Introduction to PID control scheme

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Agenda for Discussion

Outline

Terminology

- Systems can be classified as open-loop systems and closed-loop systems
- Open loop systems can be termed as uncontrolled systems.No feedback involved
- Closed loop system has a feedback and can be termed as control system

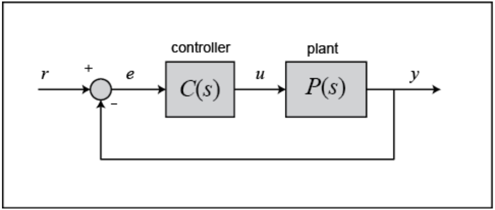
Terminology (Contd.)

Plant : The part or component of a system that is required to be controlled.

Controller : The part or component of a system that controls the plant.

Feedback : A measure of the output of the system used for feedback to control

Error : Error is the difference between desired value and measured process value



Outline

Type of Inputs

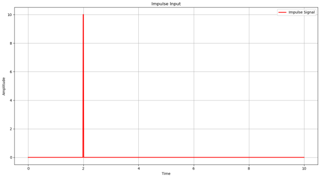


Figure: Impulse Input

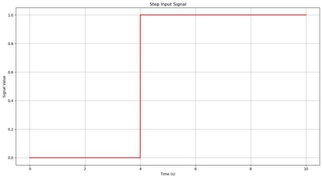
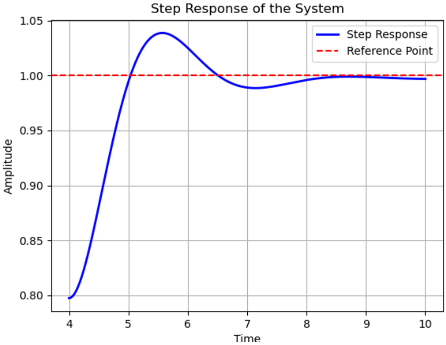


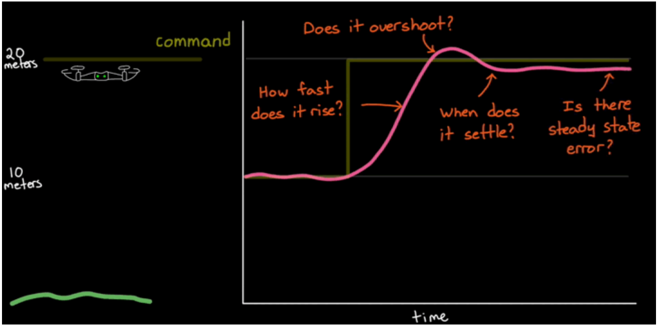
Figure: Step Input

System response

Step Response : It is how a system responds to step input.



System response



Referred a video on MATLAB Tech Talk by Brain Douglas: Step Response

Outline

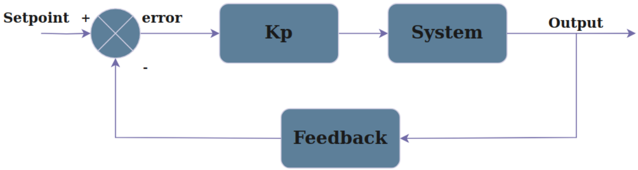
What is PID?

- PID stands for Proportional Integral Derivative controller.
- Error based controller.
- Output of controller is the a linear function of constants and errors
- Advantages : Easy to implement, no information about dynamic model of the system required, robust, widely used in industry.
- Disadvantages : Tuning of parameters, sometimes cannot work for all conditions in complex non linear systems

Proportional Controller

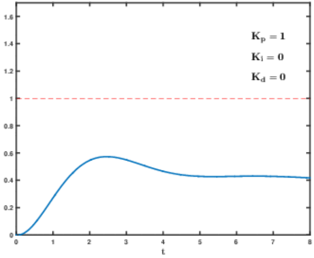
- Output is proportional to the error

$$\textbf{Output} = K_p \cdot \textbf{error}$$



Proportional Controller -P

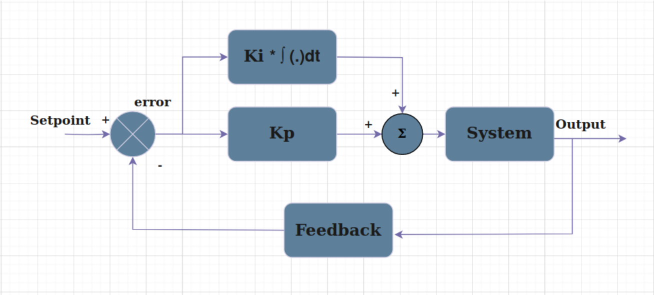
1. Increase in K_p decreases rise time.
2. Adds oscillations in the system.
3. Decreases steady state error.



Proportional Controller - PI

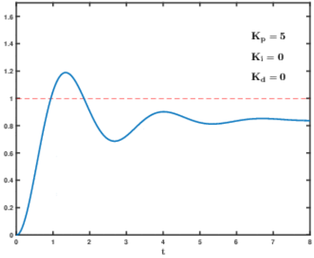
Output is the sum of the proportional and integral term:

$$\textbf{Output} = K_p \cdot \text{error} + K_i \cdot \int \text{error}\, dt$$



Proportional Controller - PI

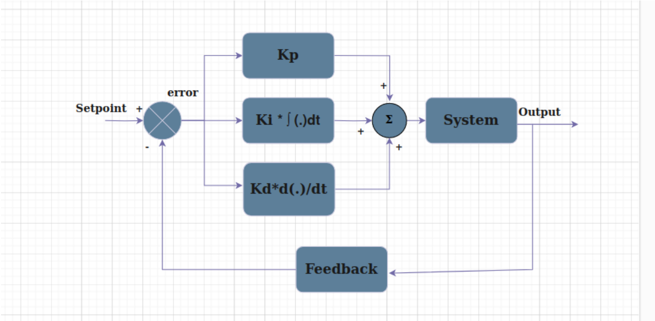
1. Addition of I term reduces steady state error
2. Also increases oscillations
3. Can lead to integral windup problems



Proportional Integral Derivative controller - PID

Output is the sum of proportional, integral, and derivative terms:

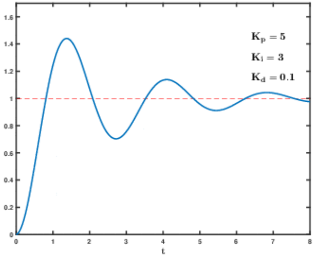
$$\text{Output} = K_p \cdot \text{error} + K_i \cdot \int \text{error}\, dt + K_d \cdot \frac{d(\text{error})}{dt}$$



Proportional Integral Derivative controller - PID

Combines features of P, I and D

Faster rise time, minimal oscillations, zero steady state error



Outline

PID Control of SBR

- **Objective**: To balance the SBR.
- **Steps**:
  1. Step 1: Calculate the error: $error = desired\_angle - current\_angle$.
  2. Step 2: Calculate the differential of the error: $difference\_error = error - prev\_error$.
  3. Step 3: Calculate the sum of the error: $sum\_error = sum\_error + error$.
  4. Step 4: Calculate the PWM output:

$$PWM\_output = K_p \times error + K_d \times difference\_error + K_i \times sum\_error$$

Outline

PID tuning Procedure

Objective: To balance the SBR.

- Start with K_p, K_d, $K_i = 0$.
- Increase K_p until sustained oscillations are achieved.
- Increase K_d to dampen oscillations.
- Add K_i to remove steady-state error.
- Fine-tune K_p, K_d, K_i to achieve desired performance.

Let's tune through Simulation

Thank You!

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