CSE 371 - Control Engineering
Introduction

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Summer 2025

Control Systems

- A control system is an interconnection of components forming a system configuration that will provide a desired system response, e.g. automobile cruise control system.

sensor → controller → actuator → change the environment.

- A sensor is a device that provides a measurement of a desired external signal.
- An actuator is a device employed by the control system to alter or adjust the environment.

Control Systems

- Control system engineering focuses on the mathematical modeling of physical systems and using those models to design controllers that will cause the systems to possess desired performance characteristics.
- Control engineering deals with the design and implementation of control systems using linear, time-invariant mathematical models representing actual physical nonlinear, time-varying systems with parameter uncertainties in the presence of external disturbances.

Open-Loop Control Systems

FIGURE 1.1 Process to be controlled.

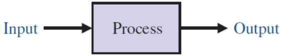
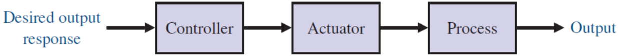


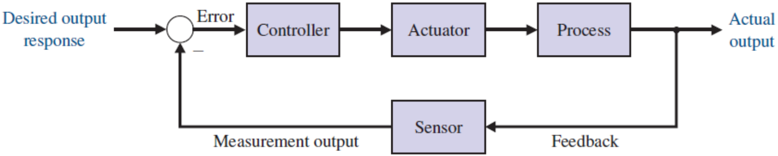
FIGURE 1.2 Open-loop control system (without feedback).



Open-Loop Control System

- An open-loop control system uses a controller and an actuator to obtain the desired response without using feedback.
- A microwave oven set to operate for a fixed time is an example of an open-loop control system.

Closed-Loop Control Systems



Closed-loop control system

Closed-Loop Control Systems

Closed-Loop Control System

- A closed-loop control system utilizes an additional measure of the actual output to compare the actual output with the desired (a.k.a. reference) output response.
- This measure of the output is called the feedback signal.
- The difference between the desired and actual output is used to control the system.

Closed-Loop Control Systems

- An example of a closed-loop control system is a person steering an automobile by looking at the auto's location on the road and observing the surrounding environment, then making the appropriate adjustments.
- A feedback control system often uses the amplified difference between the actual output of the process under control and the desired output (i.e. reference) used to control the process so that the difference is continually reduced.

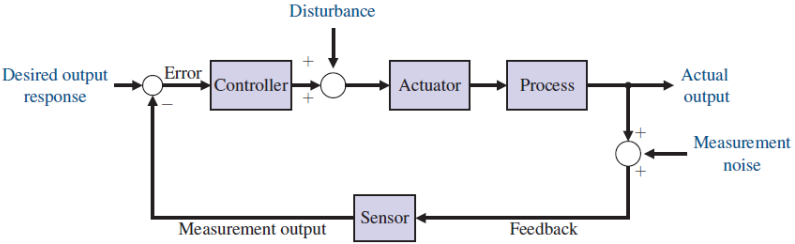
Closed-Loop Control Systems

- In general, the difference between the desired output and the actual output is referred to as the error, which is then adjusted by the controller.
- The output of the controller causes the actuator to modulate the process in order to reduce the error.
- The system shown in the previous figure is a negative feedback control system, because the output is subtracted from the input and the difference is used as the input signal to the controller.
- The feedback concept is the foundation for control system analysis and design.

Closed-Loop Control Systems

- It is inevitable that real-world control systems suffer from external disturbances and measurement noise as shown in the figure below.
- A closed-loop control system has many advantages over open-loop control, including the ability to reject external disturbances and noise.

Closed-Loop Control Systems



Closed-Loop Control Systems

- The feedback control systems shown so far are single-loop feedback systems.
- Shown below is multi-loop feedback control system with an inner loop and an outer loop.
- Muiltiloop feedback control systems represent more practical situations found in real-world applications.

Closed-Loop Control Systems

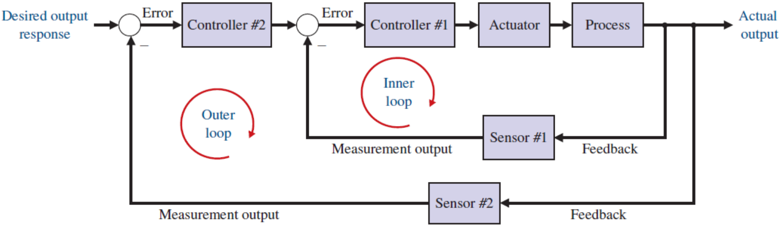


FIGURE 1.5 Multiloop feedback system with an inner loop and an outer loop.

Closed-Loop Control Systems

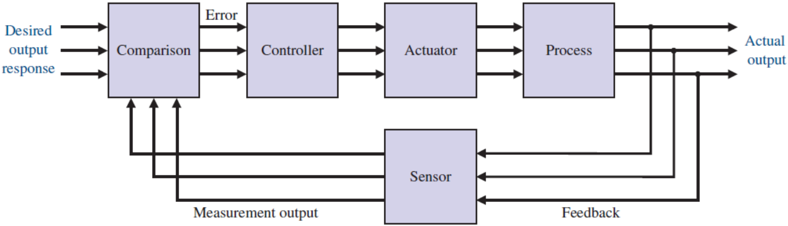


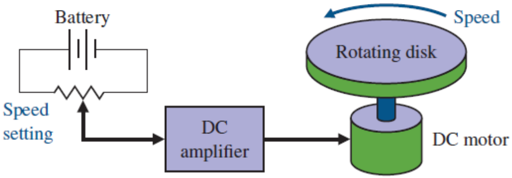
FIGURE 1.6 Multivariable control system.

Control Systems: An Example

Let's consider the task of controlling the speed of a rotating disk ...

- Our goal is to design a control system to control the speed of a rotating disk in order to ensure that the actual speed of rotation is within a specified percentage of the desired speed.
- To obtain disk rotation, we will select a DC motor as the actuator because it provides a speed proportional to the applied motor voltage.
- For the input voltage to the motor, we will select an amplifier that can provide the required power.

Control Systems: An Example



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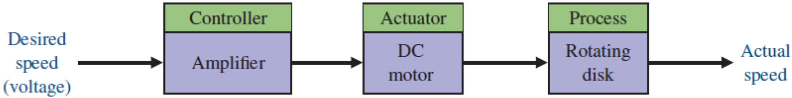

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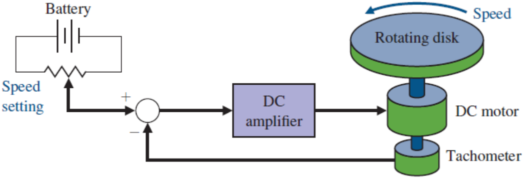
Control Systems: An Example

- To obtain a feedback system, we need to select a sensor.
- One useful sensor is a tachometer that provides an output voltage proportional to the speed of its shaft.

Control Systems: An Example



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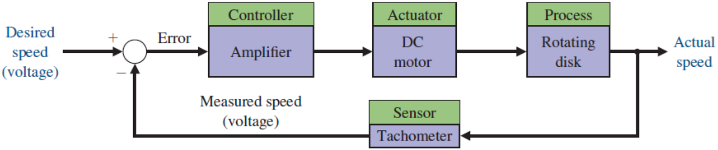

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