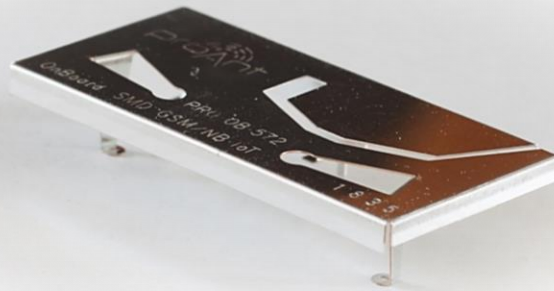


Application note and implementation guideline for GSM/UMTS operations

OnBoard™ SMD – GSM/NB-IoT antenna



Patent: SE537042 + Pending

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1. General

This document is a guideline for implementation of the OnBoard SMD GSM/NB-IoT antenna. The antenna is a combination of small size, low cost and high performance. Integration of embedded antennas is a task that involves tradeoff of different aspects, and this document aims to help when optimizing the performance of the antenna solution.

2. Intended applications

The antenna is optimized for pentaband operation in the GSM, UMTS and NB-IoT systems, which is defined by several frequency bands. This application note shows optimization of the antenna for the GSM/UMTS frequencies. Some of the supported bands are:

GSM/GPRS/EDGE	GSM 850 (824 – 894 MHz)
	GSM 900 (880 – 960 MHz)
	GSM 1800 (1710 – 1880 MHz)
	GSM 1900 (1850 – 1990 MHz)
UMTS/LTE	Band 1 (1920 – 2170 MHz)
	Band 2 (1850 – 1990 MHz)
	Band 3 (1710 – 1880 MHz)
	Band 4 (1710 – 2155 MHz)
	Band 5 (824 – 894 MHz)
	Band 6 (830 – 883 MHz)
NB-IoT	Band 8 (880 – 960 MHz)
	Band 20 (791 – 862 MHz)

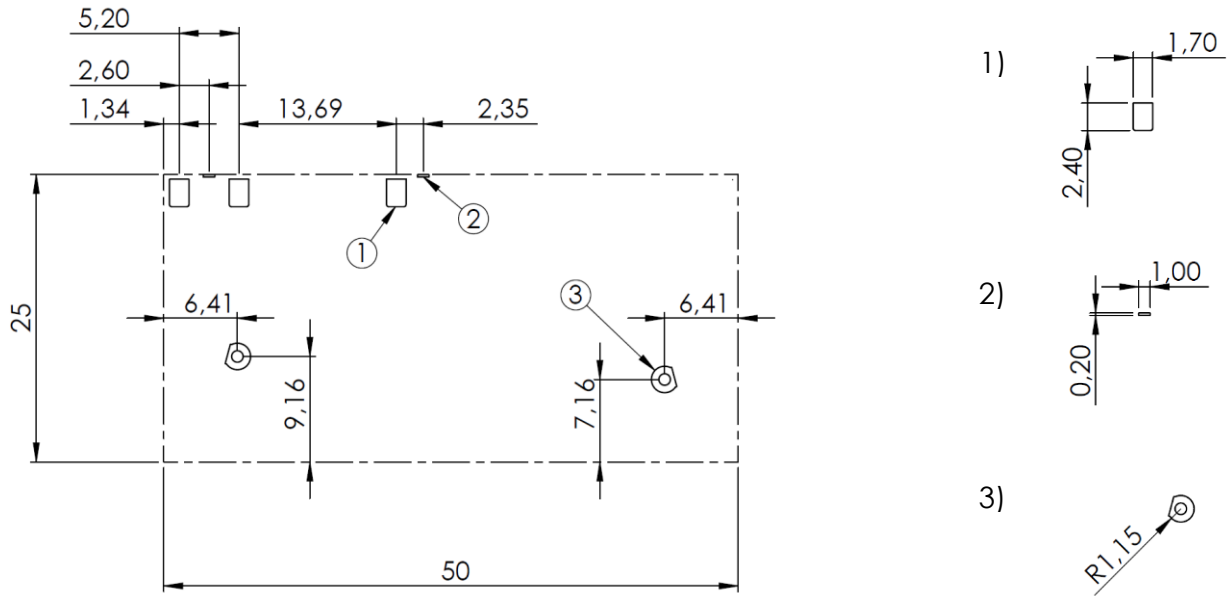
3. Technical data

Part number	PRO-OB-572
Frequency	824-960 MHz, 1710 - 2170 MHz
Impedance	50 Ω
Return loss ¹	< -6.5 dB, 824 - 960 MHz < -6.2 dB, 1710 - 2170 MHz
Total efficiency ¹	> -1.8 dB (66%), 824 - 960 MHz > -3.0 dB (50%), 1710 - 2170 MHz
Gain ¹	Max 2.2 dBi, 824 - 960 MHz Max 2.2 dBi, 1710 - 2170 MHz
Dimensions (LxWxH)	50.00 x 25.00 x 10.00 mm (1.969 x 0.984 x 0.394 in)
Assembly	Pick and place
Soldering	Reflow or equivalent
Packing	Tape and reel
Storage temperature	-40 to +125°C
Operating temperature	-40 to +125°C
Maximum temperature	400°C
RoHS status	Compliant with EU directive 2011/65/EU and 2015/863
Shelf life	10 years
MSL	Level 1, unlimited
Mechanical resistance ²	Immunity to vibrations IEC/EN 60068-2-6, Fc test Immunity to shock IEC/EN 60068-2-27, Ea test

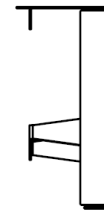
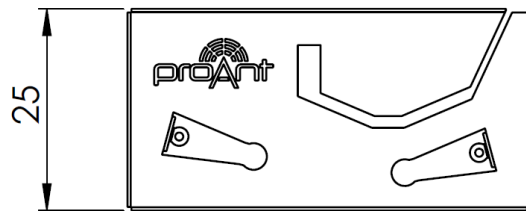
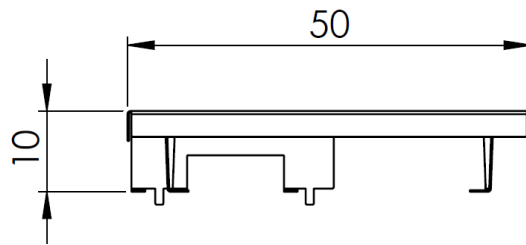
¹⁾ Measured on the Proant evaluation board

²⁾ The product has been tested according to the standard IEC 60721-3-5 – Class 5M3 (road vehicles in areas without well-developed road systems, light-weighted vehicles, tracked vehicles and self-propelled machines)

4. Mechanical dimensions



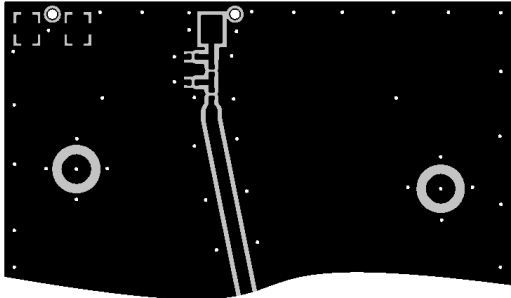
Antenna pins and keep-out block. Above dimensions are given in millimeter.



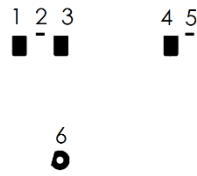
Antenna drawing. Above dimensions are given in millimeter.

5. PCB layout

The antenna is developed for optimum performance when mounted on a ground plane, and is therefore very suitably mounted on a printed circuit board, where all empty space in the layout shall be filled solid copper. This also means that no ground cutout area is required under the antenna. If there are several layers in the PCB, there is an advantage to add via holes for interconnection of the ground areas. It is also very important that there is a ground clearance around the NC pads and the RF feed pad, through all layers of the PCB. Otherwise there will be capacitive coupling which may detune the antenna.

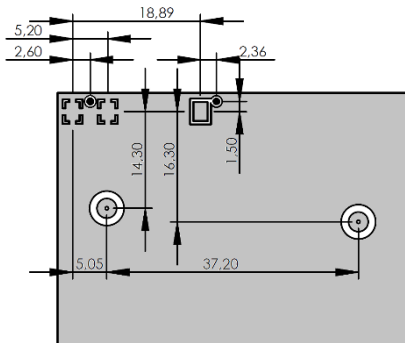


PCB Layout (from evaluation board)

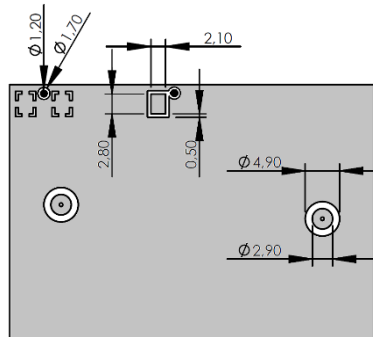


- 1. GND
- 2. TH pin (NC)
- 3. GND
- 4. Feed
- 5. TH pin (NC)
- 6. NC
- 7. NC

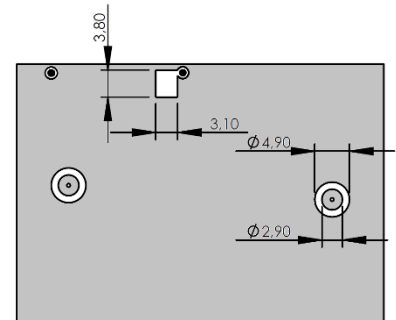
Pin configuration



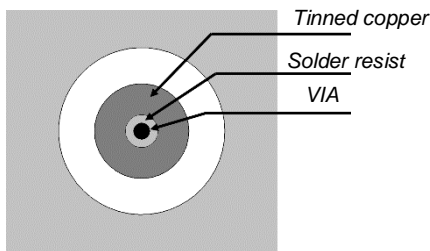
Distance between pads



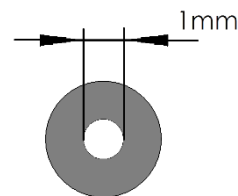
Pad dimensions (top layer). 1,3 and 4 are identical. 2 and 4 are identical. 6 and 7 are identical.



Bottom layer. Clearance through all layers. Pad 6 and 7 have identical layout as top layer and are connected by VIA



The sketch shows recommended design for pad 6 & 7 at top-layer.

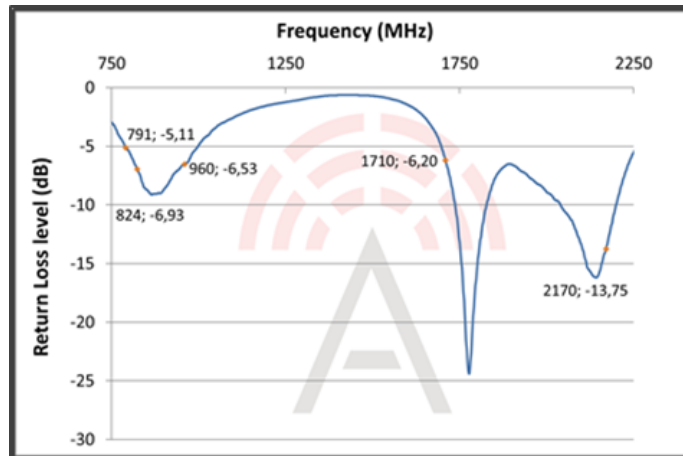


Solder mask as an annular ring with inner diameter of 1mm, the solder resist in center will prevent solder paste/tin to flow down the VIA.

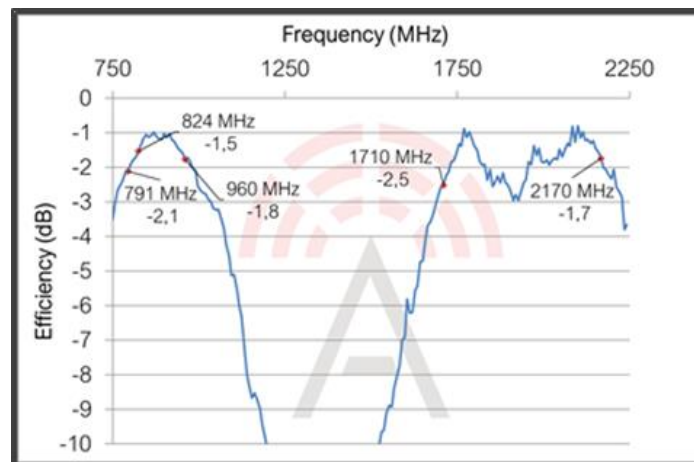
6. Electrical performance

All results are measured with the antenna mounted on the evaluation board.

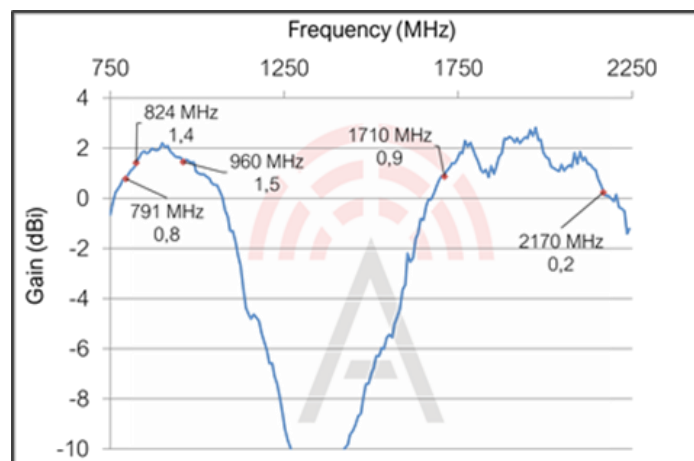
Return loss



Total radiation efficiency



Maximum radiation gain

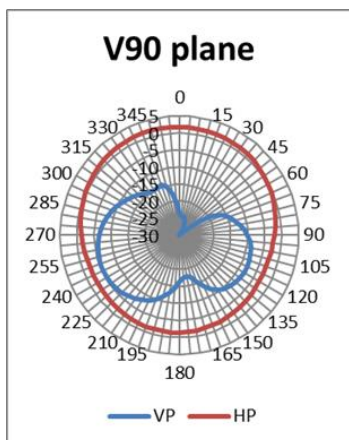
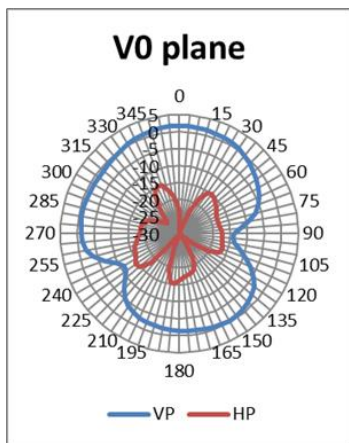
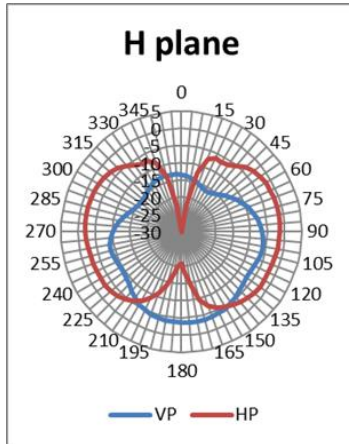


7. Radiation pattern

All results are measured with antenna mounted on the evaluation board. The figure to the right shows the corresponding antenna position for each chart. Gain values are given in dBi.

VP = Vertical Polarization, HP = Horizontal Polarization

Radiation pattern, 890 MHz

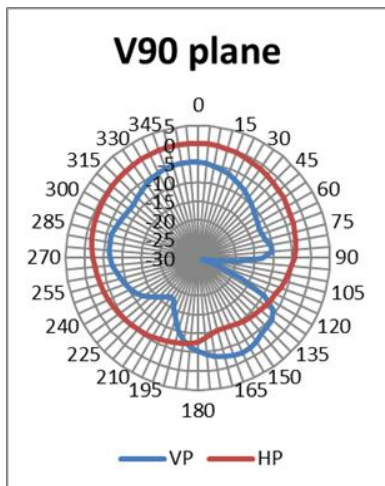
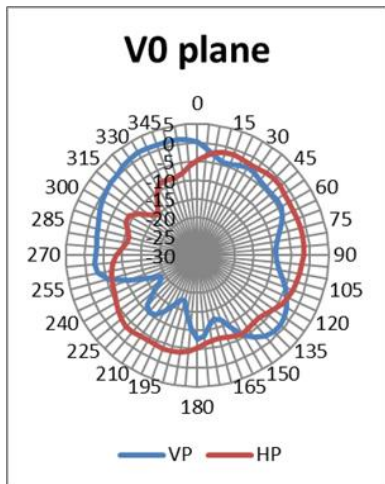
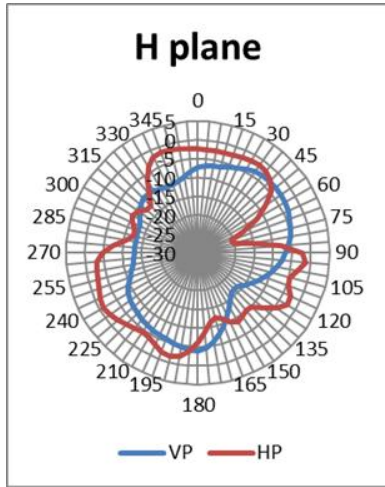


Board rotation



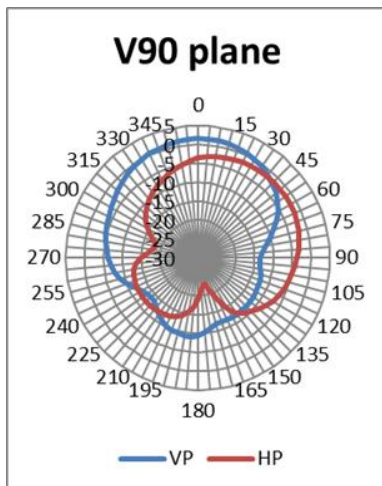
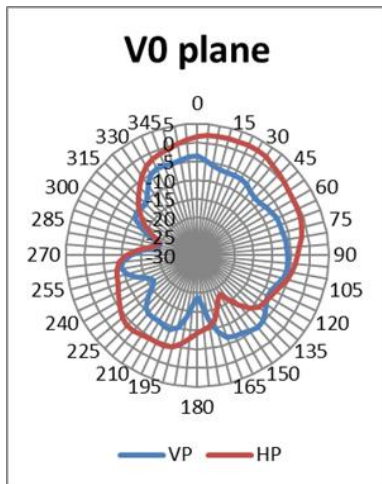
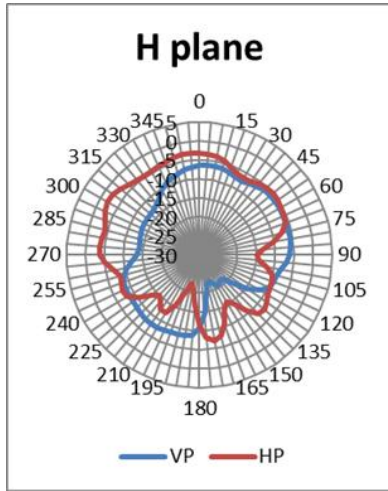
Radiation pattern, 1800 MHz

Board rotation



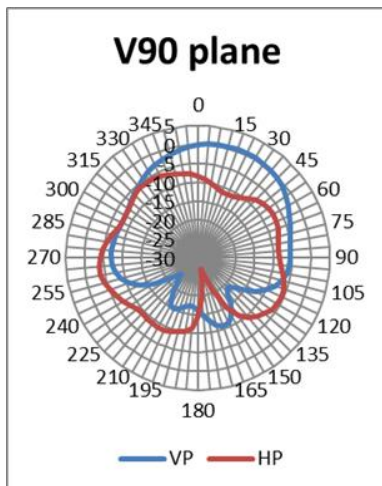
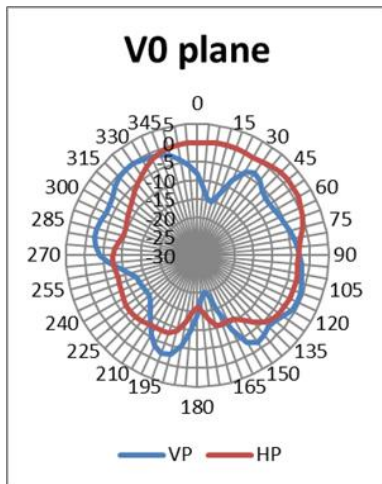
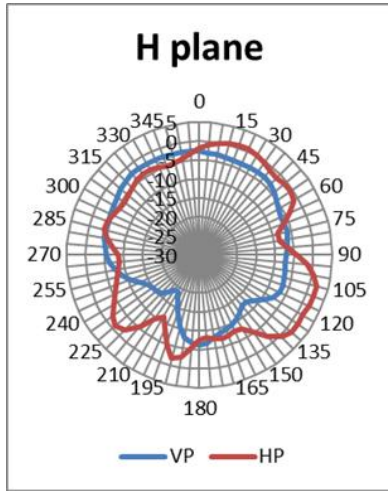
Radiation pattern, 1900 MHz

Board rotation



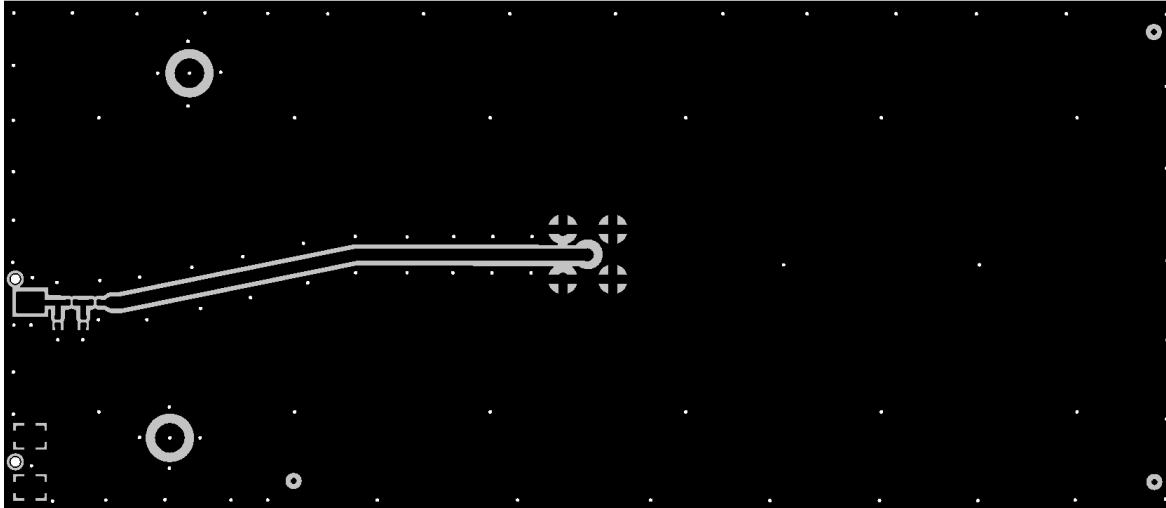
Radiation pattern, 2100 MHz

Board rotation



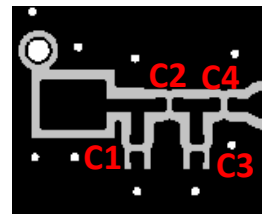
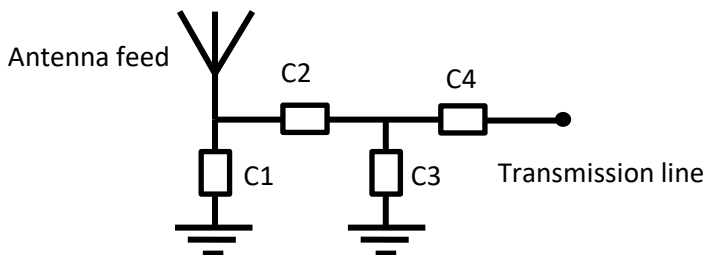
8. OnBoard SMD GSM/NB-IoT Evaluation board

The evaluation board is developed to simplify antenna testing and evaluation. It has an arbitrary size of 120 x 52 mm and includes an SMA connector. The purpose is to give a reference design for an optimal antenna implementation. The evaluation board can also be used to test other implementations by cutting and soldering the PCB into any device.



Evaluation board outline

The evaluation board has a matching circuit implemented next to the antenna. This is aimed to enable optimization possibilities for the user. The component positions are sized for 0402 (1005 metric) SMD components.



Matching circuit

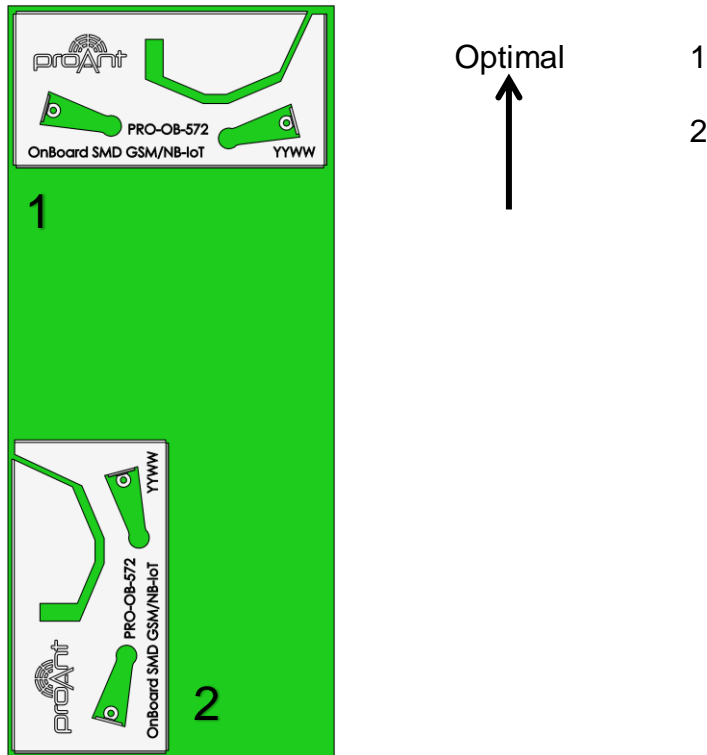
The antenna needs a matching circuit to adjust the resonant frequency balance. When delivered, the evaluation board is tuned for optimum balance at the GSM/UMTS frequency bands. The component values for this setup are:

C1 = 0.9pF (Murata GJM1555C1HR90WB01) C3 = N/A
C2 = 6.8pF (Murata GJM1555C1H6R8WB01) C4 = 2.4nH (Murata LQW15AN2N4B00)

However, it is common that the resonant frequency will shift during implementation in an arbitrary device. Therefore, this matching may be changed for compensation of such effects. This is further described in chapter 9.

9. General implementation guidelines

The antenna can be positioned in different ways, although there are some positions which are more beneficial. Below picture shows a typical PCB with two possible antenna positions. The positions have been arranged according to the best general fit.



The antenna should be aligned with the PCB edge if possible. It is also important to align pin 1, 2, 3 and 4 along the outer side of the PCB, and even more preferably close to a corner.

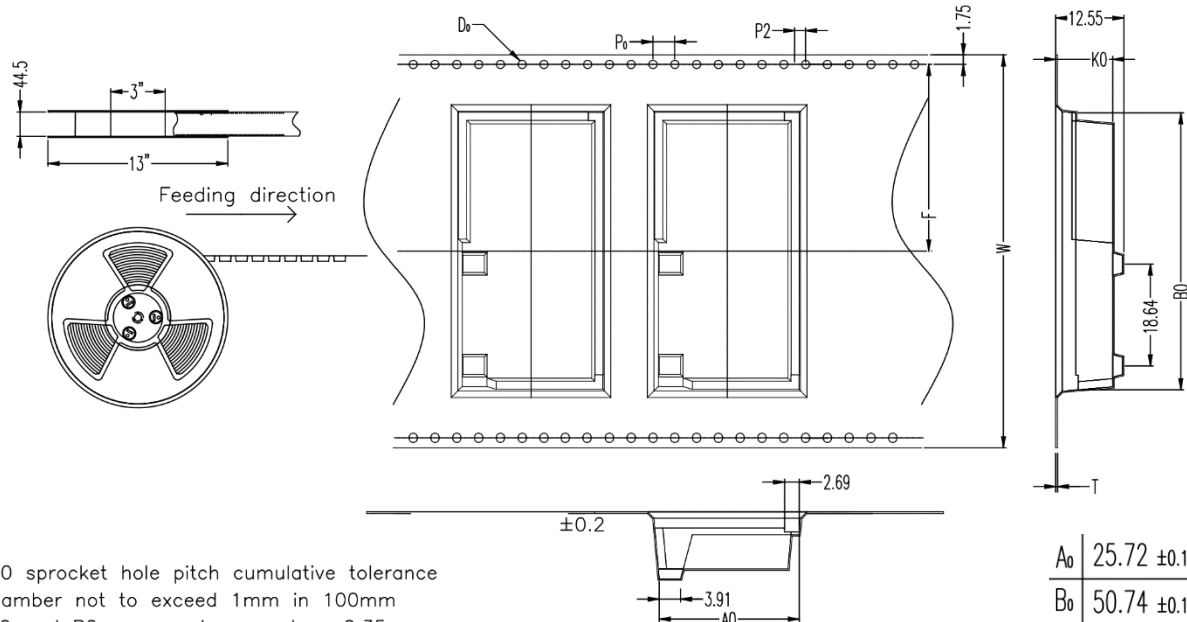
The OnBoard SMD GSM/UMTS antenna enables that small electrical components are mounted inside the antenna keep-out block. This is a space-efficient solution which has very little influence on the performance. It may have an impact on the antenna tuning, but is fully possible if there is limited space on the PCB.

Another general aspect on surface mounted antennas is regarding the PCB population. If other electrical components are positioned in the surrounding area of the antenna, some impact on the antenna tuning and radiated performance may be expected. It is recommended that such components are distributed below a topographical slope that starts on PCB level at the antenna keep-out block, and slowly increases the height.

It shall also be highlighted that plastic and metal parts in the near proximity of antennas may influence the antenna tuning and/or performance. This aspect should be noted as a general guideline for all antennas. The effects are difficult to estimate without detailed information, but it is common that a plastic housing above the antenna shifts the resonant frequency down. It is recommended to measure the antenna in the actual device after implementation.

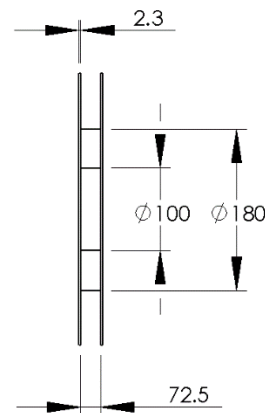
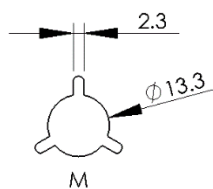
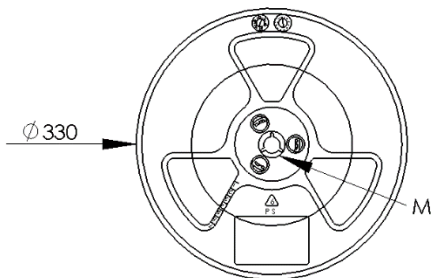
10. Package dimensions

The antenna is delivered on tape and reel according to following specifications. The quantity per 13" reel is 100 pcs.



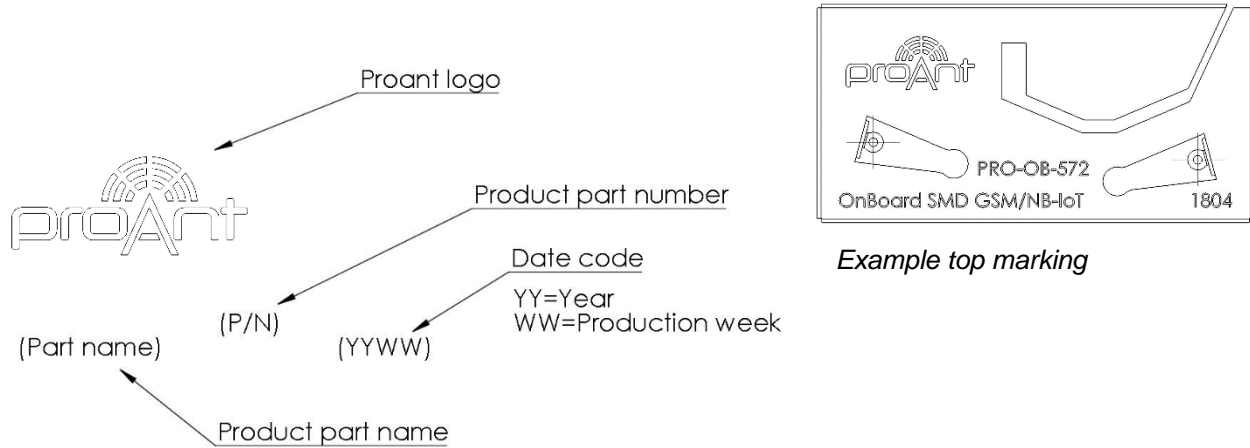
1. 10 sprocket hole pitch cumulative tolerance
2. Camber not to exceed 1mm in 100mm
3. A_0 and B_0 measured on a plane 0.35mm above the bottom of the pocket
4. K_0 measured from a plane on the inside bottom of the pocket to the top surface of the carrier
5. Pocket position relative to sprocket hole measured as true position of pocket, not pocket hole
6. Component load per 13" reel: 100 pcs
7. Packing length per 22" reel: M

A_0	25.72 ± 0.1
B_0	50.74 ± 0.1
D_0	$\phi 1.5 \begin{smallmatrix} +0.10 \\ -0.00 \end{smallmatrix}$
E_1	1.75 ± 0.1
F	34.2 ± 0.15
K_0	10.5 ± 0.1
P_0	4.0 ± 0.1
P_1	12.0 ± 0.1
P_2	2.0 ± 0.15
S_0	
T	0.35 ± 0.05
W	72.0 ± 0.3



11. Part marking

The top marking of the antenna is arranged according to the following illustration.



12. Disclaimer

The information given in this application note shall in no event be regarded as a guarantee of conditions or characteristics. With respect to any examples or hints given herein, any typical values stated herein and/or any information regarding the application of the device, Proant AB hereby disclaims any and all warranties and liabilities of any kind, including without limitation, warranties of non-infringement of intellectual property rights of any third party.

13. Ordering information

For information on sales, delivery terms and conditions and prices, please visit the Proant website for a complete list of distributors (www.proant.se/en/distributors.htm).

Proant offers consultation with design-in of the OnBoard SMD GSM/NB-IoT antenna, as well as design of matching network and transmission lines. Proant have all necessary capabilities for antenna design including anechoic chamber and prototype workshop. Please send your requests to info@proant.se.