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 = OTA (CS amp) + Buffer (SF)

Opamp vs. OTA Noise

OpAmp: $V_{o,n}^2 = \frac{4k_B T}{g_m} \frac{1}{4R_s C_L} \frac{k_B T}{R_n} \frac{R_n}{C_L R_s}$

OTA: $V_{o,n}^2 = \frac{k_B T}{g_m} \frac{1}{C_L}$
**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)
More Careful Look at Noise…
Limitations of Simple OTA

Telescopic Cascoded OTA
Why Cascoding Helps

Cascode Sizing for $r_0$
Cascode Noise?
Cascode Sizing