Feedback and Control Systems Preliminary Work 2

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1. Introduction

In this preliminary work, the main goal is to acquire a Bode plot for our DC motor's transfer function's magnitude and phase. Since Bode plot is drawn, logarithmic scale is used. Preliminary work consists of two parts. In the first part, bode plots are drawn directly. In the second part, bode plot is generated by applying sinusoidal input to the given transfer function and observing the sinusoidal output for magnitude and phase differences. Then, bode plots found in part 1 and part 2 are compared.

2. Laboratory Content

Question 1

The transfer function given in the question is the following:

$$G_p(s) = \frac{15}{0.12s + 1} \qquad (1)$$

To sketch the bode plot of this, samples were taken from the frequency range, and put into the functions. Magnitude and phase calculation of bode plot are done as in the following:

$$y = 20\log\ |G(jw)| = \frac{15}{\sqrt{(0.12w)^2+1}} \qquad x = \log|w|$$

and

$$y = phase = \ -\tan^{-1} 0.12w \qquad x = \log\ |w|$$

To implement the above calculations, following MATLAB code is written:

```
w = logspace(-1,2,100);
for k = 1:100
    s = 1i * w(k);
    G(k) = 15 / (0.12*s+1);
end
subplot(2,1,1)
semilogx(w,20*log10(abs(G)));
title("Magntude vs. Frequency");
ylabel("Magnitude");
xlabel("Frequency");
grid on
subplot(2,1,2)
semilogx(w,angle(G)*180/pi)
title("Phase vs. Frequency");
ylabel("Phase");
xlabel("Frequency");
grid on
```

When $\omega = 0$, the magnitude of transfer function is 15, which is 23.5218 in 20log10 – scale. When ω goes to infinity, transfer function goes to zero. For the same values of ω, the phase of the transfer function approaches to zero and $-\frac{\pi}{2}$ respectively. Cut-off/corner frequency is $\frac{25}{3} = 8.3333\frac{rad}{second}$. The Bode plot of magnitude and phase drawn by MATLAB can be seen below:

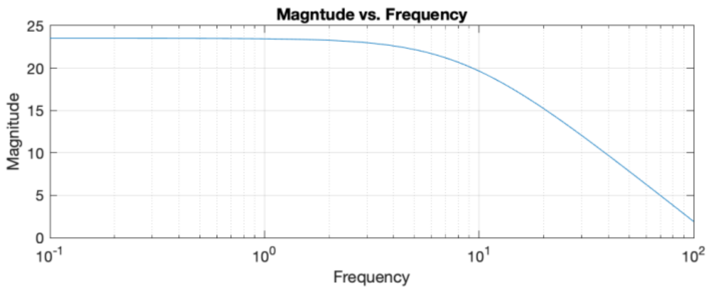

Figure 1: Bode Plot for Magnitude Vs. Frequency

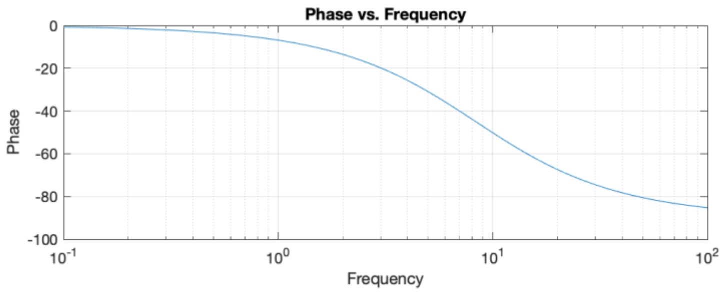

Figure 2: Bode Plot For Phase Vs. Frequency

Question 2

In this part, bode plot of the transfer function is generated by applying sinusoidal inputs and output signal is observed in order to see the magnitude and phase differences. These differences are then used to draw bode plot of magnitude and phase of the transfer function. To achieve this, following MATLAB code is written:

```
t = 0:0.001:10;
Gp = zeros(1,10); %Transfer function
Am = zeros(1,10); %Amplitude
Phi = zeros(1,10); %Phase
w = logspace(-1, 2, 10); %frequencies

for k = 1:10
    s = 1i * w(k);
```

```
    Gp(k) = 15 / ( 0.12 * s + 1 );
    input = cos( w(k) * t ); % sinusoidal signal
    output = input * Gp(k); % sin signal is applied in time domain

    INPUT = fft(input); % input's frequency response
    OUTPUT = fft(output); % output's frequency response

    [MaxInp, LocInp] = max(abs(INPUT));
    MaxOut = max(abs(OUTPUT));

    Am(k) = MaxOut / MaxInp; % magnitude of transfer function
    Phi(k) = angle( OUTPUT(LocInp) ) - angle( INPUT(LocInp) ); %phase of the transfer function

end

figure('Name', 'Bode Plot Of Transfer Function');
subplot(2,1,1);
semilogx(w, 20*log10(abs(Gp))); %Magnitude (First Plot)
grid ON;
hold ON;
semilogx(w, 20*log10(Am), 'x' );
title( 'Bode Plot for Magnitude' );
xlabel( 'Angulare Frequency (rad/s)' );
ylabel( 'Magnitude (dB)' );
subplot(2,1,2);
semilogx(w, angle(Gp) * 180/pi );
grid ON;
hold ON;
semilogx(w, Phi * 180/pi, 'x' );
ylim([-90 0]);
title( 'Bode Plot for Phase' );
xlabel( 'Angular Frequency (rad/s)' );
ylabel( 'Phase (degree)' );
```

In the code, the first two bode plots generated in part one is compared with the magnitude and phase plots acquired by applying sinusoidal input to transfer function. Comparison of the plots can be seen below:

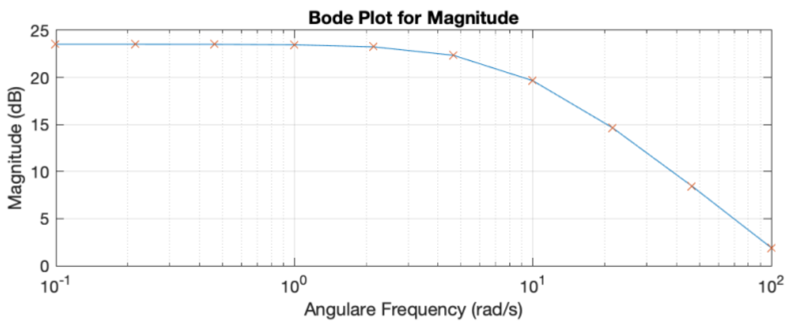

Figure 3: Magnitude Comparison

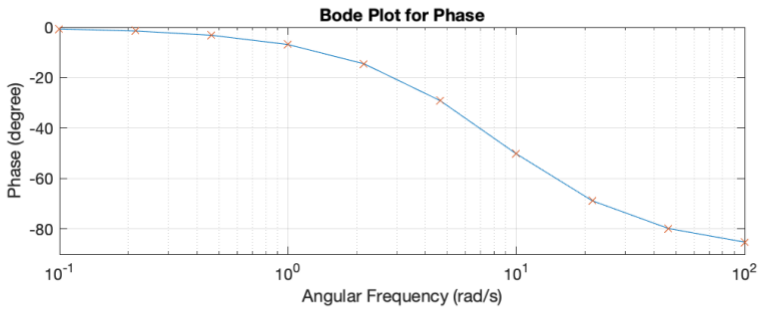

Figure 4: Phase Comparison

As it can be seen in Figure 3 and 4, logarithmic points, which are calculated by applying sinusoidal input to transfer function, are marked with 'x'. These points are perfectly matched with the original sample points of the transfer function. In fact this can be seen in below:

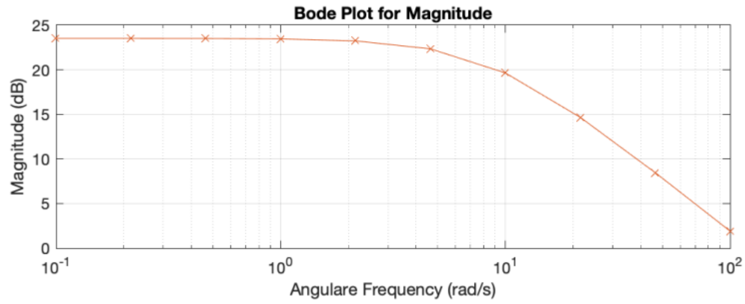

Figure 5: Magnitude Comparison of Bode Plots

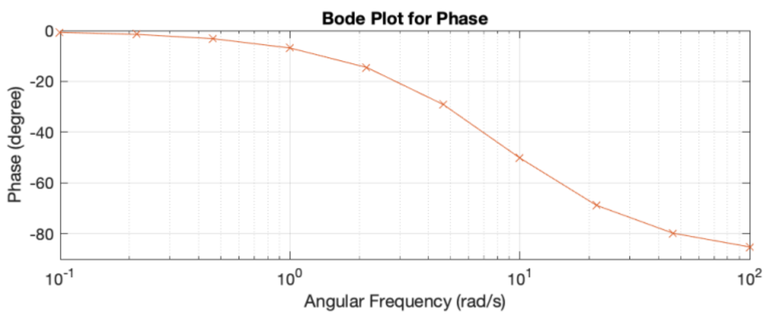

Figure 6: Phase Comparison of Bode Plots

As it can be seen in Figure 6 and 7, blue plot cannot be seen because the bode plot acquired by applying sinusoidal input is top of it.

3. Conclusion

The purpose of this preliminary work is to learn and see how to acquire a bode plot by applying sinusoidal input to the system. By utilizing frequency response of the system to sinusoidal input, magnitude and phase of the transfer function in certain frequencies can be obtained exactly as it can be seen in the plots of part 2. Additionally, I learnt how to draw a bode plot in logarithmic scale by using MATLAB.