



Exercise: The MOS Transistor

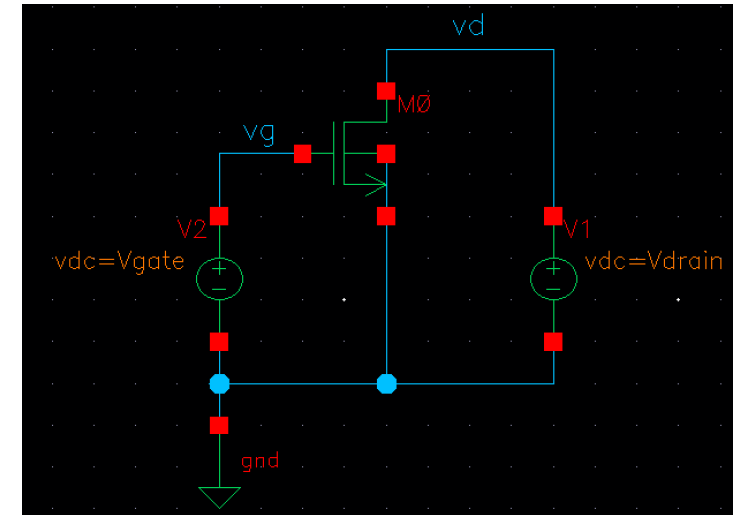
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Exercise 1: Simple MOS (Level 1 model)

- We want to simulate a MOS with a very simple model (as the formula shown in the lecture)
- Create a schematic which allows you to set V_G and V_D of a MOS:
- Use 'nmos4' from 'analogLib'
- Attach the model 'nmossimple' (see diode exercise. Add path!)



- Use the following model:

```
.model nmossimple nmos level=1
+ cox=1e-3 kp=100e-6 lambda=0.1 tox=10e-9 gamma=0.5
vto=0.5
```

- Plot

- I_D for $V_G=0..2$ V with $V_D=2$ V (Transfer characteristic)
- $\sqrt{I_D}$ for $V_G=0..2$ V with $V_D=2$ V (Sqrt of transfer characteristic)
- I_D for $V_D=0..2$ V with $V_G=1$ V (Output characteristic)



Exercise 2: Output Resistance

- Sweep I_D for $V_D=0..2$ V with $V_G=1V, 1.5V, 2V$
- What are the slopes at high drain voltages ?
- Do they correspond to what you expect ?



Exercise 3: A real MOS

- Now use the model 'nmos' provided in the file **MOSLib.lib** on the course web site (this MOS should be operated below 2V)
- Compare the transfer curves of a 'nmossimple' and 'nmos'
 - Are they both exactly quadratic?
 - What happens at low gate voltages (below threshold)?
Do a logarithmic plot!



Exercise 4: Sizing the MOS

- Set the properties W and L of both types of MOS to WL
- Compare the output characteristics for $W, L=1\mu$ and $W, L=10\mu$ for both MOS
 - Is there a change in output resistance if you change the geometry?



Exercise 5: PMOS

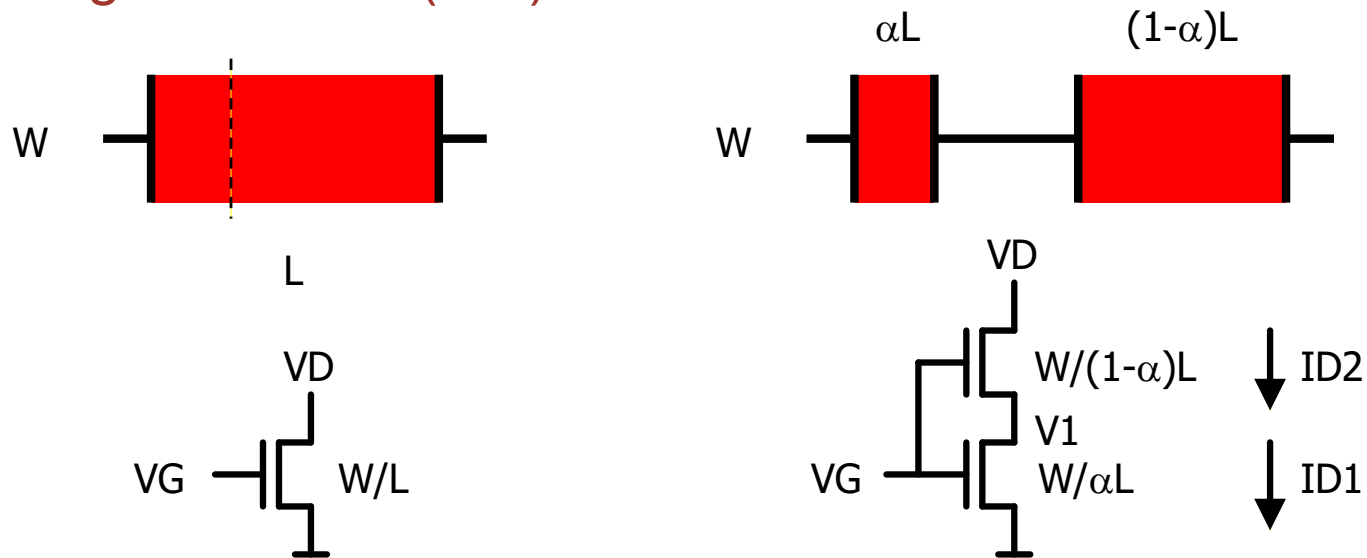
- Simulate transfer and output characteristic for a PMOS
 - Note that the source of the transistor is now ,on top‘
 - Gate and drain must be negative with respect to source

- Simulate in parallel a NMOS of the same size.
 - Plot the drain current of NMOS and PMOS simultaneously.
 - How big is the difference?
 - Does that fit the model?



Exercise 6: Do Formulae match ?

- A MOS with width W and length L is cut in two devices with lengths αL and $(1-\alpha)L$:



- The series connection must behave as the single device!
- Assume a large V_D . In which regimes do the 2 MOS operate (lin. / sat.?). Write down the formulae for $ID1$ and $ID2$
- The currents must be equal. Find α . Then find $ID1$ ($=ID2$)
- Is this the current of the single MOS?
- How large is V_1 for $\alpha=5/9$?