1. Code:

a. To generate Nichols and Bode plot.

```
s=tf('s');
G=20/(s^3+4.5*s^2+5*s);
G1=(19.4*s+20)/(0.074*s^4+1.335*s^3+4.686*s^2+5*s);
figure();
hold on;
bode(G)
bode(G1)
legend();
grid on;
hold off;
figure();
hold on;
nichols(G)
nichols(G1)
grid on;
grid minor;
hold off;
figure();
rlocus(G1);
grid on;
bw1=bandwidth(G1);
bw2=bandwidth(Gc1)
```

b. To obtain step response.

```
s=tf('s');
G=20/(s^3+4.5*s^2+5*s)
G1=G/(G+1);
Gc=(19.4*s+20)/(0.074*s^4+1.335*s^3+4.686*s^2+5*s);
Gc1=Gc/(Gc+1);
figure();
hold on;
step(G1,'--');
step(Gc1,'k');
```

2. Observations from the plots.

Phase margin without compensator (from fig.1).

PM = -176 ^{o}+180^{o} = 4^{o}

ω_g = 2.1rad/sec

Phase margin of compensator= 60^{o}(Given)

Additional phase req. = specified PM – PM of uncompensated
s/s at ω_g + ε = 60^{o} – 4^{o} + 3^{o} = 59^{o} |ε=3^{o}

ε is greater than the PM of the system hence ε=5^{o} is right assumption. But when we substitute, we get 61^{o} hence α=0.6688 which is less than 0.07 which is not acceptable hence we reduce the value of the ε to 3^{o},then we obtain α= 0.076908.
ω_n = 3.7rad/sec from bode plot(Fig 1).

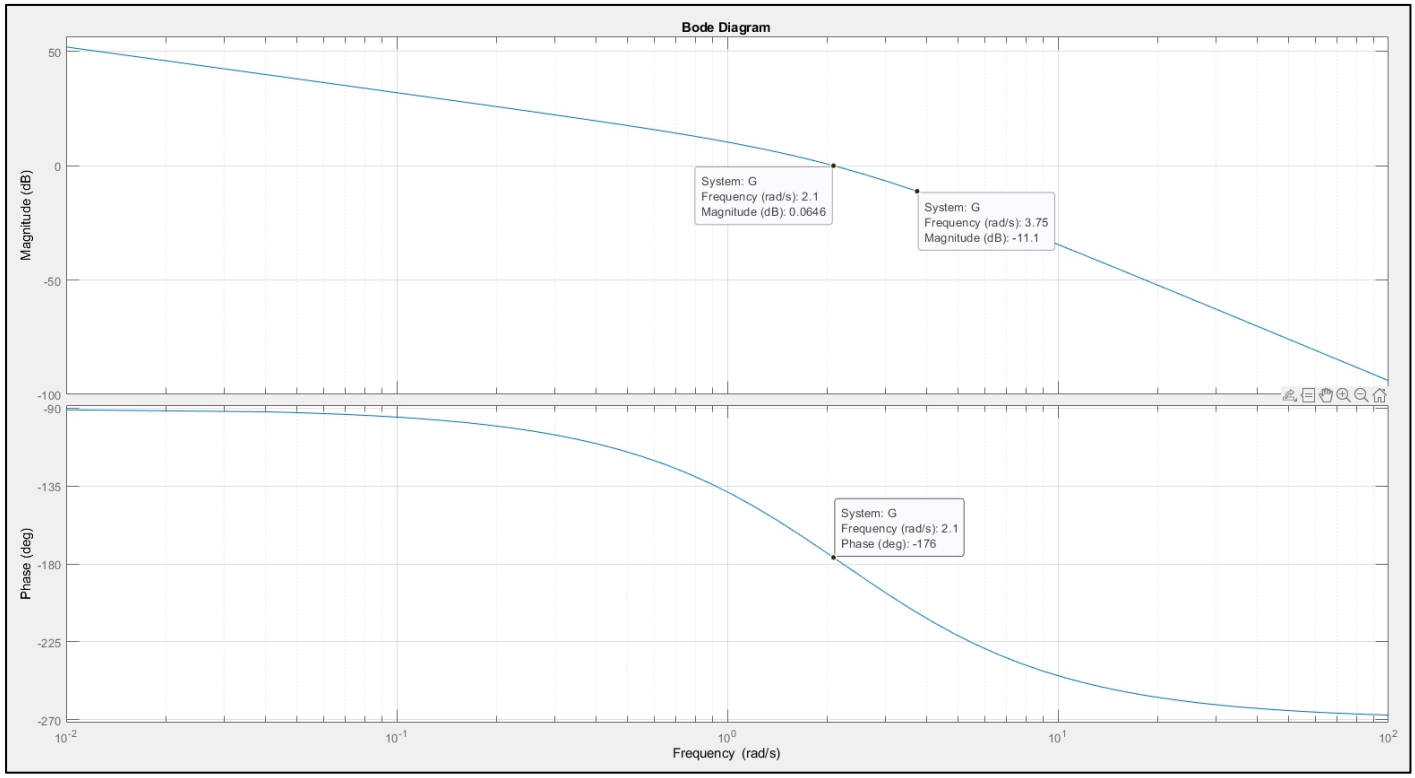

Fig. 1: Bode plot of uncompensated or without controller

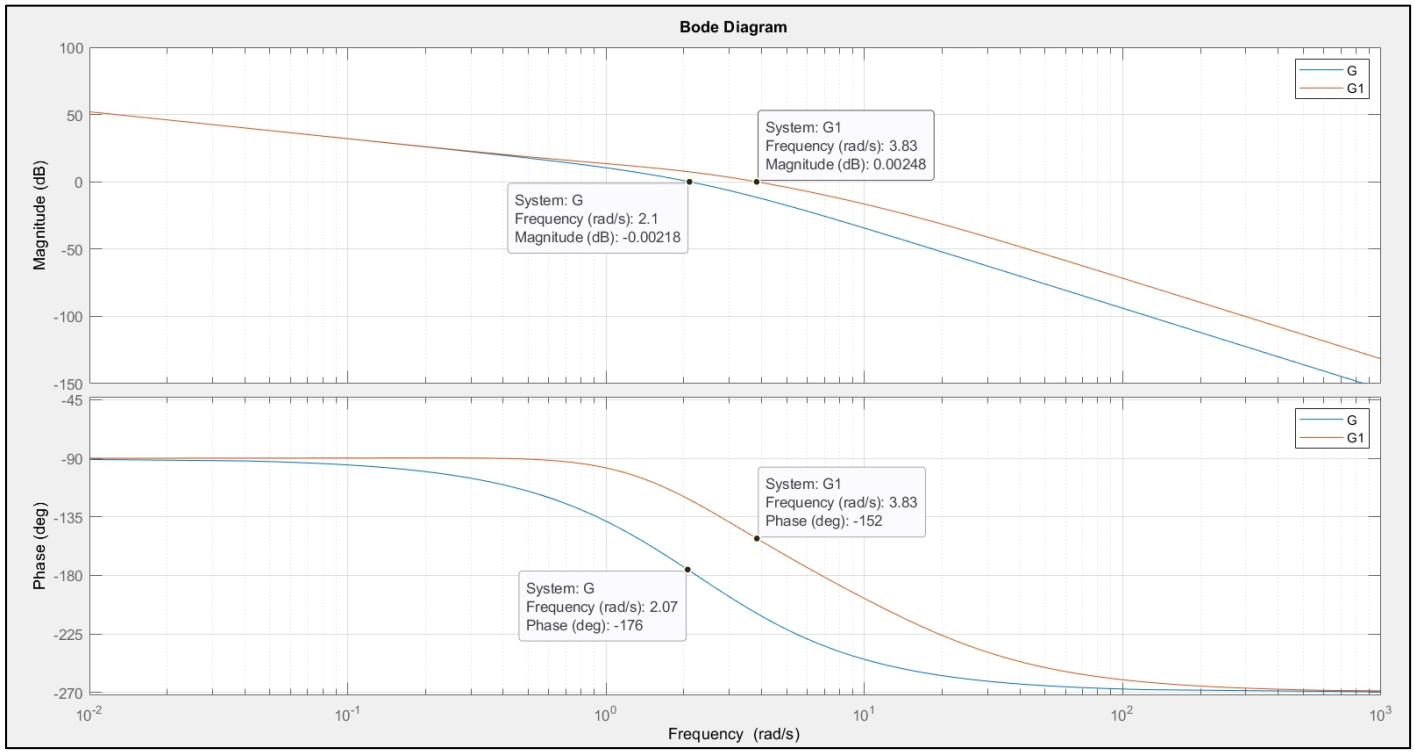

Fig. 2: Bode plot comparison of uncompensated and compensated system.

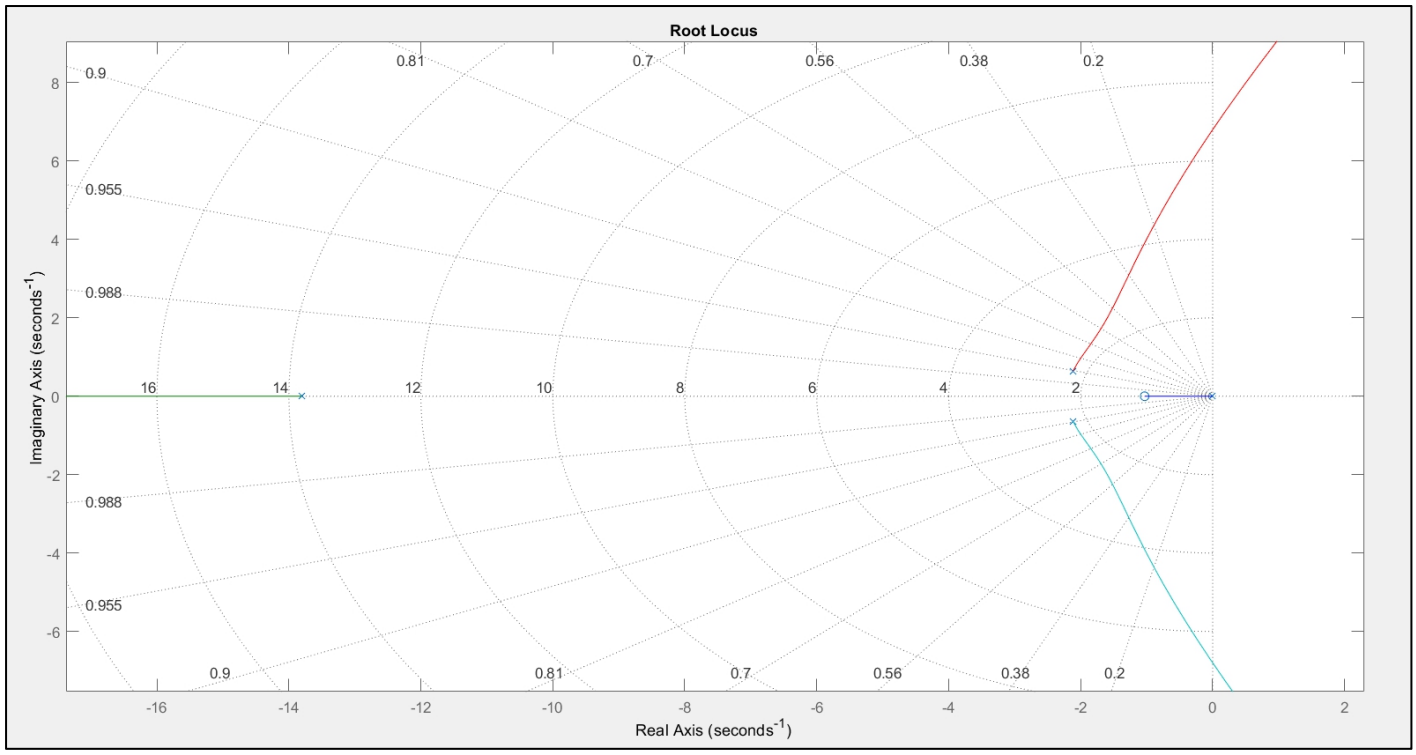

Fig. 3: Root locus plot of the compensated system.

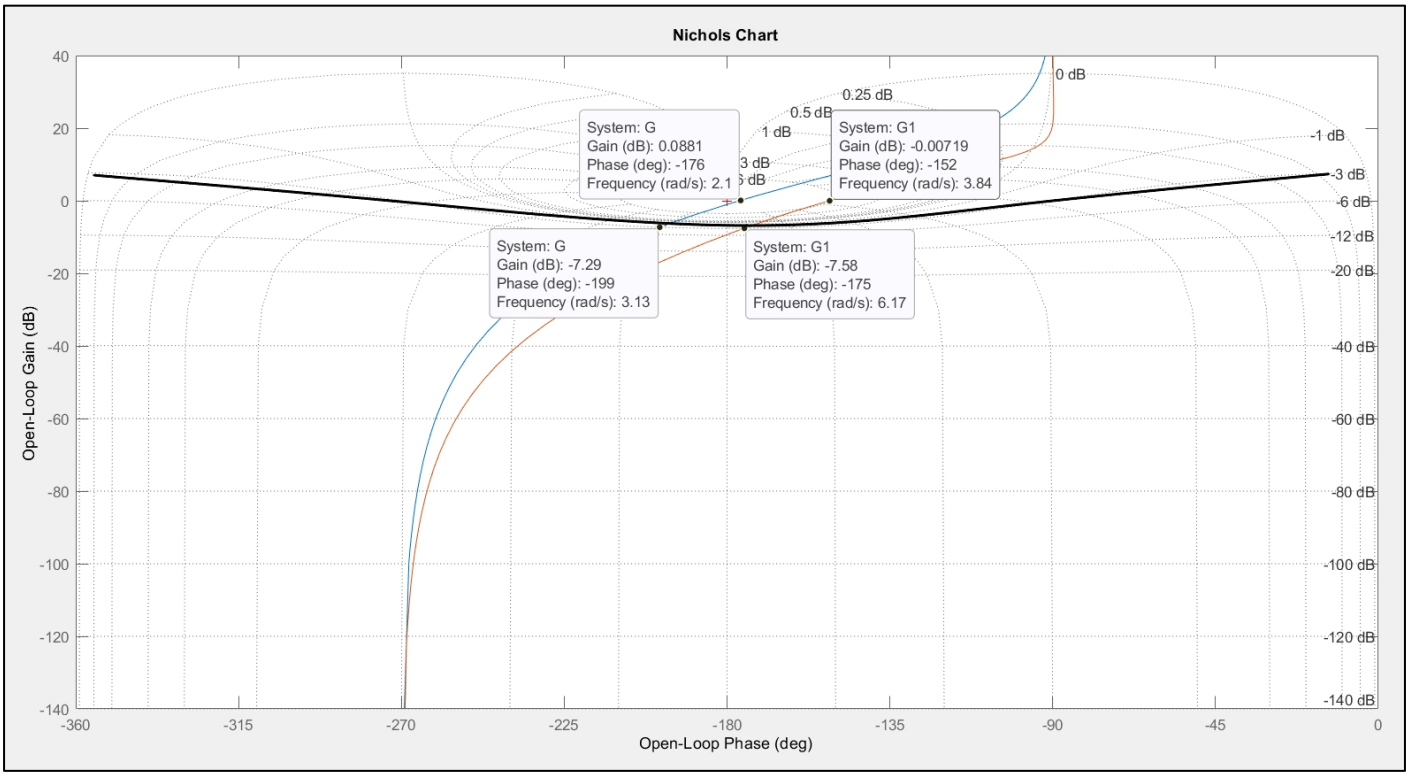

Fig. 4: Nichols chart for the system to compare with compensated and uncompensated system. And also to find the bandwidth at -3dB point from the right Y axis.

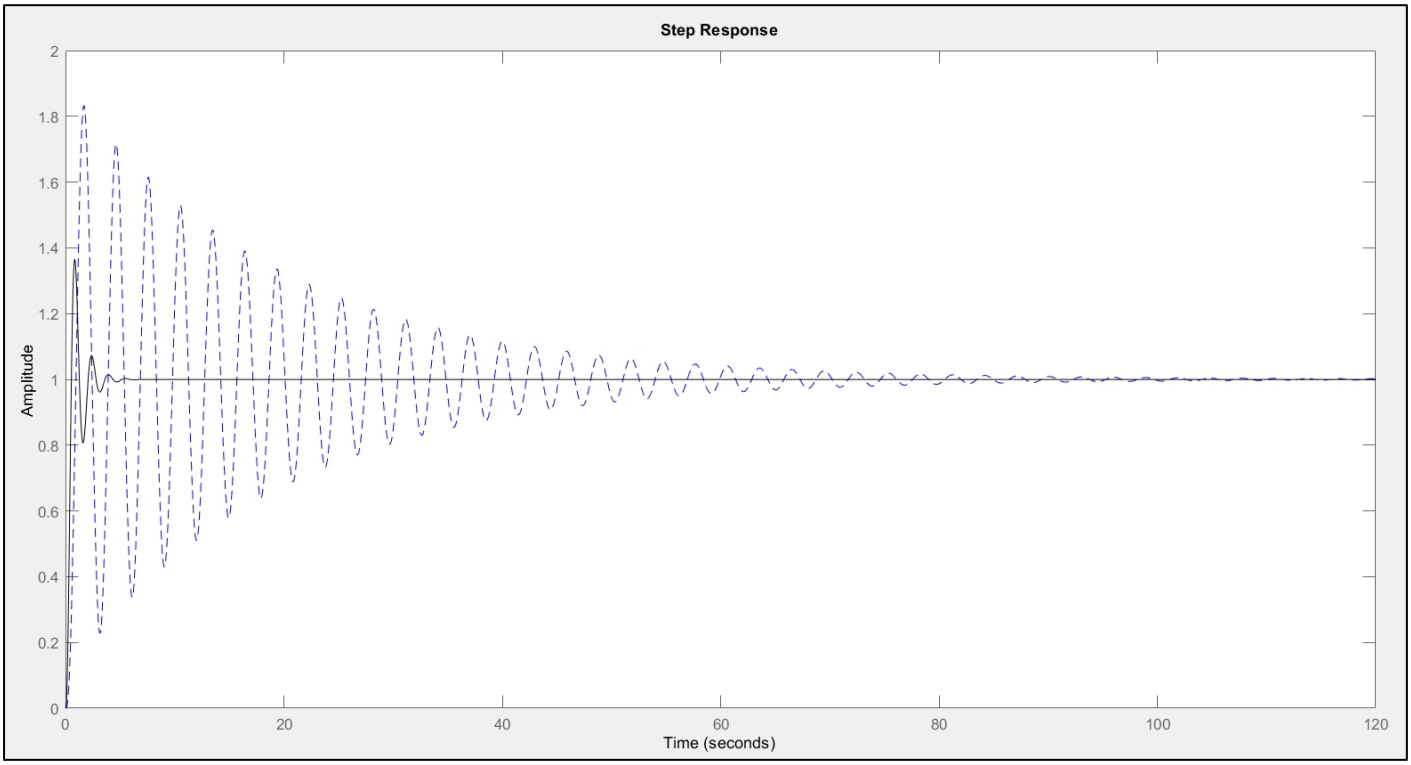

Fig. 5: Step responses for both compensated and uncompensated (dotted line is for uncompensated) Closed loop is considered for the plot.

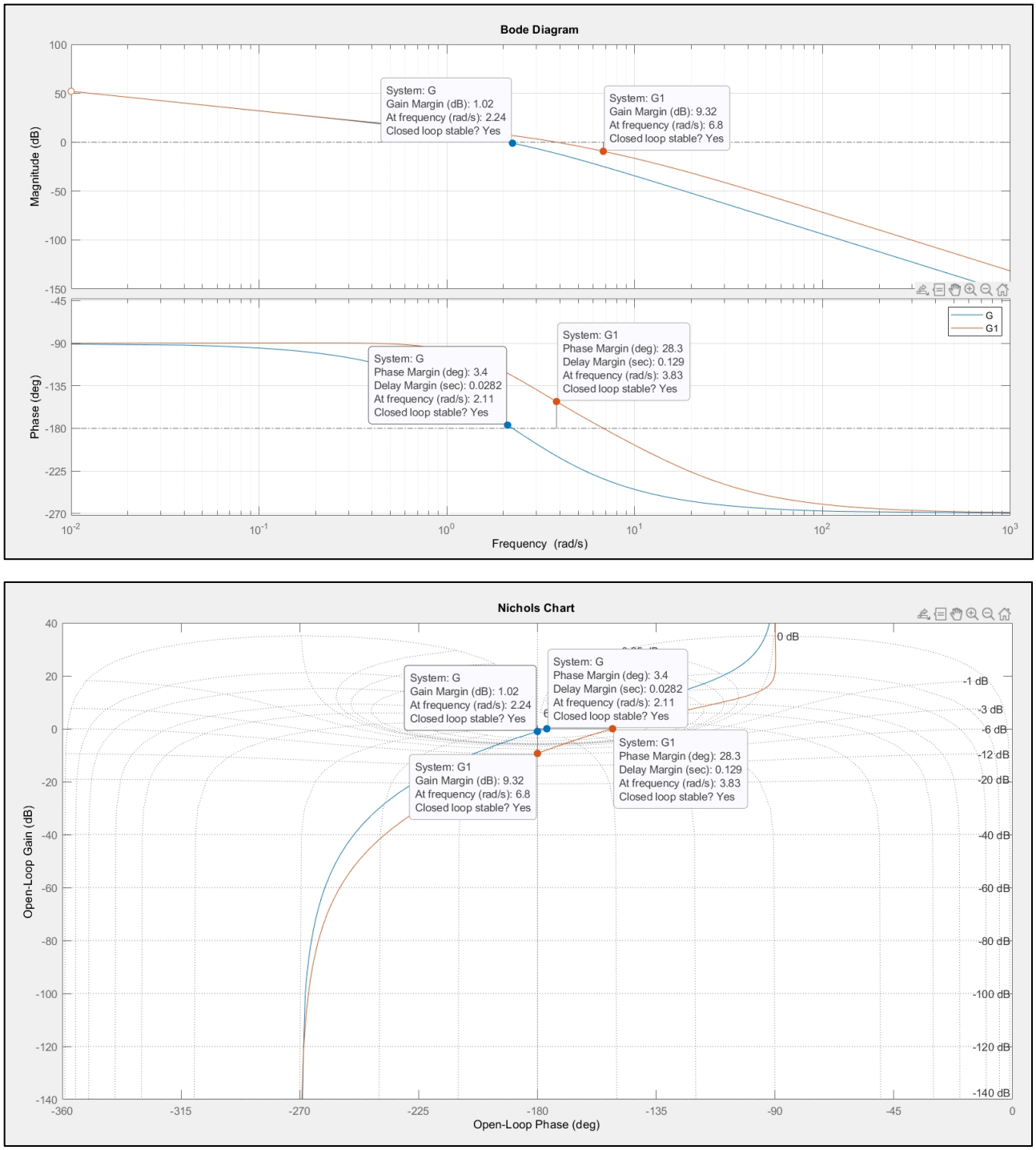

Fig. 6-7: Verification of the obtained values with All Stability margins option in the characteristics of bode plot and nichols chart.

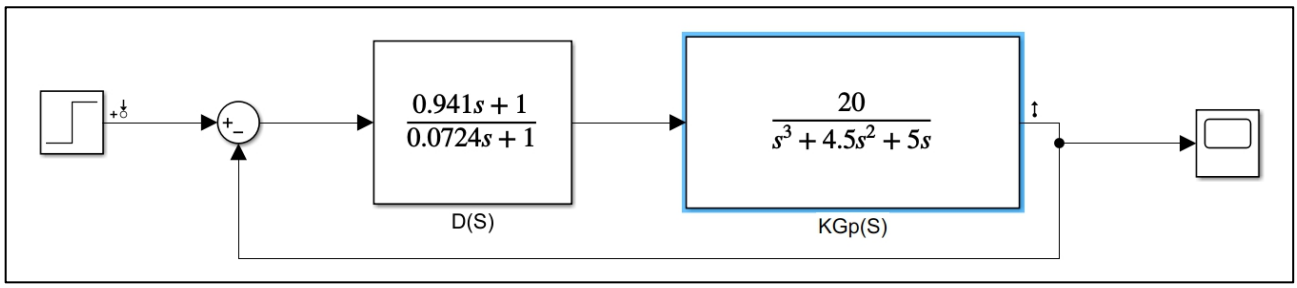

Fig 9: Block Diagram of compensated system