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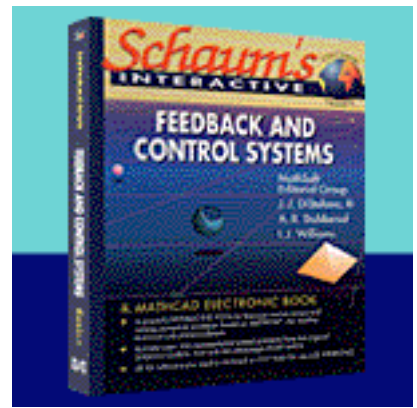


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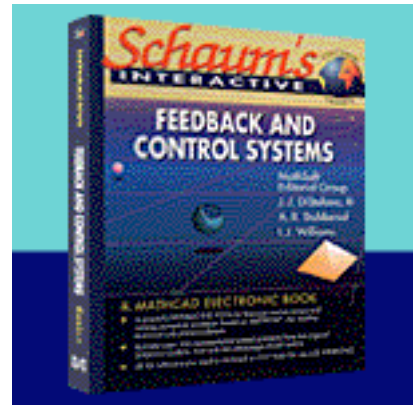
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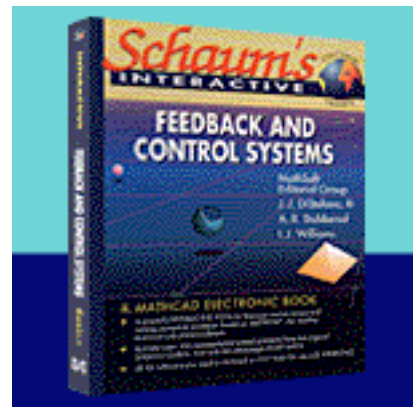
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Constructing Bode Plots

Statement

Construct the Bode plot for the frequency response function given below. Also, determine the gain and phase margins for the system.

System Parameters

$$GH(\omega) := \frac{2}{j \cdot \omega \cdot \left(1 + \frac{j \cdot \omega}{2}\right) \cdot \left(1 + \frac{j \cdot \omega}{5}\right)}$$

Solution

To create the Bode plot for this function, plot the magnitude in decibels and the phase using the phase function shown in Chapter 15.

$$GH_{\text{mag}}(\omega) := 20 \cdot \log(|GH(\omega)|)$$

$$\text{phase}(f) := \text{if}(\arg(f) > 0, \arg(f) - 2 \cdot \pi, \arg(f))$$

$$\phi_{GH}(\omega) := \text{phase}(GH(\omega))$$

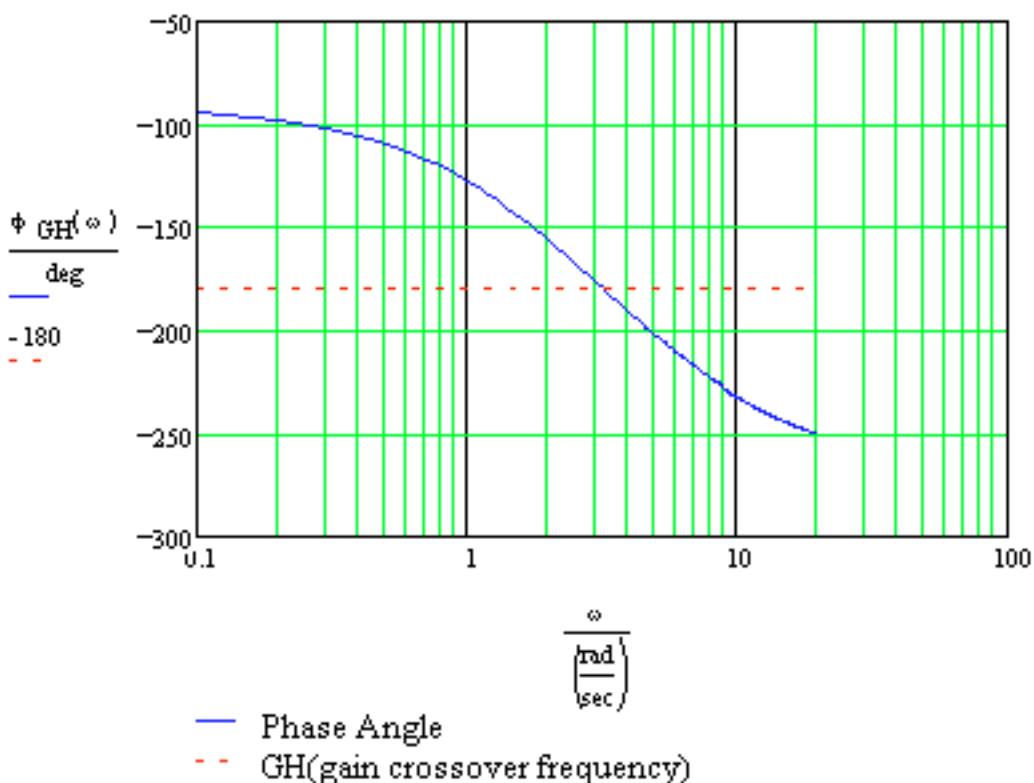
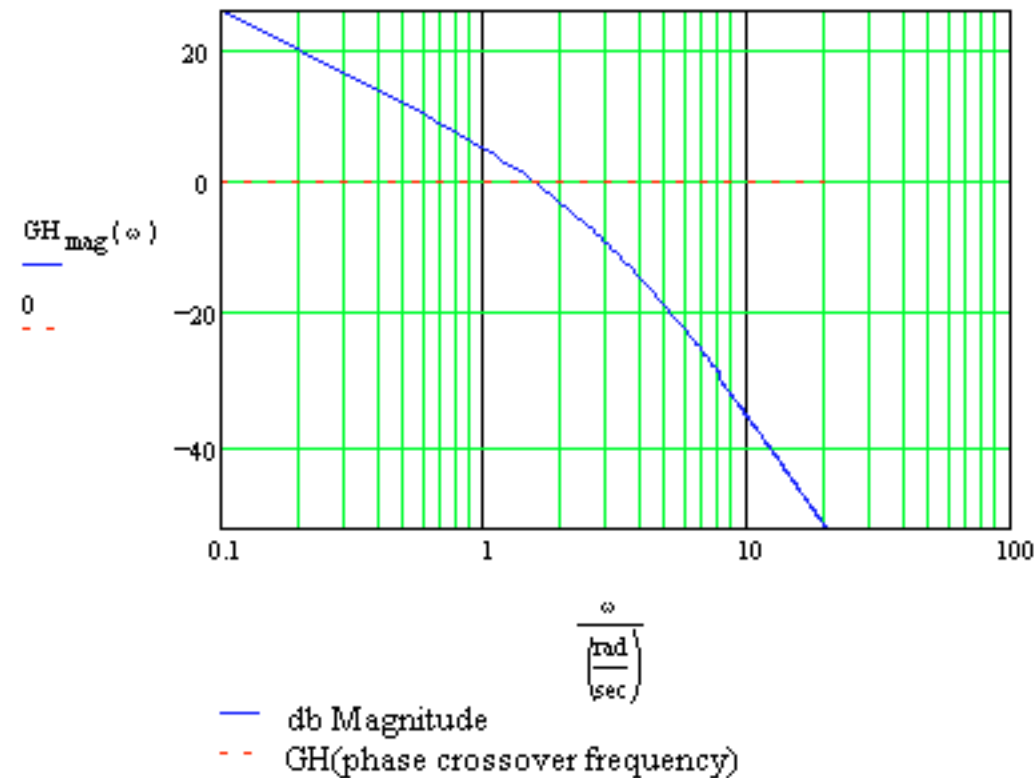
$$\omega := .1, .2 \dots 20$$

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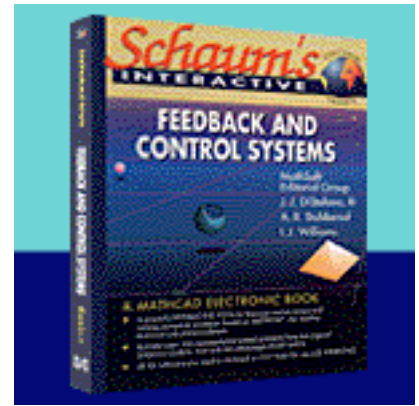


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Now find the gain and phase crossover frequencies. There are two ways to do this. First, from the magnitude and phase angle plots, we can make a good guess at where ω_1 and ω_p are, respectively, and solve the necessary equations. Or, we could find where the two curves plotted on each the magnitude and phase angle plots intersect by setting them equal to each other and solving for ω . Both ways are shown here. Solve for ω_1 by using the graph and for ω_p by using the equations.

Input a guess value for ω_1 based on the magnitude plot intersection and change it until the answer to the $|GH(\omega)|$ function is unity.

$$\omega_1 := 1.52 \quad |GH(\omega_1)| = 1$$

For ω_p , set the phase equation equal to -180° (or $-\pi$) and use the **root** function.

Guess:

$$\omega_g := 1 \quad \omega_\pi := \text{root}(\text{phase}(GH(\omega_g)) + \pi, \omega_g)$$

$$\omega_\pi = 3.2 \quad \omega_\pi = 1 \cdot \sqrt{10}$$

Therefore, the gain margin is

$$\text{gain_margin} := -20 \cdot \log(|GH(\omega_\pi)|) \quad \text{gain_margin} = 10.9$$

And the phase margin is

$$\text{phase_margin} := 180 \cdot \text{deg} + \arg(GH(\omega_1)) \quad \text{phase_margin} = 35.9 \cdot \text{deg}$$

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