

Servo & Control

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Topics

- Actuation systems
- Servo motors
 - Principle
 - Send data
- Control loop
- Servo control demo

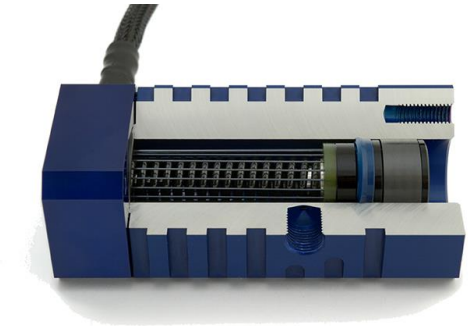
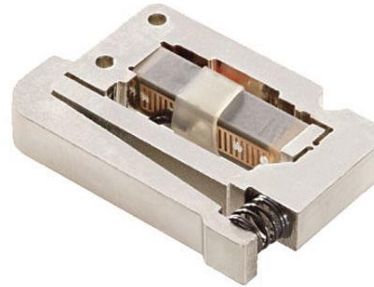
Actuation systems

- Combustion
- Hydraulics
- Pneumatics
- Electric
- Thermal



Types of electric actuators

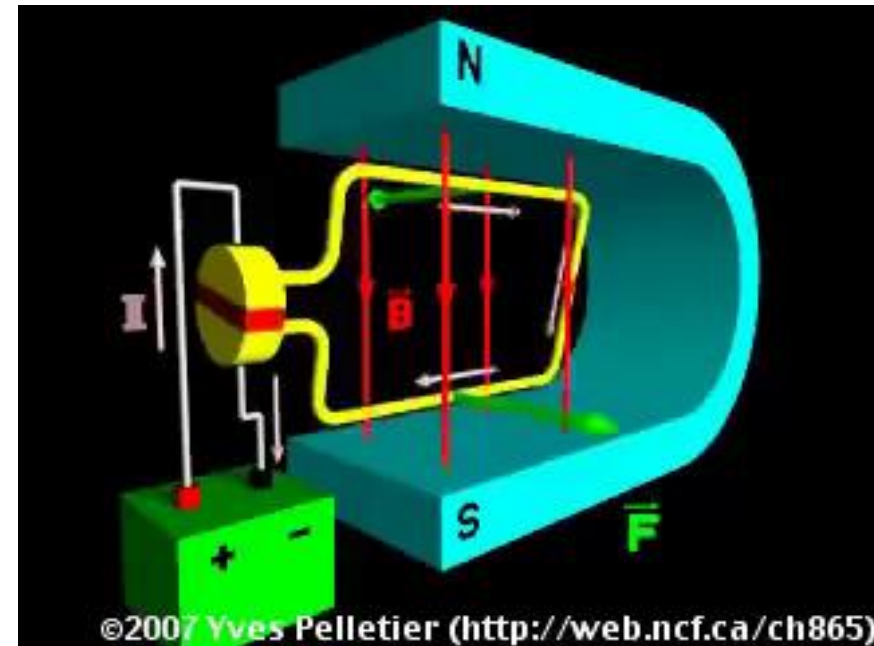
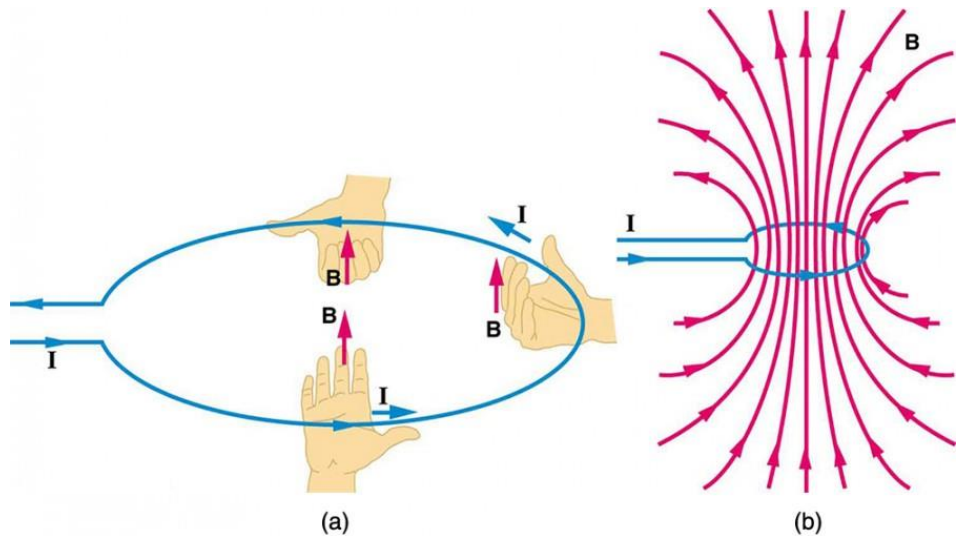
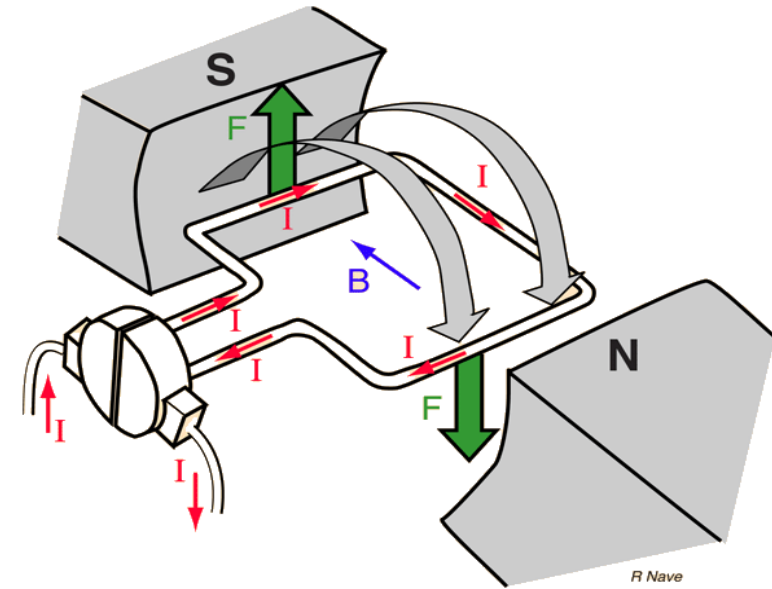
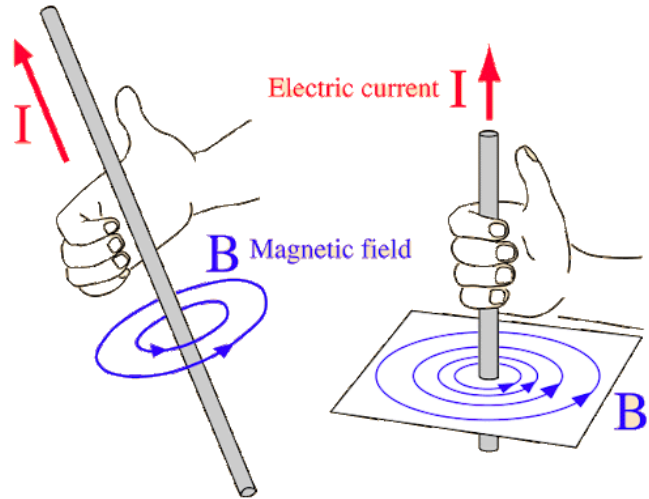
- Electric motors
- Solenoids
- Piezoelectric
- Shape memory alloys



Types of electric motors

- Brushed DC motors ←
- Brushless DC motors ←
- Stepper motors
- Servomotors
- AC induction motors
- AC synchronous motors
- Universal motors

DC motor concept



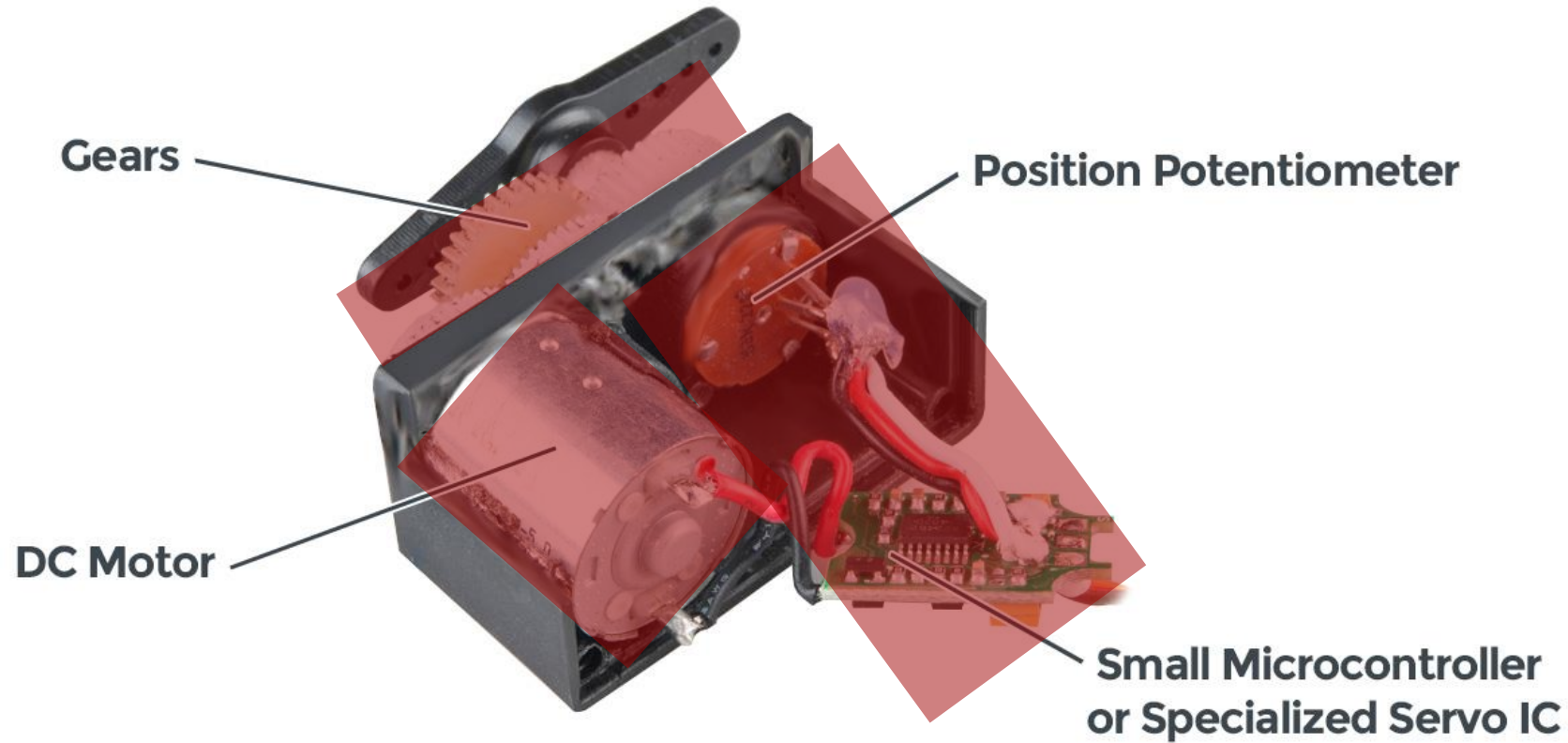
Servomotors

- DC motor with integrated **position/speed** control
- 3 main components:
 - DC motor
 - Gear box
 - Sensor and control circuit



Servomotors

- 3 main components



Servomotors

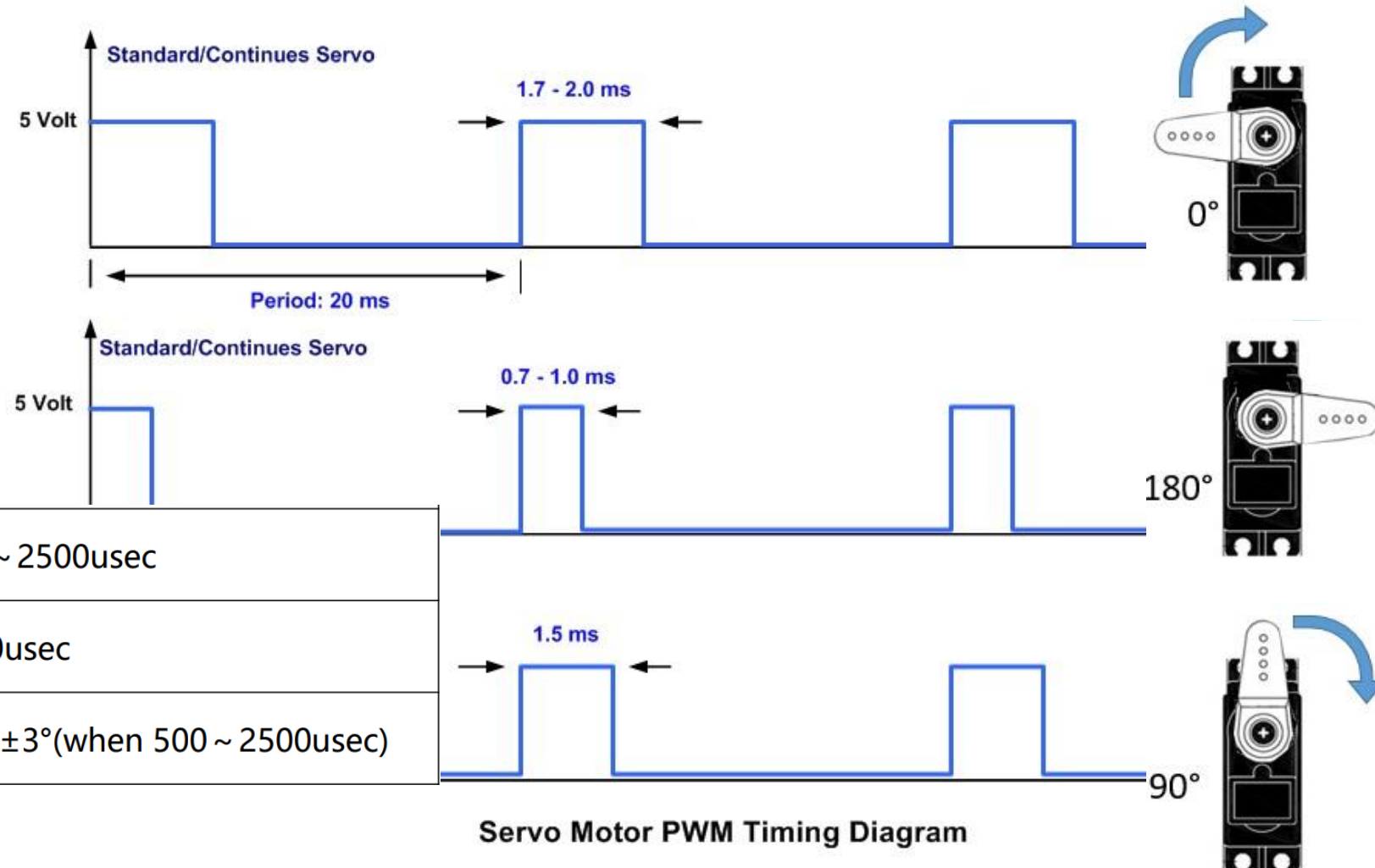
- Many different shapes and specs
 - Continuous rotation
 - Speed controlled
 - Limited rotation
 - Position controlled
- Torque: 20kg = 20kg.cm
- Rotation: 180, 270, cont. etc.
- PWM: 50Hz



Servomotors

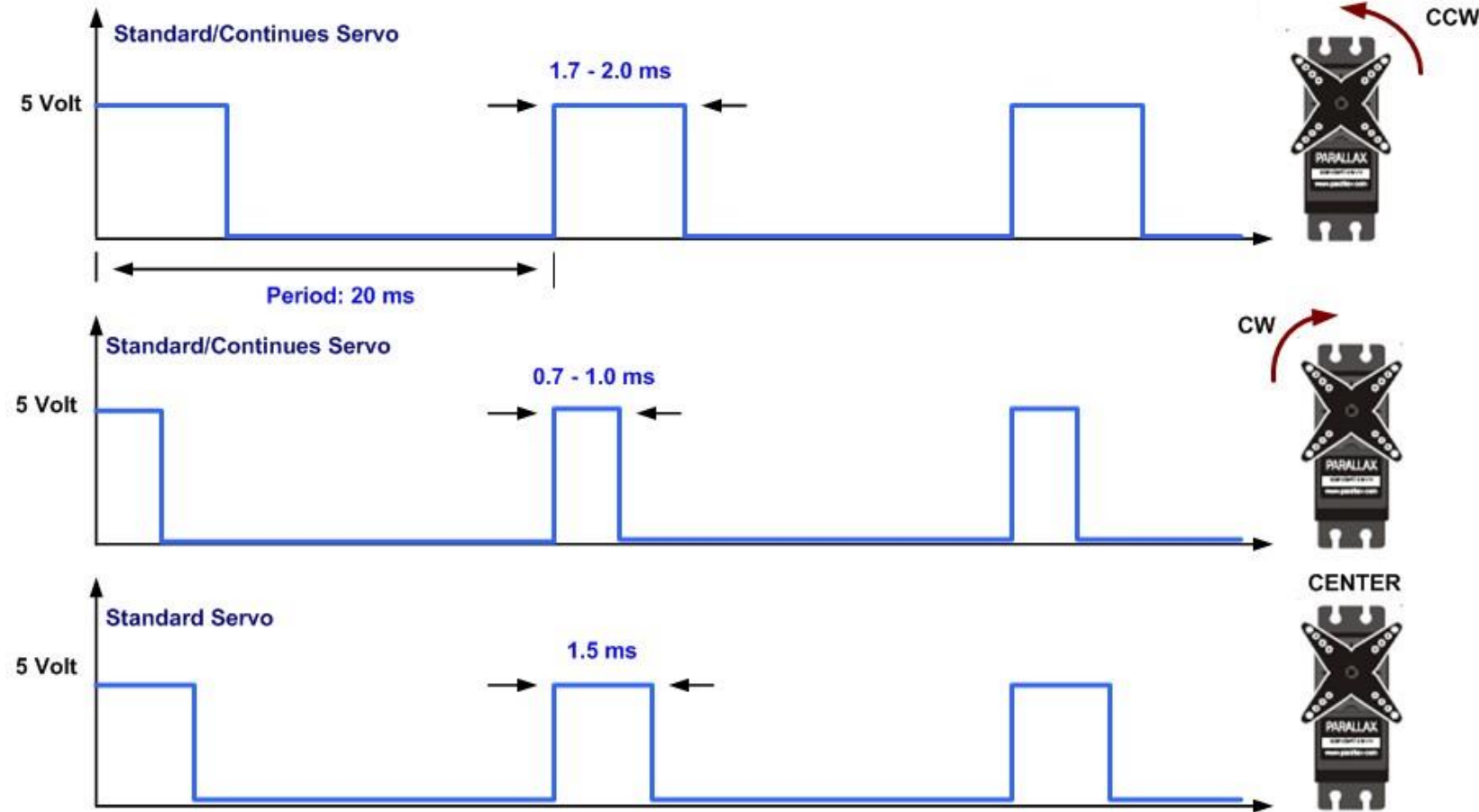
- Limited rotation
 - Position controlled
- Check datasheet
 - 0-180
 - 0-270

Pulse Width Range	500 ~ 2500usec
Neutral Position	1500usec
Running Degree	270°±3°(when 500 ~ 2500usec)



Servomotors

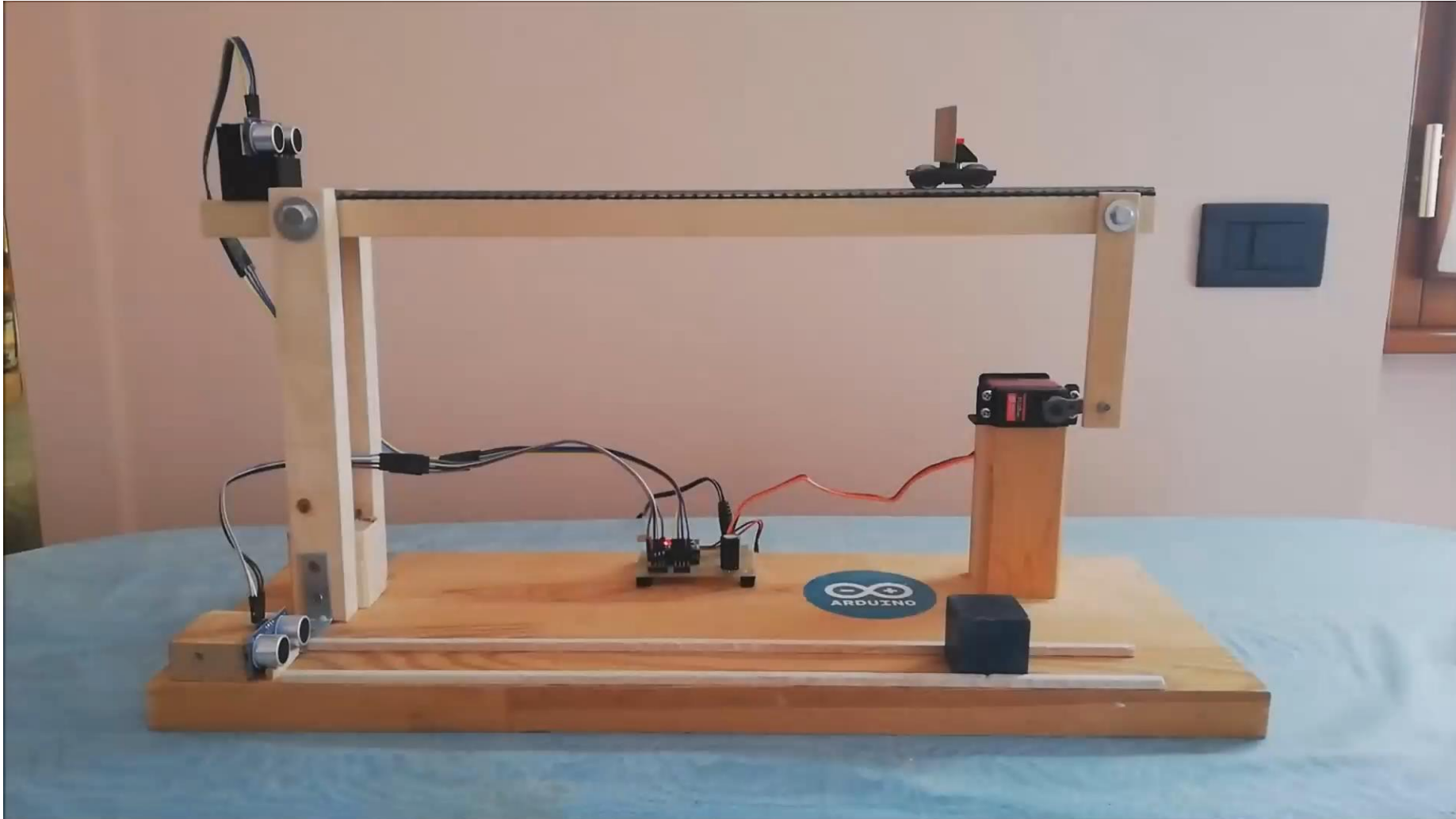
- Continuous rotation
 - Speed controlled



Servo Motor PWM Timing Diagram

Control

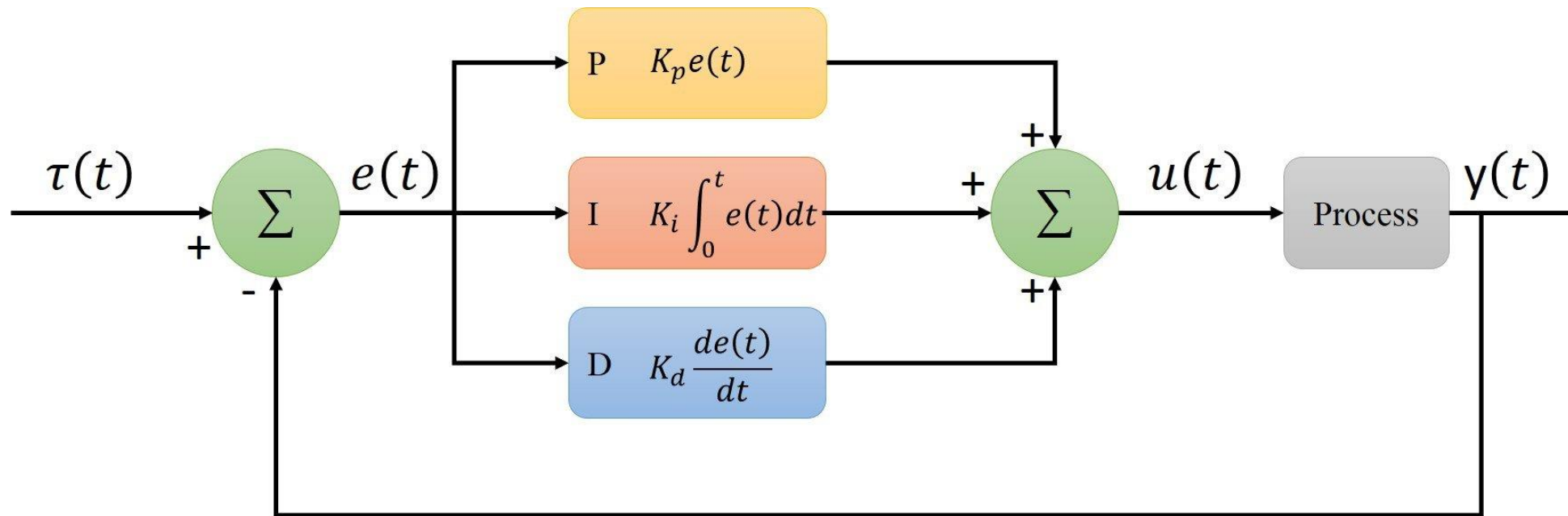
- How do servos control speed/position?
 - PID loop
- What is a PID loop?
 - A feedback control loop
- Where else?
 - Temperature – apartment, office, fridge, AC
 - Position – car steering, RC plane flaps, drones
 - Flow, pressure etc.
 - Speed – Conveyor belts, electric cars



ME-420 Advanced design for sustainable future

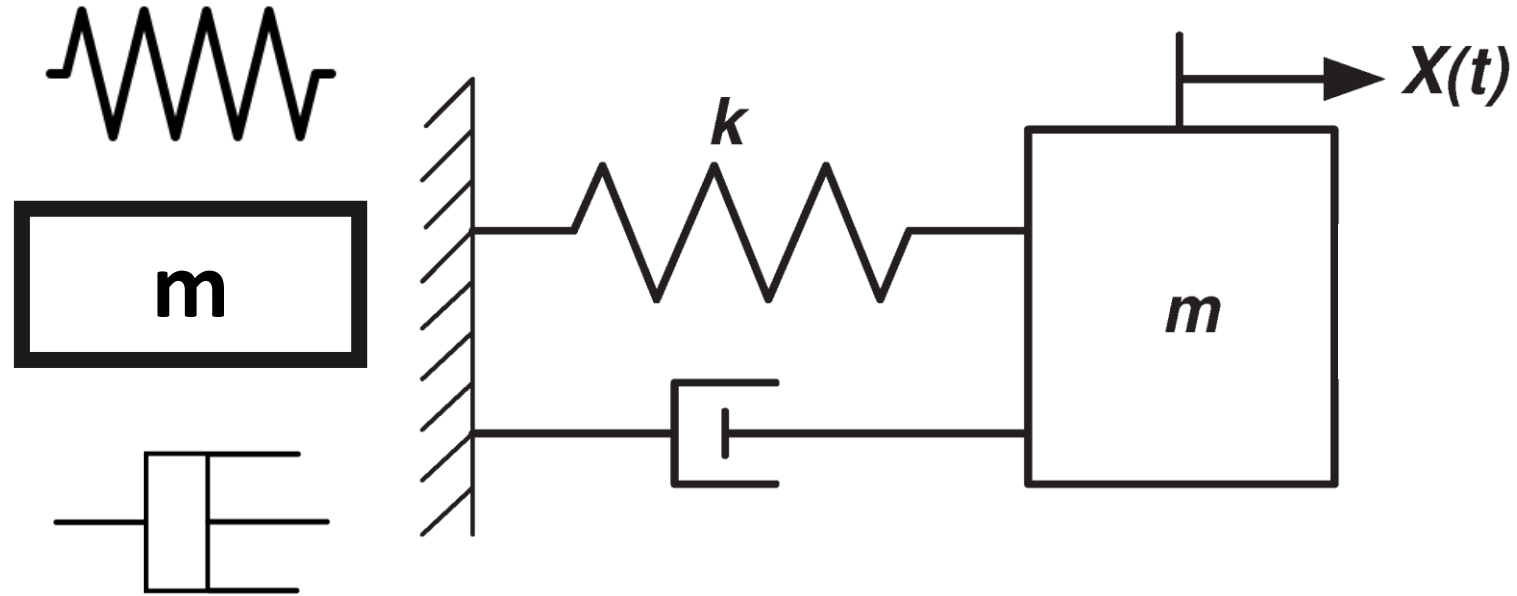
Control

- P responds to **current error**
- I responds to accumulation of **past errors**
- D responds to **future errors** (current rate)



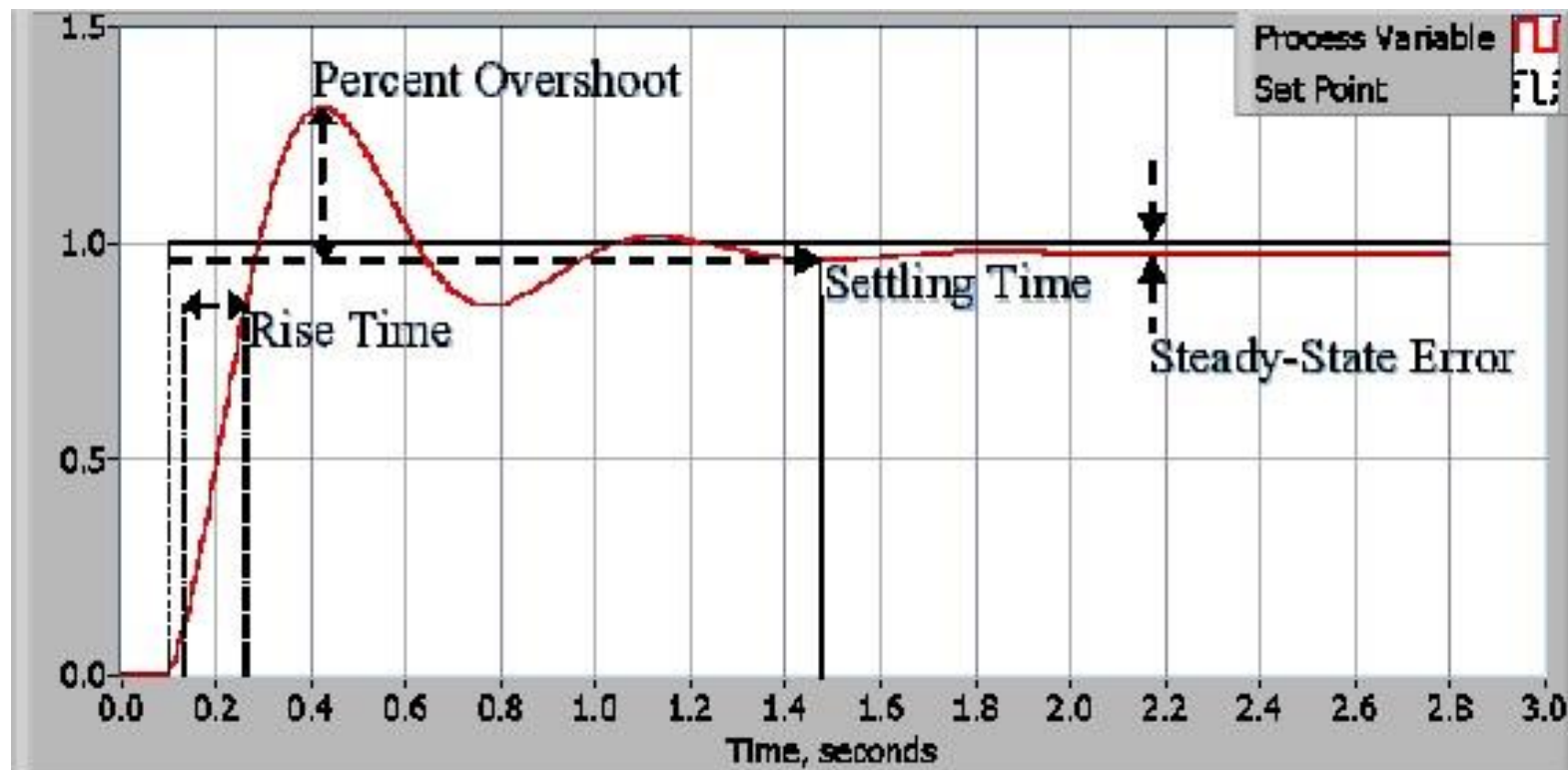
Control

- Proportional (P) term
 - $K_p * error$
- Integral (I) term
 - $K_i * \int error dt$
- Derivative (D) term
 - $K_d * \frac{\partial error}{\partial t}$



Control

- How to determine the performance of your system?
- Step response



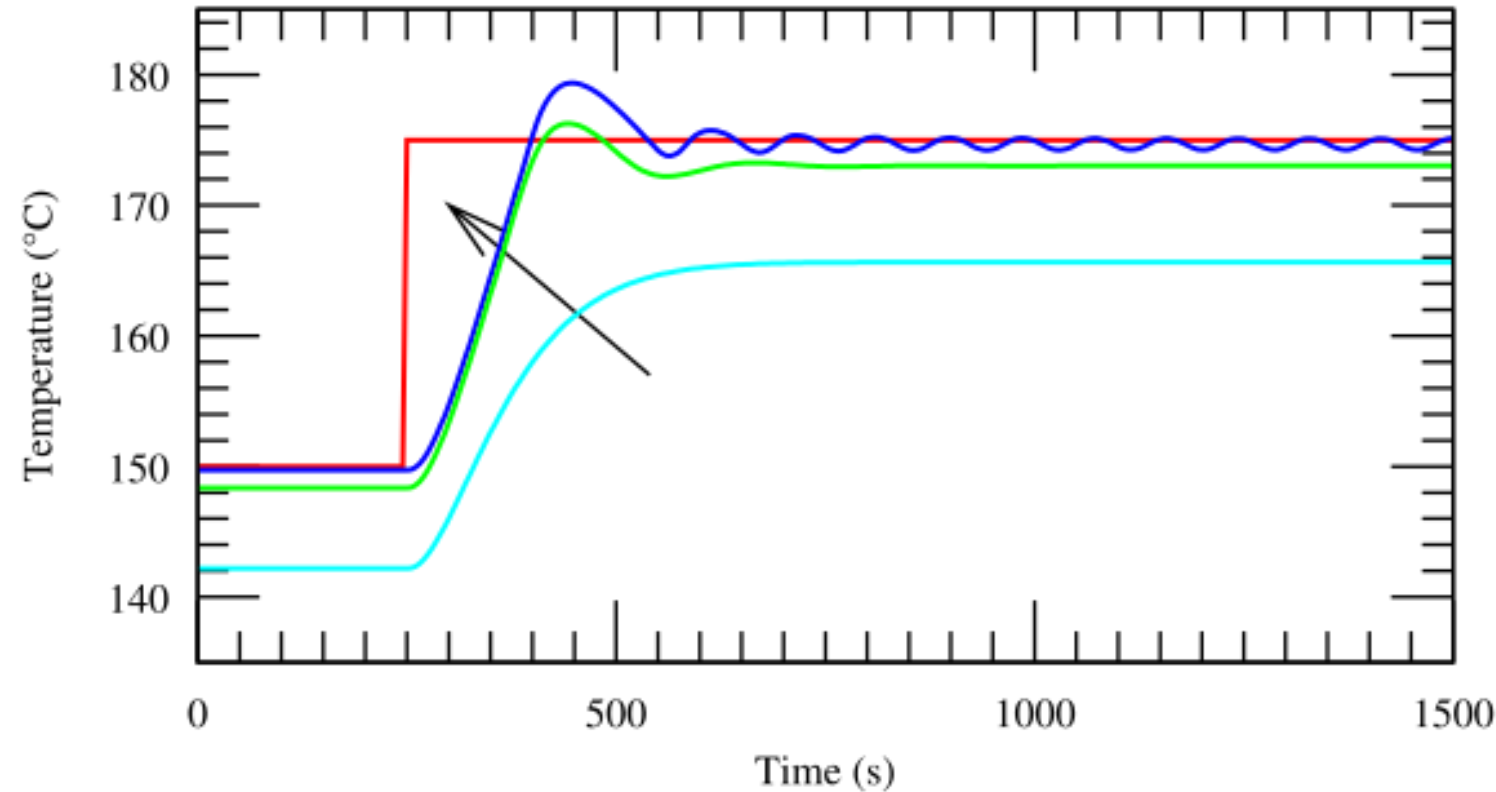
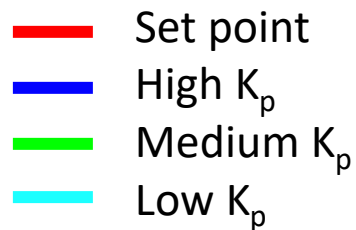
Control

- What actually P term does to a system?

Proportional to error!

Decrease: Rise time, Settling time,
Steady-state error

Increase: Overshoot



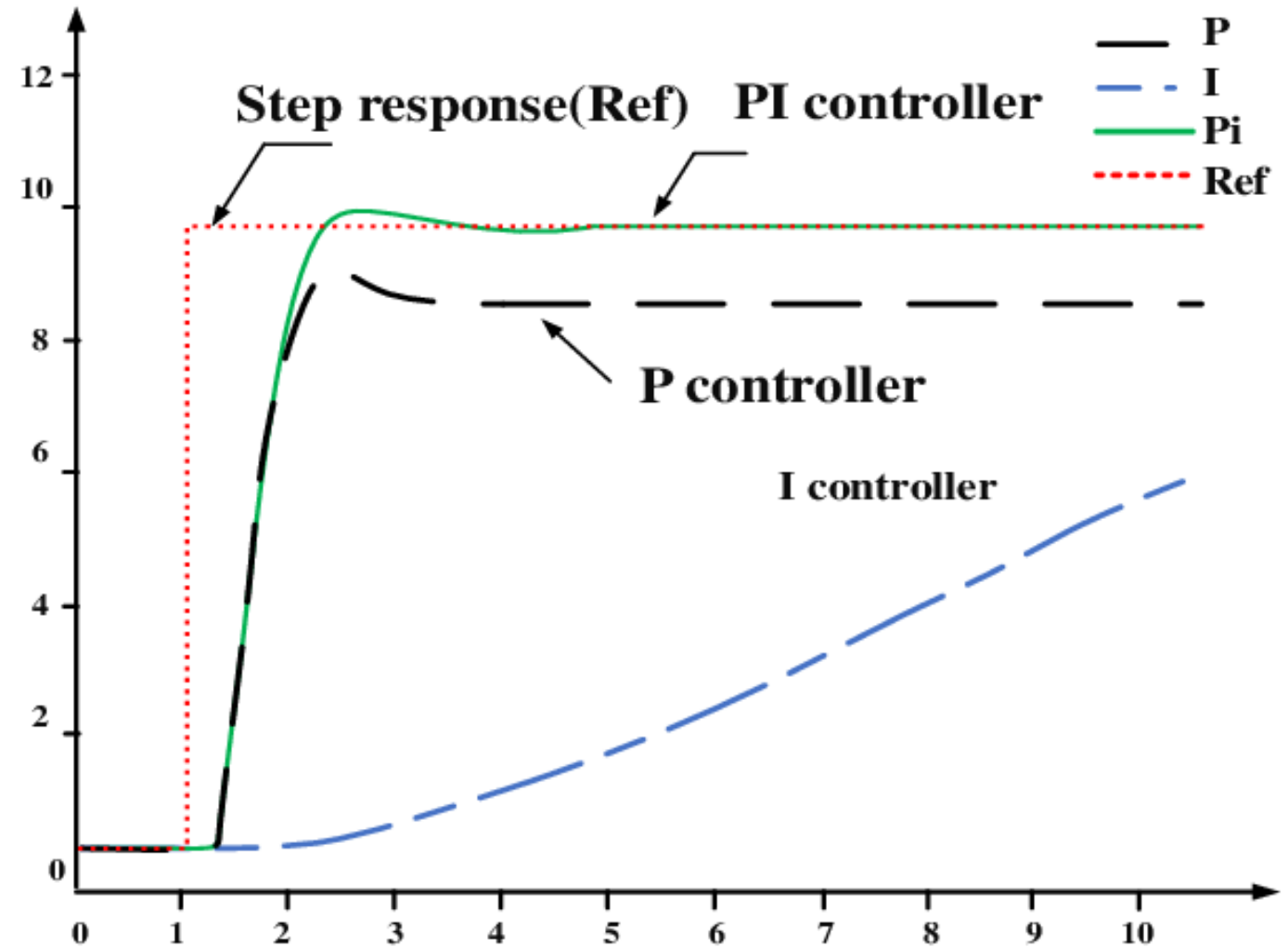
Control

- I term?

Decrease error accumulation!

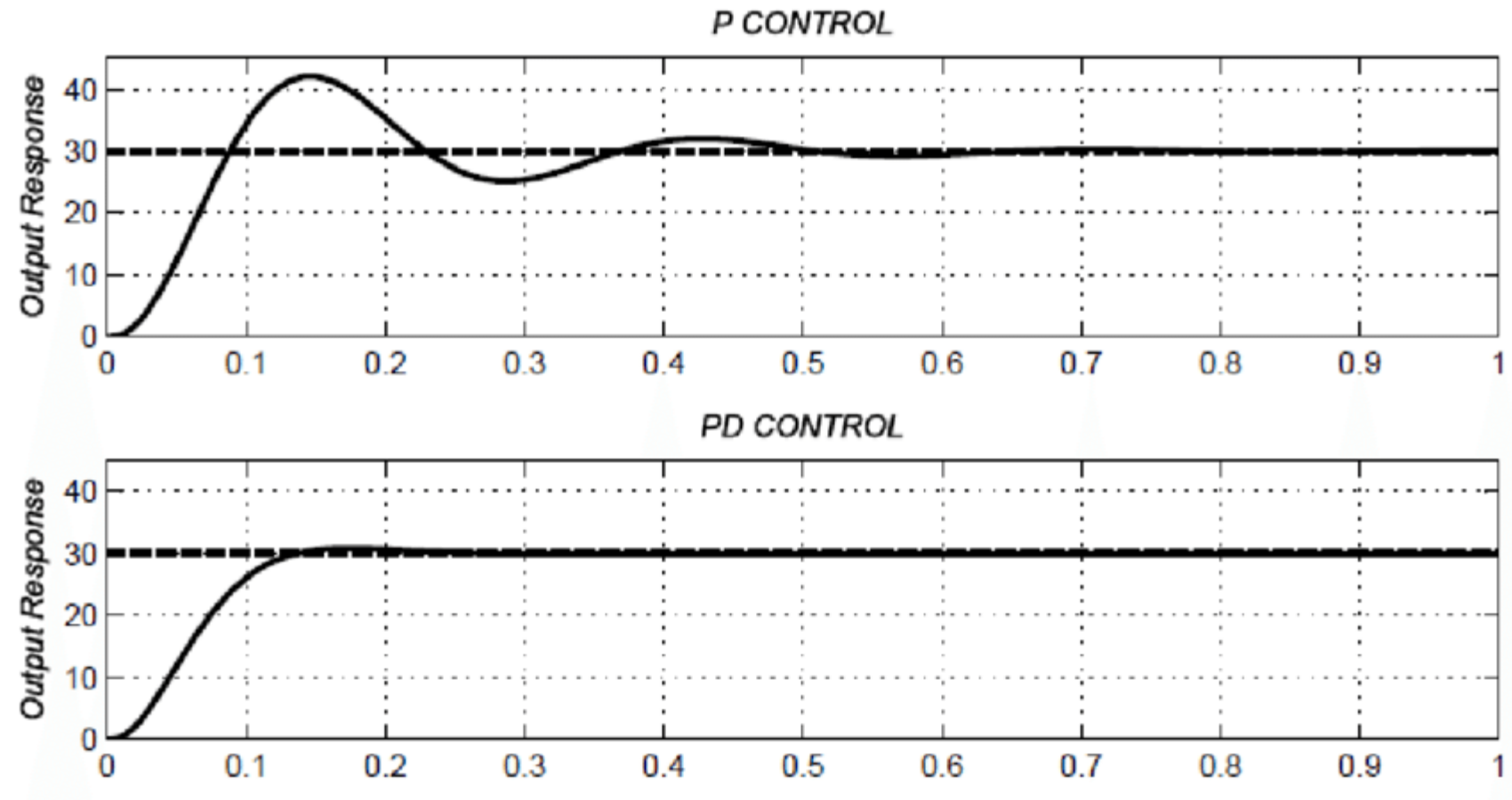
Decrease: steady-state error

Increase: Overshoot, Settling time



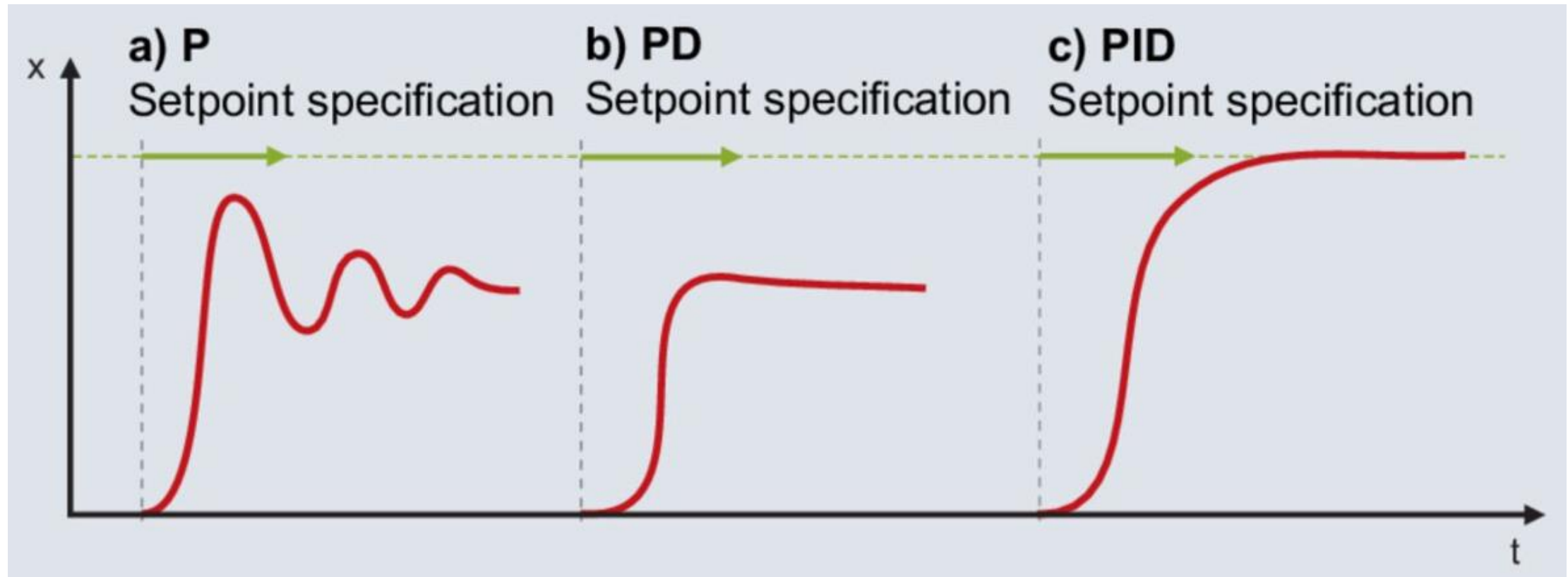
Control

- D term?
- Decrease overshoot!
- Decrease: Overshoot,
Settling time



Control

- In short:



Control

- Proportional (P) term

- $K_p * error$

- Integral (I) term

- $K_i * \int error dt$

- Derivative (D) term

- $K_d * \frac{\partial error}{\partial t}$

Numerically
→

- Proportional (P) term

- $K_p * error$

- Integral (I) term

- $K_i * \sum(error * \Delta t)$

- Derivative (D) term

- $K_d * \frac{\Delta error}{\Delta t}$

- Error = Reference – Measured
- Challenge? – Discrete

- Check Youtube
- Ask ChatGPT
- Come to the office hour tomorrow

- Demo!