Project 2nd presentation Dec 23 R, 4, 6 Apple lecture, me

Final paper RPR week
Driving output to ground
Charge injection
Strong ARM

PGA: 

- Drive output to ground: \( < 2 \) LSB
- Amplify accurately \([0, 1]\), or \( < 1 \) LSB

See note W12-L2 p 3 & 4

Charge injection:

- \( V = 0, V_{\text{d}} \)

\[ Q_{\text{ch}} = (V_{\text{d}} - V_{\text{t}}) C_{\text{ox}} \]

Fast falling edge: assume \( \frac{1}{2} Q_{\text{ch}} \) sees \( \frac{1}{2} \)

Slow falling edge: channel charge equal to source

\[ Q_{\text{ch}} = V_{\text{t}} C_{\text{ox}} W \]

Channel source at \( V_{\text{t}} \)
Say \( C_{OE} = 1 \text{ pF} \), \( W = 1 \text{ mm} \), \( C_2 = 1 \text{ pF} 

\[ V_0 = V_{-} = V_{\text{in}} C_1 \]
\[ + V_{-} C_{\text{in}} \]
\[ + (V_{-} - V_0) C_2 \] \( = 0 \)
\[-V_0 \text{ mV} \]

Choose minimum \( C_2 = 4 \text{ pF} \), say \( V_2 \) device

\[ V_0 = \frac{C_2}{C_2 + 1 \text{ pF}} \cdot \frac{1 \text{ pF}}{4 \text{ pF}} \cdot (0.6 \text{ V}) \]

150 mV error!

Many clever ways to improve

Simplest is to make \( C_2 \gg C_{OE} \)

If \( C_2 = 100 \text{ pF} \), error = 6 mV

Make switch small, \( C_2 \) big ⇒ slow response

ADC comparator
Fine to use op-amp

Compare \( V_0 \) with \( V_{\text{ref}} \)

\( \Rightarrow \) NMOS input

Like \( V_{\text{in}} < 2 \times \text{LSB} \) to create clear \( Q_1 \) output

\( Av = 1000 \) or more useful

Wall divided output

Size appropriately

What about other switches?

\[ V_5, S_1 \]

\[ V_5, S_2 \]

\[ S_3 \]

If \( S_1 \) turns off before \( S_2 \) ⇒ problem

\( Q_1 \) gets extra charge

Delay \( S_1 \) rel \( S_2 \): \( P_1 \) delay = \( \frac{1}{S_2} \) \( S_1 \)

\( C_2 \) injection affects \( ADC \)
Strong ARM latch
- clocked comparator
- faster, lower power than op-amp-based
- easy to trim input offset.
Core element: cross-coupled inverters

RHP real pole

Phase 1, CK=0

Phase 2, CK=1

Say $V_+ > V_-$

$I_{OH} > I_{OH}$

$2L$ turns on
$2L$ turns off
3R on keeps 3L off
2R on 2L off

Strombahn Switches feed - order side delay
rail-to-rail output
Can auto-trim all boot
- add small capacitors of both

P and Q

Format: 1000+times3, if balanced results

Keep copulas

Add external burst to locally to keep

C = CQ