Control Systems
(EI181402)

MODULE 1: Elementary Concepts of Control Systems

Definition, open loop and closed loop systems, definitions and examples of linear, non-linear, time-invariant and time variant, continuous and discrete control system, block diagram representation of control systems.

MODULE 2: Models of Physical Systems

Transfer function: definition and properties, poles, zeros and pole-zero map, formulation of differential equations for physical systems and derivation of transfer function: mechanical and electrical systems, derivation of transfer function using block diagrams reduction techniques and signal flow graphs, signal flow graph from block diagram, analogous systems.

MODULE 3: Introduction to Control System Components

Error detectors, rotary potentiometers, servomotors, tacho-generators, servo amplifiers and determination of transfer functions.

MODULE 4: Time Domain Analysis:

Concept of transient response and steady-state response, standard test signals - step, ramp, parabolic and impulse signals, time response of first order and second order systems, closed loop transfer function, characteristic equation, performance specifications in time domain, derivative and integral control and their effects on the performance of the 2^{nd} order systems, system types and error constants, generalized error coefficients, transient response of higher order systems (outline only).

MODULE 5: Stability Analysis

Concepts of control system stability, relation between stability and pole locations, Routh-Hurwitz stability criterion, scopes and limitations of the criterion, root-locus techniques, system analysis and design using root-locus technique.

MODULE 6: Frequency Response Analysis

Frequency response and its specifications, stability analysis using frequency response plots: Bode plot, polar plot, log-magnitude vs phase plots, Nyquist plot and Nyquist stability criterion, M and N circle.

MODULE 7: Compensation Techniques

Preliminary design specifications in time and frequency domain, gain compensation, lead and lag compensation.

Text Books:

1. Nagrath and Gopal: Control Systems Engineering
2. K Ogata: Modern Control Engineering

Reference Books:

1. B Kuo: Automatic Control Systems
2. A Anand Kumar: Control Systems
3. Salivahanan, Rengaraj and Venkata krishnan: Control Systems Engineering
4. Gibson and Teylor: Control System Components

MODULE 1: Elementary Concepts of Control Systems

Definition, open loop and closed loop systems, definitions and examples of linear, non-linear, time invariant and time variant, continuous and discrete control system, block diagram representation of control systems.

Control Systems

- A control system manages, commands, directs, or regulates the behaviour of other devices or systems using control loops to achieve a desired result.

There are two main types of control systems. They are as follow:

1. Open-loop control systems
2. Closed-loop control systems

Open loop systems

A control system in which the control action is totally independent of the output of the system is called an open-loop control system.

A manual control system is also an open-loop control system.

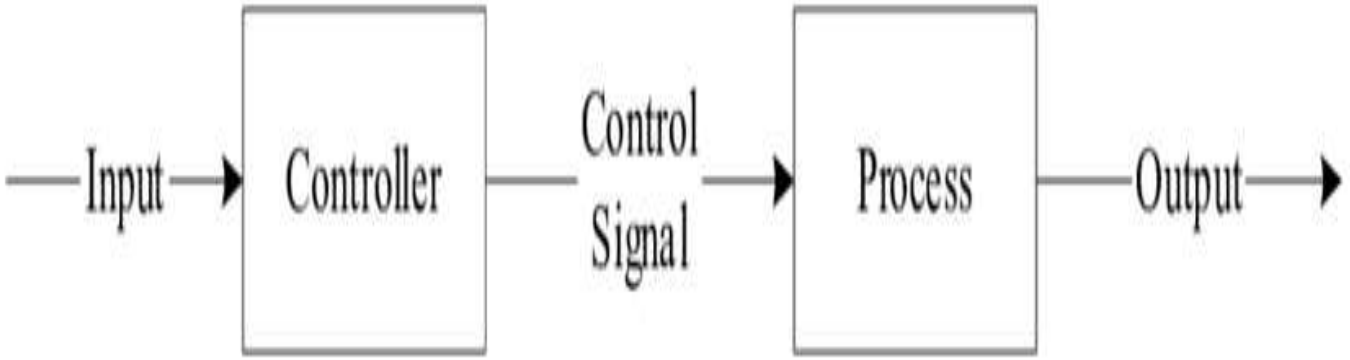

Fig. Open-loop control system

Examples:

Electric bulb
Electric hand drier
Volume of the audio system
Automatic washing machine
Clothes drier etc..

Advantages of open-loop control systems are:

1. Simple in construction and design.
2. Economical.
3. Easy to maintain.
4. Generally stable.
5. Convenient to use as output is difficult to measure.

Disadvantages of open-loop control systems are:

They are inaccurate.

They are unreliable.

Any change in output cannot be corrected automatically.

Closed loop systems

- Control systems in which the output has an effect on the input quantity in such a manner that the input quantity will adjust itself based on the output generated is called a closed-loop control system.
- An open-loop control system can be converted into a closed loop control system by providing feedback.

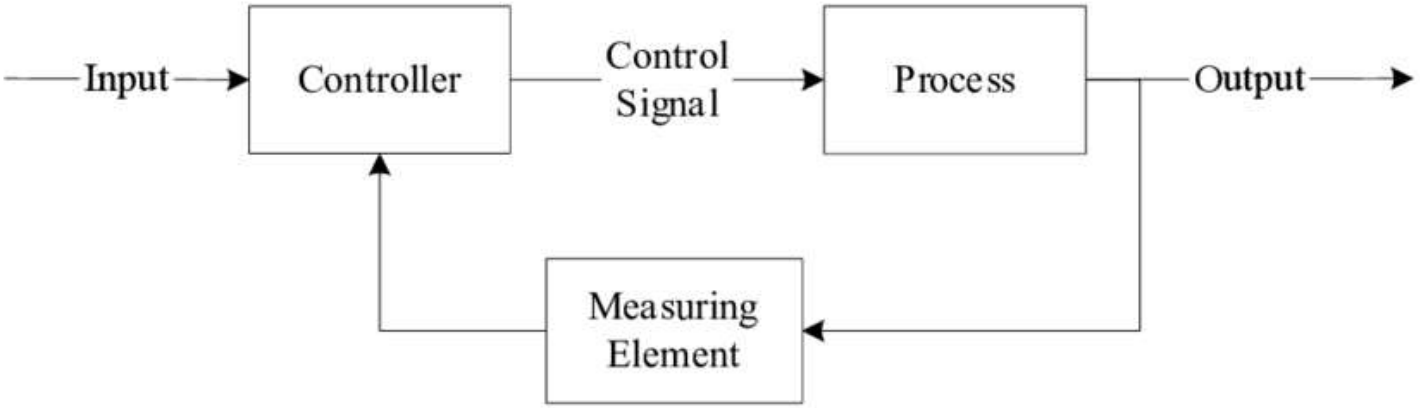

Fig. Closed-loop control system

Examples:

Automatic Electric Iron
Water Level Controller
Air Conditioner etc..

Advantages of closed-loop control systems are:

1. Closed loop control systems are more accurate even in the presence of non-linearity.
2. Highly accurate as any error arising is corrected due to the presence of a feedback signal.
3. The bandwidth range is large.
4. Facilitates automation.
5. The sensitivity of the system may be made small to make the system more stable.
6. This system is less affected by noise.

Disadvantages of a closed-loop control systems are:

1. They are costlier.
2. They are complicated to design.
3. Required more maintenance.
4. Feedback leads to an oscillatory response.
5. Overall gain is reduced due to the presence of feedback.
6. Stability is the major problem and more care is needed to design a stable closed loop system.

Linear Control Systems

- First we should understand the principle of superposition.
- The principle of superposition theorem includes two properties and they are : **Homogeneity:** A system is said to be homogeneous, if we multiply input with some constant A then the output will also be multiplied by the same value of constant (i.e. A).

- **Additivity:** Suppose we have a system S and we are giving the input to this system as a_1 for the first time and we are getting the output as b_1 corresponding to input a_1. On the second time we are giving input a_2 and correspond to this we are getting the output as b_2.

- Now if we are giving input as a summation of the previous inputs (i.e. $a_1 + a_2$) and corresponding to this input suppose we are getting the output as ($b_1 + b_2$) then we can say that system S is following the property of additivity.

Non-linear Control Systems

- A **nonlinear control system** as a control system which does not follow the principle of homogeneity.

Time invariant and time variant system

Continuous and discrete control system

Block diagram representation of control systems