

1 QUBE-Servo Integration

Topics Covered

- Getting familiarized with the Quanser QUBE-Servo hardware.
- Using **QUARC®** to interact with Quanser QUBE-Servo system.
- Sensor calibration.

Prerequisites

Before starting this lab make sure:

- The QUBE-Servo has been setup and tested. See the QUBE-Servo Quick Start Guide for details.
- Inertial disk load is on the QUBE-Servo.
- You have the QUBE-Servo User Manual. It will be required for some of the exercises.
- You are familiar with the basics of **Simulink®**.

1.1 Background

1.1.1 QUARC Software

The **QUARC®** software is used with **Simulink®** to interact with the hardware of the QUBE-Servo system. QUARC is used to drive the dc motor and read angular position of the disk.

The basic steps to create a **Simulink®** model with **QUARC®** in order to interact with the QUBE-Servo hardware are:

1. Make a Simulink model that interacts with your installed data acquisition device using blocks from the *QUARC Targets* library.
2. Build the real-time code.
3. Execute the code.

Type "doc quarc" in **Matlab®** to access QUARC documentation and demos.

1.1.2 DC Motor

Direct-current motors are used in a variety of applications. As discussed in the QUBE-Servo User Manual, the QUBE-Servo has a brushed dc motor that is connected to a PWM amplifier. See the QUBE-Servo User Manual for details.

1.1.3 Encoders

Similar to rotary potentiometers, encoders can also be used to measure angular position. There are many types of encoders but one of the most common is the rotary incremental optical encoder, shown in Figure 1.1. Unlike

potentiometers, encoders are relative. The angle they measure depends on the last position and when it was last powered. It should be noted, however, that absolute encoders are available.

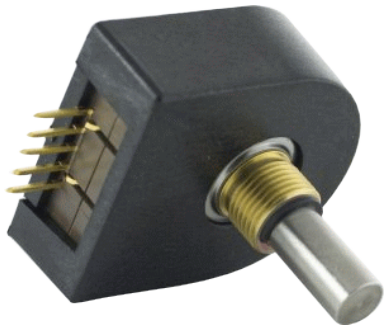


Figure 1.1: US Digital incremental rotary optical shaft encoder

The encoder has a coded disk that is marked with a radial pattern. As the disk rotates (with the shaft), the light from an LED shines through the pattern and is picked up by a photo sensor. This effectively generates the A and B signals shown in Figure 1.2. An index pulse is triggered once for every full rotation of the disk, which can be used for calibration or homing a system.

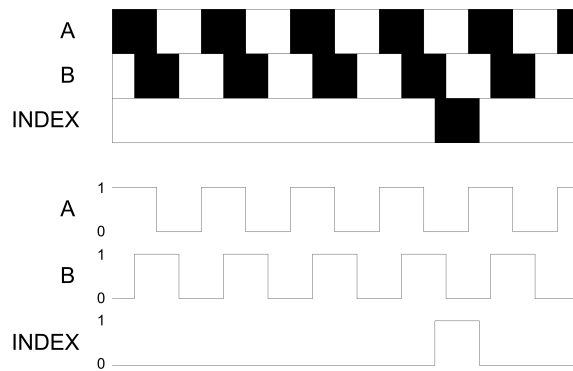


Figure 1.2: Optical incremental encoder signals

The A and B signals that are generated as the shaft rotates are used in a decoder algorithm to generate a count. The resolution of the encoder depends on the coding of the disk and the decoder. For example, a single encoder with 512 lines on the disk can generate a total of 512 counts for every rotation of the encoder shaft. However, in a quadrature decoder as depicted in Figure 1.2, the number of counts (and thus its resolution) quadruples for the same line patterns and generates 2048 counts per revolution. This can be explained by the offset between the A and B patterns: Instead of a single strip being either on or off, now there is two strips that can go through a variety of on/off states before the cycle repeats. This offset also allows the encoder to detect the directionality of the rotation, as the sequence of on/off states differs for a clockwise and counter-clockwise rotation.

1.2 In-Lab Exercises

In this lab, we will make a **Simulink®** model using **QUARC®** blocks to drive the DC motor and measure its corresponding angle - similarly as shown in Figure 1.3.

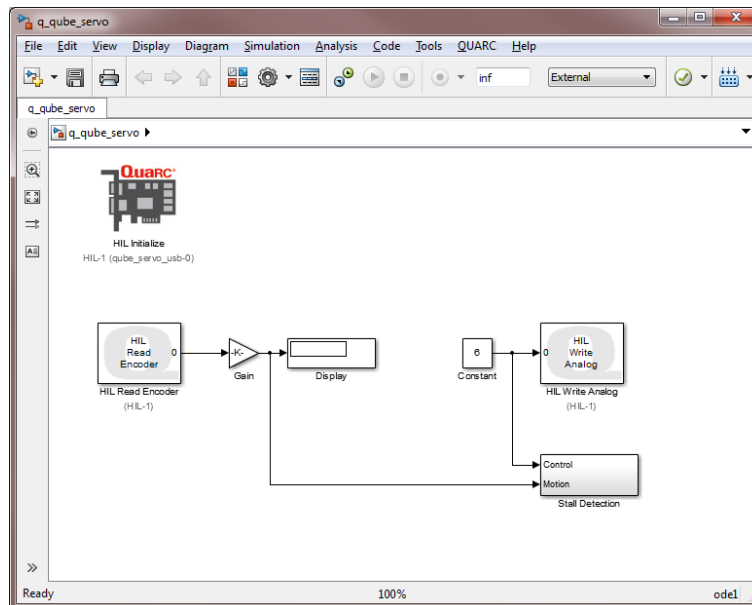


Figure 1.3: Simulink model used with QUARC to drive motor and read angle on QUBE-Servo

1.2.1 Configuring a Simulink Model for the QUBE-Servo

Follow these steps to build a **Simulink®** model that will interface to the QUBE-Servo using **QUARC®** :

1. Make sure the QUBE-Servo is connected to your PC USB port and powered ON (the Power LED should be lit).
External DAQ Users: If you are using the QUBE-Servo with an external data acquisition device, then make sure the QUBE-Servo has been properly connected to your DAQ as dictated in the QUBE-Servo User Manual.
2. Load the **Matlab®** software.
3. Create a new **Simulink®** diagram by going to File | New | Model item in the menu bar.
4. Open the Simulink Library Browser window by clicking on the View | Library Browser item in the Simulink menu bar or clicking on the Simulink icon.
5. Expand the **QUARC Targets** item and go to the Data Acquisition | Generic | Configuration folder, as shown in Figure 1.4.
6. Click-and-drag the HIL Initialize block from the library window into the blank Simulink model. This block is used to configure your data acquisition device.
7. Double-click on the HIL Initialize block.
8. In the *Board type* field, select *qube_servo_usb*.
External DAQ Users: If you are using an external data acquisition device, then select the board that is installed in your PC. For example, if you are using a Quanser Q8-USB board to connect to the QUBE-Servo then select *q8_usb*.
9. Go to the QUARC | Set default options item to set the correct Real-Time Workshop parameters and setup the Simulink model for external use (as opposed to the simulation mode).

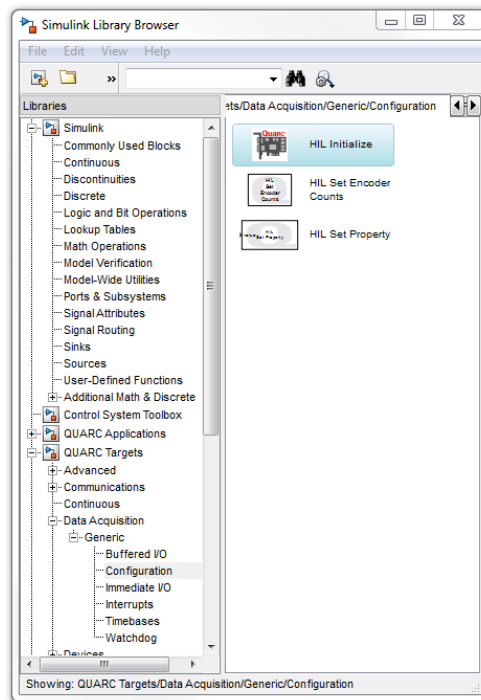


Figure 1.4: QUARC Targets in Simulink® Library Browser

10. Select the QUARC | Build item. Various lines in the Matlab® Command Window should be displayed as the model is being compiled. This creates a QUARC executable (.exe) file which we will commonly refer to as a QUARC controller.
11. Run the QUARC controller. To do this, go to the Simulink model tool bar, shown in Figure 1.5, and click on the *Connect to target* icon and then on the *Run* icon. You can also go QUARC | Start to run the code. The *Power* LED on the QUBE-Servo (or your DAQ card) should be blinking.



Figure 1.5: Simulink model toolbar: connect to target and compilation

12. If you successfully ran the QUARC controller without any errors, then you can stop the code by clicking on the *Stop* button in the tool bar (or go to QUARC | Stop).

1.2.2 Reading the Encoder

Follow these steps to read the encoder:

1. Using the Simulink model you configured for the QUBE-Servo in the previous section, add the HIL Read Encoder Timebase block from the QUARC Targets | Data Acquisition | Generic | Timebases category in the Library Browser.
2. Connect the HIL Read Encoder to a Gain and Display block similar to shown in Figure 1.3 (without the HIL Write Analog block). In the Library Browser, you can find the Display block from the Simulink | Sinks and the Gain block from Simulink | Math Operations.
3. Build the QUARC controller. The code needs to be re-generated again because we have modified the Simulink diagram.

- Run the QUARC controller.
- Rotate the disk back and forth. The Display block shows the number of counts measured by the encoder. The encoder counts are proportional to the angle of disk.
- What happens to the encoder reading every time the QUARC controller is started? Stop QUARC, move around the disk, and re-start QUARC. What do you notice about the encoder measurement when QUARC is re-started?
- Measure how many counts the encoder outputs for a full rotation. Briefly explain your procedure to determine this and validate that this matches the specifications given in the QUBE-Servo User Manual.
- Ultimately we want to display the disk angle in degrees, not counts. Set the Gain block to a value that converts counts to degrees. This is called the *sensor gain*. Run the QUARC controller and confirm that the Display block shows the angle of the disk correctly.

1.2.3 Driving the DC Motor

- Add the *HIL Write Analog* block from the Data Acquisition | Generic | Immediate I/O category into your Simulink diagram. This block is used to output a signal from analog output channel #0 on the data acquisition device. This is connected to the on-board PWM amplifier which drives the DC motor.
- Add the *Constant* block found in the Simulink | Source folder to your Simulink model. Connect the Constant and HIL Write Analog blocks together, as shown in Figure 1.3.

Note:

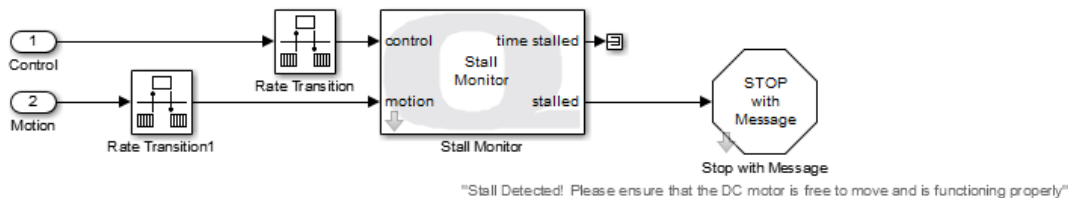


Figure 1.6: HIL Stall Monitor

We recommend including a Stall Monitor block in the main model or a subsystem as shown in Figure 1.3 and Figure 1.6. This block will monitor the applied voltage and speed of the DC motor to ensure that if the motor is motionless for more than 20 s with an applied voltage of over 5V, the simulation is halted to prevent damage to the motor.

- Build and run the QUARC controller.
- Set the Constant block to 0.5. This applies 0.5 V to the DC motor in the QUBE. Confirm that we are obtaining a *positive measurement when a positive signal is applied*. This convention is important, especially in control systems when the design assumes the measurement goes up positively when a positive input is applied. Finally, in what direction does the disk rotate (i.e., clockwise or counter-clockwise) when a positive input is applied?
- Stop QUARC.
- Power OFF the QUBE-Servo.

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