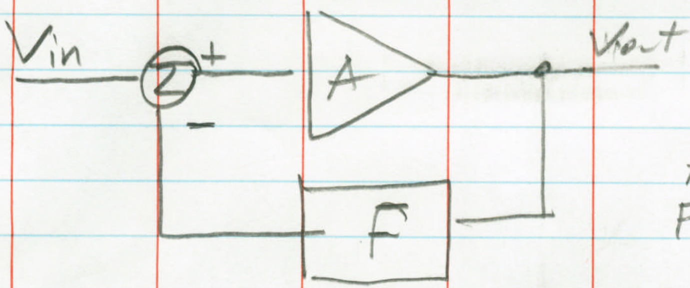
06 June 2013

Basic Idea of Feedback



$A \equiv$ Open loop gain $(A \gg 1)$
$F \equiv$ Fraction of feedback signal $(F < 1)$
Typically $F \ll 1$ and $AF \gg 1$.

$$A(V_{in} + F V_{out}) = V_{out}$$

$$\therefore \quad \frac{V_{out}}{V_{in}} = \frac{A}{1+AF}$$

$$\text{"} \quad \xrightarrow[A \to \infty]{} \quad 1/F$$

Closed loop gain $\equiv G = V_{out}/V_{in}$

$$\therefore \quad G = \frac{A}{1+AF}$$

$$\frac{\partial G}{\partial A} = \frac{(1+AF) - AF}{(1+AF)^2} = \frac{A}{(1+AF)^2}\,\frac{1}{A}$$

$$\frac{\Delta G}{G} = \frac{\cancel{A}}{(1+AF)^{\cancel{2}}}\,\frac{\cancel{(1+AF)}}{\cancel{A}}\,\frac{\Delta A}{A}$$

$$\text{"} = \frac{1}{1+AF}\,\frac{\Delta A}{A}$$

decrease sensitivity to variation in A.

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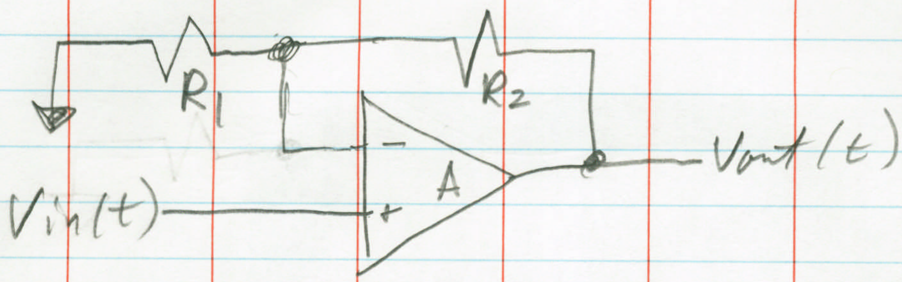
Example of non-inverting voltage amp



(1) $\frac{V_-}{R_1} + \frac{V_- - V_{out}}{R_2} = 0 \Rightarrow V_- = V_{in} - \frac{V_{out}}{A}$

(2) $A(V_{in} - V_-) = V_{out} \Rightarrow V_- = \frac{R_1}{R_1 + R_f} V_{out}$

Now, let $F = \frac{R_1}{R_1 + R_2}$; the divider part

$$V_{out}\left(\frac{R_1}{R_1+R_2} + \frac{1}{A}\right) = V_{in}$$

$V_{out}\left(F + 1/A\right) = V_{in}$ where $F \equiv \frac{R_1}{R_1+R_2}$ from voltage divider

$$G \equiv \frac{V_{out}}{V_{in}} = \frac{A}{1+AF}$$

$$\therefore \quad \frac{\Delta G}{G} = \frac{1}{AF+1}\left(\frac{\Delta A}{A}\right)$$

Suppose: $A = 10^6$, $F = 10^{-2}$, (Closed loop gain $1 + \frac{1}{F} = 101$)

$$\frac{\Delta G}{G} = (10^{-4})\,\frac{\Delta A}{A} \quad !$$

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(3)

Feedback can be used to increase the bandwidth of a system at the expense of gain

$$G = \frac{A}{1+AF} \qquad \text{Suppose } A = \frac{A_0}{1+\omega/\omega_0}$$

Gain as $\omega \to 0$

$$\therefore\ G = \frac{\dfrac{A_0}{1+(\omega/\omega_0)}}{1 + \dfrac{A_0 F}{1+(\omega/\omega_0)}} = \frac{A_0}{A_0 F + 1 + (\omega/\omega_0)}$$

$$\text{"} = \frac{A_0/(1+A_0F)}{1 + \omega/[\omega_0(1+A_0F)]}$$

New gain as $\omega \to 0$ is $\dfrac{A_0}{1+A_0F}$

just as in "DC" case.

New frequency cut-off is $\omega_0(1+A_0F) > \omega_0$

Note that "Gain-bandwidth product" stays constant at $(A_0\,\omega_0)$. This make op-amps useful even as $A(\omega)$ decreases with frequency.