ME552 Fall12 Lab 1: Electronics

Home Work Assignment

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Guidelines:

I. Submission deadline: September 13th, Thursday, 5:00pm, Prof. Awtar's office.

II. The submission has to be a "paper submission" and not an "electronic submission". You may want to keep an electronic version for your own records.

III. Portions of the report may be hand-written or hand-drawn, as long as the work is very clear and legible.

IV. There is ONLY ONE submission required per team. However, there are strict requirements placed on a fair contribution from each team member. Each person should have equally contributed to the experiments and to the written assignment. In particular, for the assignment each person of the team must be intellectually involved in each problem. You cannot divide up the various questions among various members of team. Each team should sit down, discuss, and work on each component of the submission together.

V. Please download and print the "Teamwork Participation Pedge.pdf" form that may be found in the "Course Overview and Syllabus" folder under Resources on Ctools. This form should be filled out and attached as the cover of your submission.

VI. Any questions about this assignment should be posted on Ctools → Forums.

Questions (Total 100pts):

1. Design a lead-lag compensator (on paper) using resistors, capacitors and op-amps to achieve the following transfer function:

$$G(s) = \frac{(1+0.1s)(1+5s)}{(1+0.01s)(1+10s)}$$

   a. Draw a clear schematic of your electrical circuit showing all connections that you would actually make in an experiment.

   b. Present a detailed step by step derivation that shows how your proposed circuit will achieve the above relation between the input and output voltage signals.

   c. Explicitly list any and all assumptions that you are making in arriving at the above result.

   d. Make a list of all the physical values of the components that you need in your circuit. How did you decide on what wattage rating and/or voltage rating is appropriate for the physical components that you have specified for your hardware experiment? You will have to refer to component data-sheets in some of these cases.

e. Refer to the "Lab 1 Instructions" document to build the above circuit and collect relevant experimental data.

f. Create two Bode plots that include magnitude (of the ratio of output to input) and phase (of the output w.r.t. the input) for the above transfer function – one experimental and the other theoretical. It is recommended to export the measured data into Matlab and carry out the plotting using Matlab.

To find the magnitude and phase of the output of the circuit over a relevant range of frequencies, you can measure the output magnitude ratio and relative phase at each frequency of interest, one by one, manually, or alternatively you can also automate this measurement process using LabView. For the latter, you will have to learn how to do this by putting in a bit extra effort in programming (Some useful instructions for doing this have been provided in the Lab 1 Instruction document). You may find automation of this measurement process to useful for the upcoming labs as well. In general, you should have at least 20 frequency data points. More data points are better to generate a good-quality Bode plot.

Present both plots on the same graph so that the theoretically predicted result can be compared with the experimental result. It is strongly recommended that you carry out this plotting using MATLAB.

g. Comment on how the theoretically predicted result compares with the experimental result. Explain possible reasons for any discrepancy that you see between the two.

h. For both your theoretical prediction and experimental measurements, what is the maximum phase angle that you see and at what frequency? Similarly, what is the minimum phase angle that you see and at what frequency? Look for and describe a qualitative correlation between the magnitude and phase of the circuit transfer function on the Bode plot?

i. While holding the frequency at 1Hz, measure the magnitude and phase of the above circuit / transfer function as you increase the amplitude of the input from a low value to a high value. Use the amplitude 0.5V, 1V and 2V. Repeat this with frequency 100Hz. Theoretically, would you expect the magnitude and phase of the circuit to remain constant? Why? Experimentally, do you see the magnitude and phase of the circuit remain constant? Explain why or why not?

j. Present the front panel and the block diagram of the Labview program. Explain clearly how you generated the Bode plot.

2. Design a circuit (on paper) to sum four analog voltages, as shown below, using resistors, capacitors, and ONLY one op-amp

$V_{out} = a_1 V_1 + a_2 V_2 - a_3 V_3 - a_4 V_4$, where $a_1 = 1$, $a_2 = 2$, $a_3 = 3$ and $a_4 = 4$

a. Draw a clear schematic of your electrical circuit showing all connections that you would actually make in the hardware.

b. Present a detailed step by step derivation that shows how your proposed circuit will achieve the above relation between the input and output voltage signals.

c. Explicitly list any and all assumptions that you are making in arriving at the above result.

d. Make a list of all the physical values of the components that you need in your circuit. How did you decide on what wattage rating and/or voltage rating is appropriate for the physical components that you have specified for your hardware experiment? You will have to refer to component data-sheets in some of these cases.

e. Refer to the "Lab 1 Instruction" document to build the above circuit and collect relevant experimental data.

f. Feed the following 3 sets of input voltages to the voltage summer one by one and measure the output of the circuit. Present LabView screen-shots as proof.

Set 1

	V1	V2	V3	V4
Amplitude	2V	4V	1V	3V
Frequency	0Hz	0Hz	0Hz	0Hz
Offset	0	0	0	0
Phase	0	0	0	0

Set 2

	V1	V2	V3	V4
Amplitude	6V	4V	2V	1V
Frequency	0Hz	0Hz	0Hz	0Hz
Offset	0	0	0	0
Phase	0	0	0	0

Set 3

	V1	V2	V3	V4
Amplitude	6V	7V	2V	3V
Frequency	0Hz	0Hz	0Hz	0Hz
Offset	0	0	0	0
Phase	0	0	0	0

g. Feed the following 2 sets of input voltages into the voltage summer one by one and measure the output of the circuit. Present LabView screen-shots as proof.

Set 1

	V1	V2	V3	V4
Amplitude	3V	6V	0V	0V
Frequency	4Hz	4Hz	0Hz	0Hz
Offset	0	0	0	0
Phase	0	90 deg	0	0

Set 2

	V1	V2	V3	V4
Amplitude	0V	0V	2V	3V
Frequency	0Hz	0Hz	2Hz	2Hz
Offset	0	0	2V	0
Phase	0	0	0	45 deg

Present LabView screen-shots as proof.

Explain your results. Do you see any unusual or unexpected phenomena? If so, explain possible reasons for your measured outputs.

h. Use this circuit to create a beating signal (for example, shown below) at the output. Submit LabView screen-shot and state the values and nature of V_1, V_2, V_3, and V_4 used. Additionally, provide a mathematical analysis that shows how a combination of the inputs that you have used should result in a beating signal. (5)