4-Bit-Relay-Adder

How does a Relay-CPU calculate?

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Übersicht

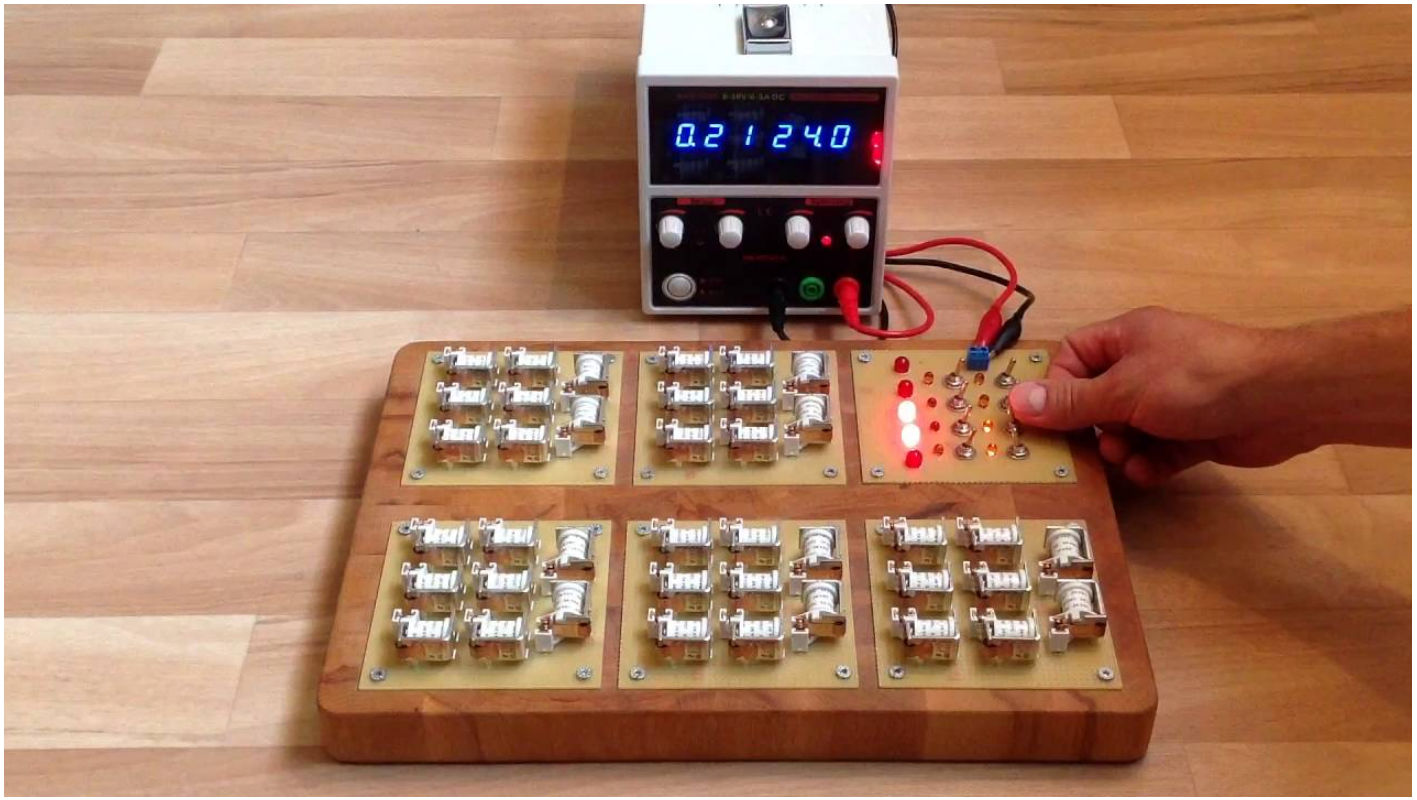
Goals

- Preproject for EuroTwo
- Explainable binary calculation
- Design aspects
  - (indirect) LED indicators for everything and illumination in general
  - boardcolor
  - haptics, feeling

Goals

- Mechanical aspects
  - connectors, mounting, screws
  - powersupply
  - switches
- Electronical aspects
  - logic family

Inspiration

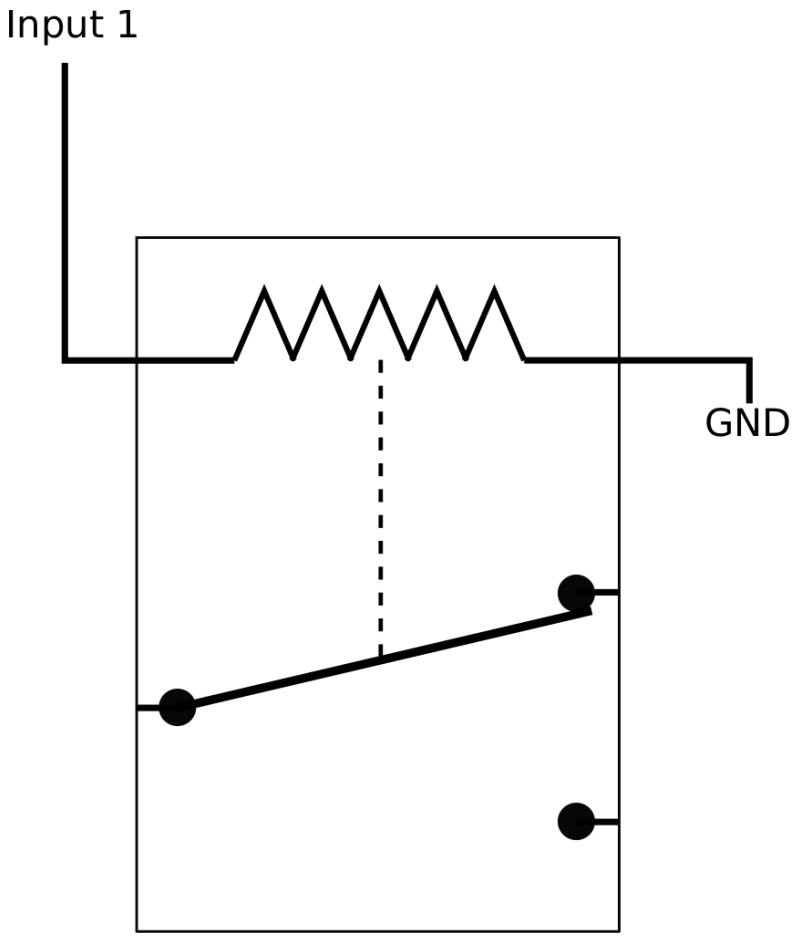


Source: `https://www.youtube.com/watch?v=x3pyi9P4N08`

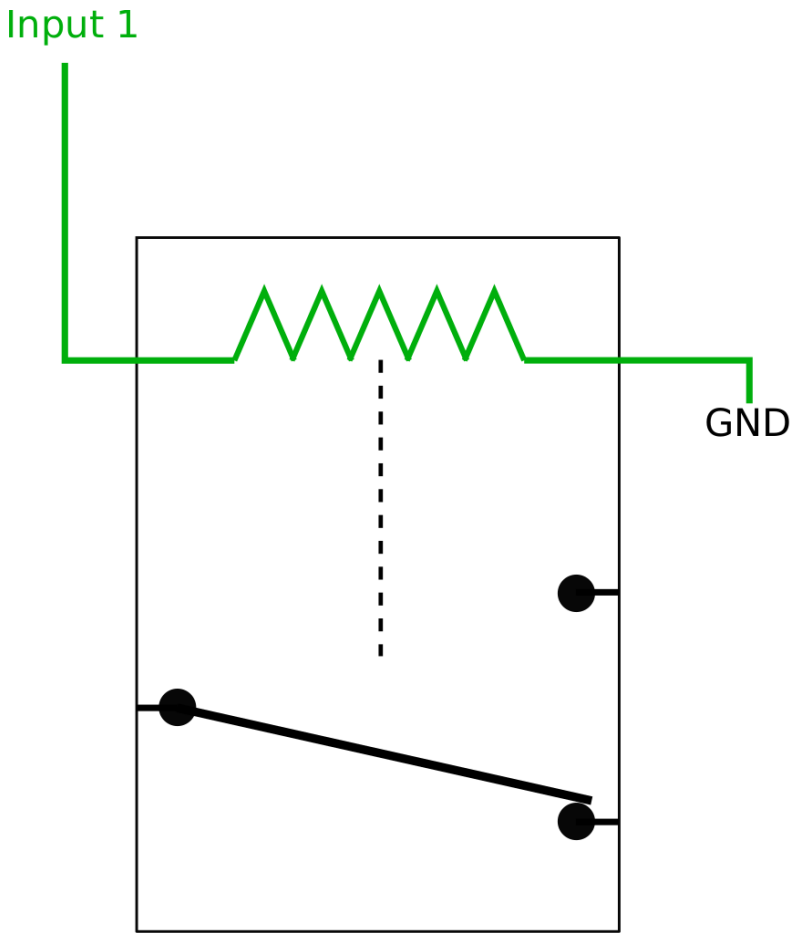
Mein Ergebnis

Übersicht

Relays



Relays



Übersicht

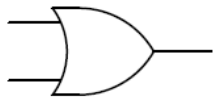
Binary

- Working with 0,1
- Logic gates
  - AND, OR, XOR, NOT, NOR, NAND
- Combining to building blocks
  - Half/Full Adder, Registers, Counters, Multiplexer, Decoder, ...

Binary

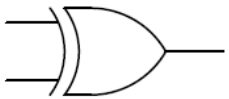
AND

A	B	Output
0	0	0
0	1	0
1	0	0
1	1	1



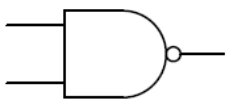
OR

A	B	Output
0	0	0
0	1	1
1	0	1
1	1	1



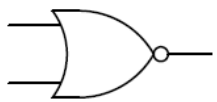
XOR

A	B	Output
0	0	0
0	1	1
1	0	1
1	1	0



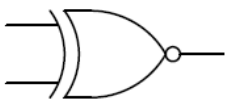
NAND

A	B	Output
0	0	1
0	1	1
1	0	1
1	1	0



NOR

A	B	Output
0	0	1
0	1	0
1	0	0
1	1	0



XNOR

A	B	Output
0	0	1
0	1	0
1	0	0
1	1	1

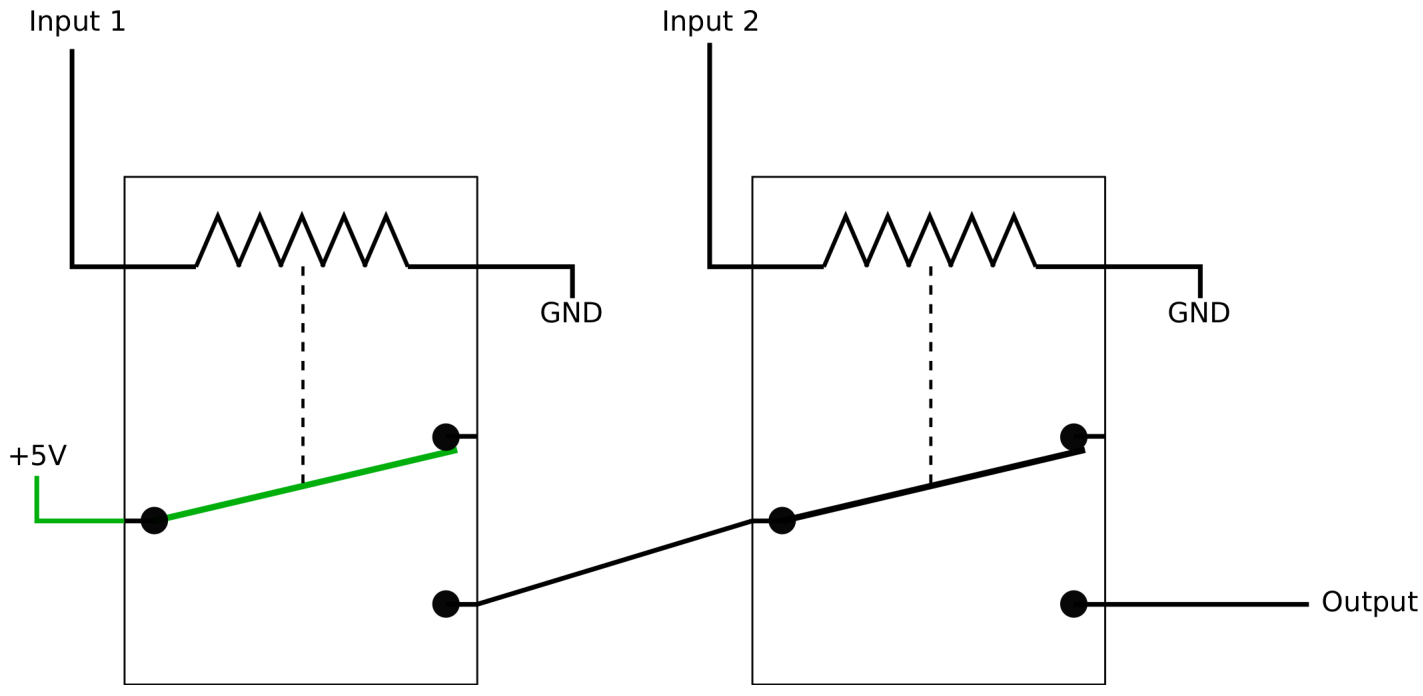
Source: `https://instrumentationtools.com/logic-gates/`

Übersicht

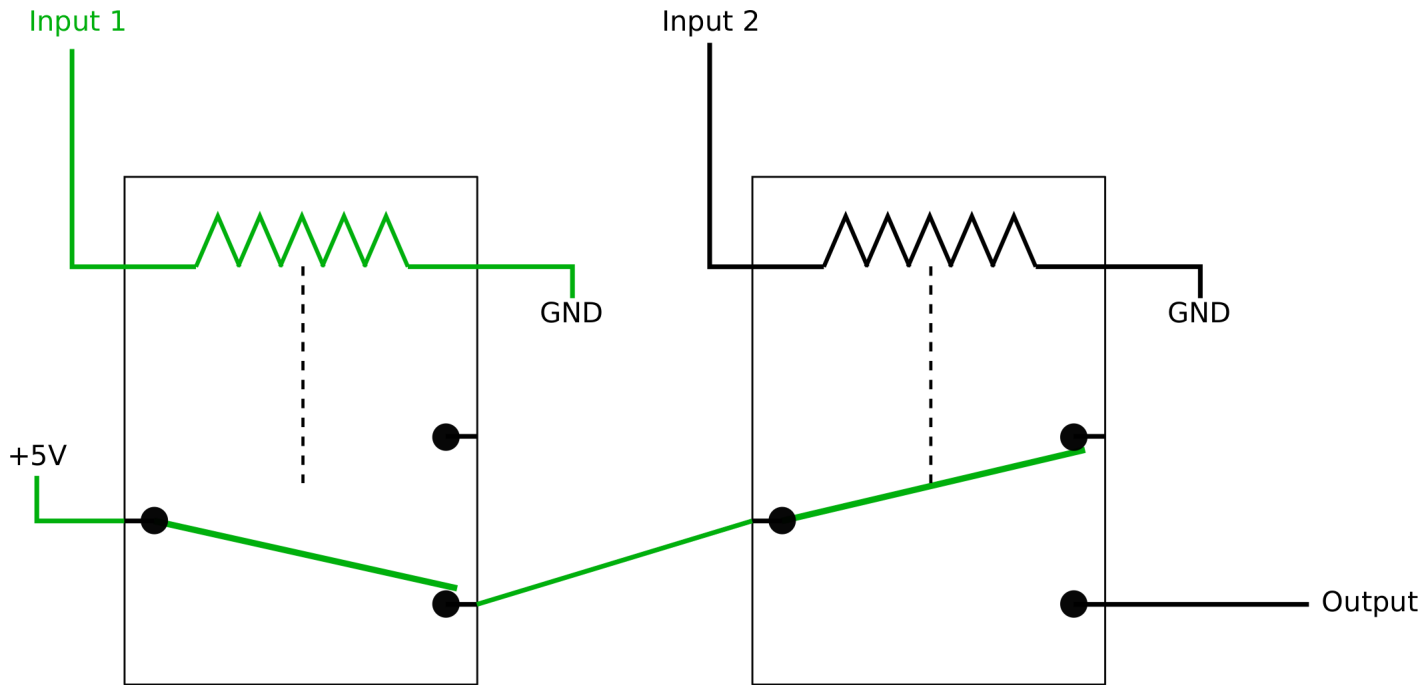
Relay logic

0	1
floating	+5V
GND	+5V

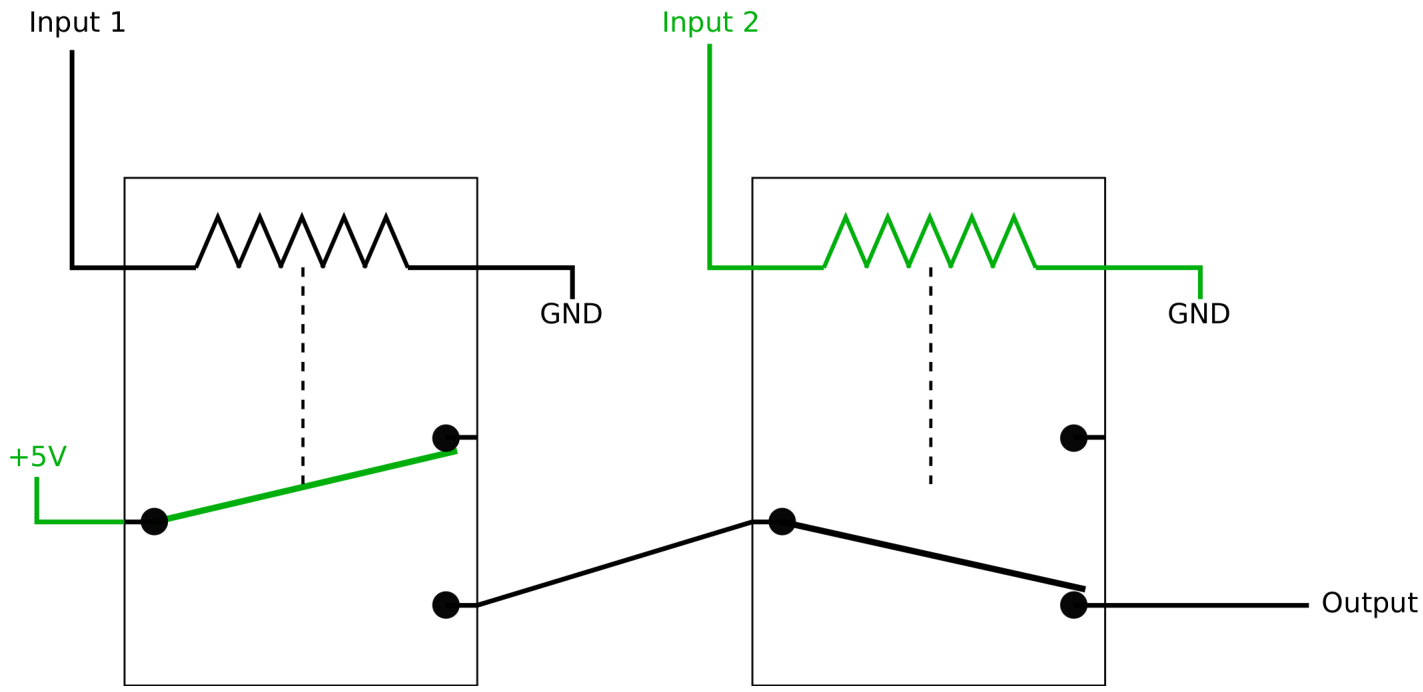
AND Gate



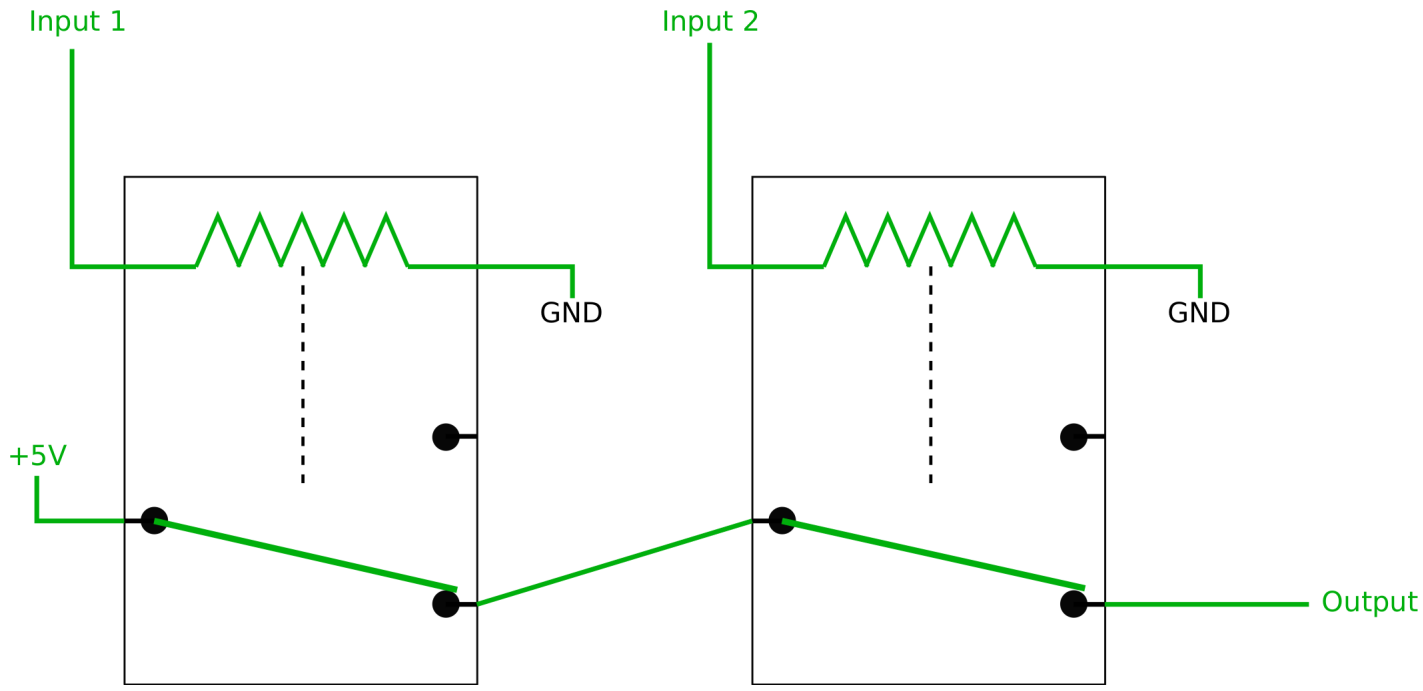
AND Gate



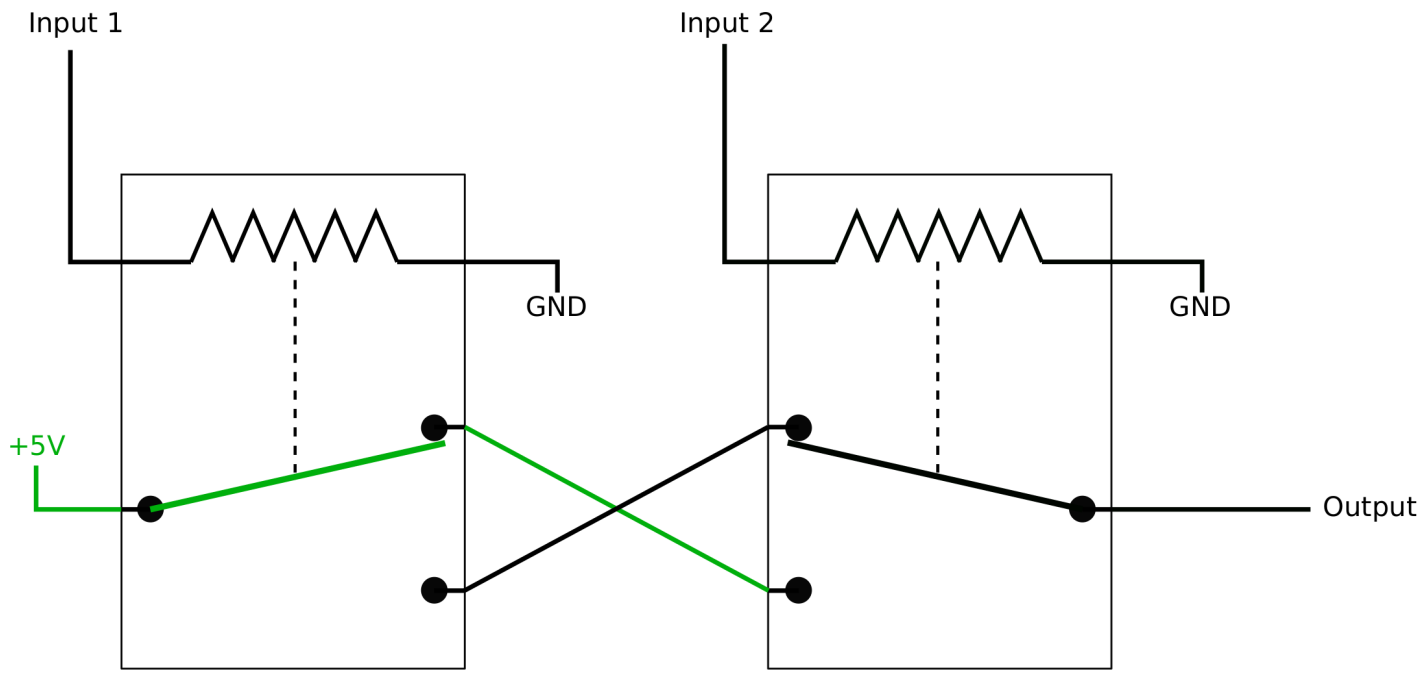
AND Gate



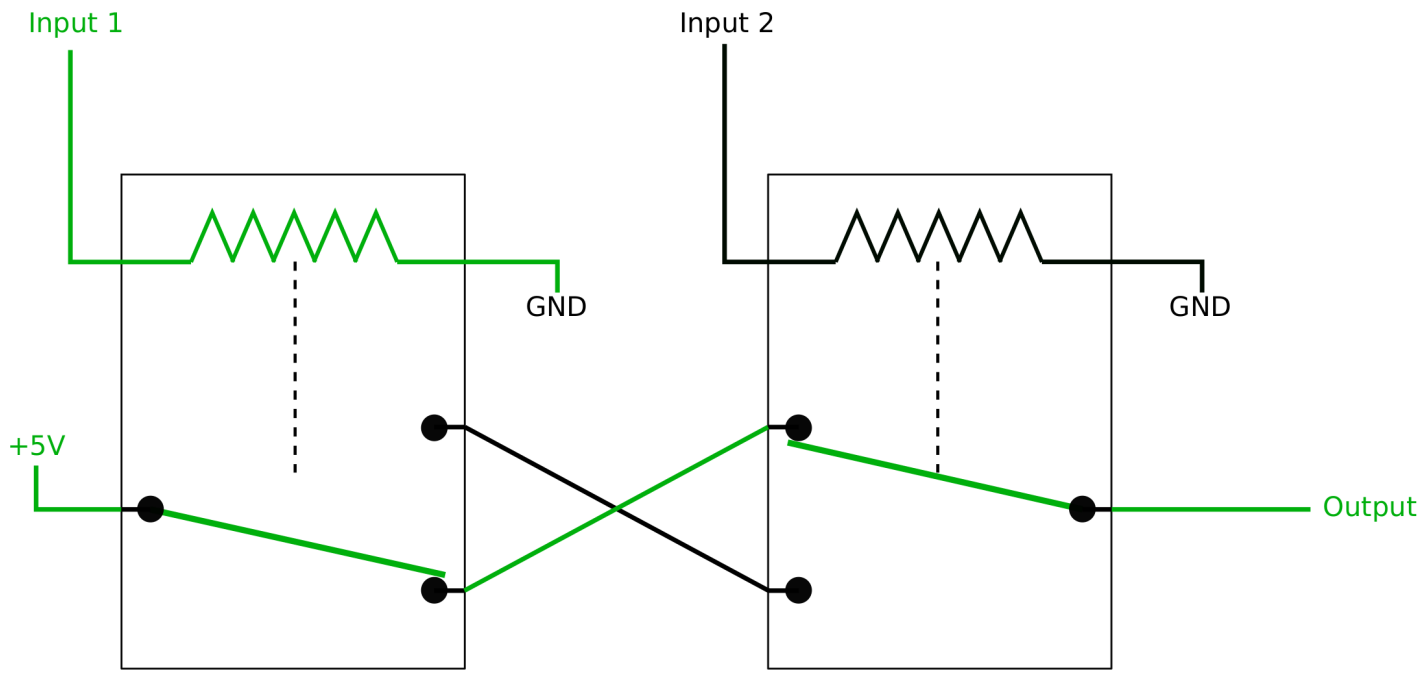
AND Gate



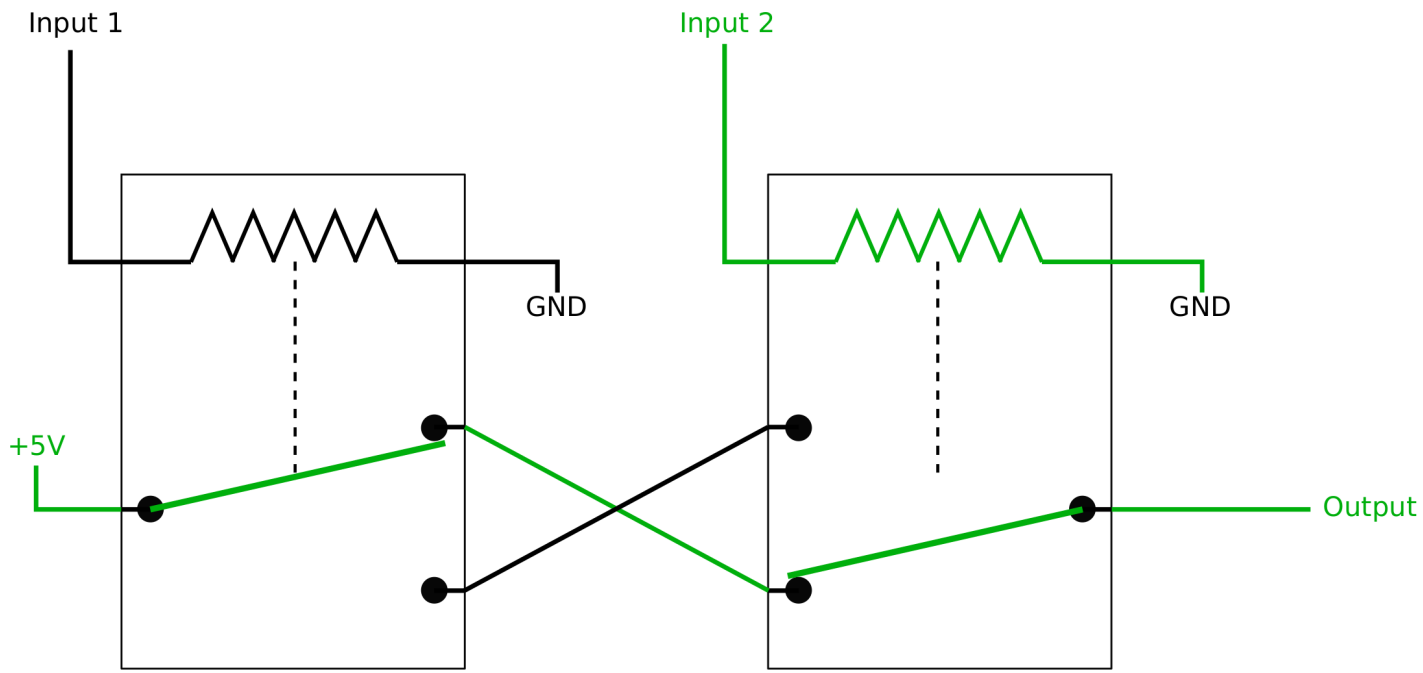
XOR Gate



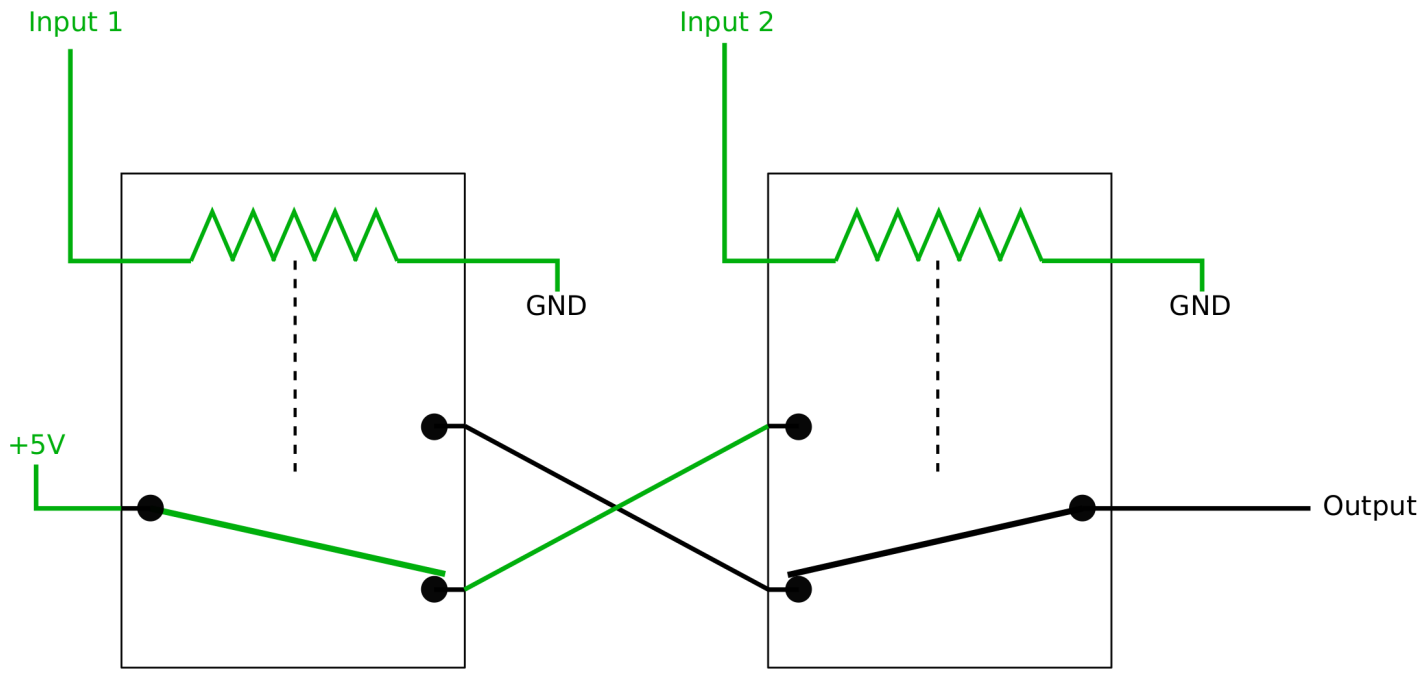
XOR Gate



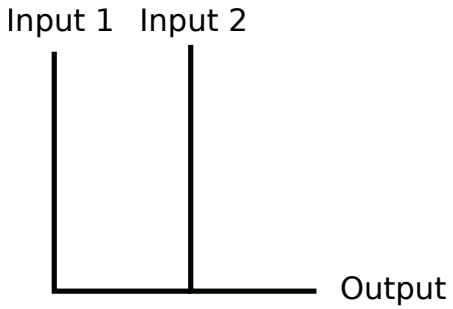
XOR Gate



XOR Gate

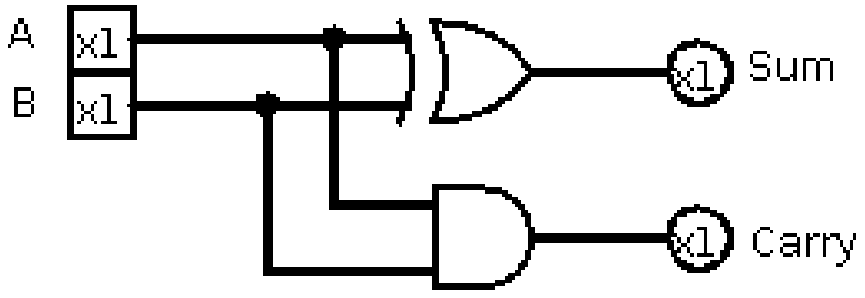


OR Gate



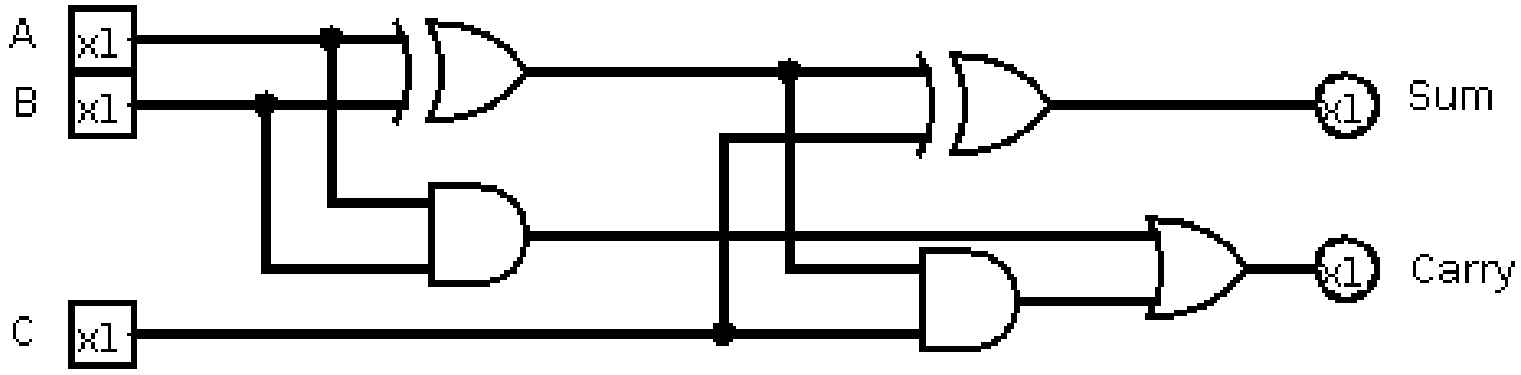
Übersicht

Half Adder



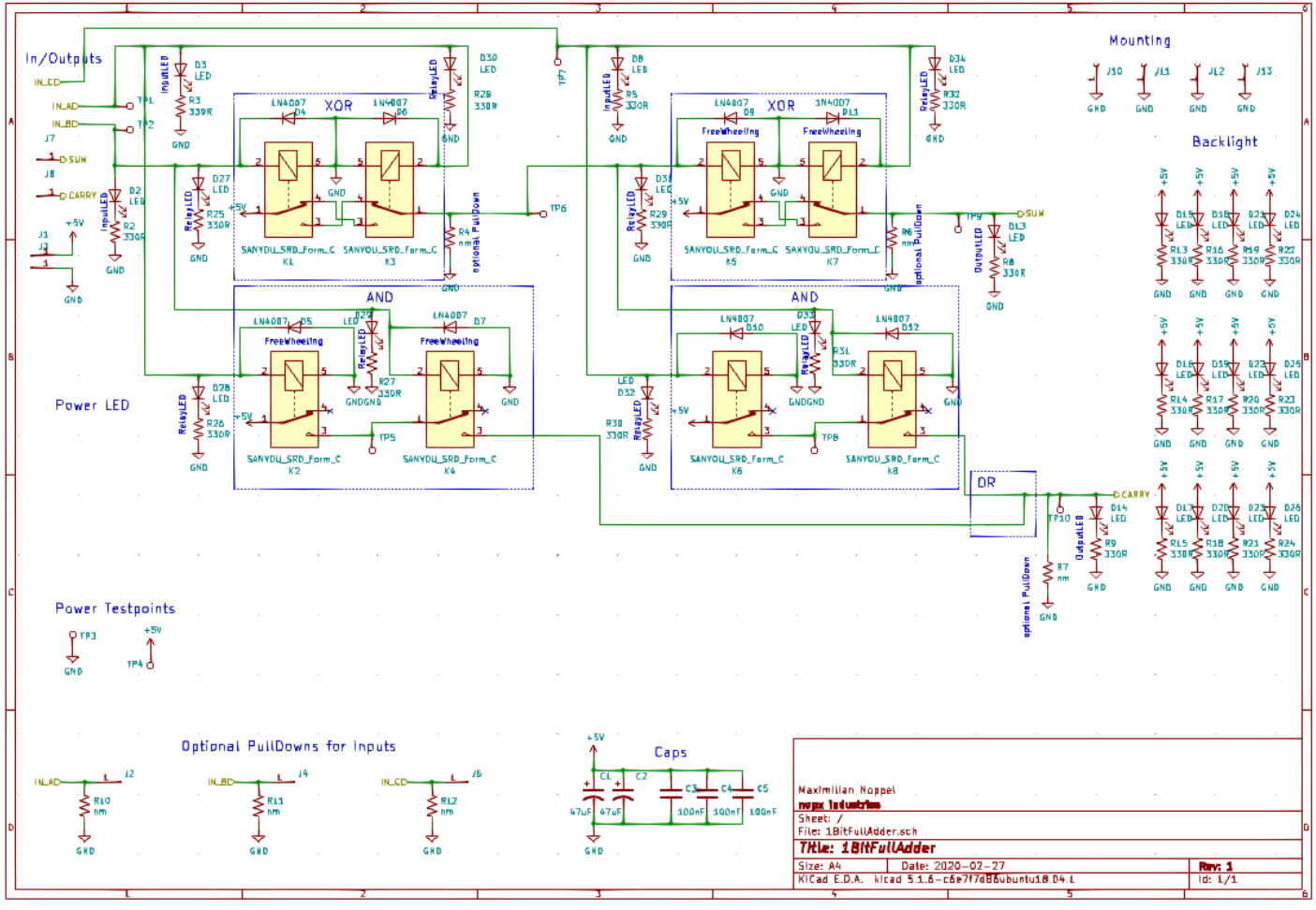
A	B	Carry	Sum	CarrySum
0	0	0	0	00
0	1	0	1	01
0	0	0	1	01
1	1	1	0	10

Full Adder

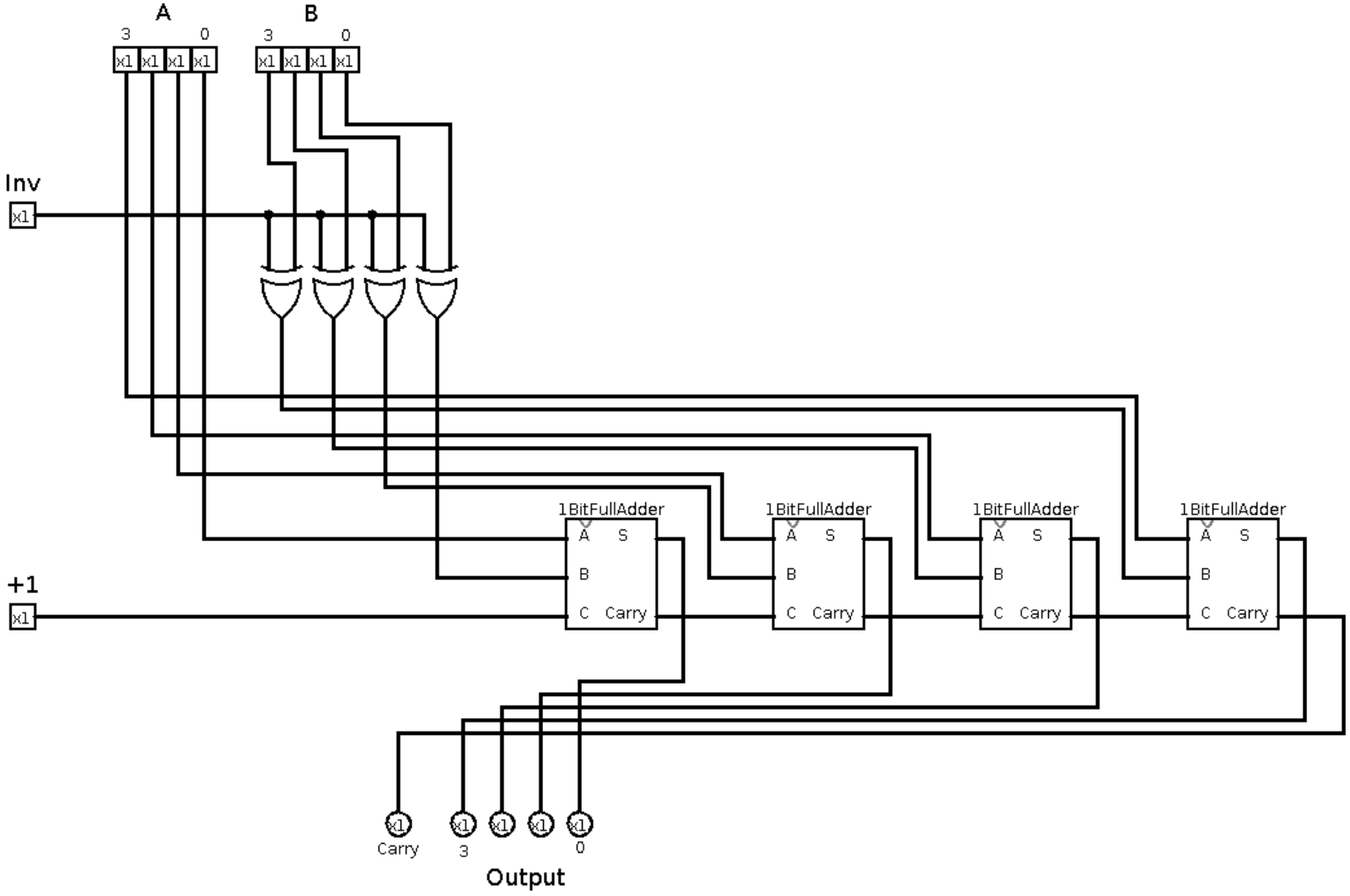


A	B	C	Carry	Sum	CarrySum
0	0	0	0	0	00
0	0	1	0	1	01
0	1	0	0	1	01
0	1	1	1	0	10
1	0	0	0	1	01
1	0	1	1	0	10
1	1	0	1	0	10
1	1	1	1	1	11

1 Bit Full Adder in Relays

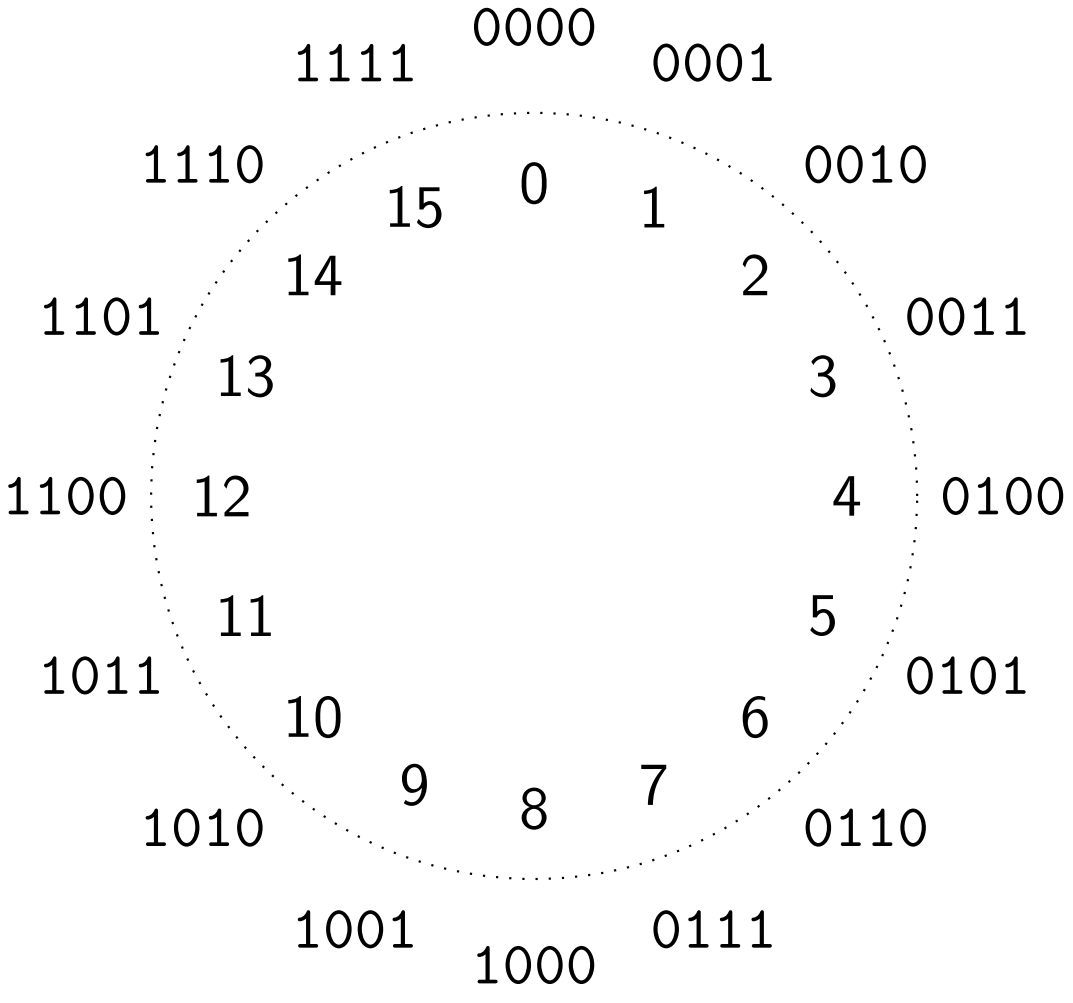


4 Bit Adder



Übersicht

Unsigned integers



Two's complement

$$0010 \mid 2 \mid$$

Two's complement

0010	2	
1101	one's complement of 2	*invert*

Two's complement

0010	2	
1101	one's complement of 2	*invert*
1110	-2 (two's complement of 2)	$+1$

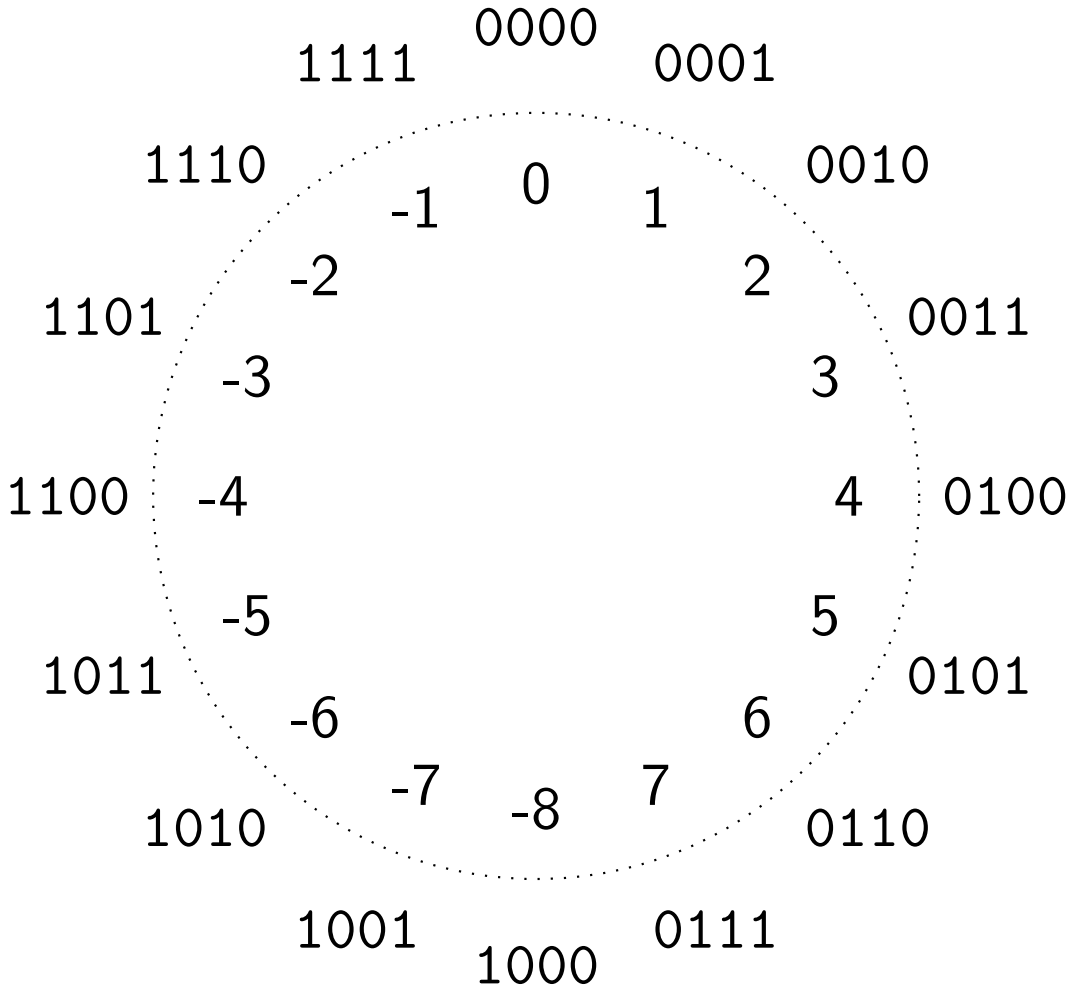
Two's complement

0010	2	
1101	one's complement of 2	*invert*
1110	-2 (two's complement of 2)	$+1$
0001	one's complement of -2	*invert*

Two's complement

0010	2	
1101	one's complement of 2	*invert*
1110	-2 (two's complement of 2)	$+1$
0001	one's complement of -2	*invert*
0010	2 (two's complement of -2)	$+1$

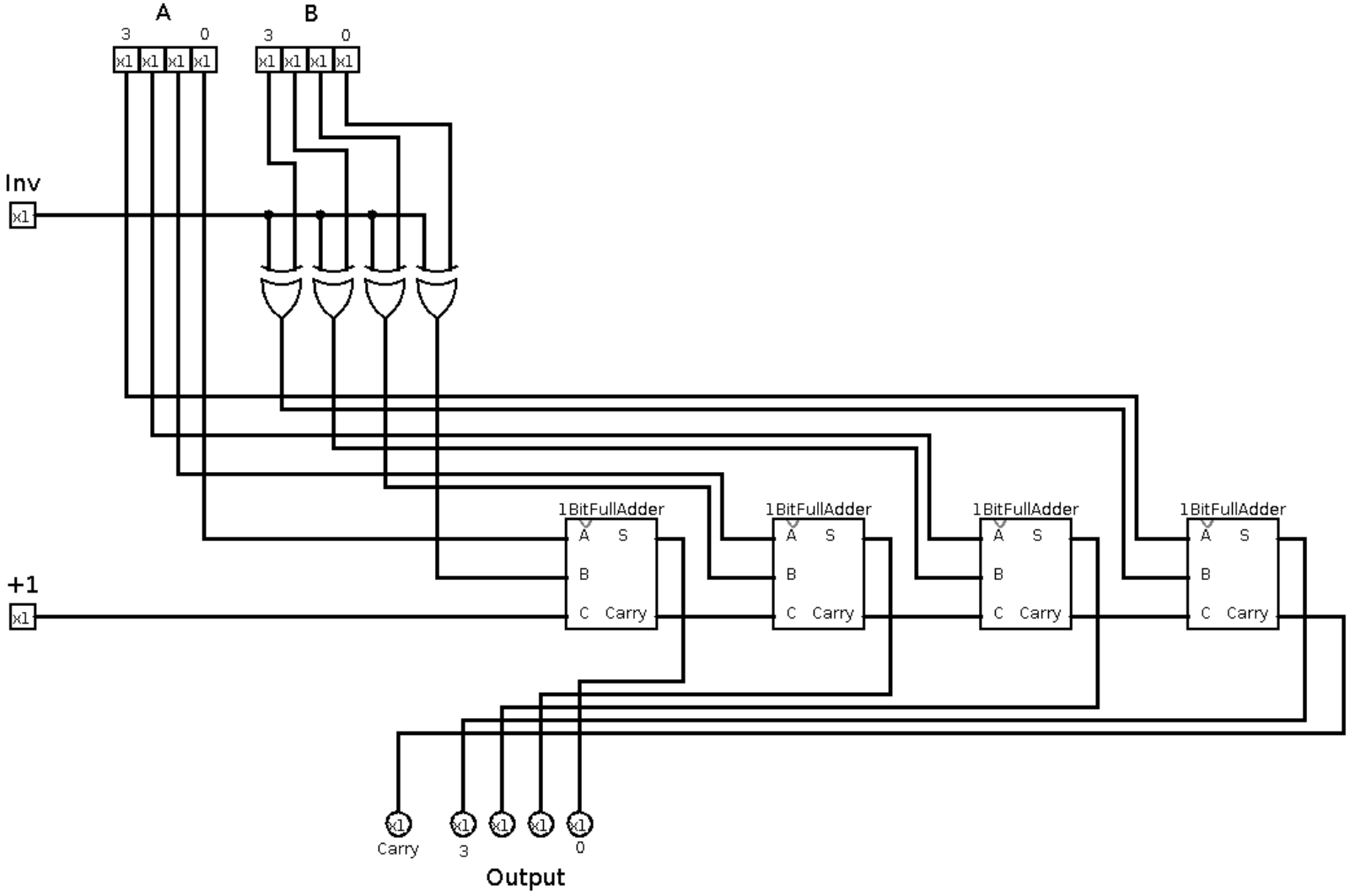
Signed integers



Solution to use signed integers

- Add controlled inverter
- Switch for C_0

4 Bit Adder



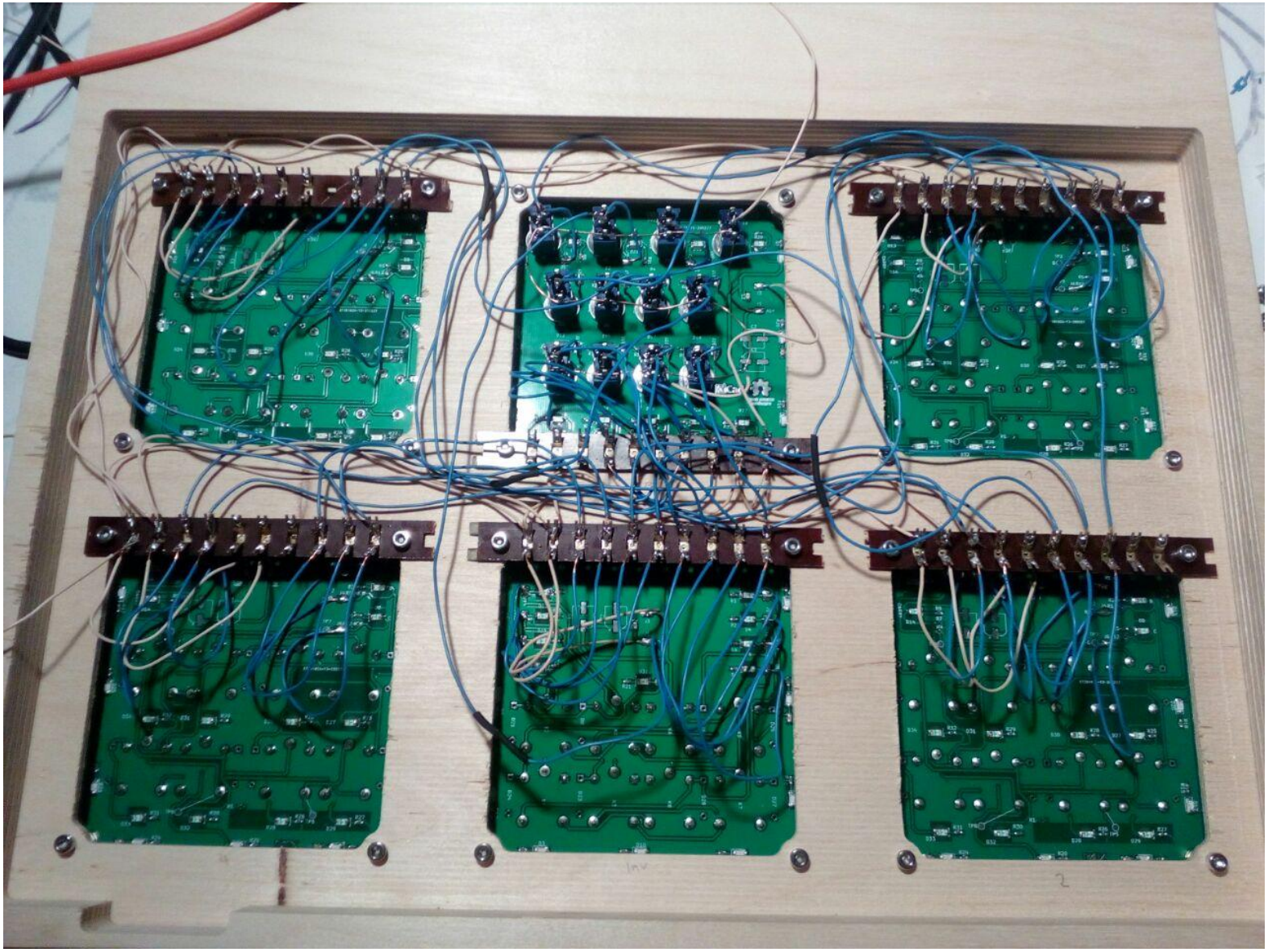
Übersicht

The finished Adder

The backboard

The lights

The wires



Übersicht

Facts!

Current:

- 90mA per Relay
- ~ 2.6A

Frequency:

- 10ms per Relay
- Targetfrequency of EuroTwo: $2 - 4$Hz

Price:

- Don't ask!

Übersicht

Lessons learned

- Backlight illumination is not worth it
- (Data)wires on the front would help explaining how is works!
- LED Backillumination: Use Cu on the front!
- Use connectors for the switches

Lessons learned

- Use DPDT Relay for MUX,DEC and Registers
- Better labels for signed calculation! Or now labels at all.
- White PCBs are better!
- Do not solder every single wire $\rightarrow$ screws!

Übersicht

Demo

Live demo!

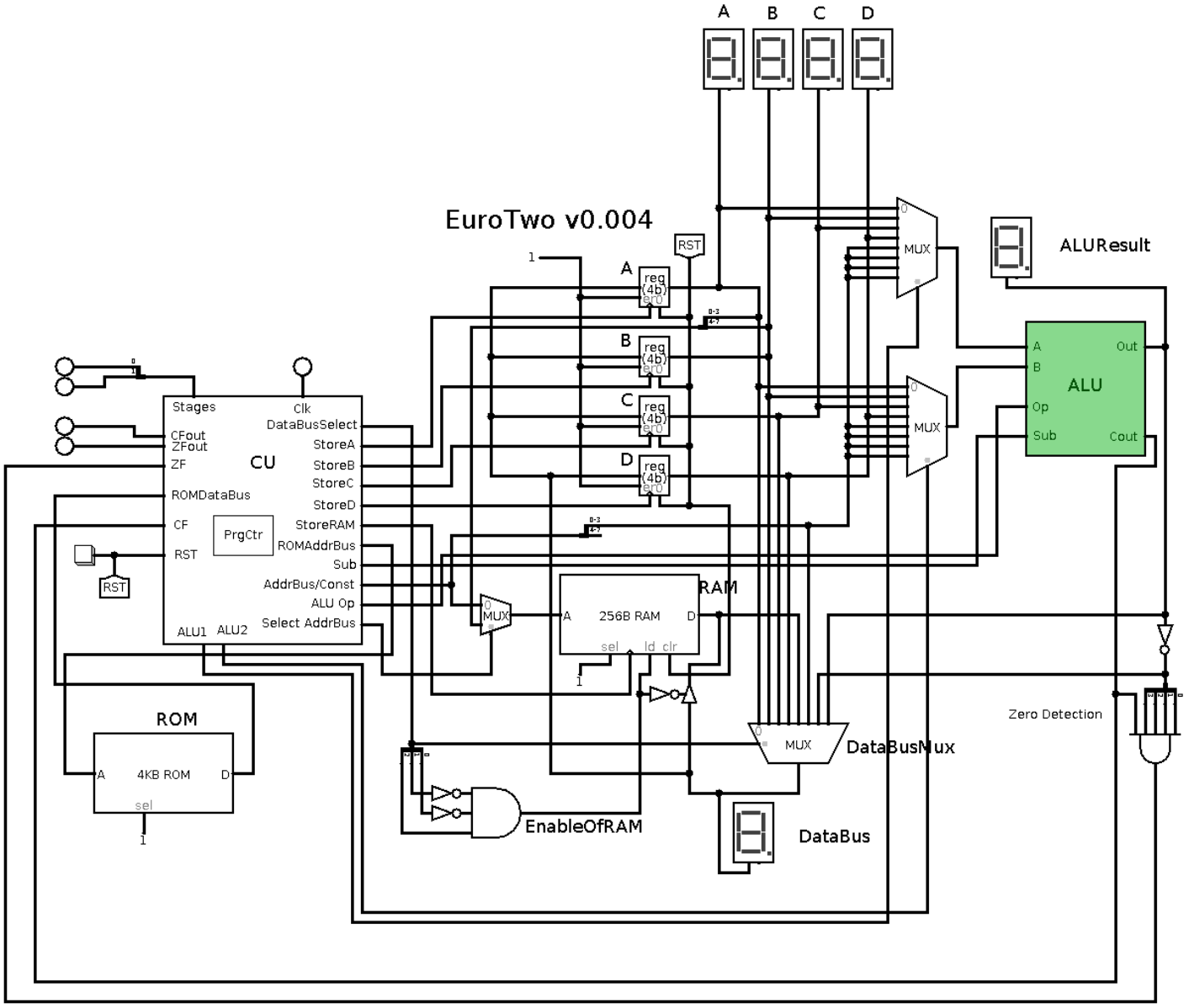
Übersicht

EuroTwo

- Most of the PCB are planned and layouted. Just need to order.
- ControlUnit (CU) left
- Datawires on the front, connected via screws
- Powersupply on the back, through mountings
- No backlight illumination
- PWR LED on the back of each PCB
- Size: 5x5 = 25 PCBs

EuroTwo

EuroTwo



Q&A

Questions?

The beamer template is online!
`https://wiki.vspace.one/lib/exe/fetch.php?media=20180918_template_presentation.zip`

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