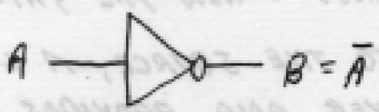
① (503-006) P. E. GRAY

NOTES FOR 6.002 LECTURE #1, FEBRUARY 4, 2003

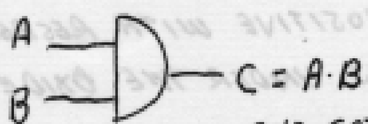
IN DIGITAL COMPUTERS VARIABLES ARE REPRESENTED BY ONLY TWO STATES, COMMONLY DESIGNATED AS 0, 1. BOOLEAN ALGEBRA IS EMPLOYED IN SYMBOLIC CHARACTERIZATIONS.

FUNCTIONAL DESCRIPTIONS OF LOGICAL OPERATIONS ARE REPRESENTED VISUALLY BY GATES AND THEIR INTERCONNECTION:



NOT GATE (INVERTER)

A	B
0	1
1	0



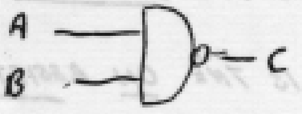
AND GATE

A	B	C
0	0	0
0	1	0
1	0	0
1	1	1

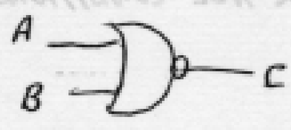
OR GATE

A	B	C
0	0	0
0	1	1
1	0	1
1	1	1

AND & OR GATES USUALLY OCCUR IN CONJUNCTION WITH AN INVERSION. THUS NAND GATES ($C = \overline{A \cdot B}$) AND NOR GATES ($C = \overline{A+B}$)



NAND GATE



NOR GATE

THESE BUILDING BLOCKS CAN BE REALIZED WITH THE BINARY VARIABLES REPRESENTED BY TWO DIFFERENT VOLTAGE LEVELS IN AN ELECTRICAL CIRCUIT WHICH EMPLOYS A METAL-OXIDE-SEMICONDUCTOR FIELD-EFFECT TRANSISTOR: A MOSFET

MOSFET

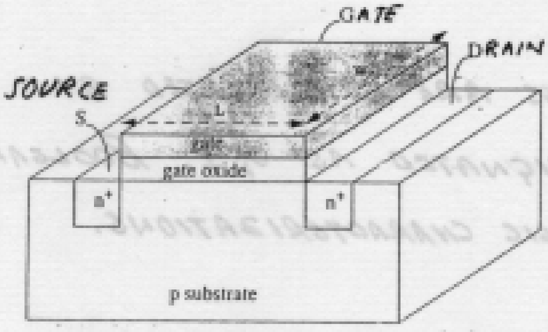


Figure 6.30: A three-dimensional view of an n-channel MOSFET

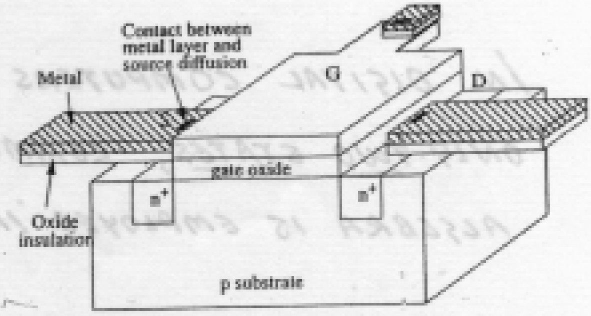
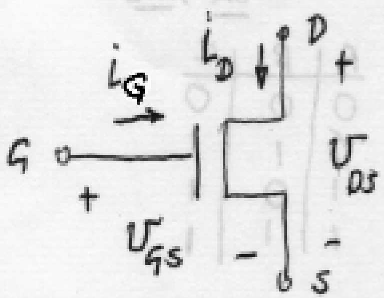
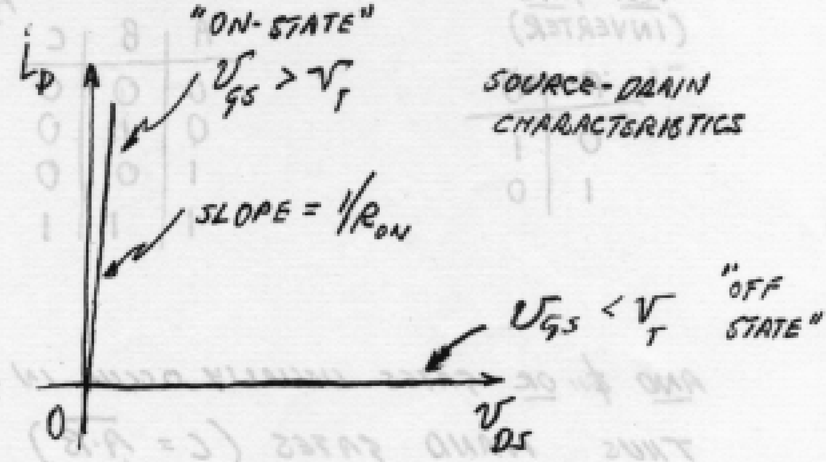


Figure 6.33: Connecting to a MOSFET

WHEN NOTHING IS CONNECTED TO THE GATE, THERE IS A HIGH RESITANCE PATH BETWEEN THE SOURCE AND DRAIN REGIONS. WHEN THE GATE IS MADE SUFFICIENTLY POSITIVE WITH RESPECT TO THE SOURCE, A LAYER OF ELECTRONS FORMS UNDER THE OXIDE LAYER AND PROVIDES A CONDUCTING PATH.



MOSFET SYMBOL WITH i, v DEFINITIONS



SOURCE-DRAIN CHARACTERISTICS

$i_G \cong 0$ UNDER ALL CONDITIONS

V_T IS THE THRESHOLD VOLTAGE

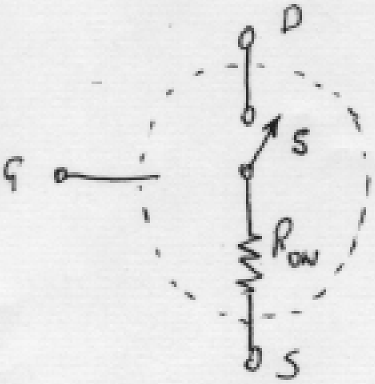
R_{ON} IS THE ON RESISTANCE

THE MOSFET IS A "VALVE" NOT UNLIKE THE SWITCH ON THE WALL.

A VALVE IS A DEVICE WHICH CONTROLS THE FLOW OF ENERGY (POWER) WITH LITTLE EXPENDITURE OF ENERGY.

TO REPRESENT THE ELECTRICAL BEHAVIOR OF THE MOSFET AS A VALVE, A MODEL IS REQUIRED: A REPRESENTATION IN ELECTRICA TERM WHICH IS "ACCURATE ENOUGH" FOR OUR PURPOSES.

MOSFET MODEL

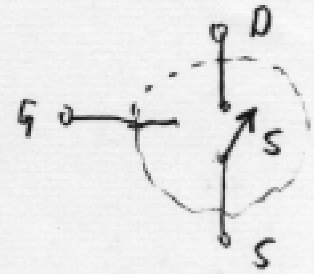


WHEN $v_{GS} < V_T$ S IS OPEN

WHEN $v_{GS} > V_T$ S IS CLOSED

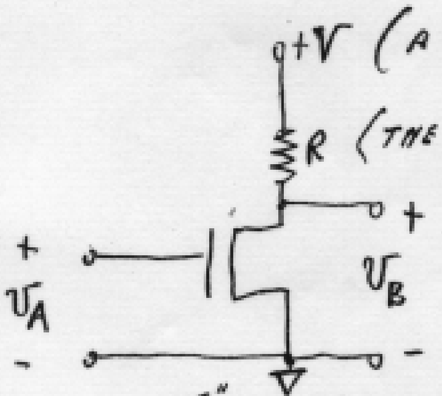
SR MODEL

SOMETIMES REDUCED TO:



S MODEL

MOSFET NOT GATE OR INVERTER

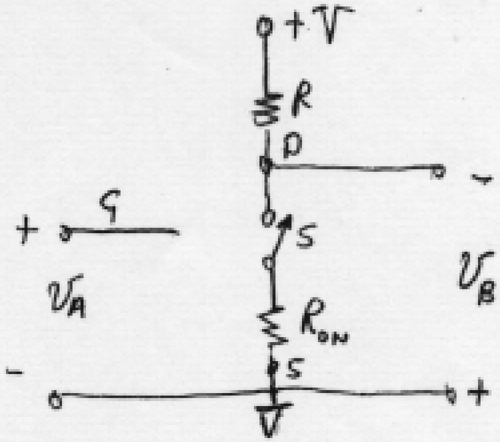


(A FIXED VOLTAGE)

(THE PULL-UP RESISTOR

("GROUND" - THE POINT IN THE CIRCUIT FROM WHICH V IS MEASURED

WITH SR MODEL INSERTED:



IF $v_A = V \; (> V_T)$ S IS CLOSED

$$v_B = V \frac{R_{ON}}{R_{ON} + R}$$

IF $v_A = 0$, S IS OPEN

$$v_B = V$$

IF $v_B = V$ REPRESENTS $B = 1$

AND $v_B \cong 0$ REPRESENTS $B = 0$

AND LIKEWISE FOR v_A, THE LOGICAL RELATIONSHIP IS $B = \bar{A}$