**LAB #6 Frequency Response of a DC Motor**

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Contents

[1. OBJECTIVE AND BACKGROUND 6](#_Toc101559271)

[2. QUESTION 1 7](#_Toc101559272)

[3. CONCLUSIONS 17](#_Toc101559364)

[Figure 1 Simulink Model for DC Motor Control 5](#_Toc101559254)

[Figure 2 Response for Frequency of 0.6 Hz 5](#_Toc101559255)

[Figure 3 Response for Frequency of 0.8 Hz 6](#_Toc101559256)

[Figure 4 Response for Frequency of 0.9 Hz 6](#_Toc101559257)

[Figure 5 Response for Frequency of 1 Hz 7](#_Toc101559258)

[Figure 6 Response for Frequency of 2 Hz 7](#_Toc101559259)

[Figure 7 Response for Frequency of 4 Hz 8](#_Toc101559260)

[Figure 8 Response for Frequency of 6 Hz 8](#_Toc101559261)

[Figure 9 Response for Frequency of 8 Hz 9](#_Toc101559262)

[Figure 10 Response for Frequency of 10 Hz 9](#_Toc101559263)

[Figure 11 Response for Frequency of 12 Hz 10](#_Toc101559264)

[Figure 12 Response for Frequency of 15 Hz 10](#_Toc101559265)

[Figure 13 Response for Frequency of 30 Hz 11](#_Toc101559266)

[Figure 14 Bode Plot for Acquired Data 11](#_Toc101559267)

[Figure 15 Nyquist Plots for Acquired Data 12](#_Toc101559268)

[Figure 16 Bode Diagram for DC Motor at Low Frequencies 13](#_Toc101559269)

[Figure 17 Nyquist Diagram for DC Motor at Low Frequencies 14](#_Toc101559270)

# OBJECTIVE AND BACKGROUND

The goal of this lab is to be able to observe and obtain the frequency domain values of a DC motor and to be able to use the acquired data to create Bode and Nyquist plots which are helpful in the frequency domain analysis and construction of systems and controllers. We know that when we are given a linear system with a sinusoidal input, we can conclude that the steady state response of the system will still be a sinusoidal input with the same frequency but different amplitude and phase angle. Nyquist plots are representations of the vector response of feedback systems that show the relationship between feedback and gain and are used for the frequency response of a system. Bode plots are similar to Nyquist plots in the sense they are used for the frequency response of a system, but are different in the fact that Bode plots use asymptotic approximations for the magnitude of systems on a 20 log(x) scale vs frequency and Phase (in degrees) vs frequency to approximate the steady state stability of responses.

# QUESTION 1

Below in Table 1 shows our values taken from different frequencies of the input signal and the effects they have on the time difference, phase angle, and amplitude of the output angle as well as the magnitude of the output over the input (B/A).

Table 1 Steady-State Response of DC Motor for Sinusoidal Inputs

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Amplitude of the input signal: | Frequency f(Hz) | Frequency (𝛚=2πf) | Amplitude of the output signal: B | ∆t (sec) |  | Phase angle φ(ω)=∆t\*ω/π\*180 (degree) |
| 1 | 0.6 | 2π0.6 | 22.59 | 0.427 | 23.56 | 0.0028 |
| 1 | 0.8 | 2π0.8 | ­16.79 | 0.347 | 16.57 | 0.0031 |
| 1 | 0.9 | 2π0.9 | 13.93 | 0.301 | 14.00 | 0.0030 |
| 1 | 1 | 2π1 | 12.79 | 0.289 | 12.85 | 0.0032 |
| 1 | 2 | 2π2 | 6.46 | 0.157 | 6.49 | 0.0035 |
| 1 | 4 | 2π4 | 2.86 | 0.088 | 2.87 | 0.0039 |
| 1 | 6 | 2π6 | 1.63 | 0.061 | 1.64 | 0.0041 |
| 1 | 8 | 2π8 | 1.05 | 0.049 | 1.05 | 0.0044 |
| 1 | 10 | 2π10 | 0.75 | 0.042 | 0.75 | 0.0046 |
| 1 | 12 | 2π12 | 0.53 | 0.038 | 0.53 | 0.0051 |
| 1 | 15 | 2π15 | 0.35 | 0.033 | 0.35 | 0.0055 |
| 1 | 30 | 2π 30 | 0.00 | 0.020 | 0.00 | 0.0067 |

Diagram, schematic

Description automatically generated

Figure 1 Simulink Model for DC Motor Control

Chart, line chart

Description automatically generated

Figure 2 Response for Frequency of 0.6 Hz

Chart, line chart

Description automatically generated

Figure 3 Response for Frequency of 0.8 Hz

Chart, line chart

Description automatically generated

Figure 4 Response for Frequency of 0.9 Hz

Chart, line chart

Description automatically generated

Figure 5 Response for Frequency of 1 Hz

Chart

Description automatically generated

Figure 6 Response for Frequency of 2 Hz

Timeline

Description automatically generated

Figure 7 Response for Frequency of 4 Hz

Chart

Description automatically generated with medium confidence

Figure 8 Response for Frequency of 6 Hz

Chart

Description automatically generated with low confidence

Figure 9 Response for Frequency of 8 Hz

Chart

Description automatically generated with low confidence

Figure 10 Response for Frequency of 10 Hz

Chart

Description automatically generated

Figure 11 Response for Frequency of 12 Hz

A picture containing timeline

Description automatically generated

Figure 12 Response for Frequency of 15 Hz

A picture containing timeline

Description automatically generated

Figure 13 Response for Frequency of 30 Hz



Figure 14 Bode Plot for Acquired Data



Figure 15 Nyquist Plots for Acquired Data



Figure 16 Bode Diagram for DC Motor at Low Frequencies

Chart

Description automatically generated

Figure 17 Nyquist Diagram for DC Motor at Low Frequencies

# CONCLUSIONS

Comparing the graphical representations of the DC Motor at its idealized low range of frequencies compared to the higher range of frequencies that we tested it at, we can being to see that the Bode plot is relatively similar on the magnitude scale, but is opposite of the Phase scale as we start to approach positive values compared to negative values which may be due to taking the absolute value of the change in time between the input and output signals. The Nyquist plots are also different in that sense and is most likely due to the same reason as the Bode plots differing from each other. But, if we draw an axis from the vertex of the Nyquist plot for the acquired data and take that as a graphical approximation without numbers, the plots are quite similar, but have a wider divergence for the acquired vs ideal plots.