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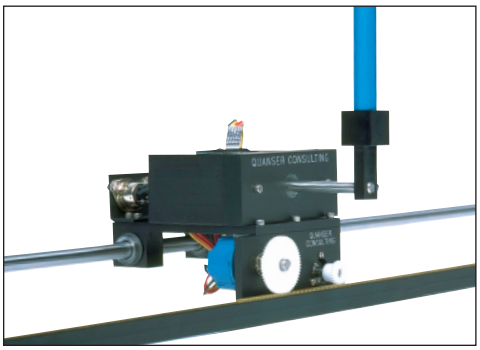
LINEAR CONTROL CHALLENGE

IP01 and IP02 Linear Motion Servo Plants

Product Information Sheet L1 - 1 - rev. C



Description

Either the IP01 or the IP02 linear motion servo plants serve as the base unit for Quanser's linear family of products. Both plants are ideal platforms to introduce fundamental control concepts and theories on an easy to use and intuitive platform. They consist of a cart driven by a DC motor, via a rack and pinion mechanism to ensure consistent and continuous traction. The cart is also equipped with a rotary joint to which a free turning rod (or pendulum) can be attached. In the case of the IP01, both cart position and pendulum angle are sensed via potentiometers. By contrast, the IP02 system has two encoders, which allow for multiple turns. As a result, the IP02 pendulum can suspend in front of the cart to perform the self-erecting and gantry experiments.

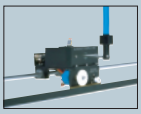
Key Features

- Fully compatible with MATLAB/Simulink
- Modular design (experiments are easily interchangeable)
- High quality DC servo motor and gearbox
- High resolution optical encoders, on the IP02, to sense both cart and pendulum positions
- Ten-turn potentiometer, on the IP01, to sense the cart position
- Single-turn potentiometer, on the IP01, to sense the angle of the inverted pendulum
- Precisely machined solid aluminum cart
- Fully documented system models & parameters
- Variable cart load mass
- Variable pendulum rod length
- Open architecture design

Curriculum Topics

- Position & Speed Control
- Disturbance Rejection
- Tracking Control & Regulation
- PID Controller Design
- Lead / Lag Compensation
- State-Feedback
- System Modeling & Simulation
- Frequency Analysis
- Phase & Gain Margin
- Nyquist Stability
- Root Locus Design
- Real-Time Control
- Discrete Time Sampling
- System Identification
- Multivariable Control Design

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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LINEAR CONTROL CHALLENGE

IP01 and IP02 Linear Motion Servo Plants

Product Information Sheet L1 - 2 - rev. C

Typical Response

The following graph depicts both actual and theoretical position responses of a PV position controller design.

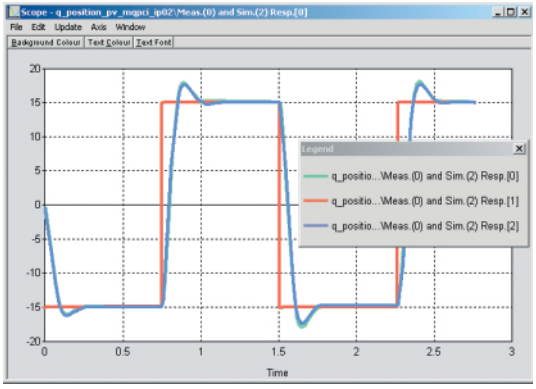

Figure 1: PV Controller: Actual and Theoretical Position Responses to a Square Wave Setpoint

The following graph depicts both actual and theoretical speed responses of a phase-lag-based controller design.

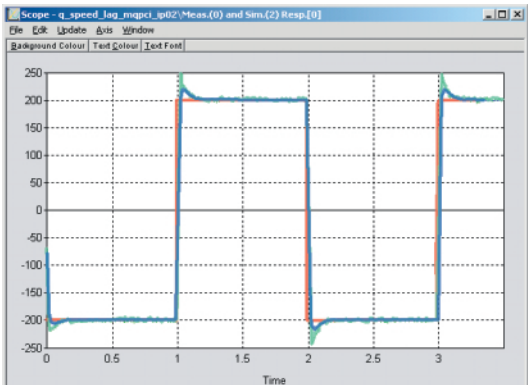

Figure 2: Phase-Lag Controller: Actual and Theoretical Speed Responses to a Square Wave Setpoint

System Requirements

The IP01 or IP02 plants require the following components 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 9	cm
Overall Rack Length	1.02	m
Cart Travel	0.814	m
Cart Mass	0.5	kg
Cart Extra Weight Mass	0.37	kg
Rated Voltage	6	V
Maximum Continuous Current	1	A
DC Motor Torque Constant	0.00767	Nm/A
Planetary Gearbox Gear Ratio	3.71	
Long Pendulum Mass	0.23	kg
Medium Pendulum Mass	0.127	kg
Long Pendulum Length (from Pivot to Tip)	0.6413	m
Medium Pendulum Length (from Pivot to Tip)	0.3365	m
IP01 Inverted Pendulum Mechanical Range	±32	deg
IP01 Cart Potentiometer Bias Power	±12	V
IP01 Cart Potentiometer Measurement Range	±5	V
IP01 Cart Potentiometer Sensitivity	0.0931	m/V
IP01 Pendulum Potentiometer Sensitivity	0.2482	rad/V
IP02 Cart Encoder Resolution	4096	counts/rev
	22.8	µm/count
IP02 Pendulum Encoder Resolution	4096	counts/rev
	0.0879	deg/count