EEE342 Prelab Report #2

Orkun İbrahim Kök

Department of Electrical and Electronics Engineering, Bilkent University, 06800 Ankara, Turkey

1. Introduction

The purpose of this prelab is to obtain Bode plot from the transfer function of used DC motor. In the first part, the Bode plot of the DC motor's transfer function is analyzed. Magnitude and phase data are plotted for this purpose. For the second part, a sinusoidal input is applied to the previous transfer function, and the Bode plot is again analyzed. The Bode plots that are generated in each part are compared at the end.

2. Laboratory Content

2.1 Question One

In this section, the given transfer function is implemented in MATLAB, and the magnitude and phase graphs are plotted. The transfer function of the DC motor is given below.

$$\frac{Y(s)}{X(s)} = G_p(s) = \frac{20}{0.5s + 1}$$

Using the given MATLAB code, Bode plot of the transfer function is plotted. Fig. 1 shows the Bode plot.

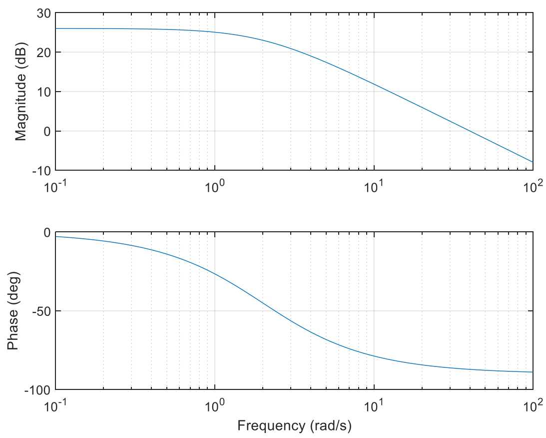

Fig. 1: Bode plot of the DC motor's Transfer function.

2.2 Question Two

In this section, a sinusoidal input is applied to the previously defined transfer function $G_p(s)$. The sinusoidal input is in the following form.

$$y(t) = A \times |G(j\omega)| \times \cos\big(\omega t + \angle G(j\omega)\big)$$

$$When\ x(t) = A \times \cos(\omega t)$$

In the code, the amplitude A is chosen as 1. Using *lsim* function of MATLAB, Y(s) is extracted from $G_p(s)$ and x(t). Then, to swap into frequency domain, MATLAB's *fft* function is used on x(t) and y(t). Finally, to get the phase and magnitude of the response of our system, the following mathematical operations are done.

$$|G(j\omega)| = \frac{|Y(\omega)|}{|X(j\omega)|}$$

Basically, to get the magnitude data, dividing the magnitude of Y(jw) by X(jw) is enough.

$$\angle G(j\omega) = \angle Y(j\omega) - \angle X(j\omega)$$

For the phase, this time, subtraction operation is done. Fig. 2 shows the new Bode plot of the system, which has sinusoidal input with cross signs, the blue curve indicates the Bode plot of the first part.

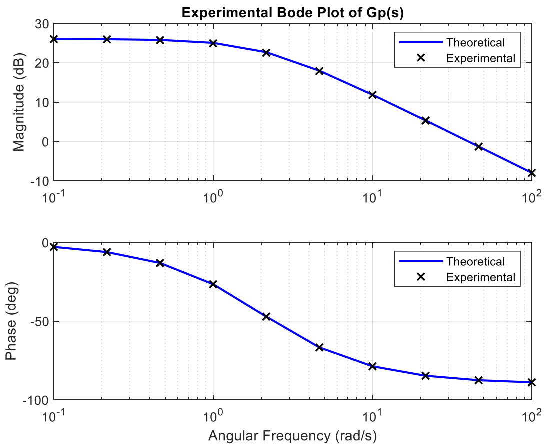

Fig. 2: Bode plot comparison of theoretical and experimental data.

As seen from Fig. 2, cross signs indicate the experimental data obtained from sinusoidal input transfer function, and the blue curve indicates the theoretical data. It can be said that about cross signs, they are exactly on the theoretical data curve, which shows the experiment is done correctly.

3. Conclusion

In this lab, Bode plot of a given transfer function is analyzed. Then, a sinusoidal input is created with arbitrary gain, and applied to the transfer function. The magnitude and phase data of the new transfer function is obtained. The results of part 1 and part 2 are compared at the end of the report. The results turned out to be similar, which is what was expected.

4. MATLAB CODE

```
% EEE342 Lab 2 – Experimental Bode Plot
% Transfer function: Gp(s) = 20 / (0.5s +
1)
num = 20;
den = [0.5 1];
```

```
sys = tf(num, den);

% Generate 10 logarithmic frequencies from 
0.1 to 100 rad/s
w = logspace(-1, 2, 10);
A = 1;  % input amplitude

% Arrays for experimental magnitude and 
phase
mag_exp = zeros(1, length(w));
ph_exp = zeros(1, length(w));

for i = 1:length(w)
    omega = w(i);

    % time vector – ensure several cycles 
for low frequencies
    T = 2*pi/omega;
    t = 0:0.001:10*T;

    % define input signal x(t)
    x = A*cos(omega*t);

    %define output signal y(t)
    y = lsim(sys, x, t);

    % FFT of input and output
    X = fft(x);
    Y = fft(y);

    % find main frequency component
    [~, idx] = max(abs(X));
    mag_exp(i) = abs(Y(idx)) / 
abs(X(idx)); %G(jw) = Y(jw)/X(jw)
    ph_exp(i) = angle(Y(idx)) - 
angle(X(idx)); %G(phase(jw)) = 
Y(phase(jw)) - X(phase(jw))
end

%Given transfer function G(s) = 
20/(0.5s+1)
for k = 1:10
s = 1j * w(k);
G(k) = 20/(0.5* s+1);
end

mag_theo = abs(G);
ph_theo = angle(G);

%plot and compare results
figure;
subplot(2,1,1);
semilogx(w, 20*log10(mag_theo), 'b', 'Li-
neWidth', 1.4); hold on;
semilogx(w, 20*log10(mag_exp), 'kx', 'Mar-
kerSize', 7, 'LineWidth', 1.2);
ylabel('Magnitude (dB)');
grid on;
legend('Theoretical','Experimental');
title('Experimental Bode Plot of Gp(s)');

subplot(2,1,2);
semilogx(w, ph_theo*180/pi, 'b', 'Li-
neWidth', 1.4); hold on;
semilogx(w, ph_exp*180/pi, 'kx', 'Marker-
Size', 7, 'LineWidth', 1.2);
xlabel('Angular Frequency (rad/s)');
ylabel('Phase (deg)');
grid on;
legend('Theoretical','Experimental');
```