ROSE-HULMAN INSTITUTE OF TECHNOLOGY
Department of Electrical and Computer Engineering

ECE 300 Signals and Systems — Fall 2002
Section 03 — B.A. Black

Problem Set 9

1. Consider a filter having frequency response $H(\omega)$. The "3 dB" frequency is that frequency for which the magnitude of the response has dropped by 3 dB. Show using hand analysis that the "3 dB" frequency is expressed by the following relationship

$$\left|H\left(\omega_{3cB}\right)\right| = \frac{1}{\sqrt{2}}\left|H_{PB}\right|$$

2. Consider a filter with a perfectly flat passband ($H_{PB} = 1$) and a group delay which varies linearly with frequency, having a slope of one. Use a computer tool such as MATLAB to perform the following:

   A. Plot the magnitude and phase of the frequency response of the filter..

   B. Find the output of the filter given a square wave input of peak-to-peak amplitude 1, DC offset 0.5, and period 10 μs.

   C. Plot the input wave and the output wave, and compare their shapes. How is the output wave impacted by the specified filter characteristics?

3. The frequency response of a particular class of Butterworth filters is given by

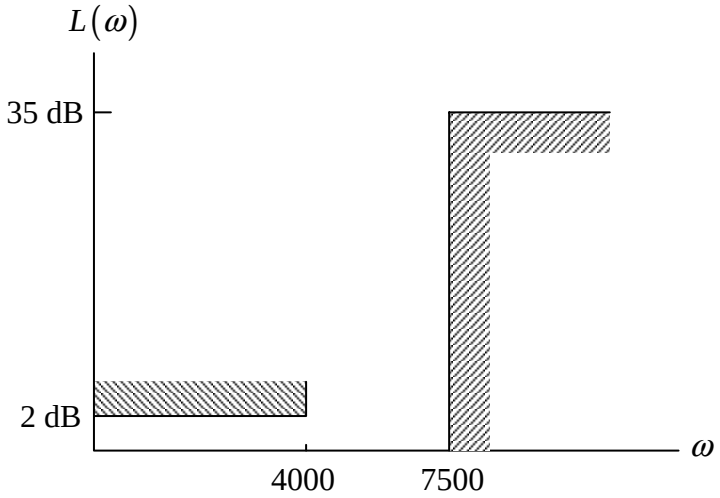
$$\left|H(\omega)\right|^2 = \frac{1}{1 + 0.015\left(\frac{\omega}{\omega_p}\right)^{2n}}$$

   where ω_p is the passband edge.

   A. Suppose the stopband edge is the frequency ω_s at which the attenuation reaches 35 dB. For this class of filters find and plot the transition ratio $t = \frac{\omega_s}{\omega_p}$ as a function of the order *n*, as *n* varies from one to ten.

   B. Find the 3 dB frequency of the Butterworth filter when $n = 5$.

4. A Chebyshev low-pass filter is required that will meet the specifications shown below:



Find values for the parameters ω_p, ε^2, and n so that $|H(\omega)|^2$ meets the specifications.

This problem set is due at the start of class on Tuesday, November 12.