USER MANUAL

Flexible Link Experiment

Set Up and Configuration

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.

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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 rotary flexible link depicted in Figure 1.1, consists of a strain gage (or strain gauge) which is mounted at the clamped end of a thin stainless steel flexible link. The system is designed to mount on a Quanser SRV02 plant resulting in a horizontally rotating flexible link that can be used to perform flexible link control experiments. A DC motor is used to rotate the flexible link from one end in the horizontal plane. The motor end of the link is instrumented with a strain gage that can detect the deflection of the tip. The final system output is an analog signal proportional to the deflection of the link.

Figure 1.1: Quanser Flexible Link System

This system is similar in nature to the control problems encountered in large light space structures where the weight constraints result in flexible structures that must be controlled using feedback techniques. The rotary flexible link is an ideal experiment intended to model a flexible link on a robot or spacecraft. This experiment is also useful in the study of vibration analysis and resonance.

■ **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.

2 COMPONENTS

The rotary flexible link components are identified in Section 2.1. Some of the those components are then described in Section 2.2.

2.1 Component Nomenclature

The main components of the rotary flexible link system are listed below in Table 2.1, and labeled in Figure 2.1 and Figure 2.2. Please use the ID # to locate each component in the figures below.

ID	Component
1	SRV02 Plant
2	FLEXGAGE Module
3	FLEXGAGE Link
4	Strain Gage
5	Strain Gage Circuit
6	Thumbscrews
7	Sensor Connector
8	OFFSET Potentiometer
9	GAIN Potentiometer

Table 2.1: Listing of Rotary Flexible Link Components

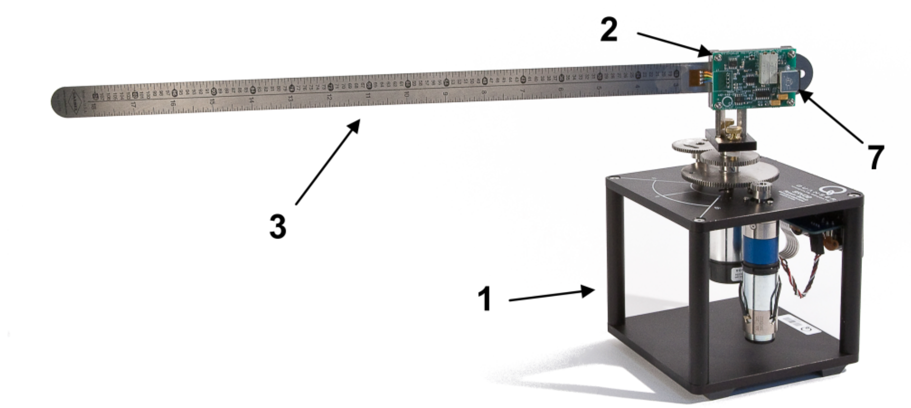


Figure 2.1: FLEXGAGE Coupled to SRV02

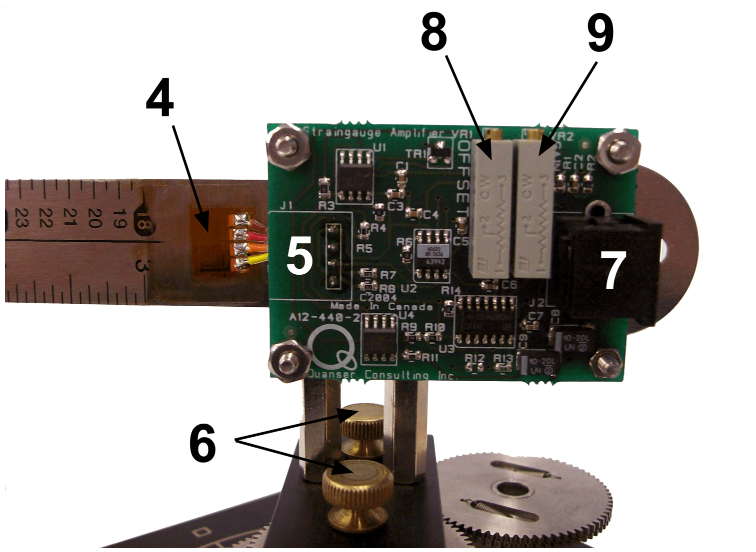


Figure 2.2: Strain Gage Closeup

2.2 Component Description

2.2.1 SRV02 Plant

For more details about SRV02 plant please refer to [1].

2.2.2 FLEXGAGE Module

This component is depicted in Figure 2.1 with ID #2, and consists of the FLEXGAGE Link (ID #3 in Figure 2.2), the strain gage, the strain gage circuitry, and a sensor connector. As shown in Figure 2.2, the FLEXGAGE module simply mounts onto the SRV02 plant using two thumbscrews.

2.2.3 Strain Gage

The strain gage sensor is depicted in Figure 2.2 with ID #4, and produces an analog signal proportional to the deflection of the tip. There are two potentiometers available on the strain gage circuitry. The OFFSET and GAIN potentiometers are depicted in Figure 2.2 by ID #'s 8 and 9 respectively and are used in the calibration process of the flexible link system. Section 4.3 of this document includes instructions on using these potentiometers to calibrate the system.

3 SPECIFICATIONS

Table 3.1 lists and characterizes the main parameters associated with the Rotary Flexible Link. The *Symbol* column denotes the variable names used in the corresponding laboratory manual.

Symbol	Description	Value	Unit
	Module Dimensions	48 x 2	cm^2
L_l	Flexible Link Length (strain gage to tip)	41.9	cm
m_l	Flexible Link Mass	0.065	kg
J_l	Flexible Link Moment of Intertia	0.0038	kg.m^2
	Strain gage bias power	$\pm$12	V
	Strain gage measurement range	$\pm$5	V
	Strain gage calibration gain	1/16.5	rad/V

Table 3.1: Flexible Link specifications

4 SYSTEM SETUP

See Section 4.1 for instructions on how to to put the rotary flexible link plant together. Once the plant is setup, you can refer to Section 4.2 for the wiring instructions and finally calibrate the system using the instructions provided in Section 4.3 before performing laboratories.

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

4.1 Assembly

Setting up the flexible link system is fairly simple. Please follow the procedure below to setup the flexible link module for experimental use. Wiring instructions are provided in Section 4.2 of this document.

1. Before beginning, ensure the SRV02 is setup in the high-gear configuration as detailed in [1].
2. Place the FLEXGAGE module (ID #2 in Figure 2.1) on the load shaft of the SRV02 plant.
3. Secure the FLEXGAGE in place by tightening the two supplied thumbscrews. The final configuration of the FLEXGAGE module after being mounted to the SRV02 plant should resemble Figure 4.1.

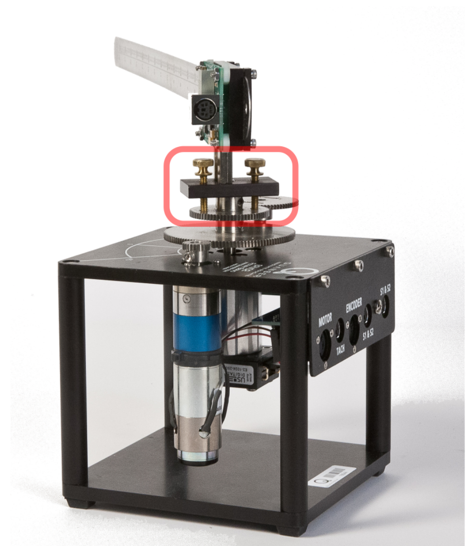


Figure 4.1: Mounting the FLEXGAGE onto the SRV02

4.2 Wiring Procedure

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

- **Power Amplifier:** Quanser Amplifier (e.g., VoltPaq).
- **Data Acquisition Board:** Quanser Q1-cRIO, Q2-USB, NI DAQ, or equivalent.
- **Flexible Link Plant:** Quanser FLEXGAGE Module.
- **Rotary Servo Plant:** Quanser SRV02-ET or SRV02-ETS.

In addition to the above listed components a calibration stand and comb as well as the required cables are also supplied with the system. Section 4.2.1 provides a listing of the cables supplied with the system and Section 4.2.2 will provide instructions for properly wiring the rotary flexible link module.

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

4.2.1 Cable Nomenclature

Table 4.1 on the next page provides a listing of the standard cables used in the wiring of the flexible link system.

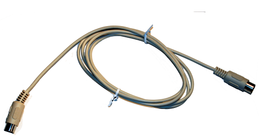
Cable	Type	Description
 (a) RCA Cable	2xRCA to 2xRCA	This cable connects an analog output channel of the data acquisition terminal board to the power module for proper power amplification.
 (b) Motor Cable	4-pin-DIN to 6-pin-DIN	This cable connects the output of the power module, after amplification, 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 (from joystick, plant sensor, etc.) to the amplifier, where the signals can be either monitored and/or used by a controller. The cable also carries a ±12VDC 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 4.1: Cable Nomenclature

4.2.2 Typical Connections

This section describes the typical connections used to connect the flexible link plant to a data-acquisition board and a power amplifier. The connections are summarized in Table 4.2 and illustrated in Figure 4.2. The wiring procedure details are given below. It is assumed that the data acquisition board has already been installed and tested.

■ **Caution: Make sure that the amplifier and your PC unit are turned off while you perform the wiring.**

Cable	From	To	Signal
1	DAQ Device: Analog Output #0	Amplifier *Command* Conector	Control signal to the amplifier.
2	Amplifier *To Load* Connector	SRV02 *Motor* Connector	Power leads to the SRV02 DC motor.
3	DAQ Device: Encoder Input #0	SRV02 *Encoder* Connector	Encoder load shaft angle measurment.
4	Amplifier *To ADC* Connector	DAQ Device: White/S2 to Analog Input #0	Carries the analog signals connected to the S1 & S2, S3, and S4 connectors on the amplifier to the data-acquisition board.
5	Amplifier *S1 & S2* connector	Strain Gage Connector on FLEXGAGE module	Carries the tip deflection measured by the strain gage.

Table 4.2: Flexible Link System Wiring Summary

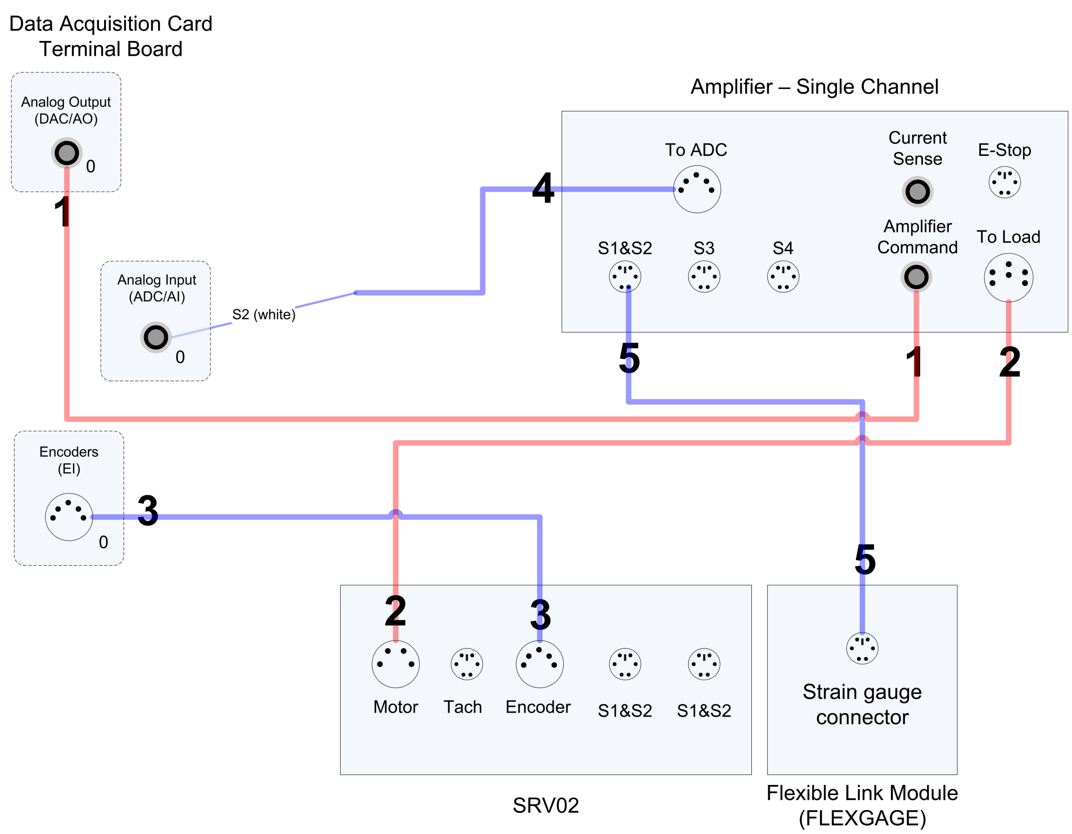


Figure 4.2: SRV02 Flexible Link Typical Wiring Diagram

Please follow these steps to connect the Quanser Rotary Flexible Link to your DAQ device and amplifier:

1. 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, ie. Use both white or both red RCA connector. This connection carries the attenuated motor voltage control signal, Vm/Ka where Ka is the amplifier gain. This is shown by connection #1 in Figure 4.2.

2. Connect the 4-PIN-stereo-DIN to 6-pin-stereo-DIN cable from the *To Load* connector on the amplifier to the *Motor* connector on the SRV02. This connection carries the amplified voltage that is applied to the SRV02 motor. This is shown by connection #2 in Figure 4.2.

   ■ **Caution:** Any encoder should be directly connected to the Quanser terminal board (or equivalent) using a standard 5-pin DIN cable. **DO NOT connect the encoder cable to the amplifier!**

3. 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 DAQ device. This is connection #3 in Figure 4.2. It carries the load shaft angle measurement.

4. Connect the *To ADC* socket on the amplifier to *Analog Inputs #0* on the terminal board using the 5-pin-DIN to 4xRCA cable as illustrated by connection #4 in Figure 4.2. The strain gage signal will be routed through the white/S2 connector. Connect the white/S2 RCA cable to *Analog Input #0* on the data acquisition device.

5. Connect the strain gage connector on the FLEXGAGE module to the *S1 & S2* connector on the SRV02 panel using the 6-pin-mini-DIN to 6-pin-mini-DIN cable. This connection carries a voltage proportional to the link deflection and is shown by connection #5 in Figure 4.2.

4.3 Calibration

The Flexible Link has a strain gage mounted at the base of the beam to measure the deflection of the link's tip. The unit is calibrated before shipment. Therefore no calibration should be required upon receiving the system. However, if the system needs be re-calibrated the instructions are given below.

As depicted in Figure 4.3, the FLEXGAGE circuit has two adjustable potentiometers, one to adjust the offset (ID #8 in Figure 2.2) and another to adjust the gain (ID #9 in Figure 2.2).

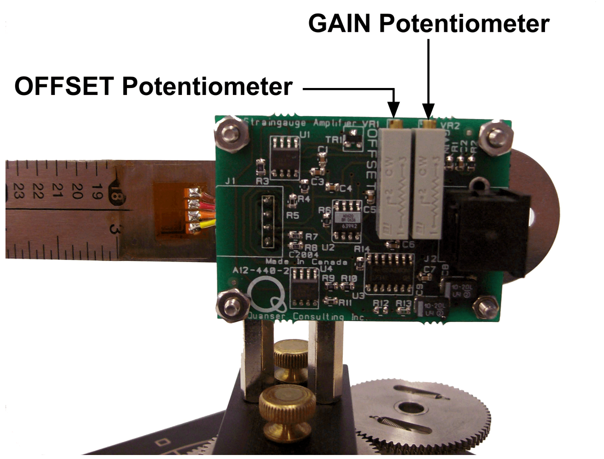


Figure 4.3: Gain and Offset Potentiometers on the FLEXGAGE Circuit

Please follow the steps below to complete the calibration process:

1. Ensure the system has be wired as described in Section 4.2.2 and summarized in Table 4.2.

2. Get the calibration base and calibration comb that were supplied with the Quanser FLEXGAGE system, shown in Figure 4.4a and Figure 4.4b.

(a) Calibration Base (b) Calibration Comb

Figure 4.4: Calibration Compoments for FLEXGAGE

3. Mount the FLEXGAGE on the calibration base as depicted in Figure 4.5 using the thumb screws.

Figure 4.5: Mounting FLEXGAGE on calibration base.

4. Place the tip in the middle tooth of the comb as seen in Figure 4.6 below.

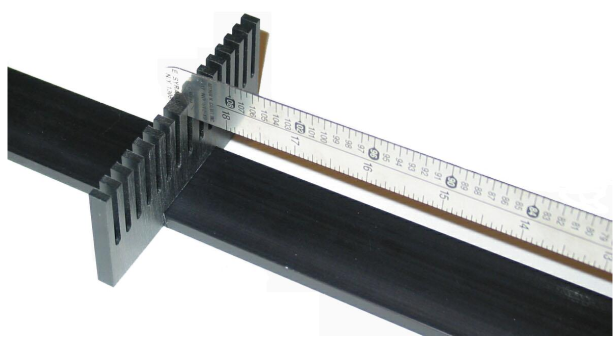


Figure 4.6: Flexible Link Tip Placed in the Middle Calibration Comb Slot

5. **Offset adjustment:** Measure the voltage of the strain gage. It should be measuring 0 V. If not, adjust the **OFFSET** potentiometer until your measurement reads 0 V.

   Note: To measure the votlage, you can use the QUARC®or LabVIEW™ files that are supplied with the system. Alternatively, you can use a voltmeter to measure the strain gage voltage.

6. **Gain adjustment**: The strain gage should read 1 V per 1 inch of tip deflection. Each slot or tooth in the calibration comb corresponds to a tip displacement of $\frac{1}{4}$ inch. Move the tip 4 slots in the counter-clockwise direction as shown in Figure 4.7. The strain gage measurement should be reading 1 V. If not, gently adjust the **GAIN** potentiometer until it reads 1 V.

7. Move the tip 8 slots in the clockwise direction (i.e., 4 slots away from 0) and verify it is reading -1 V.

8. Return the tip to the zero position and confirm that it is reading 0 V again. If not, adjust the **OFFSET** potentiometer once again to read 0 V.

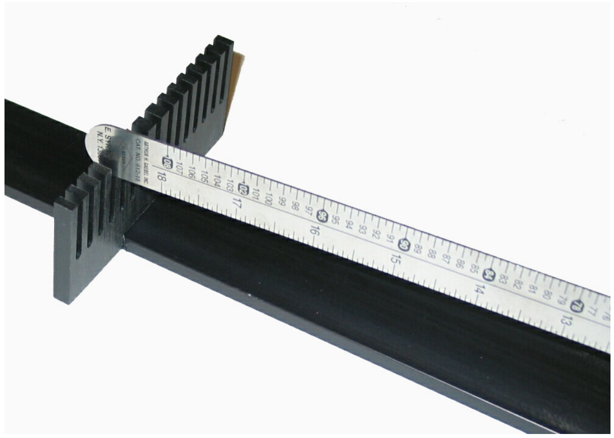


Figure 4.7: Flexible Link Tip Displaced by 1 inch in the Counter-clockwise Direction

5 TESTING AND TROUBLESHOOTING

This section describes some functional tests to determine if your flexible link system is operating normally. It is assumed that the system is connected as described in Section 4.2.2 above. It is recommended to use a software such as QUARC®or LabVIEW™ to read sensor measurements and feed voltages to the motor. But these tests can be performed using a signal generator and an oscilloscope.

5.1 SRV02 Motor and Sensors

Please refer to [1] for information on testing and troubleshooting the SRV02 separately.

5.2 Strain Gage Sensor

5.2.1 Testing

You can test the strain gage sensor in a fashion similar to calibrating it which was discussed in Section 4.3. Follow the procedure below to ensure that your strain gage sensor is operating correctly.

1. Read the Analog Input hannel #0 to the strain gage.
2. Figure 5.1 illustrates a typical strain gage reading when the tip of the link has been manually perturbed.
3. If the sensor is reading but the measurement seems incorrect (e.g., there is an offset, low amplitude), then the strain gage may need to be calibrated. Go to Section 4.3 for calibration instructions.

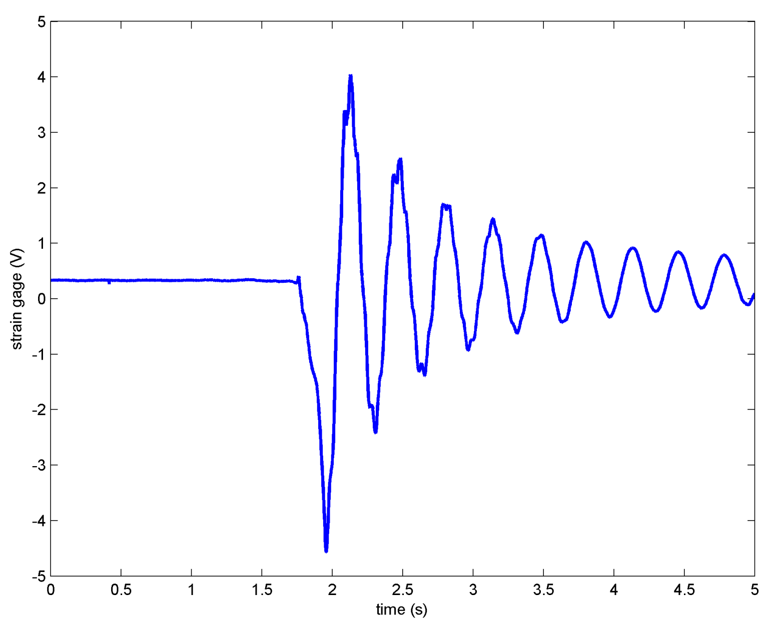


Figure 5.1: Strain Gage Sensor Typical Response

5.2.2 Troubleshooting

Follow the steps below if you are not obtaining the correct measurement:

1. Verify that the power amplifier is functional. For example when using the Quanser VoltPaq device, verify that the green LED lit. Recall that the analog sensor signal goes through the amplifier before going to the data-acquisition device. Therefore the amplifier needs to be turned on to read the strain gage.
2. Check that the data-acquisition board is functional, The data acquisition board fuse may be burnt and need replacement.

See Section 6 for information on contacting Quanser to obtain further technical support.

6 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 representative will contact you.

Note: Depending on the situation a support contract may be required to obtain technical support.

REFERENCES

[1] Quanser Inc. *SRV02 User Manual*, 2009.

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