2-input gates

The AND gate

$Y = AB$

$Y = A \cdot B$

Truth table:

A	B	Y
0	0	0
0	1	0
1	0	0
1	1	1

← AND operation produces 1 only when A and B are 1.

The OR gate

$Y = A + B$

This is "logical addition," written confusingly with '+',

Truth table

A	B	Y
0	0	0
0	1	1
1	0	1
1	1	1

← OR produces a 1 when either or both A or B is true.

Two interpretations of '+'

arithmetic: $1 + 1 = 10_2$ (binary)

$1 + 1 = 2_{10}$ (decimal)

logical: $1 + 1 = 1$

Some math math texts use $1 \vee 1 = 1$ for logical addition.

↑ "vee"

The AND, OR, and NOT operations are essential to implement logic functions.

Other 2-input gates

The XOR (exclusive-OR) gate

$Y = A \oplus B$

Truth table

AB	Y
00	0
01	1
10	1
11	0

produces a 1 if either A or B is 1, but <u>not both</u>.

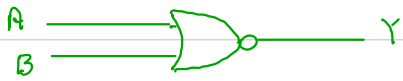
Each of the AND, OR, and XOR gates also come in inverted form

NAND (NOT-AND)

$Y = \overline{AB}$

AB	Y
00	1
01	1
10	1
11	0

NOR (NOT-OR)



$Y = \overline{A + B}$

AB	Y
00	1
01	0
11	0
10	0

XNOR (exclusive NOT-OR)

$Y = \overline{A \oplus B}$

<u>Multiple-input gates</u>

The 2-input gates are also available with 3 or more inputs (to a maximum of 8 in the 7400-series logic gates).

E.g.,

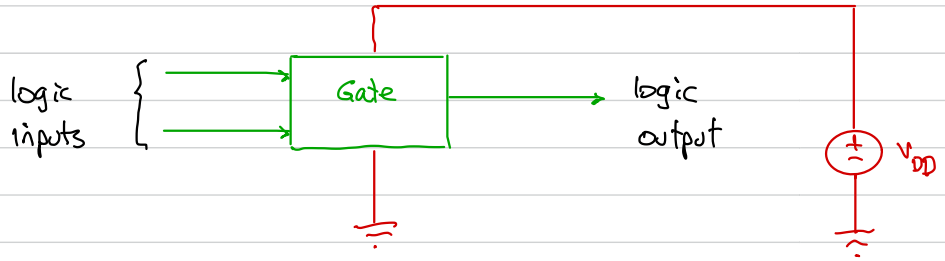
3-input NAND $Y = \overline{ABC}$

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

Logic gates as electric circuits

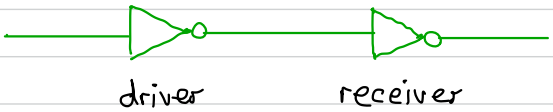
Logic gates operate on binary signals. Logic 1 and 0 are represented by ranges of actual voltages.

Gates themselves are electronic circuits and require an external power supply.

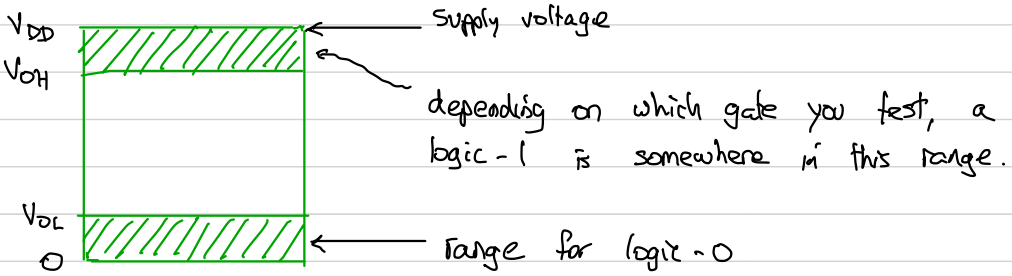


For 7400-series devices, $V_{DD} = 5V$. More modern devices use V_{DD} as low as 1.2V, or less.

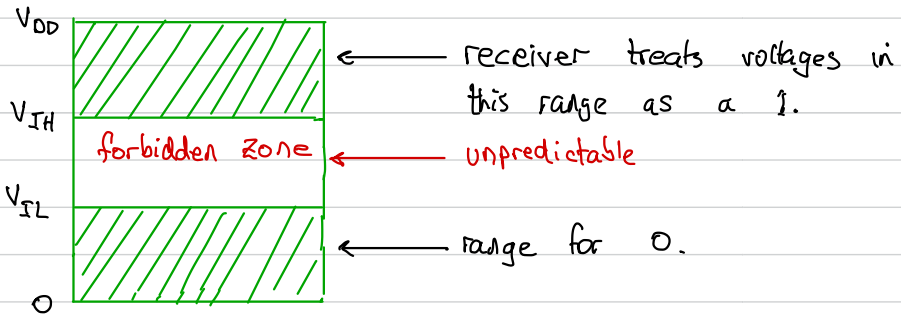
Logic levels: Consider two NOT gates in series



Consider the output voltage of the driver



Consider the input voltage of the receiver



For the circuit to operate reliably:

$$V_{OH} > V_{IH}$$
$$V_{OL} < V_{IL}$$