Radio Testing of the
Piaggio Fast Forward, Inc.
Blind Spot Information System
BLIS - Bike Module R02129-BLIS

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

America

Add value.
Inspire trust.

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

COMMERCIAL-IN-CONFIDENCE

Date: March 2022
Document Number: 72175205A Issue 02 | Version Number: 02

RESPONSIBLE FOR	NAME	DATE	SIGNATURE
Authorized Signatory	Ferdinand S. Custodio	March 29, 2022	

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. Blind Spot Information System BLIS - Bike Module R02129-BLIS
TEST REPORT NUMBER	72175205A
TEST REPORT DATE	March 2022
PREPARED FOR	Piaggio Fast Forward, Inc. 52 Roland St. Charlestown MA 02129
CONTACT PERSON	Jean-Claude Coutant Chief Technical Officer jc.coutant@piaggiofastforward.com (857) 997-2320
PREPARED BY	Xiaoying Zhang **Name** Authorized Signatory Title: Senior RF Wireless Test Engineer
APPROVED BY	Ferdinand S. Custodio **Name** Authorized Signatory Title: Senior EMC Test Engineer / Wireless Team Lead
DATED	March 29, 2022

Revision History

72175205A Piaggio Fast Forward, Inc. Blind Spot Information System BLIS - Bike Module R02129-BLIS					
DATE	OLD REVISION	NEW REVISION	REASON	PAGES AFFECTED	APPROVED BY
03/29/2022	—	Initial Release			Ferdinand Custodio
12/10/2022	Initial Release	Issue 2.0	update Average power measurement	8, 15 and 16	Ferdinand Custodio
12/14/2022	Issue 2.0	Issue 2.0 V2.0	• Update Test Methodology to ANSI C63.10 • Modulation characteristic defined • 16 antenna configurations defined	6, 8 and 11	Ferdinand Custodio

CONTENTS

SECTION 1

REPORT SUMMARY

Radio Testing of the
Piaggio Fast Forward, Inc.
Blind Spot Information System
BLIS - Bike Module R02129-BLIS

1.1 INTRODUCTION

The information contained in this report is intended to show verification of the Piaggio Fast Forward, Inc. Blind Spot Information System BLIS - Bike Module 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	Blind Spot Information System
Model Name	BLIS - Bike Module
Model Number	R02129-BLIS
FCC ID	2AY6H-101440
IC Number	27808-101440
Serial Number(s)	N/A
Number of Samples Tested	1
Test Specification/Issue/Date	• CFR 47 Part 95 Subpart M (October 1, 2021). • RSS-251 Issue 2 July 2018 Vehicular Radar and Airport Fixed or Mobile Radar in the 76-81 GHz Frequency Band
Start of Test	January 13, 2022
Finish of Test	February 18, 2022
Name of Engineer(s)	Xiaoying Zhang
Related Document(s)	• ANSI C63.10-2013. American National Standard of Procedures for Compliance testing of Unlicensed Wireless Devices. • KDB 653005 D01 76-81 GHz Radars v01r01 • Application Note 1EF107-1E Rohde & Schwarz Peak and Mean Power measurements on wideband FMCW radar signals • Rider Assist 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 a Piaggio Fast Forward, Inc. Blind Spot Information System, BLIS - Bike Module in 76-77GHz range. The Blind Spot Information System (BLIS) warns the rider against collisions that may occur due to a lane change maneuver. BLIS are intended to supplement the vehicle's rear-view mirrors, not eliminate the need for such mirrors. BLIS are intended to detect vehicles to the rear and sides of the subject vehicle and warn the rider if a lane change is not recommended. BLIS are not meant to encourage aggressive driving and the absence of a warning will not guarantee that the rider can safely make a lane change maneuver.

1.3.2 Technical Description

EUT Description	Blind Spot Information System
Model Name	BLIS - Bike Module
Model Number	R02129-BLIS
Serial Number	N/A
Input Voltage	12VDC
Output RF Power	8.14 dBm EIRP (Average band power)
Frequency Range	76GHz to 77GHz (1 GHz)
Modulation Type	FMCW
Modulation Characteristic	Sawtooth
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 *16 transmitters out of the 20 are used. It is predefined in the FW package provided, OEM integrators can't modify this configuration without a release of a dedicated new FW package from the manufacturer. The use of 16 transmitters is regulated.*

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 12VDC from an ancillary AC/DC adaptor. The manufacturer additionally provided a terminal emulator (PCAN View) on the laptop to turn on and off the radio.

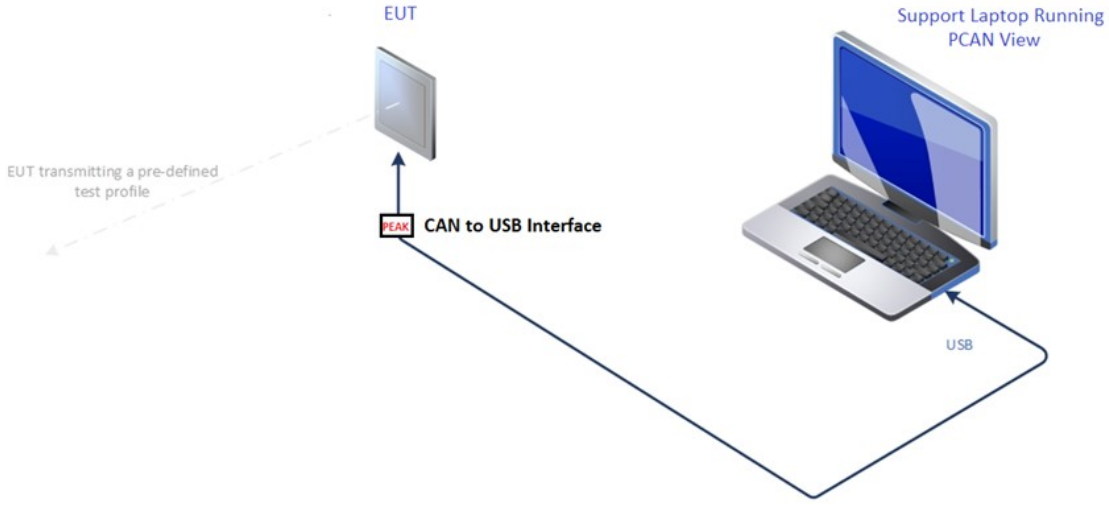
1.4.2 EUT Exercise Software

None. No special software was used to exercise the EUT however the manufacturer provided a terminal emulator (PCAN View) to turn on and off radar operation.

1.4.3 Support Equipment and I/O cables

Manufacturer	Equipment/Cable	Description
DELL	Support Laptop	Model: Precision 7520, S/N: D0MPLH2
DELL	Support Laptop AC Adapter	M/N: DA180PM111 S/N: CN-045G4G-DES00-71D-01GB-A00
XP Power	Support AC/DC Adaptor	M/N: AKM45US12, S/N: 2030-01584 IP: 100 – 240 VAC, 1.1A OP: 12 VDC, 4.0A
PEAK	CAN to USB Interface Adaptor	M/N: PEH-002021-339078
Piaggio	Customized Device Cable	LED/CAN interconnect/Power Input)

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: N/A		
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 C63.10-2013. American National Standard of Procedures for Compliance testing of Unlicensed Wireless Devices.

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 C63.10-2013. 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.
Blind Spot Information System
BLIS - Bike Module R02129-BLIS

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: N/A / Default Test Configuration

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

January 26, 2022 / XYZ
December 10, 2022 / 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	20.9 to 22.7 °C
Relative Humidity	39.3 to 41.0 %
ATM Pressure	100.7 to 100.8 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:

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

$$\mathrm{CF_{chirp}} = 5 \times \log\left(1 + 0.1947 \times \left(\frac{454\ \mathrm{MHz}}{23\mu\mathrm{s} \times 1\mathrm{MHz}^2}\right)^2\right)$$

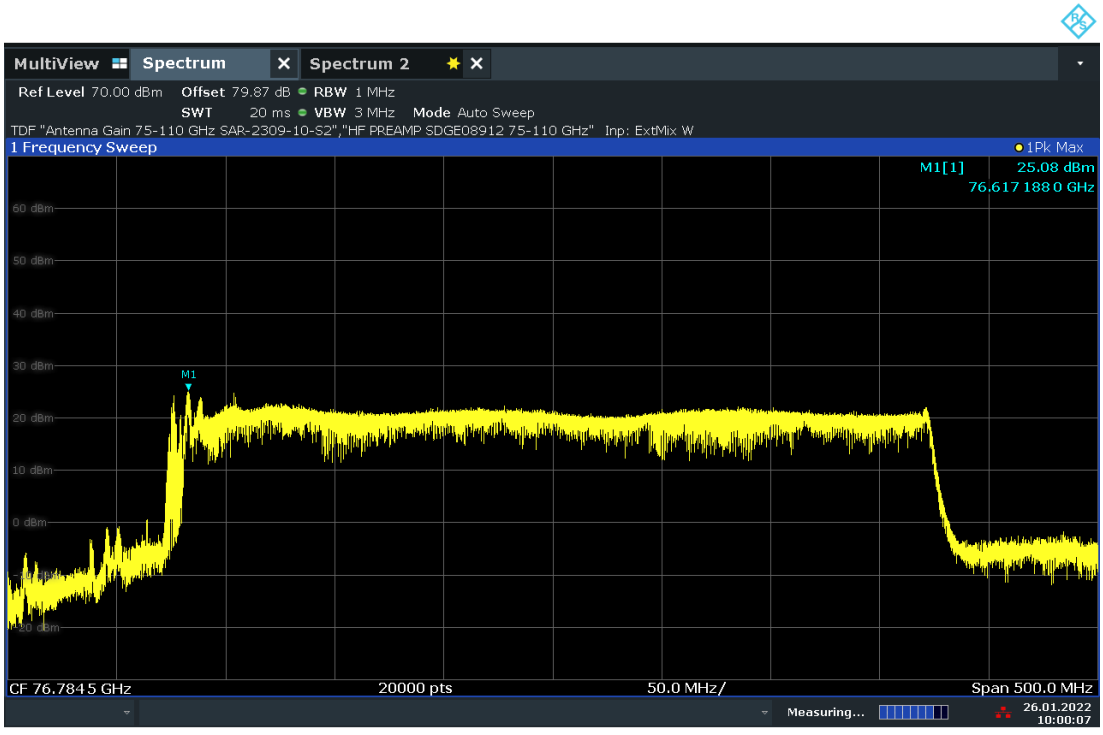
$$\mathrm{CF_{chirp}} = 9.43\ \mathrm{dB}$$

Note: Span is the measured Maximum OBW.

2.1.8 Test Results

Detector	EIRP	FMCW Chirps Correction Factor	Corrected Level (EIRP)	EIRP Limit
Peak	25.08 dBm	9.43 dB	34.51 dBm	55 dBm
Average (band power)	8.14 dBm	-	8.14 dBm	50 dBm

2.1.9 Test Plots



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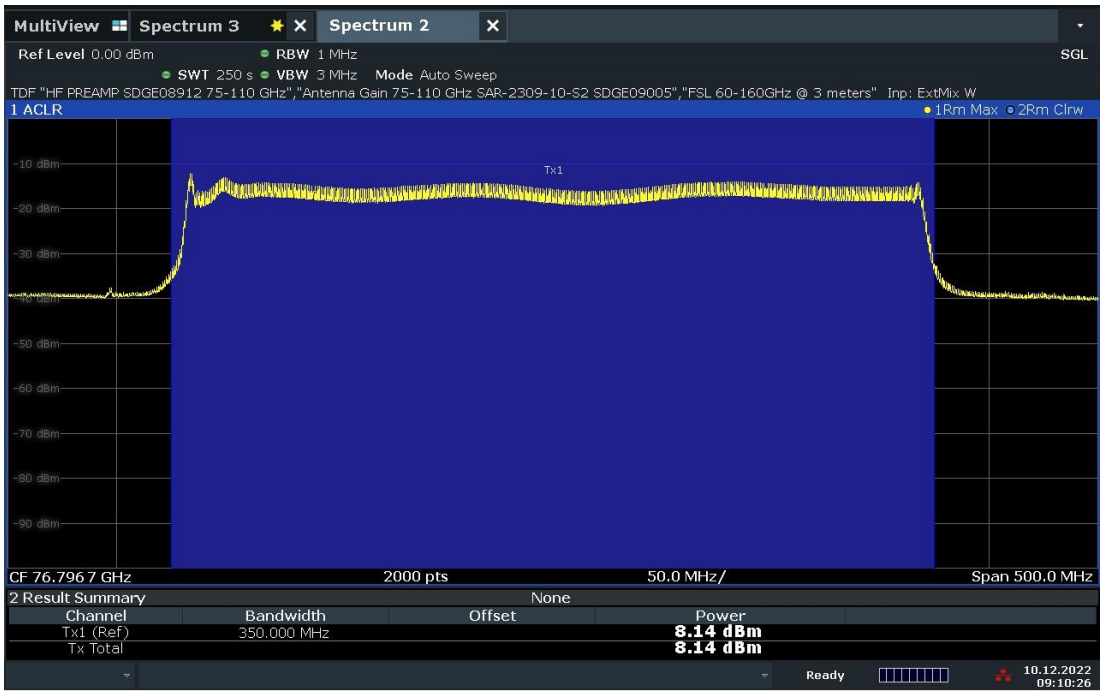
Peak Power EIRP



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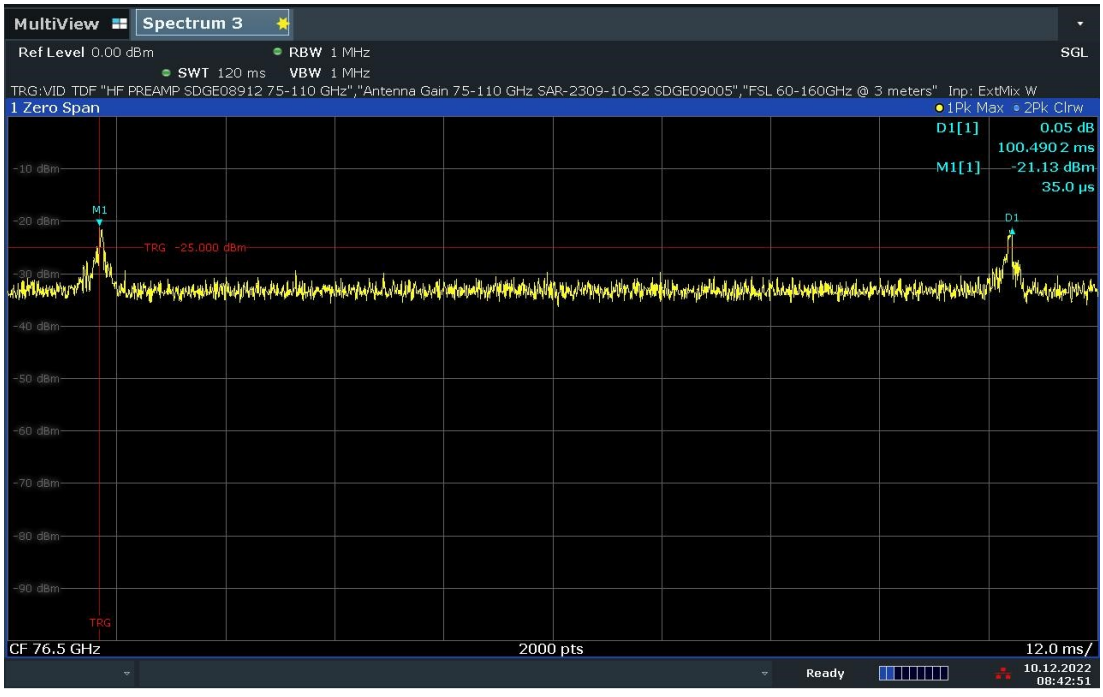
Average Power EIRP



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Observed Cycle Time

Sweep Time	≥ EUT cycle time x number of sweep points ≥ 100.4902 ms x 2000 pts ≥ 200.98 seconds (verification performed @ 250 seconds)

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: N/A / Default Test Configuration

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

January 26, 28 and February 18, 2022 / XYZ

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	19.7 – 22.7 °C
Relative Humidity	38.7 – 41.0 %
ATM Pressure	100.7 – 100.8 kPa

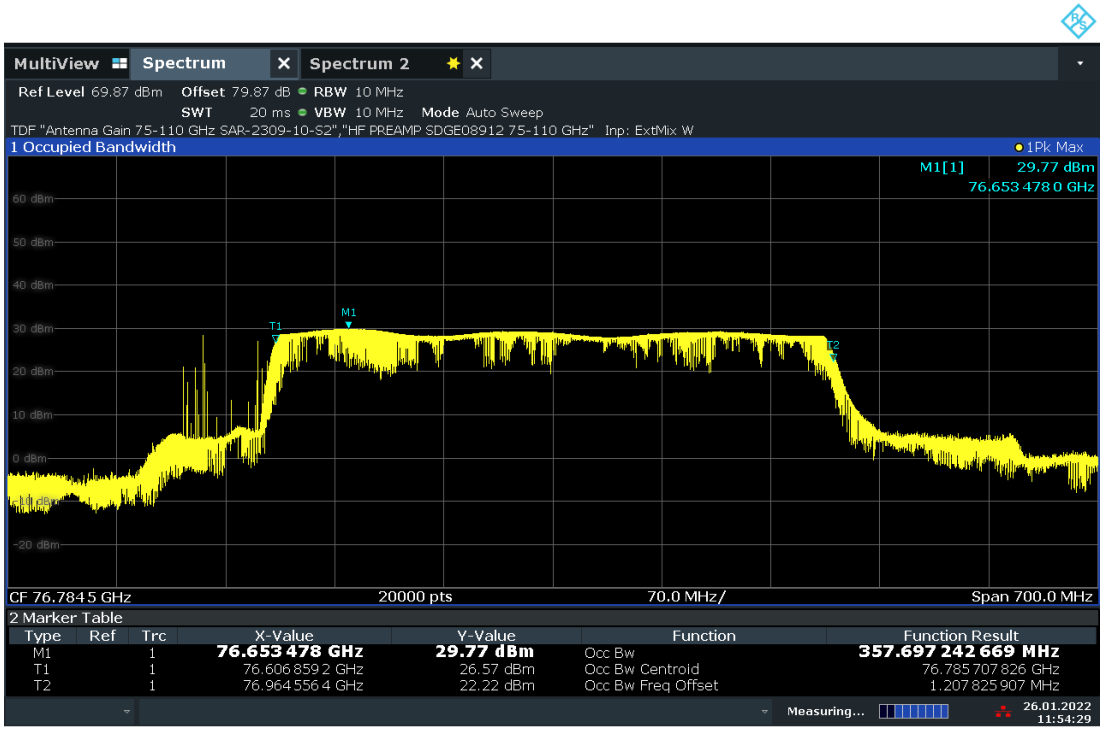
2.2.7 Additional Observations

- This is a radiated test.
- The measurements were performed under both normal and extreme test conditions.
- Span is wide enough to capture the channel transmission.
- RBW is between 1% to 5% of the anticipated OBW.
- 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.

2.2.8 Test Results

Voltage (VDC)	Temperature (°C)	99% Occupied Bandwidth (MHz)
12	+50	351.576
	+40	353.792
	+30	365.561
	+20	357.697
	+10	435.063
	0	451.834
	-10	453.693
	-20	440.059
	-30	405.206
10.2	+20	357.070
13.8		354.630

2.2.9 Sample Test Plot



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99% OBW at 20°C

2.3 UNWANTED EMISSIONS LIMITS

2.3.1 Specification Reference

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

2.3.2 Standard Applicable

FCC Part 95.3379:
(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/cm^2 (-1.68dBm) 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/cm^2 (0.53 dBm) 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.

RSS-251 Clause 10.2:
The radar device's unwanted emissions outside the 76-81 GHz frequency band shall comply with the limits in table 1, below.

Table 1: Unwanted emissions limits outside the 76 – 81 GHz frequency band

Emission frequency range (MHz)	Limit	Applicable detector
Below 40 GHz	RSS-Gen general field strength limits for license-exempt radio apparatus	RSS-Gen requirements
40 – 162 GHz*	-30 dBm/MHz (e.i.r.p)	RMS detector
Note: * 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.		

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: N/A / Default Test Configuration

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

January 13 to 27, 2022 / XYZ

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	22.3 – 24.8 °C
Relative Humidity	22.5 – 45.8 %
ATM Pressure	99.8 – 100.7 kPa

2.3.7 Additional Observations

- This is a radiated test.
- The spectrum was searched from 30MHz to 243GHz.
- 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**

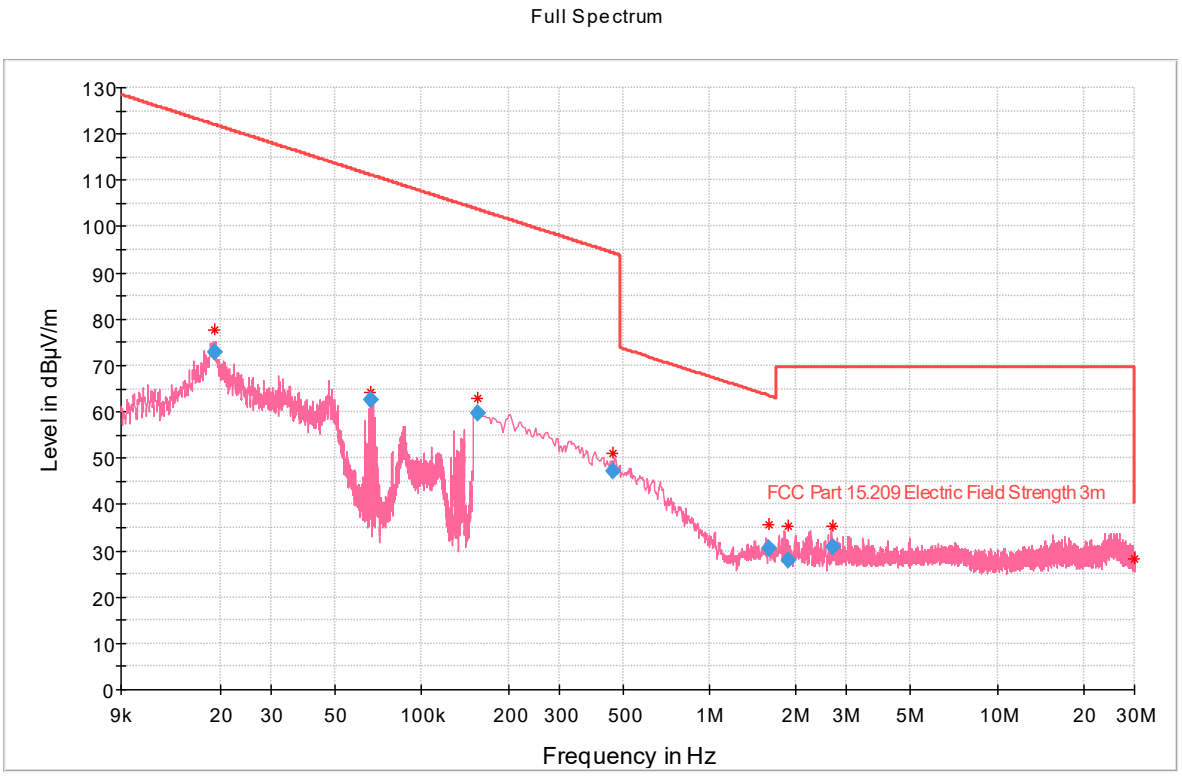
- For measurements above 40GHz, the corresponding transducer factor (TDF) were programmed directly to the Spectrum Analyzer (e.g. antenna gain, LNA and the free space loss).
- Measurements above 40GHz are maximized by hand and the worst-case plot (max hold or single capture) presented.
- Tests distances,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

Frequency Range	Test Distance	Limit	Detector
9 kHz to 490 kHz	3 meters	128.5 dBµV/m	Quasi-peak
9 kHz to 490 kHz	3 meters	93.8 dBµV/m	Quasi-peak
490 kHz to 1.705 MHz	3 meters	73.0 to 63.0 dBµV/m	Quasi-peak
1.705 MHz to 30 MHz	3 meters	69.5 dBµV/m	Quasi-peak
30 MHz to 88 MHz	3 meters	40 dBµV/m	Quasi-peak
88 MHz to 216 MHz	3 meters	43.52 dBµV/m	Quasi-peak
216 MHz to 960 MHz	3 meters	46.02 dBµV/m	Quasi-peak
960 MHz to 1 GHz	3 meters	53.98 dBµV/m	Quasi-peak
1 GHz to 18 GHz	3 meters	53.98 dBµV/m	Average
18 GHz to 26 GHz	3 meters	53.98 dBµV/m	Average
26 GHz to 40 GHz	3 meters	53.98 dBµV/m	Average
40 GHz to 50 GHz	3 meters	-30 dBm/MHz (e.i.r.p) (ISED)	Average
50 GHz to 75 GHz	3 meters	-30 dBm/MHz (e.i.r.p) (ISED)	Average
75 GHz to 76 GHz	3 meters	-30 dBm/MHz (e.i.r.p) (ISED)	Average
81 GHz to 110 GHz	1 meter	-20.46 dBm/MHz (e.i.r.p) (ISED)	Average
110 GHz to 162 GHz	1 meter	-20.46 dBm/MHz (e.i.r.p) (ISED)	Average
160 GHz to 220 GHz	1 meter	7.86 dBm/MHz (e.i.r.p) (FCC)	Average
220 GHz to 243 GHz	0.2 meter	24.05 dBm/MHz (e.i.r.p) (FCC)	Average

2.3.8 Test Results

Complies. See attached plots.

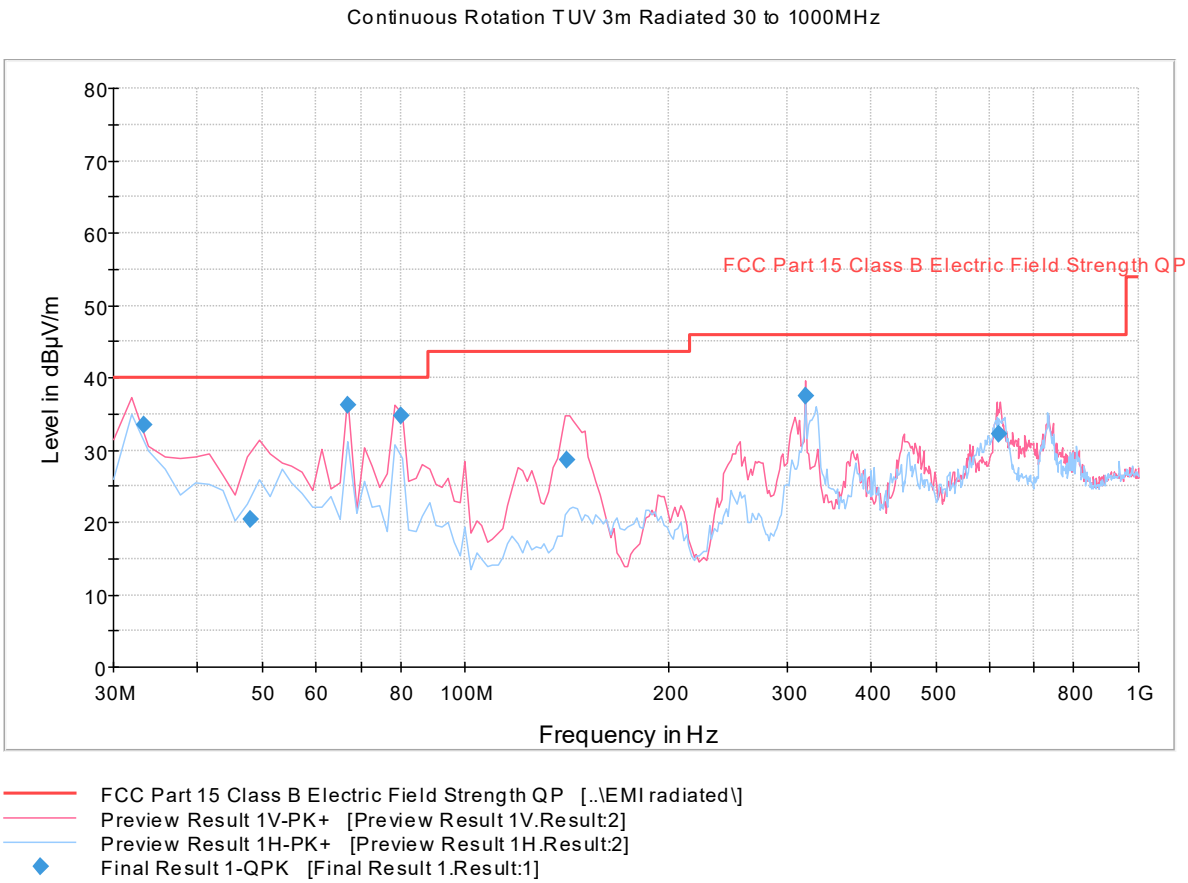
2.3.9 Below 30MHz Radiated Emission Test



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)
0.019015	72.91	122.02	49.11	1000.0	0.200	400.0	H	44.0	22
0.066534	62.62	111.14	48.52	1000.0	0.200	400.0	H	14.0	20
0.157000	59.60	103.68	44.09	1000.0	9.000	400.0	H	111.0	20
0.463565	47.20	94.28	47.08	1000.0	9.000	400.0	H	188.0	20
1.613786	30.52	63.44	32.92	1000.0	9.000	400.0	H	296.0	20
1.875247	27.80	69.50	41.70	1000.0	9.000	400.0	H	84.0	20
2.668038	30.72	69.50	38.78	1000.0	9.000	400.0	H	16.0	20

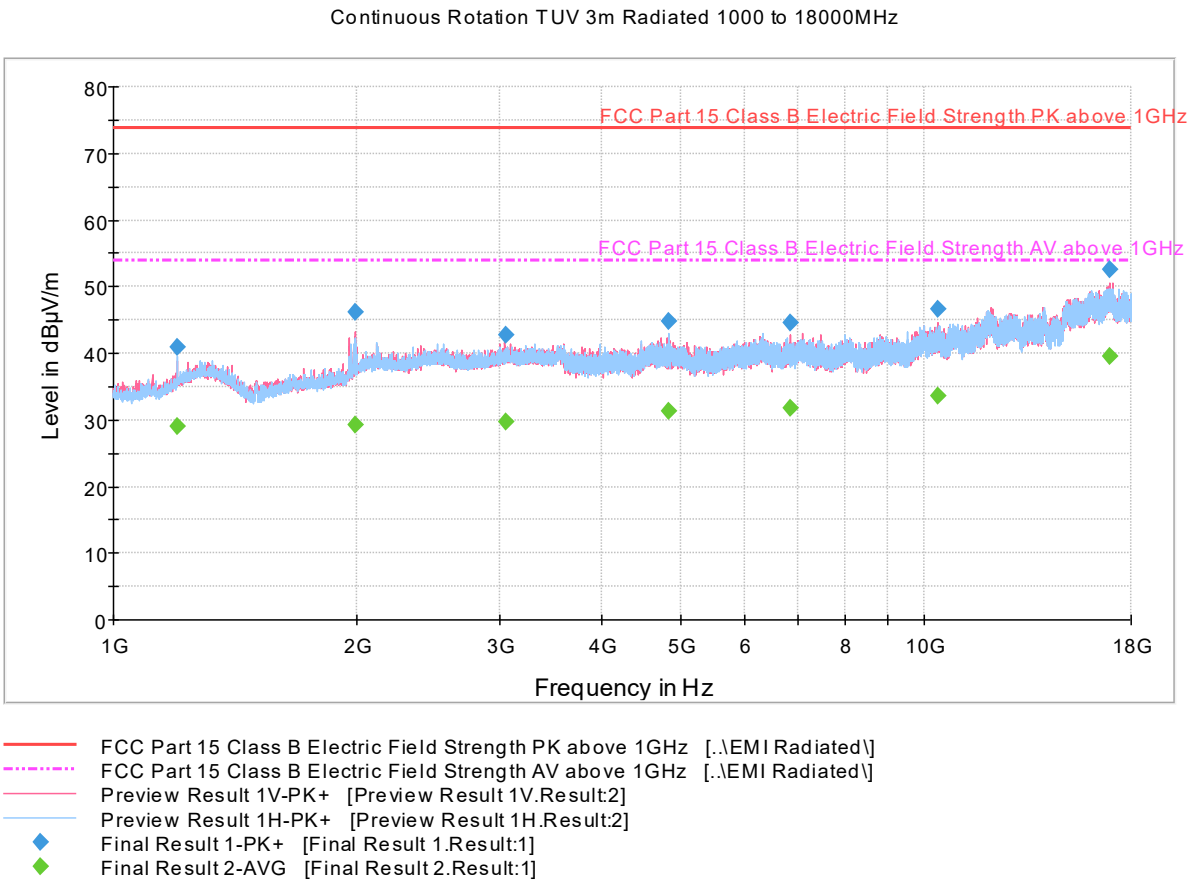
2.3.10 30MHz to 1GHz Radiated Emission Test



Quasi-Peak Data

Frequency (MHz)	QuasiPeak (dBµV/m)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Polarization	Azimuth (deg)	Corr. (dB)	Margin (dB)	Limit (dBµV/m)
33.360000	33.4	1000.0	120.000	111.0	V	327.0	-10.8	6.6	40.0
47.998878	20.5	1000.0	120.000	150.0	V	134.0	-16.7	19.5	40.0
66.773868	36.1	1000.0	120.000	100.0	V	13.0	-18.8	3.9	40.0
79.997194	34.7	1000.0	120.000	133.0	V	218.0	-17.9	5.3	40.0
141.241603	28.6	1000.0	120.000	100.0	V	6.0	-15.5	14.9	43.5
319.959279	37.5	1000.0	120.000	100.0	V	81.0	-8.2	8.5	46.0
619.405772	32.1	1000.0	120.000	127.0	V	213.0	-1.2	13.9	46.0

2.3.11 From 1GHz to 18GHz Radiated Emission Test



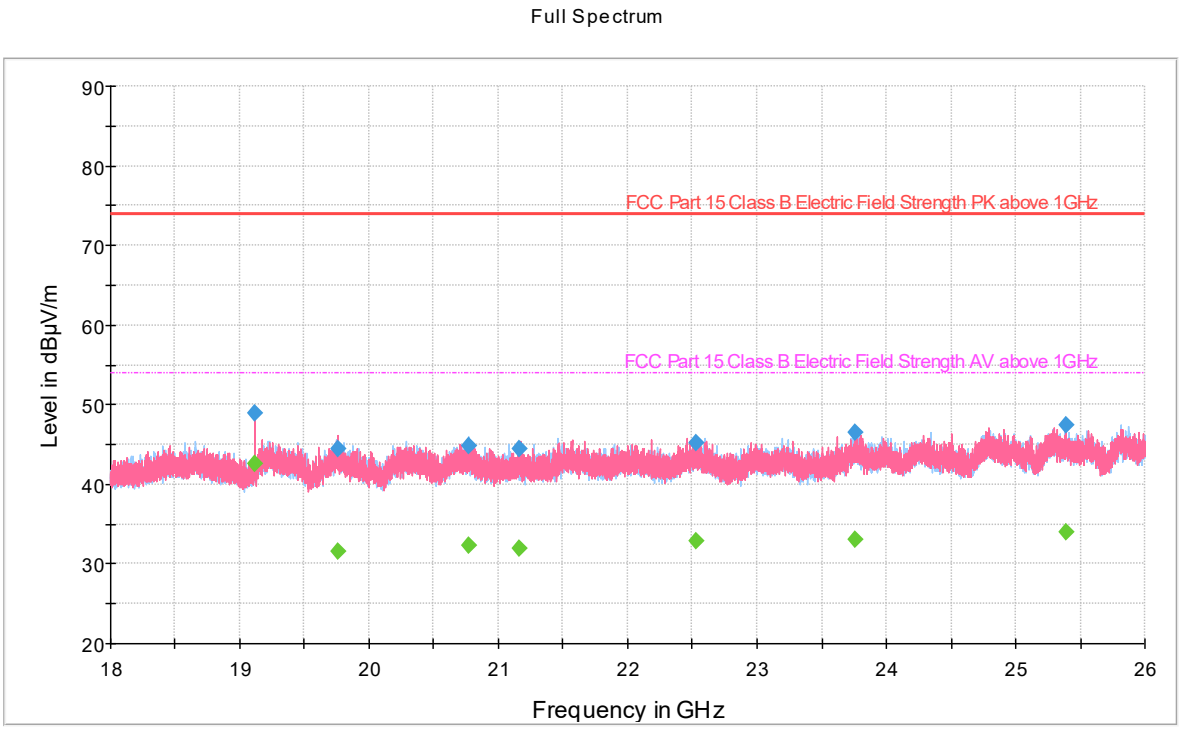
Peak Data

Frequency (MHz)	Max Peak (dBµV/m)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Polarization	Azimuth (deg)	Corr. (dB)	Margin (dB)	Limit (dBµV/m)
1200.066667	40.9	1000.0	1000.000	251.3	H	297.0	-6.6	33.0	73.9
1990.933333	46.3	1000.0	1000.000	295.2	V	310.0	-2.6	27.6	73.9
3042.100000	42.8	1000.0	1000.000	336.1	V	254.0	0.8	31.1	73.9
4847.866667	44.7	1000.0	1000.000	250.5	H	209.0	4.1	29.2	73.9
6825.700000	44.5	1000.0	1000.000	155.2	V	11.0	6.7	29.4	73.9
10388.766667	46.6	1000.0	1000.000	352.1	V	272.0	10.7	27.3	73.9
16947.366667	52.5	1000.0	1000.000	401.9	V	71.0	18.8	21.4	73.9

Average Data

Frequency (MHz)	Average (dBµV/m)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Polarization	Azimuth (deg)	Corr. (dB)	Margin (dB)	Limit (dBµV/m)
1200.066667	29.0	1000.0	1000.000	251.3	H	297.0	-6.6	24.9	53.9
1990.933333	29.2	1000.0	1000.000	295.2	V	310.0	-2.6	24.7	53.9
3042.100000	29.6	1000.0	1000.000	336.1	V	254.0	0.8	24.3	53.9
4847.866667	31.3	1000.0	1000.000	250.5	H	209.0	4.1	22.6	53.9
6825.700000	31.7	1000.0	1000.000	155.2	V	11.0	6.7	22.2	53.9
10388.766667	33.6	1000.0	1000.000	352.1	V	272.0	10.7	20.3	53.9
16947.366667	39.5	1000.0	1000.000	401.9	V	71.0	18.8	14.4	53.9

2.3.12 18GHz to 26GHz Radiated Emission Test



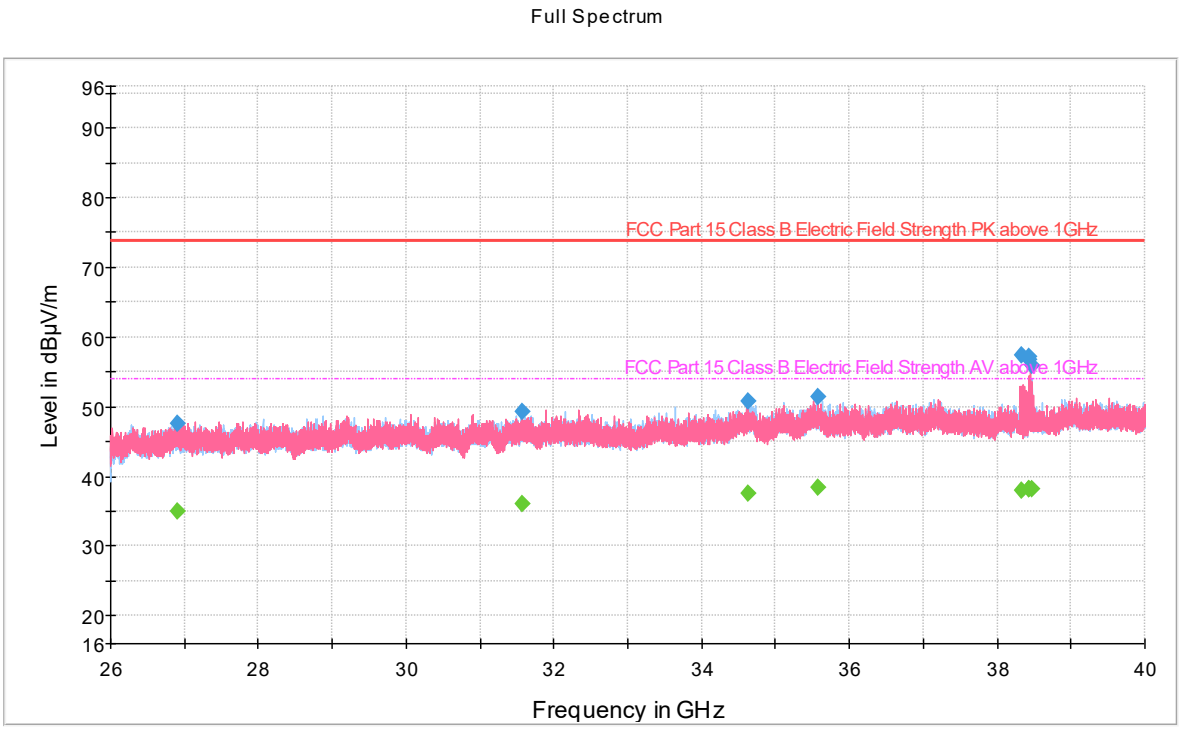
Peak Data

Frequency (MHz)	MaxPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
19118.928500	48.89	73.90	25.01	1000.0	1000.000	206.0	V	44.0	-3
19761.783500	44.40	73.90	29.50	1000.0	1000.000	192.0	V	54.0	-3
20770.065500	44.91	73.90	28.99	1000.0	1000.000	153.0	H	248.0	-2
21163.233000	44.53	73.90	29.37	1000.0	1000.000	190.0	V	277.0	-2
22529.292000	45.16	73.90	28.74	1000.0	1000.000	213.0	H	129.0	0
23761.591000	46.47	73.90	27.43	1000.0	1000.000	192.0	H	114.0	1
25387.117500	47.43	73.90	26.47	1000.0	1000.000	140.0	H	286.0	2

Average Data

Frequency (MHz)	Average (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
19118.928500	42.67	53.90	11.23	1000.0	1000.000	206.0	V	44.0	-3
19761.783500	31.66	53.90	22.24	1000.0	1000.000	192.0	V	54.0	-3
20770.065500	32.24	53.90	21.66	1000.0	1000.000	153.0	H	248.0	-2
21163.233000	31.94	53.90	21.96	1000.0	1000.000	190.0	V	277.0	-2
22529.292000	32.84	53.90	21.06	1000.0	1000.000	213.0	H	129.0	0
23761.591000	33.03	53.90	20.87	1000.0	1000.000	192.0	H	114.0	1
25387.117500	34.04	53.90	19.86	1000.0	1000.000	140.0	H	286.0	2

2.3.13 26GHz to 40GHz Radiated Emission Test



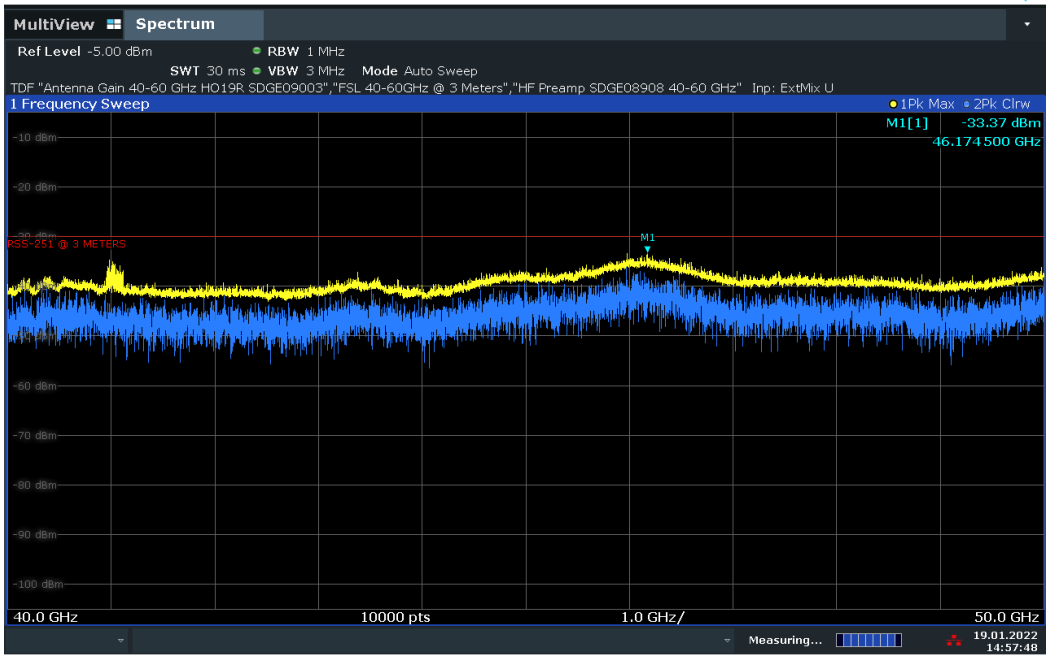
Peak Data

Frequency (MHz)	MaxPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
26895.140769	47.58	73.90	26.32	1000.0	1000.000	153.0	V	124.0	3
31567.352693	49.32	73.90	24.58	1000.0	1000.000	225.0	V	68.0	5
34623.765000	50.78	73.90	23.12	1000.0	1000.000	225.0	V	167.0	7
35579.496153	51.40	73.90	22.50	1000.0	1000.000	177.0	V	9.0	7
38325.099999	57.30	73.90	16.60	1000.0	1000.000	162.0	V	165.0	8
38432.134616	56.69	73.90	17.21	1000.0	1000.000	175.0	V	166.0	8
38438.986924	57.14	73.90	16.76	1000.0	1000.000	166.0	V	164.0	8
38477.670770	55.93	73.90	17.97	1000.0	1000.000	170.0	H	40.0	8

Average Data

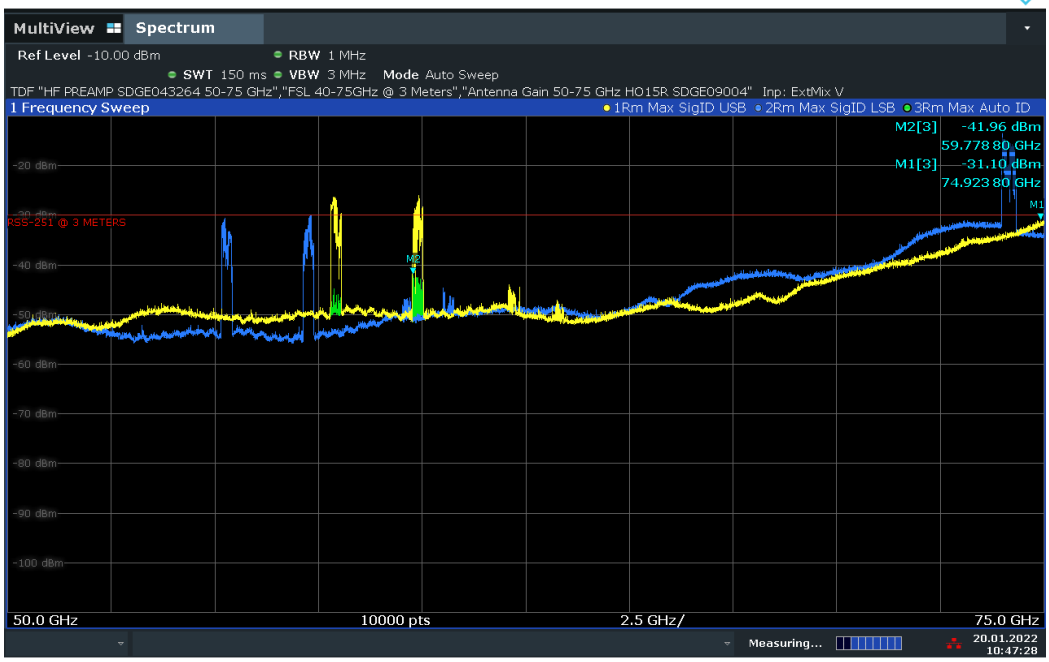
Frequency (MHz)	Average (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
26895.140769	35.08	53.90	18.82	1000.0	1000.000	153.0	V	124.0	3
31567.352693	36.09	53.90	17.81	1000.0	1000.000	225.0	V	68.0	5
34623.765000	37.62	53.90	16.28	1000.0	1000.000	225.0	V	167.0	7
35579.496153	38.51	53.90	15.39	1000.0	1000.000	177.0	V	9.0	7
38325.099999	37.97	53.90	15.93	1000.0	1000.000	162.0	V	165.0	8
38432.134616	38.23	53.90	15.67	1000.0	1000.000	175.0	V	166.0	8
38438.986924	38.24	53.90	15.66	1000.0	1000.000	166.0	V	164.0	8
38477.670770	38.16	53.90	15.74	1000.0	1000.000	170.0	H	40.0	8

2.3.14 Above 40GHz Radiated Emission Test



14:57:48 19.01.2022

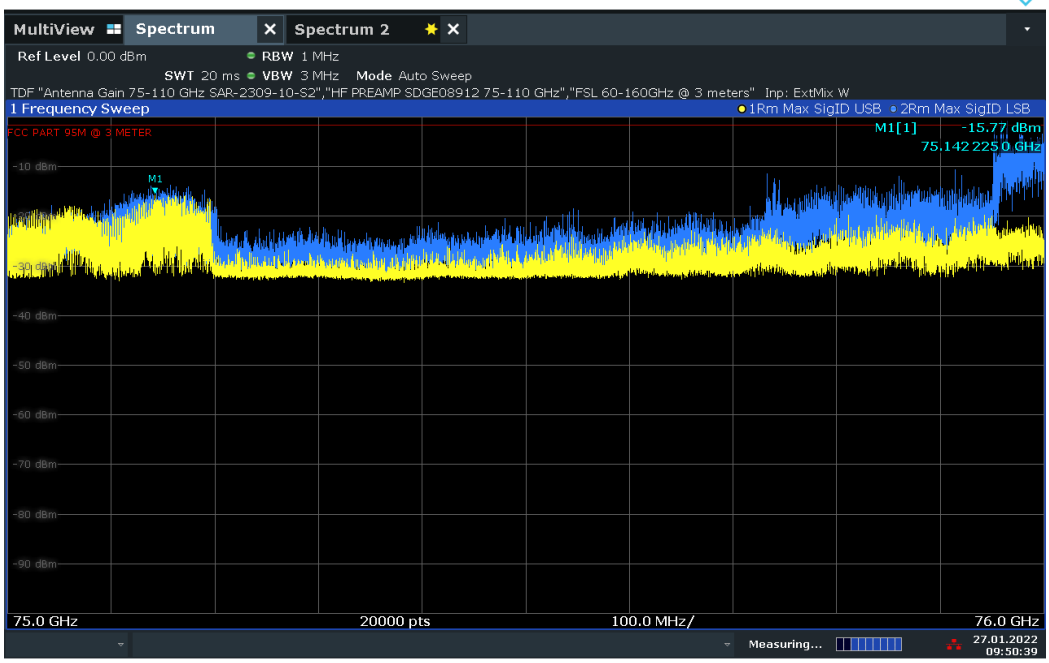
40 GHz to 50 GHz @ 3 meters



10:47:29 20.01.2022

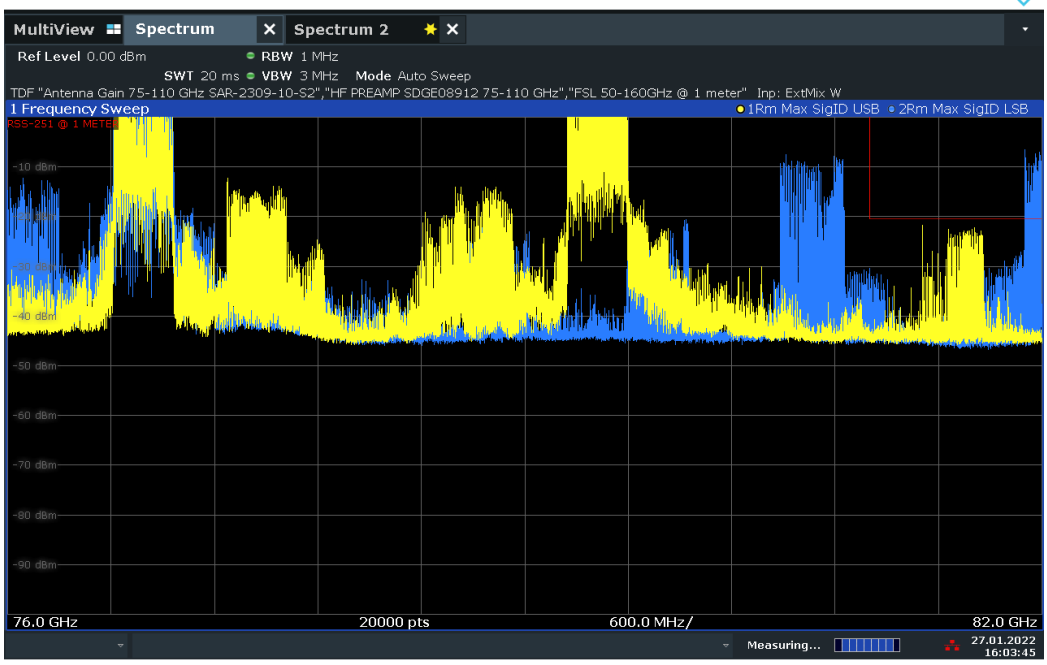
50 to 75GHz @ 3 meters

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.



09:50:39 27.01.2022

75-76GHz @ 3 meters



16:03:46 27.01.2022

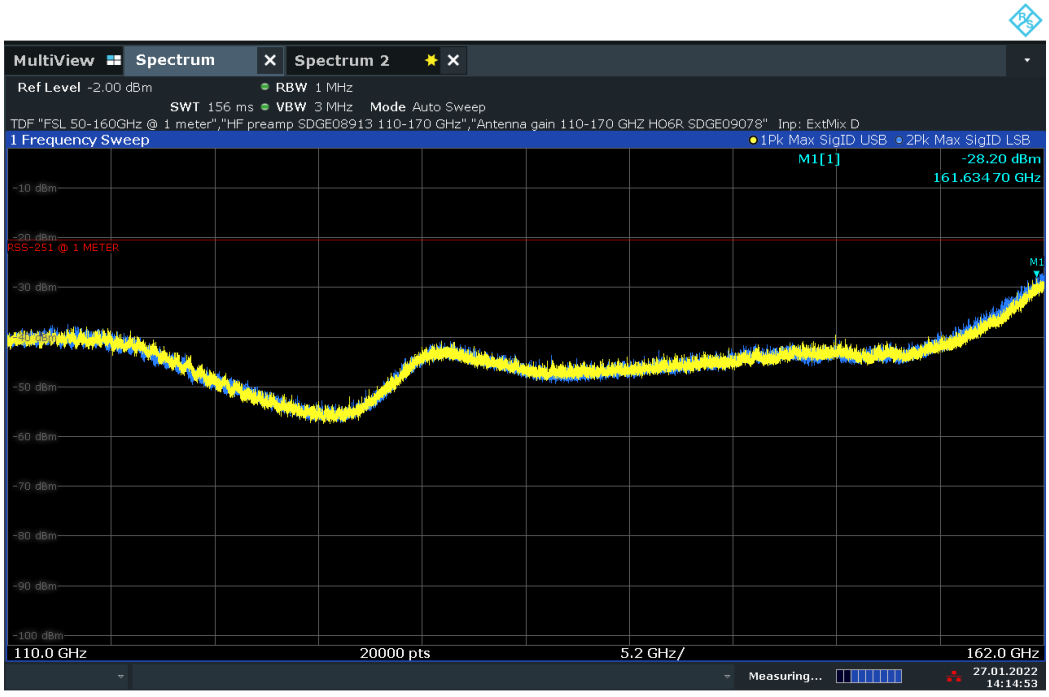
76-81GHz in band @ 1 meter

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.

13:24:57 27.01.2022

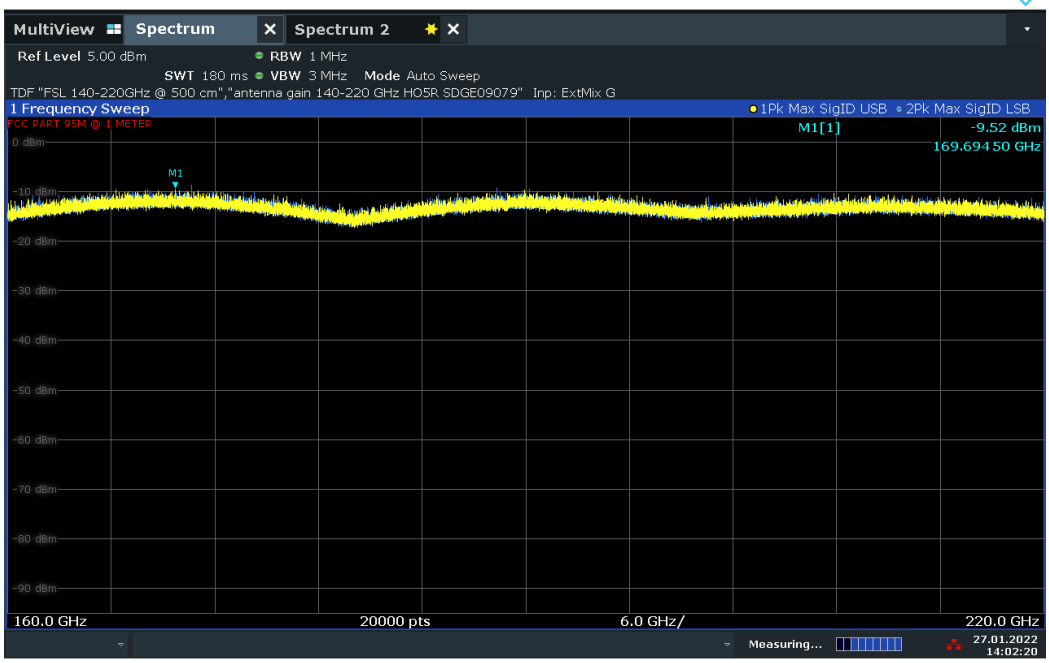
81 to 110GHz @ 1 meter

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.



14:14:54 27.01.2022

110 to 162 GHz @ 1 meter



14:02:20 27.01.2022

160 to 220 GHz @ 1 meter

14:41:41 27.01.2022

220 to 243 GHz @ 0.2 meters

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: N/A / Default Test Configuration

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

January 26, 28 and February 18, 2022 / XYZ

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	19.7 - 22.7 °C
Relative Humidity	38.7 - 41.0 %
ATM Pressure	100.7 - 100.8 kPa

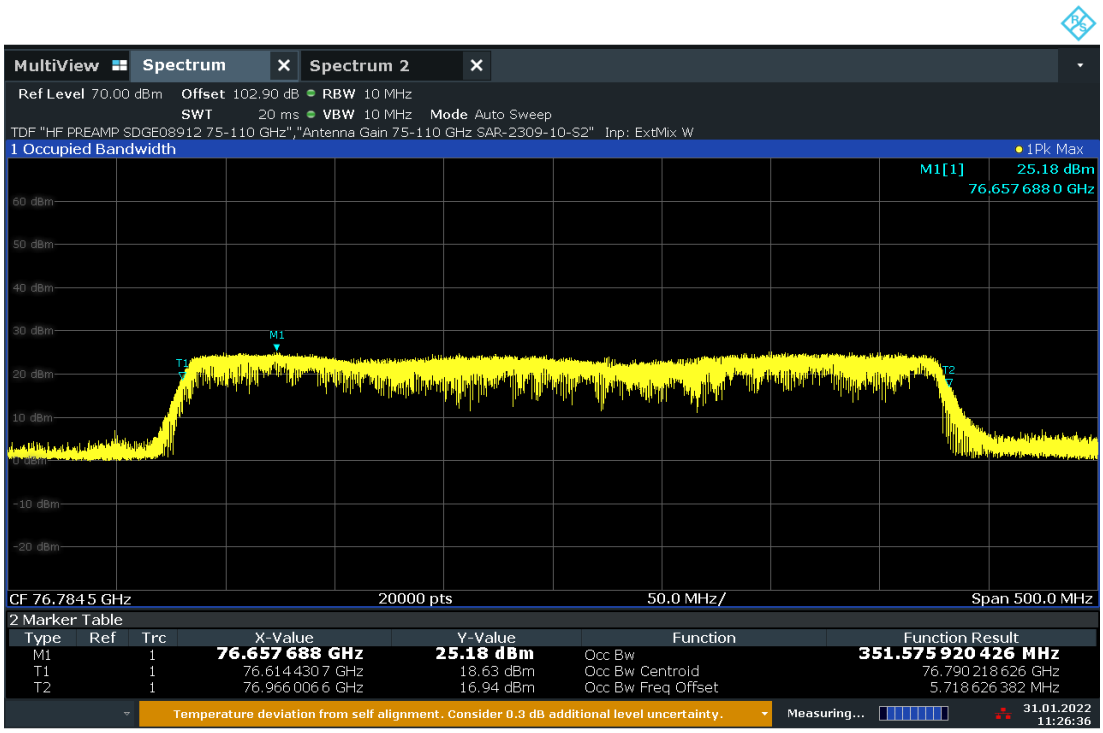
2.4.7 Additional Observations

- EUT has no antenna port available. The measurements under this section were performed using radiated measurement method.
- The measurements were performed under both normal and extreme test conditions.
- Temperature range used is -30°C to +50°C. During test the EUT spectrum was monitored in the entire temperature range at 10 °C intervals.
- RBW is between 1% to 5% of the anticipated OBW.
- 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

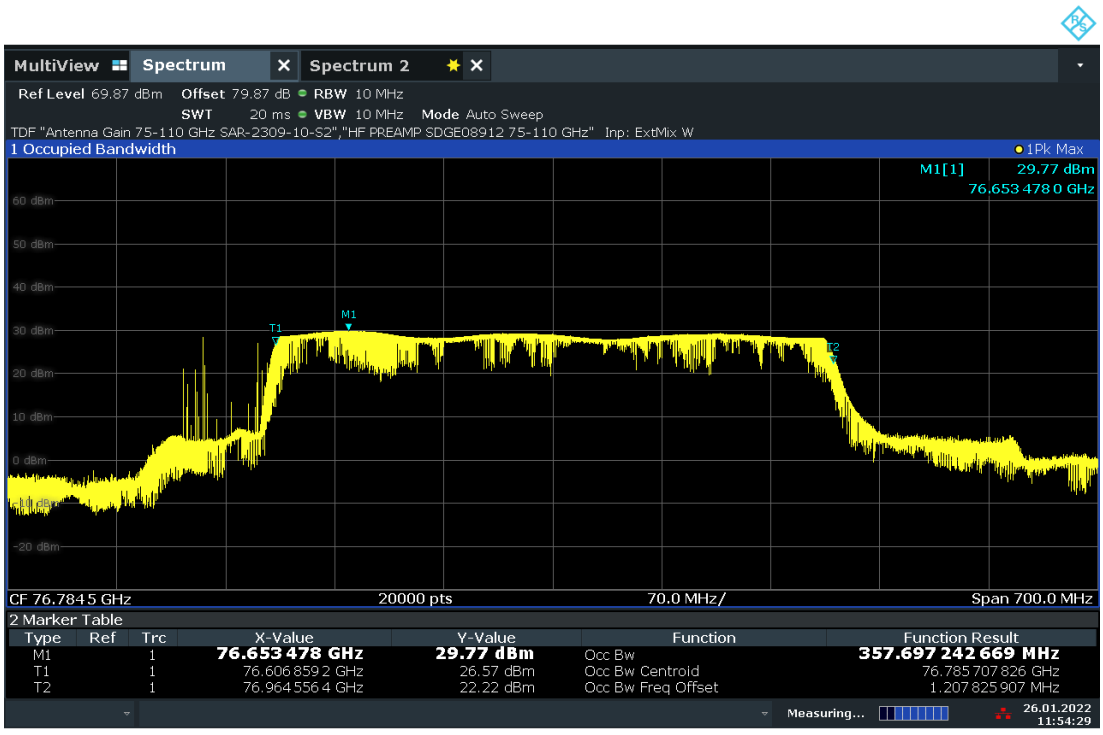
Complies. The edges (T1 and T2) stay within 76 and 81GHz band. See attached plots.

2.4.9 Sample Test Results



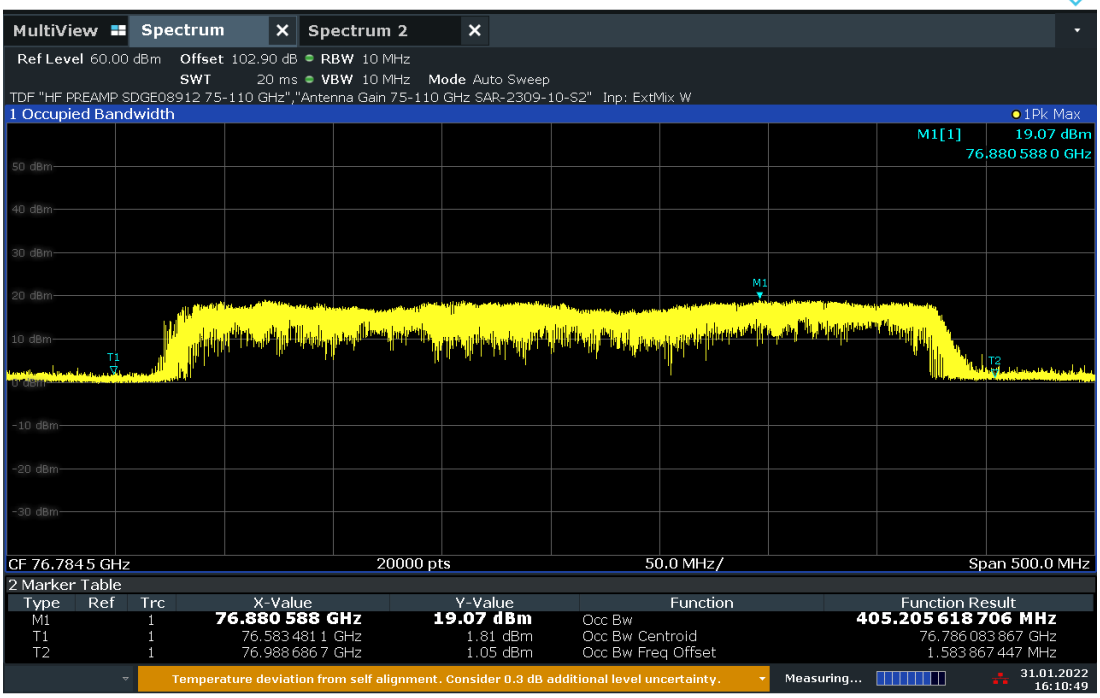
11:26:37 31.01.2022

50°C



11:54:30 26.01.2022

Nominal Voltage @ 20°C



16:10:49 31.01.2022

-30°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						
1033	Bilog Antenna	3142C	00044556	EMCO	10/05/21	10/05/23
1040	EMI Test Receiver	ESIB40	100292	Rohde & Schwarz	10/22/21	10/22/22
51235	RF Pre-Amp (9kHz to 1GHz)	310	412802	Sonoma	09/20/21	09/20/22
7620	EMI Test Receiver	ESU40	100399	Rohde & Schwarz	08/02/21	08/02/22
7575	Double ridged waveguide horn antenna	3117	00155511	ETS Lindgren	06/22/20	06/22/22
8628	Pre-amplifier	QLJ 01182835-JO	8986002	QuinStar Technologies Inc.	02/26/21	02/26/22
6628	Loop Antenna	HFH2-Z2335.4711.52	FNr.800.458/25	Rohde & Schwarz GmbH & Co.KG	05/22/21	05/22/22
9001	Horn antenna (18-26.5GHz)	HO42S	101	Custom Microwave	09/23/21	09/21/23
9003	Horn antenna (26-40 GHz)	HO28S	102	Custom Microwaves	10/14/19	07/29/23
9004	Horn antenna (50-75 GHz)	HO15R	104	Custom Microwaves	Verified by 7611 and corresponding antenna/Active multiplier combination (Standard Gain Horn Antenna)	
7628	Horn antenna (75-110 GHz)	SAR-2309-10-S2	13481-01	Sage Millimeter, Inc.		
9003	Horn antenna (40-60 GHz)	HO19R	103	Custom Microwaves		
9081	Horn antenna (110-170 GHz)	HO6R	N/A	Custom Microwaves		
9082	Horn antenna (140-220 GHz)	HO5R	N/A	Custom Microwaves		
9080	Horn antenna (220-325 GHz)	HO3R	N/A	Custom Microwaves		
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
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
1153	High-frequency cable	SucoFlex 100 SX	N/A	Suhner	Verified by 1003 and 7620	
8543	High-frequency cable	Micropore 19057793	N/A	United Microwave Products	Verified by 1003 and 7620	
40815	Pre-amplifier (18-40 GHz)	19D18	15G27	Spacek Labs	Verified by 1003 and 7620	
44137	V Band waveguide Detector	PE80T3002	V0011860417 20158046	Pasternack	Verified by 1003 and 7611	

ID Number (SDGE/SDRB)	Test Equipment	Type	Serial Number	Manufacturer	Cal Date	Cal Due Date
8872	Direct Reading Attenuator (40-60 GHz)	STA-60-19-D1	11875-01	Sage Millimeter, Inc.	Verified by 7611 and corresponding antenna/mixer combination	
8860	Direct Reading Attenuator (50-75 GHz)	STA-60-15-D1	11466-01	Sage Millimeter, Inc.		
8861	Direct Reading Attenuator (75-110 GHz)	STA-60-10-D1	11466-01	Sage Millimeter, Inc.		
8919	Direct Reading Attenuator (90-140 GHz)	STA-60-08-D1	12605-01	Sage Millimeter, Inc.		
8909	Direct Reading Attenuator (140-220 GHz)	STA-60-05-D1	12020-01	Sage Millimeter, Inc.	Verified by 7611 and corresponding antenna/mixer combination	
8873	Active Multiplier (40-60 GHz)	AMC-19-RFH00	124	Sage Millimeter, Inc.		
8914	Active Multiplier (50-75 GHz)	AMC-15-RFH00	283	Sage Millimeter, Inc.		
8915	Active Multiplier (75-110 GHz)	AMC-10-RFH00	606	Sage Millimeter, Inc.		
8920	Active Multiplier (90-140 GHz)	AMC-08-RFH00	58	Sage Millimeter, Inc.		
8909	Active Multiplier (140-220 GHz)	MCA-05-150096	13	Sage Millimeter, Inc.		
7611	Signal/Spectrum Analyzer	FSW26	102017	Rhode & Schwarz	02/09/22	02/09/23
1003	Signal Generator	SMR-40	1104.0002.40	Rhode & Schwarz	06/25/21	06/25/22
Miscellaneous						
6805	Environmental Chamber	ESL-4CA	18021	Espec	01/12/22	01/13/23
7659	Oscilloscope	TDS7404	B010181	Tectronix	10/29/21	10/29/22
34029	Mini Environmental Quality Meter	Hygrometer	850027	Sper Scientific	07/19/21	07/19/22
-	Test Software	EMC32	V11.20.00	Rhode & Schwarz	N/A	

3.2 MEASUREMENT UNCERTAINTY

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

3.2.1 Radiated Measurements (Below 30MHz) – Mira Mesa

	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	0.44 dB	Normal, k=2	2.000	0.22	0.05
4	Receiver sinewave accuracy	0.15 dB	Normal, k=2	2.000	0.08	0.01
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 10 m	3.12 dB	Rectangular	1.732	1.80	3.24
12	Phase center location at 10 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	0.00 dB	Triangular	2.449	0.00	0.00
16	Separation distance at 10 m	0.30 dB	Rectangular	1.732	0.17	0.03
17	Effect of setup table material	0.00 dB	Rectangular	1.732	0.00	0.00
18	Table height at 10 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	2.45 dB		
	Expanded uncertainty		Normal, k=2	**4.91 dB**		

3.2.2 Radiated Measurements (30MHz to 1GHz) – Rancho Bernardo

	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	1.10 dB	Normal, k=2	2.000	0.55	0.30
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	3.91	dB	Triangular	2.449	1.60	2.55
16	Separation distance at 3 m	0.30	dB	Rectangular	1.732	0.17	0.03
17	Effect of setup table material	0.21	dB	Rectangular	1.732	0.12	0.01
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	3.00	dB	
	Expanded uncertainty			**Normal, k=2**	**5.99**	**dB**	

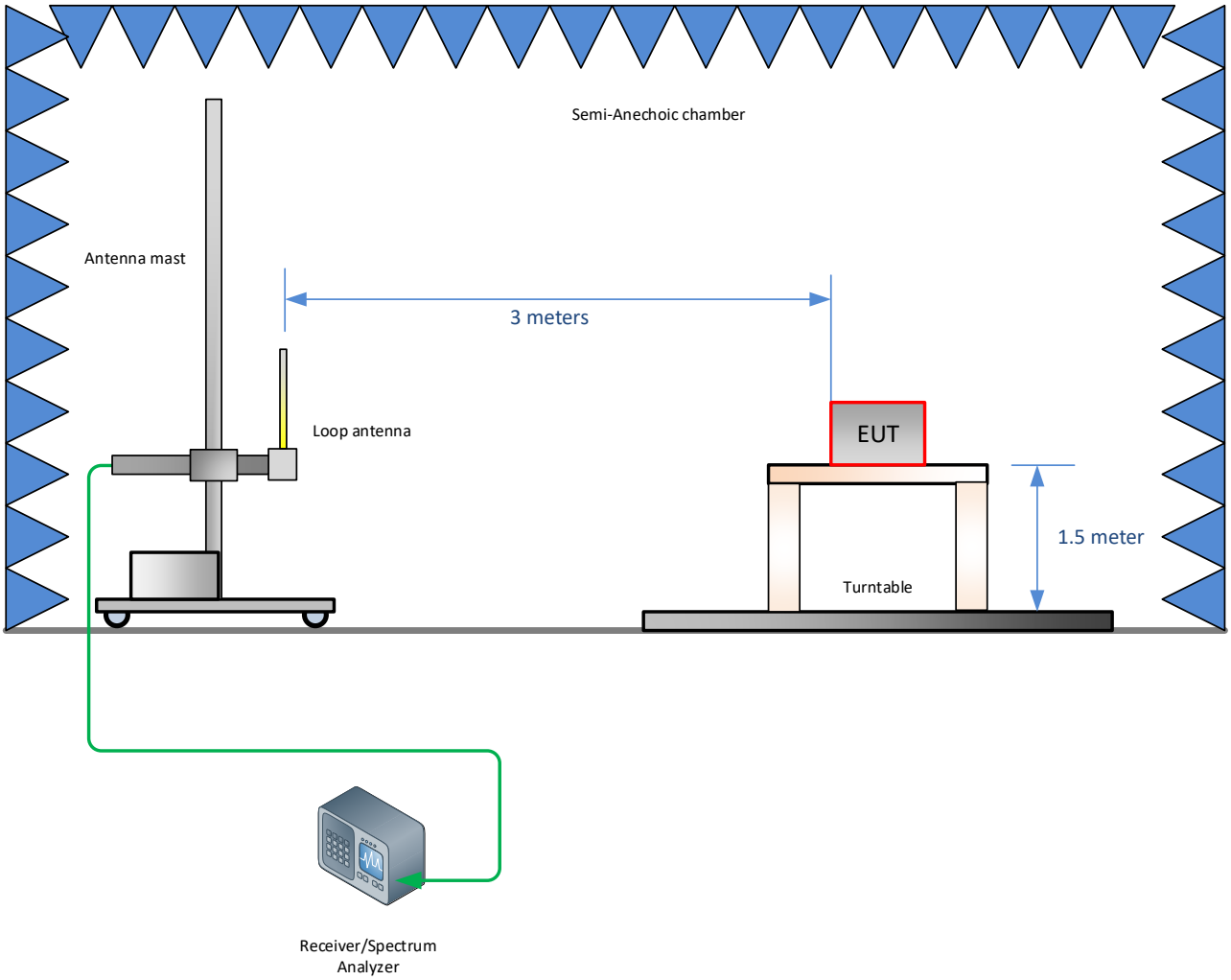
3.2.3 Radiated Emission Measurements (1G – 18 GHz) – Rancho Bernardo

	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	0.30	dB	Normal, k=2	2.000	0.15	0.02
3	Antenna factor AF	0.20	dB	Normal, k=2	2.000	0.10	0.01
4	Receiver sinewave accuracy	0.37	dB	Normal, k=2	2.000	0.19	0.03
5	Receiver pulse amplitude	0.57	dB	Normal, k=2	2.000	0.29	0.08
6	Receiver pulse repetition rate	1.21	dB	Rectangular	1.732	0.70	0.49
7	Noise floor proximity	0.70	dB	Rectangular	1.732	0.40	0.16
8	Mismatch: antenna-receiver	1.41	dB	U-shaped	1.414	1.00	0.99
9	AF frequency interpolation	1.30	dB	U-shaped	1.414	0.92	0.85
10	AF height deviations	0.30	dB	Rectangular	1.732	0.17	0.03
11	Directivity difference at 3 m	1.50	dB	Rectangular	1.732	0.87	0.75
12	Phase center location at 3 m	0.30	dB	Rectangular	1.732	0.17	0.03
13	Cross-polarisation	0.90	dB	Rectangular	1.732	0.52	0.27
14	Balance	5.48	dB	Triangular	2.449	2.24	5.01
15	Site imperfections	0.95	dB	Rectangular	1.732	0.55	0.30
16	Separation distance at 3 m	0.30	dB	Rectangular	1.732	0.17	0.03
17	Effect of setup table material	0.00	dB	Normal, k=2	2.000	0.00	0.00
	Combined standard uncertainty			Normal	3.01	dB	
	Expanded uncertainty			**Normal, k=2**	**6.02**	**dB**	

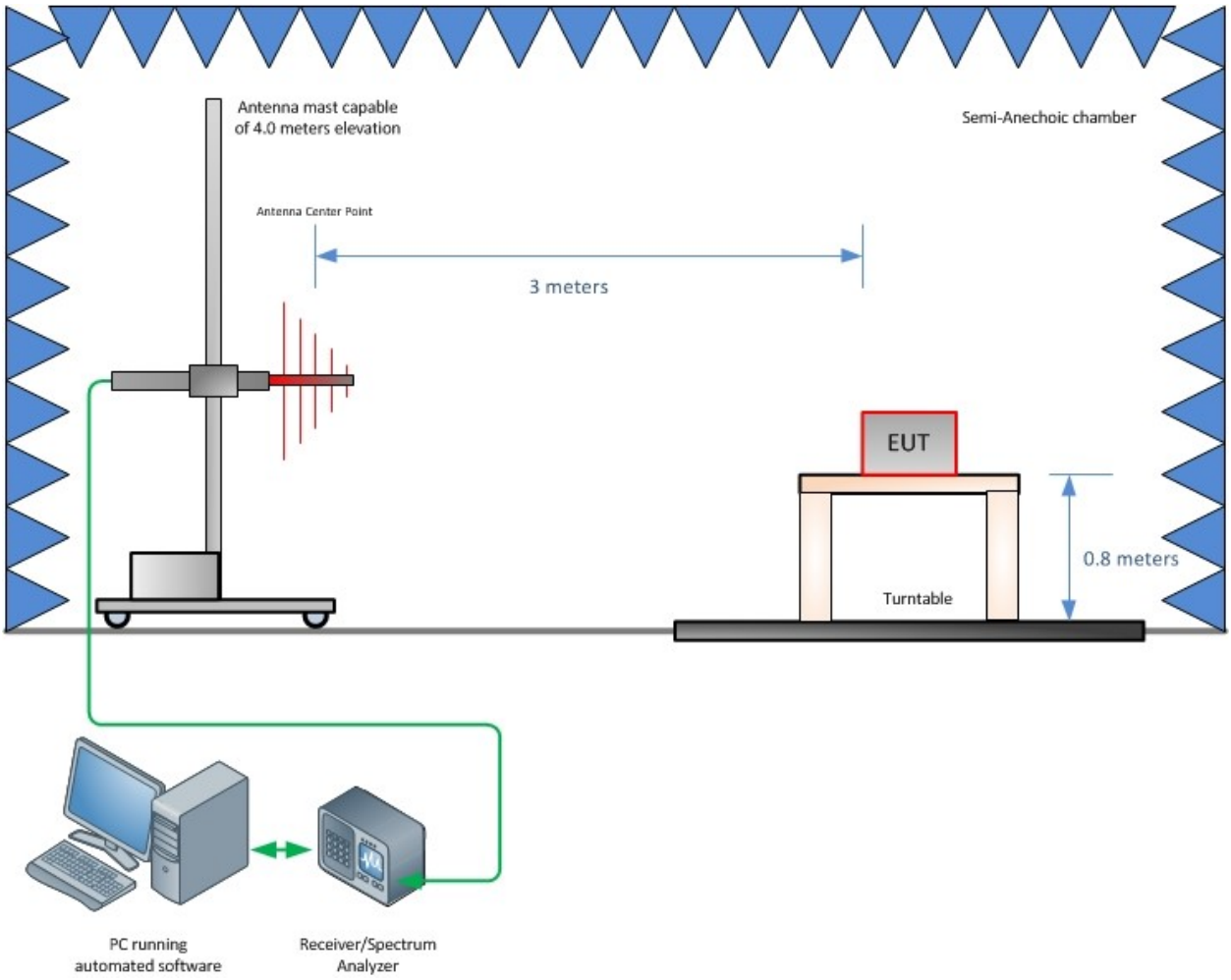
SECTION 4

DIAGRAM OF TEST SETUP

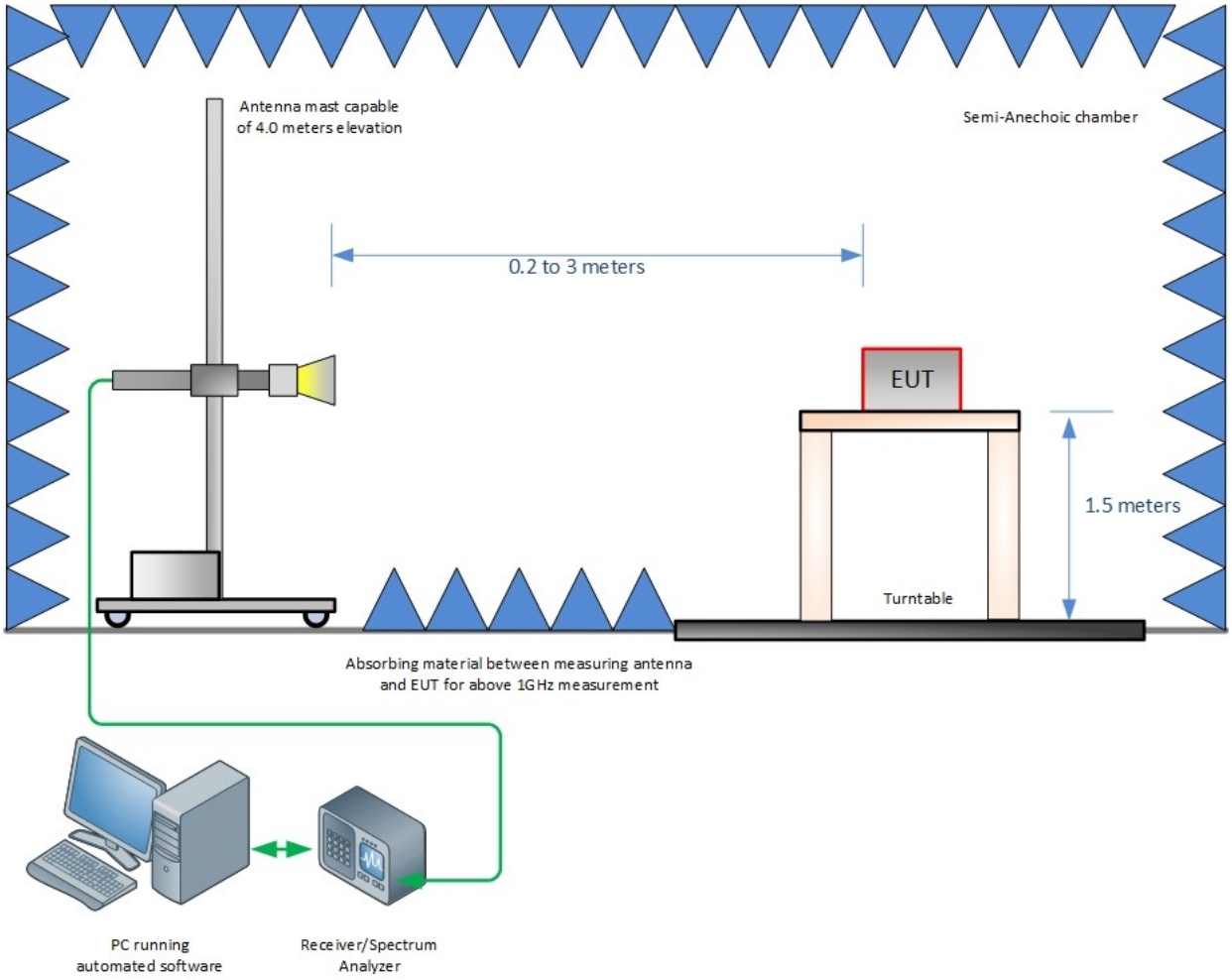
4.1 TEST SETUP DIAGRAM



Radiated Emission Test Setup (Below 30MHz)



Radiated Emission Test Setup (30MHz to 1GHz)



Radiated Emission Test Setup (Above 1GHz)

SECTION 5

ACCREDITATION, DISCLAIMERS AND COPYRIGHT

5.1 ACCREDITATION, DISCLAIMERS AND COPYRIGHT

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