Report on the FCC and IC Testing of the APTIV Services Deutschland GmbH Radar Sensor. Model: B4TR In accordance with CFR 47, Part 95, Subpart M and ISED RSS-251, Issue 2

Prepared for: APTIV Services Deutschland GmbH
Am Technologiepark 1
42119 Wuppertal
Germany

FCC ID: LTQB4TR
IC: 3659A-B4TR

Product Service

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Date: 2020-06-19
Document Number: TR-00237-85697-03 | Issue: 1

RESPONSIBLE FOR	NAME	DATE	SIGNATURE
Project Management	Alex Fink	2020-06-19	SIGN-ID 370609
Authorised Signatory	Martin Steindl	2020-06-19	SIGN-ID 370668

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

ENGINEERING STATEMENT
The measurements 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 FCC 47 CFR Part 95, Subpart M and ISED Canada RSS-251. The sample tested was found to comply with the requirements defined in the applied rules.

RESPONSIBLE FOR	NAME	DATE	SIGNATURE
Testing	Alex Fink	2020-06-19	SIGN-ID 370609

Laboratory Accreditation	Laboratory recognition	ISED 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 SUMMARY
A sample of this product was tested and found to be compliant with FCC 47 CFR Part 95, Subpart M (2018), ISED Canada RSS-251 Issue 2 (2018-06).

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).

Trade Register Munich
HRB 85742
VAT ID No. DE129484267
Information pursuant to Section 2(1)
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Summary

Prüfergebnisse / *Test Results*	Auftragsnummer / *Order No.* **N/A**

Die Prüfungen wurden nach folgenden Vorschriften durchgeführt:
Tests were performed according to:

CFR 47, Part 95, Subpart M
ISED RSS-251, Issue 2

Durchgeführte Prüfung ***Test performed***	**Prüfergebnis** ***Test result***			
Power Density	☒	☐	☐	☐
Occupied Bandwidth	☒	☐	☐	☐
Spurious Radiated Emissions	☒	☐	☐	☐
Frequency Stability	☒	☐	☐	☐
SAR Evaluation	☒	☐	☐	☐

Bemerkungen / *Remarks:*

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1 Administrative Data

Application details	
Applicant:	APTIV Services Deutschland GmbH Am Technologiepark 1 42119 Wuppertal Germany
Contact person:	Ljiljana TRIVIC
Order number:	N/A
Receipt of EUT:	2020-05-25
Return of EUT:	---
Date(s) of test:	2020-05-25 to 2020-06-18
Note(s):	---
Responsible for testing:	Mr. Alex Fink
Responsible for test report:	Mr. Alex Fink
Test report checked by:	Mr. Martin Steindl

Report details	
Report number:	TR-00237-85697-03
Edition:	1
Issue date:	2020-06-19

2 Details about the Test Laboratory

Details about the Test Laboratory	
Company name:	TÜV SÜD Product Service GmbH
Address:	Äußere Frühlingstraße 45 D-94315 Straubing Germany
Laboratory accreditation:	DAkkS Registration No. D-PL-11321-11-02 DAkkS Registration No. D-PL-11321-11-03
Laboratory recognition:	Registration No. BNetzA-CAB-16/21-15
Industry Canada test site registration:	3050A-2
Contact:	Mr. Markus Biberger Phone: +49 9421 5522-0 Fax: +49 9421 5522-99

3 Description of the Equipment Under Test

Equipment characteristics	
Type designation:	B4TR
Parts of the system:	---
Options and accessories:	---
Type of equipment:	Radar Sensor
Serial number:	00008
Manufacturer:	APTIV Services Deutschland GmbH
Power supply:	Battery supply (regulated lead-acid) Nominal: 12.0 V Nominal frequency: 0 Hz (DC)
Highest internal frequency:	1.6 GHz, 76 GHz for Radar
Version of EUT:	Hardware: 004.001.000

Technical Description
The Equipment Under Test (EUT) was an Aptiv B4TR Radar. The EUT operates in the 76 GHz – 77 GHz band. The device emplys a dynamic chirp modulated transmit array. Multiple receive antennas are used to determine target angular resolution through digital beam forming. The device is intended to be mounted at the front and rear corners of a vehicle. The EUTs normal operating voltage is DC 12 V

Marking Plate


4 Operation Mode and Configuration of EUT

Operation Mode(s)
The operating modes with single frequency, 175 MHz, 300 MHz and 425 MHz were tested on the lowest, middle and highest frequency configuration, each, as provided by the manufacturer.

List of ports and cables					
No.	*Description*	*Classification*[1]	*Cable type*	*Cable length used*	*maximum*[2]
D1	DC 12 V supply	dc power	Unshielded	2 m	2 m
S1	Wiring harness (CAN, Ethernet)	signal/control port	Unshielded	2 m	2 m

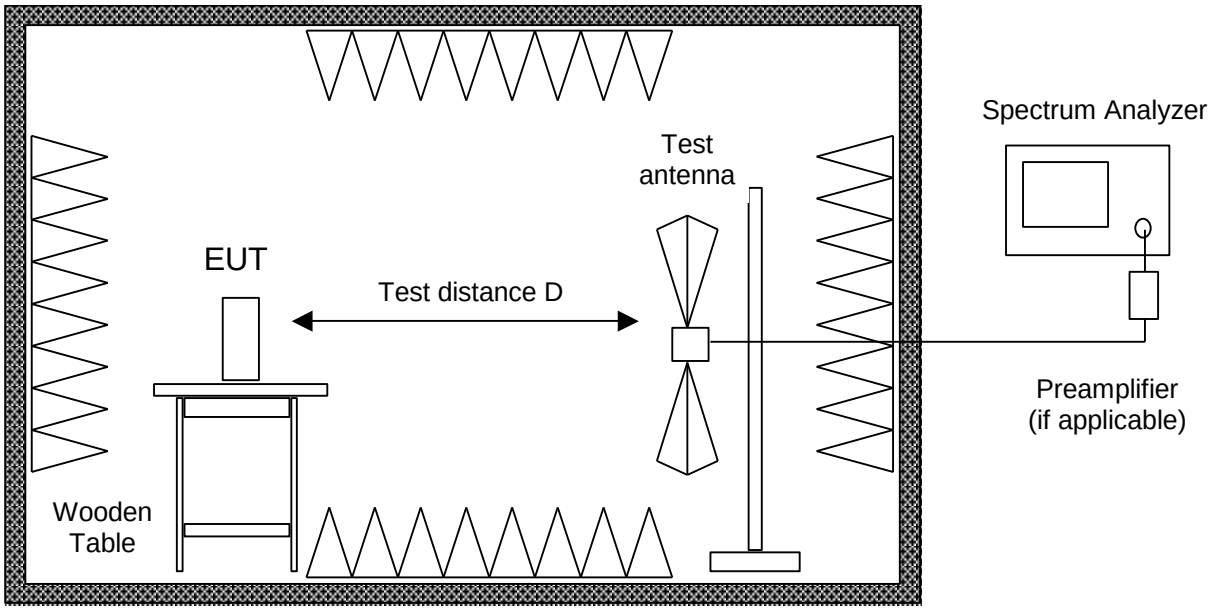
List of devices connected to EUT				
No.	*Description*	*Type designation*	*Serial no. or ID*	*Manufacturer*
	---	---	---	---

List of support devices				
No.	*Description*	*Type designation*	*Serial no. or ID*	*Manufacturer*
1	CAN/LIN-Interface	VN1640A		Vector
2	Notebook	---	---	HP

[1] Ports shall be classified as ac power, dc power or signal/control port.
[2] As specified by applicant

5 Test Setups

Radiated Emission in Fully or Semi Anechoic Room



Fully or semi anechoic room

Radiated emission in fully or semi anechoic room is measured in the frequency range from 30 MHz to the maximum frequency as specified in CFR 47 Part 15 section 15.33.

Measurements are made in both the horizontal and vertical planes of polarization using a spectrum analyzer with the detector function set to peak and resolution as well as video bandwidth set to 100 kHz (below 1 GHz) or 1 MHz (above 1 GHz).

Testing up to 1 GHz is performed with a linear polarized logarithmic periodic antenna combined with a 4:1 broadband dipole ("Trilog broadband antenna"). For testing above 1 GHz horn antennas are used.

All tests below 8.2 GHz are performed at a test distance D of 3 meters. For higher frequencies the test distance may be reduced (e.g. to 1 meter) due to the sensitivity of the measuring instrument(s) and the test results are calculated according to CFR 47 Part 15 section 15.31(f)(1) using an extrapolation factor of 20 dB/decade. If required, preamplifiers are used for the whole frequency range. Special care is taken to avoid overload, using appropriate attenuators and filters, if necessary.

If the radiated emission limits are expressed in terms of the average value of the emission there also is a peak limit corresponding to 20 dB above the maximum permitted average limit. Additionally, if pulsed operation is employed, the average field strength is determined by averaging over one complete pulse train, including blanking intervals, as specified in CFR 47 Part 15 section 15.35(c). If the pulse train exceeds 0.1 second that 0.1 second interval during which the value of the emission is at its maximum is selected for calculation. The pulse train correction is added to the peak value of the emission to get the average value.

Hand-held or body-worn devices are rotated through three orthogonal axes to determine which attitude and configuration produces the highest emission relative to the limit and therefore shall be used for final testing.

During testing the EUT is rotated all around to find the maximum levels of emissions. Equipment and cables are placed and moved within the range of position likely to find their maximum emissions.

For final testing below 1 GHz a semi anechoic room complying with the NSA requirements of ANSI C63.4 for alternative test sites is used (see 0). If prescans are recorded in fully anechoic room they are indicated appropriately.

According to section 13 of KDB558074 the requirement for radiated emissions on the band edges was performed with a reduced bandwidth of 100 kHz instead of 1 MHz.

Radiated emission in the frequency range 9 kHz to 30 MHz is measured using an active loop antenna. First the whole spectrum of emission caused by the equipment is recorded at a distance of 3 meters in a fully or semi anechoic room with the detector of the spectrum analyzer or EMI receiver set to peak. This configuration is also used for recording the spectrum of intentional radiators.

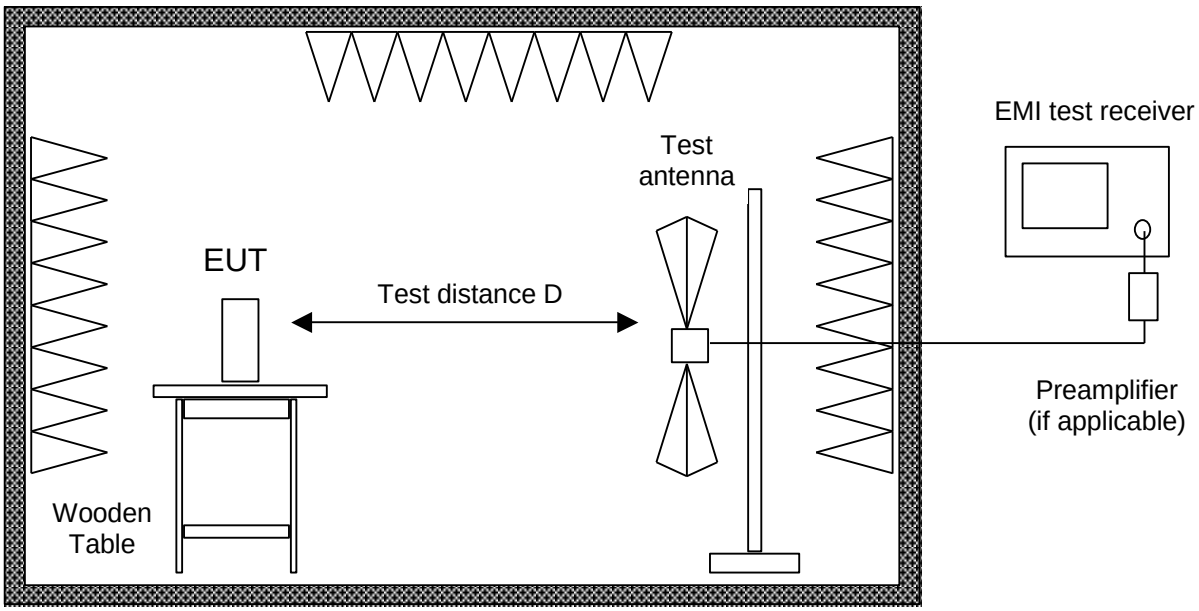
Hand-held or body-worn devices are rotated through three orthogonal axes to determine which attitude and configuration produces the highest emission relative to the limit and therefore shall be used for final testing.

EUT is rotated all around to find the maximum levels of emissions. Equipment and cables are placed and moved within the range of position likely to find their maximum emissions.
If worst case emission of the EUT cannot be recorded with EUT in standard position and loop antenna in vertical polarization the EUT (or the radiating part of the EUT) is rotated by 90 degrees instead of changing the loop antenna to horizontal polarization. This procedure is selected to minimize the influence of the environment (e.g. effects caused by the floor especially with longer distances).

Final measurement is performed at a test distance D of 30 meters using an open field test site. In case the regulation requires testing at other distances, the result is extrapolated by either making measurements at an additional distance D of 10 meters to determine the proper extrapolation factor or by using the square of an inverse linear distance extrapolation factor (40 dB/decade). In cases of very low emissions measurements are performed at shorter distances and results are extrapolated to the required distance. The provisions of CFR 47 Part 15 sections 15.31(d) and (f)(2) apply. According to CFR 47 Part 15 section 15.209(d) final measurement is performed with detector function set to quasi-peak except for the frequency bands 9 to 90 kHz and 110 to 490 kHz where, for non-pulsed operation, average detector is employed.

If the radiated emission limits are expressed in terms of the average value of the emission there also is a peak limit corresponding to 20 dB above the maximum permitted average limit. Additionally, if pulsed operation is employed, the average field strength is determined by averaging over one complete pulse train, including blanking intervals, as specified in CFR 47 Part 15 section 15.35(c). If the pulse train exceeds 0.1 second that 0.1 second interval during which the value of the emission is at its maximum is selected for calculation. The pulse train correction is added to the peak value of the emission to get the average value.

Radiated Emission at Alternative Test Site



Alternate test site (semi anechoic room)

Radiated emission in the frequency range 30 MHz to 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 polarized logarithmic periodic antenna combined with a 4:1 broadband dipole ("Trilog broadband antenna") is used. The measurement bandwidth of the test receiver is set to 120 kHz with quasi-peak detector selected.

If the radiated emission limits are expressed in terms of the average value of the emission there also is a peak limit corresponding to 20 dB above the maximum permitted average limit. Additionally, if pulsed operation is employed, the average field strength is determined by averaging over one complete pulse train, including blanking intervals, as specified in CFR 47 Part 15 section 15.35(c). If the pulse train exceeds 0.1 second that 0.1 second interval during which the value of the emission is at its maximum is selected for calculation. The pulse train correction is added to the peak value of the emission to get the average value.

Hand-held or body-worn devices are tested in the position producing the highest emission relative to the limit as verified by prescans in fully anechoic room.

If no prescan in a fully anechoic room is used first a peak scan is performed in four positions to get the whole spectrum of emission caused by EUT with the measuring antenna raised and lowered from 1 to 4 m to find table position, antenna height and antenna polarization for the maximum emission levels.
Data reduction is applied to these results to select those levels having less margin than 10 dB to or exceeding the limit using subranges and limited number of maximums. Further maximization is following.
With detector of the test receiver set to quasi-peak final measurements are performed immediately after frequency zoom (for drifting disturbances) and maximum adjustment.
Equipment and cables are placed and moved within the range of position likely to find their maximum emissions.

In cases where prescans in a fully anechoic room are taken (e. g. if EUT is operating for a short time only or battery is dircharged quickly) final measurements with quasi-peak detector are performed manually at frequencies indicated by prescan with EUT rotating all around and receiving antenna raising and lowering within 1 meter to 4 meters to find the maximum levels of emission.
Equipment and cables are placed and moved within the range of position likely to find their maximum emissions.

For measuring emissions of intentional radiators and receivers a test distance D of 3 meters is selected. Testing of unintentional radiators is performed at a distance of 10 meters. If limits specified for 3 meters shall be used for measurements performed at 10 meters distance the limits are calculated according to CFR 47 Part 15 section 15.31(d) and (f)(1) using an inverse linear-distance extrapolation factor of 20 dB/decade.

6 Photographs Taken During Testing

See “Annex to Test Report TR00237-85697-03 | Issue: 01”

7 Referenced Regulations

Publication	*Title*
CFR 47, Part 2	Code of Federal Regulations Part 2 (Frequency allocation and radio treaty matters; General rules and regulations) of the Federal Communications Comission (FCC)
CFR 47, Part 95, Subpart M	Code of Federal Regulations Part 95 (Personal Radio Services), Subpart M (76 – 77 GHz Band Radar Service) of the Federal Communications Comission (FCC)
RSS-251, Issue 2	Vehicular Radar and Airport Fixed or Mobile Radar in the 76 – 81 GHz Frequency band
ANSI C63.4-2014	American National Standard for Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz
ANSI C63.10-2013	American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices

8 Measurement Uncertainty Values

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

Radio Testing			
Test Name	kp	Expanded Uncertainty	Note
Occupied Bandwidth	2.0	±1.14 %	2
RF-Frequency error	1.96	±1 · 10-7	7
RF-Power, conducted carrier	2	±0.079 dB	2
RF-Power uncertainty for given BER	1.96	+0.94 dB / -1.05	7
RF power, conducted, spurious emissions	1.96	+1.4 dB / -1.6 dB	7
RF power, radiated			
25 MHz – 4 GHz	1.96	+3.6 dB / -5.2 dB	8
1 GHz – 18 GHz	1.96	+3.8 dB / -5.6 dB	8
18 GHz – 26.5 GHz	1.96	+3.4 dB / -4.5 dB	8
40 GHz – 170 GHz	1.96	+4.2 dB / -7.1 dB	8
Spectral Power Density, conducted	2.0	±0.53 dB	2
Maximum frequency deviation			
300 Hz – 6 kHz	2	±2,89 %	2
6 kHz – 25 kHz	2	±0.2 dB	2
Maximum frequency deviation for FM	2	±2,89 %	2
Adjacent channel power 25 MHz – 1 GHz	2	±2.31 %	2
Temperature	2	±0.39 K	4
(Relative) Humidity	2	±2.28 %	2
DC- and low frequency AC voltage			
DC voltage	2	±0.01 %	2
AC voltage up to 1 kHz	2	±1.2 %	2
Time	2	±0.6 %	2

Radio Interference Emission Testing			
Test Name	kp	Expanded Uncertainty	Note
Conducted Voltage Emission			
9 kHz to 150 kHz (50Ω/50µH AMN)	2	± 3.8 dB	1
150 kHz to 30 MHz (50Ω/50µH AMN)	2	± 3.4 dB	1
100 kHz to 200 MHz (50Ω/5µH AMN)	2	± 3.6 dB	1
Discontinuous Conducted Emission			
9 kHz to 150 kHz (50Ω/50µH AMN)	2	± 3.8 dB	1
150 kHz to 30 MHz (50Ω/50µH AMN)	2	± 3.4 dB	1
Conducted Current Emission			
9 kHz to 200 MHz	2	± 3.5 dB	1
Magnetic Fieldstrength			
9 kHz to 30 MHz (with loop antenna)	2	± 3.9 dB	1
9 kHz to 30 MHz (large-loop antenna 2 m)	2	± 3.5 dB	1
Radiated Emission			
Test distance 1 m (ALSE)			
9 kHz to 150 kHz	2	± 4.6 dB	1
150 kHz to 30 MHz	2	± 4.1 dB	1
30 MHz to 200 MHz	2	± 5.2 dB	1
200 MHz to 2 GHz	2	± 4.4 dB	1
2 GHz to 3 GHz	2	± 4.6 dB	1
Test distance 3 m			
30 MHz to 300 MHz	2	± 4.9 dB	1
300 MHz to 1 GHz	2	± 5.0 dB	1
1 GHz to 6 GHz	2	± 4.6 dB	1
Test distance 10 m			
30 MHz to 300 MHz	2	± 4.9 dB	1
300 MHz to 1 GHz	2	± 4.9 dB	1
Radio Interference Power			
30 MHz to 300 MHz	2	± 3.5 dB	1
Harmonic Current Emissions			4
Voltage Changes, Voltage Fluctuations and Flicker			4

Immunity Testing			
Test Name	kp	Expanded Uncertainty	Note
Electrostatic Discharges			4
Radiated RF-Field			
Pre-calibrated field level	2	+32.2 / -24.3 %	5
Dynamic feedback field level	2.05	+21.2 / -17.5 %	3
Electrical Fast Transients (EFT) / Bursts			4
Surges			4
Conducted Disturbances, induced by RF-Fields			
via CDN	2	+15.1 / -13.1 %	6
via EM clamp	2	+42.6 / -29.9 %	6
via current clamp	2	+43.9 / -30.5 %	6
Power Frequency Magnetic Field	2	+20.7 / -17.1 %	2
Pulse Magnetic Field			4
Voltage Dips, Short Interruptions and Voltage Variations			4
Oscillatory Waves			4
Conducted Low Frequency Disturbances			
Voltage setting	2	± 0.9 %	2
Frequency setting	2	± 0.1 %	2
Electrical Transient Transmission in Road Vehicles			4

Note 1:
The expanded uncertainty reported according to CISPR 16-4-2:2003-11 is based on a standard uncertainty multiplied by a coverage factor of kp = 2, providing a level of confidence of p = 95.45%
Note 2:
The expanded uncertainty reported according to UKAS Lab 34 (Edition 1, 2002-08) is based on a standard uncertainty multiplied by a coverage factor of kp = 2, providing a level of confidence of p = 95.45%
Note 3:
The expanded uncertainty reported according to UKAS Lab 34 (Edition 1, 2002-08) is based on a standard uncertainty multiplied by a coverage factor of kp = 2.05, providing a level of confidence of p = 95.45%
Note 4:
It has been demonstrated that the used test equipment meets the specified requirements in the standard with at least a 95%confidence.
Note 5:
The expanded uncertainty reported according to IEC 61000-4-3 is based on a standard uncertainty multiplied by a coverage factor of kp = 2, providing a level of confidence of p = 95.45%
Note 6:
The expanded uncertainty reported according to IEC 61000-4-6 is based on a standard uncertainty multiplied by a coverage factor of kp = 2, providing a level of confidence of p = 95.45%
Note 7:
The expanded uncertainty reported according ETSI TR 100 028 V1.4.1 (all parts) to is based on a standard uncertainty multiplied by a coverage factor of kp = 1.96, providing a level of confidence of p = 95.45%
Note 8:
The expanded uncertainty reported according to ETSI TR 102 273 V1.2.1 (all parts) is based on a standard uncertainty multiplied by a coverage factor of kp = 1.96, providing a level of confidence of p = 95.45%

9 Test Equipment used

T-ID	*Designation*	*Type*	*Last Cal.*	*Next Cal.*
18874	Horn antenna	3160-07	Verified	
18875	Horn antenna	3160-08	Verified	
19125	Horn antenna	3160-09	Verified	
19383	Double ridged waveguide horn antenna	3115	2020-03	2023-03
19442	Horn antenna	3160-10	Verified	
19533	Spectrum analyser	FSP30	2019-02	2020-08
19933	Double ridged horn antenna	HF907	2019-07	2021-07
19946	Horn antenna	24240-20	Verified	
20219	Signal and Spectrum Analysator	FSV40 for TS8997	2020-01	2021-01
22553	Waveguide mixer	FS-Z170	2020-02	2023-02
25849	Waveguide mixer	FS-Z60	2020-02	2023-02
25850	Waveguide mixer	FS-Z90	2020-02	2023-02
25851	Waveguide mixer	FS-Z110	2020-02	2023-02
27898	Horn antenna	26240-20	Verified	
27899	Horn antenna	27240-20	Verified	
39897	EMI test receiver	ESW44	2020-03	2021-03
36954	Harmonic Mixer	FS-Z220	2018-03	2021-03
36955	Harmonic Mixer	FS-Z325	2018-02	2021-02
37863	Horn antenna	30240-20 WG30	Verified	
37864	Horn antenna	32240-20 WG32	Verified	
38401	ULTRALOG Antenna	HL562E	2018-05	2021-05

Test software for: EMC32 V10.

10 Test Results

CFR 47, Part 2			
Section(s)	*Test performed*	*Page*	*Test Result*
§ 2.202 (a); § 2.1049	Occupied Bandwidth	31	Test passed

CFR 47, Part 95, Subpart M,			
Section(s)	*Test performed*	*Page*	*Test Result*
§ 95.3367 (a)	Radiated Power – Average	21	Test passed
§ 95.3367 (b)	Radiated Power – Peak	21	Test passed
§ 95.3379 (a)	Spurious Emissions	37	Test passed
§95.3379 (b)	Frequency Stability	59	Test passed

ISED RSS-GEN, Issue 4			
Section(s)	*Test performed*	*Page*	*Test Result*
6.6	Occupied Bandwidth	31	Test passed

ISED RSS-251, Issue 2			
Section(s)	*Test performed*	*Page*	*Test Result*
7	Occupied Bandwidth	31	Test passed
8	Average equivalent isotropically radiated power (e.i.r.p.)	21	Test passed
9	Peak (e.i.r.p.)	21	Test passed
10	Unwanted Emissions	37	Test passed
11	Frequency Stability	59	Test passed

10.1 Radiated Power

Date of Test	2020-05-25
Operator	Alex Fink
Test Site	Semi anechoic room, cabin no. 11

Test Result
☒ **Passed**
☐ **Not Passed**

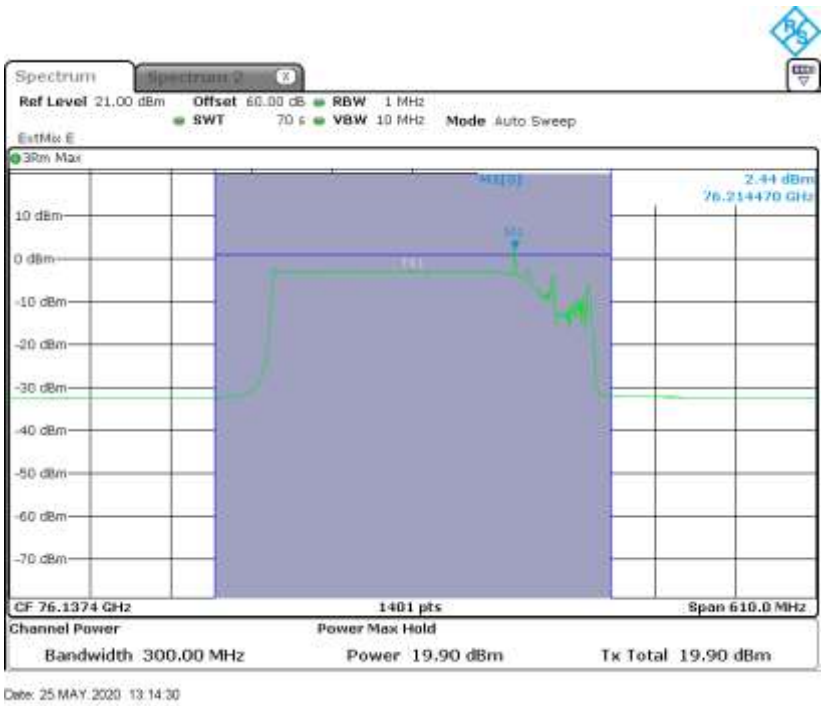
Barometric pressure:	978 hPa
Relative humidity:	38 %
Ambient temperature:	24 °C

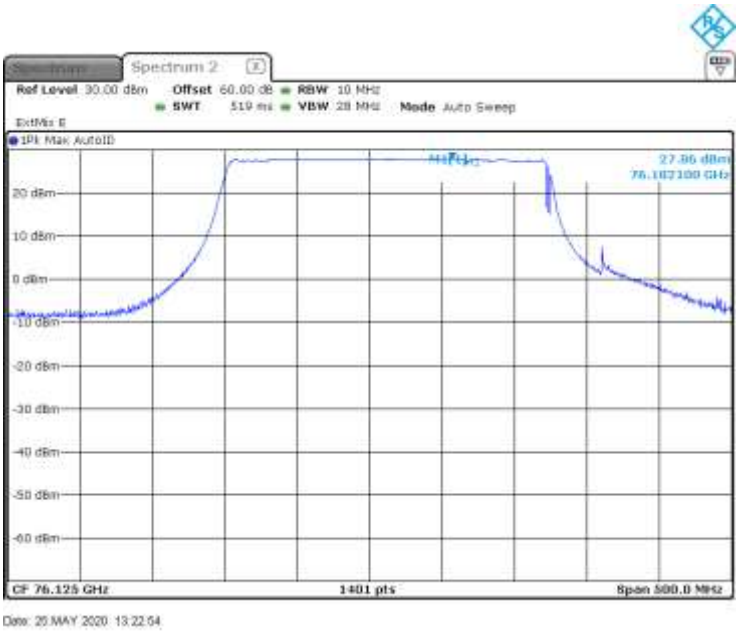
Specifications:	Part 95, Subpart M, § 95.3367(a) and (b) RSS-251 Issue 2, Sections 8 and 9
Description:	The fundamental radiated emission limits within the 76 – 81 GHz band are expressed in terms of Equivalent Isotropically Radiated Power (EIRP) and are as follows: a) The maximum power (EIRP) within the 76 – 81 GHz band shall not exceed 50 dBm bsed on measurements employing a power averaging detector with a 1 MHz Resolution Bandwidth (RBW). b) The maximum peak power (EIRP) within the 76 – 81 GHz band shall not exceed 55 dBm based on measurements employing a peak detector with a 1 MHz RBW.
Operation mode:	Transmitting continuously on frequency with modulation bandwidth as stated in table below
Comment :	Test was performed as radiated test. The test distance was 0.5 m. A correction factor of -63 dB and mixer conversion loss table were used to account for the test antenna gain, free-space loss and external mixer loss. Reading value of figures is thereby dBm not dBµV.

Modulation	*Detector*	*Lowest Channel*	*Middle Channel*	*Highest Channel*	*Limit*	*Note*
175 MHz	Average	19.90	20.26	20.18	50 dBm	NA
	Peak	27.86	28.30	28.34	55 dBm	
300 MHz	Average	19.89	20.37	20.32	50 dBm	NA
	Peak	27.64	27.77	28.11	55 dBm	
425 MHz	Average	20.23	20.32	20.36	50 dBm	NA
	Peak	28.05	28.20	28.11	55 dBm	

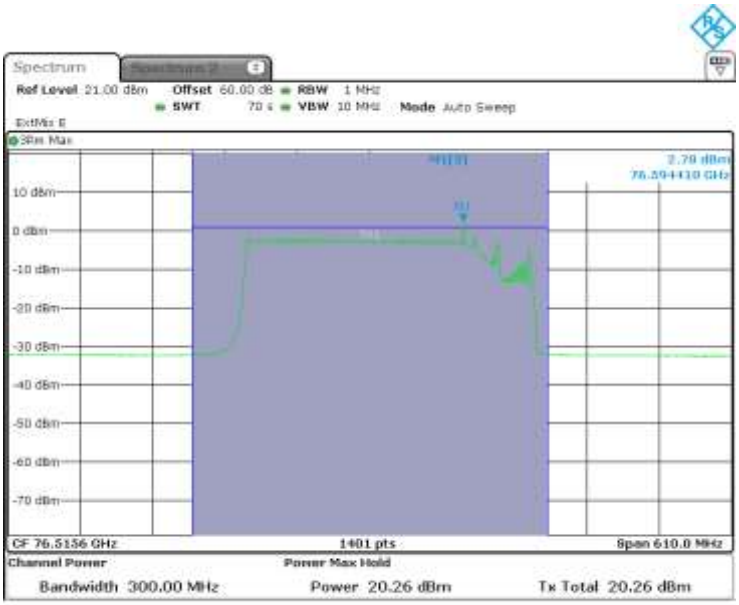
Note(s):

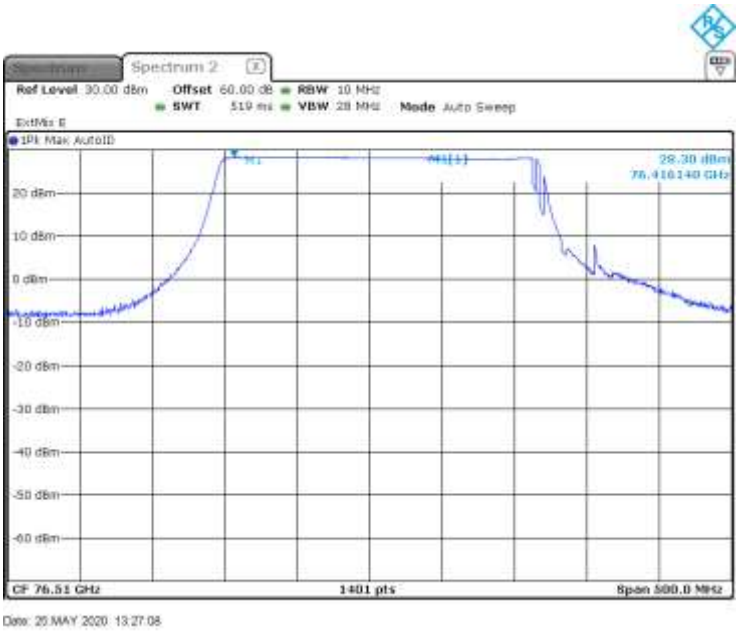
Plots taken during test



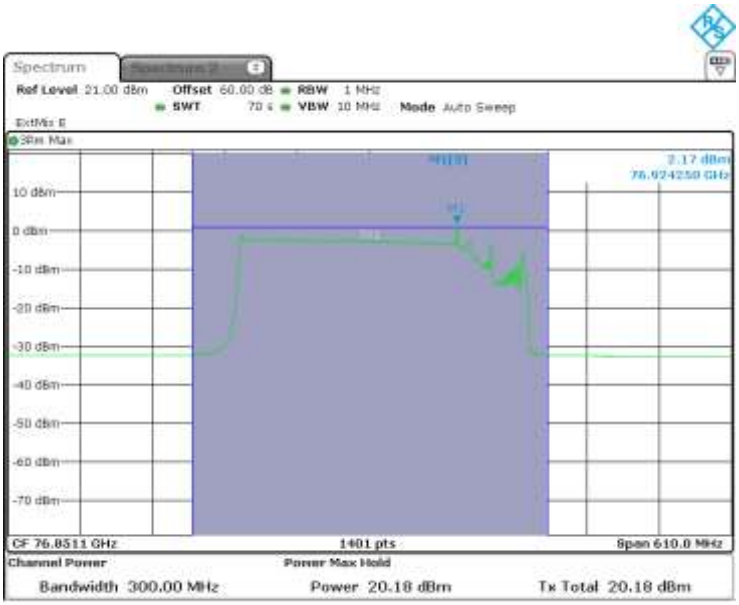


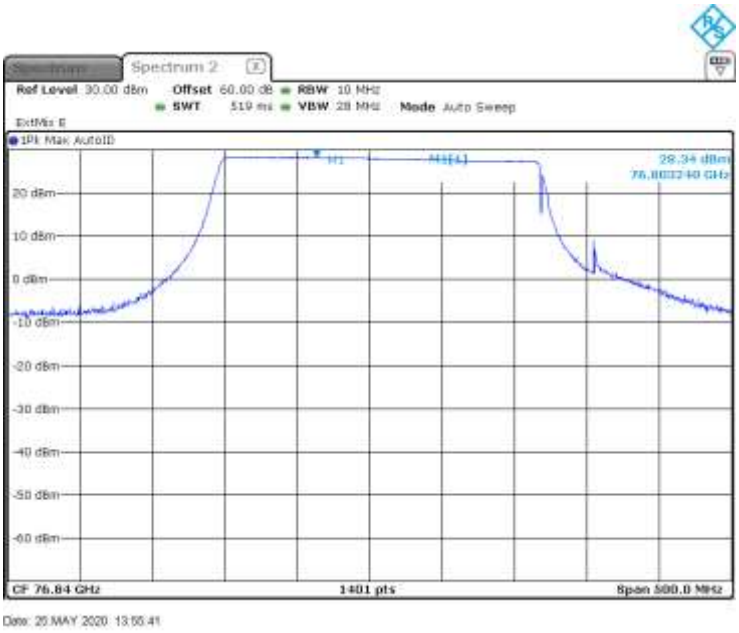
175 MHz, Lowest Channel



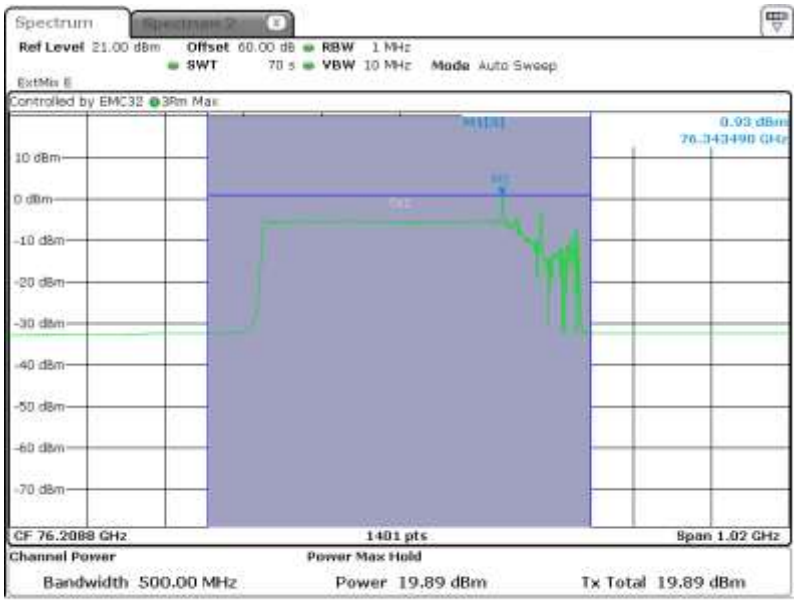


175 MHz, Middle Channel

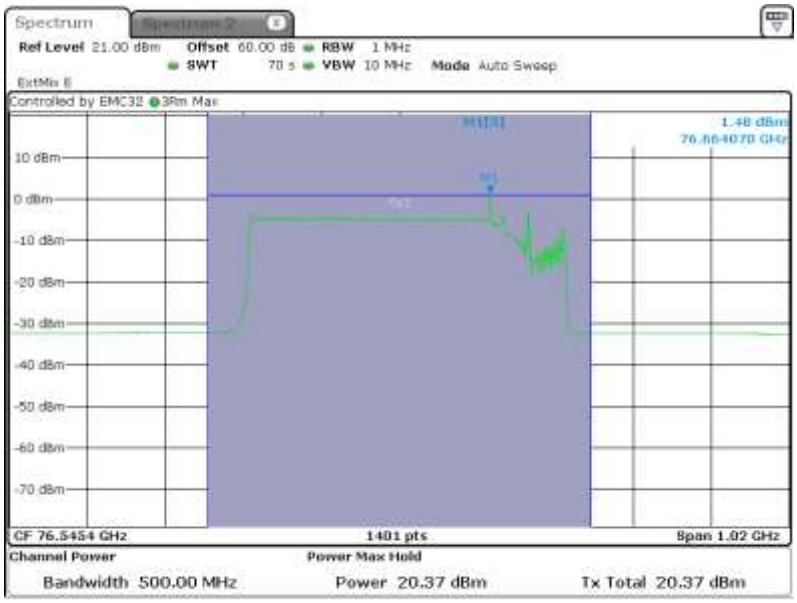


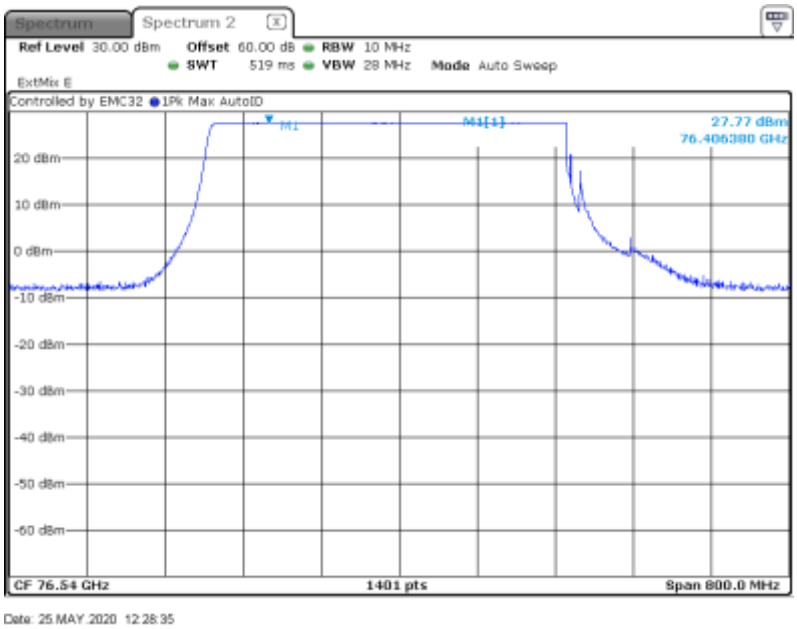


175 MHz, Highest Channel

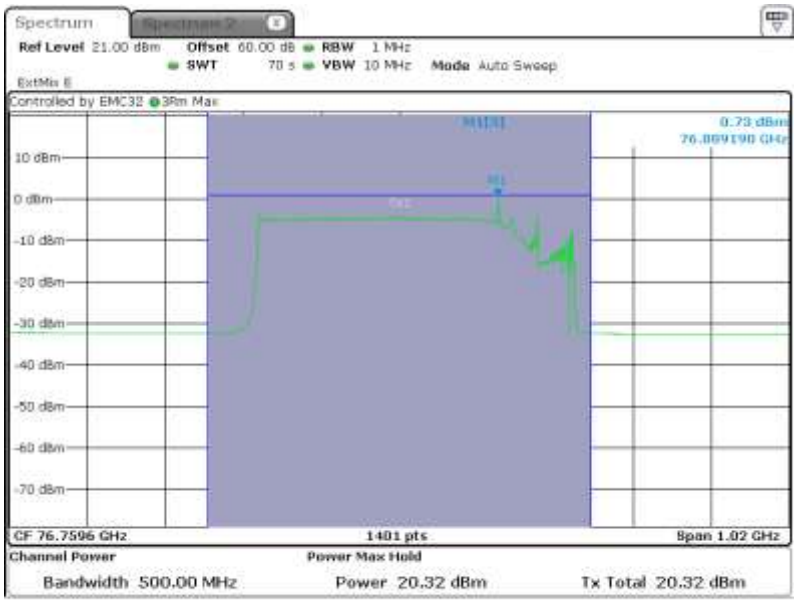


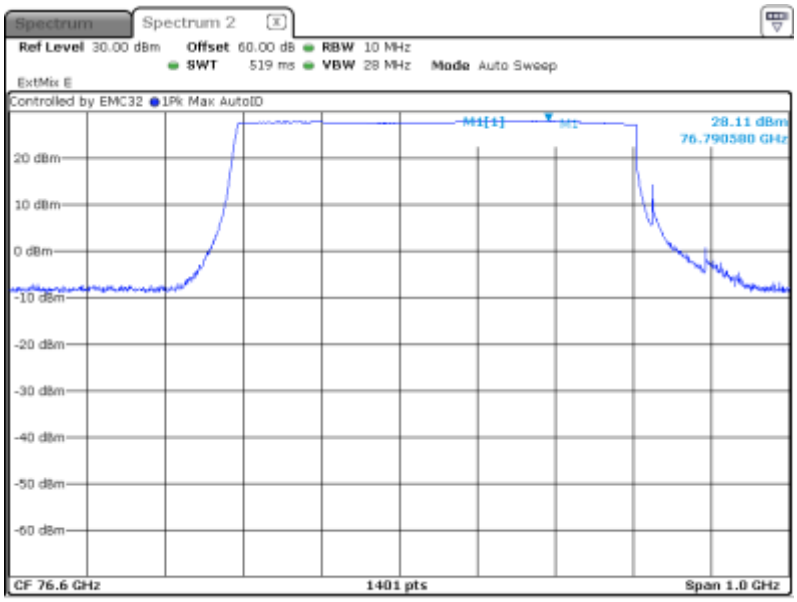
300 MHz, Lowest Channel



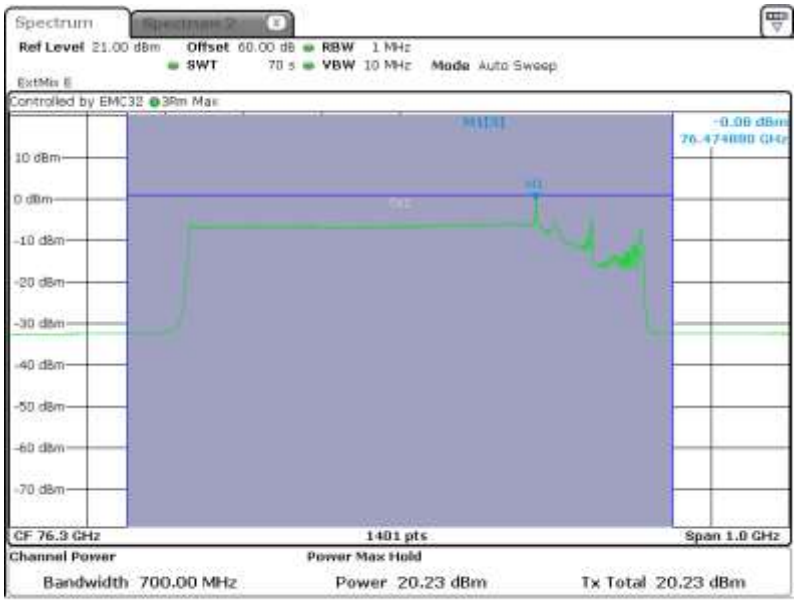


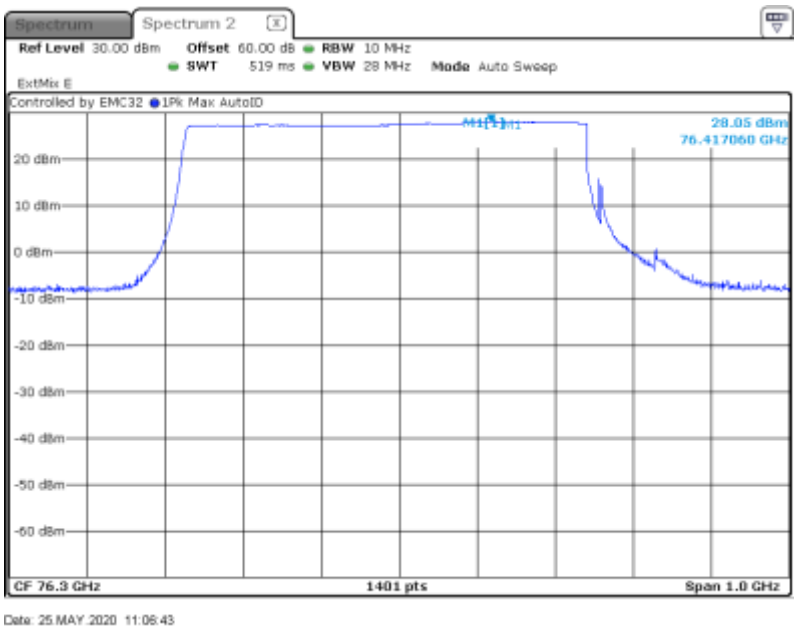
300 MHz, Middle Channel



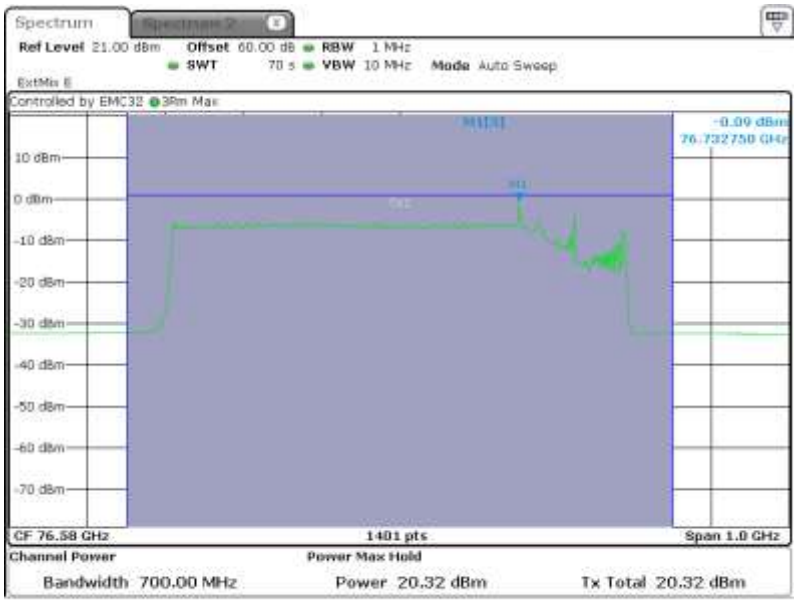


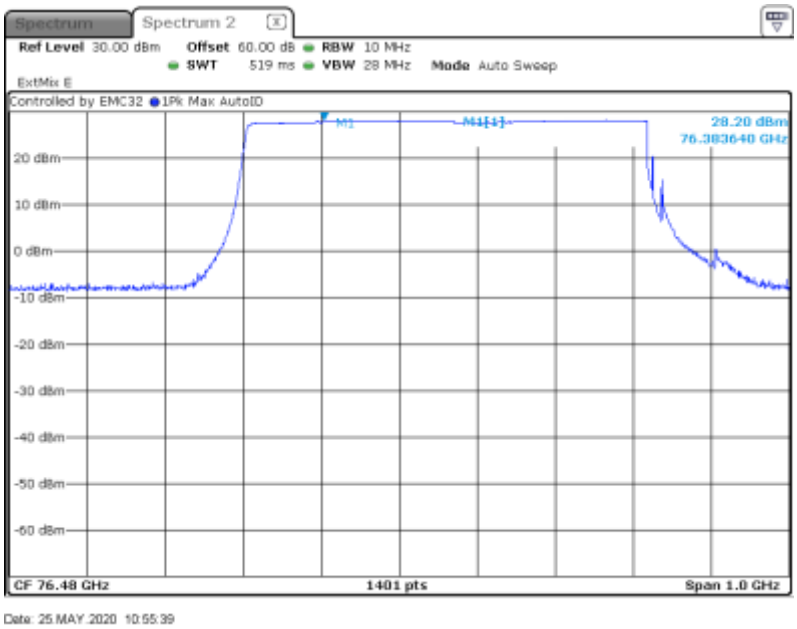
300 MHz, Highest Channel



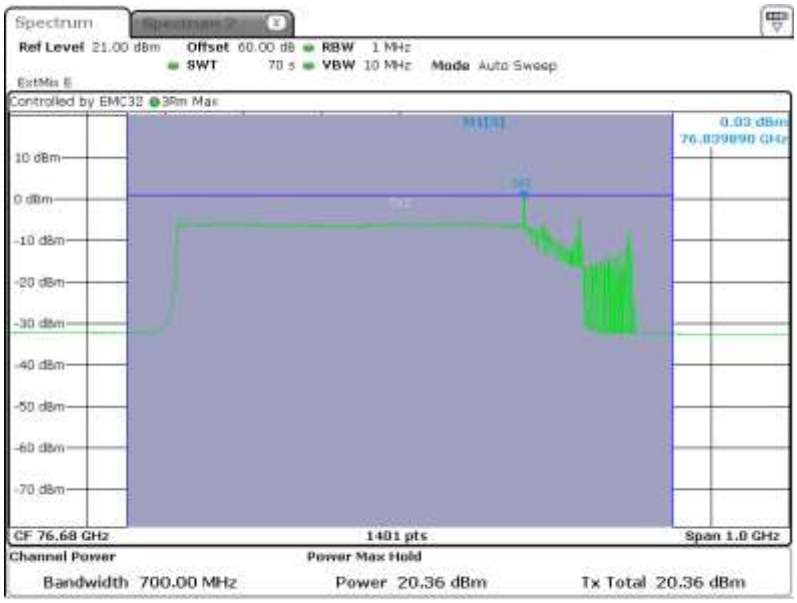


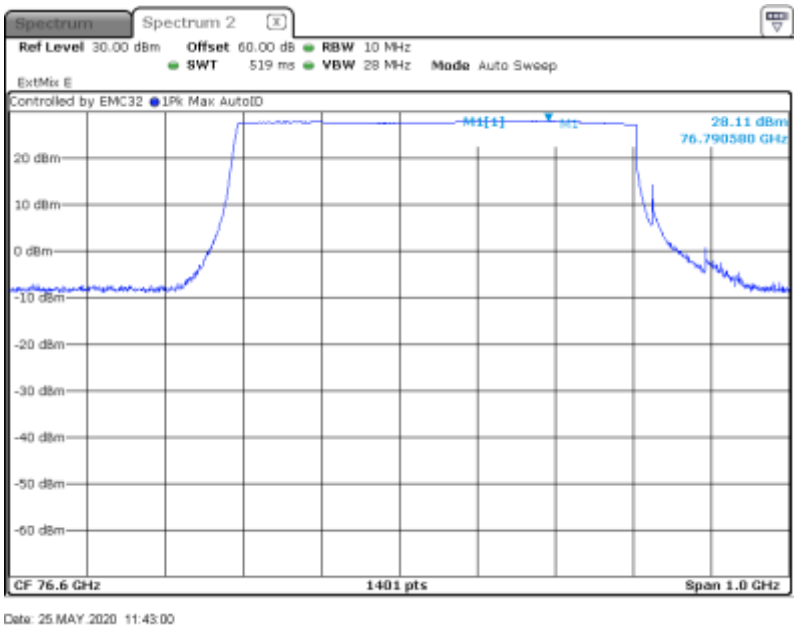
425 MHz, Lowest Channel





425 MHz, Middle Channel





425 MHz, Highest Channel

10.2 Occupied Bandwidth

Date of Test	2020-06-05
Operator	Alex Fink
Test Site	Fully anechoic room, cabin no. 2

Test Result
☒ **Passed**
☐ **Not Passed**

Barometric pressure:	977 hPa
Relative humidity:	54 %
Ambient temperature:	26 °C

Specifications*:*	CFR 47, Part 2, Clause 2.1049 and 2.202(a) RSS-GEN Issue 4, Section 6.6 RSS-251, Issue 2, Section 7
Description:	The occupied bandwidth, that is the frequency bandwidth such that, below its lower and above its upper frequency limits, the mean powers radiated are each equal to 0.5 percent of the total mean power radiated by a given emission shall be measured.
Operation mode:	The occupied bandwidth, that is the frequency bandwidth such that, below its lower and above its upper frequency limits, the mean powers radiated are each equal to 0.5 percent of the total mean power radiated by a given emission shall be measured.
Comment :	Transmitting continuously on frequency with modulation bandwidth as stated in table below

Modulation		*Lowest Channel*	*Middle Channel*	*Highest Channel*	*Limit*	*Note*
175 MHz	f_L	76.032 GHz	76.412 GHz	76.742 GHz	≥ 76 GHz	NA
	f_H	76.270 GHz	76.650 GHz	76.980 GHz	≤ 77 GHz	
300 MHz	f_L	76.031 GHz	76.351 GHz	76.576 GHz	≥ 76 GHz	NA
	f_H	76.440 GHz	76.758 GHz	76.983 GHz	≤ 77 GHz	
425 MHz	f_L	76.032 GHz	76.291 GHz	76.397 GHz	≥ 76 GHz	NA
	f_H	76.608 GHz	76.865 GHz	76.973 GHz	≤ 77 GHz	

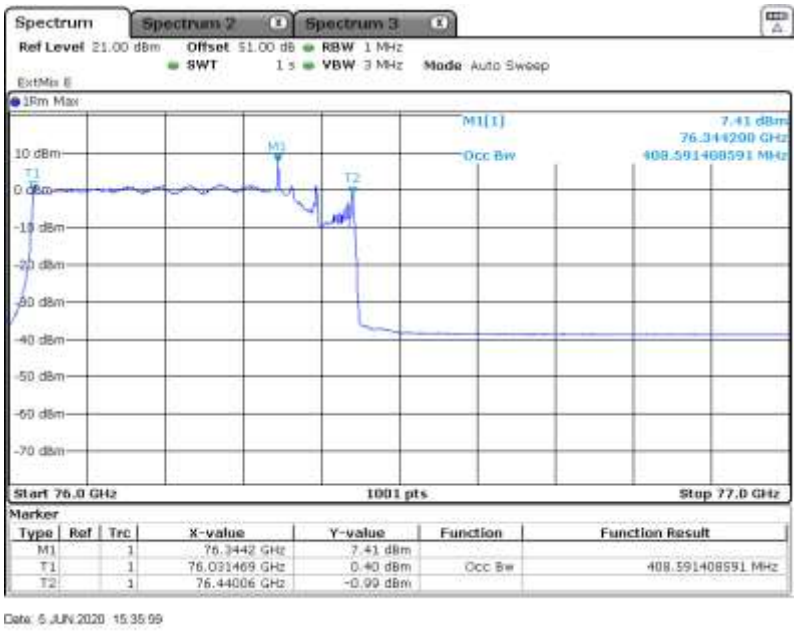
Note(s):
NA

Plots taken during test

175 MHz, Lowest Channel

175 MHz, Middle Channel

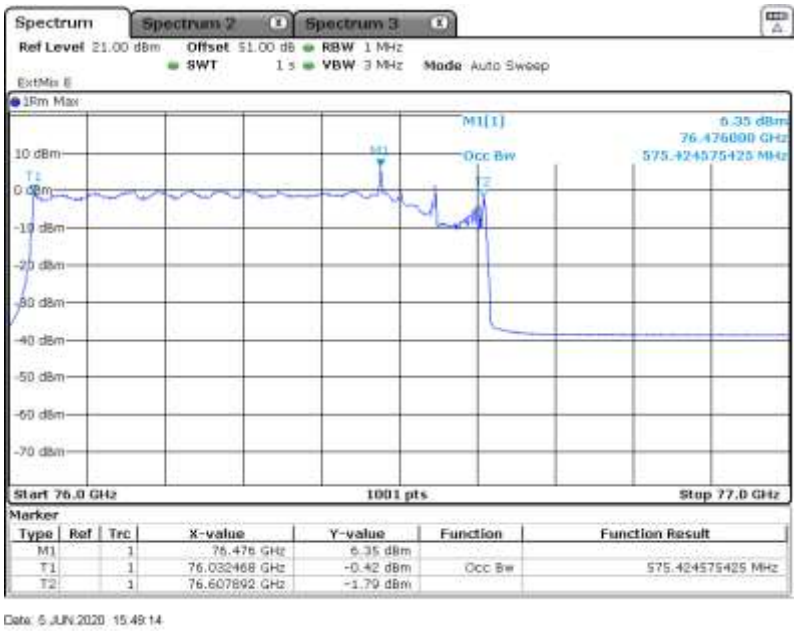
175 MHz, Highest Channel



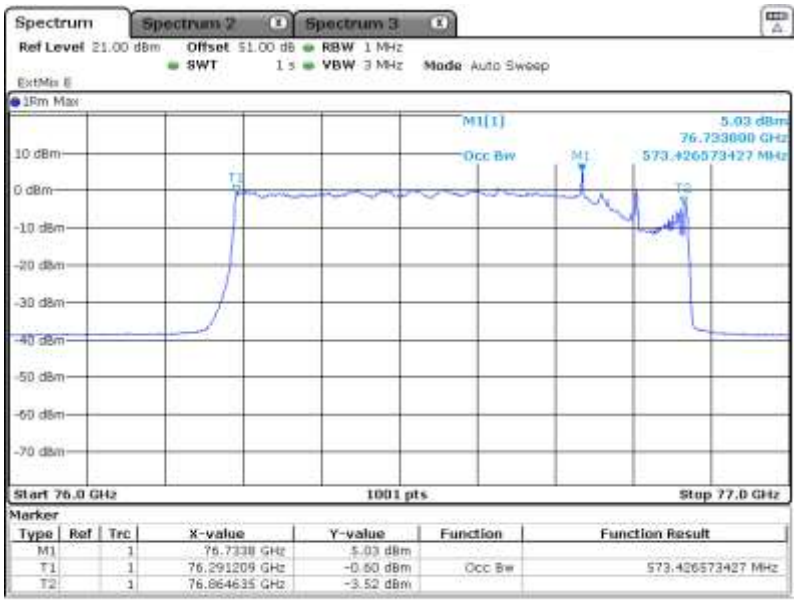
300 MHz, Lowest Channel

300 MHz, Middle Channel

300 MHz, Highest Channel



425 MHz, Lowest Channel



425 MHz, Middle Channel

425 MHz, Highest Channel

10.3 Spurious Radiated Emisions

Date of Test	2020-05- to 2020-06-03
Operator	Alex Fink
Test Site	Semi anechoic room, cabin no. 11 Fully anechoic room, cabin no. 2

Test Result
☒ **Passed**
☐ **Not Passed**

Barometric pressure:	976 hPa
Relative humidity:	51 %
Ambient temperature:	26 °C

Specifications:	CFR 47, Part 95, Subpart M, § 95.3379(a) RSS-251 Issue 2, Section 10
Description:	The power density of any emissions outside the 76 – 81 GHz band shall consist soley of spurious emissions and shall not exceed the following: Radiated emissions below 40 GHz shall not exceed the field strength as shown in the Table 1. The power density of radiated of radiated emissions outside the 76 – 81 GHz band above 40 GHz shall not exceed the power density as shown in the tables on the next page.s
Operation mode:	This test was performed as radiated test in the frequency range 30 MHz to 300 GHz. No significant spurious emissions were observed. The test distance was 3 m in the frequency ranges 30 MHz to 8.2 GHz and 40 GHz to 110 GHz, 1 m in the frequency ranges 8.2 GHz to 40 GHz and 110 GHz to 220 GHz and 0.5 m in the frequency range 220 GHz to 300 GHz.
Comment :	The measurement below was done using EMC 32 V10.40.00 automated software. Based on the antenna power measurement this test was performed with 175 MHz BW on middle frequency and 425 MHz BW on lowest and highest frequency; these modes are considered to cover the worst case scenario. See plots for details.

Sample calculation of field final values:

Final Value (dBµV/m) = Reading Value (dBµV) +(Antenna Correction Factor (dB/m) + Cable Correction Factor (dB))

Radiated emission limits 9 kHz – 40 GHz		
Frequency (MHz)	*Field strength (µV/m)*	*Measurement distance (m)*
0.009 – 0.490	2400/f(kHz)	300
0.490 – 1.705	24000/f(kHz)	30
1.705 – 30	30	30
30 – 88	100	3
88 – 216	150	3
216 – 960	200	3
960 – 40000	500	3

Note(s):

1 In the emissions table the tighter limit applies at the band edges.

2 The limits are based on the frequency of the unwanted emissions and not the fundamental frequency. However, the level of any unwanted emission shall not exceed the level of the fundamental frequency.

3 The emissions limits shown in the table are based on measurement employing CISPR quasi-peak detector except for the frequency bands 9.0 – 90 kHz, 110.0 – 490 kHz, and above 1 GHz. Radiated emissions limits in these three bands are based on measurements employing an average detector with 1 MHz RBW.

Table 1: Radiated emission limits 9 kHz – 40 GHz

Radiated emission limits 40 GHz – 231 GHz		
Frequency (GHz)	*Power Density (pW/cm²)*	*Measurement distance (m)*
40 – 200	600	3
above	1000	3

Note(s):

1 According to 47 CFR, Part 95, § 95.3379(a)(3) the spectrum shall be investigated up to 231 GHz.

2 The power density of 600 pW/cm² corresponds to a field strength of 93.5 dBµV/m for 3 m distance and 103.1 dBµV/m for 1 m distance

3 The power density of 1000 pW/cm² corresponds to a field strength of 95.8 dBµV/m for 3 m distance, 105.3 dBµV/m for 1 m distance and 111.3 dBµV/m for 0.5 m distance.

Table 2: FCC Radiated emission limits above 40 GHz

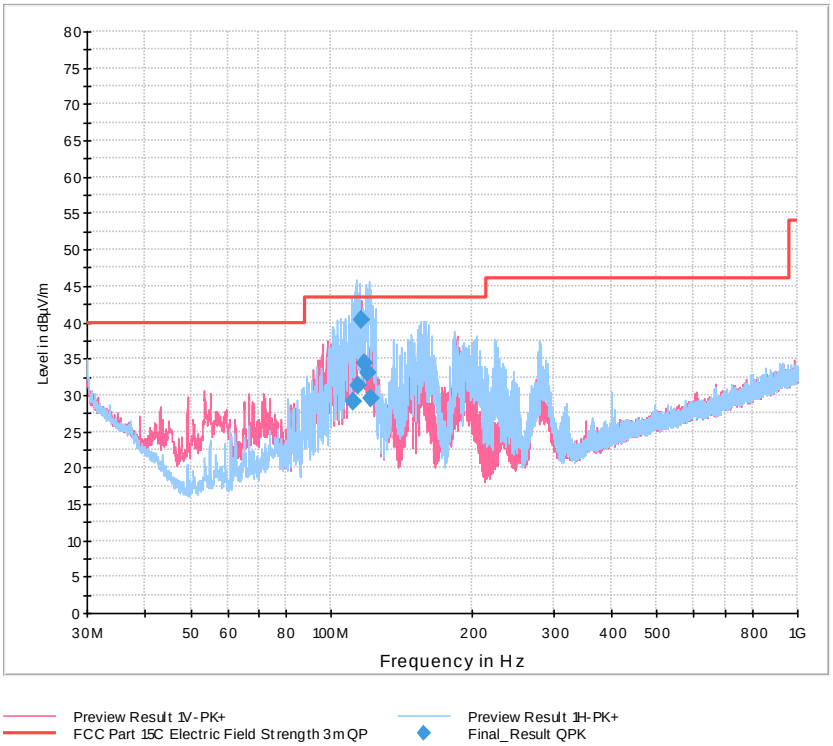
Radiated emission limits 40 GHz –162 GHz		
Frequency (GHz)	*Limit (dBm/MHz e.i.r.p.)*	*Detector*
40 – 162	-30	RMS

Note(s):

1 For radar devices that operate solely in the 76 – 76 GHz Band (i.e. the occupied bandwidth is entirely contained in the 76 – 77 GHz band), an unwanted emissions limit of 0 dBm/MHz shall apply for the unwanted emission that fall in the 73.5 – 76 GHz band. Outside the 73.5 – 76 GHz band, the unwanted emission limits prescribed above shall apply.

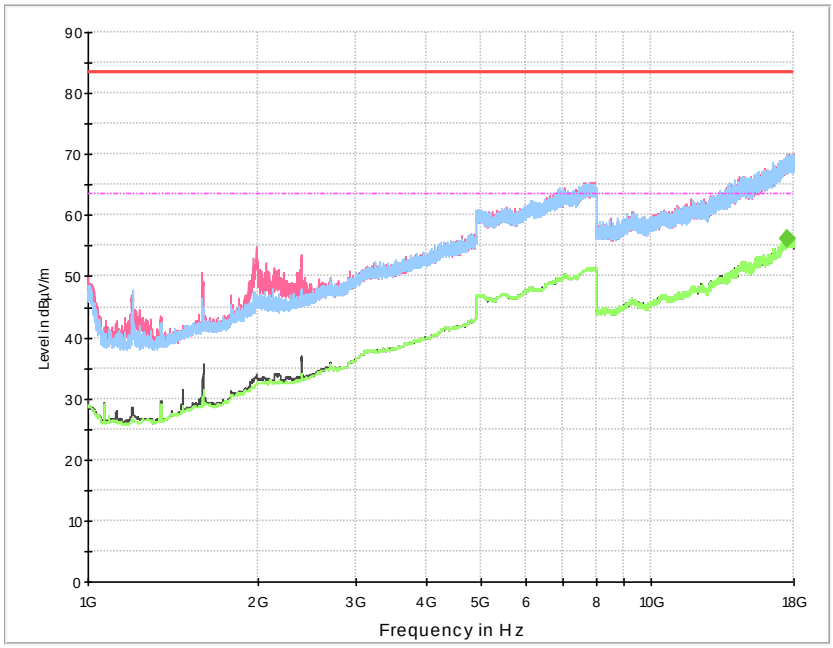
Table 3: ISED Radiated emission limits above 40 GHz

Plots taken during measurement: Lowest channel, 425 MHz BW



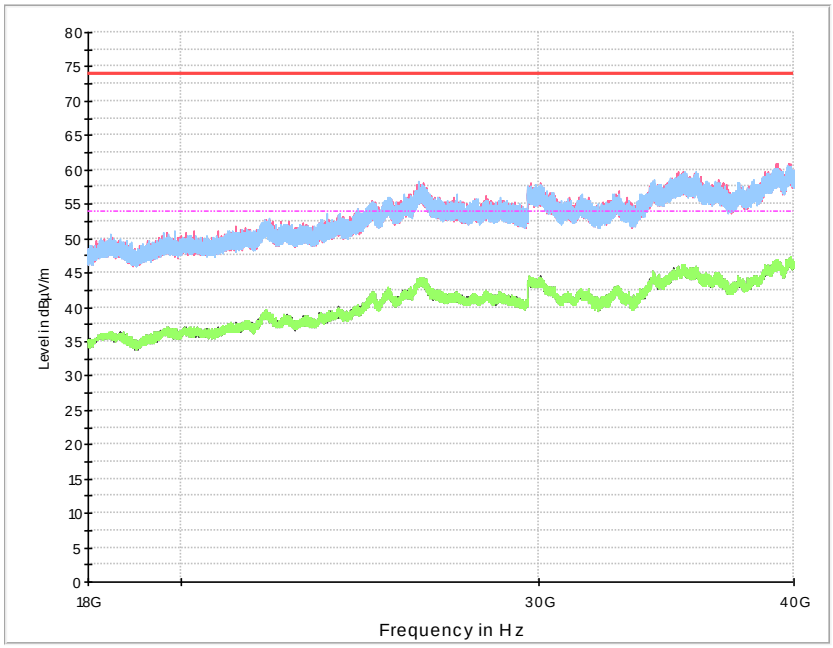
Final Results:

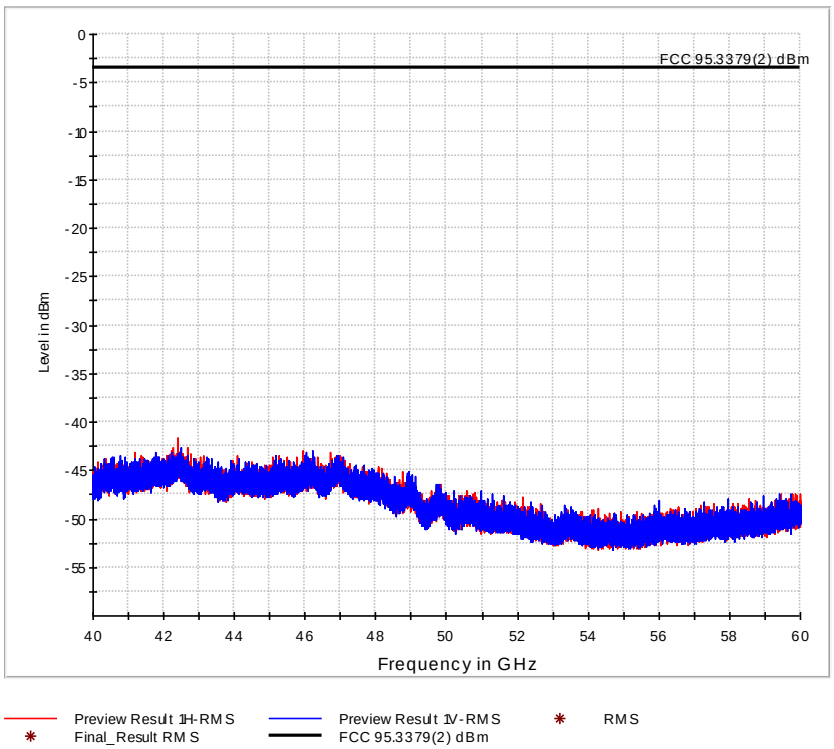
Frequency MHz	*QuasiPeak dBµV/m*	*Limit dBµV/m*	*Margin dB*	*Meas. Time ms*	*Bandwidth kHz*	*Height cm*	*Pol*	*Azimuth deg*	*Corr. dB/m*
111.330000	29.17	43.50	14.33	1000.0	120.000	153.0	H	-109.0	18.1
114.000000	31.19	43.50	12.31	1000.0	120.000	166.0	H	-85.0	18.3
116.010000	40.35	43.50	3.15	1000.0	120.000	100.0	V	26.0	18.5
117.990000	34.49	43.50	9.01	1000.0	120.000	175.0	H	-111.0	18.6
120.000000	32.98	43.50	10.52	1000.0	120.000	198.0	H	-112.0	18.5
122.010000	29.54	43.50	13.96	1000.0	120.000	200.0	H	-120.0	18.2

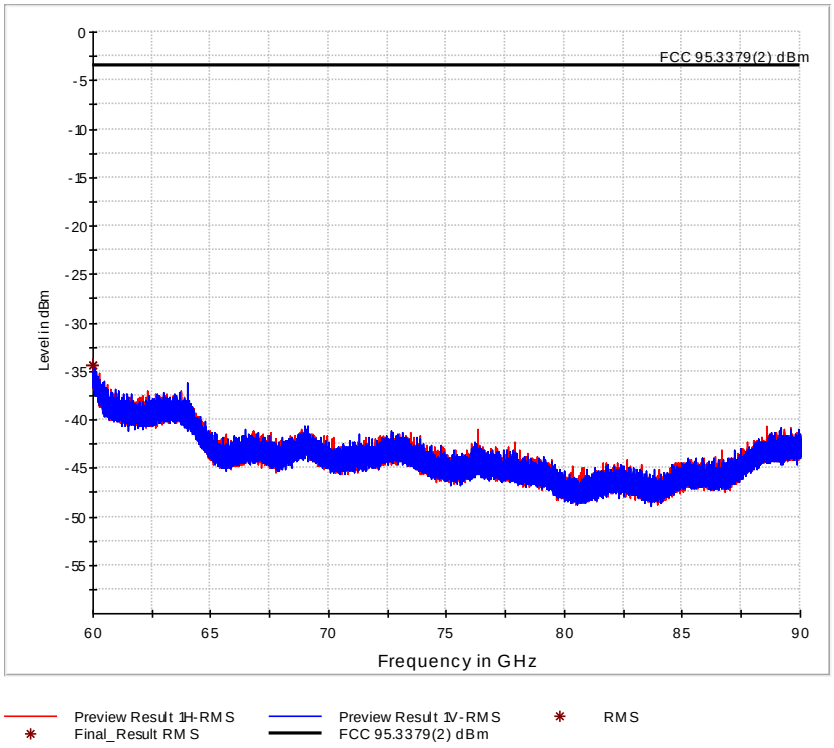


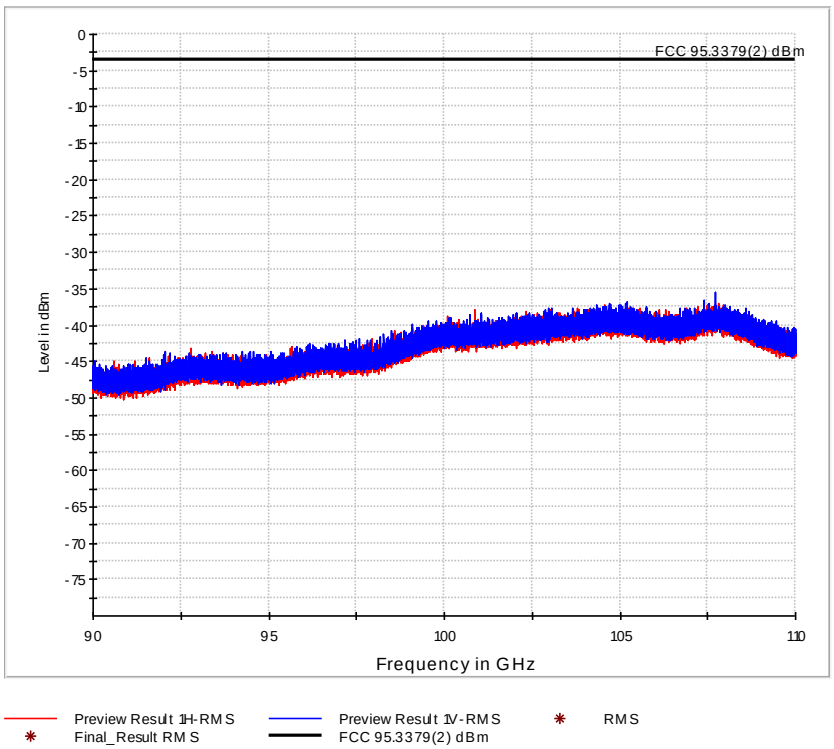
Final Results:

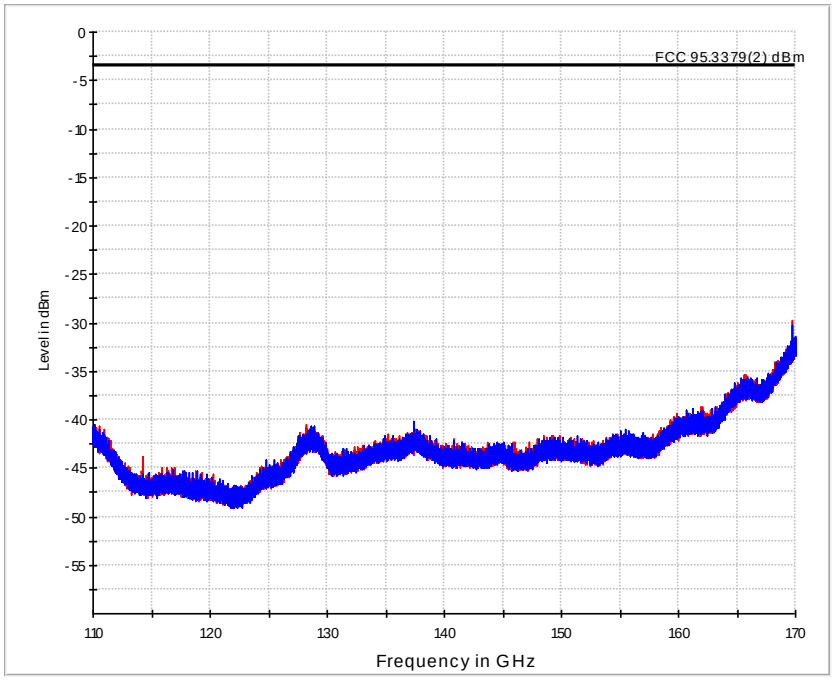
Frequency *MHz*	*CAverage* *dBµV/m*	*Limit* *dBµV/m*	*Margin* *dB*	*Meas. Time* *ms*	*Bandwidth* *kHz*	*Height* *cm*	*Pol*	*Azimuth* *deg*	*Corr.* *dB/m*
17570.250000	56.15	63.50	7.35	1000.0	1000.000	150.0	V	-120.0	54.4


Level in dBµV/m
Frequency in Hz
18G
30G
40G
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 CAV

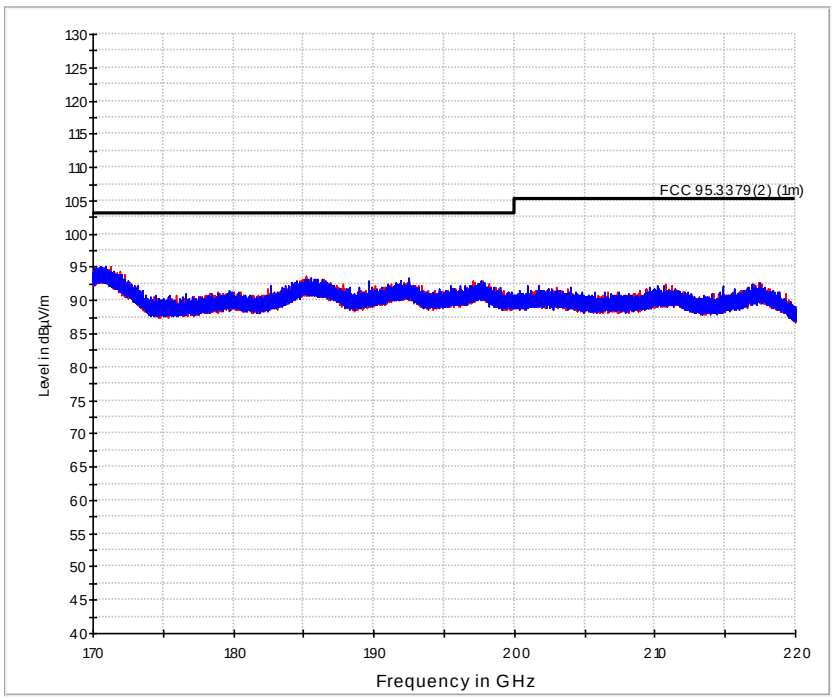

FCC 95.3379(2) dBm
Level in dBm
Frequency in GHz
Preview Result 1H-RMS
Final_Result RMS
Preview Result 1V-RMS
FCC 95.3379(2) dBm
RMS


FCC 95.3379(2) dBm
Level in dBm
Frequency in GHz
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
-50
-55
60
65
70
75
80
85
90
Preview Result 1H-RMS
Preview Result 1V-RMS
RMS
Final_Result RMS
FCC 95.3379(2) dBm

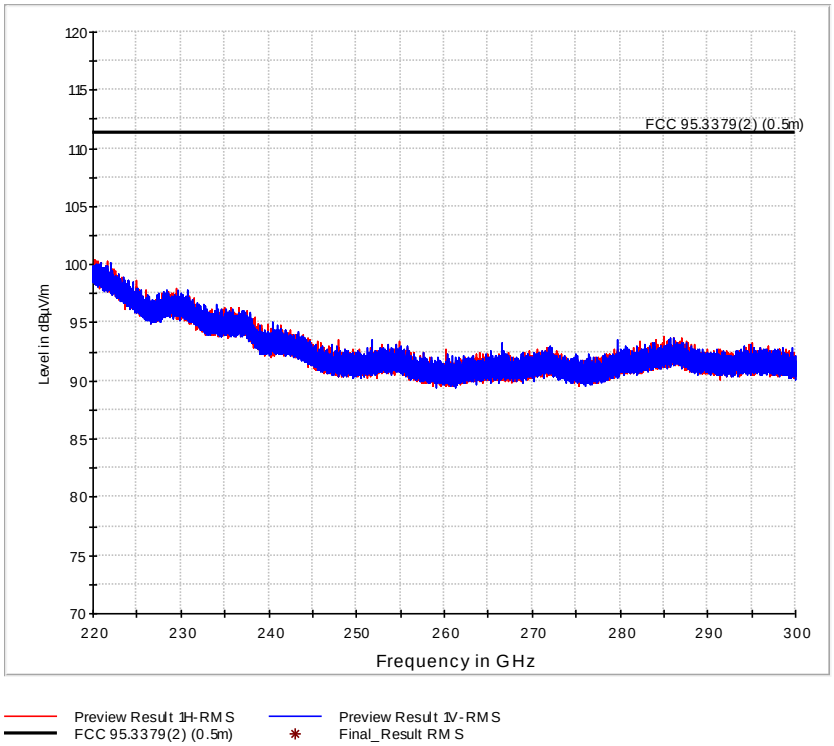

FCC 95.3379(2) dBm
Level in dBm
Frequency in GHz
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
-50
-55
-60
-65
-70
-75
90
95
100
105
110
Preview Result 1H-RMS
Preview Result 1V-RMS
RMS
Final_Result RMS
FCC 95.3379(2) dBm



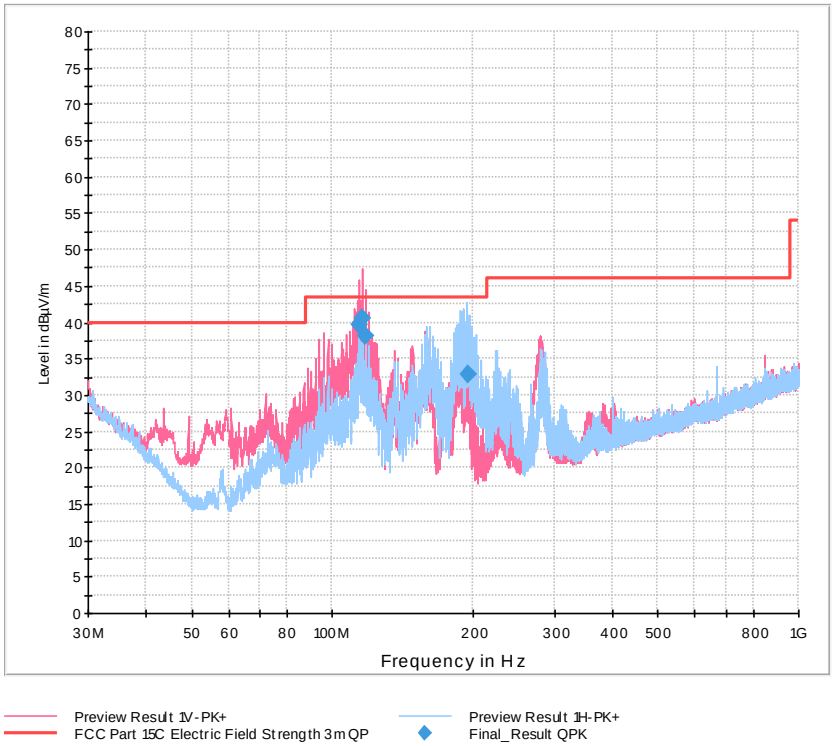
Preview Result 1H-RMS
Preview Result 1V-RMS
RMS
Final_Result RMS
FCC 95.3379(2) dBm



Preview Result 1H-RMS
Preview Result 1V-RMS
RMS
FCC 95.3379(2) (1

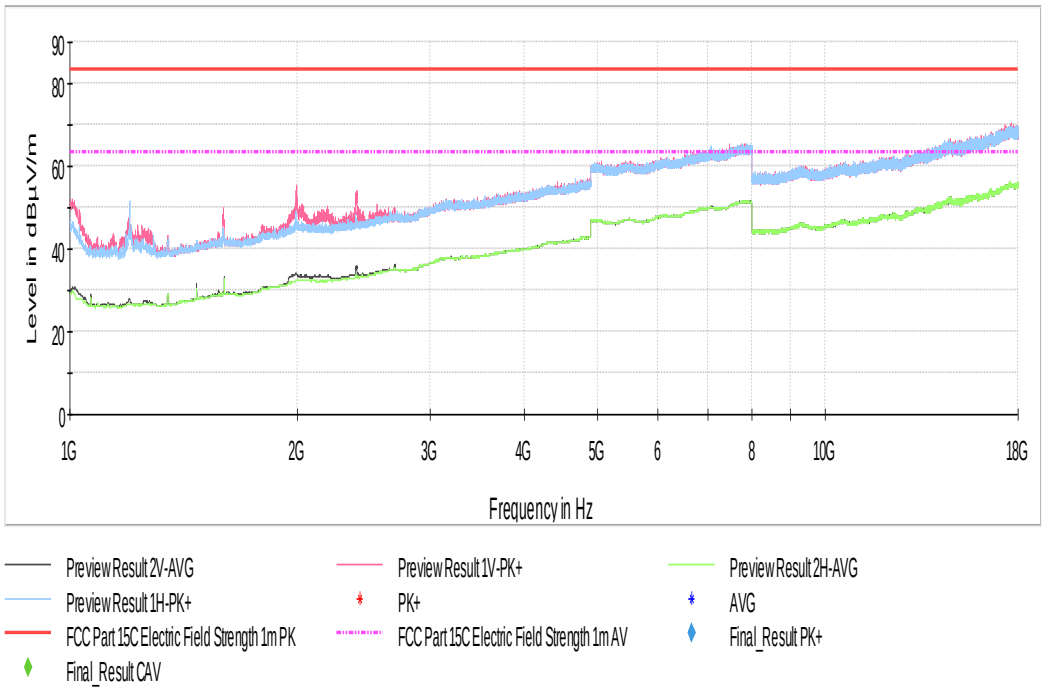

120
115
110
105
100
95
90
85
80
75
70
Level in dBµV/m
FCC 95.3379(2) (0.5m)
220
230
240
250
260
270
280
290
300
Frequency in GHz
Preview Result 1H-RMS
FCC 95.3379(2) (0.5m)
Preview Result 1V-RMS
Final_Result RMS

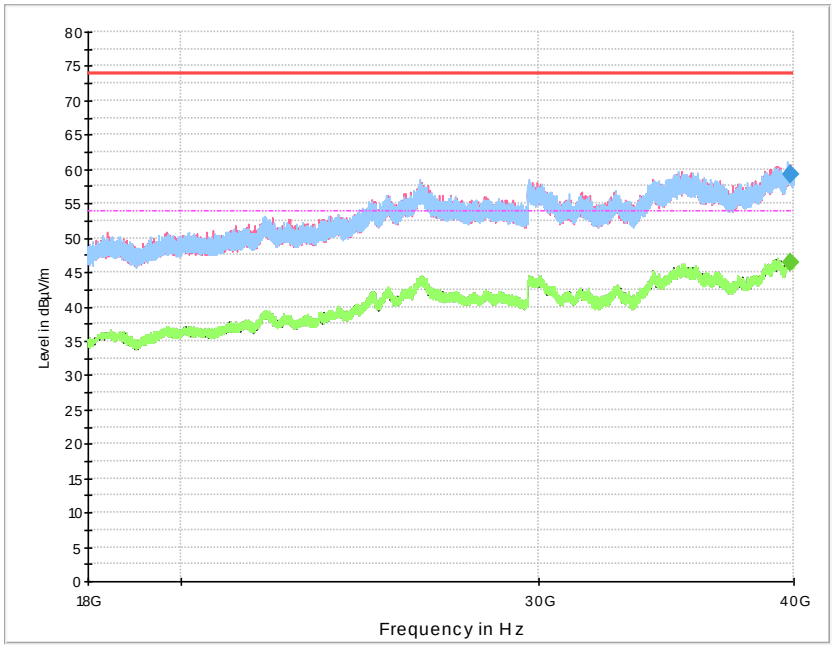
Plots taken during measurement: middle channel, 175 MHz BW



Final Results:

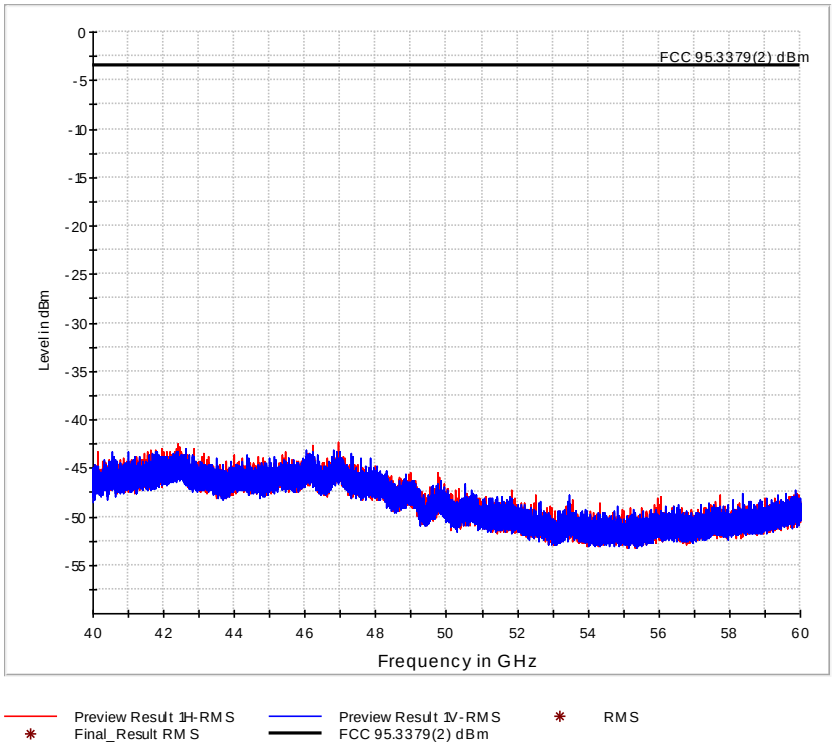
Frequency MHz	*QuasiPeak dBµV/m*	*Limit dBµV/m*	*Margin dB*	*Meas. Time ms*	*Bandwidth kHz*	*Height cm*	*Pol*	*Azimuth deg*	*Corr. dB*
114.000000	39.65	43.50	3.85	1000.0	120.000	100.0	V	0.0	18.3
116.010000	40.60	43.50	2.90	1000.0	120.000	114.0	V	37.0	18.5
117.990000	38.16	43.50	5.34	1000.0	120.000	111.0	V	100.0	18.6
195.330000	32.89	43.50	10.61	1000.0	120.000	154.0	H	-100.0	15.9

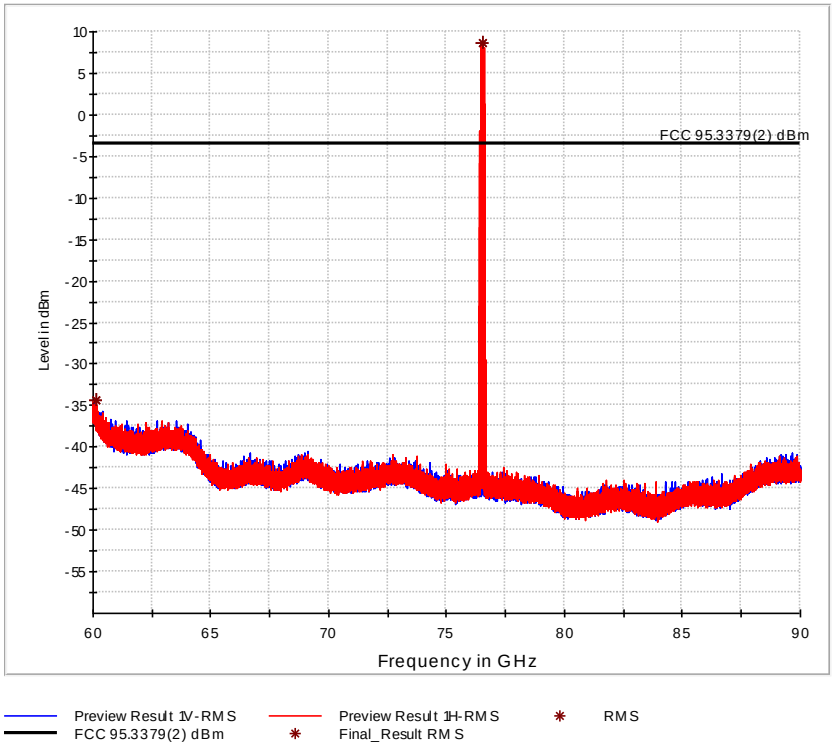

90
80
60
40
20
0
Level in dBµV/m
1G
2G
3G
4G
5G
6
8
10G
18G
Frequency in Hz
Preview Result 2V-AVG
Preview Result 1V-PK+
Preview Result 2H-AVG
Preview Result 1H-PK+
PK+
AVG
FCC Part 15C Electric Field Strength 1m PK
FCC Part 15C Electric Field Strength 1m AV
Final_Result PK+
Final_Result CAV



Final Results:

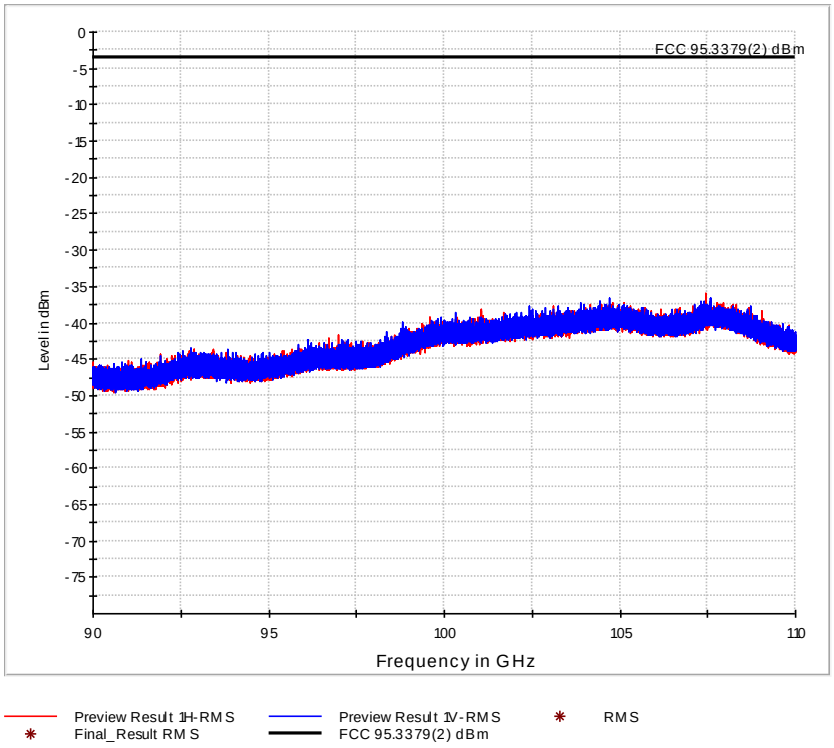
Frequency *MHz*	*MaxPeak* *dBµV/m*	*CAverage* *dBµV/m*	*Limit* *dBµV/m*	*Margin* *dB*	*Meas. Time* *ms*	*Bandwidth* *kHz*	*Height* *cm*	*Pol*	*Azimuth* *deg*	*Corr.* *dB*
39842.750000	---	46.30	53.98	7.68	1000.0	1000.000	208.0	V	101.0	25.7
39842.750000	59.34	---	73.98	14.64	1000.0	1000.000	208.0	V	101.0	25.7

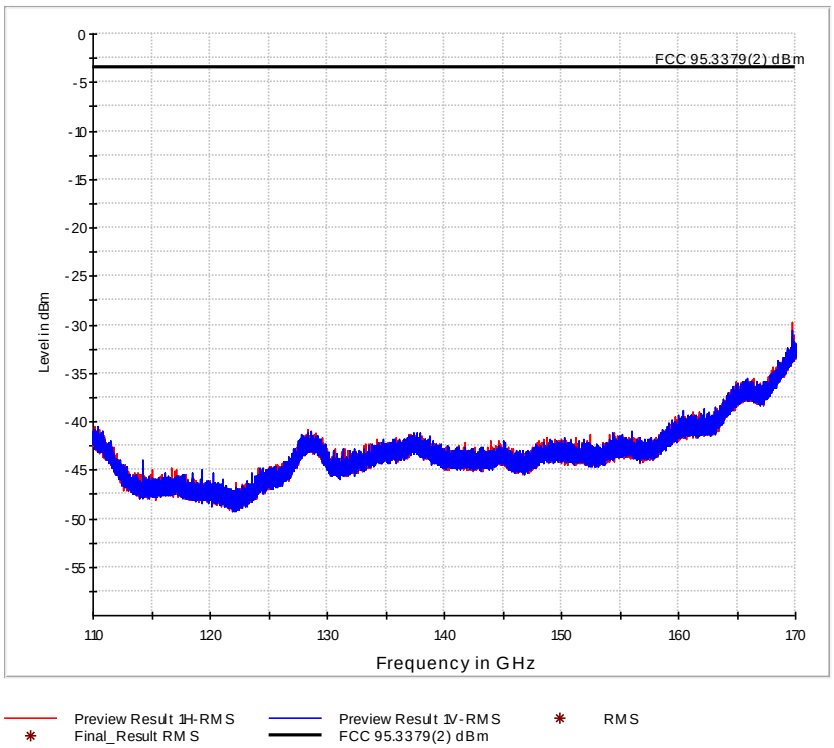

FCC 95.3379(2) dBm
Level in dBm
Frequency in GHz
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
-50
-55
40
42
44
46
48
50
52
54
56
58
60
Preview Result 1H-RMS
Preview Result 1V-RMS
RMS
Final_Result RMS
FCC 95.3379(2) dBm

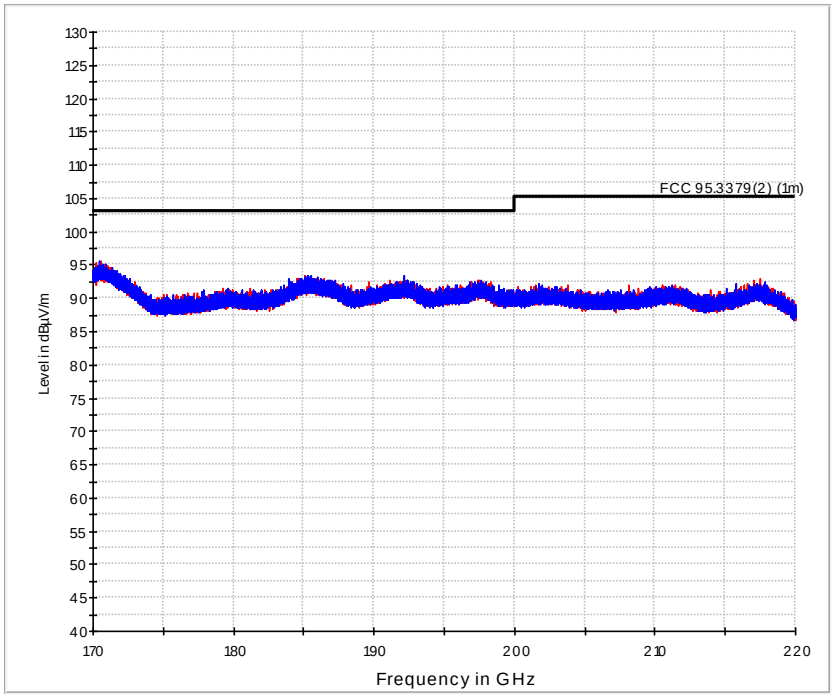


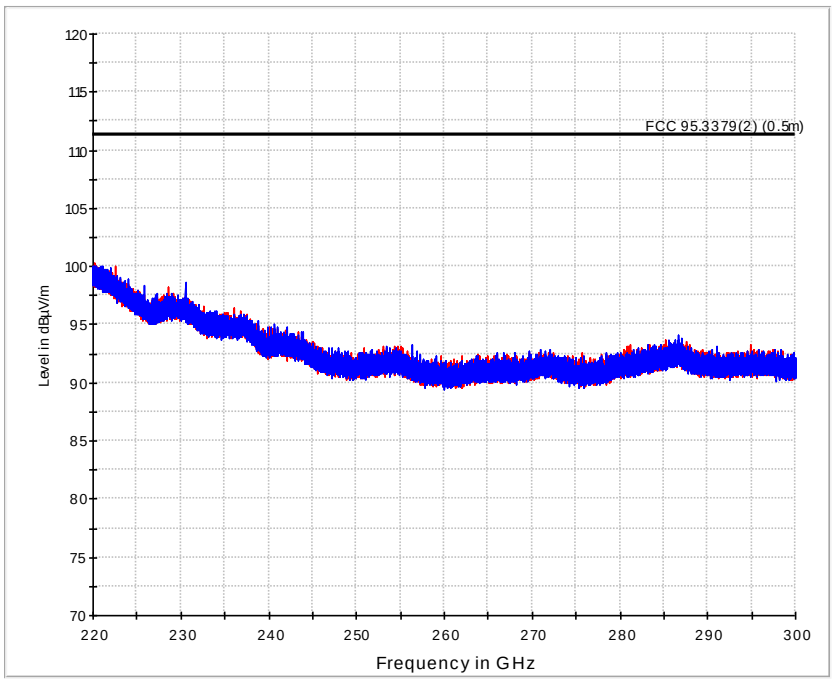
Frequency MHz	*RMS dBm*	*Limit dBm*	*Margin dB*	*Meas. Time ms*	*Bandwidth kHz*	*Height cm*	*Pol*	*Azimuth deg*	*Corr. dB*	*Comment*
76551.562500	8.74	#1	#1	5.0	1000.000	150.0	H	58.0	-63	

Note: #1 intentional radiation

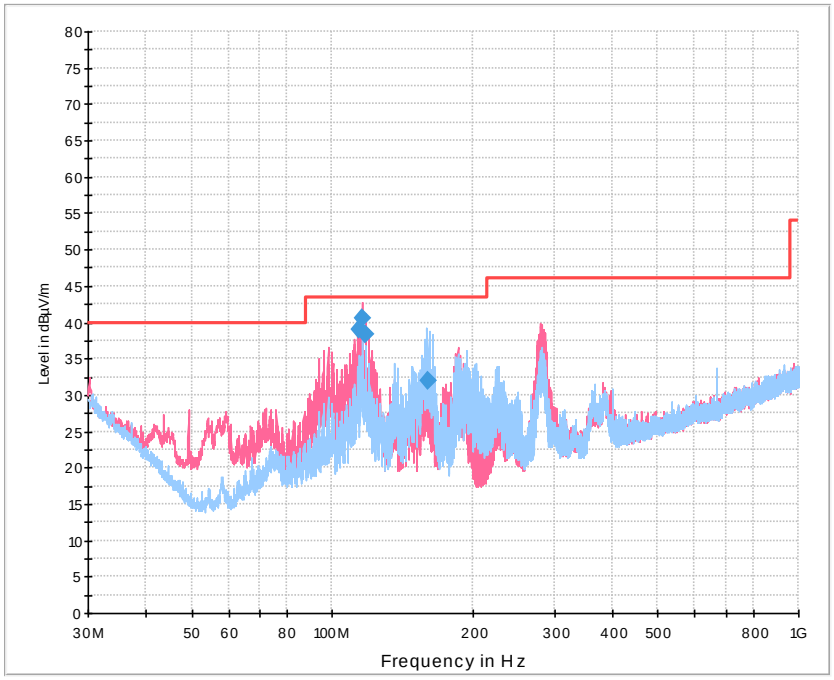

FCC 95.3379(2) dBm
Level in dBm
Frequency in GHz
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
-50
-55
-60
-65
-70
-75
90
95
100
105
110
Preview Result 1H-RMS
Preview Result 1V-RMS
RMS
Final_Result RMS
FCC 95.3379(2) dBm


FCC 95.3379(2) dBm
Level in dBm
Frequency in GHz
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
-50
-55
110
120
130
140
150
160
170
Preview Result 1H-RMS
Preview Result 1V-RMS
RMS
Final_Result RMS
FCC 95.3379(2) dBm


FCC 95.3379(2) (1m)
Level in dBµV/m
Frequency in GHz
Preview Result 1H-RMS
Preview Result 1V-RMS
FCC 95.3379(2) (1m)
RMS

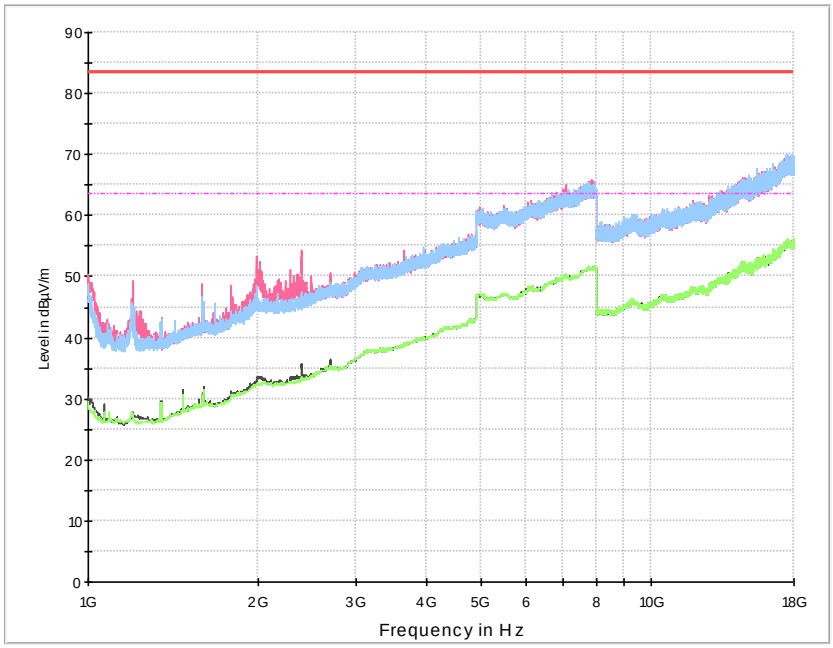

FCC 95.3379(2) (0.5m)
Level in dBµV/m
Frequency in GHz
Preview Result 1H-RMS
Preview Result 1V-RMS
FCC 95.3379(2) (0.5m)
Final_Result RMS

Plots taken during measurement: Highest channel, 425 MHz BW

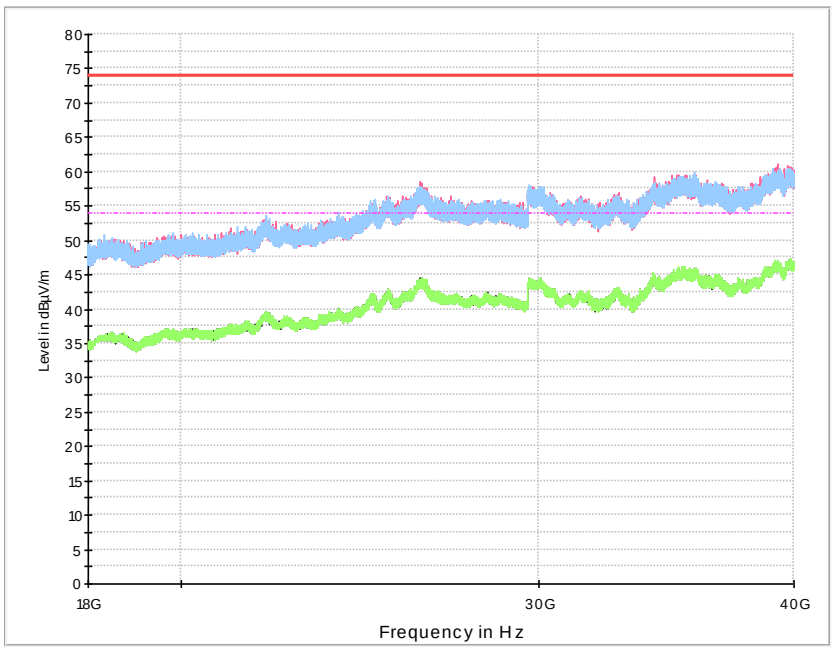


Final Results:

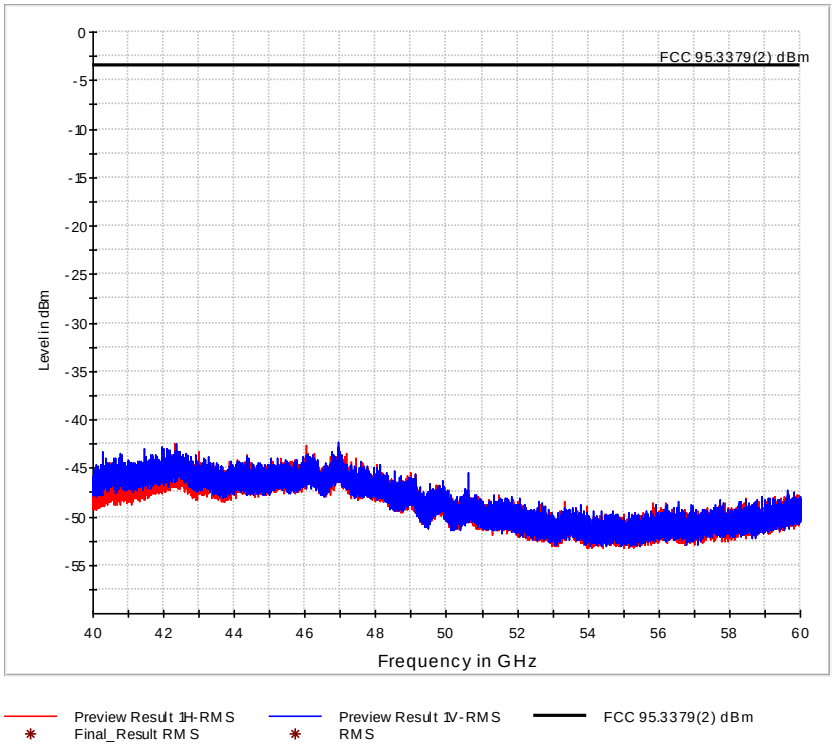
Frequency MHz	*QuasiPeak dBµV/m*	*Limit dBµV/m*	*Margin dB*	*Meas. Time ms*	*Bandwidth kHz*	*Height cm*	*Pol*	*Azimuth deg*	*Corr. dB*
114.000000	38.97	43.50	4.53	1000.0	120.000	107.0	V	4.0	18.3
116.010000	40.58	43.50	2.92	1000.0	120.000	102.0	V	104.0	18.5
117.990000	38.39	43.50	5.11	1000.0	120.000	111.0	V	47.0	18.6
160.440000	31.96	43.50	11.54	1000.0	120.000	161.0	H	117.0	16.3

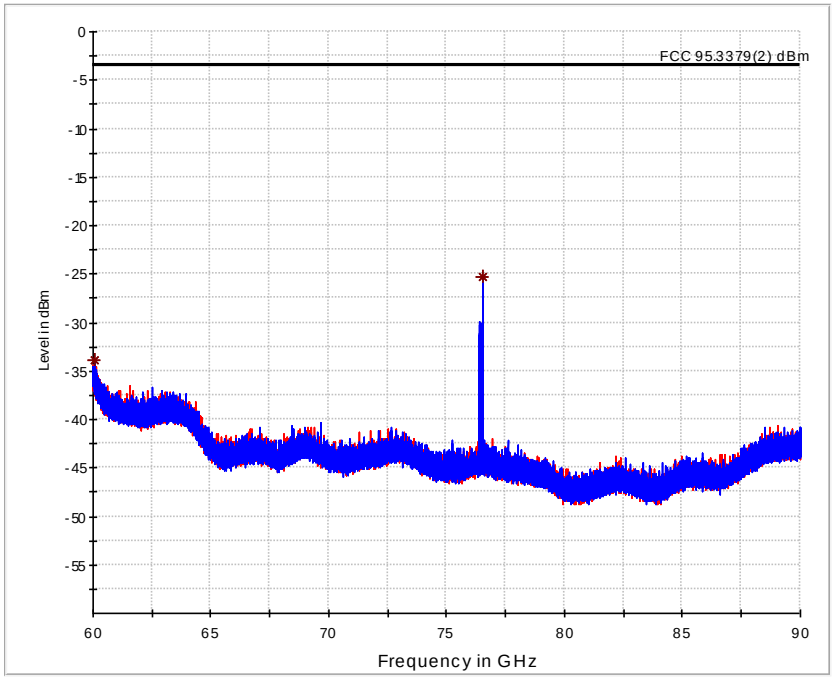


Preview Result 2V-AVG
Preview Result 2H-AVG
FCC Part 15C Electric Field Strength 1m PK
Final_Result PK+
Preview Result 1V-PK+
Preview Result 1H-PK+
FCC Part 15C Electric Field Strength 1m AV
Final_Result CAV



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 CAV

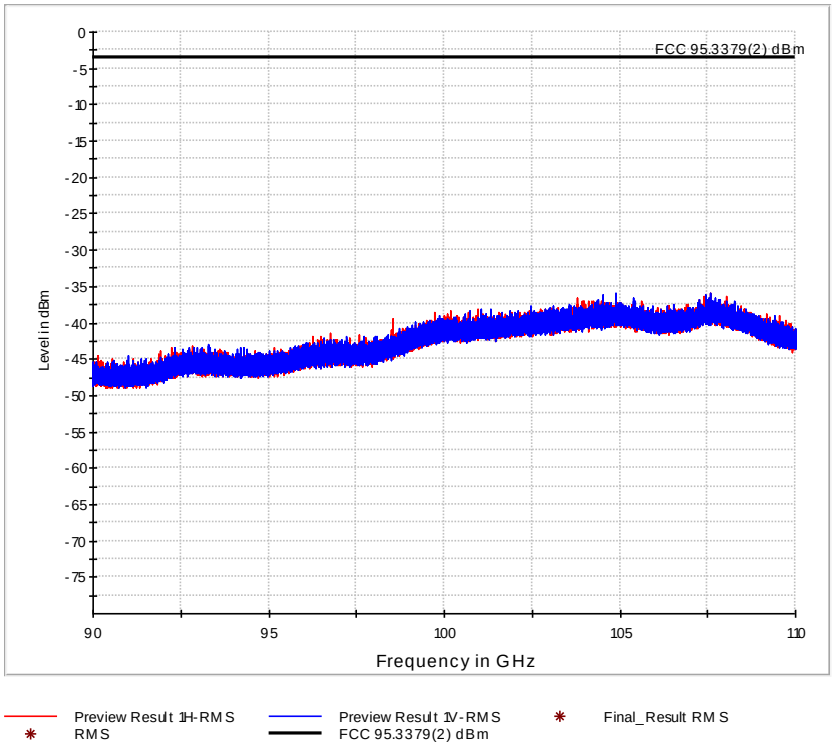

FCC 95.3379(2) dBm
Level in dBm
Frequency in GHz
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
-50
-55
40
42
44
46
48
50
52
54
56
58
60
Preview Result 1H-RMS
Final_Result RMS
Preview Result 1V-RMS
RMS
FCC 95.3379(2) dBm

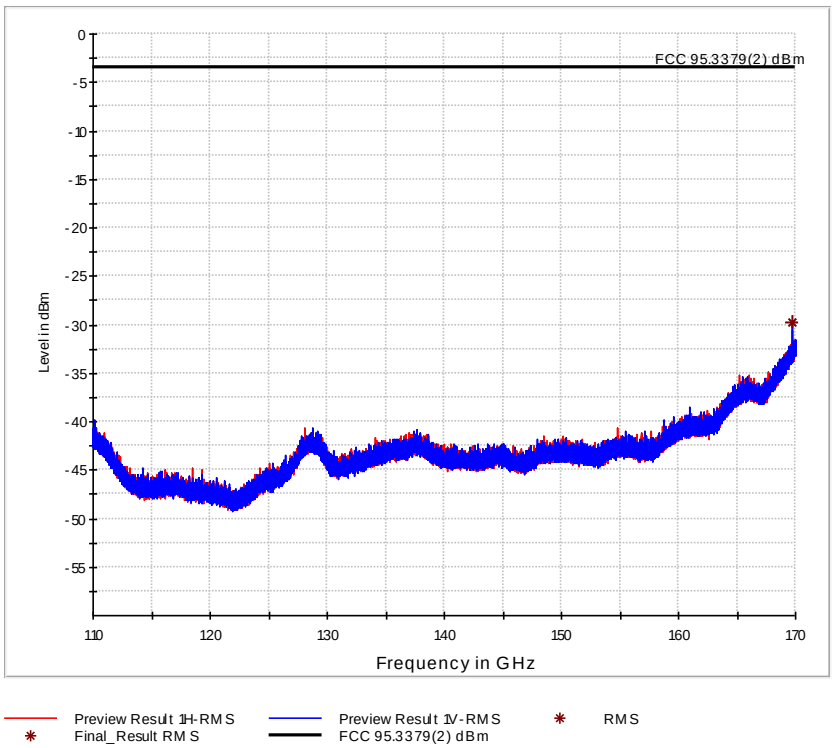


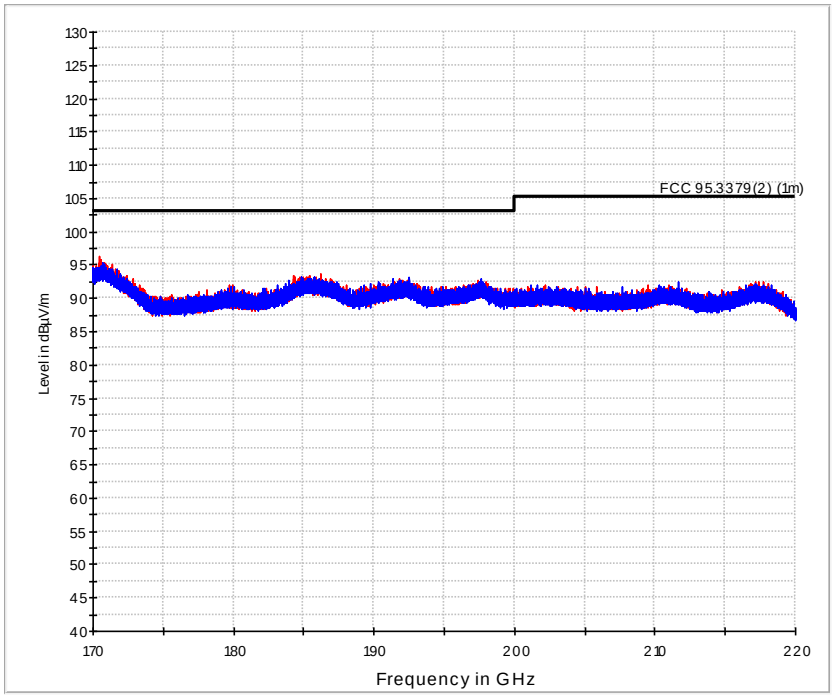
Final Results:

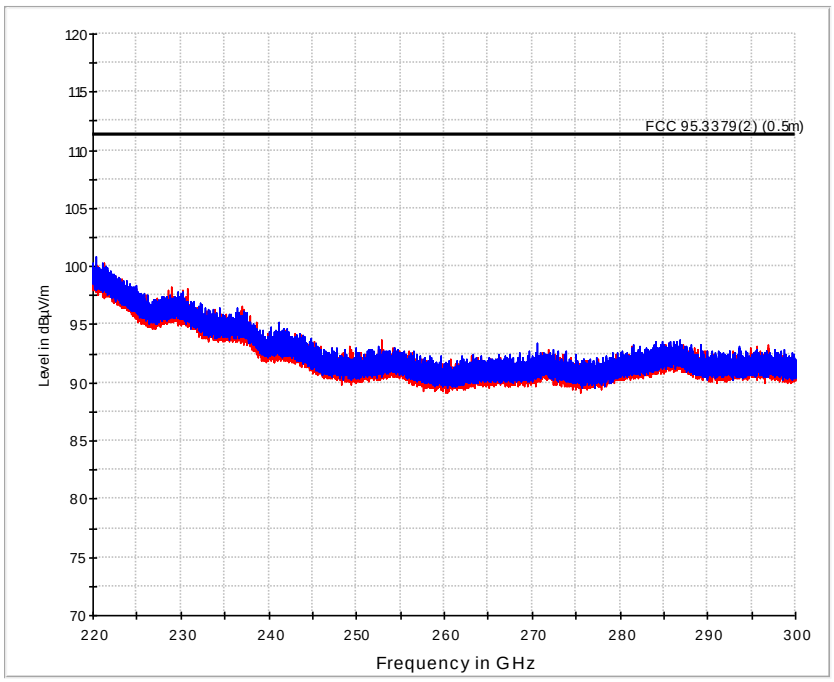
Frequency MHz	*RMS dBm*	*Limit dBm*	*Margin dB*	*Meas. Time ms*	*Bandwidth kHz*	*Height cm*	*Pol*	*Azimuth deg*	*Corr. dB*
76510.312500	-25.29	#1	#1	5.0	1000.000	150.0	V	308.0	-62.9

Note: #1 intentional radiation


FCC 95.3379(2) dBm
Level in dBm
Frequency in GHz
Preview Result 1H-RMS
Preview Result 1V-RMS
Final_Result RMS
RMS
FCC 95.3379(2) dBm


FCC 95.3379(2) dBm
Level in dBm
Frequency in GHz
Preview Result 1H-RMS
Preview Result 1V-RMS
RMS
Final_Result RMS
FCC 95.3379(2) dBm


FCC 95.3379(2) (1m)
Level in dBµV/m
Frequency in GHz
Preview Result 1H-RMS
Preview Result 1V-RMS
RMS
FCC 95.3379(2) (1


FCC 95.3379(2) (0.5m)
Level in dBµV/m
Frequency in GHz
Preview Result 1H-RMS
FCC 95.3379(2) (0.5m)
Preview Result 1V-RMS
Final_Result RMS

10.4 Frequency Stability

Date of Test	2020-06-17
Operator	Alex Fink
Test Site	Non shielded room

Prüfergebnis / *Test Result*

☒ **Erfüllt / *Passed***

☐ **Nicht erfüllt / *Not passed***

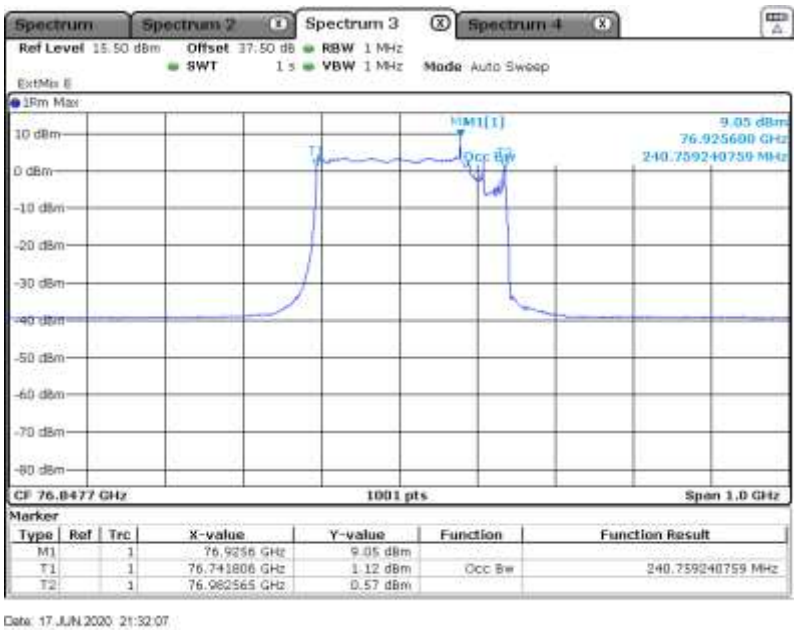
Barometric pressure:	977 hPa
Relative humidity:	48 %
Ambient temperature:	27 °C

Specifications*:*	CFR 47, Part 95, Subpart M, §95.3379(b) RSS-251, Issue 2, Section 11
Description:	b) Fundamental emissions must be contained within the frequency bands specified in this section during all conditions of operation. Equipment is presumed to operate over the temperature range -20 °C to 50 °C with a input voltage varation of 85 % to 115 % of rated input voltage unless justification is presented to demonstrate otherwise.
Operation mode:	Transmitting continuously on lowest and highest frequency with modulation 175 MHz, 300 MHz and 425 MHz.
Comment :	See plots of tests for details.

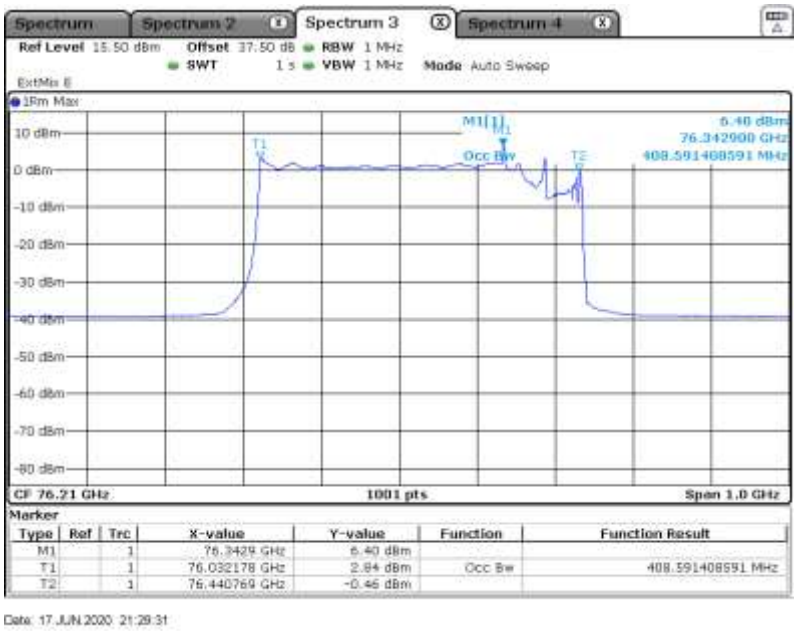
All emissions are within the 76 – 77 GHz frequency band.
See plots for details

Plots taken during test

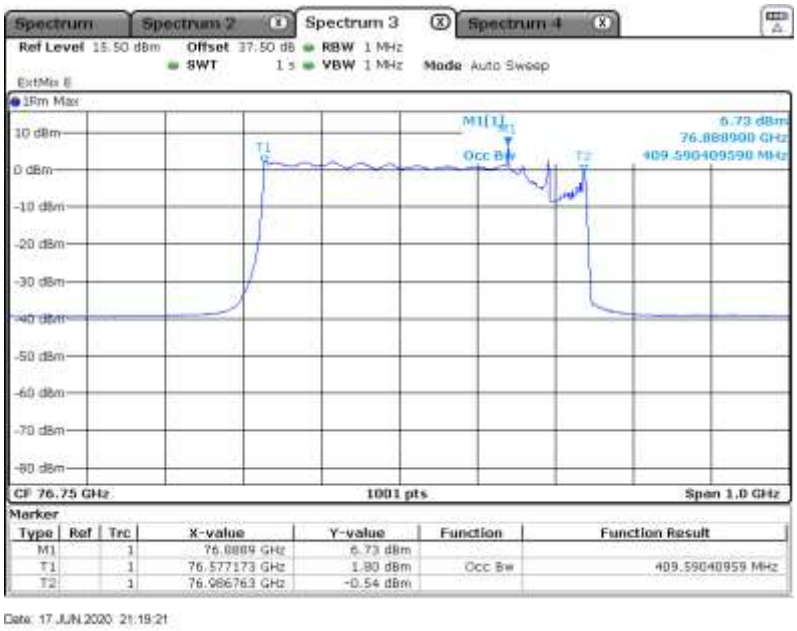
175 MHz, 20 °C, 9.2 V



175 MHz, 20 °C, 9.2 V



300 MHz, 20 °C, 9.2 V

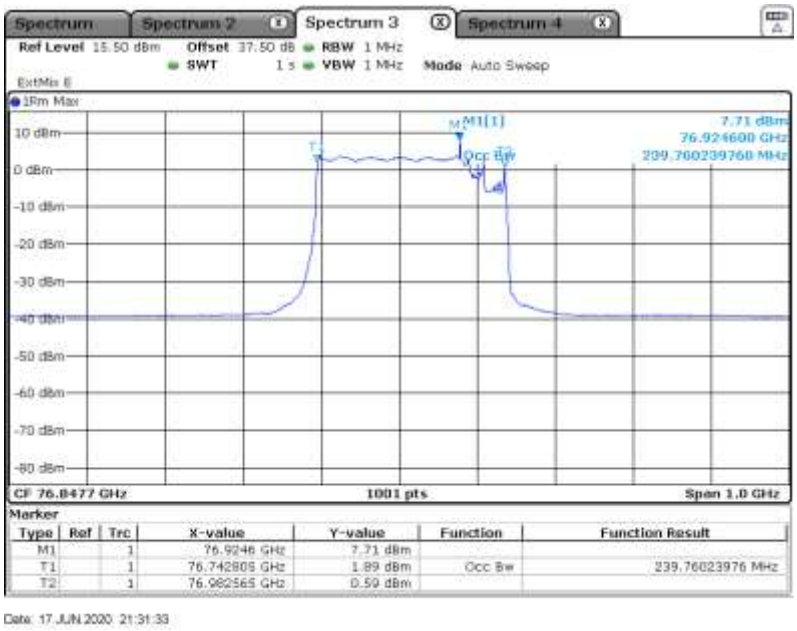


300 MHz, 20 °C, 9.2 V

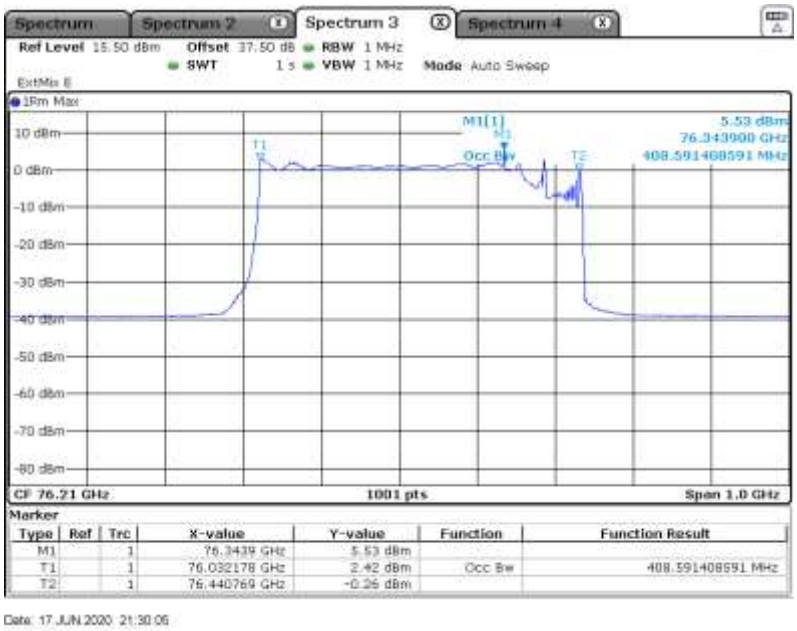
425 MHz, 20 °C, 9.2 V

425 MHz, 20 °C, 9.2 V

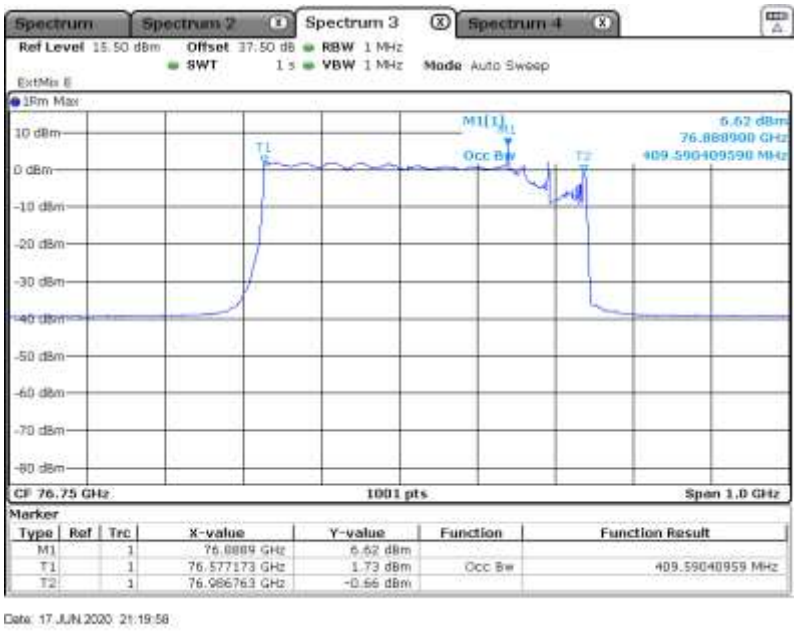
175 MHz, 20 °C, 17.0 V



175 MHz, 20 °C, 17.0 V



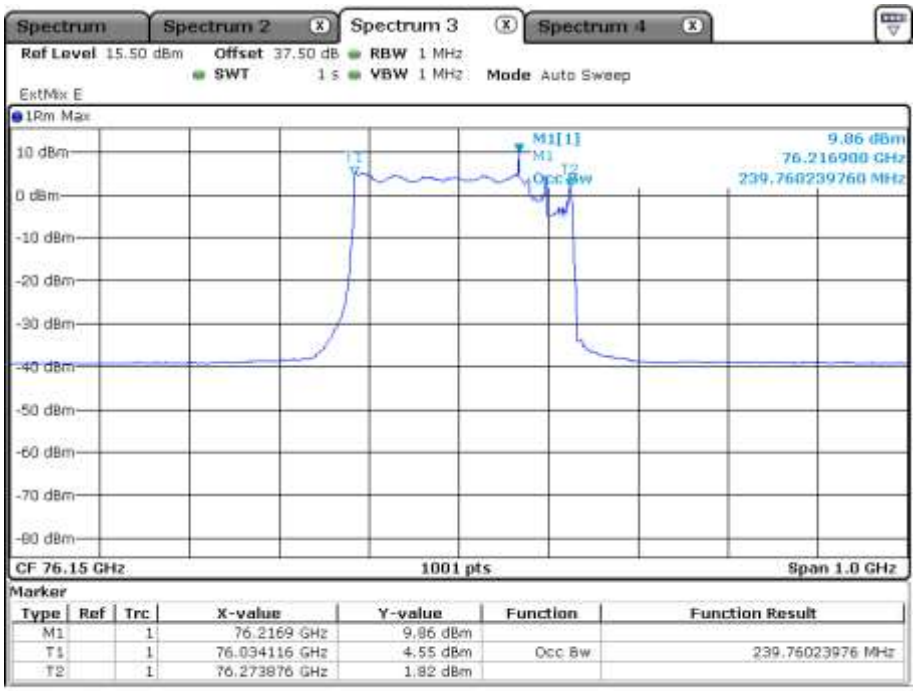
300 MHz, 20 °C, 17.0 V



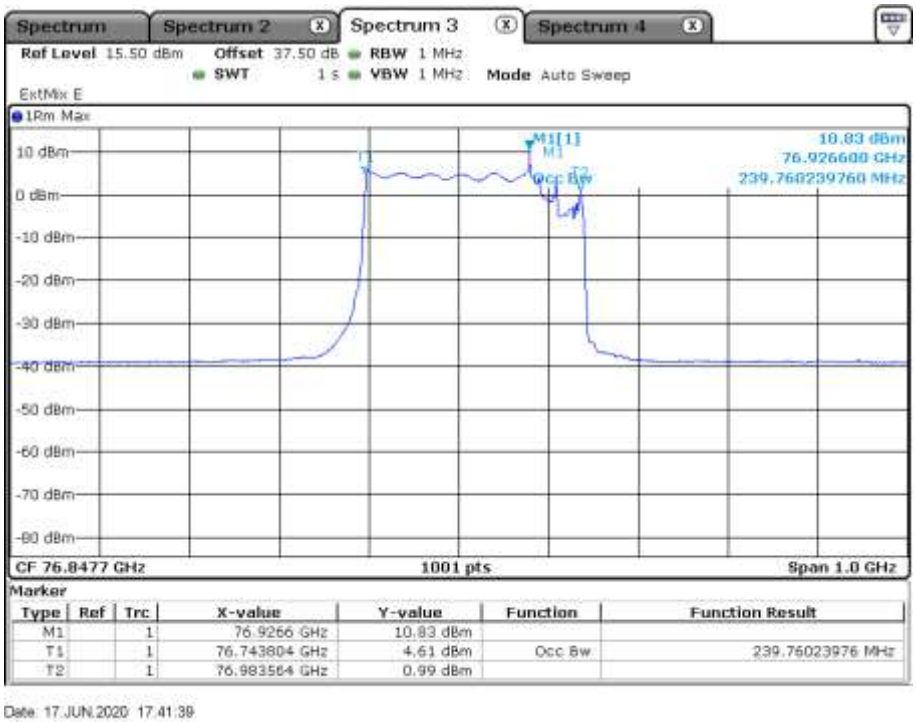
300 MHz, 20 °C, 17.0 V

425 MHz, 20 °C, 17.0 V

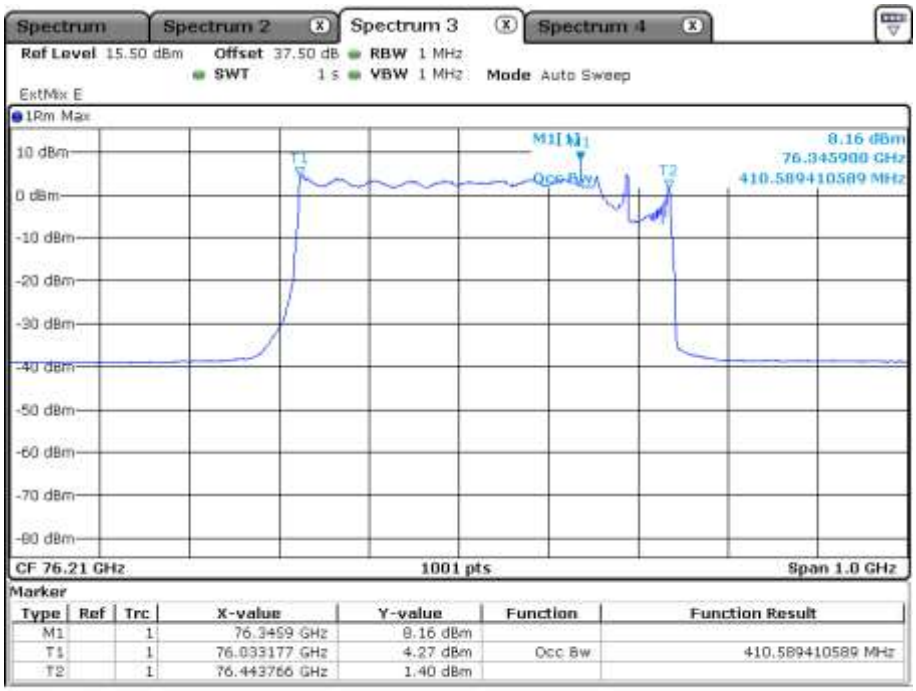
425 MHz, 20 °C, 17.0 V



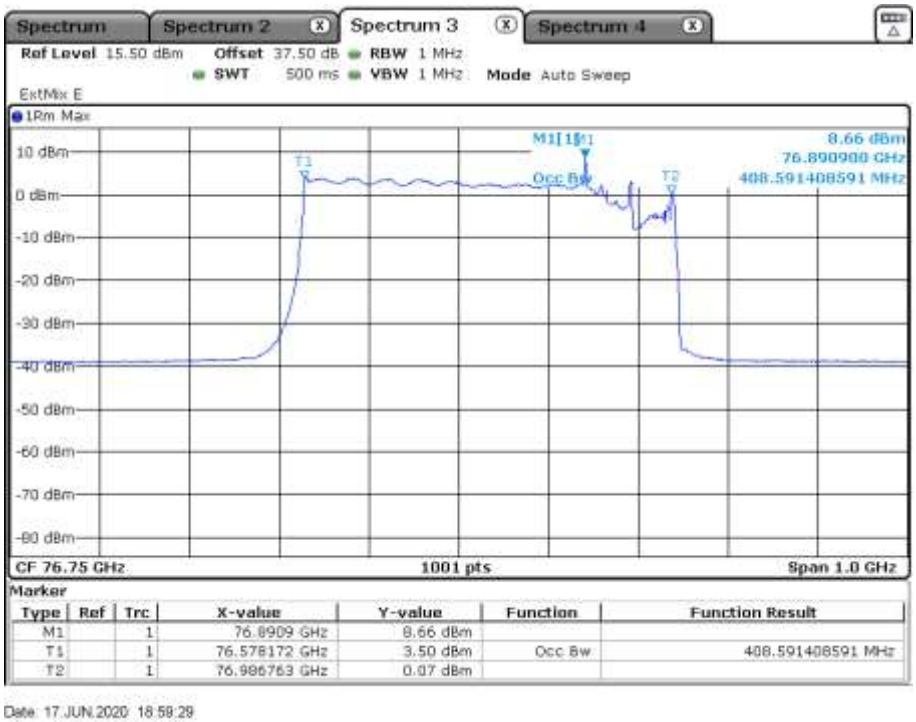
175 MHz, -40 °C, 12.0 V



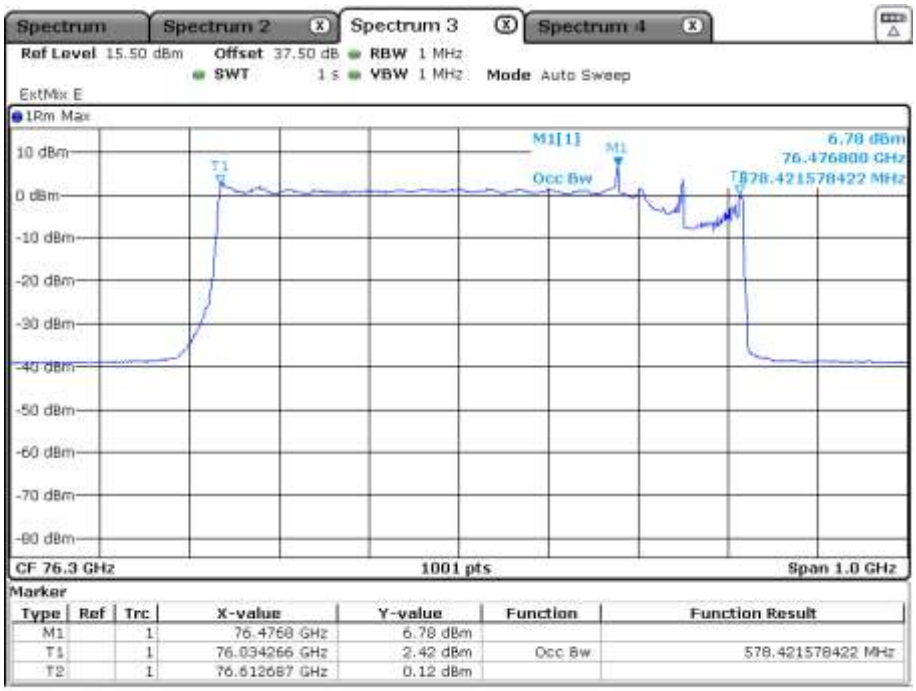
175 MHz, -40 °C, 12.0 V



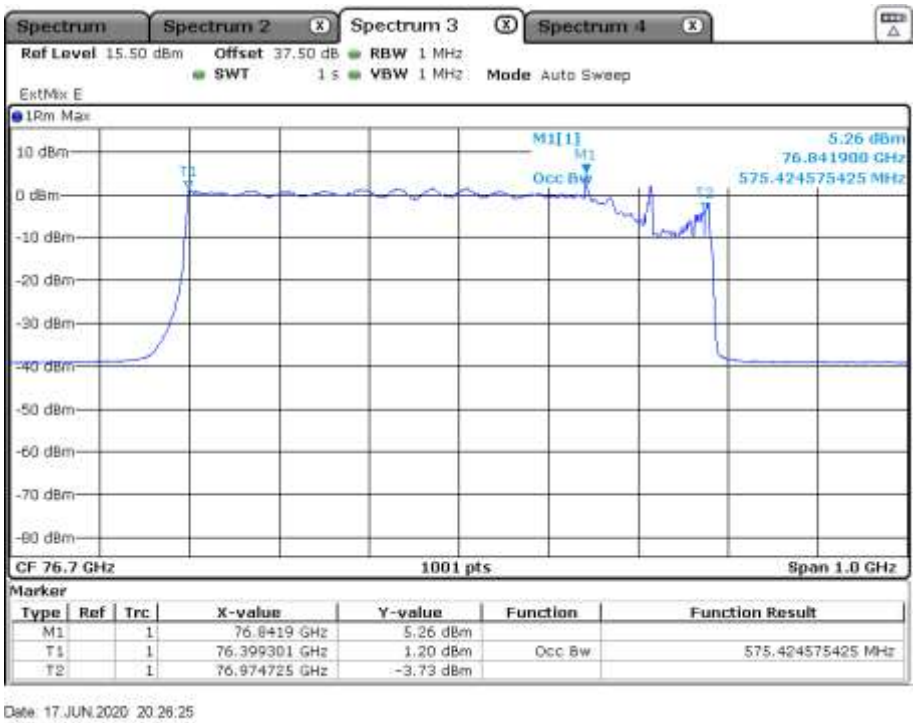
300 MHz, -40 °C, 12.0 V



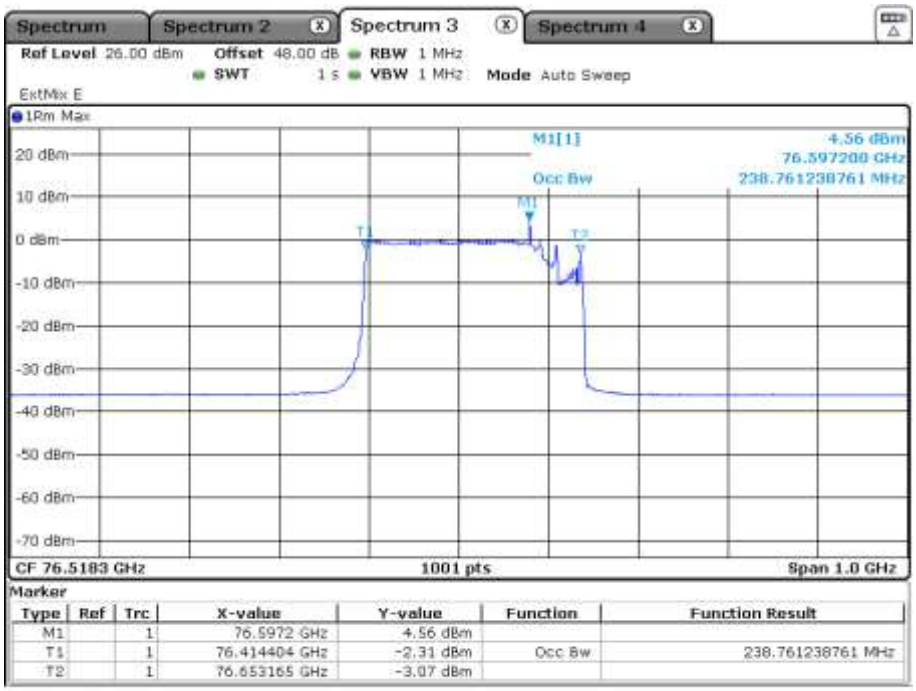
300 MHz, -40 °C, 12.0 V



425 MHz, -40 °C, 12.0 V

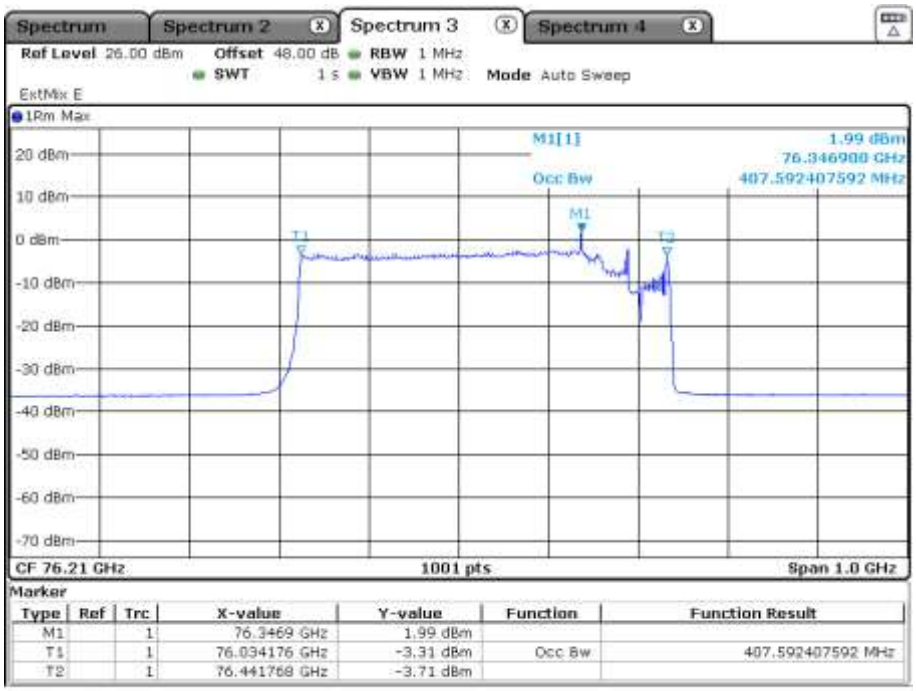


425 MHz, -40 °C, 12.0 V



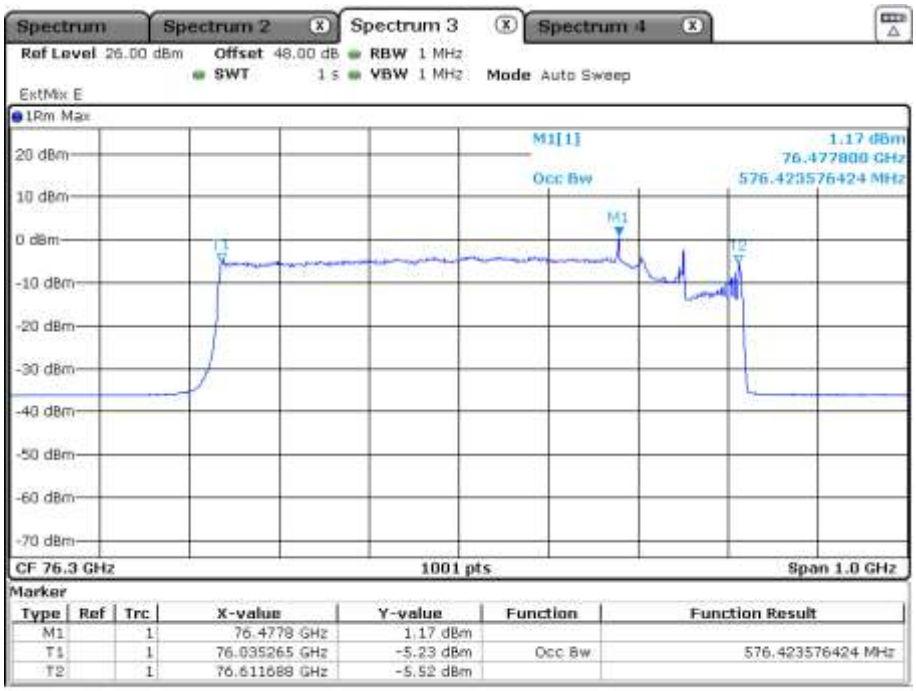
175 MHz, 85 °C, 12.0 V

175 MHz, 85 °C, 12.0 V

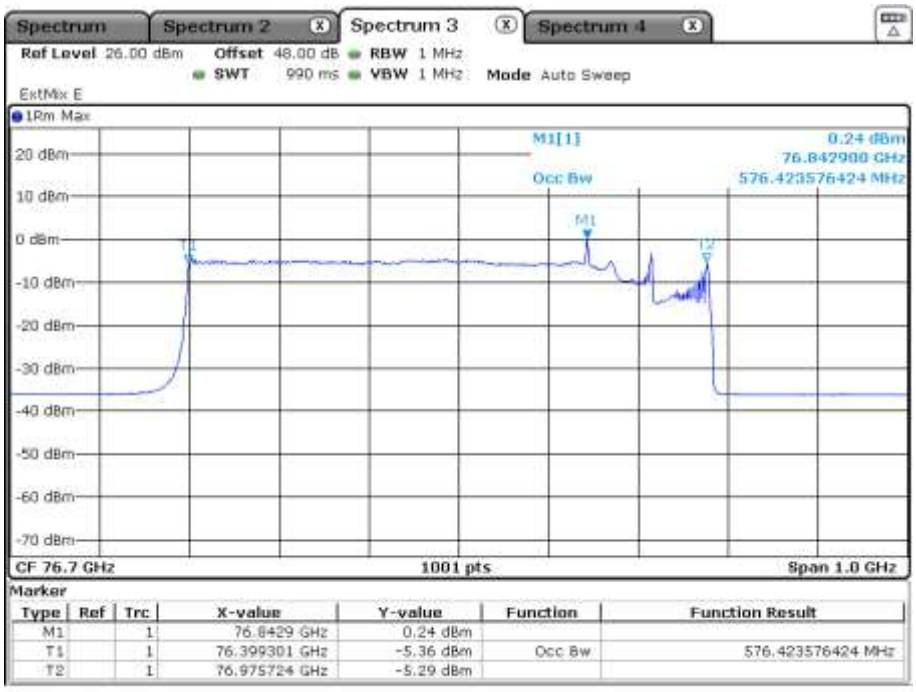


300 MHz, 85 °C, 12.0 V

300 MHz, 85 °C, 12.0 V



425 MHz, 85 °C, 12.0 V



425 MHz, 85 °C, 12.0 V

10.5 SAR Evaluation

Date of Test	2020-06-18
Operator	Alex Fink
Test Site	Non shielded room

Test Result	
☒	**Passed**
☐	**Not Passed**

Barometric pressure:	978 hPa
Relative humidity:	38 %
Ambient temperature:	24 °C

Specifications:	CFR 47, Part 1, Section 1310(d)(4) RSS-102, Issue 5, (4) Table 4) KDB 447498
Description:	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 for the specified separation distance. Output power level shall be the higher of the maximum conducted or equivalent isotropically radiated power (e.i.r.p.) source-based, time-averaged output power.
Operation mode:	Transmitting continuously on lowest and highest frequency with modulation 175 MHz, 300 MHz and 425 MHz.
Comment :	For test results see chapter 10.1 of this test report

Maximum $EIRP$ (worst case):	28.34 dBm = 682.3 mW (Peak) 20.37 dBm = 108.9 mW (Average)
Frequency:	76 GHz to 77 GHz (> 5800 MHz)
Minimum separation distance r:	20 cm (declared by applicant)
Power density $S = \frac{EIRP}{4\pi r^2}$:	0.1357 mW/cm² (Peak) 0.0217 mW/cm² (Average)
FCC Limit	1.0 mW/cm²
ISED Limit:	100 mW/cm²

11 Revision History

Revision History			
Edition	*Date*	*Issued by*	*Modifications*
1	2020-06-19	Alex Fink	First Edition