State Feedback for a DC Servo

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Abstract

In this lab you will apply the state-space feedback controller that you designed during the prelab. The idea is to control the position of the DC servo as quickly as possible with no overshoot using an encoder and the tachometer of the servo.

Contents

1   Introduction

You will implement a full state feedback controller using the gain K that you found in the prelab. You will see that you might need to tune these values since the model you use for design is not accurate. Therefore, you will tune the feedback gain matrix K.

2   Laboratory Procedures

2.1   Necessary Equipment

- 1 dSPACE software.

- 1 DS1104 interface card.

- 1 Universal Power Module, UPM-2405.

- 1 SRV 02ET servo DC motor.

- 1 Encoder cable.

- 1 To load Cable.

- 1 From D/A Cable.

- 1 To A/D Cable.

- Teeth gears for high gear ratio

2.2   Connections

We are going to connect the motor using the encoder and tachometer to perform position control via state feedback. For that, follow the next steps:

1. Fix the high gear ratio on the DC servo.

2. Use channel #3 in dSPACE (#2 in the DS1104 card), to acquire the data that comes from the tachometer. For that, first connect to the rear part of the motor the cable named "From Analog Sensors" to the bottom part, and the other side of the cable should be connected to the UPM-2405 power module.

3. Connect the cable "From D/A" to the analog output #1 (#0 in the DS1104 card), and the "To Load cable" should be connected to the motor as in the other experiments.

4. Connect one side of one of the "Encoder Cables" to "ENC1" on the DS1104 card, and the other side to the motor.

2.3   Full State Feedback Controller

In the pre-lab you designed a state-space feedback controller. Here, you will see how good your design is for the actual plant. For that, you will use the feedback gain vector K that you found previously.

1. Design one block that has two outputs: one that you will name θ, and the other that you will name $\dot{\theta}$. This block will produce the position and the velocity of the motor.

2. Remember that since you are using the tachometer and encoder you have to use the appropriate blocks to acquire these values. Besides, in this case you are using the high gear ratio, i.e., you are using a gear ratio of 14:5 instead of a gear ratio of 14:1. Hence, one of the gains of the tachometer has to change from 1/14 to 1/70.

3. Construct a block that has the following characteristics:

   - The input is the value of θ.
   - The idea is to take the value of θ and compare it to a value that you will name "Angle," and if the absolute value of θ is greater than the value of "Angle," the experiment should stop.
   - Name this block "Safety Stop Angle."

4. Fix the "Safety Stop Angle" at 55 degrees.

5. Use the "Safety Stop Time" block that you constructed in the second lab, and set the stop time at 60 seconds.

6. Use a square wave with an amplitude of 45 degrees and a frequency of 0.05 Hz. This will be the input to the system. The units that you will use in this model must be in radians. Name this output θ_d.

7. The error that you will force to be zero will be in this case $\theta - \theta_d$.

8. Use a multiplexer, and the gain K that you compute in the pre-lab to close the loop of the system. Make sure you limit the output of your controller in the range ± 5V using a saturator. Remember that some units are in degrees, and pay attention to the sign of the values that you are using.

9. Fix the sampling time as 1 ms, and compile your experiment.

10. Now, create a new experiment in dSPACE. This experiment will have the file that you already compiled, and a layout with a plotter, 2 displays that show the feedback gains, and one display that will show the actual position in degrees. You can put more elements in your experiment if you want.

11. Run the experiment the first time. Is the value of the gain vector K that you computed in the pre-lab a good one? If not, try to tune until you will have a better response.

12. Once you find the correct values for these gains, save the closed-loop response data as a Matlab file (*.mat) using any method that you want (*Hint:You can use the Save button that you have been using, or changing the x-axes in the plotter, and the length you will be able to save the data using the classical methods. Also you can apply the method described in the tutorial to save the data without seeing the plotter.*).

3   Post-Laboratory Exercises

1. Which elements did you use to build the block to acquire the position and the velocity of the motor?

2. Show how you created the model. Include the figure for your model, and explain clearly each of the blocks that you used.

3. Were the values of the gain in the pre-lab good enough in practice?

4. How did you tune the feedback gain K? What are the values of the elements of K that you finally used?

5. In the same figure, plot the response of θ_d and the final position of your DC servo, i.e. θ. Show your work by adding the commented Matlab file.

6. Compare the results that you obtained in the implementation with your simulation from the prelab. Show your work by adding the commented Matlab file.