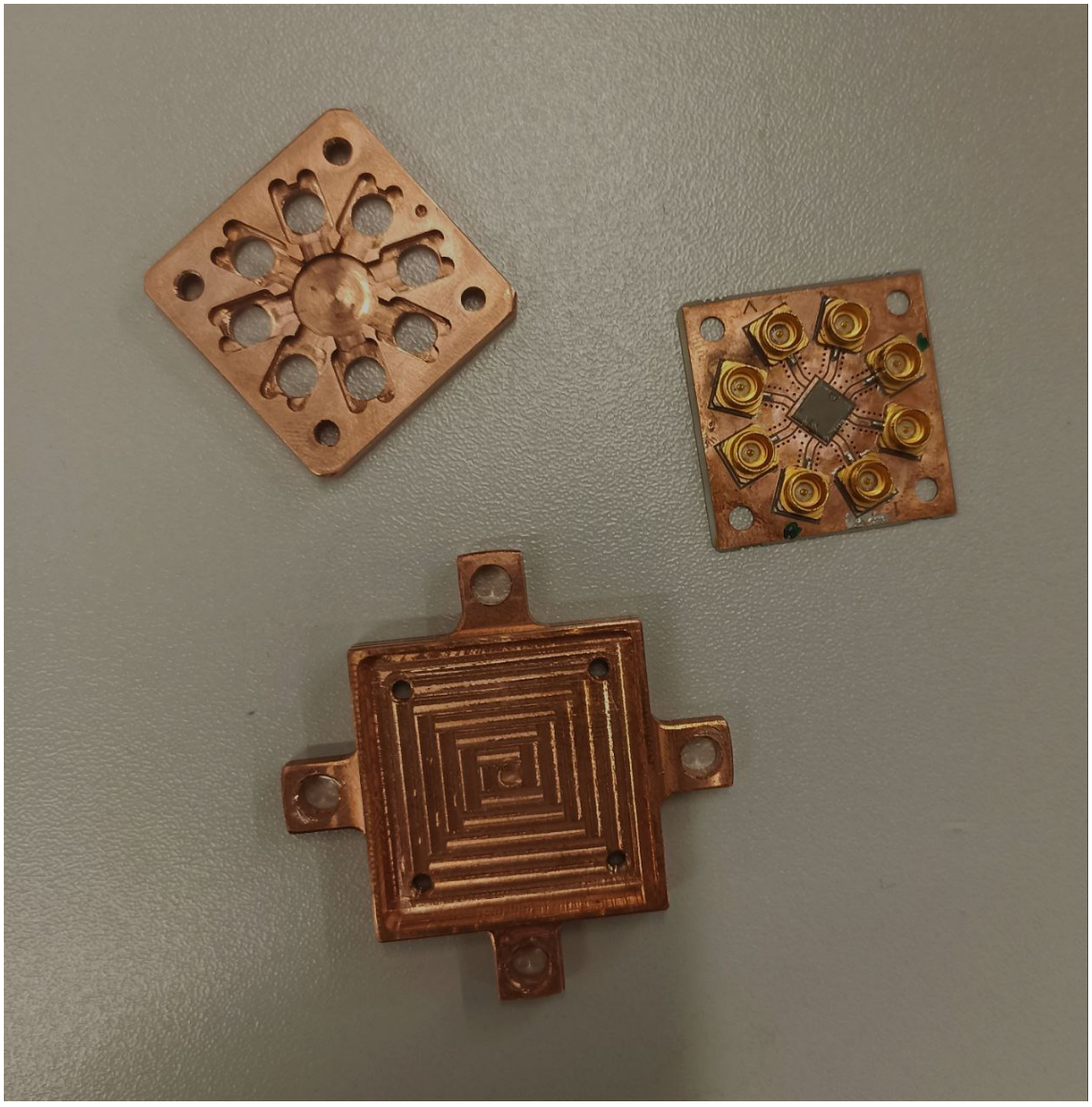
Sample holder NANO-J

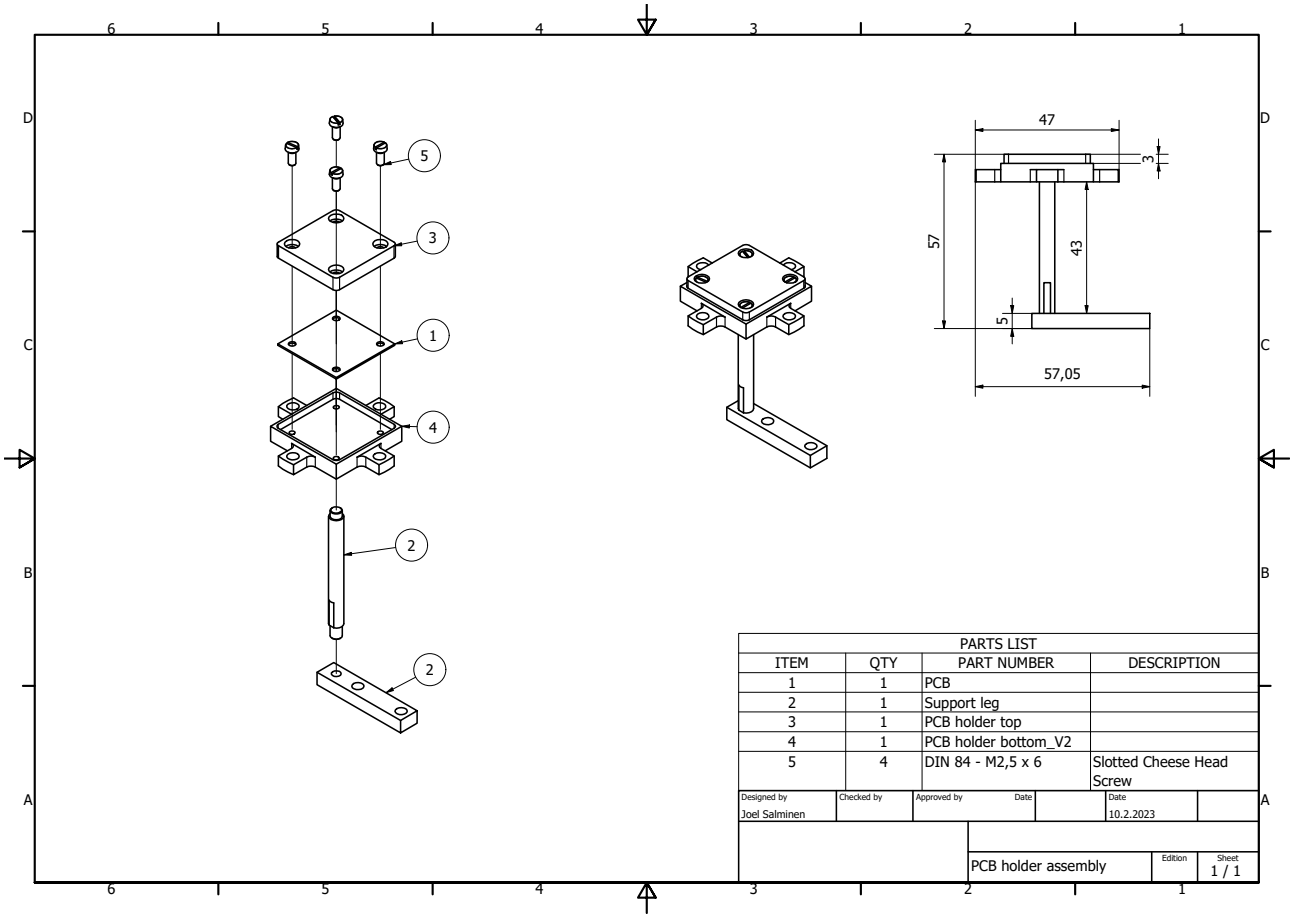
Ekaterina Mukhanova, ekaterina.mukhanova@aalto.fi

June 2023



1 Overview of NANO-J

The NANO-J sample holder is an 8-port sample holder developed in the NANO group for cryogenic measurements supporting 5x5mm chip size (see fig. 1). It is a PCB-based design (see section 2) with additional copper parts and supporting elements (see section 4). On the PCB the signals are carried by coplanar waveguides. The impedance matching is achieved with means of via-holes pattern and copper shielding to prevent cross-talk between lines (see section 3). In the design non-magnetic SMP connectors are used (see section 3.1).



PARTS LIST			
ITEM	QTY	PART NUMBER	DESCRIPTION
1	1	PCB	
2	1	Support leg	
3	1	PCB holder top	
4	1	PCB holder bottom_V2	
5	4	DIN 84 - M2,5 x 6	Slotted Cheese Head Screw

Designed by	Checked by	Approved by	Date	Date	
Joel Salminen				10.2.2023	

PCB holder assembly	Edition	Sheet
		1 / 1

Figure 1: Overall schematics of NANO-J sample holder. The setup consists of 5 parts: top copper lid with shielding pattern, PC board, bottom part with screw holes for direct attachment to MC plate and a threaded hole for supporting elements assembly, and two peaces of supporting elements: a leg with double thread and a foot with holes.

the design has good variability, all the parts of the structure can be easily replaced. The leg assumes an additional attachment of the magnet near the sample. In the holder version 2, a hole has also been added to the top lid so that it is possible to connect the magnet from that side as well. All holes fit the mixing namber plate pattern, as well as the sample stage.

2 PCB design

As mentioned above, the PCB carries eight signal ports to the chip (see fig. 2). The coplanar lines are connecting ports to a 5x5mm chip space. The transmission lines are entirely formed of the top copper layer. To prevent parasitic reflection impedance simulations were made with means of Comsol Multiphysics environment. The lines were designed to be as close to 50Ω as possible.

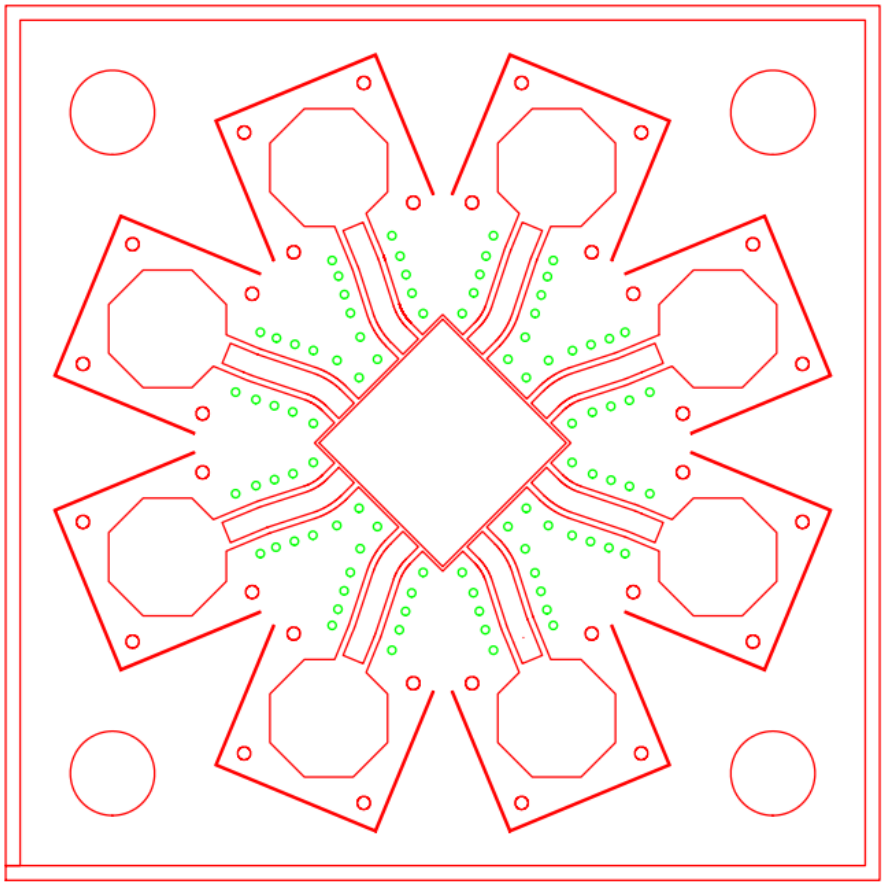


Figure 2: PCB layout.In the red colour a top copper layer pattern is presented. The green colour represents a via-holes pattern, following the lines.

The design is made in the most compact way possible in order to fit maximum possible number of lines on same PCB. The lines are maximally distributed out of each other to reduce cross-talk. So with accordance to shielding CPW line parameters would be: central line width S = 670 μm and gap W = 190 μm. The materials, used in PCB are presented in the following table:

PCB layers			
Layer	Material	ε	Thickness, μm
Top	Copper	n/a	18
Middle	Rogers Ro4003C	3.51	508
Bottom	Copper	n/a	18

3 Impedance matching

On the fig. 3 the impedance matching Comsol Multiphysics simulation setup is presented. The simulation is doing a half-size calculations: only right side is presented on the picture. The simulation is calculating impedance of the line for specific dimensions.

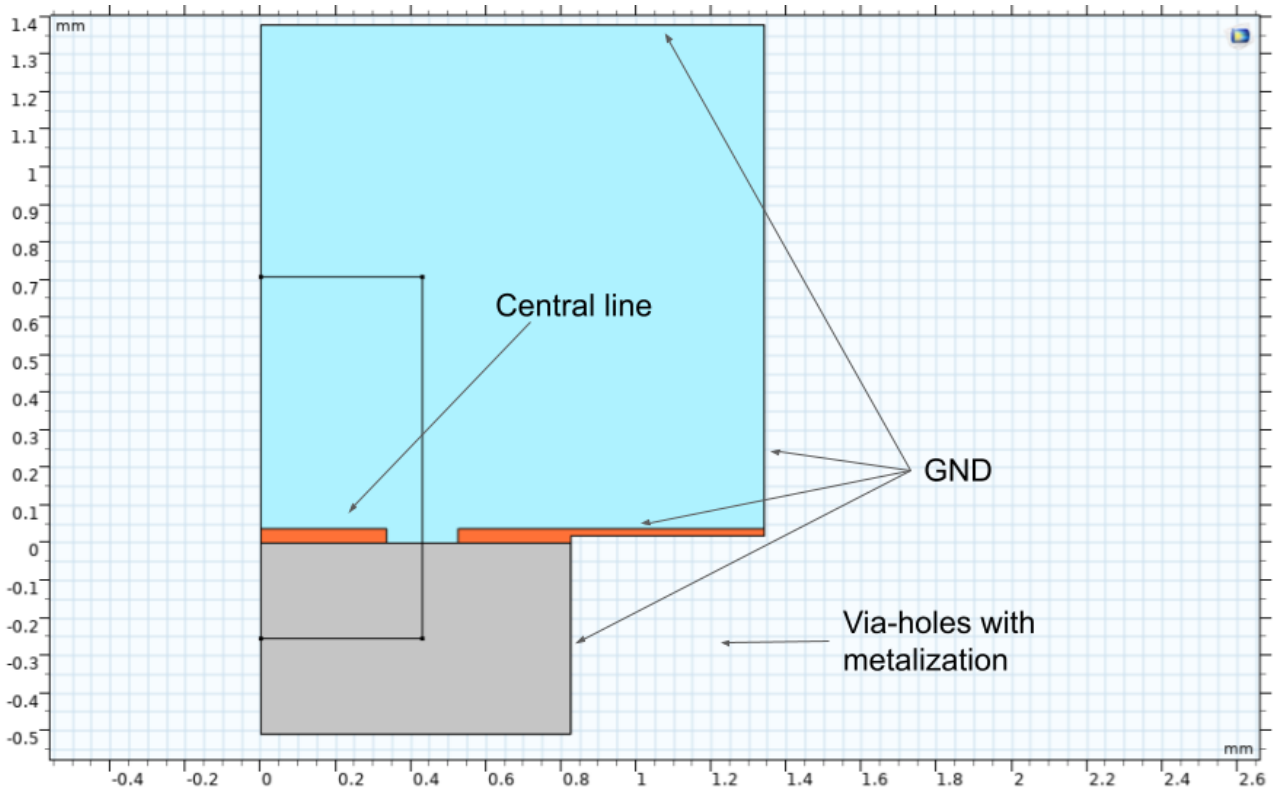


Figure 3: Impedance matching Comsol Multiphysics simulation setup. On the picture Ro dielectric is colered in gray, copper - in orange and vacuum in blue.

In the design not only bottom ground (bottom copper layer) is taken into account, but also a matalized via-holes pattern as wel ass shields comming from top lid. All this parts are marked GND in the figure. Since the space for copper shield is limited with physical rules, it was made as large as possible, but this entailed a change in the impedance of the line, which, however, being used together with the shield will still satisfy 50Ω.

3.1 SMP connectors

In NANO-J design Rosenberger 19S101-40ML5-NM STRAIGHT PLUG PCB SMP connectors are used [1]. The connectors are cryogenic, 50Ω, non-magnetic, with DC to 26.5 GHz frequency work range.

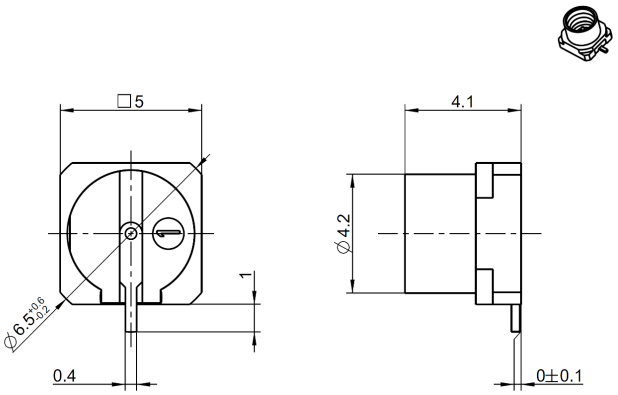


Figure 4: SMP connectors

4 Copper parts

Here a copper parts design is presented.

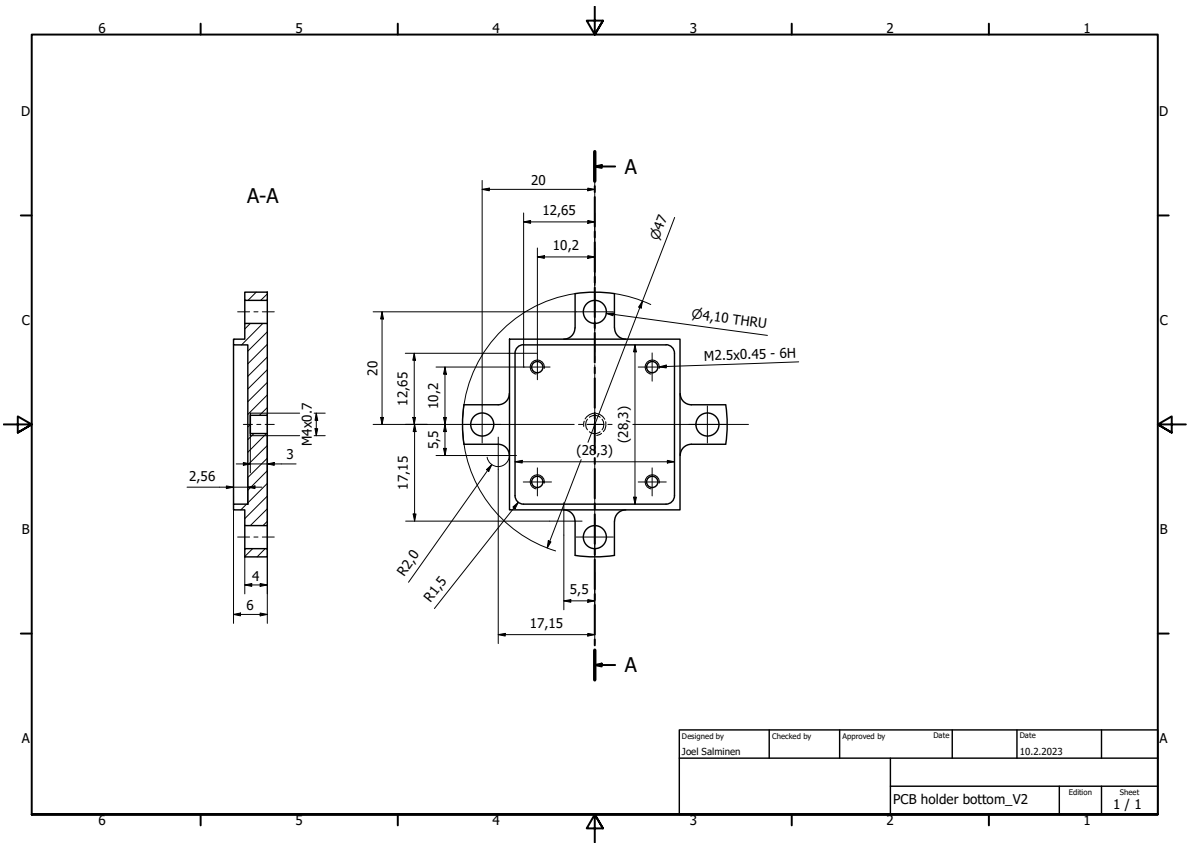


Figure 5: Bottom copper part.

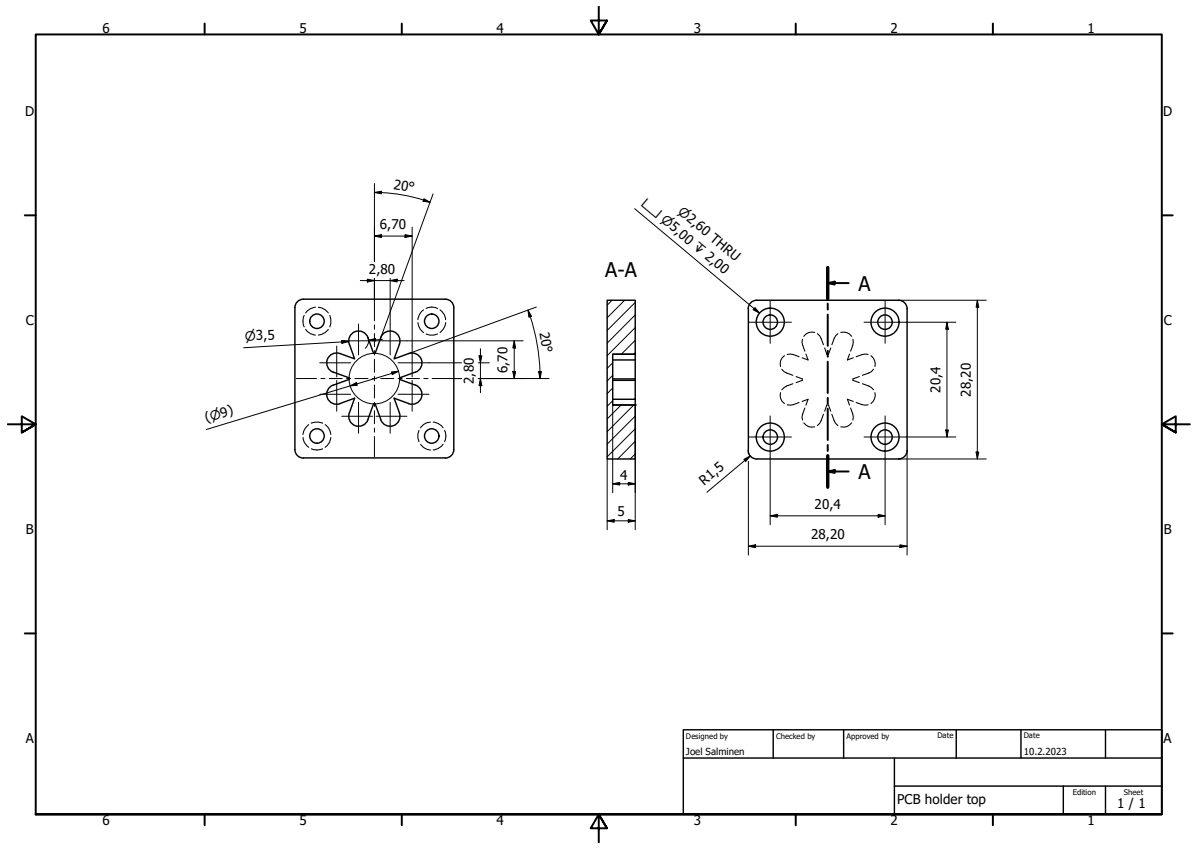


Figure 6: Top copper lid

4.1 SMA-SMP cables

In order to connect SMP connectors to the environment 6 inch SMA plug SMP jack cables by AMPHENOL SV MICROWAVE were used [2].

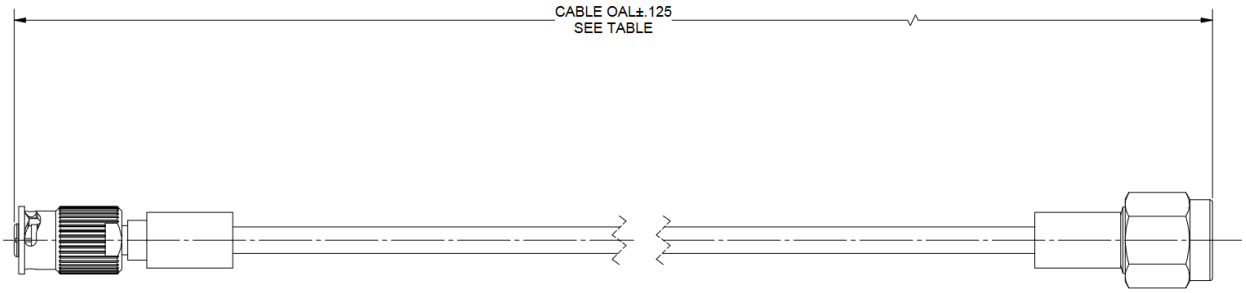


Figure 7: SMA-SMP cables

5 Measurements

In this section measurements of sample holder will be provided. Since the device is fully symmetrical, there is no need to check all 8 lines, so here only two pairs are measured. In order to test the lines a chip with clean resonances was set to the holder.

On fig. 8 an 5.8 to 6.5 GHz range was studied as the most interesting one. It can be seen that there is no parasitic resonances in the line (the ones marked with green colour comes from the chip structure, so it should not be taken into account).

On fig. 9 an 4 to 8 GHz range was studied. On this region two undercoupled parasitic resonances are found. In the picture they are marked with pink colour.

On fig. 10 an 5.6 to 6.2 GHz range was studied. On this region one resonance is found. This resonance is very undercoupled (less then 0.5π) and has a very low quality factor. This resonance might be caused by sample box.

On fig. 11 an 6.4 to 7.7 GHz range was studied. On this region 6 resonances are found. The ones that are marked in green come from the sample. The one marked in pink is parasitic. This resonance is very undercoupled (less then 0.2π) and has a very low quality factor. This resonance might be caused by sample box.

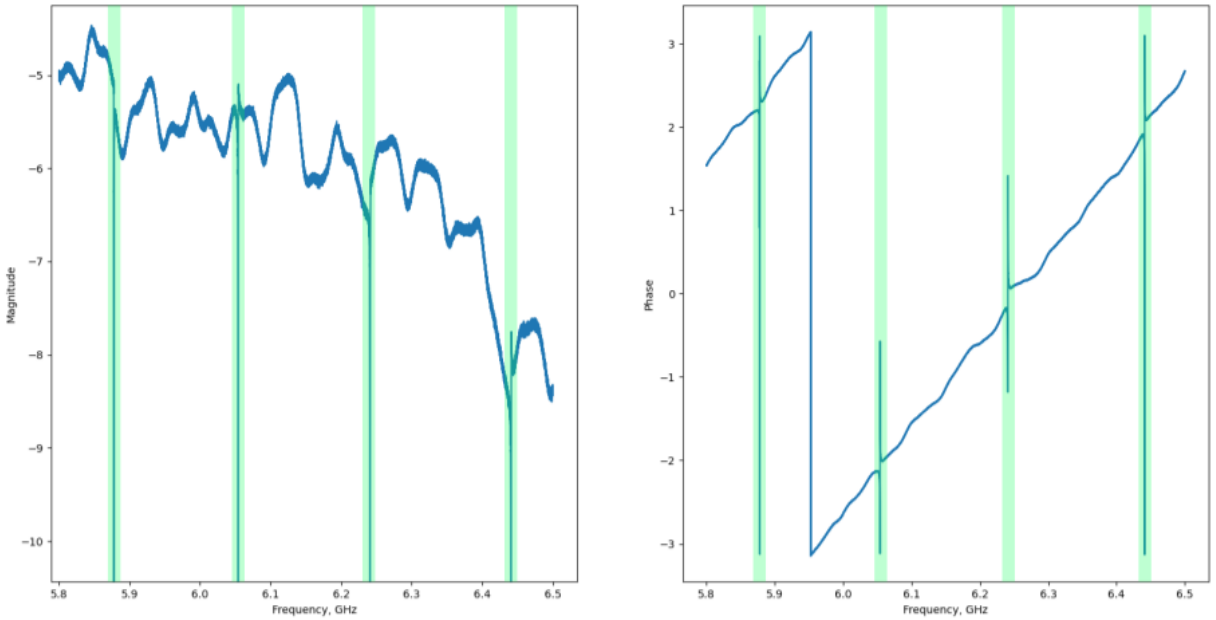


Figure 8: Measurement of 2 and 6 lines

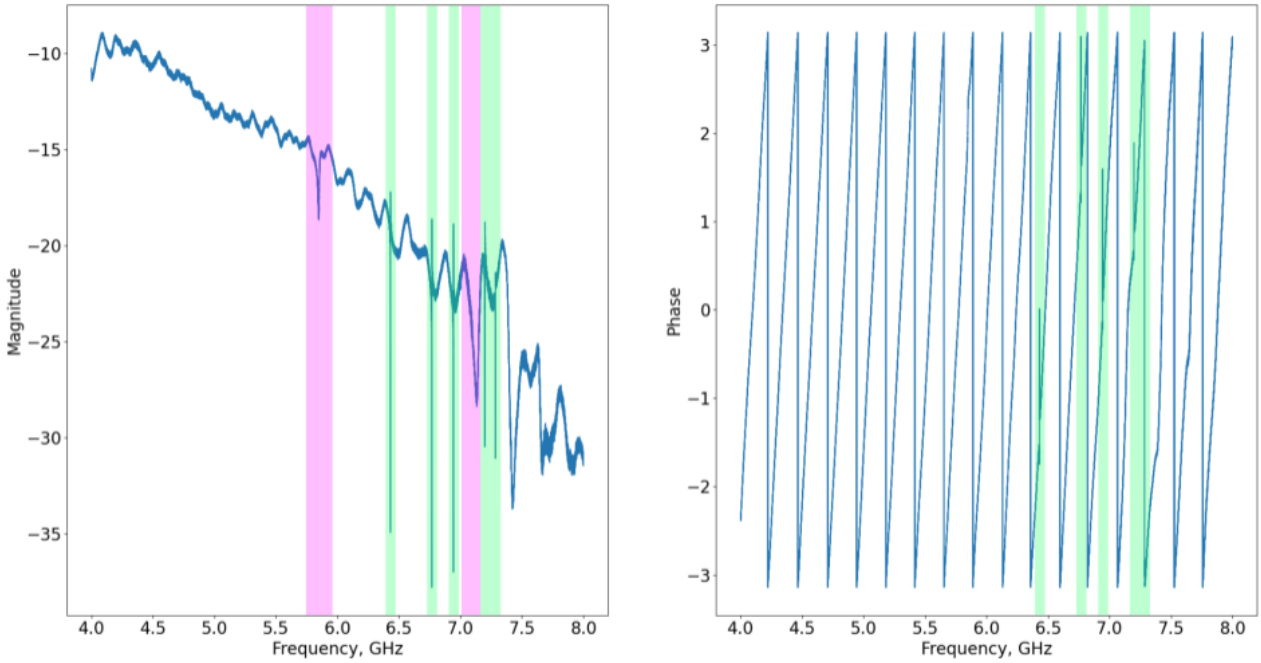


Figure 9: Measurement of 1 and 7 lines

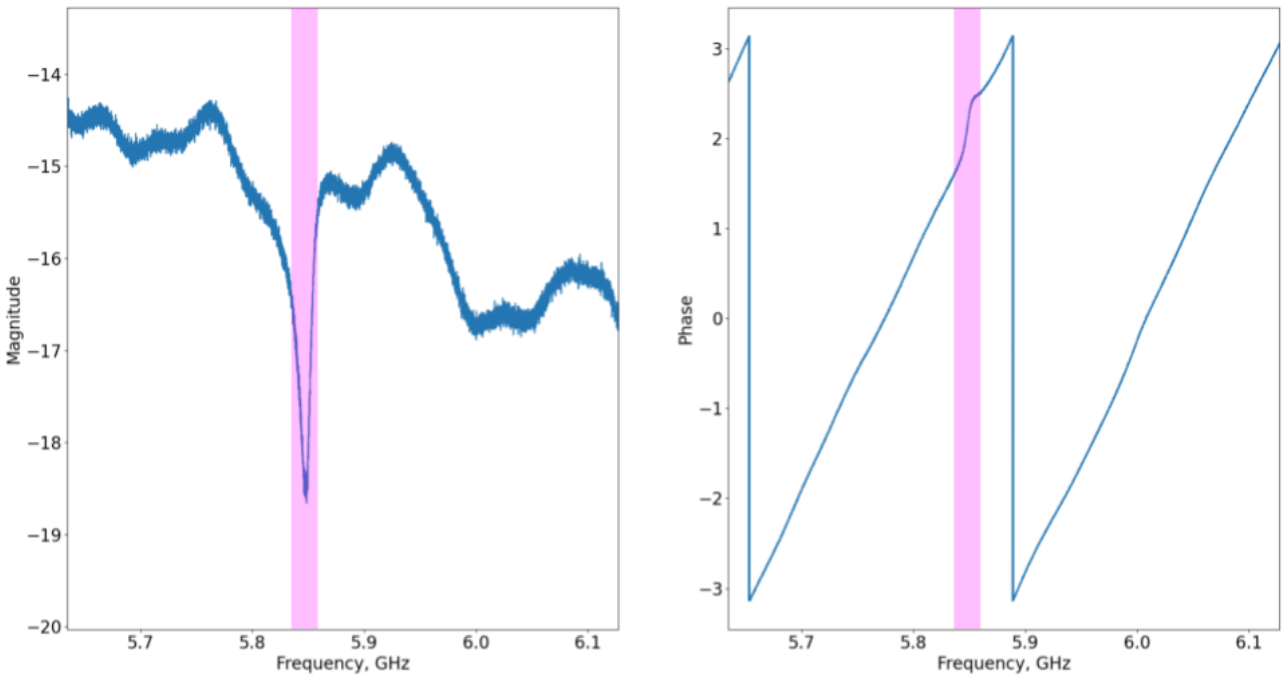


Figure 10: Measurement of 1 and 7 lines. Left region.

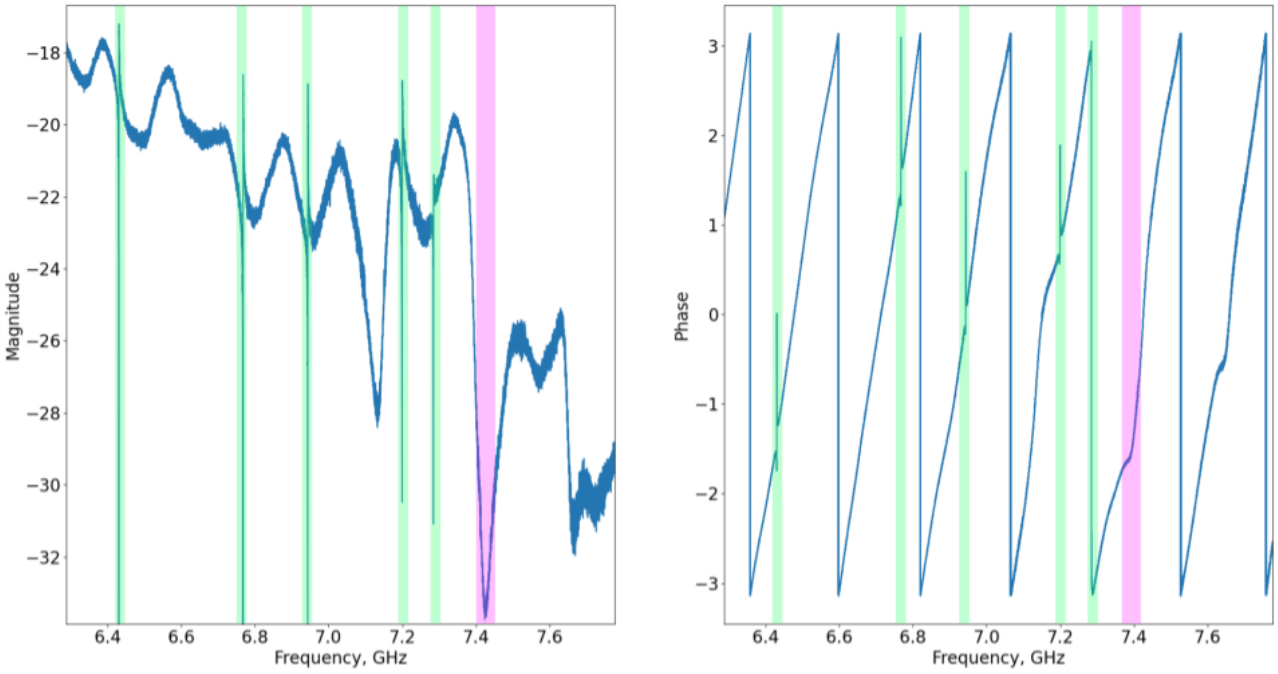


Figure 11: Measurement of 1 and 7 lines. Right region.

6 Conclusions

Sample holder NANO-J is designed for RF measurements on the range of 4 to 8 GHz. On this region only two parasitic resonances are found (5.85 GHz and 7.4 GHz), which can be easily be avoided.

References

[1] Rosenberger Hochfrequenztechnik GmbH & Co www.rosenberger.de

[2] https://fi.farnell.com/c/cable-wire-cable-assemblies/cable-assemblies/rf-coaxial-cable-assemblies?brand=amphenol-sv-microwave&connector-to-connector=sma-plug-to-smp-jack