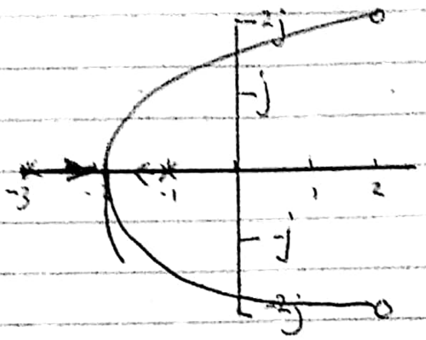
Ener 315 test 2 Joshua Benfell 30043322?

1a $G(s) = \dfrac{s^2-4s+8}{s^2+4s+3}$

$= \dfrac{(s-2+2i)(s-2-2i)}{(s+3)(s+1)}$

P-Z = 0 no asymptotes.



$G(s) = \dfrac{s+4}{s(s+6)(s+3)(s+1)}$

$P - Z = 4 - 1$
$= 3$

$\theta_a = \dfrac{(2k+1)\pi}{3}$

$k=-1 \quad \theta_a = \dfrac{-\pi}{3}$

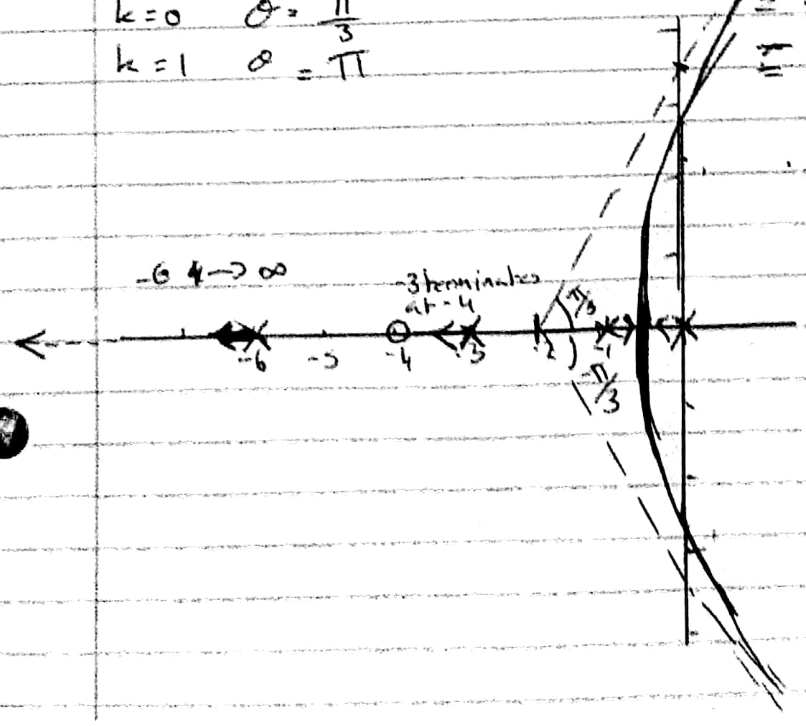
$k=0 \quad \theta = \dfrac{\pi}{3}$

$k=1 \quad \theta = \pi$

$\theta_a = \dfrac{\overbrace{0-6-3-1}^{\text{Poles}} - \overbrace{-4}^{\text{Zeros}}}{3}$

$= \dfrac{-6}{3}$

$= -2.$



1b $G(s) = \frac{s^2+10s+24}{s^2+3s+2} = \frac{(s+6)(s+4)}{(s+2)(s+1)}$

$k = \frac{-1}{G(s)}$

$= \frac{-1}{G(\sigma)}$

$\frac{dk}{d\sigma} = \frac{d}{d\sigma}\left(\frac{-\sigma^2-3\sigma-2}{\sigma^2+10\sigma+24}\right)$

$= \frac{(-2\sigma-3)(\sigma^2+10\sigma+24)+(\sigma^2+3\sigma+2)(2\sigma+10)}{(\sigma^2+10\sigma+24)^2}$

ignore denominator

$= \cancel{-2\sigma^3} - 20\sigma^2 - 48\sigma - 3\sigma^2 - 30\sigma - 72 + \cancel{2\sigma^3} + 6\sigma^2 + 4\sigma + 10\sigma^2 + 30\sigma + 20$

$= (-20+6-3+10)\sigma^2 + (-48-30+4+30)\sigma + (-72+20)$

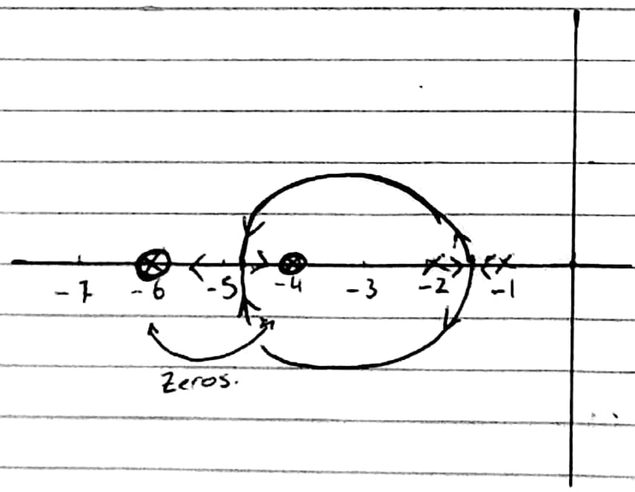
$= -7\sigma^2 - 44\sigma - 52$

$= 0$

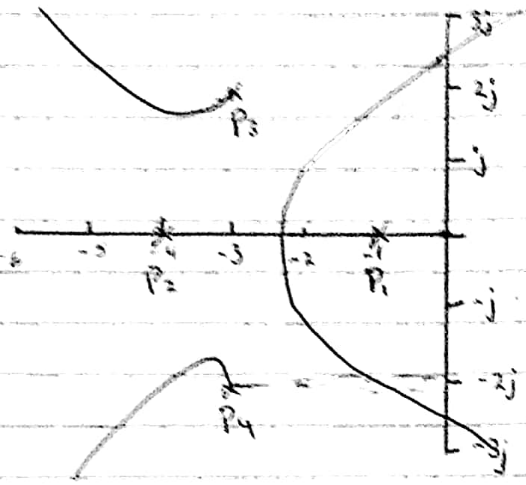
$7\sigma^2 + 44\sigma + 52 = 0$

$(\sigma+1.577)(\sigma+4.707) = 0$

$\left(\sigma + \frac{22+2\sqrt{30}}{7}\right)\left(\sigma + \frac{22-2\sqrt{30}}{7}\right) = 0$



1c. $G(s) = \dfrac{1}{(s+4)(s+1)(s+3+2j)(s+3-2j)}$



try $j\omega = \cancel{2j}\ 2.5j$

~~arg(P_1)~~

$\theta_{p_1} = \arctan \frac{2.5}{1}$
$= 68.199°$

$\theta_{p_2} = \arctan\left(\frac{2.5}{4}\right)$
$= 32°$

$\theta_{p_3} = \arctan\left(\frac{0.5}{3}\right)$
$= 9.46$

$\theta_{p_4} = \arctan\left(\frac{4.5}{3}\right)$
$= 56.31$

$-\theta_{p_1} - \theta_{p_2} - \theta_{p_3} - \theta_{p_4} = -68.199 - 32 - 9.46 - 56.31$
$= -165.969$

too low so try $j\omega = 2.8j$

$\theta_{pi} = \arctan \frac{2.8}{1}$ $\quad$ $\theta_{p_3} = \arctan\left(\frac{0.8}{3}\right)$
$= 70.346$ $\quad$ $= 14.934$

$\theta_{p_2} = \arctan\left(\frac{2.8}{4}\right)$ $\quad$ $\theta_{p_4} = \arctan\left(\frac{4.8}{3}\right)$
$= 34.99$ $\quad$ $= 57.995$

$-\theta_{p_1} - \theta_{p_2} - \theta_{p_3} - \theta_{p_4} = -178.26$ $\quad$ Bit too low try 2.85

$\theta_{p_1} = \arctan\left(\frac{2.85}{1}\right)$ $\quad$ $\theta_{p_3} = \arctan\left(\frac{0.85}{3}\right)$
$= 70.665$ $\quad$ $= 15.8192$

$\theta_{p_2} = \arctan\left(\frac{2.85}{4}\right)$ $\quad$ $\theta_{p_3} = \arctan\left(\frac{4.85}{3}\right)$
$= \cancel{70.665}\ 35.354899$ $\quad$ $= 58.26086$

$-\theta_{p_1} - \theta_{p_2} - \theta_{p_3} - \theta_{p_4} = -180.235$

→ imag intercept at ~ $j\omega = 2.85j$ and $j\omega = -2.85j$

1c cont

imag intercept $= \pm 2.85j$

Gain this occurs at

$$|k| = \frac{1}{|G(s)|}$$

$$= |(s+4)| \times |s+1| \times |s+3+2j| \times |s+3-2j|$$

~~$s = 2.85j$~~

$s = 2.85j$

$$= \sqrt{2.85^2+4^2} \times \sqrt{2.85^2+1^2} \times \sqrt{4.85^2+3^2} \times \sqrt{0.85^2+3^2}$$

$$= 263.78$$

$20\log(k) = 48.42$ dB.

2a

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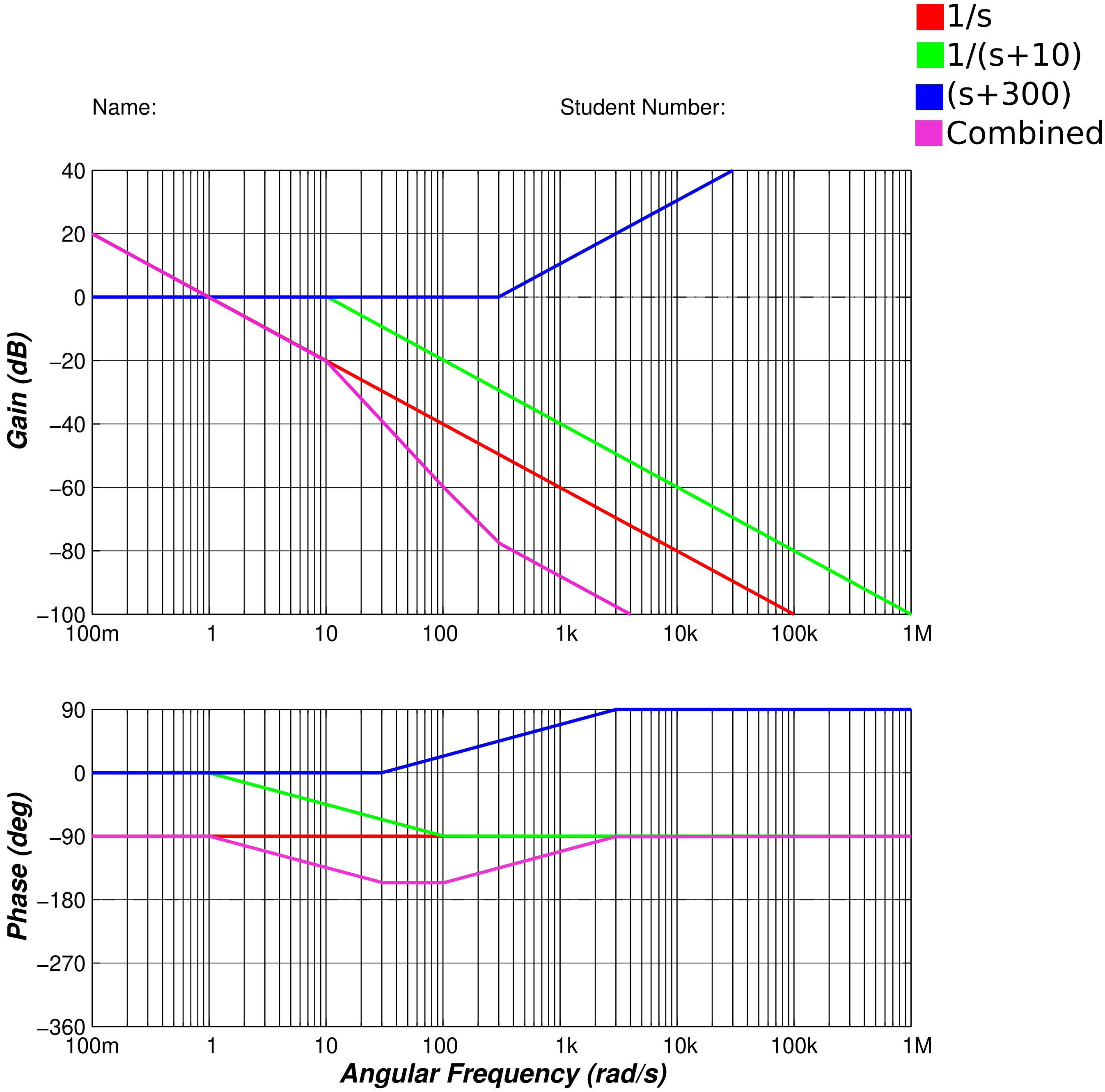


Forgot to draw in a gain of 300/10.

So you're welcome to pretend it's 29.54 dB higher than it is It's just a lot of work for a small thing to go back and change it

2a $G(s) = \frac{s+300}{s^2+10s}$

$= \frac{s+300}{s(s+10)}$

2b Roots $(s+3)$ & , $(s+8)$, $(s+100)$
all poles

$G(s) = k \frac{1}{(s+3)(s+8)(s+100)}$

$= \frac{k}{3\times8\times100}\left(\frac{1}{(\frac{s}{3}+1)(\frac{s}{8}+1)(\frac{s}{100}+1)}\right)$

$k = 24000$

$20\log \frac{k}{2400} = 20dB$

$\frac{k}{10} = 10$

$G(s) = \frac{24000}{(s+3)(s+8)(s+100)}$

2c System is type 1 as phase starts at $-90°$

SSE

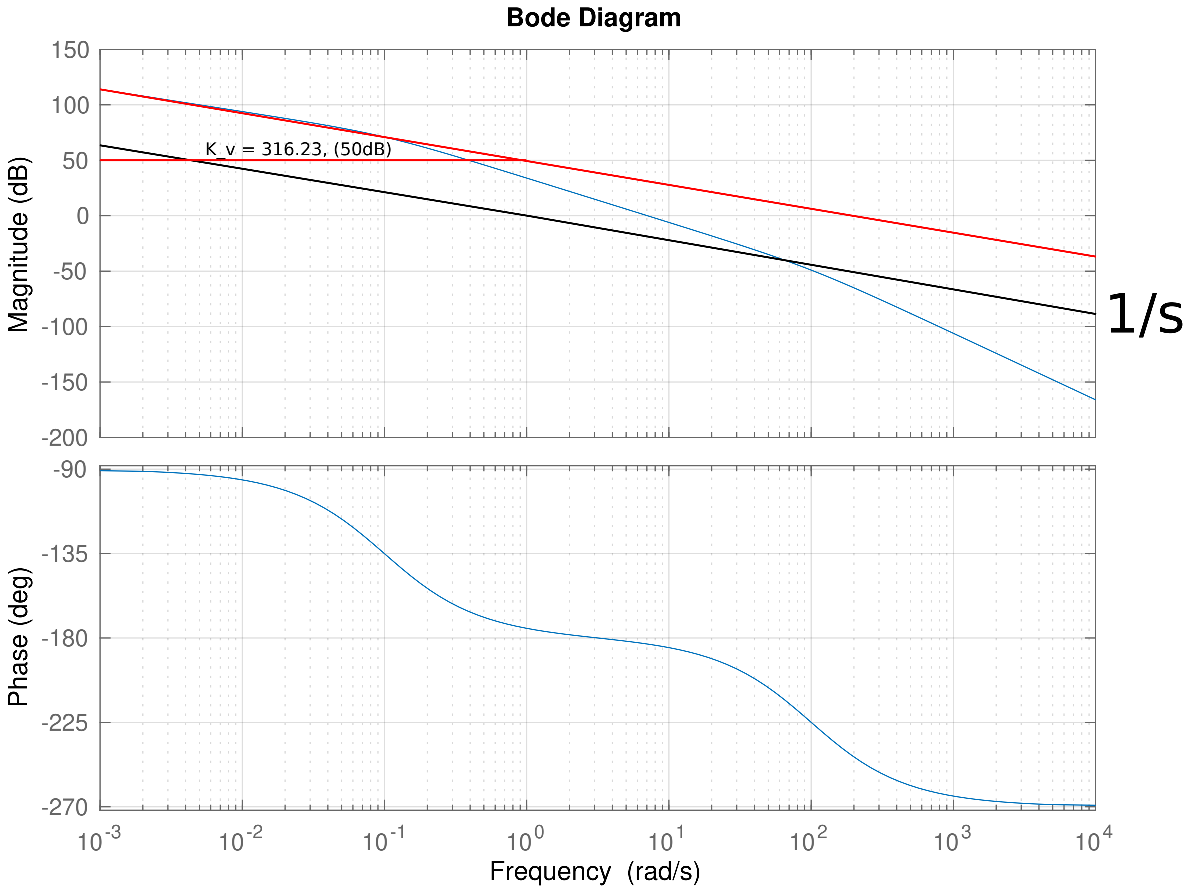
Step input: 0

Ramp input: $1/k_v$ where $k_v =$ ~~281.84 from graph~~ 316.23 $\therefore$ SSE $= \frac{1}{316.23} = 3.16 \times 10^{-3}$ ~~$\therefore$ SSE $= \frac{1}{281.84} =$~~

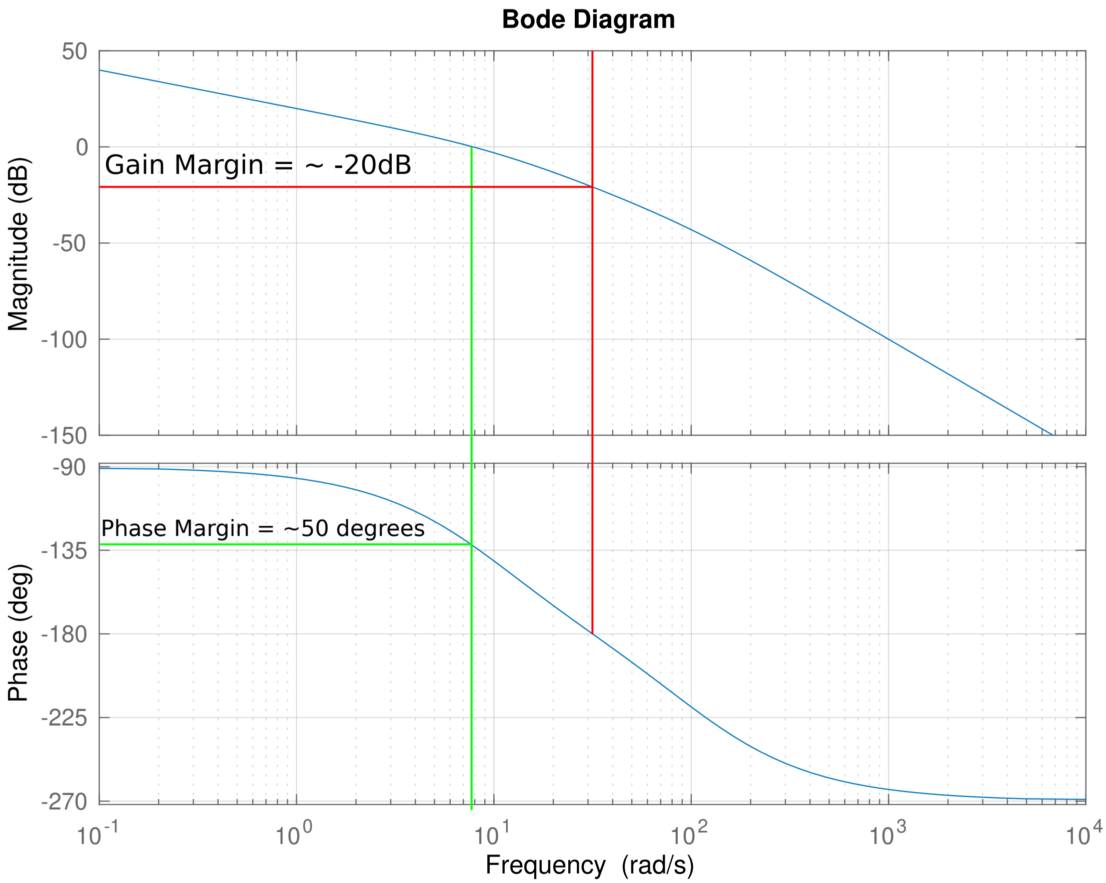
parabolic input: ∞

See attached graph

(c) (5 points) For the Bode plot displayed below, give the type of the system and the steady state error for a step, ramp and parabolic input. Show or explain how you got your result.



(d) (5 points) For the Bode plot displayed below, give the approximate gain and phase margin, as well as the approximate damping ratio.



Damping Ratio = Phase Margin/100
= 50 /100
=0.5

2e $G(s) = \frac{20000}{s(s+100)(s+10)}$ ϕ_m happens at ~ ~~80 rad/s~~ 15 rad/s

$= \frac{20000}{1000s(\frac{s}{100}+1)(\frac{s}{10}+1)}$

lead compensator $= \cancel{s+150}\ \frac{s+15}{s+150}$

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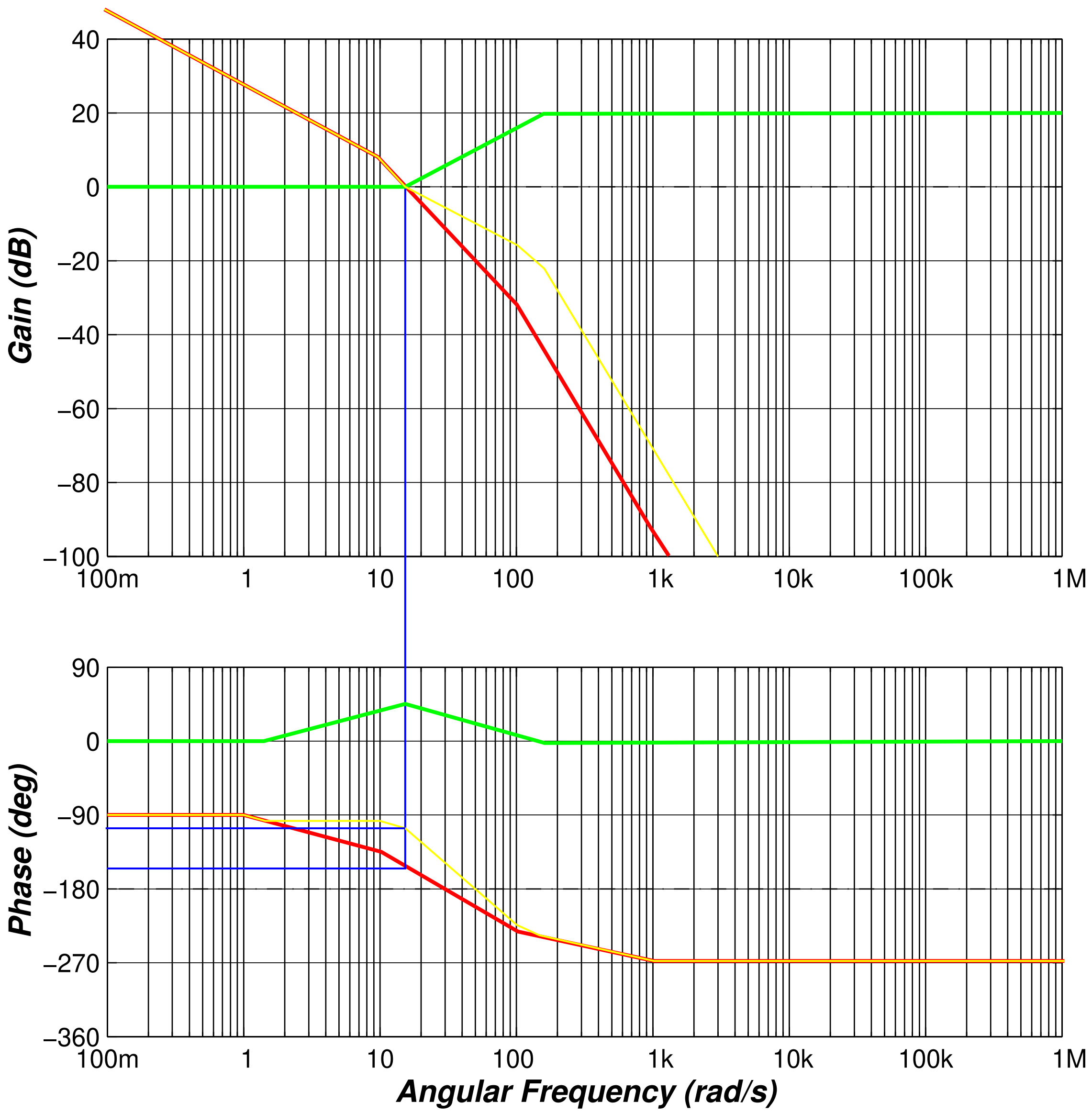

Initial Phase Margin of 30
Final Phase Margin of 75 degrees

Plant
Compensator = (s+15)/(s+150)
Phase Margin Indicator
Combined