RHEIN TECH LABORATORIES, INC.

Engineering Solutions & Electromagnetic Compatibility Services

FCC Part 15.247 Certification Report

Test Lab:	Applicant:
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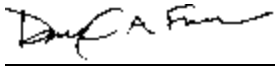
FCC ID	2ADZF-D0002	**Test Report Date**	April 8, 2022
Platform	N/A	**RTL Work Order Number**	2021076
Model	Cue+	**RTL Quote Number**	QRTL21-076A
American National Standard Institute	ANSI C63.10-2013: American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices		
FCC Classification	DTS – Digital Transmission System		
FCC Rule Part(s)	Part 15.247: Operation within the bands 902-928 MHz, 2400-2483.5 MHz and 5725-5850 MHz (10-01-2020)		

Frequency Range (MHz)	Output Power (W)*	Frequency Tolerance	Emission Designator
915 – 923	0.074	N/A	1M66F1D

*Power is conducted peak

I, the undersigned, hereby declare that the equipment tested and referenced in this report conforms to the identified standard(s) as described in this test report. No modifications were made to the equipment during testing in order to achieve compliance with these standards. Furthermore, there was no deviation from, additions to, or exclusions from, the applicable parts of FCC Part 2, FCC Part 15, and ANSI C63.10.

Signature: 

Date: April 8, 2022

Typed/Printed Name: Desmond A. Fraser

Position: President

These tests are accredited and meet the requirements of ISO/IEC 17025 as verified by ANAB.
Refer to certificate and scope of accreditation AT-1445.

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1 General Information

1.1 Scope

Applicable Standards:

FCC Part 15.247: Operation within the bands 902-928 MHz, 2400-2483.5 MHz and 5725-5850 MHz

1.2 Description of EUT

Model	Cue+
Power Supply	Internal rechargeable 3.7VDC 300mAh Lithium Ion battery
Modulation Type	FSK
Frequency Range	915 – 923 MHz
Antenna Type	Internal PCB trace

1.3 Test Facility

The open area test site and conducted measurement facility used to collect the radiated data is located at 360 Herndon Parkway, Suite 1400, Herndon, Virginia 20170. This site has been fully described in a report and approved by the Federal Communications Commission to perform AC line conducted and radiated emissions testing (ANSI C63.10 2013).

1.4 Related Submittal(s)/Grant(s)

This is an original application for certification for i1 SensorTech, Inc., Model Cue+; FCC ID: 2ADZF-D0002.

1.5 Modifications

No modifications were required for compliance.

2 Test Information

2.1 Description of Test Modes

In accordance with FCC 15.31(m), and because the EUT utilizes an operating band less than 10 MHz, the following frequencies were tested.

Table 2-1: Frequencies Tested

Channel	Frequency
Low	915
High	923

2.2 Exercising the EUT

The EUT was tested in all three orthogonal planes in order to determine worst-case emissions. The EUT was provided with software to transmit during testing. The carrier was also checked to verify that information was being transmitted. There were no deviations from the test standard(s) and/or methods. The test results reported relate only to the item tested.

2.3 Test Result Summary

Table 2-2: Test Result Summary – FCC Part 15, Subpart C (Section 15.247)

FCC Reference	C63.10 Procedure	Test	Pass/Fail or N/A
FCC 15.207	6.2	AC Power Conducted Emissions	Pass
FCC 15.209	11.12.1	Radiated Emissions	Pass
FCC 15.247(b)(3)	11.2	Maximum Peak Power Output	Pass
FCC 15.247(d)	6.7	Antenna Conducted Spurious Emissions	Pass
FCC 15.247(d)	6.10	Band Edge	Pass
FCC 15.247(a)(2)	11.8	6 dB Bandwidth	Pass
15.247(e)	11.10.2	Power Spectral Density	Pass

2.4 Test System Details

The test samples were received on July 20, 2021. The FCC identifiers for all applicable equipment, plus descriptions of all cables used in the tested system, are identified in the following tables.

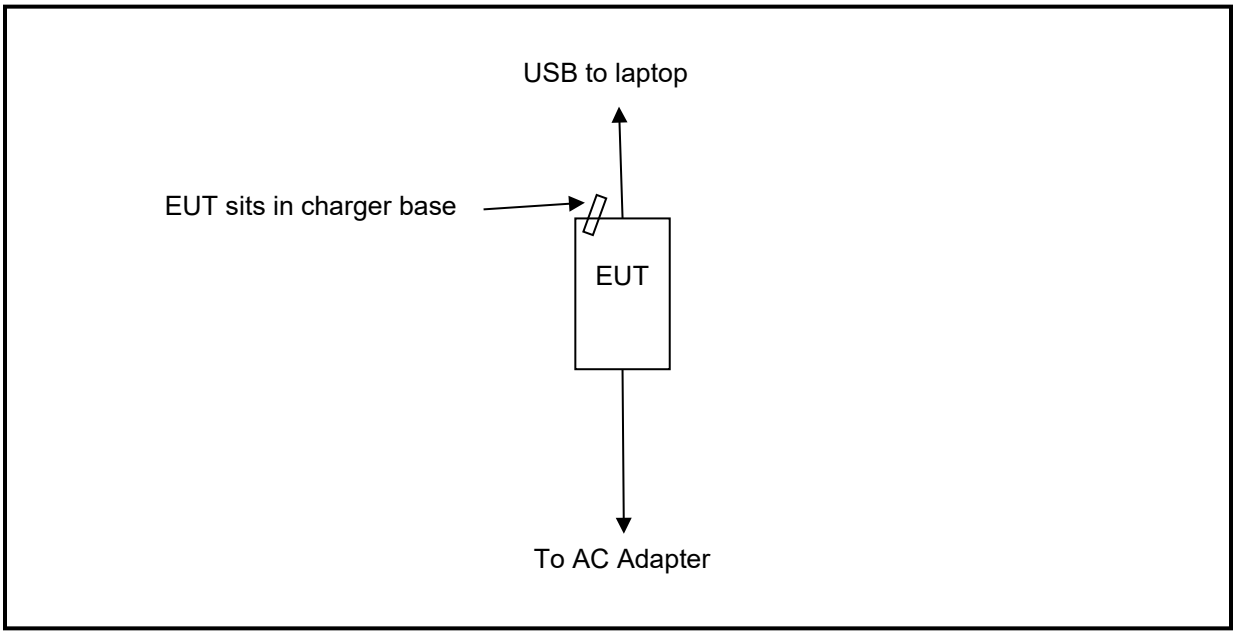
Table 2-3: Equipment Under Test

Part	Manufacturer	Model	Serial Number	FCC ID	RTL Bar Code
Transceiver (Antenna Adapter)	i1 SensorTech, Inc.	Cue+	N/A	2ADZF-D0002	23894
Transceiver	i1 SensorTech, Inc.	Cue+	N/A	2ADZF-D0002	23895

Table 2-4: Accessory Equipment

Part	Manufacturer	Model	Serial Number	FCC ID	RTL Bar Code
Charger Base	Athlete Intelligence	N/A	N/A	N/A	23896
AC Adapter, 5V DC	N/A	YU-0504	N/A	N/A	N/A

2.5 Configuration of Tested System



3 Maximum Conducted Output Power – FCC 15.247(b)(3)

3.1 Power Output Test Procedure

A conducted power measurement of the EUT was taken using a Rhode & Schwarz spectrum analyzer.

Procedure: C63.10-2013 11.2

Table 3-1: Power Output Test Equipment

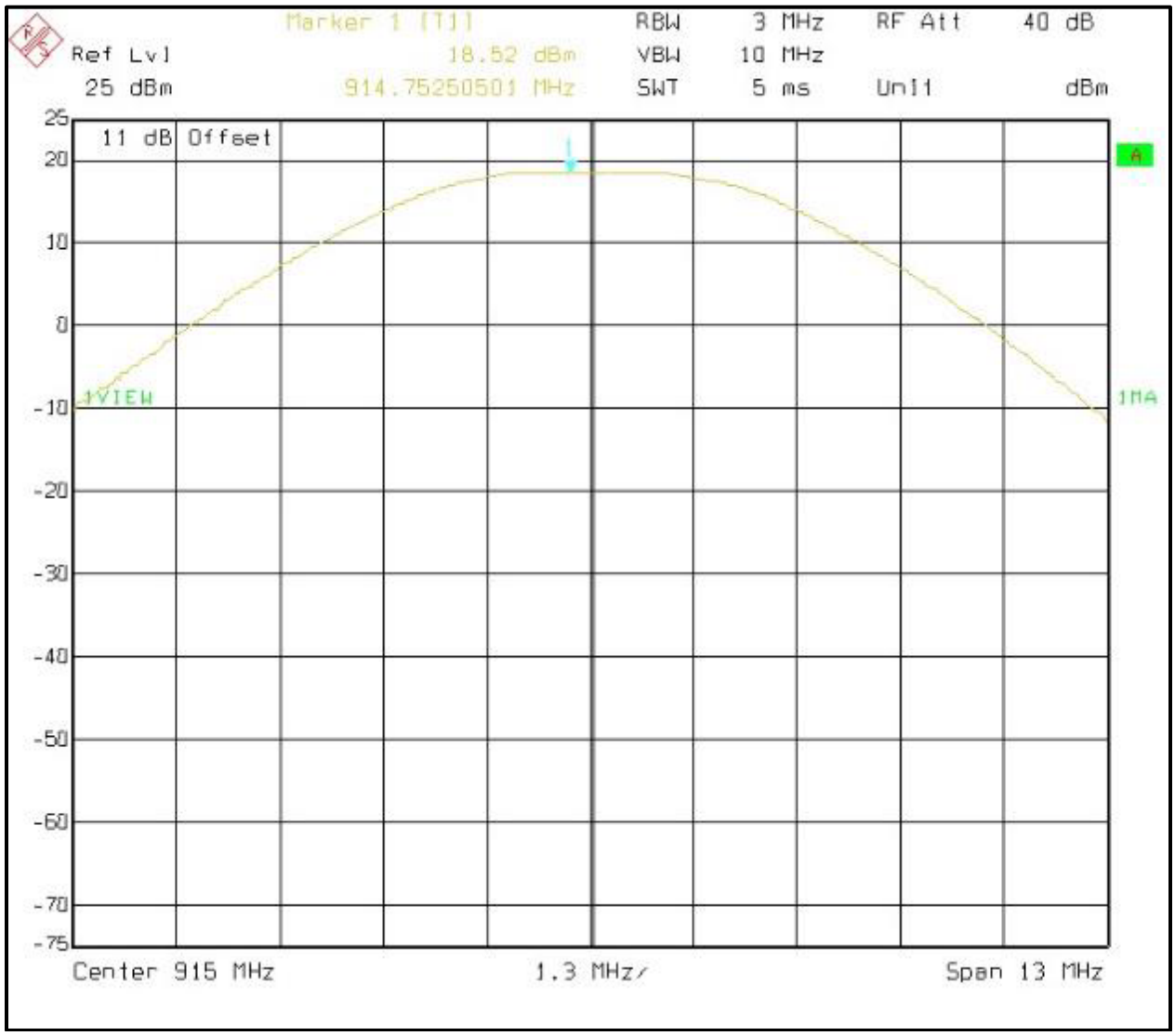
RTL Asset #	Manufacturer	Model	Part Type	Serial Number	Calibration Due Date
901672	Rohde & Schwarz	FSEM30	Spectrum Analyzer	FSEM30	04/25/22
901235	IW Microwave Products	KPS-1503-360-KPS	High Frequency 36” RF Cables	N/A	09/17/21
900819	Weinschel Corp	2	10 dB Attenuator; 5 W	BF0830	09/14/21

3.2 Power Output Test Data

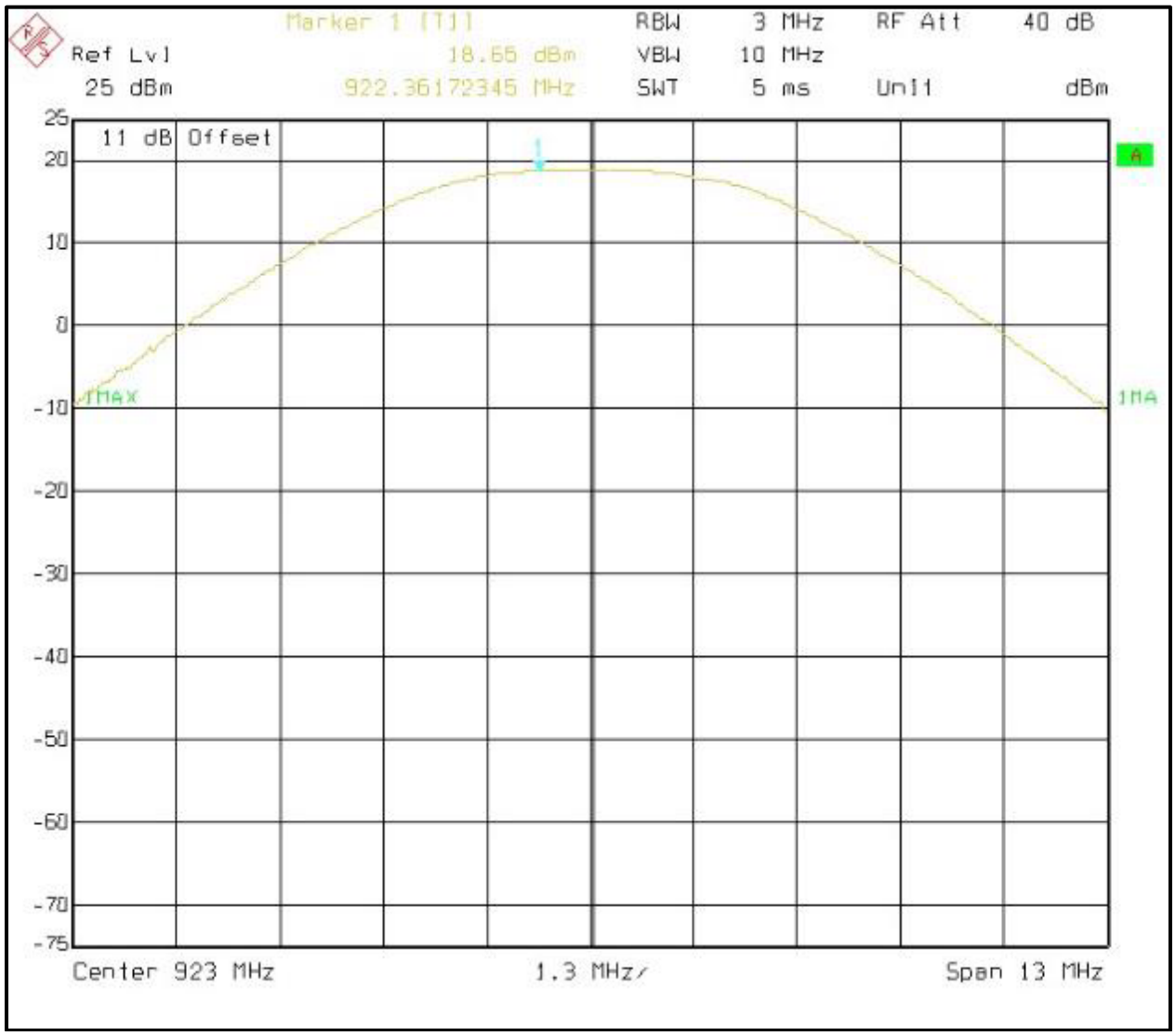
Table 3-2: Power Output Test Data

Frequency (MHz)	Conducted Power (dBm)
915	18.5
923	18.7

Plot 3-1: Maximum Conducted Output Power (915 MHz)



Plot 3-2: Maximum Conducted Output Power (923 MHz)



Measurement uncertainties shown for these tests are expanded Gaussian uncertainties expressed at 95% confidence level using a coverage factor k = 1.96. Measurement uncertainty = 0.5 dB.

Results: Pass

Test Personnel:

Daniel W. Baltzell		July 20, 2021
Test Engineer	Signature	Date of Test

4 Band Edge Compliance of RF Conducted Emissions – FCC 15.247(d)

4.1 Band Edge Test Procedure

Procedure: C63.10-2013 6.10 Peak detection

The EUT was connected to the spectrum analyzer through suitable attenuation. The spectrum analyzer was set to the following:

Center Frequency:	Frequency of the emissions to be measured
Span:	Able to see emission
RBW:	100 kHz
VBW:	3 x RBW
Detector:	Peak
Sweep:	Auto
Trace:	Max Hold

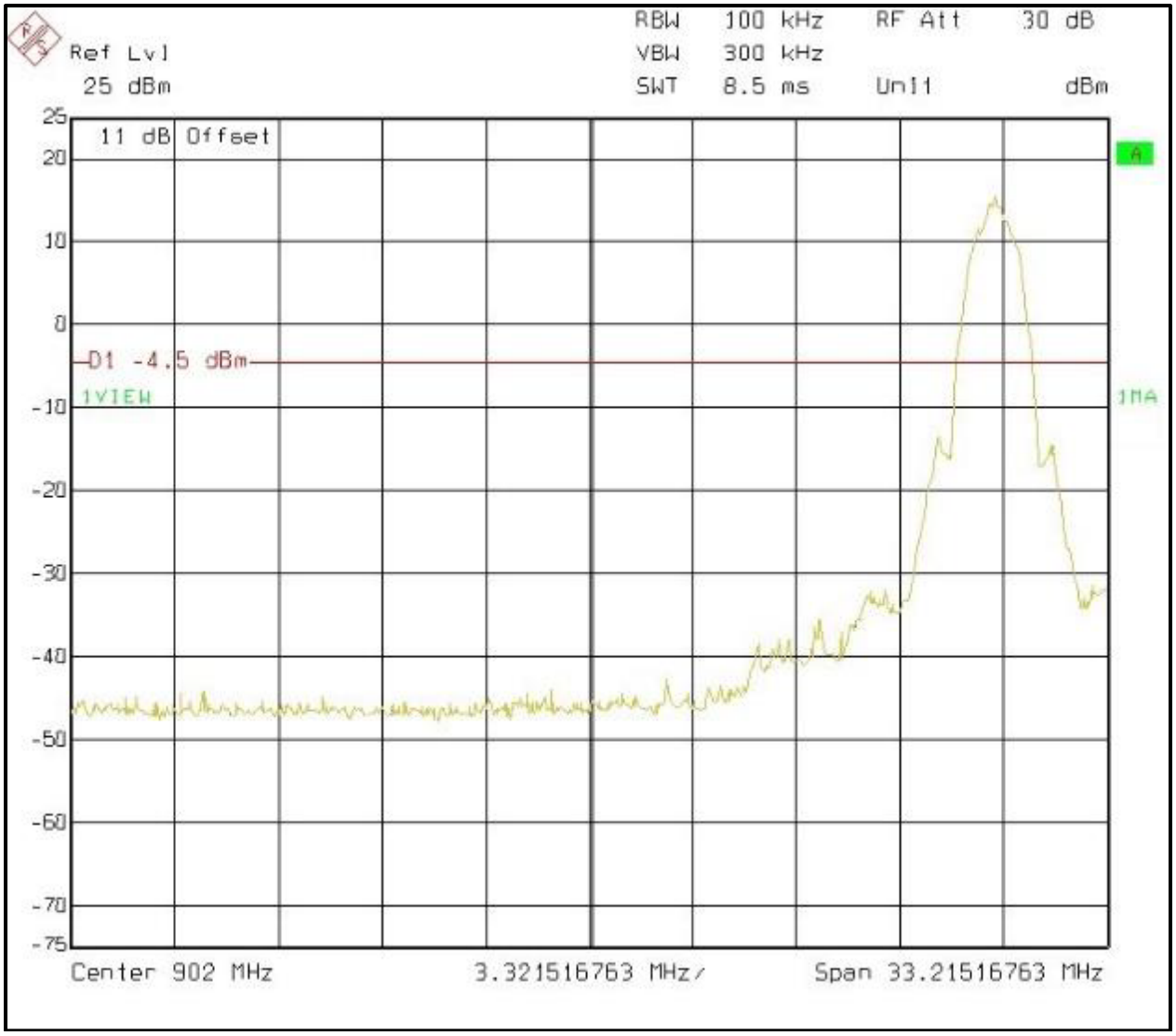
The trace was allowed to stabilize. The marker was set on the emission. The amplitude of the fundamental was used to establish the 20 dB to the band edge limit, the 20 dBc requirement of 15.247(d).

Table 4-1: Test Equipment

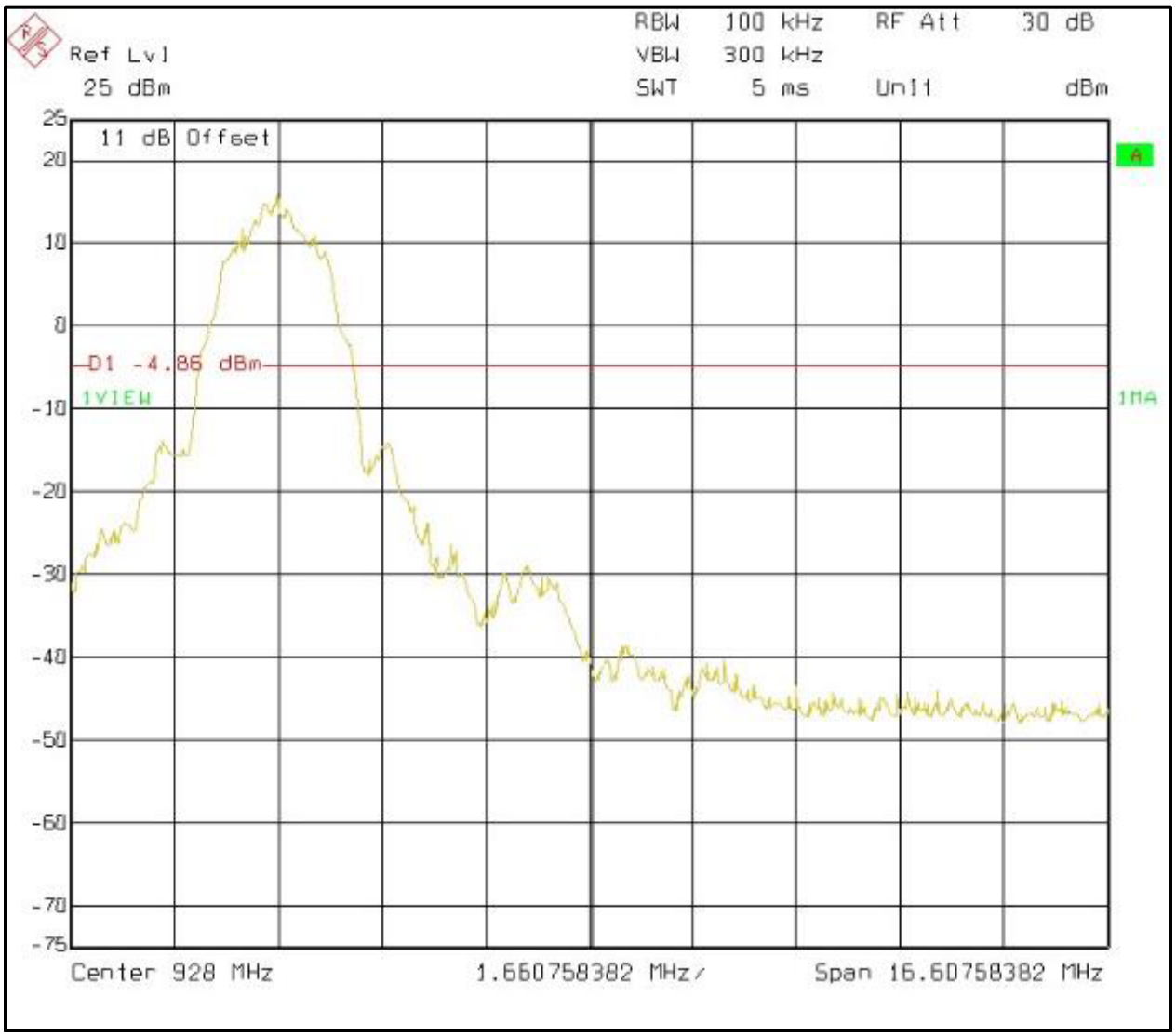
RTL Asset #	Manufacturer	Model	Part Type	Serial Number	Calibration Due Date
901672	Rohde & Schwarz	FSEM30	Spectrum Analyzer	FSEM30	04/25/22
901235	IW Microwave Products	KPS-1503-360-KPS	High Frequency 36” RF Cables	N/A	09/17/21
900819	Weinschel Corp	2	10 dB Attenuator; 5 W	BF0830	09/14/21

4.2 Test Results

Plot 4-1: Lower Band Edge (902 MHz Band Edge, 915 MHz Carrier)



Plot 4-2: Upper Band Edge (928 MHz Band Edge, 923 MHz Carrier)



Measurement uncertainties shown for these tests are expanded Gaussian uncertainties expressed at 95% confidence level using a coverage factor k = 1.96. Measurement uncertainty = 0.5 dB.

Results: Pass

Test Personnel:

Daniel W. Baltzell		July 29, 2021
Test Engineer	Signature	Date of Test

5 Antenna Conducted Spurious Emissions – FCC 15.247(d)

5.1 Antenna Conducted Spurious Emissions Test Procedures

Procedure: C63.10-2013 6.7, 11.11

Antenna spurious emissions per FCC 15.247(d) were measured from the EUT antenna port using a 50-ohm spectrum analyzer with the resolution bandwidth set at 100 kHz, and the video bandwidth set at 300 kHz. The modulated carrier was identified at the following frequencies: 915 MHz and 923 MHz. The carrier to the 10^{th} harmonic of the carrier frequency was investigated.

Table 5-1: Antenna Conducted Spurious Emissions Test Equipment

RTL Asset #	Manufacturer	Model	Part Type	Serial Number	Calibration Due Date
901773	Rohde & Schwarz	FSW50	Spectrum Analyzer	101021	08/16/22
901772	Pasternack	PE7087-10	10 dB Attenuator; 2 W	1011	08/10/22

5.2 Antenna Conducted Spurious Emissions Test Results

All spurious emissions were below the limit. Frequencies less than 20 dB below the limit are shown in the table following the plot.

Plot 5-1: Antenna Conducted Spurious Emissions (915 MHz)

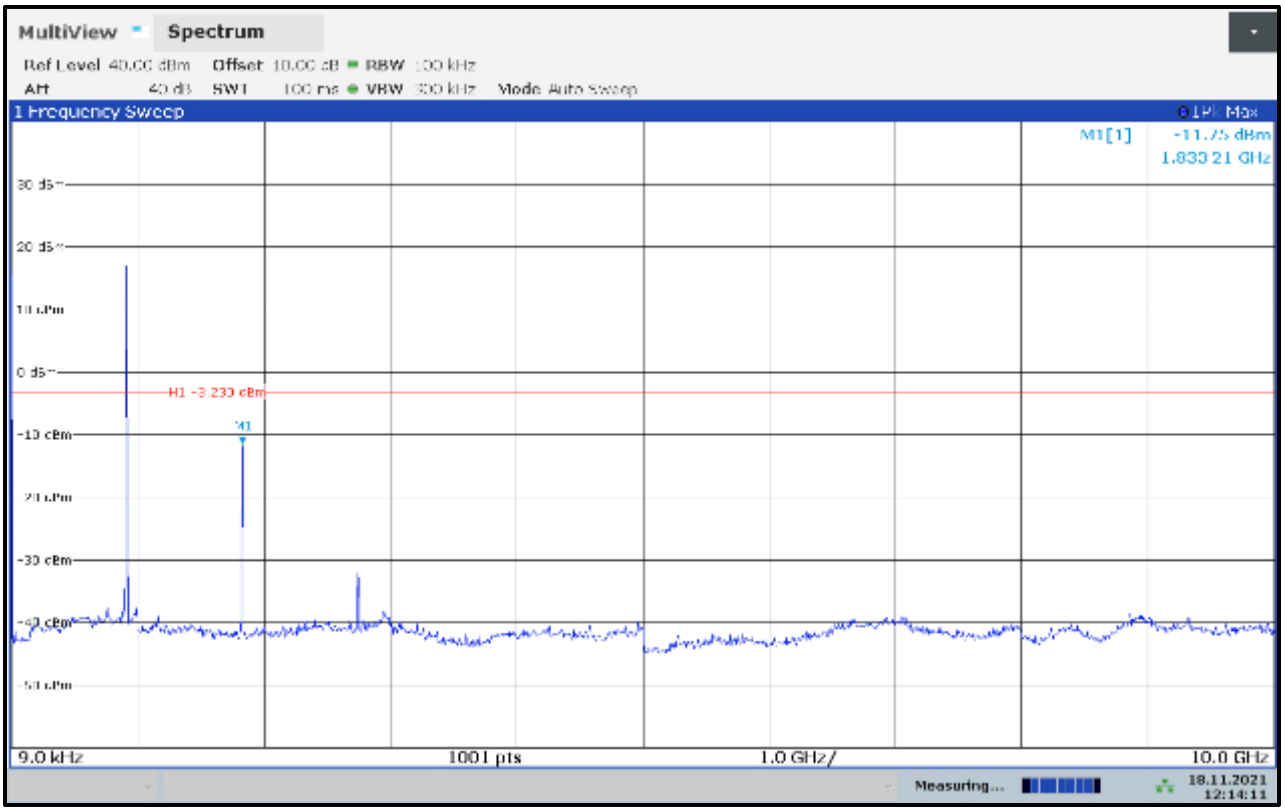


Table 5-2: Conducted Spurious Emissions (915 MHz)

Emission Frequency (MHz)	Analyzer Level (dBm)	Limit (dBuV/m)	Margin (dB)
1830	-11.8	-3.2	-8.6

Plot 5-2: Antenna Conducted Spurious Emissions (923 MHz)

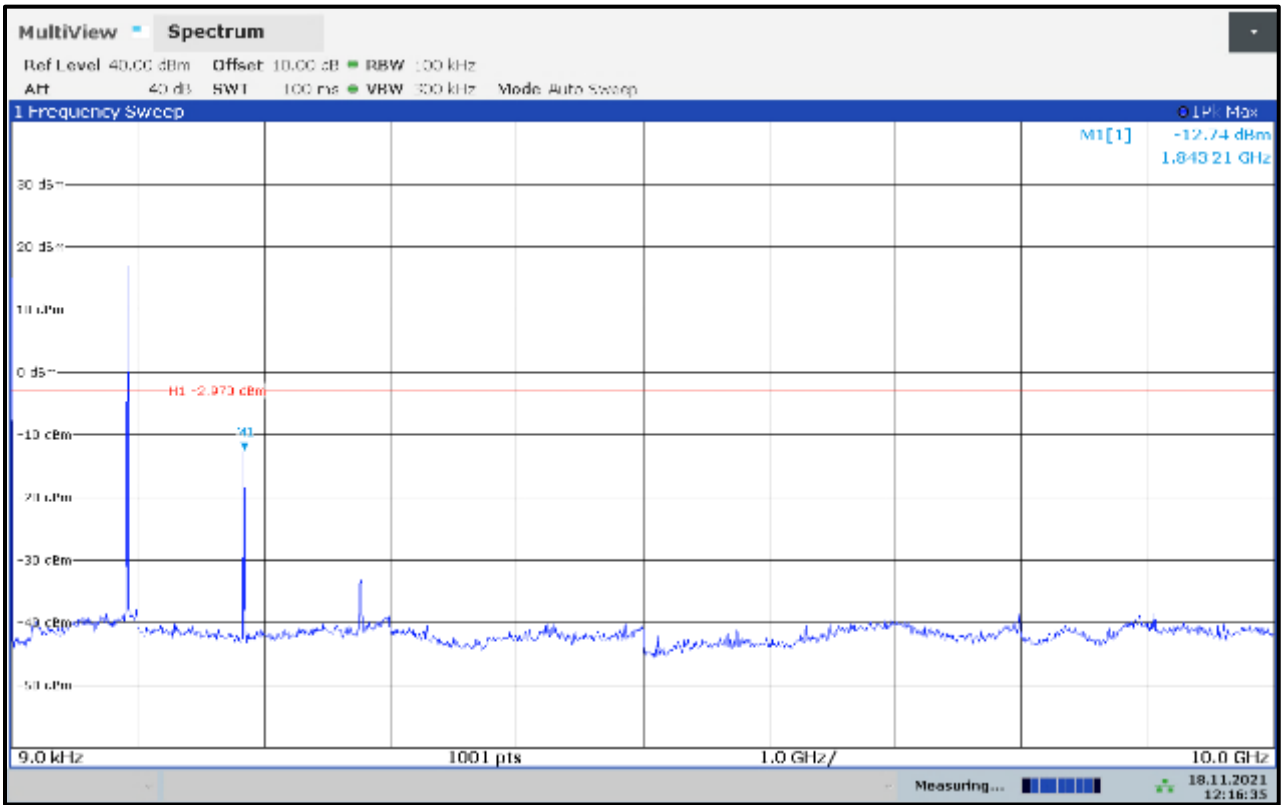


Table 5-3: Conducted Spurious Emissions (923 MHz)

Emission Frequency (MHz)	Analyzer Level (dBm)	Limit (dBuV/m)	Margin (dB)
1846	-12.7	-3.0	-9.7

Measurement uncertainties shown for these tests are expanded uncertainties expressed at 95% confidence level using a coverage factor k = 2. Measurement uncertainty: ±0.8 dB.

Results: Pass

Test Personnel:

Daniel W. Baltzell		November 18, 2021
Test Engineer	Signature	Date of Test

6 6 dB Bandwidth – FCC 15.247(a)(2)

6.1 6 dB Bandwidth Test Procedure

Procedure: C63.10-2013 11.8.

The minimum 6 dB bandwidths per FCC 15.247(a)(2) were measured using a 50-ohm spectrum analyzer with the resolution bandwidth set at 100 kHz, and the video bandwidth set at 300 kHz. The device was modulated. The minimum 6 dB bandwidths are presented below.

Table 6-1: 6 dB Bandwidth Test Equipment

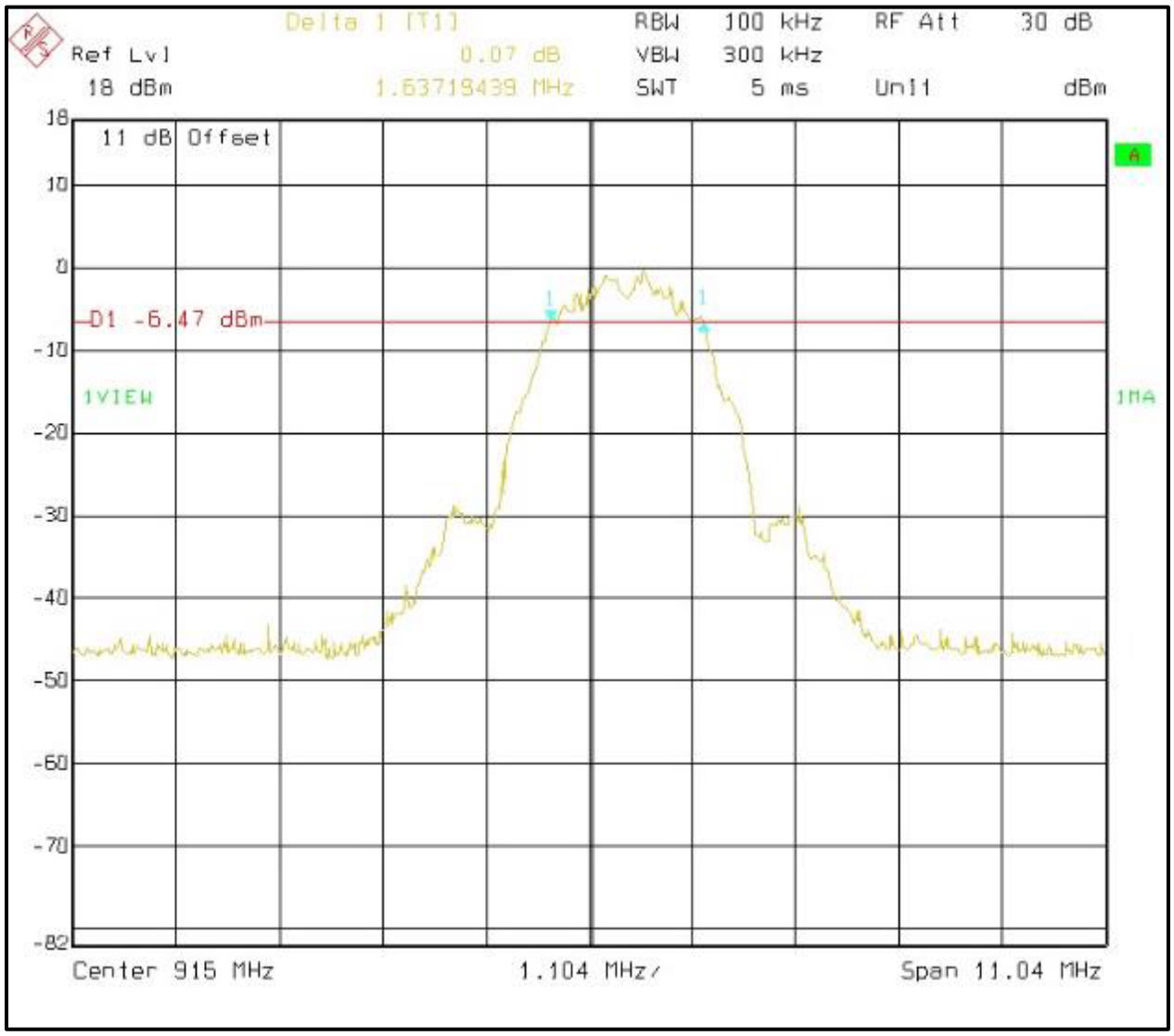
RTL Asset #	Manufacturer	Model	Part Type	Serial Number	Calibration Due Date
901672	Rohde & Schwarz	FSEM30	Spectrum Analyzer	FSEM30	04/25/22
901235	IW Microwave Products	KPS-1503-360-KPS	High Frequency 36” RF Cables	N/A	09/17/21
900819	Weinschel Corp	2	10 dB Attenuator; 5 W	BF0830	09/14/21

6.2 Bandwidth Test Results

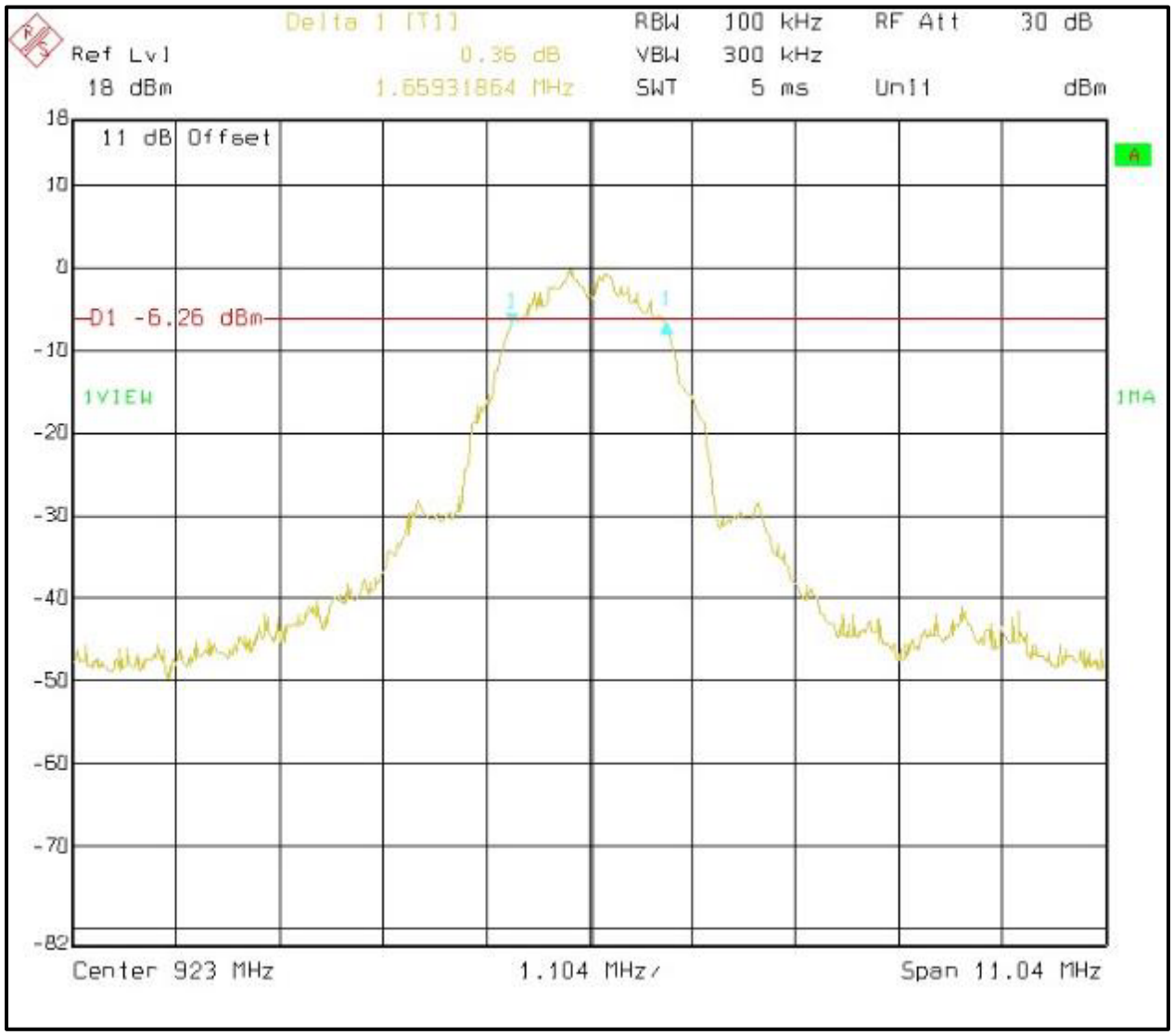
Table 6-2: 6 dB Bandwidth Test Data

Frequency (MHz)	Bandwidth (kHz)	Minimum Limit (kHz)	Pass/Fail
915	1637	500	Pass
923	1659	500	Pass

Plot 6-1: 6 dB Bandwidth – 915 MHz



Plot 6-2: 6 dB Bandwidth – 923 MHz



Measurement uncertainties shown for these tests are expanded Gaussian uncertainties expressed at 95% confidence level using a coverage factor k = 1.96. Measurement uncertainty = 12 Hz.

Results: Pass

Test Personnel:

Daniel W. Baltzell		August 3, 2021
Test Engineer	Signature	Date of Test

7 Power Spectral Density – FCC 15.247(e)

7.1 Power Spectral Density Test Procedure

Procedure: C63.10-2013 11.10.2 Peak PSD

The power spectral density per FCC 15.247(e) was measured using a 50-ohm spectrum analyzer with the resolution bandwidth set at 3 kHz and the video bandwidth set at 10 kHz. Peak detector and max hold were used to resolve the spectral density for the modulated carriers at 915 and 923 MHz. These levels are below the +8 dBm limit. See the power spectral density table and plots that follow.

Table 7-1: Power Spectral Density Test Equipment

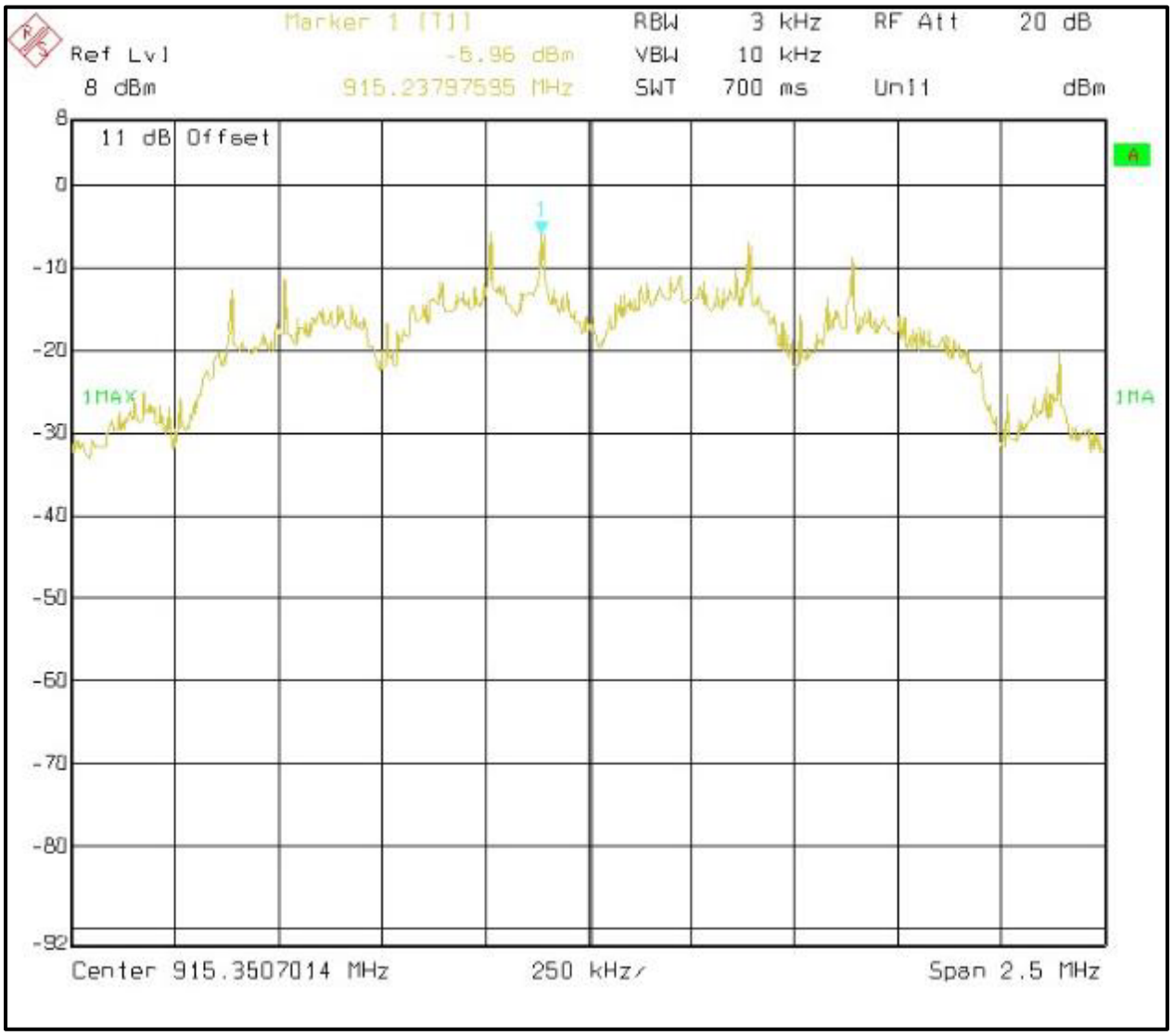
RTL Asset #	Manufacturer	Model	Part Type	Serial Number	Calibration Due Date
901672	Rohde & Schwarz	FSEM30	Spectrum Analyzer	FSEM30	04/25/22
901235	IW Microwave Products	KPS-1503-360-KPS	High Frequency 36” RF Cables	N/A	09/17/21
900819	Weinschel Corp	2	10 dB Attenuator; 5 W	BF0830	09/14/21

7.2 Power Spectral Density Test Data

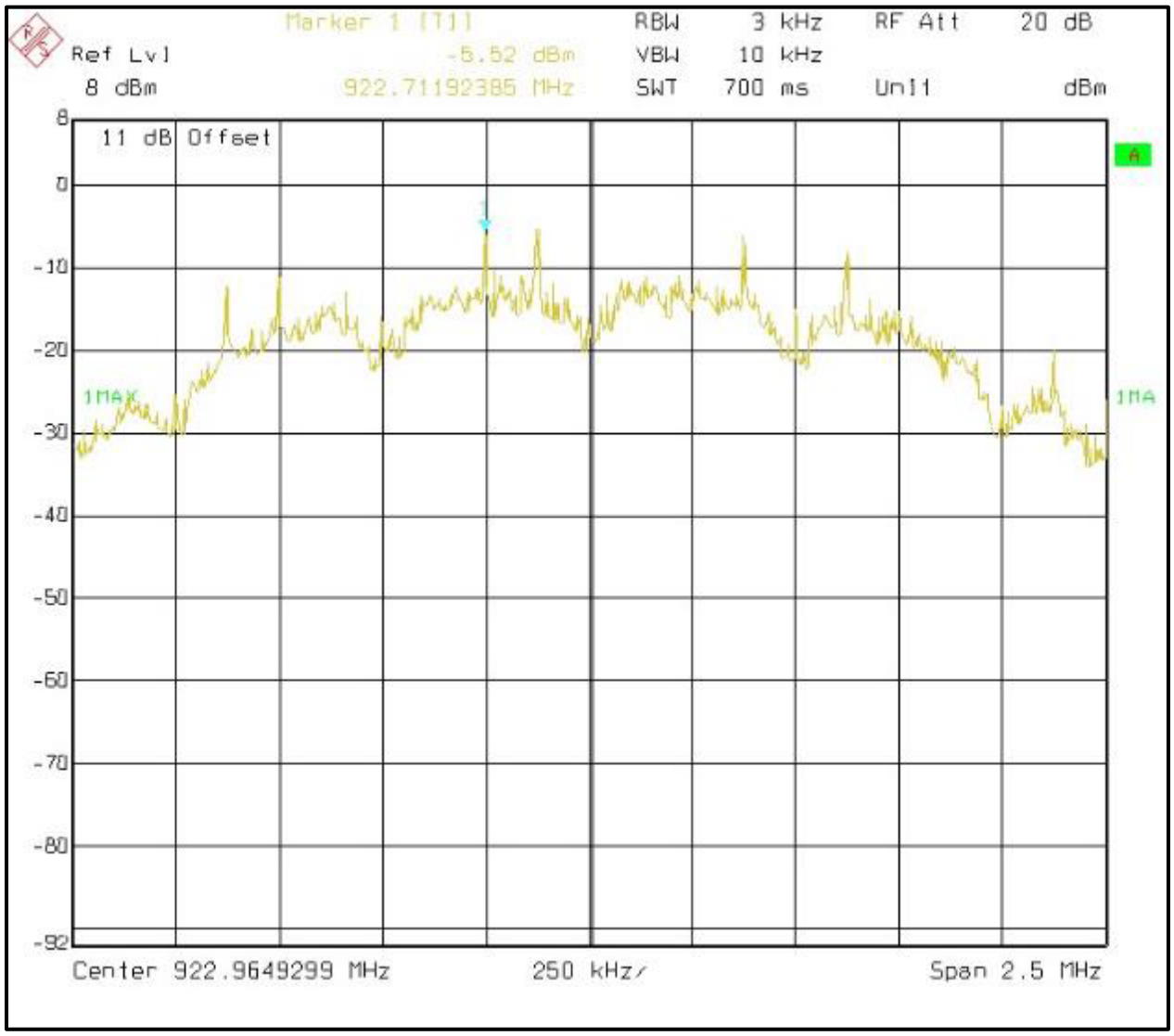
Table 7-2: Power Spectral Density Test Data

Frequency (MHz)	RF Power Level (dBm)	Maximum Limit +8 dBm	Pass/Fail
915	-6.0	8	Pass
923	-5.5	8	Pass

Plot 7-1: Power Spectral Density – 915 MHz



Plot 7-2: Power Spectral Density – 923 MHz



Measurement uncertainties shown for these tests are expanded Gaussian uncertainties expressed at 95% confidence level using a coverage factor k = 1.96. Measurement uncertainty = 0.5 dB.

Results: Pass

Test Personnel:

Daniel W. Baltzell		August 3, 2021
Test Engineer	Signature	Date of Test

8 Conducted Emissions Measurement Limits – FCC 15.207

8.1 Limits of Conducted Emissions Measurement

Frequency of Emission (MHz)	Conducted Limit (dBuV)	
	Quasi-peak	Average
0.15-0.5	66-56	56-46
0.5-5.0	56	46
5.0-30.0	60	50

8.2 Conducted Emissions Measurement Test Procedure

Procedure: C63.10-2009 6.2

The power line conducted emission measurements were performed in a Series 81 type shielded enclosure manufactured by Rayproof. The EUT was assembled on a wooden table 80 centimeters high. Power was fed to the EUT through a 50-ohm / 50 micro Henry Line Impedance Stabilization Network (EUT LISN). The EUT LISN was fed power through an A.C. filter box on the outside of the shielded enclosure. The filter box and EUT LISN housing are bonded to the ground plane of the shielded enclosure. A second LISN, the peripheral LISN, provides isolation for the EUT test peripherals. This peripheral LISN was also fed A.C. power. A metal power outlet box, which is bonded to the ground plane and electrically connected to the peripheral LISN, powers the EUT host peripherals.

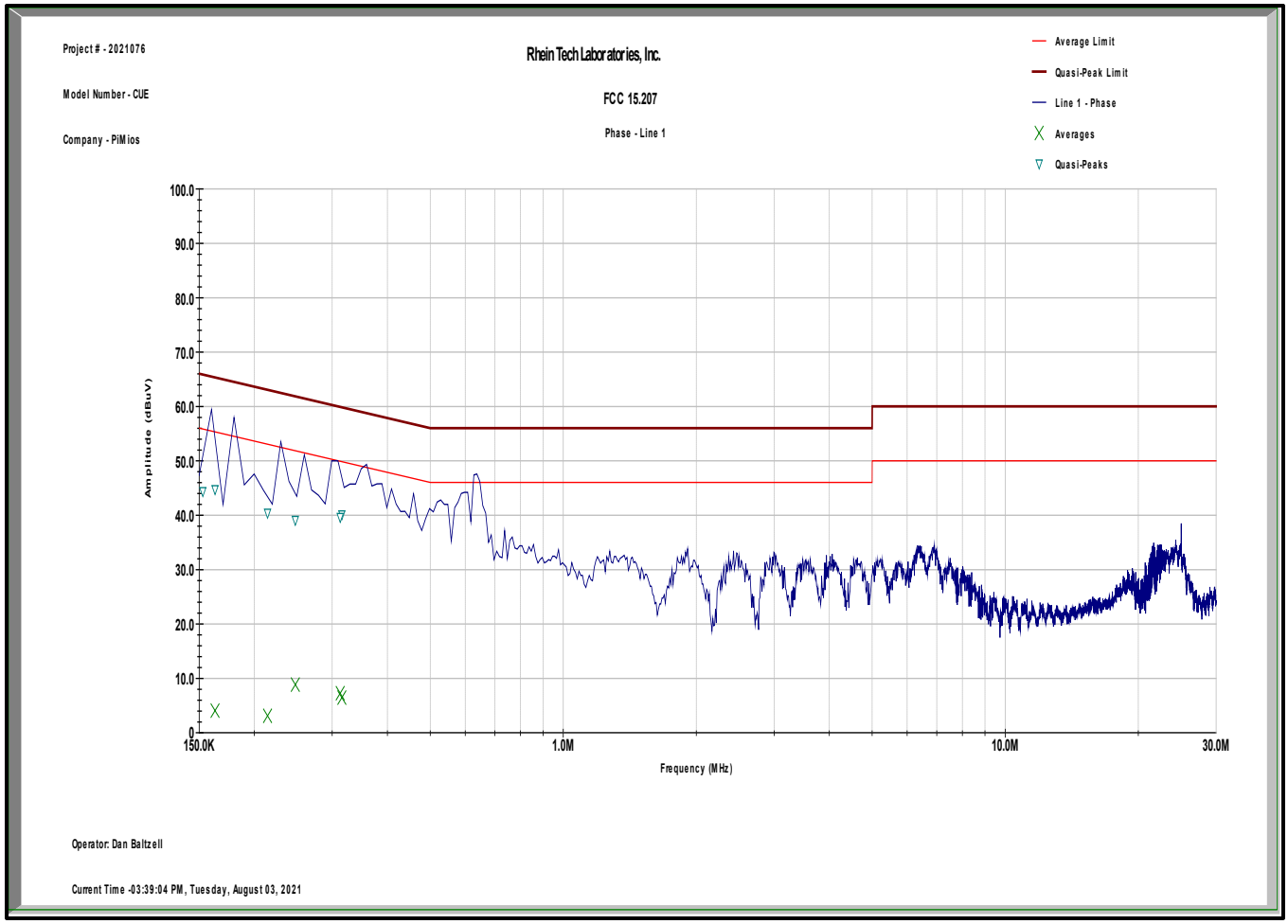
The spectrum analyzer was connected to the A.C. line through an isolation transformer. The 50-ohm output of the EUT LISN was connected to the spectrum analyzer input. Conducted emission levels were measured on each current-carrying line with the spectrum analyzer operating in the CISPR quasi-peak mode (or peak mode if applicable). The analyzer's 6 dB bandwidth was set to 9 kHz. No video filter less than 10 times the resolution bandwidth was used. Average measurements are performed in linear mode using a 10 kHz resolution bandwidth, a 1 Hz video bandwidth, and by increasing the sweep time in order to obtain a calibrated measurement. The emission spectrum was scanned from 150 kHz to 30 MHz. The highest emission amplitudes relative to the appropriate limit were measured and have been recorded in this report.

Table 8-1: Conducted Emissions Test Equipment

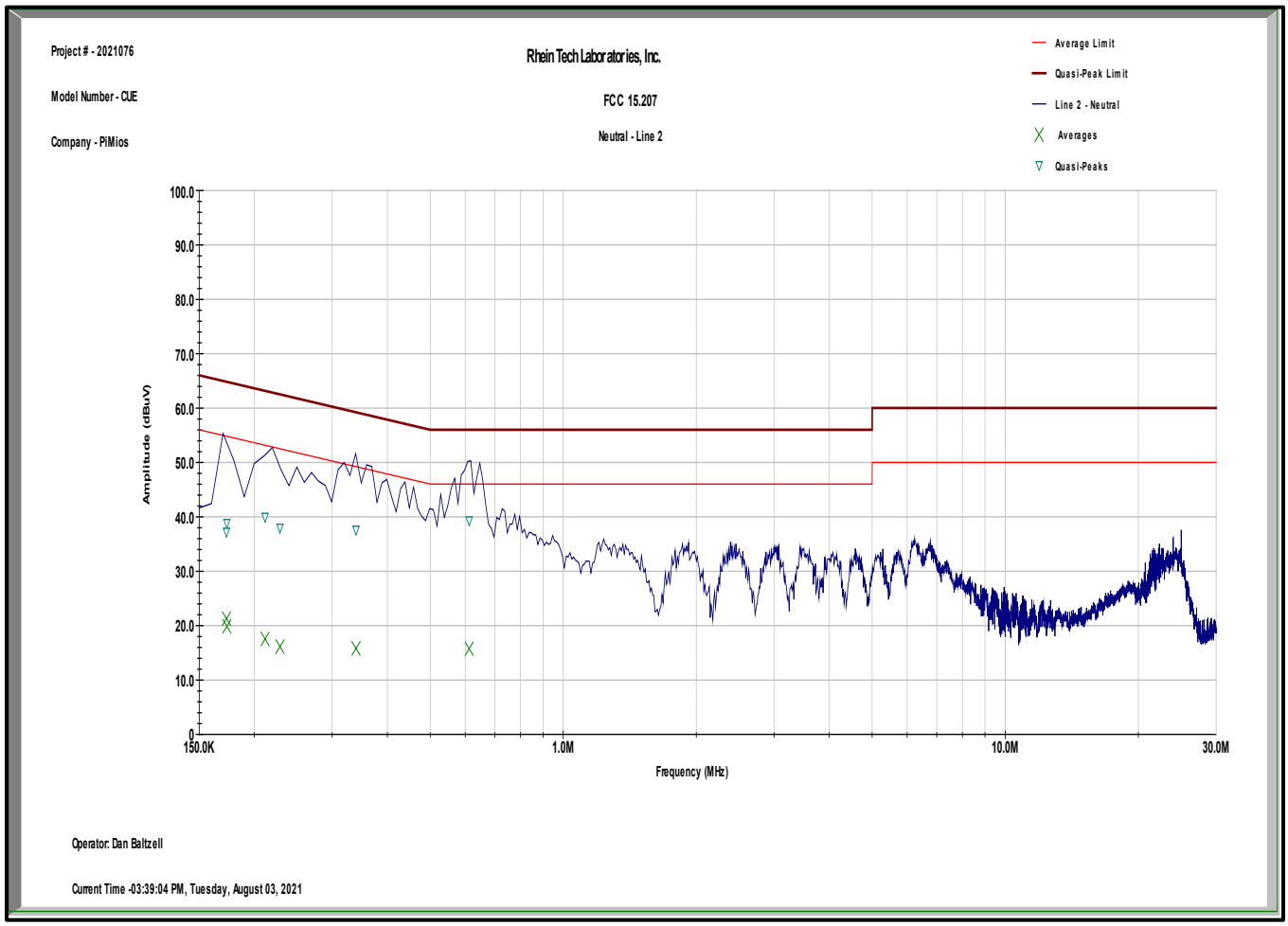
RTL Asset #	Manufacturer	Model	Part Type	Serial Number	Calibration Due Date
901083	AFJ International	LS16	16A LISN (110 V)	16010020080	02/14/23
900930	Hewlett Packard	85662A	Spectrum Analyzer Display Section	3144A20839	02/26/23
900931	Hewlett Packard	8566B	Spectrum Analyzer (100 Hz - 22 GHz)	3138A07771	02/26/23
900728	Solar	8130	Filter	947305	04/30/23
900339	Hewlett Packard	85650A	Quasi-Peak Adapter (30 Hz - 1 GHz)	2521A00743	04/24/22

8.3 Conducted Line Emissions Test Data

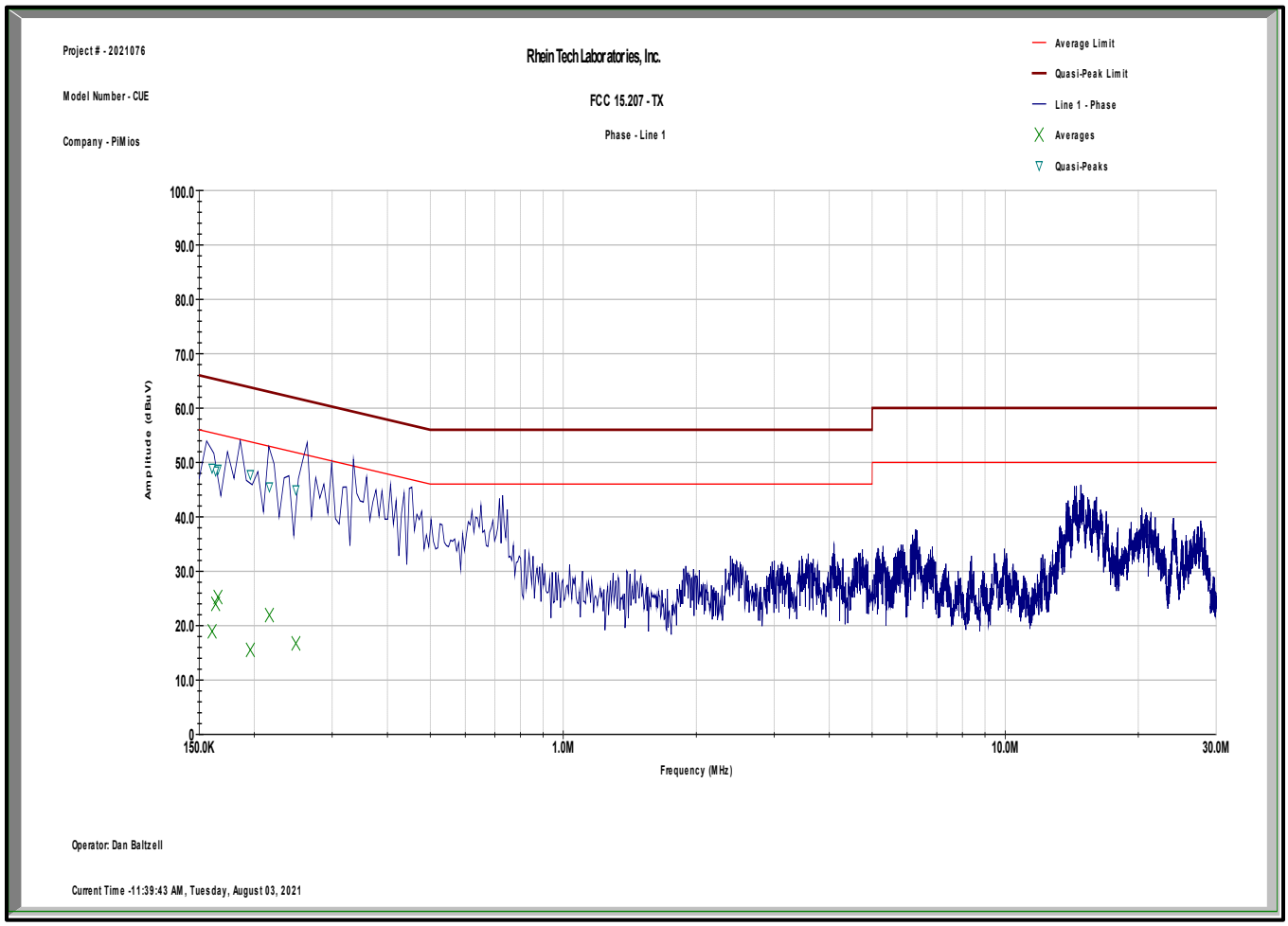
Plot 8-1: Conducted Line Emissions – Phase – Receive Mode



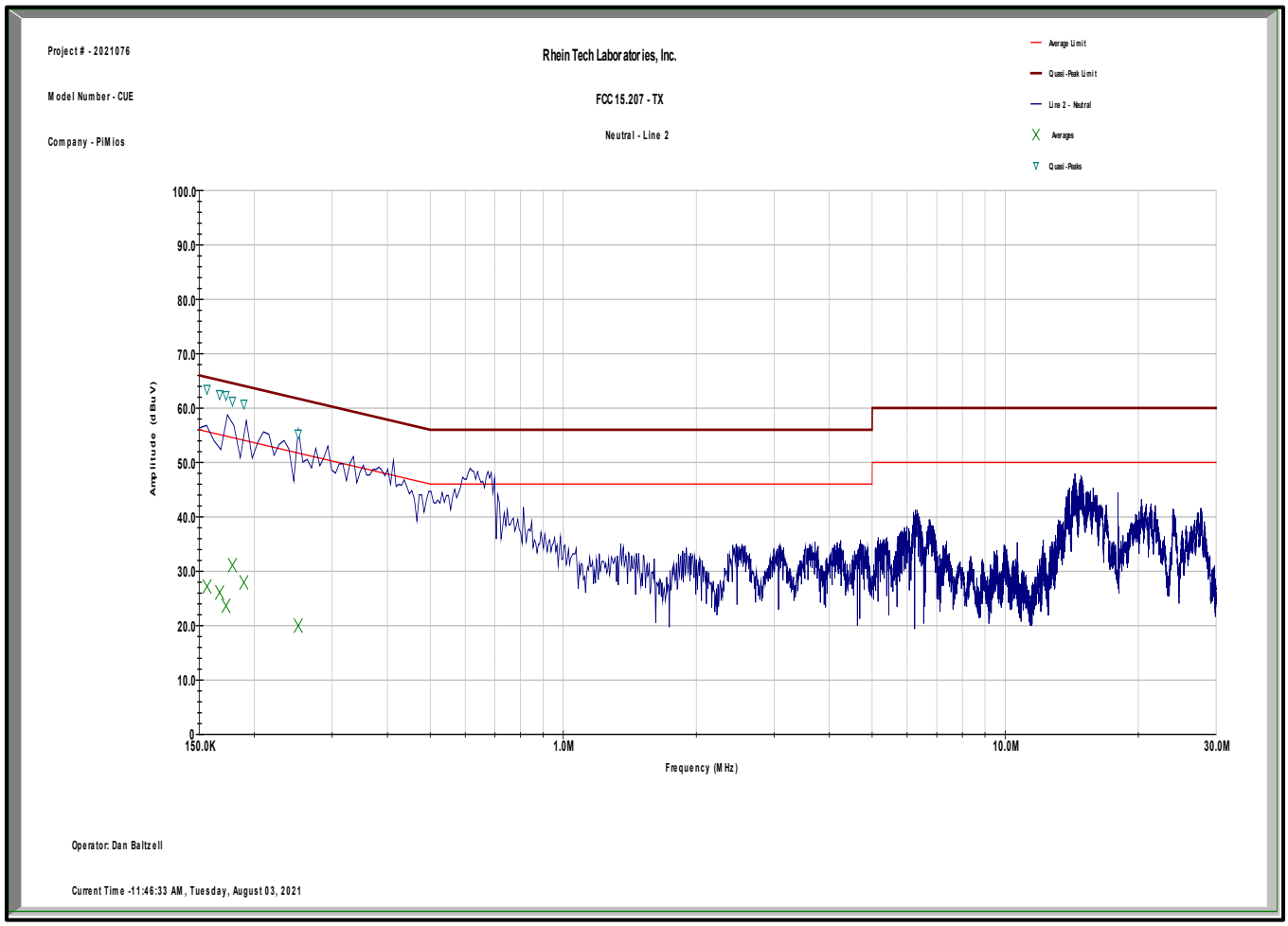
Plot 8-2: Conducted Line Emissions – Neutral – Receive Mode



Plot 8-3: Conducted Line Emissions – Phase – Transmit Mode



Plot 8-4: Conducted Line Emissions – Neutral – Transmit Mode



Measurement uncertainty: Measurement uncertainties shown for these tests are expanded uncertainties expressed at 95% confidence level using a coverage factor k = 2. Measurement uncertainty: ±3.6 dB.

Results: Pass

Test Personnel:

Daniel W. Baltzell		August 3, 2021
EMC Test Engineer	Signature	Date of Test

9 Radiated Emissions – FCC 15.209

9.1 Limits of Radiated Emissions Measurement

Frequency (MHz)	Field Strength (uV/m)	Measurement Distance (m)
0.009-0.490	2400/f (kHz)	300
0.490-1.705	24000/f (kHz)	30
1.705-30.0	30	30
30-88	100	3
88-216	150	3
216-960	200	3
Above 960	500	3

As shown in 15.35(b), for frequencies above 1000 MHz, the field strength limits are based on average detector, however, the peak field strength of any emission shall not exceed the maximum permitted average limits, specified above by more than 20 dB under any circumstances of modulation.

9.2 Radiated Emissions Measurement Test Procedure

Procedure: C63.10-2013 11.12.1

Before final measurements of radiated emissions were made on the open-field three/ten meter range, the EUT was scanned indoors at one and three meter distances. This was done in order to determine its emissions spectrum signature. The physical arrangement of the test system and associated cabling was varied in order to determine the effect on the EUT's emissions in amplitude, direction and frequency. This process was repeated during final radiated emissions measurements on the open-field range, at each frequency, in order to ensure that maximum emission amplitudes were attained.

Final radiated emissions measurements were made on the three/ten-meter, open-field test site. The EUT was placed on a nonconductive turntable 0.8 meters above the ground plane. The spectrum was examined from 9 kHz to the 10^{th} harmonic of the highest fundamental transmitter frequency (9 GHz).

At each frequency, the EUT was rotated 360°, and the antenna was raised and lowered from 1 to 4 meters in order to determine the emission's maximum level. Measurements were taken using both horizontal and vertical antenna polarizations. For frequencies between 30 and 1000 MHz, the spectrum analyzer's 6 dB bandwidth was set to 120 kHz, and the analyzer was operated in the CISPR quasi-peak detection mode. For emissions above 1,000 MHz, emissions are measured using the average detector function with a minimum resolution bandwidth of 1 MHz. No video filter less than 10 times the resolution bandwidth was used. The highest emission amplitudes relative to the appropriate limit were measured and recorded in this report.

Table 9-1: Radiated Emissions Test Equipment

RTL Asset #	Manufacturer	Model	Part Type	Serial Number	Calibration Due Date
900878	Rhein Tech Laboratories, Inc.	AM3-1197-0005	3 meter Antenna Mast, polarizing	Outdoor Range 1	N/A
901235	IW Microwave Products	KPS-1503-360-KPS	High Frequency 36" RF Cables	N/A	09/17/21
901729	Insulated Wire Inc.	KPS-1503-3150-KPR	SMK RF Cables 20'	NA	10/29/21
901242	Rhein Tech Laboratories, Inc.	WRT-000-0003	Wood rotating table	N/A	N/A
901672	Rohde & Schwarz	FSEM30	Spectrum Analyzer	FSEM30	04/25/22
901669	ETS-Lindgren	3142E	Biconilog Antenna (30 MHz – 6000 MHz)	00166065	04/24/22
900932	Hewlett Packard	8449B OPT H02	Preamplifier (1 - 26.5 GHz)	3008A00505	02/16/22
900772	EMCO	3161-02	Horn Antenna (2 - 4 GHz)	9804-1044	05/17/22
900321	EMCO	3161-03	Horn Antennas (4.0 – 8.2 GHz)	9508-1020	05/17/22
900323	EMCO	3160-7	Horn Antennas (8.2 – 12.4 GHz)	9605-1054	05/17/22
901128	Par Electronics	806-902 (25W)	UHF Notch Filter	N/A	09/14/21
901132	Par Electronics	806-902 (25W)	UHF Notch Filter	N/A	09/14/21

9.3 Radiated Emissions Test Results

9.3.1 Radiated Emissions Unintentional

Table 9-2: Radiated Emissions Unintentional

Emission Frequency (MHz)	Analyzer Detector (QP/AV)	Analyzer Level (dBuV) (1 MHz RBW/ 3 MHz VBW)	Site Correction Factor (dB/m)	Corrected Analyzer Level (dBuV/m)	Limit (dBuV/m)	Margin (dB)
100.000	QP	59.0	-27.4	31.6	43.5	-11.9
232.610	QP	50.2	-23.0	27.2	46.0	-18.8
233.927	QP	50.0	-22.8	27.2	46.0	-18.8
790.490	QP	50.0	-10.3	39.7	46.0	-6.3
853.450	QP	43.7	-10.3	33.4	46.0	-12.6
895.430	QP	36.9	-9.2	27.7	46.0	-18.3
923.401	QP	34.5	-8.2	26.3	46.0	-19.7
926.902	QP	35.1	-8.2	26.9	46.0	-19.1
1374.270	AV	44.3	-4.0	40.3	54.0	-13.7
1378.989	AV	43.4	-4.1	39.3	54.0	-14.7
1381.285	AV	45.3	-4.2	41.1	54.0	-12.9
1399.036	AV	39.6	-4.3	35.3	54.0	-18.7

9.3.2 Radiated Emissions Harmonics/Spurious

Table 9-3: Peak Radiated Emissions Harmonics/Spurious TX Frequency; 915 MHz

Emission Frequency (MHz)	Peak Detector Level (dBuV) (1 MHz RBW/ 3 MHz VBW)	Site Correction Factor (dB/m)	Peak Emission Level (dBuV/m)	Peak Limit (dBuV/m)	Peak Margin (dB)
2745.0	71.0	-8.8	62.2	74.0	-11.8
3660.0	65.0	-6.0	59.0	74.0	-15.0
4575.0	59.9	0.0	59.9	74.0	-14.1
7320.0	51.2	2.8	54.0	74.0	-20.0
8235.0	48.3	8.5	56.8	74.0	-17.2
9150.0	46.9	7.4	54.3	74.0	-19.7

Table 9-4: Average Radiated Emissions Harmonics/Spurious TX Frequency; 915 MHz

Emission Frequency (MHz)	Average Detector Level (dBuV)	Site Correction Factor (dB/m)	Average Emission Level (dBuV/m)	Average Limit (dBuV/m)	Average Margin (dB)
2745.0	45.9	1.9	47.8	54.0	-6.2
3660.0	44.1	5.0	49.1	54.0	-4.9
4575.0	27.5	7.6	35.1	54.0	-18.9
7320.0	29.7	10.8	40.5	54.0	-13.5
8235.0	31.8	11.1	42.9	54.0	-11.1
9150.0	27.9	10.8	38.7	54.0	-15.3

Table 9-5: Peak Radiated Emissions Harmonics/Spurious TX Frequency; 923 MHz

Emission Frequency (MHz)	Peak Detector Level (dBuV) (1 MHz RBW/ 3 MHz VBW)	Site Correction Factor (dB/m)	Peak Emission Level (dBuV/m)	Peak Limit (dBuV/m)	Peak Margin (dB)
2769.0	70.7	-8.8	61.9	74.0	-12.1
3692.0	65.9	-5.8	60.1	74.0	-13.9
4615.0	63.0	0.0	63.0	74.0	-11.0
7384.0	50.8	2.9	53.7	74.0	-20.3
8307.0	43.7	8.5	52.2	74.0	-21.8

Table 9-6: Average Radiated Emissions Harmonics/Spurious TX Frequency; 923 MHz

Emission Frequency (MHz)	Average Detector Level (dBuV)	Site Correction Factor (dB/m)	Average Emission Level (dBuV/m)	Average Limit (dBuV/m)	Average Margin (dB)
2769.0	39.9	1.8	41.7	54.0	-12.3
3692.0	44.1	5.2	49.3	54.0	-4.7
4615.0	23.7	7.7	31.4	54.0	-22.6
7384.0	29.7	10.7	40.4	54.0	-13.6
8307.0	31.8	11.2	43.0	54.0	-11.0

Measurement uncertainty: Measurement uncertainties shown for these tests are expanded uncertainties expressed at 95% confidence level using a coverage factor k = 2. Measurement uncertainty: ±4.6 dB

Results: Pass

Test Personnel:

Daniel W. Baltzell		July 27 - August 6, 2021
EMC Test Engineer	Signature	Dates of Test

10 Conclusion

The data in this measurement report shows the i1 SensorTech, Inc. Model Cue+, FCC ID: 2ADZF-D0002, complies with the applicable requirements of Parts 2 and 15 of the FCC rules and regulations.