

Introduction to Digital Integrated Circuits

Workshop-CANELOS24



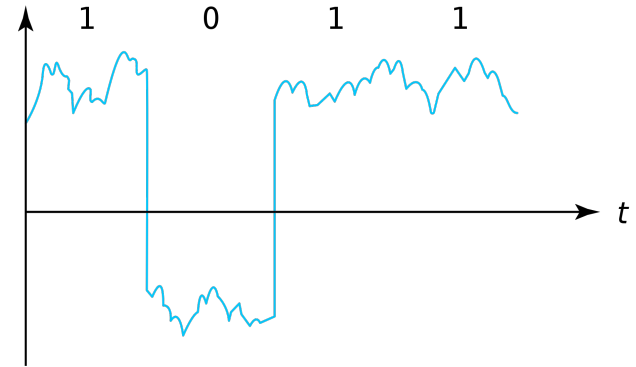
UNIVERSIDAD TECNICA
FEDERICO SANTA MARIA



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?

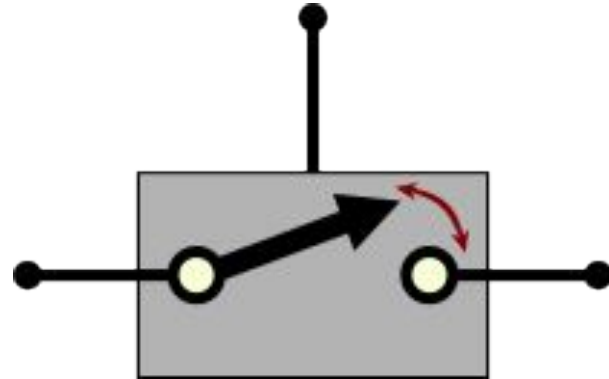


It comes from the hardware!

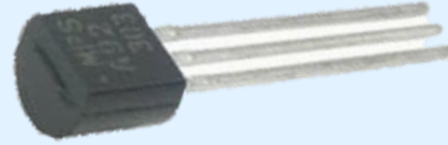
- Switching devices
- Ease of distinguishing 2 states

Switching Devices

(switches)

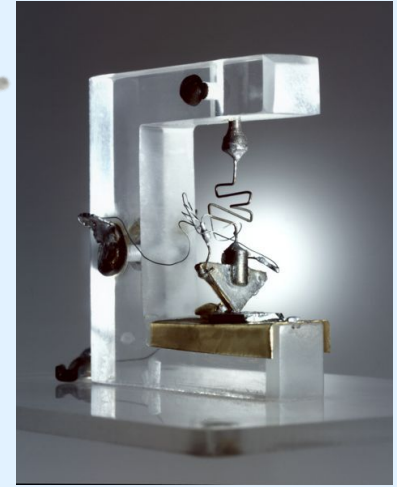
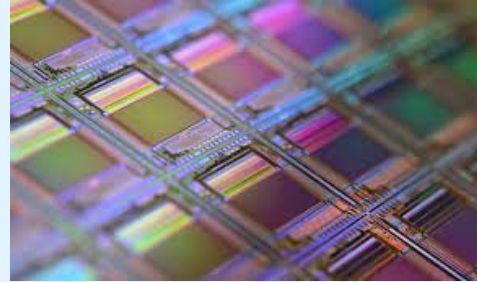


75 years of the MOS transistor

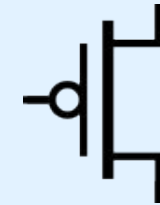
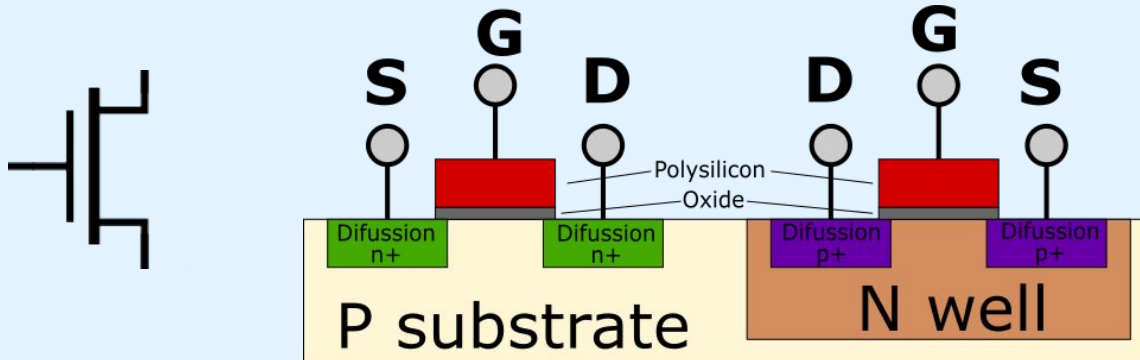


The ultimate switch

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

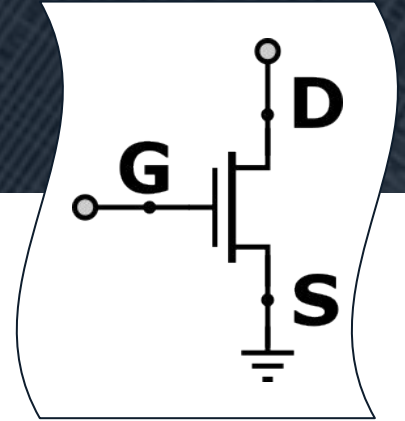
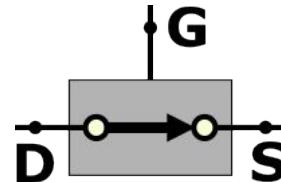
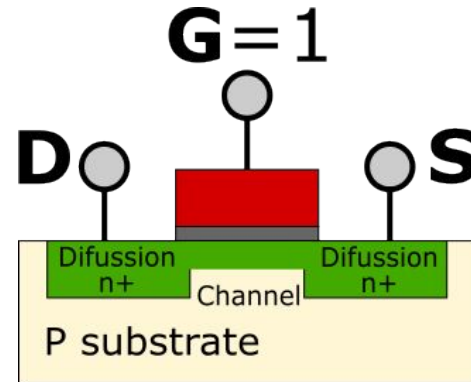
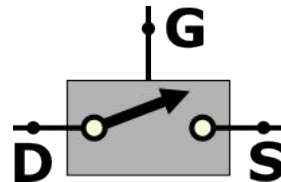
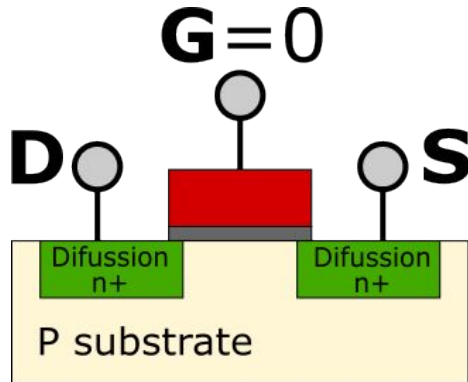


➔ predominant in today's technology



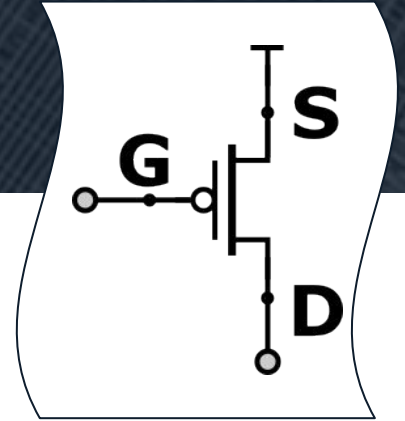
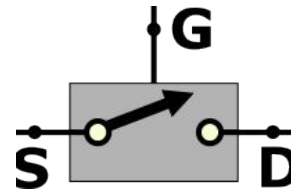
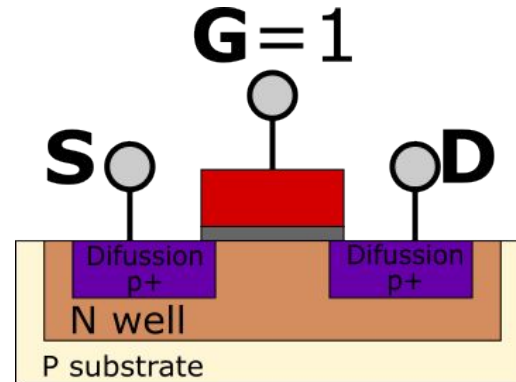
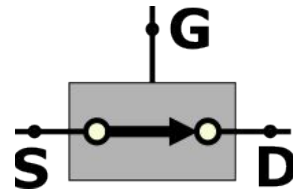
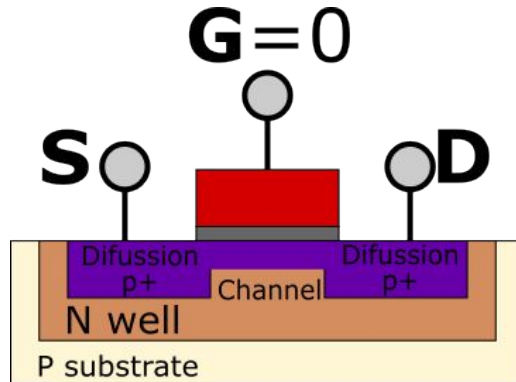
Operation

Digital Operation of an NMOS



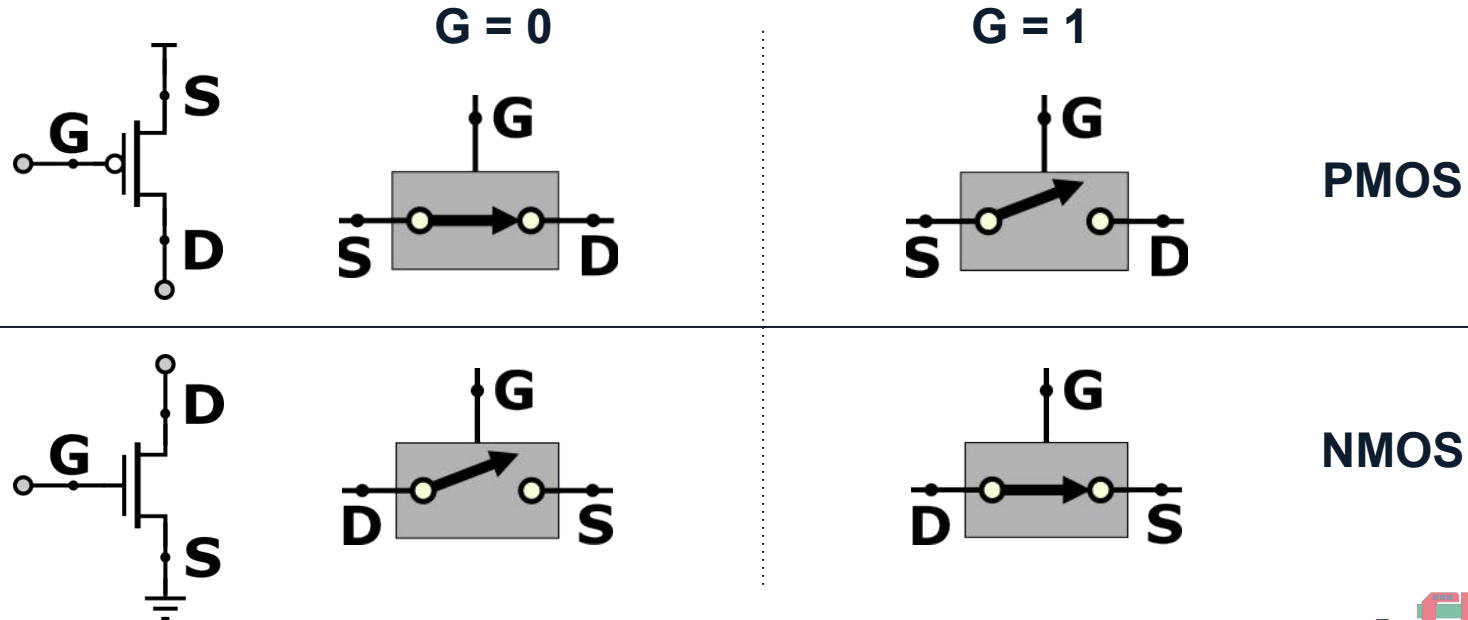
Operation

Digital Operation of an PMOS



Operation

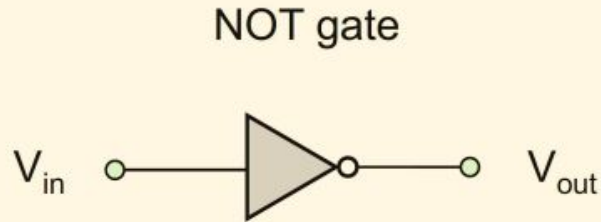
Complementary operation of NMOS and PMOS



A microscopic view of a silicon chip, showing a dense grid of rectangular logic gates and intricate circuitry. The gates are arranged in a regular pattern, with various interconnecting lines and smaller components visible between them. The overall color is a golden-yellow, typical of silicon. The text "CMOS logic gates" is overlaid in the center in a bold, black, sans-serif font.

CMOS logic gates

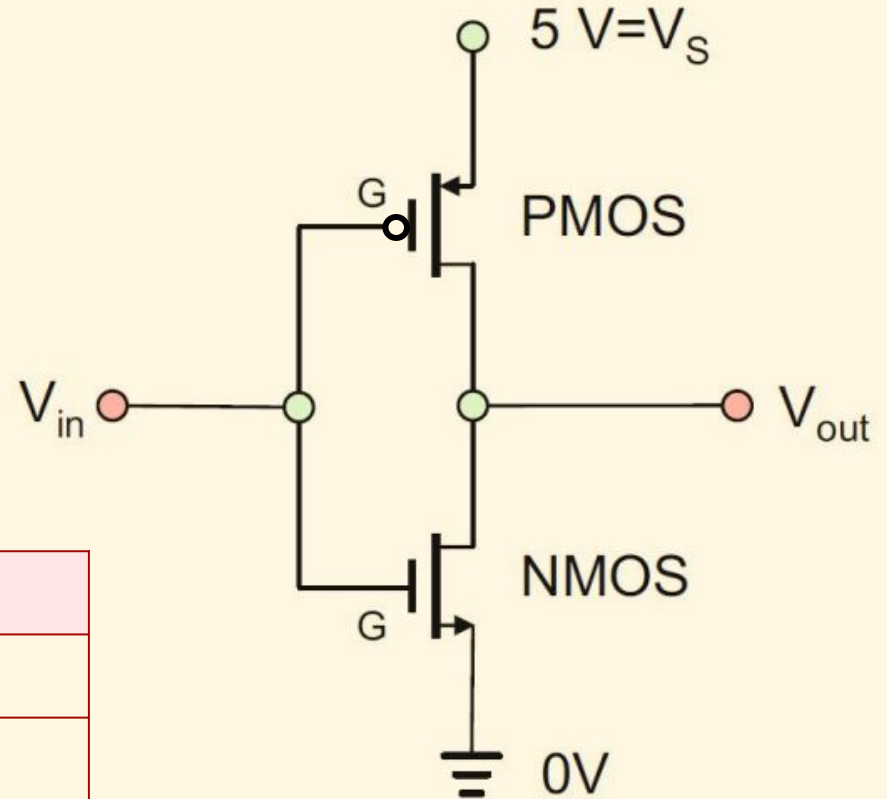
NOT gate



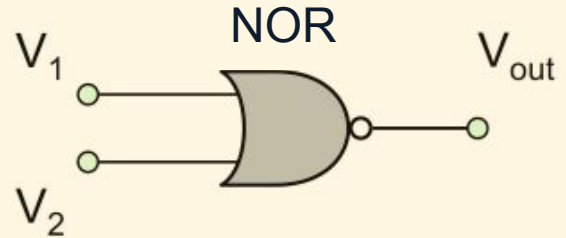
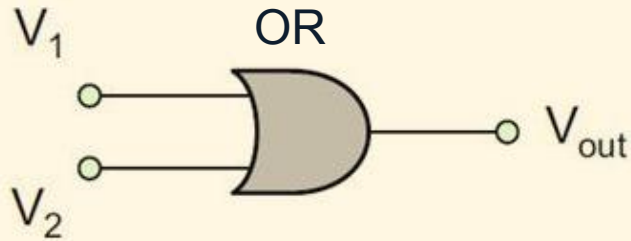
V_{in}	V_{out}
0	1
1	0



Truth table

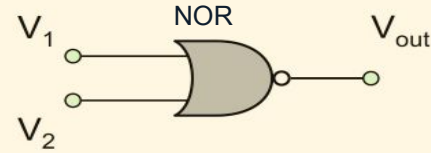


OR and NOR gates

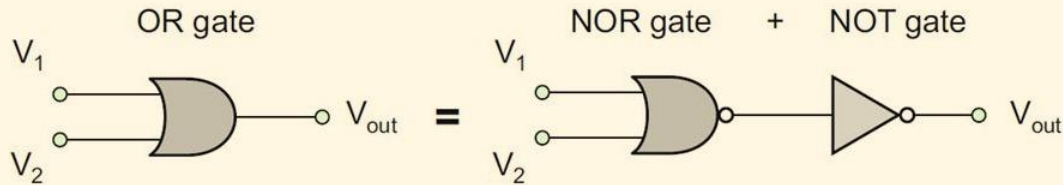
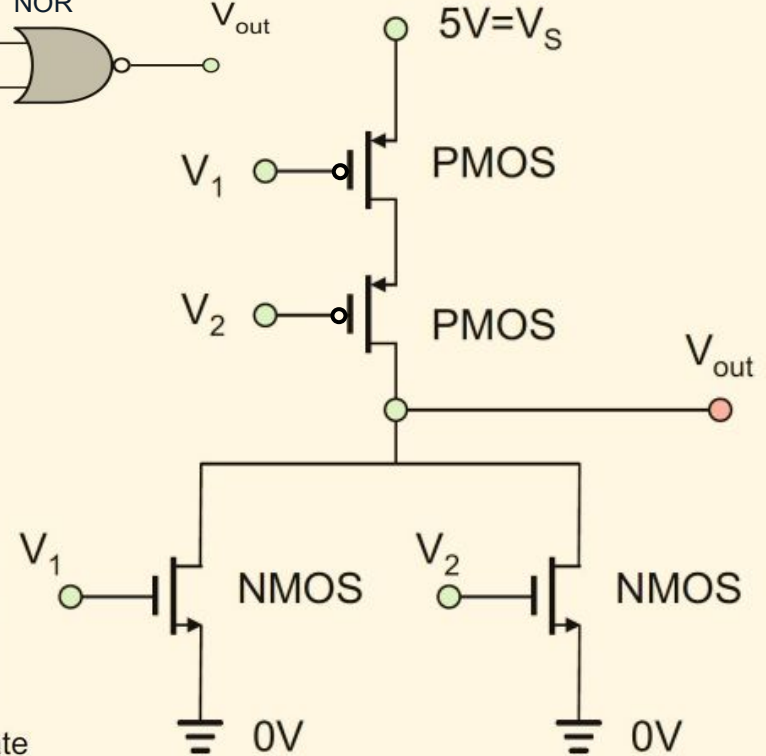


V_1	V_2	OR: $V_{out,or}$	NOR: V_{out}
0	0	0	1
0	1	1	0
1	0	1	0
1	1	1	0

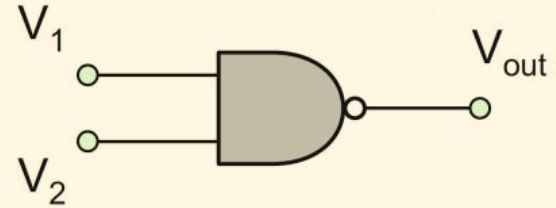
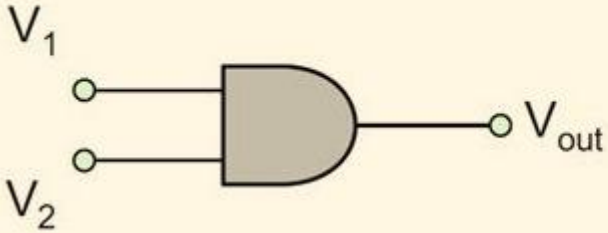
OR and NOR gates



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

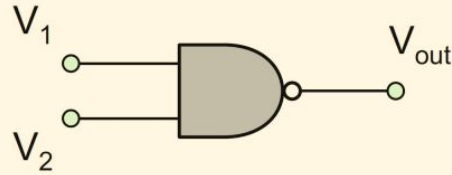


AND and NAND gates

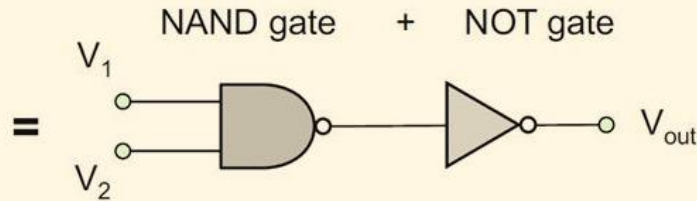
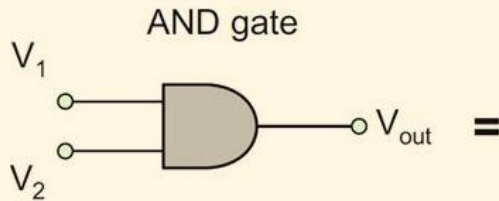
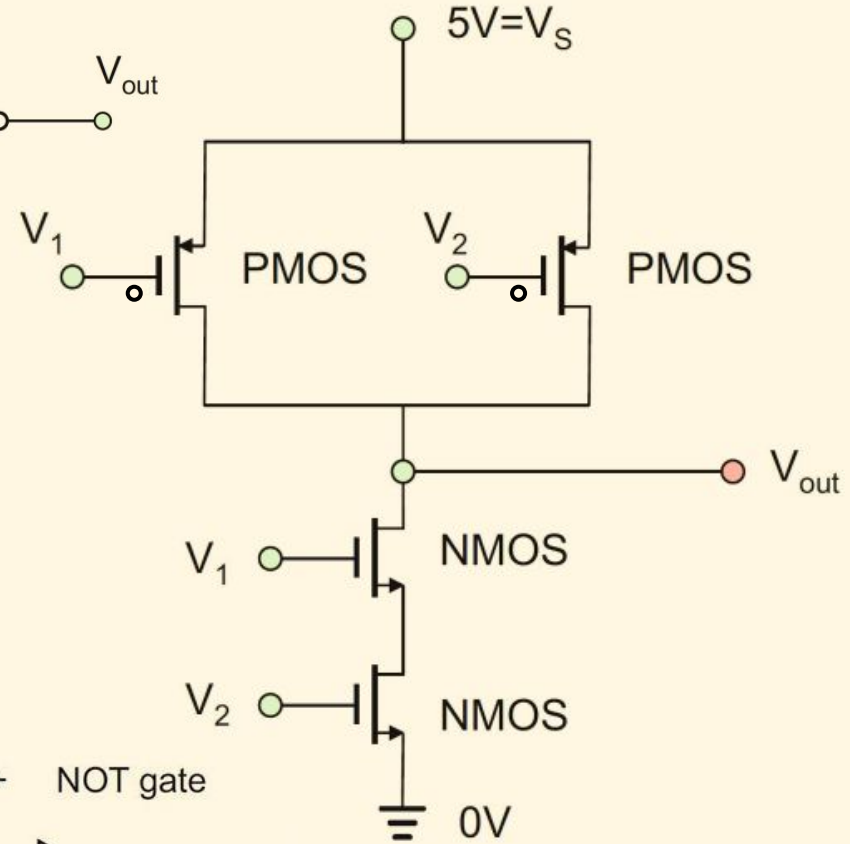


V_1	V_2	AND, V_{out}	NAND, V_{out}
0	0	0	1
0	1	0	1
1	0	0	1
1	1	1	0

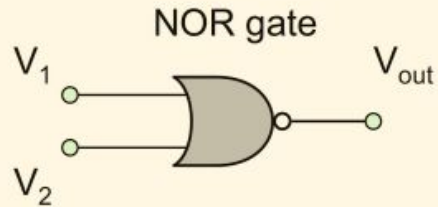
NAND gate



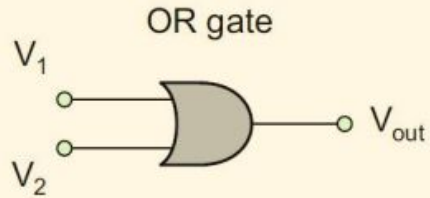
V_1	V_2	NAND, V_{out}
0	0	1
0	1	1
1	0	1
1	1	0



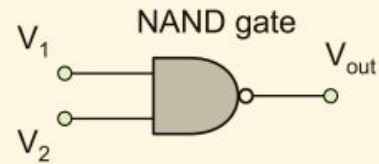
Logic gates



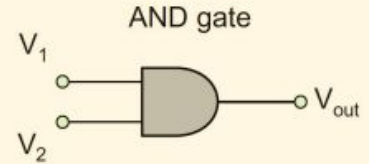
X	Y	V_{out}
0	0	1
0	1	0
1	0	0
1	1	0



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

A detailed, high-magnification photograph of a microchip, showing a complex grid of various colored rectangular blocks (dielectric, metal, and semiconductor) and fine circuit lines. The image is tilted at an angle, giving it a dynamic feel. The colors are muted, with shades of green, blue, and brown dominating the palette.

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 if and only if they have the same truth table.

De Morgan's Law

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

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



Any Questions?