BITS Pilani
Pilani | Dubai | Goa | Hyderabad

Control Systems

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Lecture 01 – Introduction

Scope

Learning Outcomes

1. Conceptualize plant models and control layouts for any given problem
2. Design, Build, Simulate, Test and Validate Control Systems
3. Formulate Control Strategies based on Business Rules

Course Structure

1. Control System Basics – Foundations
2. Mathematical Modelling – Building Plant Models
3. Plant Model Control
4. Automotive Control Systems

Assessment

- Assignment 1 – 5%
- Mid Term Test – 30%
- Assignment 2 – 5%
- Comprehensive Test – 40%
- Boot Camp – 20%

Pre-Requisites

- Fundamentals of Calculus
- Fourier & Laplace Transforms

Mathematics

- Automotive Domain – High Level Systems Knowledge

Domain Expertise

Introduction

Control Systems

- Control System vs Change System
- Control System – Acts on a system that can take inputs, to produce outputs that is desired
- Control System Design - Method of representing your system as a Differential Equation
- Convert into ODE
- Simulate and Visualize

Control System

"Hello World" Model

Control System Design

Model 1

- Fan Speed (N) inversely proportional to Temperature (T)
- T = K/N, K being a system constant
- System Input - Fan Speed, System Output – Temperature
- Control Parameter – Temperature, Compare to Set Temperature
- Not Sure if Output Temperature will be reached
- Physical Intervention??
- Touch, Feel, Measure – Feedback
- Open Loop Systems – Will work for simple setups

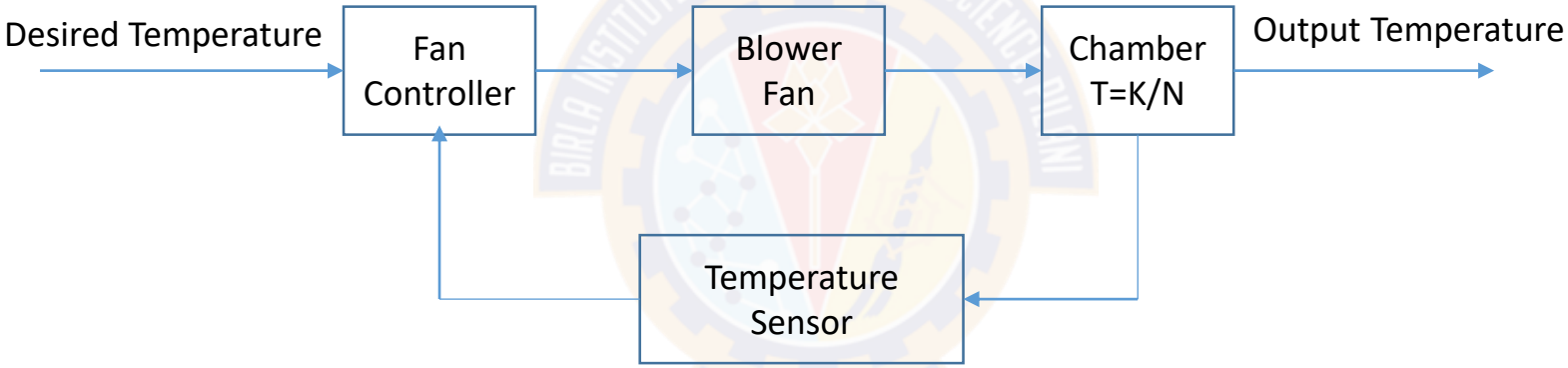
Control System Design

Open Loop vs Closed Loop

- No Feed Back Circuit
- Good for simple systems / Human Intervention Based Systems
- Complexities – Closed Loop can be termed as Open Loop
- Convection Oven

Control System Design

Model 2



- Fan Controller can change speed based on Temperature deviation
- Increase or decrease speed based on temperature difference (Delta T)
- Possible to target any set temperature (??)

Control System Design

Learning

- Possible to build a control for any physical system if
  - Model system behavior with reasonable accuracy
  - Understand business / process rules allied with it
  - Understand deliverables – Accuracy, Repeatability, Cost etc.,

Learning - Path

- Model physical systems – Plant Modelling
- Build, Simulate, Test & Validate Control System
- Handle Business / Process Rules
- With an aim to satisfy Deliverables

Learning Path

Plant Modelling – Model Building

- Analyze Deliverables – Determine Complexity Required
- Temperature control inside an oven for
  - Baking a cake
  - Heat Treatment
- Data Driven Models vs Predictive Models
- Mathematical Models vs FMU (Complex Mathematical Models)

- Model physical systems – Plant Modelling
- Build, Simulate, Test & Validate Control System
- Handle Business / Process Rules
- With an aim to satisfy Deliverables

Learning Path

Control System Design

- Analyze Deliverables – Complexity & Accuracy – Platform to be used
- Simulink to Prototype, Simulate and Validate Control System
- MIL Simulations
- Auto Code Generation & Limitations
- Sensors, Actuators, Micro Controllers, Communication – Out of Scope

- Model physical systems – Plant Modelling
- Build, Simulate, Test & Validate Control System
- Handle Business / Process Rules
- With an aim to satisfy Deliverables

Learning Path

Business / Process Rules

- Incorporating Business / Process Rules into Control System Design
- Control Strategy Development
- Automotive Control Strategies

- Model physical systems – Plant Modelling
- Build, Simulate, Test & Validate Control System
- Handle Business / Process Rules
- With an aim to satisfy Deliverables

Learning Path

Testing & Validation

- MIL Testing Methodologies & Strategies
- HIL Testing Methodologies & Strategies

- Model physical systems – Plant Modelling
- Build, Simulate, Test & Validate Control System
- Handle Business / Process Rules
- With an aim to satisfy Deliverables

Learning Path

Tools & Packages

- Matlab / Simulink – Download and install on local computers – Student Access Available
- Ricardo Wave – Engine Plant Model Development – Available through Online Servers, Details will be provided later by Lab Team

Text Books

- Uwe Kiencke, Lars Nielsen, **“Automotive Control Systems, For Engine, Driveline, and Vehicle”**
- Graham C Godwin, Stefan F Graebe, Mario E Salgado, **“Control System Design”**

Thank You!

In our next session:

Plant Model Development