Kathmandu University
Department of Electrical and Electronics Engineering
ANALOG ELECTRONICS LABORATORY WORK

EXPERIMENT 8: MOS Field Effect Transistor Characteristics

Objectives: To understand E-MOS characteristics and design a simple inverter and amplifier using an N-MOS

Software
Multisim 8

Theory:
In the NE-MOS of fig 1, when v_{GS} is less than v_t, the drain current i_D is zero irrespective of the applied drain potential because of two diodes connected in back to back fashion. When v_{GS} is higher than v_t, the channel gets induced and maintains uniform depth for small v_{DS} (*less than 50 mV).* The uniform channel is shown by dotted line in fig 1. MOS acts as a linear resistor whose resistivity is controlled by the overdrive voltage. When v_{DS} is increased, uniformity of channel depth is lost at the drain end and the channel gets completely blocked when $V_{DS} = V_{GS} - V_t$.

$V_{DS} < V_{GS} - V_t$ (Triode Region, VCR region)

$V_{DS} \geq V_{GS} - V_t$ (Saturation Region, Linear amplification region)

The volt ampere characteristic of E-MOS in triode region is given by (1) and in saturation region is given by (2).

$$i_D = K_n^{'} \frac{W}{L}\left[(v_{GS} - v_t)v_{DS} - \frac{1}{2}{v_{DS}}^2\right] \tag{1}$$

$$i_D = \frac{1}{2}K_n^{'} \frac{W}{L}\left[(v_{GS} - v_t)^2\right] \tag{2}$$

The ratio W/L is called the aspect ratio of MOSFET. $K_n^{'} = \mu_n C_{ox}$.

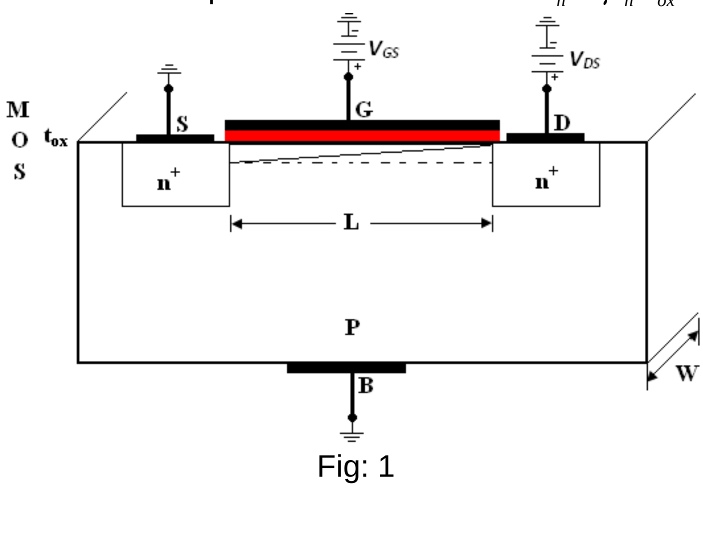


Fig: 1

VTC of NMOS Inverter

The VTC of NMOS inverter in fig 4 is shown in fig 2. In the region XA, MOS is in the cut-off region. MOS enters saturation in AQB and the output voltage falls by square law relationship given by (3).

$$v_O = V_{DD} - \frac{1}{2} K_n^{'} \frac{W}{L} (v_I - v_t)^2 R_D \quad (3)$$

Gain of MOSFET in AQB is given by $-g_m R_D$, where $g_m = K_n^{'}(W/L)V_{OV}$. We have neglected the channel length modulation effect. For small signal operation v_{gs} around the quiescent should be << $2V_{OV}$.

In BC, MOS operates as almost linear resistor. The output voltage falls as given by (4).

$$v_O = V_{DD} \frac{r_{DS}}{r_{DS} + R_D} \quad (4)$$

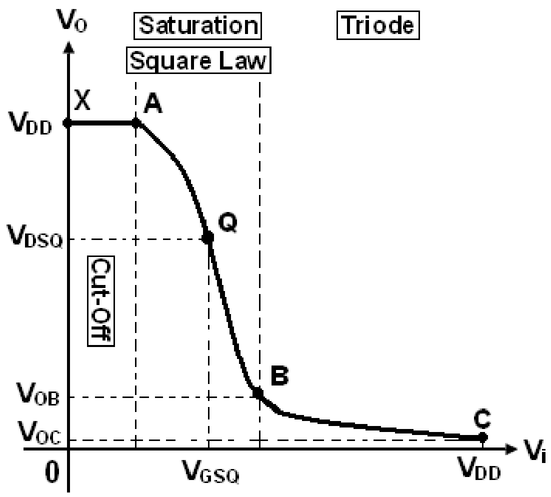


Fig: 2

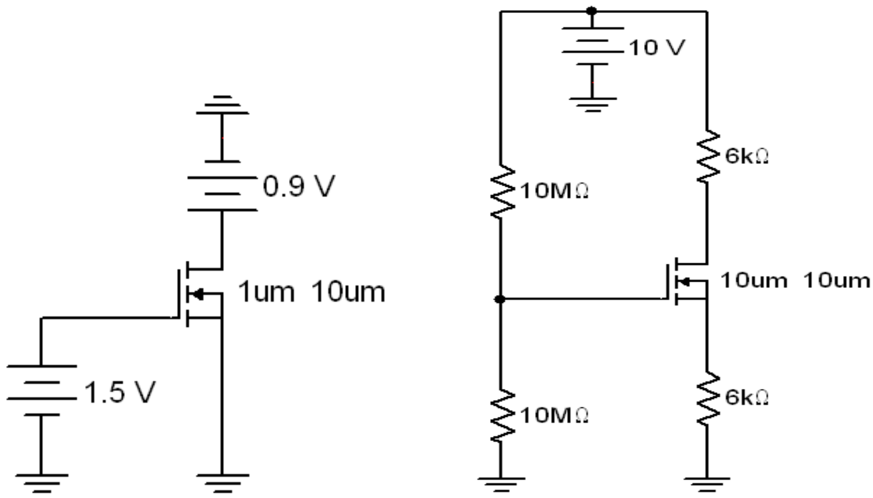
Volt Ampere Characteristics

Procedure

1. Connect the circuit as shown in fig 3 (a). Set 3TEN Virtual MOSFET parameters as, W=10um and L=1um, VTO=0.7, KP=100e-6.
2. Complete table 1.

V_D	Operating Region	I_D L=1	I_D L=0.5
0.5			
0.9			
3			

Table: 1



(a) (b)

Fig: 3

3. Connect the circuit as shown in fig 3 (b). *W=10um and L=10um, VTO=1, KP=1e-3.*
4. Complete table 2.*While calculating theoretical values assume that the MOSFET is working in the saturation region.*

Result	V_G	I_D	V_S	V_{GS}	V_D	V_{DS}	I_G	I_S
Theoretical								
Software								

Table: 2

MOS Resistive Switching Characteristics

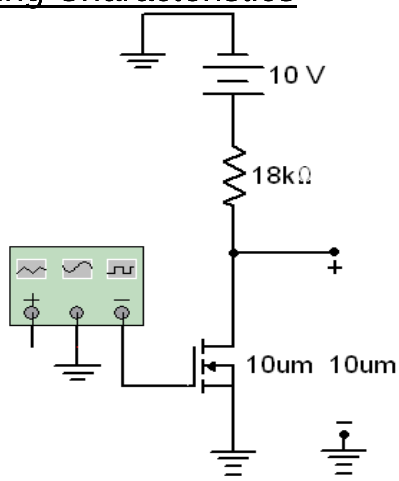


Fig: 4

Procedure

1. Connect the circuit as shown in fig 4. *W=10um and L=10um, VTO=1, KP=1e-3.*
2. Set the FG as 1 kHz, 5 V amplitude with 5 V offset, sine.

3. Connect CH1 of OSC to input and CH2 to output. See in YT mode the switching characteristics of MOSFET. *Use DC coupling mode.*
4. Change the oscilloscope display format to XY mode. The VTC will be seen like as shown in fig 5.

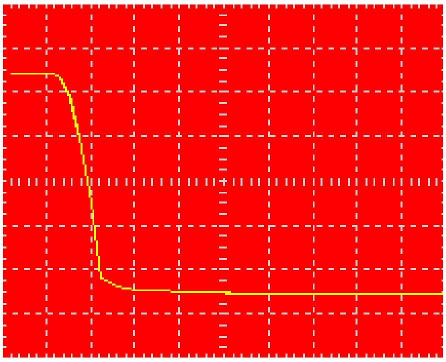


Fig: 5

5. With reference to fig 5 and fig 2 complete table 3.

Result	X	A	V_{IB}	V_{OB}	V_{OC}	Q
Theoretical						
Software						

Q should be selected to give maximum signal swing @ the output

Table: 3

MOS Amplifier Characteristics

Procedure

1. Remove FG and Oscilloscope from fig 4.
2. Give 1.816 V as the gate potential.
3. Complete table 4.

Result	V_{DSQ}	I_{DQ}
Theoretical		
Software		

Table: 4

Region of Operation: ___________________

Overdrive Voltage: _____________________

4. Set the FG as 1 kHz, 1 mV amplitude with 1.816 V offset, sine.
5. Use AC coupling mode of oscilloscope. *CH1=Input, CH2=Output.*
6. Find the gain of amplifier.
7. Sketch amplifier characteristics in XY mode.