

# Modeling and System Identification for a Temperature Control Problem

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March 23, 2004

## Abstract

In this lab, you are going to perform system identification for the temperature control system plant from the first laboratory. In particular, you are going to use both time domain and frequency domain system identification methods based on actual data taken from that plant.

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# 1 Introduction

In the pre-lab, you studied some basic ideas on how to use time and frequency domain methods to perform system identification. Now, you are going to apply those methods in the lab, but for the plant used for the temperature control problem in Laboratory 1. To acquire the data, we are going to use the dSPACE software; therefore you are going to apply all the knowledge that you acquired in the first laboratory.

## 2 Laboratory Procedures

### 2.1 Necessary Equipment

- dSPACE software.
- DS1104 interface card.
- Quanser DS1104 interface board.
- 1 Analog input cable.
- 1 Analog output cable.
- 1 LM35 CAZ.
- 1 DS2003 (Darlington Device).
- 1 Lamp.

### 2.2 Connections

Connect the lamp, the Darlington device (DS2003), and the sensor (LM35CAZ) according to the schematic in Figure 1. Use any analog input which has a resolution of 16 bits, and any desired analog output.

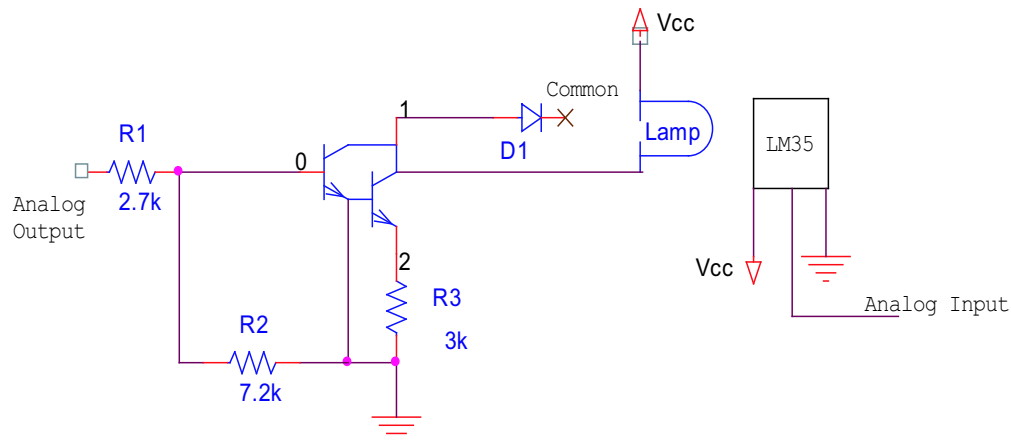


Figure 1: Schematic for the connection of the lamp, the sensor, and the DS2003.

### 2.3 Procedure

#### 2.3.1 Time Domain Approach

1. Open dSPACE and Matlab. Remember that you have to change the path where you are working (you will work under C:\EE758\LAB2\).

2. Build a Simulink model that has a step input of amplitude 1.7, and “step time” of 5 seconds. This is going to be the input of the system connected before the dSPACE gain for DAC.
3. Define a sampling time of 100 ms.
4. Use a first order system to filter the signal that comes from the sensor. This will help to reduce the noise of the LM35CAZ. For instance, you can take a filter of the form  $\frac{1}{s+1}$ .
5. The signal that comes out of the filter is in degrees Celsius. If you do not like these units, you can build a system that converts the signal into degrees Fahrenheit. In any case, the output of the filtered signal (in degrees Celsius or Fahrenheit) goes to a “terminator.” The link has to be labeled as “tempC” (or “tempF”).
6. Save the model as model1.mdl in the same directory.
7. Compile the model, and start a new experiment in dSPACE called LAB2A (it should be stored in the same directory as above, i.e., C:\EE758\LAB2\).
8. Since this is a very slow process, the layout that has to be built in dSPACE must have a plotter that can acquire data for at least 200 seconds. The data that you will acquire has to be stored in a variable called “step1.mat” (you might want to change the decimation time to a value different than 1). The data can be acquired in any of the forms described in the document “A Tutorial Introduction to Control Systems Development and Implementation with dSPACE.” Remember that if the tab that allows you to acquire the data does not appear immediately, you can press the button # 1 that appears in the right hand corner of the ControlDesk.
9. Repeat all of these steps with different amplitudes three or four times (remember that the minimum voltage that you can apply is 1.61 and the maximum one is 5 volts due to the darlington device).

### 2.3.2 Frequency Domain Approach

1. Build a model similar to the one that you built before, but instead of having a step input, you should have a sine wave. Since the system is driven by the darlington device, you have to add a DC value (e.g., you can add 1.85 volts to the output of the sine wave).
2. Fix the sampling time at 100 ms, and try a sine wave with amplitude equal to 0.2, and a frequency  $w = 0.005 \text{ rad/sec}$ .
3. Save the model as model2.mdl in the same directory.
4. Compile the model, and start a new experiment in dSPACE called LAB2B (it should be stored in the same directory as above, i.e. C:\EE758\LAB2\).
5. Follow the same steps as before to acquire the data necessary, and save it under “bode1.mat.”
6. Now, you are going to repeat this procedure with frequencies  $w = 0.007 \text{ rad/sec}$ , and  $w = 0.02 \text{ rad/sec}$ .
7. Save the data using the same procedure as above, but now name the data bode2.mat and bode3.mat respectively.
8. You are encouraged to take more data with different frequencies since this can help you to develop a better model for the temperature system.

### 3 Post-Laboratory Exercises

1. Take the data that you stored in the step\*.mat files, and deduce a discrete time difference equation that describes the temperature process from the data acquired. One way to get the data stored in Matlab from a “.mat” file is using the command *getfield*. Study this command and plot the different temperatures acquired according to their respective inputs. If you want, you can use the system identification toolbox to solve this problem. If you use this approach, explain which steps you followed to obtain the result.
2. What are the plant parameters deduced from your time domain analysis? Poles? Zeros? Gain?
3. Compare the results obtained for the temperature system, and plot both the actual data and the theoretical equation found.
4. Take the data that you stored in the bode1.mat file, and deduce a discrete time transfer function equation that describes the temperature process from the data acquired.
5. What are the plant parameters deduced from your Bode plot? Poles? Zeros? Gain?
6. Is this model accurate enough? Compare the results with the data stored in the bode\*.mat files for different frequencies.
7. Compare the results obtained for the temperature system, and do a Bode plot of both the actual data and the theoretical equation found.
8. Compare the results obtained in time domain and frequency domain. Discuss, and explain the differences if any.
9. What is the final model for the temperature system? Justify your answer.