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Exercise:
The MOS Transistor

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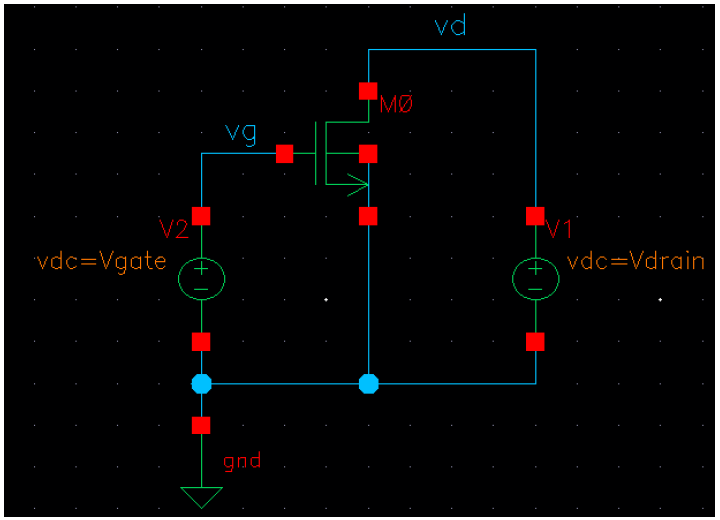
Exercise 1: Simple MOS (Level 1 model)

- 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=2V (Transfer characteristic)
  - $\sqrt{I_D}$ for V_G=0..2 V with V_D=2V (Sqrt of transfer characteristic)
  - I_D for V_D=0..2 V with V_G=1V (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 WL=1u and WL=10u for both MOS
  - Is there a change in output resistance if you change the geometry?

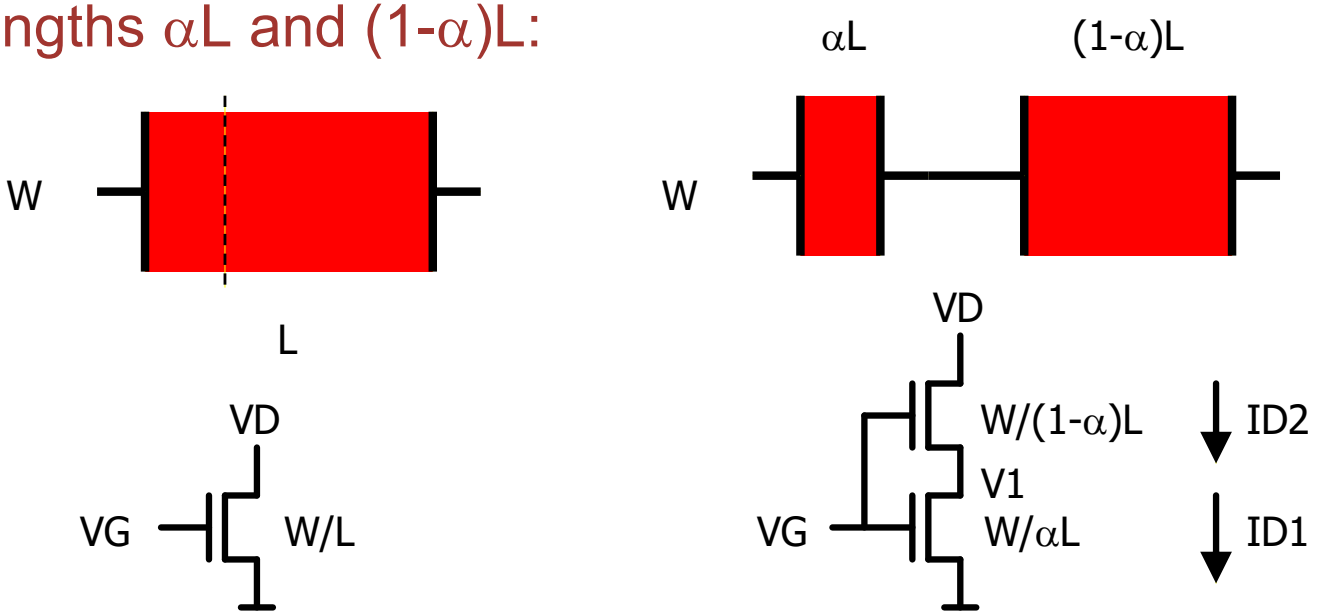
Exercise 5: PMOS

- 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: Formulae match…

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



- The series connection must behave as the single device!
- Assume a large VD. 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 V1 for α=5/9 ?