CHAPTER 1: INTRODUCTION TO CONTROL SYSTEM

Objectives

Students should be able to:

- Define the control system
- State the advantages of control system
- Describe the response characteristics, open-loop and closed-loop systems
- Find out the differences between open-loop and closed loop systems
- State the analysis and design objectives of control system
- Describe the terms in control system such as input, output, controller, feedback, plant, transient response, steady-state response, steady-state error and stability.

1.1 INTRODUCTION

Control systems are an integral part of modern society.

Numerous applications are all around us.

The control systems also exist in nature such as the pancreas, which regulates our blood sugar.

Control System Definition

Consists of *subsystems* and *processes* (or *plants*) assembled for the purpose of controlling the output of processes.

In other word, a control system provides an output or response for a given input or stimulus as shown in Figure 1.1.

Figure 1.1 : Simplified description of a control system

Advantages of Control System

- We can move large equipment with precision
- We can point huge antennas toward the farthest reaches of universe to pick up faint radio signals

We build control systems for four primary reasons:

- Power amplification
- Remote control
- Convenience of input form
- Compensation for disturbances

1.2 RESPONSE CHARACTERISTICS AND SYSTEM CONFIGURATIONS

❑ Response characteristic

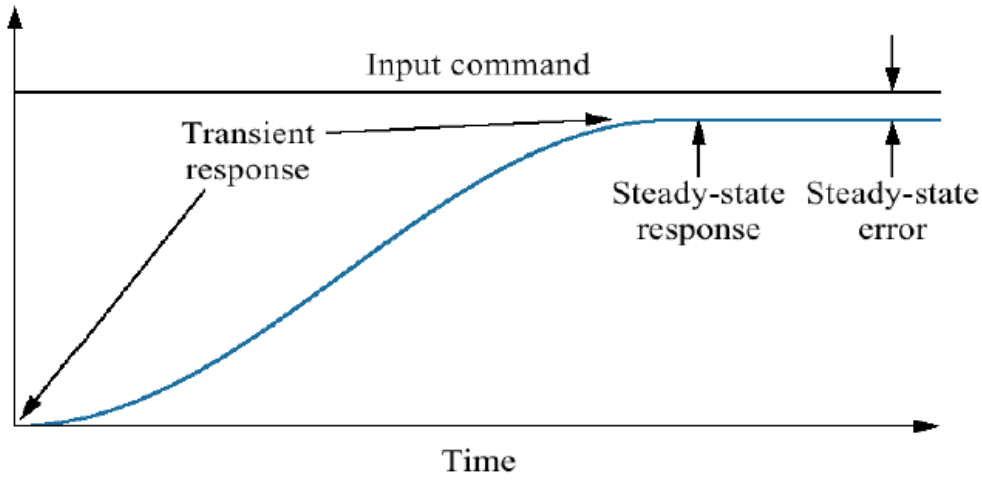

Figure 1.2: Time response

- Input/stimulus – a desired response
- Output – the actual response
- Transient response – a gradual change before the steady-state response
- Steady-state response – after the transient response, which is its approximation to the desired response
- Steady-state error – the differences between input and output

The control systems also exist in nature such as the pancreas, which regulates our blood sugar.

❑ Control system configurations: open loop and closed-loop

Two major system configurations of control system:-

- Open-Loop Systems – as shown in Figure 1.3.

  It consists of subsystems called an *input transducer, controller and process or plant.*

  Input transducer converts the form of the input to that used by the *controller*. *Controller* drives a process or plant. Other signals, such as *disturbances,* are shown added to the controller and process outputs via *summing junctions.* The open-loop system cannot correct for these disturbances.

  Examples – toasters, washing machine (washing process)

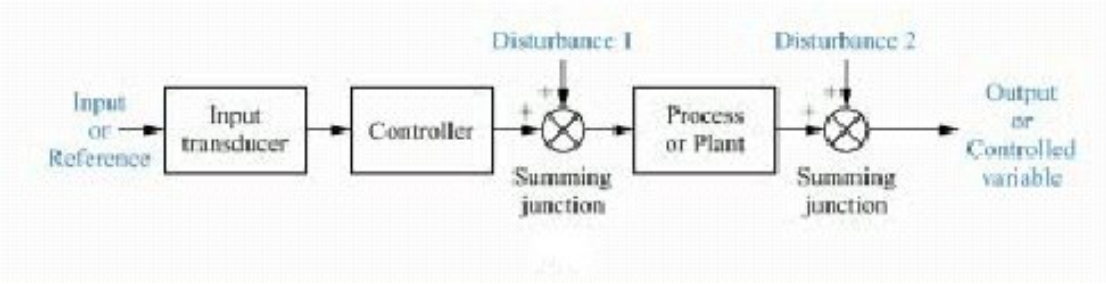

Figure 1.3: Open loop system

- Closed-Loop Systems (also known as ***Feedback Control System***) – The disadvantages of open-loop systems may be overcome in closed-loop system as shown in Figure 1.4.

  An output transducer/ sensor, measures the output response and converts into the form used by controller.

  The closed-loop systems measured the output response through a feedback path, and comparing that response to the input at the summing junction. If there is any difference between the two responses, the system drives the plant, via the actuating signal, to make a correction. If there is no difference, the system does not drive the plant.

  Examples – air conditioning with temperature control, lift, washing machine (water level control)

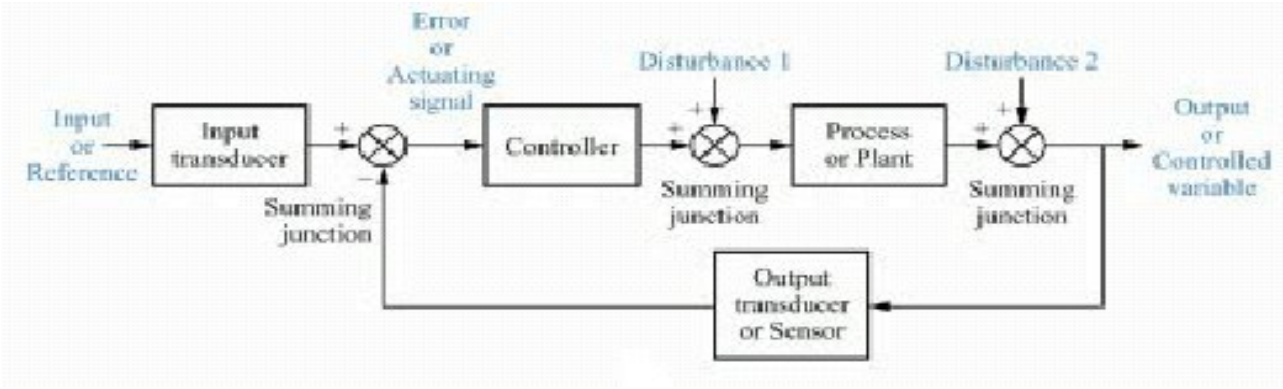

Figure 1.4: Closed-loop system

The differences between open and closed-loop system are:-

Closed-Loop System	Open-Loop System
Have the feedback path.	Does not have the feedback path.
Output response: greater accuracy.	Output response: not accurate.
Less sensitive to noise, disturbances and changes in the environment.	Sensitive to noise, disturbances and changes in the environment.
The system can compare the output response with the input and make a correction if there is any difference.	The system cannot correct the disturbances.
More complex and expensive.	Simple and inexpensive.

1.3 ANALYSIS AND DESIGN OBJECTIVES

Control systems are dynamic: they response to an input by undergoing a transient response before reaching steady-state response that generally resembles the input.

3 major objectives:-

- Producing the desired **transient response**
- Reducing **steady-state error**
- Achieving **stability**

Transient Response

Important in control system

Ex. In the case of an elevator, a slow transient makes passenger impatient, whereas an excessively rapid response makes them uncomfortable. Too fast a transient response could cause permanent physical damage.

Therefore, we have to analyze the system for its existing transient response. Then, adjust parameters or design components to yield a desired transient response.

Steady-State Response

This response resembles the input and is usually what remains after the transients have decayed to zero.

We define steady-state errors quantitatively,

Analyze a system's steady-state error, and then

Design corrective action to reduce this error.

Stability

In order to explain stability, we start from the fact that:

Total Response = Natural Response + Forced Response

(dependent on the system) *(dependent on the input)*

The transient response is the sum of natural and forced responses with the natural response is large.

The steady-state response is also the sum of natural and forced responses with natural response is small.

For a control system to be useful, natural response must approach zero.

If natural response much greater than forced response, the system is no longer controlled. This condition called *instability*.

Control system must be design to be stable. If the system is stable, the proper transient response and steady-state error characteristics can be designed.