Total: /90

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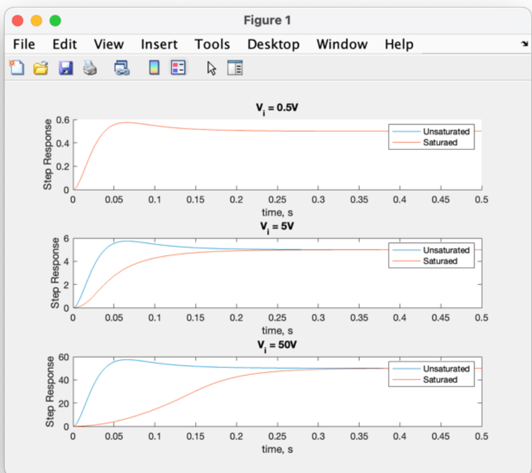
Section: AB2

Part I. Effects of Saturation Block in Simulations: ___/10

Discuss the effect of the saturation block in the simulations (if any). Overlay plot for the saturated and the non-saturated cases.

The saturation block limits the effort of the motor, which make the simulation closer to reality. It decreases the rise time and overshoot.



Part II. Motor DC Gain: ___/10

Compute the transfer function of the system from the data obtained from the DSA. Then, compute the DC gain (K) of the motor (Show how you solved for K). Compare the computed value with the value obtained in Lab 4 or PreLab 5a.

Note: First, you need to rewrite the transfer function from the DSA in radians. Then, remember that the DC gain K obtained from the DSA includes the gains of the tachometer, amplifier and compensator. That means you need to solve for K.

Hint: Read the "DSA Notes" PDF on the course website for an explanation on how to start the problem.

$K_{DSA} = 26.18$ $z_{[Hz]} = -1.878$ $p_{1[Hz]} = -17.47$ $p_{2[Hz]} = -0.843$

$$\frac{V_{tach}(s)}{V_{in}(s)} = \frac{K_{DSA}\left(\frac{s}{2\pi} - z_{Hz}\right)}{\left(\frac{s}{2\pi} - p_{1Hz}\right)\left(\frac{s}{2\pi} - p_{2Hz}\right)} = \frac{?(?s+1)}{(?s+1)(?s+1)}$$

$K_{LAB4} = 0.03057$ $K_{LAB6} = 3.3384$

Part III. Real and Simulated Response of the Low and High DC Gain Compensator: ___/30

Table of M_p, t_r, t_s and e_{ss} ___/10

We now have two different models of our motor: one from Prelab 5a, and the other from the previous part (remember to remove your compensator from the DSA data). We also have the two different lead controllers we implemented in this lab. Create a simulation in Simulink of Figure 6.1, and simulate each controller acting on each motor model. (So you will run the simulation 4 times). Collect the M_p, t_r, t_s, and e_{ss} of each response. Also include in the table the data collected from lab using the actual motor.

Table 1. Real and simulated response for low and high DC gain compensators

	Low DC Gain Lead Compensator				High DC Gain Lead Compensator			
	M_p (%)	t_r (ms)	t_s (ms)	e_{ss} (V)	M_p (%)	t_r (ms)	t_s (ms)	e_{ss} (V)
*Actual **	5.83	24	86.5	0.21	1.3	29.5	65.5	0.13
*Simulated Prelab 5a***	0	30	90	0.3	0	35	105	0.2
*Simulated Lab 6****	1.87	36	58	0.02	0	32	68	0.02

**Values from Sections II and III of Lab 6.*
***Data from simulating the closed loop system with both lead controllers and parameters calculated on Prelab 5a.*
****Data from simulating the closed loop system with both lead controllers and parameters found in Lab 6 from DSA.*

Discuss results in Table 1. ___/10

Meeting the Specifications: ___/10

Did you meet the specification ($M_p \leq 15\%$, $t_r \leq 30ms$)? Discuss.

Table 2. Overshoot and Rise time for Lead Compensators and PD controller

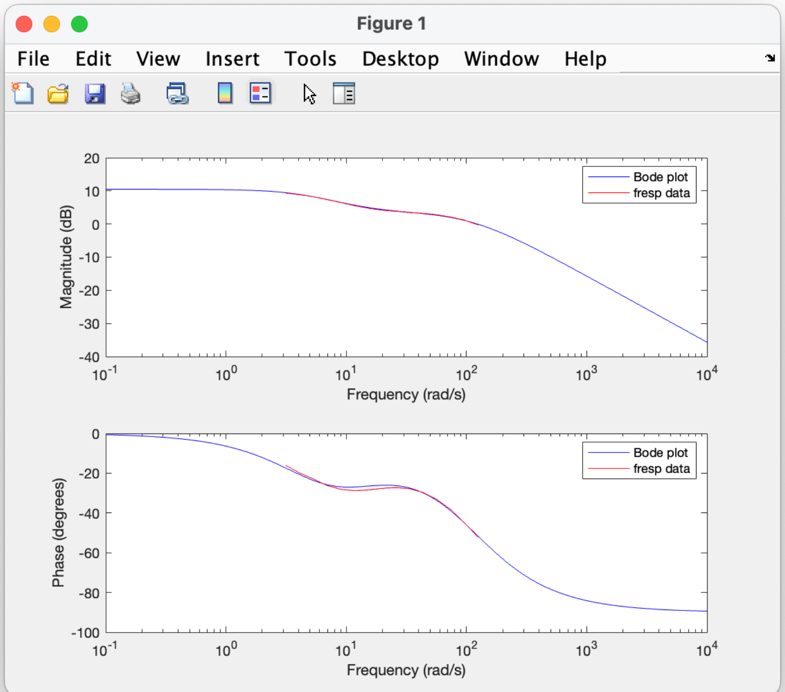
Experimental Values	M_p (%)	t_r (ms)
Low DC Gain Lead Compensator	5.83	24
High DC Gain Lead Compensator	1.3	29.5
PD Controller†	15	30

†The PD controller from Part II of lab 5 with gains designed in Prelab 5(c)

Part IV. Bode Plots of Transfer Functions ___/40

Transfer Function of $\frac{V_{tach}(s)}{V_{in}(s)}$: ___/10

Plot the Bode plots (Magnitude and Phase) in dB and Degrees for the empirical data saved in fresp.m and using the transfer function estimated by the DSA (part II of this report). ***Overlay*** *both plots. Use* *"semilogx" to scale the x-axis (frequency).* ***They should match well.***

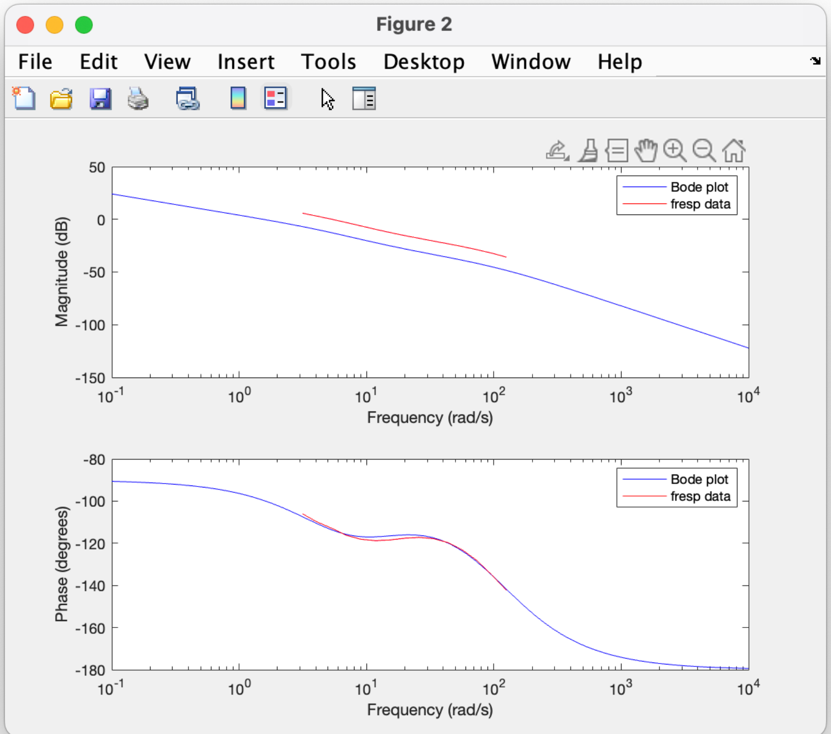


Bode Plots of transfer function $\frac{V_\theta(s)}{V_{in}(s)}$: ___/15

Use the relation between equations (6.2) and (6.3) of the Lab Manual to graph the Bode plot for the transfer function V_θ / V_{in} (in dB and degrees) using the parameters given by DSA. Use the "bode" command in Matlab. Next, use the data in the "fresp.m" file to calculate the samples of V_θ / V_{in} (See the Lab Manual and the "DSA Notes" PDF on the website for hints). Overlay the bode plot with these calculated samples. ***They should match well.*** *Find the crossover frequency and phase margin for both the DSA fit and the calculated samples from fresp.m. Do they meet the design specifications from PreLab 6 part (d)? Discuss.*

From Fit in DSA:	From data in fresp.m:
$\omega_c = 1.47$ $PM = -99$ °	$\omega_c = 5.36$ $PM = -112$ °

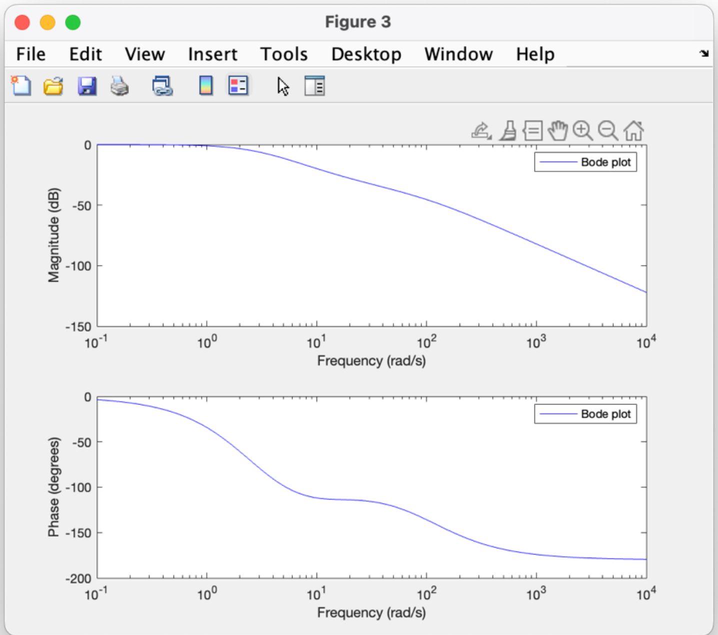
Specifications:
$\omega_c = 12$ $PM = -120$ °



Yes, they meet the requirements.

Bode Plots, Closed-loop transfer function $\frac{V_\theta(s)}{V_{in}(s)}$: ___/15

Use the transfer function from the fit (parameters obtained with DSA) and compute the closed-loop transfer function (using unity feedback). Make a Bode plot with MATLAB. Use the calculated samples from the previous question to compute the samples of the closed-loop response of V_θ / V_{in} *and* ***overlay*** *both plots.* ***They should match well.*** *What is the closed-loop bandwidth? Does this value seem reasonable? Why or why not?*



The bandwidth is 1.9586, which seems reasonable.

Attachments (8)

- Plots from saturated and non-saturated responses for V_{in} = 0.5, 5, and 50 volts (2)
- Bode Plots for Part V: V_{tach}/V_{in}, Magnitude and Phase (2).
- Bode Plots for Part VI: V_θ/V_{in}, Magnitude and Phase (2).
- Bode Plots for Part VII: closed-loop bodes plots for V_θ/V_{in}, Magnitude and Phase (2).