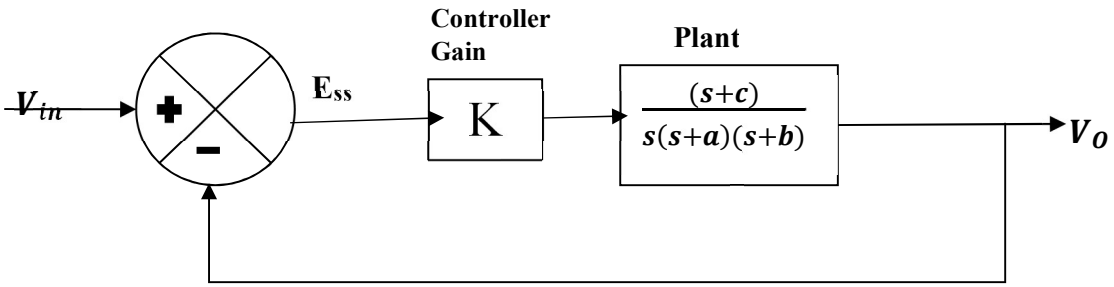
1. Consider the following closed loop system



a) You are required to design the system in Simulink environment such that the percentage overshoot, **%OS=30%** and settling time, **Ts (2%) =3 seconds** with a steady-state error, **E_{ss}= 0.045** when a **unit step input** is provided and **the system remains second order.** The value of **E_{ss}** must be displayed in the design using **"Display"** block.

According to the criteria,
From mentioned equation

$$\% \text{ Overshoot ratio} = 100\times e^{-\pi\zeta/\sqrt{1-\zeta^2}}$$

Overshoot = 30%
Damping Ratio = 0.34

And settling time 3s (for 2% error) gives natural frequency,$_n = 3.92\ rad/s$, from the equation 4

$$T_S = 4/(\omega_n * \zeta)$$

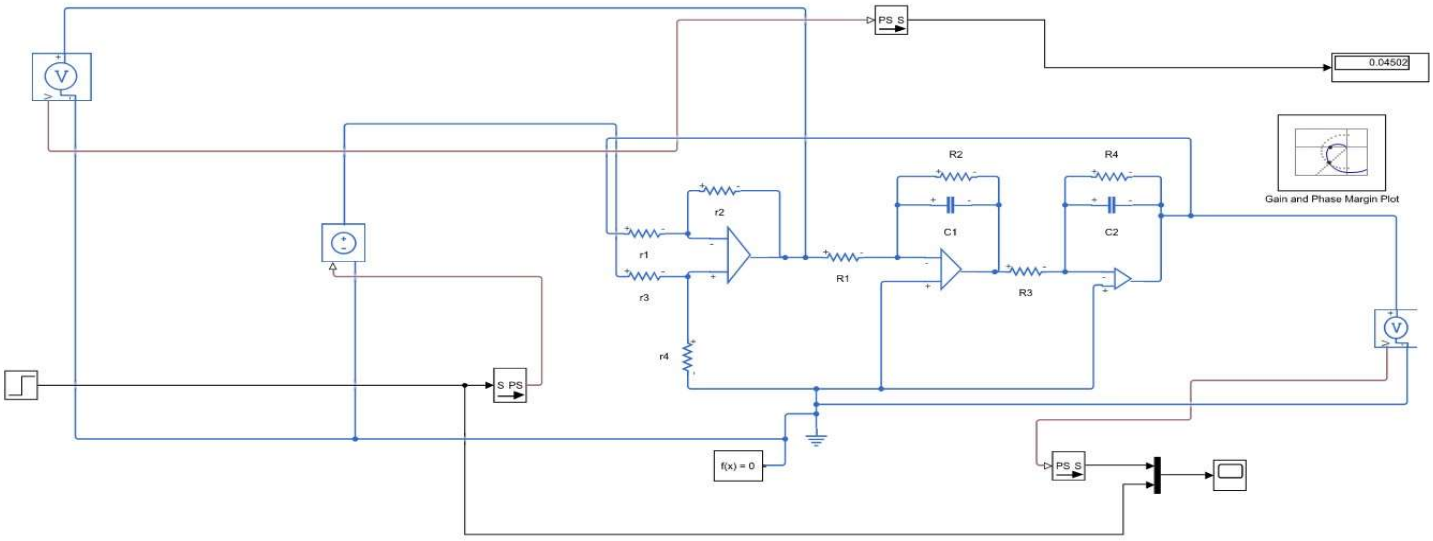
$$\text{From this equation} = (s^2 + 2\zeta\omega_n s + \omega_n^2)$$

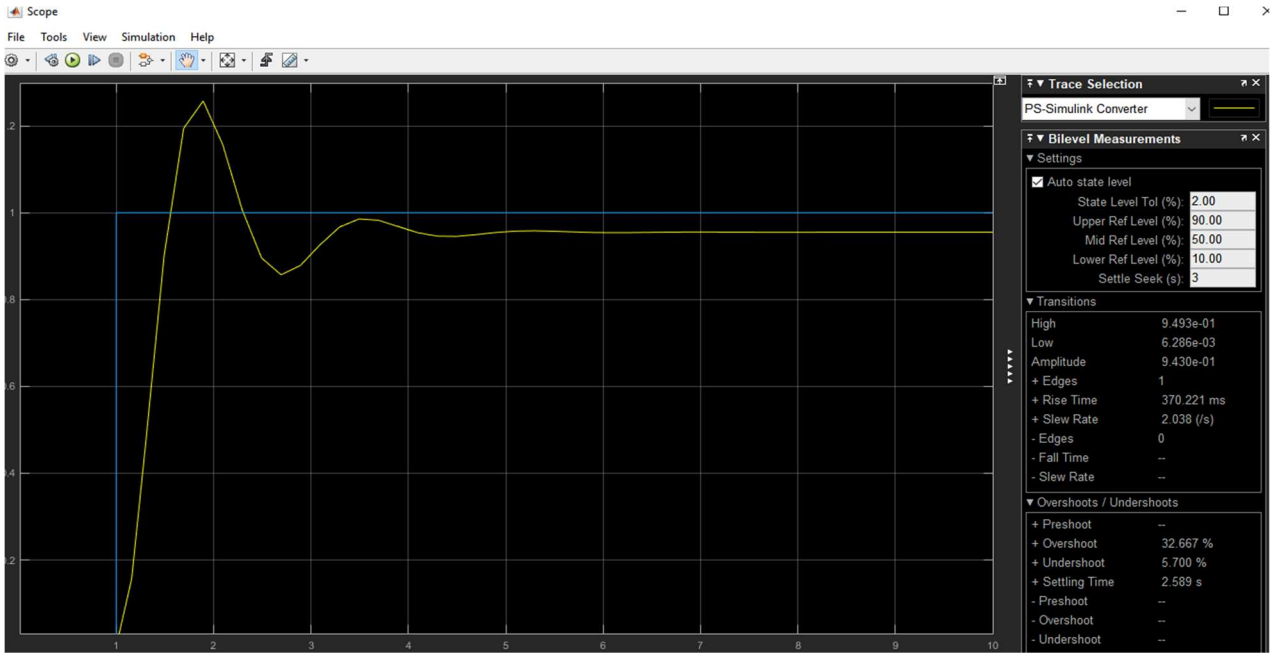
A= 0.291
B = 2.379
C= 0
K = 14.678

Designed Component Values will be

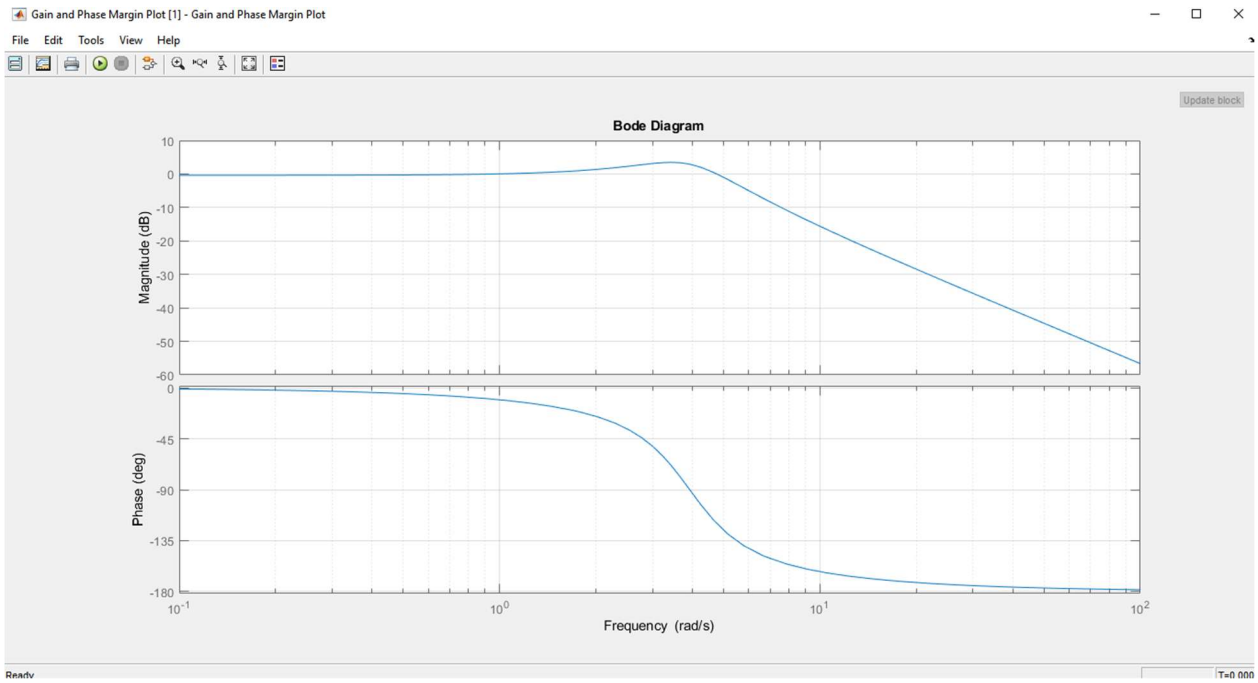
R1 = 100 KΩ
R2 = 343.64 KΩ
R3 = 6.81 KΩ
R4 = 42.034 KΩ
C1=C2 = 10 µF

Desired Design :





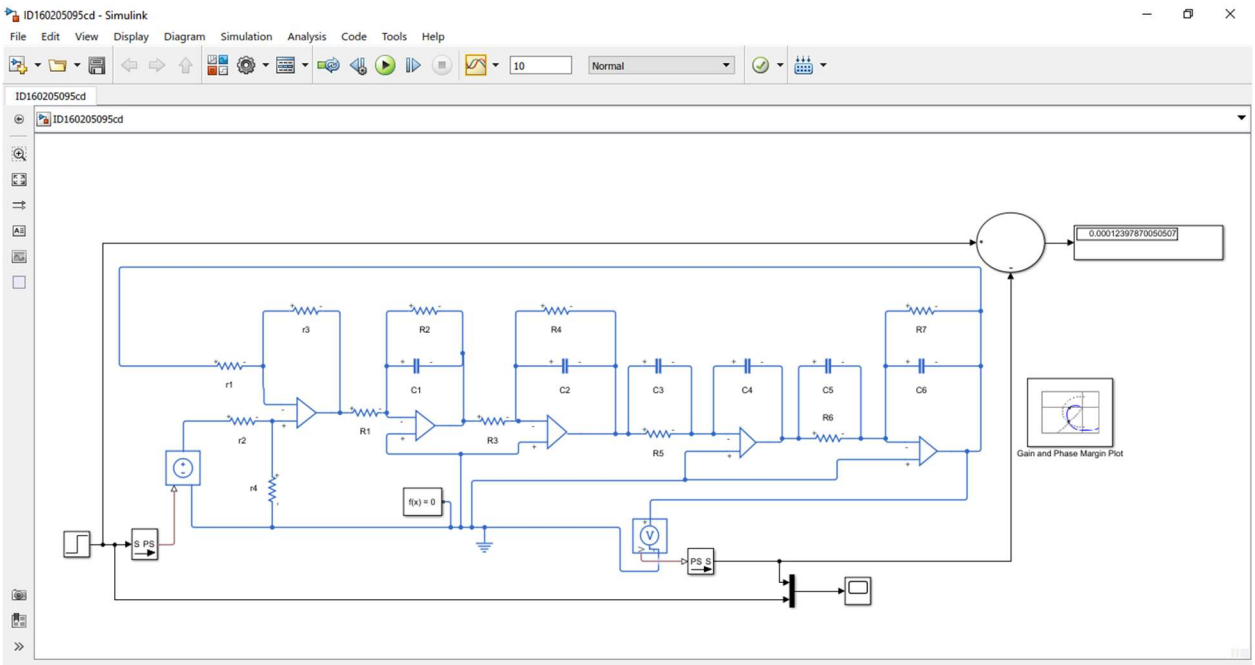
b) Show the **open loop Bode plot** for the aforementioned system and specify all the stability margins in the same Simulink model for question no. 1(a).

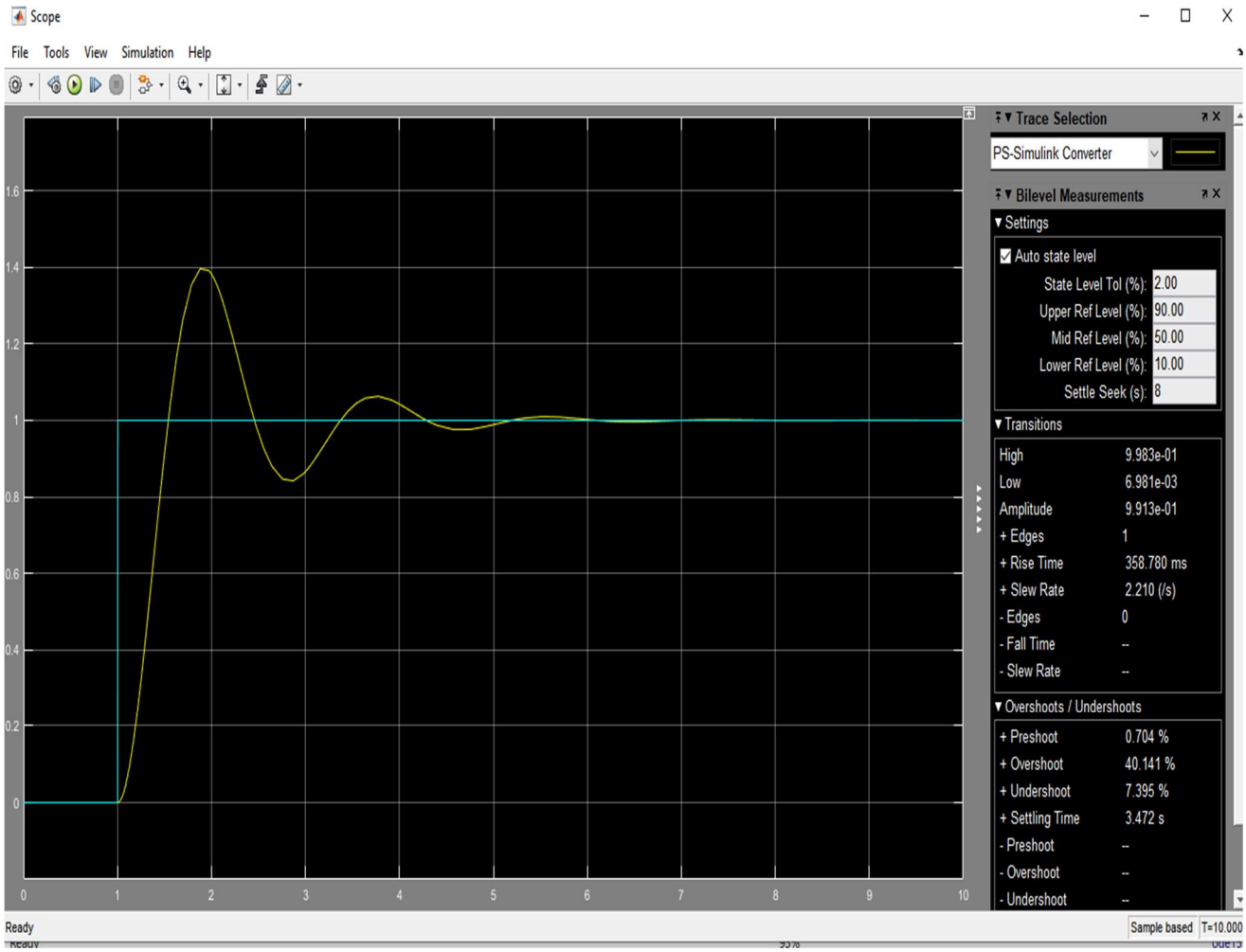


c) Now compensate the existing plant you have designed without changing the initial parameters in question no. 1(a) for the following specifications: **%OS=40% and Ts (2%) =4 seconds.** And the compensated system should be **error free.**

From Calculation:
Damping Ratio = 0.28
Natural Frequency = 3.571 rad/s
K= 12.755
New Pole = 1.9998
R1 = 343.64 KΩ
R2 = 42.034 KΩ
R3 = 50 KΩ
R4 = 100 KΩ
R5 = 42.034 KΩ
R6 = 7.84 KΩ
R9 = 343.64 KΩ
C = 10 µF

So the Desired Design :




Scope
File Tools View Simulation Help
Trace Selection
PS-Simulink Converter
Bilevel Measurements
Settings
Auto state level
State Level Tol (%): 2.00
Upper Ref Level (%): 90.00
Mid Ref Level (%): 50.00
Lower Ref Level (%): 10.00
Settle Seek (s): 8
Transitions
High 9.983e-01
Low 6.981e-03
Amplitude 9.913e-01
+ Edges 1
+ Rise Time 358.780 ms
+ Slew Rate 2.210 (/s)
- Edges 0
- Fall Time --
- Slew Rate --
Overshoots / Undershoots
+ Preshoot 0.704 %
+ Overshoot 40.141 %
+ Undershoot 7.395 %
+ Settling Time 3.472 s
- Preshoot --
- Overshoot --
- Undershoot --
Ready
Sample based
T=10.000

d) Show the **open loop Nyquist plot** for the aforementioned system and specify all the stability margins in the same Simulink model for question no. 1(c).