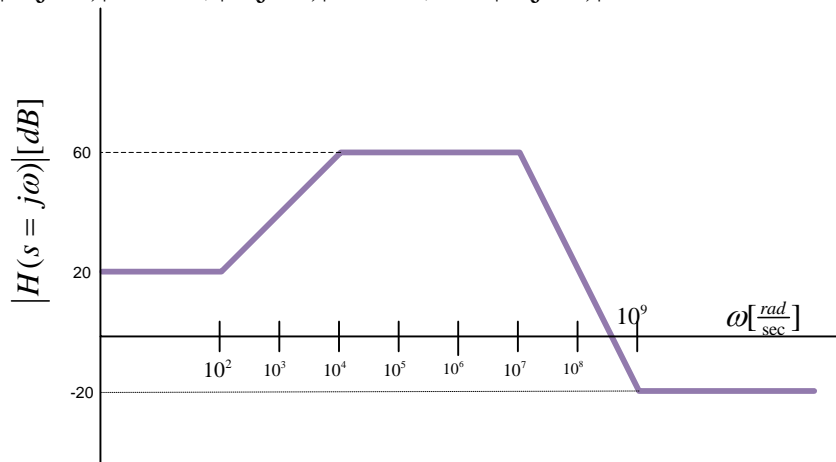


**Homework #8**  
EE233 Spring 2010  
Assigned Friday 5/28/08, Due **Friday** 6/4/08 in class

1. Given the following asymptotic magnitude plot,

(a) Determine the transfer function  $H(s)$  if the gains at the corner points are  $|H(j100)|=23$  dB,  $|H(j10^4)|=57$  dB,  $|H(j10^7)|=72$  dB, and  $|H(j10^9)|=-20$  dB.



(b) Use a math tool such as MatLab (Look under help for “Bode”) to plot the exact magnitude and phase response of the transfer function you determined in (a).

2. Nilsson & Riedel 15.12

3. Nilsson & Riedel 15.44

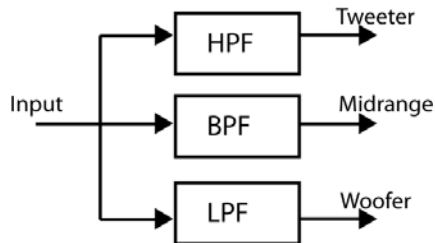
4. Nilsson & Riedel 15.48

5. Your research group has developed a small, actuated mirror for directing a low-energy laser beam to be used for projecting images directly onto the retina. The mirror is held by a short flexible armature, and is controlled by two small actuators that scan the laser across the eye at 15kHz. Unfortunately there is a resonant mode in the arm at around 2kHz that is excited by noise in the actuator control signal. The result is that even a small amount of noise at this frequency causes the mirror to vibrate severely, and reduces the image quality.

Your job is to implement a narrowband band-reject filter to eliminate noise in the motor control signal. The center frequency of your filter should be 2kHz, and the bandwidth should be 100 Hz.

Use reasonable values for each component. For ease of grading, use  $1\mu\text{F}$  capacitors when possible. Assume that you will use ideal op-amps.

6. Your company has developed a new type of loudspeaker system that uses very low power to reproduce sound. Like a home stereo system it uses 3 independent speakers, the woofer, midrange and tweeter, to reproduce the low, mid and high frequencies, respectively. The woofer is designed to reproduce frequencies up to 200Hz. The midrange delivers frequencies between 200 Hz and 1400 Hz. The tweeter is designed for frequencies above 1400 HZ.



**Figure 1: Block diagram of filter network showing three filters**

You have been given the job of designing a filter system to separate the signal and deliver only the desired frequencies to each speaker. Others on your team will take care of the rest (buffering of your input signal, level-adjustment to boost the filter output to the appropriate level, line conditioning to prevent RF interference, etc). Also assume, for this exercise, that phase-distortion is not a problem.

Each filter should be designed separately.

For the low frequency speaker use an active low-pass filter with two cascaded first order filters to get sharper roll-off (a steeper cutoff in the frequency plot). The cutoff frequency should be 100Hz and should have unity gain in the passband. Make sure to take into account the shift in cutoff frequency that occurs when you cascade the two sections.

For the midrange circuit implement a band-pass filter by cascading low-pass, high-pass, and inverting op-amp circuits. The resulting filter should pass frequencies from 100Hz to 1400Hz, and have a maximum gain of 10 (20dB).

The tweeters your company developed require more precise frequency selection. Implement a 4<sup>th</sup> order high-pass Butterworth filter with a cutoff frequency of 1400Hz.

For each of the three filters you should provide:

- A schematic of the op-amp circuit
- Specifications for all components used
- Transfer function,  $H(s)$ , for your circuit.
- Magnitude only Bode plot of the showing the frequency response of your circuit

Use reasonable values for each component. For ease of grading, use 1 $\mu$ F capacitors when possible. Assume that you will use ideal op--amps.

Bonus: Simulate your circuits in PSpice and show the frequency response.