

Erik Bosman



Creating Light Sculptures for Fun and...
Mostly for Fun

about me



Erik Bosman @brainsmoke@mastodon.social

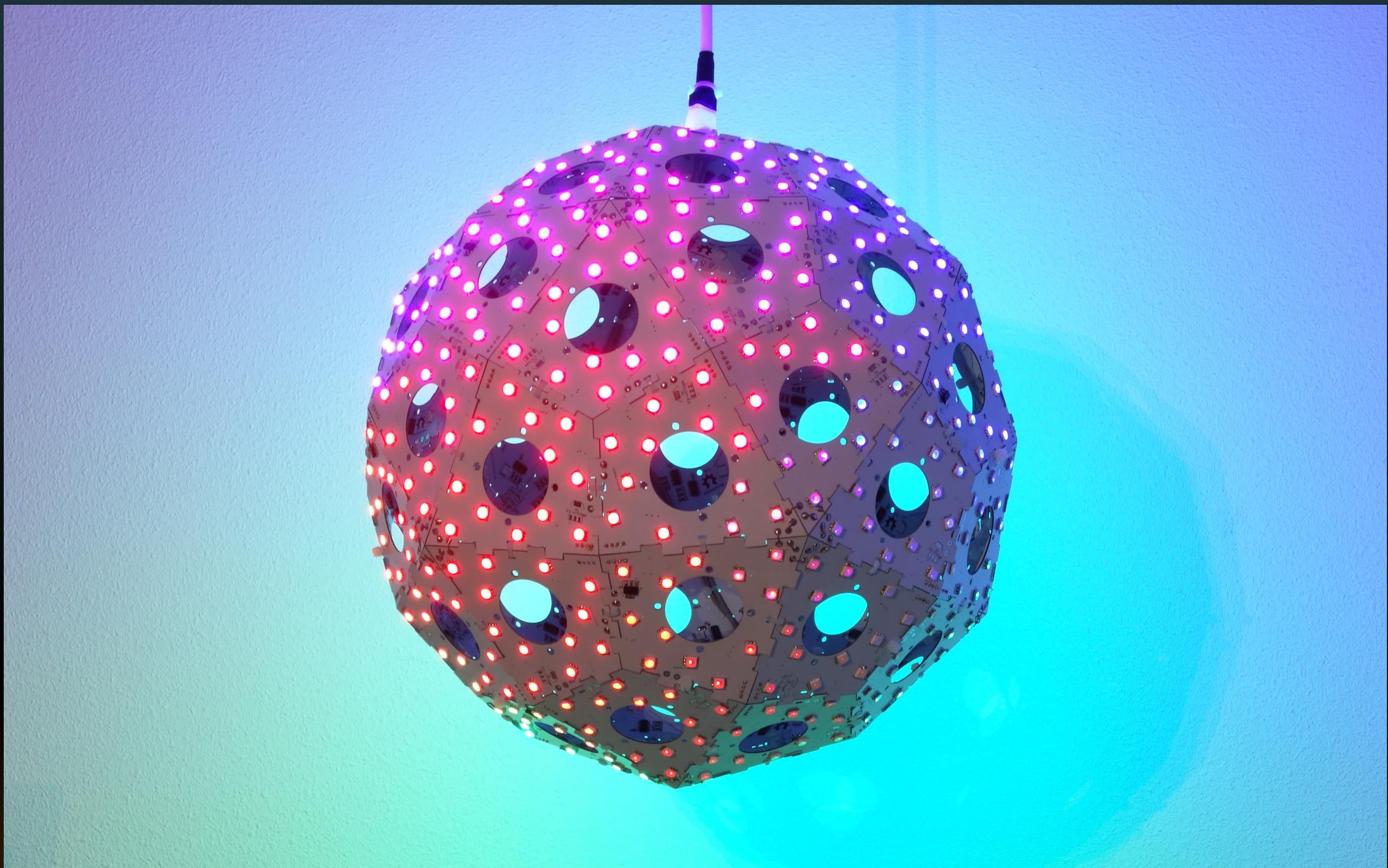
work:

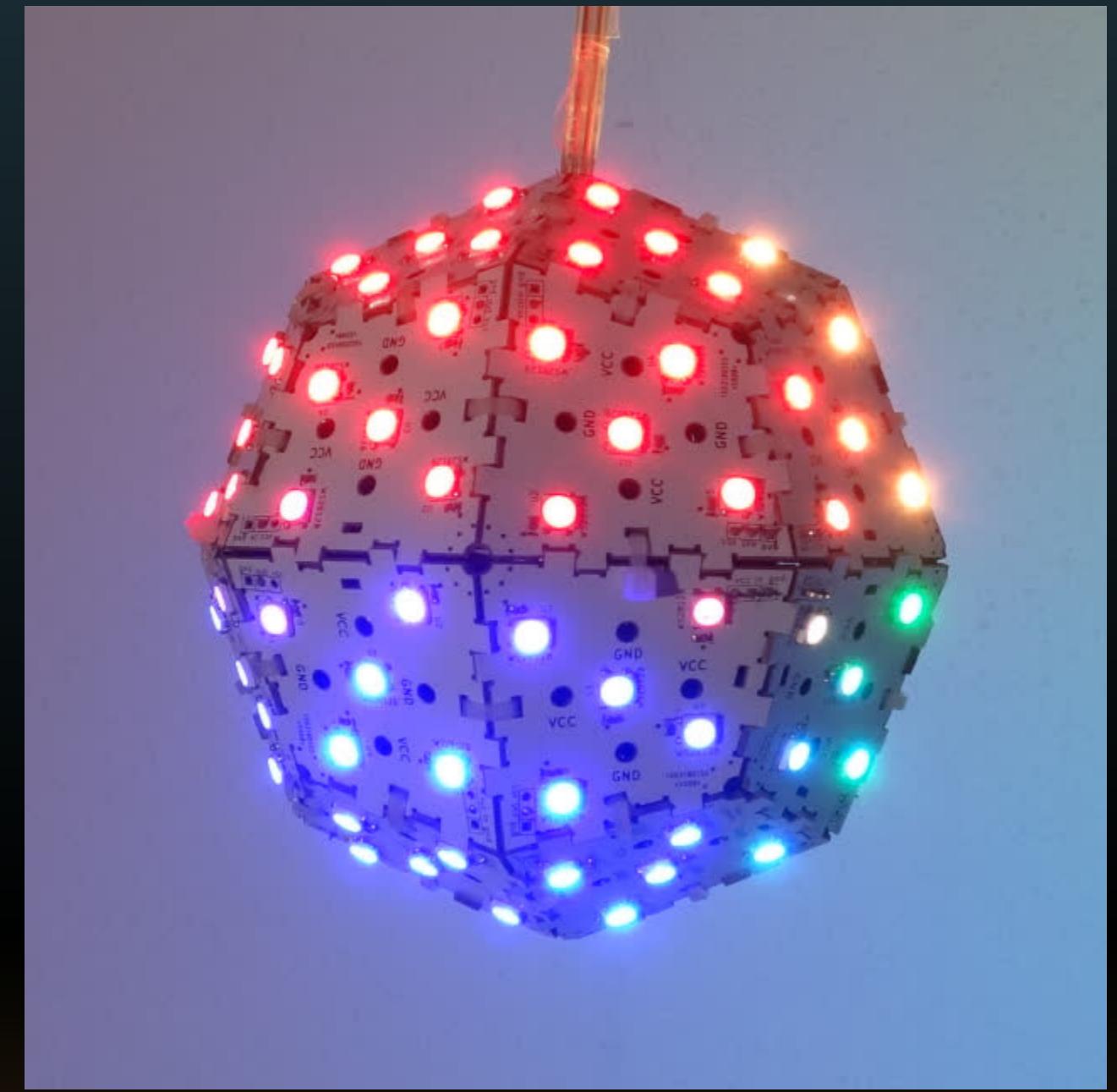
Postdoc computer security at
VU Amsterdam  VUsec

(not related to this talk)

hobby:

Creating all kinds of LED sculptures,
mostly based on polyhedra since 2014
(this talk)

















But why?



Two dodecahedra and an icosahedron on display in the Rheinisches Landesmuseum
https://en.wikipedia.org/wiki/Roman_dodecahedron

But why?

probably because I like to create puzzles for myself

- geometric puzzles
- logistical puzzles
- coding challenges

But why?

probably because I like to create puzzles for myself

- learn something new
- making a plan is part of the fun
- no risk of failure, no joy
- preferably something that can't be easily done using standard CAD programs.

But why?

probably because I like to create puzzles for myself

I like it when a plan comes together!
(and it's nice to end up with a tangible result)

But why?



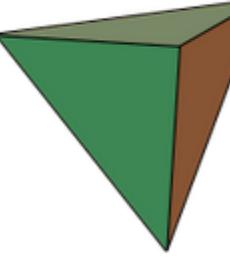
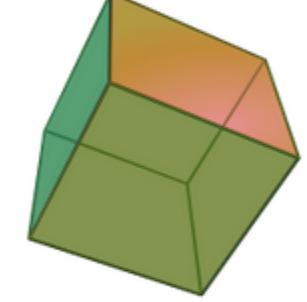
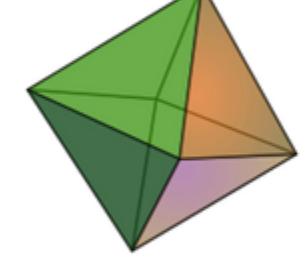
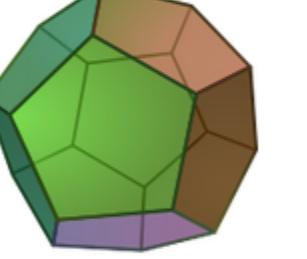
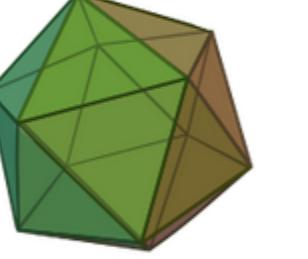
Two dodecahedra and an icosahedron on display in the Rheinisches Landesmuseum
https://en.wikipedia.org/wiki/Roman_dodecahedron

maths fun

shapes: platonic solids

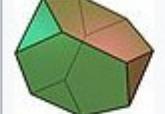
faces: identical

vertices: identical

Tetrahedron	Cube	Octahedron	Dodecahedron	Icosahedron
Four faces	Six faces	Eight faces	Twelve faces	Twenty faces
				
(Animation, 3D model)	(Animation, 3D model)	(Animation, 3D model)	(Animation, 3D model)	(Animation, 3D model)

shapes: archimedean solids

faces: multiple

Name	Solids	Vertex configurations ^[4]	Faces ^[5]	Edges ^[5]	Vertices ^[5]	Point group ^[6]
Truncated tetrahedron		3.6.6	4 triangles 4 hexagons	18	12	T _d
Cuboctahedron		3.4.3.4	8 triangles 6 squares	24	12	O _h
Truncated cube		3.8.8	8 triangles 6 octagons	36	24	O _h
Truncated octahedron		4.6.6	6 squares 8 hexagons	36	24	O _h
Rhombicuboctahedron		3.4.4.4	8 triangles 18 squares	48	24	O _h
Truncated cuboctahedron		4.6.8	12 squares 8 hexagons 6 octagons	72	48	O _h
Snub cube		3.3.3.3.4	32 triangles 6 squares	60	24	O

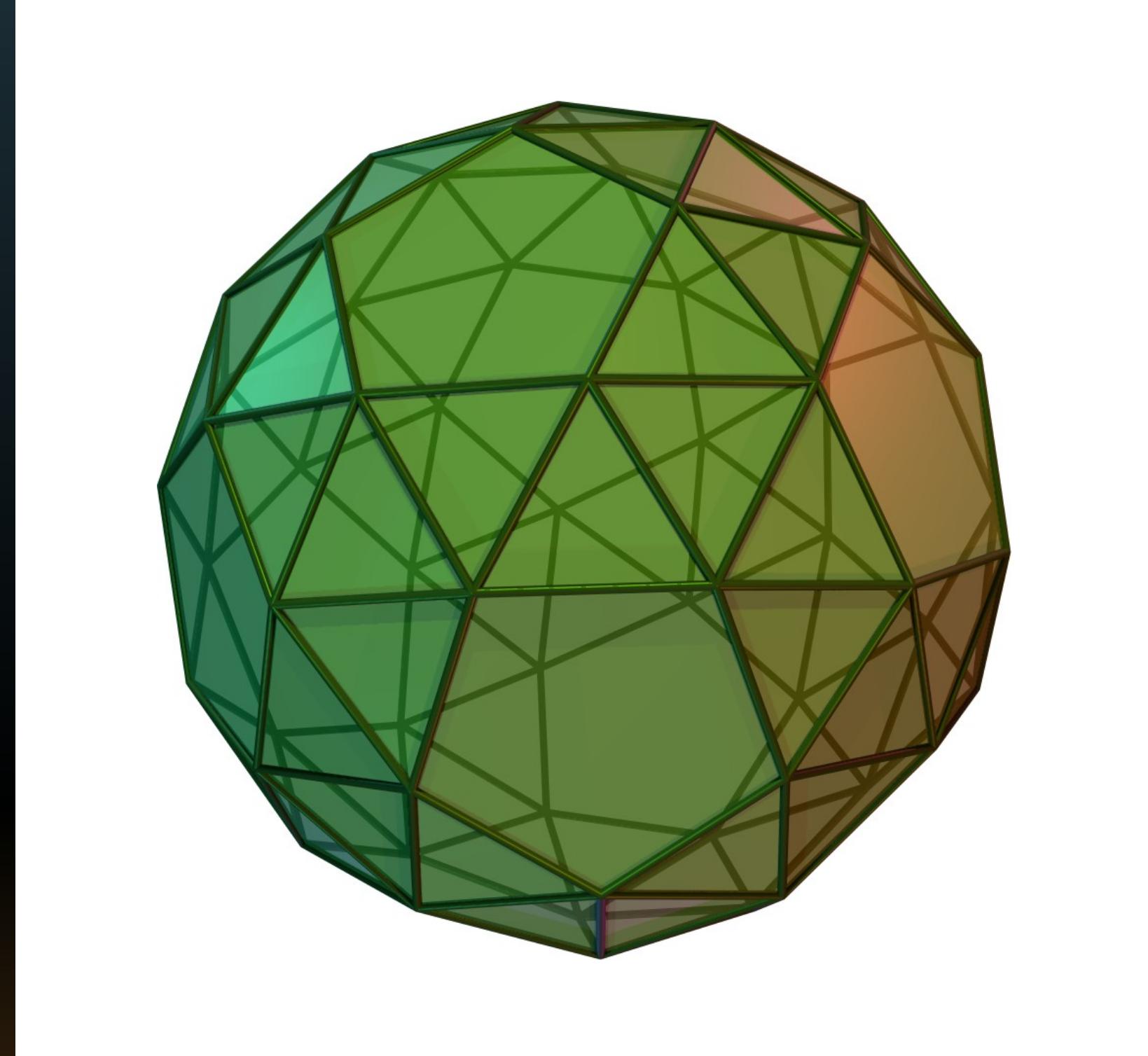
vertices: identical

Name	Solids	Vertex configurations ^[4]	Faces ^[5]	Edges ^[5]	Vertices ^[5]	Point group ^[6]
Icosidodecahedron		3.5.3.5	20 triangles 12 pentagons	60	30	I _h
Truncated dodecahedron		3.10.10	20 triangles 12 decagons	90	60	I _h
Truncated icosahedron		5.6.6	12 pentagons 20 hexagons	90	60	I _h
Rhombicosidodecahedron		3.4.5.4	20 triangles 30 squares 12 pentagons	120	60	I _h
Truncated icosidodecahedron		4.6.10	30 squares 20 hexagons 12 decagons	180	120	I _h
Snub dodecahedron		3.3.3.3.5	80 triangles 12 pentagons	150	60	I

shapes: snub dodecahedron

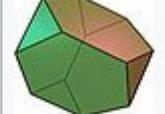
12 regular pentagons

80 regular triangles



shapes: archimedean solids

faces: multiple

Name	Solids	Vertex configurations ^[4]	Faces ^[5]	Edges ^[5]	Vertices ^[5]	Point group ^[6]
Truncated tetrahedron		3.6.6	4 triangles 4 hexagons	18	12	T _d
Cuboctahedron		3.4.3.4	8 triangles 6 squares	24	12	O _h
Truncated cube		3.8.8	8 triangles 6 octagons	36	24	O _h
Truncated octahedron		4.6.6	6 squares 8 hexagons	36	24	O _h
Rhombicuboctahedron		3.4.4.4	8 triangles 18 squares	48	24	O _h
Truncated cuboctahedron		4.6.8	12 squares 8 hexagons 6 octagons	72	48	O _h
Snub cube		3.3.3.3.4	32 triangles 6 squares	60	24	O

vertices: identical

Name	Solids	Vertex configurations ^[4]	Faces ^[5]	Edges ^[5]	Vertices ^[5]	Point group ^[6]
Icosidodecahedron		3.5.3.5	20 triangles 12 pentagons	60	30	I _h
Truncated dodecahedron		3.10.10	20 triangles 12 decagons	90	60	I _h
Truncated icosahedron		5.6.6	12 pentagons 20 hexagons	90	60	I _h
Rhombicosidodecahedron		3.4.5.4	20 triangles 30 squares 12 pentagons	120	60	I _h
Truncated icosidodecahedron		4.6.10	30 squares 20 hexagons 12 decagons	180	120	I _h
Snub dodecahedron		3.3.3.3.5	80 triangles 12 pentagons	150	60	I

shapes: catalan solids

faces: identical



vertices: multiple

Name	Image	Face shape	Faces	Edges	Vertices	Dihedral angle ^[6]	Point group
triakis tetrahedron		isosceles triangle	12	18	8	129.521°	T_d
rhombic dodecahedron		rhombus	12	24	14	120°	O_h
triakis octahedron		isosceles triangle	24	36	14	147.350°	O_h
tetrakis hexahedron		isosceles triangle	24	36	14	143.130°	O_h
deltoidal icositetrahedron		kite	24	48	26	138.118°	O_h
disdyakis dodecahedron		scalene triangle	48	72	26	155.082°	O_h
pentagonal icositetrahedron		pentagon	24	60	38	136.309°	O

Name	Image	Face shape	Faces	Edges	Vertices	Dihedral angle ^[6]	Point group
rhombic triacontahedron		rhombus	30	60	32	144°	I_h
triakis icosahedron		isosceles triangle	60	90	32	160.613°	I_h
pentakis dodecahedron		isosceles triangle	60	90	32	156.719°	I_h
deltoidal hexecontahedron		kite	60	120	62	154.121°	I_h
disdyakis triacontahedron		scalene triangle	120	180	62	164.888°	I_h
pentagonal hexecontahedron		pentagon	60	150	92	153.179°	I

shapes: catalan solids

faces: identical

vertices: multiple



each catalan solid can be generated from
its archimedean counterpart (dual)

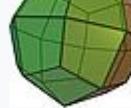
Name	Image	Face shape	Faces	Edges	Vertices	Dihedral angle ^[6]	Point group
triakis tetrahedron		isosceles	12	18	8	129.521°	Td
rhombic dodecahedron							
triakis octahedron							
tetrakis hexahedron							
deltoidal icositetrahedron		kite	24	48	26	138.118°	O _h
disdyakis dodecahedron		scalene triangle	48	72	26	155.082°	O _h
pentagonal icositetrahedron		pentagon	24	60	38	136.309°	O

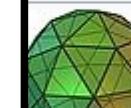
Name	Image	Face shape	Faces	Edges	Vertices	Dihedral angle ^[6]	Point group
hexecontahedron							
disdyakis triacontahedron		scalene triangle	120	180	62	164.888°	I _h
pentagonal hexecontahedron		pentagon	60	150	92	153.179°	I

shapes: catalan solids

faces: identical

vertices: multiple

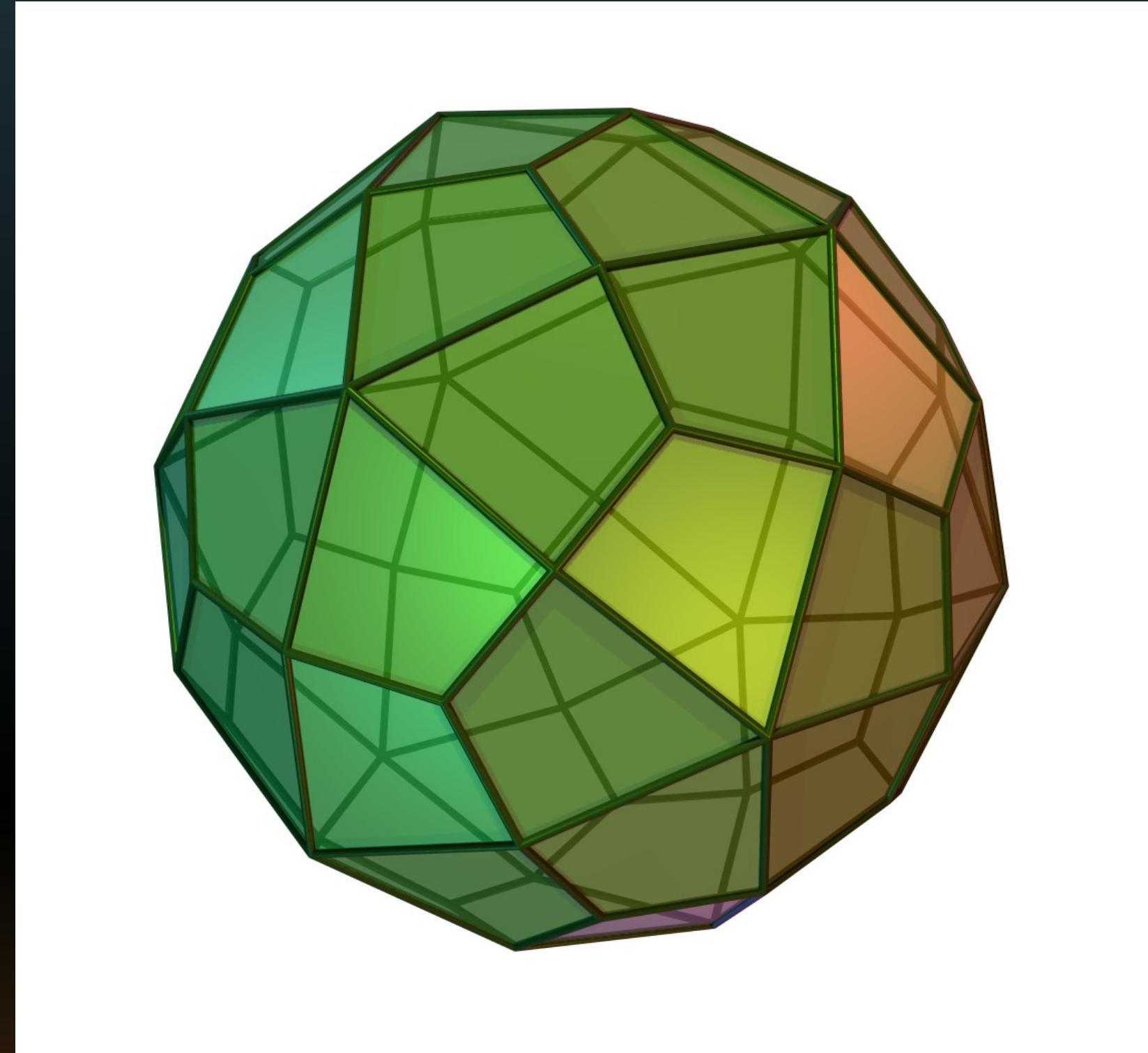
Name	Image	Face shape	Faces	Edges	Vertices	Dihedral angle ^[6]	Point group
triakis tetrahedron		isosceles	12	18	8	129.521°	Td
rhombic dodecahedron							
triakis octahedron							
tetrakis hexahedron							
deltoidal icositetrahedron		kite	24	48	26	138.118°	O _h
disdyakis dodecahedron		scalene triangle	48	72	26	155.082°	O _h
pentagonal icositetrahedron		pentagon	24	60	38	136.309°	O

Name	Image	Face shape	Faces	Edges	Vertices	Dihedral angle ^[6]	Point group
triakis octahedron		rhombus	30	60	32	144°	I _h
hexakis octahedron		isosceles triangle	60	90	32	160.613°	I _h
hexakis cube		isosceles triangle	60	90	32	156.719°	I _h
hexakis dodecahedron		kite	60	120	62	154.121°	I _h
disdyakis triacontahedron		scalene triangle	120	180	62	164.888°	I _h
pentagonal hexecontahedron		pentagon	60	150	92	153.179°	I

Nice property to have
for PCB based projects :-)

shapes: deltoidal hexecontahedron

60 identical kite-shaped faces

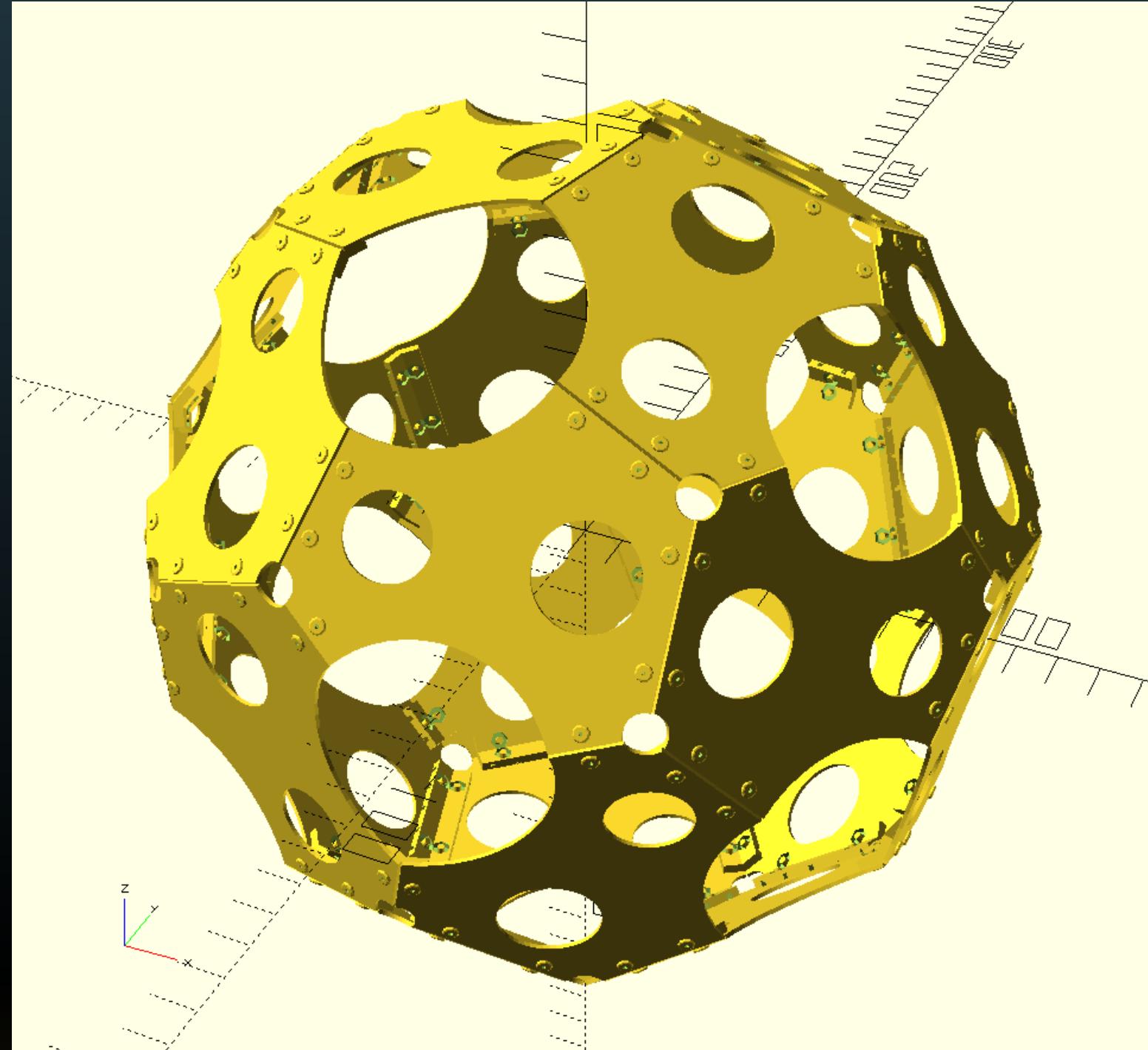


new puzzle:

calculate the shape and orientation of each facet

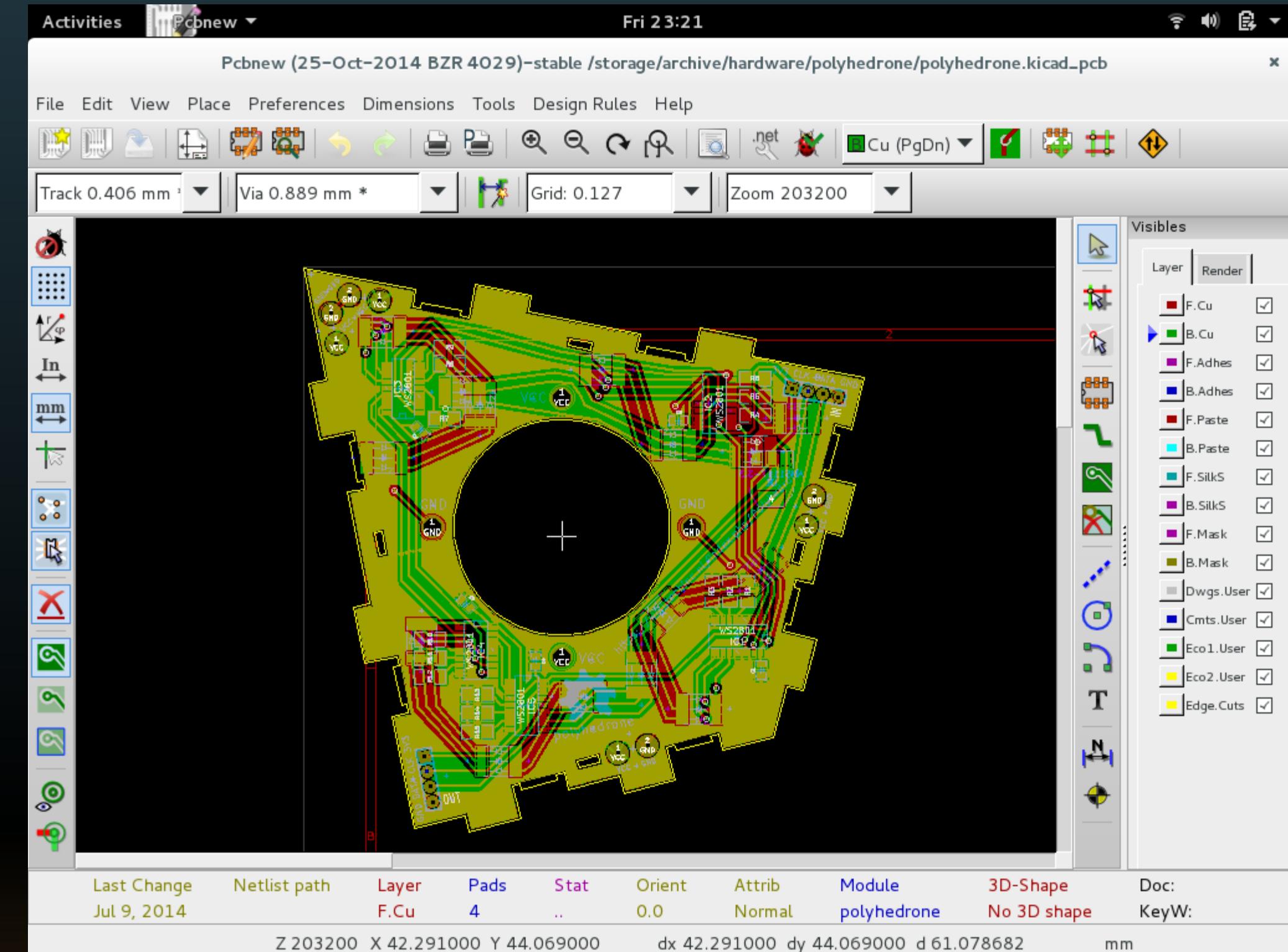
- easy for platonic / archimedian solids
- catalan solids can be generated from their archimedian dual.
- add notches / slots

<https://github.com/brainsmoke/polymap>



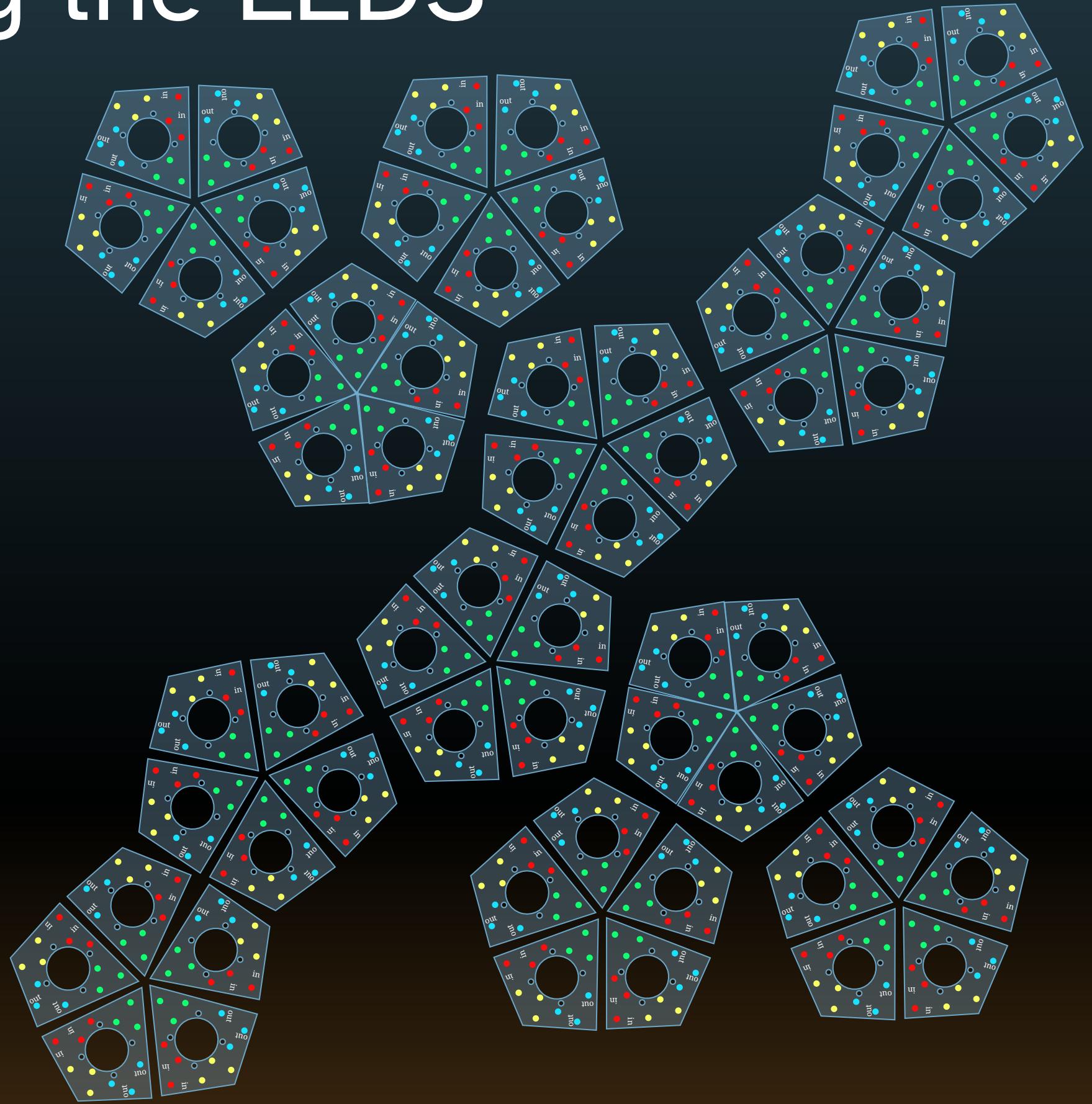
use openscad to check the validity of your
geometry generating code.

design PCB

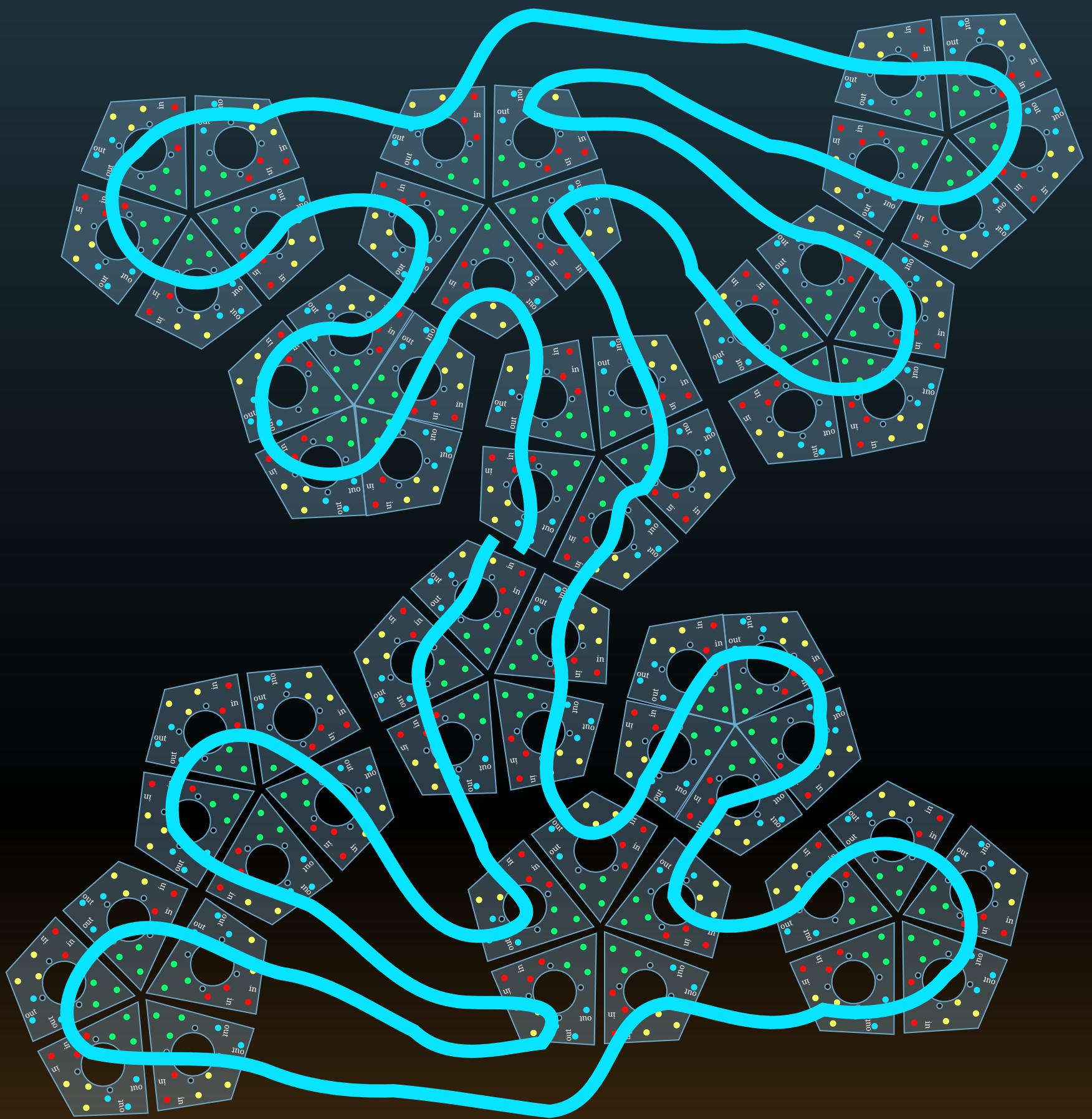


<https://github.com/brainsmoke/polyhedrone>

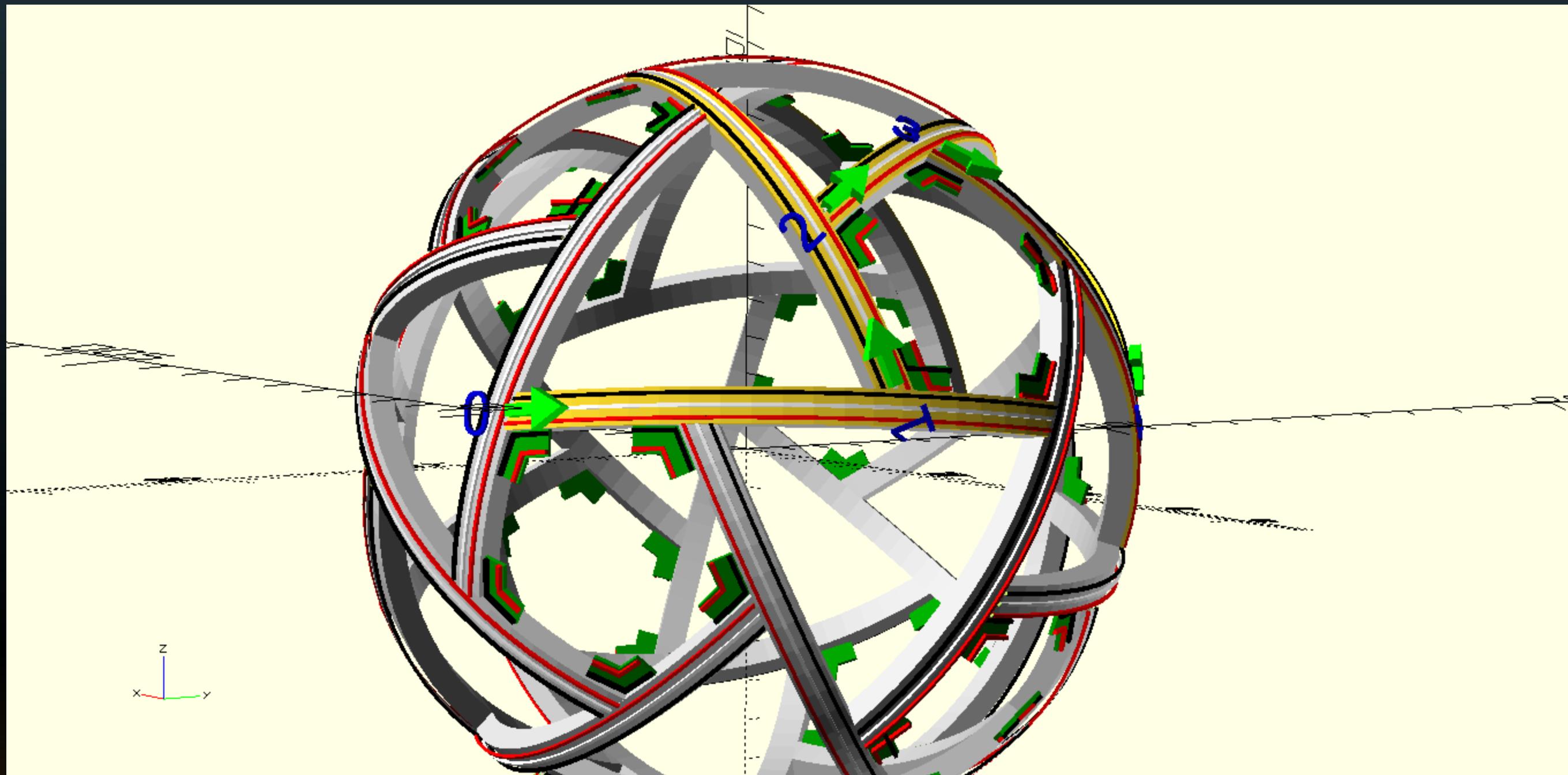
positioning the LEDs



wiring

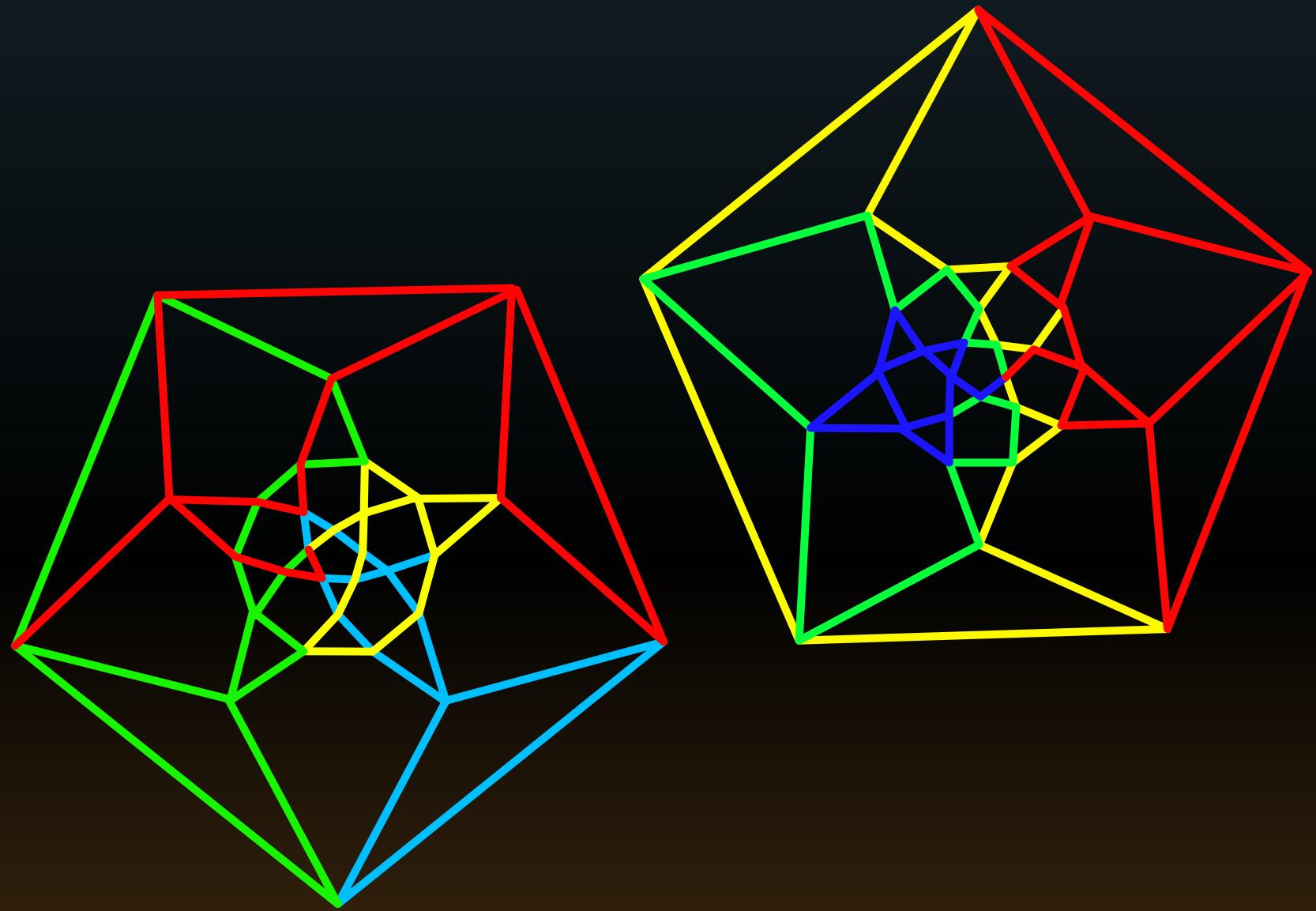


wiring

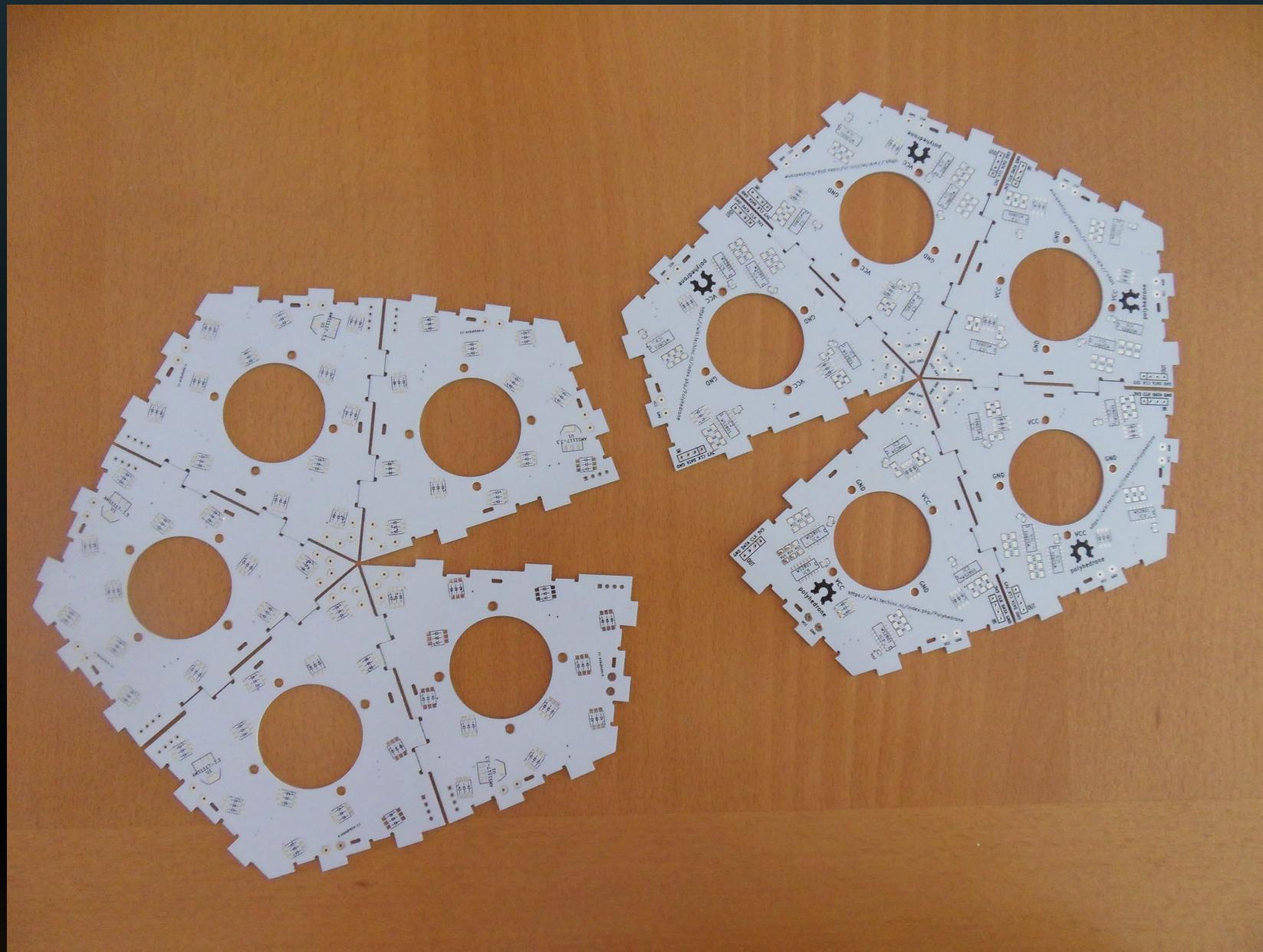


wiring

or write a script to find all possible wirings

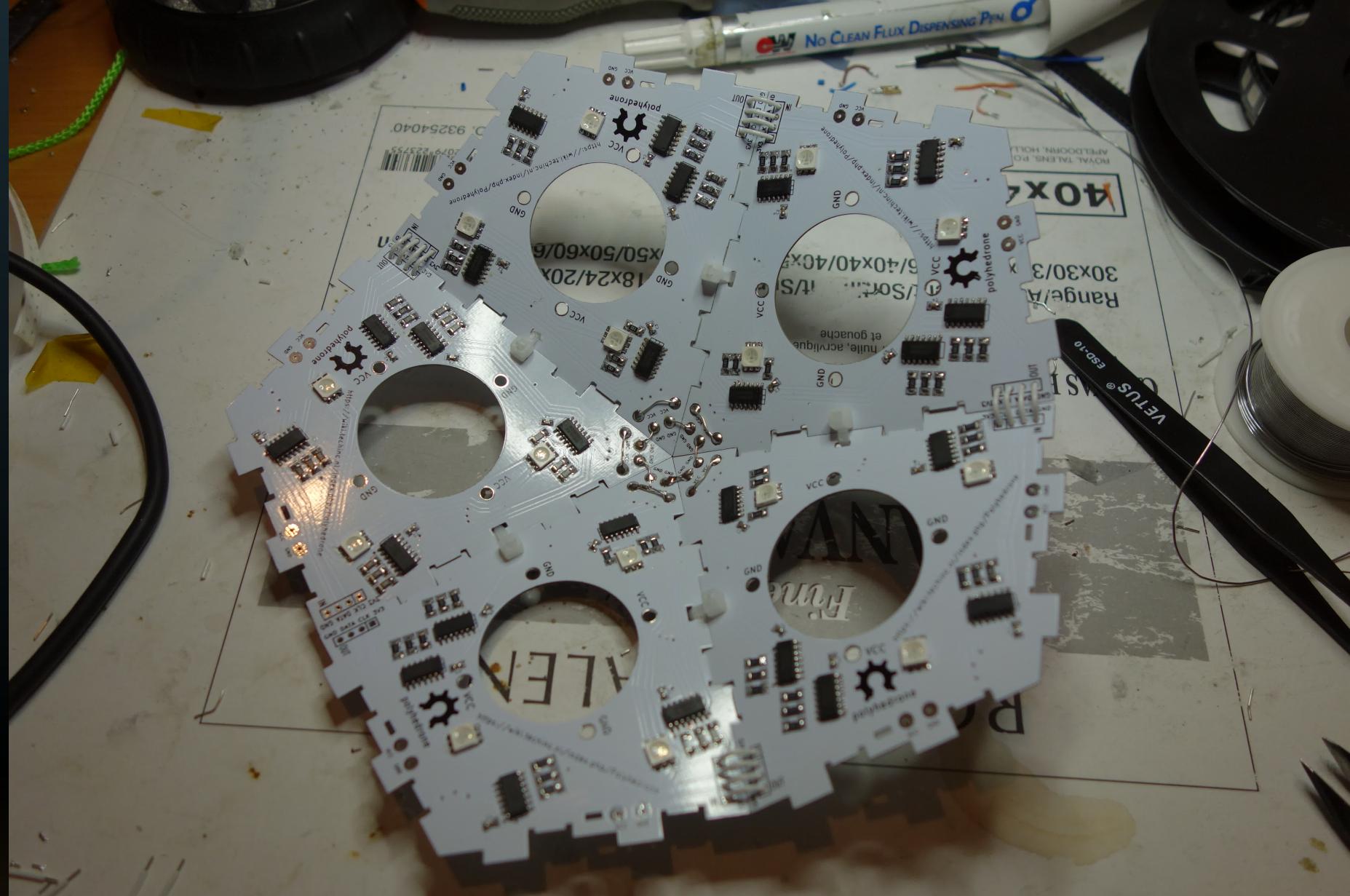


Lots of soldering



60 facets,
every minute spent on one
PCB takes an hour :-/

Lots of soldering



60 facets,

every minute spent on one
PCB takes an hour :-/

Lots of soldering



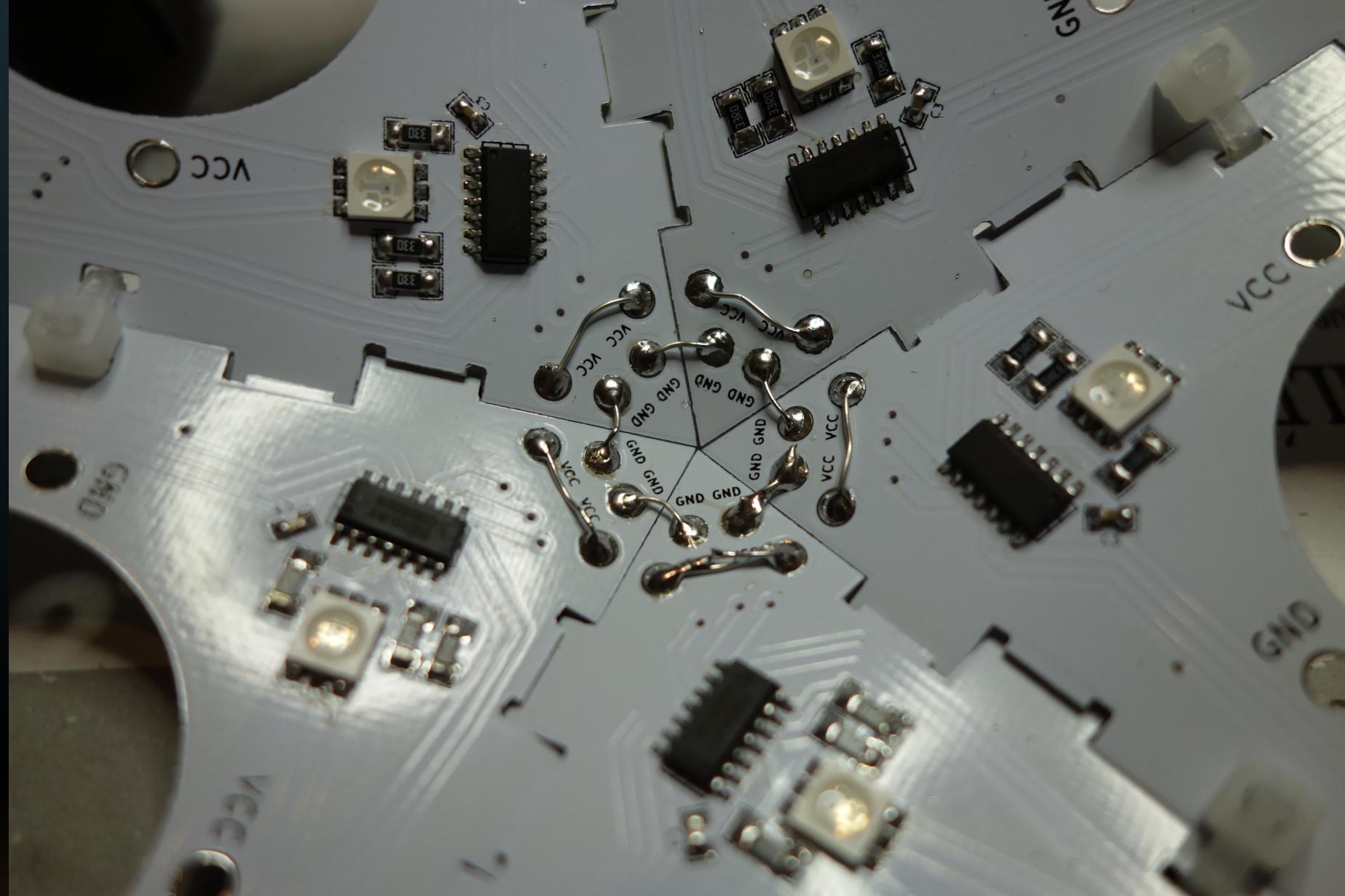
60 facets,
every minute spent on one
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Lots of soldering



60 facets,
every minute spent on one
PCB takes an hour :-/

Lots of soldering

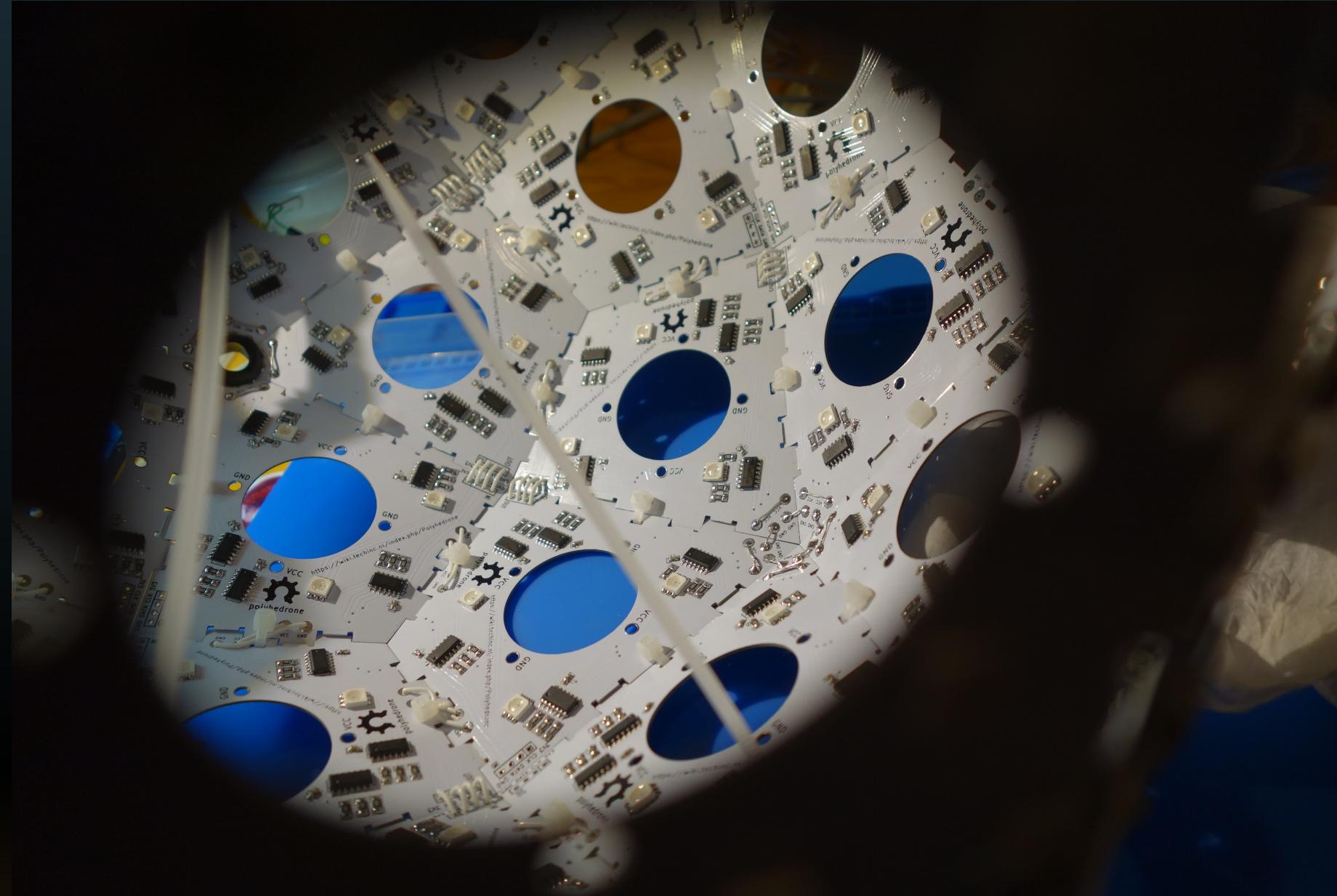


60 facets,

every minute spent on one
PCB takes an hour :-/

+ time spent on connecting
everything

Lots of soldering



60 facets,

every minute spent on one
PCB takes an hour :-/

+ time spent on connecting
everything

Lots of soldering

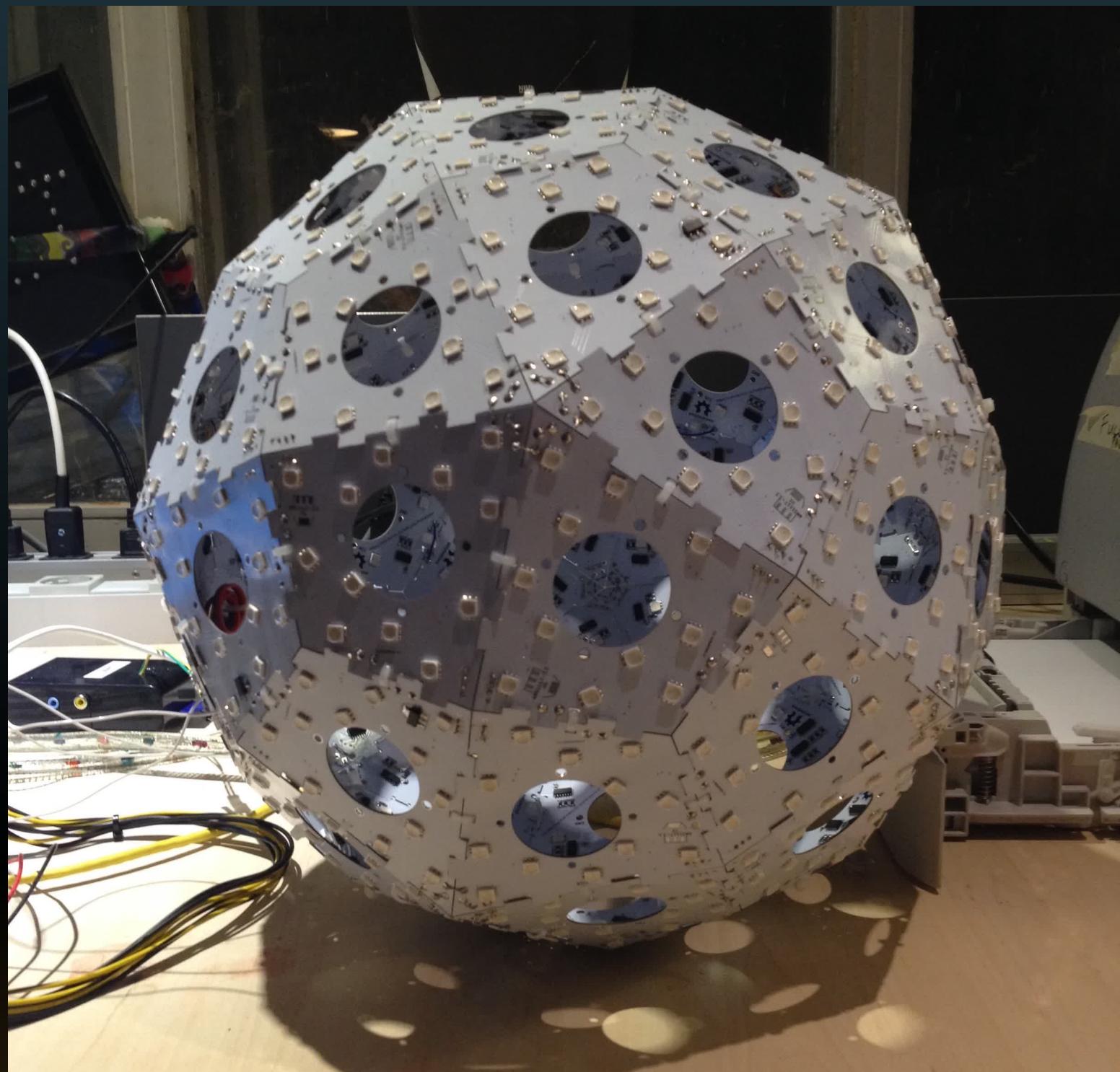


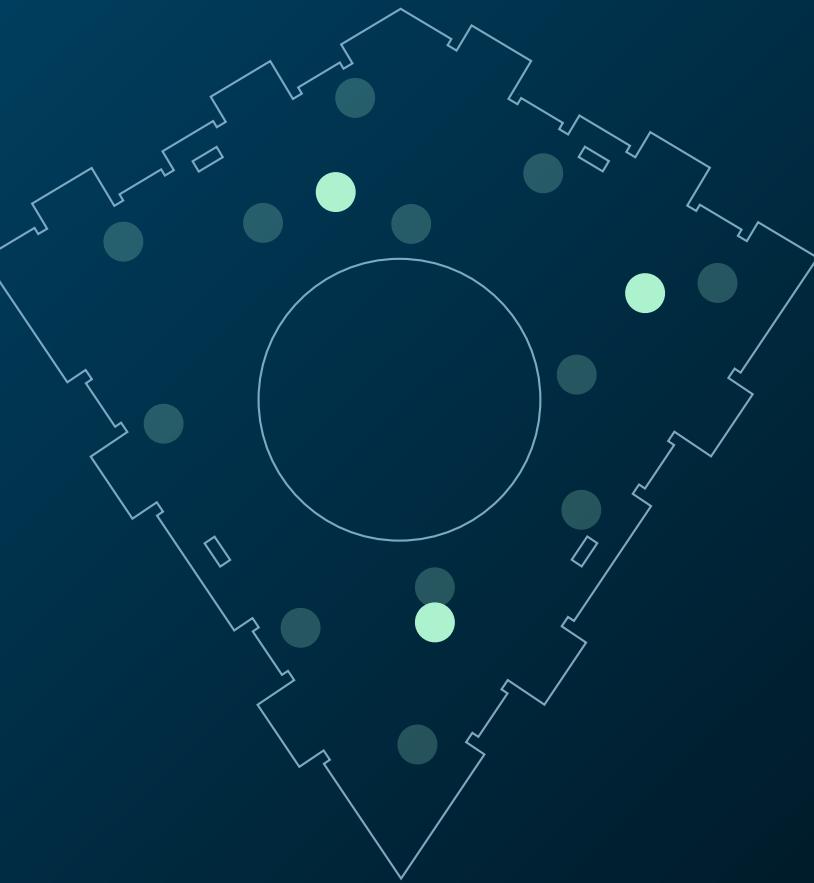
60 facets,

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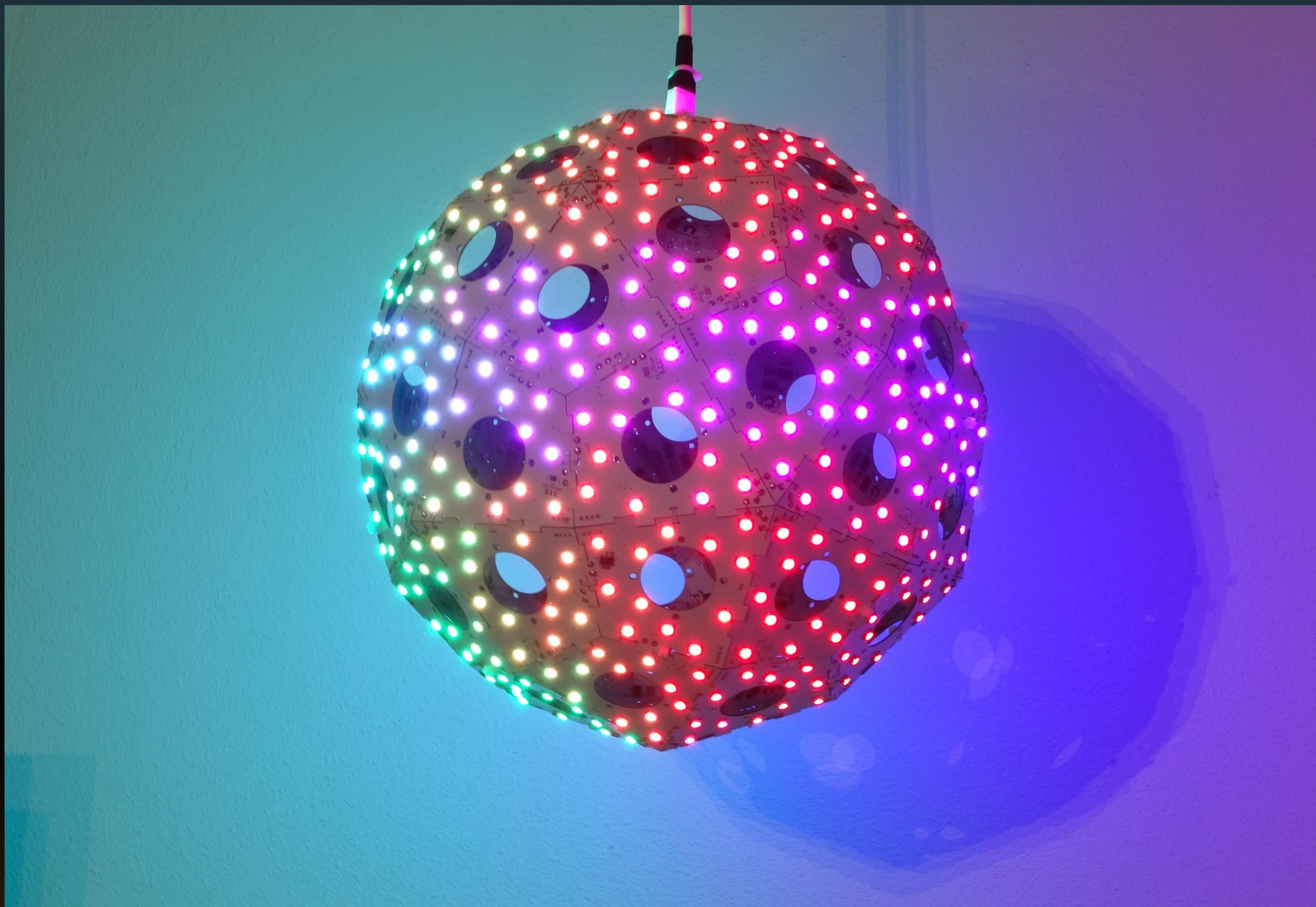
+ time spent on connecting
everything

+ wiring





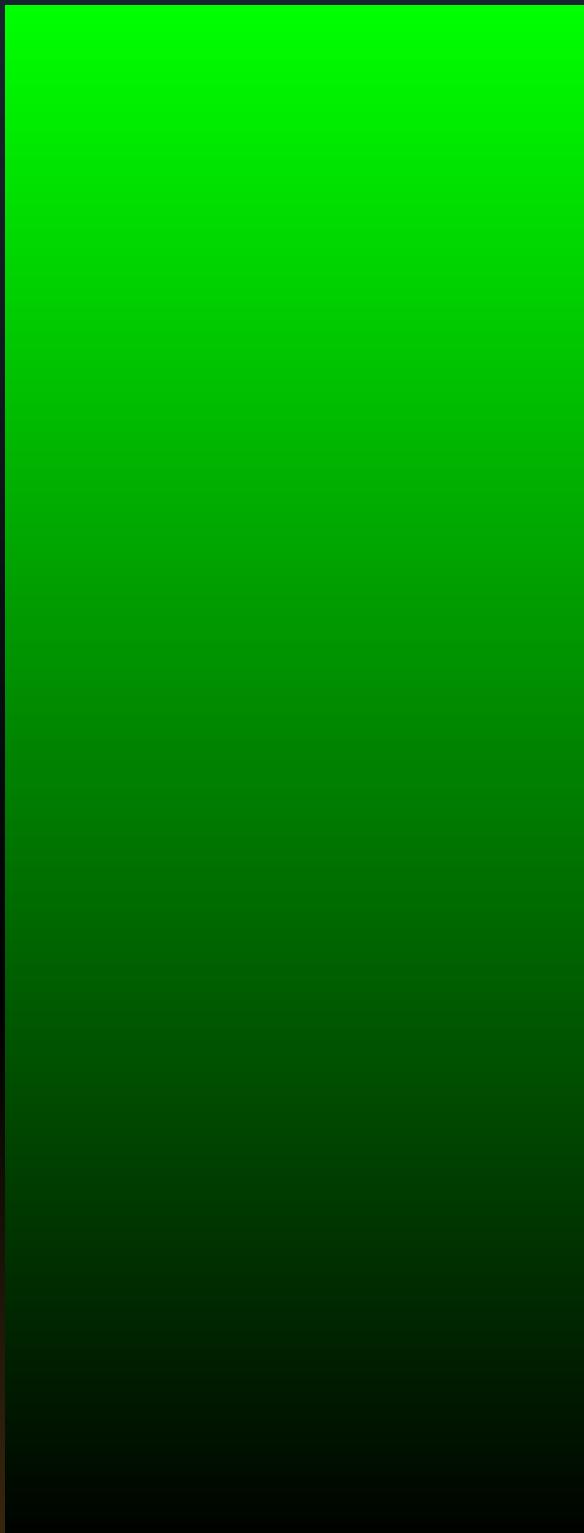
calculate the 3D position and orientation
of all LEDs for the animation software to use



programming puzzles

8-bit per color component is not enough

original animation



25% brightness

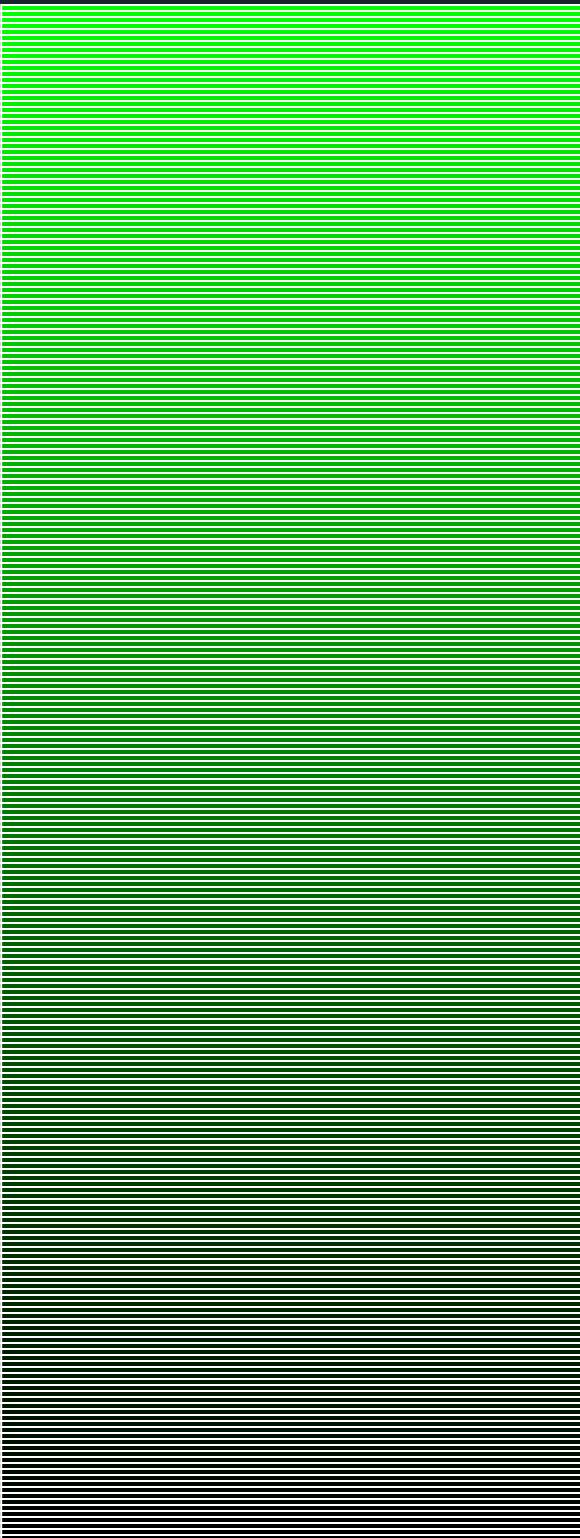


2.8 gamma applied

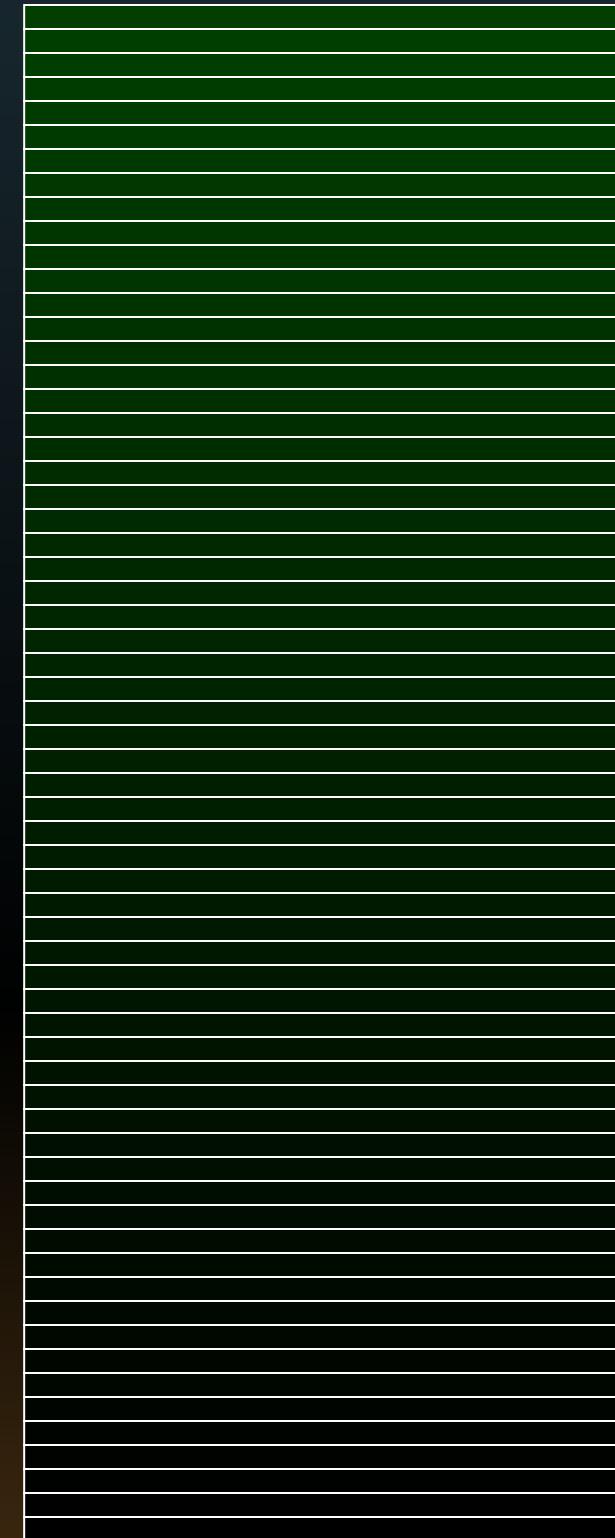


8-bit per color component is not enough

original animation



25% brightness

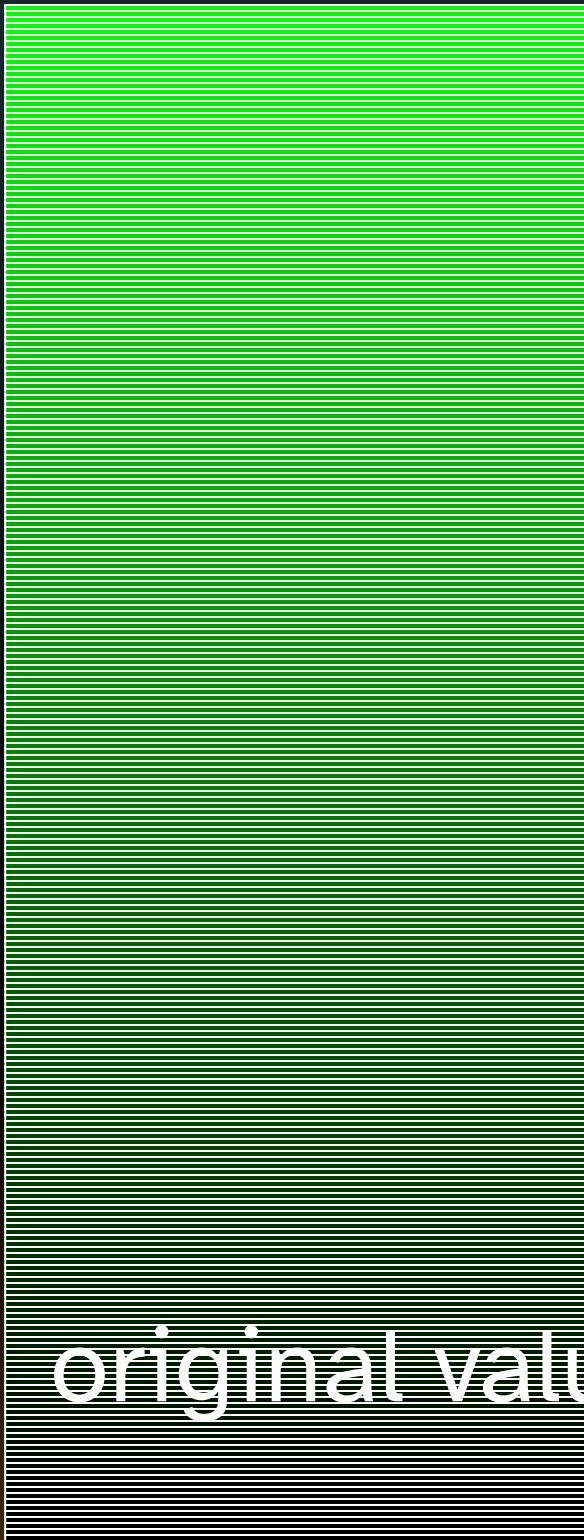


2.8 gamma applied



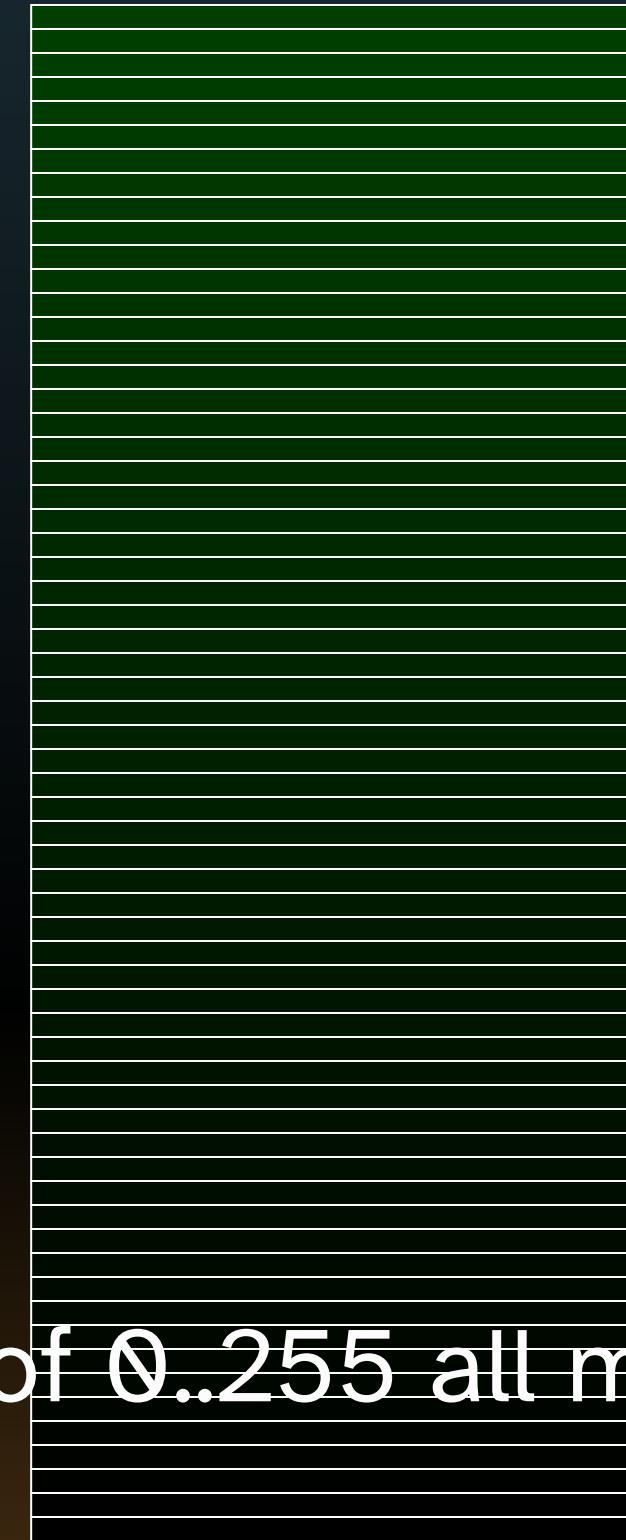
8-bit per color component is not enough

original animation

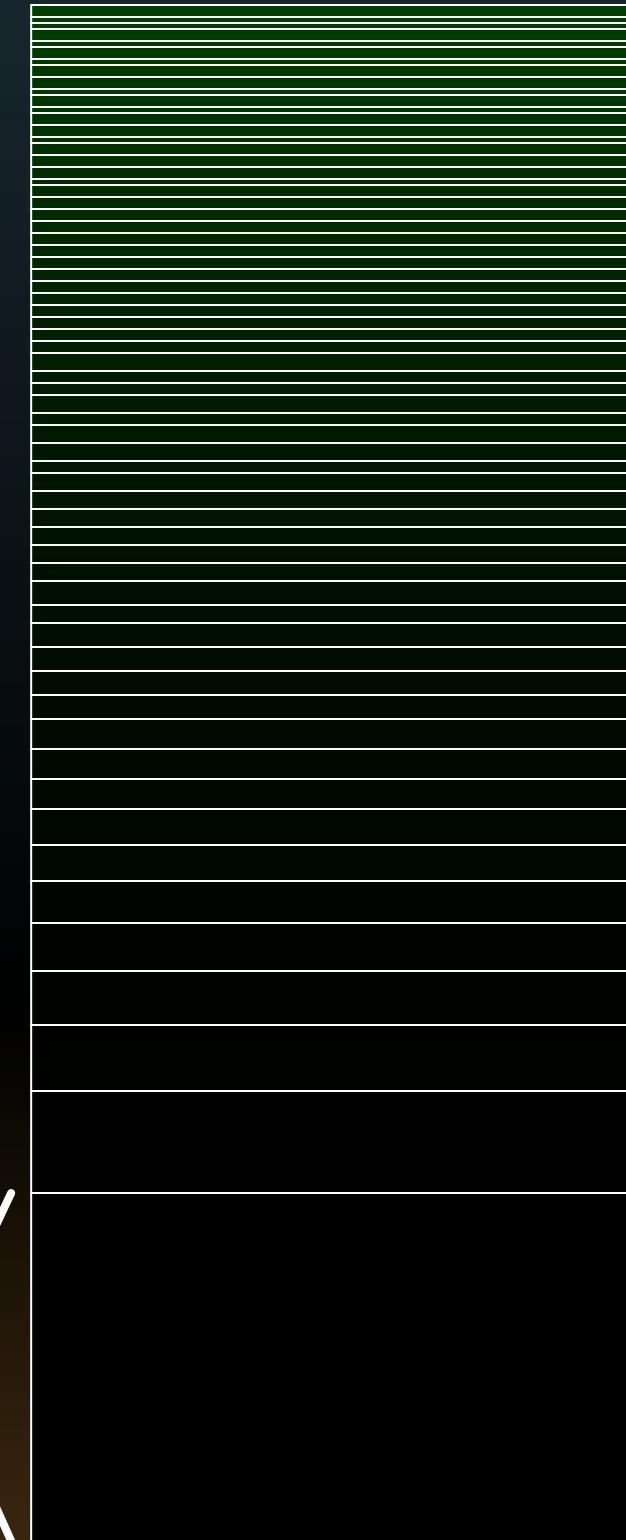


original values 0..57 out of 0..255 all map onto 0

25% brightness



2.8 gamma applied



temporal dithering

- send frames of addressable LED data at a very high framerate
- alternate between two adjacent 8-bit values to create an intermediate value

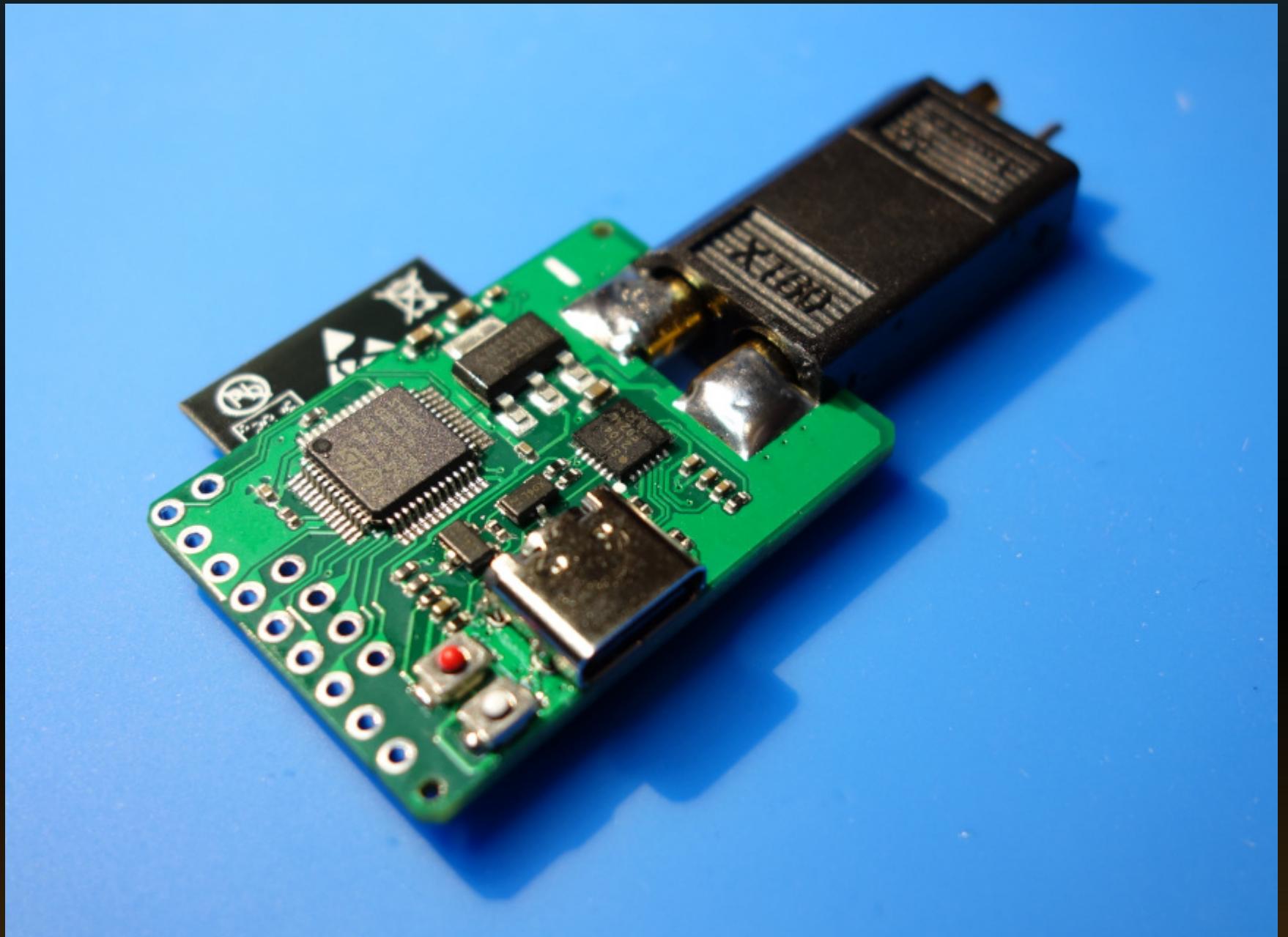


fadecandy by Scanlime
discontinued :-(

temporal dithering

can I use a simpler (cheaper) chip?

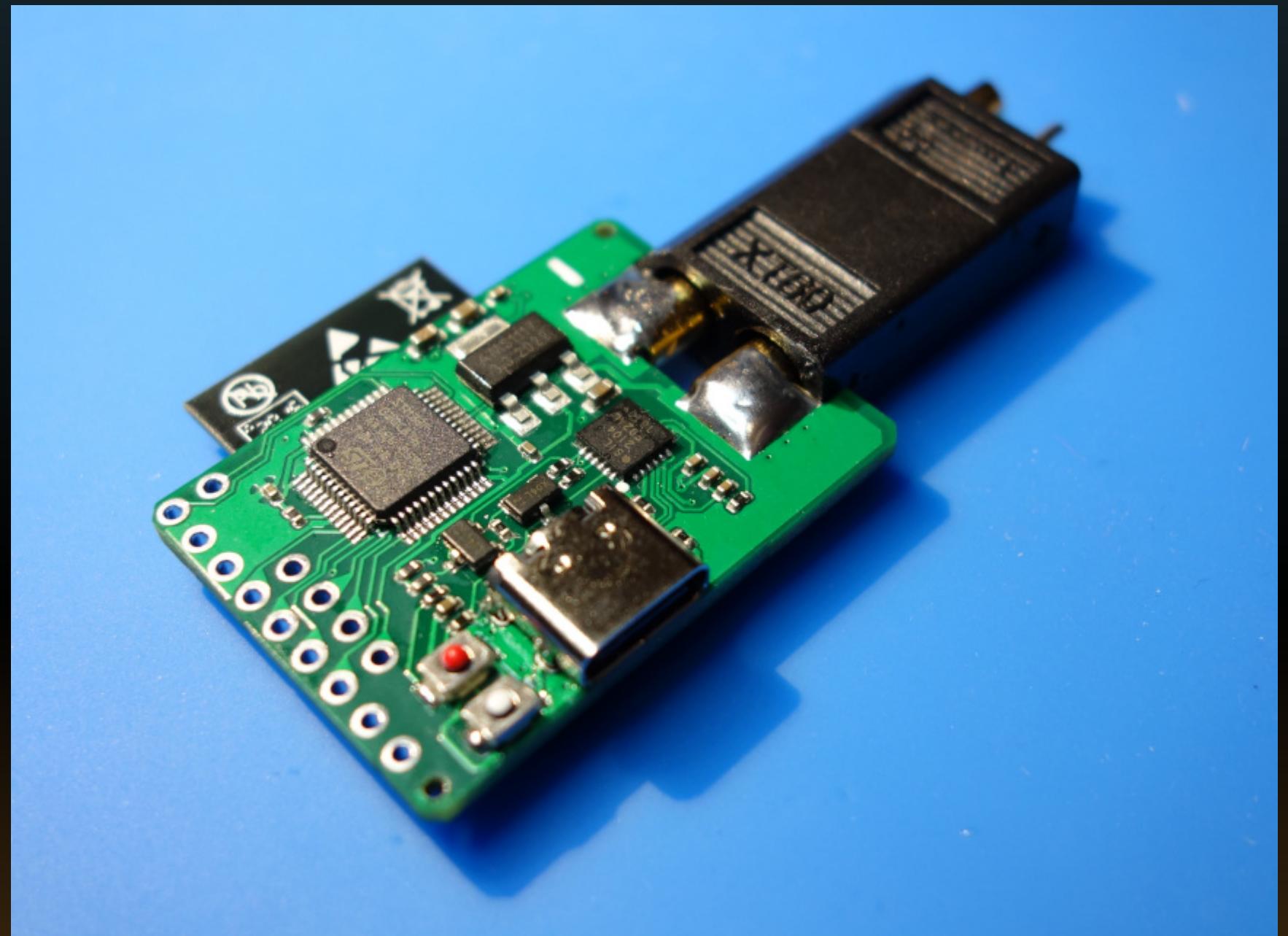
- save memory by doing calculations on the fly while sending out data
- cycle-precise coding to get the timings right
- no need to use USB



temporal dithering

can I use a simpler (cheaper) chip?

- esp32 creates animations in 48 bit color (16bits per color component)
- stm32f0 is responsible for temporal dithering



software defined routing



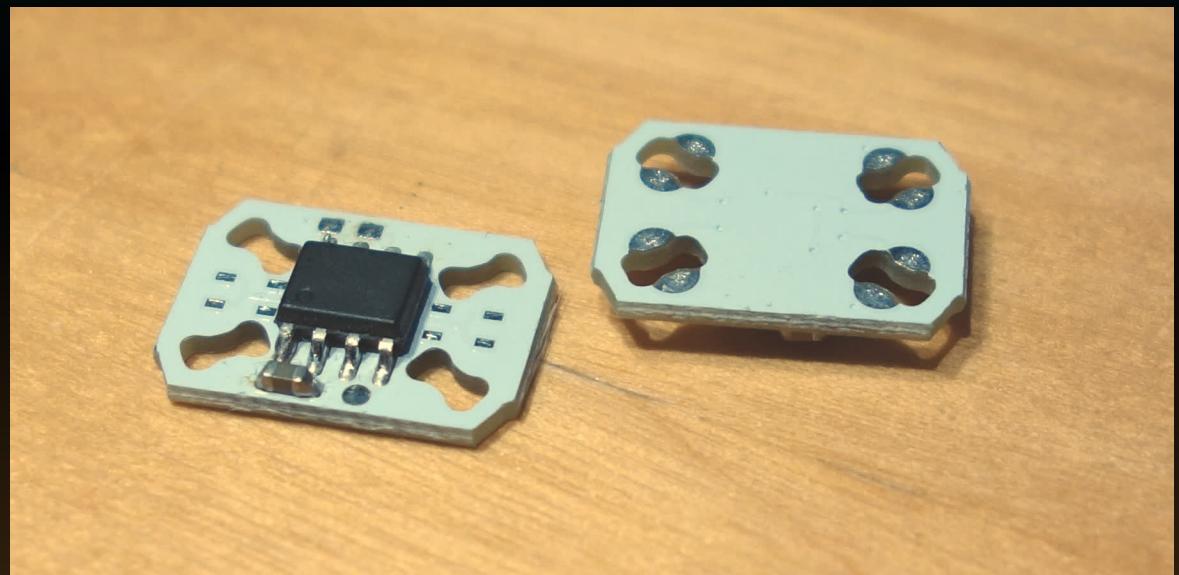
software defined routing

- 60 edges (two options for orientation)
- 30 PCBs on the vertices
(two different routing options)



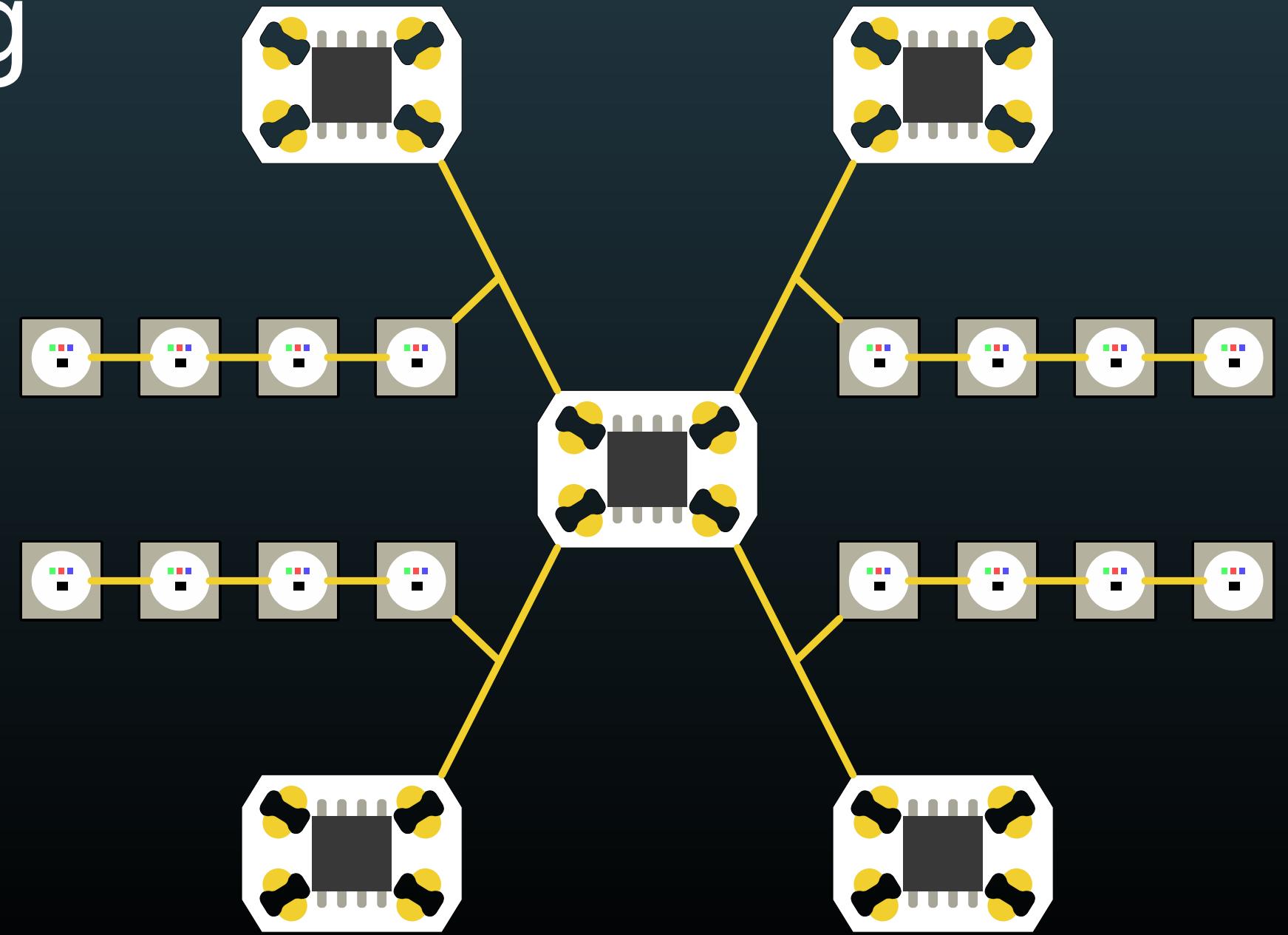
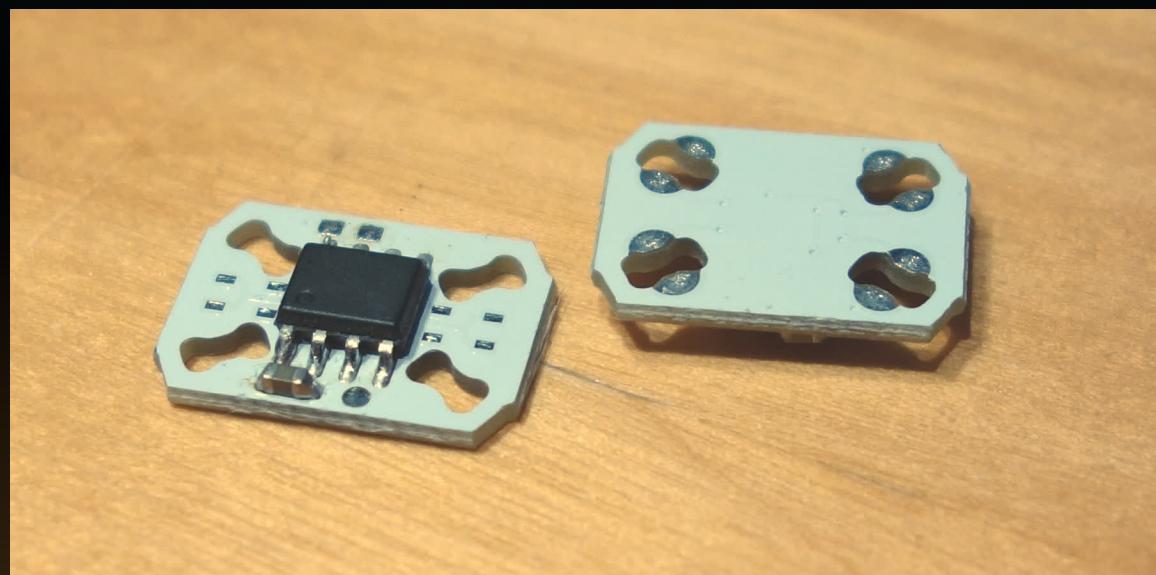
software defined routing

Instead:
use a '3-cent' Padauk MCU
on every vertex to do
the routing dynamically



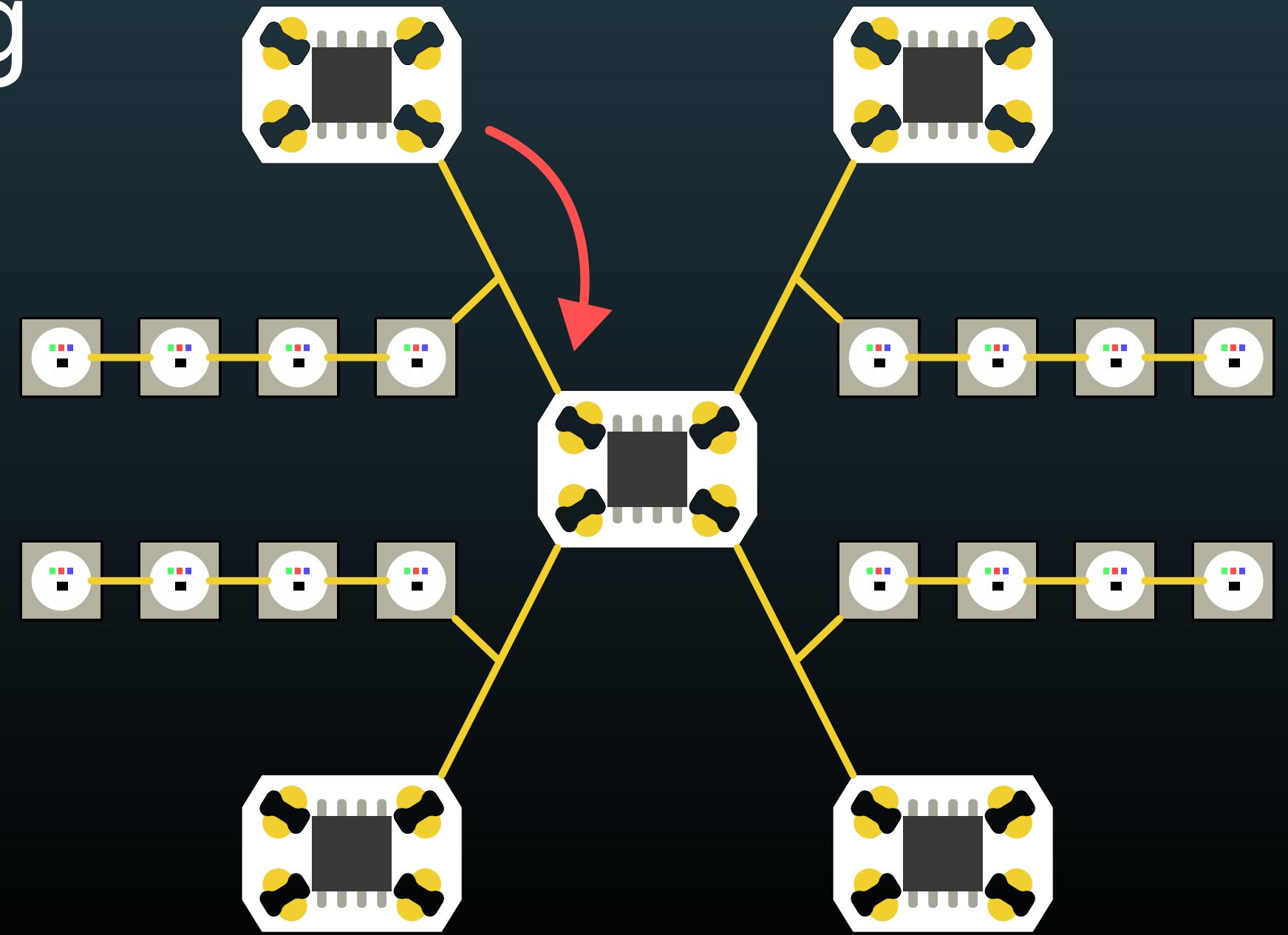
software defined routing

Instead:
use a '3-cent' Padauk MCU
on every vertex to do
the routing dynamically



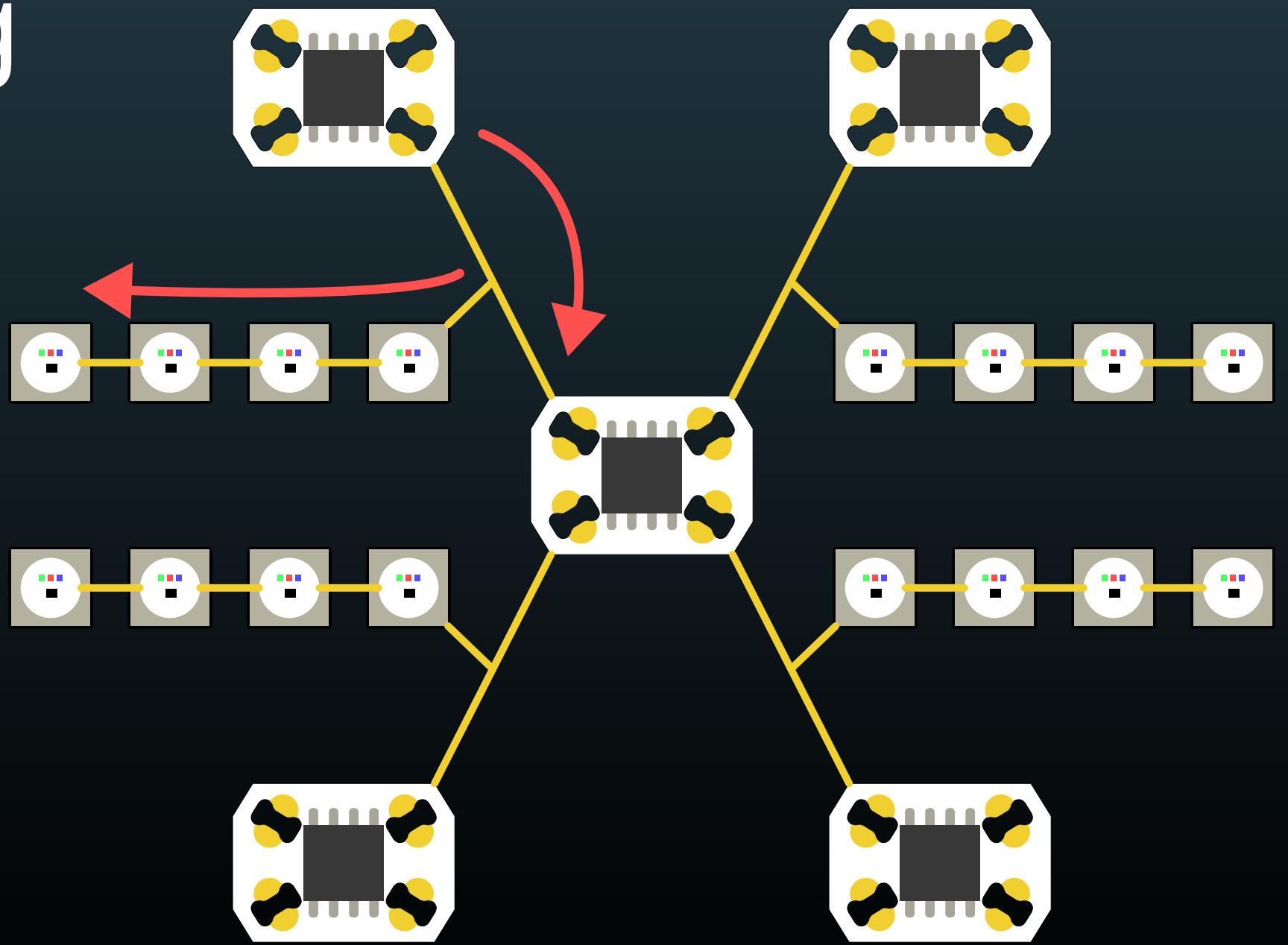
software defined routing

- listen on 4 IO pins for ws2812 signal pulses
- when data arrives on one pin, the other pins become outputs



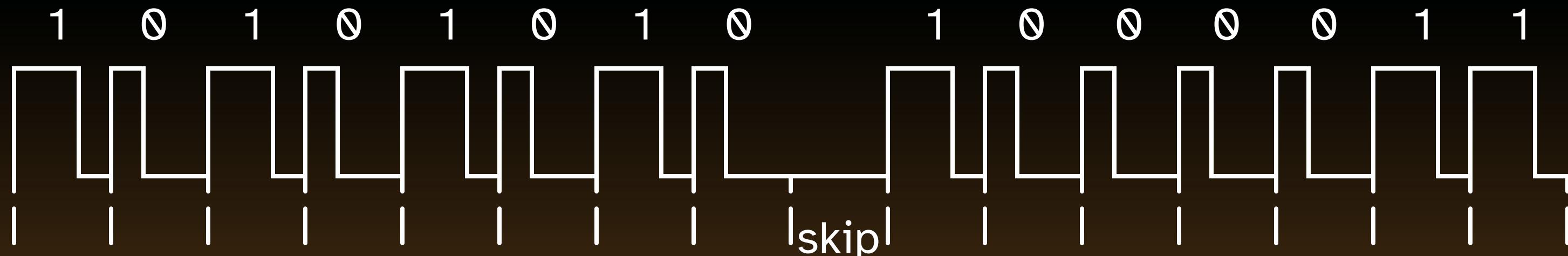
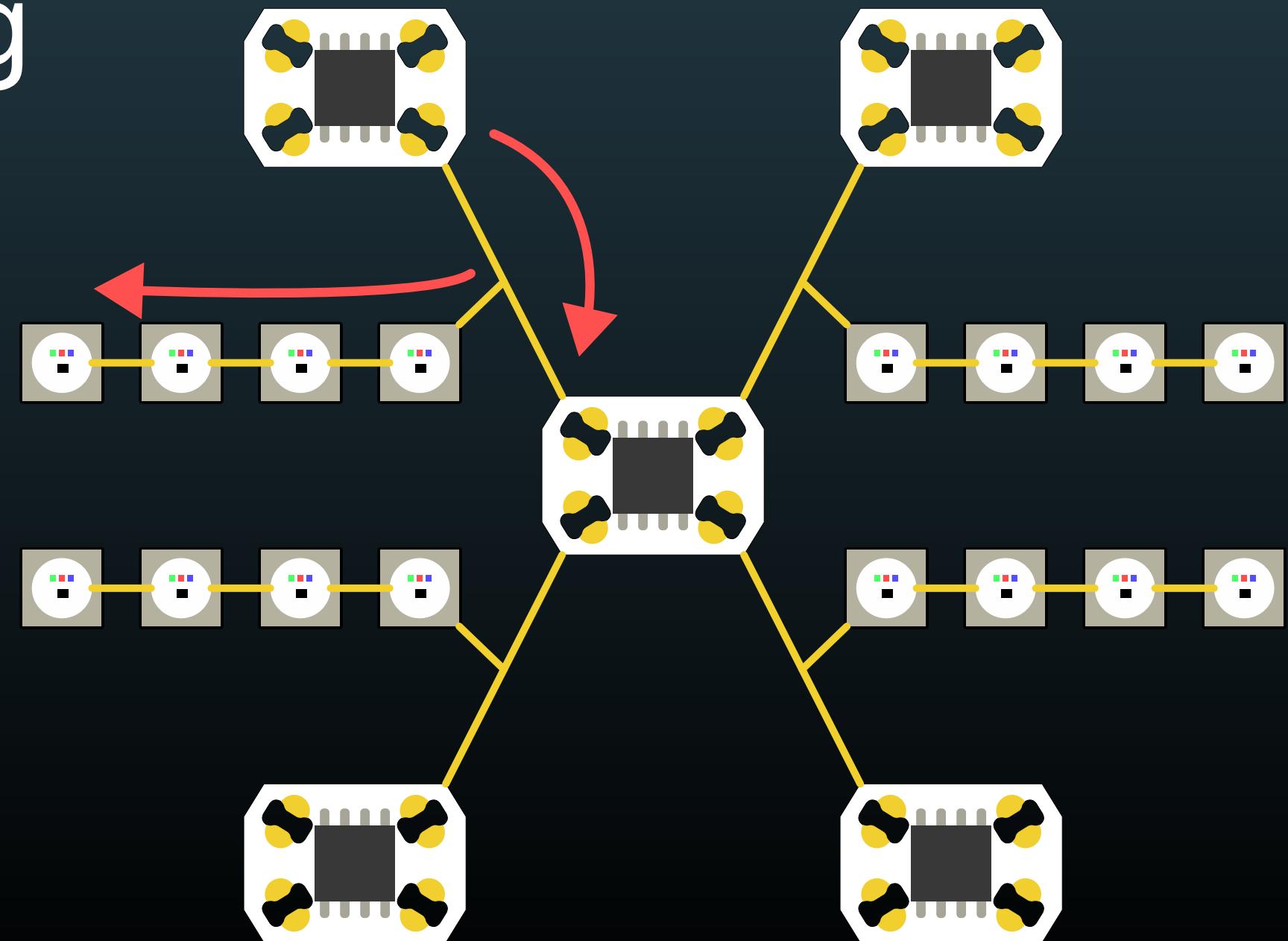
software defined routing

- synchronize code to the pulses while LED data is sent
- wait for skipped pulse & read a 7-bit in-band routing packet



software defined routing

- synchronize code to the pulses while LED data is sent
- wait for skipped pulse & read a 7-bit in-band routing packet

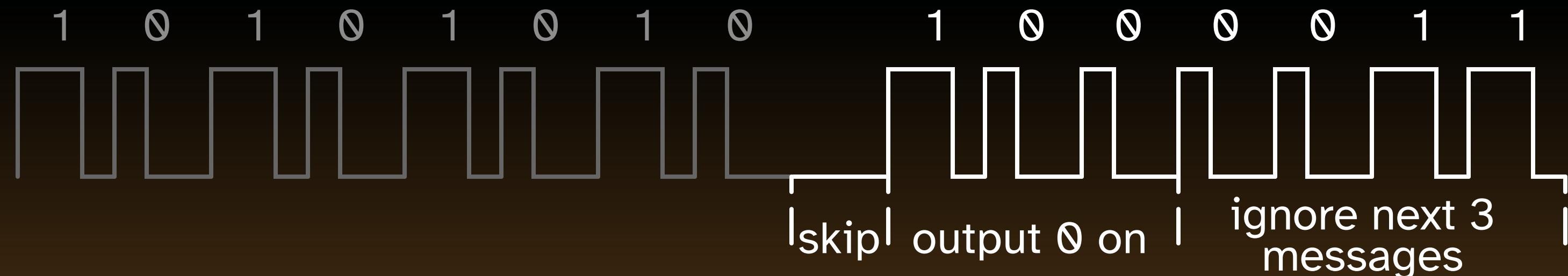
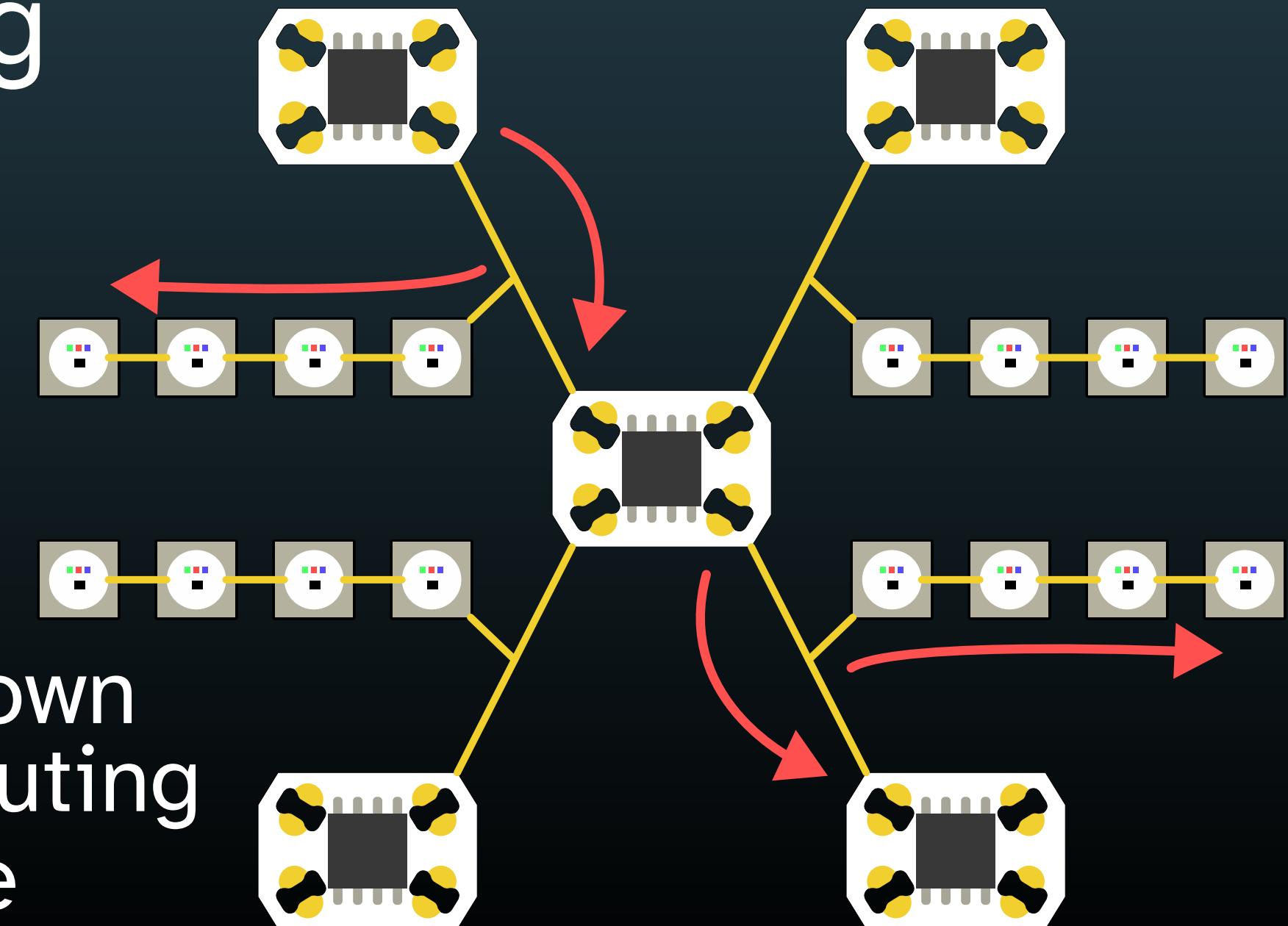


software defined routing

in-band routing packet:

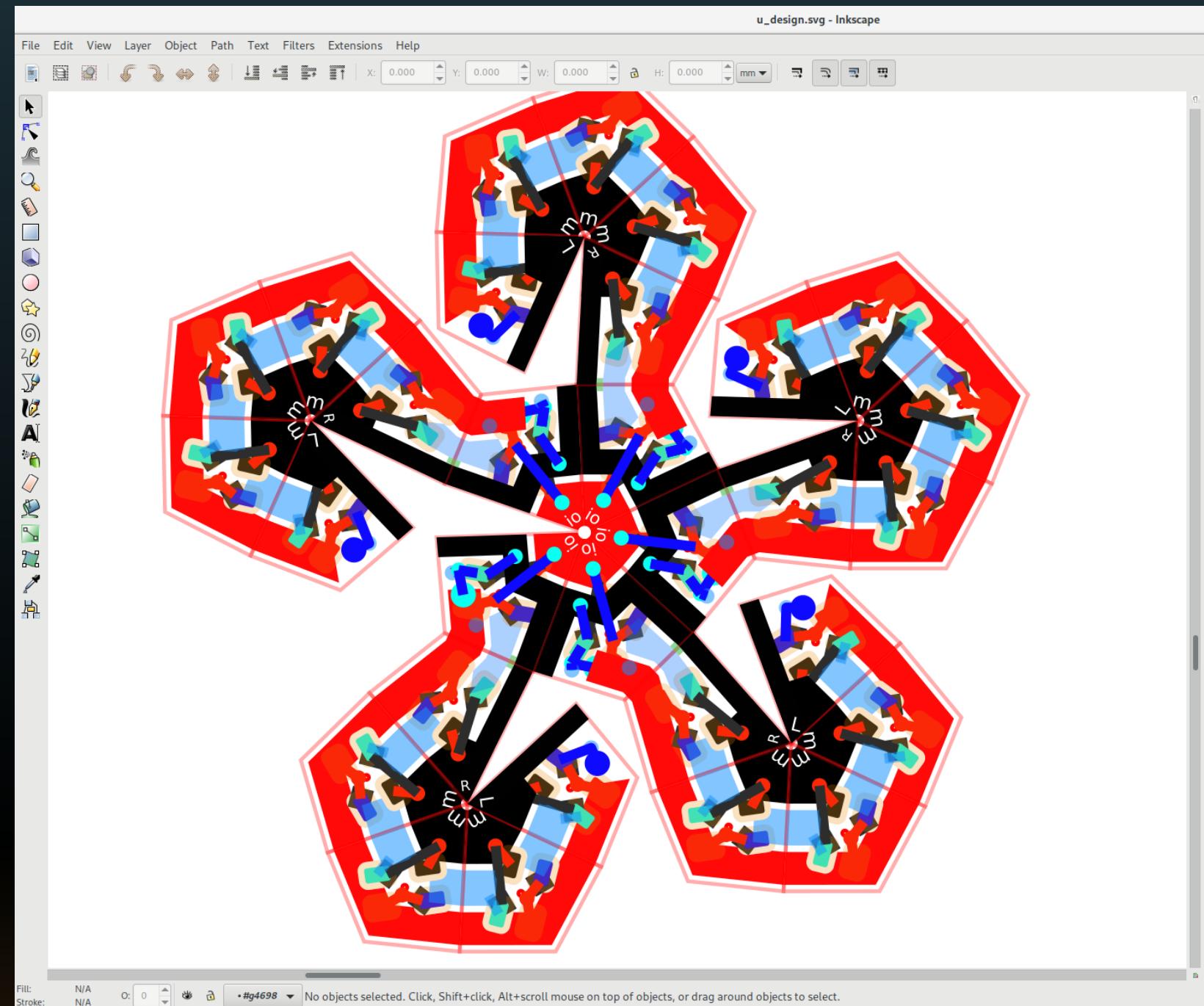
3 bits to start *relaying* to select output pins

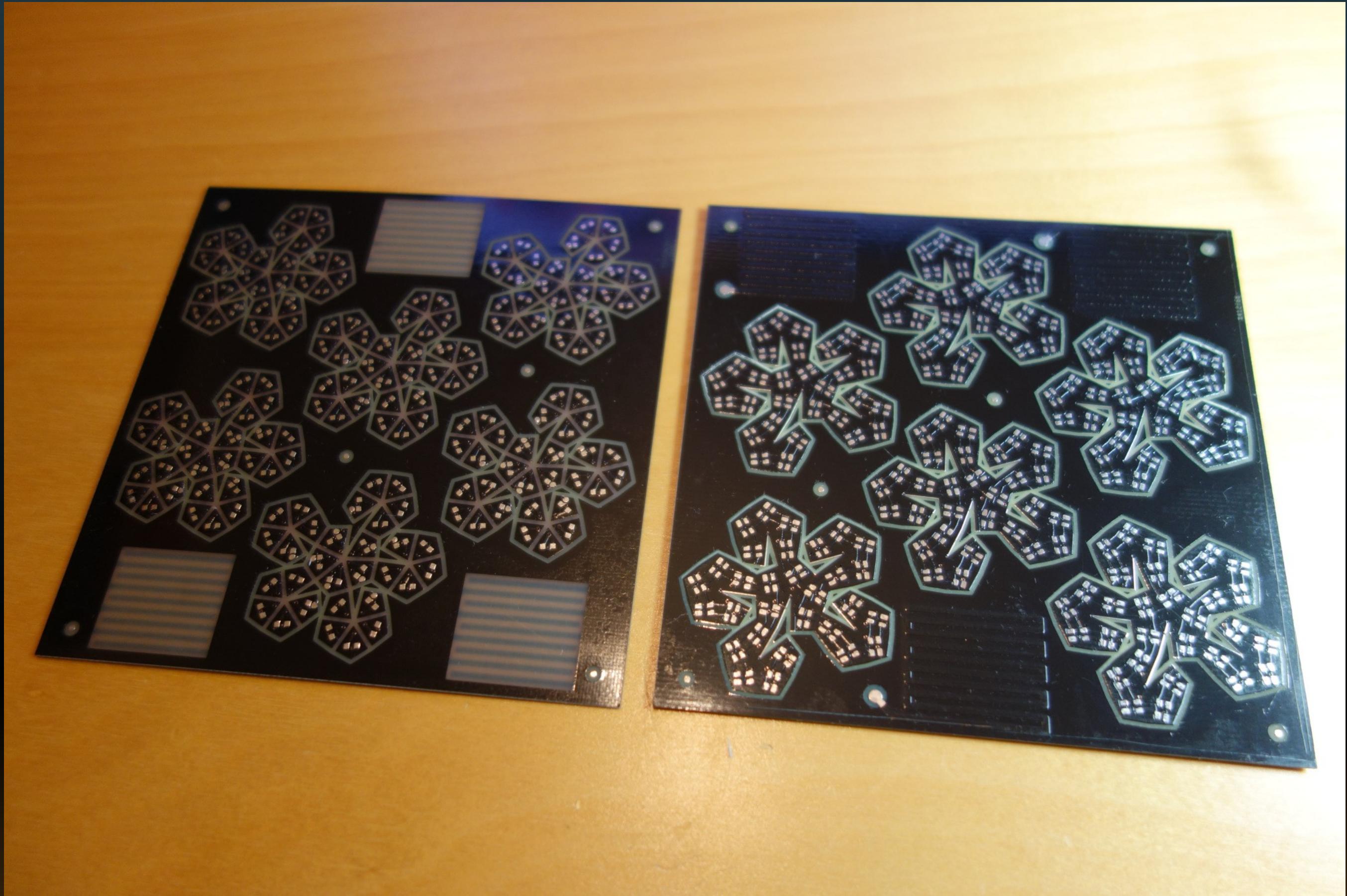
4 bit number used as a countdown to know whether subsequent routing packets are meant for this node



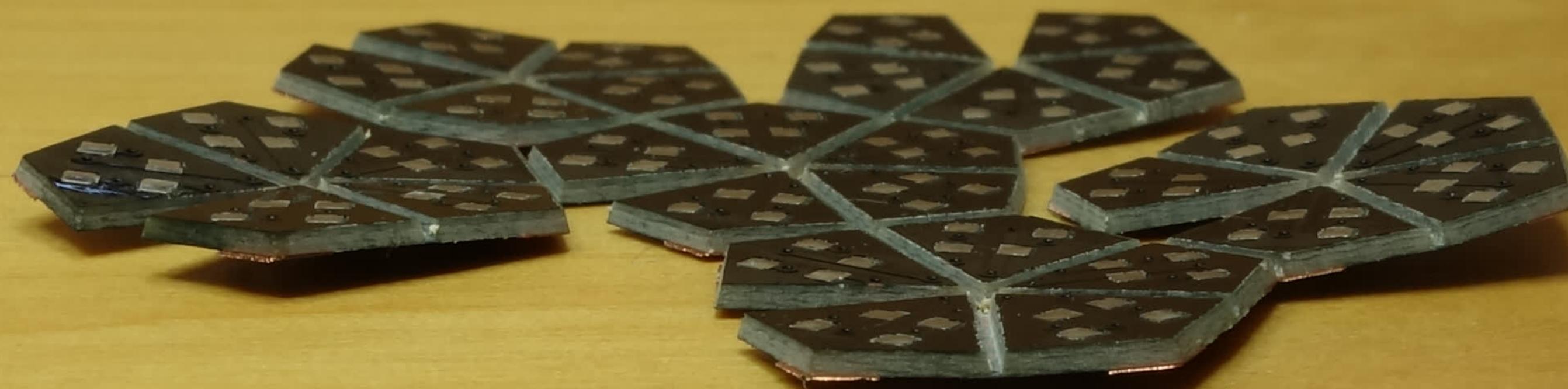
construction puzzles

How small can you get?



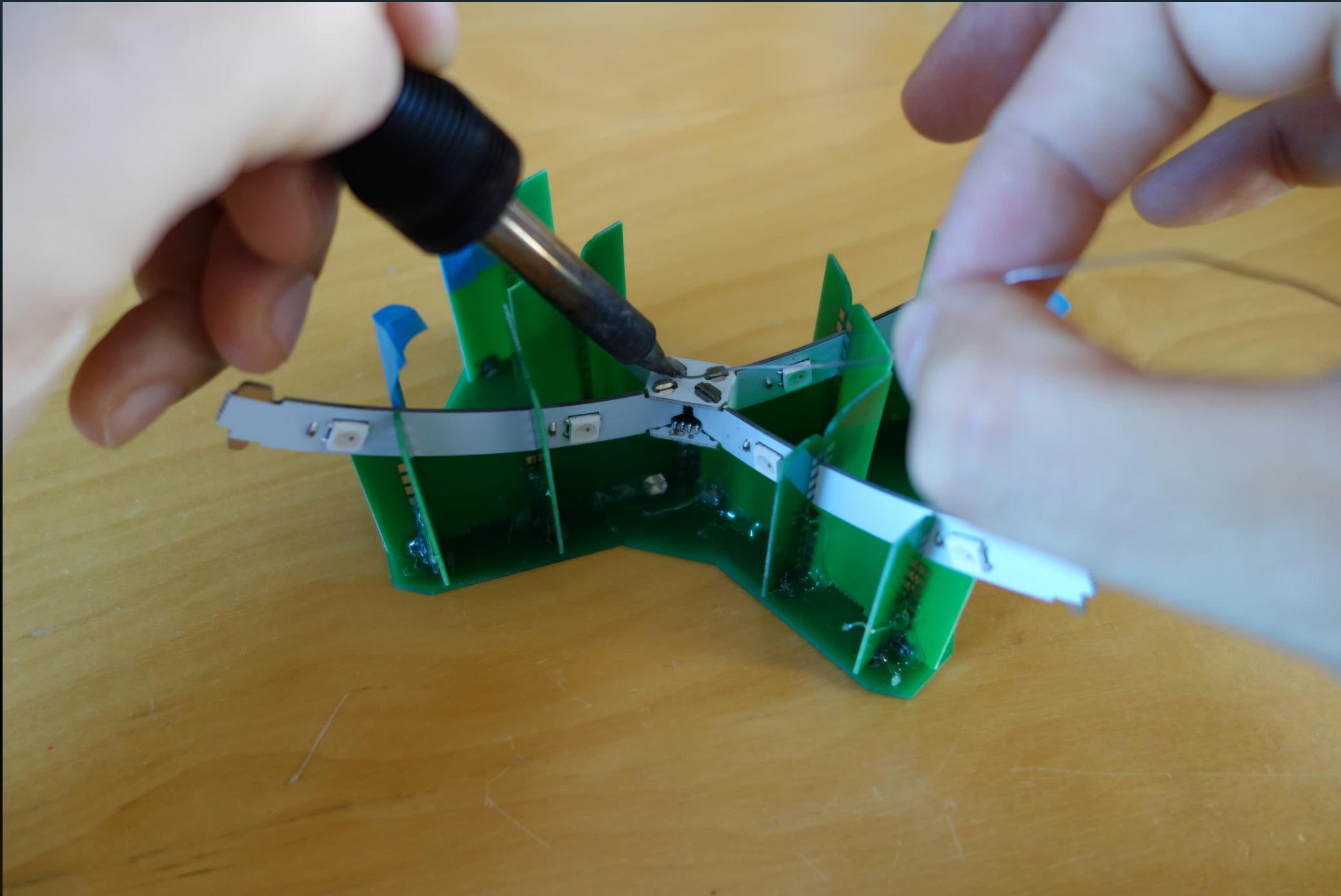




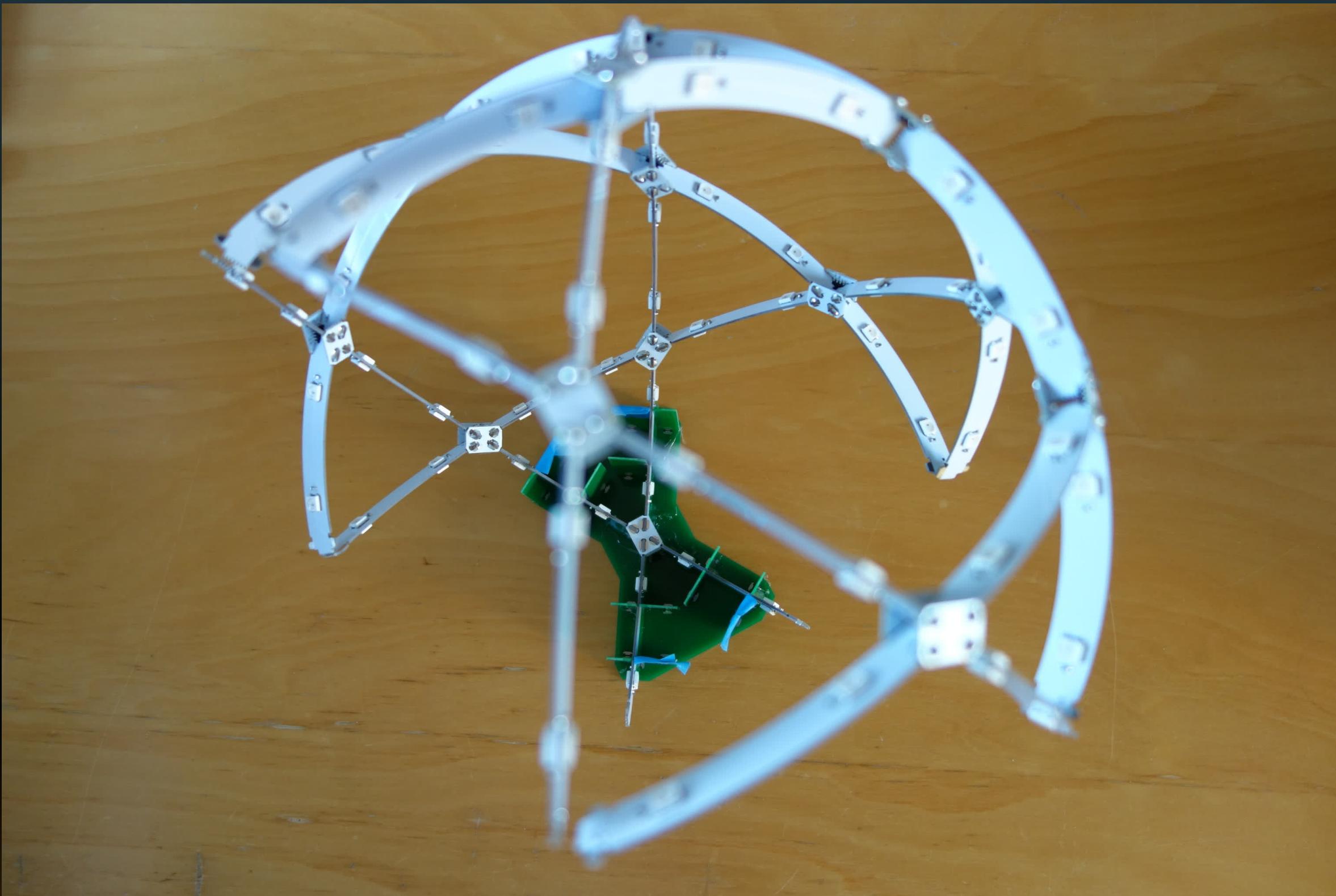




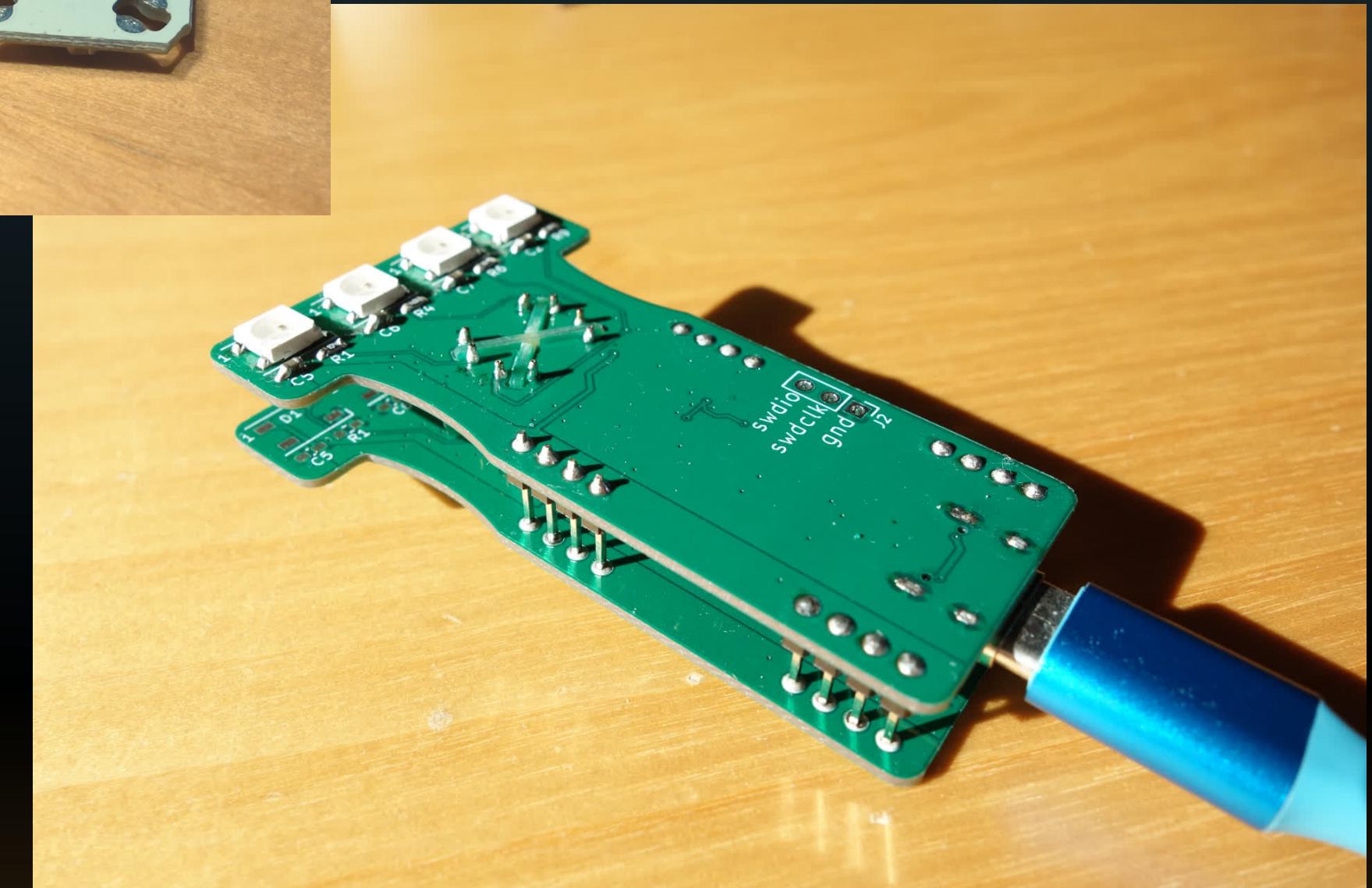
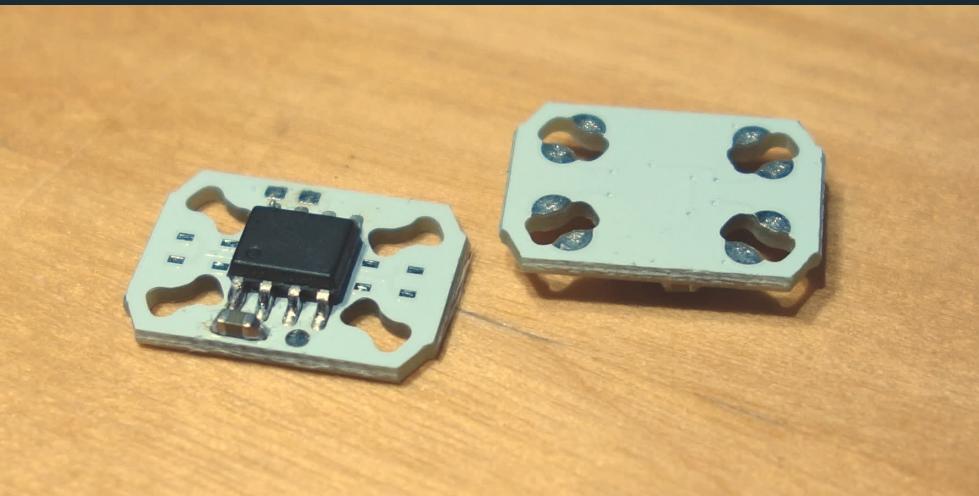
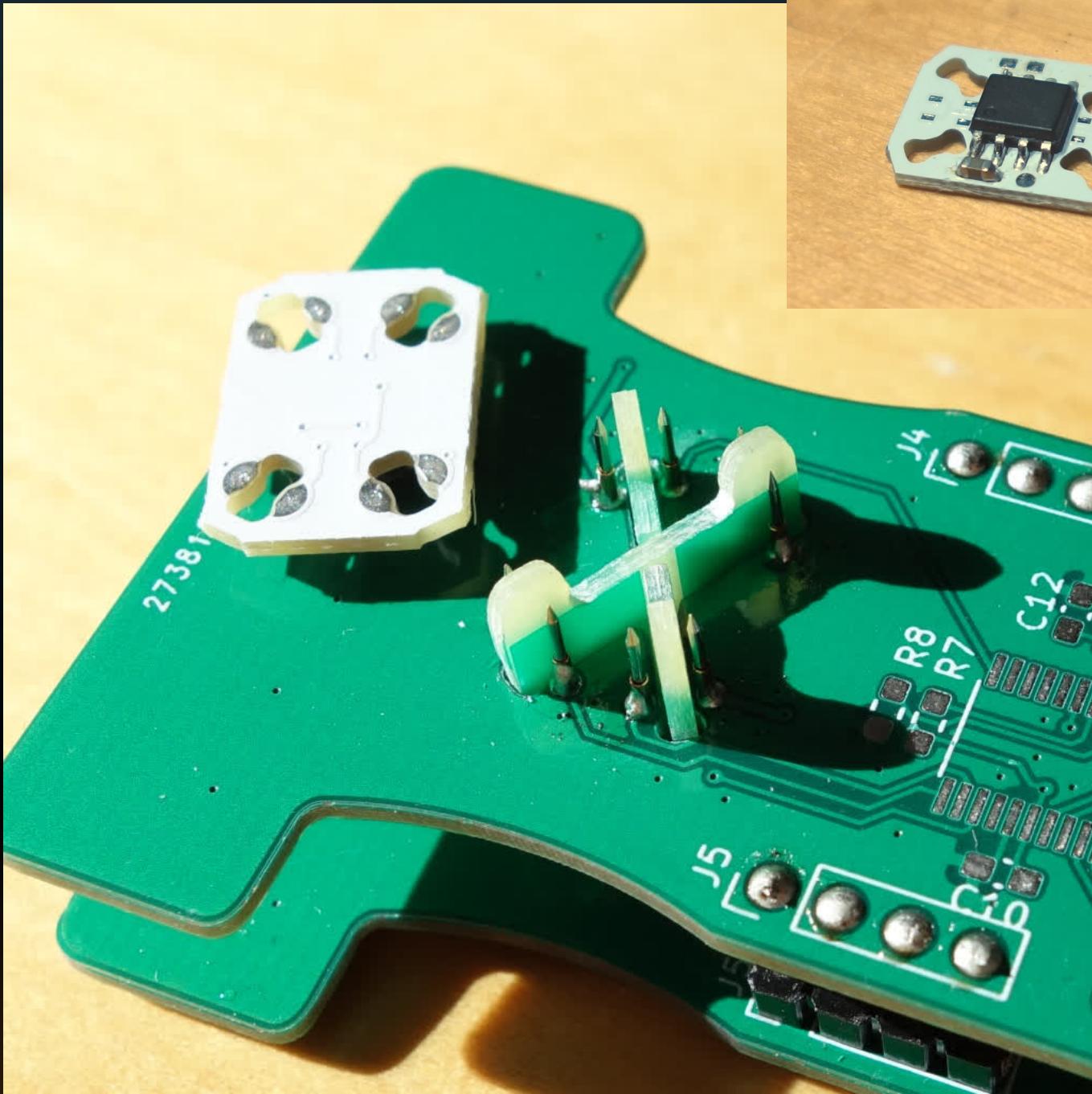
jigs



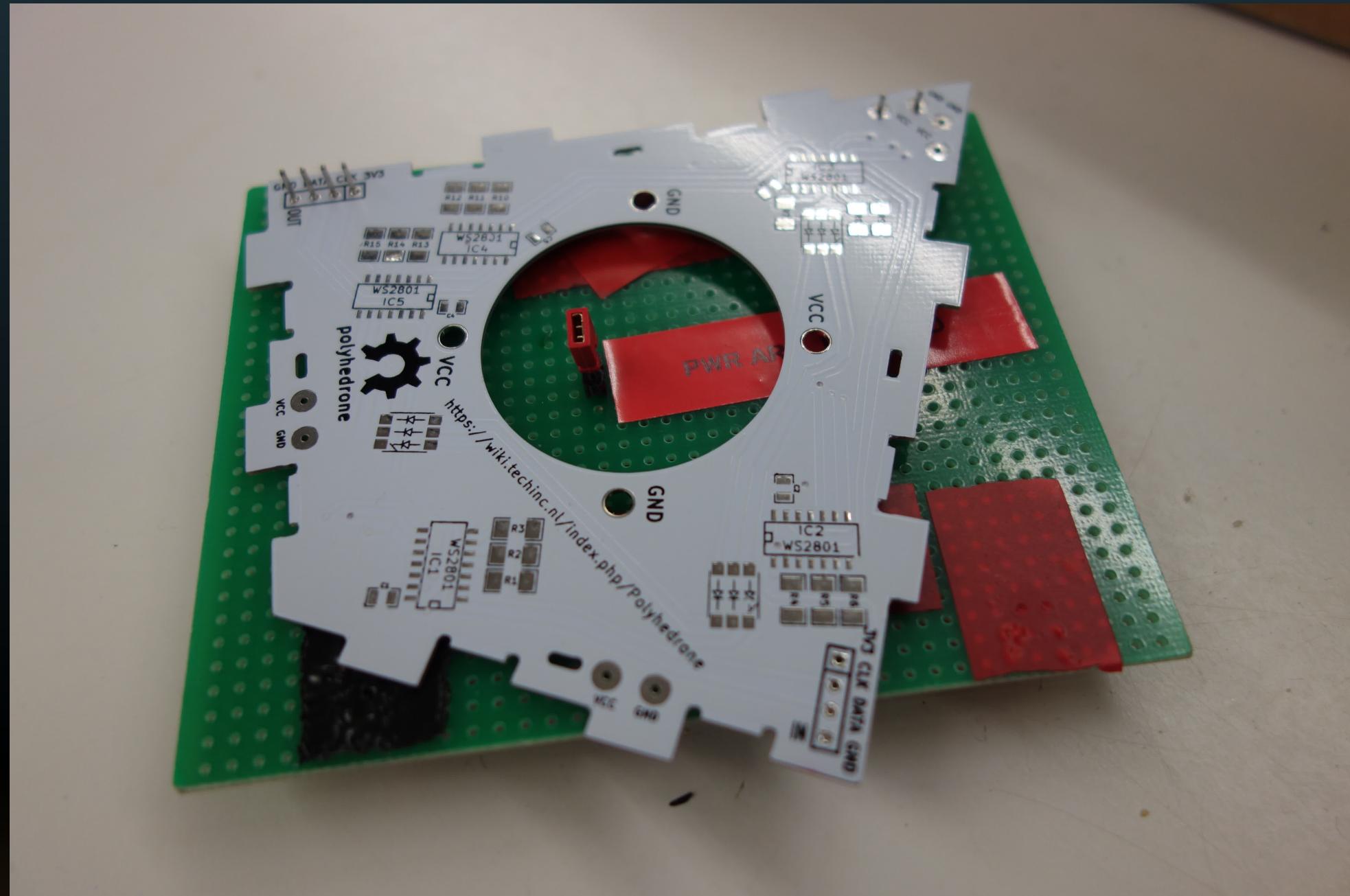
jigs



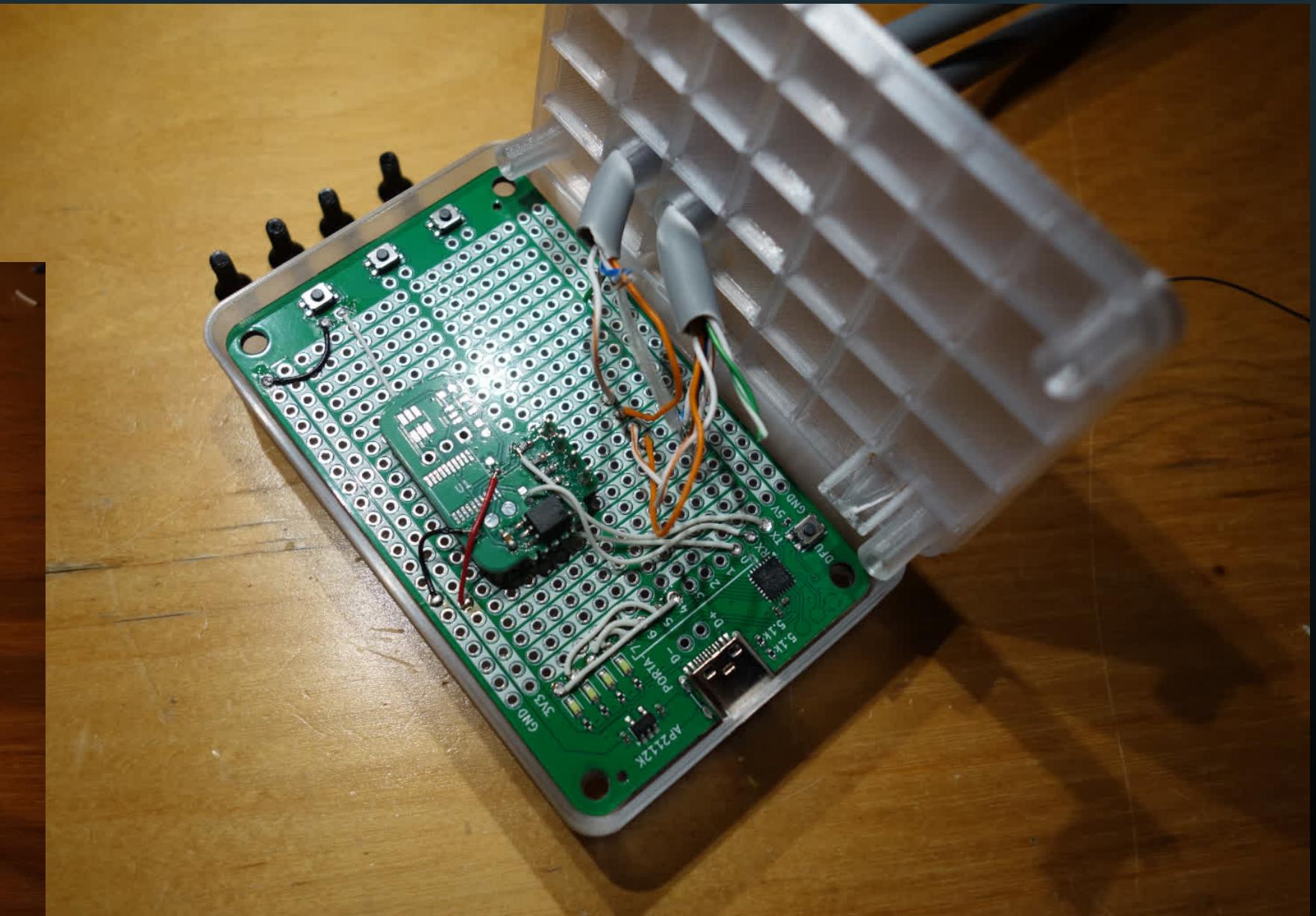
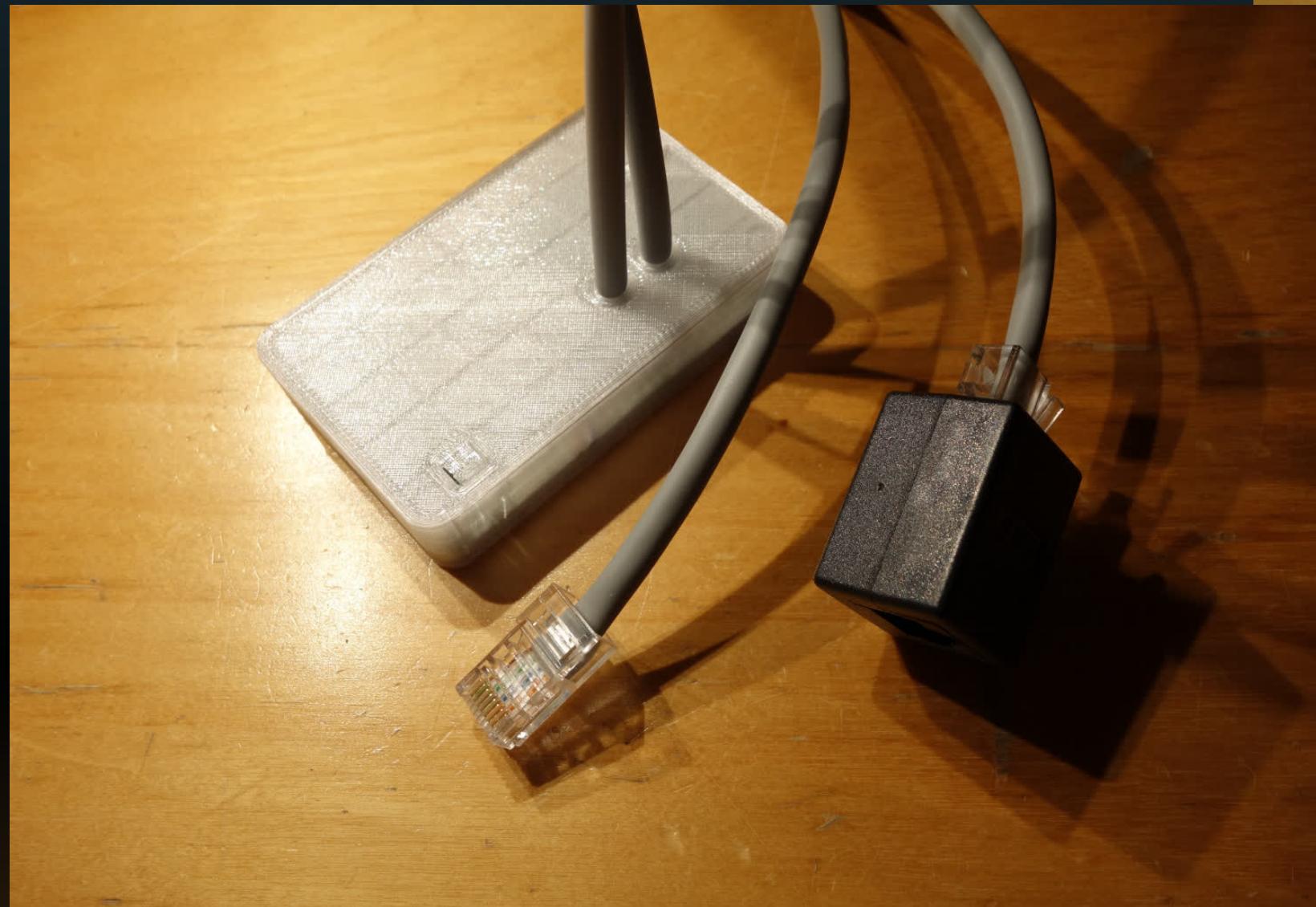
testers



testers



testers



Thanks!

