Experiment-1(a)

Aim: Plot the IV characteristics of an N-MOSFET

Apparatus used: LTSpice XVII software

Theory:

N-type metal-oxide-semiconductor uses n-type (-) MOSFETs (metal-oxidesemiconductor field-effect transistors) to implement logic gates and other digital circuits. These nMOS transistors operate by creating an inversion layer in a ptype transistor body. This inversion layer, called the n-channel, can conduct electrons between n-type "source" and "drain" terminals. The n-channel is created by applying voltage to the third terminal, called the gate. Like other MOSFETs, nMOS transistors have four modes of operation: cut-off (or subthreshold), triode, saturation (sometimes called active), and velocity saturation

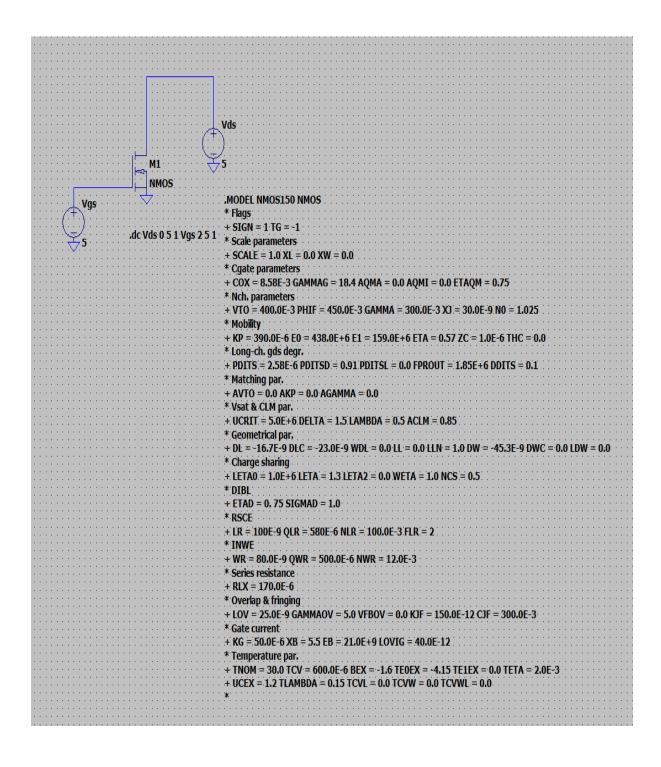
Circuit Schematic:

NMOS input Schematic

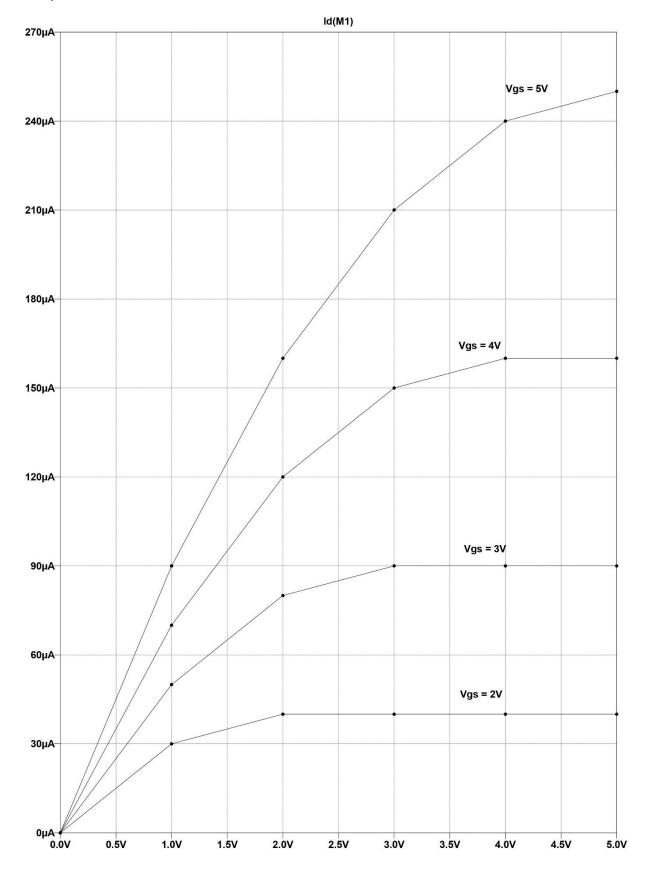
```
Vds
    M1
    NMOS
                      MODEL NMOS150 NMOS
                      * Flags
                      + SIGN = 1 TG = -1
.dc Vgs 0 5 1 Vds 2 5 1 * Scale parameters
                      + SCALE = 1.0 XL = 0.0 XW = 0.0
                      + COX = 8.58E-3 GAMMAG = 18.4 AQMA = 0.0 AQMI = 0.0 ETAQM = 0.75
                      * Nch. parameters
                      + VTO = 400.0E-3 PHIF = 450.0E-3 GAMMA = 300.0E-3 XJ = 30.0E-9 NO = 1.025
                      * Mobility
                      + \text{ KP} = 390.0E-6 E0 = 438.0E+6 E1 = 159.0E+6 ETA = 0.57 ZC = 1.0E-6 THC = 0.0
                      * Long-ch. gds degr.
                      + PDITS = 2.58E-6 PDITSD = 0.91 PDITSL = 0.0 FPROUT = 1.85E+6 DDITS = 0.1
                      * Matching par.
                      + AVTO = 0.0 AKP = 0.0 AGAMMA = 0.0
                      * Vsat & CLM par.
                      + UCRIT = 5.0E+6 DELTA = 1.5 LAMBDA = 0.5 ACLM = 0.85
                      * Geometrical par
                      + DL = -16.7E-9 DLC = -23.0E-9 WDL = 0.0 LL = 0.0 LLN = 1.0 DW = -45.3E-9 DWC = 0.0 LDW = 0.0
                      * Charge sharing
                      + LETA0 = 1.0E+6 LETA = 1.3 LETA2 = 0.0 WETA = 1.0 NCS = 0.5
                      * DIBL
                      + ETAD = 0.75 SIGMAD = 1.0
                      * RSCE
                      + LR = 100E-9 QLR = 580E-6 NLR = 100.0E-3 FLR = 2
                      * INWE
                      + WR = 80.0F-9 OWR = 500.0F-6 NWR = 12.0F-3
                      * Series resistance
                      + RIX = 170.0F-6
                      * Overlap & fringing
                      + LOV = 25.0E-9 GAMMAOV = 5.0 VFBOV = 0.0 KJF = 150.0E-12 CJF = 300.0E-3
                      * Gate current
                      + KG = 50.0E-6 XB = 5.5 EB = 21.0E+9 LOVIG = 40.0E-12
                      * Temperature par.
                      + TNOM = 30.0 TCV = 600.0E-6 BEX = -1.6 TE0EX = -4.15 TE1EX = 0.0 TETA = 2.0E-3
                      + UCEX = 1.2 TLAMBDA = 0.15 TCVL = 0.0 TCVW = 0.0 TCVWL = 0.0
```

Input Waveform: ld(M1) 270µA 240µA-Vds=5V 210µA-Vds=4V/ 180µA-Vds=3V 150µA-Vds=2V 120µA 90μA-60µA 30μA-0.0V 0.5V 1.0V 1.5V 2.0V 2.5V 3.0V 3.5V 4.0V 4.5V 5.0V

Output Schematic:







Experiment-1(b)

Aim: Plot the IV characteristics of a P-MOSFET

Apparatus used: LTSpice XVII software

Theory:

PMOS uses p-channel (+) metal-oxide-semiconductor field effect transistors (MOSFETs) to implement logic gates and other digital circuits. PMOS transistors operate by creating an inversion layer in an n-type transistor body. This inversion layer, called the p-channel, can conduct holes between p-type "source" and "drain" terminals. The p-channel is created by applying a negative voltage (-25V was common) to the third terminal, called the gate. Like other MOSFETs, PMOS transistors have four modes of operation: cut-off (or sub-threshold), triode, saturation (sometimes called active), and velocity saturation.

Circuit Schematic:

PMOS input Schematic

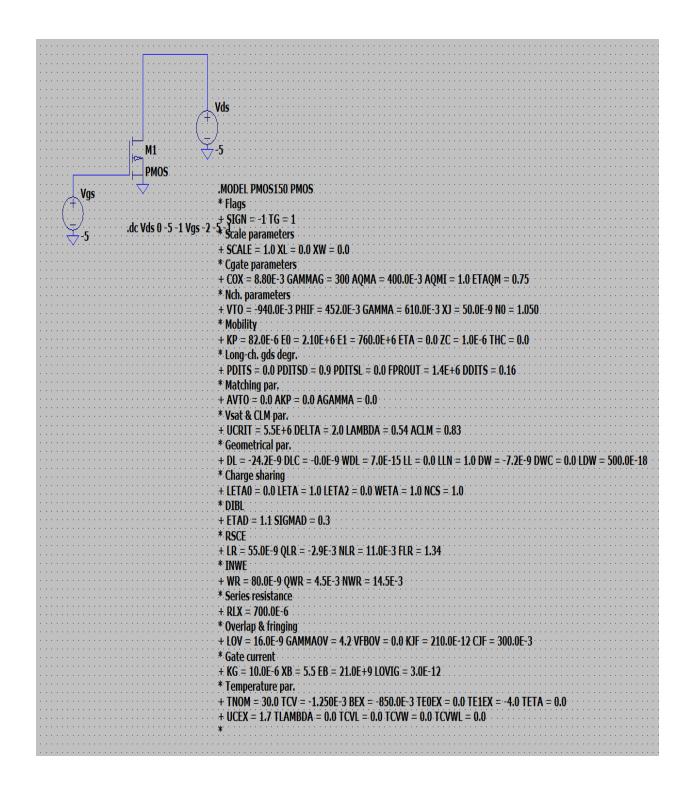
```
Vds
    M1
    PMOS
                         MODEL PMOS150 PMOS
                        * Flags
.dc Vgs 0 - 5 - 1 Vds -2 - 5 = 1 Scale parameters
                        + SCALE = 1.0 XL = 0.0 XW = 0.0
* Cgate parameters
                        + COX = 8.80E-3 GAMMAG = 300 AQMA = 400.0E-3 AQMI = 1.0 ETAQM = 0.75
                        + VTO =:-940.0E-3 PHIF =:452.0E-3 GAMMA = 610.0E-3 XJ =:50.0E-9 NO =:1.050
                        + \text{ KP} = 82.0E-6 \text{ E}0 = 2.10E+6 \text{ E}1 = 760.0E+6 \text{ E}TA = 0.0 \text{ ZC} = 1.0E-6 \text{ T}HC = 0.0 \text{ Z}
                        * Long-ch. gds deg
                        + PDITS = 0.0 PDITSD = 0.9 PDITSL = 0.0 FPROUT = 1.4E+6 DDITS = 0.16

* Matching par.

+ AVTO = 0.0 AKP = 0.0 AGAMMA = 0.0
                        * Vsat & CLM par.
                        + UCRIT = 5.5E+6 DELTA = 2.0 LAMBDA = 0.54 ACLM = 0.83
                         + DL = -24.2E-9 DLC = -0.0E-9 WDL = 7.0E-15 LL = 0.0 LLN = 1.0 DW = -7.2E-9 DWC = 0.0 LDW = 500.0E-18
                        * Charge sharing
                        \pm LETA0 \pm 0.0 LETA \pm 1.0 LETA2 \pm 0.0 WETA \pm 1.0 NCS \pm 1.0
                        * DIBL
                        + ETAD = 1.1 SIGMAD = 0.3
                        * RSCE
                        + LR = 55.0E-9 QLR = -2.9E-3 NLR = 11.0E-3 FLR = 1.34
                        * INWE
                        + WR = 80.0E-9 QWR = 4.5E-3 NWR = 14.5E-3
                         * Series resistance
                        + RLX = 700.0E-6
                         * Overlap & fringing
                        + LOV = 16.0E-9 GAMMAOV = 4.2 VFBOV = 0.0 KJF = 210.0E-12 CJF = 300.0E-3
                        * Gate current
                         + KG = 10.0E-6 XB = 5.5 EB = 21.0E+9 LOVIG = 3.0E-12
                         + TNOM = 30.0 TCV = -1.250E-3 BEX = -850.0E-3 TE0EX = 0.0 TE1EX = -4.0 TETA = 0.0
                        + UCEX = 1.7 TLAMBDA = 0.0 TCVL = 0.0 TCVW = 0.0 TCVWL = 0.0
```

Input Waveform: Id(M1) 0μΑ--30µA -60µA− -90µA Vds=-2V -120µA -150μA Vds=-3V -180µA -210μA Vds=-4V -240µA Vds=-5V -270μA 0.0V -3.5V -0.5V -1.0V -1.5V -2.0V -2.5V -3.0V -4.0V

Output Schematic:



Output Waveform: Id(M1) -30µA Vgs=-2V -60µA− Vgs=-3V -90µA− -120µA -150μA Vgs=-4V -180µA -210µA− Vgs=-5V -240µA -270μA 0.0V -1.0V -2.0V -3.5V -0.5V -1.5V -2.5V -3.0V -4.0V