

Radio Testing of the
Watkins Manufacturing Corporation
Connected Spa Kit 2 Model: 2001030

In accordance with FCC Part 15 Subpart C
§15.247 and IC RSS-247 Issue 3 August 2023

Watkins Manufacturing Corporation
1280 Park Center Dr
Vista, CA 92081 USA



America

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Date: November 2024

Document Number: 721003029A Issue 01 | Version Number: 01

RESPONSIBLE FOR	NAME	DATE	SIGNATURE
Authorized Signatory	Ferdinand S. Custodio	November 11, 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 §15.247 and IC RSS-247 Issue 3 August 2023.



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REPORT ON	Radio Testing of the Watkins Manufacturing Corporation Model: 2001030 Connected Spa Kit 2
TEST REPORT NUMBER	721003029A
TEST REPORT DATE	November 2024
PREPARED FOR	Watkins Manufacturing Corporation 1280 Park Center Dr Vista, CA 92081 USA
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APPROVED BY	 Ferdinand S. Custodio Name Authorized Signatory Title: Senior EMC Test Engineer / Wireless Team Lead
DATED	November 11, 2024



Revision History

721003029A Watkins Manufacturing Corporation Connected Spa Kit 2 Model: 2001030					
DATE	OLD REVISION	NEW REVISION	REASON	PAGES AFFECTED	APPROVED BY
11/11/2024	—	Initial Release			Ferdinand S. Custodio



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SECTION 1

REPORT SUMMARY

Radio Testing of the
Watkins Manufacturing Corporation
Connected Spa Kit 2 2001030



1.1 INTRODUCTION

The information contained in this report is intended to show verification of the 2001030 Connected Spa Kit 2 to the requirements of FCC Part 15 Subpart C §15.247 and IC RSS-247 Issue 3 August 2023.

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	Watkins Manufacturing Corporation
EUT	Connected Spa Kit 2
Model Name	2001030
FCC ID	LDL-000036
ISED/IC Number	7322A-000036
FCC Classification	Low power Communications Device Transmitter (DTS)
Serial Number(s)	D48AFCEDFCE4 D48AFCEDA2D8 D48AFCEDB5C4
Number of Samples Tested	3
Test Specification/Issue/Date	• FCC Part 15 Subpart C §15.247 (October 1, 2023). • RSS-247–Digital Transmission Systems (DTS), Frequency Hopping Systems (FHSS) and Licence-Exempt Local Area Network (LE-LAN) Devices (Issue 3, August 2023). • RSS-Gen - General Requirements for Compliance of Radio Apparatus (Issue 5, Amendment 2 February 2021).
Start of Test	October 04, 2024
Finish of Test	October 18, 2024
Name of Engineer(s)	Omar Castillo



Related Document(s)

- ANSI C63.10-2013. American National Standard of Procedures for Compliance testing of Unlicensed Wireless Devices.
- KDB 558074 D01 15.247 v05r02 Guidance for compliance measurements on Digital Transmission System, Frequency Hopping Spread Spectrum System, and Hybrid System Devices operating under Section 15.247 of the FCC rules.
- Supporting documents and test setup pictures for EUT certification are separate exhibits.
- SWE030 PN:SW20023EB56.pdf
- 140mm 868+915MHz 天线规格书.pdf
- Xinhengyang#W.01.00001061.pdf



1.2 BRIEF SUMMARY OF RESULTS

A brief summary of the tests carried out in accordance with FCC Part 15 Subpart C §15.247 and IC RSS-247 Issue 3 August 2023 with cross-reference to the corresponding IC RSS standard are shown below.

Section	§15.247 Spec Clause	RSS	Test Description	Result	Comments /Base Standard
2.1	§15.247(b)(3)	RSS-247 5.4(d)	Peak Output Power	Compliant	
2.2	§15.207(a)	RSS-Gen 8.8	Conducted Emissions	Compliant	
2.3	-	RSS-Gen 6.7	99% Emission Bandwidth	Compliant	
2.4	§15.247(a)(2)	RSS-247 5.2(a)	Minimum 6 dB RF Bandwidth	Compliant	
0	§15.247(d)	RSS-247 5.5	Out-of-Band Emissions - Conducted	Compliant	
2.6	§15.247(d)	RSS-247 5.5	Band-edge Compliance of RF Conducted Emissions	Compliant	
2.7	§15.247(d)	RSS-247 5.5	Radiated Spurious Emissions	Compliant	
-	-	RSS-Gen 7.3 and 7.4	Receiver Spurious Emissions	N/A*	
2.8	§15.247(e)	RSS-247 5.2(b)	Power Spectral Density for Digitally Modulated Device	Compliant	

Note: N/A* Not required as per RSS-Gen 5.3 The EUT does not fall into any category defined as Receiver under RSS-Gen.



1.3 PRODUCT INFORMATION

1.3.1 Technical Description

The Equipment Under Test (EUT) is an Watkins Manufacturing Corporation Connected Spa Kit 2 2001030. The Connected Spa Kit 2 solution is a two-module system that provides Mobile app based control for hot tubs manufactured by Watkins Wellness. The modules are interchangeable in their roles.

A full description and detailed product specification are available from the manufacturer.

1.3.2 EUT General Description

EUT Description	Connected Spa Kit 2
Model Name	2001030
Rated Voltage	5 VDC (AC/DC Adapter)
Mode Verified	LoRA (US 903MHz to 927MHz)
Capability	LoRA (US 903MHz to 927MHz, SF5, through SF12) and Wi-Fi 2.4GHzb/g/nHT20 and nHT40
Primary Unit (EUT)	☐ Production ☒ Pre-Production ☐ Engineering (same as Production)
Manufacturer Declared Temperature Range	-10°C to 60°C
Antenna Type (1)	868/915MHz
Manufacturer (1)	Sunnyway
Antenna Model (1)	SW20023EB56
Peak Antenna Gain (1)	1.96 dBi (915 MHz)
Antenna Type (2)	860/915MHz
Manufacturer (2)	Xinhengyang
Antenna Model (2)	W.01.00001061
Peak Antenna Gain (2)	0.61 dBi (915 MHz)
Antenna Type (3)	868/915MHz
Manufacturer (3)	Xinhengyang
Antenna Model (3)	SW.01.00001044
Peak Antenna Gain (3)	1.17 dBi (915 MHz)

Note: Above antenna specifications were taken from pdf specs provided by manufacturer (See section 1.1).

Note*: Manufacturer Declared the antenna will be bonded to the EUT.

1.3.3 Maximum Conducted Output Power

LoRa	Frequency Range (MHz)	RMS (dBm)	Duty Cycle (%)
 LoRa Alliance®	902 – 928 MHz	14.0	48.0

1.4 EUT TEST CONFIGURATION

1.4.1 Test Configuration Description

Test Configuration	Description
Default	EUT in a test mode configuration. EUT has an SMA connector for LoRa antenna. EUT was programmed in test mode with the highest possible Duty Cycle and Lowest and Highest Spreading Factors (SF5 and SF12). For cabinet spurious Emissions the EUT was programmed with the highest Duty Cycle, the antenna port was terminated with a 20dB attenuator and a 50 Ohm load.

1.4.2 EUT Exercise Software

EUT programmed in test mode by manufacturer

1.4.3 Support Equipment and I/O cables

Manufacturer	Equipment/Cable	Description
Shenzhen putuo technology co. ltd	USB AC/DC Adapter	PT-WC-03
Watkins	Hot tub's Control box	Model Name: Eagle Board Model Number: 1302501-XX
Sony	USB ACDC adapter-	AC-UB10-
Generic	USB Type A to Type C	USB Type A to Type C

1.4.1 Simplified Test Configuration Diagram

Not applicable. EUT verified on a standalone configuration.
 Supporting documents and test setup pictures for EUT certification are separate exhibits.



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: No modifications		
N/A	-	-

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 LP0002 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
Watkins Manufacturing Corporation
Connected Spa Kit 2 2001030



2.1 PEAK OUTPUT POWER

2.1.1 Specification Reference

FCC 47 CFR Part 15, Clause 15.247(b)(3)
RSS-247, Clause 5.4 (d)

2.1.2 Standard Applicable

For systems using digital modulation in the 902–928 MHz, 2400–2483.5 MHz, and 5725–5850 MHz bands, the maximum peak conducted output shall not exceed 1 Watt. As an alternative to a peak power measurement, compliance with the one Watt limit can be based on a measurement of the maximum conducted output power. Maximum Conducted Output Power is defined as the total transmit power delivered to all antennas and antenna elements averaged across all symbols in the signaling alphabet when the transmitter is operating at its maximum power control level. Power must be summed across all antennas and antenna elements. The average must not include any time intervals during which the transmitter is off or is transmitting at a reduced power level. If multiple modes of operation are possible (e.g., alternative modulation methods), the maximum conducted output power is the highest total transmit power occurring in any mode.

2.1.3 Equipment Under Test and Modification State

Serial No: D48AFCEDFCE4, D48AFCEDA2D8, D48AFCEDB5C4 and / Default Test Configuration

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

October 4, 7, 8 and 9, 2024 / OC

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 (Rancho Bernardo Satellite Facility)

Ambient Temperature	23.9 °C	22.0 °C
Relative Humidity	34.6 %	41.8 %
ATM Pressure	99.8 kPa	98.9 kPa

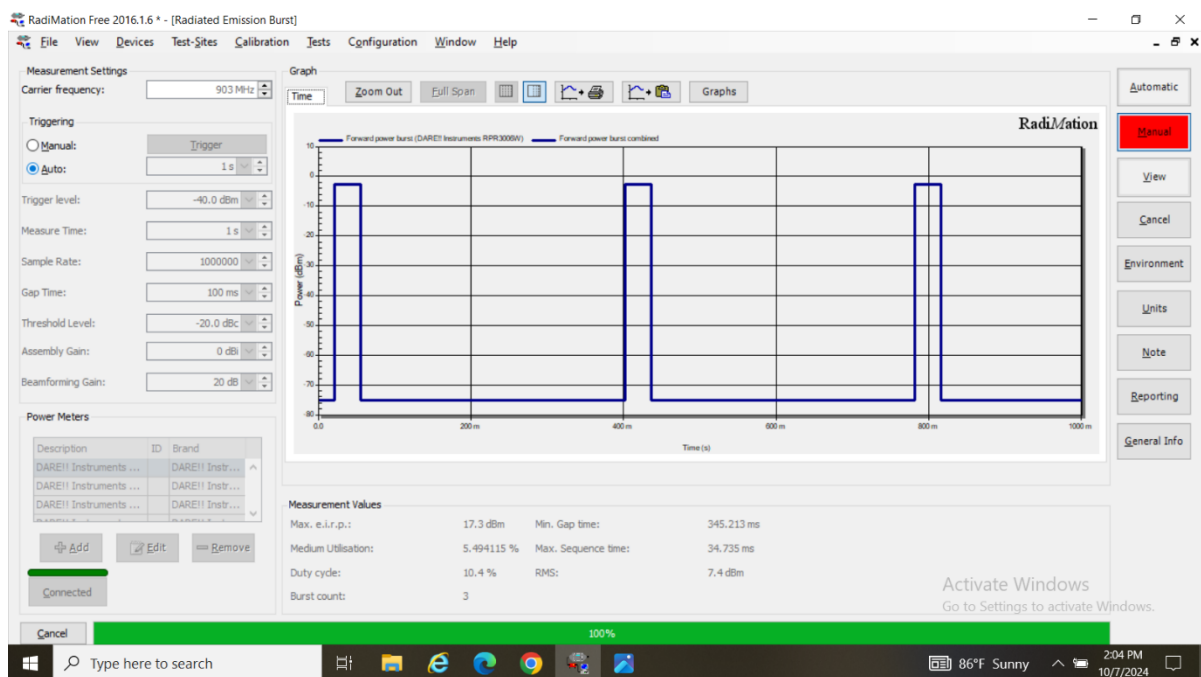
2.1.7 Additional Observations

- This is a conducted test using a Power Meter (peak and rms).
- Burst function of the Power Meter used for this test (rms measurements and Duty Cycle).

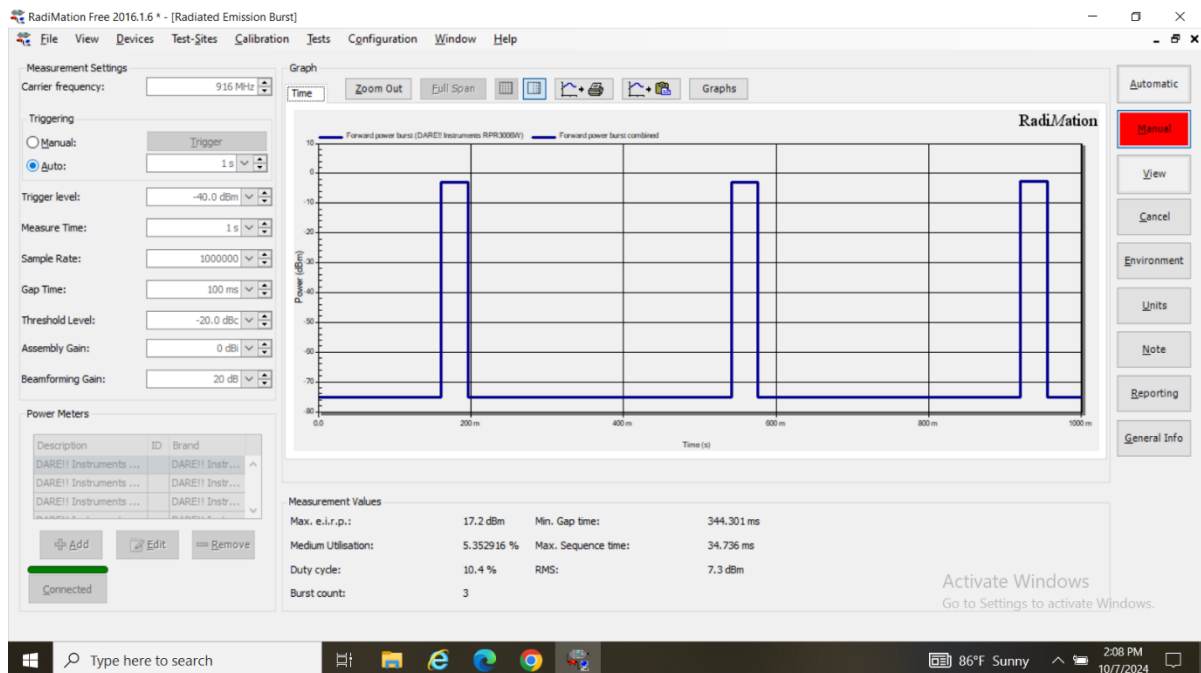
2.1.8 Test Results

DUT Frequency (MHz)	Spreading Factor	Peak (dBm)	Burst -RMS (dBm)	Limit Max (dBm)	DutyCycle (%)	Burst
903.00	SF5	20.02	7.40	30.0	10.4	PASS
916.00	SF5	19.54	7.30		10.4	PASS
927.00	SF5	12.64	1.00		10.4	PASS
903.00	SF12	20.02	14.0		48.0	PASS
916.00	SF12	19.51	13.90		48.9	PASS
927.00	SF12	13.55	7.70		48.8	PASS

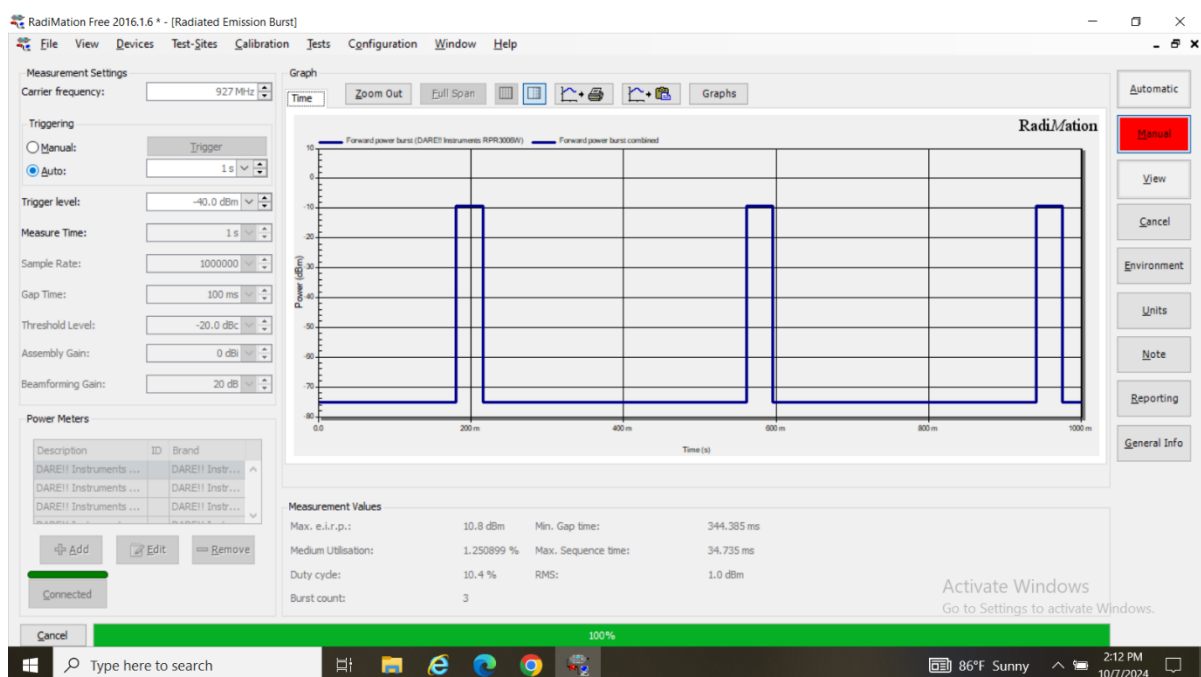
2.1.9 Test Plots (RMS)



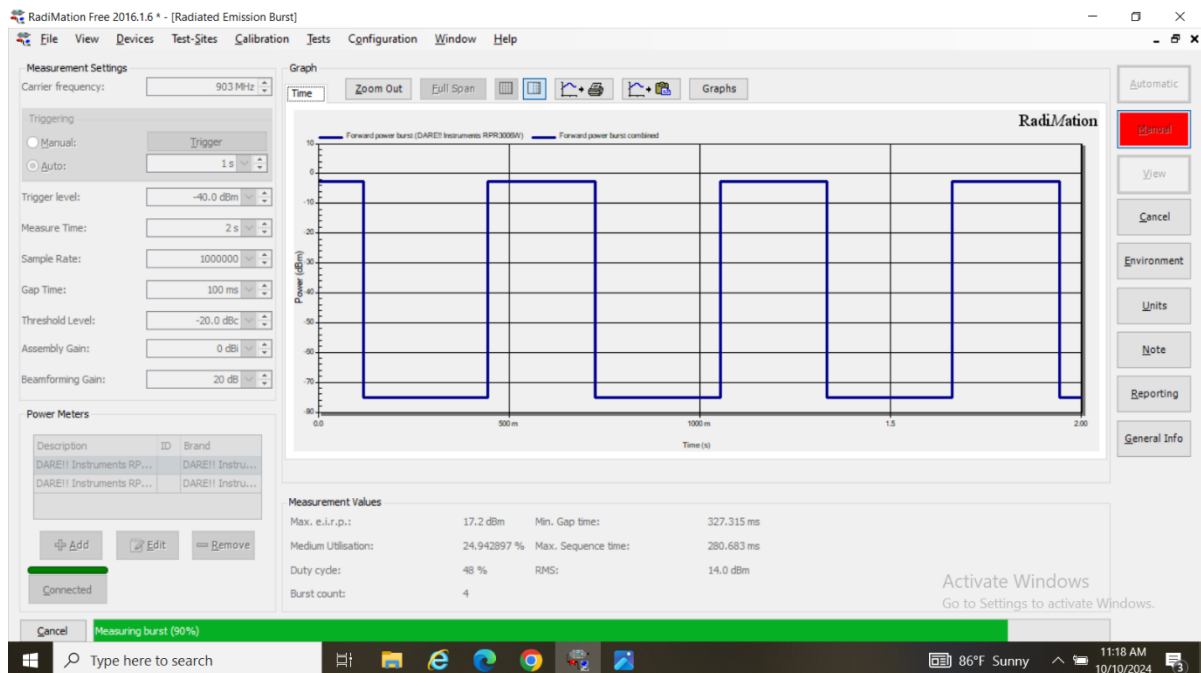
LoRA. SF5 Low Channel



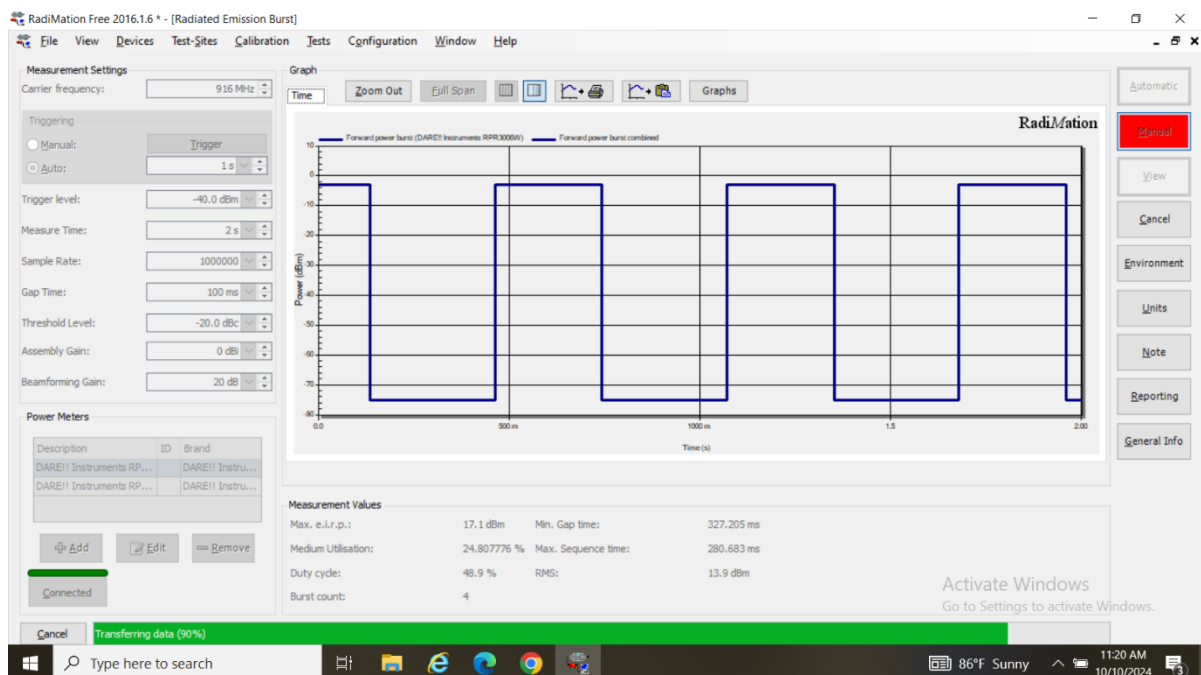
LoRA. SF5 Mid Channel



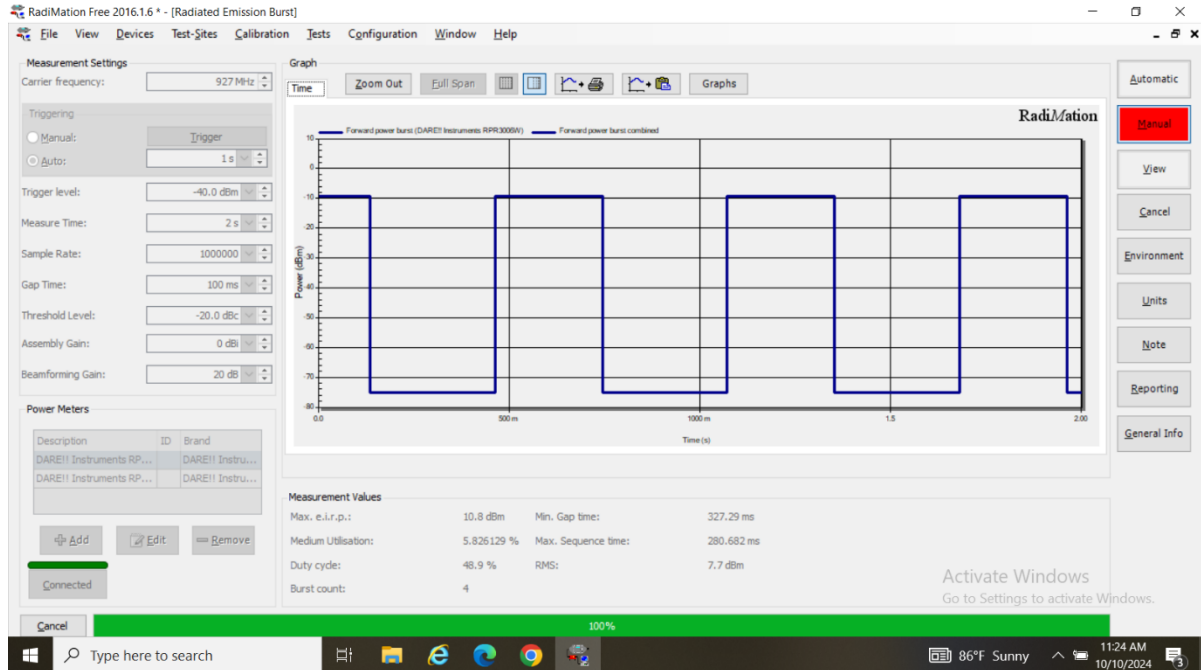
LoRA. SF5 High Channel



LoRA. SF12 Low Channel



LoRA. SF12 Middle Channel

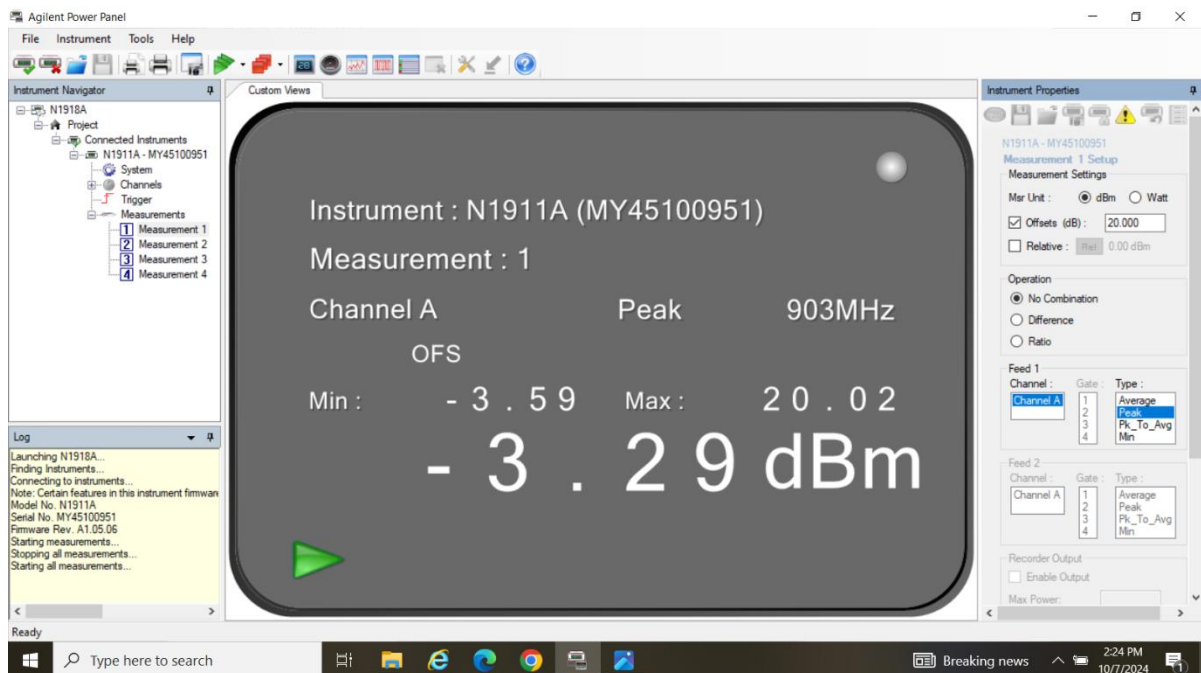


LoRA. SF12 High Channel

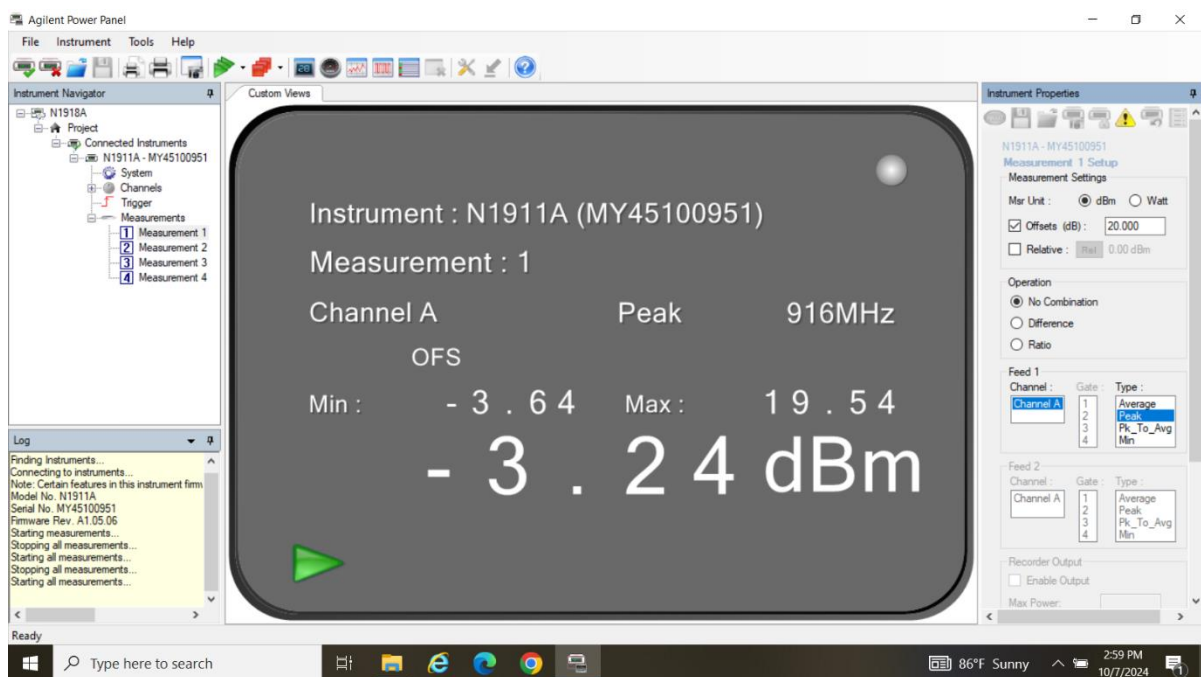
2.1.10 Power Meter Settings (RMS)

Setting	Instrument Value	Target Value
Measurement Time	1.000 s	1.000 s
Points	1000000	1000000
Time resolution	1.000 μ s	1.000 μ s

2.1.11 Test Plots (Peak Power)



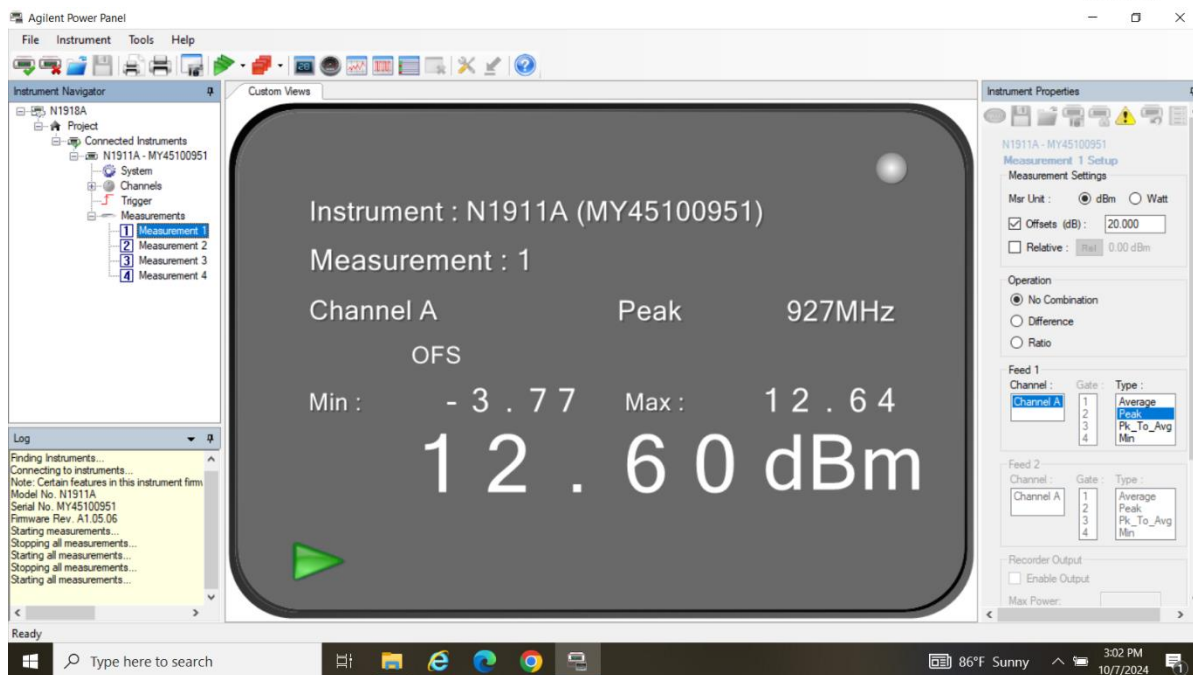
LoRA SF5 Low Channel



LoRA SF5 Middle Channel



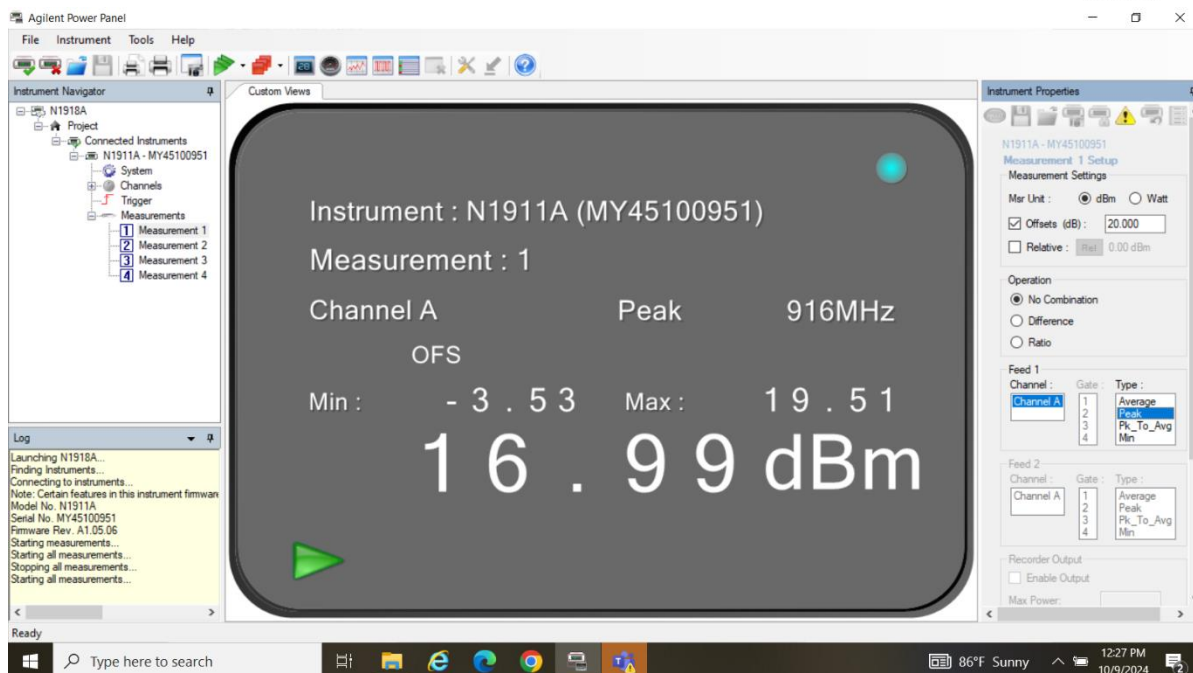
America



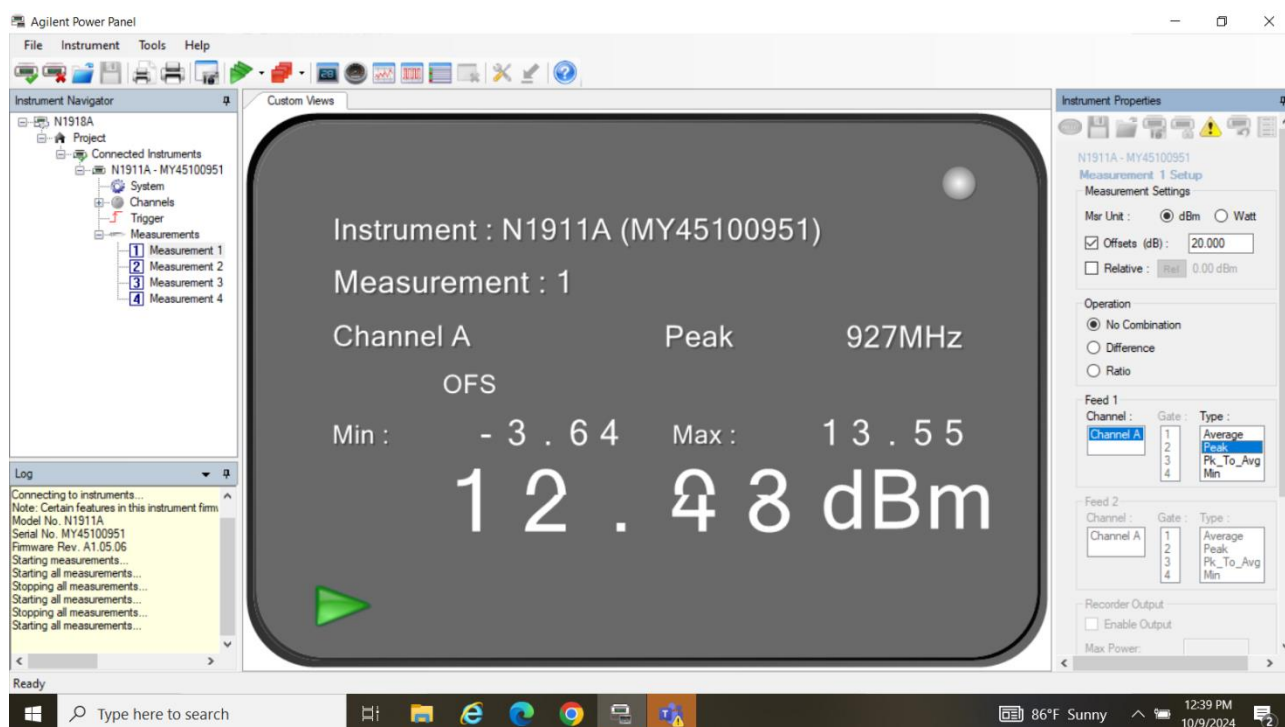
LoRA SF5 High Channel



LoRA SF12 Low Channel



LoRA SF12 Middle Channel



LoRA SF12 High Channel

2.2 CONDUCTED EMISSIONS

2.2.1 Specification Reference

FCC 47 CFR Part 15, Clause 15.207(a)
RSS-GEN, Clause 8.8

2.2.2 Standard Applicable

An intentional radiator that is designed to be connected to the public utility (AC) power line, the radio frequency voltage that is conducted back onto the AC power line on any frequency or frequencies, within the band 150 kHz to 30 MHz, shall not exceed the limits in the following table, as measured using a 50 μ H/50 ohms line impedance stabilization network (LISN).

Frequency of emission (MHz)	Conducted limit (dB μ V)	
	Quasi-peak	Average
0.15–0.5	66 to 56*	56 to 46*
0.5–5	56	46
5–30	60	50

*Decreases with the logarithm of the frequency.

2.2.3 Equipment Under Test and Modification State

Serial No: D48AFCEDFCE4 / LoRa Transmitting continuously

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

October 11, 2024 / OC

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 EUT Test Voltage

120V 60Hz (ACDC adapter)
120V 60Hz to Eagle Board)

2.2.7 Environmental Conditions

Ambient Temperature	22.0 °C
Relative Humidity	41.8 %
Atmospheric Pressure	98.9 kPa



2.2.8 Additional Observations

- Measurement was 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 2.2.9 for sample computation.
- This test was performed while EUT powered with a ACDC adapter (representative ACDC adapter model AC-UB10) and eagled board (both at 120V 60Hz).

2.2.9 Sample Computation (Conducted Emissions – Quasi Peak)

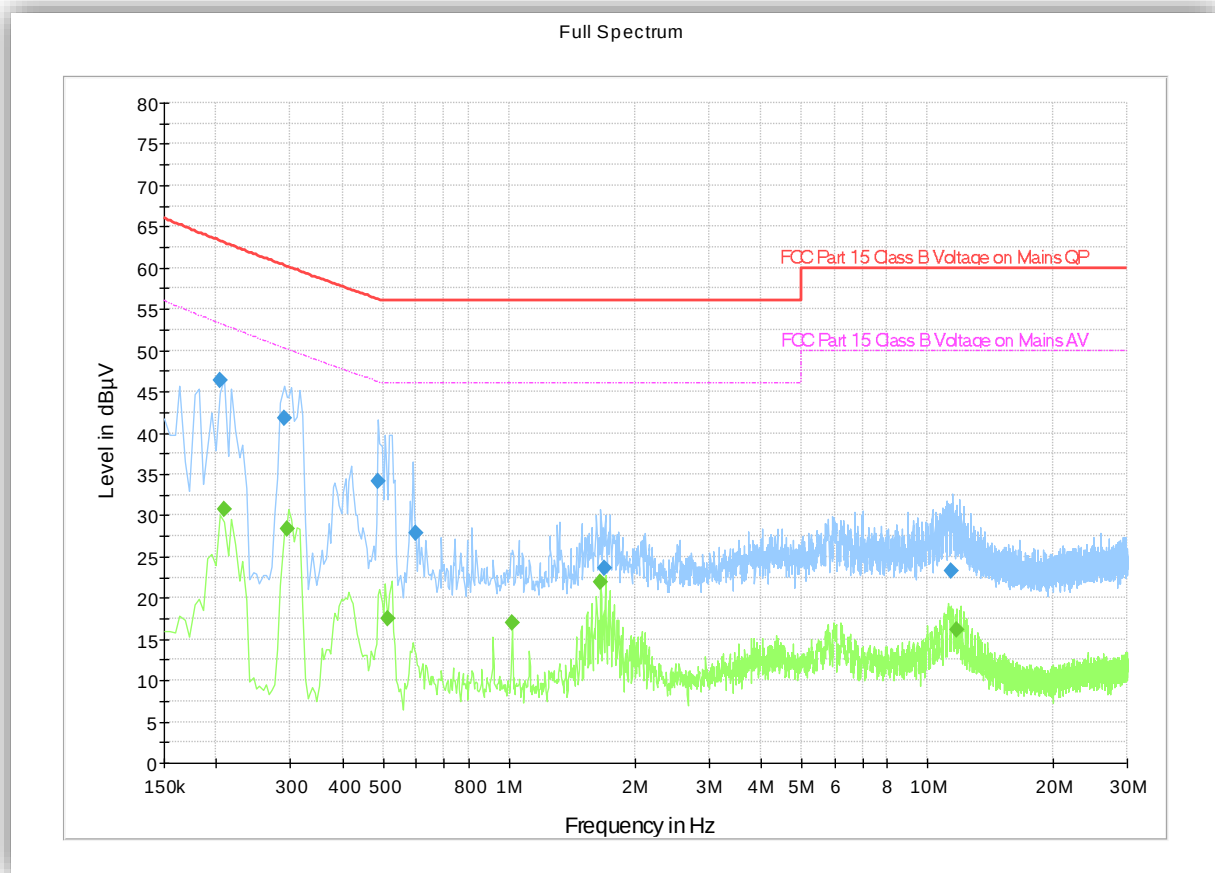
Measuring equipment raw measurement (db μ V) @ 150kHz			5.5
Correction Factor (dB)	Asset# 8607 (20 dB attenuator)	19.9	20.7
	Asset# 1177 (cable)	0.15	
	Asset# 1176 (cable)	0.35	
	Asset# 7568 (LISN)	0.30	
Reported QuasiPeak Final Measurement (db μ V) @ 150kHz			26.2

2.2.10 Test Results

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

Detailed results are shown below.

2.2.10.1 Conducted Emissions Line 1 – 120V 60Hz to ACDC adapter



Note: FCC Part 15 Class Limits are identical as §15.207

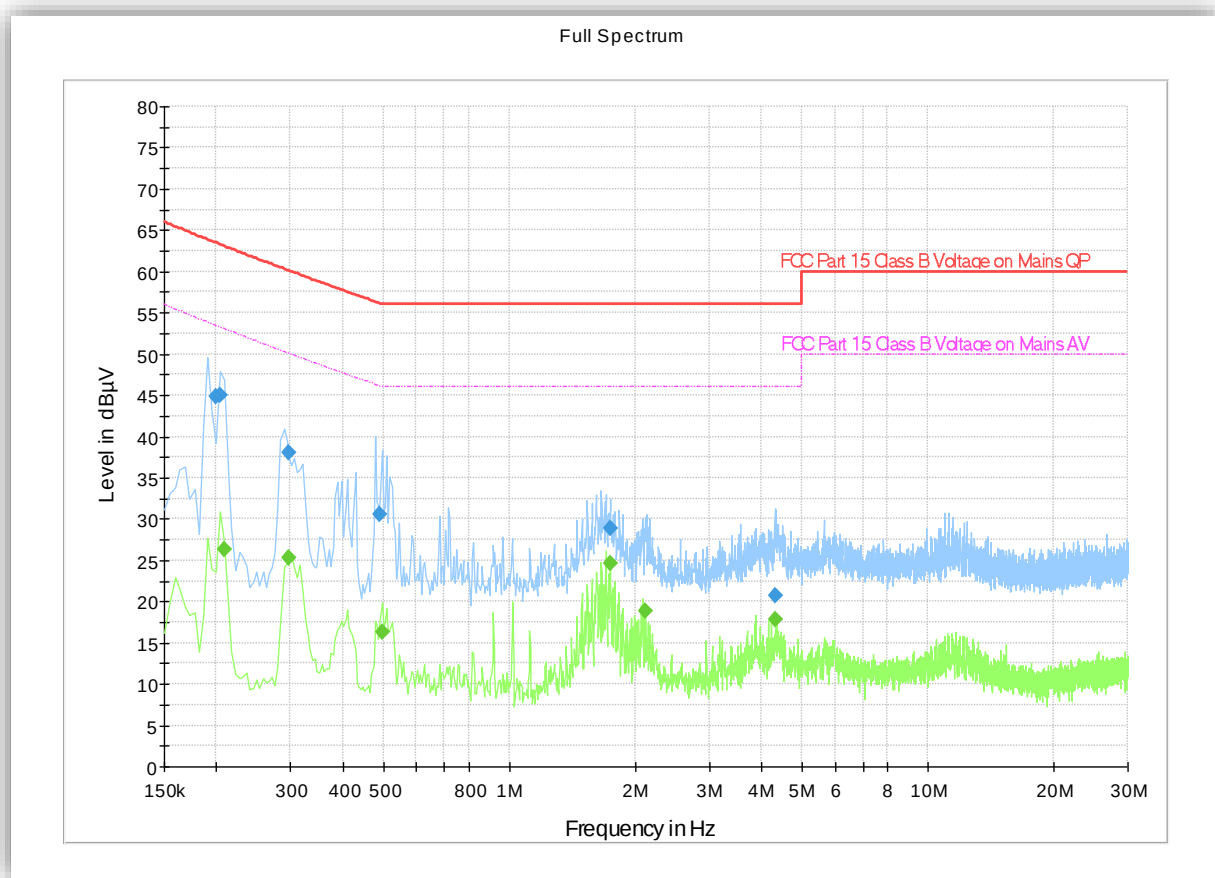
Quasi Peak Result

Frequency (MHz)	QuasiPeak (dBμV)	Limit (dBμV)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Line	Filter	Corr. (dB)
0.204000	46.37	63.29	16.92	1000.0	9.000	L1	OFF	20.1
0.289500	41.85	60.34	18.48	1000.0	9.000	L1	OFF	20.1
0.487500	34.15	56.19	22.04	1000.0	9.000	L1	OFF	20.1
0.600000	27.86	56.00	28.14	1000.0	9.000	L1	OFF	20.1
1.684500	23.58	56.00	32.42	1000.0	9.000	L1	OFF	20.1
11.422500	23.34	60.00	36.66	1000.0	9.000	L1	OFF	20.4

Average Result

Frequency (MHz)	Average (dBμV)	Limit (dBμV)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Line	Filter	Corr. (dB)
0.208500	30.66	53.07	22.41	1000.0	9.000	L1	OFF	20.1
0.294000	28.39	50.17	21.78	1000.0	9.000	L1	OFF	20.1
0.514500	17.55	46.00	28.45	1000.0	9.000	L1	OFF	20.1
1.018500	16.99	46.00	29.01	1000.0	9.000	L1	OFF	20.1
1.657500	21.97	46.00	24.03	1000.0	9.000	L1	OFF	20.1
11.755500	16.15	50.00	33.85	1000.0	9.000	L1	OFF	20.4

2.2.10.2 Conducted Emissions Neutral – 120V 60Hz to ACDC adapter



Note: FCC Part 15 Class Limits are identical as §15.207

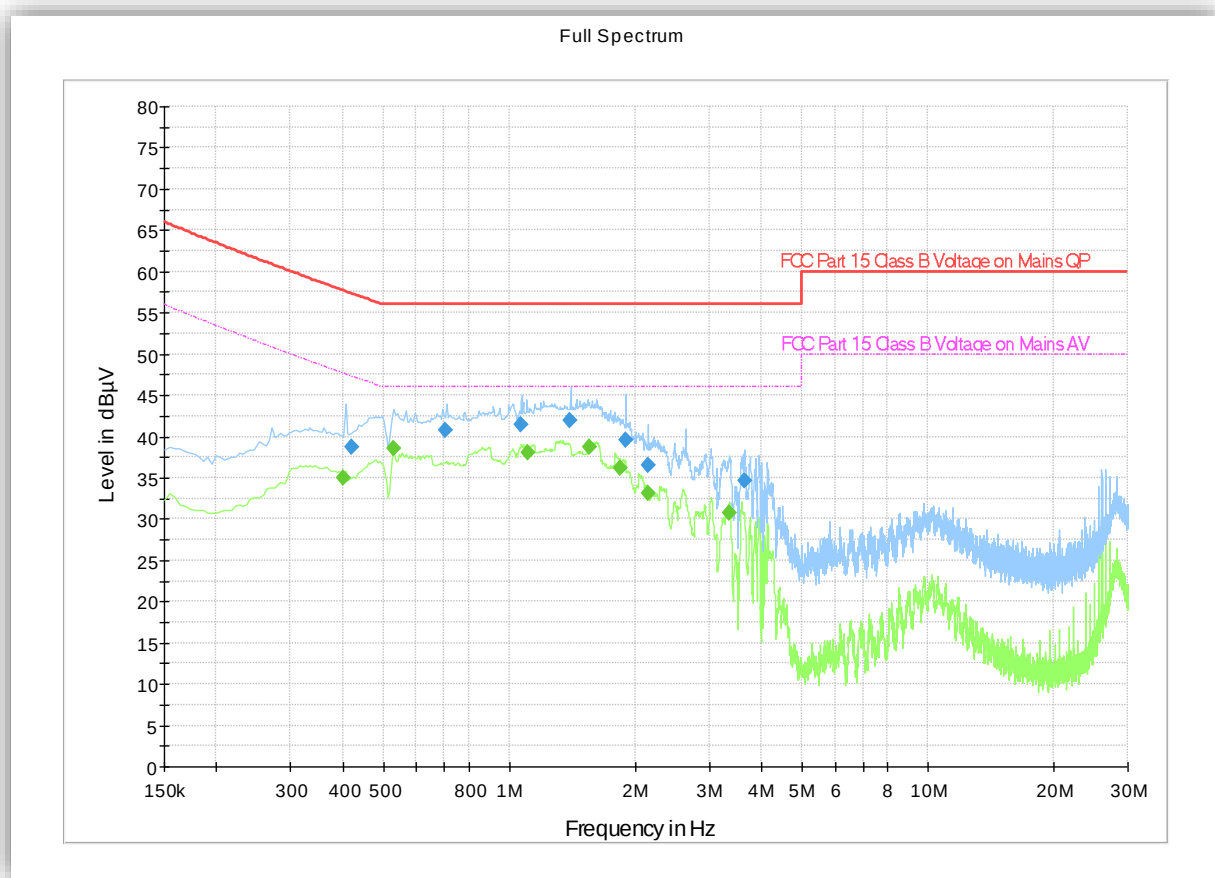
Quasi Peak Result

Frequency (MHz)	QuasiPeak (dBµV)	Limit (dBµV)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Line	Filter	Corr. (dB)
0.199500	44.77	63.48	18.71	1000.0	9.000	N	OFF	20.1
0.204000	45.08	63.29	18.20	1000.0	9.000	N	OFF	20.1
0.298500	37.97	60.08	22.11	1000.0	9.000	N	OFF	20.1
0.492000	30.62	56.12	25.51	1000.0	9.000	N	OFF	20.1
1.743000	28.84	56.00	27.16	1000.0	9.000	N	OFF	20.1
4.317000	20.64	56.00	35.36	1000.0	9.000	N	OFF	20.1

Average Result

Frequency (MHz)	Average (dBµV)	Limit (dBµV)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Line	Filter	Corr. (dB)
0.208500	26.26	53.07	26.81	1000.0	9.000	N	OFF	20.1
0.298500	25.36	50.05	24.68	1000.0	9.000	N	OFF	20.1
0.496500	16.37	46.05	29.68	1000.0	9.000	N	OFF	20.1
1.738500	24.65	46.00	21.35	1000.0	9.000	N	OFF	20.1
2.116500	18.77	46.00	27.23	1000.0	9.000	N	OFF	20.1
4.317000	17.79	46.00	28.21	1000.0	9.000	N	OFF	20.1

2.2.10.3 Conducted Emissions Line 1 – 120V 60Hz to Eagle Board



Note: FCC Part 15 Class Limits are identical as §15.207

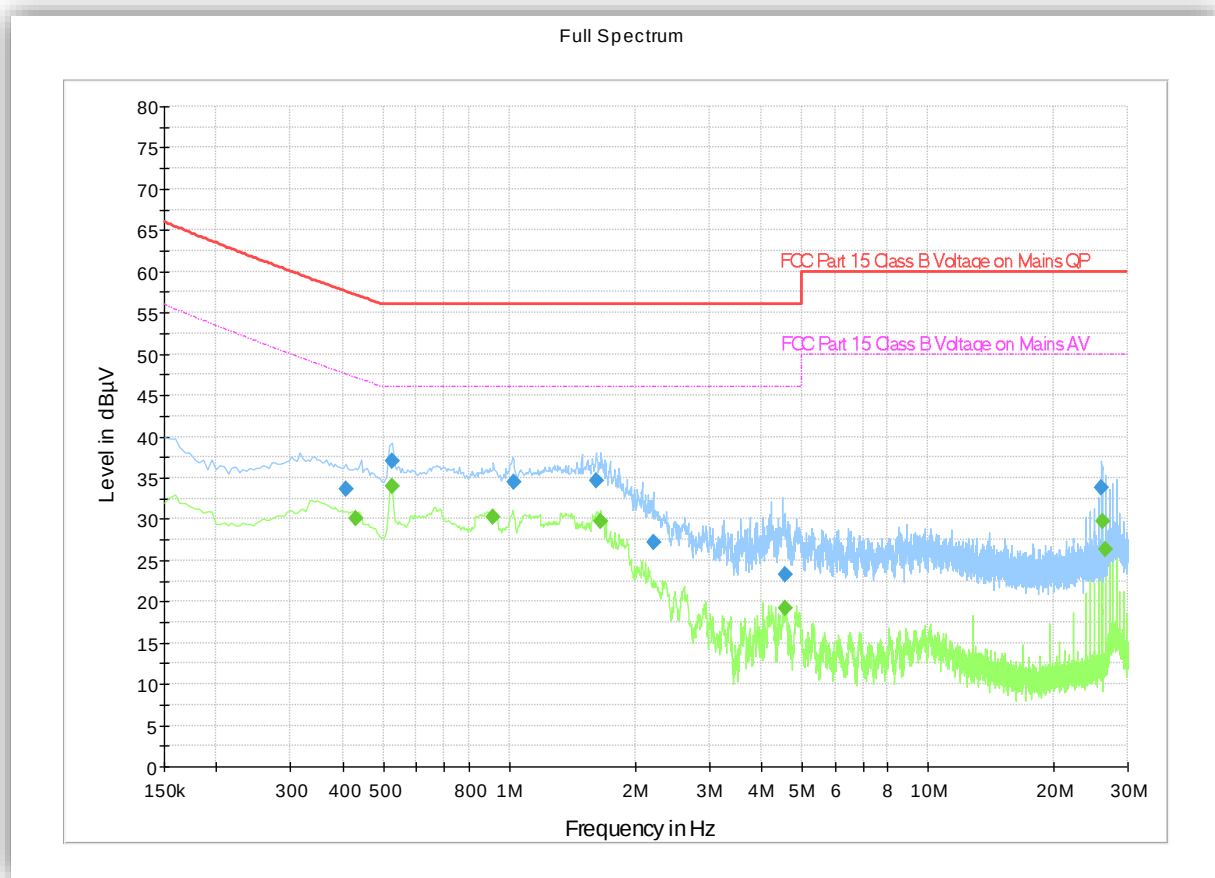
Quasi Peak Result

Frequency (MHz)	QuasiPeak (dBμV)	Limit (dBμV)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Line	Filter	Corr. (dB)
0.420000	38.69	57.35	18.66	1000.0	9.000	L1	OFF	20.1
0.703500	40.74	56.00	15.26	1000.0	9.000	L1	OFF	20.1
1.063500	41.50	56.00	14.50	1000.0	9.000	L1	OFF	20.1
1.392000	41.92	56.00	14.08	1000.0	9.000	L1	OFF	20.1
1.900500	39.60	56.00	16.40	1000.0	9.000	L1	OFF	20.1
2.152500	36.55	56.00	19.45	1000.0	9.000	L1	OFF	20.1
3.651000	34.71	56.00	21.29	1000.0	9.000	L1	OFF	20.2

Average Result

Frequency (MHz)	Average (dBμV)	Limit (dBμV)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Line	Filter	Corr. (dB)
0.402000	34.93	47.67	12.74	1000.0	9.000	L1	OFF	20.1
0.528000	38.59	46.00	7.41	1000.0	9.000	L1	OFF	20.1
1.104000	38.12	46.00	7.88	1000.0	9.000	L1	OFF	20.1
1.558500	38.64	46.00	7.36	1000.0	9.000	L1	OFF	20.1
1.846500	36.10	46.00	9.90	1000.0	9.000	L1	OFF	20.1
2.148000	33.17	46.00	12.83	1000.0	9.000	L1	OFF	20.1
3.363000	30.68	46.00	15.32	1000.0	9.000	L1	OFF	20.1

2.2.10.4 Conducted Emissions Neutral – 120V 60Hz to Eagle Board



Note: FCC Part 15 Class Limits are identical as §15.207

Quasi Peak Result

Frequency (MHz)	QuasiPeak (dBµV)	Limit (dBµV)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Line	Filter	Corr. (dB)
0.406500	33.68	57.61	23.93	1000.0	9.000	N	OFF	20.1
0.523500	36.96	56.00	19.04	1000.0	9.000	N	OFF	20.1
1.023000	34.40	56.00	21.60	1000.0	9.000	N	OFF	20.1
1.617000	34.57	56.00	21.43	1000.0	9.000	N	OFF	20.1
2.206500	27.18	56.00	28.82	1000.0	9.000	N	OFF	20.1
4.551000	23.24	56.00	32.76	1000.0	9.000	N	OFF	20.2
26.016000	33.78	60.00	26.22	1000.0	9.000	N	OFF	20.4

Average Result

Frequency (MHz)	Average (dBµV)	Limit (dBµV)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Line	Filter	Corr. (dB)
0.429000	30.04	47.17	17.13	1000.0	9.000	N	OFF	20.1
0.523500	34.03	46.00	11.97	1000.0	9.000	N	OFF	20.1
0.915000	30.17	46.00	15.83	1000.0	9.000	N	OFF	20.1
1.657500	29.71	46.00	16.29	1000.0	9.000	N	OFF	20.1
4.564500	19.20	46.00	26.80	1000.0	9.000	N	OFF	20.2
26.025000	29.78	50.00	20.22	1000.0	9.000	N	OFF	20.4
26.569500	26.32	50.00	23.68	1000.0	9.000	N	OFF	20.5



2.3 99% EMISSION BANDWIDTH

2.3.1 Specification Reference

RSS-Gen Clause 6.7

2.3.2 Standard Applicable

The emission bandwidth (x dB) is defined as the frequency range between two points, one above and one below the carrier frequency, at which the spectral density of the emission is attenuated x dB below the maximum in-band spectral density of the modulated signal. Spectral density (power per unit bandwidth) is to be measured with a detector of resolution bandwidth in the range of 1% to 5% of the anticipated emission bandwidth, and a video bandwidth at least 3x the resolution bandwidth. When the occupied bandwidth limit is not stated in the applicable RSS or reference measurement method, the transmitted signal bandwidth shall be reported as the 99% emission bandwidth, as calculated or measured.

- The transmitter shall be operated at its maximum carrier power measured under normal test conditions.
- The span of the analyzer shall be set to capture all products of the modulation process, including the emission skirts.
- The resolution bandwidth (RBW) shall be in the range of 1% to 5% of the occupied bandwidth (OBW) and video bandwidth (VBW) shall be approximately 3x RBW.

Note: Video averaging is not permitted.

A peak, or peak hold, may be used in place of the sampling detector as this may produce a wider bandwidth than the actual bandwidth (worst-case measurement). Use of a peak hold may be necessary to determine the occupied bandwidth if the device is not transmitting continuously.

The trace data points are recovered and are directly summed in linear power level terms. The recovered amplitude data points, beginning at the lowest frequency, are placed in a running sum until 0.5% of the total is reached and that frequency recorded. The process is repeated for the highest frequency data points (starting at the highest frequency, at the right side of the span, and going down in frequency). This frequency is then recorded.

The difference between the two recorded frequencies is the 99% occupied bandwidth.

2.3.3 Equipment Under Test and Modification State

Serial No: D48AFCEDFCE4, D48AFCEDA2D8, D48AFCEDB5C4 / Default Test Configuration

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

October 07 and 09, 2024 / OC

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 (Rancho Bernardo Satellite Facility)

Ambient Temperature	22.6 °C	24.1 °C
Relative Humidity	36.8 %	47.6 %
ATM Pressure	99.6 kPa	98.8 kPa

2.3.7 Additional Observations

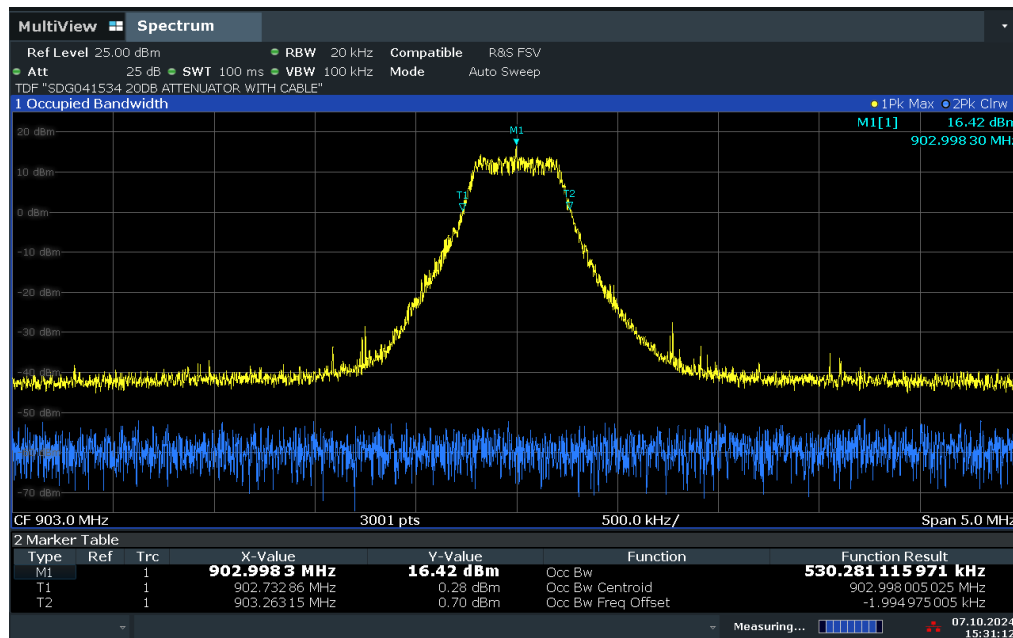
- This is a conducted test using direct connection to a spectrum analyzer.

- The path loss was all accounted for with the test setup calibration.

2.3.8 Test Results

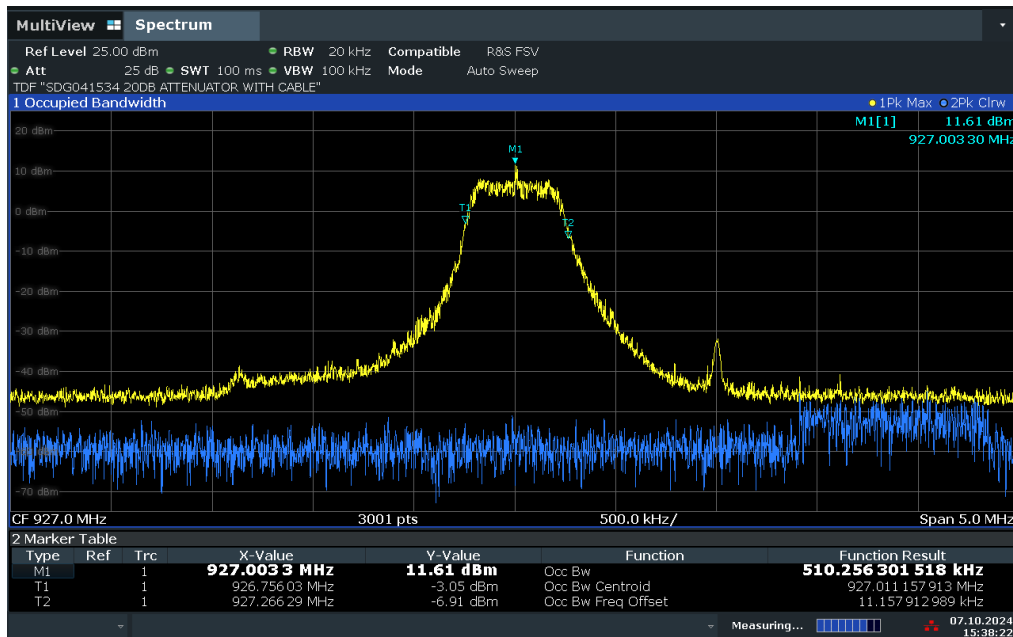
DUT Frequency (MHz)	Spreading Factor	99% Bandwidth (kHz)	Band Edge Left (MHz)	Band Edge Right (MHz)	Result
903.00	SF5	530.28	902.73	903.26	PASS
927.00	SF5	510.25	926.75	927.26	PASS
903.00	SF12	520.25	902.73	903.23	PASS
927.00	SF12	523.32	926.73	927.26	PASS
Operating band is from 902MHz to 928MHz.					

2.3.9 Test Plots



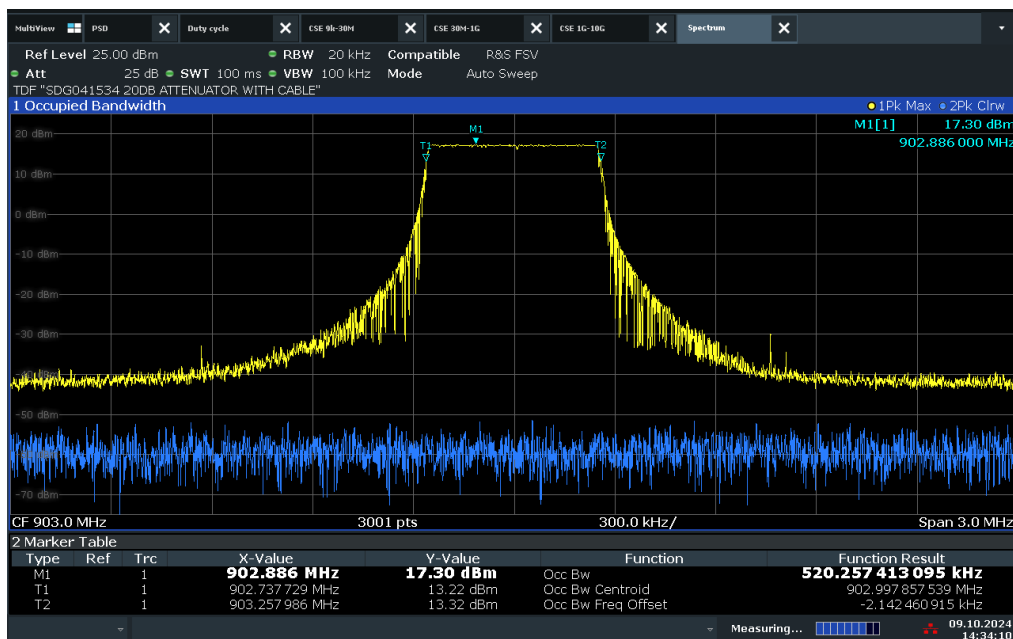
15:31:12 07.10.2024

LoRA SF5 Low Channel



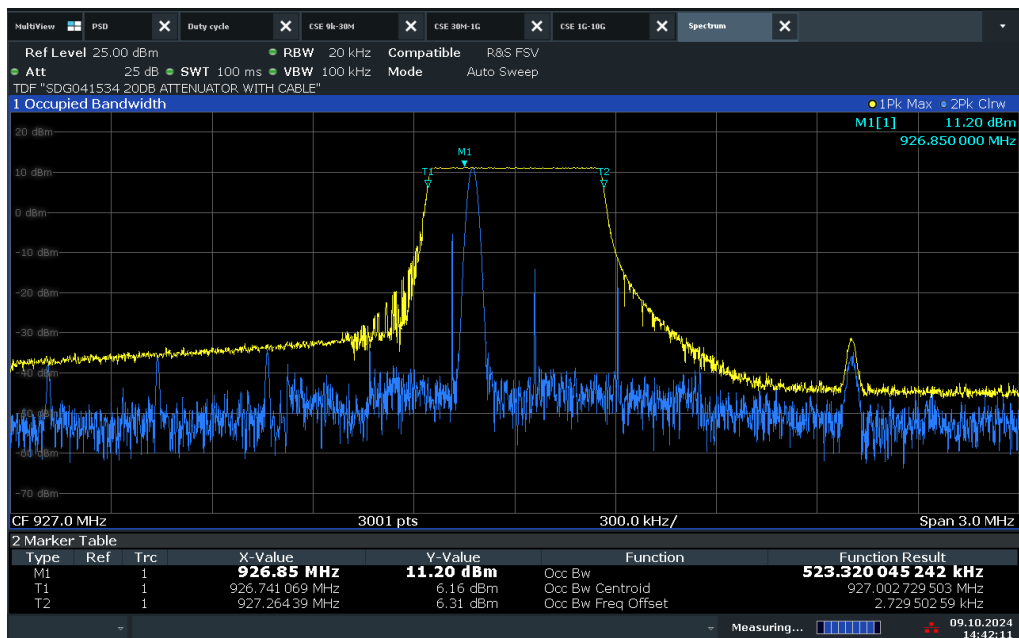
15:38:23 07.10.2024

LoRA SF5 High Channel



14:34:12 09.10.2024

LoRA SF12 Low Channel



14:42:12 09.10.2024

LoRA SF12 High Channel



2.4 MINIMUM 6 dB RF BANDWIDTH

2.4.1 Specification Reference

FCC 47 CFR Part 15, Clause 15.247(a)(2)
RSS-247, Clause 5.2 (a)

2.4.2 Standard Applicable

(2) Systems using digital modulation techniques may operate in the 902–928 MHz, 2400–2483.5 MHz, and 5725–5850 MHz bands. The minimum 6 dB bandwidth shall be at least 500 kHz.

2.4.3 Equipment Under Test and Modification State

Serial No: D48AFCEDFCE4, D48AFCEDA2D8, D48AFCEDB5C4 / Default Test Configuration

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

October 07 and 09, 2024 / OC

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 (Rancho Bernardo Satellite Facility)

Ambient Temperature	22.6 °C	24.1 °C
Relative Humidity	36.8 %	47.6 %
ATM Pressure	99.6 kPa	98.8 kPa

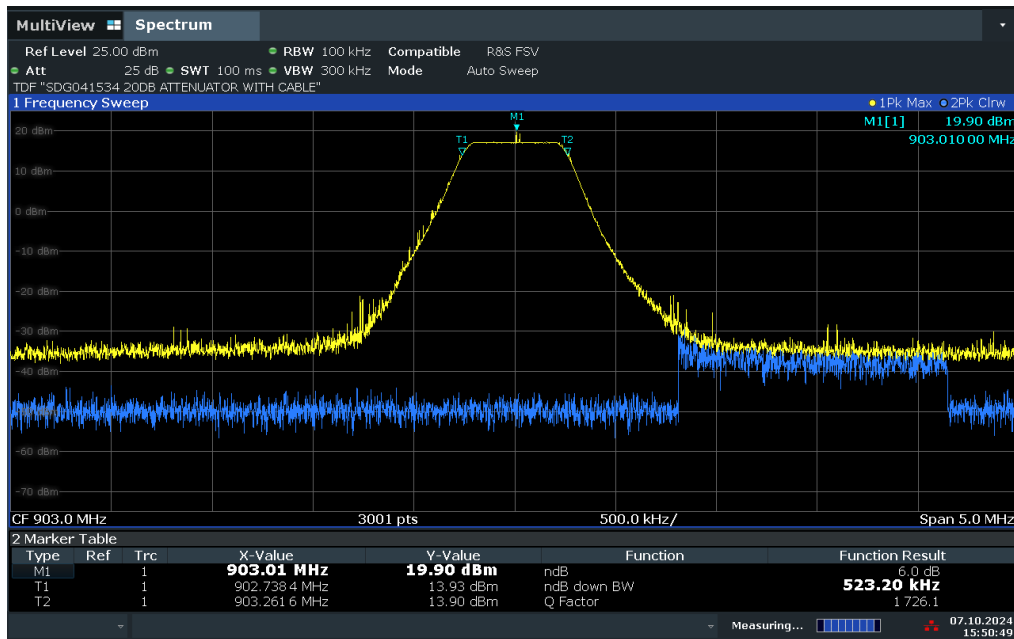
2.4.7 Additional Observations

- This is a conducted test using direct connection to a spectrum analyzer.
- The path loss was all accounted for with the test setup calibration.

2.4.8 Test Results

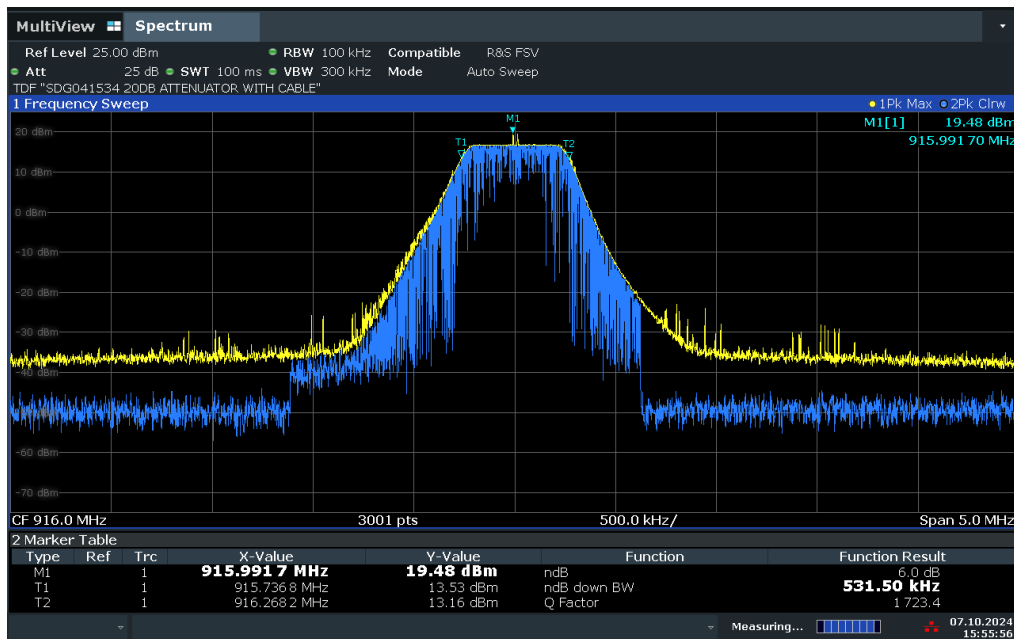
DUT Frequency (MHz)	Spreading Factor	Limit Min (kHz)	6 dB Bandwidth (kHz)	Result
903.00	SF12	500	523.20	PASS
916.00	SF12		531.50	PASS
927.00	SF12		523.20	PASS
903.00	SF7		598.80	PASS
916.00	SF7		607.80	PASS
927.00	SF7		599.80	PASS

2.4.9 Test Plots



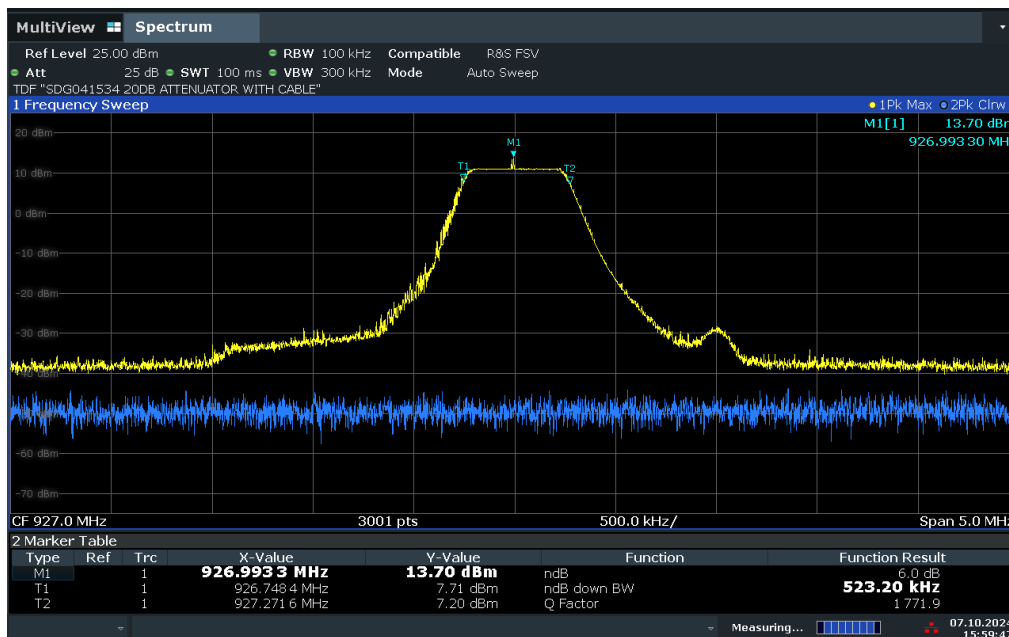
15:50:49 07.10.2024

LoRA SF5 Low Channel



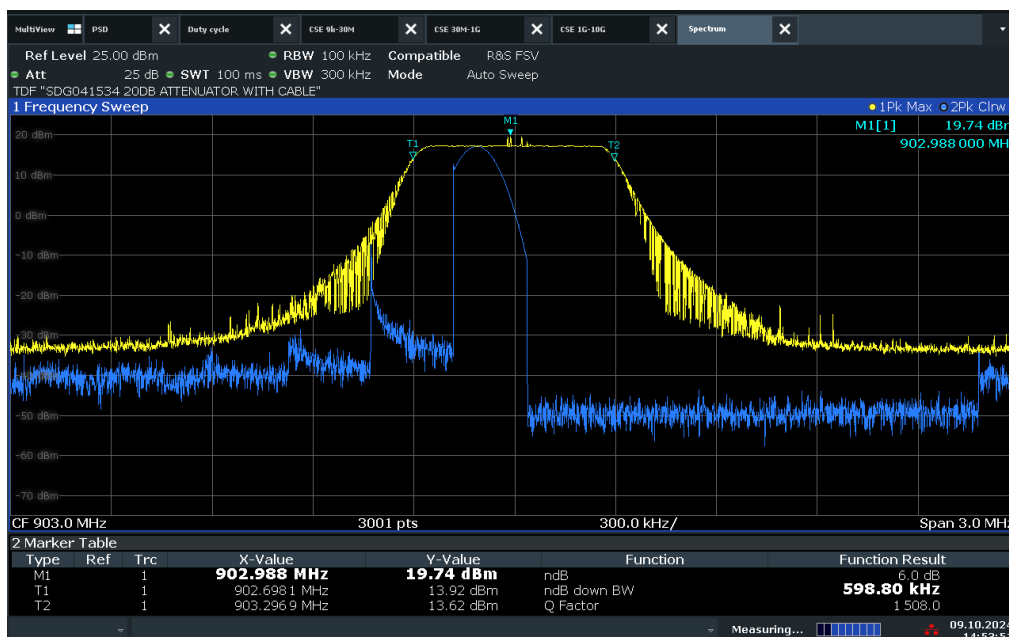
15:55:57 07.10.2024

LoRA SF5 Middle Channel



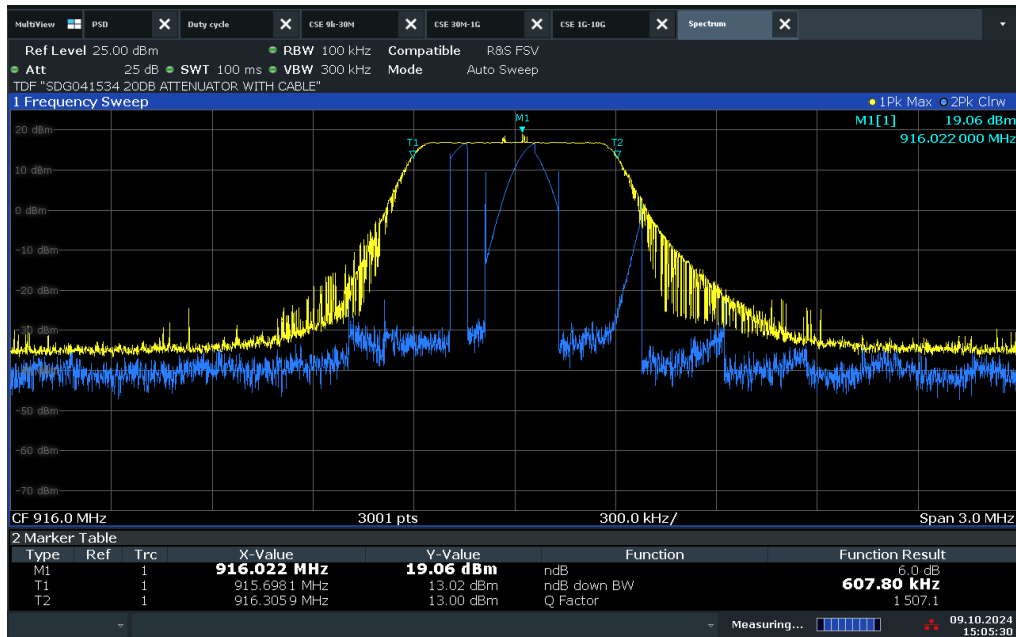
15:59:48 07.10.2024

LoRA SF5 High Channel



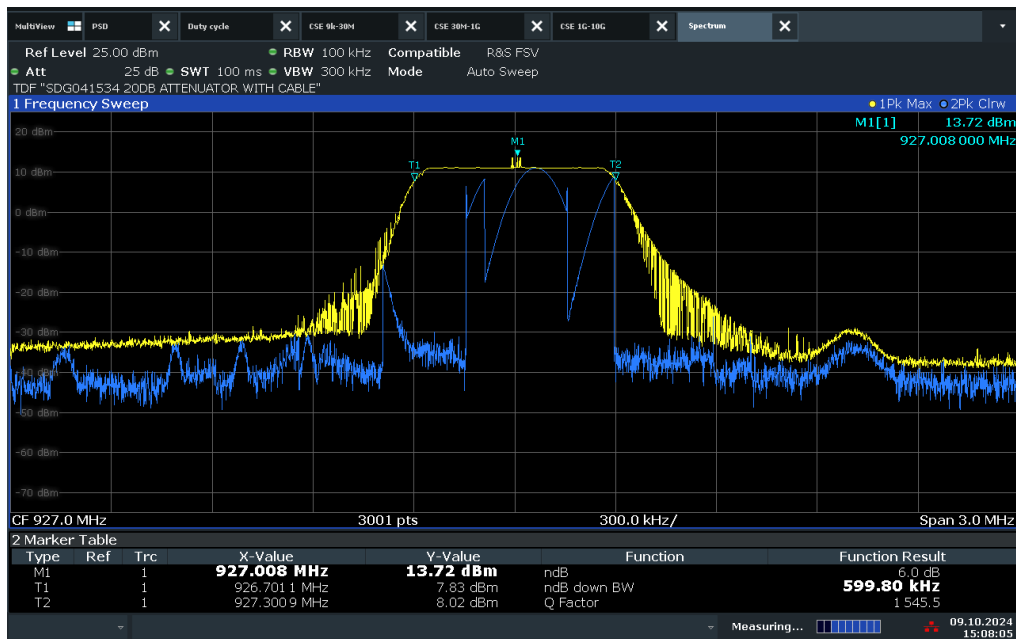
14:53:51 09.10.2024

LoRA SF12 Low Channel



15:05:31 09.10.2024

LoRA SF12 Middle Channel



15:08:06 09.10.2024

LoRA SF12 High Channel



2.5 OUT-OF-BAND EMISSIONS - CONDUCTED

2.5.1 Specification Reference

FCC 47 CFR Part 15, Clause 15.247(d)
RSS-247, Clause 5.5

2.5.2 Standard Applicable

In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, as permitted under paragraph (b)(3) of this section, the attenuation required under this paragraph shall be 30 dB instead of 20 dB. Attenuation below the general limits specified in §15.209(a) is not required. In addition, radiated emissions which fall in the restricted bands, as defined in §15.205(a), must also comply with the radiated emission limits specified in §15.209(a) (see §15.205(c)).

2.5.3 Equipment Under Test and Modification State

Serial No: D48AFCEDFCE4, D48AFCEDA2D8, D48AFCEDB5C4 / Default Test Configuration

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

October 08 and 10, 2024 / OC

2.5.5 Test Equipment Used

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

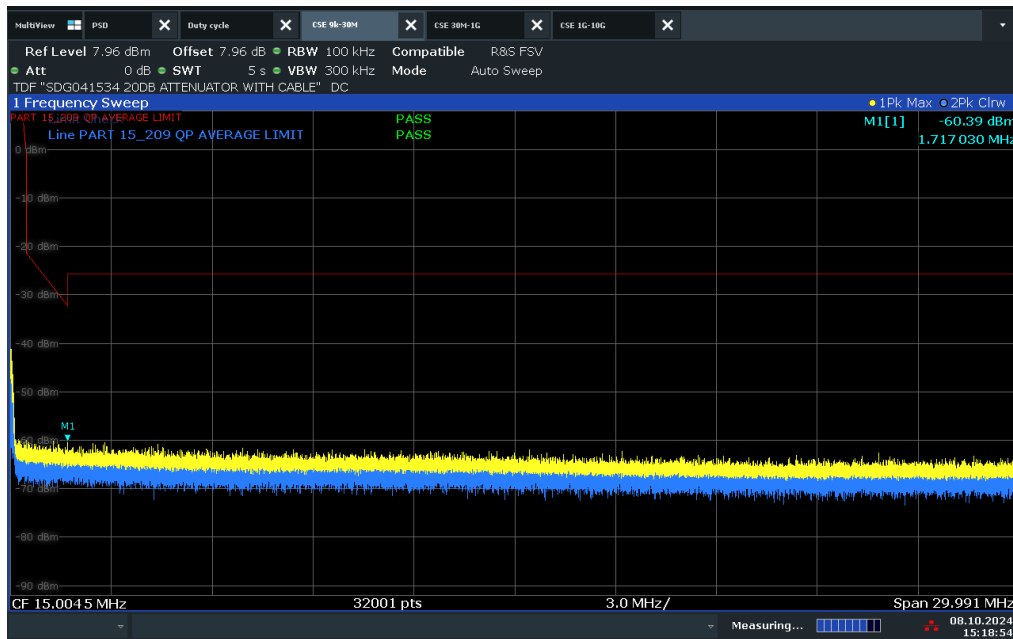
2.5.6 Environmental Conditions (Rancho Bernardo Satellite Facility)

Ambient Temperature	22.6 °C
Relative Humidity	36.8 %
ATM Pressure	99.6 kPa

2.5.7 Additional Observations

- This is a conducted test using a spectrum analyser.
- The path loss was all accounted for using a transducer factor (TDF).
- Only compliance to §15.205 presented being worse case over §15.247(d) requirements (limits of §15.247(d) is dBc).
- Limits of §15.209 is converted to EIRP using formula from Clause 12.7.2(d) of ANSI C63.10-2013. The declared antenna gain is programmed as an offset for §15.205 verification plus the appropriate maximum ground reflection factor per ANSI C63.10 Clause 11.12.2.2.

2.5.8 Test Results SF5



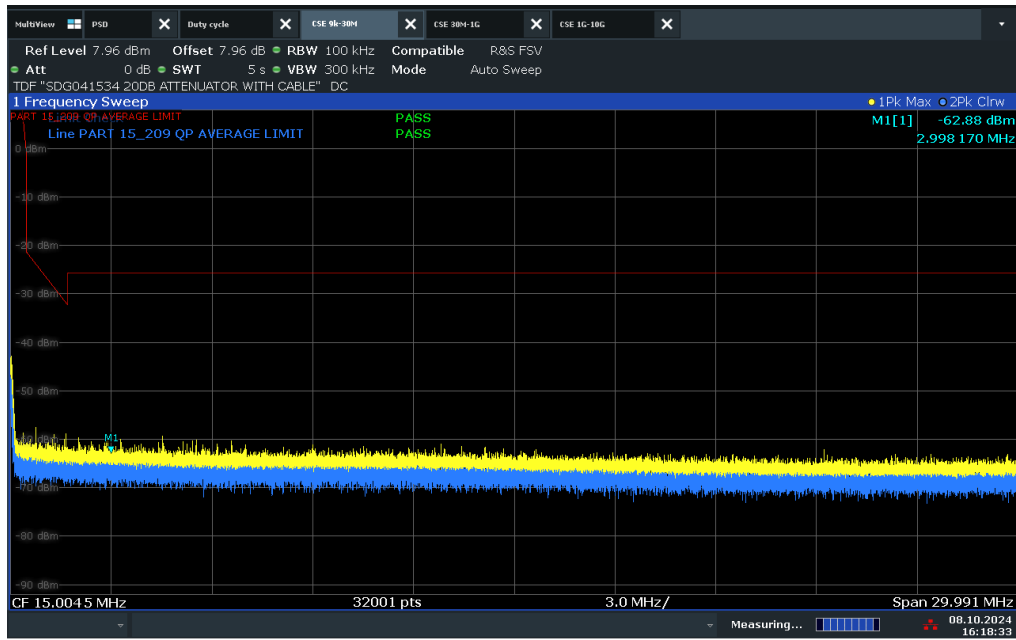
15:18:54 08.10.2024

Low Channel (9kHz to 30MHz)

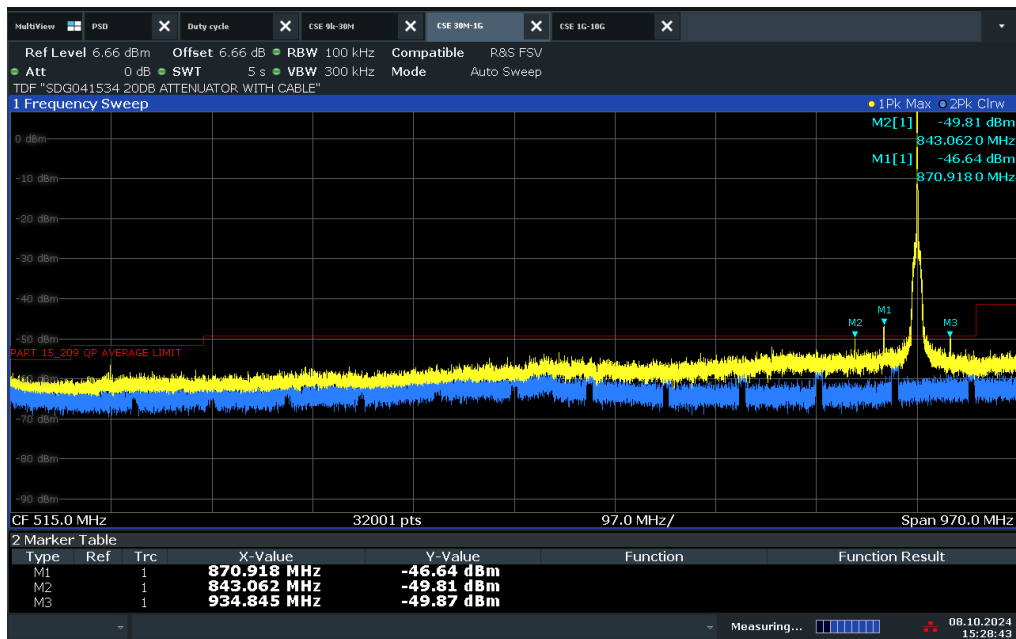


15:53:37 08.10.2024

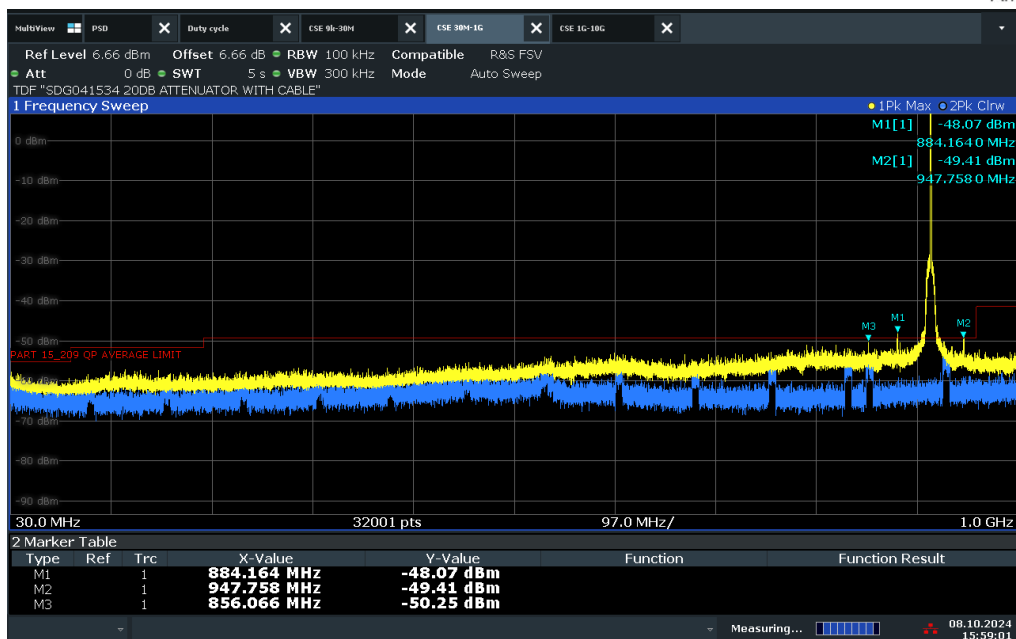
Middle Channel (9kHz to 30MHz)



High Channel (9kHz to 30MHz)

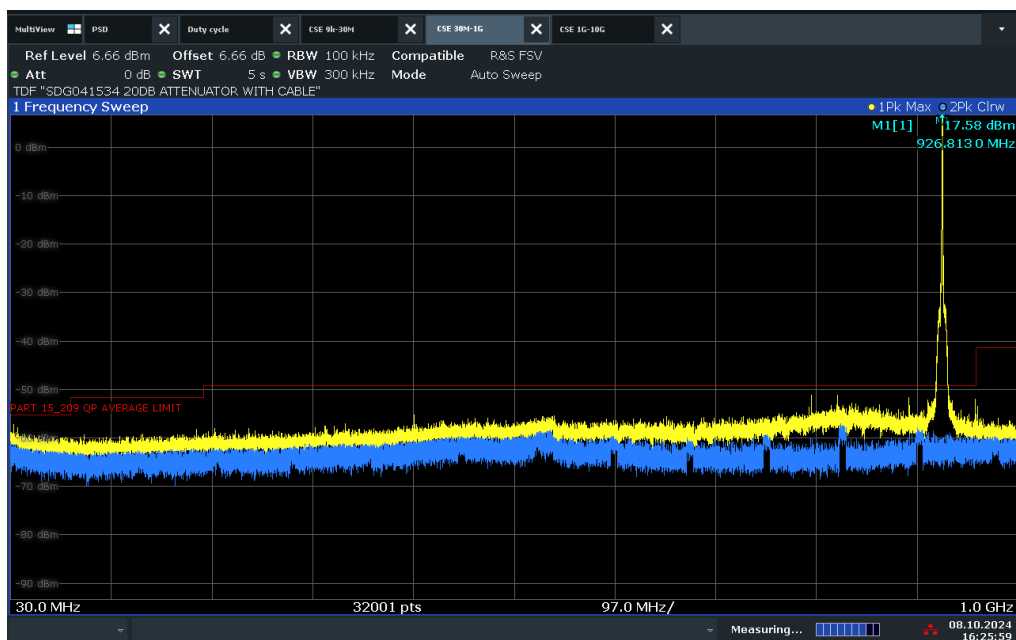


Low Channel (30MHz to 1GHz)



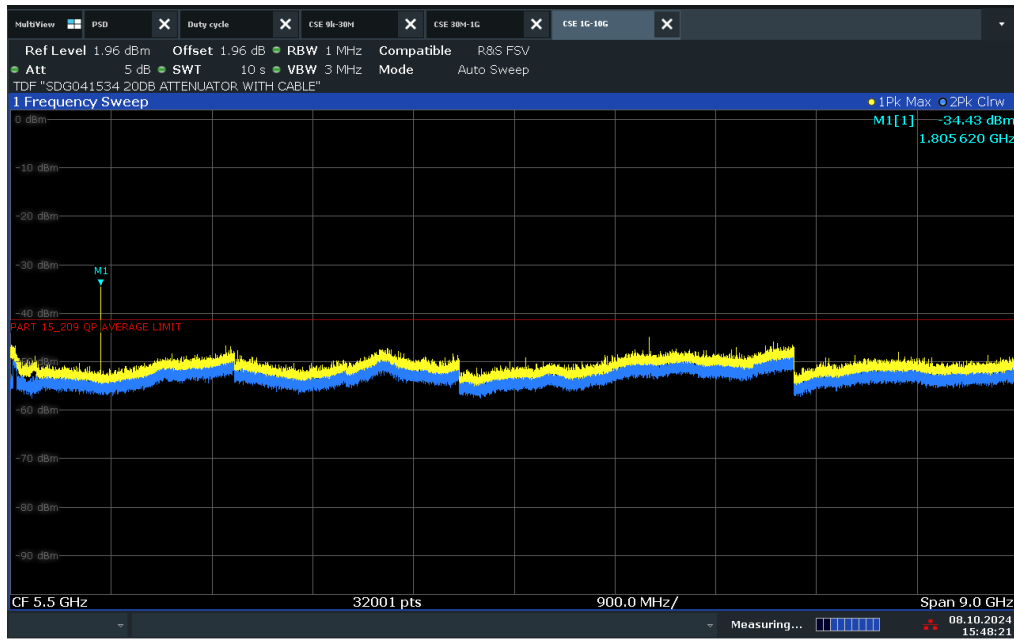
15:59:02 08.10.2024

Middle Channel (30MHz to 1GHz)



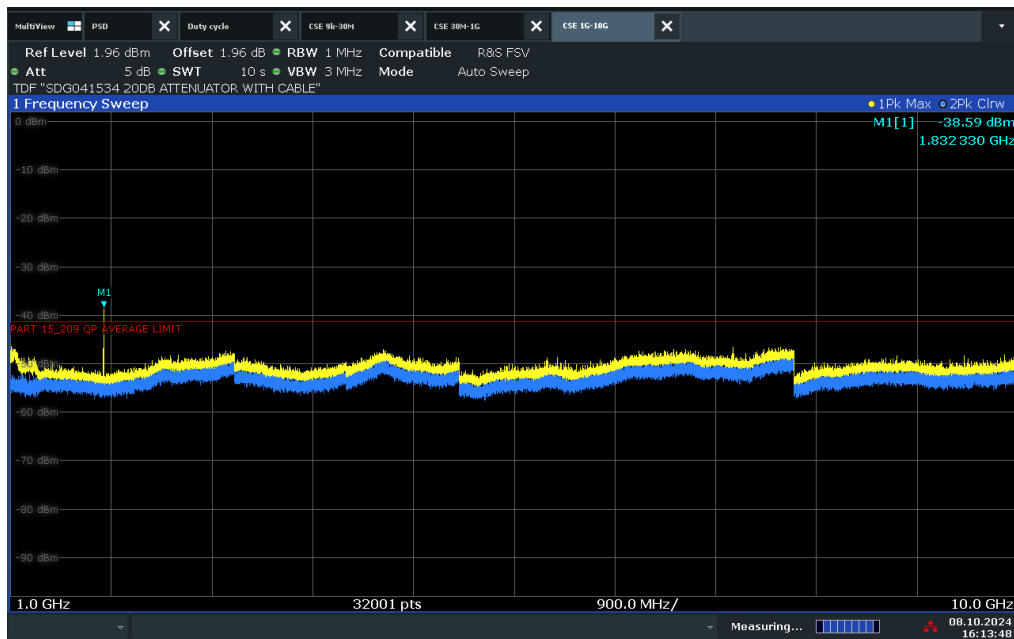
16:26:00 08.10.2024

High Channel (30MHz to 1GHz)



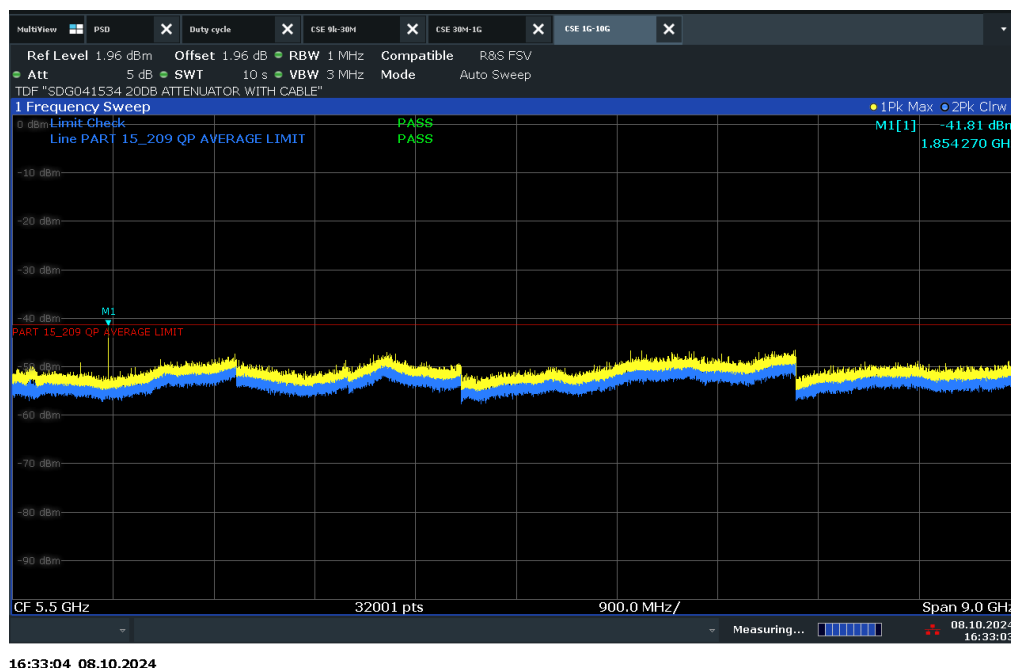
15:48:21 08.10.2024

Low Channel (1GHz to 10GHz)



16:13:49 08.10.2024

Middle Channel (1GHz to 10GHz)



High Channel (1GHz to 10GHz)

2.5.9 Sample Calculations for SF5

Spectrum analyzer offset for 30MHz to 1GHz range:

Offset = antenna gain + maximum ground reflection factor
 = 1.96dBi + 4.7dB
 = 6.66dB

M₁, M₂ and M₃ marker points in the frequency range 30MHz to 1GHz:

Reported worst case level = -46.64dBm EIRP (M₁ for Low Channel)

None of M₁ (870.918MHz), M₂ (843.062MHz) and M₃ (934.845MHz) are in the restricted bands per §15.205. Therefore, it should be subjected to §15.247(d) limits. Peak detector is used; therefore, the limit is 20dBc. Per data from Section 2.1.8 of this test report:

20.02 dBm (Peak Power for Low Channel)+ 1.96dBi (antenna gain) – (-46.64 dBm EIRP) = 68.62dB (>20dBc, **EUT complies**).

Note:

Same approach applies to 30MHz to 1GHz range (Mid channel results):
 None of M₁(884.164MHz), M₂(947.758MHz) and M₃(856.066MHz)

Reported worst case level = -48.07dBm EIRP (M₁ for Mid Channel)

19.54 dBm (Peak Power for Low Channel)+ 1.96dBi (antenna gain) – (-48.07 dBm EIRP) = 69.57dB (>20dBc, **EUT complies**).



M1 marker point in the frequency range 1GHz to 10GHz:

Offset = antenna gain
 = 1.96dBi
 = 1.96dB

Reported worst case level = -34.43 dBm EIRP (M1 for Low Channel).

M1 (1.805GHz) is not in the restricted bands per §15.205. Therefore, it should be subjected to §15.247(d) limits. Peak detector is used; therefore, the limit is 20dBc. Per data from Section 2.1.8 of this test report:

Presented M1 EIRP level is with 1MHz RBW (worst case than 100kHz).

20.02 dBm (Peak Power for Low Channel)+ 1.96dBi (antenna gain) – (-34.43 dBm EIRP) = 56.41dB
(>20dBc, **EUT complies**).

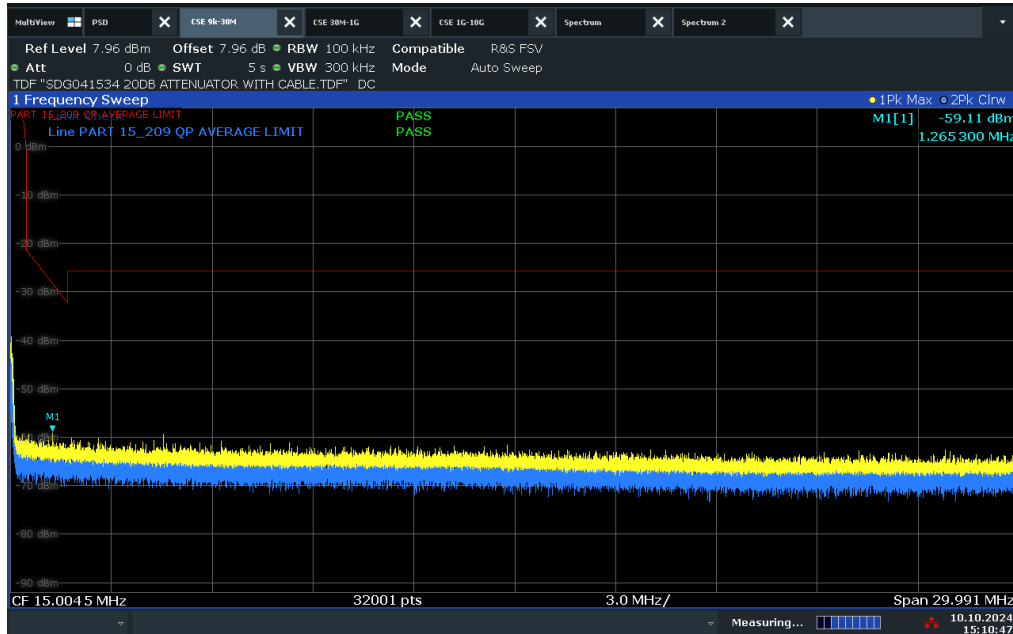
Note:

Same approach applies to 1GHz to 10GHz range (Mid channel results):
None of M1(1.832 GHz)

Reported worst case level = -38.59 EIRP (M1 for Mid Channel)

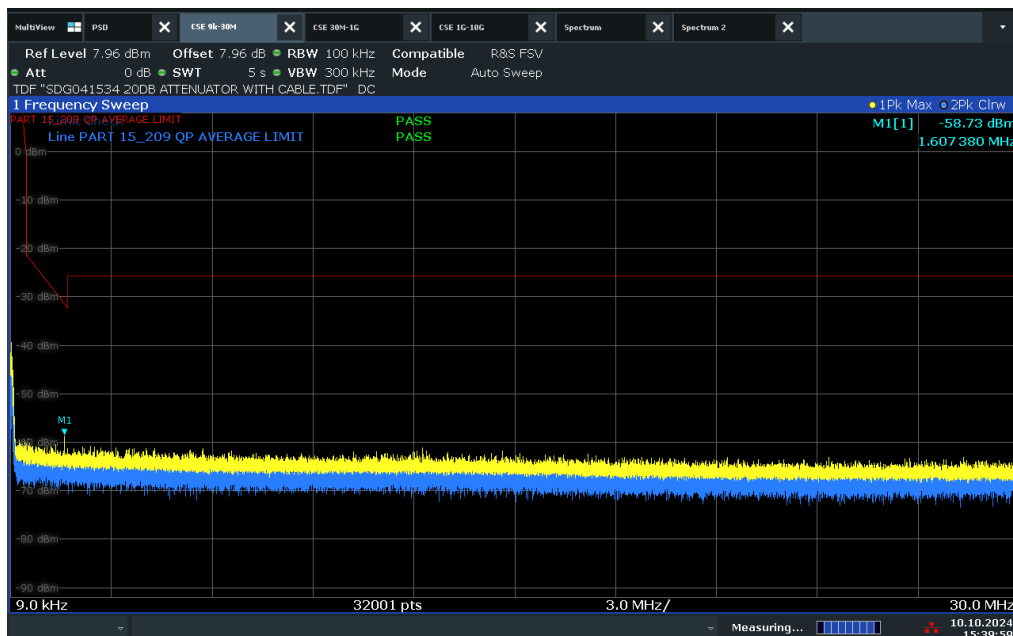
19.54 dBm (Peak Power for Low Channel)+ 1.96dBi (antenna gain) – (-38.59 dBm EIRP) = 60.09dB
(>20dBc, **EUT complies**).

2.5.10 Test Results SF12



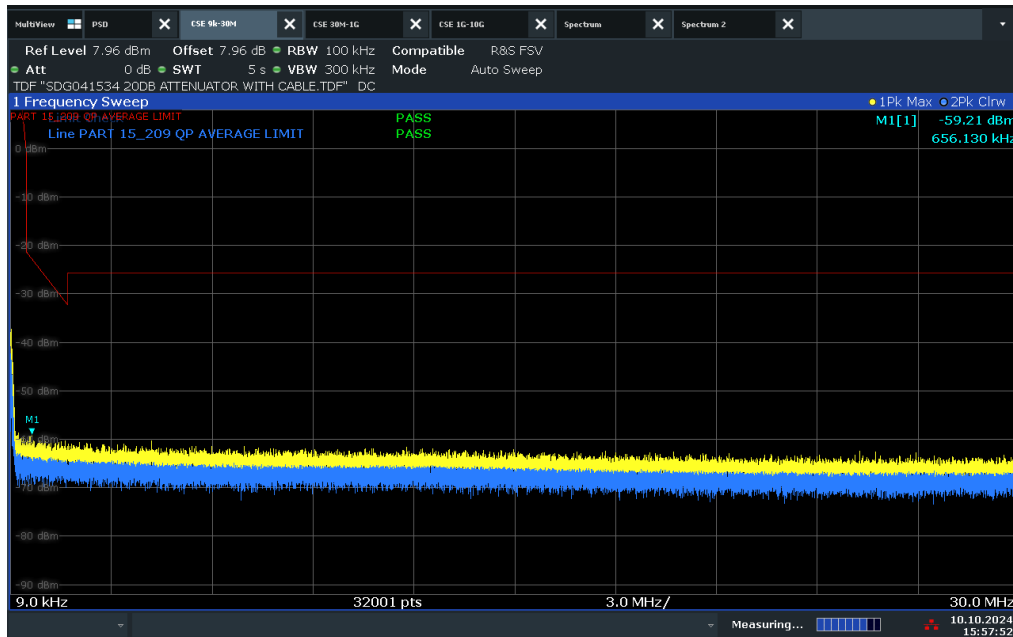
15:10:48 10.10.2024

Low Channel (9kHz to 30MHz)



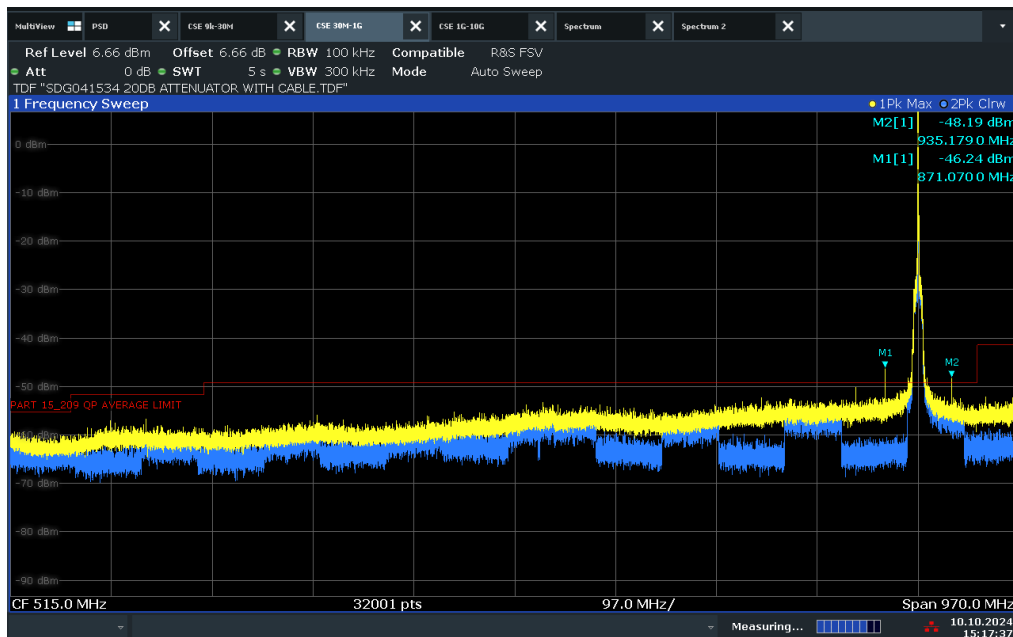
15:40:00 10.10.2024

Middle Channel (9kHz to 30MHz)



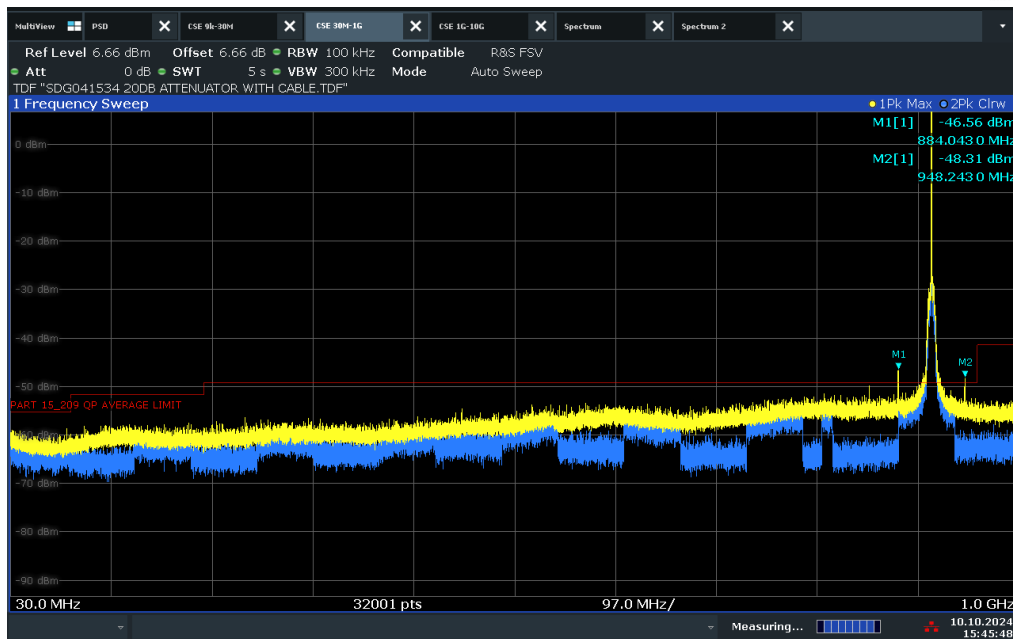
15:57:53 10.10.2024

High Channel (9kHz to 30MHz)



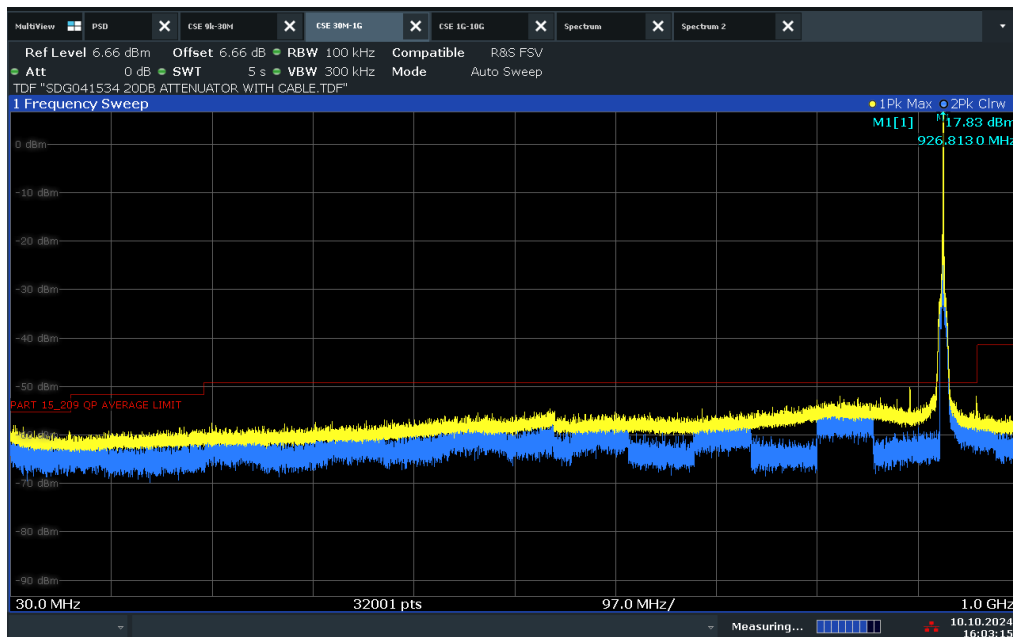
15:17:38 10.10.2024

Low Channel (30MHz to 1GHz)



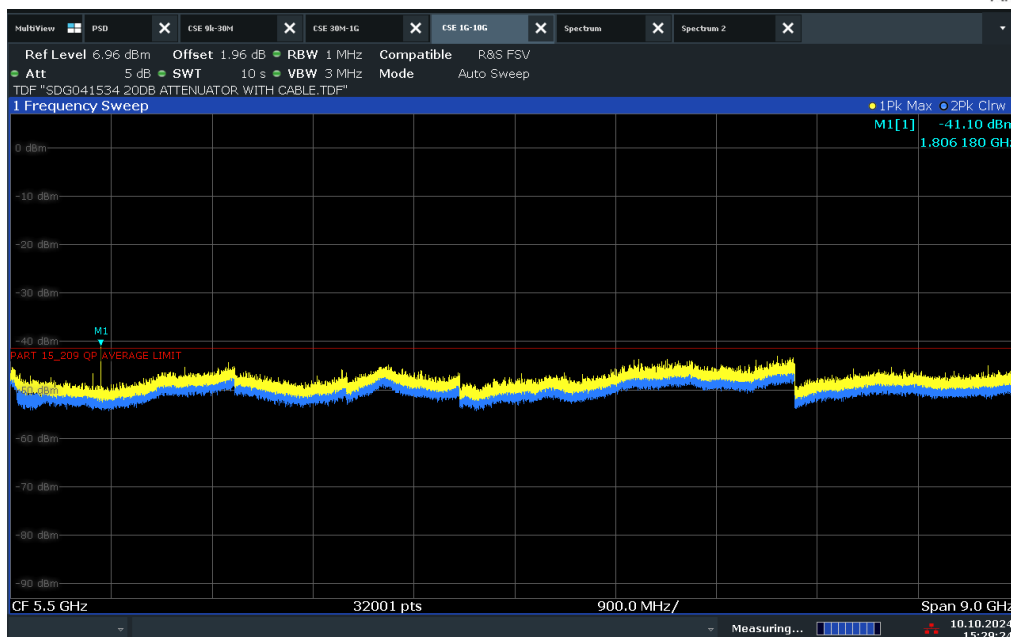
15:45:49 10.10.2024

Middle Channel (30MHz to 1GHz)



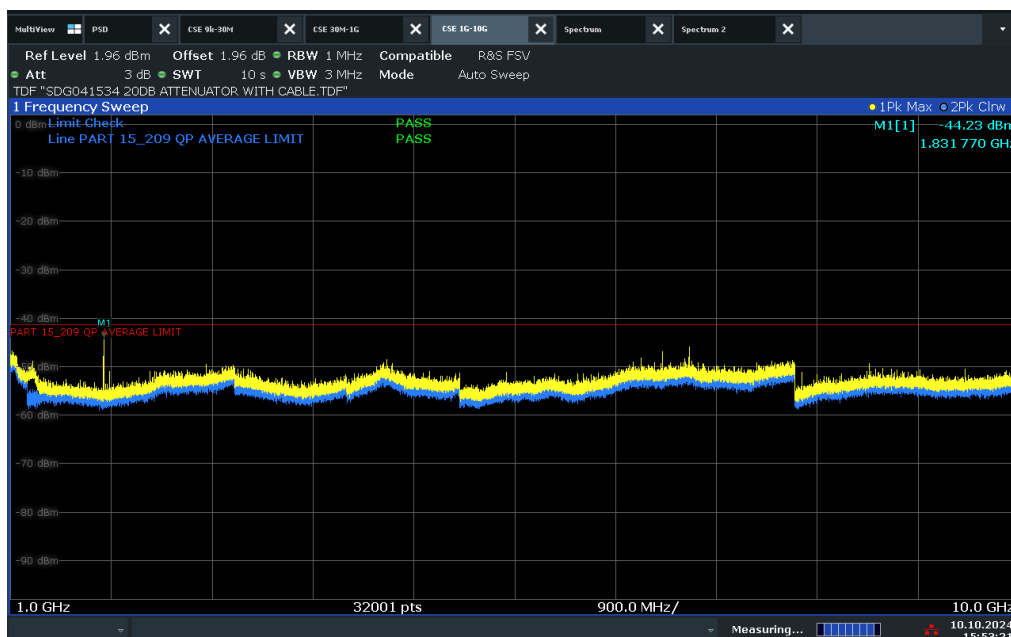
16:03:15 10.10.2024

High Channel (30MHz to 1GHz)



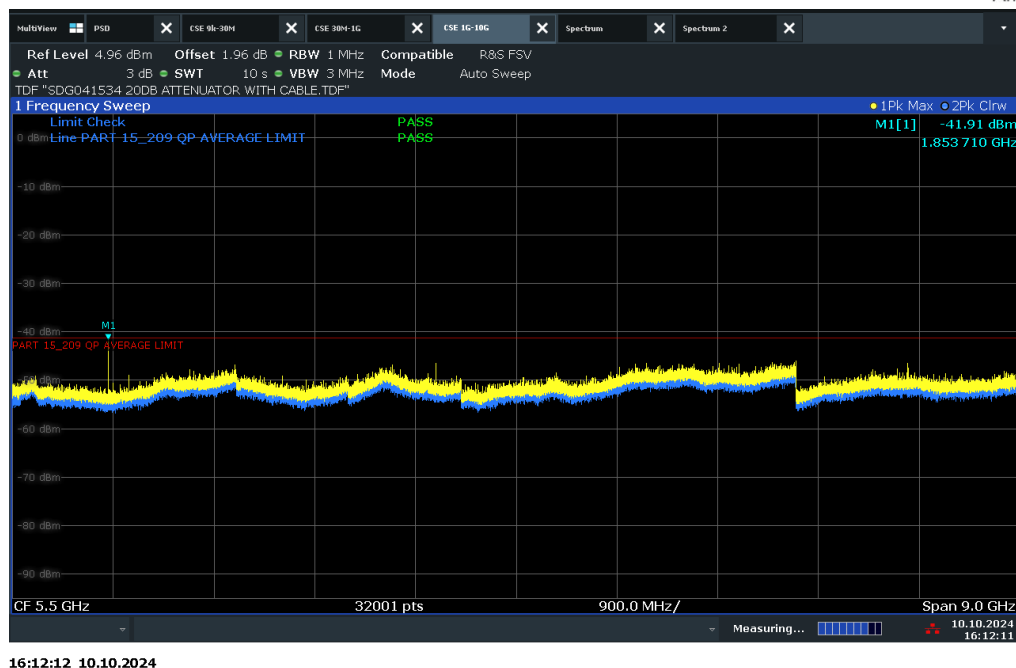
15:29:24 10.10.2024

Low Channel (1GHz to 10GHz)



15:53:22 10.10.2024

Middle Channel (1GHz to 10GHz)



High Channel (1GHz to 10GHz)

2.5.11 Sample Calculations for SF12

Spectrum analyzer offset for 30MHz to 1GHz range:

Offset = antenna gain + maximum ground reflection factor
 = 1.96dBi + 4.7dB
 = 6.66dB

M1 and M2 marker points in the frequency range 30MHz to 1GHz:

Reported worst case level = -46.24dBm EIRP (M1 for Low Channel)

None of M1 (871.070MHz) and M2 (935.179MHz) are in the restricted bands per §15.205. Therefore, it should be subjected to §15.247(d) limits. Peak detector is used; therefore, the limit is 20dBc. Per data from Section 2.1.8 of this test report:

20.02 dBm (Peak Power for Low Channel)+ 1.96dBi (antenna gain) – (-46.24 dBm EIRP) = 68.22dB (>20dBc, **EUT complies**).

Note:

Same approach applies to 30MHz to 1GHz range (Mid channel results):
 None of M1(884.043MHz) and M2(948.243MHz)

Reported worst case level = -46.56dBm EIRP (M1 for Mid Channel)

19.51 dBm (Peak Power for Low Channel)+ 1.96dBi (antenna gain) – (-46.56 dBm EIRP) = 68.03dB (>20dBc, **EUT complies**).



M1 marker point in the frequency range 1GHz to 10GHz:

Offset = antenna gain
 = 1.96dBi
 = 1.96dB

Reported worst case level = -41.10 dBm EIRP (M1 for Low Channel).

M1 (1.806GHz) is not in the restricted bands per §15.205. Therefore, it should be subjected to §15.247(d) limits. Peak detector is used; therefore, the limit is 20dBc. Per data from Section 2.1.8 of this test report:

Presented M1 EIRP level is with 1MHz RBW (worst case than 100kHz).

19.51 dBm (Peak Power for Low Channel)+ 1.96dBi (antenna gain) – (-41.10 dBm EIRP) = 62.57dB (>20dBc, **EUT complies**).



2.6 BAND-EDGE COMPLIANCE OF RF CONDUCTED EMISSIONS

2.6.1 Specification Reference

FCC 47 CFR Part 15, Clause 15.247(d)
FCC 47 CFR Part 15, Clause 15.205
RSS-247, Clause 5.5

2.6.2 Standard Applicable

In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, as permitted under paragraph (b)(3) of this section, the attenuation required under this paragraph shall be 30 dB instead of 20 dB. Attenuation below the general limits specified in §15.209(a) is not required. In addition, radiated emissions which fall in the restricted bands, as defined in §15.205(a), must also comply with the radiated emission limits specified in §15.209(a) (see §15.205(c)).

2.6.3 Equipment Under Test and Modification State

Serial No: D48AFCEDFCE4, D48AFCEDA2D8, D48AFCEDB5C4 / Default Test Configuration

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

October 08 and 09, 2024 / OC

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 (Rancho Bernardo Satellite Facility)

Ambient Temperature	23.8 °C	24.1 °C
Relative Humidity	39.4 %	47.6 %
ATM Pressure	98.9 kPa	98.8 kPa

2.6.7 Additional Observations

- This is a conducted test using Peak Detection per ANSI C63.10 Subclause 11.13.3.2.
- The path loss was all accounted for using a transducer factor.
- Limits used are from Section 2.1.8 of this test report. Peak results from Low and High channels are used adjusted 20 dB below in the 100 kHz bandwidth within the band.

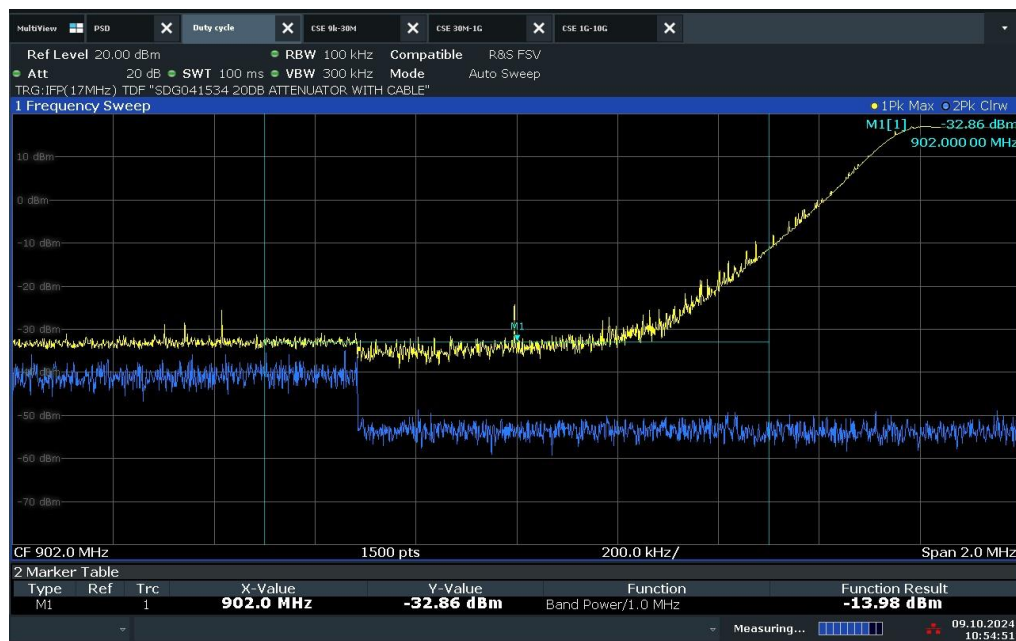
2.6.8 Test Results (Lower Band Edge)

Modulation	Frequency (MHz)	Level (dBm)	Margin (dB)	Limit (dBm)	Result
SF5	902.00	-13.98	14	0.02	Complies
SF12	902.00	-13.08	13.1	0.02	Complies

2.6.9 Test Results (Upper Band Edge)

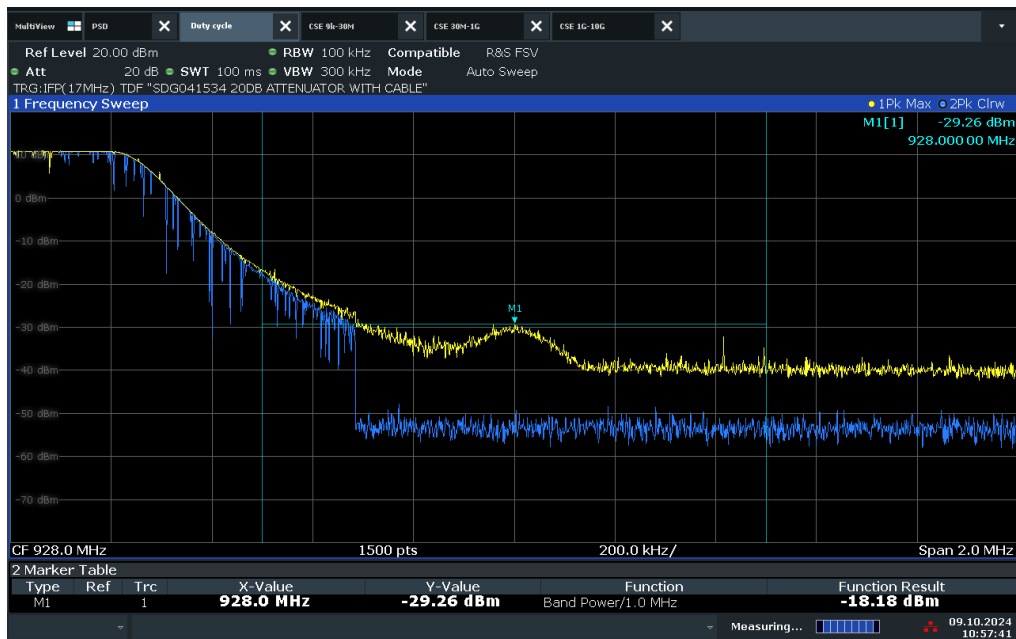
Modulation	Frequency (MHz)	Level (dBm)	Margin (dB)	Limit (dBm)	Result
SF5	928.00	-18.18	10.82	-7.36	Complies
SF12	928.00	-18.26	11.81	-6.45	Complies

2.6.10 Test Plots



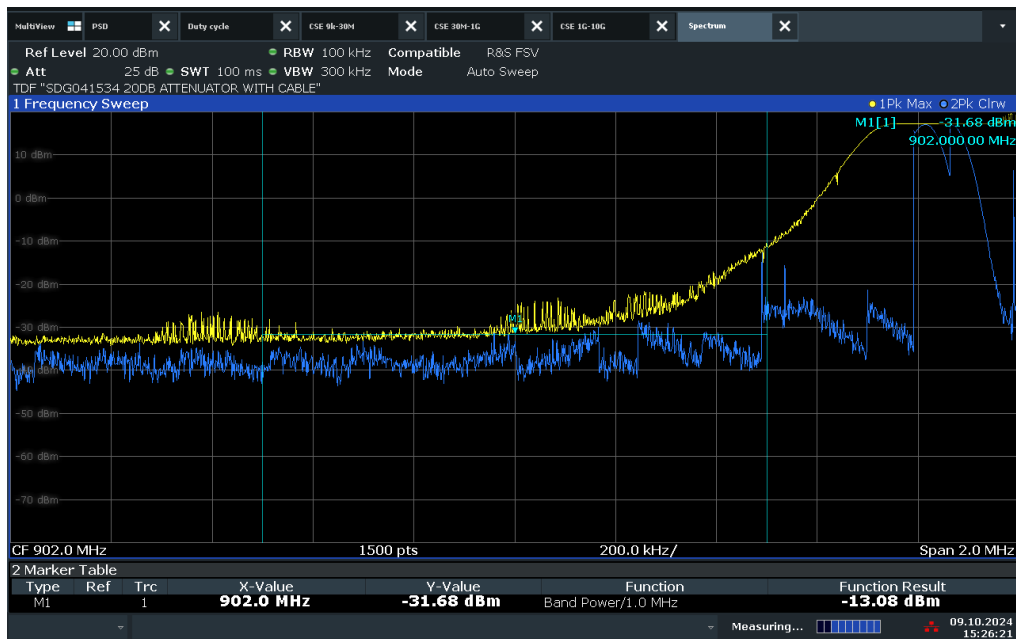
10:54:52 09.10.2024

LoRA SF5 Low Channel



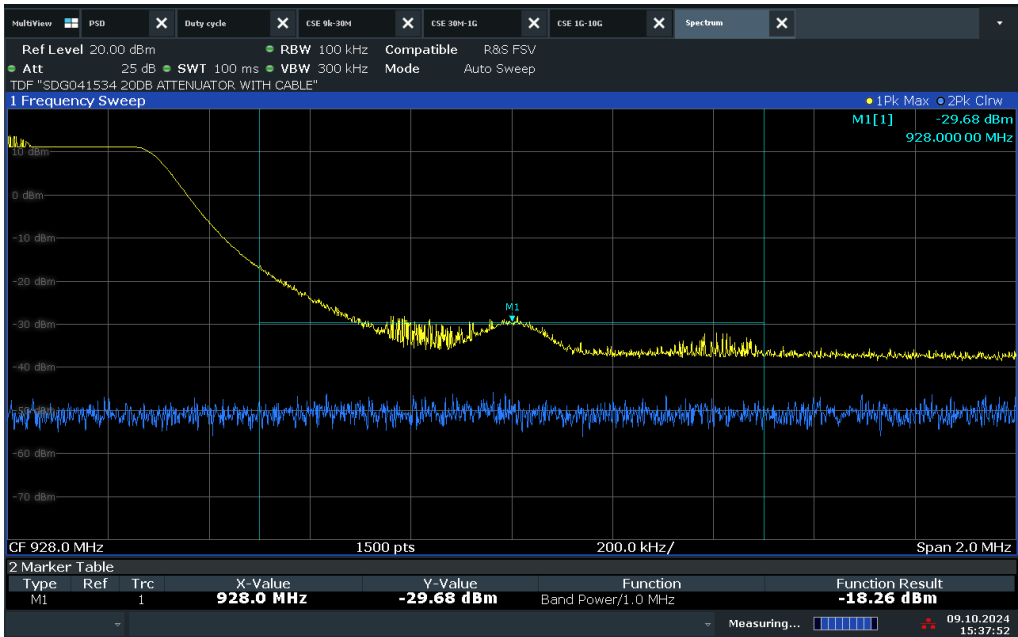
10:57:42 09.10.2024

LoRA SF5 High Channel



15:26:21 09.10.2024

LoRA SF12 Low Channel



15:37:53 09.10.2024

LoRA SF12 High Channel



2.7 RADIATED SPURIOUS EMISSIONS

2.7.1 Specification Reference

FCC 47 CFR Part 15, Clause 15.247(d)
RSS-247, Clause 5.5

2.7.2 Standard Applicable

In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, as permitted under paragraph (b)(3) of this section, the attenuation required under this paragraph shall be 30 dB instead of 20 dB. Attenuation below the general limits specified in §15.209(a) is not required. In addition, radiated emissions which fall in the restricted bands, as defined in §15.205(a), must also comply with the radiated emission limits specified in §15.209(a) (see §15.205(c)).

2.7.3 Equipment Under Test and Modification State

Serial No: D48AFCEDFCE4, D48AFCEDA2D8, D48AFCEDB5C4/ Default Test Configuration

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

October 15 and 16, 2024 / OC

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 (Mira Mesa)

Ambient Temperature	23.7 °C
Relative Humidity	33.2 %
ATM Pressure	100.3 kPa

2.7.7 Additional Observations

- This is a radiated test. The spectrum was searched from 9kHz to the 10th harmonic.
- There are no emissions found that do not comply to the restricted bands defined in FCC Part 15 Subpart C, 15.205 or Part 15.247(d).
- Only the worst-case spreading factor presented (SF12) per test plan. There are no significant differences in emissions between channels when verifying cabinet spurious emissions.
- Antenna port terminated with a 50 Ω load. Emissions coming out of the cabinet being verified.

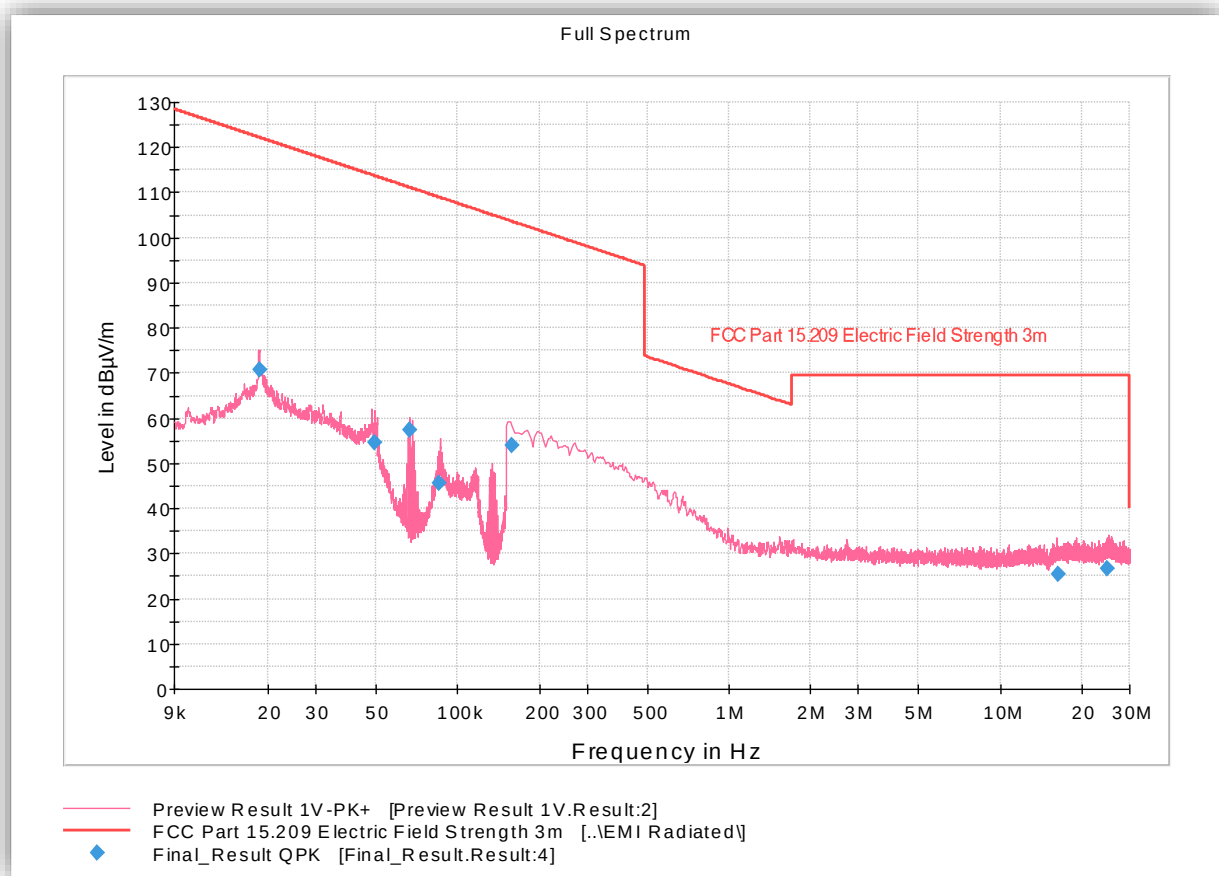


- Measurement was done using EMC32 automated software. Reported level is the actual level with all the correction factors factored in. Correction Factor column is for informational purposes only. See Section 2.7.8 for sample computation.

2.7.8 Sample Computation (Radiated Emission)

Measuring equipment raw measurement (db μ V) @ 30 MHz			-0.8
Correction Factor (dB/m)	Asset# 1066 (cable)	18.1	12.6
	Asset# 1172 (cable)	0.3	
	Asset# 1175(cable)	0.3	
	Asset# 1002 (antenna)	17.2	
Reported QuasiPeak Final Measurement (db μ V/m) @ 30MHz			11.8

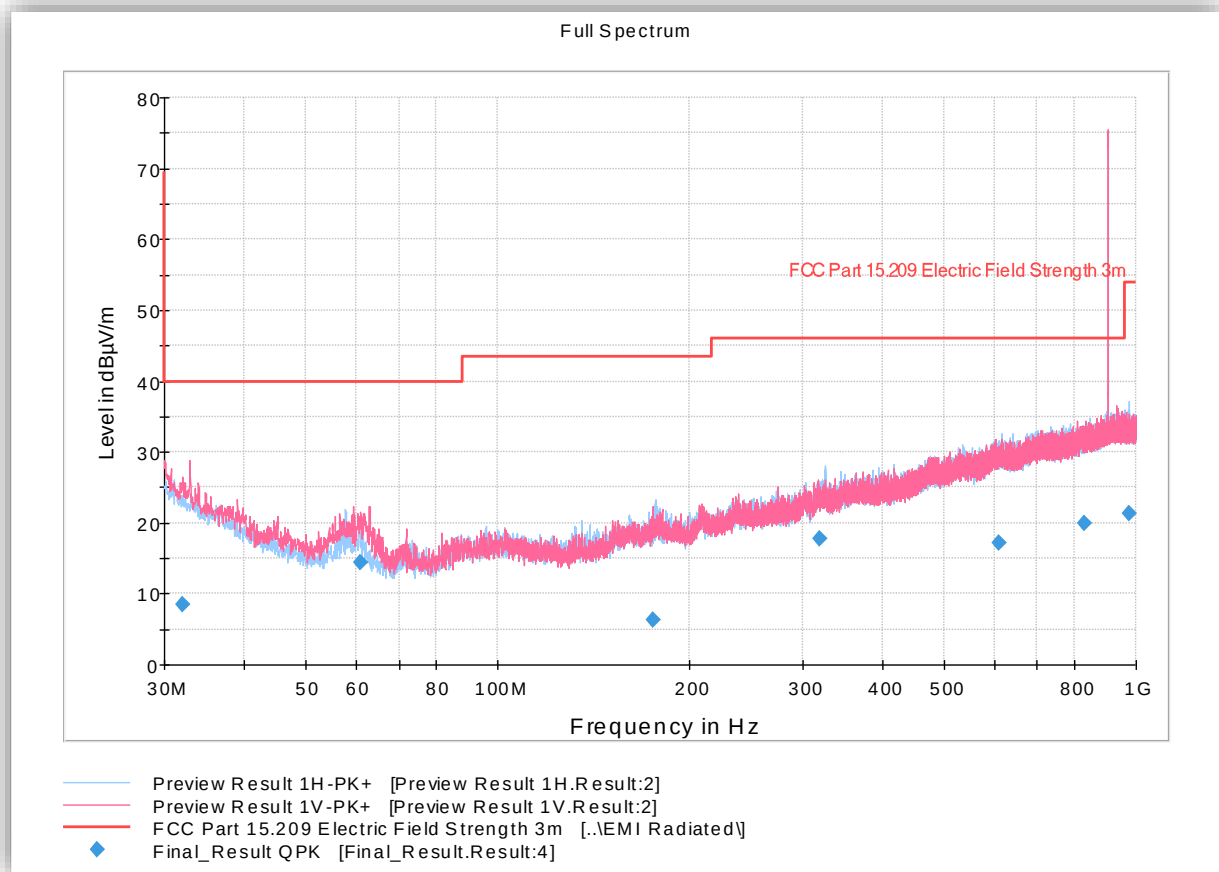
2.7.9 Test Results for 9kHz to 30MHz (worst-case channel and spreading factor)



Quasi Peak Data

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
0.018535	70.59	122.24	51.64	1000.	0.200	400.0	H	169.0	22
0.049052	54.59	113.79	59.20	1000.	0.200	400.0	H	163.0	20
0.066680	57.32	111.12	53.80	1000.	0.200	400.0	H	202.0	20
0.085103	45.59	109.00	63.41	1000.	0.200	400.0	H	41.0	20
0.158500	53.85	103.60	49.75	1000.	9.000	400.0	H	325.0	20
16.429970	25.59	69.50	43.91	1000.	9.000	400.0	H	116.0	22
24.785381	26.66	69.50	42.84	1000.	9.000	400.0	H	46.0	24

2.7.10 Test Results for 30MHz to 1GHz Low Channel

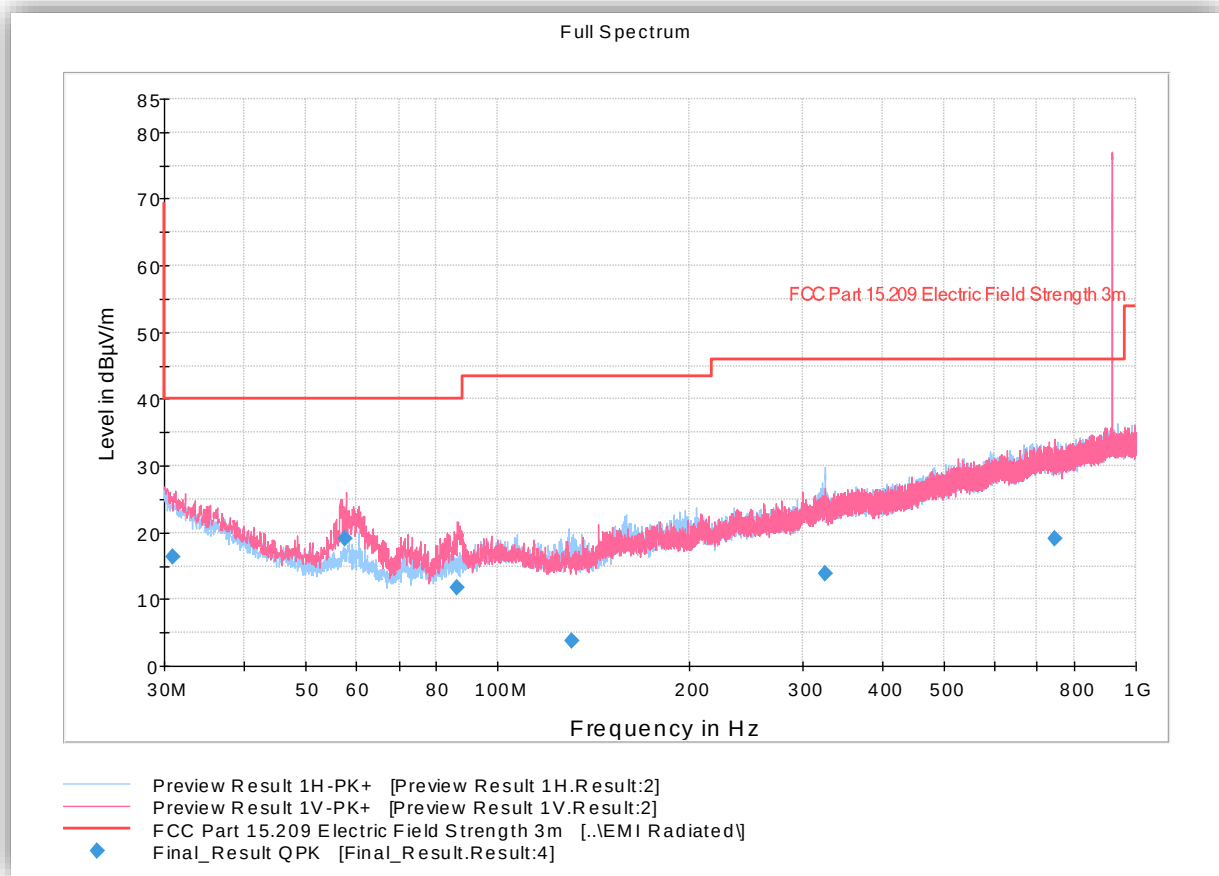


Quasi Peak Data

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
32.117667	8.40	40.00	31.60	1000.	120.000	175.0	V	319.0	21
60.719333	14.36	40.00	25.64	1000.	120.000	160.0	V	4.0	13
175.03366	6.31	43.50	37.19	1000.	120.000	233.0	V	47.0	17
319.58166	17.85	46.00	28.15	1000.	120.000	302.0	H	270.0	21
609.44400	17.27	46.00	28.73	1000.	120.000	335.0	H	279.0	28
830.83533	19.88	46.00	26.12	1000.	120.000	136.0	H	313.0	30
975.44600	21.33	53.90	32.57	1000.	120.000	255.0	H	286.0	31

Test Notes: Fundamental will be ignored for this test (antenna port terminated).

2.7.11 Test Results for 30MHz to 1GHz Middle Channel

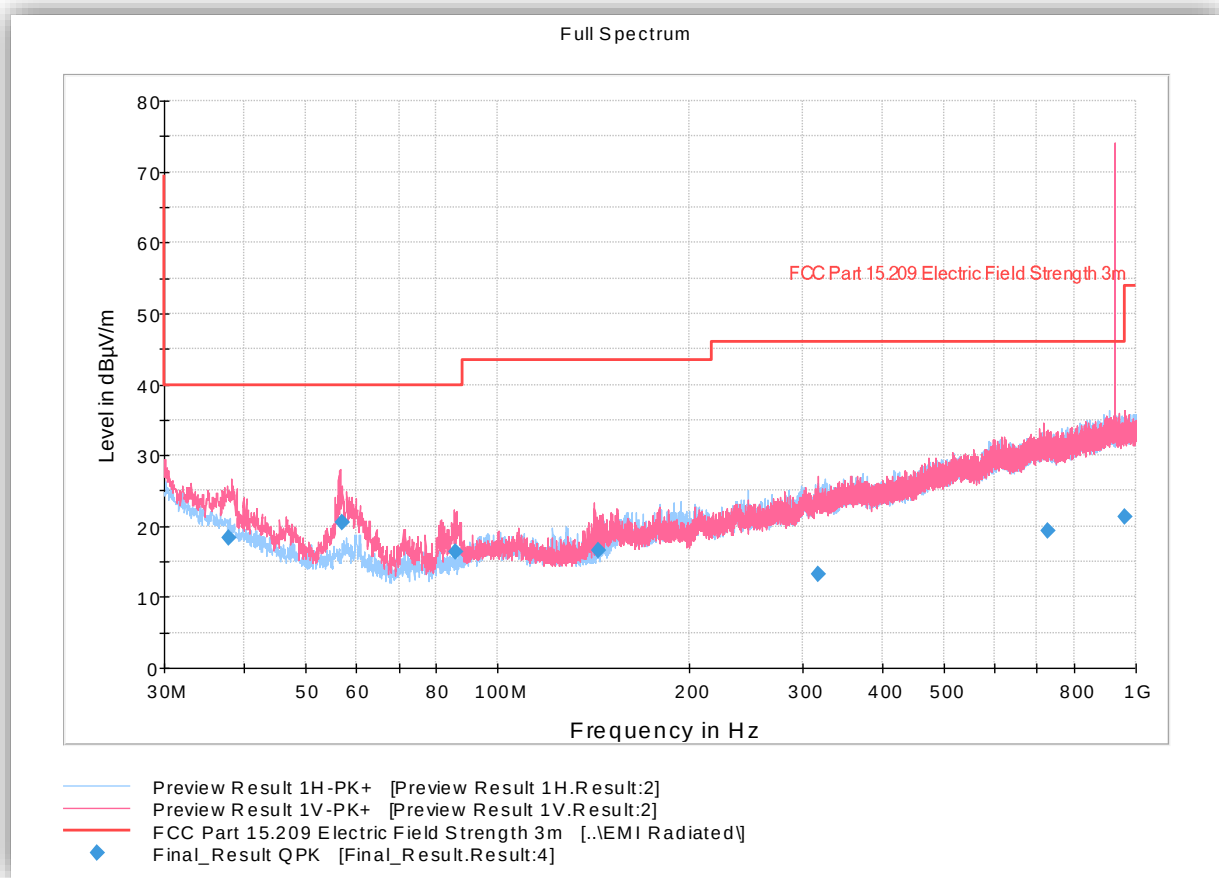


Quasi Peak Data

Frequency (MHz)	QuasiPeak (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
30.867667	16.45	40.00	23.55	1000.	120.000	132.0	V	80.0	22
57.518333	19.03	40.00	20.97	1000.	120.000	132.0	V	5.0	14
86.200333	11.84	40.00	28.16	1000.	120.000	175.0	V	157.0	14
130.44000	3.75	43.50	39.75	1000.	120.000	144.0	H	241.0	14
326.20566	13.89	46.00	32.11	1000.	120.000	322.0	H	23.0	22
744.24100	19.12	46.00	26.88	1000.	120.000	400.0	H	193.0	29

Test Notes: Fundamental will be ignored for this test (antenna port terminated).

2.7.12 Test Results for 30MHz to 1GHz High Channel

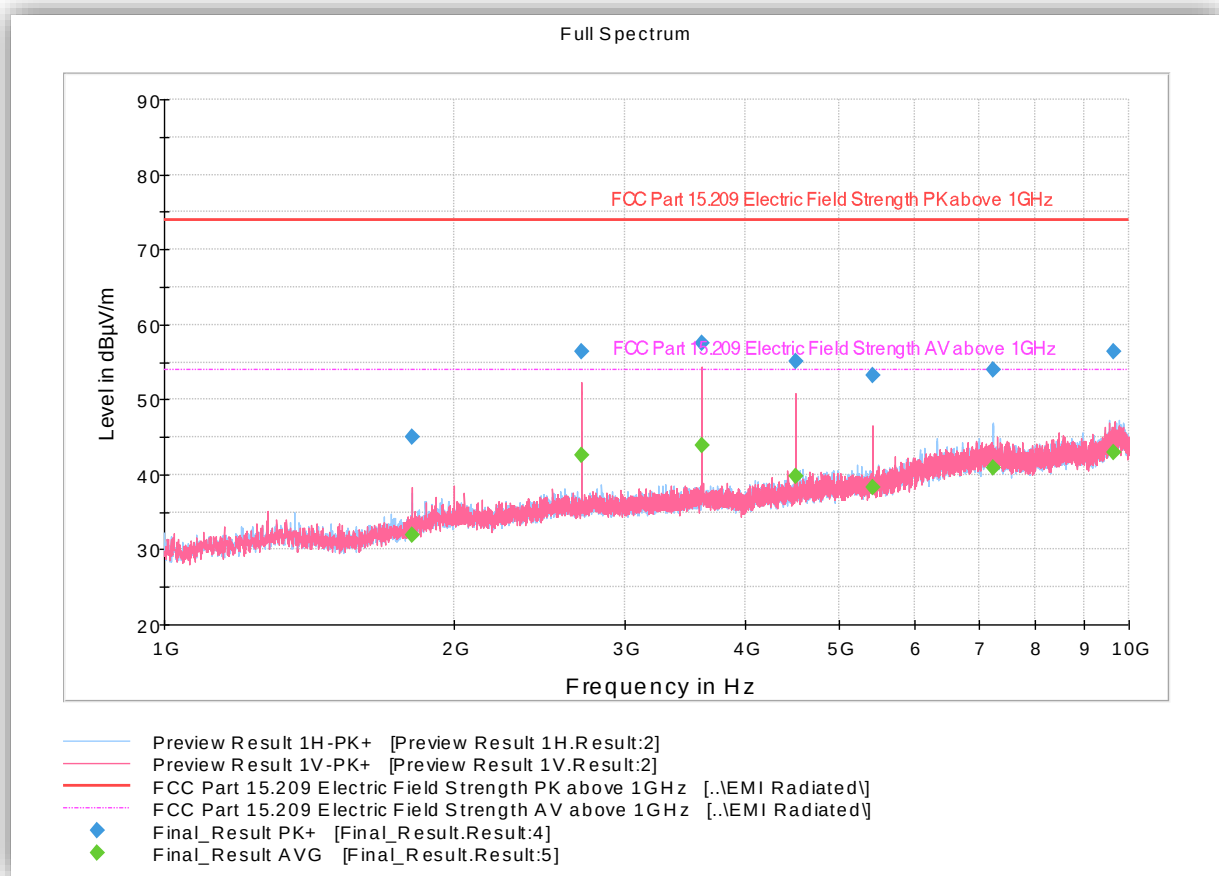


Quasi Peak Data

Frequency (MHz)	QuasiPeak (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
37.783667	18.29	40.00	21.71	1000.	120.000	100.0	V	167.0	18
56.995000	20.51	40.00	19.49	1000.	120.000	116.0	V	311.0	14
85.684667	16.39	40.00	23.61	1000.	120.000	110.0	V	189.0	14
143.48866	16.58	43.50	26.92	1000.	120.000	100.0	V	51.0	15
317.01266	13.23	46.00	32.77	1000.	120.000	400.0	V	330.0	21
727.86133	19.27	46.00	26.73	1000.	120.000	125.0	H	261.0	29
958.60666	21.39	46.00	24.61	1000.	120.000	392.0	H	25.0	31

Test Notes: Fundamental will be ignored for this test (antenna port terminated).

2.7.13 Test Results for 1GHz to 18GHz Low Channel



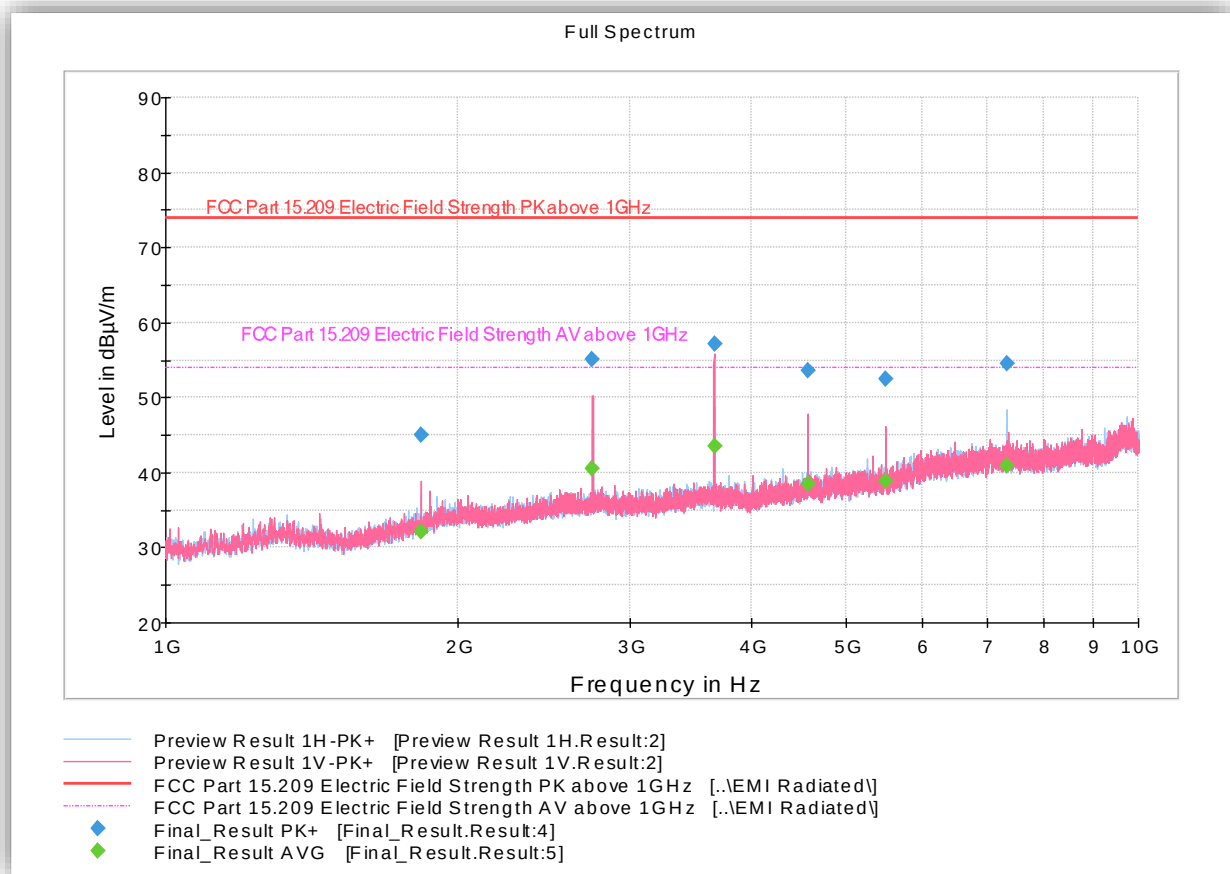
Peak Data

Frequency (MHz)	MaxPeak (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
1806.40000	45.01	73.90	28.89	1000.0	1000.000	139.0	V	320.0	2
2708.46666	56.42	73.90	17.48	1000.0	1000.000	123.0	V	294.0	5
3611.50000	57.56	73.90	16.34	1000.0	1000.000	218.0	V	320.0	6
4515.96666	55.06	73.90	18.84	1000.0	1000.000	120.0	V	312.0	7
5419.30000	53.28	73.90	20.62	1000.0	1000.000	255.0	V	301.0	8
7222.23333	54.01	73.90	19.89	1000.0	1000.000	365.0	H	154.0	11
9641.53333	56.33	73.90	17.57	1000.0	1000.000	285.0	V	19.0	13

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)
1806.40000	31.94	53.90	21.96	1000.0	1000.000	139.0	V	320.0	2
2708.46666	42.59	53.90	11.31	1000.0	1000.000	123.0	V	294.0	5
3611.50000	43.93	53.90	9.97	1000.0	1000.000	218.0	V	320.0	6
4515.96666	39.74	53.90	14.16	1000.0	1000.000	120.0	V	312.0	7
5419.30000	38.33	53.90	15.57	1000.0	1000.000	255.0	V	301.0	8
7222.23333	40.85	53.90	13.05	1000.0	1000.000	365.0	H	154.0	11
9641.53333	42.89	53.90	11.01	1000.0	1000.000	285.0	V	19.0	13

2.7.14 Test Results for 1GHz to 18GHz Middle Channel



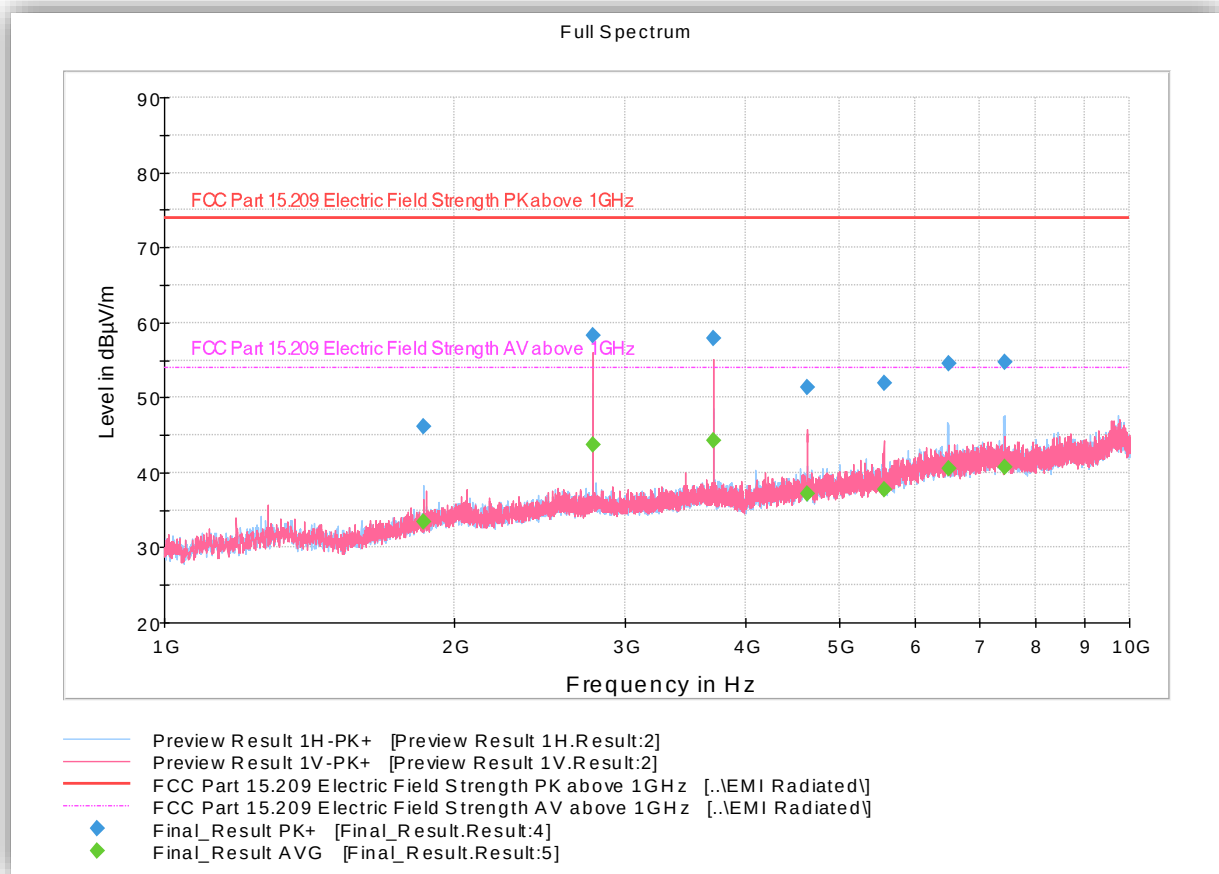
Peak Data

Frequency (MHz)	MaxPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
1832.06666	45.09	73.90	28.81	1000.0	1000.000	175.0	V	48.0	3
2747.40000	55.16	73.90	18.74	1000.0	1000.000	331.0	V	299.0	5
3664.33333	57.11	73.90	16.79	1000.0	1000.000	236.0	V	320.0	6
4579.43333	53.61	73.90	20.29	1000.0	1000.000	175.0	V	304.0	7
5496.06666	52.51	73.90	21.39	1000.0	1000.000	212.0	V	300.0	8
7329.76666	54.63	73.90	19.27	1000.0	1000.000	222.0	H	56.0	11

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)
1832.06666	32.17	53.90	21.73	1000.0	1000.000	175.0	V	48.0	3
2747.40000	40.62	53.90	13.28	1000.0	1000.000	331.0	V	299.0	5
3664.33333	43.48	53.90	10.42	1000.0	1000.000	236.0	V	320.0	6
4579.43333	38.48	53.90	15.42	1000.0	1000.000	175.0	V	304.0	7
5496.06666	38.92	53.90	14.98	1000.0	1000.000	212.0	V	300.0	8
7329.76666	40.83	53.90	13.07	1000.0	1000.000	222.0	H	56.0	11

2.7.15 Test Results for 1GHz to 18GHz High Channel



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)
1854.00000	46.12	73.90	27.78	1000.0	1000.000	251.0	H	138.0	3
2781.63333	58.21	73.90	15.69	1000.0	1000.000	236.0	V	272.0	5
3707.90000	57.91	73.90	15.99	1000.0	1000.000	335.0	V	328.0	6
4636.33333	51.28	73.90	22.62	1000.0	1000.000	255.0	V	309.0	7
5563.40000	51.92	73.90	21.98	1000.0	1000.000	255.0	V	304.0	8
6490.20000	54.53	73.90	19.37	1000.0	1000.000	335.0	H	148.0	10
7415.83333	54.73	73.90	19.17	1000.0	1000.000	175.0	H	270.0	11

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)
1854.00000	33.50	53.90	20.40	1000.0	1000.000	251.0	H	138.0	3
2781.63333	43.63	53.90	10.27	1000.0	1000.000	236.0	V	272.0	5
3707.90000	44.18	53.90	9.72	1000.0	1000.000	335.0	V	328.0	6
4636.33333	37.12	53.90	16.78	1000.0	1000.000	255.0	V	309.0	7
5563.40000	37.69	53.90	16.21	1000.0	1000.000	255.0	V	304.0	8
6490.20000	40.46	53.90	13.44	1000.0	1000.000	335.0	H	148.0	10
7415.83333	40.78	53.90	13.12	1000.0	1000.000	175.0	H	270.0	11



2.8 POWER SPECTRAL DENSITY

2.8.1 Specification Reference

FCC 47 CFR Part 15, Clause 15.247(e)
RSS-247, Clause 5.2(b)

2.8.2 Standard Applicable

For digitally modulated systems, the power spectral density conducted from the intentional radiator to the antenna shall not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission. This power spectral density shall be determined in accordance with the provisions of paragraph (b) of this section. The same method of determining the conducted output power shall be used to determine the power spectral density.

2.8.3 Equipment Under Test and Modification State

Serial No: D48AFCEDFCE4, D48AFCEDA2D8, D48AFCEDB5C4 / Default Test Configuration

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

July 08 and 10, 2024 / FSC

2.8.5 Test Equipment Used

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

2.8.6 Environmental Conditions (Rancho Bernardo Satellite Facility)

Ambient Temperature	24.1 °C
Relative Humidity	47.6 %
ATM Pressure	98.8 kPa

2.8.7 Additional Observations

- This is a conducted test using Method (for spreading factor 5) PKPSD per ANSI C63.10 Subclause 11.10.2.
- This is a conducted test using Method (for spreading factor 5) AVGPS-2 per ANSI C63.10 Subclause 11.10.5
- The path loss was all accounted for using a transducer factor.

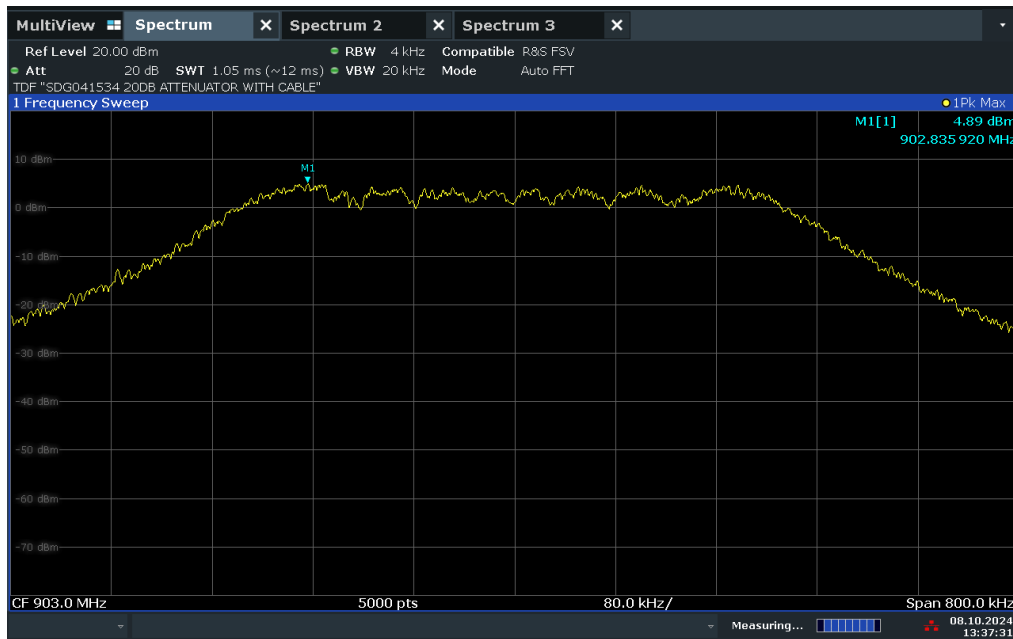


2.8.8 Test Results Summary

DUT Channel (MHz)	Modulation	PSD Frequency (MHz)	PSD (dBm)	Limit Max (dBm)	Result
903.00	SF5	902.835	4.89	8.0	Complies
916.00	SF5	916.102	4.19	8.0	Complies
927.00	SF5	927.004	1.55	8.0	Complies

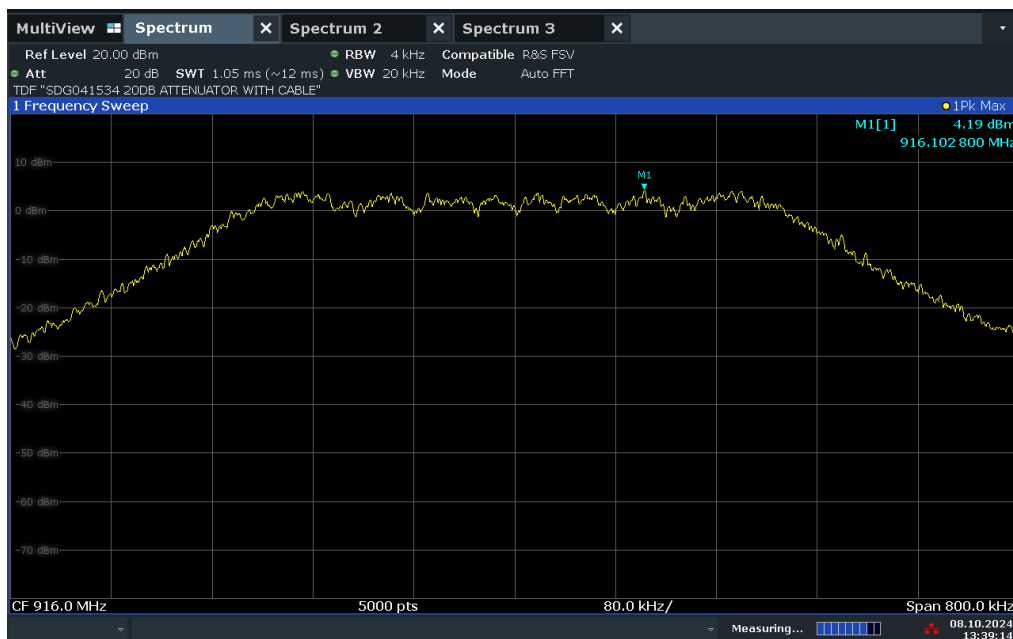
DUT Channel (MHz)	Modulation	PSD Frequency (MHz)	Duty Cycle Corrected PSD (dBm)	Limit Max (dBm)	Result
903.00	SF12	902.882	2.31	8.0	Complies
916.00	SF12	915.937	2.27	8.0	Complies
927.00	SF12	927.124	-3.67	8.0	Complies

2.8.9 Test Plots



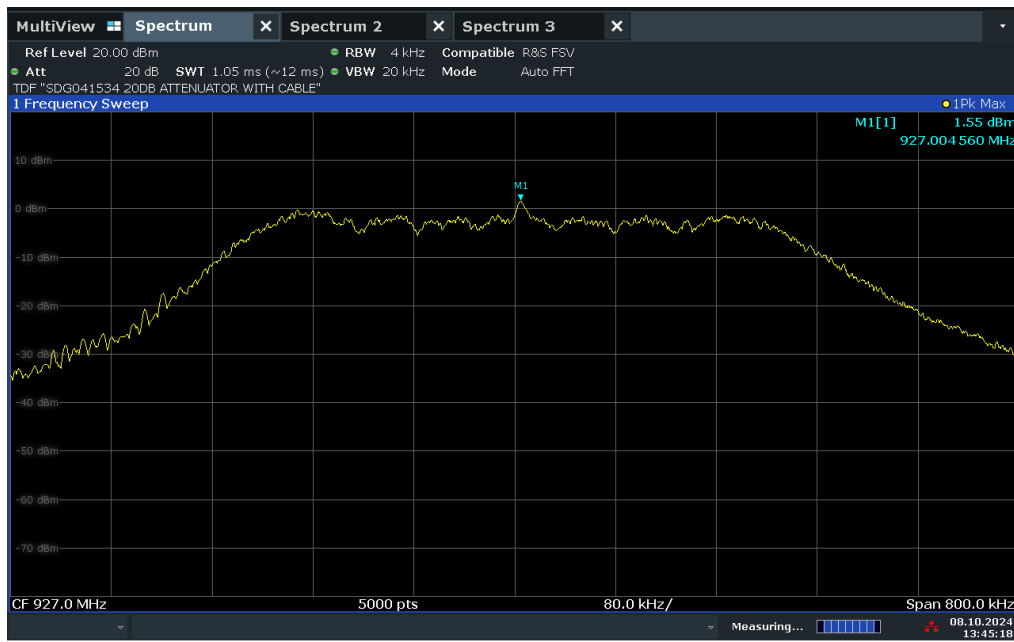
13:37:32 08.10.2024

LoRA SF5 Low Channel



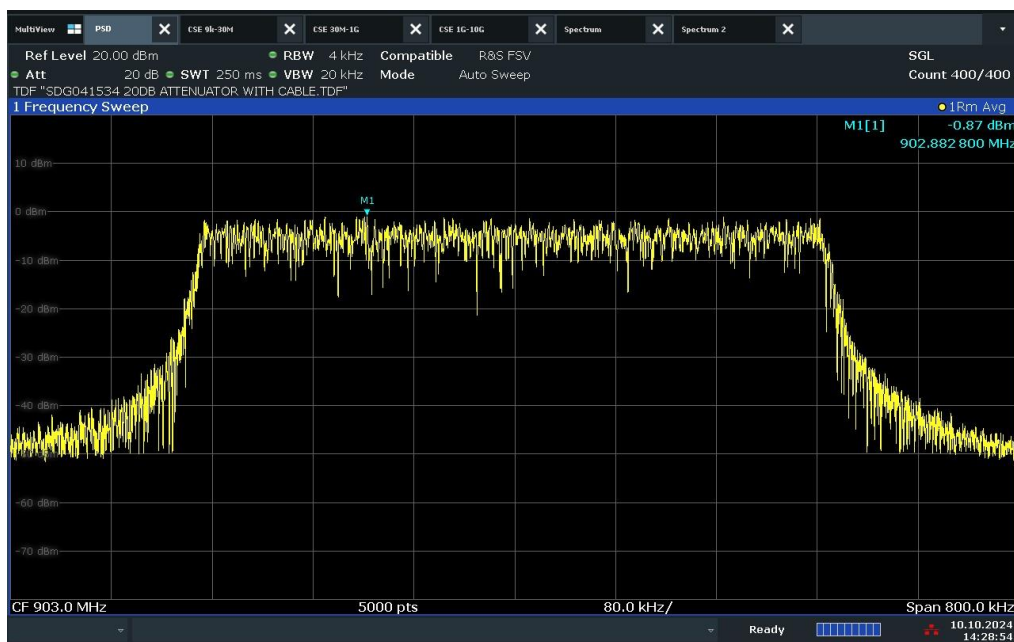
13:39:15 08.10.2024

LoRA SF5 Middle Channel



13:45:19 08.10.2024

LoRA SF5 High Channel



14:28:55 10.10.2024

LoRA SF12 Low Channel



14:37:53 10.10.2024

LoRA SF12 Middle Channel



14:44:59 10.10.2024

LoRA SF12 High Channel



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
Conducted Port Setup						
7582	Signal/Spectrum Analyzer	FSW26	101614	Rohde & Schwarz	01/25/24	01/25/25
41534	20 dB Attenuator + cable	ATX3518-20 + W17.03	N/A	Mini-Circuits	04/04/24	04/04/25
7605	Power Sensor	N1921A	MY51100054	Hewlett packard	04/05/24	04/05/25
7662	Power Meter	N1911A	MY45100951	Agilent	04/01/24	04/01/25
7607	Pulse Wireless Power Head	RPR3006W	14I0098SNO47	Dare	10/09/24	10/09/25
Radiated Emission						
SDGE68210	ESW44 EMI Test Receiver	ESW44 with HF Option	103416	Rhode & Schwarz	06/27/24	06/27/25
SDGE06628	Loop Antenna	HFH2-Z2335.4711.52	FNr.800.458/25	Rohde & Schwarz GmbH & Co KG	07/02/24	07/02/26
SDRB1033	BiConiLog Antenna	3142C	00044556	ETS Lindgren	10/16/23	10/16/25
SDGE08656	SR-5 RF Cable 9k-2GHz	8421F	M17/75-RG214	RF Precision Cables	09/03/24	09/03/25
SDGE07631	1-18 GHz Horn Antenna	3117	00205418	ETS Lindgren	01/05/23	01/05/25
SDGE46797	0.5 to 22GHz Preamplifier	PA-122	181925	Com Power	01/05/24	01/01/25
SDGE08878	SR-5 cable 1-18GHz	R90-088-240	16-02-401	Teledyne Microwave	09/03/24	09/03/25
SDGE07619	Temp, Humidity and Barometric Sensor	iBTHX-W	15050268	Omega Engineering	06/05/24	06/05/26
Miscellaneous						
30215	Barometer/Temperature/Humidity	iBTHX-W	15050268	Omega	06/05/24	06/05/25
43003	True RMS Multimeter	85 III	69880143	Fluke	10/09/24	10/09/25
-	Test Software	EMC32	v 11.50.0	Rohde & Schwarz	NCR	



3.2 MEASUREMENT UNCERTAINTY

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

3.2.1 AC Conducted Measurements

	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	LISN-receiver attenuation	0.10 dB	Normal, k=2	2.000	0.05	0.00
3	LISN voltage division factor	0.25 dB	Normal, k=2	2.000	0.13	0.02
4	Receiver sinewave accuracy	0.08 dB	Normal, k=2	2.000	0.04	0.00
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	0.00 dB	Rectangular	1.732	0.00	0.00
8	AMN VDF frequency interpolation	0.10 dB	Rectangular	1.732	0.06	0.00
9	Mismatch	0.07 dB	U-shaped	1.414	0.05	0.00
10	LISN impedance	2.65 dB	Triangular	2.449	1.08	1.17
11	Effect of mains disturbance	0.00 dB			0.00	0.00
12	Effect of the environment					
Combined standard uncertainty				Normal	1.65 dB	
Expanded uncertainty				Normal, k=2	3.29 dB	

3.2.2 Radiated Measurements (9kHz to 30MHz)

	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		

3.2.3 Radiated Measurements (30MHz to 1GHz)

	Input Quantity (Contribution) X_i	Value	Prob. Dist.	Divisor	$u_i(x)$	$u_i(x)^2$
1	Receiver reading	0.10 dB	Normal, k=1	1.000	0.10	0.01
2	Attenuation: antenna-receiver	0.20 dB	Normal, k=2	2.000	0.10	0.01
3	Antenna factor AF	0.58 dB	Normal, k=2	2.000	0.29	0.08
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	3.99 dB	Triangular	2.449	1.63	2.65
16	Separation distance at 3 m	0.30 dB	Rectangular	1.732	0.17	0.03
17	Effect of setup table material	0.57 dB	Rectangular	1.732	0.21	0.12
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	2.97 dB		
Expanded uncertainty			Normal, k=2	5.94 dB		

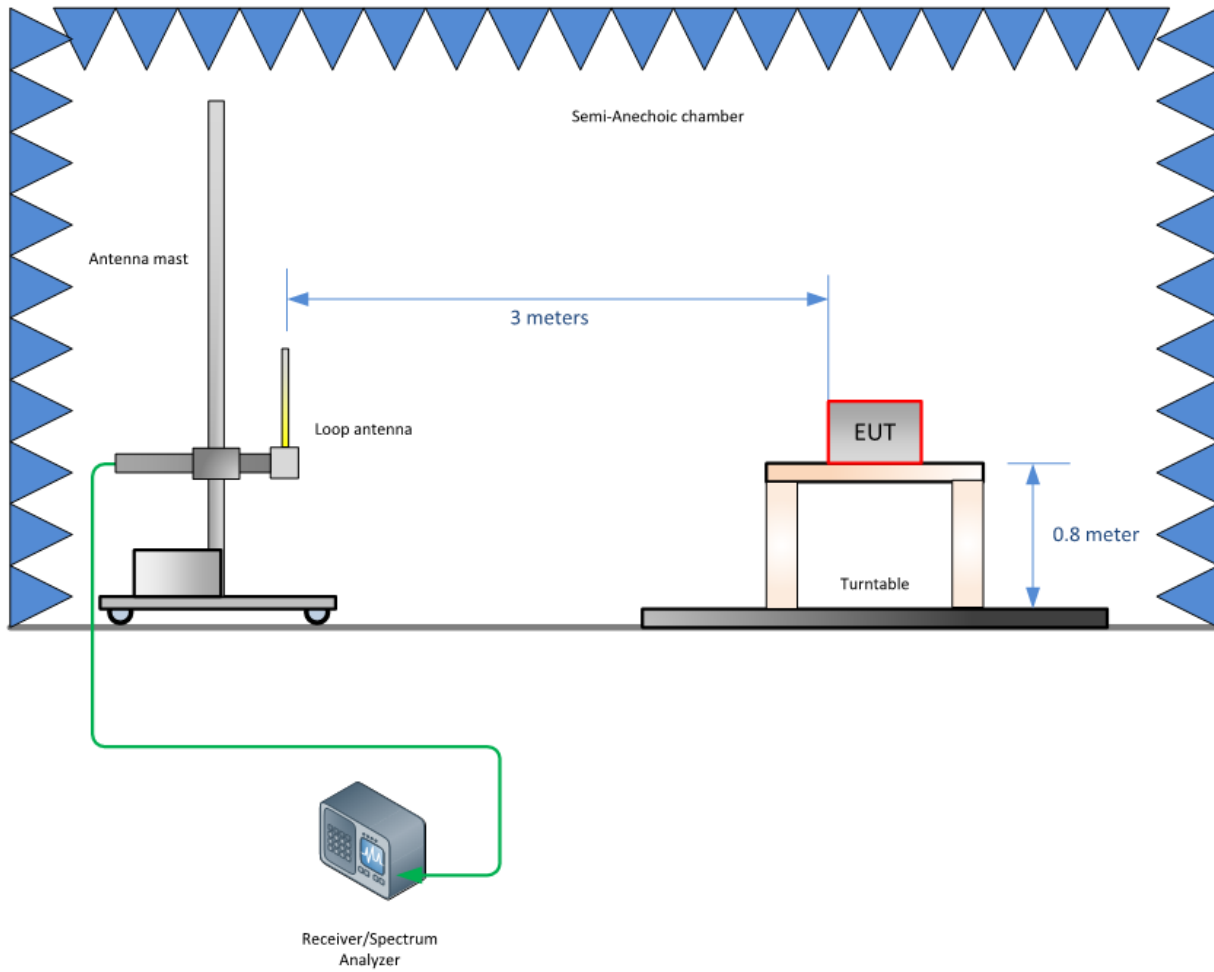
3.2.1 Radiated Emission Measurements (1GHz to 18GHz)

	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	0.20 dB	Normal, k=2	2.000	0.10	0.01
4	Antenna factor AF	0.47 dB	Normal, k=2	2.000	0.24	0.06
5	Sinewave accuracy	0.15 dB	Normal, k=2	2.000	0.08	0.01
6	Instability of preamp gain	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-preamplifier	1.41 dB	U-shaped	1.414	1.00	0.99
9	Mismatch: preamplifier-receiver	1.30 dB	U-shaped	1.414	0.92	0.85
10	AF frequency interpolation	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	Site imperfections VSWR (Method 2)	5.03 dB	Triangular	2.000	4.89	1.03
15	Effect of setup table material	1.57 dB	Rectangular	1.732	1.41	0.81
16	Separation distance at 3 m	0.30 dB	Rectangular	1.732	0.17	0.03
17	Table height at 3 m	0.00 dB	Normal, k=2	2.000	0.00	0.00
Combined standard uncertainty				Normal	2.35 dB	
Expanded uncertainty				Normal, k=2	4.71 dB	

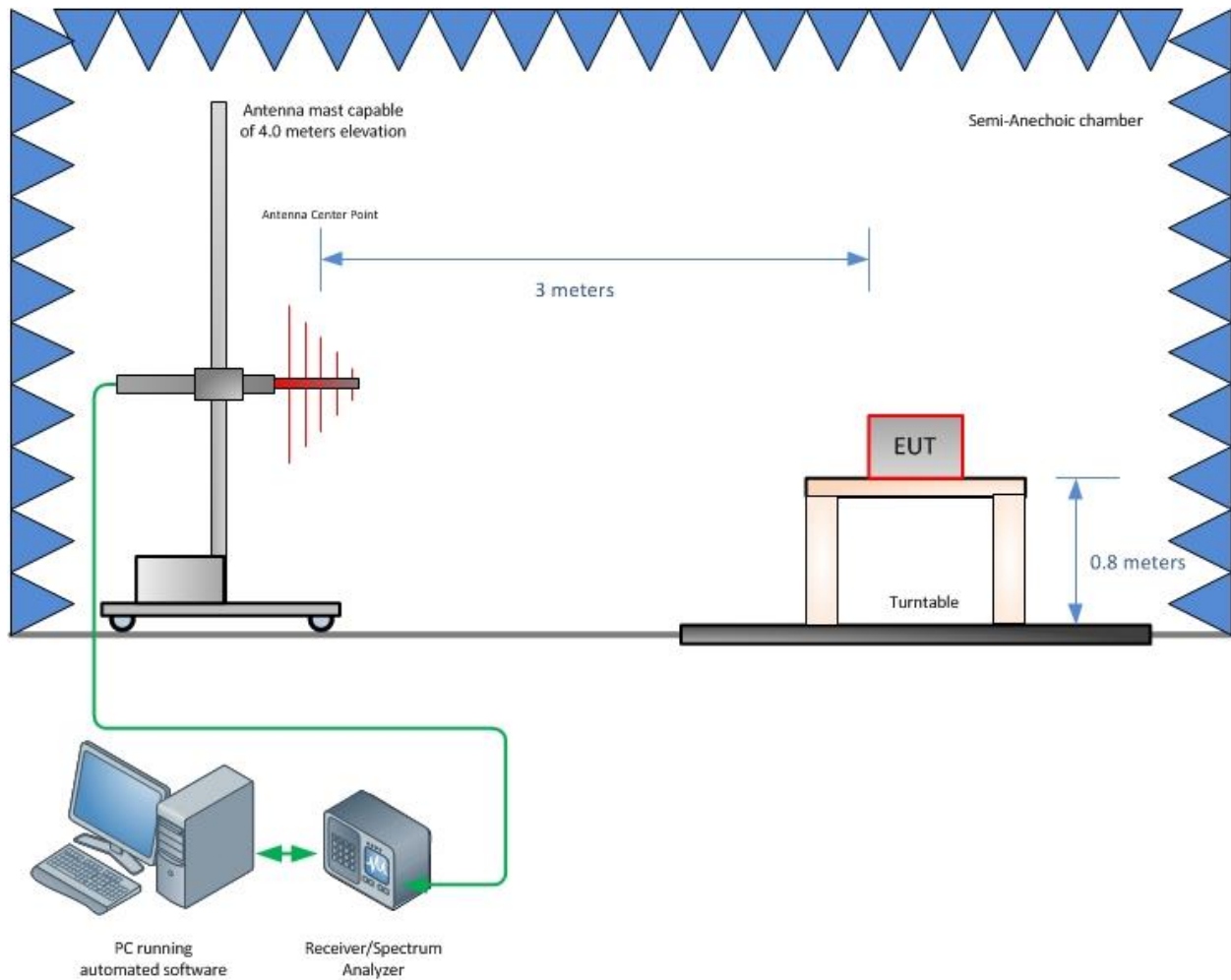


SECTION 4

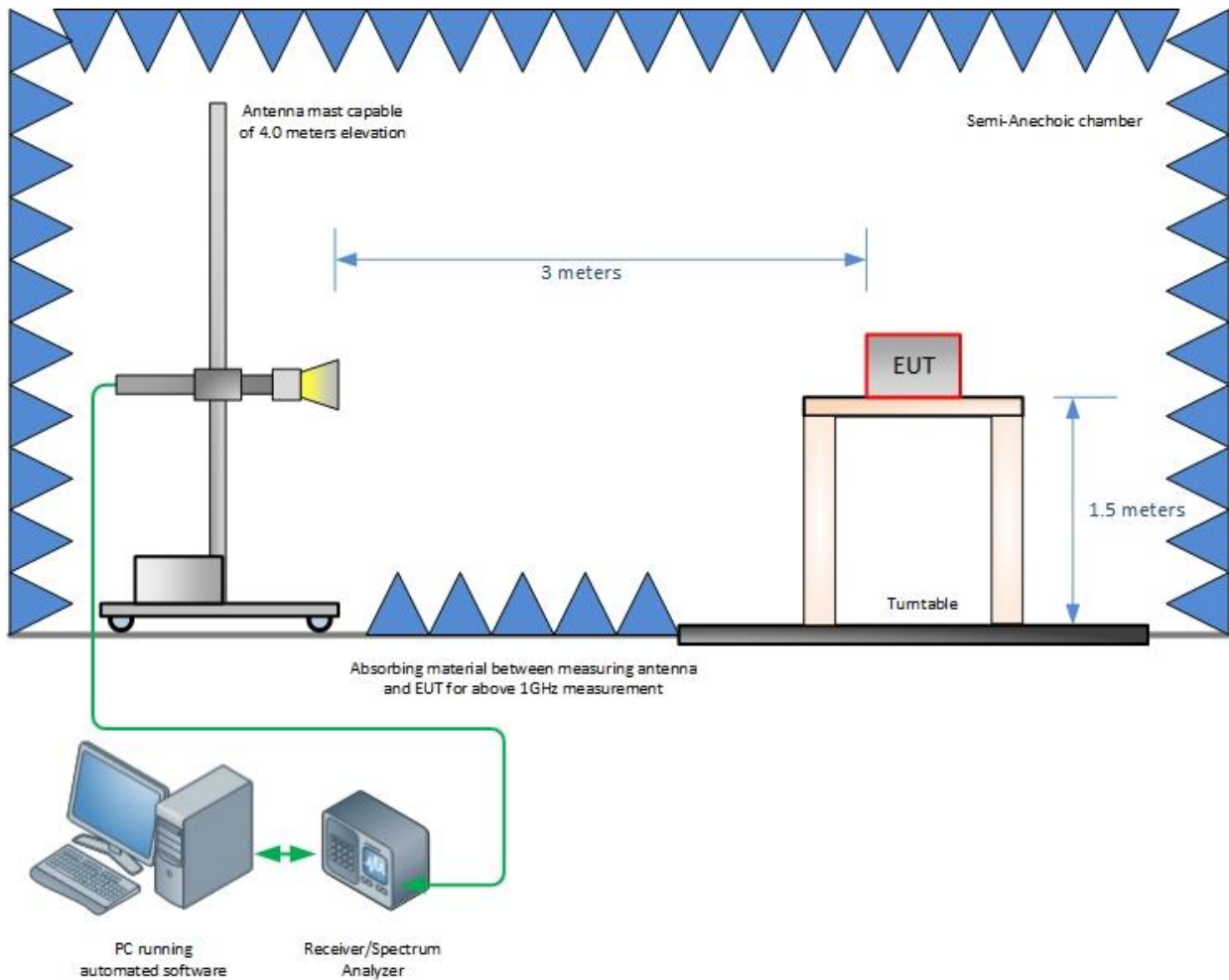
DIAGRAM OF TEST SETUP



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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