Mectron/Sfwr Eng 4AA4 - Lab 9

PID Controller

Goals:

- Learn how to estimate parameters for system identification.
- Learn how to simulate a PID controller and a plant using `MatLab` and `Simulink` for determination of suitable values of K_p, K_i and K_d for the PID controller.

Note: Before you go for your lab 9 sessions, please read the following documents at your own convenient time, in addition to the class notes:

- http://en.wikipedia.org/wiki/PID_controller
- http://igor.chudov.com/manuals/Servo-Tuning/PID-without-a-PhD.pdf

Introduction:

The transfer function for the angular speed of a servomotor can be described by:

$$\frac{A}{1+\tau s}$$

Where A is the steady state gain and τ is the time constant. In the lab we use SRV02 dc servomotor plant from Quanser for different experiments. The transfer function of this plant can be determined by using mathematical equations and various parameters of the plant supplied by the manufacturer. There are several methods to determine the transfer function experimentally in the lab. One simple method is called the Bump Test, which is based on a step response of a stable system. In this test a constant input is applied so that the system reaches an equilibrium then the input is suddenly changed to a new level and the output is recorded. Figure 1 shows the input and output signals applied.

The input signal that begins at time t_0 and its minimum and maximum values are given by u_{min}, u_{max}. The resulting output signal is initially at y_0 and eventually settles down for a steady state value of y_{ss}. The steady state gain A is given by:

$$A = \frac{\Delta y}{\Delta u}$$

Where $\Delta y = y_{ss} - y_0$ and $\Delta u = u_{max} - u_{min}$

The time constant τ is the time required for the output to increase from initial value to 0.632 of the steady state output ($0.632 \times \Delta y$). If t_1 is the time when the change in output is $0.632 \times \Delta y$:

$$y(t_1) = 0.632 \times (y_{ss} - y_0) + y_0$$

$$t_1 = \tau + t_0$$

$$\tau = t_1 - t_0$$

You will use MATLAB Simulink to generate and measure various signals for the bump test.

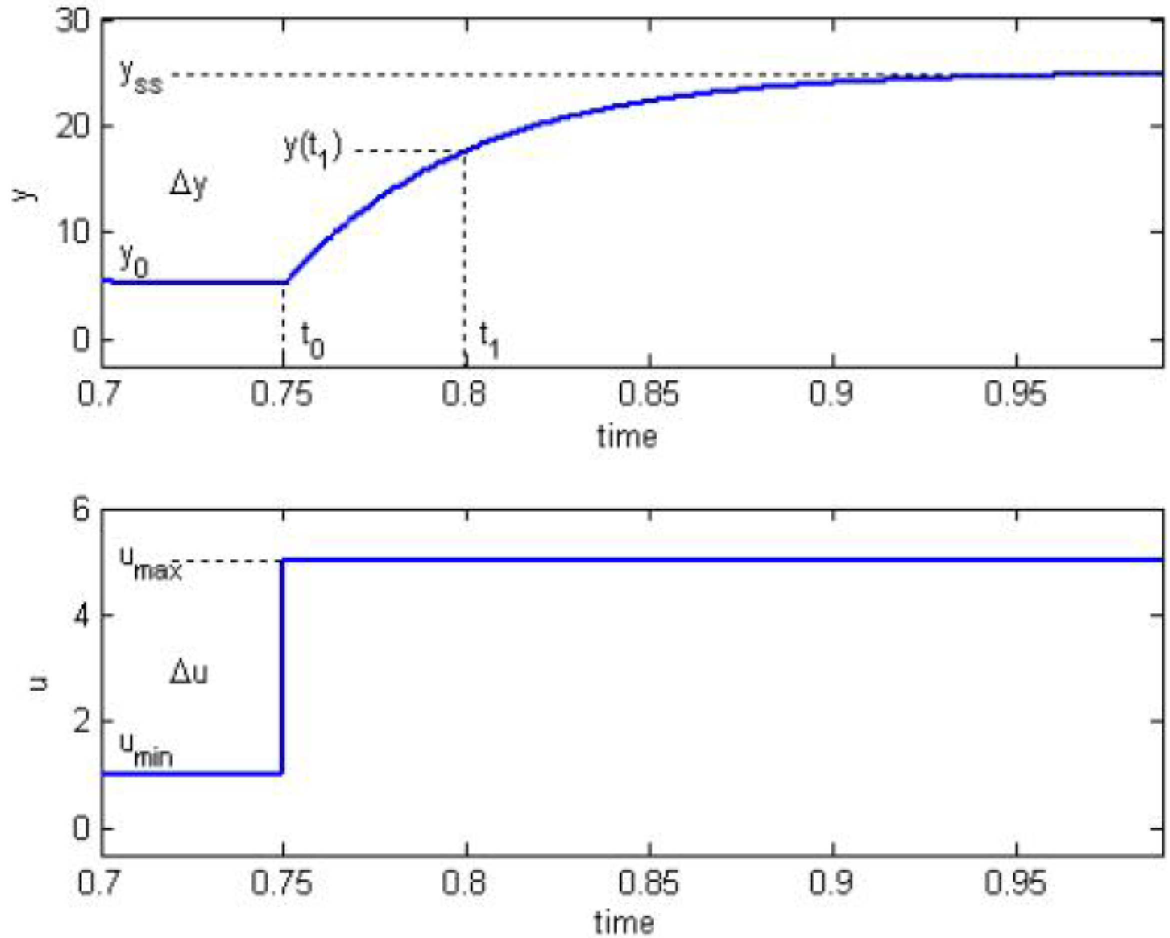

Figure 1: Input and output for a bump test

Part 1: Find the transfer function [50]

- Connect myRIO to computer and to SRV02 servo plant and power up myRIO.
- Download the file "`BumpTest.slx`" from the course web page to your PC.
- Double click the "`BumpTest.slx`" to open it MATLAB SIMULINK.
- In SIMULINK, go to **QUARC** $\gg$ **Preferences...**, then under the **model** tab in the opened window, in the "Default Model URI" input box, change the IP address part to your MyRIO's IP address.(Please see Figure 2)
- In SIMULINK, go to tab **HARDWARE**, then click button **Monitor & Tune** to start to run the model in real time. (Figure 3)
- In the **Scope**, the input voltage (V) and the motor's velocity (Rad/s) will be displayed.(See Figure 4)
- Use this plot to calculate the **gain** A and the **time constant** τ .

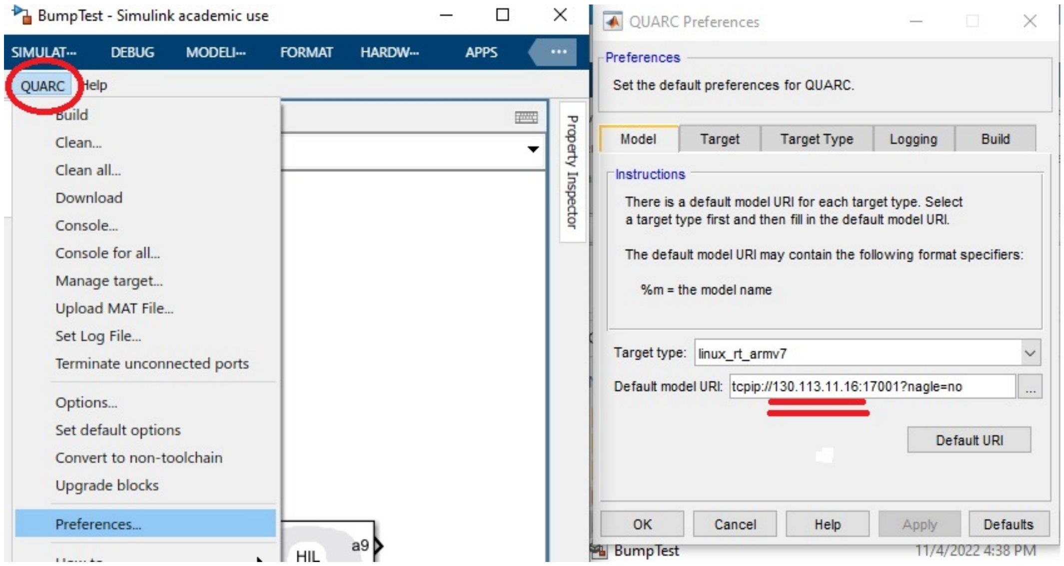

Figure 2: Input and output for a bump test

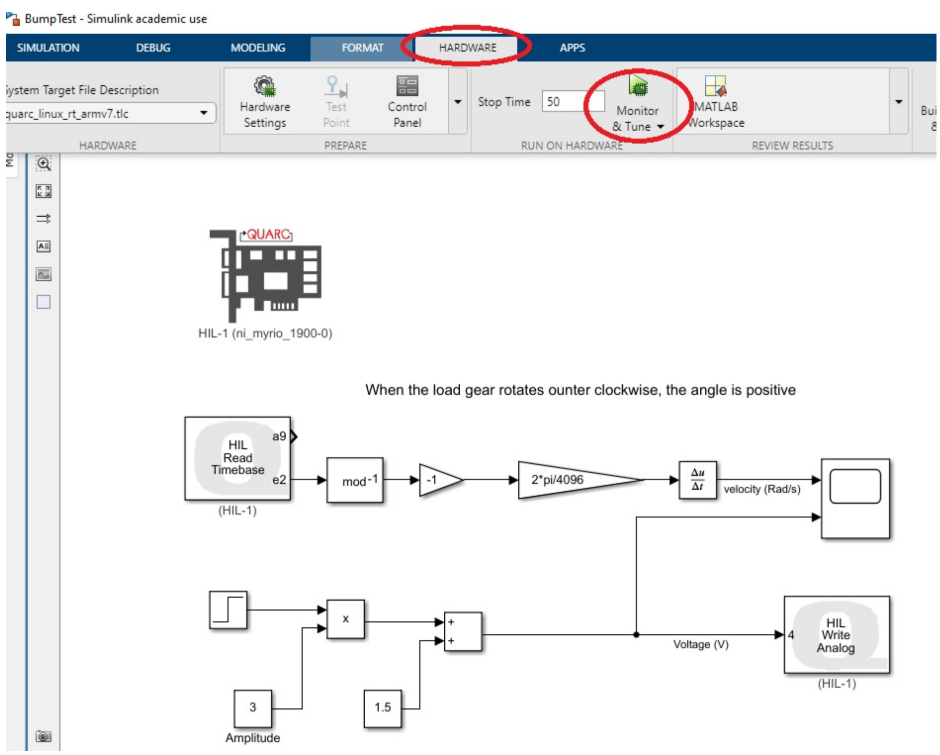

Figure 3: Input and output for a bump test

Part 2: Simulation using MATLAB and Simulink [50]

Simulink is a graphical editor of MATLAB software that can be used for constructing models of hybrid dynamical systems. Models can then be assembled, loaded, saved, compiled, and simulated. It provides a palette browser that lists all standard blocks grouped by categories. You need to select suitable blocks

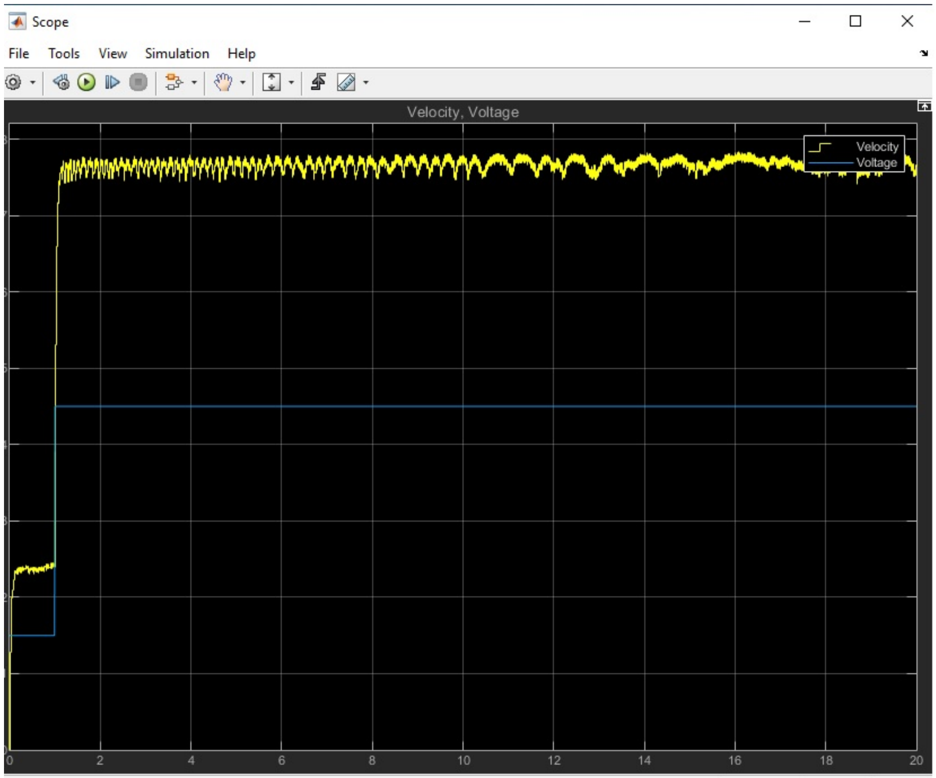

Figure 4: Input and output for a bump test

and drag them into the editor for constructing a model. The model can then be compiled and simulated. The data resulting from the simulation can then be graphically viewed in real time. The software provides facilities covering a wide range of applications.

Using suitable palettes, it is possible to simulate the transfer function of the plant estimated by you in Part 1 and use it in conjunction with a PID controller to observe the output signals as the parameters of the PID controllers are changed.

Your model will look similar to Figure 5. Adjust the values of K_p, K_d and K_i to get an output similar to that shown in Figure 6. If you prefer to read angular position in Degree rather than in Radian, please convert your **gain A** to unit of (Deg/s)/V in the model. Note the values for use in the next lab session, in which you will use a PID controller to control servo motor's angular position. Show the output of your simulation to your TAs.

Please note, in the bump test in Part 1, the system input (error input) is in unit of volt (V), the velocity is measured by unit of Rad/s, therefore the calculated gain is in unit of (Rad/s)/V. If you prefer to use unit of Degree rather than Radian to measure the angular position, you need to convert the gain to unit of (Deg/s)/V. While in this part when you simulate the system, the setpoint, feedback as well as the system error are in the same unit, which in real life would be in unit of Degree. Therefore before feed the error into PID controller, we need to convert it to unit of V.

The potential meter of the servo plant in our lab outputs signals range from -5V to +5V, which measure motor gear positions form around -180 degree to +180 degree. Therefore, to get meaningful simulation results for lab 10, in which you will implement a PID control program to control motor′s position and use setpoints and measured results in unit of Degree, you need to divide the error by 36 to convert it from unit of Degree to V before feed it to the PID Controller.

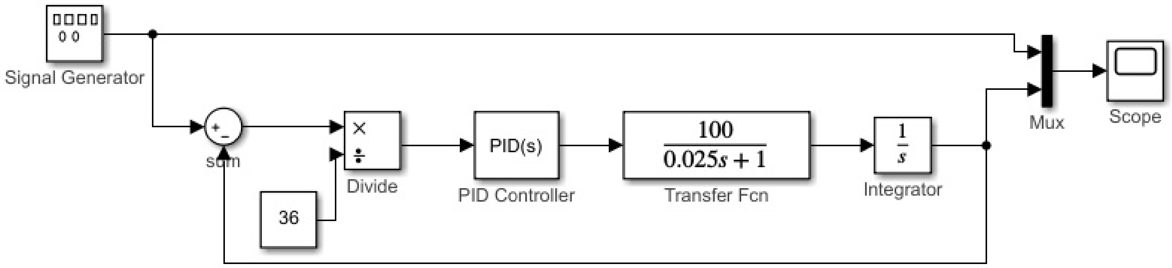

Figure 5: System Model

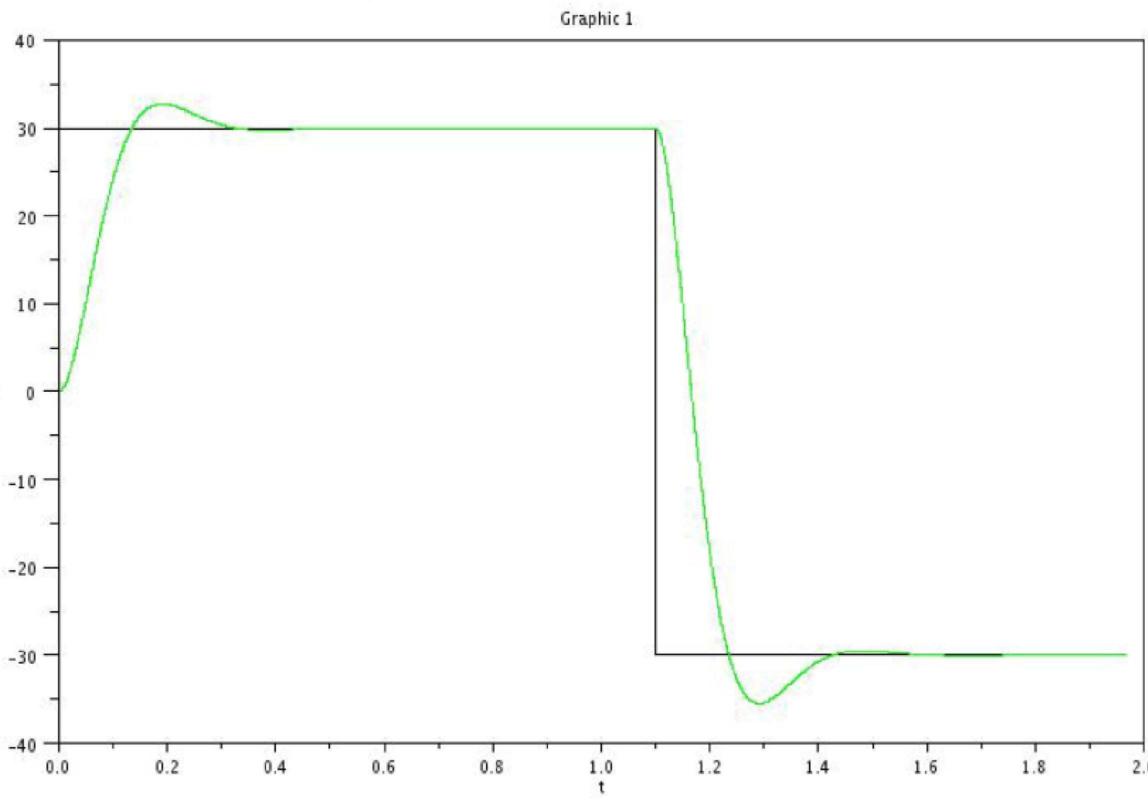

Figure 6: Simulation Result