

Combinatorial Circuits

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(Lecture adapted from Lionel Morel)

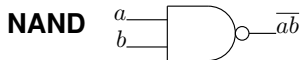
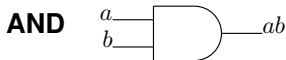
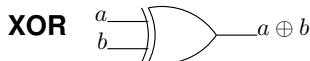
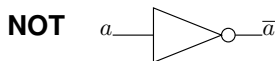
Computer Science and Information Technologies - INSA Lyon

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- ▶ Until now we have seen how to compute logical functions using Boole algebra
- ▶ Now, we will show how to implement these logical functions into digital circuits

Logical gates and circuits

Logical gates are the basic building blocks of digital circuits :



A **logical signal** is a physical mean of transmitting a truth value from one place to another. We represent them as wires.

From the outside, a **logical circuit** shows input and output signals: **every output signal is a function of the input signals (possibly a subset of).**

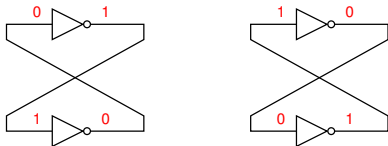
Assembly rules - combinational circuits

Combinatorial Logical Circuits (CLC) can be defined recursively:

- ▶ as a gate
- ▶ as a wire
- ▶ as a side-by-side juxtaposition of 2 CLCs
- ▶ by connecting the outputs of a CLC to inputs of **another** CLC
- ▶ by connecting inputs of a CLC together.

This definition forbids:

- ▶ to make cycles, because they introduce undefined behaviors, eg



- ▶ to connect outputs with each other (what if an output is 1 and the other is 0?)

Blackboard Example

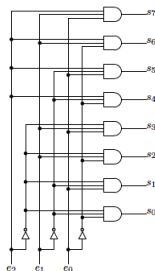
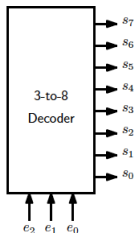
Decoder

A decoder n to 2^n is a circuit with:

- ▶ n inputs e_i , encoding an integer $(e_{n-1} \dots e_0)_2$;
- ▶ 2^n outputs s_i , indexed from 0 à $2^n - 1$.

The only active output line is $s_{(e_{n-1} \dots e_0)_2}$.

E.g., a 3-to-8 decoder



Blackboard example: Building a 2-to-4 decoder from its truth table.

Multiplexer

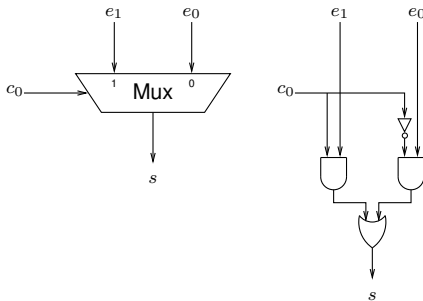
A 2^n to 1 multiplexer is a circuit with:

- ▶ 2^n inputs e_i indexed from 0 to $2^n - 1$;
- ▶ n selection lines, encoding the integer $(c_{n-1} \dots c_0)_2$;
- ▶ 1 output s .

When selection lines for the value $(c_{n-1} \dots c_0)_2$,

$$s = e_{(c_{n-1} \dots c_0)_2}.$$

E.g., a 2^1 to 1 multiplexer



Blackboard example: Building the 2 to 1 multiplexer from its truth table.

Blackboard example: 1 to 2 demultiplexer

(Another) Multiplexer

An k -bits 2^n -to-1 multiplexer is a circuit with:

- ▶ $k \cdot 2^n$ inputs and n selection lines;
- ▶ k output signals

It selects k signals among $k \cdot 2^n$ input signals

Ex : 8-bits 2-to-1 multiplexer:

