ELEC/PHYS 4680/5680
Quantum Computing Technology Laboratory

Experiment #3: Analog Amplifier Frequency Response

Prelab Assignment

Overview:

There are several tasks that you can take prior to the first in-lab meeting for this experiment that will allow you to be more efficient during your limited in-lab time. Some of this information (mostly the reading material) has already been communicated to you through Canvas. Other work is new, and calculation-oriented. You do *not* need to submit this pre-lab work other than as part of your Team Reports. However, you should each complete the calculations individually before the first day (Wednesday 9/25) and then compare your results *as a group* to determine consistent answers that will then be included in your Team Report. Any questions on this assignment should be directed to Martin.

Reading Material (all):

Read Chapters 1 (historical background), Sections 2.1-2.5 (circuit theory review), Sections 3.1-3.3 (ideal opamp review), and Sections 5.1-5.4 (feedback theory; much of Sections 5.2 and 5.3 can be skimmed—the important result is in Section 5.4) of *Op Amps for Everyone* by Ron Mancini (Texas Instruments Design Reference SLOD006B). You will, when studying data sheets, also find Chapter 11 (opamp parameters) highly relevant and useful. Despite the *number* of sections assigned, their overall *length* is reasonably manageable. Corresponding chapter & section numbers from the published book are listed in Canvas for those of you using that as a reference.

Reading Material (graduate):

Add Section 5.5, which introduces the concept of multiple poles, and their effect on the Bode plot.

Computation Material (graduate):

Read up (your choice of source material) on non-linear curve fitting or parameter extraction. The specific curve you will be fitting is a single-pole roll-off transfer function. Within an environment that you are comfortable with, find a software package that will perform this fit.

Find a basic SPICE modeling package and begin various tutorials in modeling simple inverting and non-inverting opamp circuits with vendor-supplied macromodels.

Note: As graduate students, you are expected to act more independently than undergraduate students; hence, we are not providing specific references or packages for this material. If you are having difficulty identifying appropriate material, contact the instructors.

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Tasks (1a: *Estimate the GBP of the 741 opamp*)

A. *Prelab (all):* Describe the difference between gain in linear, dimensionless units (a simple ratio) and decibels (dB). dB is typically applied to power; definitions for amplitude are critically different. Write the equations for converting between linear units and amplitude dB *in both directions*; you will be using these frequently. What dB corresponds to a voltage gain of 5 V/V? What is the voltage gain corresponding to 40 dB? What *power* gain corresponds to -3 dB? What is the equivalent *voltage* gain at -3 dB? Note: even if you know these values from prior courses, you should still perform the calculation and show your work. (*This instruction applies throughout this course!!*)

B. *Prelab (all):* Assuming that GBW is constant, write gain (A) as a function of bandwidth (f_c) and vice versa (BW as a function of gain).

4. *Prelab (all):* What is the allowed range on the M2k input? If the maximum output voltage swing of the UA741 is about ±12 V with a ±15 V supply, what is the maximum drive voltage (from the Scopy NA panel) that should be used for each EB gain? Make a table of these values, showing your calculations.

14. *Prelab (grad only):* Write the ideal complex transfer function and convert to magnitude and phase that you would expect to see on the Bode plot. You may leave the DC gain (use variable A_{dc}) and corner frequency (use variable f_c) as unknowns. What is the gain at f_c?

Tasks (1c: *Characterize high-performance opamp circuits*)

3. *Prelab (all):* Review the data sheets (provided on Canvas) of the AD797, AD848, ADA4898-1, and LMH6624 opamps. Create a table of operating parameters including GBP, input offset voltage, maximum bi-polar supply voltage, output voltage swing, and minimum stable gain (if noted), and any others you feel might be relevant. Save this information since you will be adding new parameters to it for Lab #4. Note that some parameters may vary depending on the supply voltage; you will use a ± 6 V supply for these circuits. In cases where a “typical” value is listed in the datasheet, use that; if only a minimum or maximum value is listed, use that and make a note of it.

4. *Mid-lab (all):* The nominal gains of these circuits are 15, 10, 10, and 100 for the AD797, AD848, ADA4898-1, and LMH6624, respectively (“Box #2”). On the first active lab day, inspect and note the resistor values of each EB and calculate the expected gain. The expected gain will be different from the nominal gain because of limited resistor values.

5. *Mid-lab (all):* Using the table from 1c.3, note the expected maximum output voltage swing and calculate for each circuit the maximum drive voltage that will not saturate the output.

8. *Prelab (all):* What is the minimum signal that the Scopy NA can source? Input (read)?