QUANSER
INNOVATE. EDUCATE.

USER MANUAL

SRV02 Rotary Servo Base Unit

Set Up and Configuration

Developed by:
Jacob Apkarian, Ph.D., Quanser
Michel Lévis, M.A.Sc., Quanser
Hakan Gurocak, Ph.D., Washington State University

Quanser educational solutions are powered by:

LabVIEW MATLAB SIMULINK

CAPTIVATE. MOTIVATE. GRADUATE.

Quanser Inc.
119 Spy Court
Markham, Ontario
L3R 5H6
Canada
info@quanser.com
Phone: 1-905-940-3575
Fax: 1-905-940-3576

Printed in Markham, Ontario.

For more information on the solutions Quanser Inc. offers, please visit the web site at:
http://www.quanser.com

CONTENTS

1 PRESENTATION

1.1 Description

The Quanser SRV02 rotary servo plant, pictured in Figure 1.1, consists of a DC motor that is encased in a solid aluminum frame and equipped with a planetary gearbox. The motor has its own internal gearbox that drives external gears. The SRV02 is equipped with three sensors: potentiometer, encoder, and tachometer. The potentiometer and encoder sensors measure the angular position of the load gear and the tachometer can be used to measured its velocity.

Figure 1.1: Quanser SRV02 system

There are two SRV02 options available: SRV02-ET and SRV02-ETS. The SRV02-ETS system includes a slip ring assembly that allows the modules to be rotated the full 360 degrees.

1.2 Rotary Modules and Experiment Overview

The SRV02 rotary plant can be used stand-alone for several experiments but it also serve as a base component for several add-on modules. Table 1.1 below lists these modules and the corresponding experiments that are supplied with them. Thus a new plant is obtained by adding a module which presents new modeling and control challenges.

System	Experiment	Description
SRV02	SRV02 QUARC Integration	Describes how to use
SRV02	Modeling	Model the speed of the SRV02 using a first-order transfer function.
SRV02	Position Control	Regulate position of the SRV02 load gear to a desired angle using PID.
SRV02	Speed Control	Control the angular rate of the SRV02 load gears using a PI and a lead compensator.
Ball and beam	Balance Control	Model the system and develop a cascade PD controller to stabilize the ball to a position along the beam.
Flexible Joint	Vibration Control	Derive the plant dynamics and design a controller that compensates for the flexibilities in the joint while regulating the position of the arm tip to desired location.
Flexible Link	Vibration Control	Model the plant and identify the natural frequency of the beam. Then, develop a system that controls the tip of beam to a desired position.
Single Pendulum	Self-Erecting Single Inverted Pendulum Control	Design a nonlinear energy-based swing-up controller and a linear balance compensator to swing-up the pendulum from the resting downward position to the upright vertical position.
Double Pendulum	Double-Inverted Pendulum Balance Control	Model the system and then design a controller that balances the pendulum while the servo is tracking a reference position.
Gyroscope	Heading Control	Design a feedback loop that can maintains the position of the SRV02 load gear, i.e. the heading, while the rotary base underneath is manually perturbed.
1-DOF Torsion	Vibration Control	Control the position of the output shaft to desired setpoint by rejecting the vibrations introduced by the torsional member.
2 DOF Torsion	Vibration Control	Control the position of the output shaft to desired setpoint by rejecting the vibrations introduced by both torsional members.
2 DOF Robot	2D Task-Based Position Control	Control the position of the end-effector given a desired planar (x,y) position. This involves servo position control as well as developing the forward and inverse kinematics of the plant.
2 DOF Pendulum	2 DOF Gantry Control	Control the position of the pendulum tip to a desired (x,y) position while dampening the motions of the pendulum.
2 DOF Pendulum	2 DOF Inverted Pendulum Balance Control	Develop a balance controller that keeps the 2 DOF pendulum in the upright vertical position.
2D Ball Balancer	Ball Position Control	Control the position of a ball that is free to move on a swiveling 2 DOF plate. The plate angles are controlled by attached servo units and the ball position is measured using an overhead digital camera with image processing software.

Table 1.1: SRV02-based Experiments

2 SRV02 COMPONENTS

The SRV02 components are identified in Section 2.1. Some of the those components are then described in Section 2.2.

2.1 SRV02 Component Nomenclature

The SRV02 components listed in Table 2.1 below are labeled in figures 2.1a, 2.1b, 2.1c, 2.1d, and 2.1e. Note that Figure 2.1a shows the SRV02 in the low-gear configuration and Figure 2.1b is the SRV02 in the high-gear configuration. These different gear setups will be explained later in Section 4.1.

ID	Component	ID	Component
1	Potentiometer	13	Tachometer
2	Bottom plate	14	Ball-bearing block
3	Posts	15	Motor connector
4	Motor pinion gear: 72-teeth (low-gear)	16	Tachometer connector
5	Load gear: 72-teeth (low-gear)	17	Encoder connector
6	Potentiometer anti-backlash gear	18	S1 & S2 connector (i.e. potentiometer)
7	Anti-backlash springs	19	Motor pinion gear: 24-teeth (high-gear)
8	Load shaft (i.e. output shaft)	20	Load gear: 120-teeth (high-gear)
9	Motor	21	Bar inertial load
10	Gearbox	22	Disc inertial load
11	Potentiometer	23	Thumb screws
12	Encoder		

Table 2.1: SRV02 Components

2.2 Component Description

2.2.1 DC Motor

The SRV02 incorporates a Faulhaber Coreless DC Motor model 2338S006 and is shown in Figure 2.1c with ID #9. This is a high efficiency, low inductance motor that can obtain a much faster response than a conventional dc motor. The complete specification sheet of the motor is included in [2].

■ **Caution:** *High-frequency signal applied to a motor will eventually damage the gearbox motor and the motor brushes.* The most likely source for high frequency noise is derivative feedback. If the derivative gain is set too high, a noisy voltage will be fed into the motor. To protect your motor, you should always band limit your signal (especially derivative feedback) to a value of 50 Hz.

■ **Caution:** Input ± 15 V, 3 A peak, 1 A continuous.

■ **Caution:** Exposed moving parts.

2.2.2 Potentiometer

All SRV02 models are equipped with a Vishay Spectrol model 132 potentiometer, shown in in Figure 2.1c with label #11. It is a single turn 10 kΩ sensor with no physical stops and has an electrical range of 352 deg. The total output range of the sensor is ± 5 V over the full 352 deg range. Note that a potentiometer provides an absolute position measurement as opposed to a relative measurement from, for instance, an incremental encoder. See [6] for a full listing of the potentiometer specifications.

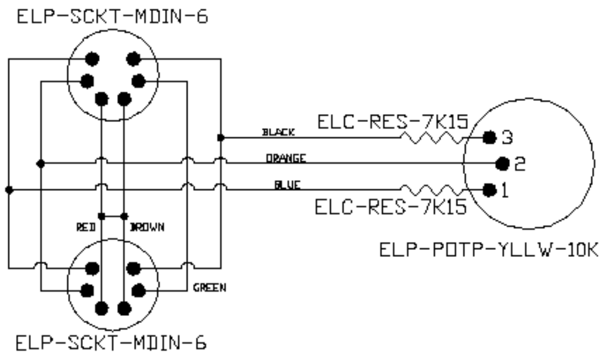


Figure 2.2: SRV02 potentiometer wiring

As illustrated in Figure 2.2, the potentiometer is connected to a ± 12 V DC power supply through two 7.15 kΩ bias resistors. Under normal operations, terminal 1 should measure -5 V while terminal 3 should measure 5 V. The actual position signal is available at terminal 2.

2.2.3 Tachometer

The SRV02-T and SRV02-ET models come equipped with a tachometer that is directly attached to the DC motor and is depicted with ID #13 in Figure 2.1c. This prevents any latencies in the timing of the response and ensures that the speed of the motor is accurately measured. Refer to [3] for the tachometer specification sheet.

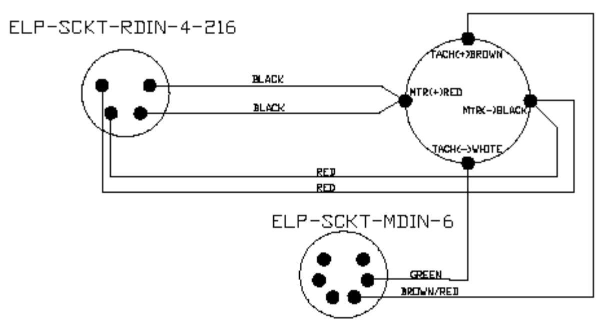


Figure 2.3: SRV02 tachometer wiring

The motor and tachometer wiring diagram is shown in Figure 2.3. The 4-pin DIN motor connector, component #19, connects the power amplifier to the positive and negative motor leads. This is the motor input voltage signal that drives the motor. The 6-pin mini DIN tachometer connector, component #18 shown in Figure 2.1d, is directly wired to the positive and negative tachometer terminals. This supplies a voltage signal that is proportional to the rotational speed. The tachometer connector is typically connected to the S3 analog input connector on the power amplifier.

2.2.4 Encoder

The SRV02-E and SRV02-EHR options have an optical encoder installed that measures the angular position of the load shaft. It is pictured in Figure 2.1c with the label #12. In the SRV02-E system, the encoder used is a US Digital S1 single-ended optical shaft encoder that offers a high resolution of 4096 counts per revolution in quadrature mode (1024 lines per revolution). The complete specification sheet of the S1 optical shaft encoder is given in [1].

The encoder in the SRV02-EHR system has a resolution of 8192 counts per revolution in quadrature mode (2042 lines per revolution). Remark that incremental encoders measure the relative angle of the shaft (as opposed to the potentiometer which measures the absolute angle).

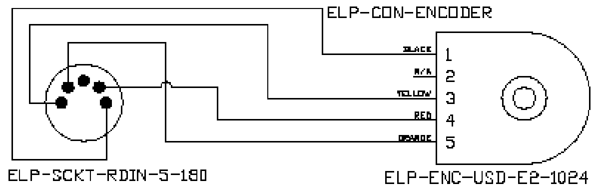


Figure 2.4: SRV02 encoder wiring

The position signal generated by the encoder can be directly connected to the data-acquisition device using a standard 5-pin DIN cable. The internal wiring of the encoder and the 5-pin DIN connector on the SRV02, component #17, is illustrated in Figure 2.4.

■ **Caution:** Make sure you connect the encoder directly to your data-acquistion device and not to the power amplifier.

2.3 SRV02-ETS Components

The SRV02-ETS, pictured in Figure 2.5, is an SRV02-ET system with a slip ring mounted on the load gear. This allows an external load attached on top of the slip ring unit to rotate 360 degrees freely without any cable entanglements. In addition to the components listed in Table 2.1, Table 2.2 lists some components found on the SRV02-ETS unit alone.

The components in Table 2.2 are shown and identified in Figure 2.6.

ID	Component	ID	Component
24	Slip ring module chassis	28	Right connector on slip ring
25	Slip ring	29	Left connector on SRV02
26	Slip ring top plate	30	Right connector on SRV02
27	Left connector on slip ring		

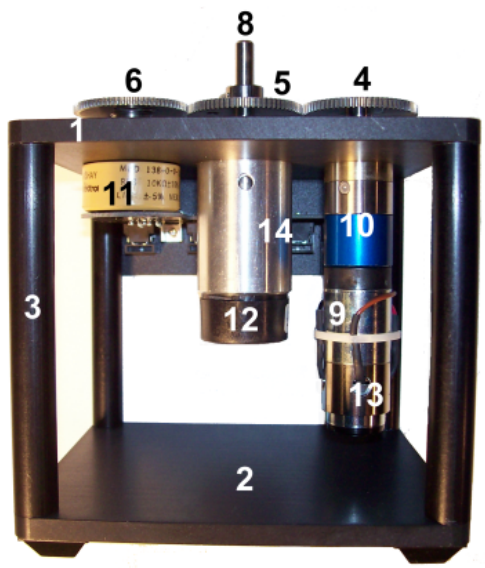
Table 2.2: Additional components on the SRV02-ETS

2.3.1 Slip Ring Description

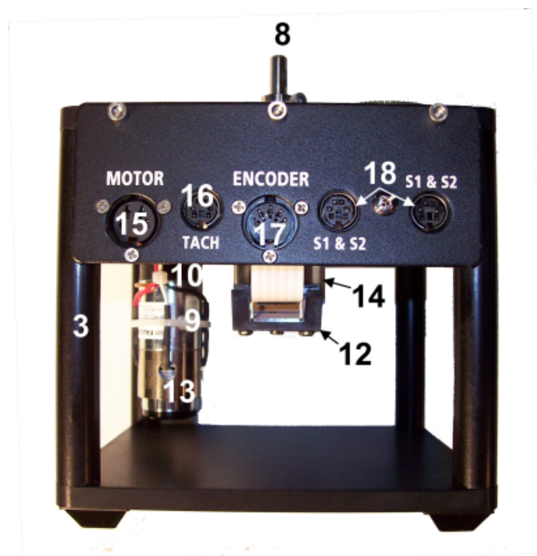
The eight-contact slip ring channels the signals attached to the Left and Right connectors on the slip ring, ID #27 and ID #28 depicted in Figure 2.6, to the *Left* and *Right* connectors on the SRV02 base, ID #27 and ID #28 shown in Figure 2.6. This allows the load attached to the load gear atop the slip ring, ID #8, to move freely 360 degrees without any cable entanglements. This is especially useful, for instance, when used with the inverted rotary pendulum experiments.

(a) Low-gear

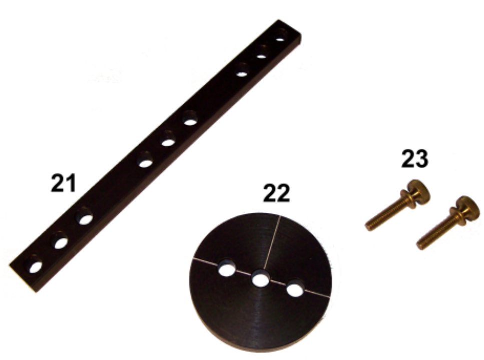
(b) High-gear



(c) Front view



(d) Connectors



(e) Inertial Loads

Figure 2.1: SRV02 components

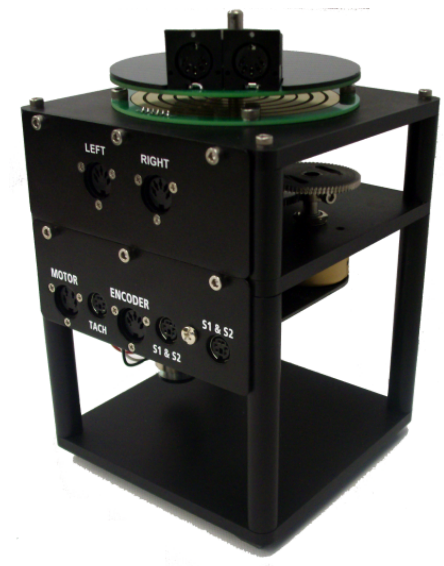


Figure 2.5: SRV02-ETS

Figure 2.6: Components on the SRV02-ETS

3 SRV02 SPECIFICATIONS

Table 3.1 lists and characterizes the main parameters associated with the SRV02. Some of these are used in the mathematical model. More detailed information about the gears is given in Table 3.2 and the calibration gains for the various sensors on the SRV02 are summarized in Table 3.3.

Symbol	Description	Matlab Variable	Value	Variation
V_{nom}	Motor nominal input voltage		6.0 V	
R_m	Motor armature resistance	Rm	2.6 Ω	$\pm$ 12%
L_m	Motor armature inductance	Lm	0.18 mH	
k_t	Motor current-torque constant	kt	7.68×10^{-3} N m/A	$\pm$ 12%
k_m	Motor back-emf constant	km	7.68×10^{-3} V/(rad/s)	$\pm$ 12%
K_g	High-gear total gear ratio	Kg	70	
	Low-gear total gear ratio	Kg	14	
η_m	Motor efficiency	eta_m	0.69	$\pm$ 5%
η_g	Geabox efficiency	eta_g	0.90	$\pm$ 10%
$J_{m,rotor}$	Rotor moment of inertia	Jm_rotor	3.90×10^{-7} kg $\cdot$ m^2	$\pm$ 10%
J_{tach}	Tachometer moment of inertia	Jtach	7.06×10^{-8} kg $\cdot$ m^2	$\pm$ 10%
J_{eq}	High-gear equivalent moment of inerta without external load	Jeq	9.76×10^{-5} kg $\cdot$ m^2	
	Low-gear equivalent moment of inertia without external load	Jeq	2.08×10^{-5} N $\cdot$ m / (rad/s)	
B_{eq}	High-gear Equivalent viscous damping coefficient	Beq	0.015 N $\cdot$ m / (rad/s)	
	Low-Gear Equivalent viscous damping coefficient	Beq	1.50×10^{-4} kg $\cdot$ m^2	
m_b	Mass of bar load	m_b	0.038 kg	
L_b	Length of bar load	L_b	0.1525 m	
m_d	Mass of disc load	m_d	0.04 kg	
r_d	Radius of disc load	r_d	0.05 m	
m_{max}	Maximum load mass		5 kg	
f_{max}	Maximum input voltage frequency		50 Hz	
I_{max}	Maximum input current		1 A	
ω_{max}	Maximum motor speed		628.3 rad/s	

Table 3.1: Main SRV02 Specifications

Symbol	Description	Matlab Variable	Value
K_{gi}	Internal gearbox ratio	Kgi	14
$K_{ge,low}$	Internal gearbox ratio (low-gear)	Kge	1
$K_{ge,high}$	Internal gearbox ratio (high-gear)	Kge	5
m_{24}	Mass of 24-tooth gear	m24	0.005 kg
m_{72}	Mass of 72-tooth gear	m72	0.030 kg
m_{120}	Mass of 120-tooth gear	m120	0.083 kg
r_{24}	Radius of 24-tooth gear	r24	6.35×10^{-3} m
r_{72}	Radius of 72-tooth gear	r72	0.019 m
r_{120}	Radius of 120-tooth gear	r120	0.032 m

Table 3.2: SRV02 Gearhead Specifications

Symbol	Description	Matlab Variable	Value	Variation
K_{pot}	Potentiometer sensitivity	K_POT	35.2 deg/V	$\pm$ 2 %
K_{enc}	SRV02-E encoder sensitivity	K_ENC	4096 counts/rev	
K_{enc}	SRV02-EHR encoder sensitivity	K_ENC	8192 counts/rev	
K_{tach}	Tachometer sensitivity	K_TACH	1.50 V/k_{RPM}	$\pm$ 2 %

Table 3.3: SRV02 Sensor Specifications

4 SRV02 SETUP AND CONFIGURATION

As discussed in Section 4.1, the SRV02 can be setup with two different gear configurations depending on the experiment being performed. Also, Section 4.2 shows how the SRV02 can be fitted with different loads.

4.1 Gear Configuration

4.1.1 Description

The SRV02 can be setup in the low-gear configuration or the high-gear configuration, as pictured in Figure 4.1a and Figure 4.1b, respectively. The high-gear setup is required to be used with additional modules such as the ball-and-beam device, the flexible link module, and the gyroscope.

(a) Low-gear (b) High-gear

Figure 4.1: SRV02 Gear Configurations

4.1.2 Changing Gear Configuration

Follow this procedure to change between high-gear and low-gear ratio:

1. Using the supplied Allen keys, loosen the set screws on the three gear shafts.
2. Remove the gears from the shafts.
3. Slide the new gears into place as described below:
   - Low-gear configuration shown in Figure 4.1a: place the 72-tooth gear, ID #5 in Figure 2.1a, onto the load shaft, ID #8 in Figure 2.1a, and the 72-tooth pinion gear, ID #4 in Figure 2.1a, on the motor shaft.
   - High-gear configuration depicted in Figure 4.1b: slide the 120-tooth gear, ID #20 in Figure 2.1b, followed by the 72-tooth gear, ID #8 in Figure 2.1b, on the load shaft and place the 20-tooth pinion gear, ID #19 in Figure 2.1b, on the motor shaft.

Note: The potentiometer gear, component #6 in Figure 2.1b, is an anti-backlash gear and special precaution need to be taken when installing it. In order to insert it properly, rotate its two faces against each other such that the springs are partially pre-loaded. Do not fully extend the springs when you pre-load the gears.

4. Ensure the teeth of all the three gears are meshed together. Remark that in the high-gear setup, the top 72-tooth load gear is meshed with the potentiometer gear, ID #6 in Figure 2.1b.
5. Tighten the set-screws on each shaft with the supplied Allen keys.

4.2 Load Configurations

4.2.1 Description

The SRV02 is supplied with two external loads: a bar and a disk. These can be attached to the SRV02 load gear to vary the moment of inertia seen at the output. The SRV02 with the end of the bar load connected is pictured in Figure 4.2a. Either the end of the bar or the center of the bar can be used. In Figure 4.2b the SRV02 with the disk load attached is shown.

(a) Bar load (b) Disc load

Figure 4.2: SRV02 Load Configurations

4.2.2 Installing Load

Follow this procedure to connect either the bar or disc load to the load gear:

1. Slide the center hole of the load on the output shaft of the SRV02, component #8 in Figure 2.1b. For the bar load (ID #21 in Figure 2.1e), use either the center hole in the middle of the bar or the center hole at the an end of the bar onto the output shaft.
2. Align the two holes adjacent to the center hole with the screw holes of the load gear.
3. Using the two 8-32 thumb screws provided, ID #23 in Figure 2.1e, fasten the inertial load to the output gear. The SRV02 with the bar load and the disk load attached is shown in Figure 4.2a and Figure 4.2b, respectively. Make sure all the screws are properly tightened before operating the servo unit.

■ **Caution:** Do not apply a load that weighs over 5 kg at any time.

For instructions on how to install one the SRV02 modules (e.g. rotary flexible joint) see the user manual corresponding to that module.

5 WIRING PROCEDURE

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

1. **Power Amplifier**: Quanser VoltPAQ-X1, or equivalent.
2. **Data Acquisition Board**: Quanser QPID, QPIDe, Q8-USB, Q2-USB, or equivalent.
3. **Rotary Servo Plant**: Quanser SRV02-ET, SRV02-ETS, or equivalent.

See the corresponding documentation for more information on these components. The cables supplied with the SRV02 are described in Section Section 5.1 and the procedure to connect the above components is given in Section 5.2.

■ **Caution:** When using the Quanser VoltPAQ-X1 power amplifier, **make sure you set the Gain to 1**!

5.1 Cable Nomenclature

The cables used to connect the Quanser SRV02 system with a power amplifier and data-acquisition device is shown in Table 5.1. Depending on your configuration, not all these cables are necessary.

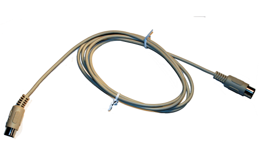
Cable	Type	Description
 (a) RCA Cable	2xRCA to 2xRCA	This cable connects an analog output of the data acquisition terminal board to the power module for proper power amplification.
 (b) Motor Cable	4-pin-DIN to 6-pin-DIN	This cable connects the output of the power module, after amplification, to the 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 board (to the encoder counter). Namely, these signals are: +5 VDC power supply, ground, channel A, and channel B
 (d) Analog Cable	6-pin-mini-DIN to 6-pin-mini-DIN	This cable carries analog signals (e.g., from joystick, plant sensor) to the amplifier, where the signals can be either monitored and/or used by a controller. The cable also carries a $\pm$ 12 VDC line from the amplifier in order to power a sensor and/or signal conditioning circuitry.
 (e) 5-pin-DIN to 4xRCA	5-pin-DIN to 4xRCA	This cable carries the analog signals, unchanged, from the amplifier to the Digital-To-Analog input channels on the data acquisition terminal board.

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

5.2 Typical Connections

This section describes the typical connections used to connect the SRV02 plant to a data-acquisition board and a power amplifier. The connections are described in detail in the procedure below, summarized in Table 5.2, and pictured in Figure 5.1.

Note: The wiring diagram shown in Figure 5.1 is using a two-channel data-acquisition board, which resembles a Quanser Q2-USB. The same connections can be applied for any data-acquisition system - as long as it has least two analog input, two analog output, and two encoder channels.

Follow these steps to connect the SRV02 system:

1. Make sure that your data-acquisition device is installed and is operational. For example, if using the Quanser Q2-USB see Reference [5].
2. Make sure everything is powered off before making any of these connections. This includes turning off your PC and the amplifier.
3. Connect one end of the 2xRCA to 2xRCA cable from the Analog Output Channel #0 on the terminal board to the *Amplifier Command* connector on the amplifier, i.e. use both white or both red RCA connectors. See cable #1 shown in Figure 5.1. This carries the attenuated motor voltage control signal, V_m/K_a, where K_a is the amplifier gain.
4. Connect the 4-pin-stereo-DIN to 6-pin-stereo-DIN that is labeled from *To Load* on the amplifier to the *Motor* connector on the SRV02. See connection #2 shown in Figure 5.1. The cable transmits the amplified voltage that is applied to the SRV02 motor and is denoted V_m.
5. Connect the 5-pin-stereo-DIN to 5-pin-stereo-DIN cable from the *Encoder* connector on the SRV02 panel to Encoder Input # 0 on the terminal board, as depicted by connection #3 in Figure 5.1. This carries the load shaft angle measurement and is denoted by the variable θ_l.

   ■ **Caution:** Any encoder should be directly connected to the data-acquisition terminal board (or equivalent) using a standard 5-pin DIN cable. **DO NOT connect the encoder cable to the amplifier!**
6. Connect the *To ADC* socket on the amplifier to Analog Inputs #0-1 on the terminal board using the 5-pin-DIN to 4xRCA cable, as illustrated in Figure 5.1. The RCA side of the cable is labeled with the channels: yellow is S1, white is S2, red is S3, and black is S4. The yellow S1 connector goes to Analog Input Channel #0 and the white S2 connector goes to Analog Input Channel #1.
7. Connect the *TACH* connector on the SRV02 to the *S1 & S2* socket on the SRV02 using the 6-pin-mini-DIN to 6-pin-mini-DIN cable. This connection is labeled #5 in Figure 5.1. It combines the potentiometer (S1) measurement with the tachometer (S2) measurement.
8. Connect the *S1 & S2* connector on the SRV02 to the *S1 & S2* socket on the amplifier using the 6-pin-mini-DIN to 6-pin-mini-DIN cable. See connection #6 in Figure 5.1. This carries the potentiometer (S1) and tachometer (S2) signals. The measured load shaft rate from the tachometer is denoted by the variable ω_l and the load shaft angle is represented by variable θ_l.

Cable	From	To	Signal
1	Terminal Board: Analog Output #0	Amplifier *Amplifier Command* connector	Control signal to the amplifier.
2	Amplifier: *To Load* connector	SRV02 *Motor* connector	Power leads to the SRV02 dc motor.
3	Terminal Board: Encoder Input #0	SRV02 *Encoder* connector	Encoder load shaft angle measurement.
4	Amplifier: *To ADC* connector	Terminal Board: • S1 to Analog Input #0 • S2 to Analog Input #1	Connects analog sensor signals S1 and S2 to Analog Input Channels #0 and #1, respectively.
5	SRV02 *S1 & S2* connector	SRV02 *TACH* connector	Combine potentiometer (S1) and tachometer (S2) signals.
6	Amplifier *S1 & S2* connector	SRV02 *S1 & S2* connector	Potentiometer load shaft angle (S1) measurement and tachometer (S2) load shaft rate measurement.

Table 5.2: SRV02 Wiring

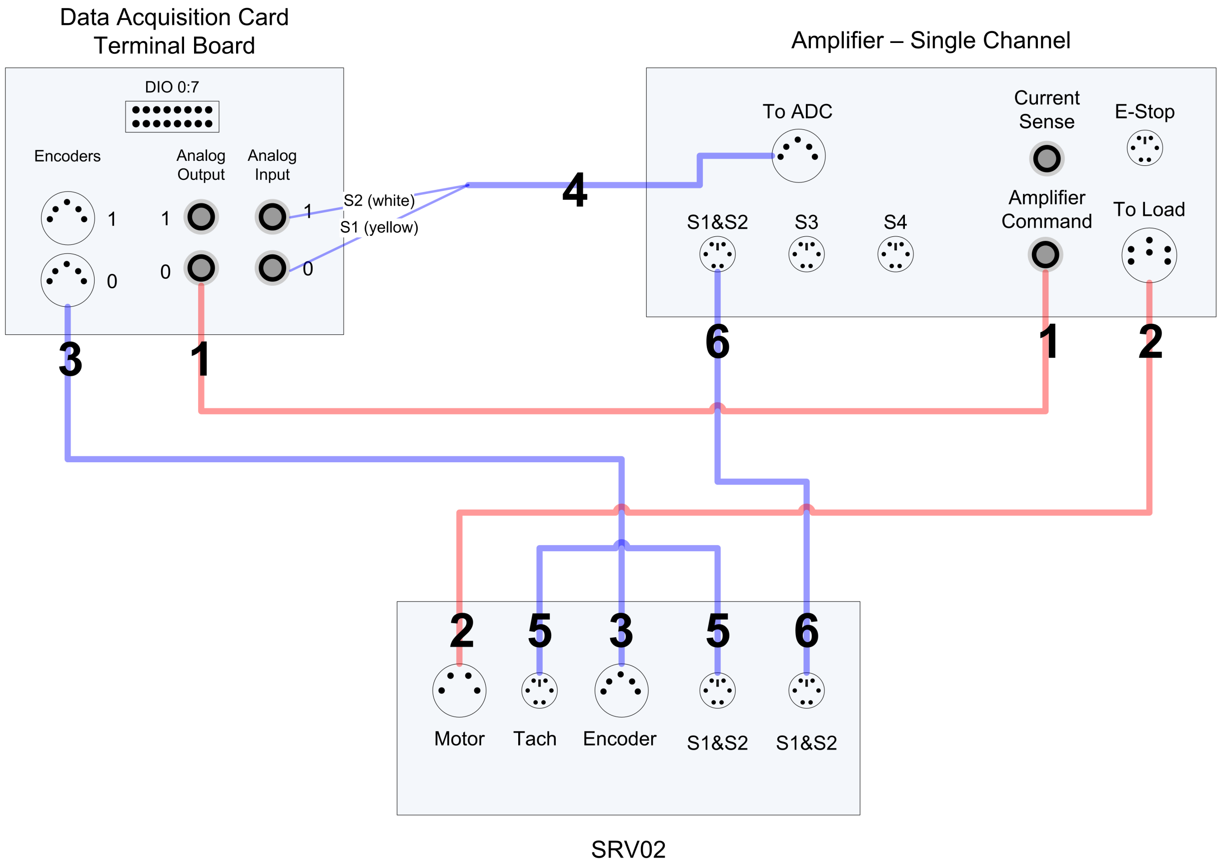


Figure 5.1: Connecting the SRV02 to a Single-Channel Amplifier and Two-Channel DAQ

5.3 Connections for VoltPAQ-X2

Some amplifiers, such as the Quanser VoltPAQ-X2, need to be enabled and have an emergency switch connected. The amplifier may not have an analog sensor interface built-in either - requiring an external device. This section describes the wiring required for that configuration. The connections are summarized in Table 5.3 and depicted in Figure 5.2.

Note: The wiring diagram shown in Figure 5.1 is using a two-channel data-acquisition board, which resembles a Quanser Q2-USB. The same connections can be applied for any data-acquisition system - as long as it has least two analog input, two analog output, and two encoder channels.

The power amplifier used resembles a VoltPAQ-X2 system, which is a two-channel amplifier that requires digital enabling and an emergency stop switch to be connected. Remark that the analog sensor are interfaced through an *Analog Signal Conditioner* box to split the potentiometer (S1) and tachometer (S2) channels.

Cable	From	To	Signal
1	Terminal Board: Analog Output #0	Amplifier *Amplifier Command* connector	Control signal to the amplifier.
2	Amplifier: *To Load* connector	SRV02 *Motor* connector	Power leads to the SRV02 dc motor.
3	Terminal Board: Encoder Input #0	SRV02 *Encoder* connector	Encoder load shaft angle measurement.
4	Analog Signal Conditioner S1 Output	Terminal Board: Analog Input #0.	Connects potentiometer to Analog Input Channel #0
5	Analog Signal Conditioner S2 Output	Terminal Board: Analog Input #1.	Connects tachometer to Analog Input Channel #1
6	SRV02 *S1 & S2* connector	SRV02 *TACH* connector	Combines potentiometer (S1) and tachometer (S2) signals.
7	Analog Signal Conditioner *Input 1* connector	SRV02 *S1 & S2* connector	Potentiometer load shaft angle (S1) measurement and tachometer (S2) load shaft rate measurement.
8	Amplifier 16-pin connector (Enable/Fault)	Terminal Board: *DIO 0* connector	Enable signal for the amplifier channels
9	Emergency Stop Switch	Amplifier E-Stop connector	Emergency stop signal

Table 5.3: SRV02 connections for amplifier requiring enabling and E-Stop

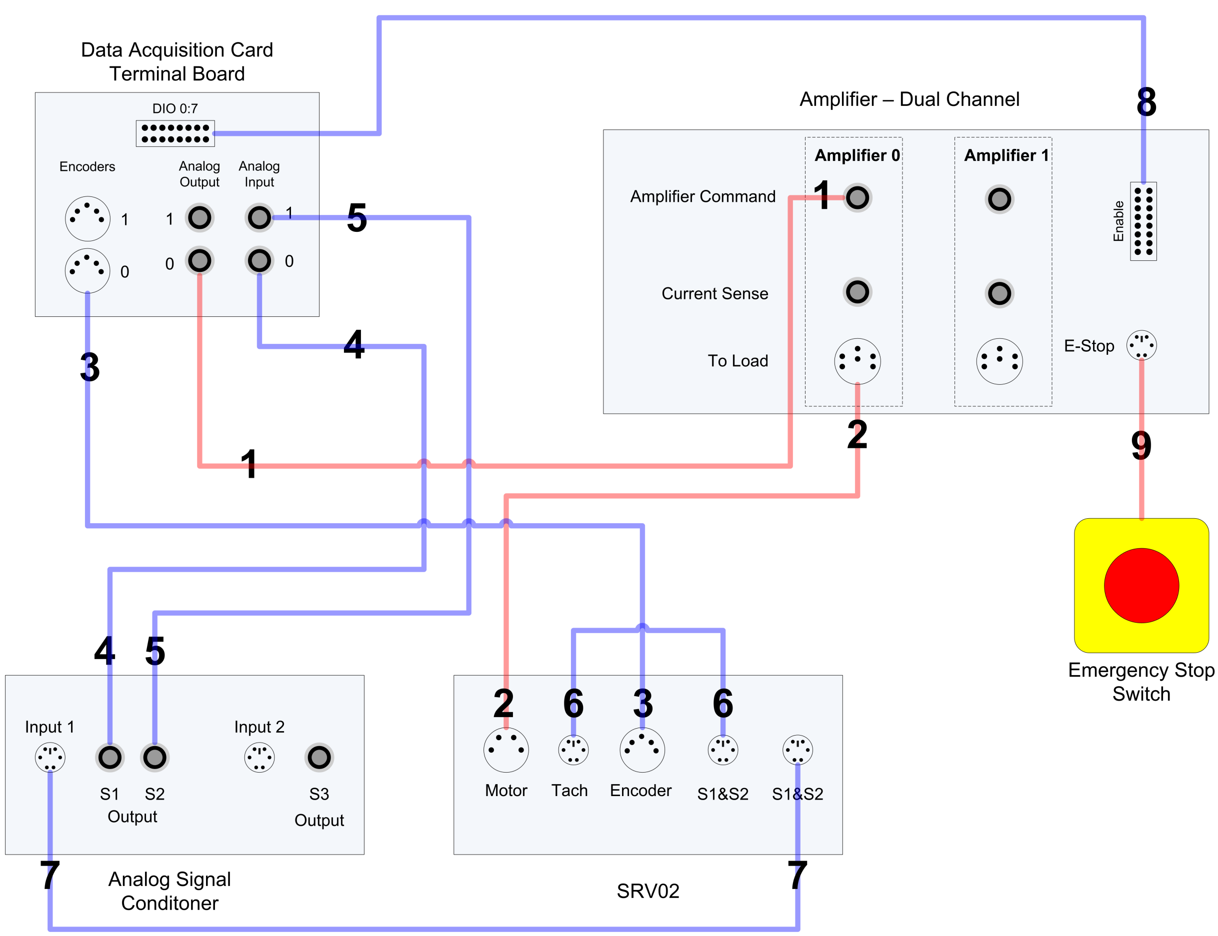


Figure 5.2: Connecting the SRV02 to a Two-Channel Amplifier and Two-Channel DAQ

6 TESTING AND TROUBLESHOOTING

This section describes some functional tests to determine if your SRV02 is operating normally. It is assumed that the SRV02 is connected as described in the Section 5, above. 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. See Reference [4] to learn how to interface the SRV02 with QUARC. Alternatively, these tests can be performed with a signal generator and an oscilloscope.

6.1 Motor

6.1.1 Testing

Ensure the SRV02 motor is operating correctly by going through this procedure:

1. Apply a voltage to analog output channel #0 of the terminal board using, for example, the QUARC software.
2. The motor gear, component #4 shown in Figure 2.1b, should rotate counter-clockwise when a positive voltage is applied and clockwise when a negative voltage is applied. Remark that the motor shaft and the load shaft turn in opposite directions.

6.1.2 Troubleshooting

If the motor is not responding to a voltage signal, go through these steps:

- Verify that the power amplifier is functional. For example when using the Quanser VoltPAQ device, is the green LED lit?
- Check that the data-acquisition board is functional, e.g. ensure it is properly connected, that the fuse is not burnt.
- Make sure the voltage is actually reaching the motor terminals (use a voltmeter or oscilloscope).
- If the motor terminals are receiving the signal and the motor is still not turning, your motor might be damaged and will need to be repaired. Please see Section 7 for information on contacting Quanser for technical support.

6.2 Potentiometer

6.2.1 Testing

Test the SRV02 potentiometer with the following procedure:

1. Using a program such as QUARC, measure the analog input channel #0.
2. The potentiometer should output a positive voltage when the potentiometer gear, component #6 in Figure 2.1b, is rotated counter-clockwise. The measurement should increase positively towards 5 V until the discontinuity is reached, at which point the signal abruptly changes to -5 V and begins to increase again.

6.2.2 Troubleshooting

Follow the steps below if the potentiometer is not measuring correctly::

- Verify that the power amplifier is functional. For example when using the Quanser VoltPAQ device, is the green LED lit? Recall the analog sensor signal go through the amplifier before going to the data-acquisition device (except when using the Q3 ControlPAQ). Therefore the amplifier needs to be turned on to read the potentiometer.
- Check that the data-acquisition board is functional, e.g. ensure it is properly connected, that the fuse is not burnt.
- Measure the voltage across the potentiometer. Ensure the potentiometer is powered with a ± 12 V at the 6-pin-mini DIN connector and ± 5 V at the potentiometer terminals, as described in Section 2.2.2. If the voltage from the wiper does not change when you rotate the potentiometer shaft, your potentiometer needs to be replaced. Please see Section 7 for information on contacting Quanser for technical support.

6.3 Tachometer

6.3.1 Testing

Test the tachometer on the SRV02 by performing the following:

1. Apply a 2.0 V signal to Analog Output Channel #0 in order to drive the motor.
2. Measure Analog Input Channel #2 to read the tachometer. When applying 2.0 V to the motor, the tachometer should be measuring a value of approximately 3.0 V.

6.3.2 Troubleshooting

If no signals are received from the tachometer, go through this method:

- Verify that the power amplifier is functional. For example when using the Quanser VoltPAQ device, is the green LED lit? Recall the analog sensor signal go through the amplifier before going to the data-acquisition device (except when using the Q3 ControlPAQ). It needs to be turned on to read from the tachometer.
- Check that the data-acquisition board is functional, e.g. ensure it is properly connected, that the fuse is not burnt.
- Measure the voltage across the tachometer. When moving the load gear back and forth, is the voltage being measured changing? If not, then the tachometer needs to be replaced. Please see Section 7 for information on contacting Quanser for technical support.

6.4 Encoder

6.4.1 Testing

Follow this procedure to test the SRV02 encoder:

1. Measure Encoder Input Channel #0 using, for instance, the QUARC software.

2. Rotate the SRV02 load gear, component #5 in Figure 2.1b, one rotation and the encoder should measure 4096 counts (or 8192 when using the SRV02-EHR option) in quadrature mode.

   Note: Some data acquisition systems do not measure in quadrature and, in this case, one-quarter of the expected counts are received, i.e. 1024 counts in the SRV02-E or 2048 in the SRV02-EHR. In addition, some data acquisition systems measure in quadrature but increment the count by 0.25 (as opposed to having an integer number of counts). Make sure the details of the data-acquisition system being used is known. The counters on the Quanser DAQ boards measure in quadrature and therefore a total of four times the number of encoder lines per rotation, e.g. a 1024-line encoder results in 4096 integer counts for every full rotation.

6.4.2 Troubleshooting

If the encoder is not measuring properly, go through this procedure:

- Check that the data-acquisition board is functional, e.g. ensure it is properly connected, that the fuse is not burnt.
- Check that both the A and B channels from the encoder are properly generated and fed to the data-acquisition device. Using an oscilloscope, there should be two square waves, signals A and B, with a phase shift of 90 degrees. If this is not observed then the encoder may be damaged and need to be replaced. Please see Section 7 for information on contacting Quanser for technical support.

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] US Digital. E2 optical kit encoder. 2007.

[2] Faulhaber. Dc-micromotors series 2338. 2002.

[3] Faulhaber. Dc-motor-tacho combinations. 2002.

[4] Quanser Inc. Srv02 quarc integration. 2008.

[5] Quanser Inc. Q2-usb data-acquisition system user's guide. 2010.

[6] Vishay Spectrol. Model 132, 138, 139. 2001.

Ten modules to teach controls from the basic to advanced level

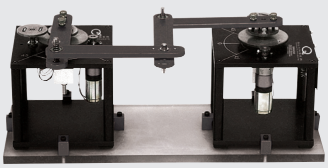
SRV02 Base Unit

Flexible Link

Inverted Pendulum

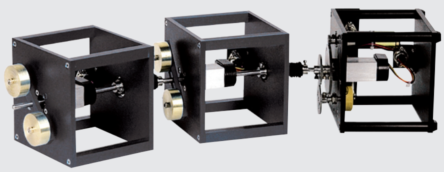
Ball and Beam

2 DOF Robot



2 DOF Inverted Pendulum

Multi-DOF Torsion



Flexible Joint

Gyro/Stable Platform

Double Inverted Pendulum

2 DOF Ball Balancer

With the SRV02 Base Unit, you can select from 10 add-on modules to create experiments of varying complexity across a wide range of topics, disciplines and courses. All of the experiments/workstations are compatible with LabVIEW™ and MATLAB®/Simulink®.

To request a demonstration or a quote, please email info@quanser.com.

QUANSER

INNOVATE. EDUCATE.

INFO@QUANSER.COM +1-905-940-3575 QUANSER.COM

Solutions for teaching and research. Made in Canada.