EE 240B – Spring 2018

Advanced Analog Integrated Circuits

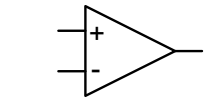
Lecture 7: Operational Transconductance Amplifiers (I)

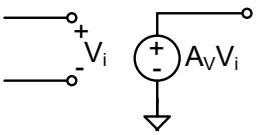
Elad Alon

Dept. of EECS

OpAmps and OTAs

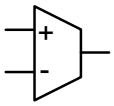
OpAmp

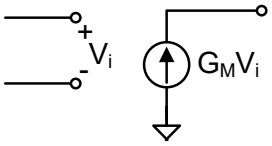




- High voltage gain, high input impedance
- Voltage source output (low impedance)

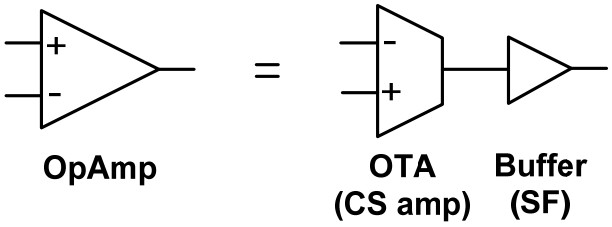
OTA



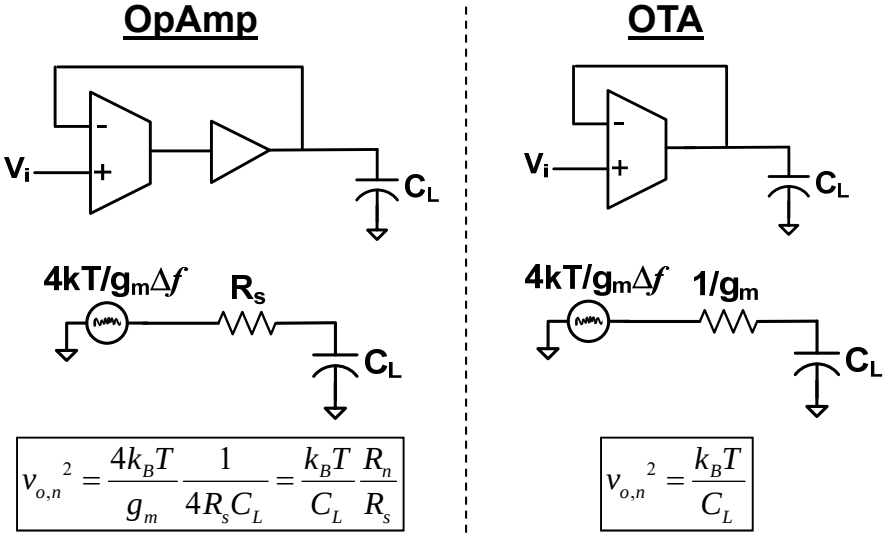


- High "voltage" gain, high input impedance
- Current source output (high impedance)

Opamp & OTA in CMOS



Opamp vs. OTA Noise

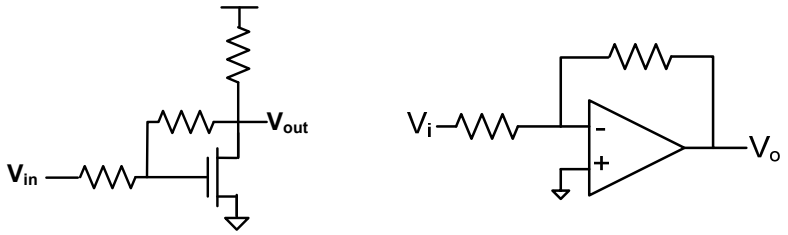


$$v_{o,n}^{\,2} = \frac{4k_BT}{g_m}\frac{1}{4R_sC_L} = \frac{k_BT}{C_L}\frac{R_n}{R_s}$$

$$v_{o,n}^{\,2} = \frac{k_BT}{C_L}$$

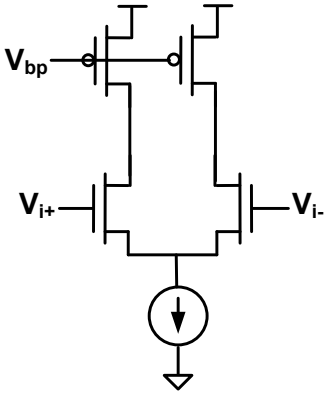
Simplest Single-Ended OTA

Differential Input?

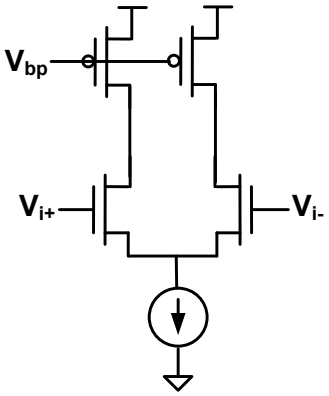


- Why use a differential input?
  - Diff. version has extra device(s) – more power, noise, etc.
- Real reason is systematic offset
  - All voltages are relative
- If used a differential input, often might as well use differential output too…

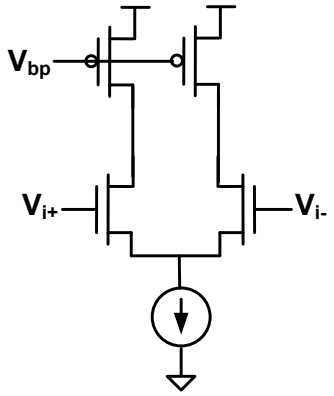
Simple Diff. Input OTA



Simple Diff. Input OTA: Noise (1)



Simple Diff. Input OTA: Noise (2)



Simple Diff. Input OTA: Noise (2)

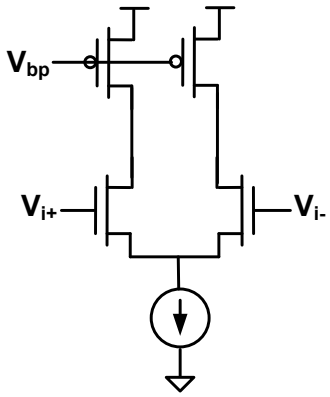
More Careful Look at Noise…

More Careful Look at Noise…

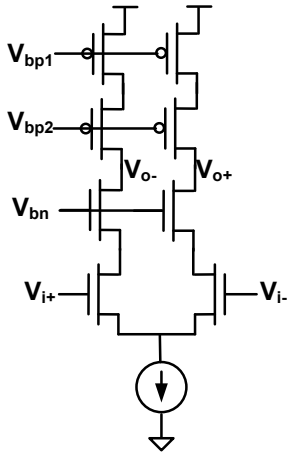
Real R vs. Current Source (1)

Real R vs. Current Source (2)

Limitations of Simple OTA

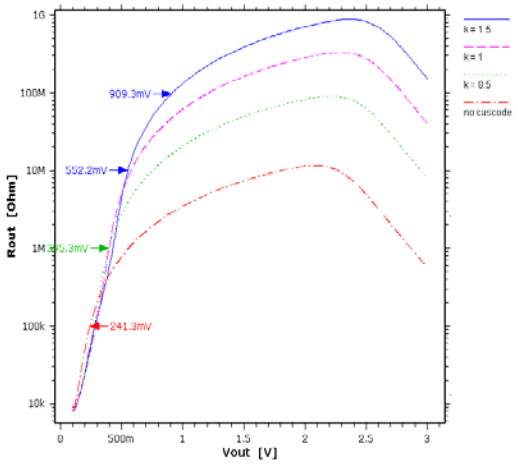


Telescopic Cascoded OTA



Why Cascoding Helps

Cascode Sizing for r_o



Cascode Noise?

Cascode Noise?

More Complete Analysis

More Complete Analysis

Cascode Sizing