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 \( R_f \))

Capacitive Feedback cont’d

- 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

- Many possible topologies – one example shown here
- Clocks generally non-overlapping

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?
**SC Gain Stage Phases**

- Phase 1:
  \[ V_i \rightarrow C_i \rightarrow V_o \]
- Phase 2:
  \[ V_o/V_i = \]

**Opamp vs. OTA Noise**

**OpAmp**

\[ 4kT/g_m \Delta y \]

**OTA**

\[ 4kT/g_m \Delta y / C_L \]

\[ V_{n,p}^2 = \frac{4kT}{g_m} \frac{1}{4R_C R} = \frac{kT}{C} \]

**SC Gain Stage Waveforms**

**SC Gain Stage Noise**

**Opamp vs. OTA Revisited**

OpAmp  =  OTA (CS amp)  Buffer (SF)