The deviation of the output of control system from desired response during steady state is known as **steady state error**. It is represented as ess. We can find steady state error using the final value theorem as follows.

Where,

E(s) is the Laplace transform of the error signal, e(t)e(t)

Let us discuss how to find steady state errors for unity feedback and non–unity feedback control systems one by one.

Steady State Errors for Unity Feedback Systems

$$e_{ss} = \lim_{t \to \infty} e(t) = \lim_{s \to 0} sE(s)$$

$$R(s) \longrightarrow r(t)$$

$$C(s) \longrightarrow c(t)$$

T.F.

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

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

o/p of the summing point

$$E(s) = R(s) - C(s)$$

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

$$E(s) = \frac{R(s) + \cancel{R(s)G(s)} - \cancel{R(s)G(s)}}{1+G(s)}$$

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

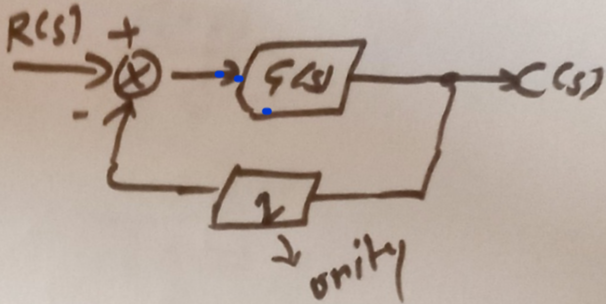
$$\boxed{e_{ss} = \lim_{s \to 0} \frac{s\,R(s)}{1+G(s)}}$$

Consider the following block diagram of closed loop control system, which is having unity negative feedback.

$e_{ss} = \frac{1}{1+K_p}, \quad \frac{1}{K_v}, \quad \frac{1}{K_a}$

$K_p = \lim_{s \to 0} G(s)$ $\quad K_v = \lim_{s \to 0} sG(s)$

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



Position →

Velocity →

acceleration →

Q. I/p signal

$r(t) = \left(5 + 2t + \frac{t^2}{2}\right) u(t)$

I/p → $r_1(t) = 5u(t)$ $\quad e_{ss_1} = \frac{5}{1+K_p} = 0$

Error constant → $K_p = \lim_{s \to 0} G(s) = \infty$ $\quad e_{ss_2} = 2/K_v = 0$

steady state error → $e_{ss_1} = \frac{5}{1+K_p} = 0$ $\quad e_{ss_3} = 1/K_a = 1$

$\boxed{e_{ss} = 0 + 0 + 1 = 1}$

(unity)

Steady State Errors for Non–Unity Feedback Systems