

Lab Exercise 2a: First Order Active Filters - PSpice

Purpose: Introduction to first-order active filters and how they differ from passive filters.

Equipment Required

Lab computer with PSpice and Excel

Components as required for the schematics on next page.

(Keep same components for next lab)

Prelab for Lab 2a meeting

1) Read H&H pages 175-180 (up to 4.07) and pages 184-185 (up to RIAA preamp), which review 261 concepts. Also Read H&H pages 185-186 (Section on RIAA preamp only) and pages 263-268 (up to 5.05), which discuss active filters.

2) **Sketch into your lab notebook** the expected gain (in dB) and phase responses of the four (2 passive and 2 active) circuits that are on the last page of this lab handout. Compute and label 3dB frequency for all the filters. Compute and label y intercepts for gain and phase plots of the filters. Have the frequency axis extends at least two decades above the highest and below the lowest 3dB cut-off frequencies of the filters for both gain and phase plots. Sketch all four gain plots on one graph (log-log) and all four phase plots on one graph (log-linear). Use 3 lines of notebook graph paper to represent a decade. Label phase axis -180 to +180 degrees. Label all plots. Make sure slopes of plots are correct.

3) **Prepare an excel workbook** with spreadsheets for recording your theoretical for passive filters and PSpice results for active filters: One sheet for capacitive filters and one for inductive filters.

4) Calculate the transfer functions (as functions of frequency in Hz) for the passive filters in figure on last page and **write them into your notebook**.

5) In Excel tables, compute the magnitude and phase of the transfer functions for the passive filters, using the component values in figures. For the parasitic resistance, use the value you measured in lab 1. Do this for frequencies 20Hz to 2 MHz at 5 values per decade. Create Bode (mag and phase) plots of the transfer function for passive filters. **Tape tables and Bode (mag and phase) plots in your lab notebook.**

Lab 2a meeting**1. Collect parts and measure them**

Collect the components needed to construct the active filters on next page (just one circuit at a time). Measure the components including parasitic resistance of inductor. Estimate and record the errors in these measurements. Save components for next lab meeting.

2. Use PSpice to analyze frequency response of first order active filters

Input into PSpice the passive and active and filters circuits that are in the figure on the last page. The figure includes two passive and two active filters (an RC filter and an RL filter), plus the sources for these circuits. They should all go into a single pspice schematic. Use a single VAC source for the sinusoidal input source to the circuits.

Set source to 1 VAC (**Why is this a good idea?**). Likewise, for the power supplies use one main source. If you label a source with “off page connectors,” and label the inputs to where the source is to be connected, then all the inputs are implicitly connected to the source (see figure). Label ALL the outputs of interest with “off page connectors,” which makes sorting out graphs much easier. In both inductive filters, include the parasitic resistance of the inductor. The parts libraries you will need are “analog,” “source,” and “opamp.” You will need the ground library “source” to get zero ground. Use measured component values in your PSpice. The LM741 pin-out is the same as the LF411 opamp that is on page 1078 in H&H. Note LM741 pins 1 and 5 offsets only need to be connected in precision circuits, which these aren't. Set frequencies to be measured from 10 Hz to 10MHz.

Probe the outputs to produce gain and phase plots (Bode diagrams) of the four filters. **Do the PSpice Bode plots for passive circuits match the excel plots you did for prelab?** Export the data for all four circuits to Excel and make Bode plots in Excel. Add passive and active filter data to your pre-lab plots. **Tape new excel tables and plots into your notebook.**

3. Use PSpice to analyze time response of first order filters

Compute the response times of your filters. Substitute the sinusoid source with a step source (e.g. VPULSE), and run a transient analysis on these circuits. You need not delete VAC, simply add VPULSE and move connection of Vs from VAC to VPULSE. Ensure that the step is long enough for the circuit to reach its final condition to within 1%. VPULSE has 7 inputs to set. Here are suggested settings: V1=starting voltage=0, V2=pulses voltage=1, TD=delay before pulse=?, TR=rise time=0, TF=fall time=0, PW=pulse width, and PER=period (not used here). Set the PW to be 10 times longer than response time of passive filters. Set delay to 1/10 of response time of filter, so you can see the start of pulse in your plots. **Note PSpice values used. Export the data to Excel and make plots in Excel. Tape tables and plots into your lab notebook.**

Data Analysis

1. Compare and contrast the Bode plots from passive and active filters. Compare and contrast observed gains, phases, roll-off frequencies, and slopes with theory of passive and active filters.

Questions

1. Discuss (qualitatively and quantitatively) the relationship between the frequency response and the step function responses of these filters.
2. Explain deviations of PSpice data from theory at high frequencies.

