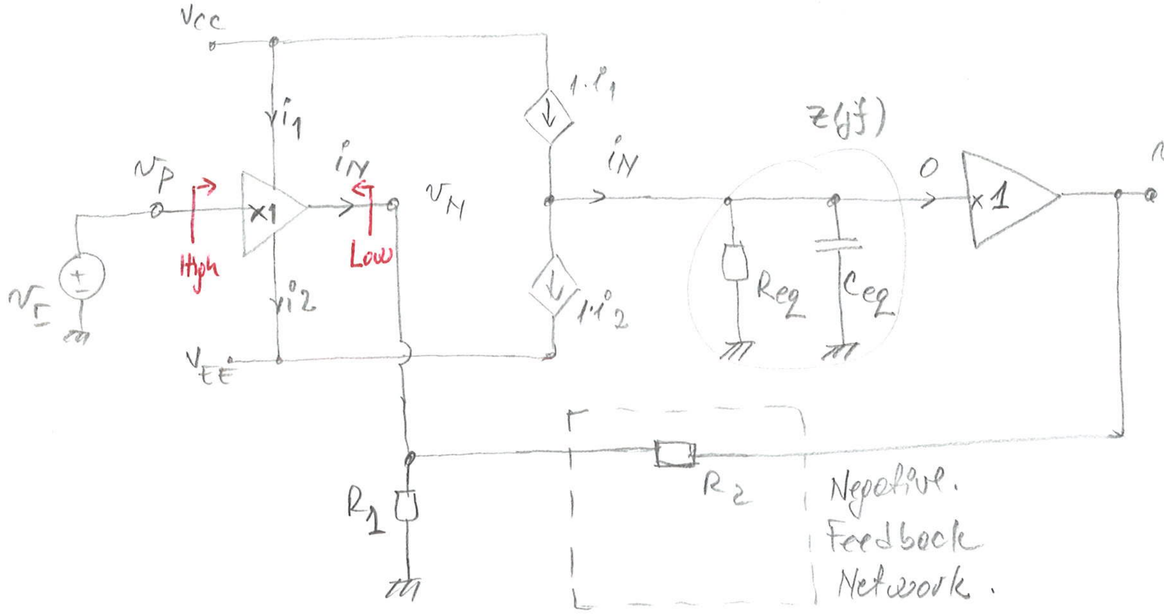
6.7. Current feedback amplifiers

current-mode operation = much faster.



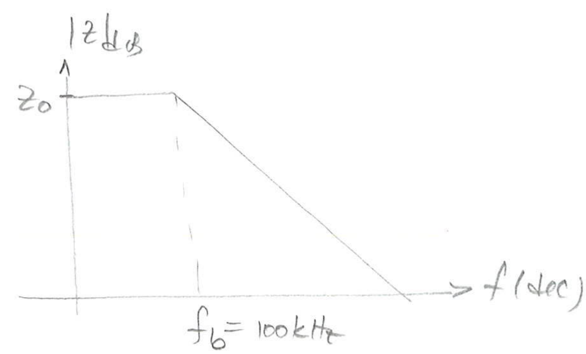
Obs: Couto application examples!

$i_N = i_1 - i_2$

(1) $V_O = Z(jf) \cdot I_n$ ← by construction

↑ open-loop transimpedance gain.

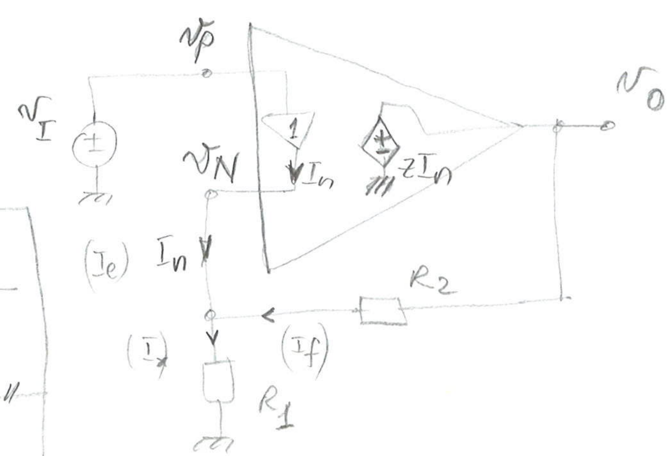
(2) $Z(jf) = \dfrac{z_0}{1 + j\, f/f_b}$, $z_0 = R_{eq}$, $f_b = \dfrac{1}{2\pi R_{eq} C_{eq}}$



Closed-loop gain

superposition

(3) $I_n = \dfrac{V_i}{R_1 \| R_2} - \dfrac{V_o}{R_2}$ ← due to feedback



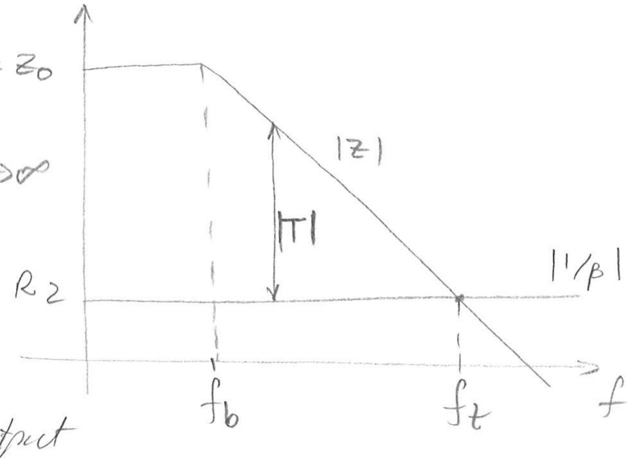
(1),(3) ⇒ $A(jf) = \dfrac{V_o}{V_i} = \left(1 + \dfrac{R_2}{R_1}\right) \dfrac{1}{1 + \dfrac{1}{T(jf)}}$

where $T(jf) = Z(jf) \cdot \dfrac{1}{R_2} = Z(jf) \cdot \beta_g$

$T(jf) \triangleq$ loop gain

To maximize $T \Rightarrow$ increase $z(jf) \to \infty$

(1)
$\Rightarrow I_n$ will be very small $\to 0$



$\Rightarrow$ CFA will provide whatever output necessary to drive I_n to zero.

Conclusion:

		CFA	VFA
input voltage constraint	$V_n \to V_p$	by design	by neg. feedback
input current constraint	$I_p \to 0$, $I_n \to 0$	by negative feedback.	by design

We can apply these constraints during CFA-based circuits as well!

CFA Dynamics – Bandwidth

closed loop gain.

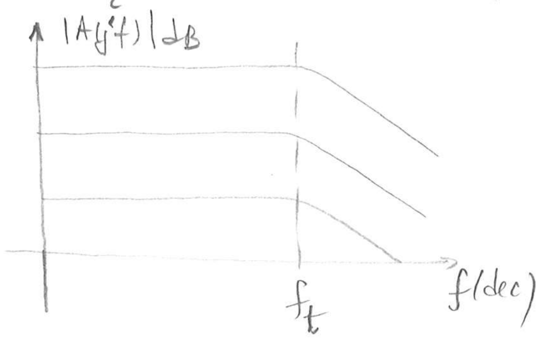
$$A(jf) = A_0 \times \frac{1}{1 + j\, f/f_t} = \left(1 + \frac{R_2}{R_1}\right) \cdot \frac{1}{1 + j\, f/f_t}$$

$$f_t = \frac{1}{2\pi R_2 C_{eq}}$$

bandwidth, depends only on R_2!

100MHz typically

Use R_2 to set bandwidth and use R_1 to adjust A_0!



Transient response

$v_I = V_{im} \cdot u(t) \Rightarrow i_N = \frac{V_{im}}{R_1 \| R_2} - \frac{v_O}{R_2}$

Also: $i_N = \frac{v_O}{R_{eq}} + C_{eq} \frac{dv_O}{dt}$ $\Rightarrow R_2 C_{eq} \frac{dv_O}{dt} + v_O = A_0 \cdot V_{im}$

$$v_O(t) = A_0 \cdot V_{im} \left[1 - e^{-\frac{t}{\tau}}\right] \cdot u(t)$$

$\tau = R_2 C_{eq}$ depends on R_2!

Compare to eq. (6.25b)

$\tau = \frac{1}{2\pi f_t}$, $f_t = \frac{g_{m1}}{2\pi C_c}$

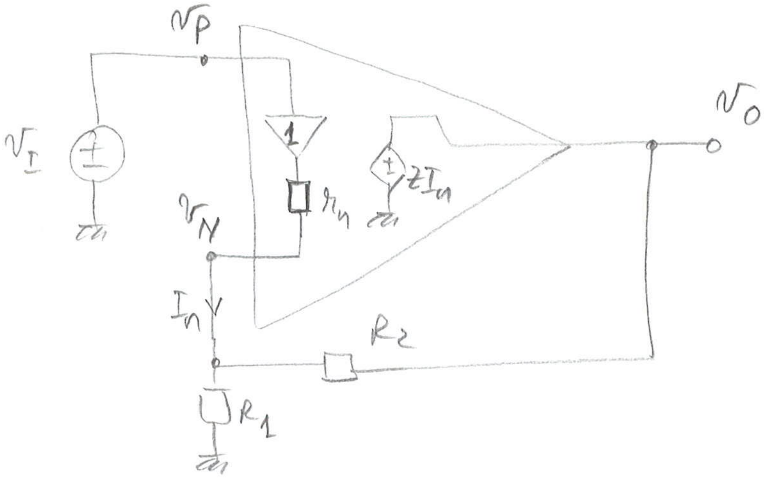
Example:

Advantages of CFA's:

$R_2 = 1.5k \Rightarrow \tau \cong 1ns$ (Contrast to 159ns of μA741)

Rise time $t_R = 2.2\tau \cong 2.2ns$ ($t_R = 350ns$ for μA741)

Second order effects



Disadvantages of CFA:

- ⊖ poorer V_{OS}, I_N, I_P characteristics!
- ⊖ Noisier because larger bandwidths!

Suitable for fast but moderately accurate applications

$$I_n = \frac{V_i}{r_n + R_1 \| R_2} - \beta' V_O$$

$$\beta' = \frac{R_1}{r_n + R_1} \times \frac{1}{R_2 + (r_n \| R_1)} = \frac{1}{R_2 + r_n\left(1 + \frac{R_2}{R_1}\right)}$$

Shift $|1/\beta|$ upwards

⇓

bandwidth is actually smaller!