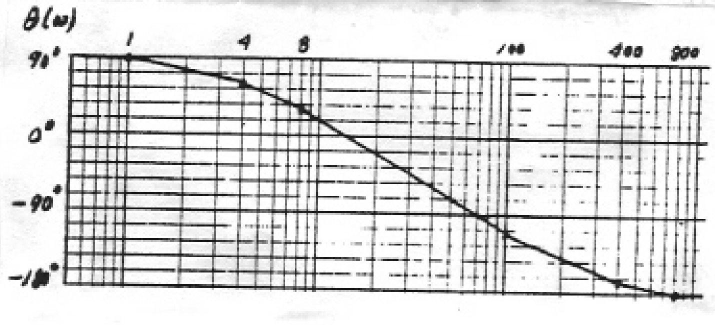


$g_{max} = 6\text{ dB}$

$\Rightarrow a_{max} = 10^{6/20} = 2$

$g = g_{max} - 3\ (\text{dB}) = 3\text{ dB}$

$\omega_l \doteqdot 7 \qquad \omega_u \doteqdot 45$

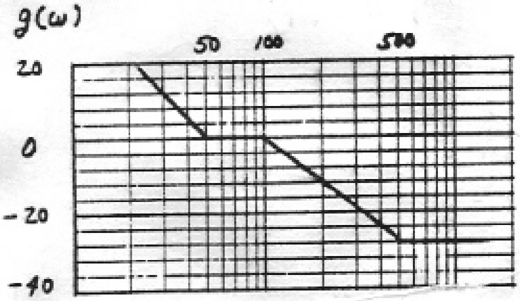


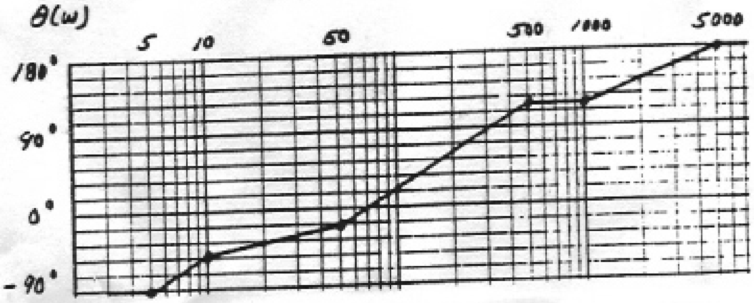
11.59

$$H(s) = \frac{-0.04 \times 500^2}{100^2} \frac{(s+50)^3}{s^3} \frac{100^2}{(s+100)^2} \frac{(s+500)^2}{500^2}$$

$$= -H_{hp}^{-3}(s;50)\, H_{lp}^{2}(s;100)\, H_{lp}^{-2}(s;500)$$

$K_{dB} = 0 \qquad \angle K = 180°$





11.64

$$H(s) = \frac{s^2}{10^2} \frac{10^2}{s^2 + (10/Q)s + 10^2} \frac{40^2}{s^2 + (40/Q)s + 40^2}$$

$$= H_r^2(s;10)\, H_q(s;10,Q)\, H_q(s;40,Q)$$

		ω	5	10	20	40	80
Q=0.5		Δg_1	-2	-6	-2	0	0
		Δg_2	0	0	-2	-6	-2
		Sum	-2	-6	-4	-6	-2
Q=1		Δg_1	1	0	1	0	0
		Δg_2	0	0	1	0	1
		Sum	1	0	2	0	1
Q=3		Δg_1	2	9.5	2	0	0
		Δg_2	0	0	2	9.5	2
		Sum	2	9.5	4	9.5	2

Best Response with $Q=1$

$g_{max} = 2\,dB \qquad \omega_L \doteq 9 \qquad \omega_u \doteq 44$