Introduction to PID control scheme

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Agenda for Discussion

1. Control Systems Terminologies

2. Plant Input and System Responses
   - Type of Inputs
   - System response

3. PID
   - What is PID?
   - Proportional Controller - P
   - Proportional Controller - PI
   - Proportional Integral Derivative controller - PID

4. PID Control of SBR

5. PID tuning Procedure

Outline

Terminology

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

Terminology (Contd.)

- 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

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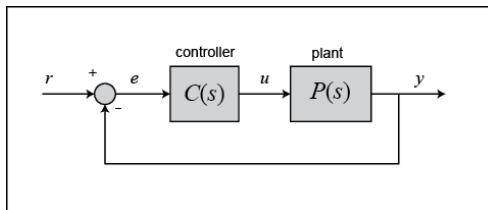
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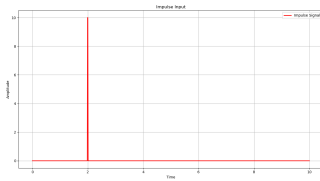
Figure: Impulse Input

Figure: Step Input

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

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

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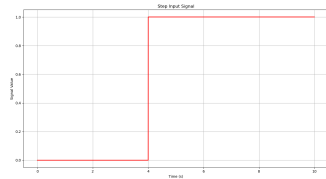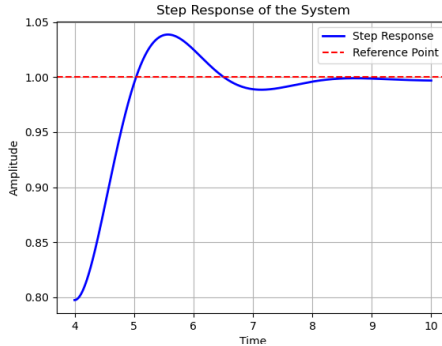
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What is PID?

- 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

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Proportional Controller

- Output is proportional to the error

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

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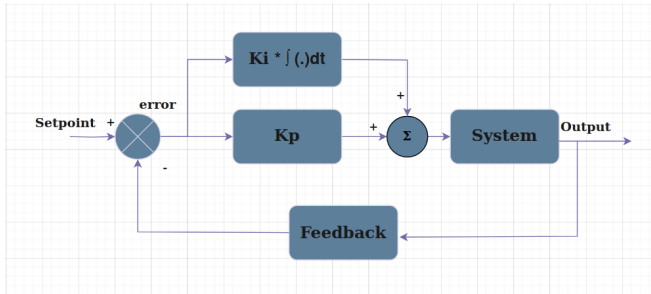Proportional Integral Derivative controller - PID
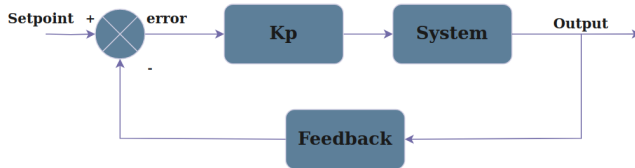
Proportional Controller -P

1. Increase in K_p decreases rise time.

2. Adds oscillations in the system.

3. Decreases steady state error.

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Output is the sum of the proportional and integral term:

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

Control Systems Terminologies
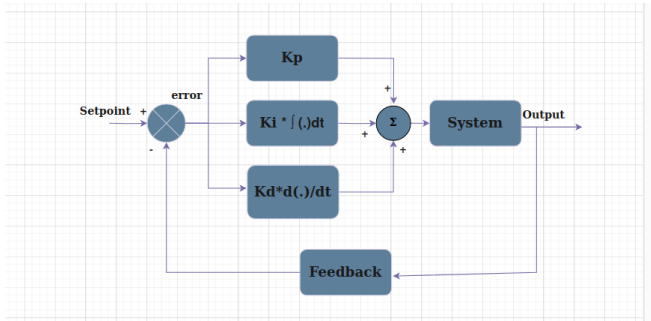Plant Input and System Responses
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1. Addition of I term reduces steady state error
2. Also increases oscillations
3. Can lead to integral windup problems

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

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

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Combines features of P, I and D

Faster rise time, minimal oscillations, zero steady state error

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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:

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

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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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