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B o uncing Ball Experiment

The bouncing ball experiment allows a student to deepen their understanding of mathematical concepts and develop their system identification and control techniques using a real-time system. Researchers can investigate new methods for approximating and controlling nonlinear systems.

Mathematical Concepts

- Nonlinear dynamics
- Periodic motion
- Periodic doubling
- Bifurcation
- Fractals
- Chaos
- Deterministic systems

System Modeling & Identification

- Parameter space studies
- Phase portrait
- Power spectrum
- Fractal dimension

Nonlinear Control

- Stabilization of periodic orbits
- Control using chaos
- Nonlinear observers
- Feedback linearization

B o uncing Ball Experiment

... for research and education

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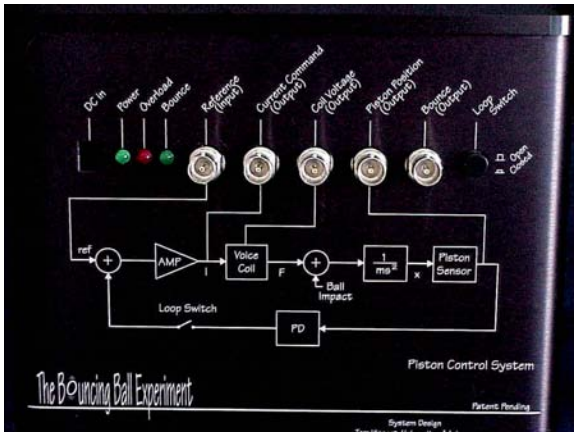
B^{O}uncing Ball Experiment

The Bouncing Ball Experiment is a precision electromechanical instrument for investigating nonlinear dynamics. A piston in the base of the instrument moves in response to a command waveform (typically a sine wave). An elastic ball bounces on the piston and exhibits a surprisingly wide range of dynamic behaviors. For example, resonance, sub-harmonic resonance, and chaos are all observable even though the model is extremely simple. The piston is actuated with a vertical linear motor, and the ball is constrained by a Teflon bushing to move on a stainless steel rod.

A high-resolution eddy current sensor is used to measure the piston position for monitoring and feedback through an internal high bandwidth PD controller. The user can augment or replace the internal controller with an external controller through easy-to-use BNC connections and front panel controls. In addition, an acoustic pick-up embedded in the piston reliably detects impacts of the ball on the piston. This impact detector can be used to construct Poincare maps, nonlinear observers, and feedback controllers.

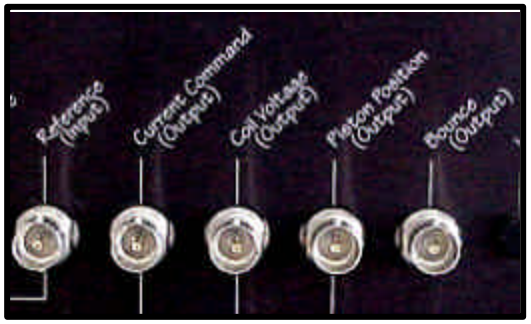
Front panel

The front panel “loop switch” allows users to either use the internal PD controller or to create their own externally.



Input and Output

The frequency and amplitude of the piston is controlled by the user supplied reference input



There are four outputs: current command (amps), coil voltage, piston position (volts), and bounce (TTL signal).

Internal Control System

The user may select the internal proportional-derivative (PD) controller for dynamics experiments