- Feed forward control measures the disturbances in the process. It uses a controller to adjust manip variables so that the effect of disturbances on the controlled variable is reduced or eliminated.
- Feed forward control acts in an anticipatory manner, while conventional feedback control ac compensatory manner after the disturbance has affected the system.
- Feed forward configuration requires an accurate measurement of disturbances. A mathem relationship of disturbances and manipulated variables with the controlled variables has established. Due to these restrictions, feed forward configuration is implemented only in case of defined processes. Schematic diagram of feed forward configuration is implemented only in c well-defined processes. Schematic diagram of feed forward configuration is shown in the above fig

Classification of industrial Controllers

Most industrial controllers may be classified according to their control actions as:

1. Two-position or on—off controllers
2. Proportional controllers
3. Integral controllers
4. Proportional-plus-integral controllers
5. Proportional-plus-derivative controllers
6. Proportional-plus-integral-plus-derivative controllers

Two-Position or On – Off Control Action.

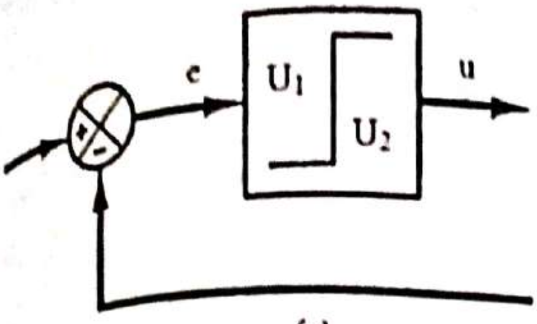
In a two-position control system, the actuating element has only two fixed positions, which are, in many c simply on and off. Two-position or on—off control is relatively simple and inexpensive and, for this rea-s very widely used in both industrial and domestic control systems.

Let the output signal from the controller be u (t) and the actuating error signal be e(t). In two-position co the signal u(t) remains at either a maximum or minimum value, depending on whether the actuating error si is positive or negative, so that

$$\begin{aligned} u(t) &= U_1, \quad \text{for } e(t) > 0 \\ &= U_2, \quad \text{for } e(t) < 0 \end{aligned}$$

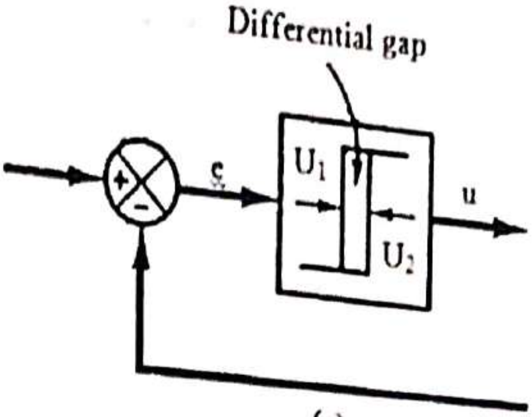
where U_1 and U_2 are constants. The minimum value U_2 is usually either zero or $-U_1$. Two-position contro are generally electrical devices, and an electric solenoid-operated valve is widely used in such contro Pneumatic proportional controllers with very high gains act as two-position controllers and are some called pneumatic two–position controllers.

Figures (a) and (b) show the block diagrams for two-position or on–off controllers The range through which actuating error, signal must move before the switching occurs



(a)

(a) Block diagram of an on – off controller;

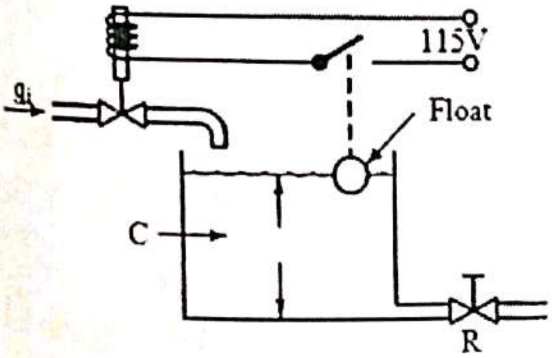


(a)

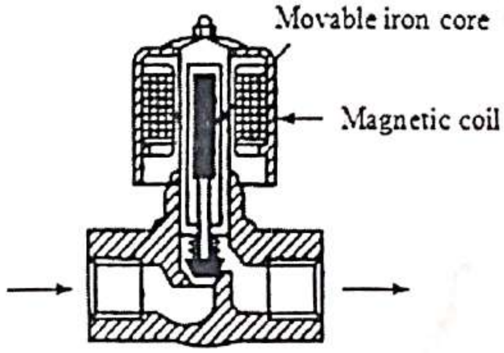
(b) block diagram of an on – off controller with differential gap.

d the differential gap. A differential gap is indicated in Figure (b). Such a differential gap causes the ler output u(t) to maintain its present value until the actuating error signal has moved slightly beyond the lue. In some cases, the differential gap is a result of unintentional friction and lost motion; however, ften it is intentionally provided in order to prevent too-frequent operation of the on-off mechanism.

ler the liquid-level control system shown in Figure (a), where the electromagnetic valve shown in Figure sed for controlling the inflow rate. This valve is either open or closed. With this two-position control, the nflow rate is either a positive constant or zero. As shown in Figure, the output signal continuously moves n the two limits required to cause the actuating element to move from one fixed position to the other. that the output curve follows one of two exponential curves, one corresponding to the filling curve and er to the emptying curve. Such output oscillation between two limits is a typical response characteristic stem under two-position control.



(a) Liquid-level control system



(b) Electromagnetic valve

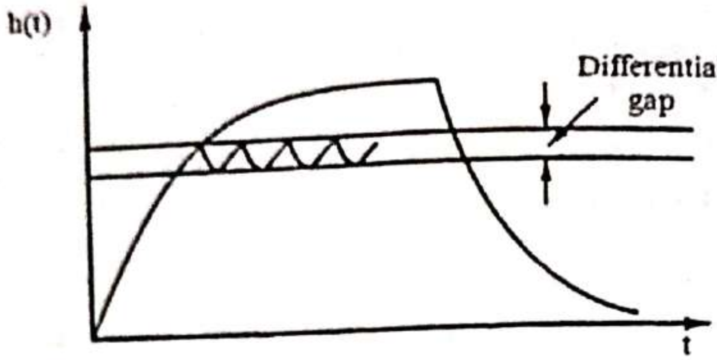


Figure Level h (t)-versus-t curve for the system shown in Figure

From Figure, we notice that the amplitude of the output oscillation Can be reduced by decreasi differential gap. The decrease in the differential gap, however, increases the number of on-off switchin minute and reduces the useful life of the component. The magnitude of the differential gap must be deter front such considerations as the accuracy required and the life of the component.

Proportional Control Action.

For a controller with proportional control action, the relationship between the output of the controller u the actuating error signal e(t) is

$$u(t) = K_p e(t)$$

or, in Laplace-transformed quantities,

$$\frac{U(s)}{E(s)} = K_p$$

where K_p is termed the proportional gain.

Whatever the actual mechanism may be and whatever the form of the operate in power, the propor controller is essentially an amplifier with an adjustable gain.

Integral Control Action

In a controller with integral control action, the value of the controller output u(t) is changed at proportional to the actuating error signal e(t). That is,

$$\frac{du(t)}{dt} == Ke(t)$$

or

$$u(t) = K_i \int_0^t e(t)dt$$

where K_i is an adjustable constant. The transfer function of the integral controller is

$$\frac{U(s)}{E(s)} = \frac{K_i}{s}$$

nal-Plus-Integral Control Action

rol action of a proportional plus – integral controller is defined by

$$u(t) = K_p e(t) + \frac{K_p}{T_i}\int_0^t e(t)dt$$

nsfer function of the controller is

$$\frac{U(s)}{E(s)} = K_p\left(1+\frac{1}{T_i s}\right)$$

T_i is called the integral time.

ional-Plus-Derivative Control Action

trol action of a proportional plus-derivative controller is defined by

$$u(t) = K_p e(t) + K_p T_d \frac{de(t)}{dt}$$

and. the transfer function is

$$\frac{U(s)}{E(s)} = K_p(1+T_d s)$$

T_d is called the derivative time.

tional-Plus-Integral-Plus-Derivative Control Action.

mbination of proportional control action, integral control action, and derivative control action is termed tional-plus-integral-plus-derivative control action. It has the advantages of each of the three individual l actions. The equation of a controller with this combined action is given by

$$u(t) = K_p e(t) + \frac{K_p}{T_i}\int_0^t e(t)dt + K_p T_d \frac{de(t)}{dt}$$

transfer function is

$$\frac{U(s)}{E(s)} = K_p\left(1+\frac{1}{T_i s}+T_d s\right)$$

K_p is the proportional gain, T is the integral and T_d is the derivative time. The block m of a proportional-plus-integral-plus-tive controller is shown in Figure .

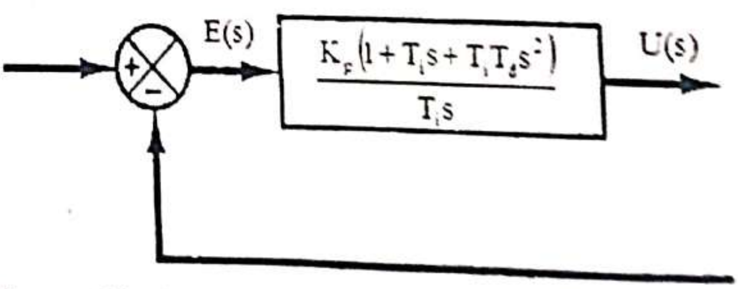


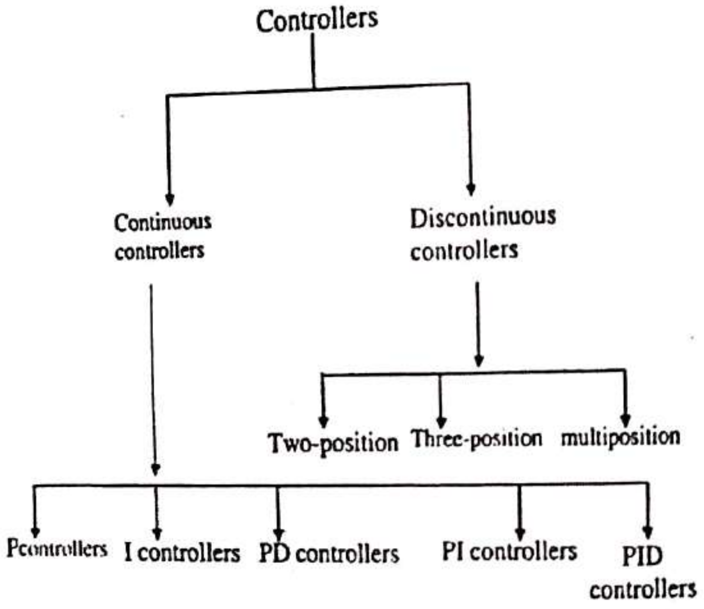
Figure: Block diagram of a proportional-plus-integral-plus- derivative controller.

Classification based on source of power they use ;

- According to this method of classification controller are of electronic pneumatic ,mechanical hydraulic type.
- Air pressure signals used are 3–15 psig , while electrical signal are 4–20 mA or 0–10 V instrument supply is 25 psig or 24 V DC signal converters like pneumatic to electrical , electrical to pneuma ,electrical to hydraulic , etc . are used to interface with process control, loop elements.

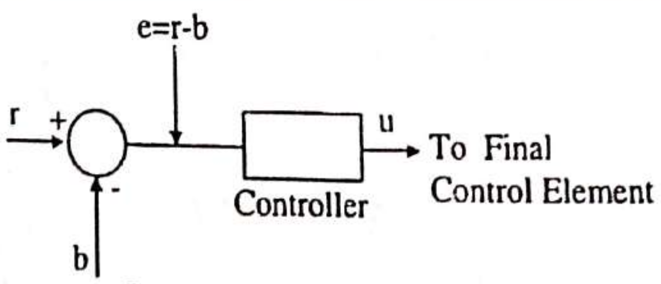
Classification based on consumption of power supply :

- According to this method of classification controls are of self actuating or powered type.
- Float level control in tanks and thermostat with bimetallic strip are examples of self actuating contro
- Industrial control instrument are usually classified in terms of controller which describes the relation between the controller and the error input.
- Depending on the type of controller , the control signal can either be continuous or discontinuous further them as shown in figure.



Classification of controllers based
On their modes of operation

Terms for Controller:



Controller terms

The above figure represents the controller in process control loop.

Error(e) is the input variable of the controller and output(u)is the output variable of a controller which are normally expressed as a percentage of full scale value .

Error: $e = r - b$

Error expressed as a percent of full scale:

$$E_P = \frac{r - b}{b_{max} - b_{min}} \times 100$$

Where b_{max} and bare the maximum and minimum measured values of the controlled variable.

Controller output expressed as a percent of full scale:

$$P = \frac{u - u_{min}}{u_{max} - u_{min}} \times 100$$

U_{max} and u_{min} are the maximum and minimum value of controlling parameter respectively.

mple 1.

A controller outputs a 4-20 mA signal to control motor speed from 150-590 rpm with linear dependence. Calculate the current corresponding to 310 rpm

ution:

we know

Sp= KI So

$150 = 4K + S_{p0}$ -------(1)

$590 = 20K + S_{p0}$ ------(2)

Solving (1) and (2).

K=27.5 rpm/mA and $S_{p0} = 40$rpm

At 310 rpm, I= 9.45 mA

ectronic Proportional Controller

- Implementation of the proportional mode requires a circuit which has a response given by:

$$P = K_p E_p + P_o$$

- Here, P is the controller output which varies from 0-100%, K_p, is the proportional gain, E_p is the error expressed in percentage, and P_o is the controller output when the error is zero.
- If both the controller output and the error are expressed in terms of voltage, then the above equation represents a summing amplifier. The op-amp circuit in figure shows such an electronic proportional controller.

$$V_{out} + K_p V_e + V_o$$

Where $K_p = \frac{R_2}{R_1}$ is the proportional gain, and V_e is the error voltage.