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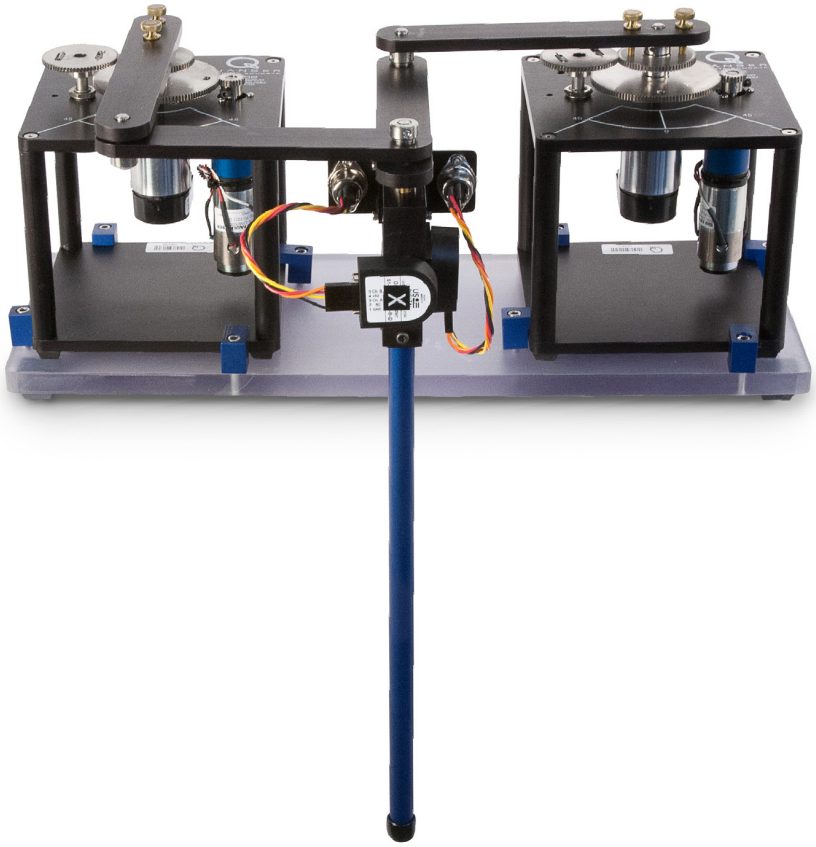
USER MANUAL

2 DOF Gantry Experiment

Set Up and Configuration



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- 2006/95/EC; Low-Voltage Directive (safety)
- 2004/108/EC; Electromagnetic Compatibility Directive (EMC)

CONTENTS

1 PRESENTATION

1.1 Description

The Quanser 2 DOF Gantry system is pictured in Figure 1.1. The module consists of an instrumented 2-DOF joint to which a 12-inch rod is mounted and free to swing about two orthogonal axes. This is attached at the end of the 2 DOF Robot end-effector.

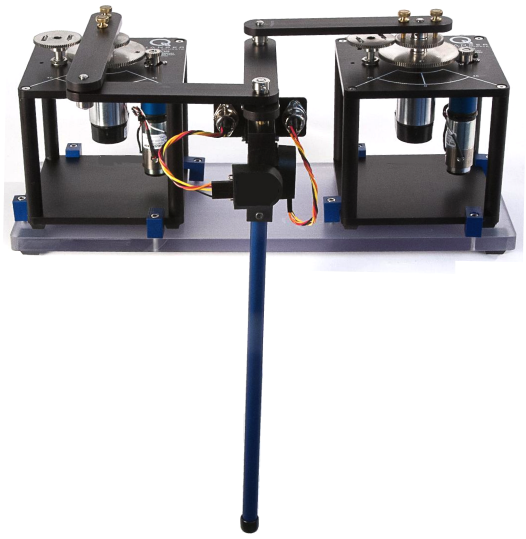

Figure 1.1: 2 DOF Gantry System

Caution: This equipment is designed to be used for educational and research purposes and is not intended for use by the general public. The user is responsible to ensure that the equipment will be used by technically qualified personnel only.

1.2 Experiment Overview

The experiments capable of being performed with the 2 DOF GANTRY modules are explained in Table 1.1, below. As summarized, the 2 DOF Robot module by itself is supplied with two position control experiments. When this is combined with the 2 DOF Joint, additional experiments can be performed such as 2 DOF Gantry and 2 DOF Inverted Pendulum.

Experiemnt Name	Module Option Need	Description
Joint Space Control	2 DOF Robot	Design a joint-level position controller for each servo using a PID-type compensator.
Work Space Control	2 DOF Robot	Design a task-space position controller that controls the position of the end-effector to a desired point in the Cartesian X-Y plane.
2 DOF Gantry	2 DOF Robot + 2 DOF Joint	Design a control the minimizes the swing of the suspended pendulum, i.e. crane, in both X and Y directions.
2 DOF Inverted Pendulum	2 DOF Robot + 2 DOF Joint	Design a controller that keeps the pendulum in the upright, vertical position.

Table 1.1: Possible experiments with the 2 DOF Robot and 2 DOF Joint modules.

2 COMPONENTS

2.1 System description

The system is comprised of a 2 DOF Robot and a 2 DOF Joint. As described in Reference [1], the output shaft of the two rotary servo plants are coupled through a four-bar linkage resulting in a planar manipulator robot. Then, the 2 DOF Joint is attached to the end-effector of the robot arms.

2.2 Components of the 2 DOF Joint

The components for the 2 DOF Joint module are listed in Table 2.1 and labeled in Figure 2.1.

ID	Component	ID	Component
1	Pendulum Link	5	Encoder X Connector
2	Pendulum T-Fitting	6	Encoder Y Connector
3	Encoder X	7	Thumbscrews
4	Encoder Y		

Table 2.1: 2 DOF GANTRY-E Components.

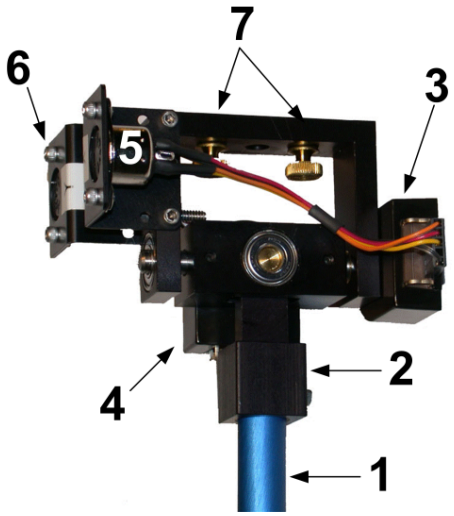

Figure 2.1: Components on 2 DOF joint.

3 SPECIFICATIONS

Table 3.1, lists and characterizes the main parameters associated with the 2 DOF Joint. Some of these parameters are used in the mathematical model.

Symbol	Description	Value	Unit
M_{lk}	Mass of four-bar linkages	0.335	kg
M_b	Mass of single link	0.065	kg
L_b	Length single bar in linkage	0.127	m
M_p	Mass of pendulum (with T-Fitting)	0.127	kg
M_h	Mass of 2 DOF hinge	0.3	kg
L_p	Full length of pendulum: from pivot to tip	0.3365	m
$J_{b,og}$	Link moment of inertia about cog.	8.74×10^{-5}	kg-m^2
$J_{b,piv}$	Link moment of inertia about pivot.	4.41×10^{-4}	kg-m^2
$J_{eq,linkage}$	Equivalent moment of inertia of 4-bar linkage	1.14×10^{-3}	kg-m^2
$J_{eq,asssembly}$	Moment of inertia of 4-bar linkage and 2 DOF hinge	5.97×10^{-3}	kg-m^2
J_{eq}	Equivalent moment of inertia of 4-bar linkage and 2 DOF hinge including motor inertia (i.e. as seen from motor shaft)	8.07×10^{-3}	kg-m^2
$K_{ENC,2DP}$	Encoder sensitivity on 2 DOF Gantry joint	0.0879	deg/count

Table 3.1: 2 DOF Joint system specifications.

4 SYSTEM SETUP

Caution: If the equipment is used in a manner not specified by the manufacturer, the protection provided by the equipment may be impaired

Follow this procedure to setup the Quanser 2 DOF Gantry experiment:

1. Setup the 2 DOF Robot system as described in Reference [1] but ensure that **link Y is underneath link X**, as shown in Figure 4.1.

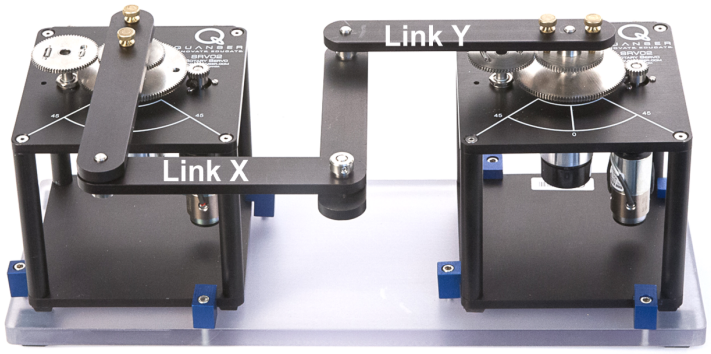

Figure 4.1: 2 DOF Robot System

2. Attach the 2 DOF Joint underneath the end-effector. Shown in Figure 4.2
3. Tighten both thumbscrews, ID #7 in Figure 2.1, to fasten the joint onto the end-effector of the 2 DOF Robot links.

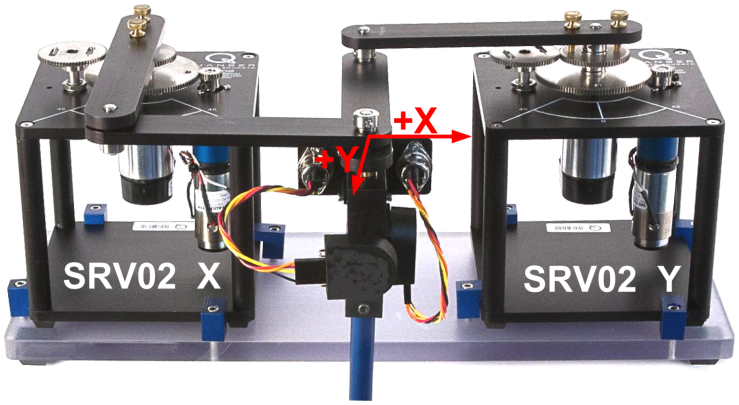

Figure 4.2: 2 DOF Joint attached to end-effector

4. Verify that the setup is as shown in Figure 4.2, above. In particular, ensure that when SRV02 X rotates, the 2 DOF Joint moves in the x-direction and similarly for the y-axis subsystem.

5 WIRING PROCEDURE

The following is a listing of the hardware components used in this experiment:

1. **Power Amplifier:** Quanser VoltPAQ-X2, 2xVoltPAQ-X1, or equivalent.
2. **Data Acquisition Device:** Q1-cRIO, Q2-USB, Q8-USB, QPID/QPIDe, NI DAQ Device, or equivalent.
3. **Rotary Servo Plant:** Quanser SRV02-ET.
4. **Rotary Module:** Quanser 2 DOF Robot, Quanser 2 DOF Joint.

See the references listed in Section 8 for more information on these devices. The cables supplied with the system are described in Section 5.1 and the procedure to connect the above components is given in Section 5.2.

Caution: When using the Quanser VoltPAQ power amplifier, **make sure set the Gain to 1!**.

5.1 Cable Nomenclature

Table 5.1, below, provides a description of the standard cables used in the wiring of the 2 DOF Gantry related experiments.

Cable	Type	Description
 (a) "2xRCA to 2xRCA" cable	2xRCA to 2xRCA	This cable connects an analog output of the data acquisition device to the power module for proper power amplification.
 (b) "To Load" Cable	4-pin-DIN to 6-pin-DIN	This cable connects the output of the power module, after amplification, to the desired DC motor on the servo.
 (c) Encoder Cable	5-pin-stereo-DIN to 5-pin-stereo-DIN	This cable carries the encoder signals between an encoder connector and the data acquisition device (to the encoder counter). Namely, these signals are: +5 VDC power supply, ground, channel A, and channel B

Table 5.1: Cables used to connect SRV02 to amplifier and DAQ device

5.2 Typical Connections

This section describes the typical connections used for to connect the SRV02 and 2 DOF Gantry system to a data acquisition (DAQ) device and a power amplifier. The connections are given in Table 5.2 and illustrated in Figure 5.1 and Figure 5.2. The detailed wiring procedure is given below.

Cable #	From	To	Signal
1	DAQ: Analog Output #0	Amplifier 0 (or amplifier "A") "Amplifier command" connector	Control signal to the amplifier driving SRV02 X.
2	DAQ: Analog Output #1	Amplifier 1 (or amplifier "B")"Amplifier Command " connector	Control signal to the amplifier driving SRV02 Y.
3	Amplifier 0 "To Load" connector	SRV02 X "Motor" connector	Power leads to the DC motor of SRV02 X.
4	Amplifier 1 "To Load" connector	SRV02 Y "Motor" connector	Power leads to the DC motor of SRV02 Y.
5	Data Acquisition Device: Encoder Input #0	SRV02 X "Encoder" connector	SRV02 X encoder load shaft angle measurement.
6	Data Acquisition Device: Encoder Input #1	SRV02 Y "Encoder" connector	SRV02 Y encoder load shaft angle measurement.
7	Data Acquisition Device: Encoder Input #2	2 DOF Joint X "Encoder" connector	2 DOF Joint X encoder angle measurement.
8	Data Acquisition Device: Encoder Input #3	2 DOF Joint Y "Encoder" connector	2 DOF Joint Y encoder angle measurement.
9	Emergency Stop Switch	E-Stop Connector on VoltPAQ	When pressed, it disable the command output of the amplifier

Table 5.2: Quanser 2DOF Gantry system wiring summary.

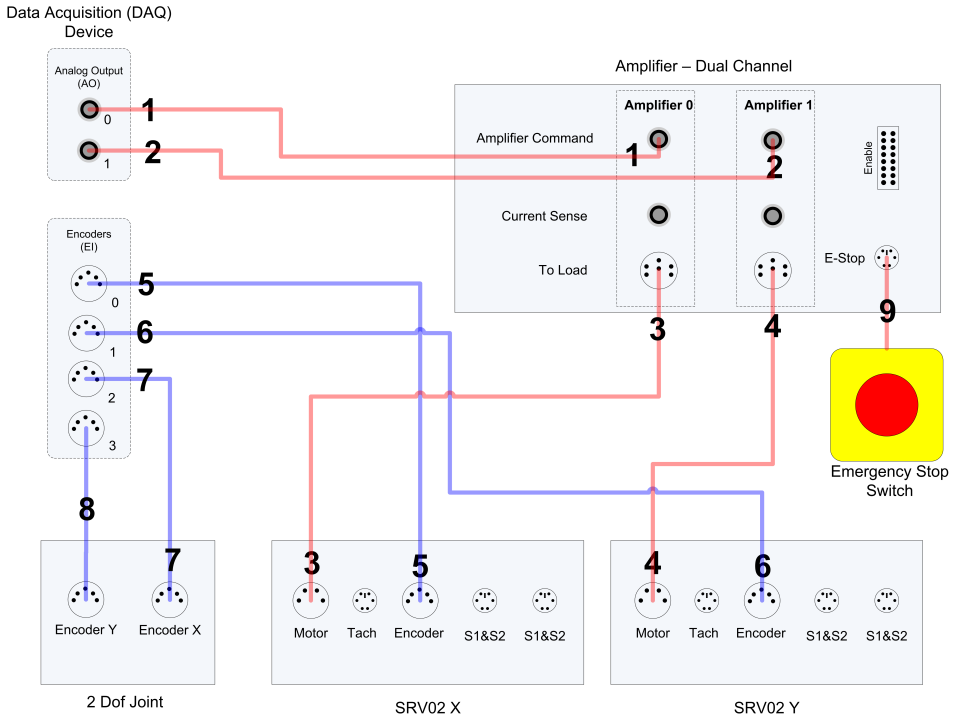

Figure 5.1: 2 DOF Gantry Connections

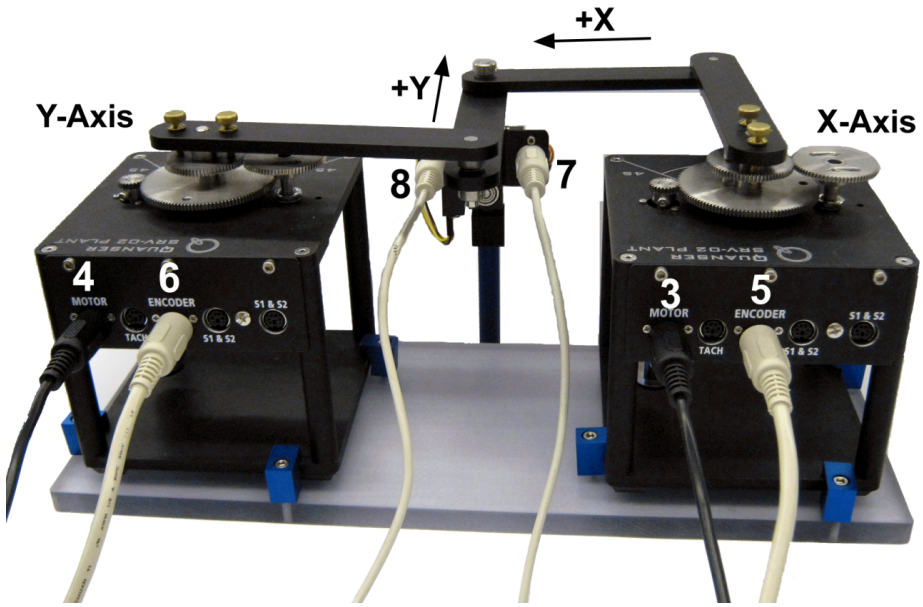

Figure 5.2: Connections on the 2 DOF Gantry

The following steps describes a detailed wiring procedure of the 2 DOF Gantry to the SRV02, data-acquisition device and a dual channel power amplifier

1. It is assumed that the data-acquisition device is already installed as discussed in its respective User Manual.
2. Make sure everything is powered off before making any of these connections. This includes turning off your PC and the amplifiers.
3. Connect one end of the 2xRCA to 2xRCA cable from the Analog Output Channel #0 on the data acquisition (DAQ) device to the Amplifier Command 0 connector on the amplifier, that will be connected to SRV02 X. See cable #1 shown in Figure 5.1. This carries the attenuated SRV02 X motor voltage control signal, $V_{m,x}/K_{a,x}$, where $K_{a,x}$, is the amplifier X gain.
4. Connect one end of the 2xRCA to 2xRCA cable from the Analog Output Channel #1 on the data acquisition (DAQ) device to the Amplifier Command 1 connector on the amplifier that will be connected to SRV02 Y. See cable #2 shown in Figure 5.1. This carries the attenuated SRV02 Y motor voltage control signal, $V_{m,y}/K_{a,y}$, where $K_{a,y}$ is the amplifier Y gain.
5. Connect the 4-pin-stereo-DIN to 6-pin-stereo-DIN from To Load 0 on the amplifier to the Motor connector on the SRV02. See connection #3 shown in Figure 5.1 and Figure 5.2. The cable transmits the amplified voltage that is applied to the SRV02 X motor and is denoted $V_{m,x}$.
6. Connect the 4-pin-stereo-DIN to 6-pin-stereo-DIN from the To Load 1 on the amplifier to the Motor connector on the SRV02. See connection #4 in Figure 5.1 and Figure 5.2. The cable transmits the amplified voltage that is applied to the SRV02 Y motor and is denoted $V_{m,y}$.
7. Connect the 5-pin-stereo-DIN to 5-pin-stereo-DIN cable from the Encoder connector on the SRV02 X panel to Encoder Input # 0 on the data acquisition (DAQ) device, as depicted by connection #5 in Figure 5.1 and Figure 5.2. This carries the SRV02 X load shaft angle measurement and is denoted by the variable $\theta_{l,x}$.

   Caution: Any encoder should be directly connected to the data acquisition (DAQ) device (or equivalent) using a standard 5-pin DIN cable. **DO NOT connect the encoder cable to the amplifier!**
8. Connect the 5-pin-stereo-DIN to 5-pin-stereo-DIN cable from the Encoder connector on the SRV02 X panel to Encoder Input #1 on the data acquisition (DAQ) device, as depicted by connectio #6 in Figure 5.1 and Figure 5.2. This carries the SRV02 Y load shaft angle measurement and is denoted by the variable $\theta_{l,y}$.

9. Connect the 5-pin-stereo-DIN to 5-pin-stereo-DIN cable from the X-Axis 2 DOF Joint Encoder connector to Encoder Input # 2 on the DAQ, as depicted by connection #7 in Figure 5.1 and Figure 5.2. This carries the X-Axis angle measurement and is denoted by the variable α_x.
10. Connect the 5-pin-stereo-DIN to 5-pin-stereo-DIN cable from the Y-Axis 2 DOF Encoder connector to Encoder Input #3 on the data acquisition (DAQ) device, as depicted by connection #8 in Figure 5.1 and Figure 5.2. This carries the Y-Axis angle measurement and is denoted by the variable α_y.
11. Conenct the Emergency Stop Switch to the E-Stop connector on the VoltPAQ. This enable or disable the command output onthe amplifier.

5.2.1 Typical Connections Using two Single Channel Amplifier

Alternatively, this section shows the typical wiring of the 2 DOF Joint when using two single channel power amplifier.

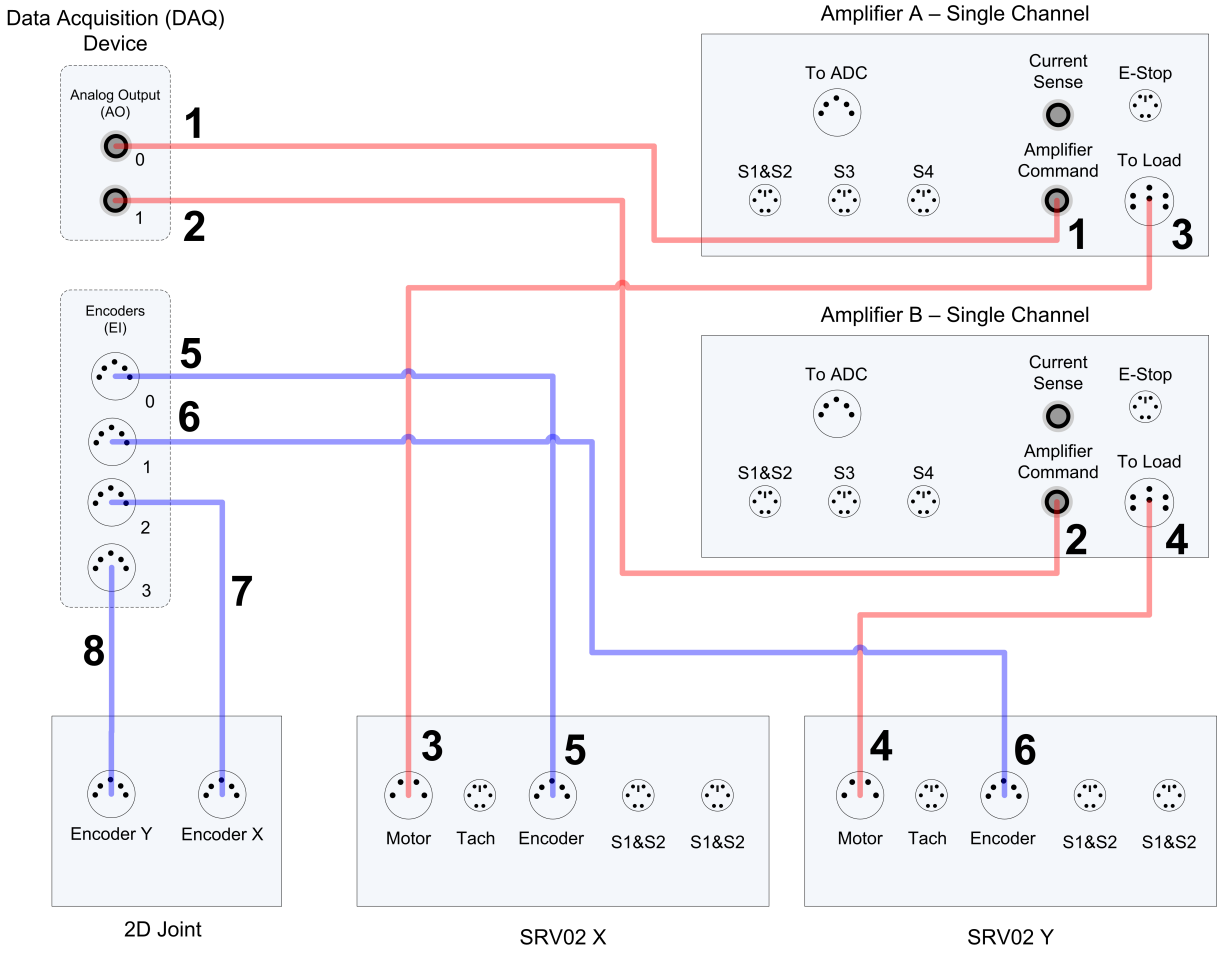

Figure 5.3: 2 DOF Joint connections using two single channel power amplifier

6 TESTING AND TROUBLESHOOTING

This section describes some functional tests to determine if your 2 DOF Gantry based system is operating normally. It is assumed that the SRV02 is connected as described in the Section 5. To carry out these tests, it is preferable if the user can use a software such as QUARC® or LabVIEW™ to read sensor measurements and feed voltages to the motor. Alternatively, these tests can be performed with a signal generator and an oscilloscope.

6.1 SRV02 Motor and Sensors

See Reference [2] for information on testing and troubleshooting the SRV02 separately.

6.2 Testing the 2 DOF GANTRY

6.2.1 Testing

Test the 2 DOF GANTRY encoder sensors with the following procedure:

1. Measure Encoder Input Channel #2 and #3.
2. As the pendulum is rotated about the x and y axes, the encoder should be outputting a count. Every revolution of the encoders represent 4096 counts (in quadrature mode).

6.2.2 Troubleshooting

See Reference [2] for information on troubleshooting an encoder.

7 TECHNICAL SUPPORT

To obtain support from Quanser, go to http://www.quanser.com/ and click on the Tech Support link. Fill in the form with all the requested software and hardware information as well as a description of the problem encountered. Also, make sure your e-mail address and telephone number are included. Submit the form and a technical support person will contact you.

REFERENCES

[1] Quanser Inc. *2 DOF Robot User Manual*, 2012.

[2] Quanser Inc. *SRV02 User Manual*, 2012.

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