A Design Study Approach to Classical Control

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Homework A.15

Draw by hand the Bode plot of the single link robot arm from torque $\tilde{\tau}$ to angle $\tilde{\theta}$ given that the equilibrium angle is $\theta_e = 0$. Use the Matlab `bode` command and compare your results.

Solution

From HW A.5, the transfer function for the single link robot arm is

$$P(s) = \frac{3/m\ell^2}{s(s + 3b/m\ell^2)} = \frac{44.44}{s(s + 0.4444)}. \tag{1}$$

In Bode canonical form we have

$$P(j\omega) = \frac{100}{(j\omega)(1 + j\frac{\omega}{0.4444})}$$

Therefore

$$20\log_{10}|P(j\omega)| = 20\log_{10} 100 - 20\log_{10}|j\omega| - 20\log_{10}\left|1 + j\frac{\omega}{0.4444}\right|. \tag{2}$$

Therefore, the Bode plot for magnitude will be the graphical addition of a constant gain, an integrator, and a pole. Similarly, the phase is given by

$$\angle P(j\omega) = \angle 100 - \angle(j\omega) - \angle(1 + j\frac{\omega}{0.4444}).$$

The straight line approximation as well as the Bode plot generated by Matlab are shown in Figure 1.

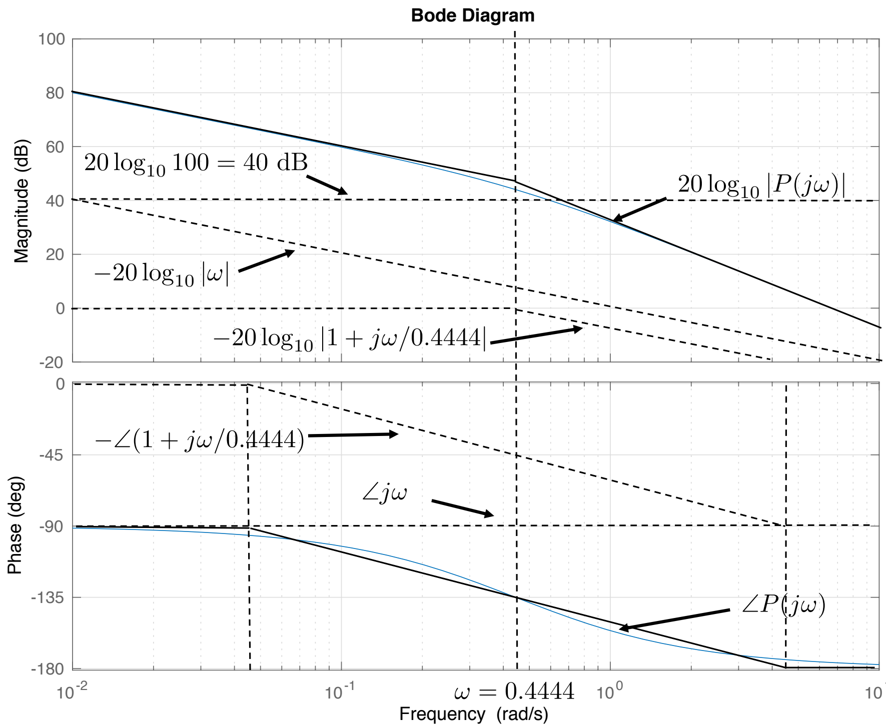

Figure 1: Bode plot for the transfer function given in Equation (1).

The Matlab command to generate the Bode plot is

```
>> P = tf([100],[1, 0.4444, 0]);
>> figure(1), clf, bode(P), grid on
```