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Q 1 A first order process with transfer func^n $G_p(s) = \frac{5}{0.1s+1}$ is controlled by a PI controller

Transfer func^n of measuring device is

$$G_m(s) = \frac{K_m}{\tau_m s+1}$$

a) Set $K_m = 1$, $\tau_m = 1$ and using Routh array criterion find a pair of values K_c & τ_I which yeild stable close loop response

b.) Using the values of K_c & τ_I found in (a) examine the effect of changing K_m on the stability of close loop response

c) Do the same with τ_m

d) Based on above results, discuss the effect that measurement dynamics have on the stability of the close-loop response.

Ans. 1.) a) CLCE: $1 + \frac{5}{(0.1s+1)} \frac{K_c(\tau_I s+1)}{\tau_I s} \frac{K_m}{(\tau_m s+1)} = 0$

$$\frac{(0.1)\tau_I\tau_m) s^3 + \tau_I(\tau_m+0.1) s^2 + \tau_I(1+5K_cK_m) s + 5K_cK_m}{(0.1s+1)(\tau_I s)(\tau_m s+1)} = 0$$

$\tau_m = 1 = K_m$

$$0.1\tau_I s^3 + 1.1\tau_I s^2 + \tau_I(1+5K_c) s + 5K_c = 0$$

Routh array

1	$0.1 \tau_I$	$\tau_I(1+5K_c)$
2	$1.1\tau_I$	$5K_c$
3	$\dfrac{1.1\tau_I^2(1+5K_c)-0.5\tau_I K_c}{1.1\tau_I}$	0
4	$5K_c$	

$K_c > 0$, $\tau_I > 0$

$1.1\tau_I^2(1+5K_c) - 0.5\tau_I K_c > 0$

satisfied for $\boxed{K_c = 1}$ & $\boxed{\tau_I = 0.1}$

b.) $K_c = 1$, $\tau_I = 0.1$

$0.01\tau_m s^3 + 0.1(\tau_m + 0.1)s^2 + 0.1(1+5K_m)s + 5K_m = 0$

Routh array

1	$0.01\tau_m$	$0.1(1+5K_m)$
2	$0.1(\tau_m+0.1)$	$5K_m$
3	$\dfrac{(0.1)^2(\tau_m+0.1)(1+5K_m)-0.05\tau_m K_m}{0.1(\tau_m+0.1)}$	0
4	$5K_m$	

$K_m > 0$ $\tau_m > 0.$

$(\tau_m + 0.1)(1+5K_m) - 5\tau_m K_m > 0.$

for $\tau_m = 1$ $\Rightarrow$ $\boxed{K_m > -2.2}$

i.e. for all value of K_m

c.) set $K_c = 1$, $Z_c = 0.1$ & $K_m = 1$

we get the inequality

$$(Z_m + 0.1)(6) - 5Z_m > 0.$$

$$\boxed{Z_m > 0.6}$$

the system is stable for all values of Z_m if $Z_m > 0.6$

d) K_m & Z_m have no effect on the stability of the closed loop response.