MASSACHUSETTS INSTITUTE OF TECHNOLOGY
Department of Electrical Engineering and Computer Science

6.302 Feedback Systems

Spring Term 2008 — Issued : Wednesday, April 16, 2008
Motor Lab Take Home Quiz — Due : Tuesday, April 29th, 2008

Instructions:

1. This examination consists of a Motor Lab Writeup and two problems.
2. You must do the motor lab writeup ALONE. You may discuss your lab results with your partner but the writeup must be done solely by you. As for the questions, treat this assignment as an examination. DO NOT discuss the questions or your answers with other students.
3. This quiz is completely open book. You may consult with the 6.302 staff and any notes, books, computers, or other inanimate objects that you find helpful, with the exception of course bibles, which you may not use.
4. Your Motor Lab Writeup along with answers to the problems in this quiz must be handed to a 6.302 staff member no later than 4:00 pm on the above due date. No extensions will be given.
5. Your motor lab writeup MUST be TYPED and stapled separately.
6. Your solutions to the problems can be written by hand and should be stapled separately. Please neatly summarize those on one page stapled to the front of them. You will be penalized for not following directions. Draw all sketches neatly and clearly. Remember to label ALL important features of any sketches.
7. Make sure you put your name on both the Writeup and the problem solutions. Clip them together with a paper clip.
8. Neat solutions get more partial credit than sloppy solutions. This isn't fair, but it's a fact of life. If your solution is written in cursive with a blunt, hard pencil, the grader may not take the time to carefully read every word of your analysis. That would probably have unfortunate consequences on your final grade.
9. Once again, treat this assignment as an examination. Do not discuss the two problems with others. Infractions will be dealt with severely.

Good luck.

PART 1
Motor Lab Writeup

Assignment

Now that you have completed all of the short motor lab assignments, with their associated informal writeups, we ask you to complete a formal writeup of all four labs. This summary should include a well organized brief description of the experiments you performed and why, a very brief summary of results, and any comments which support your presentation.

Your report should demonstrate that you fully understand **what you did in the labs** and **what your results mean**.

What we are looking for is a concise technical report that describes how to characterize and use a motor to build velocity loops and position loops. You should be able to keep this paper as future reference, in case your ever need to design a servomechanism professionally. We are NOT looking for a play-by-play of the measurements you made in lab (we already have that), but instead a summary of the concepts that you demonstrated. We are looking for you to make the connection between the laboratory experiments and the concepts we have been presenting in lecture and recitation.

The lab reports must be written **individually, must be typed, neat, and professional looking, and should be NO MORE than 6 sides of a page long (equivalent to 3 two-sided sheets of paper) - INCLUDING figures**. Additional lines of text beyond 6 pages will be penalized 1% off your grade for each line, additional figures beyond 6 pages will be penalized 5 % off your grade for each figure. Do not shrink the font size (minimum size 10pt) in order to make it fit. The use of illustrative Root Locus, Nyquist and Bode plots might be good idea. Incorporate those into the report well, with appropriate references and labels. You may include a cover page for your report which will not be counted against you.

Examples

As a brief example of the kind of report that we are looking for, here is a short excerpt from a very good (but fictional) report.

> ... These results make sense. As we can see from the Bode plot in Figure 13, lead compensation vastly improves the phase margin of the system, reducing the overshoot to 10%. This is less than the expected overshoot, but this discrepancy can be explained by comparing the assumed density of the corn syrup to the measured density. Plugging the measured density into Equation 5 reduces our measurement error to five percent, as shown in the table on Page 3...

And here is an excerpt from a very bad report.

> ... Then we set the compensator dial to 734 and applied a square wave of 2 Hertz and measured the risetime. Then we measured 45.349 ms, 44.026 ms, 39.926 ms, and 51.004 ms, the average of which is 45.07625 ms, which is an error of 43.651% from the result that we got in the prelab. This is probably due to measurement error...

Do a good job :-)

PART 2

Problem 1: Motor Response

For the motor that you used in the laboratory, sketch the position output θ for the following test inputs. In your sketches, label the characteristics of each curve (linear, exponential, etc.). Make reasonable approximations based on your experience with the dynamics or rate of response of the motor. Also, please note that inputs A–D assume a voltage drive V_m, while inputs E–F assume a current drive I_m.

A.)
Short Pulse

B.)
Unit Step

C.)
Unit Ramp

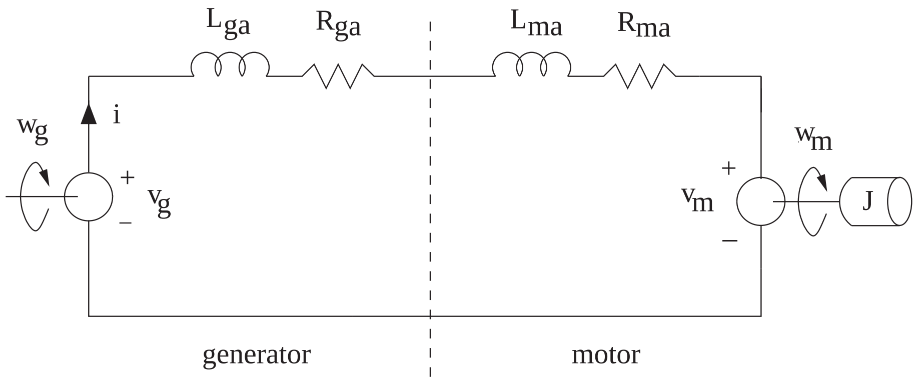
D.)
Unit Step Plus
3kHz Sine-Wave

E.)
Short Pulse

F.)
Unit Step

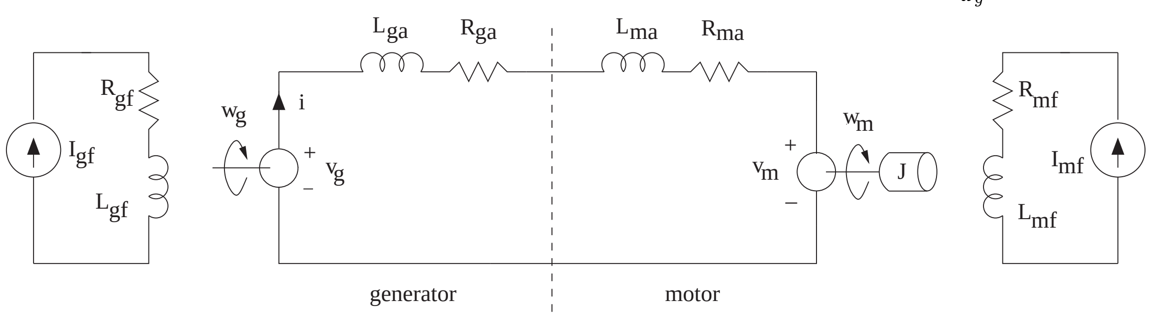
Problem 2: Morning Coffee

Just as you are about to grind some morning coffee, the power in your house goes out. You are relieved, however, when you find a motor identical to that in your coffee grinder, because you intend to hook it up as a generator, as shown in the schematic below. You may assume no friction losses in the motor, and that the torque required to grind coffee is negligible.



(a) You know that your coffee grinder spins at 1000 rpm. If the two motors that you have are identical permanent DC motors (such as those you have used in lab), and you handcrank the generator, will you be able to grind up some coffee?

(b) Now, assume that both of the motors are identical and field-wound. You plan to connect the field windings to two different current sources. Draw the block diagram for the system with $\omega_g(s)$ as your input and $\omega_m(s)$ as your output and find $\frac{\omega_m}{\omega_g}(s)$.



(c) The power comes back on, but you are still interested in trying the system of part (b). Assume that the fastest you can handcrank the generator shaft is 20 rpm. What is the minimum ratio of I_{fg} to I_{fm} for this to work?

(d) Sketch the step response of the system of (c) for a unit step input in ω_g. Label the final value and the initial slope.