CHAPTER 1
Introduction of Control System

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Content

1.1 History of Control System

History of Control System

300 BC	1900's	2000's
Early • Simple, primitive	**20th Century** • Extensive use of sensors	**Contemporary** • Widespread applications

300 BC – Early

- Water clock (300 BC)
- Steam pressure & temperature control systems (1680s)
- Speed control (1745)
- Stability Theories
  - Routh-Hurwitz (1877)
  - Lyapunov (1892)

1900's – 20th Century

- Automatic Ship Steering (1922)
- PID Controller (1920s)
- Feedback Control System Technique (1930s)
- Root locus, Bode, Nyquist (1948)

2000's – Contemporary

- Navigation
- Entertainment
- Smart Homes
- Military
- Space Application
- Chemical Process

- One of the earliest control systems known is the water clock invented by Ktesibios (300 BC)- Liquid level control.

- In 1681, Denis Papin introduced the steam pressure control
- systems, where he invented the safety valve (very similar to the present pressure cooker).

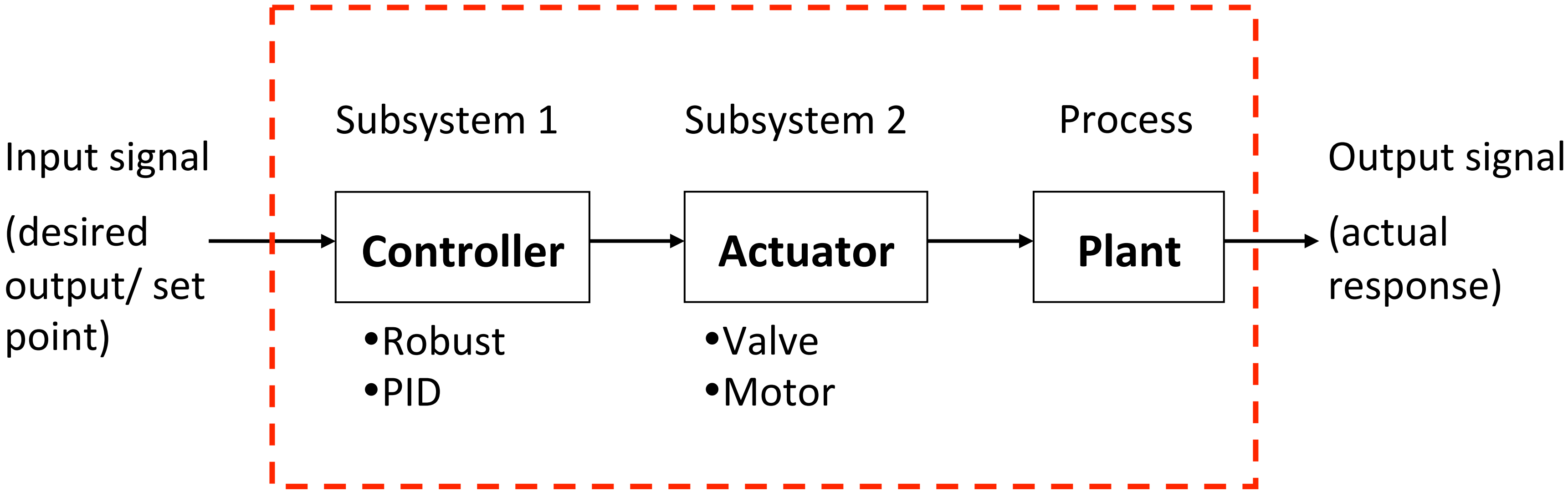
- In 17th century, hatching eggs using mechanical temperature control

- In 1745, speed of windmills are controlled
    - Pitching blades further back so less area available
    - As wind decreases, more blade area available
- In 1868, James Maxwell published the stability criterion for a 3rd order system based on the coefficients of differential equations

- In 1877, Routh Hurwitz criterion to determine the stability of a system is proposed

1.2 Control System Basics

Control System Basics
- General Control System Block Diagram



CONTROL SYSTEM

Control System Basics- Purpose & Methods

Primary Aim:

- To regulate certain variables about constant values even when there are disturbances.
- To force some parameter to vary in a specific manner.

Control Methods:

- 'Manual' control
- 'Automatic' control

4 main control purposes

1
- **For power amplification**
- e.g. in moving the radar antenna position to certain angle, small input power is amplified to produce high output torque

2
- **For remote control**
- e.g. in controlling the movements of robots working in contaminated areas where human presence should be avoided

3
- **For convenience of input form**
- e.g. in a temperature control system, the turn of a knob corresponds to certain desired room temperature.

4
- **For compensation for disturbance**
- e.g. to maintain antenna position in the presence of strong wind.

Manual Control

- Human-aided control
- Operator constantly observe the deviation and make corrections when necessary

- Not consistent
- Hundreds of variables to be controlled

Automatic Control

To replace humans with machines (nowadays, computers) to implement the control of the plant.

- Measurement → sensors/transducers
- Decision → computers
- Control action → actuators

3 Main Control System Components

1. Sensor

- sense the physical signals
- convert into electrical signals
- e.g. thermocouple measures a temperature and converts it into voltage

2. Controller

- the 'brain' of the control system
- does all the calculations and decision-making processes – computer
- compares the desired and actual plant output ➔ calculate the amount of control to be applied

3. Final control element

- accepts an input from the controller, which is then transformed into some proportional operation performed on the process
- must be operated by an actuator
- e.g. to control the yawing direction of a ship, the rudder (the final control element) is moved to certain angle by a hydraulic actuator.

2 Types of Control Problems

1. Regulation

Problem: CV deviates from SP due to disturbance.

'Regulatory control'

To maintain the quantity at some desired value regardless of external influences.

2. Servo Control

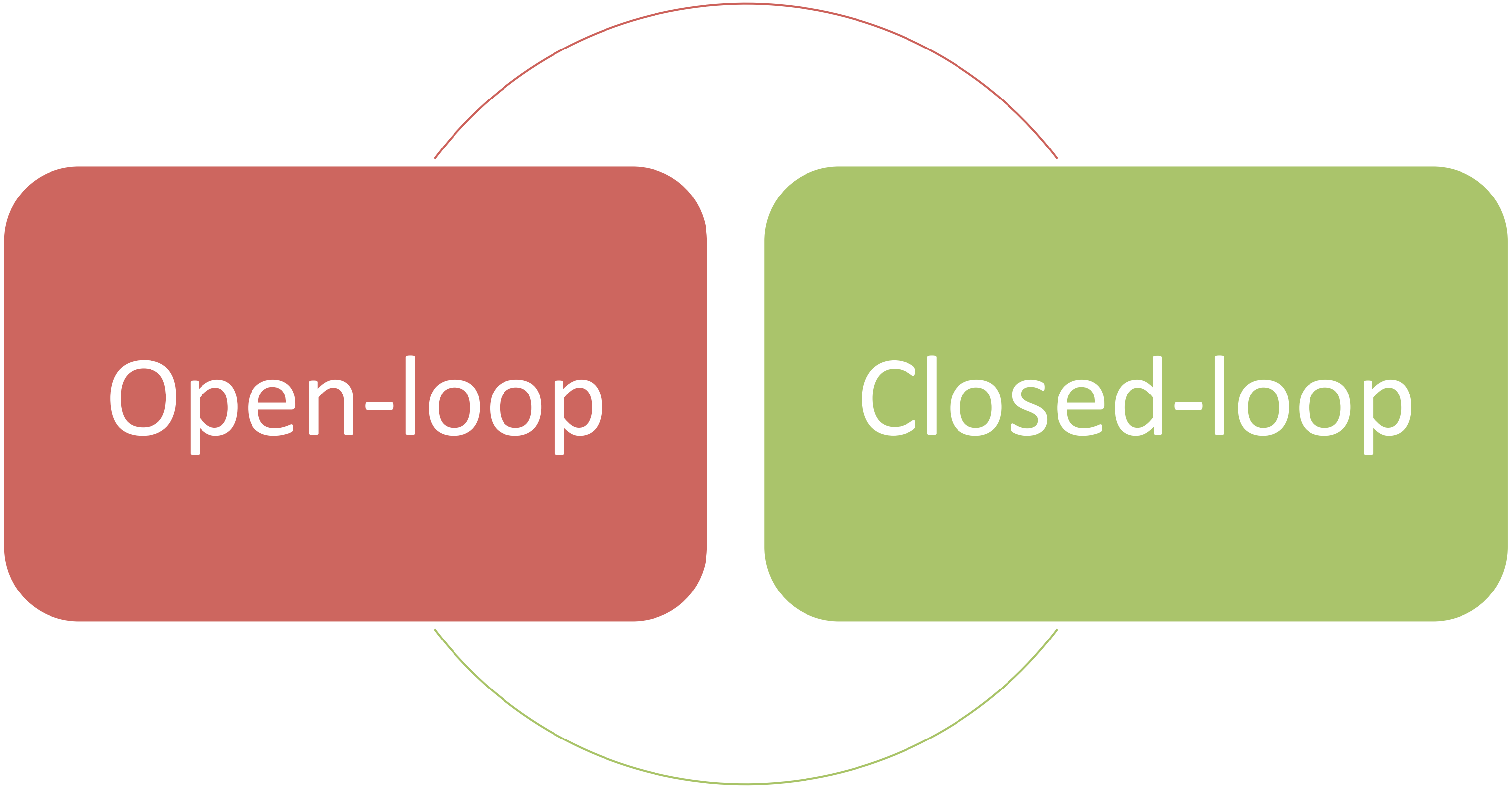
Problem: CV must follow the changes in the SP.

'Servo Control'

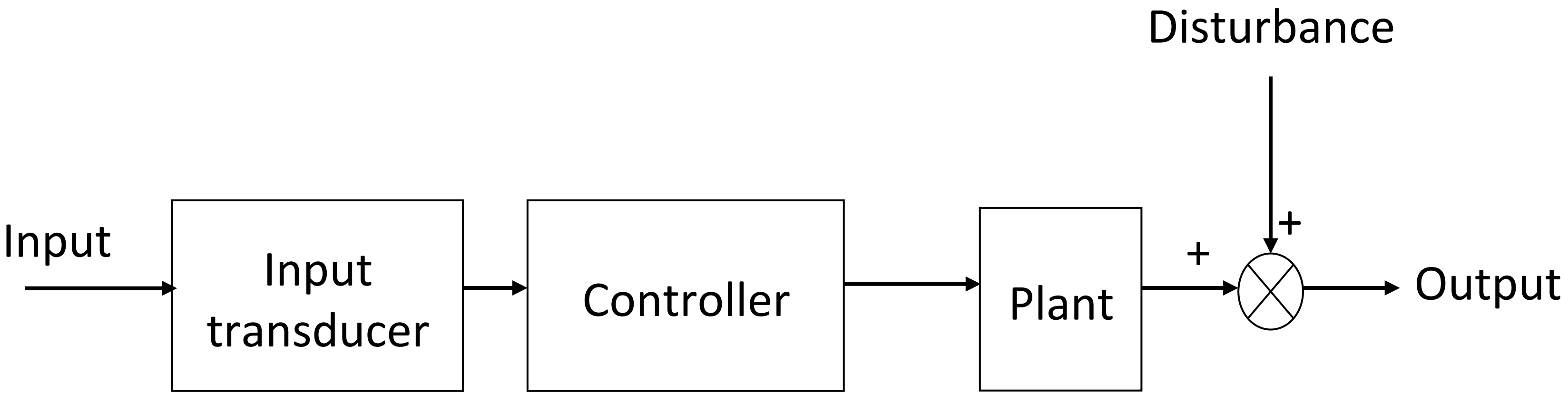
Make CV follow SP when the SP changes.

1.3 Control System Configuration

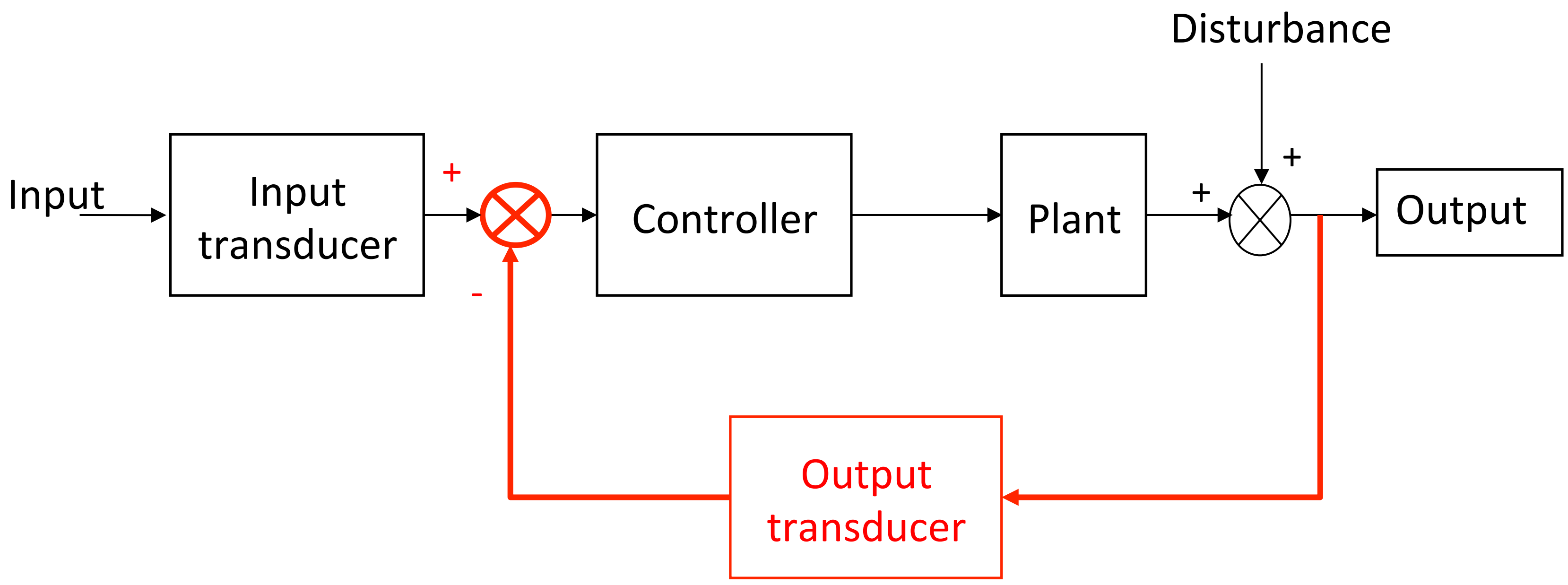
Control System Configuration



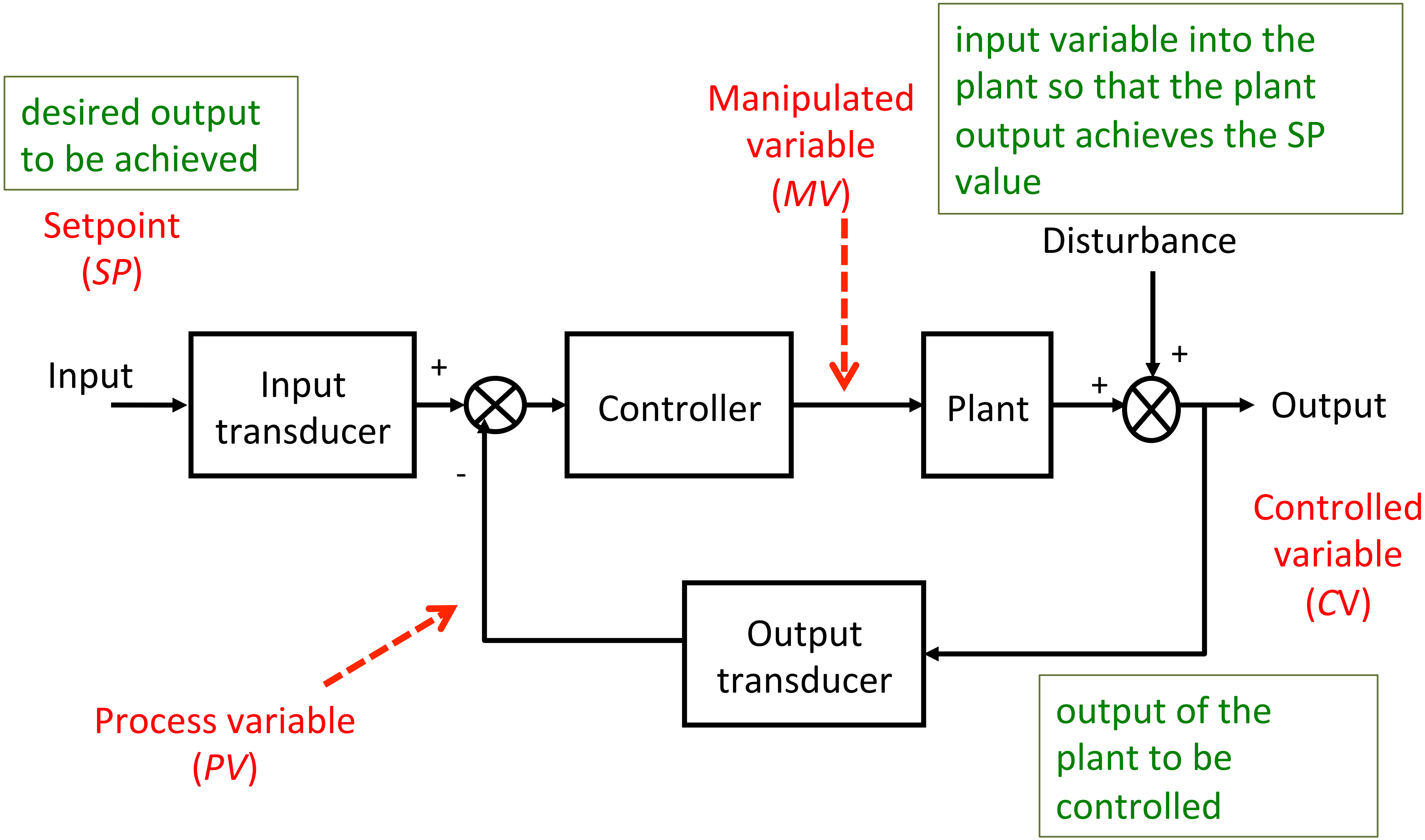
Open-loop Control System



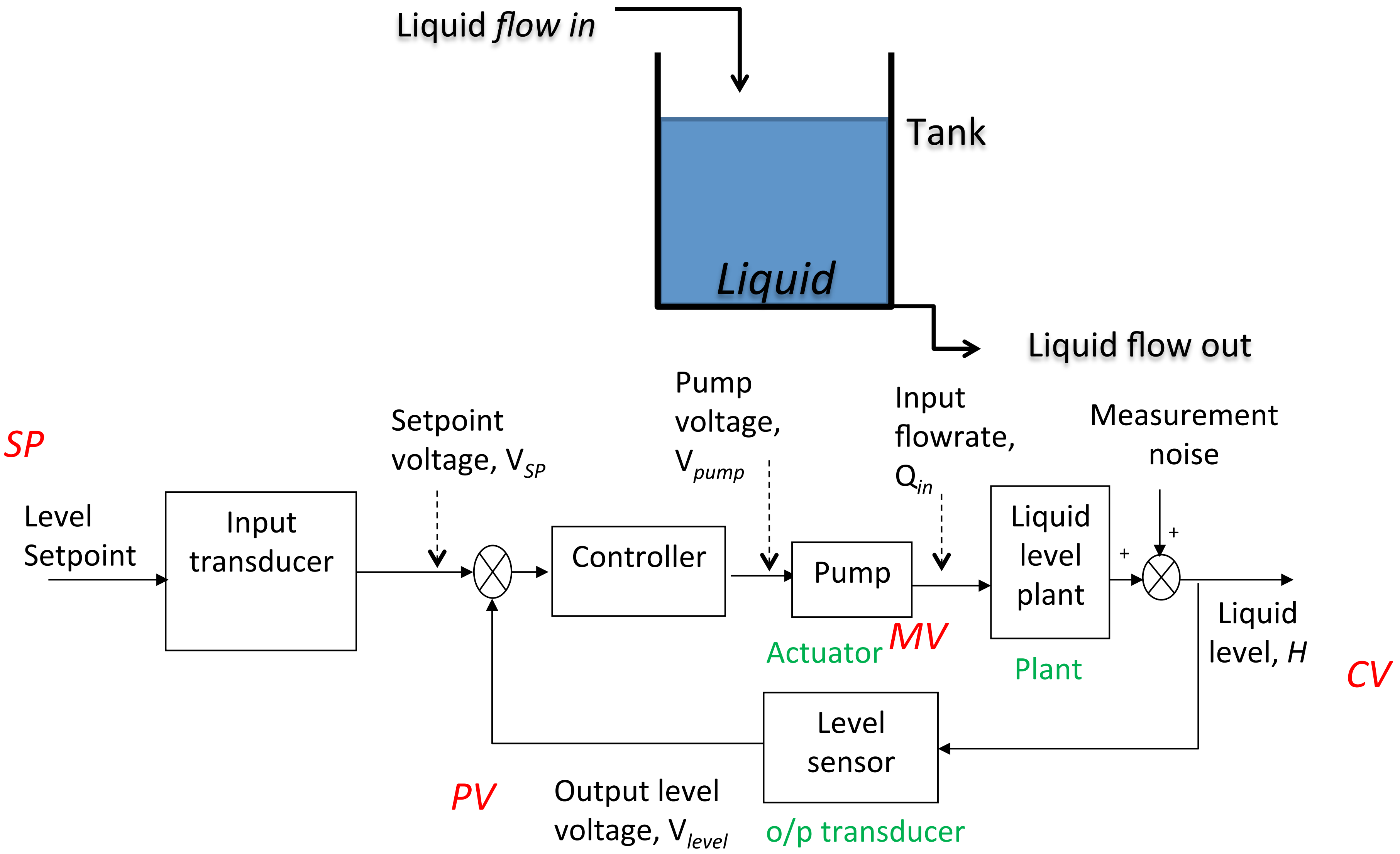
Closed-loop Control System



Closed-loop Control System



Example: Liquid Level Control System



1.4 Examples of Control Systems

Examples

Power amplification in a dish-type antennas

- Varying in diameter from 8 to 30 metres
- Serving an Earth station in a satellite communications network.

Remote control robots in contaminated area: Sojourner

- Roving on Mars in 1997.
- Solar-powered, 11.5 kg.
- Speed: 0.4 meters/minute
- Its wheel system enabled it to climb over obstacles one-and-a-half wheel diameters tall.

Convenient input for a thermostat

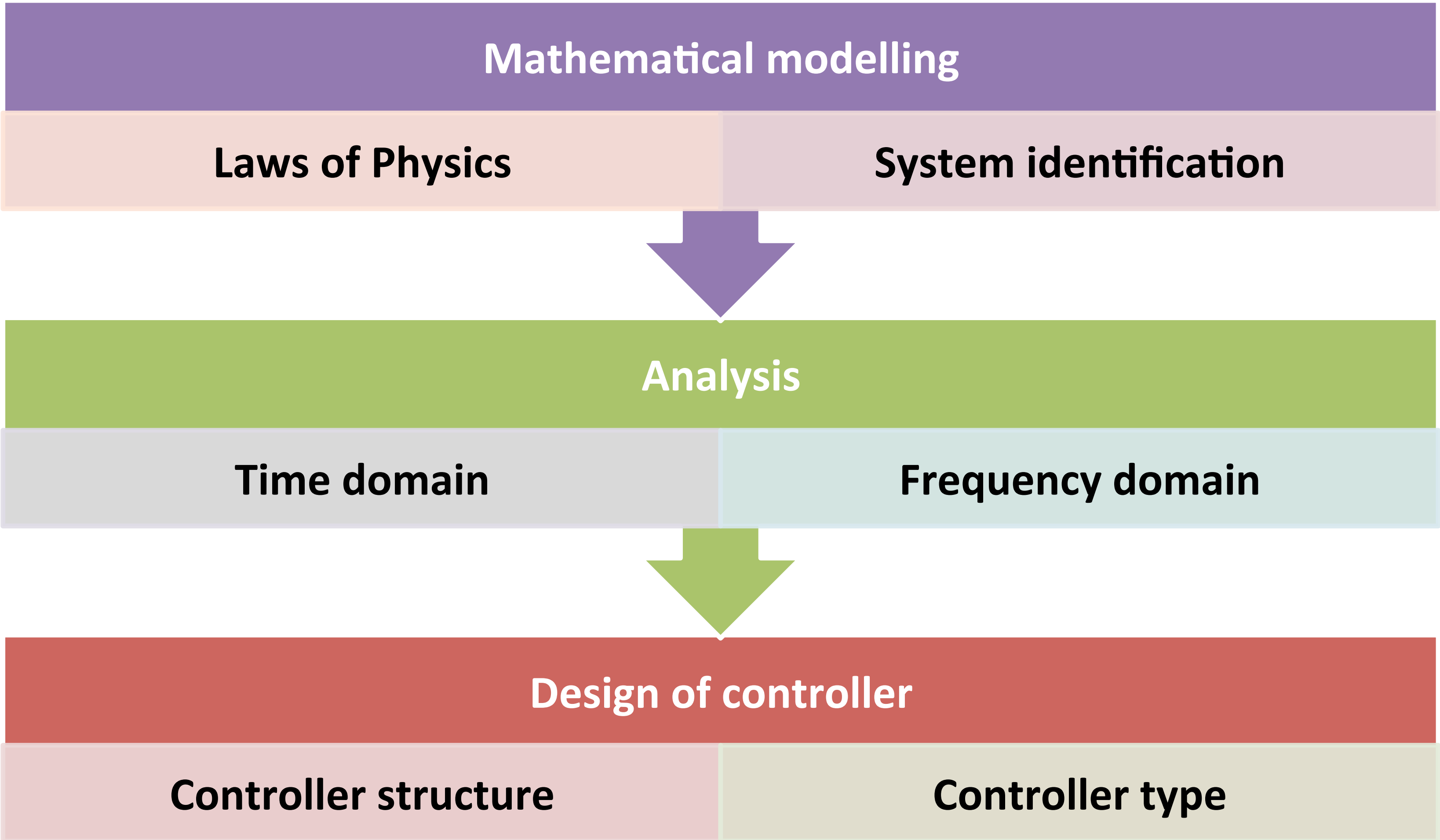
- Position to heat

Disturbance compensation in a Rolling Mill

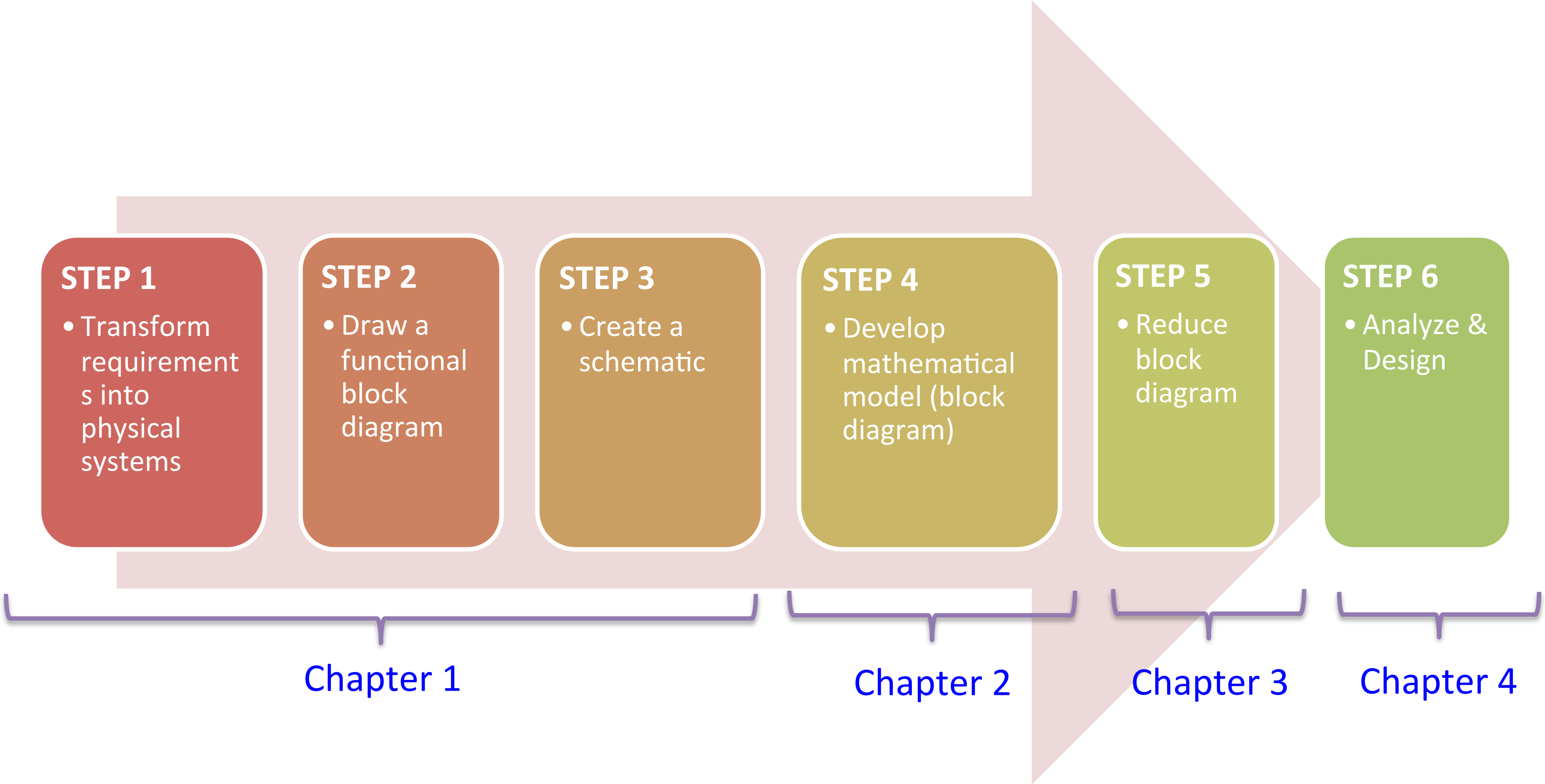
- Maintain steel thickness despite variations/disturbance

1.5 Control System Design

General Controller Design Process



Controller Design Process:- General



1.6 Simulation Software in Control - MATLAB

MATLAB

- Important tool in current control system design.

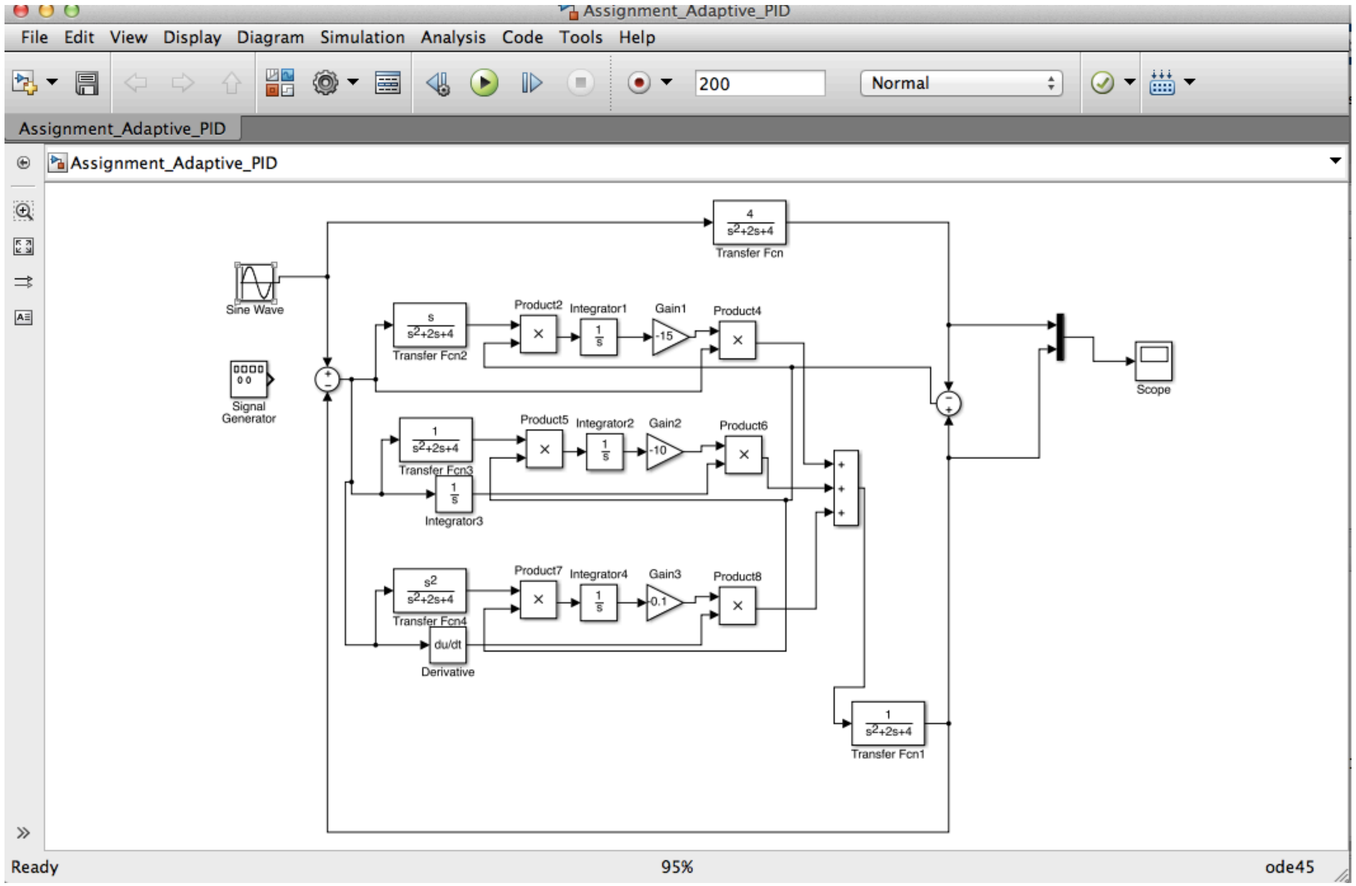
- MATLAB contains:
  - Lots of Toolboxes – one of them is 'Control System Toolbox'
  - Simulink – click and drag

Control System Toolbox

- Contains a set of functions relation to control system design.
- Can be used together with other MATLAB functions or functions from other toolboxes.

Simulink

- More graphical.
- Code writing is minimal.



Review questions

- Name 3 applications of feedback control system.
- Give 3 examples of open-loop systems.
- Give an example of what happen to a system that is unstable.
- Name 3 approaches to the mathematical modeling of control systems.
- How do we classify control systems?
- What are the steps involved in designing a control system?

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