Announcements

- Homework 5 due today
- Homework 6 due next Tuesday
- Lab 4 this week
- Reading: Chapter 4 (4.5-4.6), 8.3
- Midterm 1 in nine days
  - October 13, 6:30-8pm, Sibley

Lecture Material

- Last lecture
  - MOS amplifier example
  - MOSFET small-signal model
- This lecture
  - Finish MOSFET small-signal model
  - MOS current sources

Voltage References

- First topic: voltage and current references (9.4)
- Generating a voltage: use a current source to set $V_{GS}$

Modeling the Voltage Source

Find $i_{OUT}$ versus $v_{OUT}$ MOSFET is off or saturated: why?

$$i_{OUT} = i_{DSAT} - I_{REF} = \mu C_w \left( \frac{W}{2L} \right) (V_{GS} - V_{TH}) (1 + \lambda_s V_{TH}) - I_{REF}$$

Typical operating point: $i_{OUT} = 0 \, A$

Small-Signal Source Resistance

$$R_s = \left( \frac{di_{OUT}}{dv_{OUT}} \right)_{i_{OUT}=0} = \frac{V_s}{i_s}$$

Equivalent Circuit:
Creating a Current Source

Equivalent Circuit for $I$-Source

Find the DC current for "gray circle" equivalent circuit

$$I_{OUT} = \frac{\mu C_{IN}}{2} \left( \frac{W}{L} \right) \left( V_{REF} - V_{IN} \right)^2$$

Substitute for $V_{REF}$

Small-Signal Resistance of $I$-Source

Current Sinks and Sources

Sink: output current goes to ground

Source: output current comes from voltage supply

Current Mirrors

Idea: we only need one reference current to set up all the current sources and sinks needed for a multistage amplifier.