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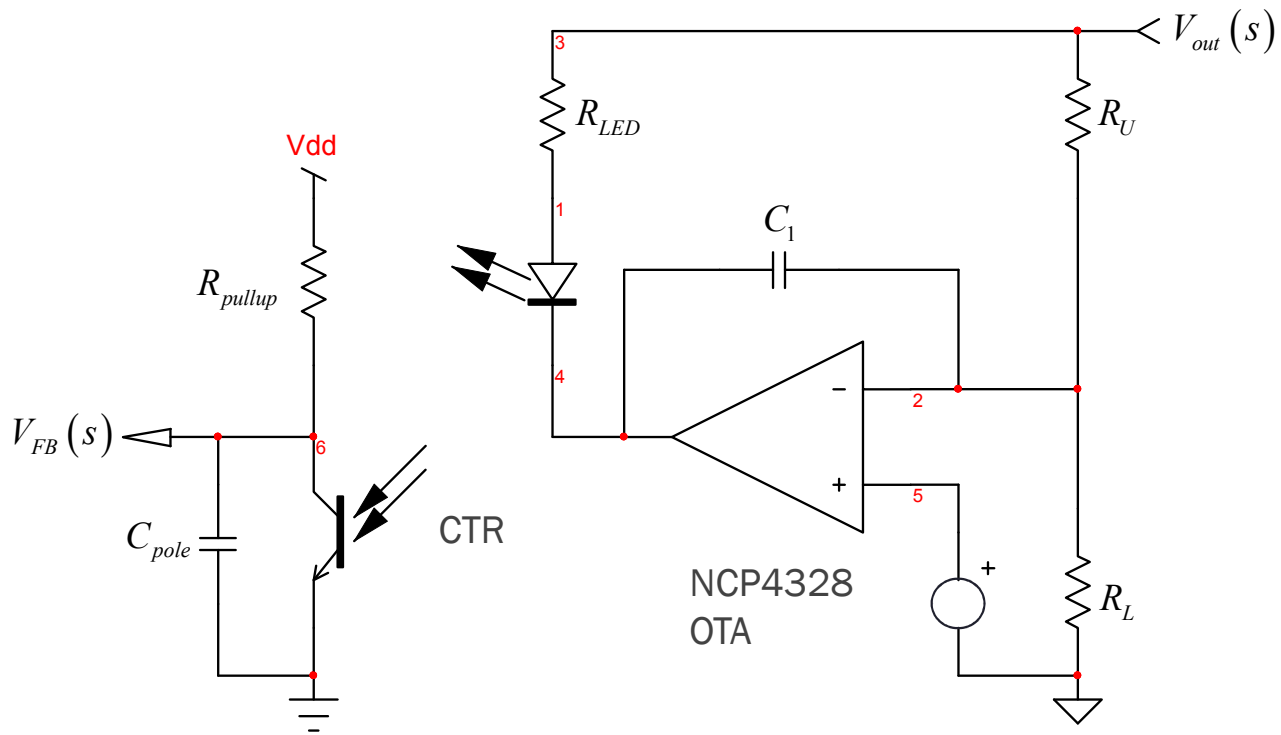
A Type 2 with NCP4352/28

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Application Schematic



For this type 2 compensator (1 pole at the origin, 1 zero and 1 pole), a single capacitor C_1 is necessary. The second capacitor C_{pole} creates the needed pole for rolling off the gain at high frequencies.

$$G(s) = \frac{V_{FB}(s)}{V_{out}(s)}$$

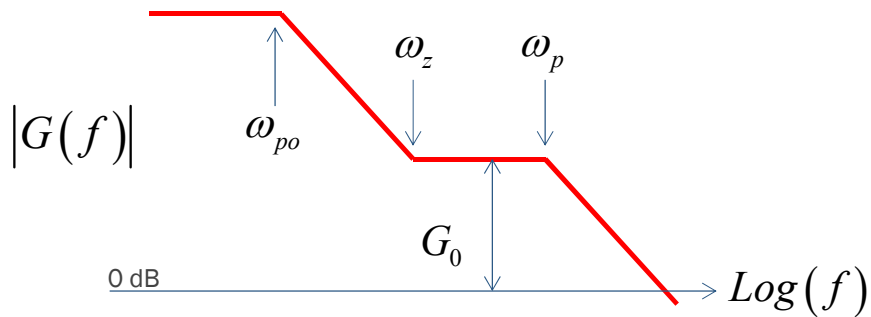
Transfer Function

$$G(s) = -G_0 \frac{1 + \frac{\omega_z}{s}}{1 + \frac{\omega_{po}}{s}} \frac{1}{1 + \frac{s}{\omega_p}}$$

$$G_0 = \frac{CTR \cdot R_{pullup} (R_U + R_L R_U g_m)}{(R_L + R_U + R_L R_U g_m) R_{LED} + R_L R_U}$$

$$\omega_z = \frac{1}{C_1 \left(\frac{R_U + R_L R_U g_m}{R_L g_m} \right)}$$

$$\omega_p = \frac{1}{C_{pole} R_{pullup}} \quad \omega_{po} = \frac{1}{C_1 \left[\frac{R_U (R_{LED} + R_L + R_L R_{LED} g_m) + R_L R_{LED}}{R_U + R_L} \right]}$$



1. Calculate R_{LED} to get G_0
2. Determine the value of C_1 for the zero
3. Determine the value of C_{pole} for the pole

The final value for C_{pole} must account for the optocoupler parasitic capacitance

Determining Components Values

$$R_U = \frac{V_{out} - V_{ref}}{i_{bias}} \quad R_L = \frac{V_{ref}}{i_{bias}} \quad \leftarrow \text{Bias current in the bridge}$$

$$C_1 = \frac{R_L g_m}{2\pi f_z (R_U + R_L R_U g_m)}$$

$$R_{LED} = \frac{R_U (CTR \cdot R_{pullup} - G_0 R_L + CTR \cdot R_L R_{pullup} g_m)}{G_0 (R_L + R_U + R_L R_U g_m)}$$

Make sure the R_{LED} value is adequately selected to allow the proper optocoupler bias.

From IC specs \rightarrow $g_m := 2S$ $R_{pullup} := 20k\Omega$ $CTR := 1$

Type 2 calculations:

$V_{out} := 12V$ $i_{bias} := 250\mu A$ $V_{ref} := 2.5V$

$R_L := \frac{V_{ref}}{i_{bias}} = 10k\Omega$ $R_U := \frac{V_{out} - V_{ref}}{i_{bias}} = 38k\Omega$

Select crossover

Crossover and phase margin selection

$f_c := 1kHz$ $pm := 70^\circ$ $G_{fc} := -20$ $pfc := -70^\circ$

Select phase margin

$G_0 := 10^{\frac{pm - pfc}{20}} = 10$ $boost := pm - (pfc) - 90^\circ = 50^\circ$

$k := \tan\left(\frac{boost}{2} + 45^\circ\right) = 2.747$

$f_z := \frac{f_c}{k} = 363.97Hz$ $f_p := k \cdot f_c = 2.747kHz$

$C_{pole} := \frac{1}{2\pi \cdot f_p \cdot R_{pullup}} = 2.896nF$

$C_1 := \frac{R_L \cdot g_m}{2\pi \cdot f_z (R_U + R_L \cdot R_U \cdot g_m)} = 11.507nF$

$R_{LED} := \frac{R_U (CTR \cdot R_{pullup} - G_0 \cdot R_L + CTR \cdot R_L \cdot R_{pullup} \cdot g_m)}{G_0 (R_L + R_U + R_L \cdot R_U \cdot g_m)} = 1.999 \times 10^3 \Omega$

Data extracted from the plant control-to-output dynamic response:
 G_{fc} is the gain/attenuation at f_c
 pfc is the phase at f_c



SPICE Simulation

parameters

Vout=12V
Ib=100u
Vref=2.5

Rupper=(Vout-Vref)/Ib
Rlower=2.5/Ib
Rpullup=20k
CTR = 1

fc=1k
pm=70
pfc=-70
Gfc=-20
boost=pm-(pfc)-90

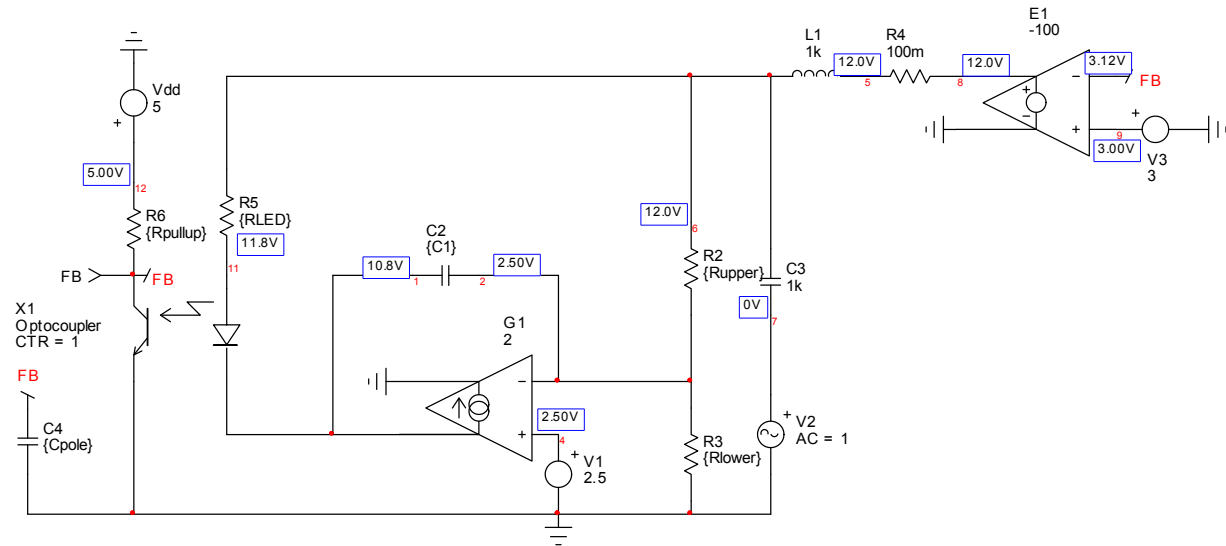
gm=2

$G=10^{(-Gfc/20)}$
pi=3.14159
 $K=\tan((boost/2+45)*\pi/180)$

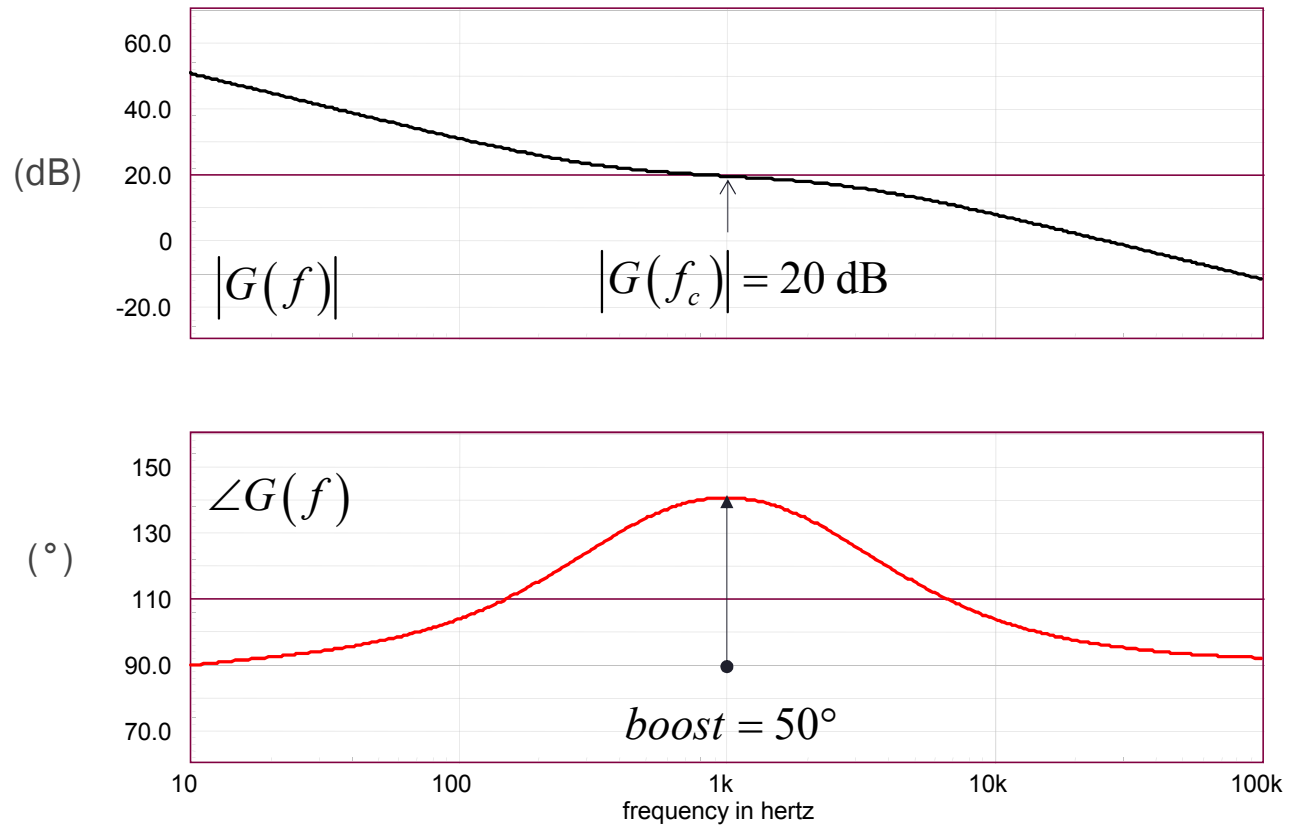
Fzero=fc/k
Fpole=k*fc

$Cpole=1/(2*\pi*Fpole*Rpullup)$
 $C1=Rlower*gm/(2*\pi*fzero*(Rupper+Rlower*Rupper*gm))$

$a=Rupper*(CTR*Rpullup-G*Rlower+CTR*Rlower*Rpullup*gm)$
 $b=G*(Rupper+Rlower+Rlower*Rupper*gm)$
RLED=a/b

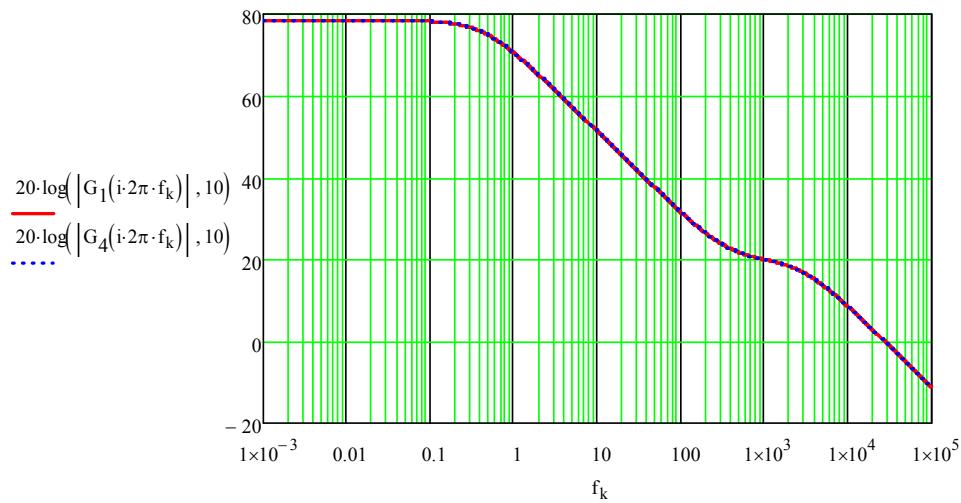


Small-Signal Response of the Compensator



Mathcad® Response

$$|G(f)|$$



$$\angle G(f)$$

