Lecture 10: High Swing Current Sources

• Announcements:
  - HW#3 due today
  - HW#4 online
  - Lab#2 online
  - Monday Labs: due to holiday next week, shift to the following Monday
  - Monday Lab#1’s are due in the 140 Box on Tuesday next week
  - No lecture during our regular time on Thursday
  - Make-up lecture still TBA ... either Thursday evening or Friday sometime, I hope

• Lecture Topics:
  - Output Swing (Headroom)
  - High Swing Current Sources
  - Current Source Matching Considerations

• Last Time:
  - Reviewed current sources using prepared lecture material
  - Finished with Widlar current sources

\[
I_D = \frac{1}{2}\mu C_{ox} \frac{W}{L} (V_{GS} - V_{T})^2 \quad U_{Dsat} = U_{DV} = V_{DD} \quad V_{O(v)} = \frac{2I_D}{\mu C_{ox} \frac{W}{L}} = V_{OV}
\]
The min. voltage that still keeps $I_1$ as a good current source (i.e., $R_o$ is large)

$$V_{omin} = V_{dsat} - V_{ov1}$$

The output swing:

$$V_{oswing} = V_{DD} - V_{ov1} - V_{ov2}$$

Noises:

- Maximum output signal
- Minimum input signal
- Determined by output swing
- Determined by noise?

Dynamic Range = DR

Novel:

What about better current source, like the Cascode current source?

Ex. Cell Phone

- Power
- Desired signal
- Very close to you
- Higher $R_o$

How can we guarantee these?
High Swing Current Sources

\[ V_{\text{in}} = V_t + 2V_{\text{ov}} \]

This is a lot in a 2V supply! With enough lots of digital, could have \( V_{\text{dd}} = 1V \), but not permissible in 1V technology (or arguably, 2V+).

**Solution**: High Swing Cascade (van der Pauw).

Basic idea: level-shift down to reduce \( V_{\text{dd}} \).

In the above, assumed pMOS are identical.

\[ V_{\text{dd}} \]

\[ V_0 \]
How do we achieve this?

Problem: Not that easy to get an exact level shift. One way to do it:

Vin → \text{want}

V_{in} \rightarrow V_{out}

V_{out} = \sqrt{\frac{2I_D}{M_{Gf}(\beta)}} - I_D

Problem: Don't like this. (\frac{W}{L})_6 \text{ must be big to send } V_{ov}

Another Option: just accept a \( V_{in} + V_{ov} \) level shift.

Wont this!

Want: \( V_{ov} = 2V_{ov3} \)

\[ V_{out} = \frac{V_{in} + V_{ov}}{2} \]

Want: \( V_{ov} = 2V_{ov3} \)