Lab Section: Tues 3-5pm

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Collaborators (if any):

**Lab 7 – Frequency Domain Control Design**

**Prelab**

Diagram, engineering drawing

Description automatically generated

**Experiment #1: Open and Closed Loop Bode Plots:**

1. *Attach open loop Bode plots and locate the plant poles. Explain the discrepancies between the model and experimentally collected Bode plots.*

Chart, line chart

Description automatically generated

0.172/0.15s^2+s

Poles at s=0, -6.6667 (where phase @-90, @-135)

Discrepancy at high and low frequencies – low frequency is deadband and high frequency is oversaturated.

1. *Attach closed loop Bode plots with a proportional controller with . Explain the discrepancies between the model and measured bode plots.*

*Chart, line chart

Description automatically generated*

Discrepancy at high and low frequencies – low frequency is deadband and high frequency is oversaturated.

1. *When the experiment and model do not agree, is this due to model, or the way we collected data? Explain your reasoning.*

The way we collected data; the friction in the flywheel causes deadband and saturation and low and high frequencies respectively.

**Experiment #2. Controller Design:**

*Time domain step response specifications: overshoot 7% or less, and 2% settling time of 0.4 seconds or less.*

*%OS<=7 => zeta >= 0.646*

*PM ≈ 100\*zeta = 64.6*

*0.4 = 4/(zeta\*w\_n) => w\_n = 15.48*

*w\_c ≈ w\_n = 15.48*

*phi\_max = 64.6-27.5 = 37.1*

1. *What values of ɸm and ωc should we use to achieve the required time domain performances?*

*64.6*

*15.48*

1. *Transfer function of your lead controller:*

*487.51(s+7.218)/(s+33.2)=106.01(0.14s+1)/(0.03s+1)*

1. *Attach the Bode plots of the simulated responses with the new controller.*

*Chart, line chart

Description automatically generated*

1. *Find the closed-loop step response characteristics by running the MATLAB command:*

stepinfo(feedback(Gc\*Gp,1))

RiseTime: 0.0872

SettlingTime: 0.2777

SettlingMin: 0.9138

SettlingMax: 1.0651

Overshoot: 6.5078

Undershoot: 0

Peak: 1.0651

PeakTime: 0.1850

1. *Include the SISOTOOL screenshot showing the root locus of the compensated system.*

*Graphical user interface, chart

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**Experiment #3. Controller Testing:**

1. *Attach open**loop Bode plots for the compensated system, ) and determine the new crossover frequency and phase margin from the actual data.*

*Chart, line chart

Description automatically generated*

*Crossover Freq = 15.4*

*Phase Margin = 64*

1. *Attach the sine wave plot when driven by a frequency equals to the crossover frequency, and include the phase and magnitude information for the crossover frequency. Do they match with the values determined from the open loop Bode plots?*

*Chart

Description automatically generated*

*Gain = (2.1983+0.3734)/(1.0461+1.0452) = 1.23 = 1.798dB*

*Phase = 360\*(0.1002-0.2306)\*2.451=-115.06deg*

1. *Attach the closed**loop Bode plots and estimate the closed loop bandwidth.Chart

   Description automatically generated*

*Bandwidth = 33.5*

1. *Attach the step response of the actual closed loop system. Measure the actual percent overshoot and settling time.*

*Chart, line chart

Description automatically generated*

%OS = 3.7

Ts = 0.22s

1. *Describe the effects of incorporating the lead controller onto the system.*

Incorporating the lead controller caused the step response to reach the transient response a lot faster. It caused a greater overshoot.