Please read carefully before starting:

- Simulation tool to be used is National Instruments (NI) Multisim.
- The setup of the NMOS transistors and their models are given at the end of the document.
- You should be divided into groups of three students (or less).
- Each group should be ready for a discussion in the project (schematics and simulations results on Multisim are needed).
- You are required to deliver a hard copy report that contains:
  1. Schematic diagrams (snapshots from Multisim showing dimensions and values)
  2. Design procedure (hand calculations)
  3. Simulation results (snapshots from Multisim)
  4. Discussion of your results and conclusions

  Any missing item from the 4 items above will be penalized in the report grading.
- The deadline to submit the project report (delivered in the TA room) will be on Sunday 29/12/2019, 12:30 PM
- Any copied reports or groups more than 3 will be given zero.

[1] Transistor Characterization:

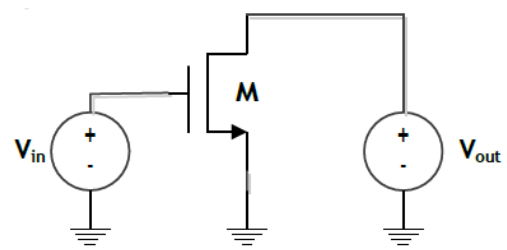


Fig. 1 Transistor Characterization

(a) For the schematic shown in Fig. 1 with W=10 μm, L=2 μm:

- Perform DC sweep for V_{out} (from 0 to 3V) while V_{in}=2V and plot I_D vs. V_{out}.
- Perform DC sweep for V_{in} (from 0 to 3V) while V_{out}=2V and plot I_D vs. V_{in}.
- From the above curves determine the value of V_{TH}, $\mu_n C_{OX}$, and λ.

[2] Single Stage Amplifier: Design the amplifier (determine the dimensions of M and value of R, C, and V_{DC}) shown in Fig. 3 with the following specifications:

- A_v (mid-band gain) ≥ 26 dB
- Accommodate an input signal with frequency band from 500 Hz to 15 MHz
- Current consumption ≤ 100 μA
- CL = 1pF

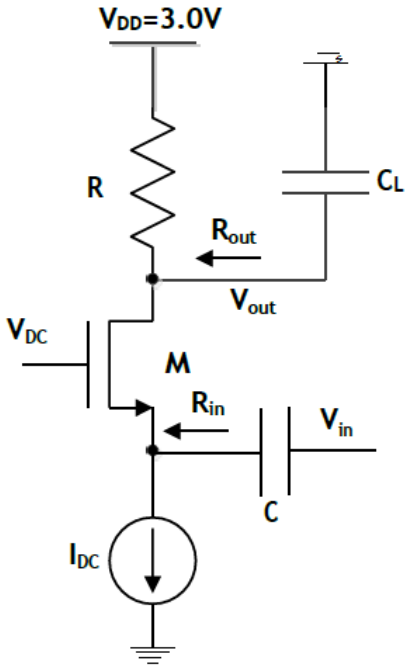


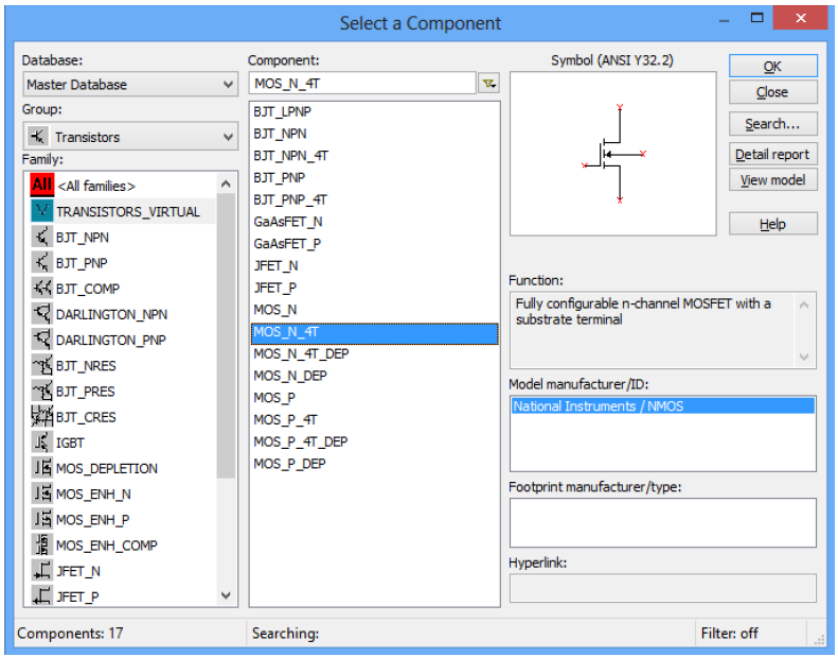
Fig. 2 Single Stage Amplifier

<u>Document the design procedure and the results of the following simulations:</u>

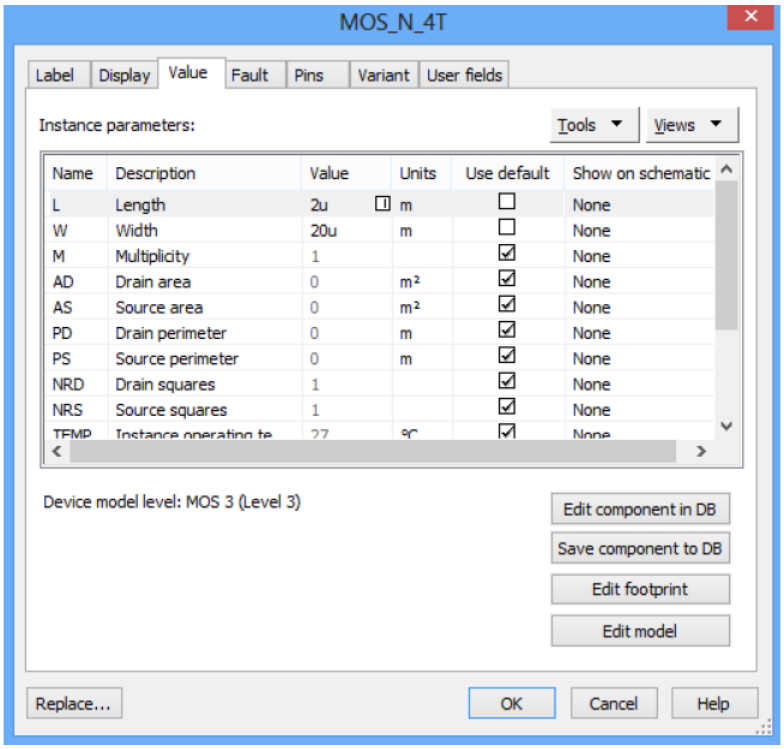
- DC analysis and show the Q-point (I_D, V_{DS}, V_{eff}), and V_{DC}
- AC analysis and show the frequency response (up to 1 GHz).
- AC analysis and show R_{in}, and R_{out} vs. frequency (up to 10 GHz).
- Transient analysis with V_{in}=A.sin(2πft) and plot V_{out}. Where A=10 mV and f=100 kHz
- Repeat transient analysis with F = 50 Hz, 150 MHz
- **Discuss your results.**

Setup of the NMOS transistors:

Choose an NMOS_4T from the menu of Place → Component (as shown below) and place it in your schematic.

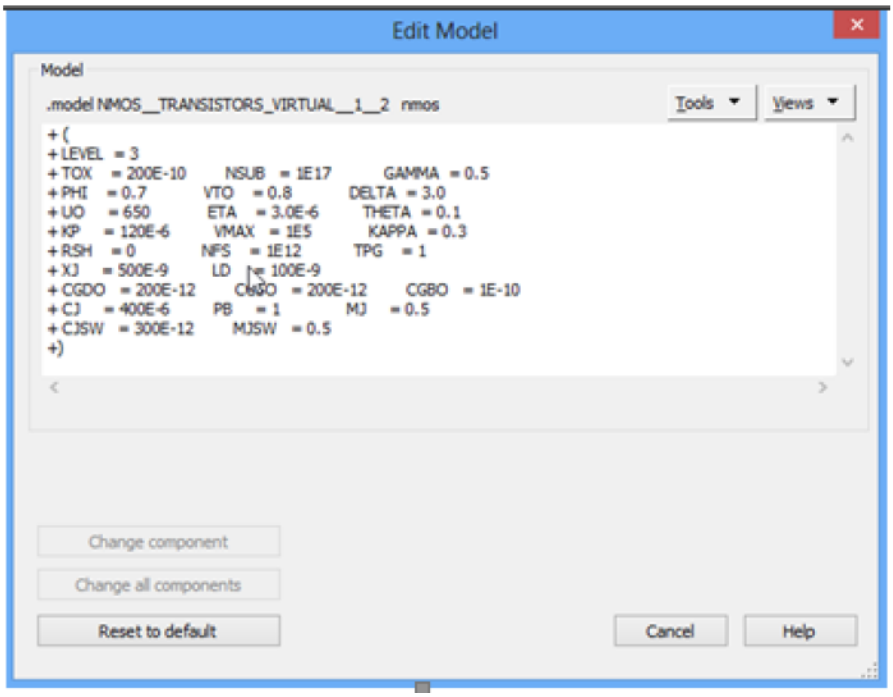


Double click on the transistor and choose the tab of "Value". This is where you can change the dimensions (W,L) of the transistor.



Click on the "Edit model" button.

Copy and paste the model of the NMOS (as shown) in the "SPICE view" Make sure to click on the "Change component" button to save changes.



If you need to place another transistor in a schematic, copy the transistor that you have just created to get the correct model and you can then change the dimensions.

Minimum length of any transistor is 1 µm. The bulk of an NMOS device should be connected to lowest voltage (ground)

NMOS:

```
+ (
+ LEVEL = 3
+ TOX    = 200E-10       NSUB   = 1E17          GAMMA = 0.5
+ PHI    = 0.7           VTO    = 0.8           DELTA = 3.0
+ UO     = 650           ETA = 3.0E-6 THETA = 0.1
+ KP     = 120E-6        VMAX   = 1E5           KAPPA = 0.3
+ RSH    = 0             NFS    = 1E12          TPG = 1
+ XJ = 500E-9 LD = 100E-9
+ CGDO = 200E-12 CGSO = 200E-12 CGBO = 1E-10
+ CJ     = 400E-6        PB     = 1             MJ = 0.5
+ CJSW = 300E-12 MJSW = 0.5
+)
```