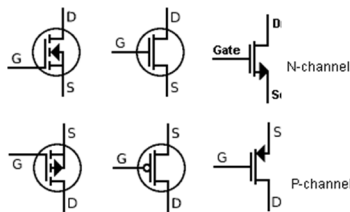# Lab 9

NMOS Transistor Characteristics

Learning outcomes

1) Studying the I-V characteristics of NMOS transistor (I_D vs V_{DS} & V_{GS})
2) Studying the transfer characteristics of NMOS transistor (V_{DS} (V_o) vs V_{GS} (V_{in}))

Note: MOSFET symbols in Multisim is different from Sedra's or Razavi's books. Different symbols are shown below
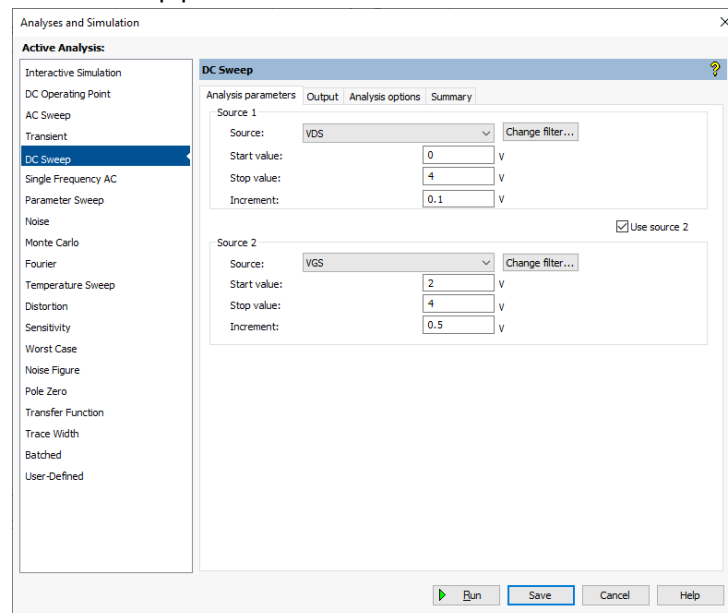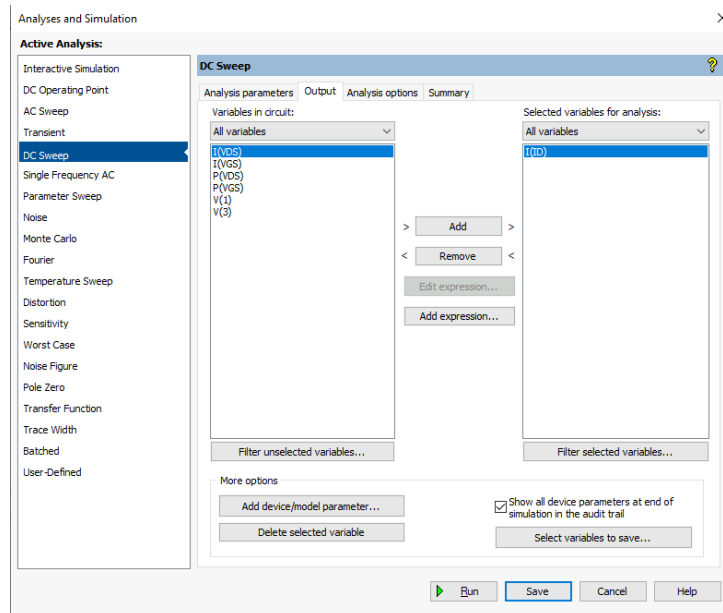

Experiment 1) Studying the I-V characteristics of NMOS transistor (I_D vs V_{DS} & V_{GS})

A) Assemble the circuit shown below, where 2N7000 is our NMOS device
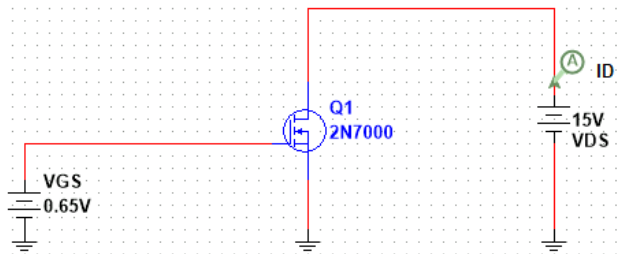
B) Run sweep analysis as follows:
   1. Set DC sweep parameters as shown below

2. Click Run and export output to excel
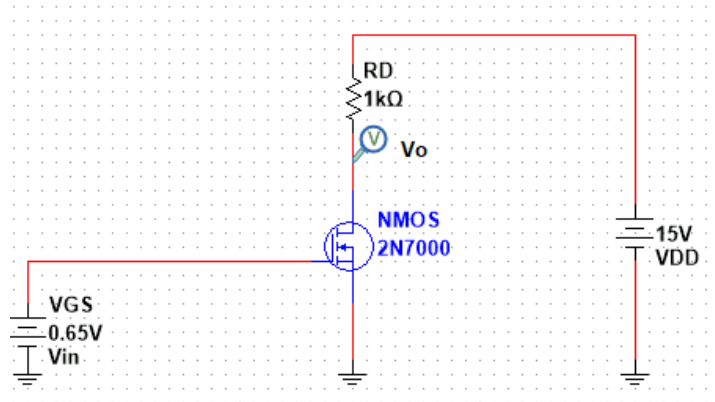3. In Excel plot I_D vs V_{DS} & V_{GS} and copy and paste the figure below here

Place holder for I_D vs V_{DS} & V_{GS} figure

4. Measure and compare V_{DSsat} = V_{GS}-V_{TH}, where V_{TH} for 2N7000 is 2V, in the following table

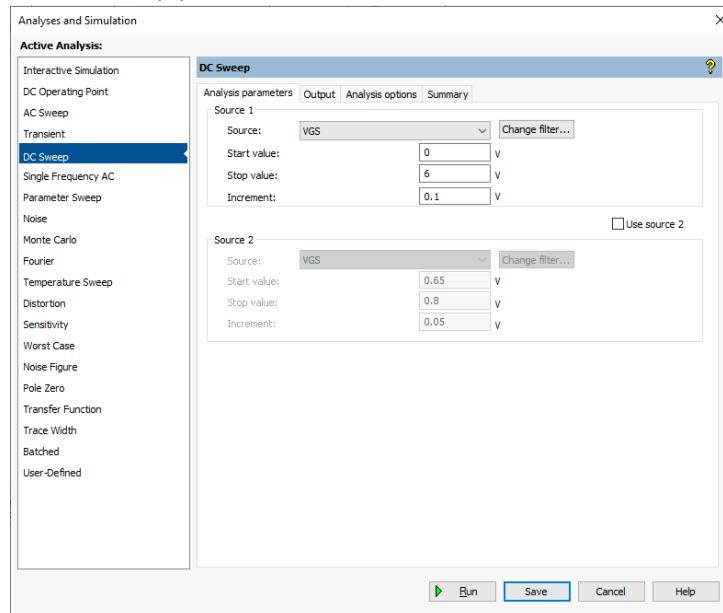| V_{GS}	V_{DSsat} (Theoretical)	V_{DSsat} (Measured)	Error %
2.5V			
3V			
3.5V			
4V			

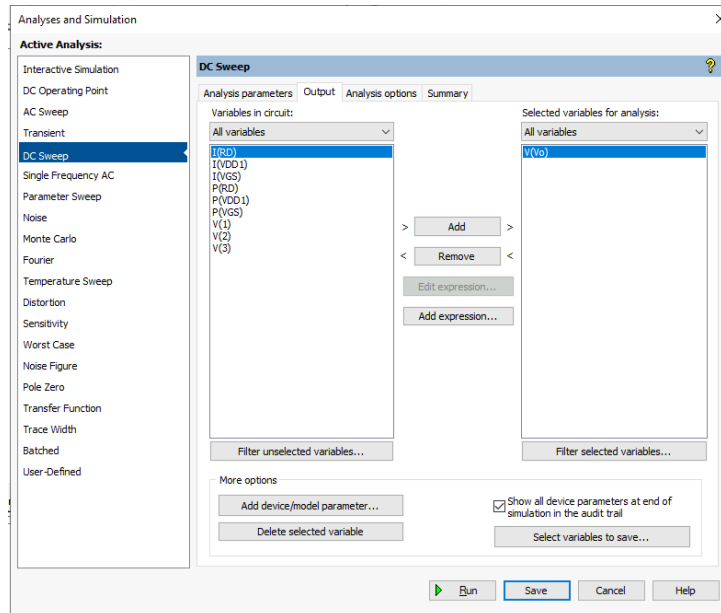**Experiment 2) Studying the transfer characteristics (V$_{GS}$ vs V$_{DS}$)**

A) Create a new Multisim project and construct the circuit shown

B) Run sweep analysis as follows:
   1. Set DC sweep parameters as shown below

2. Click Run and export output to excel
3. In Excel plot V_o vs V_{in} and copy and paste the figure below here

> Place holder for V_o vs V_{in} figure

4. Measure the switching values of the input: V_{GS-ON} and V_{GS-SAT}

Note: Theoretical V_{GS-ON} =V_{TH} and V_{GS-SAT} can be calculated by solving

$\frac{K_n R_D}{2} V_{GS} - V_{GS}(K_n R_D V_{TH} - 1) + \left(V_{TH} + V_{DD} - \frac{V_{TH}^2 K_n R_D}{2}\right) = 0$ where $V_{GS-SAT} > V_{TH}$

V_{GS-ON} (Theoretical)	V_{GS-ON} (Measured)	% Error	V_{GS-SAT} (Theoretical)	V_{GS-SAT} (Measured)	% Error

5. Put your comments below here

> Place holder for comments on Exp 2
>   1- For which Vin range we can use this NMOS circuit as a switch
>   2- For which Vin range we can use this NMOS circuit as an amplifier