MECH 421: Mechatronics System Instrumentation
2020/21 Winter Session – Term 2

Homework 1

Assigned: Jan 15, 2021
Due: Jan 22, 2021

Problem 1

Manually draw the 1) step response and 2) Bode plot of the following transfer functions. For the step responses, clearly show the first-order time constants (if exist), and the initial response and steady state response. For the Bode plots, clearly show the break frequencies (if exist) and asymptotes for the gain and phase curves, and make the transition between the asymptotes properly.

(a) $H(s) = s$

(b) $H(s) = s + \omega_o \qquad (\omega_o > 0)$

(c) $H(s) = \dfrac{1}{s}$

(d) $H(s) = \dfrac{\omega_o}{s} + 1 \qquad (\omega_o > 0)$

(e) $H(s) = \dfrac{\alpha\tau s + 1}{\tau s + 1} \qquad (\alpha = 100, \tau > 0)$

(f) $H(s) = \dfrac{\tau s + 1}{\alpha\tau s + 1} \qquad (\alpha = 100, \tau > 0)$

Problem 2

For the following transfer function

$$H(s) = \frac{1}{0.01s + 1}$$

(a) Manually draw the Bode plot of $H(s)$.

(b) Find the response $y(t)$ to an input sinusoid $x(t) = \sin(10t + \pi/3)$.

(c) Find the response $y(t)$ to an input sinusoid $x(t) = \sin(100t + 2\pi/3)$.

(d) Find the response $y(t)$ to an input sinusoid $x(t) = \sin(1000t + \pi)$.

The inputs are persistent sinusoids, that is, they exist for all time ($-\infty < t < \infty$).

Problem 3

Manually draw the Bode plot of the following transfer functions. Clearly show the break frequencies (if exist) and asymptotes for the gain and phase curves, and make the transition between the asymptotes properly. Make sure the starting point of the Bode phase curve, i.e., $\angle H(j\omega)|_{\omega\to 0}$, is within $\pm 180^\circ$ by adding or subtracting an integer multiple of 360°.

(a) $H(s) = \dfrac{1}{0.1s+1}$

(b) $H(s) = \dfrac{1}{s+0.1}$

(c) $H(s) = \dfrac{1-0.1s}{1+0.1s}$

(d) $H(s) = \left(\dfrac{1}{s+0.1}\right)\left(\dfrac{1-0.1s}{1+0.1s}\right)$