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)
Resistive Feedback

- Open-loop gain: $\infty$
- (Independent of $R_f$)
- Open-loop gain: $G_m R_f$
  - Feedback loads the OTA
  - How about large $R_f$?
    - Lots of area, parasitic poles
    - Need a different solution…

How about Capacitive Feedback?

- At low frequency:
  - No loading from feedback network ($|Z_f| = \infty$)
- Gain drops at high frequency
  - But this happens in all amplifiers
- Does this really work?
  - Hint: what happens if you simulate this in SPICE?
Capacitive Feedback cont’d

\[ V_i \rightarrow V_x \rightarrow V_o \]

- Charge on \( v_x \) is undefined – needs to be reset to known value
- Can we just do this once at start-up?
  - Depends how long you want to use the amplifier...
- Usually do this “reset” every cycle
  - Why each cycle instead of only once every \( N \) cycles?

Switched-Capacitor Gain Stage

\[ V_i \rightarrow \phi_1 \rightarrow C_s \rightarrow \phi_2 \rightarrow V_o \]

- Many possible topologies – one example shown here
- Clocks generally non-overlapping
SC Gain Stage Phases

- Phase 1:

- Phase 2:

\[
V_o/V_i = \frac{V_o}{V_i}
\]

SC Gain Stage Waveforms
Opamp vs. OTA Revisited

\[ \text{OpAmp} \quad = \quad \text{OTA (CS amp)} \quad \text{Buffer (SF)} \]

Opamp vs. OTA Noise

\[ V_{o,n}^2 = \frac{4kT}{g_m \Delta f} + \frac{1}{4R_s C_L} - \frac{k_B T}{C_L} R_n \]

\[ V_{o,n}^2 = \frac{k_B T}{C_L} \]

\[ \frac{4kT}{g_m \Delta f} \]
SC Gain Stage Noise