Physics Lab
ETH zürich

Electronics D (Digital)

D PHYS

Abstract

Digital electronics can be thought of as dealing with a world that is either black or white (or 0/1 or true/false or low/high), with no fuzzy grey areas between those levels. Whereas analogue design is the art of working in those grey areas.

Digital electronic circuits are usually made from assemblies of logic gates, often printed on integrated circuits (ICs), which are simple electronic representations of Boolean logic functions.

In this experiment you will learn how to operate logic gates and their basic functionality. At the end you will be able to build a stand-alone digital circuit, which you can design from your own imagination.

Setup

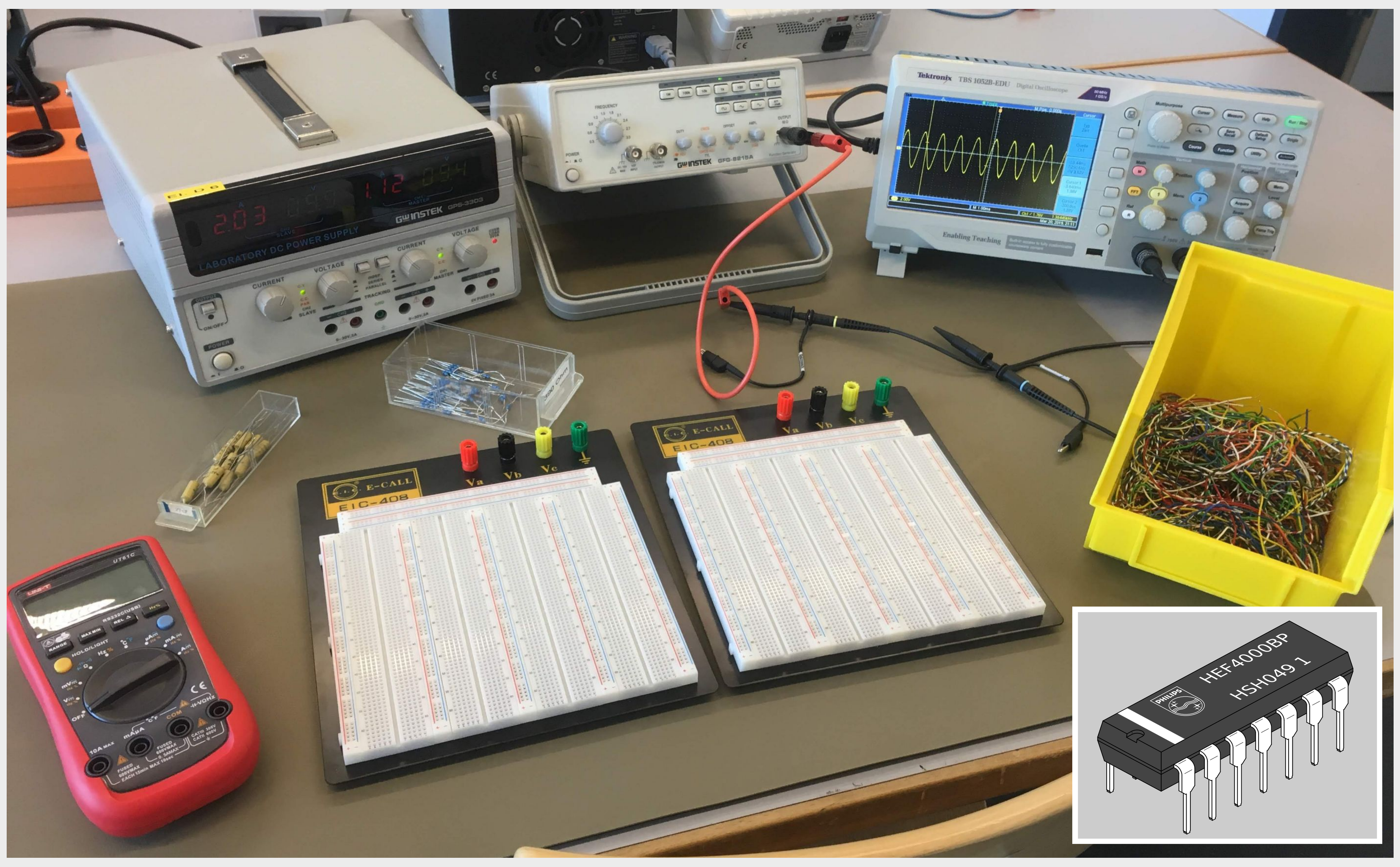


Figure: Components handed out for this experiment. An integrated circuit is shown in the inlay.

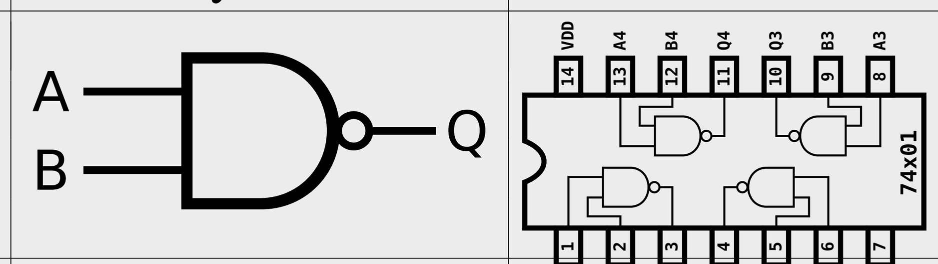
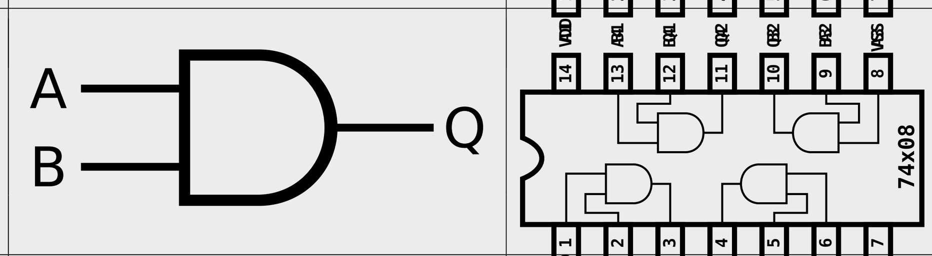
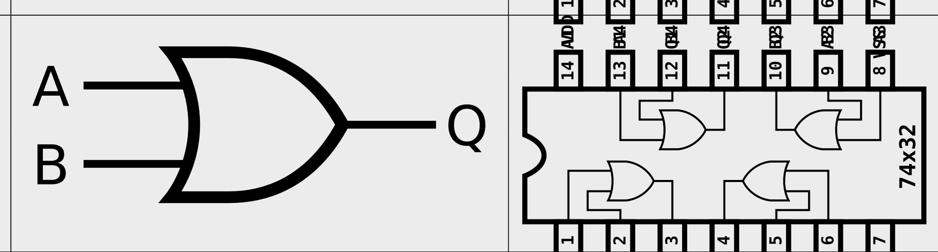
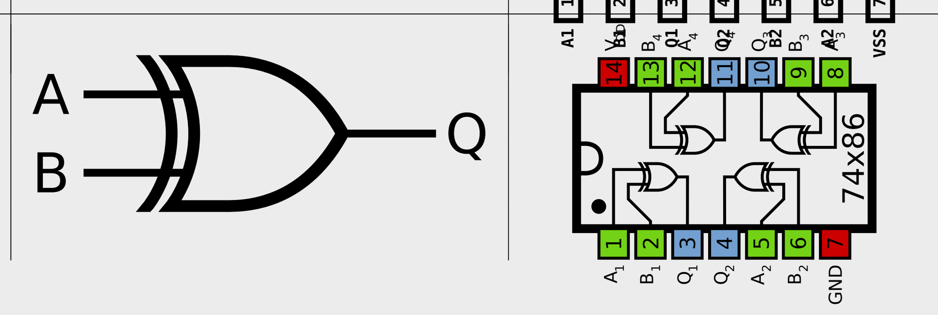
The figure above shows all the main devices provided for this experiment. In addition also several kinds of cables and passive components such as resistors and capacitors are available at the experimental site. The active components, the ICs (e.g. logic gates), and a variety of other useful materials to build electronic circuits have to be requested from the assistants. An important objective of this experiment is to get familiar with the essential tools in electronics labs such as multimeters, oscilloscopes, signal generators, etc.

Experimental Procedure

1. **Investigation of a single logic gate**
   With the help of the corresponding datasheet, you have to understand the functionality of single logic gate and verify it's specified behaviour.
2. **Construction of a pulse generator**
   Based on instructions you have to build an astable multivibrator. By drawing a time-diagram the working principle has to be understood and the limits of the circuit have to be explored by varying the values of the built-in components.
3. **Building a stand-alone circuit**
   You are encouraged to think of an own, more complex circuit, but can also choose from a list of already realised experiments. After consulting with the assistant, you have to build this circuit and demonstrate it's functionality.

Logic Gate

In electronics, a logic gate is a physical device implementing a Boolean function. It performs a logical operation on one or more binary inputs and produces a single binary output. Logic gates are primarily implemented using diodes or transistors acting as electronic switches, but can also be constructed using other parts. Logic gates can be cascaded in the same way that Boolean functions can be composed, allowing the construction of a physical model of all of Boolean logic, and therefore, all of the algorithms and mathematics that can be described with Boolean logic.

Type	Symbol / Pinout	Algebra	A	B	Q
NAND		$\overline{A \wedge B}$	0 0 1 1	0 1 0 1	1 1 1 0
AND		$A \wedge B$	0 0 1 1	0 1 0 1	1 0 0 0
OR		$A \vee B$	0 0 1 1	0 1 0 1	1 0 0 0
XOR		$A \veebar B$	0 0 1 1	0 1 0 1	0 1 1 0

Example - Full Adder

An adder is a digital circuit that performs addition of numbers. A full adder adds binary numbers and accounts for values carried in as well as out. A one-bit full-adder adds three one-bit numbers, often written as A, B, and C_{in}; A and B are the operands, and C_{in} is a bit carried in from the previous less-significant stage. The circuit produces a two-bit output: Output carry and sum typically represented by the signals C_{out} and S, where the sum equals $2C_{\text{out}} + S$.

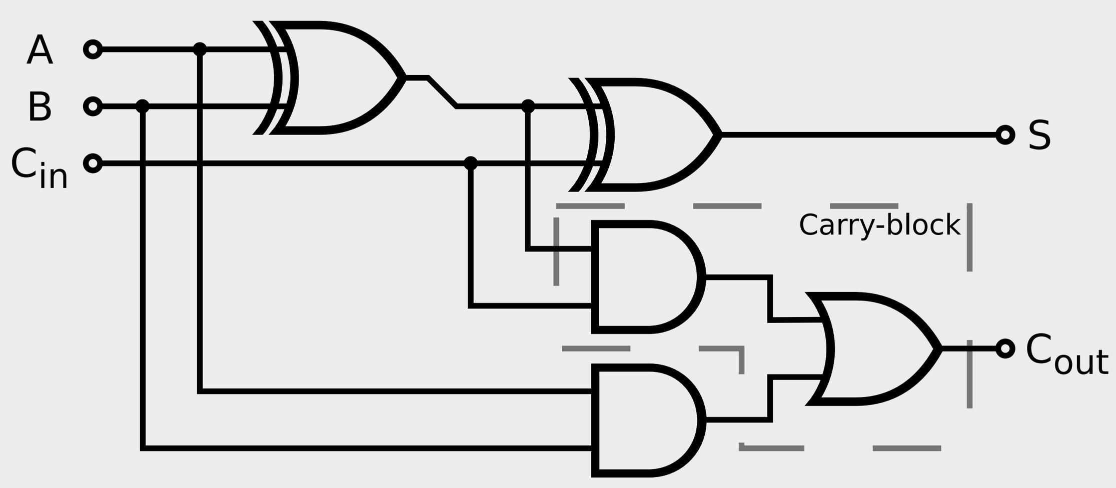


Figure: Logic diagram of a full adder.

IN			OUT	
A	B	C_{in}	S	C_{out}
0	0	0	0	0
1	0	0	1	0
0	1	0	1	0
1	1	0	0	1
0	0	1	1	0
1	0	1	0	1
0	1	1	0	1
1	1	1	1	1

Table: Logic table.

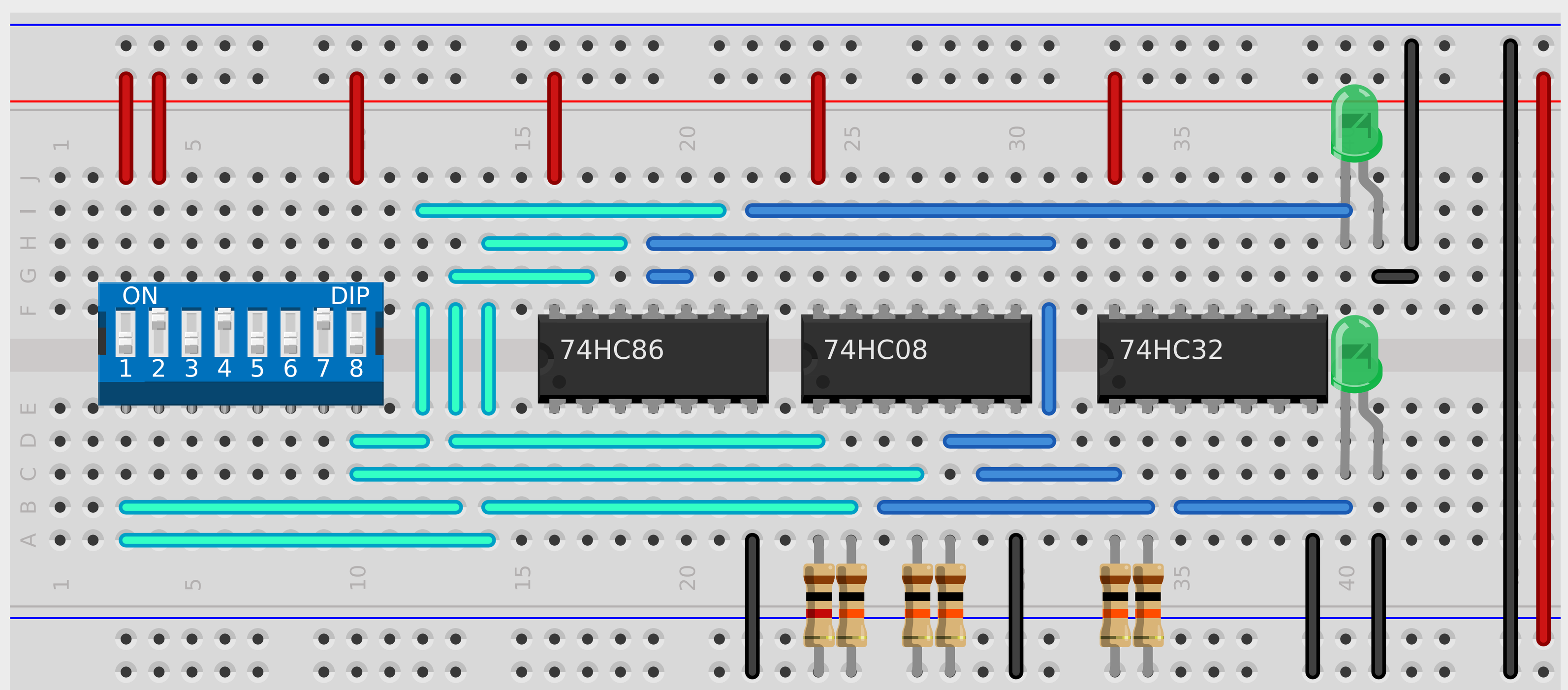


Figure: Bread board diagram of a full adder.