Name: ID #

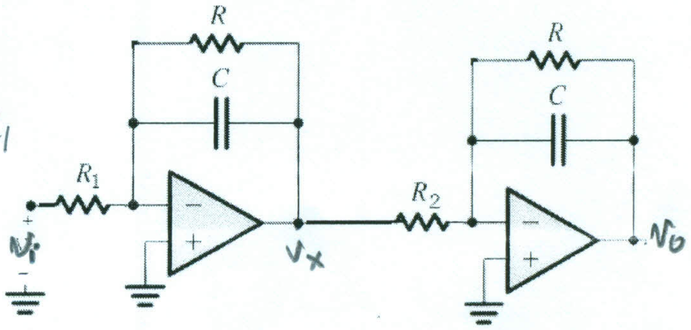
100

Q1 (35 points)

a) Assuming ideal Op-amp,

1. **Drive** the transfer function Vo/Vi and **identify** the circuit function.
2. **Select** the resistors and the capacitors to provide a 3dB corner frequency =10k rad/s and filter gain = 20 dB.

$$V_x = V_i\left(-\frac{\frac{R}{SCR+1}}{R_1}\right) = -\frac{R}{SCRR_1+R_1}$$



$$\frac{V_o}{V_i} = \left(-\frac{R}{SCRR_1+R_1}\right)\left(-\frac{R}{SCRR_2+R_2}\right)$$

$$= \frac{R^2}{S^2C^2R^2R_1R_2+2SCRR_1R_2+R_1R_2} = \frac{\frac{1}{C^2R_1R_2}}{S^2+2S\frac{1}{CR}+\frac{1}{C^2R^2}}$$ [10]

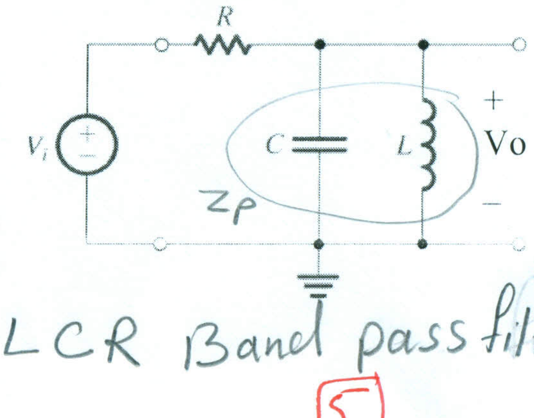
2^{nd} order low pass filter - Active opamp-RC [5]

2. $\omega_o = \frac{1}{CR} \Rightarrow 10K = \frac{1}{RC} \Rightarrow C = 0.1\mu,\ R = 1K\Omega$

$Gain = 20dB = 10\,V/V = \frac{R^2}{R_1R_2} \Rightarrow R_1R_2 = 10^5\Omega \Rightarrow R_1 = 1K\Omega$, $R_2 = 100\Omega$ [5]

b) **Drive** the transfer function Vo/Vi and **identify** the circuit function.

$$\frac{V_o}{V_i} = \frac{Z_p}{Z_p+R} = \frac{1}{1+Y_pR}$$



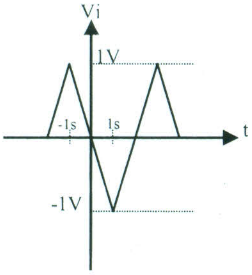
$$= \frac{1}{1+\left[SC+\frac{1}{SL}\right]R} = \frac{SL}{SL+S^2CLR+R}$$

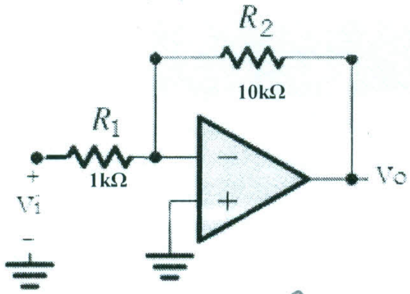
$$= \frac{S\frac{1}{CR}}{S^2+S\frac{1}{CR}+\frac{1}{CL}}$$ [10]

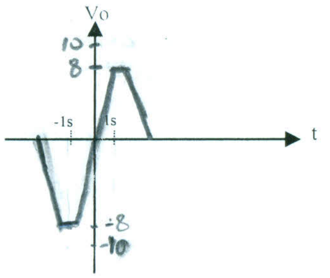
2^{nd} order LCR Band pass filter [5]

Q2 **(30 points)**

Consider the circuits shown below, Assuming ideal Op-amp with a saturation output voltage = ± 8V, sketch the output voltages and clearly label the waveforms.



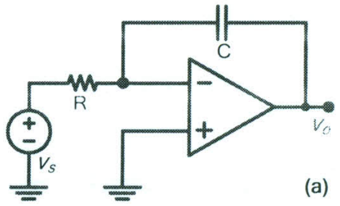




9

$$\text{Gain} = -\frac{R_2}{R_1} = -10$$

a. Drive the relation between v_o and v_s for the circuit shown in figure (a), what is the function of this circuit? **[7 Points]**

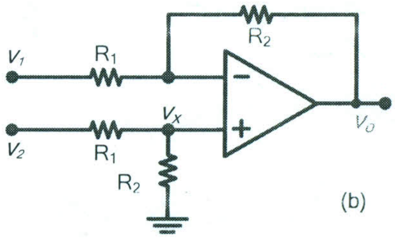


(a)

$$V_o = -\frac{1}{RC}\int V_s\,dt$$

7

b. Determine v_o as a function of v_1 and v_2 for the circuit shown in figure (b), what is the function of this circuit? **[7 Points]**



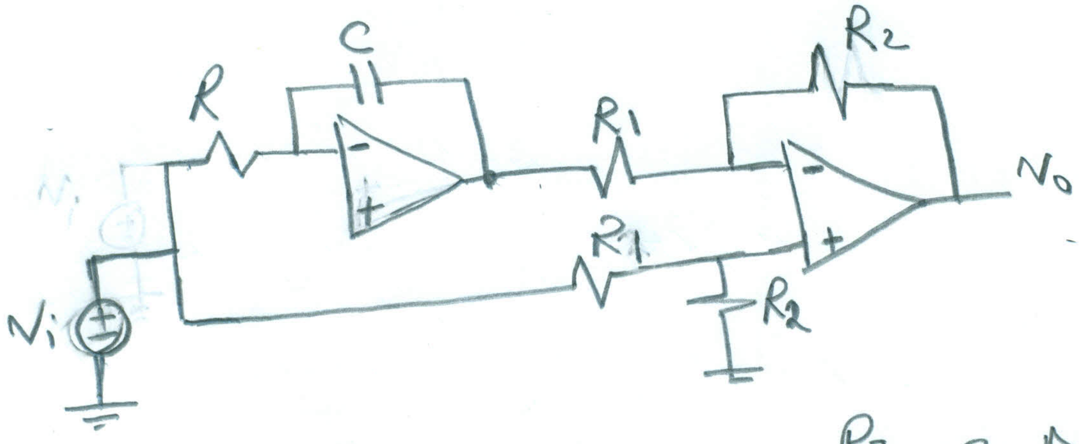
(b)

c. Using the circuits in parts (a) and (b); design a circuit to realize the following equation:

$v_o = 2v_i + 6\int v_i\,dt$; **[7 Points]**

b) $$V_o = \frac{R_2}{R_1+R_2}\left(1+\frac{R_2}{R_1}\right)V_2 - \frac{R_2}{R_1}V_1 = \frac{R_2}{R_1}(V_2 - V_1)$$ 7

c)



5

$$V_o = \frac{1}{RC}\left(\frac{R_2}{R_1}\right)\int V_i\,dt + \frac{R_2}{R_1}V_i \Rightarrow \frac{R_2}{R_1} = 2 \Rightarrow R_2 = 2K, \; R_1 = 1K$$

$$\frac{1}{RC} = 3 \Rightarrow C = 1\mu F, \; R = 333K$$

1

Q3 (35 points)

Consider the circuits shown below and answer the following questions:

i. Identify the feedback topology for each circuit. *[6 points]*

ii. Drive an expression for the feedback ratio **β** for each circuit *[12 points]*

iii. **for figure (a) only** Drive an expression for the **network A** *[11 points]*

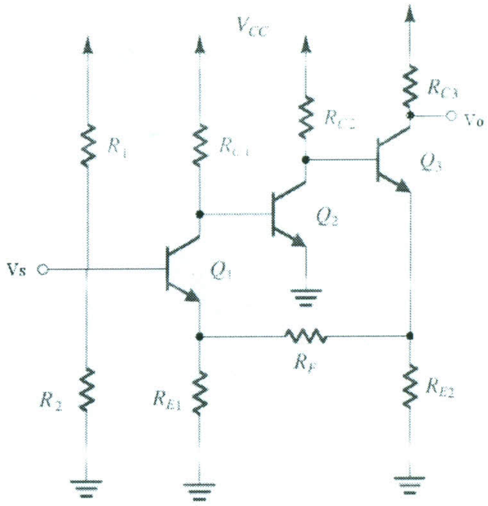
iv. **for figure (a) only** Find the closed-loop gain = v_o/v_{sig} *[6 points]*

i) a) series – series

b) series – Shunt

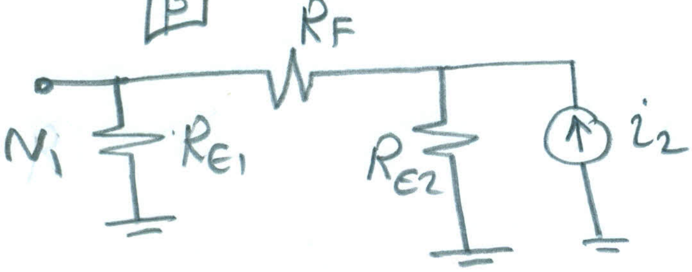
6

(a)



ii) a)

β

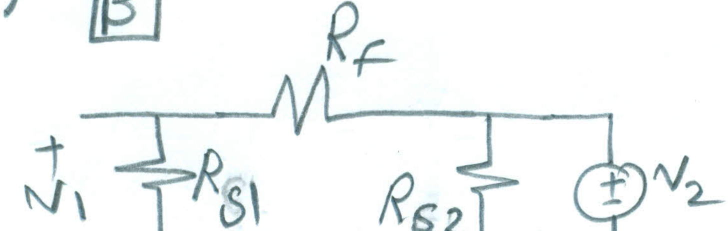


$$\beta = \frac{V_1}{i_2} = \frac{R_{E2} R_{E1}}{R_{E2} + R_F + R_{E1}}$$

6

b)

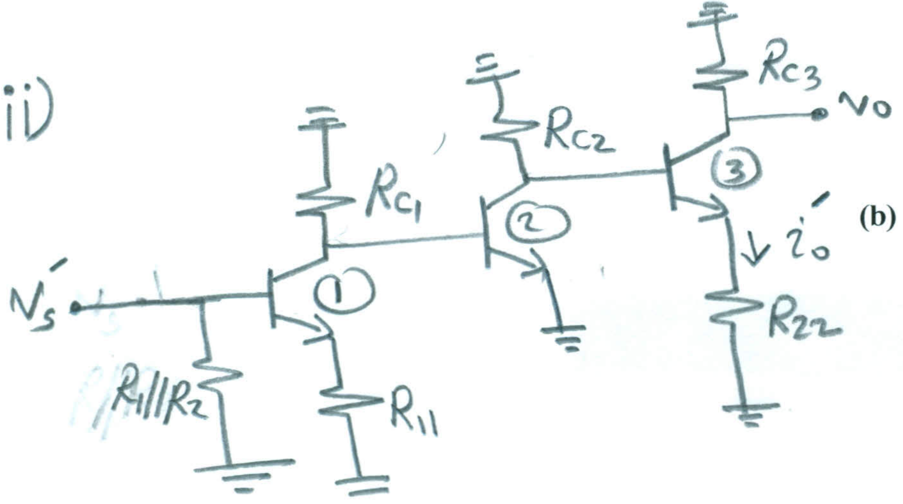
β

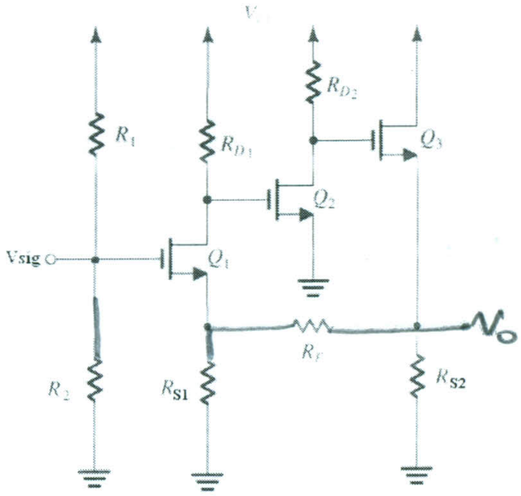


$$\beta = \frac{V_1}{V_2} = \frac{R_{S1}}{R_{S1} + R_F}$$

6

iii)





$$R_{11} = R_{E1} \,//\, (R_F + R_{E2})$$

$$R_{22} = R_{E2} \,//\, (R_F + R_{E1})$$

iv) $A_{CL} = \dfrac{i_o}{v_s} = \dfrac{A}{1+A\beta}$ [6]

$$A = \frac{i_o'}{v_s'} = \frac{-R_{C1} \,//\, r_{\pi 2}}{R_{11} + r_{e1}} \left(- \frac{R_{C2} \,//\, (\beta+1)(r_{e3} + R_{22})}{r_{e2}} \right) \frac{1}{r_{e3} + R_{22}}$$

[11]