

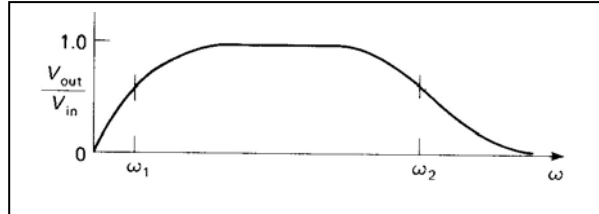
**Physics 326a-2011 Walter F. Smith**  
**Assignment 2**

**Due:** Friday 9-16-11 at the beginning of class

**Reading:** Lab Manual C11 to C12, H4 to H7

**Assigned exercises:**

1. Design a bandpass RC filter, *i.e.* a filter with the characteristic shown here;  $\omega_1$  and  $\omega_2$  are the 3 dB points. Limit the attenuation due to loading to no more than 1%; to simplify your life, use the “worst case” (see lab manual p. B12) versions of the input and output impedances.



2. a. If the voltage delivered to a fixed load resistor increases by 10 dB, by what multiplicative factor does the voltage increase?

b. By what multiplicative factor does the power delivered to the resistor increase?

c. By how many dB does the voltage change when it is increased by a factor of 10?

3. When a noise signal with rms amplitude 3 V is combined with an uncorrelated noise signal with rms amplitude 1 V, by what percent does the (total) rms noise amplitude increase?

4. The manual for your amplifier doesn't specify the current noise, which is surprising since it is very low. However, you can determine the current noise from the “noise figure”, which is quoted. This is essentially the ratio (expressed in dB) between the actual noise at the amplifier's output and the noise one would measure at the output of an ideal amplifier (*i.e.* just the amplified Johnson noise from the source resistance.) Look at the figure on p. 18 in your amplifier's manual for the graph of noise figure and further details. The manual is available online at <http://www.thinksrs.com/products/SR560.htm>

(Click on the link over at the right for “manual”.) At 1 kHz, estimate what source resistance value corresponds to a noise figure of 3 dB. (I realize this is slightly off-scale.) Use this information to determine the noise current of the amplifier. (At this frequency, the gain attenuation mentioned in the manual is not important.) I get about  $12 \text{ fA/Hz}^{1/2}$ , but your answer might vary a little from this depending on your estimate from the graph.

5. Prove the following, for both low-pass and high-pass filters:

A rule of thumb for RC filters is that the phase shift is about  $6^\circ$  from its asymptotic value at  $0.1 f_{3dB}$  and  $10 f_{3dB}$ .