ME 441 – CONTROL SYSTEMS

Lecture 1

- Design Of Feedback Control Systems, 4th Edition

R. T. Stefani, C. J. Savant, B. Shahian, G. H. Hostetter

Course Instructor:

Dr. Saad Arif – Assistant Professor – sarif@kfu.edu.sa

Office # 1056, Department of Mechanical Engineering, College of Engineering,

King Faisal University, Al-Ahsa, Saudi Arabia

Lecture Video Links

Lecture-wise: https://youtube.com/playlist?list=PLRsy8EQwnUTPJ_IsvljQzYlGvvAHbZTpU

Topic-wise: https://www.youtube.com/playlist?list=PLRsy8EQwnUTNP5gOU3NtrtyrALE1obZZH

For Further Information, Visit the Channel: www.bit.ly/saadarif

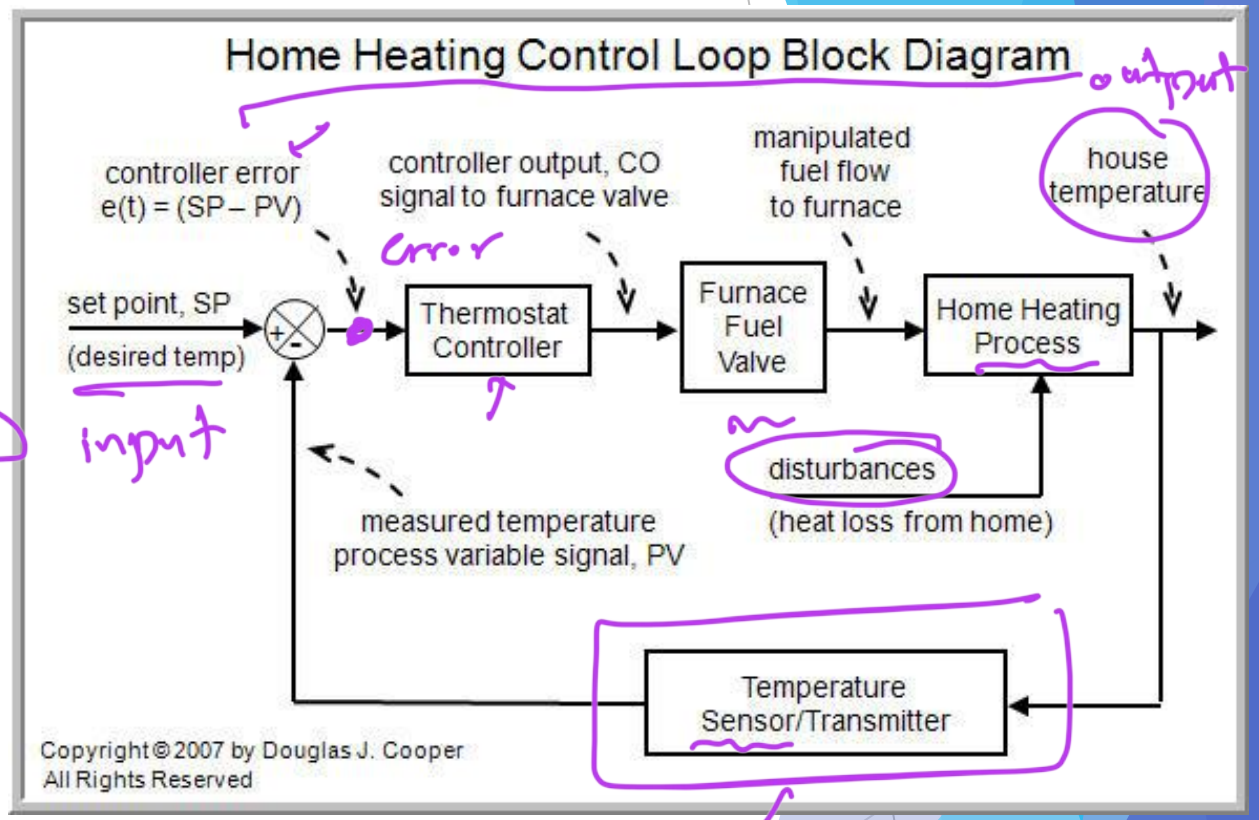
Objectives

- Define a control system
- Explain why control systems are important
- Introduce basic components of a control system
- Give some examples of control system applications
- Explain why feedback is incorporated into most control systems
- Introduce types of control systems

Basic Concepts

Control system design process consists of

- Creating a mathematical model of the system (Block Diagram)
- Identifying the contents of blocks within the diagram
- Selecting values of adjustable parameters
- Adding components to provide acceptable performance



Feedback systems actively used in

- Automated manufacturing plants
- Automobiles
- House hold appliances
- Entertainment systems

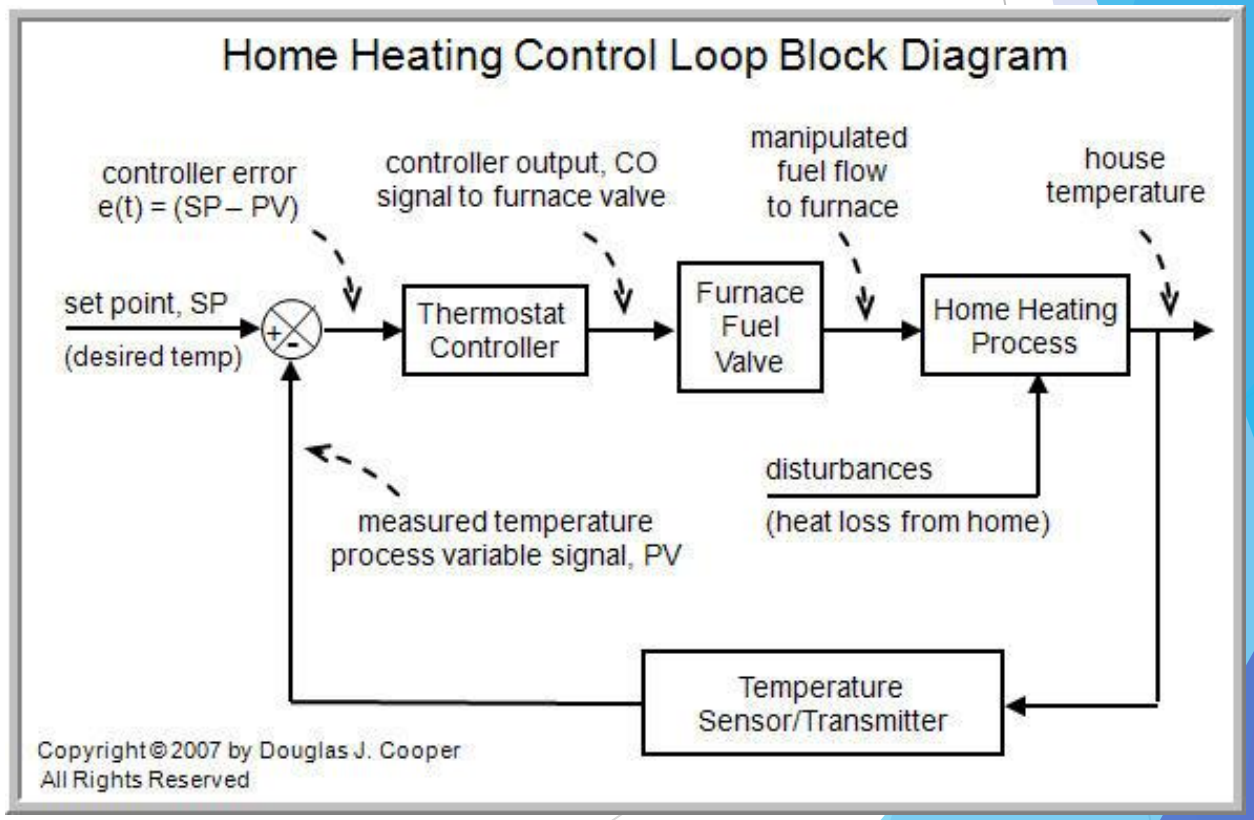
Prerequisite Knowledge

- Complex Analysis
  - Complex numbers & their properties, laws, functions and plotting on complex plane
- Ordinary Differential Equations
  - 1st & 2nd order ordinary integro-differential equations
- Laplace Transforms
  - Solution of linear ODEs using Laplace transforms and Laplace theorems, Inverse Laplace transforms
- Linear Algebra
  - Solutions of simultaneous algebraic equations
- Polynomial
  - Higher order polynomials & their arithmetic, Partial fractions
- Geometry
  - Solution of problems through geometric identities & laws over plots

Terminology

- System

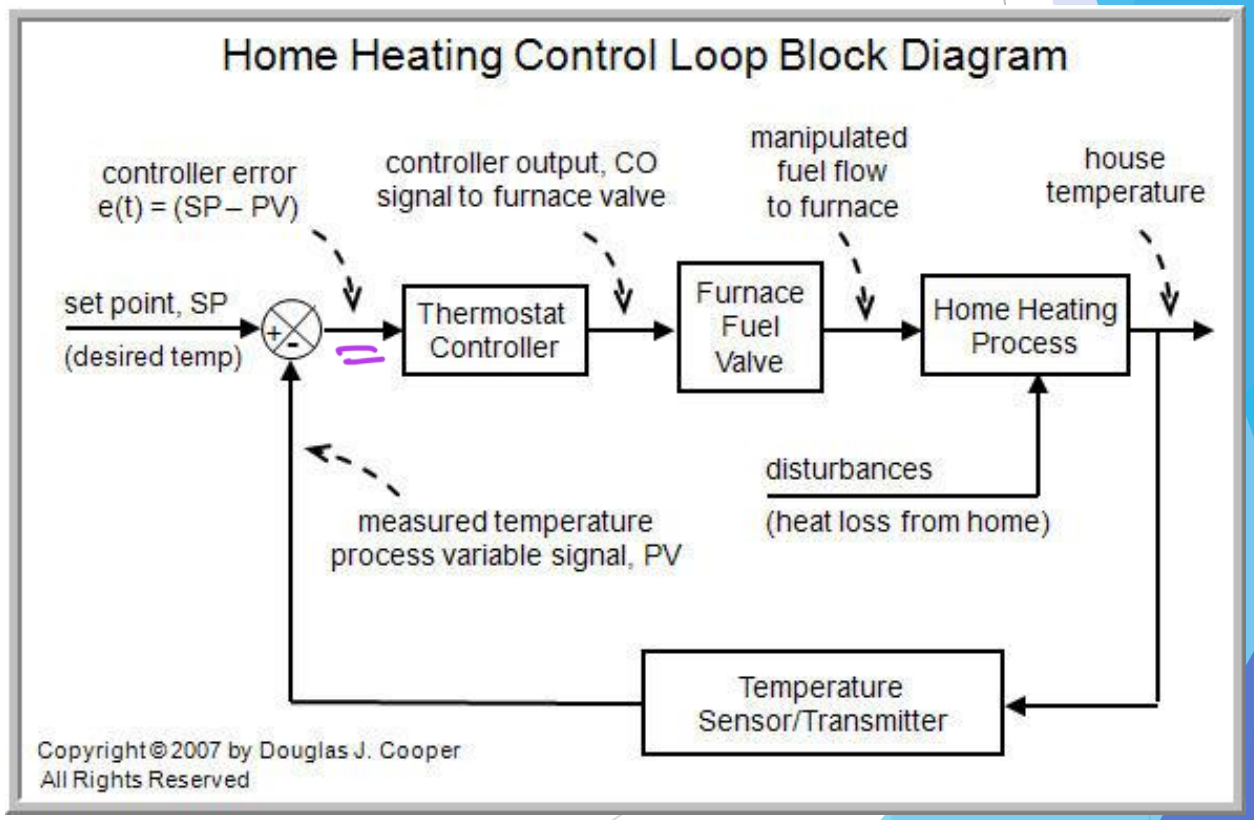
An arrangement or combination of different physical components that are connected or related together to form an entire unit to achieve a certain objective. E.g., Classroom, Car etc.



Terminology

- Control

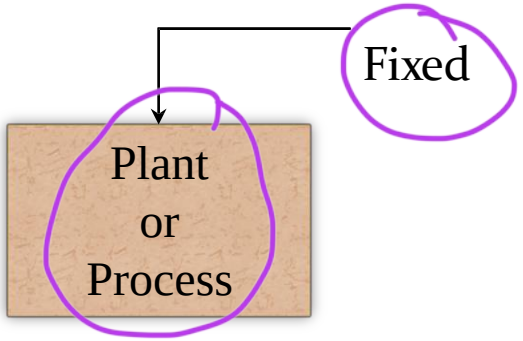
To regulate direct and command a system so that a desired objective is achieved



Terminology

- Plant/Process

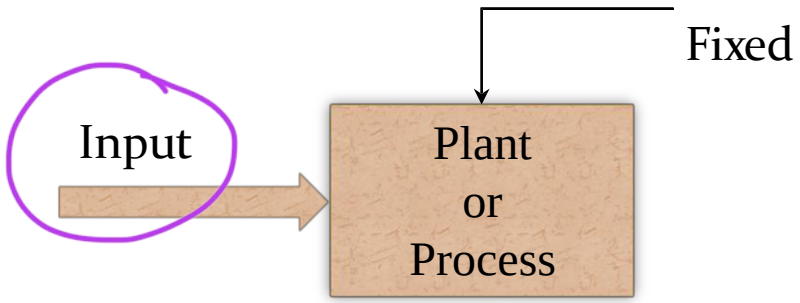
Portion of the system to be controlled. It is fixed as far as the control system designer is concerned. The designer's job is to ensure that the plant operates as required



Terminology

- Inputs

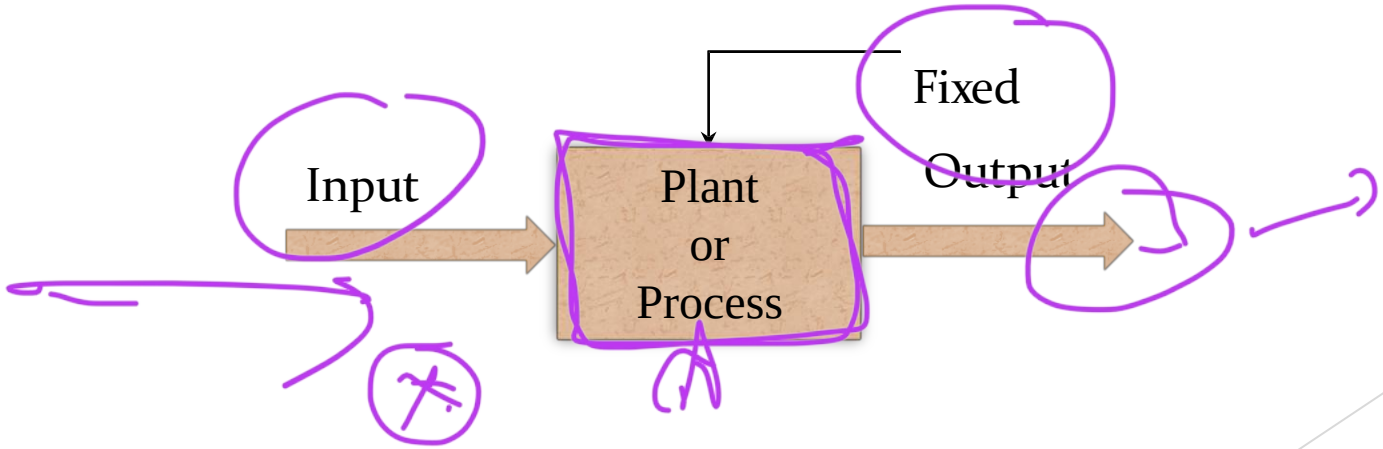
The applied or excitation signal applied to a control system to get a specific output



Terminology

- Outputs

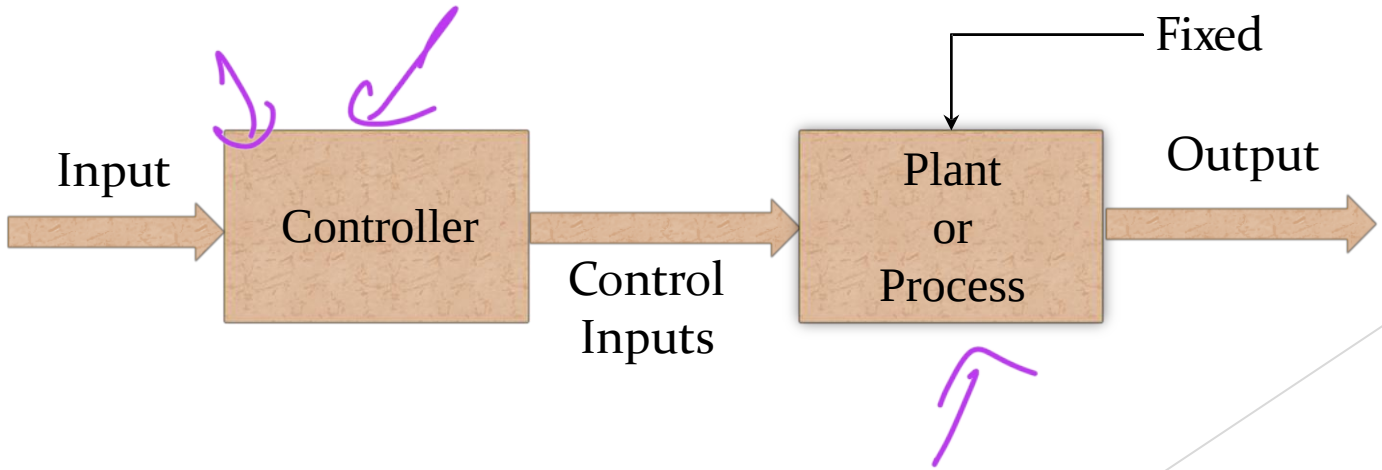
The actual response obtained from a control system due to the application of the input



Terminology

- Controller

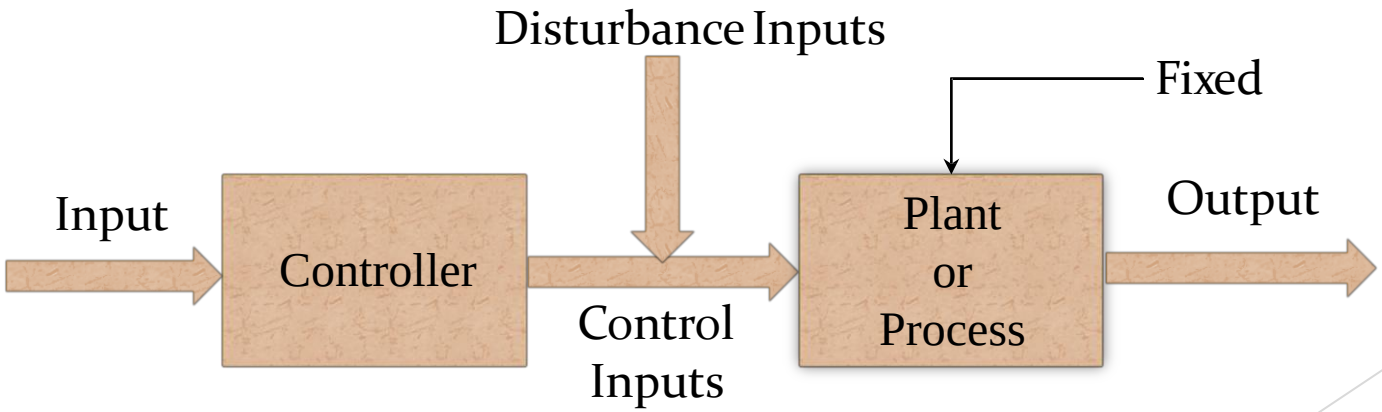
Internal or external element of the system used to control the plant or process. The controller generates plant input signals designed to produce the desired outputs. Some plant inputs are accessible to the designer and some are not available



Terminology

- Disturbances

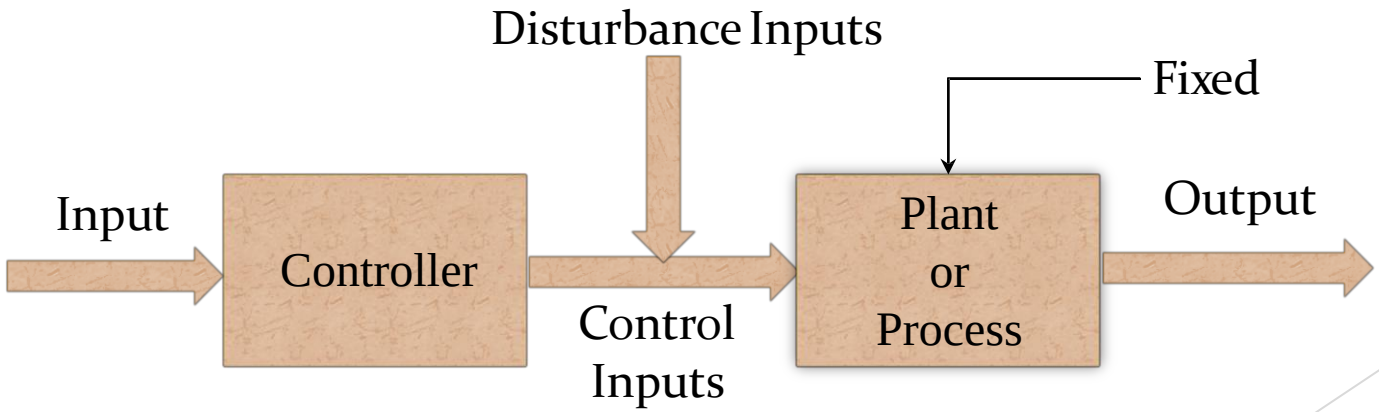
A disturbance is an uncontrollable input that has an undesired effect on the desired output of the system. It may be internal (produced within the system) or external



Terminology

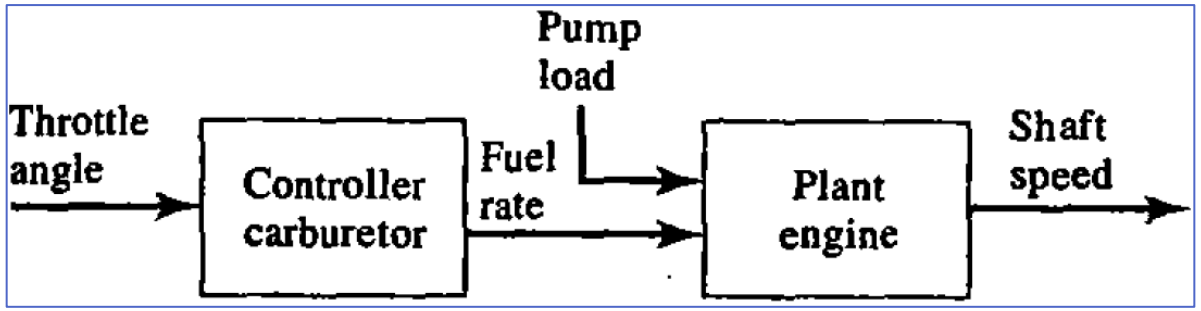
- Open Loop System

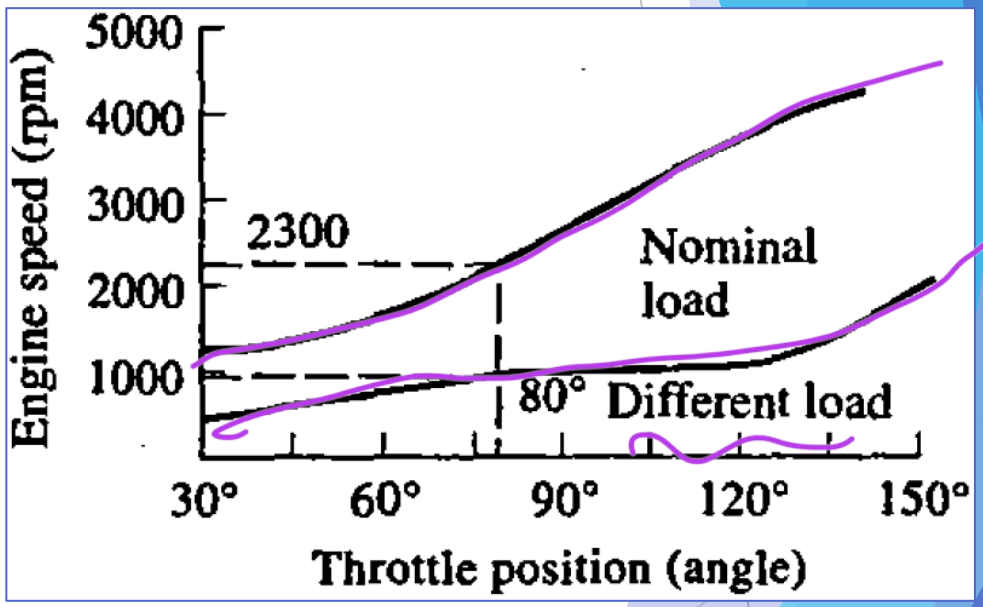
A system in which the control inputs are not influenced by the plant outputs i.e., there is no feedback around the plant



Terminology

- Open Loop System

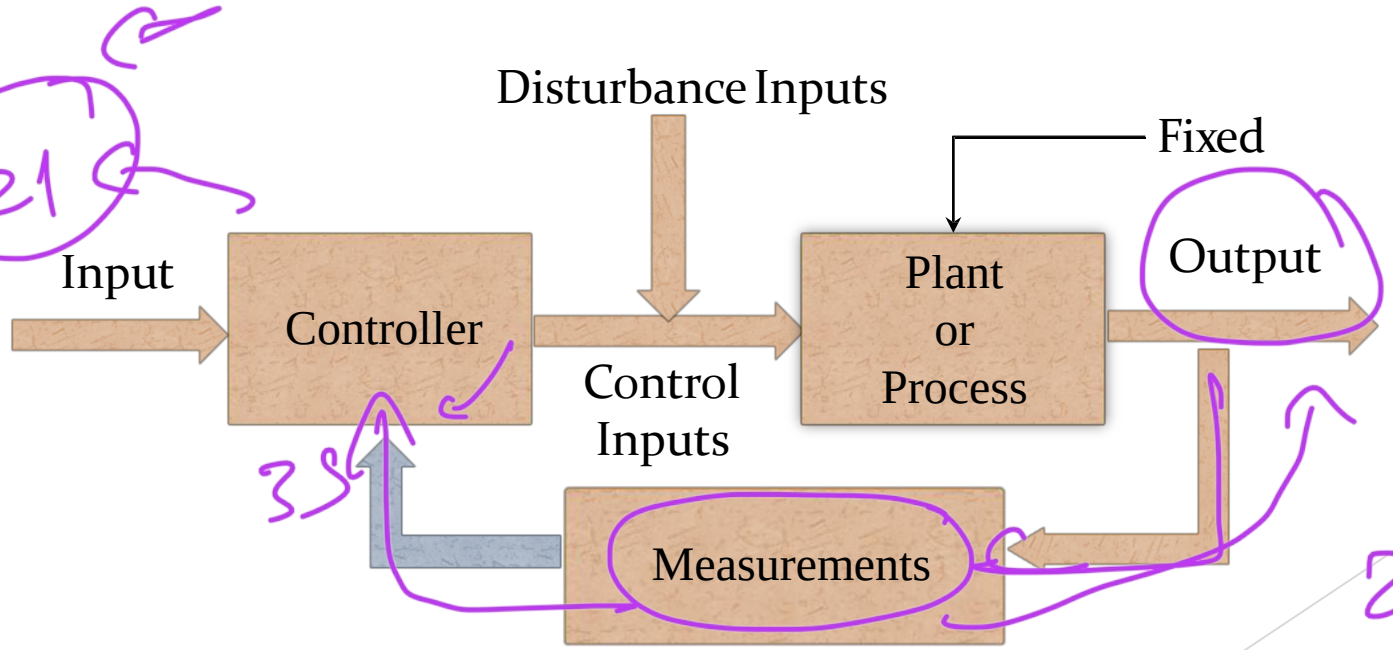




Terminology

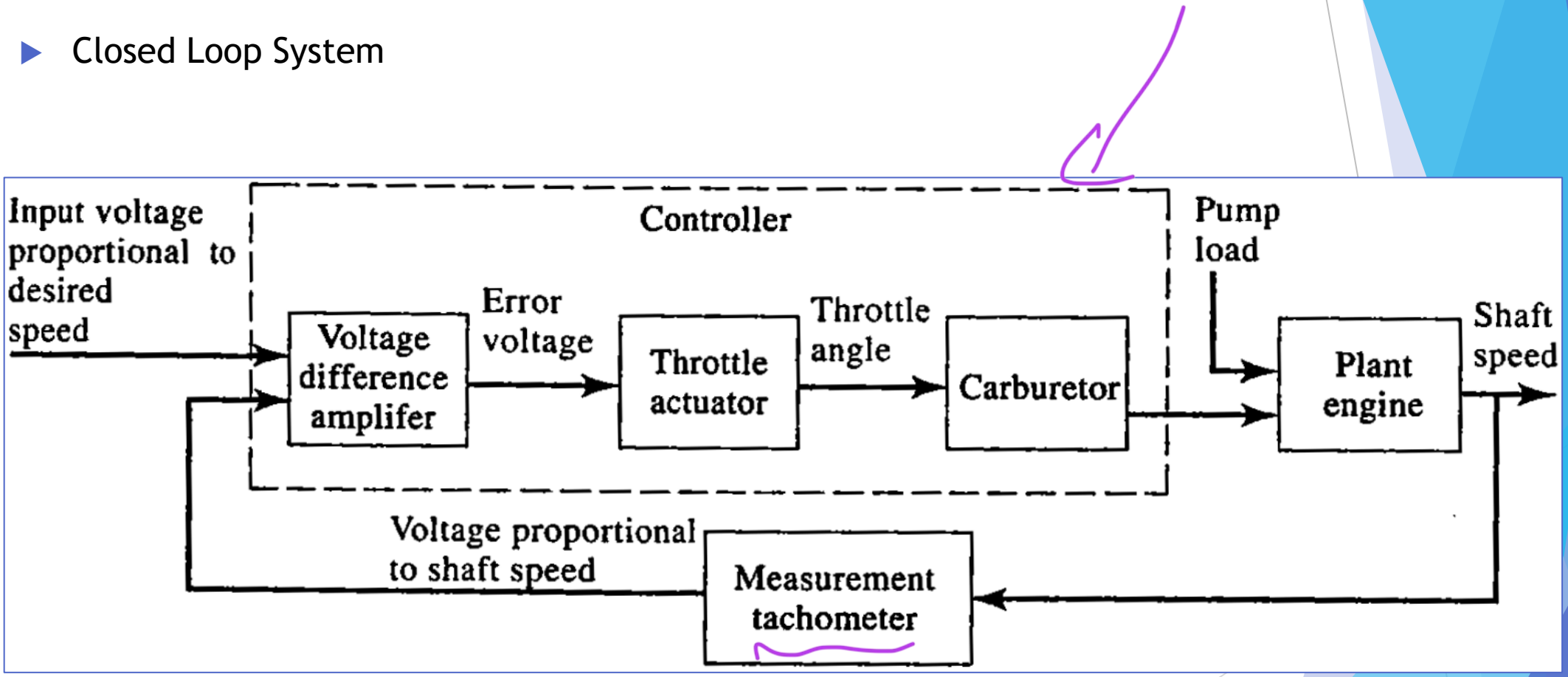
- Closed Loop System

A system in which the control inputs are influenced by the plant outputs i.e., a path (or loop) is provided from the output back to the controller.

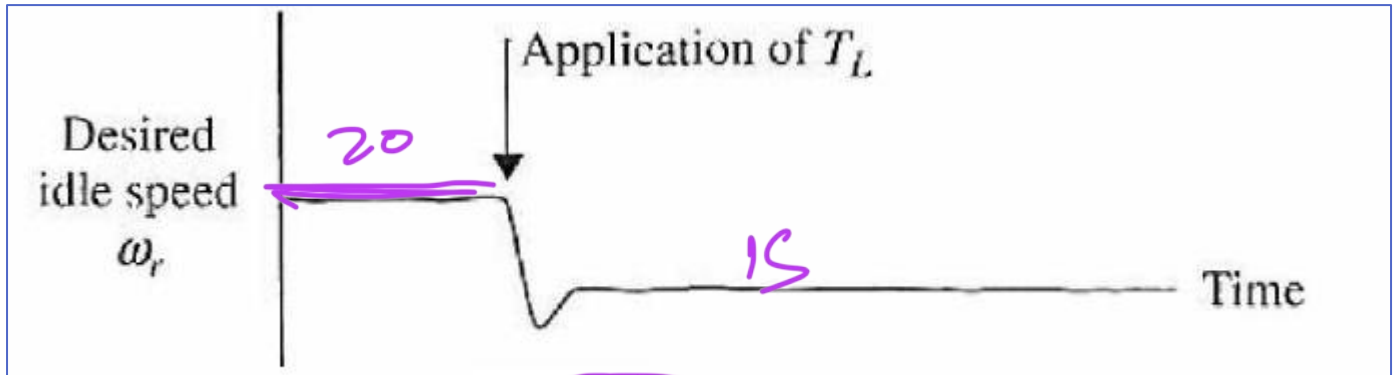


Terminology

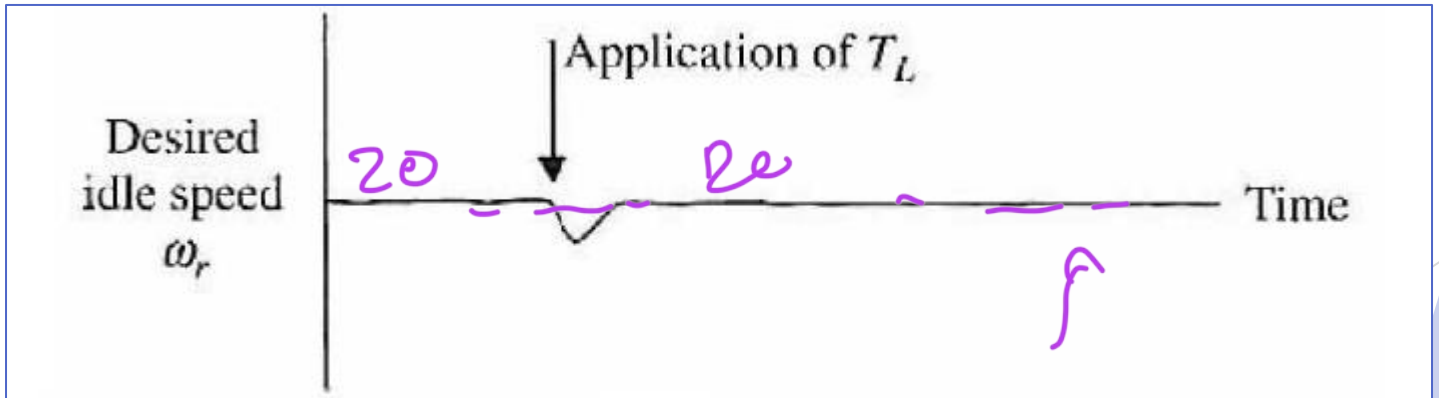
- Closed Loop System



Effect of Feedback



Typical response of the open-loop idle-speed control system.



Typical response of the closed-loop idle-speed control system.

Advantages of Feedback

- Increased accuracy
- Reduced sensitivity to changes in components
- Reduced effects of disturbances
- Increased speed of response and bandwidth

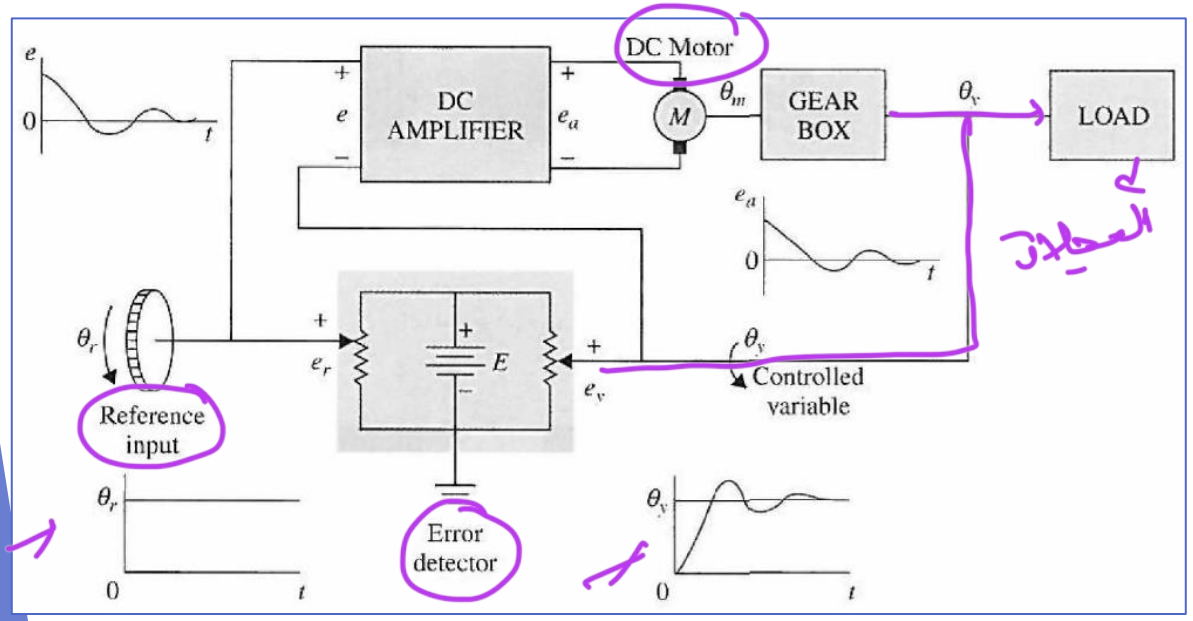
Feedback should be positive or negative?

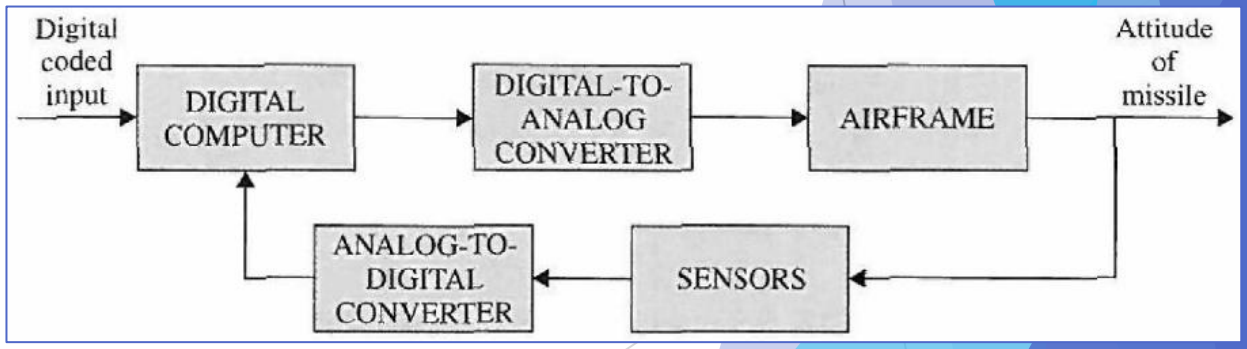
Examples of Open Loop & Closed Loop Control Systems

Input	Controller	Plant	Disturbance	Output	Measurement
Heat setting	Dial	Hair dryer	Hair dampness	Hot air temperature	None
Speed setting	Dial	Drill	Type of material	Rotating drill bit speed	None
Desired temperature	Thermostat	Furnace	Outside temperature	Hot air temperature	Room temperature
Desired speed	Cruise control	Auto engine	Driving conditions	Car speed	Engine rpm
Desired performance	Electorate	President	Economy	Decisions	Evaluation

Types of Control Systems

- Linear VS Non-Linear Control Systems
- Time Invariant VS Time Variant Systems
- Continuous Data VS Discrete Data Control Systems





Control System Applications

- Intelligent systems
  - Machine tools, Flexible robotics, Process control
- Control in virtual prototyping and hardware in the loop
- Smart Transportation Systems
  - Climate Control
  - Anti-lock Brake System (ABS)
  - Traction Control System
  - Cruise Control System
  - Dynamic Stability Control
  - Emergency Brake Assist
  - Drive-by-wire System / Steering Control
  - Driver Assist System
  - Active Suspension System and Cross Wind Stabilization