

ECE207 Lab 17: Low-Pass Filter

Objective: Design and evaluate the performance of a low-pass filter.

Deliverables:

1. Hardcopy of Bode plot comparing expected and actual frequency response
2. Hardcopy of “noisy signal” and “filtered signal” oscilloscope plots
3. Hand-in page

Approach:

1. The low-pass filter circuit (Figure 1) has a pass band gain of $-R_f/R_{in}$ and a break frequency of $(R_f C_f)^{-1}$ radians per second. Review the available circuit component values listed below, and choose values to achieve a pass band gain of 15 ± 2 dB and a break frequency of 1.0 ± 0.1 kHz. Resistance values in op-amp circuits need to be at least $1 \text{ k}\Omega$ and should not be larger than about $100 \text{ k}\Omega$. Show your design calculations on the hand-in page^A.

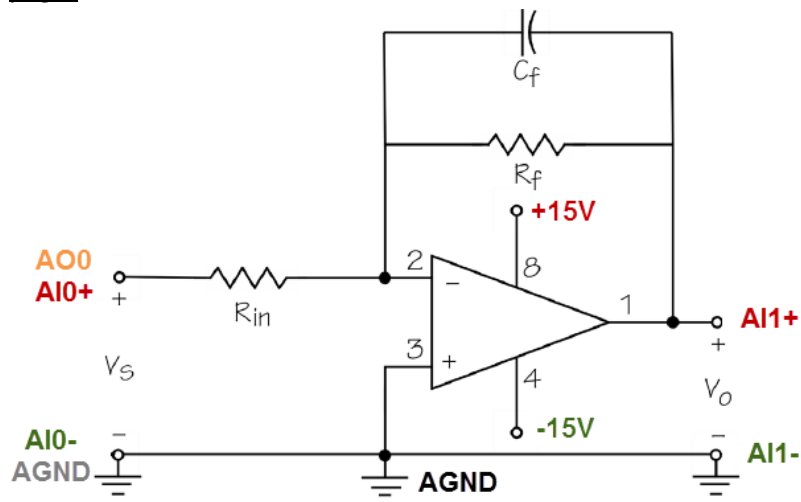


Fig. 1—Low-pass filter

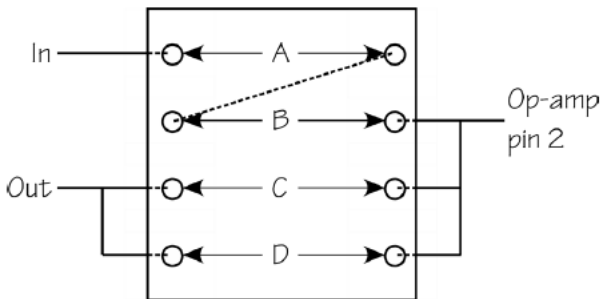
Available circuit components:

C: 0.1, 0.047, 0.01, 0.0047, 0.001 μF

R: 1, 2, 4.7, 6.2, 10, 15, 33, 68, 75, 91 $\text{k}\Omega$

2. Confirm the design of your low-pass filter with a MATLAB Bode plot. The transfer function of this low-pass filter is $H(s) = -(R_f/R_{in}) / (R_f C_f s + 1)$.
3. Measure and record the values of the three components^B that you chose for your design. Also record the DC gain in dB break frequency in kHz^C calculated from these values.

4. Construct the filter circuit using the op-amp card; populate the socket as follows: $A = R_{in}$, $B = \text{jumper}$, $C = R_f$, and $D = C_f$.



5. Connect the NI myDAQ according to the schematic diagram of Figure 1.
6. Run the NI ELVISmx Bode Analyzer to measure the frequency response of your design. Set the “Peak Amplitude” to 1.0 V and choose suitable values for start/stop frequency and steps per decade to obtain a smooth plot over the range 100 Hz to 10 kHz. Save your measurements to a logfile by clicking the “Log” button.
7. Obtain the MATLAB functions `mydaq_readbode.m` and `mydaq_comparebode.m` from ANGEL. Type `helpwin mydaq_comparebode` to learn how to compare the Bode plot of your transfer function $H(s)$ to the Bode plot of your measured data; use your measured component values to plot $H(s)$.
8. Attach hardcopy of your Bode plot^D. Also report the maximum error in magnitude and phase for your expected and actual results^E.
9. Obtain the `noisy_signal.wdt` waveform file from ANGEL for the NI ELVISmx Arbitrary Waveform Generator. This “noisy signal” represents a typical measurement scenario in which the desired low-frequency measurement signal (200 Hz sinusoid in this example) has been inadvertently corrupted by high-frequency noise (5000 Hz sinusoid in this example); this high-frequency noise is additive. Set up the Arbitrary Waveform Generator as follows:
 - a. Click the “ARB” instrument in the Instrument Launcher.
 - b. Open the “noisy_waveform.wdt” file and associate it with the AO0 output channel; click the “Enabled” box for this channel.
 - c. Leave the gain at 1 and set the “Update Rate” to 200 kS/s (“S/s” = samples per second).
 - d. Click “Run” and you should see the waveform appear in the graph.
10. Start the NI ELVISmx Oscilloscope, and view the input to your filter on channel AI0 and your filter’s output on AI1. Attach hardcopy of the oscilloscope displays for the original and filtered signals^F.
11. Discuss^G the effectiveness of your filter to reduce high-frequency noise. Try to quantify the reduction in the noise signal based on your knowledge of the Bode frequency response.

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Names: _____

Date: _____

A. Design calculations:

B. Measured component values: $R_{in} =$ _____ $R_f =$ _____ $C_f =$ _____

C. DC gain in dB: _____ break frequency in kHz: _____

D. Attach hardcopy of Bode plot comparing expected and measured frequency response.

E. Maximum magnitude error in dB: _____ max phase error in degrees: _____

F. Attach hardcopy of the original and filtered signals.

G. Discussion: