

Running Ball and Beam Experiment

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Purpose

The goal of this experiment is to design, implement and test a proportional-derivative (PD) controller that stabilizes a ball to a desired position along the beam (Fig.1).

ID #	Component	ID #	Component
1	SRV02	8	Support base
2	Lever arm	9	Support arm screws
3	Coupling screw	10	Analog ball position sensor connector
4	Steel ball	11	Calibration base
5	BB01 Potentiometer sensor	12	SS01 Potentiometer sensor
6	BB01 Steel rod	13	SS01 Steel rod
7	Support arm	14	Analog remote sensor connector

Table 1: BB01 components.

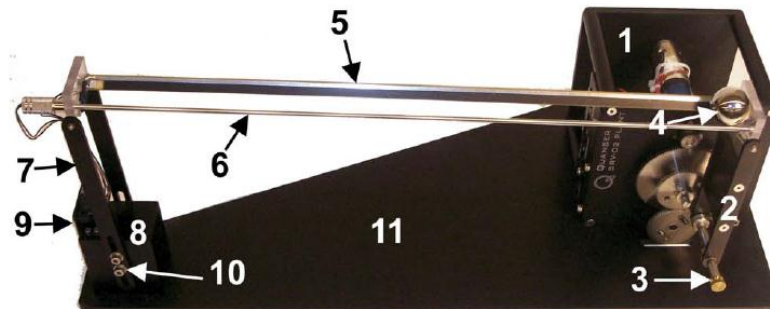


Figure 1. Beam and Ball experiment.

Physical Setup

After experiment is assembled, calibrate the BB01 by holding the load gear at 0 degrees (the picture above shows the load gear at -45 degrees) and vary the height of the support arm, component #7, such that the beam is horizontal. When the ball is centered on the beam, it should lie motionless. Tighten down the screws on the support arm.

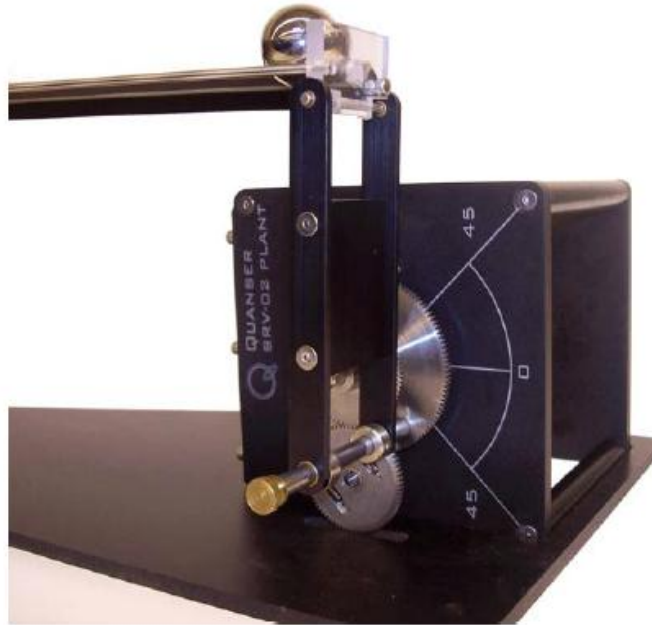


Figure 2. Calibration procedure.

The wiring setup should look like in Figure 3. Ensure you are using the correct parts or a different wiring setup will be required. The wiring diagram below assumes that you are using a Quanser VoltPAQ-X1 Power Amplifier, a Quanser Q8-USB Data Acquisition Board (you can also use but can also utilize a 2-channel DAQ board instead), a Quanser SRV02 Rotary Servo Plant, and a Quanser BB01 Ball and Beam Module.

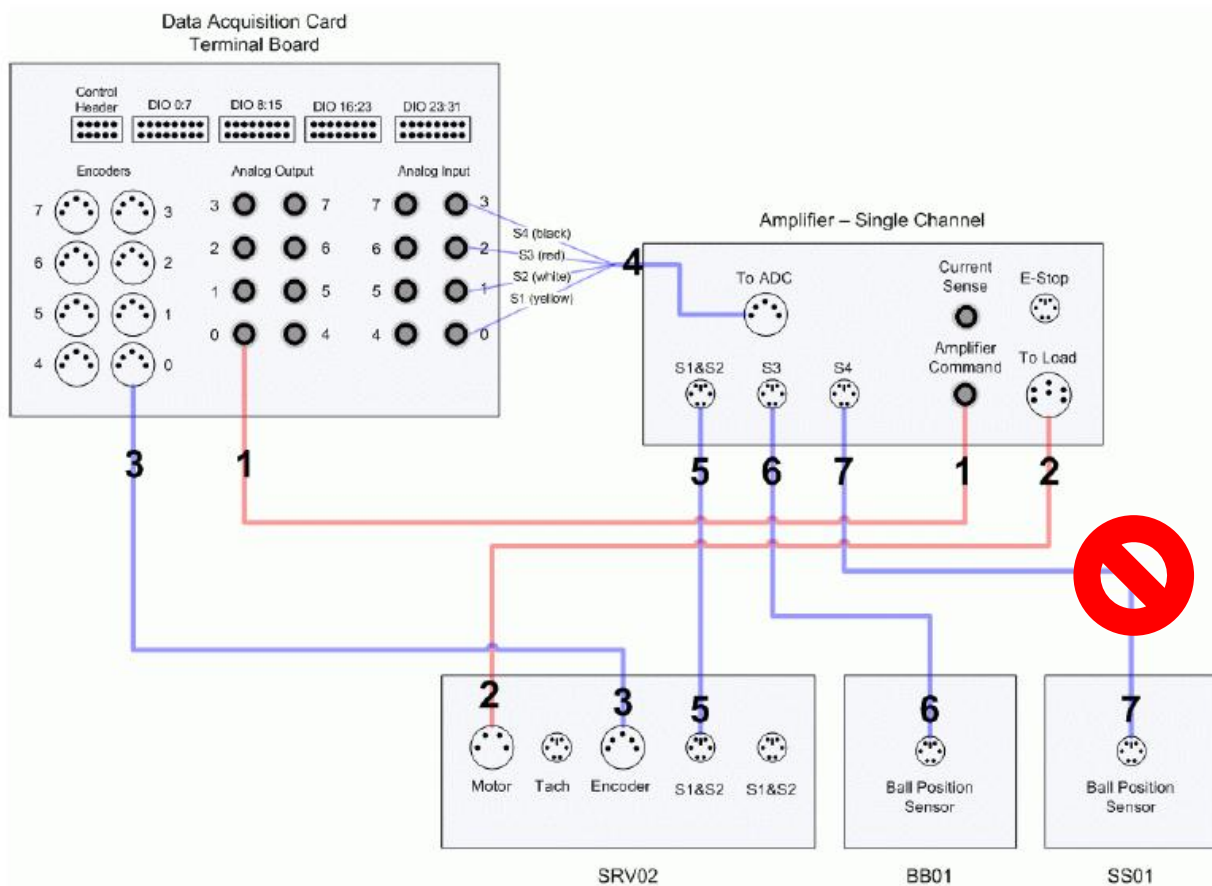


Figure 3. Wiring diagram.

Note, do not use wire number 7 unless you have an SS01 (ask if you are unsure). Most likely you will not, so use wire 6 which connects at the support beam end of the BB01. Connect all other wires as shown in Fig.2.

Procedure

Step 1: Start MATLAB

Turn on the computer and login using your NPS login & password (please be patient, the computers in this lab are slow.) Open MATLAB. (You may need to search for it under 'search all programs and files' as sometimes the shortcut does not appear on the desktop or in the list of programs.) Change 'Current Folder' in top MATLAB toolbar to

C:\Users\Public\Desktop\QUARC\Rotary Labs with Manuals\Exp04 - Ball and Beam\Lab Files

In the command window type: `mex -setup` and hit enter. When prompted, type `y`, then <Enter>, when prompted again, type `1` then enter, and when prompted again, type `y` then enter.

Step 2: Running Setup Script(s) to Compute Controller's Gains

Open and run '[setup_srv02_exp04_bb01.m](#)' script by opening and then clicking on the green arrow at the top of the .m file toolbar. MATLAB will run the setup script. You do not need to input anything.

Step 3: Opening/Building a Simulink Model, Connecting to the Target

Open '[q_bb01_pos.mdl](#)' Simulink model.

Click on Simulation tab and Configuration Parameters. Check that the Description is Win64 for an HP computer or Win32 for a Dell computer.

Double -click on the large orange block in the model. When the subsystem opens, look at the top right corner at the picture of the DAQ. Ensure that Q8_usb is the DAQ being used in the model (you can read the DAQ model just below the picture). If it does not have the Q8_usb selected, double click the picture. When it opens, select Q8_usb from the drop down menu and click ok. You have now configured your DAQ. You may close the subsystem Simulink model window.

Turn on VoltPAQ-X1 Amplifier (on/off button is located on rear of box). Wait for a green light on front of box to indicate on. Set the gain switch (located on front of box) to 1X.

In the Simulink model window, click on the 'Incremental Build' button in the toolbar (or in the QUARC dropdown, choose 'Build'). Wait for MATLAB to build the model.

In the Simulink model window, click on the 'Connect to Target' button in the toolbar. You should see a 'heartbeat' of blue boxes in the lower right corner of the Simulink screen indicating the model is connected.

Step 4: Running the Model

In the Simulink model window, click on the 'Start real-time code' button (forward arrow) in the toolbar.

You should see and hear movement of the SRV02 gears as it works to balance the ball in the required position. Using the default positions, the system will attempt to hold the ball at a position of +5 (position 0 is when the ball is at the center of the beam) for several seconds and then move it and hold it at the -5 position. The system will continue to oscillate the ball between these points on the beam for several seconds at a time until you stop the experiment. To stop the experiment click on the stop button that has replaced the play button in the Simulink toolbar.

Step 5: Finishing the Lab

Before leaving the lab, turn off the Amplifier and shut down your computer.

References

- [1] Quanser Inc., *QUARC User Manual* (type [doc quarc](#) in MATLAB to access).
- [2] Quanser Inc., *SRV02 QUARC Integration*, 2008.
- [3] Quanser Inc., *QUARC Installation Guide*, 2009.
- [4] Quanser Inc., *SRV02 User Manual*, 2009.
- [5] Quanser Inc., *Q2-USB User Manual*, 2010.

- [6] Quanser Inc., *Voltpaq User Manual*, 2010.
- [7] Quanser Inc., *Ball and Beam User Manual*, 2011.
- [8] Quanser Inc., *SRV02 Lab Manual*, 2011.