Control Systems

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Third Year ECE

Unit-III

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Lecture 7

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Relation between steady state error and Type of system

Previous Class:

Sr. No.	Type of System	Step Input		Ramp Input		Parabolic Input	
		K_P	e_{ss}	K_V	e_{ss}	K_a	e_{ss}
1	Zero	K	$\frac{A}{1+K}$	0	∞	0	∞
2	One	∞	0	K	$\frac{A}{K}$	0	∞
3	Two	∞	0	∞	0	K	$\frac{A}{K}$

Example 5

The control system having unity feedback has,

$$G(s) = \frac{20}{s(1+4s)(1+s)}$$

Determine

1. Different static error coefficients.
2. Steady State error if input $r(t) = 2 + 4t + \frac{t^2}{2}$

Solution:

Position error constant,

$$K_p = \lim_{s \to 0} G(s)H(s)$$

$$K_p = \lim_{s \to 0} \frac{20}{s(1+4s)(1+s)}$$

$$K_p = \frac{20}{0(1+4s)(1+s)}$$

$$K_p = \infty$$

Velocity error constant,

$$K_v = \lim_{s \to 0} sG(s)H(s)$$

$$K_v = \lim_{s \to 0} s[\frac{20}{s(1+4s)(1+s)}]$$

$$K_v = \frac{20}{(1+4s)(1+s)}$$

$$K_v = 20$$

Acceleration error constant,

$$K_a = \lim_{s \to 0} s^2 G(s) H(s)$$

$$K_a = \lim_{s \to 0} s^2 [\frac{20}{s(1+4s)(1+s)}]$$

$$K_a = 0[\frac{20}{s(1+4s)(1+s)}]$$

$$K_a = 0$$

Steady state error, for $r(t) = 2 + 4t + \frac{t^2}{2}$

$$R(s) = L\{r(t)\} = \frac{2}{s} + \frac{4}{s^2} + \frac{1}{s^3}$$

Steady state error is given by,

$$e_{ss} = \lim_{s \to 0} \frac{sR(s)}{1 + G(s)H(s)}$$

$$e_{ss} = \lim_{s \to 0} \frac{s[\frac{2}{s} + \frac{4}{s^2} + \frac{1}{s^3}]}{1 + \frac{20}{s(1+4s)(1+s)}}$$

$$e_{ss} = \infty$$

Example 6

The control system having,

$$G(s) = \frac{20}{s(s^2 + 2s + 5)} \qquad H(s) = \frac{10}{(s+4)}$$

Determine

1. Different static error coefficients.
2. Steady State error if input $r(t) = 5 + 10t + \frac{t^2}{2}$

Example 6 cont……

Solution:

Position error constant,

$$K_p = \lim_{s \to 0} G(s)H(s)$$

$$K_p = \lim_{s \to 0} \frac{20}{s(s^2 + 2s + 5)} \times \frac{10}{(s + 4)}$$

$$K_p = \infty$$

Velocity error constant,

$$K_v = \lim_{s \to 0} sG(s)H(s)$$

$$K_v = \lim_{s \to 0} s\left[\frac{20}{s(s^2 + 2s + 5)} \times \frac{10}{(s + 4)}\right]$$

$$K_v = \frac{200}{20}$$

$$K_v = 10$$

Acceleration error constant,

$$K_a = \lim_{s \to 0} s^2 G(s) H(s)$$

$$K_a = \lim_{s \to 0} s^2 [\frac{20}{s(s^2 + 2s + 5)} \times \frac{10}{(s + 4)}]$$

$$K_a = 0 [\frac{20}{(s^2 + 2s + 5)} \times \frac{10}{(s + 4)}]$$

$$K_a = 0$$

Example 6 cont......

Steady state error, for $r(t) = 5 + 10t + \frac{t^2}{2}$

$$R(s) = L\{r(t)\} = \frac{5}{s} + \frac{10}{s^2} + \frac{1}{s^3}$$

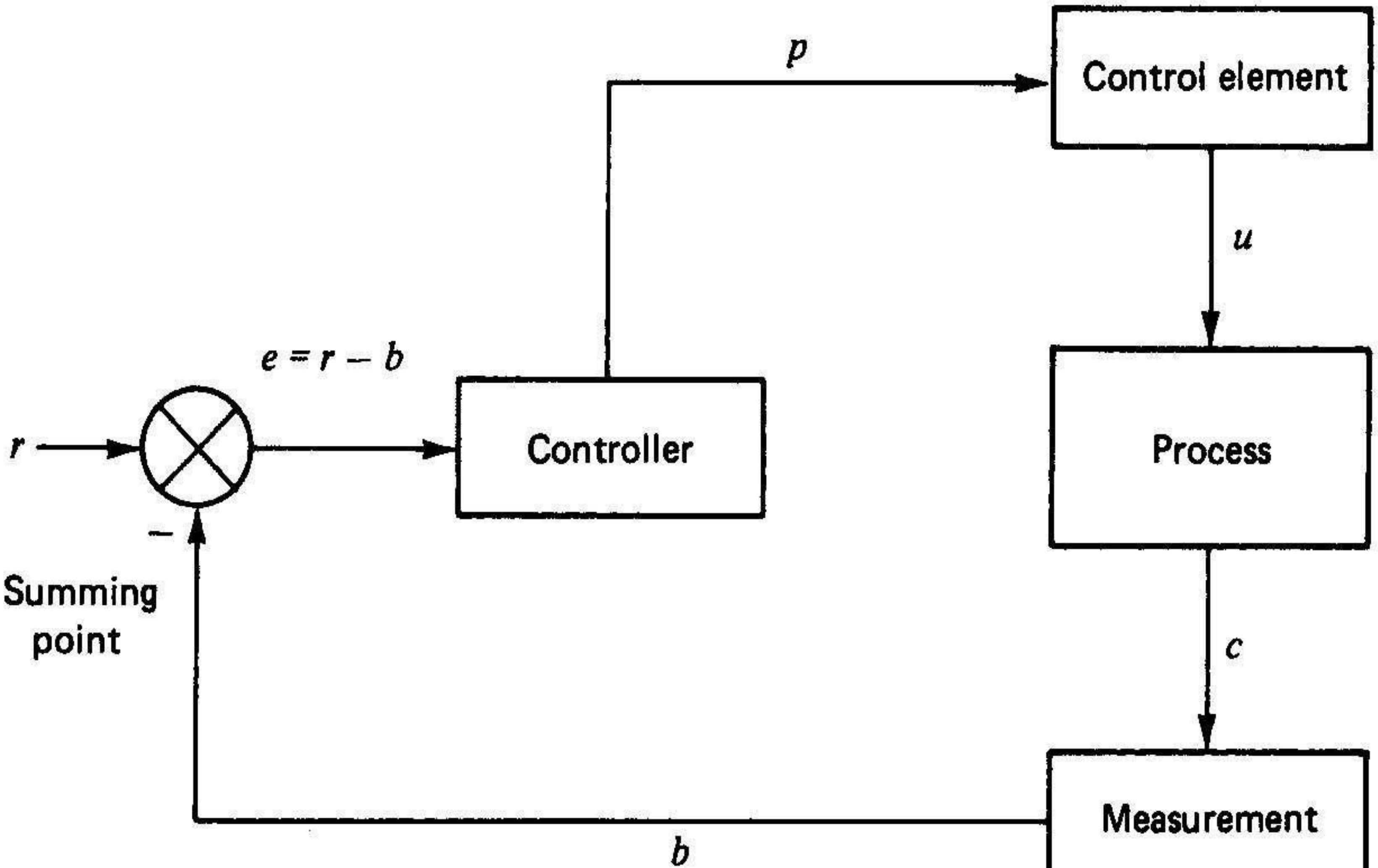
Steady state error is given by,

$$e_{ss} = \lim_{s \to 0} \frac{sR(s)}{1 + G(s)H(s)}$$

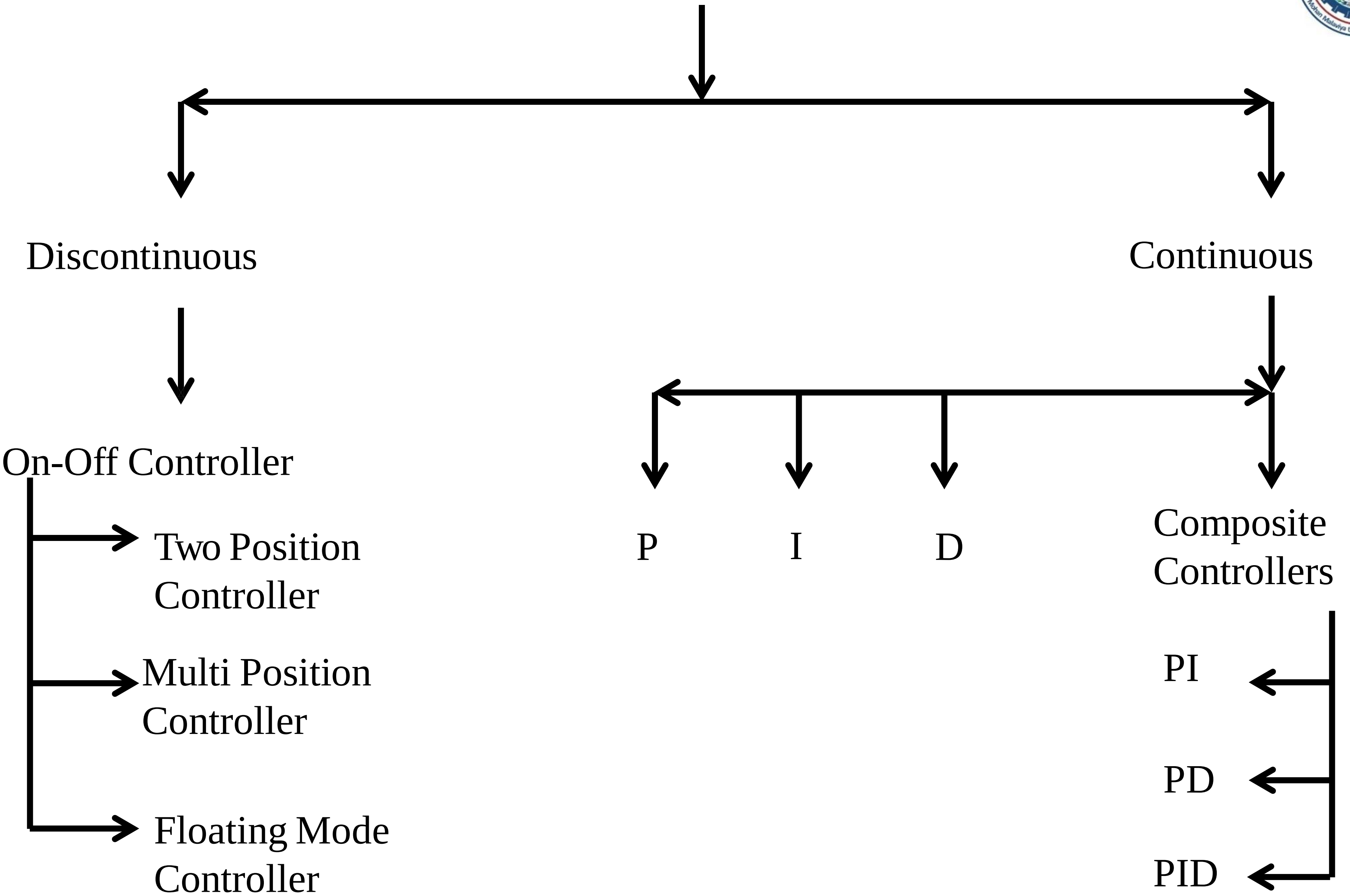
$$e_{ss} = \lim_{s \to 0} \frac{s[\frac{5}{s} + \frac{10}{s^2} + \frac{1}{s^3}]}{1 + [\frac{20}{s(s^2 + 2s + 5)} \times \frac{10}{(s+4)}]}$$

$$e_{ss} = \infty$$

Block Diagram of Process Control System



Classification of Control Actions



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Related Terms

- **Continuous Controller:** Controller that responds to continuous input variables are called continuous controller.
- **Discrete Controller:** Controller that responds to discrete signal are called discrete controllers.
- **Process Equation:** A process equation describes the mathematical relationship among the input and output variables.
- **Process Load:** The term process load refers to a set of parameters that influences or bring changes in the process excluding the controlled variable.
- **Nominal Load:** All the parameters have their normal or nominal value
- **Transient :** A temporary or sudden change or the variation of one of the variable is called transient.
- **Process Lag :** A process control loop responds to ensure that some finite time later, the variable returns to the set point value. Part of this time is consumed by the process itself and that time is called process lag.
- **Control Lag :** Control lag refers to the time for the process control loop to make necessary adjustment to the final control element.
- **Dead Time :** Another time variable associated with process control is a function of both process control system and the process. This is the elapsed time between the instant of deviation (error) occurs and when the corrective action first occurs.
- **Cycling :** Oscillation of error about the zero value. This means the dynamic variable cycling above and below the set point. For cycling we are interested in amplitude and period of oscillation.

ON-OFF Controller- 2 Position Controller

Synonyms:

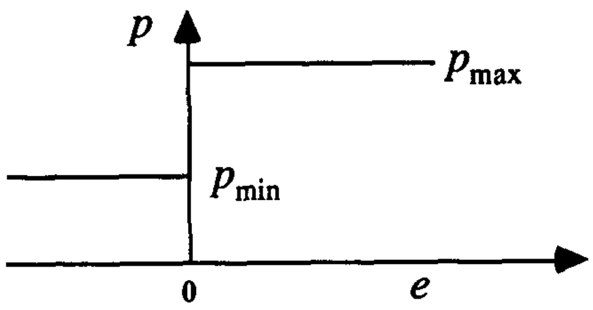
"two-position" or "bang-bang" controllers.

$$p(t) = \begin{cases} p_{max} & if \quad e > 0 \\ p_{min} & if \quad e < 0 \end{cases}$$

ideal case

e = error =
set point – measured variable

p_{max} **is the "on" value**
p_{min} **is the "off" value**



Controller output has two possible values.

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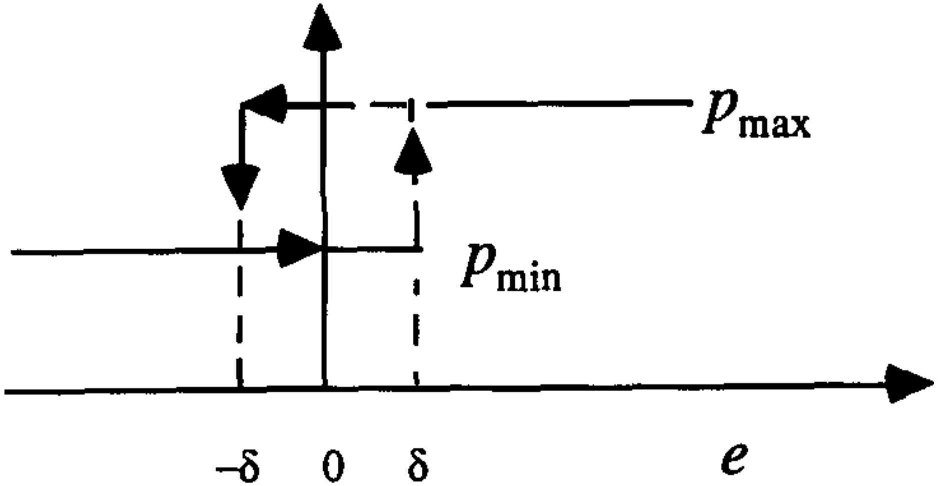
Neutral Zone

Practical case (dead band)



$$p(t) = \begin{cases} P_{max} & for \quad e > \delta \\ P_{min} & for \quad e < -\delta \end{cases}$$

δ = tolerance

system never reaches steady-state