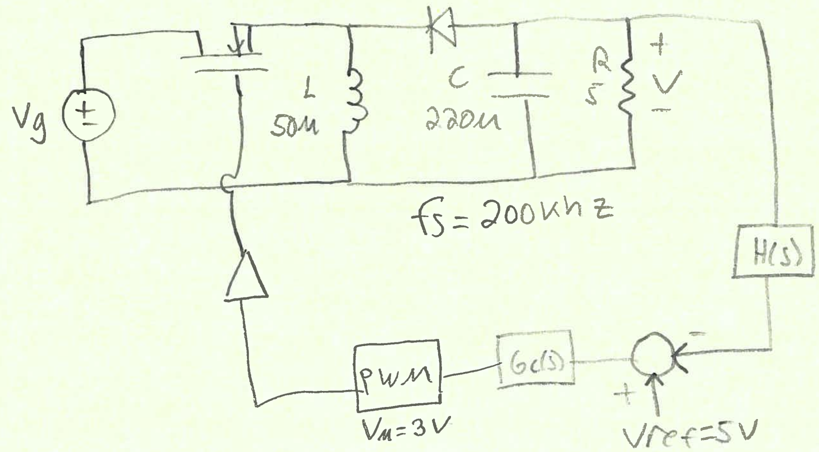
HW9

"Buck Boost"



$V_g = 48V$

$V = -15V$

Design controller for $f_{BW} = 20khz$ and phase margin $\geq 52°$

a) Specify value of $H(s)$

$VH = V_{ref}$

$$H = \frac{V_{ref}}{V} = \frac{5}{-15} = -\frac{1}{3}$$

"would require an inverting amplifier"

Small signal model $G_{vd}(s)$

$$G_{vd}(s) = G_{do}\frac{\left(1 - \frac{s}{\omega_z}\right)}{1 + \frac{s}{Q\omega_0} + \left(\frac{s}{\omega_0}\right)^2}$$

$$G_{do} = \frac{V}{DD'} \qquad D = \frac{V}{-V_g + V}$$

$$\omega_z = \frac{D'^2 R}{DL} \qquad D' = 1 - D$$

$$Q = D'R\sqrt{\frac{C}{L}}$$

$$\omega_0 = \frac{D'}{\sqrt{LC}}$$

HW9

Loop Gain

$T(s) = H(s)\, G_c(s) \left(\frac{1}{V_m}\right) G_{vd}(s)$

$T(s) = \left(-\frac{1}{3}\right) G_c(s) \left(\frac{1}{3}\right) G_{vd}(s)$

steady state bias pts.

$D = 0.2381$

$I_L = 3.9375\ A$

Salient features of $G_{vd}(s)$

$Q \approx 8$

$\omega_z = 243.81\ k\frac{rad}{s}$ or $38.803\ khz$

$\omega_o = 7.2645\ k\frac{rad}{s}$ or $1.1562\ khz$

$G_{do} = -82.6875$

From Matlab tuning in frequency domain

$$G_c(s) = 5588.9\ \frac{(1+4.4e^{-5}s)(1+.00091s)}{s(1+7e^{-8}s)}$$

zeros: $-22{,}700\ \frac{rad}{s}$, $-1100\ \frac{rad}{s}$

Poles: 0, $-1.43e7\ \frac{rad}{s}$

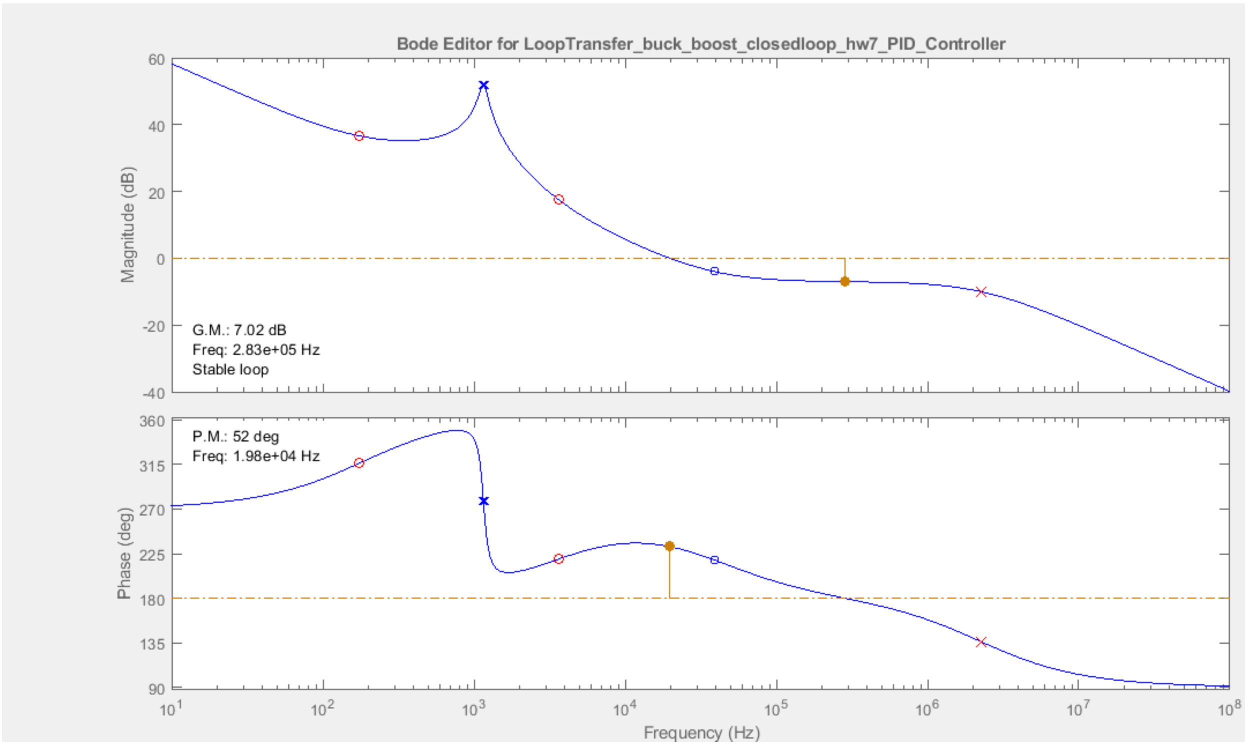
<u>in hz</u>

zeros: 3.6khz, 175hz

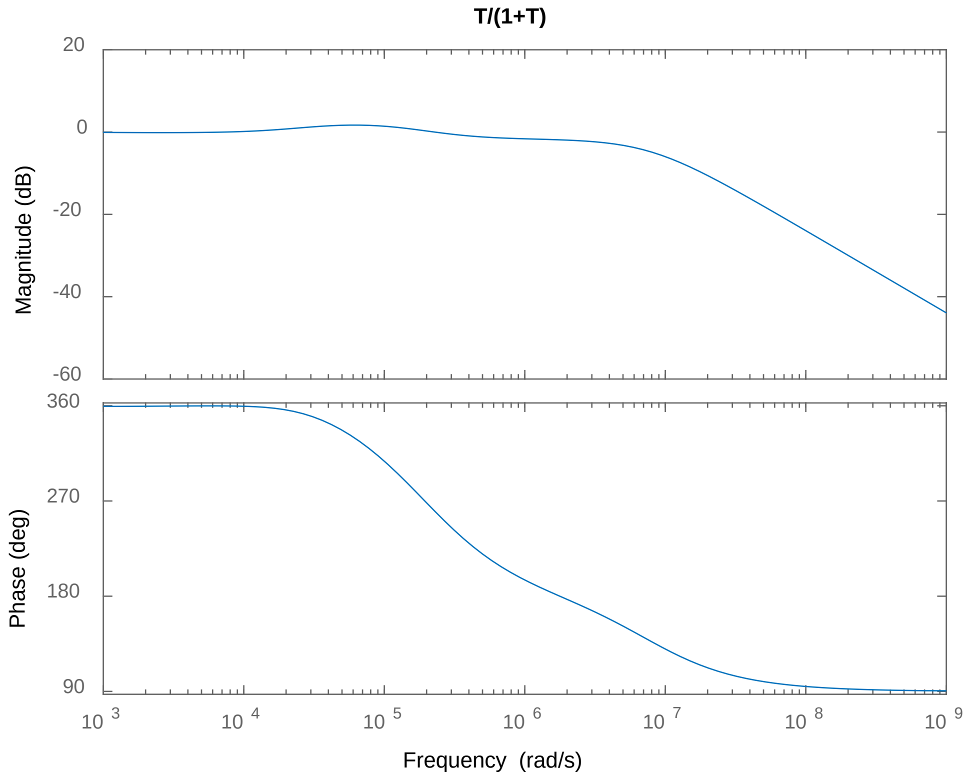
poles: 2.27Mhz, 0

Final Design BODE plots for HW 7 Closed loop Buck-Boost Design

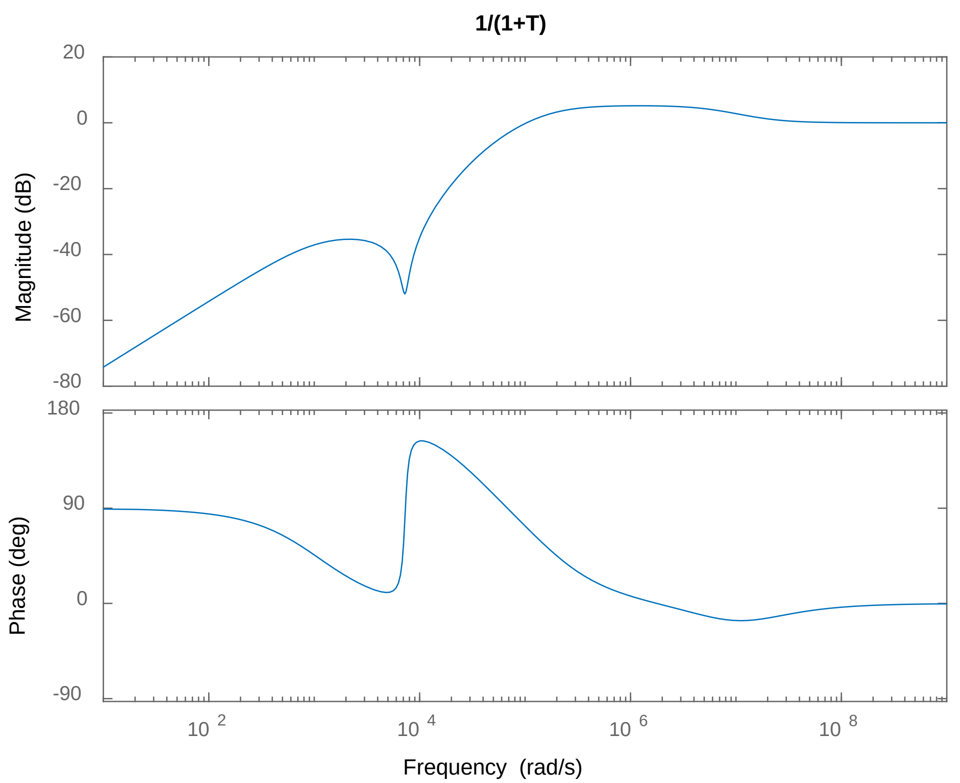
(a)



(b)



T/(1+T)
Magnitude (dB)
20
0
-20
-40
-60
Phase (deg)
360
270
180
90
10 3
10 4
10 5
10 6
10 7
10 8
10 9
Frequency (rad/s)



1/(1+T)
Magnitude (dB)
20
0
-20
-40
-60
-80
Phase (deg)
180
90
0
-90
10 2
10 4
10 6
10 8
Frequency (rad/s)

(c) The maximum achievable bandwidth (cross-over frequency) should not be greater than 10% of the switching frequency. So this design sets a maximum achievable bandwidth of 20 kHz. Another limiting factor here is the right half plane zero that occurs in the control to output transfer function of the buck-boost converter. In this case, the gain increases while the phase decreases resulting in poor phase margin if one tries to increase the bandwidth. The loop gain at 120 Hz with the final design is about 38.4 dB. It is important to achieve as much low frequency gain as possible to improve rejection to disturbances along with better tracking performance of the reference voltage.