CONTROL SYSTEM [TH-3]

6^{TH} SEM ELECTRICAL ENGG.

Under SCTE&VT, Odisha

PREPARED BY: -

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Closed-loop control system: It is a control system where its control action depends on both of its input signal and output response.

1.3. Open-loop control system and Closed-loop control system

1.3.1. Open-loop control system:

It is a control system where its control action only depends on input signal and does not depend on its output response as shown in Fig.1.1.

Fig.1.1. An open-loop system

Examples: traffic signal, washing machine, bread toaster, etc.

Advantages:

- Simple design and easy to construct
- Economical
- Easy for maintenance
- Highly stable operation

Dis-advantages:

- Not accurate and reliable when input or system parameters are variable in nature
- Recalibration of the parameters are required time to time

1.3.2. Closed-loop control system:

It is a control system where its control action depends on both of its input signal and output response as shown in Fig.1.2.

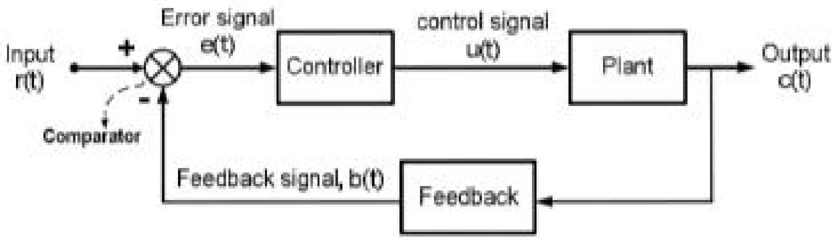

Fig.1.2. A closed-loop system

Examples: automatic electric iron, missile launcher, speed control of DC motor, etc.

Advantages:

- More accurate operation than that of open-loop control system
- Can operate efficiently when input or system parameters are variable in nature
- Less nonlinearity effect of these systems on output response
- High bandwidth of operation
- There is facility of automation
- Time to time recalibration of the parameters are not required

Dis-advantages:

- Complex design and difficult to construct

- Expensive than that of open-loop control system
- Complicate for maintenance
- Less stable operation than that of open-loop control system

1.3.3. Comparison between Open-loop and Closed-loop control systems:

It is a control system where its control action depends on both of its input signal and output response.

Sl. No.	Open-loop control systems	Closed-loop control systems
1	No feedback is given to the control system	A feedback is given to the control system
2	Cannot be intelligent	Intelligent controlling action
3	There is no possibility of undesirable system oscillation(hunting)	Closed loop control introduces the possibility of undesirable system oscillation(hunting)
4	The output will not very for a constant input, provided the system parameters remain unaltered	In the system the output may vary for a constant input, depending upon the feedback
5	System output variation due to variation in parameters of the system is greater and the output very in an uncontrolled way	System output variation due to variation in parameters of the system is less.
6	Error detection is not present	Error detection is present
7	Small bandwidth	Large bandwidth
8	More stable	Less stable or prone to instability
9	Affected by non-linearities	Not affected by non-linearities
10	Very sensitive in nature	Less sensitive to disturbances
11	Simple design	Complex design
12	Cheap	Costly

1.4. Servomechanism

It is the feedback unit used in a control system. In this system, the control variable is a mechanical signal such as position, velocity or acceleration. Here, the output signal is directly fed to the comparator as the feedback signal, b(t) of the closed-loop control system. This type of system is used where both the command and output signals are mechanical in nature. A position control system as shown in Fig.1.3 is a simple example of this type mechanism. The block diagram of the servomechanism of an automatic steering system is shown in Fig.1.4.

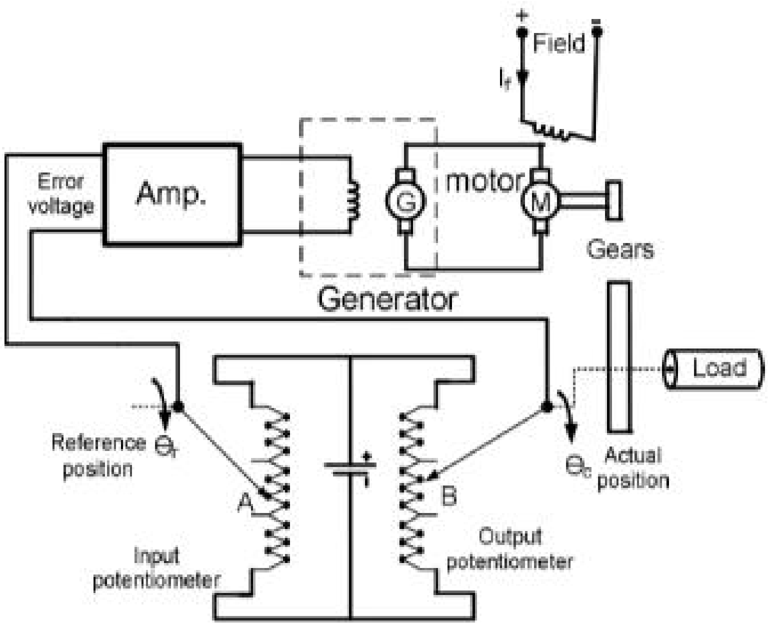

Fig.1.3. Schematic diagram of a servomechanism

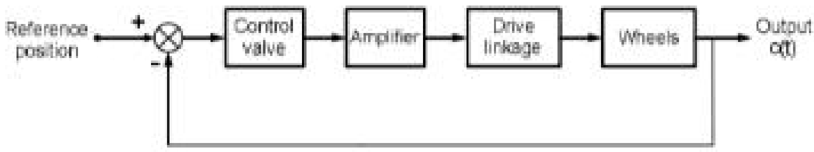

Fig.1.4. Block diagram of a servomechanism

Examples:

- Missile launcher
- Machine tool position control
- Power steering for an automobile
- Roll stabilization in ships, etc.

1.5. Regulators

It is also a feedback unit used in a control system like servomechanism. But, the output is kept constant at its desired value. The schematic diagram of a regulating system is shown in Fig.1.5. Its corresponding simplified block diagram model is shown in Fig.1.6.

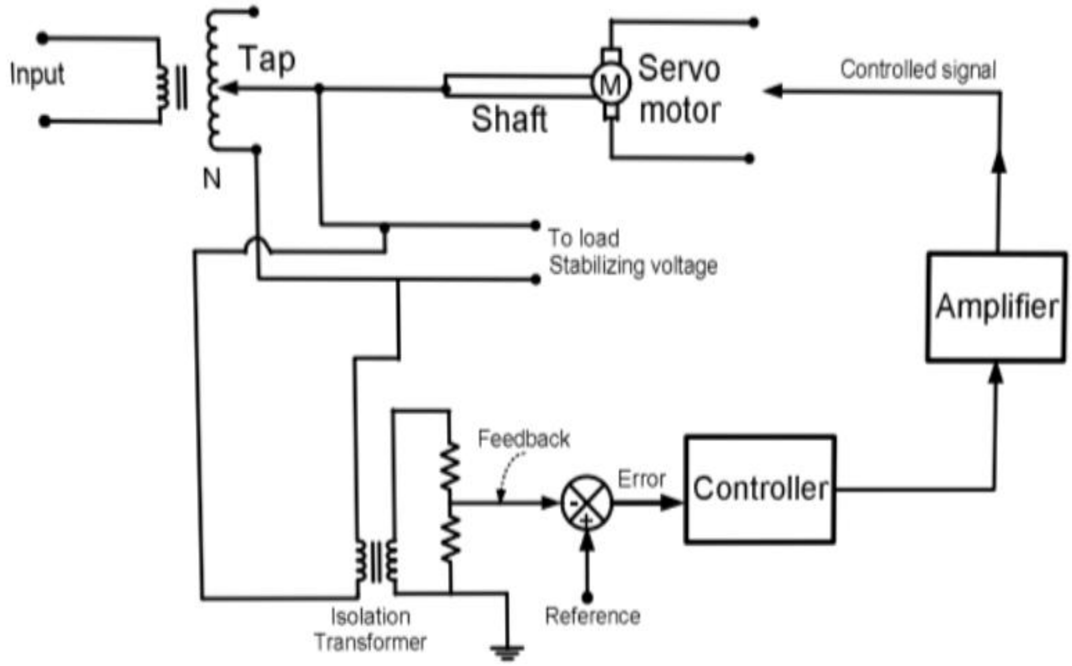

Fig.1.5. Schematic diagram of a regulating system

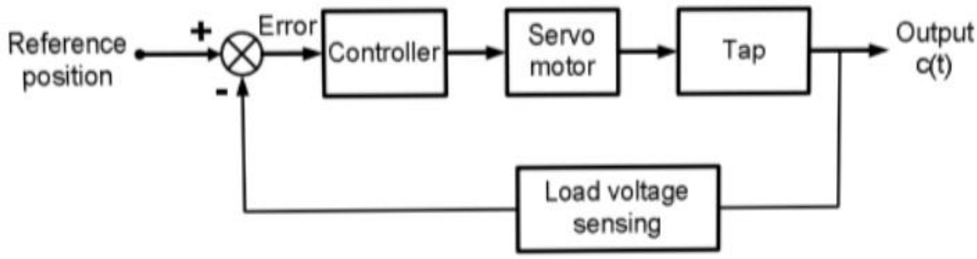

Fig.1.6. Block diagram of a regulating system

Examples:

- Temperature regulator
- Speed governor
- Frequency regulators, etc.

ii. Repeated factors
iii. Unrepeated complex factors

(i) Unrepeated factors

$$\frac{N(s)}{(s+a)(s+b)} = \frac{A}{s+a} + \frac{B}{s+b} = \frac{A(s+b)+B(s+a)}{(s+a)(s+b)} \tag{2.4}$$

By equating both sides, determine A and B.

Example 2.1:

Expand the following equation of Laplacetransform in terms of its partial fractionsand obtain its time-domain response.

$$Y(s) = \frac{2s}{(s+1)(s+2)}$$

Solution:

The following equation in Laplacetransform is expandedwith its partial fractions as follows.

$$\frac{2s}{(s+1)(s+2)} = \frac{A}{(s+1)} + \frac{B}{(s+2)}$$

$$\Rightarrow \frac{2s}{(s+1)(s+2)} = \frac{A(s+2)+B(s+1)}{(s+1)(s+2)}$$

By equating both sides, A and B are determined as $A = -2, B = 4$. Therefore,

$$Y(s) = -\frac{2}{(s+1)} + \frac{4}{(s+2)}$$

Taking Laplace inverse of above equation,

$$y(t) = -2e^{-t} + 4e^{-2t}$$

(ii) Unrepeated factors

$$\frac{N(s)}{(s+a)^2} = \frac{A}{(s+a)^2} + \frac{B}{(s+a)} = \frac{A+B(s+a)}{(s+a)^2} \tag{2.5}$$

By equating both sides, determine A and B.

Example 2.2:

Expand the following equation of Laplacetransform in terms of its partial fractionsand obtain its time-domain response.

$$Y(s) = \frac{2s}{(s+1)^2(s+2)}$$

Solution:

The following equation in Laplacetransform is expandedwith its partial fractions as follows.

$$\frac{2s}{(s+1)^2(s+2)} = \frac{A}{(s+1)^2} + \frac{B}{(s+1)} + \frac{C}{(s+2)}$$

By equating both sides, A and B are determined as $A = -2, B = 4$. Therefore,

$$Y(s) = -\frac{2}{(s+1)^2} + \frac{4}{(s+1)} - \frac{4}{(s+2)}$$

Taking Laplace inverse of above equation,

$$y(t) = -2te^{-t} + 4e^{-t} - 4e^{-2t}$$