F2 Labs
16740 Peters Road
Middlefield, Ohio 44062
United States of America
www.f2labs.com

CERTIFICATION TEST REPORT

Manufacturer:	**LTA Research and Exploration, LLC** **642 North Pastoria Avenue** **Sunnyvale, California 94085 USA**
Applicant:	**Same as Above**
Product Name:	**Freeballooning Wireless Module**
Product Description:	Wireless MCU operating in the 902-928 MHz band that provides a serial connection between up to 15 devices through a transparent wireless link.
Model:	**A4832_01**
FCC ID:	**2A9X4A4832-01**
Testing Commenced:	2023-02-14
Testing Ended:	2023-07-18
Summary of Test Results:	**In Compliance** The EUT complies with the EMC requirements when manufactured identically as the unit tested in this report, including any required modifications and/or manufacturer's statement. Any changes to the design or build of this unit subsequent to this testing may deem it non-compliant.

Rules:

- **FCC Part 15 Subpart C, Section 15.247**
- **FCC15.207 - Conducted Limits**
- **FCC Part 15.31(e)**
- **ANSI C63.10:2013**

Evaluation Conducted by:

Julius Chiller, Senior Wireless Project Engineer

Report Reviewed by:

Ken Littell, Vice President of Operations

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1 ADMINISTRATIVE INFORMATION

1.1 Measurement Location:

F2 Labs in Middlefield, Ohio. Site description and attenuation data are on file with the FCC's Sampling and Measurement Branch at the FCC Laboratory in Columbia, MD**.**

1.2 Measurement Procedure:

All measurements were performed according to ANSI C63.10 and recommended FCC procedure of measurement under Section 15.247 and in KDB558074. A list of the measurement equipment can be found in Section 6.

1.3 Uncertainty Budget:

The uncertainty in EMC measurements arises from several factors which affect the results, some associated with environmental conditions in the measurement room, the test equipment being used, and the measurement techniques adopted.

The measurement uncertainty budgets detailed below are calculated from the test and calibration data and are expressed with a 95% confidence factor. Note: Only measurements listed below which relate to tests included in this Test Report are applicable to it.

Measurement Range	Expanded Uncertainty	Combined Uncertainly
Radiated Emissions <1 GHz @ 3m	±5.07dB	±2.54
Radiated Emissions <1 GHz @10m	±5.09dB	±2.55
Radiated Emissions 1 GHz to 2.7 GHz	±3.62dB	±1.81
Radiated Emissions 2.7 GHz to 18 GHz	±3.10dB	±1.55
AC Power Line Conducted Emissions, 150kHz to 30 MHz	±2.76dB	±1.38

This Uncertainty represents an expanded uncertainty expressed at approximately the 95% confidence level using a coverage factor of k=2.

1.4 Document History

Document Number	Description	Issue Date	Approved By
F2P28874A-C1-01E	First Issue	2023-07-18	K. Littell

2 SUMMARY OF TEST RESULTS/MODIFICATIONS

Test Name	Standard(s)	Results
Occupied Bandwidth	CFR 47 Part 15.247(a)(1)(i) / KDB558074	Complies
Conducted Output Power	CFR 47 Part 15.247(b)(2) / KDB558074	Complies
Conducted Spurious Emissions	CFR 47 Part 15.247(d) / Part 15.207 / KDB558074	Complies
Radiated Spurious Emission with 3dB Antenna	CFR 47 Part 15.247(d) / Part 15.209 / KDB558074	Complies
Peak Power Spectral Density	CFR 47 Part 15.247(f) / KDB558074	Complies
Frequency Separation	ANSI 63.10 (7.8.2)	Complies
Number of Hopping Frequencies	CFR 47 Part 15.247(f)	Complies
Dwell Time	CFR 47 Part 15.247(f)	Complies
Conducted Emissions	CFR 47 Part 15.207(a)	Complies
Voltage Variations	CFR 47 Part 15.31(e)	Complies

Modifications Made to the Equipment
None

3 TABLE OF MEASURED RESULTS

Test		Low Channel 902.875 MHz	Mid Channel 915.205 MHz	High Channel 927.535 MHz
Conducted Output Power		7.55mW / 8.78dBm	8.39mW / 9.24dBm	6.15mW / 7.89dBm
Conducted Output Power Limit		250mW / 24dBm	250mW / 24dBm	250mW / 24dBm
E.I.R.P.		15.07mW / 11.78dBm	16.75mW / 12.24dBm	12.27 mW / 10.89dBm
E.I.R.P. Limit		1W / 30dBm	1W / 30dBm	1W / 30dBm
Peak Power Spectral Density		5.58dBm	6.05dBm	4.56dBm
Peak Power Spectral Density Limit		8 dBm	8 dBm	8 dBm
-20dB Occupied Bandwidth		0.406 MHz	0.409	0.409
99% Occupied Bandwidth		0.375	0.375	0.378
Occupied Bandwidth Limit		<500KHz	<500KHz	<500KHz
Voltage Variations	3.5VDC	6.56mW / 8.17dBm	7.66mW / 8.84dBm	5.42mW / 7.34dBm
	2.9VDC	6.56mW / 8.17dBm	7.66mW / 8.84dBm	5.43mW / 7.35dBm
	4.1VDC	6.58mW / 8.18dBm	7.66mW / 8.84dBm	5.43mW / 7.35dBm
Limit		1W / 30dBm	1W / 30dBm	1W/ 30dBm

4 ENGINEERING STATEMENT

This report has been prepared on behalf of LTA Research and Exploration, LLC to provide documentation for the testing described herein. This equipment has been tested and found to comply with Part 15.247 of the FCC Rules using ANSI C63.10 and KDB558074 standards. The test results found in this test report relate only to the items tested.

5 EUT INFORMATION AND DATA

5.1 Equipment Under Test:

Product: Freeballooning Wireless Module
Model: A4832_01
Serial No.: 20419-0012
FCC ID: 2A9X4A4832-01

5.2 Trade Name:

LTA Research and Exploration, LLC

5.3 Power Supply:

3.6VDC

5.4 Applicable Rules:

CFR 47, Part 15.247, subpart C

5.5 Equipment Category:

Radio Transmitter- Hybrid

5.6 Antenna:

Laird model TRAM8903NP, s/n 09

5.7 Accessories:

N/A

5.8 Test Item Condition:

The equipment to be tested was received in good condition.

5.9 Testing Algorithm:

EUT was operated in hybrid mode on the low, mid and high channels in the 902-928 MHz band. Timing measurements were made in the frequency hopping mode, powered at 3.6VDC. The highest emissions were recorded in the data tables.

6 LIST OF MEASUREMENT INSTRUMENTATION

Equipment Type	Asset Number	Manufacturer	Model	Serial Number	Calibration Due Date
Shielded Chamber	CL166-E	Albatross Projects	B83117-DF435-T261	US140023	2023-08-22
Receiver	CL151	Rohde & Schwarz	ESU40	100319	2024-04-10
Pre-Amplifier	CL285	Com-Power	PAM-0207	322	2023-04-13
Pre-Amplifier	CL250	Com-Power	PAM-118A	18040011	2023-04-15
Active 18” Loop Antenna	CL163-Loop	A.H. Systems, Inc.	EHA-52B	100	2023-10-23
Antenna, JB3 Combination	CL175	Sunol Sciences	JB3	A030315	2023-09-22
Horn Antenna	CL098	Emco	3115	9809-5580	2024-01-19
Software:	Tile Version 3.4.B.3		Software Verified: 2023-02-14, 2023-04-19		
Software:	EMC 32, Version 8.53.0		Software Verified: 2023-04-19		
Temp/Hum. Recorder	CL294	Thermpro	TP50	2	2023-05-31
Spectrum Analyzer	0204	Hewlett Packard	HP8591A	3149A02546	2023-03-29
Software:	EMC Analyzer 85712D Rev. A.00.01			Date Verified:	2023-02-14
Transient Limiter	0202	Hewlett Packard	11947A	3107A00729	2023-03-29
LISN	CL181	Com-Power	LI-125A	191226	2023-12-01
LISN	CL182	Com-Power	LI-125A	191225	2023-12-01
Temp/Hum. Recorder	CL233	Extech	445814	02	2023-04-18

7 OCCUPIED BANDWIDTH

7.1 Requirements:

For frequency hopping systems operating in the 902-928 MHz band

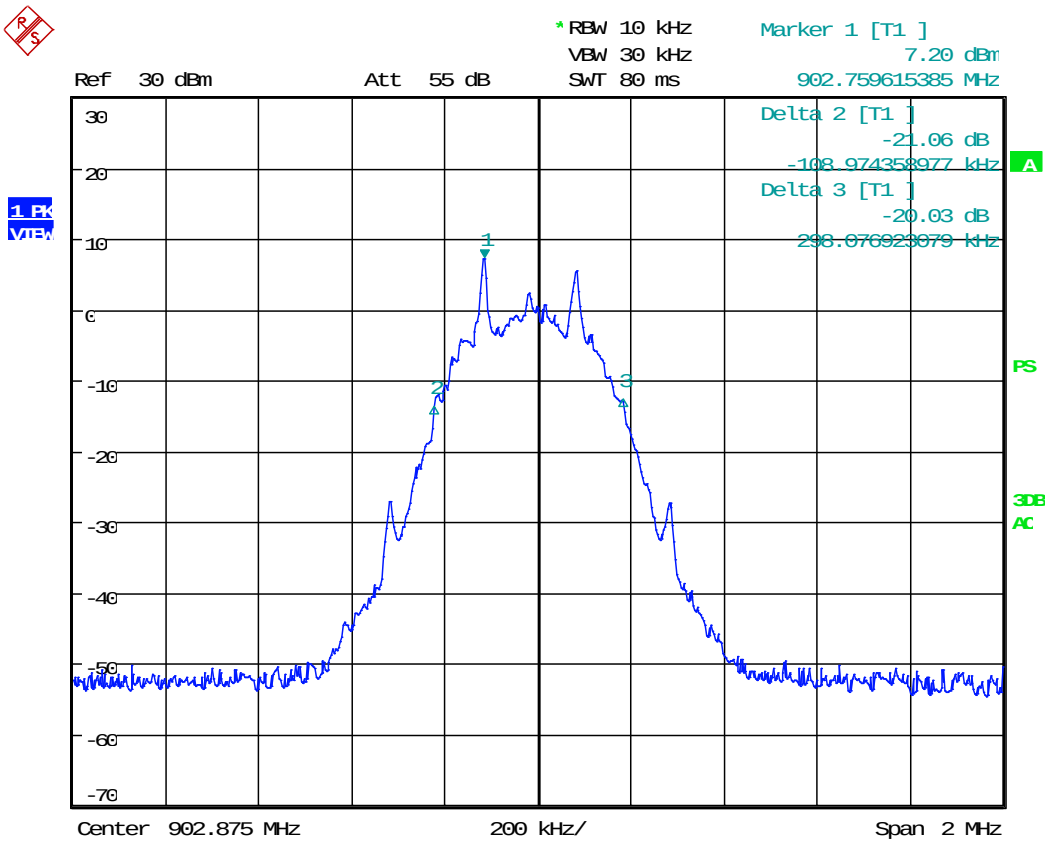
The maximum allowed 20dB bandwidth of the hopping channel is 500 kHz.

Bandwidth measurements were made at the low, mid and high frequencies. The 20dB bandwidth was measured using the marker delta method.

7.2 Occupied Bandwidth Test Data

Test Date:	2023-04-19	**Test Engineer:**	J. Chiller
Standards:	CFR 47 Part 15.247(a)(1)(i); KDB558074	**Air Temperature:**	20.4ºC
		Relative Humidity:	44

-20dB, Low Channel



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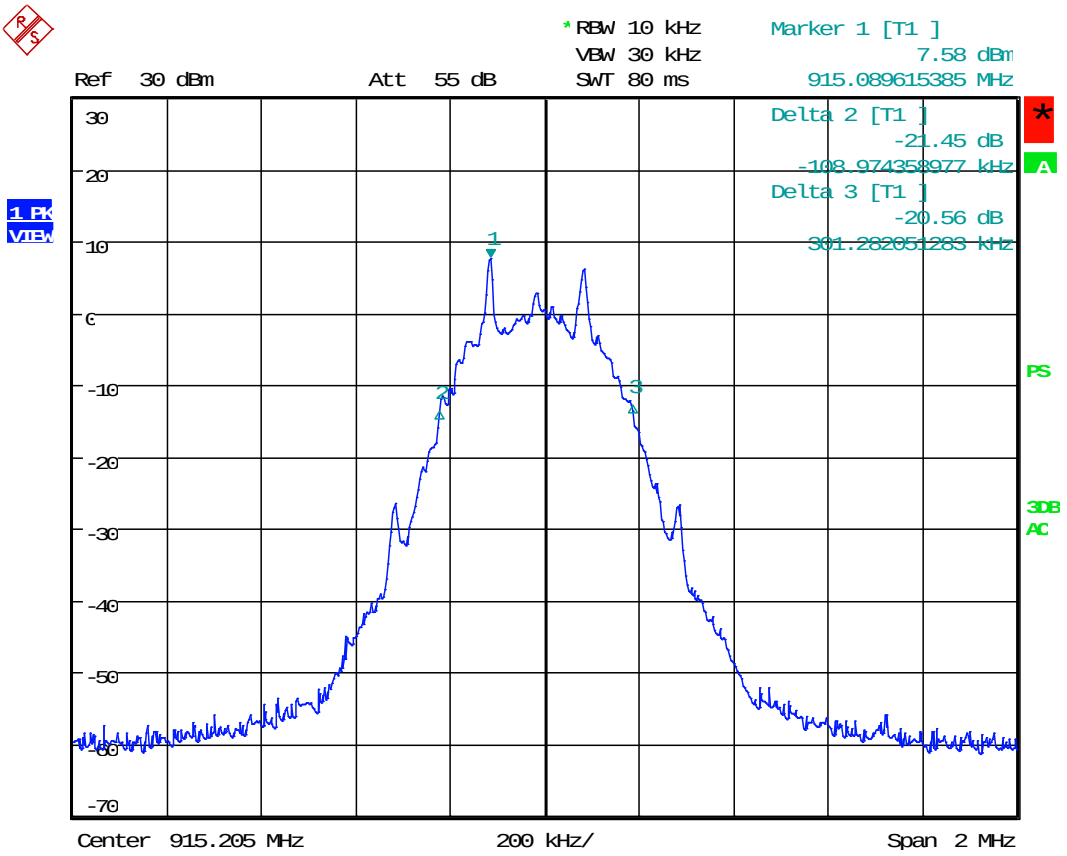
-20dB, Mid Channel



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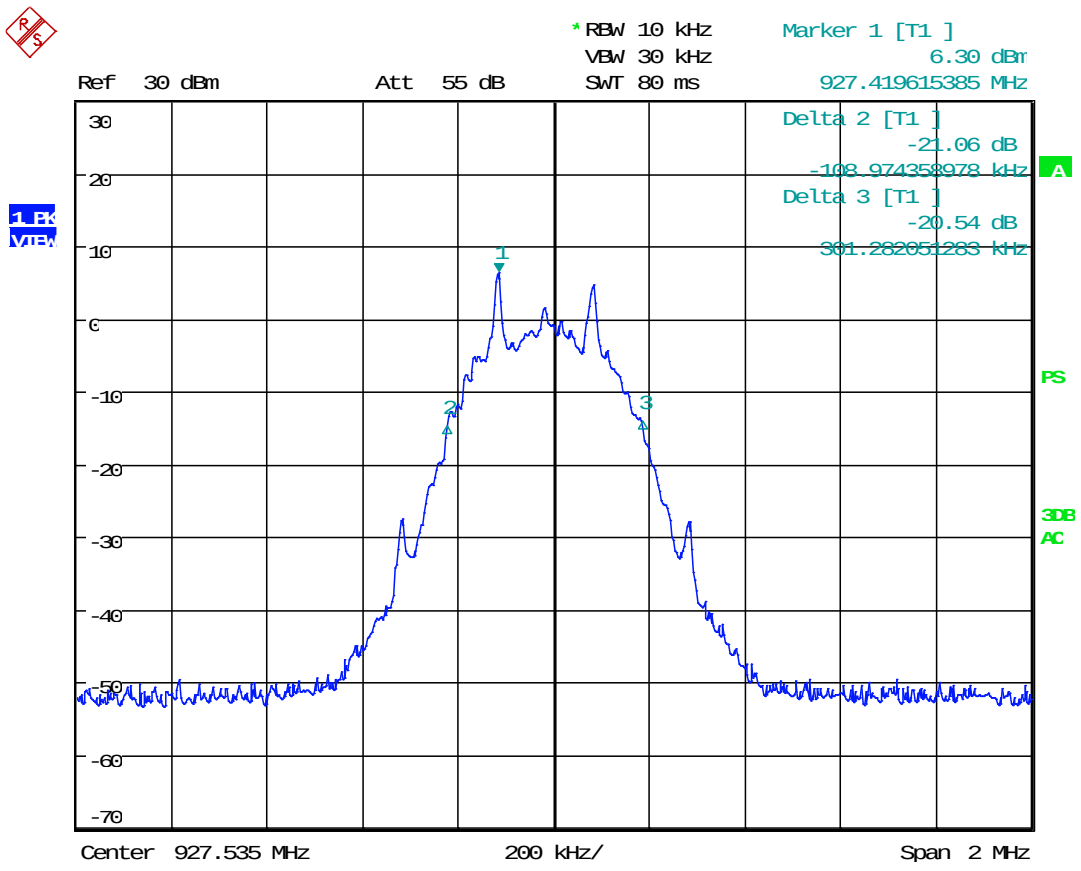
-20dB, High Channel



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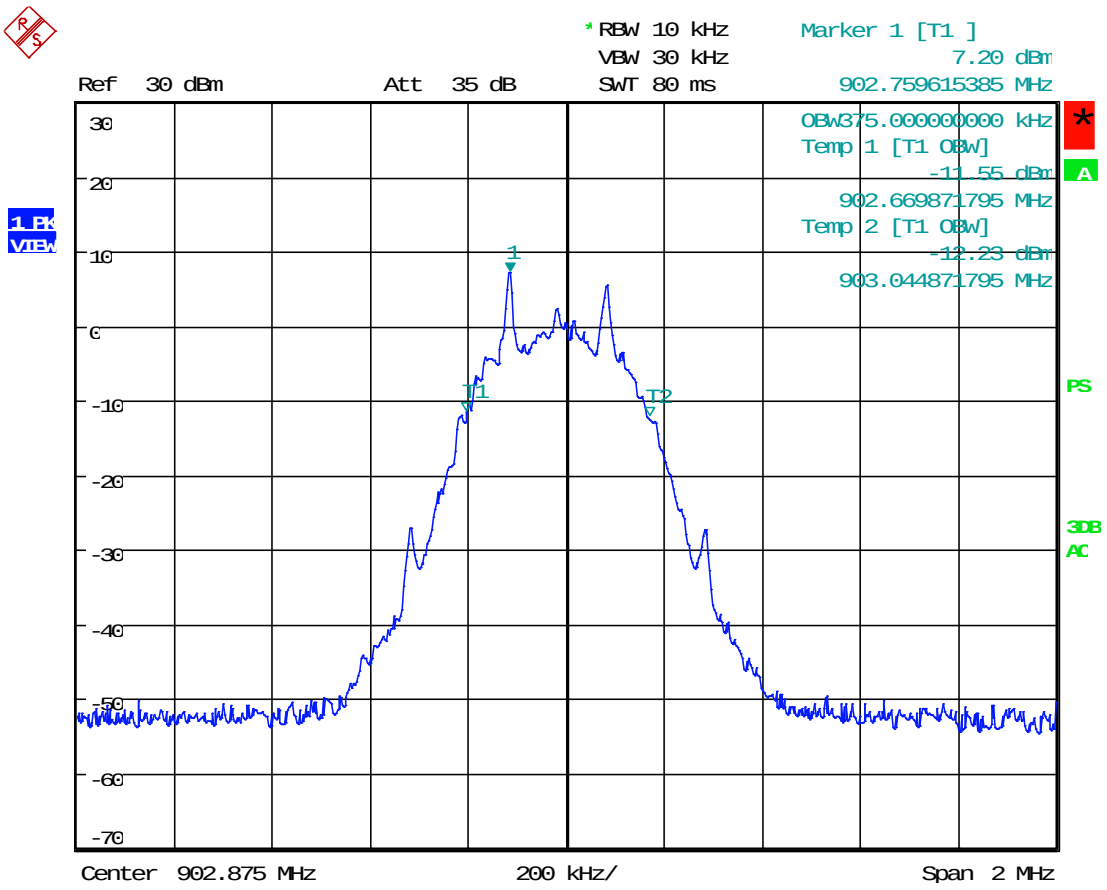
99%, Low Channel



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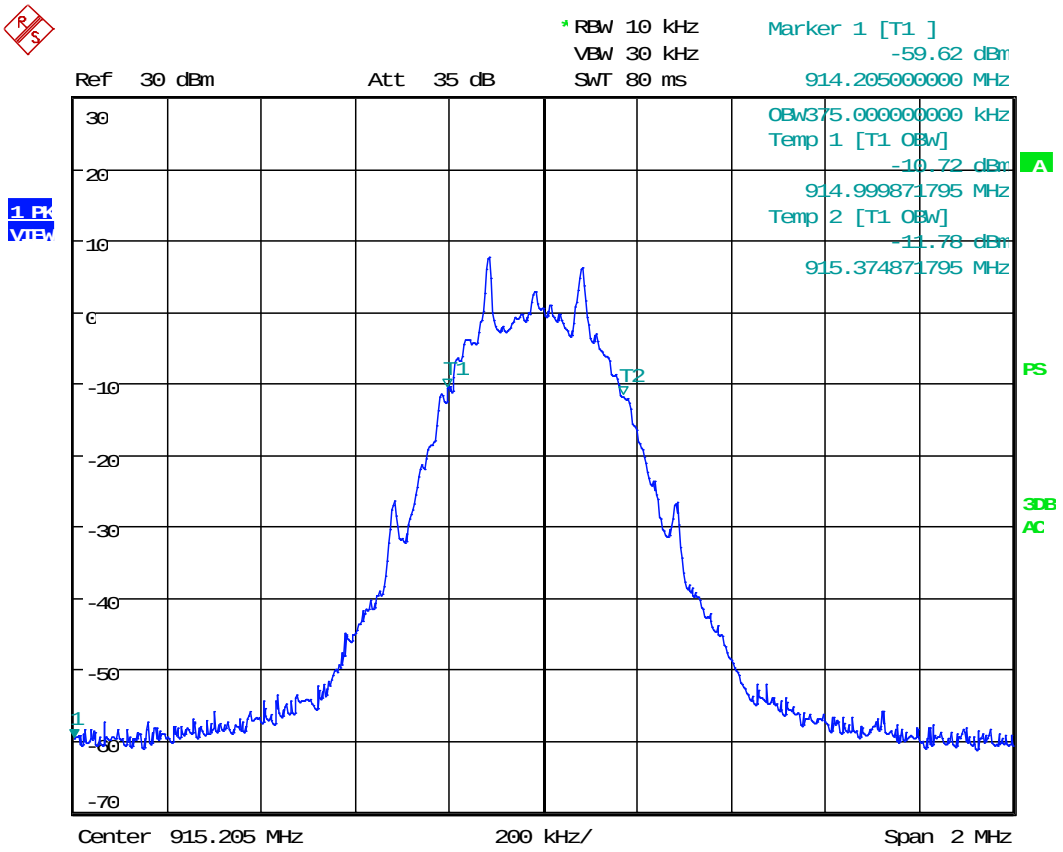
99%, Mid Channel



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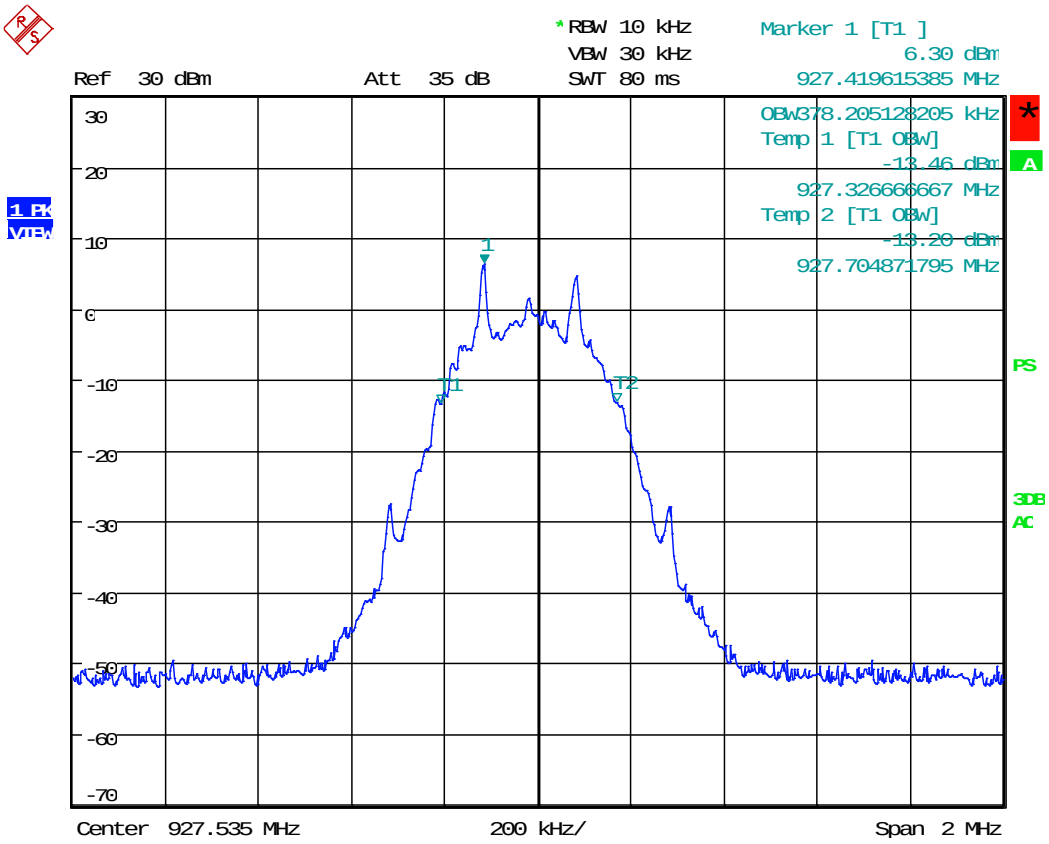
99%, High Channel



8 CONDUCTED OUTPUT POWER

The EUT antenna port was fitted with an SMA connector and directly connected to the input of the receiver. The peak power output was measured.

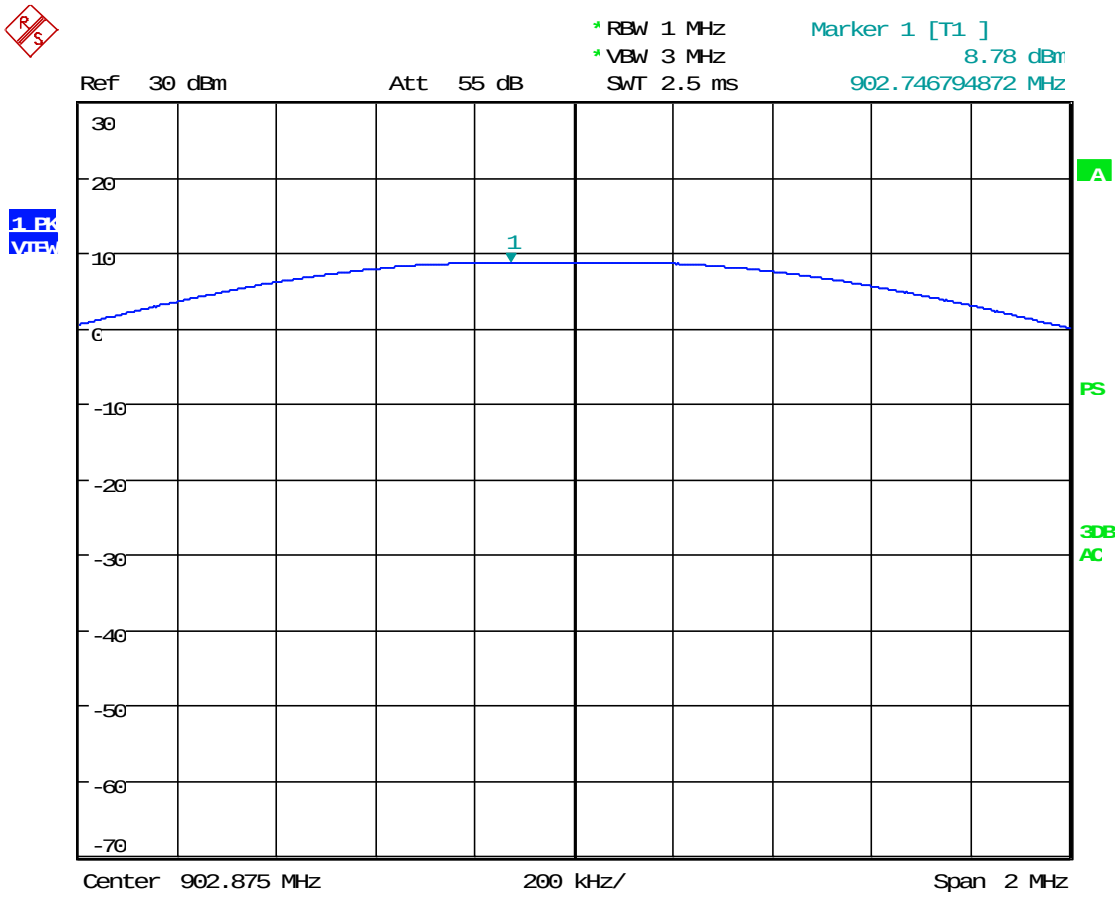
8.1 Requirements:

For frequency hopping systems operating in the 902-928 MHz band: 1 watt (30 dBm) for systems employing at least 50 hopping channels; and 0.25 watts (24 dBm) for systems employing less than 50 hopping channels, but at least 25 hopping channels, as permitted under paragraph (a)(1)(i).

8.2 Conducted Output Power Test Data

Test Date:	2023-04-19	Test Engineer:	J. Chiller
Standards:	CFR 47 Part 15.247(b)(2); KDB558074	Air Temperature:	20.4ºC
		Relative Humidity:	44%

Low Channel



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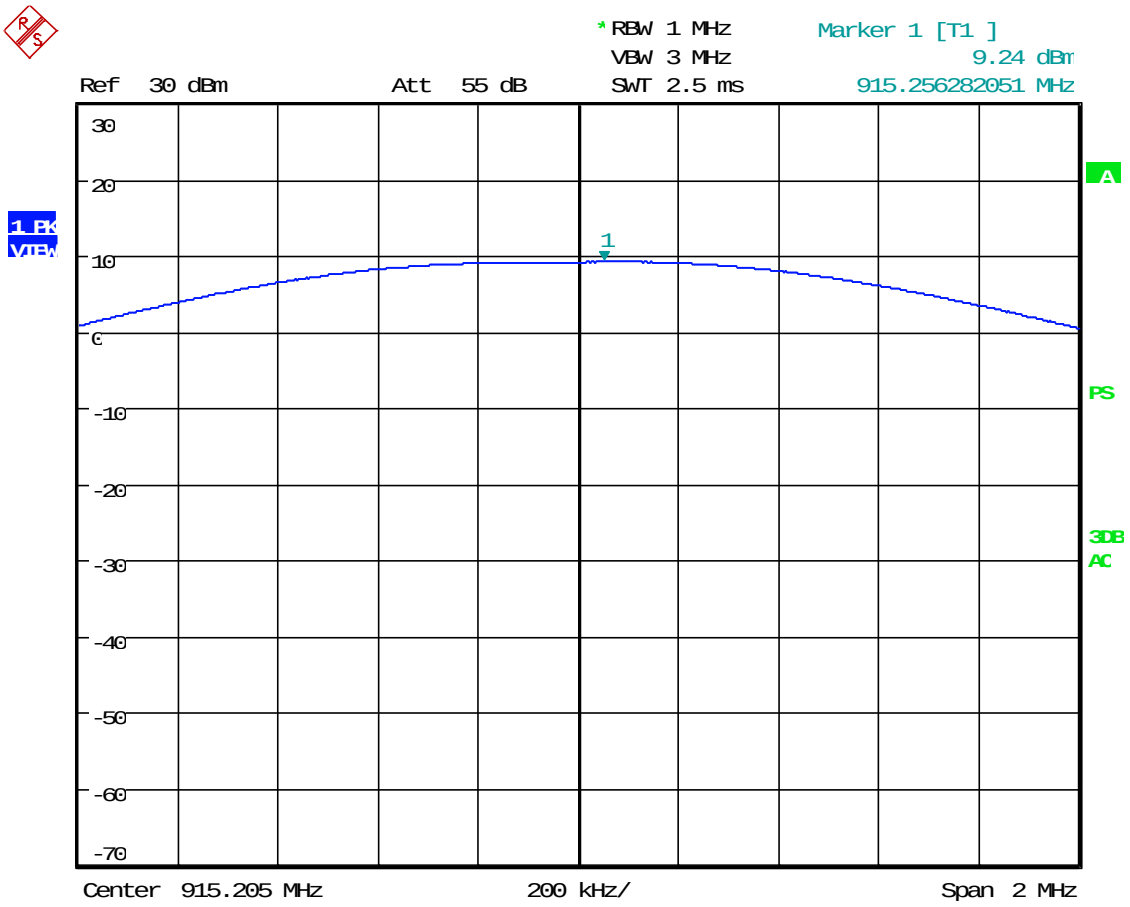
Mid Channel



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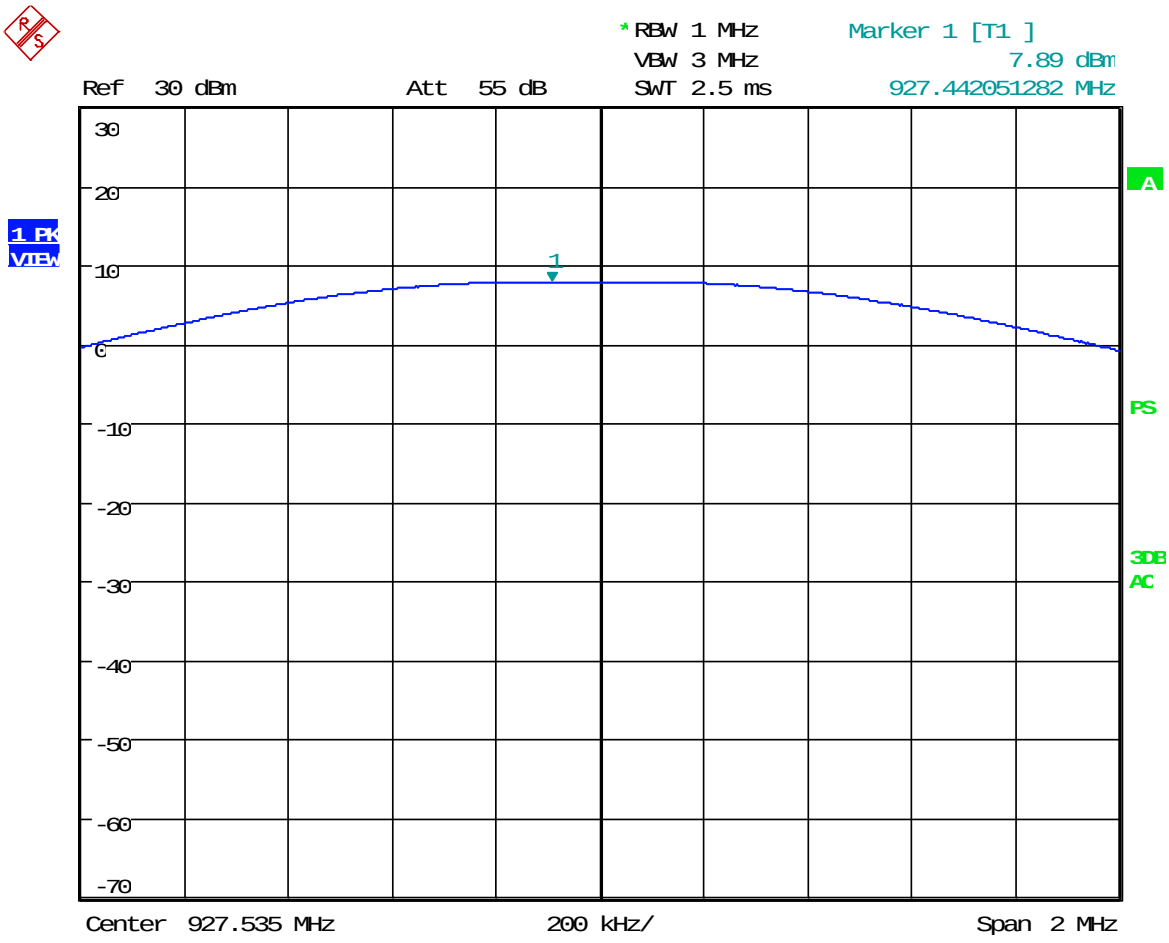
High Channel



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9 CONDUCTED SPURIOUS EMISSIONS

The following tests were performed to demonstrate compliance.

RF Antenna Conducted Test

The EUT antenna port was fitted with an SMA connector and directly connected to the input of the spectrum analyzer/receiver.

9.1 Requirements:

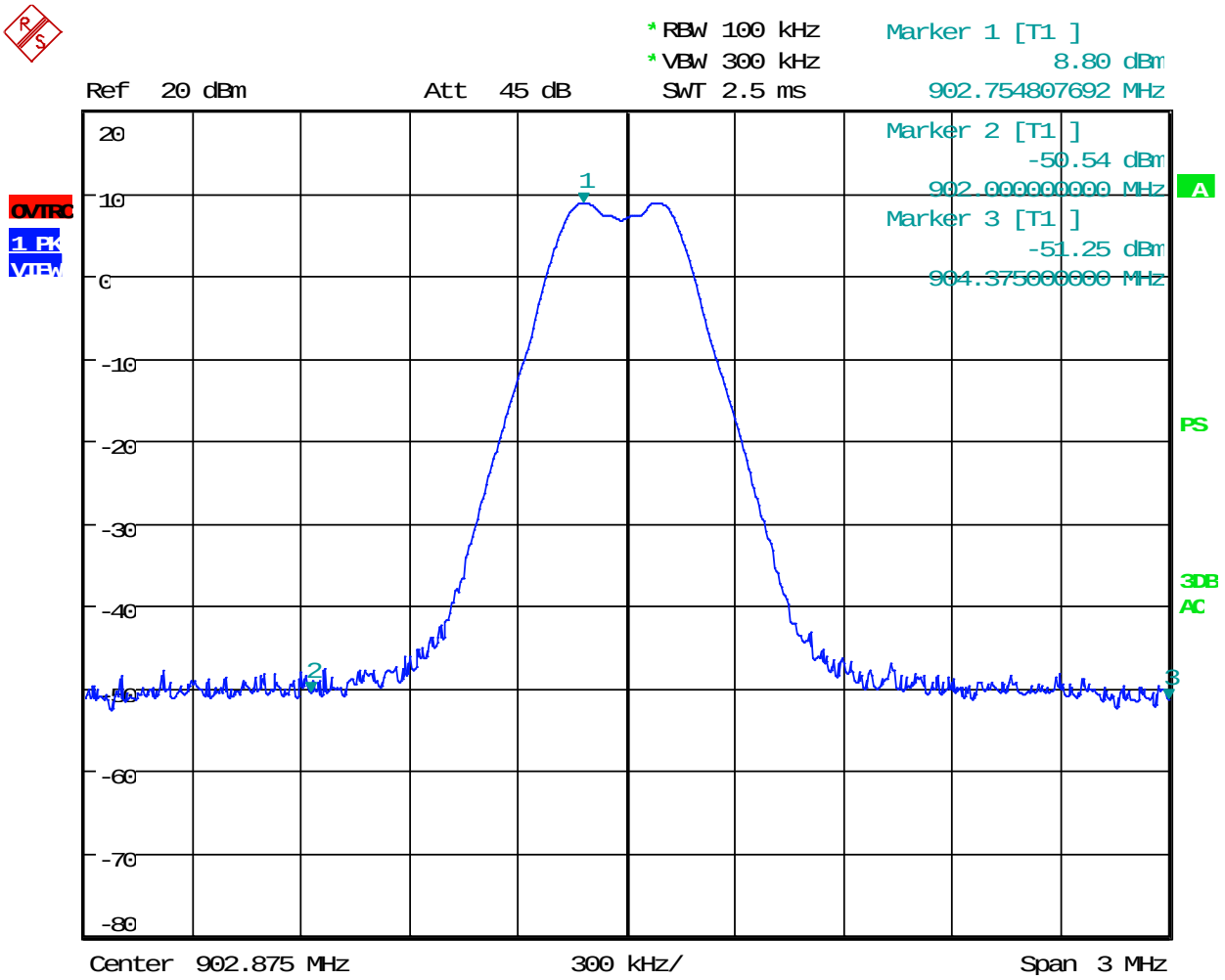
All Spurious Emissions must be at least 20dB down from the highest emission level measured within the authorized band up through the tenth harmonic.

Spurious emissions measurements were made at the low, mid, and upper channels with the appropriate spectrum analyzer resolution bandwidth. Additionally, 20dB down points were measured for the low and high channels to verify band edge compliance.

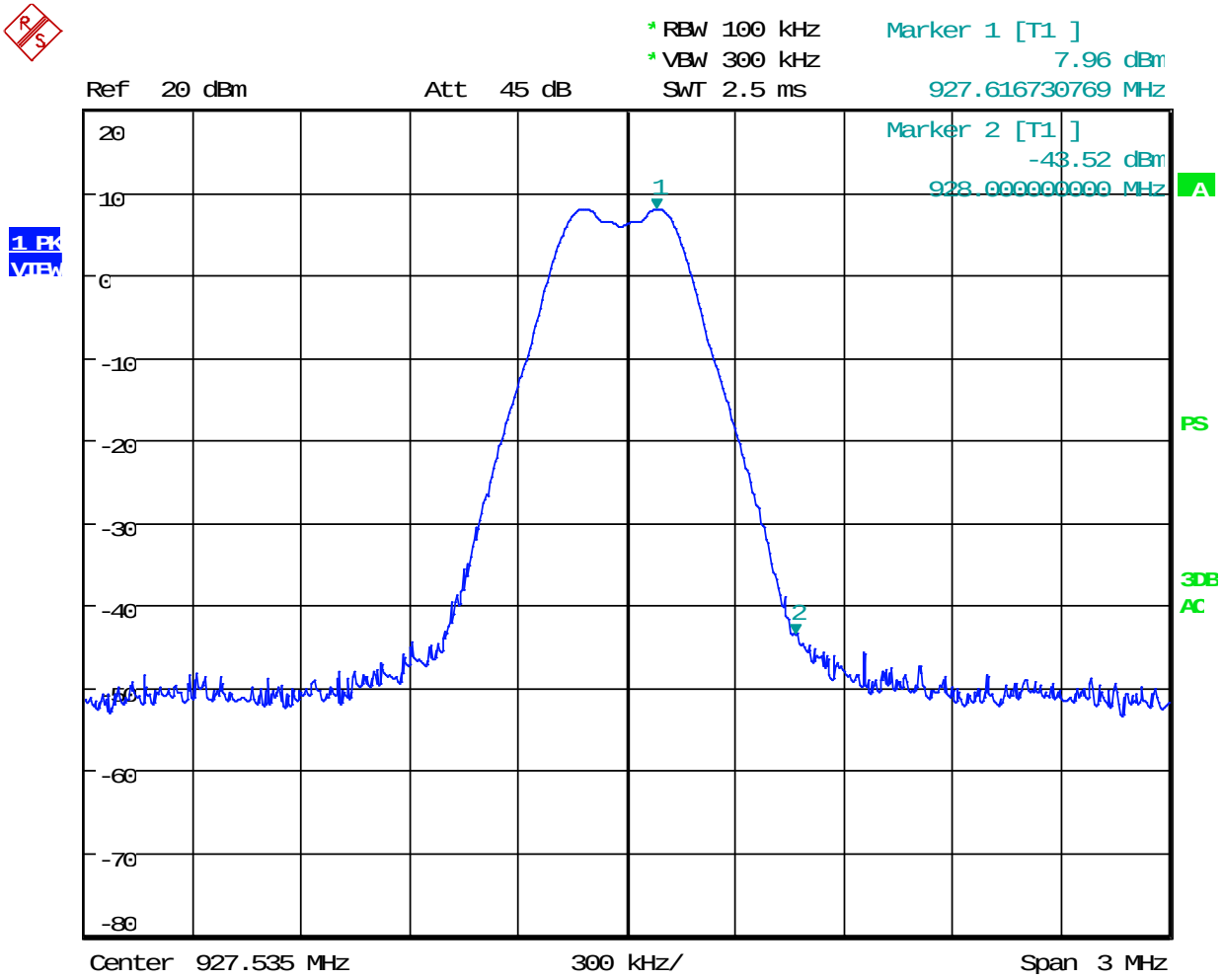
9.2 Conducted Spurious Emissions Test Data

Test Date:	2023-04-19	**Test Engineer:**	J. Chiller
Standards:	CFR 47 Part 15.247(d) / Part 15.207 KDB558074	**Air Temperature:**	20.4ºC
		Relative Humidity:	44%

Lower Band Edge



Upper Band Edge



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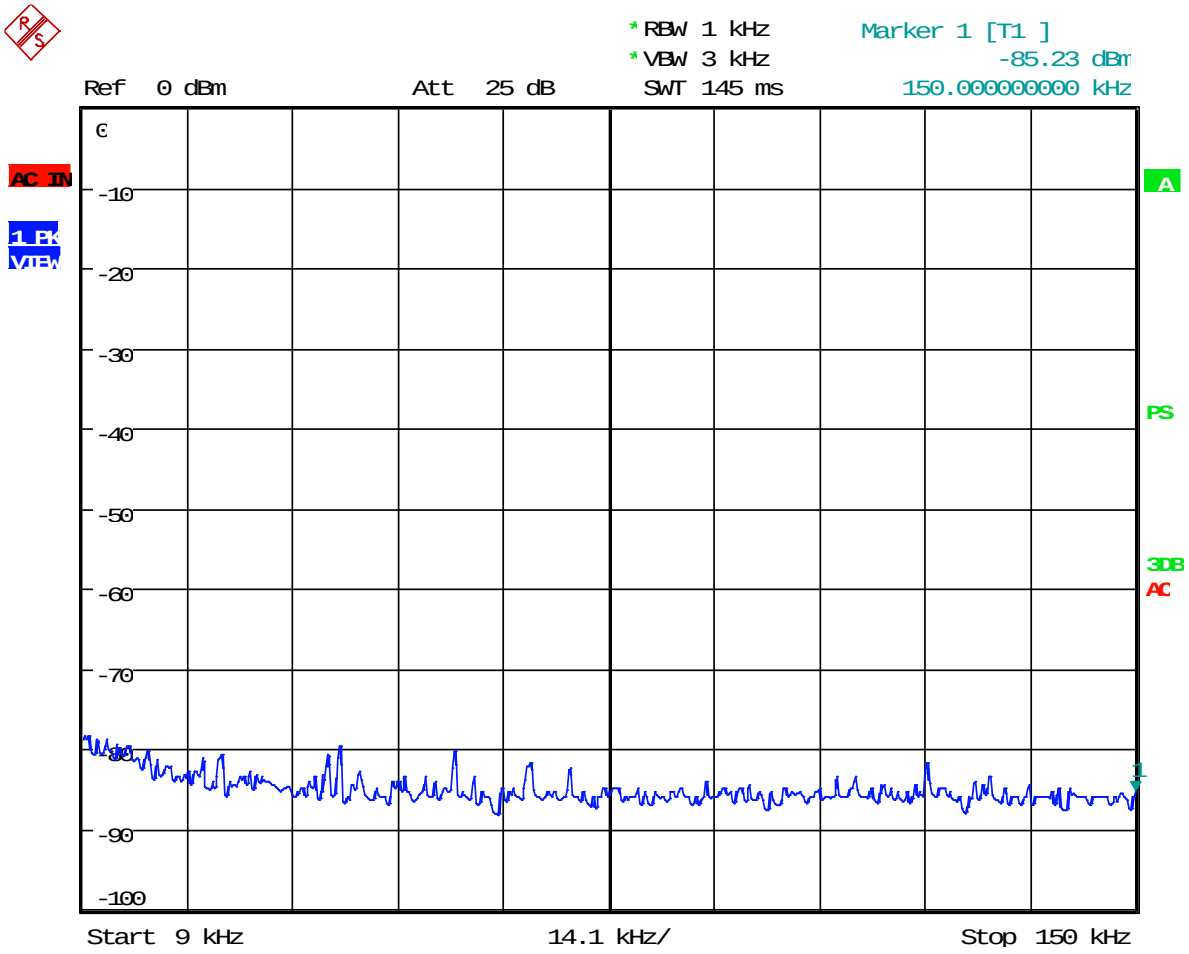
0.009 MHz to 0.15 MHz



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0.15 MHz to 30 MHz

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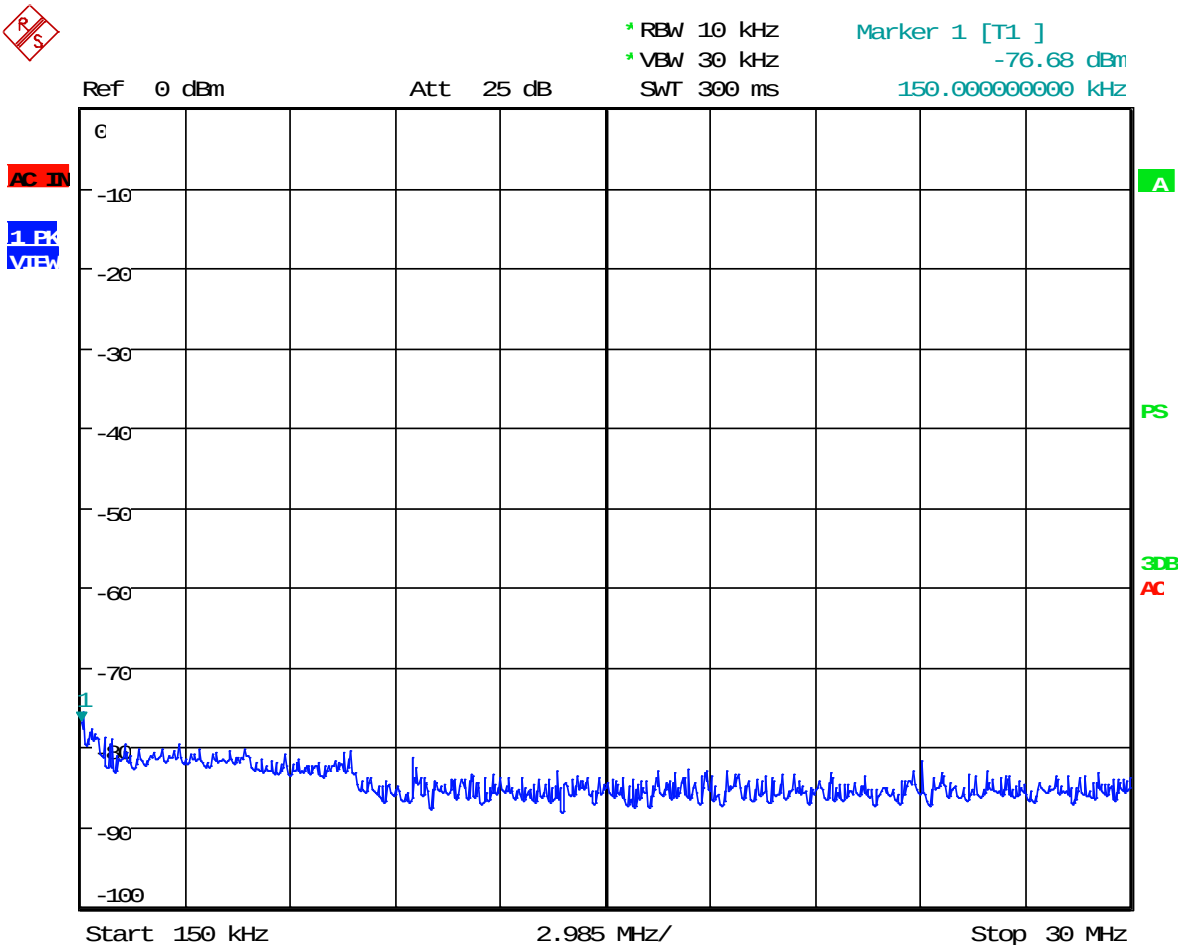

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30 MHz to 1000 MHz

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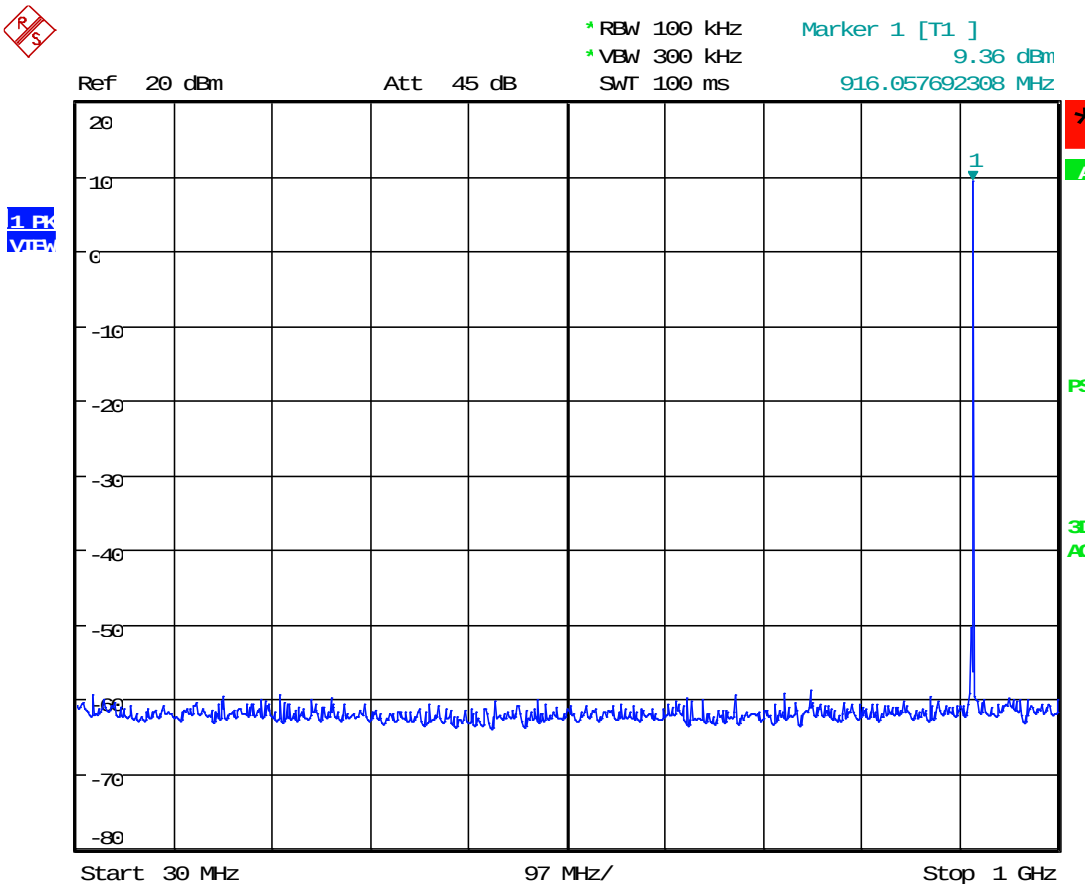

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1 GHz to 10 GHz

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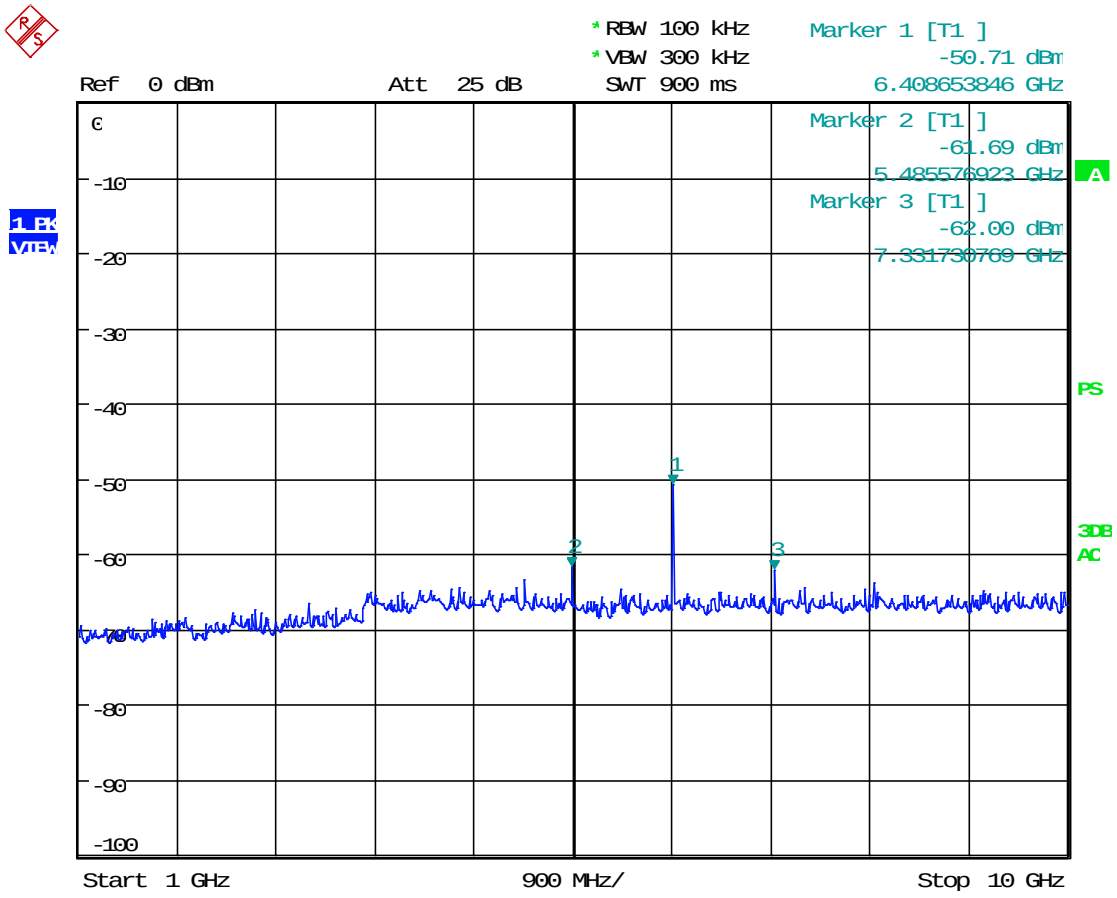

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10 RADIATED SPURIOUS EMISSION

The EUT antenna port was fitted with 3dB gain antenna. Radiated emissions were measured in a Semi-Anechoic Chamber. All emissions generated that fall in the restricted bands per FCC Part 15.205 were examined.

10.1 Requirements:

All emissions that fall in the restricted bands defined in FCC Part 15.205 shall not exceed the maximum field strength listed in FCC Part 15.209(a).

10.2 Radiated Spurious Emission Test Data

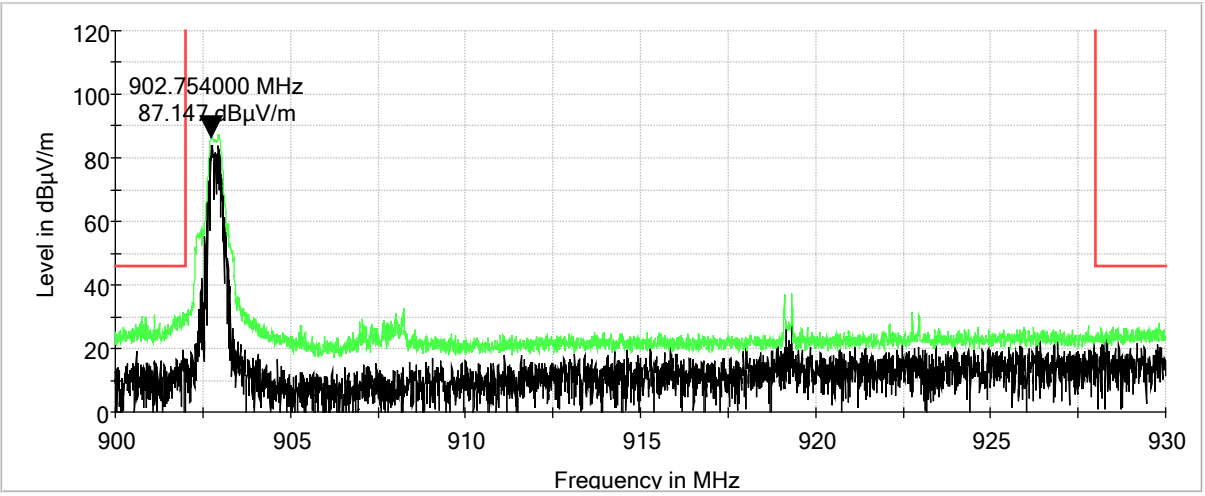
Test Date(s):	2023-04-19	**Test Engineer:**	J. Chiller
Standard(s):	CFR 47 Part 15.247(d); Part 15.209 / KDB558074	**Air Temperature:**	21.1ºC
		Relative Humidity:	43%

Notes: Plots are peak, max hold prescan data included only to determine what frequencies to investigate and measure. The EUT was initially placed in a semi-anechoic chamber and rotated in all three orthogonal positions to maximize the emissions. Scans were performed from 150 kHz up to the 10th harmonic of the highest frequency generated. Characterization measurements were then performed to determine at which frequencies significant emissions occurred. These graphs are shown in the data presented.

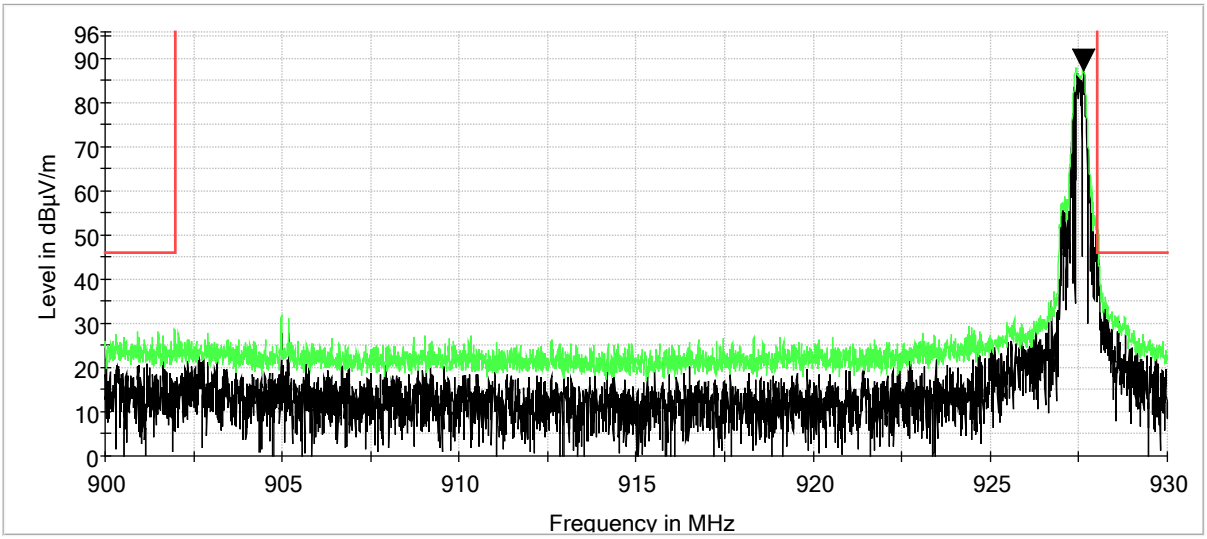
The equipment was fully exercised with all cabling attached to the EUT and was positioned in the Semi-Anechoic Chamber for maximum emissions. While the equipment was energized, the receiving antenna was scanned from 1.0 meter to 4.0 meters in both vertical and horizontal polarities while the turntable was adjusted 360 degrees to determine the maximum field strength.

Scans were performed from 9kHz to 10 GHz at the low, mid, and high channels and the mid channel was determined to be the worst case. Tables of measured results in the presented test data include measurements from all channels.

Lower Band Edge, Vertical



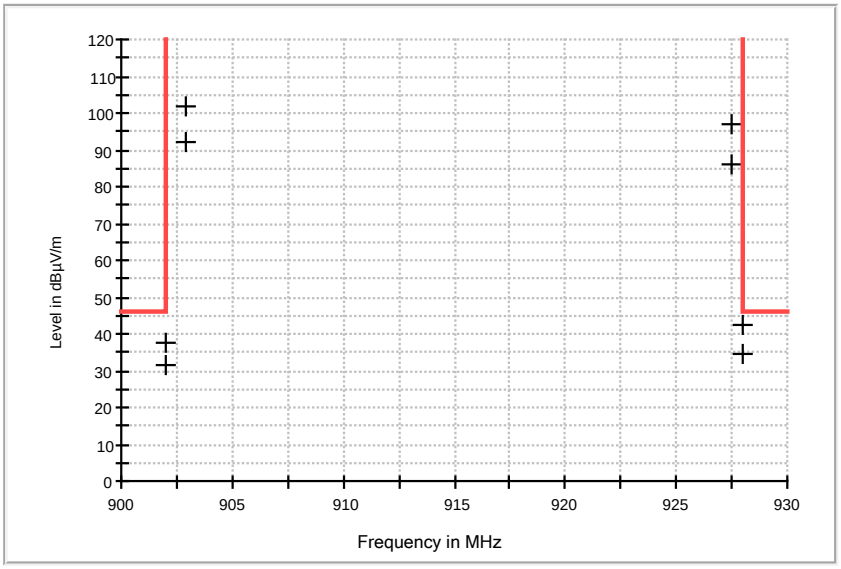
Upper Band Edge, Vertical



Measurements

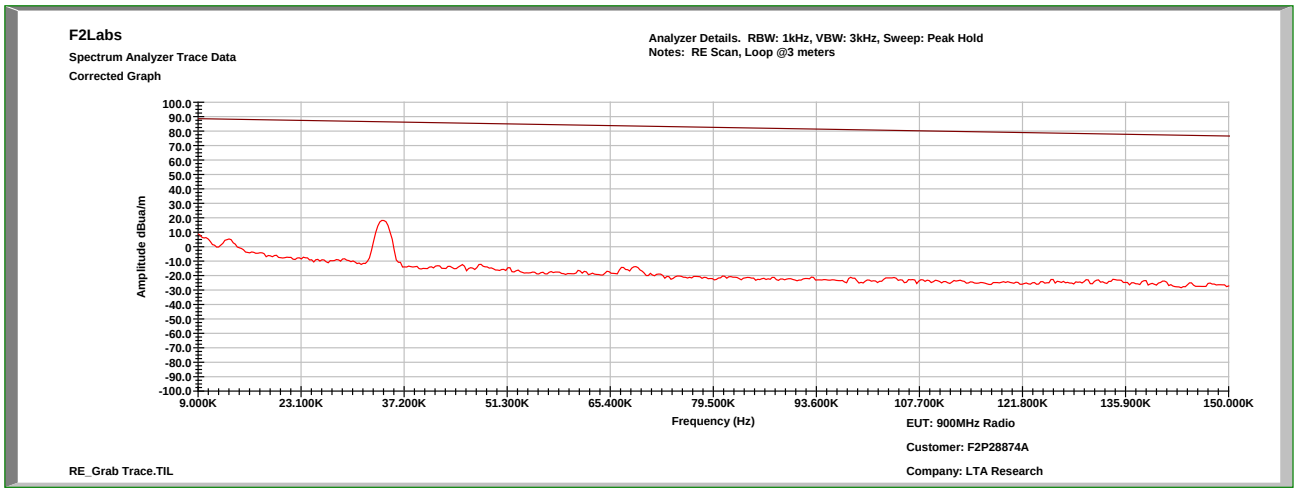
Radiated Band Edges

Frequency (MHz)	Antenna Polarization	Reading (dBµV)	Cable Loss & Antenna Factor (dB)	Emission (dBµV/m)	Limit (dBµV/m)	Margin (dB)
902.000000	H	45.6	-13.9	31.70	46.0	-14.3
902.000000	V	51.6	-13.9	37.70	46.0	-8.3
928.000000	H	47.8	-13.2	34.60	46.0	-11.4
928.000000	V	55.7	-13.2	42.50	46.0	-3.5

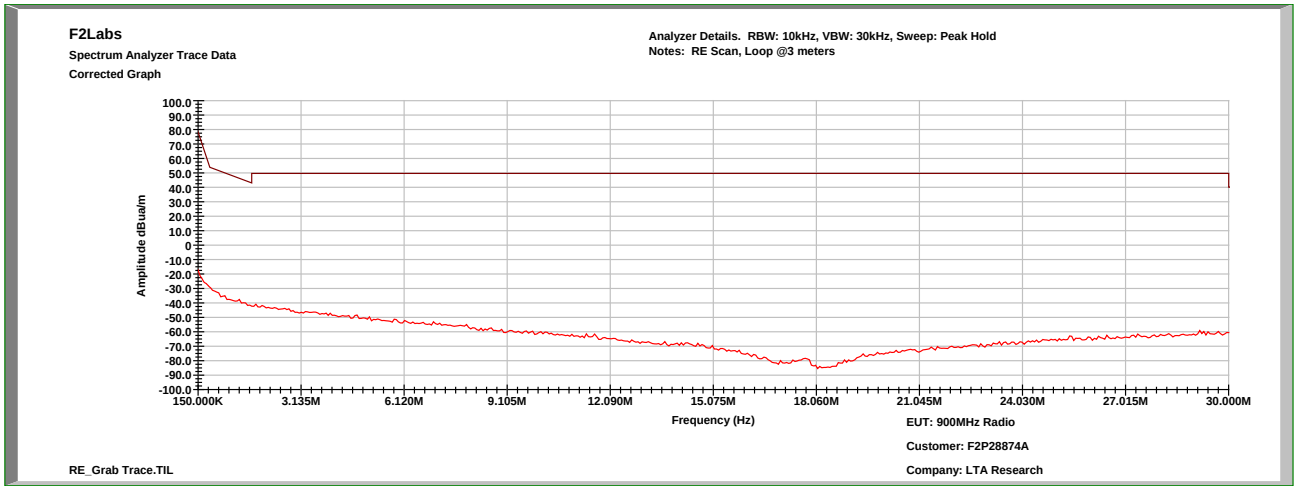


Radiated Spurious Emissions

Characterization Scan, 0.009 MHz to 0.15 MHz

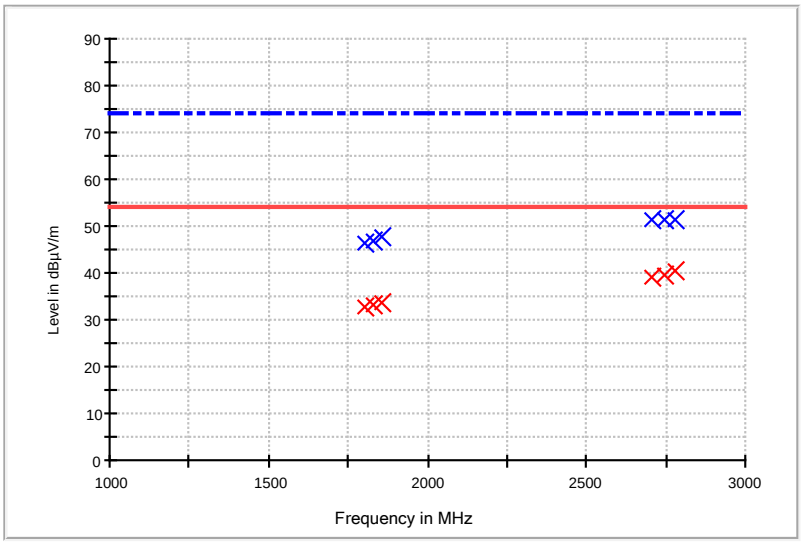


Characterization Scan, 0.15 MHz to 30.0 MHz



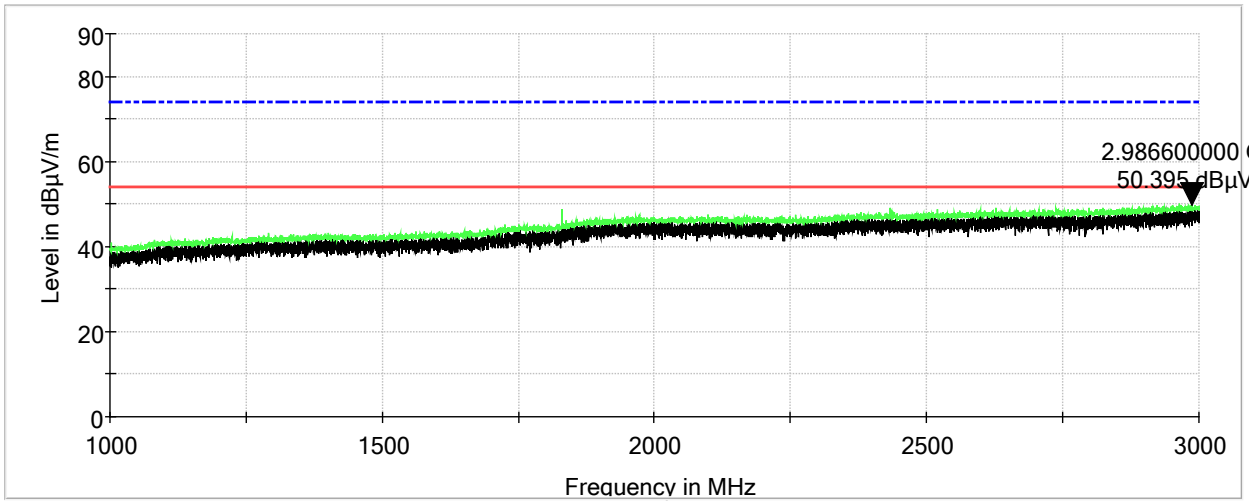
Measurements of Harmonics

Frequency (MHz)	MaxPeak (dBµV/m)	Average (dBµV/m)	Bandwidth (kHz)	Height (cm)	Polarization	Azimuth (deg)	Corr. (dB)	Margin - AVG (dB)	Limit - AVG (dBµV/m)
1805.750000	46.5	32.7	1000.000	150.0	V	0.0	7.8	21.3	54.0
1830.410000	46.9	33.0	1000.000	150.0	V	358.0	8.3	21.0	54.0
1855.070000	47.6	33.5	1000.000	150.0	V	0.0	8.8	20.5	54.0
*2708.00000	51.5	39.2	1000.000	150.0	V	0.0	11.4	14.8	54.0
*2745.61500	51.1	39.4	1000.000	150.0	V	0.0	11.4	14.6	54.0
*2782.60500	51.2	40.5	1000.000	150.0	V	342.0	11.4	13.5	54.0

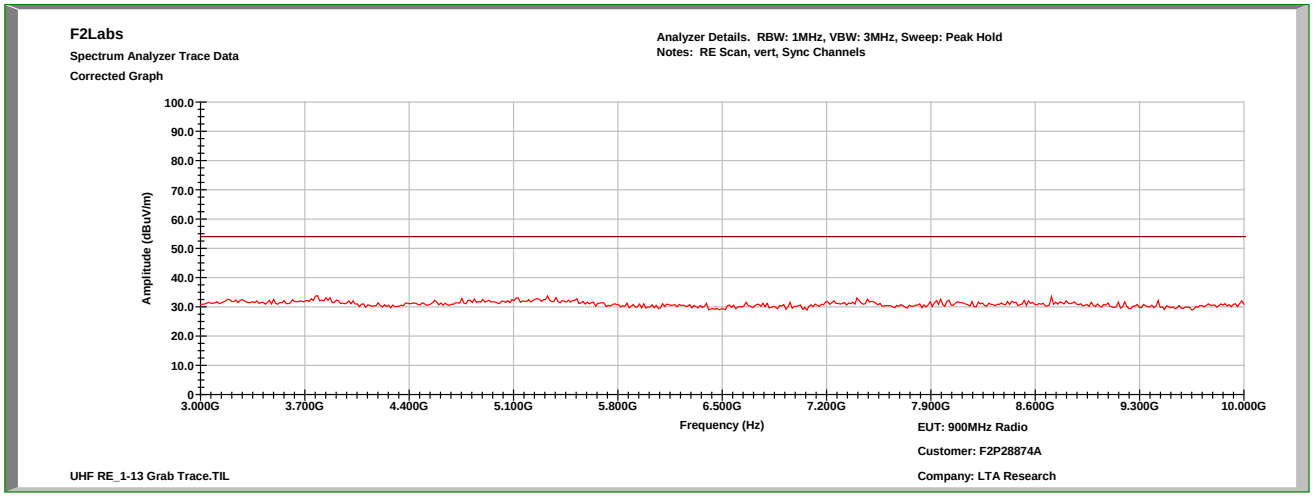


Indicates emissions are in a restricted band.

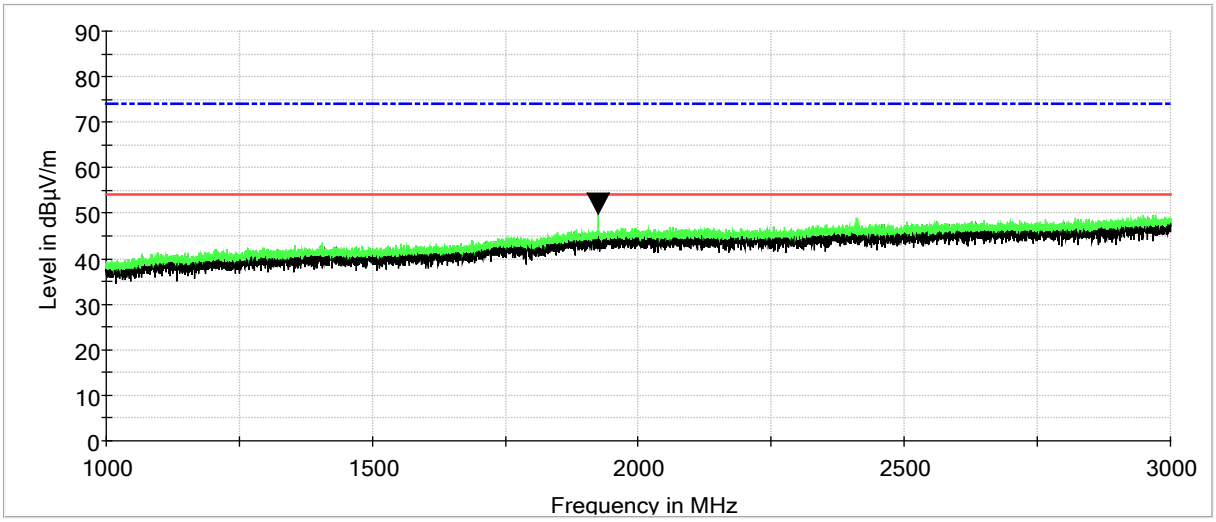
Radiated Spurious Emissions: 1 GHz to 3 GHz, Vertical



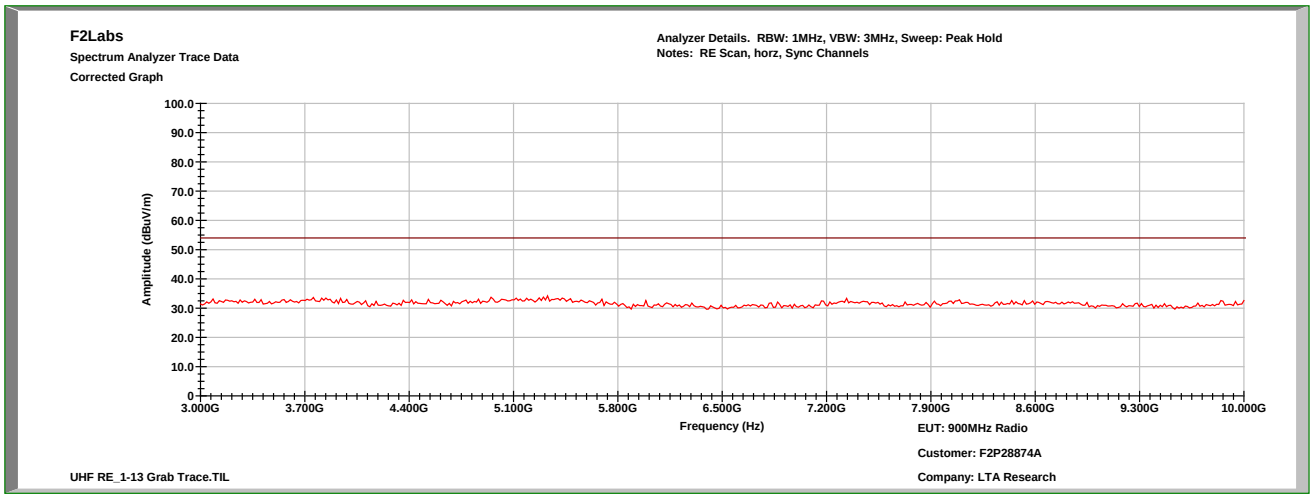
Radiated Spurious Emissions: 3 GHz to 10 GHz, Vertical



Radiated Spurious Emissions: 1 GHz to 3 GHz, Horizontal



Radiated Spurious Emissions: 3 GHz to 10 GHz, Horizontal



11 FCC PART 15.247(f) – PEAK POWER SPECTRAL DENSITY (PSD)

Peak power spectral density measurements were performed.

11.1 Requirements:

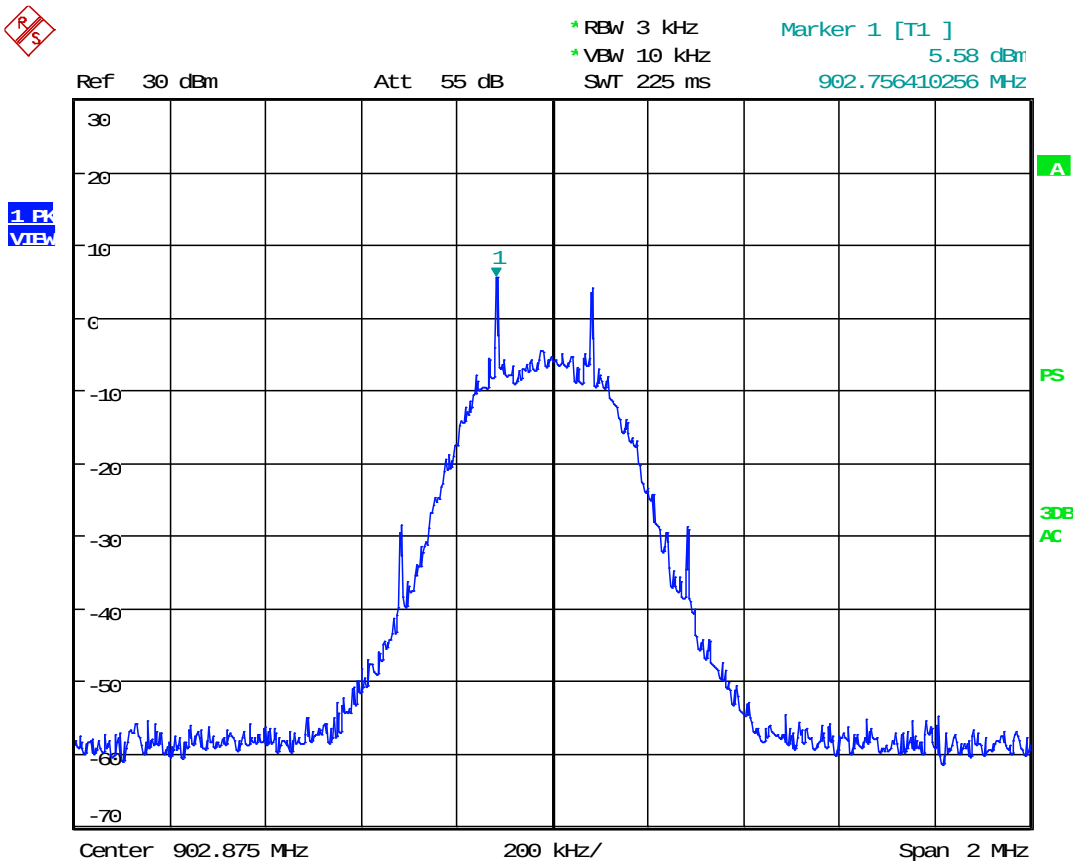
The power spectral density conducted from the intentional radiator to the antenna due to the digital modulation operation of the hybrid system, with the frequency hopping operation turned off, shall not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission.

Power spectral density measurements were performed at a resolution bandwidth of 3 kHz (video bandwidth set at 10 kHz). The peak spectral densities were measured at the low, mid and upper channels.

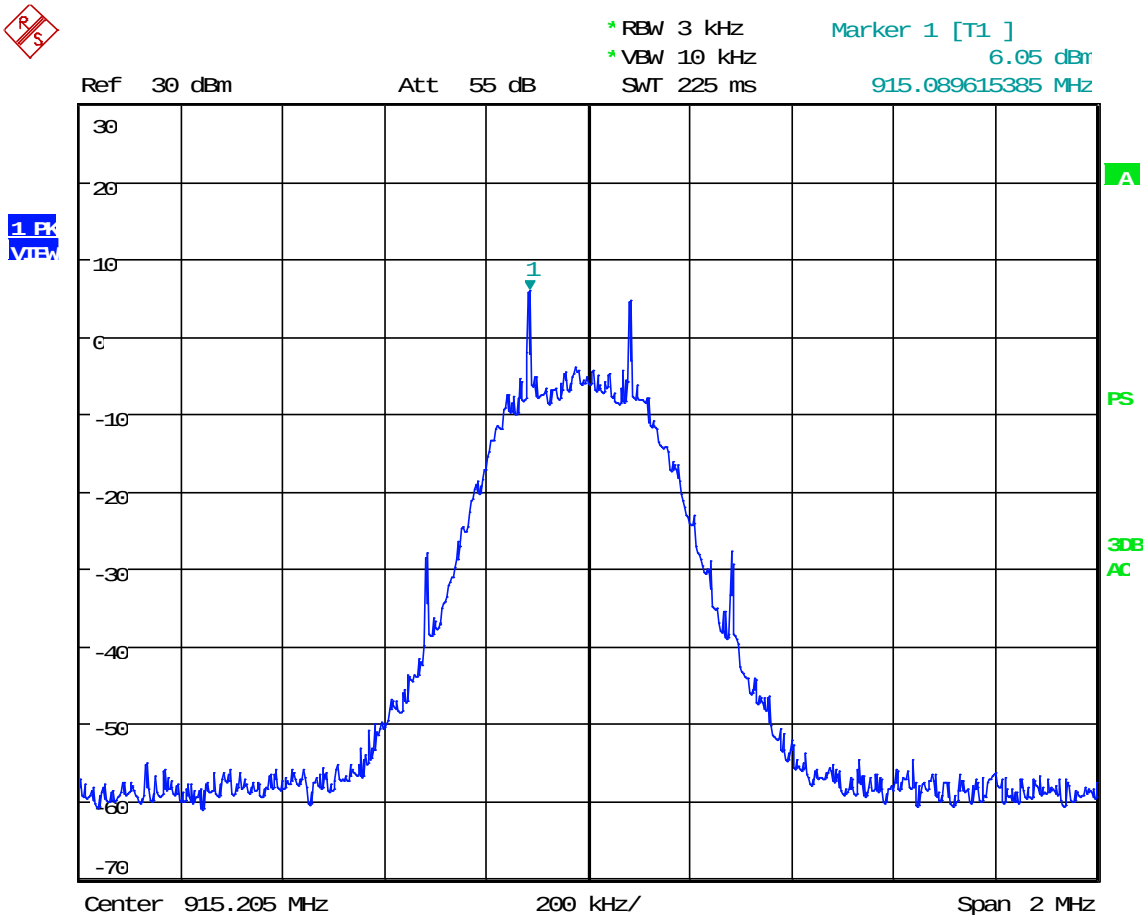
11.2 Peak Power Spectral Density Test Data

Test Date(s):	2023-04-19	Test Engineer:	J. Chiller
Standards:	CFR 47 Part 15.247(f); KDB558074	Air Temperature:	20.4ºC
		Relative Humidity:	44%

Low Channel

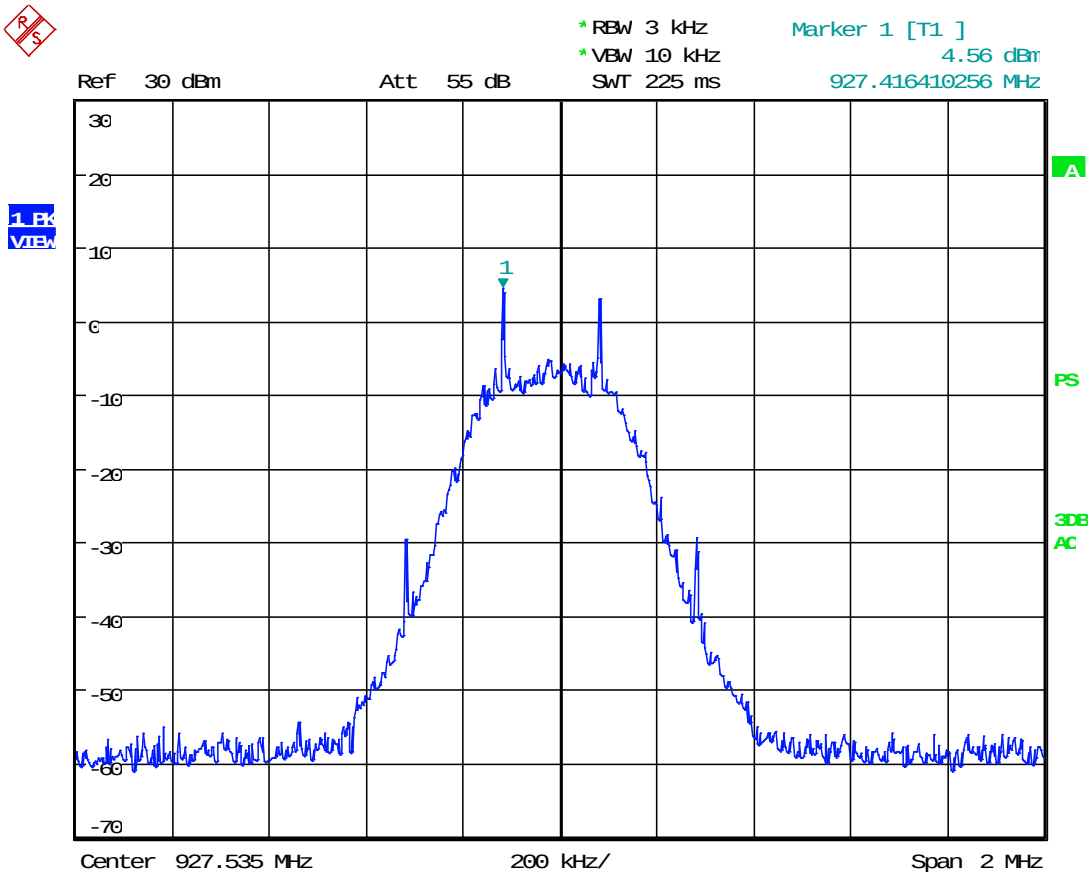


Mid Channel



Date: 19.APR.2023 10:21:09

High Channel



Date: 19.APR.2023 10:22:12

12 ANSI 63.10 7.8.2 - FREQUENCY SEPARATION

EUT was directly connected to the analyzer with the Hopping function on.

12.1 Requirements:

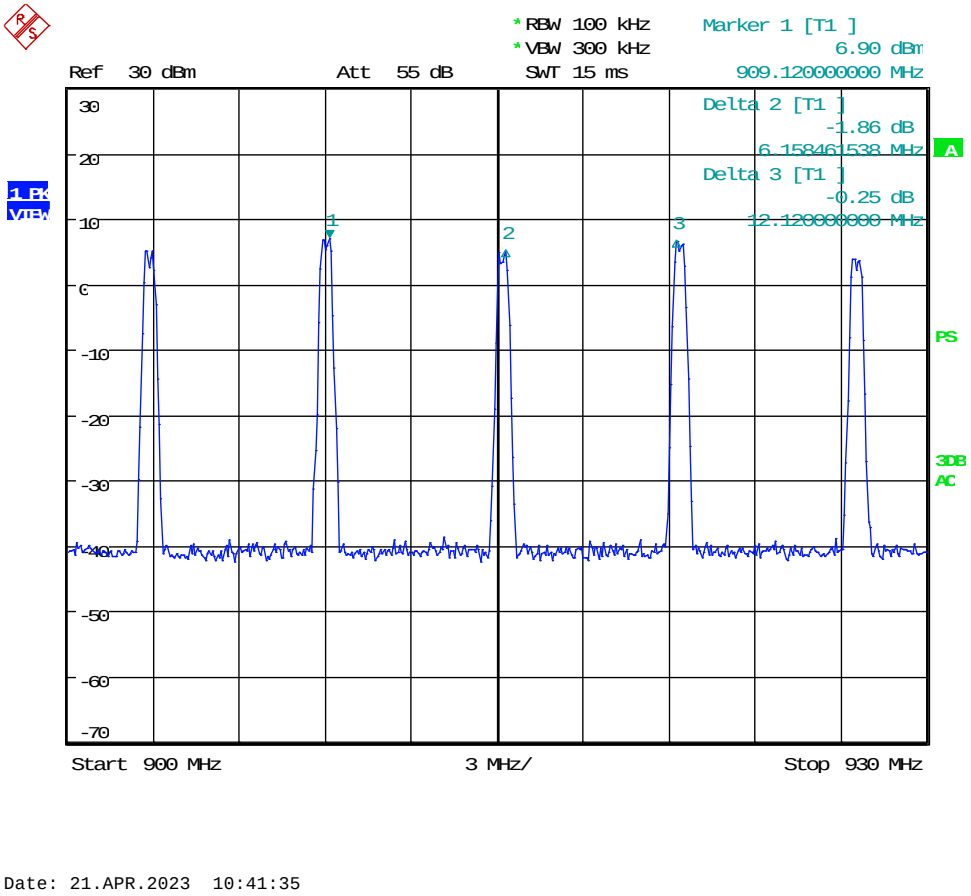
Frequency separation must be greater than 25kHz or 20dB bandwidth of the Hopping Channel, whichever is greater.

12.2 Frequency Separation Test Data

Test Date(s):	2023-04-21	Test Engineer:	J. Chiller
Standards:	ANSI 63.10 7.8.2	Air Temperature:	21.2ºC
		Relative Humidity:	34%

Limit: >409kHz (maximum 20dB OBW)

Verified all channels had a frequency separation claimed by the manufacturer. All channels had 6.165 MHz separation.



13 HYBRID HOPPING FREQUENCIES

The EUT was directly connected to the measurement device through an SMA connector. With the hopping enabled, the EUT was checked to ensure all of the hopping channels were present.

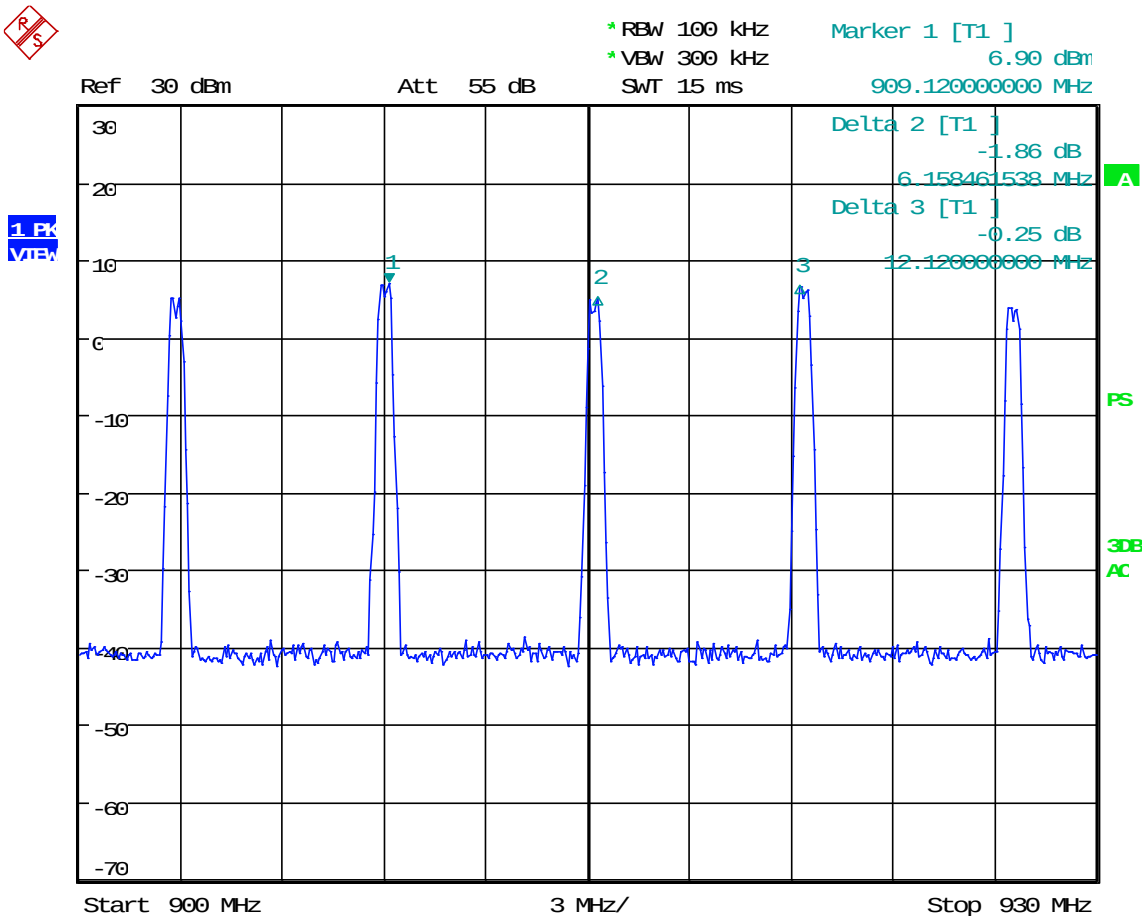
13.1 Requirements:

For the purposes of this section, hybrid systems are those that employ a combination of both frequency hopping and digital modulation techniques. The frequency hopping operation of the hybrid system, with the direct sequence or digital modulation operation turned off, shall have an average time of occupancy on any frequency not to exceed 0.4 seconds within a time period in seconds equal to the number of hopping frequencies employed multiplied by 0.4.

13.2 Number of Hopping Frequencies Test Data

Test Date(s):	2023-04-19	**Test Engineer:**	J. Chiller
Standards:	CFR 47 Part 15.247(f)	**Air Temperature:**	21.2ºC
		Relative Humidity:	34%

Manufacturer declares 5 hybrid channels. All channels were verified.



14 FCC PART 15.247(f) – DWELL TIME

Test was to verify the dwell time on any channel while Hopping was on. EUT was directly connected to analyzer. The plots on the following page show how long a transmission is, and the transmissions in two (2) seconds.

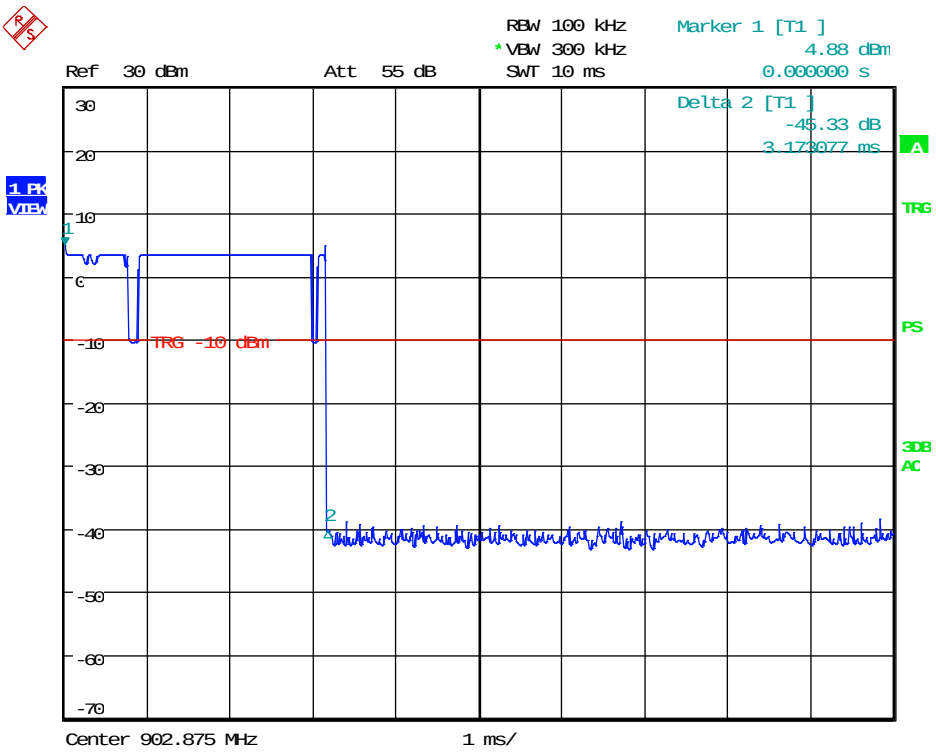
14.1 Requirements:

Limit of 0.4 seconds in a 2-second period. (400ms x 5 channels)

14.2 Dwell Time Test Data

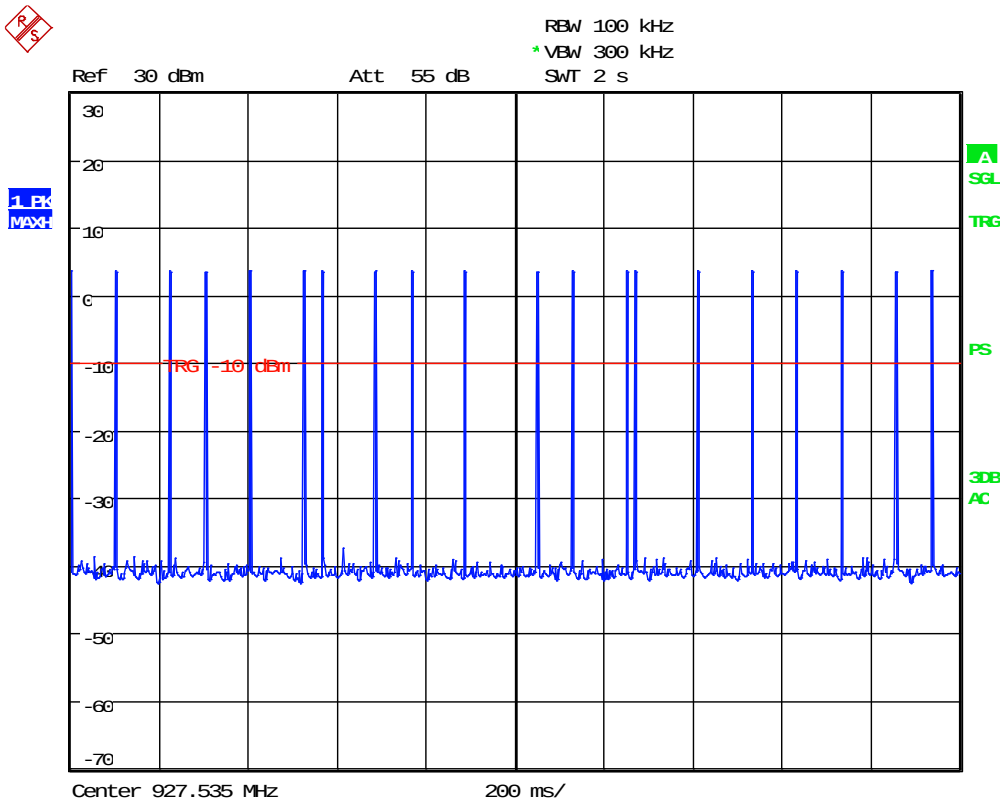
Test Date(s):	2023-04-19	Test Engineer:	J. Chiller
Standard(s):	CFR 47 Part 15.247(f)	Air Temperature:	21.6ºC
		Relative Humidity:	41%

Length of transmission = 3.17 ms



Date: 19.APR.2023 10:43:33

Number of transmissions in 2 Seconds

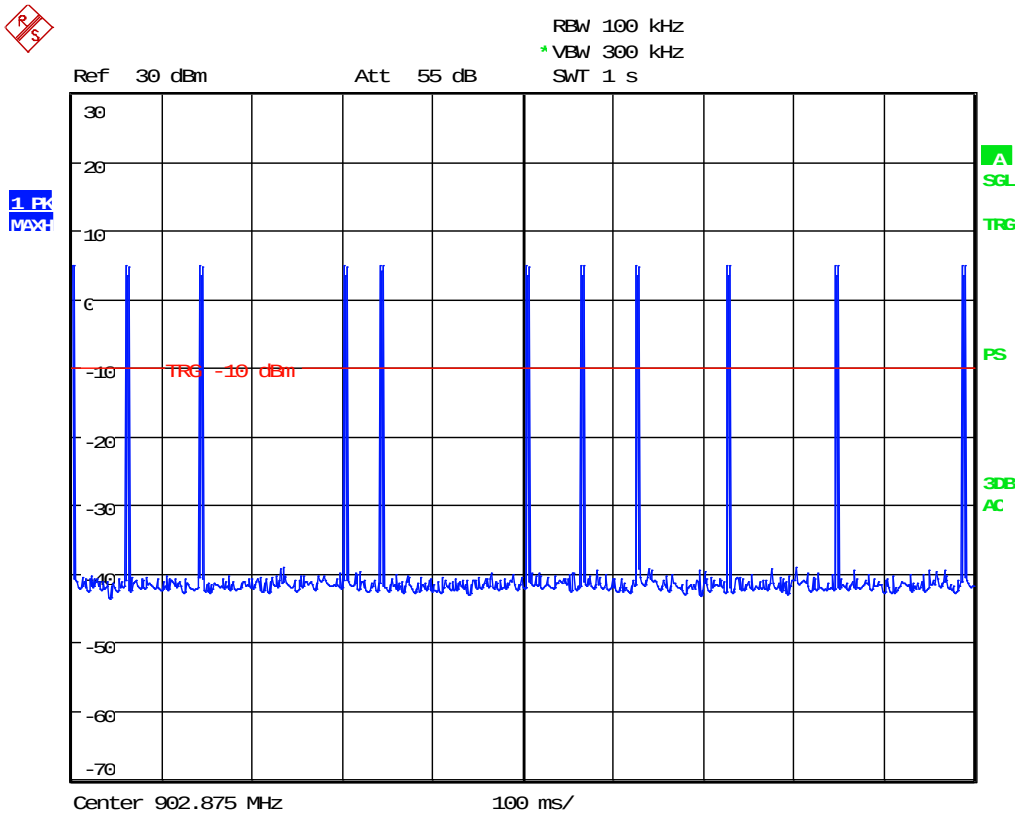


Date: 19.APR.2023 10:53:22

Dwell Limit: 0.4 Seconds

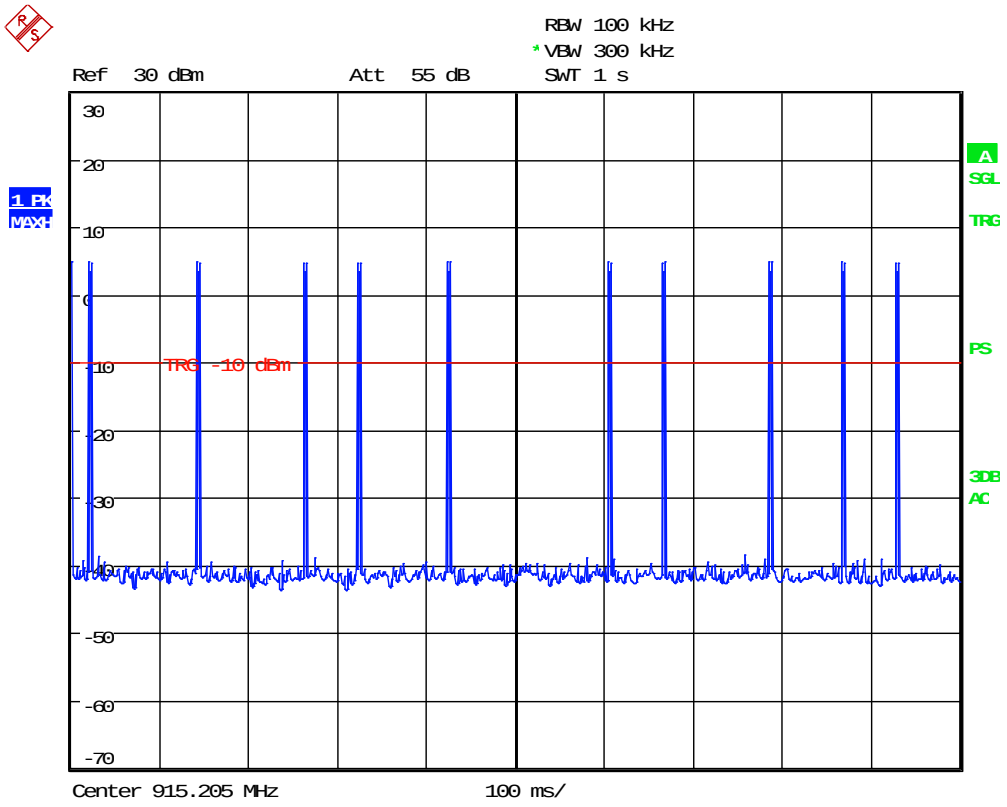
Transmission Duration: 3.17 ms
Number of Pulses in 2s: 20
Total Time: 63.4ms (0.0634 Seconds)

Low



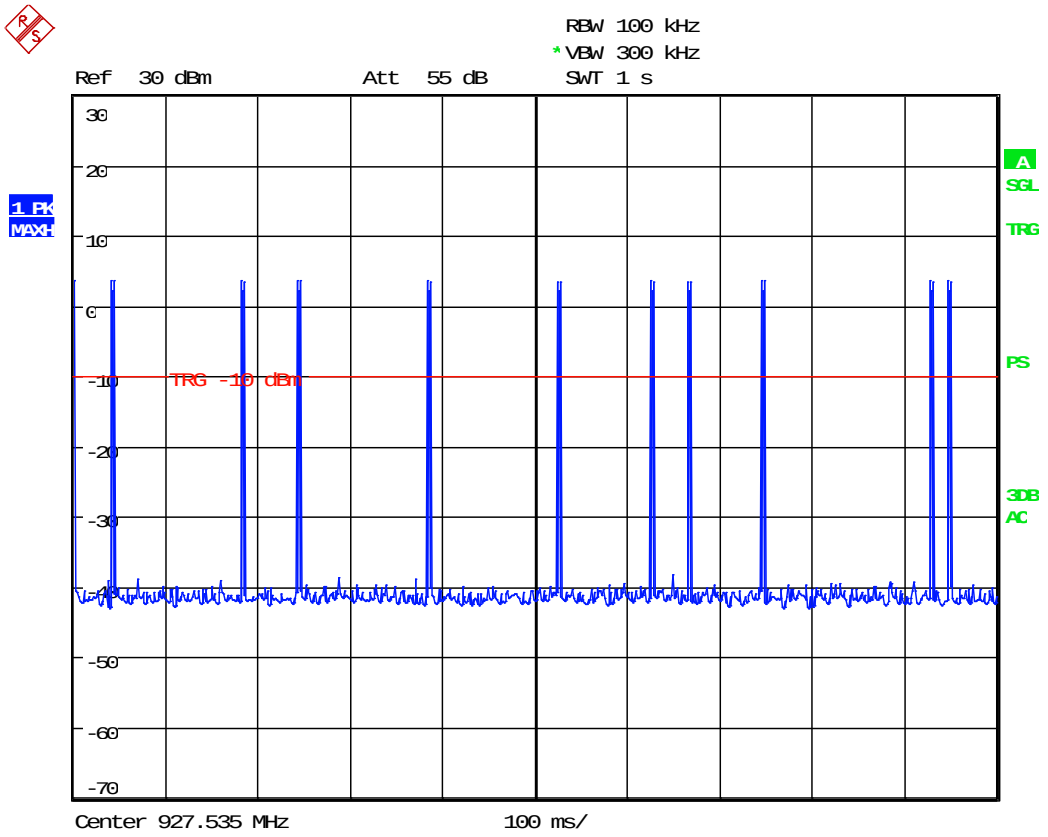
Date: 19.APR.2023 10:45:52

Mid



Date: 19.APR.2023 10:47:30

High



Date: 19.APR.2023 10:47:59

15 CONDUCTED EMISSIONS

15.1 Requirements

In accordance with FCC CFR 47 Part 15.207(a), “Except as shown in paragraphs (b) and (c) of this section, for 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). Compliance with the provisions of this paragraph shall be based on the measurement of the radio frequency voltage between each power line and ground at the power terminal. The lower limit applies at the boundary between the frequency ranges.

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.

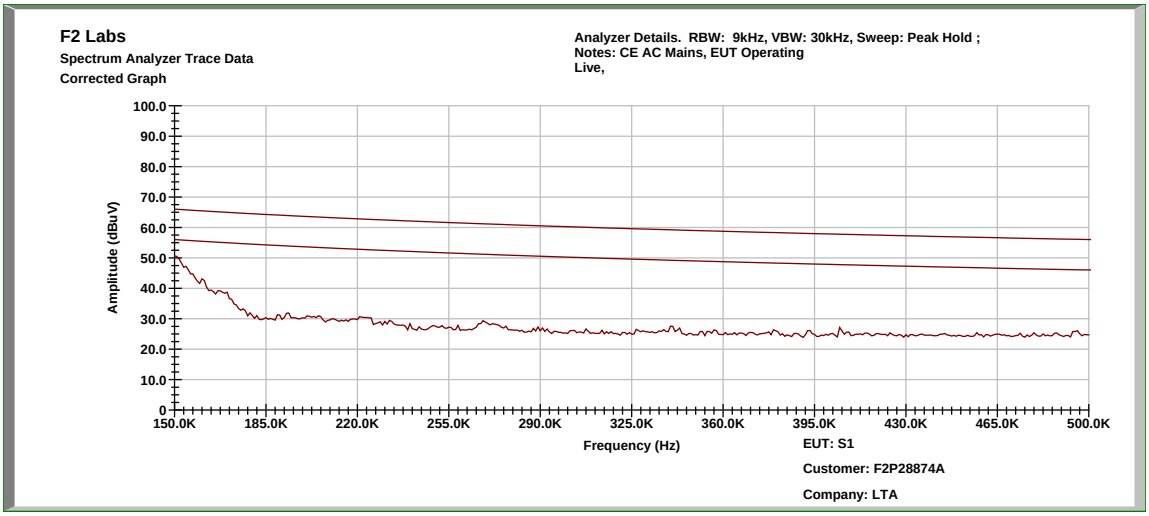
15.2 Procedure

The EUT was placed on a 1.0 x 1.5 meter non-conductive table, 0.8 meter above a horizontal ground plane and 0.4 meter from a vertical ground plane. Power was provided to the EUT through a LISN bonded to a 3 x 2 meter ground plane. The LISN and peripherals were supplied power through a filtered AC power source. The output of the LISN was connected to the input of the receiver via a transient limiter, and emissions in the range 150 kHz to 30 MHz were measured. The measurements were recorded using the quasi-peak and average detectors as directed by the standard, and the resolution bandwidth during testing was 9 kHz. The raw measurements were corrected to allow for attenuation from the LISN, transient limiter and cables.

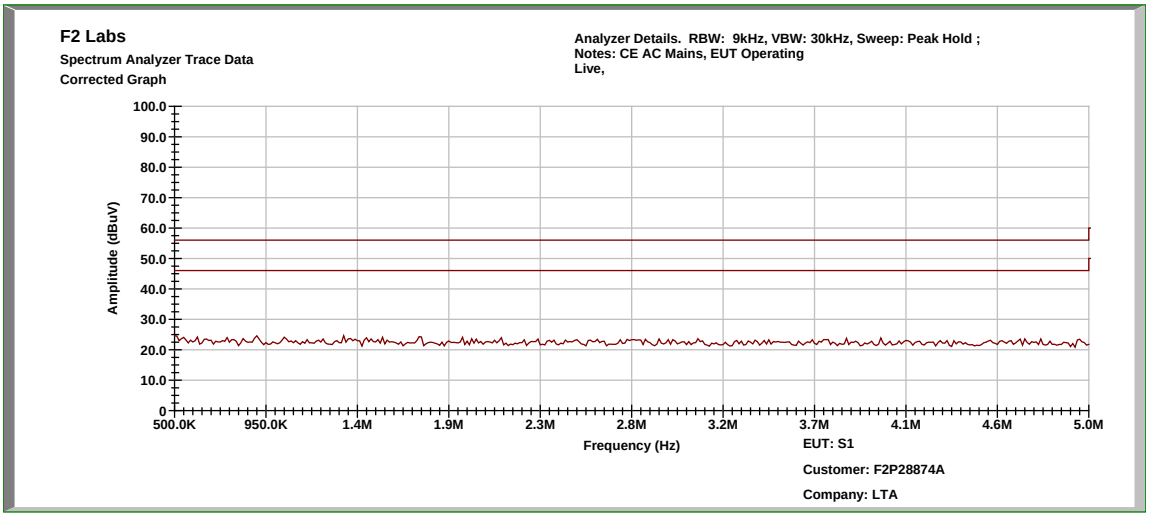
15.3 Conducted Emissions Test Data

Test Date:	2023-02-14	**Test Engineer:**	J. Chiller
Rule:	15.207	**Air Temperature:**	20.3º C
Test Results:	Pass	**Relative Humidity:**	33%

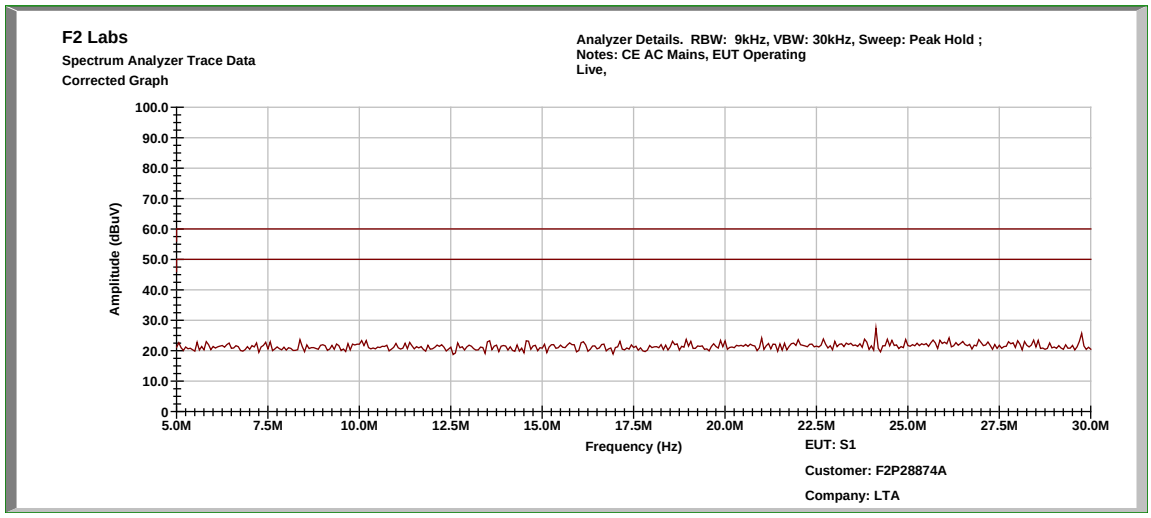
Conducted Test – Line 1: 0.15 MHz to 0.5 MHz



Conducted Test – Line 1: 0.5 MHz to 5.0 MHz

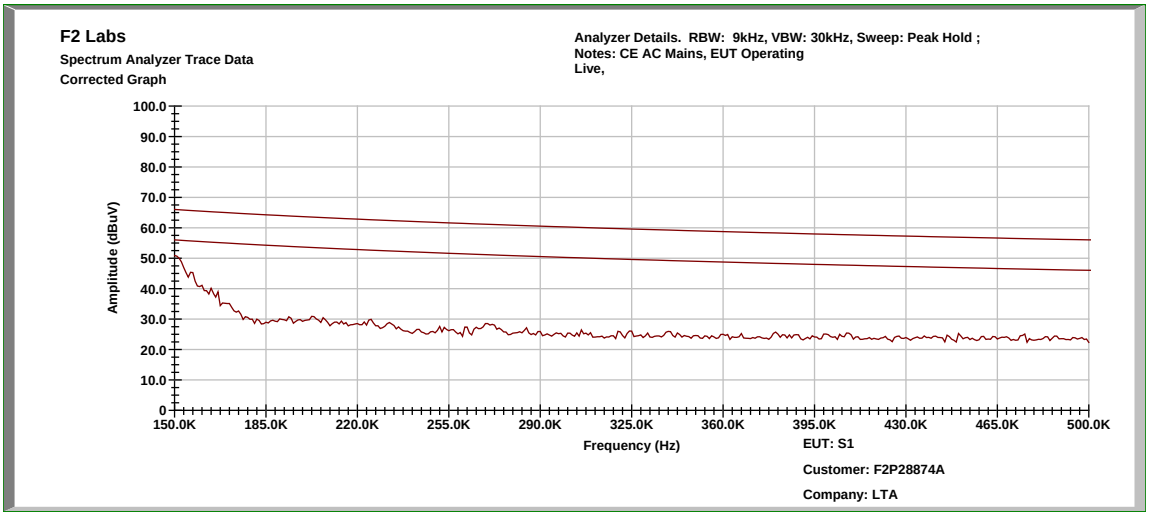


Conducted Test – Line 1: 5.0 MHz to 30.0 MHz

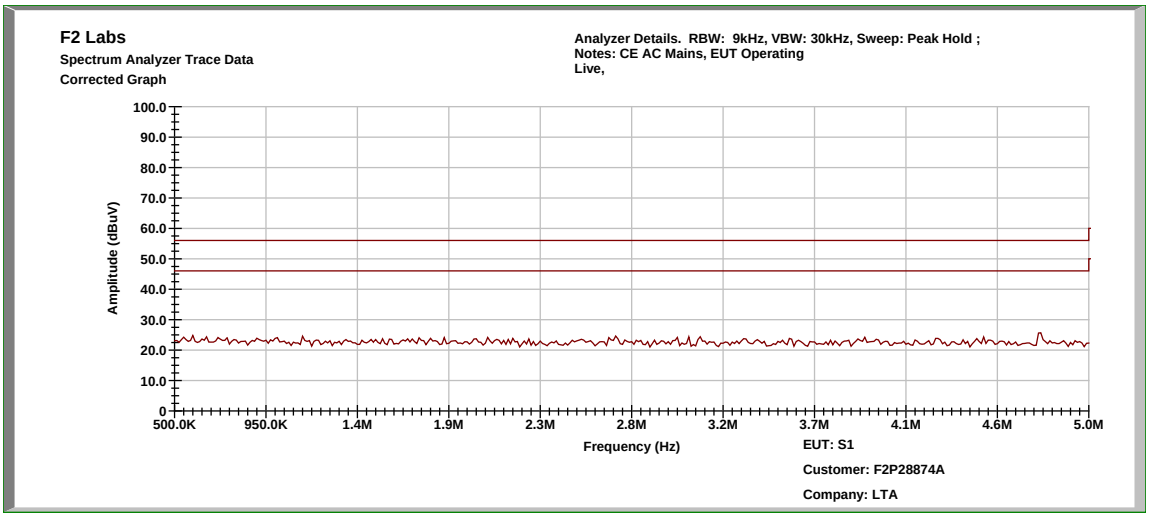


Note: All peak scans are below AVG limit.

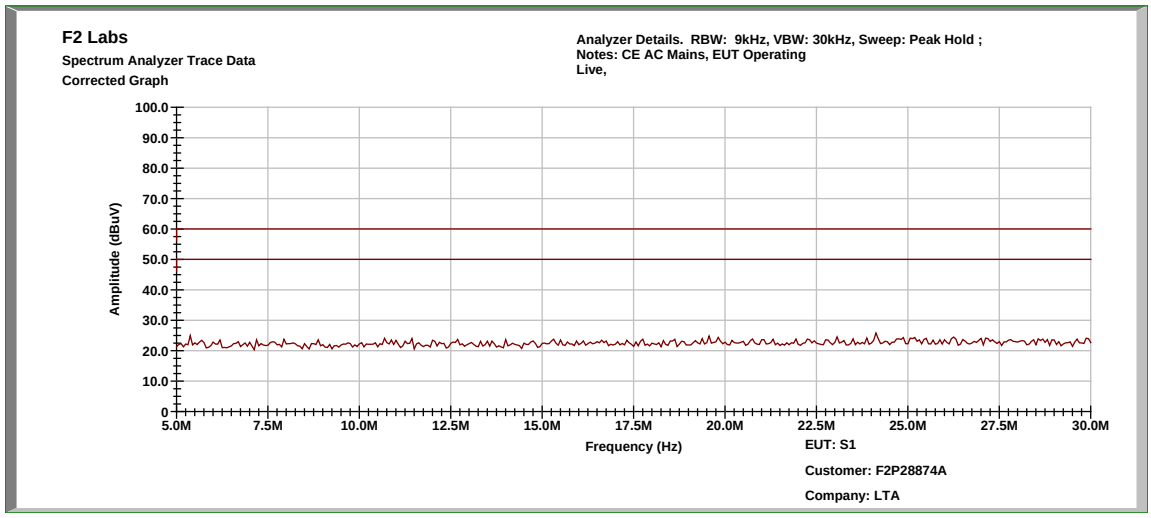
Conducted Test – Line 2: 0.15 MHz to 0.5 MHz



Conducted Test – Line 2: 0.5 MHz to 5.0 MHz



Conducted Test – Line 2: 5.0 MHz to 30.0 MHz



Note: All peak scans are below AVG limit.

16 VOLTAGE VARIATIONS

16.1 Requirements

For intentional radiators, measurements of the variation of the input power or the radiated signal level of the fundamental frequency component of the emission, as appropriate, shall be performed with the supply voltage varied between 85% and 115% of the nominal rated supply voltage. For battery-operated equipment, the equipment tests shall be performed using a new battery.

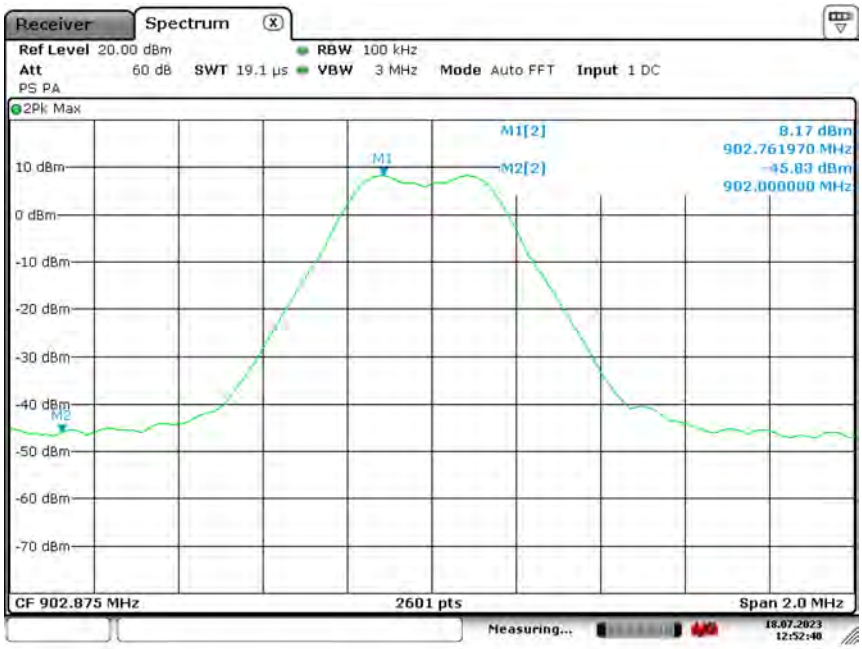
16.2 Voltage Variations Test Data

Test Date(s):	2023-07-18	**Test Engineer:**	J. Chiller
Rule:	15.31(e)	**Air Temperature:**	22.2º C
Test Results:	Complies	**Relative Humidity:**	44%

Note: EUT ceases to function below 2.9VDC. 4.1VDC is manufacturer's maximum operational voltage.

Low Channel, 3.5VDC (Nominal)

Low Channel, 2.9VDC

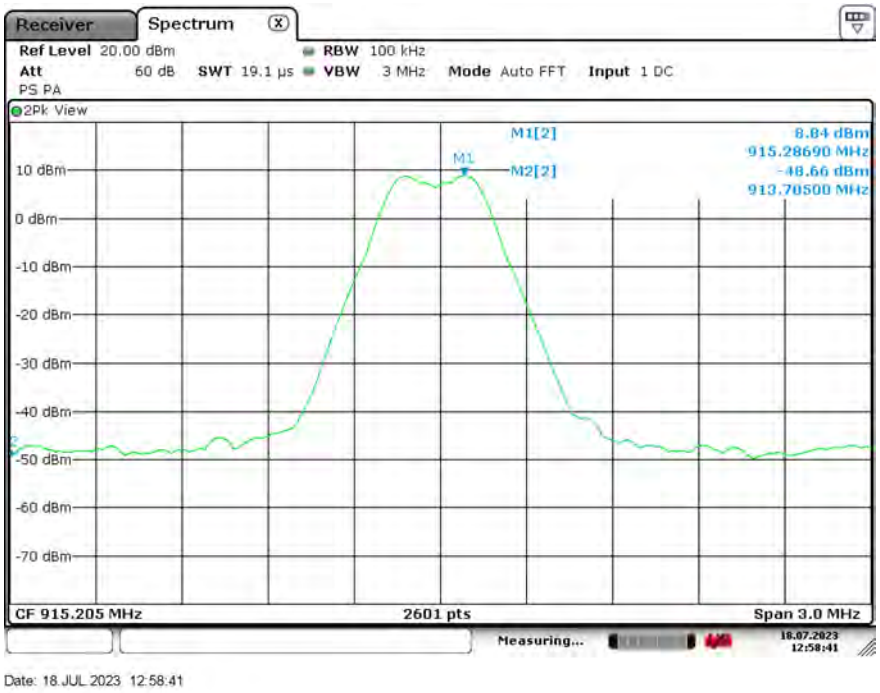


Date: 18.JUL.2023 12:52:40

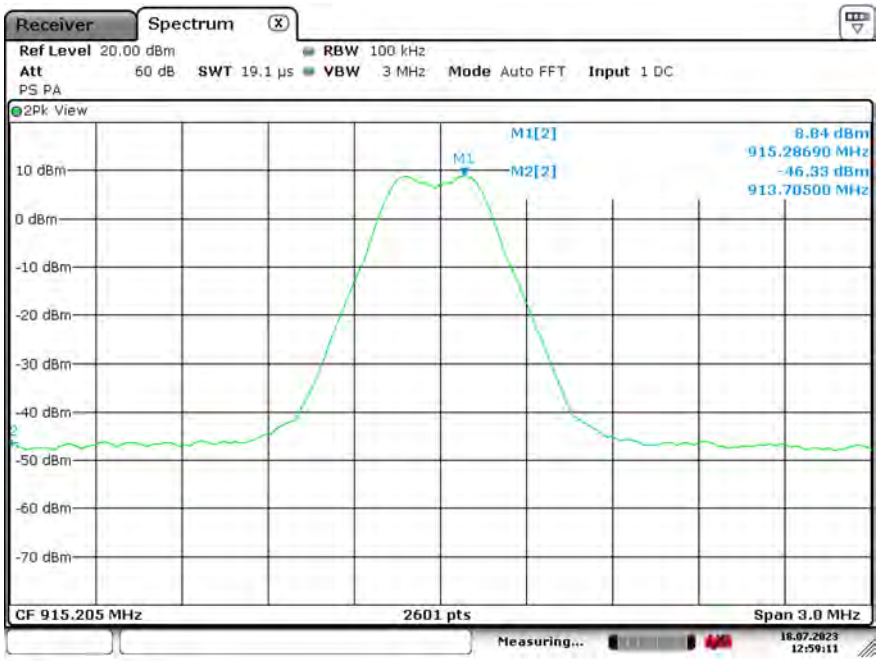
Low Channel, 4.1VDC

Date: 18.JUL.2023 12:49:46

Mid Channel, 3.5VDC (Nominal)

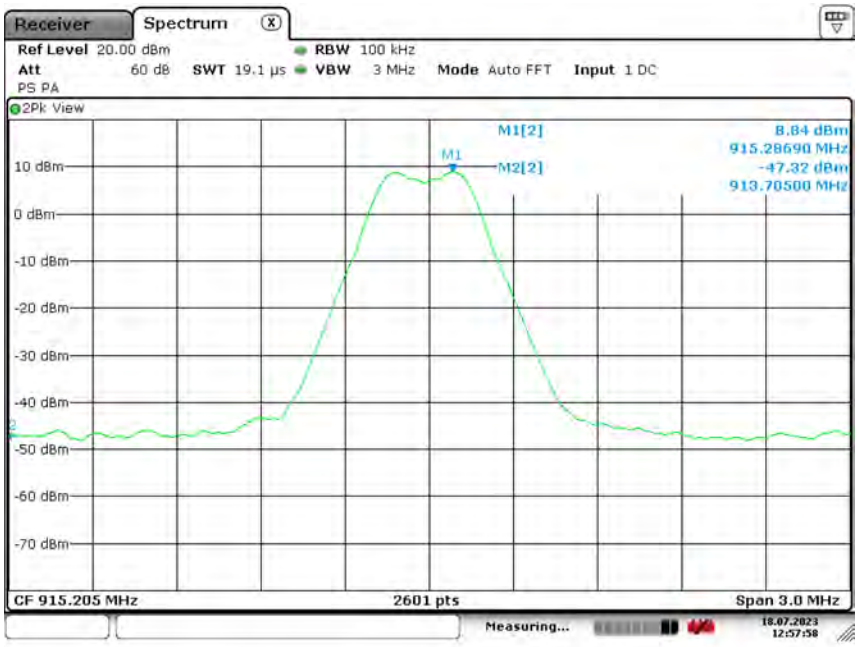


Mid Channel, 2.9VDC



Date: 18.JUL.2023 12:59:11

Mid Channel, 4.1VDC



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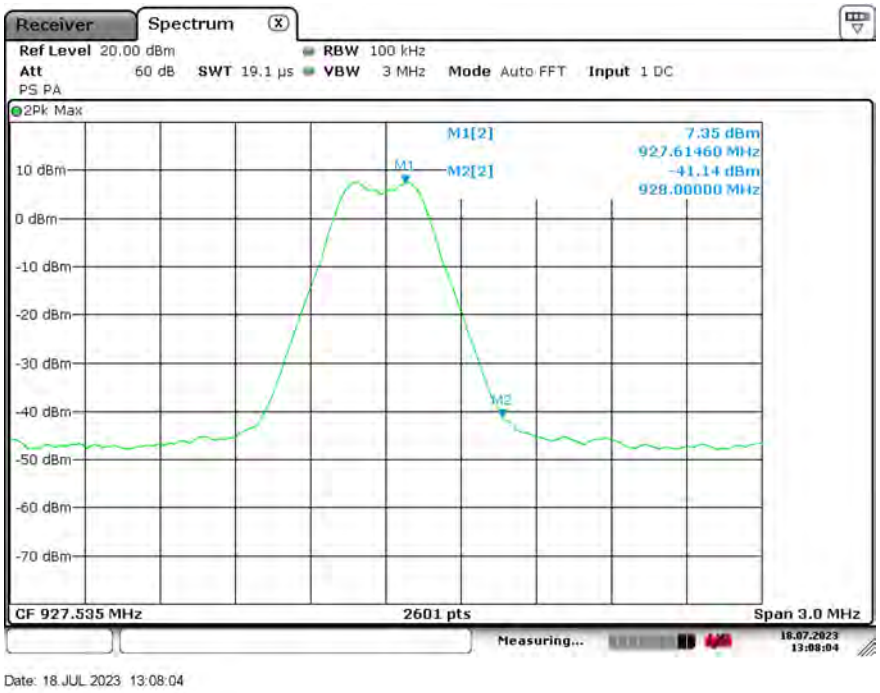
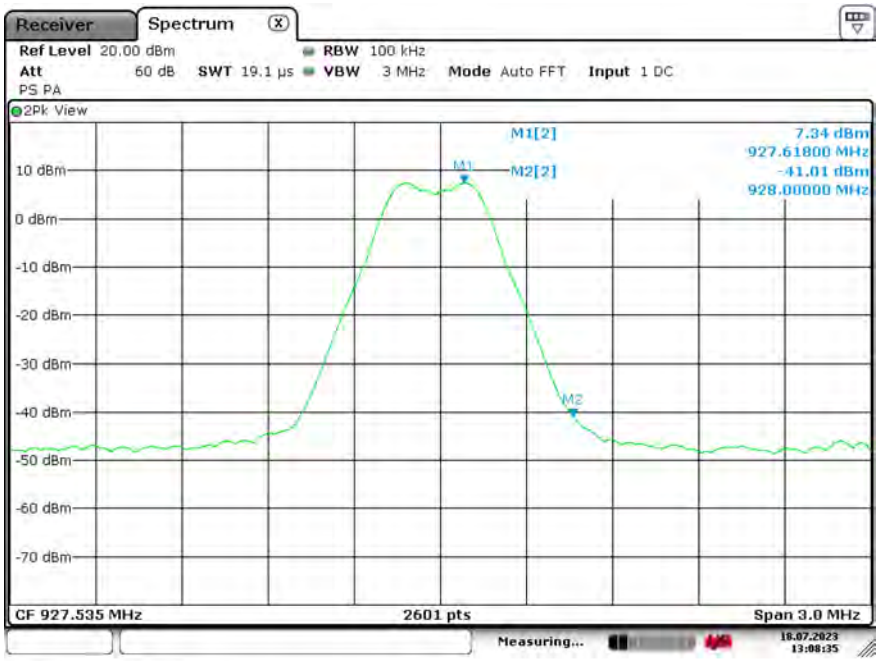
High Channel, 3.5VDC (Nominal)

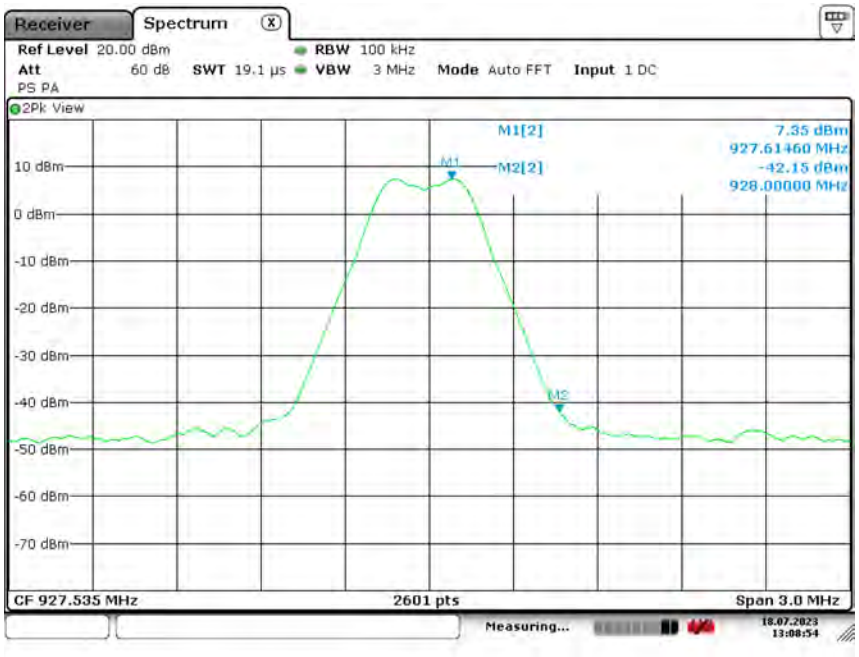


High Channel, 2.9VDC



Date: 18.JUL.2023 13:08:36

High Channel, 4.1VDC

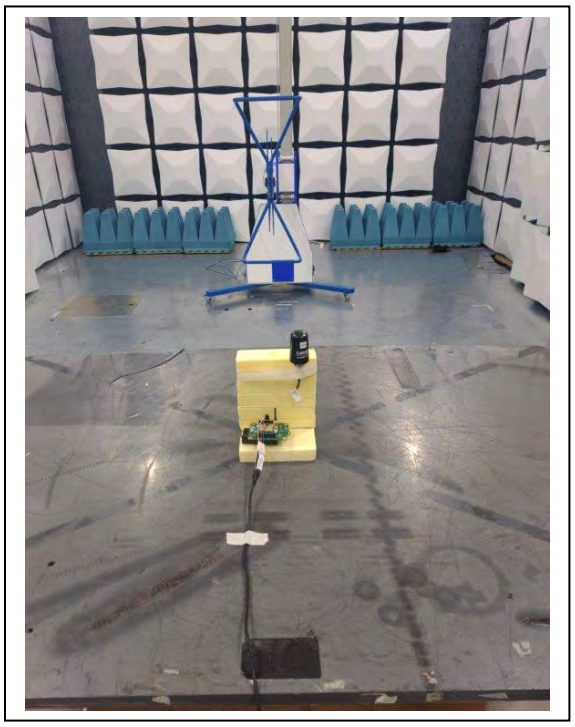


Date: 18.JUL.2023 13:08:55

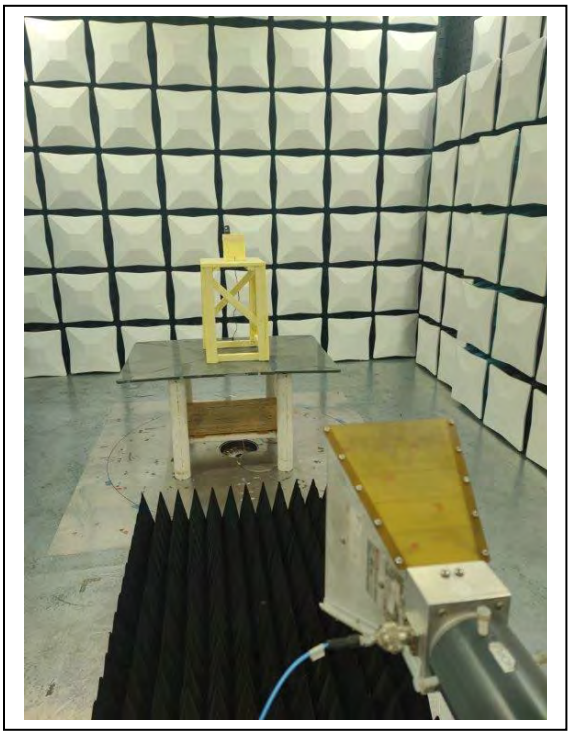
17 TEST SETUP PHOTOGRAPHS

Radiated Spurious Emissions: Loop Antenna

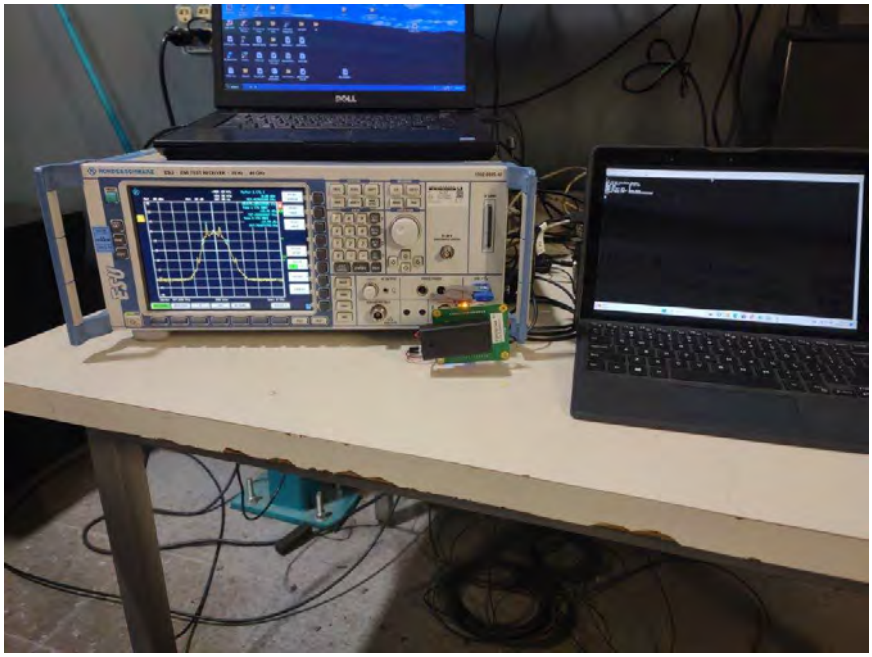
Radiated Spurious Emissions: Less Than 1 GHz

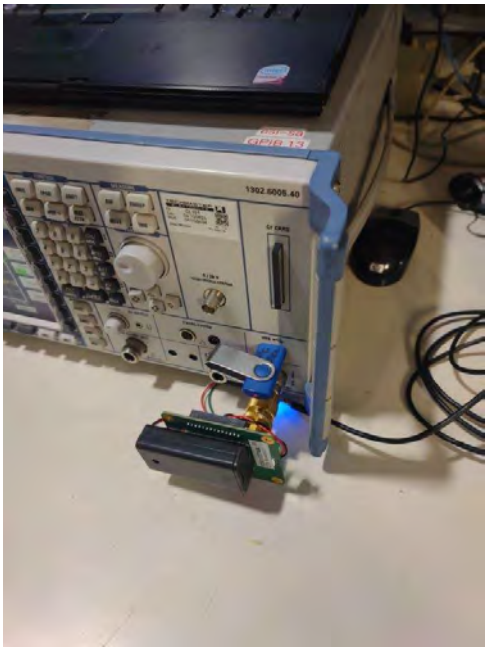


Radiated Spurious Emissions: Greater Than 1 GHz

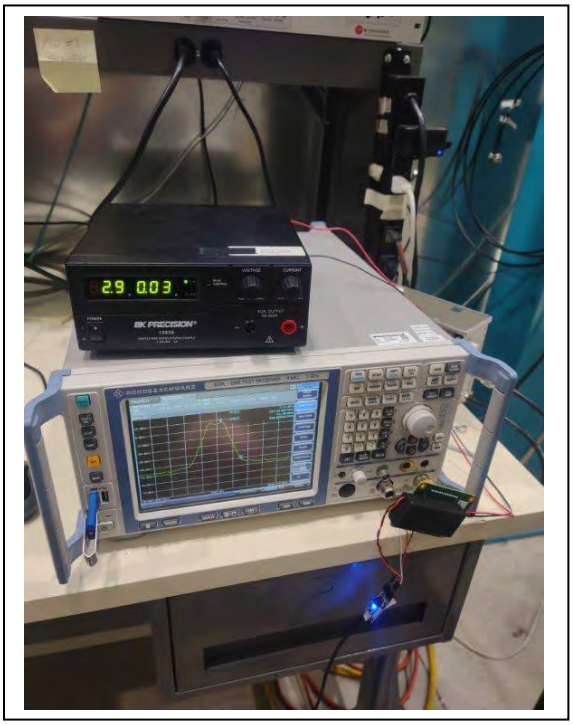


Conducted Output Power, Peak Power Spectral Density, Occupied Bandwidth, and Conducted Spurious Emissions





Voltage Variations



Conducted Emissions