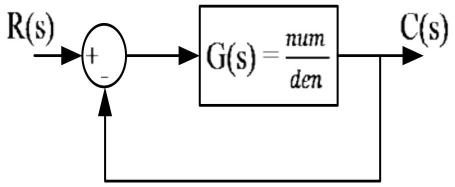
Control & Instrumentation Lab, Autumn 2021-22
Session 6: Bode and Nyquist Plots

At the end of the session, the students shall be able to

1. Analyze Bode plots, determine crossover frequencies and stability margins.
2. Draw Nyquist plots.

1.



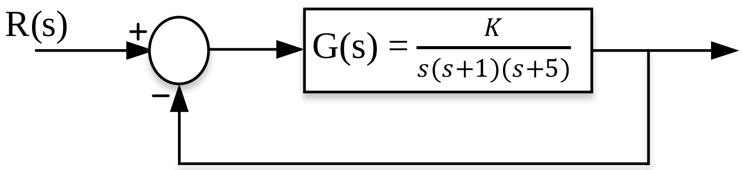
(i) $G(s) = \frac{100\,(s+2)}{s(s+5)(s+10)}$; (ii) $G(s) = \frac{20(s+1)}{s(s+5)(s^2+2s+10)}$; (iii) $G(s) = \frac{10(s^2+0.4s+1)}{s(s^2+0.8s+9)}$

(a) Plot the Bode diagrams for this system with frequency range from $\omega_1 = 0.01$ rad/sec to $\omega_2 = 10^2$ rad/sec.

(b) Determine Gain Margin, Phase Margin, phase crossover frequency and gain-crossover frequency using MATLAB.

(c) Obtain the resonant peak, resonance frequency and bandwidth.

2.



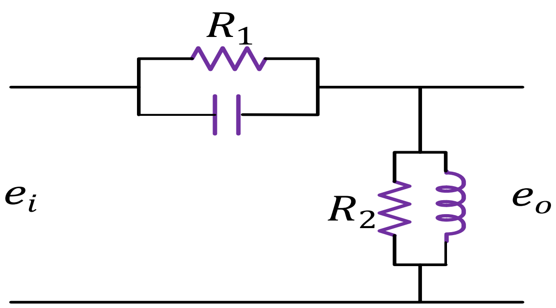
(a) Using MATLAB, plot Bode diagrams for the closed loop system for K = 10, K = 20, and K=100. Plot all the magnitude curves in one diagram and all the phase-angle curves in another diagram.

(b) What difference do you notice about them (in terms of gain margin, phase margin and stability)?

(c) Find the minimum value of K for which the system becomes stable.

(d) Determine the value of K such that phase margin is 30°, and what is the gain margin for that K?

3.

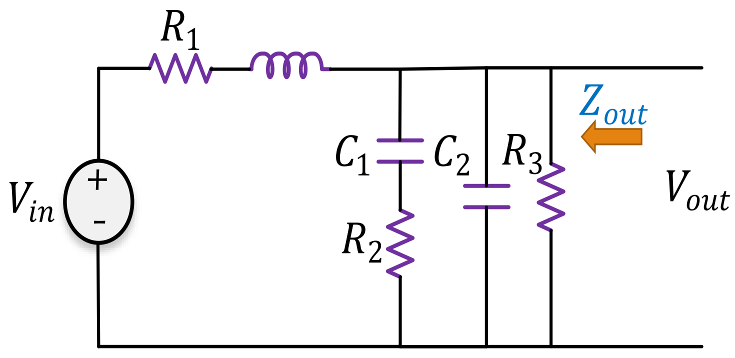


(a) Find $\frac{E_o(s)}{E_i(s)} = ?$

(b) If $\frac{E_o(s)}{E_i(s)} = \frac{Ks(\tau s+1)}{(as^2+bs+1)}$, then find out K, τ, a, and b in term of electrical components $(R_1, R_2, L\ \&\ C)$.

(c) Let $R_1 = 100\Omega$, $R_2 = 500\Omega$, $L = 1\ mH$, $C = 200\mu F$; Plot Bode diagrams of $\frac{E_o(s)}{E_i(s)}$ and determine Gain Margin, Phase Margin, phase crossover frequency and gain crossover frequency.

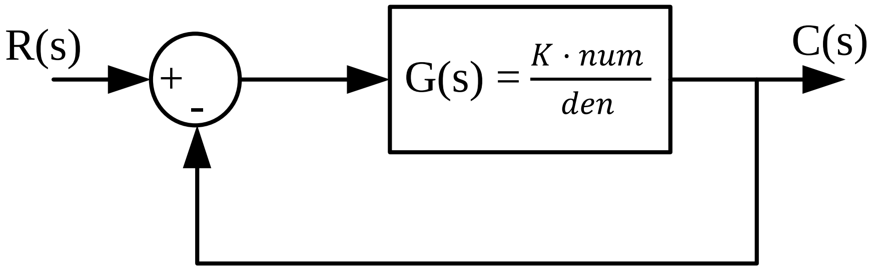
4.



$R_1 = 10\ \Omega$, $R_2 = 100\ \Omega$, $R_3 = 1\ K\Omega$, $L = 10\ mH$, $C_1 = 220\ \mu F$, $C_2 = 47nF$

Plot the Bode diagrams for the magnitudes of the Thevenin-equivalent output impedance Z_{out} and the transfer function H(s) = $\frac{V_{out}(s)}{V_{in}(s)}$. Find the corner frequencies.

5. Conduct a stability analysis of the system given below using the Nyquist Stability Criterion for different transfer functions G(s).



a) $G(s) = \frac{K}{(s+8)(s+6)(s-2)}$; K = 50, 100, 336, 350

b) $G(s) = \frac{K}{s(s+3)(s+2)}$; K = 20, 30, 100

c) $G(s) = \frac{K*(s^2+10s+24)}{s^2-8s+15}$; K = 0.5, 0.8, 1

d) $G(s) = \frac{10(s+p)}{s^2(s+3)}$; p = 2, 4

e) $G(s) = \frac{90}{(s+3)(s+6)} e^{-ps}$; p = 0, 0.05, 0.5