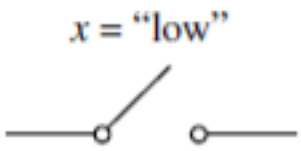
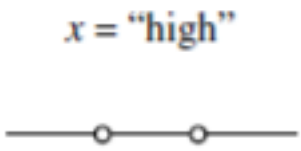
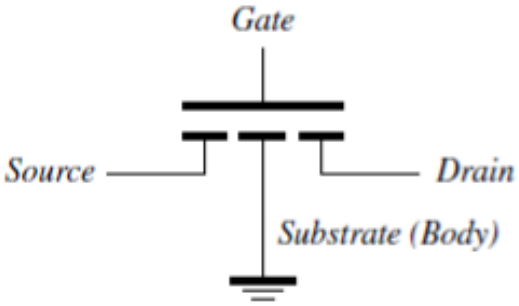
1. TicTacToe in the simulator
2. Implementation Technology (Appendix B of textbook)

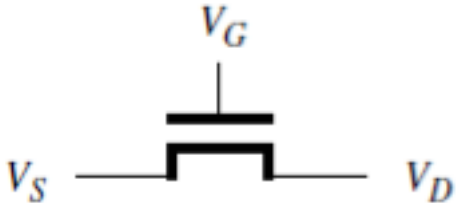
NMOS p-type (PMOS) or n-type (NMOS)

MOSFET. 'Metal oxide semiconductor
Field Effect Transitor



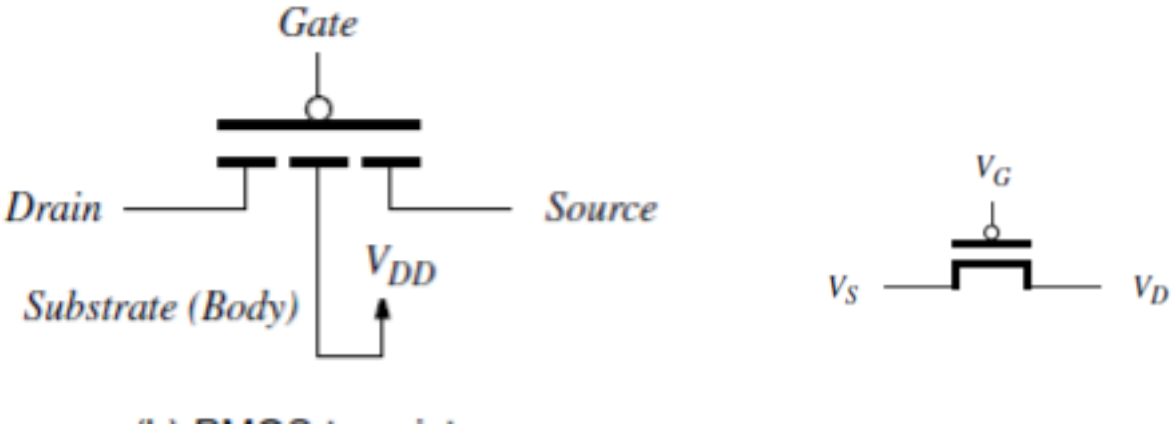




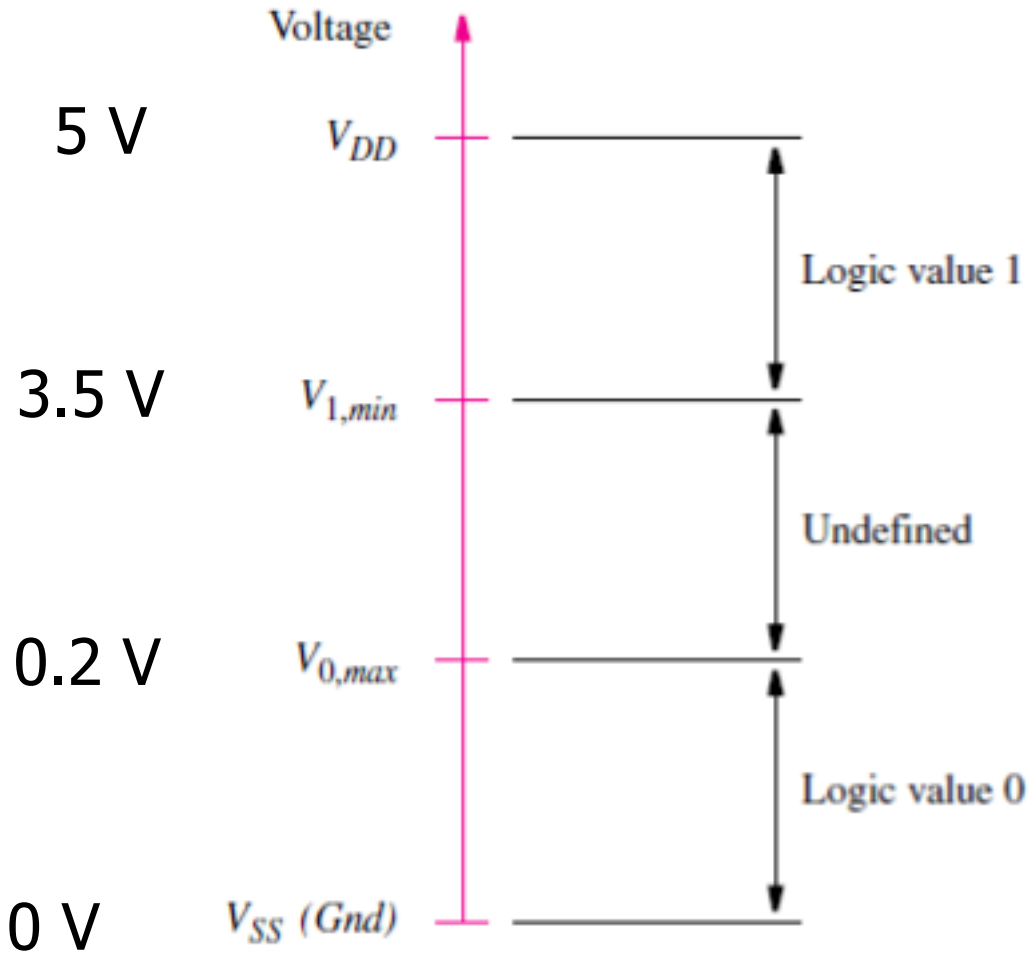


NMOS if V_g = 5V , then V_D = V_S
if V_g = 0, then V_D \ne V_S

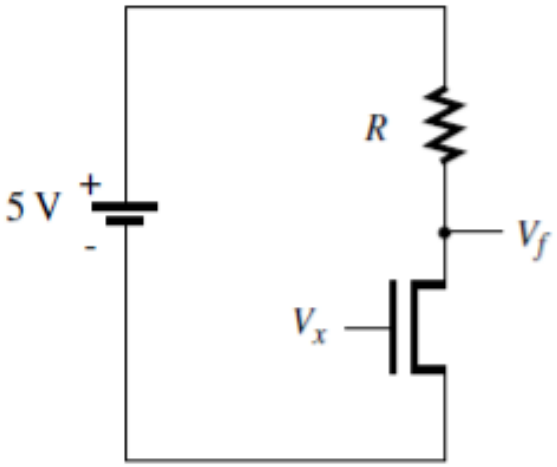
PMOS

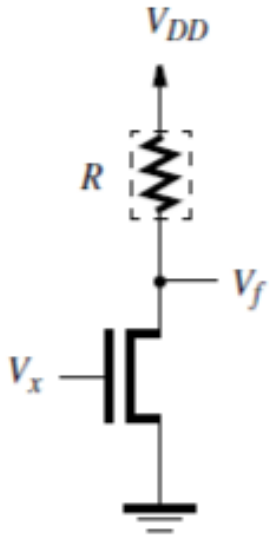


PMOS if V_G = 5 V, then V_S \ne V_D
if V_G = 0 then V_S = V_D

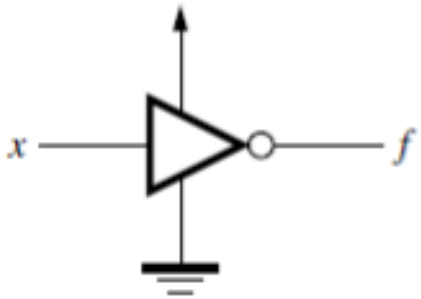

Voltage
5 V
V_{DD}
Logic value 1
3.5 V
$V_{1,min}$
Undefined
0.2 V
$V_{0,max}$
Logic value 0
0 V
V_{SS} (Gnd)

NMOS Circuits



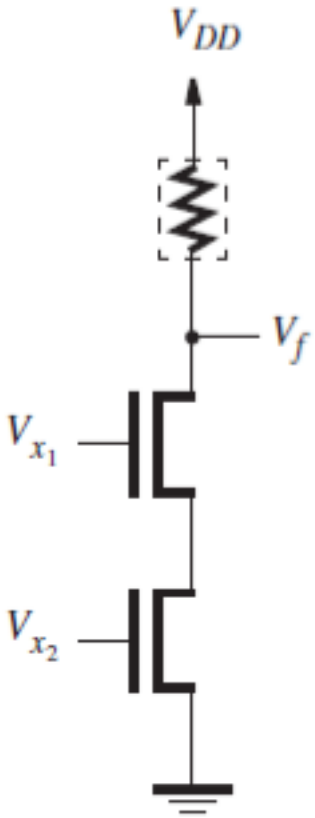


$V_x = 5\ V, V_f = 0.2\ V$
$V_x = 0\ V, V_f = 5\ V$



Pull down network/circuit

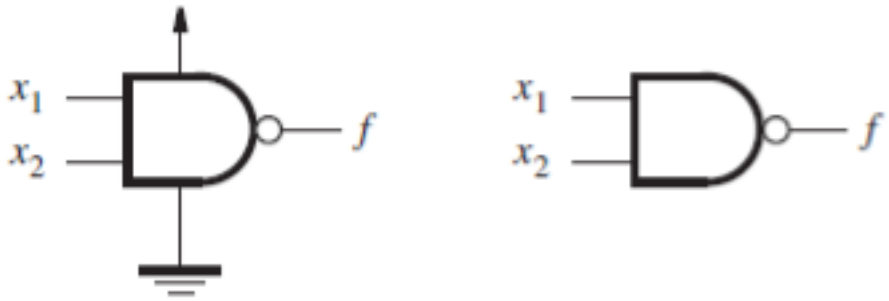
NMOS NAND gate



(a) Circuit

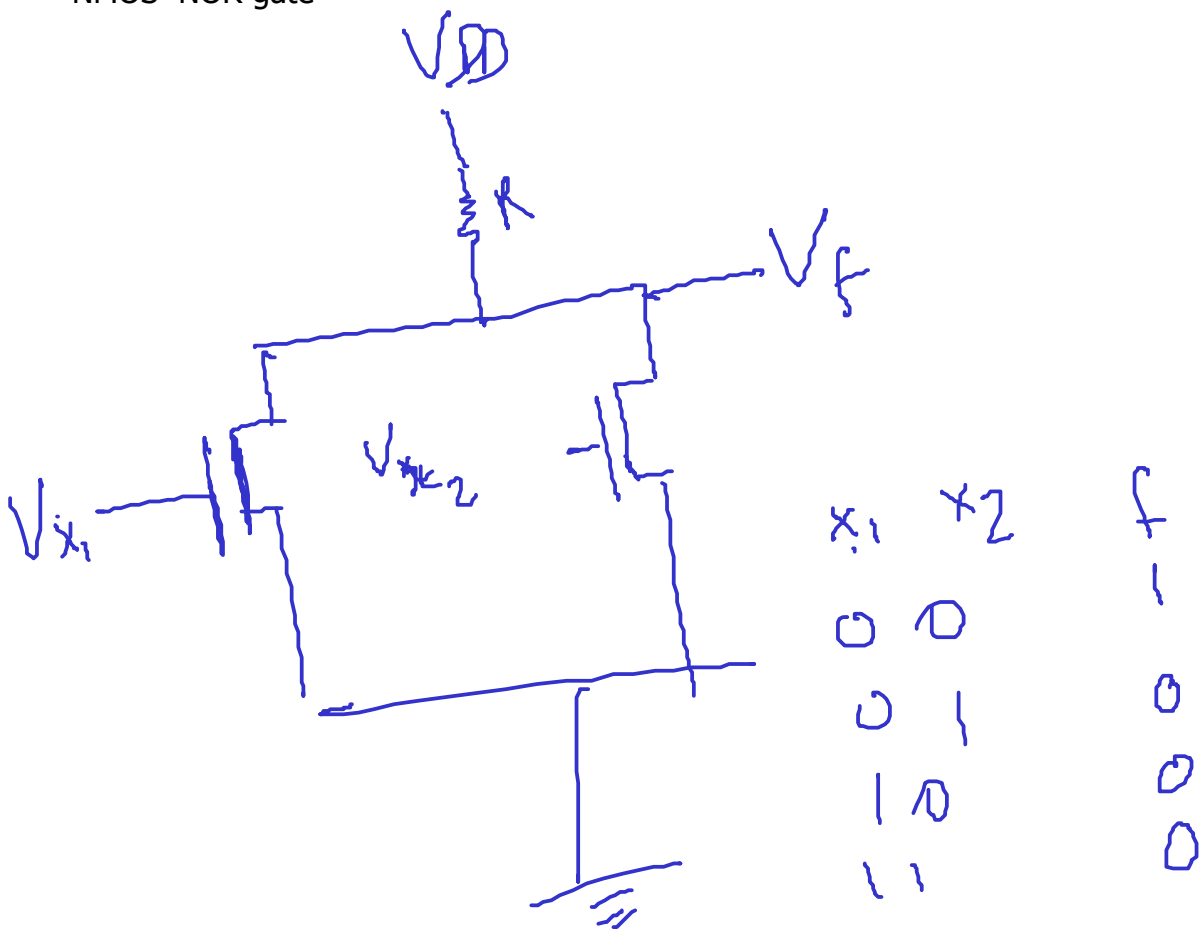
x_1	x_2	f
0	0	1
0	1	1
1	0	1
1	1	0

(b) Truth table

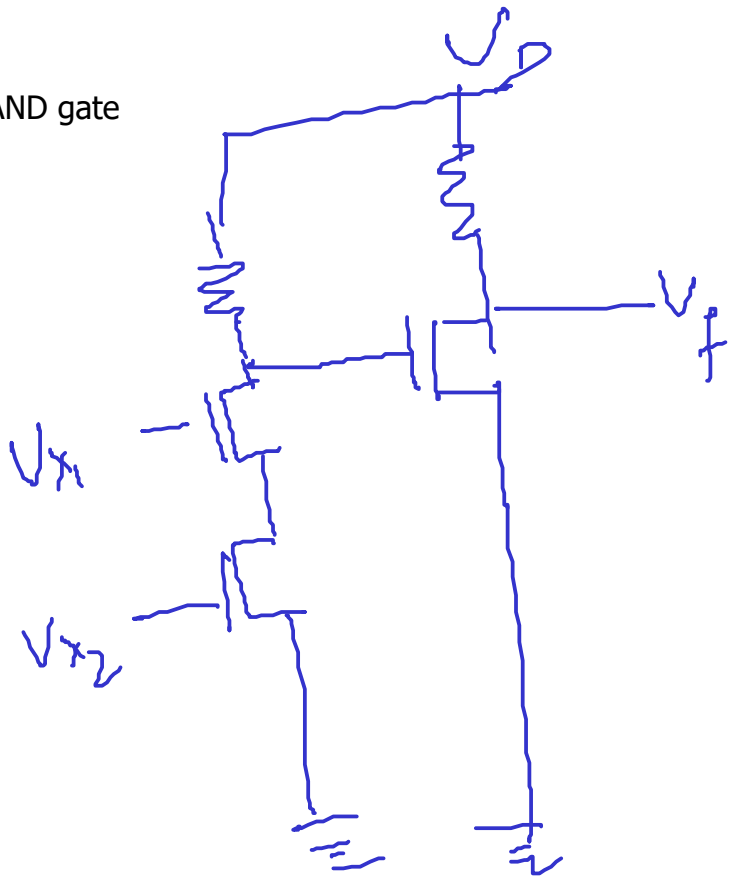


(c) Graphical symbols

NMOS NOR gate

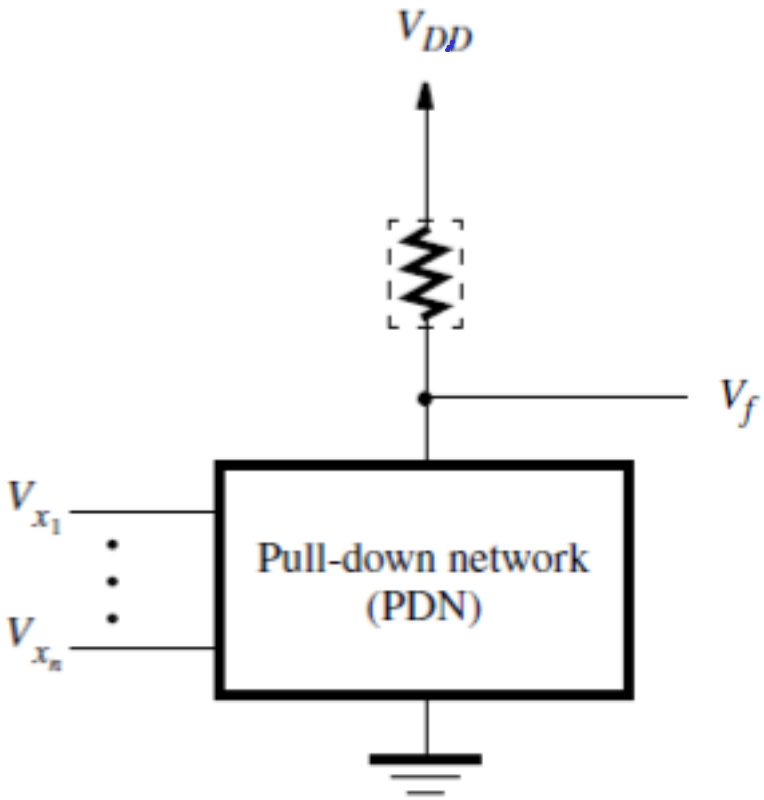


NMOS AND gate



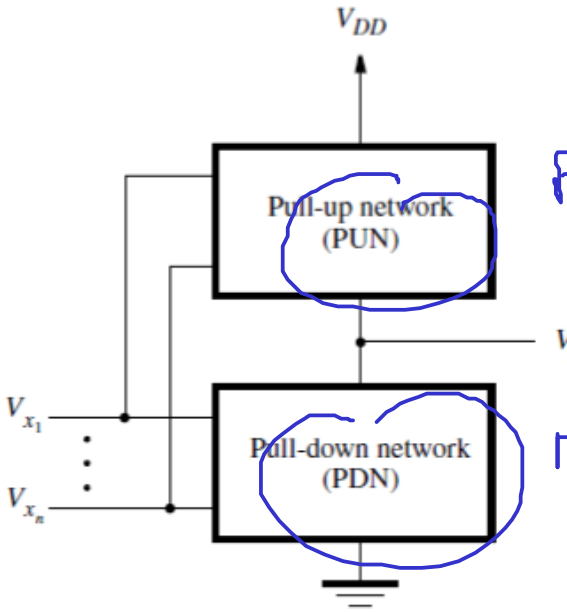
NMOS OR gate

Pull-down network

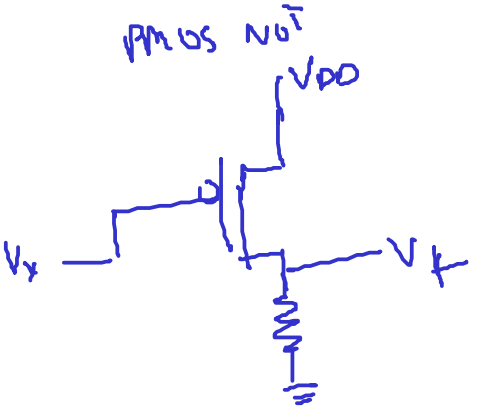


NMOS

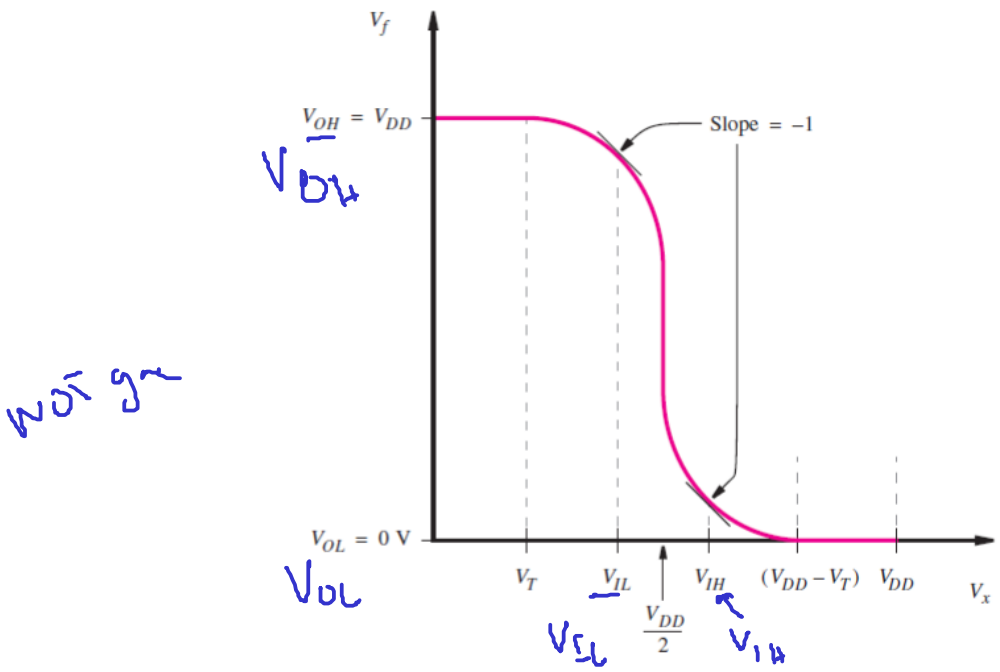
CMOS logic circuit



CMOS NOT gate



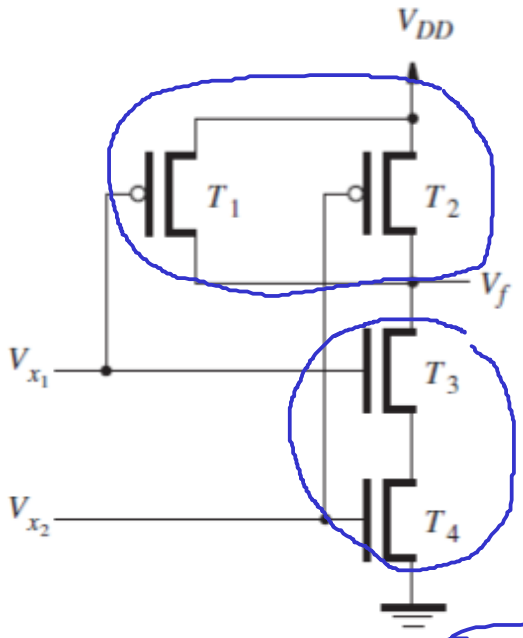
x	T_1	T_2	f
0	on	off	1
1	off	on	0



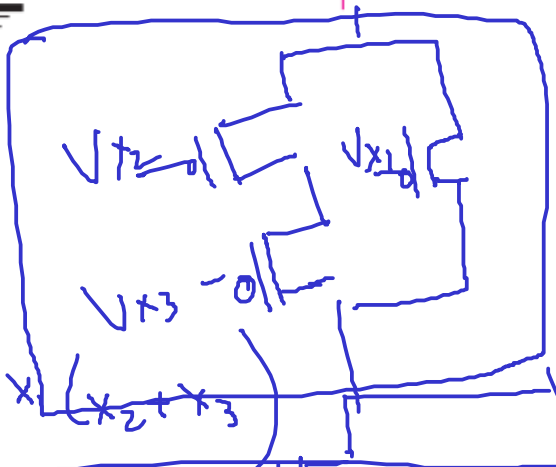
CMOS NAND gate

$f = \overline{x_1 \cdot x_2}$

$\bar{f} = \bar{x}_1 + \bar{x}_2$

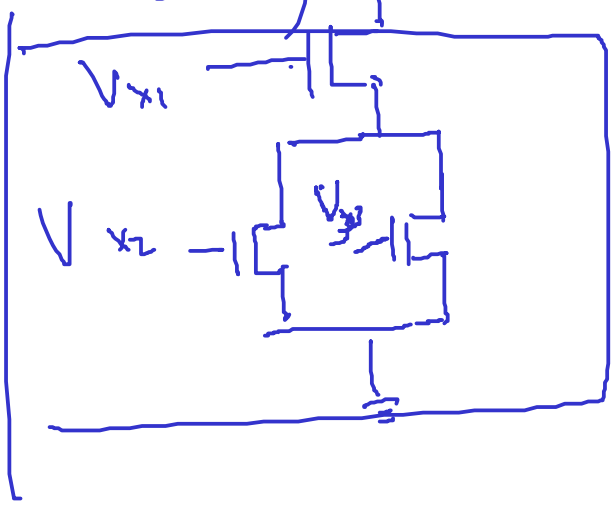


x_1	x_2	T_1	T_2	T_3	T_4	f
0	0	on	on	off	off	1
0	1	on	off	off	on	1
1	0	off	on	on	off	1
1	1	off	off	on	on	0



CMOS transistor

$f = x_1x_2 + x_1x_3 = x_1(x_2 + x_3)$



Pull down network

$\bar{f} = \bar{x}_1 + \bar{x}_2 \cdot \bar{x}_3$