ECE 3254 PreLab 11 notes

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Logic Gates

Logic in its ordinary sense is defined as a branch of philosophy that deals with what is true and false, based on what other things are true and false.[1] A logic gate is an arrangement of controlled switches used to calculate operations using Boolean algebra in digital circuits.[2] Some Boolean algebra identities and rules:

· is AND (A·B = A *AND* B). + is OR; (A+B = A *OR* B). $\overline{\ }$ is NOT; ($\overline{A}$ is A inverted).

$\overline{\overline{A}} = A$. $A \cdot A = A$ $A \cdot \overline{A} = 0$ $A + A = A$ $A + \overline{A} = 1$

$A+B = B+A$ $(A+B)+C = A+(B+C)$ $A \cdot B = B \cdot A$ $(A \cdot B) \cdot C = A \cdot (B \cdot C)$

$A \cdot (B+C) = A \cdot B + A \cdot C$

Demorgan's Theorem: $\overline{A \cdot B} = \overline{A} + \overline{B}$, $\overline{A+B} = \overline{A} \cdot \overline{B}$

Diode and resistor arrays were used to create early AND and OR logic gate functions. These were quickly succeeded by diode/transistor (DTL) arrays that were capable of more complex functions. DTL logic was replaced by transistor/transistor logic (TTL logic is still in use today). With the development of the MOSFET chip transistors, faster and more efficient complimentary MOS (CMOS) logic became possible. Advances in low power CMOS technology are rapidly making the BJT transistor logic families obsolete.

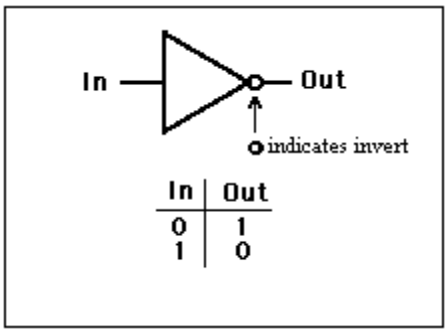
A Logic table (truth-table) is used to describe the functional relationship between inputs and output(s) of a logic device. A logic low, represented by "Logic 0", corresponds to voltage near 0V. A logic high, represented by "Logic 1", corresponds to a voltage near the 5V supply. The Voltage Values vs. Logic Levels for an ideal 7400 series TTL gate are shown in the table below.

Voltage Value		**Logic Level**	
Input	Output Y	Input	Output
0V	+5V	0	1
0V	+5V	0	1
+5V	+5V	1	1
+5V	0V	1	0

The actual output voltages are slightly different for the various 7400 families.

- The original 7400 series used TTL (transistor-to-transistor) BJT logic.
- 74S series uses Schottky BJT transistors
- 74LS uses low power Schottky BJT transistors
- 74ALS uses advanced (high speed) low power Schottky BJT transistors
- 74C uses CMOS transistors
- 74HC uses high speed CMOS transistors
- 74HCT uses high speed CMOS adjusted to TTL levels

Note: The 74C and 74HC logic levels are not compatible with the other 74, 74S, and 74LS series gates.

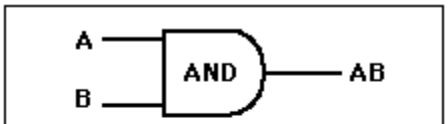


In	Out
0	1
1	0

NOT Gate 7404

Simple inverter.

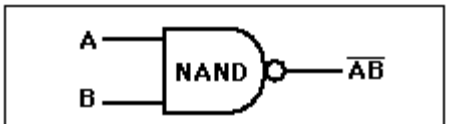
Gives an output of "1" when its input is "0".



A	B	Out
0	0	0
0	1	0
1	0	0
1	1	1

AND Gate 7408

Gives an output of "1" only when all of its inputs are "1".



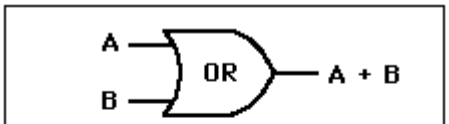
A	B	Out
0	0	1
0	1	1
1	0	1
1	1	0

NAND Gate 7400

NAND = NotAND (inverted AND).

Gives an output of "0" only when all of its inputs are "1".

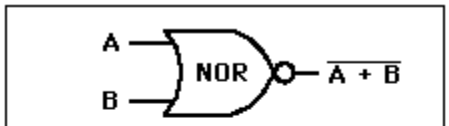
The NAND gate has the important quality of being “functionally complete.” All other gates can be derived using only NAND gates.



A	B	Out
0	0	0
0	1	1
1	0	1
1	1	1

OR Gate 7432

Gives an output of "0" only when all of its inputs are "0".



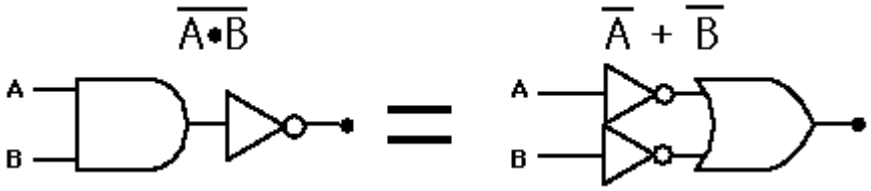
A	B	Out
0	0	1
0	1	0
1	0	0
1	1	0

NOR Gate 7402

Gives an output of "1" only when all of its inputs are "0".

Demorgan's Theorem provides a way to build logic functions from simple gates.

$\overline{A \cdot B} = \overline{A} + \overline{B}$ (means that NAND = OR with its inputs inverted).



Similarly, $\overline{A+B} = \overline{A} \cdot \overline{B}$ (means that NOR = AND with its inputs inverted)

References:
1 http://www.semiconfareast.com/logicgates.htm
2 http://en.wikipedia.org/wiki/Logic_gate