

Automatic Control Systems

Lecture-1

Basic Concepts of Classical control

Emam Fathy

Department of Electrical and Control Engineering

email: emfmz@yahoo.com

What is Control System?

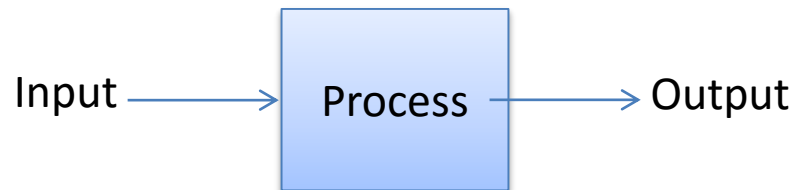
- A system Controlling the operation of another system.
- A system that can regulate itself and another system.
- A control System is a device, or set of devices to manage, command, direct or regulate the behaviour of other device(s) or system(s).

Definitions

System – An interconnection of elements and devices for a **desired purpose**.

Control System – An interconnection of components forming a system configuration that will provide a desired response.

Process – The device, **plant**, or system under control. The input and output relationship represents the cause-and-effect relationship of the process.



Definitions

Controlled Variable– It is the quantity or condition that is measured and Controlled. Normally *controlled variable* is the output of the control system.

Manipulated Variable– It is the quantity of the condition that is varied by the controller so as to affect the value of *controlled variable*.

Control – Control means measuring the value of *controlled variable* of the system and applying the *manipulated variable* to the system to correct or limit the deviation of the measured value from a desired value.

Examples

● Car cruise control

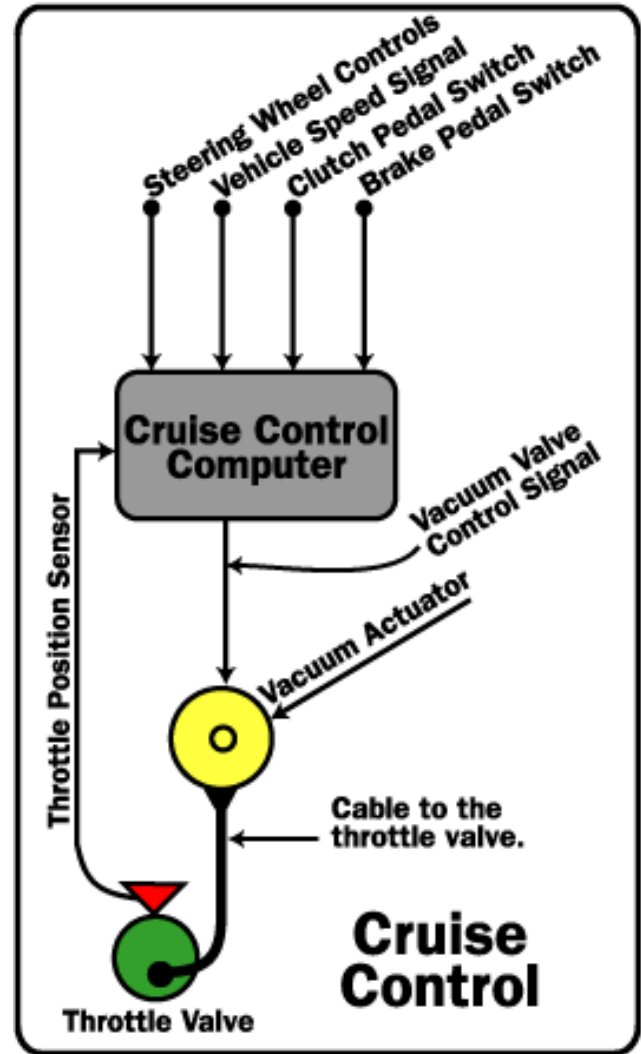
<http://auto.howstuffworks.com/cruise-control3.htm>



Cables



Electronically-controlled
Vacuum actuator



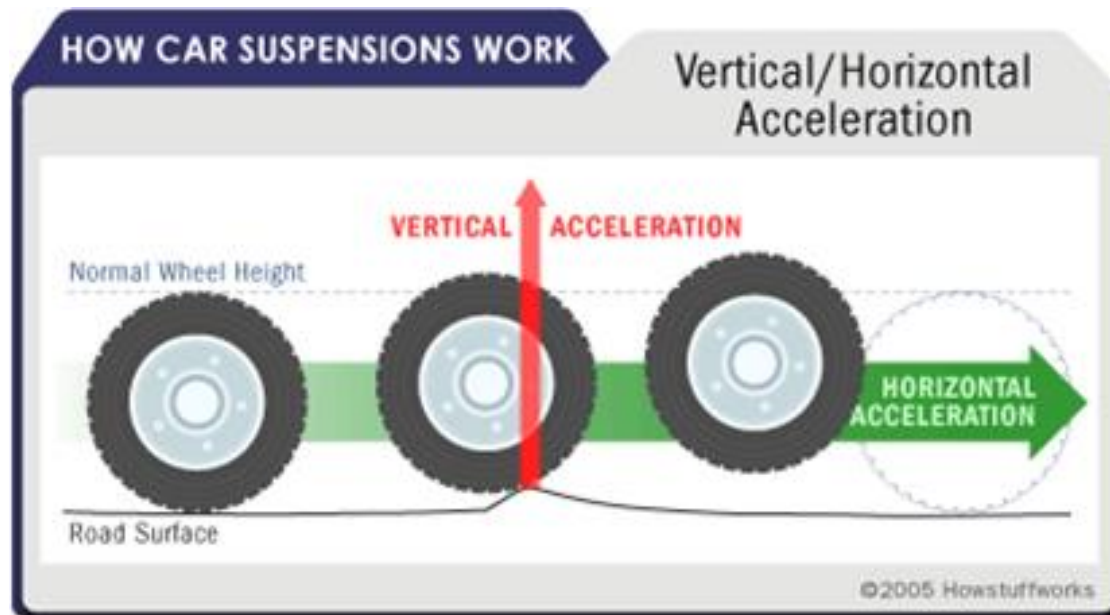
Other examples

- Anti-lock braking system (ABS)
 - Major components of the typical ABS system
 - four speed sensors (one at each wheel)
 - electronic control unit (ABS computer)



Other examples

- Vehicle suspension system
 - a system that will absorb the energy of the vertically accelerated wheel, allowing the frame and body to ride undisturbed while the wheels follow bumps in the road

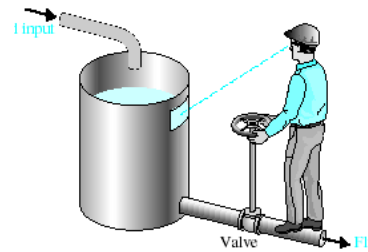


Types of Control System

- Natural Control System
 - Universe
 - Human Body
- Manmade Control System
 - Vehicles
 - Aeroplanes

Types of Control System

- Manual Control Systems
 - Room Temperature regulation Via Electric Fan
 - Water Level Control

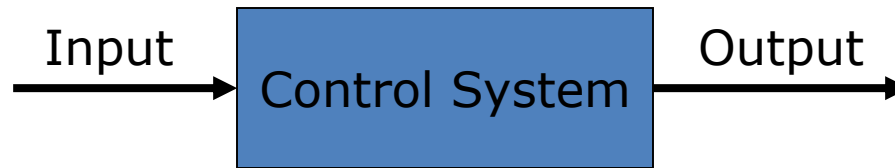


- Automatic Control System
 - Room Temperature regulation Via A.C
 - Human Body Temperature Control

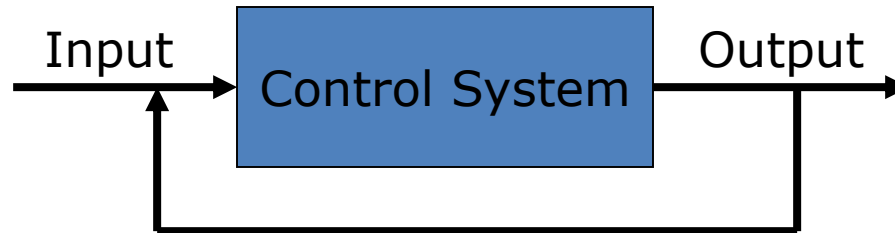
Type of systems

Control system configuration can be categorized into two:

1) Open-Loop



2) Closed-Loop

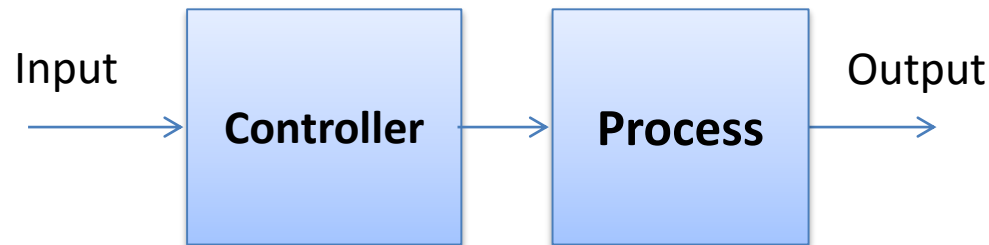


Types of Control System

Open-Loop Control Systems

Open-Loop Control Systems utilize a controller or control actuator to obtain the desired response.

- Output has no effect on the control action.
- In other words output is neither measured nor fed back.



Open-loop control system (without feedback).

Examples:- Washing Machine, Toaster, Electric Fan

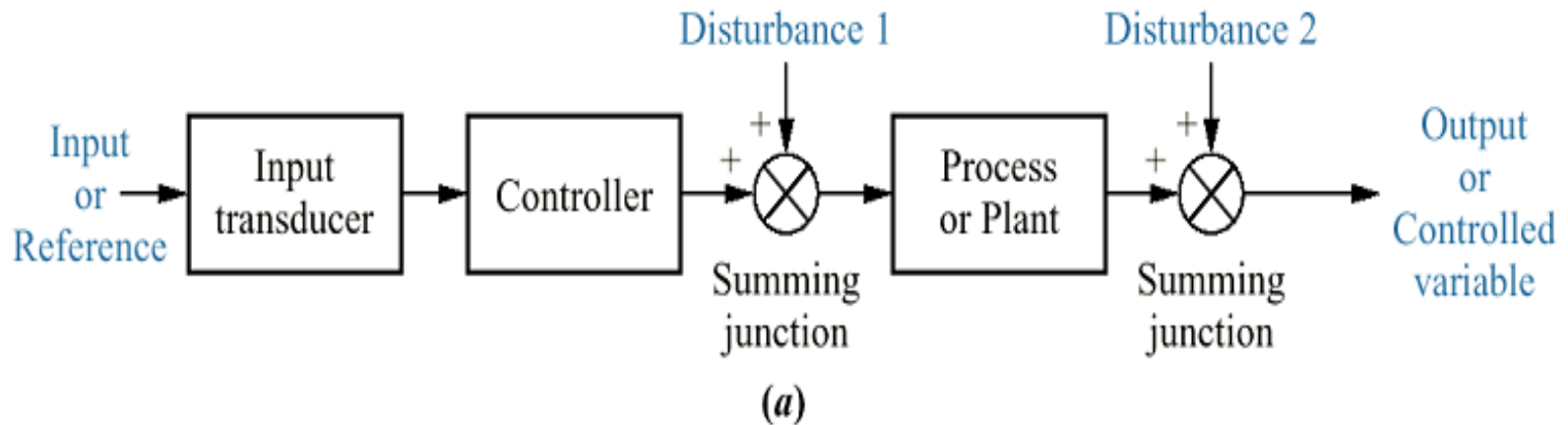
Types of Control System

Open-Loop Control Systems

- Since in open loop control systems reference input is not compared with measured output, for each reference input there is fixed operating condition.
- Therefore, the accuracy of the system depends on calibration.
- The performance of open loop system is severely affected by the presence of disturbances, or variation in operating/ environmental conditions.

Type of systems

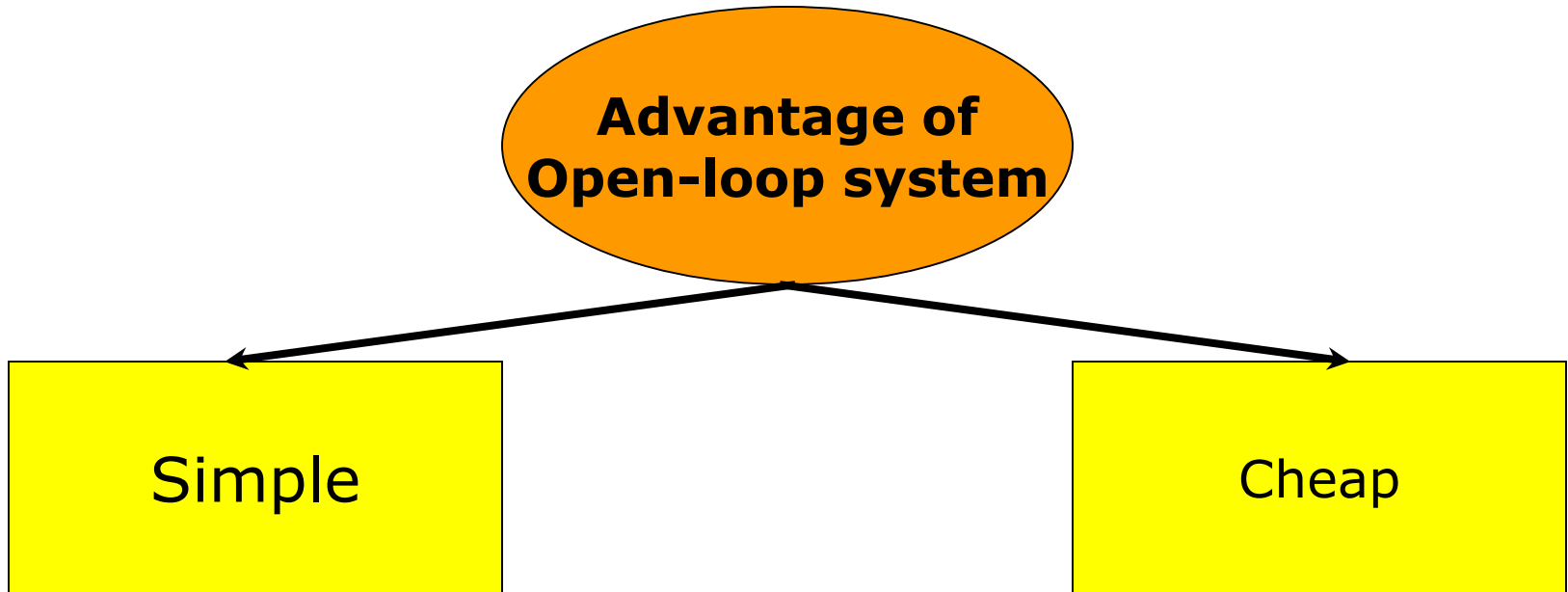
Open-loop system



A generic open-loop system

Type of systems

Open-loop system



Type of systems

Open-loop system

**Disadvantage of
Open-loop system**

Sensitive to
disturbance

Inability to correct
for disturbance

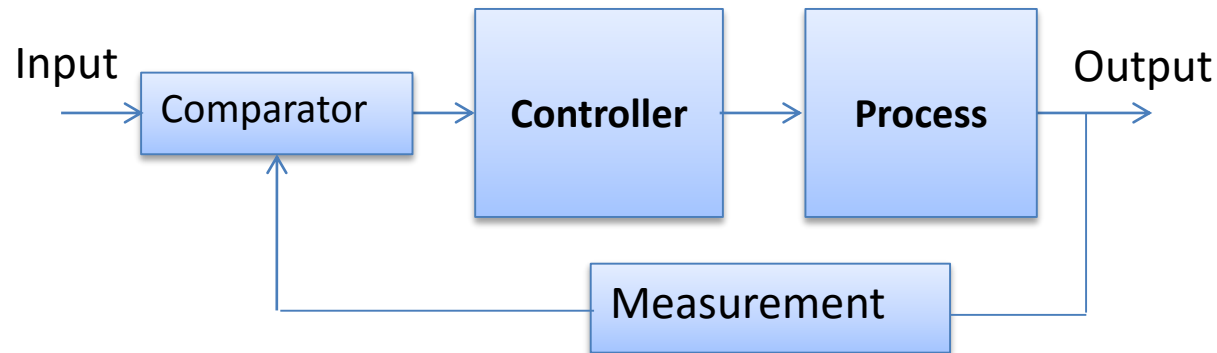
Solution

Use closed-loop system

Types of Control System

Closed-Loop Control Systems

Closed-Loop Control Systems utilizes feedback to compare the actual output to the desired output response.



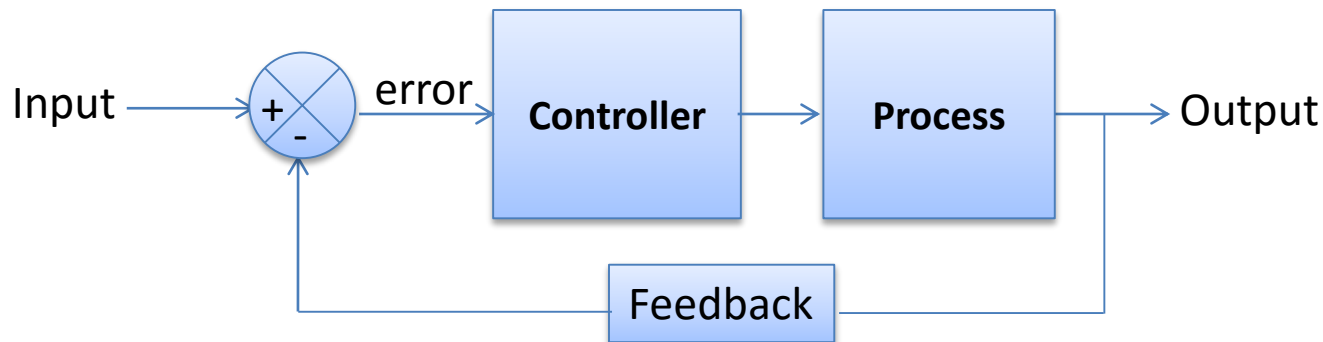
Closed-loop feedback control system (with feedback).

Examples:- Refrigerator, Iron

Types of Control System

Feedback Control System

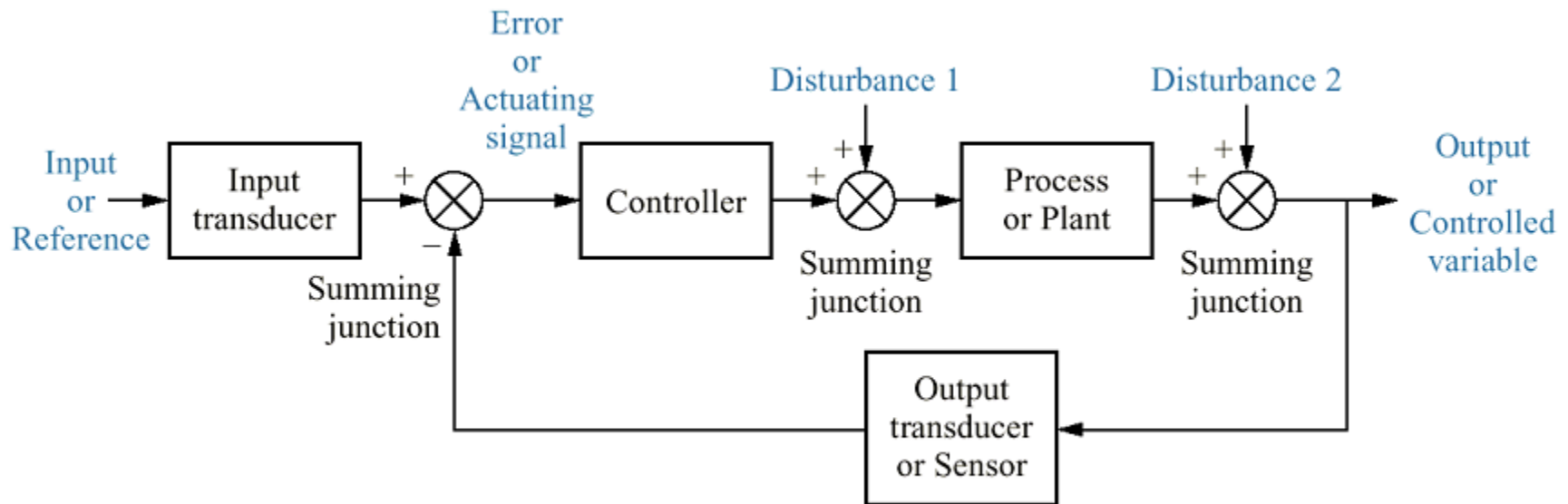
- A system that maintains a prescribed relationship between the output and some reference input by comparing them and using the difference (i.e. error) as a means of control is called a feedback control system.



- Feedback can be positive or negative.

Type of systems

Closed-loop system

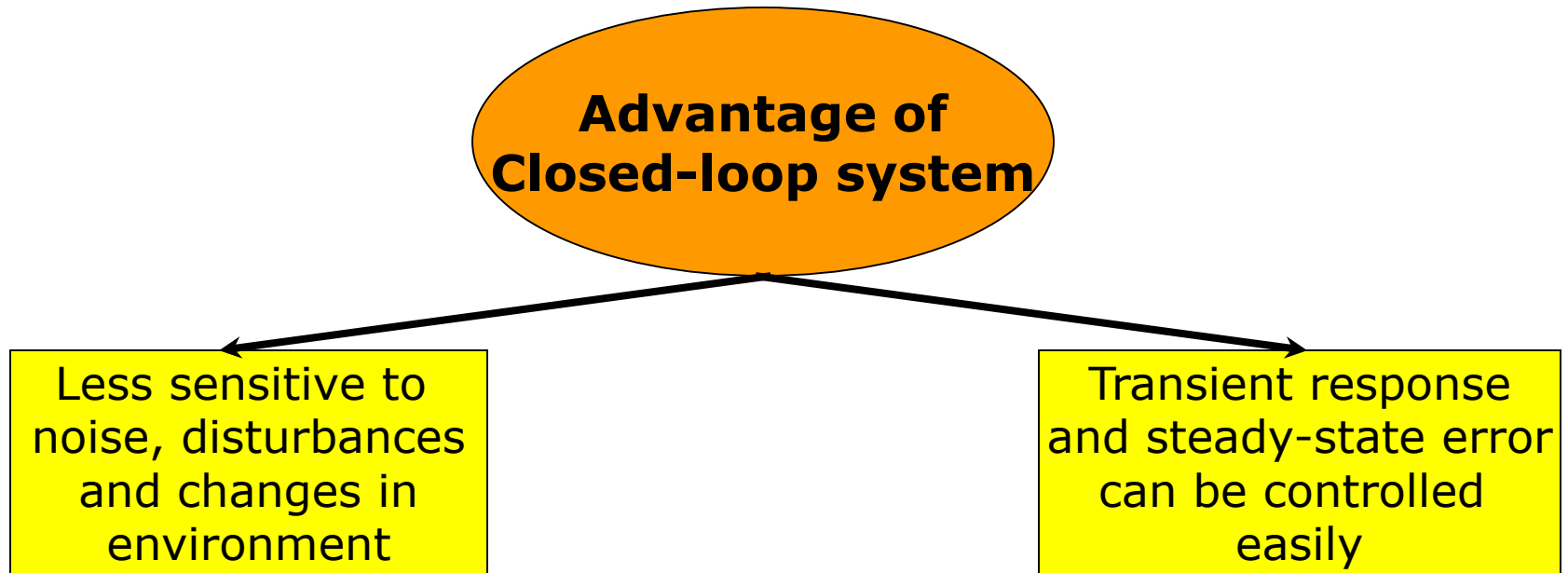


(b)

A generic closed-loop system

Type of systems

Closed-loop system



Transient response and steady-state error can be controlled by redesigning the controller. The process of redesigning is called *compensating* the system and the resulting hardware is a *compensator*

Type of systems

Closed-loop system

**Disadvantage of
Closed-loop system**

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graph TD; A([Disadvantage of Closed-loop system]) --> B[More complex]; A --> C[More expensive];
```

More complex

More expensive

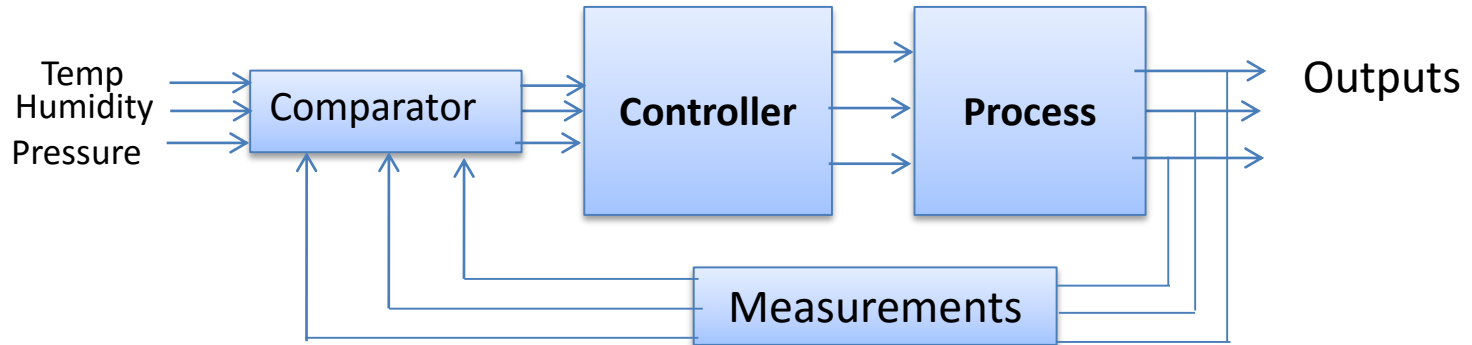
Type of systems

Open loop vs. Closed-loop system

- How do we choose OL or CL?
 - Criticality of application
 - The need to monitor output
 - The need to control the output
 - The need for reduced error or zero error
 - Cost / budget
 - Safety

Types of Control System

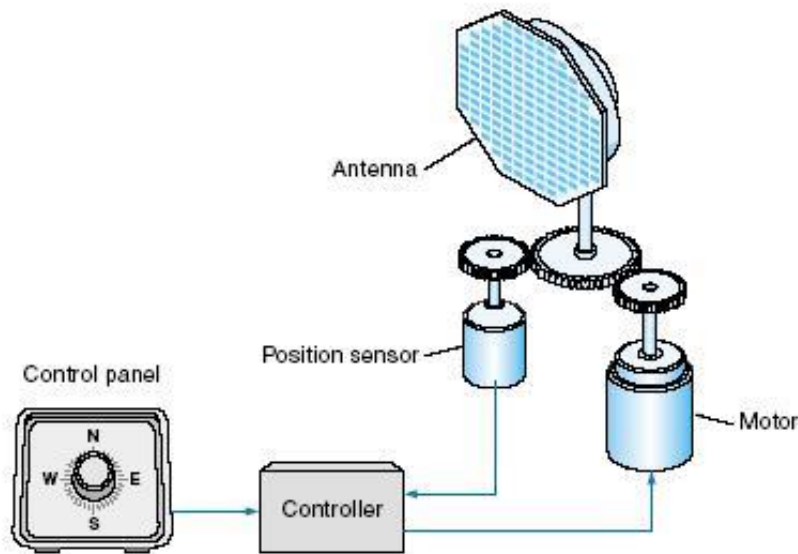
Multivariable Control System



Types of Control System

Servo System

- A Servo System (or servomechanism) is a feedback control system in which the output is some mechanical position, velocity or acceleration.



Antenna Positioning System

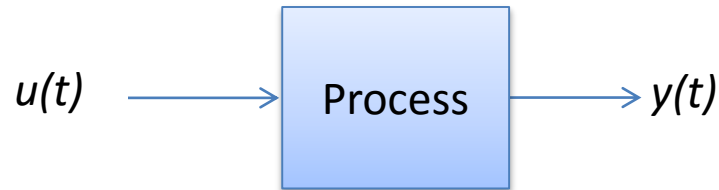


Modular Servo System (MS150)

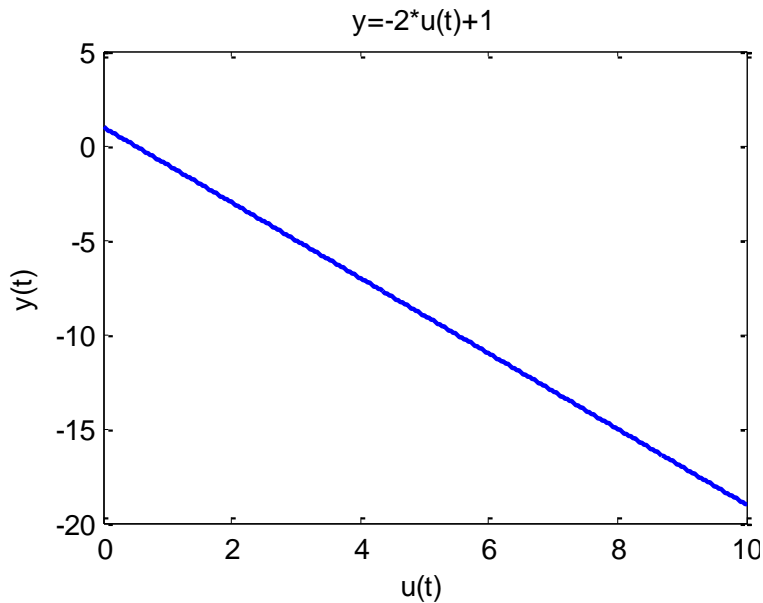
Types of Control System

Linear Vs Nonlinear Control System

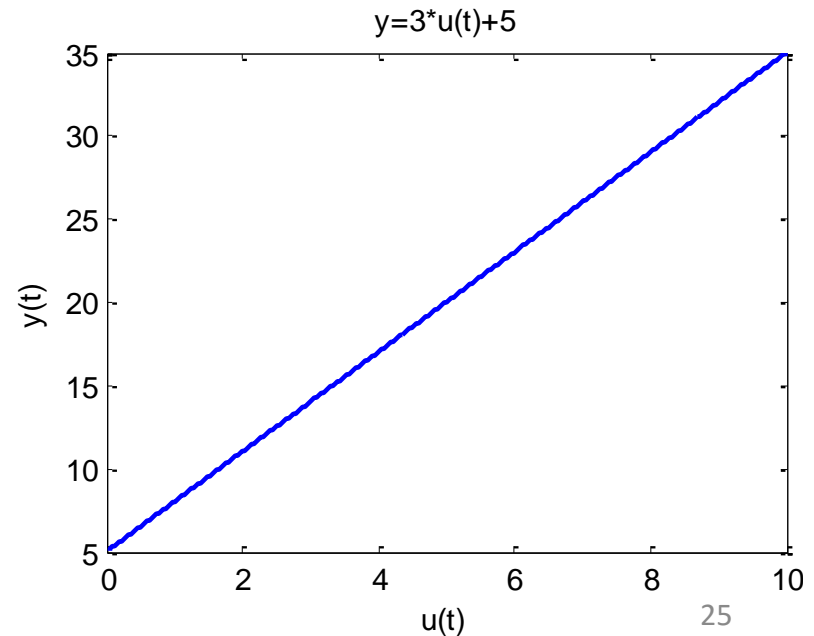
- A Control System in which output varies linearly with the input is called a linear control system.



$$y(t) = -2u(t) + 1$$



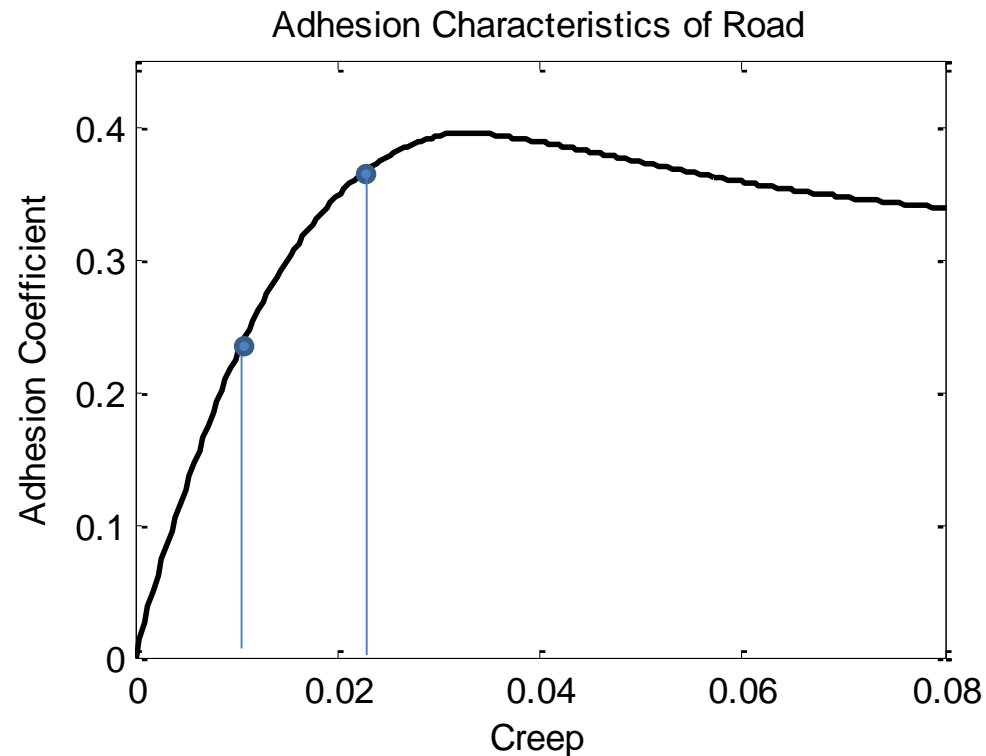
$$y(t) = 3u(t) + 5$$



Types of Control System

Linear Vs Nonlinear Control System

- Linear control System Does not exist in practice.
- Linear control systems are idealized models fabricated by the analyst purely for the simplicity of analysis and design.
- When the magnitude of signals in a control system are limited to range in which system components exhibit linear characteristics the system is essentially linear.



Types of Control System

Time invariant vs Time variant

- When the characteristics of the system do not depend upon time itself then the system is said to time invariant control system.

$$y(t) = -2u(t) + 1$$

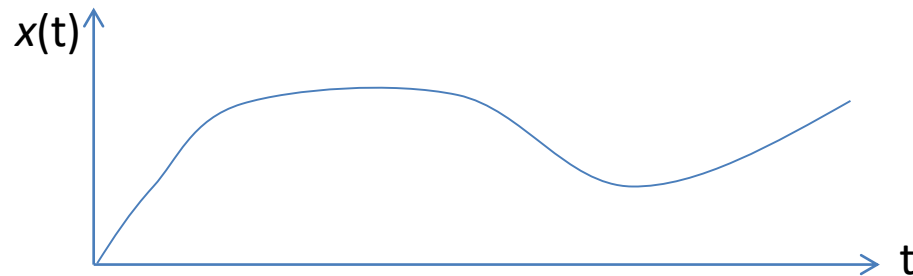
- Time varying control system is a system in which one or more parameters vary with time.

$$y(t) = 2u(t) - 3t$$

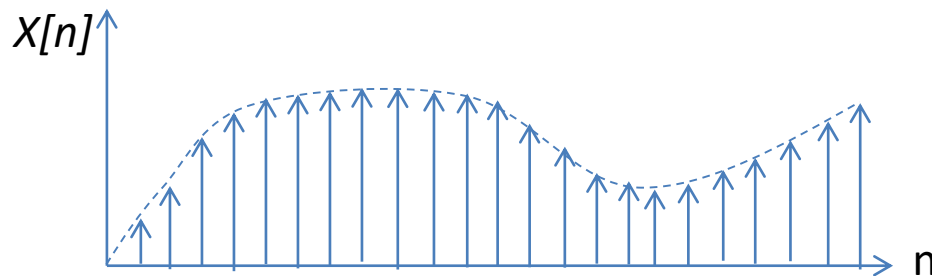
Types of Control System

Continuous Data Vs Discrete Data System

- In continuous data control system all system variables are function of a continuous time t .



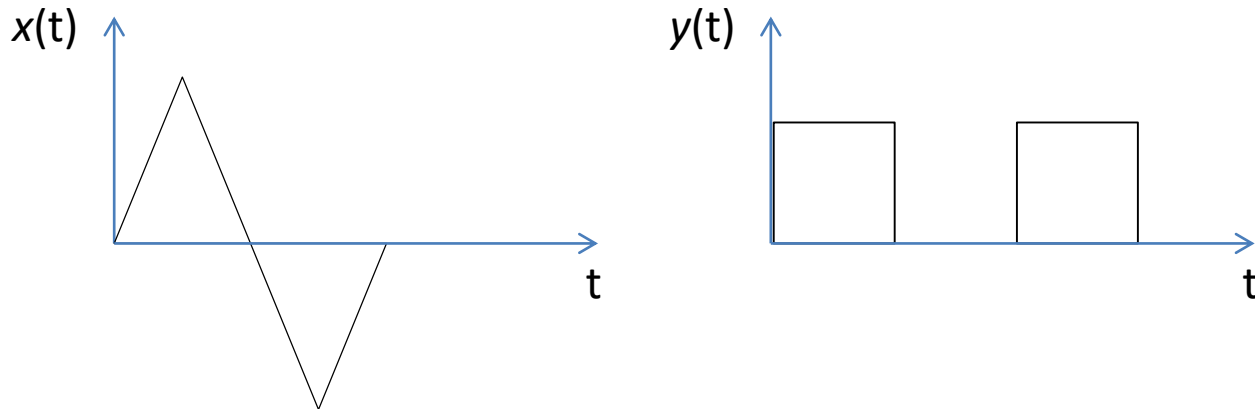
- A discrete time control system involves one or more variables that are known only at discrete time intervals.



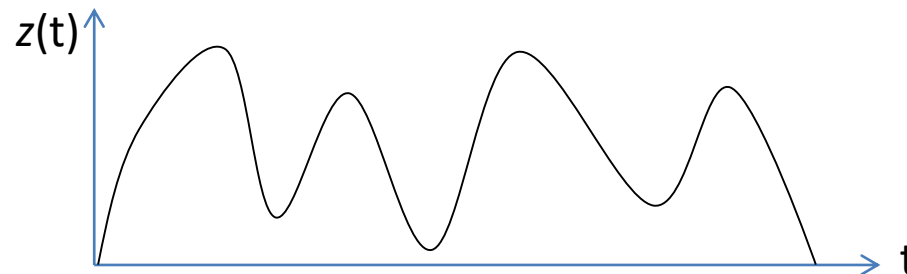
Types of Control System

Deterministic vs Stochastic Control System

- A control System is deterministic if the response to input is predictable and repeatable.



- If not, the control system is a stochastic control system



Types of Control System

Adaptive Control System

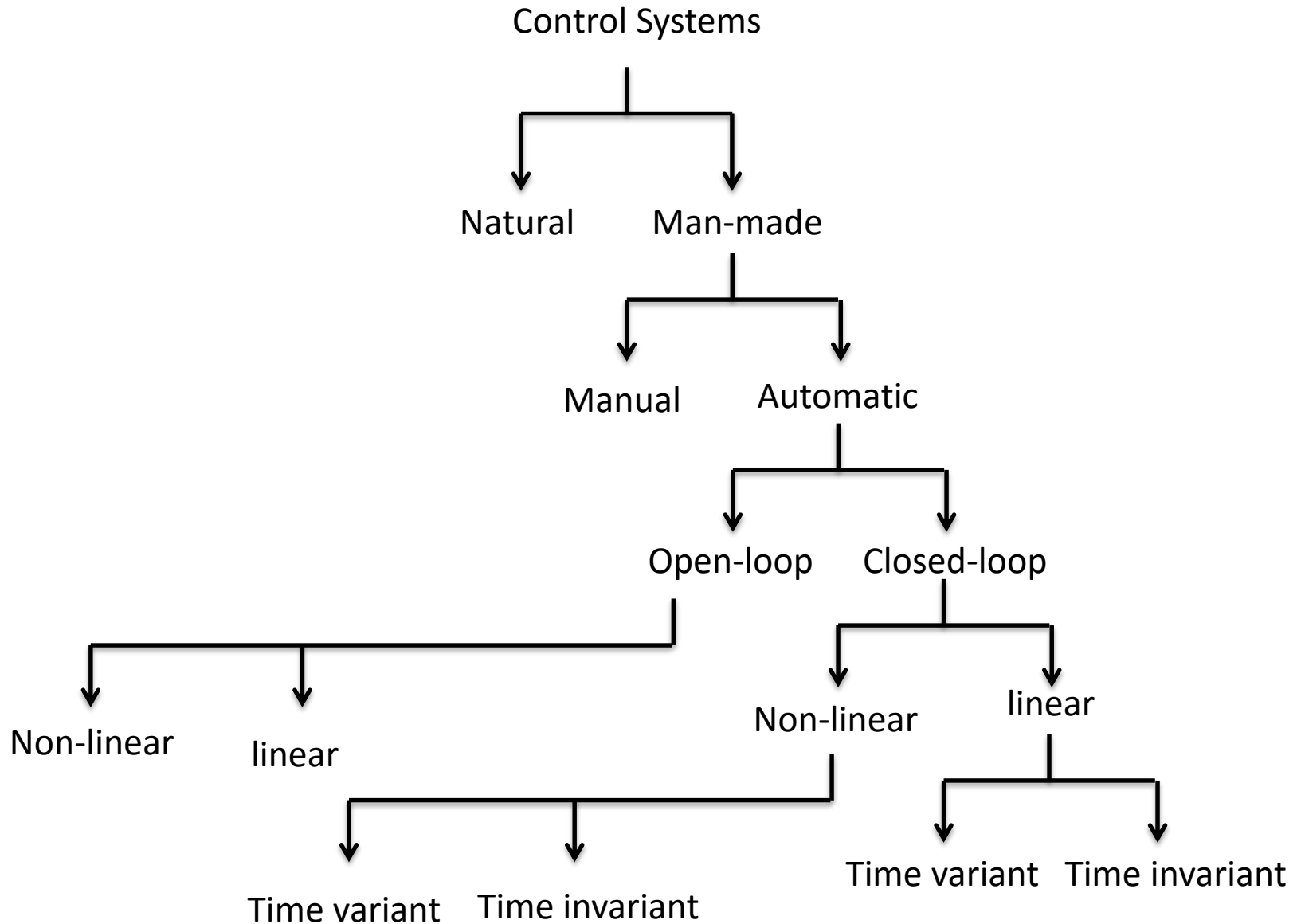
- The dynamic characteristics of most control systems are not constant for several reasons.
- The effect of small changes on the system parameters is attenuated in a feedback control system.
- An adaptive control system is required when the changes in the system parameters are significant.

Types of Control System

Learning Control System

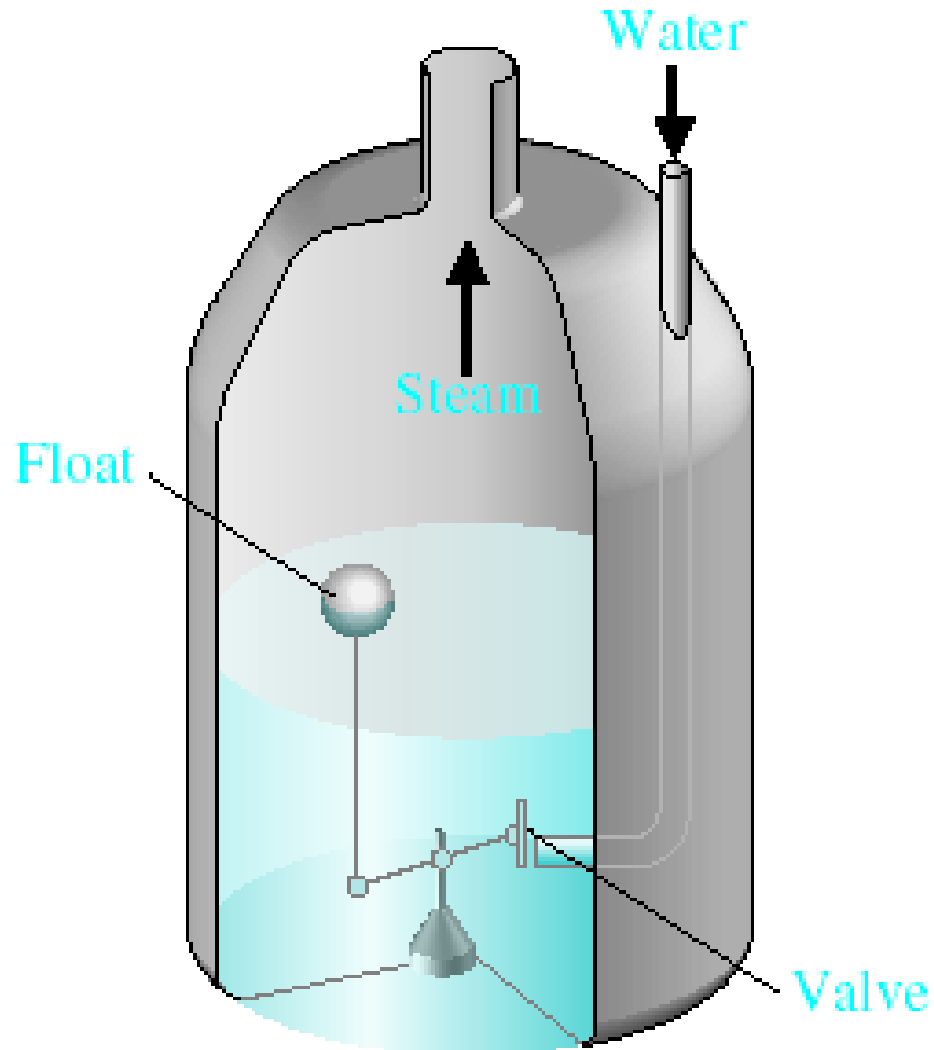
- A control system that can learn from the environment it is operating is called a learning control system.

Classification of Control Systems

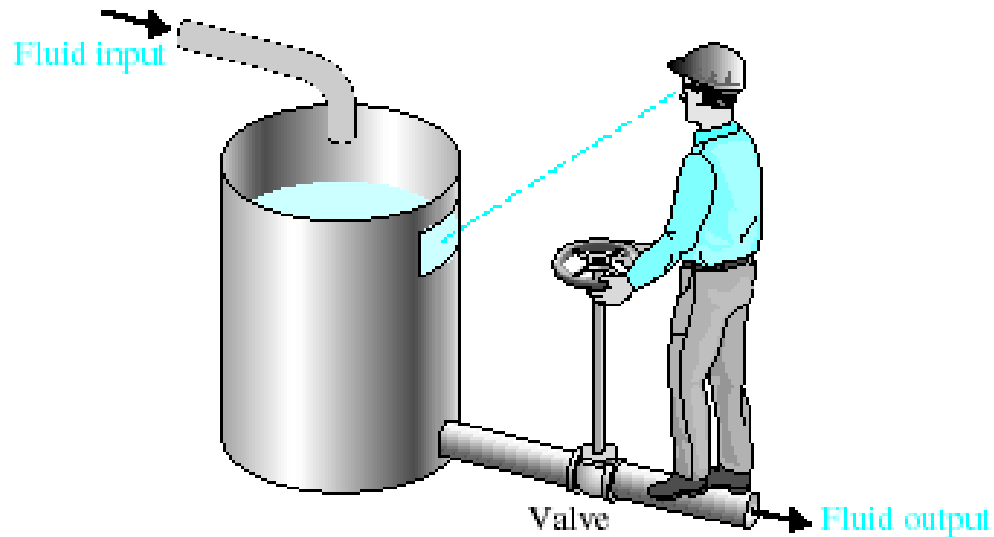


Examples of Control Systems

Water-level float regulator

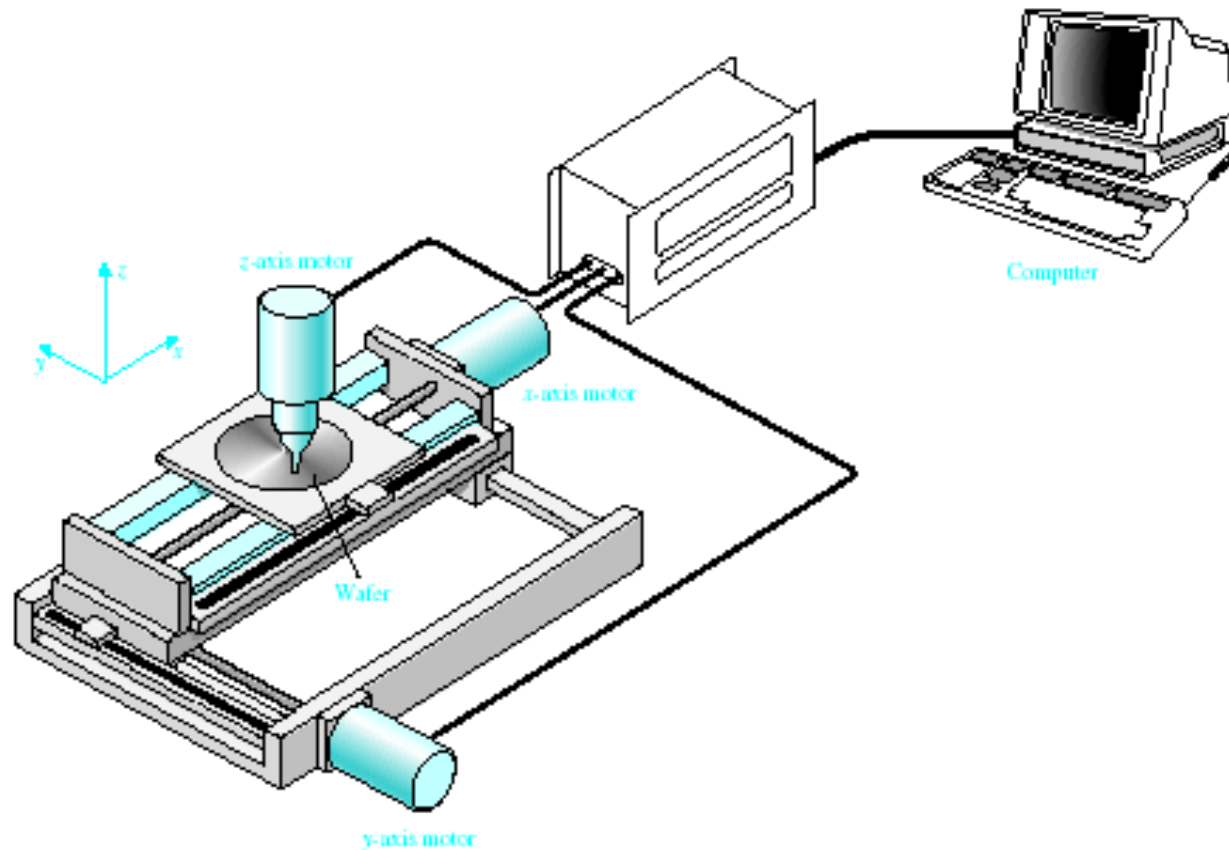


Examples of Control Systems



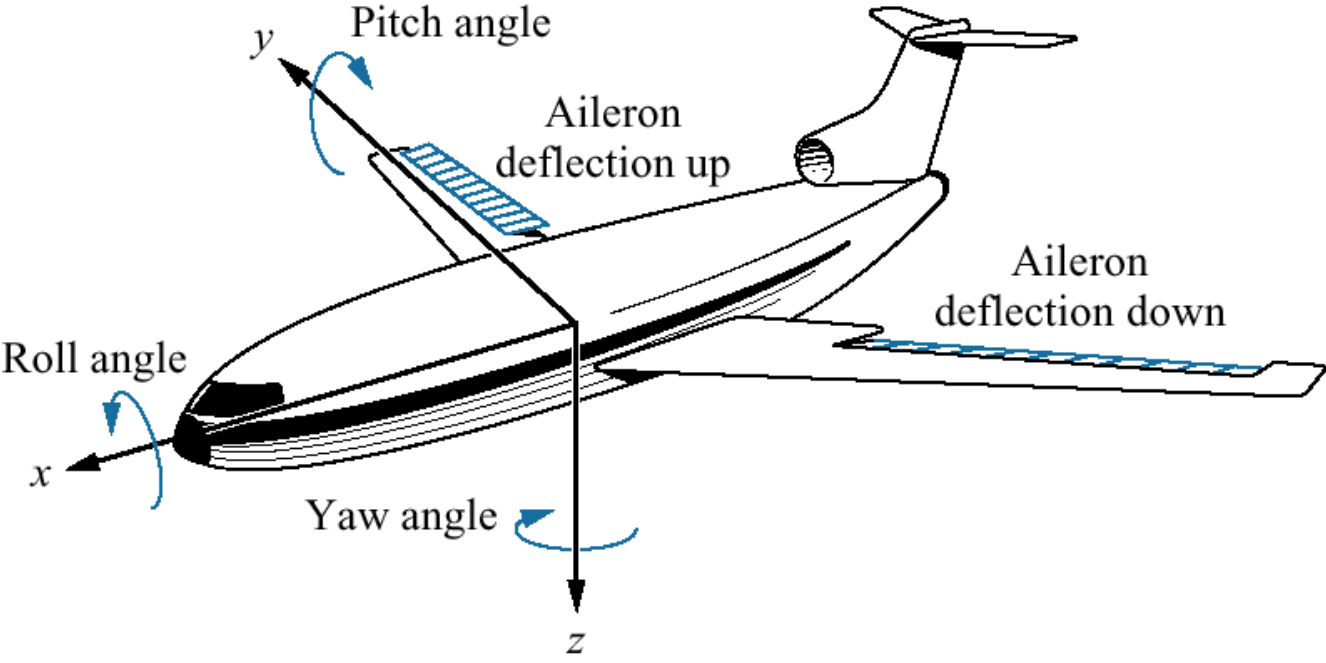
A manual control system for regulating the level of fluid in a tank by adjusting the output valve. The operator views the level of fluid through a port in the side of the tank.

Examples of Modern Control Systems



A three-axis control system for inspecting individual semiconductor wafers with a highly sensitive camera.

Examples of Modern Control Systems



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