Introduction to Digital Integrated Circuits

Workshop-CANELOS24

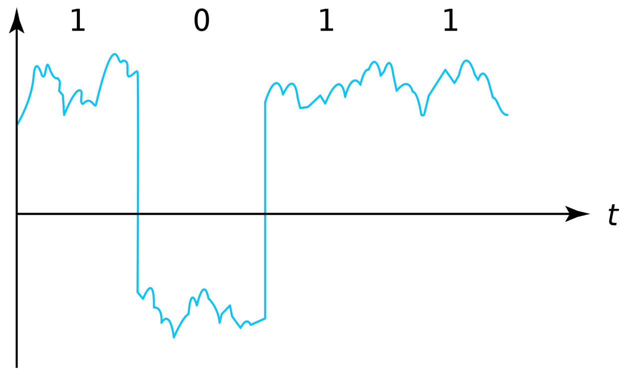
EX UMBRA IN SOLEM
UNIVERSIDAD TECNICA FEDERICO SANTA MARIA

IEEE

ChipUSM

Sistemas Digitales

Digital Signal: A signal that represents information as a sequence of discrete values.



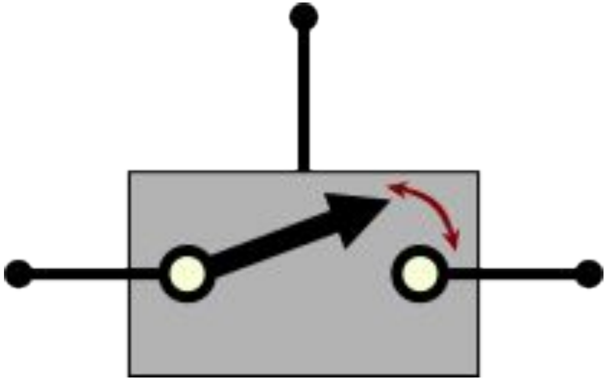
In a **binary** system, values are either 0 or 1.

Why Binary? → It comes from the hardware!

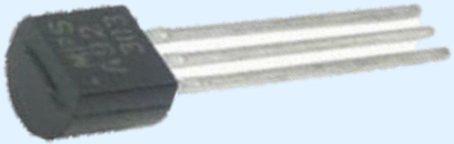
- Switching devices
- Ease of distinguishing 2 states

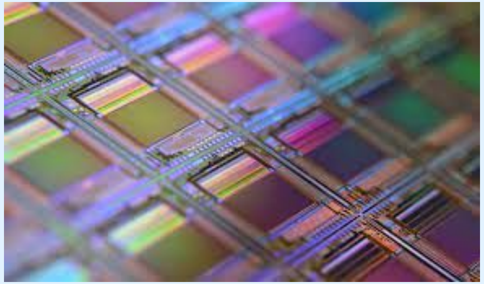
Switching Devices

(switches)



75 years of the MOS transistor

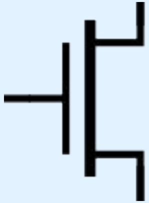


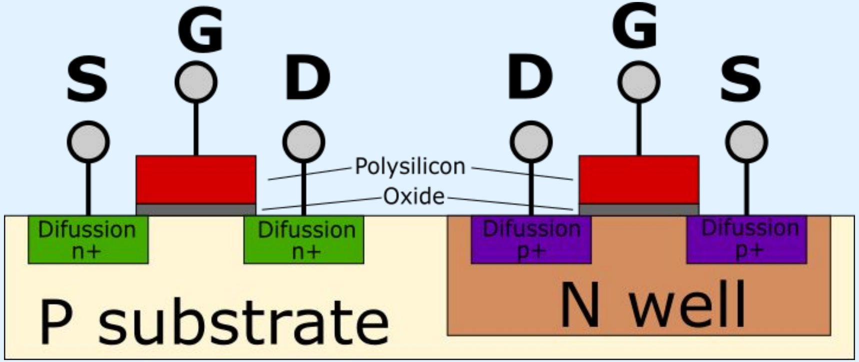


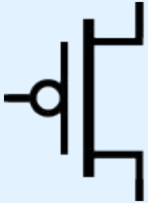
The ultimate switch

- activated by voltage
- simple geometry
- scalable for mass production

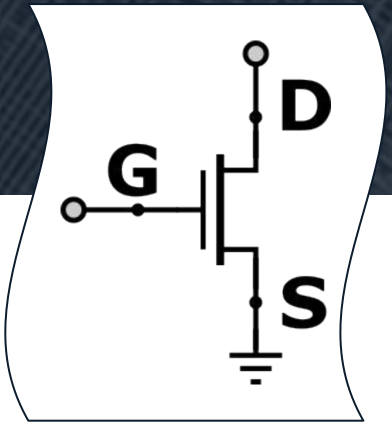
→ predominant in today's technology



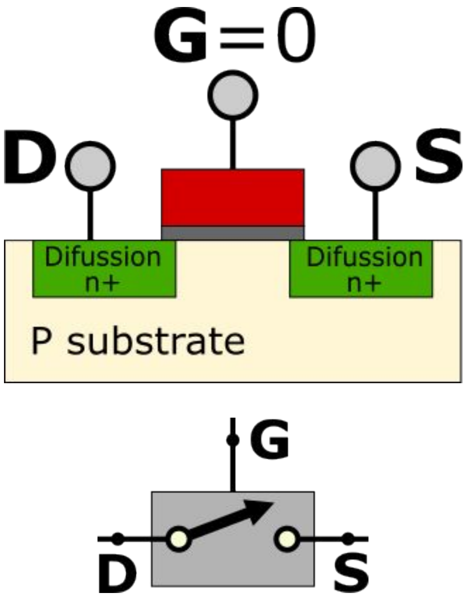


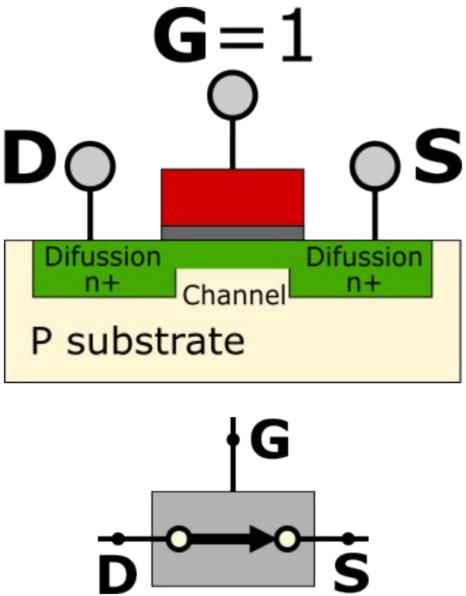


Operation

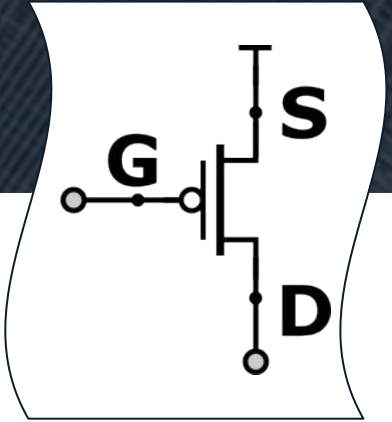


Digital Operation of an NMOS

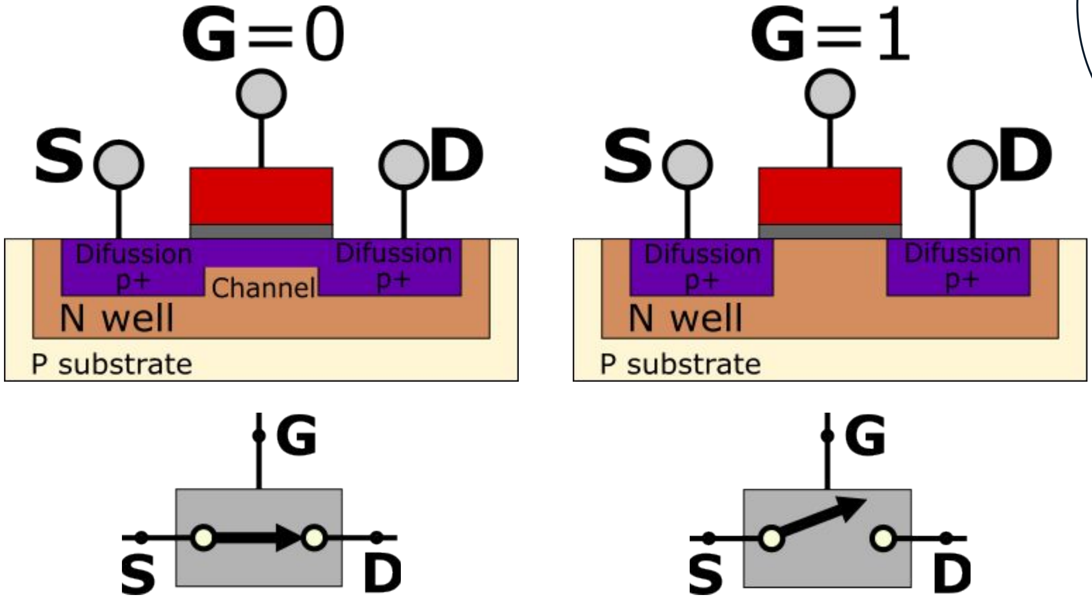




Operation

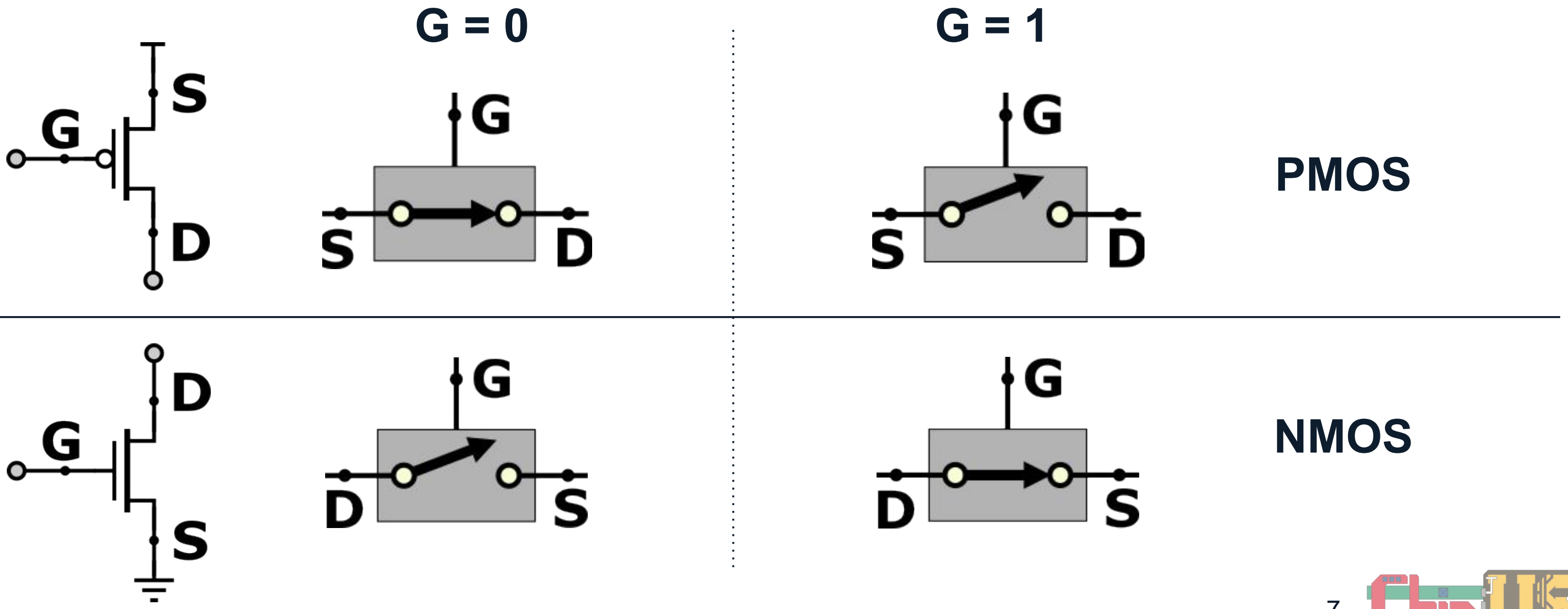


Digital Operation of an PMOS



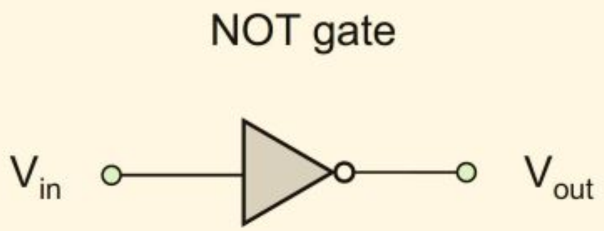
Operation

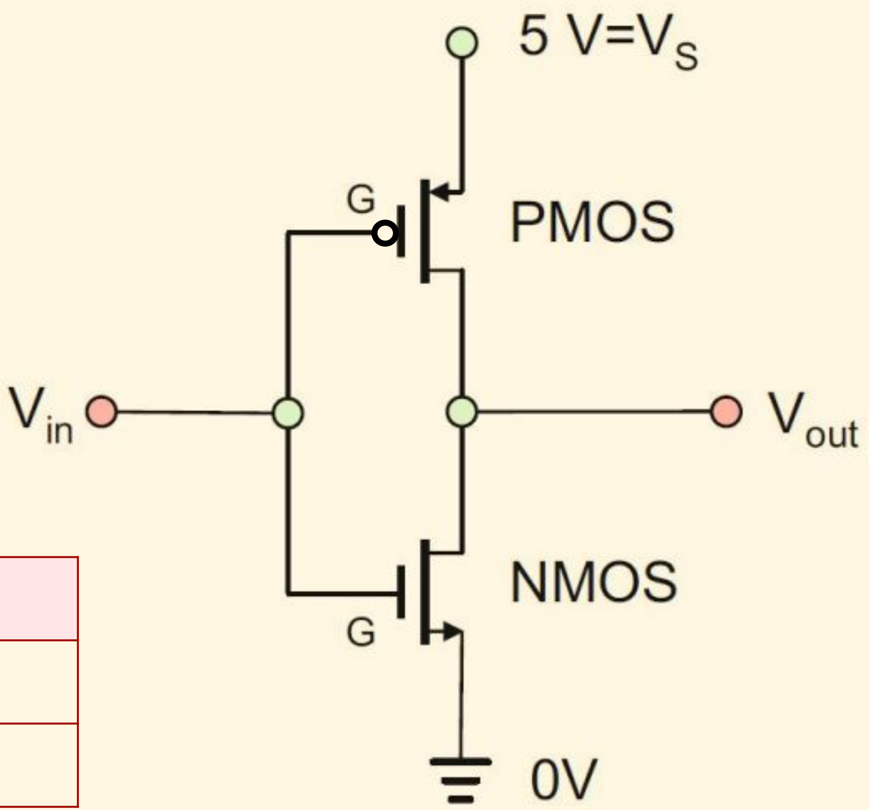
Complementary operation of NMOS and PMOS



CMOS logic gates

NOT gate

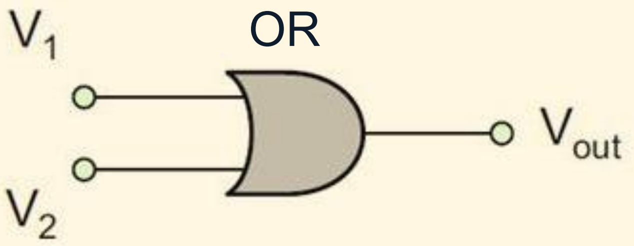


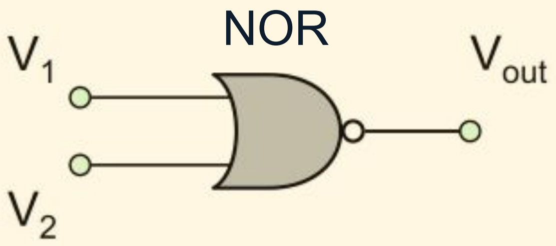


V_{in}	V_{out}
0	1
1	0

Truth table

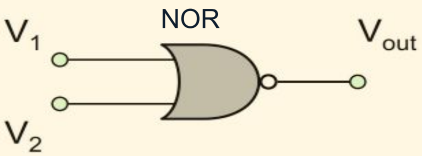
OR and NOR gates

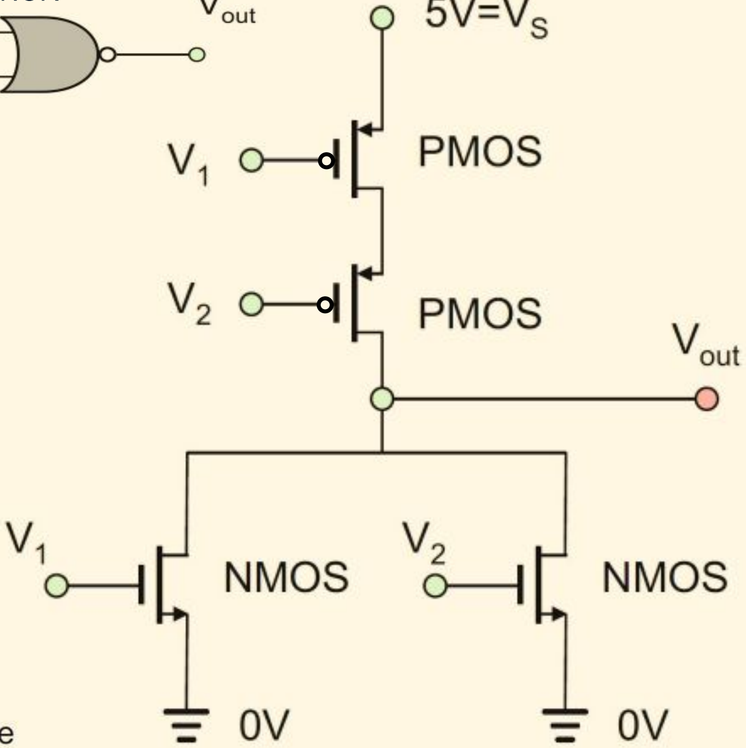




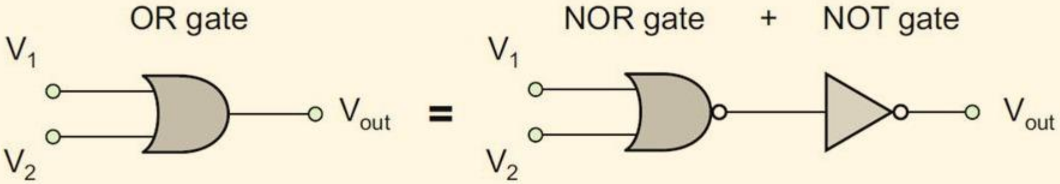
V_1	V_2	OR: $V_{out,or}$	NOR: V_{out}
0	0	0	1
0	1	1	0
1	0	1	0
1	1	1	0

OR and NOR gates

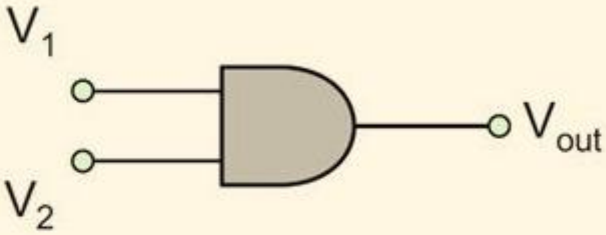


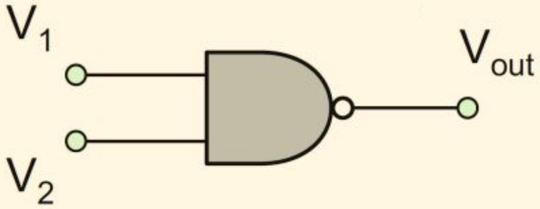


V_1	V_2	NOR, V_{out}
0	0	1
0	1	0
1	0	0
1	1	0



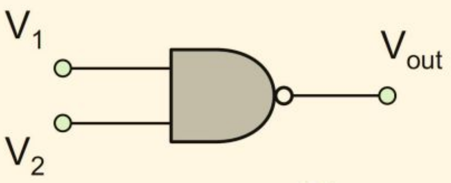
AND and NAND gates



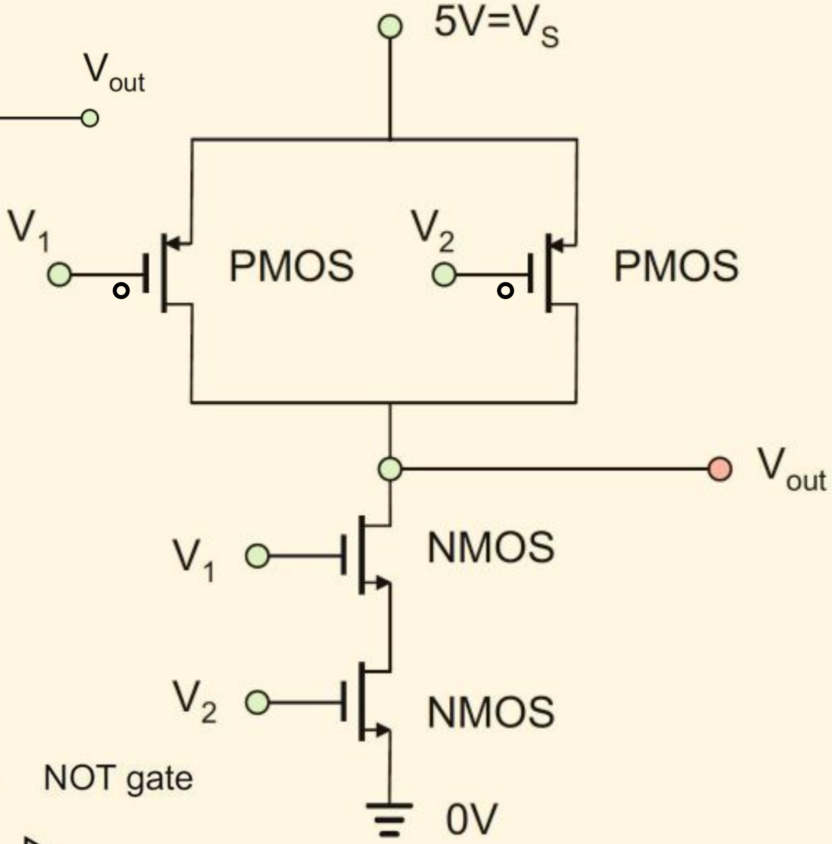


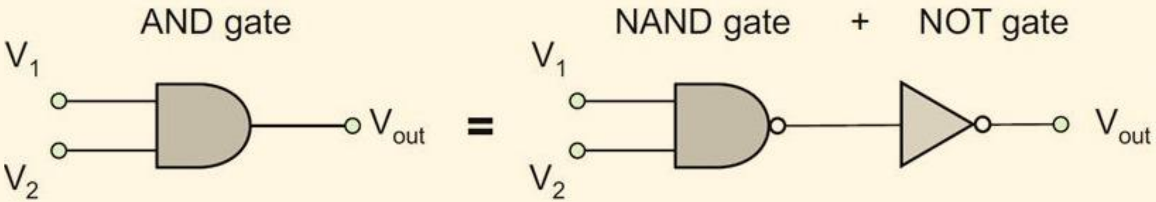
V_1	V_2	AND, V_{out}	NAND, V_{out}
0	0	0	1
0	1	0	1
1	0	0	1
1	1	1	0

NAND gate

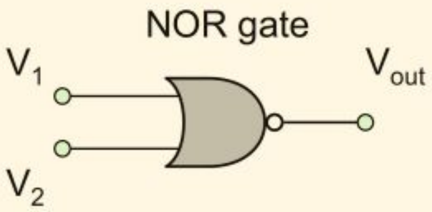


V_1	V_2	NAND, V_{out}
0	0	1
0	1	1
1	0	1
1	1	0

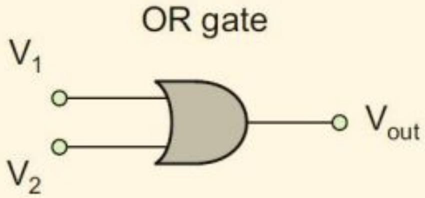




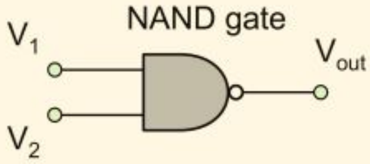
Logic gates



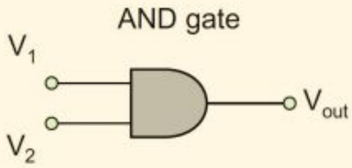
X	Y	V_{out}
0	0	1
0	1	0
1	0	0
1	1	0



X	Y	V_{out}
0	0	0
0	1	1
1	0	1
1	1	1



X	Y	V_{out}
0	0	1
0	1	1
1	0	1
1	1	0



X	Y	V_{out}
0	0	0
0	1	0
1	0	0
1	1	1

Boolean Algebra

Axioms and Properties

$A + 0 = A$

$A + 1 = 1$

$A \cdot 0 = 0$

$A \cdot 1 = A$

$A + A = A$

$A + \bar{A} = 1$

$A \cdot A = A$

$A \cdot \bar{A} = 0$

$\bar{\bar{A}} = A$

Commutativity of addition: $A + B = B + A$

Commutativity of the product: $A \cdot B = B \cdot A$

Associativity of addition: $A + (B + C) = (A + B) + C$

Associativity of the product: $A \cdot (B \cdot C) = (A \cdot B) \cdot C$

Distributivity of addition: $A + (B \cdot C) = (A + B) \cdot (A + C)$

Distributivity of the product: $A \cdot (B + C) = A \cdot B + A \cdot C$

Note: Two expressions are equivalent <u>if and only if</u> they have the same truth table.

De Morgan's Law

$$\overline{A + B} = \overline{A} \cdot \overline{B}$$

$$\overline{A \cdot B} = \overline{A} + \overline{B}$$

Any Questions?