MT240_14_4_1 Cross over network

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Title

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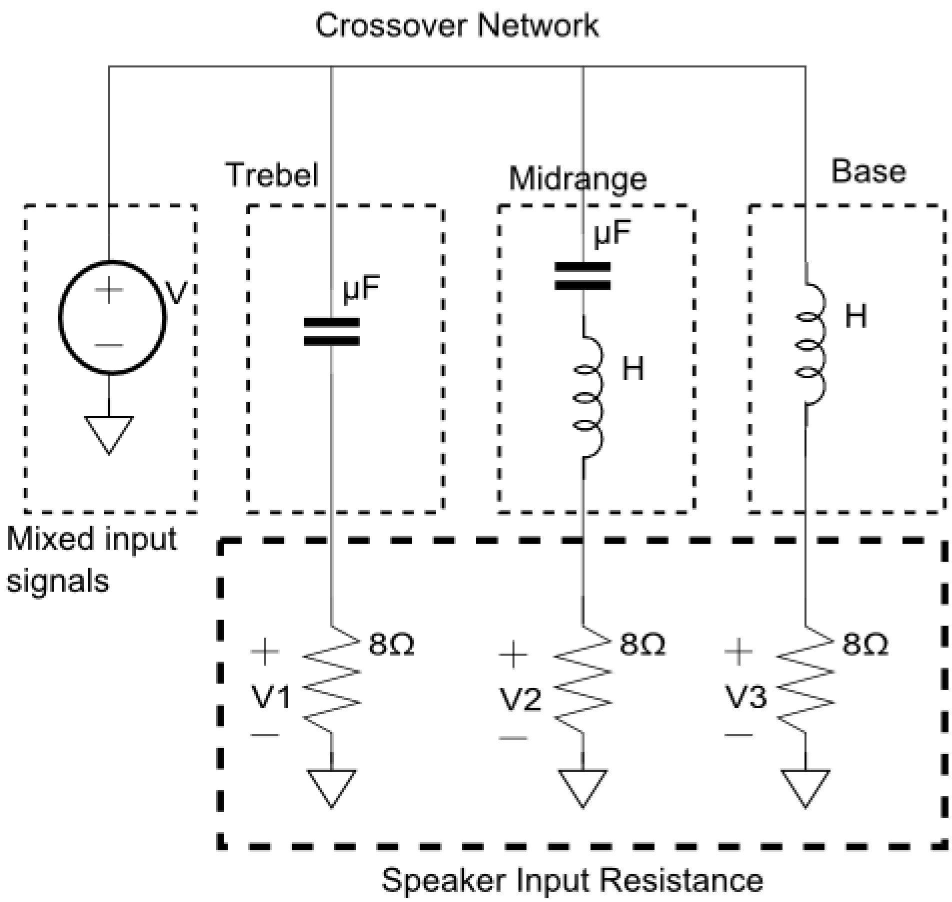
Description

The purpose of it this two week assignment is to help you evaluate your MATLAB skills that you have learned this semester by providing no MATLAB code. Exercise 1 is due the first week, and exercise 2 is due the second week.

A crossover network consists of a highpass, lowpass, and a bandpass filter. They are often used in stereo systems to separate a signal into three components: bass, treble, and midrange. You will design a basic crossover network as depicted in the image below according to the following specifications.

	Low Pass	Bandpass	High Pass
Lower cut off frequency	N/A	250 Hz	2000 Hz
Upper cut off frequency	250 Hz	2000 Hz	N/A



Exercise 1

Design the Lowpass and Highpass filter

1. Choose an appropriate inductor for the lowpass filter that will meet the specifications.
2. Choose an appropriate capacitor for the highpass filter that will meet the specifications.
3. Calculate the magnitude of the Lowpass and Highpass filter's transfer function as a function of frequency (rad/s) with w being w = 0:10*2*pi:3e5*2*pi.
4. Plot the magnitudes of the transfer functions on a bode plot. Remember that the y-axis of a bode plot is in dB and the x-axis is frequency in a logarithmic scale. For the frequency, plot in hertz and not rad/s.

Exercise 2

Design the Bandpass Filter

1. Calculate the bandwidth.
2. Solve for the inductor value using the bandwidth value.
3. Solve for the capacitor value.

4. Calculate the magnitude of the Bandpass filter's transfer function as a function of frequency (rad/s) with w being w = 0:10*2*pi:3e5*2*pi.

5. Plot the magnitudes of the lowpass, highpass, and bandpass transfer function on a bode plot. Remember that the y-axis of a bode plot is in dB and the x-axis is frequency in a logarithmic scale. For the frequency, plot in hertz and not rad/s.

Questions

Answer the question after completing the second exercise. There are no questions associated with the first exercise.

1. How could you design a bandreject filter that rejects frequencies between 250Hz and 2000Hz?

Useful Information

Design a Lowpas Filter

```
The bass speaker wants to attenuate all high frequencies and only pass
low frequencies without attenuation. An RL circuit does this perfectly
since inductors resist quick changes in current. The value of the
inductor is proportial to the resistor and the corner frequency in
rad/s. Note that the subscript B denotes Bass and the subscript c
indicates the corner frequency of the lowpass filter.
```

$$L_B = \frac{R_B}{\omega_c}$$

```
The transfer function of the RL circuit is
```

$$H(j\omega) = \frac{R/L}{jw + R/L}$$

```
The magnitude of the transfer function is
```

$$|H(j\omega)| = \frac{R/L}{\sqrt{\omega^2 + (R/L)^2}}$$

Design a Highpass Filter

```
The treble speaker wants to attenuate all low frequencies and only pass
high frequencies without attenuation. An RC circuit does this perfectly
since a capacitor cannot charge at high frequencies. The value of the
capacitor is proportional to the resistor and the corner frequency in
rad/s. Note that the subscript t denotes treble, and the subscript c
indicates the corner frequency of the the highpass filter.
```

$$C_T = \frac{1}{R_T\omega_c}$$

```
The transfer function of the RC circuit is
```

$$H(j\omega) = \frac{j\omega}{j\omega + 1/RC}$$

The magnitude of the transfer function is

$$|H(j\omega)| = \frac{\omega}{\sqrt{\omega^2 + (1/RC)^2}}$$

Design a Bandpass Filter

A bandpass filter has to reject low and high frequencies while allowing midrange frequencies to pass. We know that an inductor passes low frequencies, and a capacitor passes high frequencies. If we create an RLC circuit, the unattenuated midrange frequencies are located at the resistor. The first step in designing a bandpass filter is to calculate the bandwidth between the two corner frequencies. Note that the subscript m denotes midrange, the subscript c denotes the corner frequency in rad/s, the subscript 2 indicates the upper corner frequency and the subscript 1 indicates the lower corner frequency.

$$\beta = \omega_{c2} - \omega_{c1}$$

The inductor's value is proportional to the bandwidth and the resistor value.

$$L = \frac{R}{\beta}$$

The capacitor's value is related to the two corner frequencies, and the inductor.

$$C = \frac{1}{L_m \omega_{c1} \omega_{c2}}$$

The transfer function is

$$H(j\omega) = \frac{(R/L)\omega}{(j\omega)^2 + j\omega(R/L) + (1/LC)}$$

The magnitude of the transfer function is

$$|H(j\omega)| = \frac{\omega(R/L)}{\sqrt{[(1/LC) - \omega^2]^2 + [\omega(R/L)]^2}}$$

Bode Plot

A bode plot plots the output to input power ratio in decibels as a function of frequency in a logarithmic scale. The magnitude response of the transfer functions is the voltage ratio of the input and output voltages. The following shows you how to convert the magnitude response of the transfer function into decibels.

$$|H(j\omega)| = \frac{Vout(j\omega)}{Vin(j\omega)}$$

$$P = \frac{V^2}{R}$$

$$dB = 10\log\left(P_{out}/P_{in}\right)$$

$$dB = 10\log\left(\left(\frac{Vout(j\omega)}{Vin(j\omega)}\right)^2\right)$$

$$dB = 10\log\left(|H(j\omega)|^2\right)$$

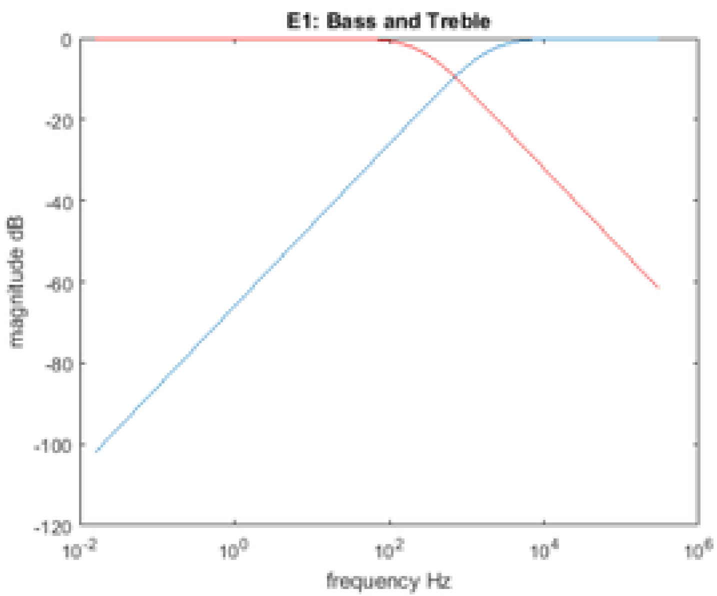
$$dB = 20\log\left(|H(j\omega)|\right)$$

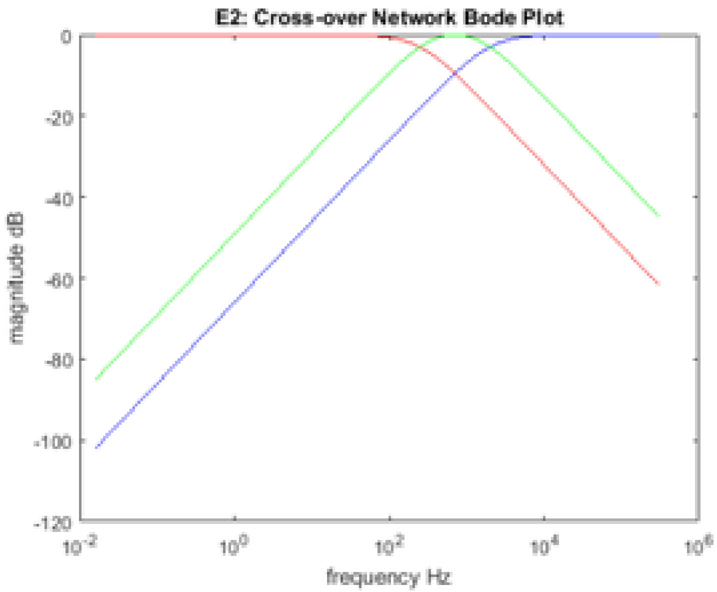
To plot the frequency axis in a logarithmic scale look up the MATLAB command 'semilogx'

Provided Code

```
% parameters
R = 8;                     % resistor, Ohms
w = 0:10*2*pi:3e5*2*pi; % the range of frequencies, rad/s
f = w/(2*pi);              % the range of the frequencies, Hz
```

Solution





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