Electrical Verification Test Plan

EVBOX G5+ **BASE US** AC Chargers

Customer - Project

TC-60.66

Test ID

Electrical Verification Test Report

Test Name

Rev	Revision Date	Originator(s)	Change Details
A0	30-Jul-2021	Bosmans Stijn	Initial Draft
A1	03-Aug-2021	Bosmans Stijn	Added measurement results
A	25-Aug-2021	Filip Reenaers	Corrected Customer project name to 3EVBOX G5+ **BASE US** AC Chargers" + Released

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18 ***Approvals***

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Revision	Title	Print Name	Signature	Date
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1 Test Objective

1.1 The purpose of this document is to document and communicate the **Electrical** Verification Test Report and Results for the **EVBOX G5+ BASE US AC Chargers** project during **B Sample / DVT** phase of the project.

2 Definitions/Terminology

Nr.	Term	Description
1.	**ADC**	Analog to Digital Converter
2.	**CAN**	Controller Area Network
3.	**CCID**	Charge Circuit Interrupting Devices
4.	**DSW**	Diagnostic Software
5.	**EVT**	Engineering Verification Tests
6.	**GPIO**	General Purpose Input Output
7.	**I2C**	Inter Integrated Circuit
8.	**LED**	Light Emitting Diode
9.	**SDIO**	Serial Digital Input Output
10.	**SPI**	Serial Peripheral Interface
11.	**SW**	Software
12.	**UART**	Universal Asynchronous Receiver Transmitter

3 Responsibilities

Item	Owner	Responsibility
1.	Originator	Responsible for the content of this document
2.	Quality Engineer	Responsible for organizing the review of this document
3.	Approvers	Responsible for approving this document

4 Referenced Documents

Item	Document Number	Description
4.1	00-PL20-82000	PLCQ-VV-Procedure-Product Verification Process
4.2	00-PL80-82020	PLCQ-VV-Template-Verification Test Procedure and Report
4.3	30-DS25-EV-Box-OEM_G5-MPVP-Master Product Verification Test Plan_rev**B**	Master Product Verification Test Plan
4.4	Product Requirements EVBox_G5+_Base_Rev_**C**	Product Requirements Document
4.5	System_Architecture_EVBox_G5+_Base_Rev_**E**	System Architecture
4.6	PCB1061493_**D**-03.pdf	Design Schematics COM board Rev D – B-sample

5 Management Summary

Test ID	Test Name	Duration (Hrs)	Sample Size	Test Result	Defect No.
TC-60.66	Antenna performance (GPS, LTE, WIFI)	40	1	**PASS**	EVBG5P-299
	Comment: • The efficiency of the antenna is for every band above the minimum efficiency that is required to meet the AT&T TRP requirements → **PASS** • The GNSS antenna efficiency is around 46%. This is above 'the rule of thumb' of 30% → **PASS** Matching circuitry needs to be updated (see chapter 8.1.6.2.1). • For US, there is no issue with max power since +30 dBm is allowed. But the Band edges are important for the US. This is also influenced by the antenna gain. The antenna gain is higher than mentioned in the datasheet if the Murata IC (FCC ID-part). Therefore, additional measurements on this are recommended. The efficiency on the 5Ghz is not optimal but due to the gain additional improvements are not recommended. Conclusion WIFI antenna measurements: **PASS**				
	Rework: **Yes**		Re-measurement required in next phase: **Yes**		

6 Equipment Requirements

Item	Equipment Name	Equipment Model	Equipment S/N	Calibration Due Date
1	Antenna chamber	Antenna chamber ETS-Lindgren AMS-8100	JA0979	NA* **: self-calibration done (check done with calibrated reference dipoles) before measurement*
2	VNA	Network analyzer R&S ZNB20	EM22033	12 Dec 2021

7 Sample Configurations

7.1 Sample Configuration Overview

Unit	Sample Description	HW/SW version	Sample ID (S/N)
1	B-sample complete **BASE US SET**	NA	JU_BA_U_FC_0007

8 Test Planning and Reporting

(Define each test procedure following the process below and record test result after test)

8.1 TC-60.66/ Antenna performance (GPS, LTE, WIFI)

8.1.1 Purpose and Scope of Test

All measurements necessary to conclude that the antennas (GPS, LTE, WIFI) are according to the expected return loss and efficiency. Checks will be done in free field on COM Board level but also built into the complete charger (set).

During the EVT phase of this project there was concluded that the Toaglass antenna that was placed in the design wasn't meeting the TRP carrier requirements. In order to meet those, the Toaglass antenna was replaced with a PCB antenna.
There was also noticed that the GPS antenna efficiency was very poor. To improve this, the GPS antenna was also replaced with a PCB antenna.

8.1.2 Reference Documents/Standards

ID	Document Number	Description
[Ref 1]	30-DS20-EVBG5P-BASE-Electrical-Verification-Test-Plan-COM Board-A2.docx	DVT test plan

8.1.3 Test Setup

8.1.3.1 Test setup Wifi measurements

(System setup, Test Configuration, Test profile, Test Environmental Conditions, etc)

Sample (COM board in a Wallbox) placed into the ETS-lindgren fully anechoic chamber.

Due to weight limitations, the long cable is sawn off at ±10cm.

Ambient room temperature: 23-25 degrees Celsius.

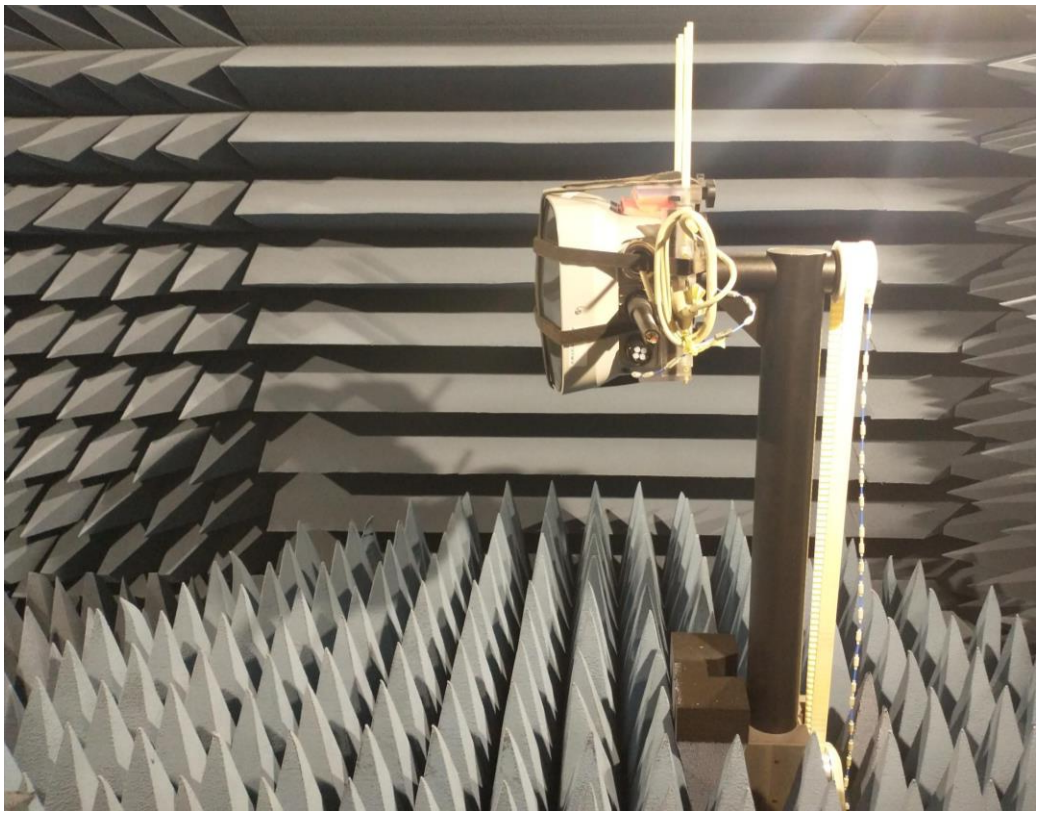
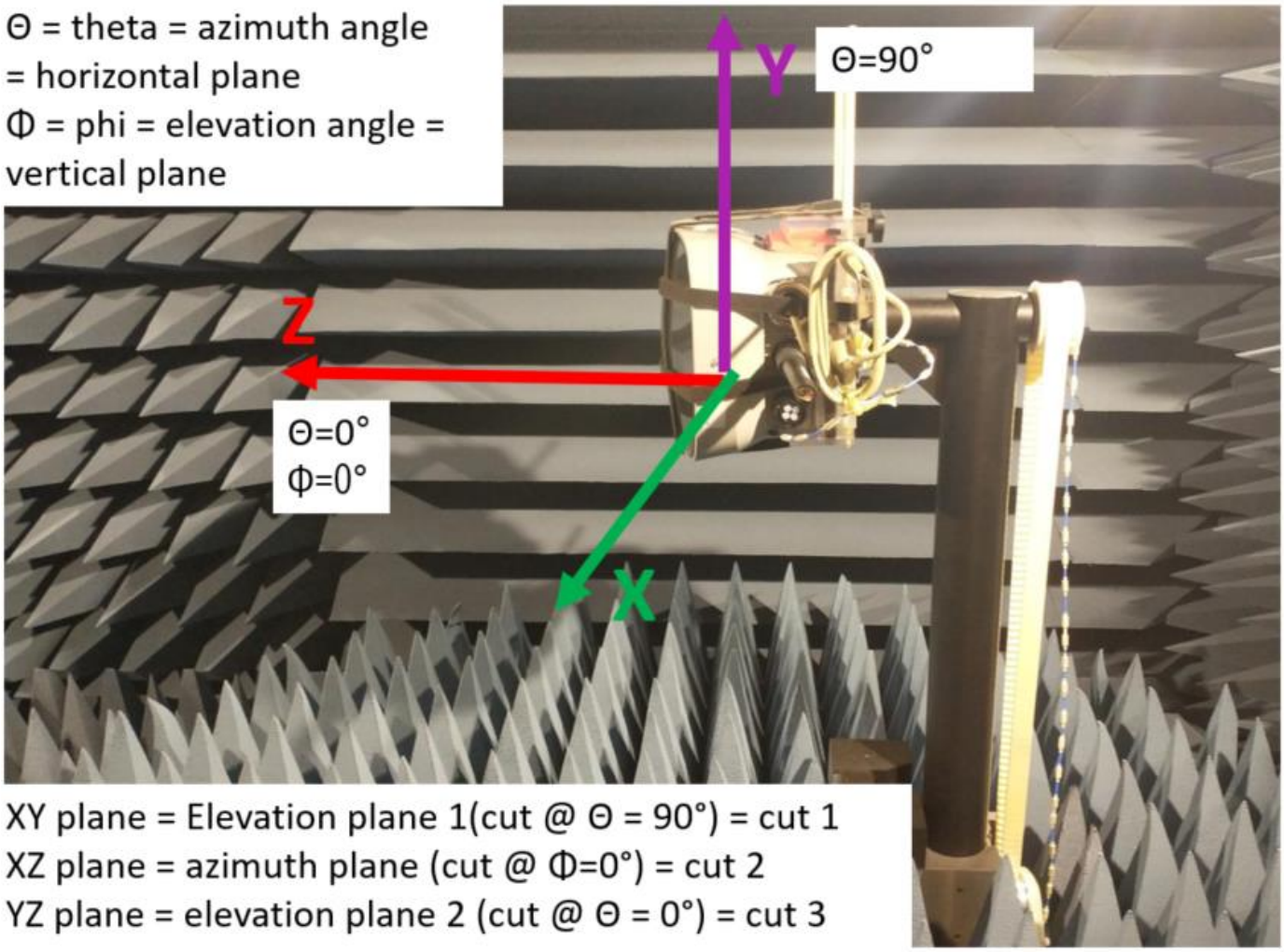


Figure 1: Measurement setup Wifi Antenna

84 Patterns, efficiency and gain of the antenna were measured with this set-up.



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86 Figure 2: Wifi measurement axis setup

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8.1.3.2 Test setup LTE/GPS Measurements

Sample (COM board in a Wallbox) placed into the ETS-lindgren fully anechoic chamber.
Due to weight limitations, the long cable is sawn off at ±10cm.
Ambient room temperature: 23-25 degrees Celsius.

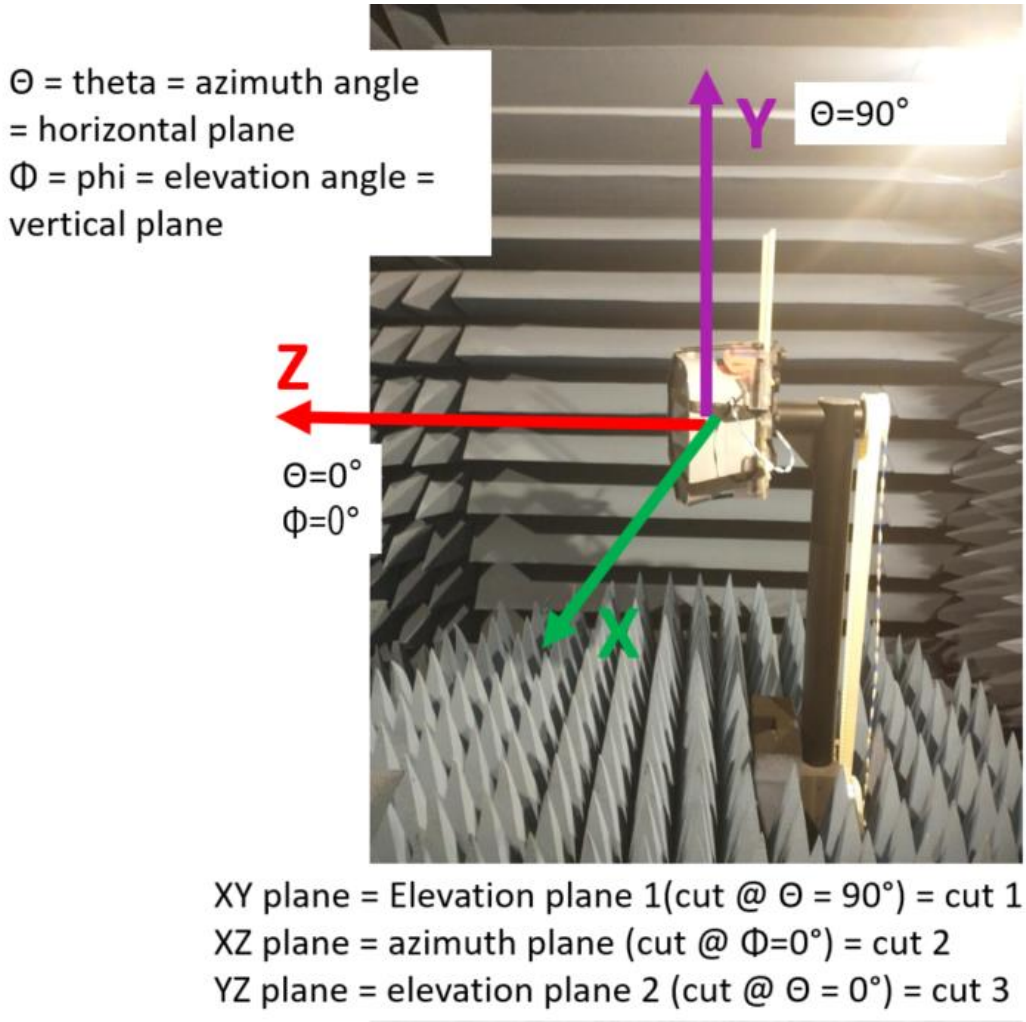


Figure 3: LTE/GNSS measurement axis setup

8.1.4 Test Pass/Fail Criteria

No real hard antenna requirements.

- In general, for all 3 (WIFI, GPS, LTE) antennas a return loss better than ~ 6-8 dB is good.
- To meet carrier requirements, the LTE antenna needs to have an efficiency bigger than 50% for the TX high bands (Band 2 and band 4) and 35% for the TX low band (Band 12 -700MHz).
- For GPS, efficiency better than 30%, the higher the better. For WIFI, efficiency of better than 40% is good for the 5GHz band 25% is acceptable.

8.1.5 Test Procedure

Coax (semi-rigid cable) connected to the antennas through the matching component structure. This is used for both network analyser (to measure return loss) and 3D antenna measurements in the antenna chamber (efficiency, gain, radiation patterns). The COM Board will be placed in the Wallbox Set for all these measurements since antenna matching can be influenced by plastic materials etc…

There is an Open-Short-Load calibration done on the VNA port. End of measurement semi-rigid will be calibrated as reference place to make sure that the VNA measures at the soldering point on the PCB (directly at the matching circuit input).
This is done by using a semi-rigid calibration kit(electrical & pysicial length of the cal. Coaxes are the same as the one used during the measurements).

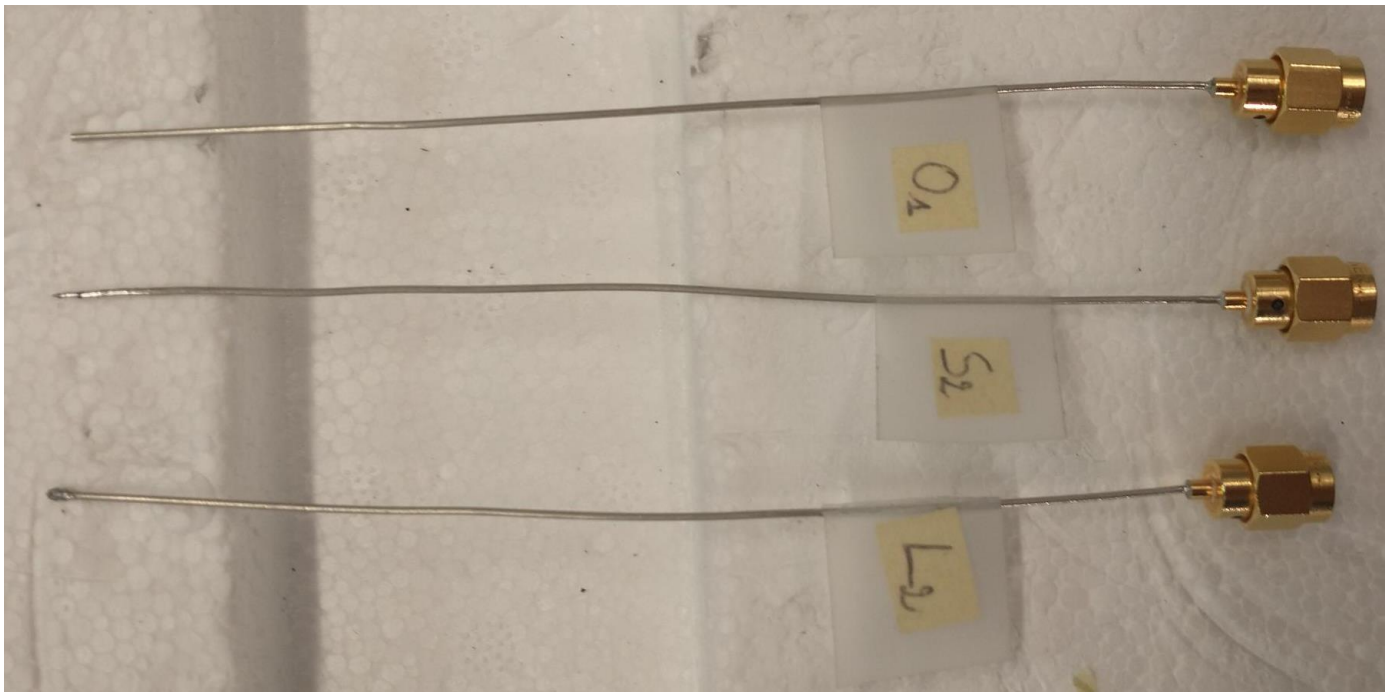


Figure 4: Calibration kit

8.1.6 Test Result/Output

8.1.6.1 LTE antenna measurements

8.1.6.1.1 LTE Matching

Matching for US LTE Bands B2, B4 and B12 in following range:

	RX (receive Freq)	TX (transit Freq)
B2	1930-1990	1850-1910
B4	2110-2155	1710-1755
B12	728-746	698-716

As outcoming of EVT, the next matching network has been implemented in the design.

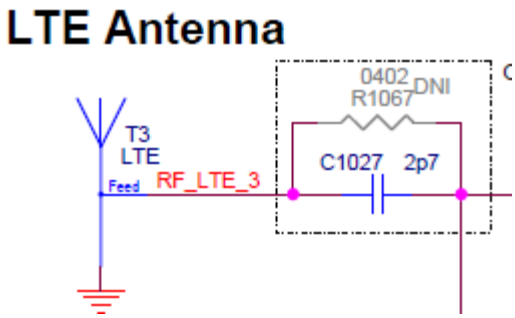


Figure 5: Matching network LTE

8.1.6.1.2 S11 (Return Loss) of LTE antenna

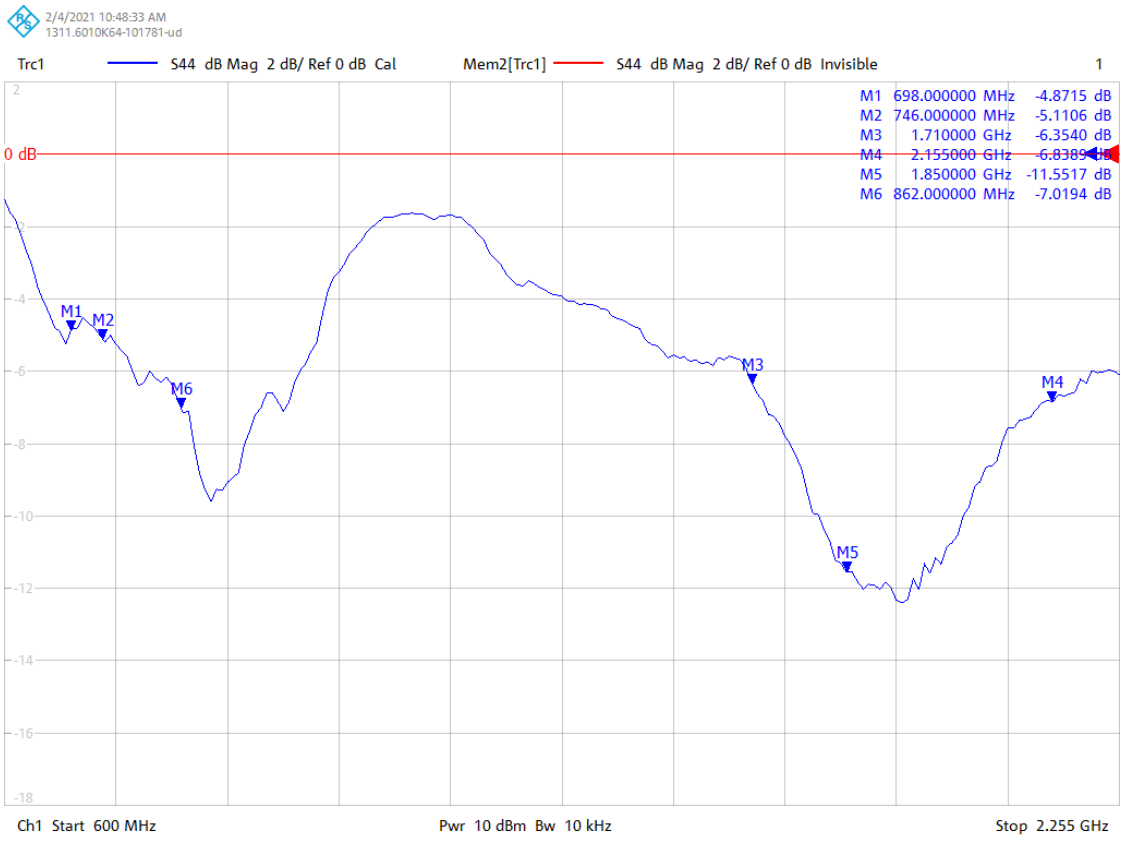
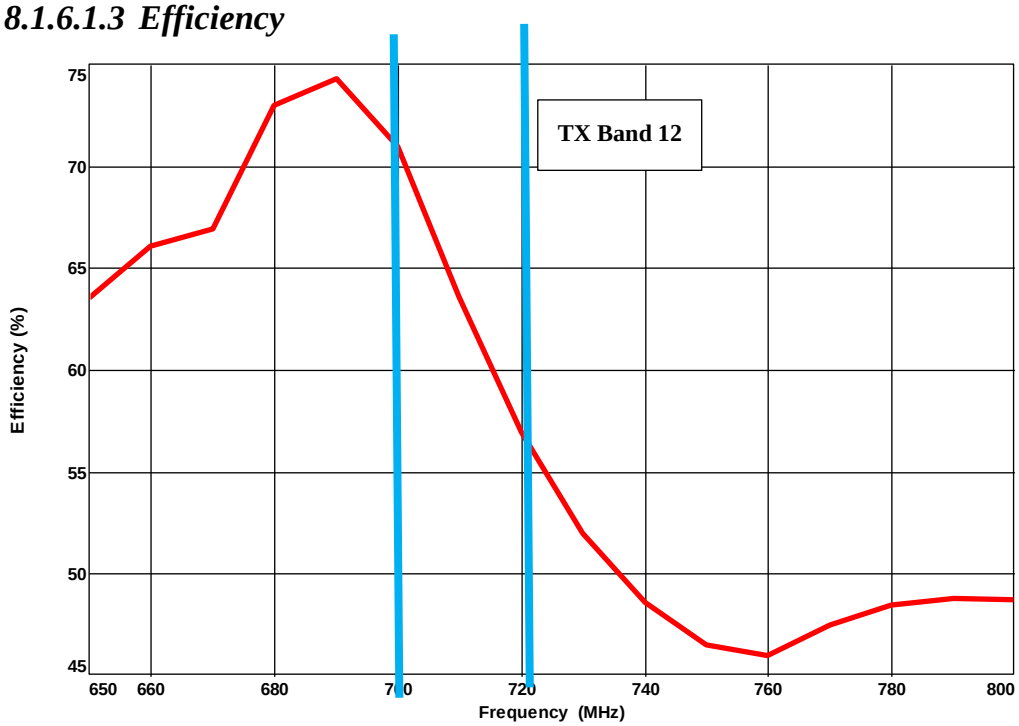


Figure 6: Return loss measurement result

The return loss is poor but acceptable for the low band. The main pass/fail criteria for these measurements are the antenna efficiency results.

135 ***8.1.6.1.3 Efficiency***



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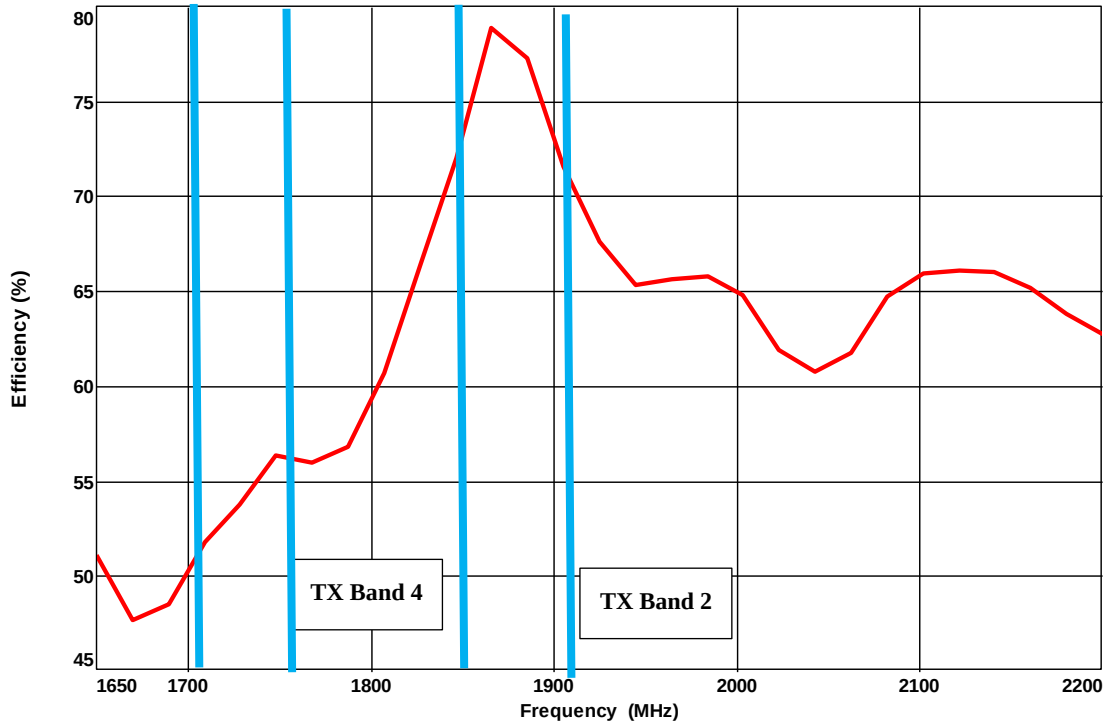
137 Figure 7: LTE Antenna - low band efficiency



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139 Figure 8: LTE Antenna - High band efficiency

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Conclusion:

The efficiency of the antenna is for every band above the minimum efficiency that is required to meet the AT&T TRP requirements → **PASS**

8.1.6.1.4 Peak Gain

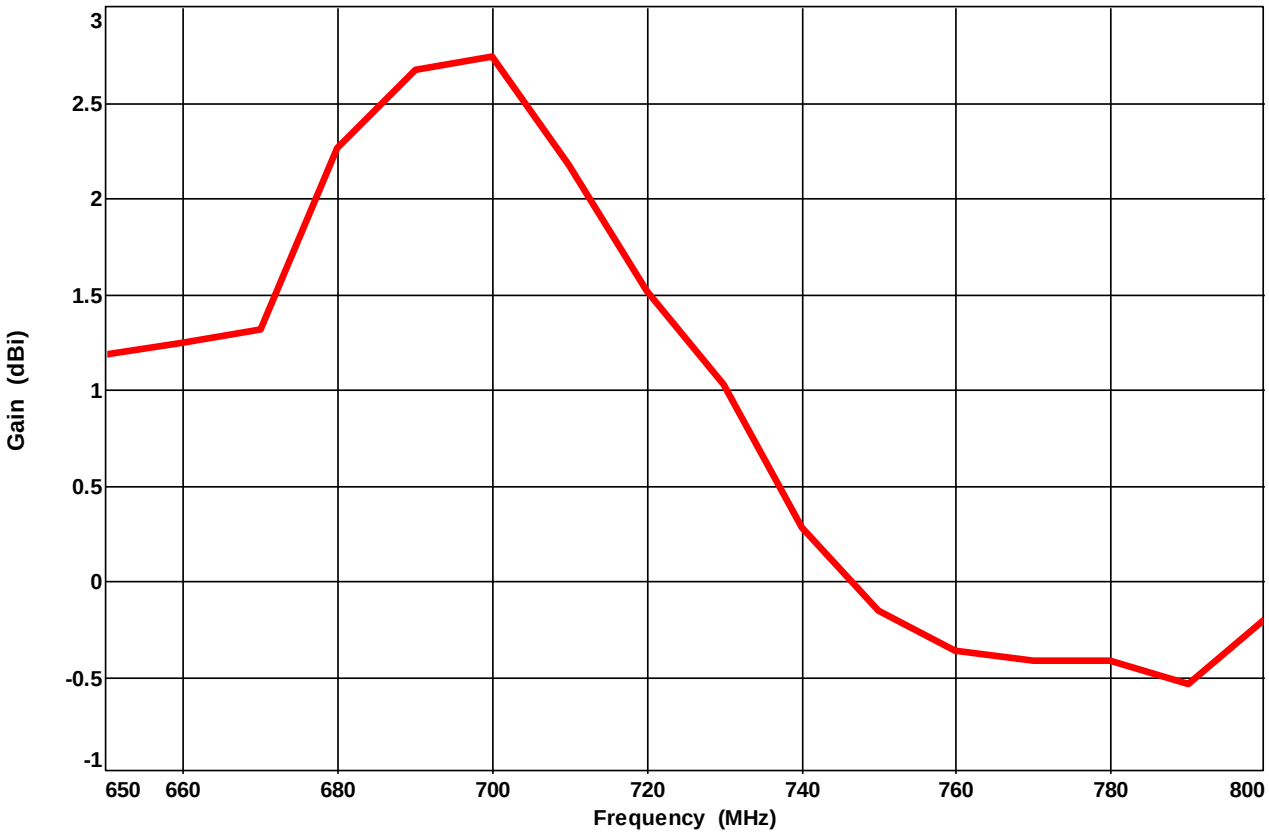

Figure 9: Peak gain LTE Antenna low band

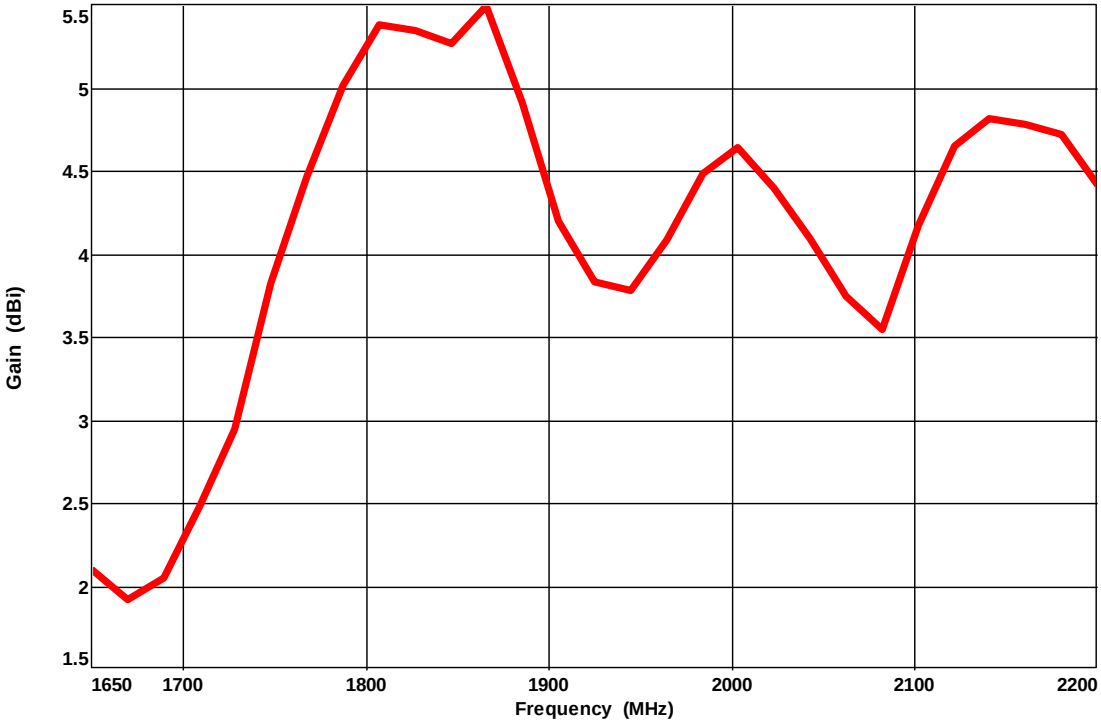

Figure 10: Peak gain LTE Antenna High band

2021.07.12.12.14.30.raw

Data result 1: Raw data LTE measurement results B12

2021.07.12.14.55.07.raw

Data result 2: Raw data LTE measurement results B2-B4

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158 ### 8.1.6.2 GPS antenna measurements

159 As outcoming of EVT, the next matching network has been implemented in the design.

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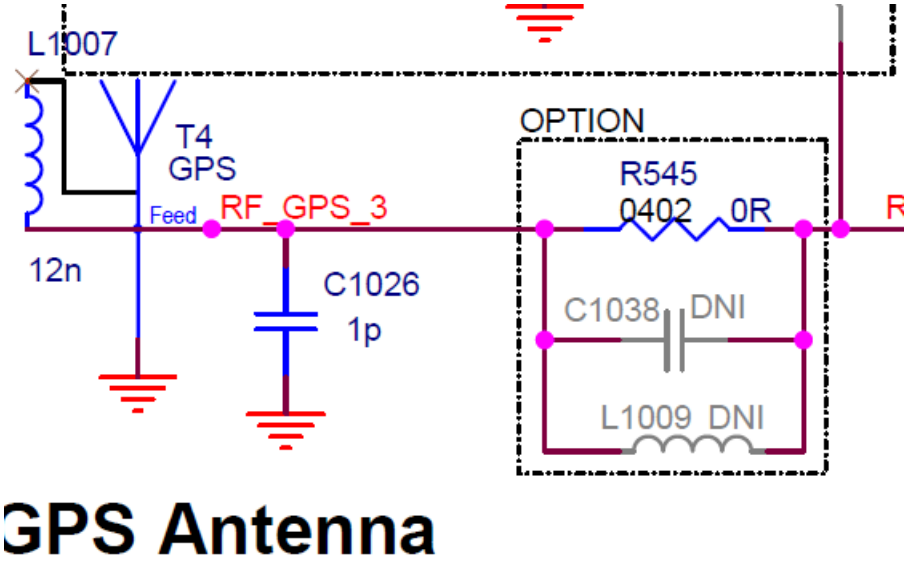

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162 Figure 11: GPS Antenna matching circuit – outcoming of EVT

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8.1.6.2.1 S11 (Return loss) of GPS antenna

During the measurements there was noticed that the antenna is not matched according to the GNSS frequency range. This can be due to the removed USB TypeC connector that isn't stuffed for the DVT phase of this product.

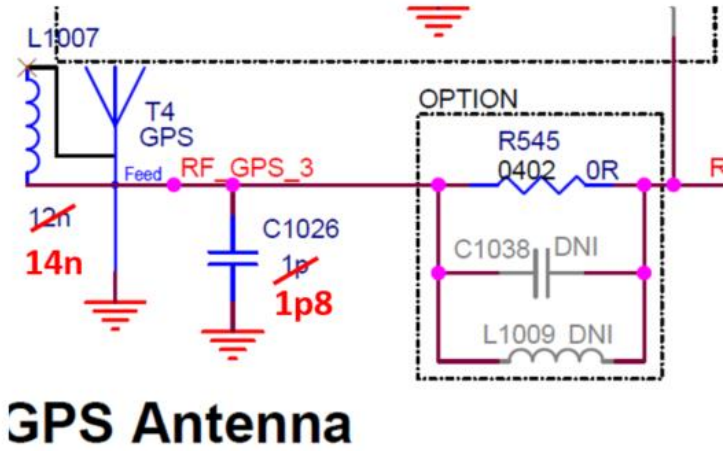


Figure 12: Adjusted matching GNSS Antenna

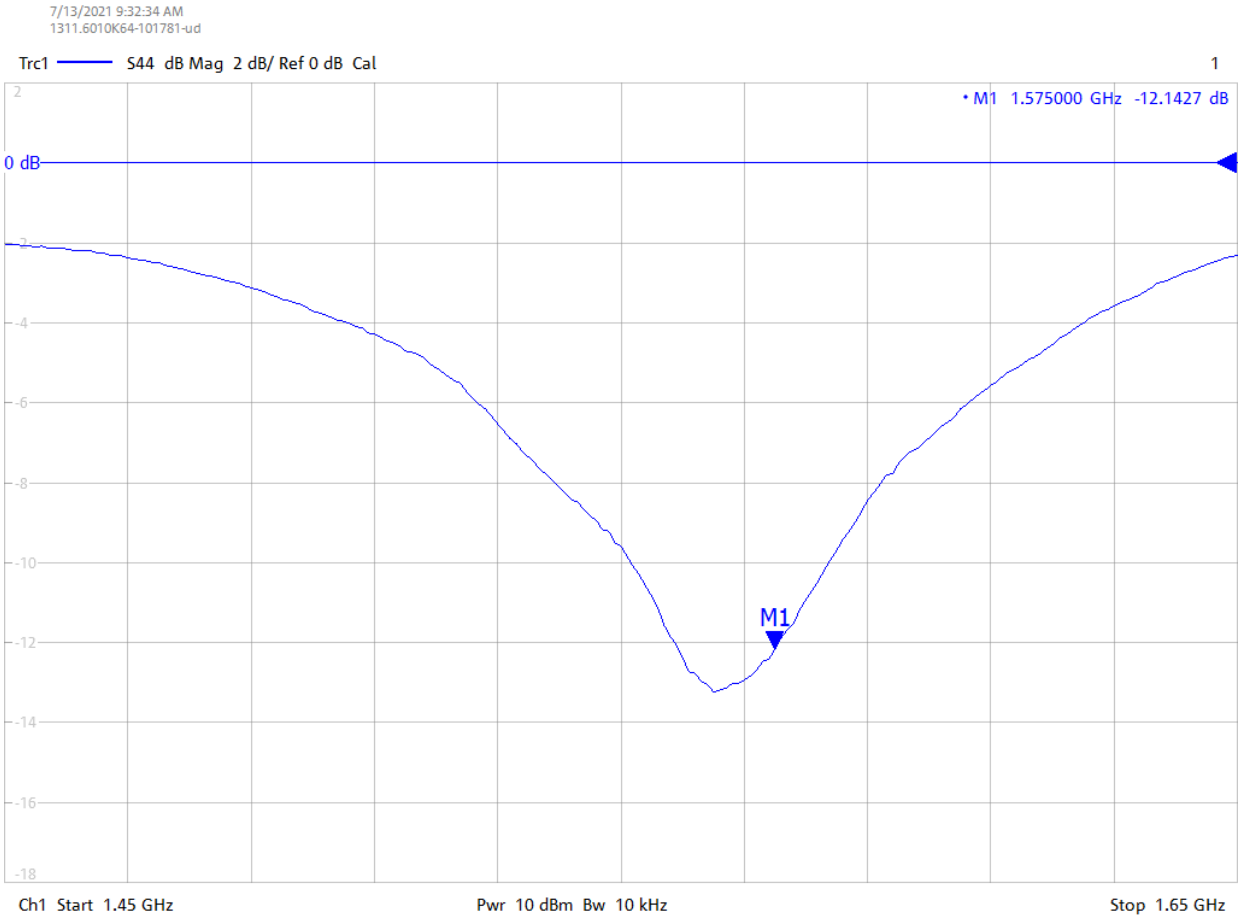


Figure 13: S11 GNSS Antenna adjusted

8.1.6.2.2 Efficiency

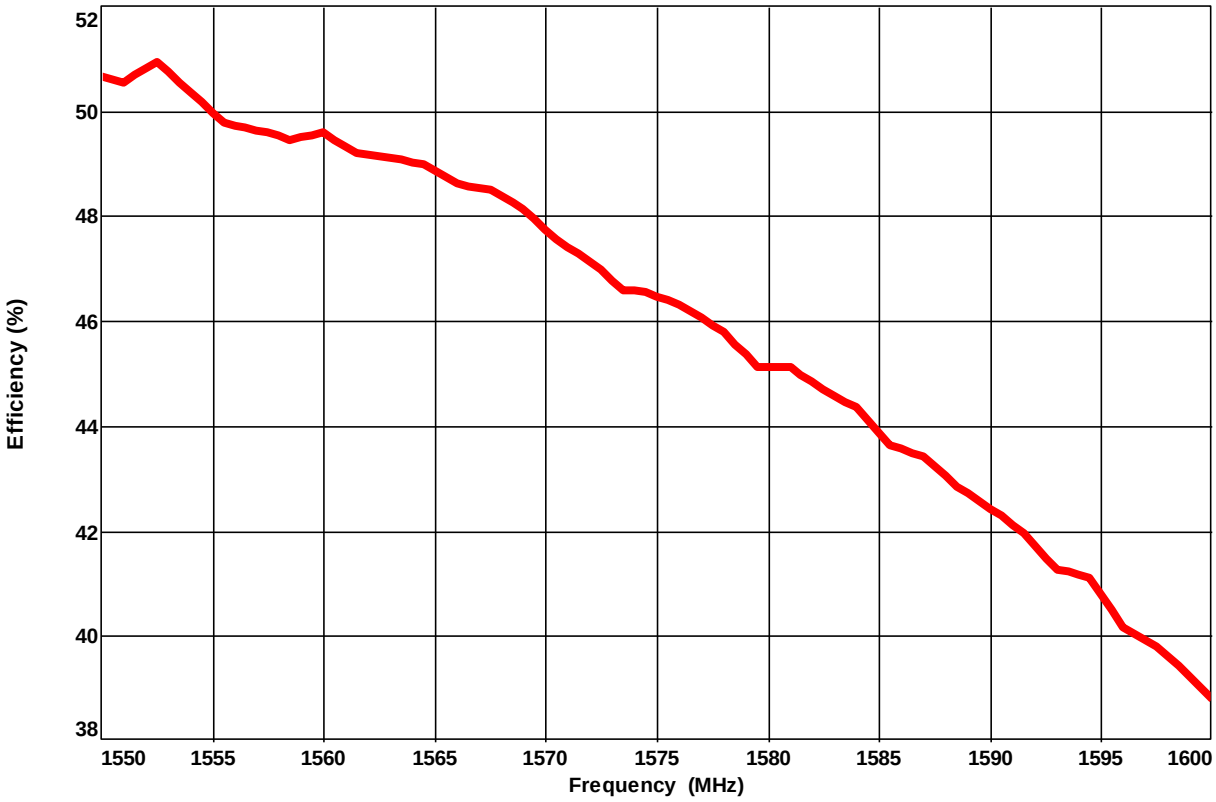


Figure 14: Efficiency GNSS antenna report

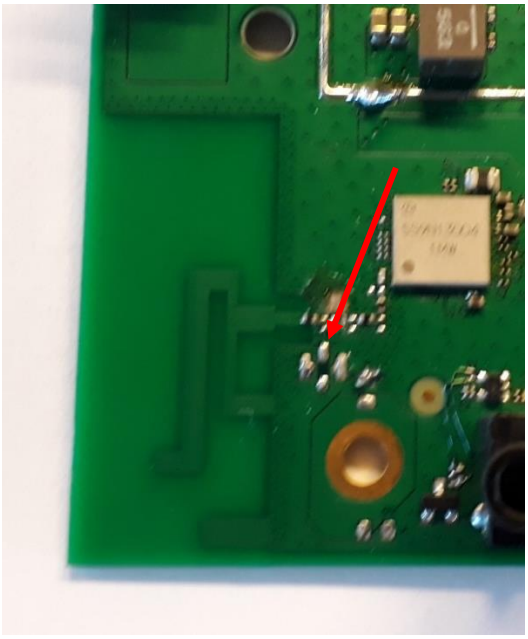
Conclusion:

The GNSS antenna efficiency is around 46%. This is above 'the rule of thumb' of 30% → **PASS**

2021.07.13.13.16.32.raw

Data result 3: Raw data GNSS results

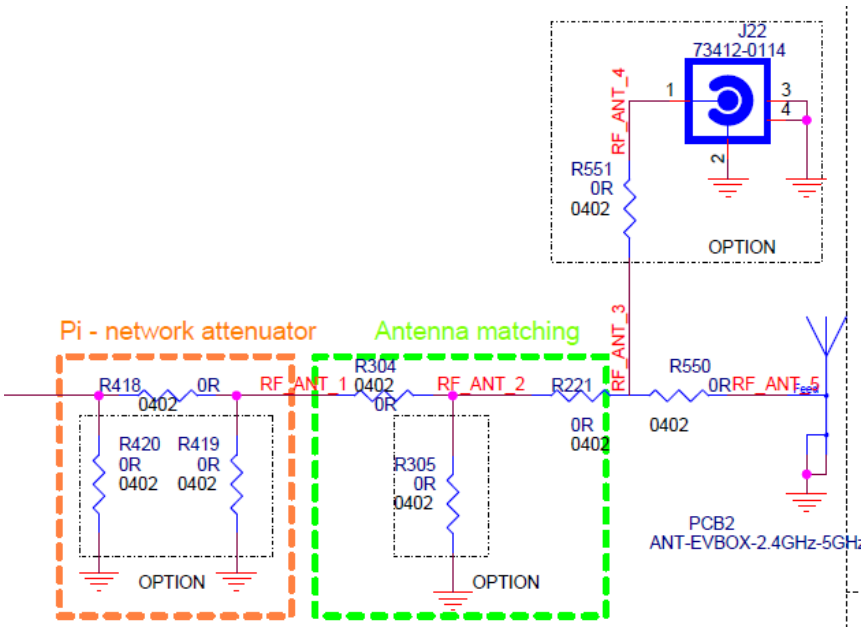
8.1.6.3 WIFI antenna measurements



8.1.6.4 WIFI measurements

8.1.6.4.1.1 Matching

No matching need, nor for 2.4GHz, nor for 5GHz; so all series components stay 0 Ohm, other not stuffed.



8.1.6.4.2 WIFI antenna S11 (return loss)

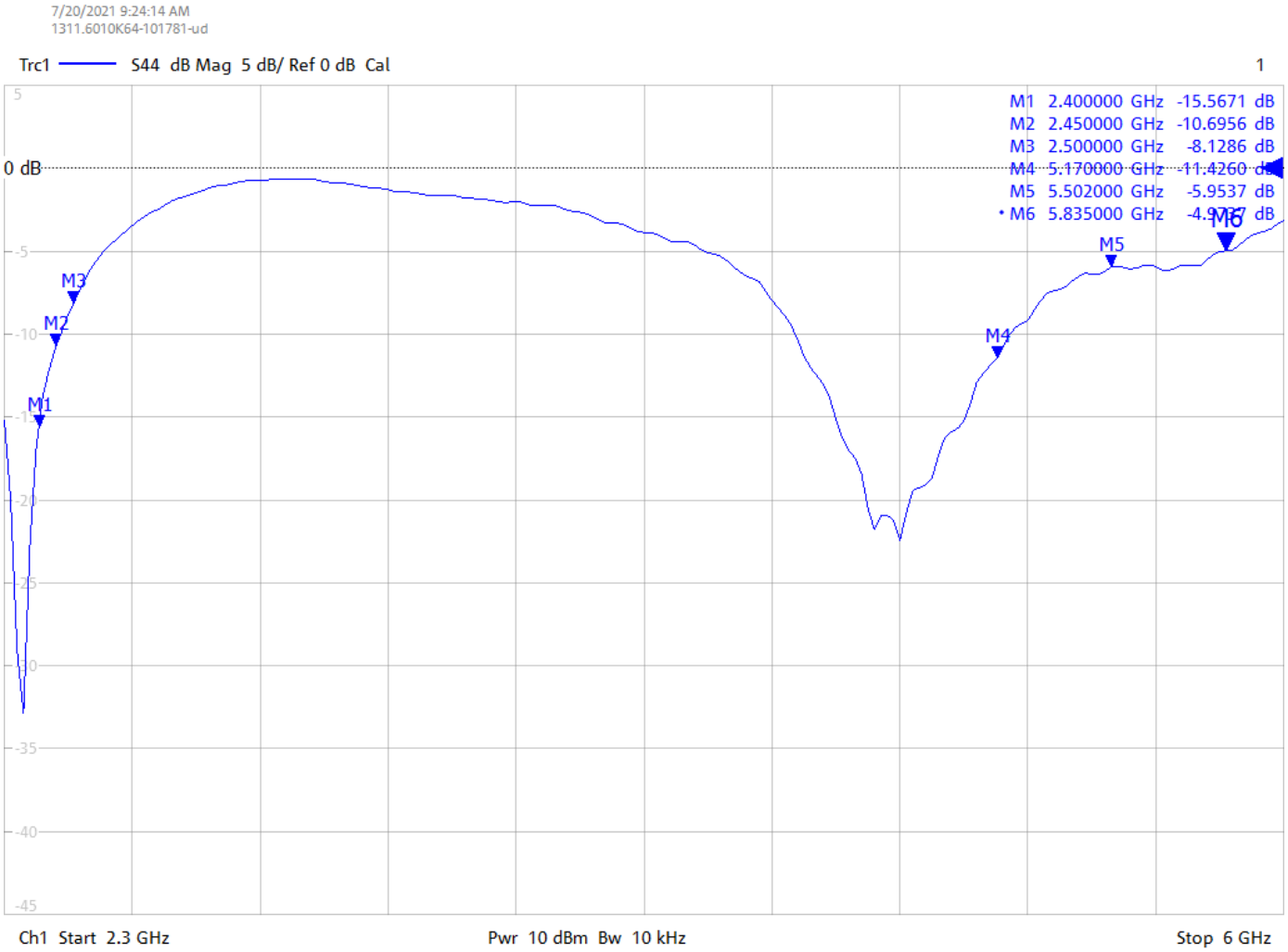


Figure 15: S11 Wi-Fi measurement result

8.1.6.4.3 Efficiency

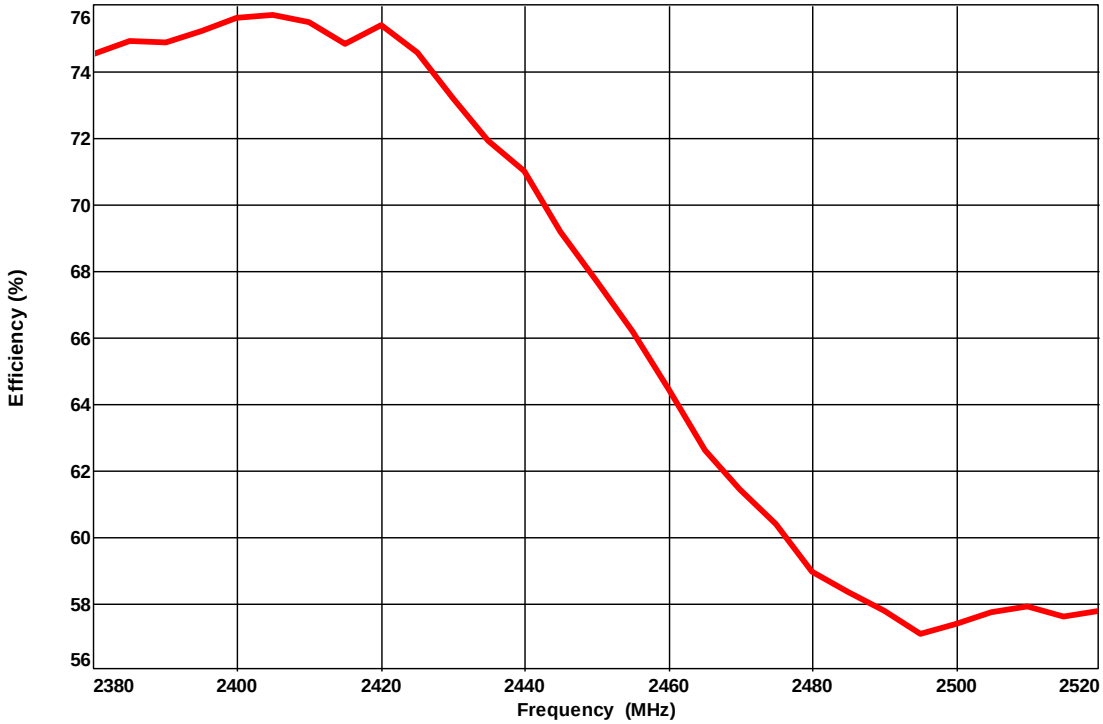


Figure 16: 2.4GHz Band efficiency WLAN Antenna

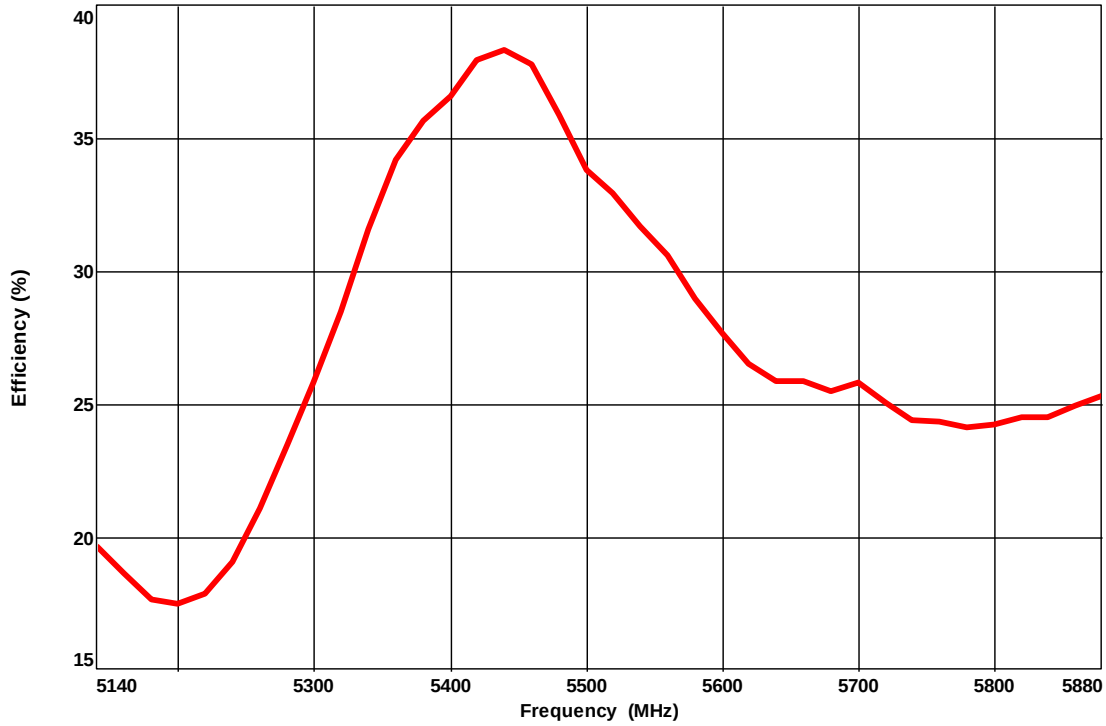


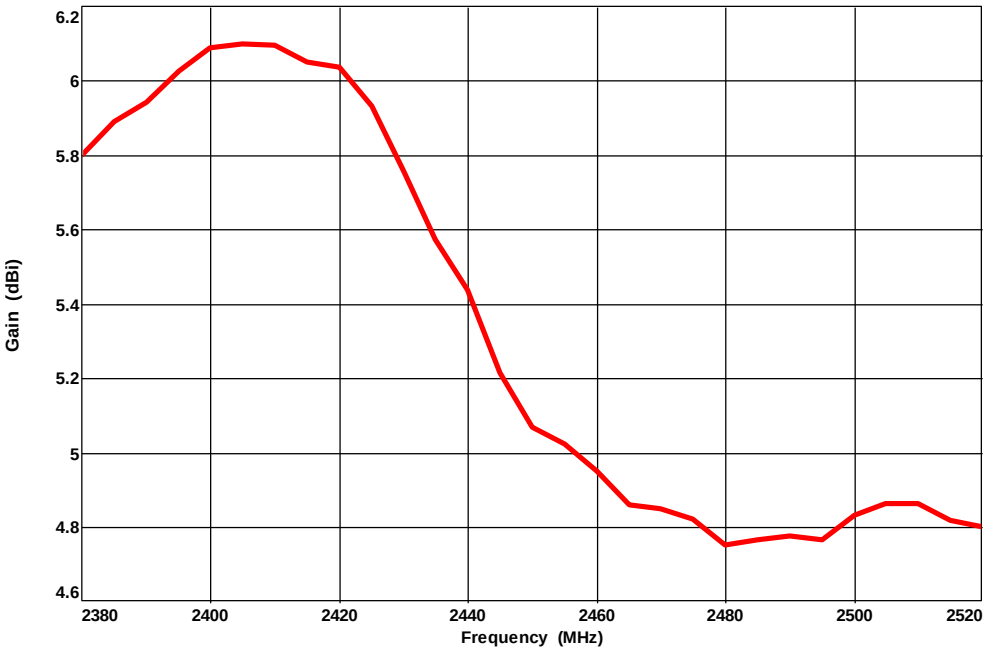
Figure 17: 5GHz Band efficiency WLAN Antenna

Conclusion:

WIFI antenna efficiency 2.4 GHz >50% ➔ **PASS**

WIFI antenna efficiency 5 GHz > 20% ➔ The 5GHz behavior of the antenna is not optimal, due to the high peak gain (next figures), it isn't advisable to improve this. Improving this will make the peak gain bigger (not good to meet FCC requirements).

230 ***8.1.6.4.4 Peak Gain***



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232 Figure 18: WLAN Peak Gain 2.4GHz

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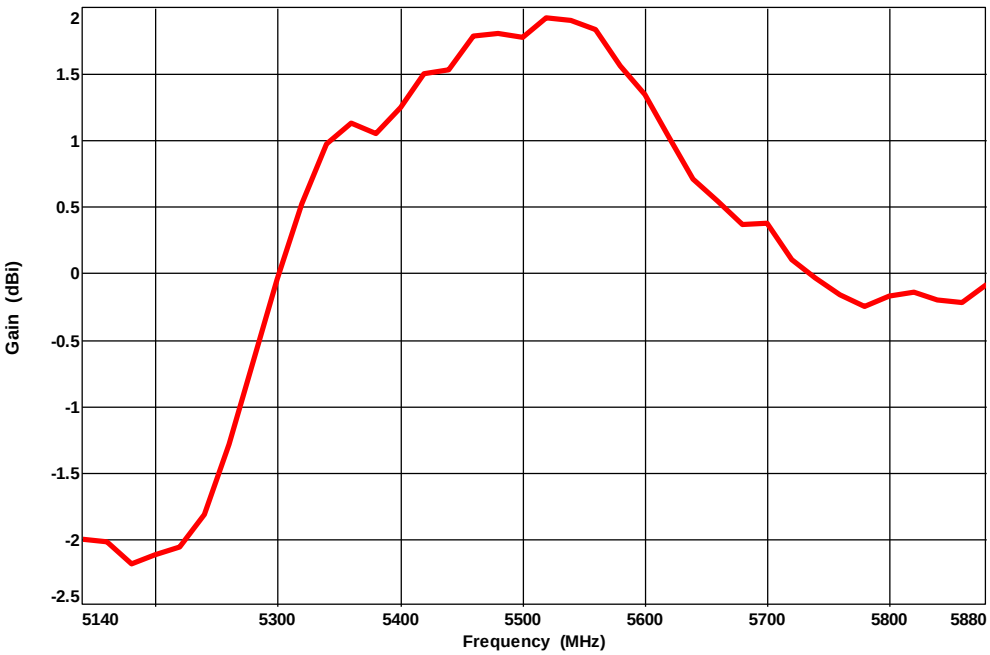

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235 Figure 19: WLAN Peak Gain 5GHz

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The WIFI antenna peak gain for 2.4 G is ~**5.1 dBi**
The WIFI antenna peak gain for 5G is > 1 **dBi (Above the limit for FCC ID according to WLAN IC)**

Conclusion:

For US, there is no issue with max power since +30 dBm is allowed. But the **Band edges** are important for the US. This is also influenced by the antenna gain.
The antenna gain is higher than mentioned in the datasheet if the Murata IC (FCC ID-part). **Therefore additional measurements on this are recommended.**
The efficiency on the 5Ghz is not optimal but due to the gain additional improvements are not recommended.

Conclusion WIFI antenna measurements: **PASS**

2021.07.28.10.10.55.raw

Data result 4: Raw data measurement result Wifi 2.4GHz

2021.07.28.11.53.06.raw

Data result 5: Raw data measurement result Wifi 5GHz