Handout 8: Lead compensation

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Lead Compensation goals: Raise phase (and gain) at high frequencies while not touching low-frequency system's characteristics: Can extend *bandwidth* of system.

Canonical lead element:

$$K_{lead}(s) = \frac{s/a+1}{s/b+1}, \quad 0 \leq a < b.$$

Typical lead Bode Plot:

Table of maximum phase lead for lead compensator:

b/a	Phase lead (deg)	Gain
3	30	
6		
10		
20		
100		

Plant under study:

$$G(s) = \frac{1/10}{(s+1)(s/10+1)^2}$$

Requirements: Want to increase BW beyond $4 rad/sec$, must beat $p(j\omega)$.

Compensation Scheme: We first adjust the gain K in the feedback loop to 150.

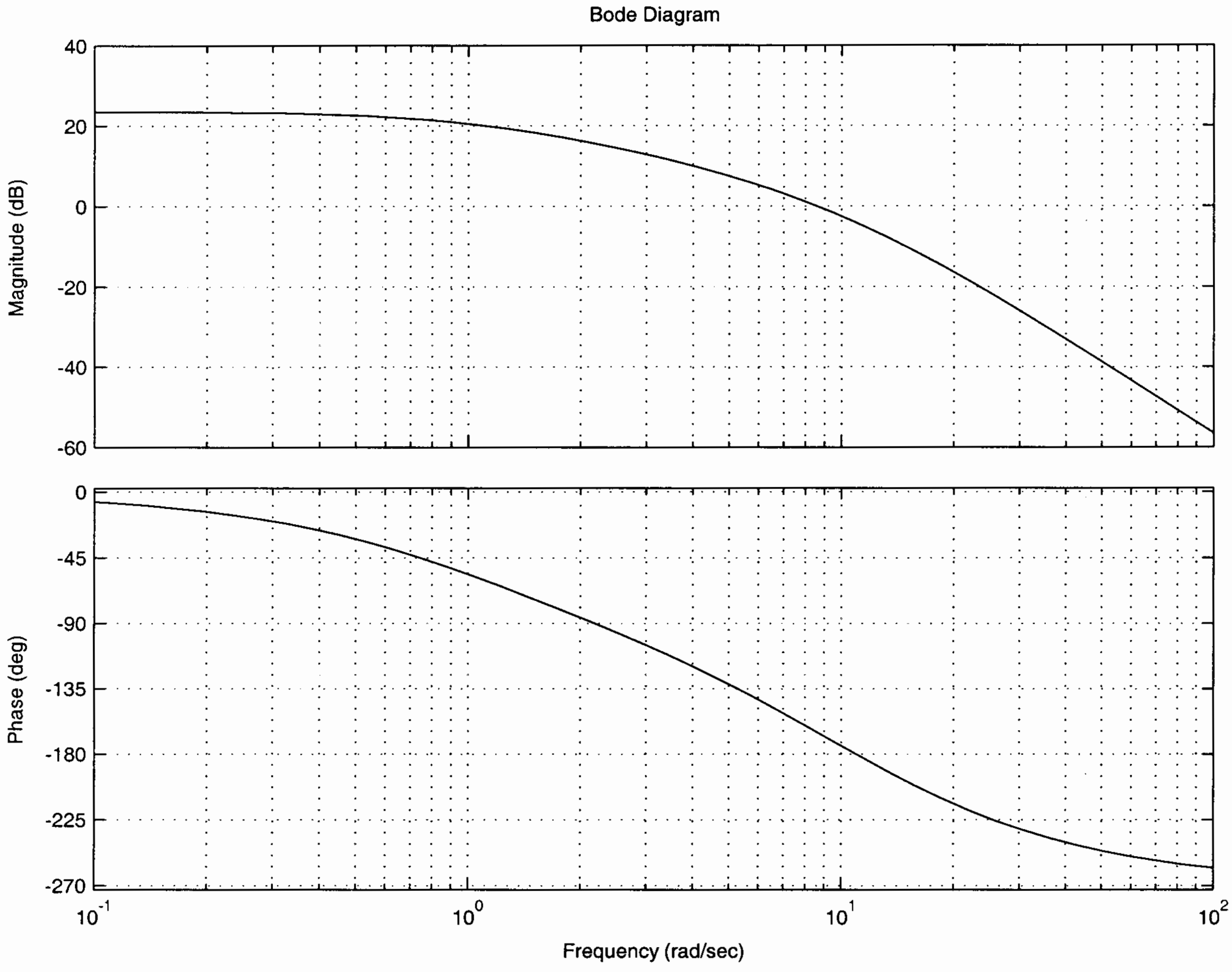
Phase Margin is

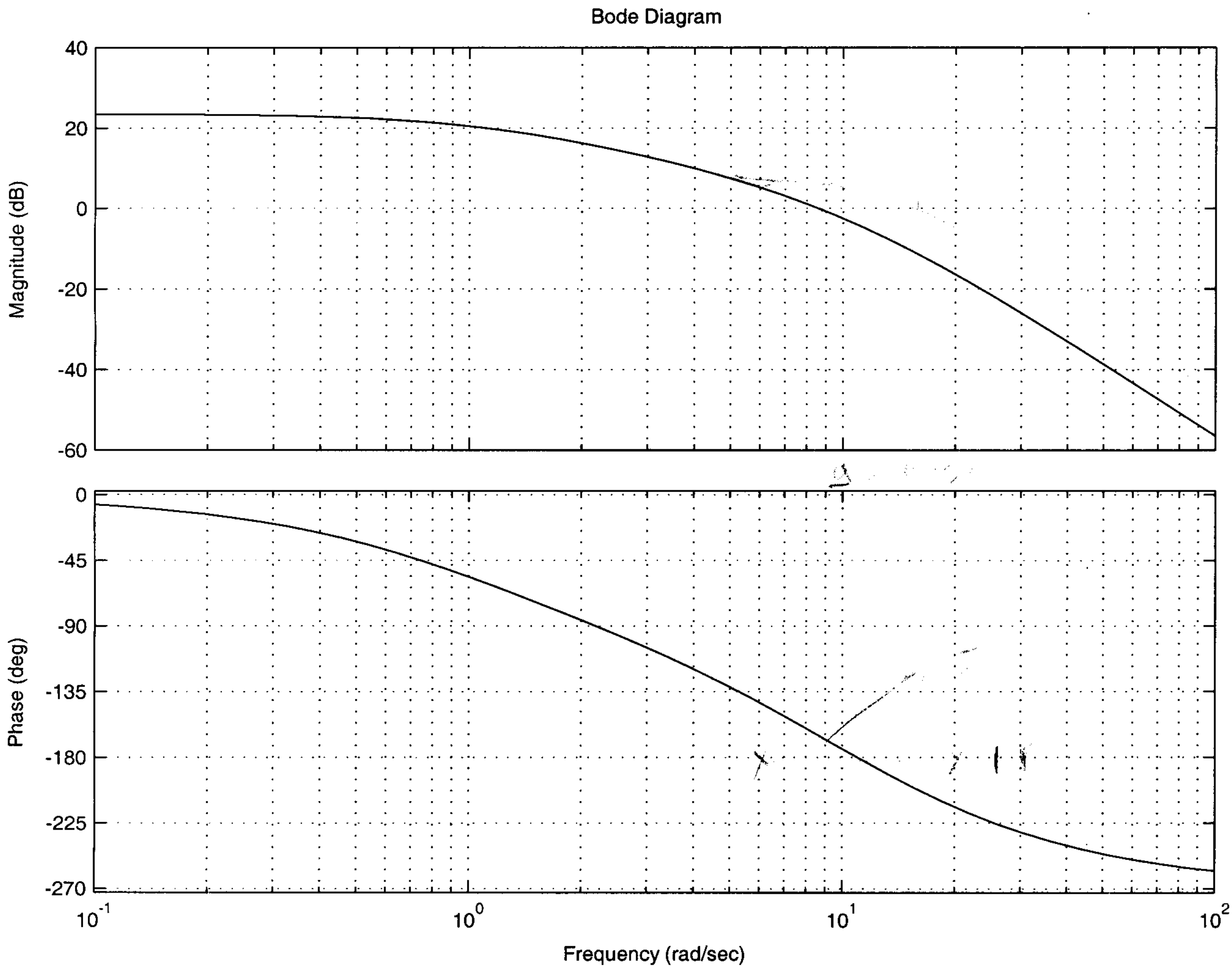
Gain Margin is

BW is

$$G = \frac{1}{10(s+1)(s/10+1)^2}$$

$$K_p = 150$$




Bode Diagram
Magnitude (dB)
40
20
0
-20
-40
-60
Phase (deg)
0
-45
-90
-135
-180
-225
-270
10^{-1}
10^{0}
10^{1}
10^{2}
Frequency (rad/sec)

```latex
\documentclass[11pt]{article}
\usepackage[dvips]{graphicx}
\title{Handout 8: Lead compensation}
\author{Eric Feron}
\date{March 1, 2003}

  egin{document}
  .ketitle

{\bf Lead Compensation goals:} Raise phase (and gain) at high frequencies while not touching low-frequency system's characteristics: Can extend {\em bandwidth} of system.

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{\bf Canonical lead element:}
\[
K_{lead}(s)= \frac{s/a+1}{s/b+1}, \;\; 0 \leq a<b.
\]

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Typical lead Bode Plot:



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Table of maximum phase lead for lead compensator:
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\begin{tabular}{|r|r|r|}
\hline
$b/a$ & Phase lead (deg) & Gain\\ \hline
3 & 30 & \\ \hline %45
6 &   &  \\ \hline %55
10 &  & \\ \hline %65
20 &  &\\ \hline %65
100 & & \\\hline %78
\end{tabular}
\vspace{10mm}

{\bf Plant under study:}

\[
G(s) = \frac{1/10}{(s+1)(s/10+1)^2}
\]

\vspace{10mm}

Requirements: Want to increase BW beyond $4 rad/sec$, must beat $p(j\omega)$.
\vspace{10mm}

{\bf Compensation Scheme:} We first adjust the gain $K$ in the feedback loop to 150.

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Phase Margin is
\vspace{10mm}

Gain Margin is
\vspace{10mm}

BW is

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 ad compensation:

K_{lead}(s) = \frac{s/a+1}{s/b+1}
\]

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Final design: Bode plot

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Final design: Root locus

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Root locus for Proportional compensator

System becomes unstable when gain is

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Bode and Nyquist plots for Proportional compensator

Phase margin becomes zero when gain is

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Closed loop transfer functions

As seen from reference input to output:

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As seen from unmodelled dynamics output to uncertain dynamics input

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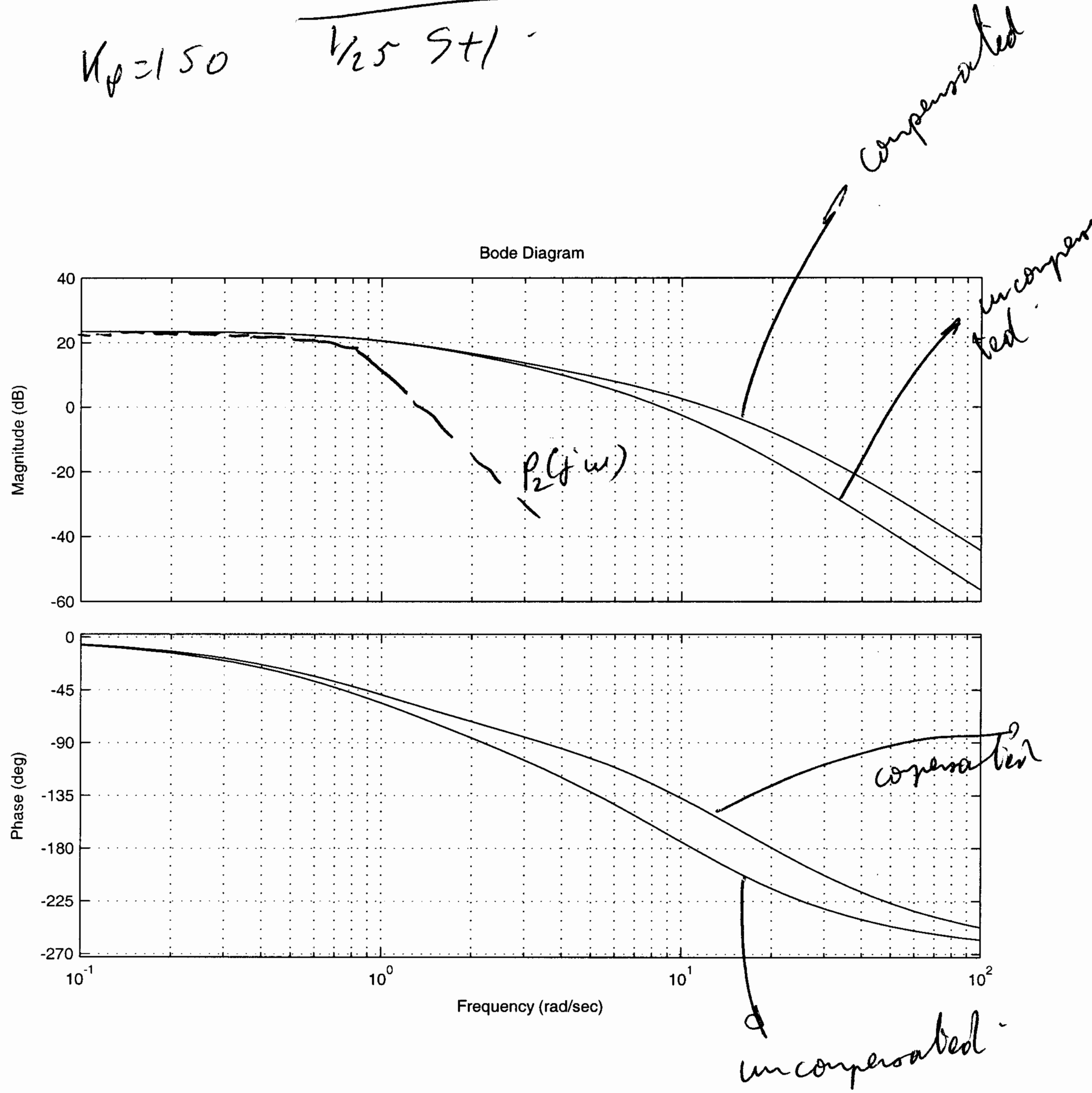
$G = \frac{1}{10(s+1)(s/10+1)^2}$

$K_{lead}: \frac{1/5\, s+1}{1/25\, s+1}$

$K_p = 150$



Lead compensation:

$$K_{lead}(s) = \frac{s/a + 1}{s/b + 1}$$

Final design: Bode plot