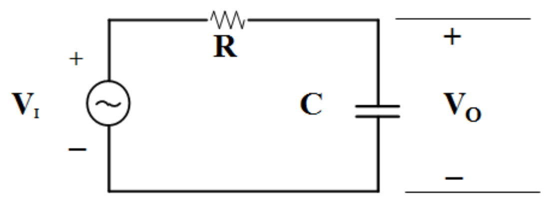
*Higher Technological Institute 10^{th} of Ramadan City
Department of Electrical & Computers Engineering
Mid Term Examination

Subject: Shaping Circuits /(EEC 242)(G1) — Term: June - August 2015
Examiner : Dr. Mustafa M. Shiple — Exam Time:90 min

ANSWER THE FOLLOWING QUESTIONS:

1. The passive filters have different disadvantages [10 marks] $[A_a, C_p]$
   (a) Draw a first order LPF circuit and drive an expression for its transfer function $|T(S)|$.
   (b) Briefly, discuss the loading problem; prove your answer by equations.
   (c) Drive an expression for active first order LPF (single zero) by using inverting opamp. (include the wiring diagram to your answer).
   (d) Compare and contrast between inverting and non-inverting realization topologies

Solution: Q1.(a)



$$V_o = V_i \frac{\frac{1}{Sc}}{R + \frac{1}{Sc}} \qquad \times SC$$

$$\frac{V_o}{V_i} = |T(S)| = \frac{1}{1 + SRc} = \frac{1}{1 + j\omega Rc}$$

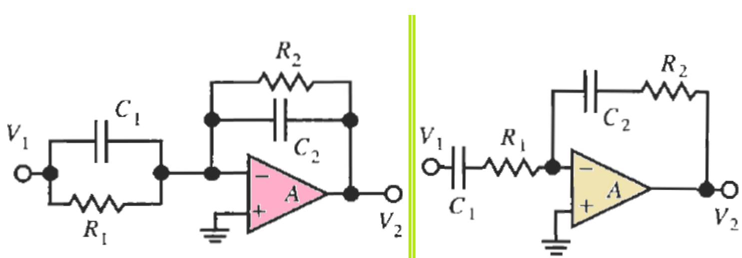
(b) The characteristic equation of passive LPF will be affected by changing the value of the loading resistor

$$|T(S)| = \frac{R_L}{R_L + R} \frac{1}{\left(S\frac{R_L RC}{R_L + R} + 1\right)} \qquad \div R_L$$

$$|T(S)| = \frac{1}{1 + \frac{R}{R_L}} \frac{1}{\left(S\frac{RC}{1 + \frac{R}{R_L}} + 1\right)}$$

Its obvious that by changing the value of R_L the gain and cutoff frequency will be decreased by $\left(\frac{1}{1 + \frac{R}{R_L}}\right)$

(c)



$$|T(S)| = \frac{R_2}{R_1} \frac{Sc_1 R_1 + 1}{Sc_2 R_2 + 1} \qquad |T(S)| = \frac{c_1}{c_2} \frac{Sc_2 R_2 + 1}{Sc_1 R_1 + 1}$$

[Total Marks is 30]

(d)

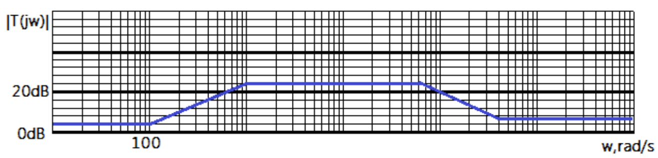
	Inverting op Amp	**Non-inverting**
Gain	Attenuation/Amplification	buffer / amplification
Component	4 passive elements	3 passive elements
Implementation Technology	-	adaptable (use resistors or capacitors)
Input Impedance	matching	∞

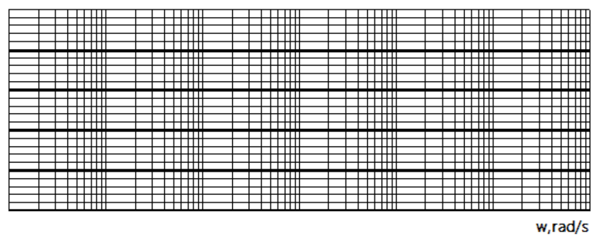
2. Consider the magnitude plot in the next figure. [10 marks] $[B_a, A_d, A_q]$

   (a) State the transfer function that express this plot. explain your answer briefly

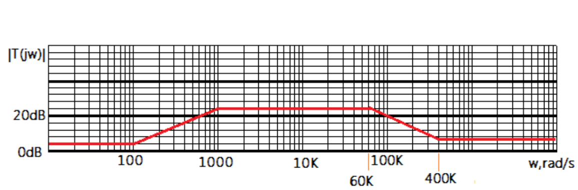
   (b) Draw the corresponding phase diagram.

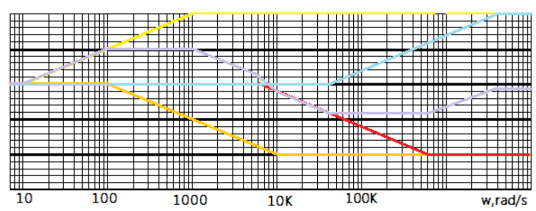
   (c) Find the circuit that will realize the given specifications. Find the proper values of the circuit components.





Solution:





- starting gain @ 4dB $\Rightarrow gain = 10^{\frac{4}{20}} = 1.58$
- vertex @ 100 Hz with slop 20dB/decade $\Rightarrow$ *zero*.
- vertex @ 1000 Hz with slop -20dB/decade $\Rightarrow$ *pole*.
- vertex @ 60K Hz with slop -20dB/decade $\Rightarrow$ *pole*.
- vertex @ 400K Hz with slop 20dB/decade $\Rightarrow$ *zero*.

$$|T(S)| = 1.58\frac{(\frac{S}{100}+1)(\frac{S}{400K}+1)}{(\frac{S}{1000}+1)(\frac{S}{60K}+1)}$$

$$|T(S)| = 1.58\frac{(\frac{S}{100}+1)}{(\frac{S}{1000}+1)} \times \frac{(\frac{S}{400K}+1)}{(\frac{S}{60K}+1)} = |T_1(S)| \times |T_2(S)|$$

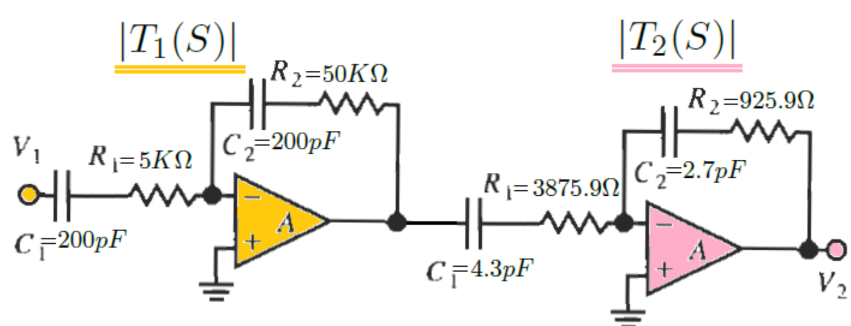
$$|T_1(S)| = \frac{(\frac{S}{100}+1)}{(\frac{S}{1000}+1)}$$

$$|T_2(S)| = 1.58\frac{(\frac{S}{400K}+1)}{(\frac{S}{60K}+1)}$$

Standered values of Capacitor																						
pF	1.2	1.3	1.5	1.6	1.8	2	2.2	2.4	2.7	3	3.3	3.6	3.9	4.3	4.7	5.1	5.6	6.2	6.8	7.5	8.2	9.1
	12	13	15	16	18	20	22	24	27	30	33	36	39	43	47	51	56	62	68	75	82	91
	120	130	150	160	180	200	220	240	270	300	330	360	390	430	470	510	560	620	680	750	820	910
	1200	1300	1500	1600	1800	2000	2200	2400	2700	3000	3300	3600	3900	4300	4700	5100	5600	6200	6800	7500	8200	9100
µF			0.015				0.022				0.033				0.047				0.068			
			0.15				0.22				0.33				0.47				0.68			
			1.5				2.2				3.3				4.7				6.8			
			15				22				33				47				68			
			150				220				330				470				680			
			1500				2200				3300				4700				6800			

By using the capacitor table:

- @ zero $R_2C_2 = \frac{1}{100}$ assume $C_2 = 200pF \Rightarrow R_2 = 50K\Omega$
- @ pole $R_1C_1 = \frac{1}{1000}$ assume $C_1 = 200pF \Rightarrow R_1 = 5K\Omega$
- @ zero $R_2C_2 = \frac{1}{400K}$ assume $C_2 = 2.7pF \Rightarrow R_2 = 925.9\Omega$
- $gain = 1.58 = \frac{C_1}{C_2} \Rightarrow C_1 = 1.58C_2 = 1.58 \times 2.7pF = 4.266 \approx 4.3pF$
- @ pole $R_1C_1 = \frac{1}{60K}$ assume $C_1 = 4.3pF \Rightarrow R_1 = 3875.9\Omega$



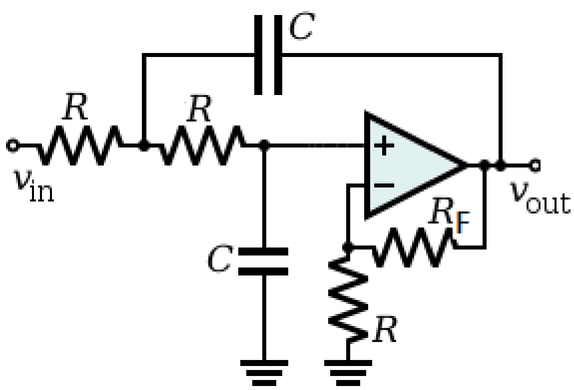
3. Design a Sallen-Key low-pass filter with no peaking and $f_o = 12.5kHz$: [10 marks] [C_o, A_m]
   (a) Draw the circuit diagram.Find the proper values of circuit components.
   (b) Plot the body plot of the designed Sallen-key.

(c) Drive an expression that illustrates the effect of component tolerance on quality factor .

(d) convert the previous circuit to be HPF with the same specifications.

Solution: (a)

no peaking means Q=0.707



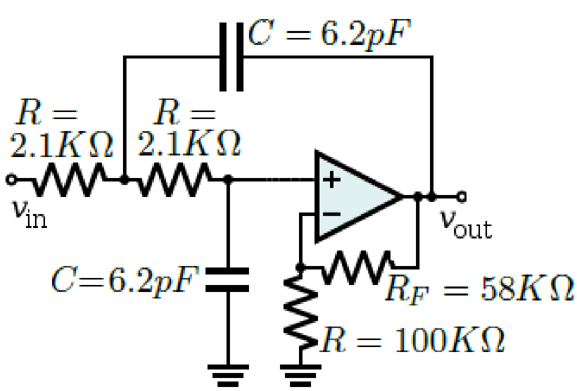
$$\omega = \frac{1}{RC} = 12.5K \times 2\pi = 78.5Krad/s \qquad \text{assume } C = 6.2pF$$

$$R = \frac{1}{78.5K \times C} = \frac{1}{78.5K \times 6.2pF} = 2.1K\Omega$$

$$K = 1 + \frac{R_F}{R} = 3 - \frac{1}{Q} = 1.58$$

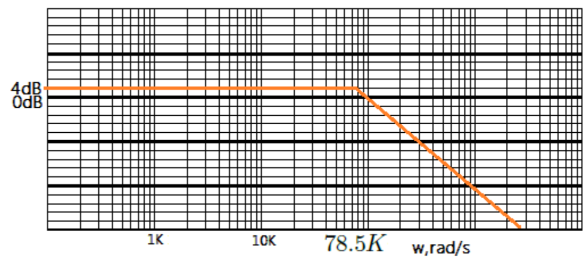
$$\therefore R_F = 0.58R = 0.58 \times 100K = 58K$$

$$\therefore R = 100K\Omega \ , \ R_F = 58K\Omega \ , \ C = 2pF \ , \ R = 2.1K\Omega$$



(b) $gain = 20log(1.58) = 3.97, \omega = 78.5Krad/s$

sallen-key is second order with slop -40dB/decade



(c)

$$Q = \frac{1}{(3-K)}$$

$$\frac{dQ(K)}{dK} = \frac{1}{(3-K)^2} = Q^2$$

$$\therefore dQ(K) = Q^2 dK$$

$$\frac{dQ(K)}{Q} = QdK \qquad \times \frac{K}{K}$$

$$\frac{dQ(K)}{Q} = KQ\frac{dK}{K}$$

(d)