ECE 321 - Homework #4

Filters. Project part (b). Due Monday, November 26th, 2018

Filters:

Problem 1) Assume x(t) and y(t) are related by the following transfer function:

$$Y = \left(\frac{10}{(s+2)(s+3)}\right)X$$

Find y(t) assuming

$$x(t) = 2 + 3\cos(4t)$$

Use superposition

x(t) = 2

s = 0

$$\left(\frac{10}{(s+2)(s+3)}\right)_{s=0} = 1.6667$$

$$Y = \left(\frac{10}{(s+2)(s+3)}\right)X$$

$$Y = (1.6667)(2)$$

$$Y = 3.3333$$

y(t) = 3.3333

x(t) = 3 cos(4t)   X = 3 + j0 (phasor form)

s = j4

$$\left(\frac{10}{(s+2)(s+3)}\right)_{s=j4} = 0.4472\angle -116^0$$

$$Y = \left(\frac{10}{(s+2)(s+3)}\right)X$$

$$Y = (0.4472\angle -116^0)(3 + j0)$$

$$Y = 1.3416\angle -116^0$$

$$y(t) = 1.3416\cos(4t - 116^0)$$

The total answer is the DC term and the AC term

$$y(t) = 3.3333 + 1.3416\cos(4t - 116^0)$$

Problem 2) Assume x(t) and y(t) are related by the following transfer function:

$$Y = \left(\frac{5s+2}{s^2+5s+300}\right) X$$

2a) Plot the gain from X to Y vs. frequency from 0 rad/sec to 30 rad/sec.

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w = [0:0.01:30]';
s = j*w;
G = (5*s+2) ./ (s.^2 + 5*s + 300);

plot(w,abs(G))
xlabel('Frequency (rad/sec)');
ylabel('Gain');
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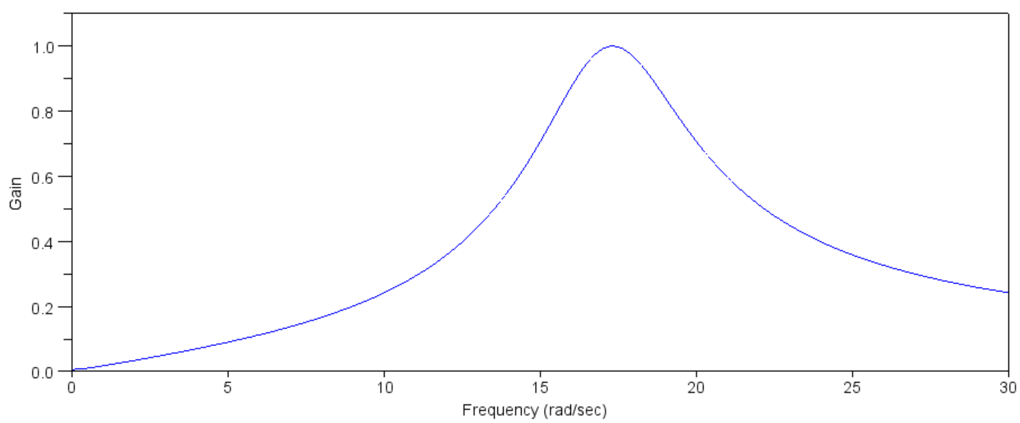


2b) Find the frequency, w, which results in the gain being a maximum (resonance):

$$x(t) = 2\cos(\omega t)$$

Find y(t) for this x(t).

The maximum is at w = 17.32 $\left(\sqrt{300}\right)$

$$\left(\frac{5s+2}{s^2+5s+300}\right)_{s=j17.32} = 1.0003\angle -1.3^0$$

$$Y = (1.0003\angle -1.3^0) \cdot 2\cos(17.32t)$$

$$y(t) = 2.0005\cos(17.32t - 1.3^0)$$

Project (part b):

Amplifier and Mixer

Problem 3) Requirements

Input: Two cell phones.

- A: 1Vpp analog signal, capable of driving 10mA
- B: 1Vpp analog signal, capable of driving 10mA

Output

- Y: -10V to +10V analog signal, capable of driving 10mA

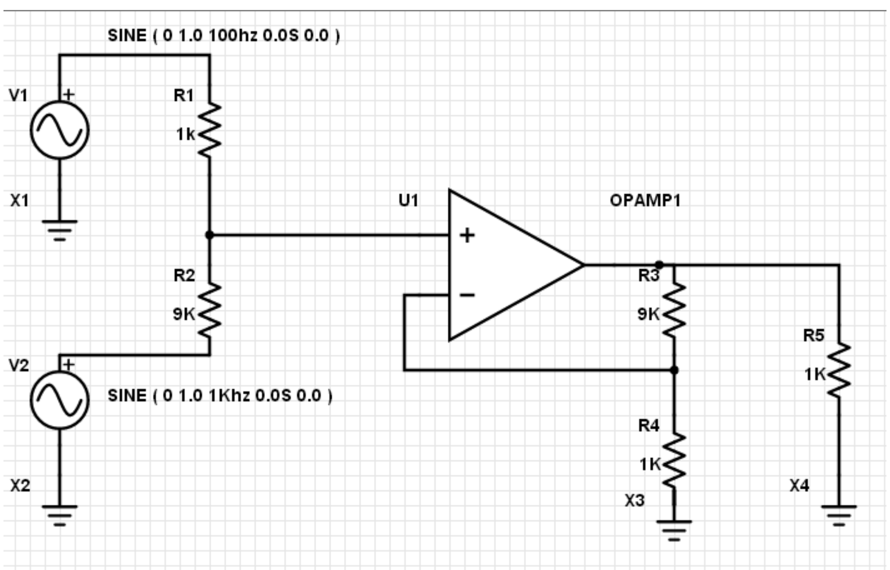
Relationship

$$Y = 10(\alpha A + (1 - \alpha)B)$$

Problem 4) Analysis

1V at 10mA = 100 Ohms. The impedance at the input must be at least 100 Ohms. Use a 10k potentiometer

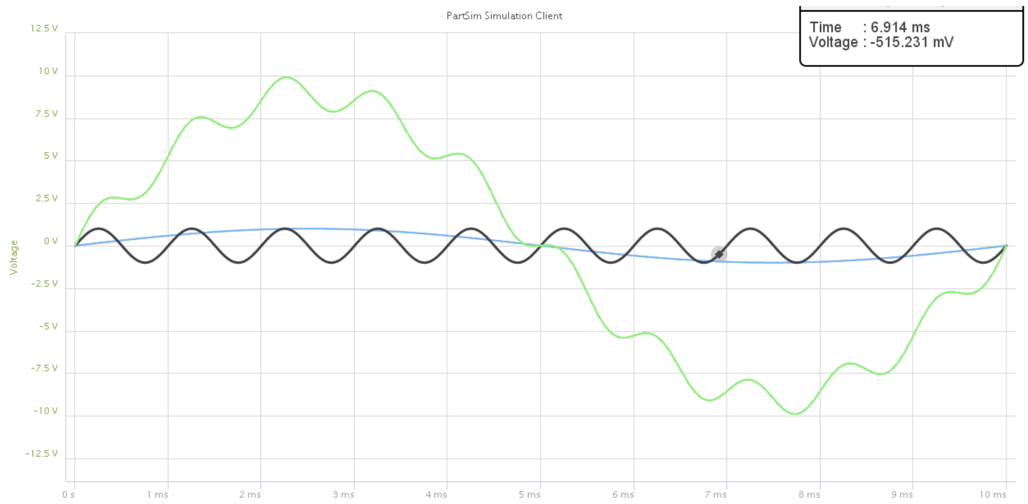
To model the 10mA @ 10V load, use a 1k resistor at the load



Problem 5) Simulate your circuit to verify it operates correctly. Check the voltages at

- At the endpoints
- One or two points in between

to see if they match your computations.



The output is

- 90% of a 10Vp 100Hz sine wave (10x the input), mixed with
- 10% of a 10Vp 1kHz sine wave (10x the input)

The result has a peak of 10V and a 1kHz component which is 1Vpp

Problem 6) Build your circuit in lab and verify it operates correctly. Check the voltages at

- At the endpoints
- One or two points in between

to see if they match your computations and simulation results.

Problem 7) Demo. Demonstrate your amplfier with the power amp from homework #1 (video or in person).