



HOW THINGS WORK

build kits · khanin.info

Building instructions

HT-04

The Visitor Counter

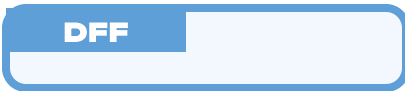
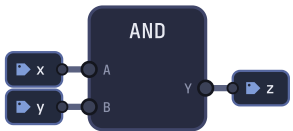
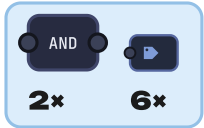
lessons 0-6 · two beams and three chips



simulator: cs.khanin.info

How to read these instructions

3



step number – follow strictly in order

parts for this step: how many to place

a part with labels on its pins

labels with the same name are connected

chip ports: input [and output]

blue frame – building a chip

grey tab – the main canvas

yellow ring – what has changed

remove a part together with its labels

double-click a label – new name

chip built in the lesson with this number

check: this is how it should work

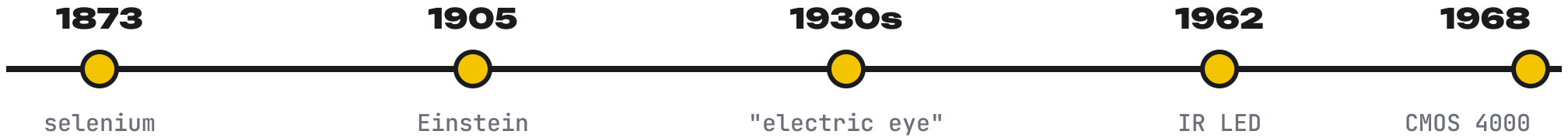
Keys

V	VCC (1)
G	GND (0)
N	transistor
I	switch
O	lamp
L	label
K	clock
U	button
[	port in
]	port out

Ctrl+G – into a chip
on a Mac Ctrl = Cmd



A little history

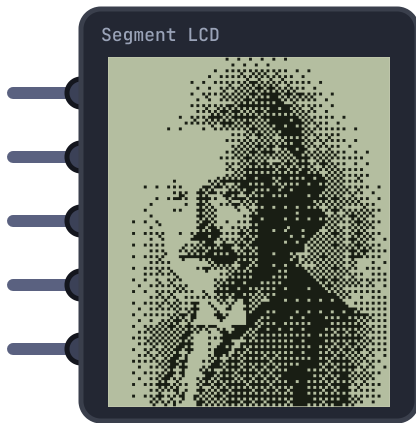


In 1873 selenium was found to conduct in light. In 1905 Einstein explained the photoelectric effect: light comes in portions and knocks charges out of metal – he got the Nobel Prize for it.

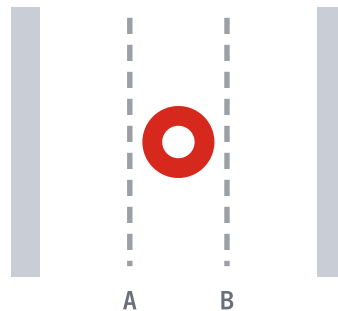
In the 1930s the "electric eye" – a photocell, an amplifier and a lamp opposite – opened doors and clicked a counter when someone crossed the beam. Two beams in a row also tell the direction: the first one blocked is where people come from.

In 1962 Texas Instruments made the infrared LED – the beam became invisible.

In 1968 RCA released CMOS 4000: you build its CD4029 counter and CD4511 decoder – after the datasheet, with the same pins.



Albert Einstein, 1921 · photo by F. Schmutzer



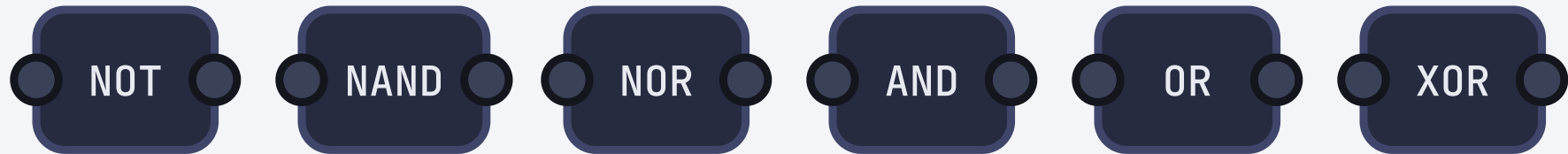
RCA, Texas Instruments are trademarks of their respective owners. This kit is not affiliated with or endorsed by them; the names are mentioned to tell the story.



Gates (optional)

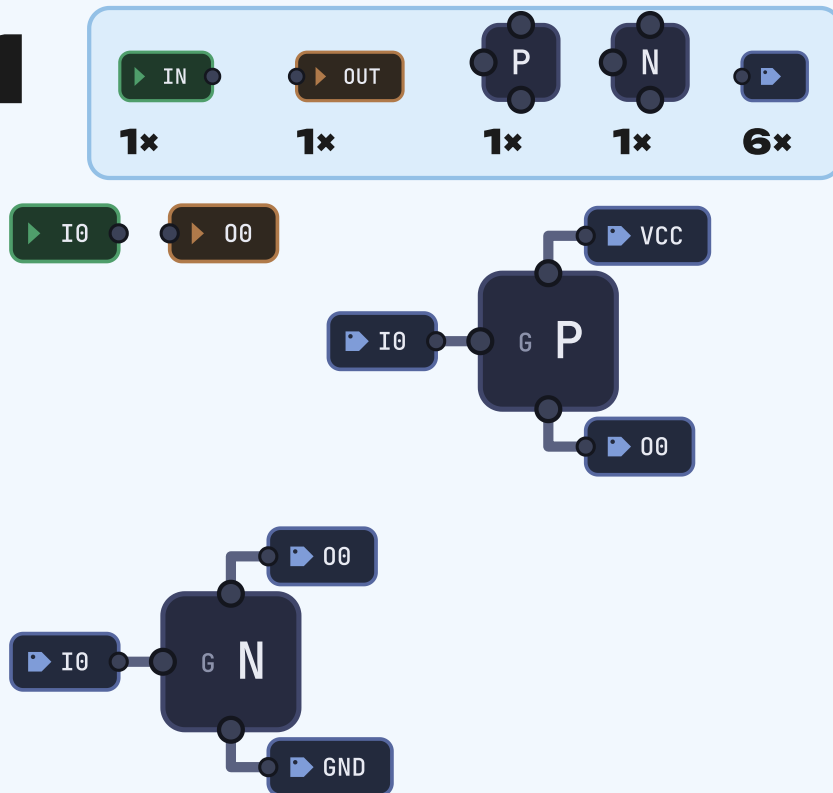
kh HT-04

NOT, NAND, NOR, AND, OR, XOR from transistors

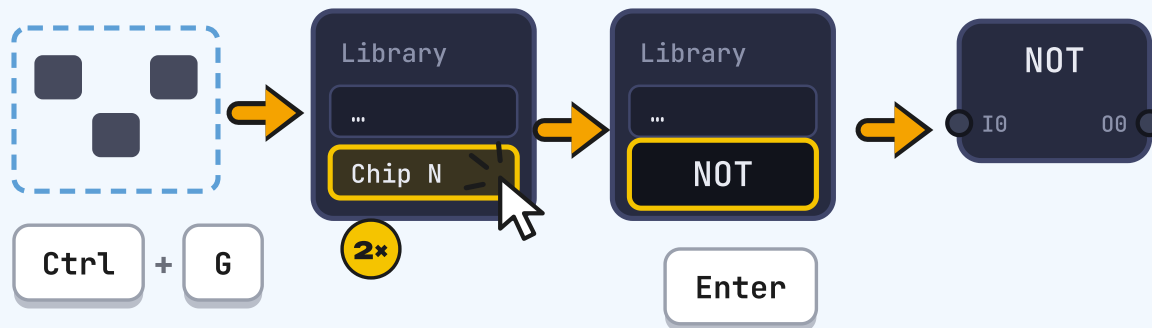


NOT

1

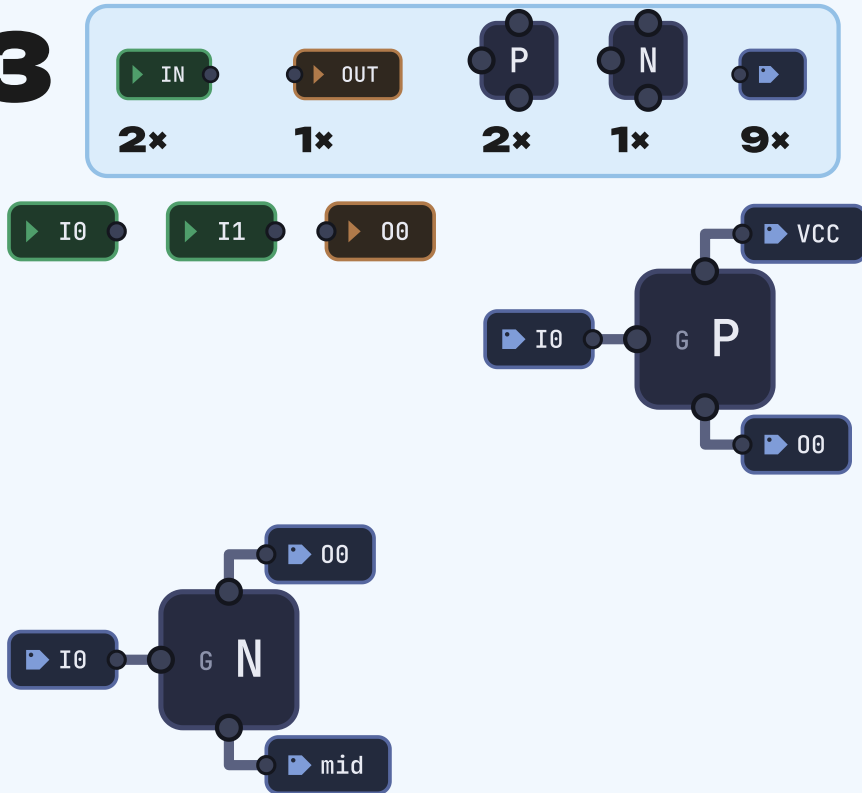


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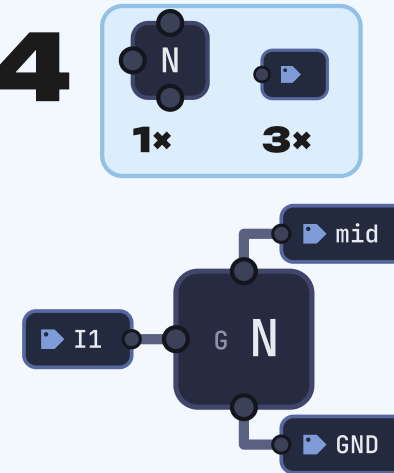


NAND

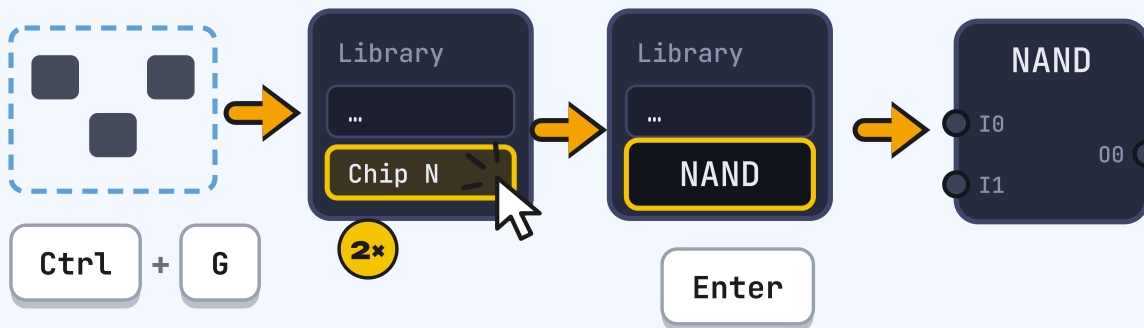
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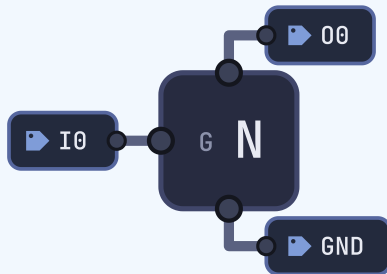
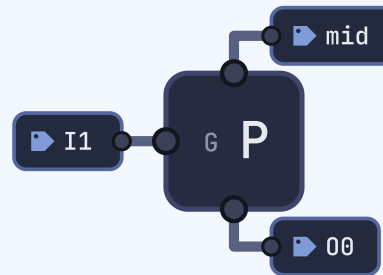
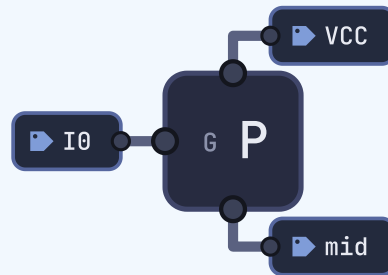


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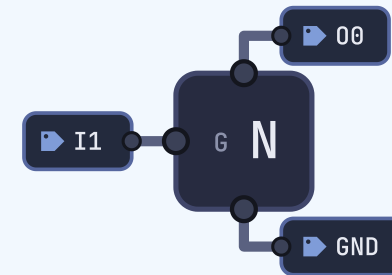


NOR

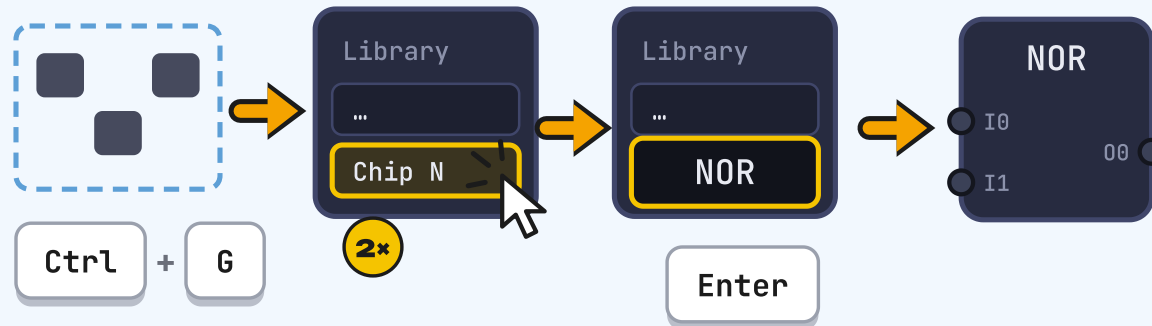
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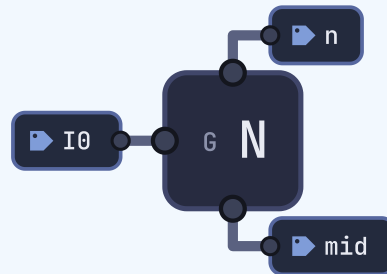
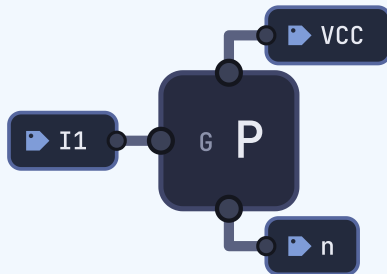
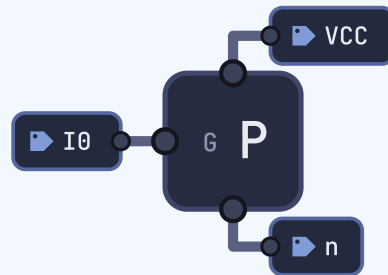


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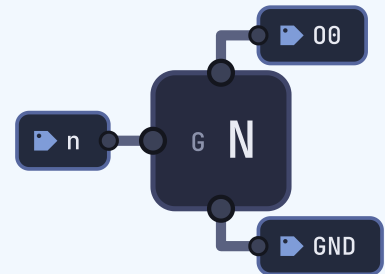
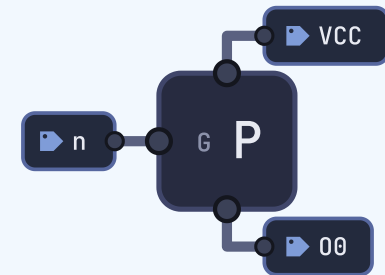
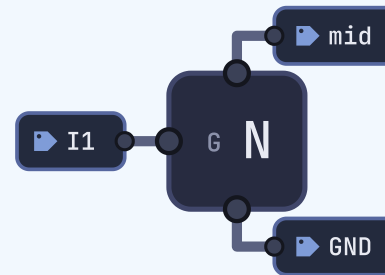
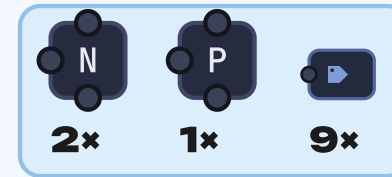


AND

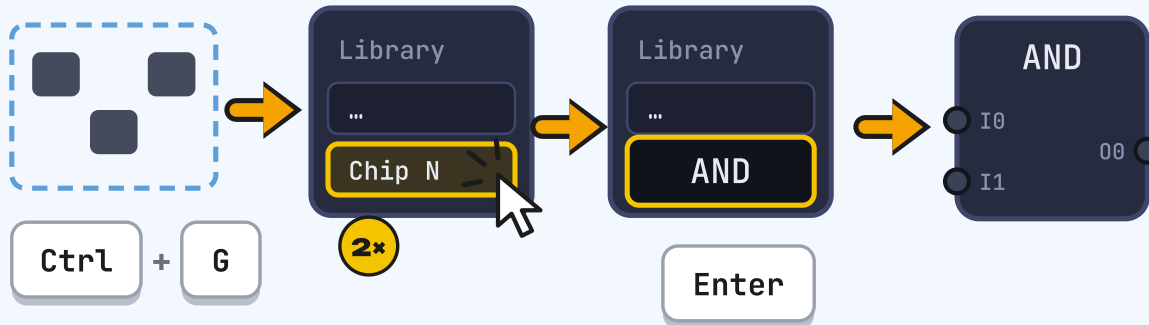
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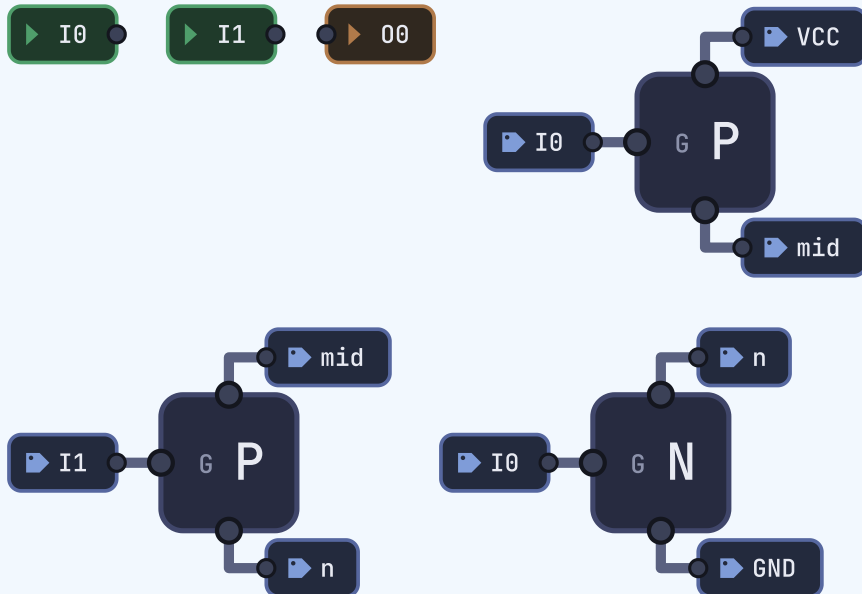
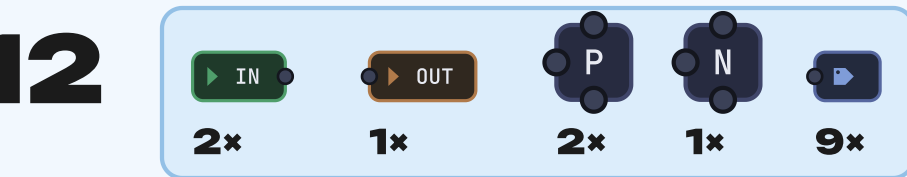
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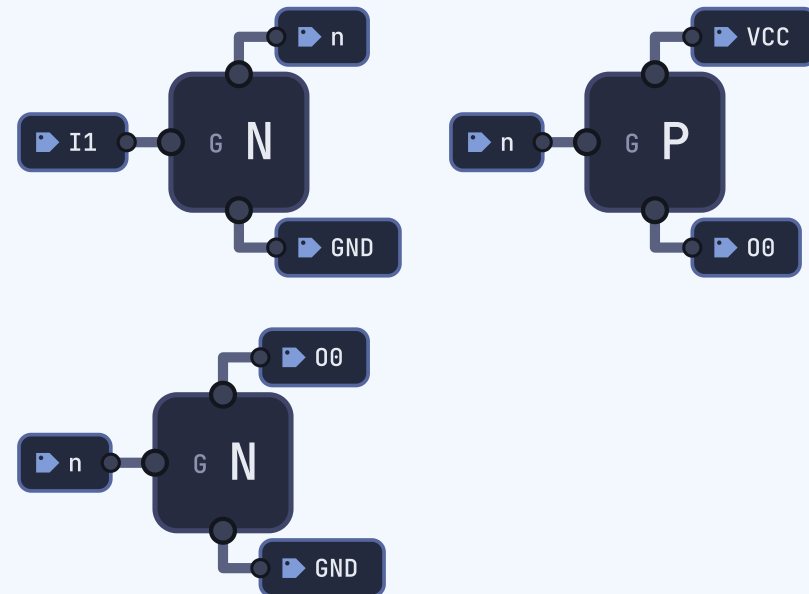
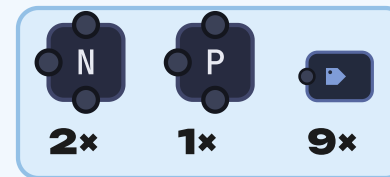
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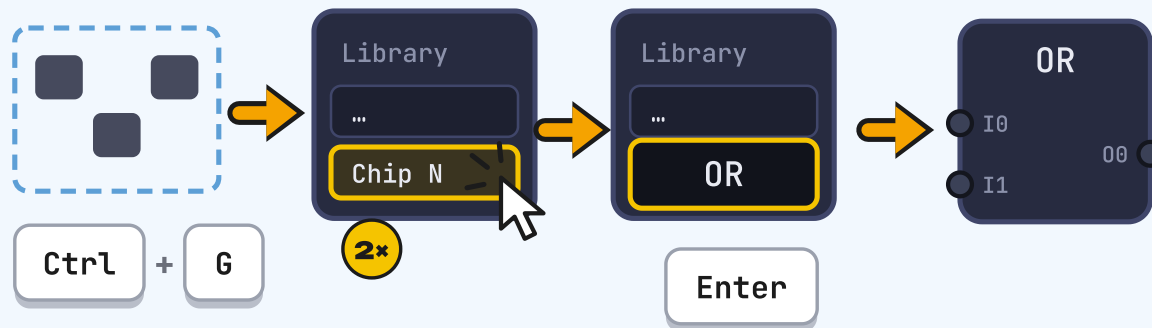
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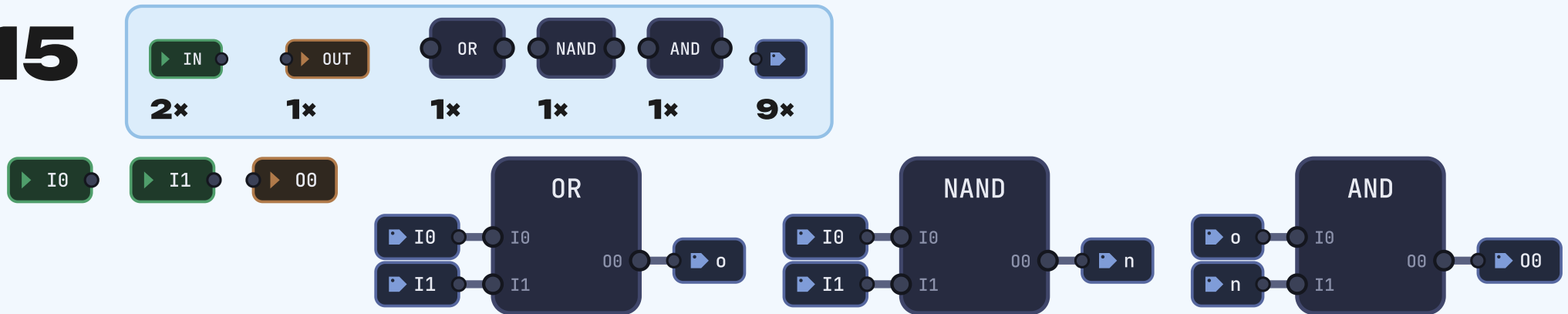


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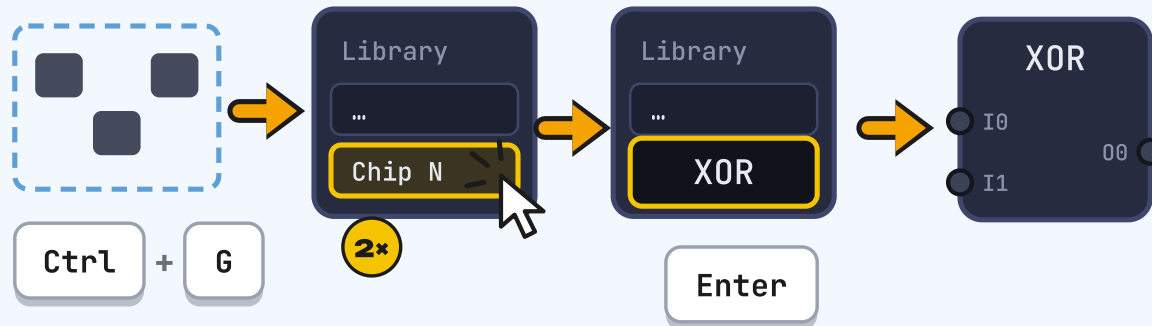


XOR

15



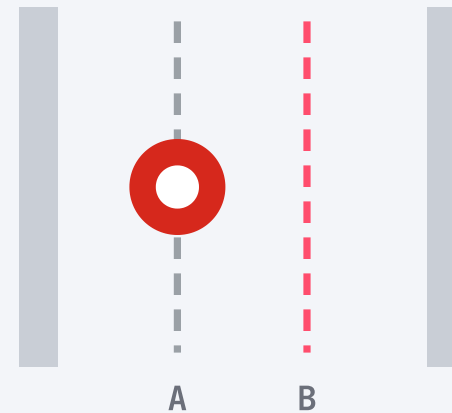
16





The beam and CD4011

an IR pair and the "someone passed" latch



8x	4x	4x	1x	1x	1x	1x	1x	2x	∞

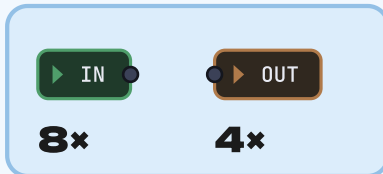
Ctrl + G > CD4011

1

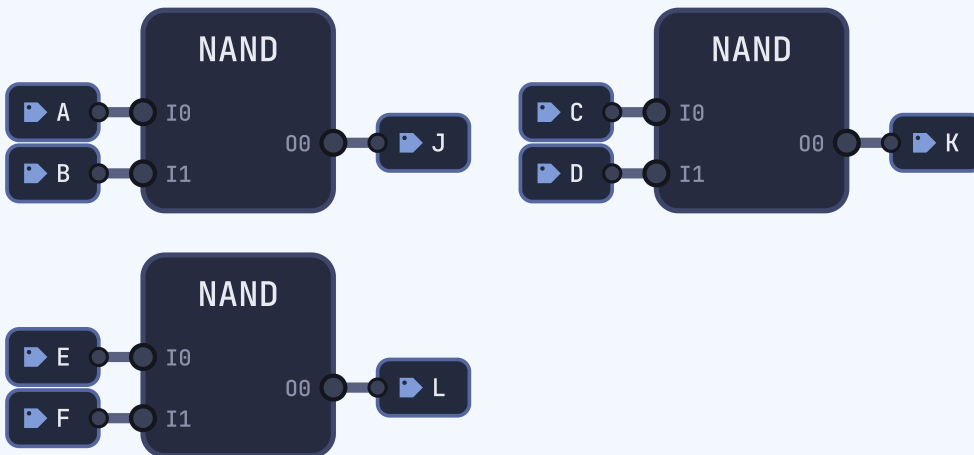
pin names as in the TI datasheet; a bar over a name in the picture = active 0, in the simulator without the bar

CD4011

2

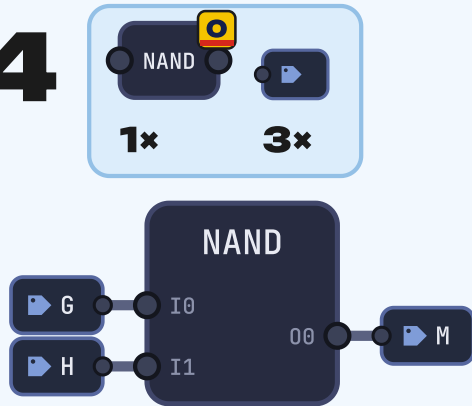


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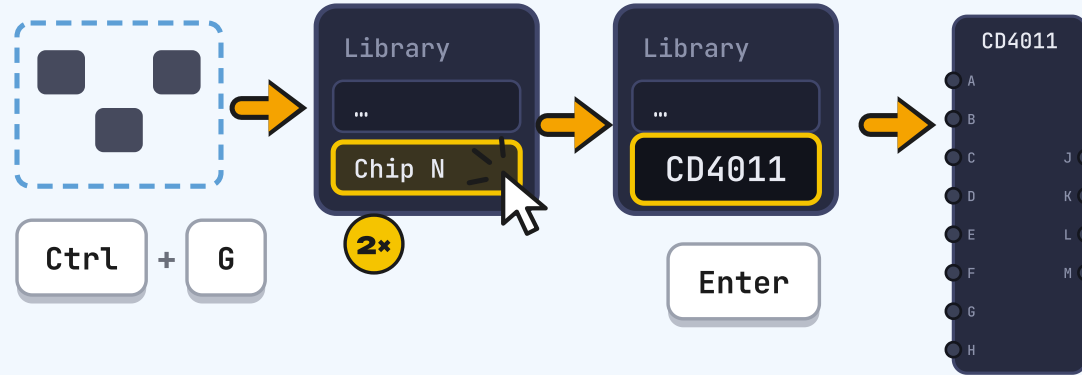


CD4011 ...

4



5

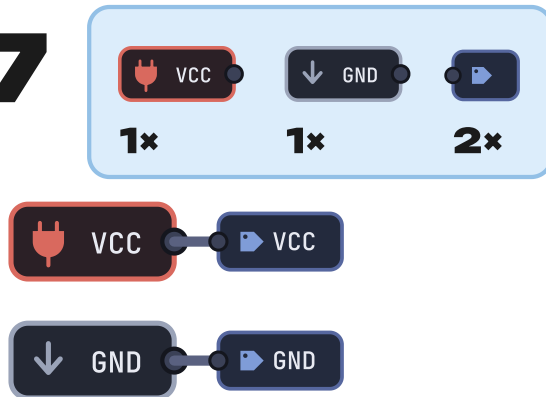


CANVAS

6

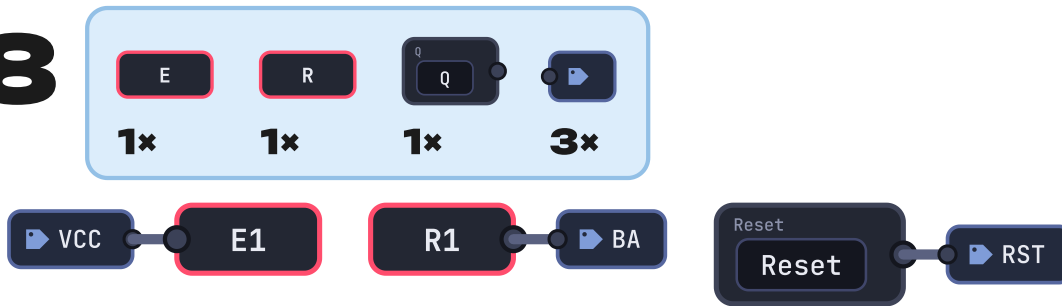
Sensors → IR pair: E and R are placed together, the channel is the pair number

7

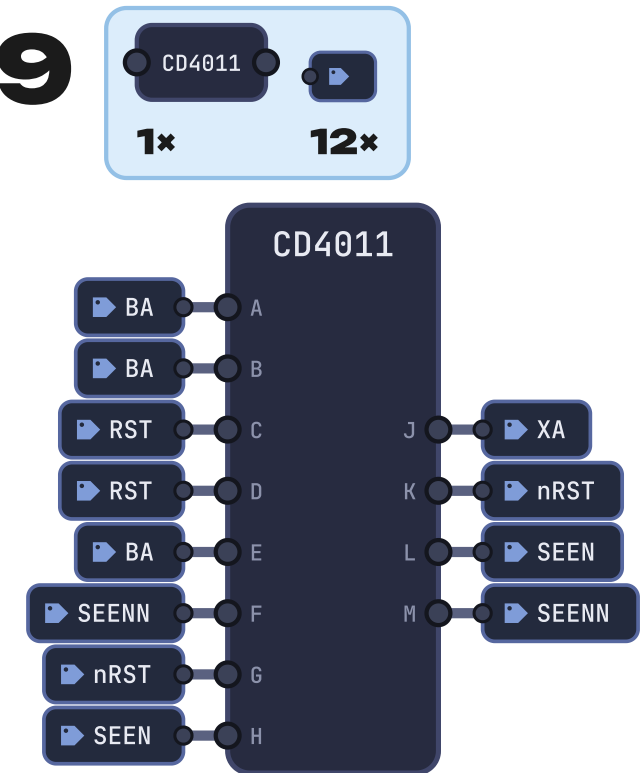


CANVAS ...

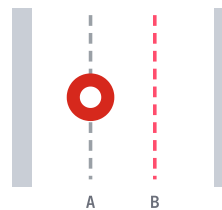
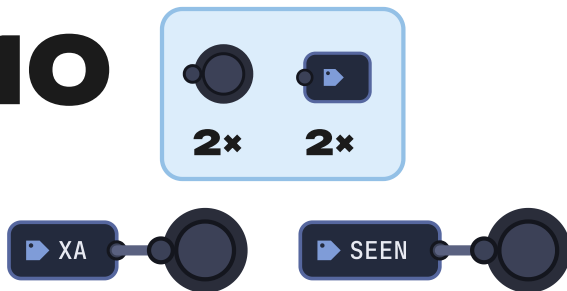
8



9



10



press the beam – XA and SEEN

let go – SEEN stays

Reset – off

11

Alt/⌘ + click on a beam – blocked and fixed; again – cleared



The F/F flip-flop

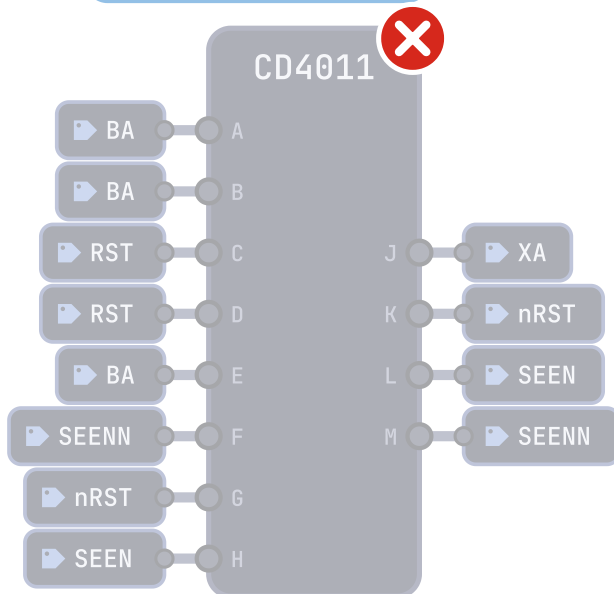
load, flip, hold



1

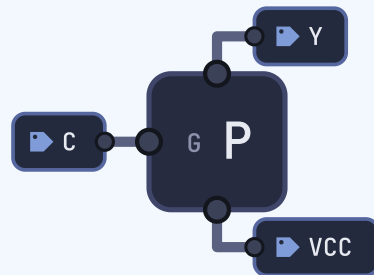
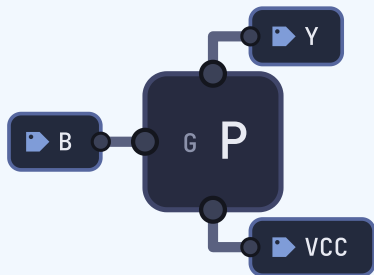
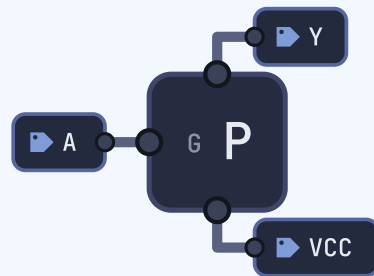
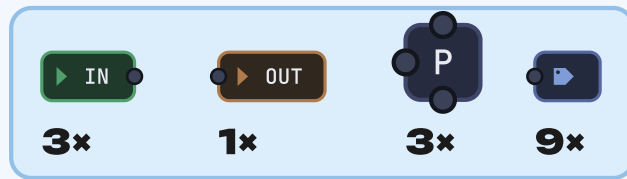


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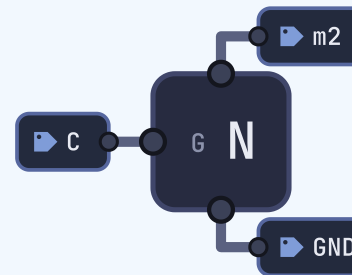
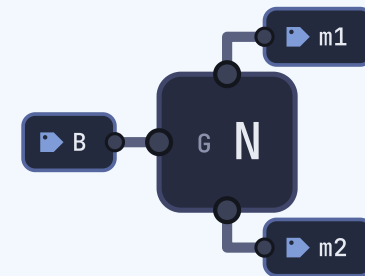
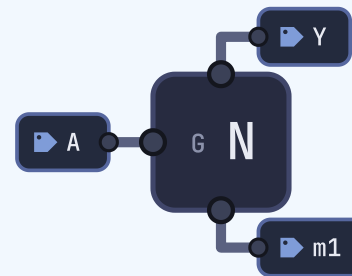


NAND3

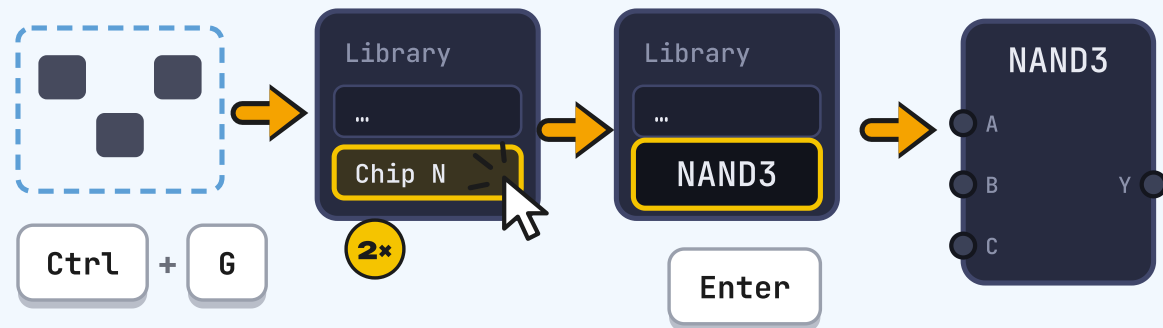
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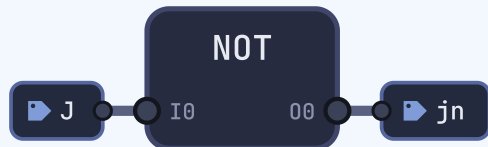
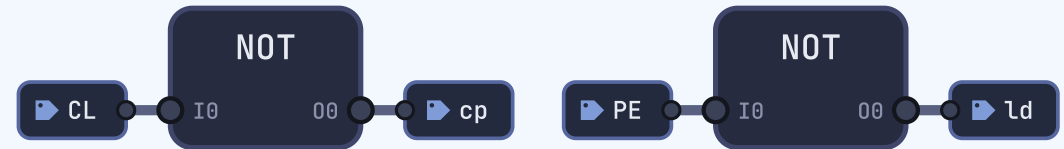
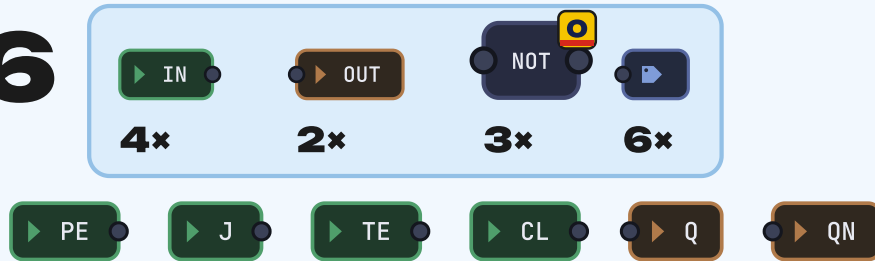
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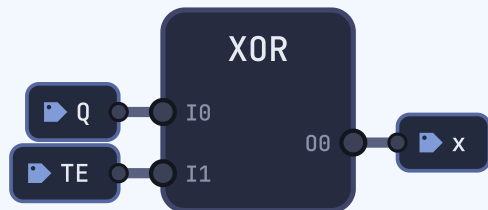
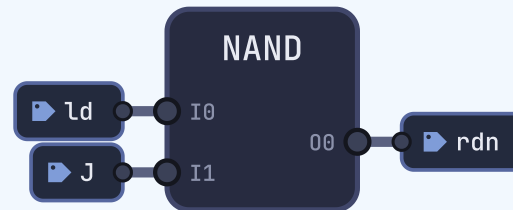
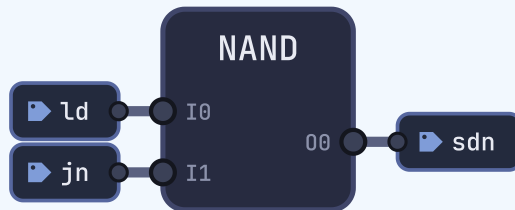
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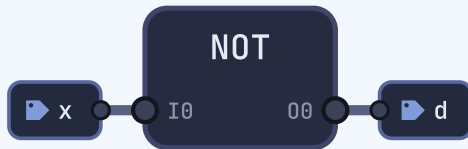
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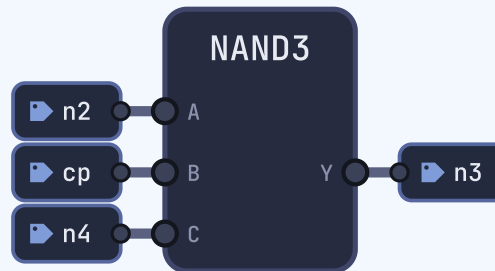
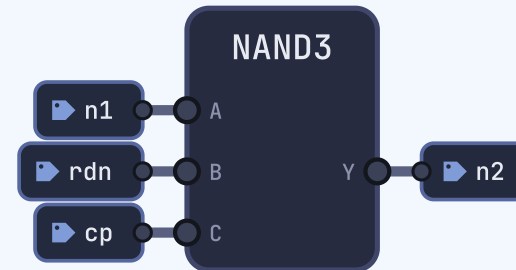
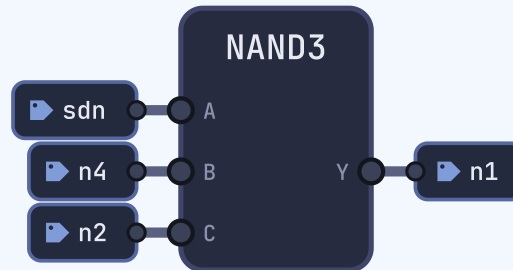
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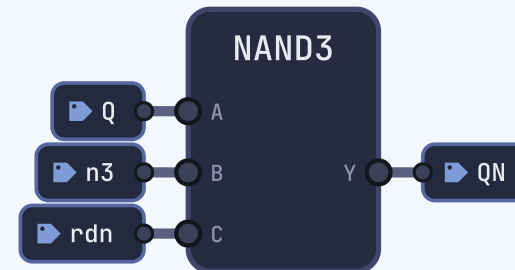
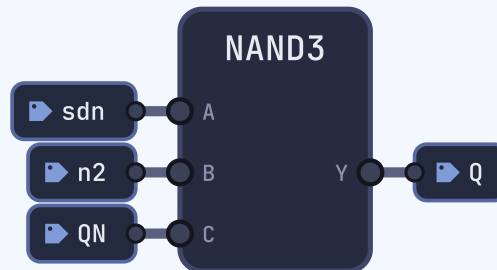
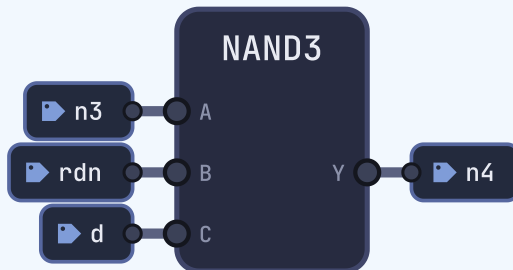
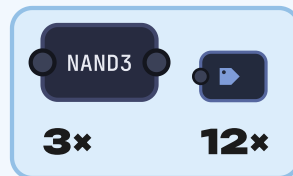
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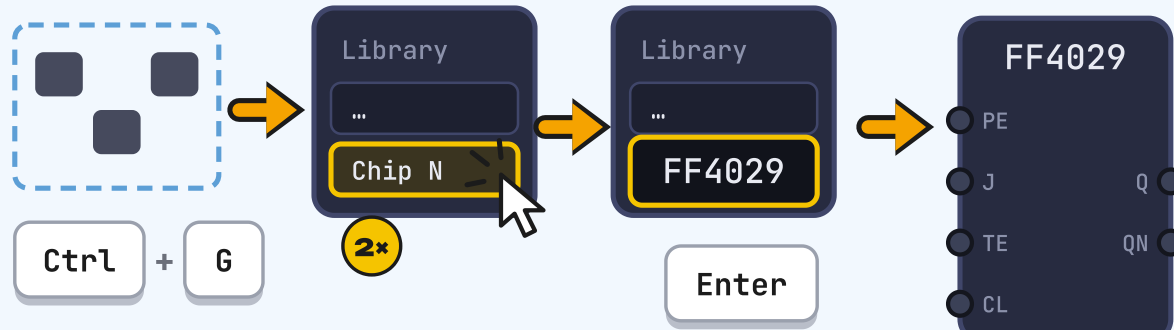


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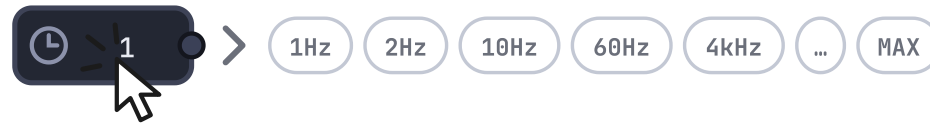
FF4029 ...

11

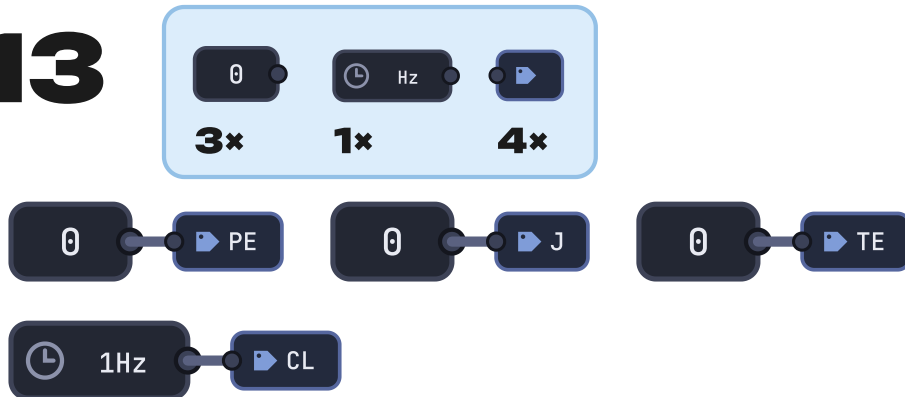


CANVAS

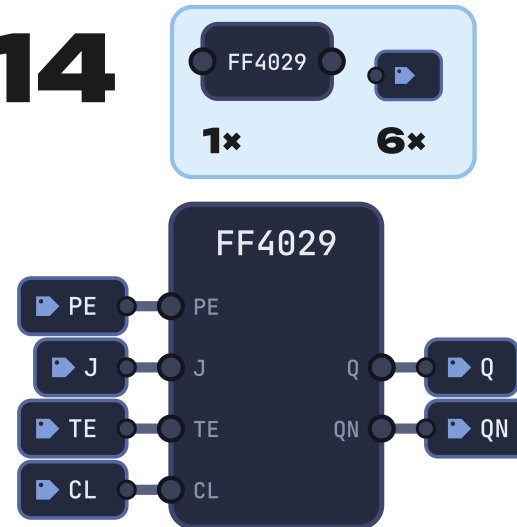
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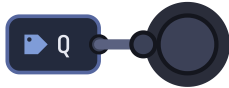
13



14



15



>



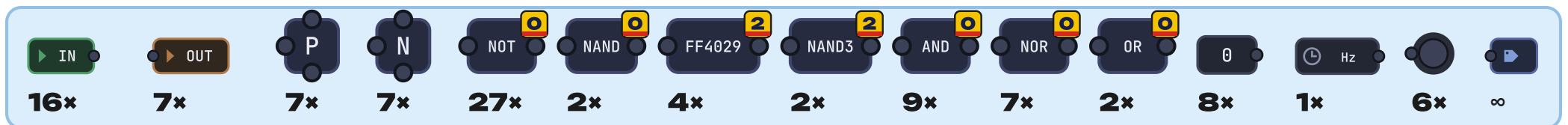
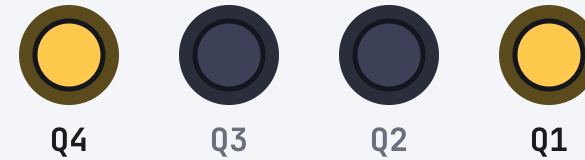
PE = 1, TE = 0: Q blinks half as often as CL



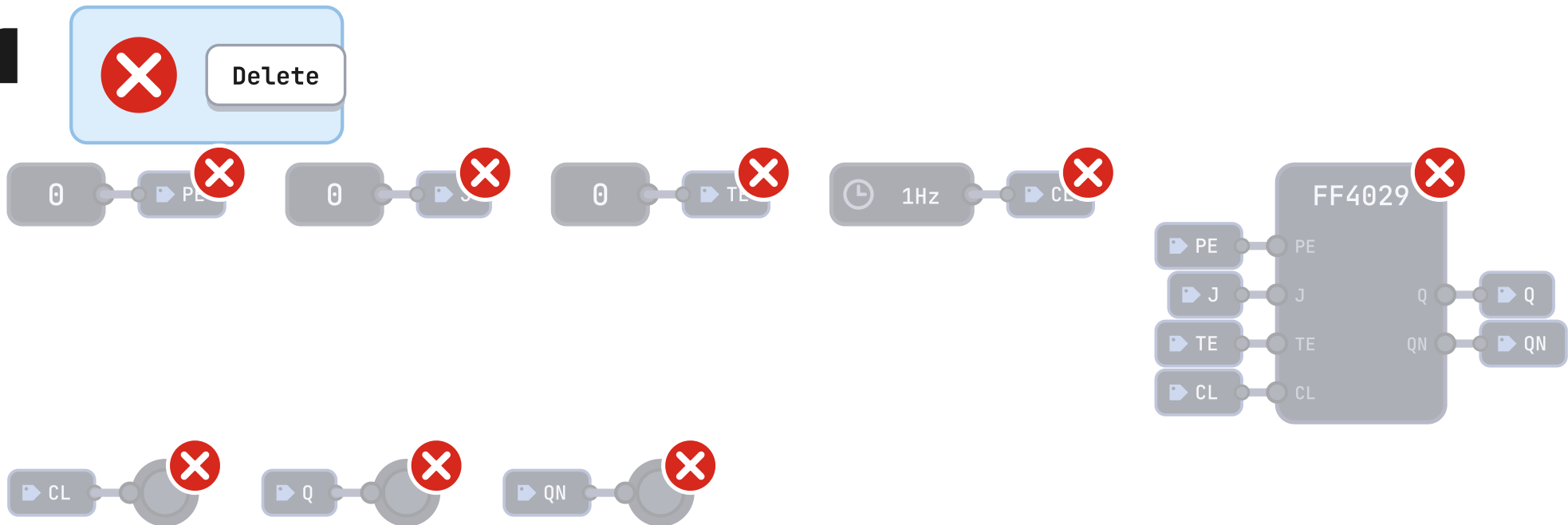
The CD4029 counter

kh HT-04

up and down, binary and decade

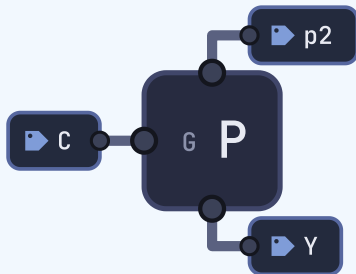
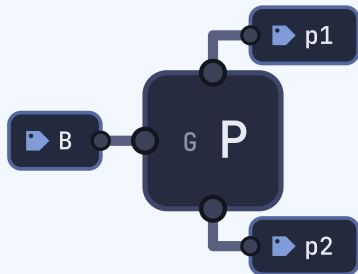
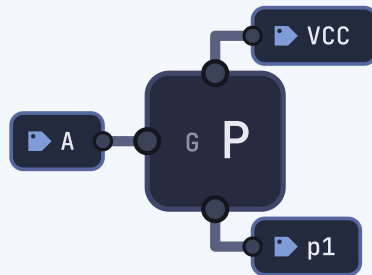


1

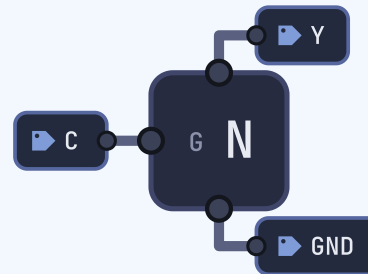
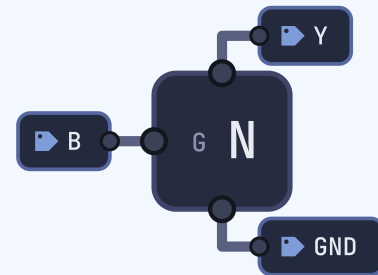
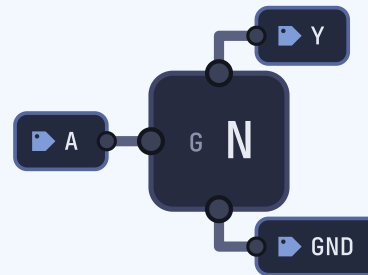


NOR3

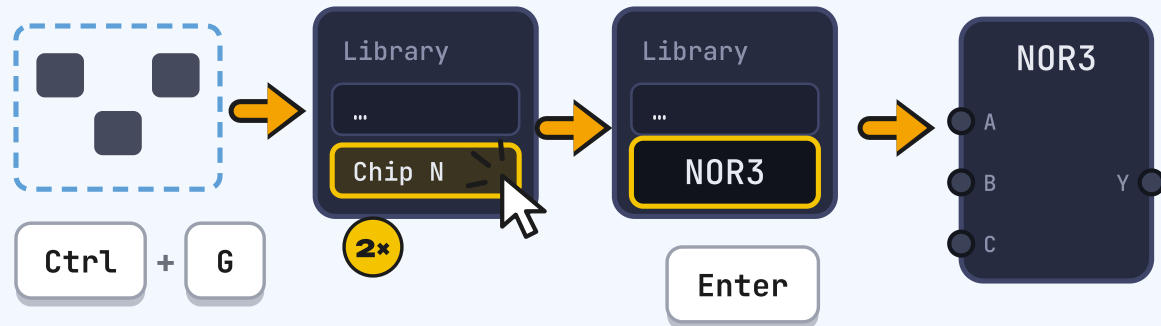
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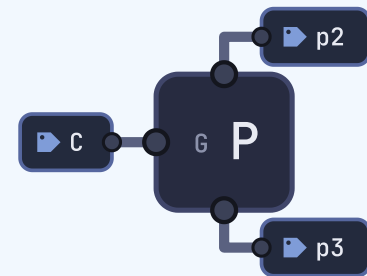
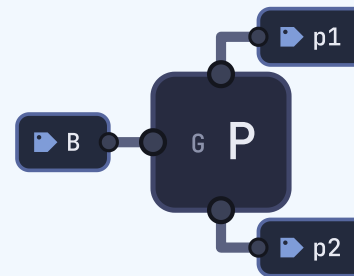
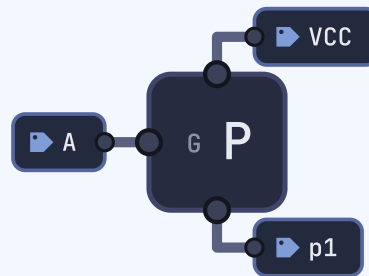


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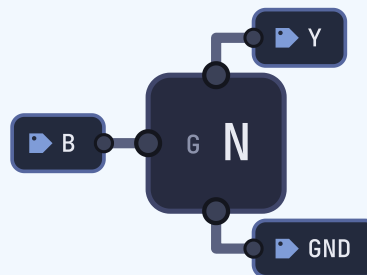
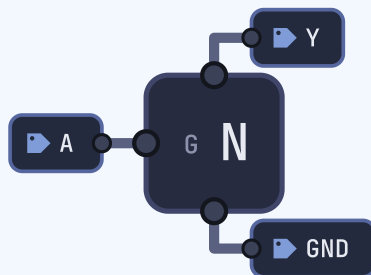
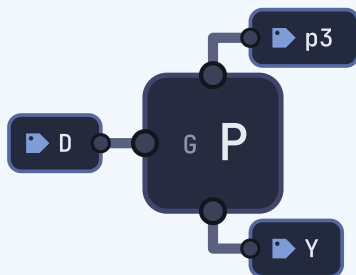


NOR4

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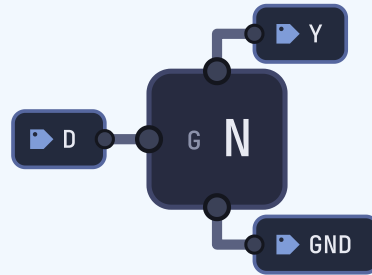
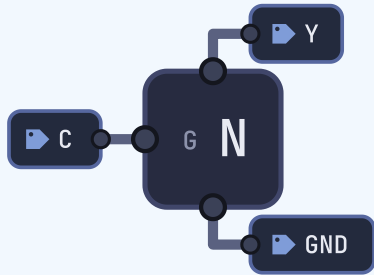
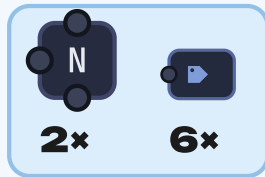


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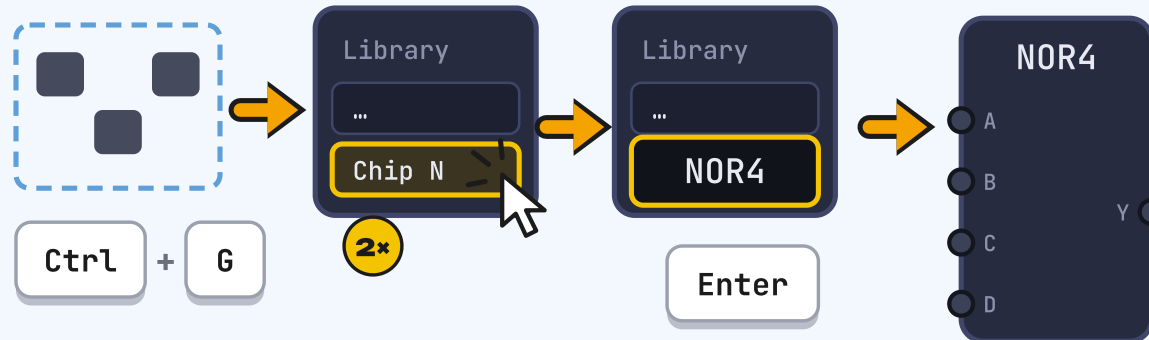


NOR4 ...

7



8

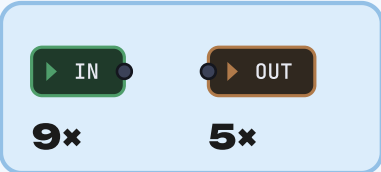


CANVAS

9

pin names as in the TI datasheet; a bar over a name in the picture = active 0, in the simulator without the bar

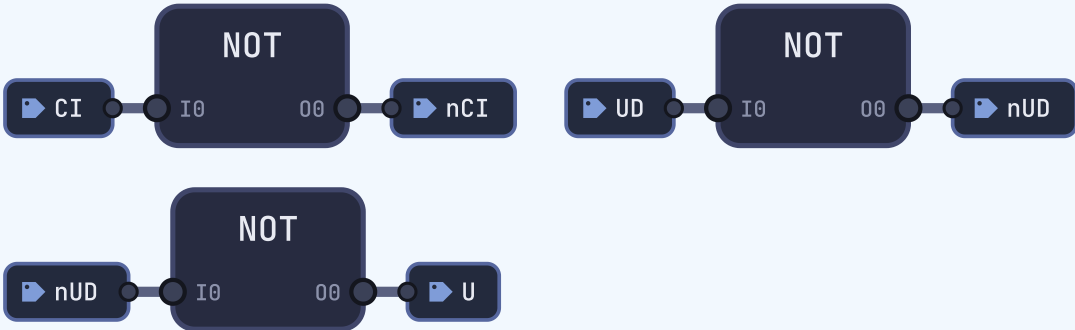
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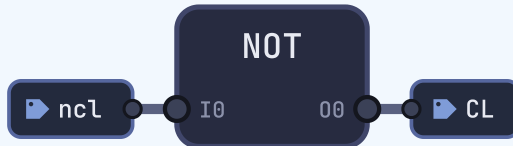
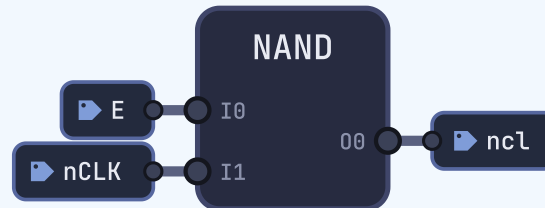
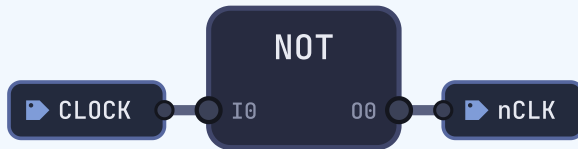
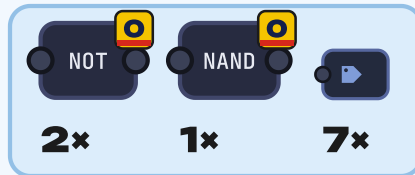
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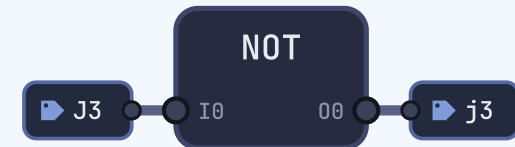
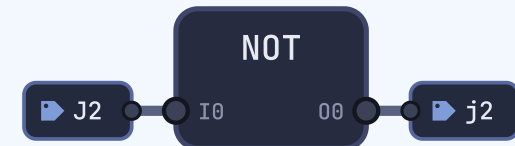
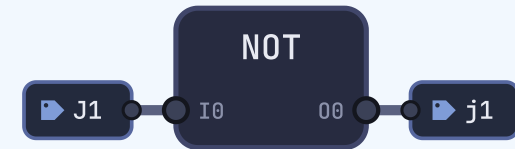
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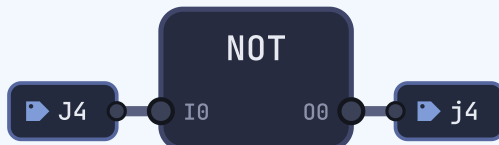
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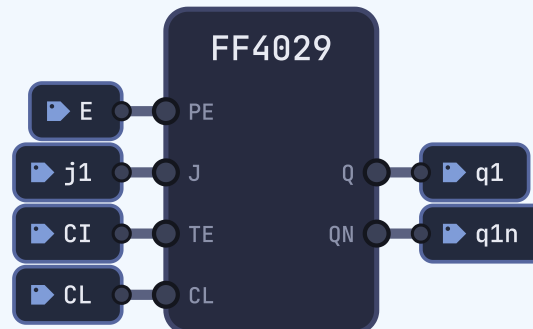
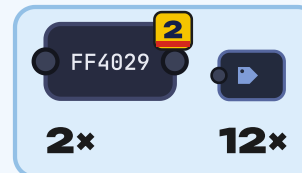
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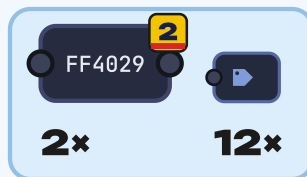
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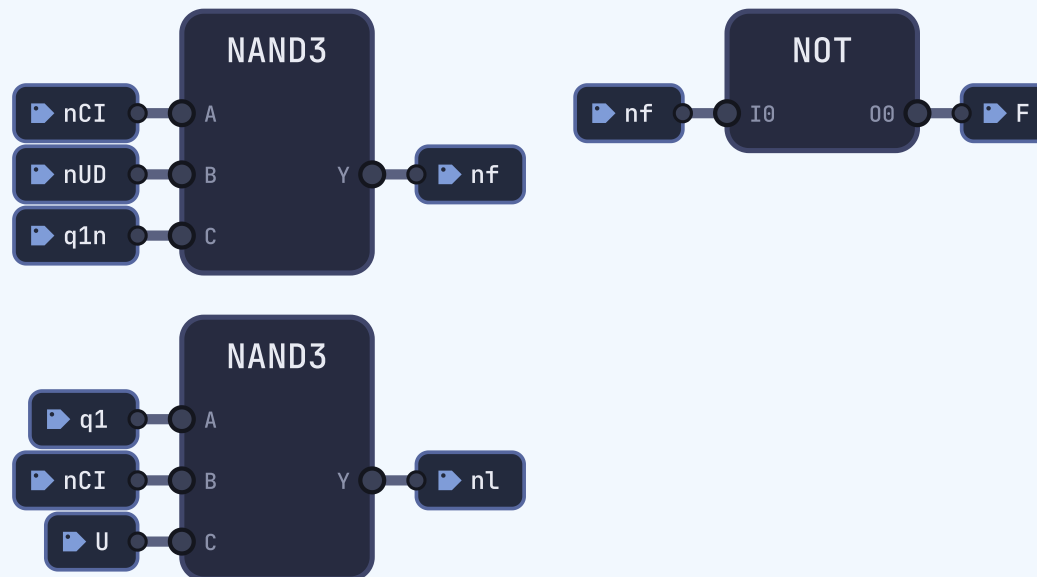
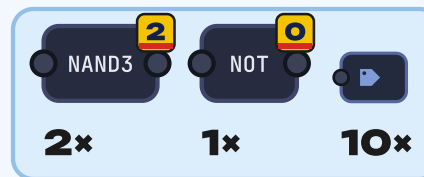
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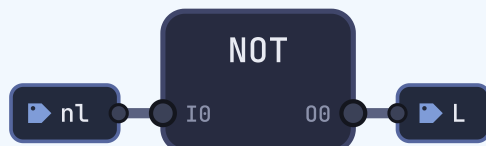
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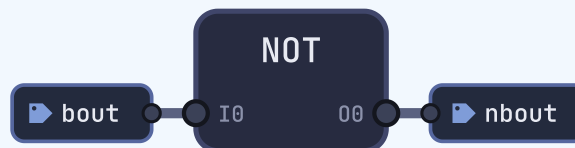
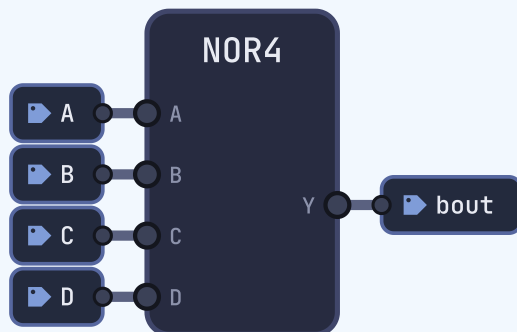
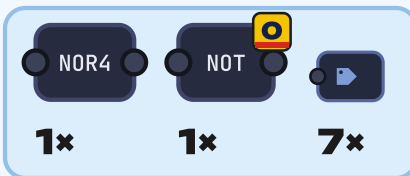
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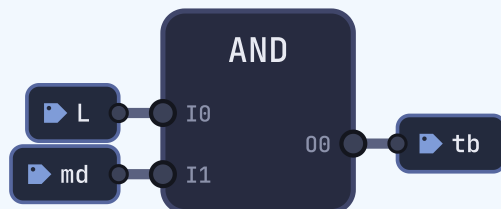
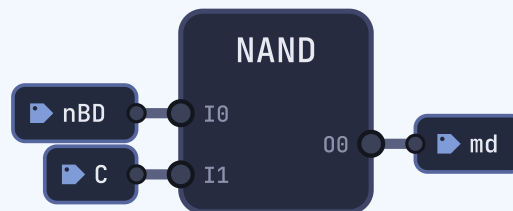
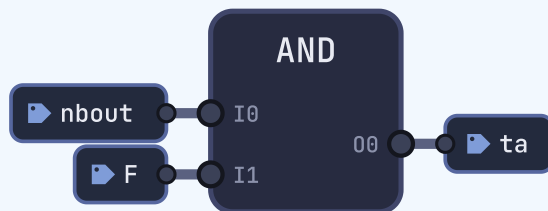
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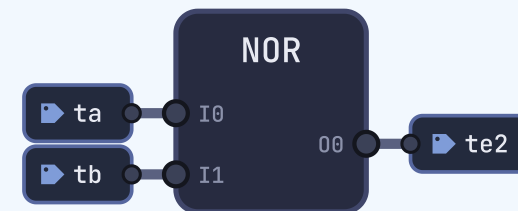
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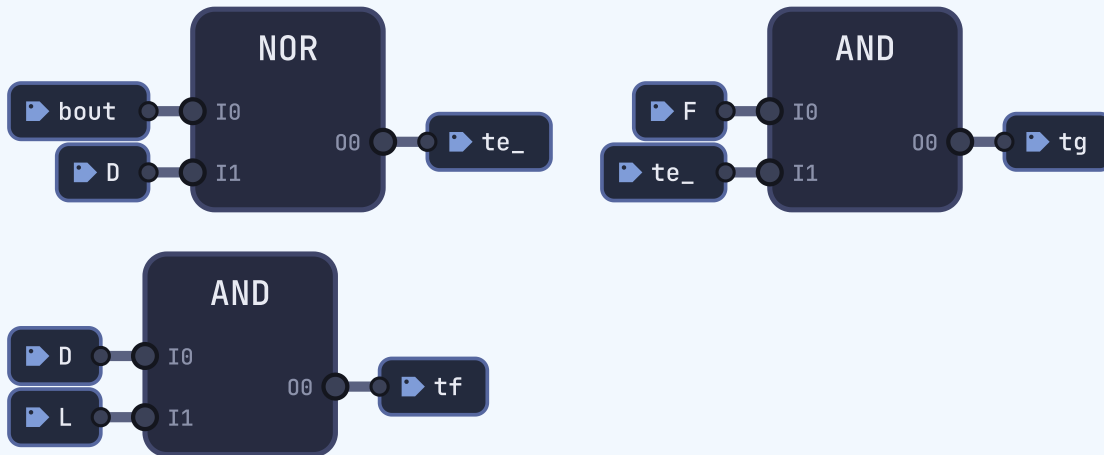
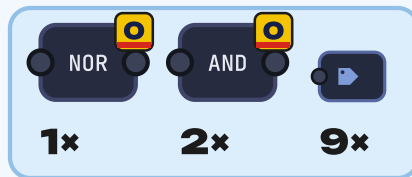
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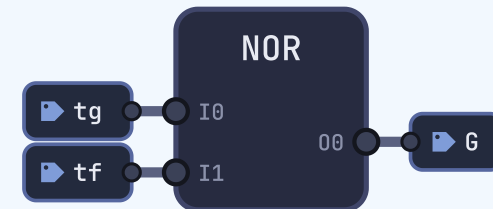
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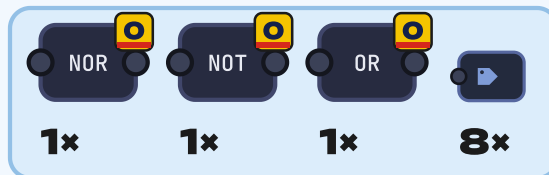
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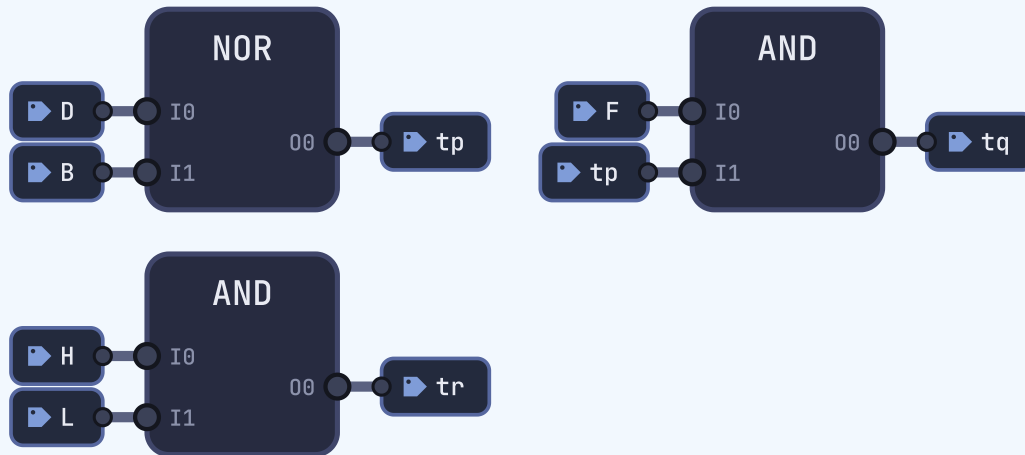
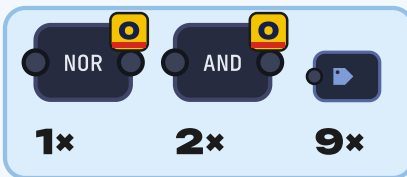
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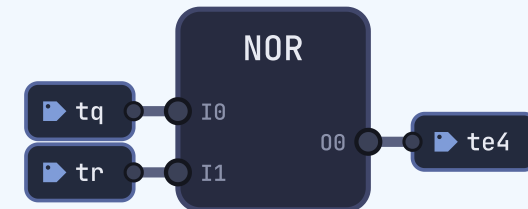
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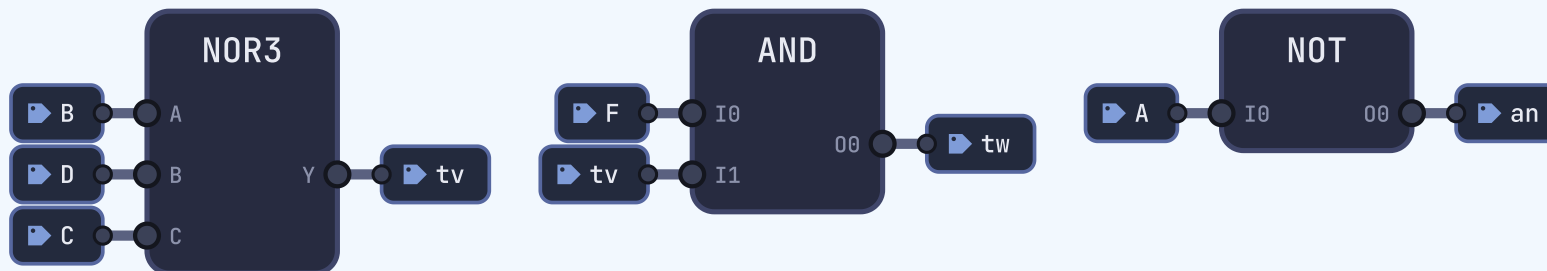
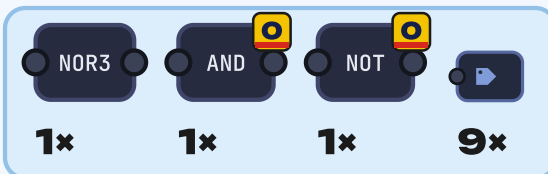
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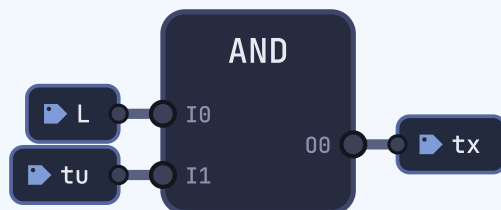
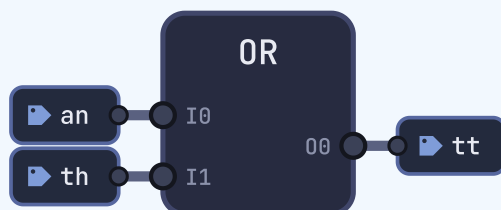
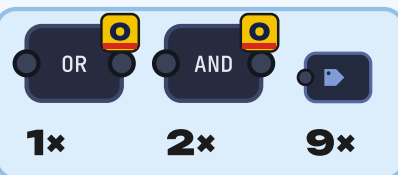
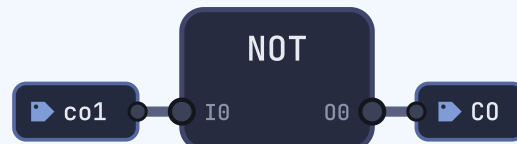
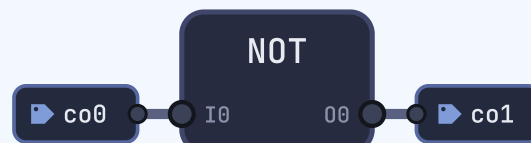
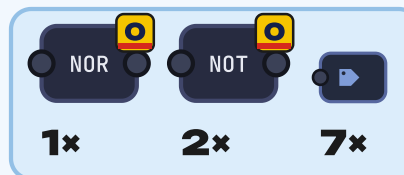
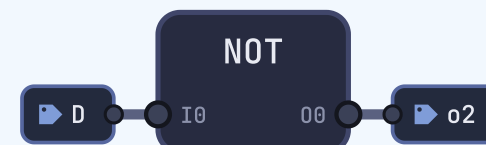
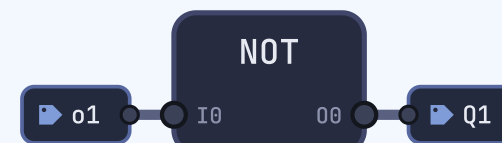
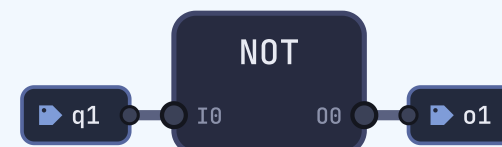
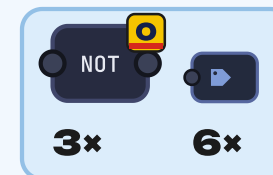
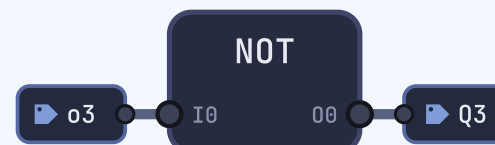
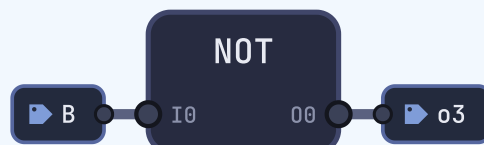
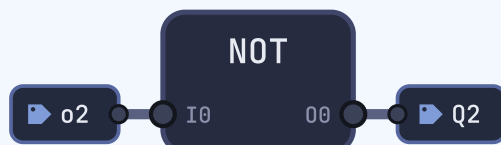
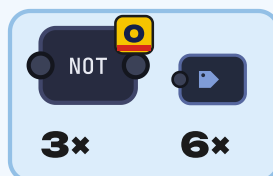


27



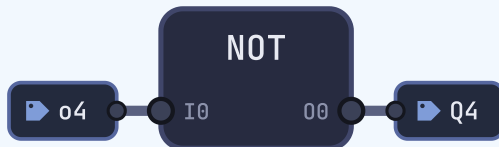
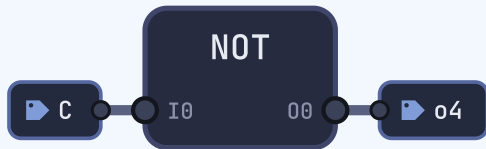
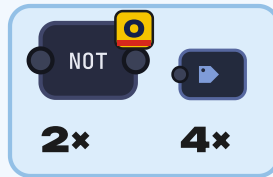
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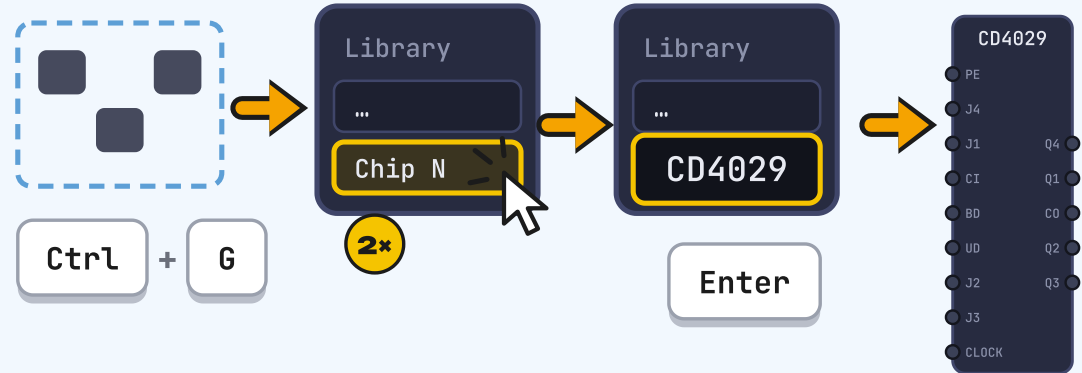
29**30****31****32**

CD4029 ...

33

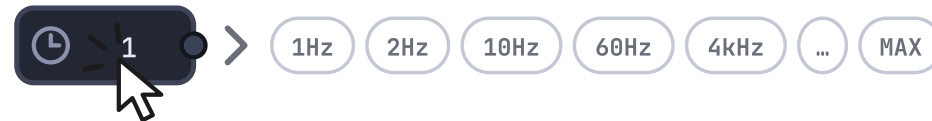


34

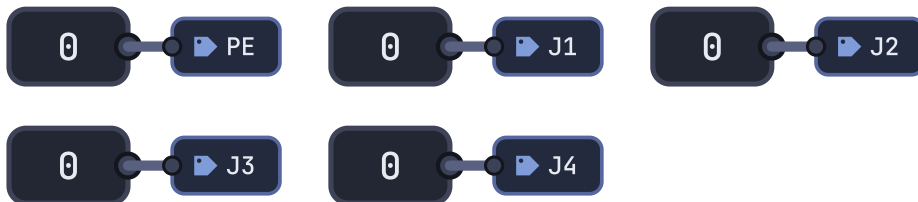


CANVAS

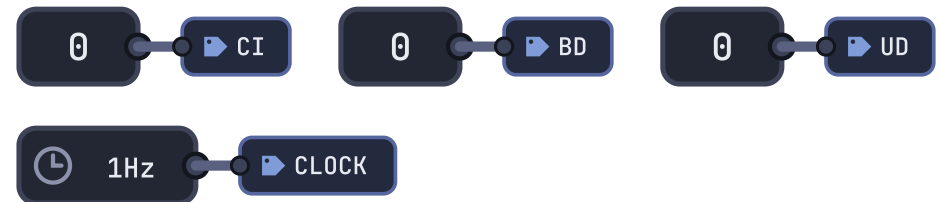
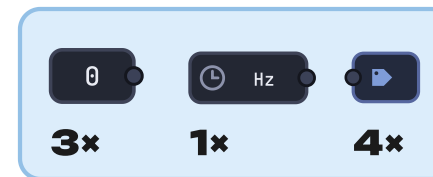
35



36



37

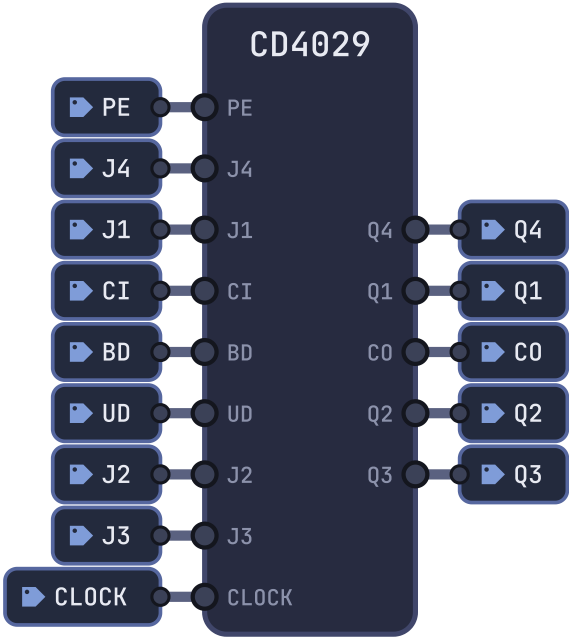


38

CD4029

1x

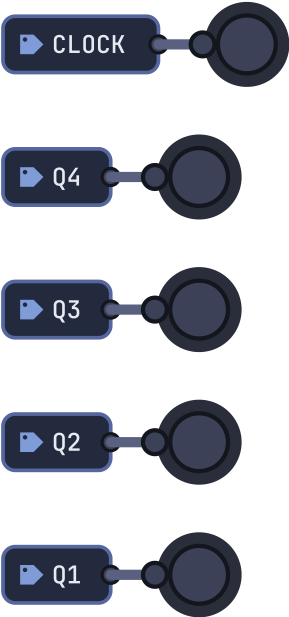
14x



39

5x

5x



40

1x

1x

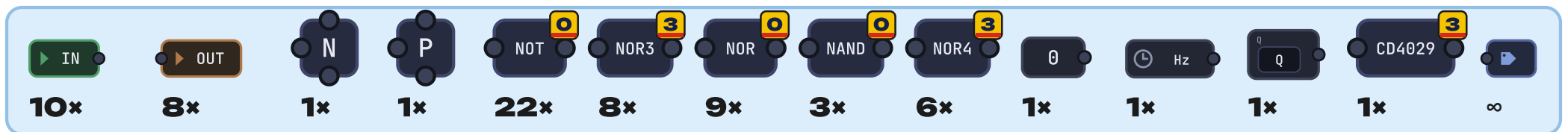
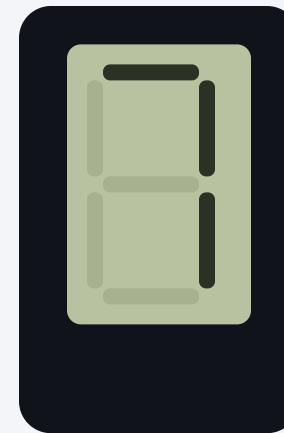


BD = 0, UD = 1: 0 → 9 → 0

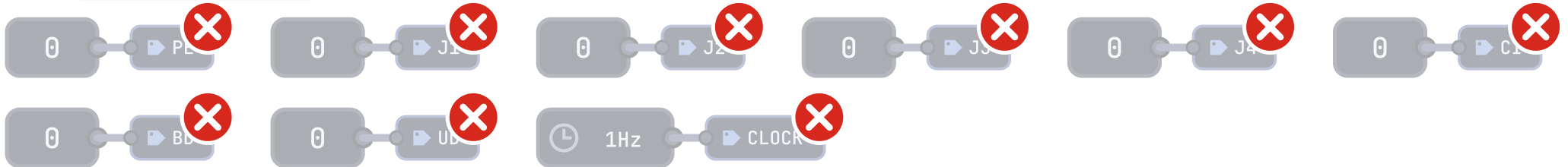


The CD4511 decoder

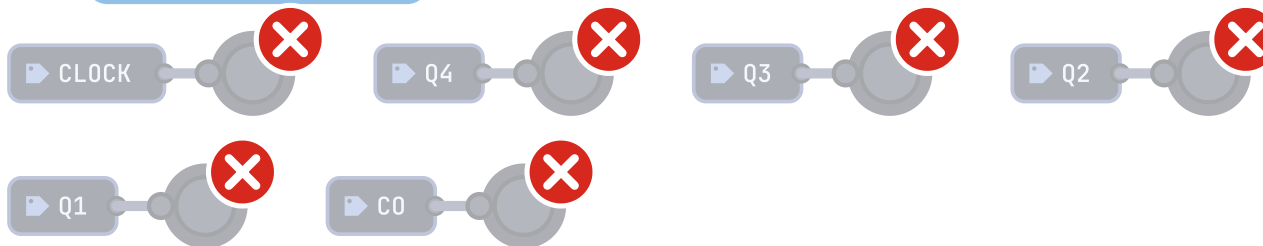
a binary code → a digit on the display



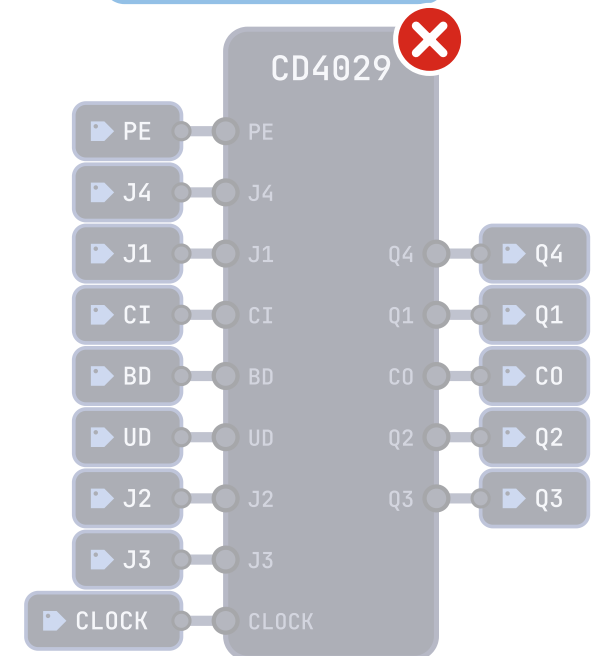
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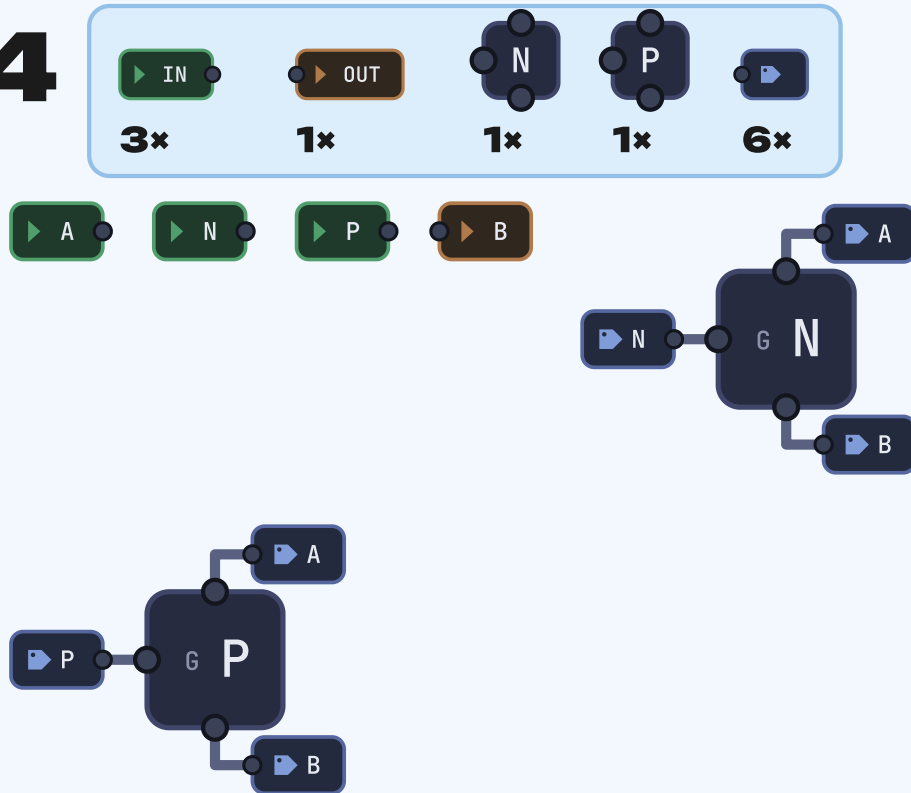
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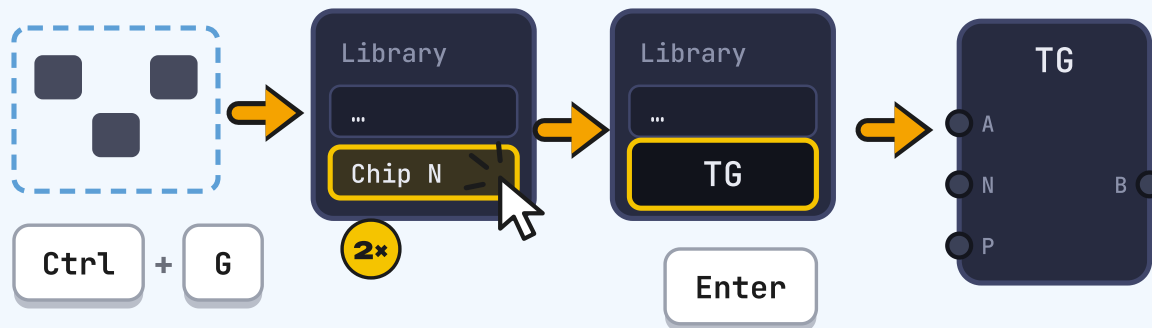
3



4



5

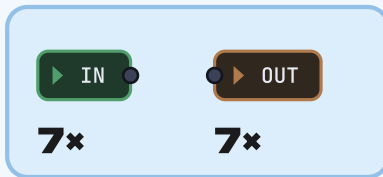


6

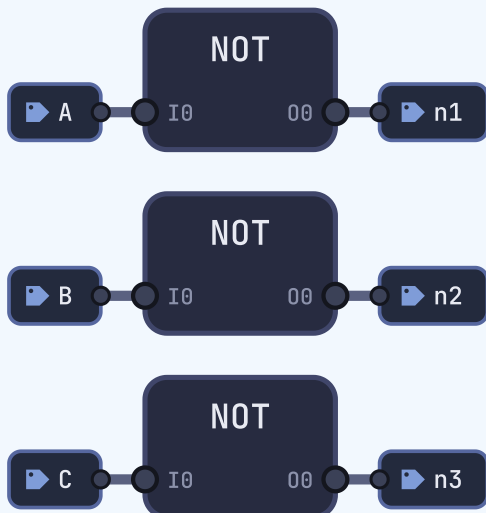
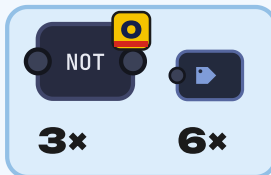
pin names as in the TI datasheet; a bar over a name in the picture = active 0, in the simulator without the bar

CD4511

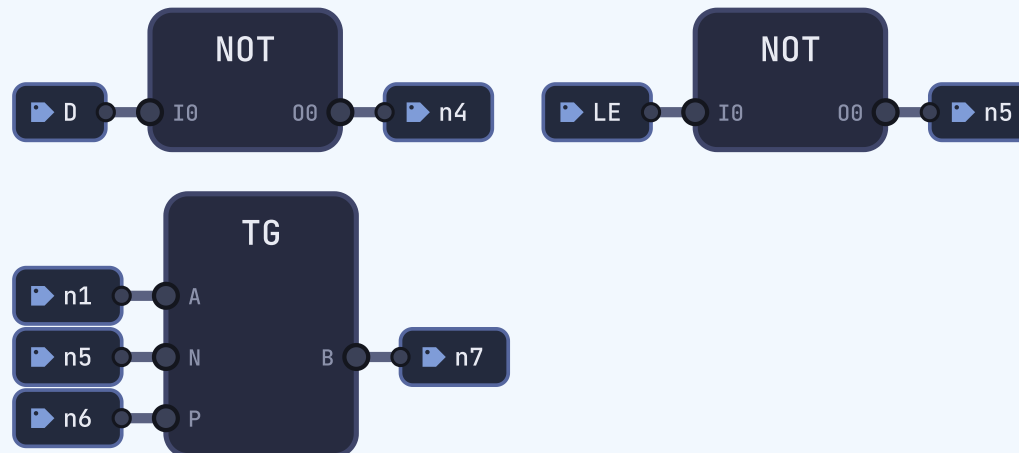
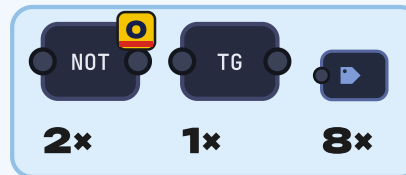
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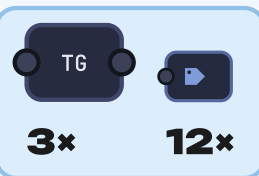
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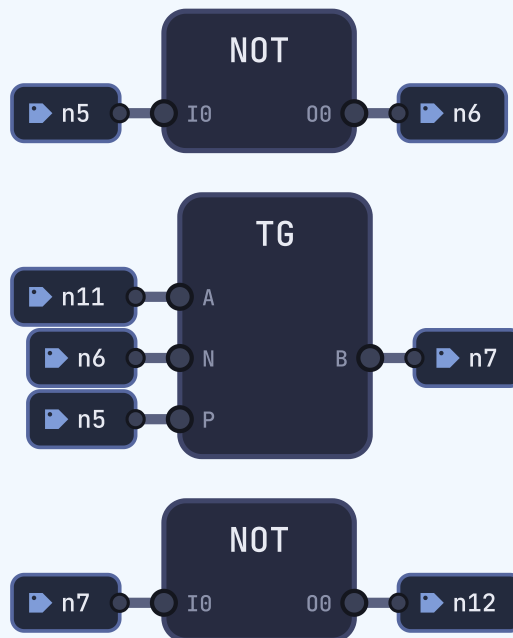
9



10



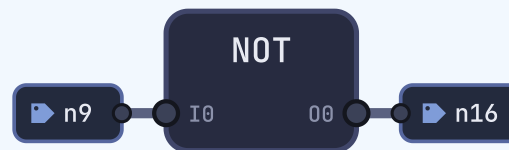
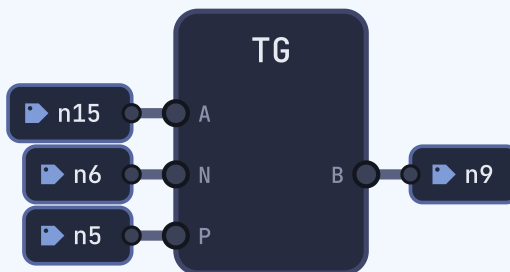
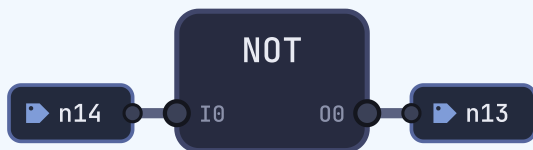
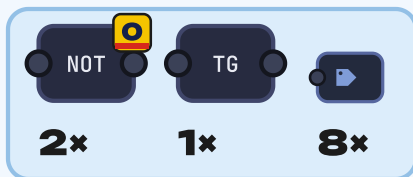
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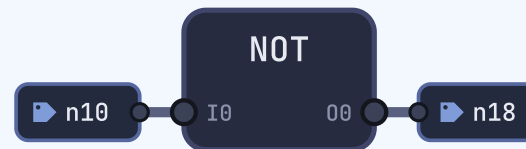
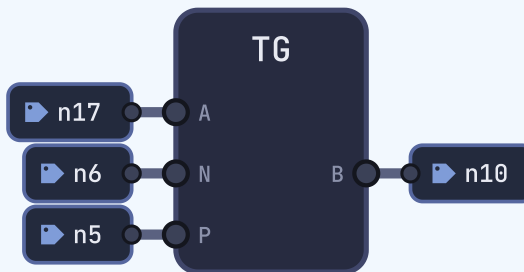
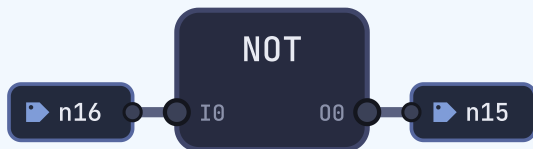
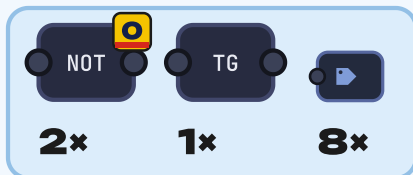
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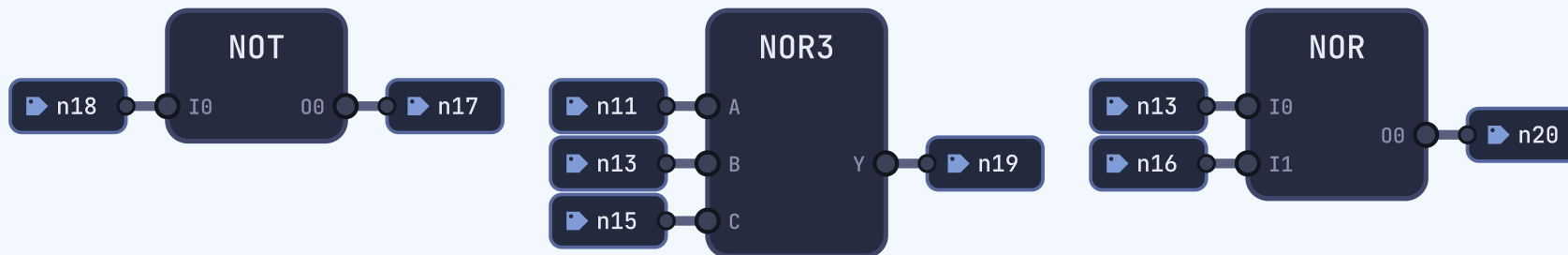
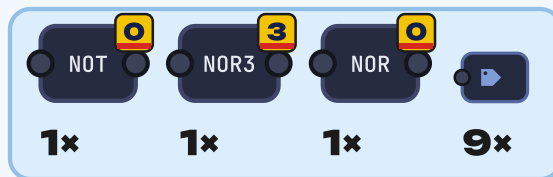
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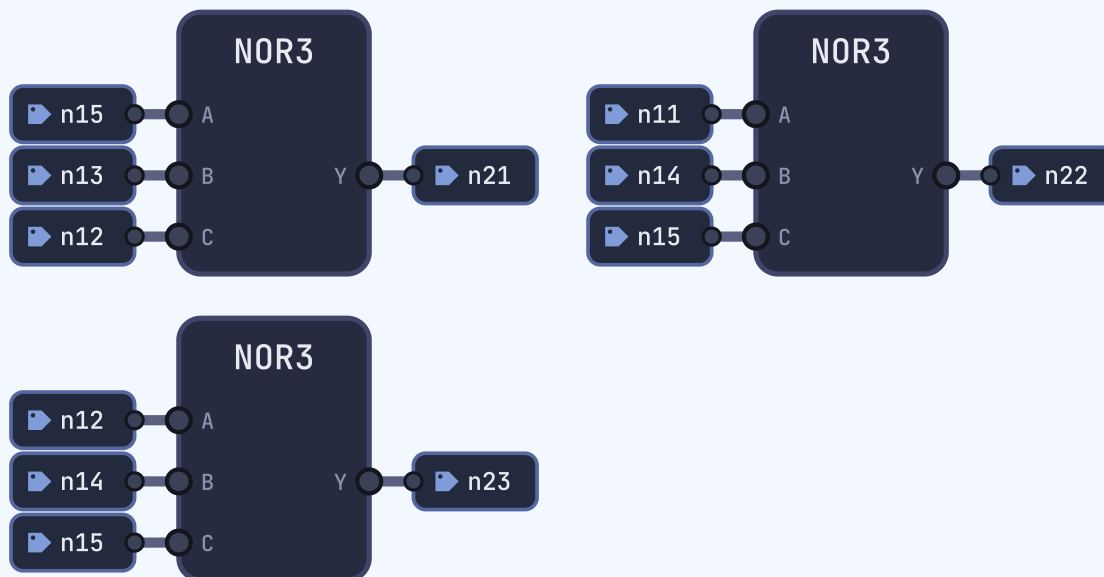
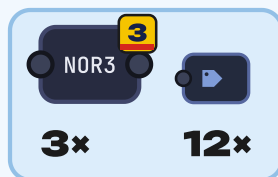
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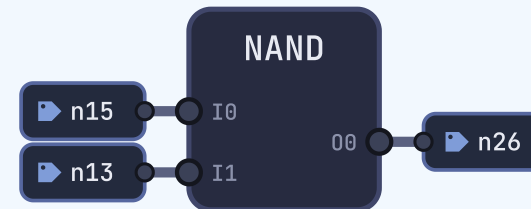
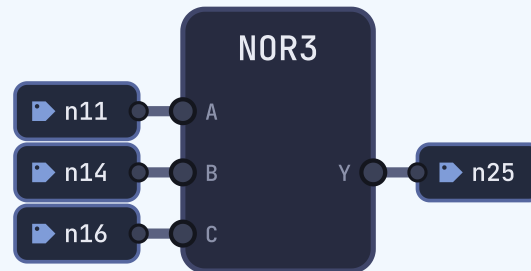
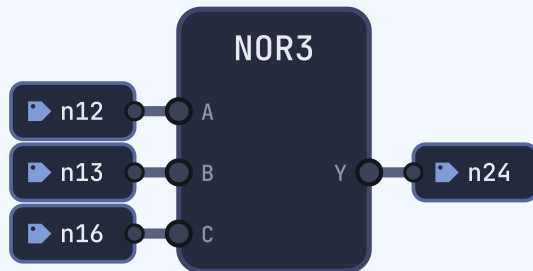
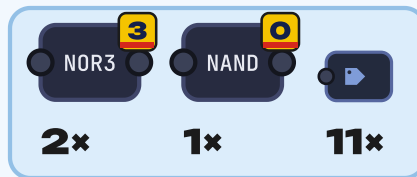
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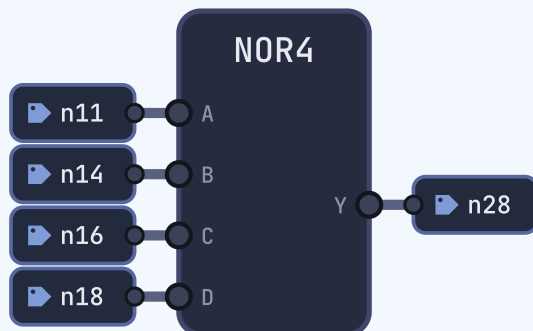
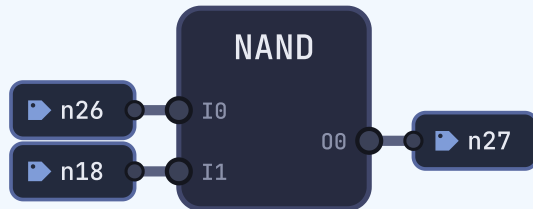
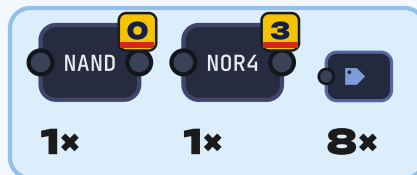
16



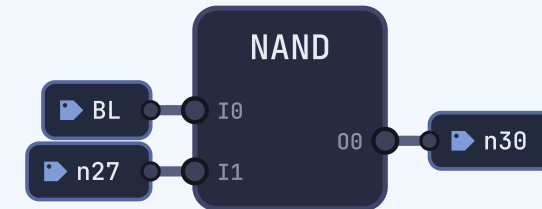
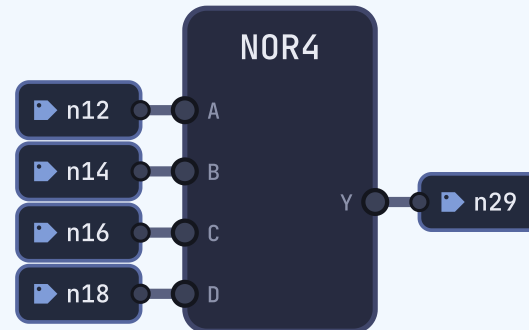
17



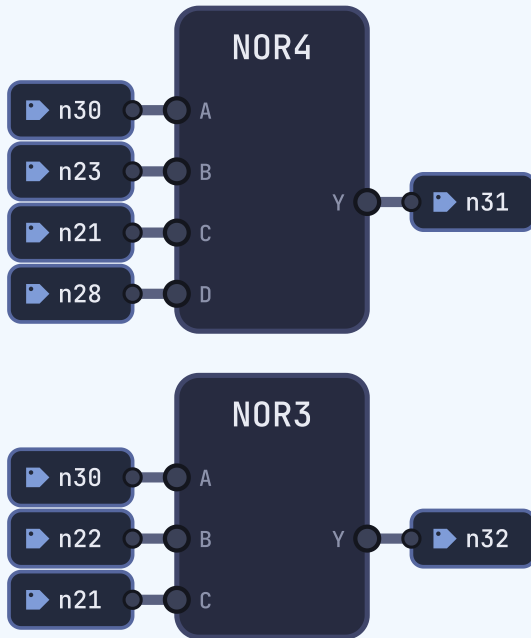
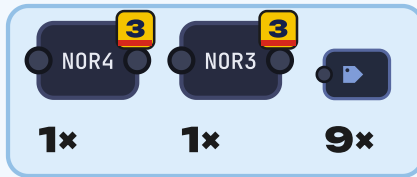
18



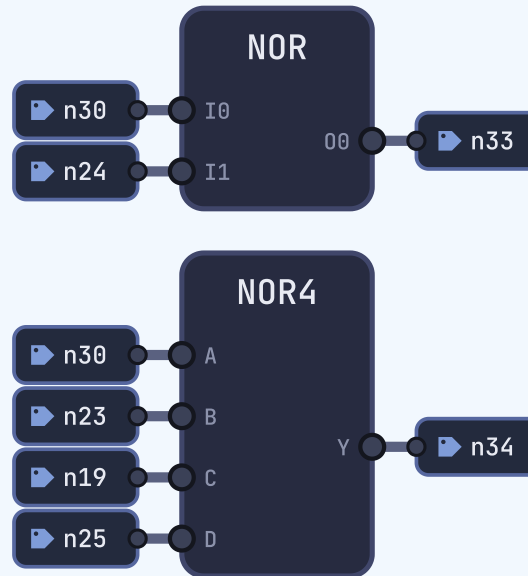
19



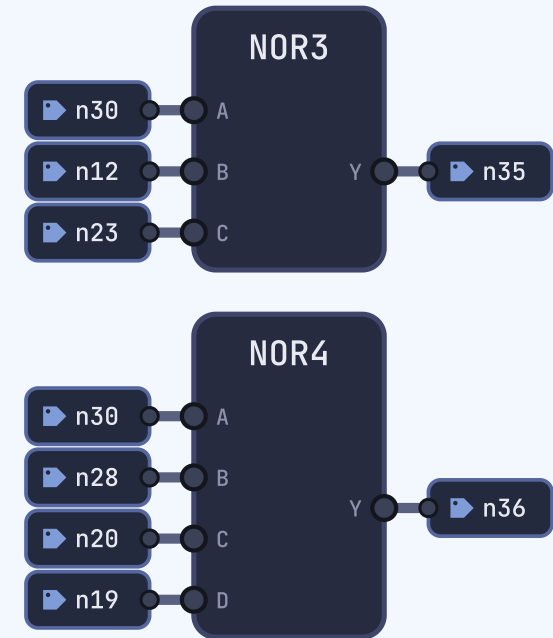
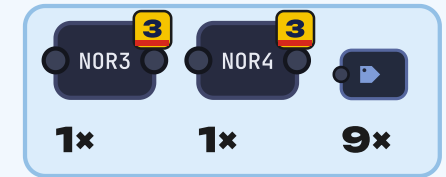
20

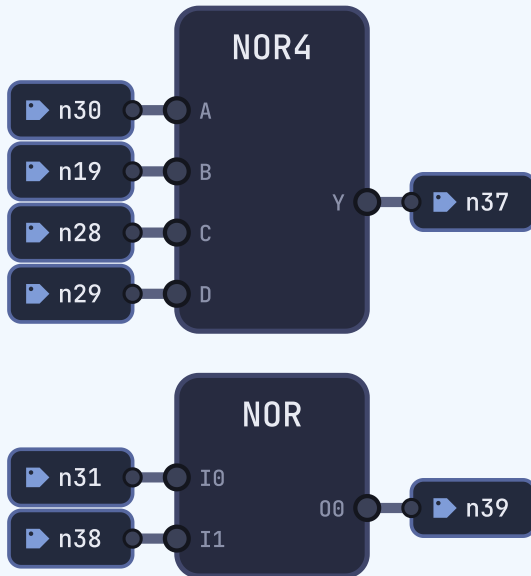
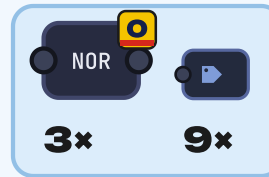
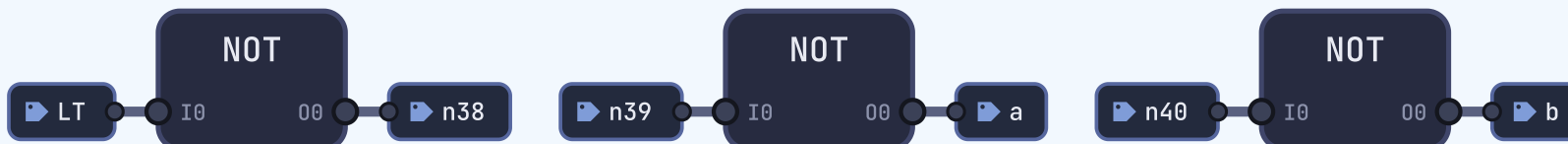
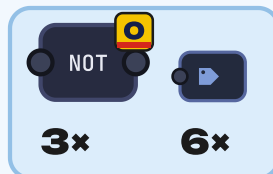


21



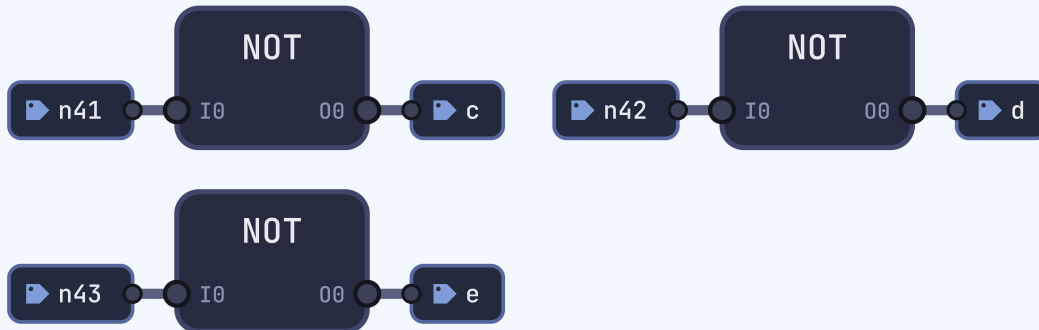
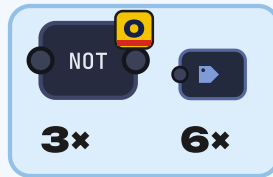
22



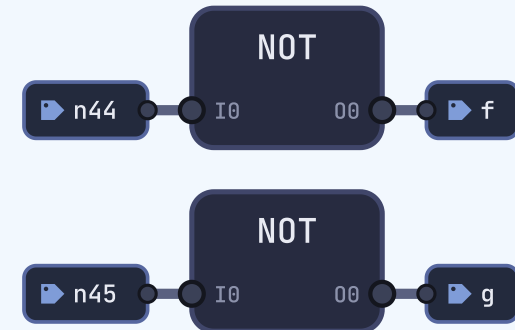
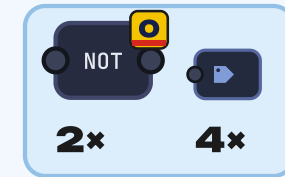
23**24****25****26**

CD4511 ...

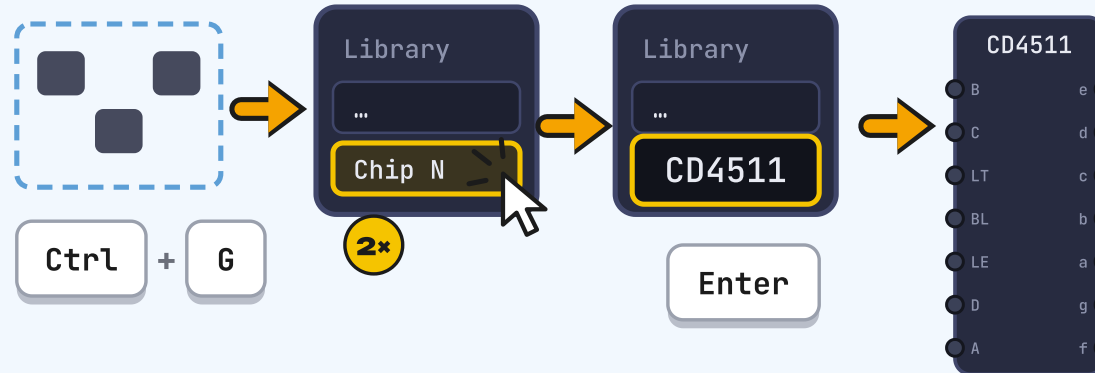
27



28

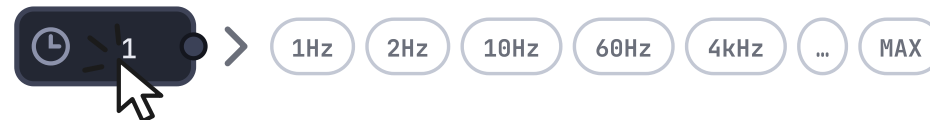


29

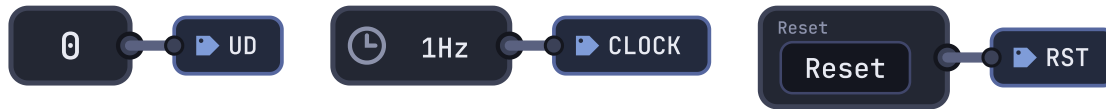


CANVAS

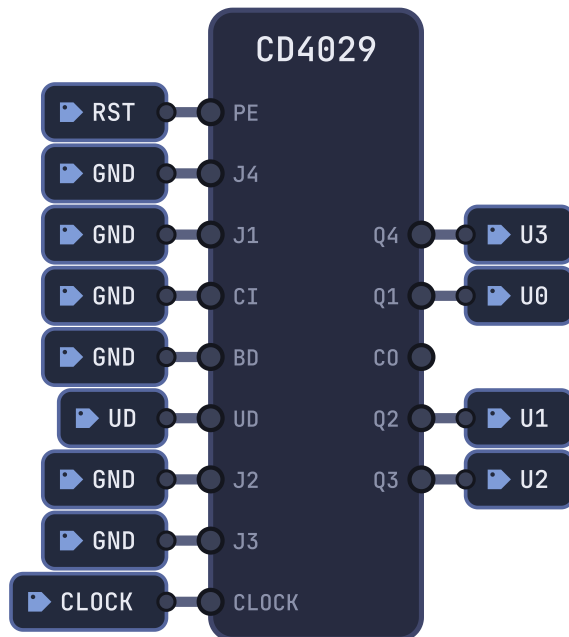
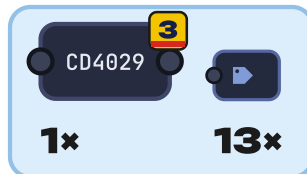
30



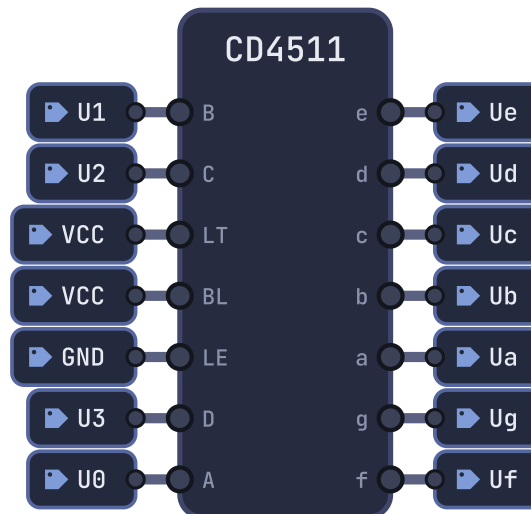
31

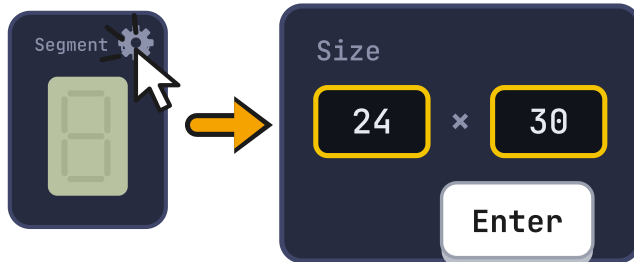
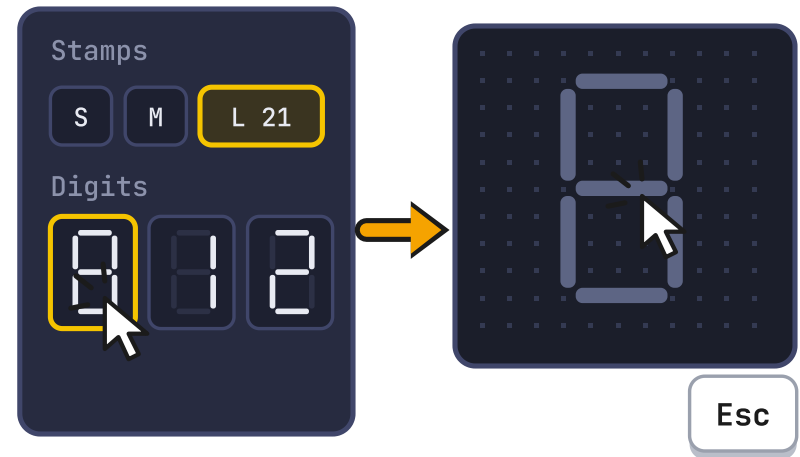
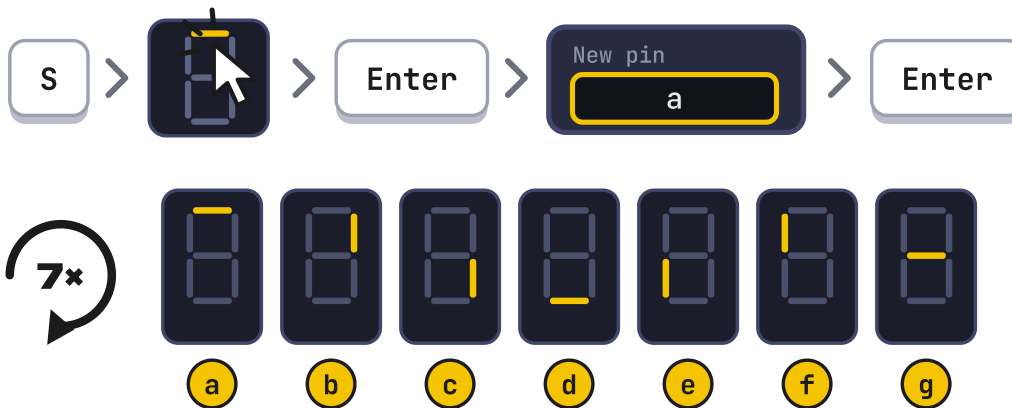
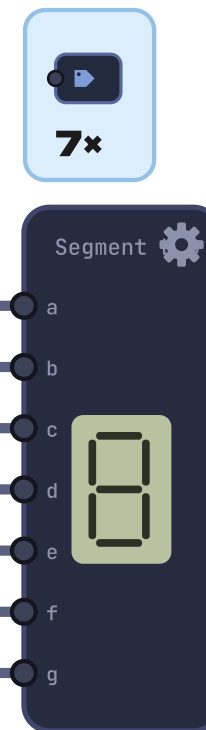


32



33



34**35****36****37**



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...

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UD = 1: 0 → 9

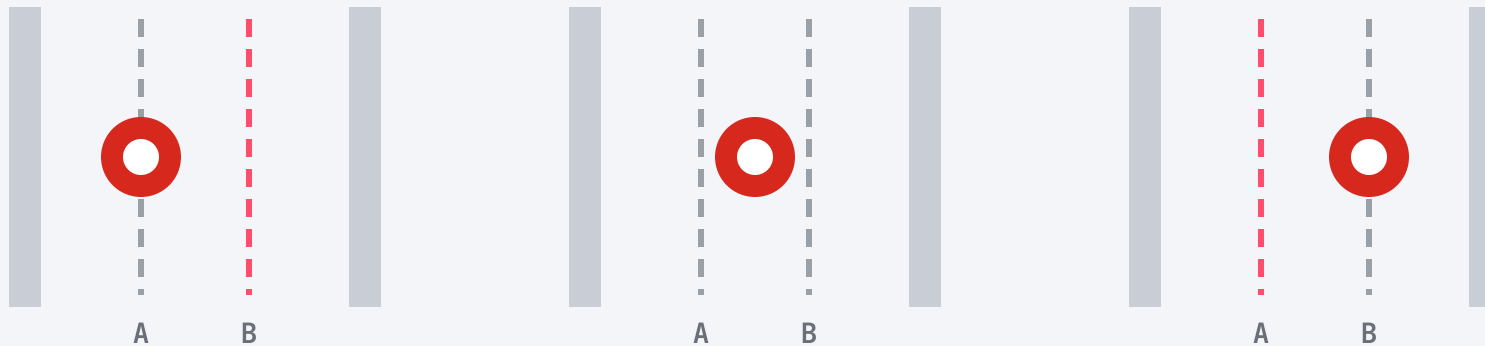
38

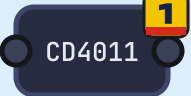
delete the probe, keep the display (without labels)



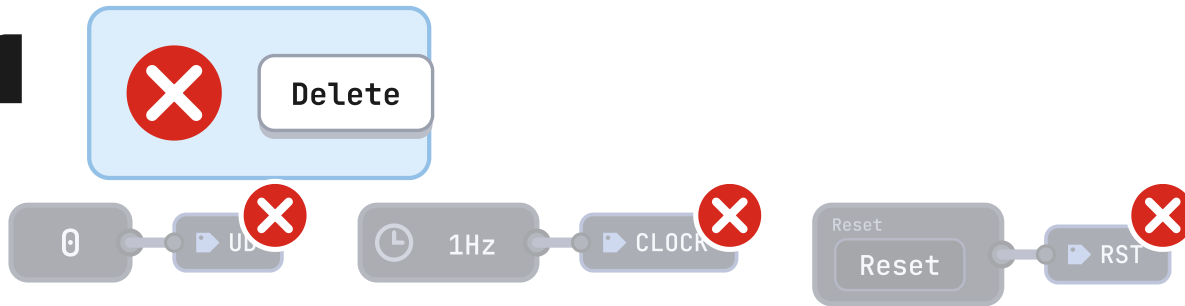
Direction

two beams: which one is blocked first

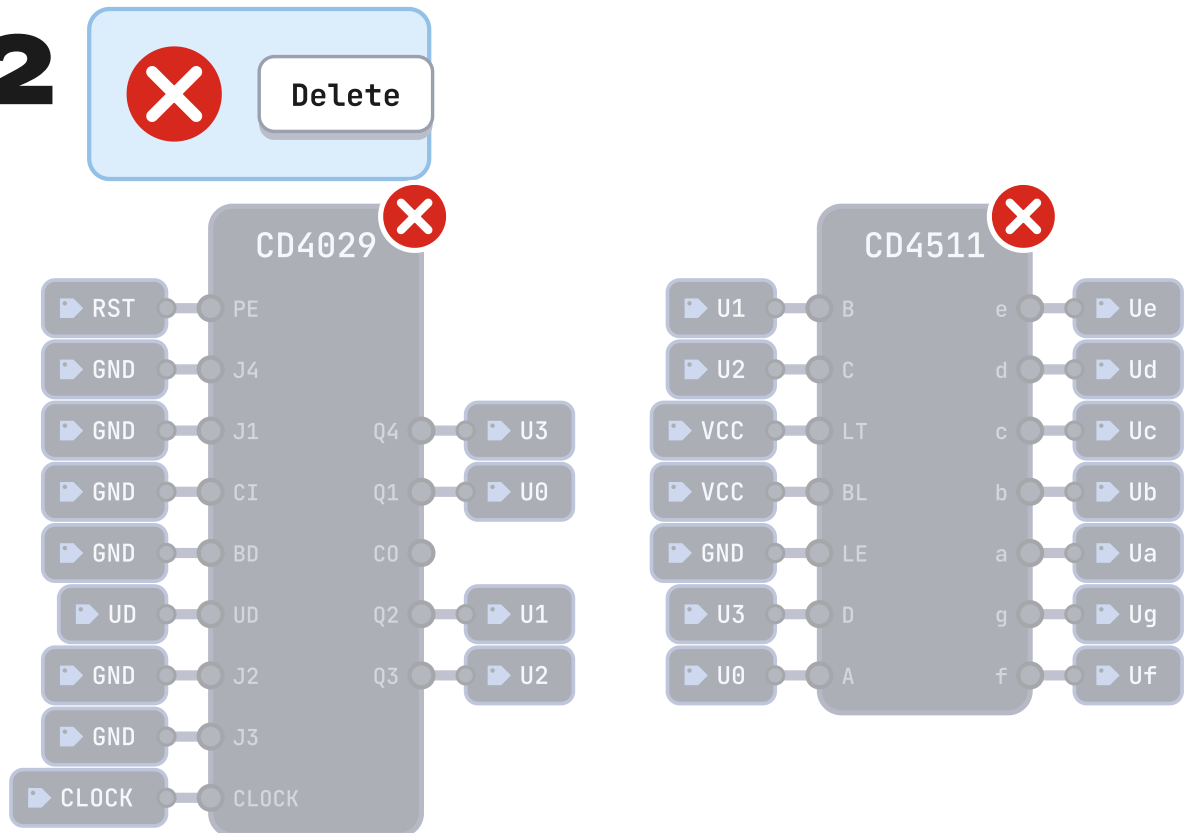


 VCC	 GND	 E	 R	 CD4011		
1×	1×	2×	2×	2×	5×	∞

1



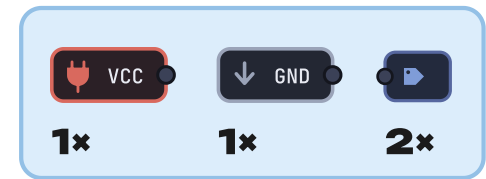
2



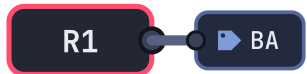
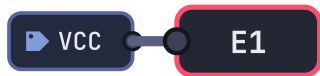
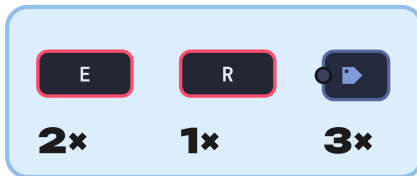
3

pairs one under the other: beam A on top (street), beam B below (shop floor)

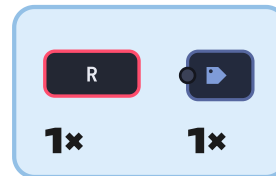
4



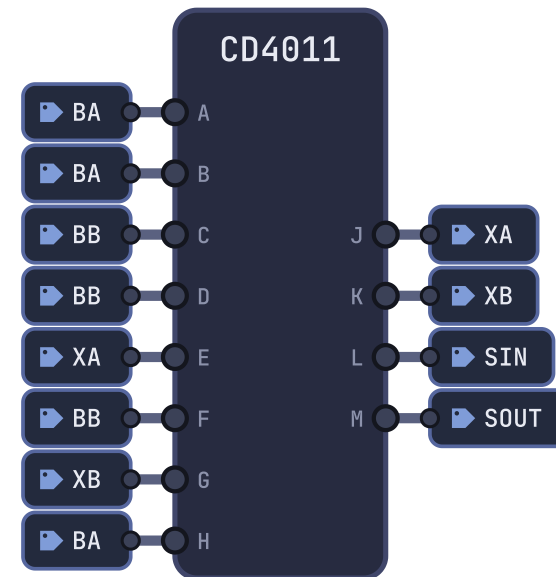
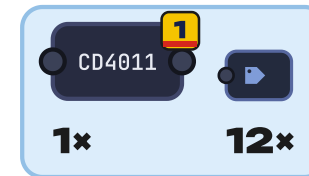
5



6

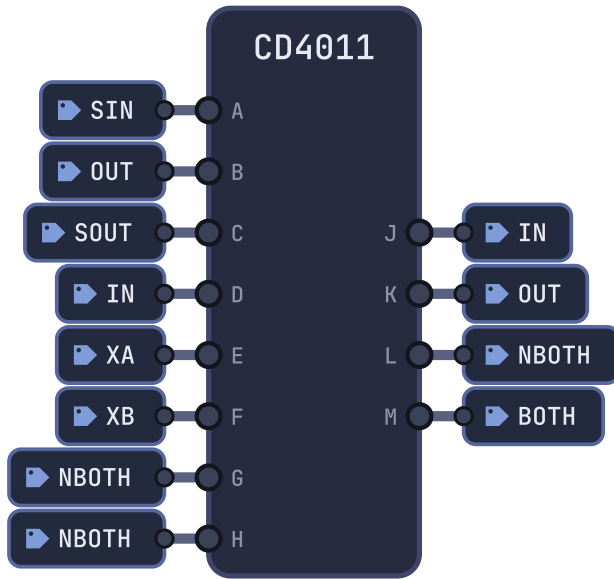
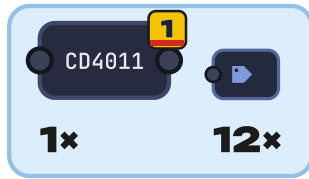


7

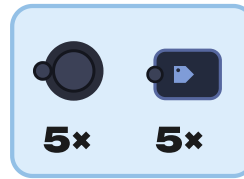


CANVAS ...

8

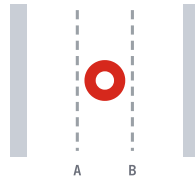
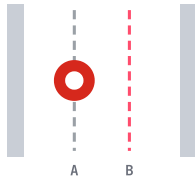


9



10

Alt/⌘ + click on a beam – blocked and fixed; again – cleared



A, both, B – IN, BOTH, OUT

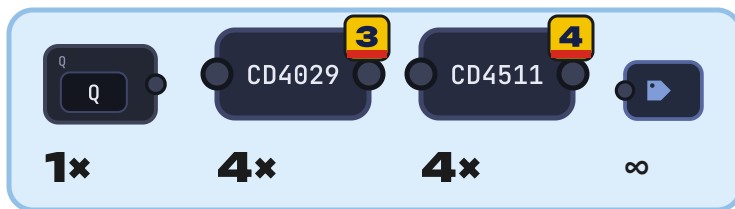
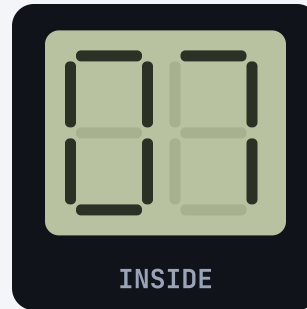
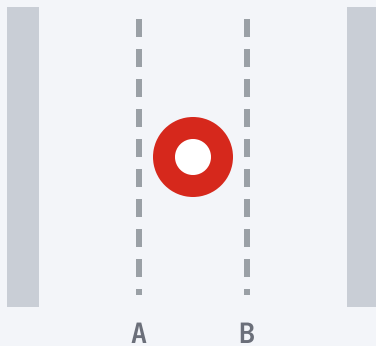




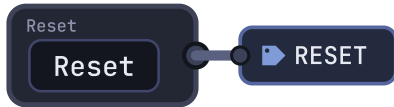
The visitor counter

kh HT-04

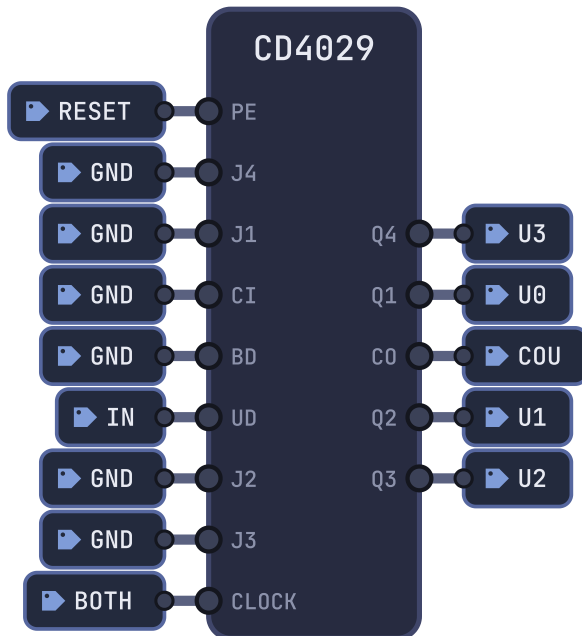
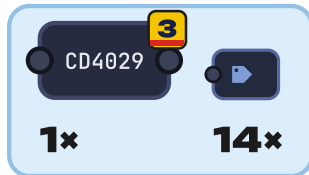
"inside" and "total in" displays



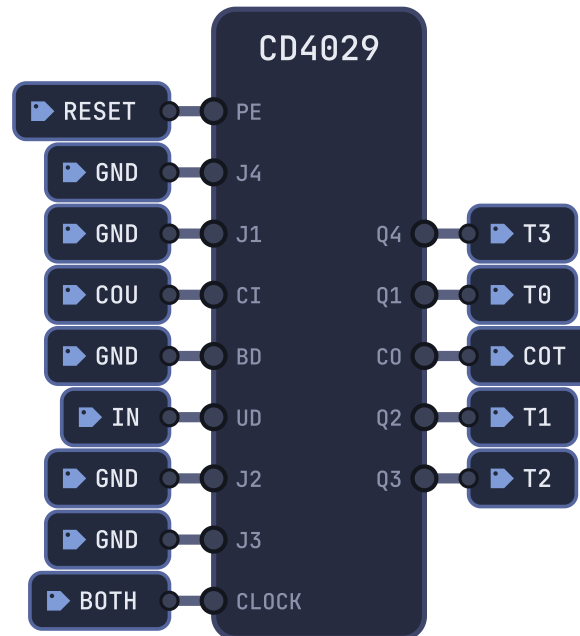
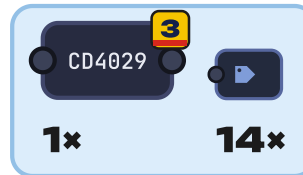
1



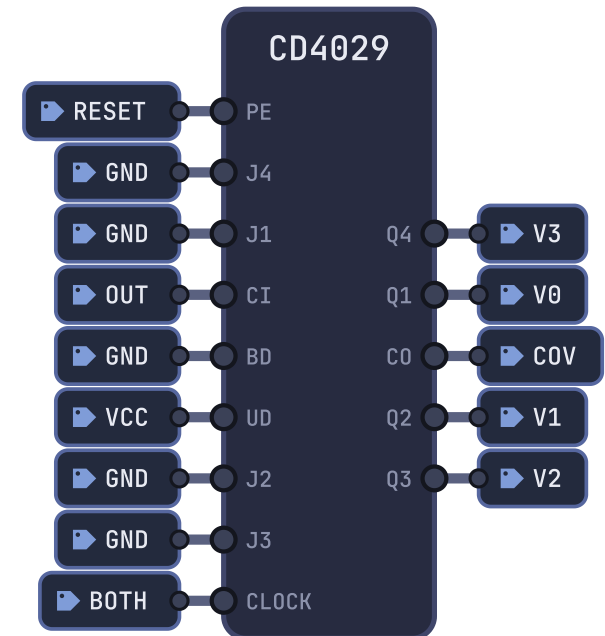
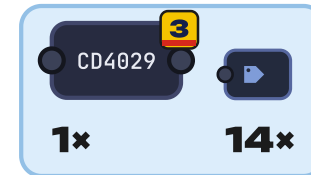
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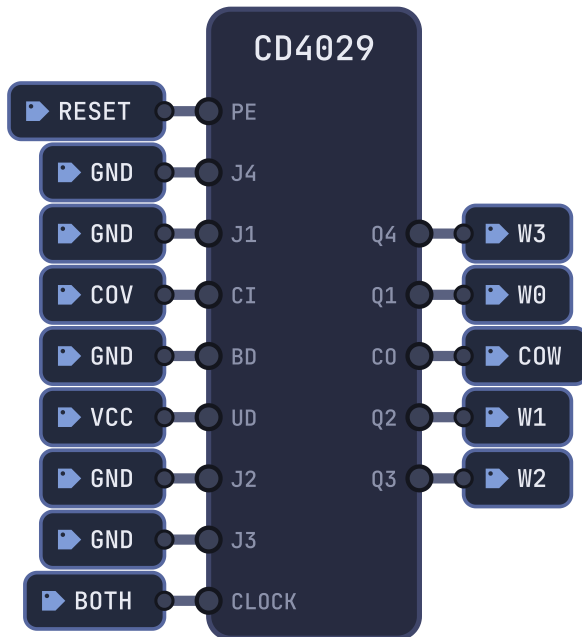
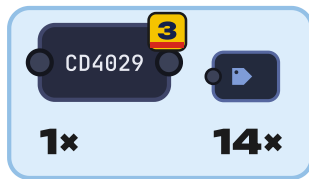
3



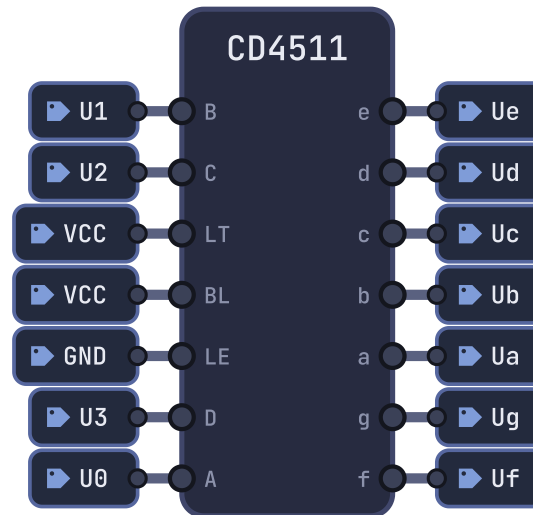
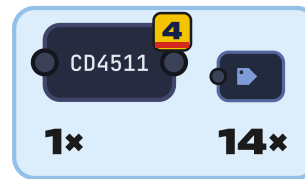
4



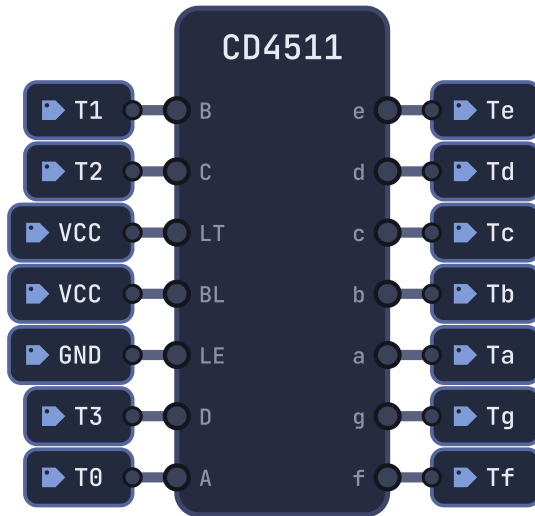
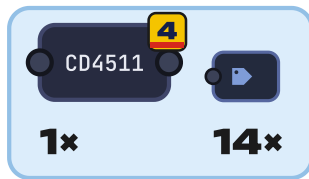
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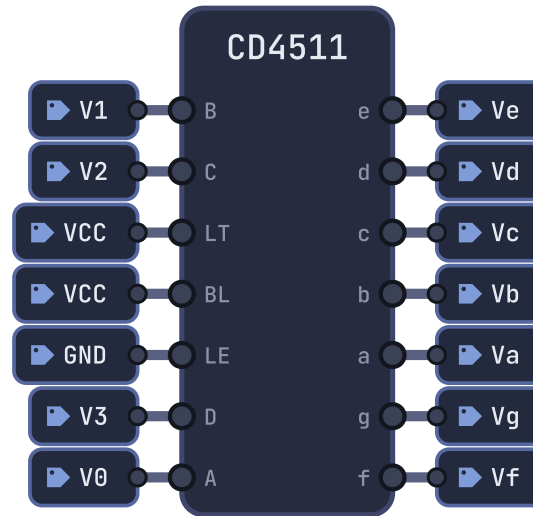
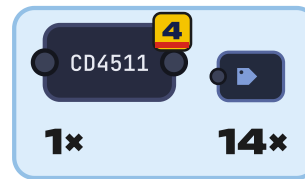
6



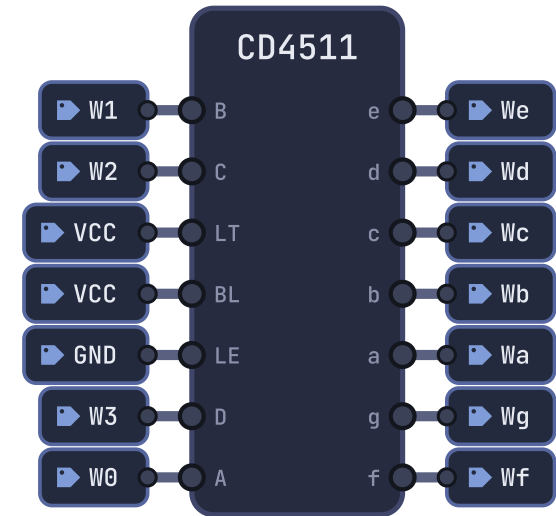
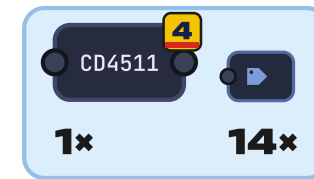
7



8



9



10

Reset – press and let go: while pressed, the displays stay at 00

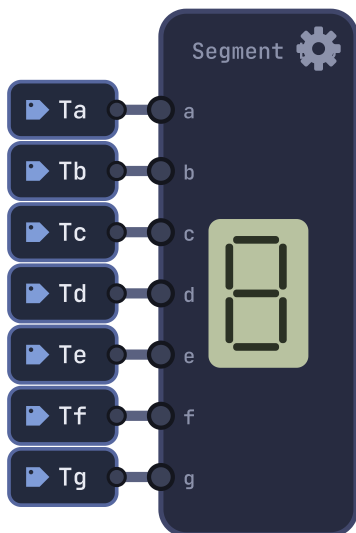
11

the lesson 4 display – Cmd+C, Cmd+V: legs a-g are already named

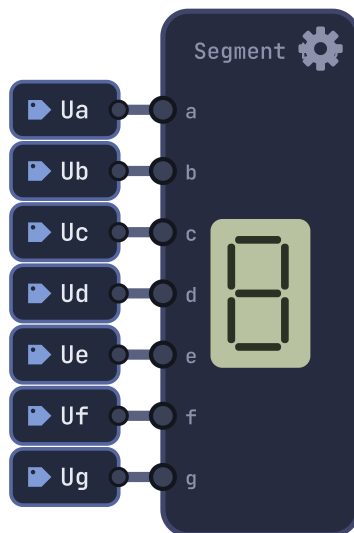
12

displays in pairs: tens on the left, units on the right; "inside" on top

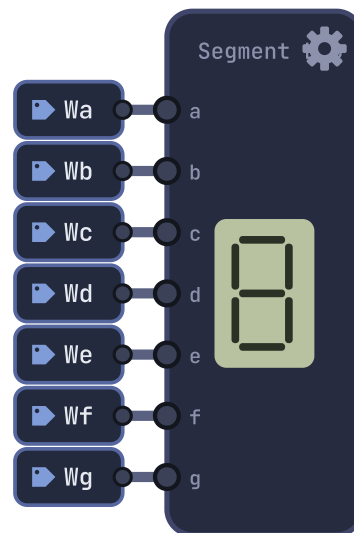
13


7×

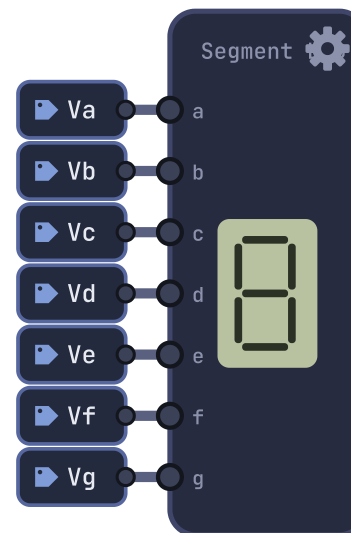
14


7×

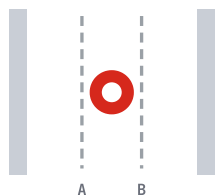
15


7×

16


7×

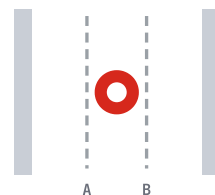
in



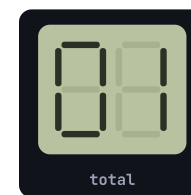
>



out



>



Kit parts

how many times you place each part over all the lessons



22×



22×



2×



2×



12×



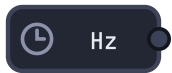
3×



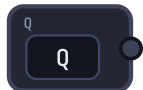
3×



16×



3×



3×



52×



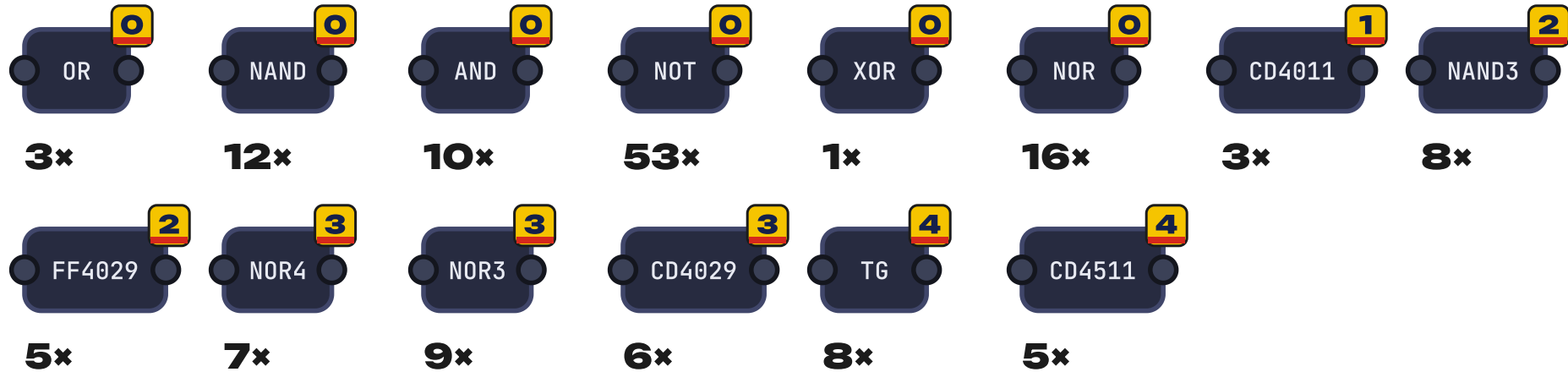
28×



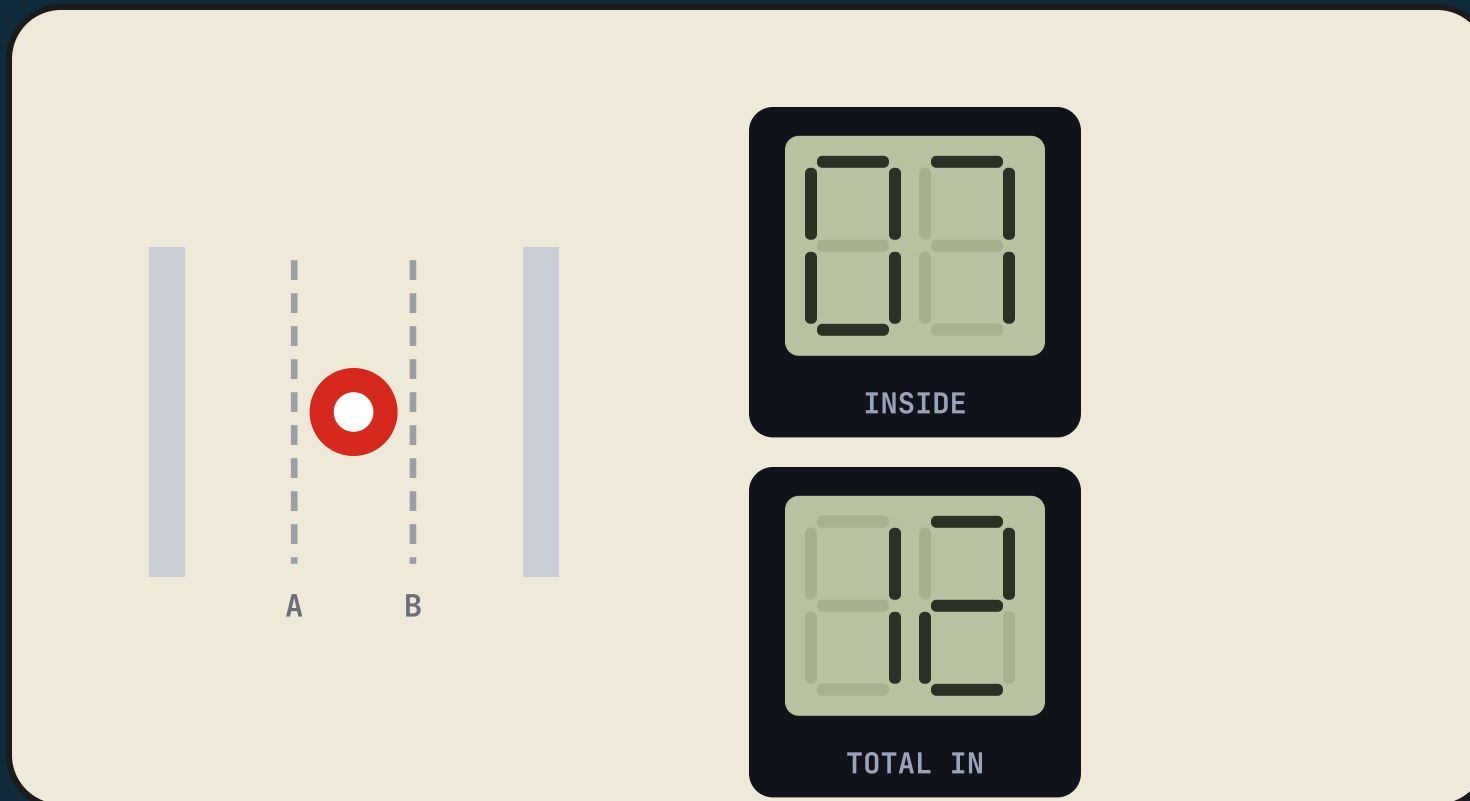
762×

Kit chips

you build them yourself: each one is made of the ones before



Done!



two displays of 2,664 transistors

walk a person through: A, B, clear A, clear B

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HT-04