WEEK 3 STEP RESPONSE TESTING

Week 3 Report

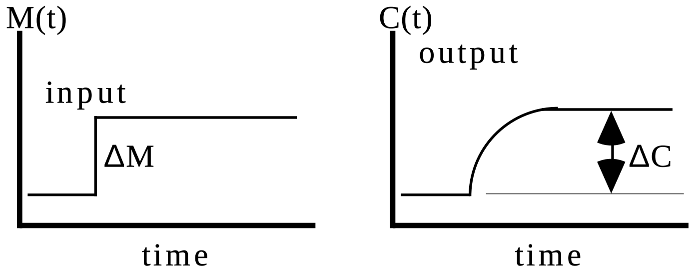
Submission of report.

Objectives

To observe experimentally the time response of the output function of the system to a step function input. To observe the system's s.s. gain, the system's response time and the system's dead time (if any). To make the observations for a number of different values for the size of the input function and the initial s.s. values. To make the observations for a variety of system configurations, if appropriate.

Reference: Smith & Corripio, problem 2-8 & pp 216-220

The purpose of this lab is to get step response data as shown in Figure 8. Figure 8(a) shows a graph of the input step function, M(t). Notice the input function is not at zero when the step occurs. This is called the base line value of M(t). At a certain time, the "start" time, the input function makes a step increase, ΔM.



(a) Step Input (b) Step Response (output)

Figure 8. Step response input and output functions

The system takes a certain time to respond to this input step. A typical response curve is shown in Figure 8(b). From this graph you can get these characteristics of the system: steady-state gain, response time and dead time. These are called the First-Order Plus Dead Time (FOPDT) parameters of the system.

Procedure for getting step response data

Prepare system for operation

Open LabVIEW program labeled "(Step)". This program emulates a programmable logic controller (PLC). It is programmed to provide a step input to the system, You should get a panel somewhat like the one shown in Figure 9, below.

Choose a value of the "input" variable that you want to be the base line value. Choose a value that you want to be the step height of the "input" variable. Click on the RUN arrow. The chart on the right of the screen emulates a strip chart recorder.

After the system reaches steady state at the input base line condition, click on the "Step" switch to initiate the step input function.

When you want to stop, click on the STOP button. As before, it will ask if you want to save the data on a disk file and if you want to draw a time-response graph of the data. If you've just been playing around, click "NO" to all of these requests.
You'll probably want to play around a bit before taking any serious data. You'll want to try different values of the step parameters: base line value and step height.

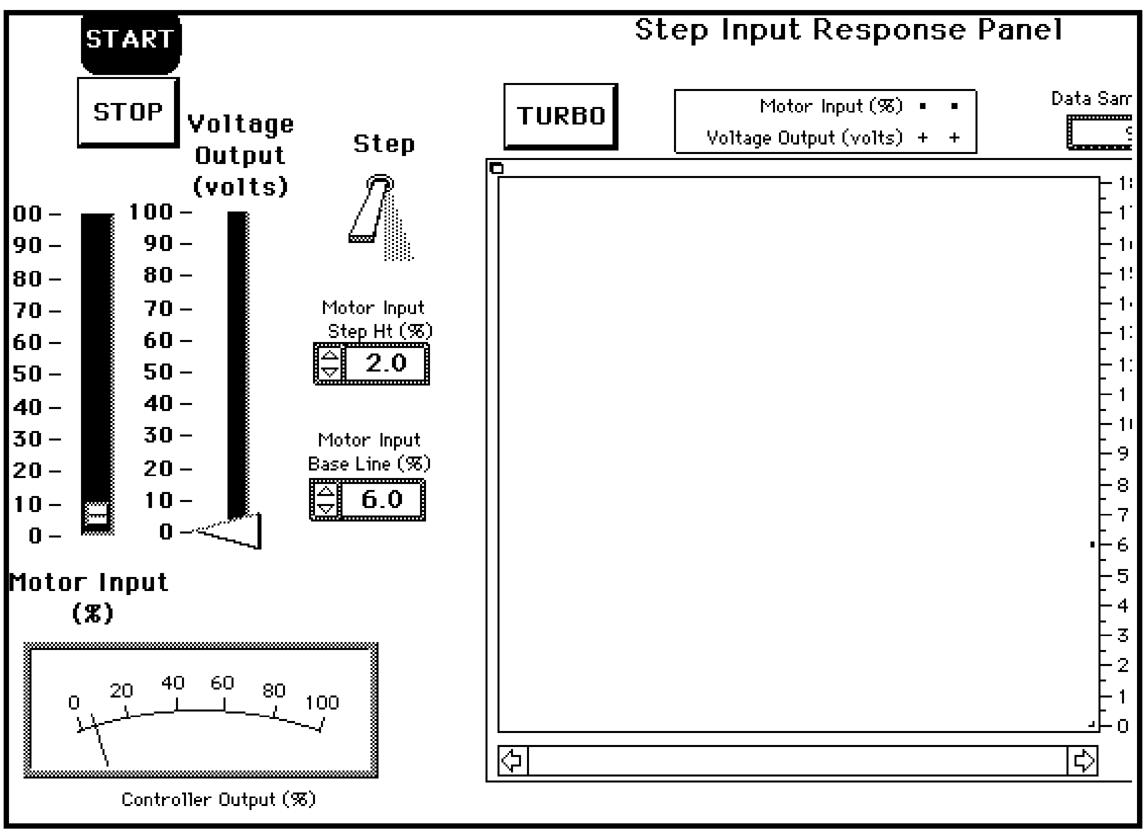


Figure 9. Step function programmed controller panel

When you are ready to get some good data, set the parameter values and start the instrument (click on the RUN arrow). After the step response has ended, click the STOP button and save the data, if you wish, and make the time-response graph.

If you want more frequent data points to complete your analysis, click the "Turbo" button just before you click the "Step" switch. In "Turbo" mode, the strip chart is turned off while all other data saving and plotting is the same.

Lab Assignments

For all stations, get step response data for the same conditions as Week 1 & 2.

For the "fast" systems (Motor Speed, Air Pressure & Water Flow) you are to obtain the system parameters for steps in the "up" direction as well as steps in the "down" direction. Also, obtain system parameters for different size steps and at different parts of your operating range.

Results

The time-response graph should look similar to the one in Figure 8(b). S&C (p 220) describes three different ways to get the parameters (K, τ and t_o). These are called Fit 1, Fit 2 and Fit 3. Another way is the Schonblom technique: Plot $\ln(C^{\Delta}/K-1)$ versus t; the slope will be $1/\tau$ if it is first order. The Cunningham extension of this is to get the slope and intercept of this curve with linear regression. You are to use any of these methods to find the parameters for your system.

If none of the first-order fit methods work very well, try a second order fit. See Coughanowr's book for how to handle higher order systems.

As the experimental measurement of your output variable has error associated with it, so too does the experimental determination of gain, dead time and time constant (K, t_o, τ). You are to get an estimate of these errors, also. A good way to do this is to make several measurements and then use Student's T statistics after your analysis by the different fits. The poster in Grote 213 (credit to Dr. Schonblom) and in the Freshman lab can help you with this.

Week 4 report described below will present and discuss the fits.

Optional Method for Temperature & Level Projects: Run the "Step Train" programs with LabVIEW. Talk with Dr. Cunningham or Dr. Henry for details.

Disk File Suggestion: For all your data files that you save this week, start their names with "W3" (meaning week #3).

Week 4 Report

A draft of Week 4 Report is due the second school day before the next scheduled lab meeting.

WEEK 4 REPORT CONTENTS
STEADY STATE AND STEP RESPONSE

Introduction

Theory & Background
Description & explanation of system components & connections.
Schematic diagram (like S&C, Fig. 5-1). Input function(s) and output function
Theory & governing equations for components and system (like S&C, equations 3-1 & 3-2)
Laplace domain descriptions in terms of deviation variables, OLTF (like S&C, equations 3-7 & 3-10)
Block diagram (like S&C, Figure 3-19)

Procedure
Results
Calibrations. Steady state performance curves. Experimental results for step input (curves, gain, time constant & dead time for different conditions) (like S&C, Figure 6-17). Include the various Fits.
Estimates of error in measurements and calculated results.
Include a table which clearly presents your results.

Discussion
Comparison with theory. Observations about the SSOC of the system

Conclusions

Recommendation

Appendices
Physical properties (dimensions, etc.) of components & system

Attachments
Include a sheet for each team member that describes the contribution to the work in the laboratory since last reported.

Disk File Suggestion: For all your report files that you save this week, start their names with "RW4" (meaning report for week #4)