

INSTRUMENTATION AND CONTROL

COEG 304

Lecture 1



Aayush Bista

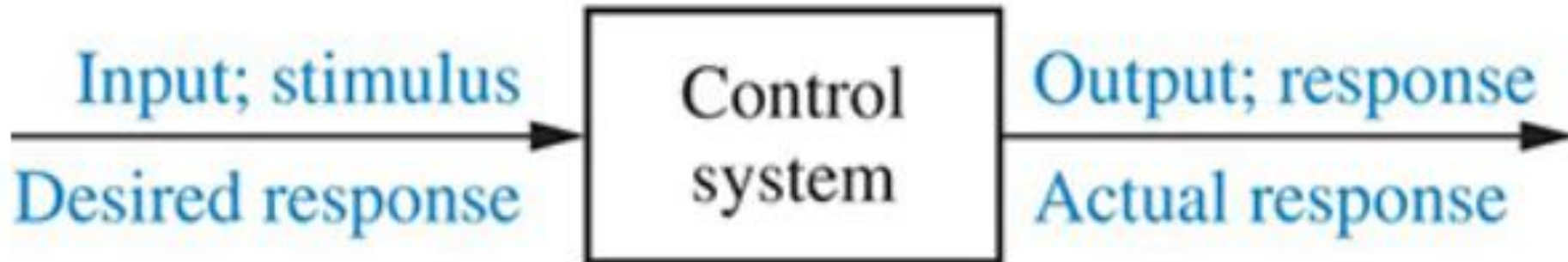
WHAT IS CONTROL SYSTEM?



- 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 behavior of other device(s) or system(s).

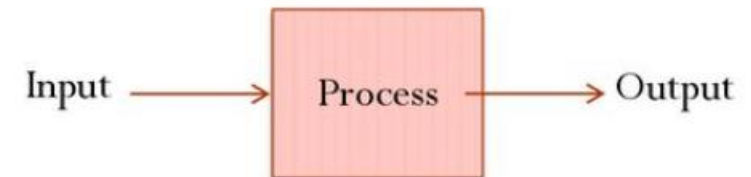
CONTROL SYSTEM

- A control system consists of *subsystems* and *processes* (or plants) assembled for the purpose of obtaining a *desired output* with *desired performance*, given a *specified input*.



DEFINITIONS

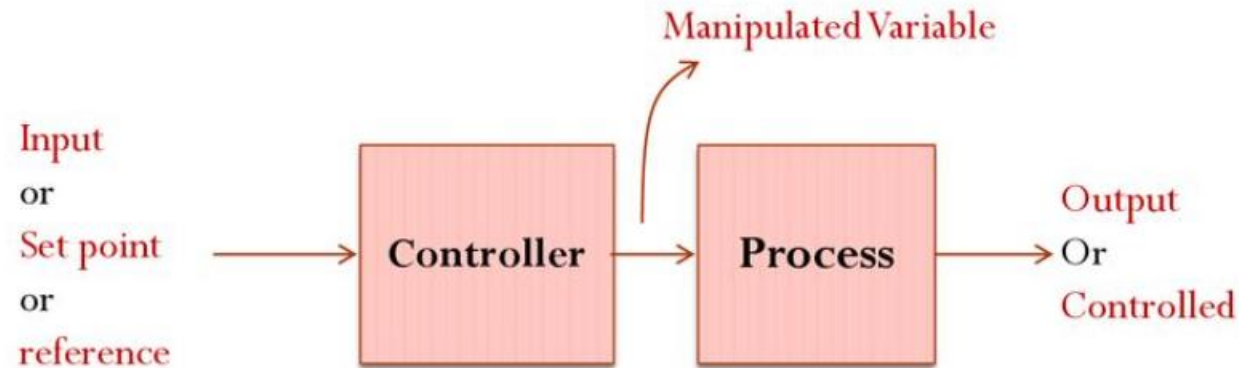
- **System** – An interconnection of elements and devices for a desired purpose.
- **Control System** – An interconnection of components forming a system configuration that will provide a desired response.
- **Process** – The device, plant, or system under control. The input and output relationship represents the cause-and-effect relationship of the process.



DEFINITIONS

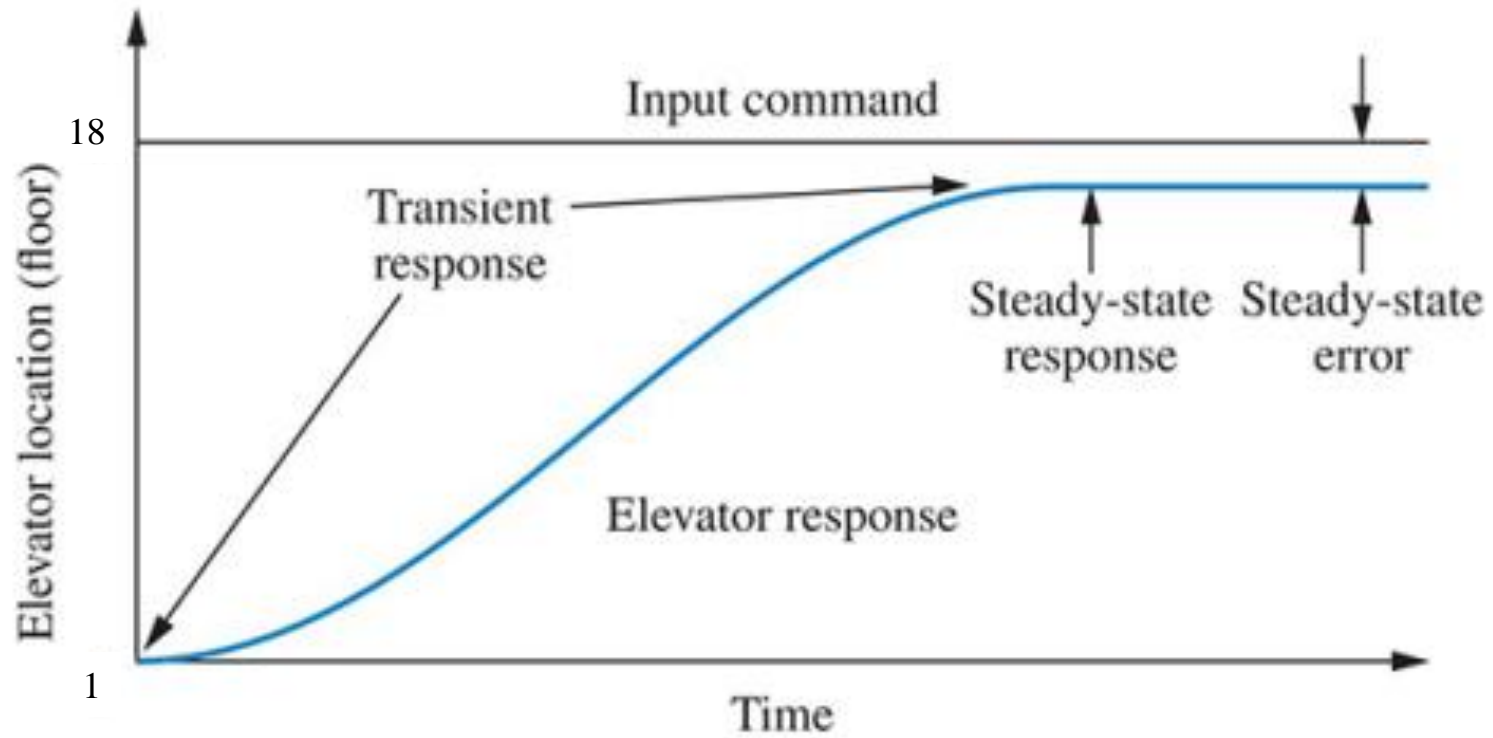
- **Controlled Variable**– It is the quantity or condition that is measured and Controlled. Normally controlled variable is the output of the control system.
- **Manipulated Variable**– It is the quantity of the condition that is varied by the controller so as to affect the value of a controlled variable.
- **Control** – Control means measuring the value of a 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.

DEFINITION



- **Disturbances**– A disturbance is a signal that tends to adversely affect the value of the system. It is an unwanted input of the system.

If a disturbance is generated within the system, it is called *internal disturbance*. While an *external disturbance* is generated outside the system.



INPUT

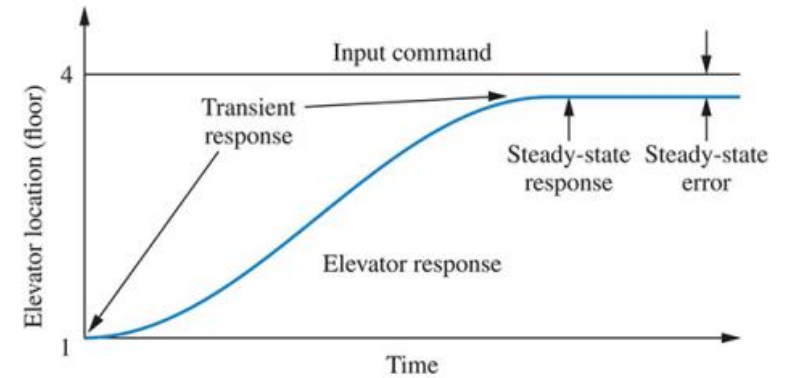
PUSH OF THE EIGHTEEN FLOOR BUTTON

OUTPUT

SHOWN AS STEP RESPONSE IN FIGURE



MEASURE OF PARAMETERS



- Transient Response
 - Steady State Response
 - Stability
- Two major measure of parameters

TRANSIENT RESPONSE

- Passenger Response
- Passenger Comfort

STEADY STATE RESPONSE

Elevator did not level properly

- Passenger Safety ❌
- Passenger Convenience ❌

ADVANTAGES OF CONTROL SYSTEM



Keeping the instruments within the acceptable limits of error



Attaining optimum performance of a dynamic system



Improves reliability and productivity of system



Maintains plant production rate at minimum cost



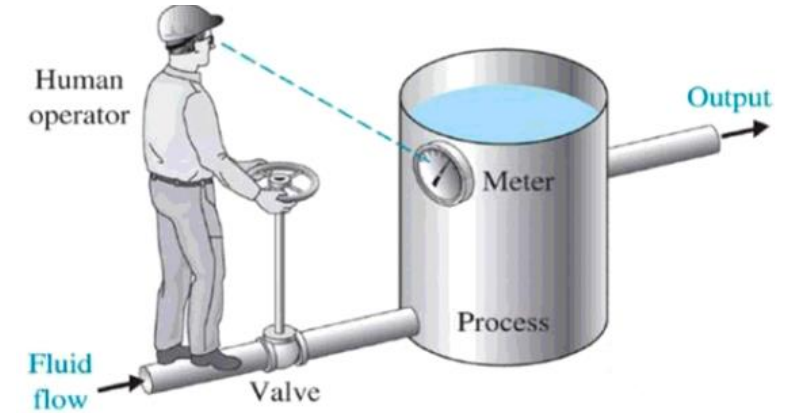
Ensures safety of the plant process, environment and the people involved

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
 - The hypothalamus works with other parts of the body's temperature-regulating system.
 - Blood Glucose Control in Body



CONFIGURATION OF CONTROL SYSTEM

- Two main configurations of control system

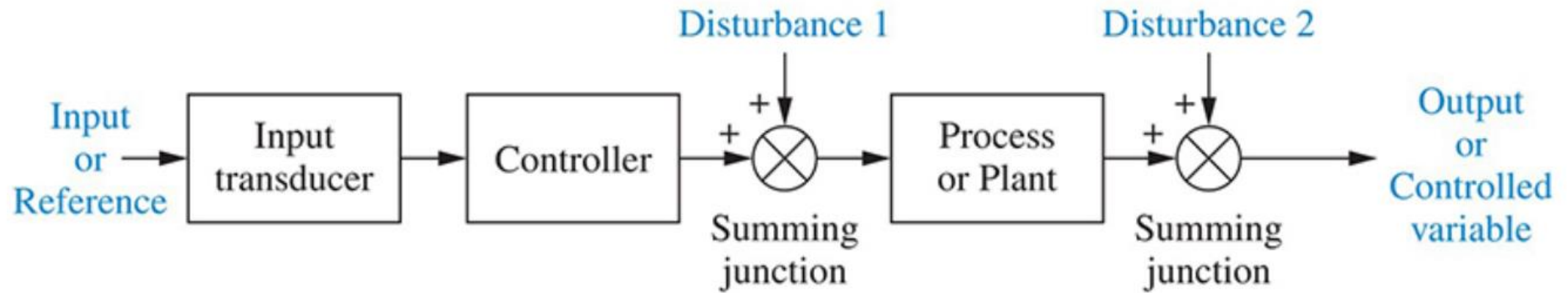


OPEN LOOP



CLOSED LOOP

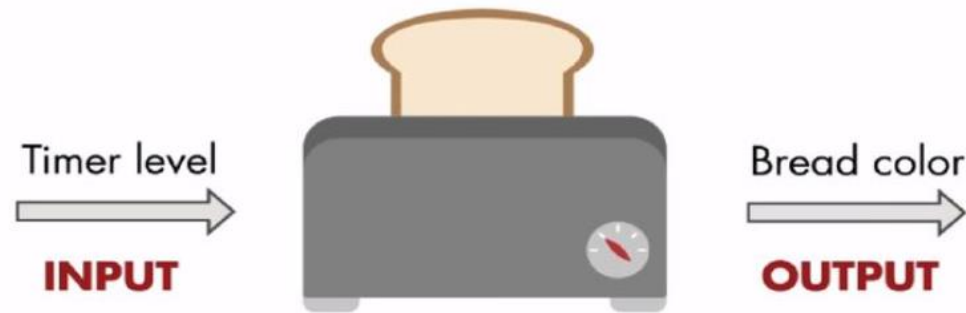
OPEN LOOP CONTROL SYSTEM



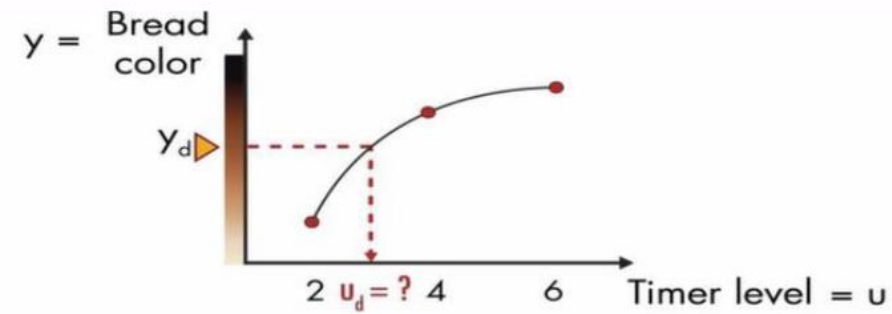
OPEN LOOP CONTROL SYSTEM



OPEN LOOP CONTROL SYSTEM



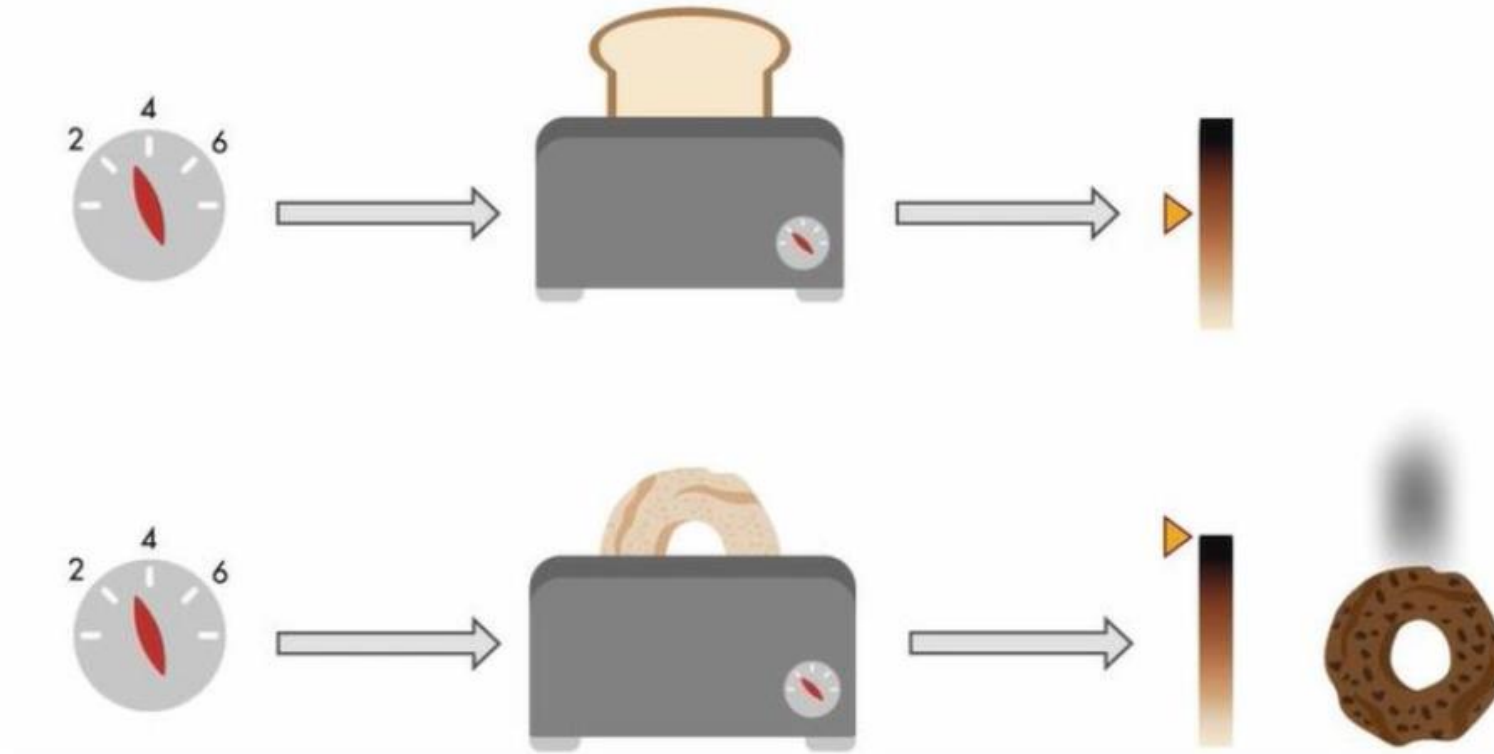
OPEN-LOOP SYSTEM



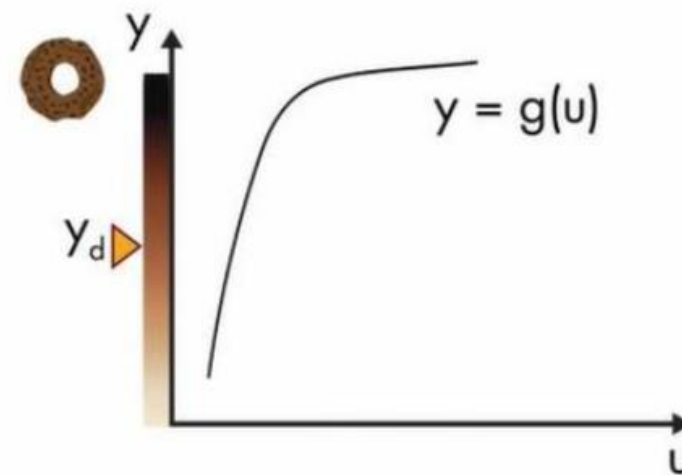
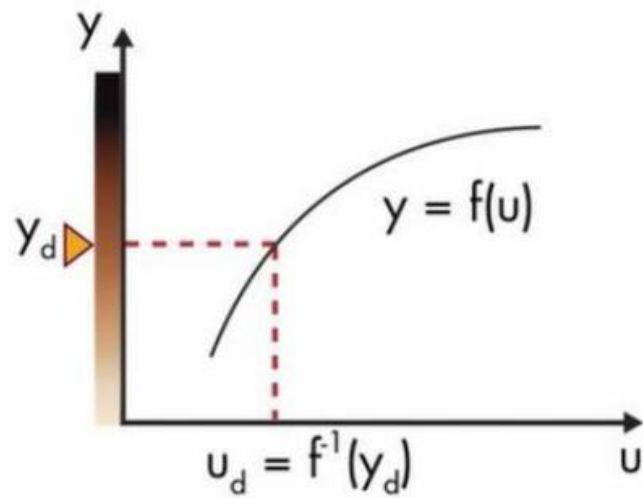
$$y = f(u)$$

$$u_d = f^{-1}(y_d)$$

OPEN LOOP CONTROL SYSTEM



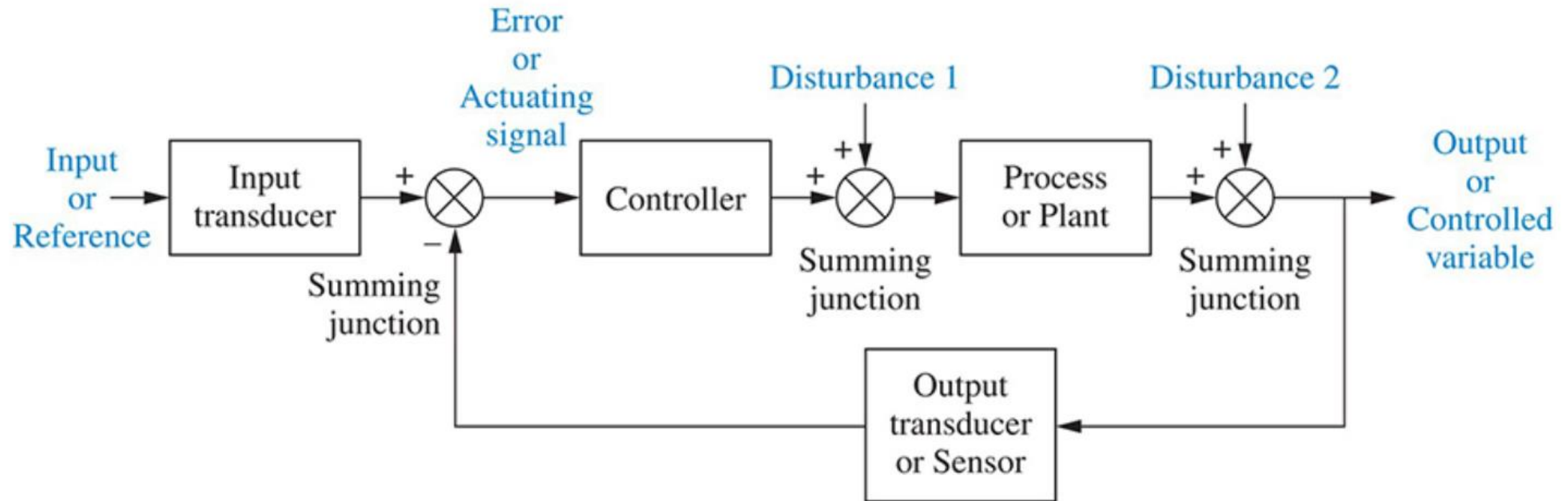
OPEN LOOP CONTROL SYSTEM



OPEN LOOP CONTROL SYSTEM

- 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.

CLOSED LOOP CONTROL SYSTEM

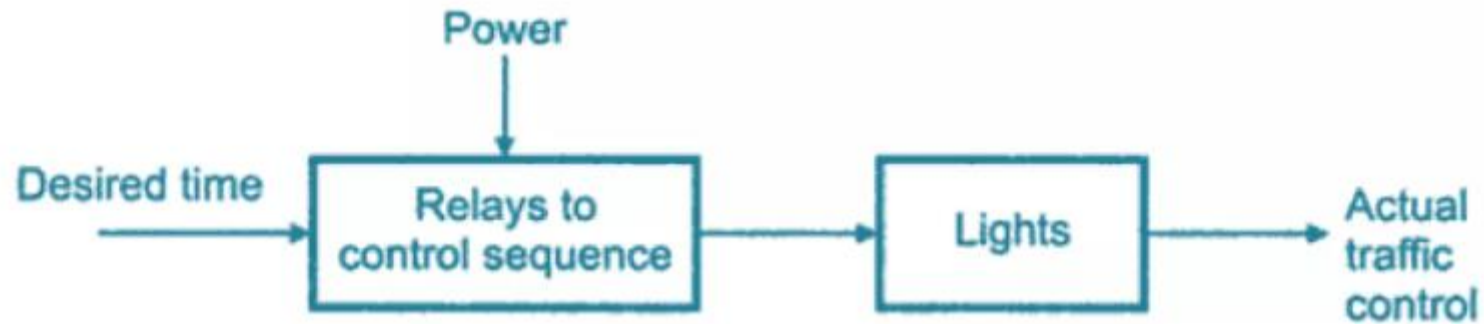


CLOSED LOOP CONTROL SYSTEM



EXAMPLE OF CONTROL SYSTEM: TRAFFIC LIGHT CONTROLLER

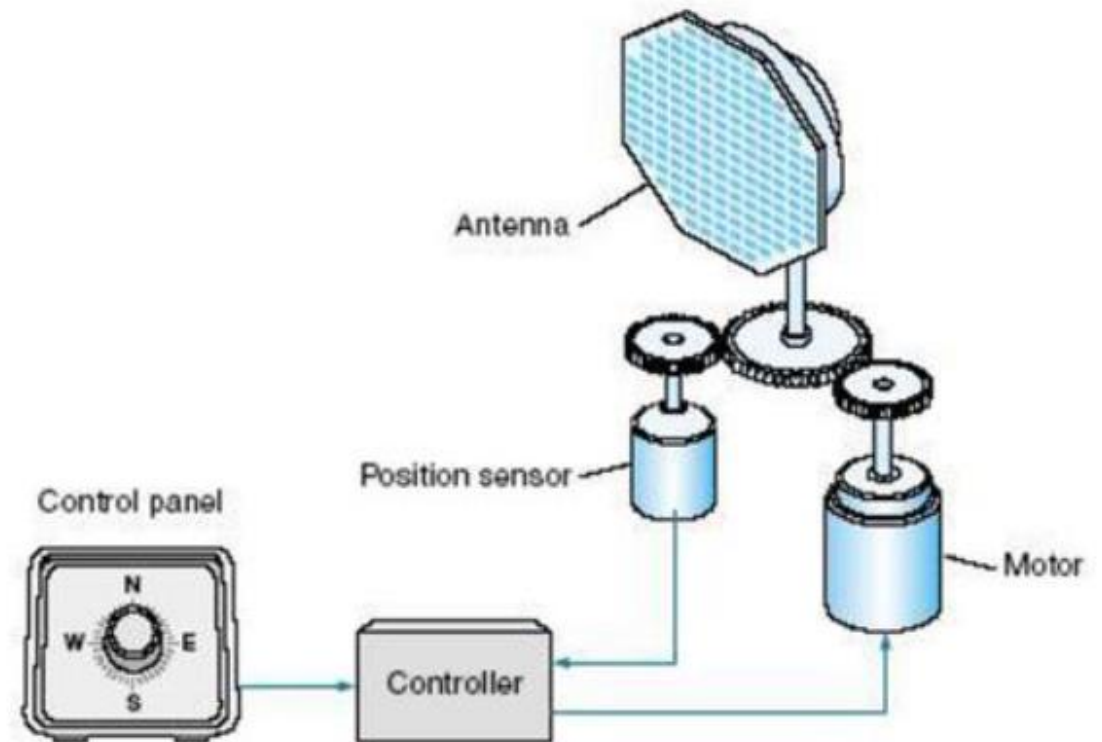
- A traffic flow control system used on roads is time dependent.
- The traffic on the road becomes mobile or stationary depending on the duration and sequence of the light glow.
- The sequence and duration are controlled by relays which are predetermined and not dependent on the rush on the road.



EXAMPLE OF CONTROL SYSTEM:

SERVO

- A Servo System (or servomechanism) is a feedback control system.
- Servo means slave/serving and mechanism means command; thus servo mechanism systems are slave to command systems.
- Usually, the output is some mechanical position, velocity or acceleration.



EXAMPLE OF CONTROL SYSTEM: HUMAN

| | |
|-----------------------------|-------------------------------|
| Human traveling on the road | |
| Input | Information about surrounding |
| Plant | Human |
| Controller | Brain |
| Output | Position adjustment |

ANALYSIS AND DESIGN OF CONTROL SYSTEM

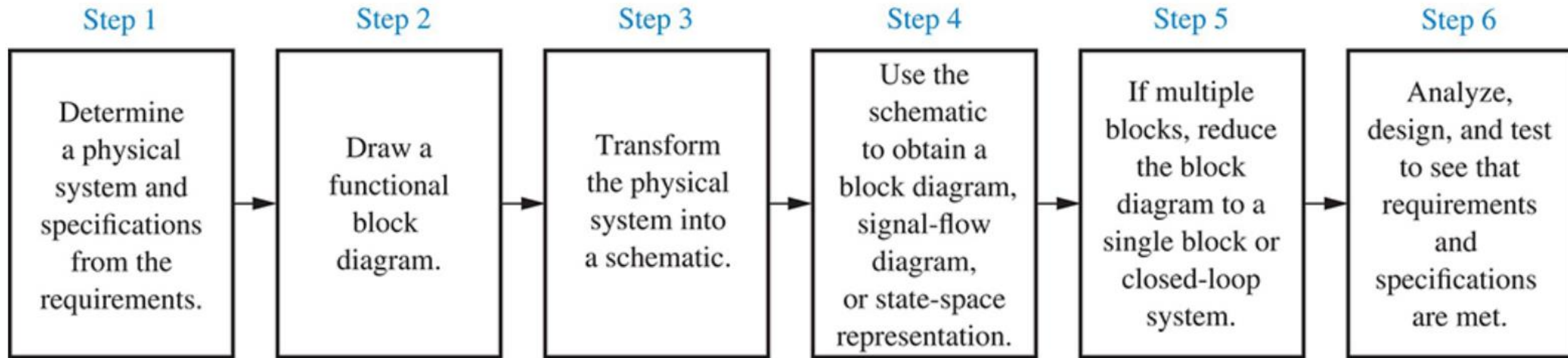
- **Linear vs. Nonlinear Control System**

- A Control System in which output varies linearly with the input is called a linear control system. In other words, a system in which the principle of superposition applies.

- **Time Invariant and Time Variant System**

- When the characteristics of the system do not depend upon time itself then the system is said to time invariant control system.
- Time varying control system is a system in which one or more parameters vary with time.

THE DESIGN PROCESS



IDEAL CONTROL SYSTEM

Accuracy

Sensitivity

External
disturbance
or noise

Stability

Bandwidth

Speed

Oscillations

READINGS

| No. | Book | Details |
|-----|--|--------------------------------------|
| 1 | Control systems Engineering, N.Nise, Seventh Edition | Chapter 1 |
| 2 | Modern Control systems Engineering, R. Dorf | Good for examples of control systems |
| 3 | Control systems Principles and Design by M.Gopal | Chapter 1, 3 (optional) |

ASSIGNMENT

1. History of Control System
2. Analog and Digital Control Systems
3. Single Input Single Output and Multiple Input Multiple Output Control System
4. Open-loop versus Closed loop systems
5. Continuous Data vs. Discrete Data System
6. Study the case study of Antenna Azimuth: An Introduction to Position Control Systems