## **Project: Design Lag-Lead and PID Controllers**

# **Abstract**

The main objective of this design project is to help students to design different types of controllers such as lag-lead and PID controllers. First of all, we start designing these two controllers by hand using several steps with checking the steadystate error for each controller. Moreover, we verify our design results using MATLAB, SIMULINK and SISOTOOL Design in order to plot the root locus for the open loop system and to plot the step response as well. Ultimately, we apply what we have learned from the lectures in designing our lead-lag and PID controllers for this project.

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# **MATLAB and SIMULINK Simulations:-**

# <u>Part I</u>

```
>> num = [1];
>> den = [1 0 0];
>> OL = tf (num,den)
Transfer function:
1
---
s^2
```

>> step(OL)



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Sisotool Design: >> sisotool(OL) %OL is the open loop transfer function

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Step response of the original system:



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### Adding Lag-Controller to the previous design:

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# SIMULINK:





#### Explanation of the results:

The known is the closer you get to the real axis the smaller the overshoot you get.

However, in this case the T.F function of the system is not the same as the general

form :  $\frac{wn^2}{s^2 + z wn s + wn^2}$ , due to the existence of a zero in the target region which

increases the percent overshoot. Thus, getting a 5% overshoot will be extremely hard.

# Effect of Disturbance on the System:

If step disturbance is added to the system after the Lead-Lag controller, it will affect the response of the system by an extremely small amount. Hence, it can be concluded that the Lead-Lag controller can resist the added step disturbance but will not completely eliminate its effect.

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# <u>Part II</u>

>> num=[1]; den=[1 0 0]; OL=tf(num,den) Transfer function: 1 --s^2

>>sisotool(OL)





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Root Locus after adding a PD controller with the design requirements



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# **SIMULINK:**





#### Explanation of the results:

The known is the closer you get to the real axis the smaller the overshoot you get. However, in this case the T.F function of the system is not the same as the general form:  $\frac{wn^2}{s^2+z wn s+wn^2}$ , due to the existence of a zero in the target region which increases the percent overshoot. Thus, getting a 5% overshoot will be extremely hard.

### Effect of Disturbance on the System:

If step disturbance is added to the system after the Lead-Lag controller, it will affect the response of the system by an extremely small amount. Hence, it can be concluded that the PID controller can resist the added step disturbance but will not completely eliminate its effect.

# **Conclusion**

Overall, after completing our project in Control Systems I (ELE353), we were able to utilize MATLAB, SIMULINK and SISOTOOL DESIGN programming to analyze and design different types of controllers such as Lag-Lead and PID controllers. Furthermore, we were able also to design by hand different types of controllers such as Lag-Lead and PID controllers. Moreover, in this project, we applied the team skills where we divided the work between ourselves in order to do the required task in fastest possible time. Ultimately, this project is one of the most important applications in the control systems I area where we can applied our gained skills from this project in designing and analyzing any controller in the future.