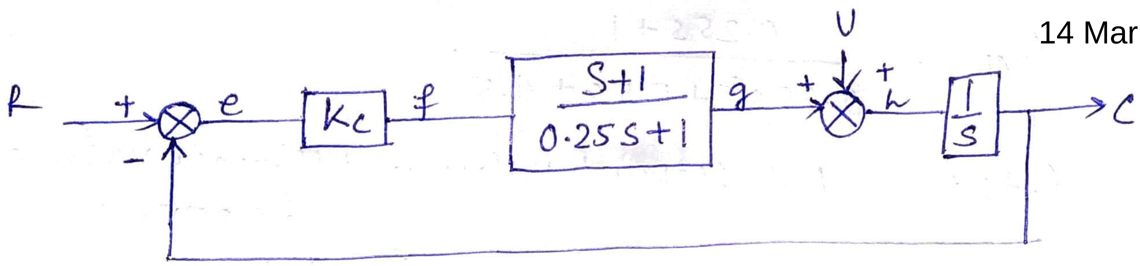
Question Paper-1 Solutions · F.M. 20 Marks

1. 14 Marks



$e = R - C$

$f = K_c e = K_c (R - C)$

$g = \dfrac{(S+1) K_c (R-C)}{0.25S+1}$

$h = U + g$

$= \dfrac{(S+1) K_c (R-C)}{0.25S+1} + U$

$C = \dfrac{1}{S} \times \dfrac{(S+1) K_c (R-C)}{(0.25S+1)} + \dfrac{U}{S}$

$C + \dfrac{(S+1) K_c C}{S(0.25S+1)} = \dfrac{(S+1) K_c R}{S(0.25S+1)} + \dfrac{U}{S}$

$C = \dfrac{(S+1)K_c}{S(0.25S+1) + (S+1)K_c} R + \dfrac{(0.25S+1)}{S(0.25S+1) + (S+1)K_c} U$

$\therefore \dfrac{C}{U} = \dfrac{0.25S+1}{S(0.25S+1) + (S+1)K_c}$

$$\boxed{\dfrac{C}{U} = \dfrac{0.25S+1}{0.25S^2 + (1+K_c)S + K_c} = G_{CL}}$$

From the closed loop Transfer function.

$\tau^2 = \dfrac{0.25}{K_c}$

$2\xi\tau = \dfrac{1+K_c}{K_c}$

$\tau = \dfrac{0.5}{\sqrt{K_c}}$

$2\xi\tau = \dfrac{\xi}{\sqrt{K_c}} = \dfrac{1+K_c}{K_c} \Rightarrow \xi = \dfrac{1+K_c}{\sqrt{K_c}}$

Given : $\xi = 3$

$\therefore \dfrac{1+K_c}{\sqrt{K_c}} = 3$

$\Rightarrow 1 + K_c^2 + 2K_c = 9K_c$

$\Rightarrow K_c^2 - 7K_c + 1 = 0 \Rightarrow \boxed{K_c = 6.85, 0.146}$

Desirable to minimize offset

Let,

$K_c = 4.5$

$$G_{CL} = \frac{0.25s+1}{0.25s^2+5.5s+4.5}$$

Offset = New setpoint value − Ultimate value of Response.

$$= 0 - \lim_{t\to\infty} \frac{1}{s} \cdot \frac{0.25s+1}{0.25s^2+5.5s+4.5}$$

$$= 0 - \lim_{s\to 0} s \cdot \frac{1}{s} \cdot \frac{0.25s+1}{0.25s^2+5.5s+4.5}$$

$$= 0 - \frac{1}{4.5} = \boxed{-0.22}$$

6 Marks

2. $G_p = \frac{1}{2s-1}$, $G_m = G_f = 1$, $G_c = K_c$

For a feedback control system, the characteristic equation is given by.

$1 + G_p G_f G_c G_m$

Characteristic equation:

$$1 + \frac{K_c}{2s-1} = \frac{2s + (K_c - 1)}{2s-1}$$

Roots of the characteristic equation.

$$\frac{2s + (K_c - 1)}{2s-1} = 0 \Rightarrow 2s + (K_c - 1) = 0$$

$$s = \frac{1-K_c}{2}$$

A feedback control system is said to produce stable response if all the roots of its characteristic equation have negative real parts.

$$\therefore \quad \frac{1-K_c}{2} < 0$$

$$\Rightarrow \boxed{K_c > 1}$$