ECE 321: Quiz #2 Name _____ 9:00 / 11:00

Op-Amp Filters - April 13, 2017

1) X and Y are related by the following low-pass filter with real poles:

$$Y = \left(\frac{30}{(s+2)(s+5)}\right)X = \left(\frac{30}{s^2+7s+10}\right)X$$

What is the differential equation relating X and Y?

Differential Equation relating X and Y
$y'' + 7y' + 10y = 30x$

What is y(t) assuming $x(t) = 2 + 3\sin(4t)$

y(t) assuming x(t) = 2 + 3 sin(4t)
$y = 6 + 3.14\sin(4t - 102°)$

$s = 0$

$gain = 3$

$y = 3 \cdot 2 = 6$

$s = j4$

$gain = \left(\frac{30}{s^2+7s+10}\right)_{s=j4}$

$gain = 1.04 \angle -102°$

$y = 3.14\sin(4t - 102°)$

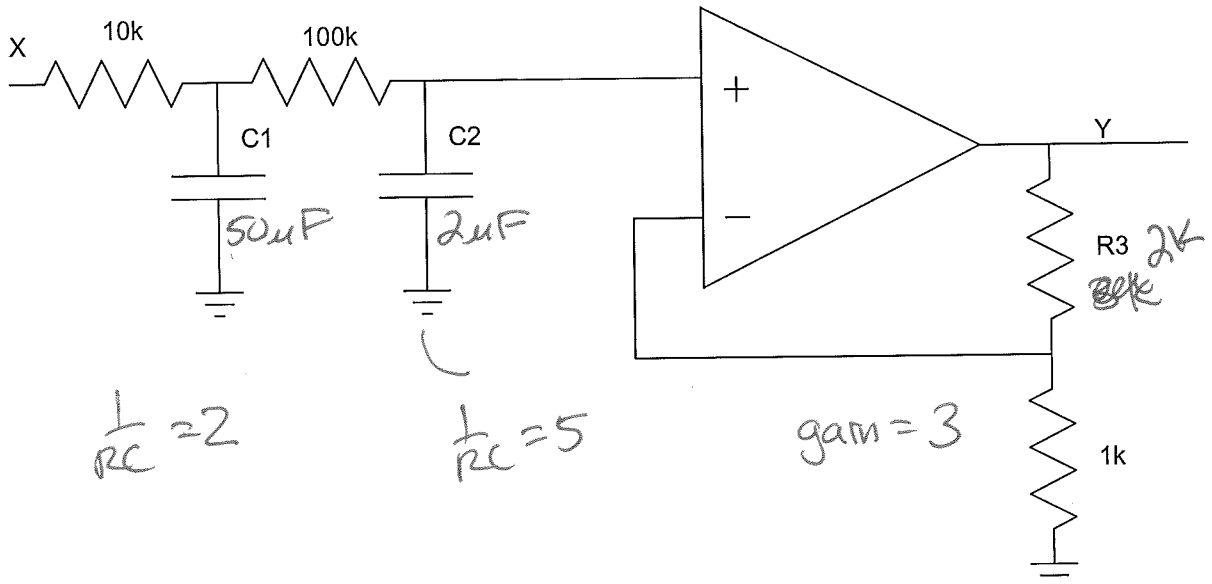
2) Find R and C to implement the following transfer function

$$Y=\left(\frac{30}{(s+2)(s+5)}\right)X=\left(\frac{30}{s^2+7s+10}\right)X$$

C1	C2	R3
50uF	2uF	~~20k~~ 2k

ok

20uF 5uF



3) X and Y are related by the following low-pass filter with complex poles:

$$Y = \left(\frac{30}{(s+2+j5)(s+2-j5)}\right)X = \left(\frac{30}{s^2+4s+29}\right)X$$

What is the differential equation relating X and Y?

Differential Equation relating X and Y
$y'' + 4y' + 29y = 30x$

What is y(t) assuming x(t) = 2 + 3 sin(4t)

y(t) assuming x(t) = 2 + 3 sin(4t)
$y = 2.06 + 4.36 \sin(4t - 51°)$

$s = 0$

gain $= 30/29$

$y = 2.06$

$s = j4$

gain $= \left(\frac{30}{s^2+4s+29}\right)_{s=j4}$

gain $= 1.455 \angle -51°$

$y = 4.36 \sin(4t - 51°)$

4) Find R and C to implement the following transfer function

$$Y=\left(\frac{300}{(s+2+j5)(s+2-j5)}\right)X=\left(\frac{300}{s^2+4s+29}\right)X$$

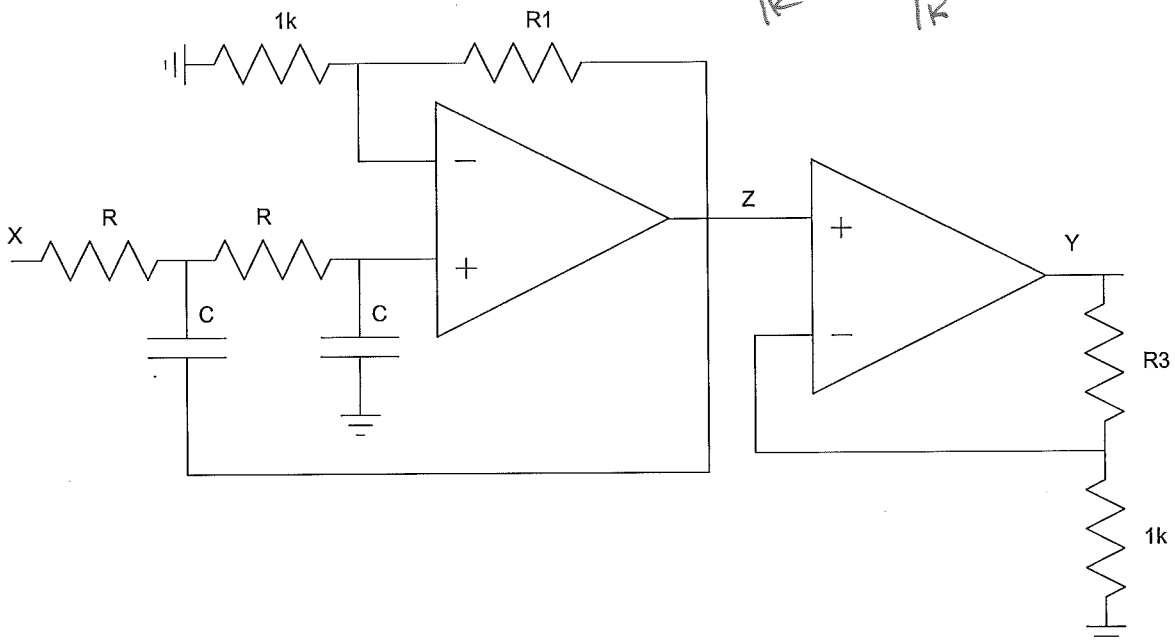
note: The filter below has the transfer function of

$$Z=\left(\frac{k\left(\frac{1}{RC}\right)^2}{s^2+\left(\frac{3-k}{RC}\right)s+\left(\frac{1}{RC}\right)^2}\right)X \qquad k=1+\frac{R_1}{1k}$$

R	C	R1	R3
100k	1.85μF	1.2572k	3.58k

$\frac{1}{RC}=5.385$

$\frac{(1+R_1)}{1K}\frac{(1+R_3)}{1K}=\frac{300}{29}$



$\frac{1}{RC}=\sqrt{29}=5.385$

total DC gain $=\frac{300}{29}$

$R=100k$

$C=1.85\mu F$

$(2.2572)(k_2)=10.34$

$k_2=4.58$

$(3-k)(5.385)=4$

$3-k=.7428$

$k=2.2572$

5) Find R and C so that the following band-pass filter has the transfer function of

$$Y = -\left(\frac{8s}{s^2+4s+100}\right)X$$

The transfer function for this filter is

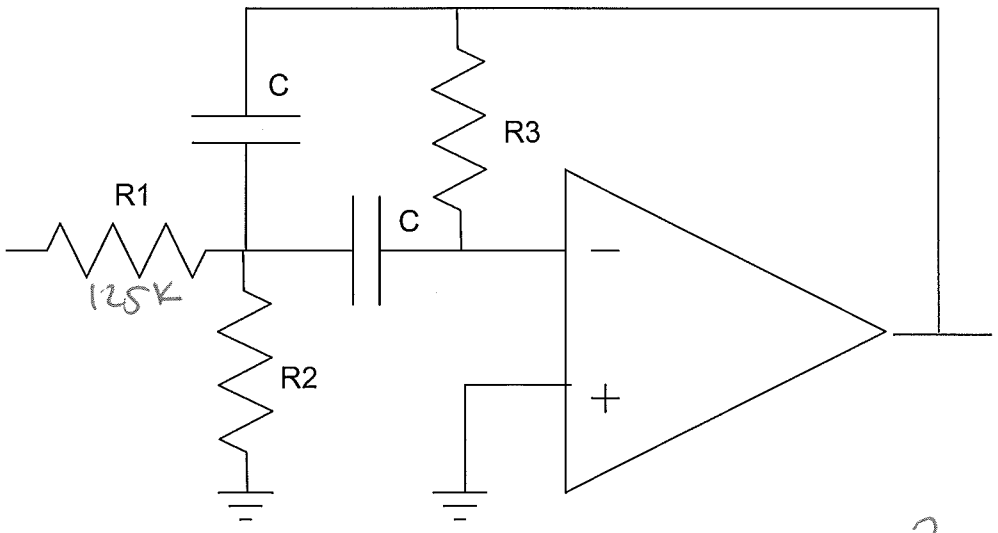
$$Y = \left(\frac{-\left(\frac{1}{R_1C}\right)s}{s^2+\left(\frac{2}{R_3C}\right)s+\left(\frac{R_1+R_2}{R_1R_2R_3C^2}\right)}\right)X$$

$$\frac{R_1+R_2}{R_1R_2R_3C^2} = 100$$

$$(R_1+R_2) = 100\,R_1R_2R_3C^2$$

$$R_2 = \frac{R_1}{100R_1R_3C^2-1}$$

R1	R2	R3	C
125K	23.8K	500K	1uF



$$\frac{1}{R_1C} = 8$$

$$R_1 = 125K$$

$$\frac{2}{R_3C} = 4$$

$$R_3 = 500K$$

$$\frac{R_1+R_2}{R_1R_2R_3C^2} = 100$$

Bonus! Why is Easter held after the 1st full moon following the spring equinox?

$$R_1+R_2 = R_2 \cdot 6.25$$

$$R_2(5.25) = R_1$$

$$R_2 = R_1/5.25$$

$$R_2 = 23.8K$$