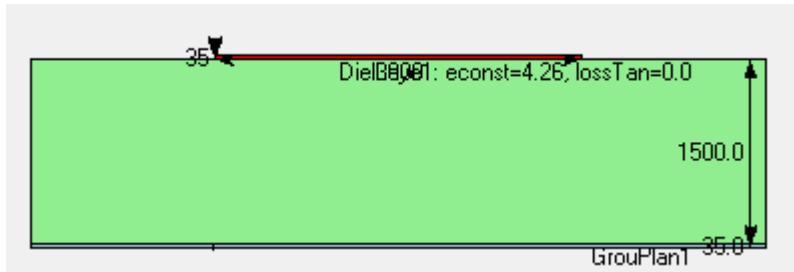


Antenas de GSM

Por manual del SIM7600, las antenas GSM tienen que tener una impedancia de 50 Ohms. Para lograr esto con 2 layers, cada capa de 2oz de espesor (35 micrones) y 1.5mm de separación, según la simulación de TNT la pista de microstrip tiene que ser de 3mm de espesor.

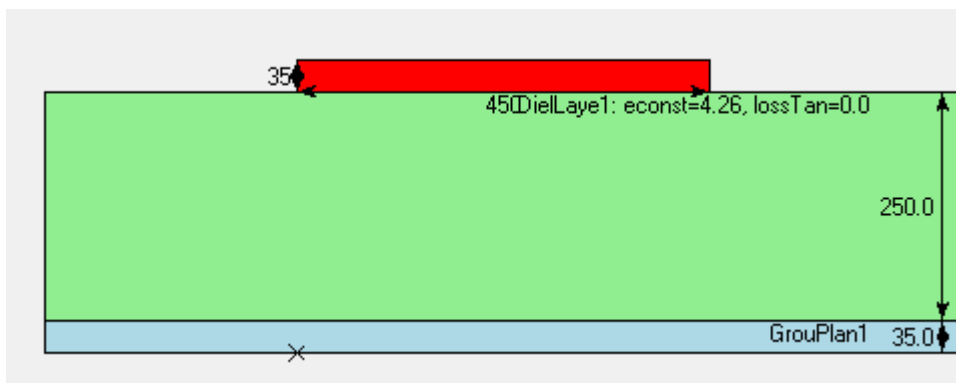


Characteristic Impedance (Ohms):

For Signal Line ::RectCond1R0= 49.188

No es posible aplicar esto en el layout.

Una opción sería cambiar a 4 layers para tener el plano de retorno más cercano. Con una separación de 250 micrones con el plano de retorno, se necesita una microstrip de 450 micrones de ancho (0.45mm)



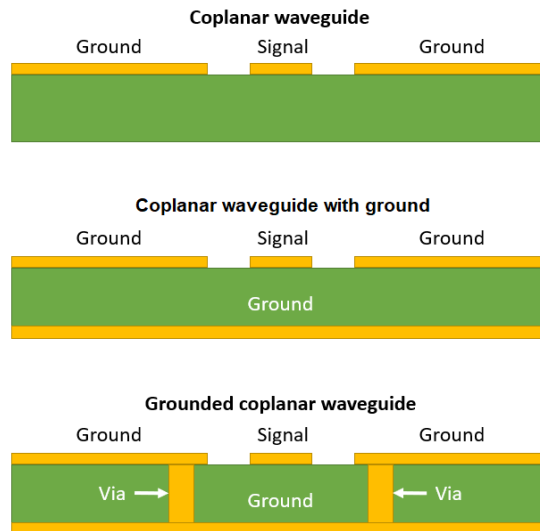
Characteristic Impedance (Ohms):

For Signal Line ::RectCond1R0= 51.1073

Una opción para mantener el stackup de 2 capas es utilizar una guía de onda coplanar con plano de masa (coplanar waveguide with ground). Se tiene en cuenta la masa rodeando la microstrip con una separación estricta y se rodea con vías al plano de la otra capa para disminuir la impedancia.

<https://www.nwengineeringllc.com/article/coplanar-waveguide-design-for-your-rf-pcb.php>

<https://electronics.stackexchange.com/questions/87473/how-to-design-a-pcb-to-connect-the-gsm-modem-with-50ohm-track-impedance>



Con Kicad calculator tools diseñamos las dimensiones para que funcione correctamente a la frecuencia de transmisión del módulo.
El resultado es 1.06mm de ancho.

Calculator Tools

File Preferences Help

- General system design
 - Regulators
 - Resistor Calculator
- Power, current and isolation
 - Electrical Spacing
 - Via Size
 - Track Width
 - Fusing Current
 - Cable Size
- High Speed
 - Wavelength
 - RF Attenuators
 - Transmission Lines
- Memo
 - E-Series
 - Color Code
 - Board Classes
 - Galvanic Corrosion

Transmission Line Type

- ☐ Microstrip Line
- ☐ Coplanar wave guide
- ☒ Coplanar wave guide w/ ground plane
- ☐ Rectangular Waveguide
- ☐ Coaxial Line
- ☐ Coupled Microstrip Line
- ☐ Stripline
- ☐ Twisted Pair

Substrate Parameters

ϵ_r : 4.5

$\tan \delta$: 0.02

ρ : 1.72e-08 $\Omega \cdot m$

H: 1.5 mm

T: 0.035 mm

$\mu(\text{conductor})$: 1

Physical Parameters

W: 1.06264 mm

S: 0.2 mm

L: 0 mm

Analyze ↓ Synthesize ↑

Electrical Parameters

Z0: 50 Ω

Ang_l: 0 rad

Results

Effective ϵ_r : 2.47261

Unit propagation delay: 52.5904 ps/cm

Conductor losses: 0 dB

Dielectric losses: 0 dB

Skin depth: 1.51428 μm

Component Parameters

Frequency: 1900 MHz

Calculator Tools

File Preferences Help

General system design

- Regulators
- Resistor Calculator

Power, current and isolation

- Electrical Spacing
- Via Size
- Track Width
- Fusing Current
- Cable Size

High Speed

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- ☐ Stripline
- ☐ Twisted Pair

Substrate Parameters

ϵ_r : 4.6

$\tan \delta$: 0.02

ρ : 1.72e-08 $\Omega \cdot m$

H: 1.5 mm

T: 0.035 mm

$\mu(\text{conductor})$: 1

Physical Parameters

W: 0.781643 mm

S: 0.15 mm

L: 0 mm

Analyze ↓ Synthesize ↑

Electrical Parameters

Z0: 50 Ω

Ang.l: 0 rad

Results

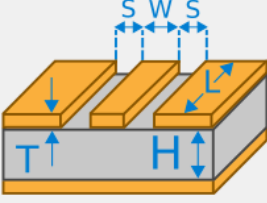
Effective ϵ_r : 2.36688

Unit propagation delay: 51.4537 ps/cm

Conductor losses: 0 dB

Dielectric losses: 0 dB

Skin depth: 1.51428 μm



Para una separación de 0.15mm el ancho es de 0.7816mm
Si utilizo 0.8mm la impedancia es de 49.5981mm

Layers: 2 PCB Thickness: 1.6 Outer Copper Weight: 1oz Unit: mm

Impedance Configure

+ New Impedance

Duplicate Impedance

Calculate

| Impedance (Ω) | Type | Signal Layer | Top Ref | Bottom Ref | Trace Spacing (mm) | Impedance trace to copper (mm) |
|------------------------|-----------------------|--------------|---------|------------|--------------------|--------------------------------|
| 50 | Coplanar Single Ended | L1 | / | L2 | / | 0.15 |

JLC0216

| Impedance (Ω) | Type | Signal Layer | Top Ref | Bottom Ref | Trace Width | Trace Spacing | Impedance trace to copper |
|------------------------|--|--------------|---------|-----------------|-------------|----------------|---------------------------|
| 50 | Coplanar Single Ended | L1 | / | L2 | 0.6322 | / | 0.1500 |
| Layer | Material | | | Thickness (mil) | | Thickness (mm) | |
| L1 | Outer Copper Weight | | | 1.38 | | 0.0350 | |
| Core | 1.5mm 1/10Z with copper (double-sided) | | | 57.68 | | 1.4650 | |
| L2 | Outer Copper Weight | | | 1.38 | | 0.0350 | |

Según el calculador online de JLCPCB 0.6322mm

Ruteo de la antena:

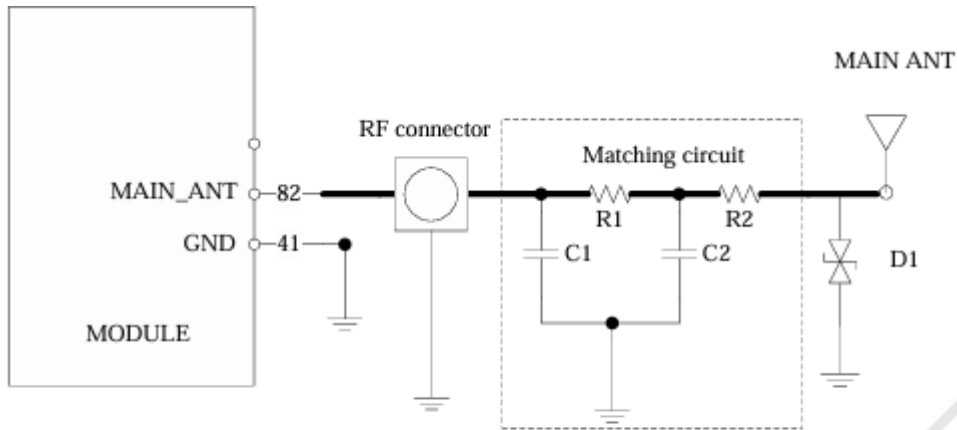
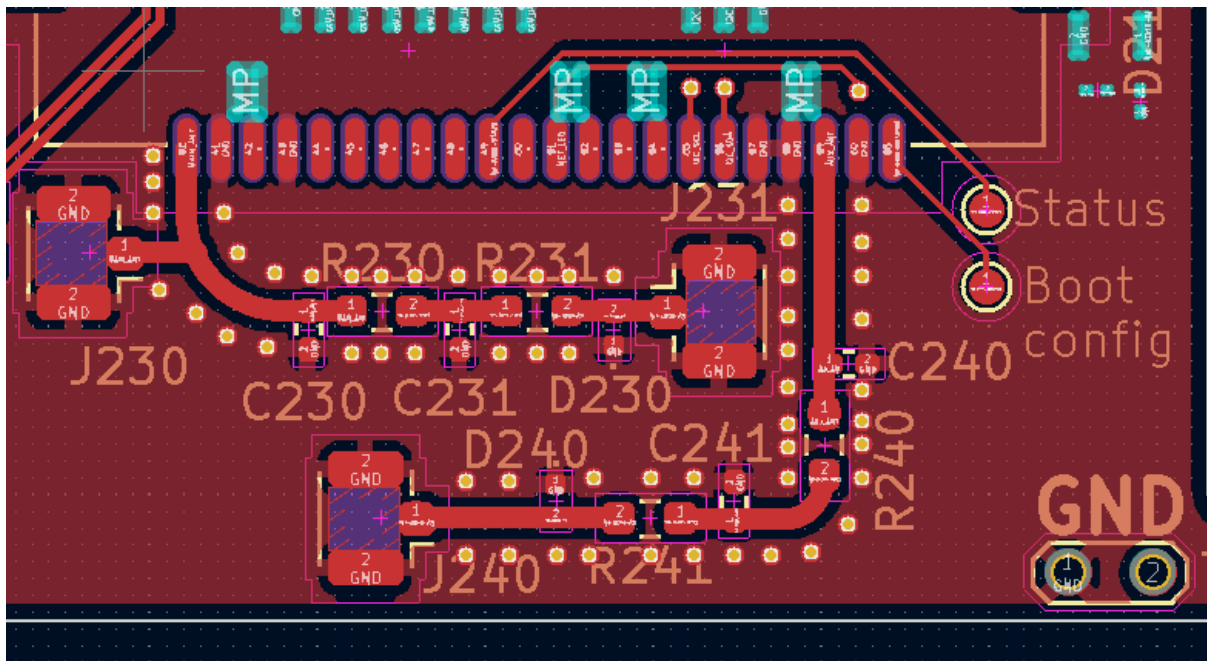


Figure 32: Antenna matching circuit (MAIN_ANT)

Del datasheet del modulo SIM7600:

In above figure, the components R1, C1, C2 and R2 are used for antenna matching. By default, the R1, R2 are 0Ω resistors, and the C1, C2 are reserved for tuning.

Se rutea un conector de antena secundario (J230) para poder medir la impedancia de la pista, y en caso de ser necesario se agregan los elementos pasivos R230, R231, C230, C231 para ajustar la impedancia a 50 Ohms.



La línea de transmisión se diseñó curva para evitar ángulos rectos y se agregó via stitching para reducir la impedancia de masa entre las dos capas. No sé qué tan necesarias son estas cosas.

Par diferencial USB 2.0

Calculator Tools
File Preferences Help

General system design
Regulators
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Fusing Current
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☐ Coplanar wave guide
☐ Coplanar wave guide w/ ground plane
☐ Rectangular Waveguide
☐ Coaxial Line
☒ Coupled Microstrip Line
☐ Stripline
☐ Twisted Pair

Substrate Parameters
 ϵ_r : 4.5
 $\tan \delta$: 0.02
 ρ : 1.72e-08 $\Omega \cdot m$
 H : 1.5 mm
 H_{t} : 1e+20 mm
 T : 0.035 mm
 Roughness: 0 mm
 $\mu(\text{conductor})$: 1

Physical Parameters
 W : 0.135 mm
 S : 0.05 mm
 L : 40 mm

Analyze Synthesize

Electrical Parameters
 Z_{even} : 258.219 Ω
 Z_{odd} : 44.9923 Ω
 Ang. I : 0.682267 rad

Results
 Effective ϵ_r (even): 2.9914
 Effective ϵ_r (odd): 2.76249
 Unit propagation delay (even): 57.845 ps/cm
 Unit propagation delay (odd): 55.5878 ps/cm
 Conductor losses (even): 0.0225098 dB
 Conductor losses (odd): 0.129109 dB
 Dielectric losses (even): 0.0517074 dB
 Dielectric losses (odd): 0.0476537 dB
 Skin depth: 3.01275 μm
 Differential Impedance (Z_d): 90.0461 Ω

Calculator Tools
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☐ Stripline
☐ Twisted Pair

Substrate Parameters
 ϵ_r : 4.5
 $\tan \delta$: 0.02
 ρ : 1.72e-08 $\Omega \cdot m$
 H : 1.5 mm
 H_{t} : 1e+20 mm
 T : 0.035 mm
 Roughness: 0 mm
 $\mu(\text{conductor})$: 1

Physical Parameters
 W : 0.7 mm
 S : 0.15 mm
 L : 40 mm

Analyze Synthesize

Electrical Parameters
 Z_{even} : 139.505 Ω
 Z_{odd} : 45.8607 Ω
 Ang. I : 0.697345 rad

Results
 Effective ϵ_r (even): 3.23585
 Effective ϵ_r (odd): 2.78716
 Unit propagation delay (even): 60.1621 ps/cm
 Unit propagation delay (odd): 55.8354 ps/cm
 Conductor losses (even): 0.0103961 dB
 Conductor losses (odd): 0.031597 dB
 Dielectric losses (even): 0.0557798 dB
 Dielectric losses (odd): 0.048106 dB
 Skin depth: 3.01275 μm
 Differential Impedance (Z_d): 91.8136 Ω

El calculador de kicad no tiene en cuenta el ground plane coplanar.

Resultado

Separación 0.05mm -> Espesor 0.135mm

Separación 0.15mm -> Espesor 0.7mm

El calculador de JLCPCB si tiene en cuenta la masa coplanar
Para 0.15mm de separación

Layers2PCB Thickness1.6Outer Copper Weight1ozUnitmm

Impedance Configure

+ New ImpedanceDuplicate ImpedanceCalculate

| Impedance (Ω) | Type | Signal Layer | Top Ref | Bottom Ref | Trace Spacing (mm) | Impedance trace to copper (mm) |
|---------------|----------------------------|--------------|---------|------------|--------------------|--------------------------------|
| 90 | Coplanar Differential Pair | L1 | / | L2 | 0.15 | 0.15 |

JLCO216

| Impedance (Ω) | Type | Signal Layer | Top Ref | Bottom Ref | Trace Width | Trace Spacing | Impedance trace to copper |
|---------------|----------------------------|--------------|---------|------------|-------------|---------------|---------------------------|
| 90 | Coplanar Differential Pair | L1 | / | L2 | 0.2764 | 0.1500 | 0.1500 |

, da como resultado 0.2764mm de espesor.

Para 0.2mm de separación

Layers2PCB Thickness1.6Outer Copper Weight1ozUnitmm

Impedance Configure

+ New ImpedanceDuplicate ImpedanceCalculate

| Impedance (Ω) | Type | Signal Layer | Top Ref | Bottom Ref | Trace Spacing (mm) | Impedance trace to copper (mm) |
|---------------|----------------------------|--------------|---------|------------|--------------------|--------------------------------|
| 90 | Coplanar Differential Pair | L1 | / | L2 | 0.2 | 0.2 |

JLCO216

| Impedance (Ω) | Type | Signal Layer | Top Ref | Bottom Ref | Trace Width | Trace Spacing | Impedance trace to copper |
|---------------|----------------------------|--------------|---------|------------|-------------|---------------|---------------------------|
| 90 | Coplanar Differential Pair | L1 | / | L2 | 0.4288 | 0.2000 | 0.2000 |

da como resultado 0.4288mm de espesor.

Para una separacion de 0.15mm si no se usa la masa coplanar

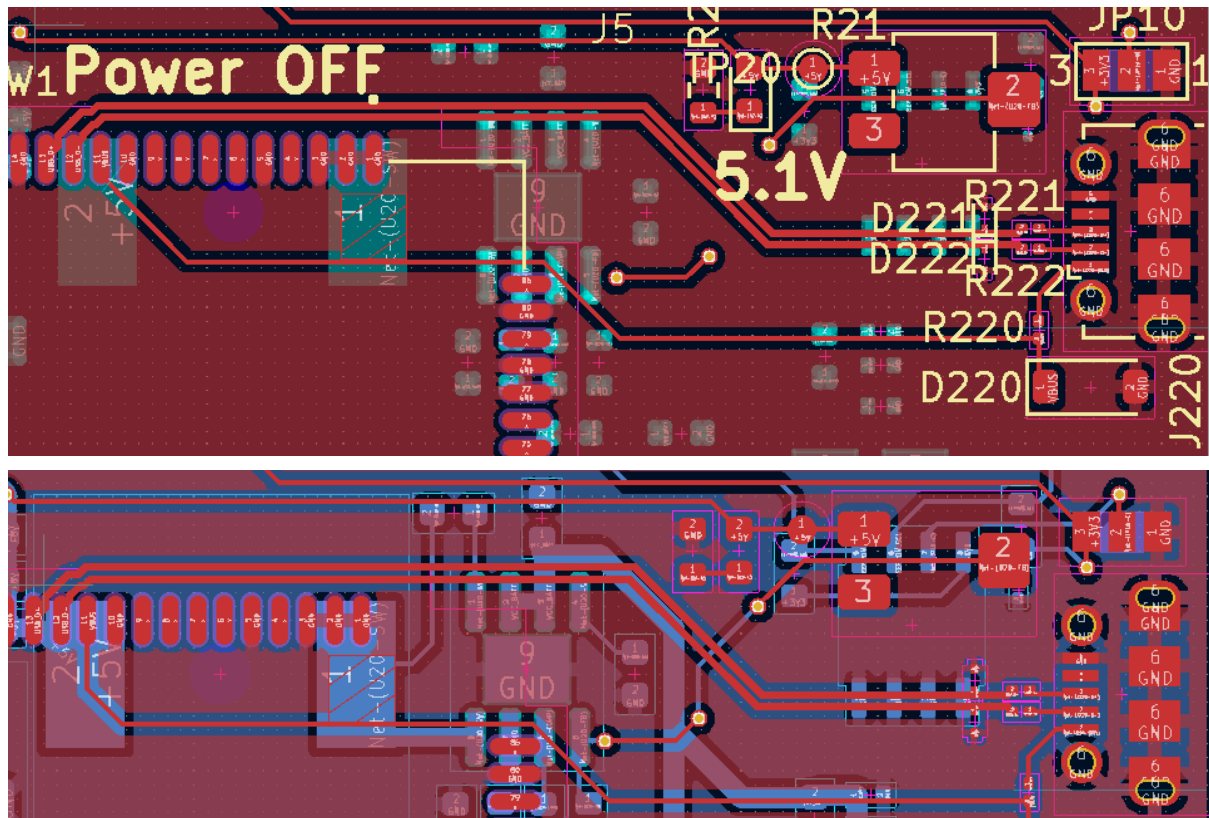
| Impedance (Ω) | Type | Signal Layer | Top Ref | Bottom Ref | Trace Spacing (mm) | Impedance trace to copper (mm) |
|---------------|----------------------------------|--------------|---------|------------|--------------------|--------------------------------|
| 90 | Differential Pair (Non coplanar) | L1 | / | L2 | 0.15 | / |

JLCO216

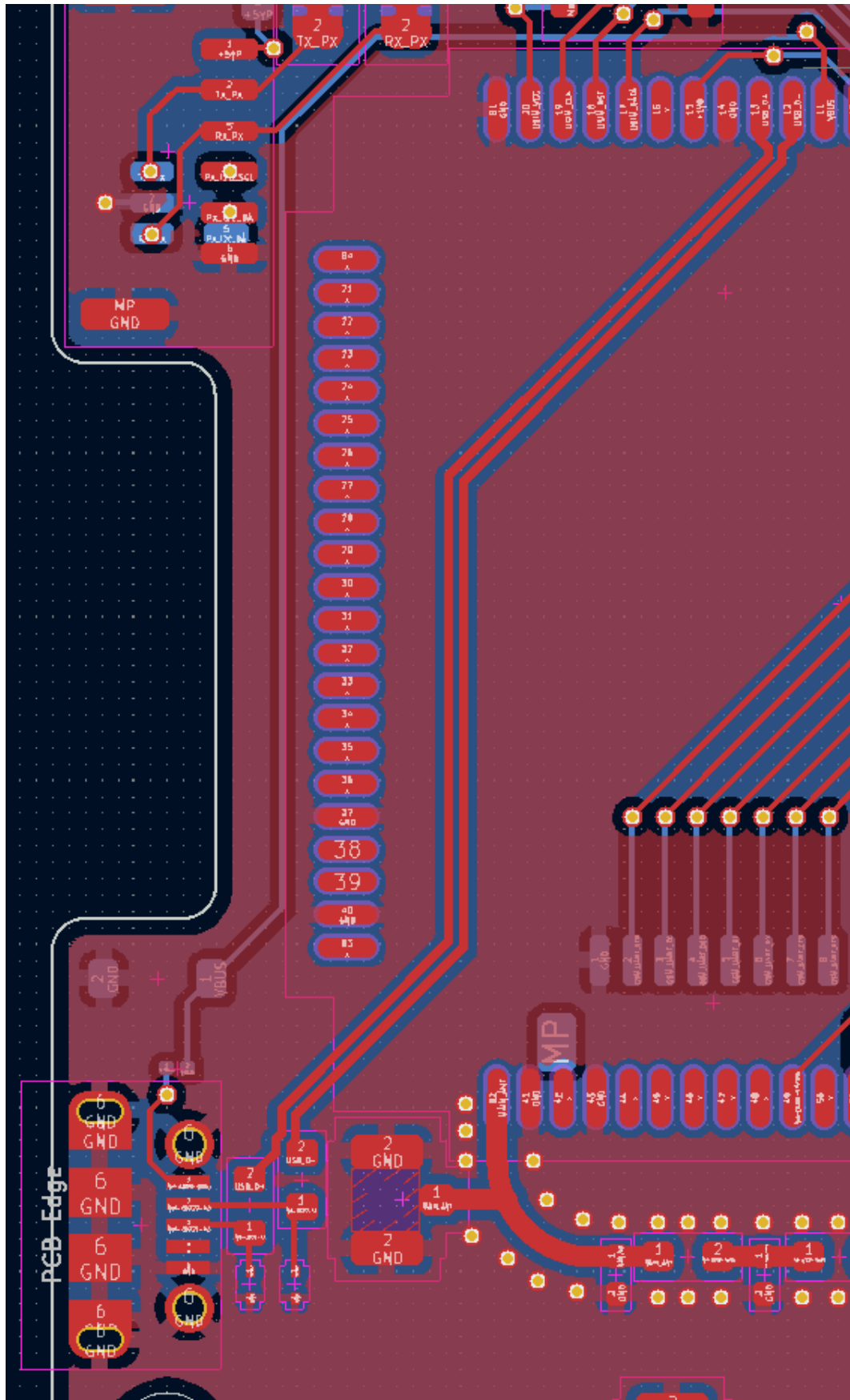
| Impedance (Ω) | Type | Signal Layer | Top Ref | Bottom Ref | Trace Width | Trace Spacing | Impedance trace to copper |
|---------------|----------------------------------|--------------|---------|------------|-------------|---------------|---------------------------|
| 90 | Differential Pair (Non coplanar) | L1 | / | L2 | 0.4862 | 0.1500 | / |

da resultado 0.4862 mm de espesor.

Dada la posición elegida del puerto USB en la primer versión, el par diferencial atraviesa discontinuidades en el plano de masa de la capa inferior. Debería tener un plano de masa ininterrumpido para asegurar la impedancia calculada.



Cambiamos la posición del puerto al inferior de la placa donde podemos mantener el plano ininterrumpido.



Version final

