Ahsanullah University of Science & Technology

(Lab Report)

(Open Ended Lab)

Course No: EEE 4106

Course Title: Control System I

Experiment Name: Designing of a PD compensated system which can operate with a peak time that is (2/3) times of the uncompensated system operating at 20% overshoot.

Date:22/08/23

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Group :3

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Name of Experiment: Designing of a PD compensated system which can operate with a peak time that is (2/3) times of the uncompensated system operating at 20% overshoot.

Objective:

- Design a physical PD controller using the concept of root locus method.
- Compensate the present system to get the desired response.
- Observe the response in SISOTOOL, Simulink and for practical circuit in Waveforms (Analog Discovery 2).

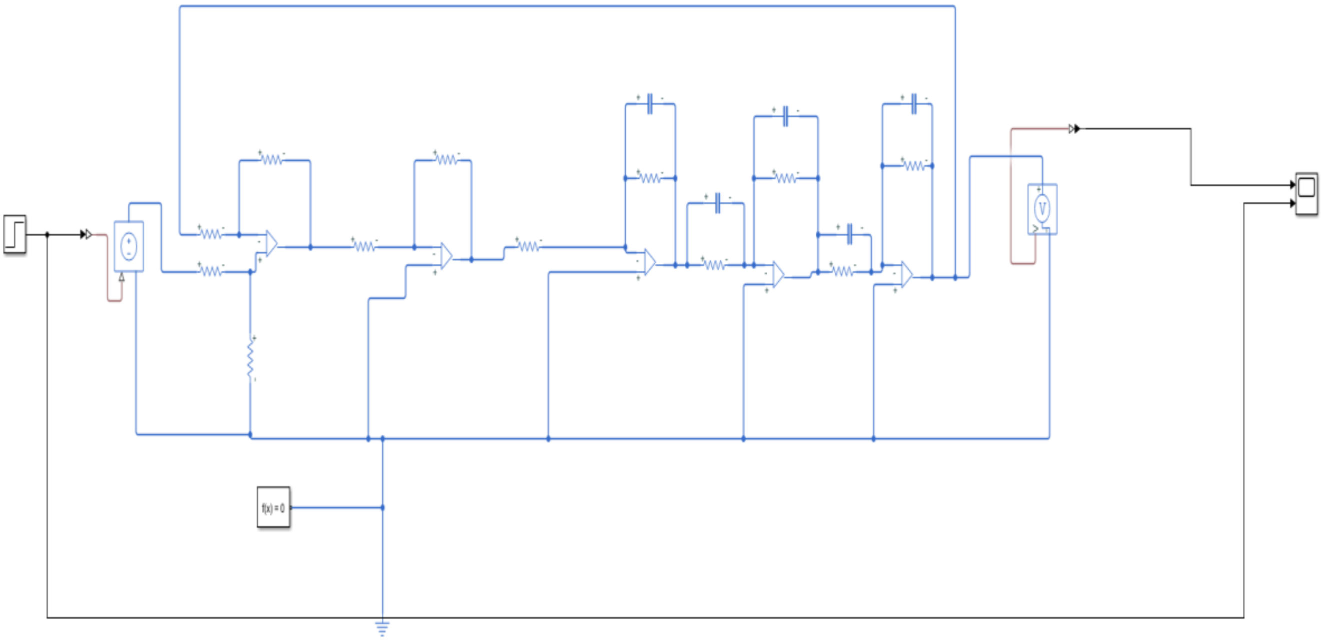
Equipments:

- Potentiometers.
- Op-amp.
- Capacitors.
- Resistors.
- Analog Discovery Device.
- Bread Board.
- Wires.

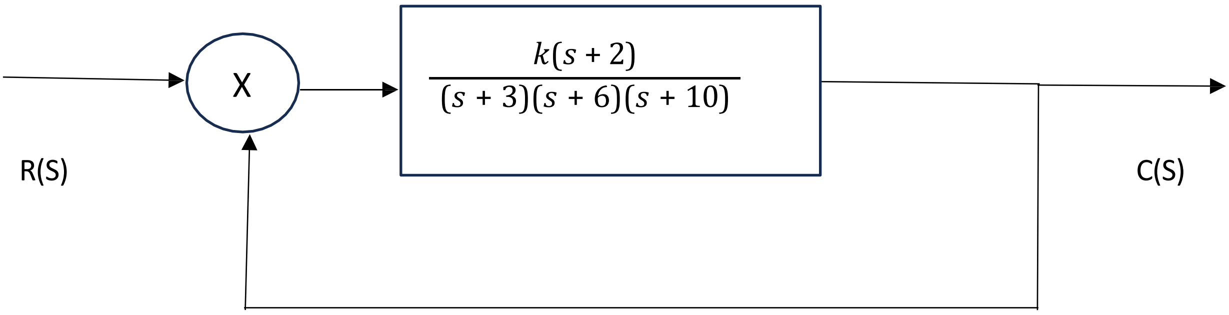
Breakdown of Work:

190205083: Hardware, Simulation, Calculation.
190205086: Hardware Setup.
190205088: Manual, SISOTOOL, Simulink, Calculation, Hardware.
190205089: Report, Calculation.

Circuit Diagram*:*



Calculation:



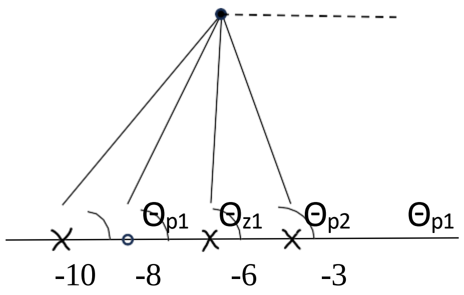
Given,

Overshoot ratio=0.20. So, $\zeta = \sqrt{\left(\frac{1}{1+\left[\frac{\pi}{\ln(Overshoot\ Ratio)}\right]^2}\right)}$

$$= \sqrt{\left(\frac{1}{1+\left[\frac{\pi}{\ln(0.2)}\right]^2}\right)}$$

Now, $\cos\theta = \zeta = 0.459$

$\therefore \theta = \cos^{-1}(0.459) = 62.67°$

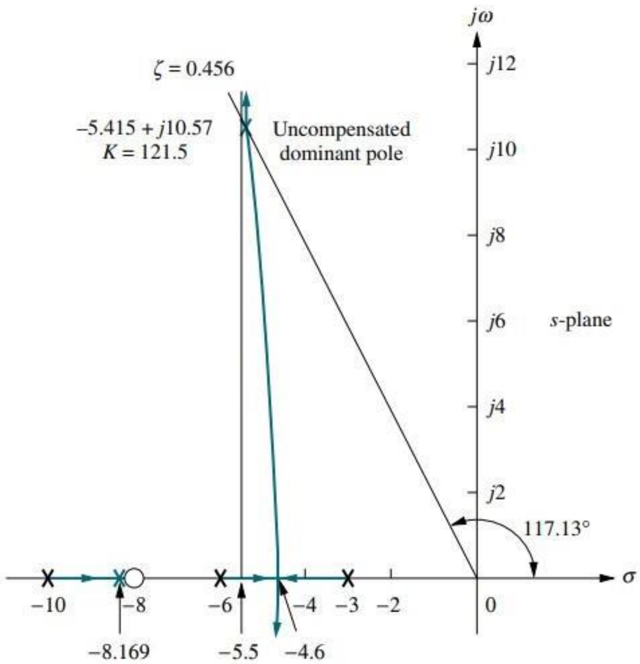


10.5

y=x.tan(62.67°)

=5.415 x tan(62.67°)

$\boxed{=10.5}$



Uncompensated Dominant Poles=-5.415±j10.57

Gain at this point-

$$\left|\frac{K(s+8)}{(s+3)(s+6)(s+10)}\right|=1 \qquad s=-5.415+j10.5$$

$$\therefore K=\left|\frac{(-5.415+10.5j+3)(-5.415+10.5j+6)(-5.415+10.5j+10)}{(-5.415+10.5j+8)}\right|$$

=121

Now,

$$T_p = \frac{\pi}{W_n\sqrt{(1-\zeta^2)}}$$

$\boxed{T_p = 0.298s}$ (Uncompensated)

$T_p' = \frac{2}{3} \times 0.298$ =0.198s (Compensated)

$$W_n = \frac{W_d}{\sqrt{(1-\zeta^2)}}$$

$$= \frac{10.8s}{1-0.456^2}$$

= 13.635

Now,

We know,

$$T_p = \frac{\pi}{W_d}$$

$$\therefore W_d = \frac{\pi}{T_p'} = 15.87 \text{ rads}^{-1}$$

Angle=62.67°

Or,

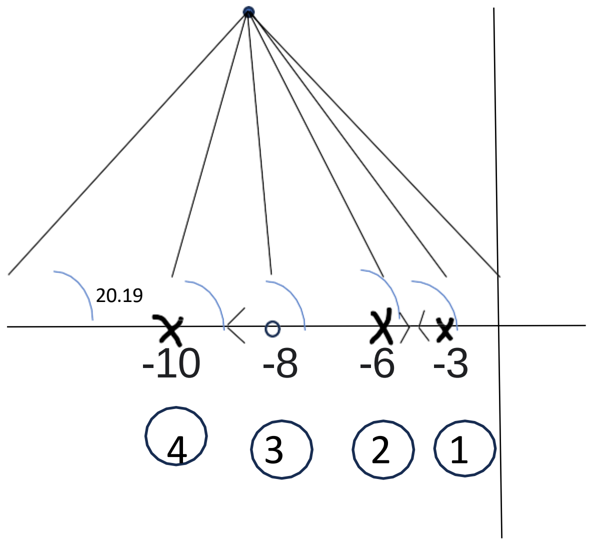
We know,

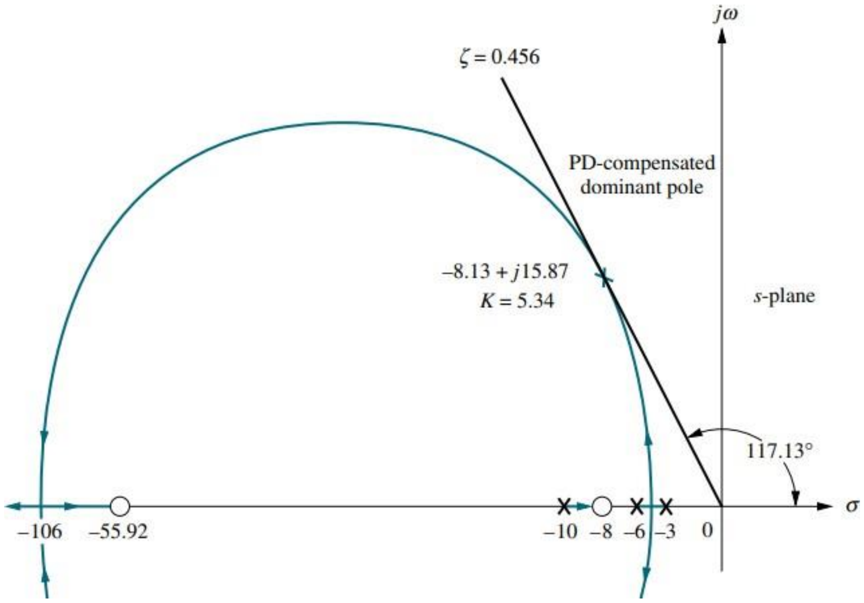
$$W_n = \frac{\pi}{T_p\sqrt{(1-\zeta^2)}} = \frac{\pi}{0.198\sqrt{(1-(0.2)^2)}} = 17.8$$

ζW_n=-8.13

$$x = \frac{y}{\tan(62.67°)} = -8.13$$

For





θ_{z1},

$\theta z1\text{-}\tan^{-1}\dfrac{15.87}{0.13}=\boxed{89.5°}$

θ_{p1}, $\theta_{p1}=180° - \tan^{-1}\left(\dfrac{15.87}{(8.13-3)}\right)=108.88°$

θ_{p2}, $\theta_{p2}=180° - \tan^{-1}\left(\dfrac{15.87}{(8.13-6)}\right)=97.64°$

θ_{p3}, $\theta_{p3}=\tan^{-1}\left(\dfrac{15.87}{(10-8.13)}\right)=23.27°$

Using the angle Criteria-

$$(\theta z + \theta z1) - (\theta p1 + \theta p2 + \theta p3) = -180°$$

$$\theta z = 20.29°$$

$$X'=\frac{15.82°}{\tan^{-1}\theta}=\frac{15.82°}{\tan^{-1} 20.19}=42.925°$$

$\boxed{Z_c=53.92}$

∴ Thus the PD controller is $G_{PD(s)}=(s+53.92)$

The OLTF(PD compensated)

$$\left| \frac{K(s+8)(s+55.93)}{(s+3)(s+6)(s+10)} \right|_{s=-8.13+15\text{-}87j}$$

$\boxed{K=10.866}$

Data:

For uncompensated System:

Peak time, Tp =0.297s.

%OS=20%. Gain

K=121.5.

Plant: T(S)= $\frac{K(S+8)}{(S+3)(s+6)(s+10)}$.

For compensated System:

Peak time, Tp=

%OS=

Gain K=

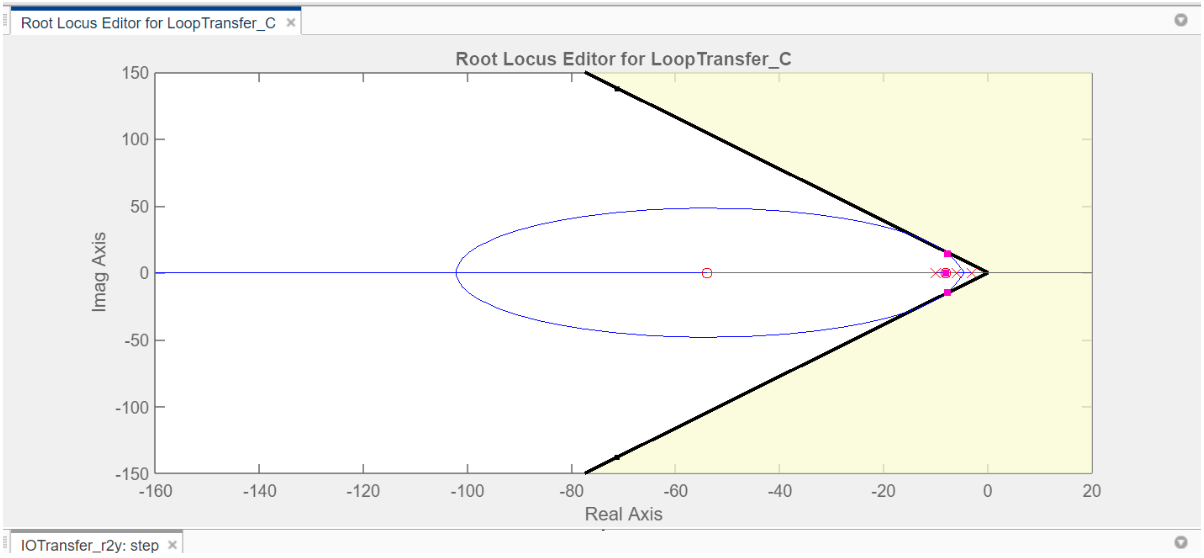
Plant: C(S)= $\frac{K'(S+8)(S+55.92)}{(S+3)(s+6)(s+10}$.

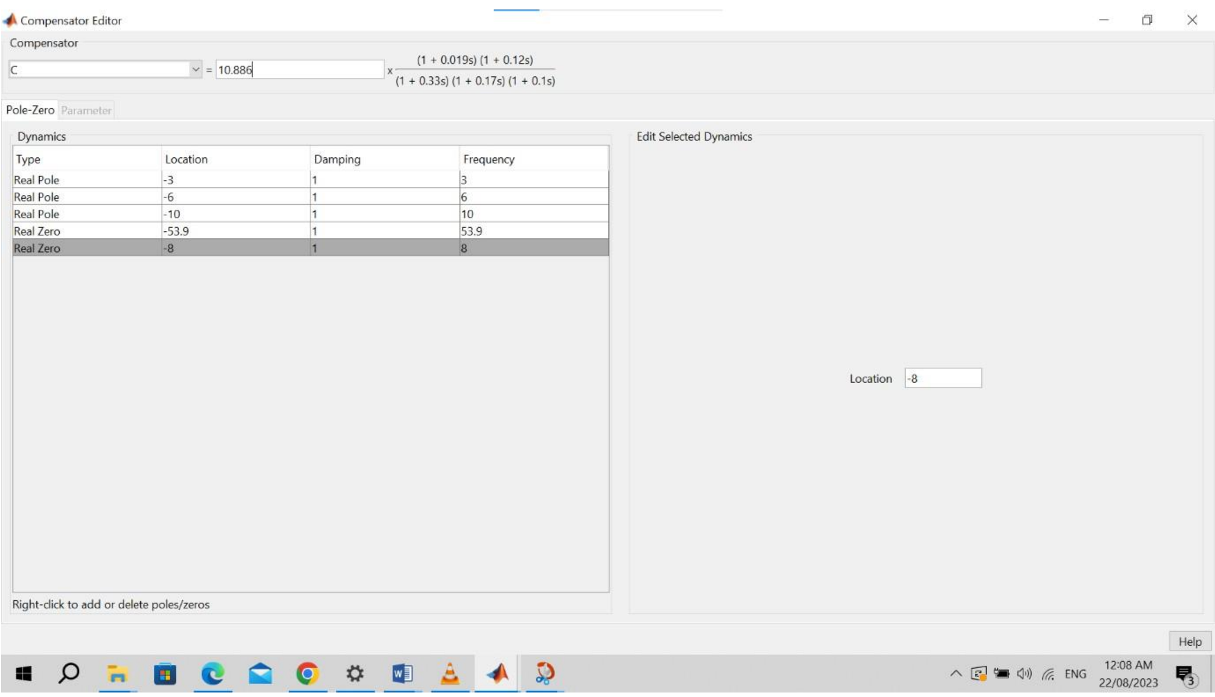
Assignment:

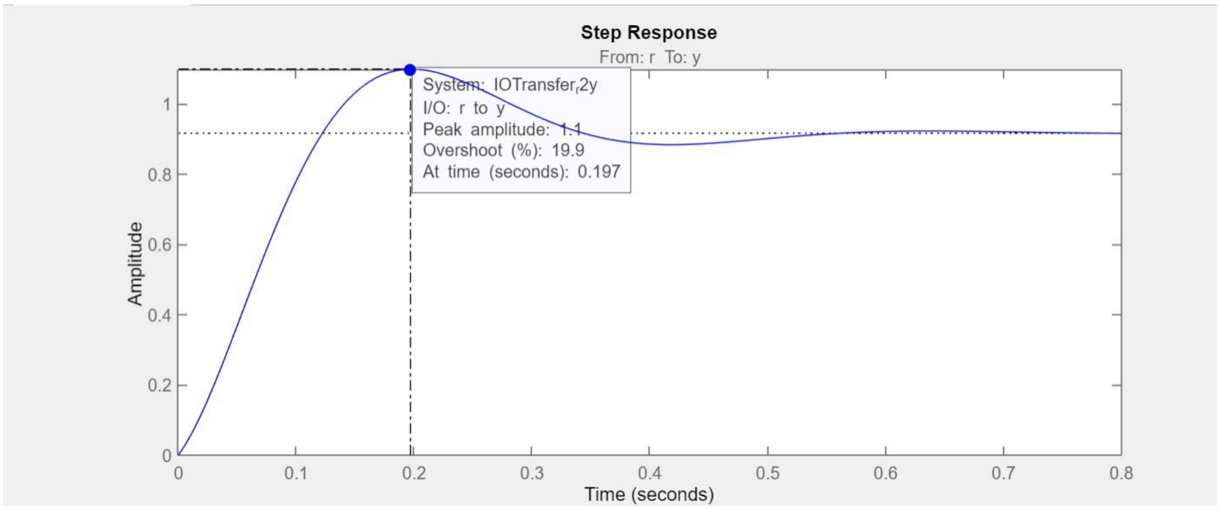
Q1: Observe the output response in SISOTOOL.

Ans:

Simulation in SISOTOOL:





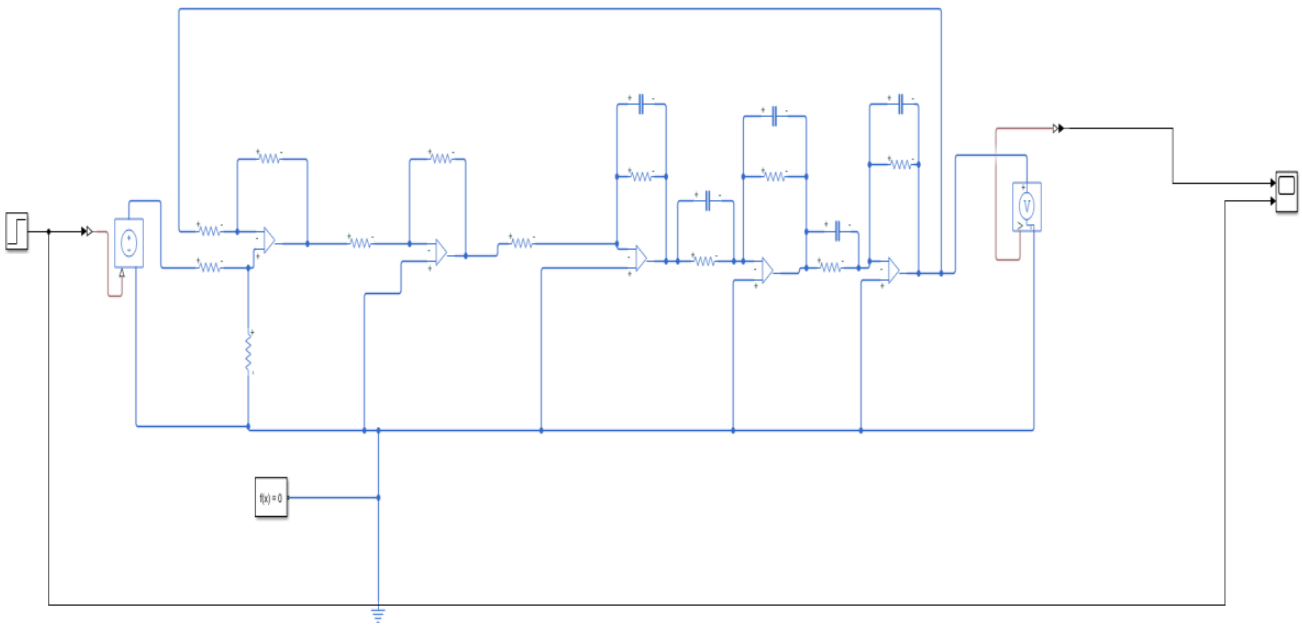


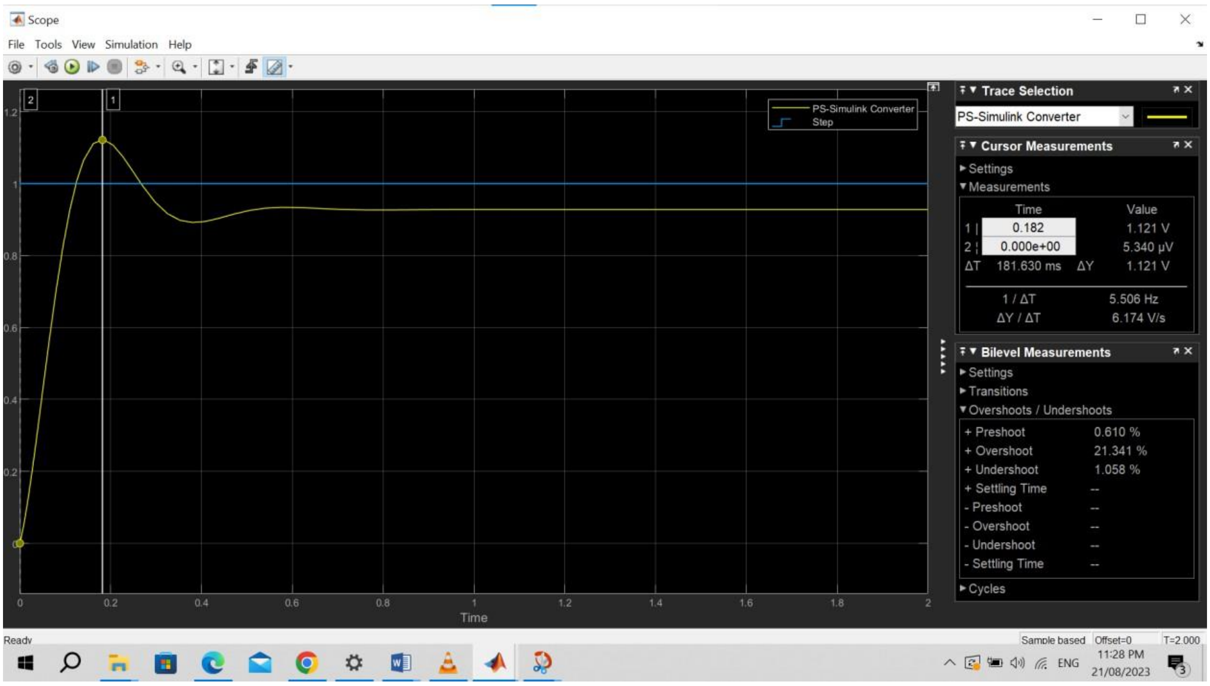
Here for the compensated system, %OS=19.9% & TP=0.197s

Q2: Design the physical circuit in simulation environment

Ans:

Simulation in Simulink:





Here from the left side of the scope we can see the %OS=21.314 & At the peak value the time TP=1.8

Discussion: In this experiment, a PD compensated system is designed. Basic geometry and the root locus method is used for the calculation. The physical system is designed using op-amp and other passive elements. The main challenge that is been faced during this experiment is varying the potentiometer. Getting the exact value of the resistance is very difficult here. The practical and the theorical values had some differences due to the rounding up of values during calculation. Also due to the resistance mismatch the practical value is been deviated. The PD controller has a significant impact in various real – world systems and applications across multiple industries. It’s ability to provide improved transient response and stability makes it a valuable tool in controlling dynamic processes. Some applications of PD controllers in real world are-Industrial automation and control, Robotics, Solar tracking system, Wind turbine pitch control, used in voltage regulation circuits, active suspension systems etc.