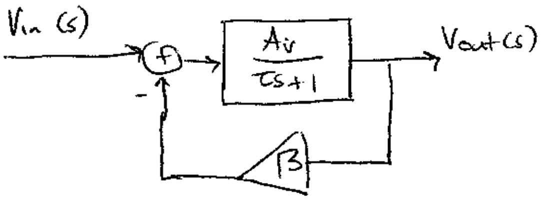
6.003 Recitation, Wed. March 17, 2010, Sections 3 & 4.

Today

1) Gain-bandwidth tradeoffs in feedback loops.
2) Voltage-feedback op-amp example
3) Getting around the trade-off: current-feedback op amps.

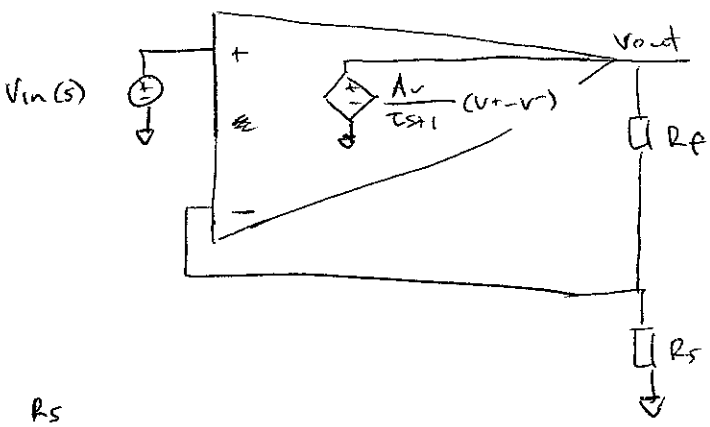
(1)



$$\frac{V_{out}(s)}{V_{in}(s)} = \frac{A_v/(\tau s+1)}{1+\frac{A_v\beta}{\tau s+1}} = \frac{A_v}{\tau s+1+A_v\beta}$$

$$= \frac{\frac{A_v\beta}{1+A_v\beta}}{\frac{\tau s}{1+A_v\beta}+1} \times \frac{1}{\beta}.$$

(2)



$\beta = \frac{R_s}{R_s+R_f}$.

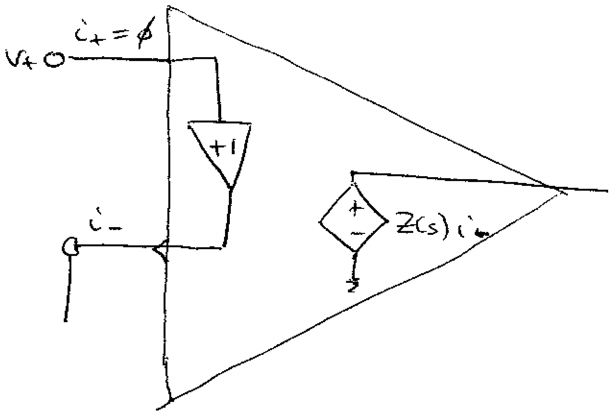
Closed-loop DC gain is then $\frac{1}{\beta} = \frac{R_s+R_f}{R_s}$

Closed-loop bandwidth $= \frac{1}{\tau}\left[A_v\left(\frac{R_s}{R_s+R_f}\right)+1\right]$.

Closed-loop DC Gain × CL Bandwidth $= \frac{A_v}{\tau}$.

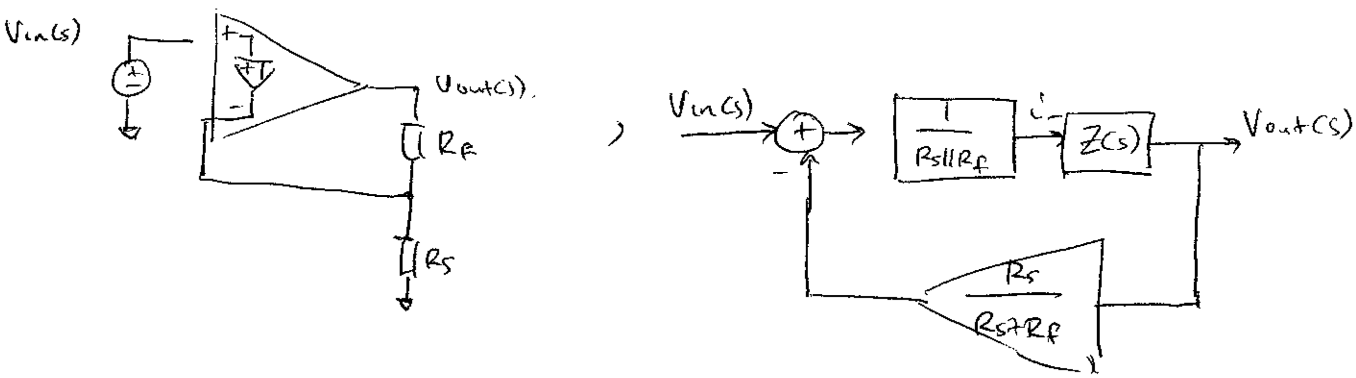
(3) The varying DC loop gain changes as β changes, so B/W changes with β.
What if we could build a 'funky op-amp' that automatically ↑ A_v as β↓, s.t. $A_v\beta$ = const., i.e. adaptive loop gain

Current-feedback operational amplifier



$$Z(s) = \frac{1}{G_o + C_o s} = \frac{Z_o}{\tau_o s + 1}$$

$$Z_o = \frac{1}{G_o}, \quad \tau_o = \frac{C_o}{G_o}.$$



$$\text{Loop transmission} = \frac{Z(s)}{R_s \| R_f} \times \frac{R_s}{R_s + R_f} = \frac{Z(s)}{R_f}.$$

$\Rightarrow$ Closed-loop bandwidth is constant if R_f is constant & indep. of R_s.

Then you pick R_s to set closed-loop D.C. gain at $\frac{R_s + R_f}{R_f}$.