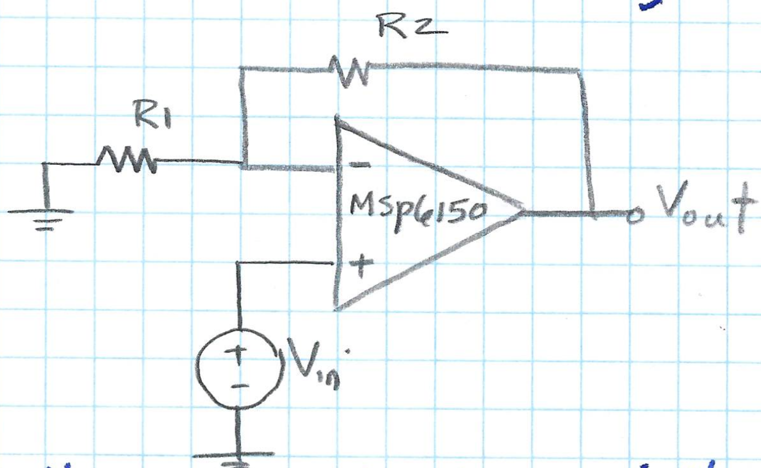
Monolithic Silicon Power F. Moravegi

Application Note 2 (Op-Amps) 3/8/2021

⇒ Noise Gain in Op-Amp

Assume op-amp is configured as non-inverting amplifier



If we apply Feedback Theory to above circuit we can write the following basic equations:

$$A_{cl} = \frac{A}{1+A\beta}$$

A_{cl} = closed-loop Gain

A = open-loop Gain

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

β ⇒ is the feedback factor that shows the portion of feedback signal to the input

$$A_{cl} = \frac{V_{out}}{V_{in}} = \frac{A}{1+A\beta} = \frac{1}{\beta}\,\frac{1}{1/A\beta+1} \quad \text{if } \frac{1}{A\beta} \ll 1 \text{ Then}$$

$$A_{cl} = 1/\beta\left[1-\frac{1}{A\beta}\right] \quad \text{if } A \Rightarrow \infty \text{ The } A_{cl} \simeq 1/\beta \text{ ideal}$$

$1/\beta$ is called Noise Gain

$$\%\text{ Gain Error} = \frac{1/\beta - 1/\beta\left[1-\frac{1}{A\beta}\right]}{1/\beta} \times 100$$

$$\boxed{\%\text{ Gain Error} = \frac{100}{A\beta}}$$

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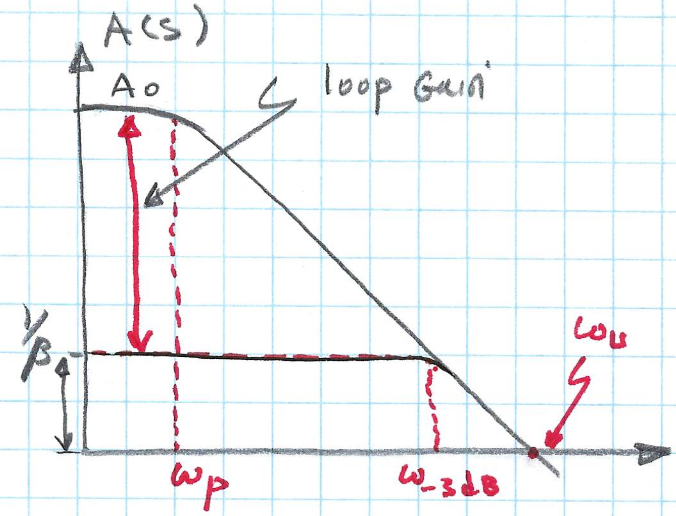
⇒ Assume op-Amp has Single Pole roll off

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



$$A_{cl} = \frac{A(s)}{1 + \beta A(s)} \Rightarrow A_{cl} = \frac{A_o}{1 + A_o\beta + j\,\omega/\omega_p}$$

$$A_{cl} = \frac{A_o}{1 + A_o\beta} \cdot \frac{1}{\left[1 + j\,\frac{\omega}{\omega_p(1 + A_o\beta)}\right]}$$ and if $A_o\beta \gg 1$

$$A_{cl} = \frac{1}{\beta}\,\frac{1}{1 + j\,\omega/\omega_u\beta} = \frac{1}{\beta}\,\frac{1}{1 + j\,\omega/\omega_{-3dB}}$$

$$\omega_{-3dB} = \frac{\omega_u}{1/\beta}$$ $1/\beta$ = Noise Gain = closed-loop Gain

ω_u = op-Amp Unity Gain Frequency = $A_o\,\omega_p$

Therefore: $$\omega_{-3dB} = \frac{\omega_u}{\text{Closed-loop Gain}}$$