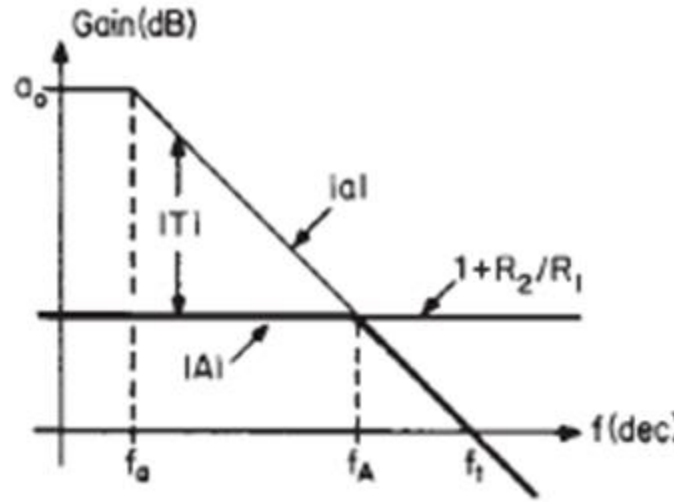
CFA1

[AN-NS92]

Conventional opamps: gain bandwidth trade-off and slew rate limitation

$$a(jf) = \frac{a_o}{1 + j(f/f_a)}$$



- For most opamp
- then $$A(jf) = \frac{1 + R_2/R_1}{1 + j(f/f_A)}$$

  with $$f_A = \frac{f_t}{1 + R_2/R_1}$$

with (GBP is constant) $f_t = a_0 f_a$

- Slew rate limitation:

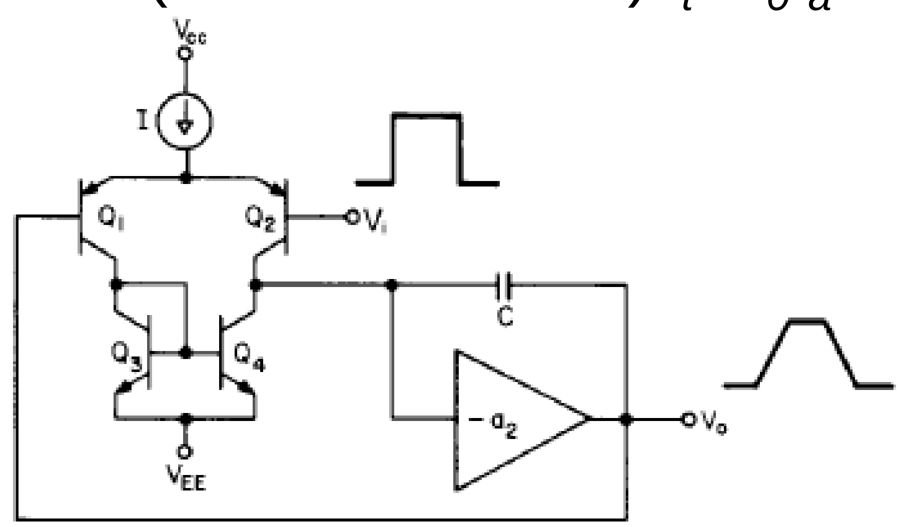


Fig. 3: Simplified slew-rate model of a conventional op amp.

CFA

Current manipulation is inherently faster than voltage manipulation

- effects of stray inductances in a circuit are usually less severe than those of its stray capacitances
- BJTs can switch currents much more rapidly than voltages

The output of the amplifier must be a voltage -> a high-speed voltage-mode operation must be provided

- gain configurations inherently immune from Miller effect
  - e.g. common-collector and cascode configurations

CFA

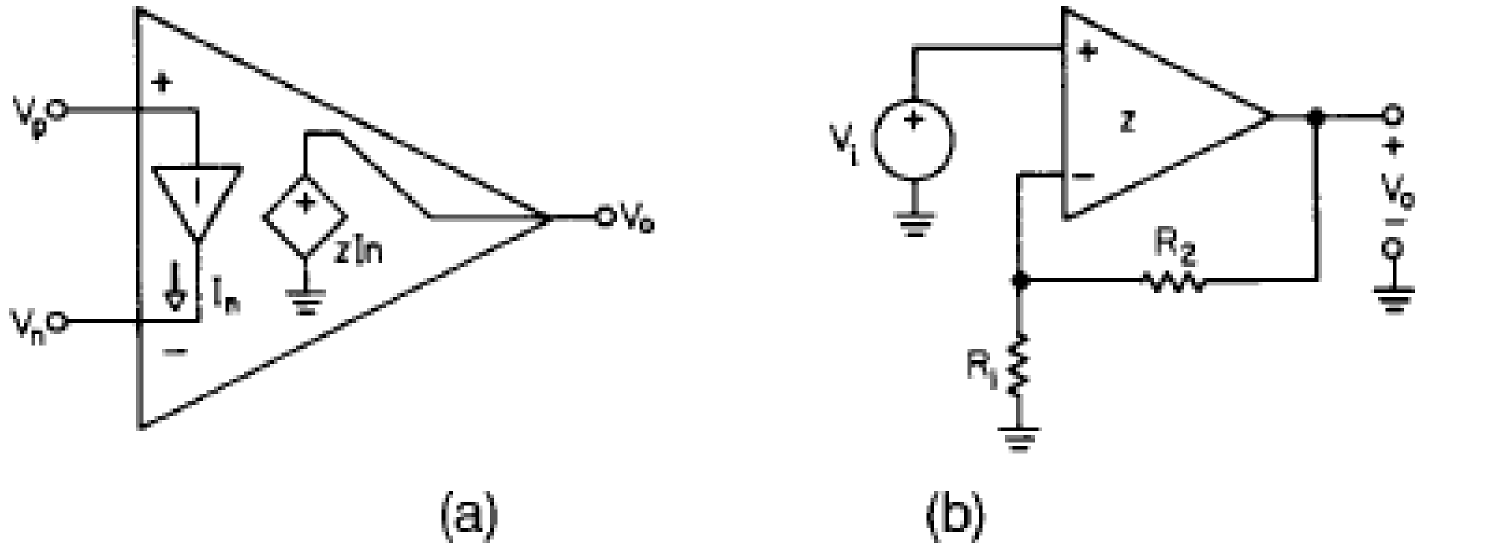


Fig. 4: Circuit model of the current-feedback amplifier, and connection as a noninverting amplifier.

$$V_o = z(jf)\,I_n$$

- $V_n = V_p$ is set by the buffer input circuit
- $I_n = 0$ is given by the negative feedback
  - just the opposite wrt VFB opamp!
- A_v here is the same, $1 + R_2 / R_1$

Block diagram of a CFA

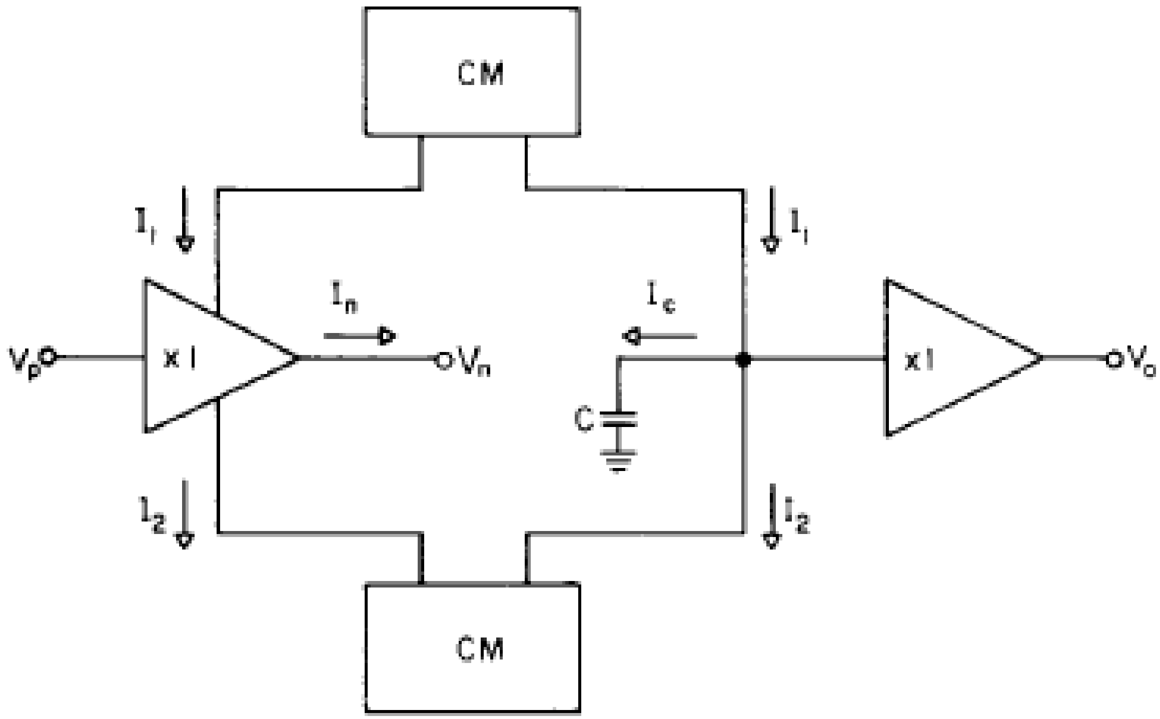
$I_p=0$ as in any opamp

$I_n=I_1-I_2$

CM: current mirror

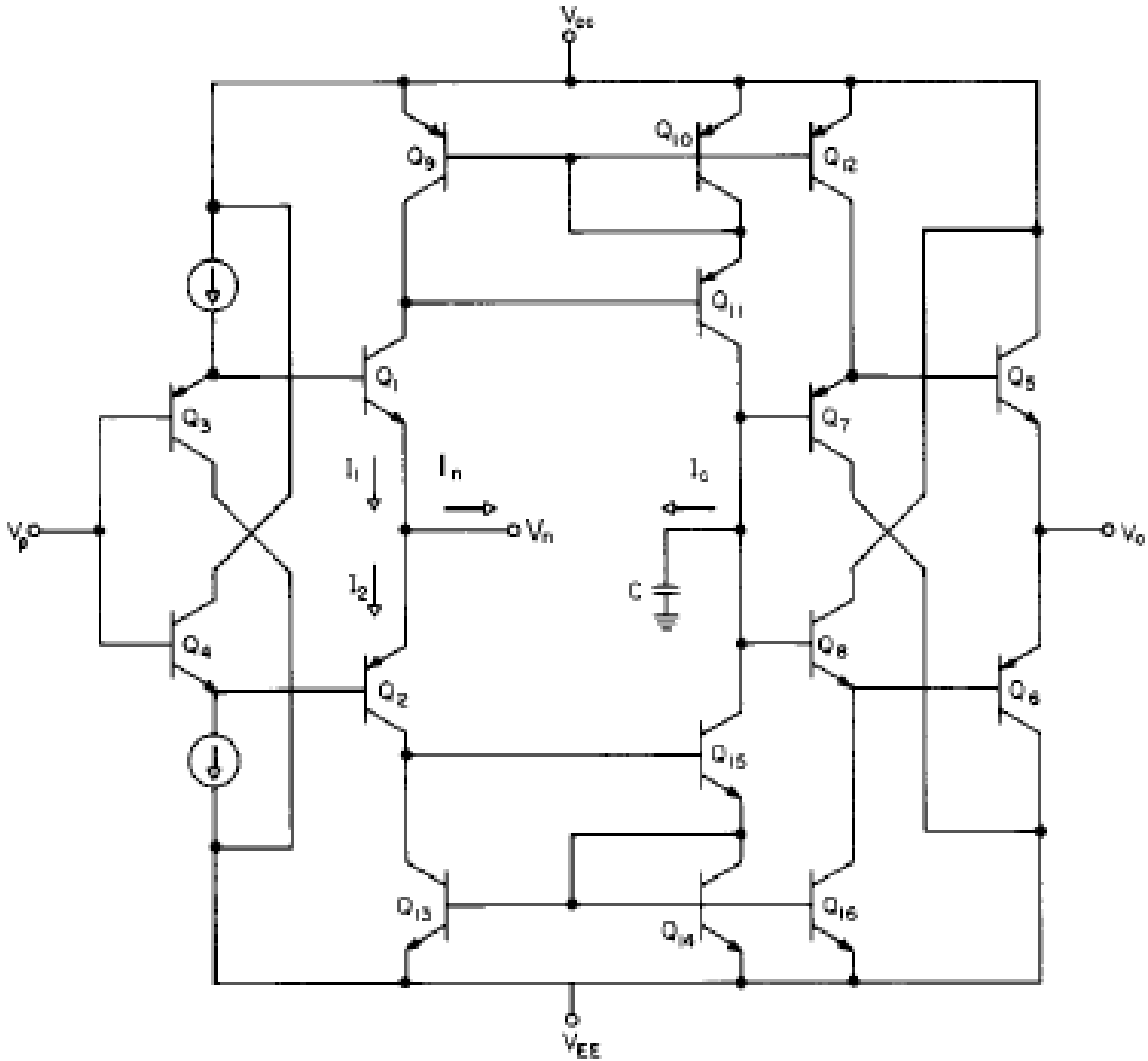
$I_c=I_1-I_2=I_n$

$V_o=I_c Z_C=I_n Z_C$



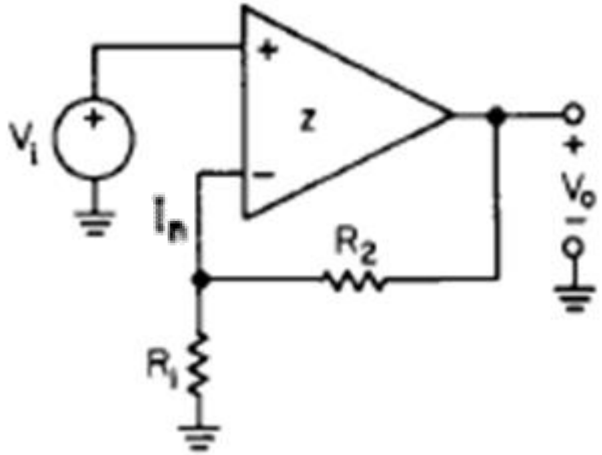
(b)

- Simplified schematics of a CFA



- It may be found that $T(jf) = \dfrac{z(jf)}{R_2}$
- and, using superposition, that

$$A(jf) \triangleq \frac{V_o}{V_i} = \left(1 + \frac{R_2}{R_1}\right)\frac{1}{1 + 1/T(jf)}$$



The cutoff frequency for *A(jf)*

- is where $|T(jf)|=1$ (as in VFB opamps)
- but depends on R_2 only!

$$f_A = \frac{z_o f_a}{R_2}$$

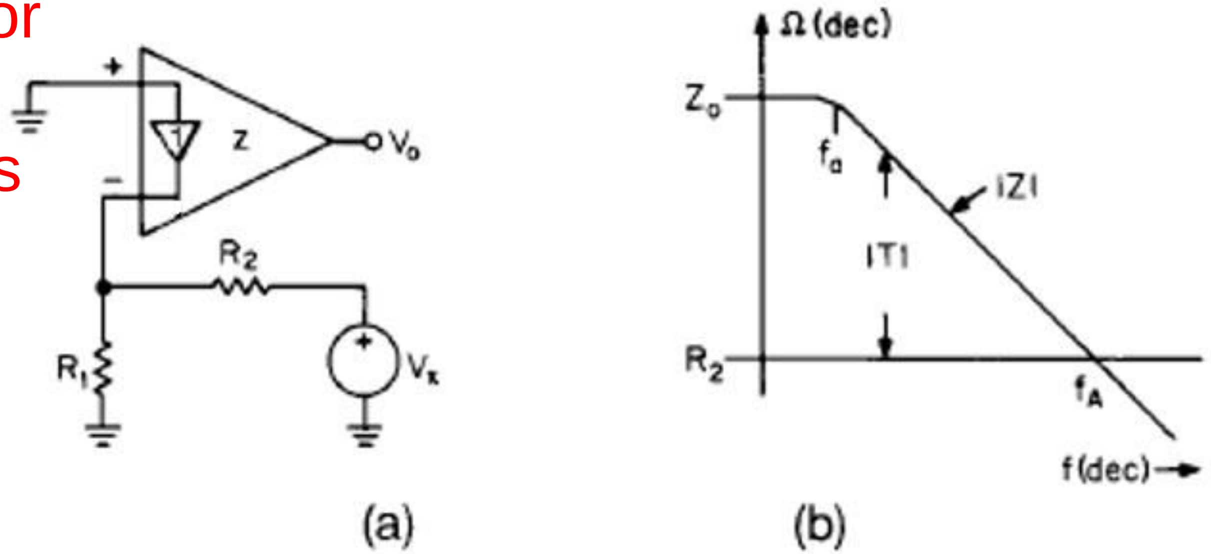


Fig. 6: Test circuit to find the loop gain, and graphical method to determine the closed-loop bandwidth f_A.

No gain-bandwidth trade-off

- (useful e.g. for automatic gain control)

$$z(jf) = \frac{z_o}{1 + j(f/f_a)}$$

$$A(jf) = \frac{1 + R_2/R_1}{1 + j(f/f_A)}$$

$$f_A = \frac{z_o f_a}{R_2}$$

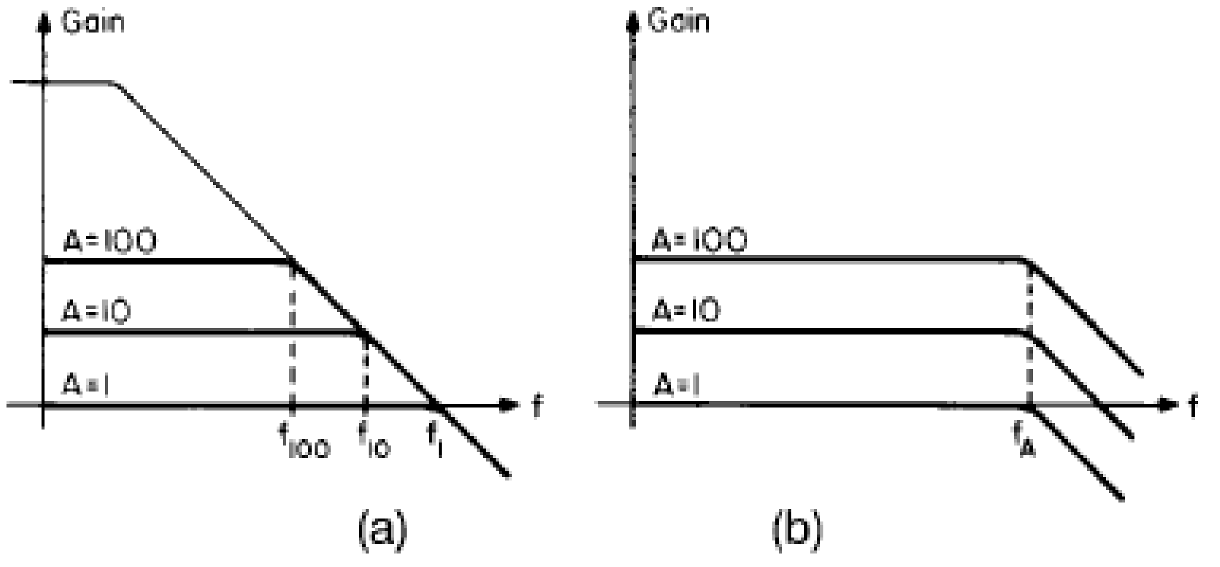


Fig. 7: Comparing the gain-bandwidth relationship of conventional op amps and current-feedback amplifiers.

No slew rate limitation

- From $$I_n = \frac{V_i}{R_1 \| R_2} - \frac{V_o}{R_2}$$
- an input step V_i gives an initial current $I_n = \Delta V_i / (R_1 \| R_2)$
- The *initial* rate of charge of C is $I_c / C = I_n / C =$

$$\Delta V_i / [(R_1 \| R_2)C] = [\Delta V_i (1 + R_2/R_1)] / (R_2 C) = \Delta V_o / (R_2 C)$$

- i.e. an exponential with $\tau = R_2 C$
  - current available to charge C is proportional to the step regardless of its size