

Lab Exercise 2b: First Order Active Filters-Expt

Purpose: Investigate the real world behavior of first-order active filters.

Equipment Required

1 – Oscilloscope	1 - Digital Multimeter
1 - Function Generator	1 - Triple Power Supply
1 – Protoboard	Components as required for the schematics on next page.

Prelab (Complete before lab meeting)

1. Theoretical filter performance

Write an equation for the complex voltage transfer function $G(f)$ for the two active filters in the schematics at the end of the lab (Circuits are the same as in Lab 2a). Include the parasitic resistance for the inductive active filter. Then write equations for the gain ($|G(f)|$) and phase responses of these filters. Use these equations to construct ideal Bode Diagrams (gain and phase) for these active filters in excel using values for components from lab 2a. Use separate sheets in excel workbook for the capacitive and inductive circuits. Combine this data in excel with the data from PSpice for the active filters and theory for the passive filters obtained in lab 2a. Plot the gain and phase plots for capacitive filters (active and passive) in one Bode diagram (two theory and one PSpice plot for both gain and phase graphs). Do likewise for the inductive filters. Use thick lines with no markers for theory plots. Use thinner lines with markers for PSpice data. Label well!!! Tape these plots into your lab book for THIS lab (not lab book for Lab 2a).

On each gain plot, draw and label the pass band, the pass band gain, slope in the stop band, and the cut-off frequency (-3dB point) for all circuits in plot. On each phase plot, label the cut-off frequency derived from the gain plot and draw a vertical line at the cut-off frequency.

2. Compare and Contrast

Briefly compare and contrast the theoretical results and the PSpice results for the active filters. Postulate on reasons for the differences between the theory and PSpice, if any.

3. Set up Excel Spreadsheet

Add to your two excel spreadsheets, a table (one for capacitive and one for inductive) with four columns: 1) Freq 2) Mag_source 3) Mag_out, and 4) Phase_out. Populate the Freq column with values from 20 Hz to 2 MHz, using the 1-2-5 convention of 3 points per decade. Insert 3 extra frequency points to columns for the decades below and above the cut-off frequency determined in part 1. (Example extra points 1.5, 3, and 7). Read rest of lab.

Lab

1. Measure gain and phase of frequency response of capacitive active filter

Build the active capacitive filter in the schematic. Use the function generator as the source. Probe the source and output voltages with the oscilloscope probes. Measure the amplitudes of the source and output voltages and the phase difference between output and source for all frequencies set up in your prelab. If the output gets noisy when the input signals are too negative, use the offset of the function generator to prevent this.

2. Investigate time response of capacitive active filters

Set function generator to 100 Hz square wave. Adjust oscilloscope so you can see max and min outputs (filling most of screen vertically) and adjust the offset of oscilloscope channel so the max and min are symmetrical about center horizontal line of oscilloscope. Set time axis of oscilloscope so you can see time response well and use cursors to measure time from start of

a square wave edge to the 50% point of the step response. With the cursors set to, print out the time response and record it in your notebook.

3. Investigate frequency and time response of inductive active filters

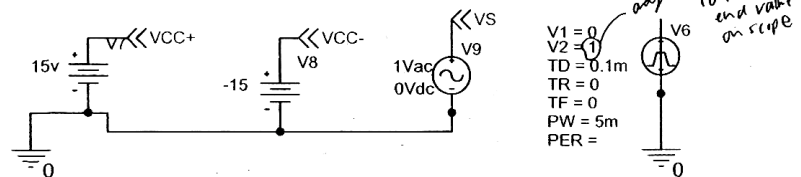
Repeat steps 1 and 2 for the inductive active filter.

Data Analysis

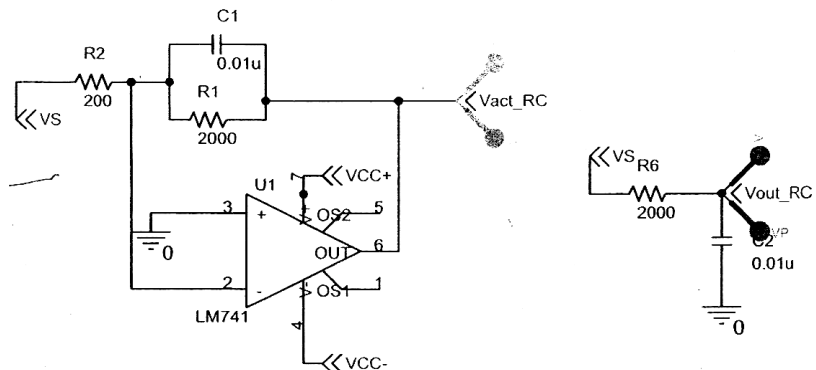
- Using the measured data you acquired, plot the actual Bode diagrams (gain and phase) for the two active filter circuits on the same plots prepared in the prelab. Tape new plots from Excel into your journal. Use the experimental data to estimate the passband gain, stopband slope, and the cut-off frequency of the actual active filters you built.
- Estimate the 1/e response times of your active filters from measurement on 50% response times. Calculate the 1/e response times from the cut-off frequencies of the active filters.

Questions

- Compute the percent error between the cut-off frequency predicted from theory and the cut-off frequency measured in the lab. Compute the error between the theoretical and the actual pass band gain measured in the lab. What could be the cause of any errors?
- For both the frequency and step function responses, comment on how well the experimental data agree with the response predicted by PSpice.
- At high frequencies the gain response of the experimental active filters may roll off more quickly or even turn back up. This behavior is not predicted by the theoretical transfer function for these circuits. Is it predicted by PSpice? Can you explain what might cause this behavior?

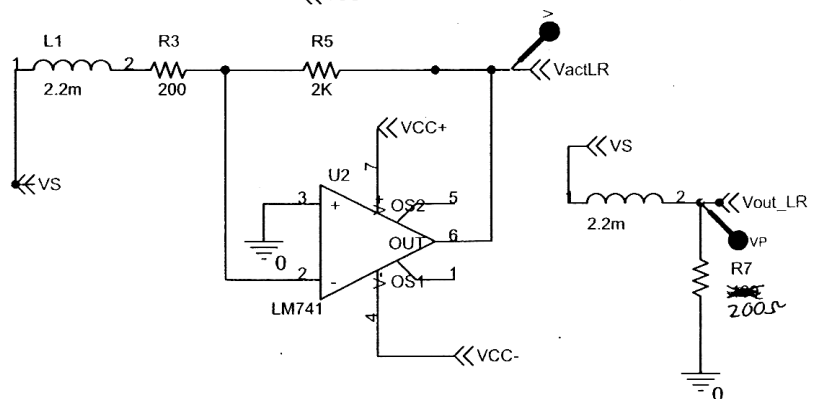


- Discuss (qualitatively and quantitatively) the relationship between the measured frequency response and the step function responses of these filters.



- Compare and contrast the behavior of these two active filter circuits.

- What is the highest frequency for which you would use each of these filters if you wanted "roughly ideal" behavior? Give your definition of "roughly ideal".



Lab 2b circuits are the same circuits as in Lab 2a.