Radio Testing of the
ACR Electronics Inc.
2-Way Iridium Satellite Communicator
Model: Bivy Stick V3

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

America

Add value.
Inspire trust.

ACR Electronics Inc.
5757 Ravenswood Road
Fort Lauderdale, Florida 33312-6645 USA

COMMERCIAL-IN-CONFIDENCE

Date: September 2024
Document Number: 72185104H Issue 01 | Version Number: 01

RESPONSIBLE FOR	NAME	DATE	SIGNATURE
Authorized Signatory	Ivan Retana	September 23, 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.

A2LA Cert. No. 2955.13

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REPORT ON	Radio Testing of the ACR Electronics Inc. Model: Bivy Stick 2-Way Iridium Satellite Communicator
TEST REPORT NUMBER	72185104H
TEST REPORT DATE	September 2024
PREPARED FOR	ACR Electronics Inc. 5757 Ravenswood Road Fort Lauderdale, Florida 33312-6645 USA
CONTACT PERSON	Tony Rosen Product & Marketing Manager anthony.rosen@ACRArtex.com +1 (612) 281-2280
PREPARED BY	Ferdinand S. Custodio **Name** Authorized Signatory Title: Senior EMC Test Engineer / Wireless Team Lead
APPROVED BY	Ivan Retana **Name** Authorized Signatory Title: EMC Technical Lead
DATED	September 23, 2024

Revision History

72185104H ACR Electronics Inc. Model: Bivy Stick 2-Way Iridium Satellite Communicator					
DATE	OLD REVISION	NEW REVISION	REASON	PAGES AFFECTED	APPROVED BY
09/23/2024	—	Initial Release			Ivan Retana

CONTENTS

SECTION 1

REPORT SUMMARY

Radio Testing of the
ACR Electronics Inc.
Bivy Stick 2-Way Iridium Satellite Communicator

1.1 INTRODUCTION

The information contained in this report is intended to show verification of the Bivy Stick V3 2-Way Iridium Satellite Communicator 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	ACR Electronics Inc.
EUT	2-Way Iridium Satellite Communicator
Model Number(s)	V3
Model Name	Bivy Stick
FCC ID	B66-ACRBV3
ISED/IC Number	1322A-ACRBV3
FCC Classification	Low power Communications Device Transmitter (DTS)
Serial Number(s)	N/A
Number of Samples Tested	1
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	July 17, 2024
Finish of Test	July 23, 2024
Name of Engineer(s)	Ferdinand Custodio Omar Castillo
Related Document(s)	• ANSI C63.10-2013. American National Standard of Procedures for Compliance testing of Unlicensed Wireless Devices. • https://abracon.com/datasheets/ACAG0801-2450-T.pdf

- 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.
- TUV Instructions for Programming Bivy Stick.pdf
- Supporting documents for EUT certification are separate exhibits.

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	N/A	
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	

N/A Not applicable. EUT is battery powered.
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 ACR Electronics Inc. Bivy Stick V3 2-Way Iridium Satellite Communicator. The EUT is used to turn your cell phone into a satellite communication device.

1.3.2 EUT General Description

EUT Description	2-Way Iridium Satellite Communicator
Model Name	Bivy Stick
Model Number	V3
Rated Voltage	3.7 VDC Internal Battery
Mode Verified	LoRA (US 915MHz)
Capability	LoRA (US 915MHz) / (868.10MHz – 868.50MHz), BLE 5.0 (2400MHz to 2483MHz), GPSL1C/A, GLONASS L1OF, BDS B1I, Galileo E1-B/C
Primary Unit (EUT)	☐ Production ☒ Pre-Production ☐ Engineering (same as Production)
Manufacturer Declared Temperature Range	-20°C to 60°C
Antenna Type	ISM 868/915MHz Flexible Antenna with cable
Manufacturer	molex
Antenna Model	2111400100
Peak Antenna Gain	1.0 dBi (902 MHz)

1.3.3 Maximum Conducted Output Power

LoRa	Frequency Range (MHz)	RMS (dBm)	Duty Cycle (%)
LoRa Alliance®	902 – 928 MHz	12.6	91.6

1.4 EUT TEST CONFIGURATION

1.4.1 Test Configuration Description

Test Configuration	Description
Default	EUT in a test mode configuration. A conducted sample (temporary antenna port with SMA connector) is provided. A series of button presses switches the RF configuration of the EUT. The manufacturer provided a detailed instruction how to switch between two separate spreading factors (SF12 and SF7).

1.4.2 EUT Exercise Software

EUT flashed with a LoRA test firmware (zeSpreading Factorr0711-fccupdated 903-927.hex)

1.4.3 Support Equipment and I/O cables

Manufacturer	Equipment/Cable	Description
-	-	-

1.4.1 Simplified Test Configuration Diagram

Not applicable. EUT verified on a standalone configuration.

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
ACR Electronics Inc.
Bivy Stick V3 2-Way Iridium Satellite Communicator

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: N/A / Default Test Configuration

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

July 17, 2024 / FSC

2.1.5 Test Equipment Used

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

2.1.6 Environmental Conditions (Rancho Bernardo Satellite Facility)

Ambient Temperature	25.7 °C
Relative Humidity	52.3 %
ATM Pressure	99.9 kPa

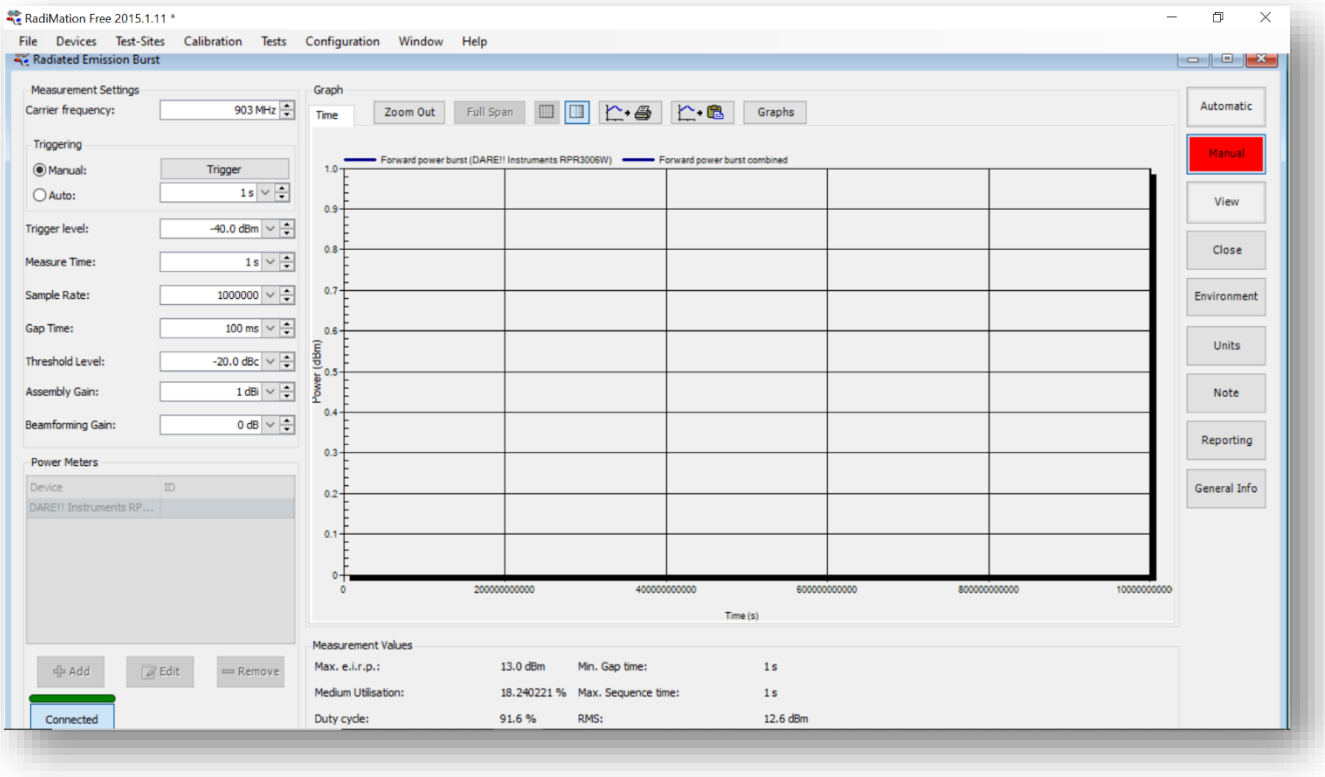
2.1.7 Additional Observations

- This is a conducted test using a Power Meter.
- Burst function of the Power Meter used for this test.

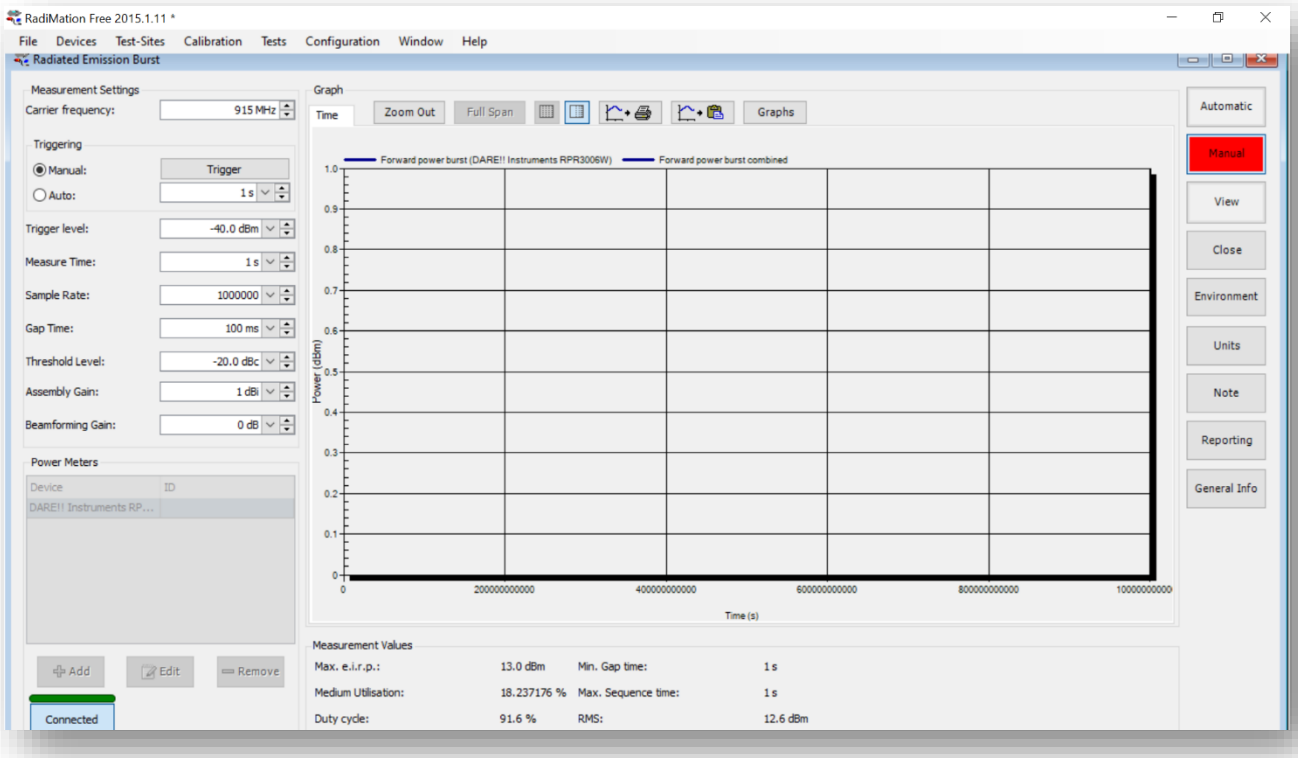
2.1.8 Test Results

DUT Frequency (MHz)	Spreading Factor	Peak (dBm)	RMS (dBm)	Limit Max (dBm)	DutyCycle (%)	Result
903.00	SF12	20.88	12.6	30.0	91.6	PASS
915.00	SF12	20.81	12.6		91.6	PASS
927.00	SF12	20.62	12.6		91.6	PASS
903.00	SF7	20.82	8.2		33.1	PASS
915.00	SF7	20.81	8.1		32.9	PASS
927.00	SF7	20.62	7.4		27.7	PASS

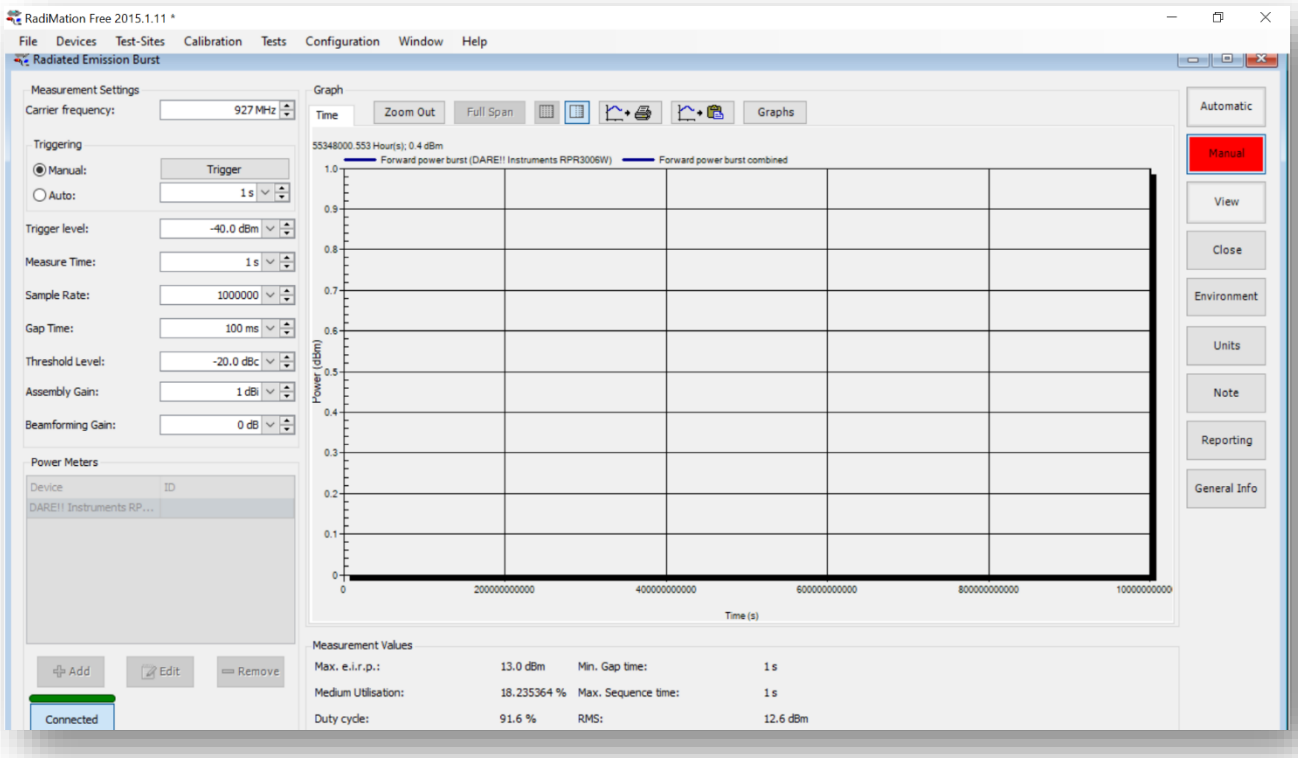
2.1.9 Test Plots (RMS)



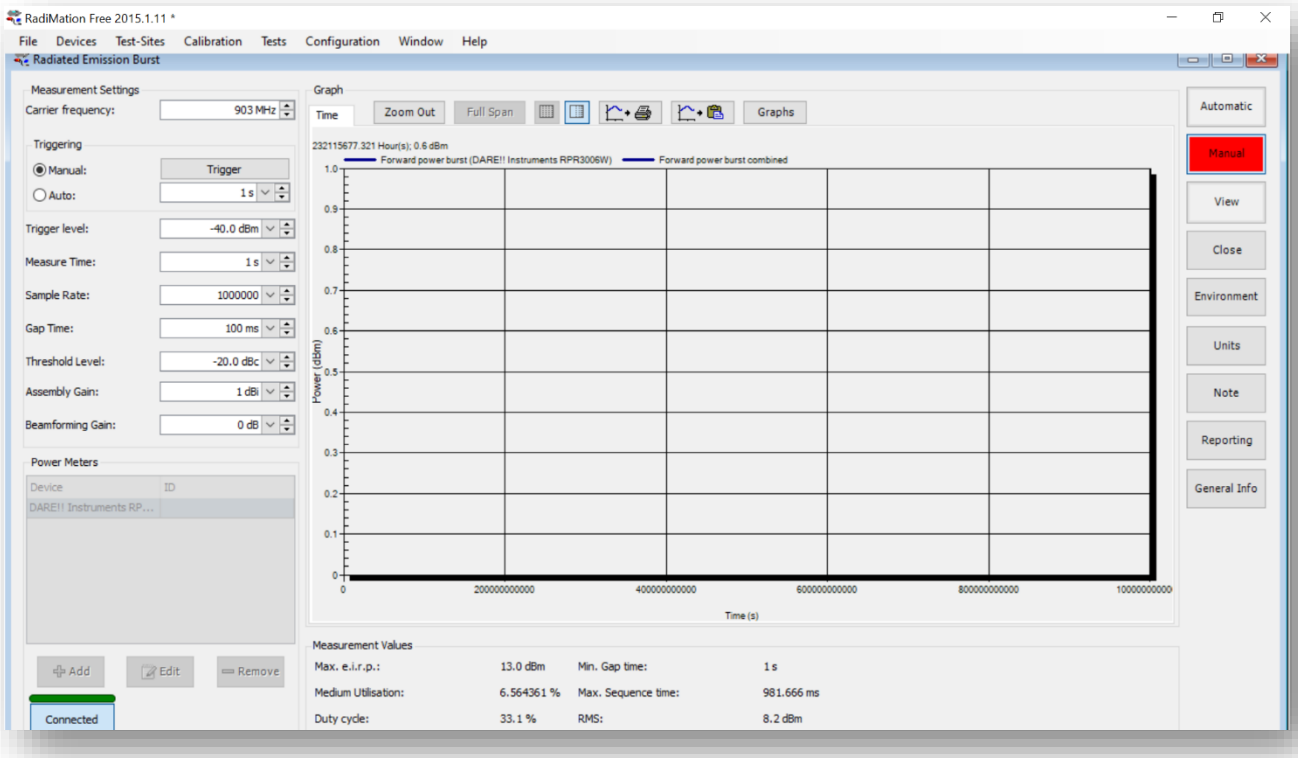
LoRA. SF12 Low Channel



LoRA. SF12 Mid Channel



LoRA. SF12 High Channel



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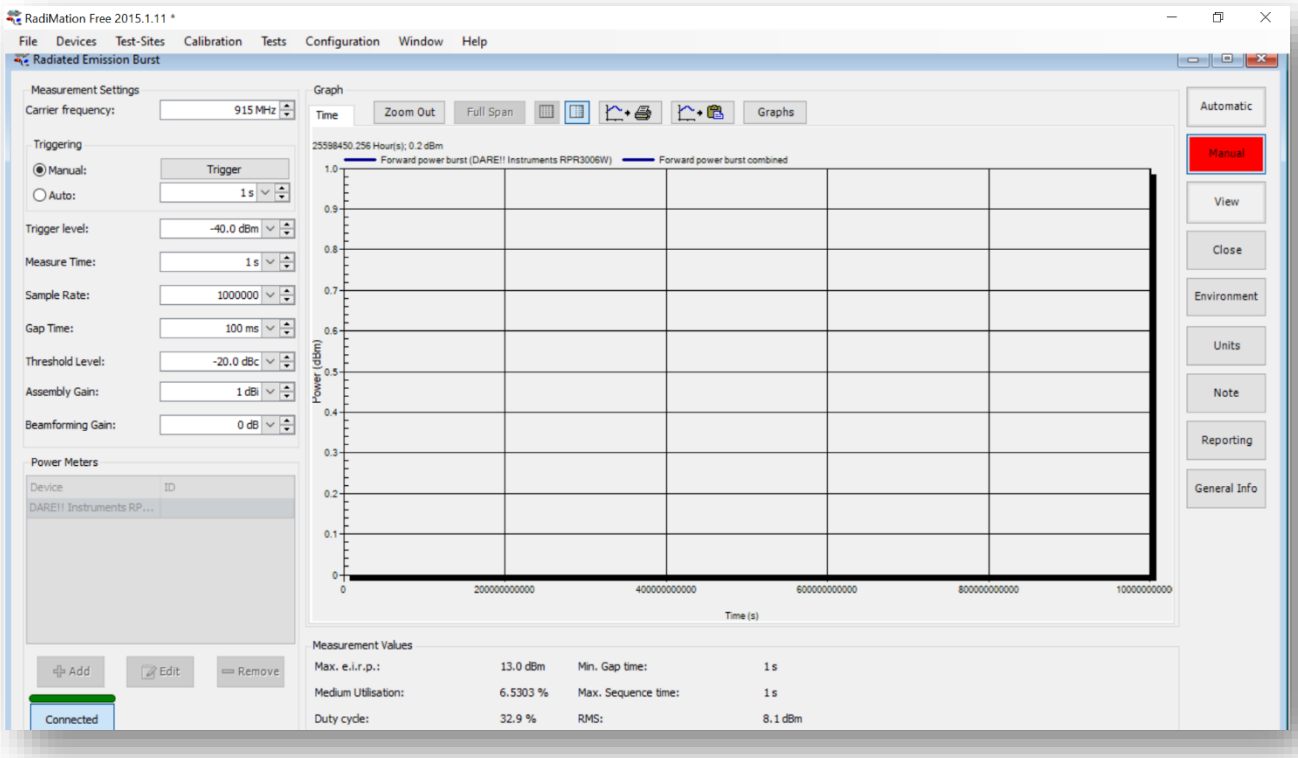

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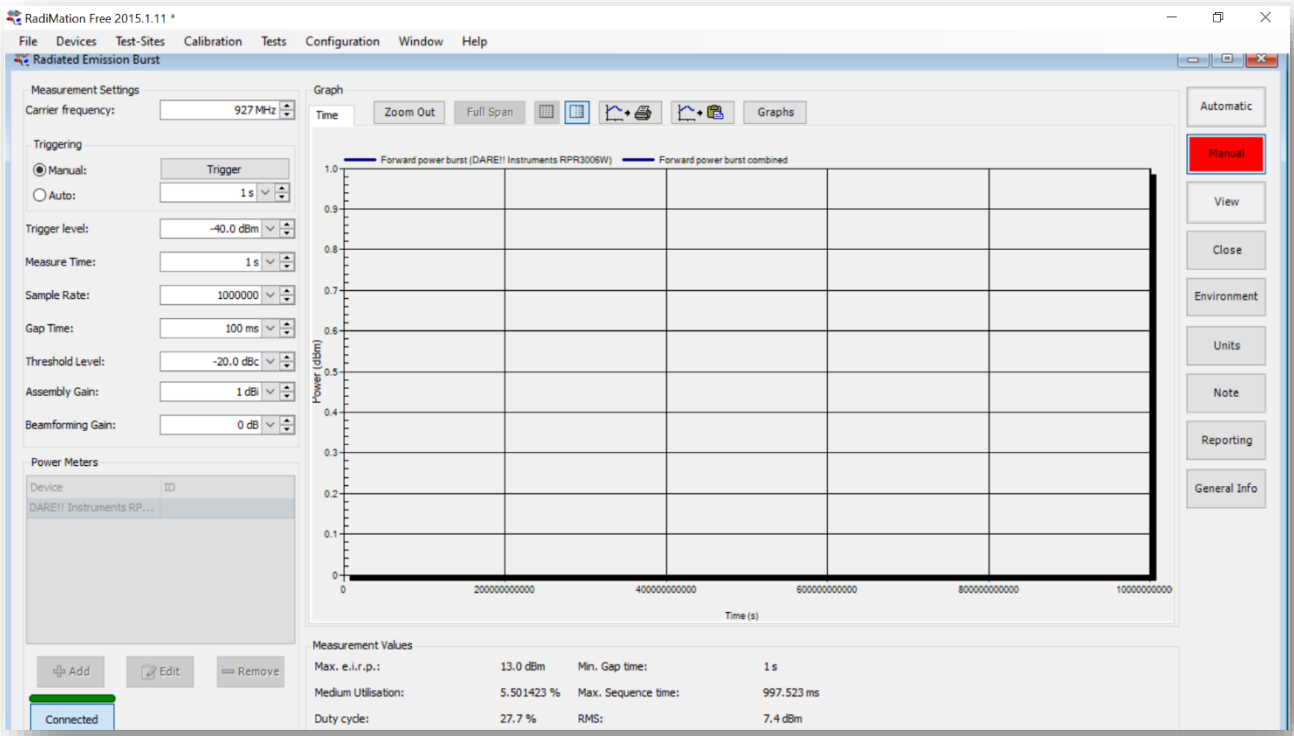
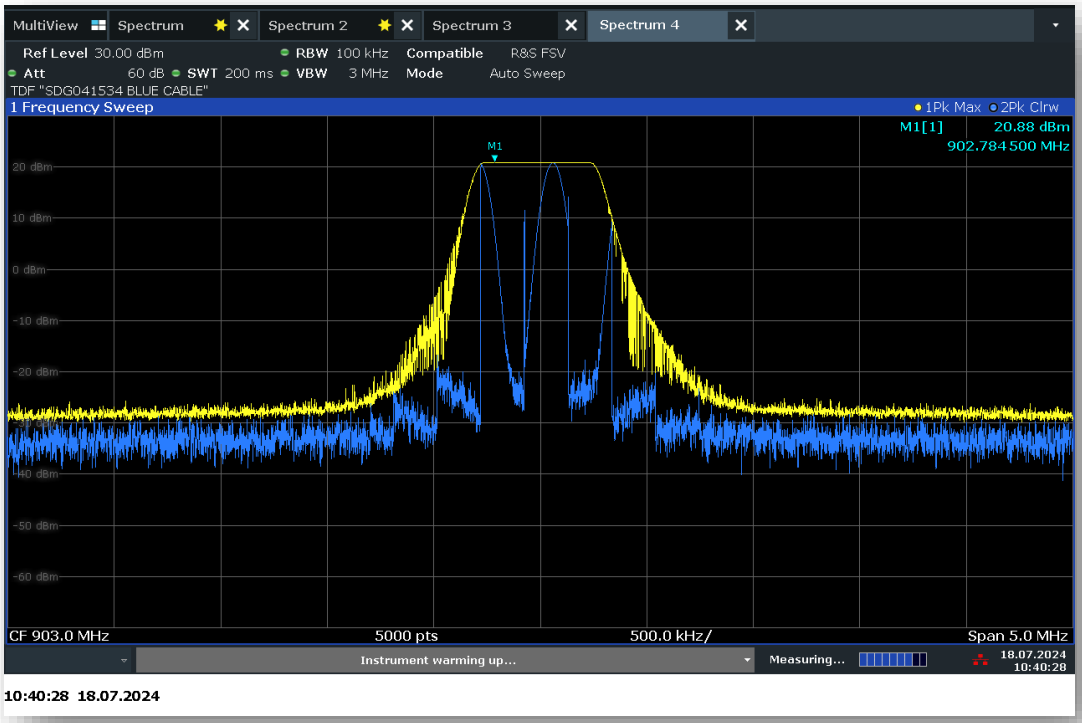


LoRA. SF7 High Channel

2.1.10 Power Meter Settings

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

2.1.11 Test Plots (Peak Detector)



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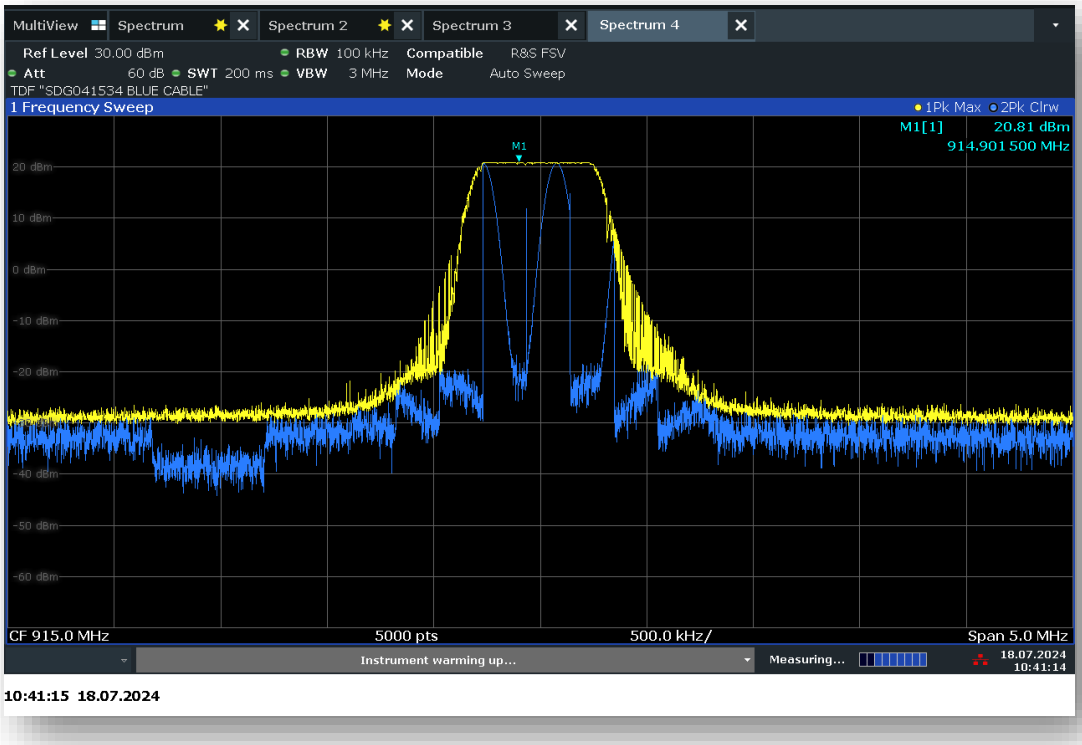

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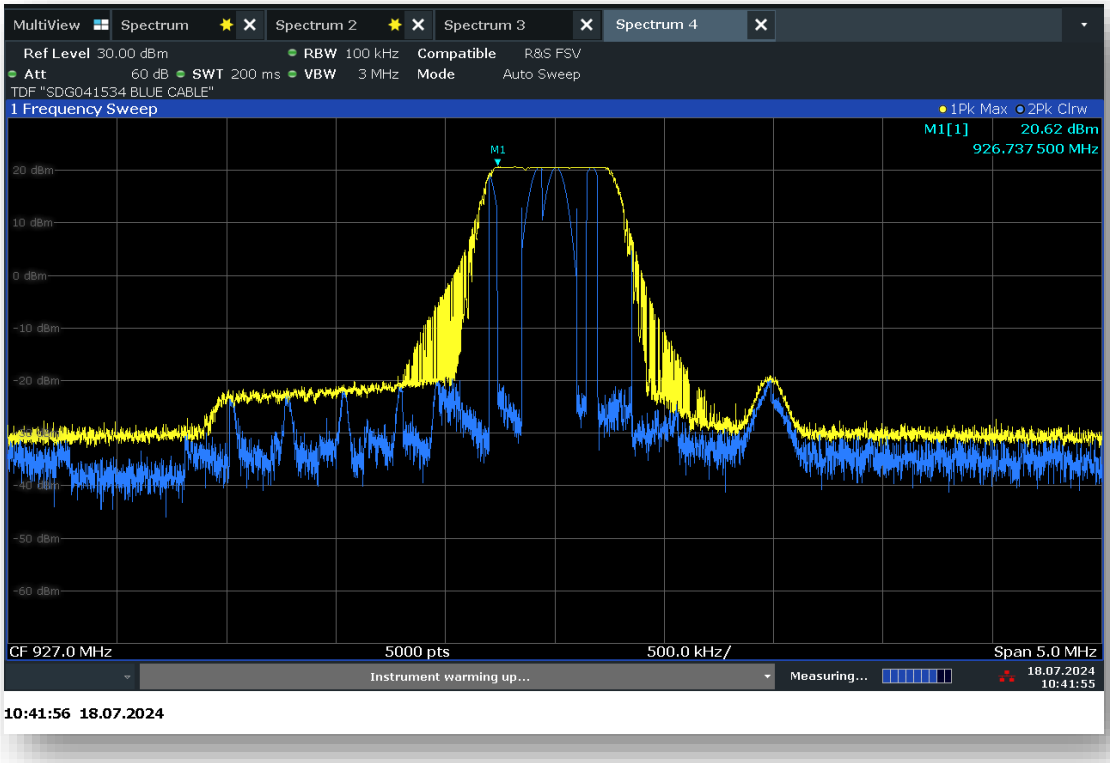

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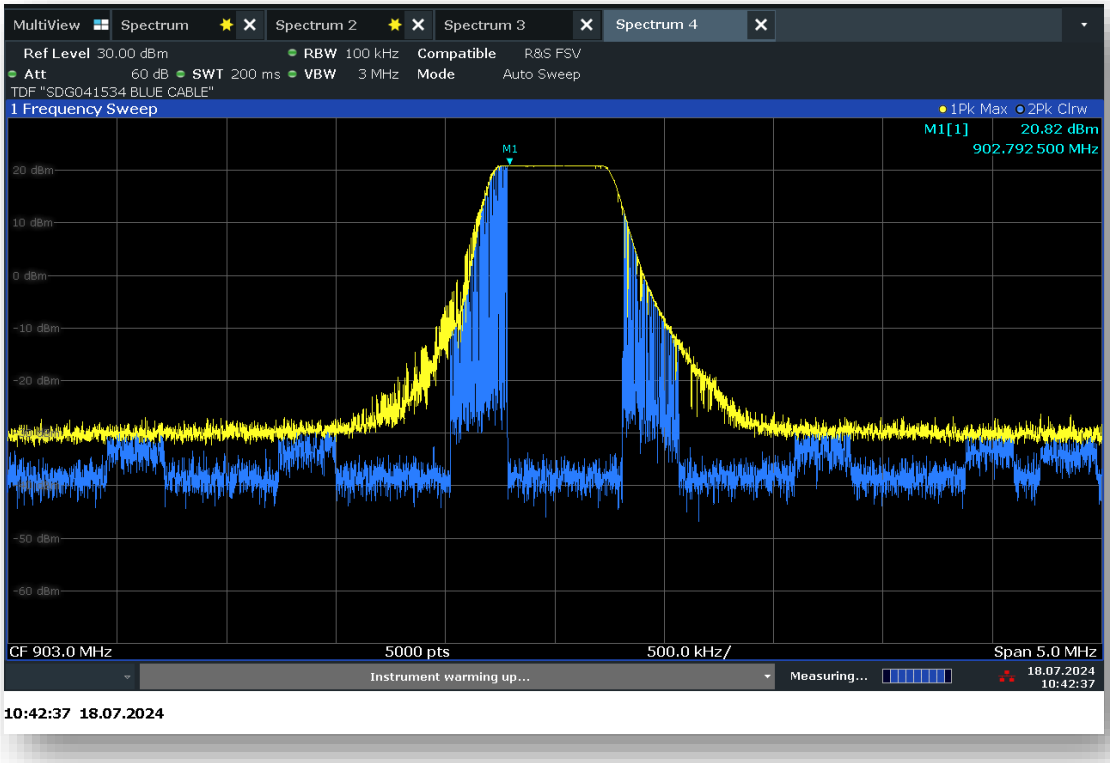

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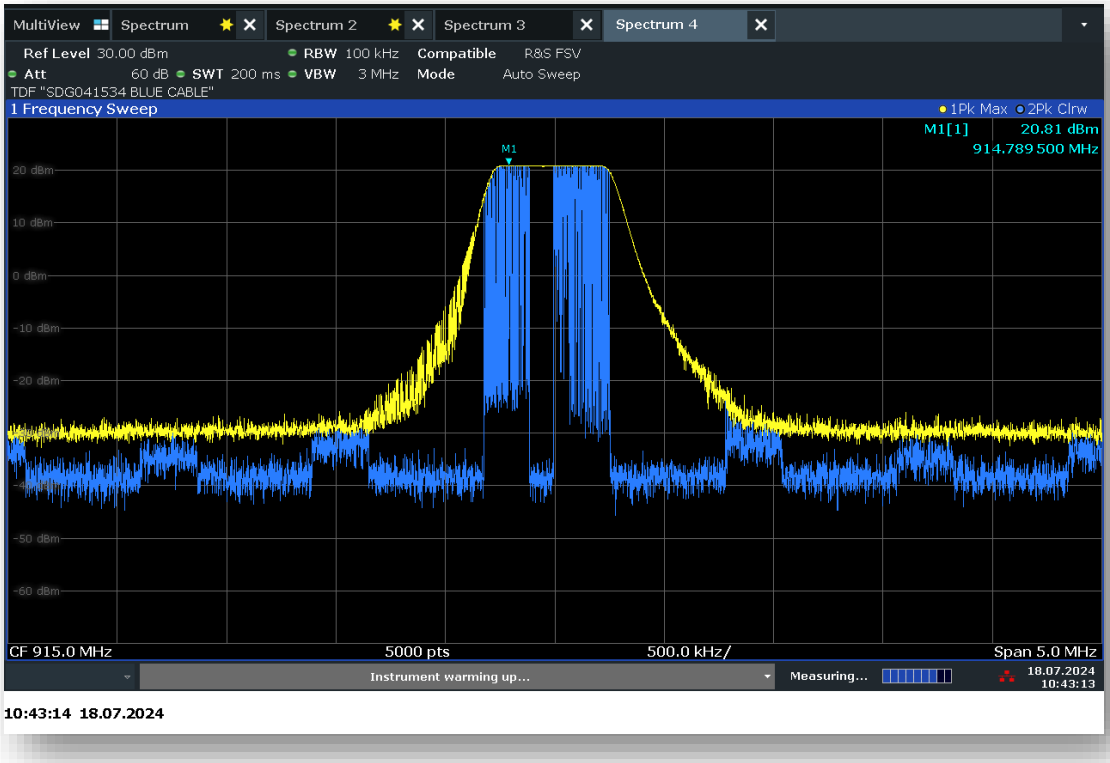

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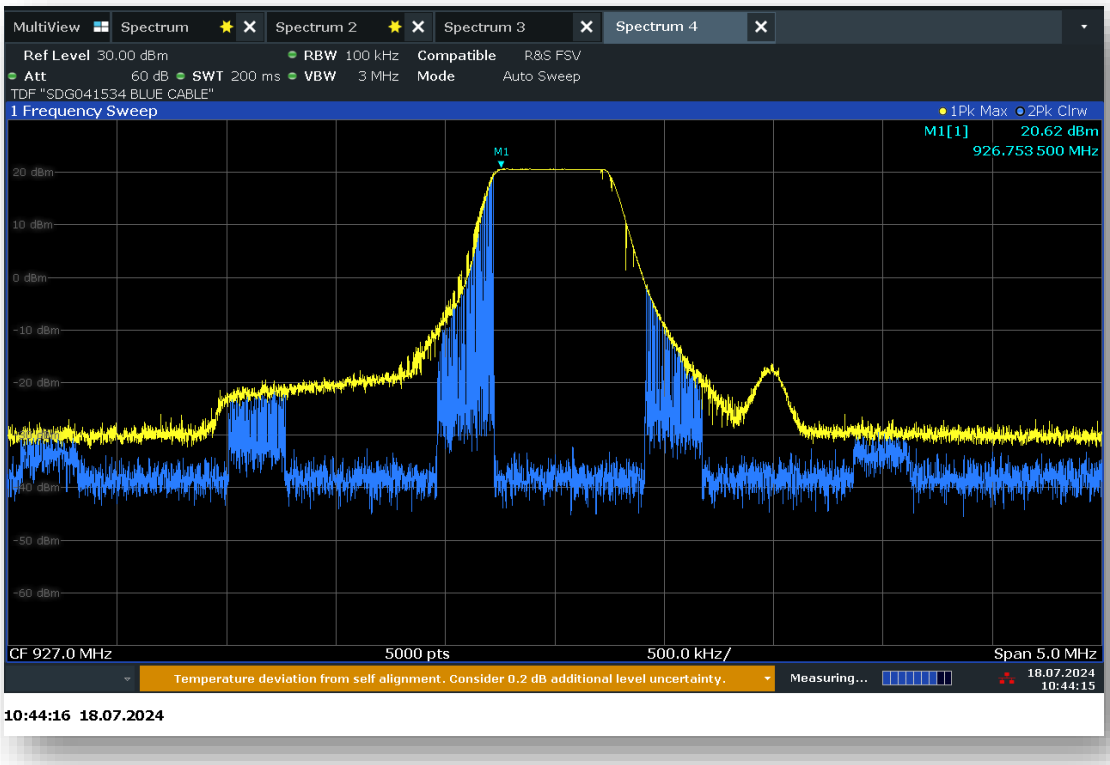


LoRA SF7 High Channel

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 µH/50 ohms line impedance stabilization network (LISN).

Frequency of emission (MHz)	Conducted limit (dBµV)	
	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

Not applicable. EUT is battery powered.

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: N/A / Default Test Configuration

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

July 19, 2024 / FSC

2.3.5 Test Equipment Used

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

2.3.6 Environmental Conditions (Rancho Bernardo Satellite Facility)

Ambient Temperature	25.5 °C
Relative Humidity	51.7 %
ATM Pressure	99.9 kPa

2.3.7 Additional Observations

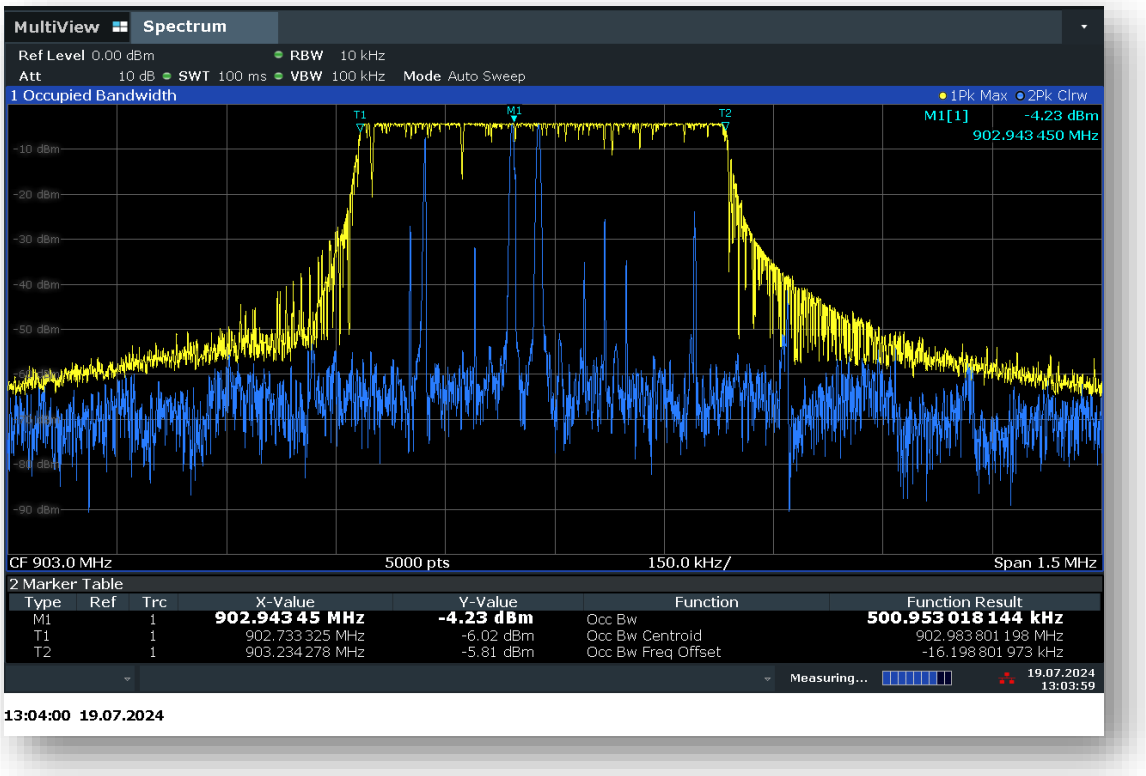
- This is a conducted test using direct connection to a spectrum analyzer.

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

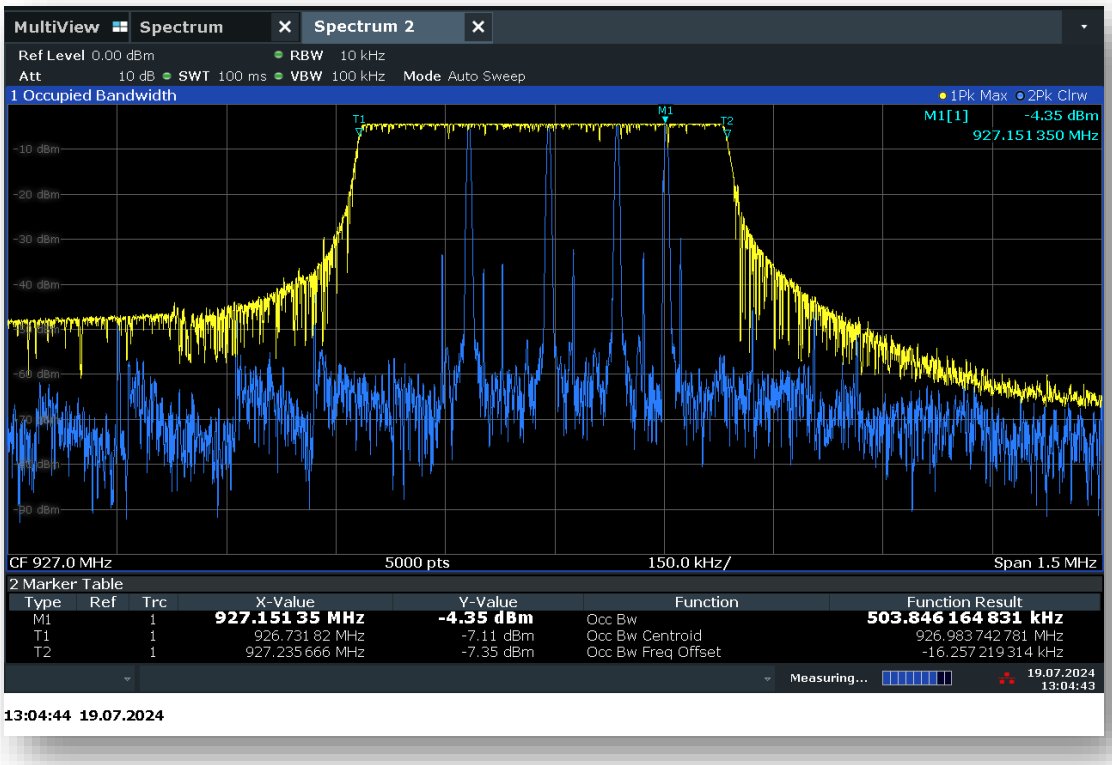
2.3.8 Test Results

DUT Frequency (MHz)	Spreading Factor	99% Bandwidth (kHz)	Band Edge Left (MHz)	Band Edge Right (MHz)	Result
903.00	SF12	500.95	***902.73***	903.23	PASS
927.00	SF12	503.85	926.73	***927.24***	PASS
903.00	SF7	507.32	***902.73***	903.23	PASS
927.00	SF7	504.65	926.73	***927.34***	PASS
Operating band is from 902MHz to 928MHz.					

2.3.9 Test Plots



LoRA SF12 Low Channel



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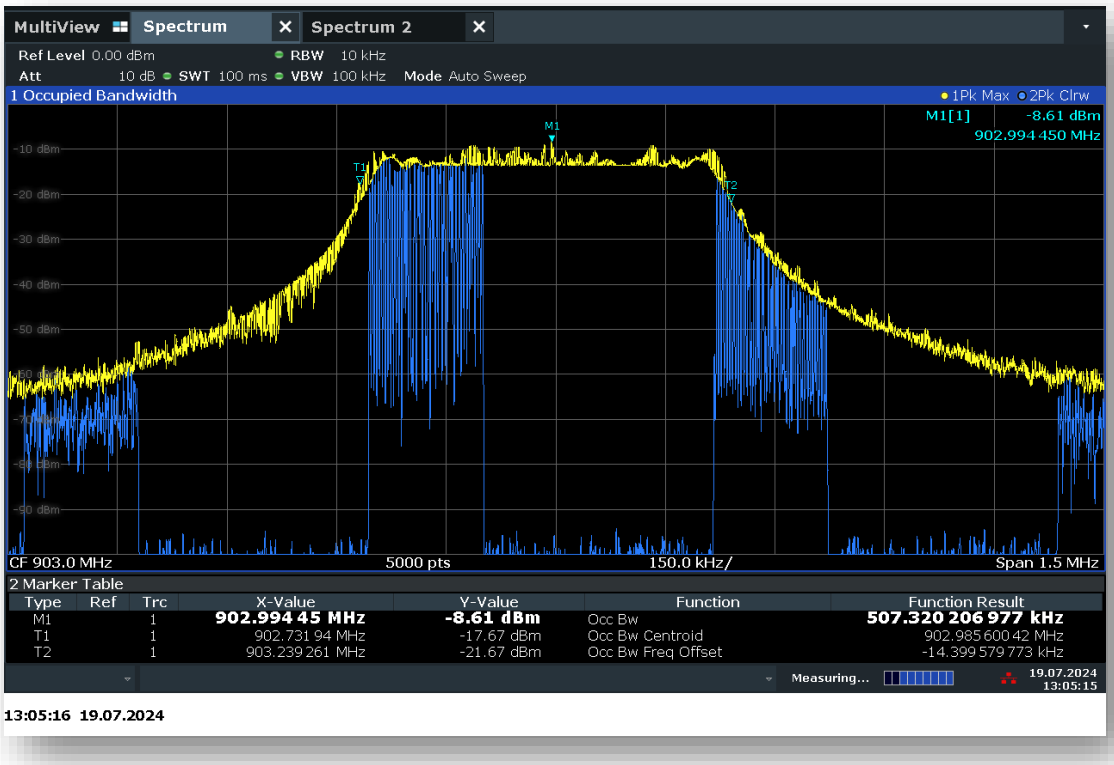
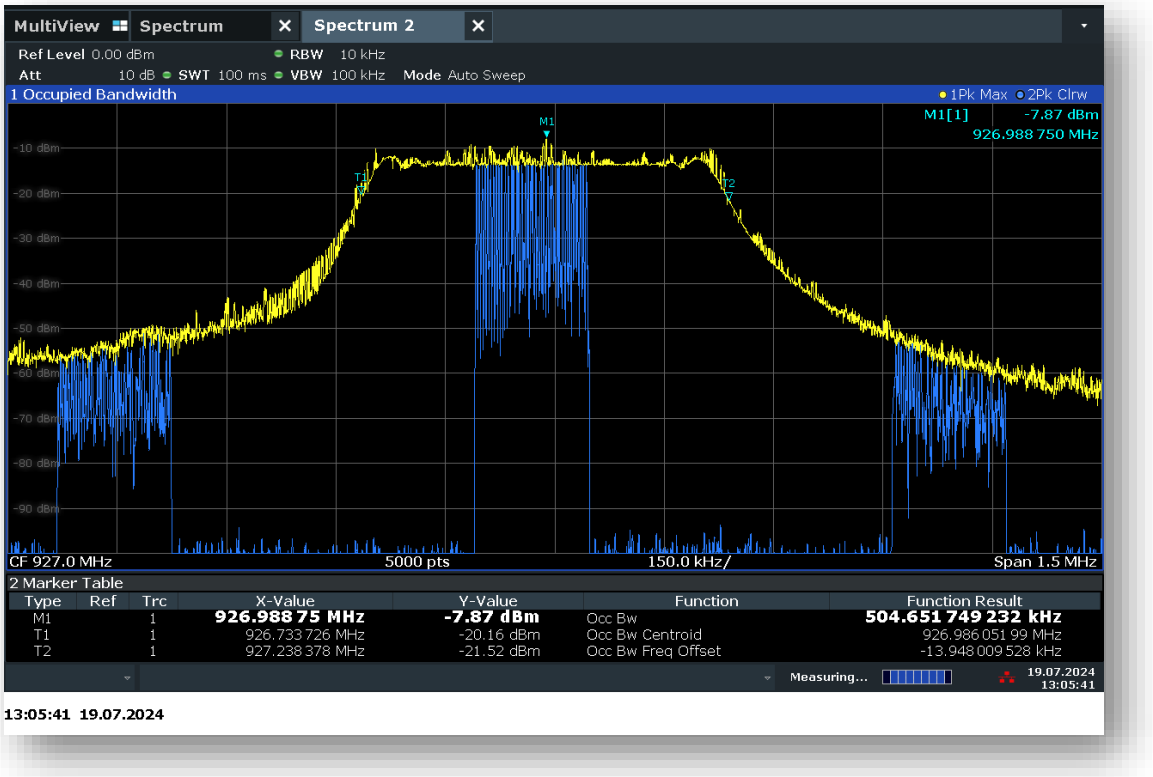


LoRA SF7 Low Channel



LoRA SF7 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: N/A / Default Test Configuration

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

July 19, 2024 / FSC

2.4.5 Test Equipment Used

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

2.4.6 Environmental Conditions (Rancho Bernardo Satellite Facility)

Ambient Temperature	25.5 °C
Relative Humidity	51.7 %
ATM Pressure	99.9 kPa

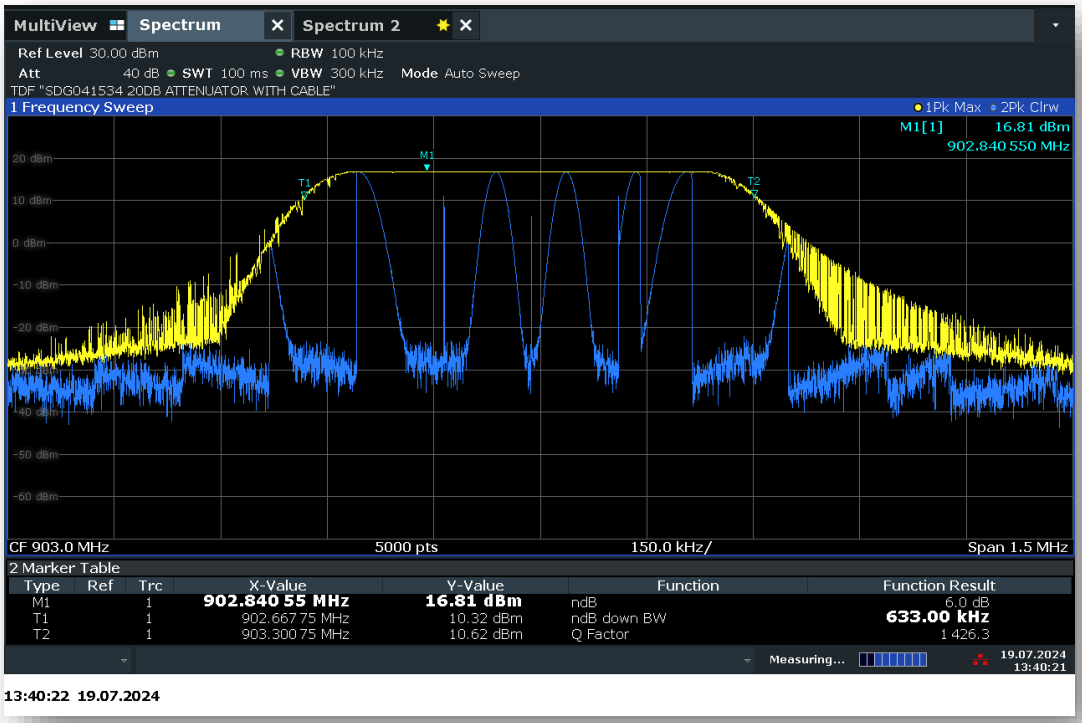
2.4.7 Additional Observations

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

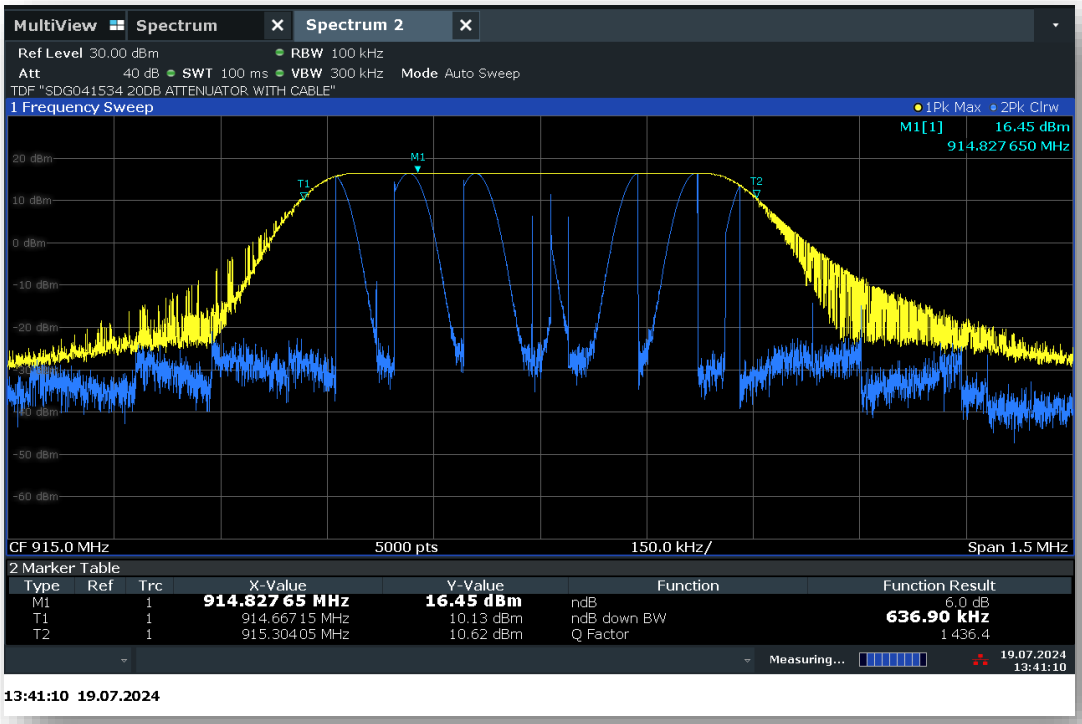
2.4.8 Test Results

DUT Frequency (MHz)	Spreading Factor	Limit Min (kHz)	6 dB Bandwidth (kHz)	Result
903.00	SF12	500	633.0	PASS
915.00	SF12		636.90	PASS
927.00	SF12		618.00	PASS
903.00	SF7		616.50	PASS
915.00	SF7		618.90	PASS
927.00	SF7		614.40	PASS

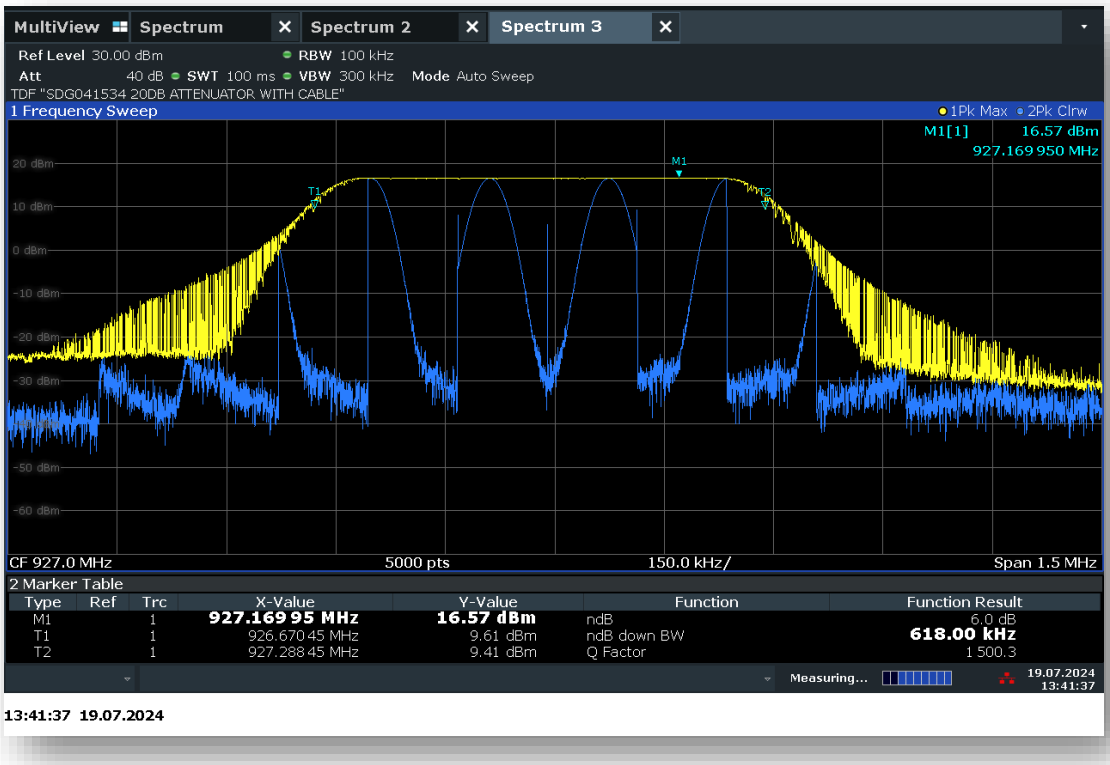
2.4.9 Test Plots



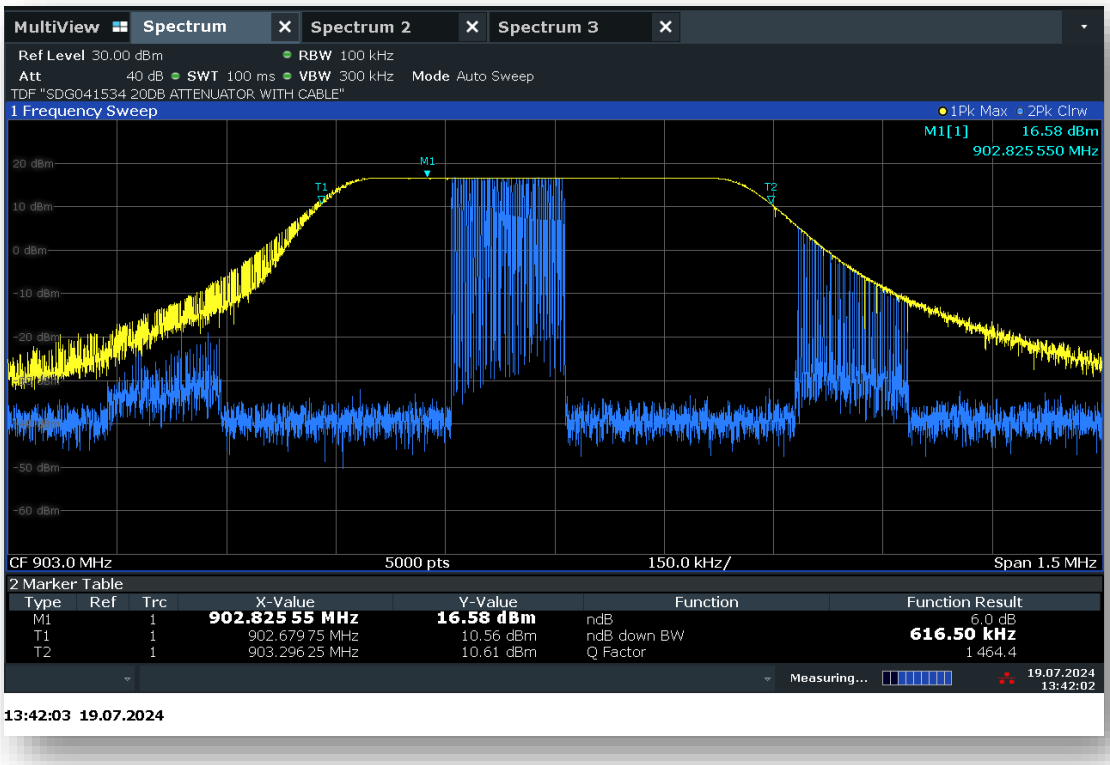
LoRA SF12 Low Channel



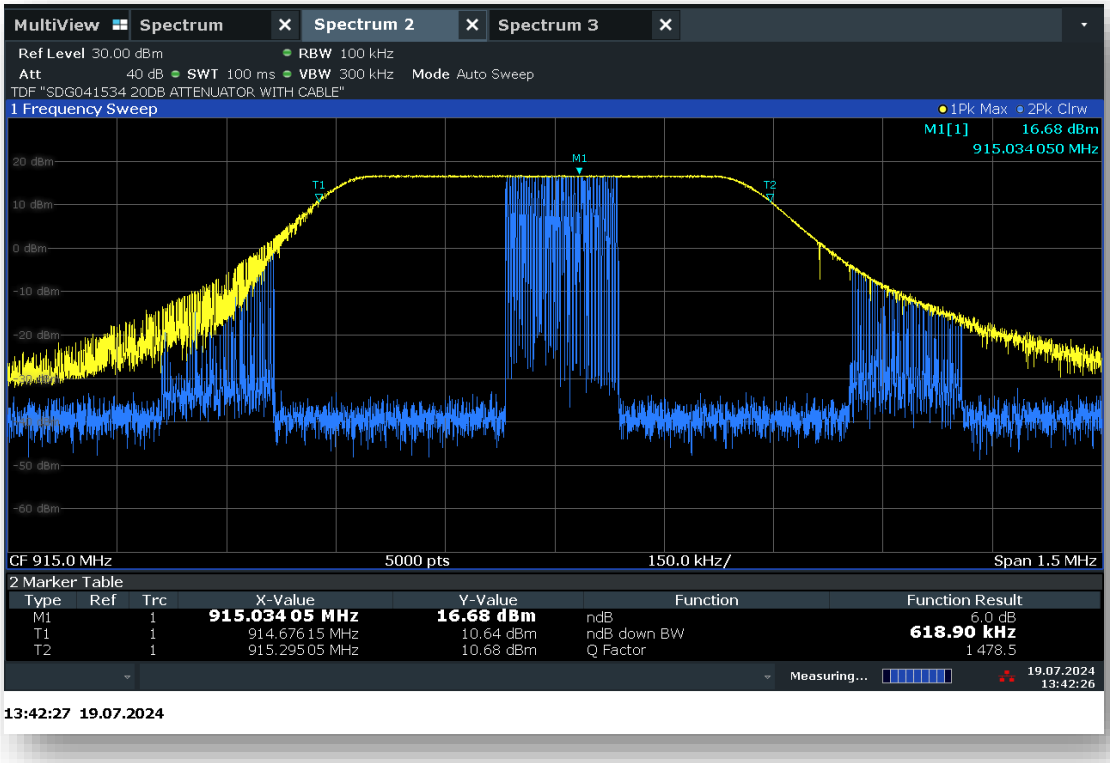
LoRA SF12 Middle Channel



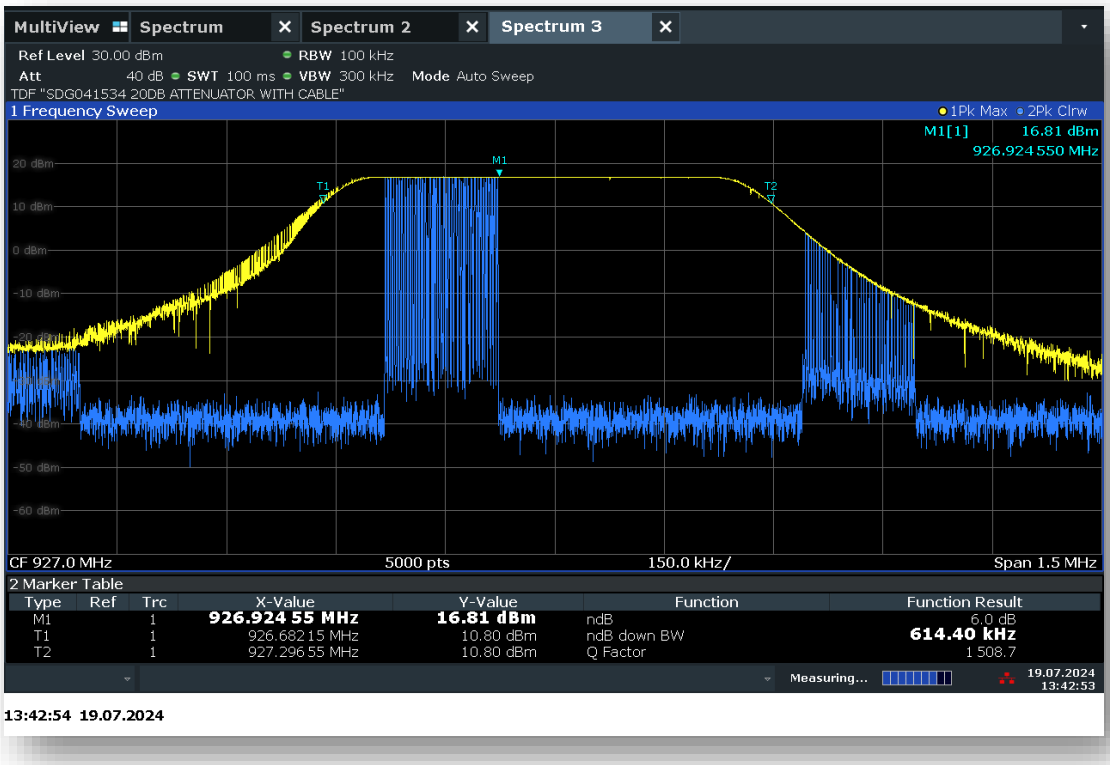
LoRA SF12 High Channel



LoRA SF7 Low Channel



LoRA SF7 Middle Channel



LoRA SF7 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: N/A / Default Test Configuration

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

July 18, 2024 / FSC

2.5.5 Test Equipment Used

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

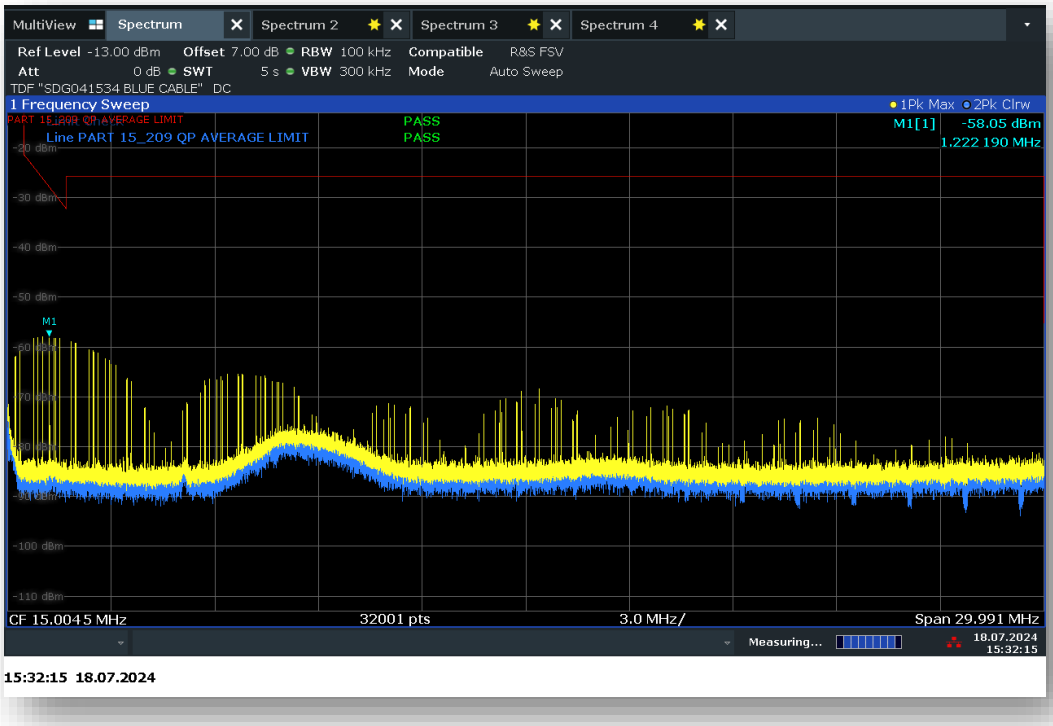
2.5.6 Environmental Conditions (Rancho Bernardo Satellite Facility)

Ambient Temperature	23.7 °C
Relative Humidity	48.2 %
ATM Pressure	99.9 kPa

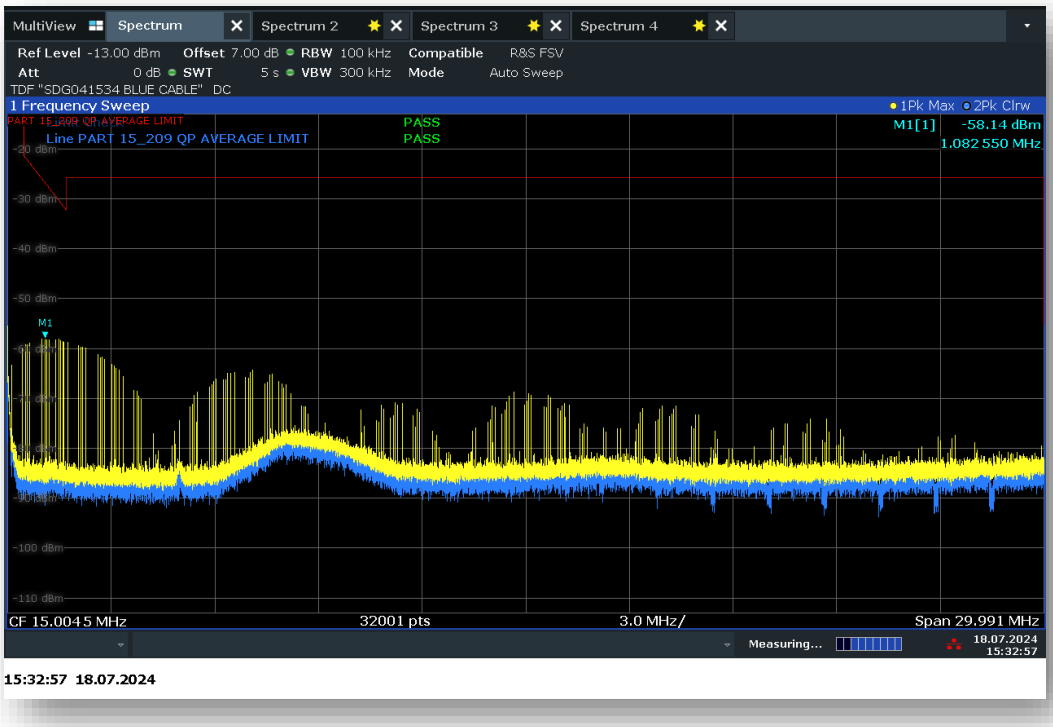
2.5.7 Additional Observations

- 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.

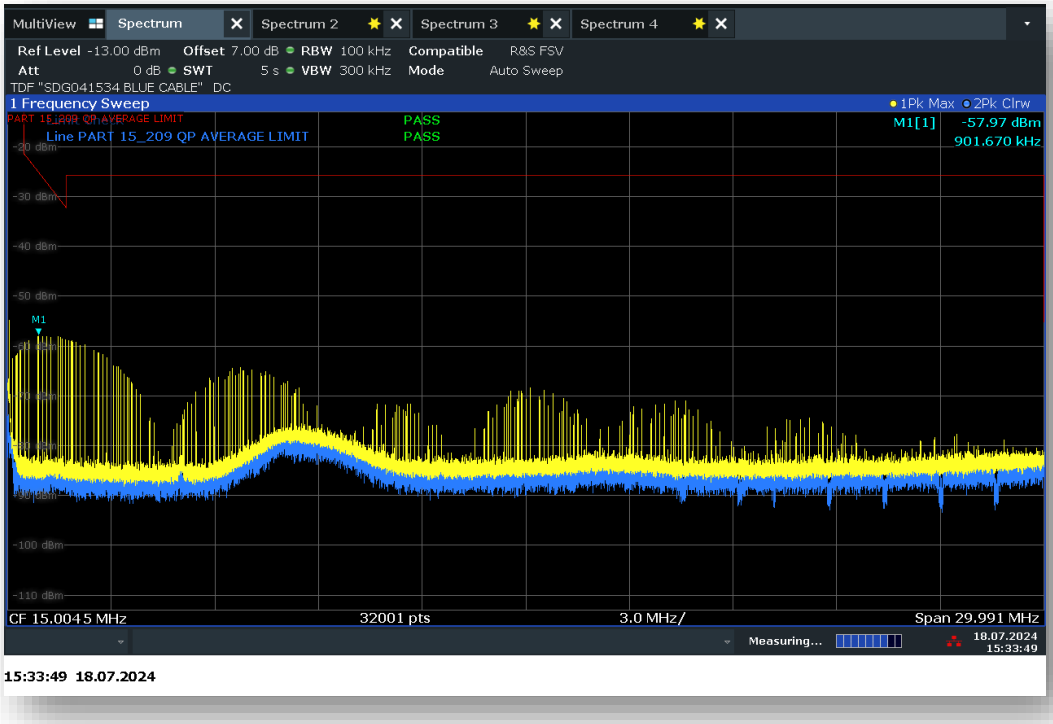
2.5.8 Test Results SF12



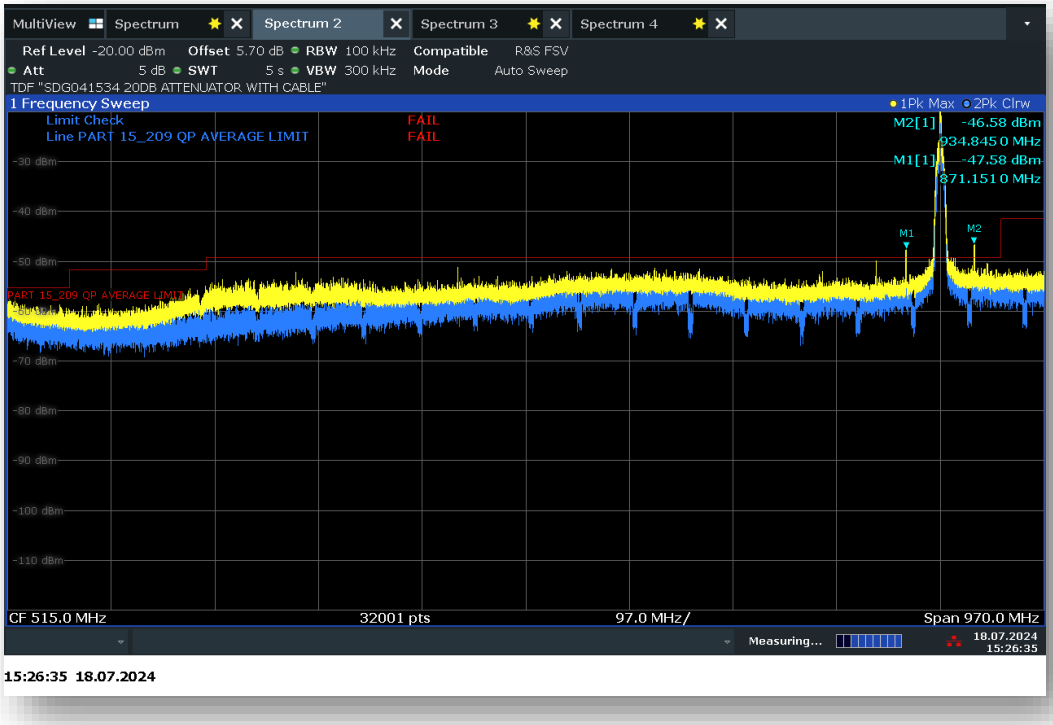
Low Channel (9kHz to 30MHz)



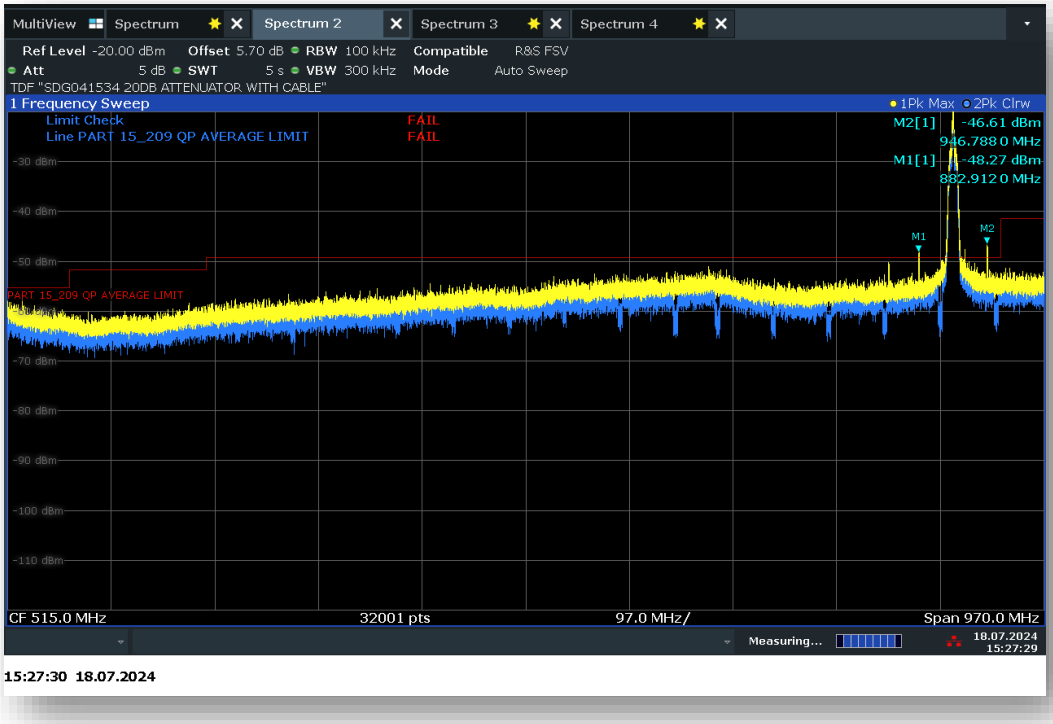
Middle Channel (9kHz to 30MHz)



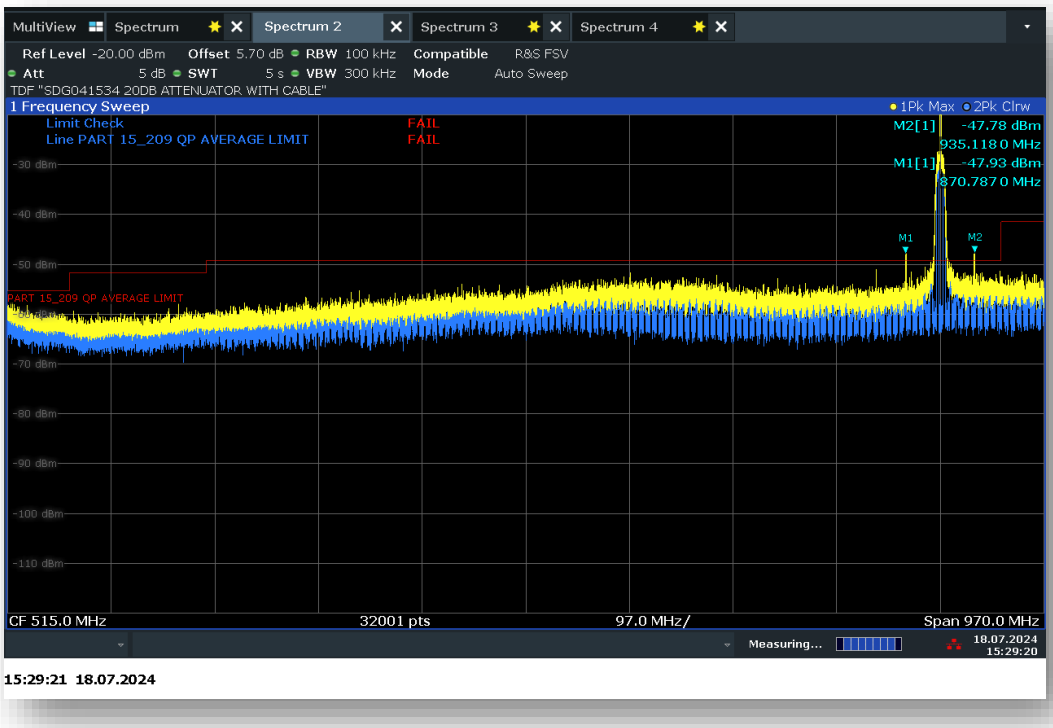
High Channel (9kHz to 30MHz)



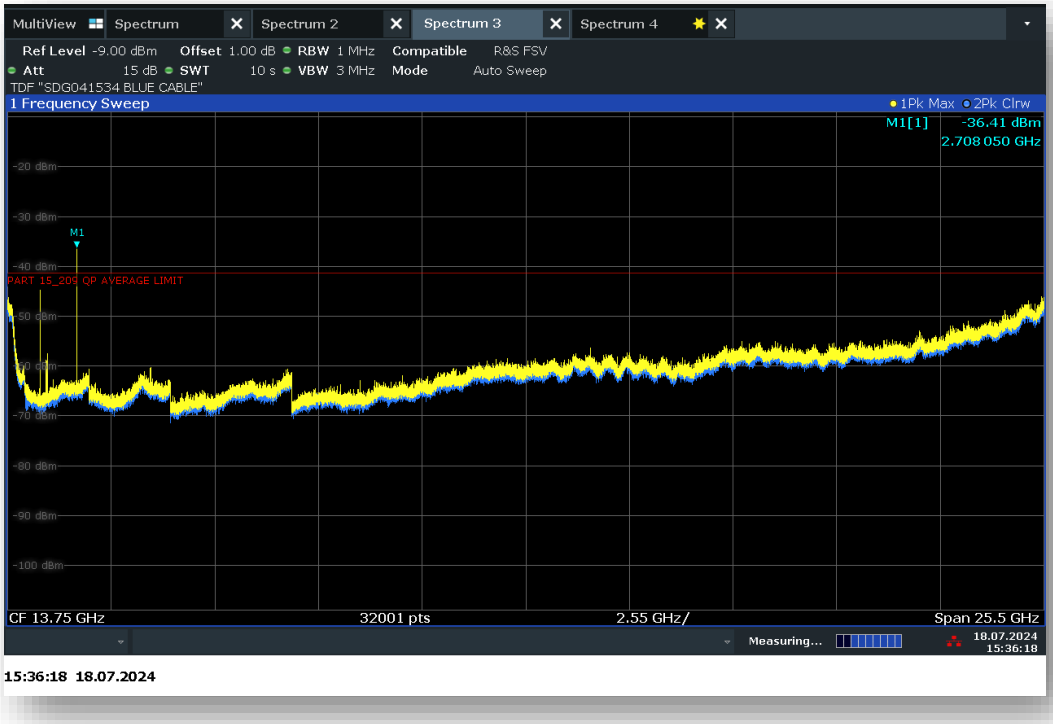
Low Channel (30MHz to 1GHz)



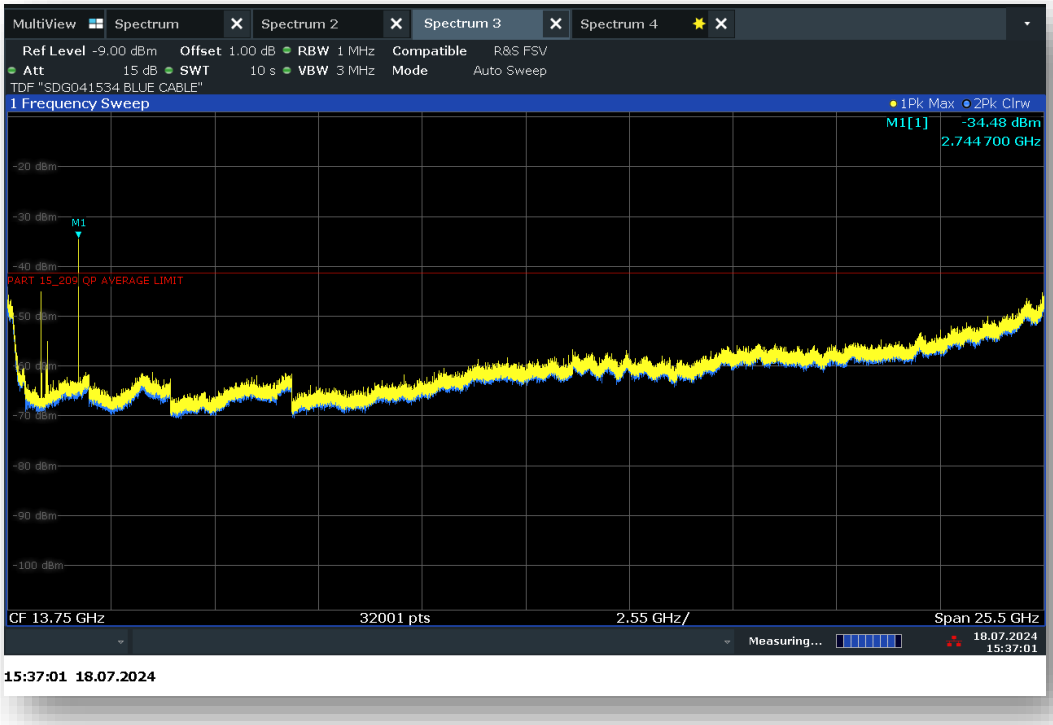
Middle Channel (30MHz to 1GHz)



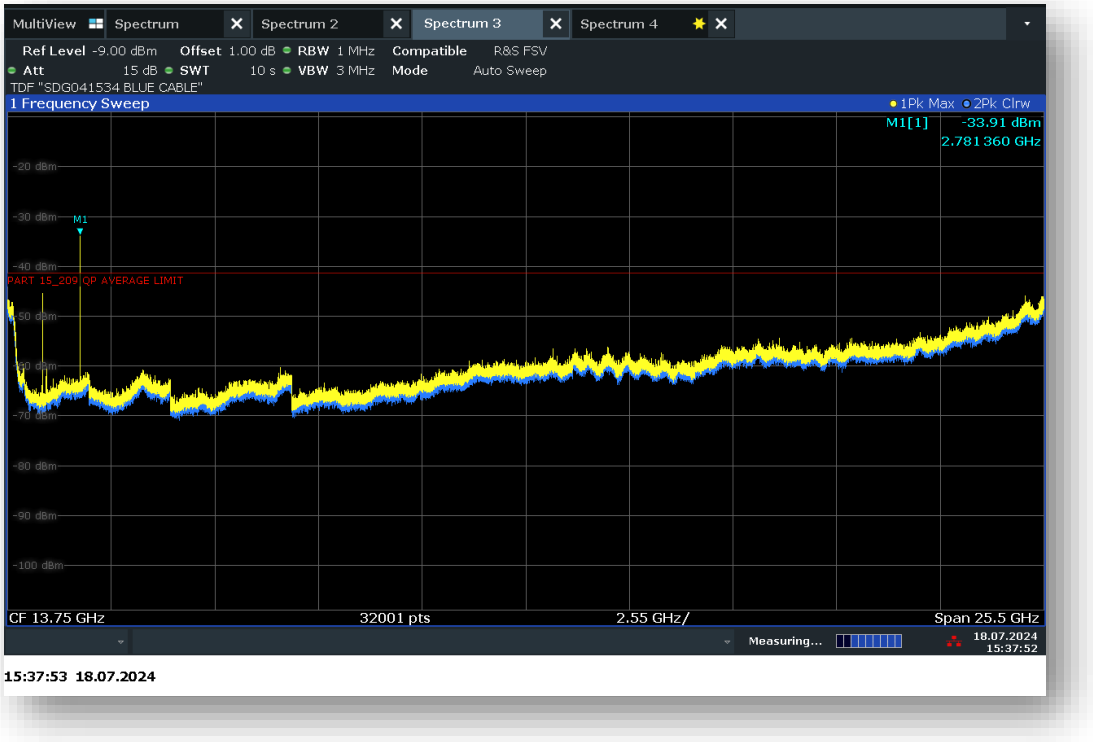
High Channel (30MHz to 1GHz)



Low Channel (1GHz to 26.5GHz)



Middle Channel (1GHz to 26.5GHz)



High Channel (1GHz to 26.5GHz)

2.5.9 Sample Calculations for SF12

Spectrum analyzer offset for 30MHz to 1GHz range:

Offset = antenna gain + maximum ground reflection factor
= 1dBi + 4.7dB
= 5.7dB

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

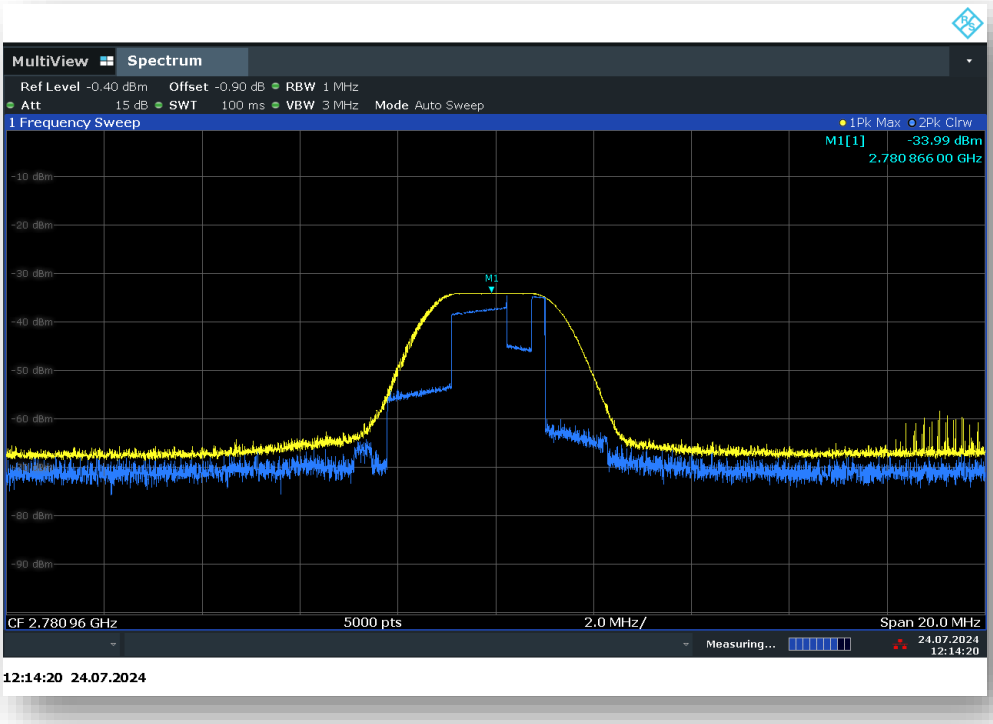
Reported worst case level = -46.58dBm EIRP (M2 for Low Channel)

Both M1 (871.151MHz) and M2 (935.118MHz) are 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:

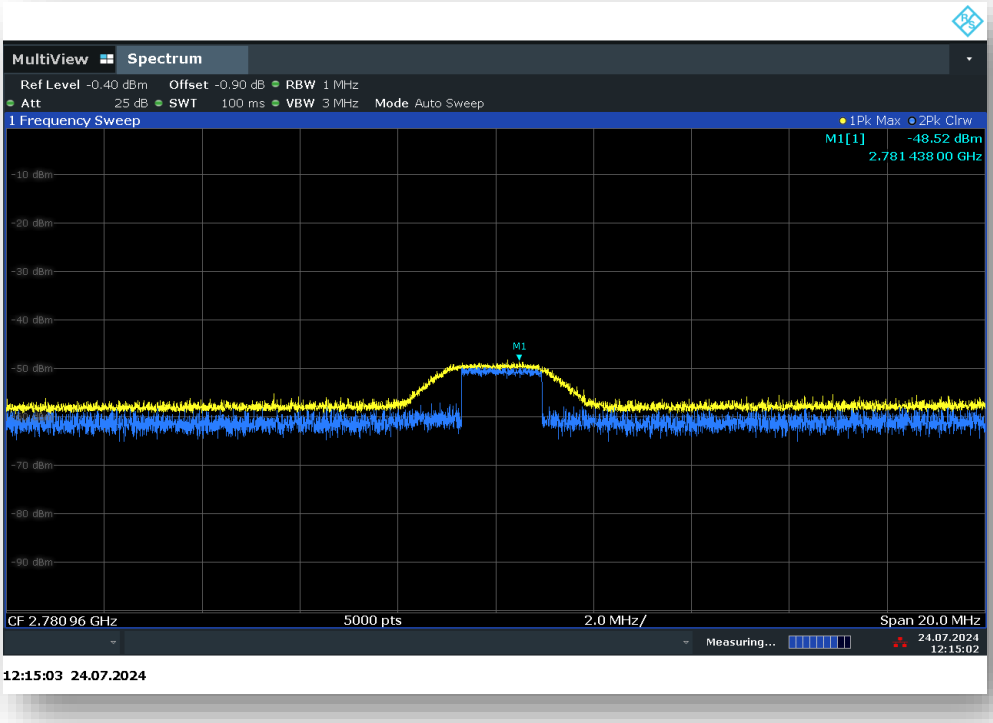
28.8 dBm (Peak Power for Low Channel)+ 1dBi (antenna gain) – (-46.58 dBm EIRP) = 76.38dB (>20dBc, EUT complies)

M1 marker point in the frequency range 1GHz to 26.5GHz:

Reported worst case level = -33.91dBm EIRP (M1 for High Channel). This level, however, is not the final level due to low attenuation setting used to improve dynamic range for the entire presented frequency range (1GHz to 26.5GHz). Confirmation plots to follow:



Original M1 (Marker) HC with 15dB attenuator setting (-33.9dBm)

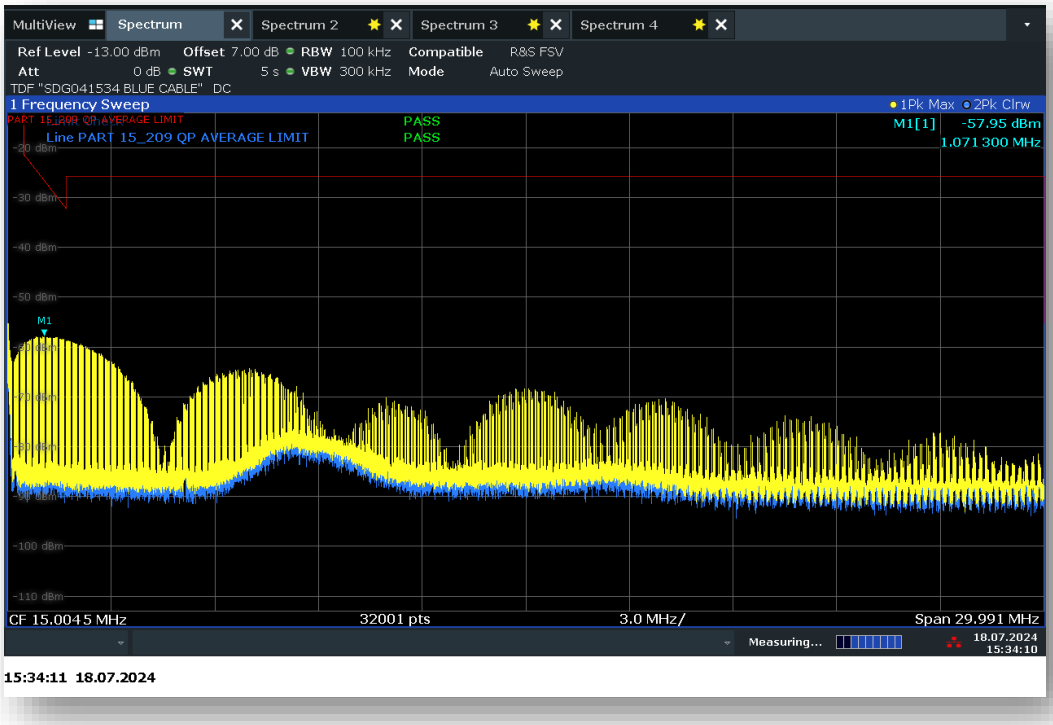


Final M1 (Marker) HC with 25dB attenuator setting (-48.52dBm)

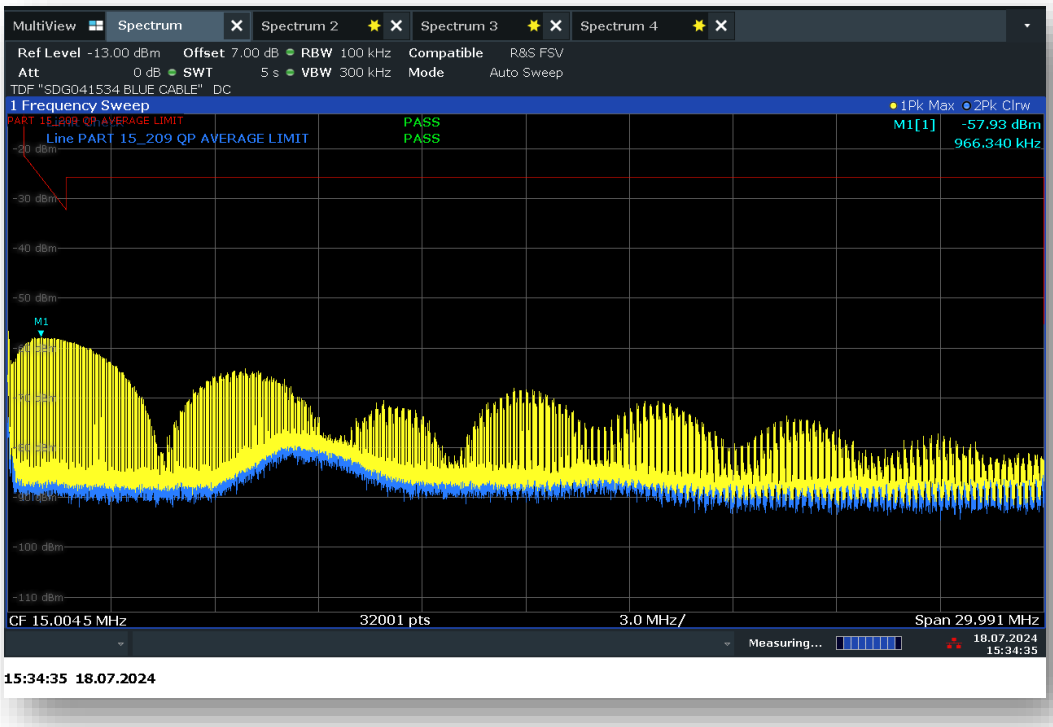
M1 (2781.360MHz) is in the restricted bands per §15.205. Procedure is per Clause 12.7.2 of ANSI C63.10-2013.Use the following formula as per Clause 12.7.2(d) of ANSI C63.10-2013:

E(dBµV/m) = EIRP (dBm) + 95.2
= -48.52 dBm + 95.2
= 46.68 dBµV/m @ 3 meters (Peak complies with 54 dBµV/m Average limit)

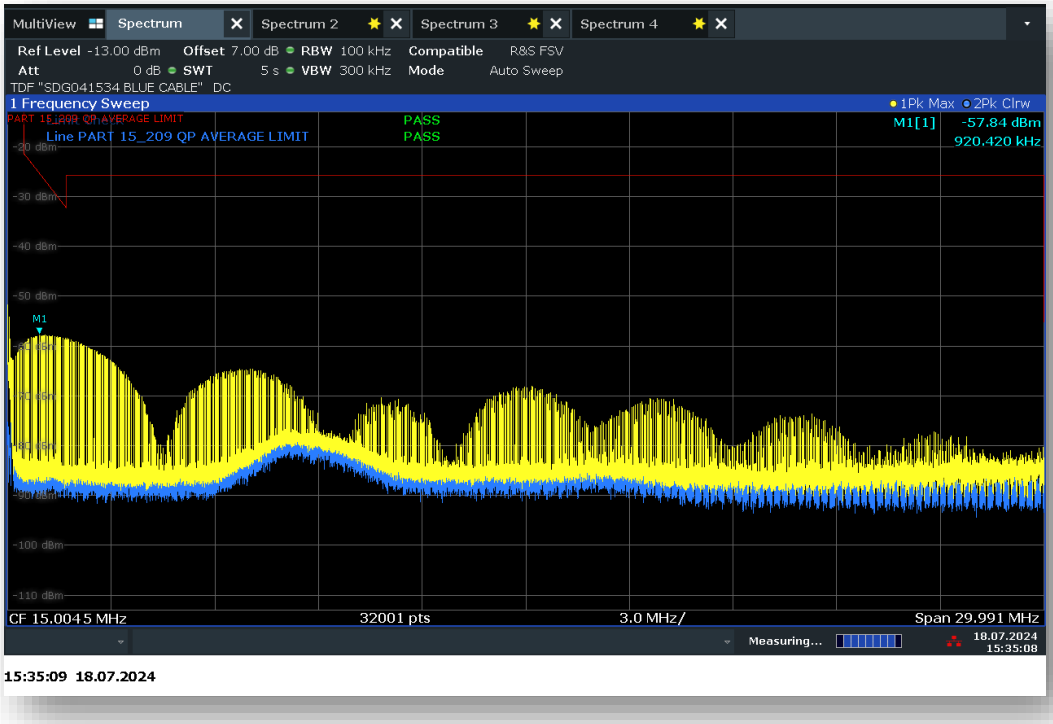
2.5.10 Test Results SF7



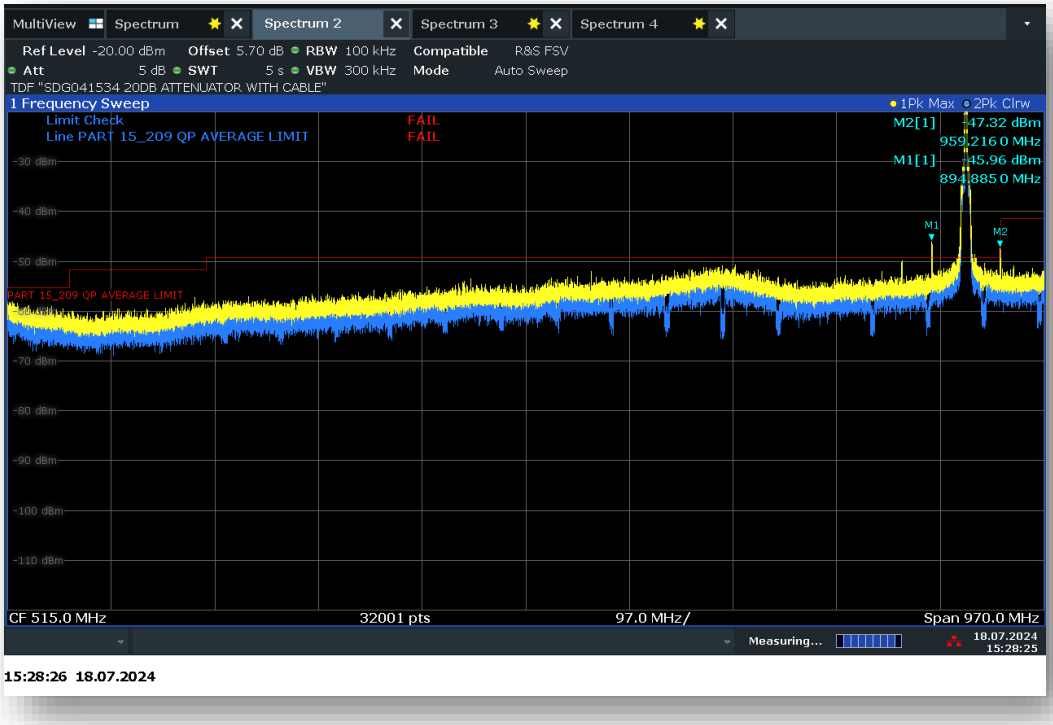
Low Channel (9kHz to 30MHz)



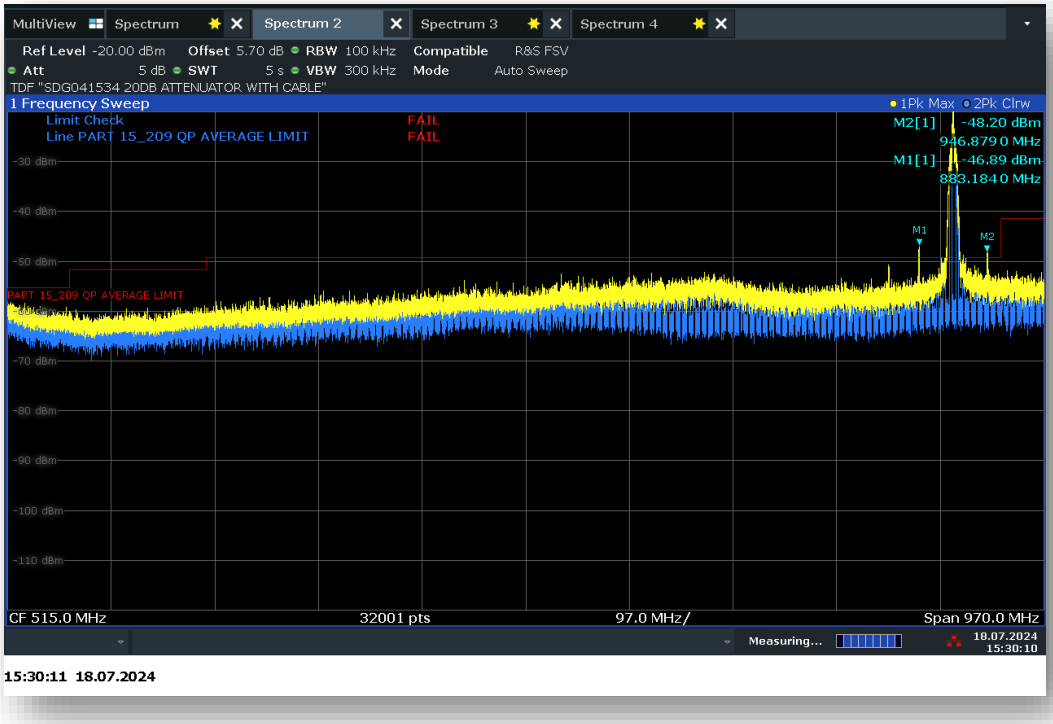
Middle Channel (9kHz to 30MHz)



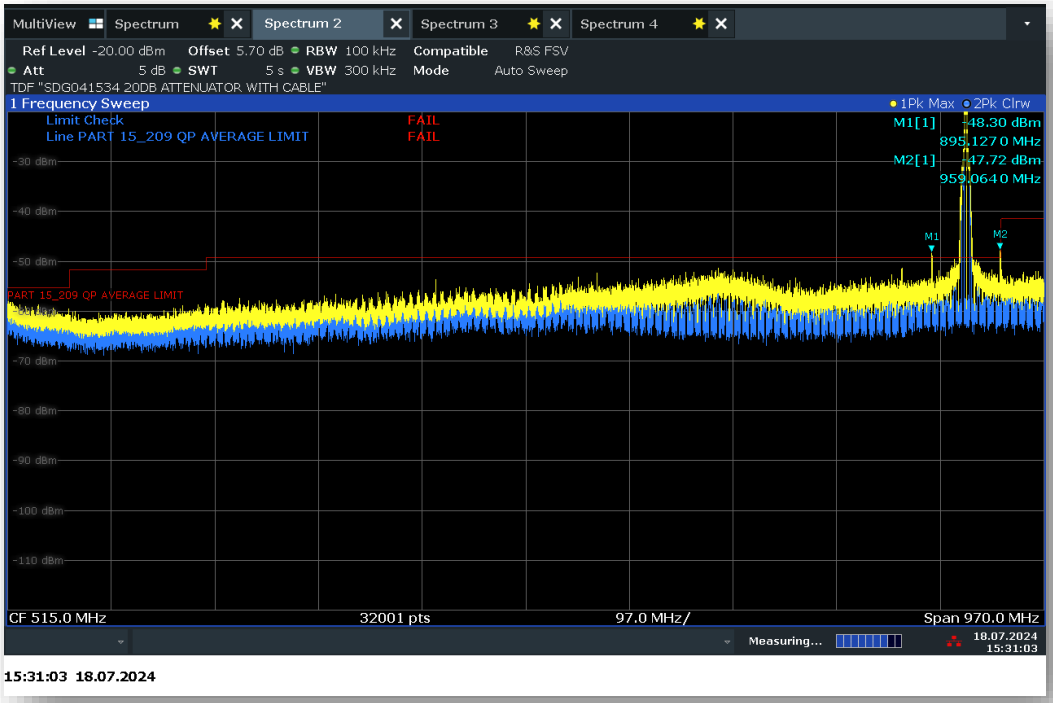
High Channel (9kHz to 30MHz)



Low Channel (30MHz to 1GHz)

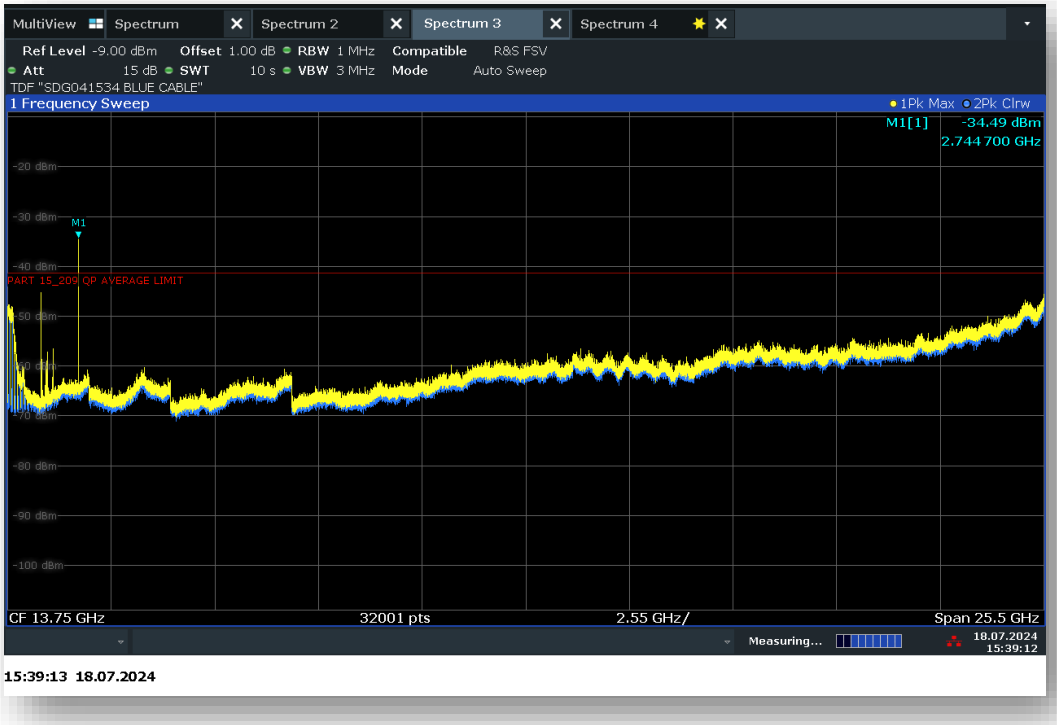


Middle Channel (30MHz to 1GHz)

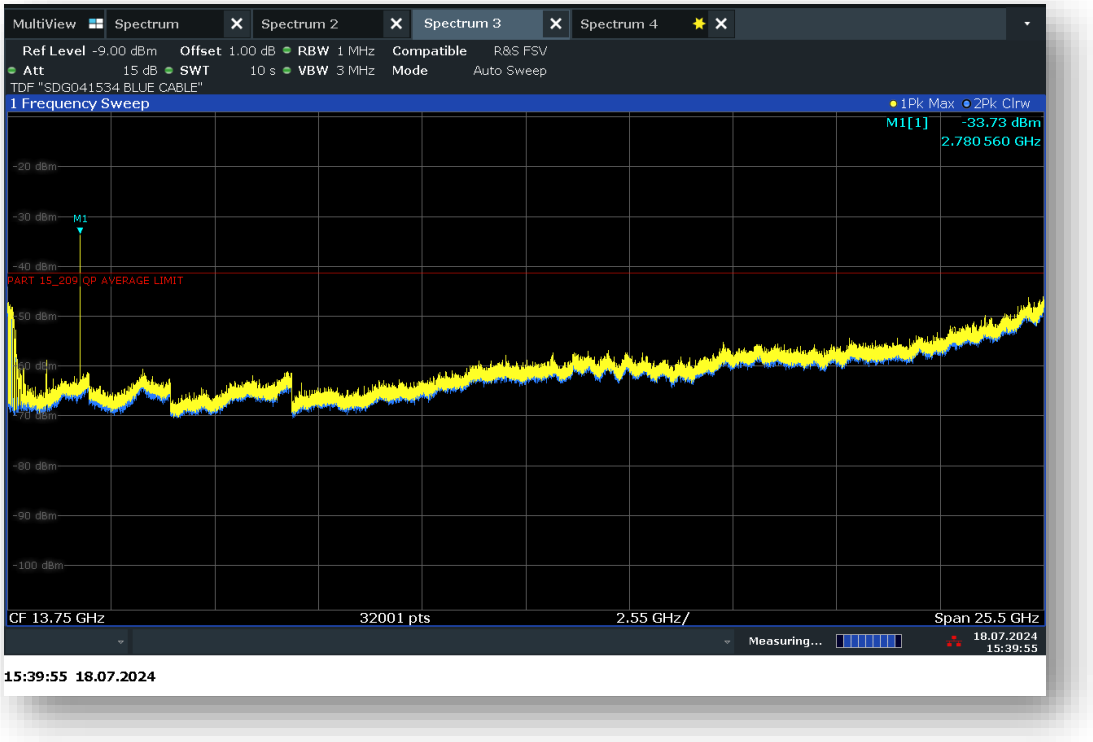


High Channel (30MHz to 1GHz)

Low Channel (1GHz to 26.5GHz)



Middle Channel (1GHz to 26.5GHz)



High Channel (1GHz to 26.5GHz)

2.5.11 Sample Calculations for SF12

Spectrum analyzer offset for 9kHz to 30MHz range:

Offset = antenna gain + maximum ground reflection factor
= 1dBi + 6dB
= 7.0dB

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

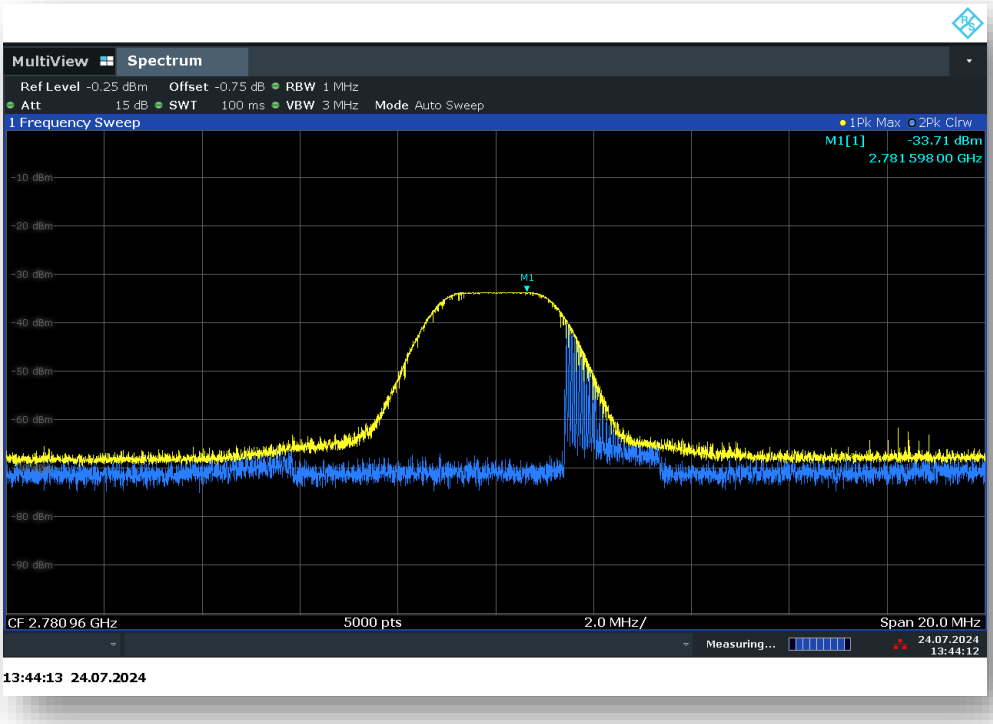
Reported worst case level = -45.96dBm EIRP (M1 for Low Channel)

Both M1 (894.885MHz) and M2 (959.064MHz) are 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:

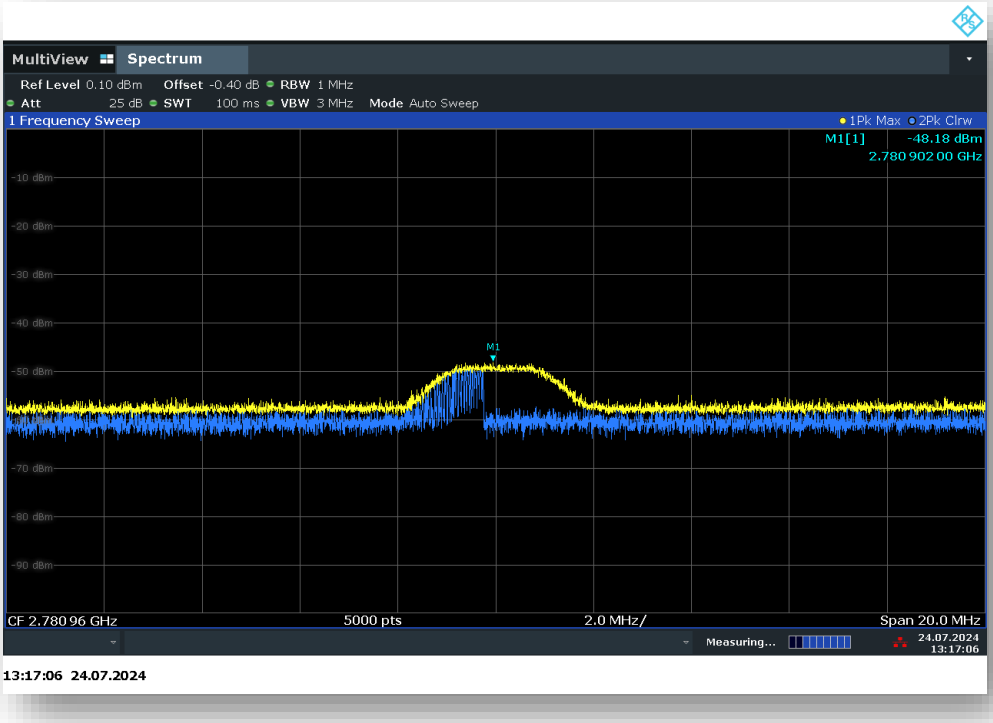
20.82 dBm (Peak Power for Low Channel)+ 1dBi (antenna gain) – (-46.58 dBm EIRP) = 68.4dB (>20dBc, EUT complies)

M1 marker point in the frequency range 1GHz to 26.5GHz:

Reported worst case level = -33.73dBm EIRP (M1 for High Channel). This level, however, is not the final level due to low attenuation setting used to improve dynamic range for the entire presented frequency range (1GHz to 26.5GHz). Confirmation plots to follow:



Original M1 (Marker) HC with 15dB attenuator setting (-33.7dBm)



Final M1 (Marker) HC with 25dB attenuator setting (-48.18dBm)

M1 (2781.360MHz) is in the restricted bands per §15.205. Procedure is per Clause 12.7.2 of ANSI C63.10-2013.Use the following formula as per Clause 12.7.2(d) of ANSI C63.10-2013:

E(dBµV/m) = EIRP (dBm) + 95.2
= -48.18 dBm + 95.2
= 47.02 dBµV/m @ 3 meters (Peak complies with 54 dBµV/m Average limit)

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: N/A / Default Test Configuration

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

July 19, 2024 / FSC

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	25.5 °C
Relative Humidity	51.7 %
ATM Pressure	99.9 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.

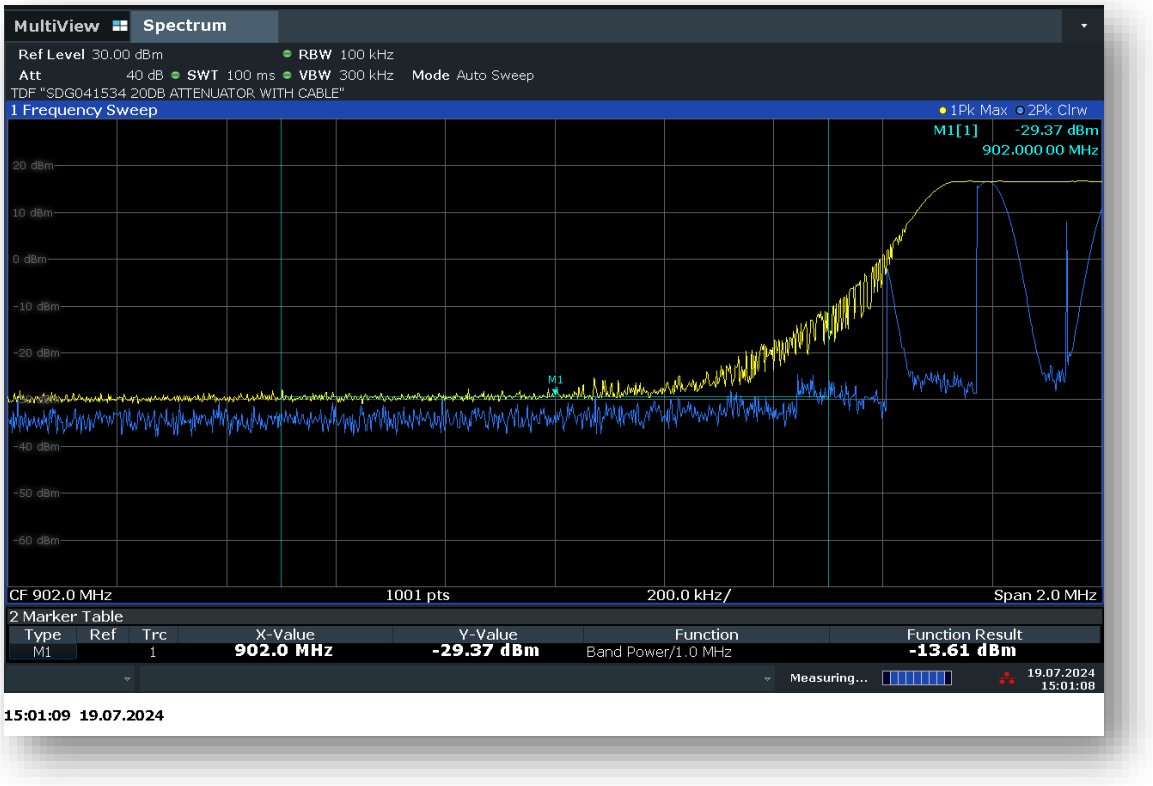
2.6.8 Test Results (Lower Band Edge)

Modulation	Frequency (MHz)	Level (dBm)	Margin (dB)	Limit (dBm)	Result
SF12	902.00	-13.61	12.73	-0.88	PASS
SF17	902.00	-13.99	13.17	-0.82	PASS

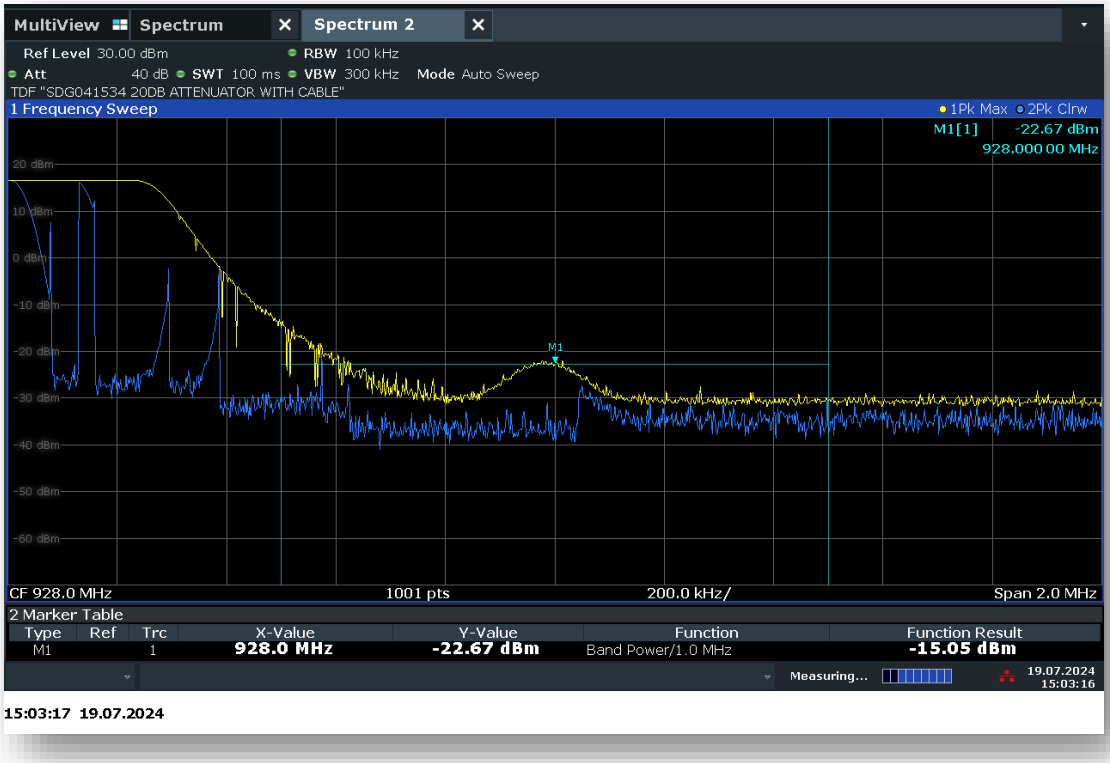
2.6.9 Test Results (Upper Band Edge)

Modulation	Frequency (MHz)	Level (dBm)	Margin (dB)	Limit (dBm)	Result
SF12	928.00	-15.05	15.67	0.62	PASS
SF17	928.00	-12.98	13.60	0.62	PASS

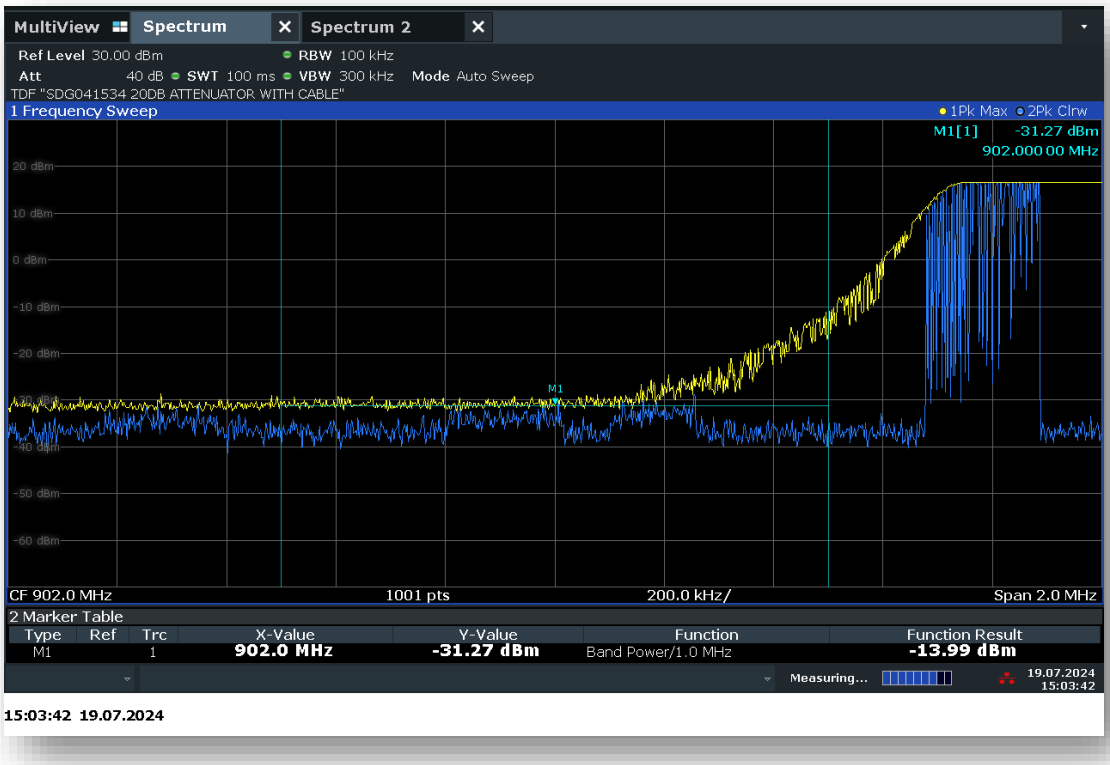
2.6.10 Test Plots



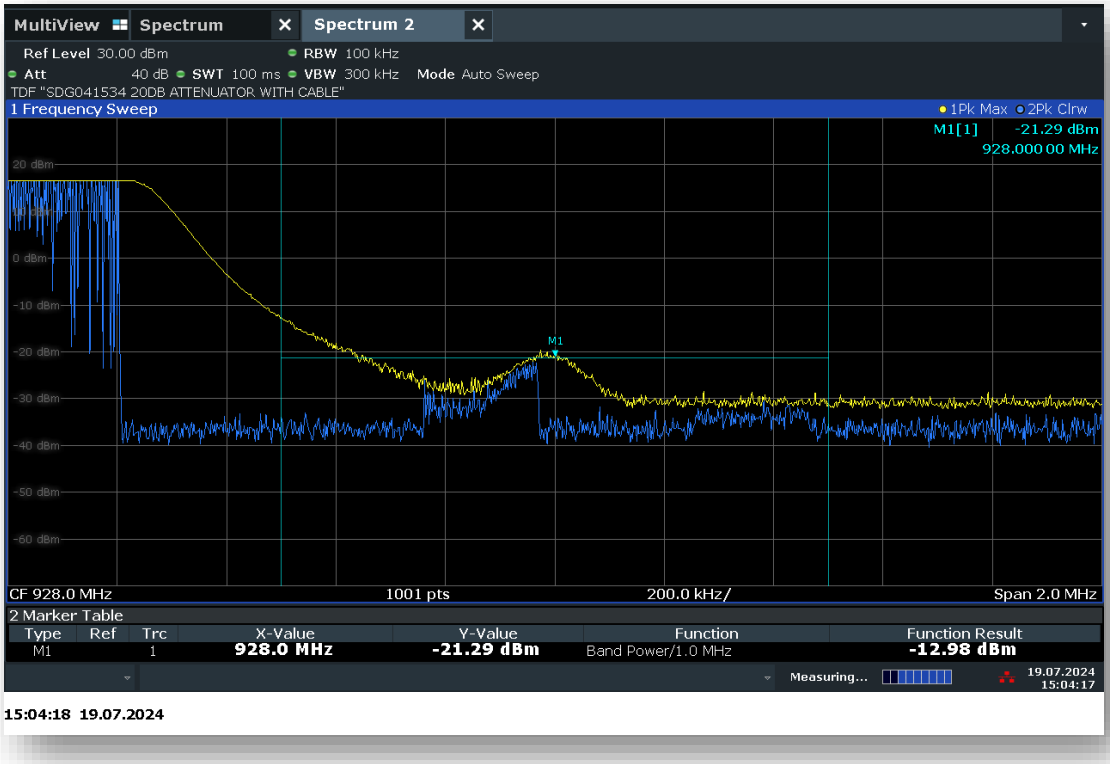
LoRA SF12 Low Channel



LoRA SF12 High Channel



LoRA SF7 Low Channel



LoRA SF7 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: N/A / Default Test Configuration

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

July 23, 2024 / FSC

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 (Rancho Bernardo Satellite Facility)

Ambient Temperature	23.5 °C
Relative Humidity	41.1 %
ATM Pressure	100.3 kPa

2.7.7 Additional Observations

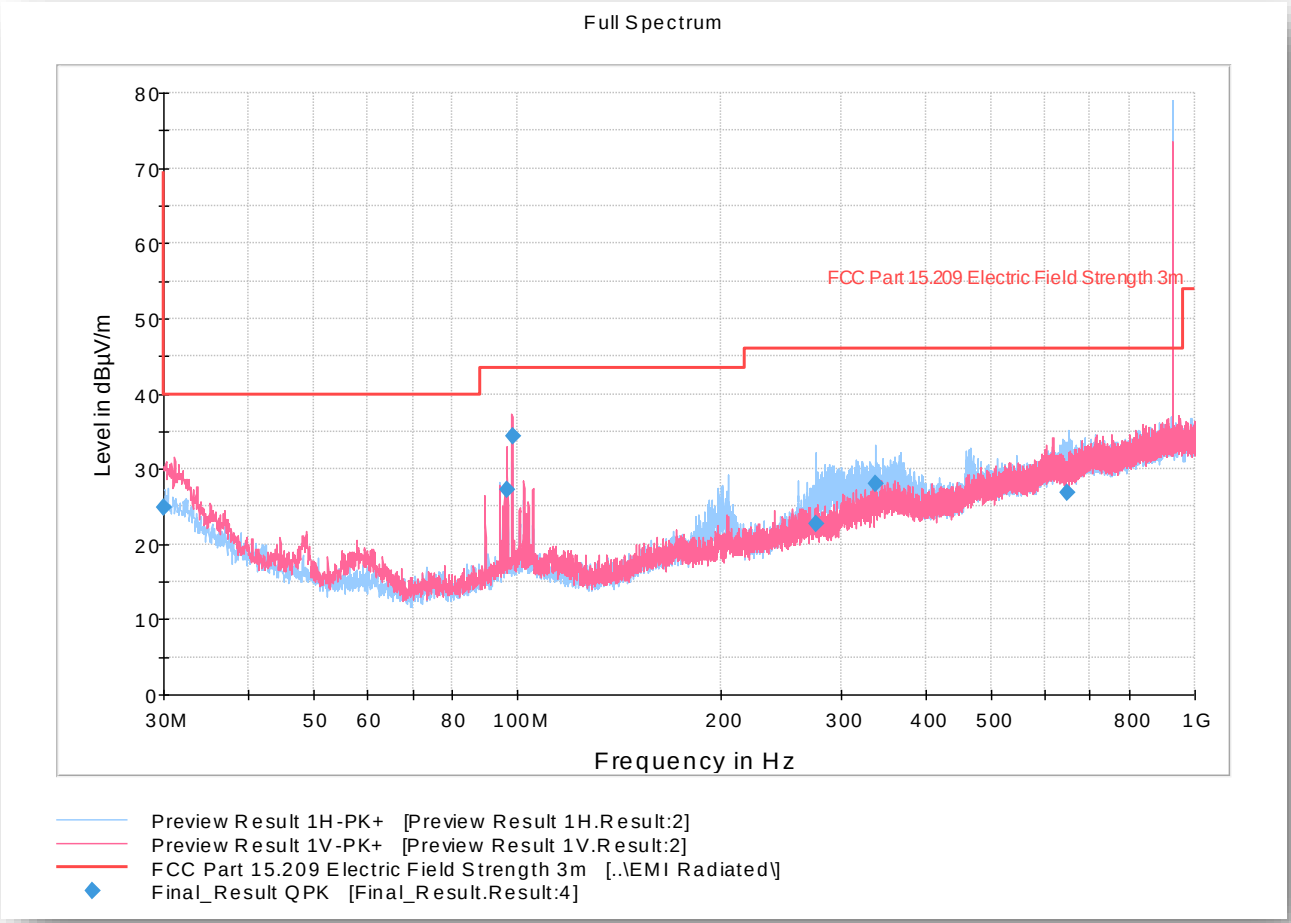
- This is a radiated test. The spectrum was searched from 30MHz to the 10th harmonic.
- There are no emissions found that do not comply to the restricted bands defined in FCC Part 15 Subpart C, 15.205 or Part 15.247(d).
- Only the worst-case spreading factor presented (SF12) per test plan. There are 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 (dbµV) @ 30 MHz			-0.8
Correction Factor (dB)	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 (dbµV/m) @ 30MHz			**11.8**

2.7.9 Test Results for 30MHz to 1GHz (worst-case channel and spreading factor)

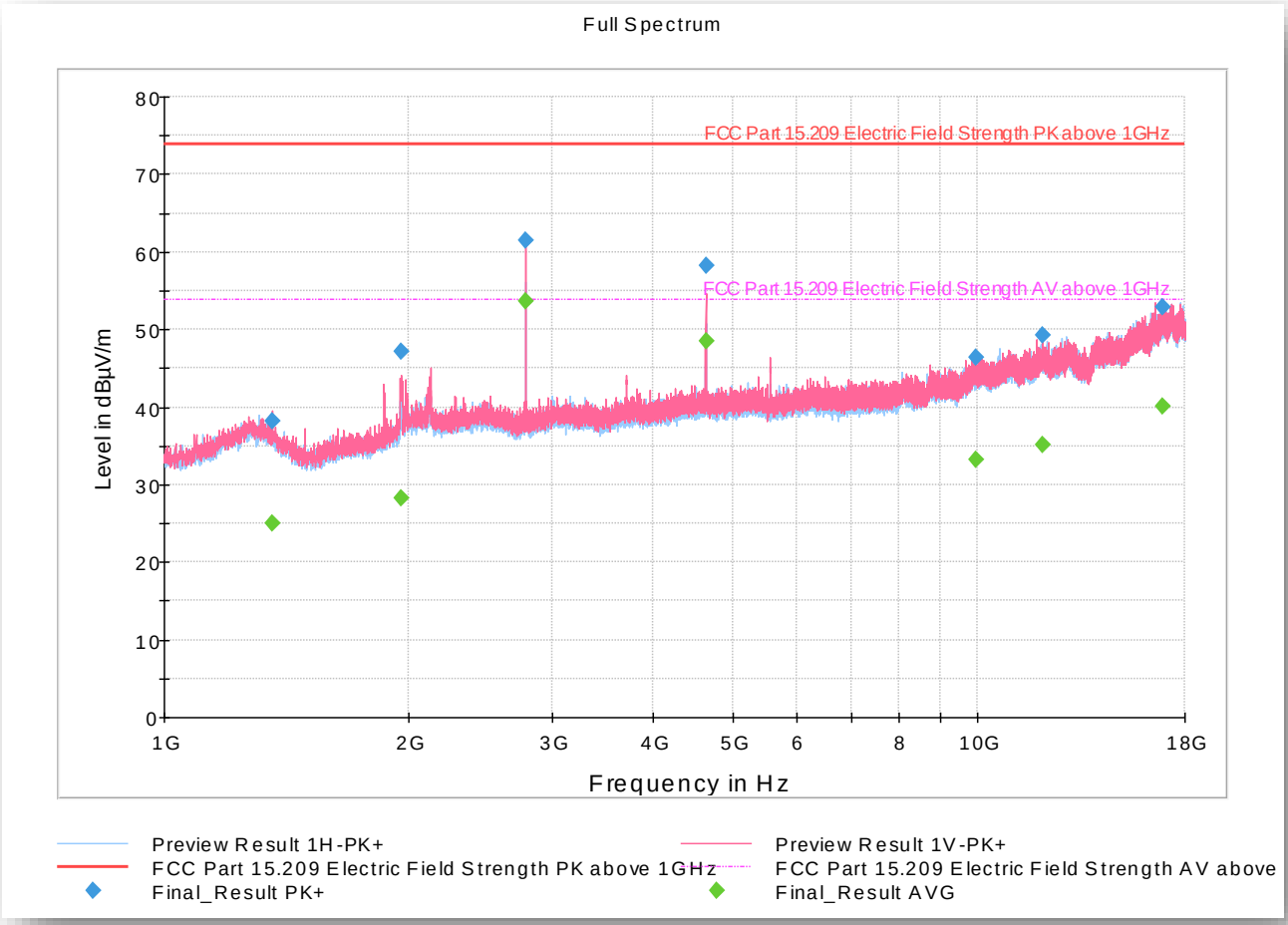


Quasi Peak Data

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
30.000000	24.94	69.50	44.56	1000.	120.000	111.0	V	353.0	23
96.557333	27.19	43.50	16.31	1000.	120.000	100.0	V	-4.0	16
98.174000	34.28	43.50	9.22	1000.	120.000	107.0	V	179.0	16
275.98433	22.73	46.00	23.27	1000.	120.000	179.0	H	50.0	20
336.81100	28.06	46.00	17.94	1000.	120.000	155.0	H	84.0	22
648.90233	26.94	46.00	19.06	1000.	120.000	167.0	H	272.0	27

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

2.7.10 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)
1356.60000	38.16	73.90	35.74	1000.0	1000.000	108.0	V	184.0	-5.3
1954.60000	47.08	73.90	26.82	1000.0	1000.000	115.0	V	174.0	-2.6
2780.86666	62.29	73.90	11.61	1000.0	1000.000	276.0	V	105.0	-0.1
2781.26666	61.44	73.90	12.46	1000.0	1000.000	299.0	V	109.0	-0.1
4634.26666	58.21	73.90	15.69	1000.0	1000.000	268.0	V	39.0	4.4
9954.30000	46.39	73.90	27.51	1000.0	1000.000	401.0	V	136.0	12.2
12037.7000	49.21	73.90	24.69	1000.0	1000.000	120.0	V	211.0	16.1
16898.4666	52.82	73.90	21.08	1000.0	1000.000	146.0	V	147.0	22.3

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)
1356.60000	25.01	53.90	28.89	1000.0	1000.000	108.0	V	184.0	-5.3
1954.60000	28.17	53.90	25.73	1000.0	1000.000	115.0	V	174.0	-2.6
2780.86666	55.55	53.90	-1.65	1000.0	1000.000	276.0	V	105.0	-0.1
2781.26666	55.63	53.90	-1.73	1000.0	1000.000	299.0	V	109.0	-0.1
4634.26666	48.52	53.90	5.38	1000.0	1000.000	268.0	V	39.0	4.4
9954.30000	33.31	53.90	20.59	1000.0	1000.000	401.0	V	136.0	12.2
12037.7000	35.20	53.90	18.70	1000.0	1000.000	120.0	V	211.0	16.1
16898.4666	40.02	53.90	13.88	1000.0	1000.000	146.0	V	147.0	22.3

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: N/A / Default Test Configuration

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

July 19, 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	25.5 °C
Relative Humidity	51.7 %
ATM Pressure	99.9 kPa

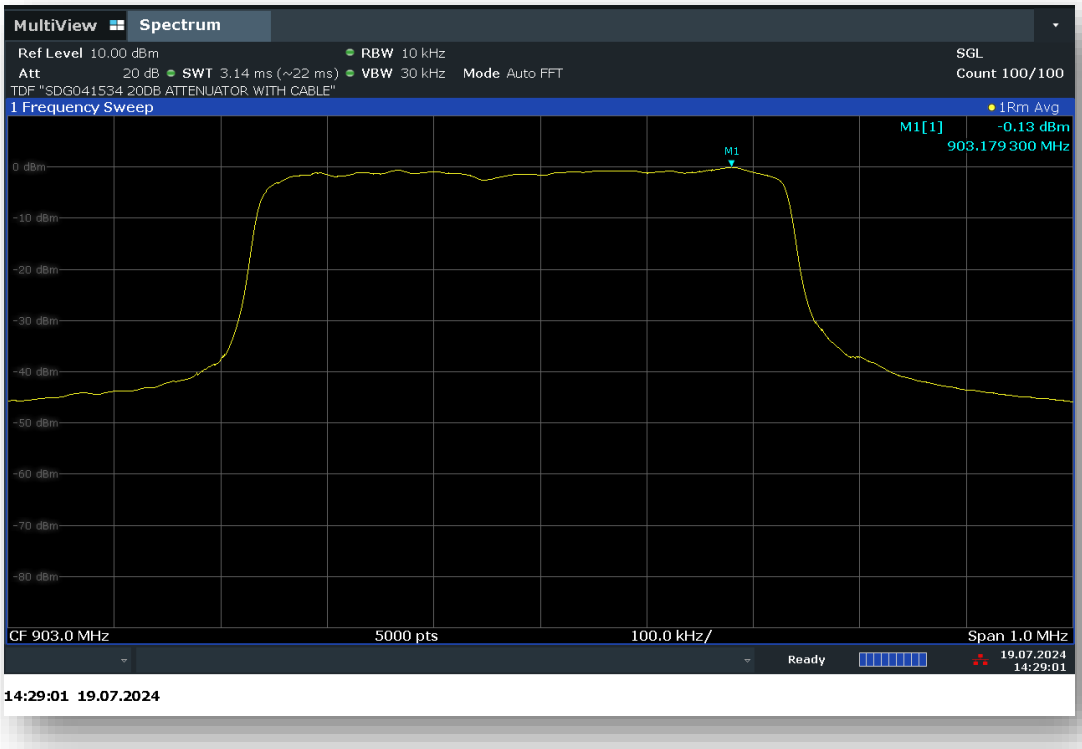
2.8.7 Additional Observations

- This is a conducted test using Method AVGPSD-2 per ANSI C63.10 Subclause 11.10.
- The path loss was all accounted for using a transducer factor.

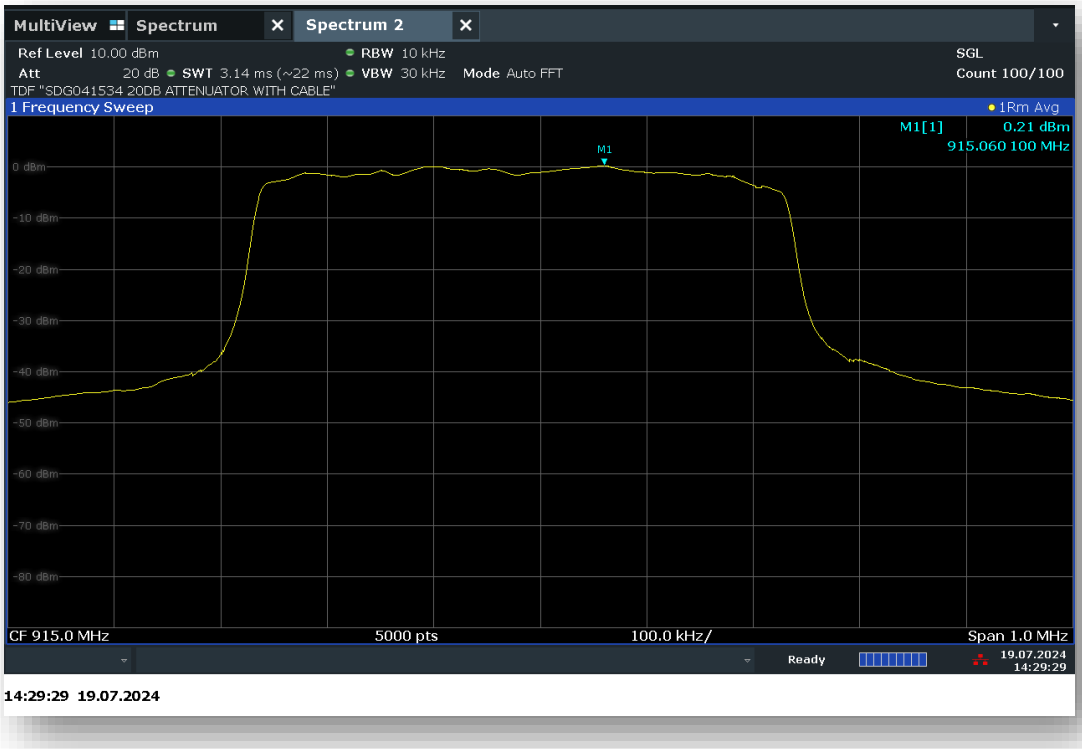
2.8.8 Test Results Summary

DUT Channel (MHz)	Modulation	PSD Frequency (MHz)	PSD (dBm)	Duty Cycle corrected PSD (dBm)	Limit Max (dBm)	Result
903.00	SF12	903.179	-0.13	0.251	8.0	PASS
915.00	SF12	915.060	0.21	0.591	8.0	PASS
927.00	SF12	926.896	0.88	1.471	8.0	PASS
903.00	SF7	902.776	-3.65	1.152	8.0	PASS
915.00	SF7	914.773	-3.89	0.938	8.0	PASS
927.00	SF7	926.775	-4.14	1.435	8.0	PASS

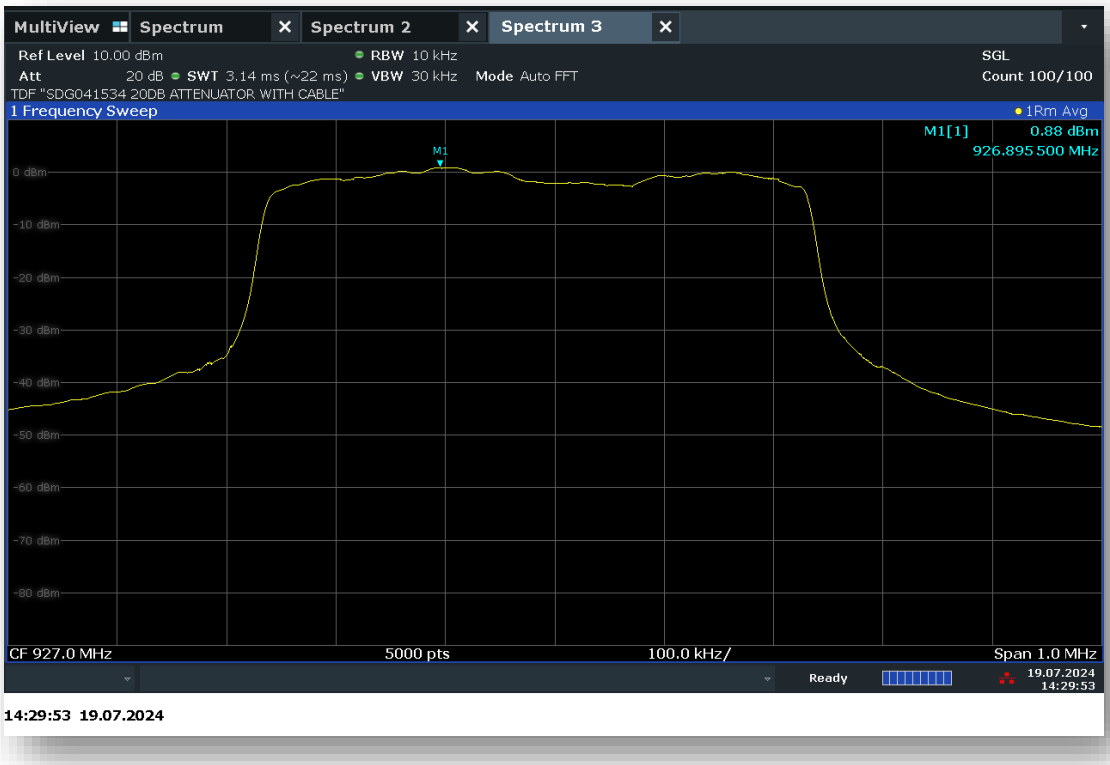
2.8.9 Test Plots



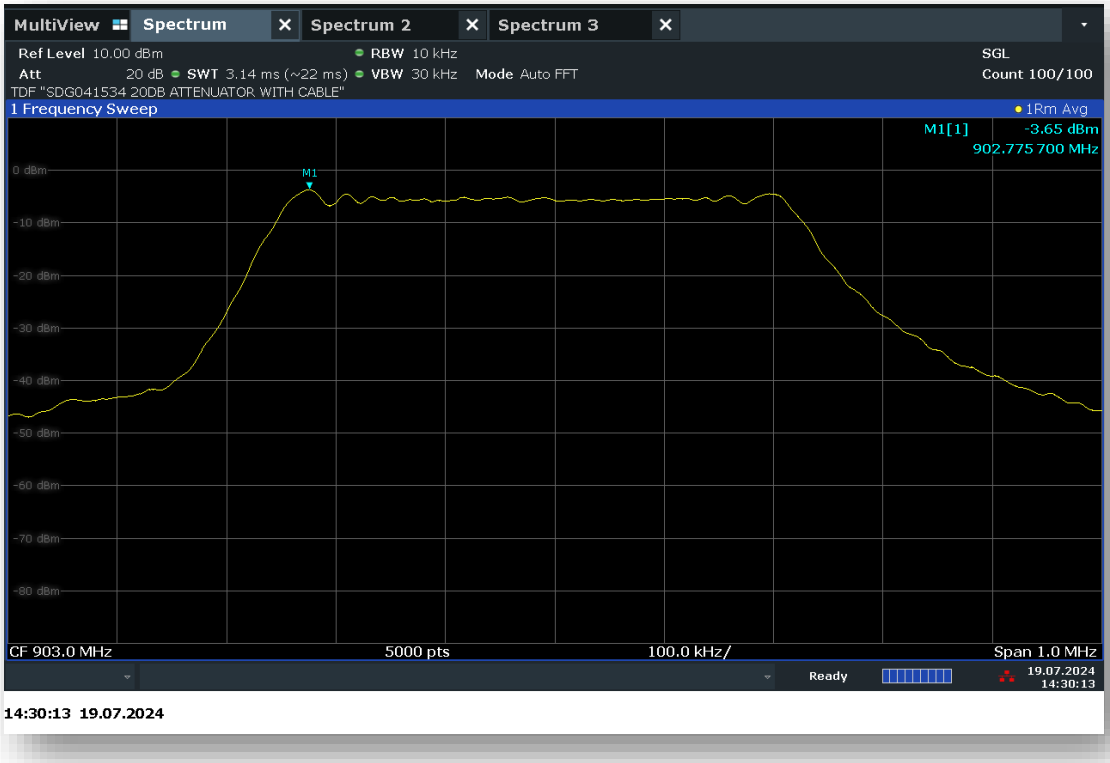
LoRA SF12 Low Channel



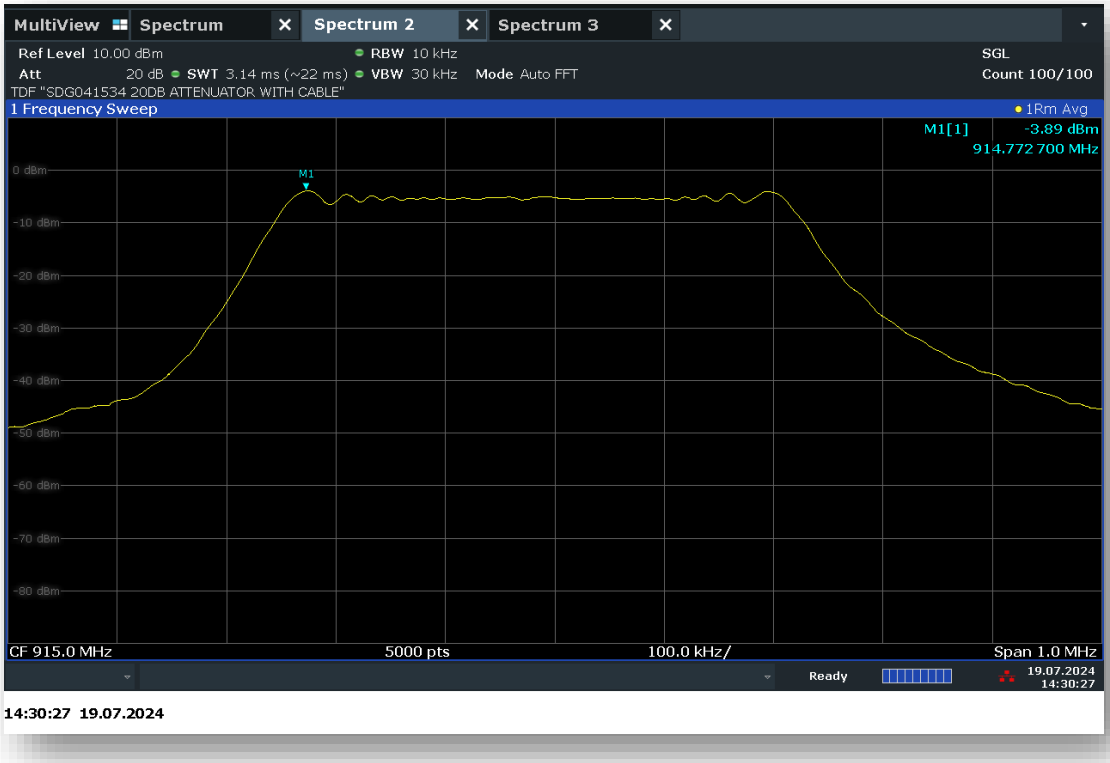
LoRA SF12 Middle Channel



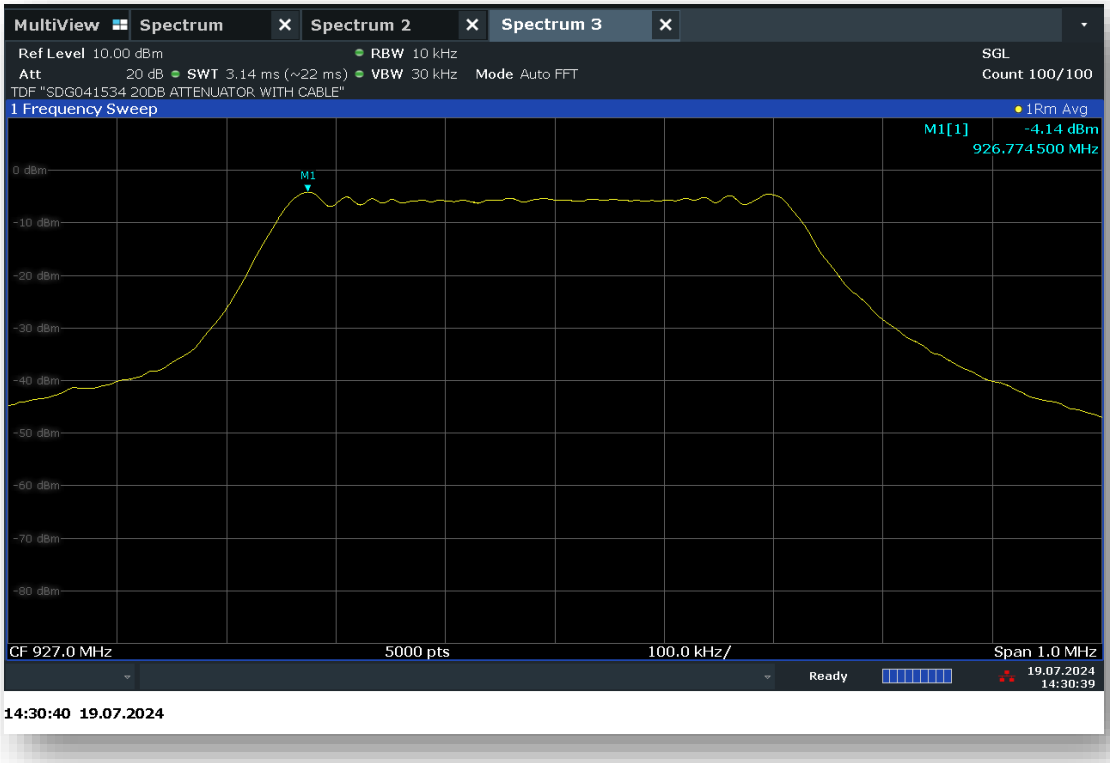
LoRA SF12 High Channel



LoRA SF7 Low Channel



LoRA SF7 Middle Channel



LoRA SF7 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
Radiated Emission						
SDRB1033	Bilog Antenna	3142C	00044556	EMCO	10/16/23	10/16/25
SDRB1040	EMI Test Receiver	ESIB40	100292	Rohde & Schwarz	10/02/23	10/02/24
SDGE51235	RF Pre-Amp (9Khz to 1GHz)	310	412802	SONOMA	08/21/23	08/21/24
SDGE07620	EMI Test Receiver	ESU40	100399	Rohde & Schwarz	08/23/23	08/23/24
SDGE07575	Double ridged waveguide horn	3117	00155511	ETS Lindgren	08/08/22	08/08/24
SDGE08628	Pre-amplifier	QLJ 01182835-JO	8986002	QuinStar Technologies Inc.	02/19/24	02/19/25
Miscellaneous						
30215	Barometer/Temperature/Humidity	iBTHX-W	15050268	Omega	06/05/24	06/05/25
43003	True RMS Multimeter	85 III	69880143	Fluke	10/02/23	10/02/24
-	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 (for reference only)

	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	0.30	dB	Normal, k=2	2.000	0.15	0.02
4	Receiver sinewave accuracy	0.36	dB	Normal, k=2	2.000	0.18	0.03
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	1.66	dB
Expanded uncertainty	**Normal, k=2**	**3.31**	**dB**

3.2.2 Radiated Measurements (30MHz to 1GHz)

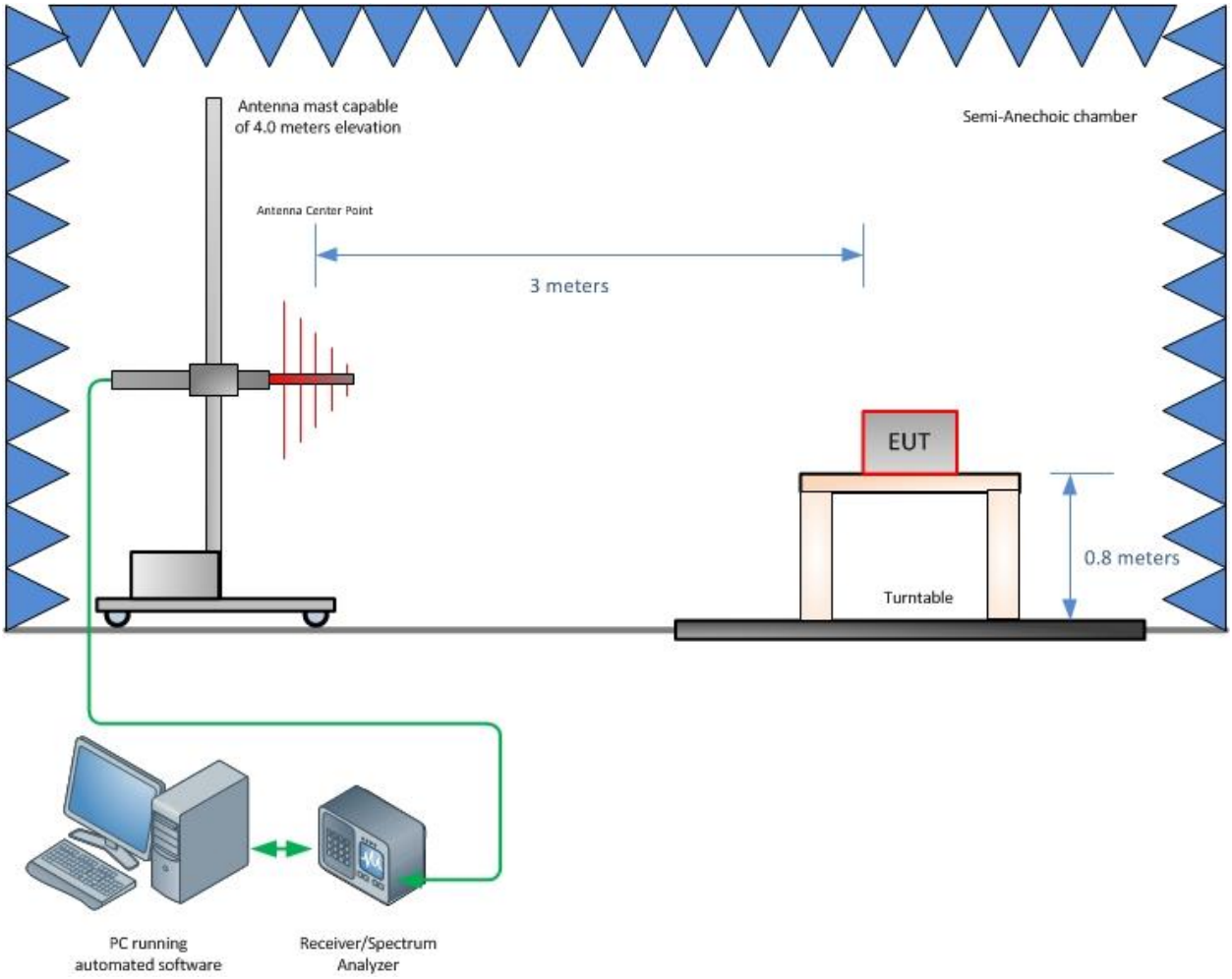
	Input Quantity (Contribution) X_i	Value		Prob. Dist.	Divisor	$u_i(x)$	$u_i(x)^2$
1	Receiver reading	0.10	dB	Normal, k=1	1.000	0.10	0.01
2	Attenuation: antenna-receiver	0.20	dB	Normal, k=2	2.000	0.10	0.01
3	Antenna factor AF	0.75	dB	Normal, k=2	2.000	0.38	0.14
4	Receiver sinewave accuracy	1.10	dB	Normal, k=2	2.000	0.55	0.30
5	Receiver pulse amplitude	1.50	dB	Rectangular	1.732	0.87	0.75
6	Receiver pulse repetition rate	1.50	dB	Rectangular	1.732	0.87	0.75
7	Noise floor proximity	0.50	dB	Rectangular	1.732	0.29	0.08
8	Mismatch: antenna-receiver	0.95	dB	U-shaped	1.414	0.67	0.45
9	AF frequency interpolation	0.30	dB	Rectangular	1.732	0.17	0.03
10	AF height deviations	0.10	dB	Rectangular	1.732	0.06	0.00
11	Directivity difference at 3 m	3.12	dB	Rectangular	1.732	1.80	3.24
12	Phase center location at 3 m	1.00	dB	Rectangular	1.732	0.58	0.33
13	Cross-polarisation	0.90	dB	Rectangular	1.732	0.52	0.27
14	Balance	0.00	dB	Rectangular	1.732	0.00	0.00
15	Site imperfections	3.64	dB	Triangular	2.449	1.49	2.21
16	Separation distance at 3 m	0.30	dB	Rectangular	1.732	0.17	0.03
17	Effect of setup table material	0.40	dB	Rectangular	1.732	0.23	0.05
18	Table height at 3 m	0.10	dB	Normal, k=2	2.000	0.05	0.00
19	Near-field effects	0.00	dB	Triangular	2.449	0.00	0.00
20	Effect of ambient noise on OATS	0.00	dB				0.00
	Combined standard uncertainty			Normal	2.95	dB	
	Expanded uncertainty			Normal, k=2	**5.89**	**dB**	

3.2.1 Radiated Emission Measurements (1GHz to 18GHz)

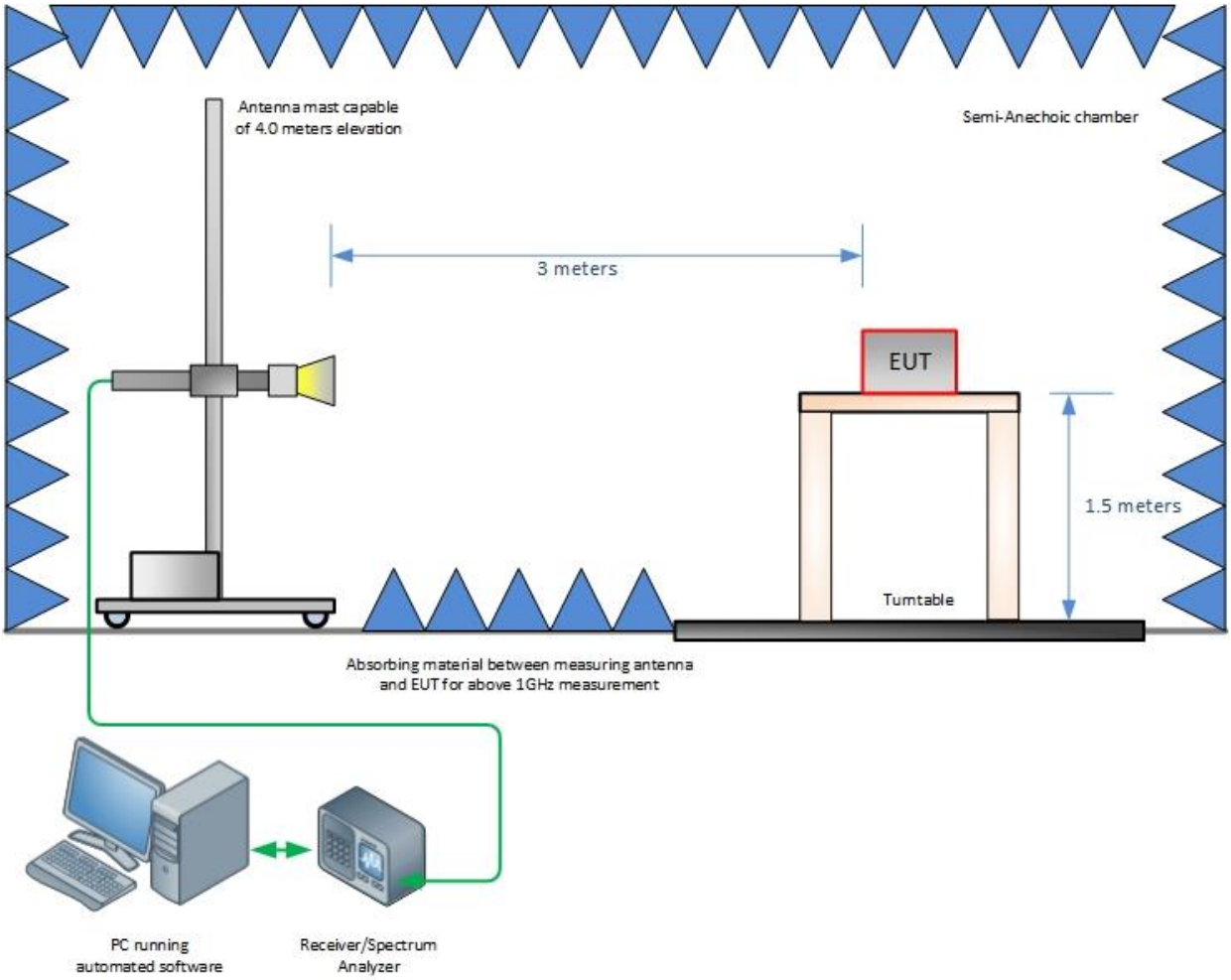
	Input Quantity (Contribution) X_i	Value		Prob. Dist.	Divisor	$u_i(x)$	$u_i(x)^2$
1	Receiver reading	0.10	dB	Normal, k=1	1.000	0.10	0.01
2	Attenuation: antenna-receiver	0.20	dB	Normal, k=2	2.000	0.10	0.01
3	Antenna factor AF	0.75	dB	Normal, k=2	2.000	0.38	0.14
4	Receiver sinewave accuracy	0.45	dB	Normal,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

SECTION 4

DIAGRAM OF TEST SETUP



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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