

# KiCAD a vysokorychlostní/mikrovlnné plošné spoje

Petr Polášek

6.10.2019

[https://github.com/MR-DOS/linuxdays2019\\_kicad\\_highspeed](https://github.com/MR-DOS/linuxdays2019_kicad_highspeed)



bastlíři SH

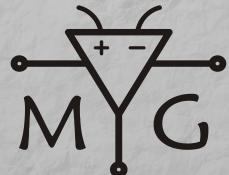
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# Prostor na dotazy bude u našeho stánku

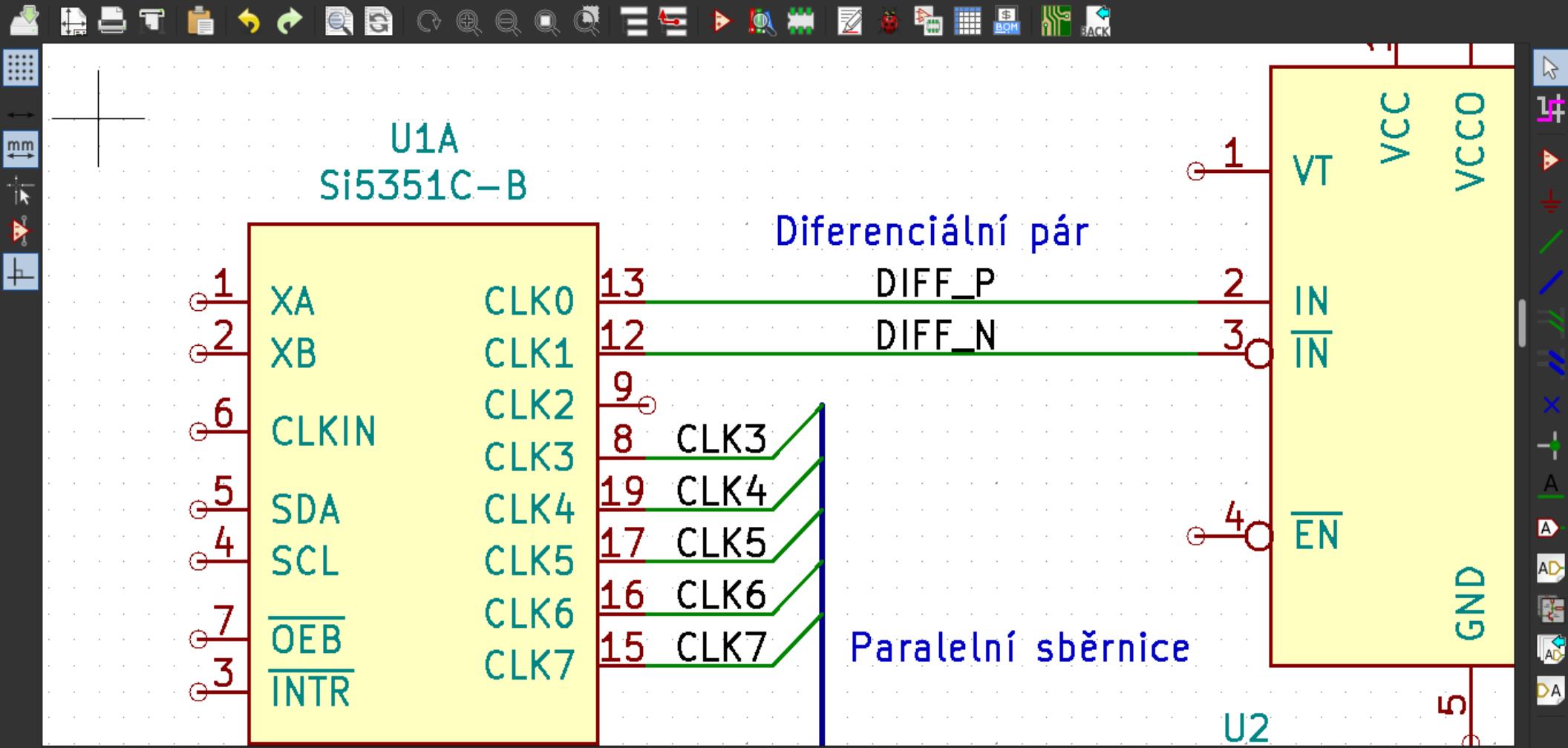


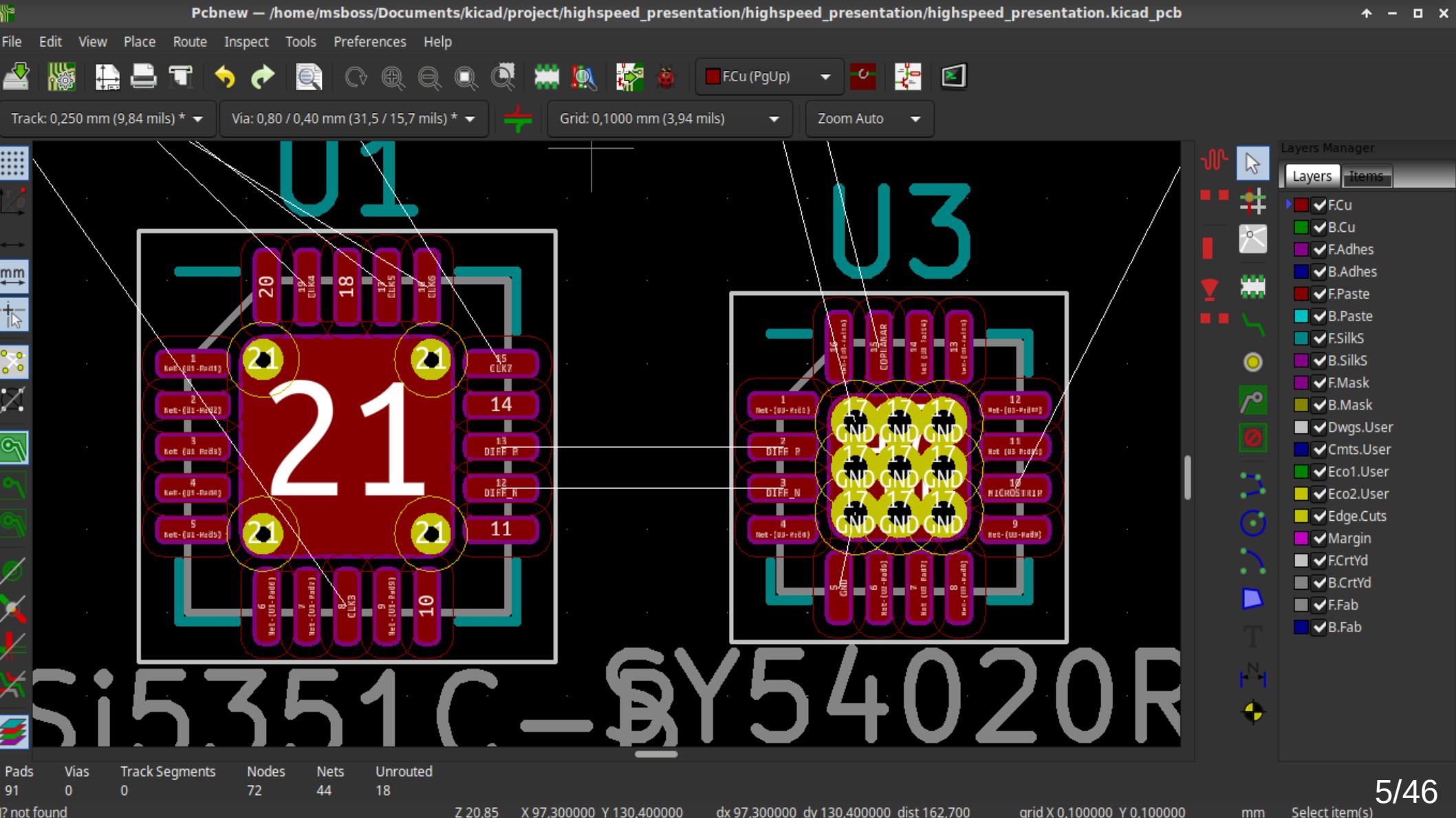
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# Diferenciální páry



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- ▼ Board Stackup
  - Board Editor Layers
  - Physical Stackup
- ▼ Defaults
  - Text & Graphics
  - Tracks & Vias
  - Solder Mask/Paste
- ▼ Design Rules
  - Constraints
  - Net Classes

## Net Classes

Name	Clearance	Track Width	Via Size	Via Drill	uVia Size	uVia Drill	dPair Width	dPair Gap
Default	0,2 mm	0,25 mm	0,8 mm	0,4 mm	0,3 mm	0,1 mm	0,2 mm	0,25 mm
DIFF_100R	0,2 mm	0,25 mm	0,8 mm	0,4 mm	0,3 mm	0,1 mm	0,2 mm	0,25 mm



## Net Class Memberships

## Filter Nets

Net class filter:

Net name filter:

## Assign Net Class

New net class:

Net	Net Class
/CLK3	Default
/CLK4	Default
/CLK5	Default
/CLK6	Default
/CLK7	Default
/COPLANAR	Default
/DIFF_N	Default
/DIFF_P	Default
/MICROSTRIP	Default

Regulators

Track Width

Via Size

Electrical Spacing

TransLine

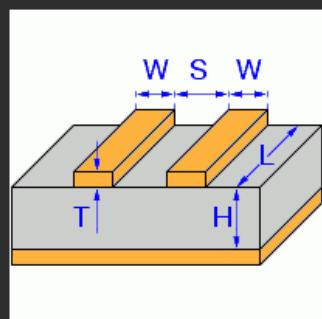
RF Attenuators

Color Code

Board Classes

Transmission Line Type:

- Microstrip Line
- Coplanar wave guide
- Coplanar wave guide with ground plane
- Rectangular Waveguide
- Coaxial Line
- Coupled Microstrip Line
- Stripline
- Twisted Pair



Substrate Parameters

Er: 4,6

...

TanD: 0,02

...

Rho: 1,72e-08

...

H: 0,2

mm ▾

H\_t: 1e+20

mm ▾

T: 0,035

mm ▾

Rough: 0

mm ▾

mu Rel C: 1

Physical Parameters:

W: 0,2

mm ▾

S: 0,2

mm ▾

L: 50

mm ▾



Analyze

Synthesize



Electrical Parameters:

Zeven: 50

Ohm ▾

Zodd: 50

Ohm ▾

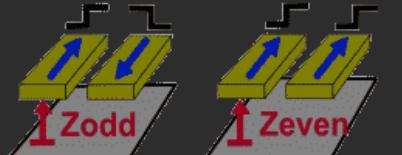
Ang\_L: 0

Radian ▾

Component Parameters:

Frequency: 1

GHz ▾



$$Z_{diff} = Z_{odd} * 2 \quad Z_{common} = Z_{even} / 2$$

Results:

ErEff Even:

ErEff Odd:

Conductor Losses Even:

Conductor Losses Odd:

Dielectric Losses Even:

Dielectric Losses Odd:

Skin Depth:

## Board Stackup

[Board Editor Layers](#)  
[Physical Stackup](#)

## Defaults

[Text & Graphics](#)  
[Tracks & Vias](#)  
[Solder Mask/Paste](#)

## Design Rules

[Constraints](#)  
[Net Classes](#)

## Net Classes

Name	Clearance	Track Width	Via Size	Via Drill	uVia Size	uVia Drill	dPair Width	dPair Gap
Default	0,2 mm	0,25 mm	0,8 mm	0,4 mm	0,3 mm	0,1 mm	0,2 mm	0,25 mm
DIFF_100R	0,2 mm	0,25 mm	0,8 mm	0,4 mm	0,3 mm	0,1 mm	0,2 mm	0,25 mm



## Net Class Memberships

## Filter Nets

Net class filter:

Net name filter:

[Show All Nets](#)[Apply Filters](#)

## Assign Net Class

New net class:

DIFF\_100R

[Assign To Listed Nets](#)[Assign To Selected Nets](#)

Net	Net Class
/CLK3	Default
/CLK4	Default
/CLK5	Default
/CLK6	Default
/CLK7	Default
/COPLANAR	Default
/DIFF_N	DIFF_100R
/DIFF_P	DIFF_100R
/MICROSTRIP	Default

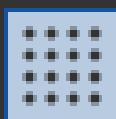
[Import Settings from Another Project...](#)[Cancel](#)[OK](#)



File Edit View Place Route Inspect Tools Preferences Help



Track: 0,250 mm (9,84 mil)



Set Layer Pair...

Route Single Track X

Route Differential Pair 6

Tune length of a single track 7

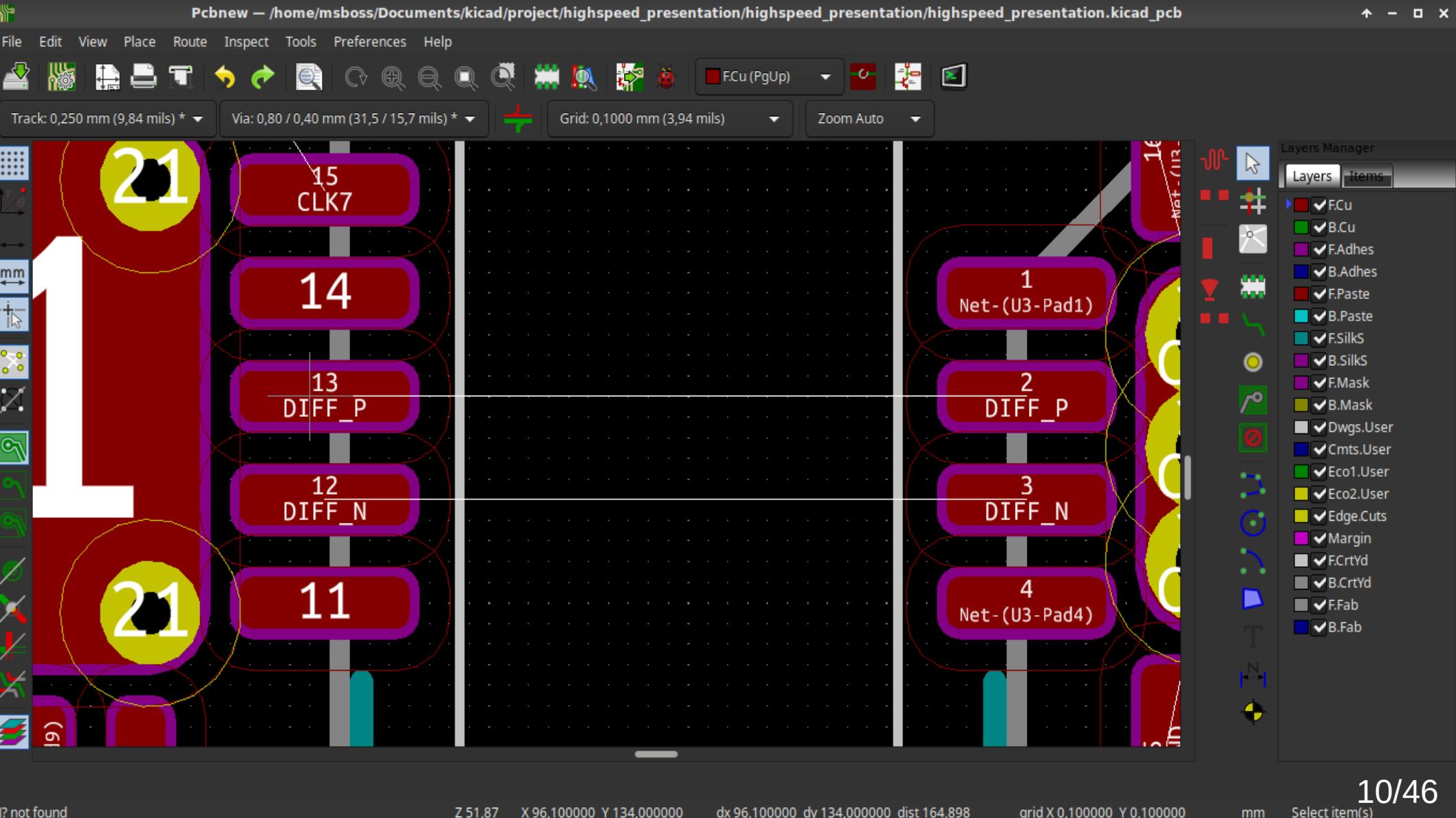
Tune length of a differential pair 8

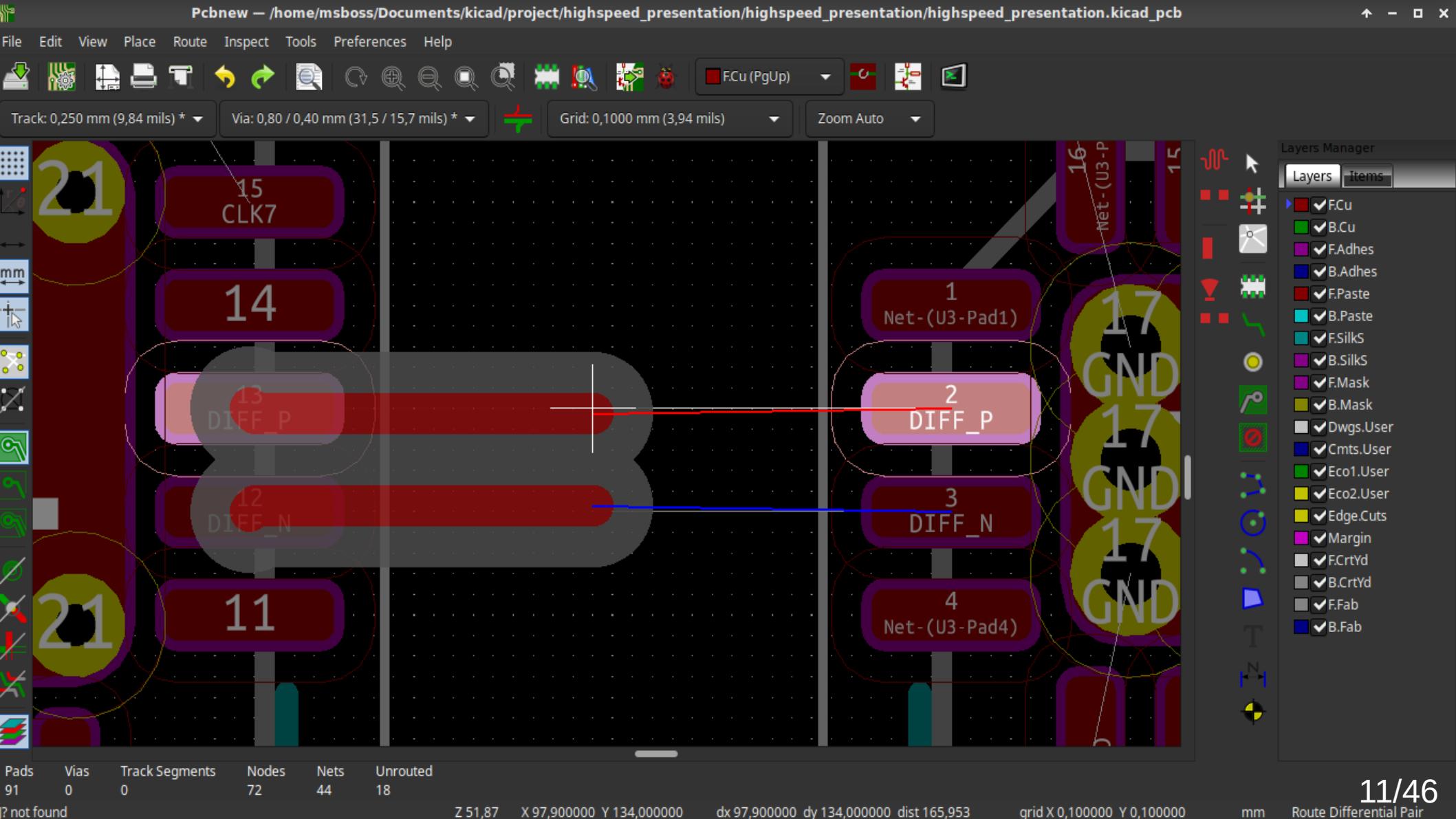
Tune skew of a differential pair 9

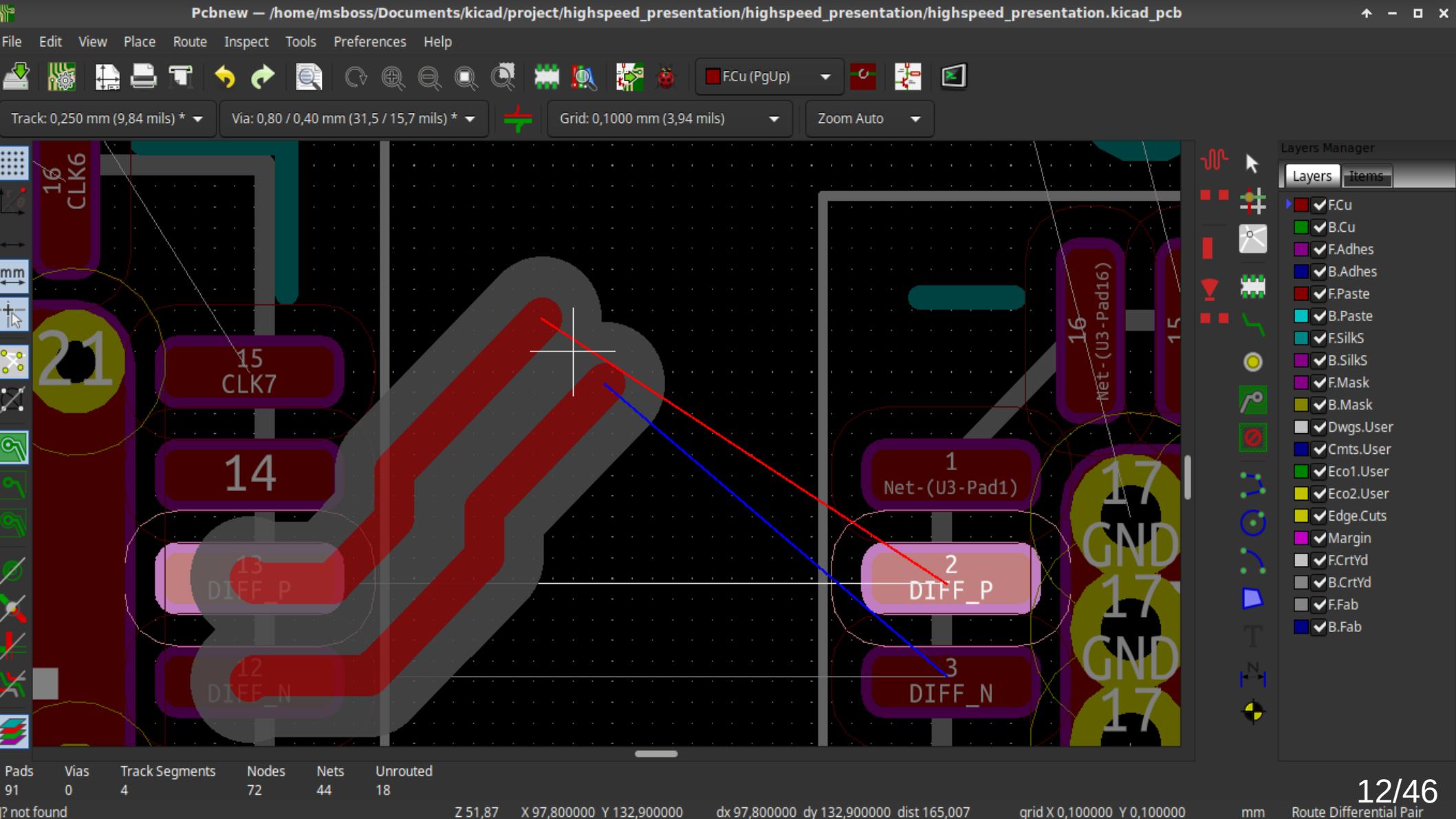
Interactive Router Settings... Shift+Ctrl+,



Grid: 0,100







File Edit View Place Route Inspect Tools Preferences Help

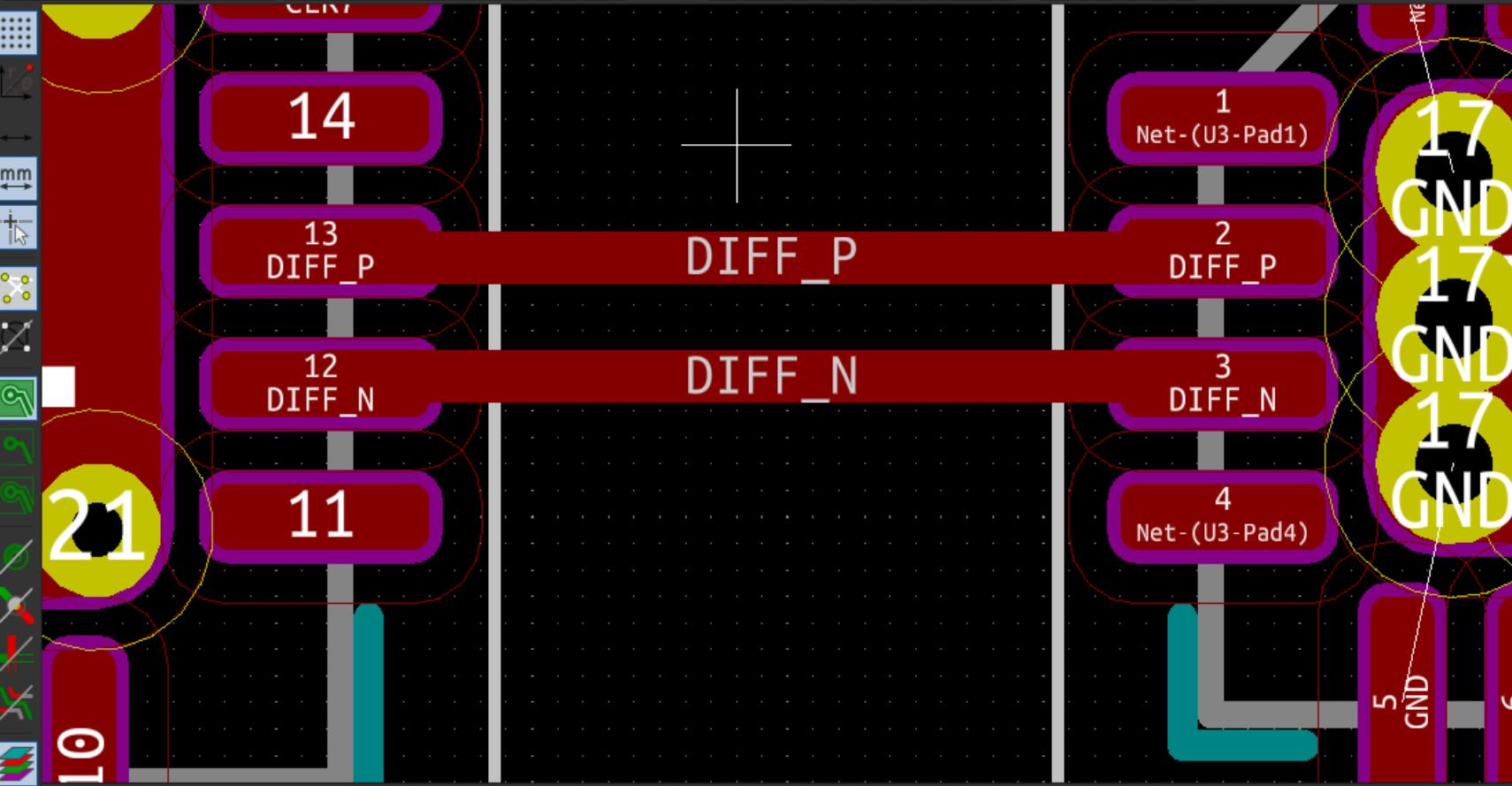


Track: 0,250 mm (9,84 mils) \*

Via: 0,80 / 0,40 mm (31,5 / 15,7 mils) \*

Grid: 0,1000 mm (3,94 mils)

Zoom Auto



Pads Vias Track Segments Nodes Nets Unrouted  
91 0 6 72 44 16

Z 51.87 X 97,800000 Y 133,600000

dx 97,800000 dy 133,600000 dist 165,571

grid X 0,100000 Y 0,100000

mm Route Differential Pair

13/46

? not found

Layers Manager

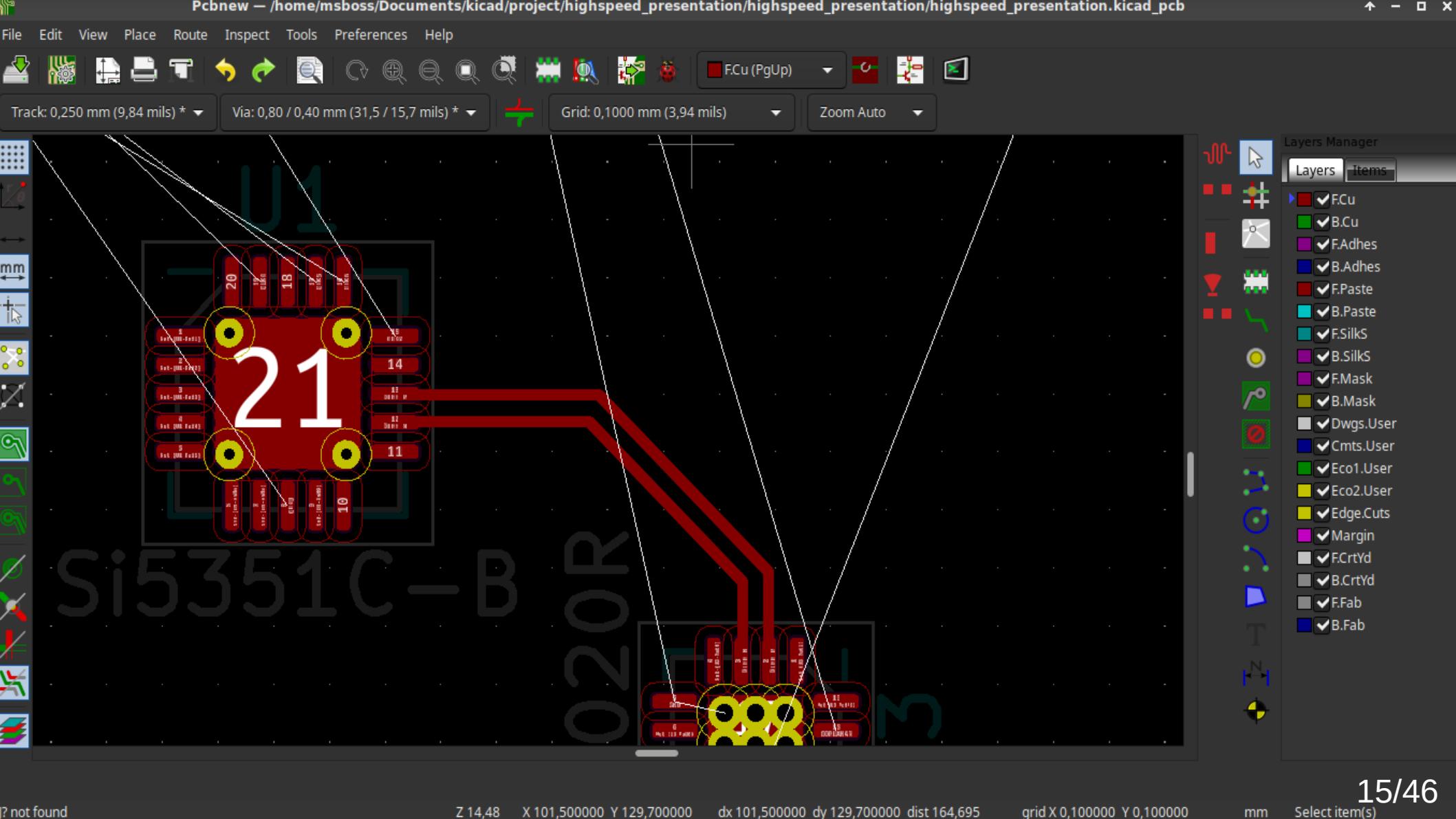
Layers Items

- F.Cu
- B.Cu
- F.Adhes
- B.Adhes
- F.Paste
- B.Paste
- F.SilkS
- B.SilkS
- F.Mask
- B.Mask
- Dwgs.User
- Cmts.User
- Eco1.User
- Eco2.User
- Edge.Cuts
- Margin
- F.CrtYd
- B.CrtYd
- F.Fab
- B.Fab

# Vyrovnaní délek



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File Edit View Place Route Inspect Tools Preferences Help



Track: 0,250 mm (9,84 mil)



mm



Set Layer Pair...

Route Single Track

Route Differential Pair

Tune length of a single track

Tune length of a differential pair

Tune skew of a differential pair

Interactive Router Settings...

X

6

7

8

9

Shift+Ctrl+,



Grid: 0,1000 mm (3,94 mil)

File Edit View Place Route Inspect Tools Preferences Help

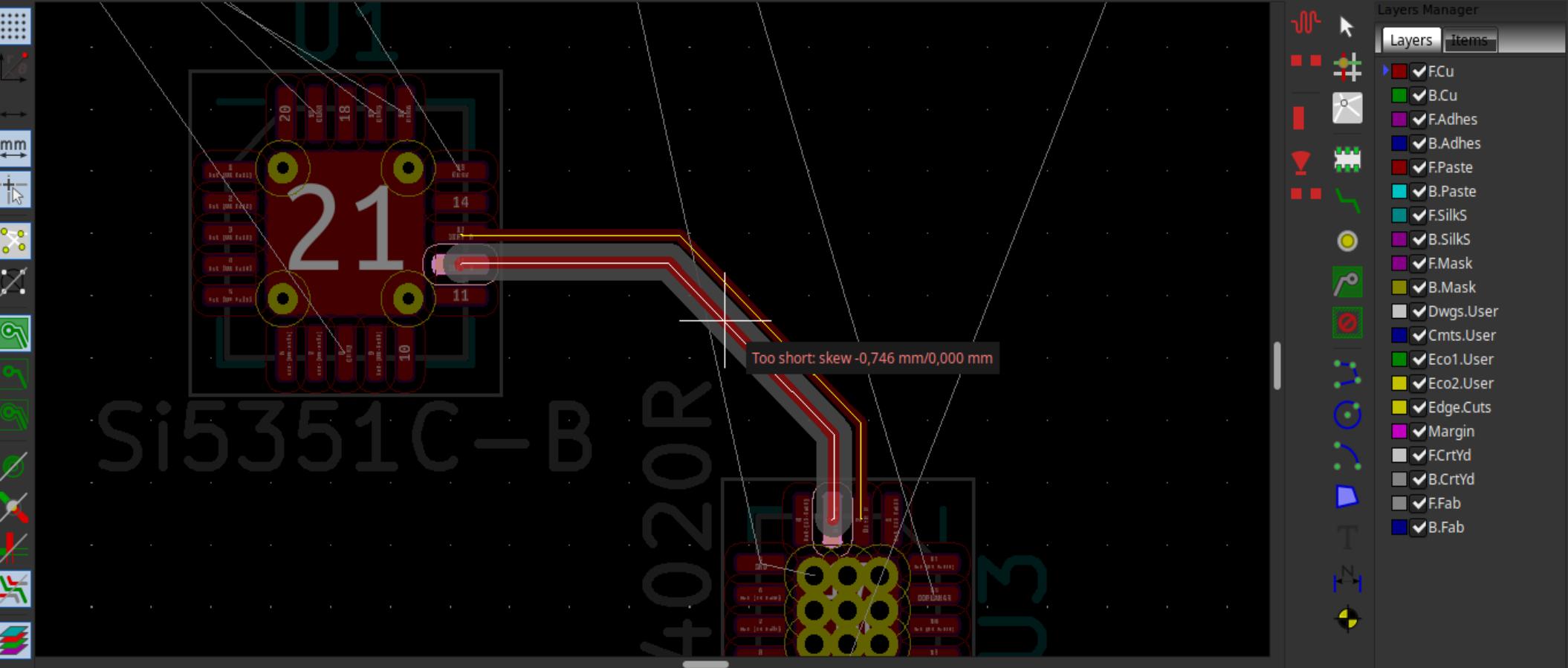


Track: 0,250 mm (9,84 mils) \*

Via: 0,80 / 0,40 mm (31,5 / 15,7 mils) \*

Grid: 0,1000 mm (3,94 mils)

Zoom Auto



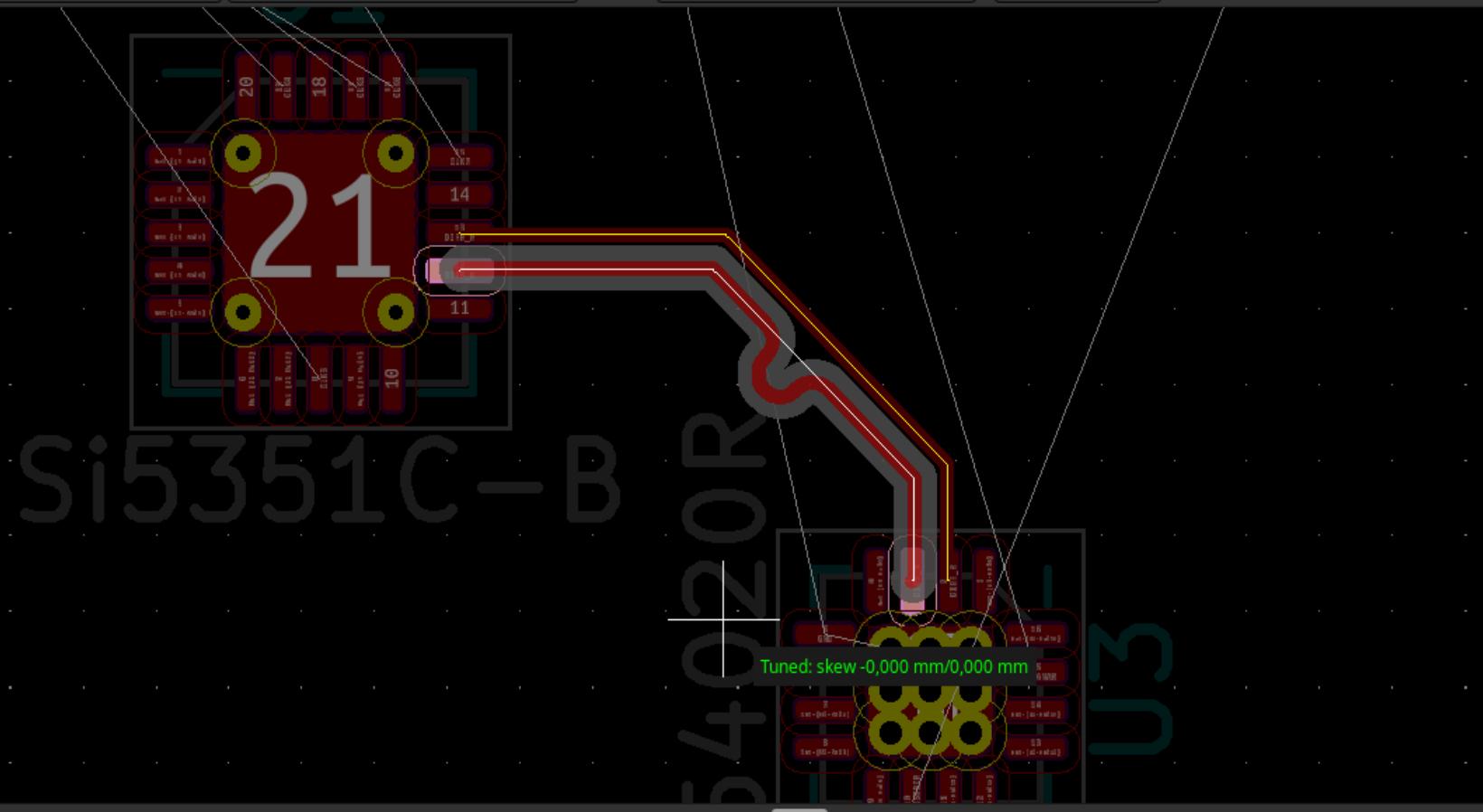
File Edit View Place Route Inspect Tools Preferences Help



Track: 0,250 mm (9,84 mils) \* Via: 0,80 / 0,40 mm (31,5 / 15,7 mils) \*

Grid: 0,1000 mm (3,94 mils)

Zoom Auto



Layers Manager

Layers Items

- F.Cu
- B.Cu
- F.Adhes
- B.Adhes
- F.Paste
- B.Paste
- F.SilkS
- B.SilkS
- F.Mask
- B.Mask
- Dwgs.User
- Cmts.User
- Eco1.User
- Eco2.User
- Edge.Cuts
- Margin
- F.CrtYd
- B.CrtYd
- F.Fab
- B.Fab

Pads Vias Track Segments Nodes Nets Unrouted  
91 0 10 72 44 16

Z 14,48 X 99,800000 Y 139,1000000 dx 99,800000 dy 139,100000 dist 171,198

grid X 0,100000 Y 0,1000000

mm Tune skew of a different...

File Edit View Place Route Inspect Tools Preferences Help



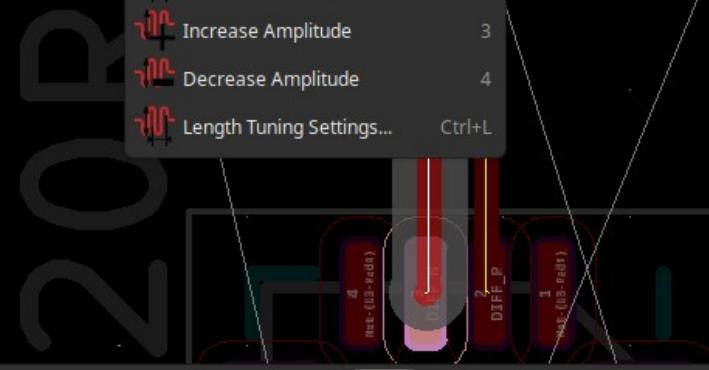
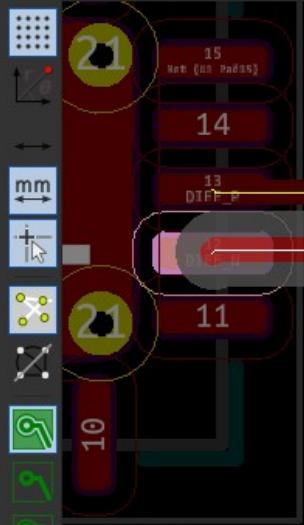
Track: 0,250 mm (9,84 mils) \*

Via: 0,80 / 0,40 mm (31,5 / 15,7 mils) \*



Grid: 0,1000 mm (3,94 mils)

Zoom Auto



- Length Tuner
- Cancel
- Increase Spacing
- Decrease Spacing
- Increase Amplitude
- Decrease Amplitude
- Length Tuning Settings... Ctrl+L

## Layers Manager

Layers Items

- F.Cu
- B.Cu
- F.Adhes
- B.Adhes
- F.Paste
- B.Paste
- F.SilkS
- B.SilkS
- F.Mask
- B.Mask
- Dwg.User
- Cmts.User
- Eco1.User
- Eco2.User
- Edge.Cuts
- Margin
- F.CrtYd
- B.CrtYd
- F.Fab
- B.Fab

Pads 187 Vias 0 Track Segments 46 Nodes 168 Nets 129 Unrouted 26

U? not found

Z 22,99 X 100,000000 Y 134,800000

dx 100,000000 dy 134,800000 dist 167,842

grid X 0,100000 Y 0,100000

mm

Tune skew of a different...

19/46

File Edit View Place Route Inspect Tools Preferences Help

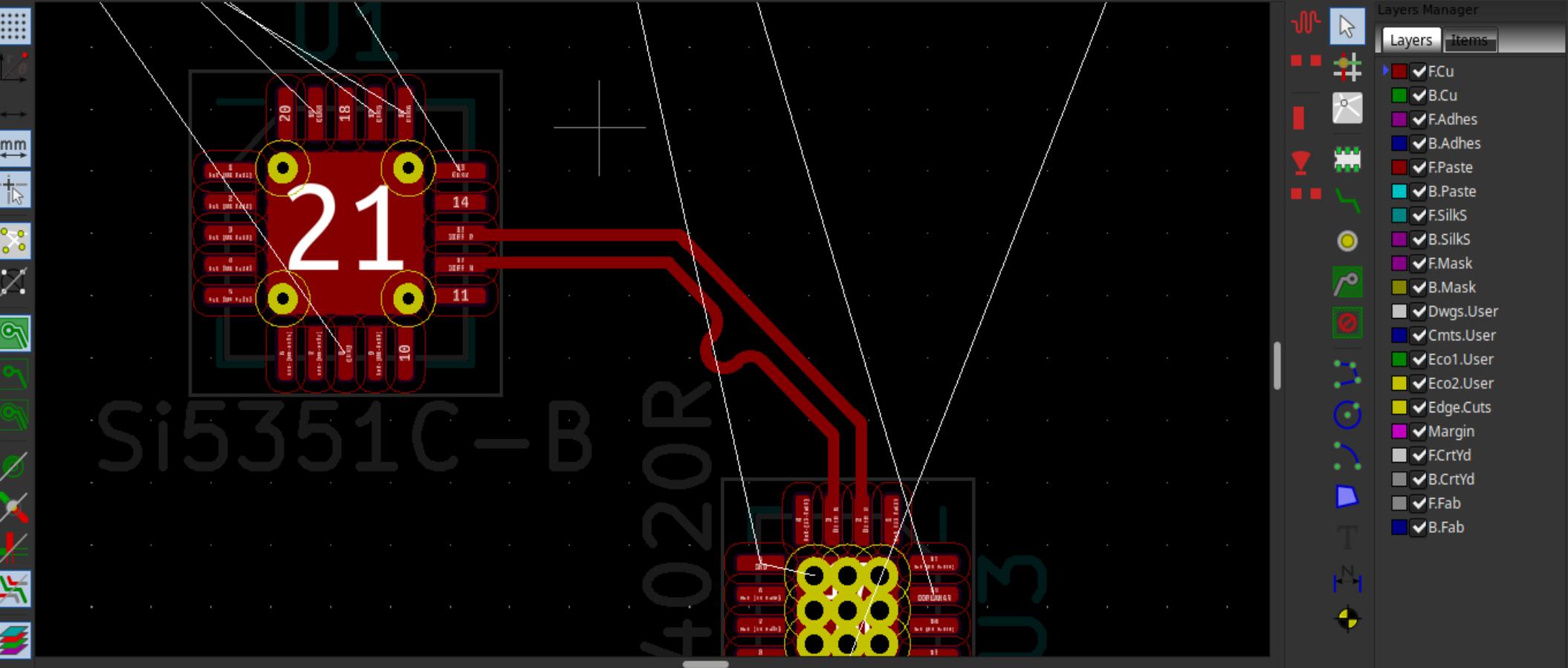


Track: 0,250 mm (9,84 mils) \*

Via: 0,80 / 0,40 mm (31,5 / 15,7 mils) \*

Grid: 0,1000 mm (3,94 mils) \*

Zoom Auto



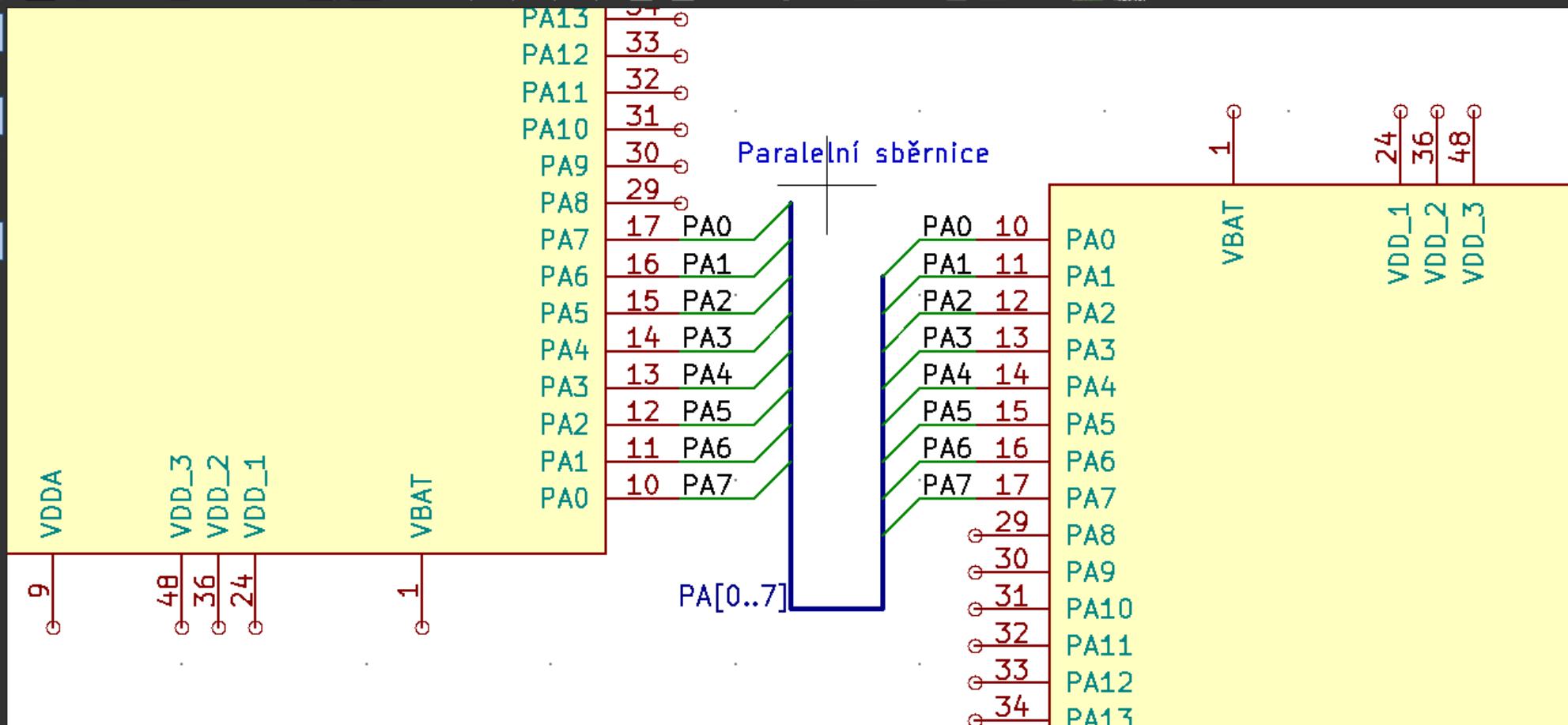
# Paralelní sběrnice



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## Eeschema — highspeed\_presentation.sch [/] — /home/msboss/Documents/kicad/project/highspeed\_presentation/highspeed\_presentation

File Edit View Place Inspect Tools Preferences Help



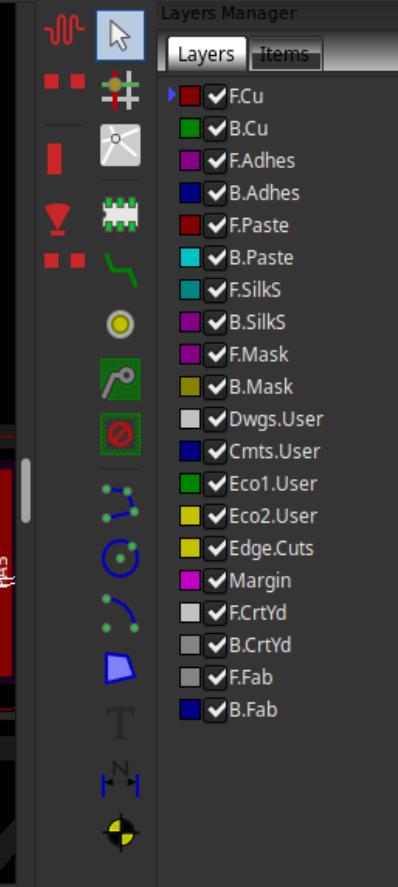
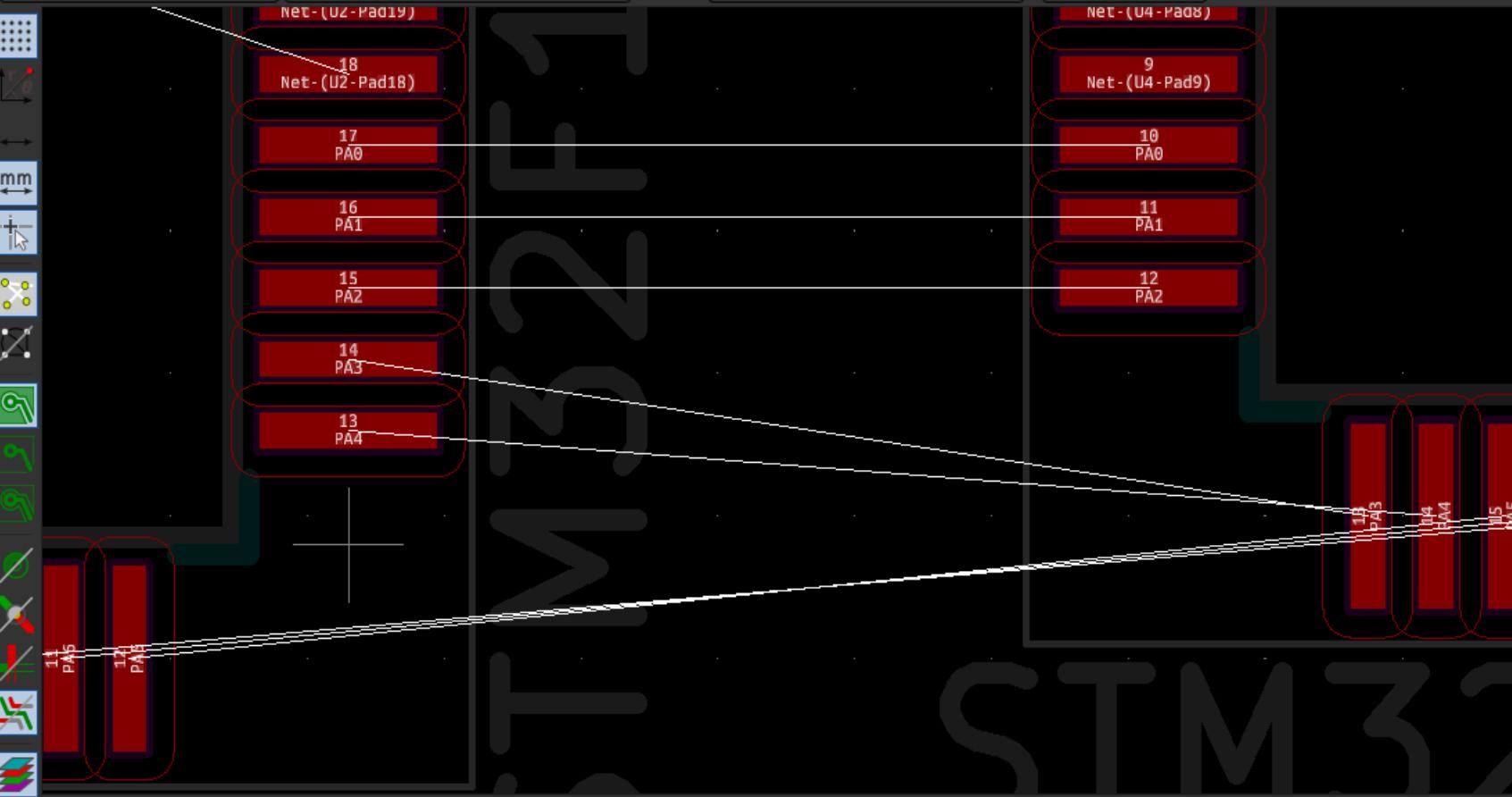


Track: 0,250 mm (9,84 mils) \*

Via: 0,80 / 0,40 mm (31,5 / 15,7 mils) \*

Grid: 0,1000 mm (3,94 mils) \*

Zoom Auto



Pads Vias Track Segments Nodes Nets Unrouted  
187 0 41 168 129 27

Z 27,59 X 123,300000 Y 132,2000000 dx 123,300000 dy 132,2000000 dist 180,775

grid X 0,100000 Y 0,1000000

mm Select item(s)

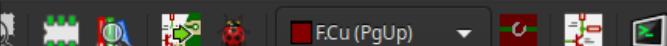


File Edit View Place Route Inspect Tools Preferences Help



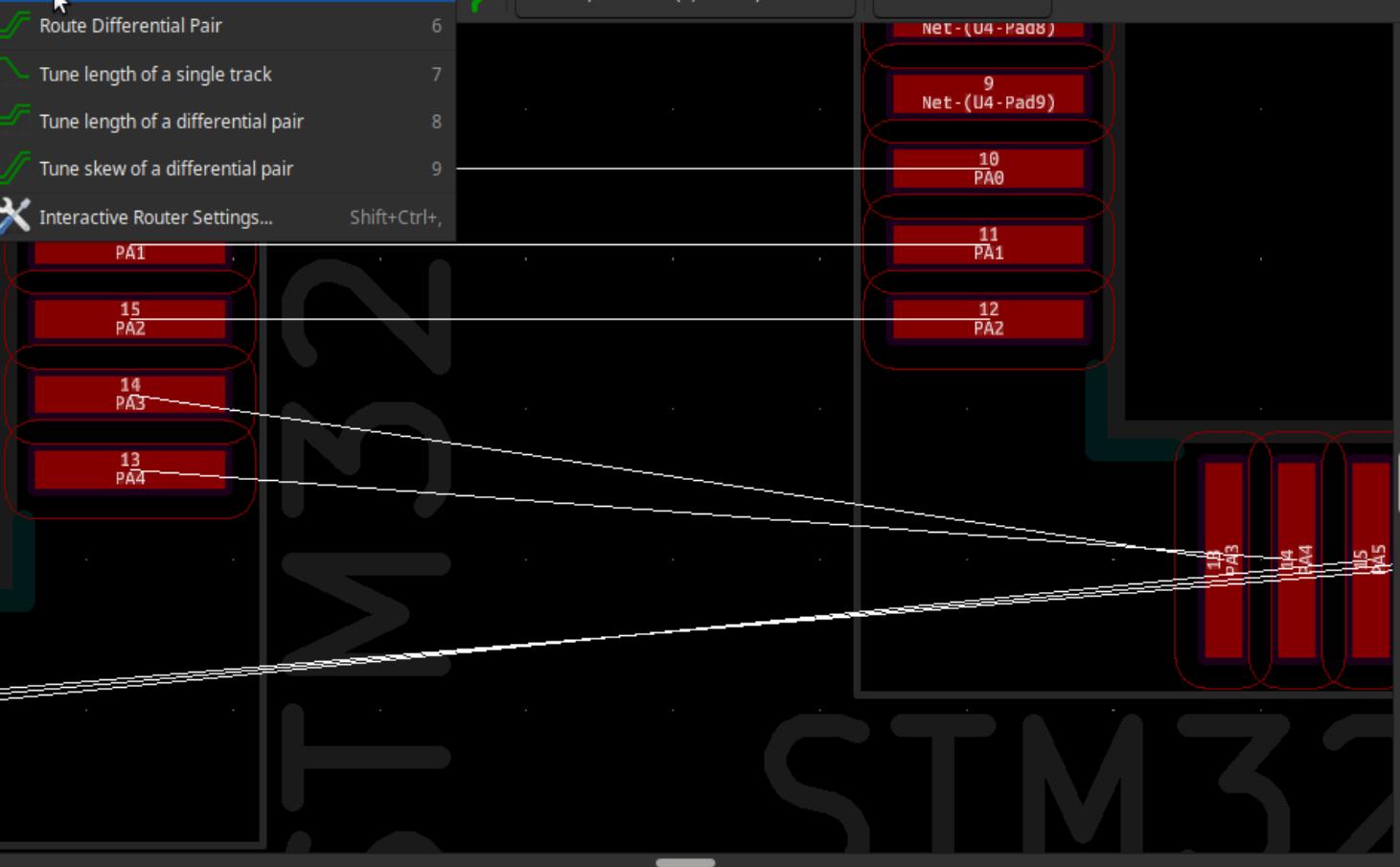
Track: 0,250 mm (9,84 mil)

- Set Layer Pair...
- Route Single Track X
- Route Differential Pair 6
- Tune length of a single track 7
- Tune length of a differential pair 8
- Tune skew of a differential pair 9
- Interactive Router Settings... Shift+Ctrl+,



Grid: 0,1000 mm (3,94 mils)

Zoom Auto



Layers Manager

Layers Items

- F.Cu
- B.Cu
- F.Adhes
- B.Adhes
- F.Paste
- B.Paste
- F.SilkS
- B.SilkS
- F.Mask
- B.Mask
- Dwgs.User
- Cmts.User
- Eco1.User
- Eco2.User
- Edge.Cuts
- Margin
- F.CrtYd
- B.CrtYd
- F.Fab
- B.Fab

Pads Vias Track Segments Nodes Nets Unrouted  
187 0 41 168 129 27

Z 27,59 X 123,100000 Y 128,200000

dx 123,100000 dy 128,200000 dist 177,733

grid X 0,100000 Y 0,100000

mm Select item 24/46



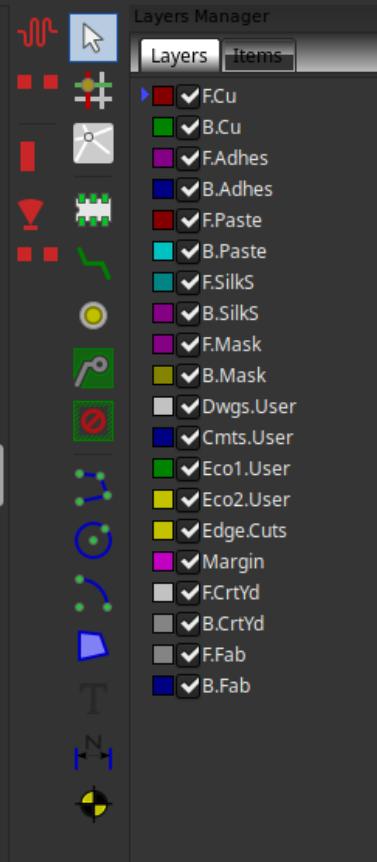
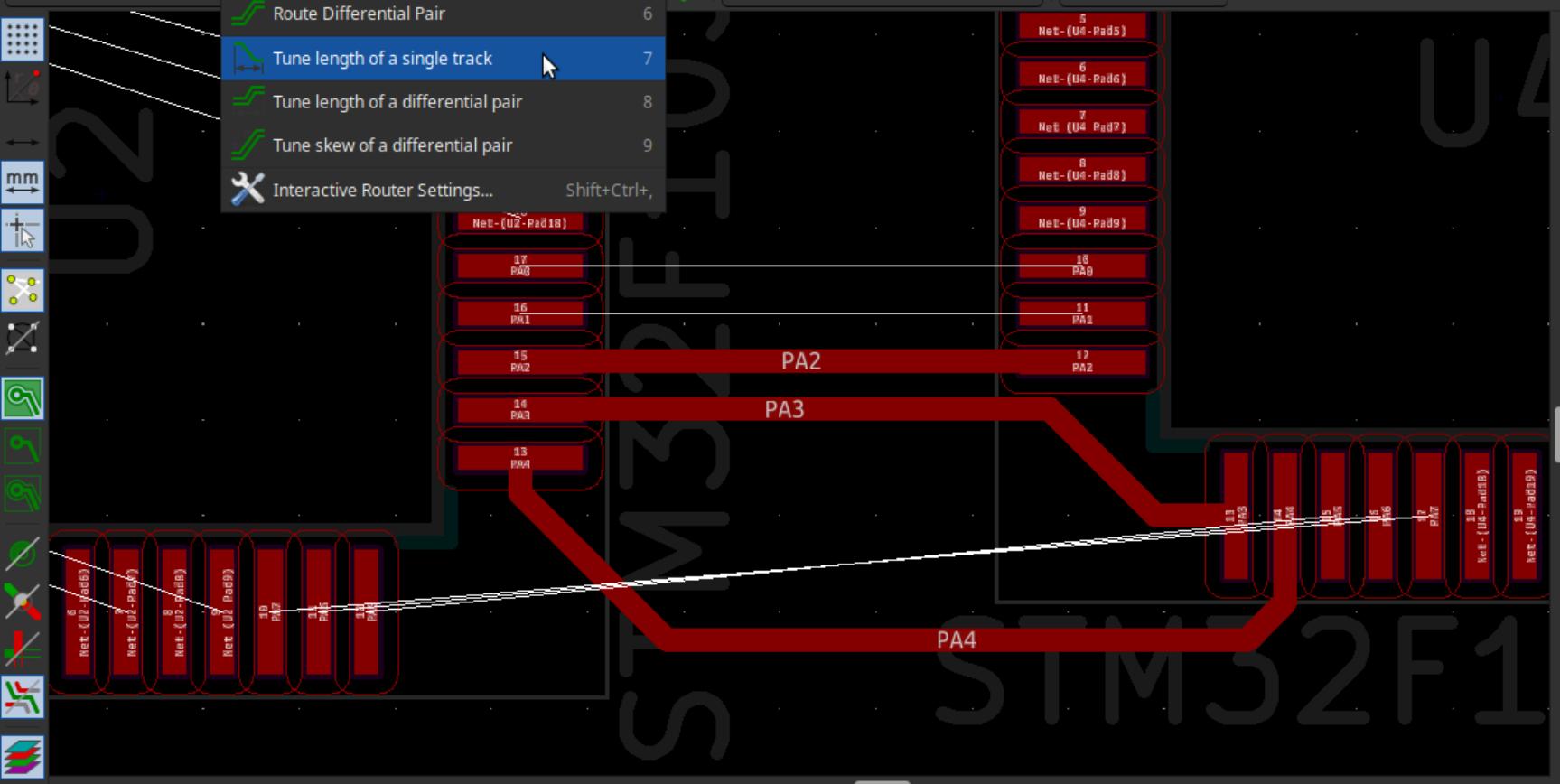
File Edit View Place Route Inspect Tools Preferences Help



Track: 0,250 mm (9,84 mil)

- Set Layer Pair...
- Route Single Track
- Route Differential Pair
- Tune length of a single track
- Tune length of a differential pair
- Tune skew of a differential pair
- Interactive Router Settings... Shift+Ctrl+,

X Grid: 0,1000 mm (3,94 mils) Zoom Auto



Pads 187 Vias 0 Track Segments 50 Nodes 168 Nets 129 Unrouted 24

(7)

Z 19,16 X 120,600000 Y 126,700000

dx 120,600000 dy 126,700000 dist 174,921

grid X 0,100000 Y 0,100000

mm Select item(s) 25/46

# Vyrovnaní délek

Podruhé a s více možnostmi



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File Edit View Place Route Inspect Tools Preferences Help

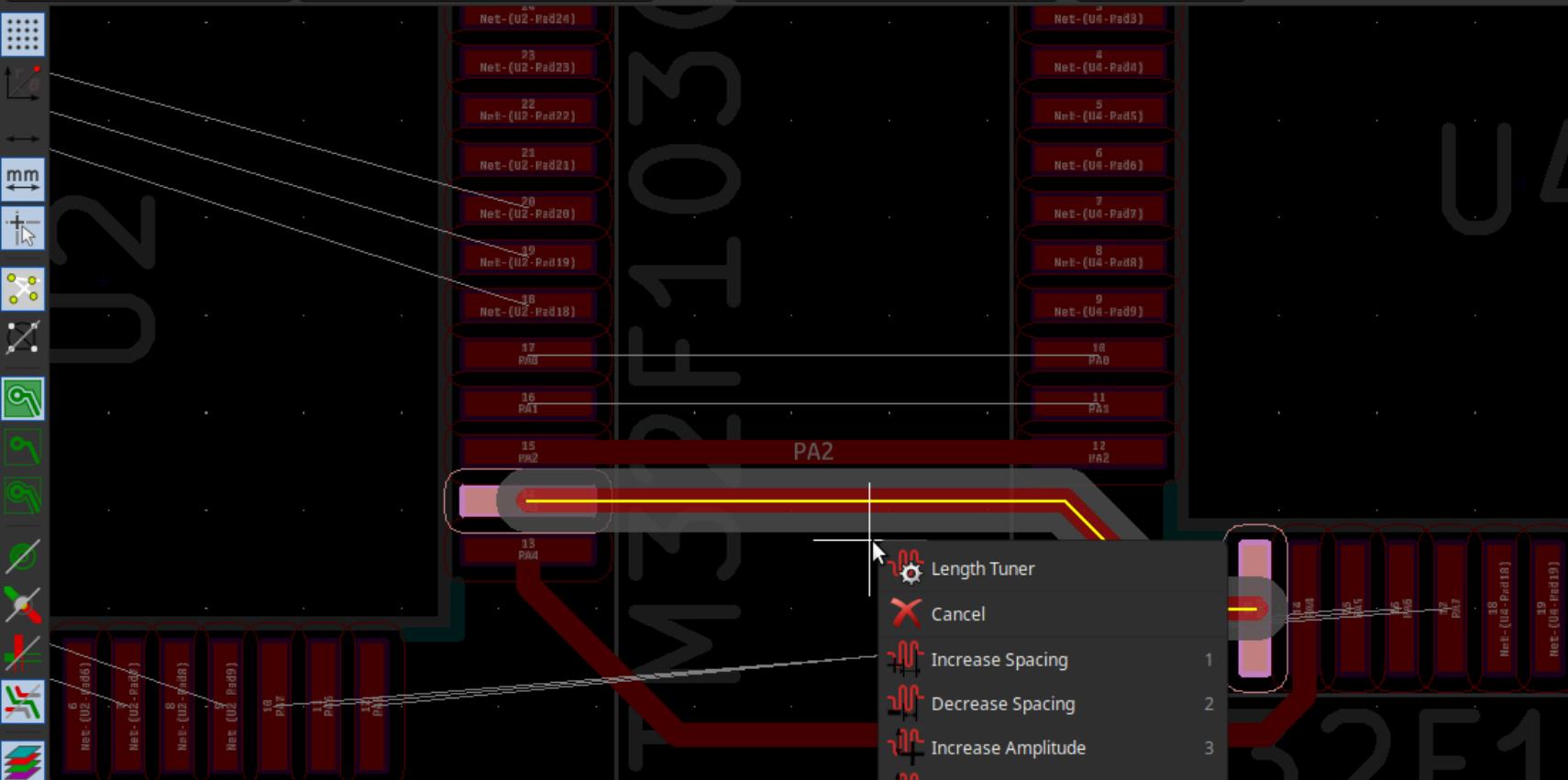


Track: 0,250 mm (9,84 mils) \*

Via: 0,80 / 0,40 mm (31,5 / 15,7 mils) \*

Grid: 0,1000 mm (3,94 mils)

Zoom Auto



## Layers Manager

Layers Items

- FCu
- BCu
- FAdhes
- B.Adhes
- FPaste
- BPaste
- FSilkS
- BSilkS
- FMask
- B.Mask
- Dwgs.User
- Cmts.User
- Eco1.User
- Eco2.User
- Edge.Cuts
- Margin
- FCrtYd
- BCrtYd
- FFab
- BFab

Pads	Vias	Track Segments	Nodes	Nets	Unrouted
187	0	50		168	24

U? not found

Z 19,16 X 126,800000 Y 131,300000

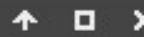
dx 120,000000 dy 151,300000 dist 182,532

grid X 0,100000 Y 0,100000

mm Tune length f simule.. 27/46



# Single Track Length Tuning



## Length / Skew

Tune from:

Tune to:

Constraint:

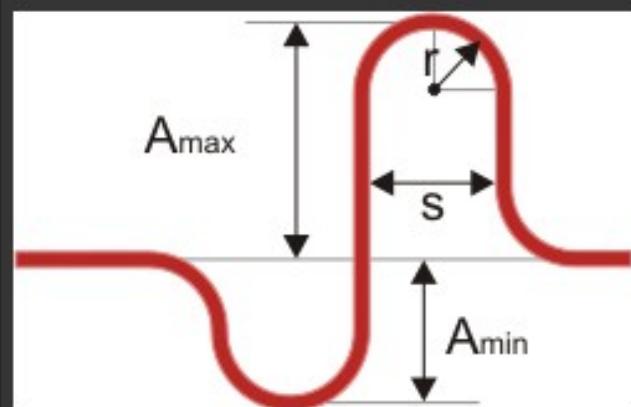
Manual

Target length:

10,022

mm

## Meandering



Min amplitude ( $A_{min}$ ):

0,1

mm

Max amplitude ( $A_{max}$ ):

1

mm

Spacing ( $s$ ):

0,6

mm

Miter style:

arc

▼

Miter radius ( $r$ ):

100

%

Cancel

OK



File Edit View Place Route Inspect Tools Preferences Help

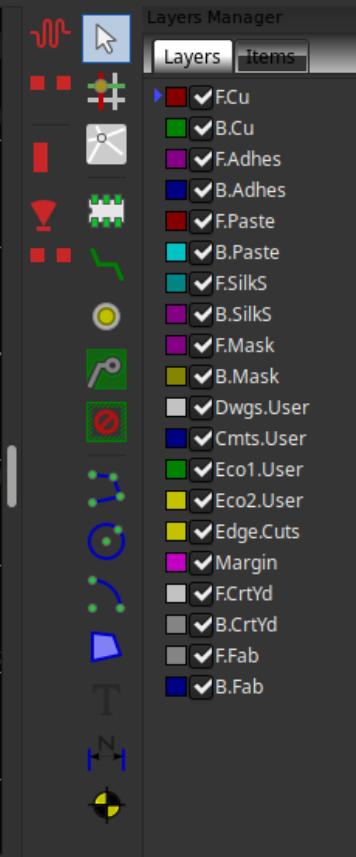
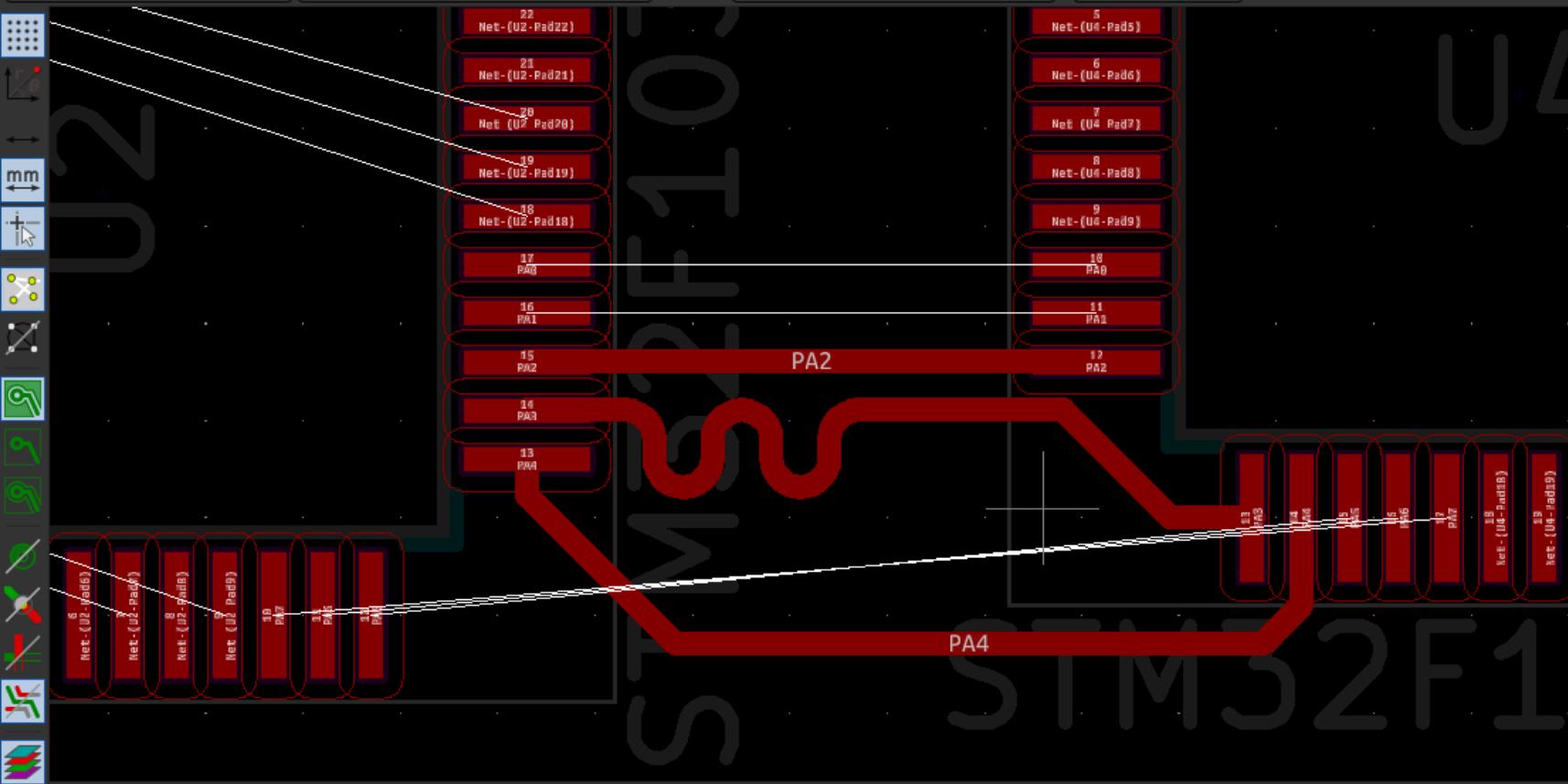


Track: 0,250 mm (9,84 mils) \*

Via: 0,80 / 0,40 mm (31,5 / 15,7 mils) \*

Grid: 0,1000 mm (3,94 mils)

Zoom Auto



Pads 187 Vias 0 Track Segments 111 Nodes 168 Nets 129 Unrouted 24

Z 19,16 X 128,600000 Y 131,900000

dx 128,600000 dy 131,900000 dist 184,216

grid X 0,100000 Y 0,100000

mm Select items



File Edit View Place Route Inspect Tools Preferences Help

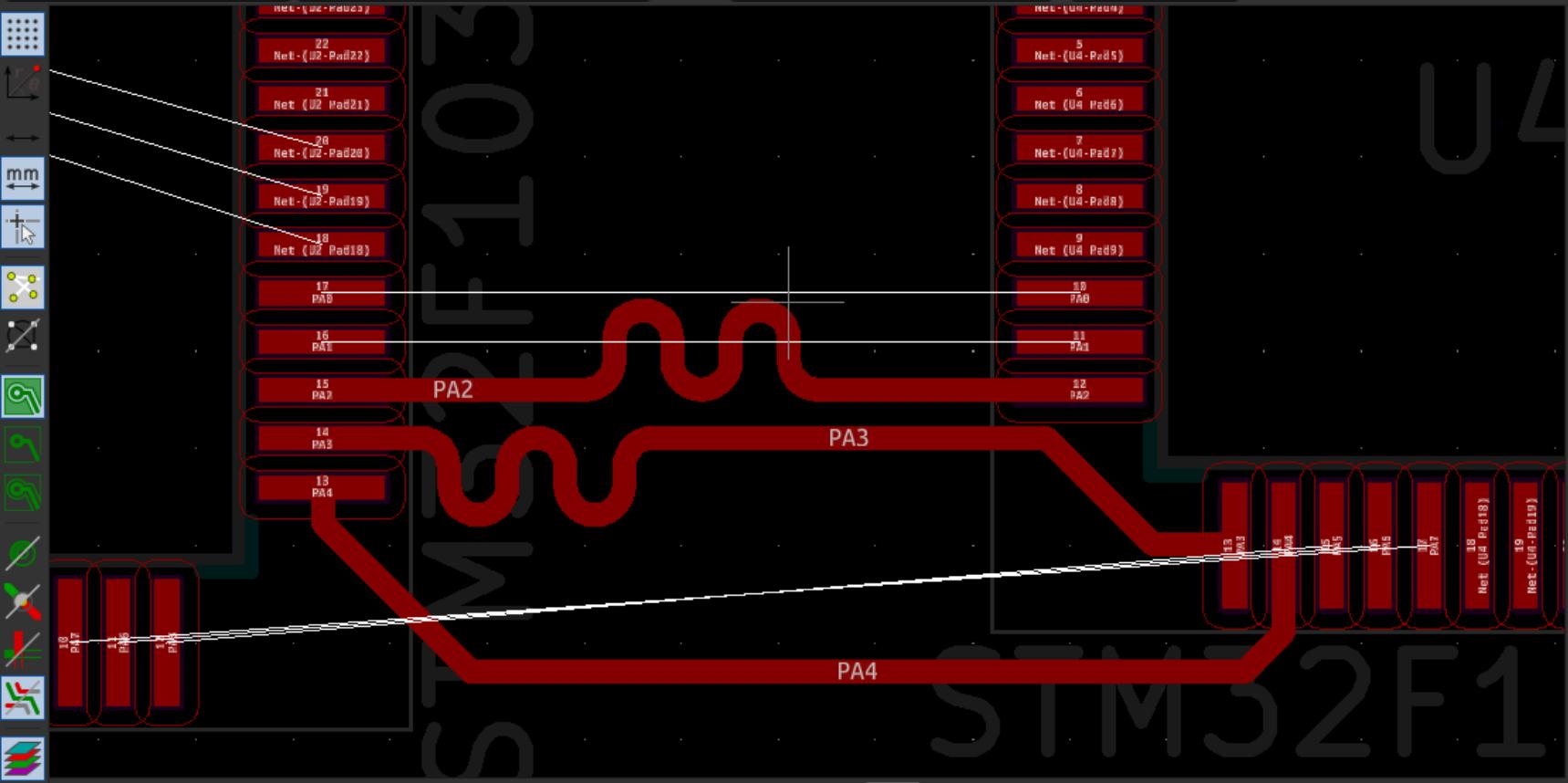


Track: 0,250 mm (9,84 mils) \* ▾

Via: 0,80 / 0,40 mm (31,5 / 15,7 mils) \* ▾

Grid: 0,1000 mm (3,94 mils) ▾

Zoom Auto ▾



Pads 187 Vias 0 Track Segments 173 Nodes 168 Nets 129 Unrouted 24

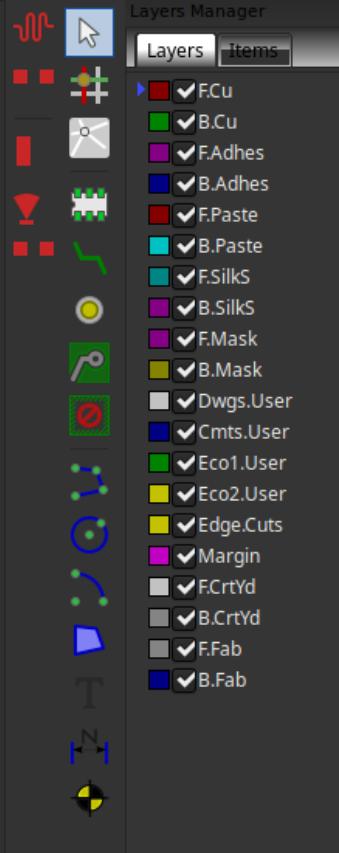
U? not found

Z 19,16 X 128,100000 Y 129,500000

dx 128,100000 dy 129,500000 dist 182,153

grid X 0,100000 Y 0,100000

mm Select items 30/46



File Edit View Place Route Inspect Tools Preferences Help



Track: 0,250 mm (9,84 mils) \*

Via: 0,80 / 0,40 mm (31,5 / 15,7 mils) \*

Grid: 0,1000 mm (3,94 mils)

Zoom Auto



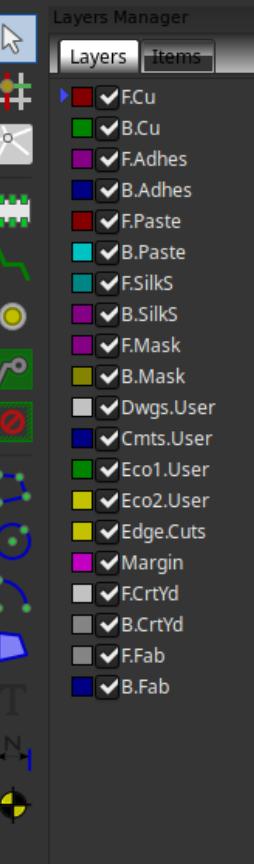
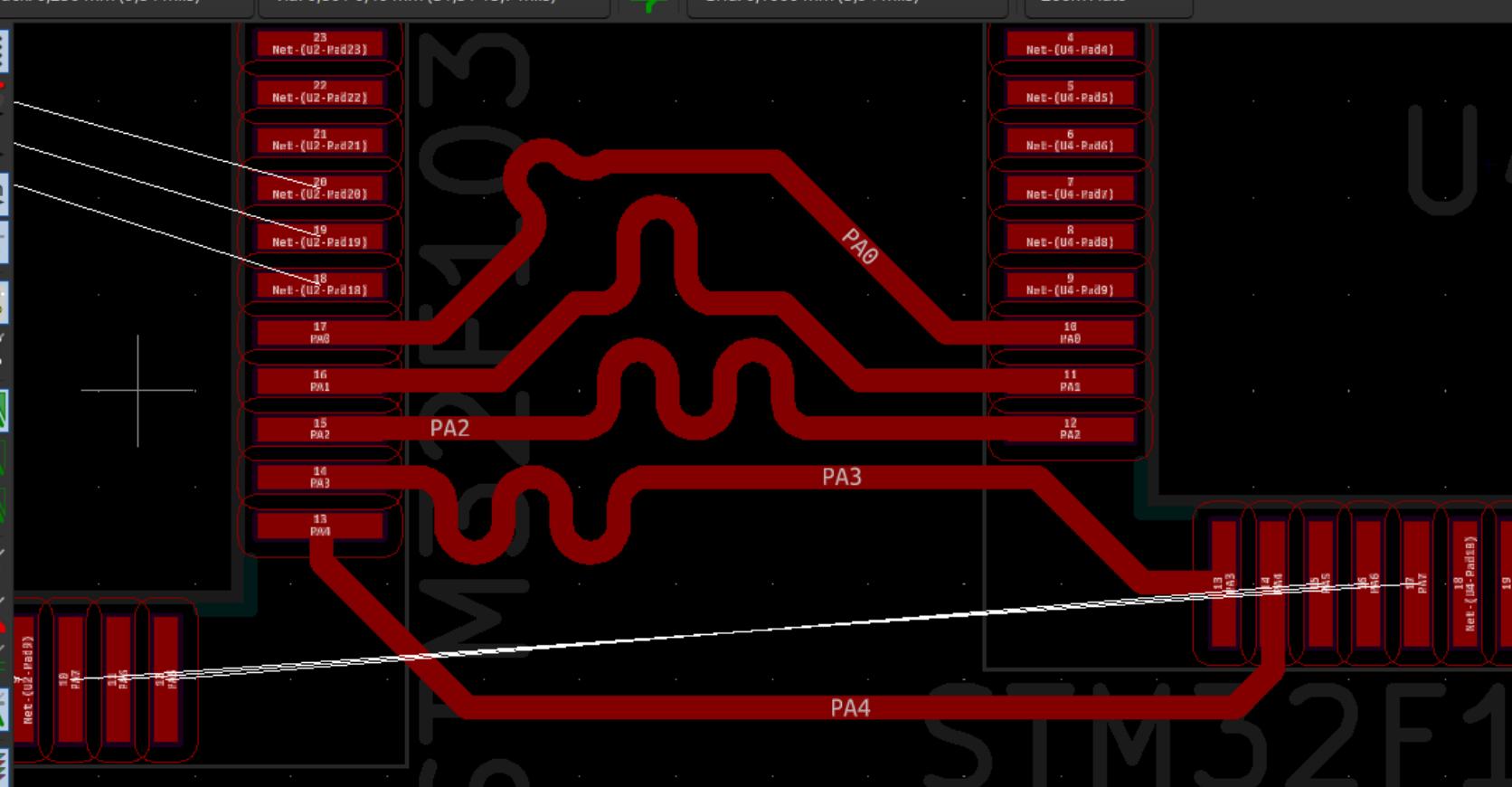
Pads 187 Vias 0 Track Segments 246 Nodes 168 Nets 129 Unrouted 22

Z 19,16 X 121,400000 Y 130,000000

dx 121,400000 dy 130,000000 dist 177,871

grid X 0,100000 Y 0,100000

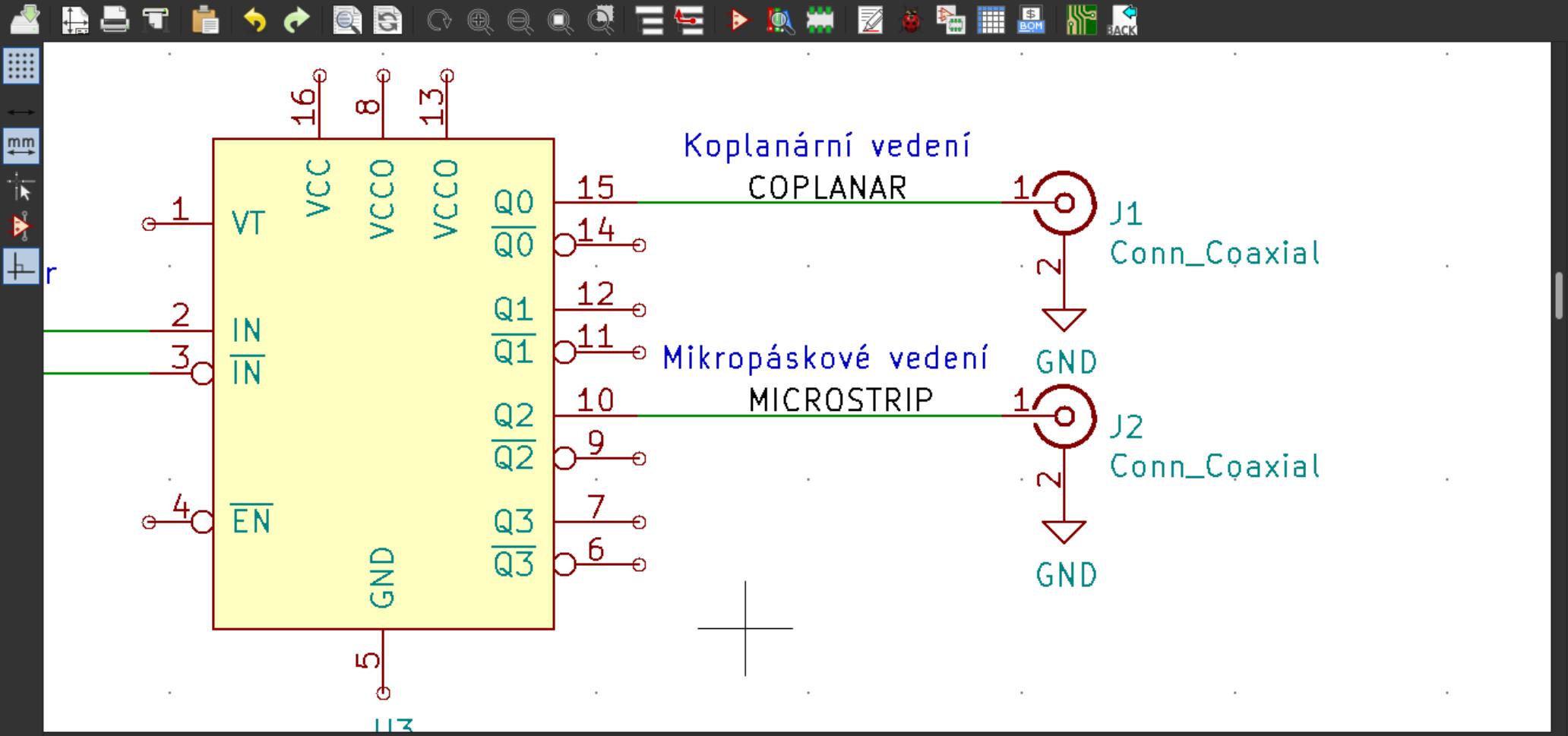
mm Select item 31/46



# Mikropásková vedení



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File Edit View Place Route Inspect Tools Preferences Help

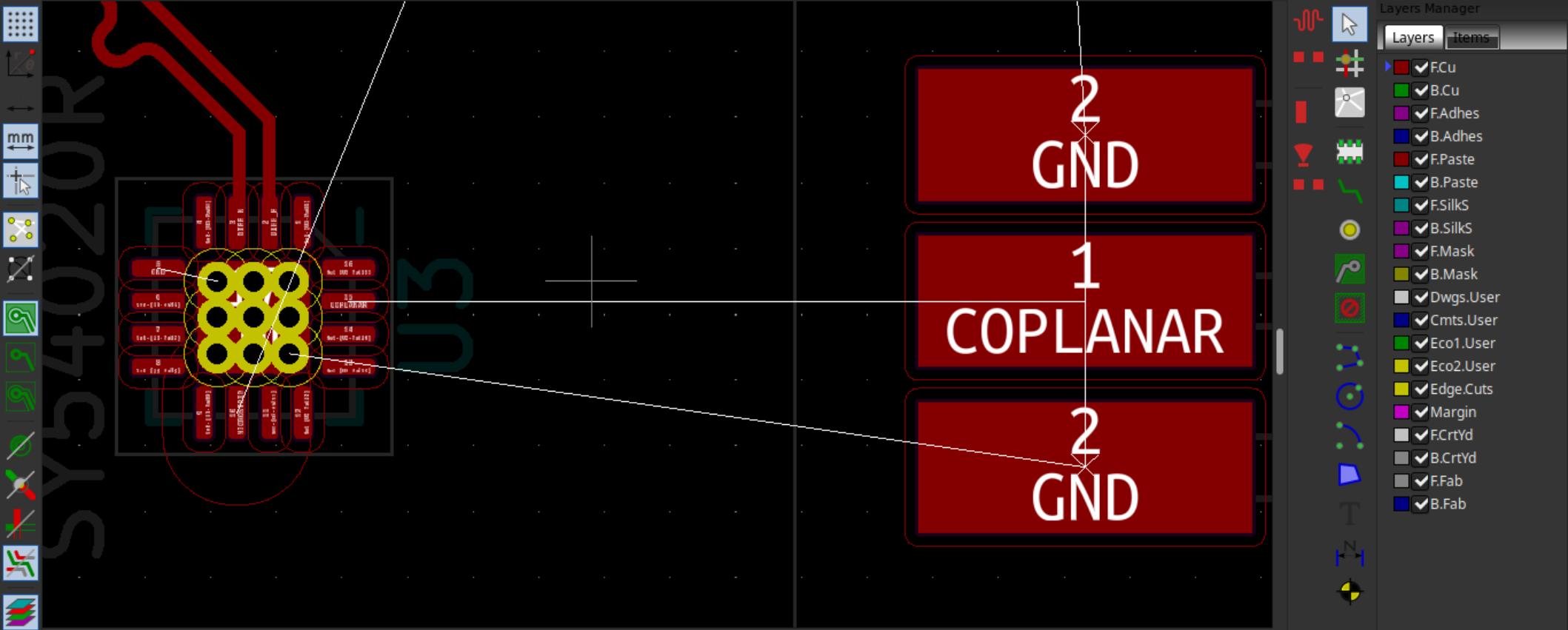


Track: 0,250 mm (9,84 mils) \*

Via: 0,80 / 0,40 mm (31,5 / 15,7 mils) \*

Grid: 0,1000 mm (3,94 mils)

Zoom Auto



Pads	Vias	Track Segments	Nodes	Nets	Unrouted
187	0	246	168	129	22

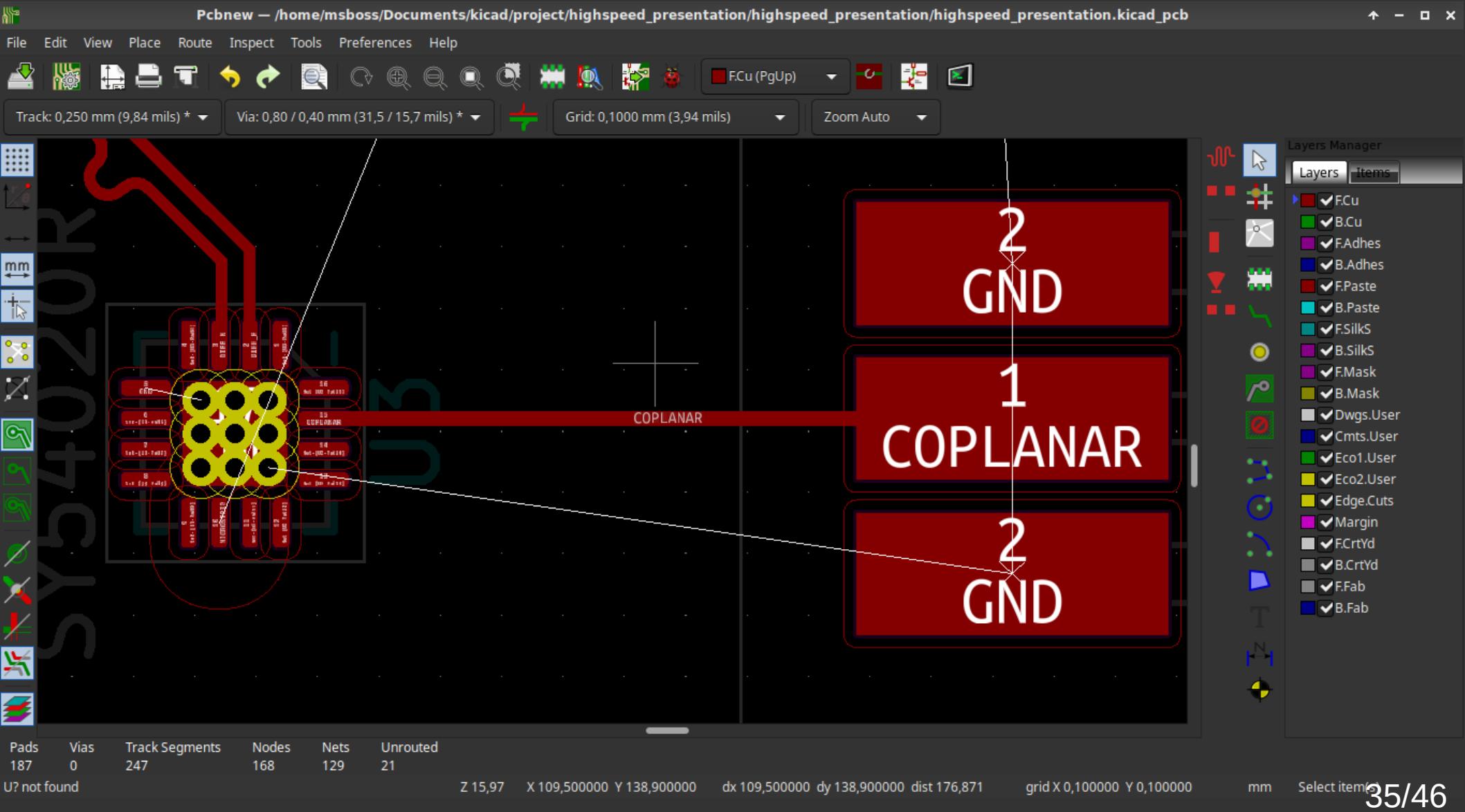
Z 15,97 X 107,800000 Y 139,500000

dx 107,800000 dy 139,500000 dist 176,298

grid X 0,100000 Y 0,100000

mm Select item

34/46





## Copper Zone Properties



## Layer

- FCu
- BCu

## Net

&lt;no net&gt;

GND

/COPLANAR

/DIFF\_N

/DIFF\_P

/MICROSTRIP

/PA0

/PA1

/PA2

/PA3

/PA4

/PA5

/PA6

Hide nets matching:

Net-\*

Show nets matching:

\*

Apply Filters

 Show all nets Sort nets by pad count

## Shape

 Constrain outline to H, V and 45 degreesZone priority level: 0  Outline display: Hatched Corner smoothing: None 

Fillet radius: 0 mm

## Electrical Properties

Clearance: 0,508 mm

Minimum width: 0,254 mm

Pad connections: Thermal reliefs 

Thermal clearance: 0,508 mm

Thermal spoke width: 0,508 mm

## Fill

Fill type: Solid shape 

Orientation: 0 deg

Hatch width: 1,016 mm

Hatch gap: 1,524 mm

Smoothing effort: 0  Smooth value (0..1): 0  

Export Settings to Other Zones



File Edit View Place Route Inspect Tools Preferences Help

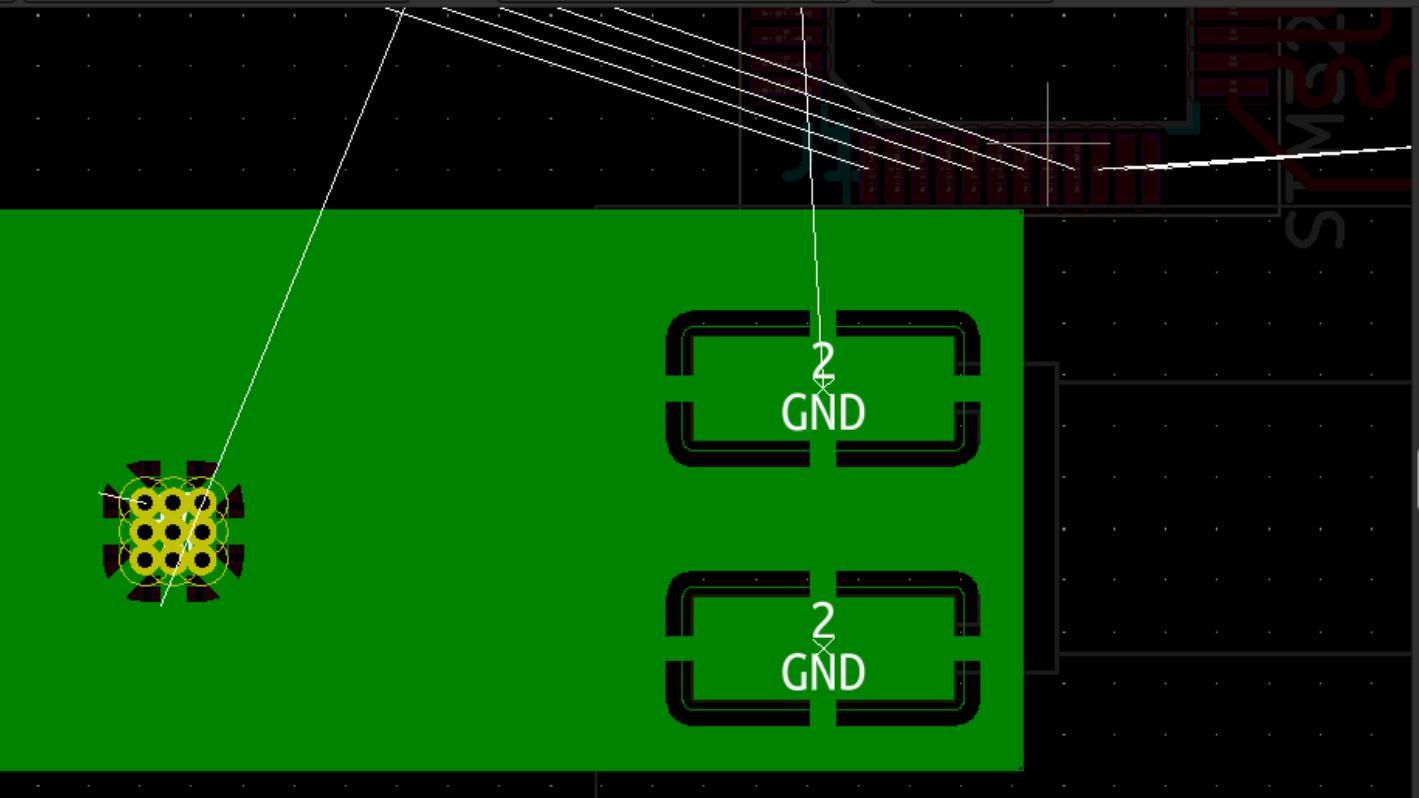
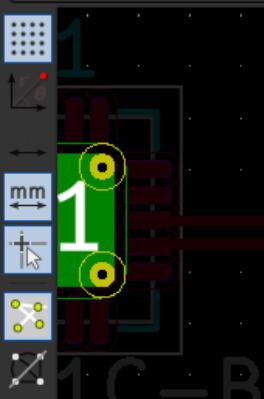


Track: 0,250 mm (9,84 mils) \*

Via: 0,80 / 0,40 mm (31,5 / 15,7 mils) \*

Grid: 0,1000 mm (3,94 mils)

Zoom Auto



Layers Manager  
Layers items

Pads 187 Vias 0 Track Segments 247 Nodes 168 Nets 129 Unrouted 19

U? not found

Z 9,24

X 119,700000 Y 132,500000

dx 119,700000 dy 132,500000 dist 178,562

grid X 0,100000 Y 0,100000

mm Select item 37/46

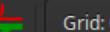


File Edit View Place Route Inspect Tools Preferences Help



Track: 0,250 mm (9,84 mils) \*

Via: 0,80 / 0,40 mm (31,5 / 15,7 mils) \*

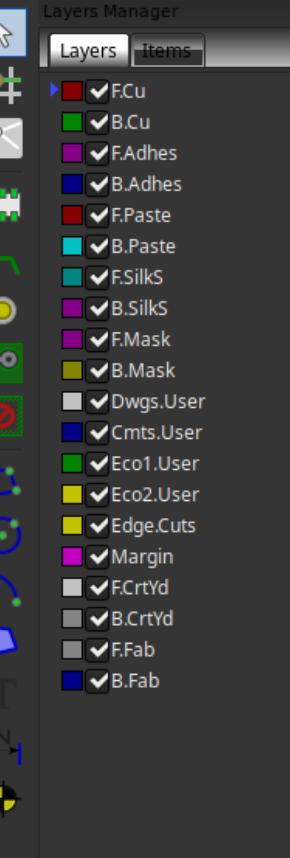
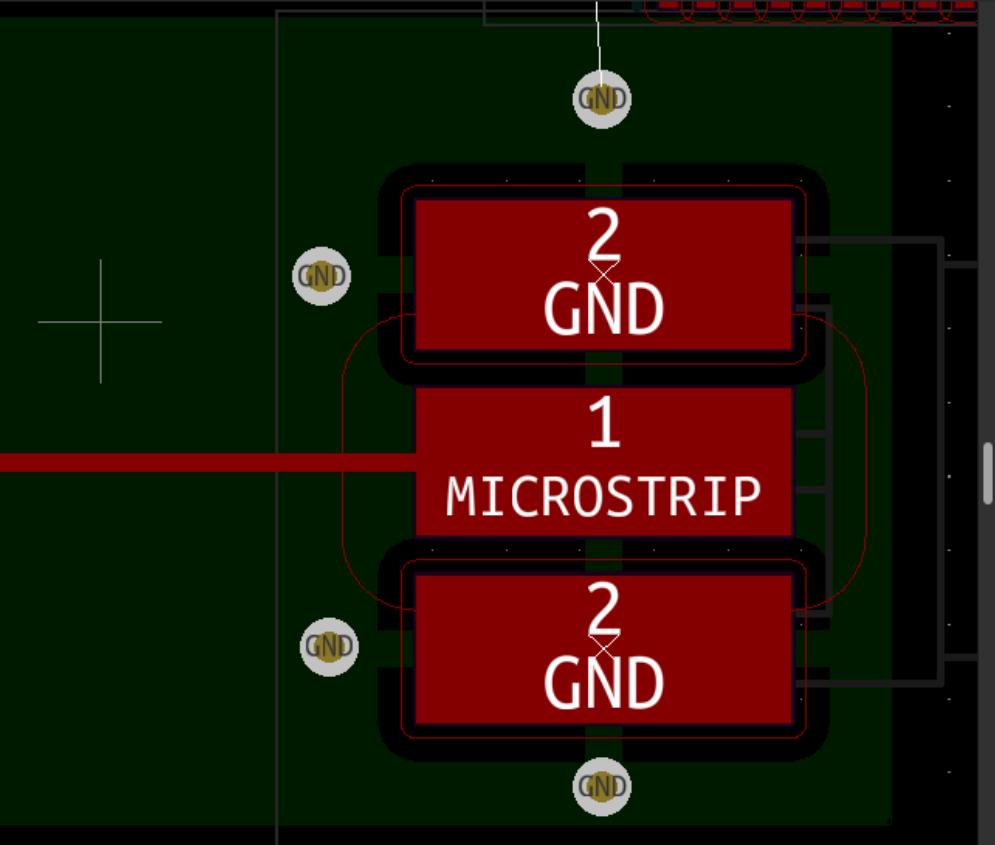
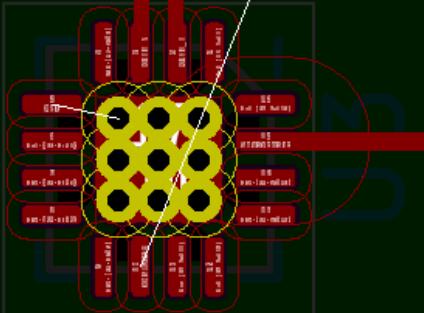


Grid: 0,1000 mm (3,94 mils)

Zoom Auto



SY54020R



Pads	Vias	Track Segments	Nodes	Nets	Unrouted
187	4	247	168	129	19

U? not found

Z 13,30 X 108,500000 Y 137,900000

dx 108,500000 dy 137,900000 dist 175,467

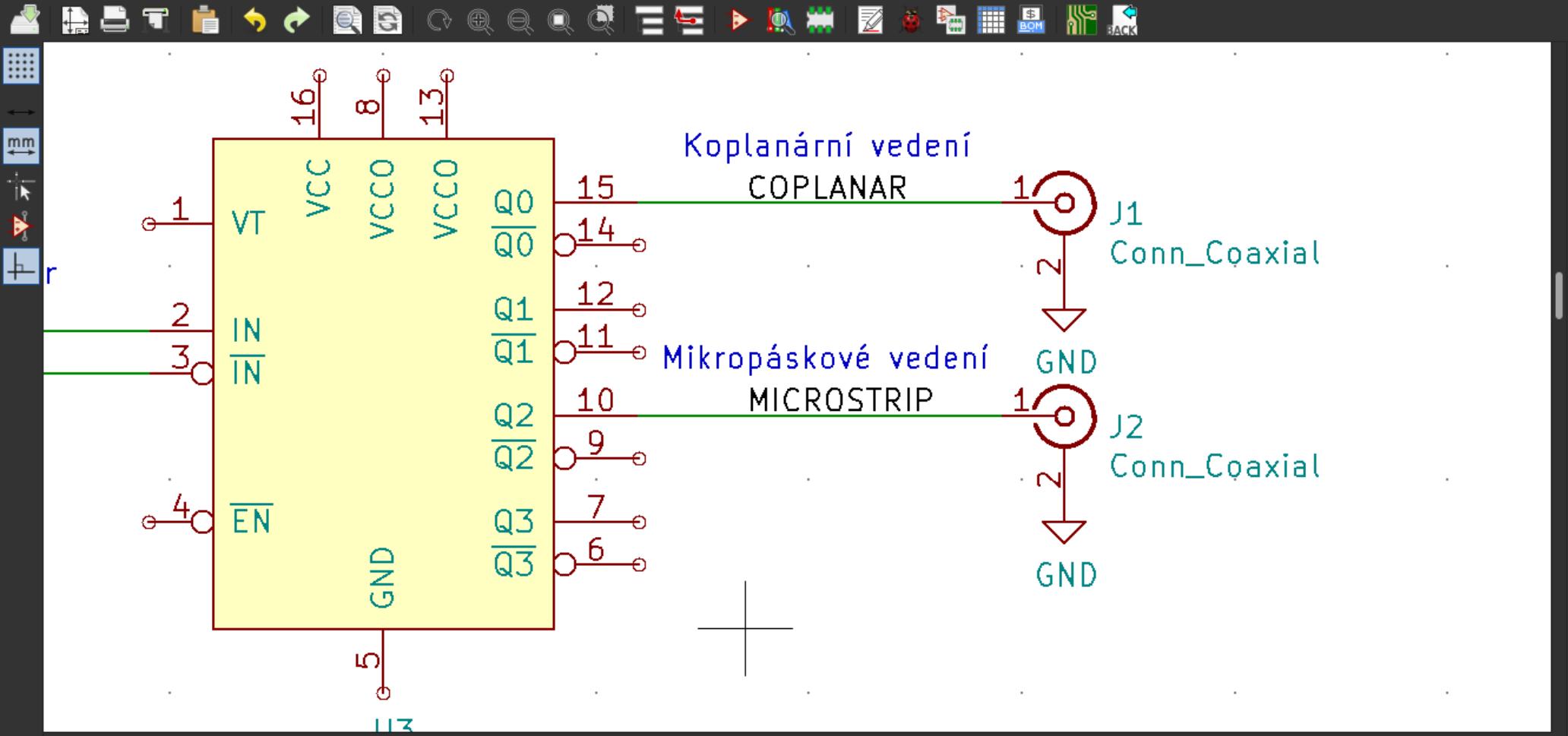
grid X 0,100000 Y 0,100000

mm Select item 38/46

# Mikropásková vedení



bastlíři SH  
**MacGyver**  
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File Edit View Place Route Inspect Tools Preferences Help

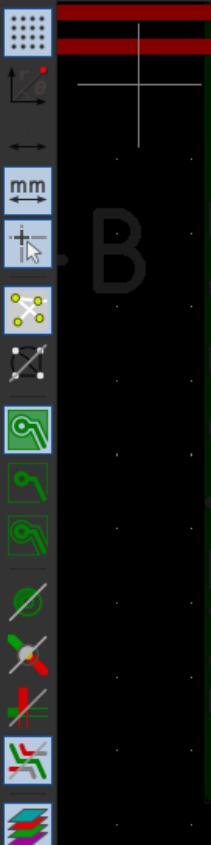


Track: 0,250 mm (9,84 mils) \*

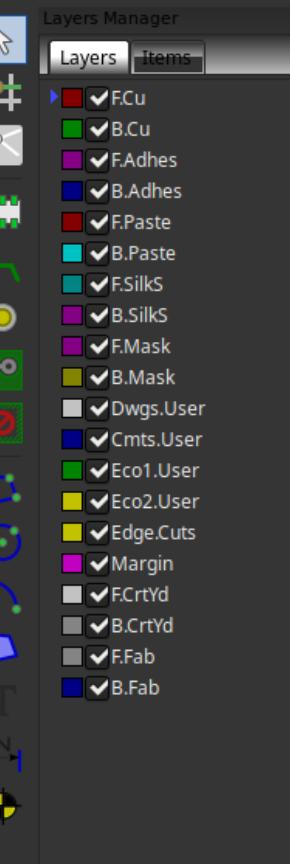
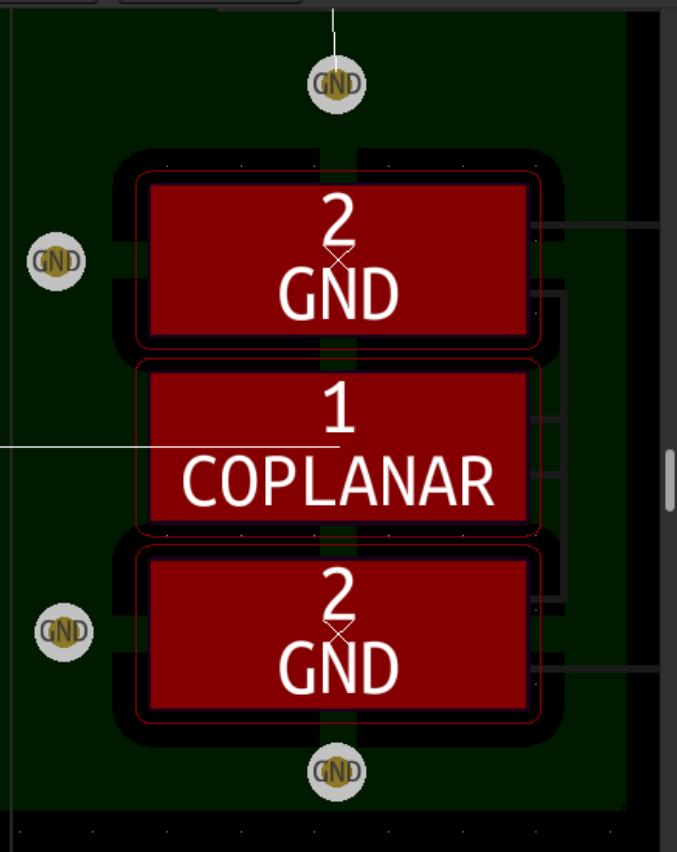
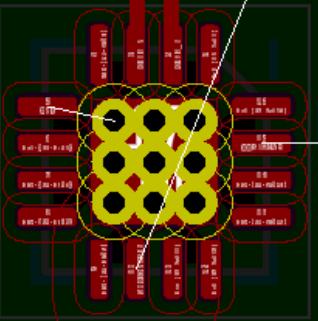
Via: 0,80 / 0,40 mm (31,5 / 15,7 mils) \*

Grid: 0,1000 mm (3,94 mils)

Zoom Auto



SY54020R



Pads	Vias	Track Segments	Nodes	Nets	Unrouted
187	4	246	168	129	20

U? not found

Z 13,30 X 98,300000 Y 135,000000

dx 98,300000 dy 135,000000 dist 166,997

grid X 0,100000 Y 0,100000

mm Select item(s)  
41/46

File Edit View Place Route Inspect Tools Preferences Help



Track: 0,250 mm (9,84 mils) \*

Via: 0,80 / 0,40 mm (31,5 / 15,7 mils) \*

Grid: 0,1000 mm (31,5 mils)

Right-click context menu open over a green-filled zone:

- Select
- Move
- Rotate Counterclockwise
- Rotate Clockwise
- Flip
- Delete
- Properties...
- Move Exactly...
- Position Relative To...
- Duplicate
- Create Array...
- Cut
- Copy
- Paste
- Create Corner
- Zones
  - Create Pad from Selected Shapes
  - Renumber Pads...
  - Center
  - Zoom In at Cursor
  - Zoom Out at Cursor
  - Zoom to Fit
- Fill
  - Fill All
  - Unfill
  - Unfill All
  - Merge Zones
  - Duplicate Zone onto Layer...
  - Add a Zone Cutout
  - Add a Similar Zone

Layers Manager (right sidebar):

- F.Cu
- B.Cu
- F.Adhes
- B.Adhes
- F.Paste
- B.Paste
- F.SilkS
- B.SilkS
- F.Mask
- B.Mask
- Dwgs.User
- Cmts.User
- Eco1.User
- Eco2.User
- Edge.Cuts
- Margin
- F.CrtYd
- B.CrtYd
- F.Fab
- B.Fab

Type	NetName	NetCode	Priority	Layer	Vertices	Fill Mode	Hatch Lines
Zone Outline	GND	2	0	B.Cu	5	Solid	96

Z 13,30 X 110,200000 Y 144,700000

42/46



File Edit View Place Route Inspect Tools Preferences Help

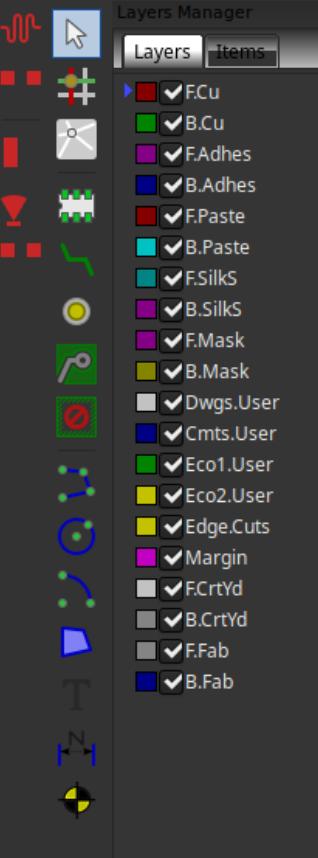
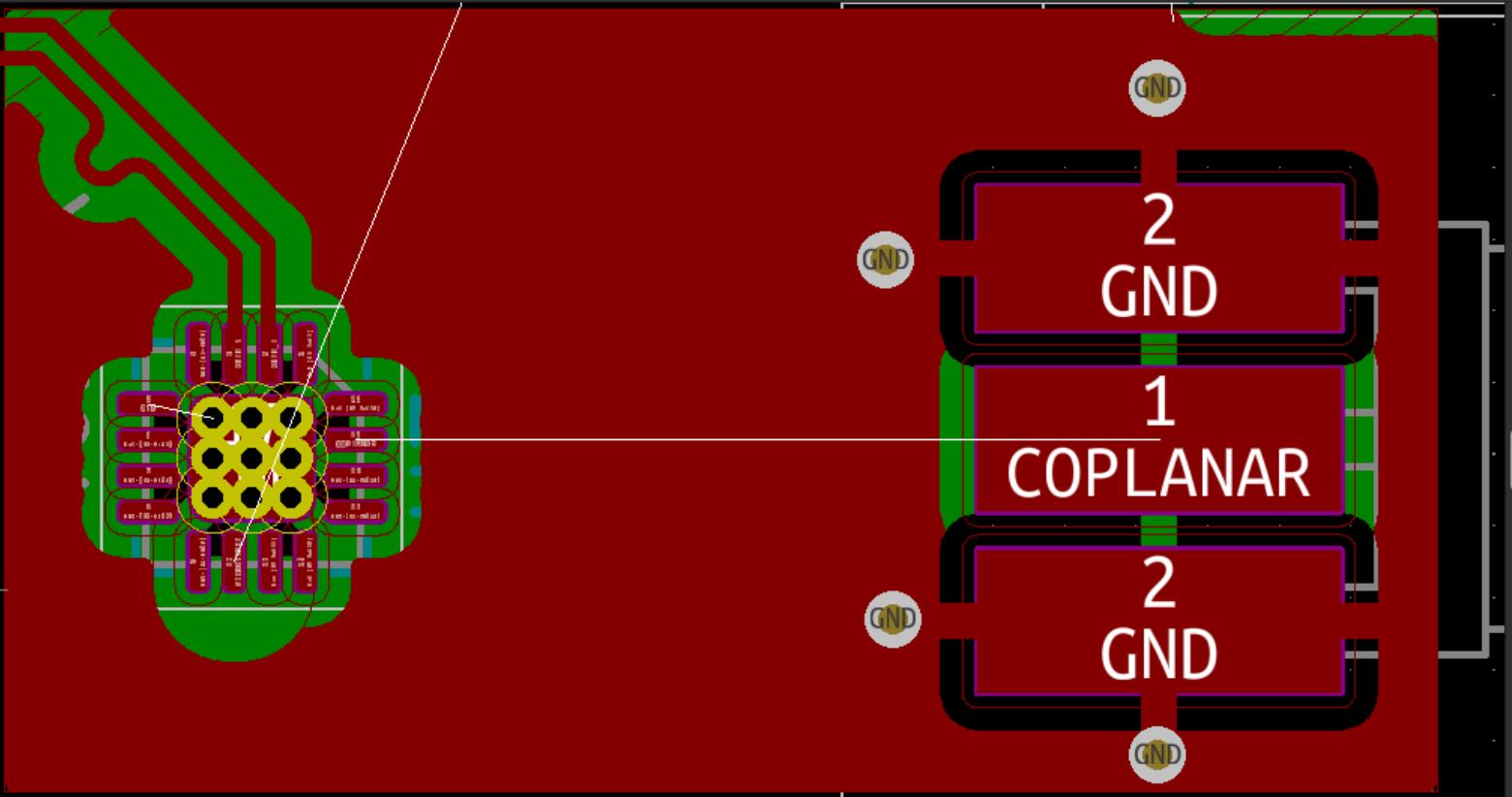


Track: 0,250 mm (9,84 mils) \*

Via: 0,80 / 0,40 mm (31,5 / 15,7 mils) \*

Grid: 0,1000 mm (3,94 mils)

Zoom Auto



Pads 187  
Vias 4  
Track Segments 246  
Nodes 168  
Nets 129  
Unrouted 18

Z 13,30 X 98,400000 Y 141,900000

dx 98,400000 dy 141,900000 dist 172,679

grid X 0,100000 Y 0,100000

mm Select item(s)



File Edit View Place Route Inspect Tools Preferences Help

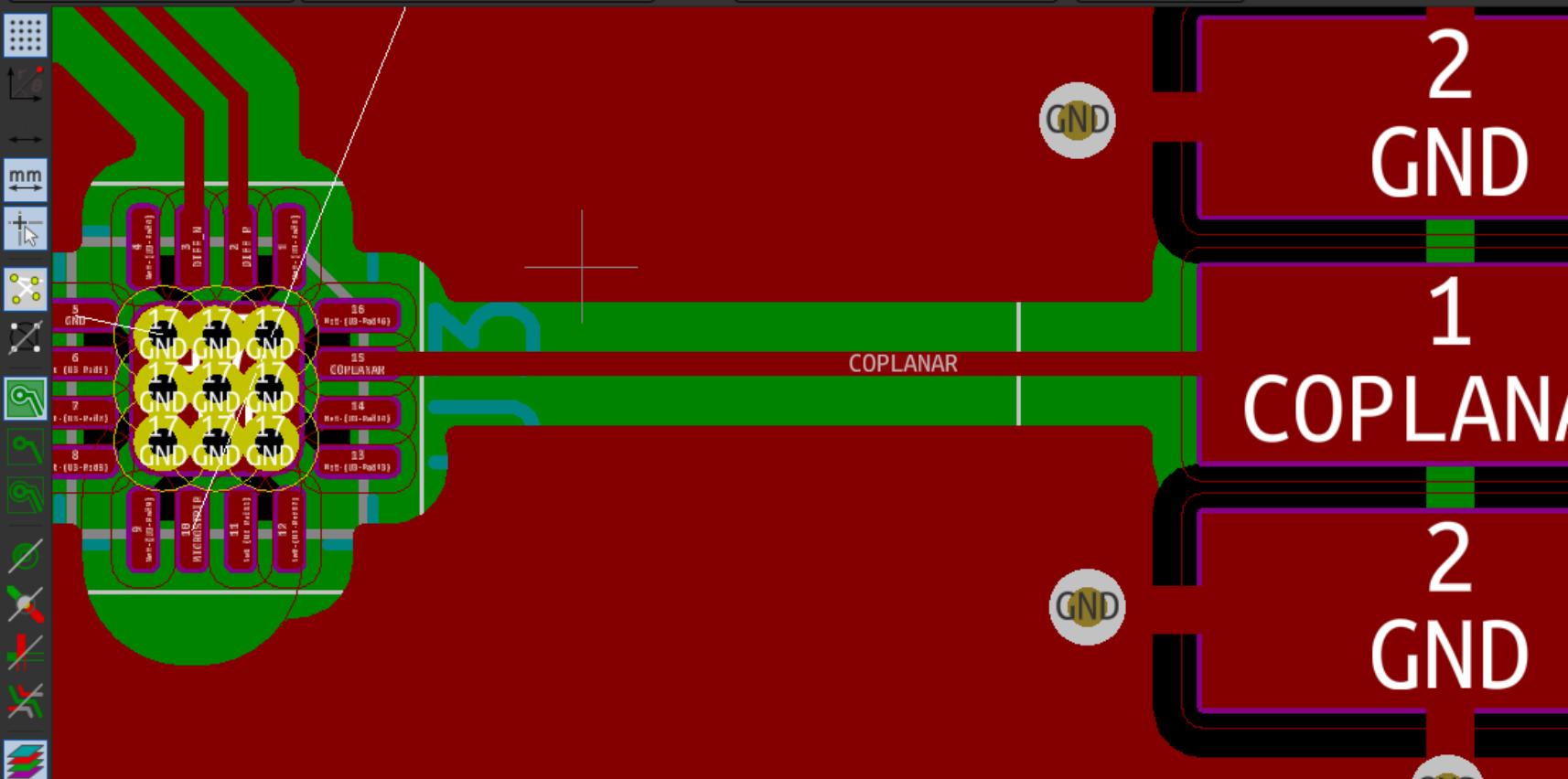


Track: 0,250 mm (9,84 mils) \*

Via: 0,80 / 0,40 mm (31,5 / 15,7 mils) \*

Grid: 0,1000 mm (3,94 mils)

Zoom Auto



## Layers Manager

## Layers

- F.Cu
- B.Cu
- F.Adhes
- B.Adhes
- F.Paste
- B.Paste
- F.SilkS
- B.SilkS
- F.Mask
- B.Mask
- Dwgs.User
- Cmts.User
- Eco1.User
- Eco2.User
- Edge.Cuts
- Margin
- F.CrtYd
- B.CrtYd
- F.Fab
- B.Fab

Backup file: "/home/msboss/Documents/kicad/project/highspeed\_presentation/highspeed\_presentation/highspeed\_presentation.kicad\_pcb-bak"

Wrote board file: "/home/msboss/Documents/kicad/project/highspeed\_presentation/highspeed\_presentation/highspeed\_presentation.kicad\_pcb"

U? not found

Z 19,16 X 106,400000 Y 138,800000 dx 106,400000 dy 138,800000 dist 174,890

grid X 0,100000 Y 0,100000

mm

Select item(s)

44/46



File Edit View Place Route Inspect Tools Preferences Help

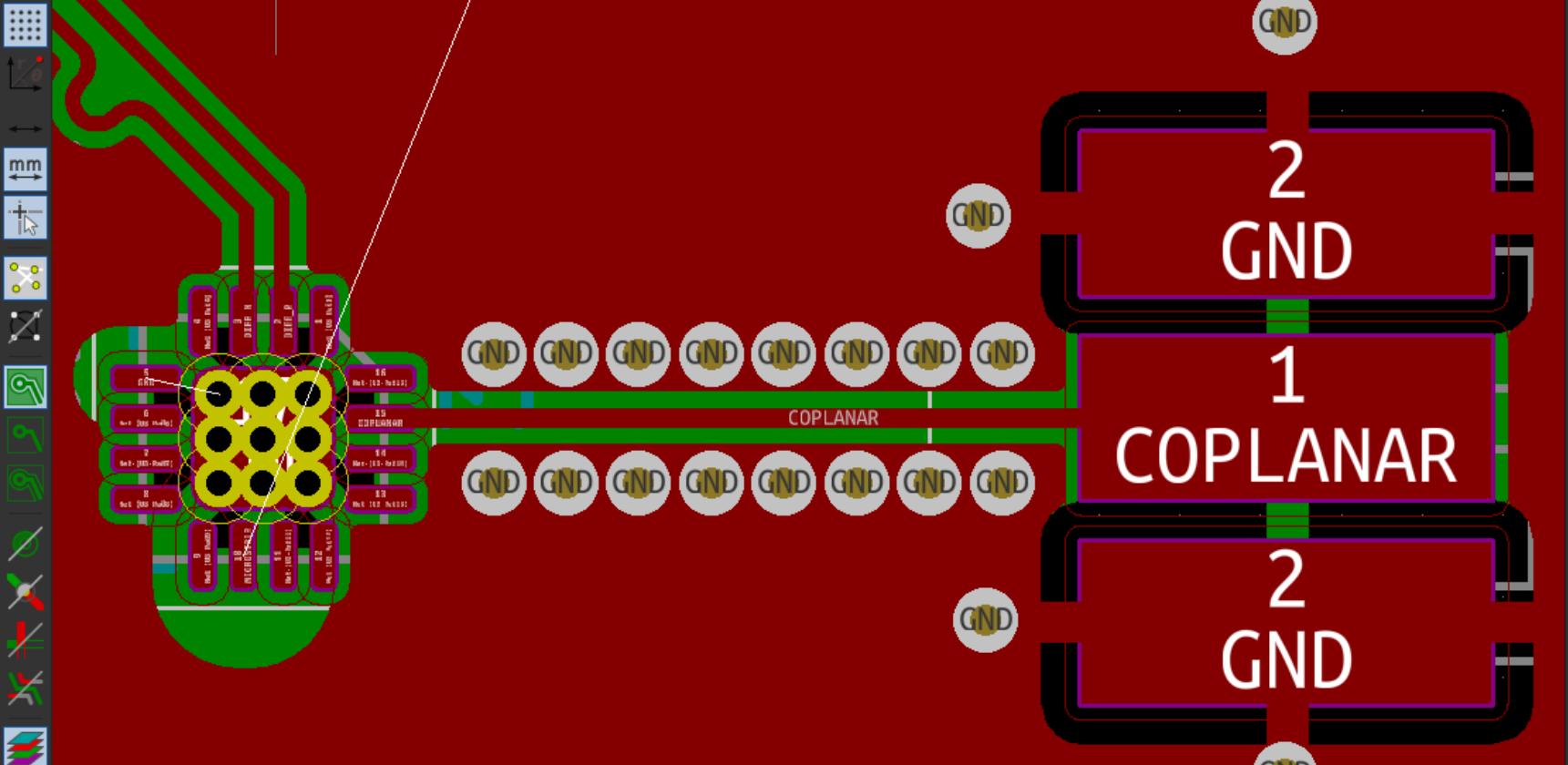


Track: 0,250 mm (9,84 mils) \*

Via: 0,80 / 0,40 mm (31,5 / 15,7 mils) \*

Grid: 0,1000 mm (3,94 mils)

Zoom Auto



Layers Manager

Layers Items

- F.Cu
- B.Cu
- F.Adhes
- B.Adhes
- F.Paste
- B.Paste
- F.Silks
- B.Silks
- F.Mask
- B.Mask
- Dwgs.User
- Cmts.User
- Eco1.User
- Eco2.User
- Edge.Cuts
- Margin
- F.CrtYd
- B.CrtYd
- F.Fab
- B.Fab

Backup file: "/home/msboss/Documents/kicad/project/highspeed\_presentation/highspeed\_presentation.kicad\_pcb.bak"  
Wrote board file: "/home/msboss/Documents/kicad/project/highspeed\_presentation/highspeed\_presentation.kicad\_pcb"

U? not found

Z 15,97 X 102,800000 Y 134,600000 dx 102,800000 dy 134,600000 dist 169,366

grid X 0,100000 Y 0,100000

mm

Select item(s)

45/46

# Prostor na dotazy bude u našeho stánku



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