Interfacing dSPACE to the Quanser Rotary Series of Experiments (SRV02ET)

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Abstract

This document presents the main steps needed to interface the Quanser rotary series of experiments to the DS1104 dSPACE data acquisition card and software. The rotary series include the DC servo, flexible link, flexible joint, ball on a beam, and rotational inverted pendulum. First, we discuss the Quanser "Universal Power Module" (UPM), DC servo motor (that is used in all the other experiments in the rotary series), and the Quanser DS1104 Interface Board. Second, we provide a description of how to connect to the potentiometer, encoder, and tachometer on the DC servo. Finally, we explain how to connect all the remaining experiments in the rotary series.

Contents

1 Connecting the DC Servo

The main components to focus on in connecting the Quanser experiments are the Power Module, the DS1104 Interface Board, and the servo rotary motor. With these elements, plus the necessary interface cables, we are able to run most of the plants that were designed by Quanser (http://www.quanser.com/).

1.1 Quanser Universal Power Module

This module is shown in the Figure 1 (the cables that we are going to use are not connected in the same way as you can see in this figure). From the Figure 1, we may identify the following connectors[1]:

- From Analog Sensors (see boxed region in figure): These are for inputs from analog sensors (e.g., potentiometers, tachometer or any other transducer) that transform a physical quantity (e.g. angle or temperature) into a DC voltage. The area "From Analog Sensors" uses "6 pin Mini to Din / 6 pin Mini Din cables" to connect the UPM-2405 to the plant. The cable shown at the center of the figure is going to be referred to here as the "Analog sensor cable," and is a light tan cable. The general idea of these connection points is to take their signals and internally connect them to the analog input connector, "To A/D," where you can see the sensor signal labels also (e.g., S1). For the case of this module, we only have 4 analog sensor inputs (S1-S4), hence only 4 analog inputs.

- To A/D: This connector uses a 5 Pin Din-stereo / 4 x RCA cable to connect all 4 of the analog inputs to the dSPACE card. This cable is going to be referred to here as the "To A/D cable," and it is a black cable. The RCA termination (like for your stereo) is going to be connected to the data acquisition board and the 5 Pin Din-stereo is going to be connected to the power module.

- From D/A: This connector uses a 5 Pin Din-mono / RCA cable to connect one analog output from the dSPACE board to the plant. This cable will be referred to as the "D/A cable," and it is black. The RCA termination is hooked up to the data acquisition board and the 5 Pin Din-mono is connected to the power module.

- To Load: This connector uses a 6 pin Din / 4 pin Din, and goes from the amplifier to the actuator in the plant. This cable is going to be referred to here as the "To Load cable," and it is black. Note that one end of the cable has six pins, and the other has four so you must match appropriately. This cable then transfers power to the plant and the analog control input to the plant.

- Other: We have other inputs and outputs that are going to be used occasionally in some of the experiments. The supply voltage (top left of the UPM-2405) is between 12 Volts; the test points S1-S2, S3, and S4 are used to measure the outputs of the analog sensors directly at these points (e.g., to see their values on a scope).

1.2 Quanser DS1104 Interface Board

Next, we consider the Quanser DS1104 Interface Board (green), which is used to interface signals directly to the dSPACE DS1104 card that we have inside the computer. This card is shown in Figure 2 and has the following characteristics:

- It has eight (8) analog inputs located in the top left of Figure 2.

- It has eight (8) analog outputs located in the top right of Figure 2.

- In the middle of the card, we can see the twenty (20) digital I/Os (Input/Outputs).

- Also in the middle, but in the left part of Figure 2, notice that there are two 5 Pin Din-stereo connectors and two other connectors (double row / straight sockets). These are for the encoders. If you are using the Quanser plants, and you want to connect directly to the encoder (as in the pendulum experiment),

[1]Document provided by Quanser: sysproc.pdf page 6

Figure 1: Universal Power Module

you have to use one of these 5 Pin Din-stereo/5 Pin Din-stereo cables to hook up your experiment. But, if you are using your own plant, you might want to directly use the other pins that are available in the other connectors (double row / straight sockets). These encoders are quadrature encoders that generate 2 square waves that are 90 degrees out of phase. The two signals (called A and B) are connected to a counter that counts the transitions in the signals. For this case, an encoder that generates 1000 pulses per revolution per channel will result in 4000 counts per revolution.

- In the middle right of the card's picture in Figure 2, you have two SCSI 3 Female Connectors to interface the DS1104 Interface Board to the dSPACE data acquisition card. The one that is on the far right side (the outer one), should be connected to the cable labeled P1A in the dSPACE configuration, and the other one to the cable labeled P1B.
- Finally, in the bottom part of Figure 2, you have four sockets. The first one (the one which is on the left side) is for the PWM outputs. The next one (labeled J8 on the card) is for the 3-phase PWM. Lastly, the other two, labeled J6 and J7 (from left to right), are those used for SPI/CAPTURE, and RS-232 respectively.

1.3 DC Servo Motor Connections

Next, we describe how to connect the DC servo motor system that is used in the "rotational series" of the Quanser plants. The "rotational series" that we have is the SRV-02ET, and the DC servo is shown in the Figure 3. The connections that we see in Figure 3 do not correspond to the one that we are going to describe in the next pages, where we consider the motor position experiment.

The description of this motor can be found in http://www.quanser.com/, which we place here for convenience:

> A high quality DC servo motor is mounted in a solid aluminum frame. The motor drives a built-in Swiss-made 14:1 gearbox whose output drives an external gear. The motor gear drives a gear attached to an independent output shaft that rotates in a precisely machined aluminum ball

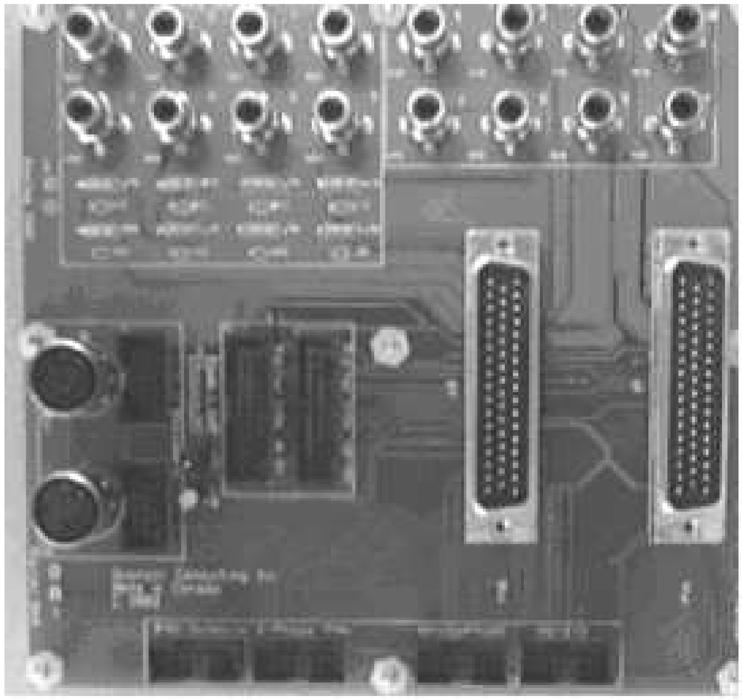

Figure 2: Quanser DS1104 Interface Board

bearing block. The output shaft is equipped with an encoder. This second gear on the output shaft drives an anti-backlash gear connected to a precision potentiometer. The potentiometer is used to measure the output angle. The external gear ratio can be changed from 1:1 to 5:1 using various gears. Two inertial loads are supplied with the system in order to examine the effect of changing inertia on closed loop performance. In the high gear ratio configuration, rotary motion modules attach to the output shaft using two 8-32 thumbscrews. The square frame allows for installations resulting in rotations about a vertical or a horizontal axis[2].

To connect the SRV-02ET we have a couple of options. As you may see in the Figure 4, you have 5 connectors in the rear part of the motor. We can see that we have three kind of sensors: the potentiometer (it can measure in two ways), the encoder (which has this 5 pin Din Connector), and the tachometer (which has the 6 pin Mini Din connector). The other connector that is in the top part of the rear of the motor, is to connect the "To load" cable. When we want to measure the velocity of the system, we use the tachometer, and if we want to measure position, the encoder is more accurate than the potentiometer. The tachometer should be connected directly to the Universal Power Module using the Analog Sensors Cable, and the encoder should be connected to the DS1104 Interface Card.

There is an IMPORTANT POINT that you must be alerted to. A "high frequency voltage applied to any motor will eventually damage the gearbox or the brushes. You should have a band-limited differentiator rather than a pure differentiator running in the feedback loop. If you hear a "buzz" in the motor you are feeding high frequency noise to the motor and it will DAMAGE it. Turn the motor off immediately!!!"[3]

The motor can be used in two configurations: the low gear, and the high gear ratio. Normally, the first one is used in the position control experiments, and the high gear ratio is used when you want to place other elements, such the flexible joint, the pendulum, etc. on the DC servo. Figures 5 and 6 show the low gear and the high gear respectively.

[2] http://www.quanser.com

[3] Quanser Consulting docment: A comprehensive and modular laboratory for control systems design and implementation.

Figure 3: SRV02ET

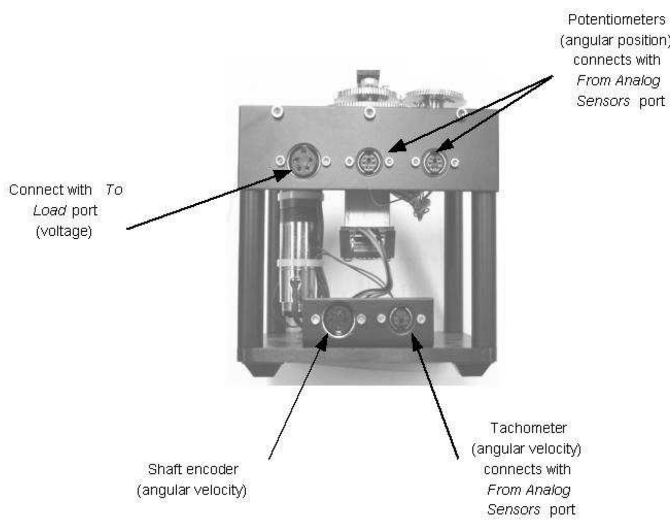

Figure 4: SRV02ET (figure provided by Prof. John Watkins).

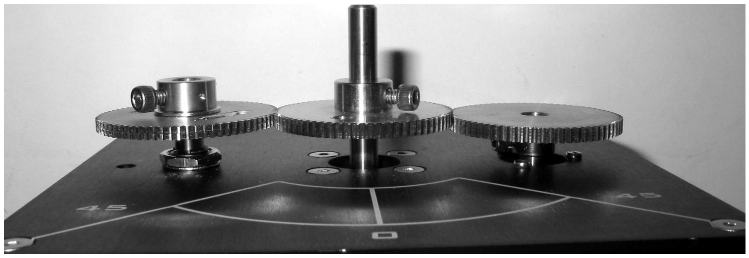

Figure 5: Low gear ratio.

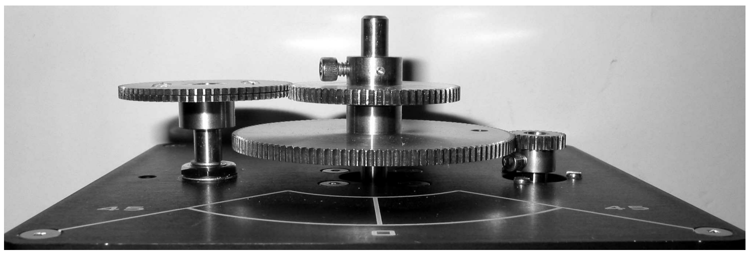

Figure 6: High gear ratio.

2 Connecting the Quanser Flexible Joint

To connect the flexible joint we need to first connect the motor in the high gear ratio (see Figure 6). In the top of the center gear we have to put the flexible joint, as we can see in the Figure 7. If we want to connect the flexible joint and the motor to the dSPACE card, we have to use the Universal Power Module to obtain the signals that come from/to the card. Besides the other cables (To A/D cable, From D/A cable, To Load Cable, and the Analog Sensors Cable—this one is used only if you are using the tachometer or the potentiometer), we need to use one (or two) encoders two acquire the position data of the joint (and the motor). The connections of the cables are shown in the Figure 8. As we can notice, in this figure, we put the connections of the encoder and the tachometer of the motor, but sometimes we have to use only one (it depends on which variable do we want to measure).

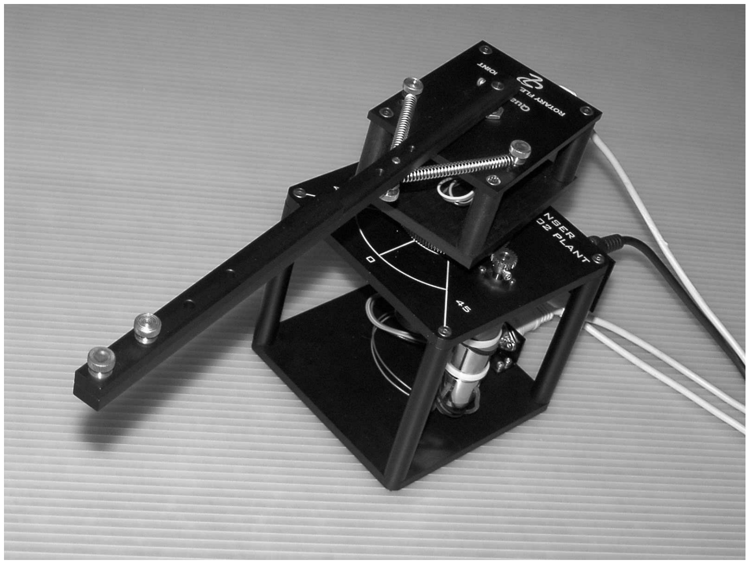

Figure 7: SRV02ET module plus flexible joint.

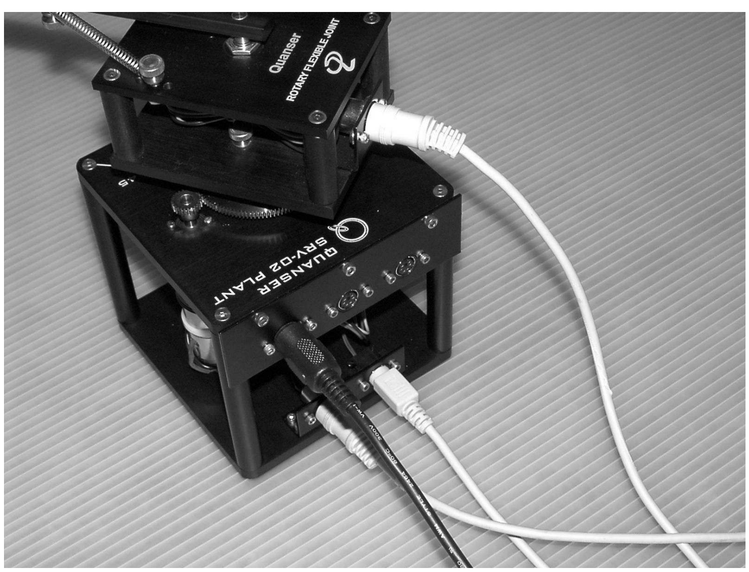

Figure 8: Connections to the flexible joint.