EIT FAKULTÄT FÜR ELEKTROTECHNIK UND INFORMATIONSTECHNIK

Systems and Control

Lecture IX

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Introduction

- The open loop gain K_0 is used to modify the phase margin which is in relation to the damping ratio D / percent overshoot $\%OS$.
- Assumption:

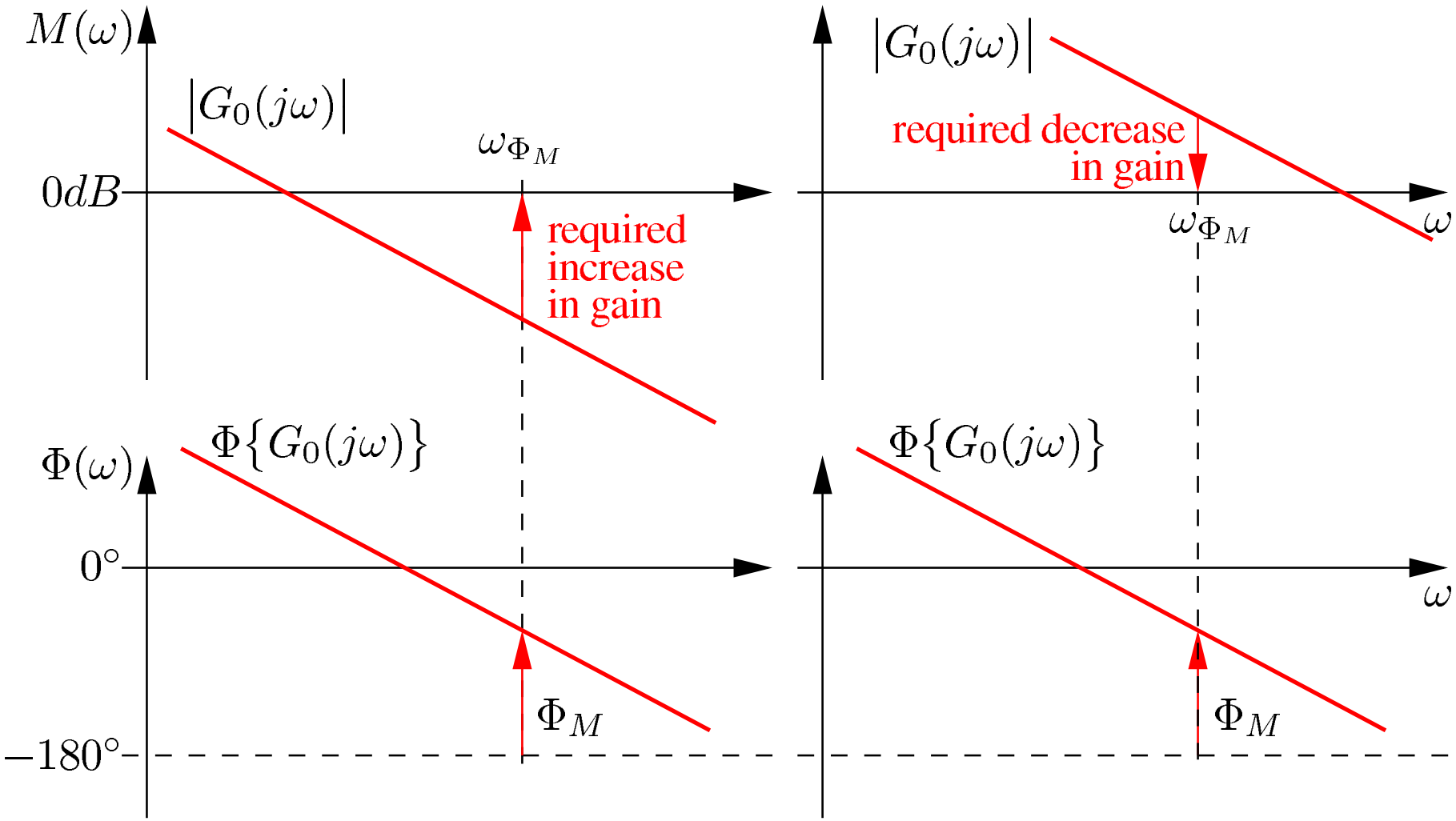
$$\begin{aligned} G_0(j\omega) &= \frac{1}{\frac{1}{\omega_n^2}(j\omega)^2 + \frac{2D}{\omega_n}j\omega} \\ &= \frac{\frac{\omega_n}{2D}}{j\omega\left(\frac{1}{2D\omega_n}j\omega + 1\right)} \\ &= \frac{K_0}{j\omega\left(Tj\omega + 1\right)} \end{aligned} \tag{1}$$

  - to obtain the desired closed-loop second order system
  - The relations between open-loop frequency response and closed-loop transient response specifications are known.
  - The integral term provides steady state accuracy ($e_\infty = 0$) for constant input signals.

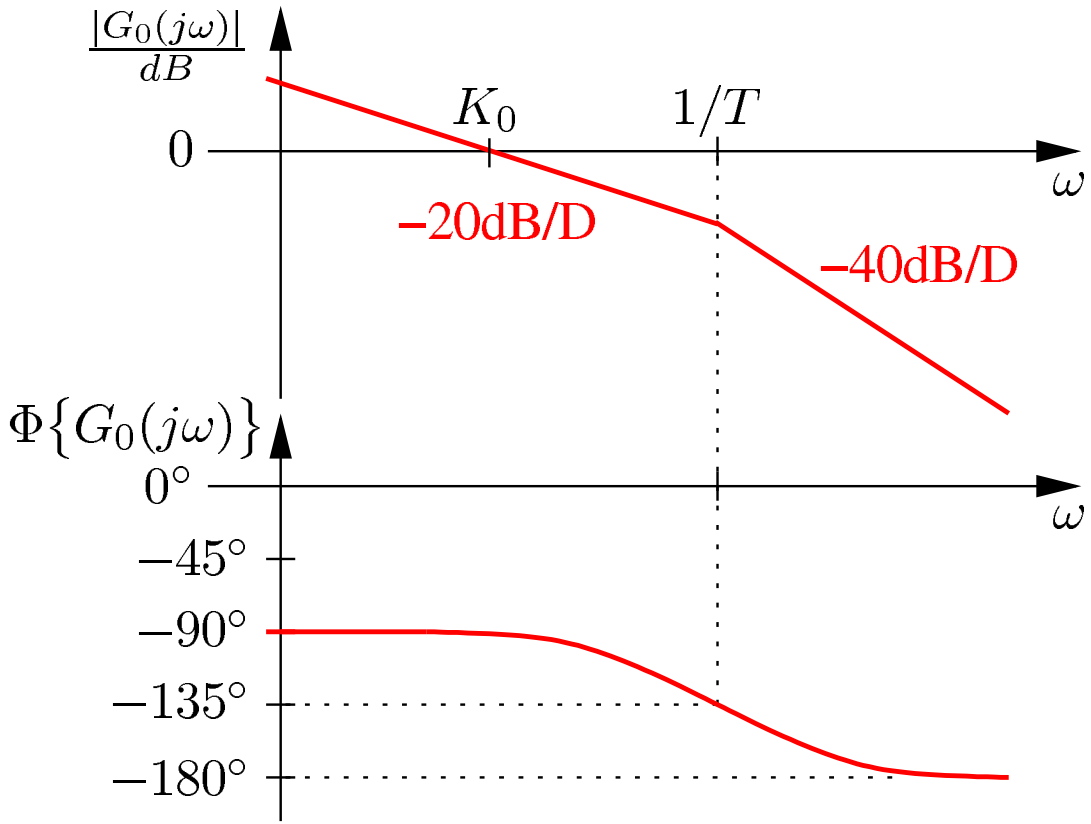
Design Procedure

1. Draw the Bode diagram of $G_0(j\omega)$ for a convenient value of gain K_0.
2. Determine the desired phase margin Φ_M from the desired damping ratio D / percent overshoot $\%OS$.
3. Find the frequency, ω_{Φ_M}, on the phase curve, where the desired phase margin Φ_M occurs.
4. Modify the open loop gain by the factor G to raise or to drop the magnitude curve to go through $0dB$ at ω_{Φ_M}.
   G is the factor by which the open loop gain has to be increased or decreased to obtain the desired phase margin Φ_M.

Illustration



Bode Plot of the Desired Open-Loop Frequency Response



- Remark:
  - Steady-state accuracy ($e_\infty = 0$) is obtained if the low-frequency magnitude approaches infinity:

$$\lim_{\omega \to 0} \left| G_0(j\omega) \right| = \infty. \tag{2}$$