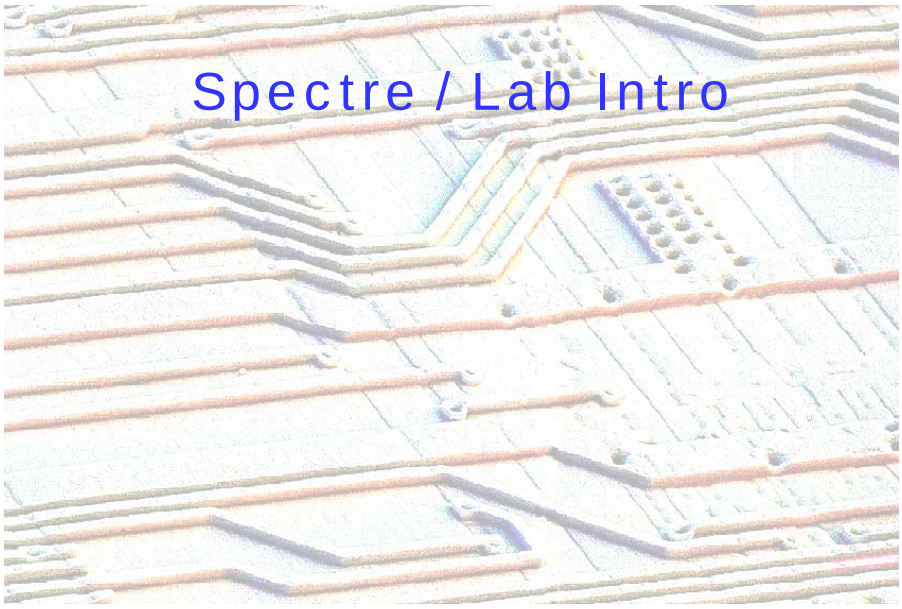


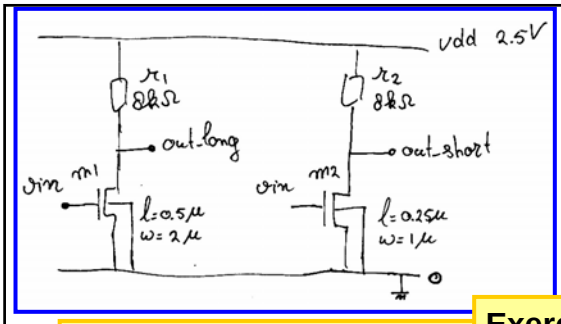
Lab / Project

- Prepare yourself, form **pairs**
- Become familiar with linux, cadence
- Can use computers in MSc lab (16th floor)
- Instructions are posted on web, being augmented through the course
- Need a **login**:
  - One login account for a team
  - Visit **Antoon Frehe**, room 17.070, a.frehe@EWI.TUDelft.NL, ✆81796

This Week's Plan

1. **Become familiar with linux**
   - **Tutorial: http://www.ee.surrey.ac.uk/Teaching/Unix/**
   - **In general, resources on class website**
   - **Use (!) BB forum to ask questions and share knowledge**
2. **Become familiar with Spectre (ckt sim)**
   - **Next slides show how to solve Rabaey Exercise 3.11**
3. **Use Spectre for Rabaey Exercises 3.4 and 3.5**
   - **Spectre instructions follow**
   - **Hand-in 1 A4 with 4 annotated graphs on Mon 18/2 before class**
   - **Write you names (as a team) on it**
   - **Will not be graded, I will provide feedback if necessary**

Simulation Example



- **Make sketch**
- **Assign node names**
- **Write file**
- **Add control statements**

Exercise 3.11

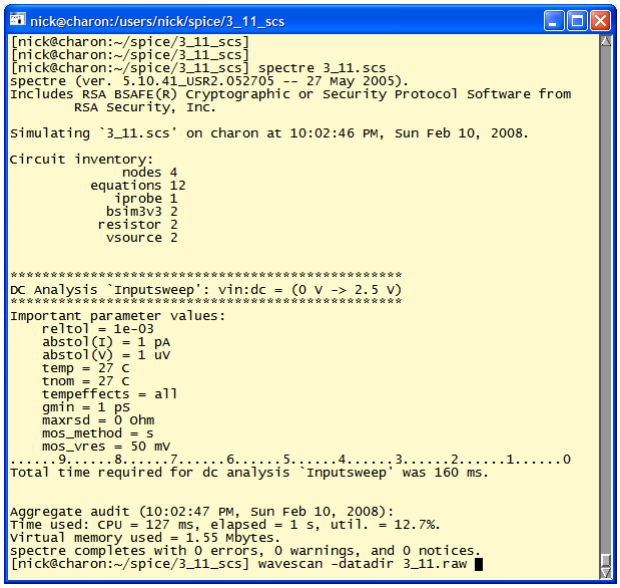
```
simulator lang=spectre
include "g25_scs.lib"
vdd (vdd 0) vsource dc=2.5
vin (in 0) vsource dc=2.5
r1 (vdd out_long) resistor r=8K
r2 (vdd out_short) resistor r=8k
m1 (out_long in 0 0) nmos l=0.5u w=2u
m2 (out_short in 0 0) nmos l=0.25u w=1u
Inputsweep dc param=dc dev=vin start=0 stop=2.5 step=0.1
save vin out_long out_short
```

250nm Spectre BSIM3 MOS Models

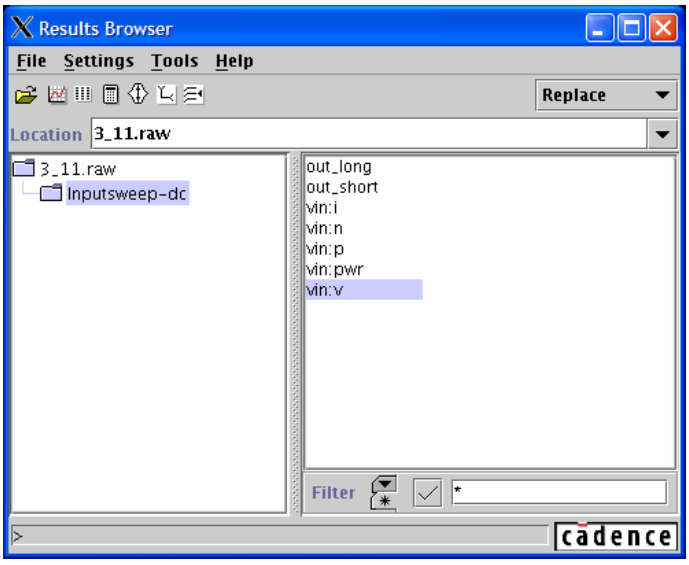
```
simulator lang=spectre
model nmos bsim3v3
+version=3.1
+type=n
+tnom    = 25             xl      = 3e-8
+xw      = 0              tox     = 5.8e-9
+xj      = 1e-07          nch     = 2.354946e+17   lln     = 1
+vth0    = 0.4321336      lvth1   = 2.081814e-08   wvth0   = -5.470342e-11
+pvth0   = -6.721795e-16  k1      = 0.3281252      lk1     = 9.238362e-08
... 60 lines deleted ...
+tlev    = 1              tlevc   = 1              js      = 1e-06
+jsw     = 5e-11
```

- **Similar for pmos device**

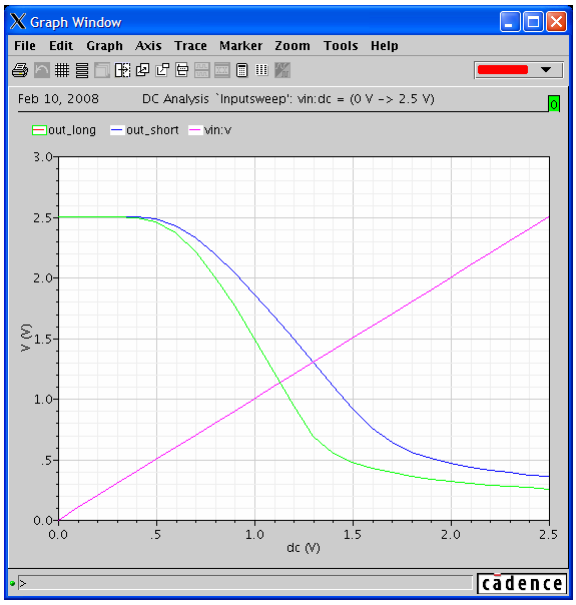
Spectre Terminal Interface



WaveScan Results Browser



WaveScan Graph Window



Exercise 4+5

4. [E, SPICE, 3.3.2] Using SPICE plot the *I-V* characteristics for the following devices.

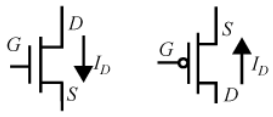


Figure 0.3 NMOS and PMOS devices.

a. NMOS $W = 1.2\mu m$, $L = 0.25\mu m$
b. NMOS $W = 4.8\mu m$, $L = 0.5\mu m$
c. PMOS $W = 1.2\ \mu m$, $L = 0.25\ \mu m$
d. PMOS $W = 4.8\ \mu m$, $L = 0.5\ \mu m$

5. [E, SPICE, 3.3.2] Indicate on the plots from problem 4.
a. the regions of operation.
b. the effects of channel length modulation.
c. Which of the devices are in velocity saturation? Explain how this can be observed on the *I-V* plots.

Tips

- **Make 4 circuits, 1 for each of the cases 4a-4b**
- **Each circuit will have 6 transistors**
  - **All drains are connected, drain voltage to be swept from 0 to 2.5 V**
  - **All gates unconnected, different gate voltages: 0, 0.5, 1.0, 1.5, 2.0, 2.5 V**
- **Plot each circuit in a separate graph, combine them on 1 page (word or latex)**
  - **Wavescan can export png files, looks better compared to screen dumps**

TA Help

- Help will be available in MSc lab
- Schedule to be determined, options are:
  - Tuesday afternoon
  - Friday morning
  - Friday afternoon
  - …
- BB Forum – me and TA's will answer questions