RF Test Report

Project Number:	**5214055**	**Proposal:**	**SUW-202405006470**
Report Number:	**5214055EMC01**	**Revision Level:**	**2**

Client: **Sanmina Corporation**
Equipment Under Test: **Encircle Remote Termite Detection System (RTDS)**
Model: **1005400-MDC-001**
FCC ID: **2AMS3ENCRICLE**

Applicable Standards: **ANSI C63.10: 2013 (FCC Part 15 Subpart C, § 15.247)**

Report issued on: **30 August 2024**
Report revised on: **26 November 2024**
Test Result: **Compliant**

FOR THE SCOPE OF ACCREDITATION UNDER CERTIFICATE NUMBER: 3212.01
This report must not be used by the client to claim product certification, approval, or endorsement by A2LA, NIST, or any agency of the Federal Government.

Tested by: _____
Daniel Alvarez, RF/EMC Sr. Staff Engineer

Reviewed by: _____
Martin Taylor, EMC/RF Sr. Project Engineer

Table of Contents

1 Summary of Test Results

Test Description	Test Specification		Test Result
Occupied Bandwidth	15.247(a)(1)	RSS-247 5.1(a) RSS-GEN 6.7	Compliant
Peak Output Power	15.247(b)(2), (b)(3)	RSS-247 5.4(a), 5.4(d)	Compliant
Power Spectral Density	15.247(e)	RSS-247 S5.2 (b)	Compliant
Conducted Spurious Emissions / Band Edge	15.247(d)	RSS-247 5.5	Compliant
Field Strength of Spurious Radiation	15.247(d), 15.35(b) 15.205, 15.209	RSS-247 5.5 RSS-GEN 8.9, 8.10	Compliant
Radiated Emissions at Band Edge / Restricted Bands	15.205, 15.209	RSS-GEN 8.9, 8.10	Compliant
Pseudo-Random Hop Sequence	15.247(a)(1)	RSS-247 5.1(a)	Compliant
Channel Separation	15.247(a)(1)	RSS-247 5.1(b)	Compliant
Number of Hopping Channels	15.247(a)(1)(iii)(h)	RSS-247 5.1(d)	Compliant
Dwell Time	15.247(a)(1)(iii)(g)	RSS-247 5.1(d)	Compliant
AC Powerline Conducted Emissions	15.207	RSS-GEN 8.8	N/A (2)
Antenna Requirement	15.203	RSS-GEN 6.8	Compliant (1)

(1) The device uses a PCB trace PIFA antenna which cannot be replaced by the end user.
(2) Product is Battery powered. Mains testing does not apply.

1.1 *Modifications Required for Compliance*

None

2 General Information

2.1 *Client Information*

Company Name:	Sanmina Corporation
Address:	13000 South Memorial Parkway
City, State, Zip, Country:	Huntsville, Alabama, 35803 USA

2.2 *Test Laboratory*

Name:	SGS North America, Inc.
Address:	620 Old Peachtree Road NW, Suite 100
City, State, Zip, Country:	Suwanee, GA 30024, USA
Accrediting Body:	A2LA
Type of lab:	Testing Laboratory
Certificate Number:	3212.01
FCC Designation Number:	US1126

2.3 *General Information of EUT*

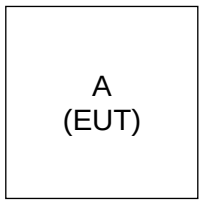
Manufacturer:	Sanmina Corporation
Product Marketing Name (PMN):	Encircle Remote Termite Detection System (RTDS)
Model Number:	1005400-MDC-001
Serial Number:	NIM2428F000021 (Conducted Sample) NIM2428F000017 (Radiated Sample)
Type / Frequency Range:	LoRa / 902 – 928 MHz
Modulation / Data Rate(s):	CSS / 125kHz, 500 kHz
Antenna*:	PCB antenna: +0.9 dBi
Rated Voltage:	3.3 to 3 VDC (Two coin cell batteries)
Test Voltage:	3.3 to 3 VDC (Two coin cell batteries)
Sample Received Date:	12 August 2024
Dates of testing:	12 August 2024 – 16 August 2024

**Data was not measured; therefore, the lab is not responsible for accuracy. Data was obtained via customer, specification sheet, previous regulatory filing, or other means.*

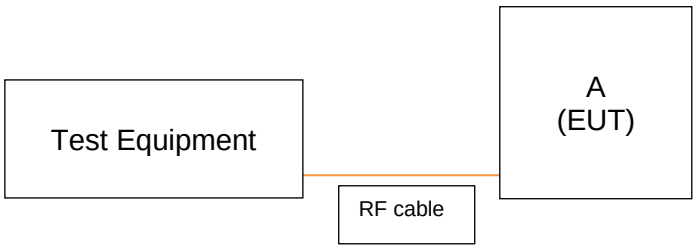
2.4 *Product Description:*

The Lora Sensor was running test mode firmware which allowed commands to be sent to transmit on low, middle and high channels in all necessary modulation and modes of operation. During emissions testing, the EUT was powered at its ~3VDC test voltage and set to its test mode to exercise the transmitter during testing.

2.5 *EUT Connection Block Diagram – Radiated Measurements*



2.6 *EUT Connection Block Diagram – Conducted Measurements*



2.7 *System Configurations*

Device reference	Manufacturer	Description	Model Number	Serial Number
A	Sanmina Corporation	Encircle Remote Termite Detection System (RTDS) (Conducted Sample)	1005400-MDC-001	NIM2428F000021
A	Sanmina Corporation	Encircle Remote Termite Detection System (RTDS) (Radiated Sample)	1005400-MDC-001	NIM2428F000017

2.8 *Cable List*

Cable reference	Port Name	Start	End	Cable Length (m)	Ferrite installed?	Shielded?
	None					

3 Occupied Bandwidth

3.1 *Test Result*

Test Description	Basic Standards	Test Result
6db Bandwidth 99% Bandwidth 20dB Bandwidth	ANSI C63.10:2013 15.247(a)(1) RSS-247 5.1(a) RSS-GEN 6.7	Compliant

3.2 *Test Method*

Occupied bandwidth measurements were taken using the methods defined an ANSI C63.10, Clause 6.9. Measurements were recorded using both 6dB OBW and 99% OBW function of the measurement receiver.

3.3 *Test Site*

SGS EMC Laboratory, Suwanee, GA

Environmental Conditions

Temperature:	23.34 °C
Relative Humidity:	55.2 %
Atmospheric Pressure:	98.33 kPa

3.4 *Test Equipment*

Test End Date: 14-Aug-2024 Tester: SGM

Equipment	Manufacturer	Model	Asset Number	Cal Date	Cal Due Date
RF CABLE SMA TO SMA, 0.01-40GHZ	TELEDYNE STORM MICROWAVE	084-0505-059	20108	20-Mar-2024	20-Mar-2025
TSTPASS SWITCHBOX	TSTPASS	SB2	23009	8-Apr-2024	8-Apr-2025
SIGNAL ANALYZER (TS8997)	ROHDE & SCHWARZ	FSV30	B085749	3-Jan-2024	3-Jan-2025

3.5 *Test Data – 20dB Bandwidth / 99% Bandwidth*

125 kHz BW

Mode	TX Type	Frequency (MHz)	ANT	99% Occupied Bandwidth (MHz)		Verdict
				Result	Limit	
LoRa	SISO	902.3	1	0.125	/	Pass
		908.9	1	0.125	/	Pass
		914.9	1	0.124	/	Pass

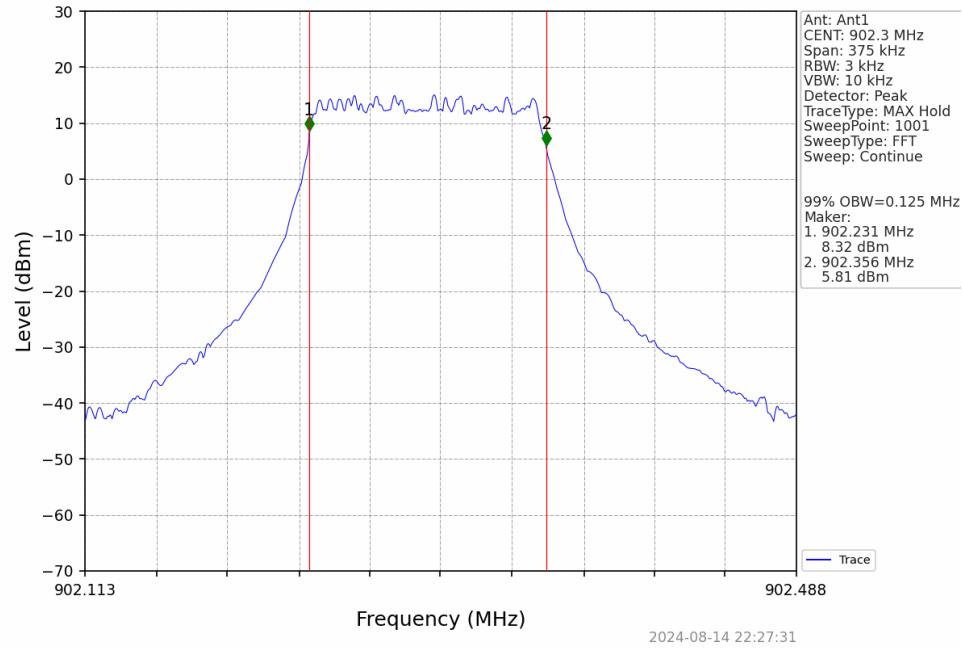
Mode	TX Type	Frequency (MHz)	ANT	20dB Bandwidth (MHz)		Verdict
				Result	Limit	
LoRa	SISO	902.3	1	0.145	/	Pass
		908.9	1	0.143	/	Pass
		914.9	1	0.142	/	Pass

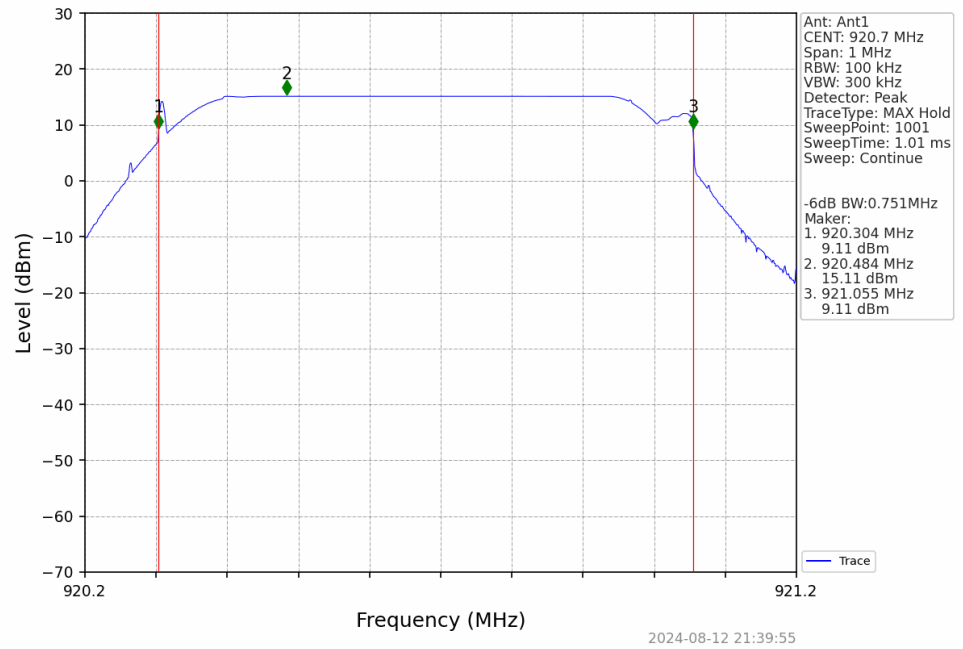
500 kHz BW

Mode	TX Type	Frequency (MHz)	ANT	99% Occupied Bandwidth (MHz)		Verdict
				Result	Limit	
LoRa	SISO	915.9	1	0.648	/	Pass
		920.7	1	0.581	/	Pass
		927.1	1	0.580	/	Pass

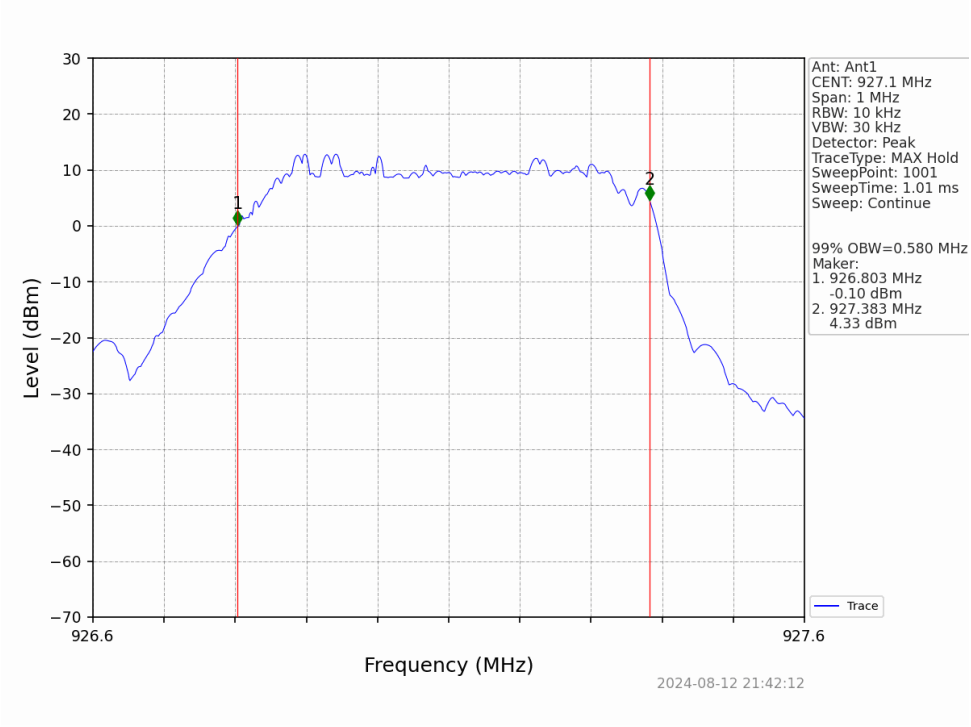
Mode	TX Type	Frequency (MHz)	ANT	6dB Bandwidth (MHz)		Verdict
				Result	Limit	
LoRa	SISO	915.9	1	0.796	>=0.5	Pass
		920.7	1	0.751	>=0.5	Pass
		927.1	1	0.783	>=0.5	Pass

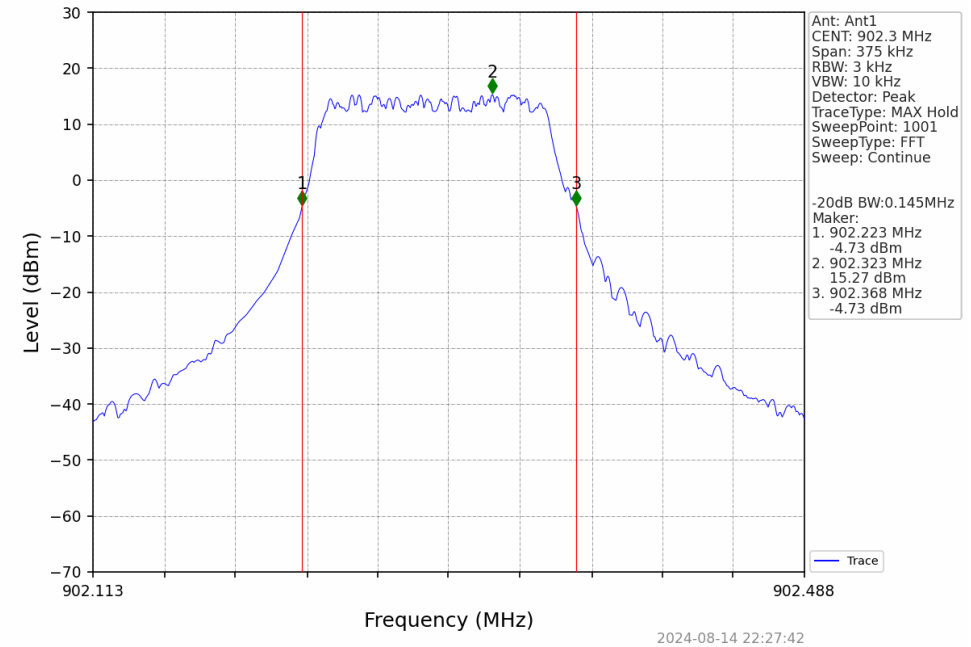
Representative Plot
125kHz BW





500 kHz BW


Ant: Ant1
CENT: 927.1 MHz
Span: 1 MHz
RBW: 10 kHz
VBW: 30 kHz
Detector: Peak
TraceType: MAX Hold
SweepPoint: 1001
SweepTime: 1.01 ms
Sweep: Continue
99% OBW=0.580 MHz
Maker:
1. 926.803 MHz
-0.10 dBm
2. 927.383 MHz
4.33 dBm
Trace
Level (dBm)
Frequency (MHz)
926.6
927.6
2024-08-12 21:42:12


Ant: Ant1
CENT: 902.3 MHz
Span: 375 kHz
RBW: 3 kHz
VBW: 10 kHz
Detector: Peak
TraceType: MAX Hold
SweepPoint: 1001
SweepType: FFT
Sweep: Continue
-20dB BW:0.145MHz
Maker:
1. 902.223 MHz
-4.73 dBm
2. 902.323 MHz
15.27 dBm
3. 902.368 MHz
-4.73 dBm
Trace
Level (dBm)
Frequency (MHz)
902.113
902.488
2024-08-14 22:27:42

4 Peak Output Power

4.1 *Test Result*

Test Description	Test Specification	Test Result
Peak Output Power	ANSI C63.10:2013 15.247(b)(2), (b)(3) RSS-247 5.4(a), 5.4(d)	Compliant

4.2 *Test Method*

Output power measurements were taken using the methods defined an ANSI C63.10, Clause 7.8.5.

Limit

§15.247(b)(2) For frequency hopping systems operating in the 902-928 MHz band: 1 watt for systems employing at least 50 hopping channels; and, 0.25 watts for systems employing less than 50 hopping channels, but at least 25 hopping channels, as permitted under paragraph (a)(1)(i) of this section.

§15.247(b)(3): For systems using digital modulation in the 902-928 MHz, 2400-2483.5 MHz, and 5725-5850 MHz bands: 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.

4.3 *Test Site*

SGS EMC Laboratory, Suwanee, GA

Environmental Conditions

Temperature:	23.34 °C
Relative Humidity:	55.2 %
Atmospheric Pressure:	98.33 kPa

4.4 *Test Equipment*

Test End Date: 14-Aug-2024 Tester: SGM

Equipment	Manufacturer	Model	Asset Number	Cal Date	Cal Due Date
RF CABLE SMA TO SMA, 0.01-40GHZ	TELEDYNE STORM MICROWAVE	084-0505-059	20108	20-Mar-2024	20-Mar-2025
TSTPASS SWITCHBOX	TSTPASS	SB2	23009	8-Apr-2024	8-Apr-2025
SIGNAL ANALYZER (TS8997)	ROHDE & SCHWARZ	FSV30	B085749	3-Jan-2024	3-Jan-2025

4.5 *Test Data*

125kHz BW

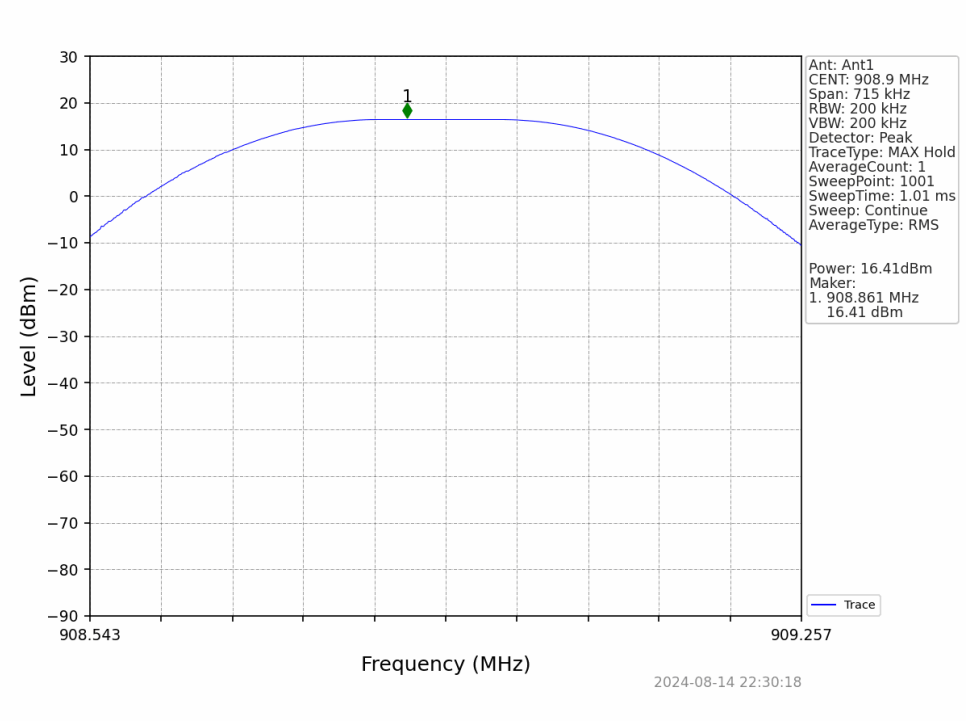
Mode	TX Type	Frequency (MHz)	Maximum Peak Conducted Output Power (dBm)		Verdict
			ANT1	Limit	
LoRa	SISO	902.3	16.47	<=30	Pass
		908.9	16.41	<=30	Pass
		914.9	16.59	<=30	Pass
Note1: Antenna Gain: Ant1: 0.90dBi;					

500kHz BW

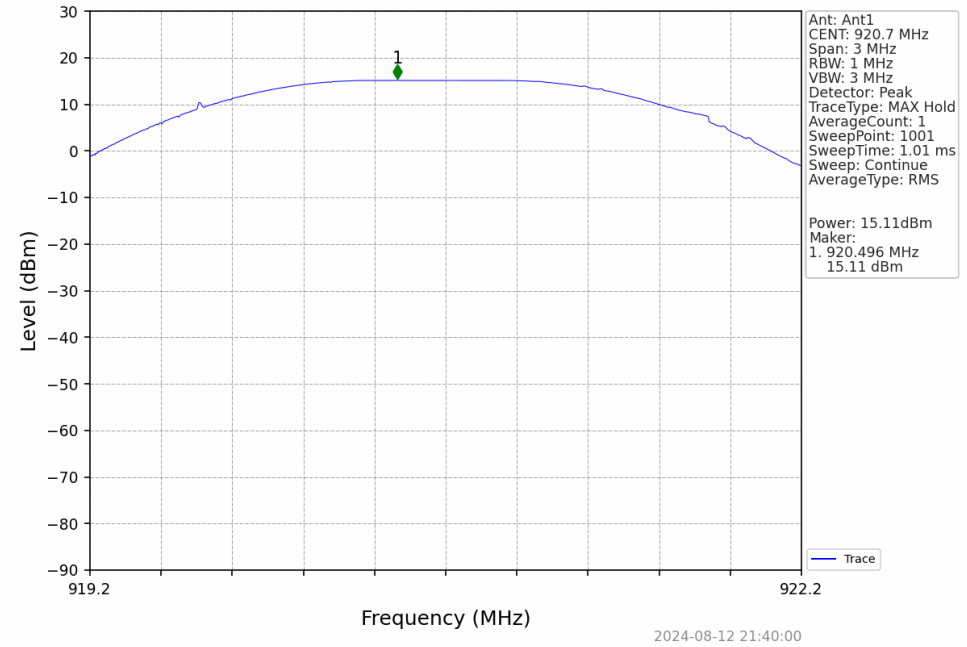
Mode	TX Type	Frequency (MHz)	Maximum Peak Conducted Output Power (dBm)		Verdict
			ANT1	Limit	
LoRa	SISO	915.9	16.16	<=30	Pass
		920.7	16.01	<=30	Pass
		927.1	15.84	<=30	Pass
Note1: Antenna Gain: Ant1: 0.90dBi;					

Representative Plot

125 kHz BW



500kHz BW



5 Power Spectral Density

5.1 *Test Result*

Test Description	Test Specification		Test Result
Power Spectral Density	15.247(e)	RSS-247 S5.2 (b)	Compliant

5.2 *Test Method*

Peak power spectral density measurements were performed using the procedures from ANSI C63.10: 2013 clause 11.10.2. These procedures are referenced in KDB 558074 D01 15.247 Meas Guidance v05r02.

The LoRa 500 kHz modulation was used for this test.

Limit
The maximum limit is 8 dBm / 3 kHz.

5.3 *Test Site*

SGS EMC Laboratory, Suwanee, GA

Environmental Conditions
Temperature: 23.34 °C
Relative Humidity: 55.2 %
Atmospheric Pressure: 98.33 kPa

5.4 *Test Equipment*

Test End Date: 14-Aug-2024 Tester: SGM

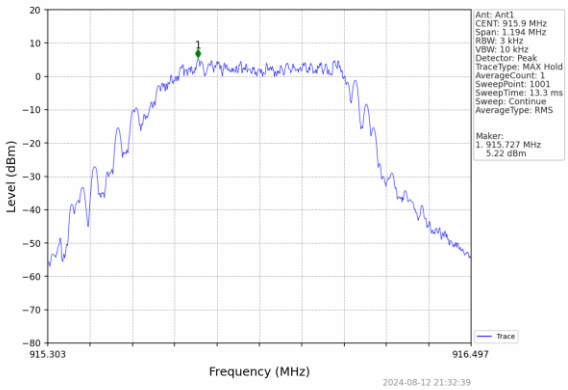
Equipment	Manufacturer	Model	Asset Number	Cal Date	Cal Due Date
RF CABLE SMA TO SMA, 0.01-40GHZ	TELEDYNE STORM MICROWAVE	084-0505-059	20108	20-Mar-2024	20-Mar-2025
TSTPASS SWITCHBOX	TSTPASS	SB2	23009	8-Apr-2024	8-Apr-2025
SIGNAL ANALYZER (TS8997)	ROHDE & SCHWARZ	FSV30	B085749	3-Jan-2024	3-Jan-2025

5.5 *Test Data*

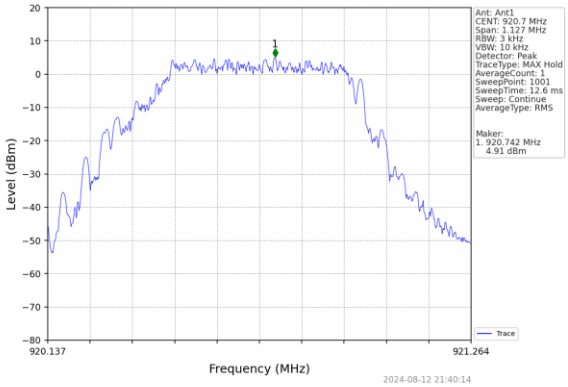
500kHz Modulation

Mode	TX Type	Frequency (MHz)	Maximum PSD (dBm/3kHz)		Verdict
			ANT1	Limit	
LoRa	SISO	915.9	5.22	<=8	Pass
		920.7	4.91	<=8	Pass
		927.1	4.74	<=8	Pass
Note1: Antenna Gain: Ant1: 0.00dBi;					

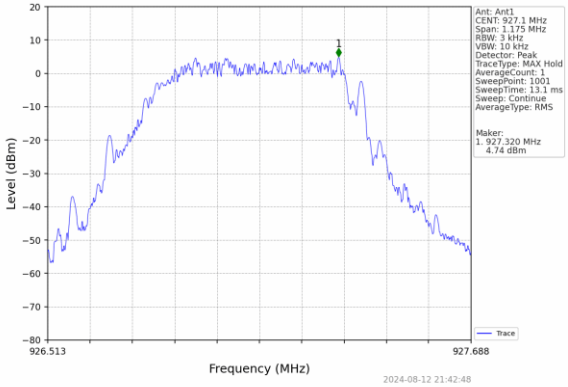
LoRa_LCH_915.9MHz_Ant1_NTNV



LoRa_MCH_920.7MHz_Ant1_NTNV



LoRa_HCH_927.1MHz_Ant1_NTNV



6 Conducted Spurious Emissions / Band Edge

6.1 *Test Result*

Test Description	Test Specification	Test Result
Conducted Spurious and Band Edge Emissions	ANSI C63.10:2013 15.247(d) RSS-247 5.5	Compliant

6.2 *Test Method*

Conducted spurious emissions measurements were taken using the methods defined an ANSI C63.10, Clauses 5.5, 5.6, & 6.7. Authorized band edge measurements were recorded using the methods in clause 6.10.4. 125 kHz & 500 kHz LoRa modulation types were used for spurious measurements. Band edge measurements were also recorded using each modulation.

The limit is 20 dB below the measured peak power.

6.3 *Test Site*

SGS EMC Laboratory, Suwanee, GA

Environmental Conditions

Temperature:	23.34 °C
Relative Humidity:	55.2 %
Atmospheric Pressure:	98.33 kPa

6.4 *Test Equipment*

Test End Date: 14-Aug-2024 Tester: SGM

Equipment	Manufacturer	Model	Asset Number	Cal Date	Cal Due Date
RF CABLE SMA TO SMA, 0.01-40GHZ	TELEDYNE STORM MICROWAVE	084-0505-059	20108	20-Mar-2024	20-Mar-2025
TSTPASS SWITCHBOX	TSTPASS	SB2	23009	8-Apr-2024	8-Apr-2025
SIGNAL ANALYZER (TS8997)	ROHDE & SCHWARZ	FSV30	B085749	3-Jan-2024	3-Jan-2025

6.5 *Test Data - Band Edge - Conducted Spurious Emissions*

125 kHz Modulation:

Reference:

Mode	TX Type	Frequency (MHz)	ANT	Level of Reference (dBm)
LoRa	SISO	902.3	1	15.01
		908.9	1	14.97
		914.9	1	14.95
Note1: Refer to FCC Part 15.247 (d) and ANSI C63.10-2013, the channel contains the maximum PSD level was used to establish the reference level.				

CSE

Mode	TX Type	Frequency (MHz)	ANT	Level of Reference (dBm)	Limit (dBm)	Verdict
LoRa	SISO	902.3	1	15.01	-4.99	Pass
		908.9	1	15.01	-4.99	Pass
		914.9	1	15.01	-4.99	Pass
Note1: Refer to FCC Part 15.247 (d) and ANSI C63.10-2013, the channel contains the maximum PSD level was used to establish the reference level.						

500 kHz Modulation:

Reference:

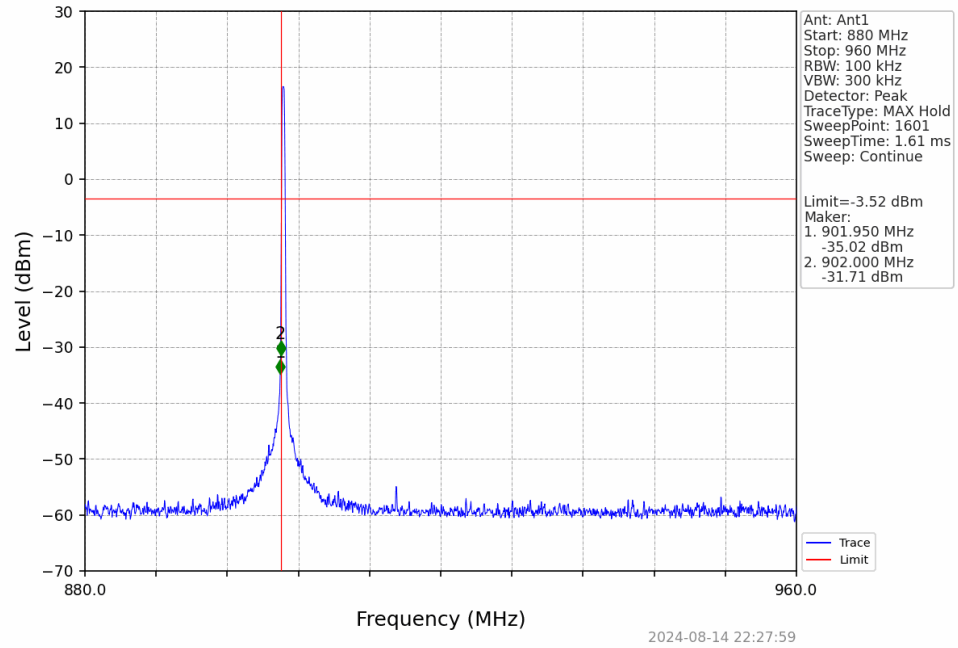
Mode	TX Type	Frequency (MHz)	ANT	Level of Reference (dBm)
LoRa	SISO	915.9	1	15.25
		920.7	1	15.10
		927.1	1	14.93
Note1: Refer to FCC Part 15.247 (d) and ANSI C63.10-2013, the channel contains the maximum PSD level was used to establish the reference level.				

CSE

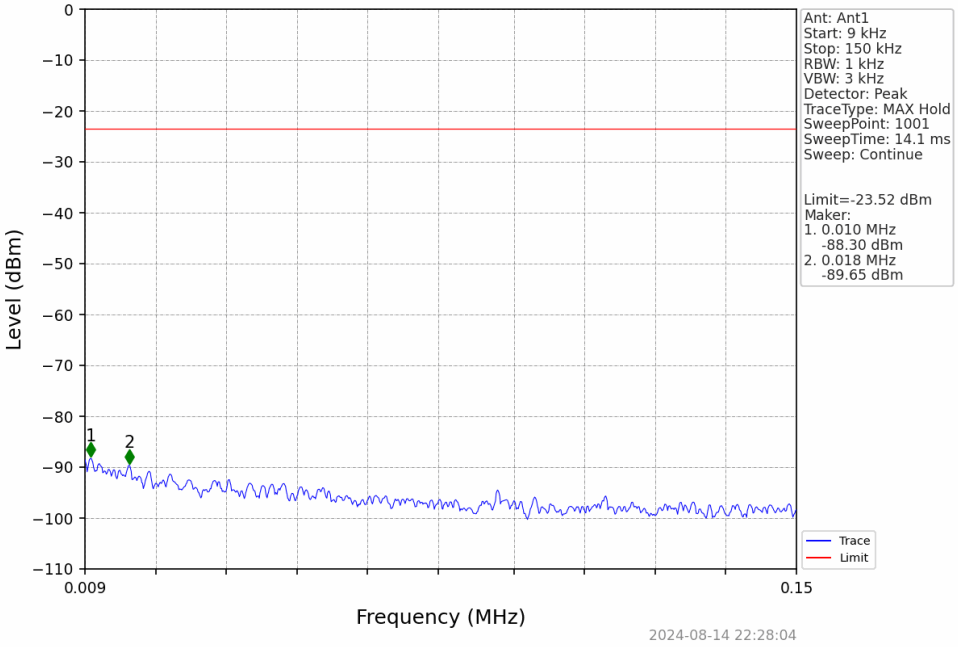
Mode	TX Type	Frequency (MHz)	ANT	Level of Reference (dBm)	Limit (dBm)	Verdict
LoRa	SISO	915.9	1	15.25	-4.75	Pass
		920.7	1	15.25	-4.75	Pass
		927.1	1	15.25	-4.75	Pass
Note1: Refer to FCC Part 15.247 (d) and ANSI C63.10-2013, the channel contains the maximum PSD level was used to establish the reference level.						

125 kHz Modulation:

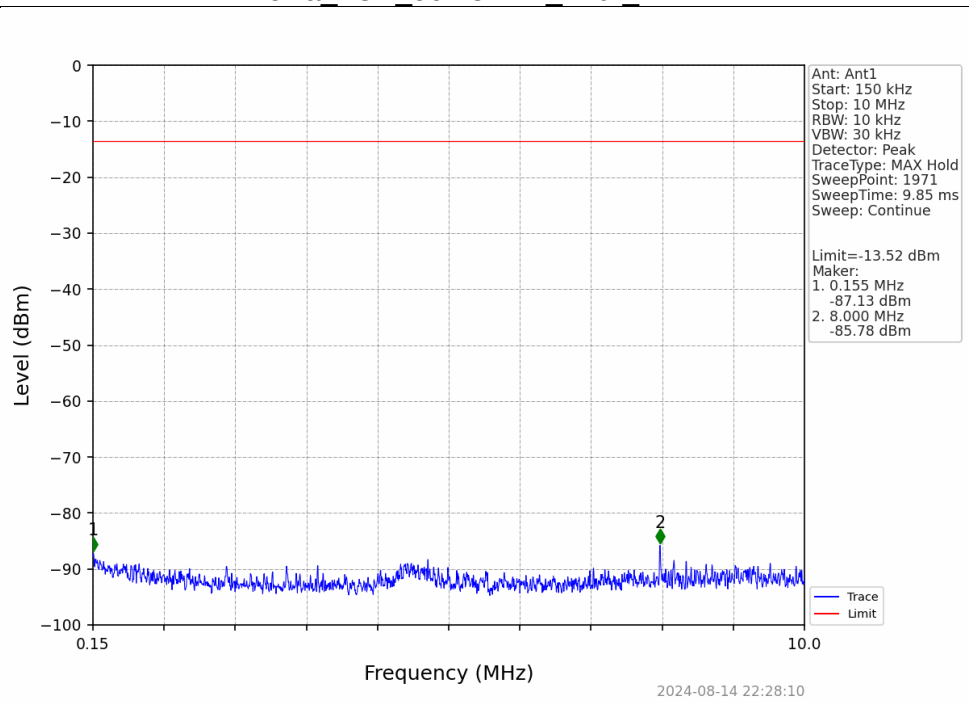
LoRa_LCH_902.3MHz_Ant1_NTNV



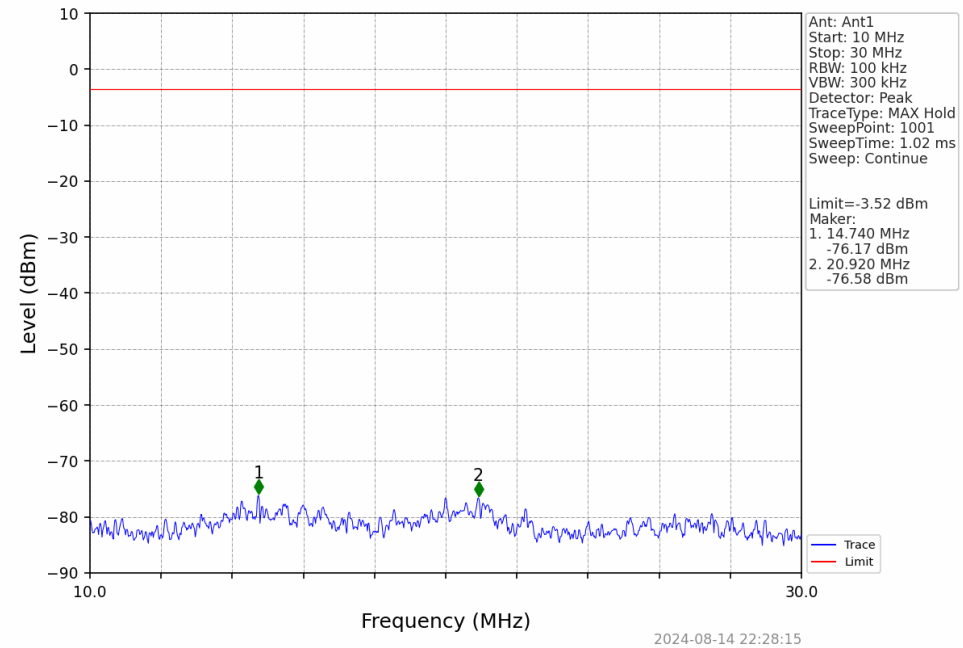
LoRa_LCH_902.3MHz_Ant1_NTNV



LoRa_LCH_902.3MHz_Ant1_NTNV



LoRa_LCH_902.3MHz_Ant1_NTNV



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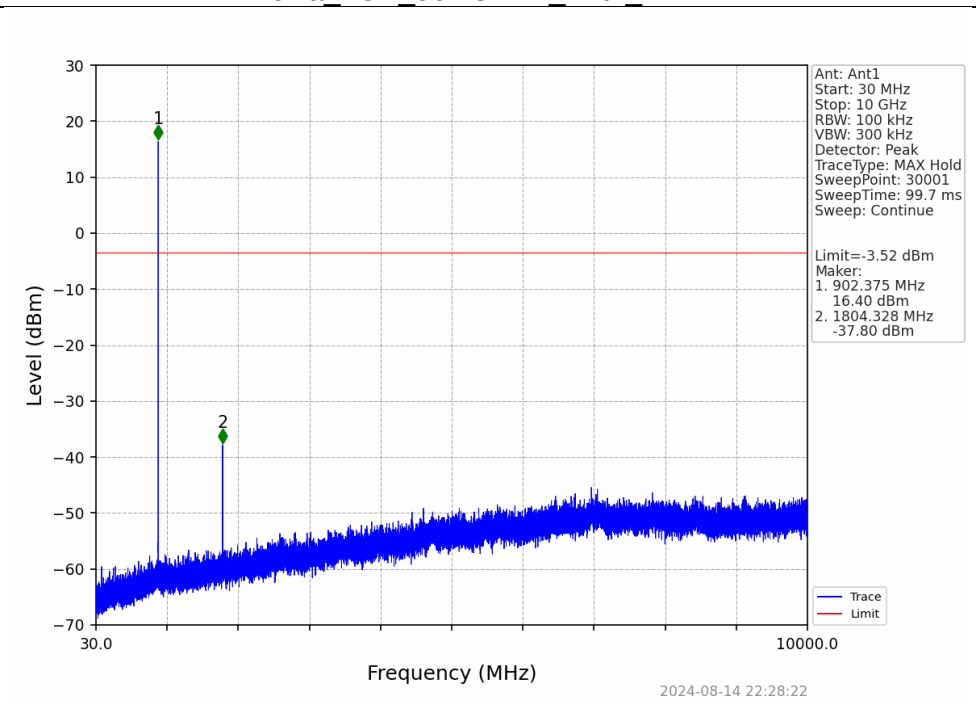

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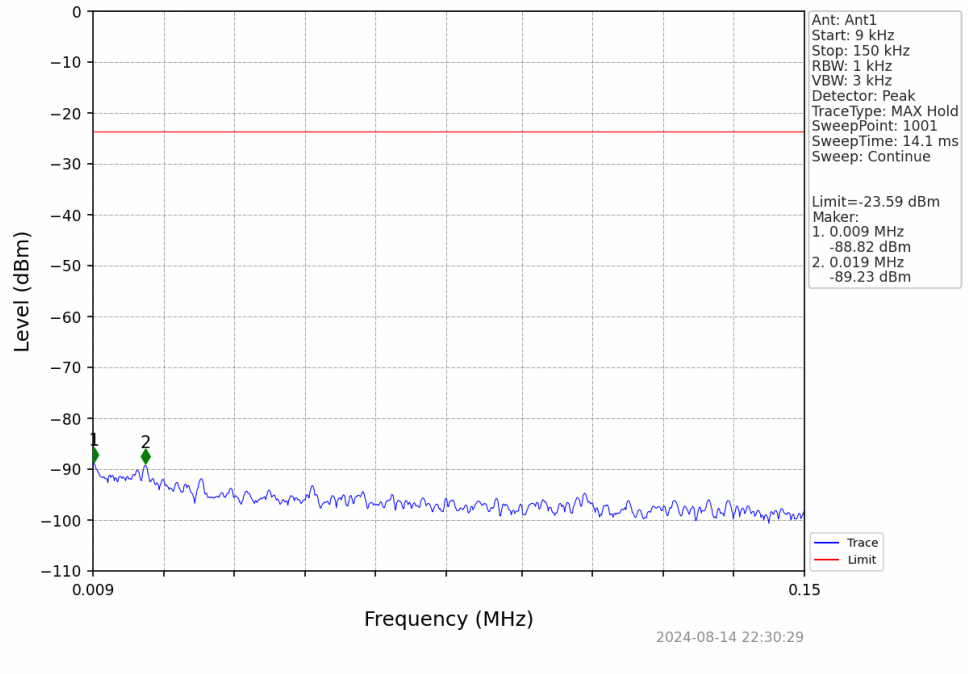
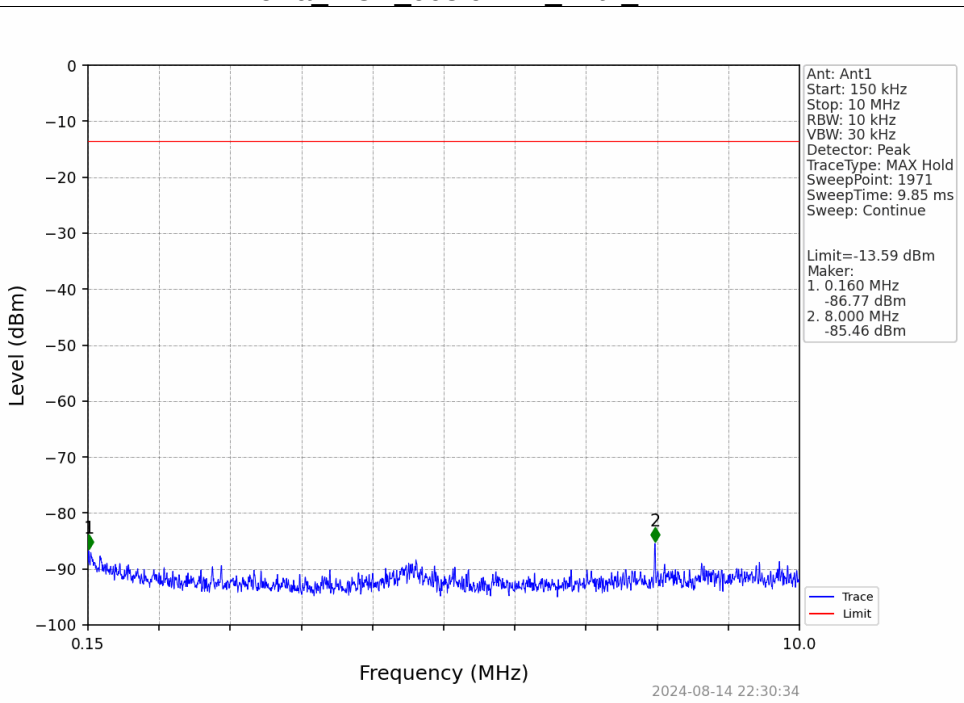
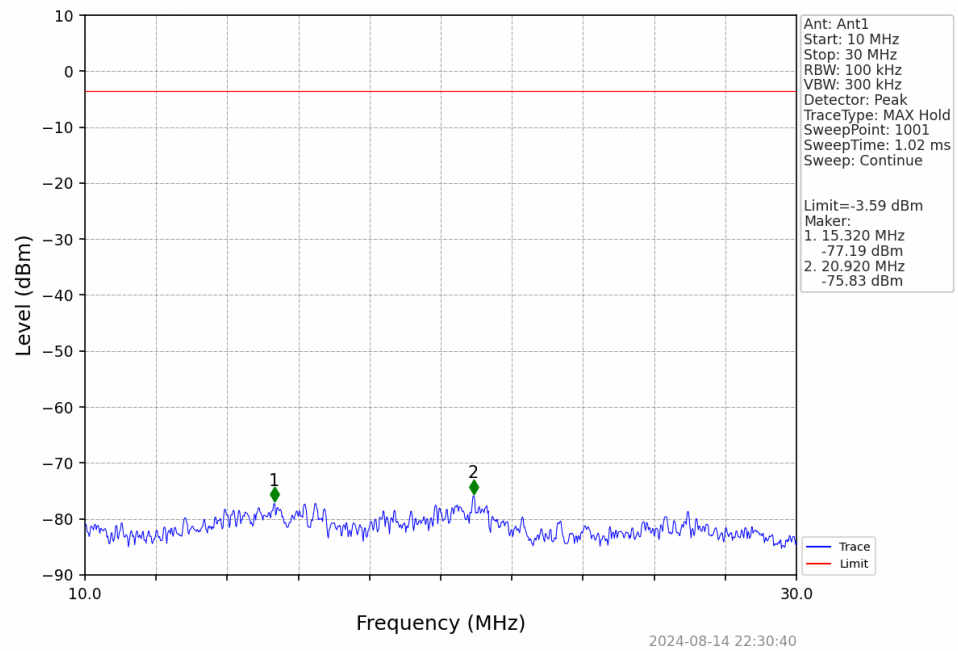


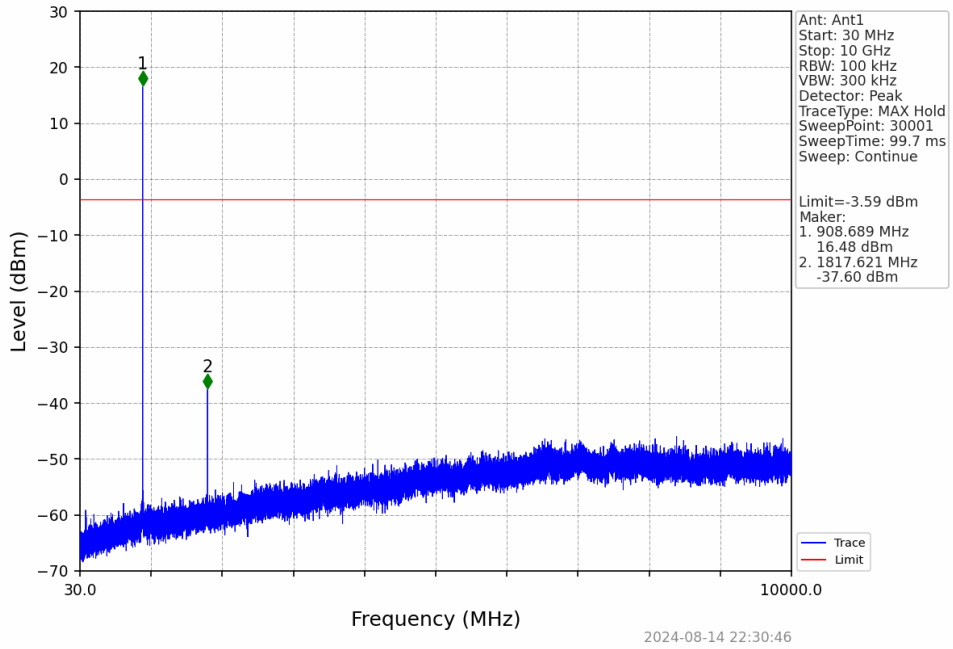
LoRa_MCH_908.9MHz_Ant1_NTNV



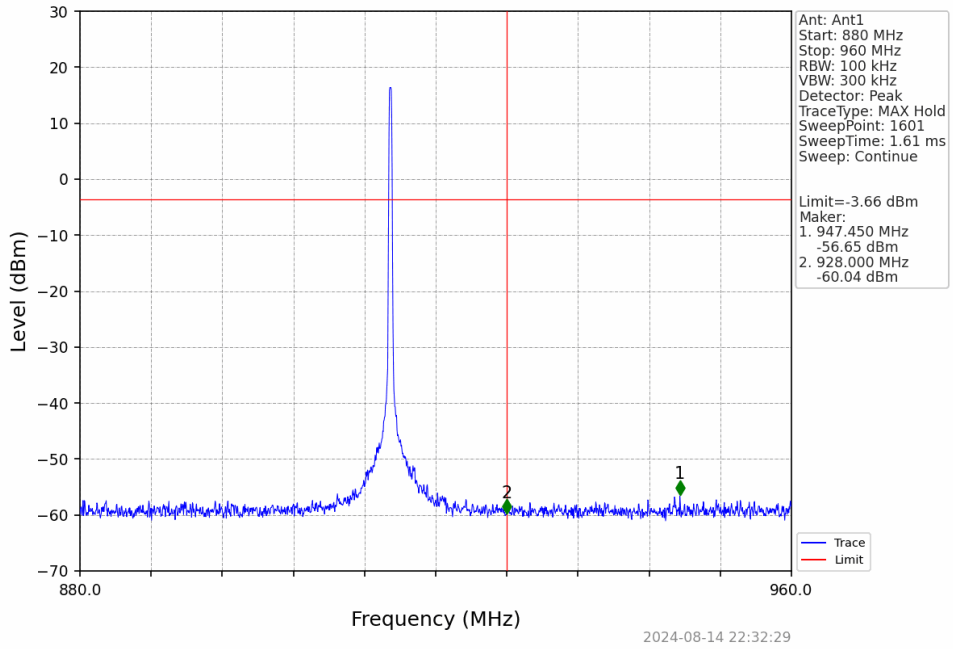
LoRa_MCH_908.9MHz_Ant1_NTNV



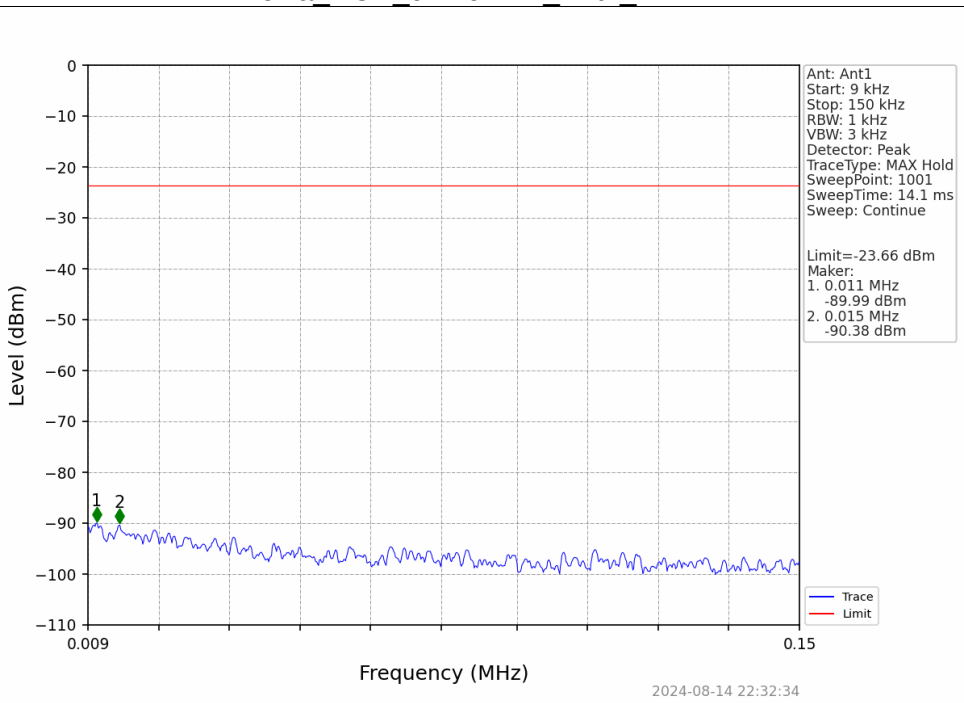
LoRa_MCH_908.9MHz_Ant1_NTNV



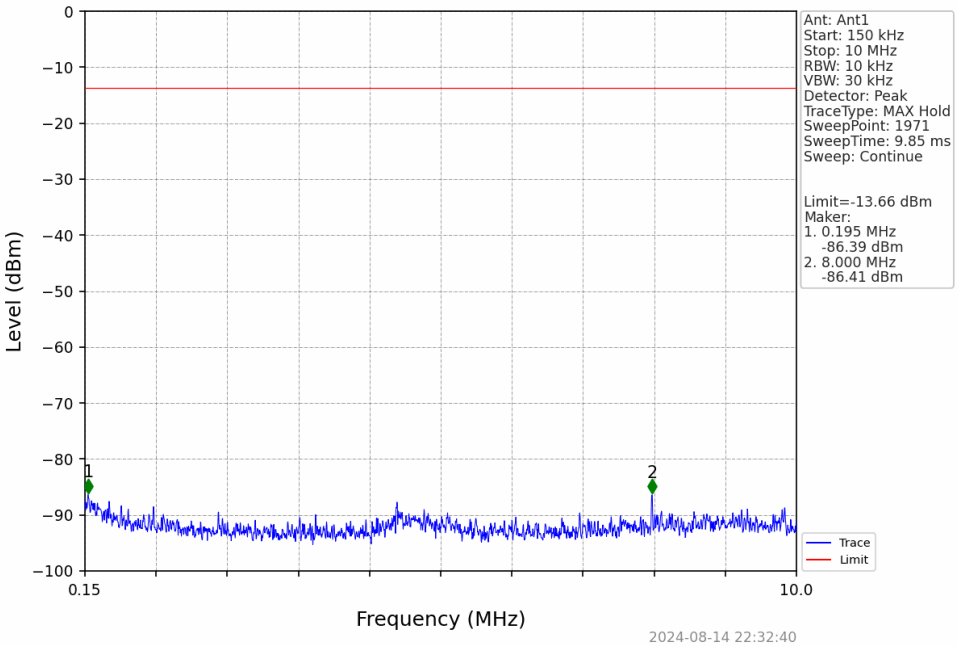
LoRa_HCH_914.9MHz_Ant1_NTNV



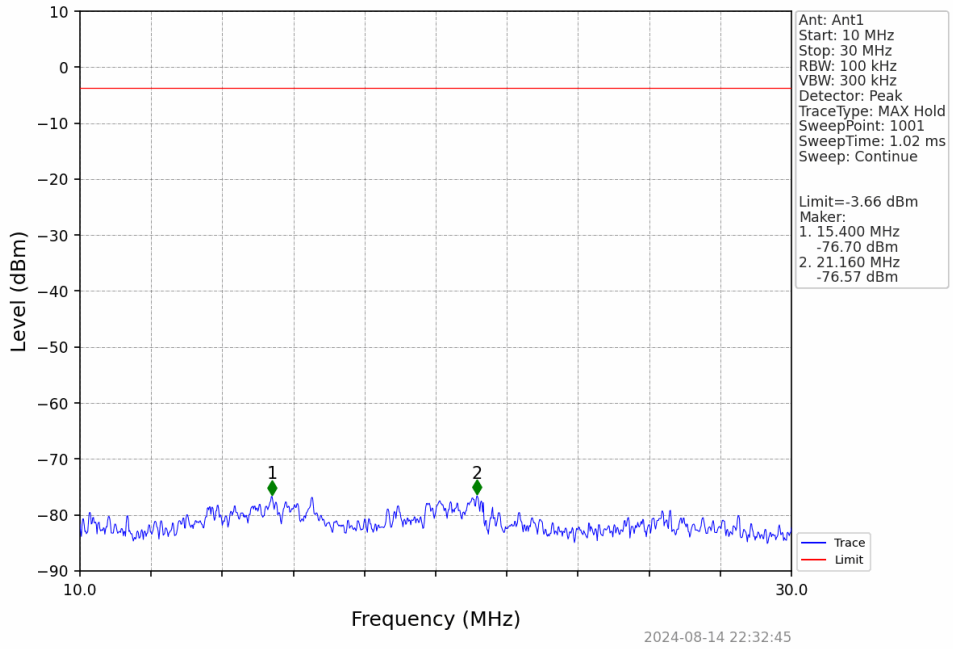
LoRa_HCH_914.9MHz_Ant1_NTNV



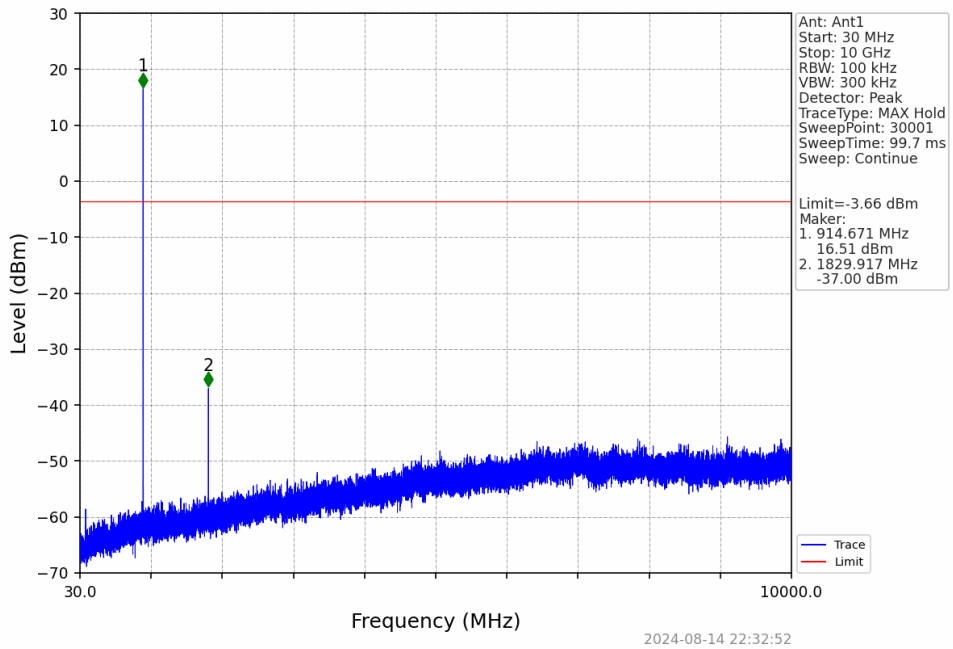
LoRa_HCH_914.9MHz_Ant1_NTNV



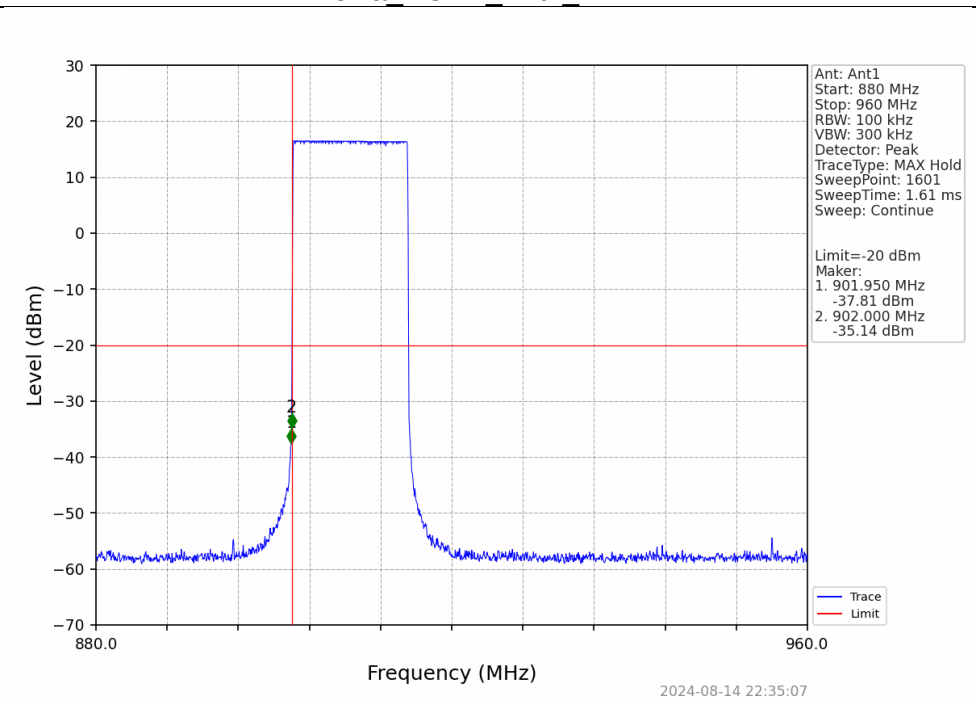
LoRa_HCH_914.9MHz_Ant1_NTNV



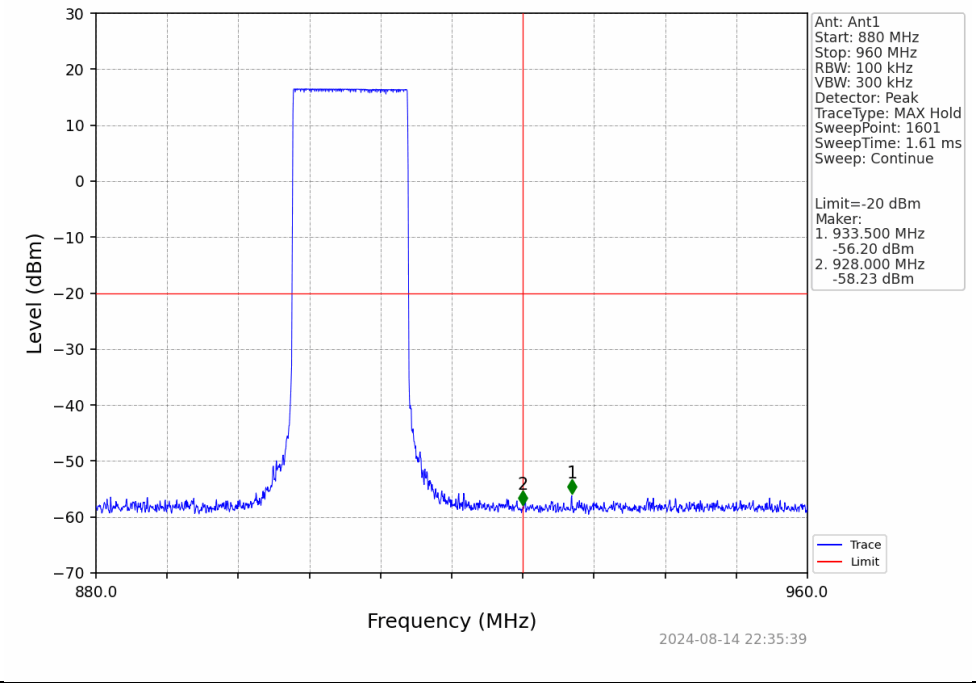
LoRa_HCH_914.9MHz_Ant1_NTNV



LoRa_HOPP_Ant1_NTNV

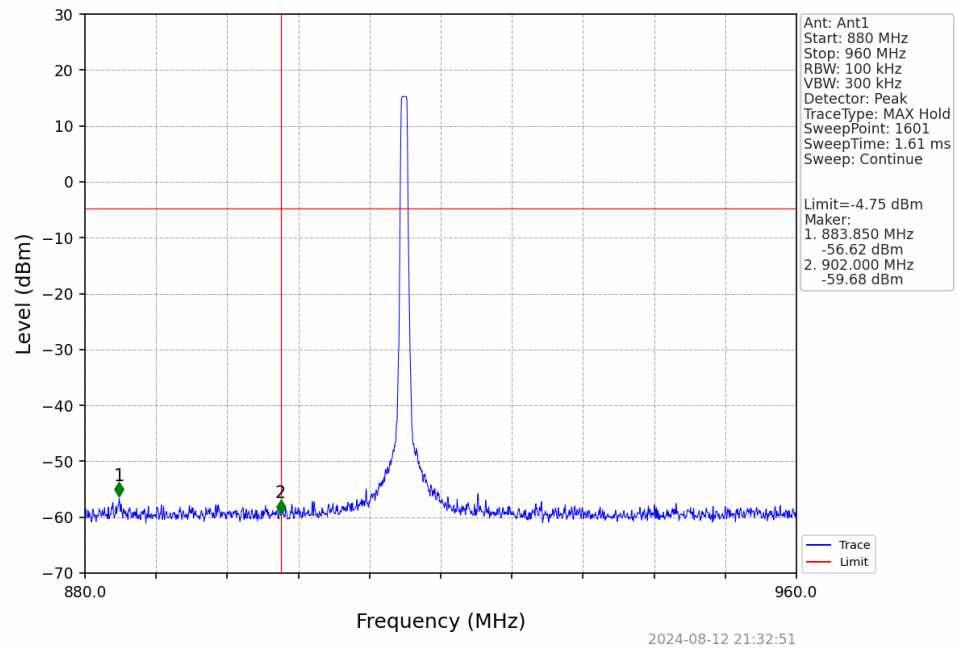


LoRa_HOPP_Ant1_NTNV

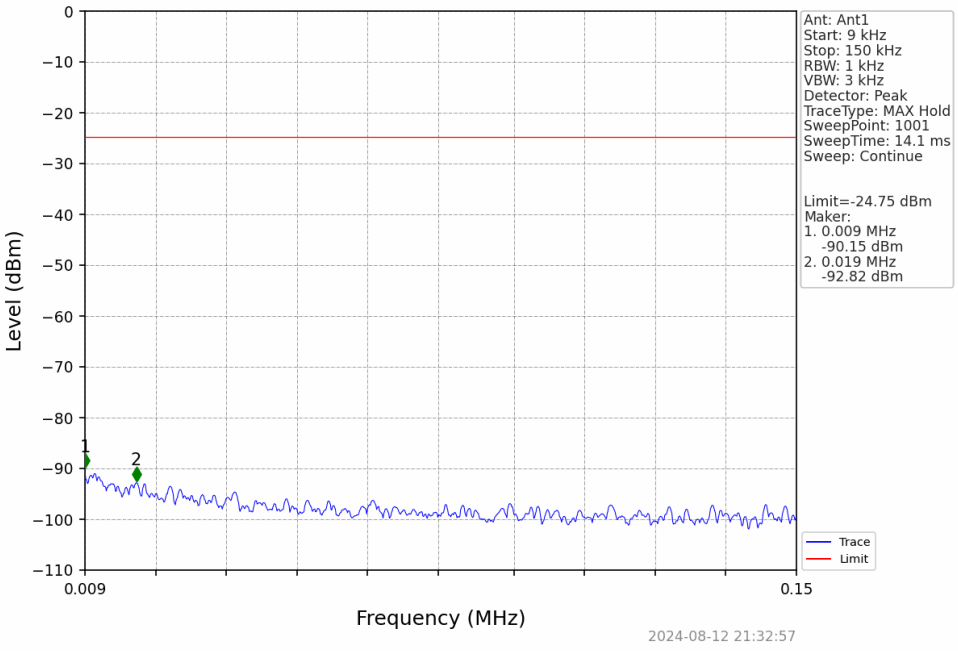


500 kHz Modulation:

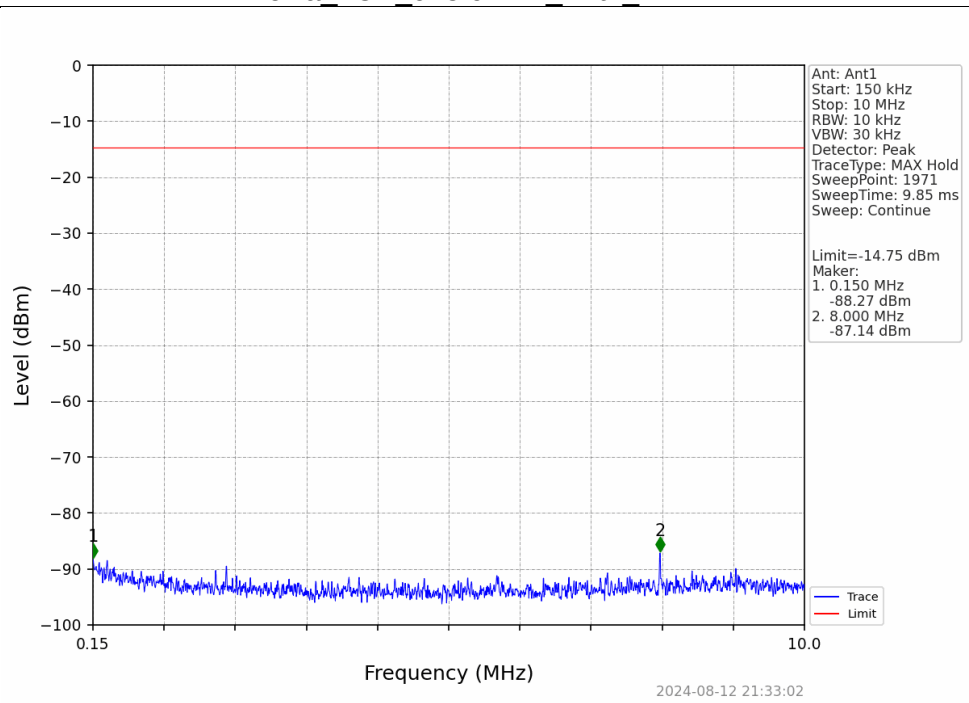
LoRa_LCH_915.9MHz_Ant1_NTNV



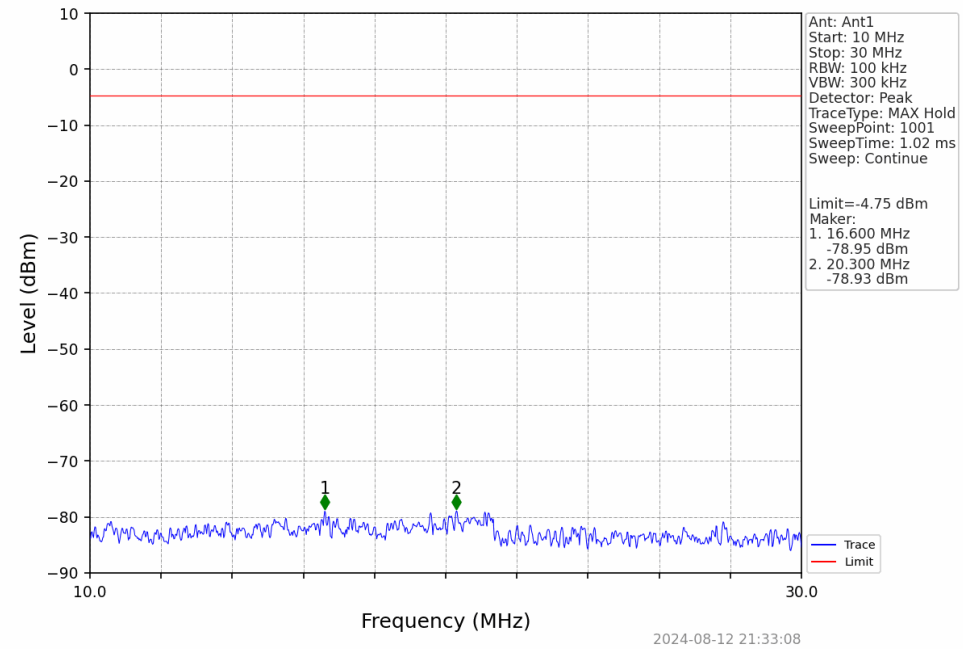
LoRa_LCH_915.9MHz_Ant1_NTNV



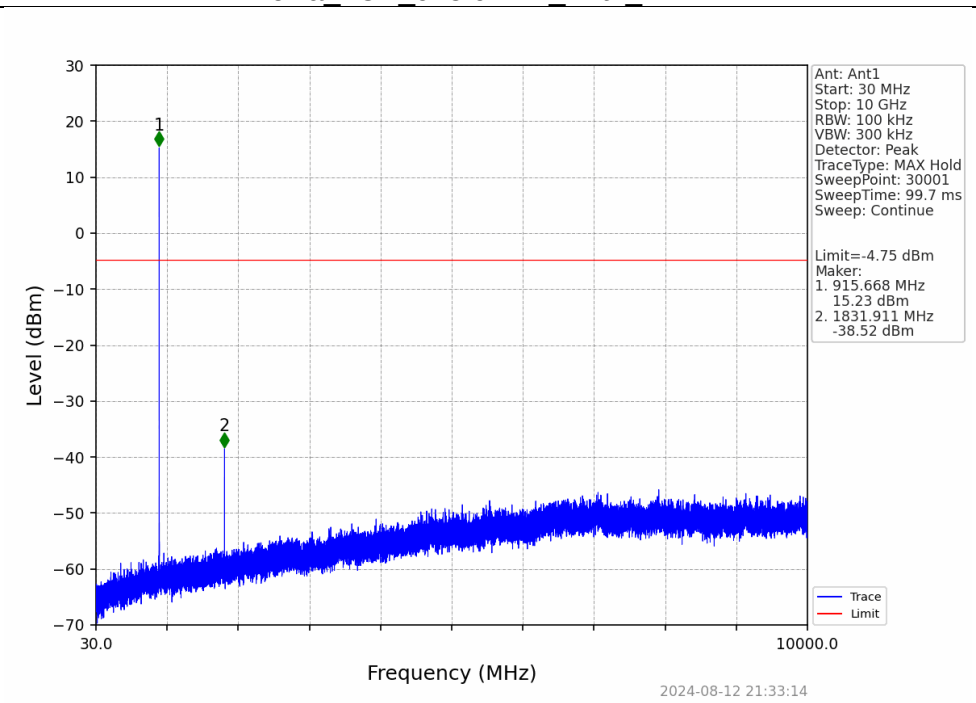
LoRa_LCH_915.9MHz_Ant1_NTNV



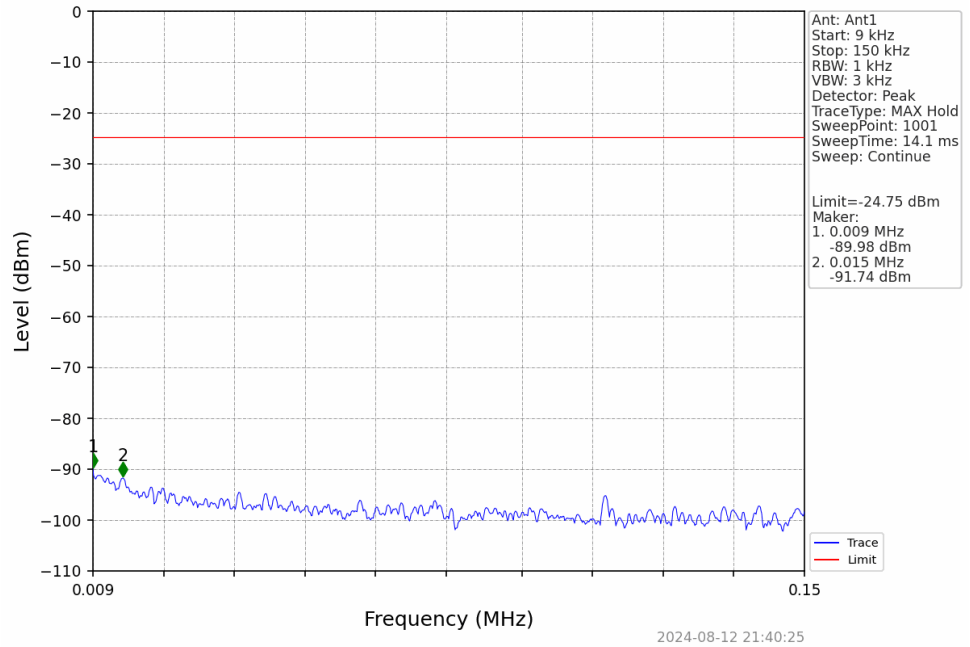
LoRa_LCH_915.9MHz_Ant1_NTNV



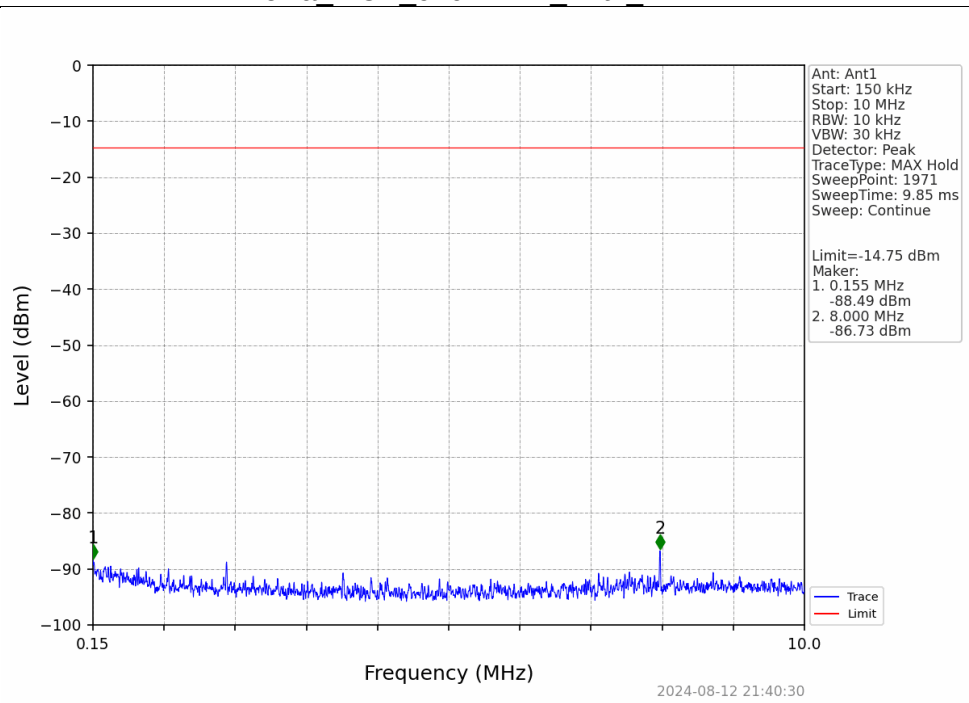
LoRa_LCH_915.9MHz_Ant1_NTNV



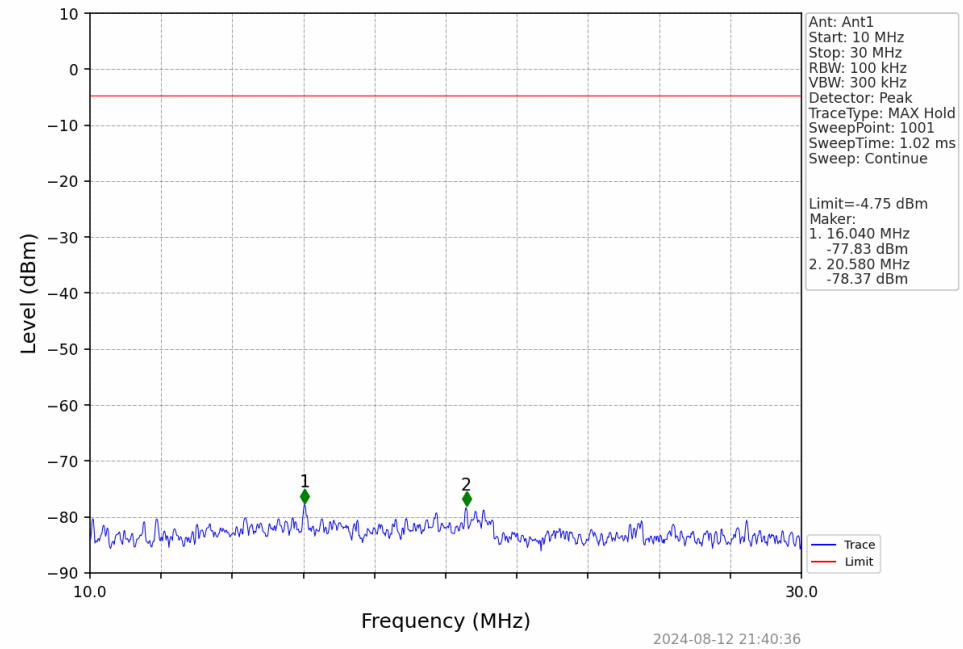
LoRa_MCH_920.7MHz_Ant1_NTNV



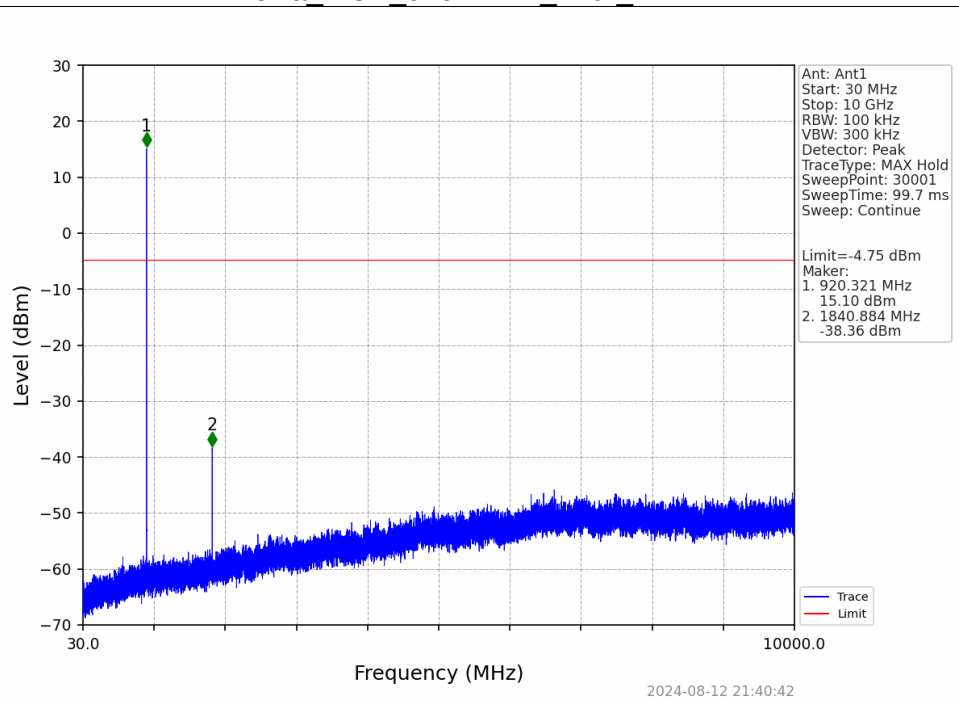
LoRa_MCH_920.7MHz_Ant1_NTNV



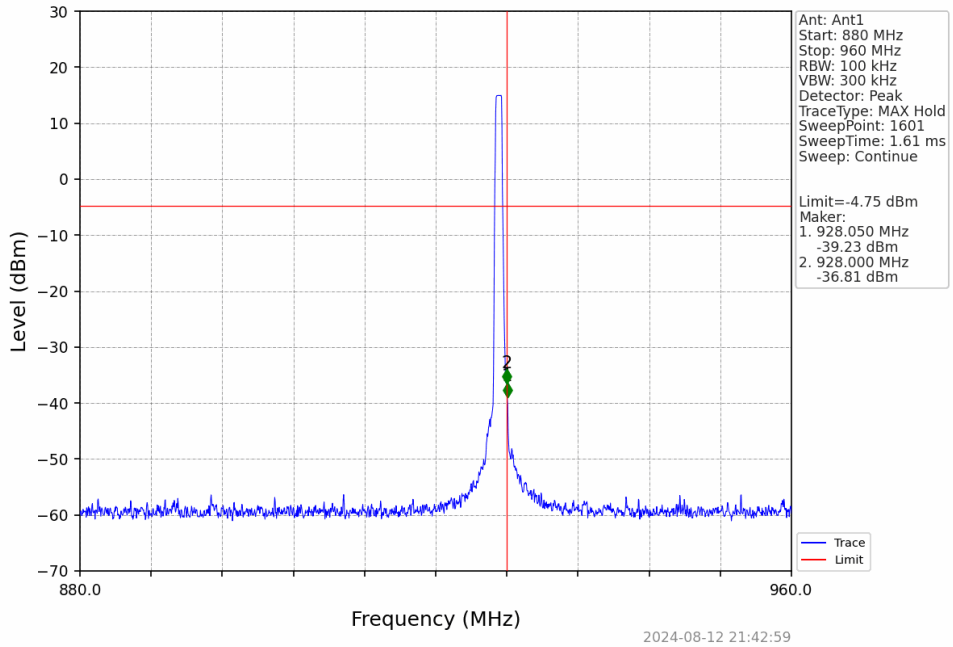
LoRa_MCH_920.7MHz_Ant1_NTNV



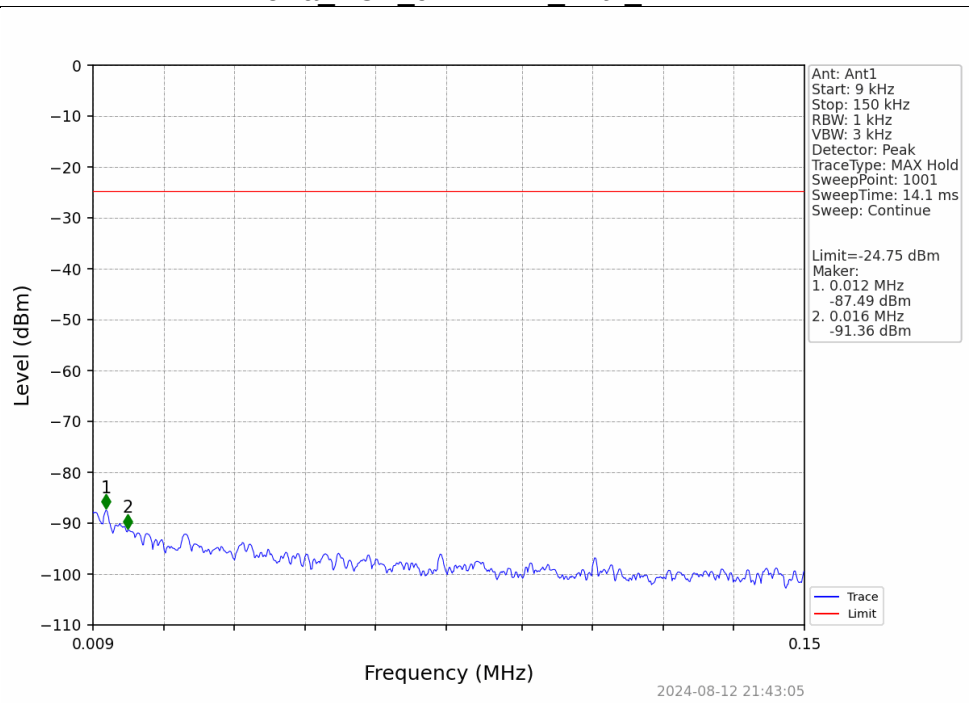
LoRa_MCH_920.7MHz_Ant1_NTNV



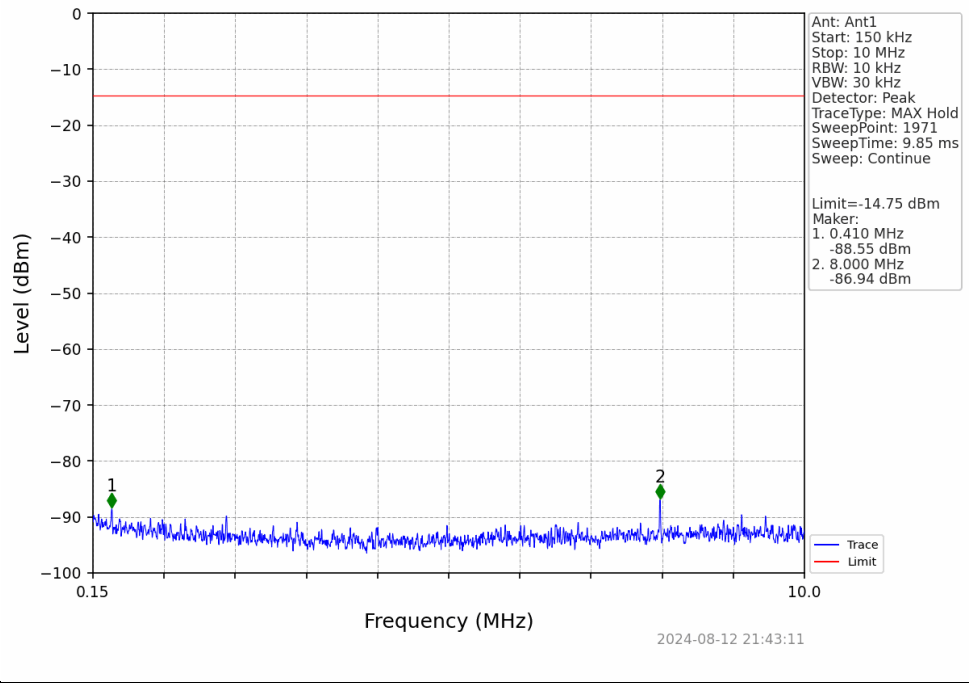
LoRa_HCH_927.1MHz_Ant1_NTNV



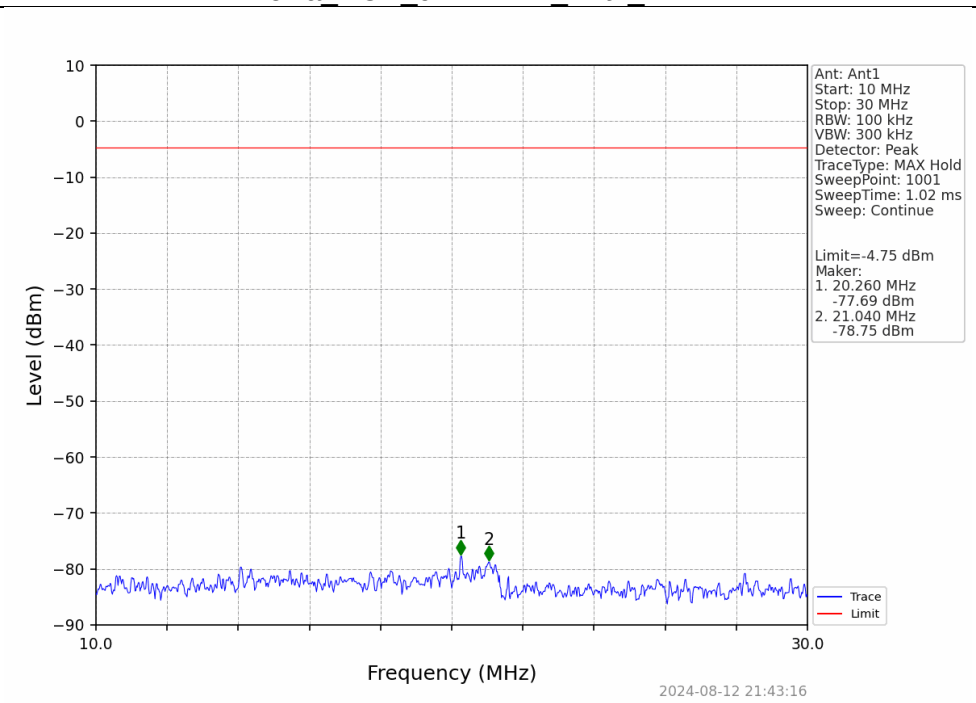
LoRa_HCH_927.1MHz_Ant1_NTNV



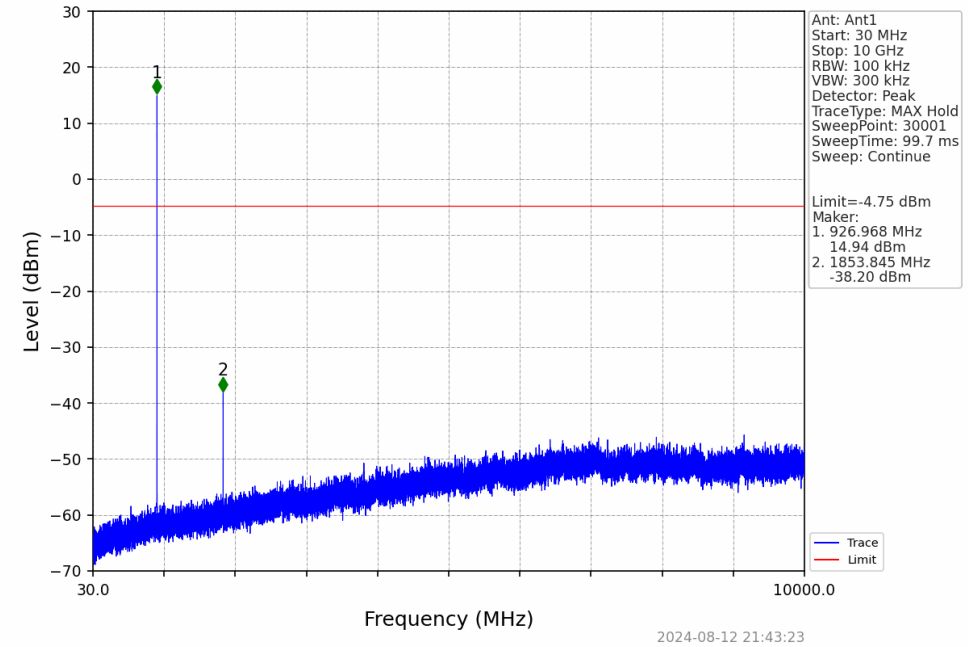
LoRa_HCH_927.1MHz_Ant1_NTNV



LoRa_HCH_927.1MHz_Ant1_NTNV



LoRa_HCH_927.1MHz_Ant1_NTNV



7 Field Strength of Spurious Radiation

7.1 *Test Result*

Test Description	Test Specification		Test Result
Radiated Spurious Emissions	15.247(d), 15.35(b) 15.205, 15.209	RSS-247 5.5 RSS-GEN 8.9, 8.10	Compliant

7.2 *Test Method*

The measurement methods defined in ANSI C63.10: 2013 were used.

Lowest, middle, and highest channels were investigated – the device was commanded to continuously transmit on low, middle, and high channels.

Test distance:

9k to 30 MHz – Near field prescan to determine if there were any emissions
30 to 1000 MHz - The EUT to measurement antenna distance was 3 meters
1 to 18 GHz - The EUT to measurement antenna distance was 3 meters
18 to 26 GHz - The EUT to measurement antenna distance was 3 meters

Limits within restricted bands of operation:

Frequency	Limits(1)		Peak Limits dBuV/m
	Microvolts/m	dBuV/m	
30 - 88 MHz	100	40 (2)	--
88 - 216 MHz	150	43.5 (2)	--
216 - 960 MHz	200	46 (2)	--
960 - 1000 MHz	500	54 (2)	--
1 - 40 GHz	500	54 (3)	74

(1) These limits are applicable to emissions outside of the intentional transmit frequency band.
(2) Quasi-peak limit
(3) Average limit

7.3 *Test Site*

SGS EMC Laboratory, Suwanee, GA

Environmental Conditions	30-1000MHz	1-18GHz
Temperature:	23.57 °C	23.08 °C
Relative Humidity:	56.1 %	61.4 %
Atmospheric Pressure:	98.20 kPa	98.3 kPa

7.4 *Test Equipment*

30-1000 MHz

Test End Date: 13-Aug-2024 Tester: SGM

Equipment	Manufacturer	Model	Asset Number	Cal Date	Cal Due Date
ANTENNA, BILOG	SUNOL	JB6	B079689	16-May-2024	16-May-2026
N to N RF Cable	ECHELON	EM-B810NM-276	23007	31-Mar-2024	31-Mar-2025
N-FEMALE TO N-MALE RF CABLE	ECHELON	EM-B810NMNF-118	23010	17-Apr-2024	17-Apr-2025
RF CABLE NM TO NM, 0.01-18GHZ	TELEDYNE STORM MICROWAVE	90-195-118	20125	7-Aug-2024	7-Aug-2025
RF CABLE	HUBER & SUHNER	SF106	B085895	20-Mar-2024	20-Mar-2025
EMI TEST RECEIVER	ROHDE & SCHWARZ	ESW44	22032	15-Nov-2023	15-Nov-2024
LOW NOISE AMPLIFIER	MINI-CIRCUITS	ZKL-2+	B079800	14-Sep-2023	14-Sep-2024

1-18 GHz

Test End Date: 13-Aug-2024 Tester: SGM

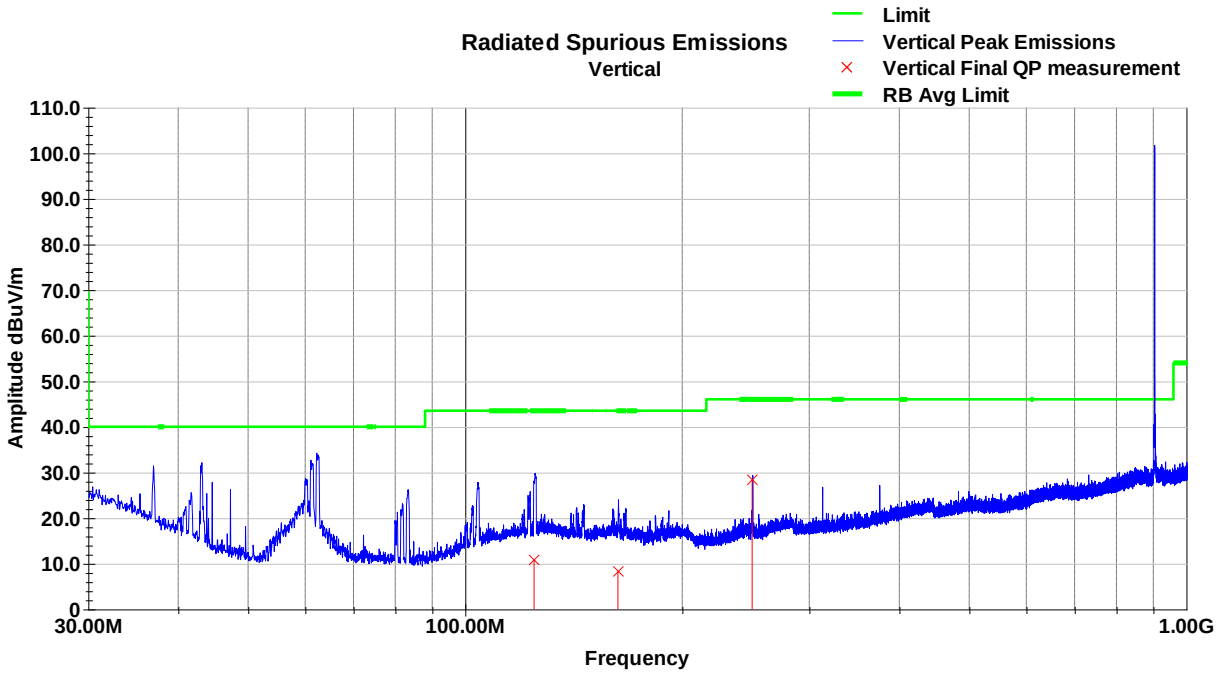
Equipment	Manufacturer	Model	Asset Number	Cal Date	Cal Due Date
ANTENNA, DRG HORN (MEDIUM)	ETS LINDGREN	3117	B079699	23-Jul-2024	23-Jul-2026
N to N RF Cable	ECHELON	EM-B810NM-276	23007	31-Mar-2024	31-Mar-2025
RF CABLE	HUBER & SUHNER	SF106	B085895	20-Mar-2024	20-Mar-2025
LOW NOISE AMPLIFIER	ROHDE & SCHWARZ	TS-PR18	B094463	5-Jul-2024	5-Jul-2025
EMI TEST RECEIVER	ROHDE & SCHWARZ	ESW44	22032	15-Nov-2023	15-Nov-2024
FILTER, HIGH PASS, >1000MHZ	MICRO-TRONICS	HPM50108	B079802	5-Jul-2024	5-Jul-2025

7.5 *Test Data*

No emissions were detected in the 9kHz to 30MHz frequency range.

7.5.1 30-1000 MHz

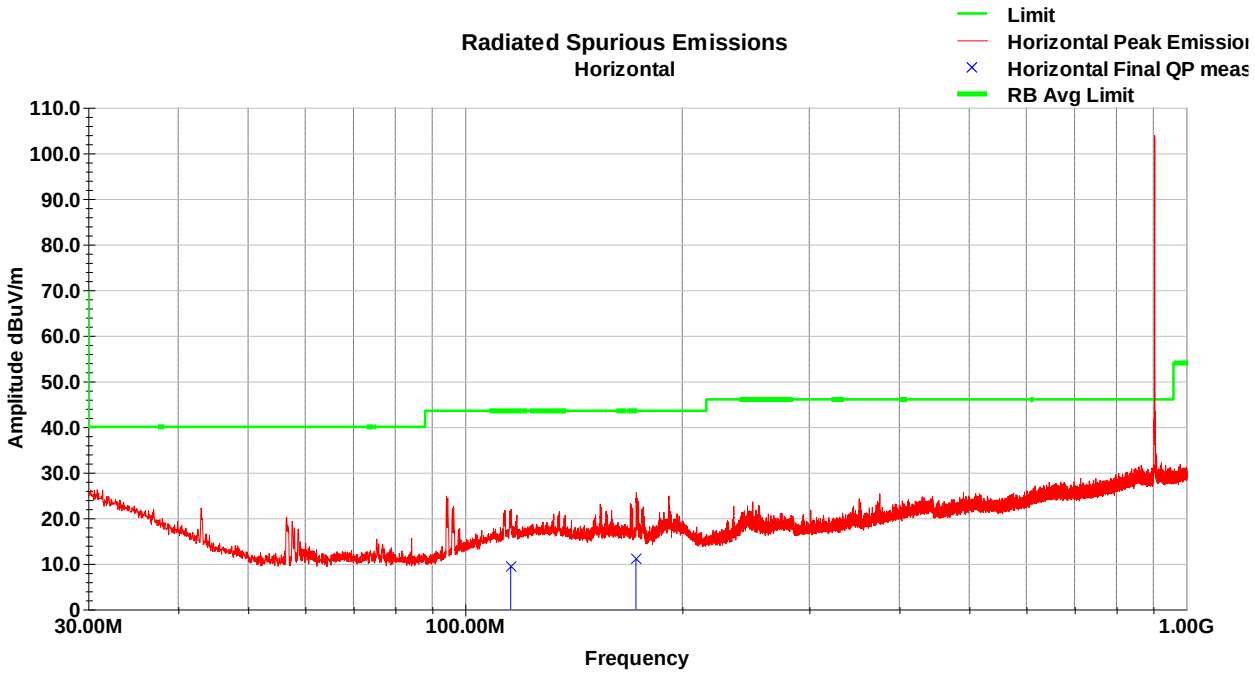
Vertical Polarity Peak Plot Low Channel



Vertical Polarity Tabular Data Low Channel

Frequency MHz	Raw QP (dBuV)	Polarity (V/H)	Azimuth (degrees)	Height (cm)	AF (dB/m)	Loss (dB)	Amp (dB)	QP Value (dBuV/m)	Limit (dBuV/m)	Margin (dB)
124.60	23.8	V	339.0	174.0	18.0	0.8	31.8	10.8	43.5	-32.7
162.87	22.3	V	28.0	174.0	17.0	0.8	31.8	8.3	43.5	-35.2
250.03	42.7	V	234.0	100.0	16.2	1.2	31.7	28.4	46.0	-17.6
QP Value = Raw QP + AF + Loss - Amp										
Margin = QP Value - Limit										

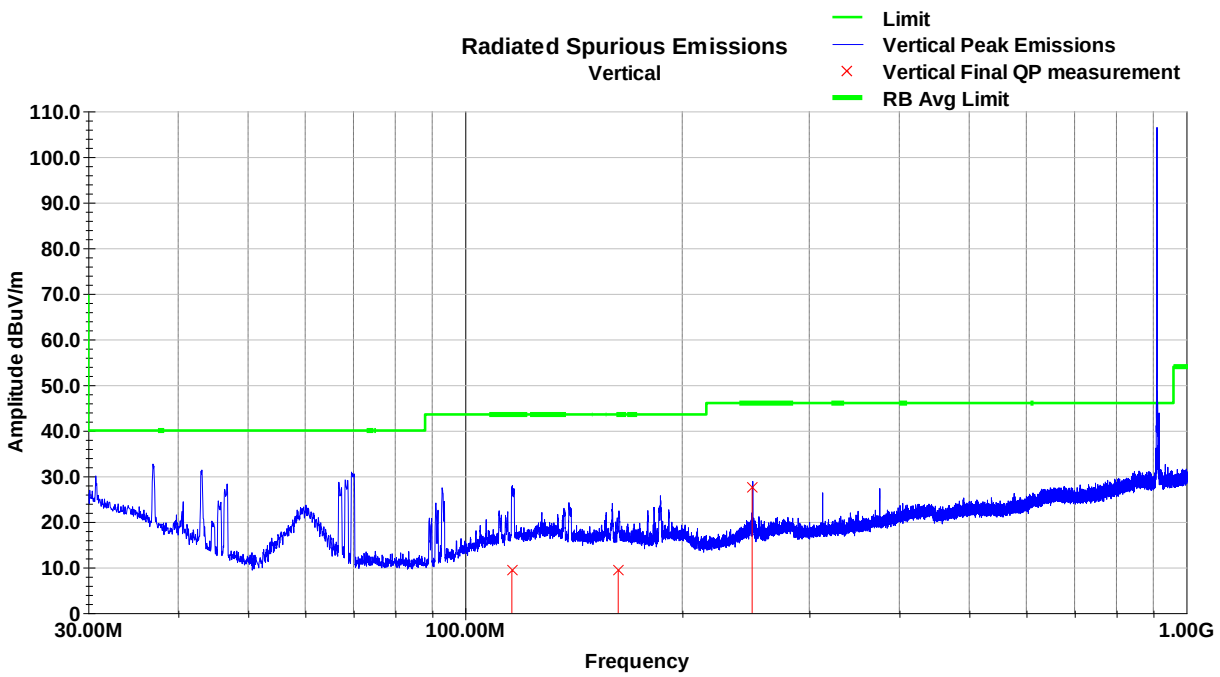
Horizontal Polarity Peak Plot Low Channel



Horizontal Polarity Tabular Data Low Channel

Frequency MHz	Raw QP (dBuV)	Polarity (V/H)	Azimuth (degrees)	Height (cm)	AF (dB/m)	Loss (dB)	Amp (dB)	QP Value (dBuV/m)	Limit (dBuV/m)	Margin (dB)
115.67	22.8	H	36.0	188.0	17.5	0.8	31.8	9.3	43.5	-34.2
172.47	25.8	H	360.0	175.0	16.1	0.8	31.7	11.0	43.5	-32.6
QP Value = Raw QP + AF + Loss - Amp										
Margin = QP Value - Limit										

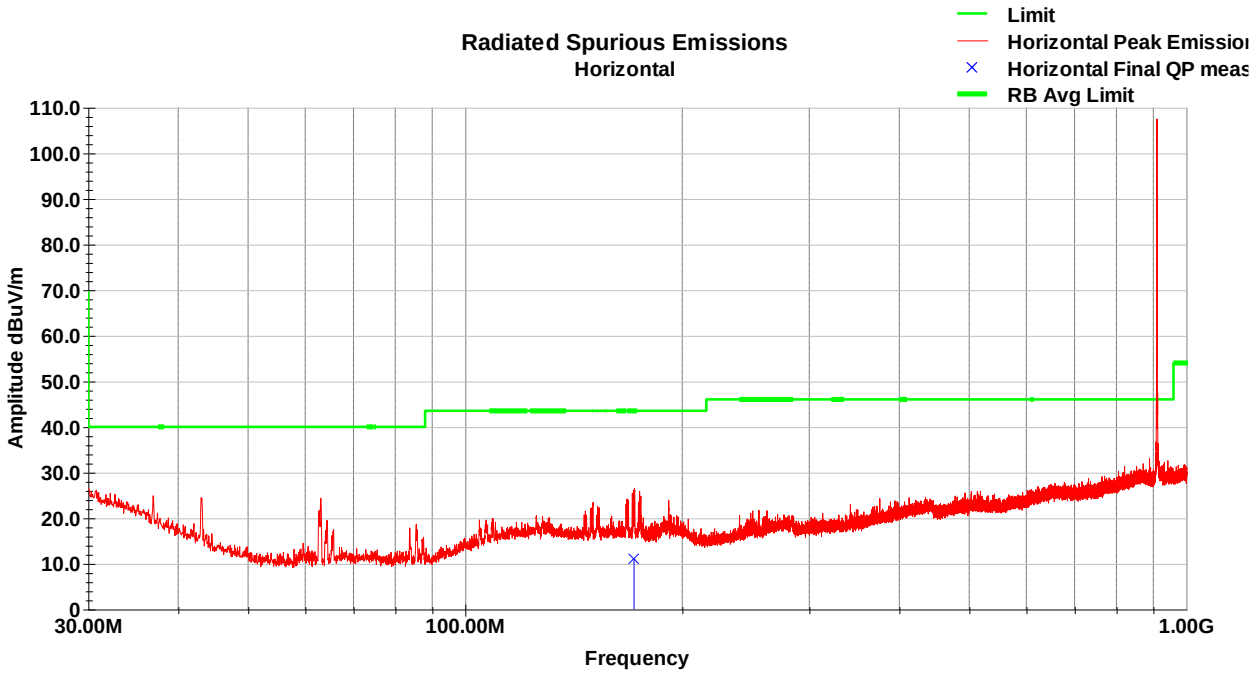
Vertical Polarity Peak Plot Mid Channel



Vertical Polarity Tabular Data Mid Channel

Frequency MHz	Raw QP (dBuV)	Polarity (V/H)	Azimuth (degrees)	Height (cm)	AF (dB/m)	Loss (dB)	Amp (dB)	QP Value (dBuV/m)	Limit (dBuV/m)	Margin (dB)
116.07	22.8	V	251.0	129.0	17.5	0.8	31.8	9.3	43.5	-34.3
163.01	23.3	V	249.0	145.0	17.0	0.8	31.8	9.3	43.5	-34.2
250.03	41.7	V	94.0	100.0	16.2	1.2	31.7	27.4	46.0	-18.6
QP Value = Raw QP + AF + Loss - Amp										
Margin = QP Value - Limit										

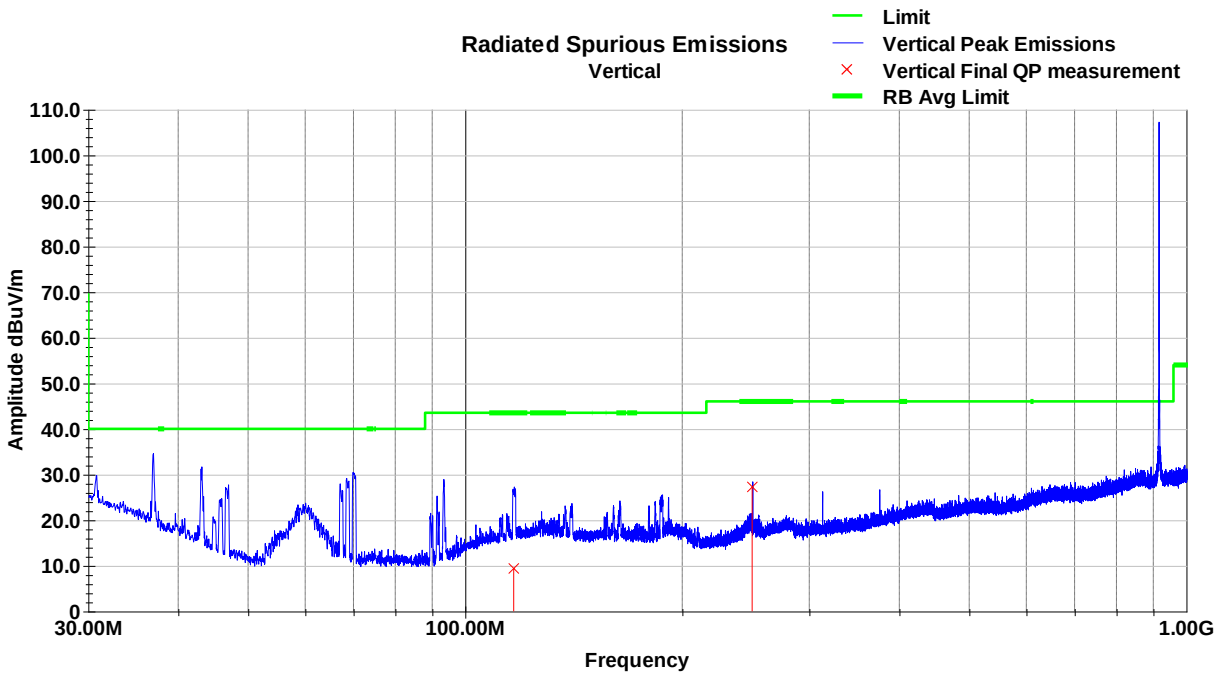
Horizontal Polarity Peak Plot Mid Channel



Horizontal Polarity Tabular Data Mid Channel

Frequency MHz	Raw QP (dBuV)	Polarity (V/H)	Azimuth (degrees)	Height (cm)	AF (dB/m)	Loss (dB)	Amp (dB)	QP Value (dBuV/m)	Limit (dBuV/m)	Margin (dB)
171.47	25.8	H	323.0	250.0	16.2	0.8	31.7	11.1	43.5	-32.4
QP Value = Raw QP + AF + Loss - Amp										
Margin = QP Value - Limit										

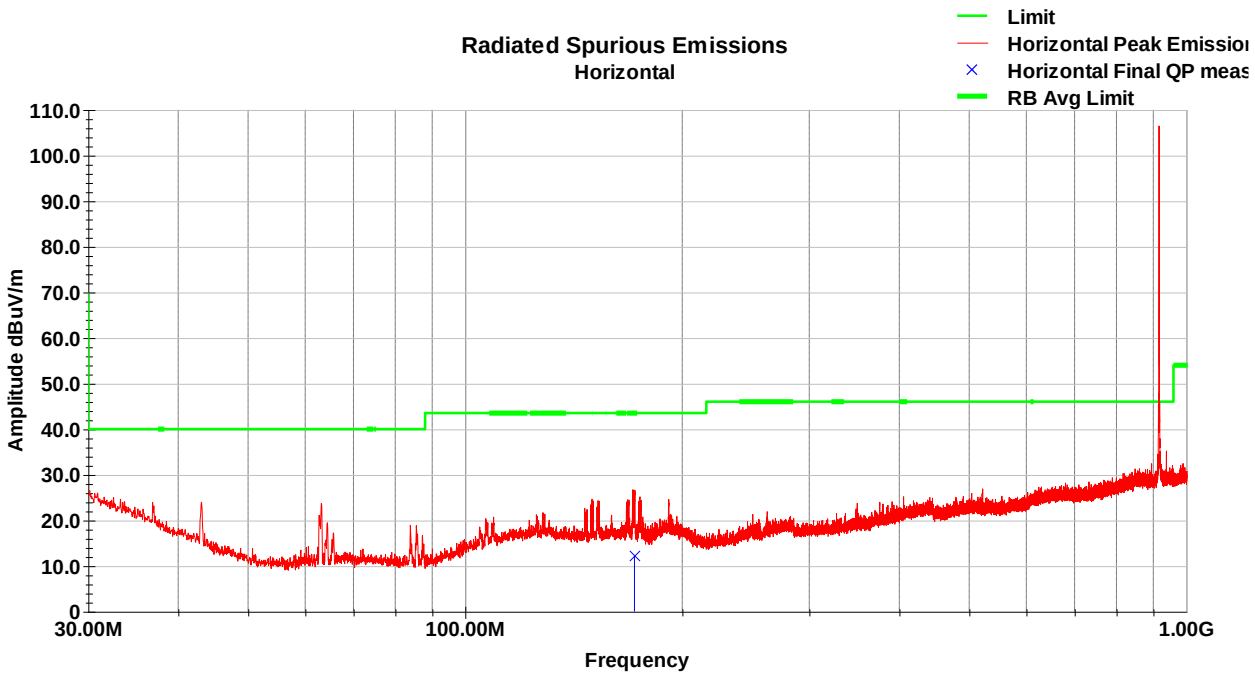
Vertical Polarity Peak Plot High Channel



Vertical Polarity Tabular Data High Channel

Frequency MHz	Raw QP (dBuV)	Polarity (V/H)	Azimuth (degrees)	Height (cm)	AF (dB/m)	Loss (dB)	Amp (dB)	QP Value (dBuV/m)	Limit (dBuV/m)	Margin (dB)
116.75	22.9	V	283.0	160.0	17.6	0.8	31.8	9.5	43.5	-34.1
250.02	41.6	V	149.0	115.0	16.2	1.2	31.7	27.3	46.0	-18.7
QP Value = Raw QP + AF + Loss - Amp										
Margin = QP Value - Limit										

Horizontal Polarity Peak Plot High Channel



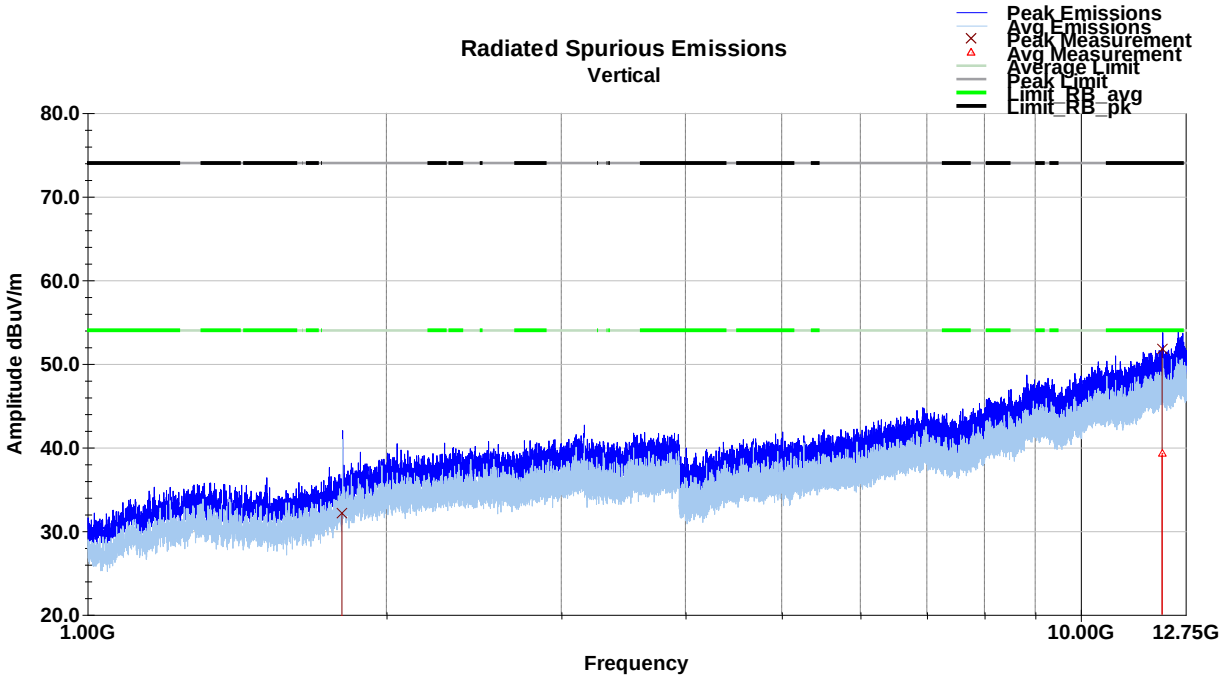
Horizontal Polarity Tabular Data High Channel

Frequency MHz	Raw QP (dBuV)	Polarity (V/H)	Azimuth (degrees)	Height (cm)	AF (dB/m)	Loss (dB)	Amp (dB)	QP Value (dBuV/m)	Limit (dBuV/m)	Margin (dB)
171.70	27.0	H	331.0	188.0	16.1	0.8	31.7	12.2	43.5	-31.3
QP Value = Raw QP + AF + Loss - Amp										
Margin = QP Value - Limit										

7.5.2 **1-3 GHz**

All channels had similar plots (worst case shown).

Vertical Polarity Peak Plot Low Channel



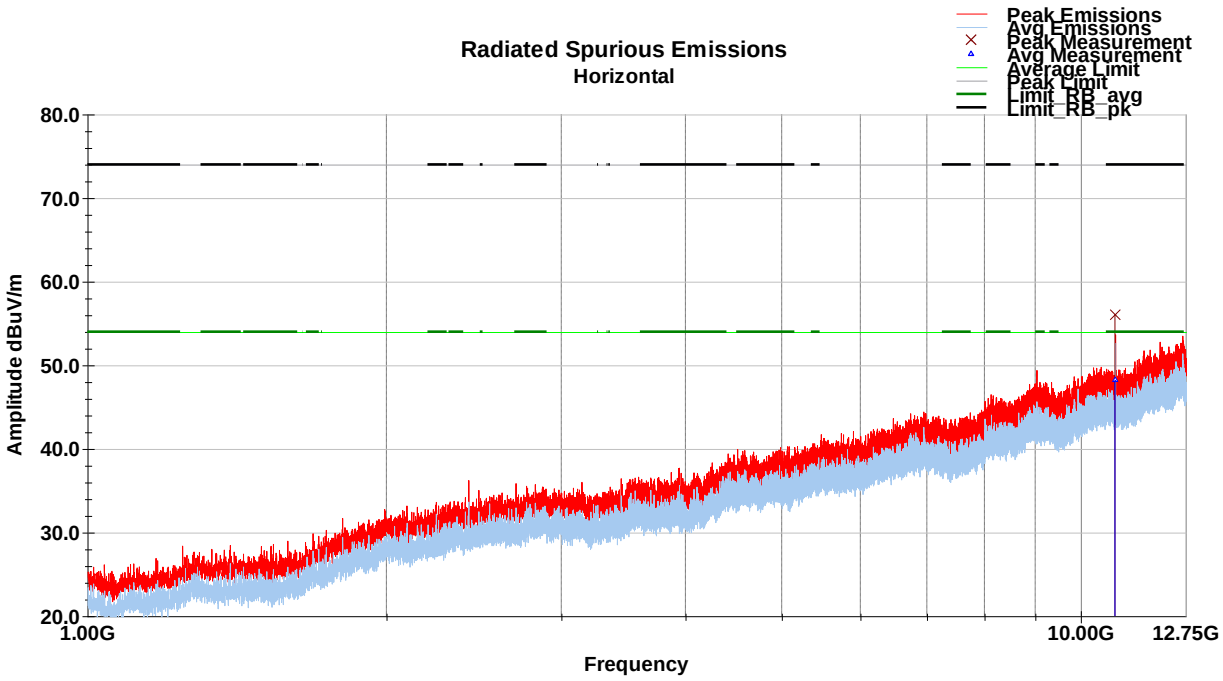
Average

Frequency MHz	Raw Avg dBuV	Polarity (V/H)	Azimuth (degrees)	Height (cm)	AF (dB/m)	Loss (dB)	Amp (dB)	Final Avg dBuV/m	Limit (dBuV/m)	Margin (dB)
1804.38	19.1	V	39.0	102.0	30.3	2.0	35.3	15.9	54.0	-38.0
12078.83	31.6	V	26.0	226.0	38.9	4.9	36.0	39.3	54.0	-14.6
Final Avg = Raw Avg + AF + Loss - Amp										
Margin = Final Avg - Limit										

Peak

Frequency MHz	Raw Pk dBuV	Polarity (V/H)	Azimuth (degrees)	Height (cm)	AF (dB/m)	Loss (dB)	Amp (dB)	Final Pk dBuV/m	Limit dBuV/m	Margin dB
1804.38	35.2	V	39.0	102.0	30.3	2.0	35.3	32.1	74.0	-41.9
12078.83	44.0	V	26.0	226.0	38.9	4.9	36.0	51.8	74.0	-22.2
Final Pk = Raw Pk + AF + Loss - Amp										
Margin = Final Pk - Limit										

Horizontal Polarity Peak Plot Low Channel



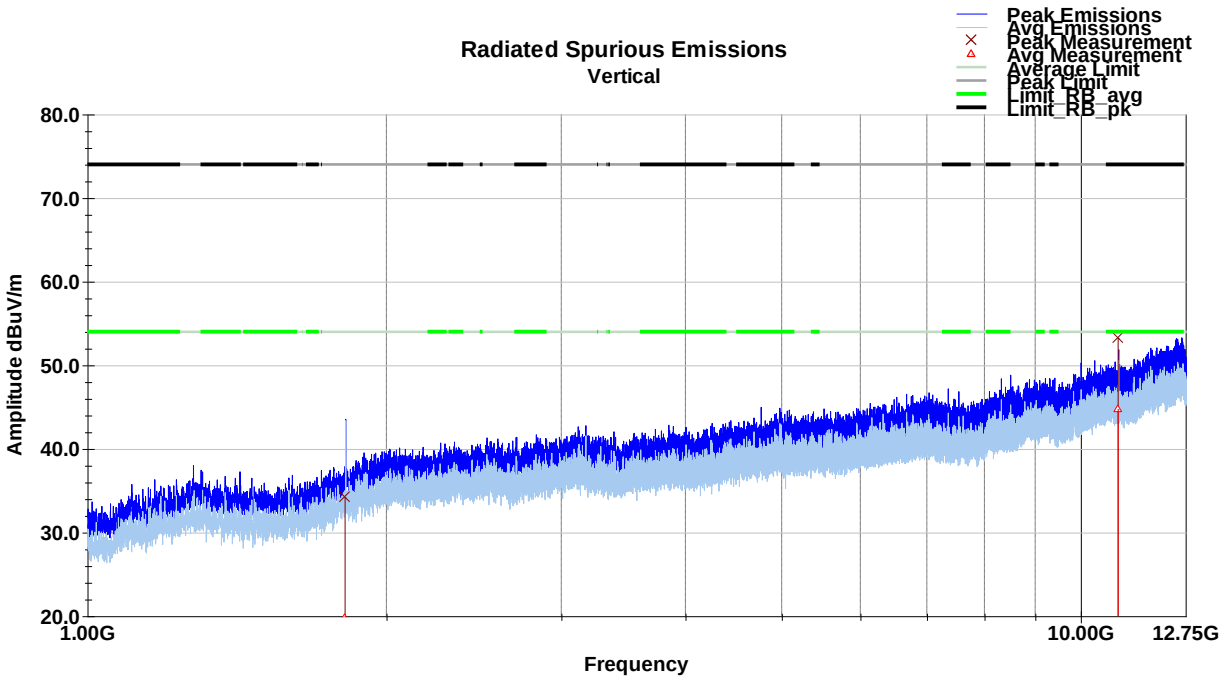
Average

Frequency MHz	Raw Avg dBuV	Polarity (V/H)	Azimuth (degrees)	Height (cm)	AF (dB/m)	Loss (dB)	Amp (dB)	Avg Value dBuV/m	Limit (dBuV/m)	Margin (dB)
10827.98	42.2	H	43.0	212.0	37.7	4.3	35.9	48.2	54.0	-5.7
Final Avg = Raw Avg + AF + Loss - Amp										
Margin = Final Avg - Limit										

Peak

Frequency MHz	Raw Pk dBuV	Polarity (V/H)	Azimuth (degrees)	Height (cm)	AF (dB/m)	Loss (dB)	Amp (dB)	Final Pk dBuV/m	Limit dBuV/m	Margin dB
10827.98	50.0	H	43.0	212.0	37.7	4.3	35.9	56.1	74.0	-17.9
Final Pk = Raw Pk + AF + Loss - Amp										
Margin = Final Pk - Limit										

Vertical Polarity Peak Plot Mid Channel



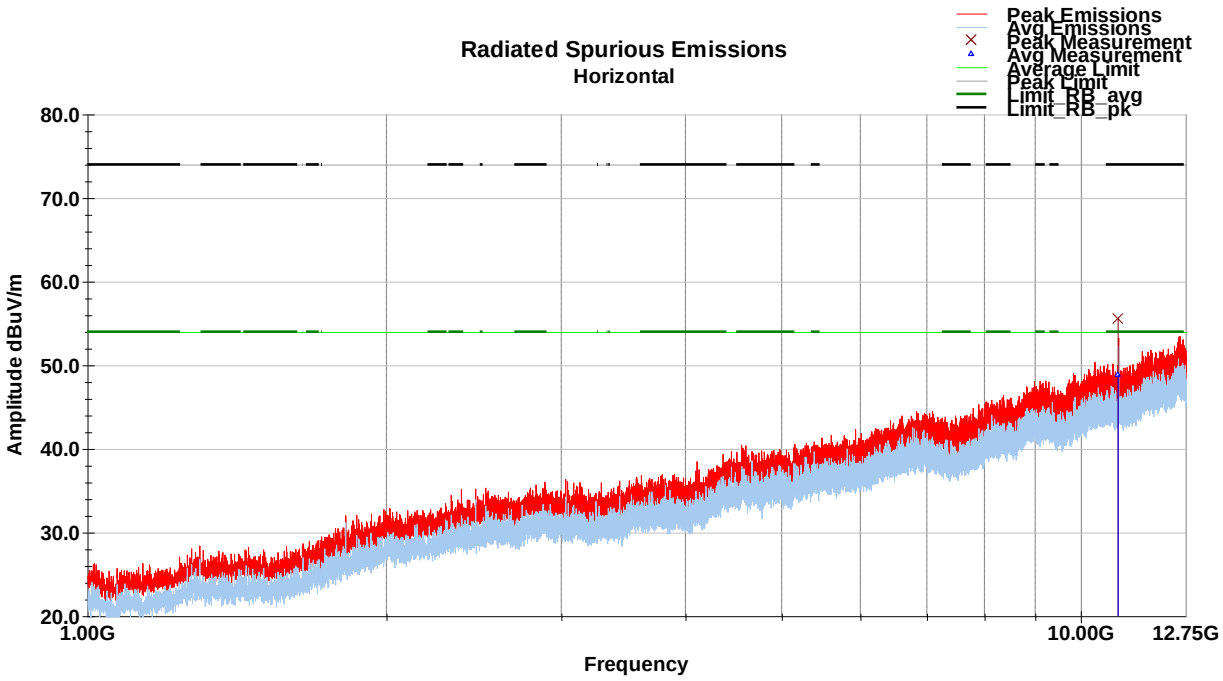
Average

Frequency MHz	Raw Avg dBuV	Polarity (V/H)	Azimuth (degrees)	Height (cm)	AF (dB/m)	Loss (dB)	Amp (dB)	Final Avg dBuV/m	Limit (dBuV/m)	Margin (dB)
1817.84	22.9	V	-1.0	104.0	30.4	1.9	35.3	19.9	54.0	-34.1
10906.45	38.3	V	-1.0	100.0	37.7	4.5	35.9	44.7	54.0	-9.2
Final Avg = Raw Avg + AF + Loss - Amp										
Margin = Final Avg - Limit										

Peak

Frequency MHz	Raw Pk dBuV	Polarity (V/H)	Azimuth (degrees)	Height (cm)	AF (dB/m)	Loss (dB)	Amp (dB)	Final Pk dBuV/m	Limit dBuV/m	Margin dB
1817.84	37.2	V	-1.0	104.0	30.4	1.9	35.3	34.2	74.0	-39.8
10906.45	46.9	V	-1.0	100.0	37.7	4.5	35.9	53.3	74.0	-20.7
Final Pk = Raw Pk + AF + Loss - Amp										
Margin = Final Pk - Limit										

Horizontal Polarity Peak Plot Mid Channel



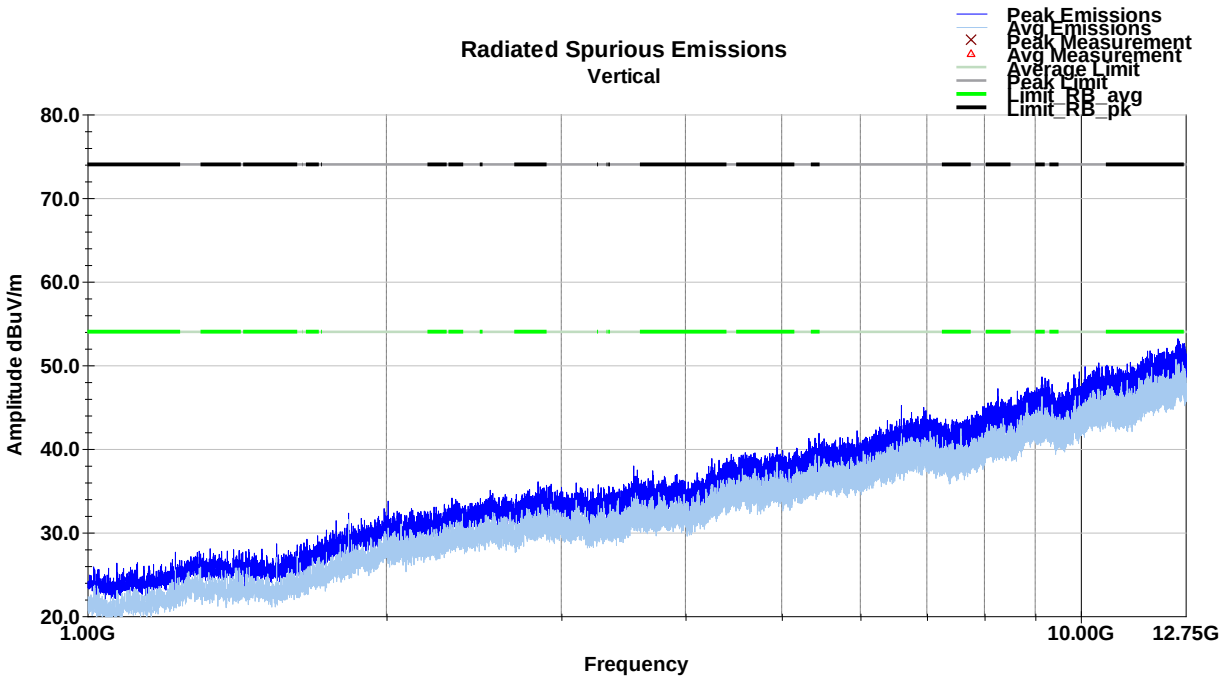
Average

Frequency MHz	Raw Avg dBuV	Polarity (V/H)	Azimuth (degrees)	Height (cm)	AF (dB/m)	Loss (dB)	Amp (dB)	Avg Value dBuV/m	Limit (dBuV/m)	Margin (dB)
10906.76	42.5	H	30.0	213.0	37.7	4.5	35.9	48.9	54.0	-5.1
Final Avg = Raw Avg + AF + Loss - Amp										
Margin = Final Avg - Limit										

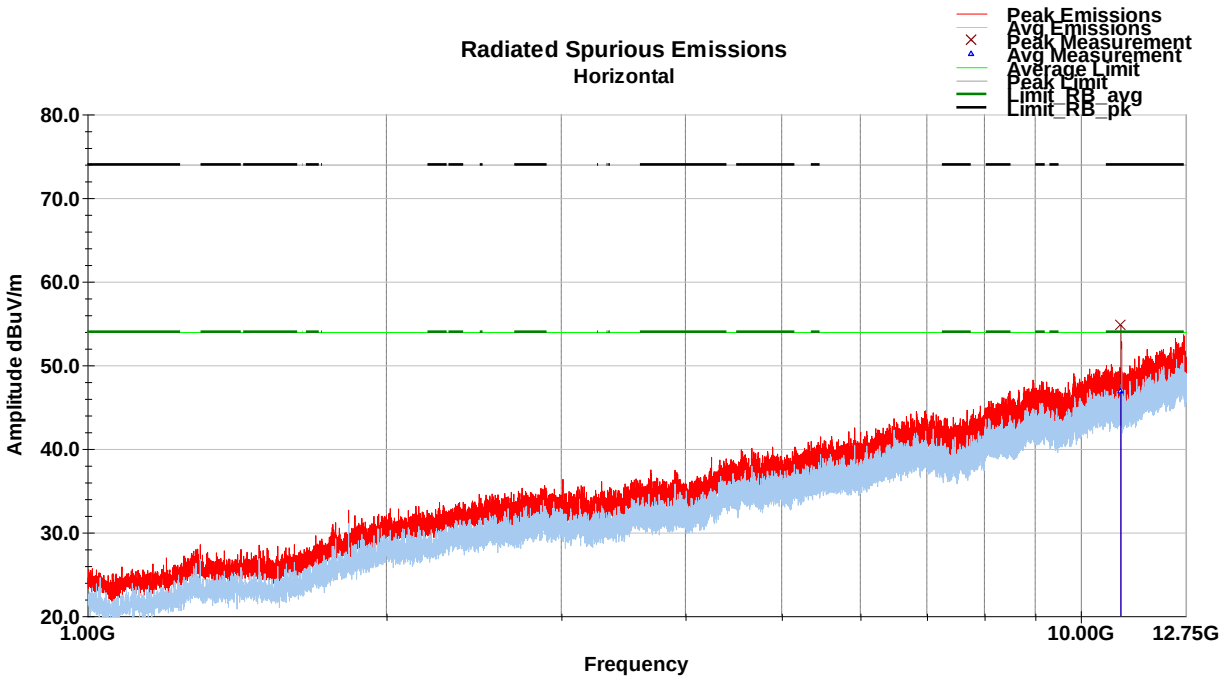
Peak

Frequency MHz	Raw Pk dBuV	Polarity (V/H)	Azimuth (degrees)	Height (cm)	AF (dB/m)	Loss (dB)	Amp (dB)	Final Pk dBuV/m	Limit dBuV/m	Margin dB
10906.76	49.2	H	30.0	213.0	37.7	4.5	35.9	55.6	74.0	-18.4
Final Pk = Raw Pk + AF + Loss - Amp										
Margin = Final Pk - Limit										

Vertical Polarity Peak Plot High Channel



Horizontal Polarity Peak Plot High Channel



Average

Frequency MHz	Raw Avg dBuV	Polarity (V/H)	Azimuth (degrees)	Height (cm)	AF (dB/m)	Loss (dB)	Amp (dB)	Avg Value dBuV/m	Limit (dBuV/m)	Margin (dB)
10978.37	40.3	H	25.0	223.0	37.7	4.7	35.8	46.9	54.0	-7.1
Final Avg = Raw Avg + AF + Loss - Amp										
Margin = Final Avg - Limit										

Peak

Frequency MHz	Raw Pk dBuV	Polarity (V/H)	Azimuth (degrees)	Height (cm)	AF (dB/m)	Loss (dB)	Amp (dB)	Final Pk dBuV/m	Limit dBuV/m	Margin dB
10978.37	48.2	H	25.0	223.0	37.7	4.7	35.8	54.8	74.0	-19.2
Final Pk = Raw Pk + AF + Loss - Amp										
Margin = Final Pk - Limit										

8 Radiated Emissions at Band Edge / Restricted Bands

8.1 *Test Result*

Test Description	Test Specification	Test Result
Radiated Emissions at Band Edge / Restricted Bands	ANSI C63.10:2013 15.205, 15.209 RSS-GEN 8.9, 8.10	Compliant

8.2 *Test Method*

Field strength measurements were performed at the restricted band edges of 902 MHz and 928 MHz for each modulation. Measurements were made using the conducted method following the procedures in ANSI C63.10 section 6.10.5

8.3 *Test Site*

SGS EMC Laboratory, Suwanee, GA
Environmental Conditions

Temperature:	23.34 °C
Relative Humidity:	55.2 %
Atmospheric Pressure:	98.33 kPa

8.4 *Test Equipment*

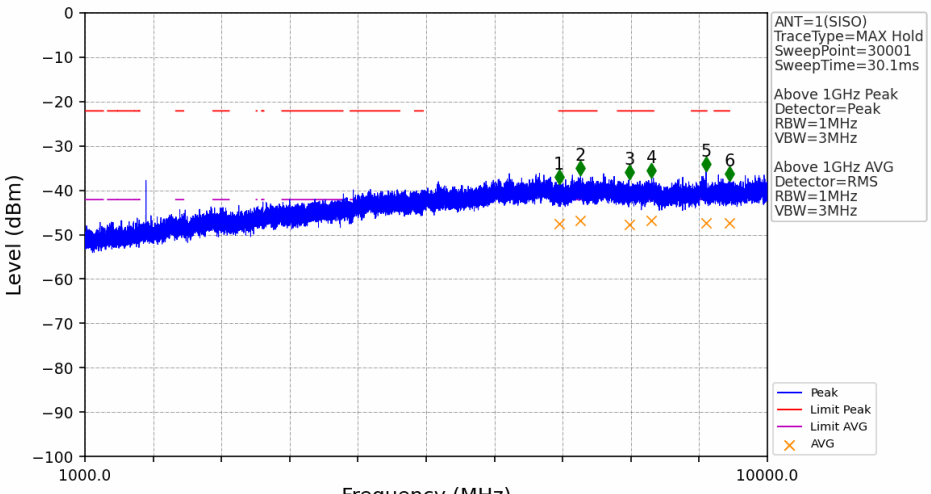
Test End Date: 14-Aug-2024 Tester: SGM

Equipment	Manufacturer	Model	Asset Number	Cal Date	Cal Due Date
RF CABLE SMA TO SMA, 0.01-40GHZ	TELEDYNE STORM MICROWAVE	084-0505-059	20108	20-Mar-2024	20-Mar-2025
TSTPASS SWITCHBOX	TSTPASS	SB2	23009	8-Apr-2024	8-Apr-2025
SIGNAL ANALYZER (TS8997)	ROHDE & SCHWARZ	FSV30	B085749	3-Jan-2024	3-Jan-2025

8.5 *Test Data – Restricted Band Edge*

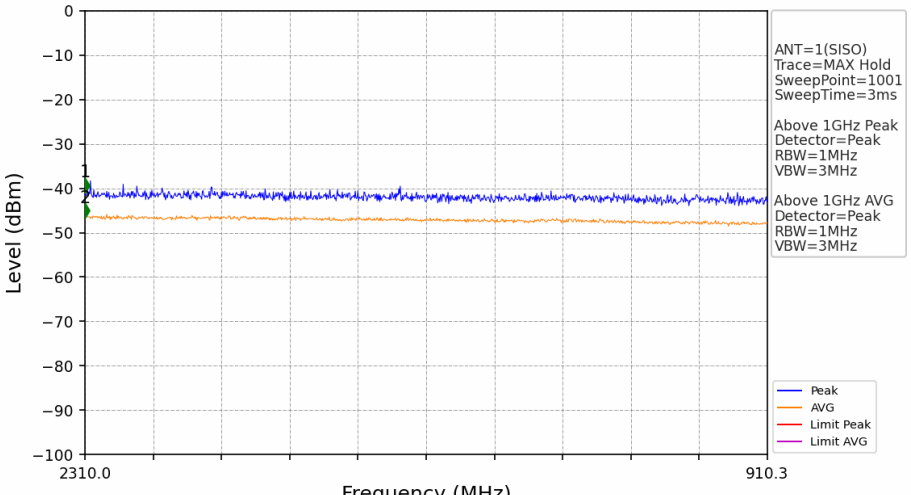
8.5.1 125kHz Modulation – Worst Case

LoRa_LCH_902.3MHz_Ant1_NTNV



No	Frequency (MHz)	Level (dBm)	Limit (dBm)	Margin (dB)	Status	Remark	No	Frequency (MHz)	Level (dBm)	Limit (dBm)	Margin (dB)	Status	Remark
1	7252.9	-38.62	-21.20	16.52	Pass	Peak	7	7252.9	-47.49	-41.20	5.39	Pass	AVG
2	7536.1	-36.48	-21.20	14.38	Pass	Peak	8	7536.1	-46.87	-41.20	4.77	Pass	AVG
3	8176.3	-37.49	-21.20	15.39	Pass	Peak	9	8176.3	-47.68	-41.20	5.58	Pass	AVG
4	8473	-37.15	-21.20	15.04	Pass	Peak	10	8473	-46.81	-41.20	4.71	Pass	AVG
5	9191.8	-35.56	-21.20	13.46	Pass	Peak	11	9191.8	-47.36	-41.20	5.26	Pass	AVG
6	9499.3	-37.89	-21.20	15.79	Pass	Peak	12	9499.3	-47.27	-41.20	5.17	Pass	AVG

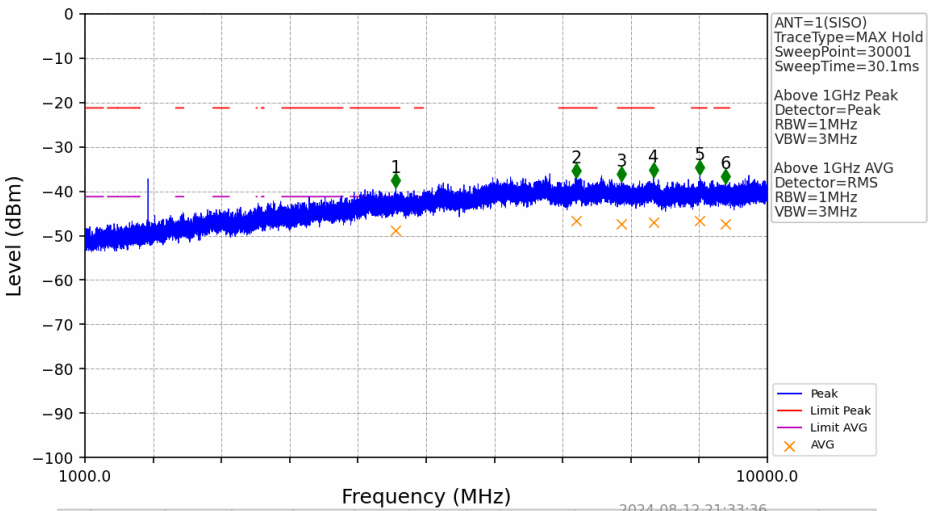
LoRa_LCH_902.3MHz_Ant1_NTNV



No	Frequency (MHz)	Level (dBm)	Limit (dBm)	Margin (dB)	Status	Remark	No	Frequency (MHz)	Level (dBm)	Limit (dBm)	Margin (dB)	Status	Remark
1	2310.000	-40.84	-21.20	18.74	Pass	Peak	2	2310.000	/	-21.20	/	/	AVG

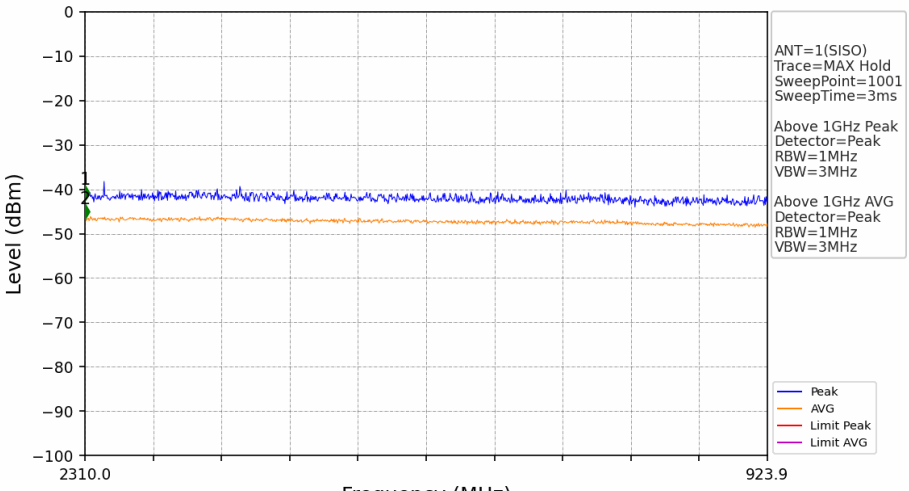
8.5.2 500kHz Modulation – Worst Case

LoRa_LCH_915.9MHz_Ant1_NTNV



No	Frequency (MHz)	Level (dBm)	Limit (dBm)	Margin (dB)	Status	Remark	No	Frequency (MHz)	Level (dBm)	Limit (dBm)	Margin (dB)	Status	Remark
1	5099.8	-39.12	-21.20	17.92	Pass	Peak	7	5099.8	-48.90	-41.20	7.70	Pass	AVG
2	7481.5	-36.96	-21.20	15.76	Pass	Peak	8	7481.5	-46.64	-41.20	5.44	Pass	AVG
3	8076.1	-37.70	-21.20	16.50	Pass	Peak	9	8076.1	-47.40	-41.20	6.20	Pass	AVG
4	8497.9	-36.67	-21.20	15.47	Pass	Peak	10	8497.9	-46.92	-41.20	5.72	Pass	AVG
5	9111.4	-36.27	-21.20	15.07	Pass	Peak	11	9111.4	-46.64	-41.20	5.44	Pass	AVG
6	9450.7	-38.23	-21.20	17.03	Pass	Peak	12	9450.7	-47.37	-41.20	6.17	Pass	AVG

LoRa_LCH_915.9MHz_Ant1_NTNV



No	Frequency (MHz)	Level (dBm)	Limit (dBm)	Margin (dB)	Status	Remark	No	Frequency (MHz)	Level (dBm)	Limit (dBm)	Margin (dB)	Status	Remark
1	2310.000	-42.30	-21.20	21.10	Pass	Peak	2	2310.000	/	-21.20	/	/	AVG

9 Pseudo-Random Hop Sequence

9.1 *Test Result*

Test Description	Test Specification	Test Result
Pseudo-Random Hop Sequence	ANSI C63.10:2013 15.247(a)(1) RSS-247 5.1(a)	Compliant(1)

Note (1): The theory of operation states that the device is LoRa and operates using a pseudo-random hopping technique @ 125 kHz modulation.

9.2 *Test Method*

Compliance is demonstrated by Manufacturer's declaration or is stated in the Theory of Operation.

Requirement
The hopset shall be such that the near-term distribution of frequencies appears random, with sequential hops randomly distributed in both direction and magnitude of change in the hopset, while the long-term distribution appears evenly distributed.

10 Channel Separation

10.1 *Test Result*

Test Description	Test Specification	Test Result
Channel Separation	ANSI C63.10:2013 15.247(a)(1) RSS-247 5.1(b)	Compliant

10.2 *Test Method*

Measurements were taken using the methods defined in ANSI C63.10, Clause 7.8.2. The test data was measured using a spectrum analyzer with Peak detector (max hold) and a resolution bandwidth of 100 kHz. The trace was allowed to stabilize until all channels were displayed.

Requirement
Frequency hopping systems shall have hopping channel carrier frequencies separated by a minimum of 25 kHz or the -20 dB bandwidth of the hopping channel, whichever is greater.

Test Site
SGS EMC Laboratory, Suwanee, GA

Environmental Conditions

Temperature:	19.17 °C
Relative Humidity:	52.1 %
Atmospheric Pressure:	98.2 kPa

10.3 *Test Equipment*

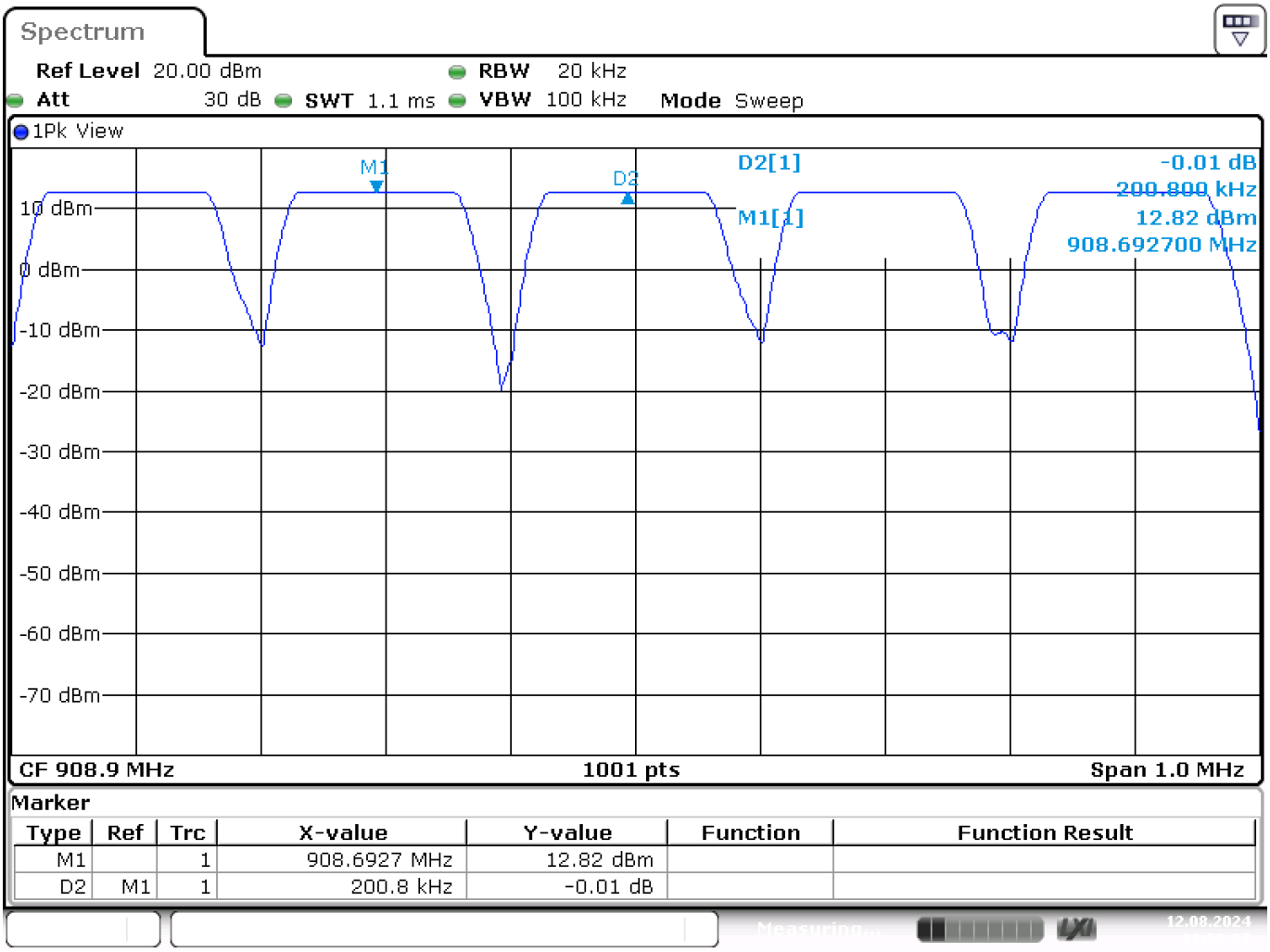
Test End Date: 14-Aug-2024 Tester: SGM

Equipment	Manufacturer	Model	Asset Number	Cal Date	Cal Due Date
RF CABLE SMA TO SMA, 0.01-40GHZ	TELEDYNE STORM MICROWAVE	084-0505-059	20108	20-Mar-2024	20-Mar-2025
TSTPASS SWITCHBOX	TSTPASS	SB2	23009	8-Apr-2024	8-Apr-2025
SIGNAL ANALYZER (TS8997)	ROHDE & SCHWARZ	FSV30	B085749	3-Jan-2024	3-Jan-2025

10.4 *Test Data – 125 kHz Modulation*

Test Mode	TX Type	ANT No.	Channel Separation (MHz)	20dB Bandwidth (MHz)	Limits (MHz)	Verdict
LoRa	SISO	1	0.2	0.143	≥0.143	PASS

Sample Plot



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11 Number of Hopping Channels

11.1 *Test Result*

Test Description	Test Specification	Test Result
Number of Hopping Channels	ANSI C63.10:2013 15.247(a)(1)(iii)(h) RSS-247 5.1(d)	Compliant

11.2 *Test Method*

Measurements were taken using the methods defined in ANSI C63.10, Clause 7.8.3. The test data was measured using a spectrum analyzer with Peak detector (max hold) and a resolution bandwidth of 30 kHz. The trace was allowed to stabilize until all channels were displayed.

Requirement

For frequency hopping systems operating in the 902-928 MHz band: if the 20 dB bandwidth of the hopping channel is less than 250 kHz, the system shall use at least 50 hopping frequencies and the average time of occupancy on any frequency shall not be greater than 0.4 seconds within a 20 second period; if the 20 dB bandwidth of the hopping channel is 250 kHz or greater, the system shall use at least 25 hopping frequencies and the average time of occupancy on any frequency shall not be greater than 0.4 seconds within a 10 second period.

Test Site
SGS EMC Laboratory, Suwanee, GA

Environmental Conditions

Temperature:	19.17 °C
Relative Humidity:	52.1 %
Atmospheric Pressure:	98.2 kPa

11.3 *Test Equipment*

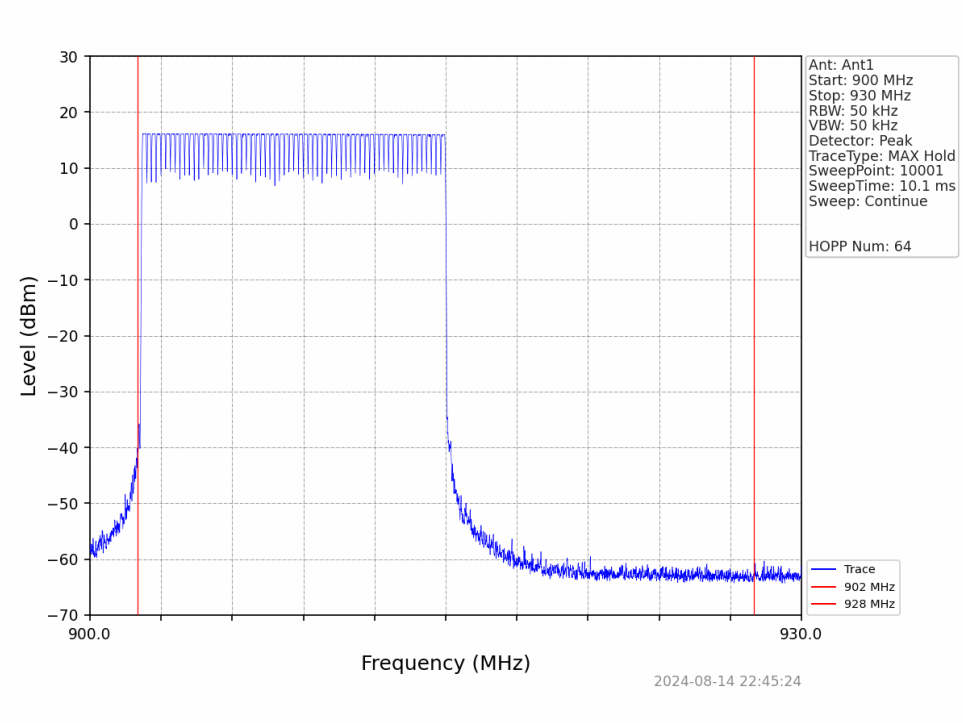
Test End Date: 14-Aug-2024 Tester: SGM

Equipment	Manufacturer	Model	Asset Number	Cal Date	Cal Due Date
RF CABLE SMA TO SMA, 0.01-40GHZ	TELEDYNE STORM MICROWAVE	084-0505-059	20108	20-Mar-2024	20-Mar-2025
TSTPASS SWITCHBOX	TSTPASS	SB2	23009	8-Apr-2024	8-Apr-2025
SIGNAL ANALYZER (TS8997)	ROHDE & SCHWARZ	FSV30	B085749	3-Jan-2024	3-Jan-2025

11.4 *Test Data - 125 kHz Modulation*

Mode	TX Type	Frequency (MHz)	Num of Hopping Frequencies		Verdict
			ANT1	Limit	
LoRa	SISO	HOPP	64	>=50	Pass

Sample Plot



12 Dwell Time

12.1 *Test Result*

Test Description	Test Specification	Test Result
Dwell Time	ANSI C63.10:2013 15.247(a)(1)(iii)(g) RSS-247 5.1(d)	Compliant

12.2 *Test Method*

Measurements were taken using the methods defined in ANSI C63.10, Clause 7.8.4. For each packet type and data rate, the pulse width of the packet was measured, and the pulses were counted over the total observation period.

Requirement

The average time of occupancy on any channel shall not be greater than 0.4 seconds within a period of 0.4 seconds, multiplied by the number of hopping channels employed (0.4*79=31.6s).

12.3 *Test Site*

SGS EMC Laboratory, Suwanee, GA

Environmental Conditions

Temperature:	19.17 °C
Relative Humidity:	52.1 %
Atmospheric Pressure:	98.2 kPa

12.4 *Test Equipment*

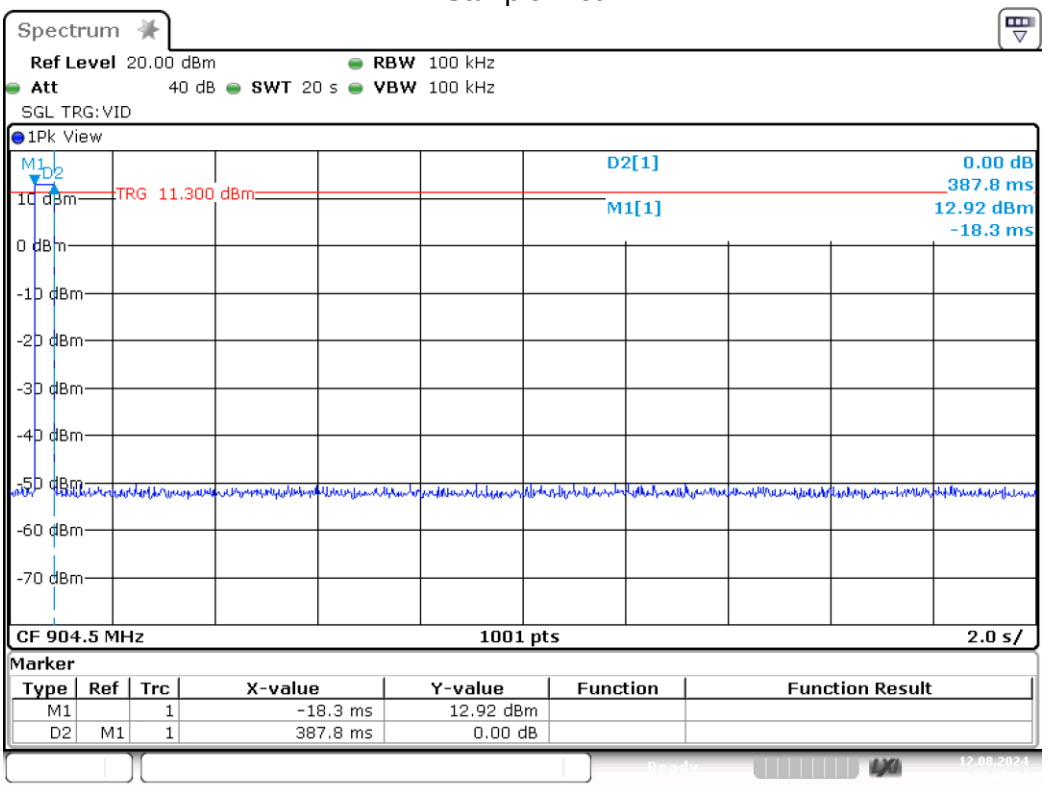
Test End Date: 14-Aug-2024 Tester: SGM

Equipment	Manufacturer	Model	Asset Number	Cal Date	Cal Due Date
RF CABLE SMA TO SMA, 0.01-40GHZ	TELEDYNE STORM MICROWAVE	084-0505-059	20108	20-Mar-2024	20-Mar-2025
TSTPASS SWITCHBOX	TSTPASS	SB2	23009	8-Apr-2024	8-Apr-2025
SIGNAL ANALYZER (TS8997)	ROHDE & SCHWARZ	FSV30	B085749	3-Jan-2024	3-Jan-2025

12.5 *Test Data - 125 kHz Modulation*

Test Mode	Packet Type	TX Type	ANT No.	Duration of Single Pulse (ms)	Obeservation Period (s)	Num of Pulse in Observation Period	Dwell Time (ms)	Limits (ms)	Verdict
LoRa	DH1	SISO	1	387.8	20	1	387.800	≤400	PASS

Sample Plot



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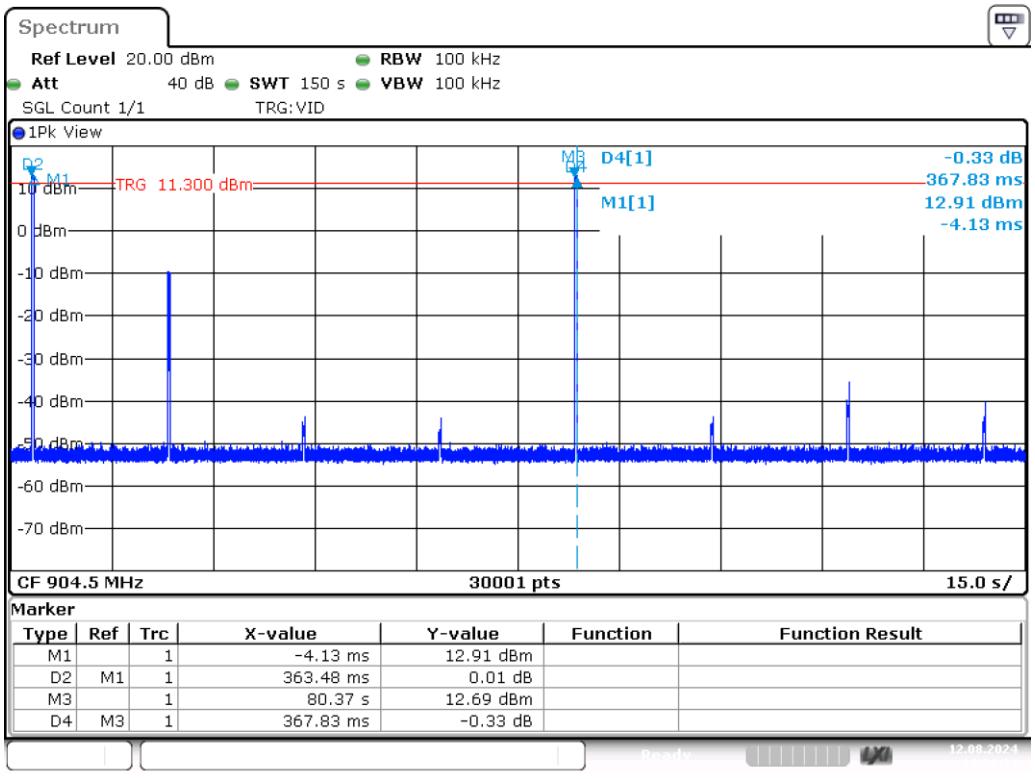

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13 Measurement Uncertainty

The measurement uncertainty figures are be calculated in accordance with TR 100 028-1 [2] and correspond to an expansion factor (coverage factor) k = 2 (which provide confidence levels of 95,45 % in the case where the distributions characterizing the actual measurement uncertainties are normal (Gaussian)).

	Expanded Uncertainty for Normal k factor equal to 2	
Parameter	Required	Laboratory Actual
Radio Frequency	±1 x 10-5	±9.8 x 10-8
total RF power, conducted	±1.5 dB	±1.2 dB
RF power density, conducted	±3 dB	±0.7 dB
spurious emissions, conducted	±3 dB	±2.1 dB
all emissions, radiated	±6 dB	±4.8 dB
temperature	±1°C	±0.5°C
humidity	±5 %	±3.5%
DC and low frequency voltages	±3 %	±0.4%

14 Revision History

Revision Level	Description of changes	Revision Date
Draft	Draft Release	16 August 2024
0	Initial Release	30 August 2024
1	Updated section 3, 5, and 7	26 November 2024
2	Updated sections to clarify 125 kHz modulation from 500 kHz. Added PSD section.	27 November 2024