Monolithic Silicon Power Application Note (Op-Amps)

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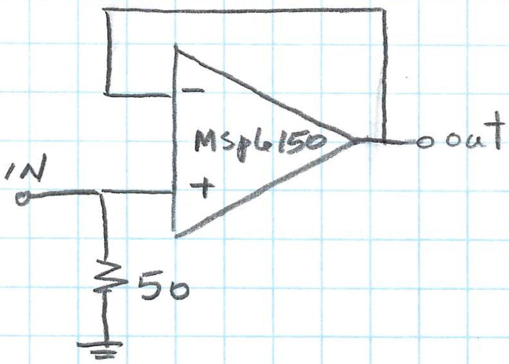
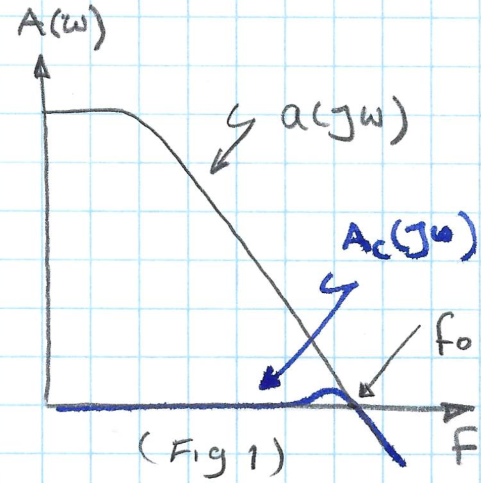
3/5/2021

⇒ How to Calculate The effect of phase Margin on The Peaking of an op-Amp Follower





(Fig 1)

Assume Msp6150 has an open-loop Frequency response shown in Fig. 1

$$A_c(j\omega) = \frac{a(j\omega)}{1+a(j\omega)\beta}$$

β = feedback factor $1/\beta$ = Noise gain

If amplifier is configured as follower, Then $1/\beta = 1$

For any closed-loop gain $|a(j\omega)\beta| = 1$ @ $f = f_o$, if it is follower Then $a(j\omega_o)\beta = 1\angle\theta$ $|a(j\omega)| = 1/\beta$

Therefore we can write: $A_c(j\omega) = \frac{1}{1+1\angle\theta}$

As we can see, at $\omega = \omega_o$ gain will deviate from its nominal Value

$$P = \left|\frac{1}{1+1\angle\theta}\right| = \frac{1}{|1+\cos\theta + j\sin\theta|} \Rightarrow \boxed{\theta = \cos^{-1}\left(\frac{1}{2P^2} - 1\right)}$$

Example: if $P = 1.48\,dB \Rightarrow P = 1.185$

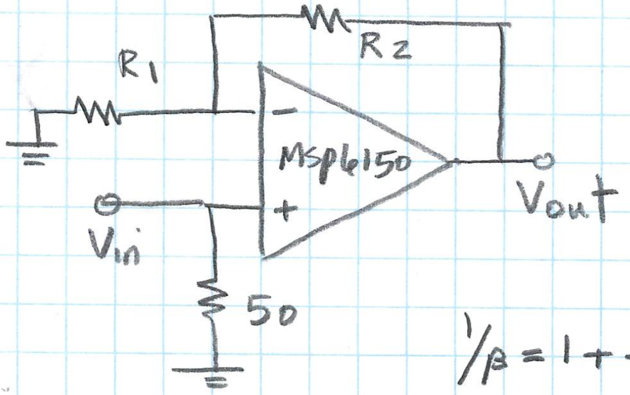
$$\theta = \cos^{-1}\left(\frac{1}{2\times 1.185^2} - 1\right) = 130^\circ \qquad PM = 180 - 130^\circ = 50^\circ$$

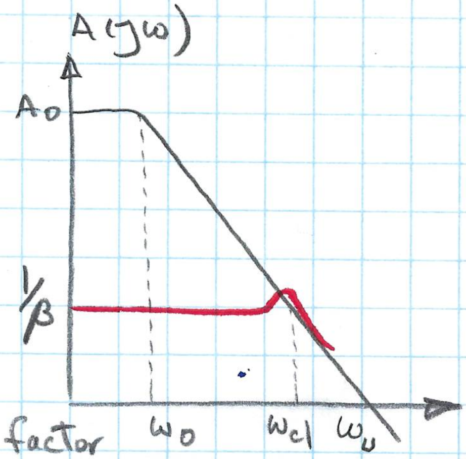
Monolithic Silicon Power — F. Moravej

Application Note 2 (Op-Amp) — 3/5/2021

⇒ How to Calculate gain Peaking at any noise gain

Assume MSP6150 is Configured at any gain





$$1/\beta = 1 + \frac{R_2}{R_1}$$

$$A(j\omega) = \frac{A_o}{1 + j\,\omega/\omega_o}$$

β = Feedback factor

$$A_{cl} = \frac{A(j\omega)}{1 + A(j\omega)\beta} = \frac{\dfrac{A_o}{1 + j\,\omega/\omega_o}}{1 + \dfrac{A_o\beta}{1 + j\,\omega/\omega_o}}$$

$$A_{cl} = \frac{A_o}{1 + j\,\omega/\omega_o + A_o\beta}$$

if $A_o\beta \gg 1$ then

$$A_{cl} = 1/\beta \; \frac{1}{1 + j\,\dfrac{\omega}{\omega_o A_o \beta}}$$

⇒ $\omega_o A_o = \omega_u$ = unity Gain frequency

$$A_{cl} = 1/\beta \cdot \frac{1}{1 + j\,\omega/\omega_{cl}}$$

At $\omega = \omega_{cl}$, closed-loop start to track open-loop

$A(j\omega_{cl})\beta = 1 \Rightarrow |A(j\omega_{cl})| = 1/\beta \Rightarrow A(j\omega_{cl})\beta = 1\angle\theta$

$$A(j\omega_{cl}) = 1/\beta \; \frac{1}{1 + j\angle\theta} \Rightarrow P = \frac{1}{1 + j\angle\theta}$$

$$\theta = \cos^{-1}\left(\frac{1}{2P^2} - 1\right)$$

P = peaking with respect to noise gain

if $PM = 90^\circ$ $\quad P = -3\,dB$