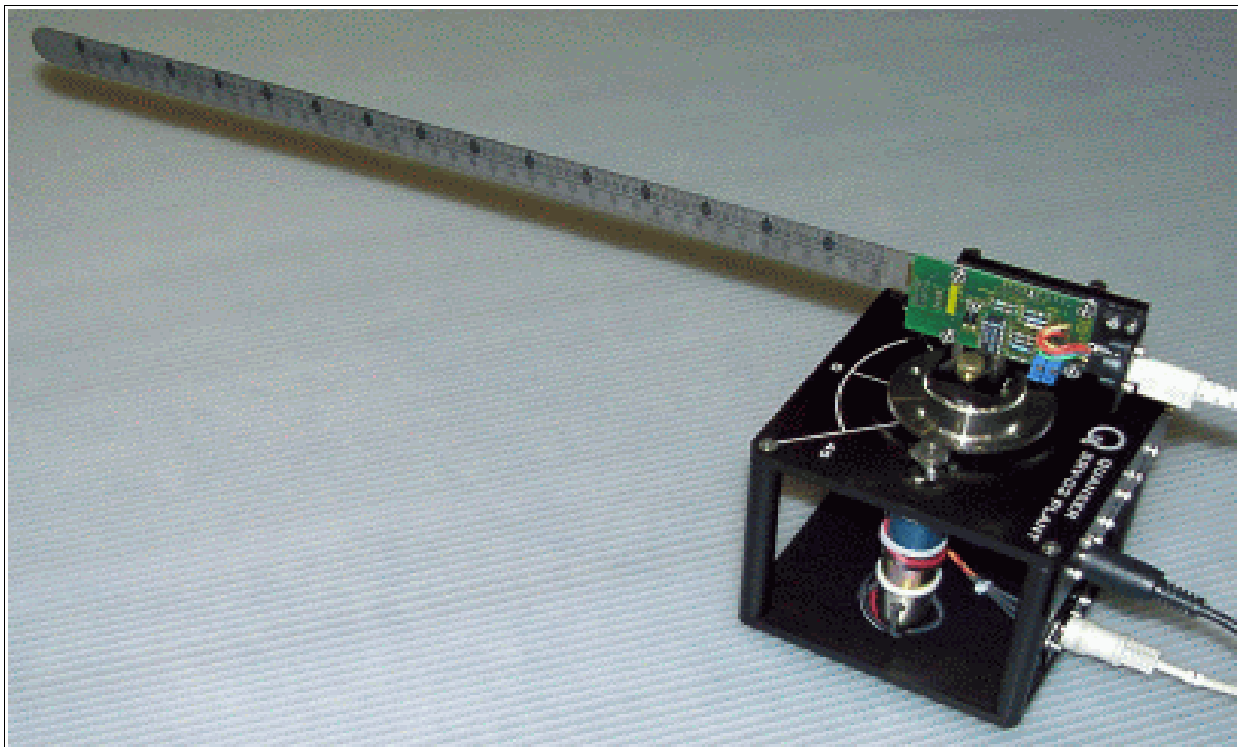


SRV02-Series

Rotary Flexible Link



User Manual

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FLEXGAGE - Rotary Flexible Link

User Manual

1. Description

The rotary flexible Link consists of a strain gage which is mounted at the clamped end of a thin stainless steel flexible link. The output is an analog signal proportional to the deflection of the link. The system is designed to mount on a Quanser rotary servo plant resulting in a horizontally rotating flexible link to perform flexible link control experiments.

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. A DC motor rotates a 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 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.

1.1 Modular Options

Quanser values itself for the modularity of its experiments. The SRV02 rotary plant module serves as the base component for the rotary family of experiments. This modular philosophy facilitates the change from one experimental setup to another with relative ease of work and a valuable savings in cost. The following table lists the experiments currently available in the rotary family of products utilizing the SRV02 as the base.

<i>Module Name</i>	<i>Description</i>
Ball & Beam	The Ball & Beam experiment requires the user to manipulate the position of a rolling ball on a beam.
Flexible Link	The Flexible Link experiment requires the user to command a <i>tip</i> position of the flexible link attached to the SRV02.
Flexible Joint	A rigid beam is mounted on a flexible joint that rotates via the SRV02 and the user is to command the tip position of this beam.
Gyro/Stable Platform	The purpose is to maintain the line of sight of an instrument mounted on a rotating platform (SRV02).
Inverted Pendulum	The purpose is to balance the inverted pendulum through a rotary motion arm (SRV02).
Double Inverted Pendulum	The double inverted problem adds to the complexity of the single pendulum by introducing a 2 nd pendulum.
2 DOF robot module	This experiment requires the x-y positioning of the “end effector”.
2 DOF Rotary Gantry	This experiment requires the control of the swing of a x-y gantry crane using a 5 DOF linkage.
2 DOF inverted pendulum	Balance a pendulum that is free to fall in 2 directions. The pendulum is attached to the tip of the 2 DOF robot.

Table 1 - Rotary Family Modules

2. System Nomenclature and Components

Figure 1 & Figure 2 below depict the FLEXGAGE module. The standard FLEXGAGE is equipped with a strain gage sensor resulting in an analog signal proportional to the deflection of the tip. Refer to the following table to associate the *components* with their corresponding photographs.

1	SRV02 Base	5	Strain gage circuit
2	FLEXGAGE module	6	Thumbscrews
3	FLEXGAGE Link	7	Sensor connector
4	Strain gage		

Table 2 - Component Names

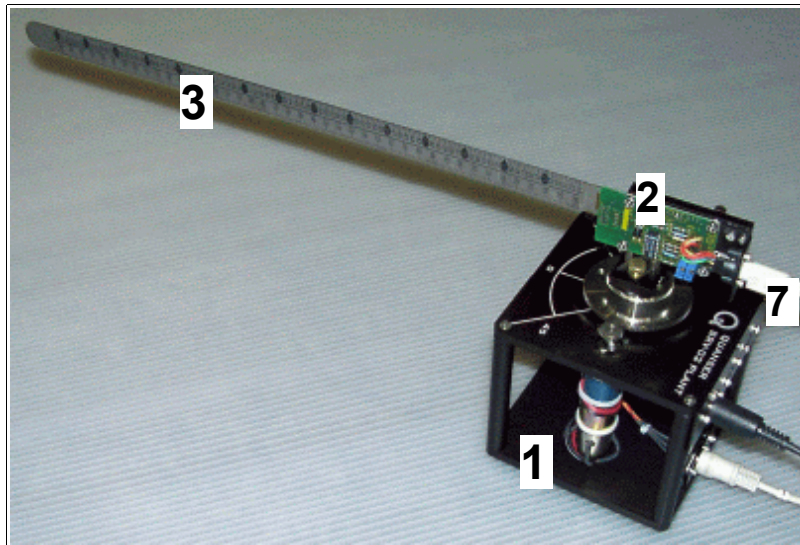


Figure 1 - FLEXGAGE coupled to SRV02

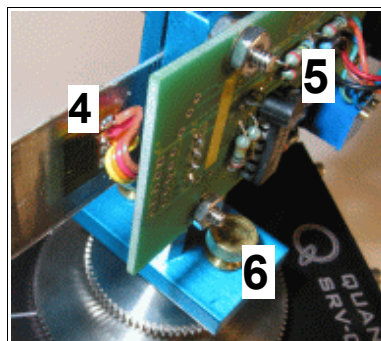


Figure 2 - Strain gage close up

3. System Setup and Assembly

The rotary flexible Link module requires minimal assembly. Figure 3 Below shows the components of the FLEXGAGE package you should have received. The FLEXGAGE package includes the module itself, a calibration stand and the sensor wire *Note the FLEXGAGE is already pre-calibrated to the correct settings.

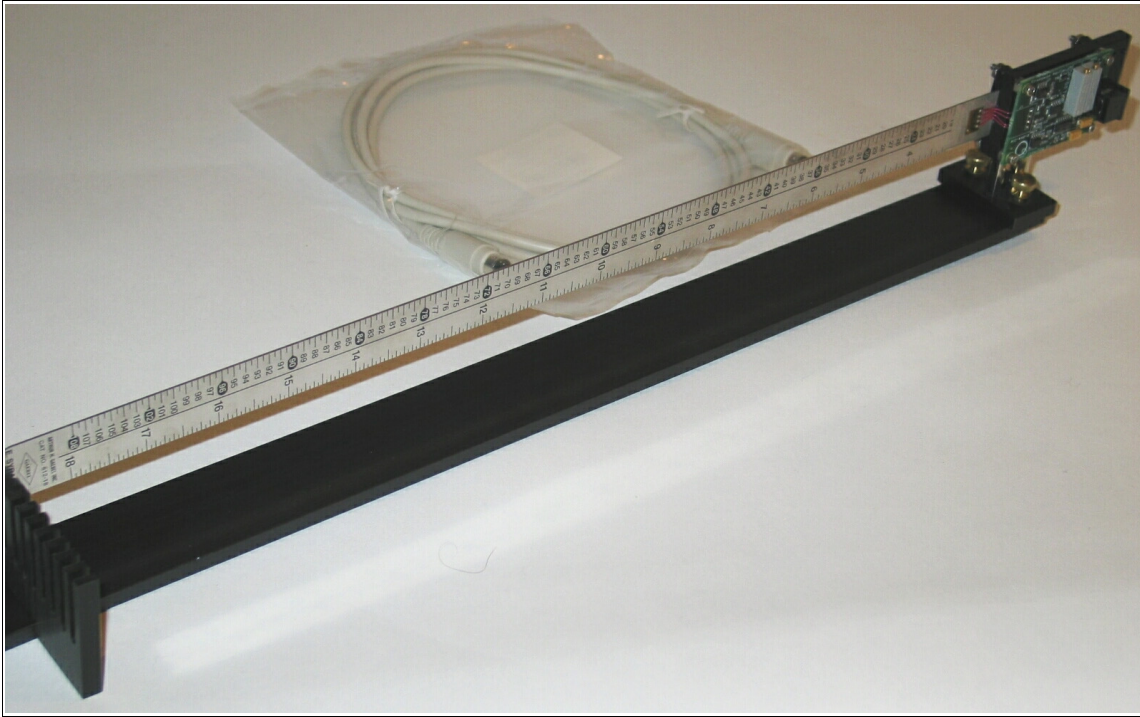


Figure 3 - Contents of FLEXGAGE package

The only assembly required is to mount the FLEXGAGE onto the SRV02. Make sure the SRV02 is configured in the High-Gear configuration. If you are unsure about the SRV02, please refer to the *SRV02 User Guide*. Simply place the FLEXGAGE onto the load shaft (middle shaft) and secure the FLEXGAGE in place by tightening the 2 thumbscrews as seen in Figure 4 below.

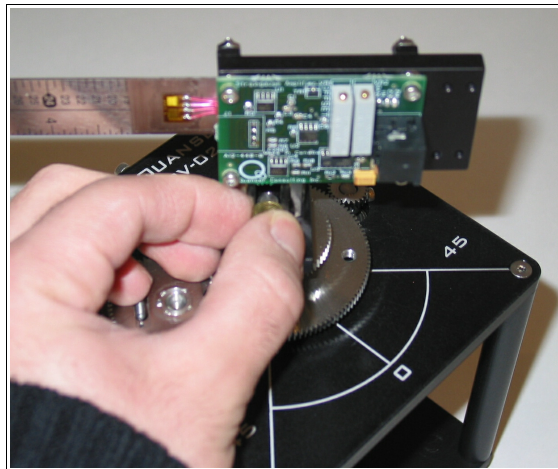


Figure 4 - Attaching to the SRV02

3.1 Typical Connections for the SRV02 – FLEXGAGE Experiment

The following table describes the typical setup using the complete Quanser solution. It is assumed that the FLEXGAGE is being used along with an SRV02, UPM and Q8 DAQ board.

<i>From...</i>	<i>To...</i>	<i>Cable</i>	<i>Description</i>
FLEXGAGE Strain Gage (<i>Component 4</i>)	<i>S2</i> Connector on <i>UPM</i> .	6-pin mini DIN to 6-pin mini DIN.	This cable results in delivering a $\pm 12V$ bias to the potentiometer and measuring the potentiometer signal voltage on <i>S2</i> of the UPM.
SRV02 Encoder <i>*This is the load gear position measurement</i>	<i>Encoder 0</i> connector on the terminal board.	5-pin Stereo DIN to 5-pin Stereo DIN.	The terminal board should supply the encoder with the +5V and ground. The load shaft position signal will then be measure on Encoder channel 0.
'To Load' Connector on <i>UPM</i> .	<i>Motor</i> on SRV02.	6-pin DIN to 4-pin DIN.	This connects the output of the amplifier to the motor. You can use a variety of cables resulting in a different gain from input to output. The cables available are Gain=1, Gain=3, Gain=5.
Analog Signals (<i>To A/D</i>)	Analog input channels 0-3 on the DAQ.	5-pin DIN to 4x RCA.	From the <i>UPM</i> , connect all the analog sensor signals to the terminal board such that <i>S1</i> is measured on analog input 0. <i>S2</i> - AI # 1, <i>S3</i> - AI # 2, <i>S4</i> - AI # 3.
Analog output channel 0 on the DAQ.	<i>UPM</i> input (<i>From D/A</i>)	RCA to 5-pin DIN.	This is the command output from the DAQ that will be amplified and drive the motor.

Table 3 - Typical Connections

3.2 Calibrating the Strain Gage

The FLEXGAGE uses a strain gage mounted at the base of the link to measure the deflection of the tip of the link. Before the module is shipped, the unit would have been fully calibrated to the correct specifications. The following section will describe the calibration routine in order to ensure the unit maintains its correct calibration and thus remains operating correctly.

This section describes functional tests to determine if your FLEXGAGE sensors are operating normally. It does **not** cover any performance tests. All these tests require an understanding of Simulink (or Labview), WinCon (or equivalent), and Q8 (or equivalent data acquisition board you are using). You should be able to “*build*” a controller that can measure and apply desired signals.

In the following sections, it is also assumed that the FLEXGAGE is connected as described in the *Typical Connections* table above.

As you can see in Figure 4 above, the FLEXGAGE circuit has 2 adjustable potentiometers. One is for the **Offset** adjustment and the other is for the **Gain** adjustment. Build a controller that displays the measurement from analog input # 1 (This is the signal connected to S2 on the UPM).

3.2.1. Offset Adjustment

Mount the FLEXGAGE onto the calibration stand that shipped with the module. Place the tip in the middle tooth of the comb as seen in Figure 5 below.

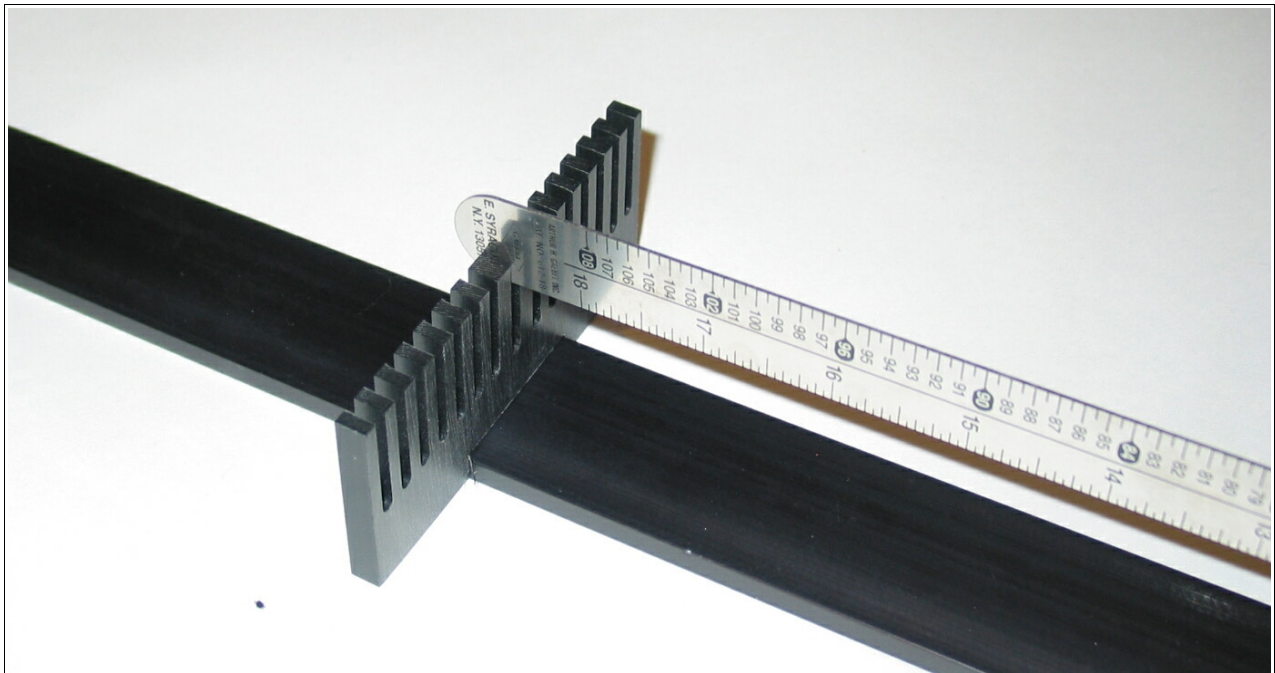


Figure 5 - Place tip in middle slot

Your controller should be running and reading 0 Volts. If there is an offset in your measurement, adjust the **Offset** potentiometer such that your measurement reads 0 volts.

3.2.2. Gain Adjustment

After adjusting the measurement to its 0 measurement, you should check and make sure the sensor is calibrated as desired. The sensor should read 1 Volt per 1 inch of tip deflection. Each slot or tooth in the calibration comb corresponds to $\frac{1}{4}$ inch displacement. Move the tip counter-clockwise 4 slots as seen in Figure 6 below.

4. Rotary Flexible Link Module – Range of Experiments & Features

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. The model is designed to accentuate the effects of flexible links in robot control systems. Such flexibility is common in lightweight robots designed for space applications. The students will be exposed to control the vibrations in the link as well as dealing with higher modes of vibration.

FLEXGAGE Key Features:

- High Quality Aluminum chassis with precision crafted parts
- High Resolution Strain Gage to sense link deflection
- Fully documented system models & parameters
- Fast and Easy attachment to the SRV02 plant
- Open Architecture Facilitates Matlab/Simulink Design
- Modular Design
- Optional High Precision Light Sensor

Curriculum Topics:

- System Modeling & Simulation
- Real-Time Control
- Full-State Feedback
- Frequency Analysis
- Vibration & Resonance
- Hardware in the Loop
- Robotics
- Observer Design
- Nonlinear Control

6. System Requirements & Specifications

The Rotary Flexible Link Module (FLEXGAGE) is designed as an attachment to the SRV02 plant. Along with the SRV02 plant, the following components are required to complete the experimental setup.

<i>Component</i>	<i>Quanser Recommended (Common Configuration)</i>	<i>Alternative</i>
Power Module	Quanser UPM 1503/2405	Other Power Supply that can deliver the required power.
Data Acquisition	Quanser Q8	dSPACE DS 1104 National Instruments E-Series DAQs Any other DAQ with at least one A/D, one D/A and one Encoder input.
Control Software	Quanser WinCon / SLX / WebLab	The Mathworks – RTWT, xPC dSPACE – ControlDesk National Instruments – Labview RT

Table 4 - System Requirements

6.1 System Specifications

<i>Specification</i>	<i>Value</i>	<i>Units</i>
Module Dimensions	48 x 2	cm ²
Flexible Link Length	30	cm
Strain Gage Bias Power	±12	Volts
Strain Gage Measurement Range	±5	Volts
Strain Gage Calibration Gain	1	Volts/Inch
Flexible Link mass	0.065	kg
Flexible Link rigid body inertia	0.005	kgm ²
Equivalent Link Stiffness	0.5	Nm/rad
Fundamental Natural Frequency	3.2	Hz

Table 5 - FLEXGAGE Specifications