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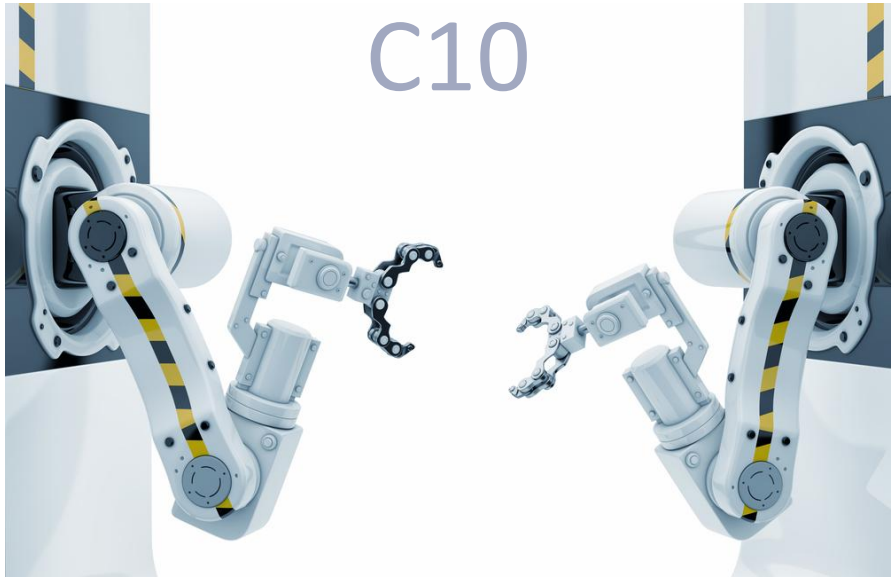

Controller For A Robotic System

Robotics and AI Faculty

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Chapter 6: Index

01

Introduction to Control Systems

A **controller** is a component in a control system that processes input signals and issues commands to actuators or other devices to produce a desired output.

It serves as the decision-making unit that maintains stability, accuracy, and efficiency in robotic systems.

A **control system** is a mechanism designed to regulate the behavior of other devices or systems using control loops.

- **Importance of controllers:** They enable,
  - Precise movement and operation
  - Feedback-based decision-making
  - Automation of repetitive or complex tasks

Examples of Control Systems in Daily Life

- **Fan Speed Regulation**:

The speed of a ceiling fan can be adjusted using a regulator, which controls the voltage to the fan motor.

- **Refrigerator Temperature Control:**

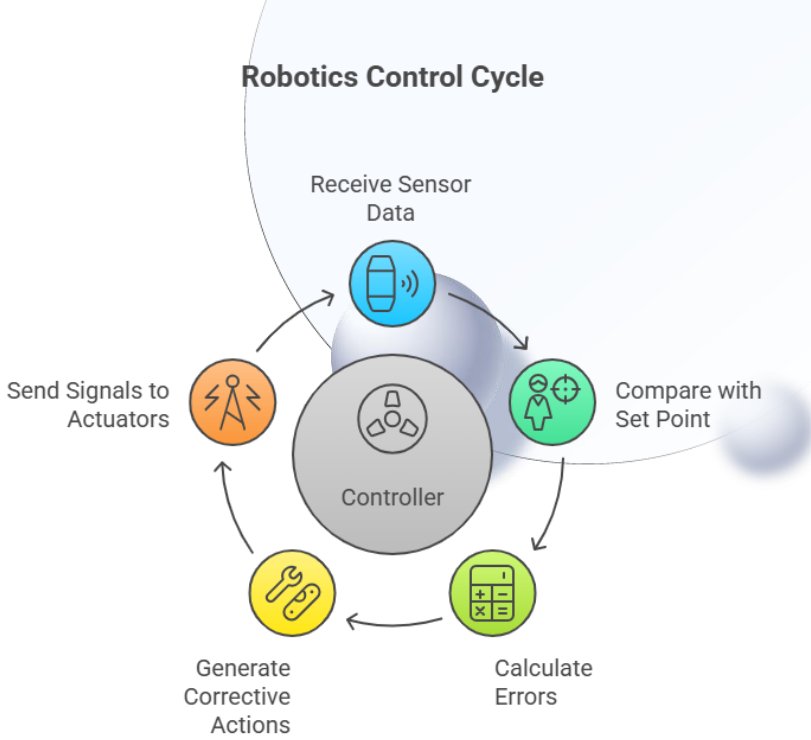
A thermostat monitors the internal temperature and switches the compressor on or off to maintain the set point.

- **Air Conditioner Thermostat System**

Automatically maintains room temperature by controlling the compressor based on user-defined settings.

02

Control Systems in Robotics

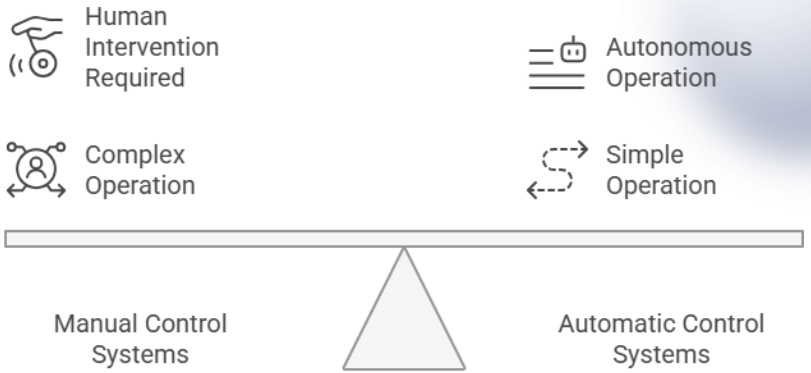


Functions and Working Principles

❑ Meaning and Role of Controllers in Robotics

In robotics, a controller is the central system that interprets sensor data and determines the robot's response. It ensures the robot performs tasks accurately and adapts to environmental changes.

Manual vs. Automatic Control Systems



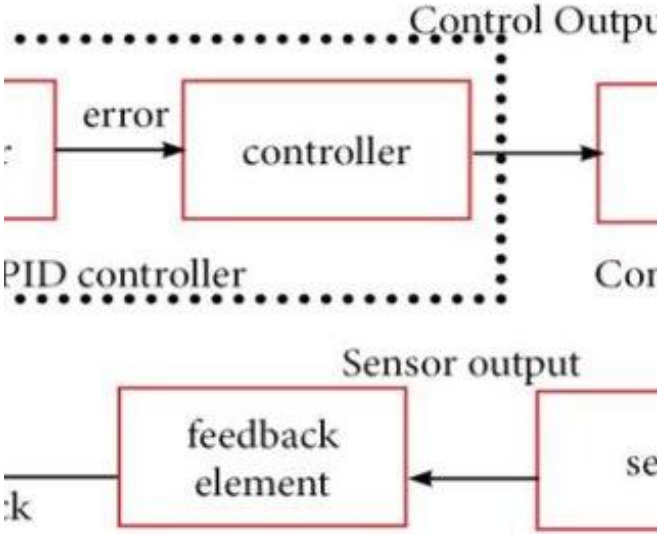
Joystick-controlled robot or remote-operated drones

Line-following robot, robotic vacuum cleaner

Feature	Manual Control	Automatic Control
Input Source	Human	Sensors/Data-driven
Accuracy	Depends on user	Consistent and precise
Response Time	Slower	Faster
Adaptability	Limited	High

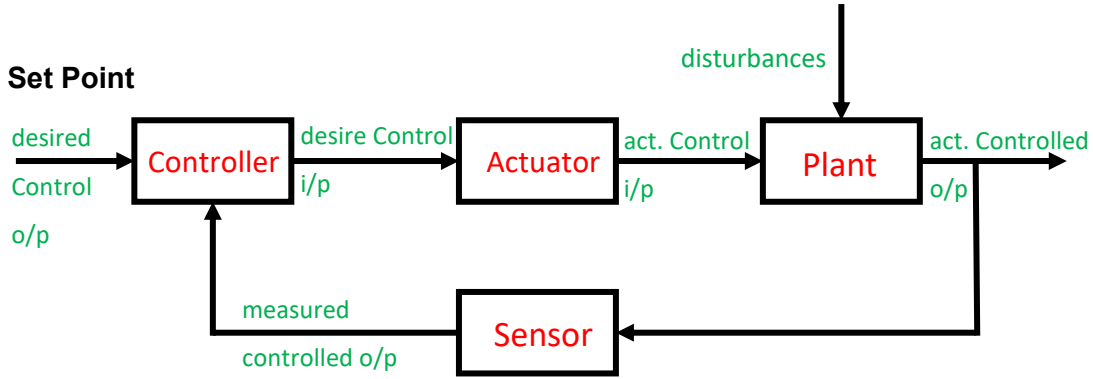
03

Block Diagram Representation



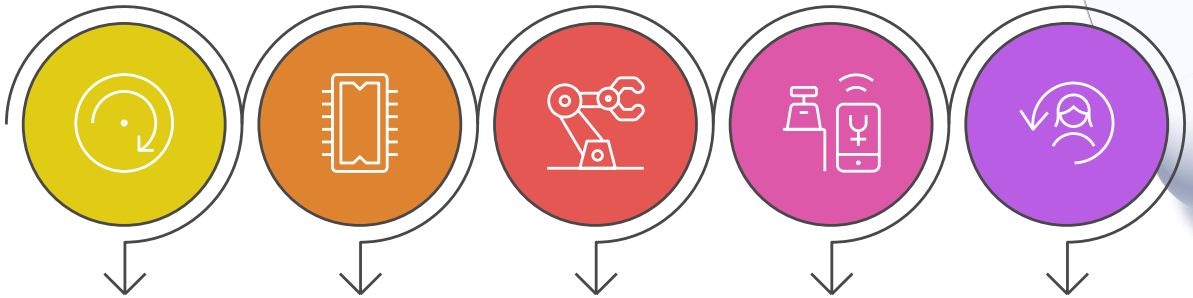
- **Block:** behavior of the system as an input-output map ie an operator that transforms an “input” variable to an “output” variable
- **Information flow** in a control system is often viewed as an interconnection of info flowing through blocks

Generic Block Diagram



Set Point / Reference Controller Actuator Sensor Feedback

Control System Components



Set Point / Reference

Defines the desired state or target for the system. This is the goal the control system aims to achieve.

Controller

Calculates the necessary control action based on the set point and feedback. It uses algorithms to minimize errors.

Actuator

Implements the control signal by manipulating the system. It translates the controller's output into physical action.

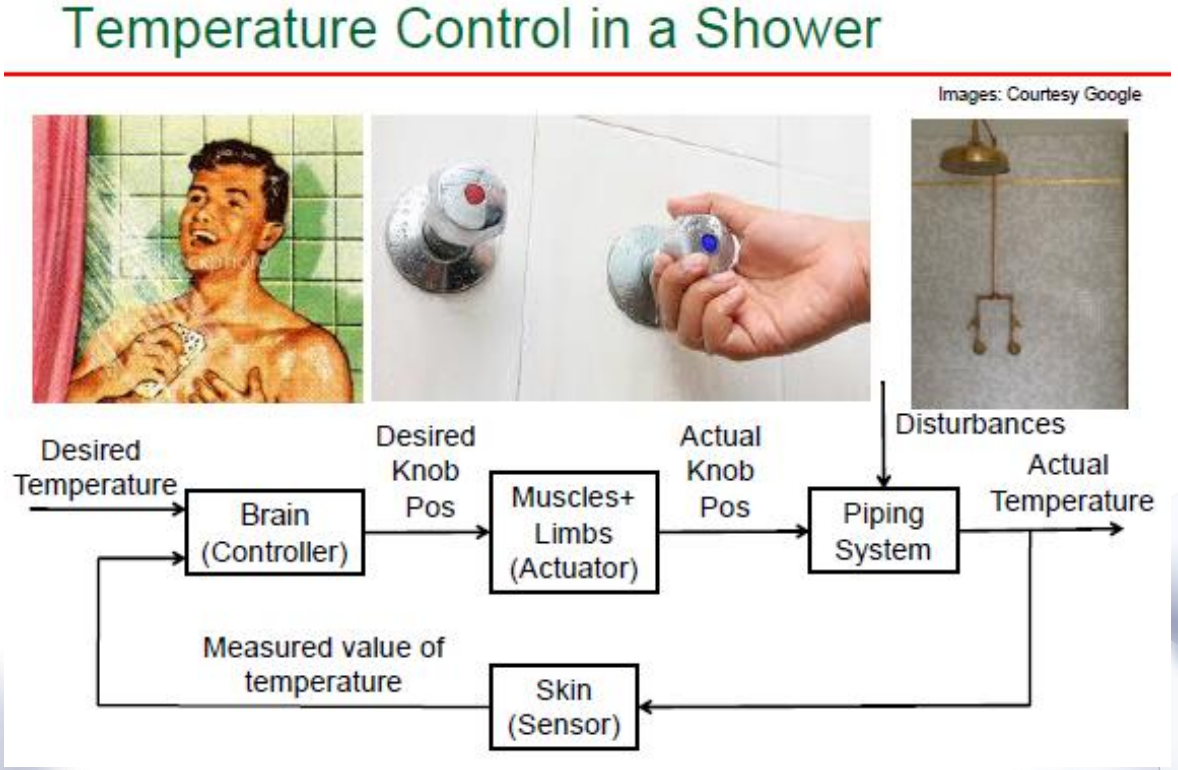
Sensor

Measures the actual output or state of the system. Provides data for comparison with the set point.

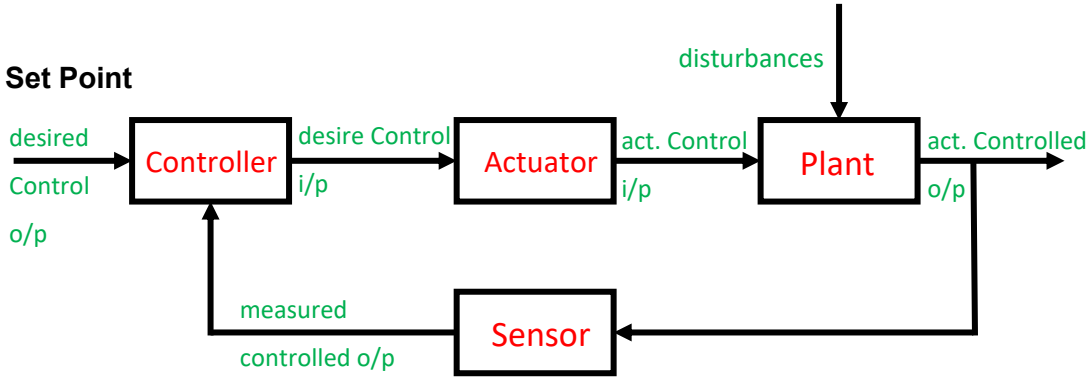
Feedback

The measured output is sent back to the controller. This allows for continuous adjustment and error correction.

Mannual Control System Example



Example: Robotic Arm Picking an Object



- Command to pick up an object from location X
- Calculates required angles and movement
- Moves arm to position and grasps object
- Sensors confirm object has been picked and arm returned

Set Point / Reference **Controller** **Actuator** **Sensor** **Feedback**

Economics, Inflation Control

1. The monetary policy committee (MPC) of the Reserve Bank of India (RBI) is now entrusted with the task of keeping inflation within a band. To achieve this objective, decisions that this committee makes include fixing, from time-to-time, the repo rate (the interest rate at which RBI lends to commercial banks), the reverse repo rate (the interest rate at which commercial banks lend to RBI) and cash reserve ratio (the minimum fraction of the deposits of customers of a commercial bank which the commercial bank has to maintain as cash or as deposits with the central bank).

   (a) Draw a block diagram detailing information flow in the inflation control system in which the MPC of the RBI is the controller.

   (b) Clearly identify the following.

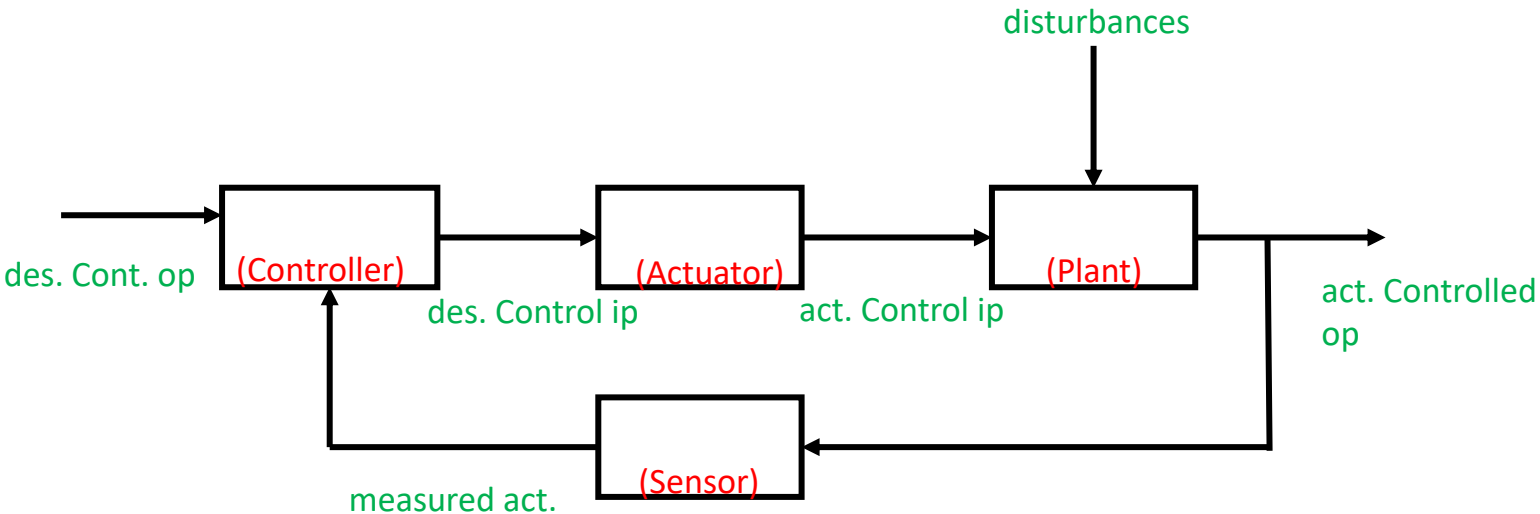
      i. Control objective

      ii. Signals: reference, controlled output, control input, disturbances, meaurements

      iii. Systems: plant, controller, actuator, sensors

   (c) What all, according to your judgement, makes it difficult for the MPC to achieve its control objective of keeping inflation in a desired band?

Inflation Control



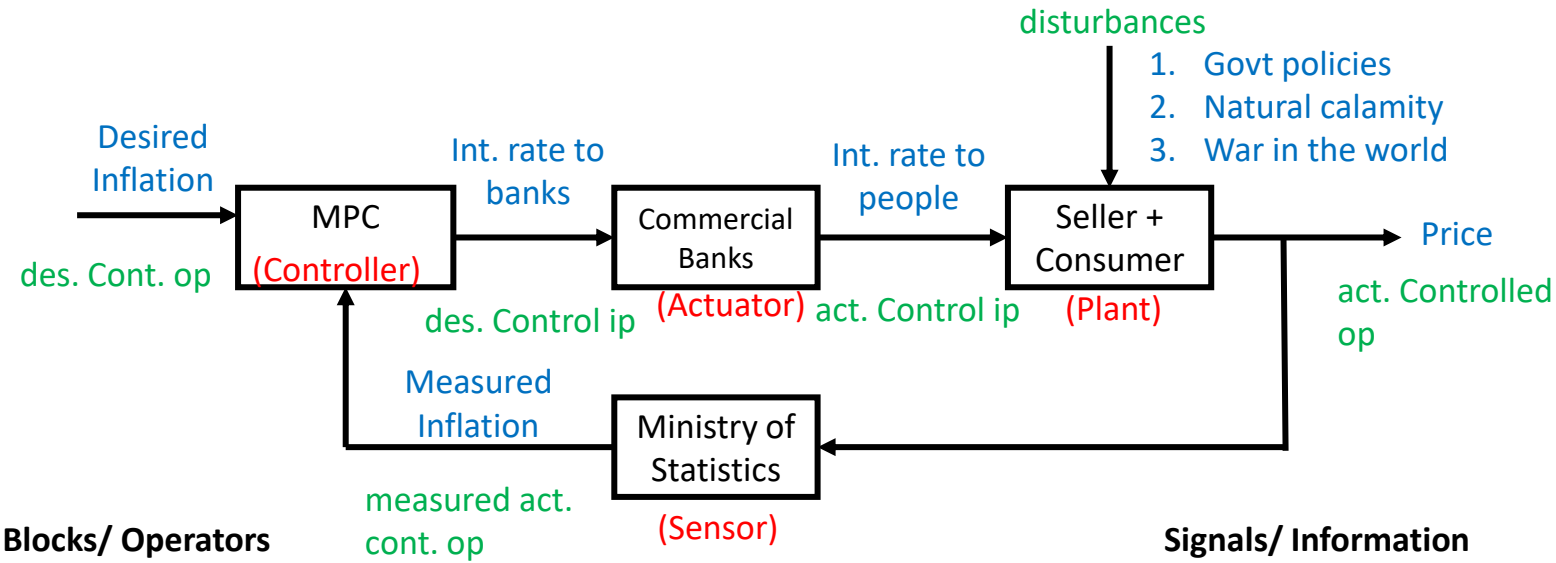
Blocks/ Operators

1. Controller: MPC
2. Actuator: Commercial Banks
3. Plant: Consumer+ seller
4. Sensor: Ministry of Stat

Signals/ Information

1. Rapo Rate
2. CRR
3. Rev Rapo Rate
4. Inflation
5. Price

Inflation Control (cont.)



Blocks/ Operators

1. Controller: MPC
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Signals/ Information

1. Rapo Rate
2. CRR
3. Rev Rapo Rate
4. Inflation
5. Price

PMDC Motor Control

2. A wide variety of position control systems use permanent magnet DC (PMDC) motors.

   In a typical position control system involving a PMDC motor, the inertia required to be moved is coupled to the output shaft of a gearhead whose input shaft in turn is coupled to the PMDC motor (**M**). Gearheads help with increasing torques/reducing rotational speeds. The control input is typically voltage V imposed, by a PWM amplifier, on **M**. The desired voltage V_{des} to be imposed on **M** is determined by an electronic control unit (ECU) which such desire in the form of a PWM signal. While one end of the motor shaft is usually coupled to a gearhead, the other end is often coupled to an encoder which provides motor shaft position information to the ECU.

   (a) Draw a block diagram detailing information flow in a position control system involving a PMDC motor.

   (b) Clearly identify the following.

      i. Control objective

      ii. Signals: reference, controlled output, control input, disturbances, meaurements

      iii. Systems: plant, controller, actuator, sensors

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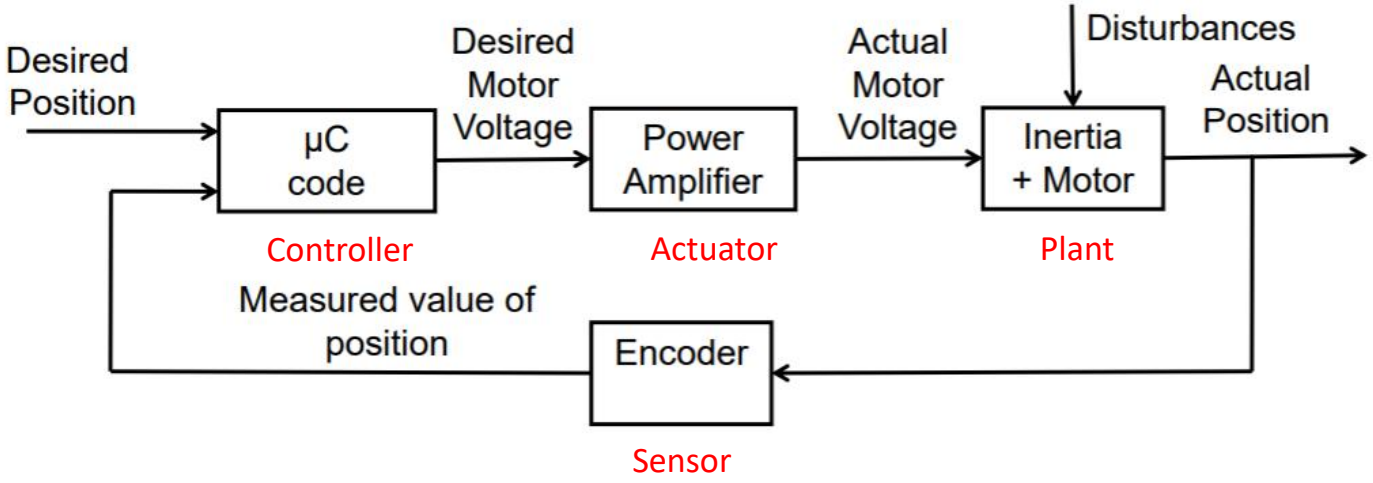
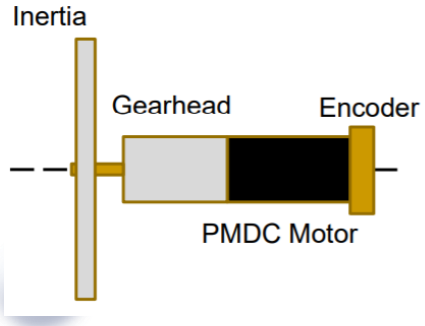
PMDC Motor Control



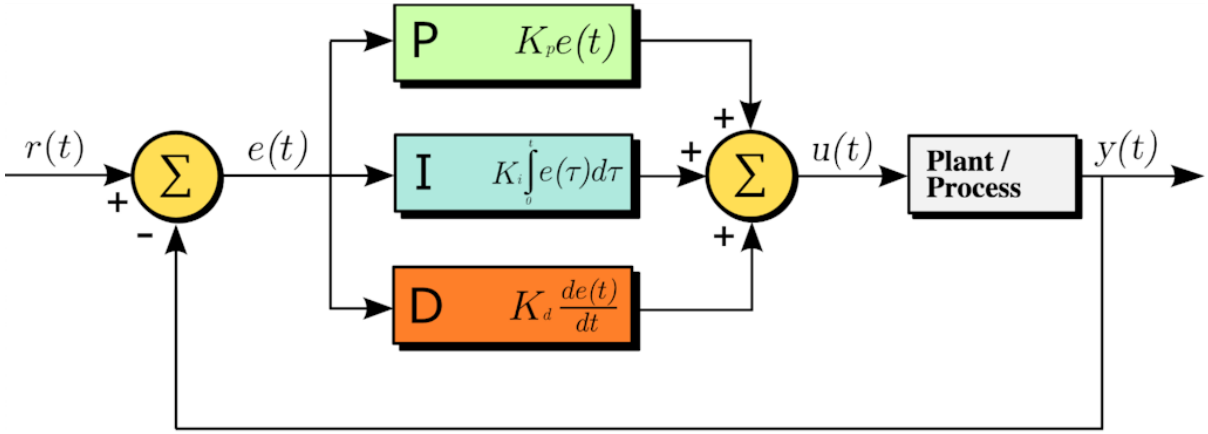
Blocks/ Operators

Signals/ Information



*Source: Lecture Slide

PID Controller



THANK YOU

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