Lecture Module - Automatic Control

ME3050 - Dynamics Modeling and Controls

Mechanical Engineering

Tennessee Technological University

Automatic Control

Lecture Module - Automatic Control

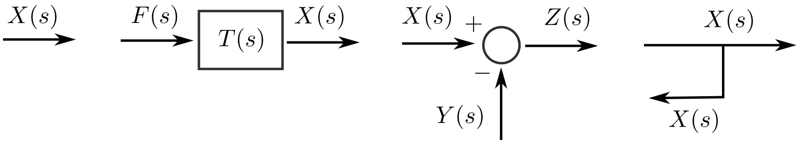
- Topic 1 - Introduction to Control Systems
- Topic 2 - Control of First Order Plants
- Topic 3 - Control of Second Order Plants
- Topic 4 - Application and Implementation

Topic 1 - Introduction to Control Systems

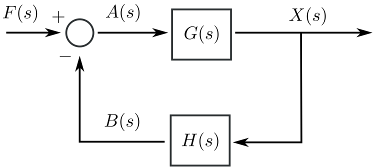
- Open-Loop and Closed-Loop Control
- Control System Terminology
- Modeling and Analysis
- The PID Control Algorithm

Open-Loop and Closed-Loop Control

Block Diagrams and Transfer Functions



Generalized Feedback Loop



$$T(s) = \frac{X(s)}{F(s)}$$

$$T(s) = \frac{G(S)}{1 + G(s)H(s)}$$

Open-Loop and Closed-Loop Control

Control System Examples:

- Thermal Control - HVAC - 3D Printing
- Vehicle Control - Cruise - ACC
- Precision Motion Control - Robotics - Automation

Goal: cause system *output* to go to specfied state

Strategy: set the system input to appropriate value to do so

- No Control
- Bang-Bang Control
- Open-Loop Control
- Closed-Loop Control

Open-Loop and Closed-Loop Control

Open-Loop Control

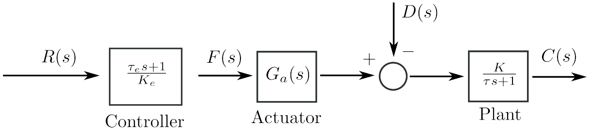
- uses prediction of model behavior, not system state
- less complex, known as *sensorless*
- less robust to input disturbances
- single path block diagram

Closed-Loop Control

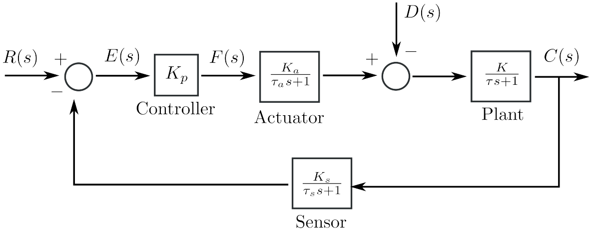
- uses measurement or estimation of model state and behavior
- more complex, requires integrated sensor
- can be robust to range of input disturbances
- feedback loop in block diagram

Open-Loop and Closed-Loop Control

Open-Loop Control



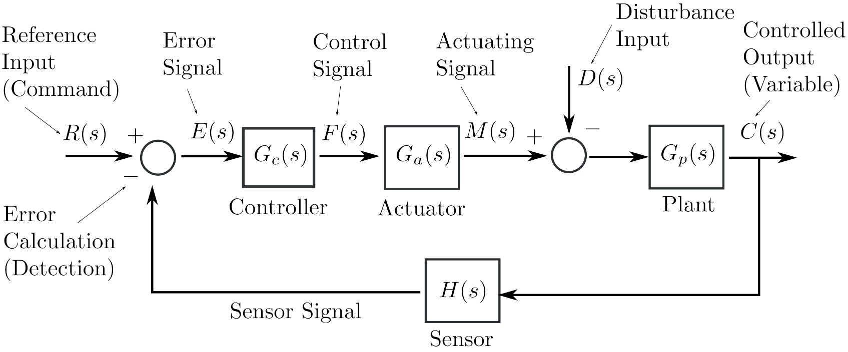
Closed-Loop Control



images: T.Hill - modified from System Dynamics, Palm 3rd Ed.

Control System Terminology

Closed-Loop Control Terminology



images: T.Hill - modified from System Dynamics, Palm 3rd Ed.

Control System Terminology

Modeling and Analysis

Modeling and Analysis

The PID Control Algorithm

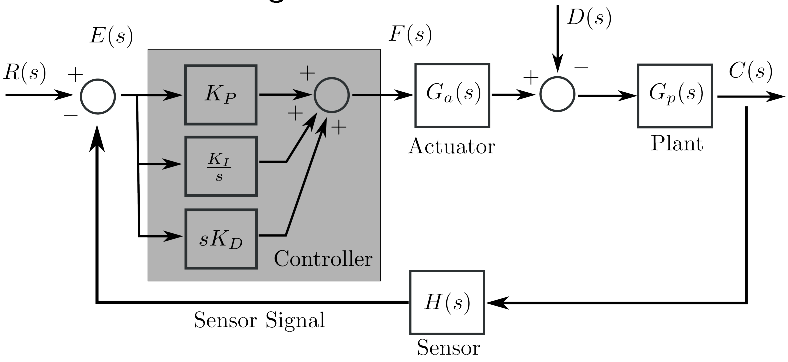
The goal of the controller is to achieve the following:

- Minimize the steady state error
- Minimize the settling time
- Achieve other transient specifications (see time response)

Text: System Dynamics - Palm 3rd.

The PID Control Algorithm

The PID Control Algorithm



The PID Control Algorithm

The control gains scale the calculated error to adjust the system input(s).

- K_P - *Proportional* Gain - Correction from current error
- K_I - *Integral* Gain - Correction from acculated error
- K_D - *Derivative* Gain - Correction from change in error

Note: P, PI, and PD controllers can be used, but the combination PID is prefered.

References

- System Dynamics, Palm III, Third Edition - Chapter 10 - Introduction to Feedback Control Systems

Topic 2 - Control of First Order Plants

- Block Diagram of Controlled System
- DC Motor Example
- Simulation with Simulink
- Simulation with Simulink + Simscape

Harmonic Input Function

Block Diagram of Controlled System

Block Diagram of Controlled System

DC Motor Example

DC Motor Example

Simulation with Simulink

DC Motor Example

Simulation with Simulink

Simulation with Simulink

Simulation with Simulink

Simulation with Simulink + Simscape

Simulation with Simulink + Simscape

Topic 3 - Control of Second Order Plants

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Topic 3 - Application and Implementation