No Math for Basic Bode plots.

Ex. 1

\[ G = \frac{K}{s^2 + 1} \]

eg \( K = 5 \)

\( \omega = 0.5 \Rightarrow \phi_B \approx 2 \)

Phase(\( \infty \)) \(-50\)

Phase(\( \infty \)) \(-90\)
Ex. \( G(s) = \frac{10}{(2s+1)(0.5s+1)} \)

- \( \omega_{b1} = 0.5 \text{ rad/s} \)
- \( \omega_{b2} = 2 \text{ rad/s} \)

**Graphical Addition**
Definition: \( \text{dB} = "\text{decibels}" \)

\[ x_{\text{dB}} = 20 \log{x} \]
\[ G(s) = \frac{j\omega}{s + j\omega} \]

\[ |F| = \frac{1}{\omega} \]

\[ \log |F| = 0 - \log \omega \]

\[ \omega \to \infty \]

\[ -\infty < \omega = 0 \]

\[ \text{Phase}(\infty) = -90^\circ \]

\[ |z(\infty)| \]

\[ \text{Phase}(\infty) = -90^\circ \]
Zero
\( z = 2 \)
\( G(s) = 25 + 1 \)

Pole
\( \omega_p \)

-20
+70
The Bode plot of a second order system

The transfer function of a second order system (e.g., RCL circuit with voltage across the capacitor C) as the output is...
So far $10 < \omega < \infty$

$AA \gg t \rightarrow$ open-loop

$F(j\omega)$

let $\phi = -180^\circ$
Error at scanning point:

\(-y(t)\)

\(r(t)\)

\(y(t)\) is inverted

if at \(\phi = -180^\circ\)

\(y(t) > y_{ref}\)

My quiet criterion:

if at \(\phi = -180^\circ\)

\(|F| > 1\), then closed loop is unstable
Gain and Phase Margins

see also Fig 6.33 and 6.34 in book

Gain = 1 |

| F | < 1 \Rightarrow \text{is stable} |

Closed loop

\pm 10 \text{dB or Gain} = 1

Phase Margin

Phase Margin
P-control
Use Bode for compensator design

focus comp better. Example:

\[ G(s) = \frac{2}{s(s+4)(s+6)} \]

Compensator with \( \rho/\varepsilon = 10 \)

i.e.

\[ \text{Comp} = \frac{s+\varepsilon}{s+p} \cdot \frac{P}{\varepsilon} \text{() \overline{\text{Keps}} \text{ sos gain}} = 1 \]
raise k by 30 dB

I or raise k by 40 dB or 3 times higher

p-control
Bode Example of plant addition, gain adjusted, Plant* Lead

\[ \text{new } k = 100 \]

Phase (deg) vs Frequency (rad/sec)