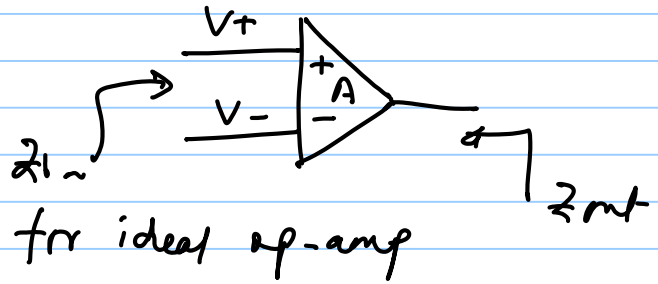
EE2019 Analog systems & Lab

Note Title 2/4/2020

Properties of operational Amplifier



for ideal op-amp

- $Z_{in} = \infty$
- $Z_{out} = 0$
- $A = \infty$

when connected in negative feedback

$V_+ = V_-$ (virtual short) → no offset

Bandwidth = ∞

For non-ideal op-amp

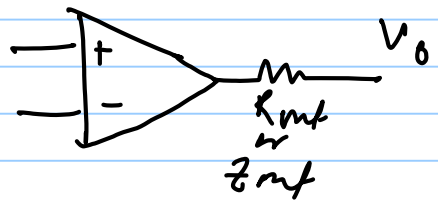
$A \neq \infty$ (> 60 dB)

Bandwidth is limited (order of MHz)
(Wrgb → unity gain BW)

$Z_{in} = \infty$ for MOSFET based

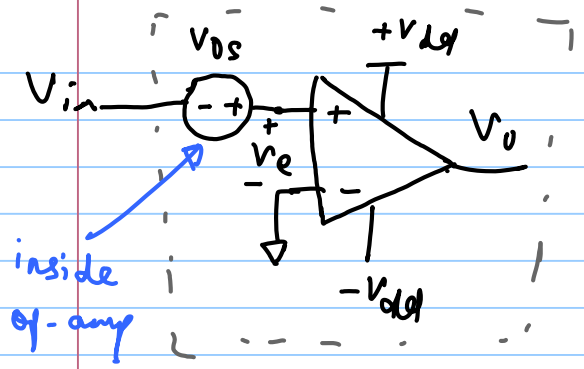
$Z_{in} \neq \infty$ (order of MΩ) for BJTs

$Z_{out} \neq \infty$ (low for resistive loads)

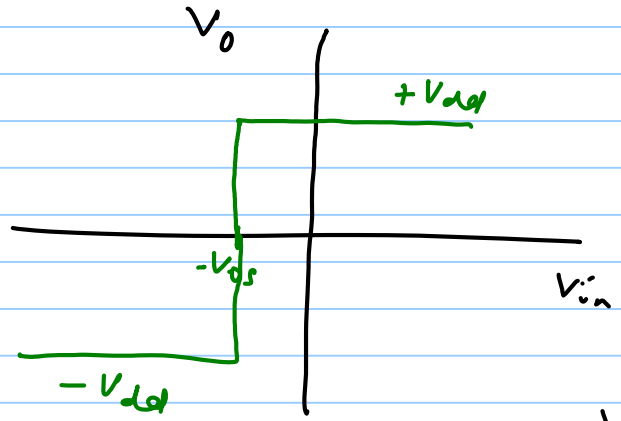


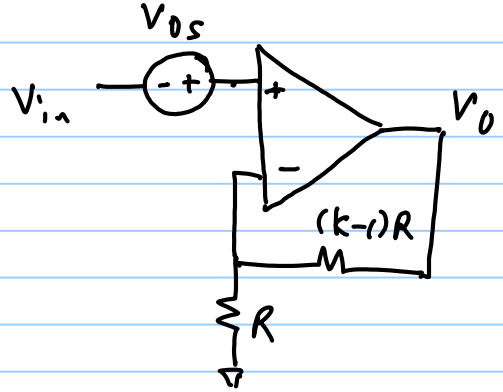
when connected in negative feedback

$V_+ = V_-$ if no offset. $V_+ \neq V_-$ if there is an offset

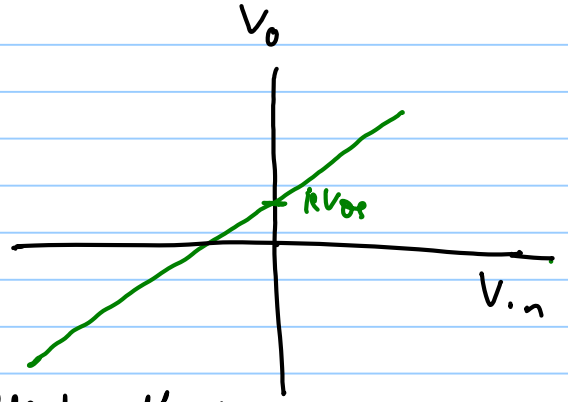


$$V_e = V_{in} + V_{os}$$



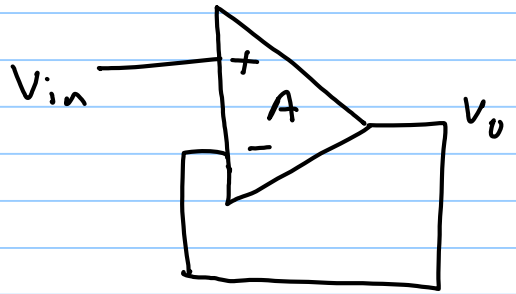


$$V_o = K V_{os}$$



input referred offset

$V_{os} = V_o / K$ when $V_{in} = 0$



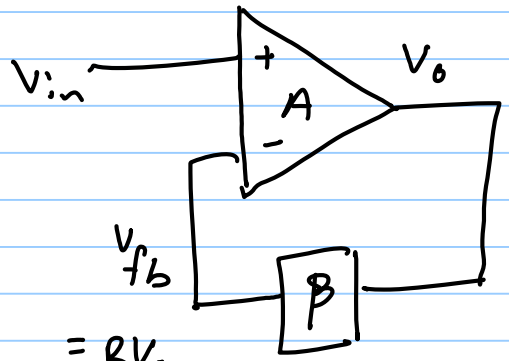
$$V_o = \frac{A}{1+A} V_{in}$$

$$A = 100$$

$$V_o = \frac{100}{101} V_{in} \simeq -1\% \text{ error}$$

Error due to finite gain

$$V_{o\text{-}err} = V_o - V_{in} = -V_{in}\left(1 - \frac{A}{1+A}\right) = -\frac{1}{1+A}$$



$= \beta V_o$

$\beta = \frac{1}{k}$

$$V_o = (V_{in} - V_{fb})\,A$$

$$V_{fb} = \beta V_o$$

$$V_o = (V_{in} - \beta V_o)\,A = A V_{in} - A\beta V_o$$

$$A V_{in} = V_o(1 + A\beta) \Rightarrow V_o = \frac{A}{1 + A\beta} V_{in}$$

$$V_{o\text{-}error} = \frac{A}{1 + A\beta} V_{in} - \frac{V_{in}}{\beta} = V_{in} \frac{A\beta - 1 - A\beta}{(1 + A\beta)\beta} = \frac{1}{\beta}\left(\frac{1}{1 + A\beta}\right)$$

Op-amp has two sources of error.

1. finite gain
2. offset

Biasing of Signals