Introduction to Control System

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- In the modern era the control systems play a major role in our day today life. control systems are everywhere in our home like refrigerator, water heaters , toasters. The control systems are used from house hold equipments to the space programs everywhere they have the existence ..

- **Control System :** It is arrangement of different physical systems connected together in order to execute certain tasks or to execute the commands.

- every control system can have one or many has inputs and one or many output and a **control action**. the control systems can be classified in to two main categories

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

- **Open loop control System :**

  A open loop control system is the most simple control system that can process an input condition to produce a specified output. It is also the most common form of control system used widely in domestic as well as in the industries systems because it is cheap to install and simple to operate.

  A control system in which the control action is independent of the output is called a open loop control system. Figure 1.2 shows the open control system. Normally the time dependent systems are open loop control systems.

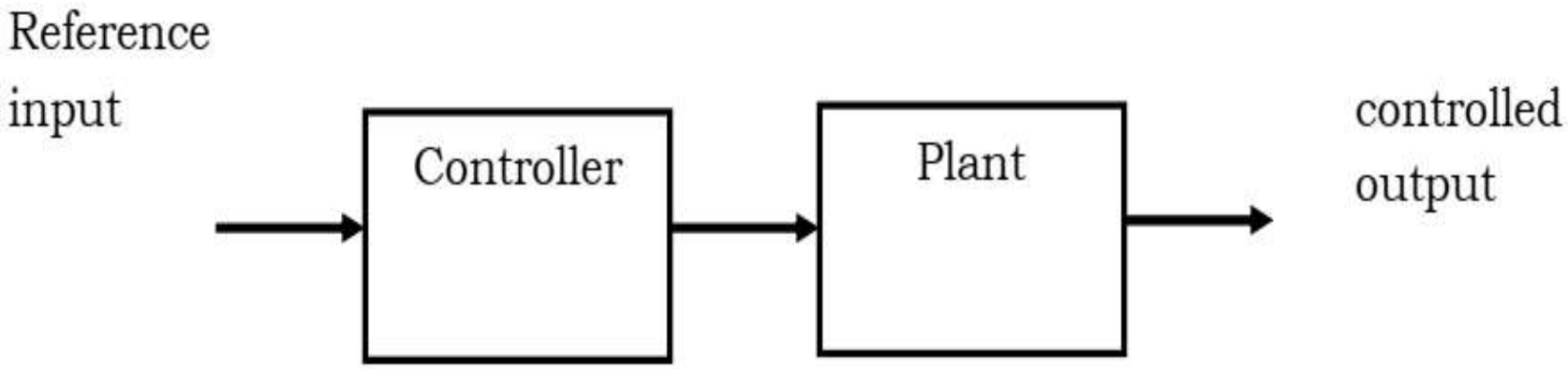


Figure 1.1 Open loop control system

- **Automatic Sprinklers**
  These kind are systems are used to water lawns and farms. The system is set to operate on particular day time and it remains operate ON for specific time period set by the operator.

- **Automatic Toaster**
  The bread toaster is the best example of a open loop control system. It simply heat the bread for predefined time. it doesn't take any input such as status of the bread. the control action has nothing to do with the toasts.
- The heater inside will be ON for the predefined time period.

- **Stepper Motor positioning**
  In stepper motor positioning a step sequence is provided to the motor and it rotates with some specific angle. the actual position of the stepper motor is not monitored. if the step angle and number of steps are known then angle of rotation can be calculated.

- **Washing Machine**
  washing machine is another example of open loop control system. its task is to clean the cloths. so the input is dirty cloths and the out is clean cloths. when the cloths are put for the wash. The machine checks the weight of the cloths. According to its weight it decides how much detergent is required, socking time and the springing time to wash the cloths. these inputs has nothing to do with the cleanness of the cloths. if we perform an experiment in which the same quantity of clean and dirty clothes are put for the wash. the washing machine will take same time. the output cleanness of the cloths has nothing to do with the status of the input cloths.

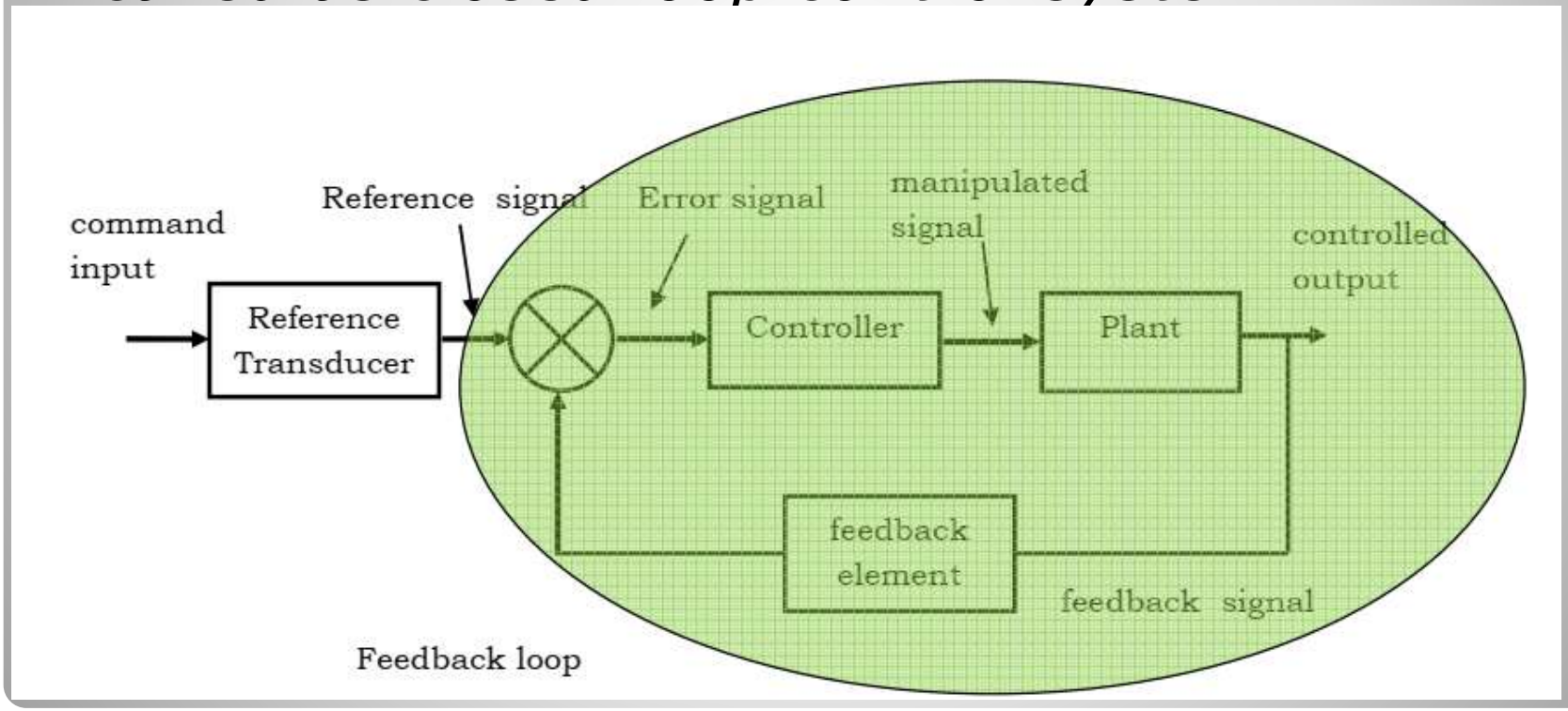
- **Electric Room Heater**

The Electric room heater used in winter seasons is also an example of open loop control system. the heater remains on for the particular time according to input set by the user. it doesn't check the present temperature of air inside the room.

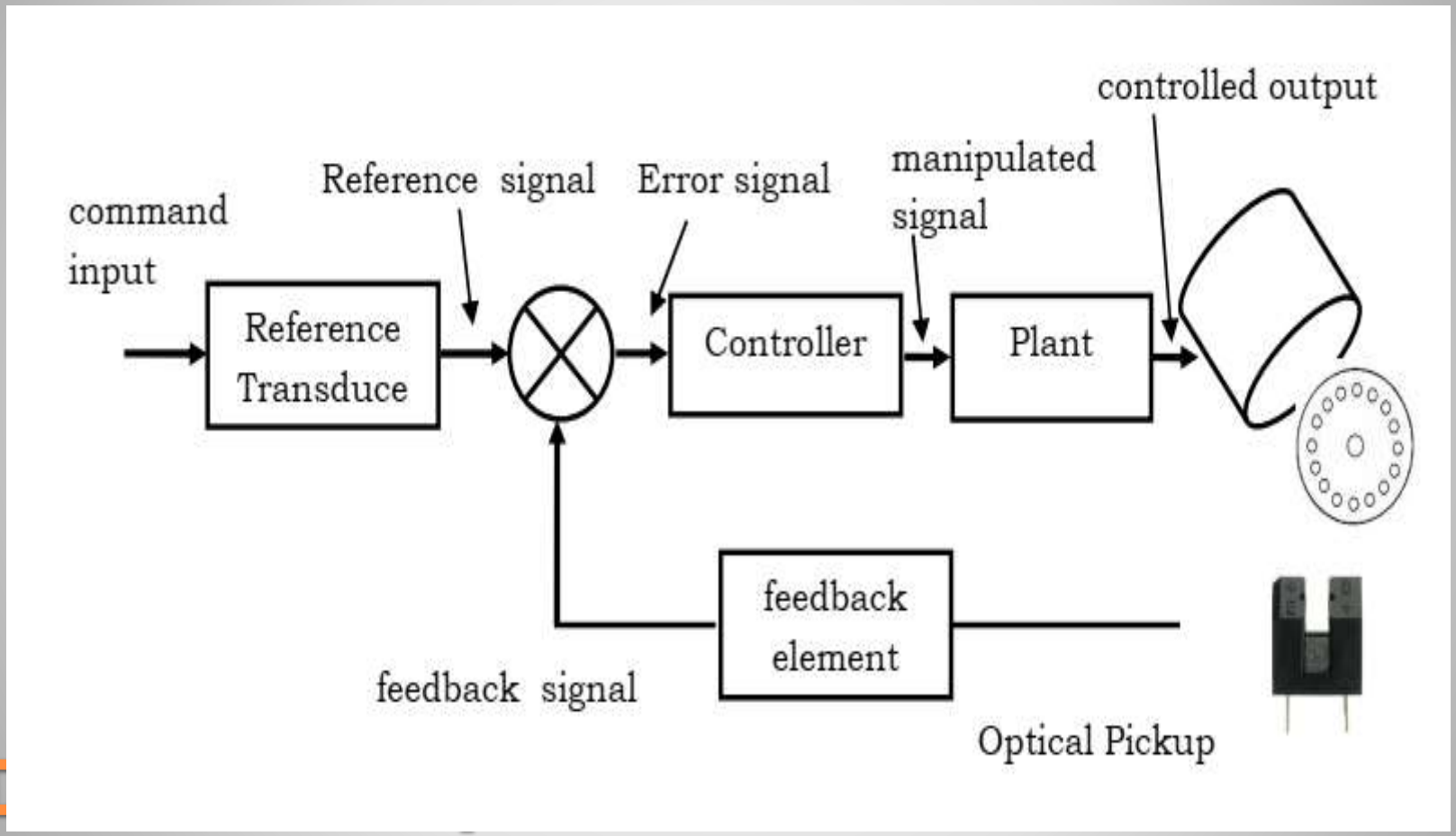
- **Advantages of Open Loop Control Systems:**
  1. Open loop control systems are easy to design
  As the open loop control system is simple to operate and less number of components. These systems are easy to design.
  2. Easy to Maintain
  As the open loop control system is simple to operate and less number of components. These systems are easy to maintain.
  3. These systems are normally time dependent
  Most of the control systems are operate for specific time duration. In open loop control system the control system is provided
  by timer.
  4. Open loop control system is much more economical solution
  As the simple algorithm is used to operate the control system and minimum number of components are used to achieve the control.
  This makes the open loop control system more economical.
  5. Convenient when output is difficult to measure
  In some cases the out of the system is very difficult to measure or it requires a specialized kind of setup to measure the output. In such cases open loop control systems are extensively used.

- **Disadvantages of Open Loop Control Systems:**
  1. Less stability
  As there is no feedback mechanism in the open loop control system. if the external disturbance hits the system then the system
  gets unstable or it will not give the controllered output.
  2. time to time calibration is required
  To maintain the quality and accuracy Due to change in the external
  environments calibrations. these kind of systems requires time to time.
- ***3. prone to environmental changes***
  As there is no feedback element and a comparator. if the surrounding environment is changed then the performance of the system gets affected.
  4. Transfer function of the controlled element should be precisely
  known
  The characteristic of the control elements should be precisely known before design the system to achieve the exact results.

- **Closed loop control system:**
- *control system in which the **controlled action is dependent on the output** is called as closed loop control system.*



- In closed-loop control *the value* of the *output* is constantly monitored *as the system operates and this value is compared with the set (or reference) value. If there is* ***any difference*** **between the actual value and the set value (an *error*),** then the *input* to the system is varied in order to *reduce* the *output error* to zero. Closed-loop control systems are therefore capable of making decisions and adjusting their performance to suit changing output conditions.
- An example is a **thermostatically** controlled **fan heater.**


controlled output
manipulated signal
Reference signal
Error signal
command input
Reference Transduce
Controller
Plant
feedback element
feedback signal
Optical Pickup

- The speed of the DC motor is measured with transducer such as shaft encoder or photo transceiver pair or a tachometer.

- This measured speed act as a input to the control algorithm. The controller compares the speed measured by the transducer and the speed set by the operator. By comparing these quantities the controller generates the necessary control signals.
- If the operator wants to increase the speed of the motor it receives the signal from the input transducer and it compares with the reading from the tachometer. To achieve increase in a speed, now controller will increase the voltage or current till the necessary speed is maintained.

If the operator wants to decrease the speed of DC motor. The controller will receive the control signal from the input transducer. According to input it will reduce the amount of voltage/ current feed to the DC motor

- Here in this example, increase or decrease in the speed is achieved by comparing with the reference input and current speed of the DC motor Theses mechanisms are called as *feedback mechanism.*

  In feedback mechanism even if the external disturbance introduced in the system then also system remains stable. In DC motor speed control the increase in the load can be a disturbance which results in to suddenly decrease in the speed.

  This decrease in the speed is measured by the tachometer, controller compare this input value, and to increase the speed the DC motor necessary voltage/current will increase. As in open loop control system there is no such feedback , so they are less stable.

- **Automatic Electric Iron:**
  Now a day in automatic electric iron we can adjust the temperature according to type of cloths. cloths like cotton can be iron at *higher* temperature and silk or polyester are temperature sensitive.
- when the iron is **set** to the **particular** setting. This input sensed by the input **transducer**. the controller adjust the voltage/current to achieve the **set** temperature. present temperatures of the coil is measured with the temperatures transducer. Then controller compares the input value with the current temperature and necessary voltage/ current is feed to heating coil.

- **Advantages of the Control System**
  1.Highly accurate.
  As the feedback system, the output is continually monitored. even if external disturbance hits, due to feedback mechanism out s corrected and it maintains at the set value.

- ***2.Stable against the external is disturbance.***
  In feedback system even if the eternal disturbance hits the system the output value shifts from its set value for short time period. But as the time goes on, feedback loop correct the output by changing the value of control signal.
- ***3.No calibration is required.***
  Even if there are external disturbance hits the system due to environmental changes. feedback loop will take care of all these disturbances. So no time to time calibrations is required.
- ***4.Large error bandwidth***
  in feedback control systems the set value and present value of the output are continually monitored. so even if the error is large feedback mechanism will nullify this error.

- **Disadvantages of the control system**

  1. As the feedback system has additional components, so feedback systems are costly as compare to open loop control system
  2. Due to additional components in the feedback system these are hard to maintain
  3. some time due to over feedback system may become unstable.

Sr.No.	Open loop Control system	Feed back Control system
1	No feedback element is present	Feedback element is present
2	No error detector amplifier is present	Error amplifier is present
3	Small error bandwidth	Large error bandwidth
4	Prone to external disturbances	Robust against the external disturbances
5	Unstable	Stable
6	Most economical as there is no feedback element	These systems are costly because of additional elements.
7	Sensitive to environmental changes	Less Sensitive to environmental changes
8	It has less accuracy	More accuracy
9	Highly affected by non-linearity	Less affected by non- linearity
10	Example automatic toaster, hand drier, hair drier	

- **Feed Forward Control System**
  In feedback control systems, *if the disturbance hits the system and then the controller corrective action taken to maintain the o/p.* In feedback system this is the major drawback because the action taken when the output is shifted from its **set value** .
- If the disturbance is **measurable**, in feed-forward control mechanism the disturbance is measured before hitting system and the corrective action is taken. thus the corrective action is taken without waiting for effect due to disturbance to show up in the output. This mechanism is called as **feed forward** control.

- Consider water heating system shown in the figure.
- In this system there two dominant parameters which can act as a disturbance to a system that can affect the output. The first parameter is flow of inlet water and second is temperature of inlet water. if the inlet water flow increases, ,then it will decrease the temperature of outlet water due to insufficient time period. On the other hand if the inlet flow in heater decreases, then the water will expose to heat for more time and hence increasing temperature.
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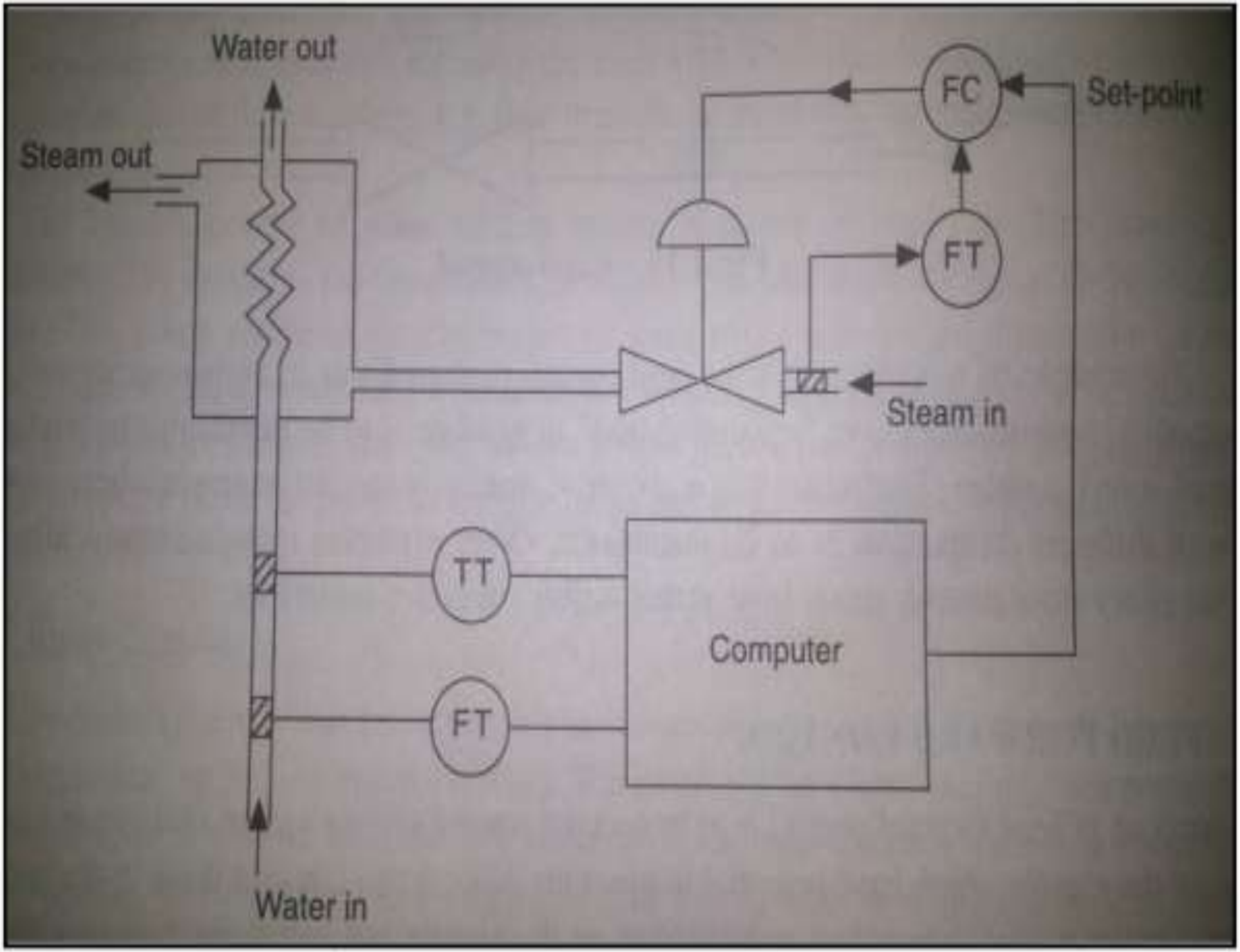
- If the inlet water temperature is decreased due to some reason the system has to provide the more amount of heat raise the temperature. And if the temperature of the inlet water is already high then the it will further increase the water temperature. These are all disturbances in control system. These disturbances can be measured with the flow meter and a temperature transducer. These additionally measured parameter are feed to controller. In controller compile the input values in a mathematical model and take a corrective action.(FT- Flow Transmitter sensor ,TT-Temperature Transmitter sensor, FC- flow controller)


Water out
Steam out
FC
Set-point
FT
Steam in
TT
Computer
FT
Water in

Adaptive Control System

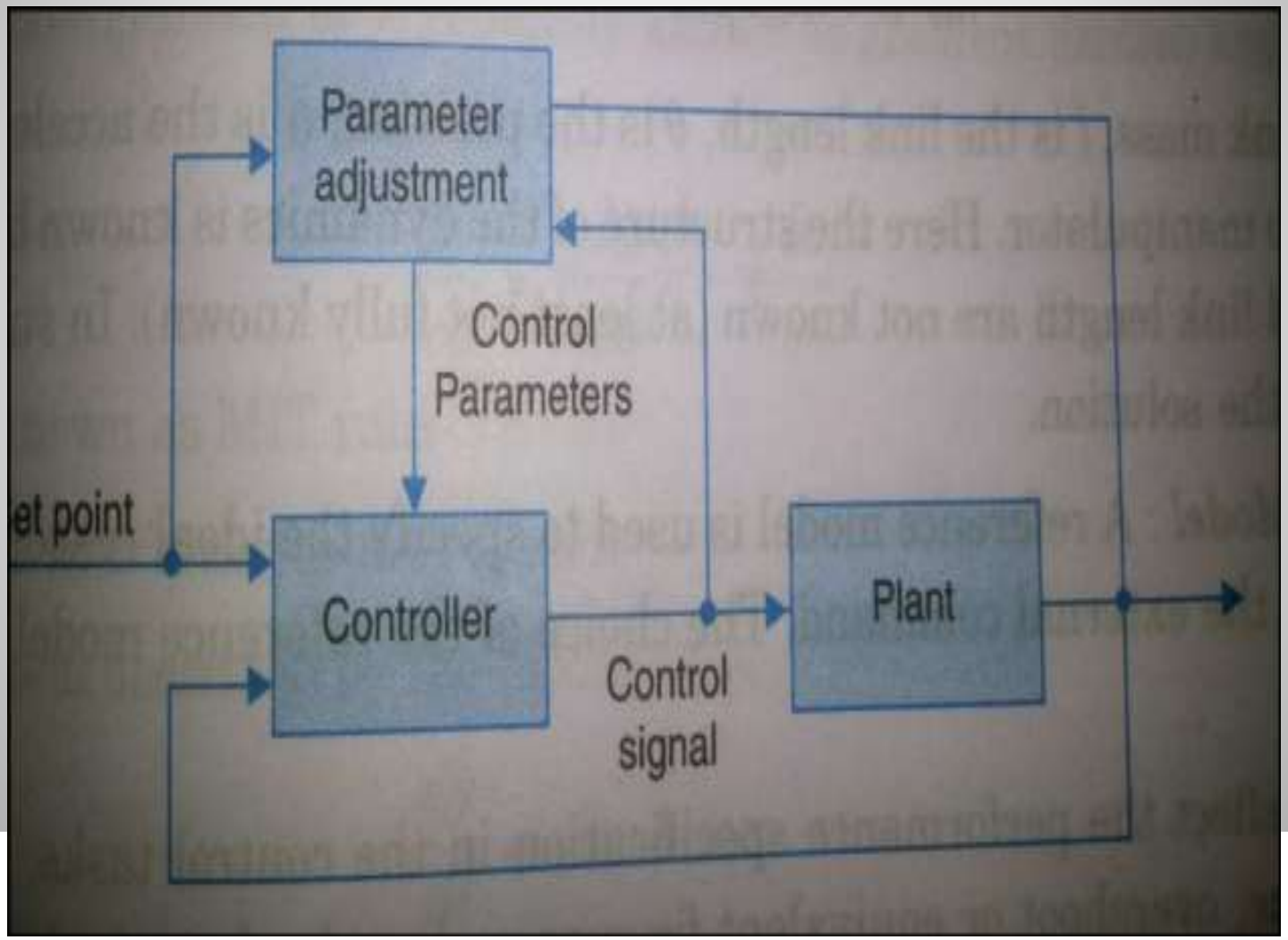
- *Adaptive Control* covers a set of techniques which provide a systematic approach for automatic adjustment of controllers ***in real time, in order to achieve or to maintain a desired level of control system performance*** when the parameters of the plant dynamic model are unknown and/or change in time.

- An adaptive controller is a controller that can modify it parameter in a response to changes in the processes and the disturbances surrounding the system. one of the main goal of the adaptive system is to **compensate them for the parameter which are nonlinear in nature**, changes in the operating conditions and disturbances acting on the control system.

  The basic objective of the control system is to maintain its consistent performance of the system in the presence of uncertainty and unknown variation in the plant parameters. *An adaptive system is automatically tuned up to such conditions.*

- In a simplified manner any adaptive system is having two loops. one loop is normal feedback loop and a controller and the used to adjust the parameters. The parameter adjustment another loop this loop is kind of "self tuning" loop which adjust the control parameter according to the disturbances and processes variations in a plant.

  A complex mathematical algorithm is used to adjust these parameters. adaptive systems are required more computational power than other control algorithm. figure bellow shows the block diagram of adaptive control system.


Parameter adjustment
Control Parameters
et point
Controller
Control signal
Plant