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LINEAR CONTROL CHALLENGE

IP01/IP02 + LFJC = Linear Flexible Joint Experiment

Description

The Linear Flexible Joint Cart (LFJC) module consists of a passive linear cart coupled to an IP01 or IP02 through a linear spring. The LFJC is made of solid aluminum and also uses linear bearings to slide along the IP01 or IP02 ground stainless steel shaft. As an implementation of the classical mass-damper-spring quadratic system, the linear flexible joint is an ideal textbook-type of experiment. The experiment is useful in the study of vibration analysis and resonance. The system is similar in nature to the control problems encountered, for example, in elastic linkages and mechanical transmissions (e.g. gearboxes). Depending on the module options, the LFJ cart position can either be sensed via a potentiometer or an encoder, whose shaft meshes with the IP01 or IP02 track via a pinion. Lastly, the LFJC-PEN-E module is also equipped with a rotary joint atop of it, where a free-swinging pendulum rod can then be attached to and suspend in front of the cart. A quadrature optical encoder measures the angle of the rod optionally mounted on the cart.

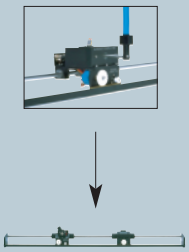
Key Features

- Modular design (experiments are easily interchangeable)
- Precisely machined solid aluminum cart with high quality parts
- High Resolution Optical Encoders to sense the LFJC(-PEN)-E position and the LFJC PEN-E pendulum angle
- Ten-turn potentiometer to sense the LFJC position
- Variable LFJ Cart Load
- Variable Spring Stiffness
- Variable Pendulum Rod Length, on the LFJC-PEN-E
- Fully documented system models & parameters
- Fast and Easy attachment to the IP01 or IP02 servo plant
- Open architecture design
- Fully compatible with Matlab/Simulink

Curriculum Topics

- Tracking Control & Regulation
- Disturbance Rejection
- Robust Control (H-Infinity, μ - Synthesis, Sliding Mode)
- Predictive Control (GPC, ILC)
- State-Space Design (Full/Partial State-Feedback, Observer Design)
- Multivariable Control Design
- Root Locus Design
- Vibration & Resonance
- Frequency Analysis (Bode and Nyquist Methods, Lead-Lag Compensation)
- System Modeling & Simulation
- System Identification
- Real-Time Control
- Discrete Time Sampling
- Robotics

Range of IP01/IP02 Challenges



Either the IP01 or the IP02 linear motion servo plant serves as the base unit for Quanser's Linear Control Challenges. With easily interchangeable modules, you can transform the IP01 or IP02 into any of these experiments:

SISO Configurations ***(Single Input, Single Output)***

IP01 or IP02: Position Control
IP01 or IP02: Speed Control
SIP: Linear Single Inverted Pendulum Control
SPG: Linear Single Pendulum Gantry Control
SESIP: Linear Self-Erecting Single Inverted Pendulum Control
SLFJ: Single Linear Flexible Joint Control
SLFJ-plus-SIP: Single Linear Flexible Joint with Single Inverted Pendulum Control
DLFJ: Double Linear Flexible Joint Control
SEESAW: Seesaw Control
SEESAW-plus-SLFJ: Seesaw with Single Linear Flexible Joint Control
FIP: Linear Flexible Inverted Pendulum Control
DBIP: Linear Double Inverted Pendulum Control
AMD-1: One-Floor Active Mass Damper Control

MIMO Configurations (***Multiple Input, Multiple Output***)

SEESAW-Pendulum: Two Seesaw Modules Coupled Together to Control the Single Inverted Pendulum
AMD-2: Two-Floor Active Mass Damper Control

Some configurations require IPO2, please confirm at time of order.

IP01/IP02 Model Range

Model	Description
IP01	The IP01 is instrumented with a 10-turn potentiometer to measure cart position. Pendulum angle is measured using a potentiometer whose range is restricted by mechanical stops.
IP02	The IP02 is instrumented with two quadrature optical encoders,one each for cart position and pendulum angle. The shaft to which the pendulum is attached allows for the pendulum to be suspended in front of the cart, free of the mechanical stops. This permits additional configurations with unrestricted movement of the pendulum.

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LFJC Model Range

The Linear Flexible Joint Cart is supplied with two additional masses, which are available for attachment atop of it. They can be used for assessing the robustness of the controller and the effects of variations in parameters.

Model / Option	Description
LFJC	Standard LFJC module. The module is equipped with a 10-turn potentiometer to measure the cart position.
LFJC-E	Similar to the LFJC module but with an optical encoder instead of the potentiometer to measure the cart position.
LFJC-PEN-E	Similar to the LFJC-E module but equipped with an additional rotary joint atop of it, whose axis of rotation is perpendicular to the direction of motion of the cart. A free-swinging pendulum rod can then be attached to it and suspends in front of the cart. The pendulum angle is also measured by an optical encoder.

Typical Response

The following graph depicts both LFJC actual and theoretical position responses of a full-state-LQR-plus-Integrator closed-loop design.

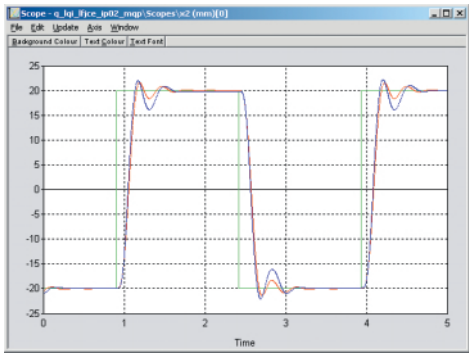

Figure 1 - Actual and Theoretical LFJC Vibration Minimization Responses Using Full-State Feedback

System Requirements

The Linear Flexible Joint Cart (LFJC) module is designed as an attachment to the IP01 or IP02 linear motion servo plant. Along with the IP01 or IP02 plant, the following components are required to complete the experimental setup:

Component	Quanser Recommended (Common Configuration)	Alternative
Power Module	Quanser UPM 1503/2405	Alternate Power Amplifier (Minimum requirements: +/- 12V, 3A)
Control Hardware	Quanser Q4, Q8 Series Quanser Q3 ControlPaQ-FW*	dSPACE DS1104** National Instruments E- or M-Series DAQs**
Control Software	Quanser QuaRC	The Mathworks – RTWT, xPC dSPACE – ControlDesk National Instruments – LabVIEW

* configuration with Q3 ControlPaQ-FW amplifier-on-board control unit does not require UPM power module

** Quanser offers interface boards for NI E- and M- series & dSPACE DS1104 boards.

System Specifications

Specification	Value	Units
Cart Dimensions (L x D x H)	10 x 14 x 12	cm
Linear Spring Length	0.29	m
LFJ Cart Mass	0.23	kg
Cart Extra Weight Mass	0.12	kg
Spring Assembly Mass	0.145	kg
Linear Spring Stiffness	150	N/m
LFJC Potentiometer Bias Power	±12	V
LFJC Potentiometer Measurement Range	±5	V
LFJC Potentiometer Sensitivity	0.0931	m/V
LFJC(-PEN)-E Position Encoder Resolution	4096	counts/rev
	22.8	µm/count
LFJC-PEN-E Pendulum Encoder Resolution	4096	counts/rev
	0.0879	deg/count

For IP01/IP02 specifications please refer to Product Information Sheet L1