

Radio Testing of the

Gems Sensors & Controls Level Probing Radar Model: RLI80

In accordance with FCC Part 15 Subpart C
§15.256 and ISSED RSS-211

Gems Sensors & Controls
1 Cowles Rd
Plainville, Connecticut 06062
USA



America

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Date: January 2024

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RESPONSIBLE FOR	NAME	DATE	SIGNATURE
Authorized Signatory	Ferdinand S. Custodio	01/30/2024	

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 FCC Part 15 Subpart C §15.256 and ISSED RSS-211.



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TÜV SÜD America, Inc.
10040 Mesa Rim Road
San Diego, CA 92121-2912

TÜV SÜD America, Inc.
Rancho Bernardo Facility
16936 Via Del Campo
San Diego, CA 92127

Phone: 858 678 1400
www.tuv-sud-america.com



REPORT ON Radio Testing of the
Gems Sensors & Controls
Model RLI80 Level Probing Radar

TEST REPORT NUMBER 72193358A

TEST REPORT DATE January 2024

PREPARED FOR Gems Sensors & Controls
1 Cowles Rd
Plainville, Connecticut 06062
USA

CONTACT PERSON Paul Coscia
Senior Engineer/Lab Manager
paul.coscia@gemssensors.com
+248 912-8905

PREPARED BY

A handwritten signature in black ink, appearing to read 'Joe Salvador'.

Joe Salvador

Name

Authorized Signatory

Title: Wireless / RF Test Engineer

APPROVED BY

A handwritten signature in black ink, appearing to read 'Ferdinand S. Custodio'.

Ferdinand S. Custodio

Name

Authorized Signatory

Title: Senior EMC Test Engineer / Wireless Team Lead

DATED

January 30, 2024



Revision History

72193358A Gems Sensors & Controls Model RLI80 Level Probing Radar					
DATE	OLD REVISION	NEW REVISION	REASON	PAGES AFFECTED	APPROVED BY
01/30/2024	—	Initial Release			Ferdinand S. Custodio



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SECTION 1

REPORT SUMMARY

Radio Testing of the
Gems Sensors & Controls
RLI80 Level Probing Radar

Frame Time

1.1 INTRODUCTION

The information contained in this report is intended to show verification of the Gems Sensors & Controls Radar Sensor Level Probing Radar to the requirements of FCC Part 15 Subpart C §15.256 and ISED RSS-211.

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	Gems Sensors & Controls
EUT	Level Probing Radar
Trade Name	Radar Sensor
Model Name	RLI80
FCC ID	2A6KIRLI80
IC Number	28453-RLI80
Serial Number(s)	002,003
Number of Samples Tested	3
Test Specification/Issue/Date	• FCC Part 15 Subpart C §15.256 (October 1, 2023) • ISED RSS-211 (Issue 1 March 2015) • ISED RSS-Gen (Issue 5 April 2018)
Start of Test	September 12, 2023
Finish of Test	December 12, 2023
Name of Engineer(s)	Joe Salvador
Related Document(s)	• ANSI C63.10-2013. American National Standard of Procedures for Compliance testing of Unlicensed Wireless Devices. • KDB890966 D01 Meas level Probing Radars v01r01 • Supporting documents for EUT certification are separate exhibits. • RL180_BLE_Configuration_Process.docx • RL180_Circuit_Operation.pdf



1.2 BRIEF SUMMARY OF RESULTS

A brief summary of the tests carried out in accordance with FCC Part 15 Subpart C §15.256 and ISSED RSS-211 with cross-reference to the corresponding ISSED RSS standard are shown below:

Section	§15.256 Spec Clause	RSS-211	Test Description	Result	Comments/Base Standard
2.1	§15.256(f)	Clause 5.1(a)(b)	Transmitter Fundamental Emission Bandwidth	Compliant	
2.2	§15.256(g)(2)(ii)	Clause 5.2(b)	Transmitter Maximum Peak EIRP	Compliant	
2.3	§15.256(g)	Clause 5.2(b)	Transmitter Maximum Average EIRP	Compliant	
2.4	§15.256(f)	RSS-Gen Clause 8.11	Transmitter Frequency Stability	Compliant	
2.5	§15.256(h) and §15.209	RSS-Gen Clause 8.9	Transmitter Unwanted Emissions	Compliant	
	§15.207	RSS-Gen Clause 8.8	Transmitter AC Conducted Emissions	N/A	
2.6	§15.256(i)(B)	Clause 5.2(a)	Antenna Beamwidth	Compliant	
2.7	§15.256(j)	Clause 5.2(c)	Antenna Side Lobe Gain	Compliant	

N/A Not performed. The EUT as declared by the manufacturer is DC powered and does not have provisions to connect directly with Public AC Mains. It is however recommended to perform this test on the final host if the final host will be connected to AC power lines.



1.3 PRODUCT INFORMATION

1.3.1 Technical Description

The Equipment Under Test (EUT) is a Gems Sensors & Controls Radar Sensor Level Probing Radar.

1.3.2 EUT General Description

EUT Description	Level Probing Radar
Trade Name	Radar Sensor
Model Name	RLI80
Rated Voltage	24VDC
Mode Verified	77GHz radar
Capability	77GHz radar and BLE
Frequency Range	77-81GHz
Primary Unit (EUT)	☐ Production ☒ Pre-Production ☐ Engineering
PRF	50Hz
Frame Time	500 ms
Duty Cycle	10%
Transmission Mode	MIMO (3x4)
Dimensions	63mm x 45mm x 13mm
Weight	0.05 kg
Antenna Type	Wave Guide antenna
Manufacturer	Custom
TX Antenna Gain	0.14 dBi
RX Antenna Gain	0.14 dBi



1.4 EUT TEST CONFIGURATION

1.4.1 Test Configuration Description

Test Configuration	Description
Default	The RLI80 radar was provided as a plug-and-play unit. Once power is applied, the RLI80 radar starts transmitting continuously. In Normal operation (Highest PRF), each processing frame is comprised of 2 FMCW chirps separated by 10 msec. Each chirp is active for approximately 214 usecs. The next processing frame occurs in 2000 msec or greater. In Continuous mode (Lowest PRF), the radar processor is continuously powered and generates a processing frame every 500 msec comprised of 1 FMCW chirp. The chirp is active for approximately 214 usecs.

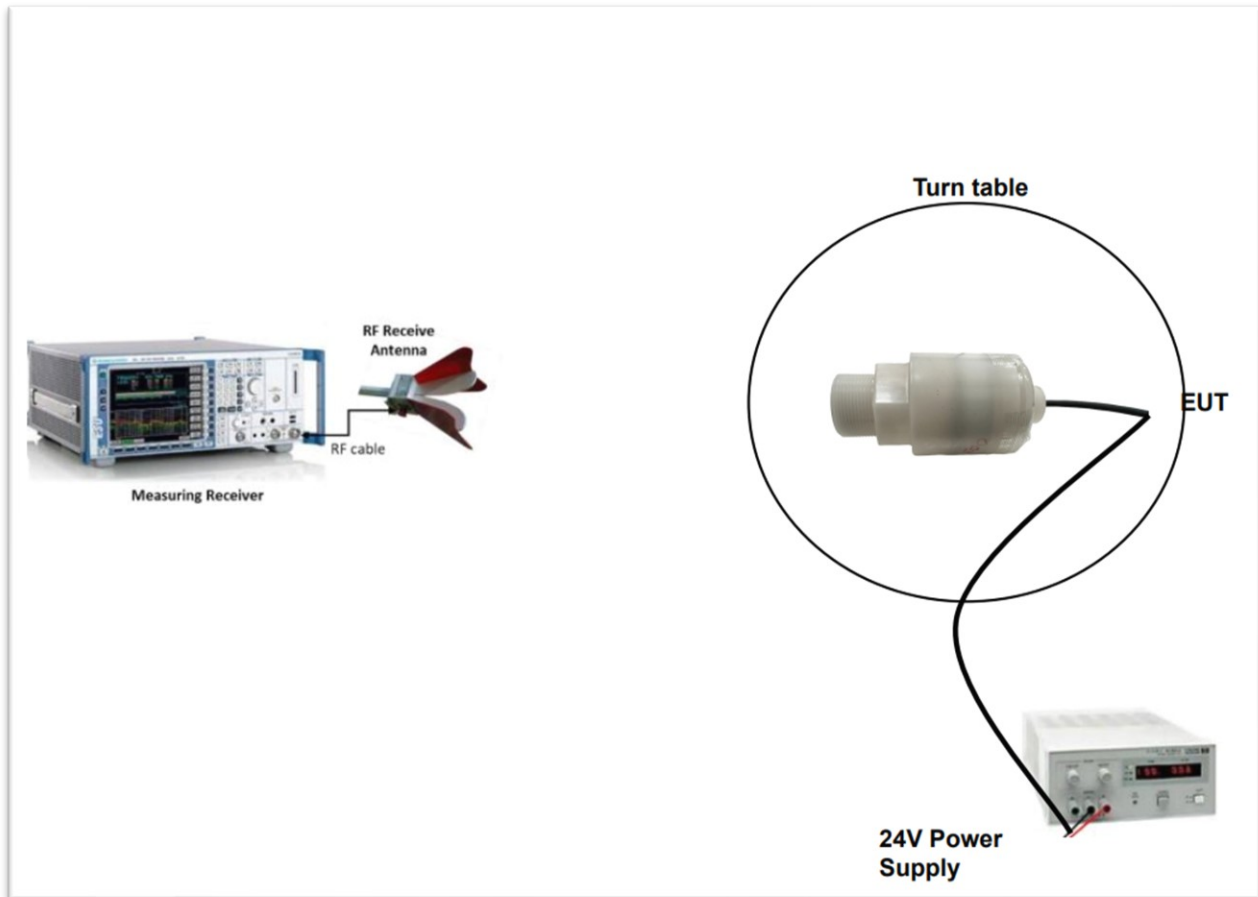
1.4.2 EUT Exercise Software

None

1.4.3 Support Equipment and I/O cables

Manufacturer	Equipment/Cable	Description
Custom	Harness cable	5 conductors (BAT, GND, WAKE, CAN High and CAN Low)

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: 002,003		
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 (ISED) 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-0412 and A-0413

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
Gems Sensors & Controls
RLI80 Level Probing Radar

2.1 TRANSMITTER FUNDAMENTAL EMISSION BANDWIDTH

2.1.1 Specification Reference

FCC 47 CFR Part 15, Clause 15.256(f)(1)
RSS-211 Clause 5.1(a)(b)

2.1.2 Standard Applicable

(f) The fundamental bandwidth of an LPR emission is defined as the width of the signal between two points, one below and one above the center frequency, outside of which all emissions are attenuated by at least 10 dB relative to the maximum transmitter output power when measured in an equivalent resolution bandwidth.

(1) The minimum fundamental emission bandwidth shall be 50 MHz for LPR operation under the provisions of this section.

2.1.3 Equipment Under Test and Modification State

Serial No: 002/ Default Test Configuration

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

December 16, 2023 / JS

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 Location

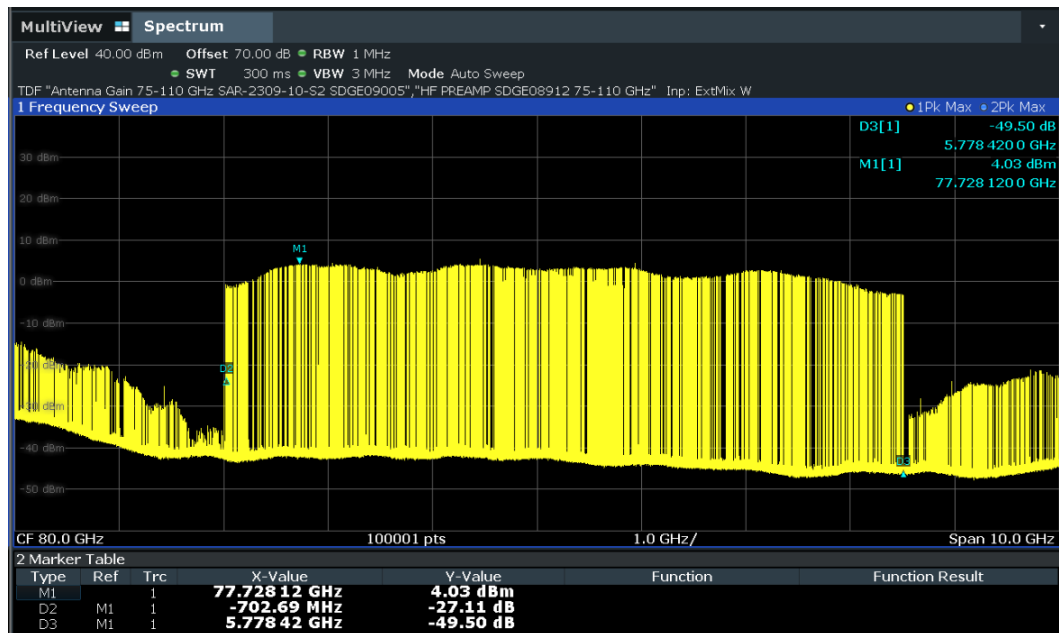
Test performed at TÜV SÜD America Inc. Mira Mesa facility SR5

Ambient Temperature	25.1 °C
Relative Humidity	56.2 %
ATM Pressure	100.3 kPa

2.1.7 Additional Observations

- This is a radiated test.
- Test methodology is per Section 9.10 of ANSI C63.10-2013.
- The manufacturer provided a test profile with the highest possible duty cycle.
- "n" dB down function of SA (for measuring 10dB BW) doesn't provide accurate measurement due to steep edges, Marker function used instead.
- Reported 10dB BW points are considered worst case. However, reported 10dB BW should be similar.

2.1.8 Test Results



10 dB Bandwidth Points		Limit
D2 (FL)	77.02 (GHz)	> 75 GHz
D3 (FH)	83.50 (GHz)	< 85 GHz
Bandwidth	6.48 (GHz)	> 50 MHz
RESULT		PASS

2.2 TRANSMITTER MAXIMUM PEAK EIRP

2.2.1 Specification Reference

FCC 47 CFR Part 15, Clause 15.256(g)(2)(ii)
RSS-211 Clause 5.2(b)

2.2.2 Standard Applicable

(ii) The EIRP in 50 MHz is computed from the maximum power level measured with a peak detector in a 50-MHz bandwidth centered on the frequency at which the maximum average power level is realized and this 50 MHz bandwidth must be contained within the authorized operating bandwidth. For a RBW less than 50 MHz, the peak EIRP limit (in dBm) is reduced by $20 \log(\text{RBW}/50)$ dB where RBW is the resolution bandwidth in megahertz. The RBW shall not be lower than 1 MHz or greater than 50 MHz. The video bandwidth of the measurement instrument shall not be less than the RBW. If the RBW is greater than 3 MHz, the application for certification filed shall contain a detailed description of the test procedure, calibration of the test setup, and the instrumentation employed in the testing.

Frequency Band (GHz)	Average Emission Limit (EIRP in dBm/MHz) as Measured Boresight	Peak Emission Limit (EIRP in dBm Measured in 50 MHz) as Measured Boresight
5.65-8.50	-33	+7
24.05-29.00	-14	+26
75-85	-3	+34

2.2.3 Equipment Under Test and Modification State

N/A

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

2.2.5 Equipment Under Test and Modification State

Serial No: 002/ Default Test Configuration

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

December 20, 2023 / JS

2.2.7 Test Equipment Used

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

2.2.8 Environmental Conditions/ Test Location

Test performed at TÜV SÜD America Inc. Mira Mesa facility

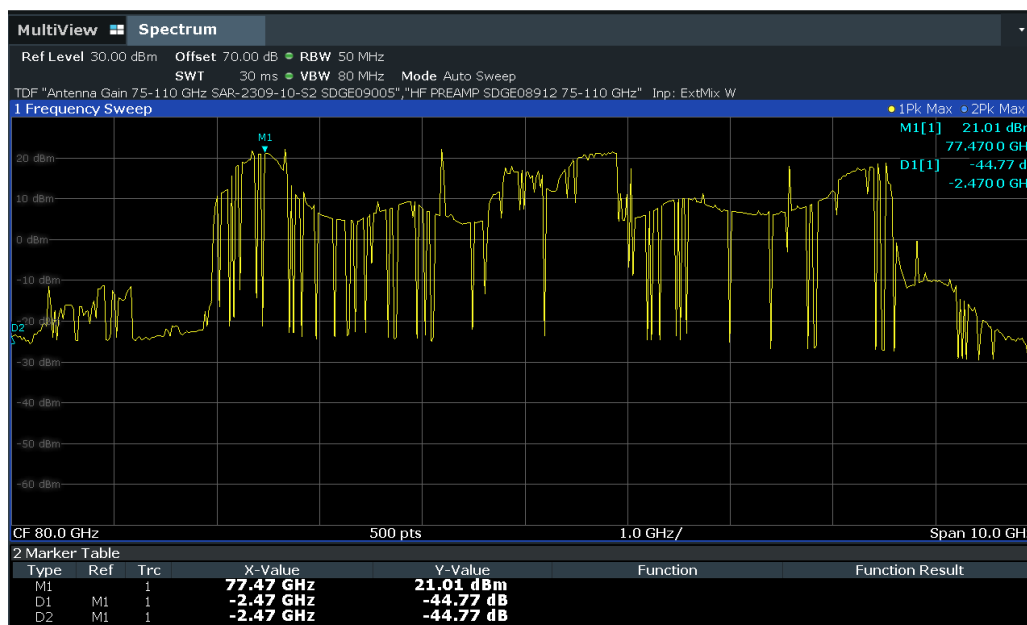
Ambient Temperature 22.7 °C
Relative Humidity 43.2 %
ATM Pressure 100.6 kPa

2.2.9 Additional Observations

- This is a radiated test. The spectrum was searched from 75GHz to 85GHz.
- The FMCW chirps correction factor was calculated using the formula:
-

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

- Guidance for calculating the correction factor is from Application Note 1EF107-1E Rohde & Schwarz Peak and Mean Power measurements on wideband FMCW radar signals.
- Guidance is based on 1MHz RBW/3MHz VBW since measurement uses 50MHz RBW/80MHz VBW, correction factor per Fig. 5 of the Application Note is utilized.



Frequency	Peak EIRP @ 50MHz RBW (dBm)	Peak Power Correction (dB)	Corrected Level (EIRP)	Limit (dBm)	Result
77 GHz	21.01	0.0	21.01	34	Passed

2.3 TRANSMITTER MAXIMUM AVERAGE EIRP

2.3.1 Specification Reference

FCC 47 CFR Part 15, Clause 15.256(g)(2)(i)
RSS-211 Clause 5.2(b)

2.3.2 Standard Applicable

(i) The EIRP in 1 MHz is computed from the maximum power level measured within any 1-MHz bandwidth using a power averaging detector.

2.3.3 Equipment Under Test and Modification State

Serial No: 002/ Default Test Configuration

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

December 20, 2023 / JS

2.3.5 Test Equipment Used

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

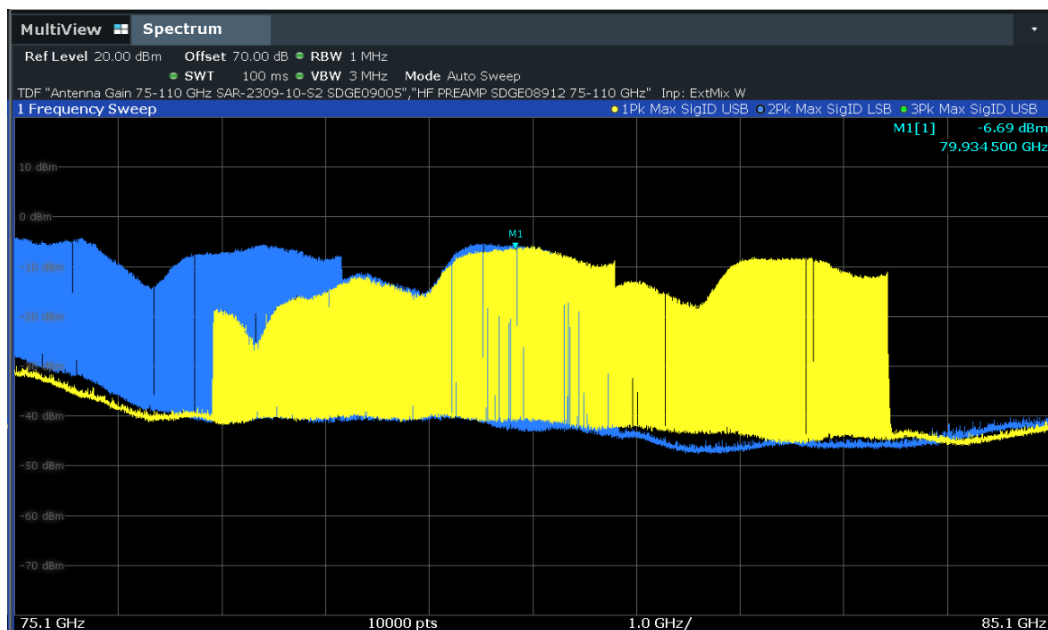
2.3.6 Environmental Conditions/ Test Location

Test performed at TÜV SÜD America Inc. Mira Mesa facility

Ambient Temperature	22.7 °C
Relative Humidity	43.2 %
ATM Pressure	100.6 kPa

2.3.7 Additional Observations

- This is a radiated test. The spectrum was searched from 75GHz to 85GHz.
- Offset of 70 dB corresponds to free space loss at 77.7GHz.
- The entire fundamental bandwidth was swept to determine the max peak power level



Frequency (GHz)	Average Factor (dB)	Peak detector (dBm)	Average EIRP (dBm)	Limit (dBm)	Result
77	-18.78	-6.69	-25.47	-3	Pass

Dwell Time (TD) = Frequency sweep time (Ts)/ Chirp Bandwidth (F)
 = .000215sec (Ts)/6500 MHz (F)
 = .000000033sec (TD)

Average Factor = $10 \cdot \log [(TD)/\text{cycle time}]$
 = $10 \cdot \log [(.000000033\text{sec})/.0000025\text{sec}]$
 = -18.78 dB

Average EIRP = Average Factor + Peak @ 1MHz RBW
 = -18.78dB + (-6.69dBm)
 = -25.47dBm

2.4 TRANSMITTER FREQUENCY STABILITY

2.4.1 Specification Reference

FCC 47 CFR Part 15, Clause 15.256(f)(2)
RSS-Gen Clause 8.11

2.4.2 Standard Applicable

(2) LPR devices operating under this section must confine their fundamental emission bandwidth within the 5.925–7.250 GHz, 24.05–29.00 GHz, and 75–85 GHz bands under all conditions of operation.

Clause 8.11. If the frequency stability of the licence-exempt radio apparatus is not specified in the applicable RSS, the fundamental emissions of the radio apparatus should be kept within at least the central 80% of its permitted operating frequency band in order to minimize the possibility of out-of-band operation. In addition, its occupied bandwidth shall be entirely outside the restricted bands and the prohibited TV bands of 54-72 MHz, 76-88 MHz, 174-216 MHz, and 470-602 MHz, unless otherwise indicated.

2.4.3 Equipment Under Test and Modification State

Serial No: 003/ Default Test Configuration

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

December 20, 2023 / JS

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 Location

Test performed at TÜV SÜD America Inc. Mira Mesa facility

Ambient Temperature	22.7 °C
Relative Humidity	43.2 %
ATM Pressure	100.6 kPa

2.4.7 Additional Observations

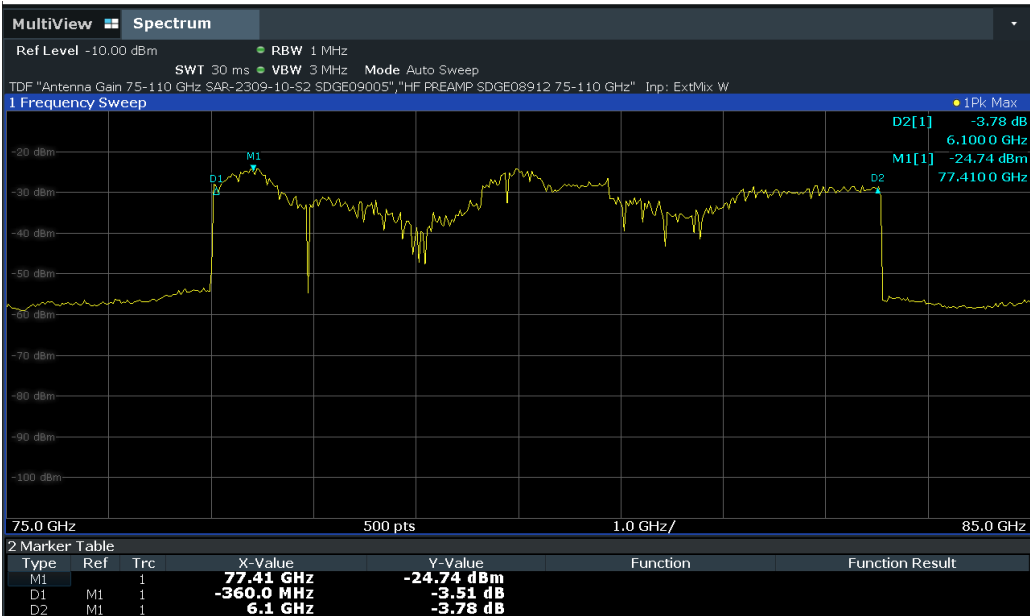
- This is a radiated test.
- Test methodology is per Section 6.8.1 and 6.8.2 of ANSI C63.10-2013.
- Temperature range used is -20°C to +50°C. During test the EUT spectrum was monitored in the entire temperature range at 10 °C intervals.

- Markers D1 and D2 represent the Bandwidth edges. The EUT was monitored at each temperature range to comply within the 76GHz to 84GHz (central 80% of the permitted operating frequency band).
- “n” dB down function of SA (for measuring 10dB BW) doesn’t provide accurate measurement due to steep edges, Marker function used instead.
- Reported 10dB BW points should be similar to the actual 10dB BW points.

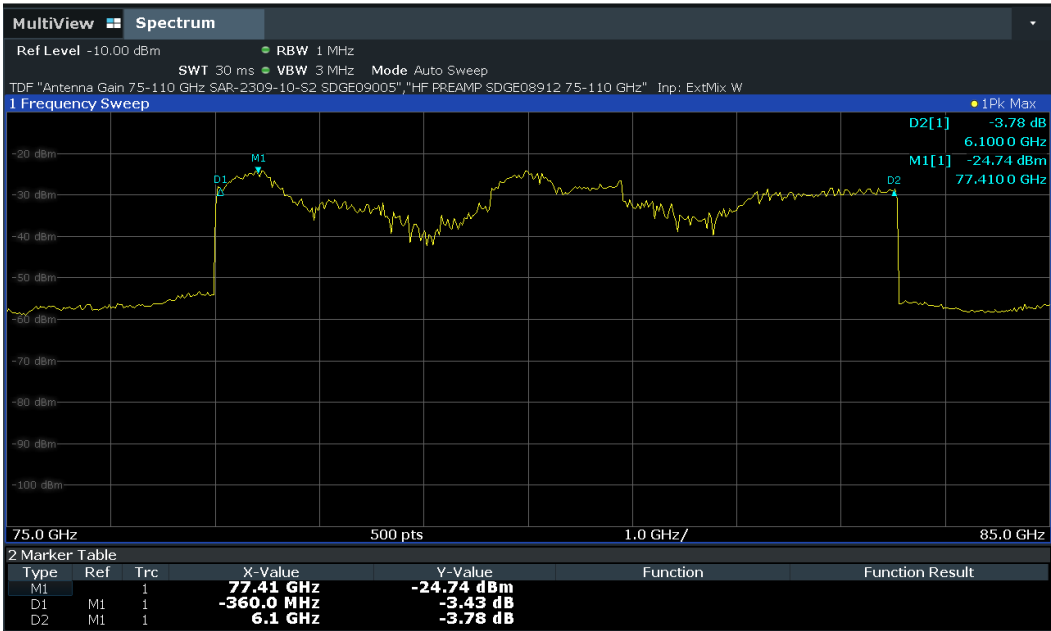
2.4.8 Test Results

Performance assessment of the EUT made during this test: **Pass**

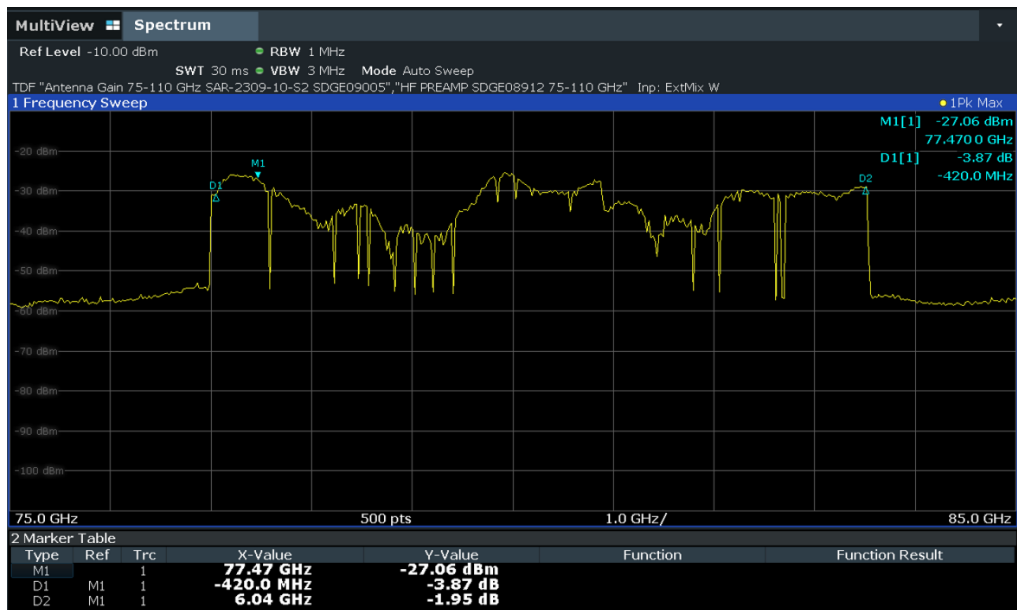
Temperature	Test Voltage	Observation
50°C	24VDC	Stayed within the operating frequency band
40°C	24VDC	
30°C	24VDC	
20°C	20.4VDC	
20°C	24VDC	
20°C	27.6VDC	
10°C	24VDC	
0°C	24VDC	
-10°C	24VDC	
-20°C	24VDC	



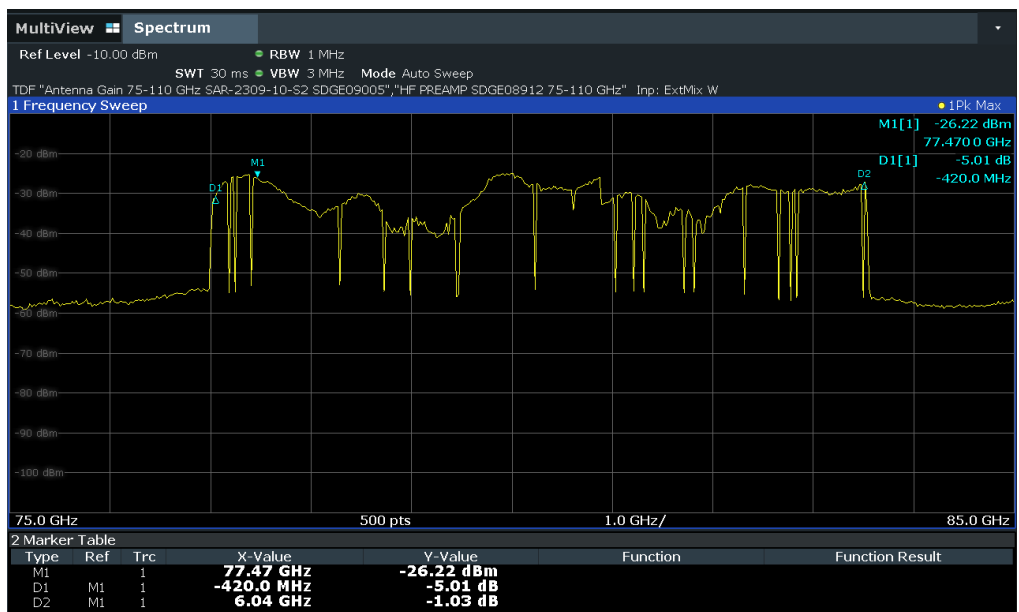
50°C at nominal voltage (24VDC)



40°C at nominal voltage (24VDC)



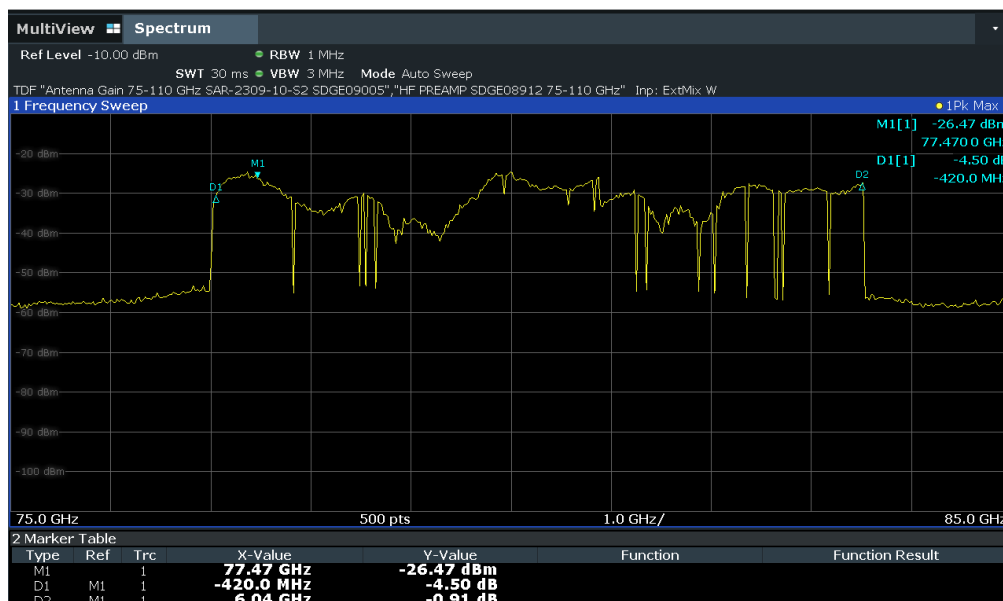
30°C at nominal voltage (24VDC)



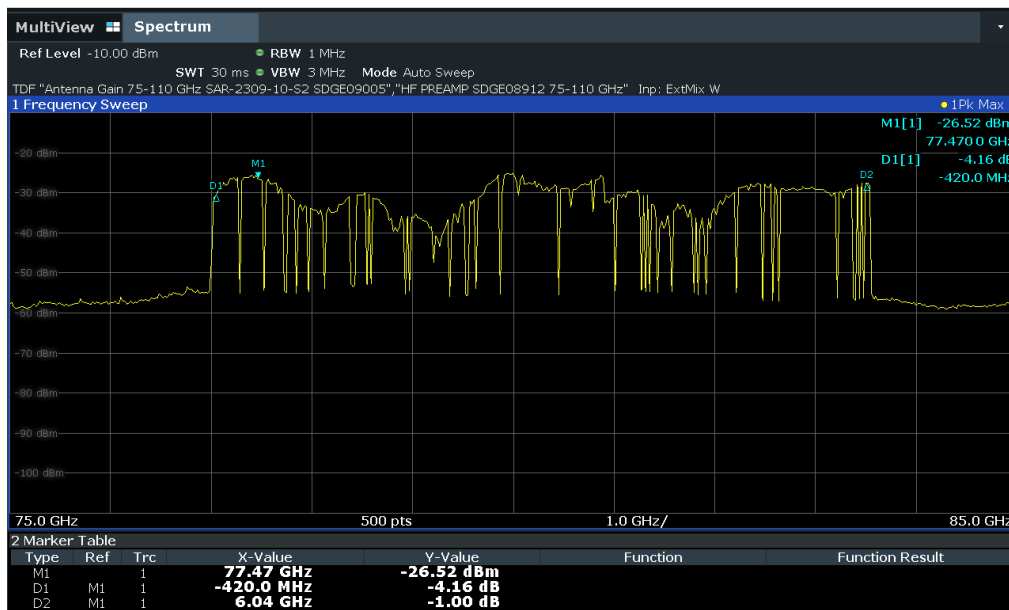
20°C at 115% nominal voltage (27.4VDC)



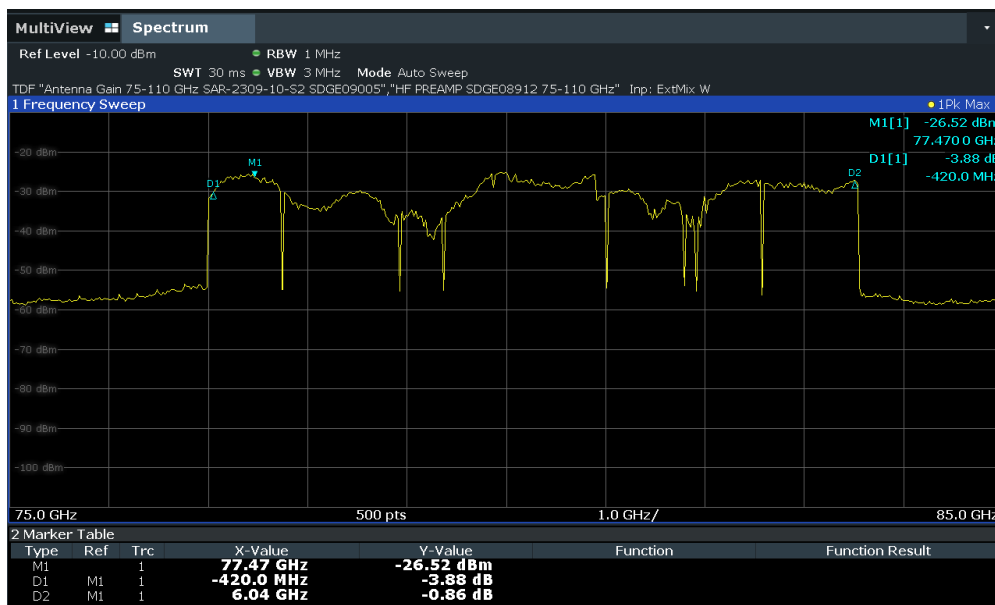
20°C at nominal voltage (24VDC)



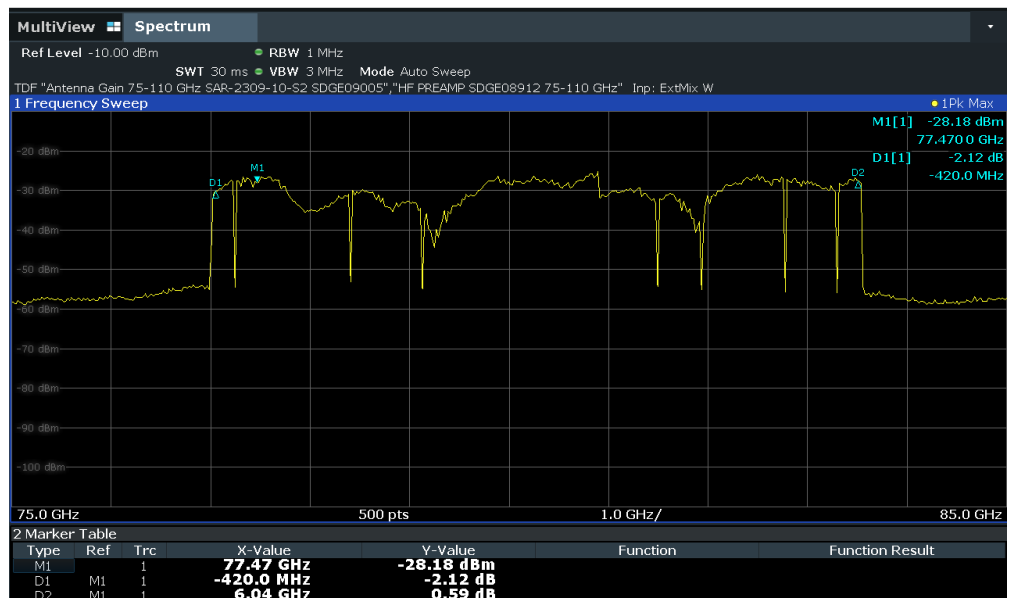
20°C at 85% nominal voltage (20.4VDC)



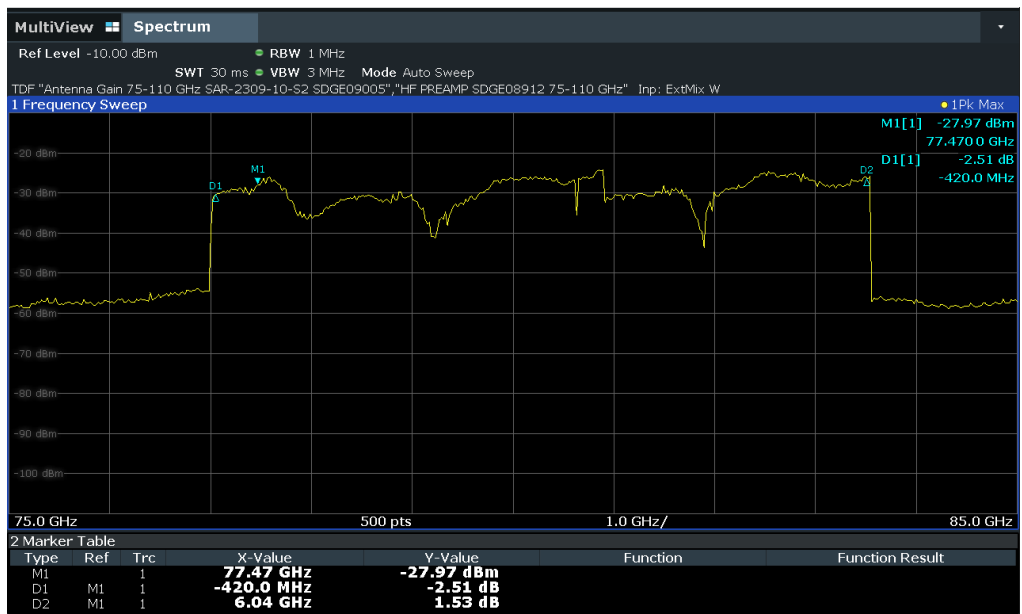
10°C at nominal voltage (15VDC)



0°C at nominal voltage (24VDC)



-10°C at nominal voltage (24VDC)



-20°C at nominal voltage (24VDC)



2.5 TRANSMITTER UNWANTED EMISSIONS

2.5.1 Specification Reference

FCC 47 CFR Part 15, Clause 15.256(h)
RSS-Gen Clause 8.9

2.5.2 Standard Applicable

(h) Unwanted emissions limits. Unwanted emissions from LPR devices shall not exceed the general emission limit in § 15.209 of this chapter.

2.5.3 Equipment Under Test and Modification State

Serial No: 002,003/ Default Test Configuration

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

December 20, 2023 / JS

2.5.5 Test Equipment Used

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

2.5.6 Environmental Conditions/ Test Location

Test performed at TÜV SÜD America Inc. Mira Mesa facility

Ambient Temperature	22.7 °C
Relative Humidity	43.2 %
ATM Pressure	100.6 kPa

2.5.7 Additional Observations

- This is a radiated test. The spectrum was searched from 9kHz to 200GHz.
- Measurements below 40GHz were done using EMC32 automated software. Reported level is the actual level with all the correction factors factored in. Correction Factor column is for informational purposes only. See Section 2.5.8 for sample computation.
- Measurement above 40GHz were done using harmonic mixers. Corresponding TDF (Transducer Factor) are programmed for each range.
- Lowest and Highest Pulse Repetition Frequencies were tested.
- The spectrum was not searched from 75GHz to 85GHz for spurious emissions. See section 2.1 for this frequency range.
- Tests distances and frequency ranges performed are summarized below:

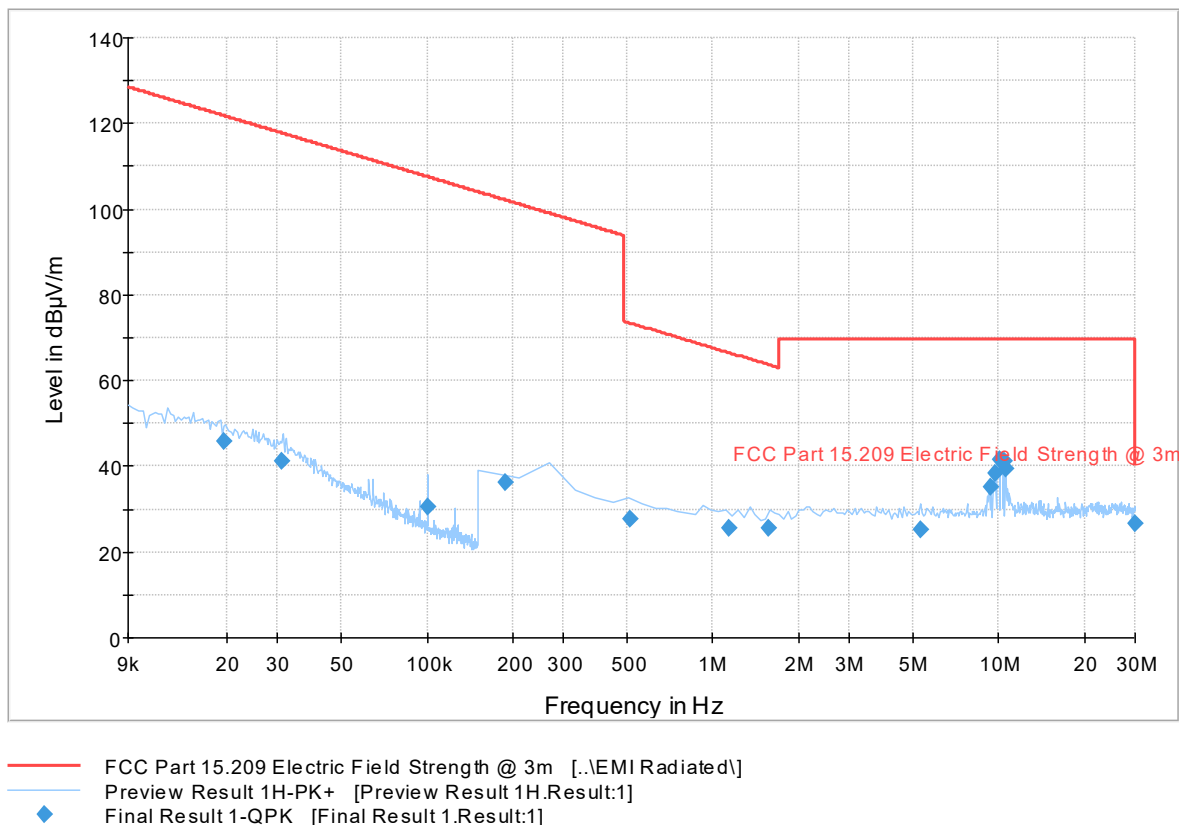
Frequency Range	Test Distance
9 kHz to 30 MHz	3 meters
30 MHz to 1GHz	3 meters
1 GHz to 18 GHz	3 meters
18 GHz to 26 GHz	3 meters
26 GHz to 40 GHz	3 meters
40 GHz to 60 GHz	1 meter
60 GHz to 75 GHz	1 meter
75 GHz to 110 GHz	1 meter
110 GHz to 140 GHz	1 meter
140 GHz to 200 GHz	0.5 meter

2.5.8 Sample Computation (Radiated Emission)

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

2.5.9 Below 30MHz Radiated Emission Test

Discrete Rotation TUV 3m Radiated 9kHz to 30MHz..

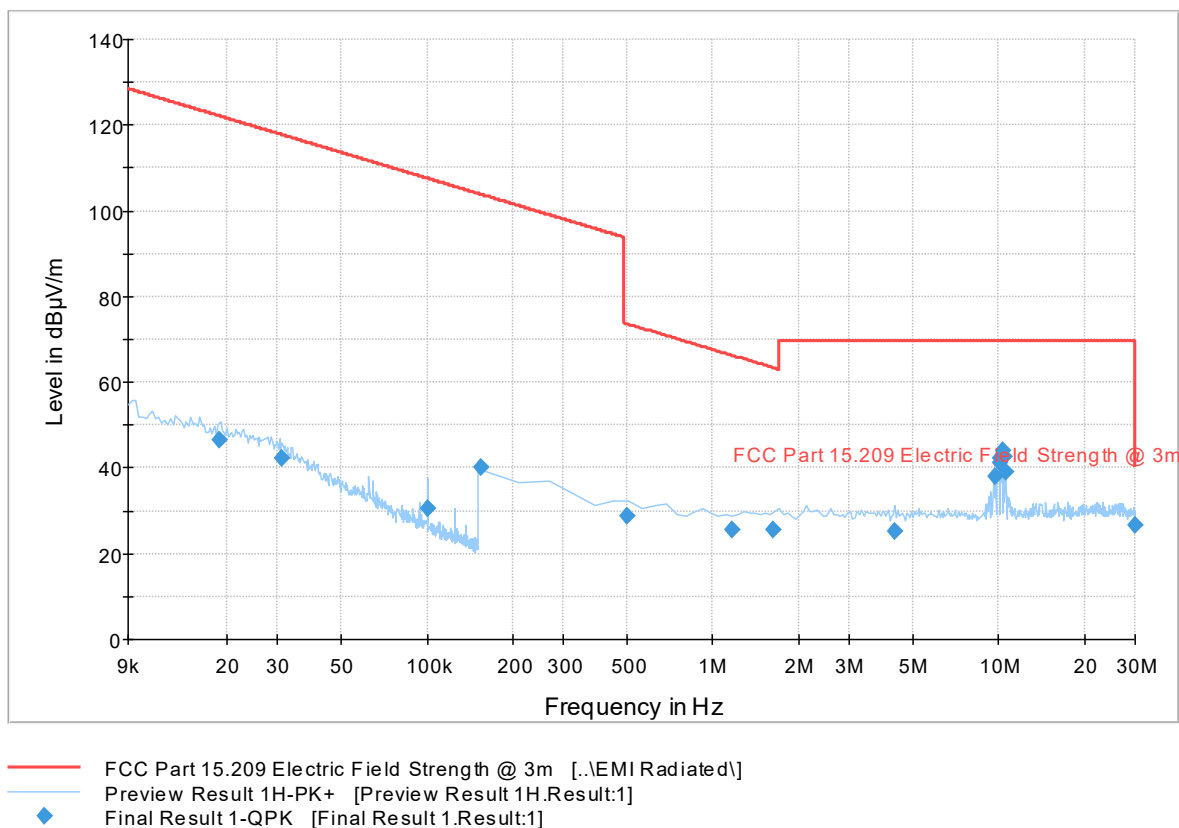


(Highest PRF)

Quasi-Peak Data

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Polarization	Azimuth (deg)	Corr. (dB)
0.019490	45.8	15000.0	0.200	H	125.0	21.5	0.019490	45.8
0.031123	41.1	15000.0	0.200	H	115.0	21.5	0.031123	41.1
0.100069	30.7	15000.0	0.200	H	125.0	19.7	0.100069	30.7
0.186820	36.1	1500.0	9.000	H	321.0	19.7	0.186820	36.1
0.513918	27.6	1500.0	9.000	H	57.0	19.8	0.513918	27.6
1.134114	25.6	1500.0	9.000	H	101.0	20.1	1.134114	25.6
1.558671	25.6	1500.0	9.000	H	-9.0	20.1	1.558671	25.6
5.359309	25.3	1500.0	9.000	H	169.0	20.5	5.359309	25.3
9.419044	35.3	1500.0	9.000	H	145.0	20.9	9.419044	35.3
9.722142	38.5	1500.0	9.000	H	169.0	21.0	9.722142	38.5
10.025241	41.5	1500.0	9.000	H	301.0	21.1	10.025241	41.5
10.328339	41.4	1500.0	9.000	H	132.0	21.1	10.328339	41.4
10.431978	41.2	1500.0	9.000	H	308.0	21.2	10.431978	41.2
10.531617	39.5	1500.0	9.000	H	277.0	21.2	10.531617	39.5
29.985000	26.5	1500.0	9.000	H	257.0	25.2	29.985000	26.5

Discrete Rotation TUV 3m Radiated 9kHz to 30MHz..

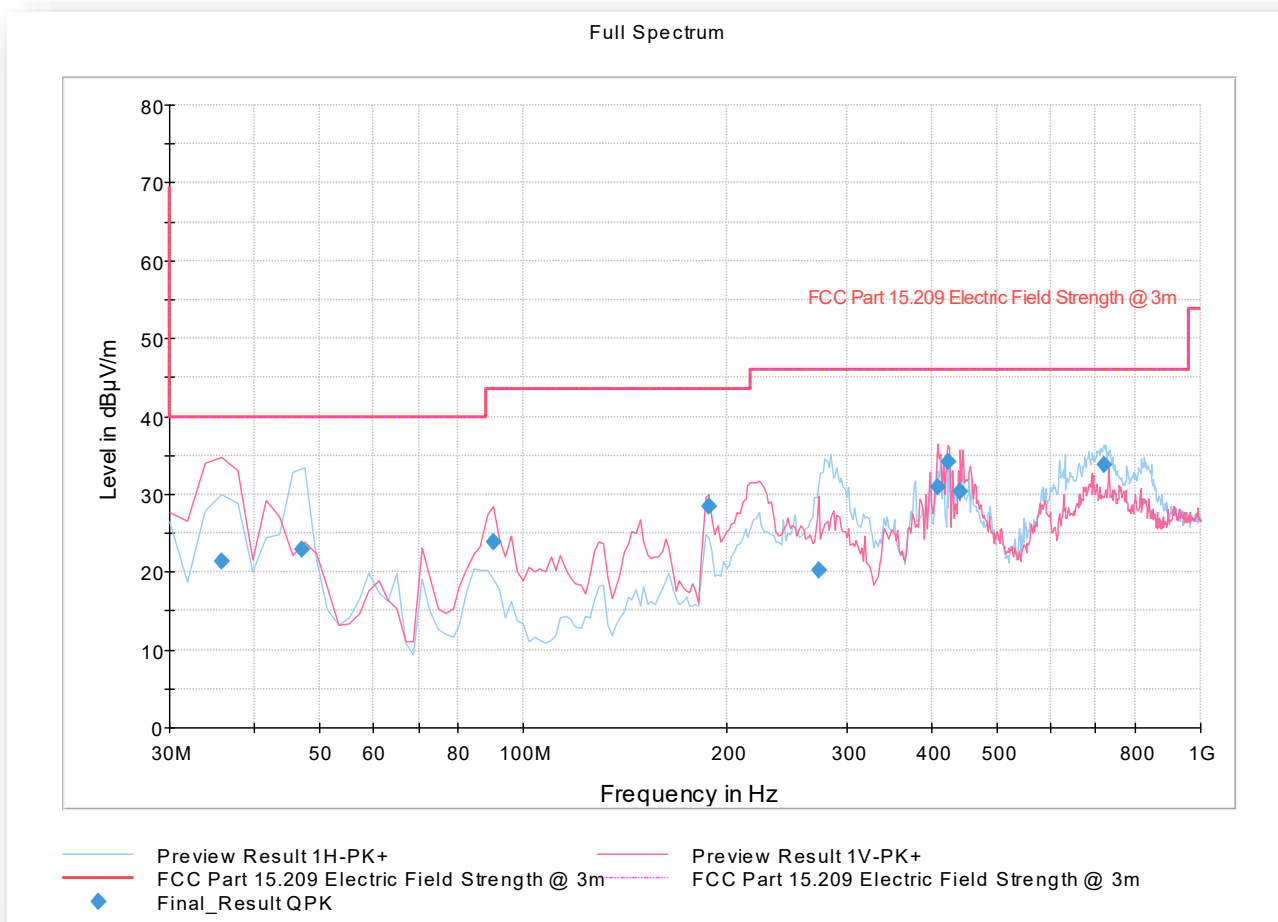


(Lowest PRF)

Quasi-Peak Data

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Polarization	Azimuth (deg)	Corr. (dB)
0.018690	46.5	122.2	75.6	15000.	0.200	H	117.0	21.7
0.031075	42.4	117.7	75.3	15000.	0.200	H	125.0	21.5
0.100069	30.4	107.6	77.1	15000.	0.200	H	208.0	19.7
0.154000	40.0	103.9	63.8	1500.0	9.000	H	138.0	19.7
0.497918	28.8	73.7	44.9	1500.0	9.000	H	123.0	19.8
1.163934	25.6	66.3	40.7	1500.0	9.000	H	79.0	20.1
1.626491	25.6	63.4	37.8	1500.0	9.000	H	257.0	20.1
4.322375	25.3	69.5	44.2	1500.0	9.000	H	323.0	20.4
9.722142	38.0	69.5	31.5	1500.0	9.000	H	337.0	21.0
10.025241	41.3	69.5	28.2	1500.0	9.000	H	220.0	21.1
10.124880	42.2	69.5	27.3	1500.0	9.000	H	123.0	21.1
10.332339	44.0	69.5	25.5	1500.0	9.000	H	0.0	21.2
10.431978	42.6	69.5	27.0	1500.0	9.000	H	323.0	21.2
10.531617	39.2	69.5	30.3	1500.0	9.000	H	235.0	21.2
29.981000	26.5	69.5	43.1	1500.0	9.000	H	315.0	25.2

2.5.10 Below 1GHz Radiated Emission Test

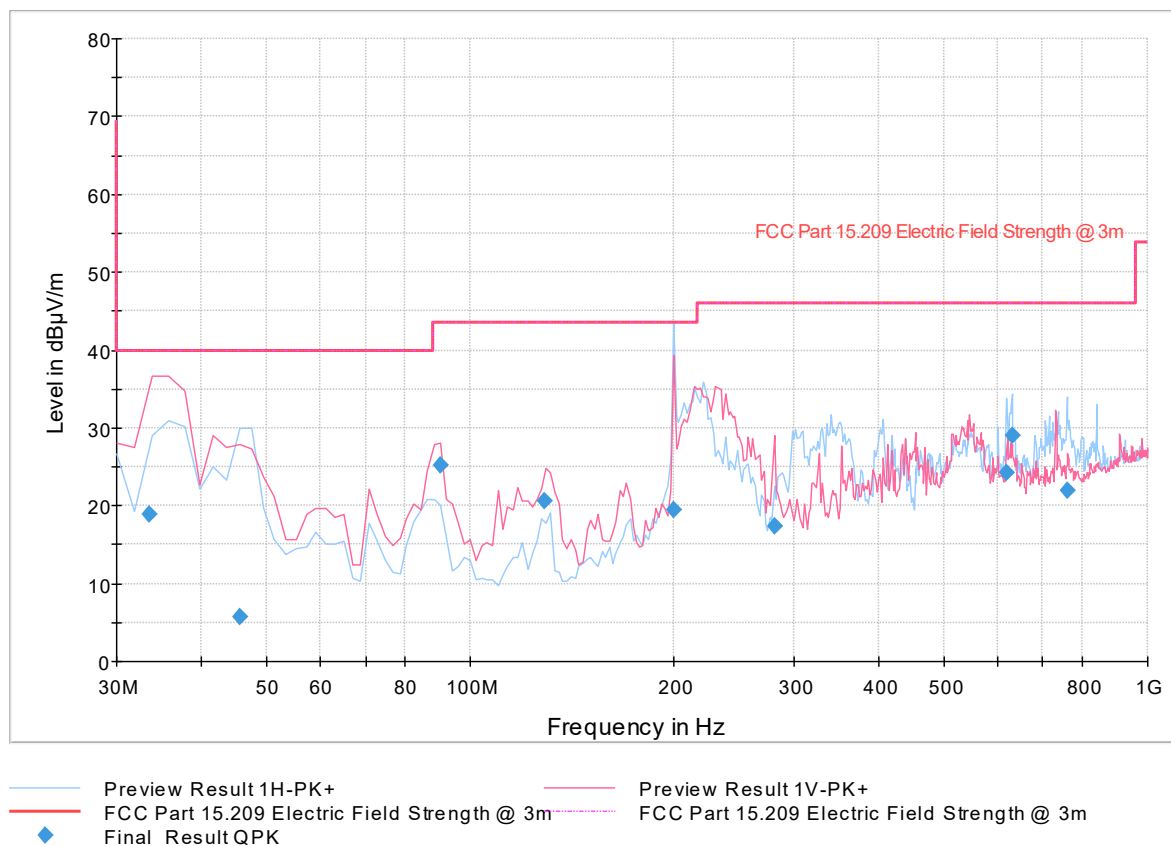


(Highest PRF)

Quasi-Peak Data

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Polarization	Azimuth (deg)	Corr. (dB)
35.831663	21.29	39.99	18.70	1000.0	120.000	100.0	V	302.0	-11.9
47.134990	22.90	39.99	17.09	1000.0	120.000	327.0	H	15.0	-16.2
90.260521	23.90	43.49	19.59	1000.0	120.000	117.0	V	24.0	-16.3
187.454910	28.38	43.49	15.11	1000.0	120.000	100.0	V	22.0	-13.0
272.945972	20.23	45.99	25.77	1000.0	120.000	100.0	V	155.0	-9.7
409.018116	31.02	45.99	14.97	1000.0	120.000	123.0	V	172.0	-6.3
422.945331	34.11	45.99	11.88	1000.0	120.000	118.0	V	158.0	-5.8
441.744208	30.32	45.99	15.67	1000.0	120.000	106.0	V	145.0	-5.5
719.880160	33.77	45.99	12.22	1000.0	120.000	107.0	H	263.0	0.4

Full Spectrum

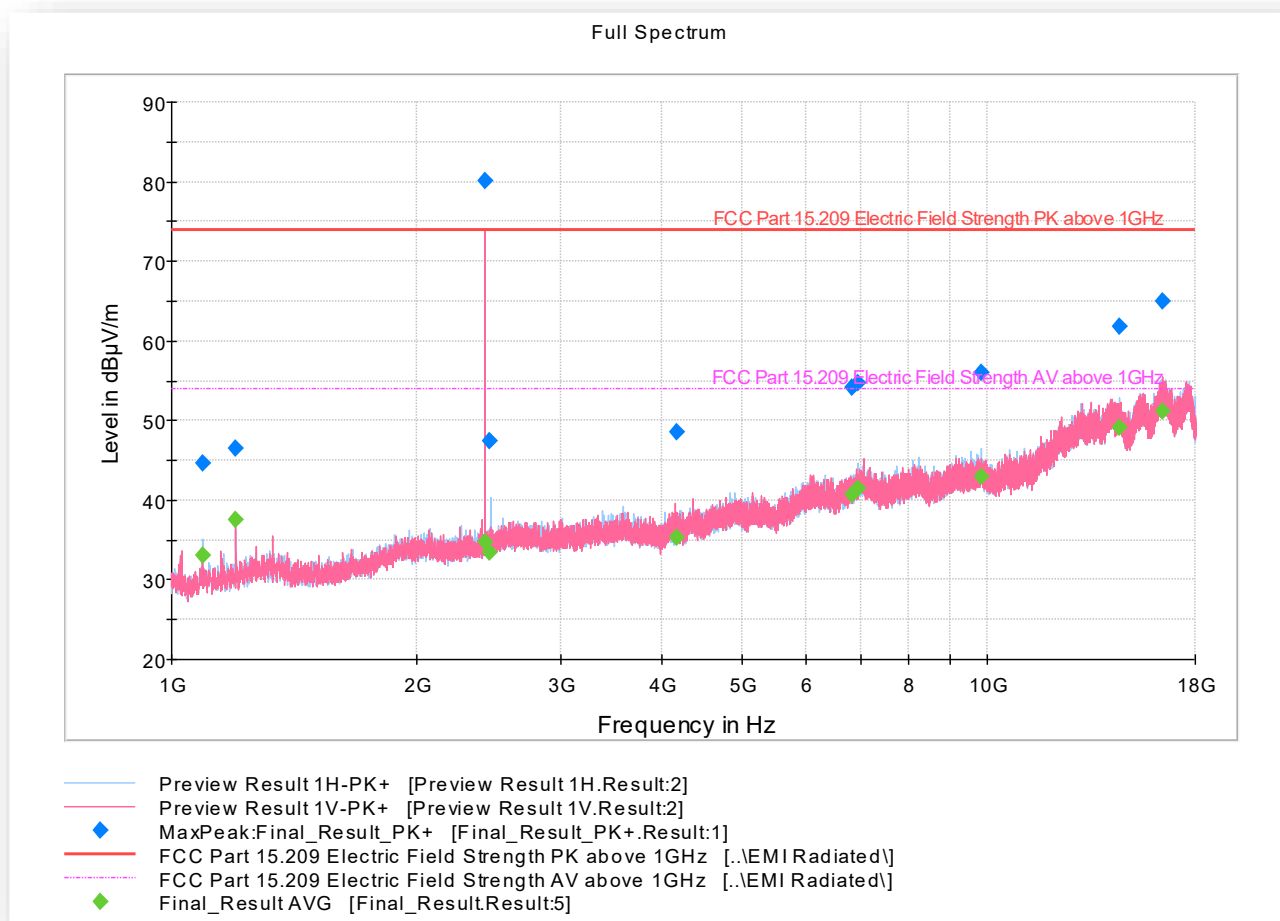


(Lowest PRF)

Quasi-Peak Data

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Polarization	Azimuth (deg)	Corr. (dB)
33.607776	18.93	39.99	21.06	1000.0	120.000	103.0	V	354.0	-10.9
45.591102	5.66	39.99	34.33	1000.0	120.000	379.0	H	146.0	-15.9
90.340521	25.22	43.49	18.27	1000.0	120.000	116.0	V	24.0	-16.3
128.818277	20.59	43.49	22.90	1000.0	120.000	145.0	V	-10.0	-16.2
199.398236	19.39	43.49	24.10	1000.0	120.000	150.0	H	289.0	-13.0
280.961523	17.46	45.99	28.53	1000.0	120.000	142.0	V	191.0	-9.8
618.717996	24.16	45.99	21.83	1000.0	120.000	104.0	H	74.0	-1.0
630.341323	29.10	45.99	16.89	1000.0	120.000	393.0	H	-9.0	-1.2
761.221804	22.00	45.99	23.99	1000.0	120.000	223.0	H	138.0	0.4

2.5.11 1GHz to 18GHz Radiated Emission Test



(Highest PRF)

Peak Data

Frequency (MHz)	MaxPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Polarization	Azimuth (deg)	Corr. (dB)
1090.30000	44.61	73.90	29.29	1000.0	1000.000	317.0	H	278.0	-1
1200.06666	46.53	73.90	27.37	1000.0	1000.000	248.0	V	60.0	-1
2425.53333	80.10	73.90	-6.20	1000.0	1000.000	342.0	V	110.0	4
2457.00000	47.50	73.90	26.40	1000.0	1000.000	219.0	H	50.0	4
4160.50000	48.49	73.90	25.41	1000.0	1000.000	335.0	V	293.0	7
6842.36666	54.16	73.90	19.74	1000.0	1000.000	306.0	H	27.0	10
6954.80000	54.77	73.90	19.13	1000.0	1000.000	335.0	V	282.0	10
9849.33333	56.12	73.90	17.78	1000.0	1000.000	342.0	H	287.0	13
14524.6333	61.86	73.90	12.04	1000.0	1000.000	175.0	H	256.0	18
16434.7000	64.94	73.90	8.96	1000.0	1000.000	316.0	V	52.0	21

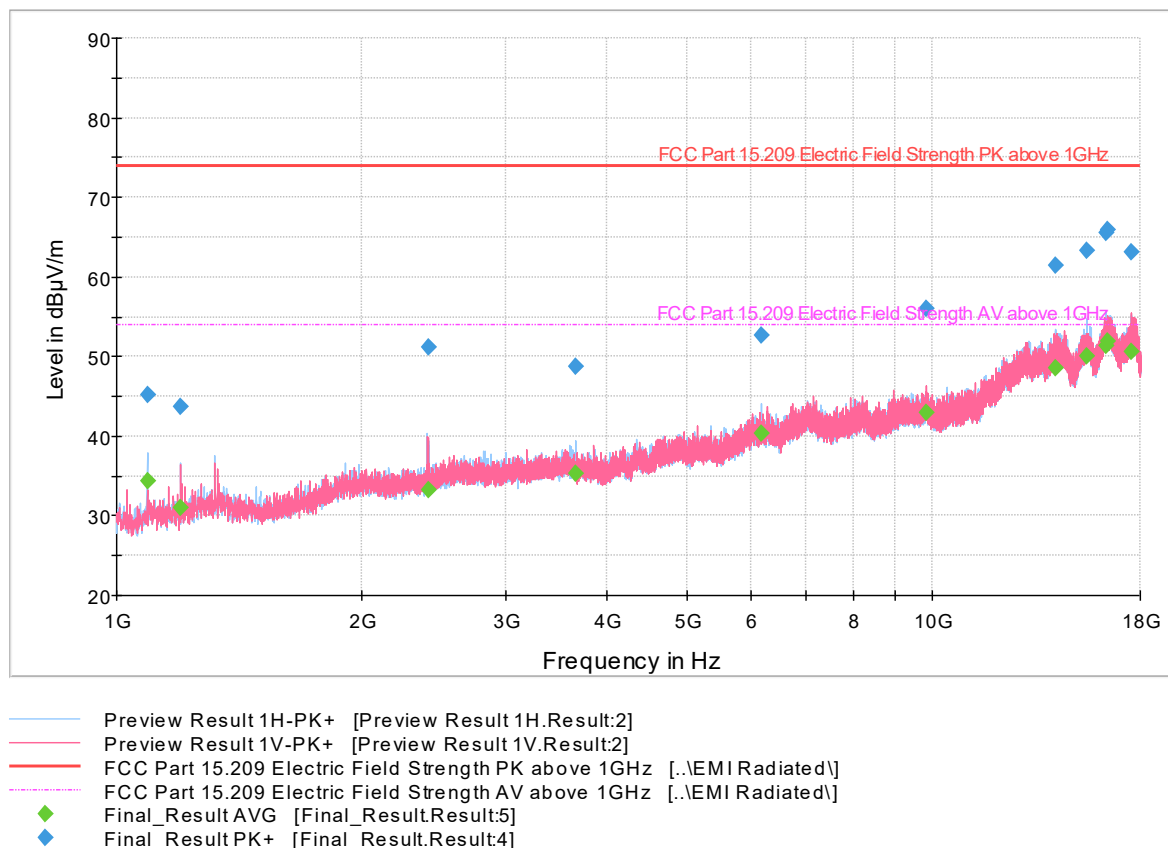
Test note BLE module transmitting at 2425.53 MHz



Average Data

Frequency (MHz)	Average (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Polarization	Azimuth (deg)	Corr. (dB/m)
1090.30000	32.98	53.90	20.92	1000.0	1000.000	317.0	H	278.0	-1
1200.06666	37.49	53.90	16.41	1000.0	1000.000	248.0	V	60.0	-1
2425.53333	34.72	53.90	19.18	1000.0	1000.000	342.0	V	110.0	4
2457.00000	33.35	53.90	20.55	1000.0	1000.000	219.0	H	50.0	4
4160.50000	35.38	53.90	18.52	1000.0	1000.000	335.0	V	293.0	7
6842.36666	40.69	53.90	13.21	1000.0	1000.000	306.0	H	27.0	10
6954.80000	41.42	53.90	12.48	1000.0	1000.000	335.0	V	282.0	10
9849.33333	42.90	53.90	11.00	1000.0	1000.000	342.0	H	287.0	13
14524.6333	49.18	53.90	4.72	1000.0	1000.000	175.0	H	256.0	18
16434.7000	51.11	53.90	2.79	1000.0	1000.000	316.0	V	52.0	21

Full Spectrum



(Lowest PRF)

Peak Data

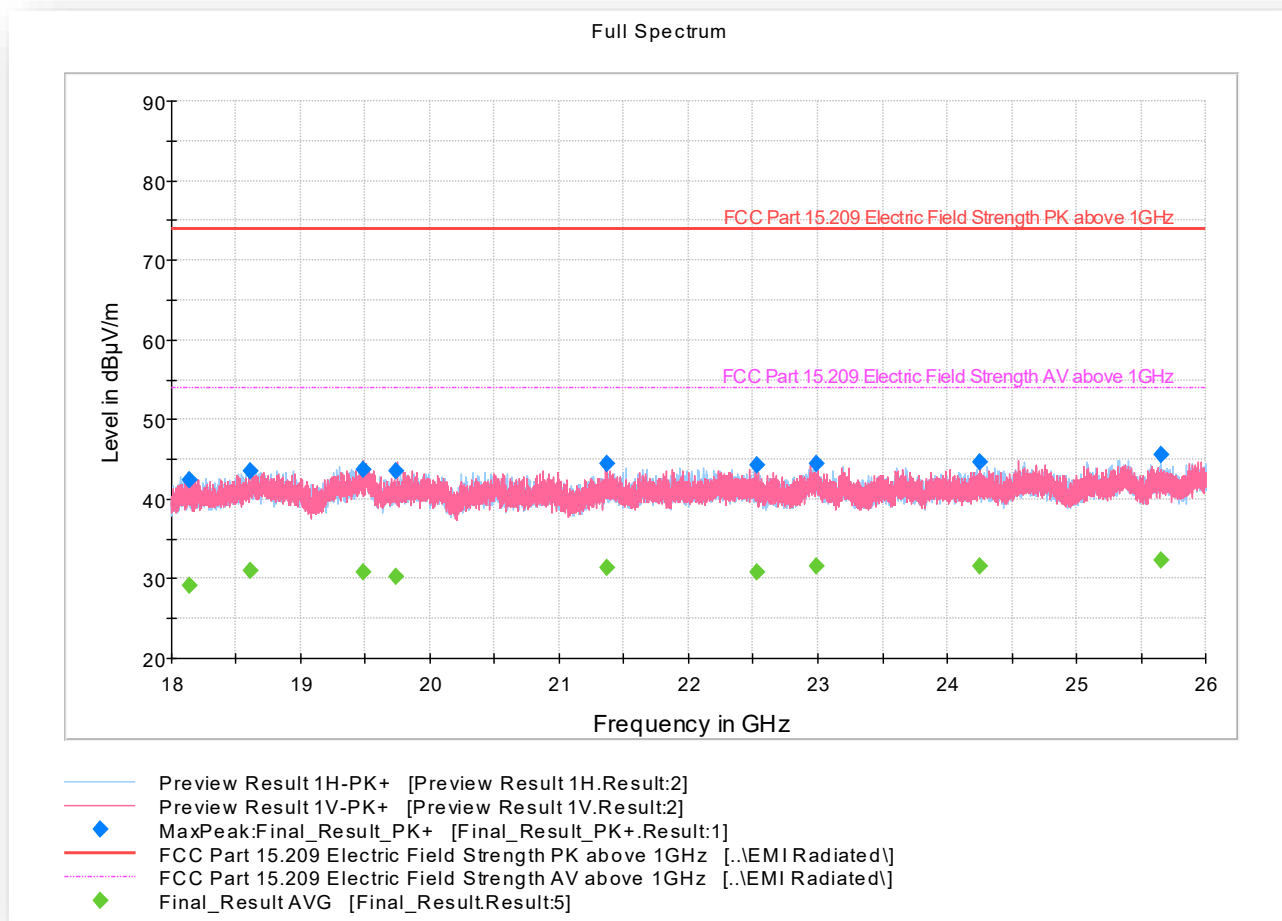
Frequency (MHz)	MaxPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Polarization	Azimuth (deg)	Corr. (dB)
1090.30000	45.27	73.90	28.63	1000.0	1000.000	317.0	H	6.0	-1
1199.83333	43.67	73.90	30.23	1000.0	1000.000	150.0	H	62.0	-1
2411.06666	51.12	73.90	22.78	1000.0	1000.000	207.0	H	207.0	4
3650.26666	48.81	73.90	25.09	1000.0	1000.000	335.0	H	112.0	6
6172.56666	52.63	73.90	21.27	1000.0	1000.000	351.0	H	134.0	9
9853.00000	56.01	73.90	17.89	1000.0	1000.000	175.0	V	353.0	13
14159.7666	61.46	73.90	12.44	1000.0	1000.000	175.0	H	22.0	18
15445.6333	63.27	73.90	10.63	1000.0	1000.000	348.0	H	232.0	19
16366.2333	65.62	73.90	8.28	1000.0	1000.000	302.0	H	232.0	21
16391.4333	65.90	73.90	8.00	1000.0	1000.000	335.0	H	226.0	21
17581.5666	63.17	73.90	10.73	1000.0	1000.000	286.0	V	248.0	23



Average Data

Frequency (MHz)	Average (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Polarization	Azimuth (deg)	Corr. (dB/m)
1090.30000	32.98	53.90	20.92	1000.0	1000.000	317.0	H	278.0	-1
1200.06666	37.49	53.90	16.41	1000.0	1000.000	248.0	V	60.0	-1
2425.53333	34.72	53.90	19.18	1000.0	1000.000	342.0	V	110.0	4
2457.00000	33.35	53.90	20.55	1000.0	1000.000	219.0	H	50.0	4
4160.50000	35.38	53.90	18.52	1000.0	1000.000	335.0	V	293.0	7
6842.36666	40.69	53.90	13.21	1000.0	1000.000	306.0	H	27.0	10
6954.80000	41.42	53.90	12.48	1000.0	1000.000	335.0	V	282.0	10
9849.33333	42.90	53.90	11.00	1000.0	1000.000	342.0	H	287.0	13
14524.6333	49.18	53.90	4.72	1000.0	1000.000	175.0	H	256.0	18
16434.7000	51.11	53.90	2.79	1000.0	1000.000	316.0	V	52.0	21

2.5.12 18GHz to 26GHz Radiated Emission Test



(Highest PRF)

Peak Data

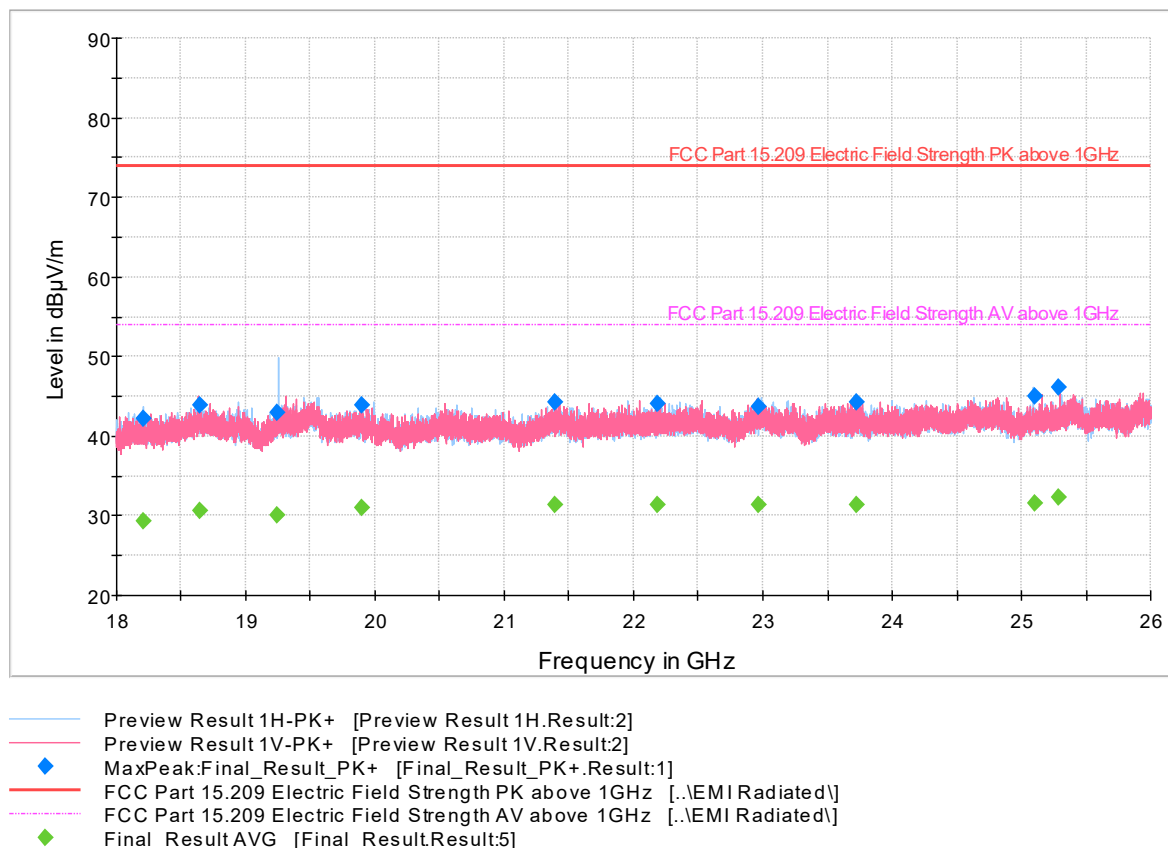
Frequency (MHz)	MaxPeak (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Polarization	Azimuth (deg)	Corr. (dB)
18140.2335	42.39	73.90	31.51	1000.0	1000.000	162.0	V	291.0	-5
18611.2690	43.60	73.90	30.30	1000.0	1000.000	213.0	V	170.0	-4
19479.0660	43.74	73.90	30.16	1000.0	1000.000	150.0	V	144.0	-5
19740.6710	43.44	73.90	30.46	1000.0	1000.000	150.0	V	4.0	-5
21363.2385	44.50	73.90	29.40	1000.0	1000.000	141.0	V	46.0	-4
22532.5460	44.20	73.90	29.70	1000.0	1000.000	150.0	H	1.0	-3
22985.4410	44.49	73.90	29.41	1000.0	1000.000	192.0	H	317.0	-3
24256.6710	44.66	73.90	29.24	1000.0	1000.000	212.0	V	38.0	-3
25658.8720	45.66	73.90	28.24	1000.0	1000.000	150.0	H	334.0	-1



Average Data

Frequency (MHz)	Average (dB μ V/m)	Limit (dB μ V/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Polarization	Azimuth (deg)	Corr. (dB/m)
18140.2335	29.21	53.90	24.69	1000.0	1000.000	162.0	V	291.0	-5
18611.2690	31.05	53.90	22.85	1000.0	1000.000	213.0	V	170.0	-4
19479.0660	30.84	53.90	23.06	1000.0	1000.000	150.0	V	144.0	-5
19740.6710	30.36	53.90	23.54	1000.0	1000.000	150.0	V	4.0	-5
21363.2385	31.42	53.90	22.48	1000.0	1000.000	141.0	V	46.0	-4
22532.5460	30.81	53.90	23.09	1000.0	1000.000	150.0	H	1.0	-3
22985.4410	31.60	53.90	22.30	1000.0	1000.000	192.0	H	317.0	-3
24256.6710	31.57	53.90	22.33	1000.0	1000.000	212.0	V	38.0	-3
25658.8720	32.24	53.90	21.66	1000.0	1000.000	150.0	H	334.0	-1

Full Spectrum



(Lowest PRF)

Peak Data

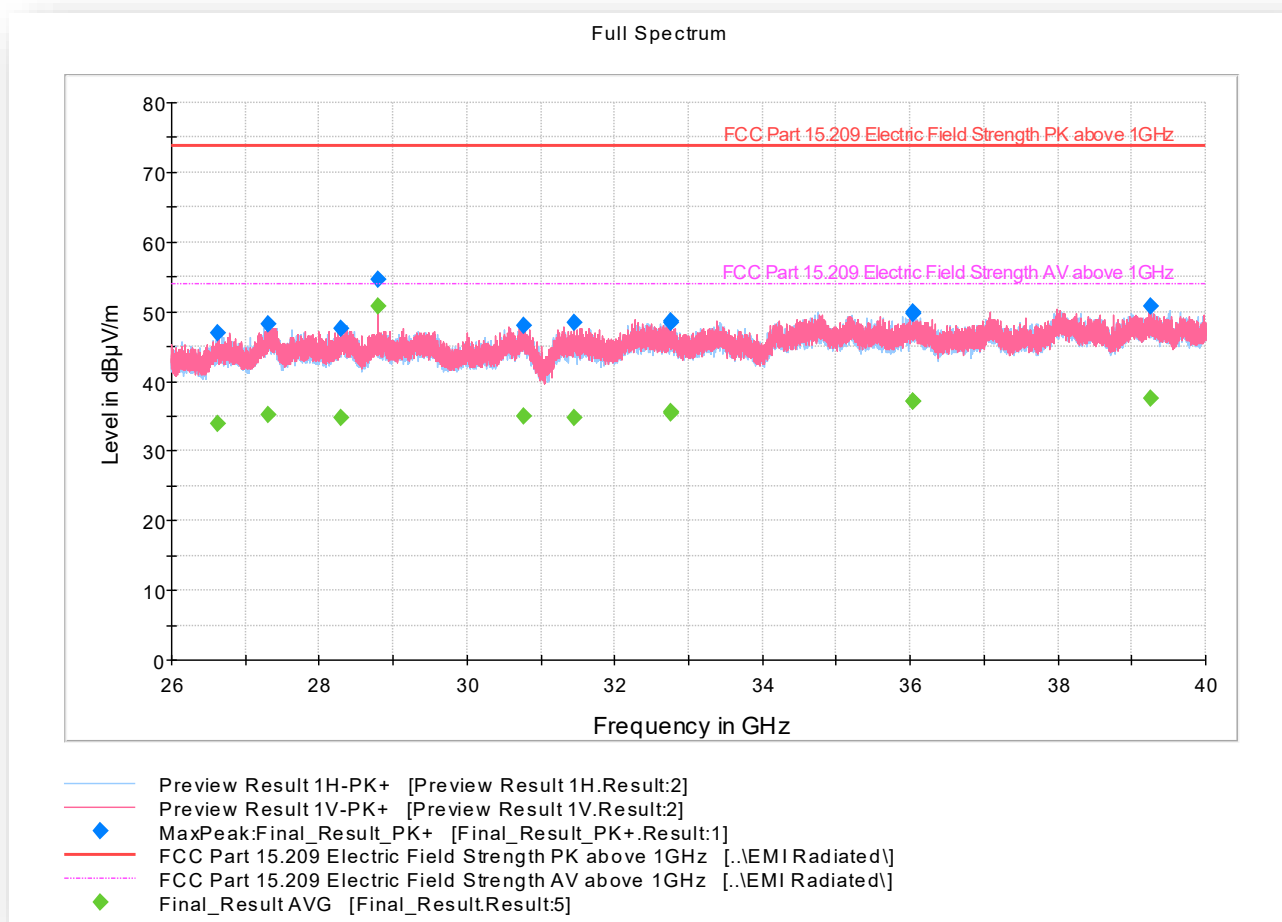
Frequency (MHz)	MaxPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Polarization	Azimuth (deg)	Corr. (dB)
18204.0305	42.22	73.90	31.68	1000.0	1000.000	162.0	V	332.0	-5
18639.6100	43.93	73.90	29.97	1000.0	1000.000	150.0	V	292.0	-5
19246.8870	42.95	73.90	30.95	1000.0	1000.000	189.0	H	22.0	-5
19897.9710	43.89	73.90	30.01	1000.0	1000.000	189.0	V	338.0	-5
21391.7575	44.22	73.90	29.68	1000.0	1000.000	213.0	V	76.0	-4
22189.0210	44.12	73.90	29.78	1000.0	1000.000	162.0	V	321.0	-3
22964.0615	43.74	73.90	30.16	1000.0	1000.000	162.0	H	68.0	-3
23721.2230	44.19	73.90	29.71	1000.0	1000.000	213.0	V	359.0	-2
25105.4775	44.99	73.90	28.91	1000.0	1000.000	187.0	H	130.0	-2
25292.8840	46.16	73.90	27.74	1000.0	1000.000	151.0	V	24.0	-1



Average Data

Frequency (MHz)	Average (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Polarization	Azimuth (deg)	Corr. (dB/m)
18204.0305	29.34	53.90	24.56	1000.0	1000.000	162.0	V	332.0	-5
18639.6100	30.63	53.90	23.27	1000.0	1000.000	150.0	V	292.0	-5
19246.8870	30.15	53.90	23.75	1000.0	1000.000	189.0	H	22.0	-5
19897.9710	31.01	53.90	22.89	1000.0	1000.000	189.0	V	338.0	-5
21391.7575	31.39	53.90	22.51	1000.0	1000.000	213.0	V	76.0	-4
22189.0210	31.34	53.90	22.56	1000.0	1000.000	162.0	V	321.0	-3
22964.0615	31.37	53.90	22.53	1000.0	1000.000	162.0	H	68.0	-3
23721.2230	31.42	53.90	22.48	1000.0	1000.000	213.0	V	359.0	-2
25105.4775	31.59	53.90	22.31	1000.0	1000.000	187.0	H	130.0	-2
25292.8840	32.36	53.90	21.54	1000.0	1000.000	151.0	V	24.0	-1

2.5.13 26GHz to 40GHz Radiated Emission Test



(Highest PRF)

Peak Data

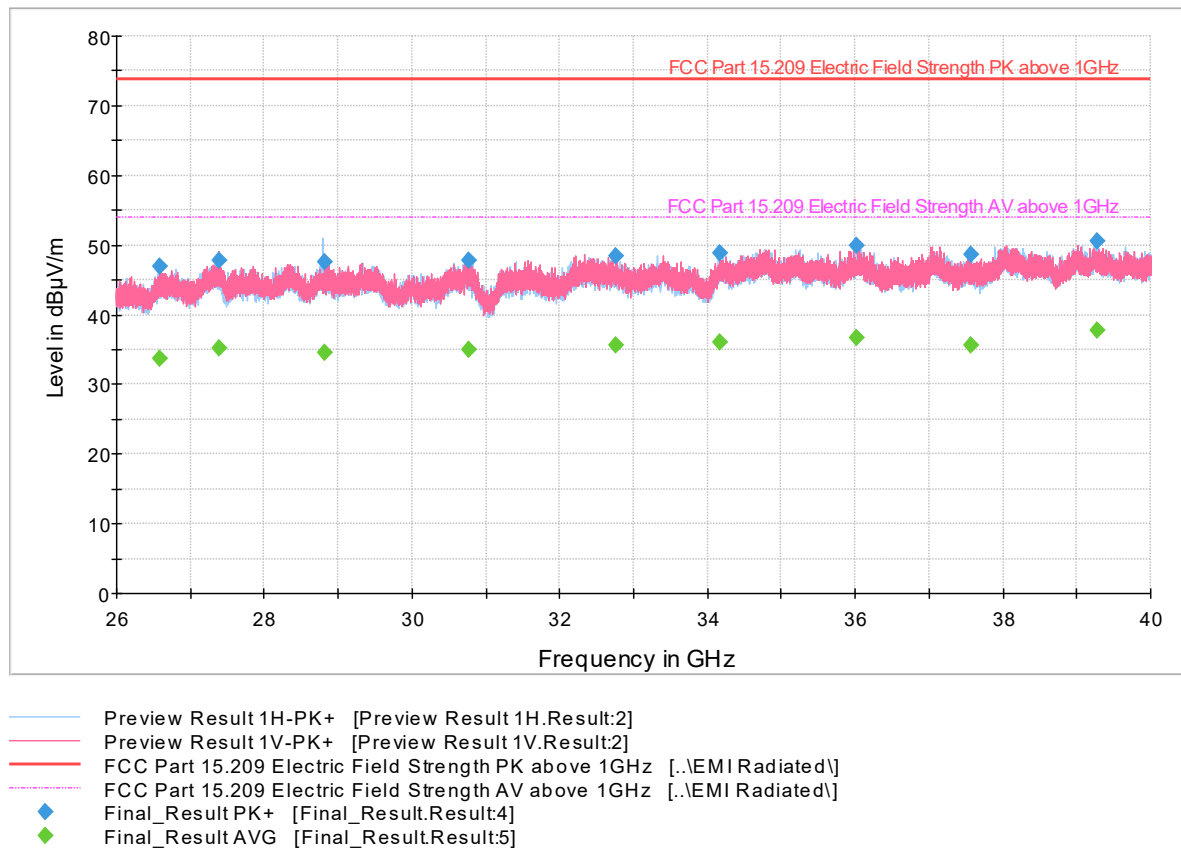
Frequency (MHz)	MaxPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Polarization	Azimuth (deg)	Corr. (dB)
26616.7638	47.01	73.90	26.89	1000.0	1000.000	203.0	V	94.0	0
27306.0530	48.15	73.90	25.75	1000.0	1000.000	177.0	H	86.0	1
28292.8400	47.62	73.90	26.28	1000.0	1000.000	225.0	H	26.0	1
28799.3542	54.52	73.90	19.38	1000.0	1000.000	178.0	V	214.0	1
30759.7961	47.95	73.90	25.95	1000.0	1000.000	225.0	H	40.0	1
31457.2796	48.53	73.90	25.37	1000.0	1000.000	147.0	V	348.0	2
32757.4853	48.44	73.90	25.46	1000.0	1000.000	168.0	V	318.0	3
32766.8984	48.57	73.90	25.33	1000.0	1000.000	175.0	V	281.0	3
36038.6192	49.84	73.90	24.06	1000.0	1000.000	143.0	H	7.0	5
36039.1769	49.74	73.90	24.16	1000.0	1000.000	150.0	H	45.0	5
39250.6411	50.79	73.90	23.11	1000.0	1000.000	135.0	V	150.0	5



Average Data

Frequency (MHz)	Average (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Polarization	Azimuth (deg)	Corr. (dB/m)
26616.7638	33.92	53.90	19.98	1000.0	1000.000	203.0	V	94.0	0
27306.0530	35.10	53.90	18.80	1000.0	1000.000	177.0	H	86.0	1
28292.8400	34.75	53.90	19.15	1000.0	1000.000	225.0	H	26.0	1
28799.3542	50.67	53.90	3.23	1000.0	1000.000	178.0	V	214.0	1
30759.7961	35.05	53.90	18.85	1000.0	1000.000	225.0	H	40.0	1
31457.2796	34.83	53.90	19.07	1000.0	1000.000	147.0	V	348.0	2
32757.4853	35.42	53.90	18.48	1000.0	1000.000	168.0	V	318.0	3
32766.8984	35.69	53.90	18.21	1000.0	1000.000	175.0	V	281.0	3
36038.6192	37.12	53.90	16.78	1000.0	1000.000	143.0	H	7.0	5
36039.1769	37.07	53.90	16.83	1000.0	1000.000	150.0	H	45.0	5
39250.6411	37.51	53.90	16.39	1000.0	1000.000	135.0	V	150.0	5

Full Spectrum



(Lowest PRF)

Peak Data

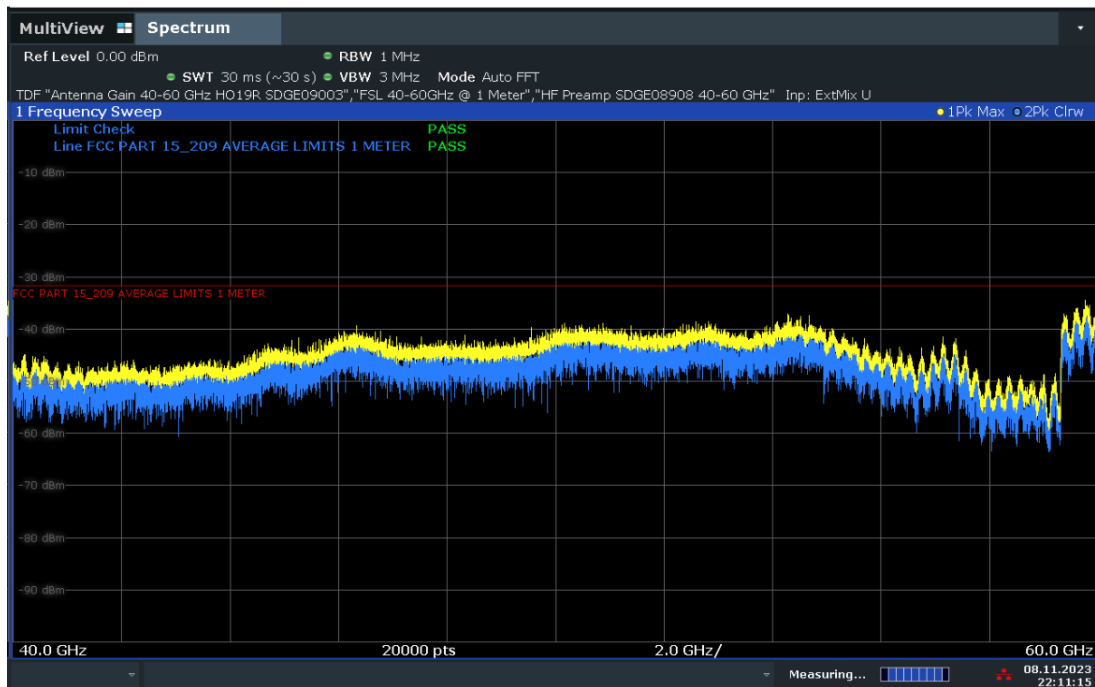
Frequency (MHz)	MaxPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Polarization	Azimuth (deg)	Corr. (dB)
26587.5511	46.87	73.90	27.03	1000.0	1000.000	175.0	V	278.0	0
27394.2761	47.74	73.90	26.16	1000.0	1000.000	175.0	V	142.0	1
28812.7826	47.50	73.90	26.40	1000.0	1000.000	225.0	H	178.0	1
30760.4246	47.87	73.90	26.03	1000.0	1000.000	175.0	V	170.0	1
32753.5969	48.36	73.90	25.54	1000.0	1000.000	143.0	V	185.0	3
34164.4480	48.87	73.90	25.03	1000.0	1000.000	175.0	H	90.0	4
36013.5953	49.90	73.90	24.00	1000.0	1000.000	126.0	H	100.0	5
37563.6980	48.62	73.90	25.28	1000.0	1000.000	159.0	V	272.0	4
39275.9580	50.60	73.90	23.30	1000.0	1000.000	187.0	H	317.0	5



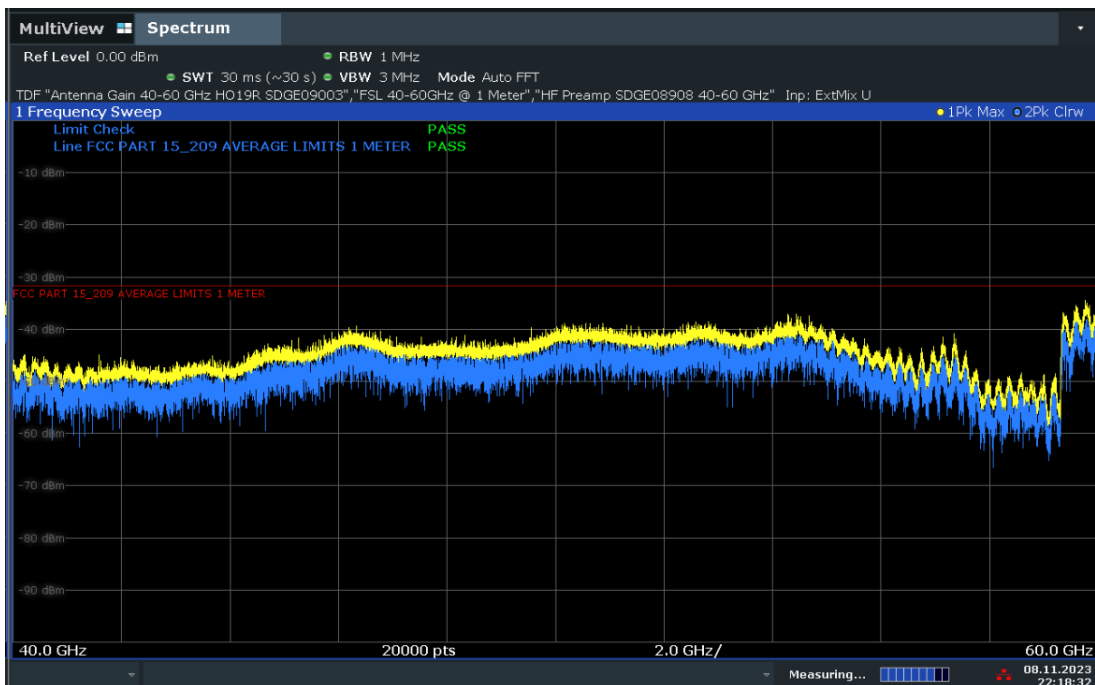
Average Data

Frequency (MHz)	Average (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Polarization	Azimuth (deg)	Corr. (dB/m)
26587.5511	33.76	53.90	20.14	1000.0	1000.000	175.0	V	278.0	0
27394.2761	35.10	53.90	18.80	1000.0	1000.000	175.0	V	142.0	1
28812.7826	34.48	53.90	19.42	1000.0	1000.000	225.0	H	178.0	1
30760.4246	34.99	53.90	18.91	1000.0	1000.000	175.0	V	170.0	1
32753.5969	35.55	53.90	18.35	1000.0	1000.000	143.0	V	185.0	3
34164.4480	36.09	53.90	17.81	1000.0	1000.000	175.0	H	90.0	4
36013.5953	36.73	53.90	17.17	1000.0	1000.000	126.0	H	100.0	5
37563.6980	35.71	53.90	18.19	1000.0	1000.000	159.0	V	272.0	4
39275.9580	37.69	53.90	16.21	1000.0	1000.000	187.0	H	317.0	5

2.5.14 40GHz to 200GHz Maximized Plots

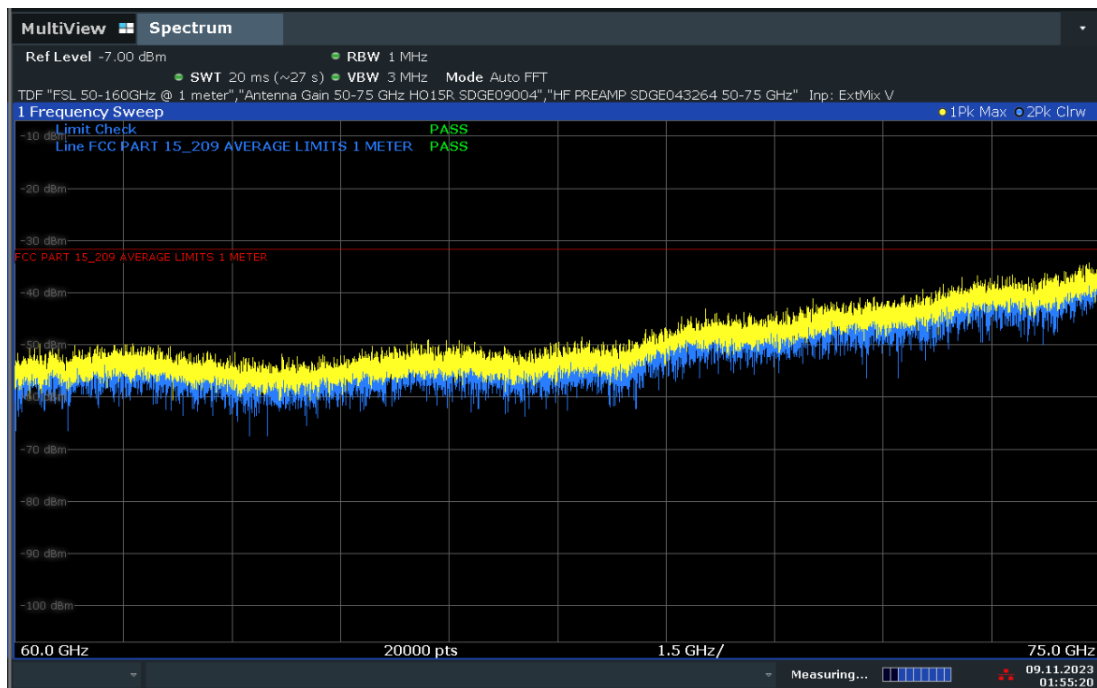


(Highest PRF)

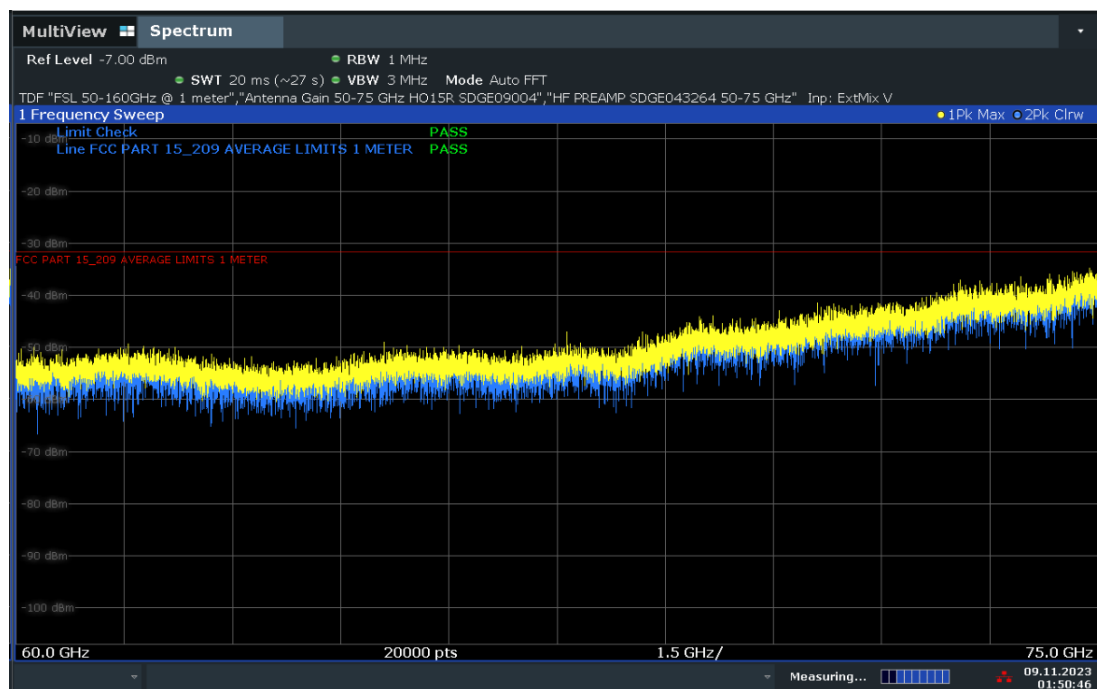


(Lowest PRF)

40GHz to 60GHz Plots

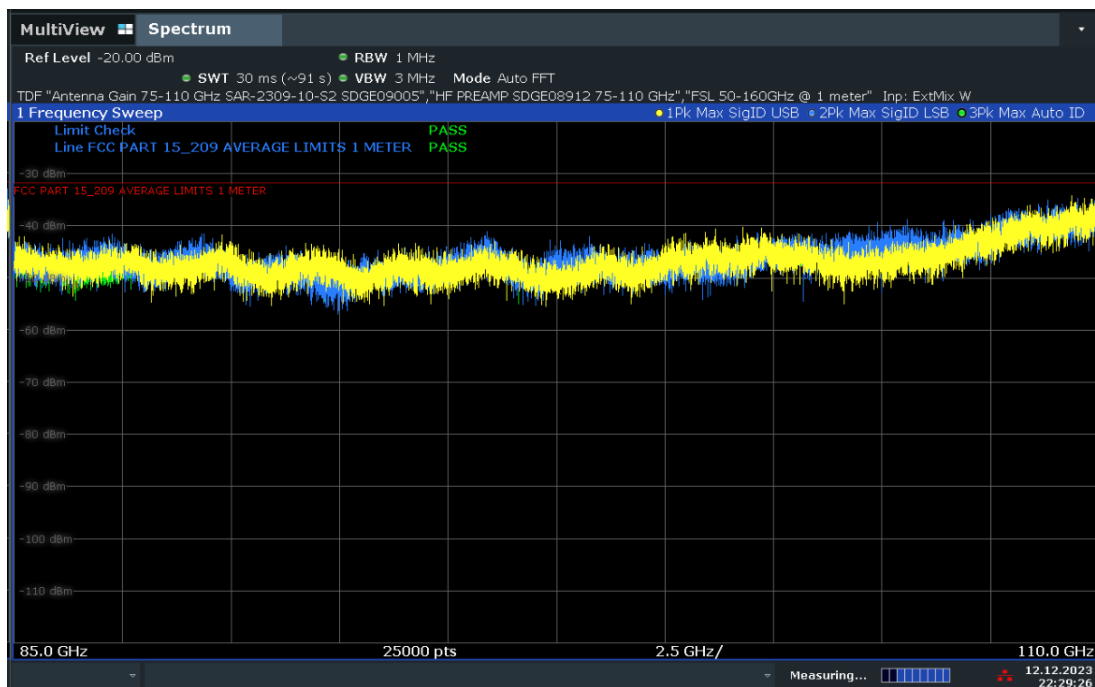


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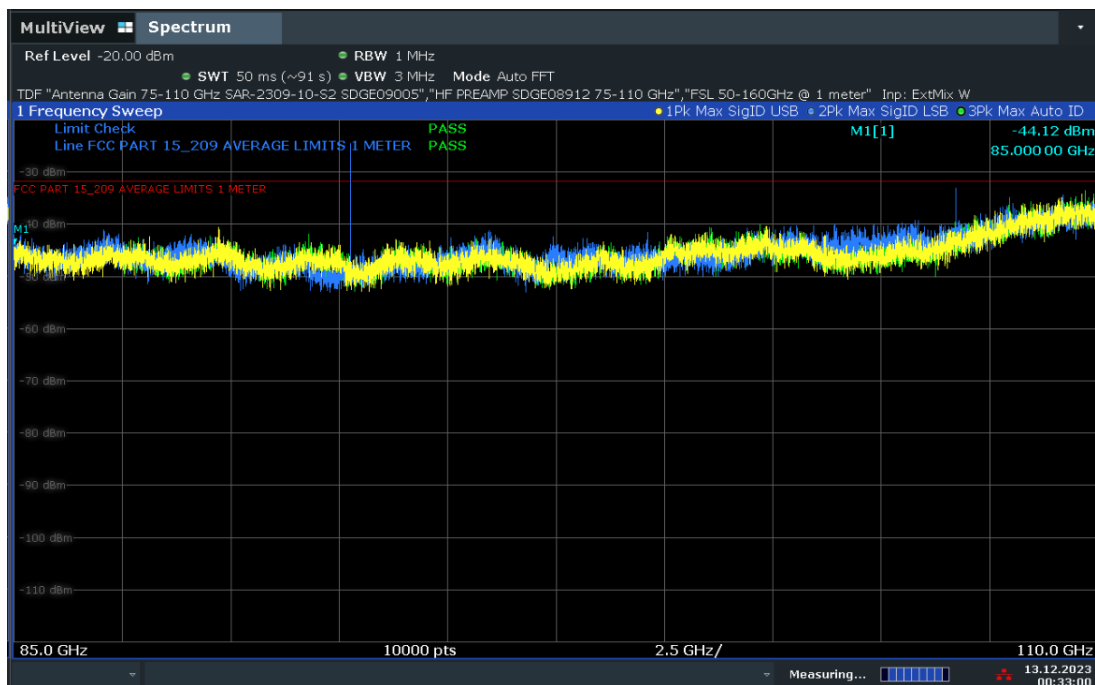


(Lowest PRF)

60GHz to 75GHz Plot

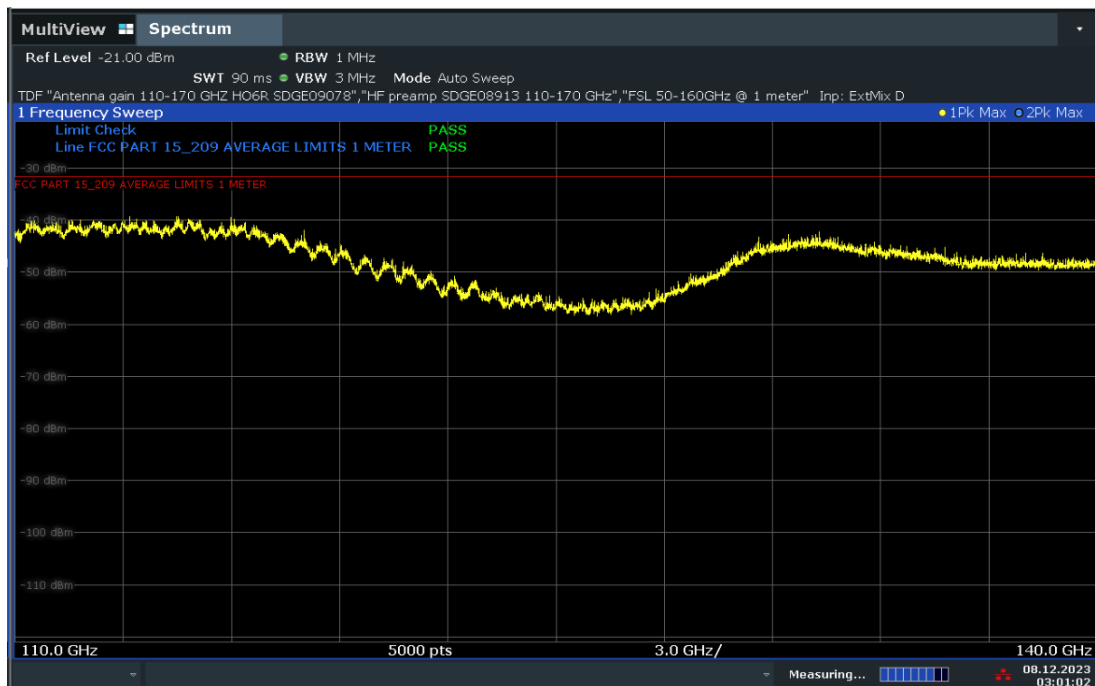


(Highest PRF)

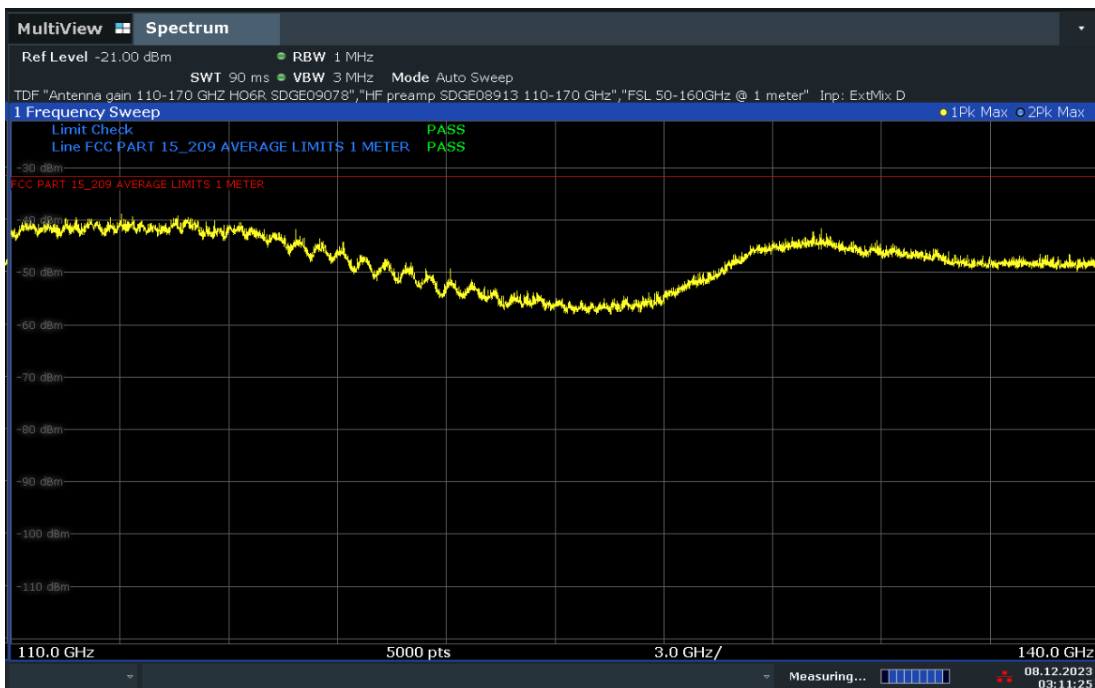


(Lowest PRF)

85GHz to 110GHz Plot

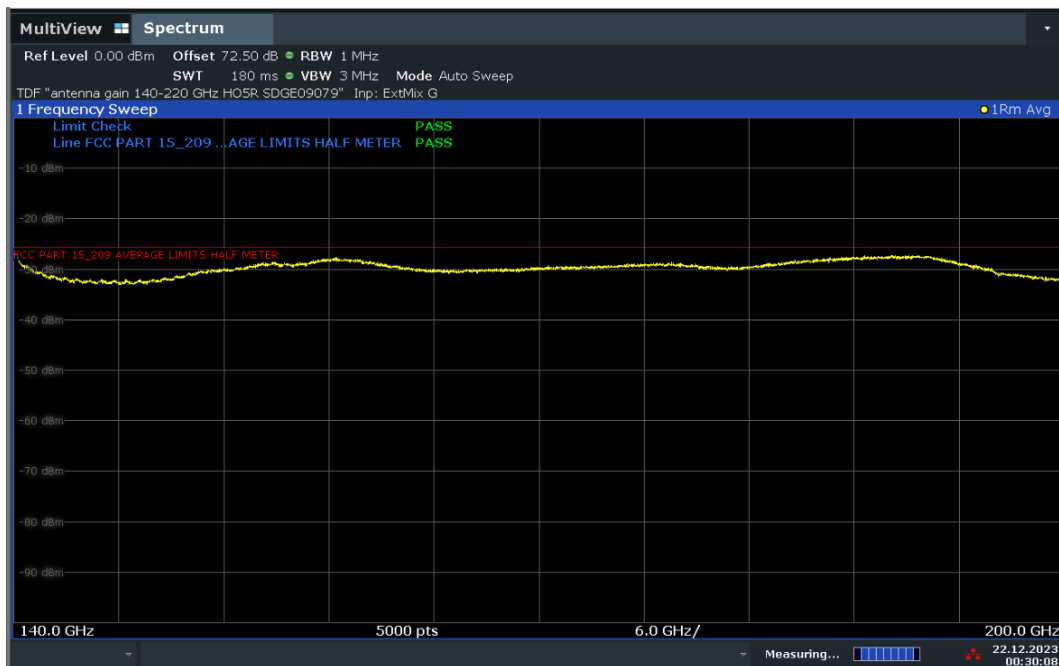


(Highest PRF)

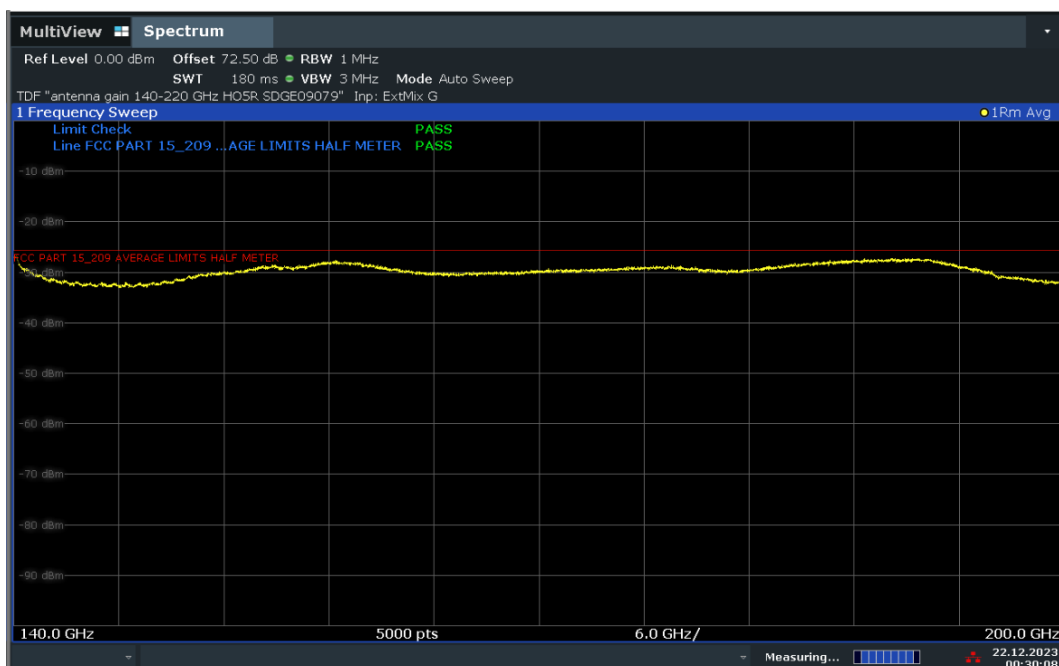


(Lowest PRF)

110GHz to 140GHz Plot



(Highest PRF)



(Lowest PRF)

140GHz to 200GHz Plot

2.6 ANTENNA BEAMWIDTH

2.6.1 Specification Reference

FCC 47 CFR Part 15, Clause 15.256(i)(B)
RSS-211 Clause 5.2(a)

2.6.2 Standard Applicable

(B) LPR devices operating under the provisions of this section within the 75–85 GHz band must use an antenna with a –3 dB beamwidth no greater than 8 degrees.

2.6.3 Equipment Under Test and Modification State

Serial No: 001/ Default Test Configuration

2.6.4 Date of Test/Initial of test personnel who performed the test.

December 13, 2023 / JS

2.6.5 Test Equipment Used

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

2.6.6 Environmental Conditions/ Test Location

Test performed at TÜV SÜD America Inc. Mira Mesa facility

Ambient Temperature	24.0 °C
Relative Humidity	50.1 %
ATM Pressure	99.9 kPa

2.6.7 Additional Observations

- This is a radiated antenna pattern test.
- The EUT is configured for CW operation.
- Test results from Section 2.7.8 of this test report applies.
- The half-power beamwidth of the EUT is verified as no greater than 8 degrees relative to the main beam gain.

2.7 ANTENNA SIDE LOBE GAIN

2.7.1 Specification Reference

FCC 47 CFR Part 15, Clause 15.256(j)
RSS-211 Clause 5.2(c)

2.7.2 Standard Applicable

Antenna side lobe gain. LPR devices operating under the provisions of this section must limit the side lobe antenna gain relative to the main beam gain for off-axis angles from the main beam of greater than 60 degrees to the levels provided in the following table:

Frequency Range (GHz)	Antenna side lobe gain limit relative to main beam gain
5.925 – 7.250	-22
24.05 – 29.00	-27
75 -85	-38

2.7.3 Equipment Under Test and Modification State

Serial No: 001/ Default Test Configuration

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

December 13, 2023 / JS

2.7.5 Test Equipment Used

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

2.7.6 Environmental Conditions/ Test Location

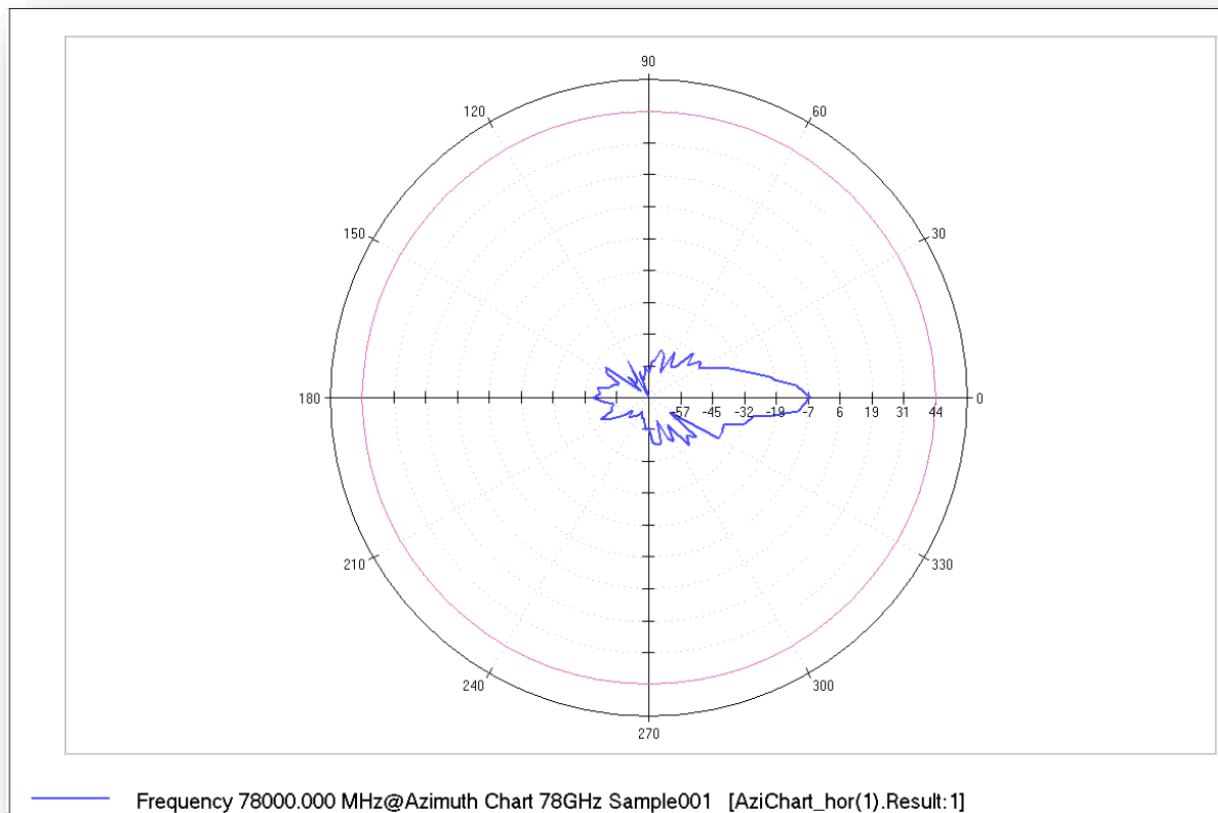
Test performed at TÜV SÜD America Inc. Mira Mesa facility

Ambient Temperature	24.0 °C
Relative Humidity	50.1 %
ATM Pressure	99.9 kPa

2.7.7 Additional Observations

- This is a radiated antenna pattern test.
- The EUT is configured for CW operation.
- At no greater than 8°, the antenna side lobe gain relative to main beam gain is - 3dB.
- At greater than 60°, the antenna side lobe gain relative to main beam gain is - 38dB.
- Only relevant polarity presented.

2.7.8 Test Results



Degrees	Gain (dB)	Degrees	Gain (dB)	Degrees	Gain (dB)	Degrees	Gain (dB)	Degrees	Gain (dB)
0	0	70	-46.3	145	-43.3	220	-56.3	295	-46.3
5	-5.3	75	-44.3	150	-45.0	225	-53.3	300	-44.3
8	-13.3	80	-49.3	155	-51.3	230	-54.3	305	-51.3
10	-15.3	85	-50.3	160	-49.3	235	-55.3	310	-39.3
15	-24.1	90	-54.3	165	-48.3	240	-57.3	315	-43.3
20	-29.8	95	-52.3	170	-43.8	245	-58.3	320	-39.5
25	-35.3	100	-55.3	175	-45.3	250	-55.3	325	-54.3
30	-41.3	105	-57.3	180	-42.3	255	-56.3	330	-32.2
35	-38.9	110	-53.3	185	-46.3	260	-54.3	335	-32.3
40	-44.3	115	-64.3	190	-50.3	265	-51.3	340	-32.4
45	-39.3	120	-47.3	195	-49.3	270	-52.6	345	-24.5
50	-48.3	125	-56.3	200	-48.3	275	-46.3	350	-22.1
55	-49.3	130	-57.3	205	-43.3	280	-45.3	352	-14.3
60	-43.3	135	-52.3	210	-47.3	285	-44.8	355	-4.5
65	-53.3	140	-60.3	215	-52.3	290	-54.5	360	0



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	04/03/23	04/03/24
7611	Signal/Spectrum Analyzer	FSW26	102017	Rohde & Schwarz	02/02/23	02/20/24
1002	Bilog Antenna	3142C	0058717	EMCO	12/01/23	12/01/25
7631	Double-ridged waveguide horn	3117	00205418	ETS-Lindgren	05/01/23	05/01/25
46797	Preamplifier	PA-122	181925	Com Power	12/03/22	01/03/24
6628	Loop Antenna	HFH2-Z2335.4711.52	FNr.800.458/25	Schwarbeck	06/23/22	06/23/24
9001	Horn antenna (18-26.5GHz)	HO42S	101	Custom Microwave	10/26/23	10/26/25
9003	Horn antenna (26-40 GHz)	HO28S	102	Custom Microwaves	08/30/22	08/30/24
40815	Pre-amplifier (18-40 GHz)	19D18	15G27	Spacek Labs	09/06/23	09/06/24
7637	Harmonics mixer (40-60 GHz)	FS-Z60	100009	Rhode & Schwarz	07/29/20	01/23/24
-	Harmonics mixer (50-75 GHz)	FS-Z75	100988	Rhode & Schwarz	10/19/23	10/19/25
7633	Harmonics mixer (75-110 GHz)	HM-110-7	101000	Radiometer Physics	10/19/23	10/19/25
7634	Harmonics mixer (110-170 GHz)	HM-170	0062	Radiometer Physics	10/19/23	10/19/25
7635	Harmonics mixer (170-220 GHz)	HM-220	020022	Radiometer Physics	10/19/23	10/19/25
7632	Harmonics mixer (220-325 GHz)	HM-325	020075	Radiometer Physics	10/19/23	10/19/25
9003	Horn antenna (40-60 GHz)	HO19R	103	Custom Microwaves	08/30/22	08/30/24
9004	Horn antenna (50-75 GHz)	HO15R	104	Custom Microwaves	08/30/22	08/30/24
9079	Horn antenna (140-220 GHz)	HO5R	HO5R	Custom Microwaves	08/30/22	08/30/24
9078	Horn antenna (110-170 GHz)	HO6R	HO6R	Custom Microwaves	08/30/22	08/30/24
7628	Horn antenna (75-110 GHz)	SAR-2309-10-S2	13481-01	Sage Millimeter, Inc.	Verified by 7611 and corresponding antenna/Active multiplier combination	
9082	Horn antenna (140-220 GHz)	HO5R	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.	Verified by 7611 and corresponding antenna/mixer combination	
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						
6805	Environmental Chamber	ESL-4CA	18021	Espec	04/18/23	04/18/24
7619	Temp/Humidity Sensor	iBTHX-W	15050268	Omega	06/15/23	06/15/24
43003	True RMS Multimeter	85 III	69880143	Fluke	01/09/23	01/09/24
-	Test Software	EMC32	V11.20.00	Rohde & 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 (9 kHz to 30 MHz)

<i>Radiated Measurement 9kHz - 30 MHz at a distance of 3 m</i>							
	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 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	0.00 dB	Triangular	2.449	0.00	0.00	
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	Rectangular	1.732	0.00	0.00	
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	2.45 dB		
Expanded uncertainty				Normal, k=2	4.91 dB		

3.2.2 Radiated Emission Measurements (30 MHz to 1GHz)

<i>Radiated Measurement 30 - 1000 MHz at a distance of 3 m</i>					
Input Quantity (Contribution) X_i	Value	Prob. Dist.	Divisor	$u_i(x)$	$u_i(x)^2$
Receiver reading	0.10 dB	Normal, k=1	1.000	0.10	0.01
Attenuation: antenna-receiver	0.20 dB	Normal, k=2	2.000	0.10	0.01
Antenna factor AF	0.58 dB	Normal, k=2	2.000	0.29	0.08
Receiver sinewave accuracy	0.15 dB	Normal, k=2	2.000	0.08	0.01
Receiver pulse amplitude	1.50 dB	Rectangular	1.732	0.87	0.75
Receiver pulse repetition rate	1.50 dB	Rectangular	1.732	0.87	0.75
Noise floor proximity	0.50 dB	Rectangular	1.732	0.29	0.08
Mismatch: antenna-receiver	0.95 dB	U-shaped	1.414	0.67	0.45
AF frequency interpolation	0.30 dB	Rectangular	1.732	0.17	0.03
AF height deviations	0.10 dB	Rectangular	1.732	0.06	0.00
Directivity difference at 3 m	3.12 dB	Rectangular	1.732	1.80	3.24
Phase center location at 3 m	1.00 dB	Rectangular	1.732	0.58	0.33
Cross-polarisation	0.90 dB	Rectangular	1.732	0.52	0.27
Balance	0.00 dB	Rectangular	1.732	0.00	0.00
Site imperfections	3.99 dB	Triangular	2.449	1.63	2.65
Separation distance at 3 m	0.30 dB	Rectangular	1.732	0.17	0.03
Effect of setup table material	0.57 dB	Rectangular	1.732	0.33	0.11
Table height at 3 m	0.10 dB	Normal, k=2	2.000	0.05	0.00
Near-field effects	0.00 dB	Triangular	2.449	0.00	0.00
Effect of ambient noise on OATS	0.00 dB				0.00
Combined standard uncertainty		Normal	2.97 dB		
Expanded uncertainty		Normal, k=2	5.94 dB		

3.2.3 Radiated Emission Measurements (Above 1GHz)

<i>Radiated Measurement (1 GHz-40 GHz) at a distance of 3 m</i>					
Input Quantity (Contribution) X_i	Value	Prob. Dist.	Divisor	$u_i(x)$	$u_i(x)^2$
Receiver reading	0.10 dB	Normal, k=1	1.000	0.10	0.01
Attenuation: antenna-receiver	0.30 dB	Normal, k=2	2.000	0.15	0.02
Preamplifier Gain	0.20 dB	Normal, k=2	2.000	0.10	0.01
Antenna factor AF	0.47 dB	Normal, k=2	2.000	0.24	0.06
Sinewave accuracy	0.15 dB	Normal, k=2	2.000	0.08	0.01
Instability of preamp gain	1.21 dB	Rectangular	1.732	0.70	0.49
Noise floor proximity	0.70 dB	Rectangular	1.732	0.40	0.16
Mismatch: antenna-preamplifier	1.41 dB	U-shaped	1.414	1.00	0.99
Mismatch: preamplifier-receiver	1.30 dB	U-shaped	1.414	0.92	0.85
AF frequency interpolation	0.30 dB	Rectangular	1.732	0.17	0.03
Directivity difference at 3 m	1.50 dB	Rectangular	1.732	0.87	0.75
Phase center location at 3 m	0.30 dB	Rectangular	1.732	0.17	0.03
Cross-polarisation	0.90 dB	Rectangular	1.732	0.52	0.27
Site imperfections VSWR (Method 2)	5.53 dB	Triangular	2.000	4.89	1.13
Effect of setup table material	1.57 dB	Rectangular	1.732	0.91	0.82
Separation distance at 3 m	0.30 dB	Rectangular	1.732	0.17	0.03
Table height at 3 m	0.00 dB	Normal, k=2	2.000	0.00	0.00
Combined standard uncertainty			Normal	2.38 dB	
Expanded uncertainty			Normal, k=2	4.76 dB	

3.2.4 Radiated Emission Measurements (Above 40GHz)

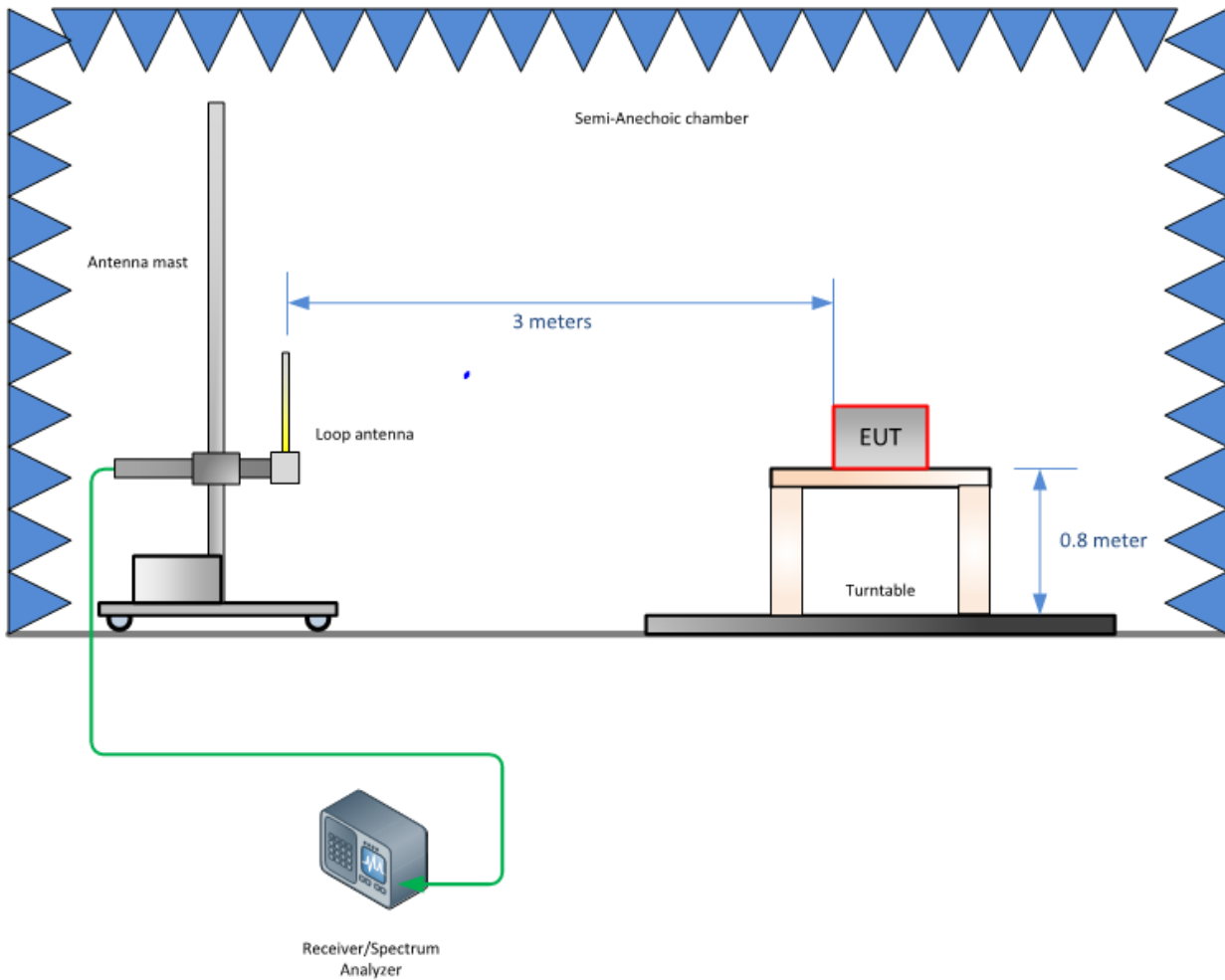
Radiated Measurement (above 40 GHz) at a distance of 3 m						
	Input Quantity (Contribution) X_i	Value	Prob. Dist.	Divisor	$u_i(x)$	$u_i(x)^2$
1	Receiver reading	0.10 dB	Normal, k=1	1.000	0.10	0.01
2	Attenuation: antenna-receiver	0.30 dB	Normal, k=2	2.000	0.15	0.02
3	Preamplifier Gain	0.50 dB	Normal, k=2	2.000	0.25	0.06
4	Antenna Gain	0.75 dB	Normal, k=2	2.000	0.38	0.14
5	Sinewave accuracy	0.15 dB	Normal, k=2	2.000	0.08	0.01
6	Mixer Operation	1.21 dB	Rectangular	1.732	0.70	0.49
7	Instability of preamp gain	1.21 dB	Rectangular	1.732	0.70	0.49
8	Noise floor proximity	0.70 dB	Rectangular	1.732	0.40	0.16
9	Mismatch: antenna-preamplifier	1.41 dB	U-shaped	1.414	1.00	0.99
10	Mismatch: preamplifier-receiver	1.30 dB	U-shaped	1.414	0.92	0.85
11	AF frequency interpolation	0.30 dB	Rectangular	1.732	0.17	0.03
12	Cross-polarisation	0.90 dB	Rectangular	1.732	0.52	0.27
Combined standard uncertainty			Normal	1.88 dB		
Expanded uncertainty			Normal, k=2	3.75 dB		



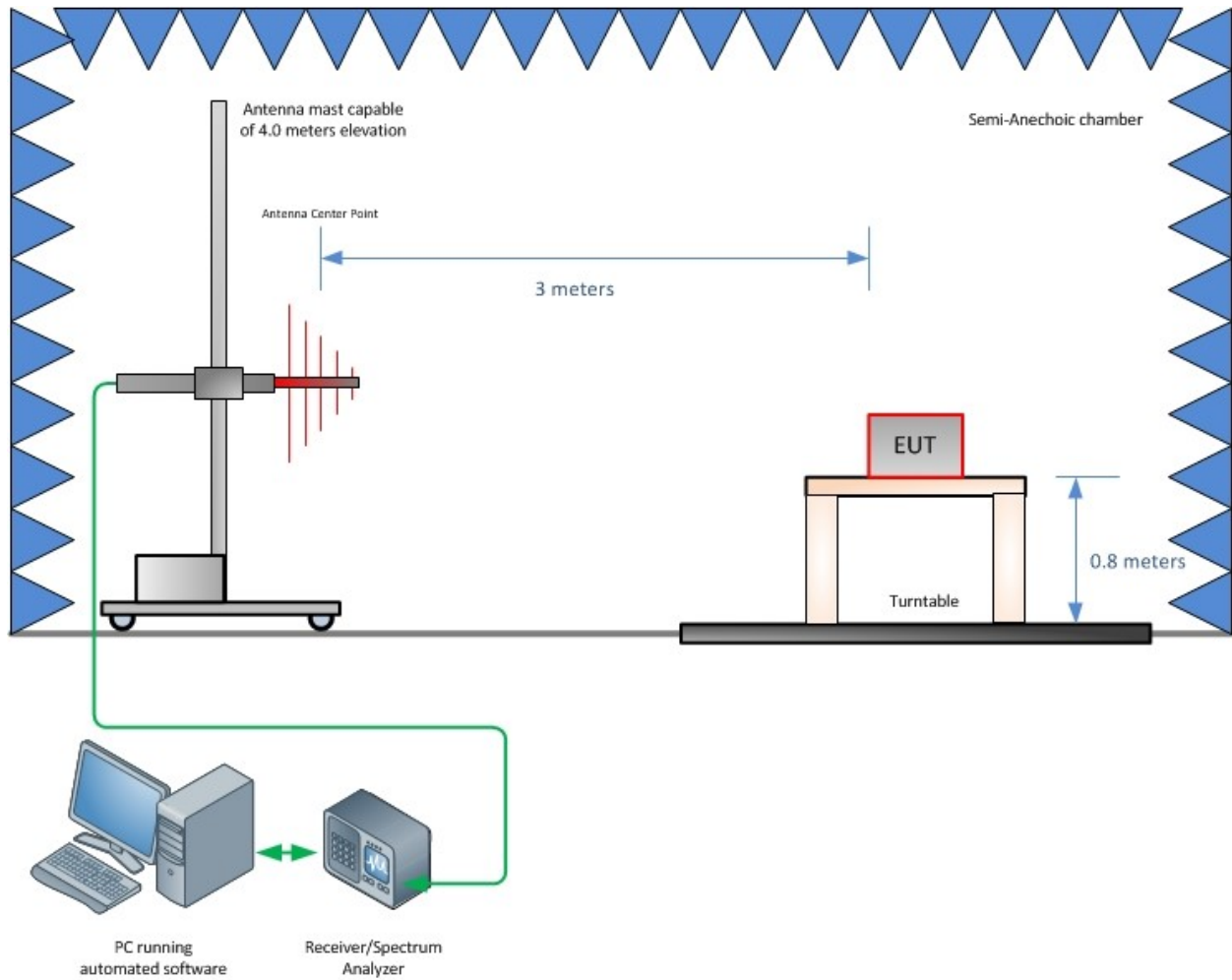
SECTION 4

Diagram of Test Setup

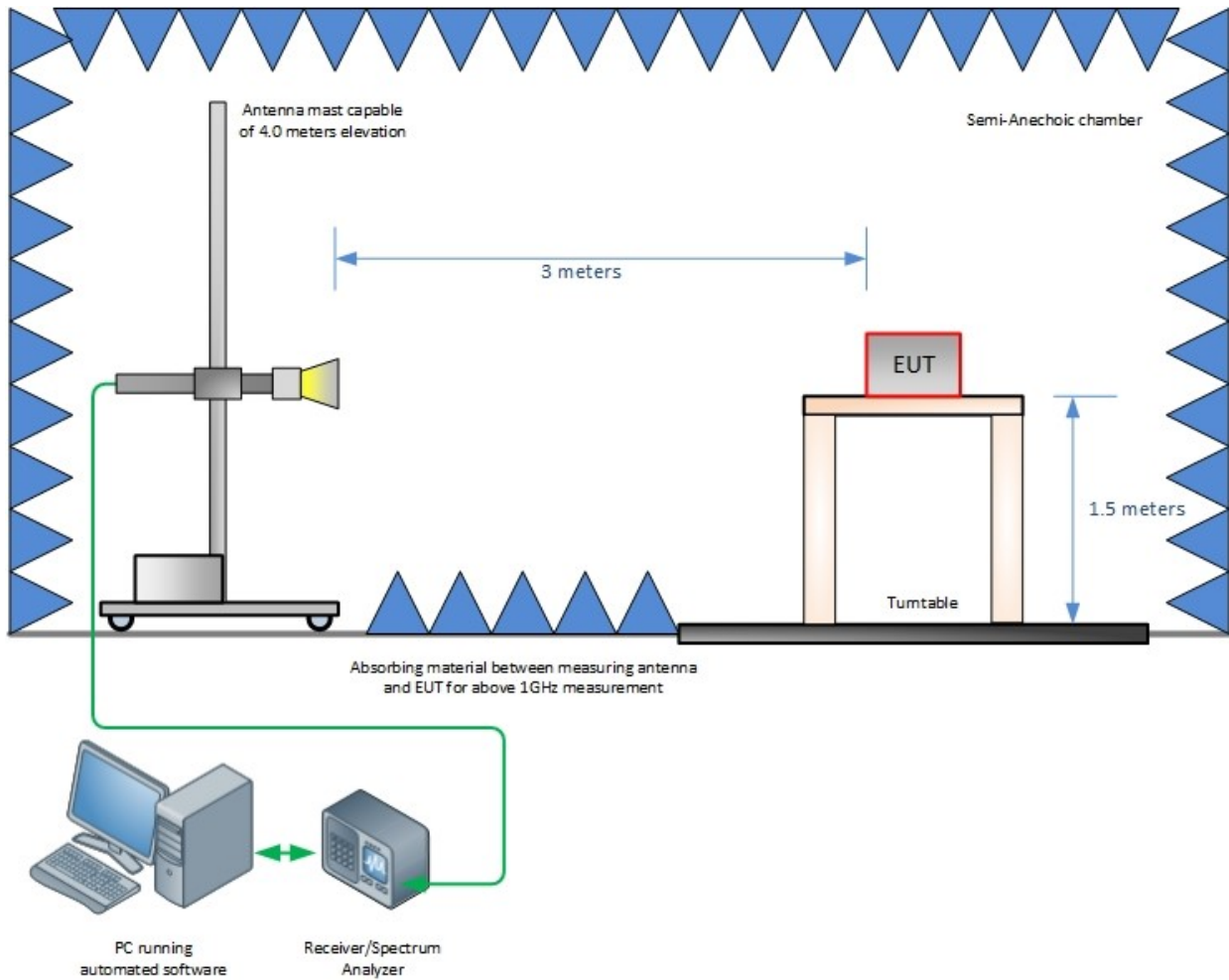
4.1 TEST SETUP DIAGRAM



Radiated Emission Test Setup (Below 30MHz)



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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