Department of Electrical & Computer Engineering
ECED – 3901 Design Methods II
Assignment #4
Due: July 6th, 2015 @ 12:30 PM - Submitted via BBLearn Website (PDF files only), OR printed files in 3901 Mail-Slot at ECED Office

1. Design a low-pass RC filter. The cut-off frequency of the filter in Hz is the lower four digits of your banner (B00) number. For example if your student ID is B0012**3456**, you must design a low-pass filter with a cut-off frequency of **3456 Hz**.

    a) Specify the *ideal* resistor and capacitor values to achieve this cut-off frequency. Be sure to specify your cut-off frequency too!

    b) Specify *actual* resistor and capacitor values. Use one of the capacitors in your design kit, and assume you have access to standard "5% tolerance" resistors (known as the E24 series).

    c) Calculate the cut-off frequency of your *actual* filter under two conditions:

        a. Assuming the resistor and capacitor values are as specified (i.e. a 2200 ohm resistor is actually 2200 ohms).

        b. Assuming the capacitor value is as specified, but the resistor values are at the lower end of their allowed tolerance range, assuming 5% tolerance. A 2200 ohm resistor for example could *actually* be a 2200 * (1-0.05) = 2200 * 0.95 = 2090 ohm resistor and 'within tolerance'.

    d) Using a circuit simulator, simulate the frequency response of the circuit from 0-20000 Hz. See https://www.youtube.com/watch?v=EeH3h7NU66o&hd=1 for an example of how to use the LTSpice IV Circuit simulator (which you can download at http://www.linear.com/designtools/software/ for Windows and Mac).

2. You have a desired signal at 550 Hz of 500 mV amplitude, and an undesired signal at 2 kHz of 2.2V amplitude.

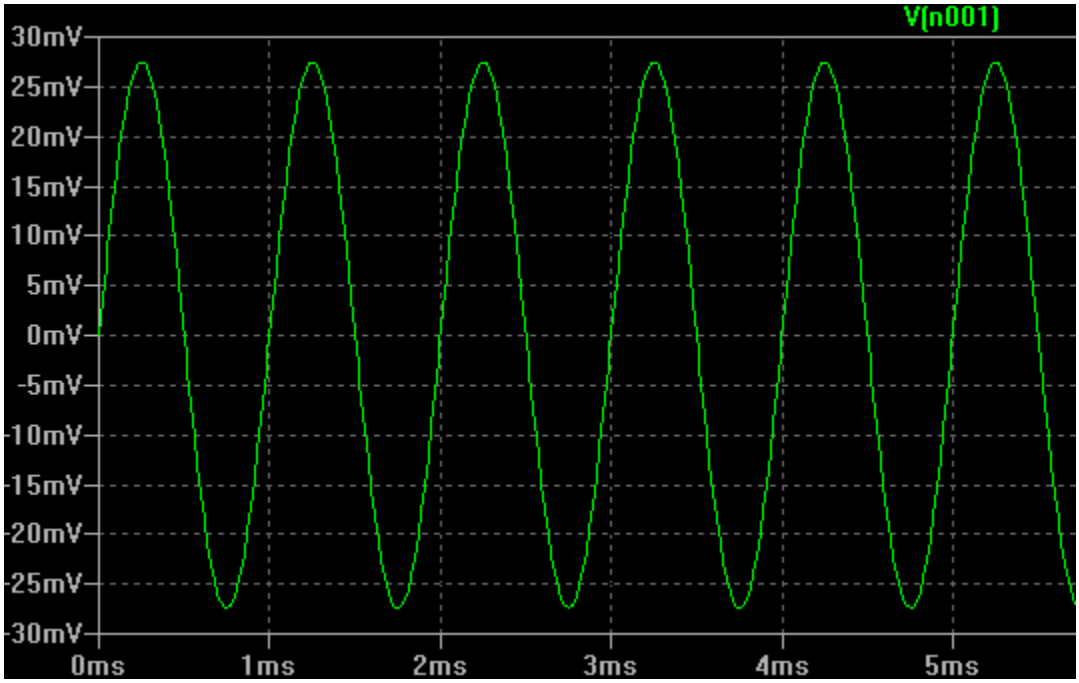
    1) What is the *signal to noise ratio (SNR)* in dB? The SNR is simply calculated as Vsignal / Vnoise, where the 'noise' is the undesired signal here. Be sure when you convert to dB to use the correct dB conversion (i.e. - power vs. voltage), and be careful of ensuring you have the correct sign (i.e. – ratios less than one should be a *negative* sign).

    2) Your system specification says the SNR should be +12 dB. What should the *voltage ratio* be for the signal to noise?

3) Assuming your desired signal remains constant at 500mV, what is the amplitude reduction of the noise (2 kHz signal) in dB you require?

4) Can you use a low-pass 1st order RC filter, to sufficiently supress the undersigned signal to meet the design requirements? If so design such a filter. You must ensure the final **SNR** is at least 12dB, it's insufficient to *only* check the suppression of the noise at 2 kHz. Your filter may reduce the amplitude of the desired signal as well as the undesired signal, which does not actually improve the SNR, since the ratio between the signal/noise is not improving.

3. Design an op-amp circuit with the following characteristics:
   - Power supply of the op-amp is single-ended, 10V supply.
   - Op-amp device is a TL-074
   - Input signal is a 0 - 55mV peak-to-peak, 1kHz, sine centered around 0-volts. The following shows a 55mV peak-to-peak signal – pay careful attention to peak-to-peak measurements, in this example the wave swings ±27.5mV.



   - Desired output is a signal of around 2-5V indicating the amplitude of the sine wave, which will be fed into an AVR input. This means it must perform both amplification and envelope detection.
   - Be sure to include the protection circuit to avoid blowing up the AVR input as required.
   - Simulate the circuit for two conditions and include a graph of the output showing the output voltage:
     - No input (i.e. 0 mV peak-to-peak)
     - 40mV peak-to-peak.