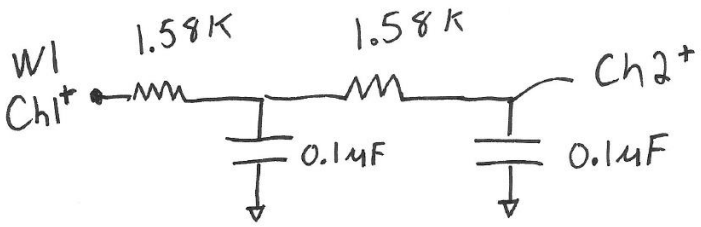
Problem set: Filters in series

Consider the circuit below.



The circuit comprises two low-pass filters in series. Build the circuit and create the experimental Bode plot using the Analog discovery network analyzer. You can decide the appropriate frequency range. Recall that the amplitude of the output sine wave for a single low-pass filter is:

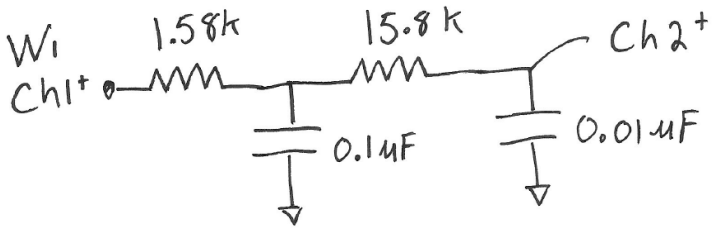
$$A = \frac{1}{\sqrt{1 + (RC\omega)^2}}$$
$$\phi = \text{atan}(-RC\omega)$$

When we have two filters in series with no current flow between them, then the amplitudes multiply and the phases add, namely the ideal response for 2 low-pass filters in series would be

$$A = \frac{1}{1 + (RC\omega)^2}$$
$$\phi = 2\,\text{atan}(-RC\omega)$$

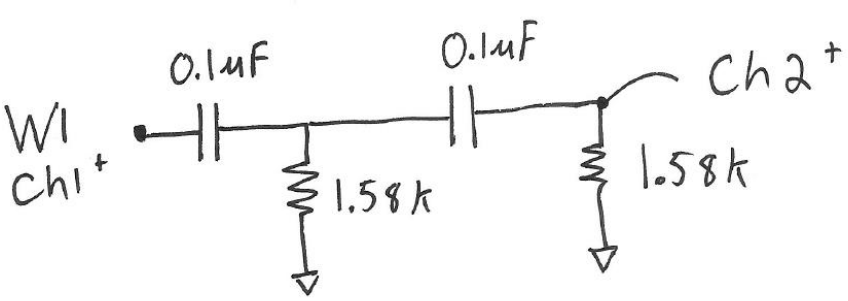
Create the experimental Bode plot and compare your results to the prediction above. Remember that the default for the experimental network analyzer is to use Decibels. To convert the analytical result to dB, take 20 log(A).

Now change the circuit as follows (note the new values of R and C on the second filter).



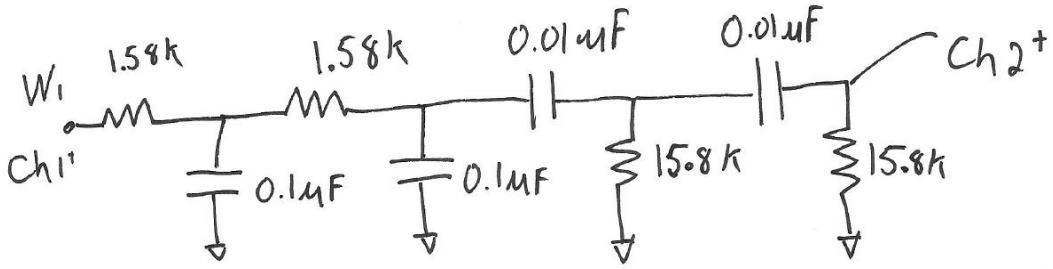
The RC time of the two filters is the same as circuit #1, but now the resistance of the second filter is higher. This strategy will tend to reduce the current flow from one filter to the next. This circuit should be a closer approximation to the ideal behavior where the two filters in series act as though they were each independent. Create the experimental Bode plot and save the data. Finally switch the order such that he first filter uses the 15.8 K resistor and 0.01 uF capacitor and the second filter uses the 1.58K resistor and 0.1 uF capacitor.

Now try two high-pass filters in series as shown below.



Compare the experimental Bode plot to the expected response if the two high pass filters were independent of each other (i.e look up the high pass filter response from the book and square the amplitude and sum the phase). For the low pass filter, just conduct this one experiment.

Finally try two low-pass and two high pass in series as shown below.



Create the experimental Bode plot using the Network Analyzer in Waveforms. Note that if there were no current flow between the filters, the amplitude response would just be the product of the four independent filters. Compare the experimental amplitude plot to the ideal theory. You can ignore the phase relationship.

For this assignment, turn in a bunch of Bode plots. All your plots should be clear, have axis labeled and have a short caption for each one so we know what circuit corresponds to what data and whether the data is a measurement, analytical expression or both.