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**CHE381 Lab:6**

## GIVEN:

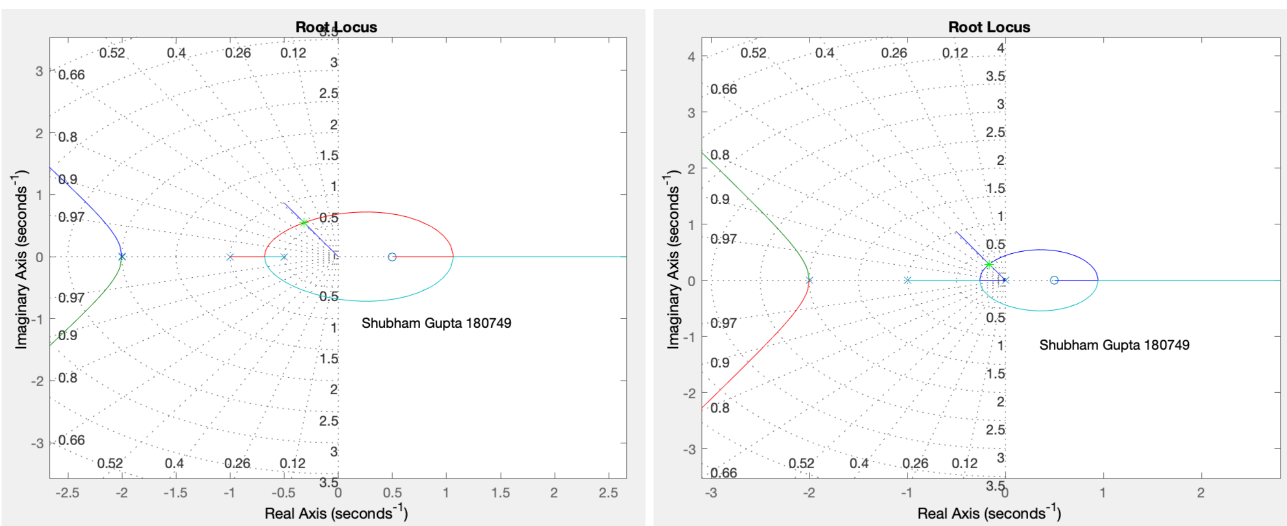
A SISO system with the process transfer function is given to us

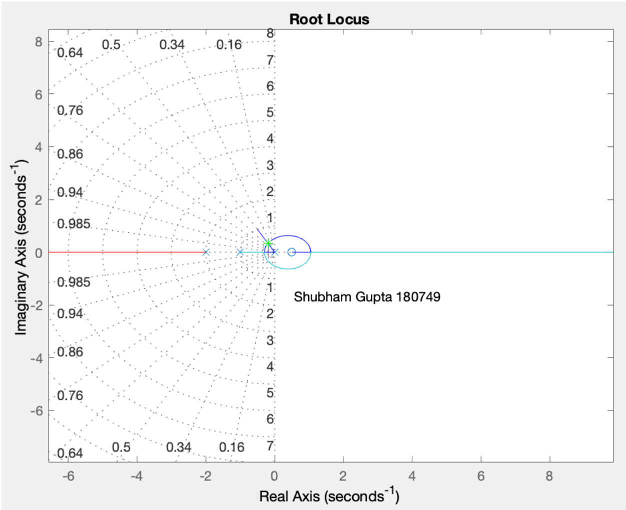
$$G_p = 2\frac{(-2s+1)}{(2s+1)(s+1)\left(\frac{1}{2}s+1\right)^2}$$

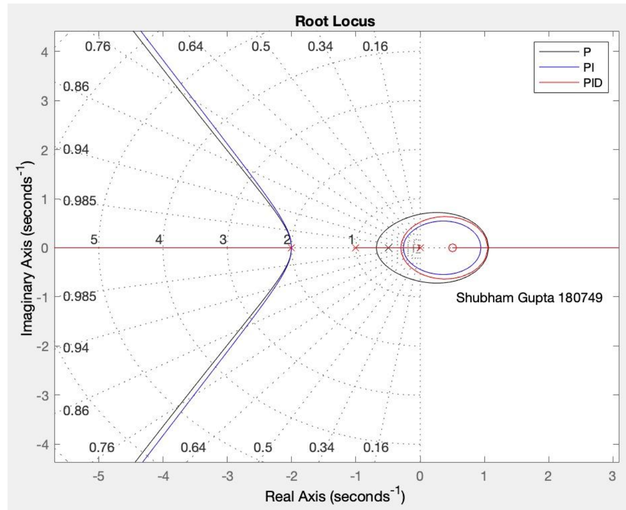
## AIM:

1. Design P, PI, and PID controllers using the root locus technique such that ξ = 1/2 for the dominant closed-loop pole pair. We need to set $\tau_I$ to the largest process time constant and $\tau_D$ to the fastest process time constant.
2. Compare the unit step servo responses for P, PI, and PID. Also, obtain the ZN and TL settings.
3. Compare the tuning parameters and servo responses with those obtained from the root locus technique.

## Root Locus for P, PI, PID, and all together, respectively:



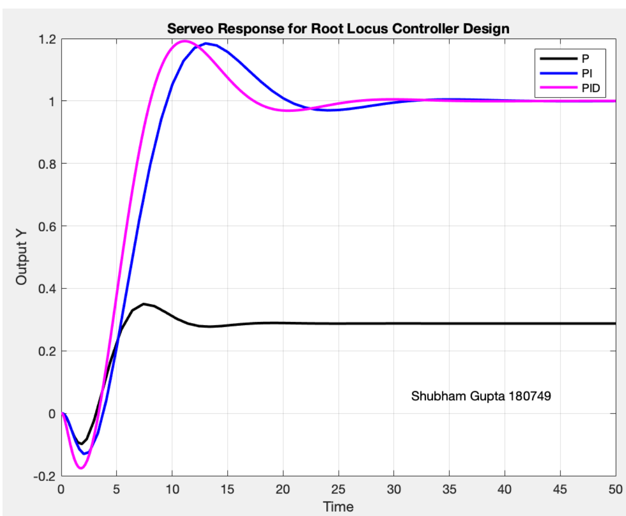





## Servo Response for Root Locus Controller Design:

Tuning Parameters:

- For P, $K_C$ = 0.2018 ; Dominant Pole: -0.3161 + 0.5475j
- For PI, $K_C$ = 0.1737, $\tau_I$ = 2; Dominant Pole: -0.1654 + 0.2865j
- For PID, $K_C$ = 0.1999, $\tau_I$ = 2, $\tau_D$ = 0.5; Dominant Pole: -0.1941 + 0.3362j

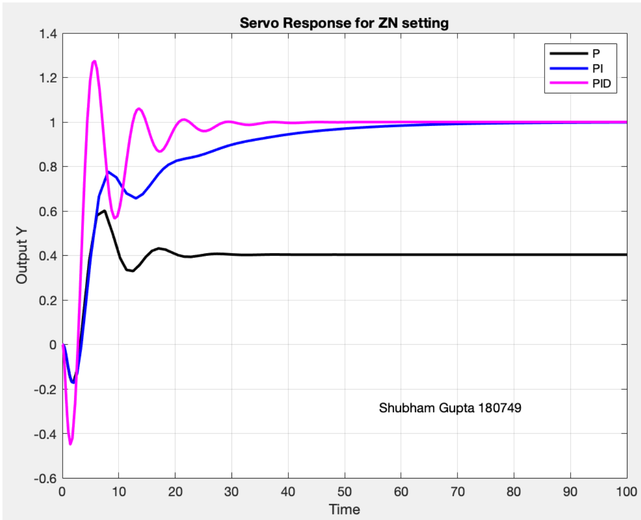



For ZN and TL, we need to compute $K_U$ and $P_U$ by solving the CLCE equation with s = $\omega$j and equation both real and imaginary part to 0. $K_U$ comes out to be 0.6772 and $P_U$ comes out to be 9.17.

## Servo Response for ZN setting:

Tuning Parameters:

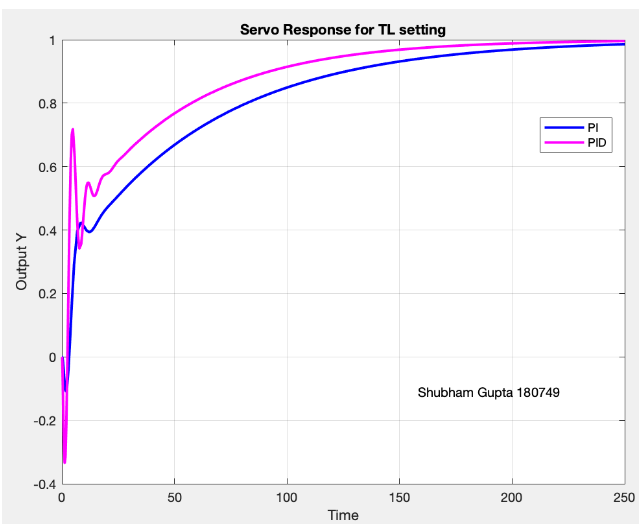
- For P, $K_C$ = 0.039
- For PI, $K_C$ = 0.308, $\tau_I$ = 7.642
- For PID, $K_C$ = 0.398, $\tau_I$ = 4.585, $\tau_D$ = 1.146



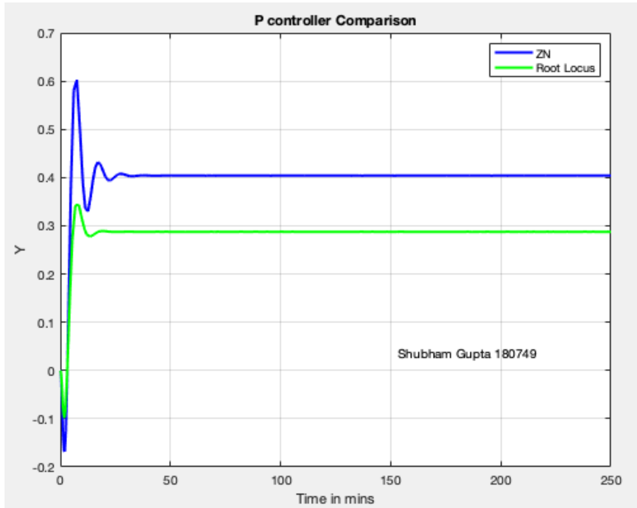

## Servo Response for TL setting:

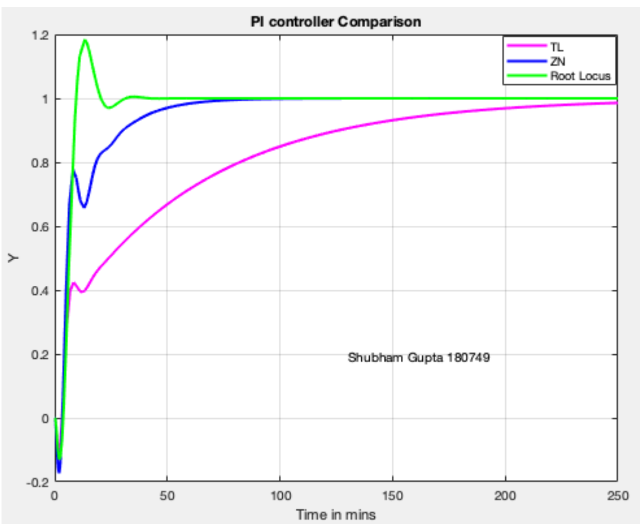
Tuning Parameters:

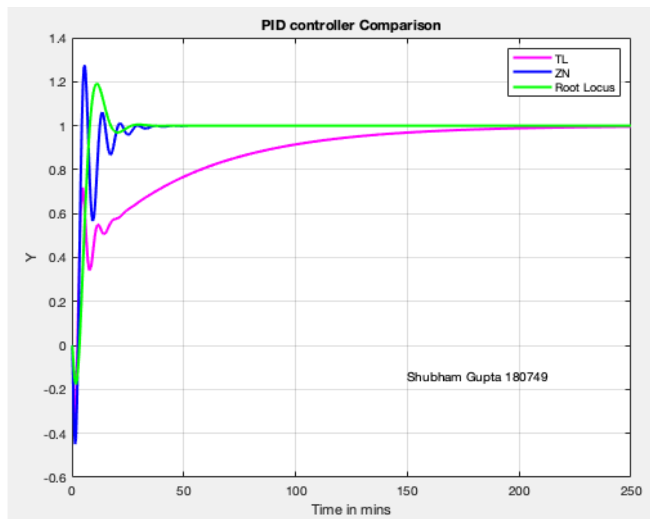
- For PI, $K_C = 0.212$, $\tau_I = 20.174$
- For PID, $K_C = 0.308$, $\tau_I = 20.174$, $\tau_D = 1.45$



## Comparative illustration of Root Locus method with ZN/TL Settings:




## CONCLUSION:

- For the P controller only we see an offset, for the PI controller we see no offset but it takes a longer time to reach steady-state and for the PID controller we see no offset and it reaches quickly to steady-state but it is prone to deviate due to minor change in our parameters.
- Ellipse for root locus is largest for the P controller and smallest for the PI controller. This is because $K_C$ is maximum for the P controller and minimum for the PI controller.
- When the root locus method is compared to the ZN/TL settings method for determining parameters of the controller, we observe that the root locus converges faster and with lesser fluctuations than the ZN/TL settings
- When we compare the ZN setting and TL setting, we see that the ZN setting reach the steady-state much faster than the TL setting. This is because ZN is not lag dominant while TL is lag dominant.