Experiment 2

**Submission Template**

# The following should be included in your experimental checklist. Everything should be labeled and easy to find. Credit will be deducted for poor labeling or unclear presentation. ALL PLOTS SHOULD INDICATE WHICH TRACE CORRESPONDS TO THE SIGNAL AT WHICH POINT AND ALL KEY FEATURES SHOULD BE LABELED.

**Hand written schematics are required for physically built circuits, ONLY!!!**

# Part A – RC circuit, RL circuits, and AC Sweeps (22 points)

A.1 Include the following plots:

1. PSpice transient plot of RC circuit (in Figure A-2). (2 pt)
2. PSpice AC sweep plot of the RC circuit voltage. (2 pt)

1. PSpice AC sweep plot of the RC circuit phase. (2 pt)
2. PSpice transient plot of RL circuit (in Figure A-3). (2 pt)
3. PSpice AC sweep plot of the RL circuit. (2 pt)
4. PSpice AC sweep plot of RL circuit phase. (2 pt)

A.2 Answer the following questions:

1. What is the amplitude and phase of the output of the RC circuit at 1kHz? (2 pt)

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1. In what frequency range is the amplitude of the output of the RC circuit about equal to the input amplitude? In what frequency range is the amplitude of the output about zero? (2 pt)

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1. In what frequency range is the phase of the output of the RC circuit about equal to the input phase? In what frequency range is the phase of the output about -90o? (2 pt)

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1. What is the amplitude and phase of the output of the RL circuit at 1kHz? (2 pt)

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1. In what frequency range is the amplitude of the output of the RL circuit about equal to the input amplitude? In what frequency range is the amplitude of the output about zero? (1 pt)

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1. In what frequency range is the phase of the output of the RL circuit about equal to the input phase? In what frequency range is the phase of the output about +90o? (1 pt)

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# Part B – Transfer Functions and Filters (26 points)

B.1 Include the following plots:

1. PSpice plot of capacitor and resistor sum adding to the input voltage at 1kHz. (2 pt)
2. PSpice plot of capacitor and resistor sum adding to the input voltage at 10Hz. (1 pt)
3. PSpice plot of capacitor and resistor sum adding to the input voltage at 10kHz. (2 pt)
4. PSpice plot of transfer function of RC circuit (Figure A-2) with corner frequency marked. (2 pt)
5. PSpice plot of transfer function of RL circuit (Figure A-3) with corner frequency marked. (2 pt)
6. Wave Forms picture of RC circuit at 1kHz. (1 pt)
7. Wave Forms picture of RC circuit at corner frequency. (1 pt)

B.2 Answer the following questions:

1. Write out the mathematical expressions for the output voltage of the capacitor for the first RC circuit case you considered (plot 1). Write it in the form V(t)=A Sin(ωt+ϕ). (1 pt)

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1. What kind of filter is the RC circuit? (1 pt)

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1. At what frequency did you find the corner on the PSpice plot of the transfer function of the RC circuit? What frequency did you calculate using f=1/(2πRC)? How do the two compare? (3 pt)

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1. Find the transfer function of the RC circuit in terms of R, C and j. Take the limit of this function at very low and very high frequencies. Show that these results are consistent with the PSpice plot of the transfer function. (3 pt)

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1. What kind of filter is the RL circuit (Figure A-3)? (1 pt)

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1. Derive the equation for the corner frequency of the RL circuit. (2 pt)

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1. At what frequency did you find the corner on the PSpice plot of the transfer function of the RL circuit? What frequency did you calculate using the equation you derived in the previous question? How do the two compare? (3 pt)

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1. At what frequencies did the output of the RC circuit you built look roughly the same as the input? At what frequencies did the output disappear into the noise? (1 pt)

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# Part C – Transfer Functions, Filters, and RLC Circuits (16 points)

C.1 Include the following plots

1. PSpice plot of the transfer function of the RLC circuit in Figure C-3 (magnitude and phase), with three resonant frequency values marked [PSpice value, calculated value, experimental value] (original component values). (3 pt)
2. PSpice plot of the transfer function of the RLC circuit in Figure C-3 (magnitude and phase), with the resonant frequency marked (real component values). Also put the 5 experimental points on this plot. (3 pt)

C.2 Answer the following questions:

1. Why is it necessary to plot the phase and the magnitude of the transfer function separately, rather than on the same plot? (1 pt)

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1. For the three RLC circuits labeled (a), (b) and (c) in Figure C-1 indicate what type of filter the circuit is (high pass, low pass, band reject, or band pass filter) and explain why each is the filter it is. [Filter (d) is discussed in the Background section for part C.] Recall that a capacitor can be modeled as an open circuit al low frequencies and a short at high frequencies. Also recall that an inductor can be modeled as a short at low frequencies and an open circuit at high frequencies. Redraw the circuits at low and high frequencies and consider the value of the output between C and D for each case. You can check your answers in PSpice if you want. (3 pt)

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1. What is the phase shift between the output and input of plot 1 above at low and high frequencies? Does the phase shift change when you adjust the values of the components to create plot 2? Why or why not? (2 pt)

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1. Determine the resonant frequency of the RLC circuit you analyzed with PSpice. (This occurs at the extreme point.) Calculate the resonant frequency with the equation f = 1/[2π√(LC)]. How similar are they? What factors do you think account for the discrepancy? (3 pt)

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1. Why do you suppose it is that, in practice, we generally use filters designed with capacitors and not inductors? (1 pt)

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# Part D – Equivalent Impedance (12 points)

D.1 Include the following plots

1. PSpice AC Sweep plot of circuit in Figure D-1 with 5% point marked with cursor. (2 pt)

D.2 Answer the following questions:

1. When the capacitor is added, for what range of frequencies does the capacitor change the voltage across R2 by less than 5%? (1 pt)

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1. What is the amplitude of the output of the parallel RC circuit? What is the value you calculated for the equivalent impedance (Z) of the parallel combination at 1MegHz? (3 pt)

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1. Find the transfer function for the parallel RC circuit. Determine the magnitude of the transfer function at 1MegHz. Calculate the amplitude of the output voltage for this circuit at 1MegHz? How well does it agree with the output amplitude you found using PSpice? (6 pt)

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**List group member *responsibilities (4 pts)*.**

This section is NOW an opportunity for partners to write their contributions to the project and their overall participation/attendance in lab.

Jane Doe 50% - Part A and C experiment and write up

Jack Doe 50% - Part B and D experiment and write up

Ulysses Doe 0% - He did no work and unexpectedly did not show up to class on 2 out of 3 experiment days. To our knowledge he did not come to a make-up session. Please check with and contact Ulysses.

With our random attendance check, if we find that a student is given credit without attendance or a make-up attendance, all lab members will receive a zero for the experiment.

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**Summary/Overview** (0 to -10 pts) There are two parts to this section, both of which require revisiting everything done on this experiment and addressing broad issues. Grading for this section works a bit differently in that the overall report grade will be reduced if the responses are not satisfactory.

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***Experiment 2***

***Checklist w/ Signatures for Main Concepts***

INSERT SIGNED COPY OF CHECKLIST BELOW (OR ADD SCANNED PDF VERSION)