



HARDWARE BASICS

build kits · khanin.info

Building instructions

HB-05

74-Series Chips

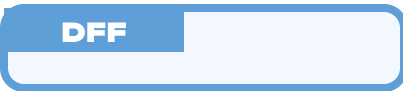
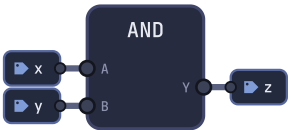
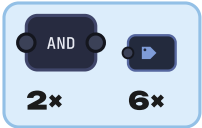
lessons 0-7 · twelve real chips from transistors

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

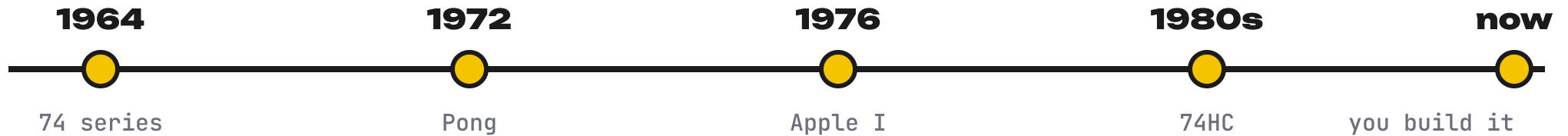
Keys

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



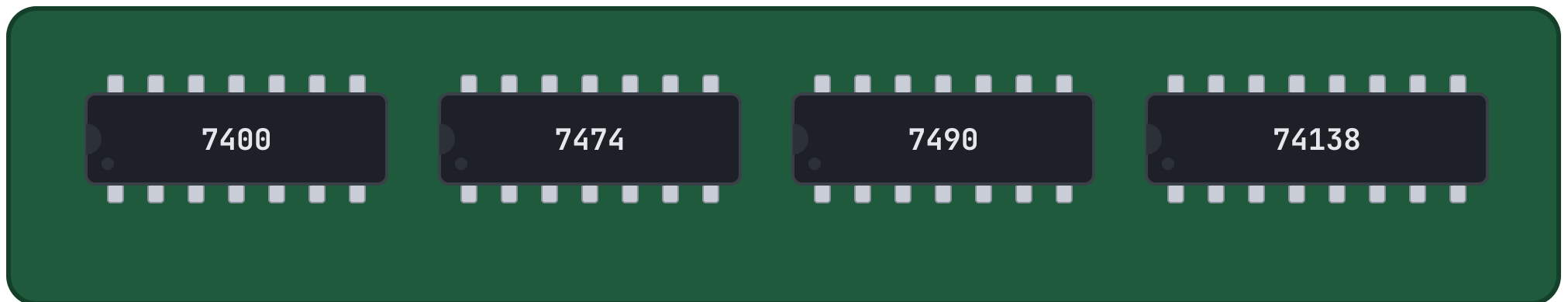
A little history



In 1964 Texas Instruments released the 54/74 series: several gates in one package with pins. The number told what was inside: 7400 – four NANDs, 7474 – two flip-flops, 7490 – a counter.

Arcade machines were built from such packages with no processor, and in 1976 Steve Wozniak built the Apple I: a 6502 processor and around it a few dozen 74-series chips chosen from the catalogue.

In the 1980s came 74HC on CMOS: the same numbers and pins, pairs of P and N transistors inside. Twelve such chips are what you build – with the same pin names as in the datasheet.



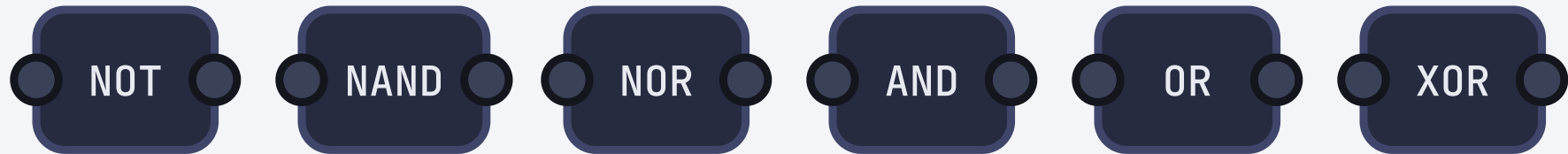
Texas Instruments, Apple, Pong are trademarks of their respective owners. This kit is not affiliated with or endorsed by them.



Gates (optional)

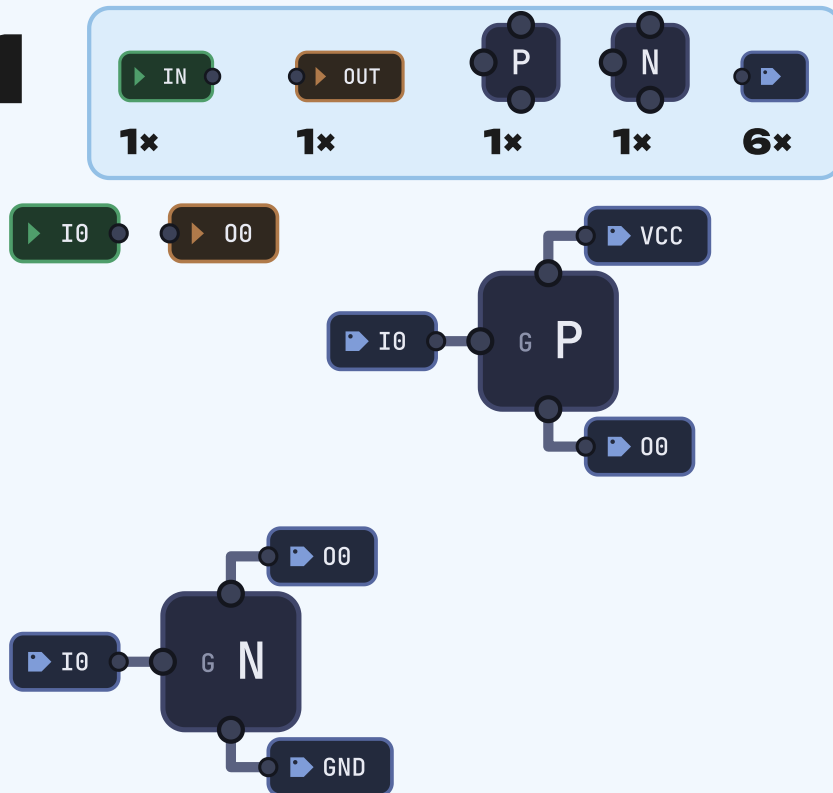
kh HB-05

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

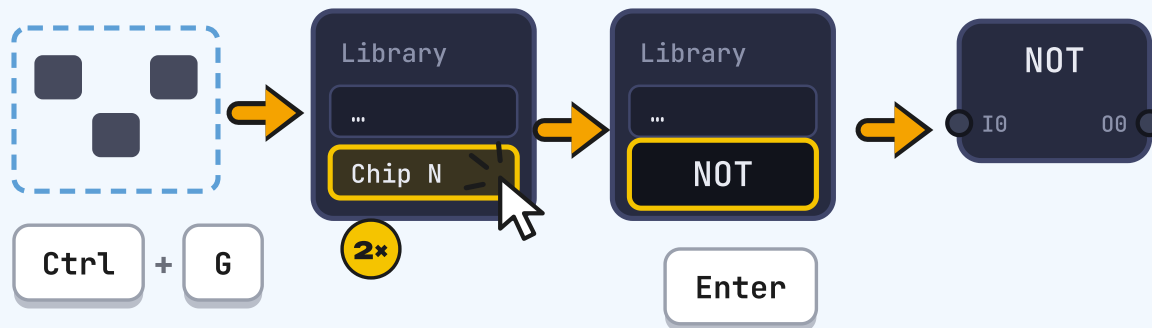


NOT

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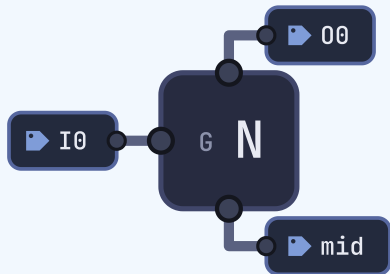
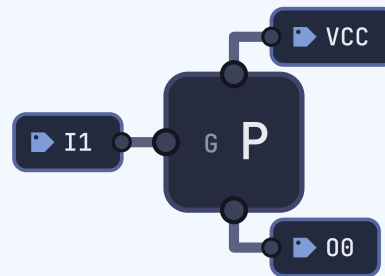
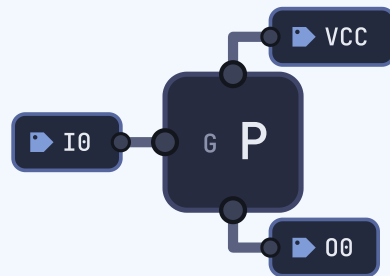
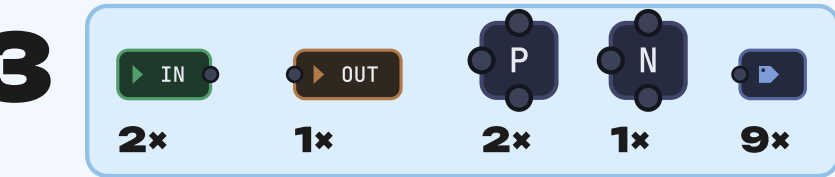


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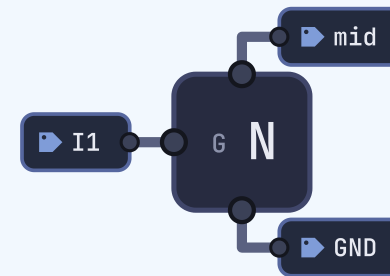


NAND

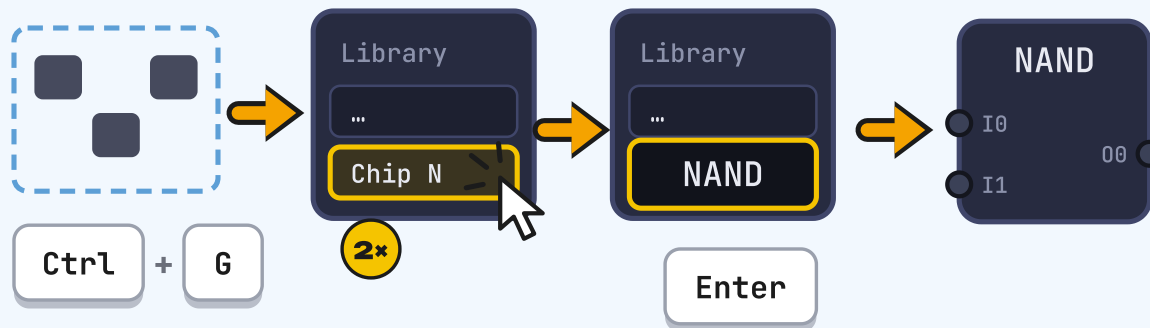
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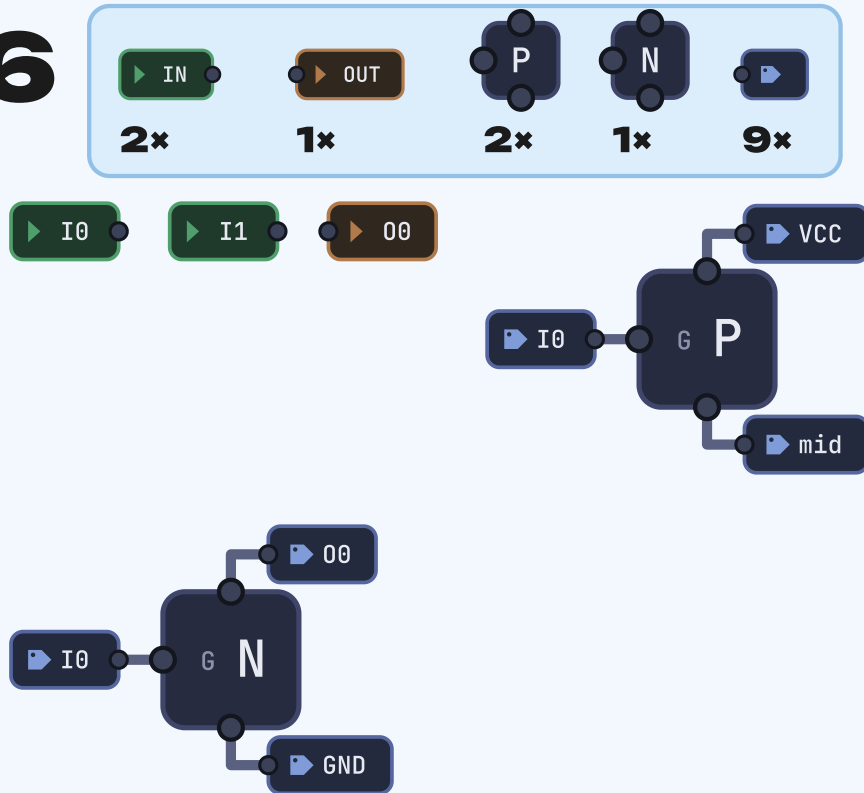


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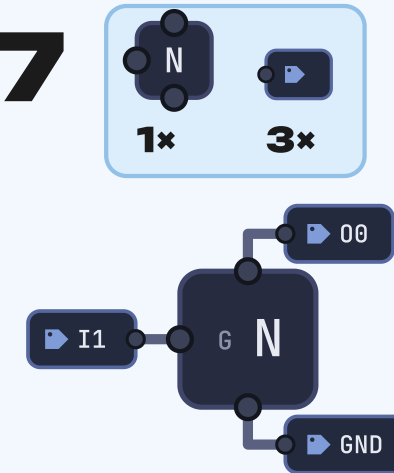


NOR

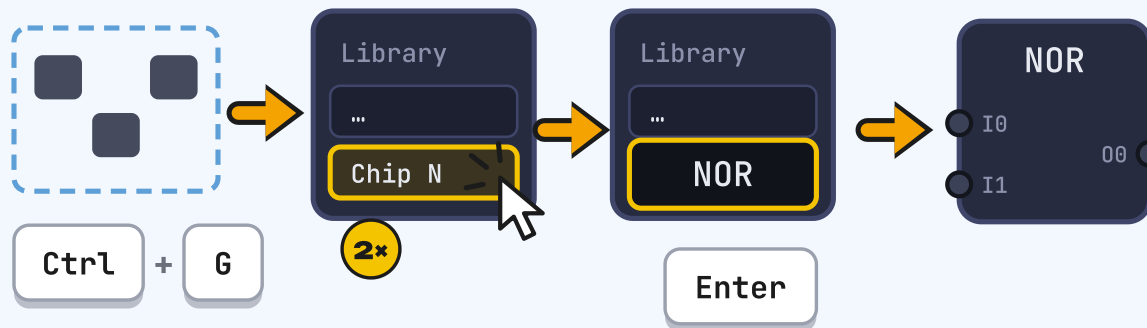
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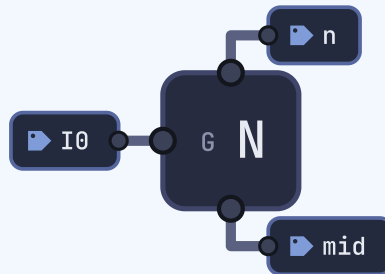
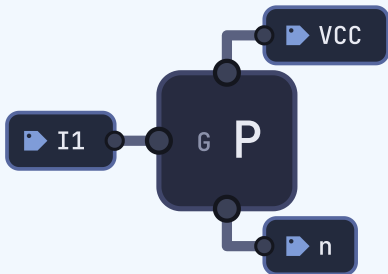
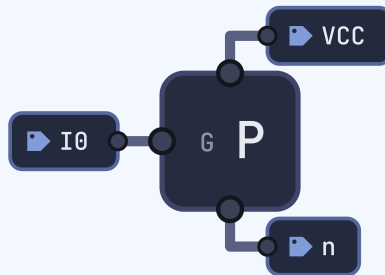


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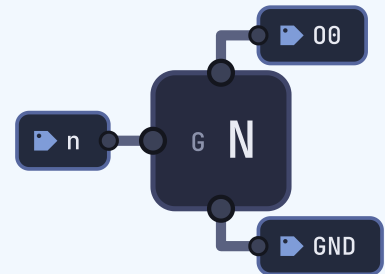
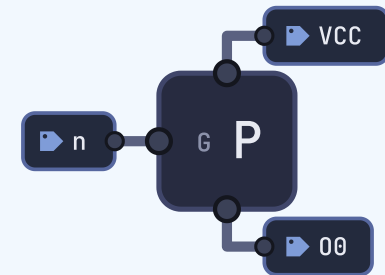
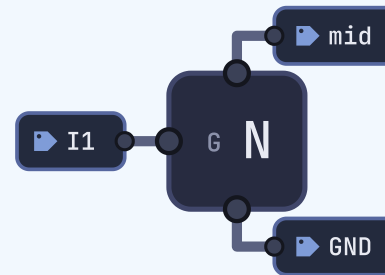
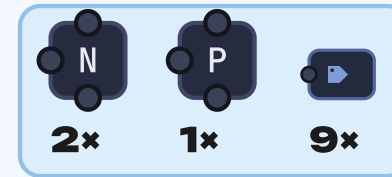


AND

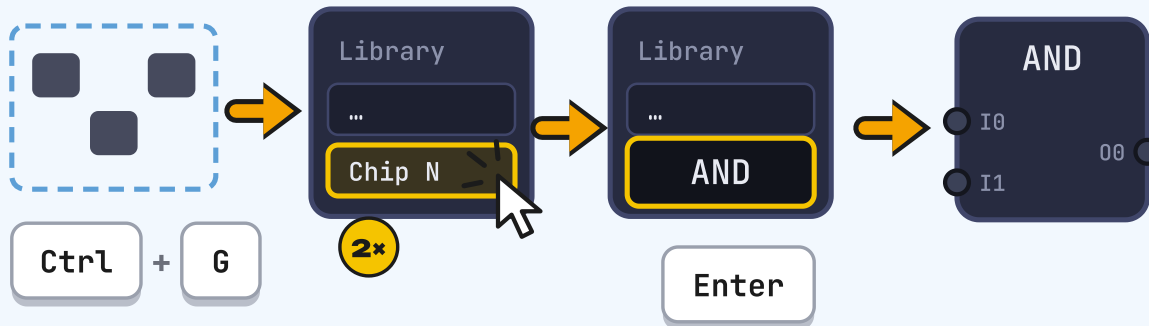
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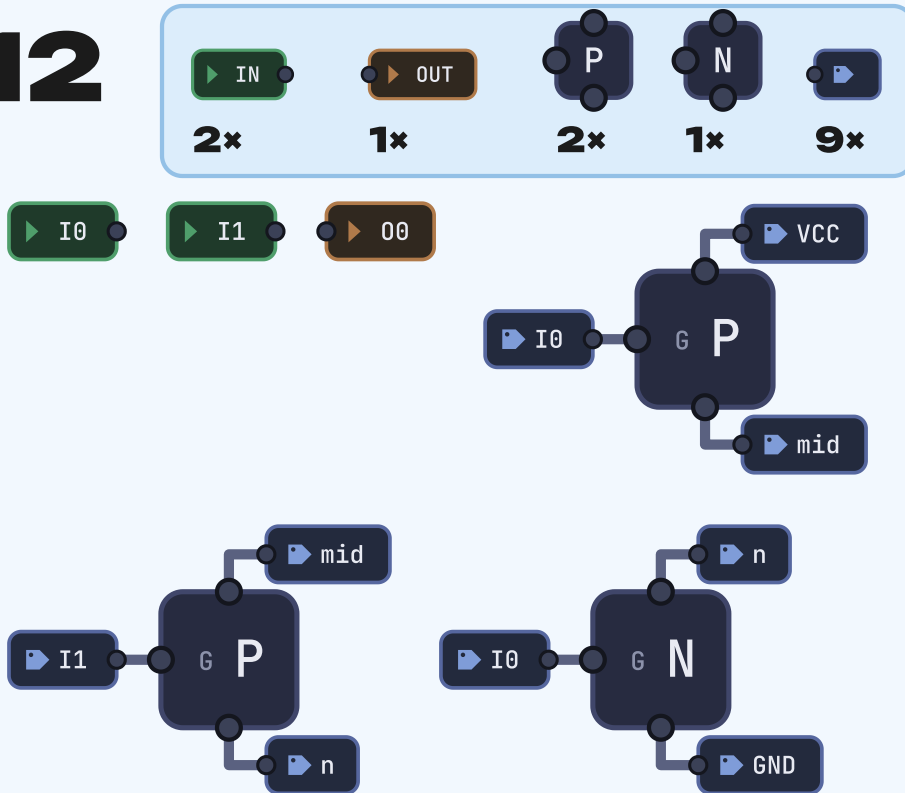
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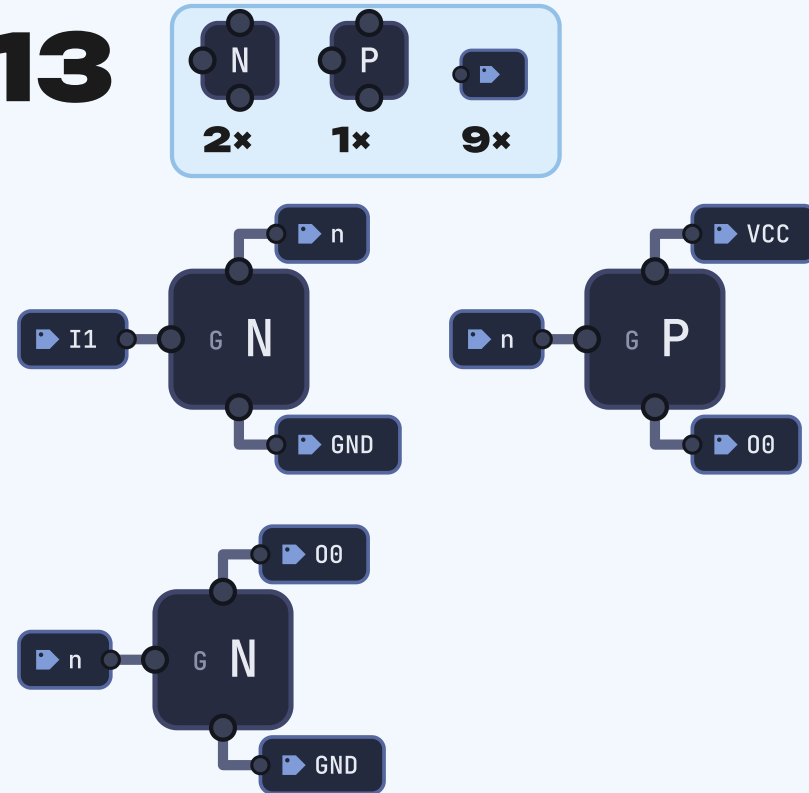
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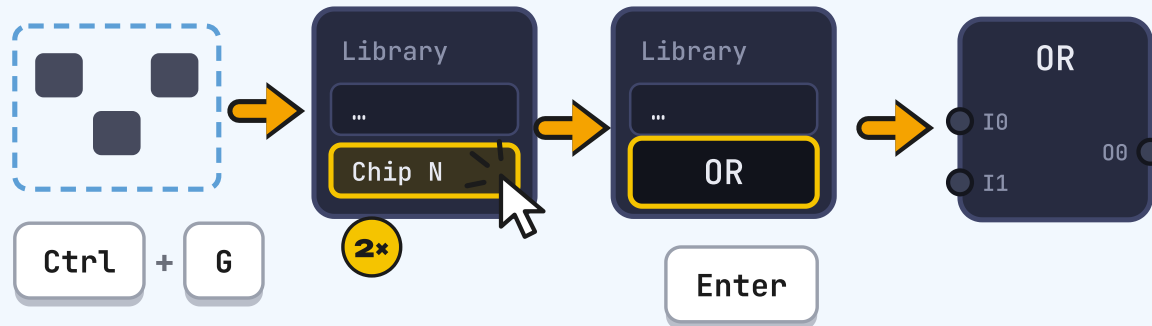
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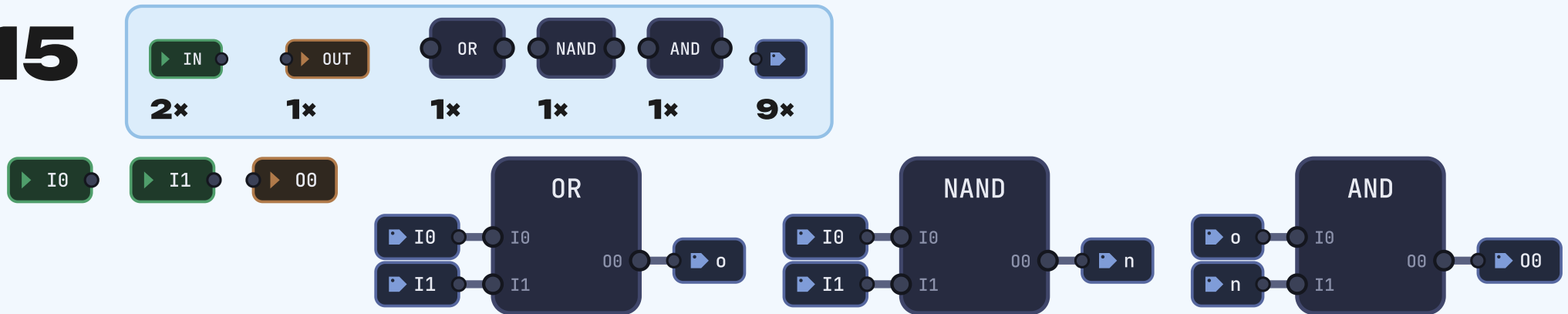


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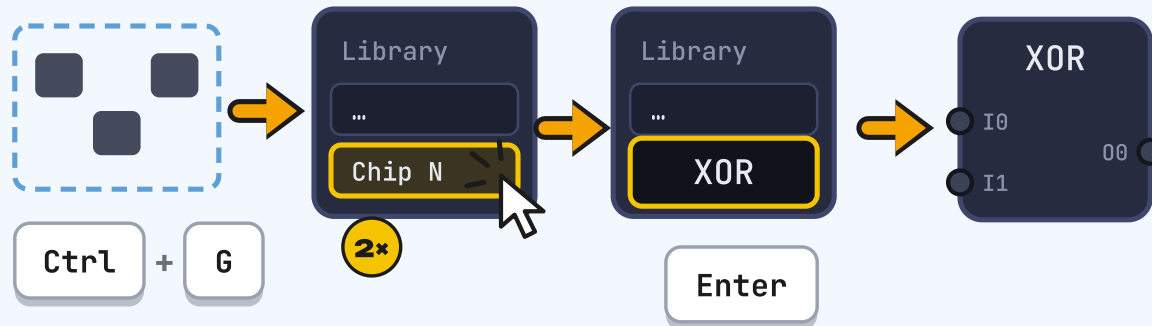


XOR

15



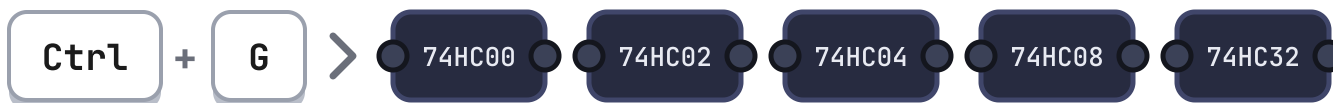
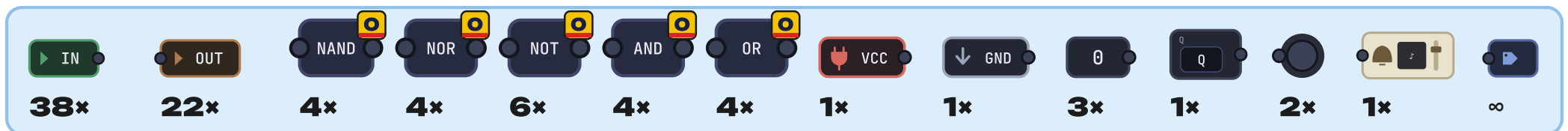
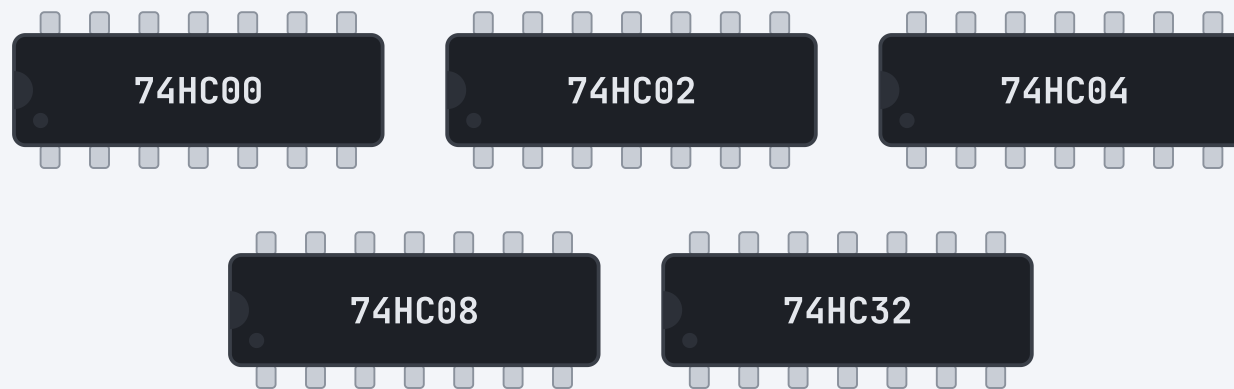
16





Logic in packages

74HC00, 02, 04, 08, 32 and an alarm built from them

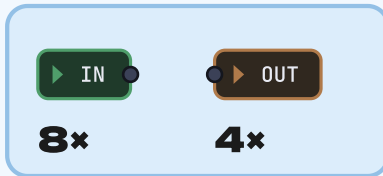


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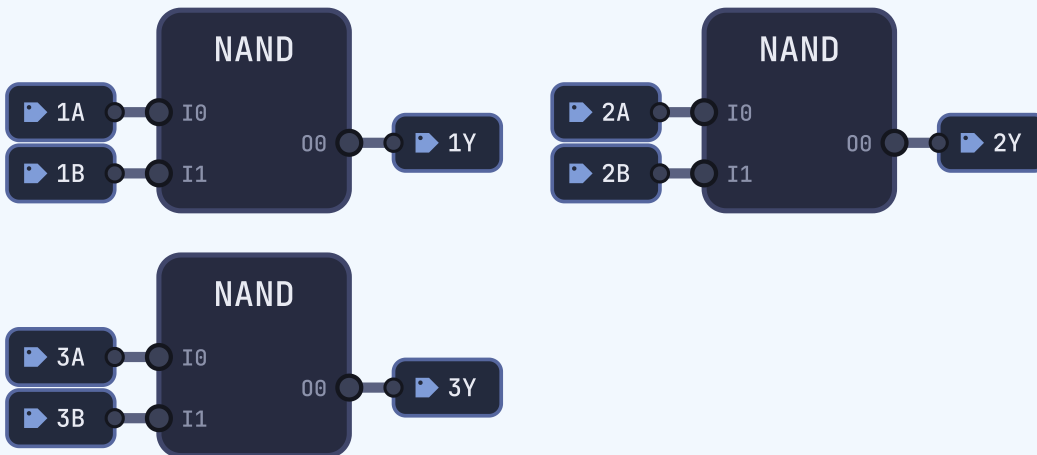
pin names as in the datasheet; a bar over a name in the picture = active 0, in the simulator without the bar

74HC00

2

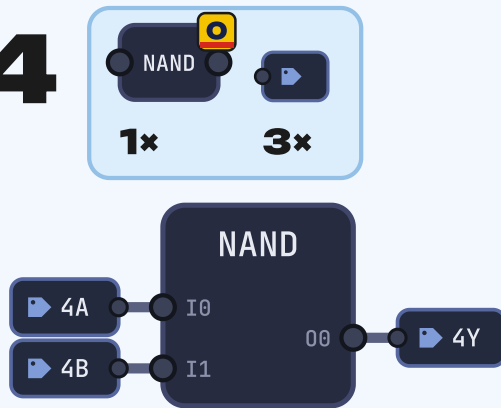


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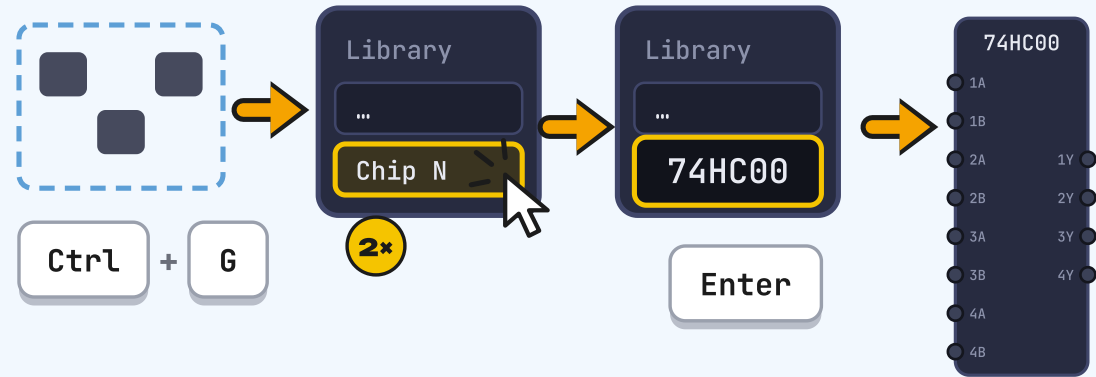


74HC00 ...

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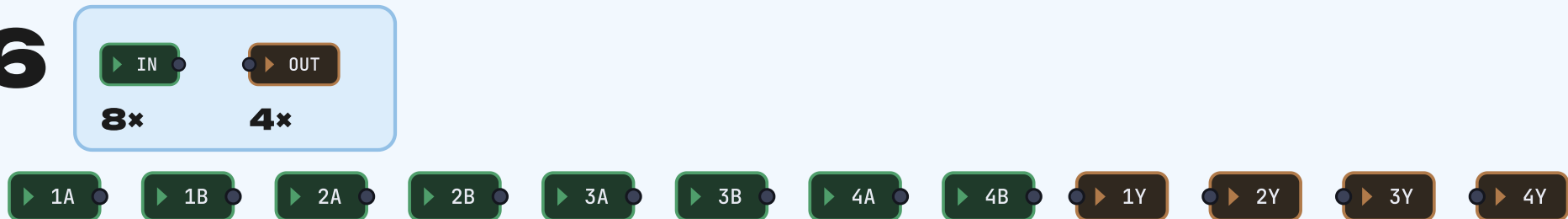


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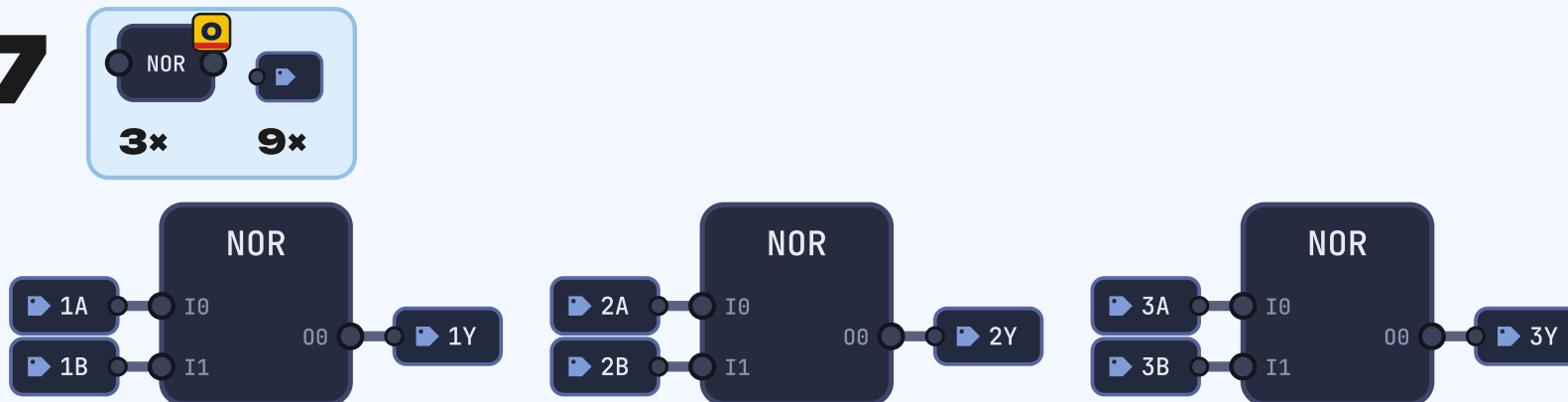


74HC02

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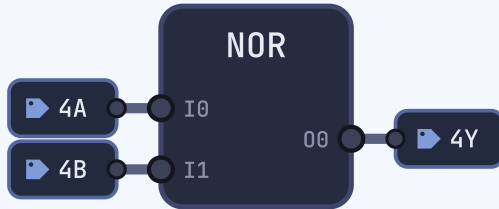


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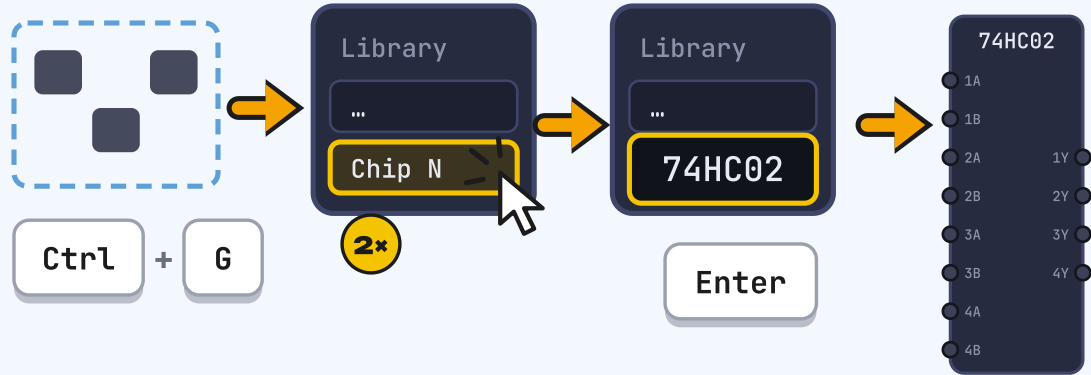


74HC02 ...

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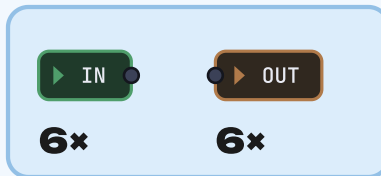


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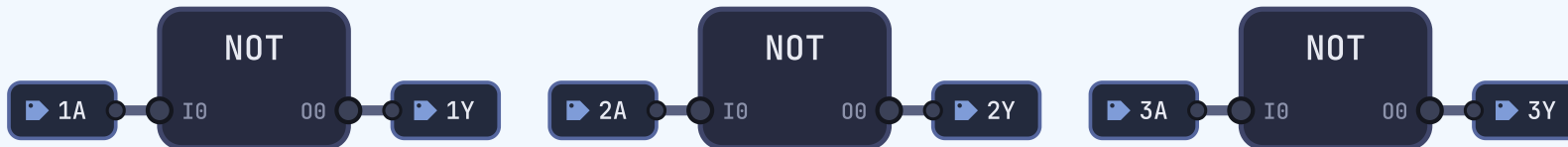
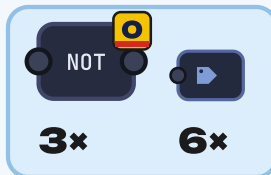


74HC04

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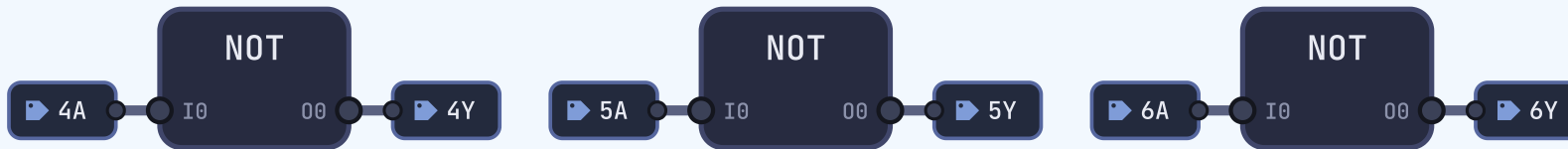
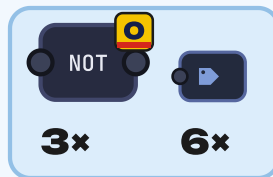


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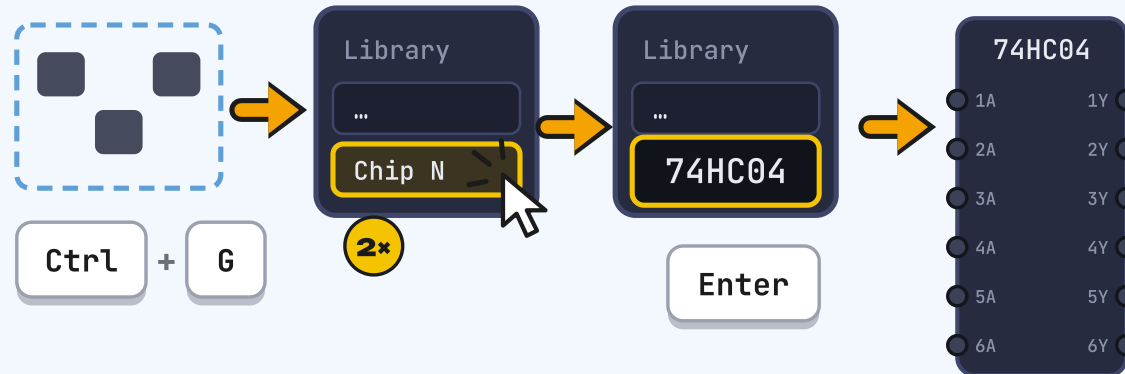


74HC04 ...

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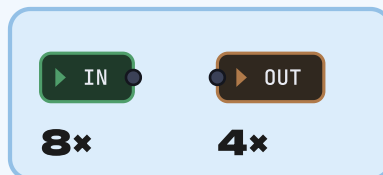


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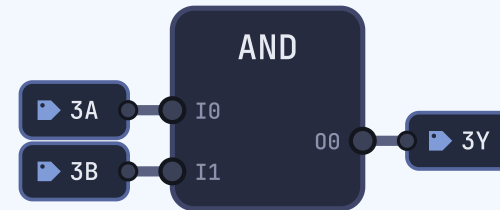
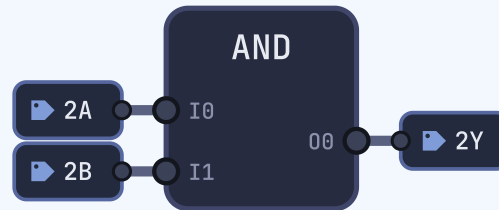
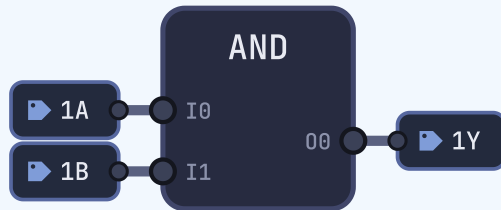
74HC08

14

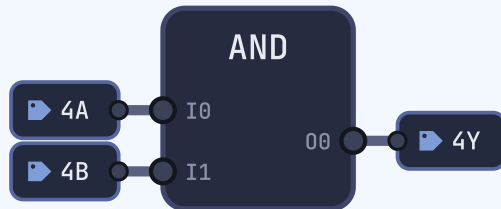


74HC08 ...

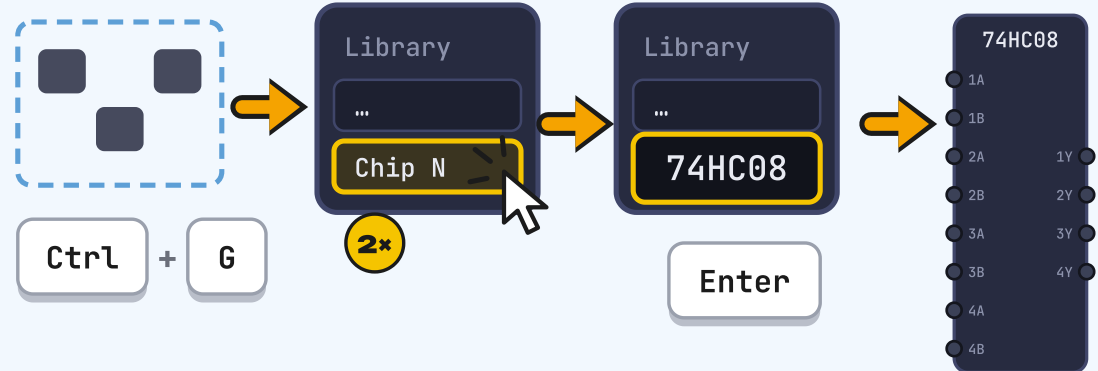
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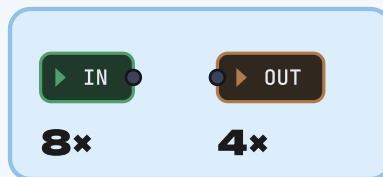


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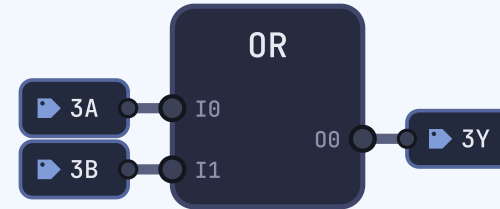
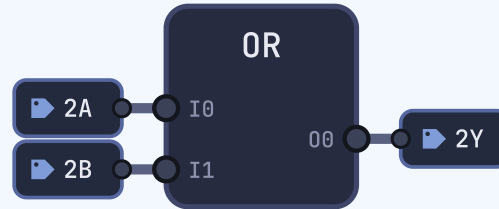
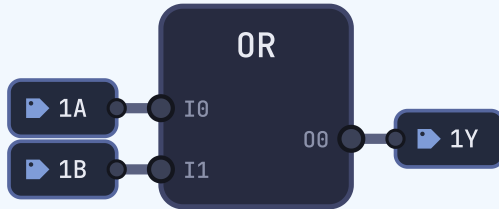
74HC32

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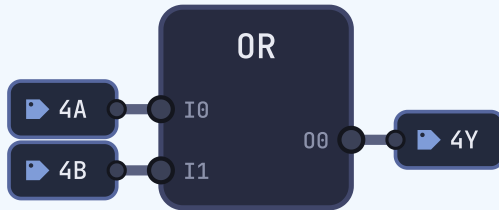
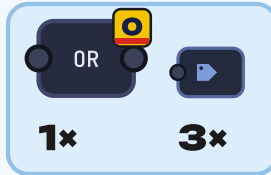


74HC32 ...

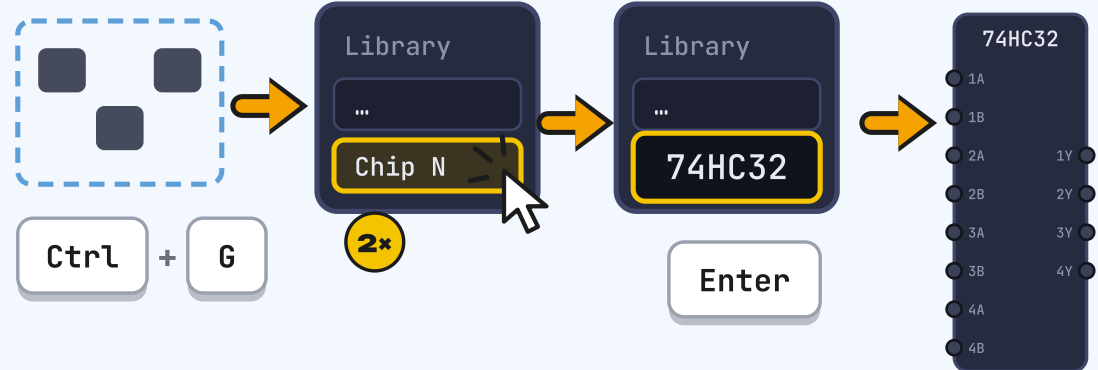
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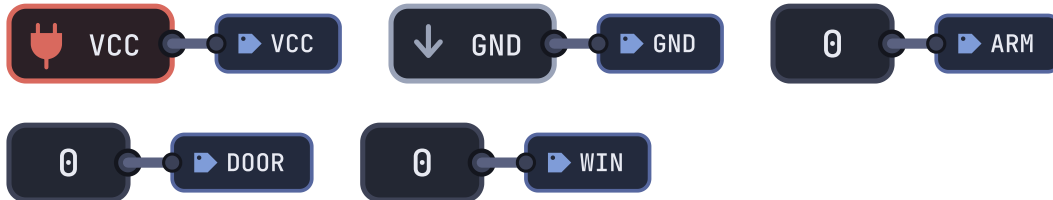
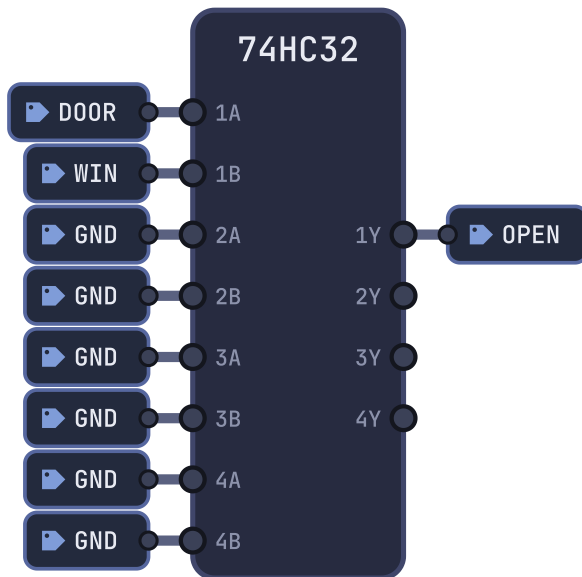
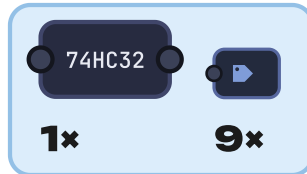
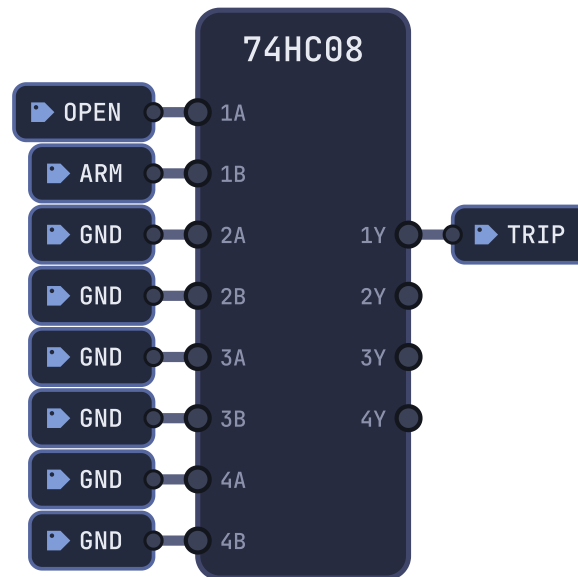
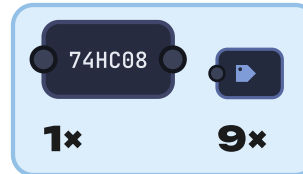
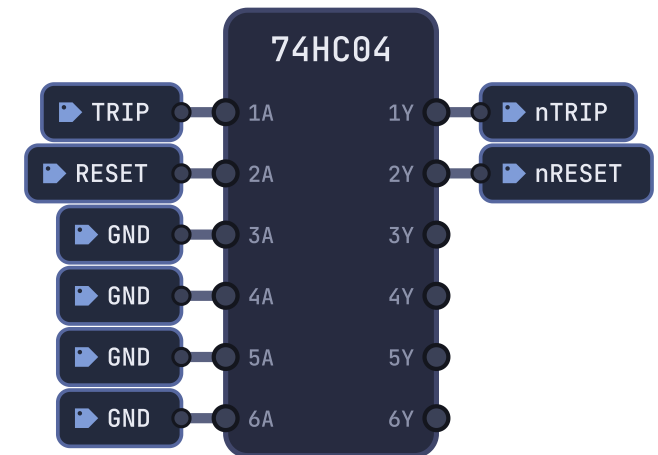
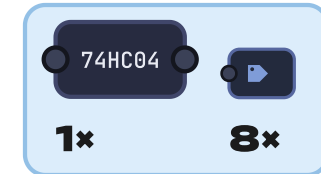
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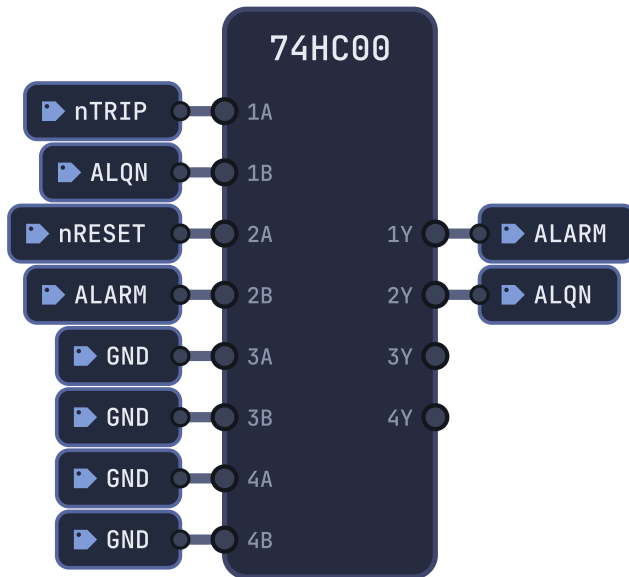
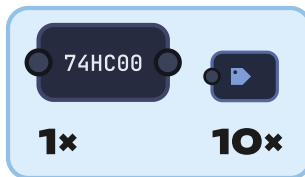
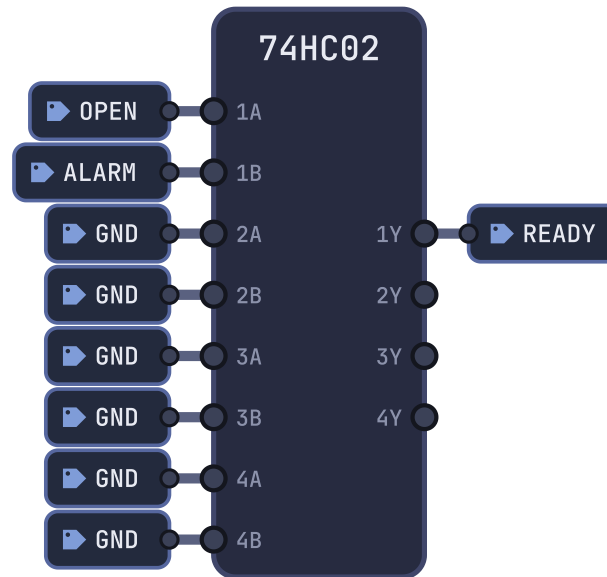
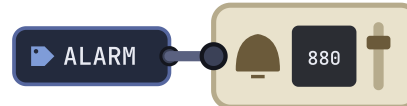
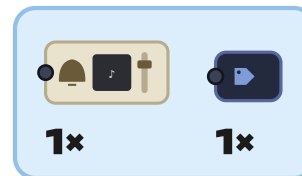


CANVAS

22

free gate inputs in a package – to GND

23**24****25****26****27**

28**29****30****31**

32

Speaker: on the left – «buzzer», the grille – 880



ARM



DOOR



ALARM

ARM = 1, DOOR = 1 → alarm

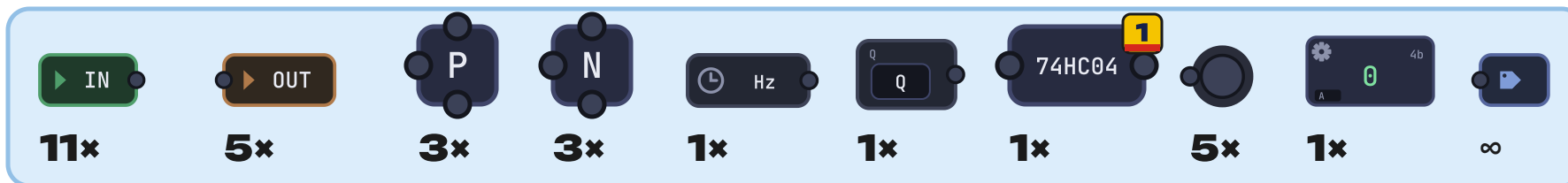
DOOR = 0 – the alarm stays

Reset – off

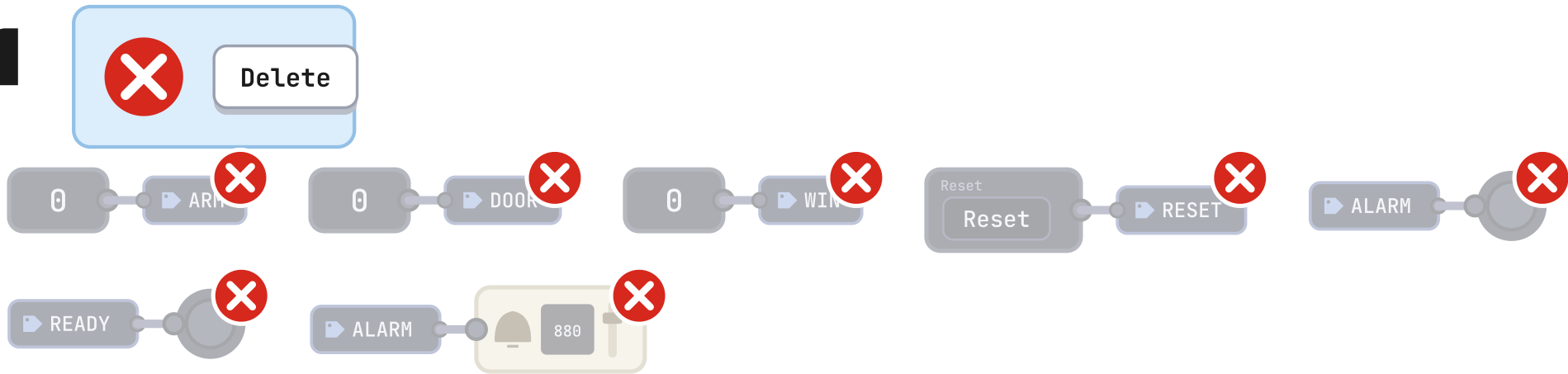


Flip-flops: 74HC74

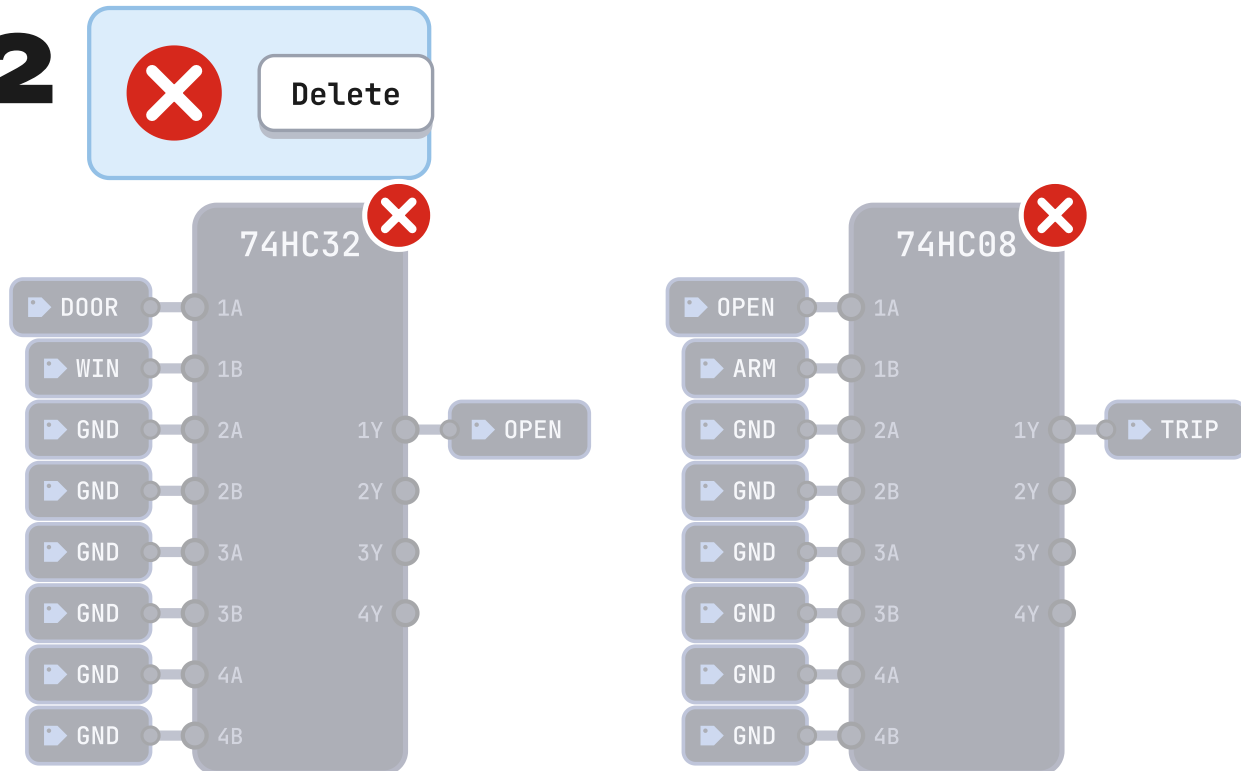
a frequency divider – the lamps blink slower and slower



1



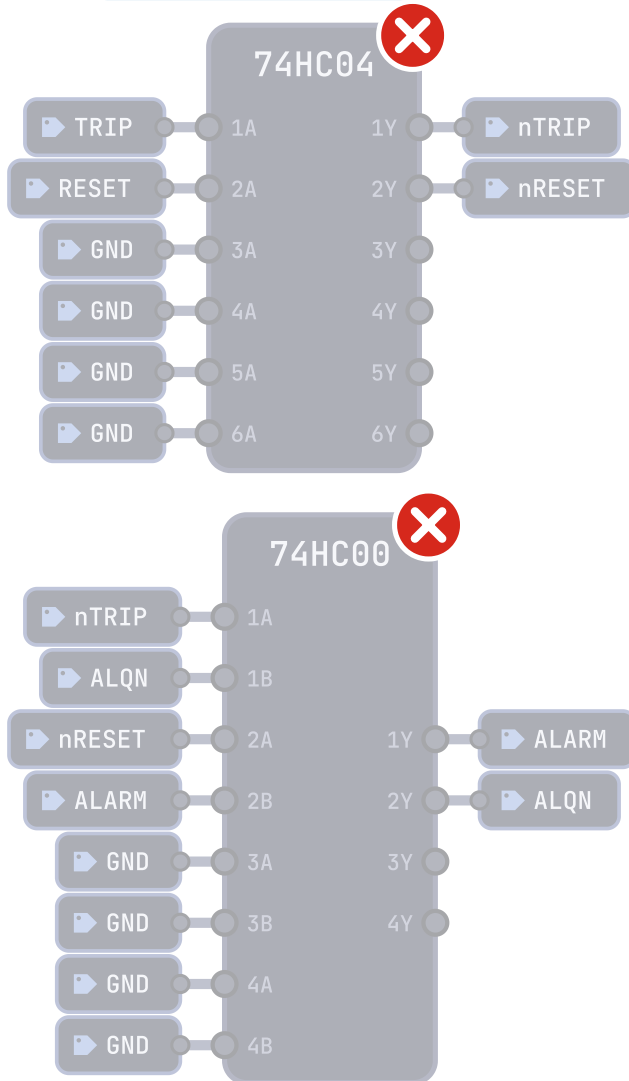
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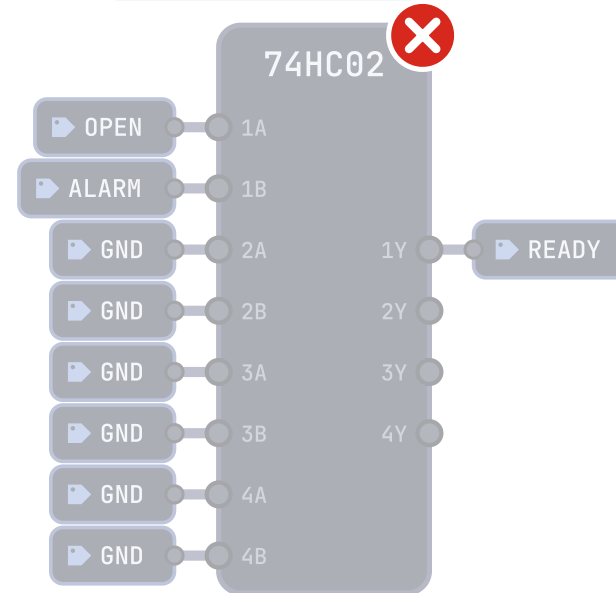
Delete



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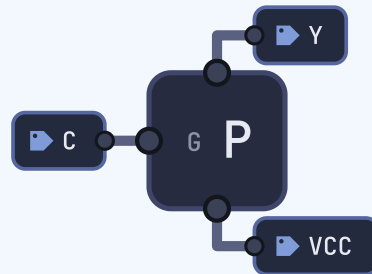
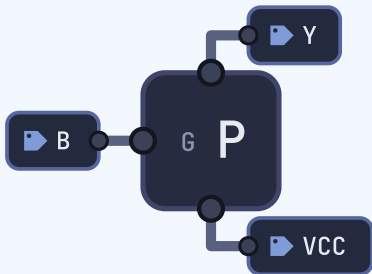
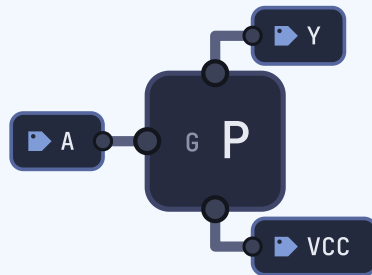


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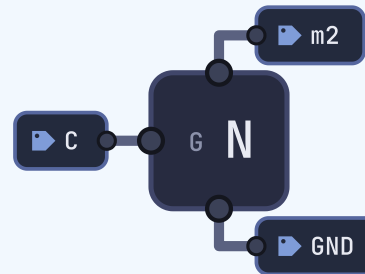
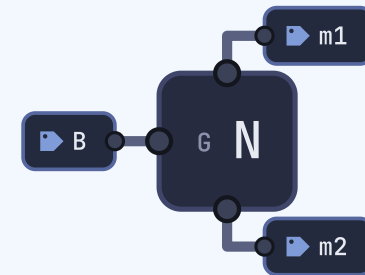
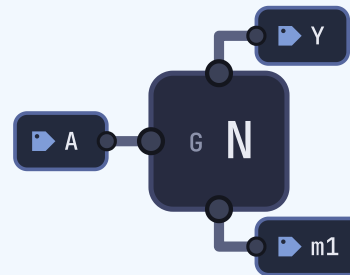


NAND3

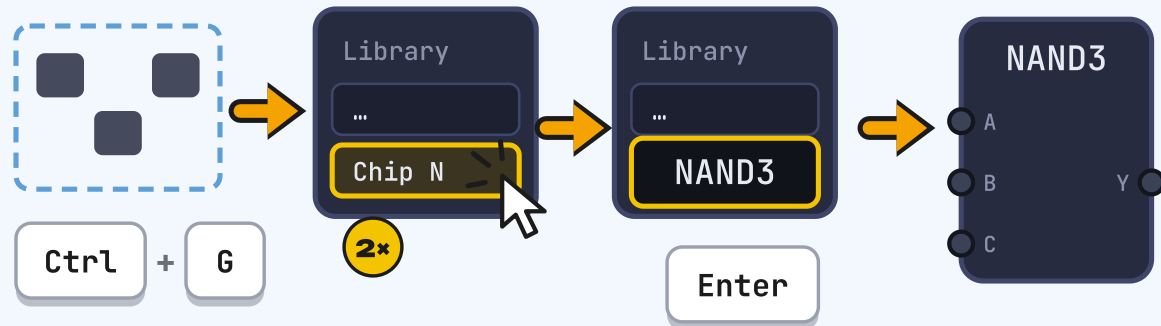
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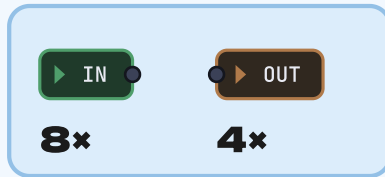


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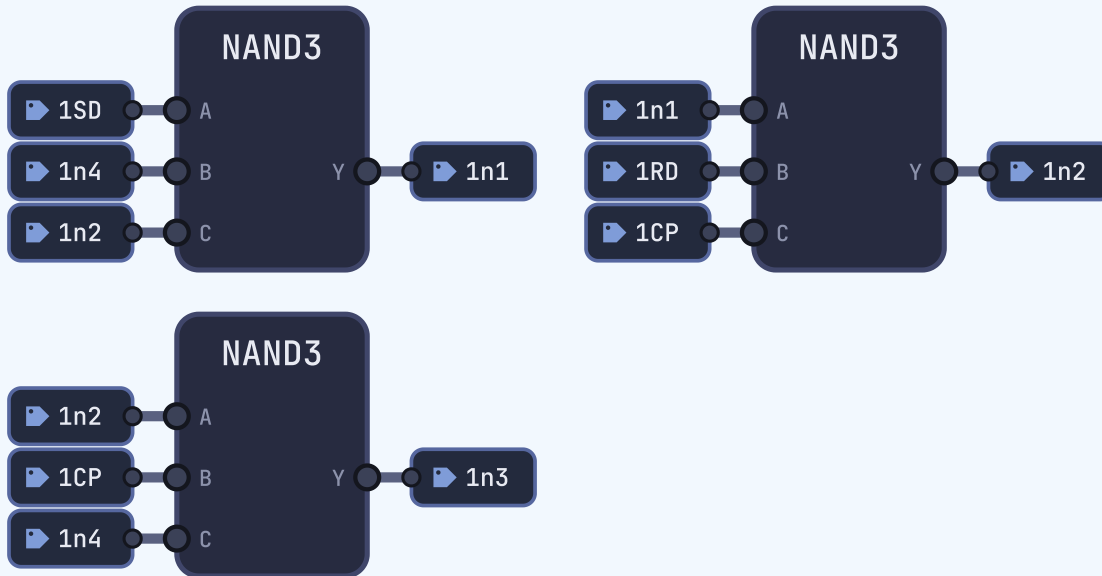
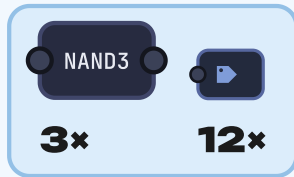


74HC74

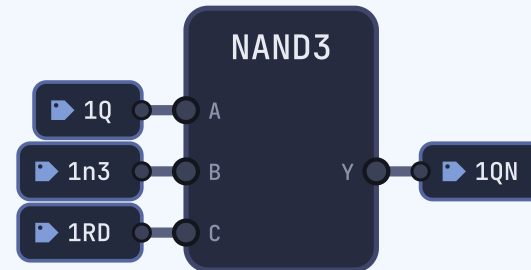
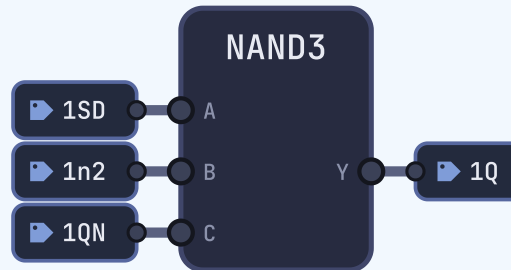
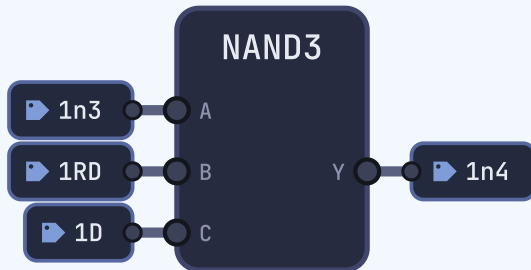
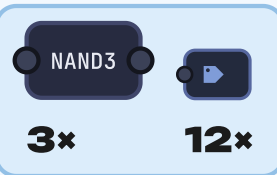
8



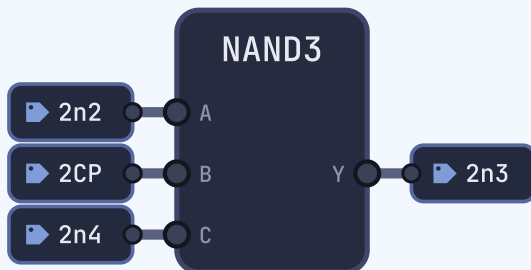
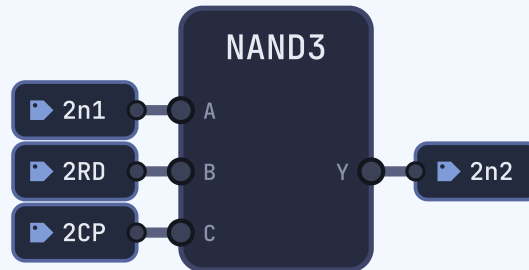
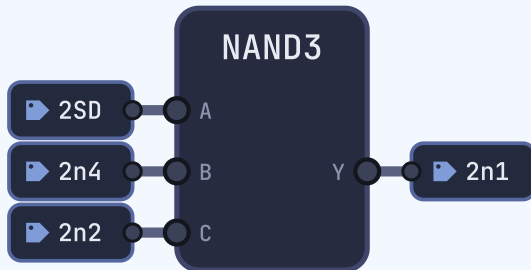
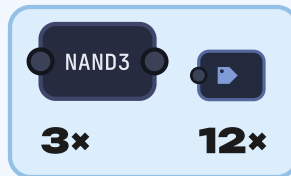
9



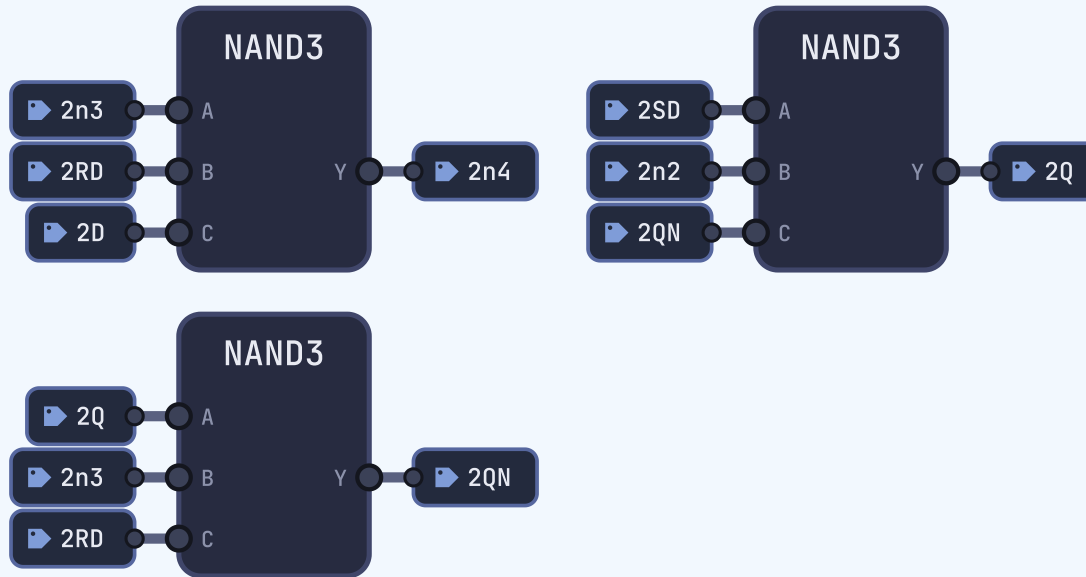
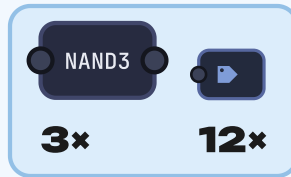
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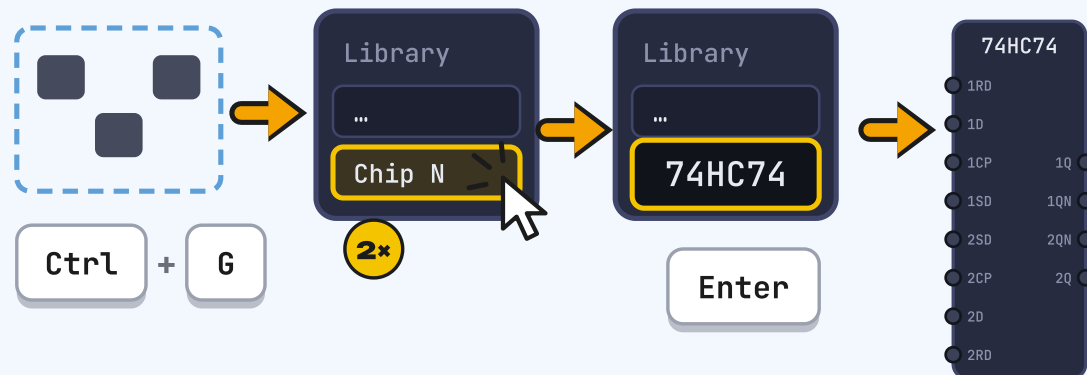
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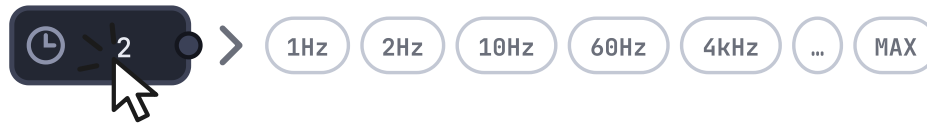
12



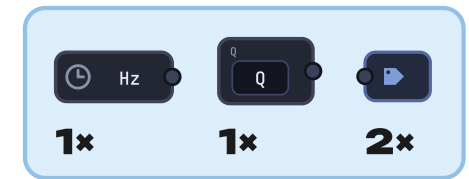
13



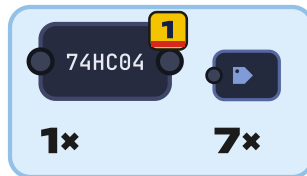
14



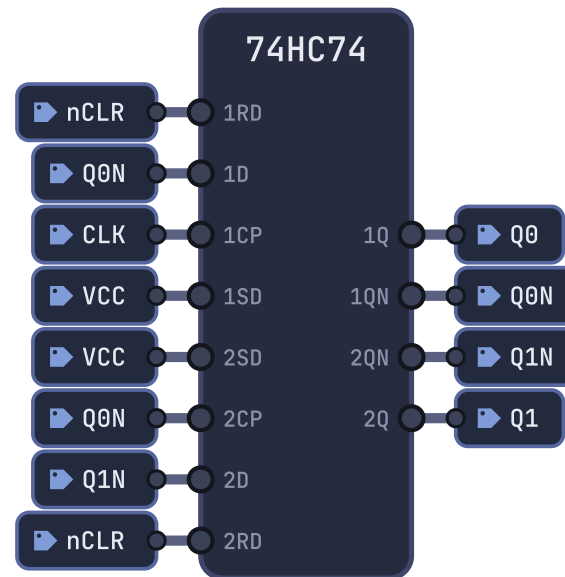
15



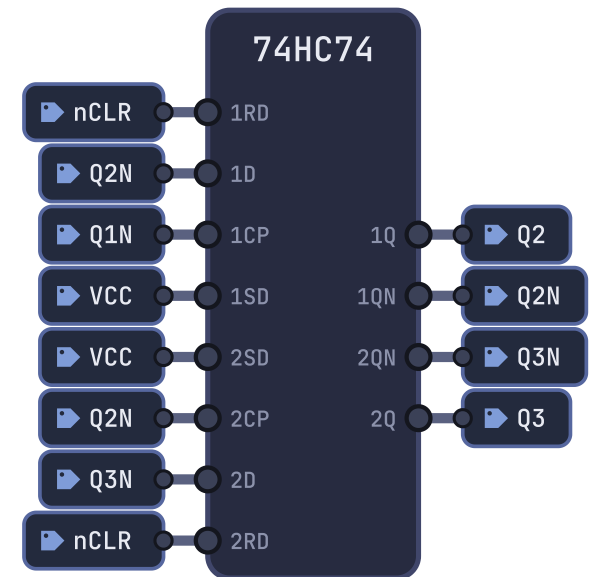
16



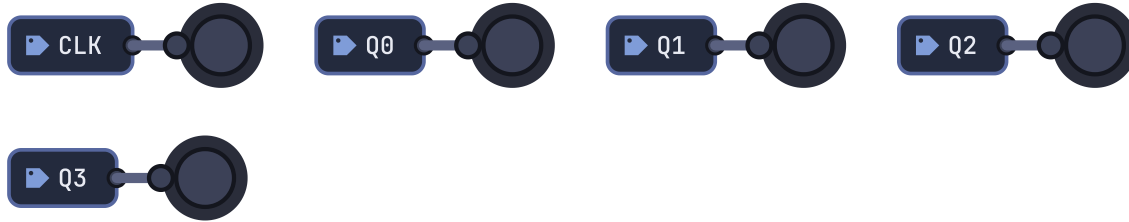
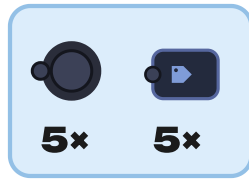
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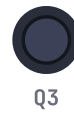
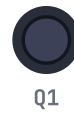
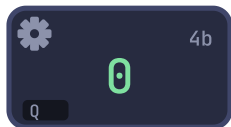
18



19



20

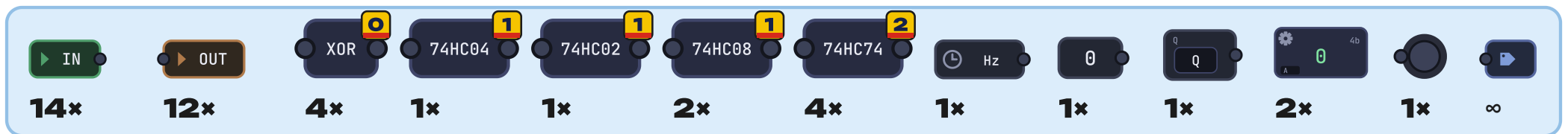


Q3 Q2 Q1 Q0 = 0101 → 5

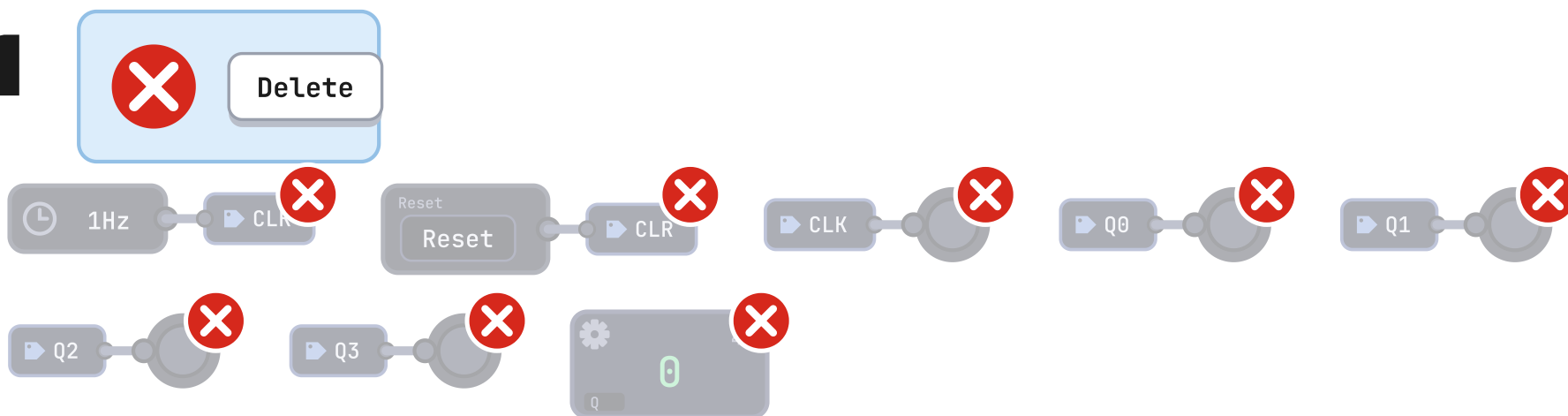


Counter: 74HC390

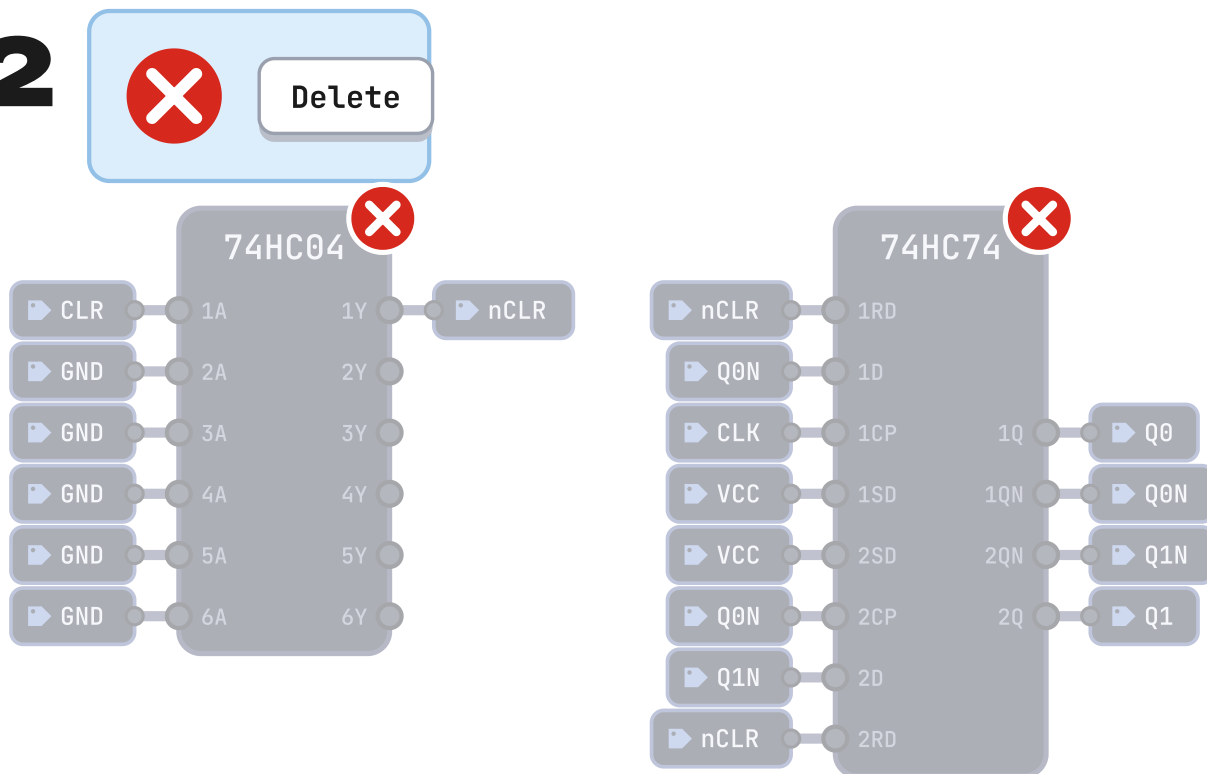
and 74HC86 – a stopwatch 00–99



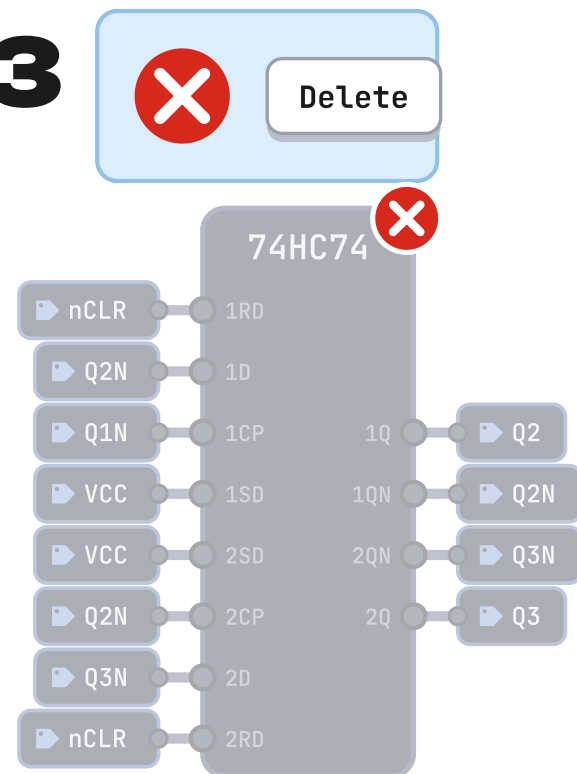
1



2

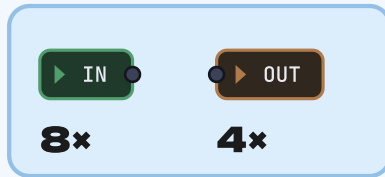


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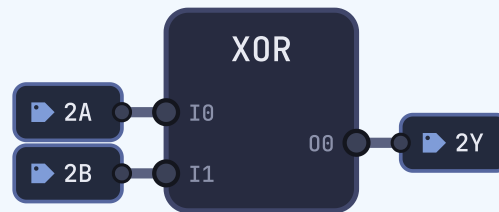
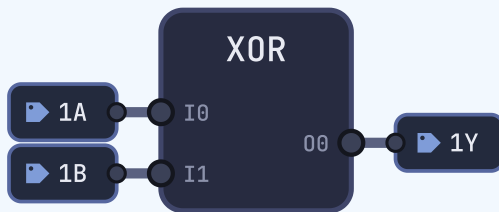
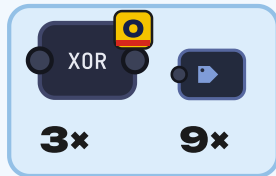


74HC86

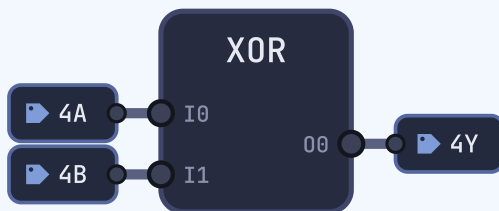
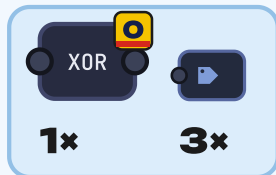
4



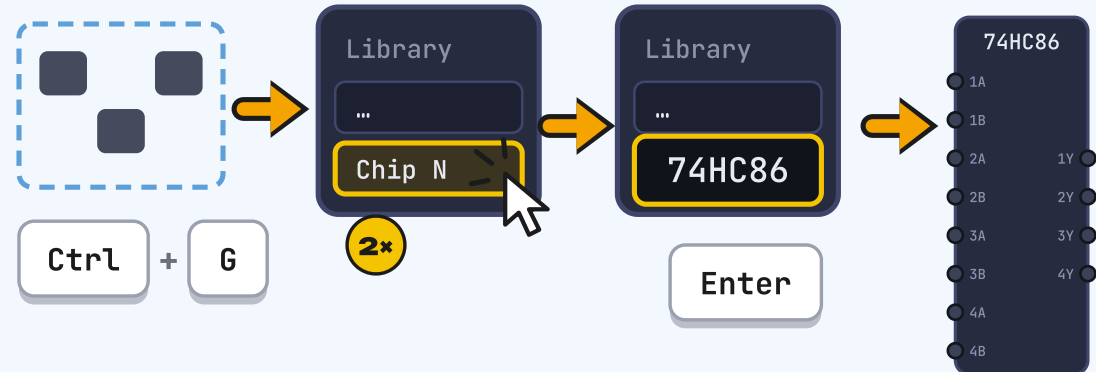
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6

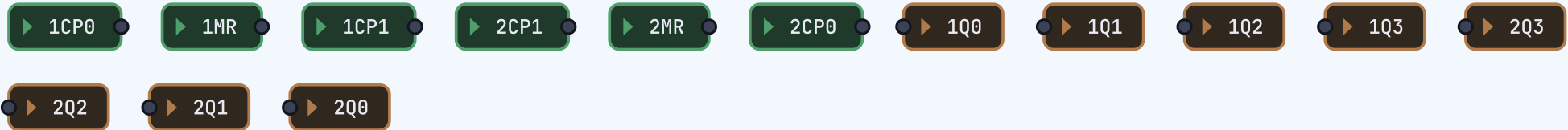
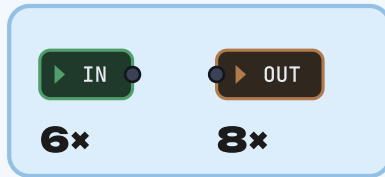


7

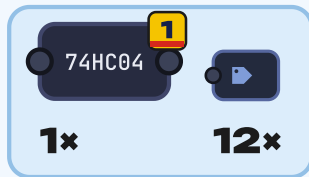


74HC390

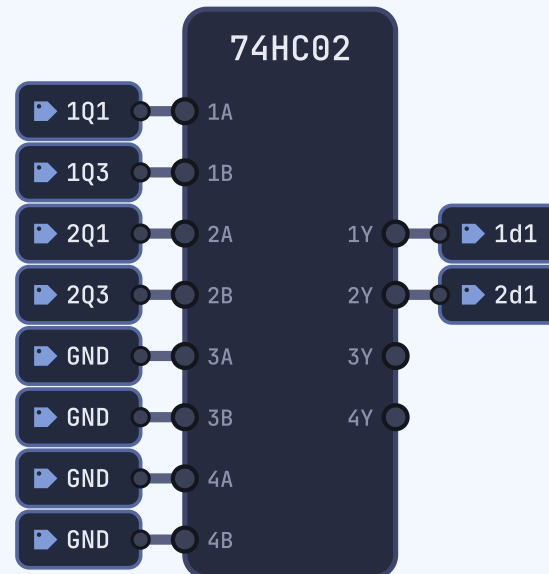
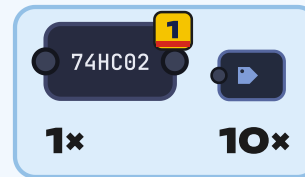
8



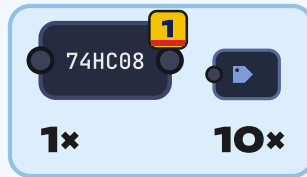
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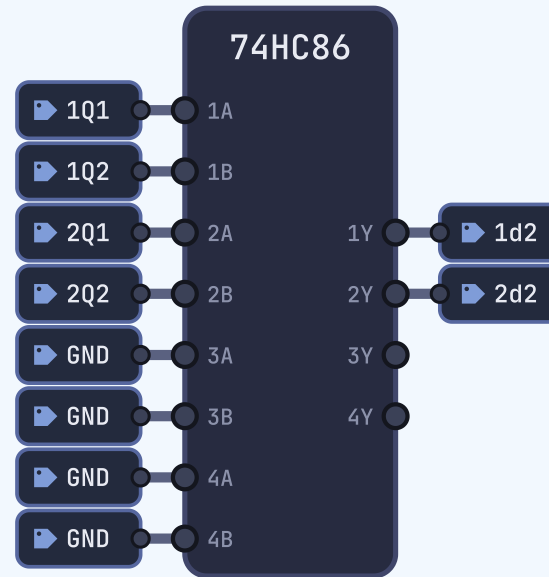
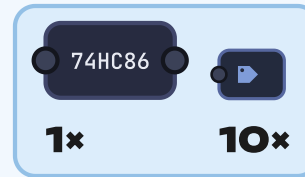
10



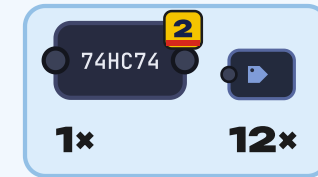
11



12

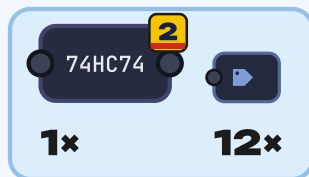


13

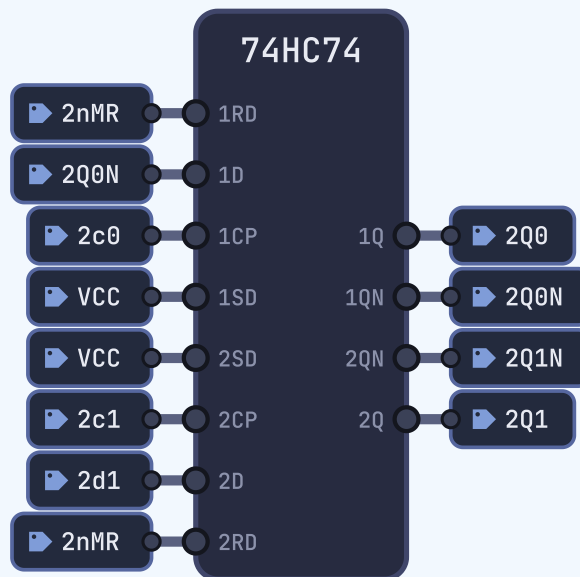
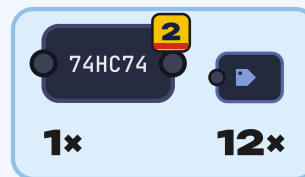


74HC390 ...

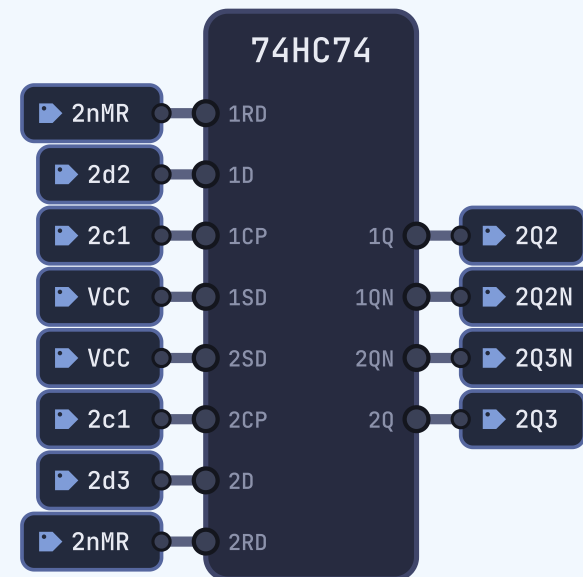
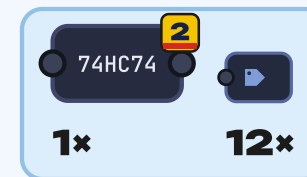
14



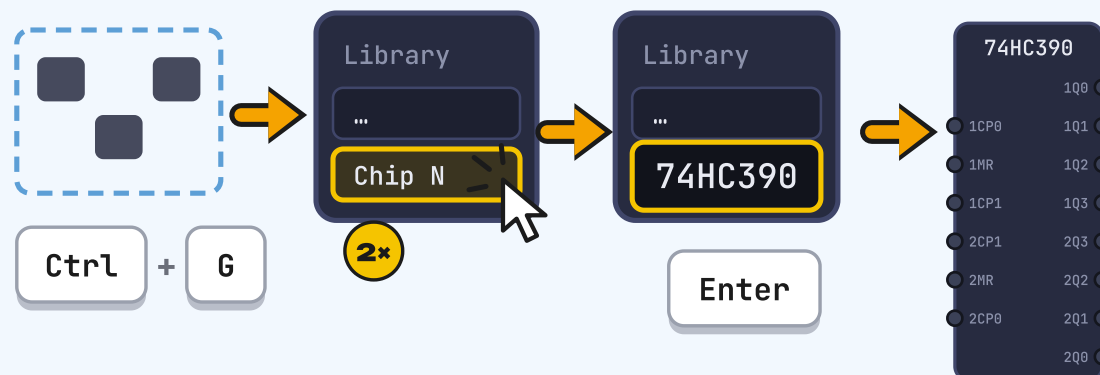
15



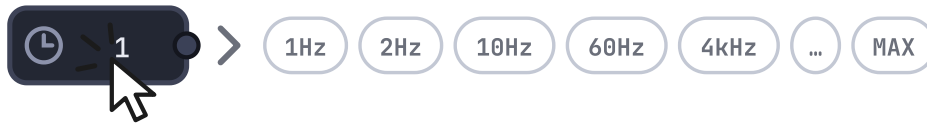
16



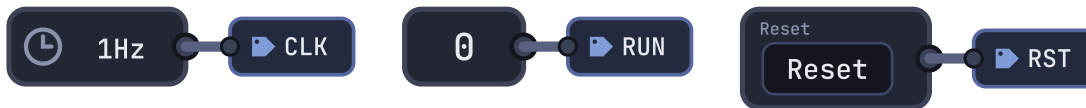
17



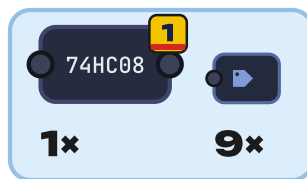
18



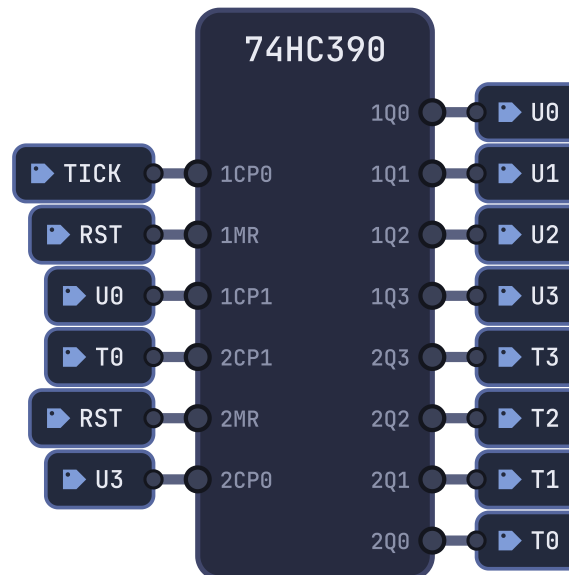
19



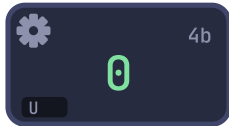
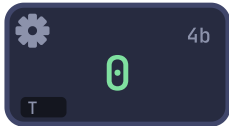
20



21



22

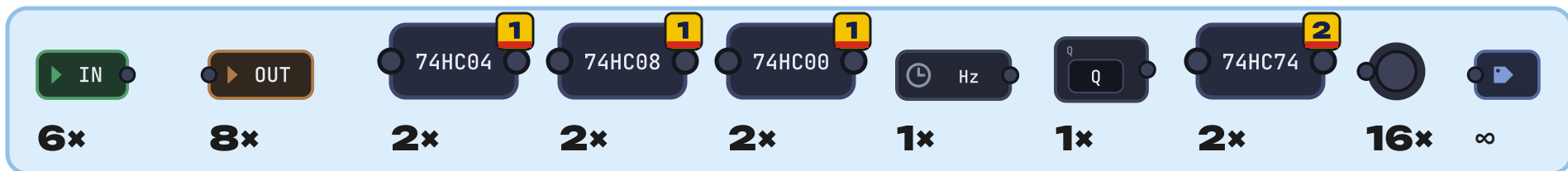


RUN = 1: 00 → 99

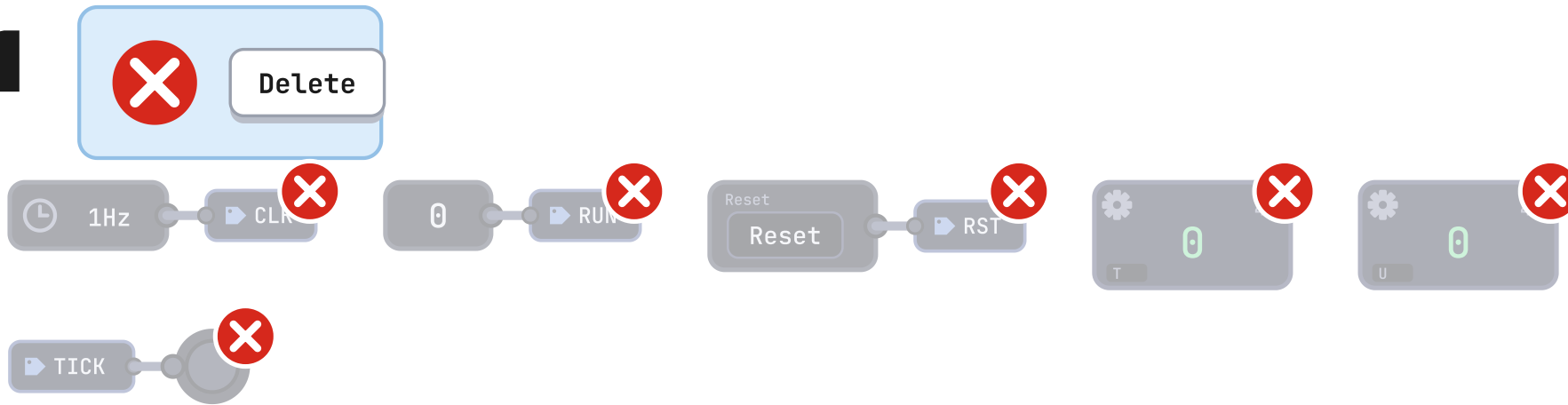


Decoder: 74HC138

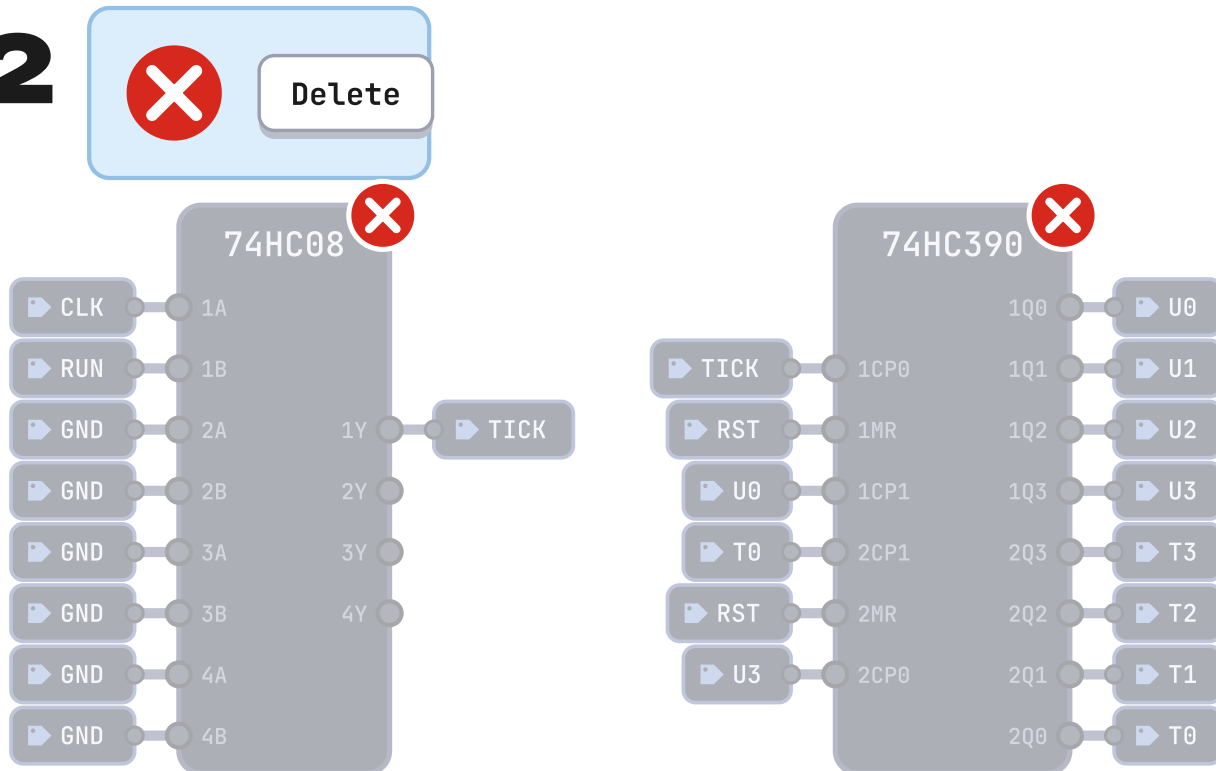
a running light on 16 lamps



1

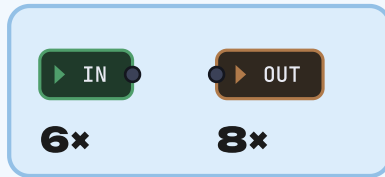


2

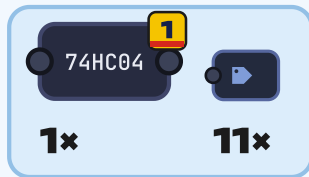


74HC138

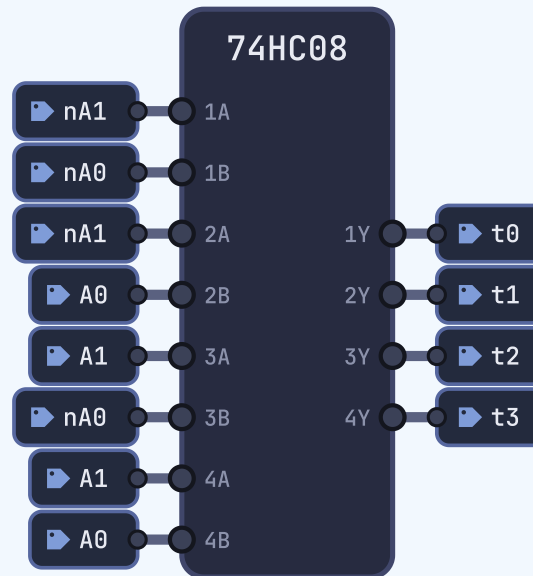
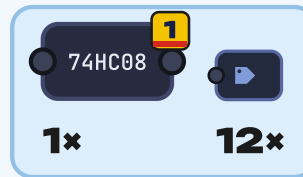
3



4

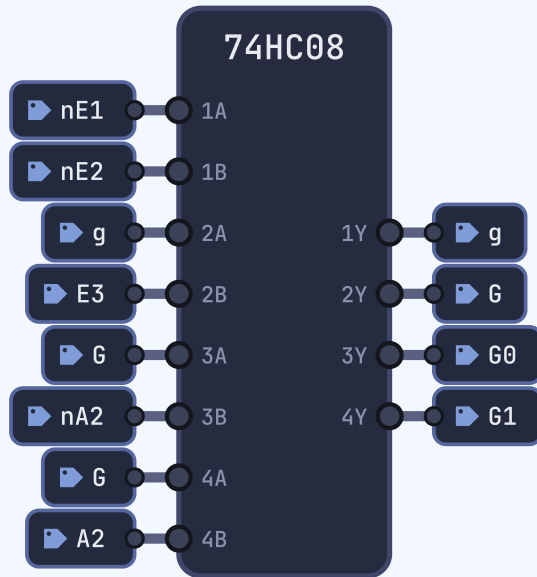
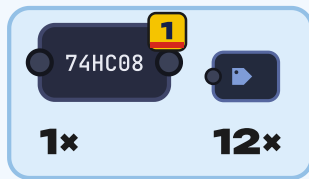


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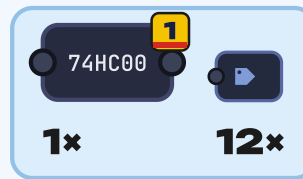


74HC138 ...

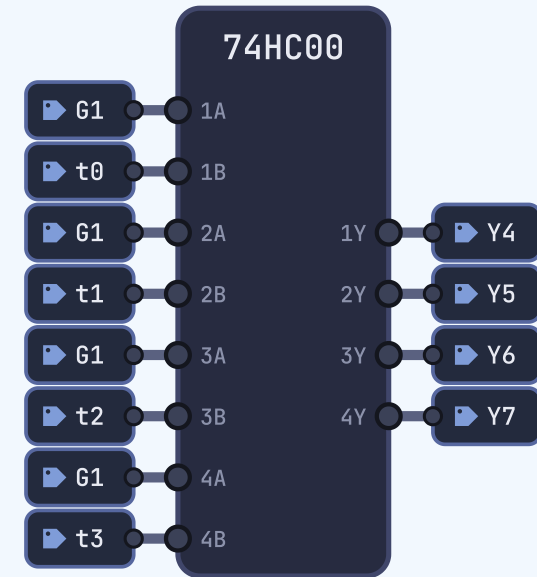
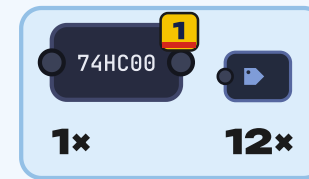
6



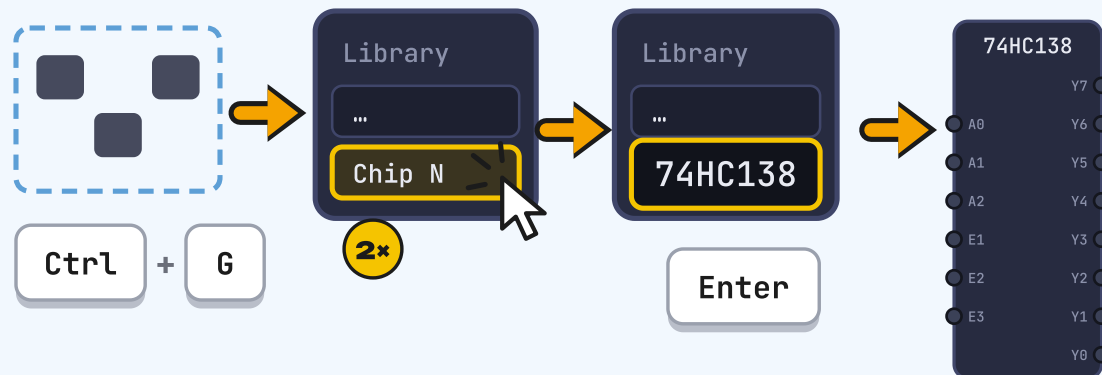
7



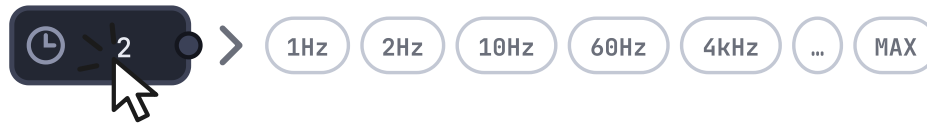
8



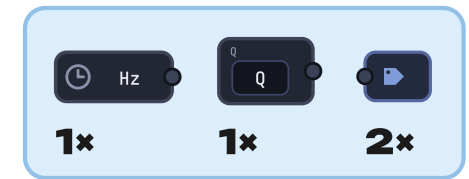
9



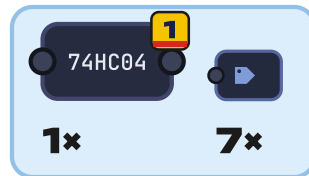
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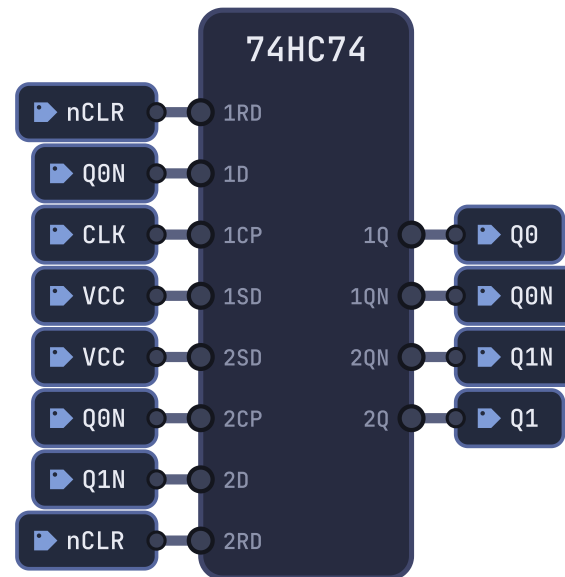
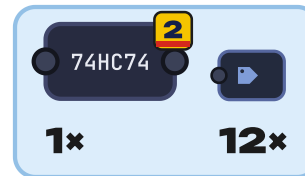
11



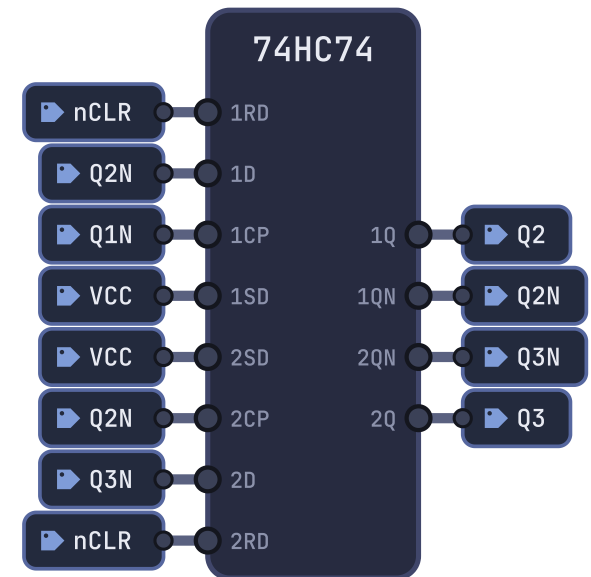
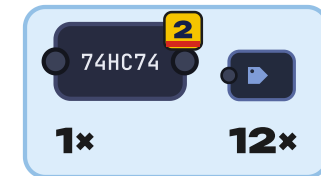
12



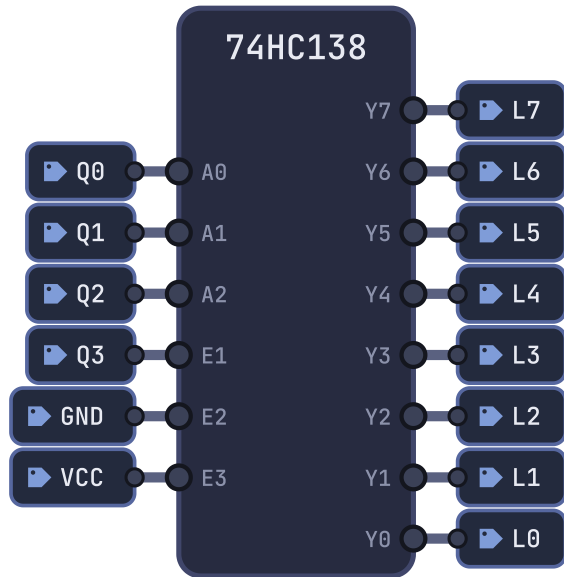
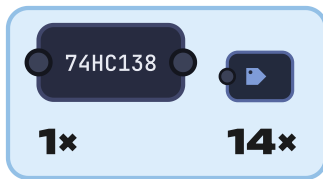
13



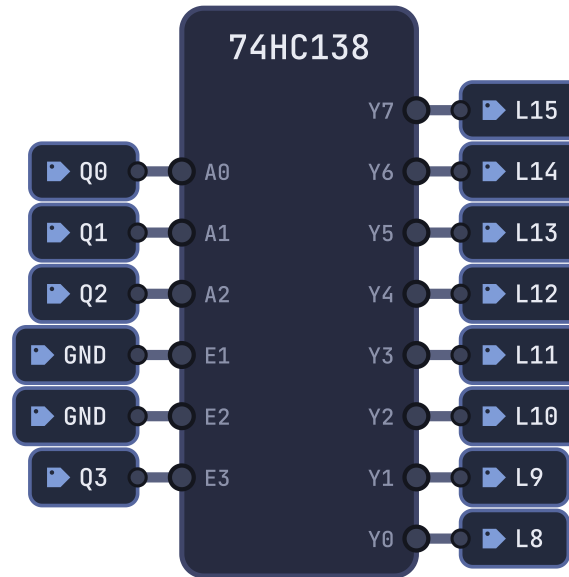
14



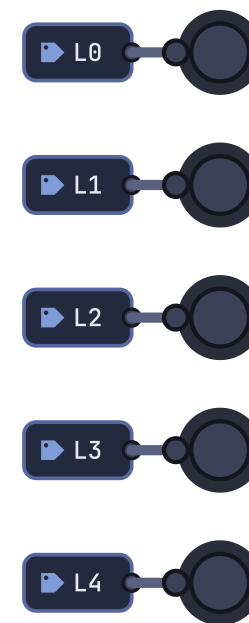
15



16



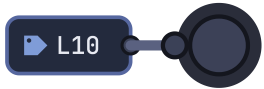
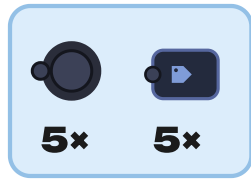
17



18



19



L0



L1



L2



L3



L4



L5

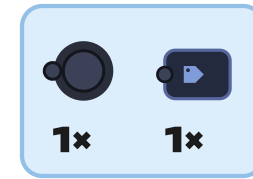


L6



L7

20



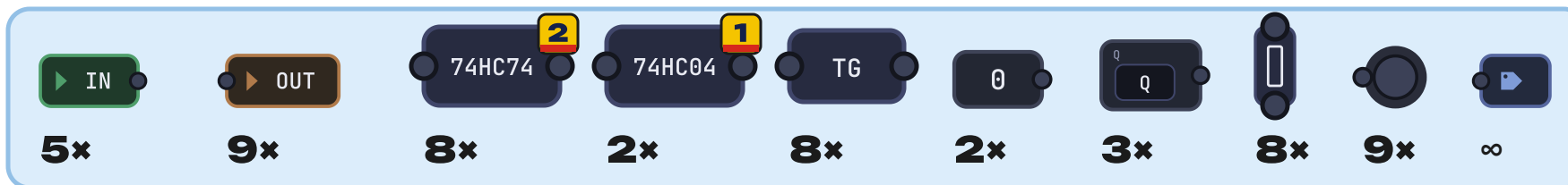
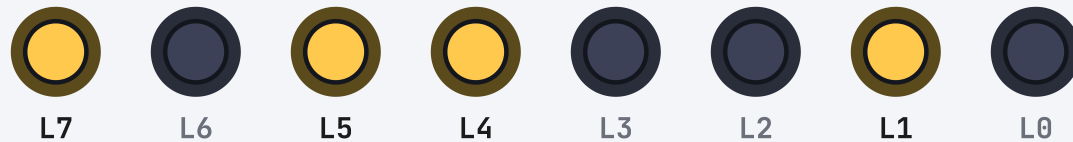
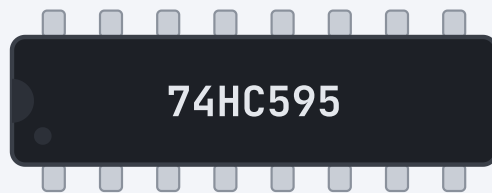
a "shadow" runs: one lamp goes out

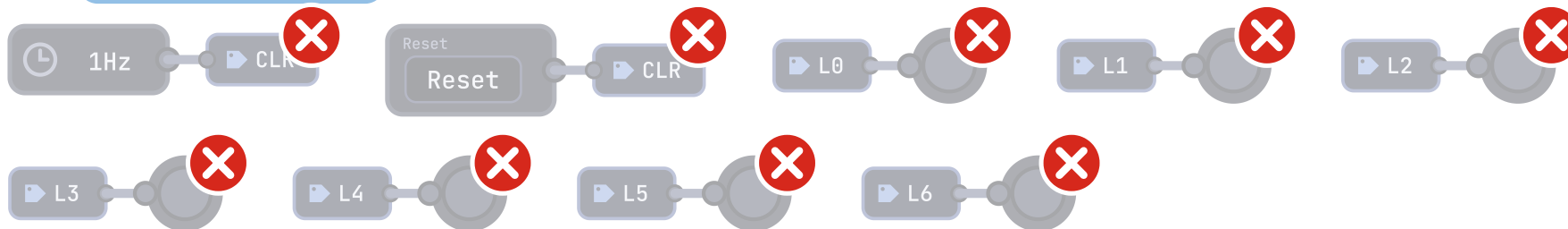


Shift register: 74HC595

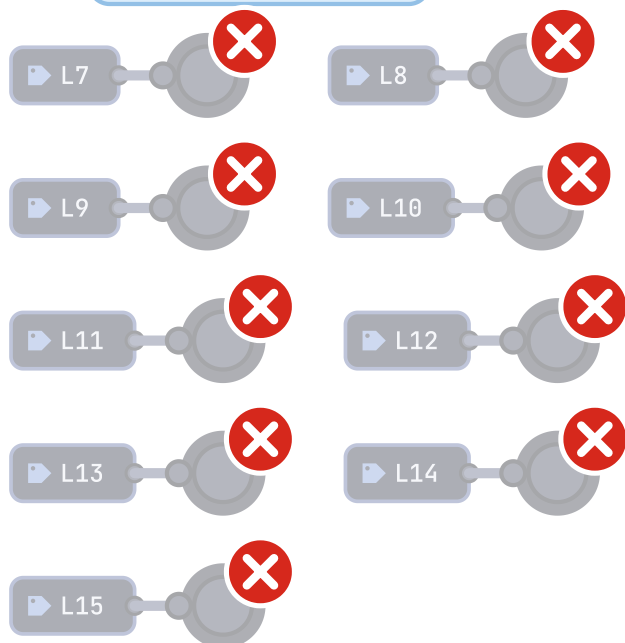
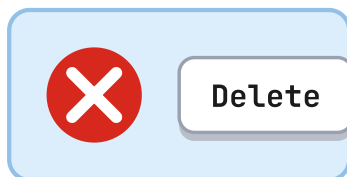
kh HB-05

8 lamps over three wires

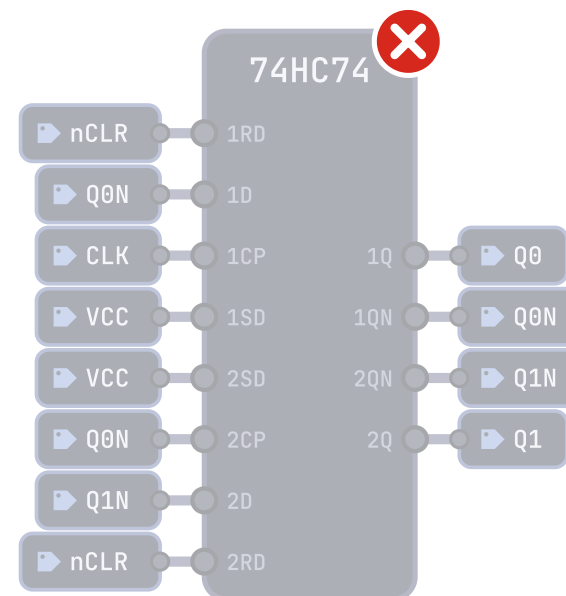
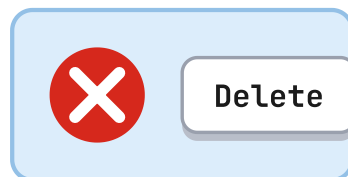




2



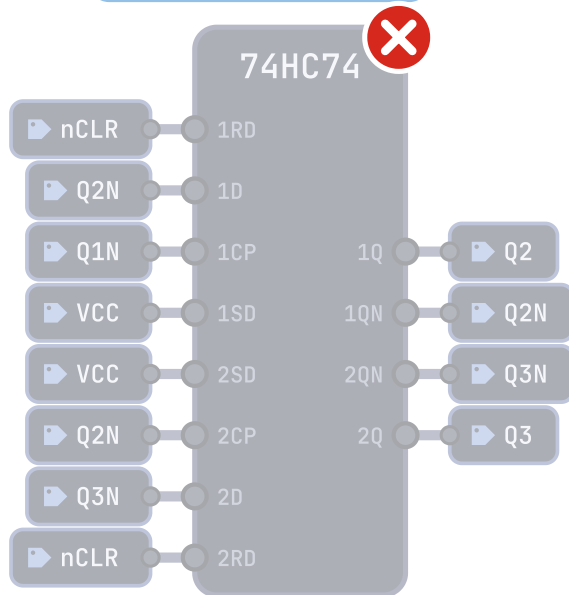
3



4



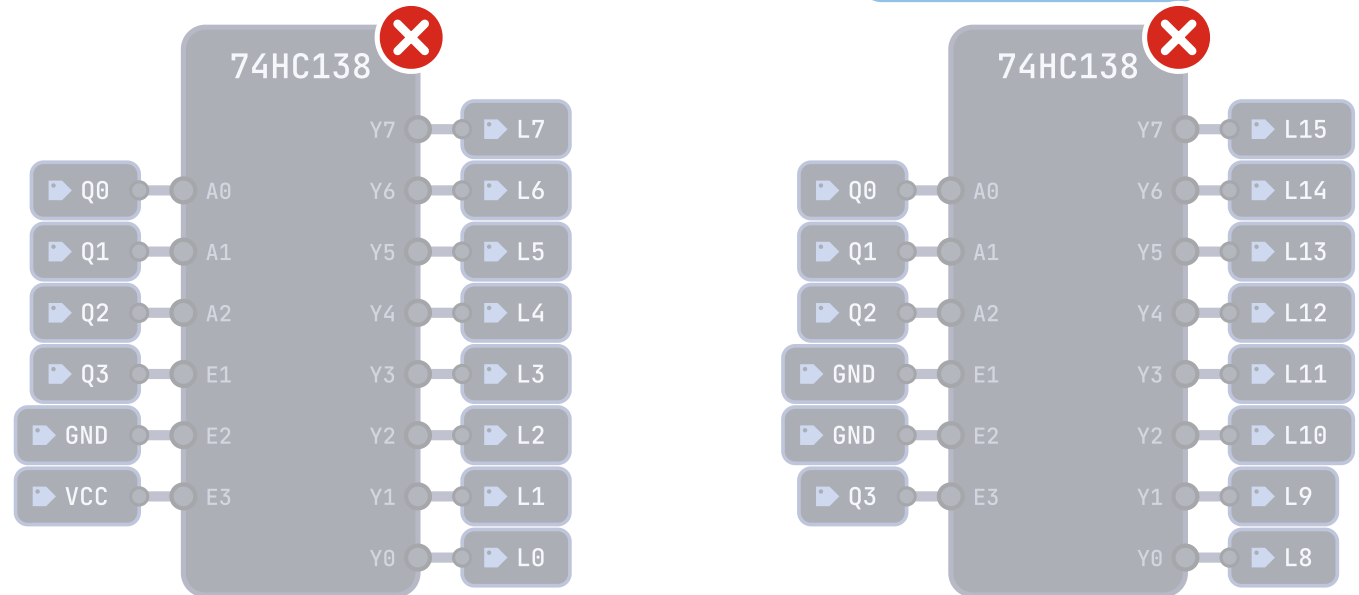
Delete



5

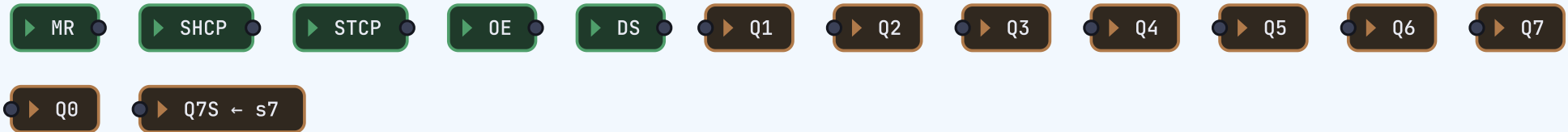


Delete

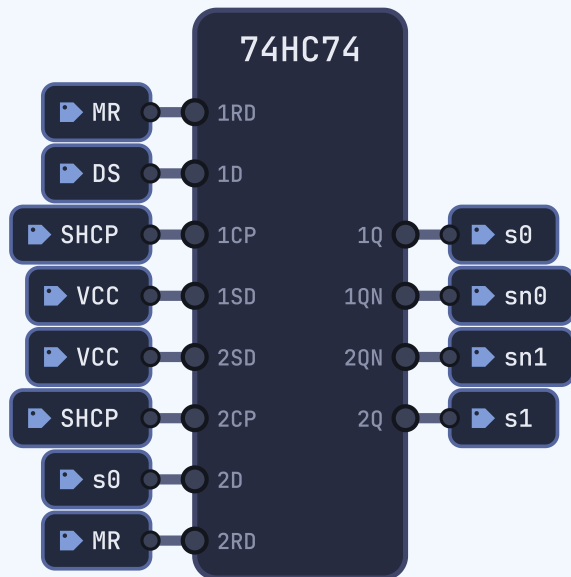
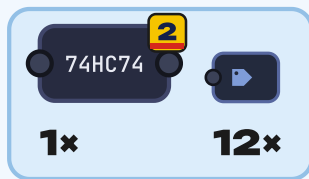


74HC595

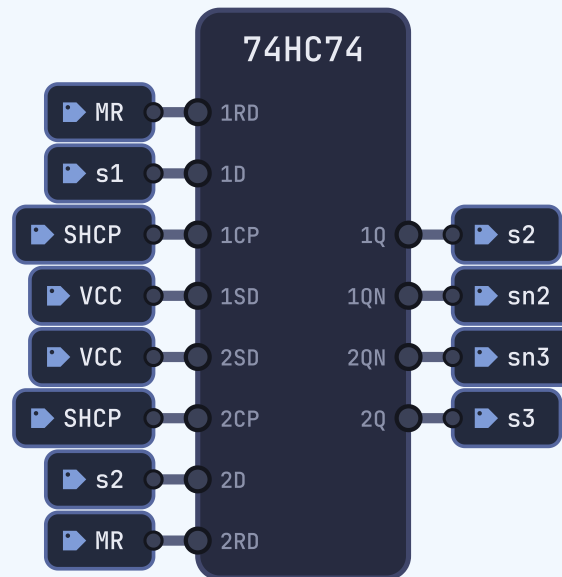
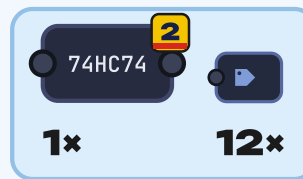
6



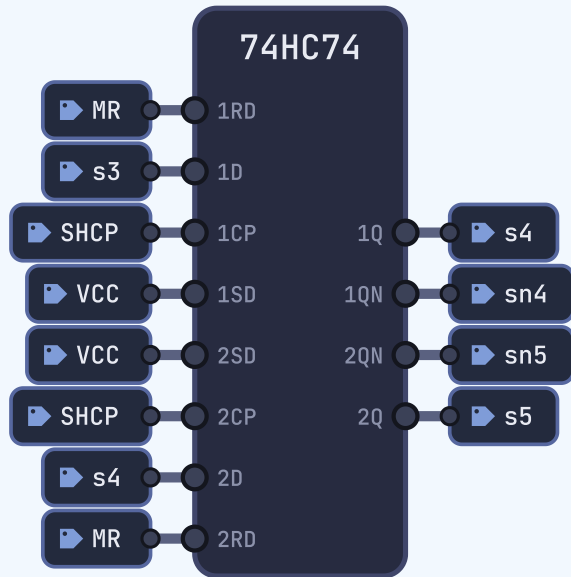
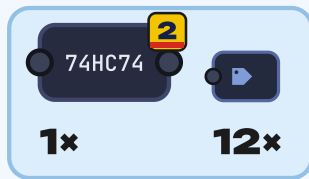
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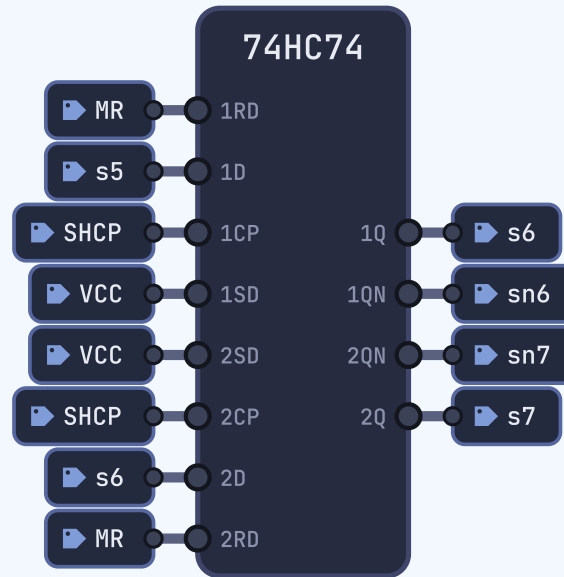
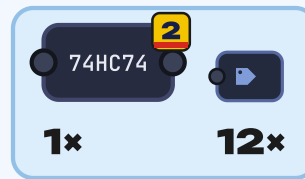
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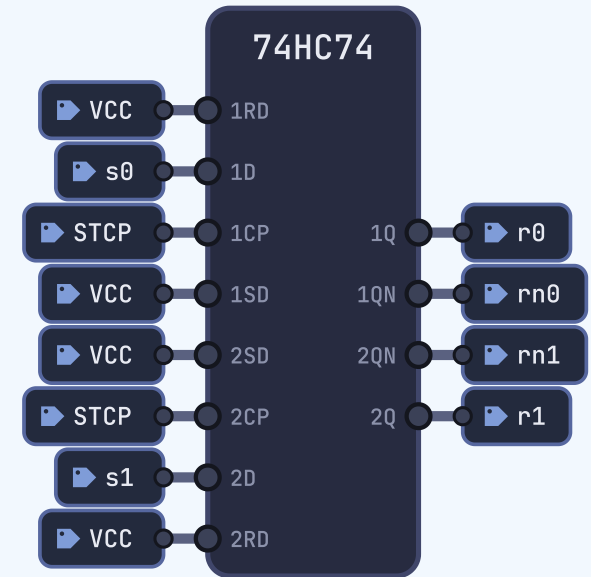
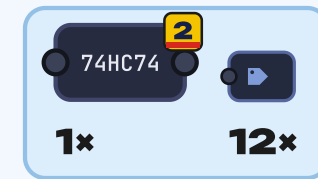
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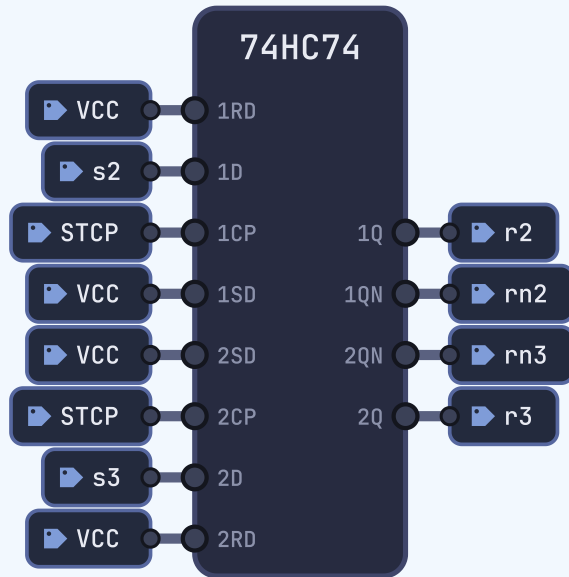
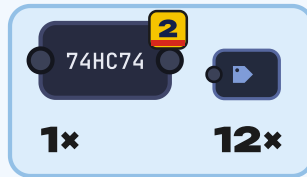
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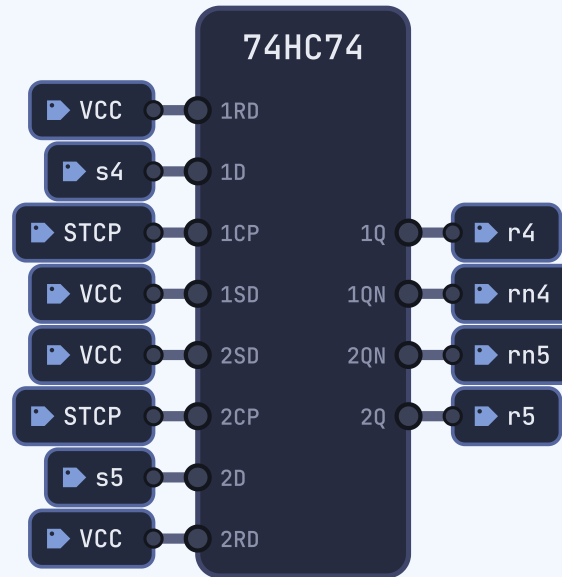
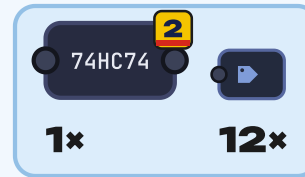
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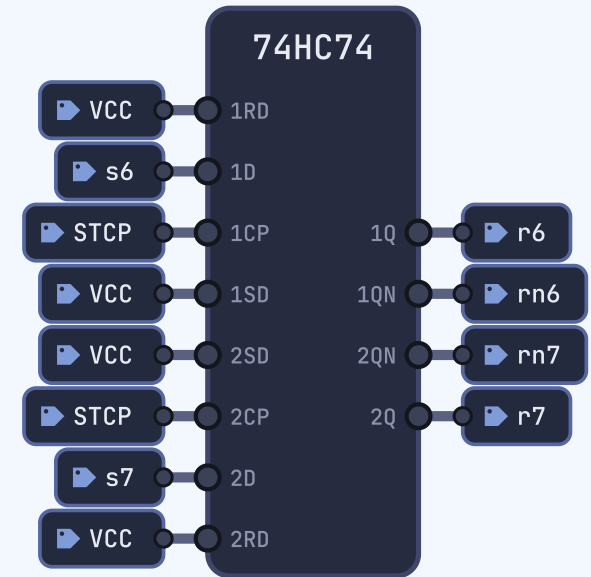
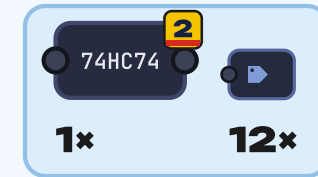
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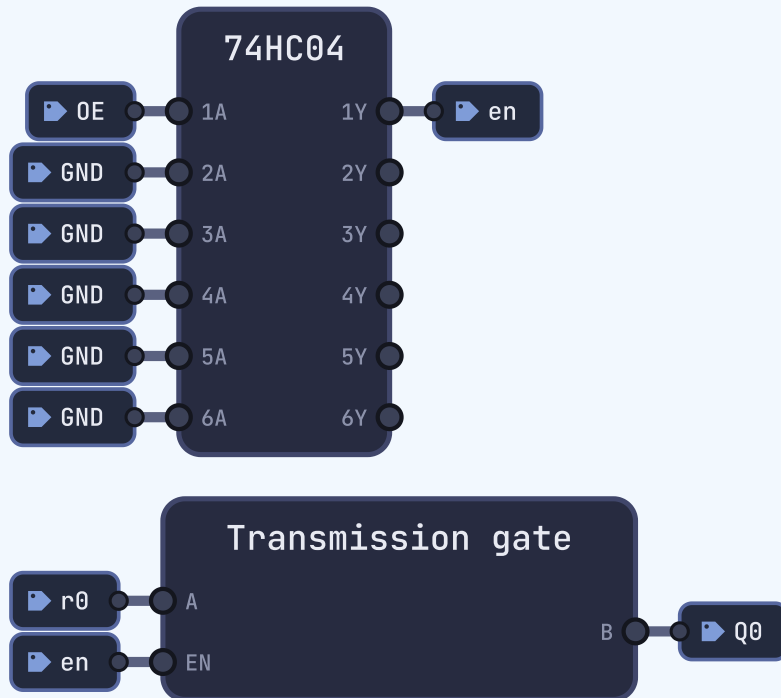
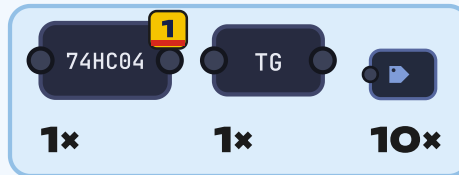
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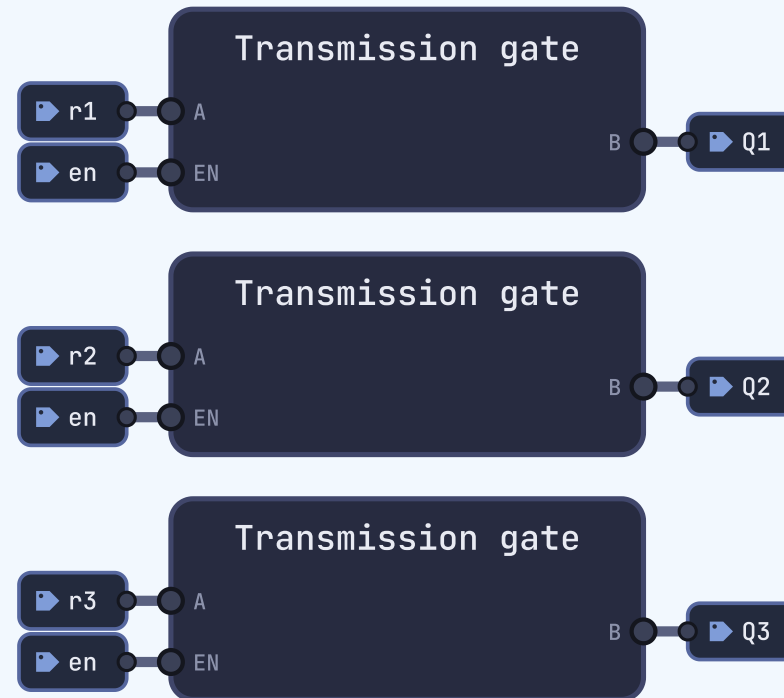
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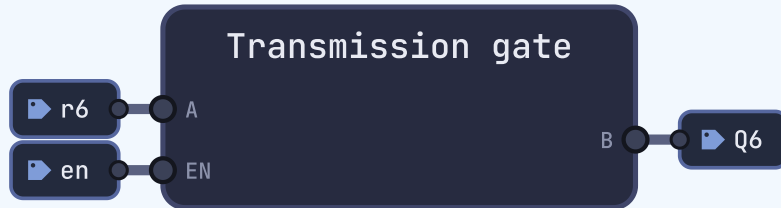
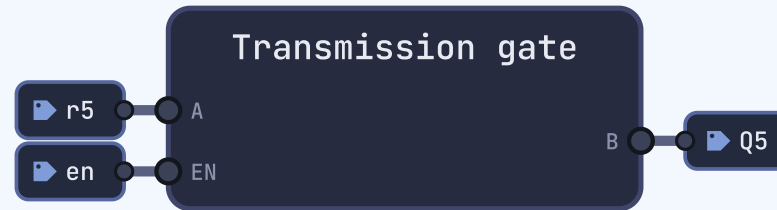
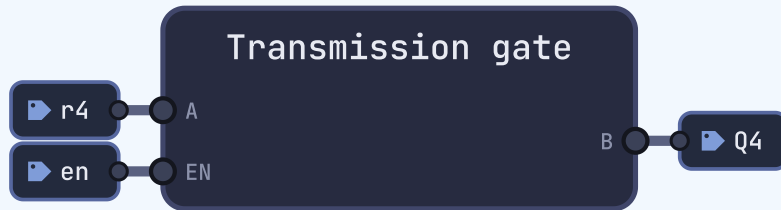
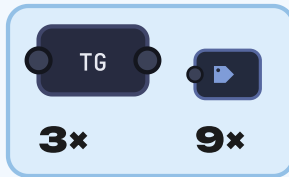
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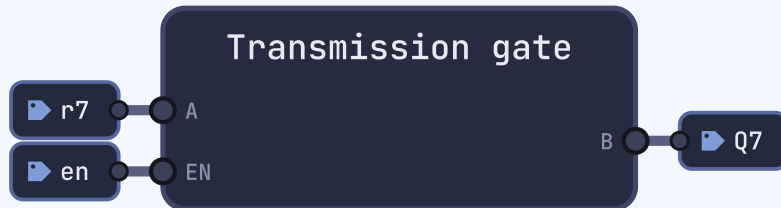
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17

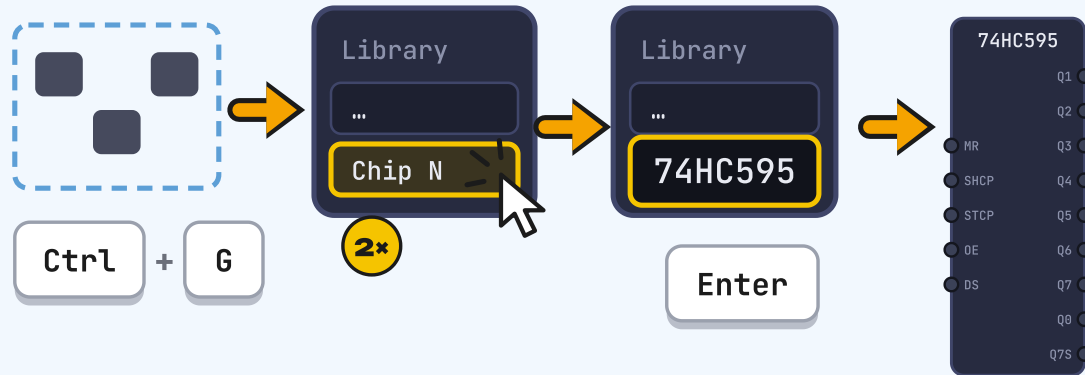


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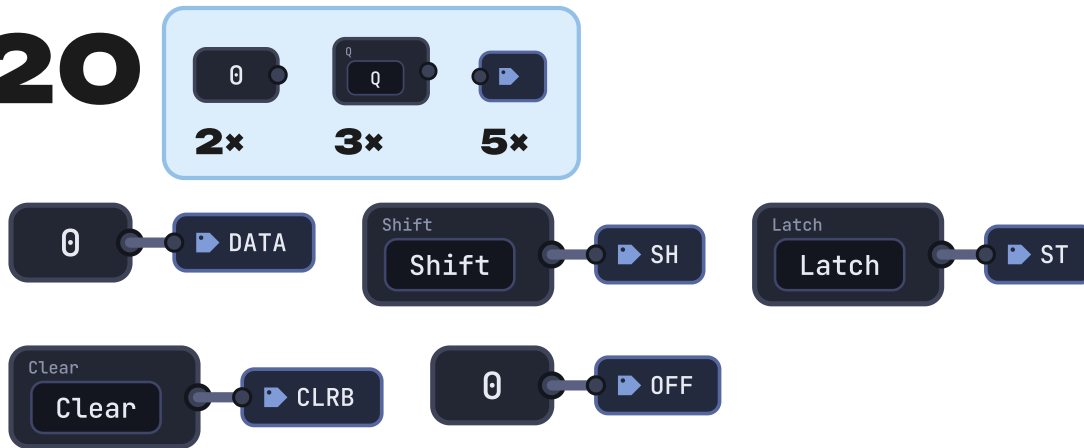
74HC595 ...

19



CANVAS

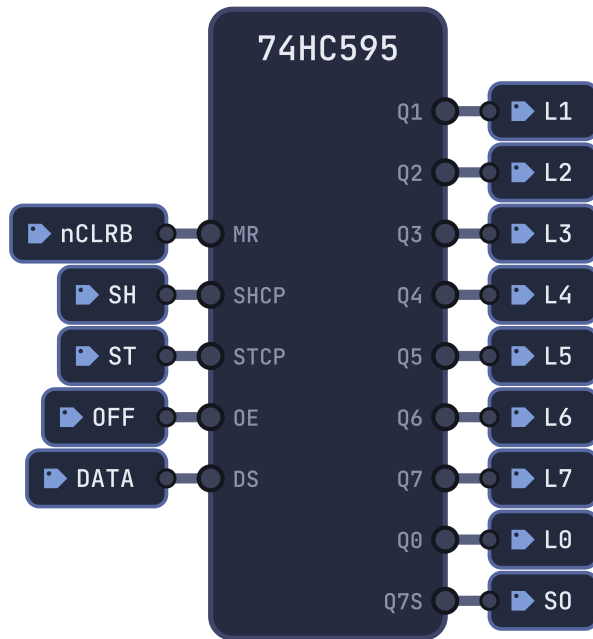
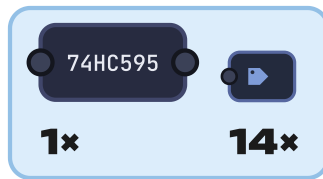
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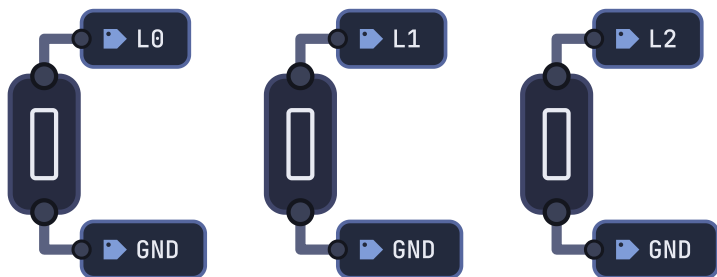
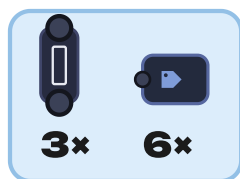
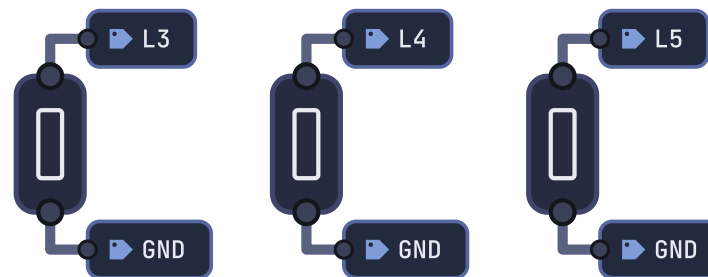
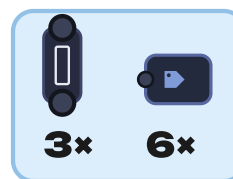
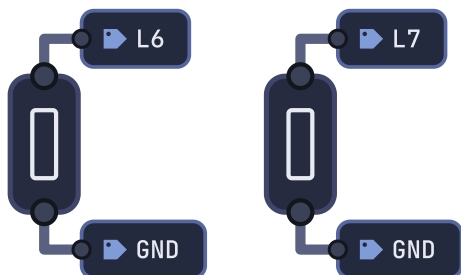
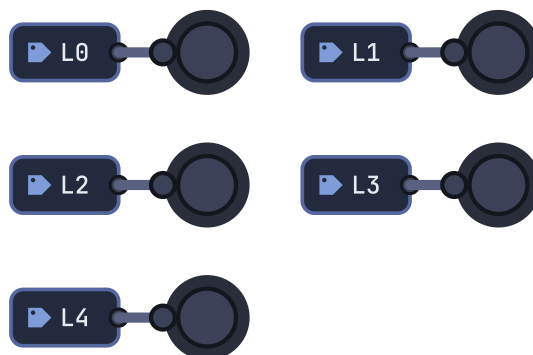


21



22



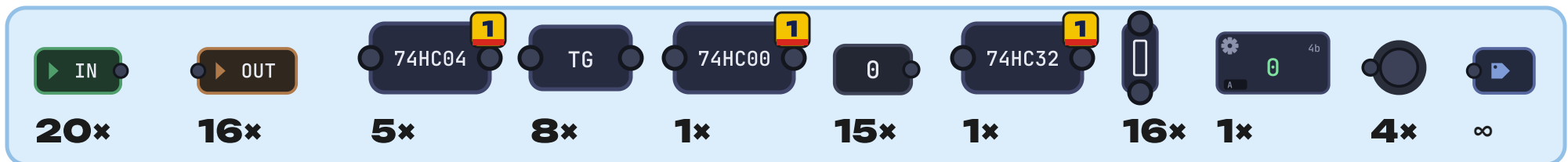
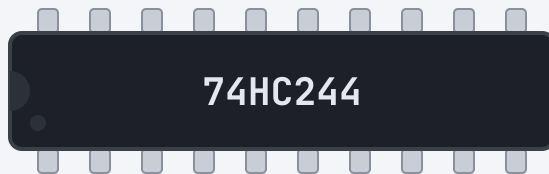
23**24****25****26****27**

1011 0010 → Latch

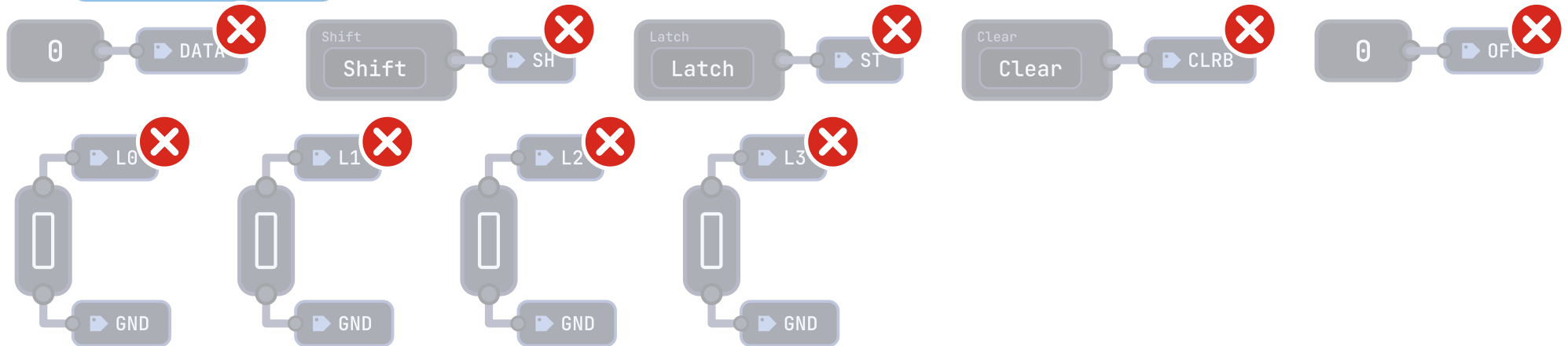


Bus buffers

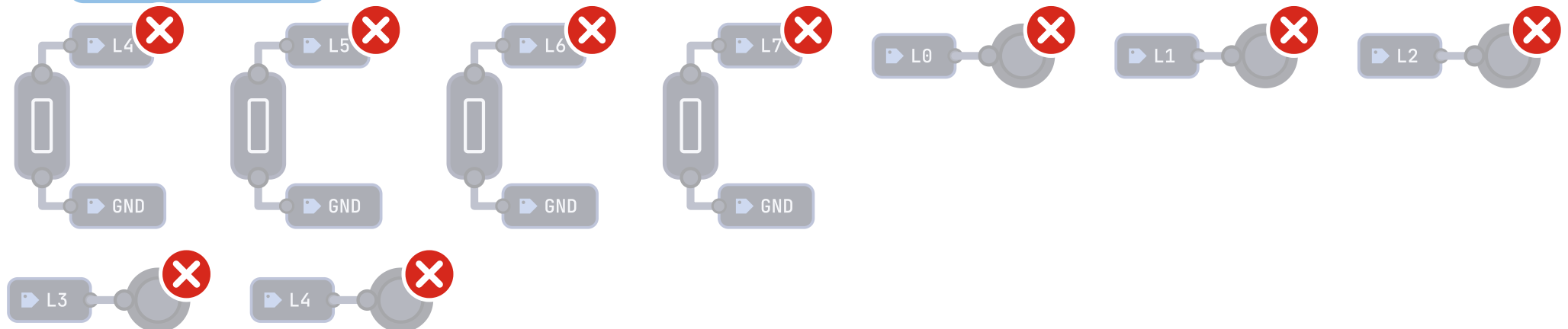
74HC244 and 74HC245: shared wires – only one talks



1



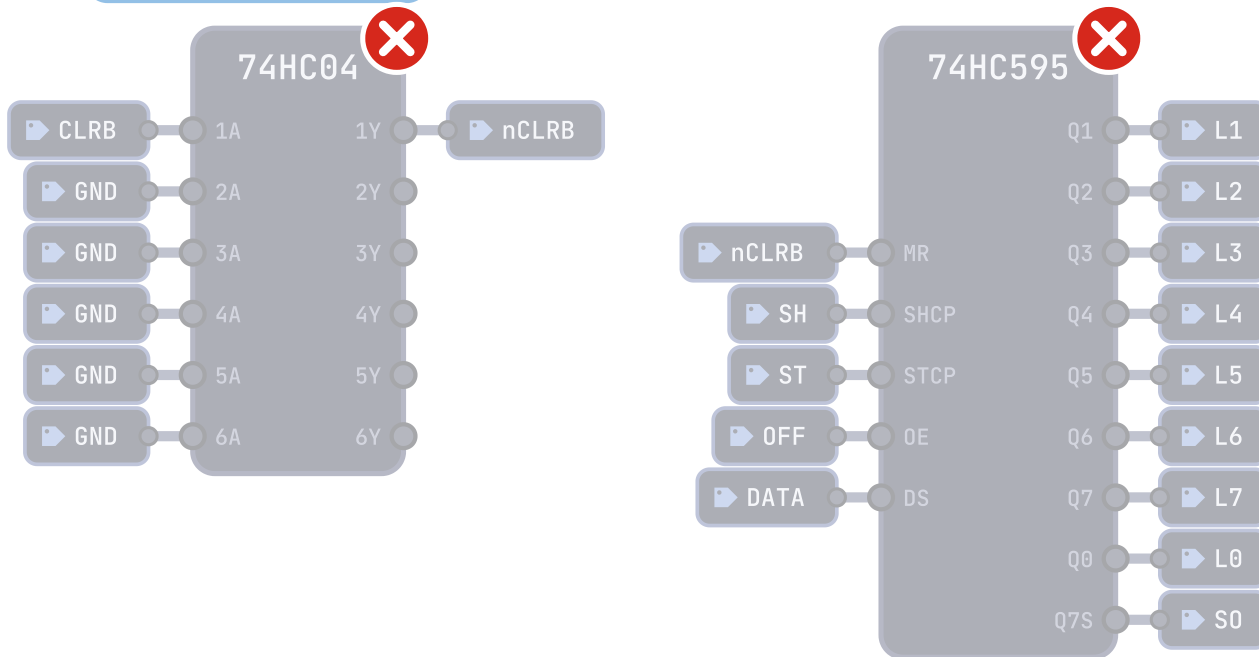
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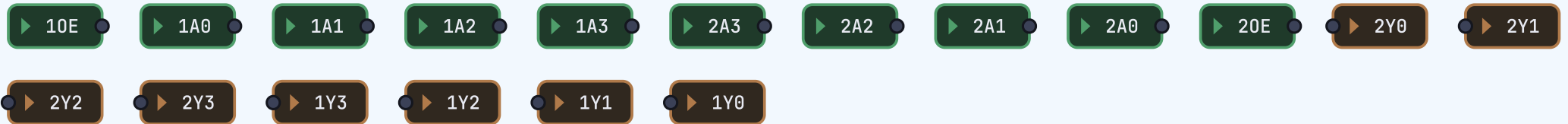
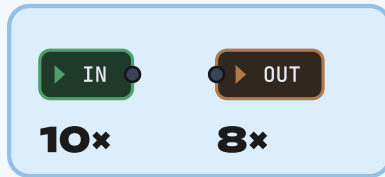


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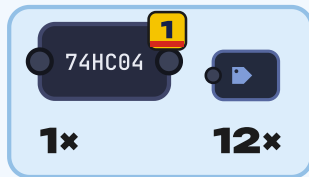


74HC244

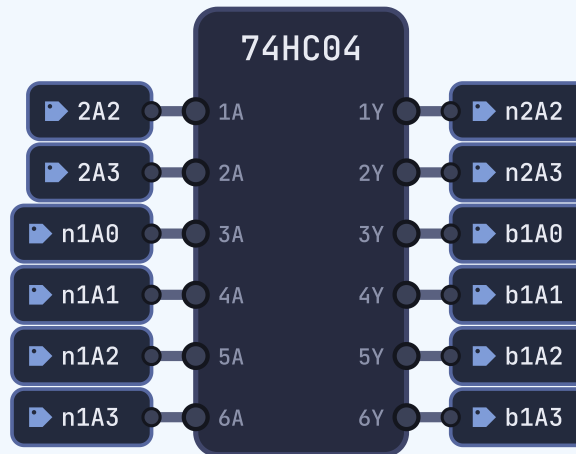
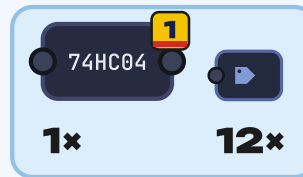
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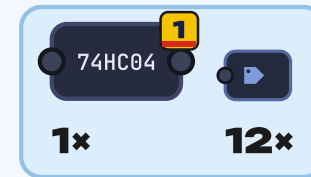
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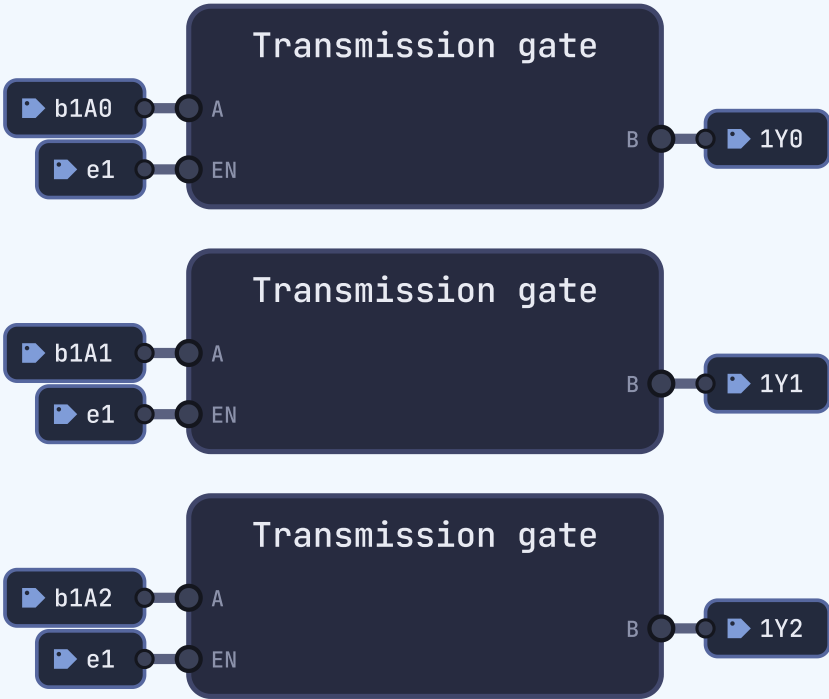
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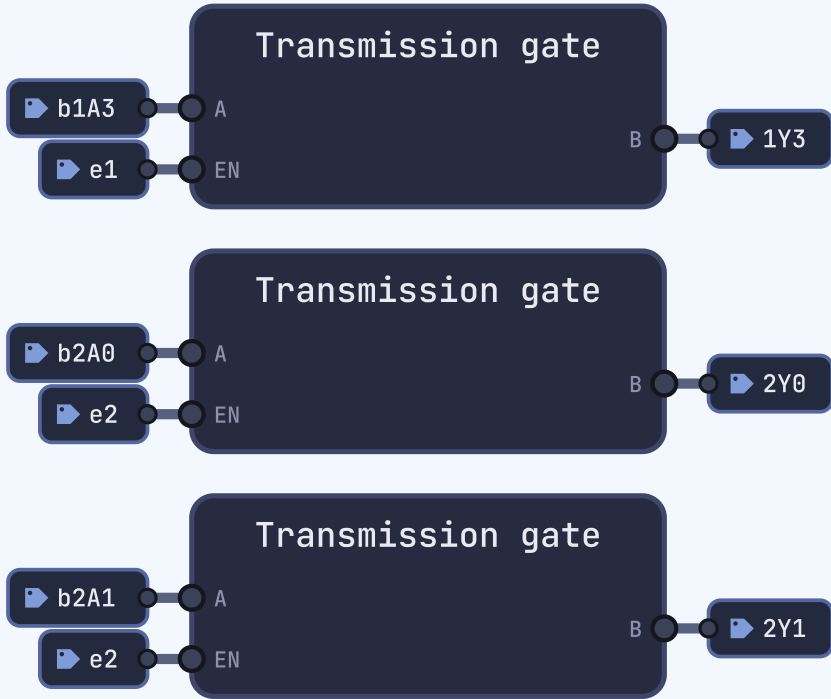
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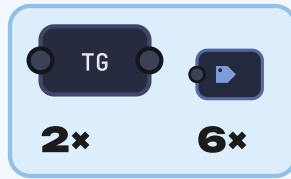


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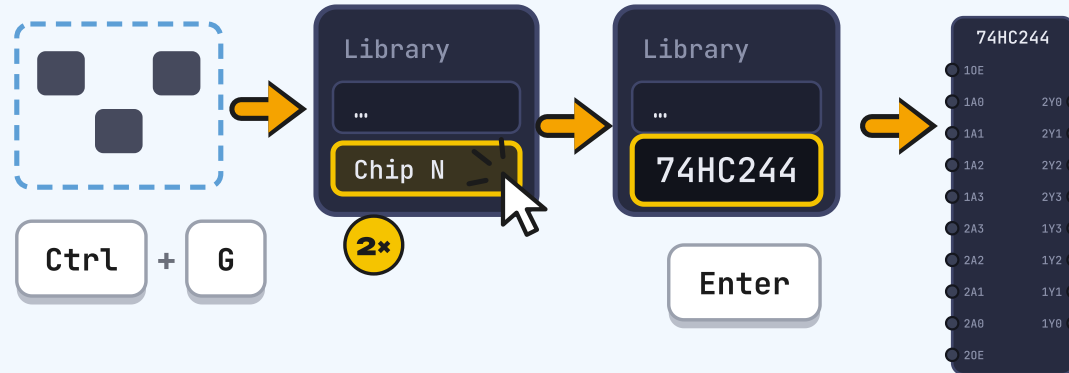


74HC244 ...

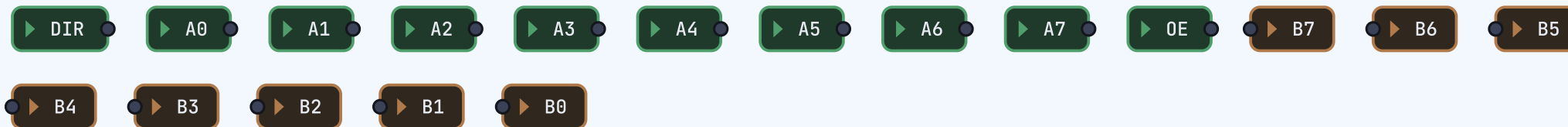
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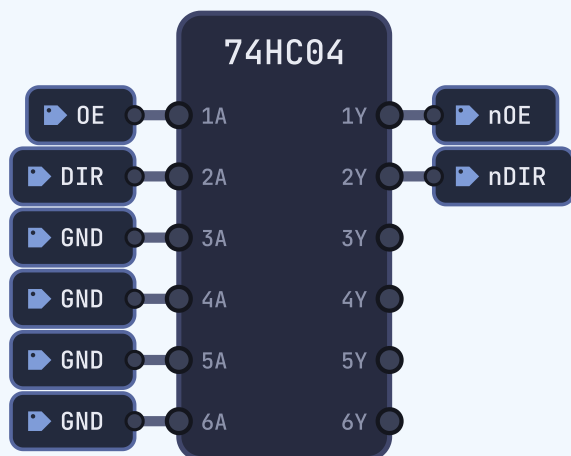
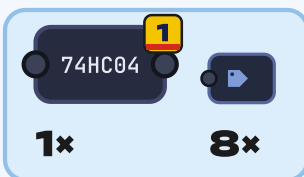
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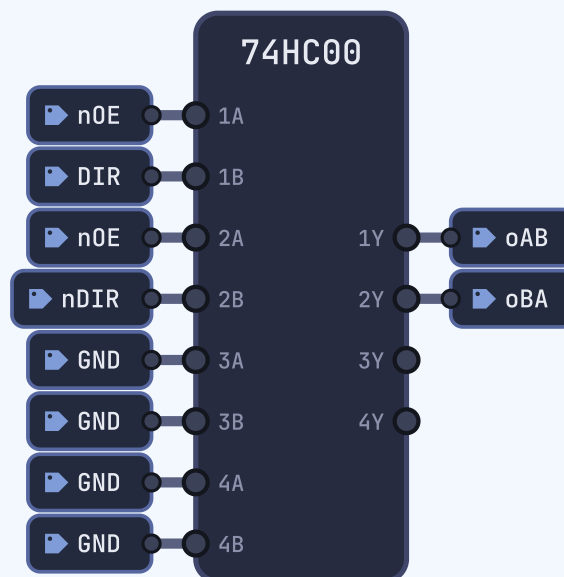
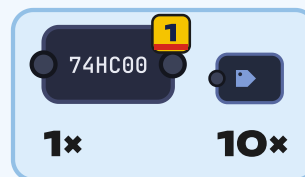
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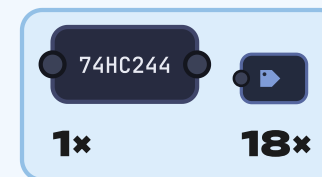
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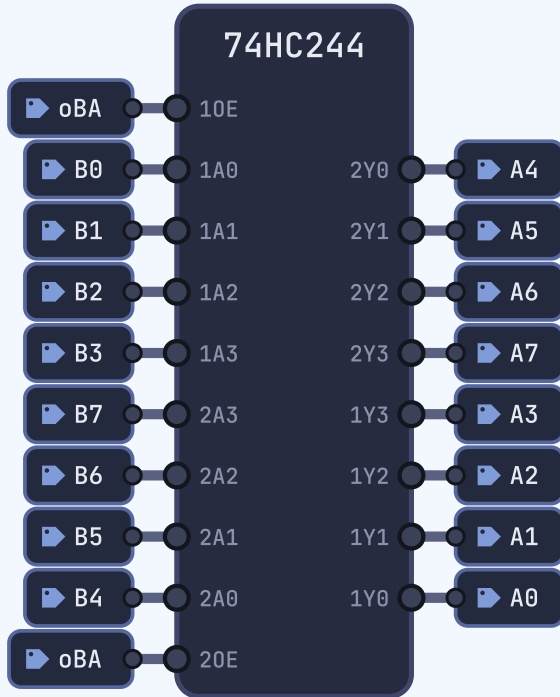
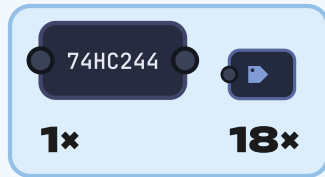


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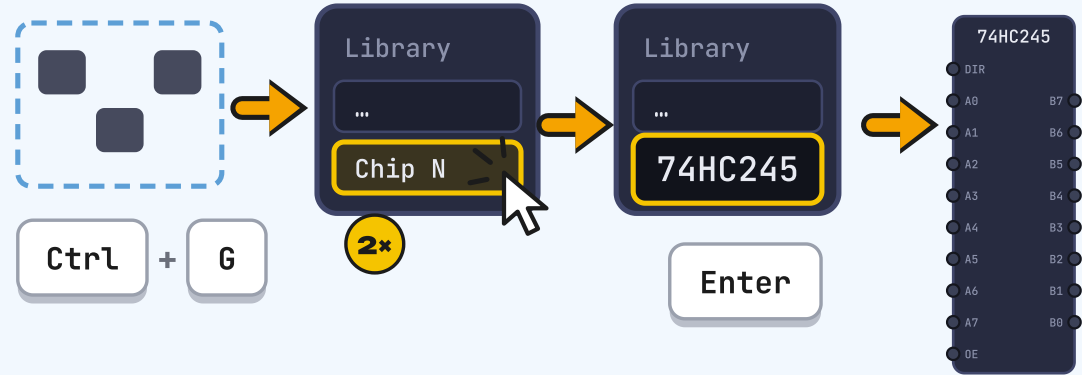


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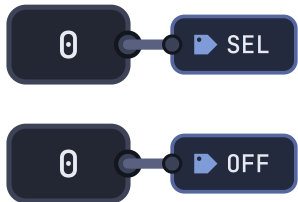
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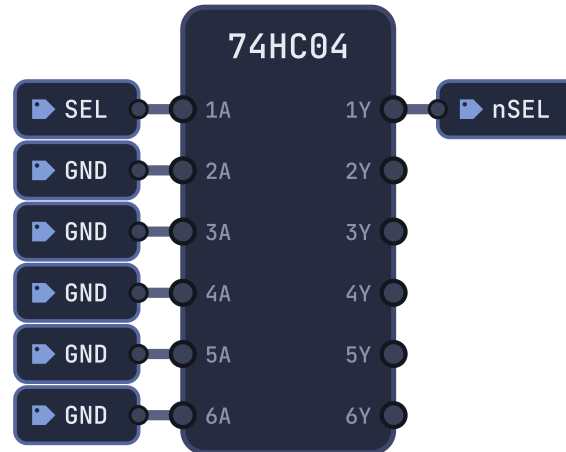
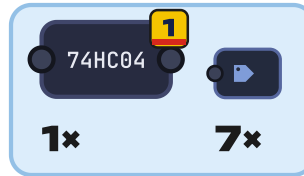
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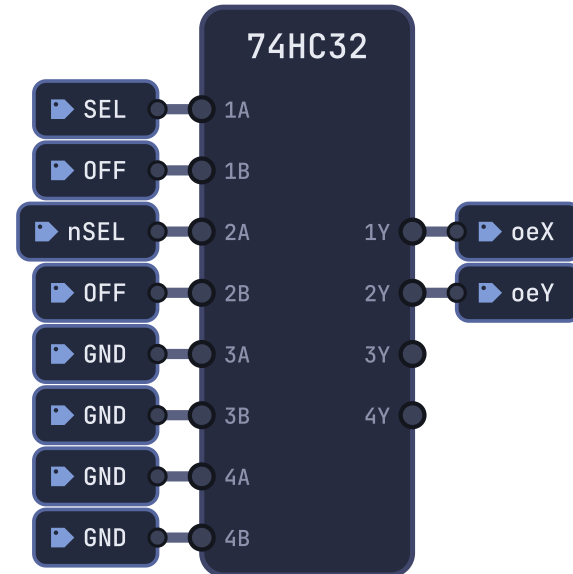
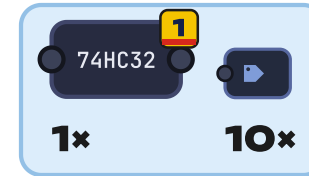
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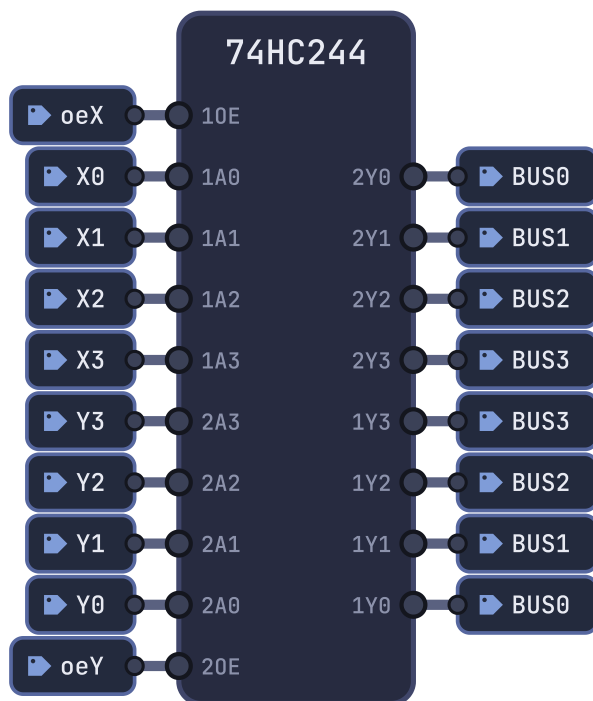
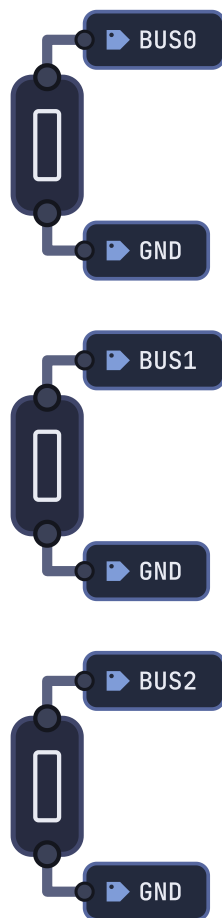
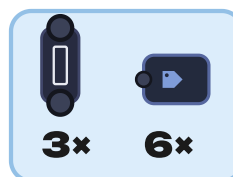
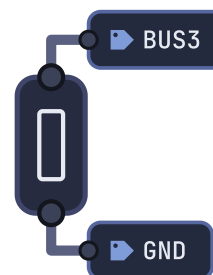
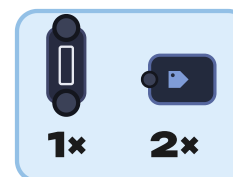


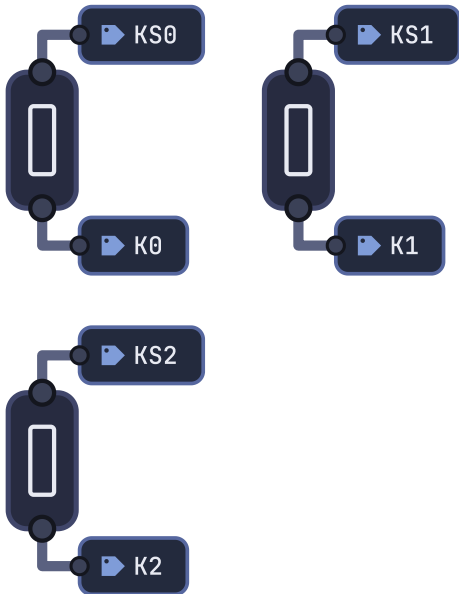
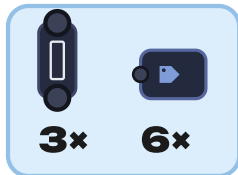
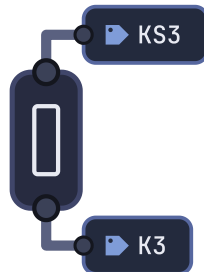
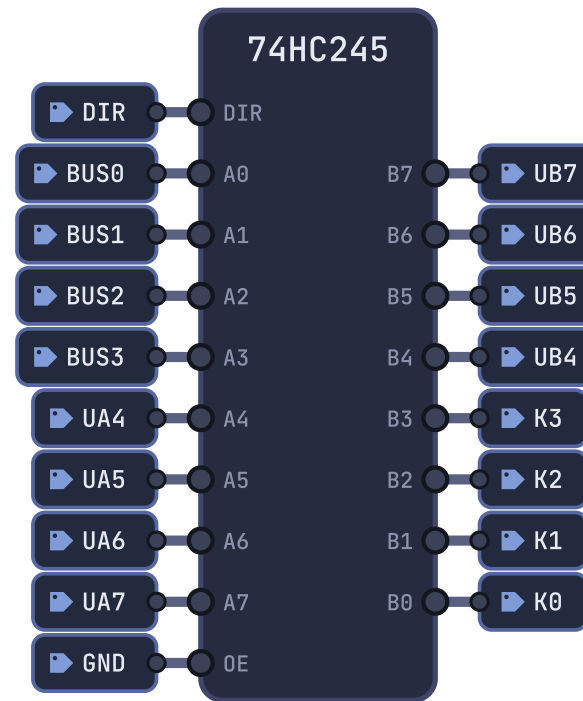
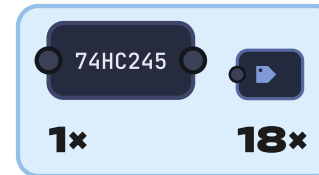
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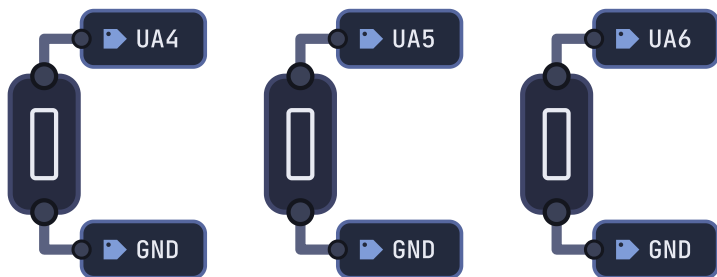
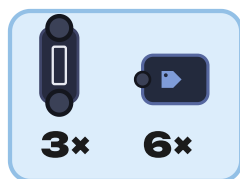
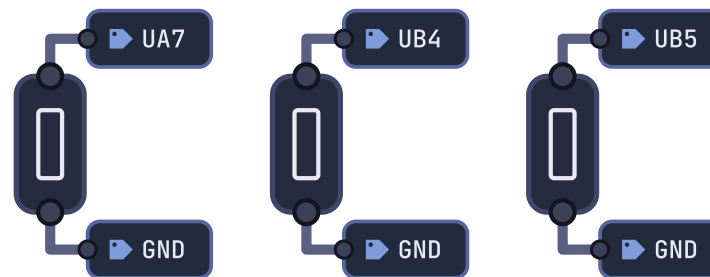
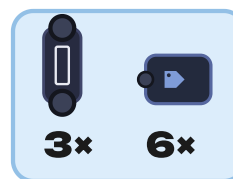
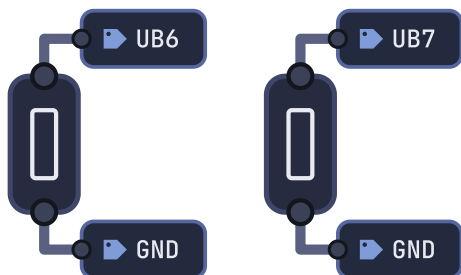
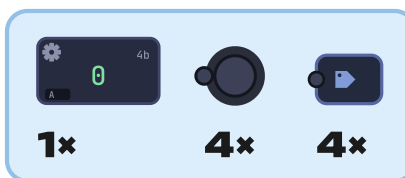


23



24**25****26**

27**28****29****30**

31**32****33****34**

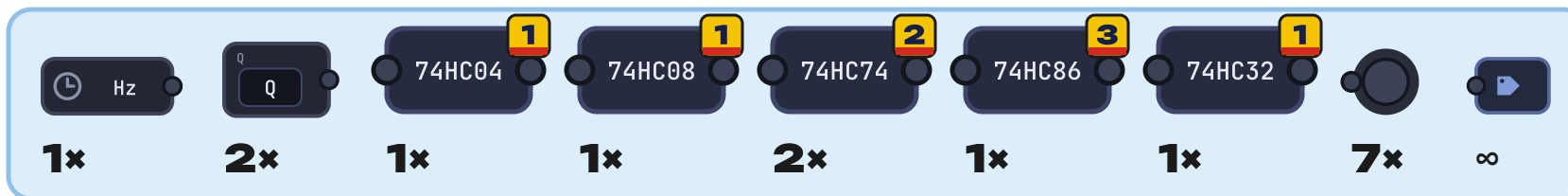
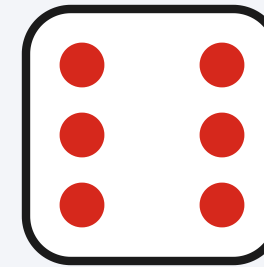
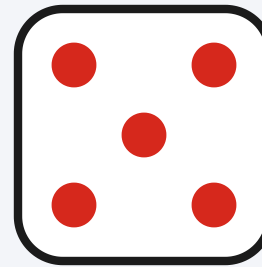
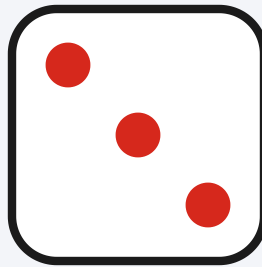
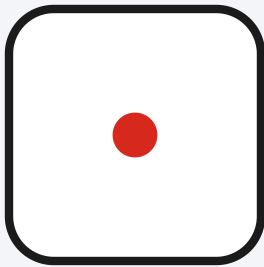
SEL = 0 → X, SEL = 1 → Y



Electronic dice

kh HB-05

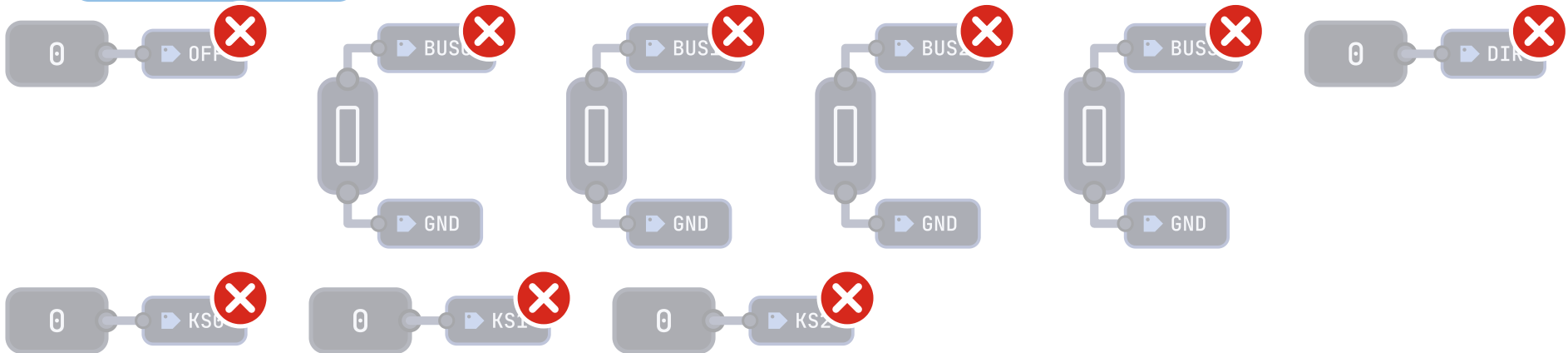
the finale: a counter to six and seven dots



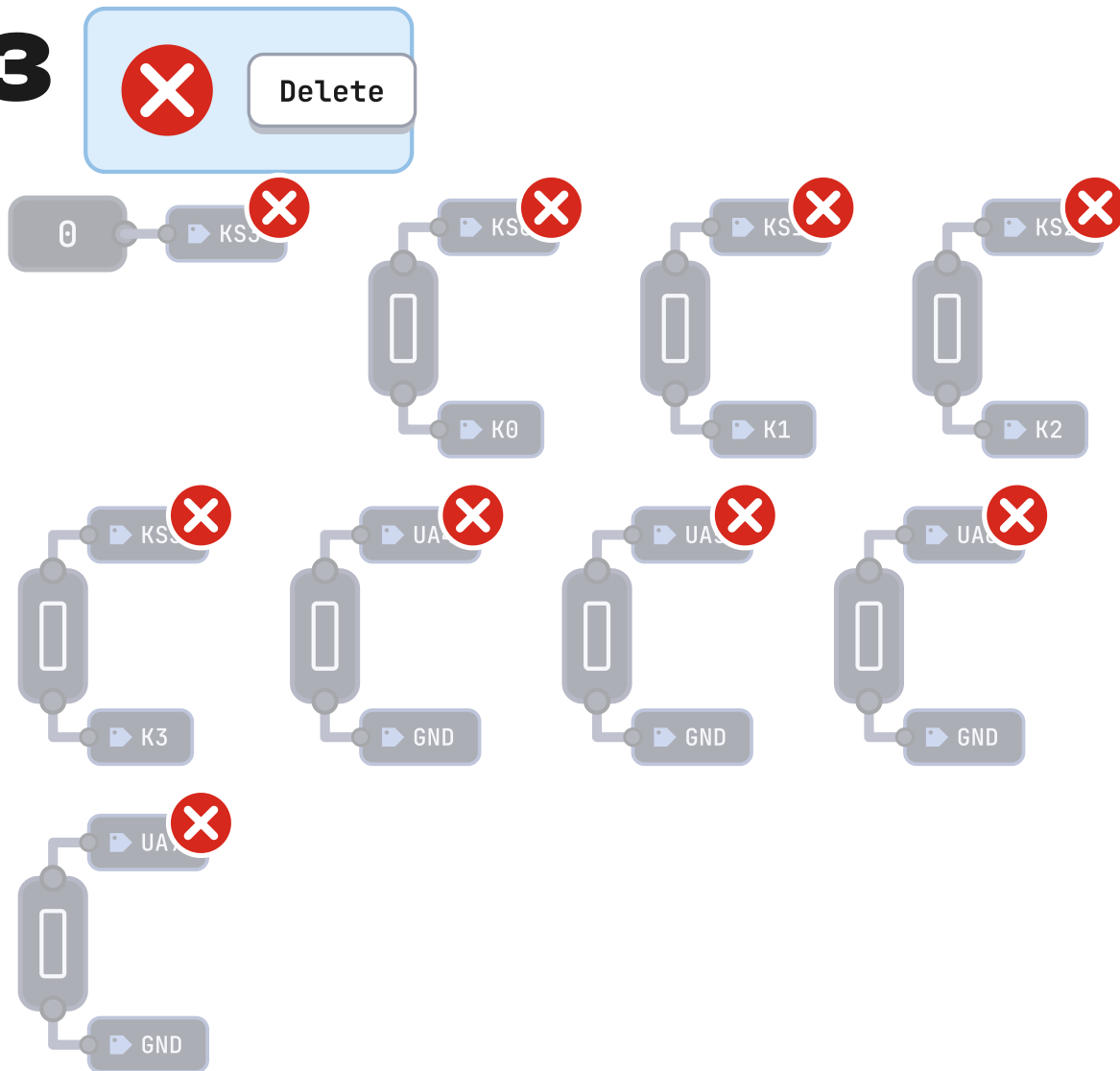
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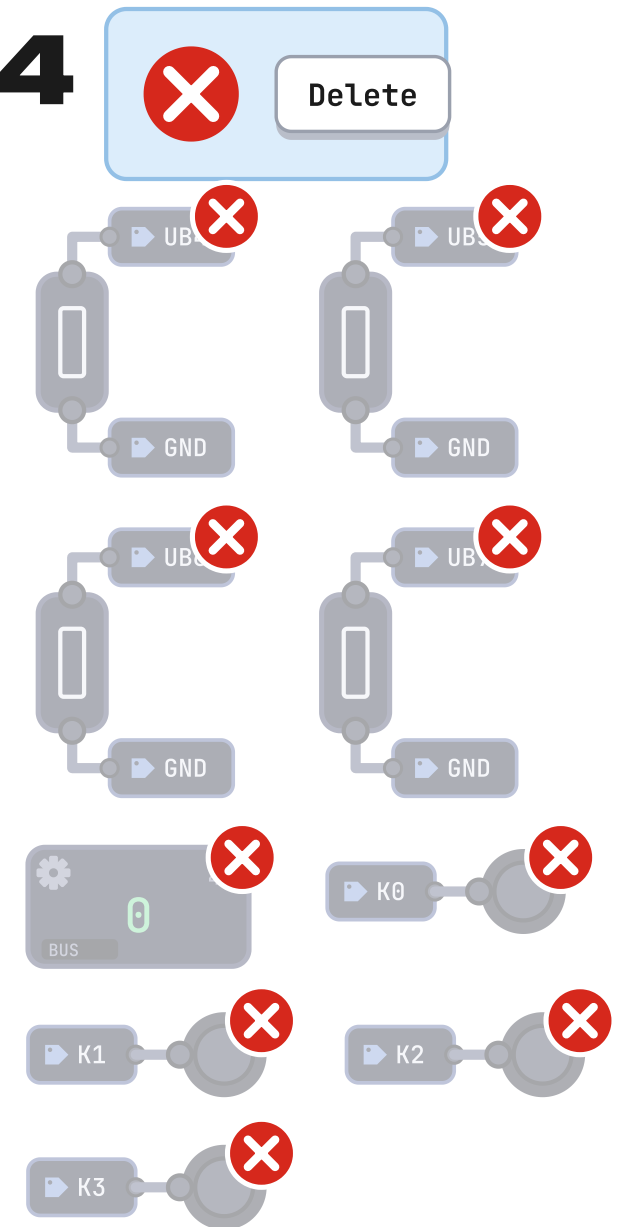
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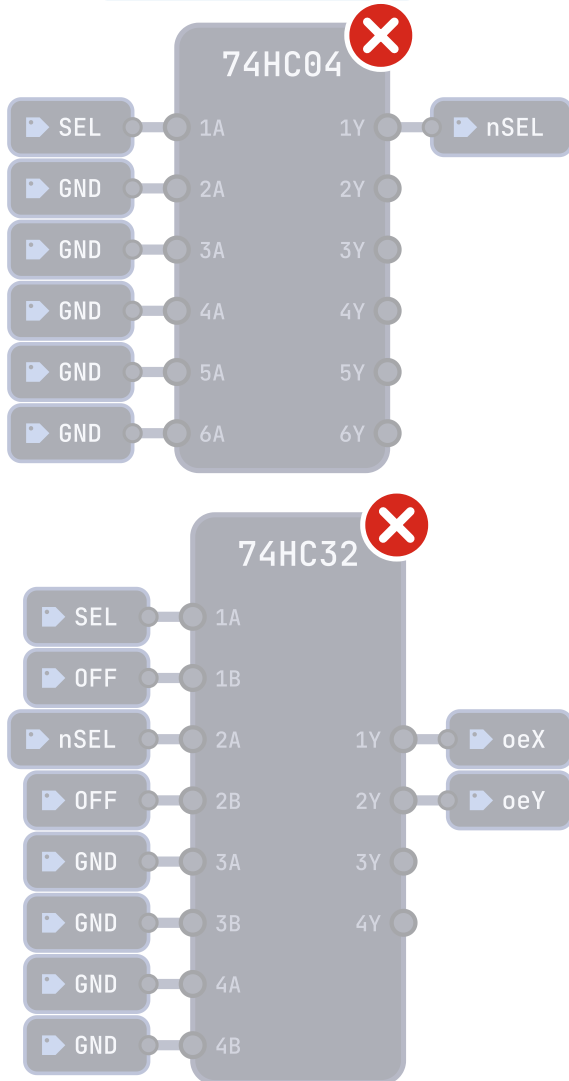
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5



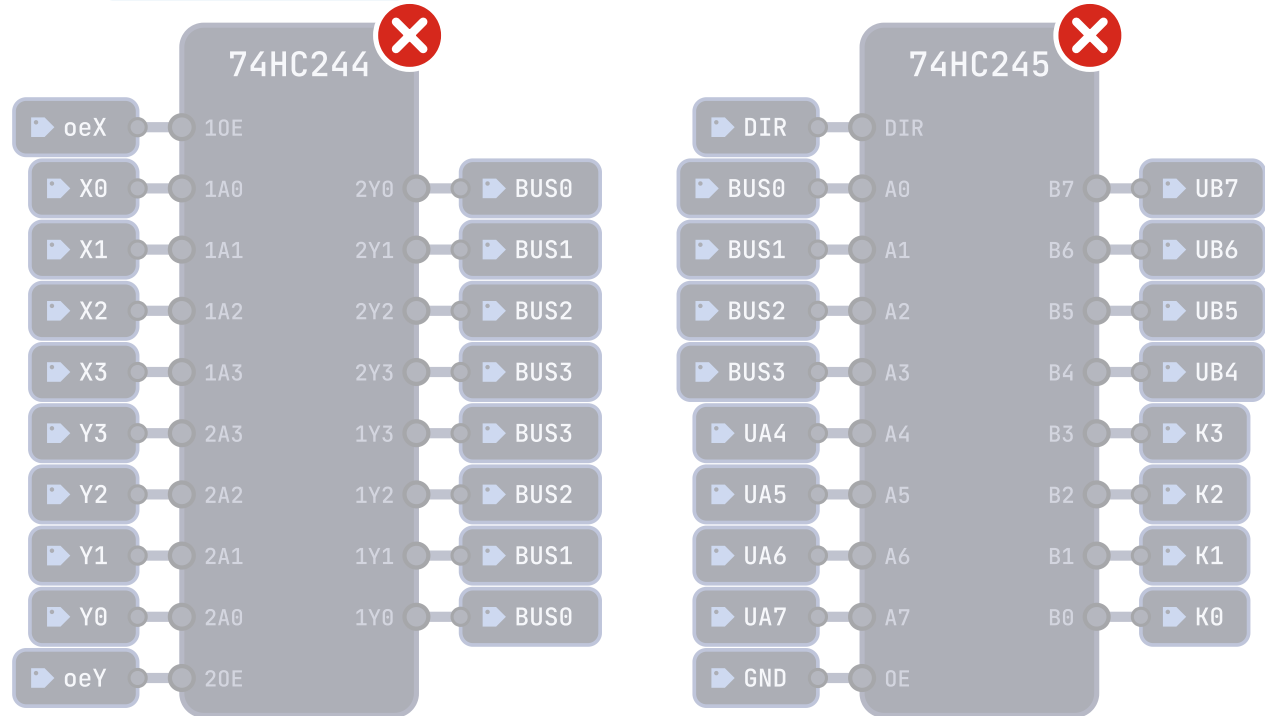
Delete



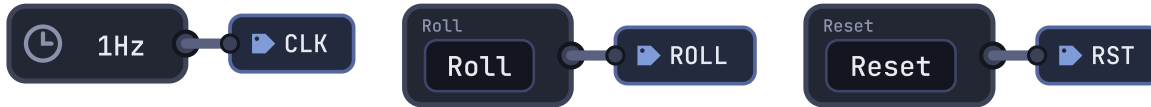
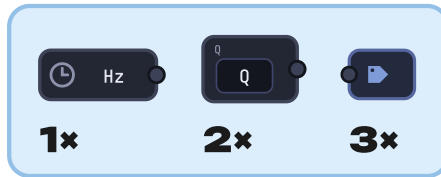
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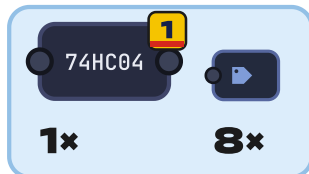
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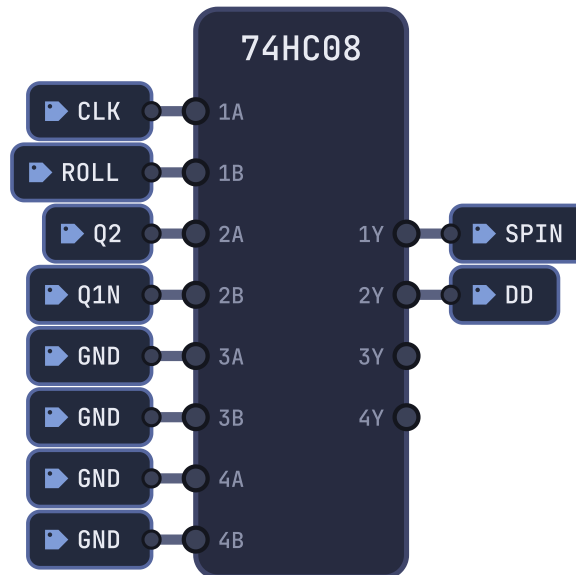
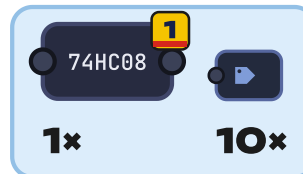
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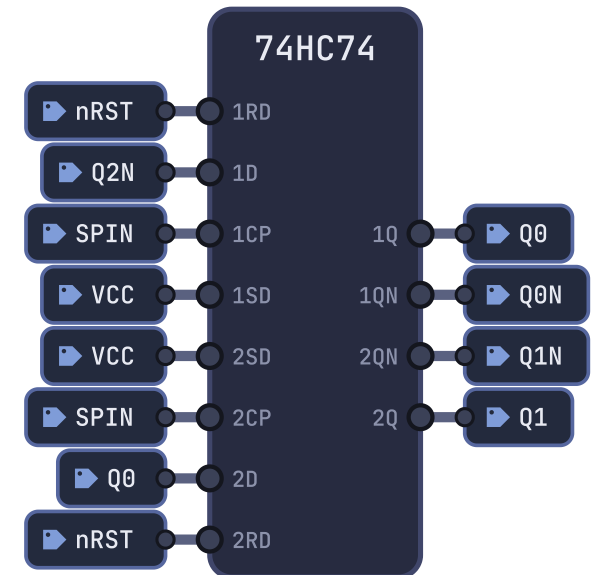
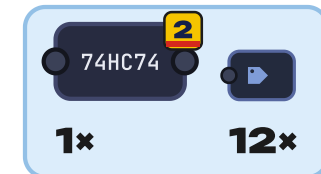
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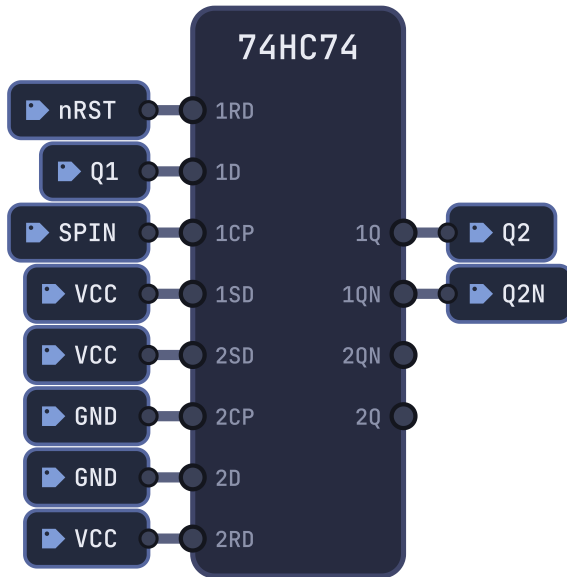
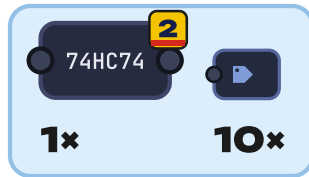
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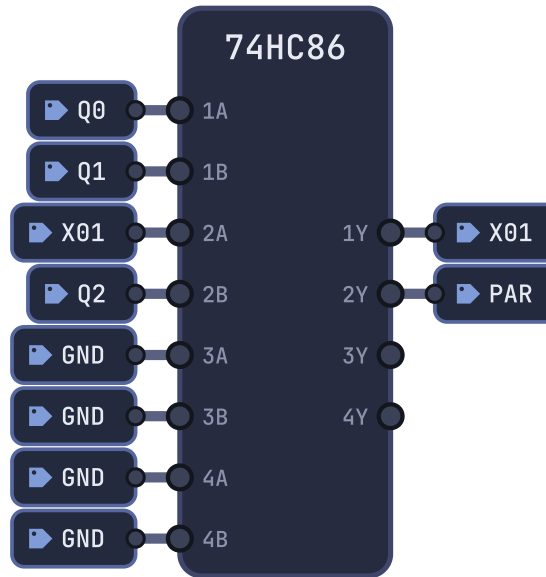
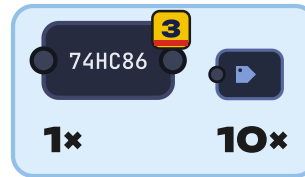
10



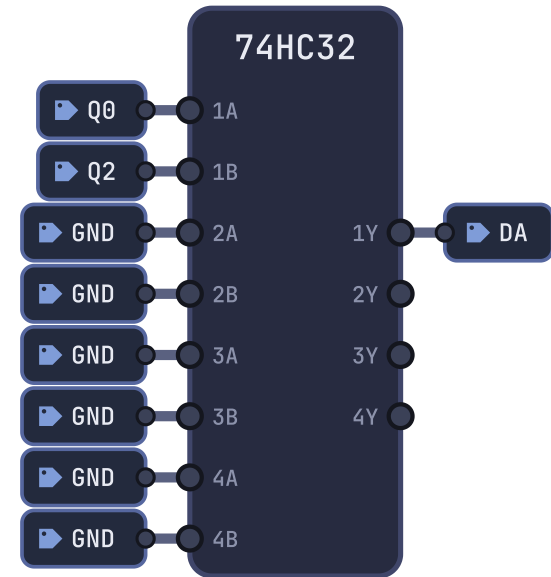
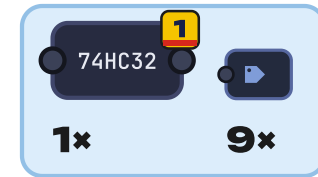
11



12



13



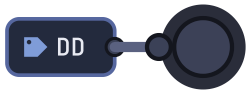
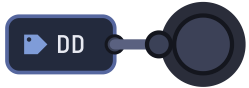
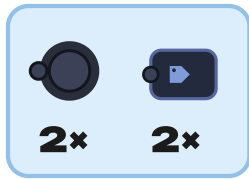
14

lamps in a 3 × 3 square, like the dots of a dice

15

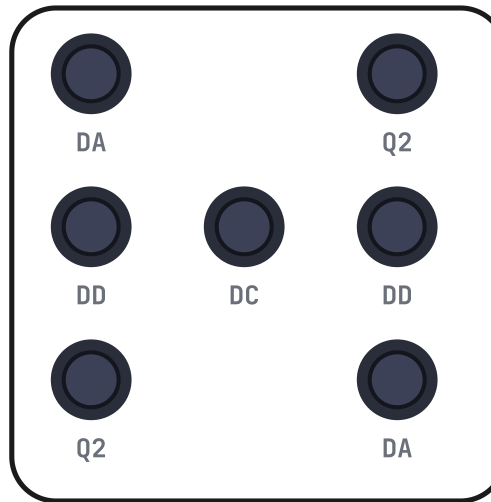


16

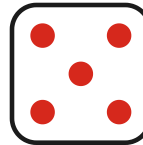


Reset - 1

17



↖ ↘ - DA · ↗ ↙ - Q2
← → - DD · · - DC



hold Roll - let go

Kit parts

how many times you place each part over all the lessons



14×



14×



24×



1×



1×



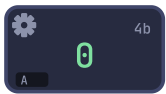
21×



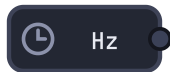
44×



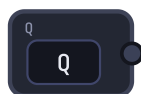
16×



4×



4×



9×



1×



105×



78×



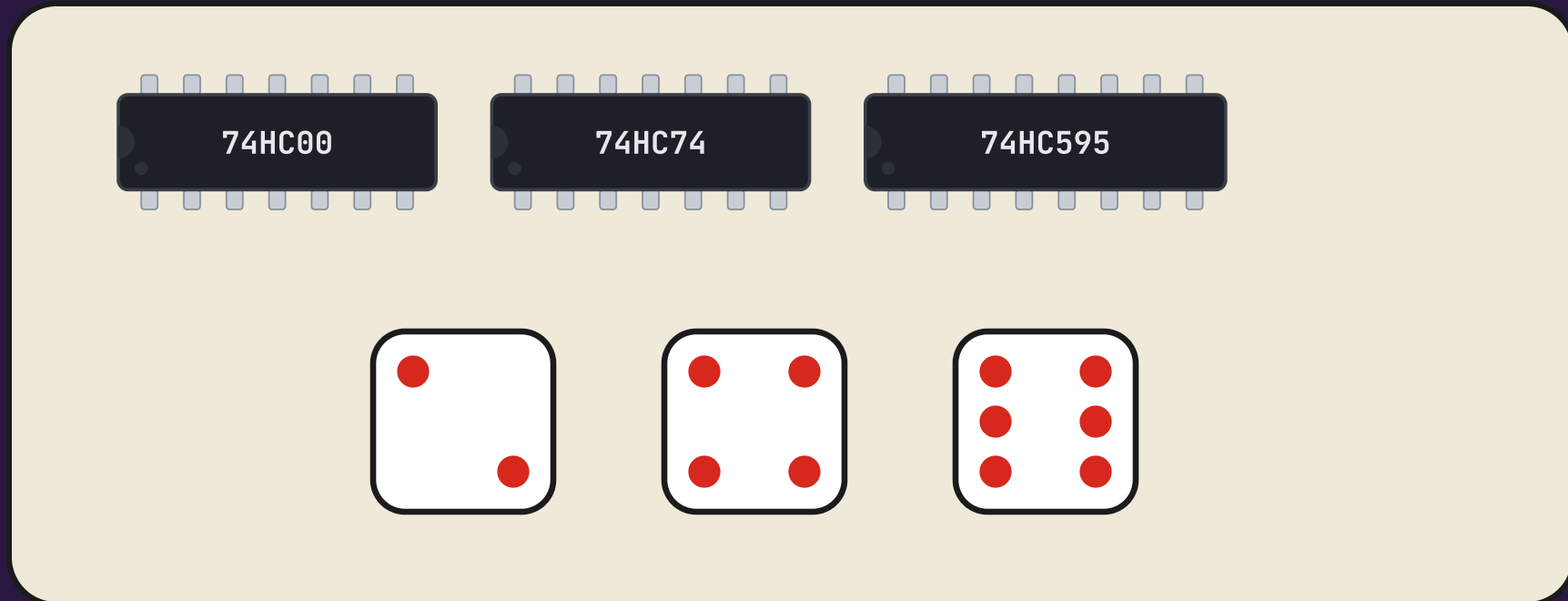
1023×

Kit chips

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



Done!



twelve chips – 1,448 transistors, the dice – 268

hold Roll – and let go

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HB-05