20-01-23

Lab-02

Aim: Plot output characteristics and transfer characteristics of n-mos and P-mos devices

Apparatus: ngspice Software.

Theory:
The mosfet is actually a four-terminal device.
(i) Gate
(ii) Source
(iii) Drain
(iv) Body
* Body and Source are always short circuited to neglect body effect.
* And for n mos $V_D > V_S$; And for pmos $V_S > V_D$. ; In n-mos current flows from Drain to Source and in P-mos current flows from Source to drain

Transfer characteristics: The plot between Vgs [voltage between gate and source] and current flowing from drain to source [I_{DS}]

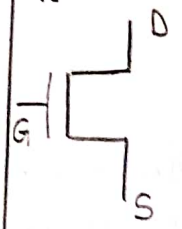
$V_{gs} - I_{DS}$

Output characteristics: The plot between Vds [voltage between drain and source] and current flowing from drain to source [I_{DS}]

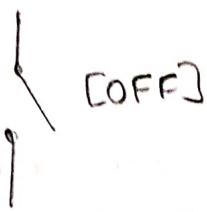
$V_{DS} - I_{DS}$

TO work n-mos $V_{GS} > V_{th}$ where V_{th} = threshold voltage.
TO work P-mos $V_{SG} > |V_{th}|$

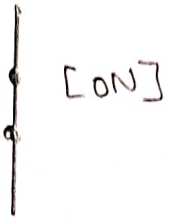
N-mos.



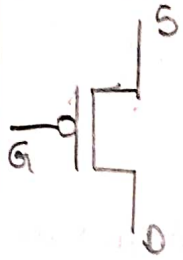
$G_1 = 0$

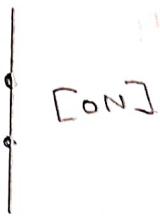


$G_1 = 1$

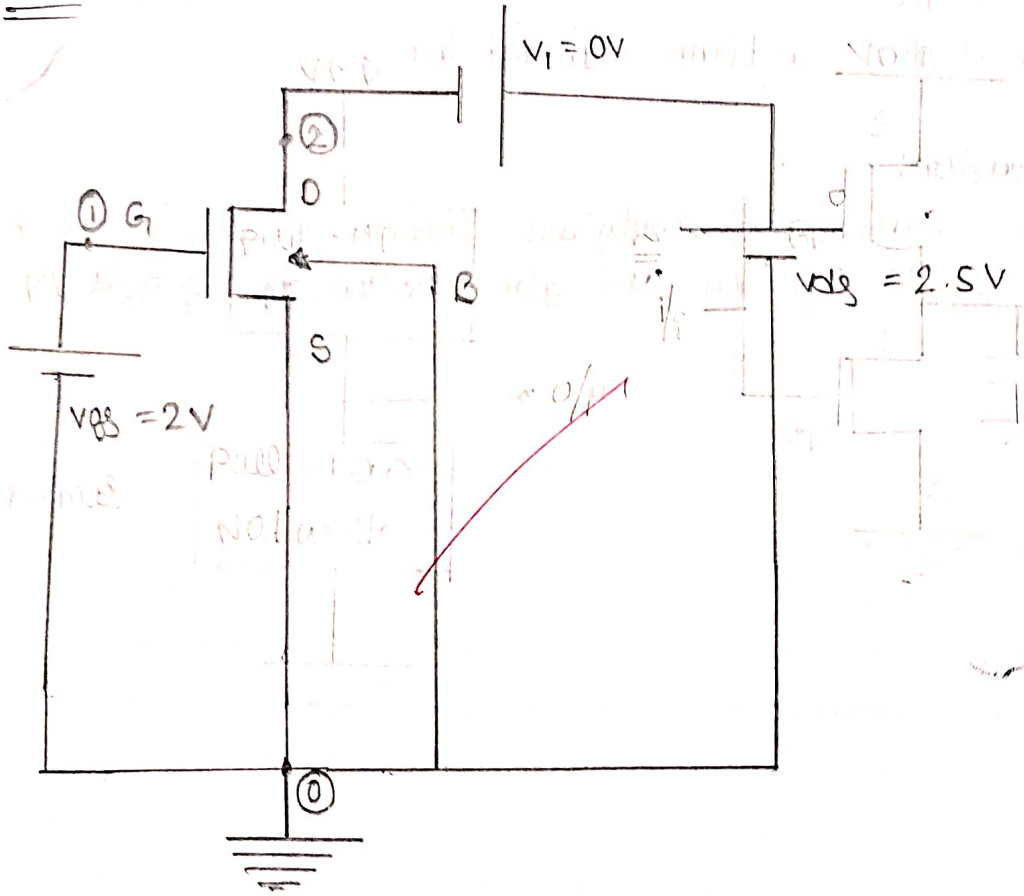


P-mos





C-mos [Network]:-



Procedure:-

1. Name the nodes of the circuits by numbers and Give "0" to ground.
2. Make netlist by nodes. i.e the components between which nodes like resister, capacitor etc.
3. Now give the dc input for gate and check the values of Curent through resistor (or) dummy voltage
4. For transfer characteristics plot the graph between Gate voltage and Curent through resistor.
5. For output characteristics plot the graph between Drain voltage and Curent through resistor.
6. For nmos select model nmod level = 54 ; version = 4.7
7. For Pmos select model pmod level = 54 ; version = 4.7
8. At device selecting always use order of D G S B respectively
   D = Drain voltage (or) node number
   G = Gate node number
   S = Source node number
   B = Body node number

For Saturation mode

$$I_{DS} = \frac{1}{2}\mu_n C_{ox}\frac{W}{L}(V_{GS} - V_{th})^2$$

For Linear region

$$I_{DS} = \mu_n C_{ox}\frac{W}{L}\left[(V_{GS}-V_{th})V_{DS} - \frac{V_{DS}^2}{2}\right]$$

mosfet works in only saturation mode and Linear region.

Code:-

(i) nmos

a) Transfer characteristics

```
Vg   1   0   2V
Vd   3   0   2.5V
V1   3   2   0V
.model nmod nmos level=54 version=4.7
M1   2   1   0   0   nmod   w=100u   l=10u
.dc  Vg  0   2   0.1
.control
run
plot i(V1) xlabel 'Vgs' ylabel 'Id' title "I-V char of NMOS"
.endc
.end
```

b) output characteristics:

```
Vg   1   0   2V
Vd   3   0   5V
V1   3   2   0V
.model nmod nmos level=54 version=4.7
M1   2   1   0   0   nmod   w=100u   l=10u
.dc  Vdd 0   5   0.1
.control
run
plot i(Vd) ylabel "Ids" xlabel "Vds" title "V-I char of NMOS"
.endc
.end
```

(ii) P-mos

a) Transfer Characteristics

```
Vg   1   0   -2V
Vd   3   0   -2.5V
V1   3   2   0V
.model  Pmod  Pmos  level = 54  version = 4.7
M1   0   1   2   0   Pmod   w=100u   l=10u
.dc  Vg  0  -2  -0.1
.control
run
plot  i(V1)  xlabel 'Vg'  ylabel 'Id'  title 'V-I char of pmos'
.endc
.end
```

b) output Characteristics

```
Vg   1   0   -2V.
Vd   3   0   -2.5V
V1   3   2   0V
.model  Pmod  Pmos  level = 54  version = 4.7
M1   0   1   2   0   Pmod   w = 100u ; l = 10u
.dc  Vd  0  -2.5  -0.1
.control
run
plot  i(Vd)  xlabel "Vd"  ylabel 'Id"  title 'V-I char of Pmos'
.endc
.end.
```

Observations:

We observed that if we put V_{DS} as constant and V_{GS} is increased the current graph will be same but intensity is increased.

$V_D \rightarrow$ Constant

cutoff → saturation → Linear

$V_{G_1} \rightarrow$ Constant

cutoff → Linear → saturation

Result/ conclusion:-

We have successfully plotted the V-I characteristics, out-put characteristics and transfer characteristics of n-mos and p-mos devices.

(A)

17/2