Benha University	Electronic circuits (B)	Electrical Eng. Dept.
Faculty of Engineering		3^{rd} year communication
Shoubra		2012-2013

Sheet (3)

1. A certain low-pass filter has critical frequency of 800Hz. What is its bandwidth?

$$BW = f_c = \mathbf{800\ Hz}$$

2. A single pole high-pass filter has a frequency-selective circuit with R=2.2KΩ and C=0.0015μF. What is the critical frequency?

$$f_c = \frac{1}{2\pi RC} = \frac{1}{2\pi(2.2\ k\Omega)(0.0015\ \mu F)} = \mathbf{48.2\ Hz}$$

3. What is the roll-off rate of the filter described in problem 3?

The roll-off is **20 dB/decade** because this is a single-pole fi

4. What is the Bandwidth of a band-pass filter whose critical frequencies are 3.2 KHz and 3.9 KHz? What is the Q of this filter?

$$BW = f_{ch} - f_{cl} = 3.9\ kHz - 3.2\ kHz = 0.7\ kHz = \mathbf{700\ Hz}$$

$$f_0 = \sqrt{f_{cl} f_{ch}} = \sqrt{(3.2\ kHz)(3.9\ kHz)} = 3.53\ kHz$$

$$Q = \frac{f_0}{BW} = \frac{3.53\ kHz}{700\ Hz} = \mathbf{5.04}$$

5. What is the center frequency of a filter with a Q of 15 and a bandwidth of 1 KHz?

$$Q = \frac{f_0}{BW}$$

$$f_0 = Q(BW) = 15(1\ kHz) = \mathbf{15\ kHz}$$

6. What is the damping factor in each active filter shown in figure (1)? Which filter optimized for a Butterworth response characteristic?

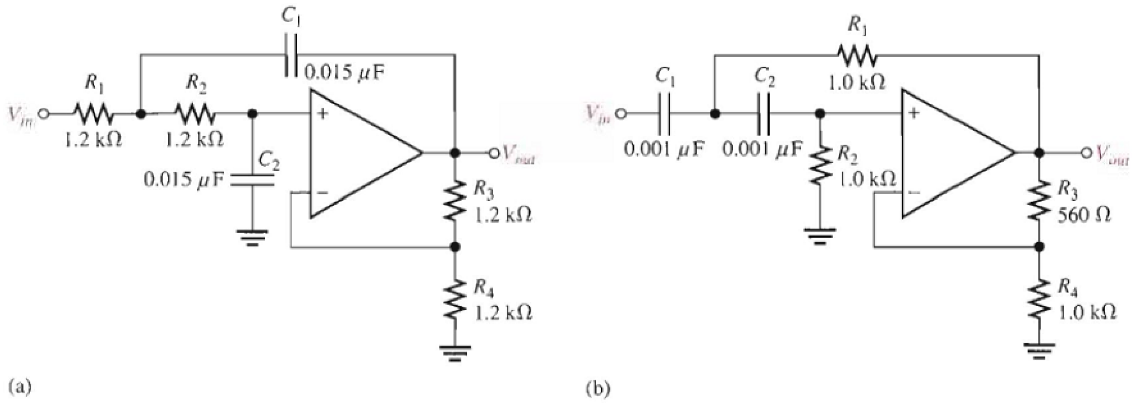


Figure (1)

(a) 2nd order, 1 stage

$$DF = 2 - \frac{R_3}{R_4} = 2 - \frac{1.2\ \text{k}\Omega}{1.2\ \text{k}\Omega} = 2 - 1 = \mathbf{1}$$ **Not Butterworth**

(b) 2nd order, 1 stage

$$DF = 2 - \frac{R_3}{R_4} = 2 - \frac{560\ \Omega}{1.0\ \text{k}\Omega} = 2 - 0.56 = \mathbf{1.44}$$ **Approximately Butterw**

7. For the filter in figure (1-a) that do not have a Butterworth response, specify the necessary changes to convert it to Butterworth response.

From Table 15-1 in the textbook, the damping factor must be 1.414; there

$$\frac{R_3}{R_4} = 0.586$$

$R_3 = 0.586R_4 = 0.586(1.2\ \text{k}\Omega) = \mathbf{703\ \Omega}$

Nearest standard value: **720 Ω**

8. For the figure (2) shown:

(a) Is the four-pole filter approximately optimized for a Butterworth response? What is the roll-off rate?

High Pass

1st stage:

$$DF = 2 - \frac{R_3}{R_4} = 2 - \frac{1.0\ \text{k}\Omega}{6.8\ \text{k}\Omega} = 1.85$$

2nd stage:

$$DF = 2 - \frac{R_7}{R_8} = 2 - \frac{6.8\ \text{k}\Omega}{5.6\ \text{k}\Omega} = 0.786$$

From Table 15-1 in the textbook:

1st stage $DF = 1.848$ and 2nd stage $DF = 0.765$

Therefore, this filter is **approximately Butterworth.**

Roll-off rate = **80 dB/decade**

(b) Without changing the response curve, adjust the component values in the filter to make it an equal-value filter. Select C=0.22μF for both stages.

$R = R_1 = R_2 = R_5 = R_6$ and $C = C_1 = C_2 = C_3 = C_4$

Let $C = \mathbf{0.22\ \mu F}$ (for both stages).

$$f_c = \frac{1}{2\pi\sqrt{R^2C^2}} = \frac{1}{2\pi RC}$$

$$R = \frac{1}{2\pi f_c C} = \frac{1}{2\pi(190\text{ Hz})(0.22\ \mu\text{F})} = 3.81\text{ k}\Omega$$

Choose $R = \mathbf{3.9\ k\Omega}$ (for both stages)

(c) Modify the filter to increase the roll-off rate to -120dB/decade while maintaining an approximate Butterworth response.

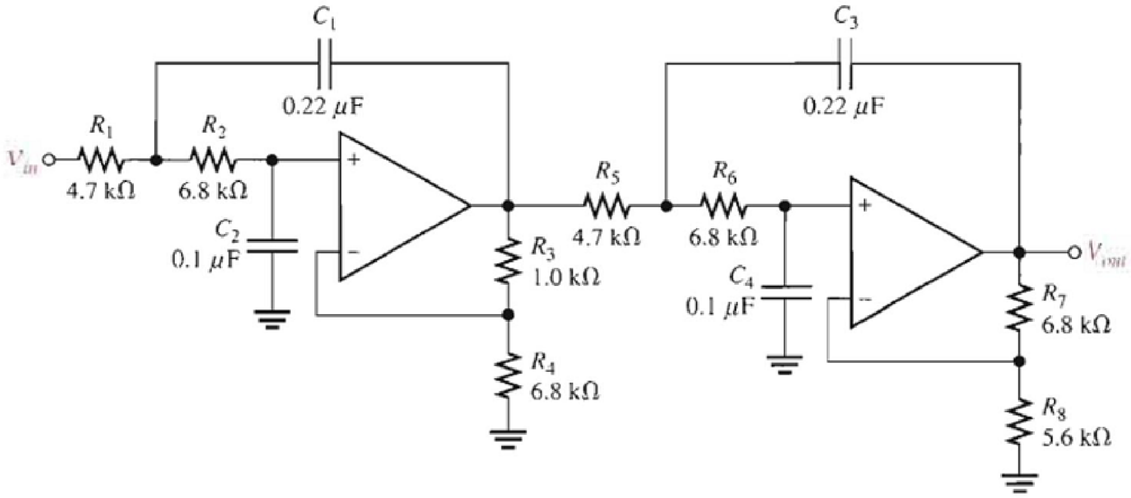
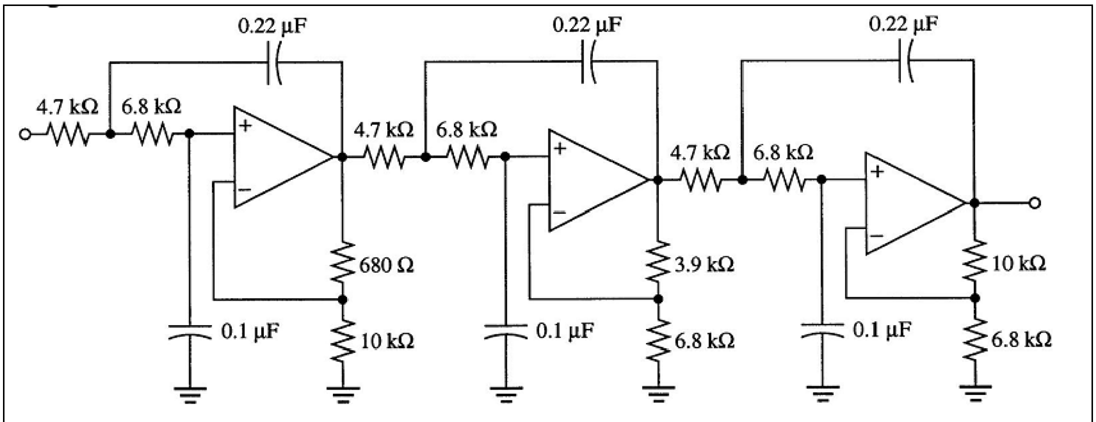


Figure (2)



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9. For the filter shown in figure (3):
   (a) How would you increase the critical frequency?
   (b) How would you increase the gain?

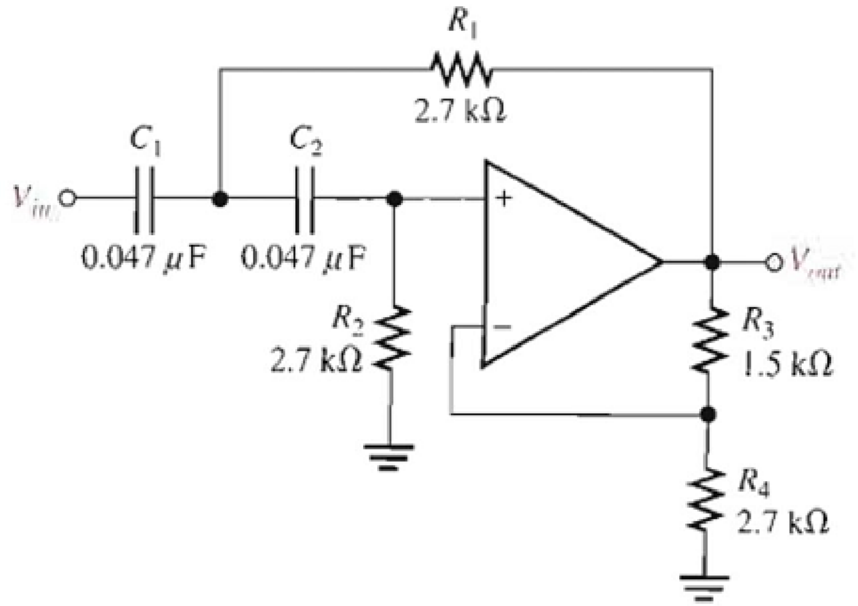

Figure (3)

(a) Decrease R_1 and R_2 or C_1 and C_2.
(b) Increase R_3 or decrease R_4.

10. Optimize the state variable filter in figure (4) for Q=50. What bandwidth is achieved?

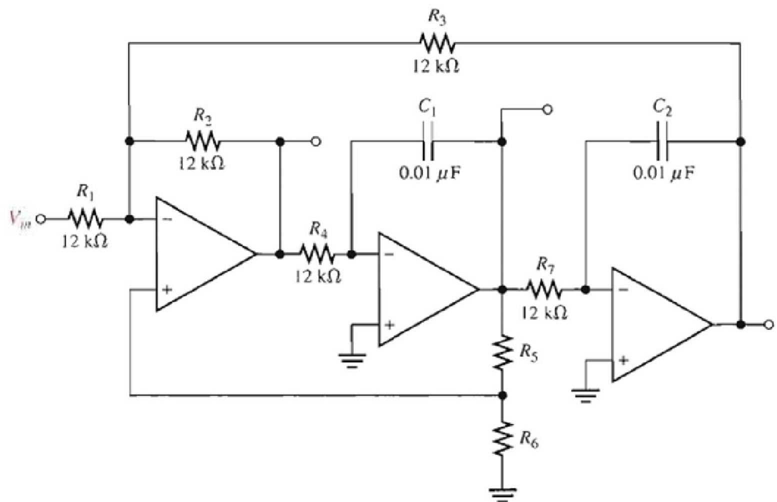

Figure (4)

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$$Q = \frac{1}{3}\left(\frac{R_5}{R_6} + 1\right)$$

Select $R_6 = \mathbf{1}$ **kΩ**.

$$Q = \frac{R_5}{3R_6} + \frac{1}{3} = \frac{R_5 + R_6}{3R_6}$$

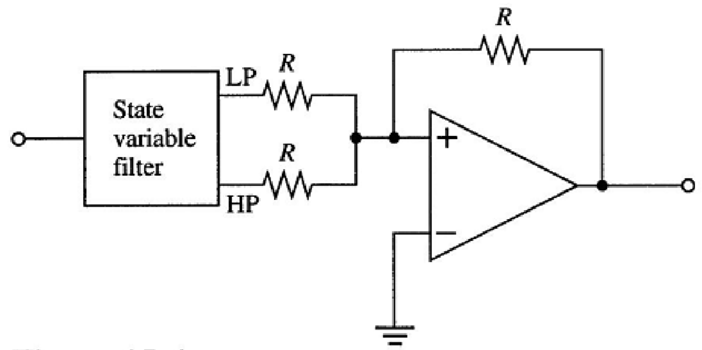
$$3R_6Q = R_5 + R_6$$

$$R_5 = 3R_6Q - R_6 = 3(1.0\ \text{k}\Omega)(50) - 10\ \text{k}\Omega = 150\ \text{k}\Omega - 10\ \text{k}\Omega = 149\text{k}\Omega$$

$$f_0 = \frac{1}{2\pi(12\ \text{k}\Omega)(0.01\ \mu\text{F})} = 1.33\ \text{kHz}$$

$$BW = \frac{f_0}{Q} = \frac{1.33\ \text{kHz}}{50} = \mathbf{26.6\ Hz}$$

11. Show how to make a notch filter using the basic circuit in figure (4).



12. Modify the band-stop filter in problem 11 for a center frequency of 120Hz.

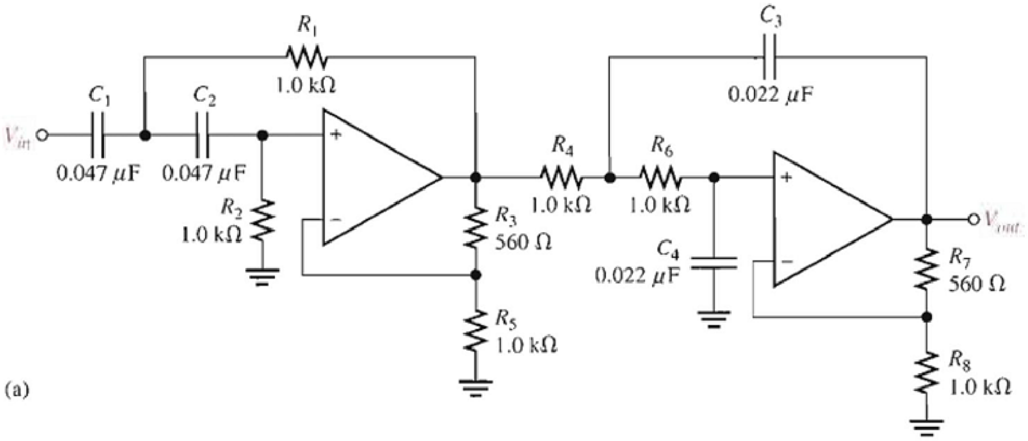
$$f_0 = f_c = \frac{1}{2\pi RC}$$

Let C remain 0.01 μF.

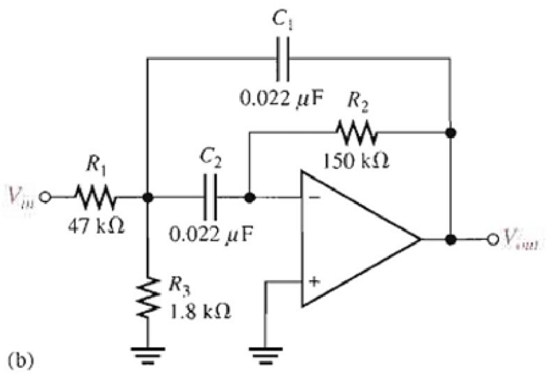
$$R = \frac{1}{2\pi f_0 C} = \frac{1}{2\pi(120\ \text{Hz})(0.01\ \mu\text{F})} = \mathbf{133\ k\Omega}$$

Change R in the integrators from 12 kΩ to 133 kΩ.

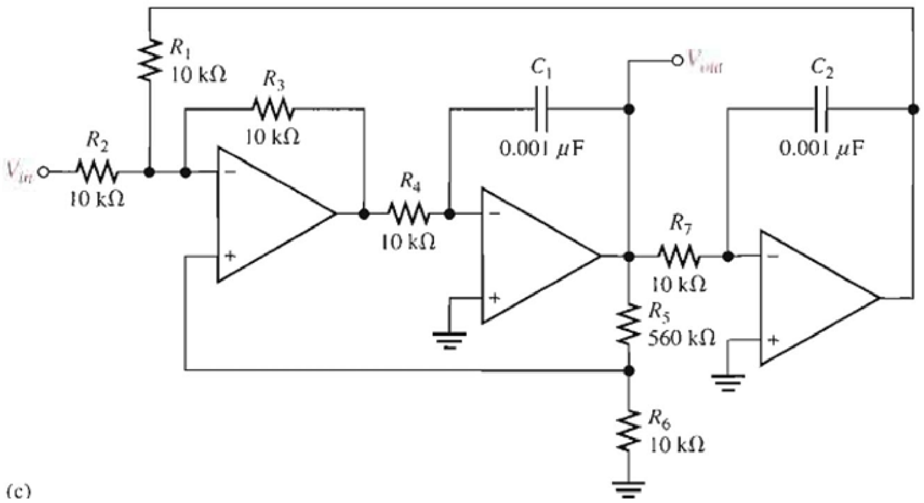
13. Determine the center frequency and bandwidth for each filter in figure (5).


R1
1.0 kΩ
C1
C2
C3
0.022 μF
Vin
0.047 μF
0.047 μF
R2
1.0 kΩ
R3
560 Ω
R4
1.0 kΩ
R6
1.0 kΩ
C4
0.022 μF
Vout
R5
1.0 kΩ
R7
560 Ω
R8
1.0 kΩ

(a)


C1
0.022 μF
R2
150 kΩ
Vin
R1
47 kΩ
C2
0.022 μF
Vout
R3
1.8 kΩ

(b)


R1
10 kΩ
R3
10 kΩ
C1
0.001 μF
Vout
C2
0.001 μF
Vin
R2
10 kΩ
R4
10 kΩ
R7
10 kΩ
R5
560 kΩ
R6
10 kΩ

(c)

(a) 1st stage:

$$f_{c1} = \frac{1}{2\pi RC} = \frac{1}{2\pi(1.0\,\text{k}\Omega)(0.047\,\mu\text{F})} = 3.39\text{ kHz}$$

2nd stage:

$$f_{c2} = \frac{1}{2\pi RC} = \frac{1}{2\pi(1.0\,\text{k}\Omega)(0.022\,\mu\text{F})} = 7.23\text{ kHz}$$

$$f_0 = \sqrt{f_{c1}f_{c2}} = \sqrt{(3.39\,\text{kHz})(7.23\,\text{kHz})} = \mathbf{4.95\ kHz}$$

$$BW = 7.23\text{ kHz} - 3.39\text{ Hz} = \mathbf{3.84\ kHz}$$

(b) $$f_0 = \frac{1}{2\pi C}\sqrt{\frac{R_1 + R_2}{R_1R_2R_3}} = \frac{1}{2\pi(0.022\,\mu\text{F})}\sqrt{\frac{47\,\text{k}\Omega + 1.8\,\text{k}\Omega}{(47\,\text{k}\Omega)(1.8\,\text{k}\Omega)(150\,\text{k}\Omega)}} = \mathbf{449\ Hz}$$

$$Q = \pi f_0CR_3 = \pi(449\text{ Hz})(0.022\,\mu\text{F})(150\text{ k}\Omega) = 4.66$$

$$BW = \frac{f_0}{Q} = \frac{449\text{ Hz}}{4.66} = \mathbf{96.4\ Hz}$$

(c) For each integrator:

$$f_c = \frac{1}{2\pi RC} = \frac{1}{2\pi(10\,\text{k}\Omega)(0.001\,\mu\text{F})} = 1\ 5.9\text{ kHz}$$

$$f_0 = f_c = \mathbf{15.9\ kHz}$$

$$Q = \frac{1}{3}\left(\frac{R_5}{R_6}+1\right) = \frac{1}{3}\left(\frac{560\,\text{k}\Omega}{10\,\text{k}\Omega}+1\right) = \frac{1}{3}(56+1) = 19$$

$$BW = \frac{f_0}{Q} = \frac{15.9\text{ kHz}}{19} = \mathbf{838\ Hz}$$

Good Luck

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