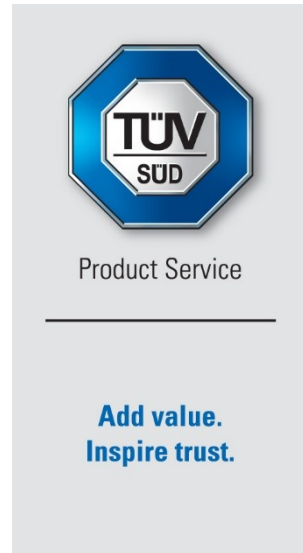


Report on the FCC and IC Testing of the Marquardt GmbH Passive Car Entry Key Model: MS5

In accordance with FCC 47 CFR Part 15 C and ISED RSS-210 and ISED RSS-GEN

Prepared for: Marquardt GmbH
Schloss-Str. 16
78604 Rietheim-Weilheim
Germany

FCC ID: IYZMS5I
IC: 2701A-MS5I



COMMERCIAL-IN-CONFIDENCE

Date: 2022-08-29

Document Number: TR-713269545-00 | Revision: 0

RESPONSIBLE FOR	NAME	DATE	SIGNATURE
Project Management	Alex Fink	2022-08-29	 SIGN-ID 692305
Authorised Signatory	Markus Biberger	2022-08-29	 SIGN-ID 692512

Signatures in this approval box have checked this document in line with the requirements of TÜV SÜD Product Service document control rules.

Engineering Statement:

This measurement shown in this report were made in accordance with the procedures described on test pages.

All reported testing was carried out on a sample equipment to demonstrate limited compliance with with FCC 47 CFR Part 15 C and ISED RSS-210 and RSS-GEN.

The sample tested was found to comply with the requirements defined in the applied rules.

RESPONSIBLE FOR	NAME	DATE	SIGNATURE
Testing	Alex Fink	2022-08-29	 SIGN-ID 692305

Laboratory Accreditation

DAkkS Reg. No. D-PL-11321-11-03

DAkkS Reg. No. D-PL-11321-11-04

Laboratory recognition

Registration No. BNetzA-CAB-16/21-15

Industry Canada test site registration

3050A-2

Executive Statement:

A sample of this product was tested and found to be compliant with FCC 47 CFR Part 15 C:2021 and ISED RSS-210:2020 and RSS-GEN:2021

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Content

1	Report Summary	2
1.1	Modification Report.....	2
1.2	Introduction.....	2
1.3	Brief Summary of Results	3
1.4	Product Information	4
1.5	EUT Modifications Record	6
1.6	Test Location.....	6
2	Test Details	7
2.1	Bandwidth of Momentary Signals.....	7
2.2	Periodic Operation Requirement.....	12
2.3	Temperature Stability.....	16
2.4	Radiated emissions	19
3	Measurement Uncertainty	37

Annex to Test Report TR-713269545-00 | Revision: 0



1 Report Summary

1.1 Modification Report

Alternations and additions of this report will be issued to the holders of each copy in the form of a complete document.

<i>Revision</i>	<i>Description of changes</i>	<i>Date of Issue</i>
0	First Issue	2022-08-29

Table 1: Report of Modifications

1.2 Introduction

Applicant	Marquardt GmbH
Manufacturer	Marquardt GmbH
Model Number(s)	MS5
Serial Number(s)	---
Hardware Version(s)	---
Software Version(s)	---
Number of Samples Tested	1
Test Specification(s) / Issue / Date	FCC 47 CFR Part 15 C: 2021 ISED RSS-210, Issue 10, Amendment 1: 2020 ISED RSS-GEN, Issue 5, Amendment 1: 2019 and Amendment 2: 2021
Test Plan/Issue/Date	---
Order Number	---
Date	2022-08-19
Date of Receipt of EUT	2022-08-19
Start of Test	2022-08-23
Finish of Test	2022-08-24
Name of Engineer(s)	Alex Fink
Related Document(s)	ANSI C63.4: 2014 ANSI C63.10: 2013 FCC 47 CFR Part 2 J: 2019 KDB 558074 D01 V05R02 ISED RSS-102, Issue 5, 2015 KDB 447498 D04 Interim General RF Exposure Guidance v01



1.3 Brief Summary of Results

A brief summary of the tests carried out in accordance with FCC 47 CFR Part 15 C, ISED RSS-210 and ISED RSS-GEN is shown below.

<i>Section</i>	<i>Specification Clause</i>	<i>Test Description</i>	<i>Result</i>
Transmitting continuously			
2.1	15.231(c)	Bandwidth of momentary signals	Pass
2.2	15.231(a)/ 15.231(3)	Periodic operation requirement	Pass
2.4	15.231(a) 15.205, 15.209	Radiated Emissions	Pass
N/A	15.207	Conducted Emissions on Mains Terminals	Not applicable, battery supply

Table 2: Results according to FCC 47 CFR Part 15 C

<i>Section</i>	<i>Specification Clause</i>	<i>Test Description</i>	<i>Result</i>
Transmitting continuously			
2.1	A1.3	Bandwidth of momentary signals	Pass
2.2	A.1.1	Periodic operation requirement	Pass
2.4	A.1.1	Radiated Emissions	Pass

Table 3: Results according to ISED RSS-210

<i>Section</i>	<i>Specification Clause</i>	<i>Test Description</i>	<i>Result</i>
Transmitting continuously			
2.1	6.7	Bandwidth of momentary signals	Pass
2.4	8.9, 8.10	Spurious Emissions	Pass
2.3	6.11	Temperature Stability	Pass
N/A	8.8	Conducted Emissions on Mains Terminals	Not applicable, battery supply

Table 4: Results according to RSS-Gen



1.4 Product Information

1.4.1 Technical Description

The MS5, as a passive entry car key, is part of a driving authorisation system of a car. The complete driver authorisation system consists of the MS5 (Passive Entry Car Key), the BODY CONTROL UNIT (Body Control Unit) and an external antenna module which is connected to the BODY CONTROL UNIT. The BODY CONTROL UNIT sends an LF signal to the MS5 to wake it up. The MS5 responds using the RF part to an external antenna module. The components exchange encrypted data for car access, to start the engine and to locate the key.

User manual

The MS5 has up to three key buttons, Open, Close and Trunk. On each button press it initiates the communication to the body control module. Wireless transmission is indicated by a flashing red LED.

Open Button

- To unlock the vehicles doors when the button is pressed short.
- In case the button is pressed long the windows will open additionally.

Close Button

- Locks the vehicles doors when the button is pressed short.
- When the button is pressed long the windows will close additionally.
- To activate the power save mode when pressed twice. This mode is deactivated by pressing any button.

Trunk Button

To unlock and open the vehicles trunk lid.

Optional the car can be accessed without handling the key. In this case RF signals are exchanged bidirectional when touching the door handle.

In case the battery is low car access is possible by means of an integrated mechanic emergency key. The MS5 is then to be placed into a dedicated slot inside the vehicles centre console to be powered wireless by means of a magnetic field.



Working temperature: -20° to +65° C (UHF)
Rough mechanical dimensions: 83 X 42 X 18 mm
Weight: 75 g

Data of UHF-Part

Transmission mode: bidirectional RF
3 channels

Receiver

Channel frequencies (center): Channel 1: 433.47 MHz
Channel 2: 433.92 MHz
Channel 3: 434.37 MHz

Frequency tolerance:
(production, aging, temperature) +/- 16.5 kHz (433 MHz)

Sensitivity: -88 dBm

Modulation: BFSK

Frequency deviation: +/- 10 kHz

Antenna: integrated PCB loop antenna, combined for
Rx / Tx

Transmitter:

Center frequency: see Rx

Transmitter power -16 dBm

Frequency tolerance:
(production, aging, temperature) +/- 16.5 kHz

Modulation: BFSK

Frequency deviation: +/- 10 kHz

Antenna: integrated PCB loop antenna, combined for
Rx / Tx



1.5 EUT Modifications Record

The table below details modifications made to the EUT during the test programme.
The modifications incorporated during each test are recorded on the appropriate test pages.

<i>Modification State</i>	<i>Description of Modification still fitted to EUT</i>	<i>Modification Fitted By</i>	<i>Date Modification Fitted</i>
0	As supplied by the customer, S/N: --- - test sample with normal antenna	Not Applicable	Not Applicable

Table 5

1.6 Test Location

TÜV SÜD Product Service conducted the following tests at our Straubing test laboratory:

Test Name	Name of Engineer(s)
Transmitting continuously	
Bandwidth of momentary signals	Alex Fink
Periodic operation requirement	Alex Fink
Radiated Emissions	Alex Fink
Temperature Stability	Alex Fink

Office Address:

Äußere Frühlingstraße 45
94315 Straubing
Germany



2 Test Details

2.1 Bandwidth of Momentary Signals

2.1.1 Specification Reference

FCC 47 CFR Part 15 C, Clause 15.231(c)
ISED RSS-210, Clause A.1.3
ISED RSS-Gen, Clause 6.7

2.1.2 Equipment under Test and Modification State

MS5, S/N: --- - Modification State 0

2.1.3 Date of Test

2022-08-23

2.1.4 Environmental Conditions

Ambient Temperature	24 °C
Relative Humidity	48 %

2.1.5 Specification Limits

FCC 47 CFR, clause 15.231(c)

The bandwidth of the emission shall be no wider than 0.25 % of the center frequency for devices operating above 70 MHz and below 900 MHz. For devices operating above 900 MHz, the emission shall no wider than 0.5 % of the center frequency. Bandwidth is determined at the points 20 dB down from the modulation carrier.

ISED RSS-210 Issue 10, Amd. 1; clause A1.3

The occupied bandwidth of the momentary devices shall be less than or equal to 0.25 % of the centre frequency for devices operating between 70 MHz and 900 MHz. For devices operating above 900 MHz, the occupied bandwidth shall be less than or equal to 0.5 % of the centre frequency.

2.1.6 Test Method

The test was performed according to ANSI C63.10, clauses 6.9
See section 2.4.6 of this test report for details.

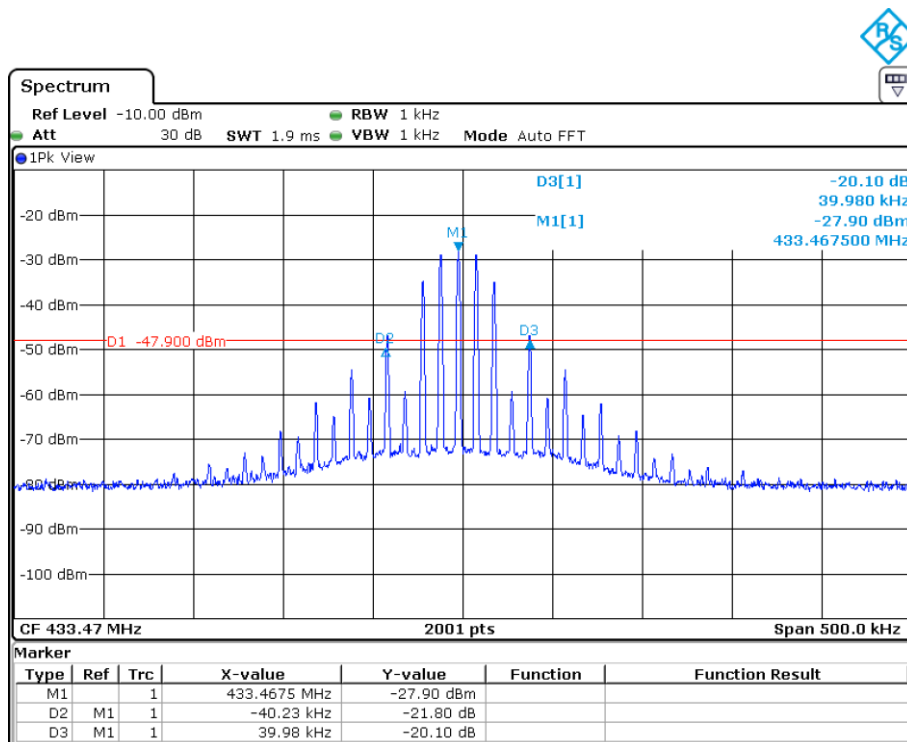


2.1.7 Test Results

Transmitting continuously on 433.47 MHz

<i>Center frequency</i>	<i>20 dB Bandwidth</i>
433.47 MHz	80.21 kHz

Table 6: 20 dB Bandwidth



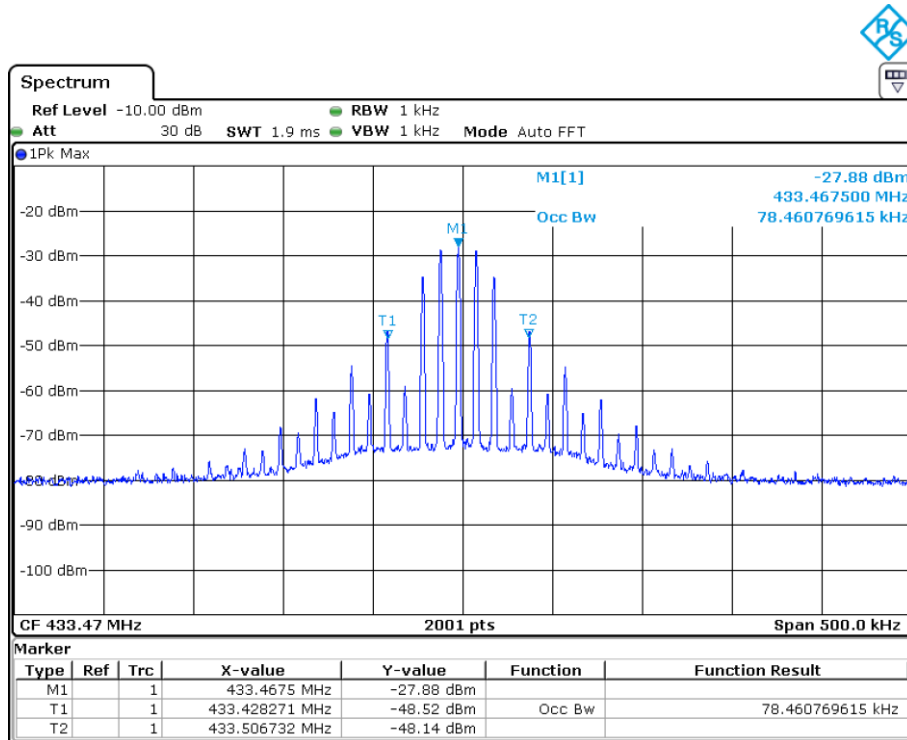
Date: 23.AUG.2022 14:09:34



Transmitting continuously on 433.47 MHz

Centre Frequency	99% Bandwidth
433.47 MHz	78.46 kHz

Table 7: 99% Bandwidth



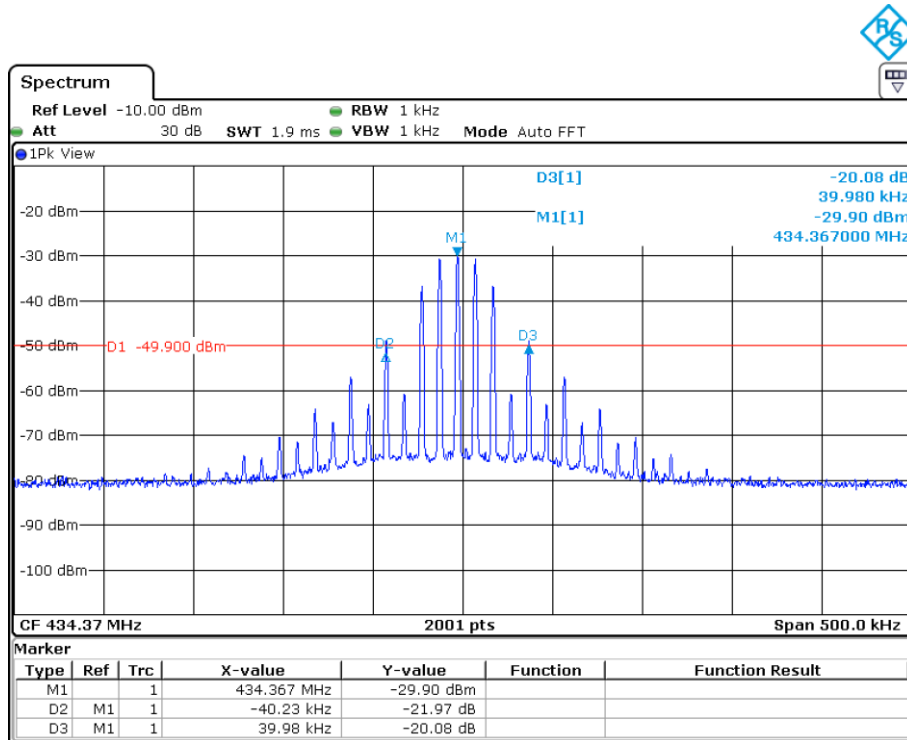
Date: 23.AUG.2022 14:10:58



Transmitting continuously on 434.37 MHz

<i>Centre Frequency</i>	<i>99% Bandwidth</i>
434.37 MHz	80.21 kHz

Table 8: 20 dB Bandwidth



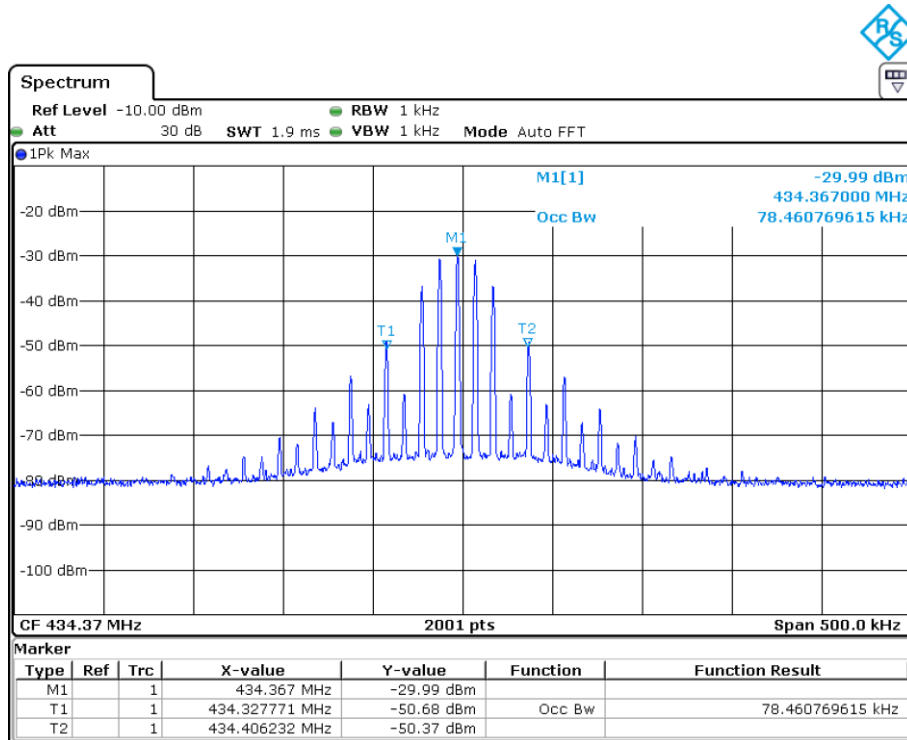
Date: 23.AUG.2022 14:07:43



Transmitting continuously on 434.37 MHz

<i>Centre Frequency</i>	<i>99% Bandwidth</i>
434.37 MHz	78.46 kHz

Table 9: 99% Bandwidth



Date: 23.AUG.2022 14:03:55

2.1.8 Test Location and Test Equipment

The test was carried out in Semi anechoic room - cabin no. 11

<i>Instrument</i>	<i>Manufacturer</i>	<i>Type No</i>	<i>TE No</i>	<i>Calibration Period (months)</i>	<i>Calibration Due</i>
TRILOG Broadband Antenna	Rohde & Schwarz	VULB 9162	20116	36	2025-01-31
Spectrum and signal analyser	Rohde & Schwarz	FSV40	20219	24	2024-02-29

Table 10



2.2 Periodic Operation Requirement

2.2.1 Specification Reference

FCC 47 CFR Part 15 C, Clause 15.231(a)
ISED RSS-210, Clause A.1.1

2.2.2 Equipment under Test and Modification State

MS5, S/N: --- - Modification State 0

2.2.3 Date of Test

2022-08-23

2.2.4 Environmental Conditions

Ambient Temperature	24 °C
Relative Humidity	48 %

2.2.5 Test Method

The test was performed using a spectrum analyzer in zero-span-mode with the frequency set to the center frequency of the transmitter and the resolution bandwidth set to a value greater of the emission bandwidth to cover the full output power of the transmitter. Sweep time and sweep points were set to values given a reasonable resolution of test results.

Center frequency:	434 MHz
RBW:	3 MHz
Sweep time:	10 sec
Sweep points:	4001



2.2.6 Specification Limits

FCC 47 CFR 15.231(a) and ISED RSS-210 A1.1

1. A manually operated transmitter shall employ a push-to-operate switch that will automatically deactivate the transmitter within not more than 5 s of being released.
2. A transmitter activated automatically shall cease transmission within 5 s after activation.
3. Periodic transmissions at regular predetermined intervals are not permitted (except as defined in FCC 47 CFR 15.231(e) and ISED RSS-210 A1.1.4). However, polling or supervision transmissions, including data, to determine system integrity of transmitters used in security or safety applications are allowed if the total duration of transmissions does not exceed more than two seconds per hour (2 s/h) for each transmitter. There is no limit on the number of individual transmissions, provided the total transmission time does not exceed 2 s/h.
4. Intentional radiators which are employed for radio control purposes during emergencies involving fire, security of goods (e.g. burglar alarms), and safety-of-life, when activated to signal an alarm, may operate during the pendency of the alarm condition.

FCC 47 CFR 15.231(e) and ISED RSS-210 A1.1.4

In additions, devices operated under these section shall be capable of automatically limiting their operation so that the duration of each transmission is not greater than 1 s and the silent period between transmission is at least 30 times the duration of the transmission, but not less than 10 s und all circumstances.



2.2.7 Test Results

General information on transmitter:

The transmitter is used for

- Security or safety applications
- other applications

- Declared by applicant
- Declared by applicant

The transmitter is operated

- manually
- automatically

- Declared by applicant ¹
- Declared by applicant

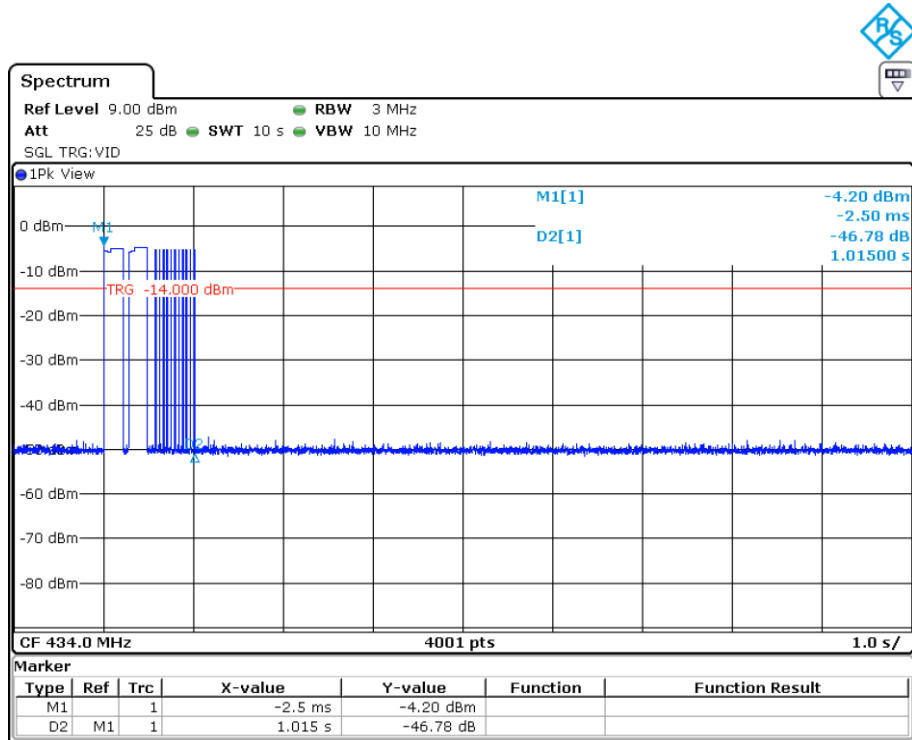
Periodic operation according to

CFR 47 Part 15, clause 15.231(a)
ISED RSS-210, Issue 10, Amd. 1, section A1.1

- Only control signals are sent and there is no continuous transmission.
- A manually operated transmitter employs a switch that will automatically deactivate the transmitter within not more than 5 s of being released.
- A transmitter activated automatically ceased transmission within 5 s after activation
- Periodic transmissions at regular predetermined intervals are:
 - not performed
 - performed with total time of two seconds per hour or less (for polling or supervision transmissions to determine system integrity of transmitters used in security or safety applications)

- Declared by applicant
- Test performed
- Passed
- Test performed
- Passed
- Declared by applicant
- Declared by applicant
- Test performed
- Passed

¹ Please refer to external photos in annex for details.



Date: 23.AUG.2022 14:26:40

Result: transmission stopped after 1.015 s

2.2.8 Test Location and Test Equipment

The test was carried out in Semi anechoic room - cabin no. 11

Instrument	Manufacturer	Type No	TE No	Calibration Period (months)	Calibration Due
TRILOG Broadband Antenna	Rohde & Schwarz	VULB 9162	20116	36	2025-01-31
Spectrum and signal analyser	Rohde & Schwarz	FSV40	20219	24	2024-02-29

Table 11



2.3 Temperature Stability

2.3.1 Specification Reference

ISED RSS-Gen, Clause 6.11, 8.11

2.3.2 Equipment under Test and Modification State

MS5, S/N: --- - Modification State 0

2.3.3 Date of Test

2022-08-23

2.3.4 Environmental Conditions

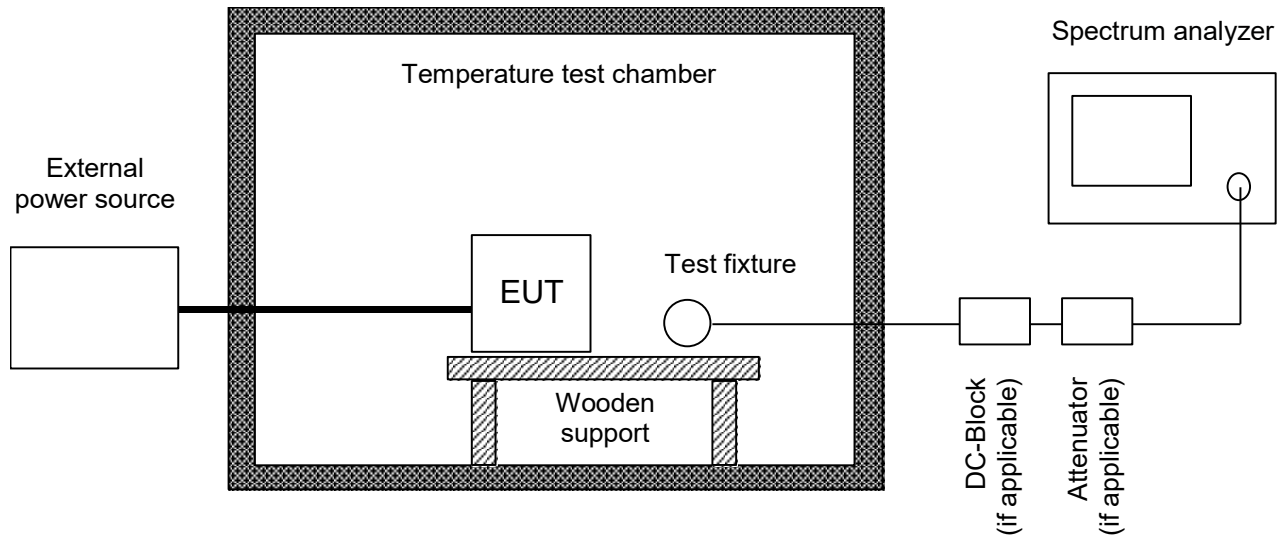
Ambient Temperature	24 °C
Relative Humidity	48 %

2.3.5 Specification Limits

If the stability of the license-exempt radio apparatus is not specified in the applicable RSS, the fundamental emissions of the radio apparatus should be kept within at least the central 80 % of its permitted operating frequency band in order to minimize the possibility of out-of-band operation. In additions, its occupied bandwidth shall be entirely outside the restricted bands and the prohibited TV bands of 85 MHz – 72 MHz, 76 MHz – 88 MHz, 174 MHz – 216 MHz, and 470 MHz – 602 MHz, unless otherwise indicated.

2.3.6 Test Method

The test was performed according to ANSI C63.10, section 6.8.



The frequency tolerance of the carrier signal is measured over a temperature variation of $-20\text{ }^{\circ}\text{C}$ to $+50\text{ }^{\circ}\text{C}$ at normal supply voltage, and for a variation in the primary supply voltage from 85 % to 115 % of the rated supply voltage at a temperature of $20\text{ }^{\circ}\text{C}$. Temperature and voltage range may vary if the manufacturer states another temperature or voltage range.

If the EUT provides an antenna connector the spectrum analyzer is connected to this port. If required, a resistive matching network equal to the impedance specified or employed for the antenna is used as well as a DC block and appropriate ($50\text{ }\Omega$) attenuators. In case where the EUT does not provide an antenna connector or a test fixture is used.

For battery operated equipment, the test is performed using a new battery. Alternatively, an external supply voltage can be used and is at least set to:

- The maximum battery voltage as delivered by a new battery or 115 % of the battery nominal voltage;
- The battery nominal voltage
- 85 % of the battery nominal voltage
- The battery operating end point voltage which shall be specified by the equipment manufacturer.

The EUT is operating providing an unmodulated carrier for frequency error tests. The peak detector of the spectrum analyzer is selected and resolution as well as video bandwidth are set to values appropriate to shape of the spectrum of the EUT. The frequency counter mode of the spectrum analyzer is used to maximize the accuracy of the measured frequency tolerance.

If an unmodulated carrier is not available a significant and stable point of the spectrum is selected and the span is reduced to a value that delivers an accuracy which shall be better than 1 % of the maximum frequency tolerance allowed for the carrier signal. This method may be performed as long as the margin to the frequency tolerance is larger than the uncertainty of the measured frequency tolerance.



2.3.7 Test Results

Transmitting continuously on 433.47 MHz

<i>Temperature</i>	<i>Supply Voltage</i>	<i>Tested Centre Frequency</i>	<i>Frequency drift</i>
20.0°C	3.0 V DC	433.467500 MHz	0
20.0°C	2.5 V DC	433.467500 MHz	0
20.0°C	3.2 V DC	433.467500 MHz	0
-20.0°C	3.0 V DC	433.465500 MHz	-2.00 kHz
65.0°C	3.0 V DC	433.465750 MHz	-1.75 kHz

Table 12

Transmitting continuously on 434.37 MHz

<i>Temperature</i>	<i>Supply Voltage</i>	<i>Tested Centre Frequency</i>	<i>Frequency drift</i>
20.0°C	3.0 V DC	434.367000 MHz	0
20.0°C	2.5 V DC	434.367000 MHz	0
20.0°C	3.2 V DC	434.367000 MHz	0
-20.0°C	3.0 V DC	434.365250 MHz	-1.75 kHz
65.0°C	3.0 V DC	434.364500 MHz	-3.50 kHz

Table 13

2.3.8 Test Location and Test Equipment

The test was carried out in Semi anechoic room - cabin no. 11

<i>Instrument</i>	<i>Manufacturer</i>	<i>Type No</i>	<i>TE No</i>	<i>Calibration Period (months)</i>	<i>Calibration Due</i>
Spectrum and signal analyser	Rohde & Schwarz	FSV40	20219	24	2024-02-29
Climatic test chamber	Feutron	KPK200-2	19868	18	2023-02-28

Table 14



2.4 Radiated emissions

2.4.1 Specification Reference

FCC 47 CFR Part 15 C, Clauses 15.205, 15.209 and 15.231(a)
ISED RSS-210, Clause A.1.1
ISED RSS-Gen, Clauses 8.9 and 8.10

2.4.2 Equipment under Test and Modification State

MS5, S/N: --- - Modification State 0

2.4.3 Date of Test

2022-08-23 to 2022-08-24

2.4.4 Environmental Conditions

Ambient Temperature	25 °C
Relative Humidity	46 %



2.4.5 Specification Limits

General radiated emission limits:					
Frequency Range (MHz)	Test distance (m)	Field strength		Field strength	
		($\mu\text{A}/\text{m}$)	($\text{dB}\mu\text{A}/\text{m}$)	($\mu\text{V}/\text{m}$)	($\text{dB}\mu\text{V}/\text{m}$)
0.009 – 0.49	300	$6.37 / f$	$20*\lg(6.37 / f)$	$2400 / f$	$20*\lg(2400 / f)$
0.49 – 1.705	30	$63.7 / f$	$20*\lg(63.7 / f)$	$24000 / f$	$20*\lg(24000 / f)$
1.705 - 30	30	0.08	$20*\lg(0.08 / f)$	30	$20*\lg(30 / f)$
30 – 88	3	---	---	100	40
88 – 216	3	--	---	150	43.5
126 – 960	3	--	---	200	46
above 960	3	--	---	500	54

Note 1: f in kHz

Table 15 General radiated emission limits

FCC 47 CFR Part 15 C, Clause 15.231(a); ISED RSS-210, Clause A.1.1

Frequency Range (MHz)	Field strength of fundamental		Field strength of spurious emissions	
	($\mu\text{V}/\text{m}$)	($\text{dB}\mu\text{V}/\text{m}$)	($\mu\text{V}/\text{m}$)	($\text{dB}\mu\text{V}/\text{m}$)
40.66 – 40.70	2500	67.96	225	47.96
70 – 130	1250	61.94	125	41.94
130 – 174	1250 – 3750 *	61.94 – 71.48 *	125 – 375 *	41.94 – 51.48 *
174 – 260	3750	71.48	375	51.48
260 – 470	3750 – 12500 *	71.48 – 81.94 *	375 – 1250 *	51.48 – 61.94 *
Above 470	12500	81.94	1250	61.94

* linear interpolation
 The above field strength limits are specified at a distance of 3 m. The tighter limits apply at the band edges.
 Intentional radiators shall demonstrate compliance with the limits above based on the (linear) average value of the measured emissions. As an alternative, compliance with these limits may be based on the use of measurement instrumentations with a CISPR quasi-peak detector. If average emission measurements are employed, the provisions for averaging pulsed emissions and for limiting peak emissions apply.
 The limits on the field strength of the spurious emissions in the table are based on the fundamental frequency of the intentional radiator. Spurious emissions shall be attenuated to the average (or alternatively, CISPR quasi-peak) limits shown in this table or to the general spurious emission limits, whichever limit permits a higher field strength.



FCC 47 CFR Part 15 C, Clause 15.231(e); ISED RSS-210, Clause A.1.4

<i>Frequency Range (MHz)</i>	<i>Field strength of fundamental</i>		<i>Field strength of spurious emissions</i>	
	<i>(μV/m)</i>	<i>(dBμV/m)</i>	<i>(μV/m)</i>	<i>(dBμV/m)</i>
40.66 – 40.70	1000	60	100	40
70 – 130	500	53.98	50	33.98
130 – 174	500 – 1500 *	53.98 – 63.52 *	50 – 150 *	33.98 – 43.52
174 – 260	1500	63.52	150	43.52
260 – 470	1500 – 5000 *	63.52 – 73.98 *	150 – 500 *	43.52 – 53.98
Above 470	5000	73.98	500	53.98

* linear interpolation

The above field strength limits are specified at a distance of 3 m. The tighter limits apply at the band edges.

Intentional radiators shall demonstrate compliance with the limits above based on the (linear) average value of the measured emissions. As an alternative, compliance with these limits may be based on the use of measurement instrumentations with a CISPR quasi-peak detector. If average emission measurements are employed, the provisions for averaging pulsed emissions and for limiting peak emissions apply.

The limits on the field strength of the spurious emissions in the table are based on the fundamental frequency of the intentional radiator. Spurious emissions shall be attenuated to the average (or alternatively, CISPR quasi-peak) limits shown in this table or to the general spurious emission limits, whichever limit permits a higher field strength.

2.4.6 Test Method

The test was performed according to ANSI C63.10, sections 11.11 and 11.12

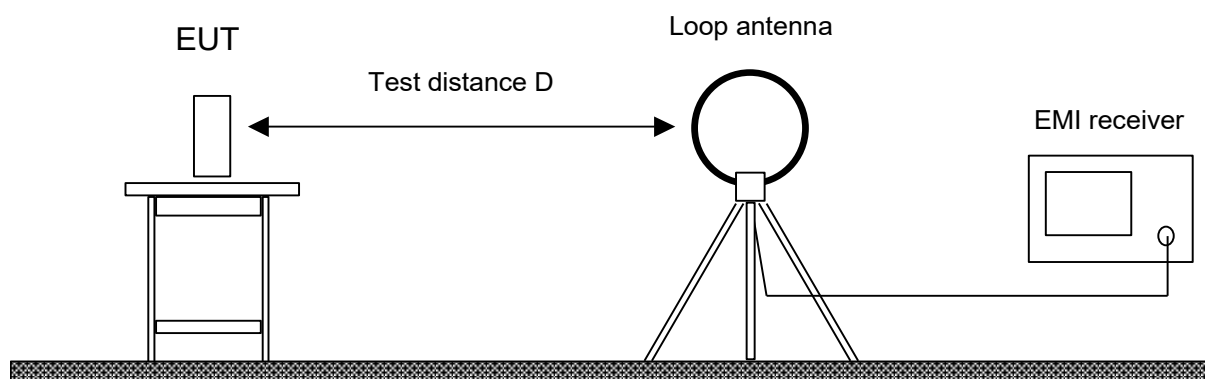
Prescans are performed in six positions of the EUT to get the full spectrum of emission caused by the EUT with the measuring antenna raised and lowered from 1 m to 4 m with vertical and horizontal polarisation to find the combination of table position, antenna height and antenna polarisation for the maximum emission levels.

Data reduction is applied to these results to select those levels having less margin than 10 dB or exceeding the limit using subranges and limited number of maximums.

Further maximisation for adjusting the maximum position is following.

Equipment and cables are placed and moved within the range of position likely to find their maximum emissions.

2.4.6.1 Frequency range 9 kHz – 30 MHz

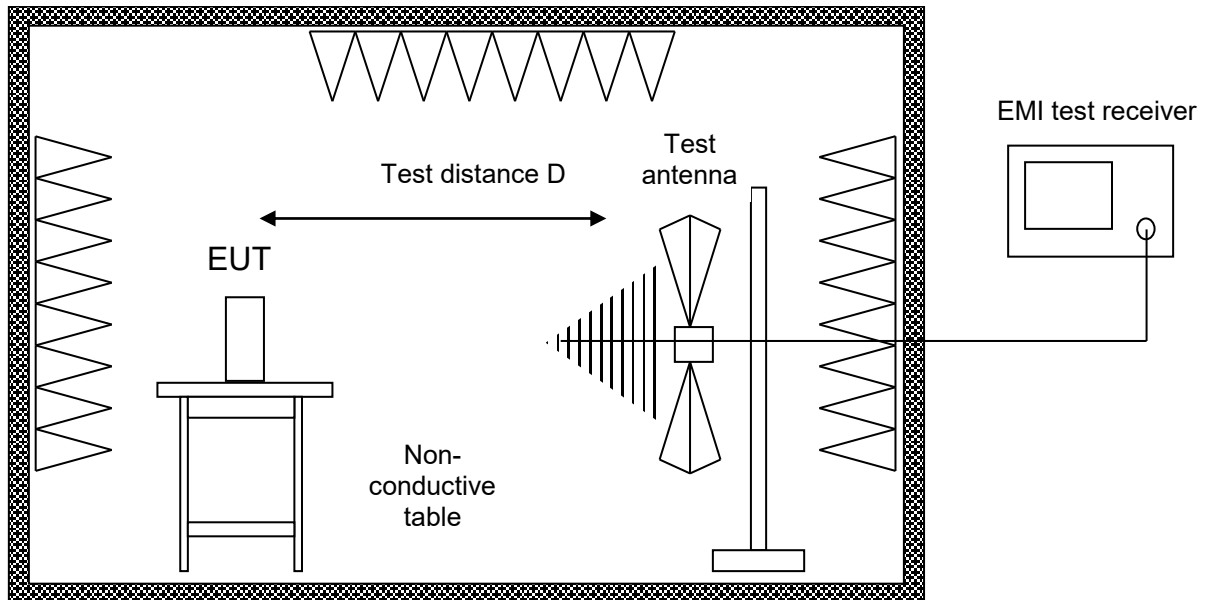


The EUT was placed on a non-conductive table, 0.8 m above the ground.

Radiated emissions in the frequency 9 kHz – 30 MHz is measured within a semi-anechoic room with an active loop antenna with the measurement detector set to peak. In addition, in the frequency range 9 kHz to 490 kHz also an average detector was used. The measurement bandwidth of the receiver was set to 300 Hz in the frequency range 9 kHz to 150 kHz and 10 kHz in the frequency range 150 kHz to 30 MHz. Prescans were performed in six positions of the EUT.

For final measurements the detector was set to CISPR quasi-peak and in addition to CISPR average in the frequency range 9 kHz to 490 kHz with a resolution bandwidth 200 Hz in the frequency range 9 kHz to 150 kHz and 9 kHz in the frequency range 150 kHz to 30 MHz. Final tests were performed immediately after a final frequency and zoom (for drifting disturbances) and maximum adjustment.

2.4.6.2 Frequency range 30 MHz – 1 GHz



Alternate test site (semi anechoic room)

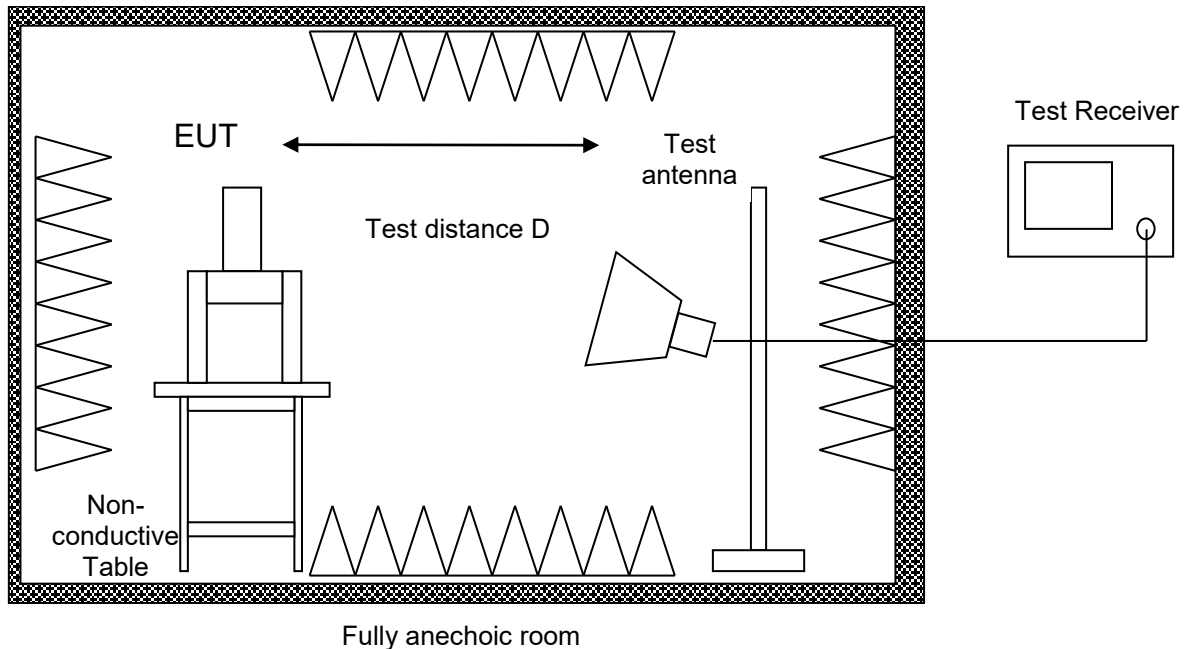
The EUT was placed on a non-conductive table, 0.8 m above the ground plane

Radiated emissions in the frequency range 30 MHz – 1 GHz is measured within a semi-anechoic room with groundplane complying with the NSA requirements of ANSI C63.4. for alternative test sites. A linear polarised logarithmic periodic antenna combined with a 4:1 broadband dipole (“Trilog broadband antenna”) is used.

For prescan tests the test receiver is set to peak-detector with a bandwidth of 120 kHz.

With the measurement bandwidth of the test receiver set to 120 kHz CISPR quasi-peak detector is selected for final measurements following immediately after a final frequency zoom (for drifting disturbances) and maximum adjustment.

2.4.6.3 Frequency range above 1 GHz



The EUT was placed on a non-conductive table, 1.5 m above the ground plane

Radiated emission tests above 1 GHz are performed in a fully anechoic room with the S_{VSWR} requirements of ANSI C63.4. Measurements are performed both in the horizontal and vertical planes of polarisation using a test receiver with the detector function set to peak and average and the resolution bandwidth set to 1 MHz. Testing above 1 GHz is performed with horn antennas with the EUT in boresight of the antenna.

For prescan tests the test receiver is set to peak- and average-detector with a bandwidth of 1 MHz.

With the measurement bandwidth of the test receiver set to 1 MHz and peak- and CISPR average-detector is selected for final measurements following immediately after a final frequency zoom (for drifting disturbances) and maximum adjustment.



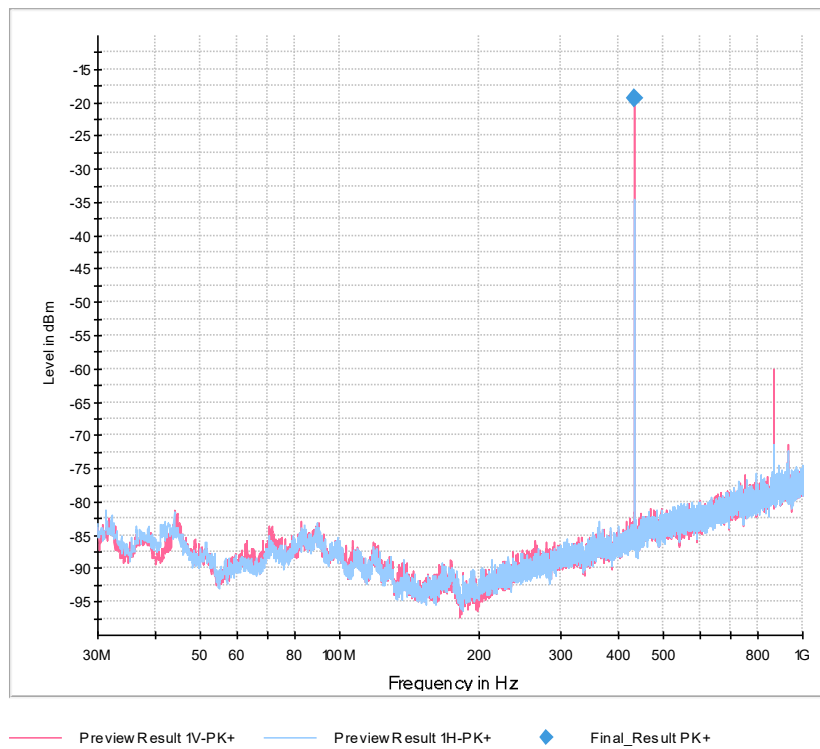
2.4.7 Test Results

Sample calculation:

$$\text{Final Value (dB}\mu\text{V/m)} = \text{Reading Value (dB}\mu\text{V)} + (\text{Cable attenuation (dB)} + \text{Antenna Transducer (dB(1/m)))}$$

Transmitting continuously on 433.47 MHz - Preliminary pre-scans for the worst-case orientation

x axis



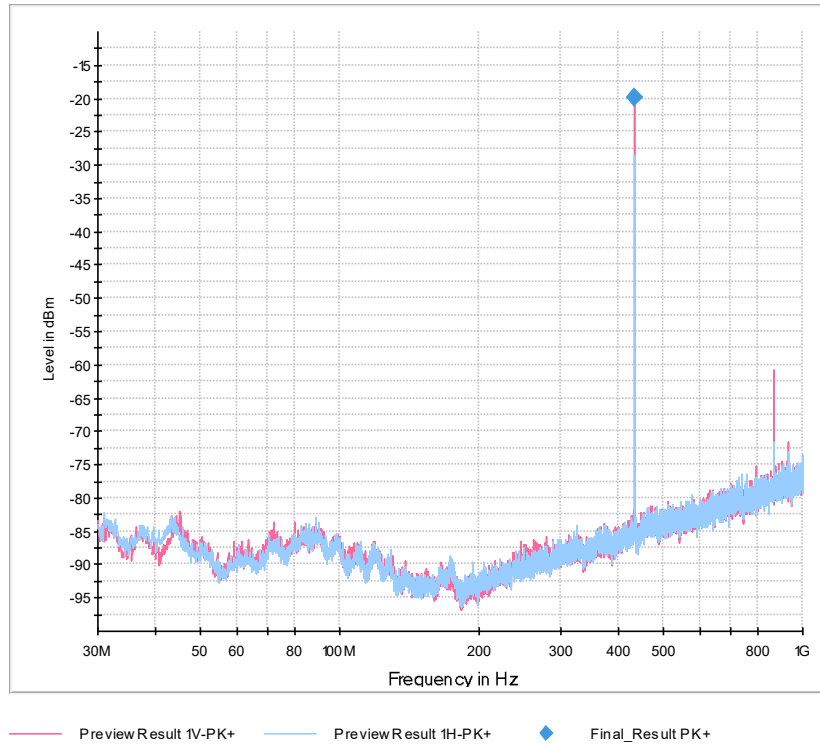
Final Results:

Frequency MHz	Max-Peak dBm	Limit dBm	Margin dB	Meas. Time ms	Band- width kHz	Height cm	Pol	Azi- muth deg	Corr. dB
433.466111	-19.38	---	---	2.5	100.000	150.0	V	91.0	-112

➔ Worst case orientation is x axis



y axis

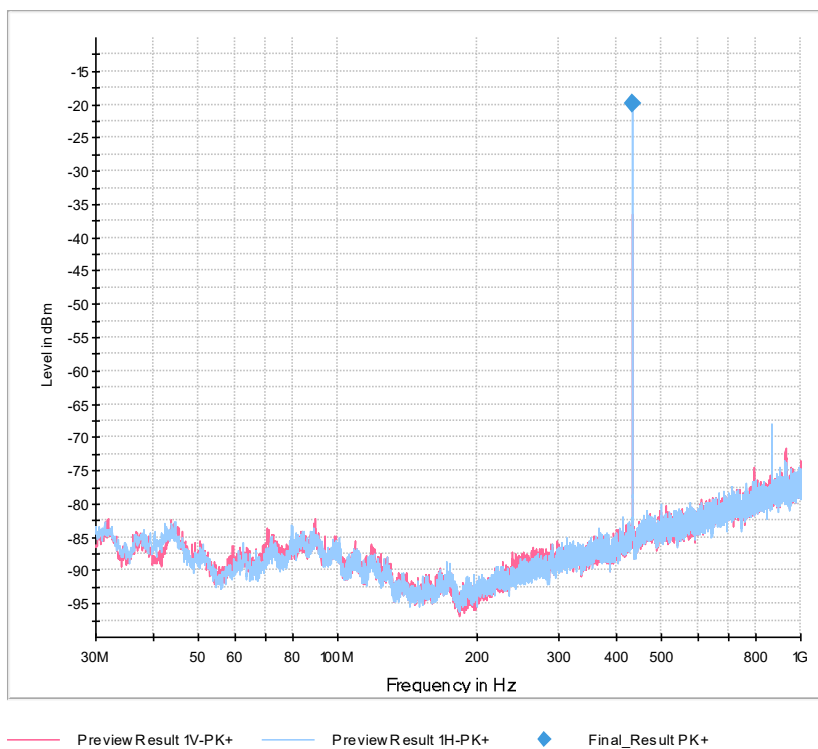


Final Results:

<i>Frequency</i>	<i>MaxPeak</i>	<i>Limit</i>	<i>Margin</i>	<i>Meas. Time</i>	<i>Bandwidth</i>	<i>Height</i>	<i>Pol</i>	<i>Azimuth</i>	<i>Corr.</i>
<i>MHz</i>	<i>dBm</i>	<i>dBm</i>	<i>dB</i>	<i>ms</i>	<i>kHz</i>	<i>cm</i>		<i>deg</i>	<i>dB</i>
433.412222	-19.82	---	---	2.5	100.000	150.0	V	93.0	-112



z axis



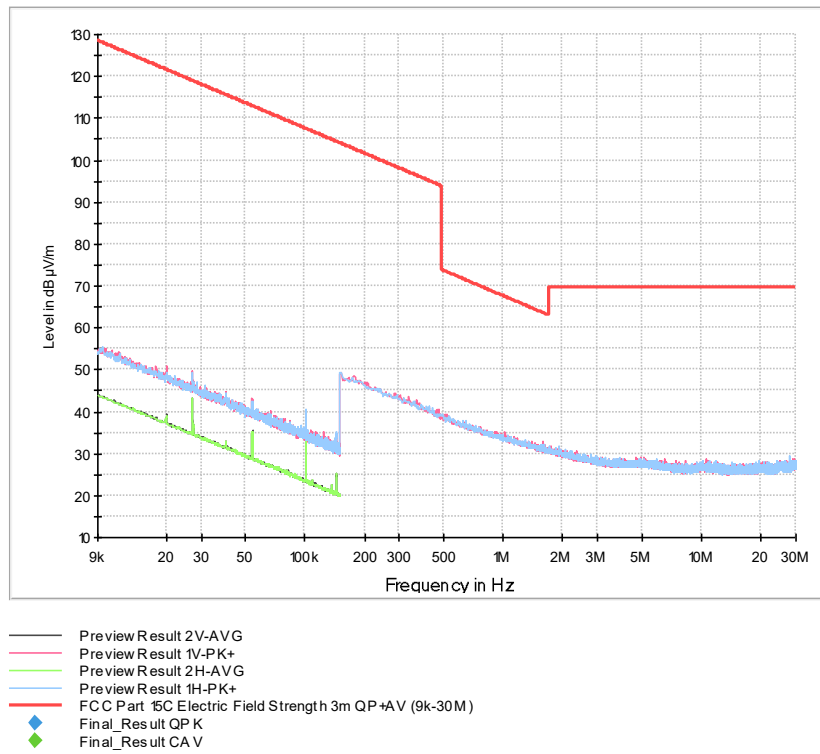
Final Results:

Frequency MHz	Max- Peak dBm	Limit dBm	Mar- gin dB	Meas. Time ms	Band- width kHz	Height cm	Pol	Azi- muth deg	Corr. dB
433.466111	-19.88	---	---	2.5	100.000	150.0	H	322.0	-112



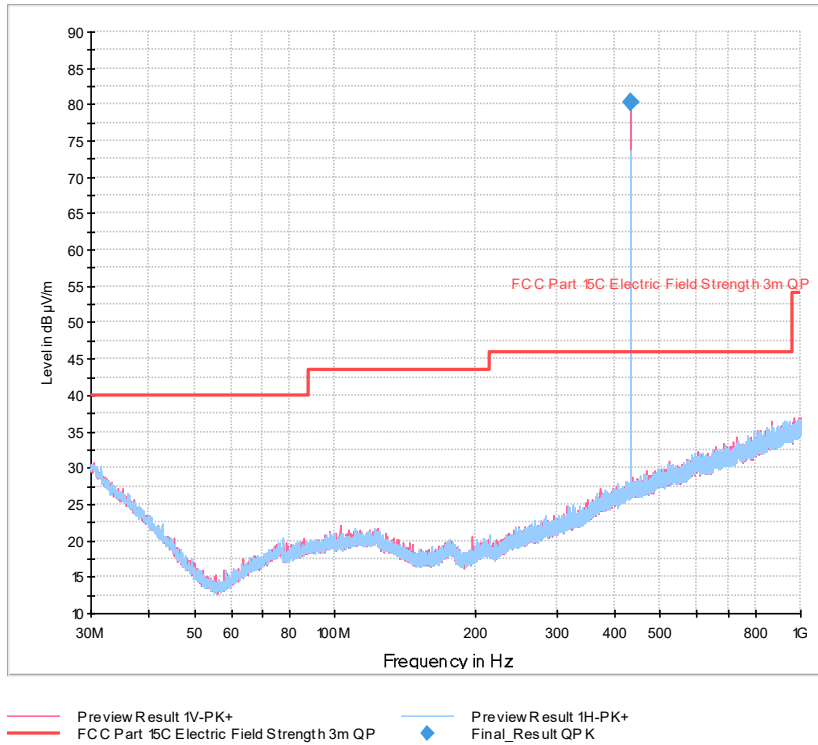
Transmitting continuously on 433.47 MHz – final measurement in x axis

Frequency range 9 kHz – 30 MHz:





Frequency range 30 MHz – 1 GHz:

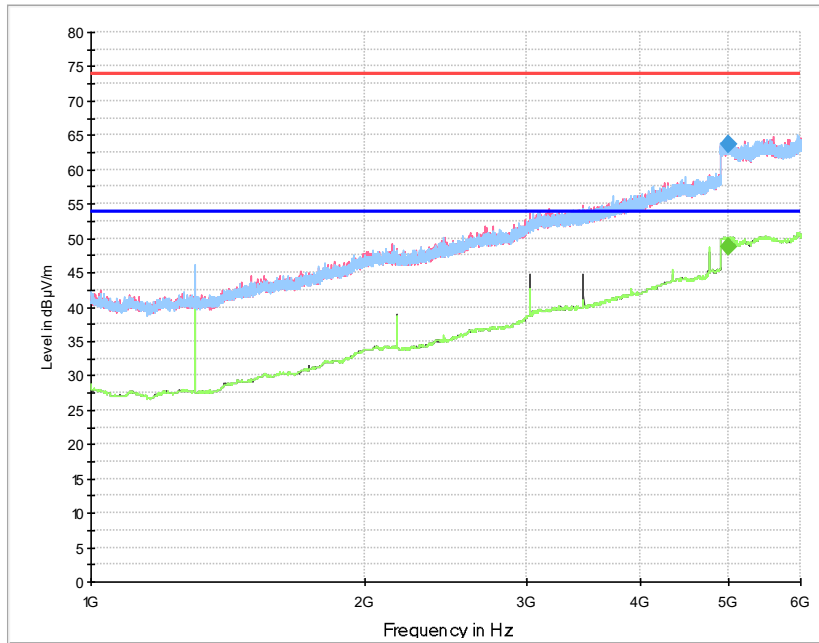


Final Results:

Frequency MHz	QuasiPeak dBµV/m	Limit dBµV/m	Margin dB	Meas. Time ms	Bandwidth kHz	Height cm	Pol	Azimuth deg	Corr. dB/m
433.470000	80.28	80.81	0.53	1000.0	120.000	138.0	V	-85.0	23.4



Frequency range 1 GHz – 6 GHz:



— Preview Result 2V-AVG
 — Preview Result 2H-AVG
 — FCC Part 15C Electric Field Strength 3m PK
 ◆ Final_Result PK+
 — Preview Result 1V-PK+
 — Preview Result 1H-PK+
 — FCC Part 15C Electric Field Strength 3m AV
 ◆ Final_Result CA V

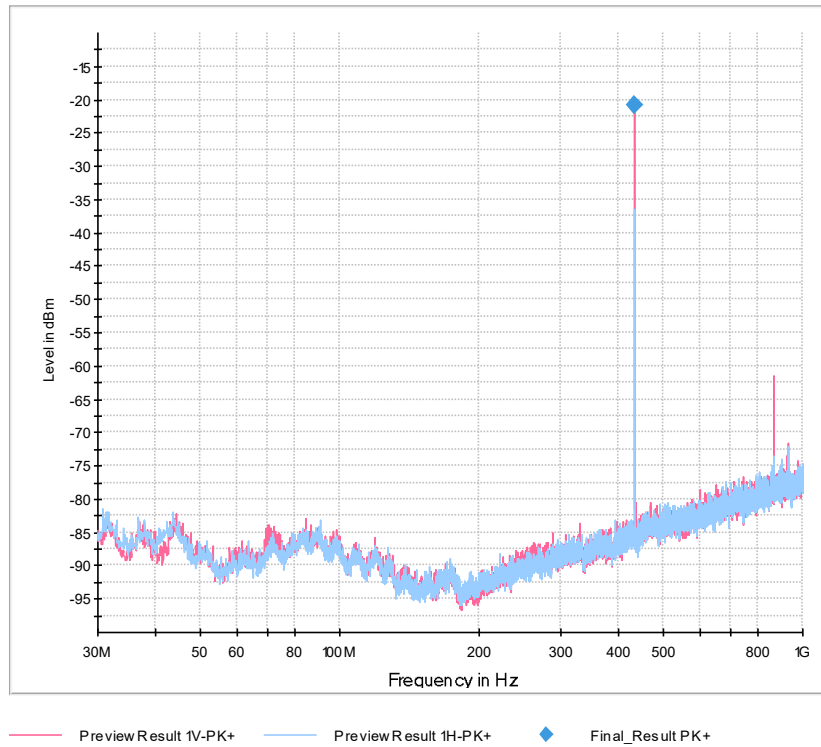
Final Results:

Frequency MHz	Max- Peak dBµV/m	CAverage dBµV/m	Limit dBµV/m	Mar- gin dB	Meas. Time ms	Band- width kHz	Height cm	Pol	Azi- muth deg	Corr. dB/m
4993.2500	63.69	---	73.98	10.29	1000.0	1000.000	325.0	V	-153.0	42.2
4993.2500	---	48.66	53.98	5.32	1000.0	1000.000	325.0	V	-153.0	42.2



Transmitting continuously on 434.37 MHz - Preliminary pre-scans for the worst-case orientation

x axis



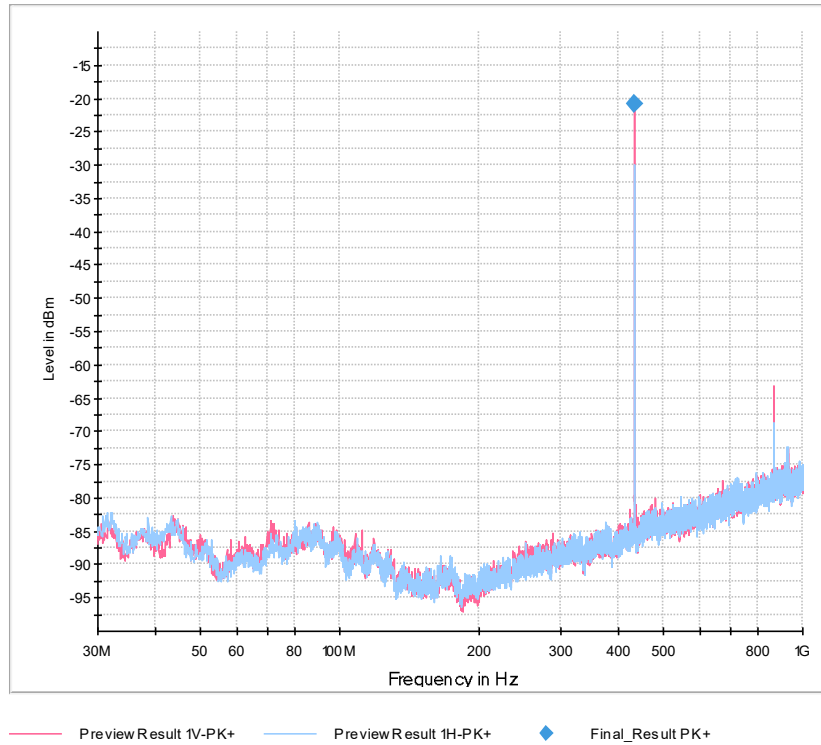
Final Results:

Frequency MHz	MaxPeak dBm	Limit dBm	Margin dB	Meas. Time ms	Bandwidth kHz	Height cm	Pol	Azimuth deg	Corr. dB
434.382222	-20.78	---	---	2.5	100.000	150.0	V	91.0	-112

➔ Worst case orientation is x axis



y axis

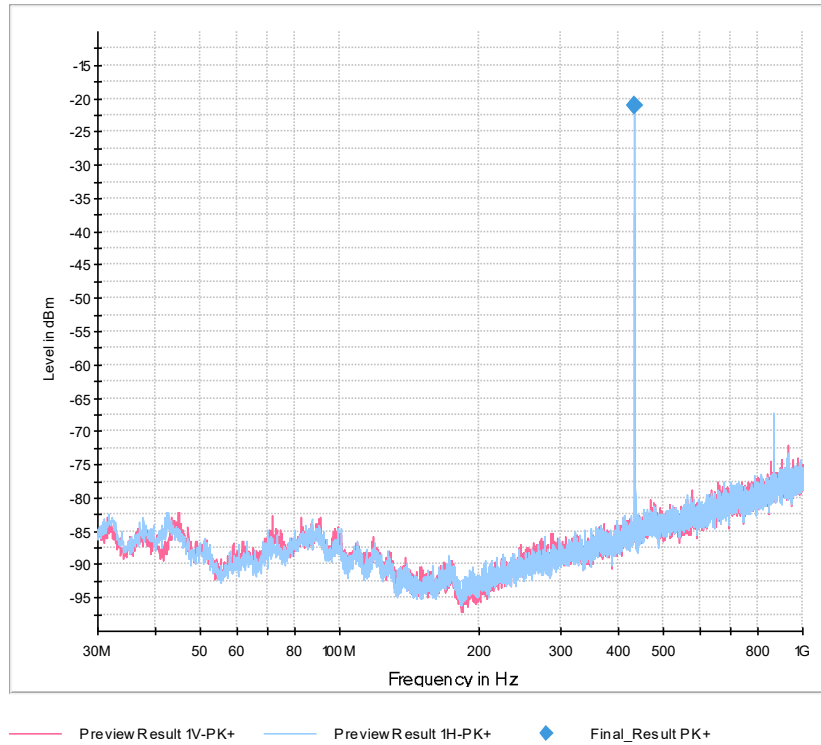


Final Results:

<i>Frequency</i>	<i>MaxPeak</i>	<i>Limit</i>	<i>Margin</i>	<i>Meas. Time</i>	<i>Bandwidth</i>	<i>Height</i>	<i>Pol</i>	<i>Azimuth</i>	<i>Corr.</i>
<i>MHz</i>	<i>dBm</i>	<i>dBm</i>	<i>dB</i>	<i>ms</i>	<i>kHz</i>	<i>cm</i>		<i>deg</i>	<i>dB</i>
434.328333	-20.81	---	---	2.5	100.000	150.0	V	96.0	-112



z axis



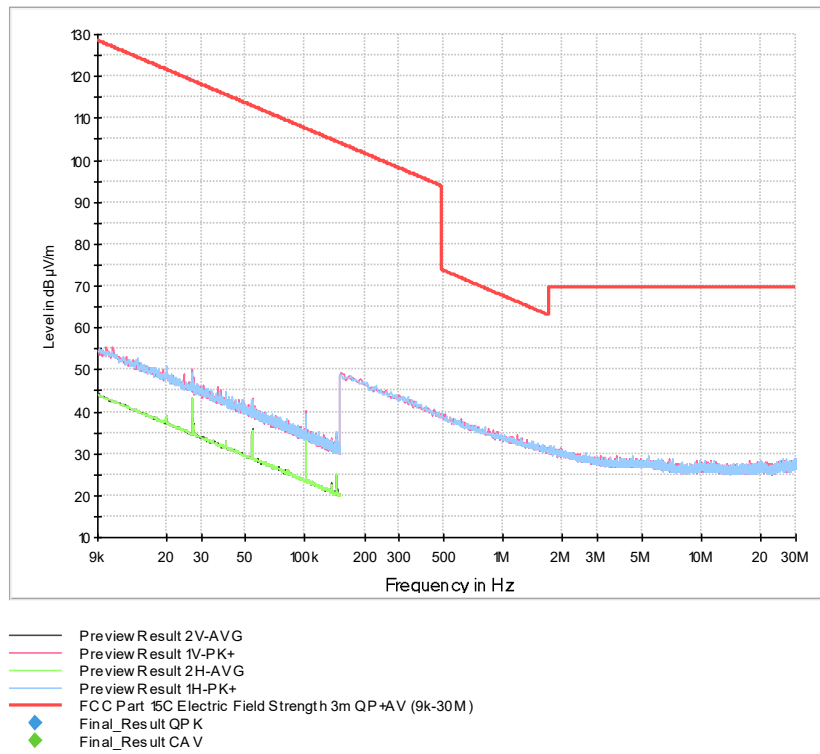
Final Results:

Frequency MHz	MaxPeak dBm	Limit dBm	Margin dB	Meas. Time ms	Bandwidth kHz	Height cm	Pol	Azimuth deg	Corr. dB
434.328333	-21.16	---	---	2.5	100.000	150.0	H	316.0	-112



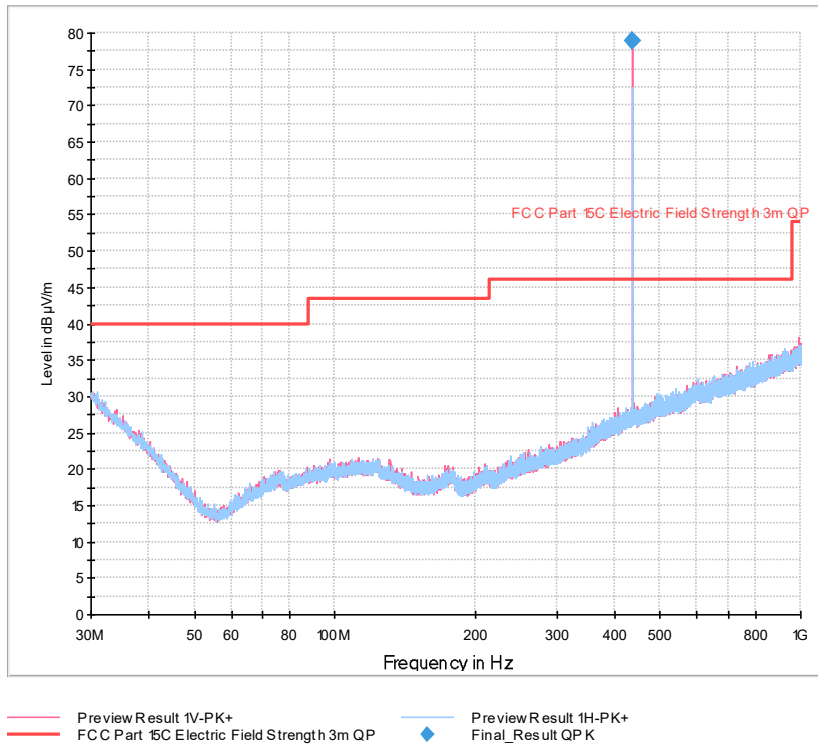
Transmitting continuously on 434.37 MHz – final measurement in x axis

Frequency range 9 kHz – 30 MHz:





Frequency range 30 MHz – 1 GHz:

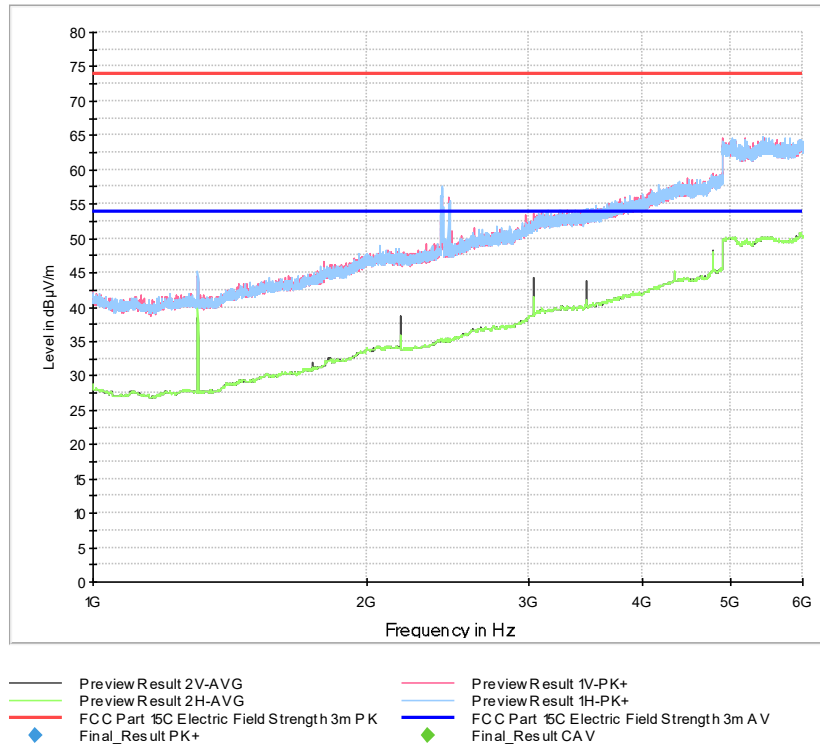


Final Results:

Frequency MHz	QuasiPeak dBµV/m	Limit dBµV/m	Margin dB	Meas. Time ms	Bandwidth kHz	Height cm	Pol	Azimuth deg	Corr. dB/m
434.370000	78.94	80.84	1.90	1000.0	120.000	136.0	V	-84.0	23.4



Frequency range 1 GHz – 6 GHz:



2.4.8 Test Location and Test Equipment

The test was carried out in Semi anechoic room - cabin no. 11

<i>Instrument</i>	<i>Manufacturer</i>	<i>Type No</i>	<i>TE No</i>	<i>Calibration Period (months)</i>	<i>Calibration Due</i>
EMI test receiver	Rohde & Schwarz	ESW44	39897	12	2023-04-30
Loop antenna	Schwarzbeck	FMZB 1519 B	44334	36	2023-01-31
TRILOG Broadband Antenna	Rohde & Schwarz	VULB 9162	20116	36	2025-01-31
Double ridged horn antenna	Rohde & Schwarz	HF907	40089	24	2023-02-28
EMC measurement software	Rohde & Schwarz	EMC32 Emission K11 - V10.50.10	42986	---	---
Semi Anechoic Room	Frankonia	Cabin No. 11	42961	36	2022-08-31

Table 16



3 Measurement Uncertainty

For a 95% confidence level, the measurement uncertainties for defined systems are:

The measurement uncertainty in the laboratory is less than or equal to the maximum measurement uncertainty according to CISPR16-4-2: 2011 + A1 + A2 + Cor1 (U_{CISPR}). This normative regulation means that the measured value is also the value to be assessed in relation to the limit value.

<i>Radio Interference Emission Testing</i>		
<i>Test Name</i>	<i>kp</i>	<i>Expanded Uncertainty</i>
Conducted Voltage Emission		
9 kHz to 150 kHz (50Ω/50μH AMN)	2	± 3.8 dB
150 kHz to 30 MHz (50Ω/50μH AMN)	2	± 3.4 dB
100 kHz to 200 MHz (50Ω/5μH AMN)	2	± 3.6 dB
Discontinuous Conducted Emission		
9 kHz to 150 kHz (50Ω/50μH AMN)	2	± 3.8 dB
150 kHz to 30 MHz (50Ω/50μH AMN)	2	± 3.4 dB
Conducted Current Emission		
9 kHz to 200 MHz	2	± 3.5 dB
Magnetic Fieldstrength		
9 kHz to 30 MHz (with loop antenna)	2	± 3.9 dB
9 kHz to 30 MHz (large-loop antenna 2 m)	2	± 3.5 dB
Radiated Emission		
30 MHz to 300 MHz	2	± 4.9 dB
300 MHz to 1 GHz	2	± 5.0 dB
1 GHz to 6 GHz	2	± 4.6 dB
Test distance 10 m		
30 MHz to 300 MHz	2	± 4.9 dB
300 MHz to 1 GHz	2	± 4.9 dB
The expanded uncertainty reported according to CISPR16-4-2: 2011 + A1 + A2 + Cor1 is based on a standard uncertainty multiplied by a coverage factor of $k_p = 2$, providing a level of confidence of $p = 95.45\%$		

Table 17 Measurement uncertainty based on CISPR 16-4-2



<i>Radio Interference Emission Testing</i>		
<i>Test Name</i>	<i>kp</i>	<i>Expanded Uncertainty</i>
Occupied Bandwidth	2	± 5 %
Conducted Power		
9 kHz ≤ f < 30 MHz	2	± 1.0 dB
30 MHz ≤ f < 1 GHz	2	± 1.5 dB
1 GHz ≤ f ≤ 40 GHz	2	± 2.5 dB
1 MS/s power sensor (TS8997)	2	± 1.5 dB
Occupied Bandwidth	2	± 5 %
Power Spectral Density	2	± 3.0 dB
Radiated Power		
9 kHz ≤ f < 26.5 GHz	2	± 5.6 dB
26.5 GHz ≤ f < 60 GHz	2	± 8.0 dB
60 GHz ≤ f < 325 GHz	2	± 10 dB
Conducted Spurious Emissions	2	± 3.0 dB
Radiated Spurious Emissions	2	± 6.0 dB
Voltage		
DC	2	± 1.0 %
AC	2	± 2.0 %
Time (automatic)	2	± 5 %
Frequency	2	± 10 ⁻⁷
The expanded uncertainty reported according to to ETSI TR 100 028:2001 is based on a standard uncertainty multiplied by a coverage factor of $k_p = 2$, providing a level of confidence of $p = 95.45\%$		

Table 18 Measurement uncertainty based on ETSI TR 100 028