Recommended Assessment

Frequency Response Modeling

1. From the first section of the Lab where a constant voltage was applied to the system, measure the speed of the load disk and calculate the steady-state gain of the system, K, in rad/s/V (linear and decibel dB).

2. When using a sinusoidal input to the system, what are the maximum speed of the response and the gains of the system as they increment every 0.4Hz? Fill the results from the table in the lab.

Freq (Hz)	Max Amplitude (V)	Max Load Speed (rad/s)	Gain ($\|G(\omega)\|$) ($rad/s/V$)	Gain ($\|G(\omega)\|$) (dB)
0.0				
0.4				
0.8				
1.2				
1.6				
2.0				
2.4				
2.8				

Table 1. Frequency Response Data

3. Using the data from Table 1, generate a Bode magnitude plot. The amplitude scale should be in decibels (dB) and the frequency scale should be logarithmic. Plot it using the MATLAB workspace and use the `semilogx` command to have a logarithmic scale in the X axis. Do a linear interpolation of the gains at frequencies in between. *Note:* Ignore the entry for a frequency of 0 Hz when drawing the Bode plot. The logarithm of 0 is not defined.

4. Given the equation: $|G(\omega)| = \frac{K}{\sqrt{1+\tau^2\omega^2}}$. What is the expression to determine the time constant, τ, of the system. *Hint*: Begin by evaluating the magnitude of the transfer function at the cutoff frequency, ω_C.

5. Calculate the time constant, τ, using the Bode magnitude plot obtained in a previous question. Create a new plot where you label the location of the −3 dB cutoff frequency. *Hint:* Use the MATLAB Figure Data Tips tool to obtain the values directly from the plot.

6. From the phase delay section of the lab, using the voltage to speed transfer function:

$$P(s) = \left|\frac{\Omega_m(s)}{V_m(s)}\right| = \frac{K}{\tau s + 1}$$

Find an expression for the time constant, τ, in terms of the frequency of the input sinusoid and the resulting phase delay?

7. Express the time constant equation found in the previous answer with the time delay of the input and output signals.

8. Using your results from the phase delay analysis section of your lab, attach the response of the time delay scope you obtained. Measure the time delay of the speed output when applying a 3 V at 0.4 Hz sinusoidal input.

9. Determine the corresponding phase shift in degrees and radians. Based on these measurements, compute the time constant, τ, for the Qube - Servo 3. Compare with the time constant found using the Bode Plot. If they are different, list one source that may have contributed to the different results.