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DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

CONTROL SYSTEMS NOTES (15EC43)
(As per Choice based Credit System (CBCS) Scheme)
IVTH SEMESTER

MODULE-1

Syllabus: Introduction to Control Systems: Types of Control Systems, Effect of Feedback Systems, Differential equation of Physical Systems – Mechanical Systems, Electrical Systems, Analogous Systems. Block diagrams and signal flow graphs: Transfer functions, Block diagram algebra and Signal Flow graphs.

Study Material Referred:

- ✓ Modern Control engineering-K Ogata.
- ✓ Control Systems Engineering- J.Nagarath and M.Gopal.
- ✓ Automatic Control Systems-Benjamin C. Kuo.
- ✓ **VTU Previous year Question papers (2010-2016)**.
- ✓ Problems and solution of controls systems -AK Jairath.
- ✓ Control Systems –KR Varamah.
- ✓ Control System Engineering-Sathyanarayan and P Ramesh Babu

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Introduction to Control System:-

Control System:- It is an arrangement of different physical components such that it gives the desire output for the given input by means of regulate or control either direct or indirect method.

Plant:- It is defined as the portion of a system which is to be controlled or regulated. It is also called as Process.

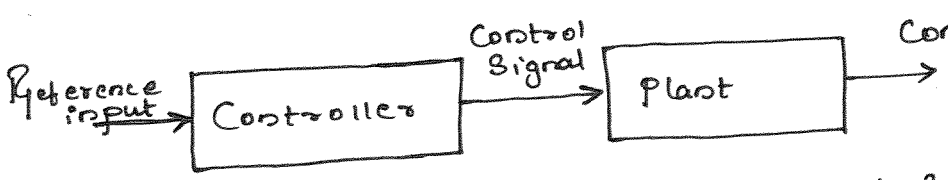
Controller:- It is an Element of the system itself or may be external to the System. It controls the plant or the process.

Input:- The applied Signal or Excitation Signal that is applied to a Control System to get a specified Output is called input.

Output:- The actual response that is Obtained from a Control system due to the application of the input is termed as Output

Types Of Control Systems:-

* Open - loop Control System :



* Open - loop Control system are Control systems in which the Output has no Effect upon the Control action.

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* In such systems, there is no measurement of the output and no subsequent use of that output to generate any control action.

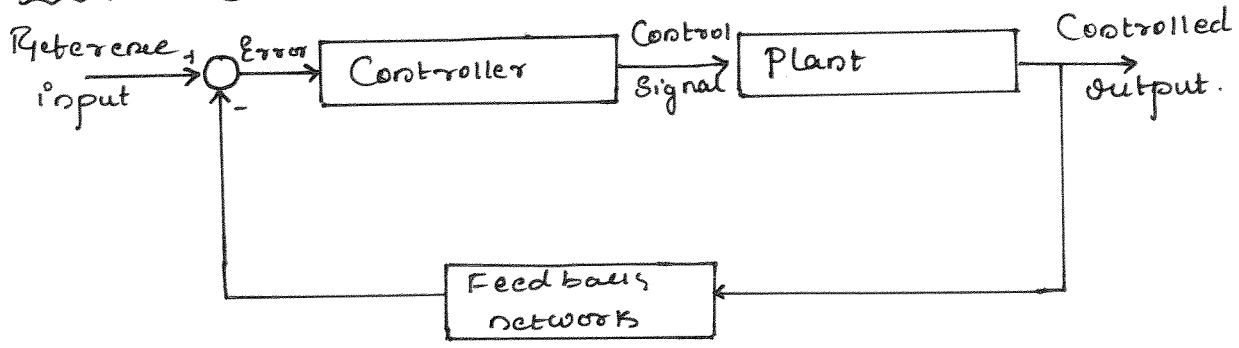
Advantages:-

* It is simple to construct and easy to maintain.
* It is less expensive because of the use of minimum control devices.
* The problem of instability does not exist.
* It is able to perform accurately once the calibration of the input is done.

Dis-advantages:-

* Disturbances, internal or external, causes drifts in the desired output.
* Changes in calibration cause errors in the system.
* Re-calibration of the system may be necessary from time-to-time in order to maintain the required quality of the output.

Closed-Loop Control System:-



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* A closed-loop Control System is one that measures its output and adjusts its input accordingly by using a feedback signal.

* Feedback network consists of passive elements like R, L, C which is been used to feedback the obtained output to the input.

* The Controller subsequently produces the necessary Control signal, which is then applied to the plant or process to reduce the Error and bring the output of the system to the desired value.

* In closed loop system the functionality of the system depends on the difference between input and the feedback.

* A closed loop Control System is also called as feedback Control system.

Advantages:

* Relatively more accurate and Expensive. Components may be used to obtain an accurate control of a given process.

* The influence of internal and External disturbances on the output can be made almost ineffective.

* Transient response of the system can be improved.

* Steady-state Error can be reduced.

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Disadvantages:-

* It requires more Equipment and Components and it is costlier
* There is a tendency to Over Correct Errors, which may Create Oscillations in the System Output. This may Cause the System to drift to instability.

Comparission between Open-Loop and Closed-Loop Control System.

Sl.No	Open-Loop Control System	Closed-Loop Control System
1.	The Open-loop System are simple to construct and cheap.	The Closed Loop system are Complicated to Construct and Costly.
2.	It Consumes less power	It Consumes more power.
3.	Any Change in the Output has no Effect On the input i.e, feedback does not Exists	Changes in the Output, affects the input which is possible by use of feedbacks.
4.	Highly sensitive to the disturbances	Less sensitive to the disturbances.
5.	It is Inaccurate and un-reliable	Highly accurate and reliable.
6.	The Open-loop systems are generally stable.	More care is required to design a stable System
7.	Highly sensitive to the Environmental Changes	Less sensitive to the Environmental Changes.

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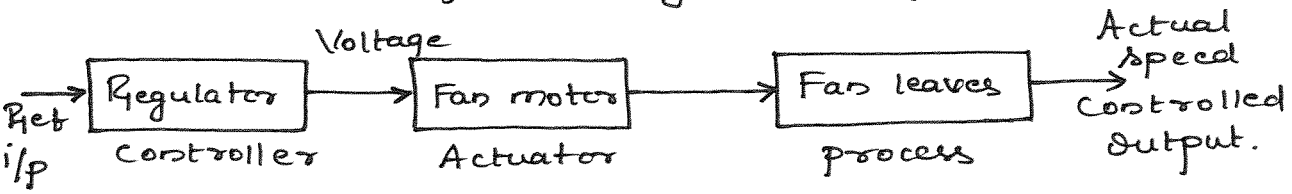
Application of an Open-loop System :-

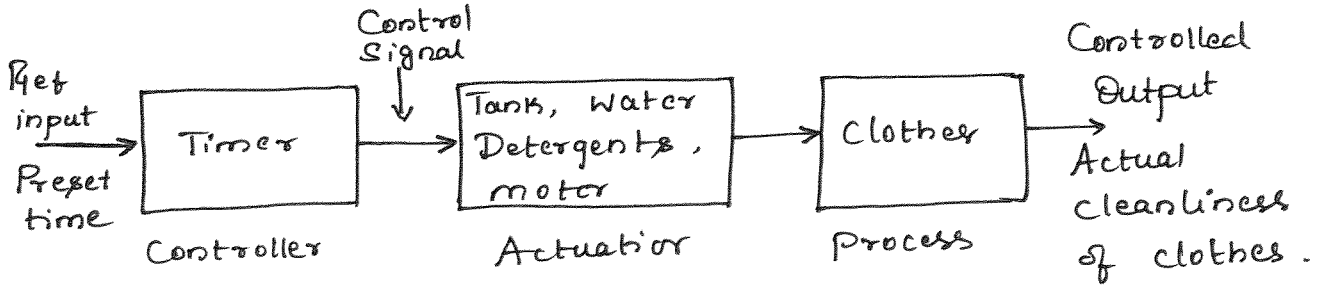
1) Control action of a Celing-fan regulator :



Blocks diagram of Fan Regulator

A fan regulator is a combination of a series switch and a speed regulator. For a given speed setting on the fan regulator, the fan runs at a specific speed. To obtain a different speed, the setting on the regulator is to be changed. This changes the voltage applied to the motor. The specific setting on the regulator is the reference input and the variable voltage applied to the fan motor is the control signal. The speed of the fan is the controlled output. the output speed is not measured so the control scheme is open-loop. The blocks diagram is shown in the figure above.

2) Working of an automatic washing machine :



Blocks diagram of Automatic Washing Machine.

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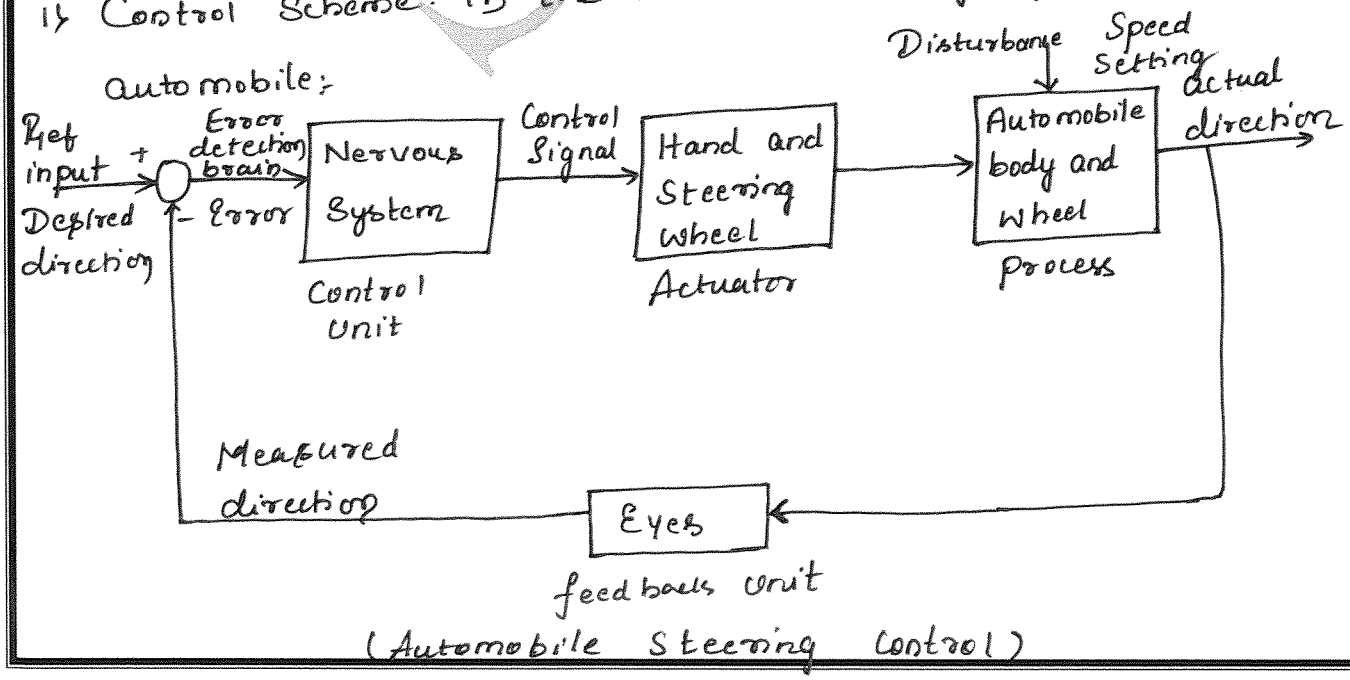
* An automatic Washing machine is one with present wash times. The different operations like soaking, washing, rinsing, wringing and drying are all performed on a time basis.
* After the clothes to be washed are kept inside the tank, water and detergent are added in proper amounts
* The timer and the relays act as the Controller. The tank, water, detergent and the motor Constitute the actuator.
* The clothes that are to be washed from the process. There is no measurement of quality of wash. If cleanliness of clothes is the output parameter, there is no mechanism to judge it. The system is thus open-loop. The block diagram is shown above.

Applications of an closed loop Control System:-

1) Control Scheme in the manual steering system of an automobile;



(Automobile Steering Control)

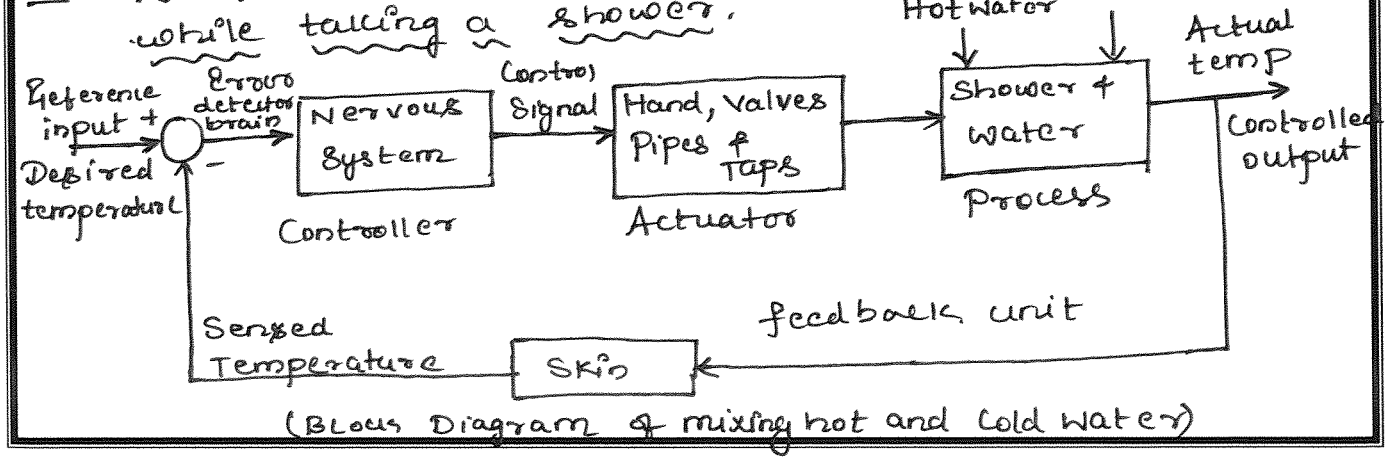
* The driver of an automobile watches the direction or heading of the vehicle with respect to a specified direction of the road. The Eye senses the deviation, if any, and the information is fed to the brain, through the nervous system.

* The brain processes the signal and generates a Corrective signal and it is transmitted to the hand and then to the steering wheel. The direction of the road is the reference input and. heading of the automobile is the controlled input.

* The human Eye acts as the Error detector. The brain and the nervous system acts as the Comparator and the Controller. The Corrective signal generated in the brain is the Control signal, which is transmitted to the hands.

* The human hands and the steering wheel form the actuator unit, The automobile body and the wheels from the process. The scheme represents a manual feedback system and it is shown in the figure above.

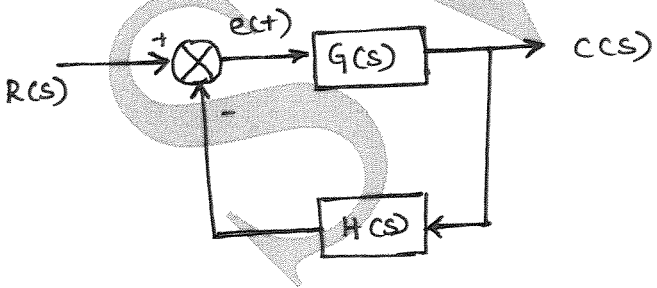
2) The control scheme for mixing cold and hot water while taking a shower.



(Block Diagram of mixing hot and Cold water)

* One must have some idea of the water temperature he/she wants while taking a shower. The skin acts as a temperature sensor, which measures the temperature not quantitatively but qualitatively, and conveys the information to the brain. There it is compared with the water temperatures the person desires. the brain computes the differences in terms of 'too cold' or 'too hot' and activates the hand muscles to manipulate the hot and cold water valves to reduce the temperature if it is too hot or increase the temperature if it is too cold. This corrective action is reciprocal until the required water temperature is achieved. The block diagram is shown above.

Feedback System :-



* If Error signal e(t) is zero, output is Controlleel.
* If Error signal e(t) is not zero, output is not Controlled.

  For positive feedback, Error signal = r(t) + c(t)

  For Negative feedback, Error signal = r(t) − c(t)

* The purpose of feedback is to reduce the Error between the reference input and the system output.

$\Rightarrow$ +Ve feed back

Unity feed back ($H(s)=1$)

$$\frac{C(s)}{R(s)} = \frac{G(s)}{1-G(s)}$$

Non-unity feed back ($H(s)\neq 1$)

$$\frac{C(s)}{R(s)} = \frac{G(s)}{1-G(s)H(s)}$$

$\Rightarrow$ -Ve feed back

Unity feed back ($H(s)=1$)

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

Non-unity feed back ($H(s)\neq 1$)

$$\frac{C(s)}{R(s)} = \frac{G(s)}{1+G(s)H(s)}$$

Where $G(s)$ = T.F of the forward path.

$H(s)$ = T.F of the feed back path.

* The feed back has effects on such system performance characteristics as stability, bandwidth, overall gain, impedance and sensitivity.

* Effect of feed back on stability:

* Stability is a notion that describes whether the system will be able to follow the input command.
* A system is said to be unstable, if its output is out of control.
* The closed loop system, stability depends on loop gain. If loop gain $GH = 1$, the output of the system becomes infinity for any finite input. and the system is said to be unstable.

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