



HOW THINGS WORK

build kits · khanin.info

Building instructions

HT-06

The Colour Plotter

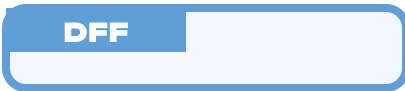
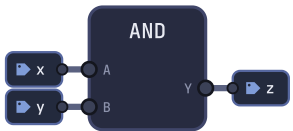
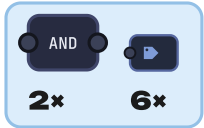
lessons 1-4 · mechanics, a card and a program

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

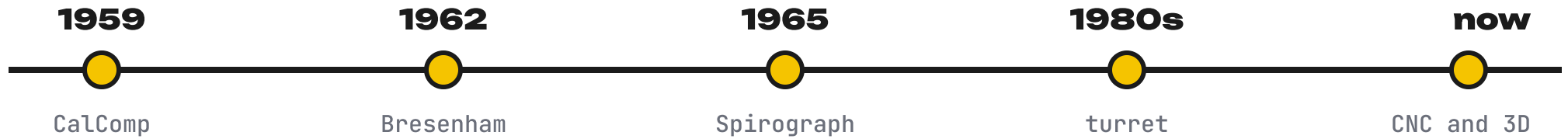
Keys

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



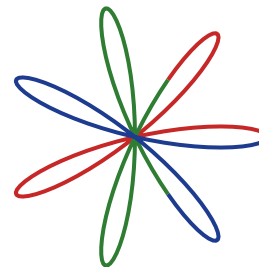
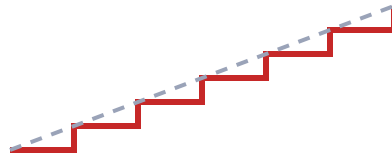
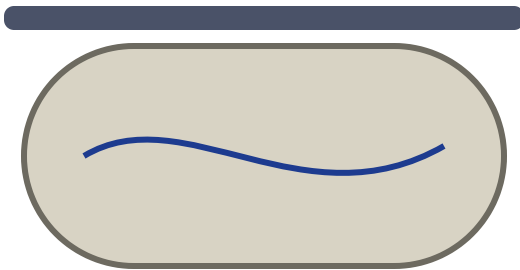
A little history



In 1959 the CalComp 565 drew on a drum: the drum turns – the Y axis, the pen rides a rail – the X axis. Each step a hundredth of an inch. Drawings, maps and charts – the computer now drew them itself.

In 1962 Jack Bresenham found how to build a slanted line from X and Y steps – with additions only. Screens draw his way, and so does our program. In 1965 came the Spirograph – picture seven of the menu.

In the 1980s colour plotters changed the pen themselves: four pens in a circle in a turret head. The computer named a colour – the head turned. CNC machines and 3D printers move the same way today.



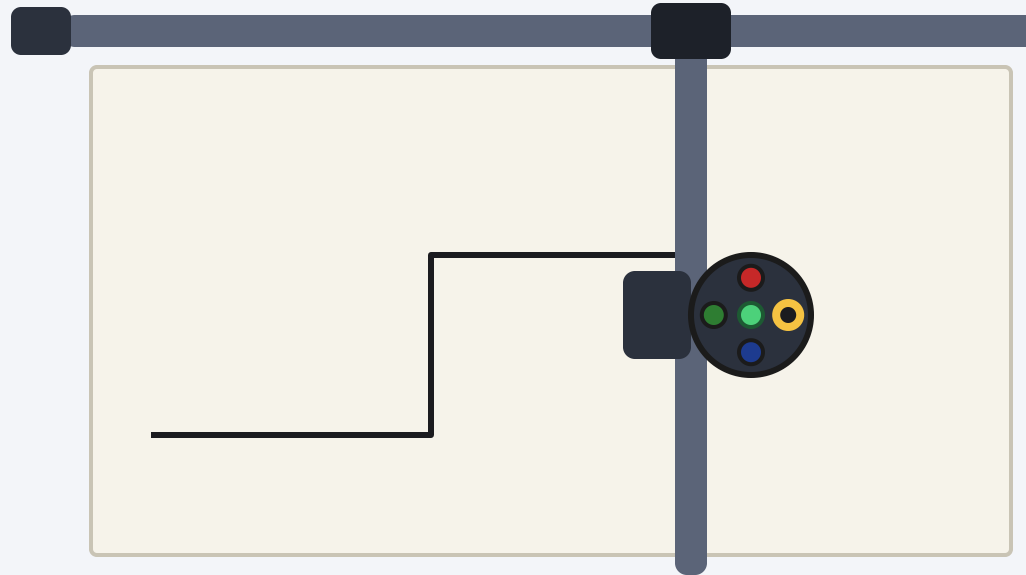
CalComp, IBM, Apple are trademarks of their respective owners. This kit is not affiliated with or endorsed by them; the names are mentioned to tell the story.



The plotter and the panel

kh HT-06

two axes, a pen, arrows and PEN UP/DOWN



CANVAS

1

library → import → plotter-chips.json: a Plotter folder, eight chips

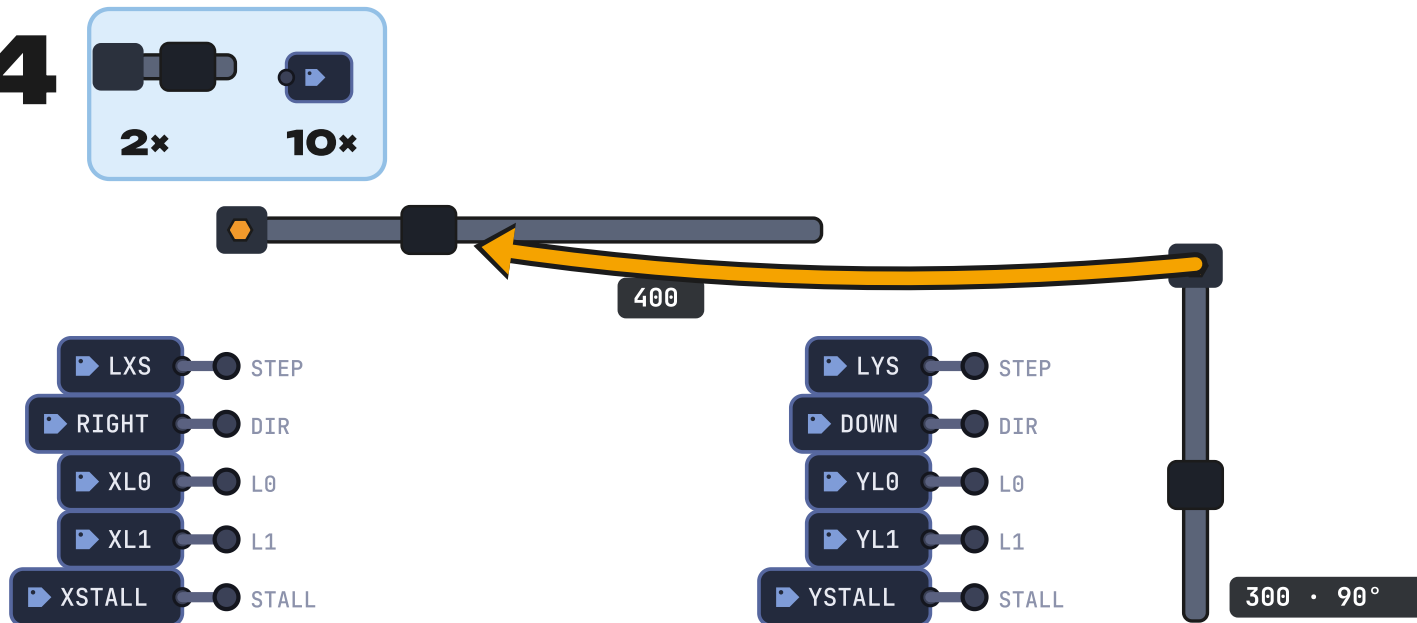
2

the DEMO button – the Apple][machine; the plotter goes to its right, on the same canvas

3

Mechanics → Linear axis: two axes; turn Y by 90° and mount it on the X carriage

4



CANVAS ...

5

the Turntable – onto the Y axis carriage; pins A...D stay empty for now

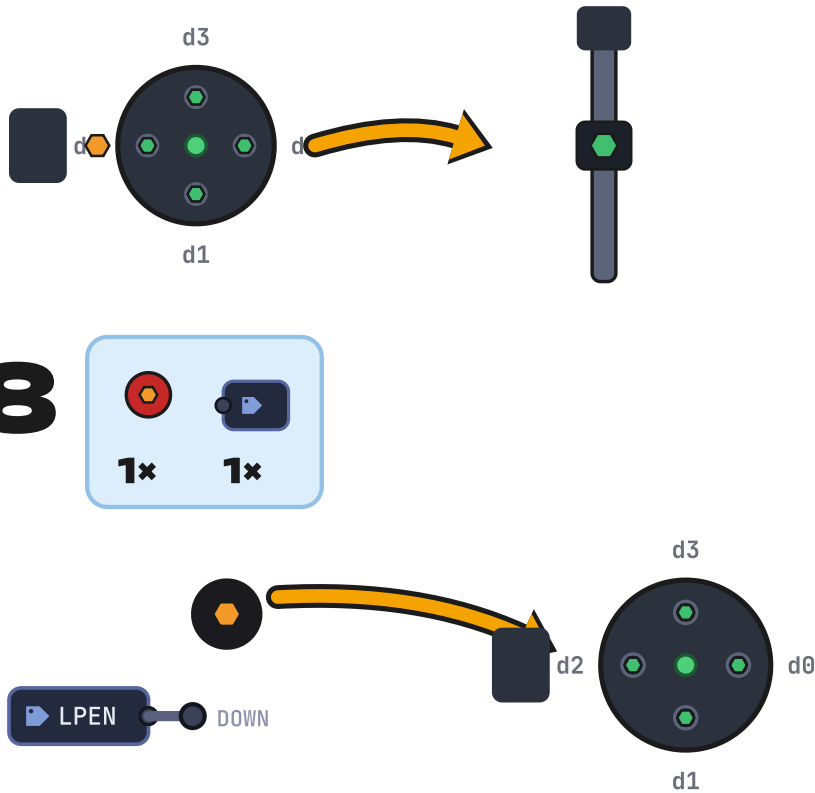
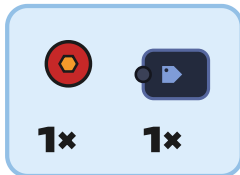
6



7

the pen – into hole d0 of the table: drag it by the orange nut

8

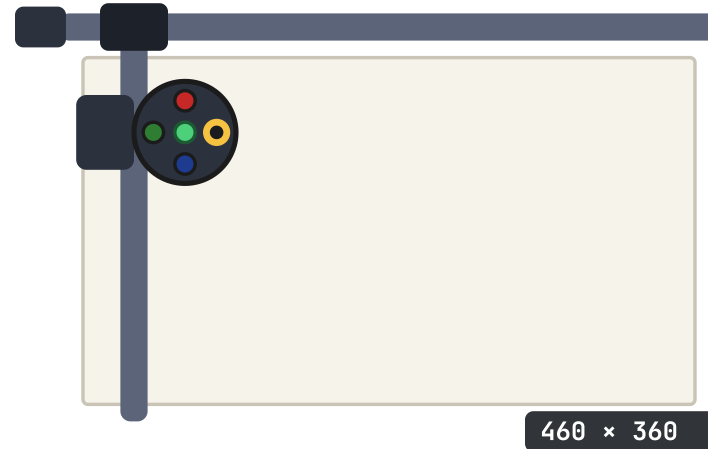
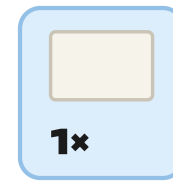


CANVAS ...

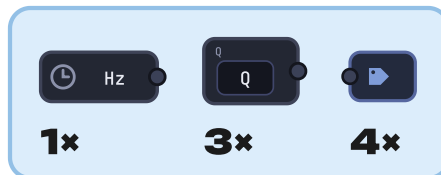
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the paper: the black pen at its top-left corner

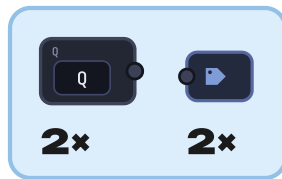
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11



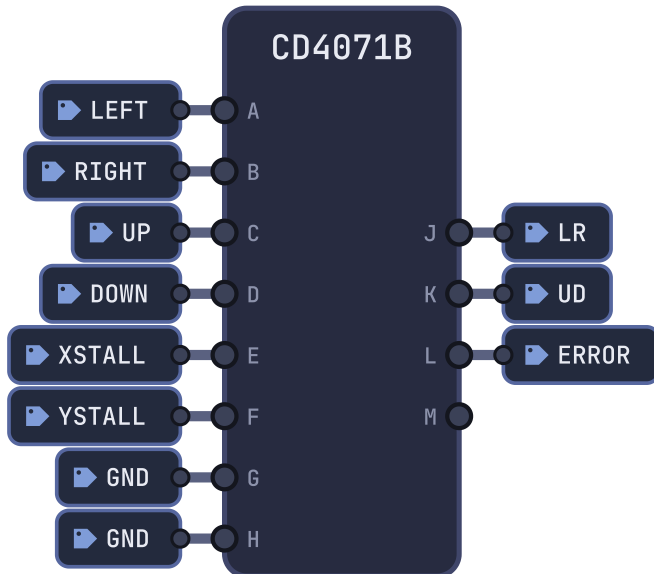
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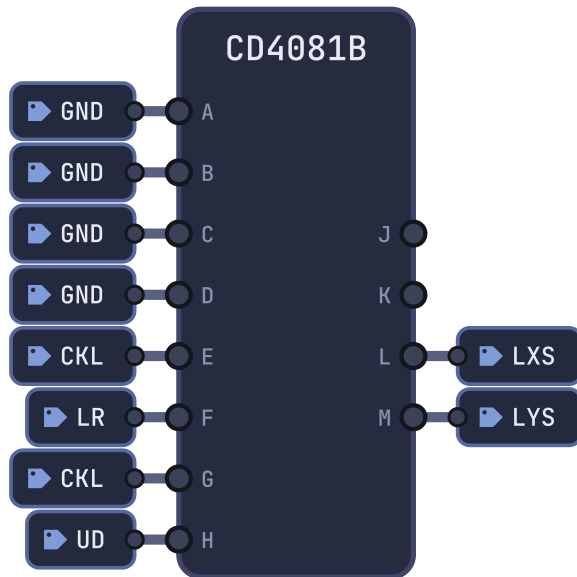
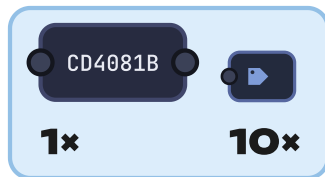
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the chips are ready: pin names as in the TI datasheet; labels – double-click a pin

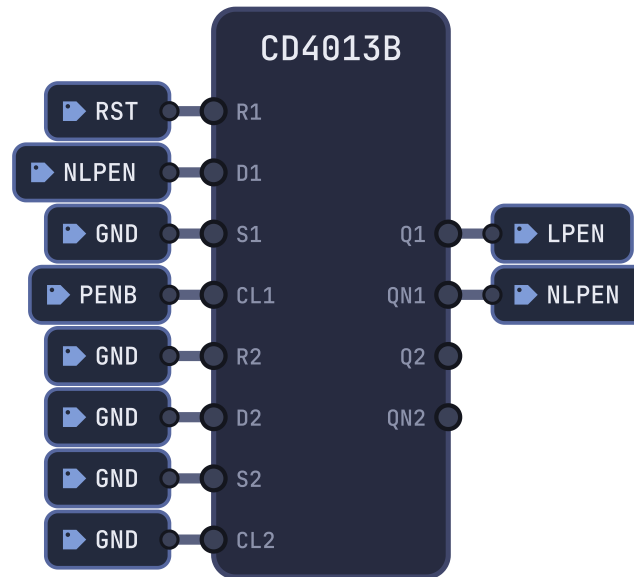
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15



16



17



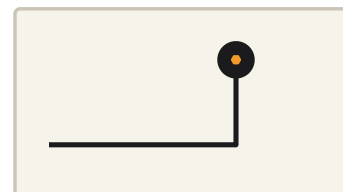
18

Turbo

Turbo mode: the Apple runs at its real speed



60 steps a second



the pen draws



ERROR

stuck – ERROR



The turret

four pens: SELECT – the head turns by itself



black



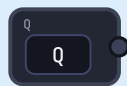
red



green



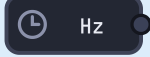
blue



1×



4×



1×



1×



1×



1×



2×



1×



1×



3×



∞

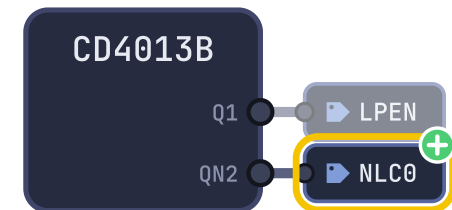
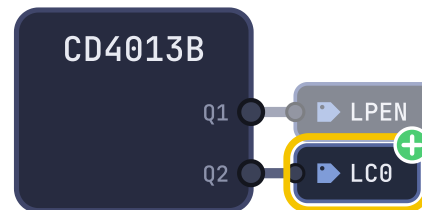
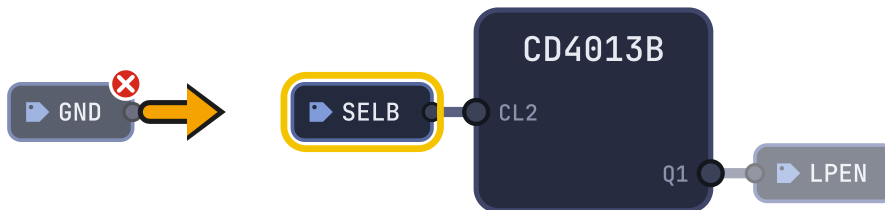
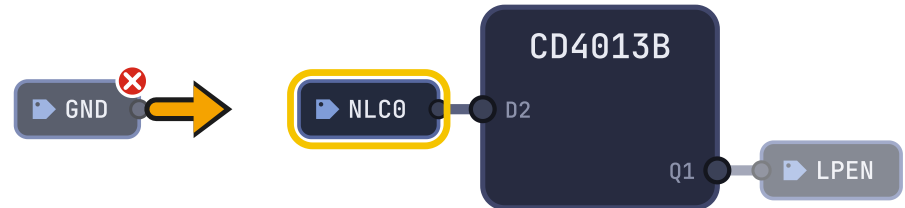
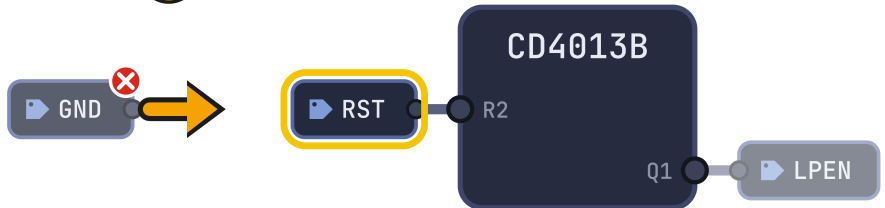
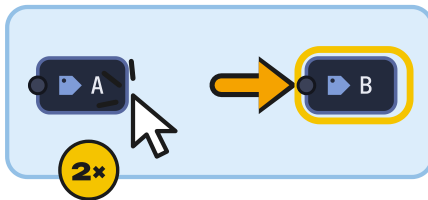
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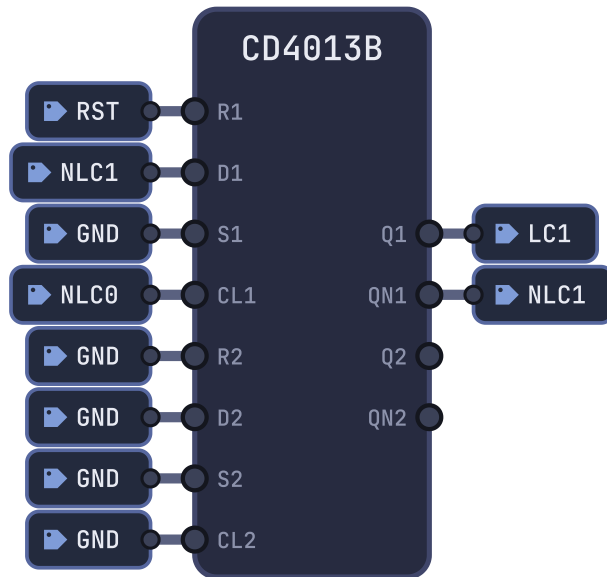
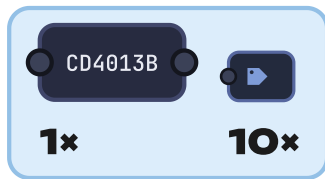
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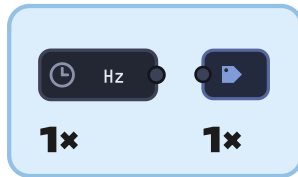
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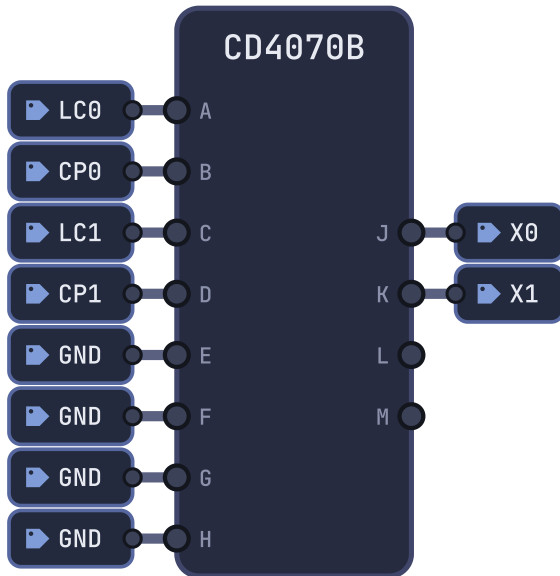
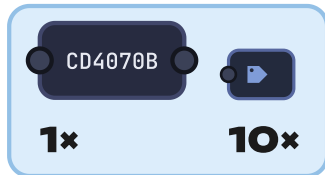
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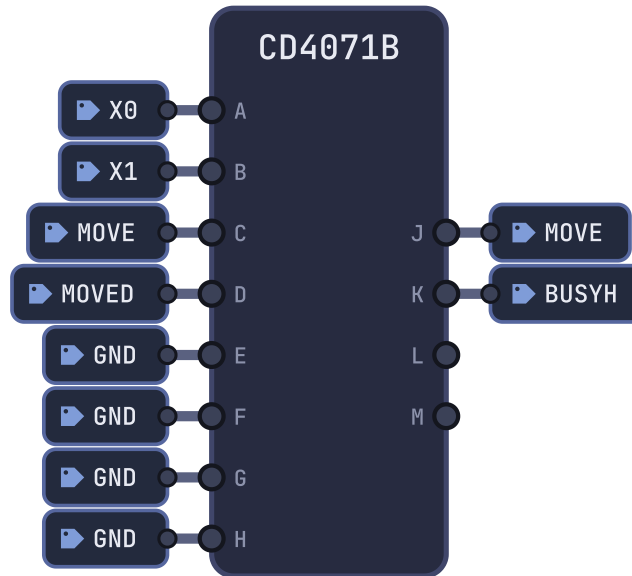
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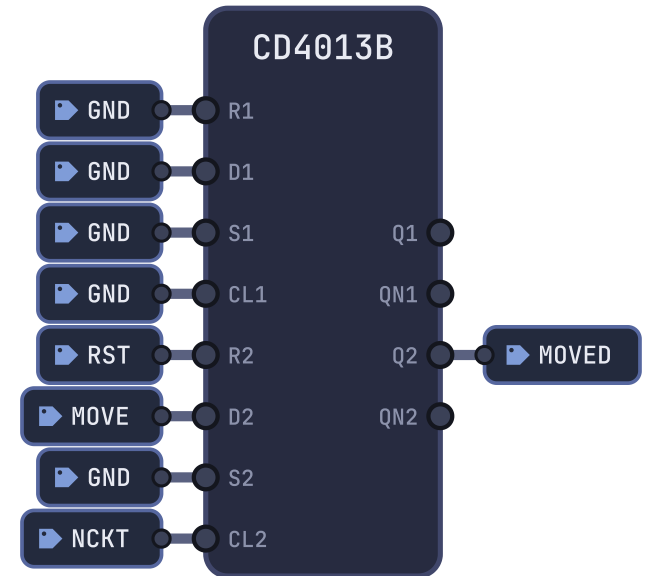
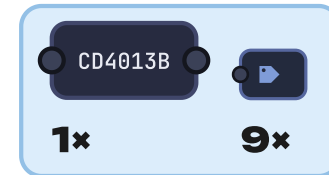
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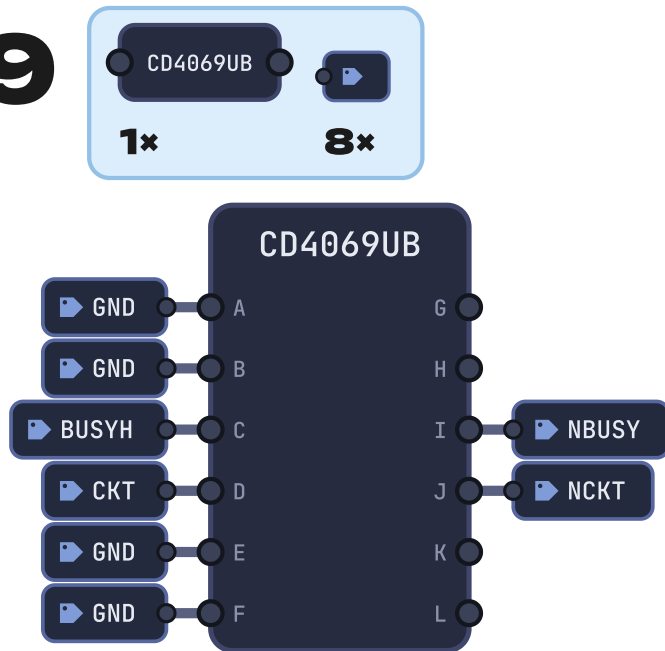
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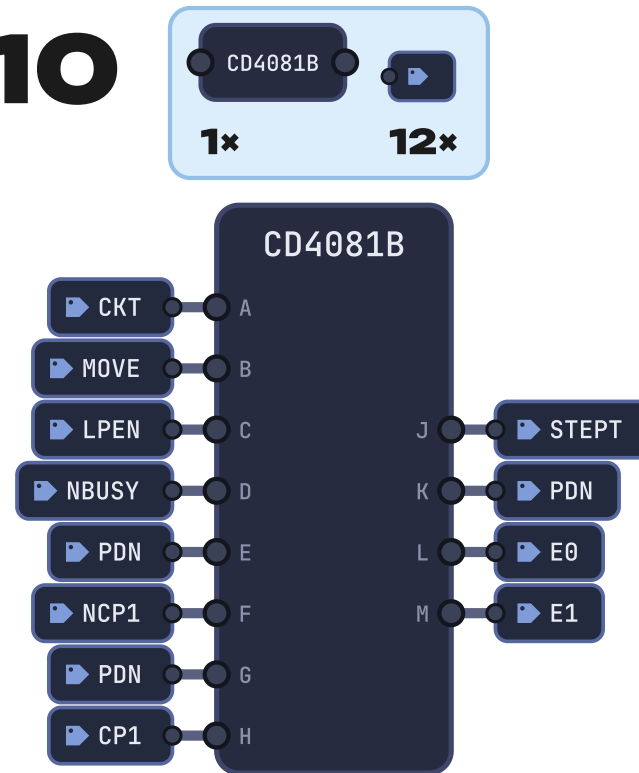
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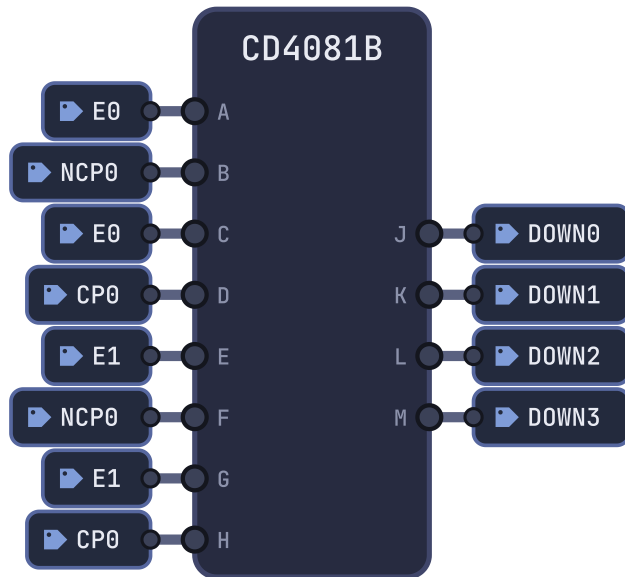
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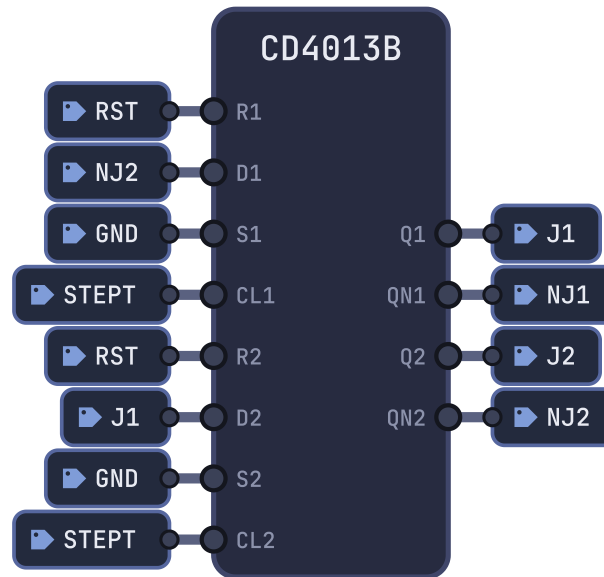
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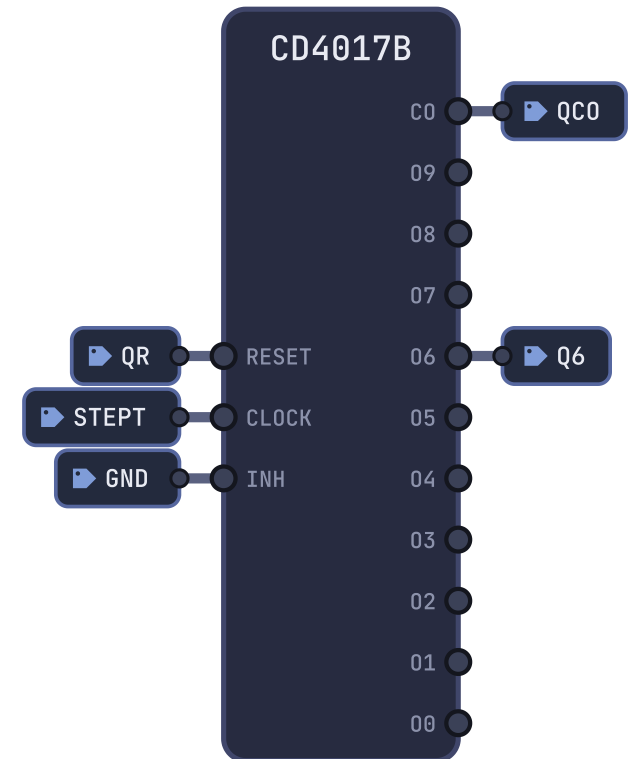
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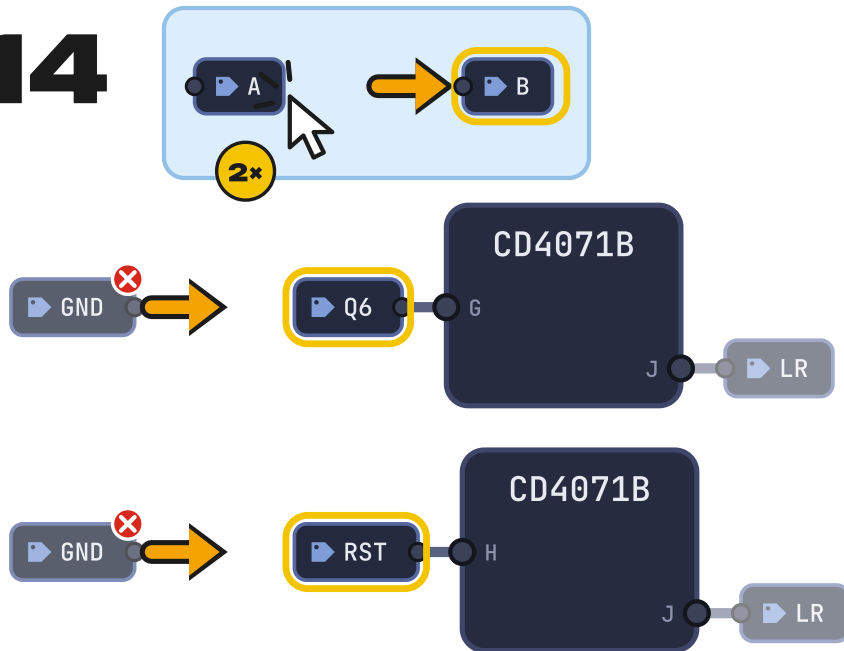
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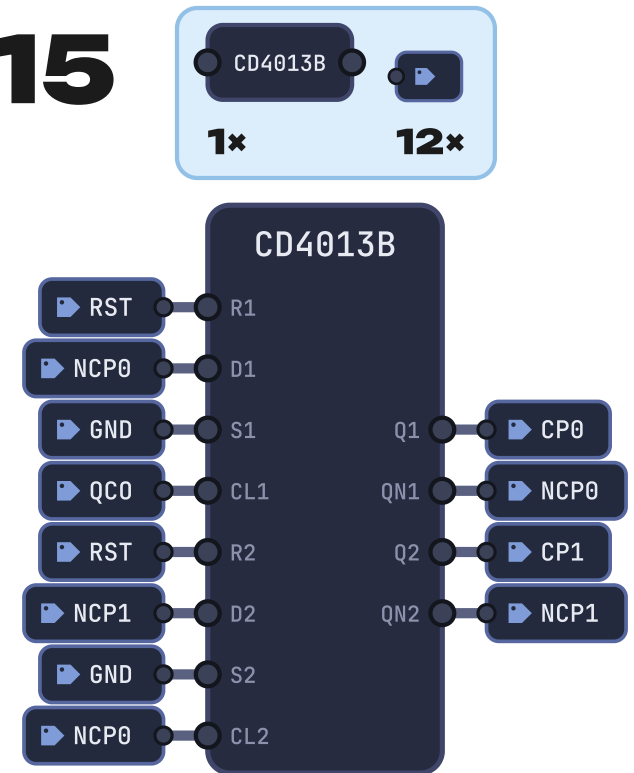
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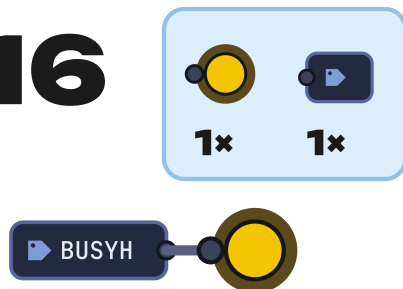
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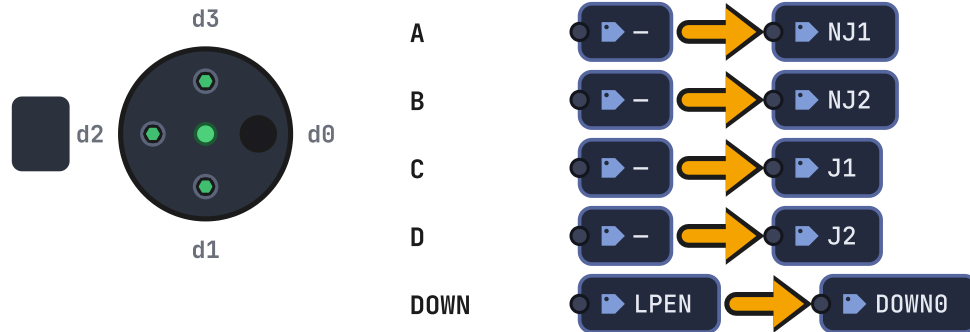
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17

table pins A...D and the lesson 1 pen – new labels

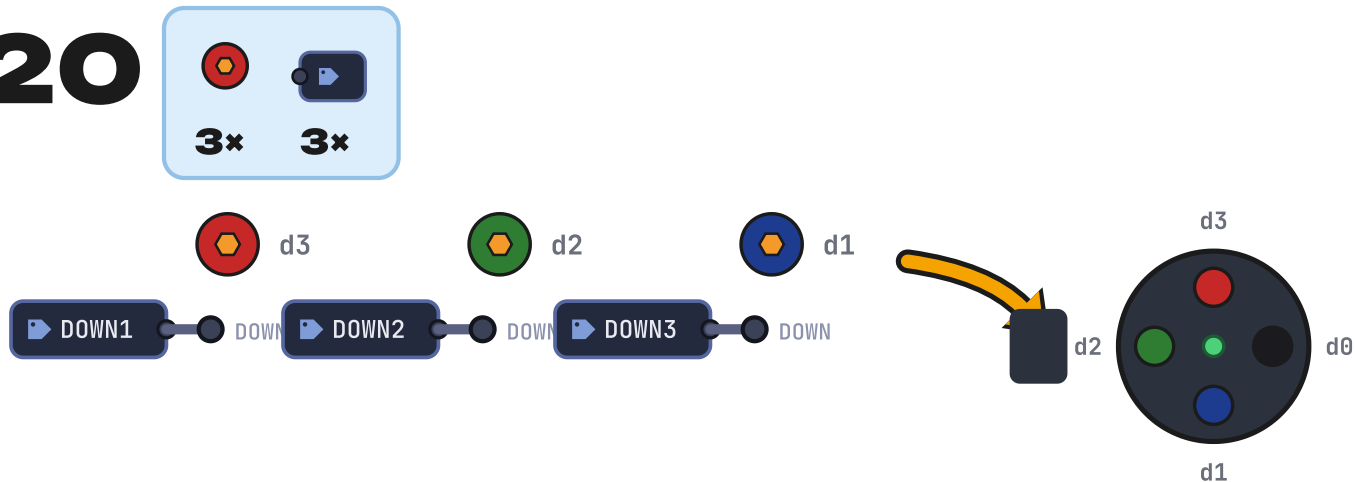
18



19

three pens – into d3, d2, d1; colour – Alt/%+click the pen

20



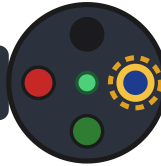
21

Turbo

Turbo mode: the Apple runs at its real speed



BUSY



BUSY – the pen is up

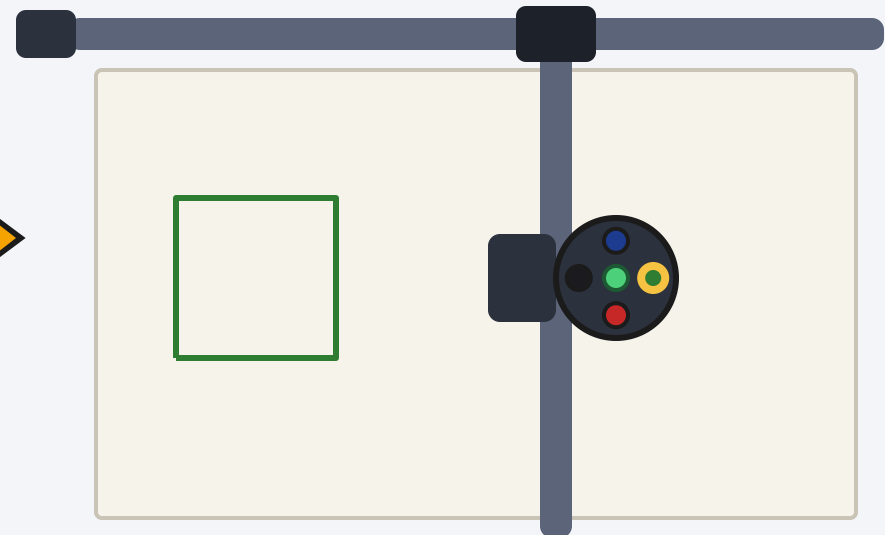


The card in the slot

kh HT-06

the computer draws: \$C090, \$C091, \$C092

```
] POKE 49298,2  
] PRINT PEEK(49297)  
21  
] RUN
```



1×

2×

2×

3×

3×

1×

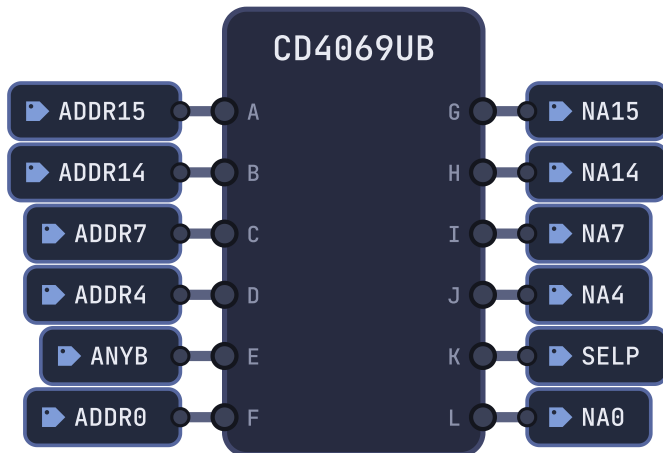
2×

∞

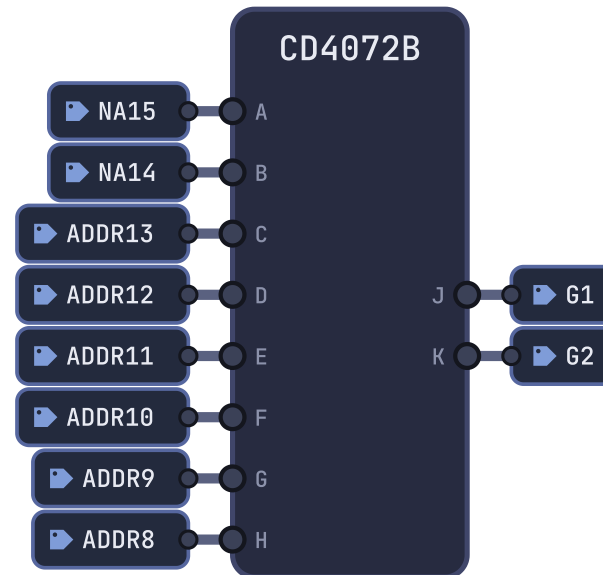
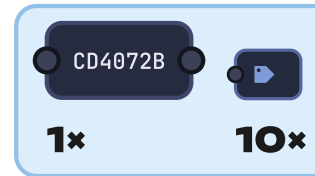
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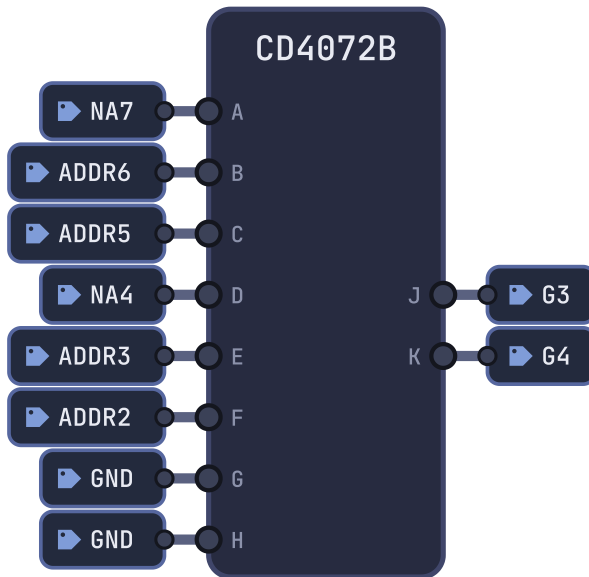
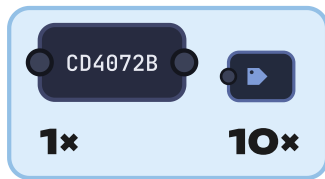
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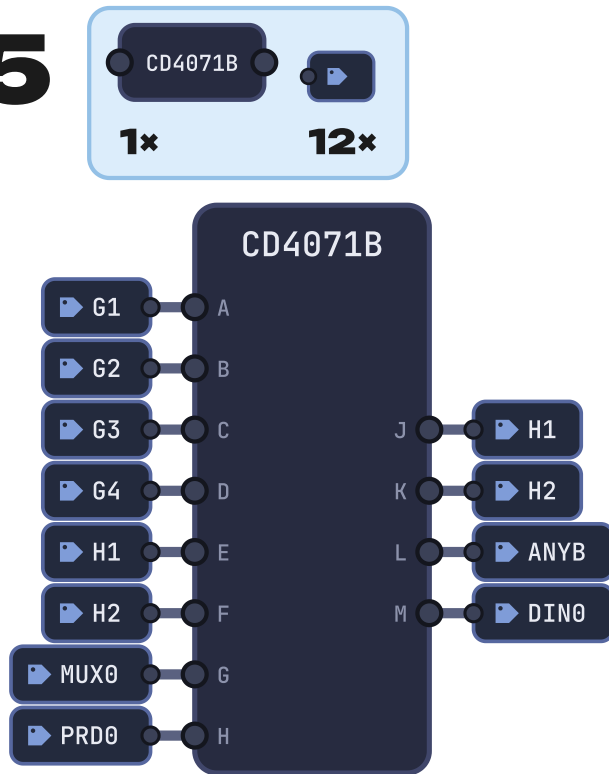
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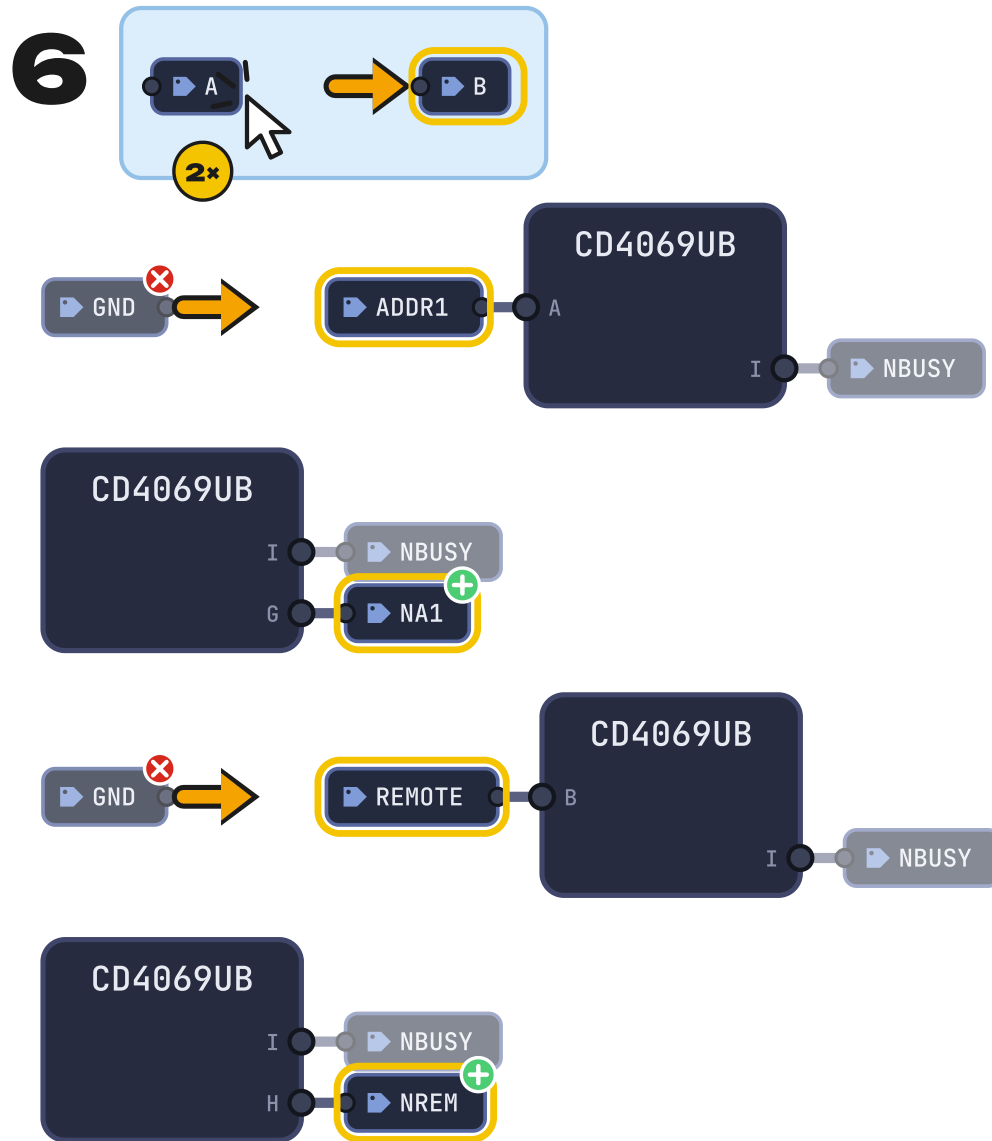
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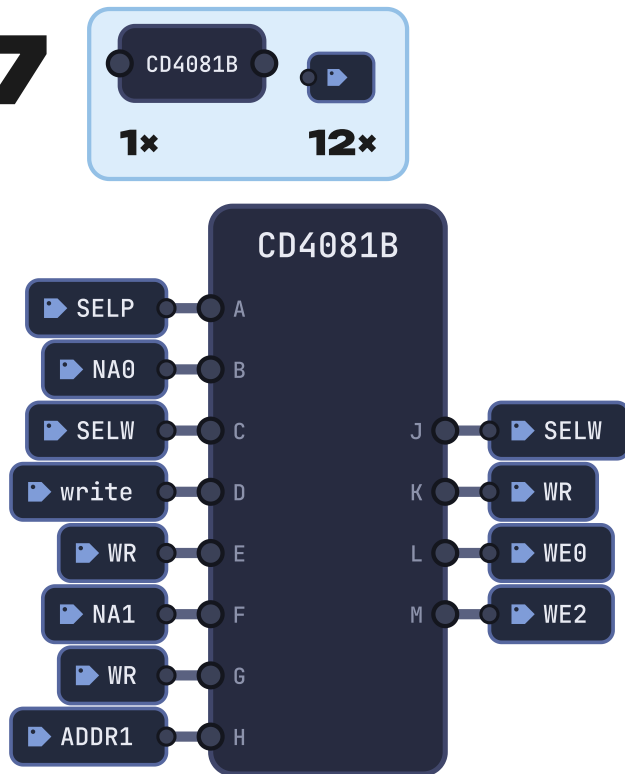
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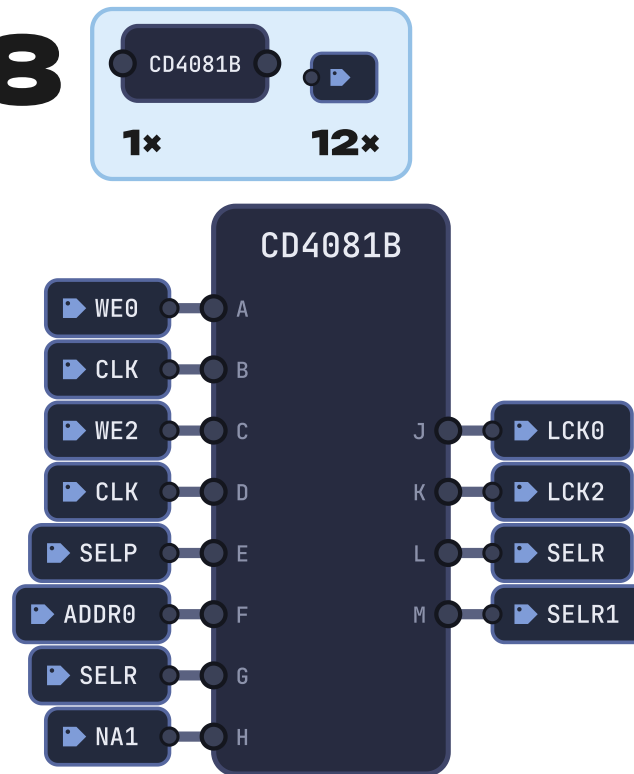
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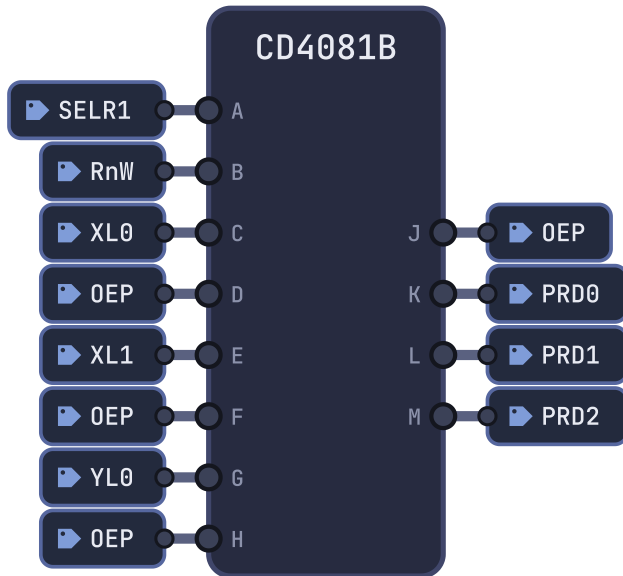
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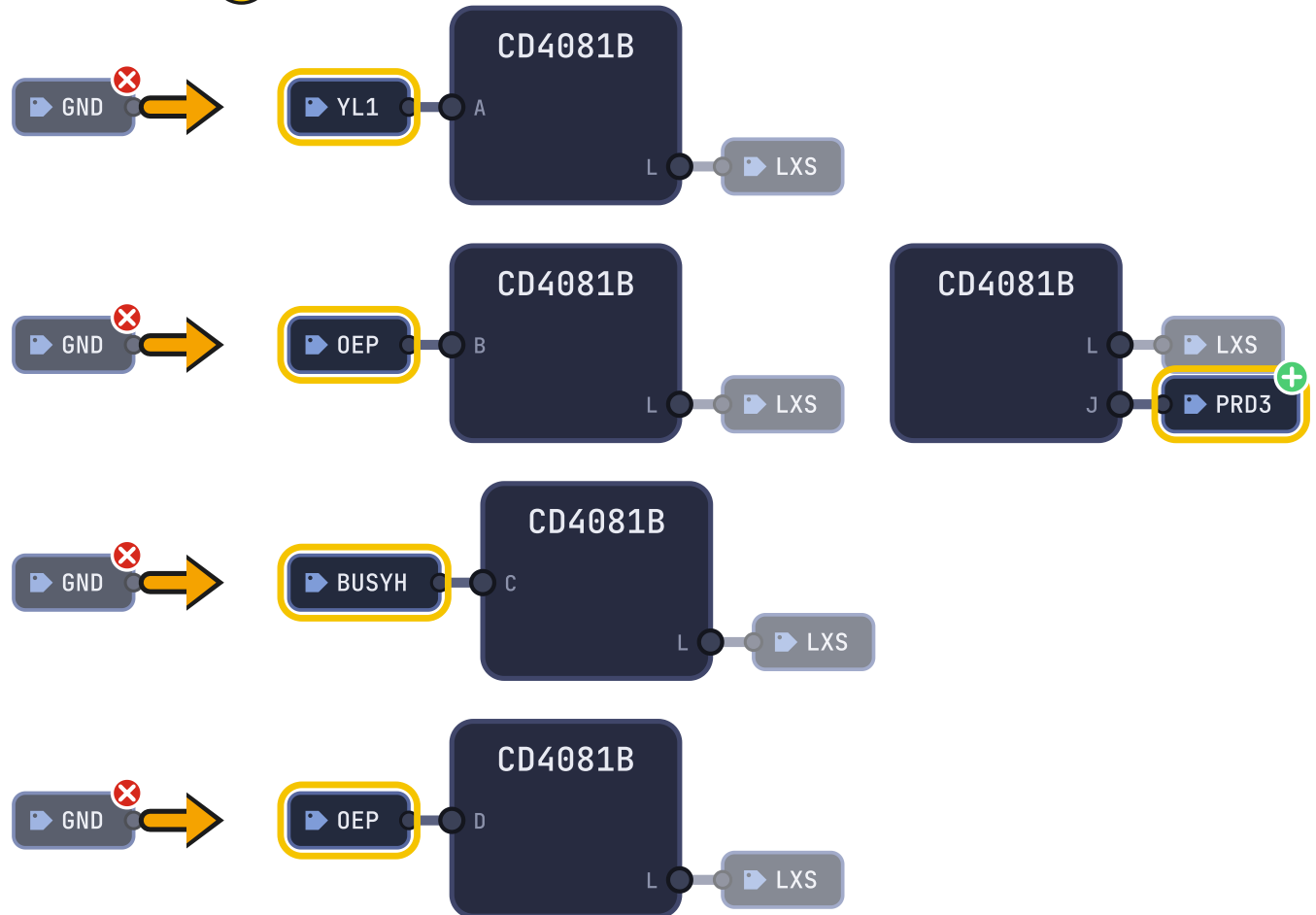
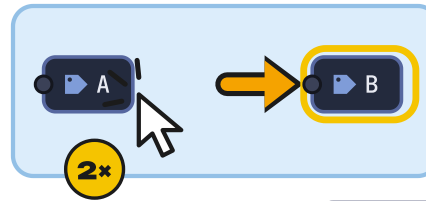
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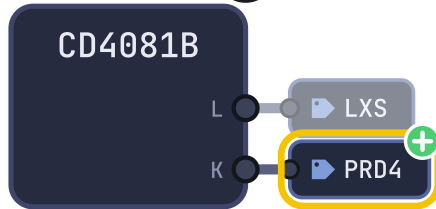
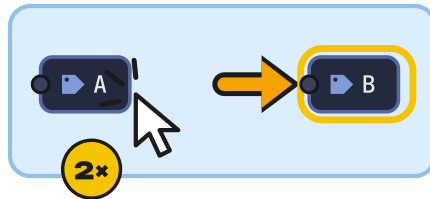
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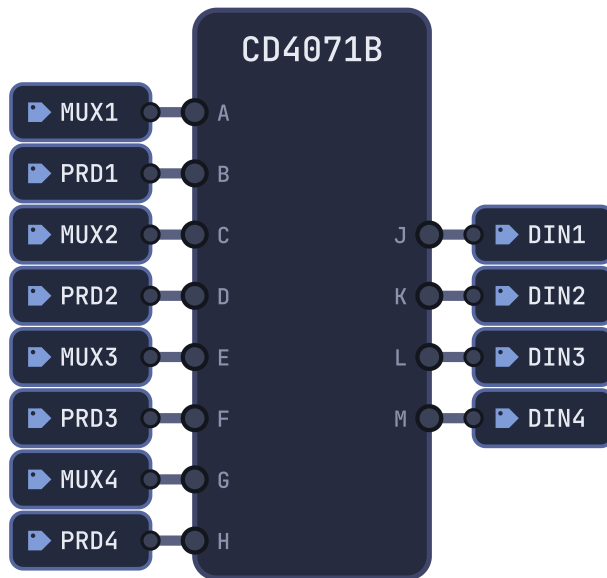
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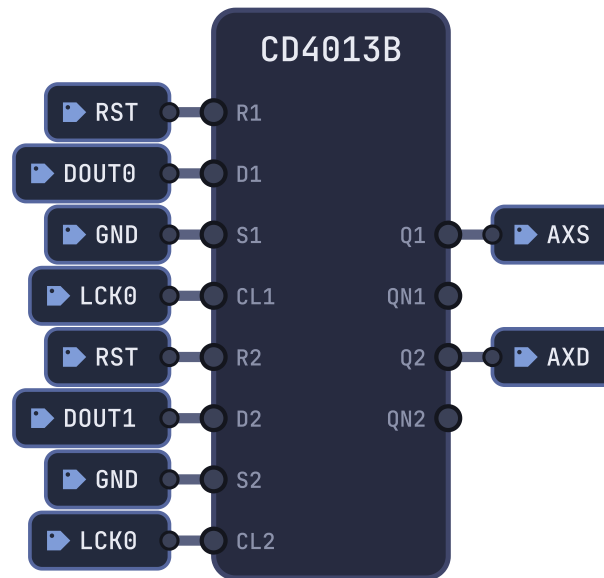
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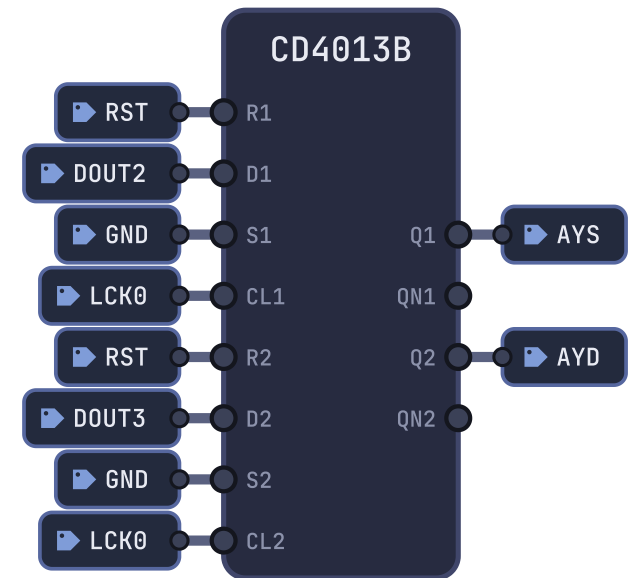
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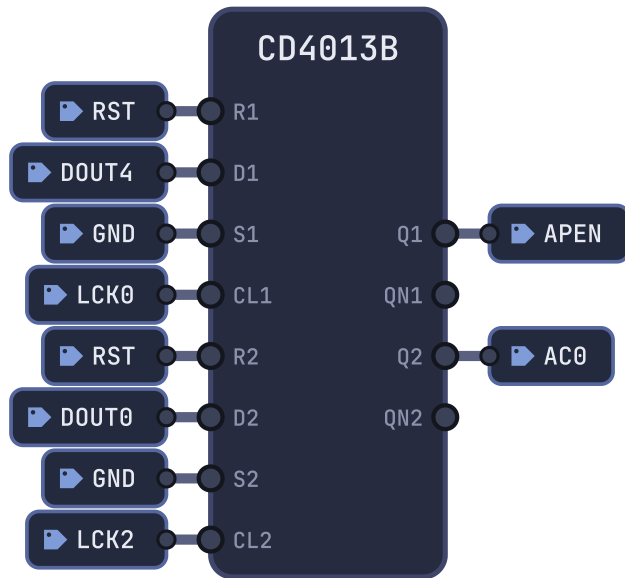
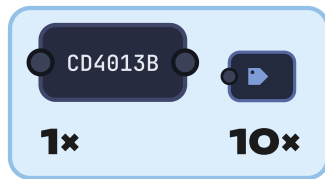
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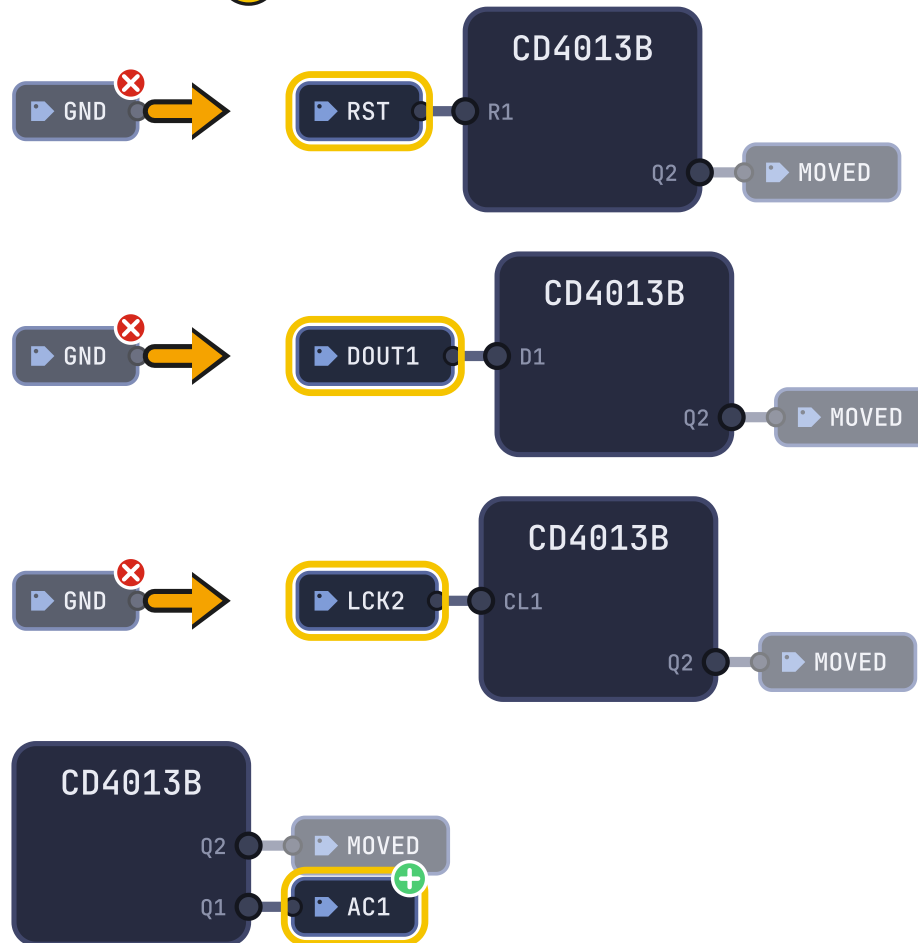
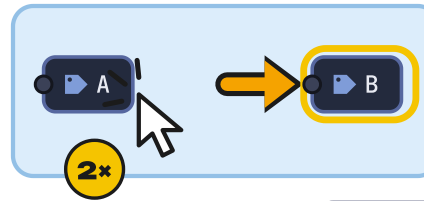
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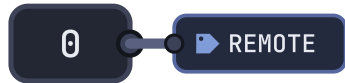
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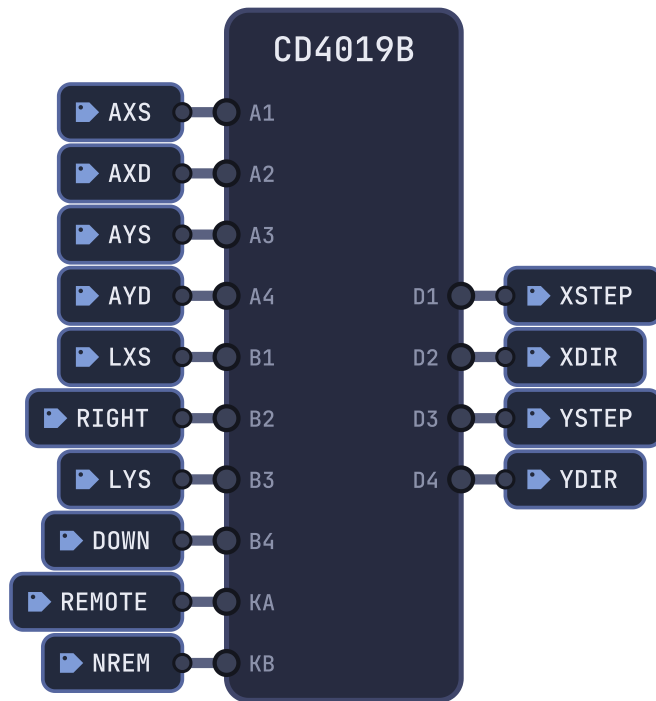
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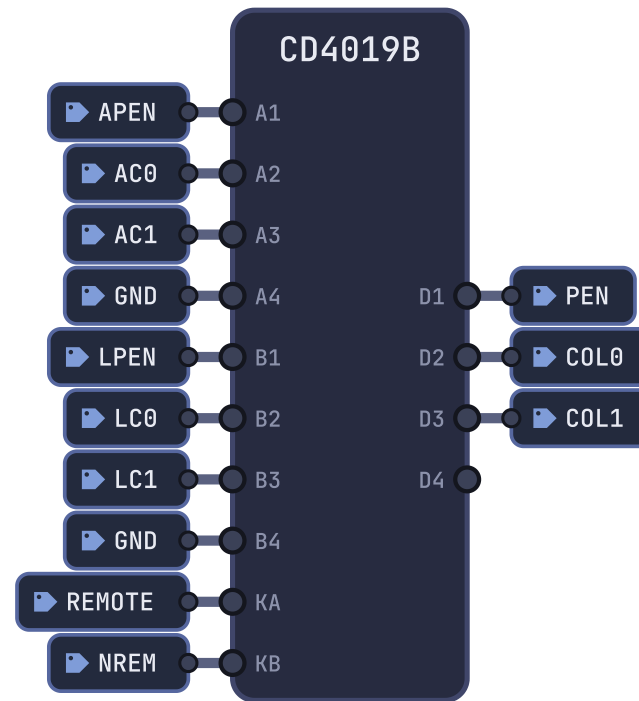
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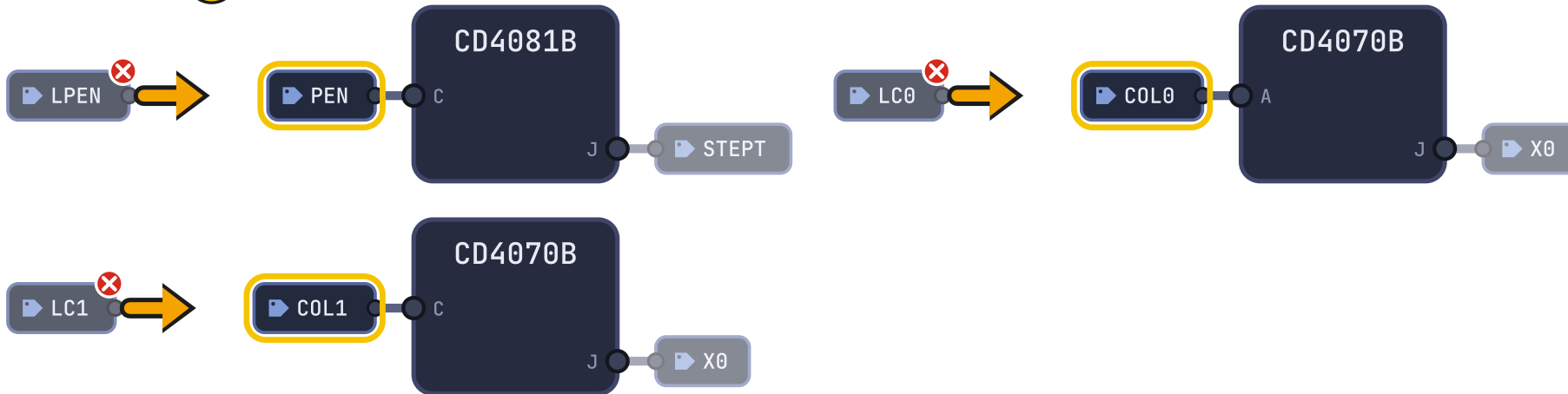
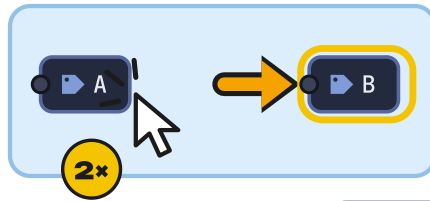
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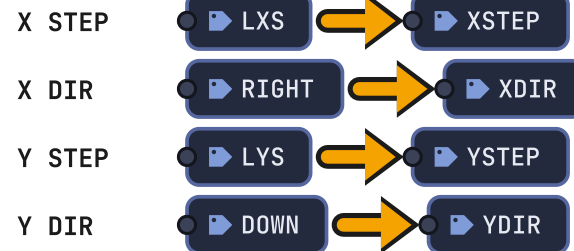
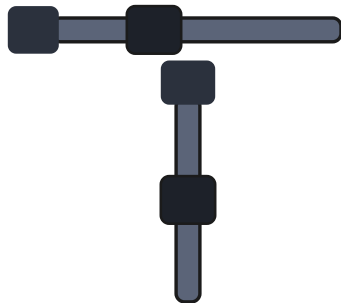
20



21

the axes' pins – to the CD4019 outputs: double-click the label

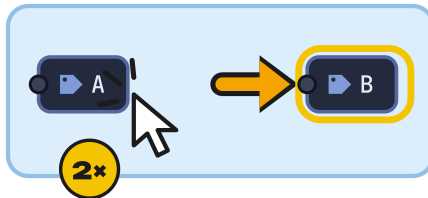
22



23

on the machine's DataInMux DIN0...DIN4 → MUX0...MUX4; the processor keeps DIN0...DIN4

24



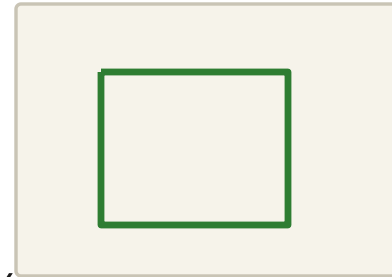
25

Turbo

Turbo mode: the Apple runs at its real speed



```
] PRINT PEEK(49297)
5
] POKE 49298,2
] PRINT PEEK(49297)
21
```



both carriages at the motors • BUSY: a number 16 higher

a green square



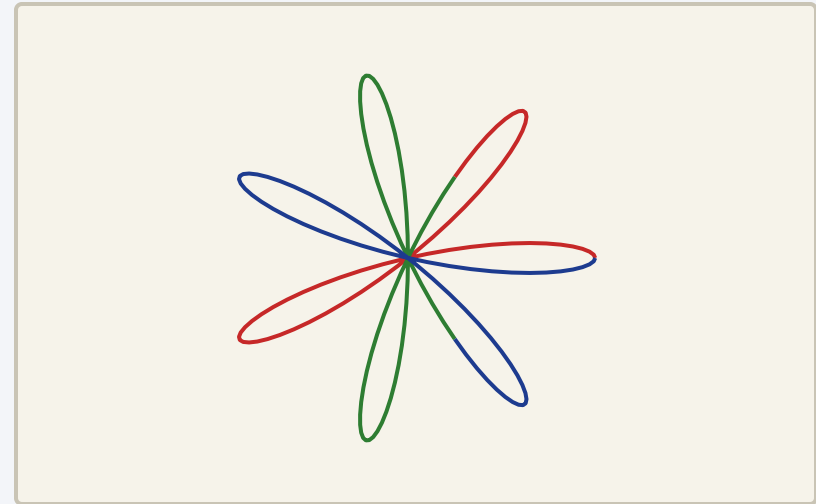
A program with a menu

the PLOTTER4 disk: seven pictures

COLOR PLOTTER

1 HOUSE 5 SPIRAL
2 RAINBOW 6 HELLO
3 FLOWER 7 SPIROGRAPH
4 STAR 0 EXIT

PICTURE: 7



1

disk drive ↑ → PLOTTER4.dsk

2

PLOTTER4.dsk



Disk II ↑

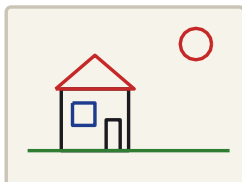
3

REMOTE on, speed MAX

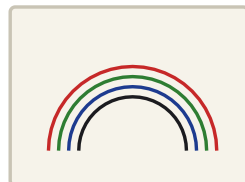
4

```

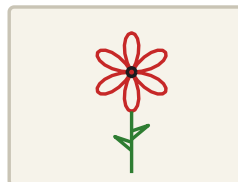
]RUN PLOTTER
PICTURE: 1
PUT A NEW SHEET, PRESS RETURN
    
```



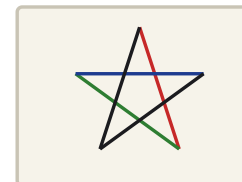
1 house



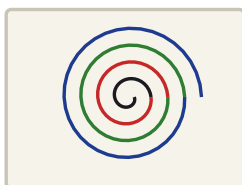
2 rainbow



3 flower



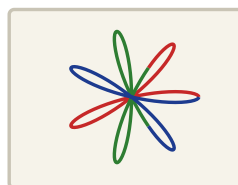
4 star



5 spiral



6 HELLO



7 spirograph

Kit parts

how many times you place each part over all the lessons



1x



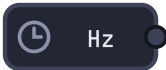
1x



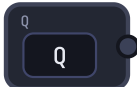
1x



1x



2x



6x



306x



1x



4x



2x



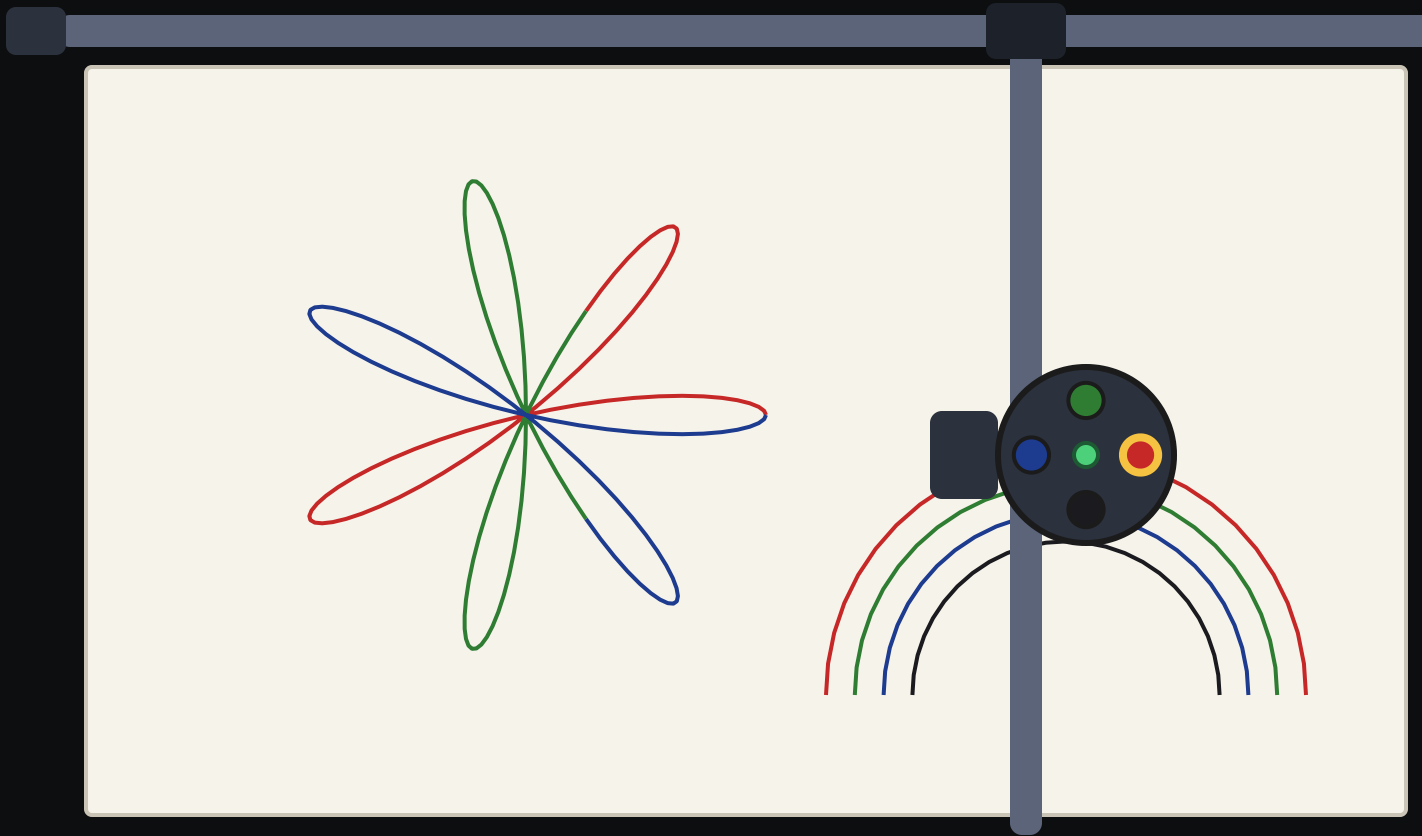
1x

Kit chips

ready TI chips from the kit file `plotter-chips.json` – how many you place

CD4071B	CD4081B	CD4013B	CD4070B	CD4069UB	CD4017B	CD4072B	CD4019B
4×	6×	8×	1×	2×	1×	2×	2×

Done!



26 chips · 1,490 transistors · 4 pens

RUN PLOTTER — and pick a picture: a house, a rainbow, a flower, a star, a spiral, HELLO, a spirograph

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HT-06