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Radio Testing of the

Piaggio Fast Forward, Inc.
Radar Sensor
Model: gita®

In accordance with CFR 47 Part 95 Subpart M and RSS-251 Issue 2 July 2018

Piaggio Fast Forward, Inc.
52 Roland St.
Charlestown MA 02129

COMMERCIAL-IN-CONFIDENCE

Date: October 2021
Document Number: 72171303A Issue 01 | Version Number: 01

RESPONSIBLE FOR	NAME	DATE	SIGNATURE
Authorized Signatory	Xiaoying Zhang	October 28, 2021	

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

EXECUTIVE SUMMARY
A sample of this product was tested and found to be in compliance with CFR 47 Part 95 Subpart M and RSS-251 Issue 2 July 2018.

A2LA Cert. No. 2955.13

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REPORT ON	Radio Testing of the Piaggio Fast Forward, Inc. Model 012-101187 Radar Sensor
TEST REPORT NUMBER	72171303A
TEST REPORT DATE	October 2021
PREPARED FOR	Piaggio Fast Forward, Inc. 52 Roland St. Charlestown MA 02129
CONTACT PERSON	Mitchell Weiss Chief Operating Officer mitch.weiss@piaggiofastforward.com (857) 997-2320
PREPARED BY	Ferdinand S. Custodio **Name** Authorized Signatory Title: Senior EMC Test Engineer / Wireless Team Lead
APPROVED BY	Xiaoying Zhang **Name** Authorized Signatory Title: Senior RF Wireless Test Engineer
DATED	October 28, 2021

Revision History

72171303A Piaggio Fast Forward, Inc. Radar Sensor Model 012-101187					
DATE	OLD REVISION	NEW REVISION	REASON	PAGES AFFECTED	APPROVED BY
10/28/2021	—	Initial Release			Xiaoying Zhang

CONTENTS

SECTION 1

REPORT SUMMARY

Radio Testing of the
Piaggio Fast Forward, Inc.
Radar Sensor Model gita®

1.1 INTRODUCTION

The information contained in this report is intended to show verification of the Piaggio Fast Forward, Inc. Radar Sensor Model gita® to the requirements of CFR 47 Part 95 Subpart M and RSS-251 Issue 2 July 2018.

Objective	To perform Radio testing to determine the Equipment Under Test's (EUT's) compliance with the test specification, for the series of tests carried out.
Manufacturer	Piaggio Fast Forward, Inc.
EUT	Radar Sensor
Model Name	gita®
Part Number	012-101187
FCC ID	2AY6H-101187
IC Number	27808-101187
Serial Number(s)	2021-05-17
Number of Samples Tested	1
Test Specification/Issue/Date	• CFR 47 Part 95 Subpart M (October 1, 2020). • RSS-251 Issue 2 July 2018 Vehicular Radar and Airport Fixed or Mobile Radar in the 76-81 GHz Frequency Band
Start of Test	August 11, 2021
Finish of Test	August 27, 2021
Name of Engineer(s)	Ferdinand Custodio
Related Document(s)	• ANSI C63.26-2015. American National Standard for Compliance Testing of Transmitters Used in Licensed radio Services. • KDB 653005 D01 76-81 GHz Radars v01r01 • Application Note 1EF107-1E Rohde & Schwarz Peak and Mean Power measurements on wideband FMCW radar signals • Radar Compliance Testing.pdf

1.2 BRIEF SUMMARY OF RESULTS

A brief summary of the tests carried out in accordance with CFR 47 Part 95 Subpart M and RSS-251 Issue 2 July 2018 are shown below:

Part 2	Part 95 Subpart M	RSS-251 / RSS-Gen*	Test Description	Result
§2.1046	§95.3367 (b)	9	Radiated Power Limits – Peak Power (EIRP)	Compliant
	§95.3367 (a)	8	Radiated Power Limits – Average Power (EIRP)	Compliant
§2.1049		6.7*	Occupied Bandwidth	Compliant
§2.1047		6b	Modulation Characteristics	N/A
§2.1053	§95.3379	10 and 6.13*	Unwanted Emissions Limits	Compliant
§2.1055	§95.3379 (b)	11	Frequency Stability	Compliant

N/A -Not verified. Declared by the Manufacturer as part of the Operational Description exhibit. See also Technical Description section of this test report (Section 1.3.2).

1.3 PRODUCT INFORMATION

1.3.1 EUT General Description

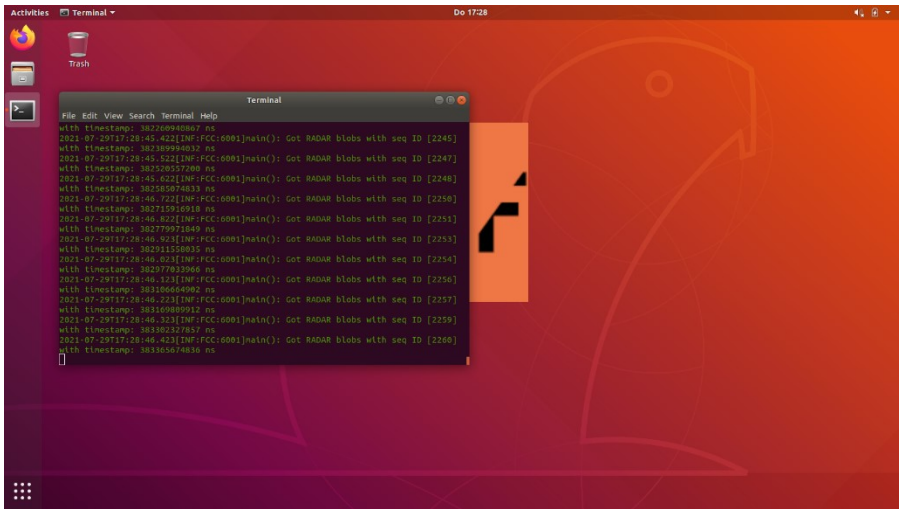
The Equipment Under Test (EUT) is an Piaggio Fast Forward, Inc. Model gita® Radar Sensor. The EUT is a multi-antenna MIMO-radars, transmitting reference signals, receiving the radio signals reflected from the objects at the positions to be determined, and comparing the reflected signals with the reference signals.

1.3.2 Technical Description

EUT Description	Radar Sensor
Model Name	gita®
Model Number	012-101187
Serial Number	2021-05-17
Input Voltage	5VDC via USB
Output RF Power	24.91 dBm EIRP (Average band power)
Frequency Range	77.7GHz to 78.7GHz (1 GHz)
Modulation Type	FMCW
Chirp Time	352 µs (16 x 22 µs)
Type of Equipment	☐ Fixed ☒ Mobile ☐ Portable
Directional Antenna Gain	16.5 dBi From 4.5 dBi + 10 log (N_{ANT}) Where 4.5 dBi is the single element gain N_{ANT} is 16, or the number of transmitting antenna at any given time

1.4 EUT TEST CONFIGURATION

1.4.1 Test Configuration Description

Test Configuration	Description
Default	The EUT is designed to enter its operational mode (continuous TX mode) once powered via USB of the support laptop. The manufacturer additionally provided a terminal emulator on the laptop showing status of the radar operation: 

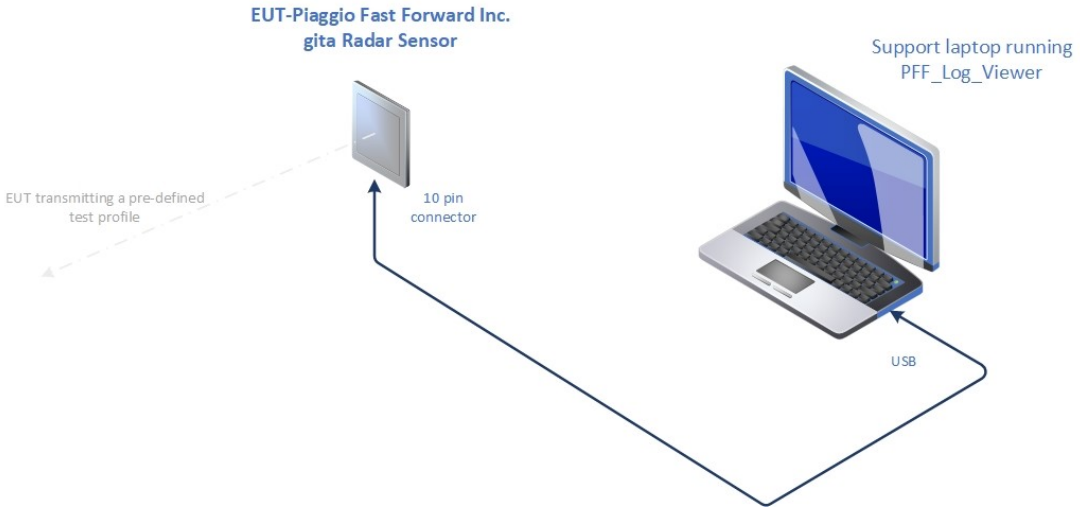
1.4.2 EUT Exercise Software

None. No special software was used to exercise the EUT however the manufacturer provided a terminal emulator (PFF_Log_Viewer) to monitor the radar operation.

1.4.3 Support Equipment and I/O cables

Manufacturer	Equipment/Cable	Description
Space Shuttle-Z	USB Cable	1.8 meters unshielded with 10 pin interface connector
HP	Support Laptop	Model EliteBook 840 S/N 5CG5103KBT

1.4.4 Simplified Test Configuration Diagram



1.5 DEVIATIONS FROM THE STANDARD

No deviations from the applicable test standards or test plan were made during testing.

1.6 MODIFICATION RECORD

Description of Modification	Modification Fitted By	Date Modification Fitted
Serial Number: 2021-05-17		
None	—	—

The table above details modifications made to the EUT during the test programme. The modifications incorporated during each test (if relevant) are recorded on the appropriate test pages.

1.7 TEST METHODOLOGY

All measurements contained in this report were conducted with ANSI C63.26-2015. American National Standard for Compliance Testing of Transmitters Used in Licensed radio Services.

For conducted and radiated emissions, the equipment under test (EUT) was configured to measure its highest possible emission level. This level was based on the maximized cable configuration from exploratory testing per ANSI C63.26-2015. The test modes were adapted according to the Operating Instructions provided by the manufacturer/client.

1.8 TEST FACILITY LOCATION

1.8.1 TÜV SÜD America Inc. (Mira Mesa)

10040 Mesa Rim Road, San Diego, CA 92121-2912 (32.901268,-117.177681). Phone: 858 678 1400 FAX: 858 546 0364

1.8.2 TÜV SÜD America Inc. (Rancho Bernardo)

16936 Via Del Campo, San Diego, CA 92127-1708 (33.018644,-117.092409). Phone: 858 678 1400 Fax: 858 546 0364.

1.9 TEST FACILITY REGISTRATION

1.9.1 FCC – Designation No.: US1146

TÜV SÜD America Inc. (San Diego), is an accredited test facility with the site description report on file and has met all the requirements specified in §2.948 of the FCC rules. The acceptance letter from the FCC is maintained in our files and the Designation is US1146.

1.9.2 Innovation, Science and Economic Development Canada (IC) Registration No.: 3067A-1 & 22806-1

The 10m Semi-anechoic chamber of TÜV SÜD America Inc. (San Diego Rancho Bernardo) has been registered by Certification and Engineering Bureau of Innovation, Science and Economic Development Canada for radio equipment testing with Registration No. 3067A-1.

The 3m Semi-anechoic chamber of TÜV SÜD America Inc. (San Diego Mira Mesa) has been registered by Certification and Engineering Bureau of Innovation, Science and Economic Development Canada for radio equipment testing with Registration No. 22806-1.

1.9.3 BSMI – Laboratory Code: SL2-IN-E-028R (US0102)

TÜV Product Service Inc. (San Diego) is a recognized EMC testing laboratory by the BSMI under the MRA (Mutual Recognition Arrangement) with the United States. Accreditation includes CNS 13438 up to 6GHz.

1.9.4 NCC (National Communications Commission - US0102)

TÜV SÜD America Inc. (San Diego) is listed as a Foreign Recognized Telecommunication Equipment Testing Laboratory and is accredited to ISO/IEC 17025 (A2LA Certificate No.2955.13) which under APEC TEL MRA Phase 1 was designated as a Conformity Assessment Body competent to perform testing of equipment subject to the Technical Regulations covered under its scope of accreditation including RTTE01, PLMN01 and PLMN08 for TTE type of testing and LP002 for Low-Power RF Device type of testing.

1.9.5 VCCI – Registration No. A-0280 and A-0281

TÜV SÜD America Inc. (San Diego) is a VCCI registered measurement facility which includes radiated field strength measurement, radiated field strength measurement above 1GHz, mains port interference measurement and telecommunication port interference measurement.

1.9.6 RRA – Identification No. US0102

TÜV SÜD America Inc. (San Diego) is National Radio Research Agency (RRA) recognized laboratory under Phase I of the APEC Tel MRA.

1.9.7 OFCA – U.S. Identification No. US0102

TÜV SÜD America Inc. (San Diego) is recognized by Office of the Communications Authority (OFCA) under Appendix B, Phase I of the APEC Tel MRA.

SECTION 2

TEST DETAILS

Radio Testing of the
Piaggio Fast Forward, Inc.
Radar Sensor Model 012-101187

2.1 RADIATED POWER LIMITS

2.1.1 Specification Reference

Part 2.1046(a), Part 95 Subpart M §95.3367(a) (b) and RSS-251 Sec. 8.0 and Section 9.0

2.1.2 Standard Applicable

The fundamental radiated emission limits within the 76-81 GHz band are expressed in terms of Equivalent Isotopically Radiated Power (EIRP) and are as follows:

(a) The maximum power (EIRP) within the 76-81 GHz band shall not exceed 50 dBm based 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

2.1.3 Equipment Under Test and Modification State

Serial No: 2021-05-17 / Default Test Configuration

2.1.4 Date of Test/Initial of test personnel who performed the test

August 14, 2021 / FSC

2.1.5 Test Equipment Used

The major items of test equipment used for the above tests are identified in Section 3.1.

2.1.6 Environmental Conditions

Test performed at TÜV SÜD America Inc. Mira Mesa facility

Ambient Temperature	27.7 °C
Relative Humidity	45.4 %
ATM Pressure	100.5 kPa

2.1.7 Additional Observations

- This is a radiated test.
- Test distance of 3 m was used for the fundamental emissions measurement.
- Offset is for the free space loss of the relevant frequency being investigated otherwise antenna gain is programmed as a transducer factor (TDF) while mixer conversion loss is programmed in the SA mixer setup.
- The FMCW chirps correction factor was calculated using the formula:

$$\mathrm{CF_{chirp}} = 5 \times \log\left(1 + \mathrm{K} \times \left(\frac{\mathrm{Span}}{\mathrm{t} \times \mathrm{RBW}^2}\right)^2\right)$$

- Guidance for calculating the correction factor is from Application Note 1EF107-1E Rohde & Schwarz Peak and Mean Power measurements on wideband FMCW radar signals.

- Sample calculation for FMCW chirps correction factor:

$$CF_{chirp} = 5 \times \log\left(1 + K \times \left(\frac{Span}{t \times RBW^2}\right)^2\right)$$

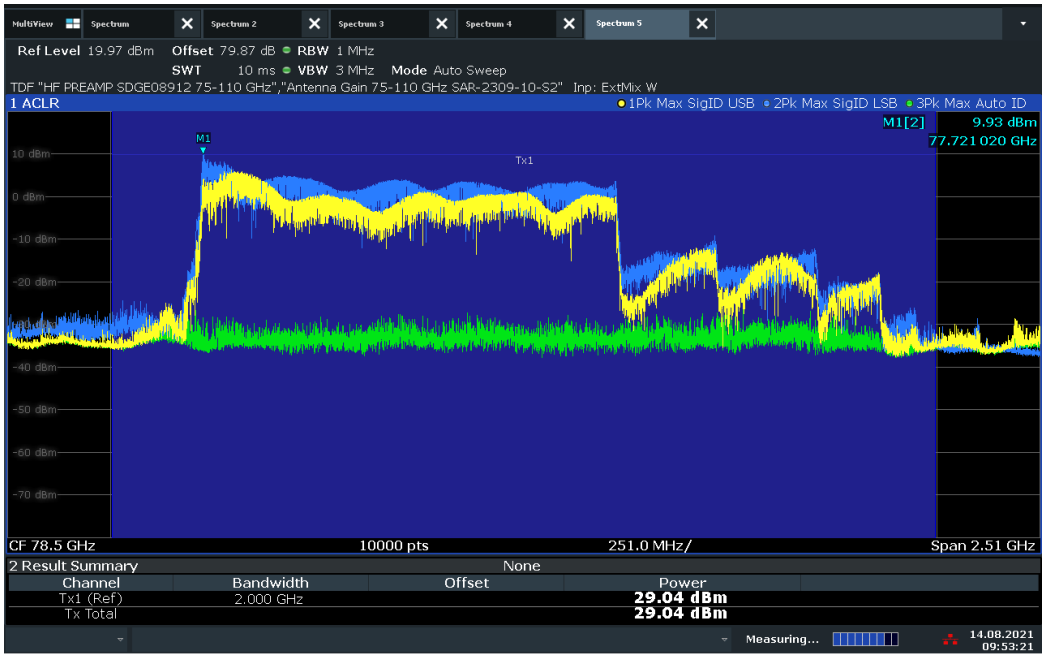
$$CF_{chirp} = 5 \times \log\left(1 + 0.1947 \times \left(\frac{1000000\ MHz}{22\mu s \times 1MHz^2}\right)^2\right)$$

$$CF_{chirp} = 13.03\ dB$$

2.1.8 Test Results

Detector	Measured	FMCW Chirps Correction Factor	Corrected Level (EIRP)	EIRP Limit
Peak	9.93 dBm	13.03 dB	22.96 dBm	55 dBm
Average (band power)	24.91 dBm	-	24.91 dBm	50 dBm

2.1.9 Test Plots



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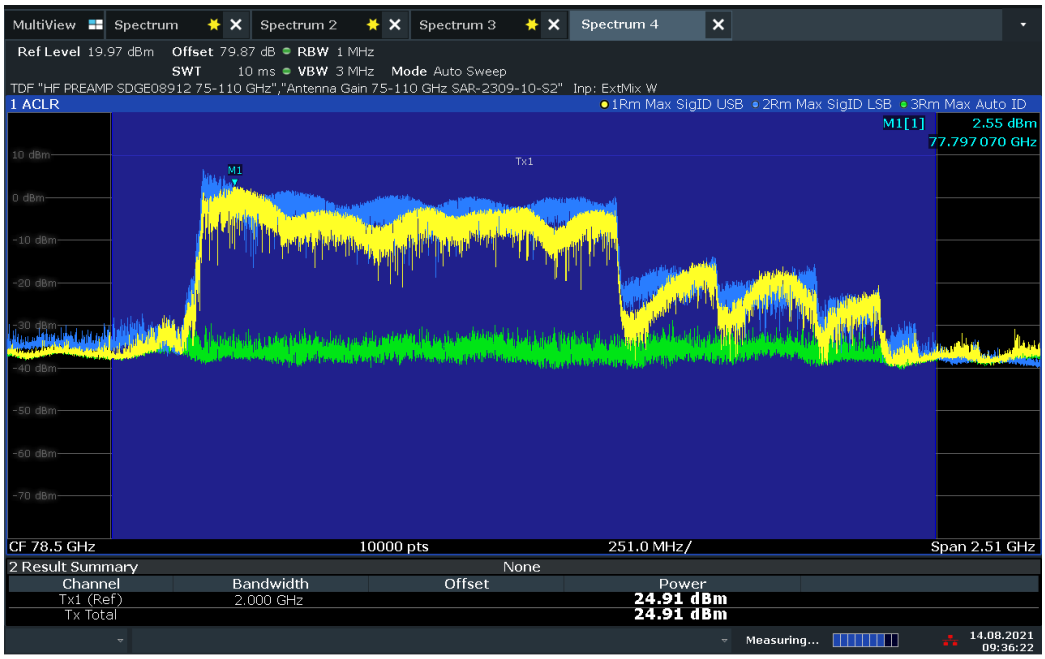
Peak Power EIRP



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Average Power EIRP

2.2 OCCUPIED BANDWIDTH

2.2.1 Specification Reference

Part 2.1049 and RSS-GEN Issue 5 Section 6.7

2.2.2 Standard Applicable

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.

2.2.3 Equipment Under Test and Modification State

Serial No: 2021-05-17 / Default Test Configuration

2.2.4 Date of Test/Initial of test personnel who performed the test

August 23, 2021 / FSC

2.2.5 Test Equipment Used

The major items of test equipment used for the above tests are identified in Section 3.1.

2.2.6 Environmental Conditions

Test performed at TÜV SÜD America Inc. Mira Mesa facility

Ambient Temperature	28.8 °C
Relative Humidity	41.2 %
ATM Pressure	99.9 kPa

2.2.7 Additional Observations

- This is a radiated test.
- Span is wide enough to capture the channel transmission.
- VBW > RBW.
- Trace is max hold.
- Detector is peak.
- Sweep time is set to Auto.
- 99% OBW measurement function of the spectrum analyzer was used for this test.
- RBW is between 1% to 5% of the anticipated OBW.

2.2.8 Test Results

99% OBW	1.025 GHz

2.2.9 Test Plot

15:02:26 23.08.2021

99% OBW

2.3 UNWANTED EMISSIONS LIMITS

2.3.1 Specification Reference

Part 2.1053, FCC Part 95 Subpart M §95.3379 and RSS-251 Section 10

2.3.2 Standard Applicable

(a) The power density of any emissions outside the 76-81 GHz band shall consist solely of spurious emissions and shall not exceed the following:

(1) Radiated emissions below 40 GHz shall not exceed the field strength as shown in the following emissions table.

Frequency (MHz)	Field strength (microvolts/meter)	Measurement distance (meters)
0.009-0.490	2400/F(kHz)	300
0.490-1.705	24000/F(kHz)	30
1.705-30.0	30	30
30-88	100	3
88-216	150	3
216-960	200	3
Above 960	500	3

(i) In the emissions table in paragraph (a)(1) of this section, the tighter limit applies at the band edges.

(ii) The limits in the table in paragraph (a)(1) of this section are based on the frequency of the unwanted emissions and not the fundamental frequency. However, the level of any unwanted emissions shall not exceed the level of the fundamental frequency.

(iii) The emissions limits shown in the table in paragraph (a)(1) of this section are based on measurements employing a CISPR quasi-peak detector except for the frequency bands 9.0-90.0 kHz, 110.0-490.0 kHz, and above 1000 MHz. Radiated emissions limits in these three bands are based on measurements employing an average detector with a 1 MHz RBW.

(2) The power density of radiated emissions outside the 76-81 GHz band above 40.0 GHz shall not exceed the following, based on measurements employing an average detector with a 1 MHz RBW:

(i) For radiated emissions outside the 76-81 GHz band between 40 GHz and 200 GHz from field disturbance sensors and radar systems operating in the 76-81 GHz band: 600 pW/cm2 at a distance of 3 meters from the exterior surface of the radiating structure.

(ii) For radiated emissions above 200 GHz from field disturbance sensors and radar systems operating in the 76-81 GHz band: 1000 pW/cm2 at a distance of 3 meters from the exterior surface of the radiating structure.

(3) For field disturbance sensors and radar systems operating in the 76-81 GHz band, the spectrum shall be investigated up to 231.0 GHz.

For radar devices that operate solely in the 76-77 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 of the 73.5-76 GHz band, the unwanted emission limits prescribed in table 1 shall apply.

2.3.3 Equipment Under Test and Modification State

Serial No: 2021-05-17 / Default Test Configuration

2.3.4 Date of Test/Initial of test personnel who performed the test

August 11 to 27, 2021 / FSC

2.3.5 Test Equipment Used

The major items of test equipment used for the above tests are identified in Section 3.1.

2.3.6 Environmental Conditions

Test performed at TÜV SÜD America Inc. Mira Mesa facility

Ambient Temperature	22.8 – 27.8 °C
Relative Humidity	39.6 – 42.9 %
ATM Pressure	100.1– 100.5 kPa

2.3.7 Additional Observations

- This is a radiated test.
- The spectrum was searched from 30MHz to 231GHz.
- Measurement was done using EMC32 automated software for below 40GHz. Reported level is the actual level with all the correction factors factored in. Correction Factor column is for informational purposes only. See below table for sample computation at 30MHz:

Measuring equipment raw measurement (dbµV) @ 30 MHz			24.4
Correction Factor (dB)	Asset# 1066 (cable)	0.3	-12.6
	Asset# 1172 (cable)	0.3	
	Asset# 1016 (preamplifier)	-30.7	
	Asset# 1175(cable)	0.3	
	Asset# 1002 (antenna)	17.2	
Reported QuasiPeak Final Measurement (dbµV/m) @ 30MHz			**11.8**

- For measurements above 40GHz, the corresponding transducer factor (TDF) were programmed directly to the Spectrum Analyzer (e.g. antenna gain, LNA and the free space loss).
- Measurement above 40GHz are maximized by hand and the worst case plot (max hold) presented.
- Tests distances and frequency ranges performed are summarized below:

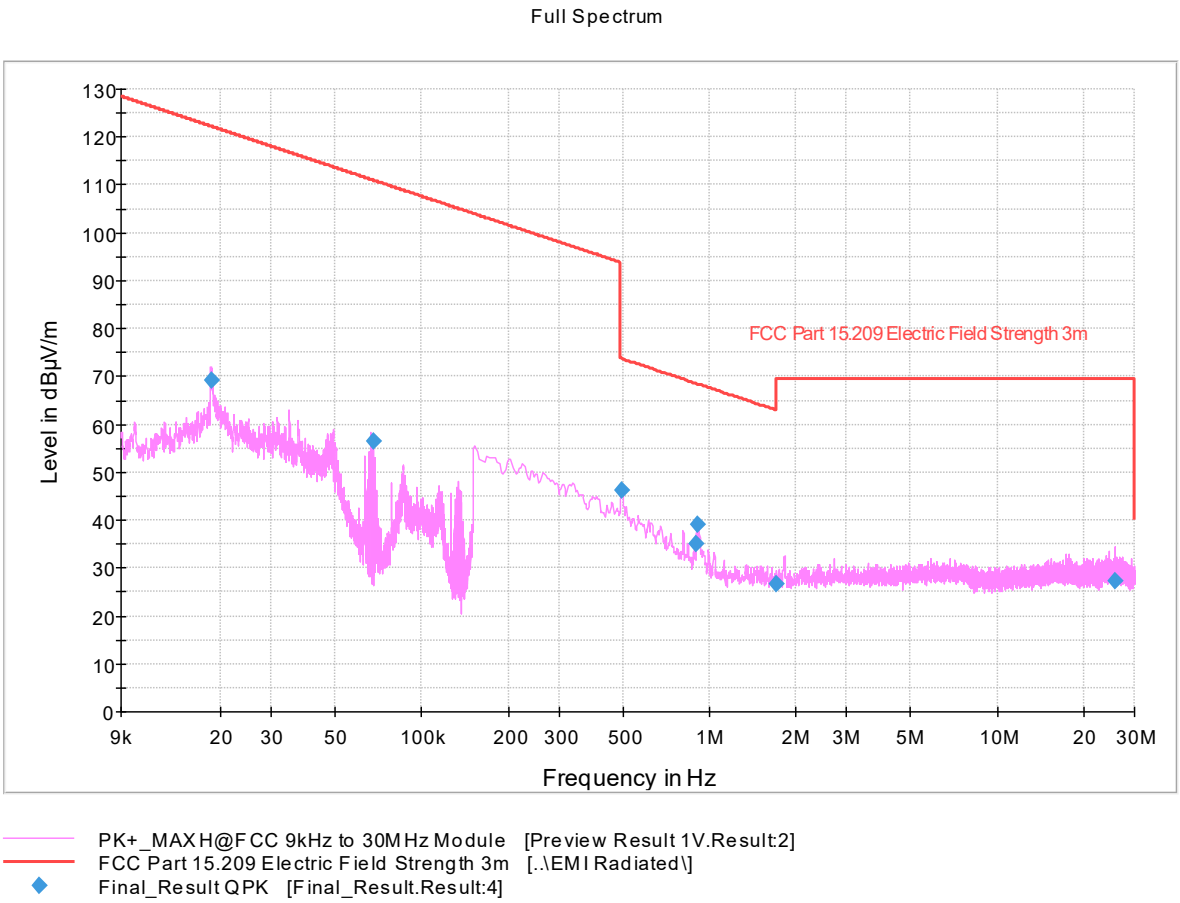
Frequency Range	Test Distance
30 MHz to 1GHz	3 meters
1 GHz to 18 GHz	3 meters
18 GHz to 26 GHz	3 meters
26 GHz to 40 GHz	3 meters

40 GHz to 60 GHz	3 meters
60 GHz to 75 GHz	3 meters
75 GHz to 81 GHz	3 meters
81 GHz to 110 GHz	1 meter
110 GHz to 160 GHz	1 meter
140 GHz to 220 GHz	1 meter
220 GHz to 231 GHz	0.2 meter

2.3.8 Test Results

Complies. See attached plots.

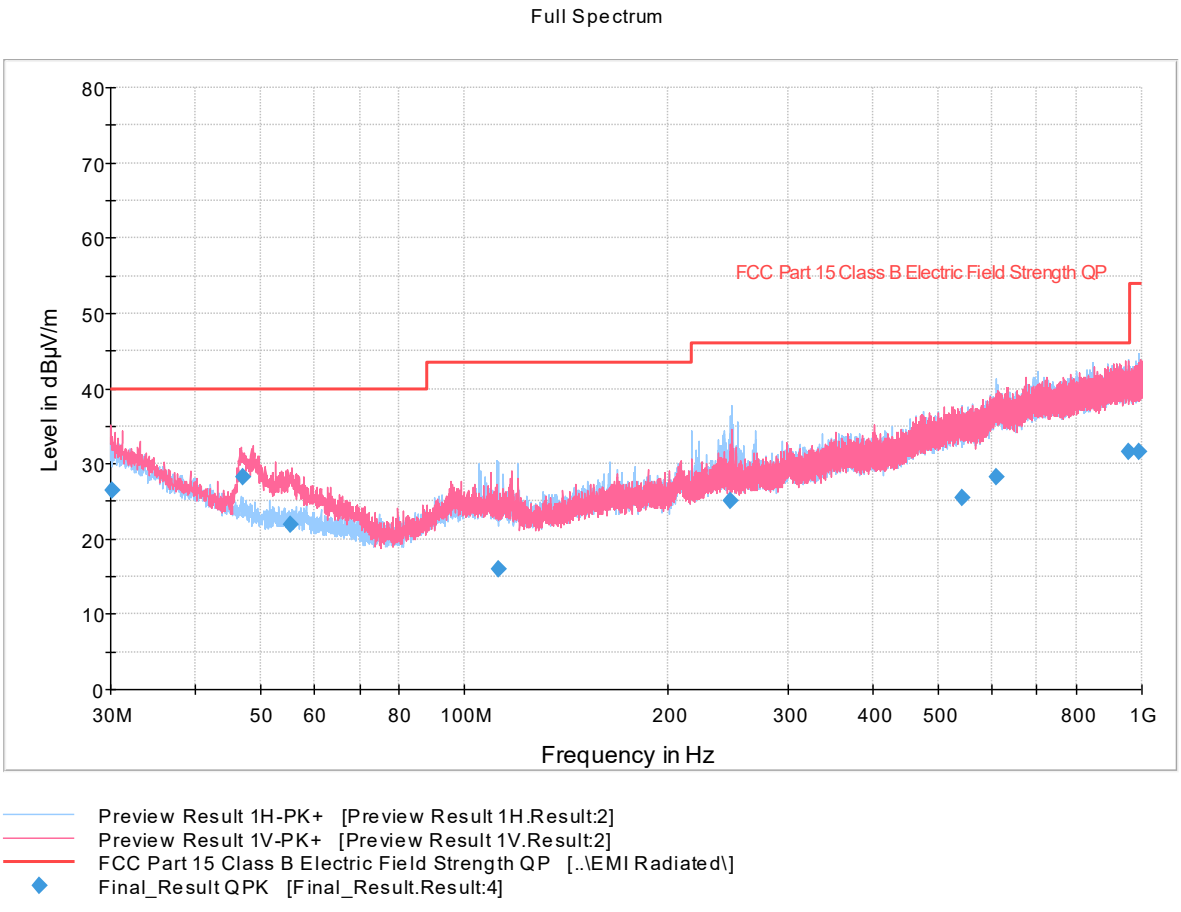
2.3.9 Below 30MHz Radiated Emission Test



Quasi-Peak Data

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Pol	Height (cm)	Azimuth (degrees)	Corr. (dB/m)
0.018615	69.06	122.20	53.14	1000.0	0.200	100.0	H	160.0	22
0.067630	56.49	111.00	54.51	1000.0	0.200	100.0	H	350.0	20
0.495760	46.26	73.70	27.44	1000.0	9.000	100.0	H	151.0	20
0.899185	35.10	68.52	33.42	1000.0	9.000	100.0	H	69.0	20
0.906644	38.98	68.45	29.47	1000.0	9.000	100.0	H	37.0	20
1.707898	26.62	69.50	42.88	1000.0	9.000	100.0	H	30.0	20
25.639041	27.20	69.50	42.30	1000.0	9.000	100.0	H	56.0	24

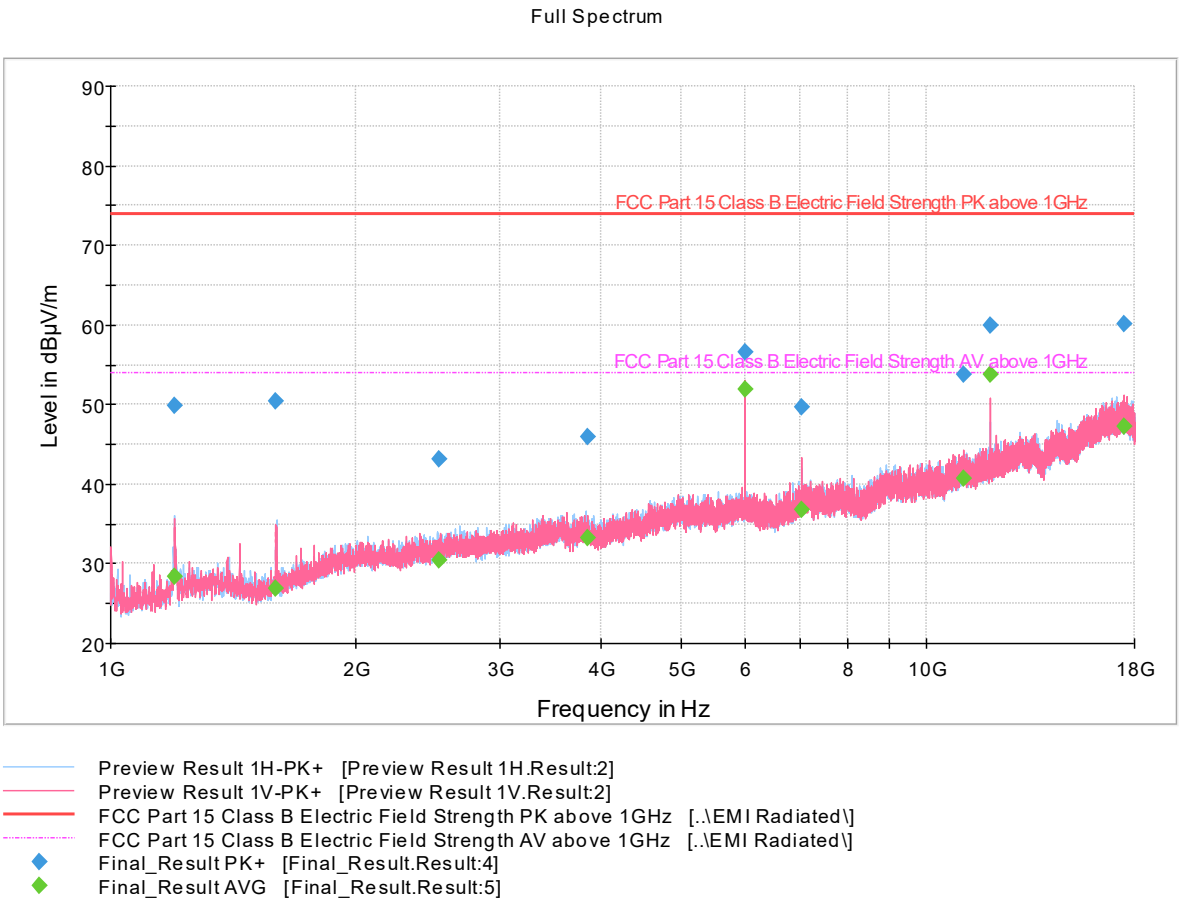
2.3.10 30MHz to 1GHz Radiated Emission Test



Quasi-Peak Data

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
30.120000	26.44	40.00	13.56	1000.0	120.000	125.0	V	304.0	22.6
47.088667	28.28	40.00	11.72	1000.0	120.000	100.0	V	274.0	15.1
55.368000	21.88	40.00	18.12	1000.0	120.000	112.0	V	-18.0	14.3
112.394000	15.91	43.50	27.59	1000.0	120.000	390.0	H	163.0	15.1
247.126667	25.00	46.00	21.00	1000.0	120.000	202.0	H	339.0	19.6
542.952333	25.52	46.00	20.48	1000.0	120.000	381.0	H	116.0	26.1
610.929667	28.29	46.00	17.71	1000.0	120.000	325.0	H	353.0	27.7
955.879333	31.63	46.00	14.37	1000.0	120.000	275.0	H	286.0	30.8
989.653667	31.61	53.90	22.29	1000.0	120.000	221.0	H	24.0	30.7

2.3.11 From 1GHz to 18GHz Radiated Emission Test



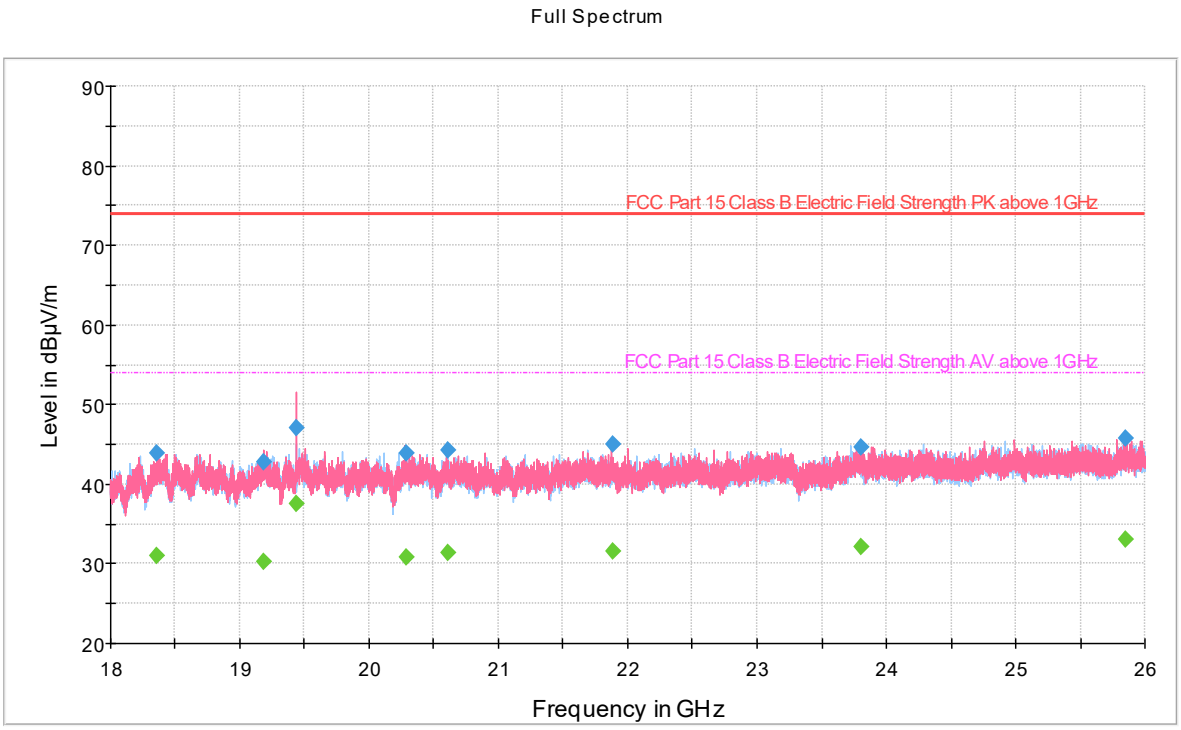
Peak Data

Frequency (MHz)	MaxPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
1198.70000	49.83	73.90	24.07	1000.0	1000.000	329.0	H	293.0	-2
1594.76667	50.41	73.90	23.49	1000.0	1000.000	227.0	H	15.0	-3
2524.70000	43.14	73.90	30.76	1000.0	1000.000	164.0	H	208.0	1
3840.63333	45.91	73.90	27.99	1000.0	1000.000	138.0	H	18.0	4
5999.90000	56.59	73.90	17.31	1000.0	1000.000	175.0	V	322.0	6
7037.73333	49.69	73.90	24.21	1000.0	1000.000	286.0	V	202.0	6
11100.3333	53.72	73.90	20.18	1000.0	1000.000	255.0	V	275.0	14
11999.9333	59.96	73.90	13.94	1000.0	1000.000	175.0	V	264.0	14
17495.7000	60.11	73.90	13.79	1000.0	1000.000	365.0	V	334.0	19

Average Data

Frequency (MHz)	MaxPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
1198.70000	28.40	53.90	25.50	1000.0	1000.000	329.0	H	293.0	-2
1594.76667	26.91	53.90	26.99	1000.0	1000.000	227.0	H	15.0	-3
2524.70000	30.47	53.90	23.43	1000.0	1000.000	164.0	H	208.0	1
3840.63333	33.16	53.90	20.74	1000.0	1000.000	138.0	H	18.0	4
5999.90000	51.97	53.90	1.93	1000.0	1000.000	175.0	V	322.0	6
7037.73333	36.78	53.90	17.12	1000.0	1000.000	286.0	V	202.0	6
11100.3333	40.71	53.90	13.19	1000.0	1000.000	255.0	V	275.0	14
11999.9333	53.87	53.90	0.03	1000.0	1000.000	175.0	V	264.0	14
17495.7000	47.30	53.90	6.60	1000.0	1000.000	365.0	V	334.0	19

2.3.12 18GHz to 26GHz Radiated Emission Test



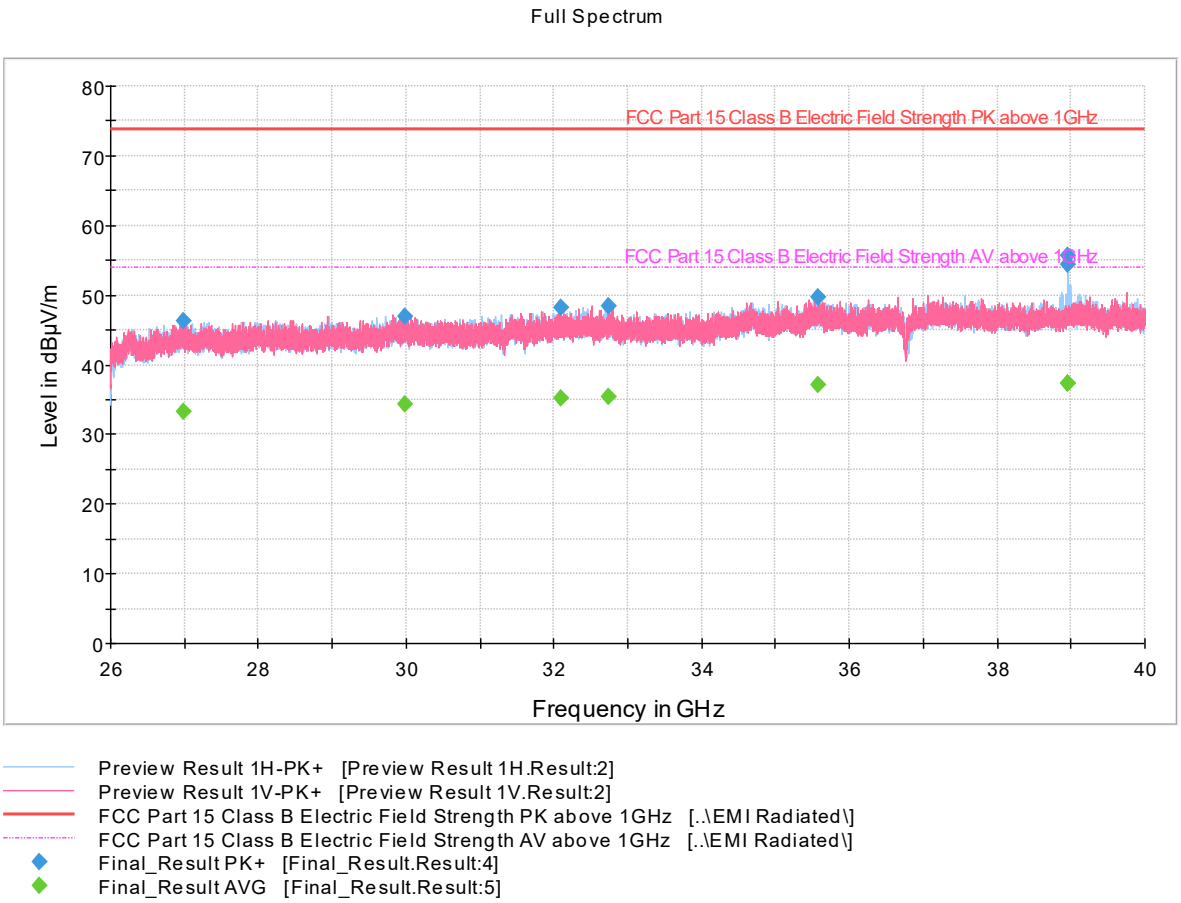
Peak Data

Frequency (MHz)	MaxPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
18358.2900	43.86	73.90	30.04	1000.0	1000.000	163.0	H	140.0	-3
19184.4500	42.71	73.90	31.19	1000.0	1000.000	157.0	V	118.0	-3
19438.6700	47.08	73.90	26.82	1000.0	1000.000	137.0	V	159.0	-3
20288.9500	43.84	73.90	30.06	1000.0	1000.000	137.0	V	162.0	-3
20605.6500	44.18	73.90	29.72	1000.0	1000.000	198.0	H	110.0	-3
21885.5700	44.94	73.90	28.96	1000.0	1000.000	206.0	V	237.0	-2
23802.9900	44.69	73.90	29.21	1000.0	1000.000	187.0	H	347.0	0
25845.1400	45.69	73.90	28.21	1000.0	1000.000	190.0	V	37.0	1

Average Data

Frequency (MHz)	MaxPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
18358.2900	31.01	53.90	22.89	1000.0	1000.000	163.0	H	140.0	-3
19184.4000	30.21	53.90	23.69	1000.0	1000.000	157.0	V	118.0	-3
19438.6700	37.47	53.90	16.43	1000.0	1000.000	137.0	V	159.0	-3
20288.9500	30.88	53.90	23.02	1000.0	1000.000	137.0	V	162.0	-3
20605.6500	31.41	53.90	22.49	1000.0	1000.000	198.0	H	110.0	-3
21885.5700	31.58	53.90	22.32	1000.0	1000.000	206.0	V	237.0	-2
23802.9900	32.06	53.90	21.84	1000.0	1000.000	187.0	H	347.0	0
25845.1400	33.02	53.90	20.88	1000.0	1000.000	190.0	V	37.0	1

2.3.13 26GHz to 40GHz Radiated Emission Test

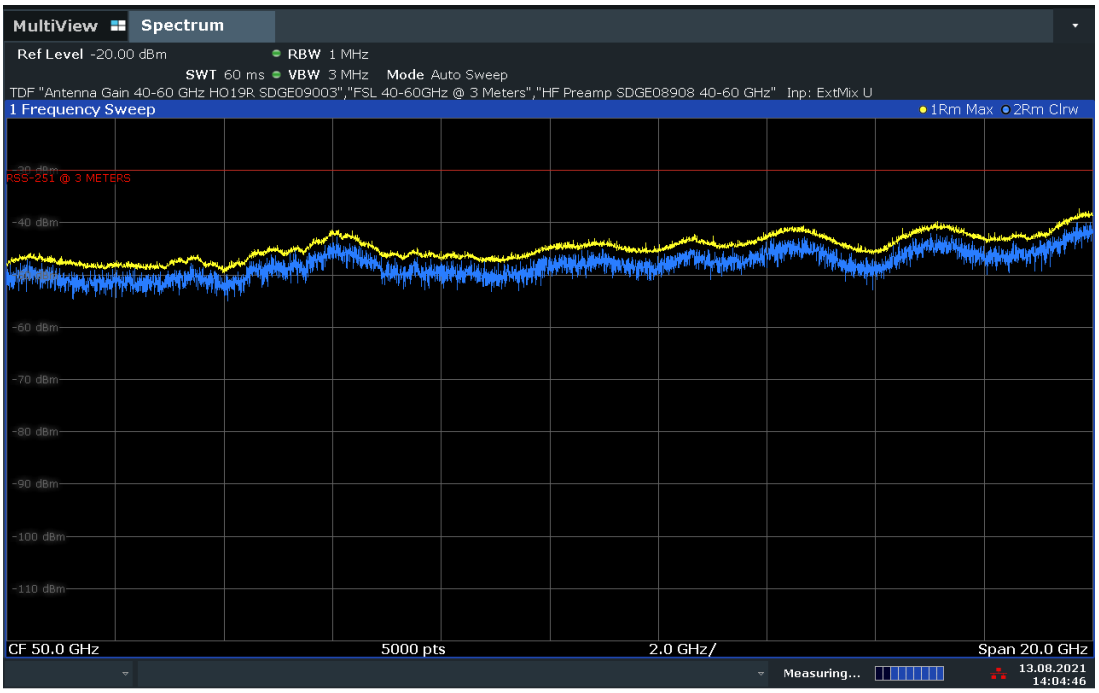


Peak Data

Frequency (MHz)	MaxPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
26976.8654	46.36	73.90	27.54	1000.0	1000.000	175.0	V	197.0	1.5
29977.1293	46.92	73.90	26.98	1000.0	1000.000	183.0	V	27.0	2.7
32101.2007	48.25	73.90	25.65	1000.0	1000.000	175.0	H	10.0	4.9
32729.7153	48.35	73.90	25.55	1000.0	1000.000	175.0	V	294.0	5.2
35573.7999	49.67	73.90	24.23	1000.0	1000.000	175.0	H	35.0	6.4
38956.7677	54.34	73.90	19.56	1000.0	1000.000	209.0	H	37.0	6.9
38959.7438	55.76	73.90	18.14	1000.0	1000.000	179.0	H	35.0	6.9

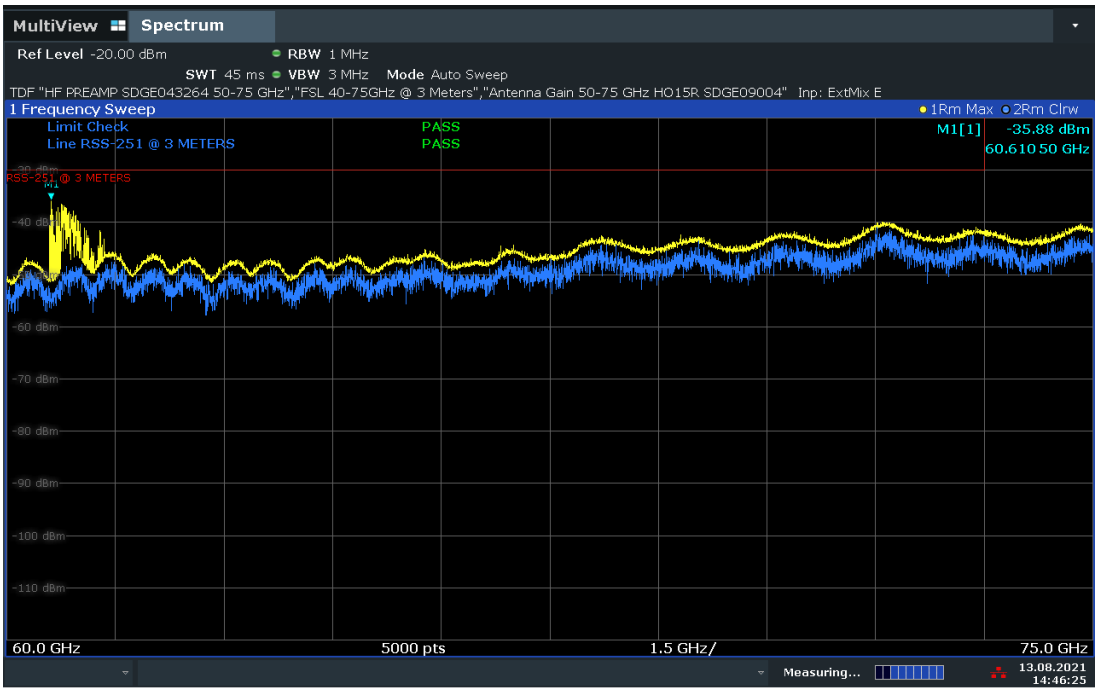
Average Data

Frequency (MHz)	MaxPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
26976.8654	33.22	53.90	20.68	1000.0	1000.000	175.0	V	197.0	1.5
29977.1693	34.38	53.90	19.52	1000.0	1000.000	183.0	V	27.0	2.7
32101.2307	35.17	53.90	18.73	1000.0	1000.000	175.0	H	10.0	4.9
32729.7363	35.41	53.90	18.49	1000.0	1000.000	175.0	V	294.0	5.2
35573.7999	37.08	53.90	16.82	1000.0	1000.000	175.0	H	35.0	6.4
38956.7077	37.24	53.90	16.66	1000.0	1000.000	209.0	H	37.0	6.9
38959.7438	37.28	53.90	16.62	1000.0	1000.000	179.0	H	35.0	6.9



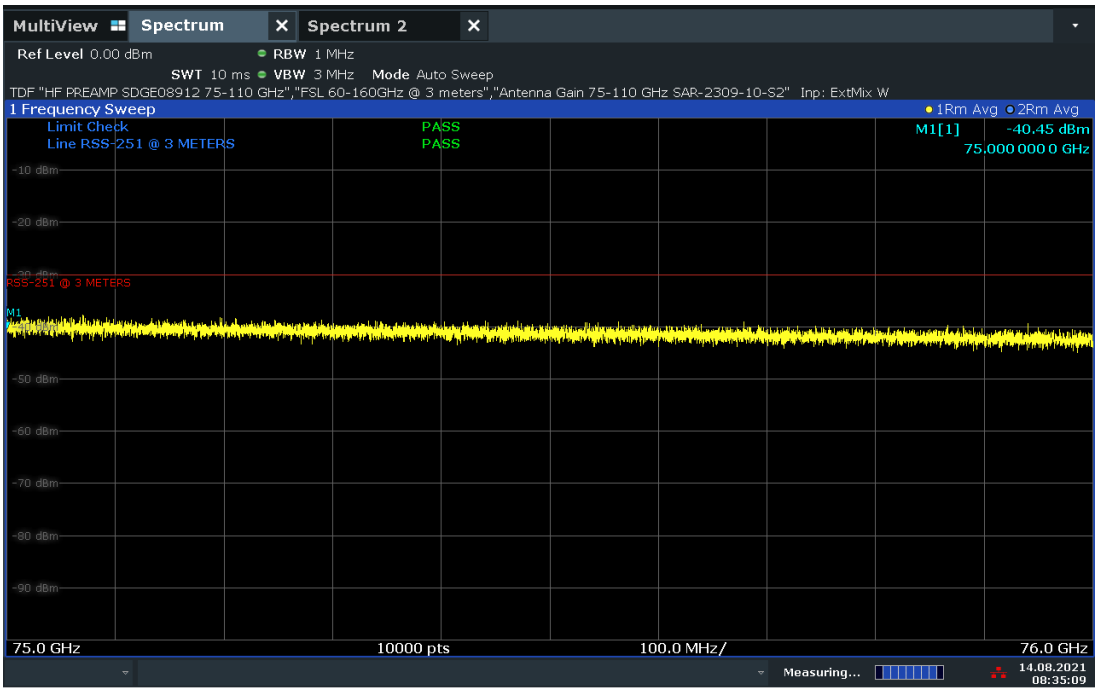
14:04:47 13.08.2021

40-60 GHz



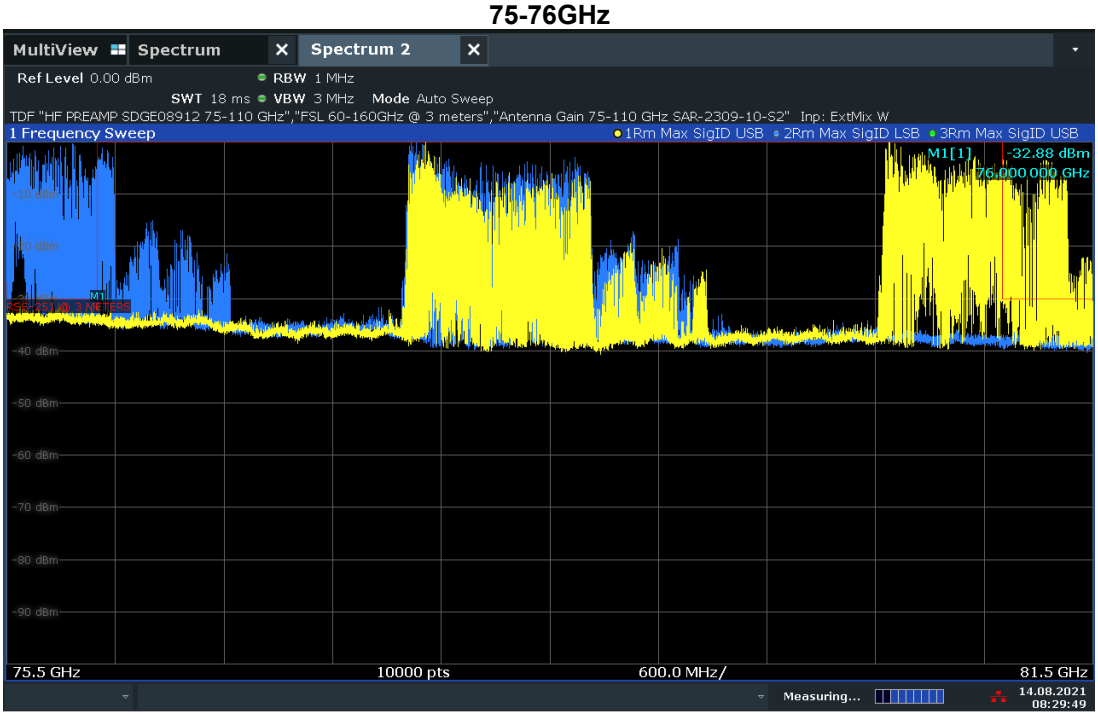
14:46:25 13.08.2021

60 to 75GHz



08:35:10 14.08.2021

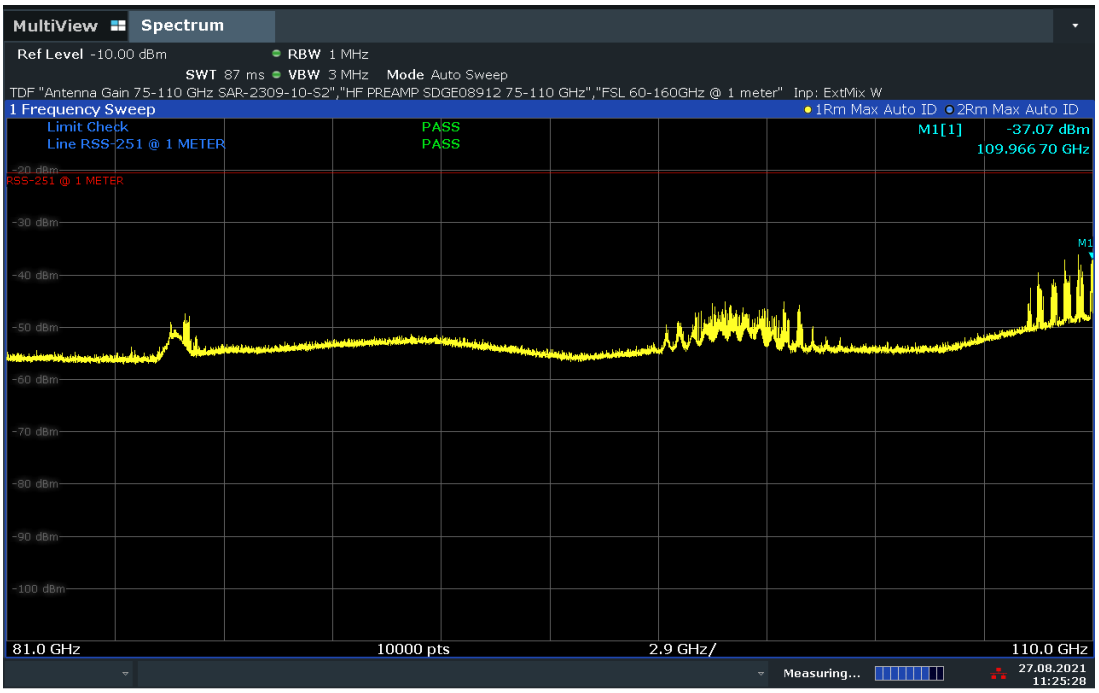
75-76GHz



08:29:50 14.08.2021

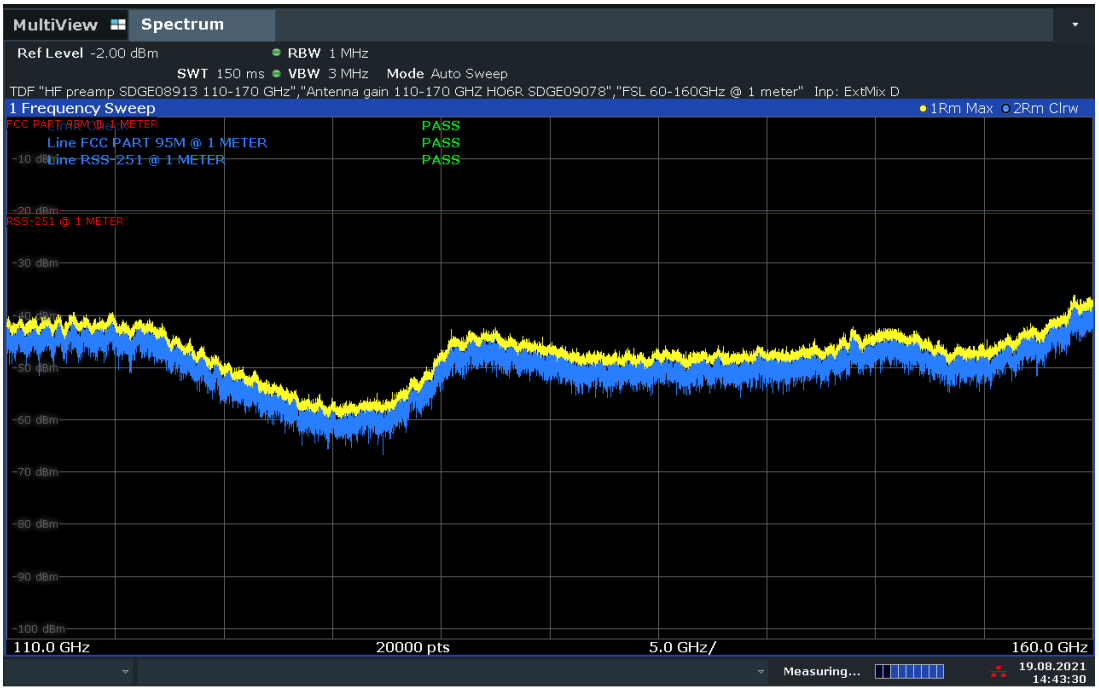
76-81GHz in band

Test Note: When using Signal ID function, traces not common to both Yellow and Blue traces are by-products of the mixing and are not real.



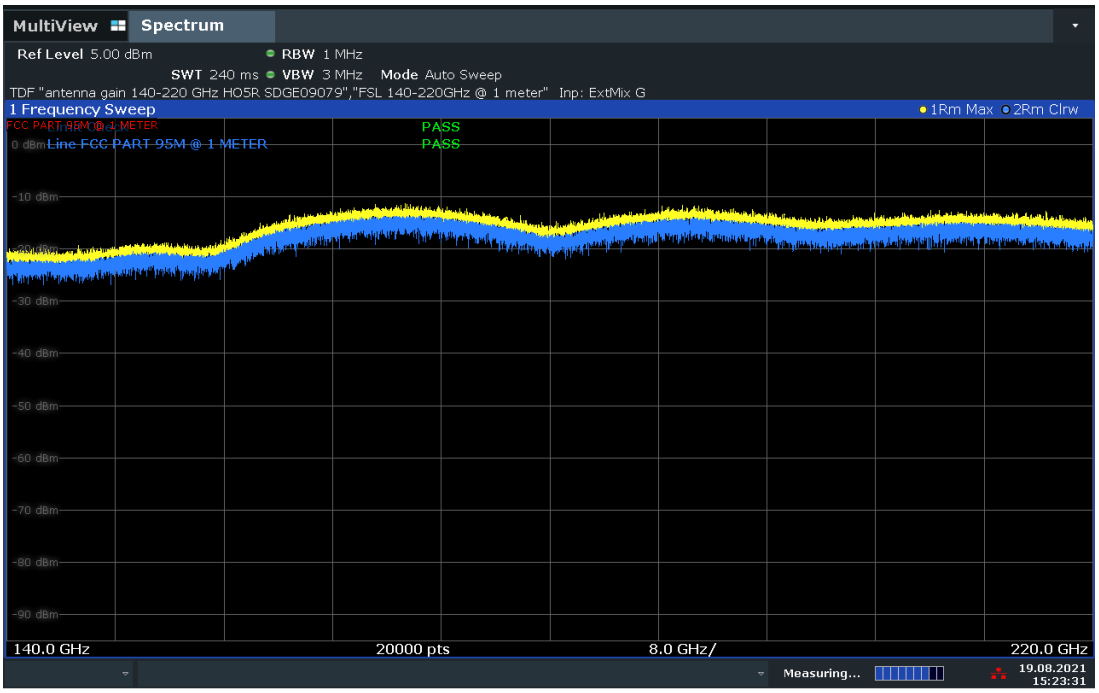
11:25:28 27.08.2021

81 to 110GHz



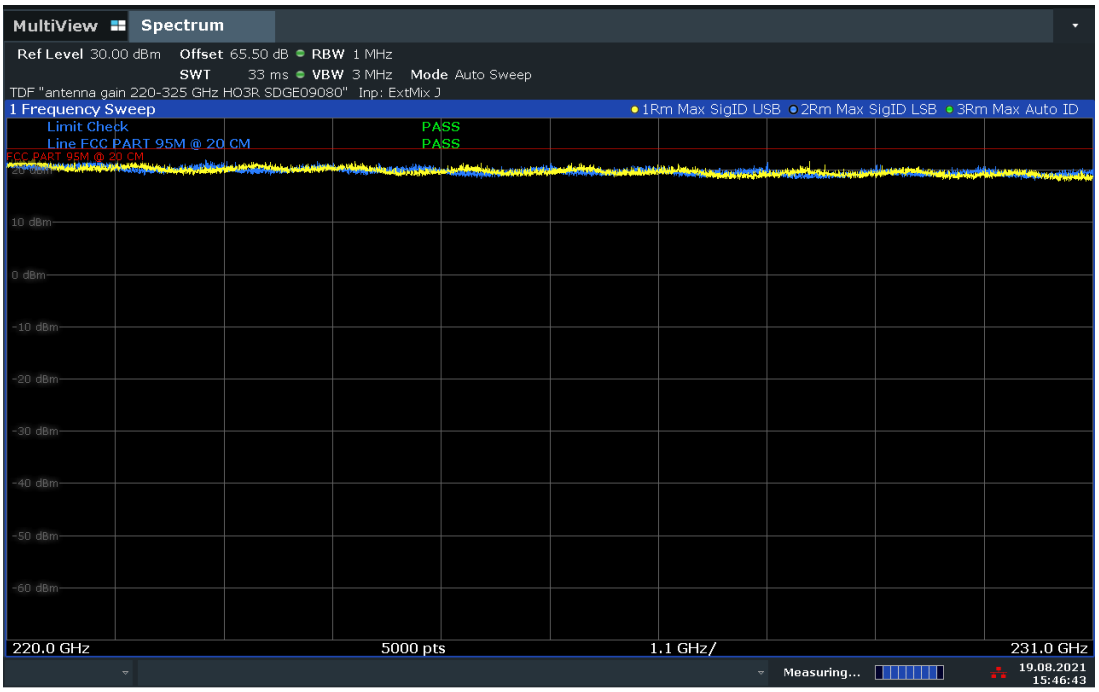
14:43:30 19.08.2021

110 to 160 GHz



15:23:31 19.08.2021

140 to 220 GHz



15:46:44 19.08.2021

220 to 231 GHz

2.4 FREQUENCY STABILITY

2.4.1 Specification Reference

Part 2.1055, FCC Part 95 Subpart M §95.3379(b) and RSS-251 Section 11

2.4.2 Standard Applicable

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 to +50 degrees Celsius with an input voltage variation of 85% to 115% of rated input voltage, unless justification is presented to demonstrate otherwise.

2.4.3 Equipment Under Test and Modification State

Serial No: 2021-05-17 / Default Test Configuration

2.4.4 Date of Test/Initial of test personnel who performed the test

August 17, 2021 / FSC

2.4.5 Test Equipment Used

The major items of test equipment used for the above tests are identified in Section 3.1.

2.4.6 Environmental Conditions

Test performed at TÜV SÜD America Inc. Mira Mesa facility

Ambient Temperature	25.0 °C
Relative Humidity	49.4 %
ATM Pressure	100.1 kPa

2.4.7 Additional Observations

- EUT has no antenna port available. The measurements under this section were performed using radiated measurement method.
- Temperature range used is -20°C to +50°C. During test the EUT spectrum was monitored in the entire temperature range at 10 °C intervals.
- Input voltage variation is not performed as the EUT is powered by USB 5V which is regulated.
- RBW is 1 MHz while VBW is 3 MHz
- Detector is Peak
- Trace is Max Hold
- The OBW function of the Spectrum Analyzer is used for this test. The edges (T1 and T2) were observed verifying they stayed within 76 and 81GHz band during the entire test.

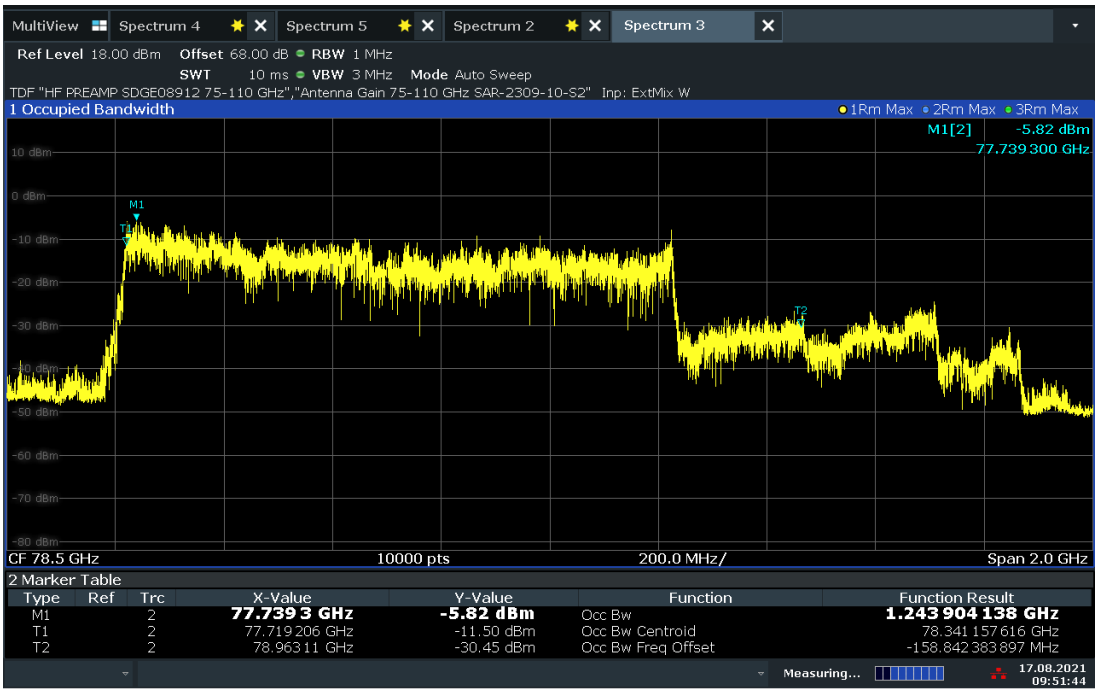
2.4.8 Test Results

Complies. See attached plots.

2.4.9 Test Results

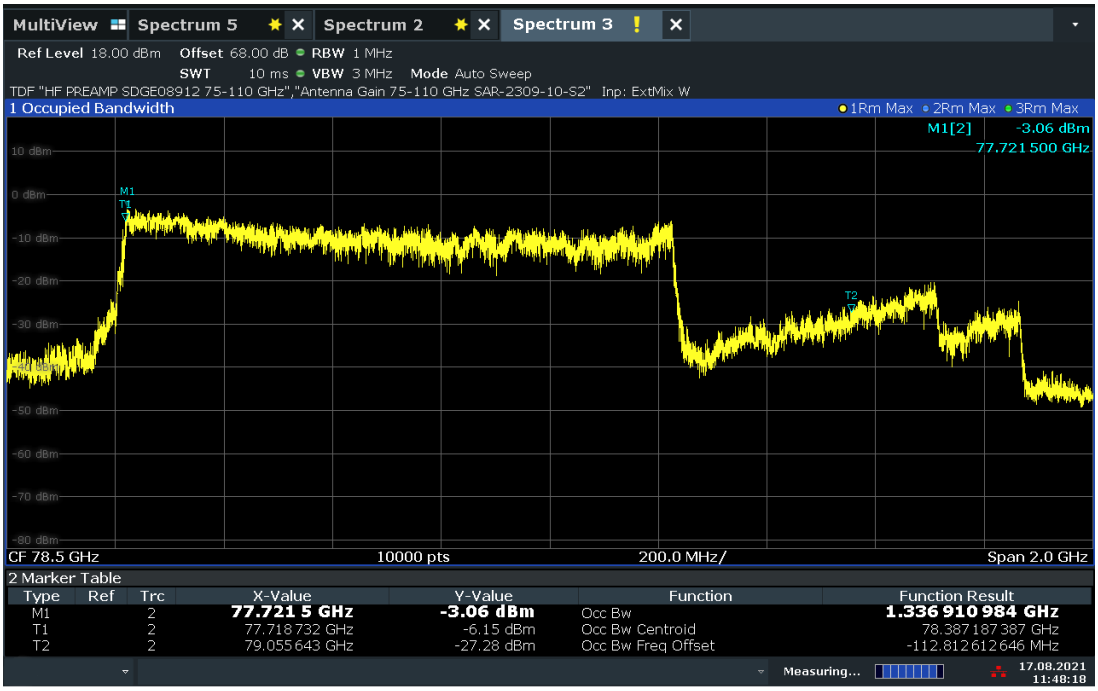
07:41:53 17.08.2021

50°C



09:51:44 17.08.2021

Nominal Voltage @ 20°C



11:48:18 17.08.2021

-20°C

SECTION 3

TEST EQUIPMENT USED

3.1 TEST EQUIPMENT USED

List of absolute measuring and other principal items of test equipment.

ID Number (SDGE/SDRB)	Test Equipment	Type	Serial Number	Manufacturer	Cal Date	Cal Due Date
Radiated Emission						
1049	EMI Test Receiver	ESU40	100133	Rohde & Schwarz	09/25/20	09/25/21
7611	Signal/Spectrum Analyzer	FSW26	102017	Rohde & Schwarz	02/02/21	02/02/22
1003	Signal Generator	SMR40	100443	Rohde & Schwarz	06/25/21	06/25/22
1002	Bilog Antenna	3142C	0058717	EMCO	10/09/19	10/09/21
7631	Double-ridged waveguide horn	3117	00205418	ETS-Lindgren	09/16/20	09/16/22
46797	Preamplifier	PA-122	181925	Com Power	10/28/20	10/28/21
6628	Loop Antenna	HFH2-Z2335.4711.52	FNr.800.458/25	Rohde & Schwarz	05/22/20	05/20/22
9001	Horn antenna (18-26.5GHz)	HO42S	101	Custom Microwave	09/09/19	09/09/21
9003	Horn antenna (26-40 GHz)	HO28S	102	Custom Microwaves	09/09/19	09/09/21
40815	Pre-amplifier (18-40 GHz)	19D18	15G27	Spacek Labs	10/05/20	10/05/21
7637	Harmonics mixer (40-60 GHz)	FS-Z60	100009	Rhode & Schwarz	07/29/20	07/29/23
7636	Harmonics mixer (60-90 GHz)	FS-Z90	100092	Rhode & Schwarz	07/29/20	07/29/23
51288	Harmonics mixer (50-75 GHz)	FS-Z75	102099	Rohde & Schwarz	03/11/21	07/29/23
7633	Harmonics mixer (75-110 GHz)	HM-110-7	101000	Radiometer Physics	02/22/21	07/29/23
7634	Harmonics mixer (110-170 GHz)	HM-170	0062	Radiometer Physics	02/22/21	07/29/23
7635	Harmonics mixer (170-220 GHz)	HM-220	020022	Radiometer Physics	02/22/21	07/29/23
7632	Harmonics mixer (220-325 GHz)	HM-325	020075	Radiometer Physics	02/22/21	07/29/23
8908	Pre-amplifier (40-60 GHz)	SBL-4036033080-1919-E1	12020-01	Sage Millimeter, Inc.	07/07/21	07/29/23
8892	Pre-amplifier (50-75 GHz)	SBL-5037533050-1515-E1	12020-01	Sage Millimeter, Inc.	07/07/21	07/29/23
8912	Pre-amplifier (75-110 GHz)	FLNA-10-0005	FTL17328	Farran Technology Ltd.	07/07/21	07/29/23
8913	Pre-amplifier (110-170 GHz)	D LNA 110-170 30 6	100004	Radiometer Physics	Verified by 7611 and corresponding direct reading attenuator/active multiplier combination	
9003	Horn antenna (40-60 GHz)	HO19R	103	Custom Microwaves		
9004	Horn antenna (50-75 GHz)	HO15R	104	Custom Microwaves		
7628	Horn antenna (75-110 GHz)	SAR-2309-10-S2	13481-01	Sage Millimeter, Inc.		
9079	Horn antenna (140-220 GHz)	HO5R	HO5R	Custom Microwaves		

ID Number (SDGE/SDRB)	Test Equipment	Type	Serial Number	Manufacturer	Cal Date	Cal Due Date
9078	Horn antenna (110-170 GHz)	HO6R	HO6R	Custom Microwaves	Verified by 7611 and corresponding direct reading attenuator/active multiplier combination	
9082	Horn antenna (140-220 GHz)	HO5R	N/A	Custom Microwaves		
9080	Horn antenna (220-325 GHz)	HO3R	N/A	Custom Microwaves		
8872	Direct Reading Attenuator (40-60	STA-60-19-D1	11875-01	Sage Millimeter, Inc.	Verified by 7611 and corresponding antenna/mixer combination	
8860	Direct Reading Attenuator (50-75	STA-60-15-D1	11466-01	Sage Millimeter, Inc.		
8861	Direct Reading Attenuator (75-110	STA-60-10-D1	11466-01	Sage Millimeter, Inc.		
8919	Direct Reading Attenuator (90-140	STA-60-08-D1	12605-01	Sage Millimeter, Inc.		
8909	Direct Reading Attenuator (140-220	STA-60-05-D1	12020-01	Sage Millimeter, Inc.		
8873	Active Multiplier (40-60 GHz)	AMC-19-RFH00	124	Millitech, Inc.		
8914	Active Multiplier (50-75 GHz)	AMC-15-RFH00	283	Millitech, Inc.		
8915	Active Multiplier (75-110 GHz)	AMC-10-RFH00	606	Millitech, Inc.		
8920	Active Multiplier (90-140 GHz)	AMC-08-RFH00	58	Millitech, Inc.		
8909	Active Multiplier (140-220 GHz)	MCA-05-150096	13	Millitech, Inc.		
Miscellaneous						
43003	True RMS Multimeter	85 III	69880143	Fluke	10/23/20	10/23/21
6805	Environmental Chamber	ESL-4CA	18021	Espec	01/13/21	01/13/22
7619	Temp/Humidity Sensor	iBTHX-W	15050268	Omega	03/09/21	03/09/22
-	Test Software	EMC32	V10.50.40	Rhode & Schwarz	N/A	

3.2 MEASUREMENT UNCERTAINTY

Calculation of Measurement Uncertainty per CISPR 16-4-2:2011 with Corr. 1

3.2.1 Antenna Conducted Port Measurements

Antenna Port Conducted Measurements						
	Input Quantity (Contribution) Xi	Value	Prob. Dist.	Divisor	ui(x)	ui(x)2
1	Receiver reading	0.10 dB	Normal, k=1	1.000	0.10	0.01
2	Cable attenuation	1.00 dB	Normal, k=2	2.000	0.50	0.25
3	Receiver sinewave accuracy	0.08 dB	Normal, k=2	2.000	0.04	0.00
4	Receiver pulse amplitude	0.00 dB	Rectangular	1.732	0.00	0.00
5	Receiver pulse repetition rate	0.00 dB	Rectangular	1.732	0.00	0.00
6	Noise floor proximity	0.00 dB	Rectangular	1.732	0.00	0.00
7	Frequency interpolation	0.10 dB	Rectangular	1.732	0.06	0.00
8	Mismatch	0.07 dB	U-shaped	1.414	0.05	0.00
	Combined standard uncertainty		Normal	0.52 dB		
	Expanded uncertainty		**Normal, k=2**	**1.03 dB**		

3.2.2 Radiated Measurements (Below 1GHz)

	Input Quantity (Contribution) X_i	Value	Prob. Dist.	Divisor	$u_i(x)$	$u_i(x)^2$
1	Receiver reading	0.10 dB	Normal, k=1	1.000	0.10	0.01
2	Attenuation: antenna-receiver	0.20 dB	Normal, k=2	2.000	0.10	0.01
3	Antenna factor AF	0.75 dB	Normal, k=2	2.000	0.38	0.14
4	Receiver sinewave accuracy	0.45 dB	Normal, k=2	2.000	0.23	0.05
5	Receiver pulse amplitude	1.50 dB	Rectangular	1.732	0.87	0.75
6	Receiver pulse repetition rate	1.50 dB	Rectangular	1.732	0.87	0.75
7	Noise floor proximity	0.50 dB	Rectangular	1.732	0.29	0.08
8	Mismatch: antenna-receiver	0.95 dB	U-shaped	1.414	0.67	0.45
9	AF frequency interpolation	0.30 dB	Rectangular	1.732	0.17	0.03
10	AF height deviations	0.10 dB	Rectangular	1.732	0.06	0.00
11	Directivity difference at 3 m	3.12 dB	Rectangular	1.732	1.80	3.24
12	Phase center location at 3 m	1.00 dB	Rectangular	1.732	0.58	0.33
13	Cross-polarisation	0.90 dB	Rectangular	1.732	0.52	0.27
14	Balance	0.00 dB	Rectangular	1.732	0.00	0.00
15	Site imperfections	3.76 dB	Triangular	2.449	1.54	2.36
16	Separation distance at 3 m	0.30 dB	Rectangular	1.732	0.17	0.03
17	Effect of setup table material	0.77 dB	Rectangular	1.732	0.44	0.20
18	Table height at 3 m	0.10 dB	Normal, k=2	2.000	0.05	0.00
19	Near-field effects	0.00 dB	Triangular	2.449	0.00	0.00
20	Effect of ambient noise on OATS	0.00 dB				0.00
	Combined standard uncertainty		Normal	2.95 dB		
	Expanded uncertainty		**Normal, k=2**	**5.90 dB**		

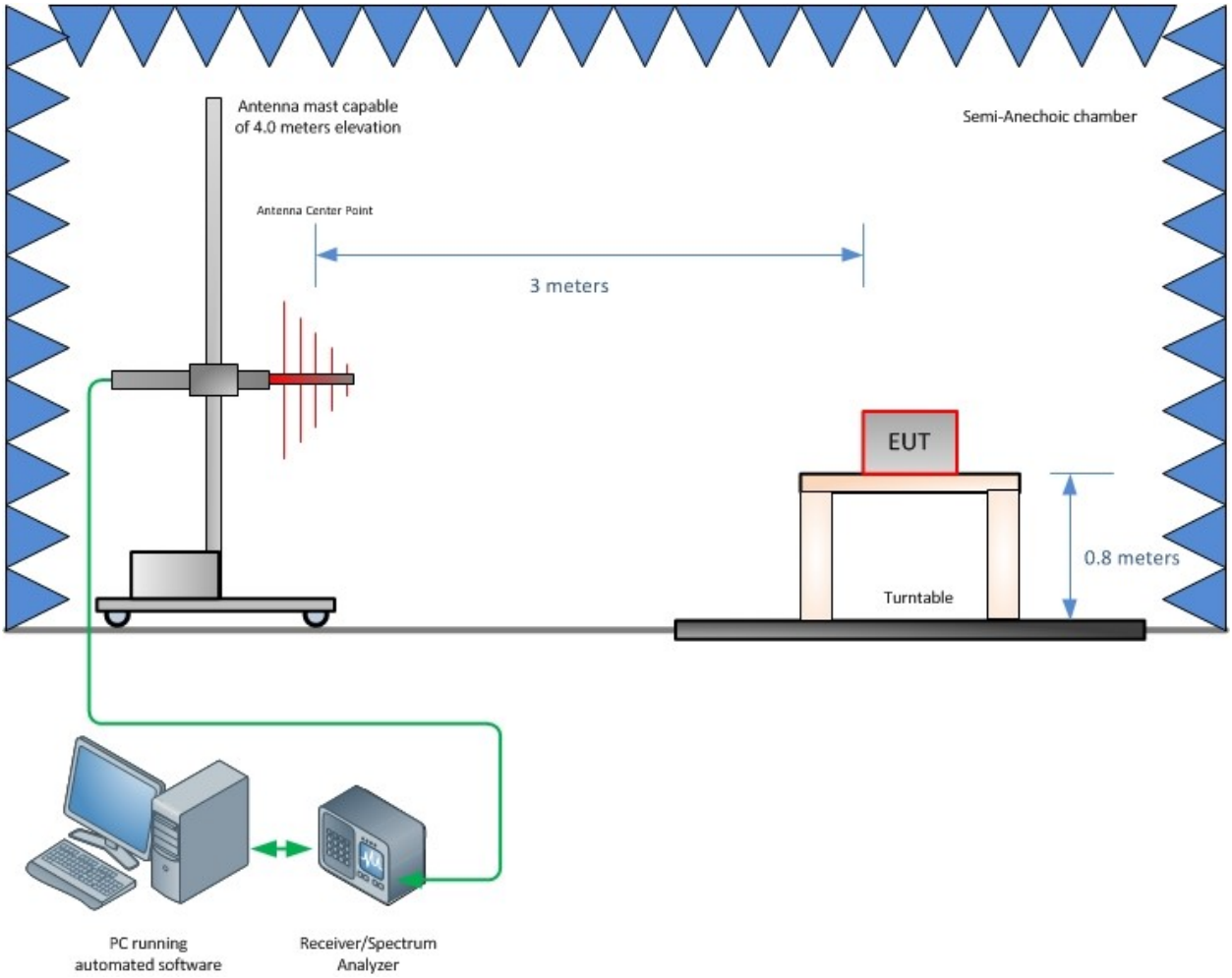
3.2.3 Radiated Emission Measurements (Above 1GHz)

	Input Quantity (Contribution) X_i	Value	Prob. Dist.	Divisor	$u_i(x)$	$u_i(x)^2$
1	Receiver reading	0.10 dB	Normal, k=1	1.000	0.10	0.01
2	Attenuation: antenna-receiver	0.20 dB	Normal, k=2	2.000	0.10	0.01
3	Antenna factor AF	0.75 dB	Normal, k=2	2.000	0.38	0.14
4	Receiver sinewave accuracy	0.45 dB	Normal, k=2	2.000	0.23	0.05
5	Receiver pulse amplitude	1.50 dB	Rectangular	1.732	0.87	0.75
6	Receiver pulse repetition rate	1.50 dB	Rectangular	1.732	0.87	0.75
7	Noise floor proximity	0.50 dB	Rectangular	1.732	0.29	0.08
8	Mismatch: antenna-receiver	0.95 dB	U-shaped	1.414	0.67	0.45
9	AF frequency interpolation	0.30 dB	Rectangular	1.732	0.17	0.03
10	AF height deviations	0.10 dB	Rectangular	1.732	0.06	0.00
11	Directivity difference at 3 m	3.12 dB	Rectangular	1.732	1.80	3.24
12	Phase center location at 3 m	1.00 dB	Rectangular	1.732	0.58	0.33
13	Cross-polarisation	0.90 dB	Rectangular	1.732	0.52	0.27
14	Balance	0.00 dB	Rectangular	1.732	0.00	0.00
15	Site imperfections	3.25 dB	Triangular	2.449	1.33	1.76
16	Separation distance at 3 m	0.30 dB	Rectangular	1.732	0.17	0.03
17	Effect of setup table material	0.77 dB	Rectangular	1.732	0.44	0.20
18	Table height at 3 m	0.10 dB	Normal, k=2	2.000	0.05	0.00
19	Near-field effects	0.00 dB	Triangular	2.449	0.00	0.00
20	Effect of ambient noise on OATS	0.00 dB				0.00
	Combined standard uncertainty		Normal	2.85 dB		
	Expanded uncertainty		**Normal, k=2**	**5.70 dB**		

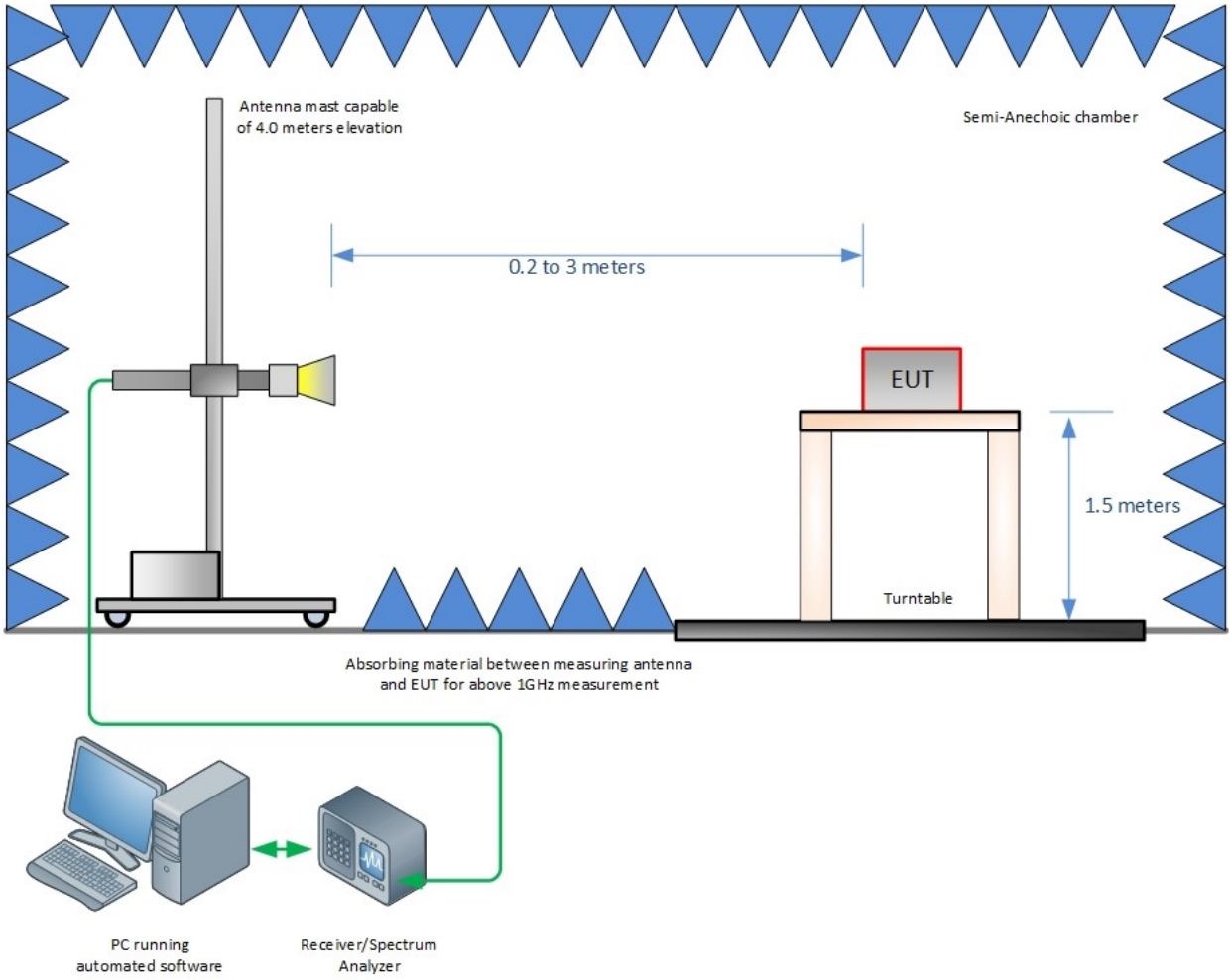
SECTION 4

DIAGRAM OF TEST SETUP

4.1 TEST SETUP DIAGRAM



Radiated Emission Test Setup (Below 1GHz)



Radiated Emission Test Setup (Above 1GHz)

SECTION 5

ACCREDITATION, DISCLAIMERS AND COPYRIGHT

5.1 ACCREDITATION, DISCLAIMERS AND COPYRIGHT

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