Name: Solution

The Ohio State University
Department of Electrical and Computer Engineering

ECE 551 | Quiz #3 | May 16, 2008

Given the transfer function

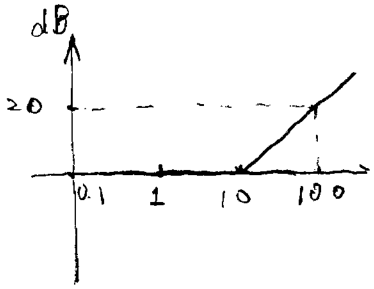
$$G(s) = \frac{-(s-10)}{s(s+10)}$$

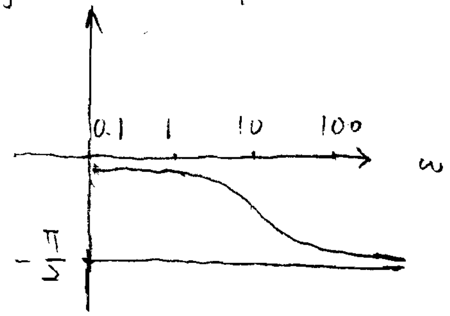
Sketch the Bode magnitude (dB vs logω in radians) and phase (degrees vs. logω in radians) plots below. You must label each portion of the plot, clearly indicating the final result.

$$G(s) = \frac{10\left(1-\frac{1}{10}s\right)}{10\cdot s\left(1+\frac{1}{10}s\right)} = \frac{1-\frac{1}{10}s}{s\left(1+\frac{1}{10}s\right)}, \quad G(j\omega) = \frac{1-j\frac{\omega}{10}}{j\omega\left(1+j\frac{\omega}{10}\right)}$$

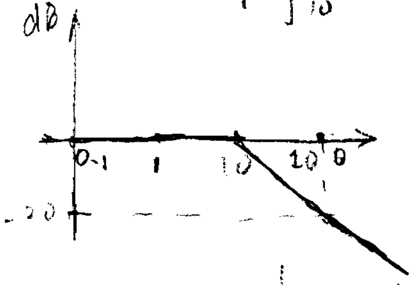
1. For $G_1(j\omega) = 1 - j\frac{\omega}{10}$ $\quad 20\lg|G_1(j\omega)| = 20\lg\sqrt{1+\left(\frac{\omega}{10}\right)^2}$

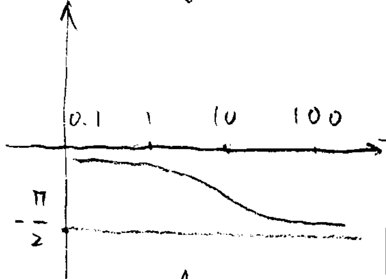
$$\angle G_1(j\omega) = \tan^{-1}\left(-\frac{\omega}{10}\right) = -\tan^{-1}\frac{\omega}{10}$$





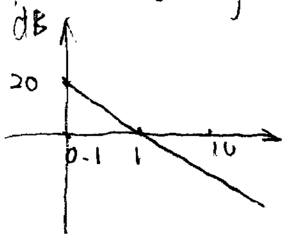
2. For $G_2(j\omega) = \frac{1}{1+j\frac{\omega}{10}}$. $20\lg|G_2(j\omega)| = -20\lg\sqrt{1+\left(\frac{\omega}{10}\right)^2}$. $\angle G_2(j\omega) = -\tan^{-1}\frac{\omega}{10}$

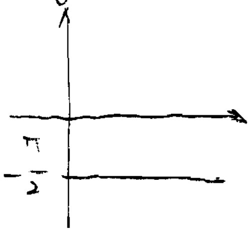




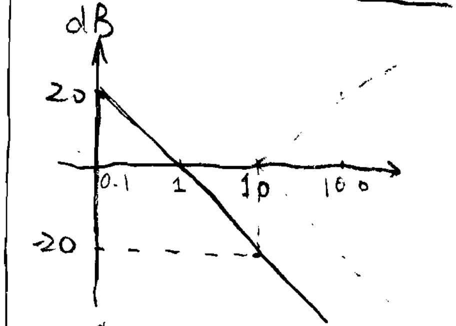
3. For $G_3(j\omega) = \frac{1}{j\omega}$. $20\lg|G_3(j\omega)| = -20\lg\omega$.

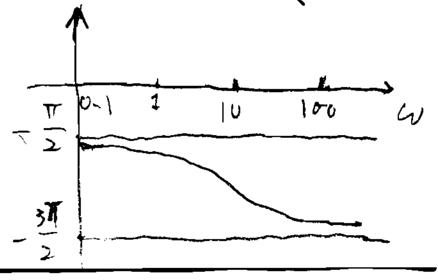
$$\angle G_3 = -\frac{\pi}{2}$$





4. $G(j\omega) = \frac{1-j\frac{\omega}{10}}{j\omega\left(1+j\frac{\omega}{10}\right)}$ → total





Design Project #1. Solution.

P10.1 $\zeta = 0.6 \Rightarrow P.O. = e^{-\pi\zeta/\sqrt{1-\zeta^2}} \times 100\% = 9.48\%$

$T_s < 2.5 \Rightarrow \frac{4}{\zeta\omega_n} < 2.5, \quad \zeta\omega_n > 1.6 \quad \omega_n > 2.67$

Lead Compensator $G_c(s) = \frac{s+z_c}{s+p_c}$, $z_c < p_c$

Pick a zero z_c to drag root locus to LHP, pick a pole far from origin to make root locus move to real axis. Also pick a large k to ensure that $\omega_n > 2.67$ to meet overshoot specification.

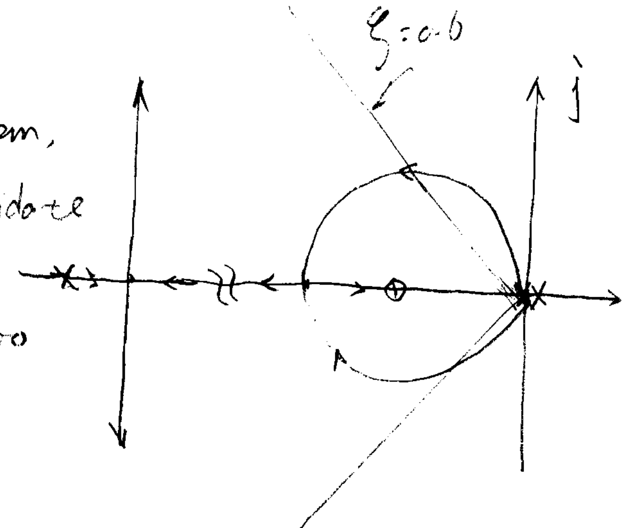
Since this is a design problem, I can only give one candidate design.

I pick $k_1 = 1$, $z_c = 3$, $p_c = 300$

$k_2 = 6300$

$$G_c = 6300 \frac{s+3}{s+300}$$

overshoot 9.47%, $t_s = 0.71s$.



P10.3 $G(s) = \frac{16(s+1)}{s(s^2+2s+16)}$, $P.O. < 5\% \Rightarrow \zeta_d > 0.69$

$T_s < 5 \quad \zeta\omega_n > 0.8 \quad \omega_n > 1.15$

design strategy is same as 10.1.

Here we also use $G_c(s) = \frac{k(s+3)}{s+300}$

choose $k = 2000$

$P.O. = 2.35\%$, $t_s = 1.08s$.