Report on the FCC and IC Testing of the Marquardt GmbH Passive Car Entry Key Model: BK1 In accordance with FCC 47 CFR Part 15 C and ISED RSS-210 and ISED RSS-GEN

Product Service

Add value.
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Prepared for: Marquardt GmbH
Schloss-Str. 16
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Germany

FCC ID: IYZBK1
IC: 2701A-BK1

COMMERCIAL-IN-CONFIDENCE

Date: 2020-09-17
Document Number: TR-64038-83123-06 | Issue 2

RESPONSIBLE FOR	NAME	DATE	SIGNATURE
Project Management	Alex Fink	2020-09-17	SIGN-ID 401684
Authorised Signatory	Markus Biberger	2020-09-17	SIGN-ID 401707

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 reporded testing was carried out on a sample equipment to demonstrate limited compilance 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	2020-09-17	SIGN-ID 401684

Laboratory Accreditation	Laboratory recognition	Industry Canada test site registration
DAkkS Reg. No. D-PL-11321-11-02 DAkkS Reg. No. D-PL-11321-11-03	Registration No. BNetzA-CAB-16/21-15	3050A-2

Executive Statement:

A sample of this product was tested and found to be compilant with FCC 47 CFR Part 15 C:2019 and ISED RSS-210:2020 and RSS-GEN:2019

ACCREDITATION
Our BNetzA Accreditation does not cover opinions and interpretations and any expressed are outside the scope of our BNetzA Accreditation. Results of tests not covered by our BNetzA Accreditation Schedule are marked NBA (Not BNetzA Accredited).

Product Service

Content

Annex to Test Report TR-64038-83123-06 | Issue: 01

Product Service

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.

Issue	*Description of changes*	*Date of Issue*
1	First Issue	2020-08-19
2	Typing error in test specification corrected from RSS-231 to RSS-210	2020-09-17

Table 1: Report of Modifications

1.2 Introduction

Applicant	Marquardt GmbH
Manufacturer	Marquardt GmbH
Model Number(s)	BK1
Serial Number(s)	48BA99B6
Hardware Version(s)	---
Software Version(s)	---
Number of Samples Tested	1
Test Specification(s) /	FCC 47 CFR Part 15 C: 2019
Issue / Date	ISED RSS-210, Issue 10, Amendment 1: 2020 ISED RSS-GEN, Issue 5, Amendment 1: 2019
Test Plan/Issue/Date	---
Order Number	6200401493-G51
Date	2020-02-28
Date of Receipt of EUT	2020-07-29
Start of Test	2020-08-04
Finish of Test	2020-08-19
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

Product Service

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.

Section	*Specification Clause*	*Test Description*	*Result*
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
2.5	15.212 (1)(viii)	RF Exposure	Pass

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

Section	*Specification Clause*	*Test Description*	*Result*
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

Section	*Specification Clause*	*Test Description*	*Result*
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
2.5	3.4	RF Exposure	Pass

Table 4: Results according to RSS-Gen

Product Service

1.4 Product Information

1.1.1 Technical Description

The BK1, as a passive entry vehicle key, is part of a driving authorisation system, which further consists of a Body Control Unit and up to 6 UWB vehicle modules.
The Body Control Unit sends an LF signal for wake up. The BK1 corresponds in return over RF bidirectionally. In the meantime, a time-of-flight measurement is triggered bidirectionally between the UWB vehicle module and the BK1.
The distance is measured between the UWB vehicle module and the BK1 by means of the time of flight based on speed of light.
The components exchange encrypted data for car access, to start the engine and to locate the key.

User manual
The BK1 has up to four keys. Open, Close, Trunk and Panic (optional for North American market). On each button press it initiates the communication to the Body Control Module and the range measurement process. 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 BK1 is then to be placed into a dedicated slot inside the vehicles centre console to be powered wireless by means of a magnetic field for passive Transponder communication.

Working temperature: -20° to +65° C (UHF and UWB)
Rough mechanical dimensions: 87 X 44 X 13 mm
Weight: 50 g

Data of UHF-Part

Transmission mode:	bidirectional RF 2 channels
Receiver	
Channel frequencies (center):	Channel 1: 433.20 MHz Channel 2: 434.64 MHz
Frequency tolerance: (production, aging, temperature)	+/- 10 kHz
Sensitivity:	-88 dBm
Modulation:	BFSK
Frequency deviation:	+/- 10 kHz
Antenna:	integrated PCB antenna, combined for Rx / Tx
Transmitter:	
Center frequency:	see Rx
Frequency tolerance: (production, aging, temperature)	+/- 10 kHz
Modulation:	BFSK
Frequency deviation:	+/- 20 kHz
Antenna:	integrated PCB 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.

Modification State	*Description of Modification still fitted to EUT*	*Modification Fitted By*	*Date Modification Fitted*
0	As supplied by the customer, S/N: 48BA99B6 - test sample with antenna	Not Applicable	Not Applicable

Table 5

Product Service

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
RF Exposure	Alex Fink

Office Address:
Äußere Frühlingstraße 45
94315 Straubing
Germany

Product Service

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

BK1, S/N: 48BA99B6 - Modification State 0

2.1.3 Date of Test

2020-08-04 and 2020-08-19

2.1.4 Environmental Conditions

Ambient Temperature	24 °C
Relative Humidity	50 %

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.

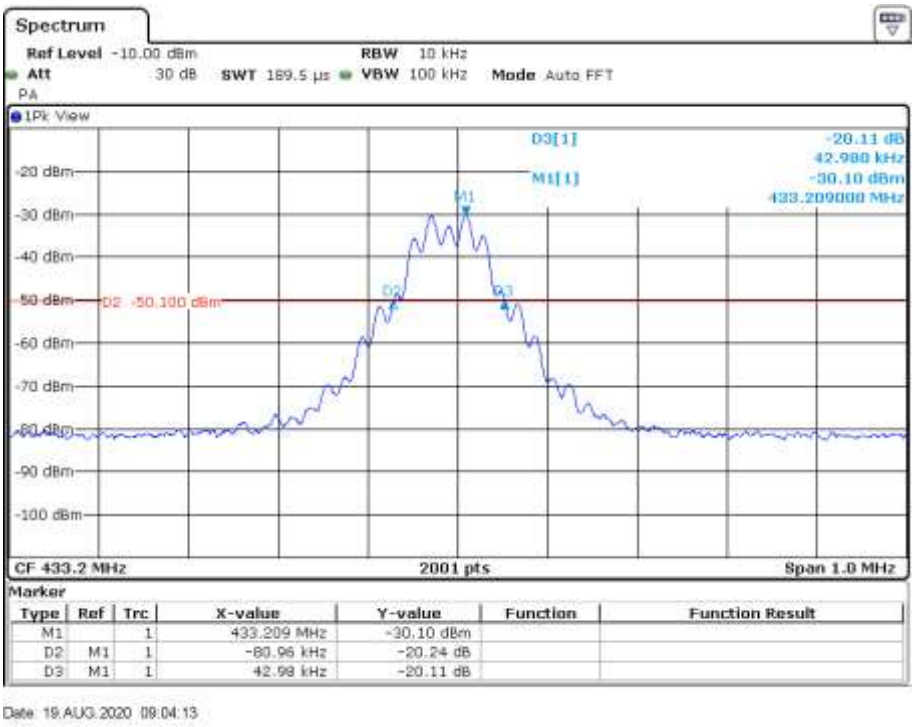
Product Service

2.1.7 Test Results

Transmitting continuously on 433.2 MHz

Center frequency	*20 dB Bandwidth*
433.19 MHz	124 kHz

Table 6: 20 dB bandwidth

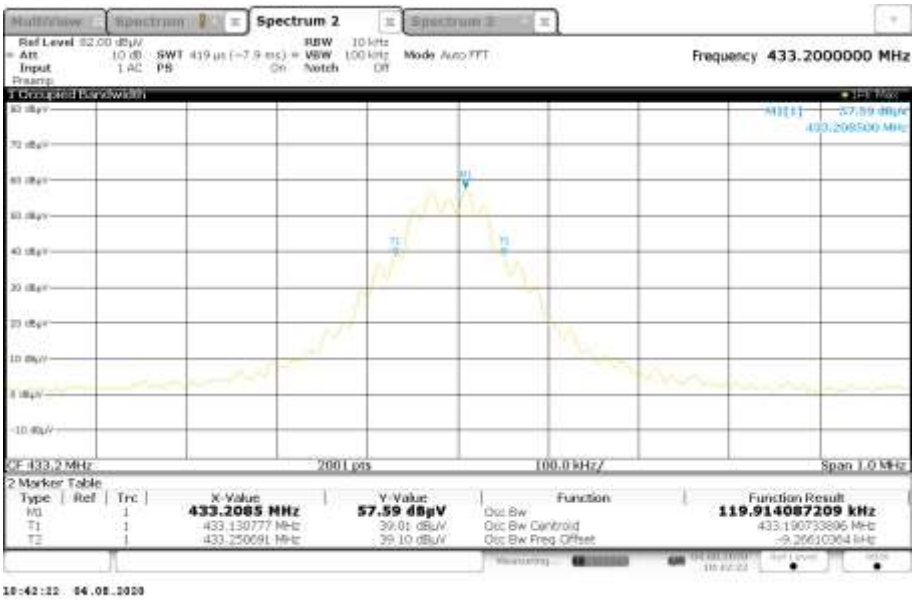


Product Service

Transmitting continuously on 433.2 MHz

Centre Frequency	*99% Bandwidth*
433.19 MHz	120 kHz

Table 7: 99% bandwidth

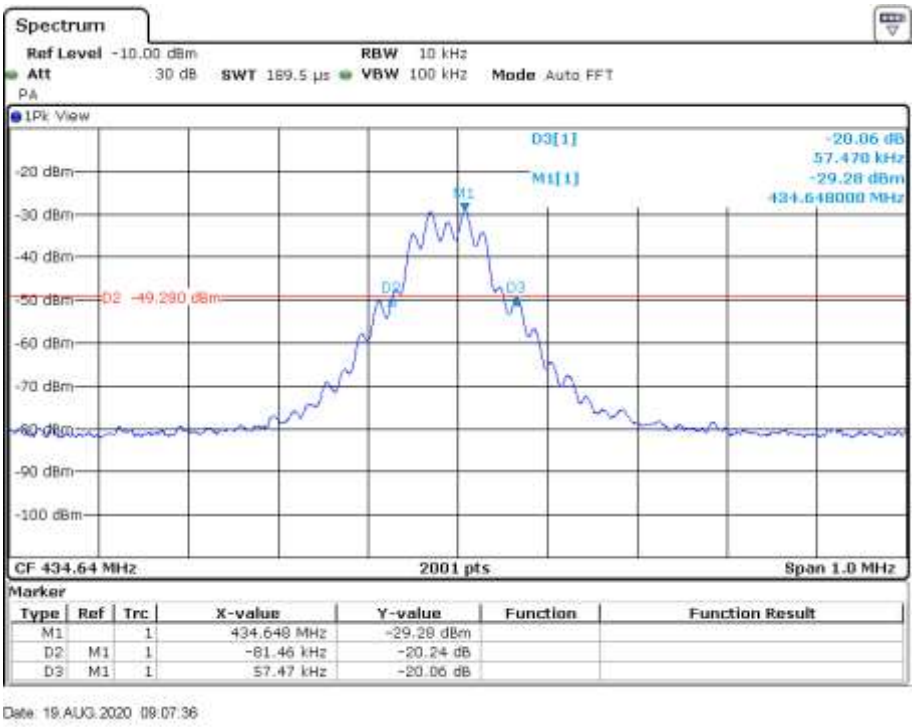


Product Service

Transmitting continuously on 434.64 MHz

Centre Frequency	*99% Bandwidth*
434.63 MHz	139 kHz

Table 8: 20 dB bandwidth

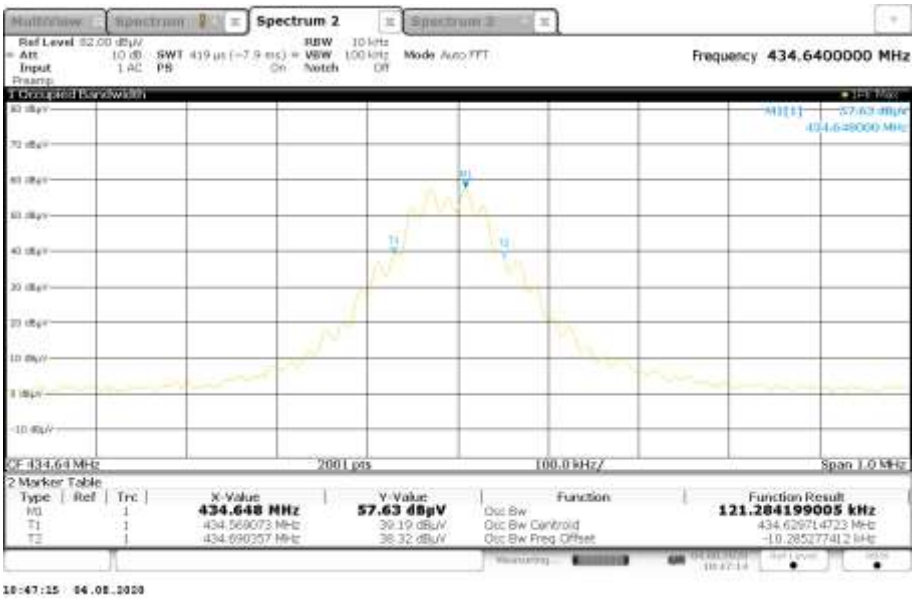


Product Service

Transmitting continuously on 434.64 MHz

Centre Frequency	*99% Bandwidth*
434.63 MHz	121 kHz

Table 9: 99% bandwidth



2.1.8 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*
EMI test receiver	Rohde & Schwarz	ESW44	39897	12	2021-03-31
TRILOG Broadband Antenna	Rohde & Schwarz	VULB 9162	20116	36	2022-01-31
Spectrum and signal analyser	Rohde & Schwarz	FSV40	20219	24	2021-01-31

Table 10

Product Service

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

BK1, S/N: 48BA99B6 - Modification State 0

2.2.3 Date of Test

2020-08-04

2.2.4 Environmental Conditions

Ambient Temperature	24 °C
Relative Humidity	50 %

2.2.5 Test Method

The test was performed using a spectrum analysator 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:	2 MHz
Sweep time:	10 sec
Sweep points:	1001

Product Service

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 than5 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.

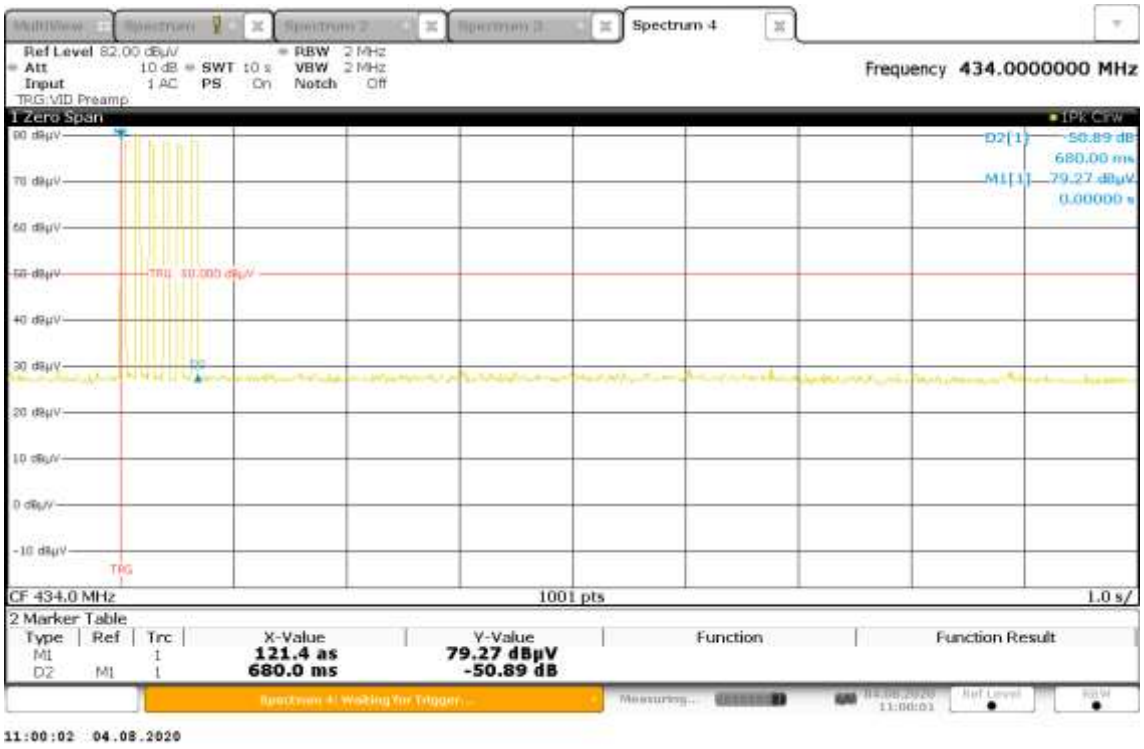
Product Service

2.2.7 Test Results

General information on transmitter:

The transmitter is used for	
☐ Security or safety applications	☐ Declared by applicant
☒ other applications	☐ Declared by applicant
The transmitter is operated	
☒ manually	☐ Declared by applicant [1]
☐ automatically	☐ 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.	☐ Declared by applicant
☐ A manually operated transmitter employs a switch that will automatically deactivate the transmitter within not more than 5 s of being released.	☐ Test performed ☐ Passed
☒ A transmitter activated automatically ceased transmission within 5 s after activation	☒ Test performed ☒ Passed
☐ Periodic transmissions at regular predetermined intervals are:	
☐ not performed	☐ Declared by applicant
☐ 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

[1] Please refer to external photos in annex for details.



Result: transmission stopped after 680ms

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*
EMI test receiver	Rohde & Schwarz	ESW44	39897	12	2021-03-31
TRILOG Broadband Antenna	Rohde & Schwarz	VULB 9162	20116	36	2022-01-31

Table 11

Product Service

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

BK1, S/N: 48BA99B6 - Modification State 0

2.3.3 Date of Test

2020-08-06

2.3.4 Environmental Conditions

Ambient Temperature	25 °C
Relative Humidity	50 %

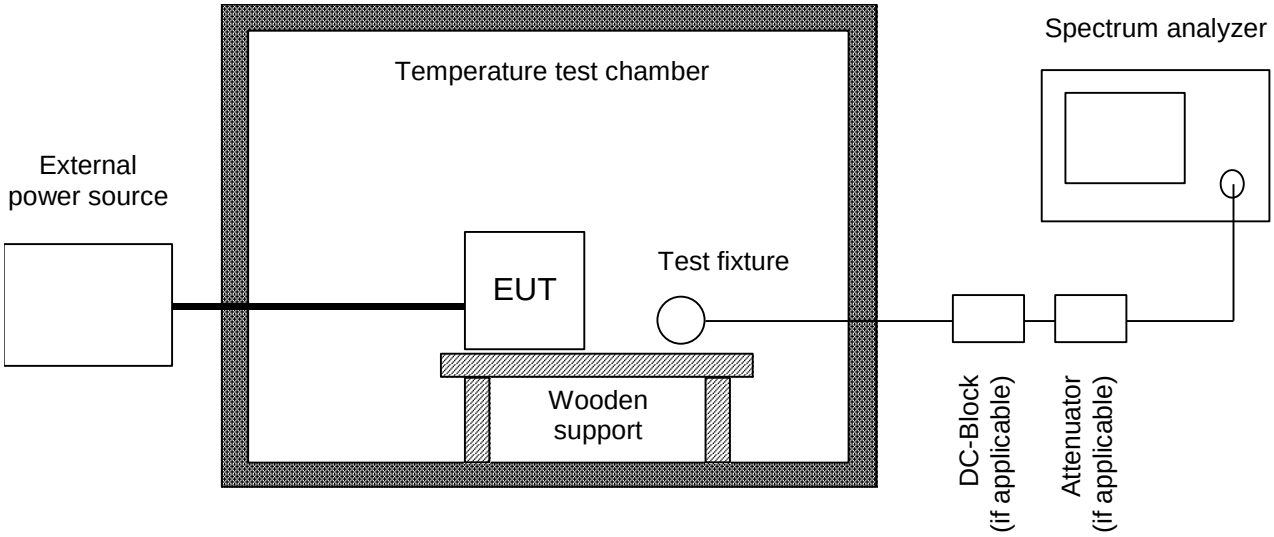
2.3.5 Specification Limits

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.

Product Service

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 °C to +50 °C at normal supply voltage, and for a variation in the primary supply voltage from 85 % to 115 % of the rates supply voltage at a temperature of 20 °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 Ω) 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.

Product Service

2.3.7 Test Results

Transmitting continuously on 433.2 MHz

Temperature	*Supply Voltage*	*Tested Centre Frequency*	*Frequency drift*
20.0°C	3.0 V DC	433.209230 MHz	0
20.0°C	2.55 V DC	433.197360 MHz	-11.87 kHz
20.0°C	3.3 V DC	433.168020 MHz	-41.21 kHz
-40.0°C	3.0 V DC	433.197360 MHz	-11.87 kHz
65.0°C	3.0 V DC	433.168020 MHz	-41.21 kHz

Table 12

Transmitting continuously on 434.64 MHz

Temperature	*Supply Voltage*	*Tested Centre Frequency*	*Frequency drift*
20.0°C	3.0 V DC	434.648240 MHz	0
20.0°C	2.55 V DC	434.645600 MHz	-26.40 kHz
20.0°C	3.3 V DC	434.640660 MHz	-75.80 kHz
-30.0°C	3.0 V DC	434.640990 MHz	-72.50 kHz
50.0°C	3.0 V DC	434.647030 MHz	-12.10 kHz

Table 13

2.3.8 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*
Spectrum and signal analyser	Rohde & Schwarz	FSV40	20219	24	2021-01-31
Climatic test chamber	Feutron	KPK200-2	19868	12	2021-08-31

Table 14

Product Service

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

BK1, S/N: 48BA99B6 - Modification State 0

2.4.3 Date of Test

2020-08-04 and 2020-08-19

2.4.4 Environmental Conditions

Ambient Temperature	25 °C
Relative Humidity	49 %

Product Service

2.4.5 Specification Limits

General radiated emission limits:					
Frequency Range	*Test distance*	*Field strength*		*Field strength*	
(MHz)	*(m)*	*(µA/m)*	*(dBµA/m)*	*(µV/m)*	*(dBµV/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	*Field strength of fundamental*		*Field strength of spurious emissions*	
(MHz)	*(µV/m)*	*(dBµV/m)*	*(µV/m)*	*(dBµV/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.

Product Service

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

Frequency Range	*Field strength of fundamental*		*Field strength of spurious emissions*	
(MHz)	*(µV/m)*	*(dBµV/m)*	*(µV/m)*	*(dBµV/m)*
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.

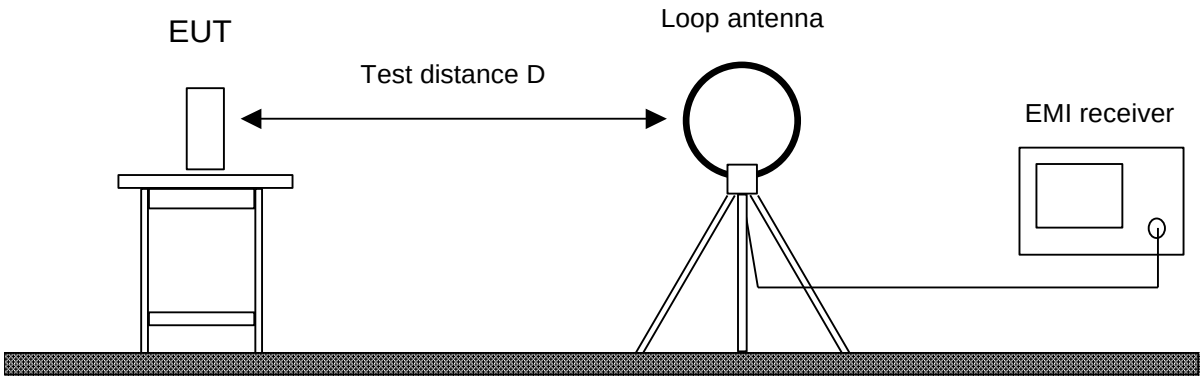
Product Service

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.

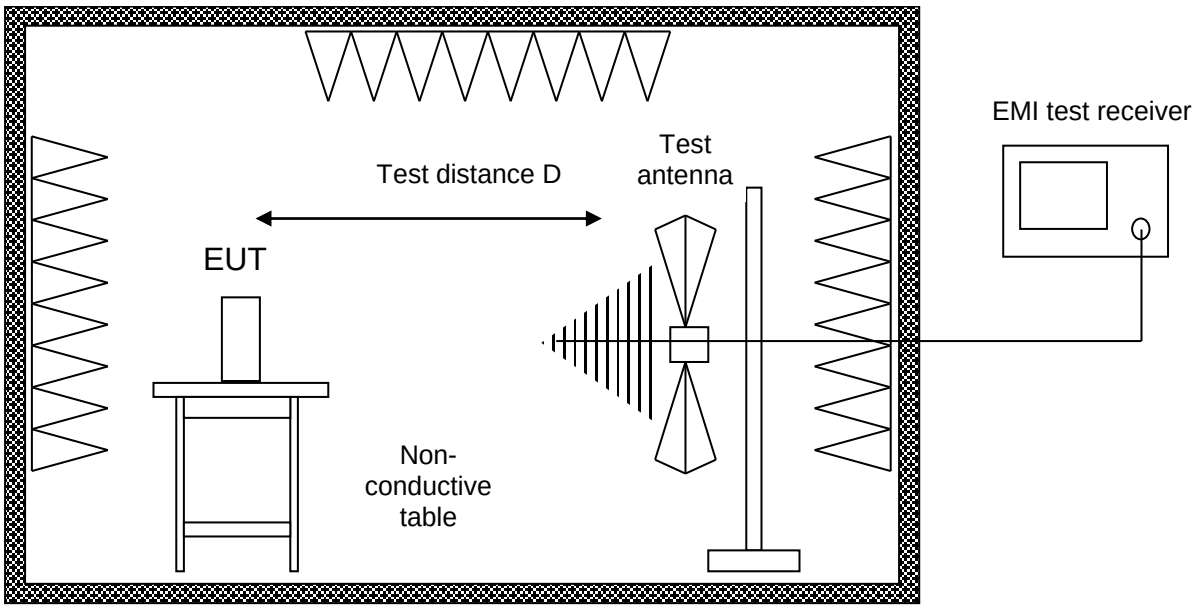
2.4.6.1 Frequency range 9 kHz – 30 MHz



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.

Product Service

2.4.6.2 Frequency range 30 MHz – 1 GHz

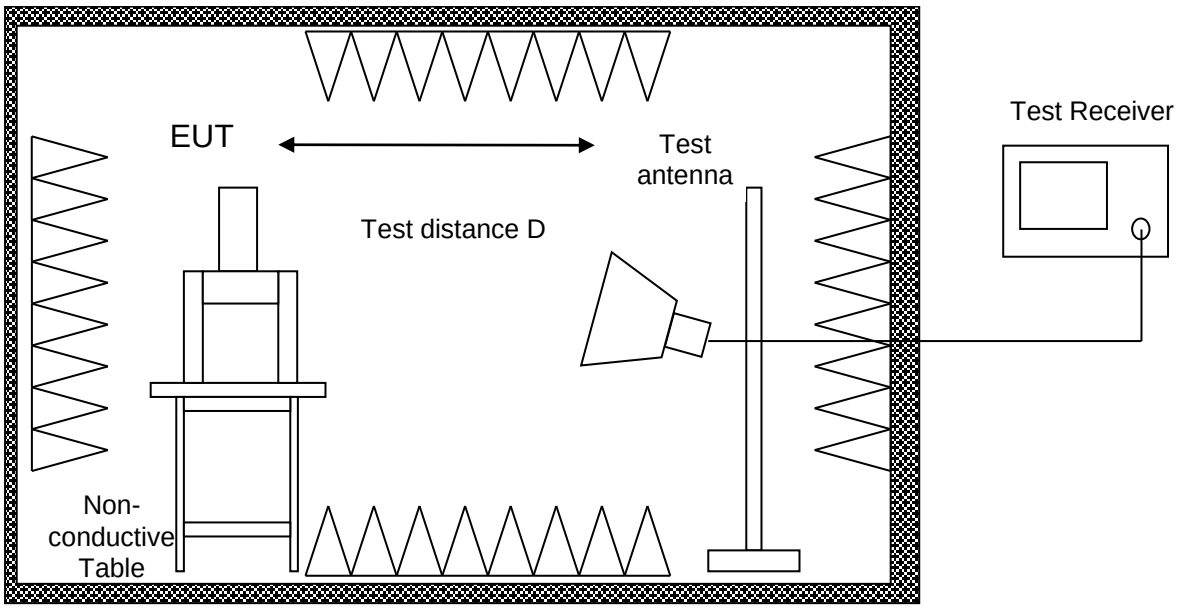


Alternate test site (semi anechoic room)

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.

Product Service

2.4.6.3 Frequency range above 1 GHz



Fully anechoic room

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.

Product Service

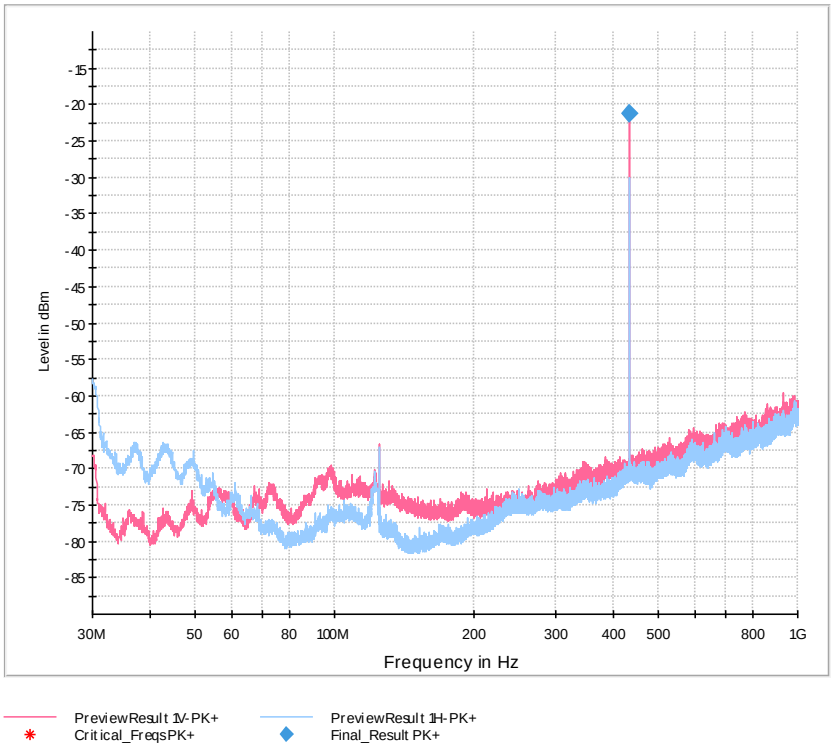
2.4.7 Test Results

Sample calculation:

Final Value (dBµV/m) = Reading Value (dBµV) + (Cable attenuation (dB) + Antenna Transducer (dB(1/m)))

Transmitting continuously on 433.2 MHz - Preliminary pre-scans for the worst-case orientation

x axis

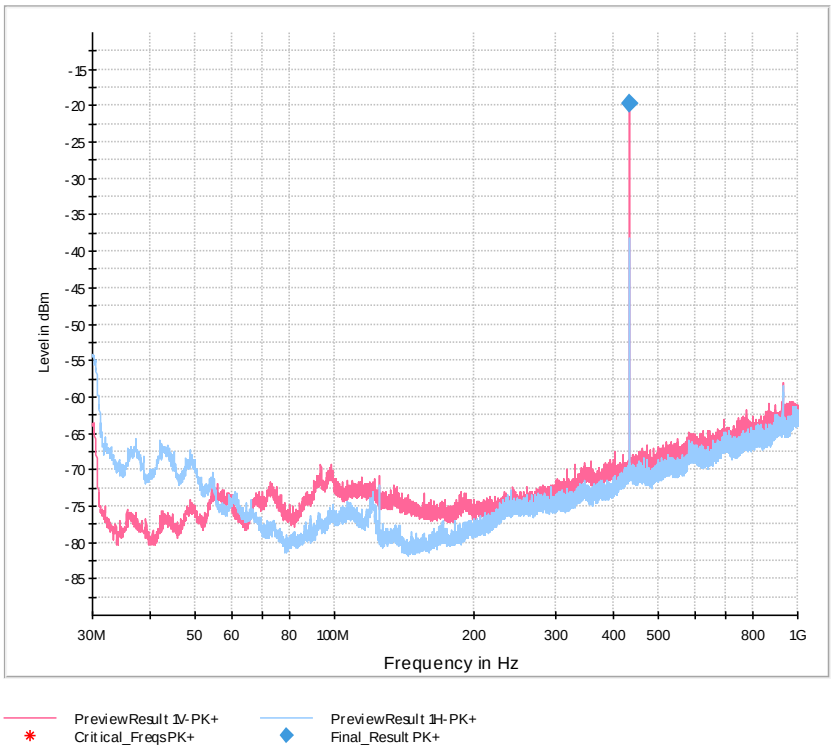


Final Results:

Frequency MHz	*MaxPeak dBm*	*Meas. Time ms*	*Bandwidth kHz*	*Height cm*	*Pol*	*Azimuth deg*	*Corr. dB*
433.210000	-21.22	1000.0	120.000	146.0	V	95.0	-81.8

Product Service

y axis



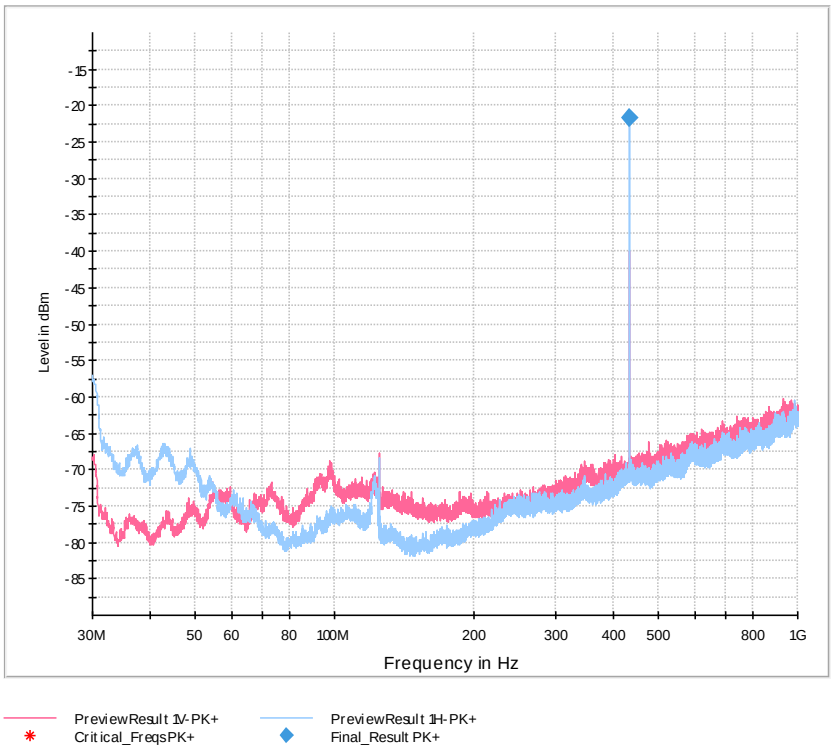
Final Results:

Frequency MHz	*MaxPeak dBm*	*Meas. Time ms*	*Bandwidth kHz*	*Height cm*	*Pol*	*Azimuth deg*	*Corr. dB*
433.210000	-19.60	1000.0	120.000	143.0	V	-37.0	-81.8

➔ Worst case orientation is y axis

Product Service

z axis



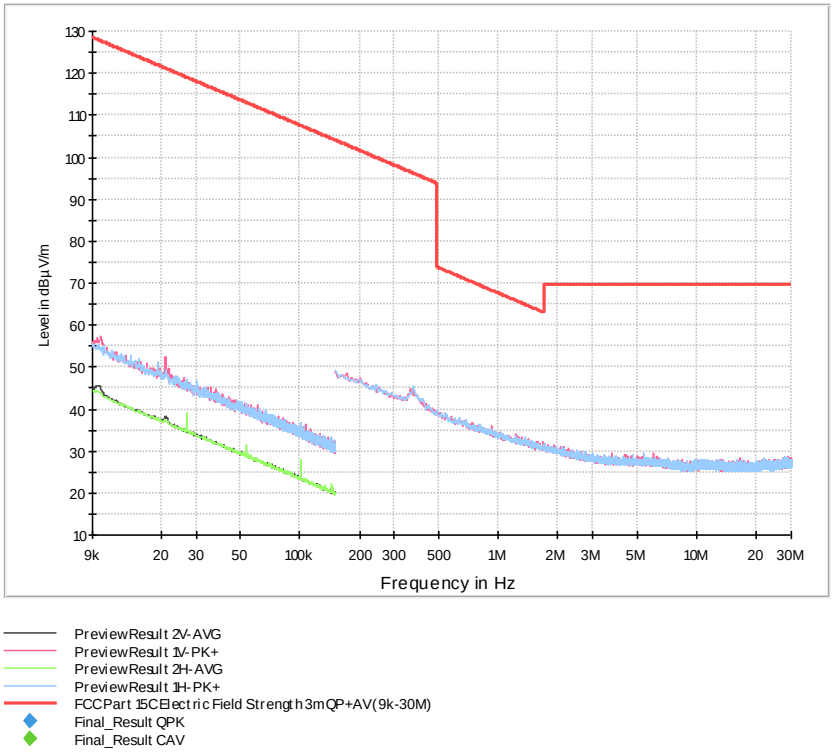
Final Results:

Frequency MHz	*MaxPeak dBm*	*Meas. Time ms*	*Bandwidth kHz*	*Height cm*	*Pol*	*Azimuth deg*	*Corr. dB*
433.210000	-21.61	1000.0	120.000	197.0	H	2.0	-82.4

Product Service

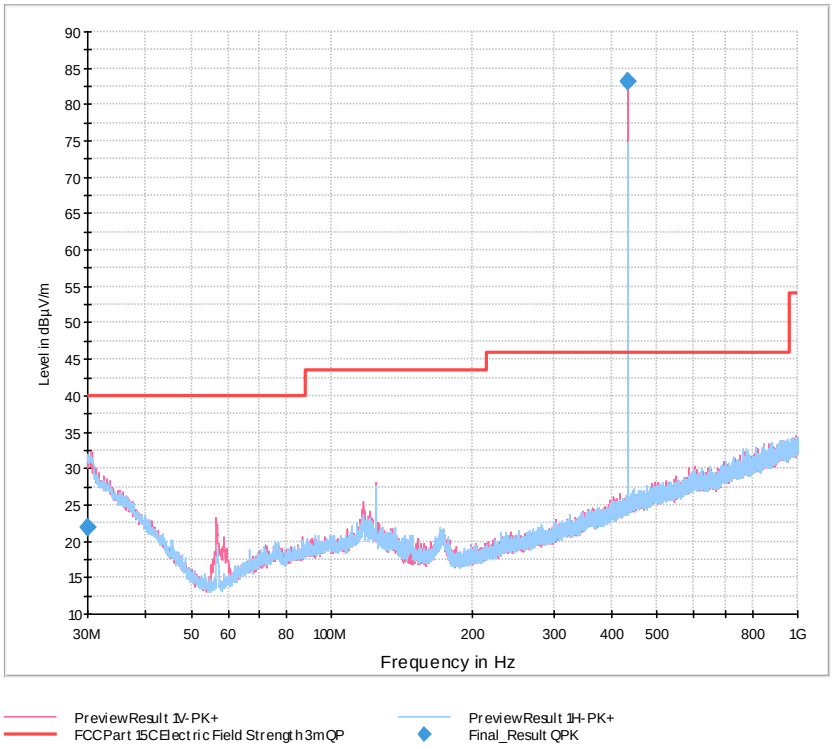
Transmitting continuously on 433.2 MHz – final measurement in y axis

Frequency range 9 kHz – 30 MHz:



Product Service

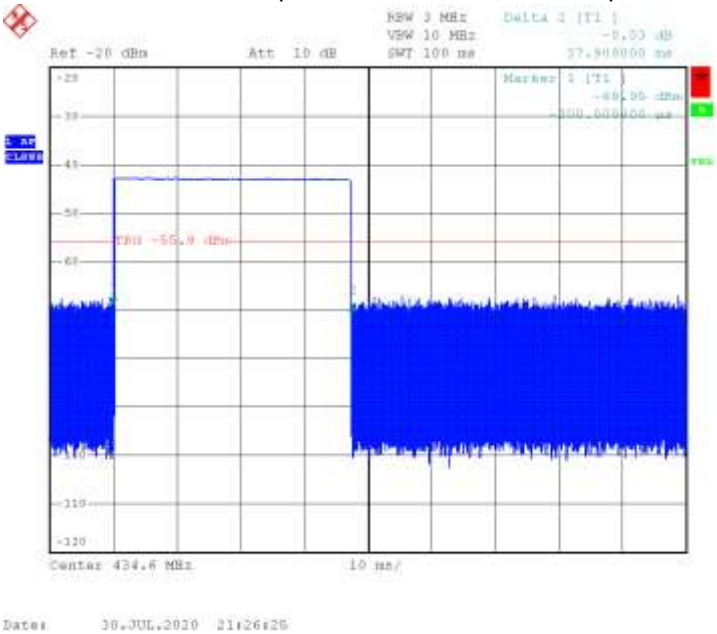
Frequency range 30 MHz – 1 GHz:



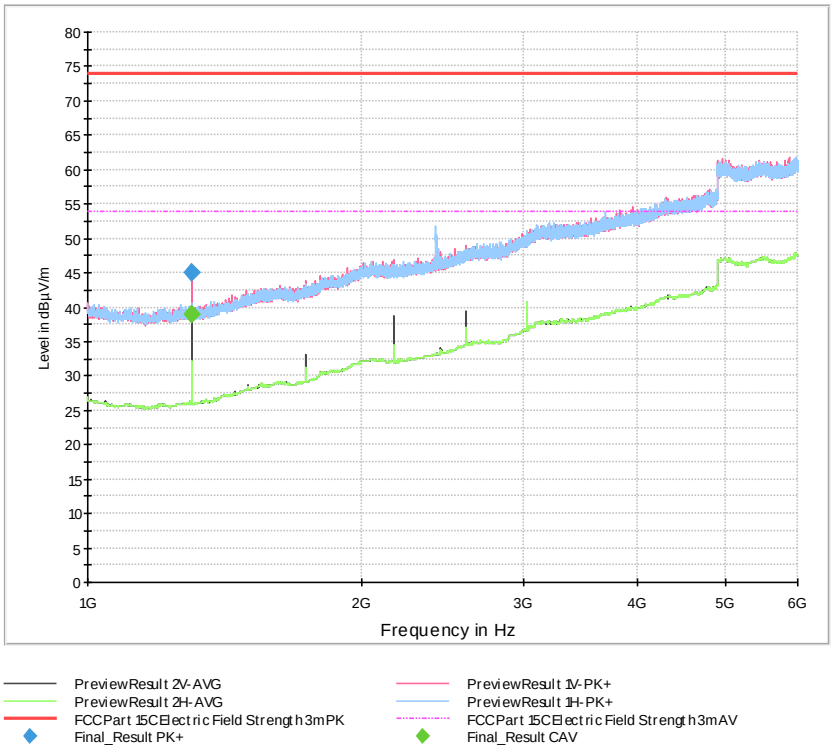
Final Results:

Frequency MHz	*Qua-siPeak dBµV/m*	*Max-Peak dBµV/m*	*Limit dBµV/m*	*Mar-gin dB*	*Meas. Time ms*	*Band-width kHz*	*Height cm*	*Pol*	*Azi-muth deg*	*Corr. dB/m*
30.060000	21.92	---	40.00	18.08	1000.0	120.000	148.0	V	-161.0	25.8
433.230000	---	75.00[#1]	77.17	2.17	1000.0	120.000	131.0	V	-22.0	22.4

Note #1: 83.42 dBµV/m measured with max peak detector and -8.42 dB pulse train correction factor



Frequency range 1 GHz – 6 GHz:



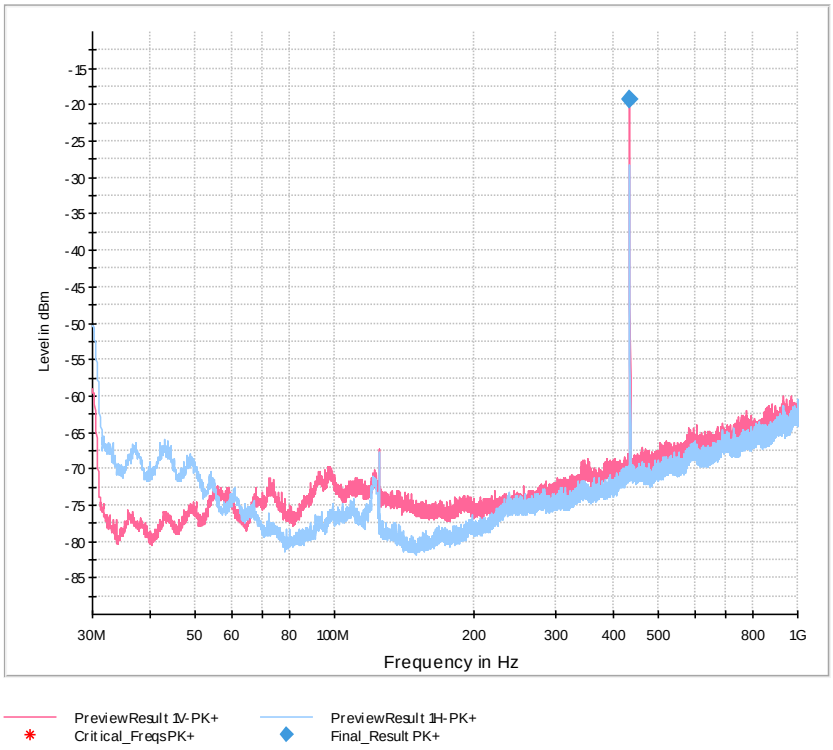
Final Results:

Frequency MHz	*Max-Peak dBµV/m*	*CAver-age dBµV/m*	*Limit dBµV/m*	*Mar-gin dB*	*Meas. Time ms*	*Band-width kHz*	*Height cm*	*Pol*	*Azi-muth deg*	*Corr. dB/m*
1299.500000	---	38.98	53.98	15.00	1000.0	1000.000	215.0	V	-42.0	27.2
1299.500000	45.05	---	73.98	28.93	1000.0	1000.000	215.0	V	-42.0	27.2

Product Service

Transmitting continuously on 434.64 MHz - Preliminary pre-scans for the worst-case orientation

x axis

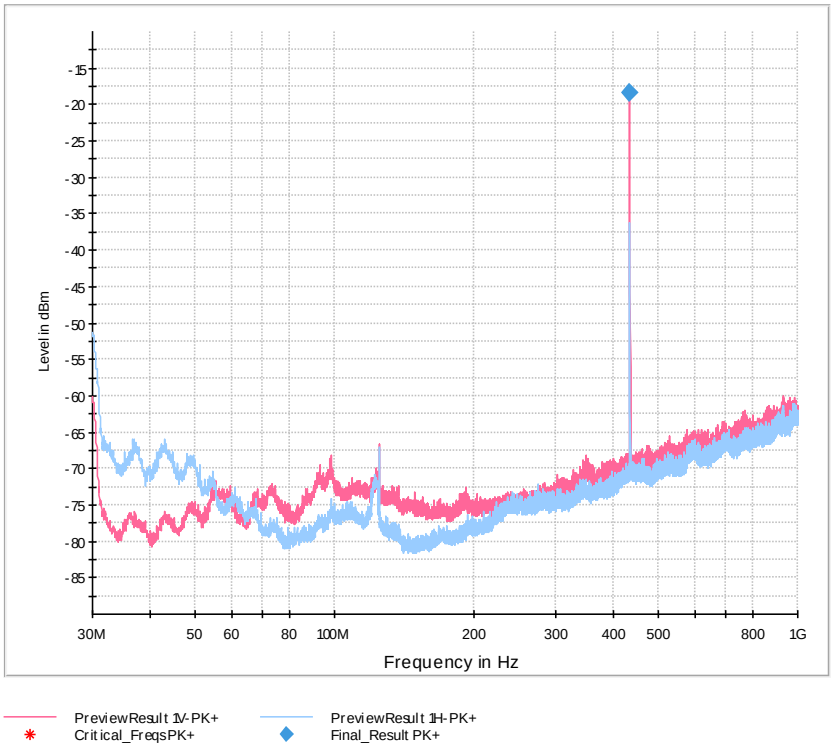


Final Results:

Frequency MHz	*MaxPeak dBm*	*Meas. Time ms*	*Bandwidth kHz*	*Height cm*	*Pol*	*Azimuth deg*	*Corr. dB*
434.650000	-19.30	1000.0	120.000	148.0	V	93.0	-81.7

Product Service

y axis

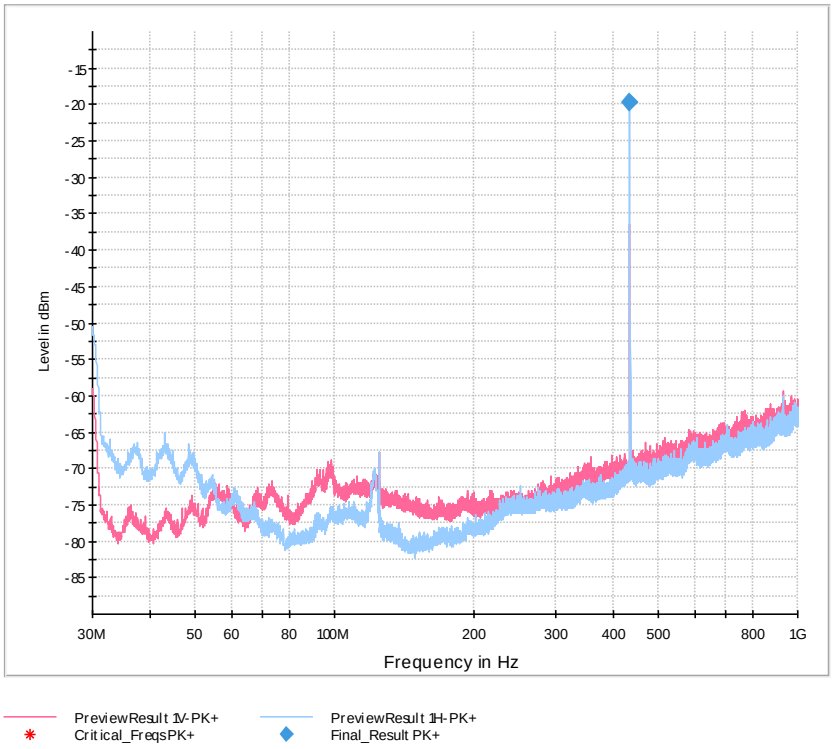


Final Results:

Frequency MHz	*MaxPeak dBm*	*Meas. Time ms*	*Bandwidth kHz*	*Height cm*	*Pol*	*Azimuth deg*	*Corr. dB*
434.650000	-18.45	1000.0	120.000	144.0	V	-42.0	-81.7

➔ Worst case orientation is y axis

z axis



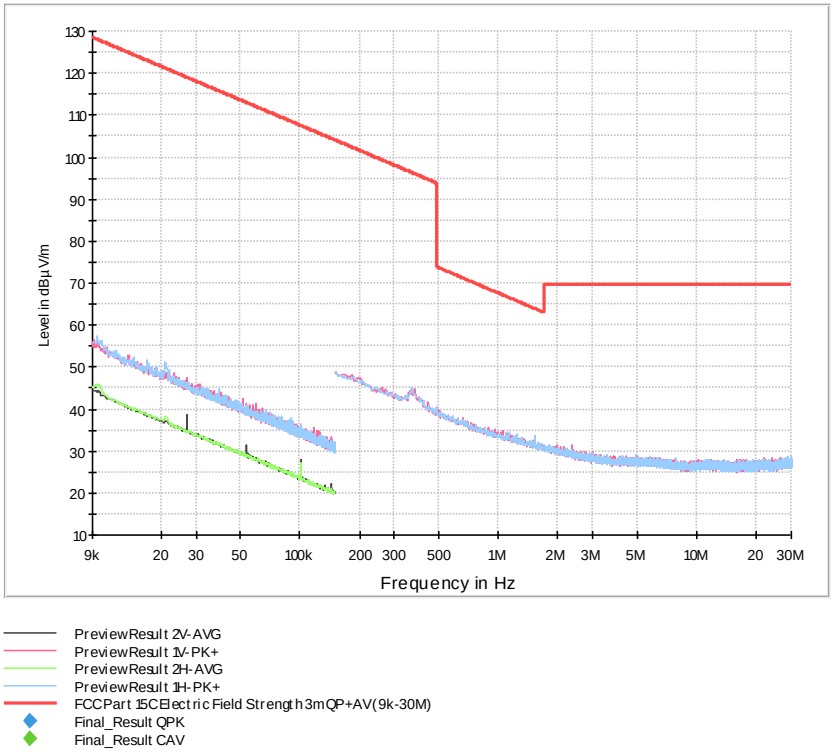
Final Results:

Frequency MHz	*MaxPeak dBm*	*Meas. Time ms*	*Bandwidth kHz*	*Height cm*	*Pol*	*Azimuth deg*	*Corr. dB*
434.650000	-19.77	1000.0	120.000	200.0	H	189.0	-82.4

Product Service

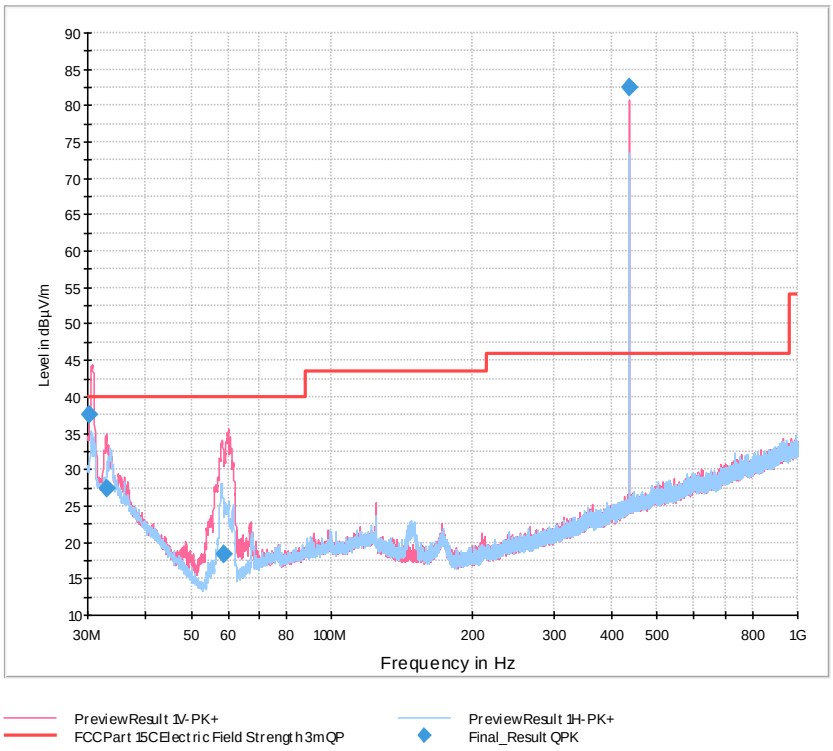
Transmitting continuously on 434.64 MHz – final measurement in y axis

Frequency range 9 kHz – 30 MHz:



Product Service

Frequency range 30 MHz – 1 GHz:



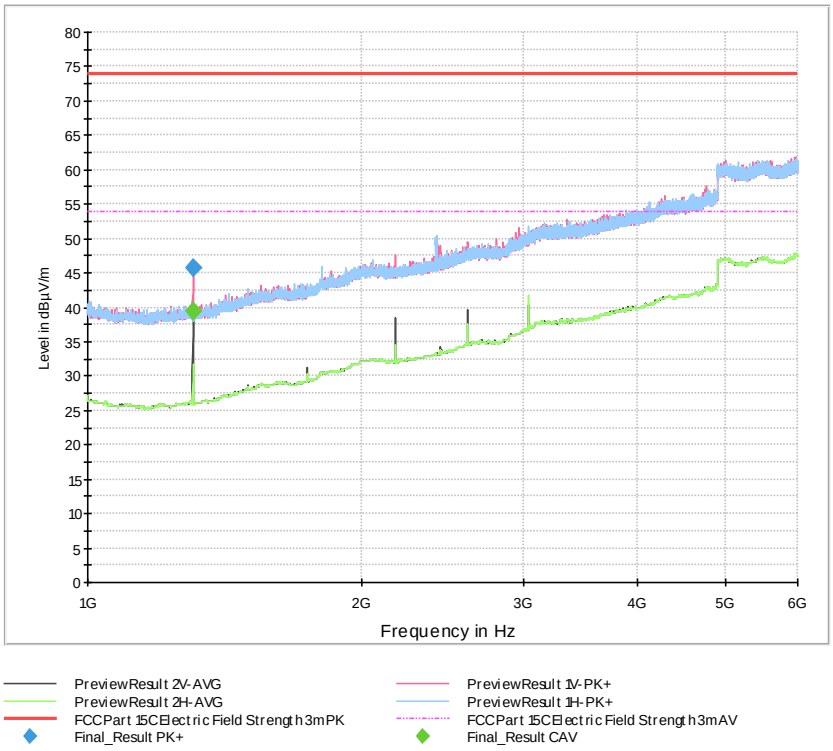
Final Results:

Frequency MHz	*QuasiPeak dBµV/m*	*Limit dBµV/m*	*Margin dB*	*Meas. Time ms*	*Bandwidth kHz*	*Height cm*	*Pol*	*Azimuth deg*	*Corr. dB/m*
30.210000	37.53	40.00	2.47	1000.0	120.000	100.0	V	232.0	25.7
33.030000	27.52	40.00	12.48	1000.0	120.000	123.0	V	-83.0	24.3
58.980000	18.34	40.00	21.66	1000.0	120.000	122.0	V	-50.0	12.4
434.640000	74.30[#1]	77.24	2.94	1000.0	120.000	134.0	V	-44.0	22.4

Note #1: 82.72 dBµV/m measured with max peak detector and -8.42 dB pulse train correction factor

Product Service

Frequency range 1 GHz – 6 GHz:



Final Results:

Frequency MHz	*Max-Peak dBµV/m*	*CAver-age dBµV/m*	*Limit dBµV/m*	*Mar-gin dB*	*Meas. Time ms*	*Band-width kHz*	*Height cm*	*Pol*	*Azi-muth deg*	*Corr. dB/m*
1304.000000	---	39.32	53.98	14.65	1000.0	1000.000	102.0	V	-70.0	27.2
1304.000000	45.67	---	73.98	28.31	1000.0	1000.000	102.0	V	-70.0	27.2

2.4.8 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*
EMI test receiver	Rohde & Schwarz	ESW44	39897	12	2021-03-31
Loop antenna	Schwarzbeck	FMZB 1519 B	44334	36	2023-01-31
TRILOG Broadband Antenna	Rohde & Schwarz	VULB 9162	20116	36	2022-01-31
Double ridged horn antenna	Rohde & Schwarz	HF907	40089	24	2021-02-28
EMC measurement software	Rohde & Schwarz	EMC32 Emis-sion K11 - V10.50.10	42986	---	---
Semi Anechoic Room	Frankonia	Cabin No. 11	42961	36	2022-08-31

Table 16

Product Service

2.5 RF Exposure

2.5.1 Specification Reference

FCC 47 CFR Part 2 J, Clause 2.1093
KDB 447498 D01 V06, section 4.3.1
ISED RSS-Gen, Clause 3.4
ISED RSS-102, Clause

2.5.2 Equipment under Test and Modification State

BK1, S/N: 48BA99B6 - Modification State 0

2.5.3 Date of Test

2020-08-04

2.5.4 Environmental Conditions

Ambient Temperature	24 °C
Relative Humidity	50 %

2.5.5 Test Method

Estimation is based on output power test.
For details please refer to section 2.4.7 of this test report.

2.5.6 Specification Limits

FCC 47 CFR Part 15 C, Clause 15.212(viii)
Systems operating under the provisions of this section shall be operated in a manner that ensure that the public is not exposed to radio frequency energy levels in excess of the Commission's guideline.
Acc. to KDB 477498:
The 1 g and 10 g SAR test exclusion thresholds for 100 MHz to 6 GHz at test separations distances ≤ 50 mm are determined by:

$$\frac{max.\ power\ of\ channel, incl.\ tune-up\ tol., mW}{min. test\ separation\ distance, mm} \cdot \sqrt{f, GHz} \leq \begin{Bmatrix} 3.0\ \ for\ 1\ g \\ 7.5\ for\ 10\ g \end{Bmatrix} extremity\ SAR$$

1. *f* (GHz) is the RF channel frequency in GHz;
2. Power and distance are rounded to the nearest mW and mm before calculation;
3. The result is rounded to one decimal place for comparison;
4. 3.0 and 7.5 are referred to as the numeric thresholds

Product Service

The test exclusions are applicable only when the minimum test separation distance is ≤ 50 mm, and for transmission frequencies between 100 MHz and 6 GHz. When the minimum test separation distance is < 5 mm, a distance of 5 mm is applied.

ISED RSS-102, Clause 2.5.1
SAR evaluation is required if the separation distance between the user and/or bystander and the antenna and/or radiating element of the device is less than or equal to 20 cm, except when the device operates at or below the applicable output power level (adjusted for tune-up tolerance) for the specified separation distance defined in the table.
For controlled use devices where the 8 W/kg for 1 gram of tissue applies, the exemption limits for routine evaluation in the table are multiplied by a factor of 5. For limb-worn devices where the 10 gram value applies, the exemption limits for routine evaluation in the table are multiplied by a factor of 2.5. If the operating frequency of the device is between two frequencies located in the table, linear interpolation shall be applied for the applicable separation distance. For test separation distance less than 5 mm, the exemption limits for a separation distance of 5 mm can be applied to determine if a routine evaluation is required.
For medical implants devices, the exemption limit for routine evaluation is set at 1 mW. The output power of a medical implants device is defined as the higher of the conducted or e.i.r.p to determine whether the device is exempt from the SAR evaluation.:

Frequency (MHz)	Exemption limits (mW)[2] at separation distance of									
	≤5 mm	10 mm	15 mm	20 mm	25 mm	30 mm	35 mm	40 mm	45 mm	≥50 mm
≤300 [3]	71	101	132	162	193	223	254	284	315	345
450	52	70	88	106	123	141	159	177	195	213
835	17	30	42	55	67	80	92	105	117	130
1900	7	10	18	34	60	99	153	225	316	431
2450	4	7	15	30	52	83	123	173	235	309
3500	2	6	16	32	55	86	124	170	225	290
5800	1	6	15	27	41	56	71	85	97	106

[2] The excemption limit in the table are based on measurements and simulations on half-wave dipole antennas at separaton distances of 5 mm to 25 mm from a flat phantom, providing a SAR value of approximately 0.4 W/kg for 1 g of tissue. For low frequencies (300 MHz to 835 MHz), the exemption limits are derived from alinear fit. For high frequencies (1900 MHz and above), the exemption limits are derived from athird order polynomial fit.
[3] Transmitters operating between 3 kHz and 10 MHz, meeting the exemption from routine SAR evaluation, shall demonstrate compliance to the instantaneous limits in IC RSS-102, issue 5, section 4.

Product Service

2.5.7 Test Results

FCC 47 CFR Part 15 C, Clause 15.247(i)

Maximum output power:	0.066 mW
Minimum test separation distance:	2 mm
Frequency:	433.2 MHz
SAR test exclusion threshold (calculated):	0.0217
Limit (1 g SAR):	3.0
Limit (10 g SAR):	7.5
Test Result:	Pass: 0.0217 < 3.0

ISED RSS-Gen, Clause 3.4

Frequency:	433.2 MHz
Test distance:	3 m
Carrier Power (e.i.r.p.):	0.066 mW
Exemption limit:	52 mW
Test Result:	Pass

Product Service

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.

Radio Interference Emission Testing		
Test Name	*kp*	*Expanded Uncertainty*
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 to CISPR16-4-2: 2011 + A1 + A2 + Cor1 is based on a standard uncertainty multiplied by a coverage factor of kp = 2, providing a level of confidence of p = 95.45%		

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

Product Service

Radio Interference Emission Testing		
Test Name	*kp*	*Expanded Uncertainty*
Occupied Bandwdith	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	± 6.5 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 kp = 2, providing a level of confidence of p = 95.45%		

Table 18 Measurement uncertainty based on ETSI TR 100 028