EGGN 307: Introduction to Feedback Control

Homework Assignment #10

Due: Wednesday April 3rd.

(1) A system has transfer function

$$G(s) = \frac{s+5}{s+1}.$$

If the input is $u(t) = 2\cos(3t + \pi/4)$, find the steady state output using the frequency response.

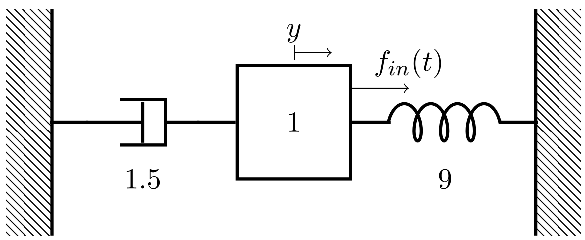
(2) Using the linear approximation rules, sketch the Bode plot for the following systems. Compare to the Bode plot generated in MATLAB using the `bode` command.

(a) $G(s) = \frac{1}{s^2+s+1}$

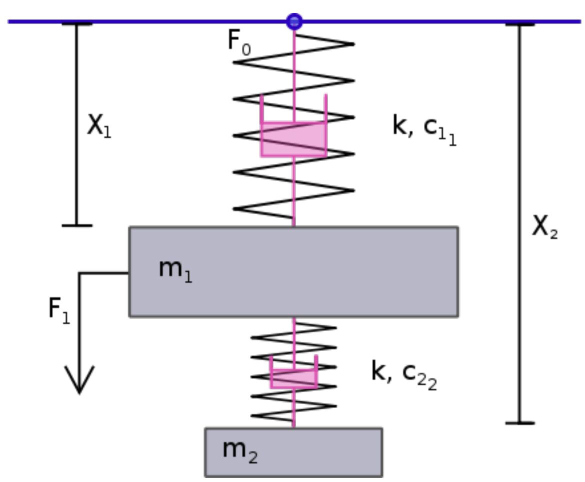
(b) $G(s) = \frac{(s+5)}{s(s+1)(s+100)}$

(c) $G(s) = \frac{(s+5)}{s(s^2+s+1)}$

(3) Sketch the frequency response (Bode plot) for the following system, taking the input as f_{in} and the output as y. For a second order system, the resonance peak can be calculated using $|G(j\omega_n)| = K\frac{1}{2\zeta}$. Use this to adjust your sketch to better show the frequency response from any resonance. Compare to the Bode plot generated in MATLAB using the `bode` command.



(4) Read about tuned mass dampers `http://en.wikipedia.org/wiki/Mass_damper`. The following system figure is given in the article:

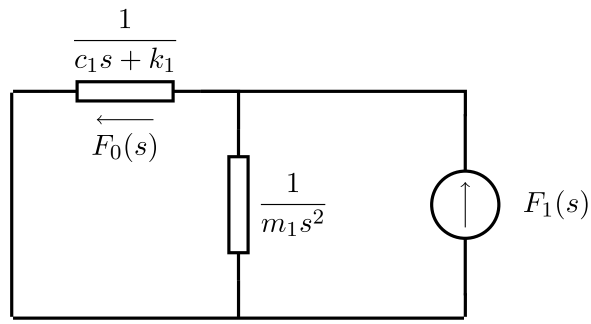


Note that there is a typo in this figure, as the upper spring and damper constants should be k_1, c_1 and the lower spring and damper constants should be k_2, c_2.

The following description is given for the figure:

> Given a motor with mass m_1 attached via motor mounts to the ground, the motor vibrates as it operates and the soft motor mounts act as a parallel spring and damper, k_1 and c_1. The force on the motor mounts is F_0. In order to reduce the maximum force on the motor mounts as the motor operates over a range of speeds, a smaller mass, m_0, is connected to m_1 by a spring and a damper, k_2 and c_2. F_1 is the effective force on the motor due to its operation.

(a) First, we will analyze the system with the absorber removed (i.e. take $m_2 = c_2 = k_2 = 0$). Take $m_1 = 5$, $c_1 = 5$, and $k_1 = 420$. We want to find the transfer function $F_0(s)/F_1(s)$ (i.e. how much force on the motor mount occurs due to motor vibration). Show that the impedance network corresponding to this system is the following.



Using this impedance network, find $F_0(s)/F_1(s)$ (Hint: Current divider). Using MATLAB, plot the Bode plot

(b) Now, attach the absorber with $m_1 = 0.5$, $c_1 = .5$ and $k_1 = 42$. Find the new impedance network and new transfer function $F_0(s)/F_1(s)$ in this case (Hint: Current divider!!!). Plot the Bode plot.

When comparing your plots to the ones in the Wikipedia page, note that they used a log-scale magnitude plot, rather than plotting in decibels.