**Problem set: Filters in series**



What is this Pset about?

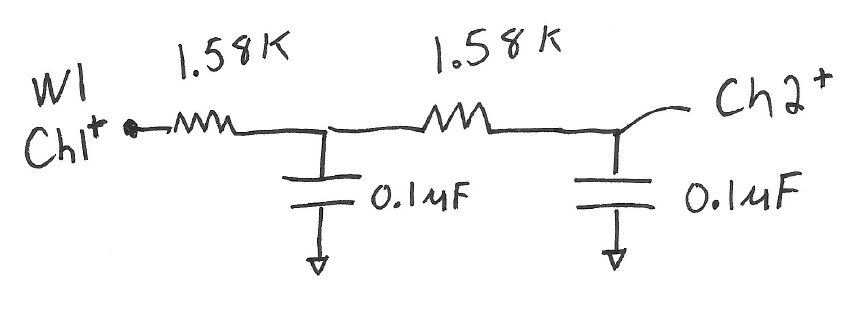
The world is noisy and it is hiding your signal. (Where did I put my little plastic chicken anyway?) But humans are clever and they invented tools to help you with this problem:

* We can choose whether we observe our signals in the time domain or frequency domain.
* We can design filter obstacle courses for our signal to reject unwanted frequencies, and allow our most precious plastic chicken frequency survive. 

What do we hope you will be able to do?

* See how filters work in series and see how they behave at their limits
* Learn how to design a series of filters so that they function as if they were independent of one another
* Become more comfortable with the relationship between time, frequency, time constant, and RC, and the units we use when describing them
* Become more comfortable with ways to describe amplitude and relative amplitude, and the units we use to describe them

**1.** Build the circuit below. The circuit comprises two filters in series.



**2.** Connect the Discovery to your circuit. 





**3.** Add to collect an *experimental* Bode plot 



**4.** Compare the experimental results with the theoretical values

Recall that the amplitude of the output sine wave for a single filter of this type is:

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

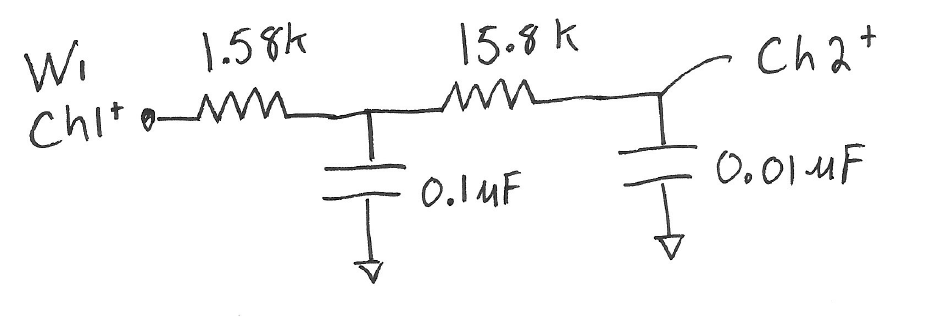


Compare your *experimental* Bode plot results to the prediction. 



**5.** Change the R & C values and generate the Bode plot.

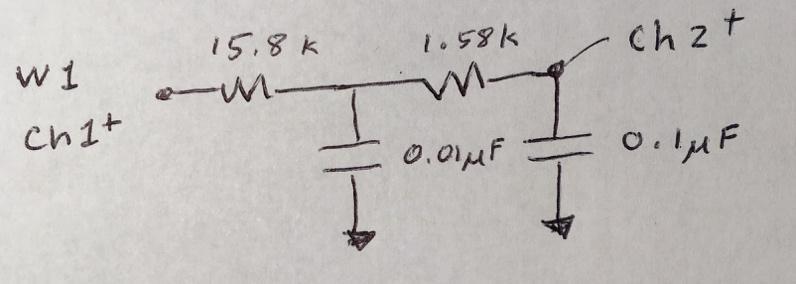
Now change the circuit as follows. 



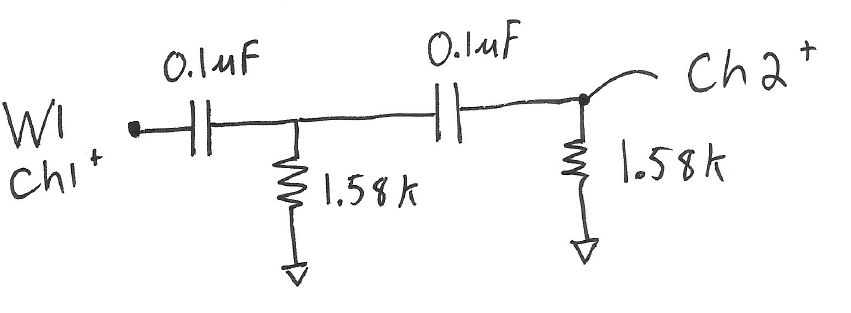
This strategy will tend to reduce the current flow from one filter to the next. This circuit should be a closer approximation to the ideal behavior where the two filters in series act as though they were each independent. 

Create the experimental Bode plot and export the data.

**6.** Swap the position of the two filters (now the 15.8k and 0.01 μF filter comes first) and generate the Bode plot. 



**7.** Try two different filters in series as shown.

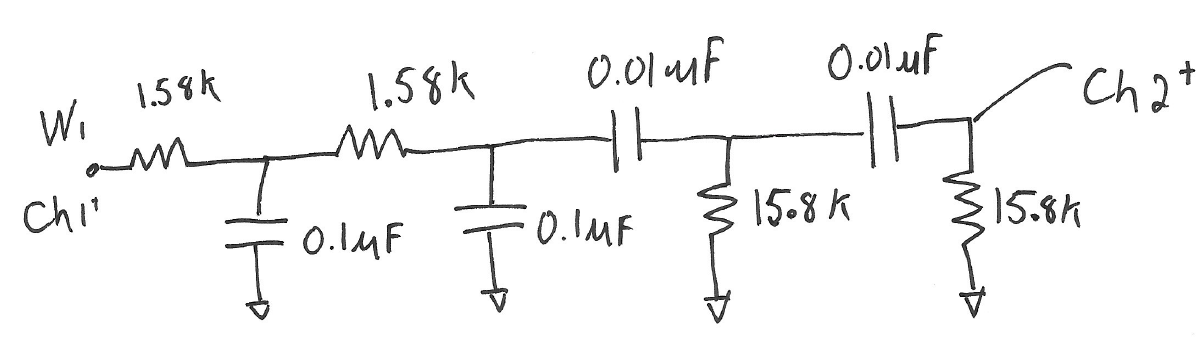


Generate and save the experimental Bode plot for the above circuit.

Like the two filters in series above, if these filters were acting independently of one another, we would simply square the equation for the amplitude, A, and sum the phase shifts of each filter. 



**8.** Now try two low-pass and two high pass in series as shown below.



Generate and save the experimental Bode plot for the above circuit.

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, A, plot to the ideal theory.

(You can ignore the phase relationship. )

**Deliverables**

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.