Examiner : Dr. Mustafa M. Shiple
Subject: Shaping Circuits /(EEC 242)
Score: 40 Marks

Term: Feb / May 2015
Exam Time:90 min

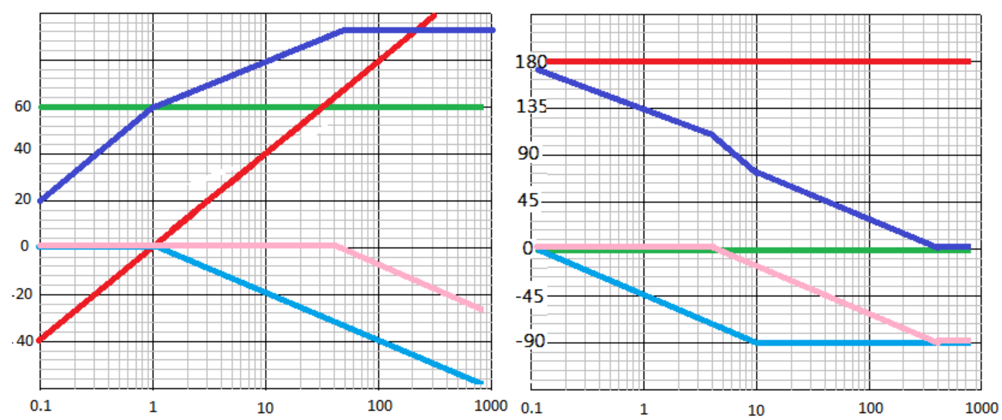
ANSWER THE FOLLOWING QUESTIONS:

1. Draw an asymptotic of bode plot for both magnitude and phase for the following $T(S)$. [5 marks] $[A_q, A_u, B_k]$

$$T(s) = 1000\frac{s^2}{(1+s)(1+0.025s)}$$

Solution: Q1.

- $1000 \Rightarrow 20\log 1000 = 60$ dB and $\phi = 0$.
- $S^2 \Rightarrow$ slop $= +40$ crosses 0 dB at 1 rad and $\phi = 180$.
- $(1+S) \Rightarrow$ slop = -20 starts at 1 rad and $\phi|_{0.1} = 0, \phi|_{10} = -90$.
- $(1+\frac{1}{40}S) \Rightarrow$ slop = -20 starts at 40 rad and $\phi|_{4} = 0, \phi|_{400} = -90$.
- Total.



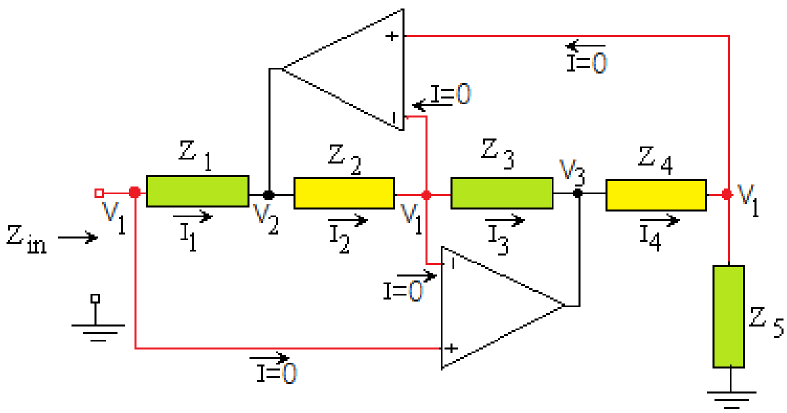
2. Draw the wiring diagram of generalized impedance converter (GIC). [10 marks] $[B_a, A_d, A_q]$
   (a) Drive an expression for transfer function of GIC.
   (b) Design a passive maximum flat high pass filter characterized by:$\alpha_{min} = 40dB$, $\alpha_{max} = 1dB$, $\omega_{stop} = 100krad/s$, and $\omega_{pass} = 625krad/s$. Use GIC in your design, The available resistors are 50Ω.

Order	R_S	C_1 a_1	L_2 a_2	C_3 a_3	L_4 a_4	C_5 a_5	L_6 a_6	C_7 a_7
1	1.0	2.0000						
2	1.0	1.4142	1.4142					
3	1.0	1.0000	2.0000	1.0000				
4	1.0	0.7654	1.8478	1.8478	0.7654			
5	1.0	0.6180	1.6180	2.0000	1.6180	0.6180		

[Total Marks is 40]

Solution:

(a)



For ideal Op-Amp:

$$V_o = A(V^+ - V^-) \qquad\qquad A = \infty$$

$$V^- = V^+$$

$$I_2 = I_3 \Rightarrow \frac{v_2 - v_1}{z_2} = \frac{v_1 - v_3}{z_3} \Rightarrow \boxed{v_2 = (1 + \frac{z_2}{z_3})v_1 - \frac{z_2}{z_3}v_3} \qquad (1)$$

$$I_4 = I_5 \Rightarrow \frac{v_3 - v_1}{z_4} = \frac{v_1}{z_5} \Rightarrow \boxed{v_3 = (1 + \frac{z_4}{z_5})v_1} \qquad (2)$$

By substituting (2) in (1):

$$v_2 = (1 + \frac{z_2}{z_3})v_1 - \frac{z_2}{z_3}(1 + \frac{z_4}{z_5})v_1$$

$$v_1 - v_2 = \frac{z_2 z_4}{z_3 z_5}v_1 \qquad\qquad \because z_{in} = \frac{v_1}{I_1}$$

$$\frac{v_1 - v_2}{z_1} = \frac{z_2 z_4}{z_1 z_3 z_5}v_1 = I_1$$

$$\therefore \boxed{z_{in} = \frac{z_1 z_3 z_5}{z_2 z_4} = \frac{odd}{even}}$$

Select z_4 or $z_2 = \frac{1}{Sc}$ and rest of z=R $\therefore z_{in} = S\frac{R_1 R_3 R_5 C_4}{R_2}$
For sake of normalization:
$R_1 = R_2 = R_3 = 1\Omega$ and $C_4 = 1F \Rightarrow z_{in} = SR_5 = SL \Rightarrow \boxed{L = R_5}$

(b)

1. $$n = \frac{\log\left(\frac{(10^{\frac{\alpha_{min}}{10}} - 1)}{(10^{\frac{\alpha_{max}}{10}} - 1)}\right)}{2\log\frac{\omega_S}{\omega_P}} = \frac{\log\left(\frac{(10^{\frac{40}{10}} - 1)}{(10^{\frac{1}{10}} - 1)}\right)}{2\log\frac{6.25}{1}} = 2.88 \approx 3$$

2. $\omega_{BLP} = \dfrac{\omega_P}{(10^{\frac{\alpha_{max}}{10}} - 1)^{\frac{1}{2n}}} = \dfrac{1}{(10^{\frac{1}{10}} - 1)^{\frac{1}{6}}} = 1.25$

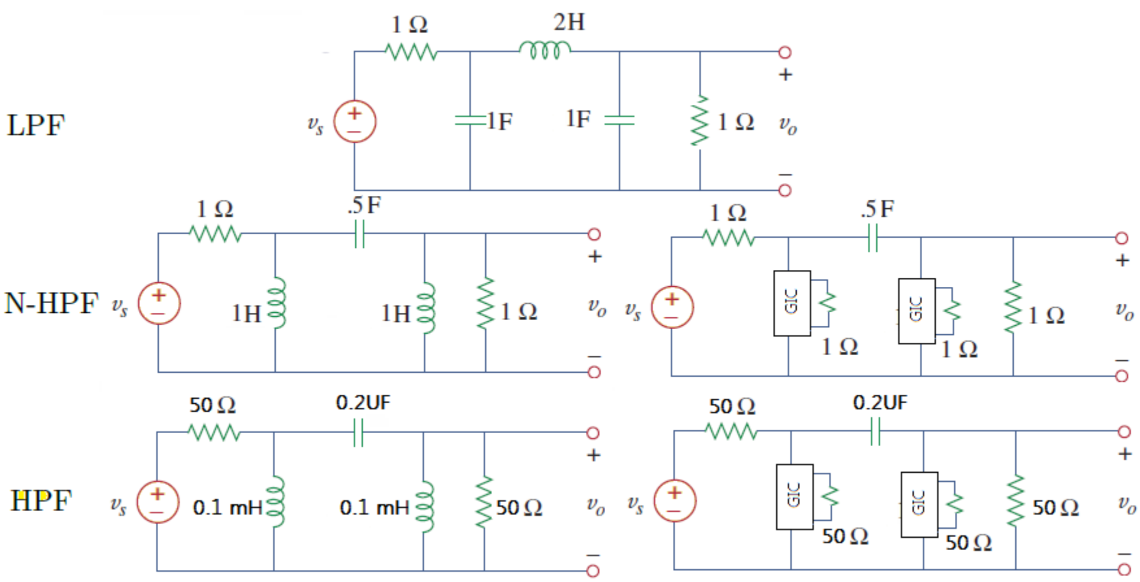
3. $\omega_{BHP} = \frac{625K}{\omega_{BLP}} = \frac{625K}{1.25} = 500K$

LPF	RS	C1	L2	C3
n=3	1	1	2	1

4.

N-HPF	RS	L1	C2	L3
n=3	1	1	0.5	1
$Km = 50$	$k_f = \omega_{BHP} = 500k$			
HPF	50	0.1mH	$0.2\mu F$	0.1mH

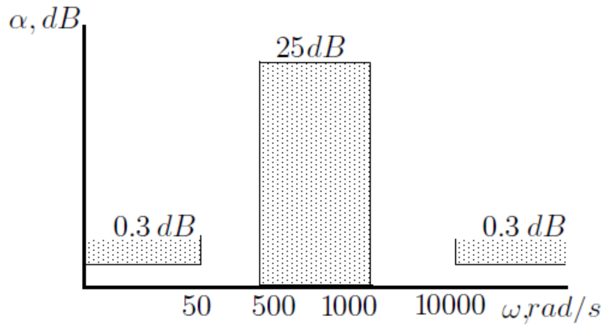
5. @ N-HPF $L = R_5 = 1\Omega \Rightarrow$ @ HPF $L = R_5 = 50\Omega$



3. Design an active band-rejection filter with maximum flat response to meet attenuation specification given in next Figure.(Hint:The available capacitor is $10nF$). [10 marks] [C_o, A_m]

   (a) Adjust band-rejection gain to be 5.

   (b) Find pole locations, ω_{PL}, ω_{PH}, and ω_o.



Solution:

(a) Low pass Filter

$$n = \frac{\log\left(\frac{(10^{\frac{\alpha_{min}}{10}}-1)}{(10^{\frac{\alpha_{max}}{10}}-1)}\right)}{2\log\frac{\omega_S}{\omega_P}} = \frac{\log\left(\frac{(10^{\frac{25}{10}}-1)}{(10^{\frac{0.3}{10}}-1)}\right)}{2\log\frac{500}{50}} = 1.822 \approx 2$$

$$\omega_o = \sqrt{500 * 1000} = 707.11 rad/s$$

$$\psi = \frac{180}{2} = 90^\circ$$

$$\epsilon = \sqrt{(10^{\frac{\alpha_{max}}{10}} - 1)} = 0.2$$

$$\omega_{BLP} = \epsilon^{-\frac{1}{n}} \times \omega_P = 96.69 rad/s$$

$$\text{assume } C = 10nF \Rightarrow R = \frac{1}{C\omega_{BLP}} \approx 1K\Omega$$

Gain and quality factor: $S^2 + \frac{\omega_0}{Q}S + \omega_0^2$ and $k = 3 - \frac{1}{Q}$

#	Degree	Location	$\frac{1}{Q}$	Q	$K = 3 - \frac{1}{Q}$	$R_F = (K-1)R$
pole 1,2	45	$-0.71 \pm j0.71$	1.41	0.71	1.59	605Ω

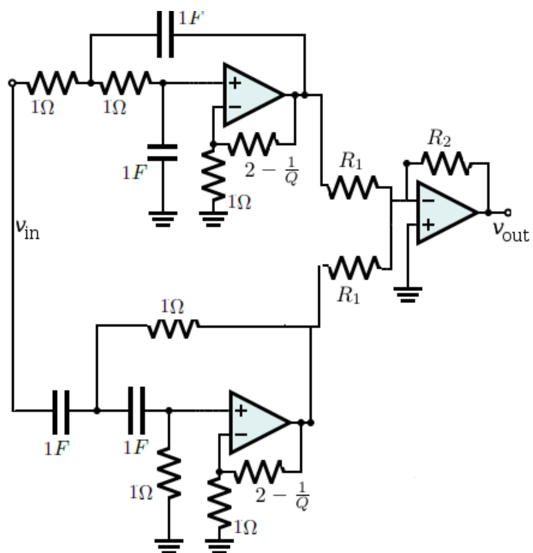
(b) High pass Filter

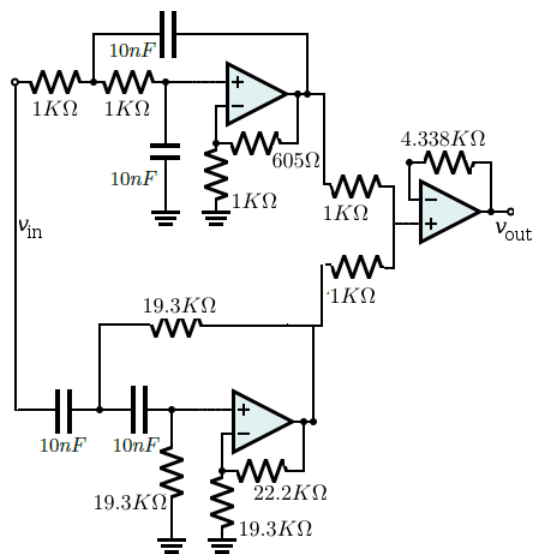
$$\omega_{BHP} = \frac{\omega_o^2}{\omega_{BLP}} = 5171.2 rad/s = k_f$$

$$k_m = \frac{1}{K_F C} = \frac{1}{5171.2 * 10n} = 19.3K\Omega$$

$$R_F = 22.2K\Omega$$

(c) To adjust overall gain $= \frac{5}{1.15} = 4.38 \Rightarrow R_2 = 4.38R_1 = 4.338K\Omega$





4. Max Wien is German physicist who invented Wien-bridge oscillator. [10 marks] [C_o, A_m]

   (a) Derive expressions for oscillation conditions of Wien-bridge oscillator.

   (b) Design the Wien-bridge oscillator with $f_o = 30kHz$. The available resistor is $10k\Omega$.

Solution:

(a)

$$\frac{v_I}{v_o} = \frac{Z_p}{Z_p + Z_s}$$

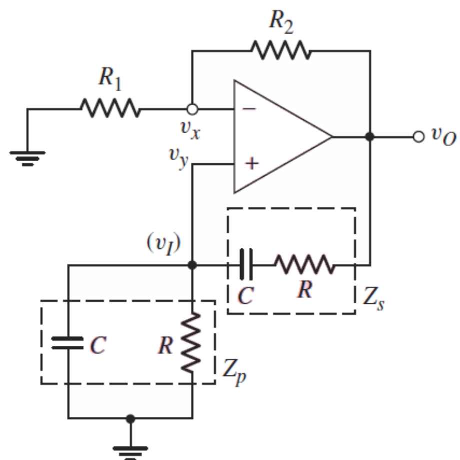
$$V_o = (1 + \frac{R_2}{R_1})v_y$$

$$\frac{v_o}{v_I} = (1 + \frac{R_2}{R_1})\frac{Z_p}{Z_p + Z_s}$$

$$Z_p = \frac{R}{1 + ScR}$$

$$Z_s = \frac{1 + ScR}{Sc}$$

$$\boxed{T(S) = (1 + \frac{R_2}{R_1})\frac{1}{3 + SRc + \frac{1}{SRc}}}$$



Apply Barkhuasen conditions:
unity gain $A\beta = 1$

$$|T(j\omega)| = A\beta = T(S) = (1 + \frac{R_2}{R_1})\frac{1 + j0}{3 + SRc + \frac{1}{SRc}} = 1$$

$\therefore$ real=real & img=img

$$\therefore SRc + \frac{1}{SRc} = 0 \Rightarrow \omega_o = \frac{1}{Rc}$$

$$(\frac{R_2}{R})(\frac{1}{3}) = 1 \qquad \text{let } R_1 = R$$

$$R_2 = 2R$$

in Phase $\angle A\beta = 0$
by using ω_o

$$\angle T(j\omega) = \angle A\beta = \angle(1 + \frac{R_2}{R_1})\frac{1 + j0}{3 + SRc + \frac{1}{SRc}}$$

$$= tan^{-1}(\frac{0}{\frac{R_2}{R_1}}) - tan^{-1}(\frac{0}{3}) = 0$$

(b)

$$f_o = \frac{1}{2\pi Rc} \Rightarrow c = \frac{1}{2\pi \times 10k \times 30k} = 530pF$$

$$R_2 = 2R = 10k2 = 20k\Omega$$

5. Briefly, discuss the function of phase detector. Compare between its types. [5 marks] $[C_o, A_m]$

Solution: Phase Detector: This circuit produces an output voltage proportional to the phase difference between two input signals.

#	Type	θ_e	k_d
1	analog multiplier	$-\frac{\pi}{2} < \theta_e < \frac{\pi}{2}$	$\frac{k_1 k_2}{2}$
2	XOR Phase Detector	$-\frac{\pi}{2} < \theta_e < \frac{\pi}{2}$	$\frac{U_B}{\pi}$
3	JK-FF Phase Detector	$-\pi < \theta_e < \pi$	$\frac{U_B}{2\pi}$
4	PFD Phase Frequency Detector	$-2\pi < \theta_e < 2\pi$	$\frac{U_B}{4\pi}$