SUB - Control System

Faculty Name : Ipseta Mohanty

4. CONTROL SYSTEM :-

Introduction → A system is a collection of objects / components connected together to serve an objective ; or a system is a combination of components that act together to perform an objective.

→ A control system is that means by which any quantity of interest in a machine on which the output quantity is controlled by varying the input quantity.

→ The control system was invented by watts flyball governer in 1767.

→ In control system the behaviour of the system is described by the differential equation.

→ The control system can be classified into two types i.e open loop system and closed loop system.

Classification of control system :-

i. Depending upon the hierarchy, it may be classified as :-
   - a. open-loop control system
   - b. closed-loop control system.
   - c. Optimal control system.
   - d. Adaptive control system.
   - e. Learning control system.

ii. According to presence of human being → a. Manually controlled
   b. Automatic controlled

iii. Depending upon the presence of feedback → a. open-loop
   b. closed-loop.

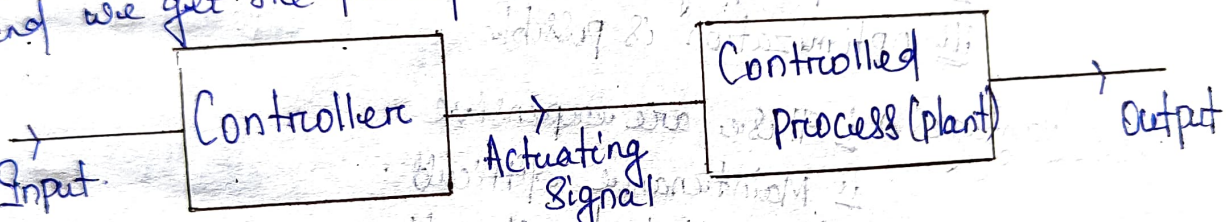
iv. According to the main purpose of the system :-
   - a. position control system
   - b. velocity control system.
   - c. process control system.
   - d. Temp. control system
   - e. Traffic control system.

v According to the method of Analysis :- a Linear control System
b Non-Linear control System.

vi According to order of differential equation :-
a First order control System.
b Second order control System.

Open Loop control System :- The open loop control System is also known as control System without feedback on non-feedback control System.

→ In open loop systems the control action is independent of the desired output.
→ In this System the output is not compared with the reference i/p.
→ The component of the open loop systems are controller and Controlled process.
→ The controller may be amplifier, filter depends upon the System An i/p is applied to the controller gives to the controlled process and we get the desired output.



Ex :- ~~Automatic~~ washing machine.
Field control d.c motor.
Traffic Lamp (automatic)

Advantages :- i Open loop control System are simple
ii This System is economical.
iii Less maintenance is required & not difficult.

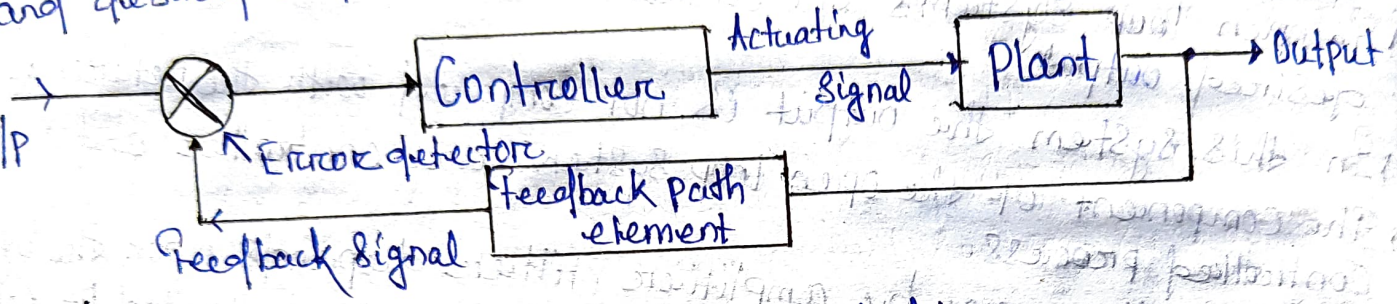
Disadvantages :- i This System is inaccurate.
ii These are not reliable
iii These are very slow.
iv Optimization is not possible.

Closed Loop control System :- Closed loop control systems are also known as feedback control system. In closed loop control system the control action is dependent on the desired output.

→ If any system having one, or more feedback paths forming a closed loop system.

→ In closed loop system the output is compared with the reference input and error signal is produced.

→ The error signal is fed to the controller to reduce the error and desired output is obtained.



Advantages :- i These systems are more reliable.
ii Closed loop systems are faster
iii optimization is possible

Disadvantages → i These are expensive
ii Maintenance difficult.
iii Complicated installation.

Ex :- Room heating system.

Comparision in between open loop and closed loop :-

Open Loop System	Closed loop System.
→ This loop systems are simple and economical.	→ This systems are complex and costlier
→ They consume less power.	→ They consume more power.
→ They are easilier to construct because of less no. of component is required.	→ They are not easy to construct because of more number of component is required.

→ This systems are generally more stable.	→ These are less stable.
→ This systems are inaccurate and unreliable.	→ These are accurate because of feedback.
→ They are more sensitive to noise and other disturbance.	→ They are less sensitive to noise and other disturbance.
→ Optimization is not possible.	→ Optimization is possible.

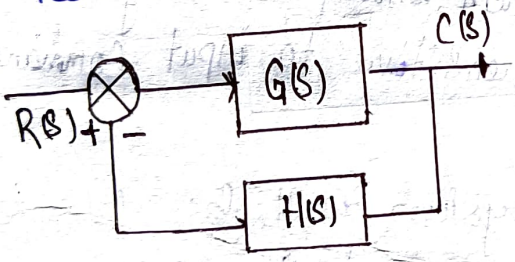
(*) WHAT IS FEEDBACK AND WHAT ARE ITS EFFECT ?

→ Feedback is a process of reducing the errore between the reference input and the system output.

→ The reduction of system errore is merely one of the many important effects that feedback may have upon a system.

→ Feedback also has effects on such system performance characteristic as stability, bandwidth, overall gain, disturbance & sensitive

→ whenever a closed sequence of cause-and-effect relationships exist among the variable of a system, feedback said to exist



$$M = \frac{C}{R} = \frac{G}{1+GH}$$

Effect of feedback on overall gain:-

In open loop control system $\frac{C(S)}{R(S)} = G(S)$ but in closed loop control system $\frac{C(S)}{R(S)} = \frac{G(S)}{1 \mp G(S) * H(S)}$ in case of negative feedback closed loop system $\frac{C(S)}{R(S)} = \frac{G(S)}{1 + G(S) \times H(S)}$

Therefore if we use feedback the gain is reduced by factor $\frac{1}{1+G(S)\times H(S)}$ therefore if we use feedback the overall gain is reduced.

Effect of feedback on Stability:- In an open loop system the parameter variation is does not depend upon noise but in closed loop system the parameter variation is depends upon the atm parameter i.e the open loop system is more stable than closed loop system.

→ If we used feedback then the stability will be decreased.

Effect of feedback on External disturbance or Noise :-

All physical systems are effected by the noise but in without feedback system the noise affection is less as compared to with feedback system.

Effect of feedback on sensitivity:- In sensitivity consideration is more important to design the control system. since all the physical elements have properties that change in environment and edge. i.e we can not consider the parameter of control system to be completly stationary over the entire operating life of the system i.e a good control system should be very insensitive to the parameter variation. but sensitive to input command.

* Stability defines wheather the system will be able follow the input command or be used in general.
* A system is said to be unstable if its output is out of control.

we have $G(s) = \frac{C(s)}{R(s)} = \frac{G}{1+GH}$

If $GH = -1$ the o/p is infinite for any finite input & the system is unstable. But by proper selection of feedback gain the system is stable.

5TH CHAPTER

SERVOMECHANISM

In modern usage, the term Servo is restricted to feedback control systems in which the controlled variable is mechanical position or time derivative of position.

Ex :- Velocity, Acceleration.

Automatic Tank Level control System :-

→ The purpose of this system is to maintain the liquid level h (output) in the tank as close to the desired liquid level (H) as possible, even when the o/p flow rate is varied by opening valve V_1, this has to be done by controlling the opening the valve V_2.

→ The potentiometer act as an error detector. The slider arm A is positioned corresponding to the desired liquid level (H) (i/p reference)

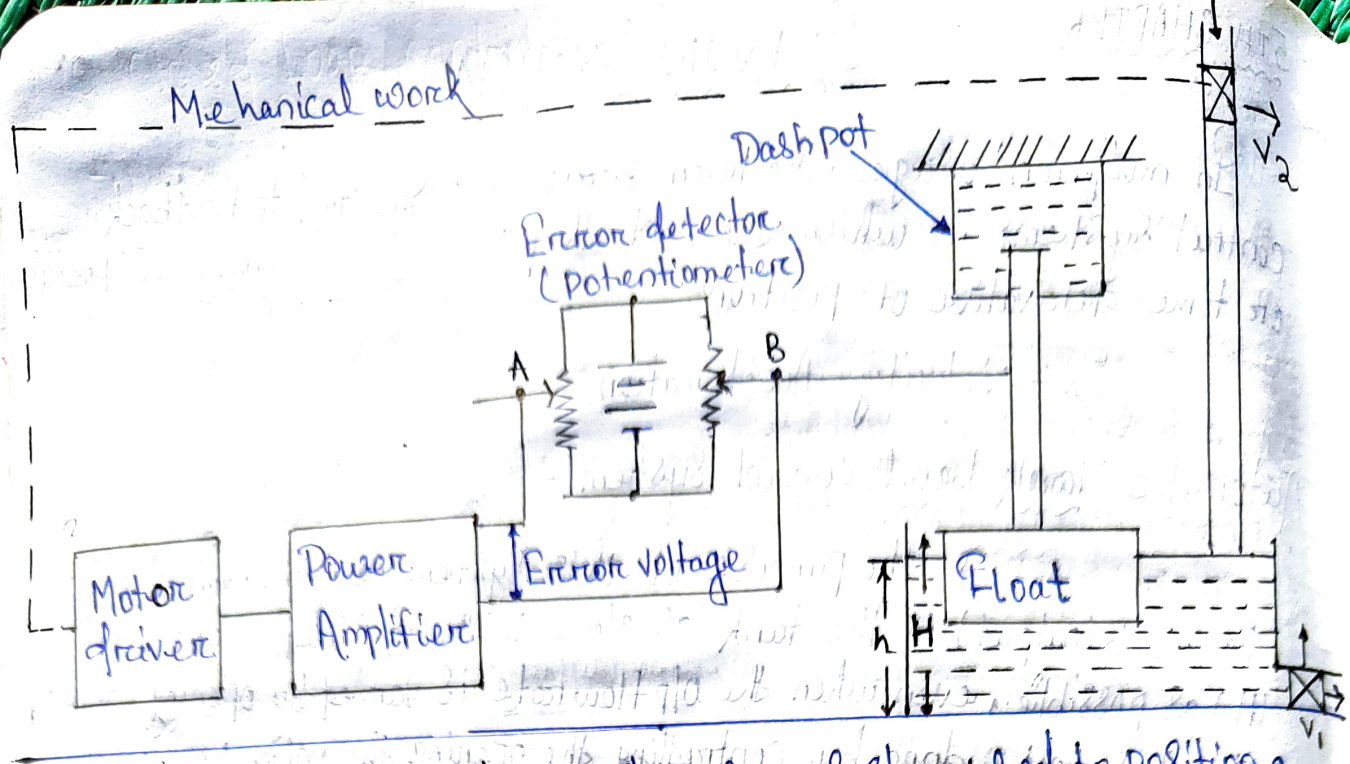
→ The power amplifier and the motor drive from the control element & The float forms the feedback path element. The valve V_2 to be controlled is the plant

→ The liquid level is sensed by a float and its positions the slider arm B on the potentiometer.

→ when the liquid level rises or falls the potentiometer gives an error voltage proportional to the change in liquid level

→ The error voltage actuates the motor through a power amplifier which in turn conditions the plant in order to restore the desired liquid level.

→ Thus, the control system automatically attempts to correct any deviation betn the actual and desired liquid levels in the tank.



Position Control System :- This servosystem used to position a load shaft. In this, the driving motor is geared to the load to be moved.

→ The potentiometer is used as the error detector. The output and desired positions θ_C and θ_R respectively are measured and compared by the potentiometer pair whose o/p voltage V_E is directly proportional to the error in angular position

$$\theta_E = \theta_R - \theta_C$$

→ The voltage $V_E = K_P \theta_E$ is amplified and is used to control the field current of a d.c generator, which supplies armature voltage to the driving motor.

→ Application → machine tool control system, Control of sheet metal thickness in hot rolling mills, radar tracking system. etc.

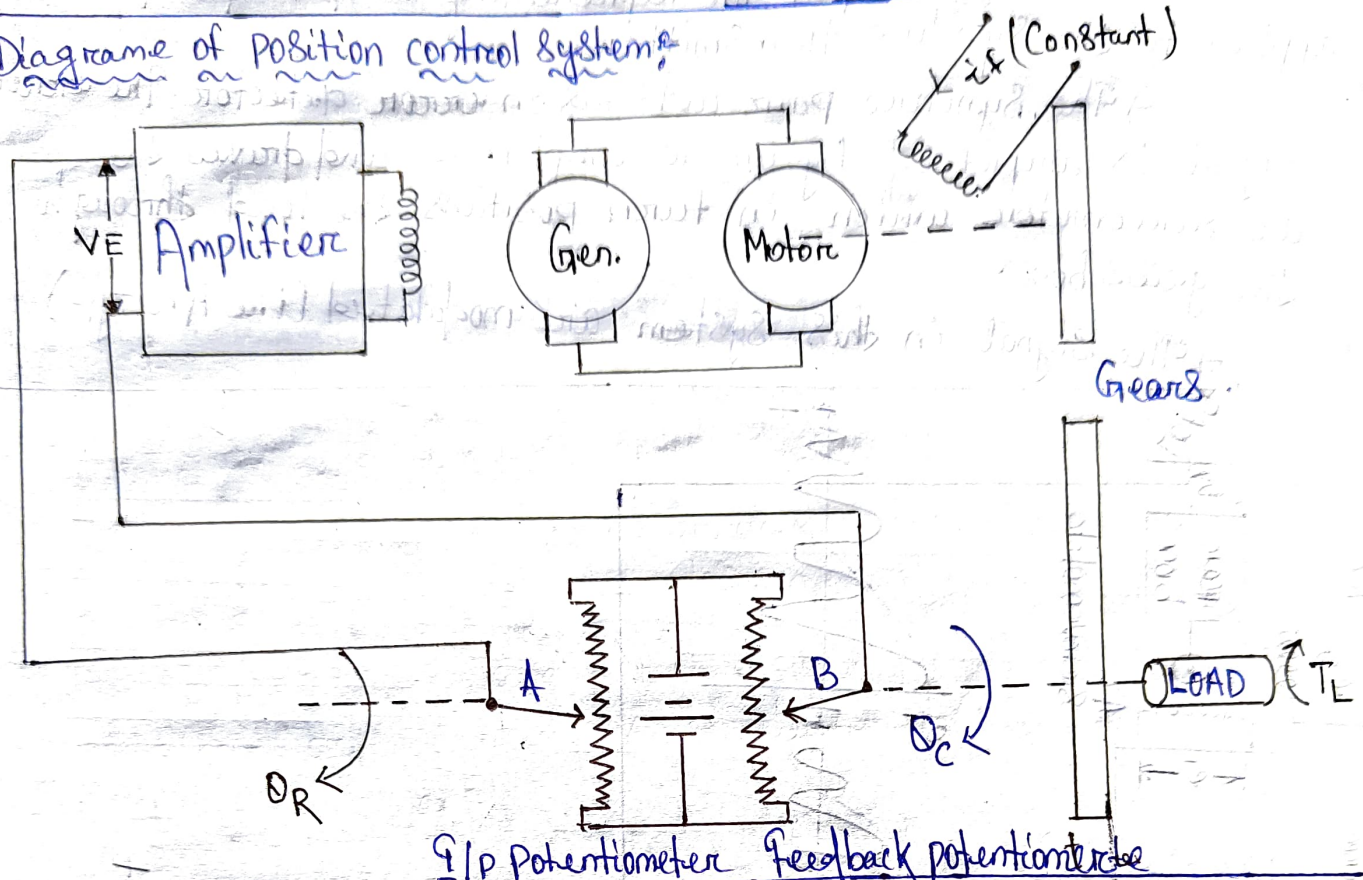
D.C Closed Loop Control System :- Here show a typical d.c (unmodulated) Control System. The output signal θ_Y represents the actual load position and the reference input θ_R represents the desired position of the load.

→ A potentiometer used as a error detector.

→ The electrical error signal proportional to the difference in

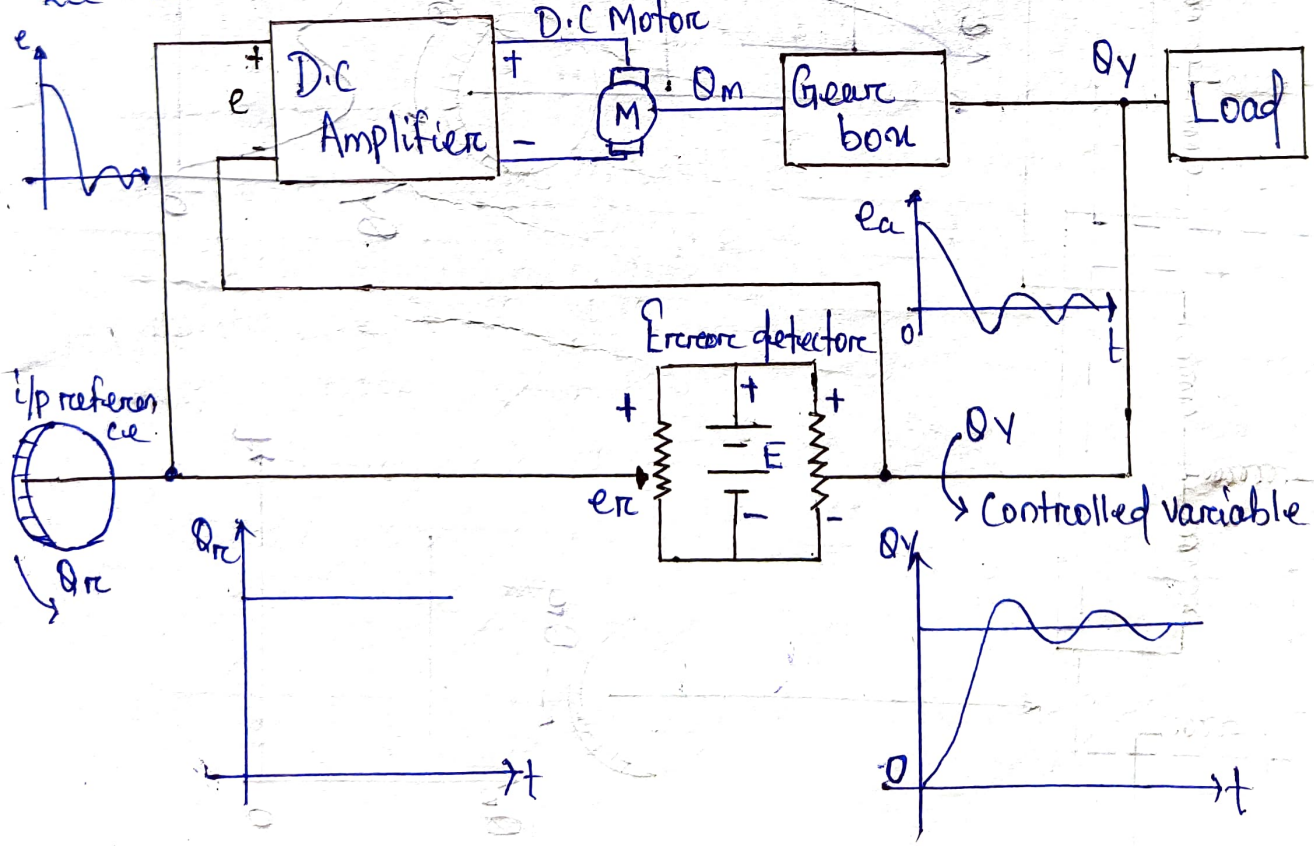
the positions of actual and desired load position is amplified by the d.c amplifier and o/p drives the d.c motor which in turn through the gear box decides the position of load. The signals are all unmodulated (i.e. dc).

Diagrame of position control system:



I/p Potentiometer Feedback potentiometer

D.C closed loop control system:



A.C. Closed Loop control System:-

→ Here the output signal θ_y representing the load position is applied to the Synchro control transformer.

→ The reference input θ_r representing the desired output is applied to the Synchro transmitter.

→ The Synchro pair acts as an error detector. The error signal is amplified by an ac amplifier and drives the ac servomotor which in turn positions the load through the gear box.

→ The signal in this system are modulated (i.e A.C type).