ELG4152: DGD Solution (Chapter 13)

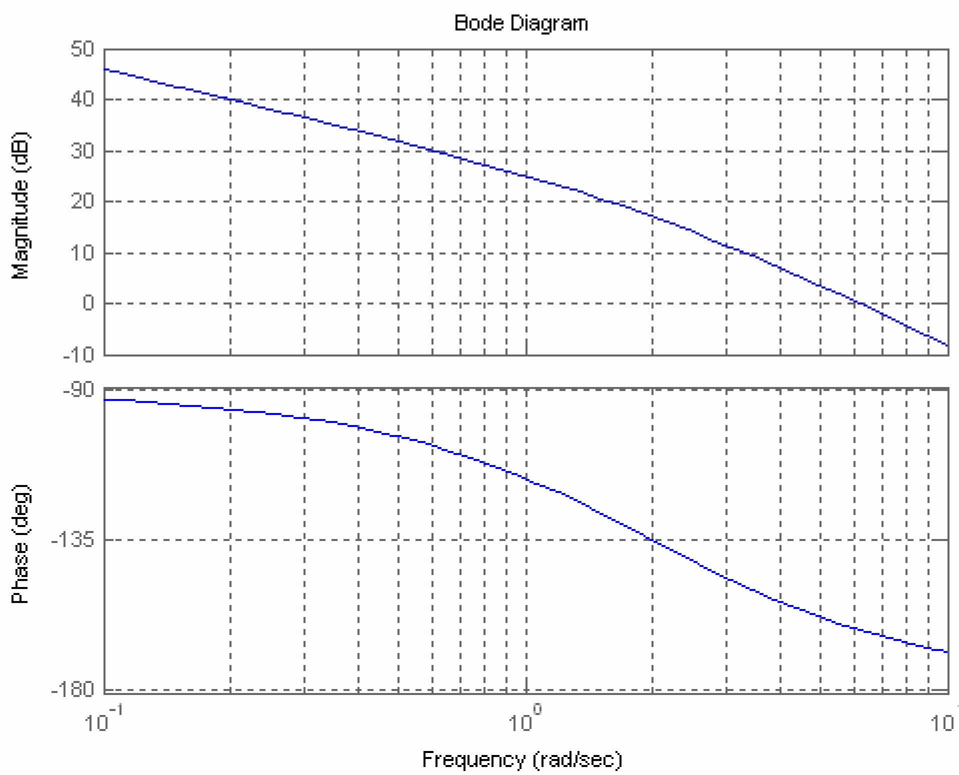
E13.6

Design for a Phase-lag network on the Bode diagram with phase margin 45°, desired Kv=20;

1 Obtain the Bode diagram of the uncompensated system with the gain adjusted for the desired error constant,

Uncompensated transfer function $G(j\omega) = \dfrac{20}{j\omega(0.5j\omega+1)}$

Plot the Bode diagram



2 Determine the phase margin of the uncompensated system
ensure 5 degree addition phase lag

$\phi_{pm} = 50^\circ$

3 Determine the frequency where the phase margin requirement would be satisfied $\phi(\omega) = -130^\circ$, $\omega_c' = 1.5$

The attenuation necessary to cause $\omega_c' = 1.5$ to be new crossover frequency is equal to 20dB

Then we find that 20dB=20logα, or, α=10. Therefore, the zero is one decade below the crossover, $\omega_z = \omega_c'/10 = 1.5/10 = 0.15$, the pole is at $\omega_p = \omega_z/\alpha = 0.015$.

The transfer function of the phase-lag network is

$$G_c(s) = \frac{s/0.15+1}{s/0.015+1} = 0.1\frac{s+0.15}{s+0.015} = K\frac{s+a}{s+b}$$

$a = 0.15, b = 0.015; \quad K = 0.1;$

The compensated system is then

133.3 s + 20

33.33 s^3 + 67.17 s^2 + s

As a final check, the phase margin is $\phi_{pm} = 45^\circ$, $\omega_c^{'} = 1.5$

(b)

T=0.001;

We use the relationships

$a = 0.15, b = 0.015; \quad K = 0.1; T = 0.001$

$$A = e^{-aT}, B = e^{-bT} and \qquad C\frac{1-A}{1-B} = K\frac{a}{b}$$

to compute

$$D(z) = C\frac{z-A}{z-B} = 0.1\frac{z-0.99985}{z-0.999985}$$

P13.11

Design for a Phase-lag network on the Bode diagram :

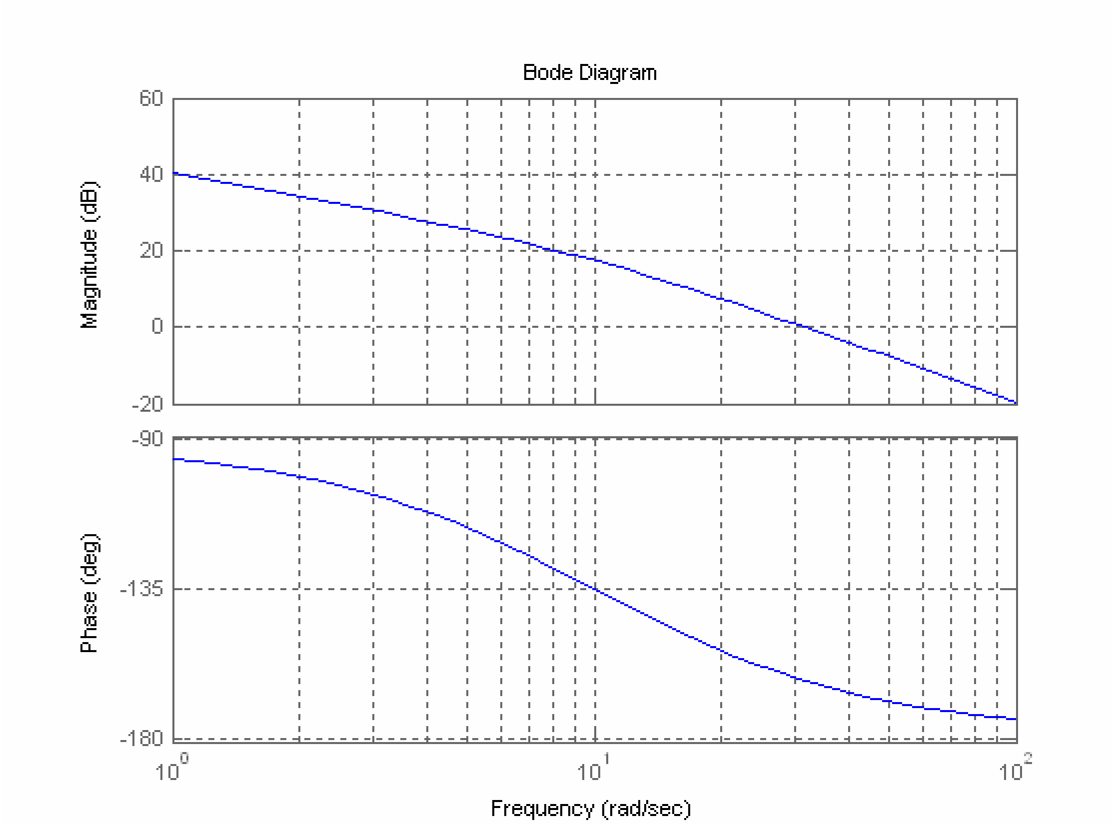
1 Obtain the Bode diagram of the uncompensated system with the gain adjusted for the desired error constant

$e_{ss} = \frac{10}{K} \le 0.01, \qquad K \ge 1000$

select K=1050,

Uncompensated transfer function $G(s) = \dfrac{1050}{s(s+10)}$

Plot the Bode diagram



2 Determine the phase margin of the uncompensated system

$\xi = 0.45$, overshoot is 20%, (Table 5.2)

$\phi_{pm} = \frac{\xi}{0.01} = 45^\circ$

ensure 5 degree addition phase lag

$\phi_{pm} = 50^\circ$

3 Determine the frequency where the phase margin requirement would be satisfied

$\phi(\omega) = -130^\circ$, $\omega_c^{'} = 8$

The attenuation necessary to cause $\omega_c^{'} = 8$ to be new crossover frequency is equal to 20dB

Then we find that 20dB=20logα, or, α=10. Therefore, the zero is one decade below the crossover, $\omega_z = \omega_c^{'}/10 = 8/10 = 0.8$, the pole is at $\omega_p = \omega_z/\alpha = 0.08$.

The transfer function of the phase-lag network is

$$G_c(s) = 1050\frac{s/0.8+1}{s/0.08+1} = 105\frac{s+0.8}{s+0.08} = K\frac{s+a}{s+b}$$

$a = 0.8, b = 0.08; \quad K = 105;$

The compensated system is then

1313 s + 1050

12.5 s^3 + 126 s^2 + 10 s

As a final check, the phase margin is $\phi_{pm} = 45^\circ$, $\omega_c^{'} = 8$

Overshoot is 26.4%, $e_{ss} < 0.01$

(b) T=0.1

We use the relationships

$$a = 0.8, b = 0.08; \quad K = 105; T = 0.1$$

$$A = e^{-aT}, B = e^{-bT} and \qquad C\frac{1-A}{1-B} = K\frac{a}{b}$$

to compute

$$D(z) = C\frac{z-A}{z-B} = 109\frac{z-0.9231}{z-0.992}$$

(e) T=0.01;

We use the relationships

$$a = 0.8, b = 0.08; \quad K = 105; T = 0.01$$

$$A = e^{-aT}, B = e^{-bT} and \qquad C\frac{1-A}{1-B} = K\frac{a}{b}$$

to compute

$$D(z) = C\frac{z-A}{z-B} = 105\frac{z-0.992}{z-0.9992}$$