Young Scholars Program,
Northeastern University

Northeastern University
COLLEGE OF ENGINEERING
Department of Mechanical and Industrial Engineering

Feedback Control in Ball Beam Dynamics

- Experimenting Delay Effects

Benjamin Gertner

Framingham High School

Mike Wilson

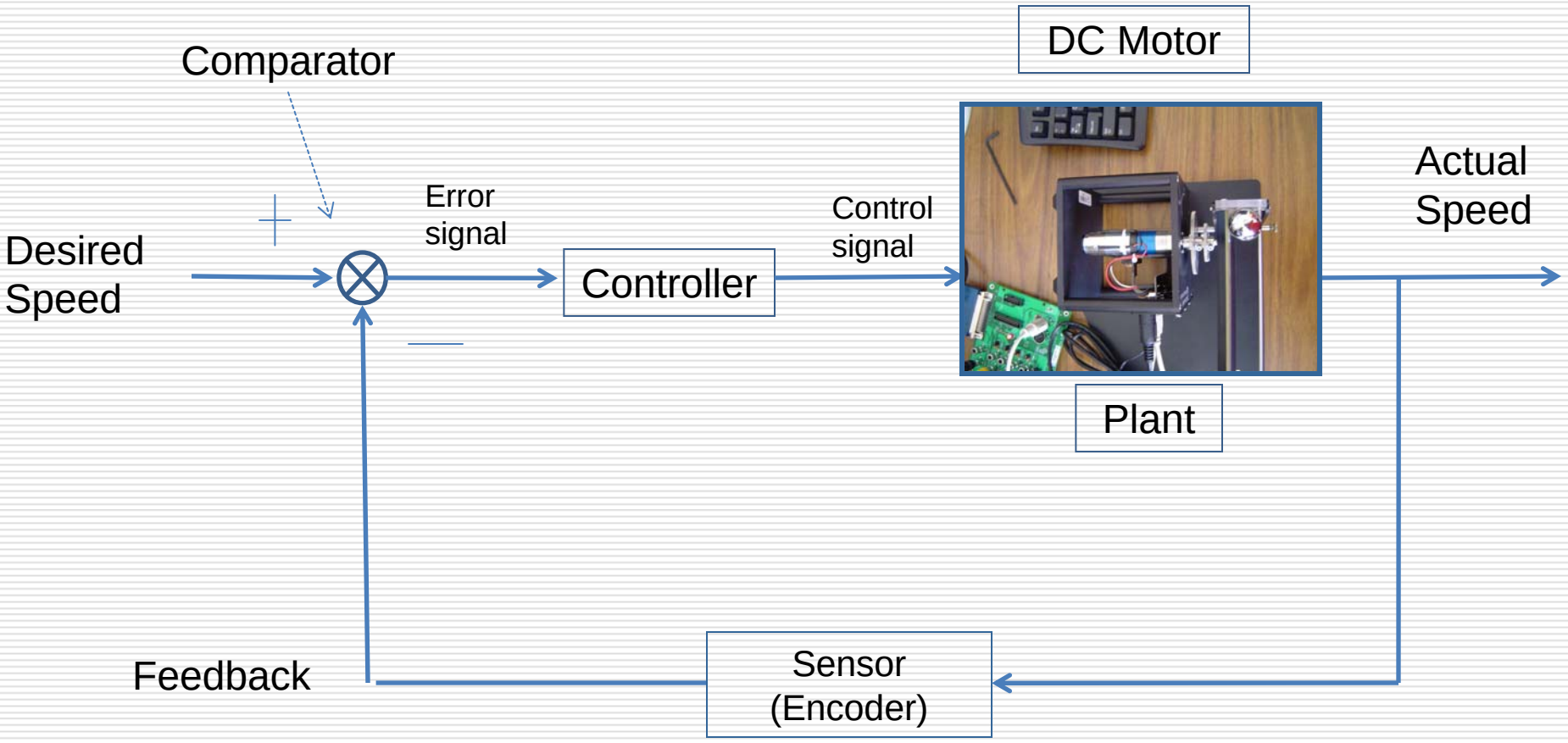
Beverly High school

Professor Rifat Sipahi
Northeastern University

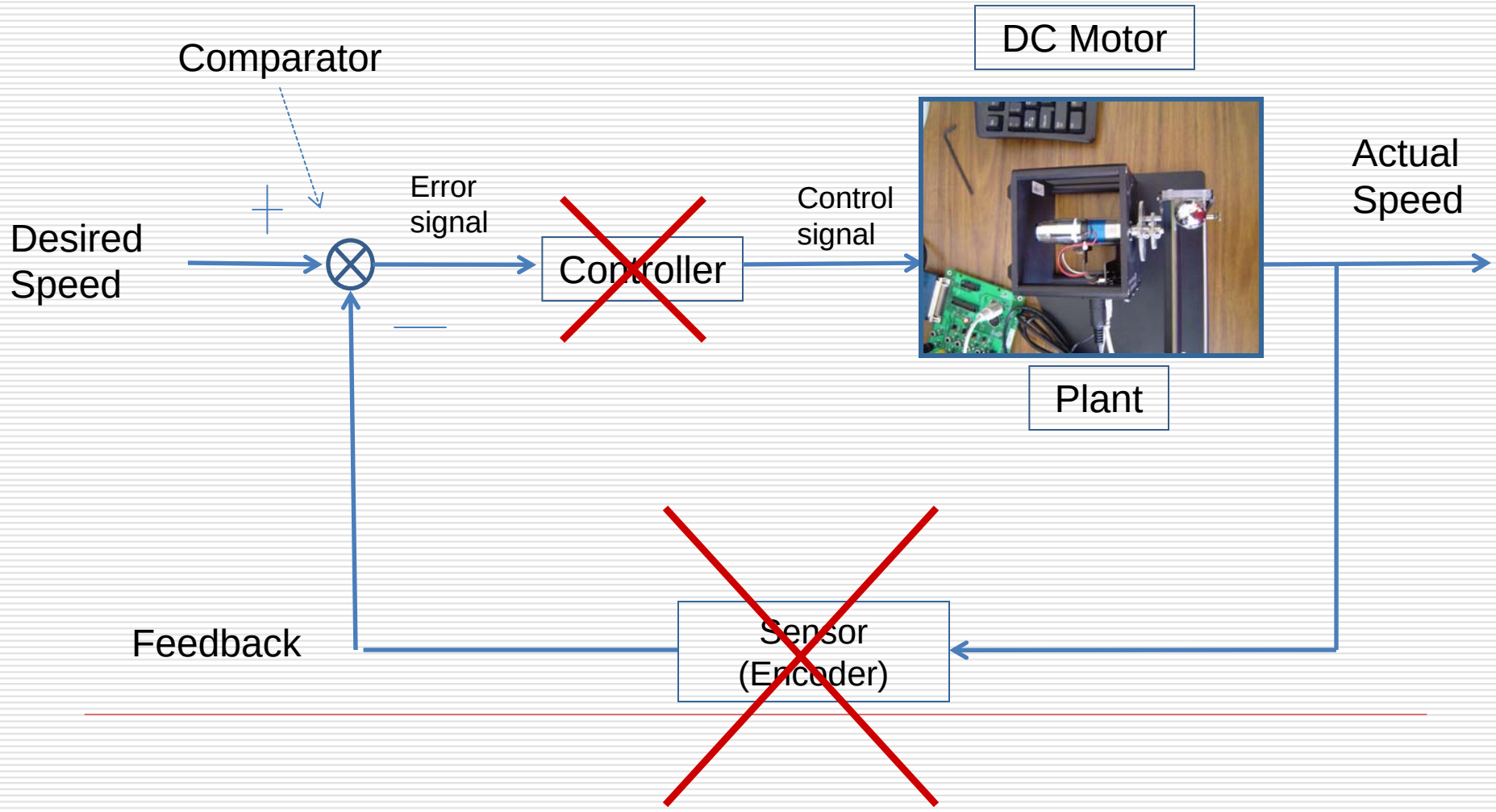
Background & Terminology

- What is “feedback control” ?
- Sensors
- Stability / Instability
- Cruise Control

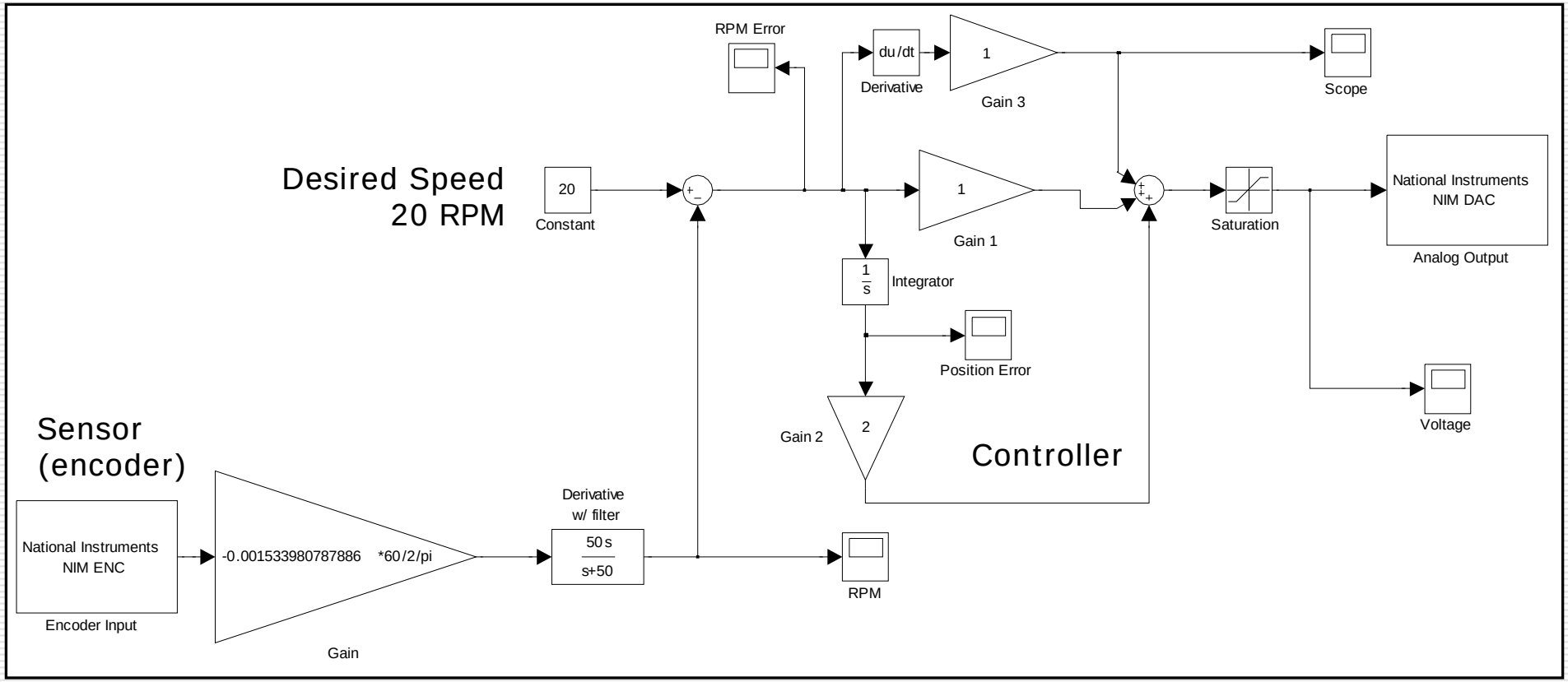
Block Diagram Convention (Controlled)



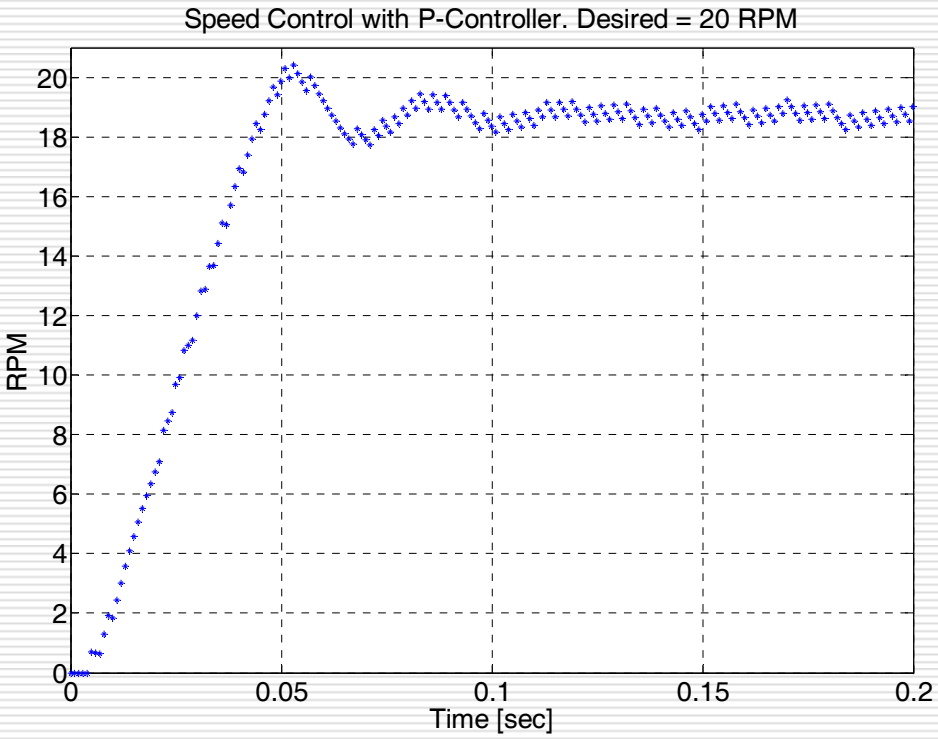
Block Diagram Convention (Uncontrolled)

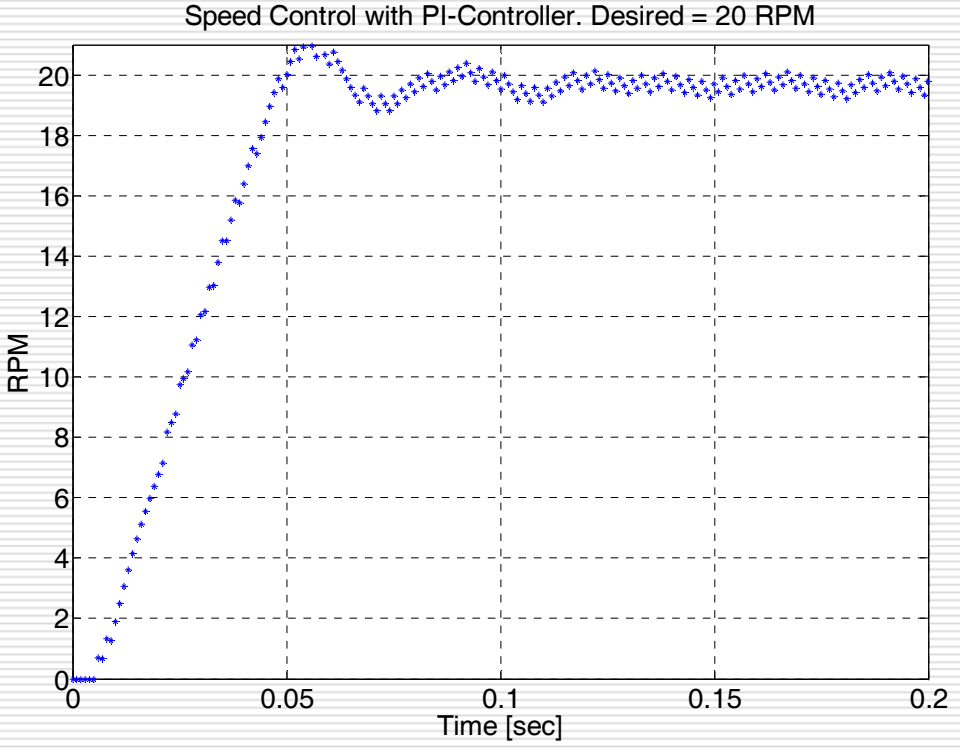


Block Diagram—Motor (PID Controller)

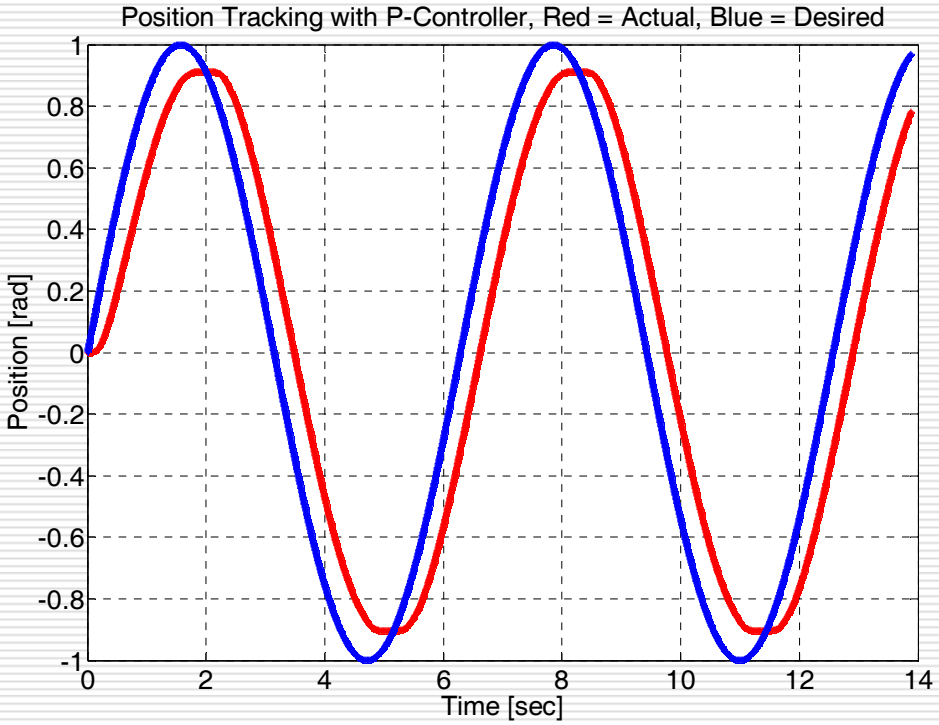


Speed Control of the Motor-Experiments

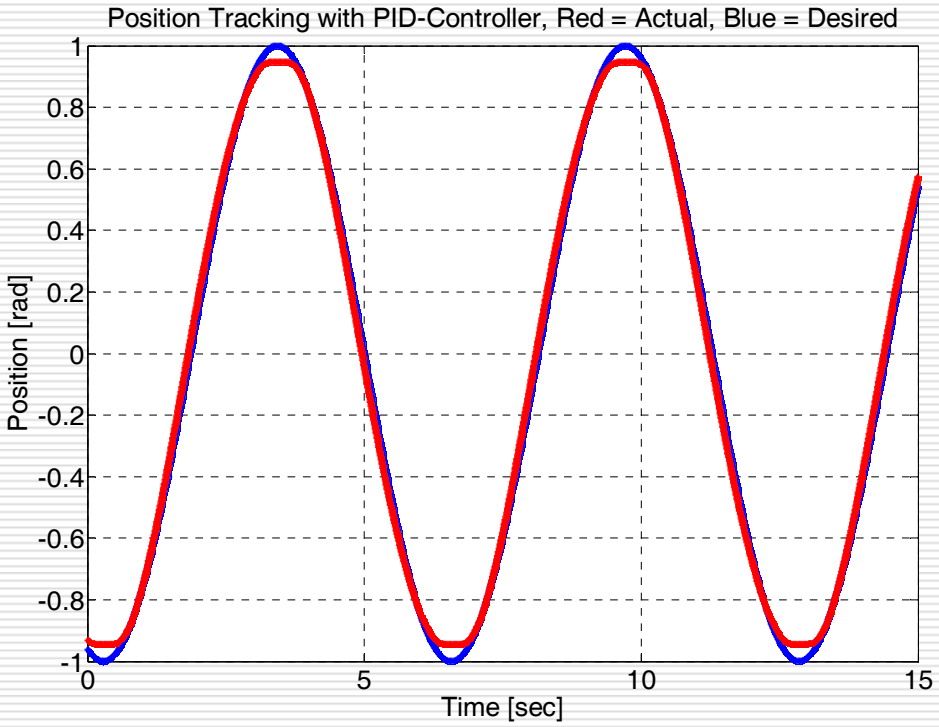




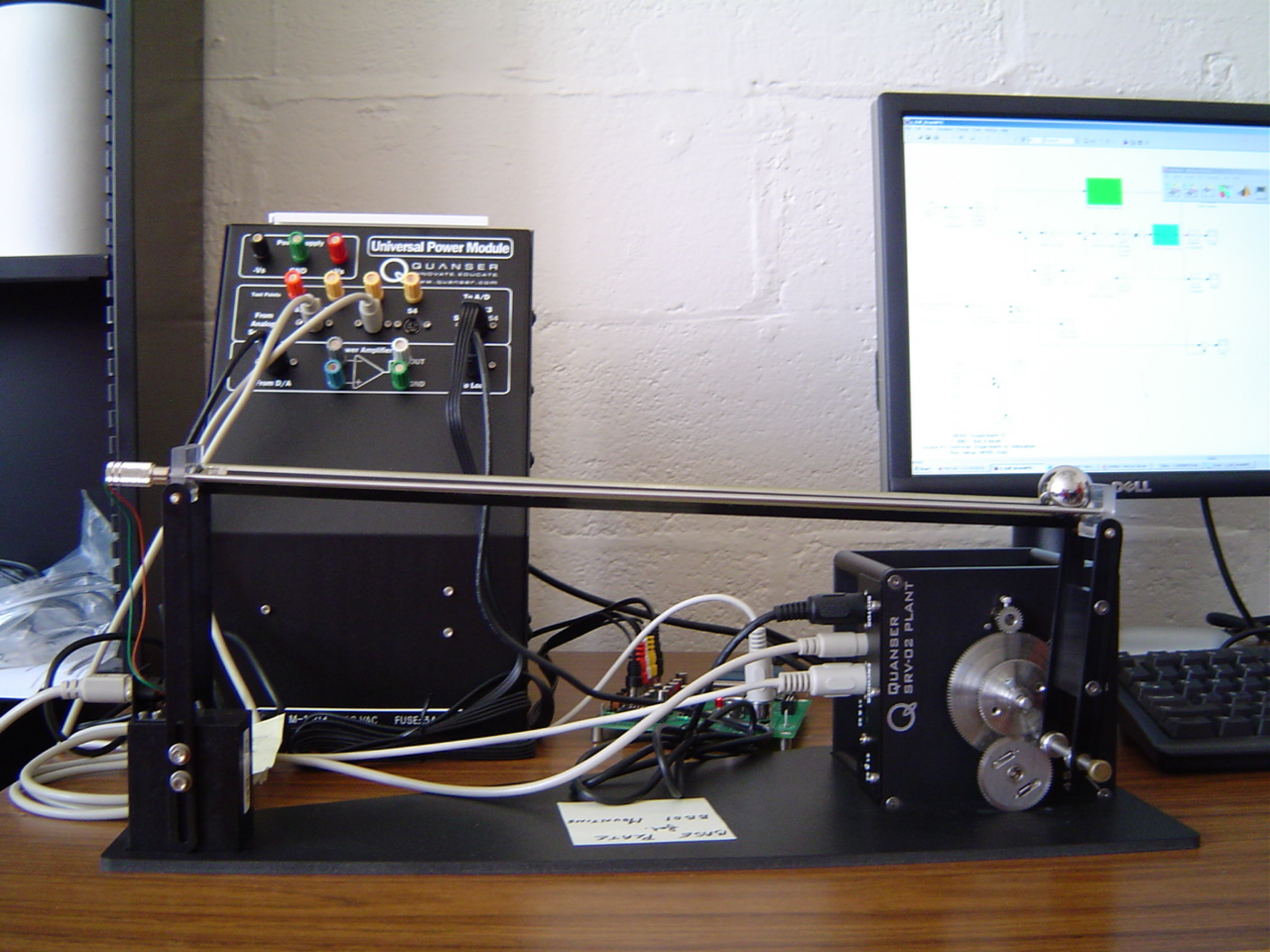
Position Control of the Motor- Experiments



Error = ±15°!!

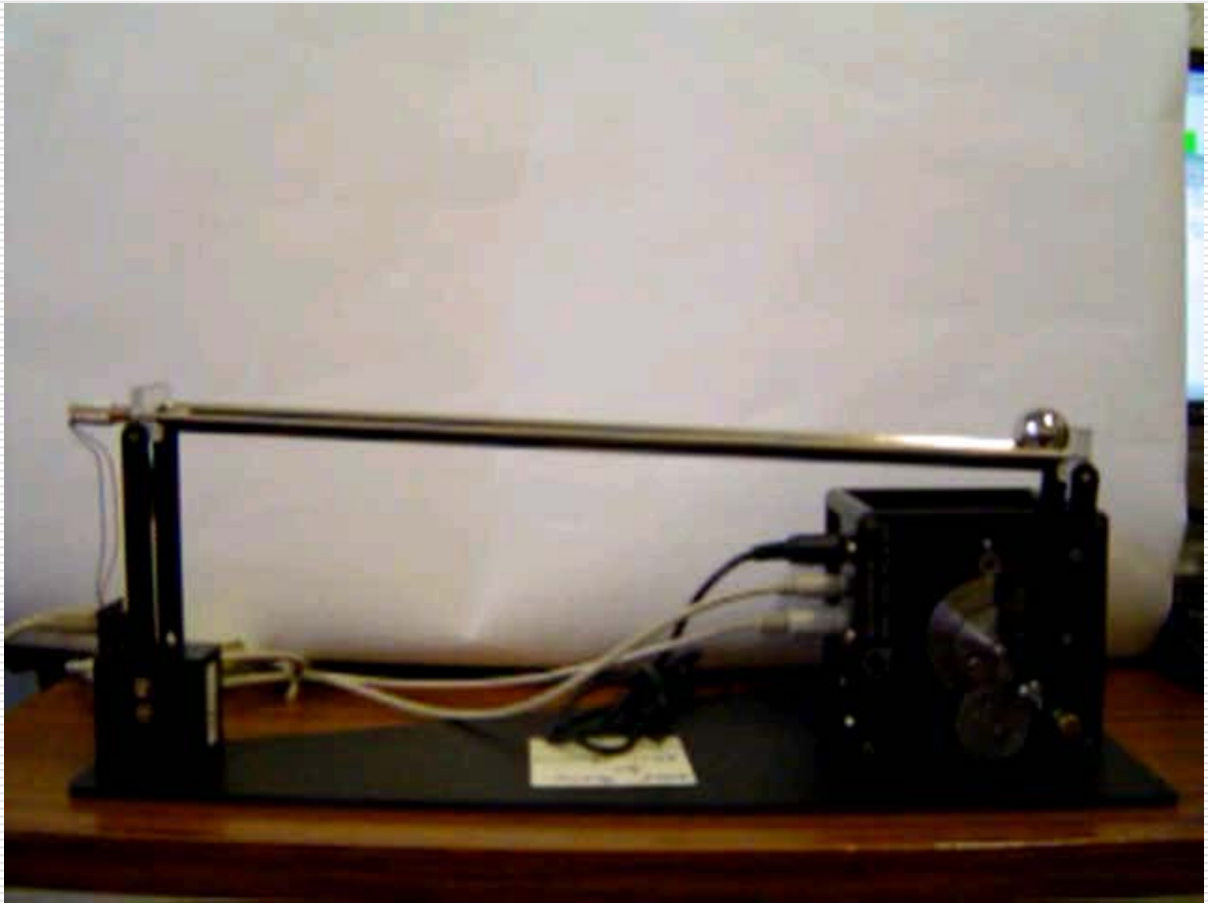


Error = ±3°


Universal Power Module
QUANSER
QUANSER
SRV-02 PLANT

No Delay – Ball At Start

Introduction to Ball Beam Dynamics



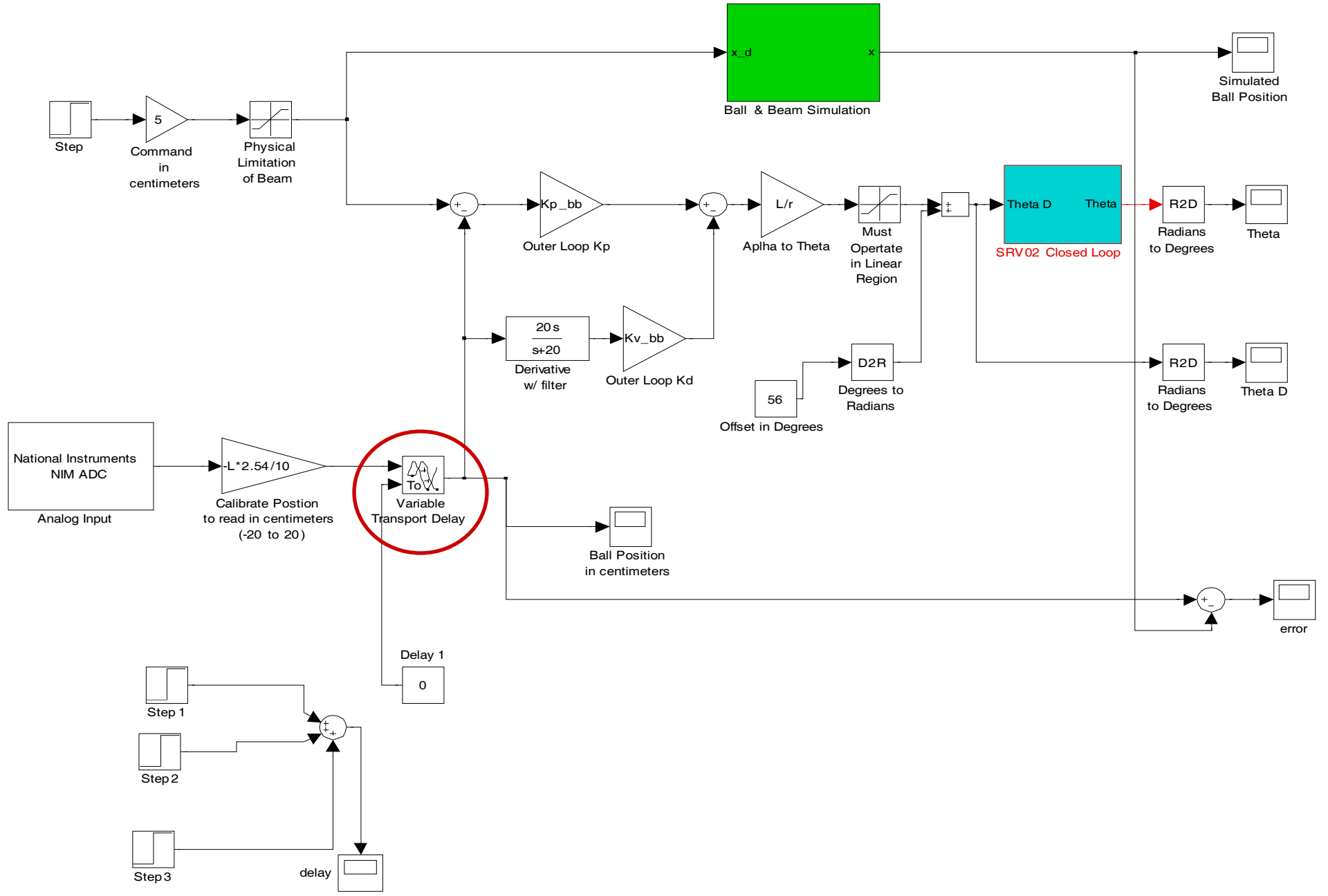
What is Delay and Where is it?

- Time that it takes to receive a signal

- Where:
  - Remote surgery
  - Human reaction delays
  - Chemical processes
  - Robotics
  - Tele-operation
  - Missiles and targets
  - Light delay (circuits, all electronics)

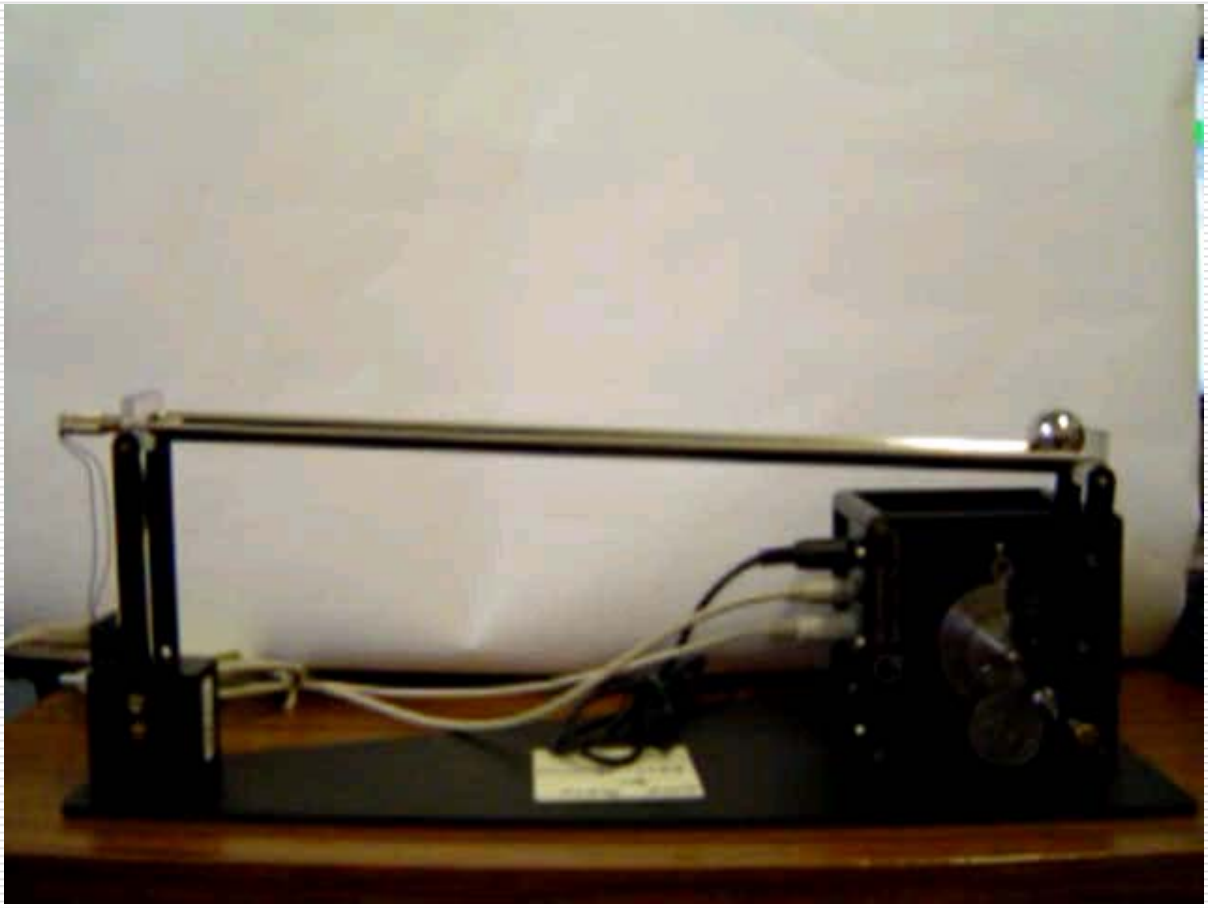
Delay Effects

- How would you implement delay?
- Why does delay lead to instability?
- Compensation of undesirable effects
  - Wait before you act (observe trends)
  - Be less aggressive when compensating
  - Advanced controller development (research)

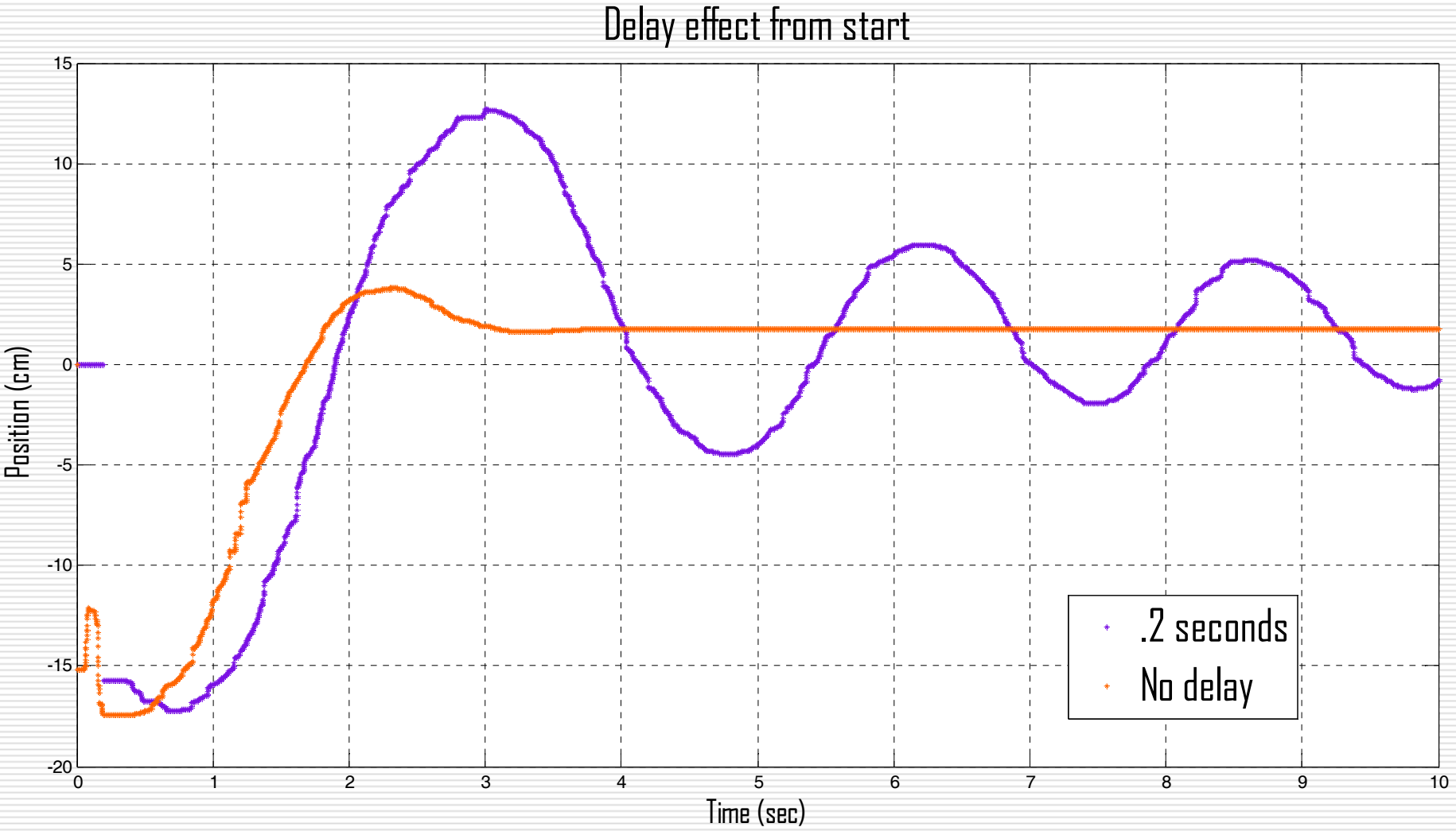


SRV02 - Experiment #3
BB01 - Ball & Beam
Double PV Controller : Experiment vs . Simulation
Run: Setup_SRV02_Exp3

0.2 Second Delay– Ball At Start

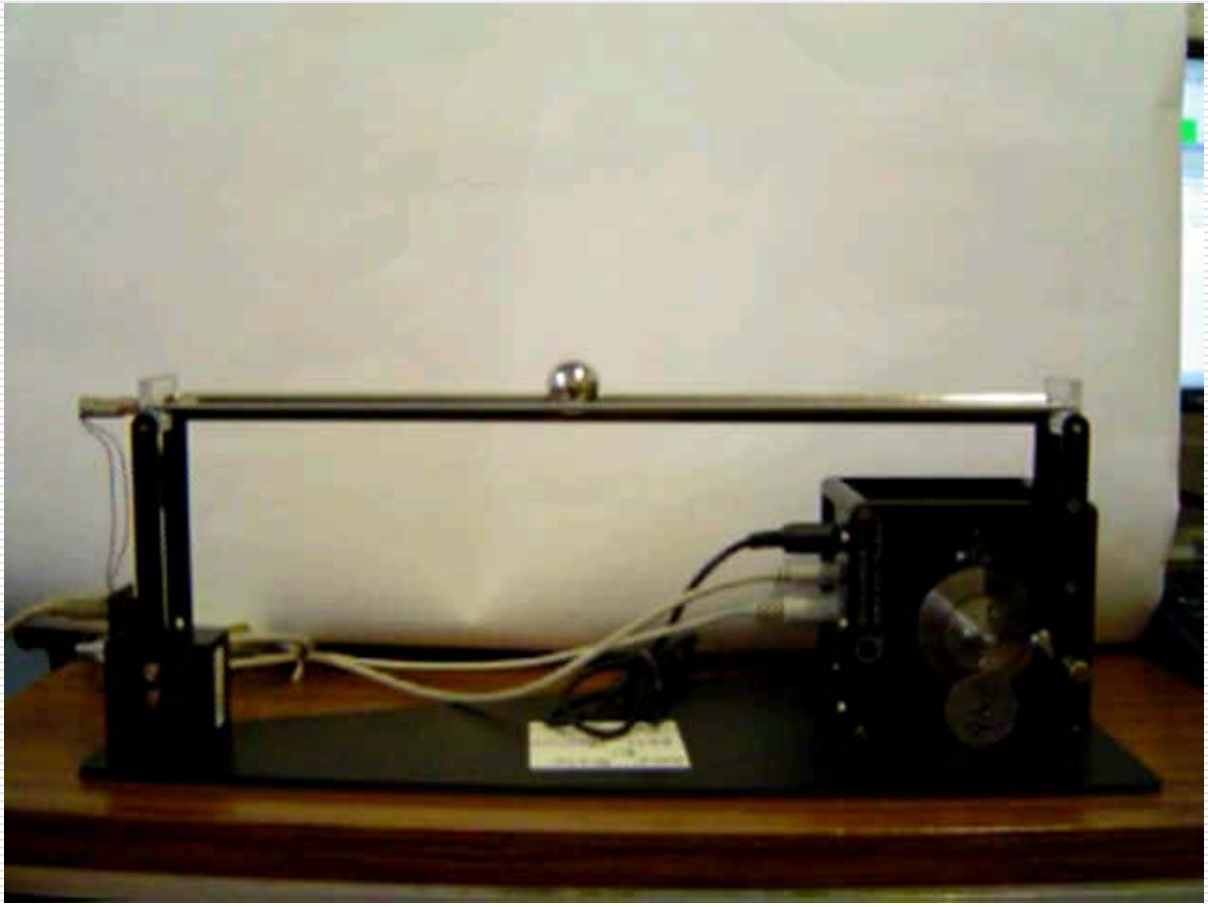


Delay—Graph

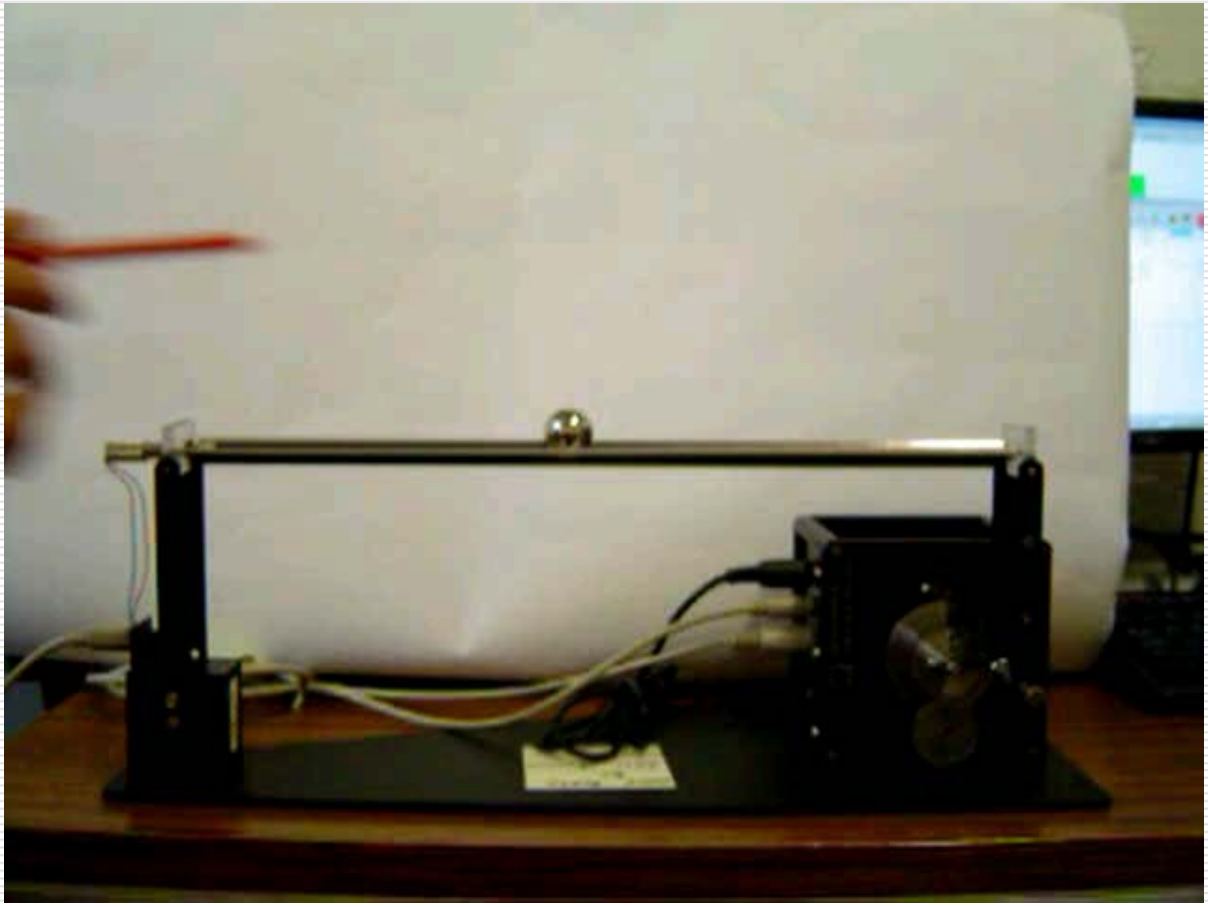


Kv_bb=.006 Kp_bb=.01

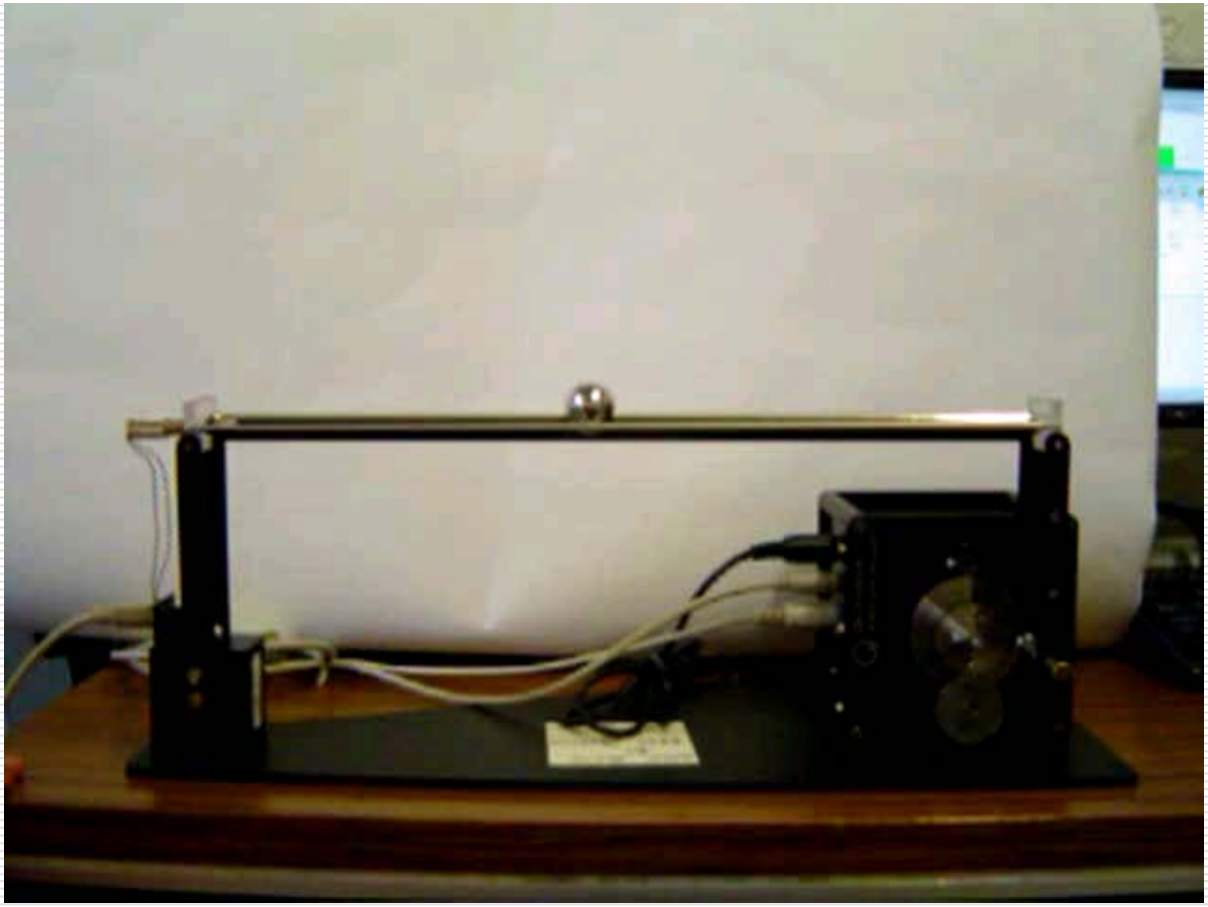
No Delay – Ball At Equilibrium



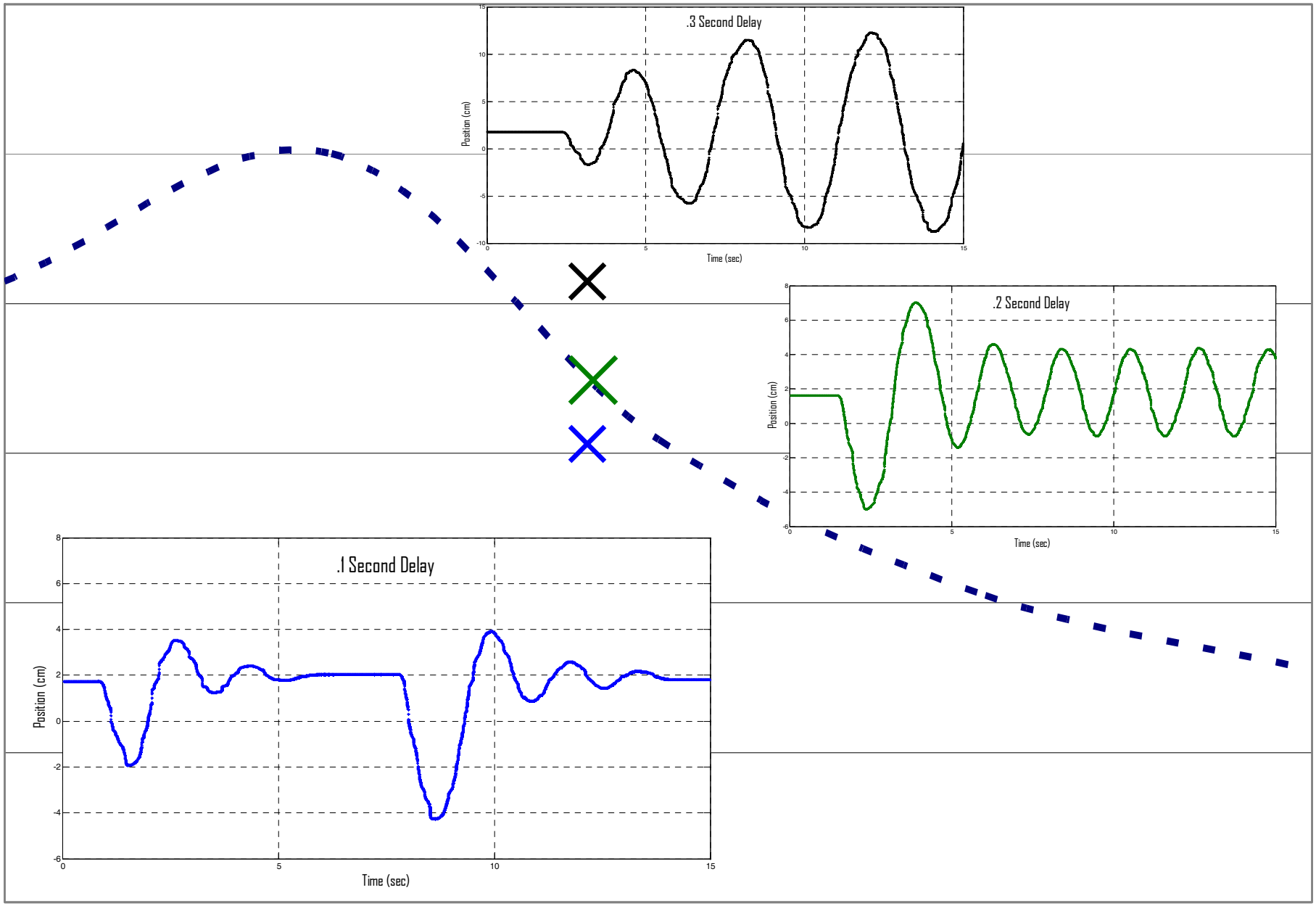
0.1 Second Delay– Ball At Equilibrium



0.2 Second Delay– Ball Equilibrium



Max Delay for Kv_bb



Getting Better

- Optimization
  - Energy efficient
  - Quickest result
  - Safest voltage
- Improving the Controller
  - New degrees of freedom—P, PI, PID controllers
  - Have the computer guess—Penalize the guess
- Gain, Too Much of a good thing?
  - Kp=1, Kp=1000

Thank you