

ELECENG 3CL4 Lab 5 Report

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1 Design of a Lead-Lag Compensator for the Quanser Servomotor

The design of the lead-lag compensator uses the lead compensator that was designed in Lab 4, and modifies it to reach a steady-state error target without affecting the transient response significantly. This is achieved by introducing a lag compensator with the addition of an additional pole and zero. The zero was placed at 0.2, a point close to the origin. As the design objective of the lag compensator is to reduce the steady state error due a step disturbance by a factor of 10, the pole is placed at $z/10 = 0.02$. The angle between the zero and pole relative to the closed-loop pole was found to be 0.52 degrees, below the 1 degree design guideline. This lag compensator is simply added in series to the existing lead compensator. The addition of the lag compensator in MATLAB can be seen in Listing 1.

Listing 1: Lag compensator

```
69 G = tf(A/tau_m,[1,1/tau_m,0]);
70 Gc_lead=tf(kc*[1,z],[1,p]);
71
72 zlag = 0.2;
73 plag = zlag/10;
74
75 %Construct the transfer function model of the lead-lag
    compensator
76 lag_system=tf([1,zlag],[1,plag]);
77 Gc_leadlag=series(lag_system,Gc_lead);
78
79 %Construct the open loop transfer functions
80 L_lead=series(Gc_lead,G);
81 L_leadlag=series(Gc_leadlag,G);
```

The addition of the lag compensator does not have a significant effect on the transient performance of the system, as seen in the root locus in Figure 1, the step response in Figure 2, and the ramp response in Figure 3.

The addition of the lag compensator significantly reduces the steady state error of the system, as seen in the response to a step disturbance in Figure 4. The steady state error in the system with the lead-lag compensator is about 10% of the error in the system with just a lead compensator. The steady state error design objective of the lead-lag compensator is achieved, while also keeping the transient response that is designed with the lead compensator largely unchanged.

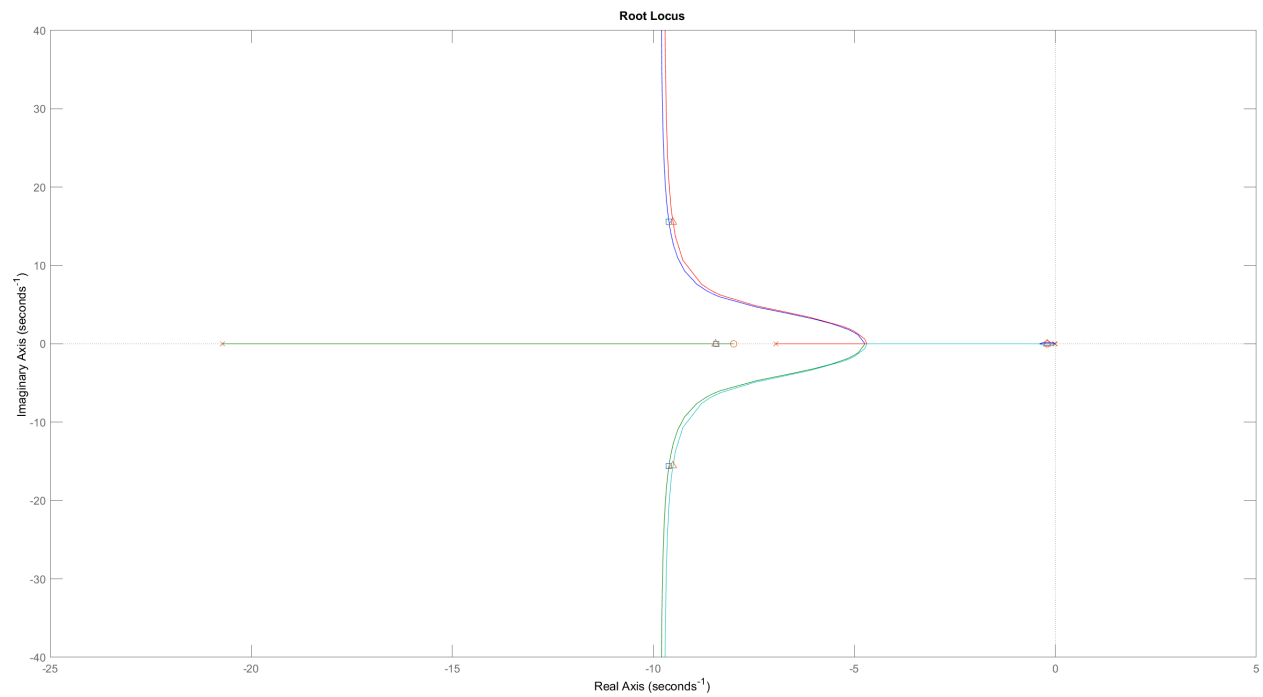


Figure 1: Root Locus

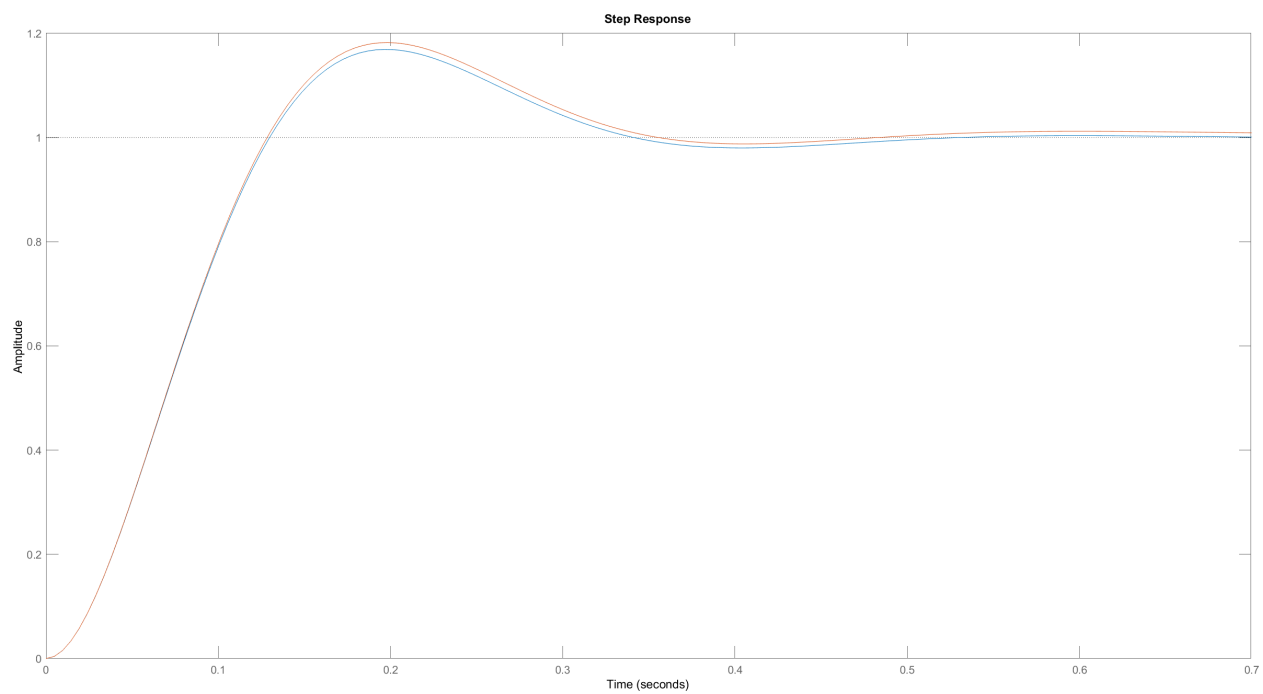


Figure 2: Step Response

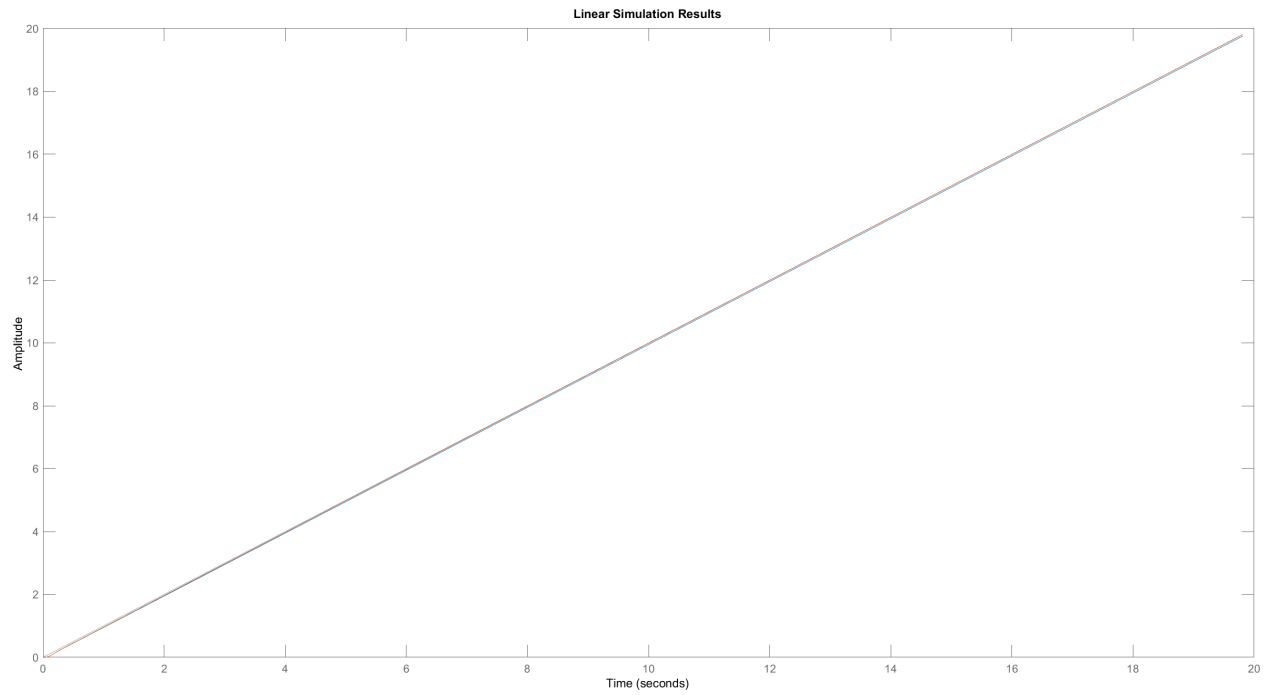


Figure 3: Ramp Response

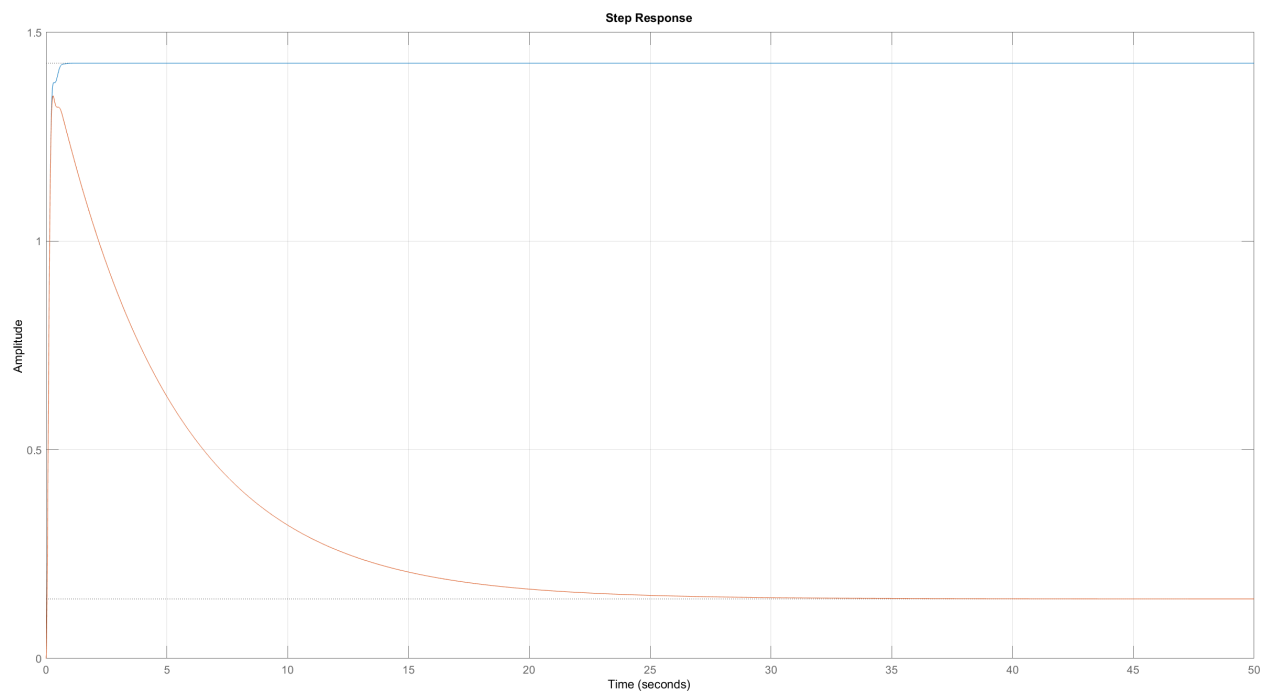


Figure 4: Step Disturbance

2 Experiment: Implementation of Your Lead-Lag Compensator

The step response of the system with the lead compensator is shown in Figure 5, and the step response of the system with the lead-lag compensator is shown in Figure 6

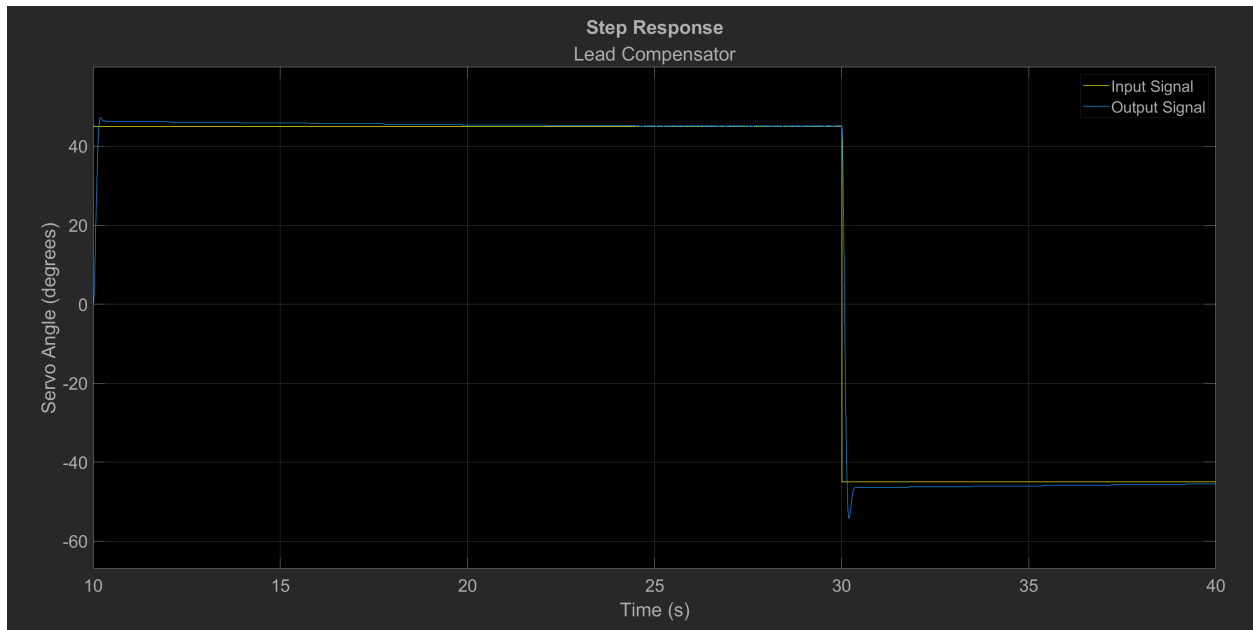


Figure 5: Lead Compensator: Step Response

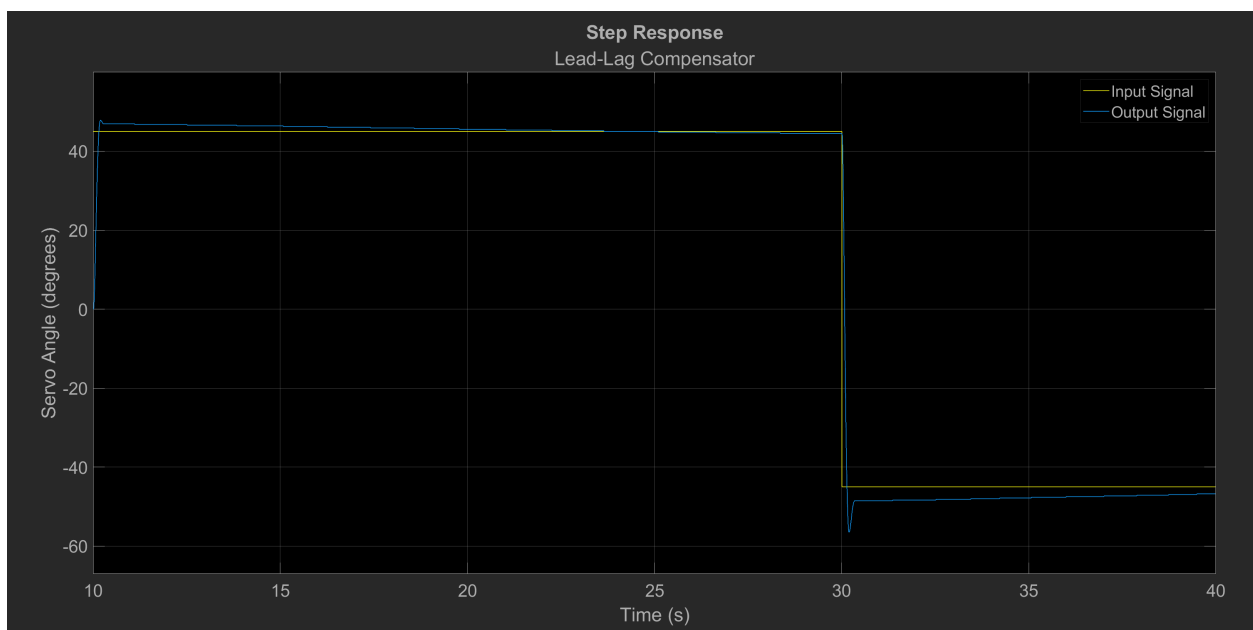


Figure 6: Lead-Lag Compensator: Step Response

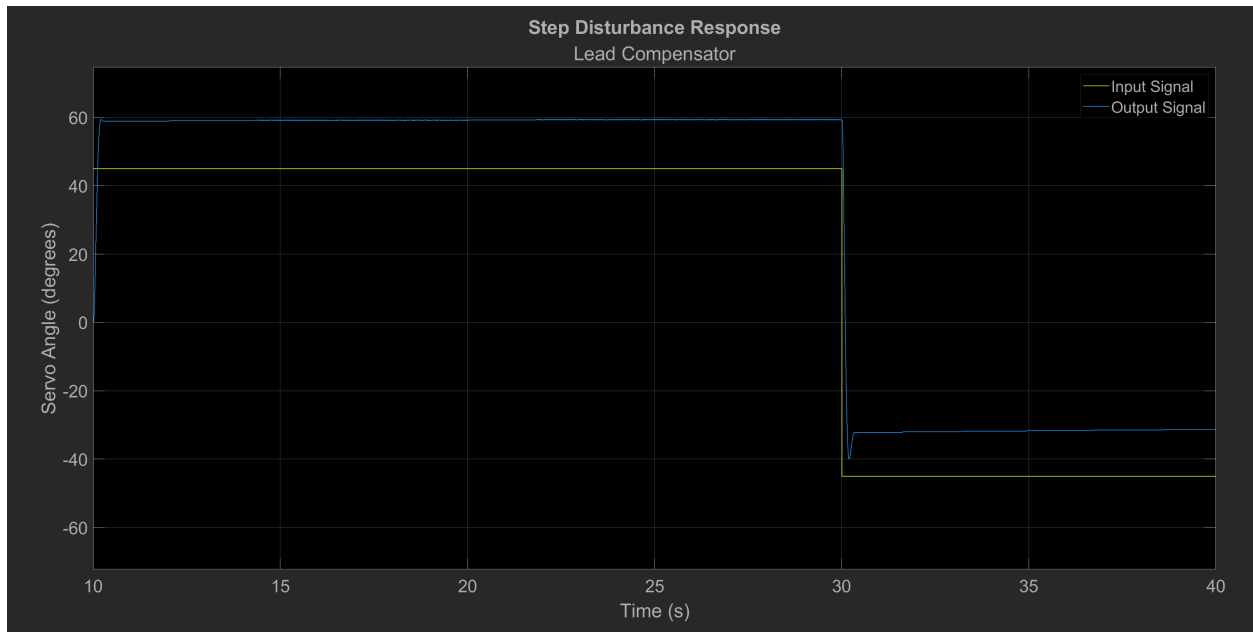


Figure 7: Lead Compensator: Step Disturbance Response

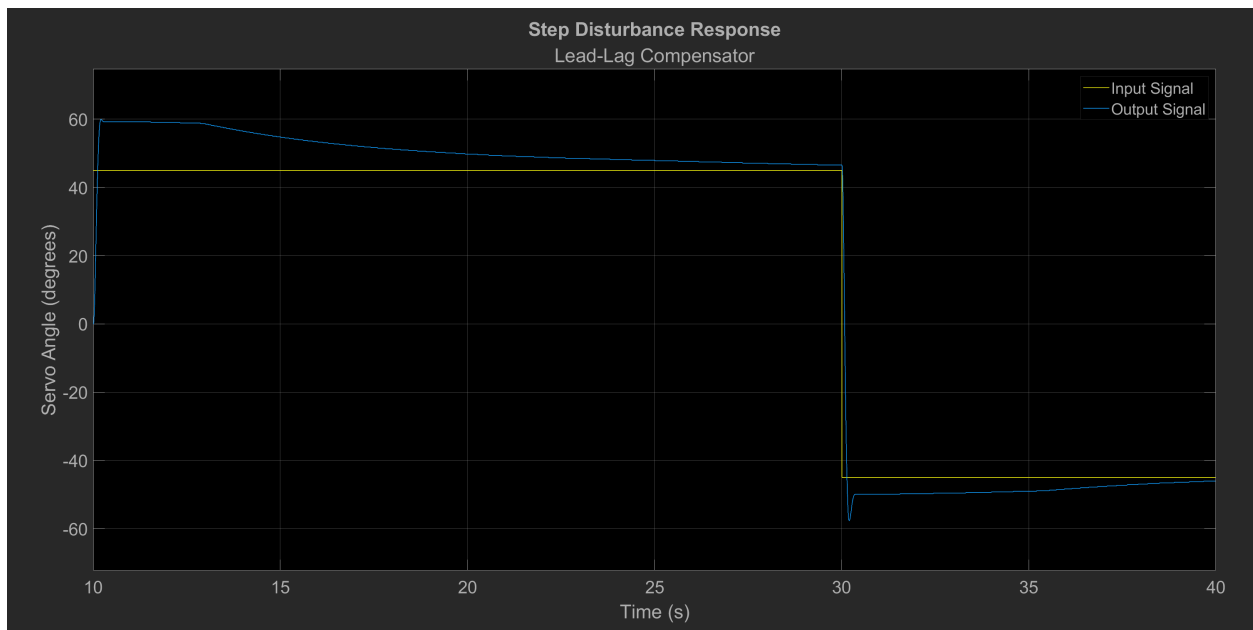


Figure 8: Lead-Lag Compensator: Step Disturbance Response

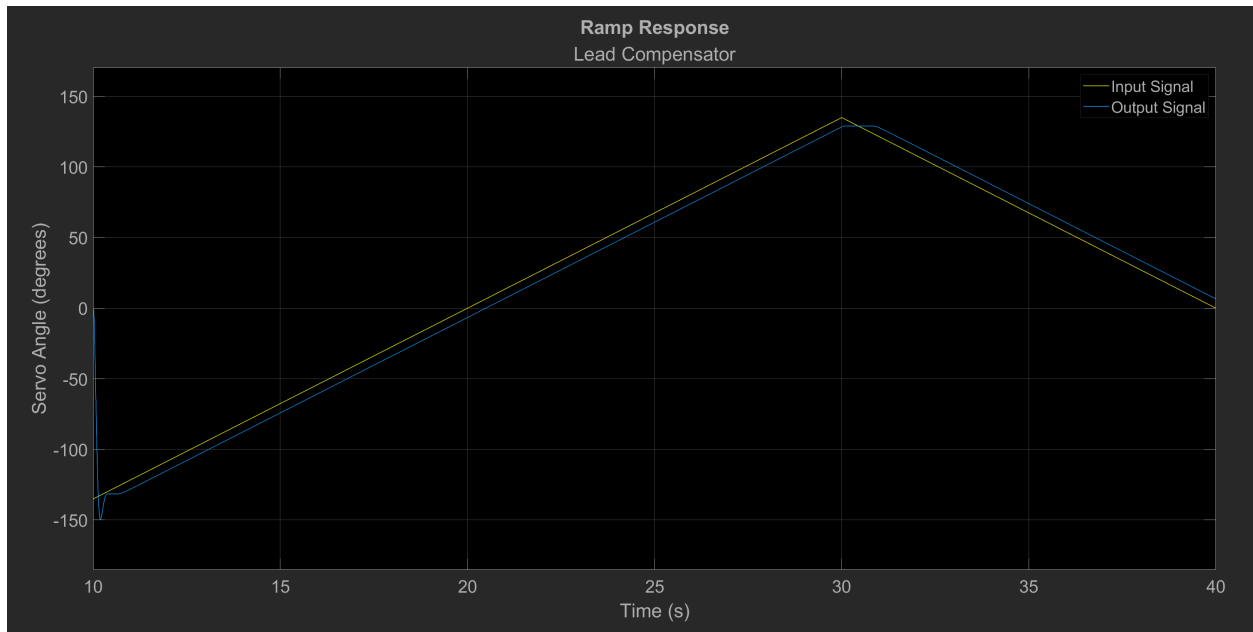


Figure 9: Lead Compensator: Ramp Response

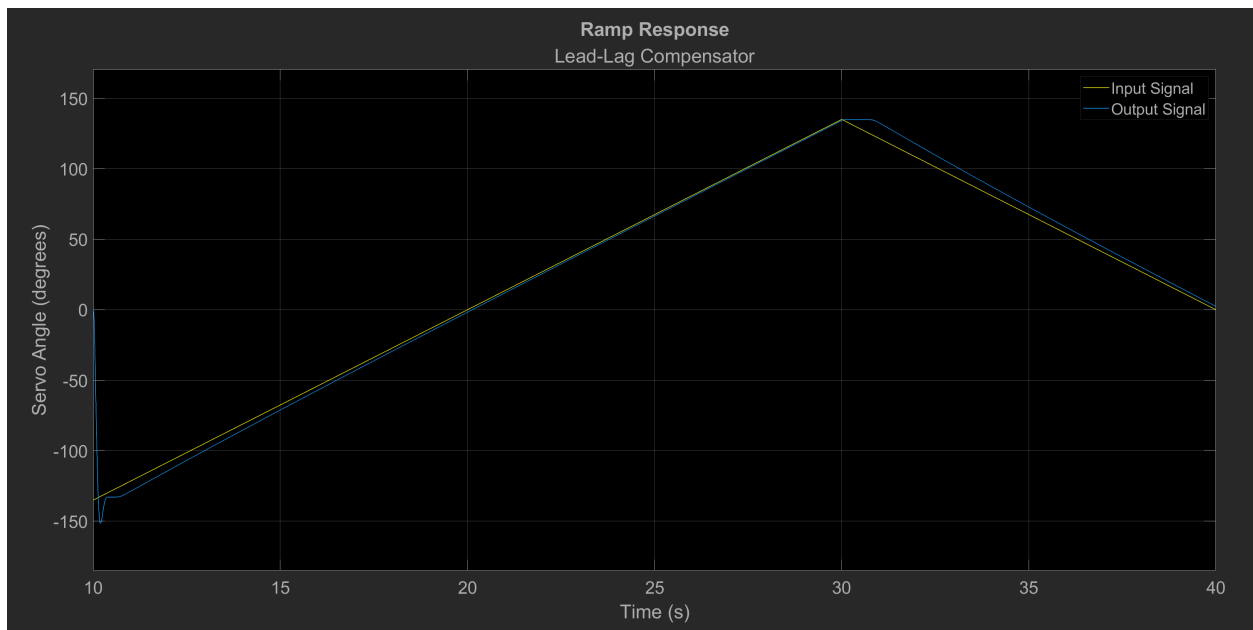


Figure 10: Lead-Lag Compensator: Ramp Response