REPORT No.: SZ23110148W02

TEST REPORT

APPLICANT	:	Shenzhen RAKwireless Technology Co.,Ltd.
PRODUCT NAME	:	Multiple External Temperature Sensor
MODEL NAME	:	SL103-HF-A1
BRAND NAME	:	Rejeee,
FCC ID	:	2AF6B-SL103
STANDARD(S)	:	47 CFR Part 15 Subpart C
RECEIPT DATE	:	2023-11-15
TEST DATE	:	2023-11-29 to 2024-02-21
ISSUE DATE	:	2024-04-24

Edited by: Peng Mi (Rapporteur)

Approved by: Shen Junsheng (Supervisor)

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MORLAB

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DIRECTORY

Change History		
Version	**Date**	**Reason for change**
1.0	2024-04-24	First edition

1. Summary of Test Result

No.	Section	Description	Test Date	Test Engineer	Result	Method Determination /Remark
1	15.203	Antenna Requirement	N/A	N/A	PASS	No deviation
2	15.247(a) 15.247(h)	Hopping Mechanism	N/A	N/A	PASS	No deviation
3	15.247(a)	Number of Hopping Frequency	Nov, 30, 2023	Su Xiaoxian	PASS	No deviation
4	ANSI C63.10	Duty Cycle	Nov, 30, 2023	Su Xiaoxian	PASS	No deviation
5	15.247(b)	Maximum Peak Conducted Output Power	Nov, 30, 2023	Su Xiaoxian	PASS	No deviation
6	15.247(b)	Maximum Average Conducted Output Power	Nov, 30, 2023	Su Xiaoxian	PASS	No deviation
7	15.247(a)	20dB Bandwidth	Nov, 30, 2023	Su Xiaoxian	PASS	No deviation
8	15.247(a)	Carrier Frequency Separation	Nov, 30, 2023	Su Xiaoxian	PASS	No deviation
9	15.247(a)	Time of Occupancy (Dwell time)	Nov, 30, 2023	Su Xiaoxian	PASS	No deviation
10	15.247(d)	Conducted Spurious Emission	Nov, 30, 2023	Su Xiaoxian	PASS	No deviation
11	15.207	Conducted Emission	Nov. 29, 2023	Wang Deyong	PASS	No deviation
12	15.209, 15.247(d)	Radiated Emission	Feb. 21, 2024	Su Zhan	PASS	No deviation

Note 1: The tests were performed according to the method of measurements prescribed in ANSI C63.10-2013, KDB 558074 D01 v05r02 and DA 00-075.

Note 2: Additions to, deviation, or exclusions from the method shall be judged in the "method determination" column of add, deviate or exclude from the specific method shall be explained in the "Remark" of the above table.

Note 3: When the test result is a critical value, we will use the measurement uncertainty give the judgment result based on the 95% confidence intervals.

1.1. Testing Applied Standards

According to the specifications of the manufacturer, the EUT must comply with the requirements of the following standards:

• 47 CFR Part 15 Subpart C Radio Frequency Devices

1.2. Test Equipment List

1.2.1 Conducted Test Equipments

Equipment Name	Serial No.	Type	Manufacturer	Cal. Date	Due Date
EXA Signal Analzyer	MY53470836	N9010A	Agilent	2023.02.27	2024.02.26
RF Cable (30MHz-26GHz)	CB01	RF01	Morlab	N/A	N/A
Coaxial Cable	CB02	RF02	Morlab	N/A	N/A
SMA Connector	CN01	RF03	HUBER-SUHNER	N/A	N/A

1.2.2 Conducted Emission Test Equipments

Equipment Name	Serial No.	Type	Manufacturer	Cal. Date	Due Date
Receiver	MY56400093	N9038A	KEYSIGHT	2023.02.09	2024.02.08
				2024.01.25	2025.01.24
LISN	8127449	NSLK 8127	Schwarzbeck	2023.02.21	2024.02.20
				2024.02.02	2025.02.01
Pulse Limiter (10dB)	VTSD 9561 F-B #206	VTSD 9561-F	Schwarzbeck	2023.06.27	2024.06.26
RF Coaxial Cable (DC-100MHz)	BNC	MRE04	Qualwave	N/A	N/A

1.2.3 List of Software Used

Description	Manufacturer	Software Version
Test System	MaiWei	2.0.0.0
Morlab EMCR	Morlab	V1.2
TS+ -[JS32-CE]	Tonscend	V2.5.0.0

1.2.4 Radiated Test Equipments

Equipment Name	Serial No.	Type	Manufacturer	Cal. Date	Due Date
Receiver	MY54130016	N9038A	Agilent	2023.06.21	2024.06.20
Test Antenna - Bi-Log	9163-519	VULB 9163	Schwarzbeck	2023.07.01	2024.06.30
Test Antenna - Loop	1519-022	FMZB1519	Schwarzbeck	2023.06.26	2024.06.25
Test Antenna – Horn	01774	BBHA 9120D	Schwarzbeck	2023.07.01	2024.06.30
Test Antenna – Horn	BBHA9170 #773	BBHA9170	Schwarzbeck	2023.07.01	2024.06.30
Preamplifier (10MHz-6GHz)	46732	S10M100L3802	LUCIX CORP.	2023.06.26	2024.06.27
Preamplifier (2GHz-18GHz)	61171/61172	S020180L3203	LUCIX CORP.	2023.06.26	2024.06.27
Preamplifier (18GHz-40GHz)	DS77209	DCLNA0118-40C-S	Decentest	2023.07.04	2024.07.03
RF Coaxial Cable (DC-18GHz)	MRE001	PE330	Pasternack	2023.06.27	2024.06.26
RF Coaxial Cable (DC-18GHz)	MRE002	CLU18	Pasternack	2023.06.27	2024.06.26
RF Coaxial Cable (DC-18GHz)	MRE003	CLU18	Pasternack	2023.06.27	2024.06.26
RF Coaxial Cable (DC-40GHz)	22290045	QA360-40-KK-0.5	Qualwave	2023.07.04	2024.07.03
RF Coaxial Cable (DC-40GHz)	22290046	QA360-40-KKF-2	Qualwave	2023.07.04	2024.07.03
RF Coaxial Cable (DC-18GHz)	22120181	QA500-18-NN-5	Qualwave	2023.07.04	2024.07.03
Notch Filter	N/A	WRCG-2400-2483.5-60SS	Wainwright	N/A	N/A
Anechoic Chamber	N/A	9m*6m*6m	CRT	2022.05.10	2025.05.09

1.3. Measurement Uncertainty

Test Items	Uncertainty	Remark
Number of Hopping Frequency	±5%	Confidence levels of 95%
Peak Output Power	±2.22dB	Confidence levels of 95%
Bandwidth	±5%	Confidence levels of 95%
Carrier Frequency Separation	±5%	Confidence levels of 95%
Time of Occupancy (Dwell time)	±5%	Confidence levels of 95%
Conducted Spurious Emission	±2.77dB	Confidence levels of 95%
Restricted Frequency Bands	±5%	Confidence levels of 95%
Radiated Emission	±2.95dB	Confidence levels of 95%
Conducted Emission	±2.44dB	Confidence levels of 95%

1.4. Testing Laboratory

Laboratory Name	Shenzhen Morlab Communications Technology Co., Ltd.
Laboratory Address	FL.3, Building A, FeiYang Science Park, No.8 LongChang Road, Block 67, BaoAn District, ShenZhen, GuangDong Province, P. R. China
Telephone	+86 755 36698555
Facsimile	+86 755 36698525
FCC Designation Number	CN1192
FCC Test Firm Registration Number	226174

2. General Description

2.1. Information of Applicant and Manufacturer

Applicant	Shenzhen RAKwireless Technology Co.,Ltd.
Applicant Address	Room 506, Building B, New Compark, Pingshan First Road, Taoyuan Street, Nanshan District, Shenzhen, Guangdong, China
Manufacturer	Shenzhen RAKwireless Technology Co.,Ltd.
Manufacturer Address	Room 506, Building B, New Compark, Pingshan First Road, Taoyuan Street, Nanshan District, Shenzhen, Guangdong, China

2.2. Information of EUT

Product Name:	Multiple External Temperature Sensor	
Sample No.:	3#	
Hardware Version:	1.1	
Software Version:	1007	
Equipment Type:	FHSS	
Modulation Type:	LoRa	
Data Rate:	SF7 - SF10	
Operating Frequency Range:	FHSS: 902.3MHz - 914.9MHz	
Antenna Type:	Copper spring Antenna	
Antenna Gain:	3dBi	
Accessory Information:	Battery	
	Brand Name:	RAMWAY
	Model No.:	ER14505
	Serial No.:	N/A
	Capacity:	2700mAh
	Rated Voltage:	3.6V
	Charge Limit:	N/A
	Manufacturer:	Guangxi Ramway New Energy Corp., Ltd

Note 1: We use the dedicated software to control the EUT continuous transmission.

Note 2: For a more detailed description, please refer to Specification or User's Manual supplied by the applicant and/or manufacturer.

2.3. Channel List of EUT

Channel	Frequency (MHz)	Channel	Frequency (MHz)	Channel	Frequency (MHz)	Channel	Frequency (MHz)
1	**902.3**	17	905.5	33	908.7	49	911.9
2	902.5	18	905.7	34	908.9	50	912.1
3	902.7	19	905.9	35	909.1	51	912.3
4	902.9	20	906.1	36	909.3	52	912.5
5	903.1	21	906.3	37	909.5	53	912.7
6	903.3	22	906.5	38	909.7	54	912.9
7	903.5	23	906.7	39	909.9	55	913.1
8	903.7	24	906.9	40	910.1	56	913.3
9	903.9	25	907.1	41	910.3	57	913.5
10	904.1	26	907.3	42	910.5	58	913.7
11	904.3	27	907.5	43	910.7	59	913.9
12	904.5	28	907.7	44	910.9	60	914.1
13	904.7	29	907.9	45	911.1	61	914.3
14	904.9	30	908.1	46	911.3	62	914.5
15	905.1	31	908.3	47	911.5	63	914.7
16	905.3	**32**	**908.5**	48	911.7	**64**	**914.9**

Note 1: The black bold channels were selected for test.

2.4. Test Configuration of EUT

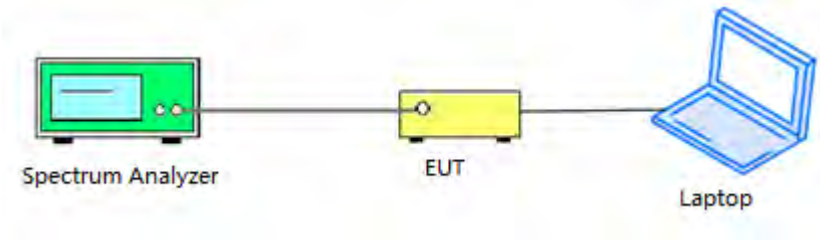
Test mode is used to control the EUT under the maximum power level during test.

2.5. Test Conditions

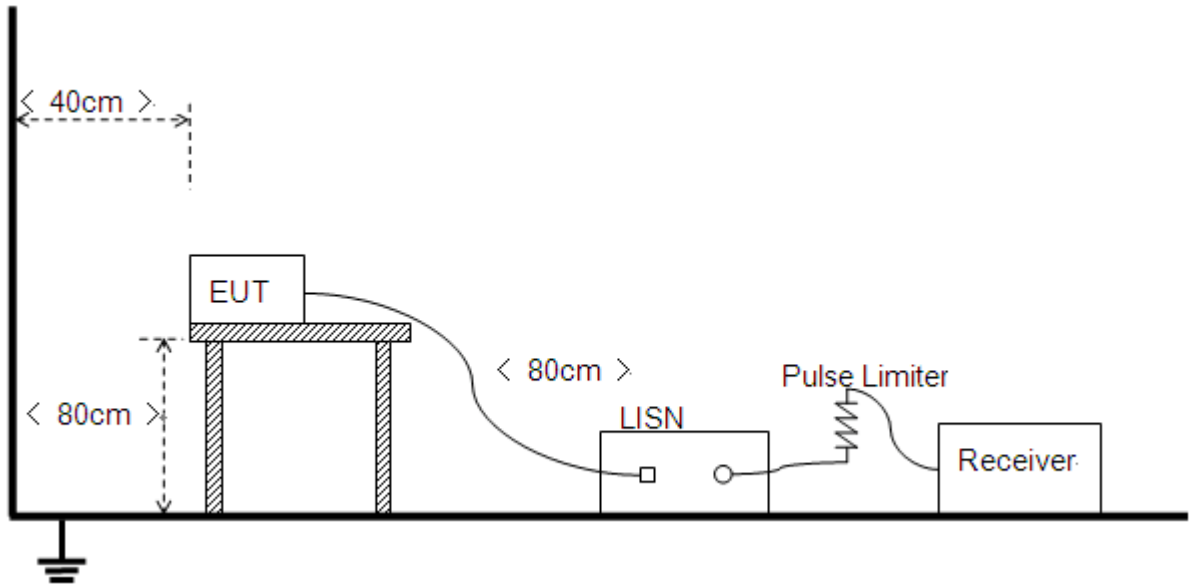
Temperature (°C)	15-35
Relative Humidity (%)	30-60
Atmospheric Pressure (kPa)	86-106

2.6. Test Setup Layout Diagram

2.6.1.Conducted Measurement

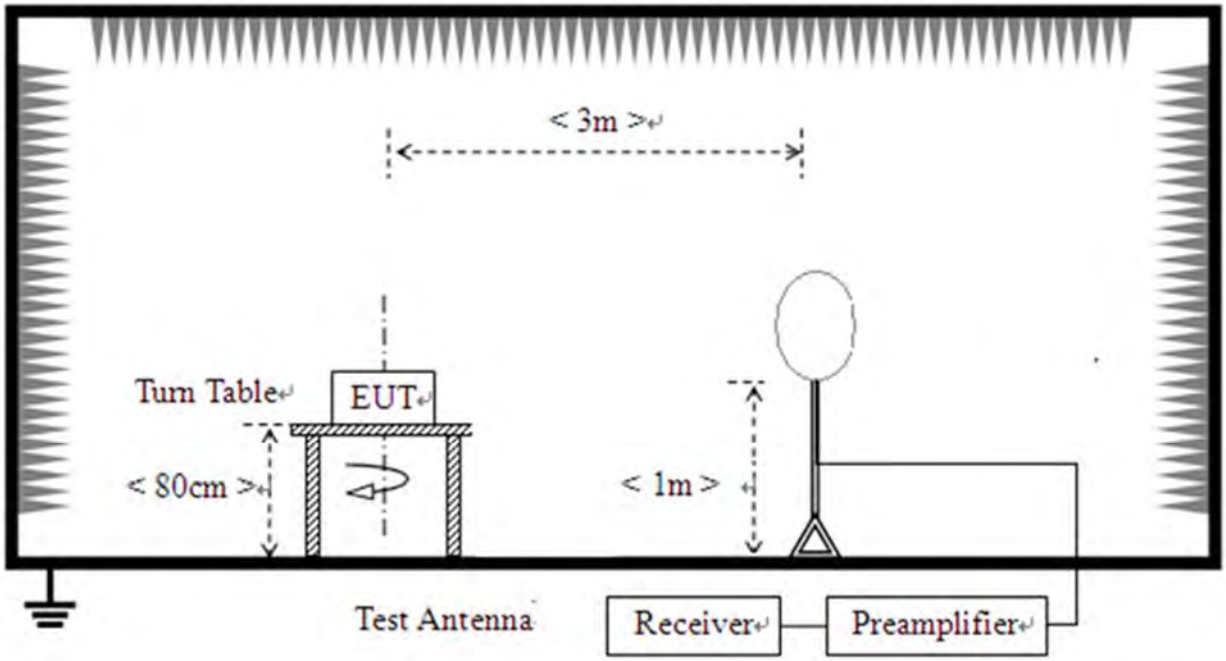


2.6.2.Conducted Emission Measurement

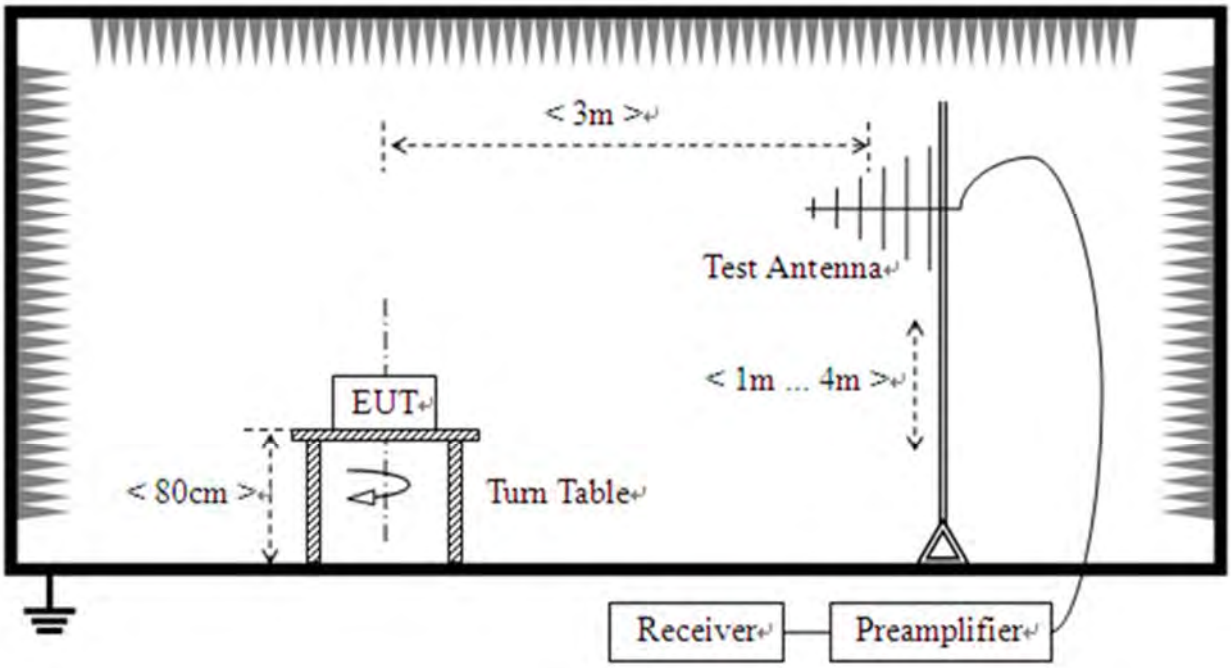


2.6.3.Radiation Measurement

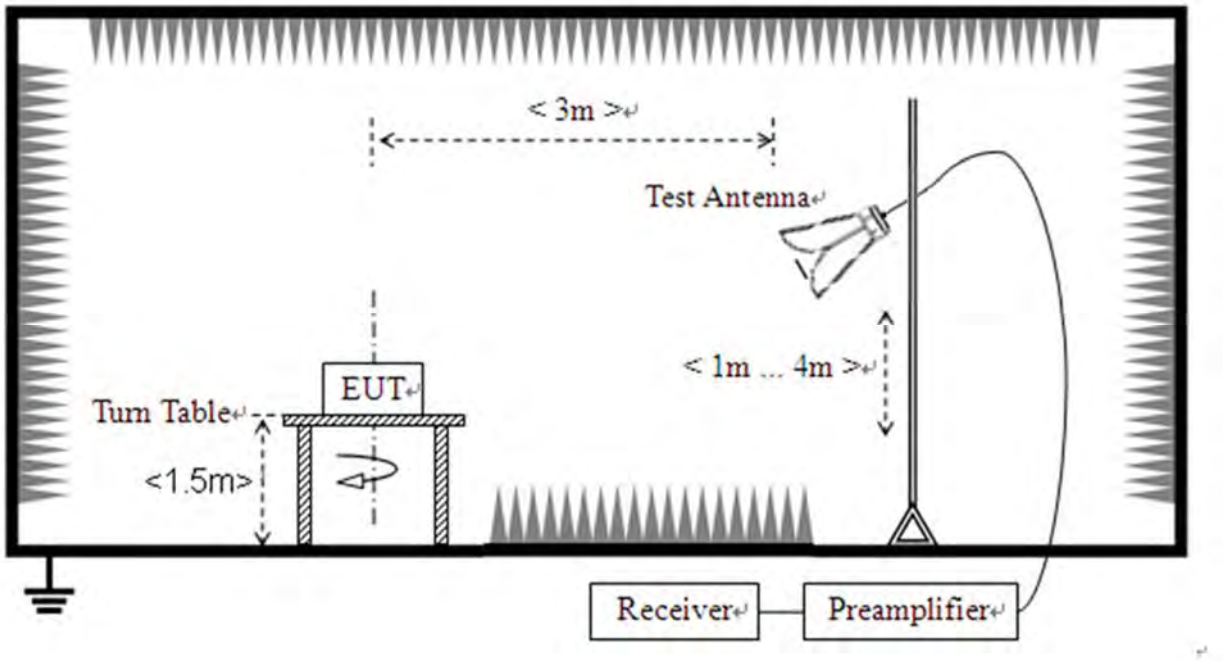
1) For radiated emissions from 9kHz to 30MHz



2) For radiated emissions from 30MHz to1GHz



3) For radiated emissions above 1GHz



3. Test Results

3.1. Antenna Requirement

3.1.1.Requirement

According to FCC 15.203, an intentional radiator shall be designed to ensure that no antenna other than that furnished by the responsible party shall be used with the device. The use of a permanently attached antenna or of an antenna that uses a unique coupling to the intentional radiator shall be considered sufficient to comply with the provisions of this section.

3.1.2.Test Result

The EUT has a permanently and irreplaceable attached antenna. Please refer to the EUT internal photos.

3.2. Hopping Mechanism

3.2.1.Requirement

According to FCC section 15.247(a)(1), a frequency hopping spread spectrum system shall hop to channel frequencies that are selected at the system hopping rate from a pseudo randomly ordered list of hopping frequencies. Each frequency must be used equally on the average by each transmitter. The system receivers shall have input bandwidths that match the hopping channel bandwidths of their corresponding transmitters and shall shift frequencies in synchronization with the transmitted signals.
According to FCC section 15.247(h), the incorporation of intelligence within a frequency hopping spread spectrum system that permits the system to recognize other users within the spectrum band so that it individually and independently chooses and adapts its hop sets to avoid hopping on occupied channels is permitted. The coordination of frequency hopping systems in any other manner for the express purpose of avoiding the simultaneous occupancy of individual hopping frequencies by multiple transmitters is not permitted.

3.2.2.Test Result

The hopping mechanism of the EUT is based on the protocol that "***LoRaWAN***".

3.3. Number of Hopping Frequency

3.3.1.Requirement

According to FCC section 15.247(a)(1)(i), frequency hopping systems operating in the 902MHz to 928MHz bands shall use at least 50 hopping frequencies if the 20dB bandwidth of the hopping channel is less than 250KHz; or at least 25 hopping frequencies if the 20dB bandwidth of the hopping channel is 250KHz or greater.

3.3.2.Test Procedures

The EUT must have its hopping function enabled. Use the following spectrum analyzer settings:
Span = the frequency band of operation
RBW: To identify clearly the individual channels, set the RBW to less than 30% of the channel spacing or the 20 dB bandwidth, whichever is smaller.
VBW ≥ RBW
Sweep = auto
Detector function = peak
Trace = max hold
Allow the trace to stabilize

3.3.3.Test Setup Layout

Refer to chapter 2.6.1 in this report.

3.3.4.Test Result

Refer to Annex A.1 in this report.

3.4. Duty Cycle of Test Signal

3.4.1.Requirement

Preferably, all measurements of maximum conducted (average) output power will be performed with the EUT transmitting continuously (i.e., with a duty cycle of greater than or equal to 98%).When continuous operation cannot be realized, then the use of sweep triggering/signal gating techniques can be used to ensure that measurements are made only during transmissions at the maximum power control level. Such sweep triggering/signal gating techniques will require knowledge of the minimum transmission duration(T) over which the transmitter is on and is transmitting at its maximum power control level for the tested mode of operation. Sweep triggering/signal gating techniques can then be used if the measurement/sweep time of the analyzer can be set such that it does not exceed T at any time that data are being acquired (i.e.,no transmitter OFF-time is to be considered).
When continuous transmission cannot be achieved and sweep triggering/signal gating cannot be implemented, alternative procedures are provided that can be used to measure the average power; however, they will require an additional measurement of the transmitter duty cycle (D). Within this sub clause, the duty cycle refers to the fraction of time over which the transmitter is ON and is transmitting at its maximum power control level. The duty cycle is considered to be constant if variations are less than ±2%; otherwise, the duty cycle is considered to be non constant.

3.4.2.Test Result

Refer to Annex A.2 in this report.

3.5. Maximum Peak Conducted Output Power

3.5.1.Requirement

According to FCC section 15.247(b)(2), for frequency hopping systems that operates in the 902MHz to 928MHz band employing at least 50 hopping channels, the maximum peak output power of the intentional radiator shall not exceed 1Watt, and 0.25 watts for systems employing less than 50 hopping channels, but at least 25 hopping channels.

3.5.2.Test Procedures

KDB 558074 Section 8.3.1 was used in order to prove compliance.

3.5.3.Test Setup Layout

Refer to chapter 2.6.1 in this report.

3.5.4.Test Result

Refer to Annex A.3 in this report.

3.6. Maximum Average Conducted Output Power

3.6.1.Requirement

According to FCC section 15.247(b)(2), for frequency hopping systems that operates in the 902MHz to 928MHz band employing at least 50 hopping channels, the maximum peak output power of the intentional radiator shall not exceed 1Watt, and 0.25 watts for systems employing less than 50 hopping channels, but at least 25 hopping channels.

3.6.2.Test Procedures

KDB 558074 Section 8.3.2 was used in order to prove compliance.

3.6.3.Test Setup Layout

Refer to chapter 2.6.1 in this report.

3.6.4.Test Result

Refer to Annex A.4 in this report.

3.7. 20 dB Bandwidth

3.7.1.Requirement

According to FCC section 15.247(a)(1), the 20 dB bandwidth is known as the 99% emission bandwidth, or 20 dB bandwidth (10*log1% = 20 dB) taking the total RF output power.

3.7.1.Test Procedures

Use the following spectrum analyzer settings:
Span = between 2 to 5 times the OBW, centered on the test channel
RBW= 1% to 5% of the OBW
VBW ≥ 3 x RBW
Sweep = auto
Detector function = peak
Trace = max hold

3.7.2.Test Setup Layout

Refer to chapter 2.6.1 in this report.

3.7.3.Test Result

Refer to Annex A.5 in this report.

3.8. Carried Frequency Separation

3.8.1.Requirement

According to FCC section 15.247(a)(1), frequency hopping systems shall have hopping channel carrier frequencies separated by a minimum of 25kHz or two-thirds of the 20dB bandwidth of the hopping channel, whichever is greater.

3.8.2.Test Procedures

The EUT must have its hopping function enabled. According to DA 00-705, use the following spectrum analyzer settings:
Span = wide enough to capture the peaks of two adjacent channels
Resolution (or IF) Bandwidth (RBW) ≥ 1% of the span
Video (or Average) Bandwidth (VBW) ≥ RBW
Sweep = auto
Detector function = peak
Trace = max hold
Allow the trace to stabilize. Use the marker-delta function to determine the separation between the peaks of the adjacent channels.

3.8.3.Test Setup Layout

Refer to chapter 2.6.1 in this report.

3.8.4.Test Result

Refer to Annex A.6 in this report.

3.9. Time of Occupancy (Dwell time)

3.9.1.Requirement

According to FCC §15.247(a) (1) (i), 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. The maximum allowed 20 dB bandwidth of the hopping channel is 500 kHz.

3.9.2.Test Procedures

The transmitter output is connected to a spectrum analyzer. The span is set to 0 Hz, centered on a single, selected hopping channel. The width of a single pulse is measured in a fast scan. The number of pulses is measured in 10 second scan, to enable resolution of each occurrence.
The average time of occupancy in the specified 20 second period is equal to (# of pulses in 20s) * pulse width.

3.9.3.Test Setup Layout

Refer to chapter 2.6.1 in this report.

3.9.4.Test Result

Refer to Annex A.7 in this report.

3.10. Conducted Spurious Emissions and Band Edge

3.10.1.Requirement

According to FCC section 15.247(d), in any 100kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20dB below that in the 100kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement.

3.10.2.Test Procedures

Use the following spectrum analyzer settings:
Span = wide enough to capture the peak level of the in-band emission and all spurious emissions (e.g., harmonics) from the lowest frequency generated in the EUT up through the 10th harmonic. Typically, several plots are required to cover this entire span.
RBW = 100 kHz
VBW ≥ RBW
Sweep = auto
Detector function = peak
Trace = max hold
Allow the trace to stabilize.

3.10.3.Test Setup Layout

Refer to chapter 2.6.1 in this report.

3.10.4.Test Result

Refer to Annex A.8 and A.9 in this report.

3.11. Conducted Emission

3.11.1.Requirement

According to FCC section 15.207, 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 within the band 150kHz to 30MHz shall not exceed the limits in the following table, as measured using a 50μH/50Ω line impedance stabilization network (LISN).

Frequency Range (MHz)	Conducted Limit (dBμV)	
	Quai-peak	Average
0.15 - 0.50	66 to 56	56 to 46
0.50 - 5	56	46
5 - 30	60	50

Note:

(a) The lower limit shall apply at the band edges.

(b) The limit decreases linearly with the logarithm of the frequency in the range 0.15 - 0.50MHz.

3.11.2.Test Procedures

The Table-top EUT was placed upon a non-metallic table 0.8m above the horizontal metal reference ground plane. EUT was connected to LISN and LISN was connected to reference Ground Plane. EUT was 80cm from LISN. The set-up and test methods were according to ANSI C63.10: 2013.

3.11.3.Test Setup Layout

Refer to chapter 2.6.2 in this report.

3.11.4.Test Result

Refer to Annex A.10 in this report.

3.12. Radiated Emission

3.12.1.Requirement

According to FCC section 15.247(d), radiated emission outside the frequency band attenuation below the general limits specified in FCC section 15.209(a) is not required. In addition, radiated emissions which fall in the restricted bands, as defined in FCC section 15.205(a), must also comply with the radiated emission limits specified in FCC section 15.209(a).

According to FCC section 15.209 (a), except as provided elsewhere in this subpart, the emissions from an intentional radiator shall not exceed the field strength levels specified in the following table:

Frequency (MHz)	Field Strength (μV/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

Note1: For above 1000MHz, the emission limit in this paragraph is based on measurement instrumentation employing an average detector, measurement using instrumentation with a peak detector function, corresponding to 20dB above the maximum permitted average limit.
Note2: For above 1000MHz, limit field strength of harmonics: 54dBuV/m@3m (AV) and 74dBuV/m@3m (PK).In addition, radiated emissions which fall in the restricted bands, as defined in Section 15.205(a), also should comply with the radiated emission limits specified in Section 15.209(a)(above table).

3.12.2.Test Procedures

The EUT is placed on a non-conducting table 80 cm above the ground plane for measurement below 1GHz; 1.5 m above the ground plane for measurement above 1GHz.The antenna to EUT distance is 3meters. The EUT is configured in accordance with ANSI C63.10. The EUT is set to transmit in a continuous mode.

For measurements below 30MHz, the emission limits shown in the above table are based on measurements employing a CISPR quasi-peak detector except for the frequency bands 9kHz-90 kHz, 110kHz-490 kHz. Radiated emission limits in these two bands are based on measurements employing an average detector.

For measurements below 1GHz the resolution bandwidth is set to 100kHz for peak detection measurements or 120kHz for quasi-peak detection measurements. Peak detection is used unless otherwise noted as quasi-peak.

For measurements above 1GHz the resolution bandwidth is set to 1MHz, the video band width is set to 3MHz for peak measurements and as applicable for average measurements.

The EUT is rotated through 360 degrees to maximize emissions received. The antenna is scanned from 1 to 4 meters above the ground plane to further maximize the emission. Measurements are made with the antenna polarized in both the vertical and the horizontal positions. For measurements above 1 GHz, keeping the measurement antenna aimed at the source of emissions at each frequency of significant emissions, with polarization oriented for maximum response.

3.12.3.Test Setup Layout

Refer to chapter 2.6.3 in this report.

3.12.4.Test Result

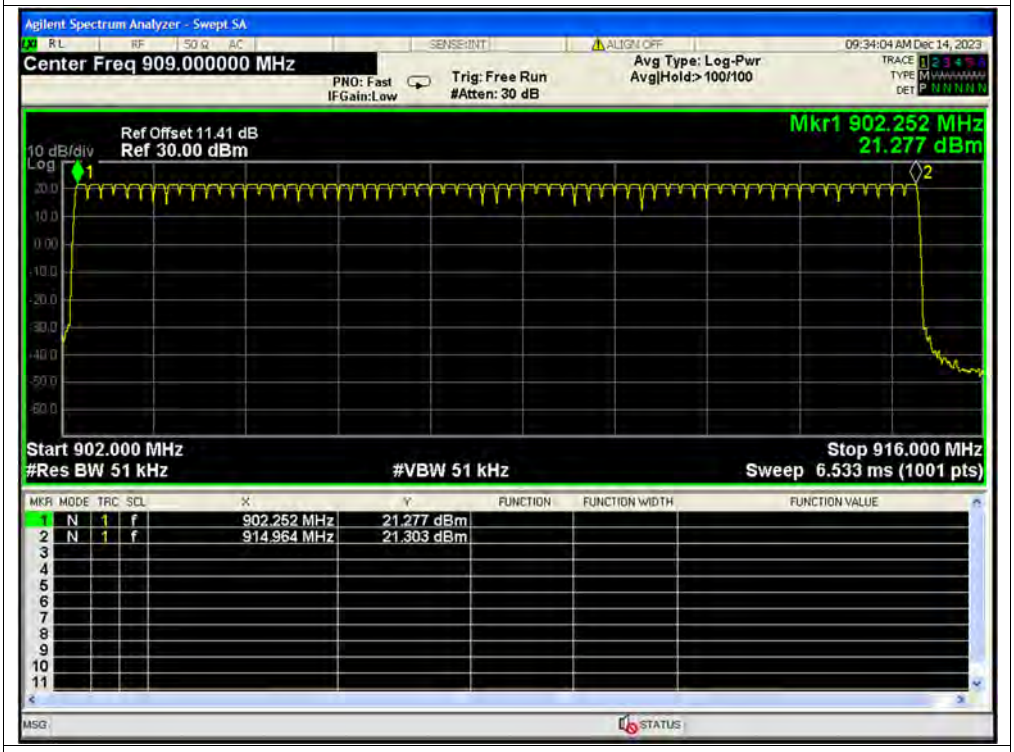
Refer to Annex A.11 in this report.

Annex A Test Data and Result

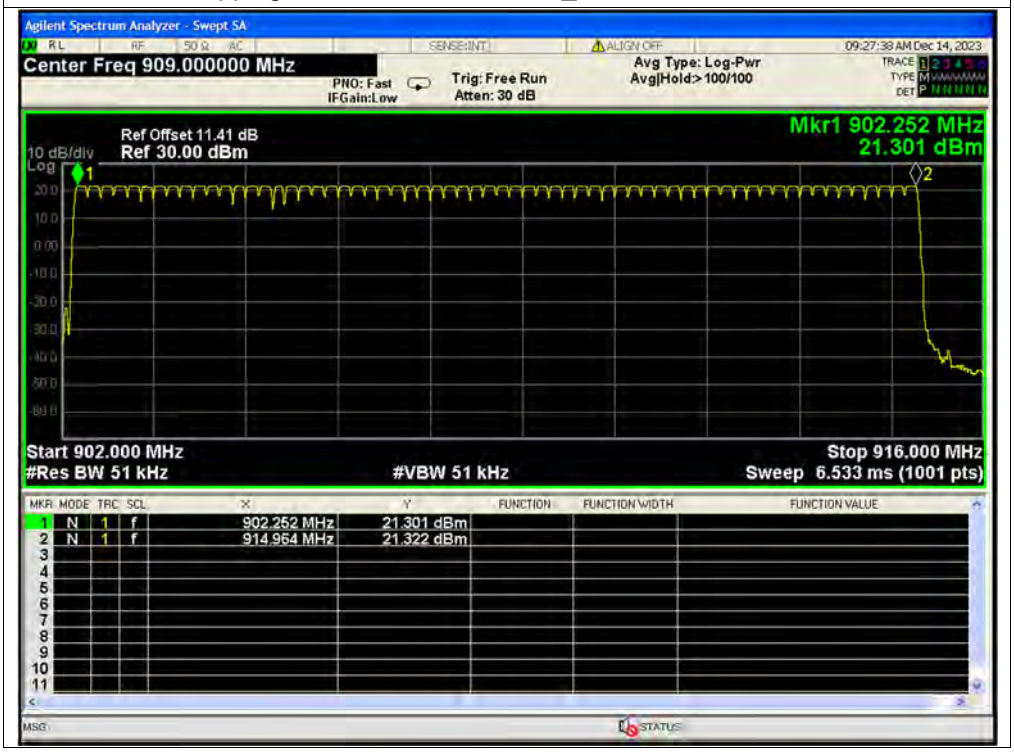
A.1. Number of Hopping Frequency

Condition	Mode/Data Rate	Antenna	Hopping Number	Limit	Verdict
NVNT	LoRa FHSS_SF7	Ant1	64	50	Pass
NVNT	LoRa FHSS_SF10	Ant1	64	50	Pass

Test Graphs
Hopping No. NVNT LoRa FHSS_SF7 902.3MHz Ant1



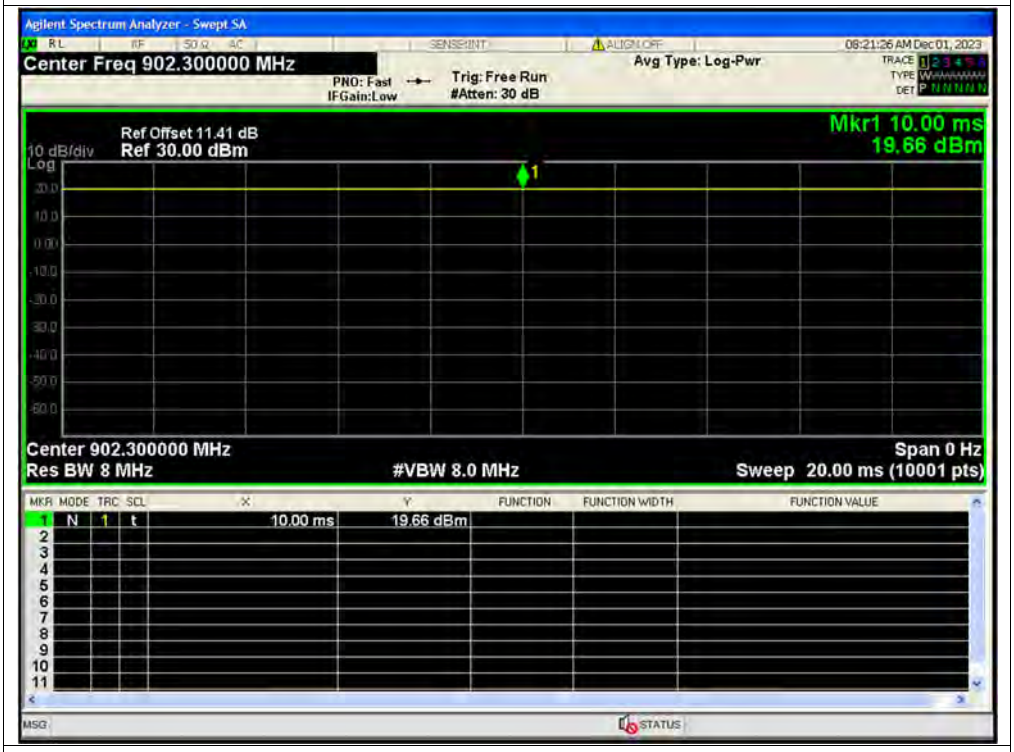
Hopping No. NVNT LoRa FHSS_SF10 902.3MHz Ant1



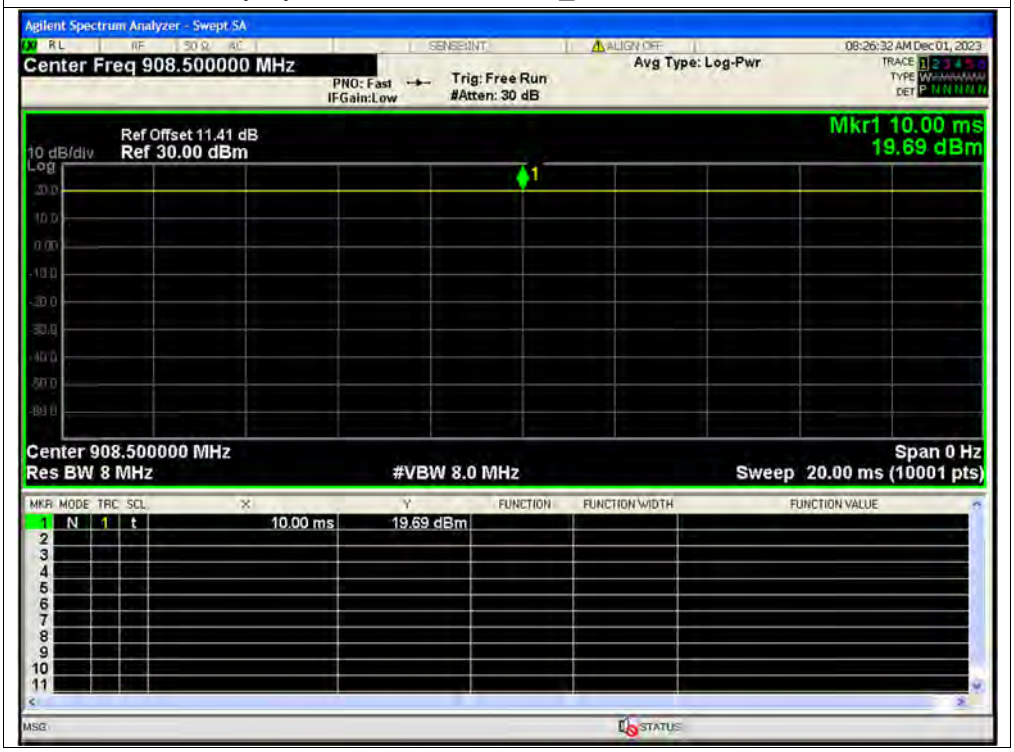
A.2. Duty Cycle of Test Signal

Condition	Mode/Data Rate	Frequency (MHz)	Antenna	Duty Cycle (%)	Correction Factor (dB)	1/T (kHz)
NVNT	LoRa FHSS_SF7	902.3	Ant1	100	0	0
NVNT	LoRa FHSS_SF7	908.5	Ant1	100	0	0
NVNT	LoRa FHSS_SF7	914.9	Ant1	100	0	0
NVNT	LoRa FHSS_SF10	902.3	Ant1	100	0	0
NVNT	LoRa FHSS_SF10	908.5	Ant1	100	0	0
NVNT	LoRa FHSS_SF10	914.9	Ant1	100	0	0

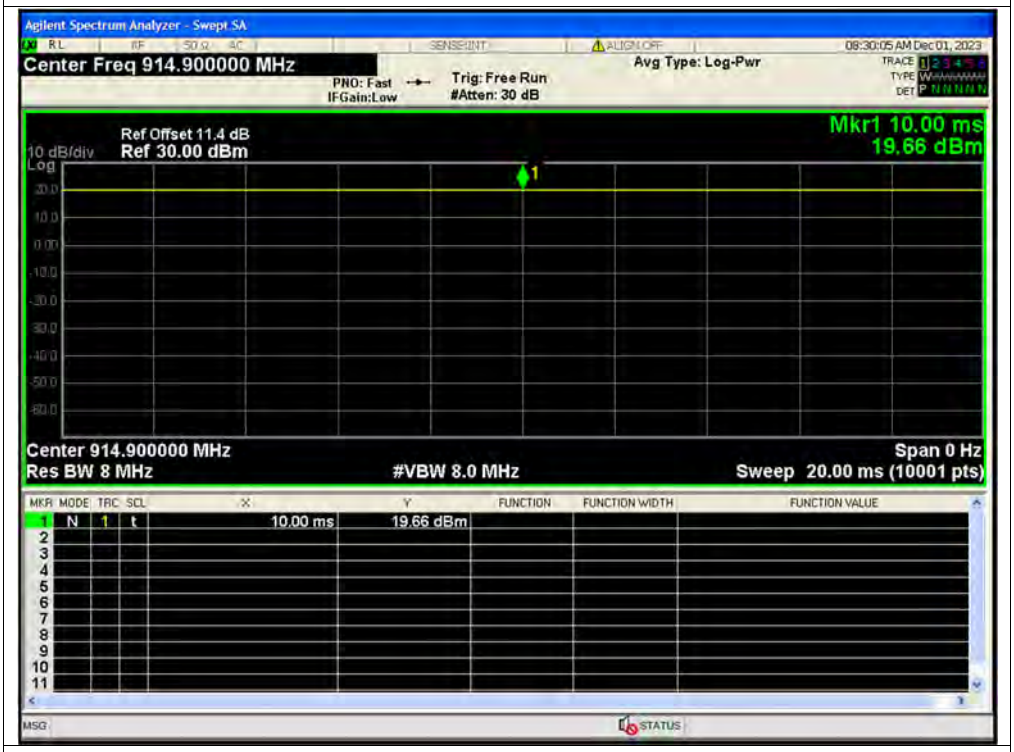
Test Graphs
Duty Cycle NVNT LoRa FHSS_SF7 902.3MHz Ant1



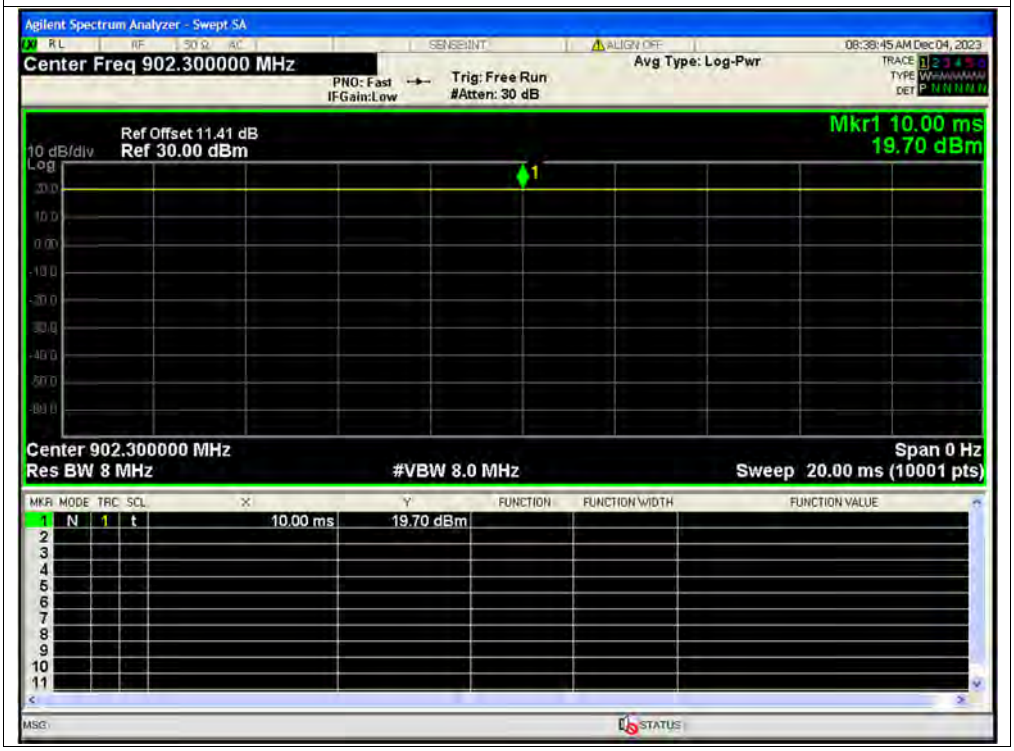
Duty Cycle NVNT LoRa FHSS_SF7 908.5MHz Ant1



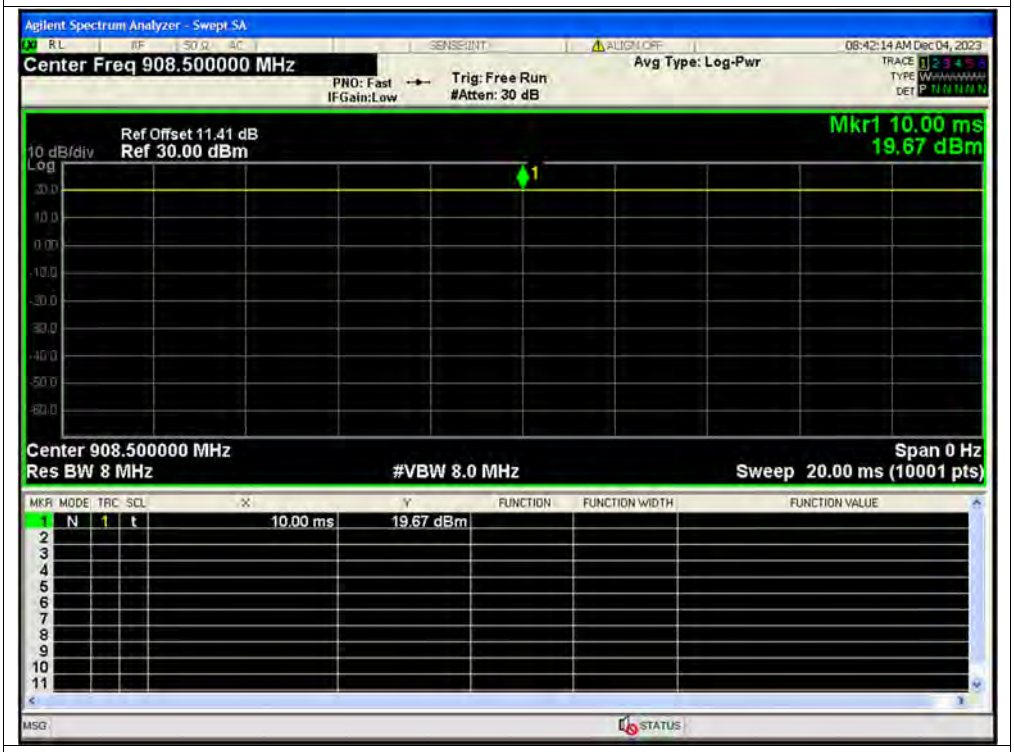
Duty Cycle NVNT LoRa FHSS_SF7 914.9MHz Ant1



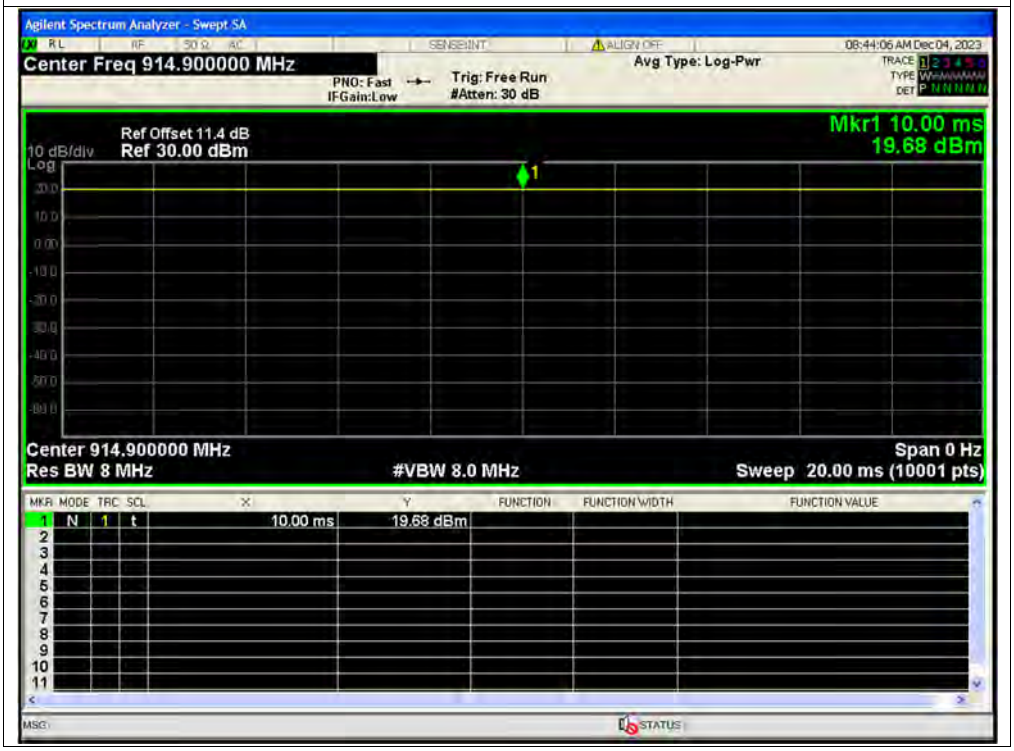
Duty Cycle NVNT LoRa FHSS_SF10 902.3MHz Ant1



Duty Cycle NVNT LoRa FHSS_SF10 908.5MHz Ant1



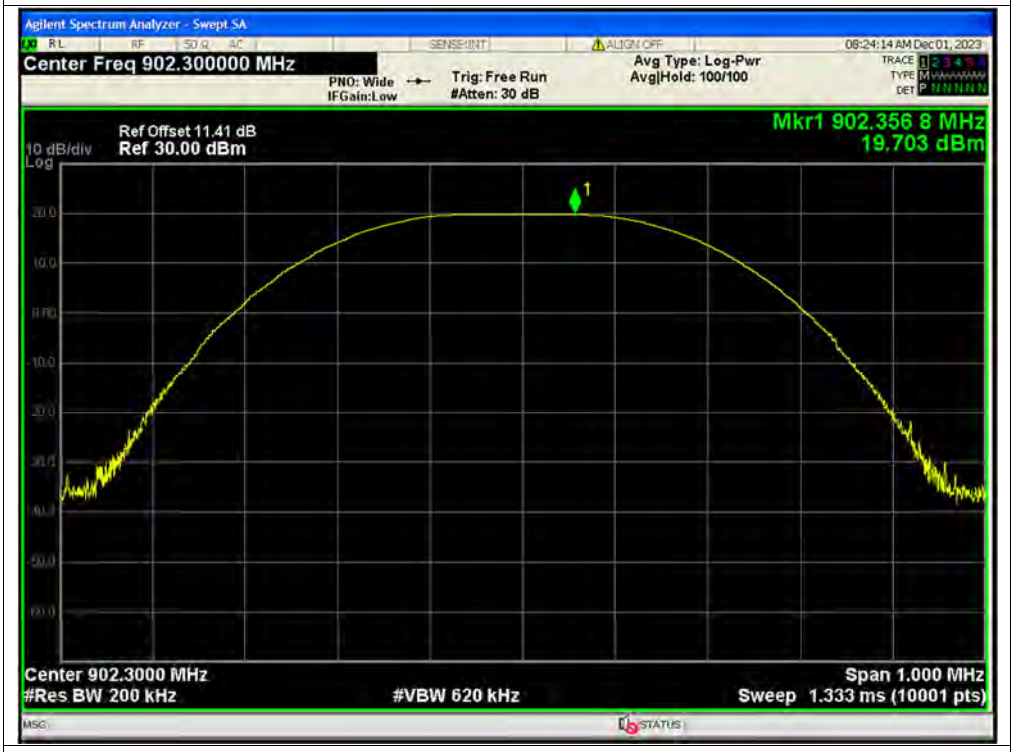
Duty Cycle NVNT LoRa FHSS_SF10 914.9MHz Ant1



A.3. Maximum Peak Conducted Output Power

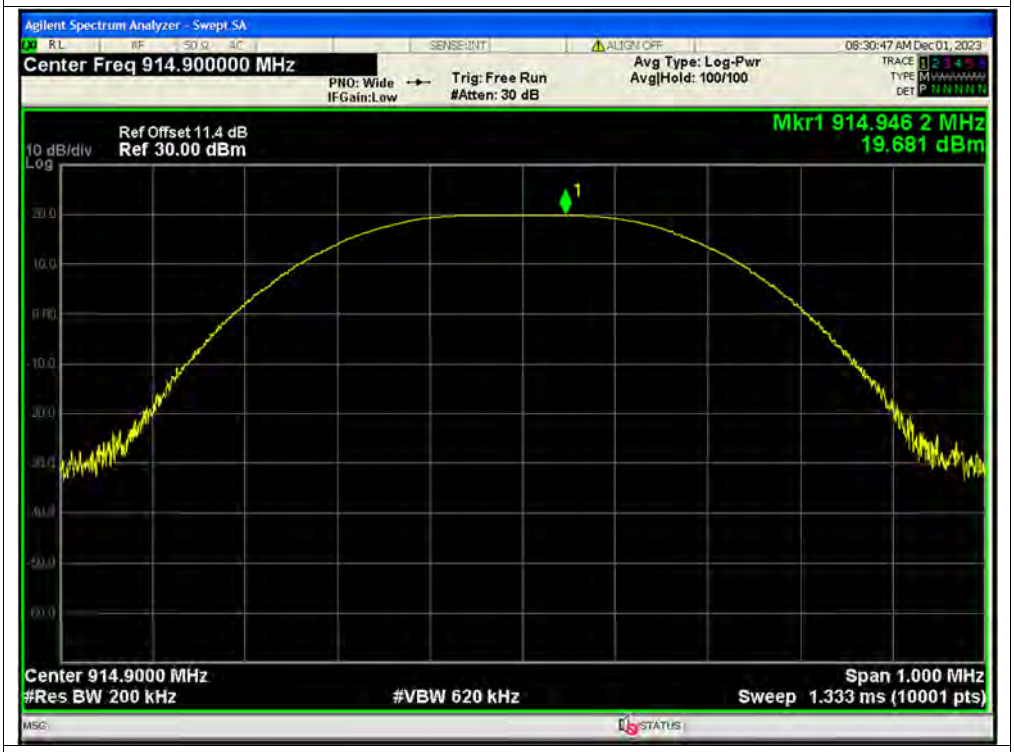
Condition	Mode/Data Rate	Frequency (MHz)	Antenna	Conducted Power (dBm)	Duty Factor (dB)	Total Conducted Power (dBm)	Total Conducted Power (W)	Limit (dBm)	Verdict
NVNT	LoRa FHSS_SF7	902.3	Ant1	19.7	0	19.7	0.09333	30	Pass
NVNT	LoRa FHSS_SF7	908.5	Ant1	19.69	0	19.69	0.09311	30	Pass
NVNT	LoRa FHSS_SF7	914.9	Ant1	19.68	0	19.68	0.0929	30	Pass
NVNT	LoRa FHSS_SF10	902.3	Ant1	19.69	0	19.69	0.09311	30	Pass
NVNT	LoRa FHSS_SF10	908.5	Ant1	19.69	0	19.69	0.09311	30	Pass
NVNT	LoRa FHSS_SF10	914.9	Ant1	19.7	0	19.7	0.09333	30	Pass

Test Graphs
Peak Power NVNT LoRa FHSS_SF7 902.3MHz Ant1

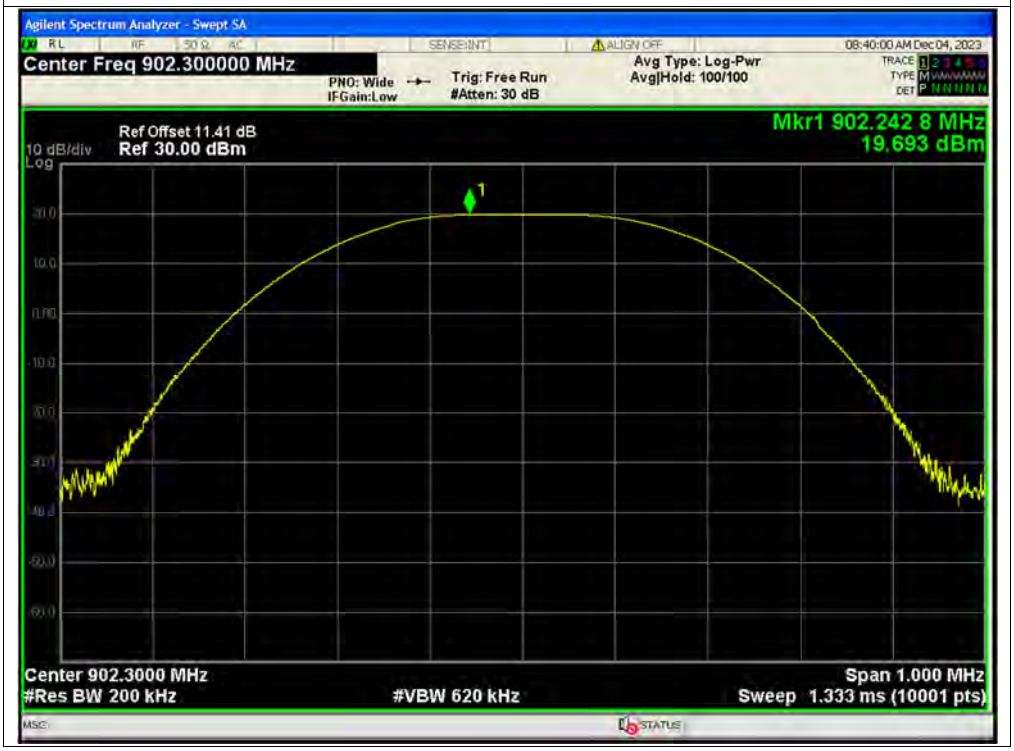


Peak Power NVNT LoRa FHSS_SF7 908.5MHz Ant1

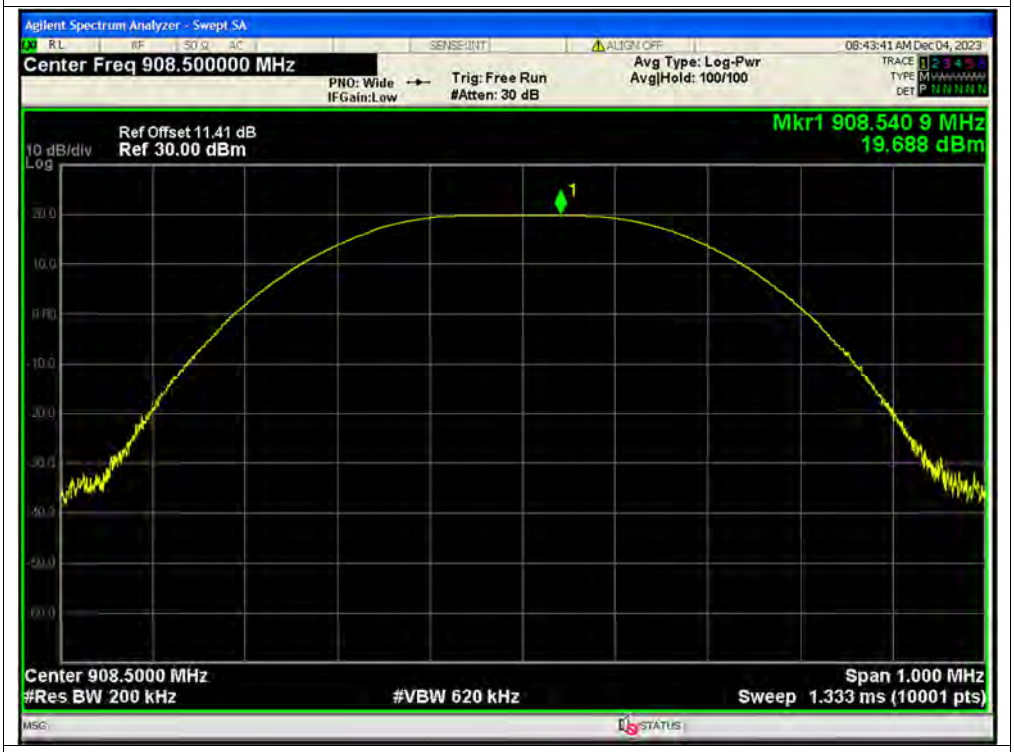
Peak Power NVNT LoRa FHSS_SF7 914.9MHz Ant1



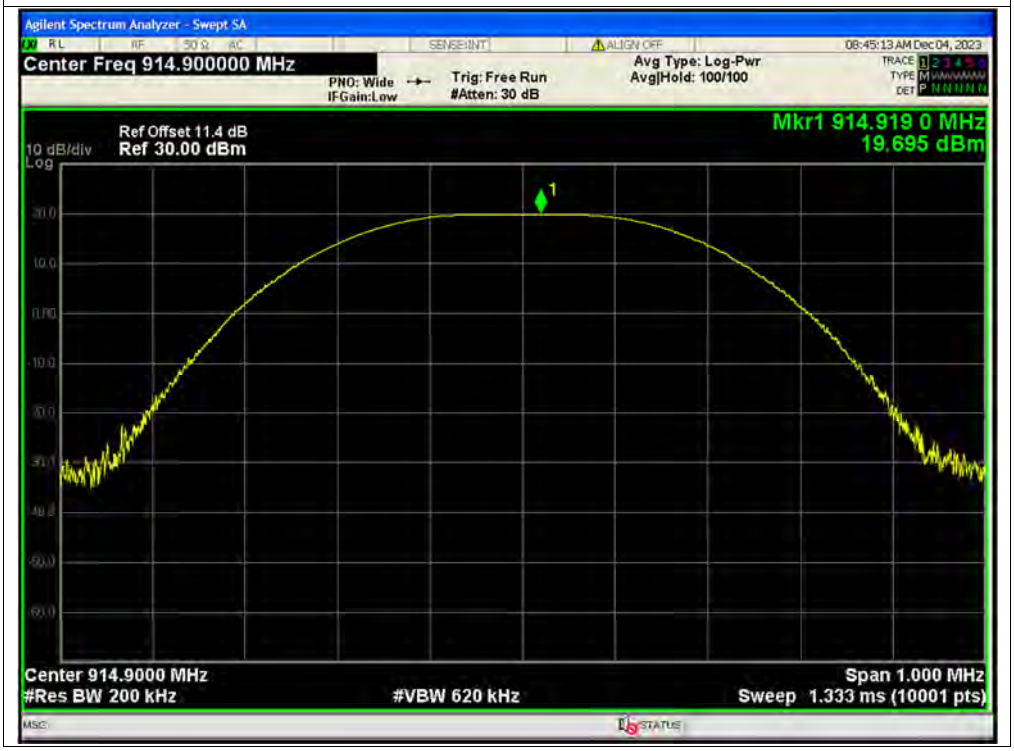
Peak Power NVNT LoRa FHSS_SF10 902.3MHz Ant1



Peak Power NVNT LoRa FHSS_SF10 908.5MHz Ant1



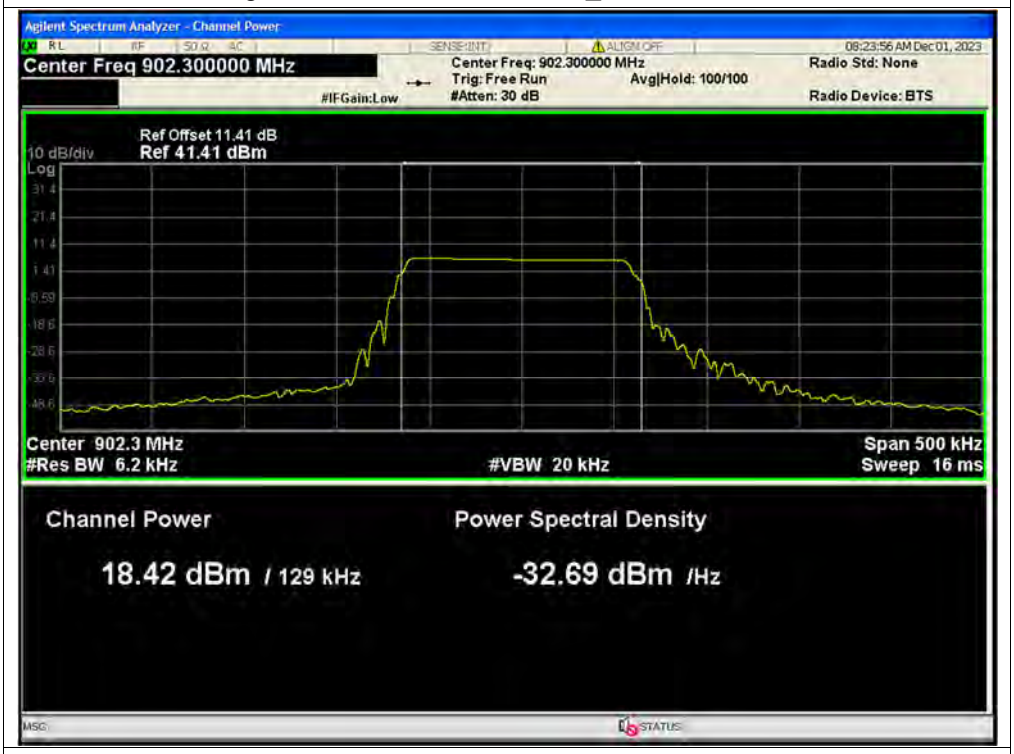
Peak Power NVNT LoRa FHSS_SF10 914.9MHz Ant1



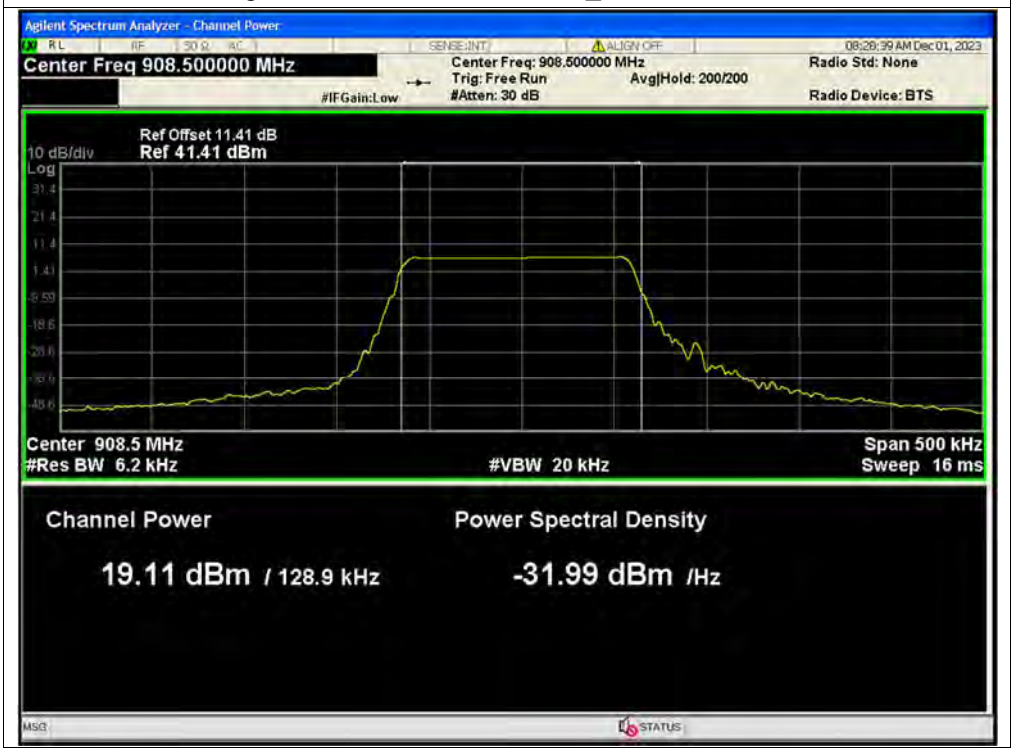
A.4. Maximum Average Conducted Output Power

Condition	Mode/Data Rate	Frequency (MHz)	Antenna	Conducted Power (dBm)	Duty Factor (dB)	Total Conducted Power (dBm)	Total Conducted Power (W)	Limit (dBm)	Verdict
NVNT	LoRa FHSS_SF7	902.3	Ant1	18.42	0	18.42	0.0695	30	Pass
NVNT	LoRa FHSS_SF7	908.5	Ant1	19.11	0	19.11	0.08147	30	Pass
NVNT	LoRa FHSS_SF7	914.9	Ant1	19.43	0	19.43	0.0877	30	Pass
NVNT	LoRa FHSS_SF10	902.3	Ant1	19.58	0	19.58	0.09078	30	Pass
NVNT	LoRa FHSS_SF10	908.5	Ant1	19.6	0	19.6	0.0912	30	Pass
NVNT	LoRa FHSS_SF10	914.9	Ant1	19.68	0	19.68	0.0929	30	Pass

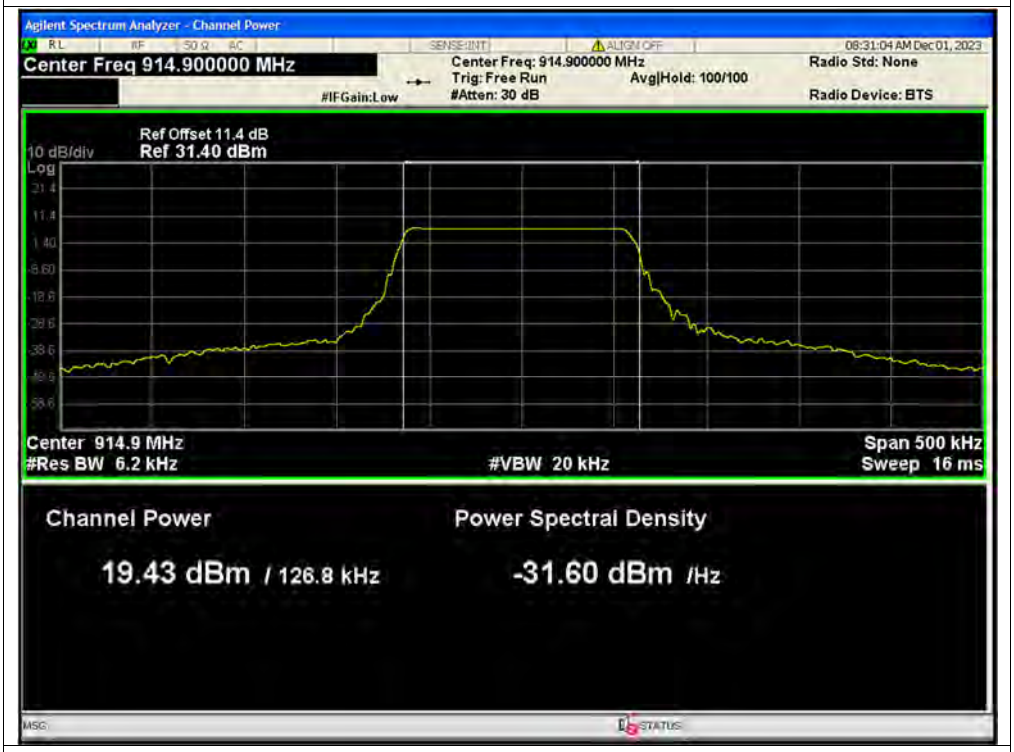
Test Graphs
Average Power NVNT LoRa FHSS_SF7 902.3MHz Ant1



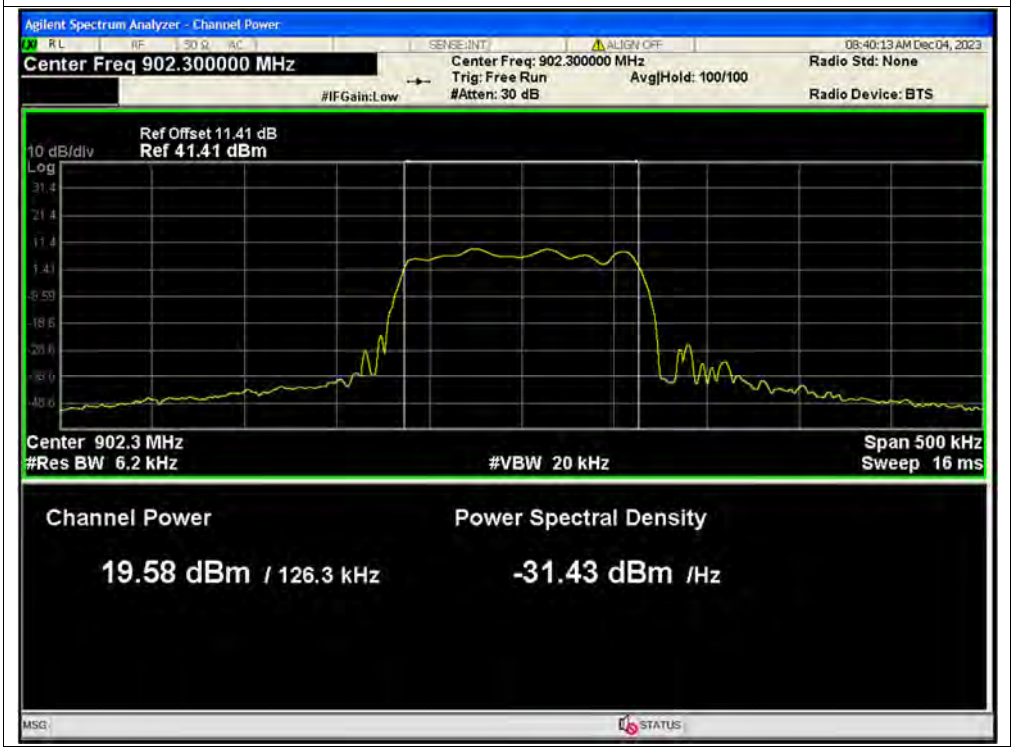
Average Power NVNT LoRa FHSS_SF7 908.5MHz Ant1



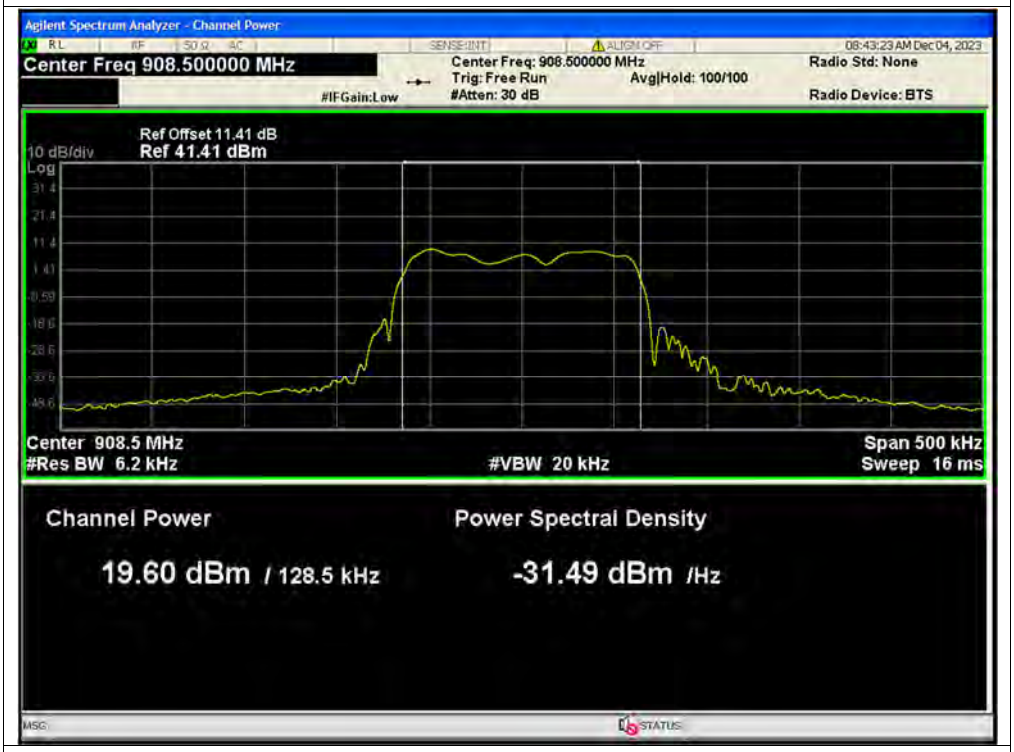
Average Power NVNT LoRa FHSS_SF7 914.9MHz Ant1



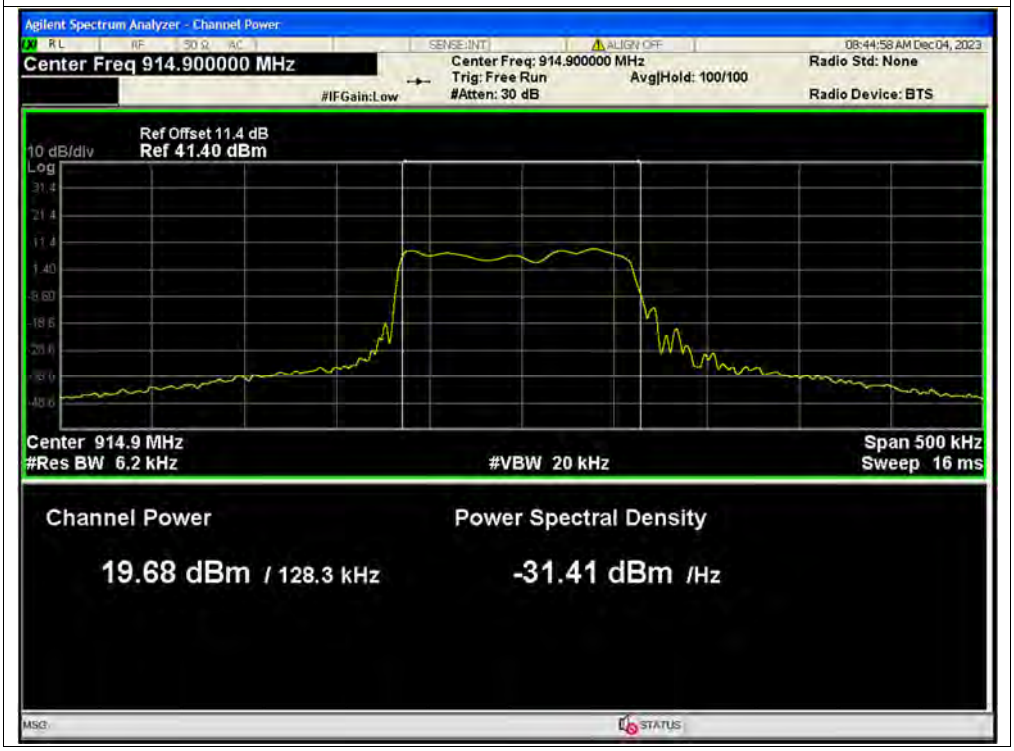
Average Power NVNT LoRa FHSS_SF10 902.3MHz Ant1



Average Power NVNT LoRa FHSS_SF10 908.5MHz Ant1



Average Power NVNT LoRa FHSS_SF10 914.9MHz Ant1



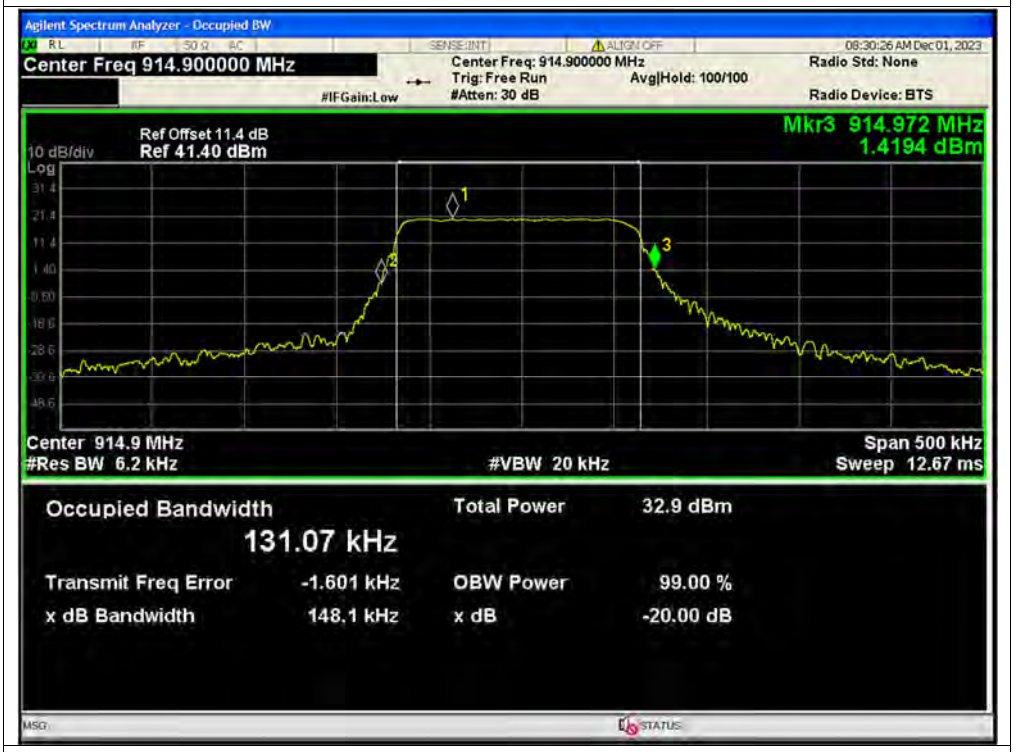
A.5. 20 dB Bandwidth

Condition	Mode/Data Rate	Frequency (MHz)	Antenna	-20 dB Bandwidth (MHz)	Verdict
NVNT	LoRa FHSS_SF7	902.3	Ant1	0.15	Pass
NVNT	LoRa FHSS_SF7	908.5	Ant1	0.148	Pass
NVNT	LoRa FHSS_SF7	914.9	Ant1	0.148	Pass
NVNT	LoRa FHSS_SF10	902.3	Ant1	0.149	Pass
NVNT	LoRa FHSS_SF10	908.5	Ant1	0.147	Pass
NVNT	LoRa FHSS_SF10	914.9	Ant1	0.146	Pass

Test Graphs
-20dB Bandwidth NVNT LoRa FHSS_SF7 902.3MHz Ant1

-20dB Bandwidth NVNT LoRa FHSS_SF7 908.5MHz Ant1

-20dB Bandwidth NVNT LoRa FHSS_SF7 914.9MHz Ant1



-20dB Bandwidth NVNT LoRa FHSS_SF10 902.3MHz Ant1

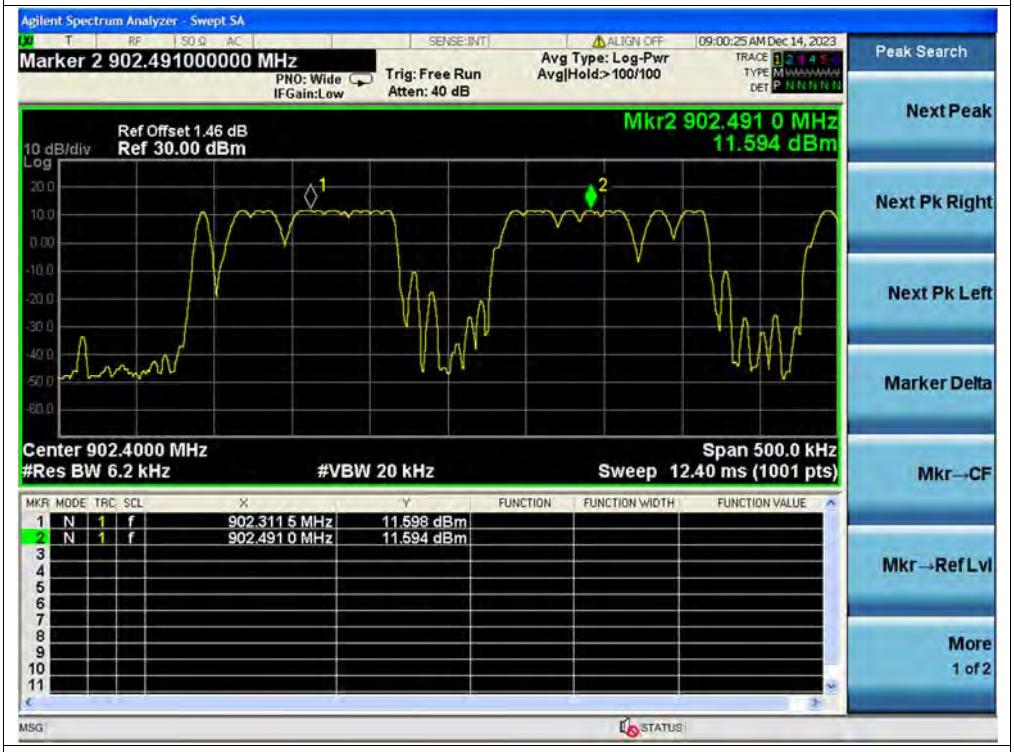
-20dB Bandwidth NVNT LoRa FHSS_SF10 908.5MHz Ant1

-20dB Bandwidth NVNT LoRa FHSS_SF10 914.9MHz Ant1

A.6. Carried Frequency Separation

Condition	Mode/Data Rate	Antenna	Hopping Freq1 (MHz)	Hopping Freq2 (MHz)	HFS (MHz)	Limit (MHz)	Verdict
NVNT	LoRa FHSS_SF7	Ant1	902.3115	902.491	0.1795	0.1	Pass
NVNT	LoRa FHSS_SF10	Ant1	902.3025	902.5065	0.204	0.099	Pass

Test Graphs
CFS NVNT LoRa FHSS_SF7 902.3MHz Ant1

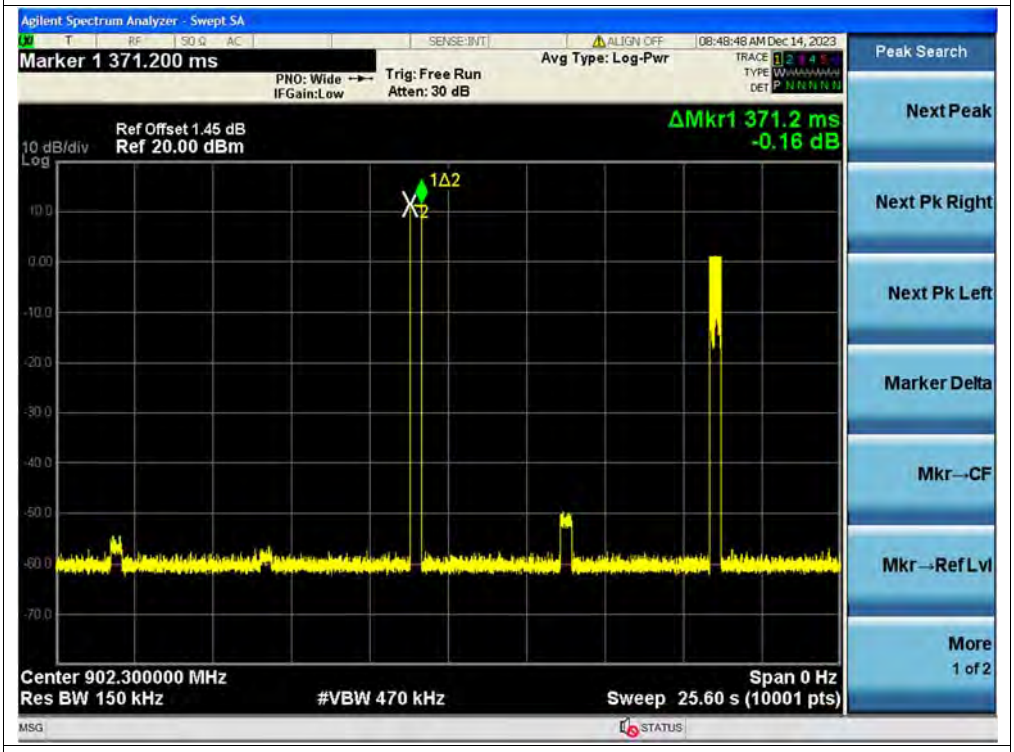


CFS NVNT LoRa FHSS_SF10 902.3MHz Ant1

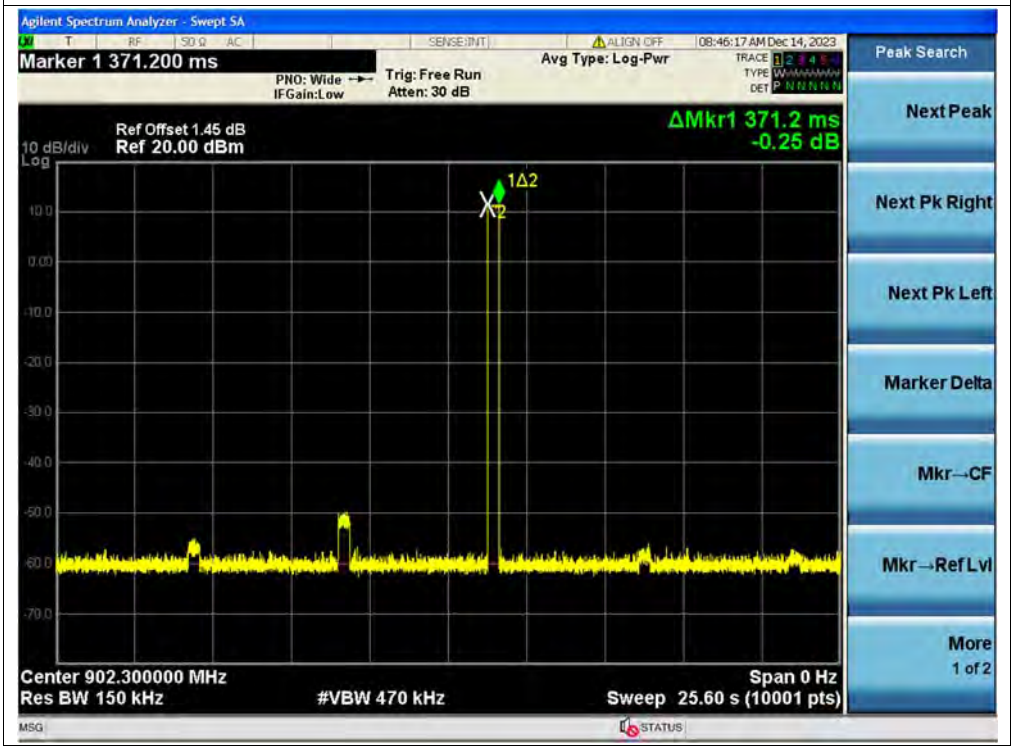
A.7. Time of Occupancy (Dwell time)

Condition	Mode/ Data Rate	Frequency (MHz)	Antenna	Pulse Time (ms)	Total Dwell Time (ms)	Burst Count	Period Time (ms)	Limit (ms)	Verdict
NVNT	LoRa FHSS_SF7	902.3	Ant1	371.2	371.2	1	20000	400	Pass
NVNT	LoRa FHSS_SF10	902.3	Ant1	371.2	371.2	1	20000	400	Pass

Test Graphs
Dwell NVNT LoRa LoRa FHSS_SF7 902.3MHz Ant1



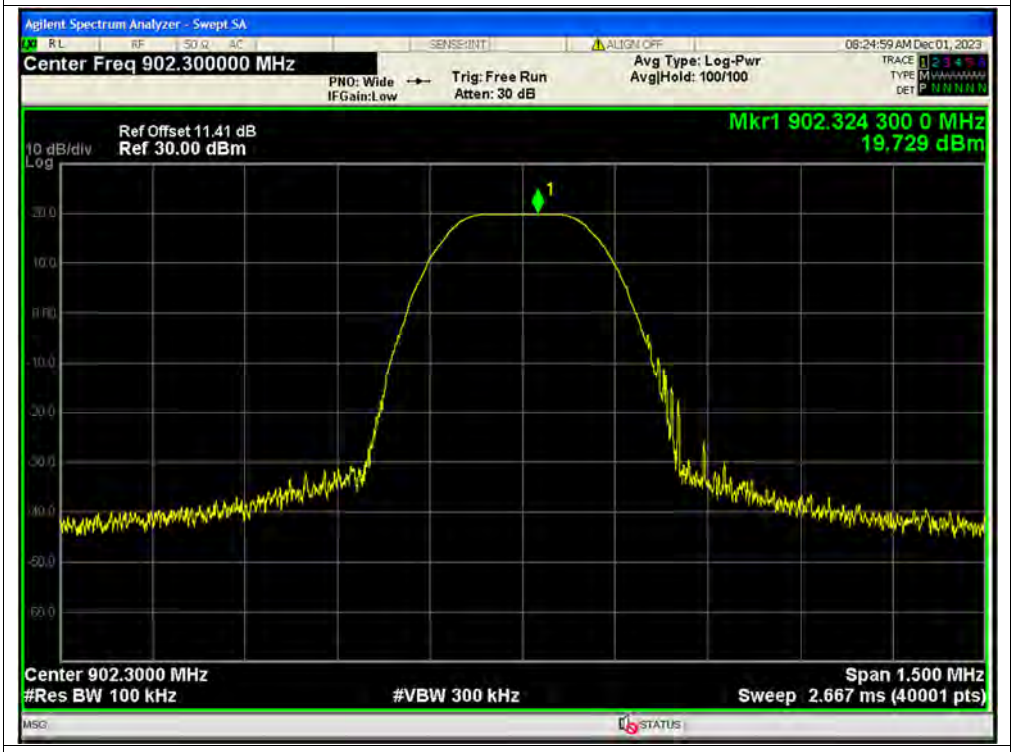
Dwell NVNT LoRa LoRa FHSS_SF10 902.3MHz Ant1



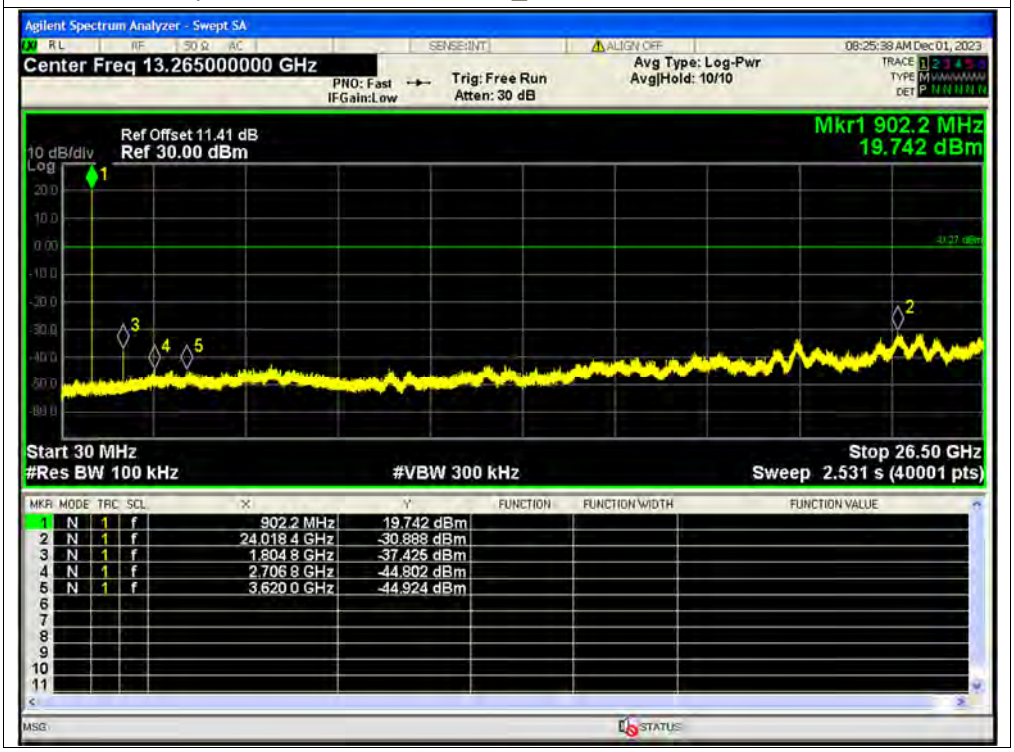
A.8. Conducted Spurious Emissions

Condition	Mode/ Data Rate	Frequency (MHz)	Antenna	Max Value (dBc)	Limit (dBc)	Verdict
NVNT	LoRa FHSS_SF7	902.3	Ant1	-50.61	-20	Pass
NVNT	LoRa FHSS_SF7	908.5	Ant1	-50.78	-20	Pass
NVNT	LoRa FHSS_SF7	914.9	Ant1	-50.38	-20	Pass
NVNT	LoRa FHSS_SF10	902.3	Ant1	-50.11	-20	Pass
NVNT	LoRa FHSS_SF10	908.5	Ant1	-49.23	-20	Pass
NVNT	LoRa FHSS_SF10	914.9	Ant1	-50.61	-20	Pass

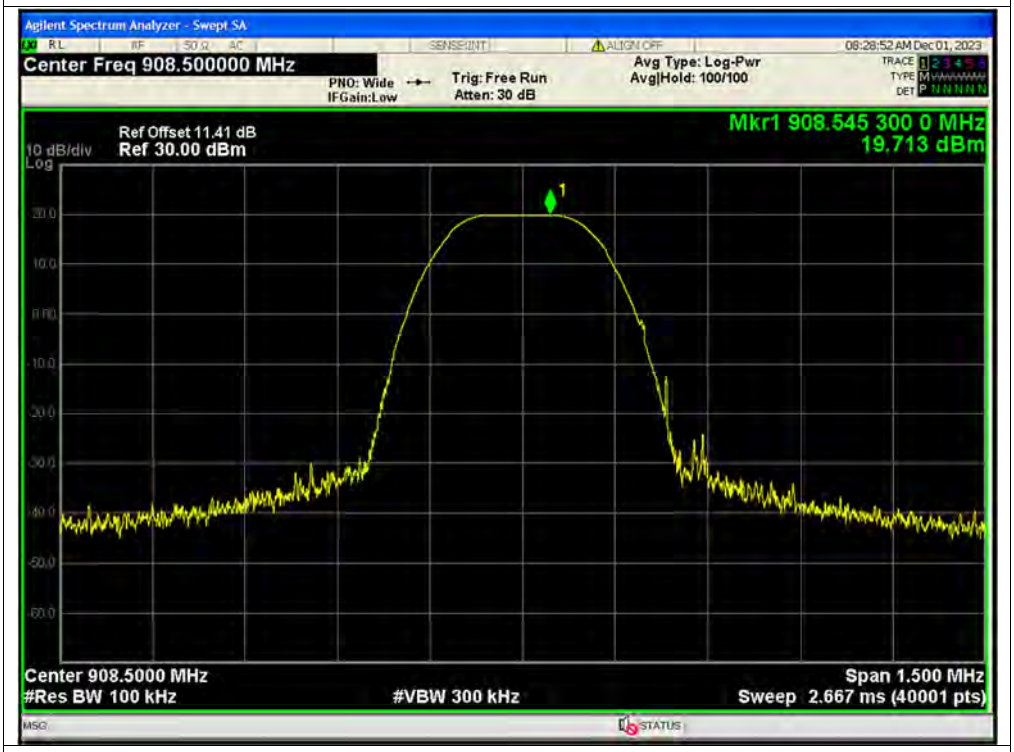
Test Graphs
Tx. Spurious NVNT LoRa FHSS_SF7 902.3MHz Ant1 Ref



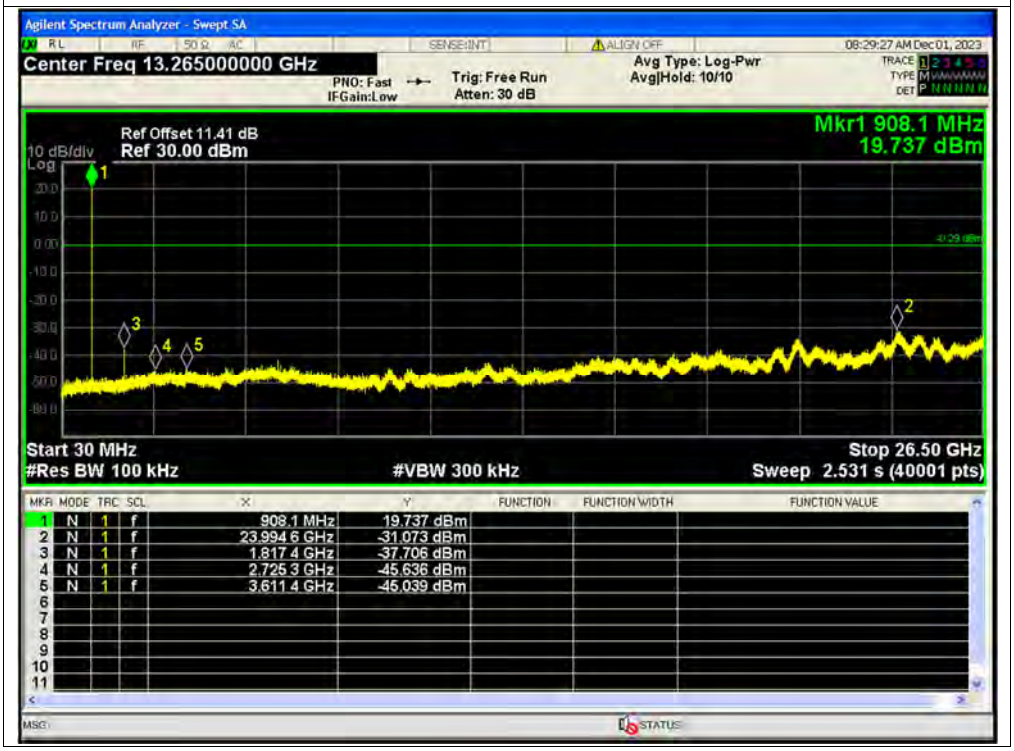
Tx. Spurious NVNT LoRa FHSS_SF7 902.3MHz Ant1 Emission



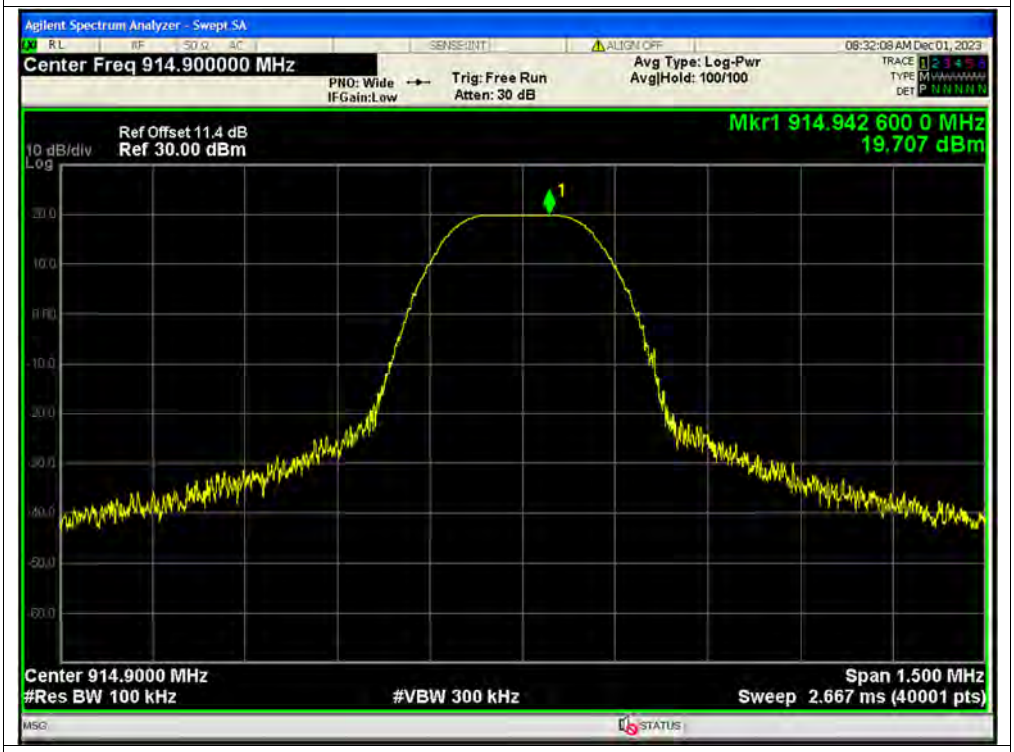
Tx. Spurious NVNT LoRa FHSS_SF7 908.5MHz Ant1 Ref



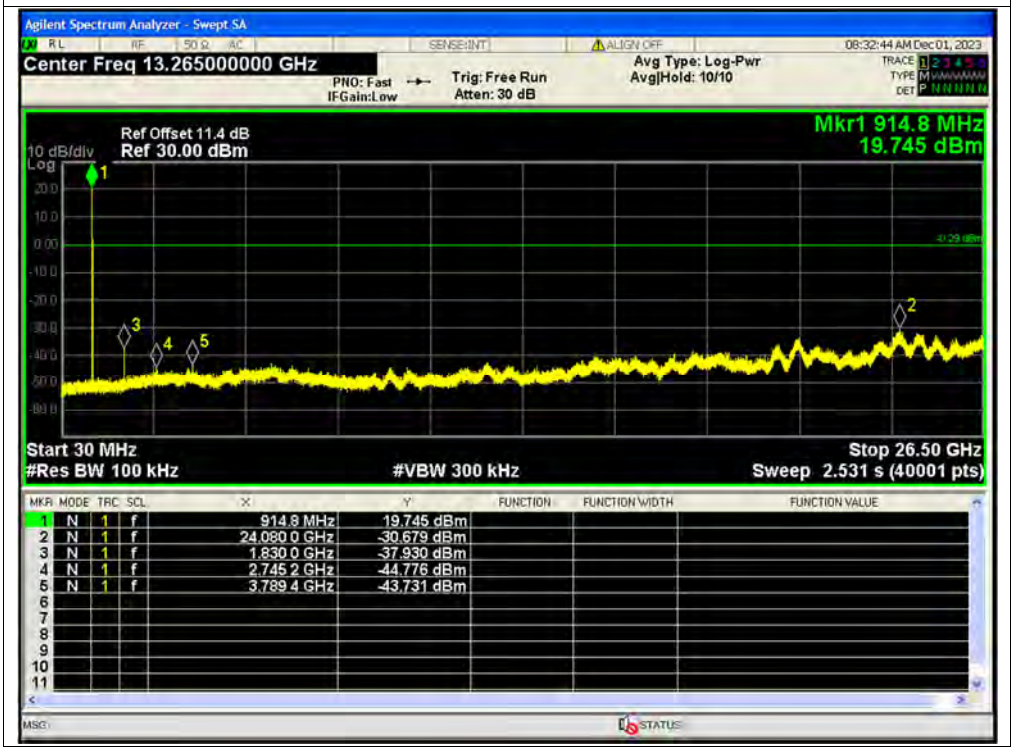
Tx. Spurious NVNT LoRa FHSS_SF7 908.5MHz Ant1 Emission



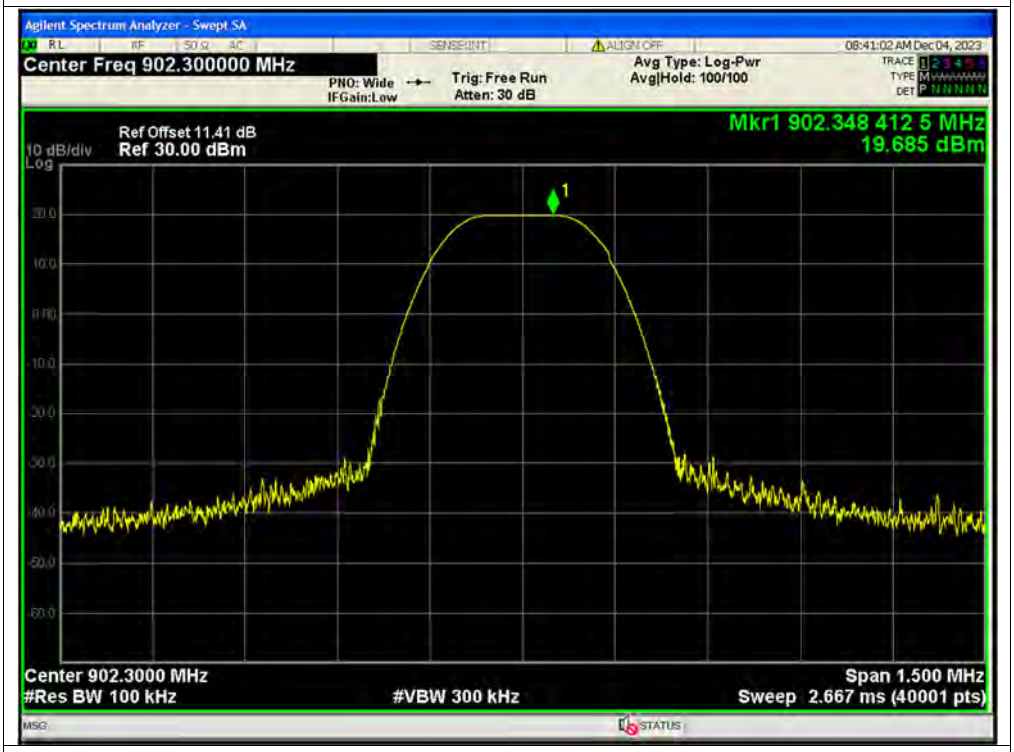
Tx. Spurious NVNT LoRa FHSS_SF7 914.9MHz Ant1 Ref



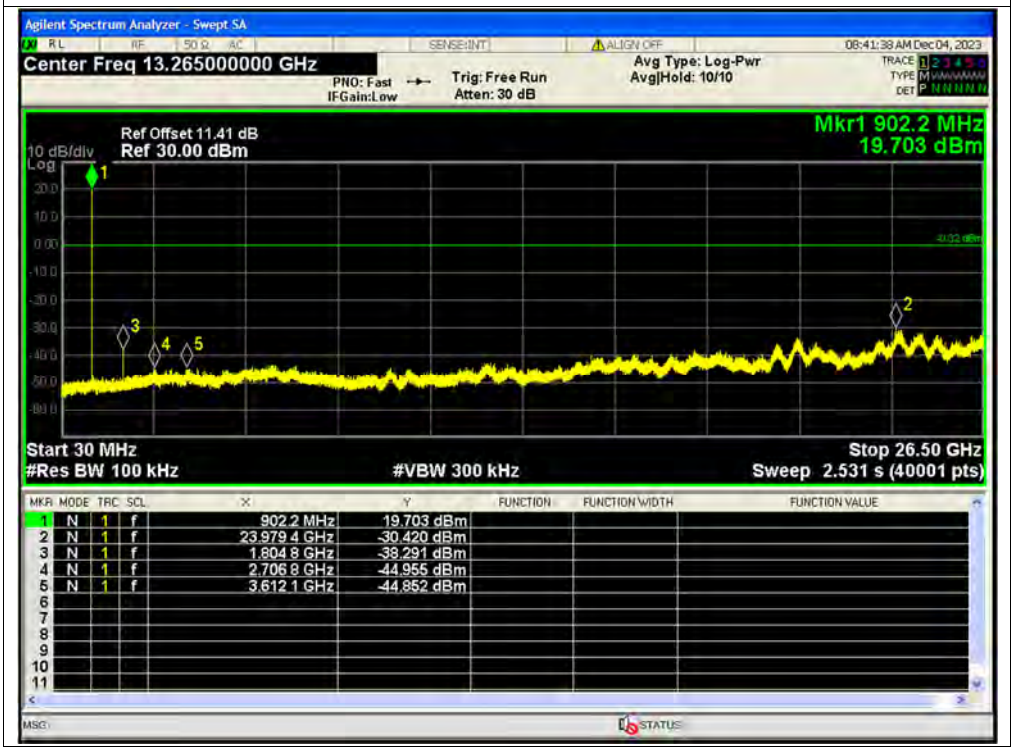
Tx. Spurious NVNT LoRa FHSS_SF7 914.9MHz Ant1 Emission



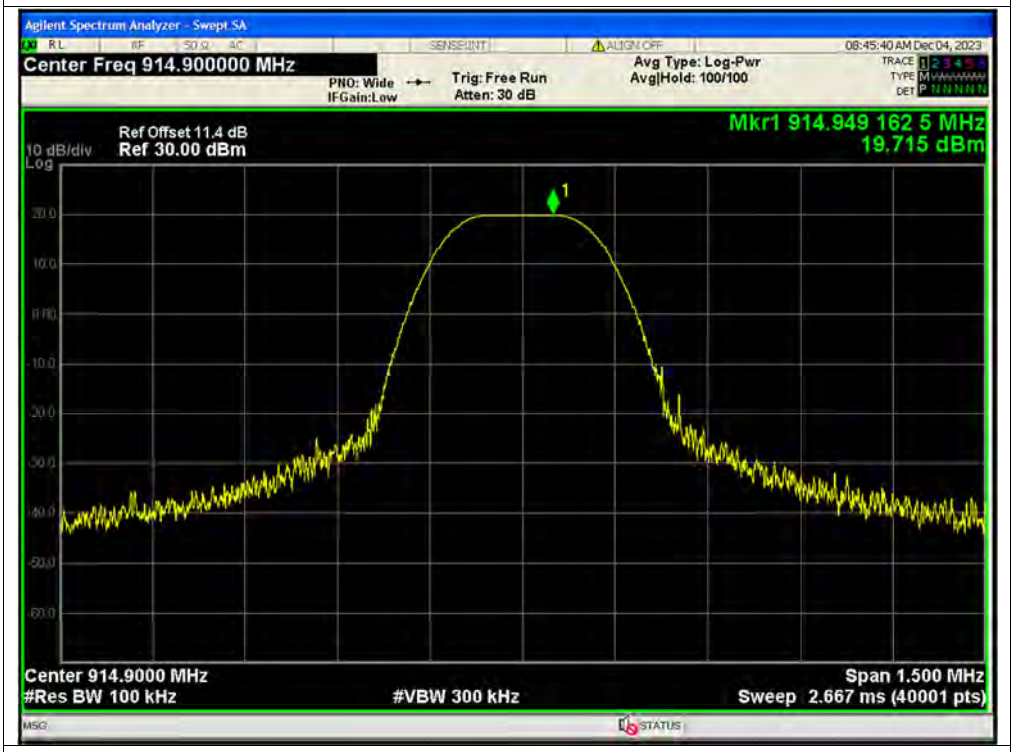
Tx. Spurious NVNT LoRa FHSS_SF10 902.3MHz Ant1 Ref



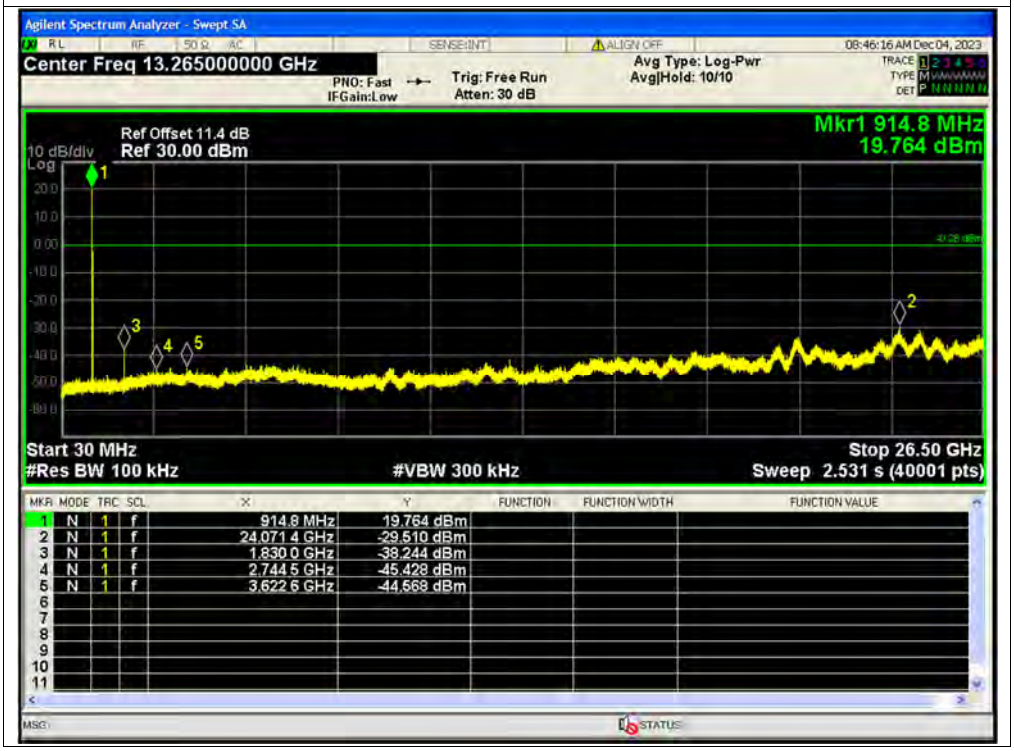
Tx. Spurious NVNT LoRa FHSS_SF10 902.3MHz Ant1 Emission



Tx. Spurious NVNT LoRa FHSS_SF10 914.9MHz Ant1 Ref



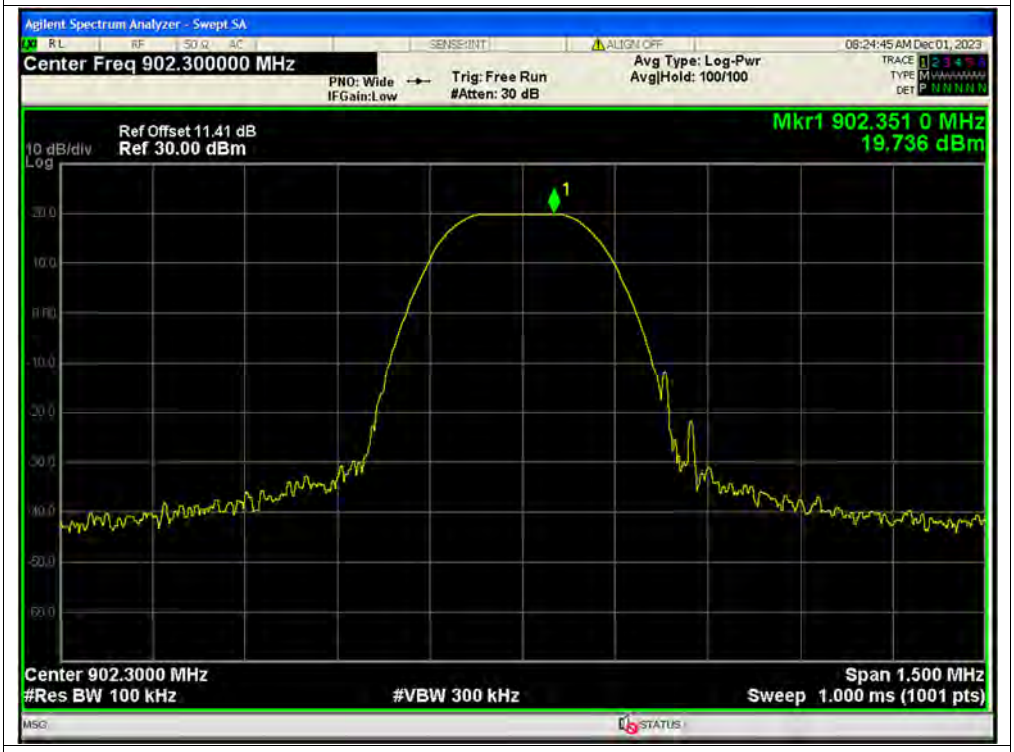
Tx. Spurious NVNT LoRa FHSS_SF10 914.9MHz Ant1 Emission



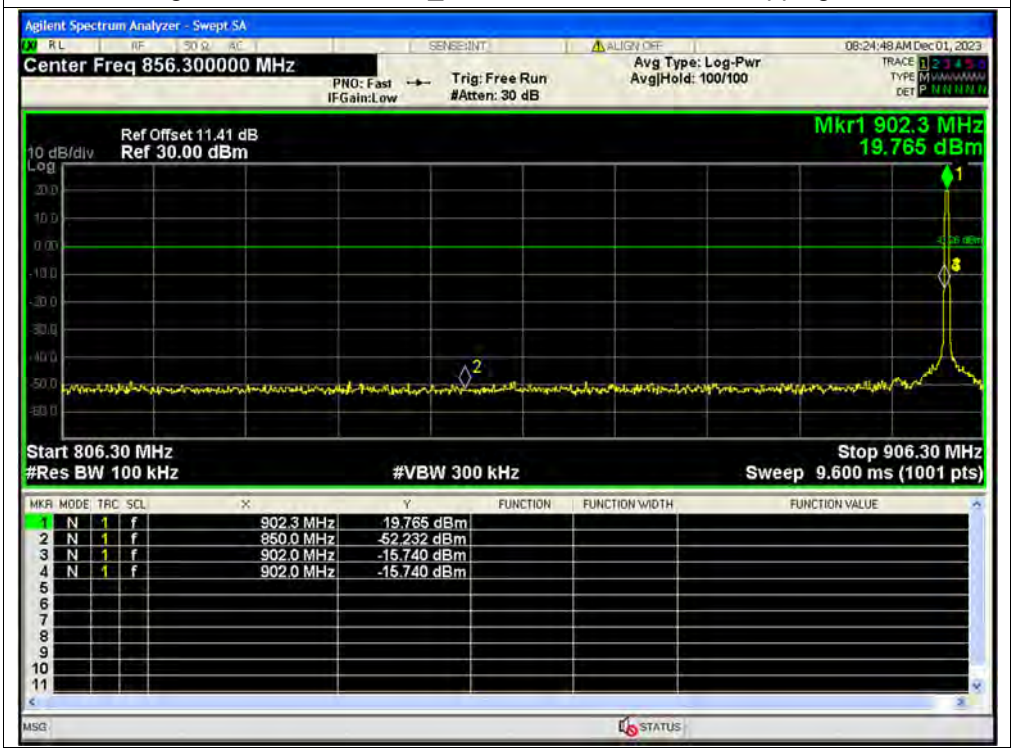
A.9. Band Edge

Condition	Mode/ Data Rate	Frequency (MHz)	Antenna	Hopping Mode	Max Value (dBc)	Limit (dBc)	Verdict
NVNT	LoRa FHSS_SF7	902.3	Ant1	No-Hopping	-35.48	-20	Pass
NVNT	LoRa FHSS_SF7	914.9	Ant1	No-Hopping	-67.41	-20	Pass
NVNT	LoRa FHSS_SF10	902.3	Ant1	No-Hopping	-36.03	-20	Pass
NVNT	LoRa FHSS_SF10	914.9	Ant1	No-Hopping	-67.71	-20	Pass
NVNT	LoRa FHSS_SF7	902.3	Ant1	Hopping	-52.96	-20	Pass
NVNT	LoRa FHSS_SF7	914.9	Ant1	Hopping	-68	-20	Pass
NVNT	LoRa FHSS_SF10	902.3	Ant1	Hopping	-60.48	-20	Pass
NVNT	LoRa FHSS_SF10	914.9	Ant1	Hopping	-67.88	-20	Pass

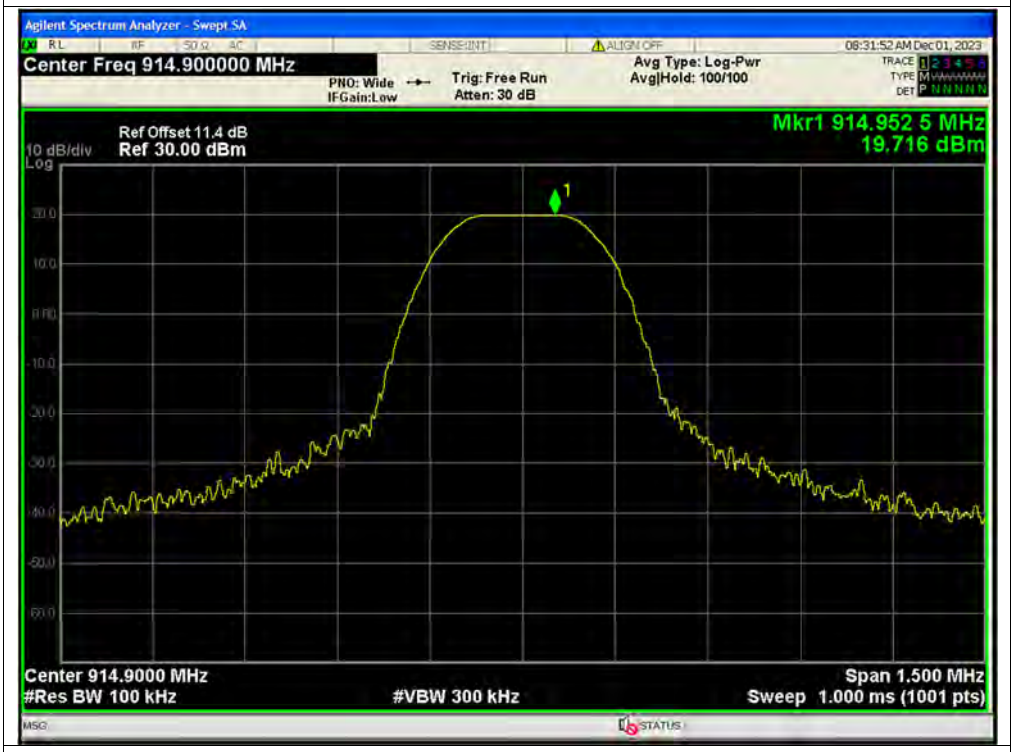
Test Graphs
Band Edge NVNT LoRa FHSS_SF7 902.3MHz Ant1 No-Hopping Ref



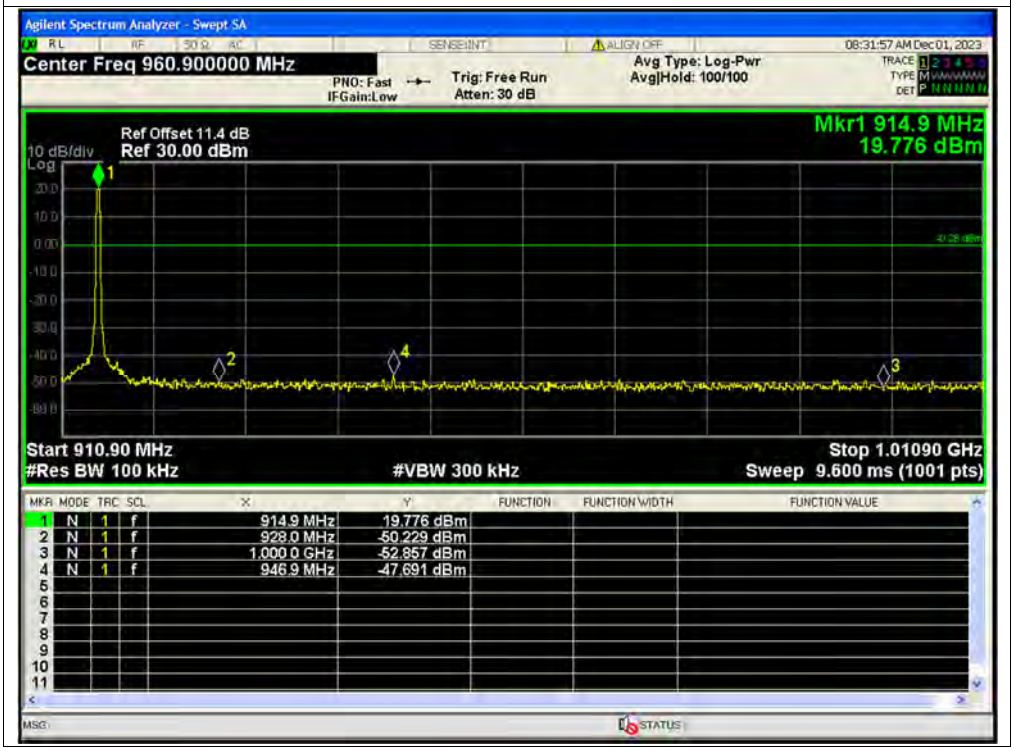
Band Edge NVNT LoRa FHSS_SF7 902.3MHz Ant1 No-Hopping Emission



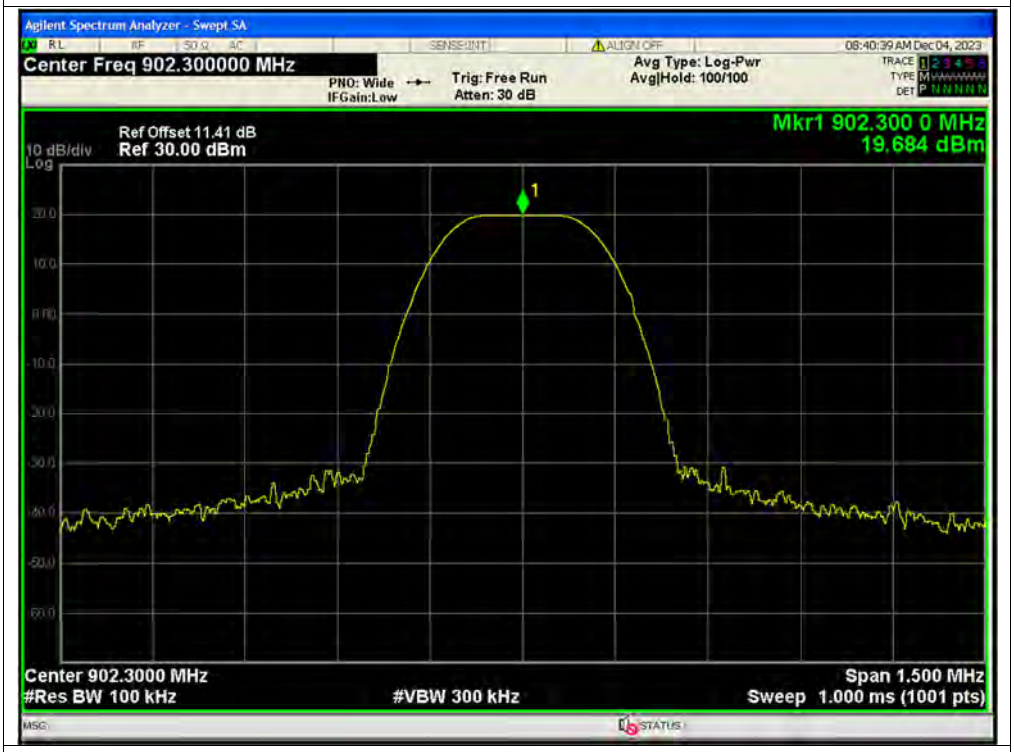
Band Edge NVNT LoRa FHSS_SF7 914.9MHz Ant1 No-Hopping Ref



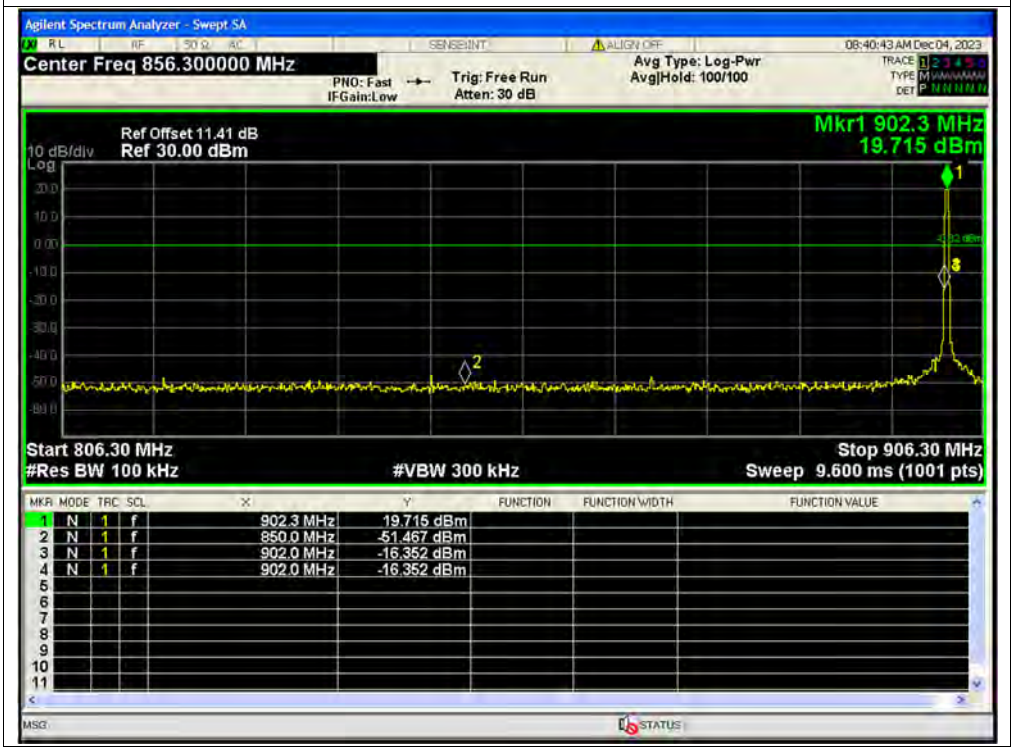
Band Edge NVNT LoRa FHSS_SF7 914.9MHz Ant1 No-Hopping Emission



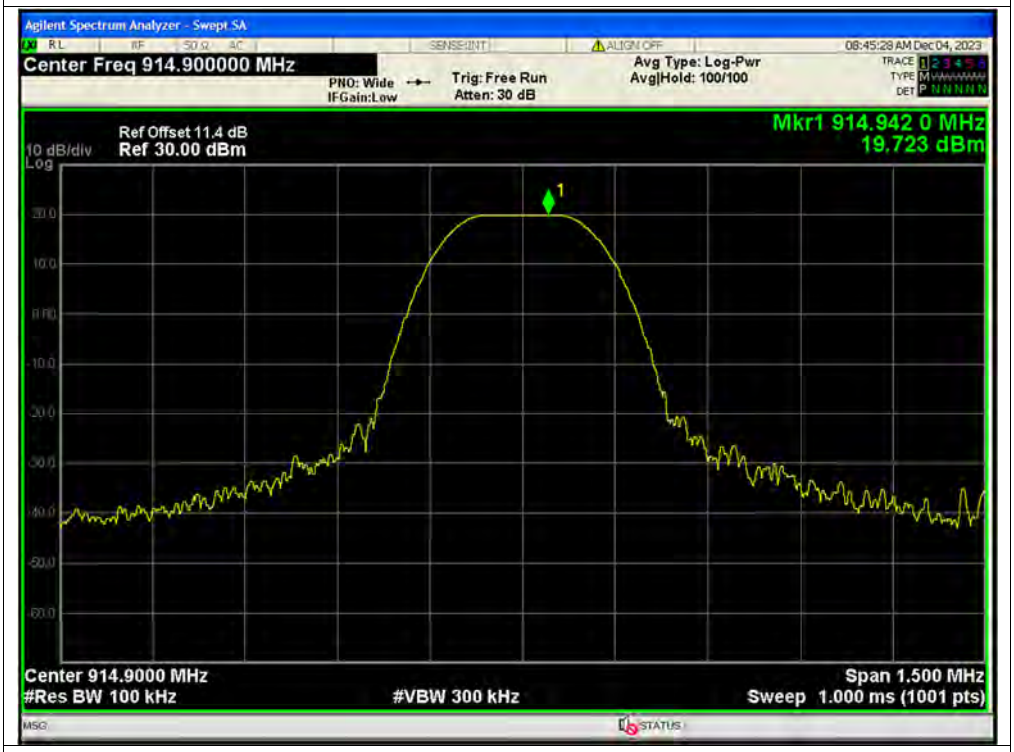
Band Edge NVNT LoRa FHSS_SF10 902.3MHz Ant1 No-Hopping Ref



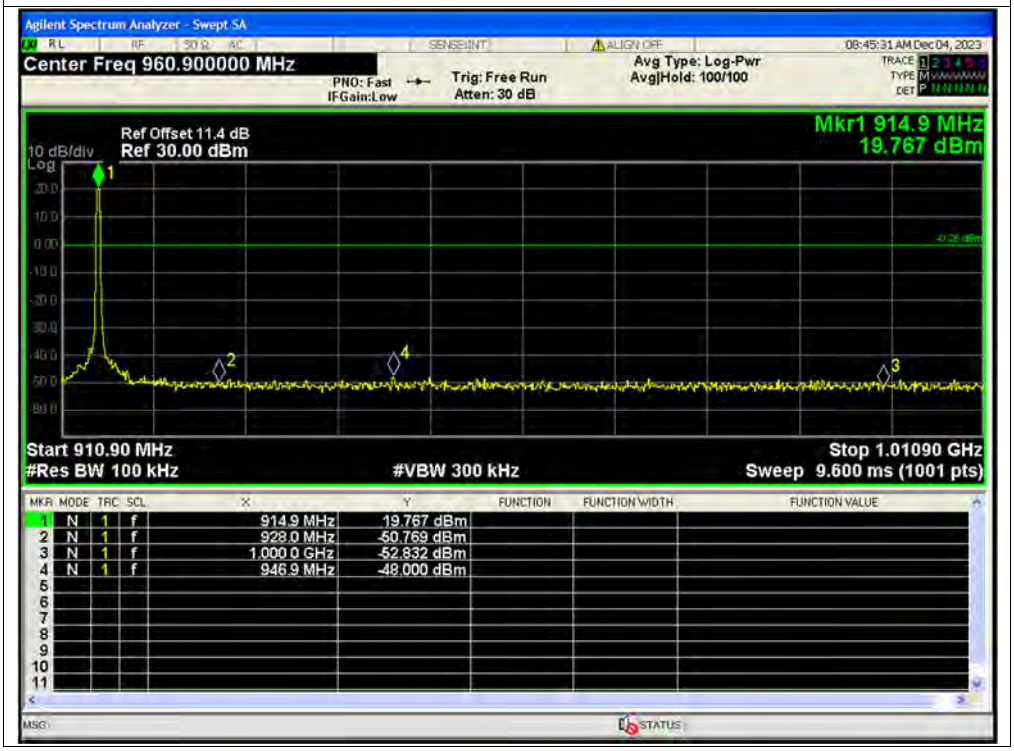
Band Edge NVNT LoRa FHSS_SF10 902.3MHz Ant1 No-Hopping Emission



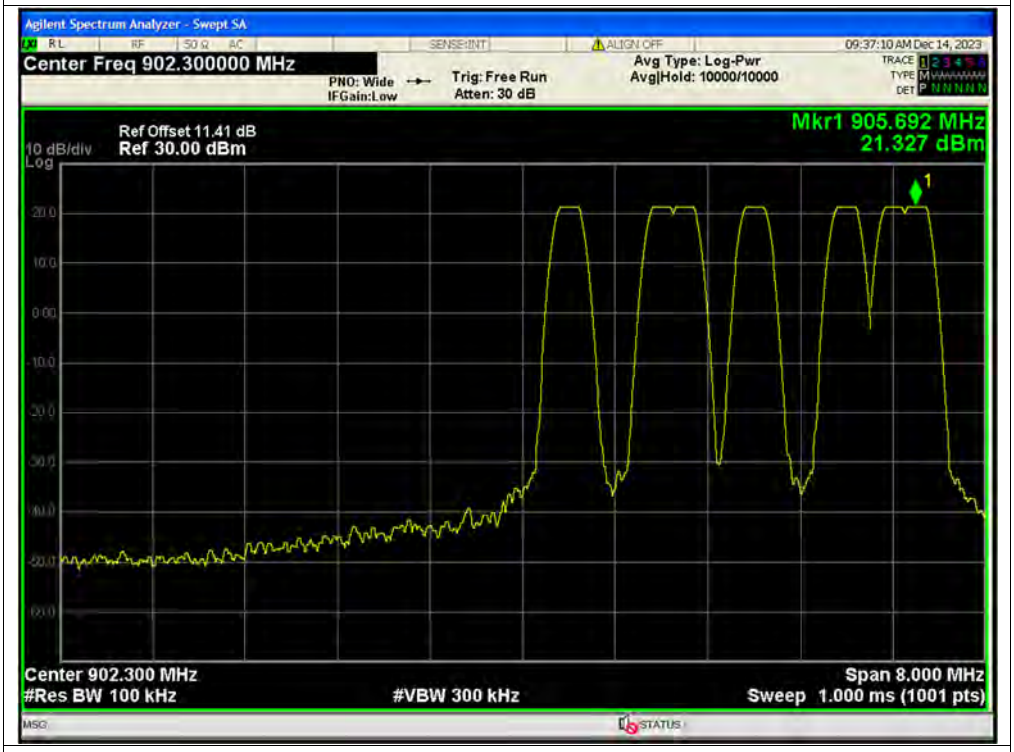
Band Edge NVNT LoRa FHSS_SF10 914.9MHz Ant1 No-Hopping Ref



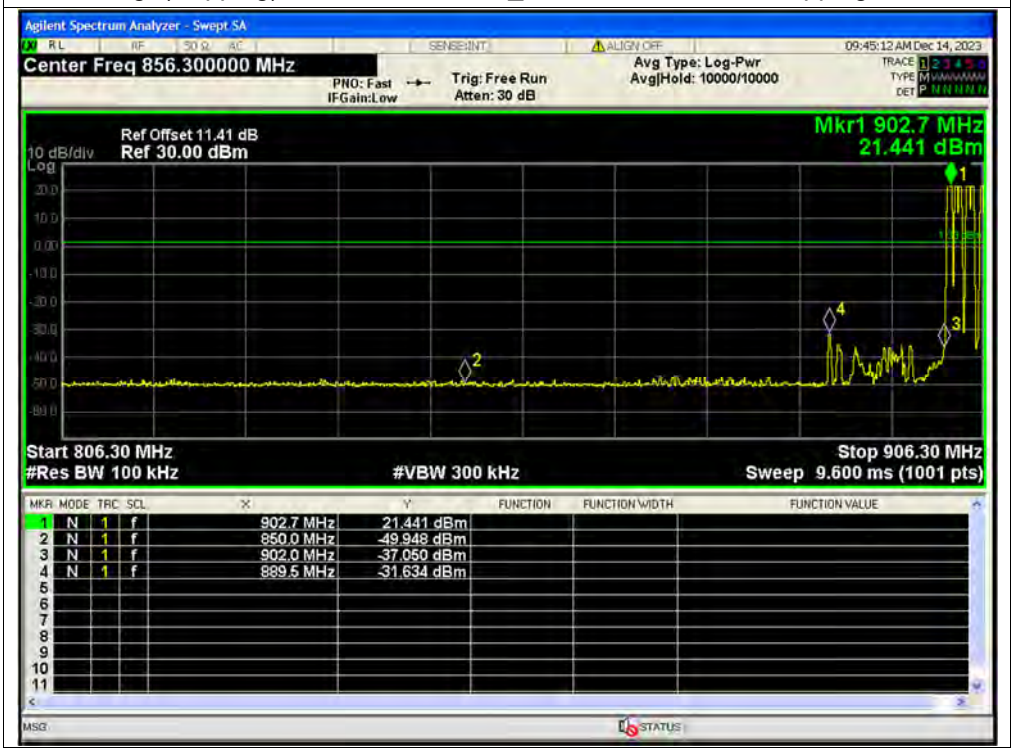
Band Edge NVNT LoRa FHSS_SF10 914.9MHz Ant1 No-Hopping Emission



Test Graphs
Band Edge(Hopping) NVNT LoRa FHSS_SF7 902.3MHz Ant1 Hopping Ref

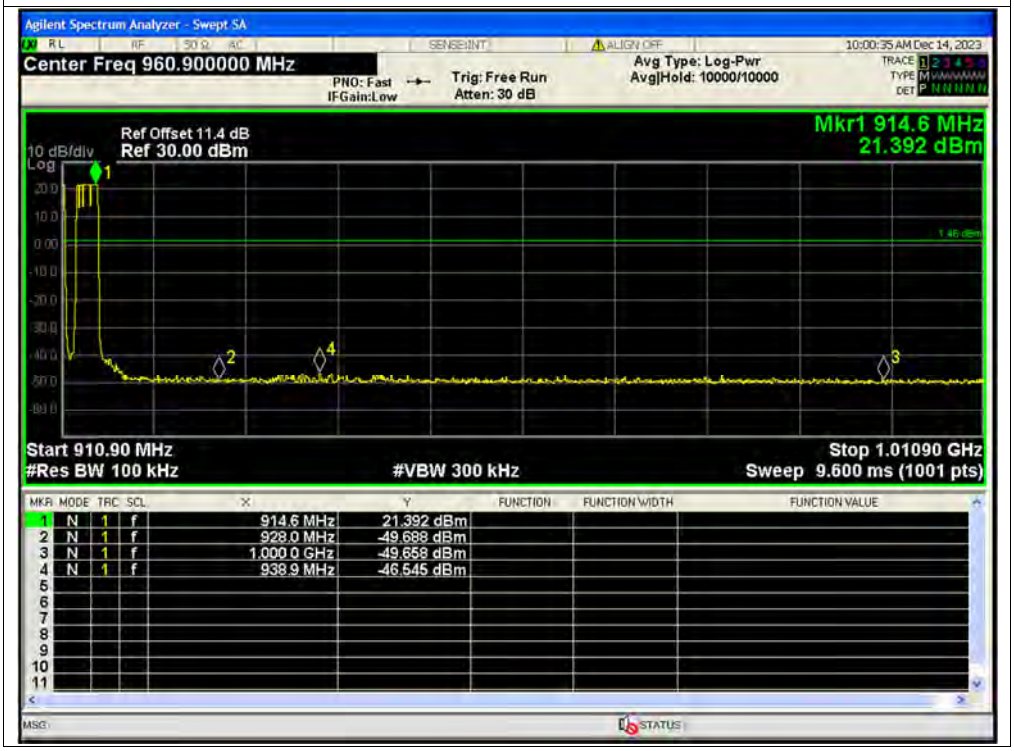


Band Edge(Hopping) NVNT LoRa FHSS_SF7 902.3MHz Ant1 Hopping Emission

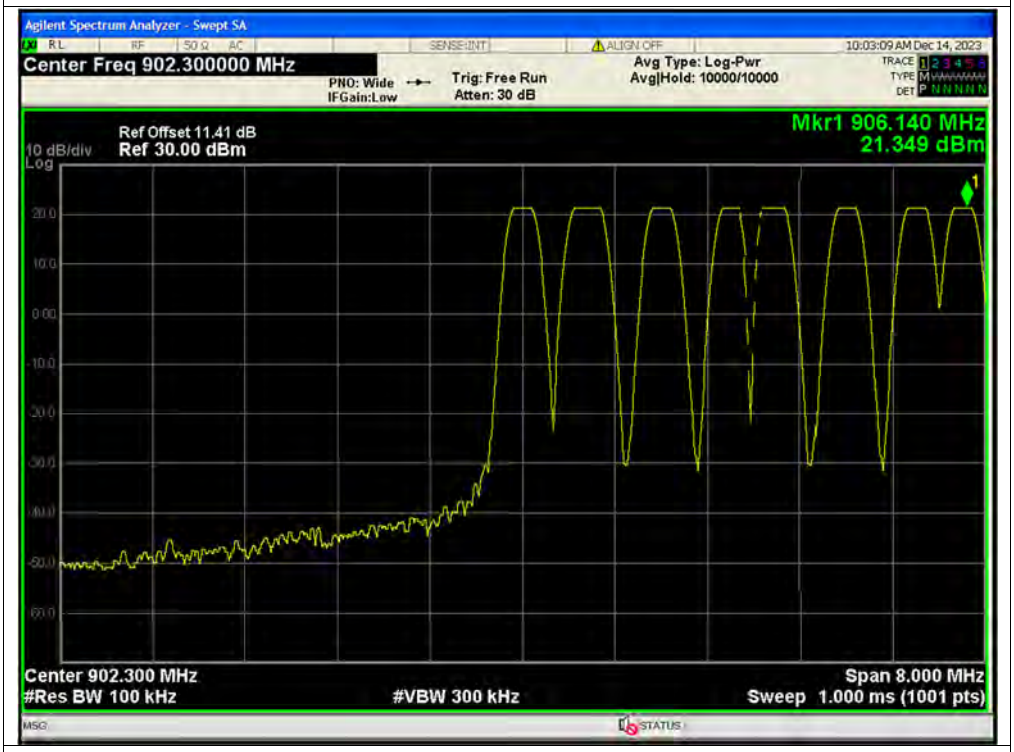


Band Edge(Hopping) NVNT LoRa FHSS_SF7 914.9MHz Ant1 Hopping Ref

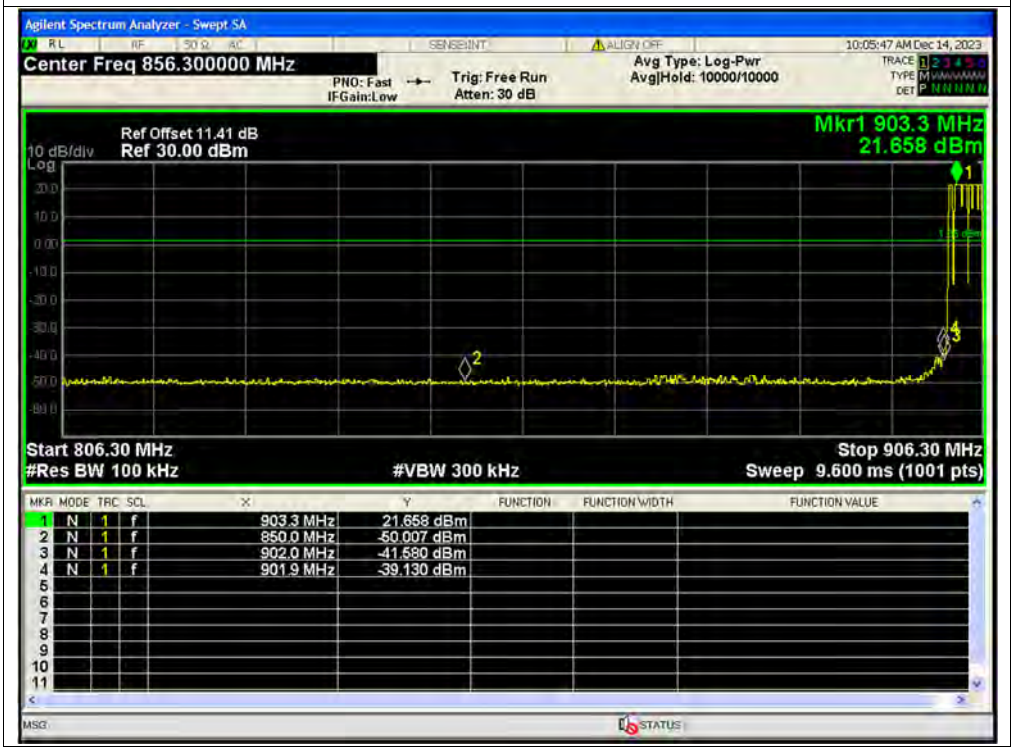
Band Edge(Hopping) NVNT LoRa FHSS_SF7 914.9MHz Ant1 Hopping Emission



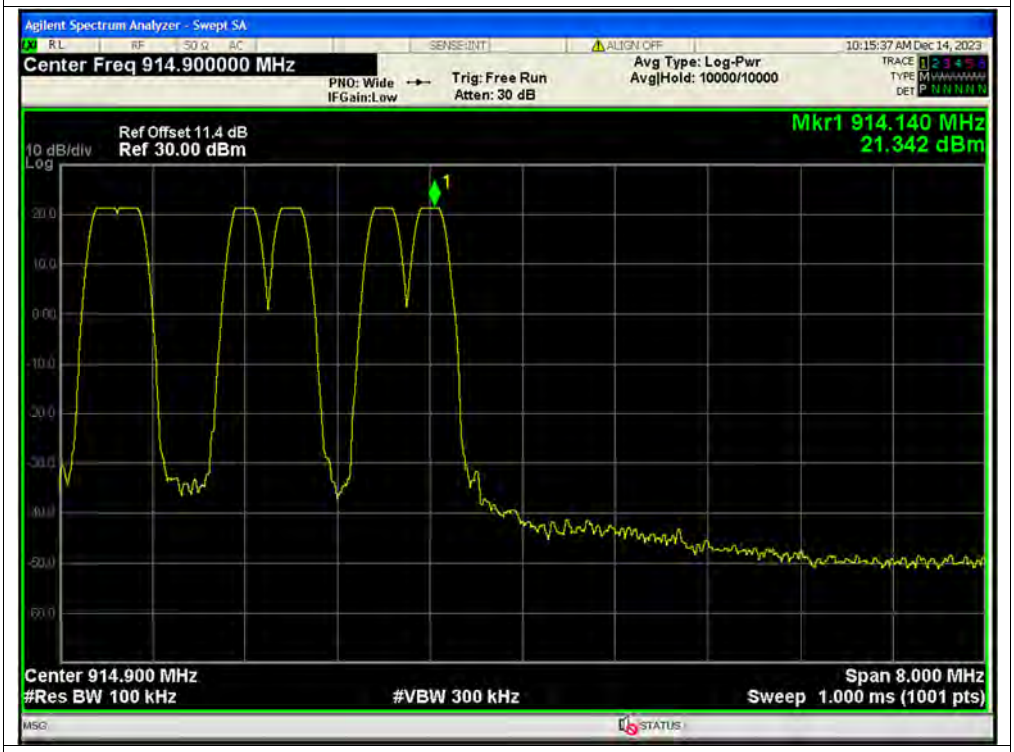
Band Edge(Hopping) NVNT LoRa FHSS_SF10 902.3MHz Ant1 Hopping Ref



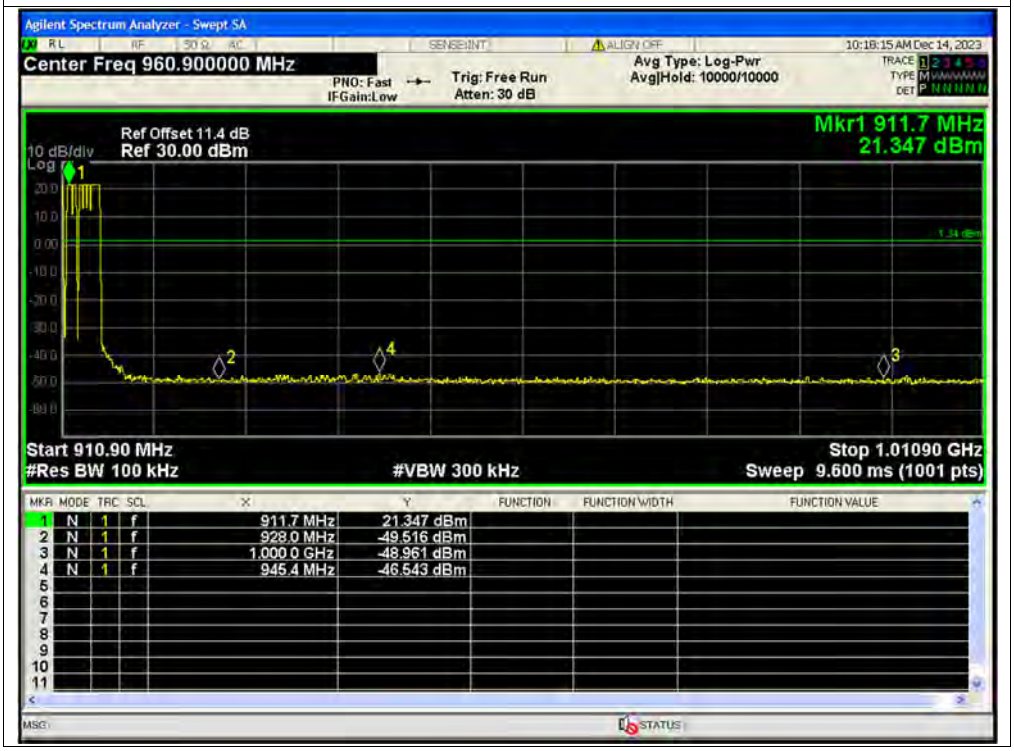
Band Edge(Hopping) NVNT LoRa FHSS_SF10 902.3MHz Ant1 Hopping Emission



Band Edge(Hopping) NVNT LoRa FHSS_SF10 914.9MHz Ant1 Hopping Ref



Band Edge(Hopping) NVNT LoRa FHSS_SF10 914.9MHz Ant1 Hopping Emission



A.10. Conducted Emission

The maximum conducted interference is searched using Peak (PK), if the emission levels more than the AV and QP limits, and that have narrow margins from the AV and QP limits will be re-measured with AV and QP detectors. Tests for both L phase and N phase lines of the power mains connected to the EUT are performed. Set RBW=9kHz, VBW=30kHz. Refer to recorded points and plots below.

Note: Both of the test voltage AC 120V/60Hz and AC 230V/50Hz were considered and tested respectively, only the results of the worst case AC 120V/60Hz were recorded in this report.

A. Test Setup:

Test Mode: EUT+USB Cable +PC +PC Adapter +902M TX

Test voltage: AC 120V/60Hz

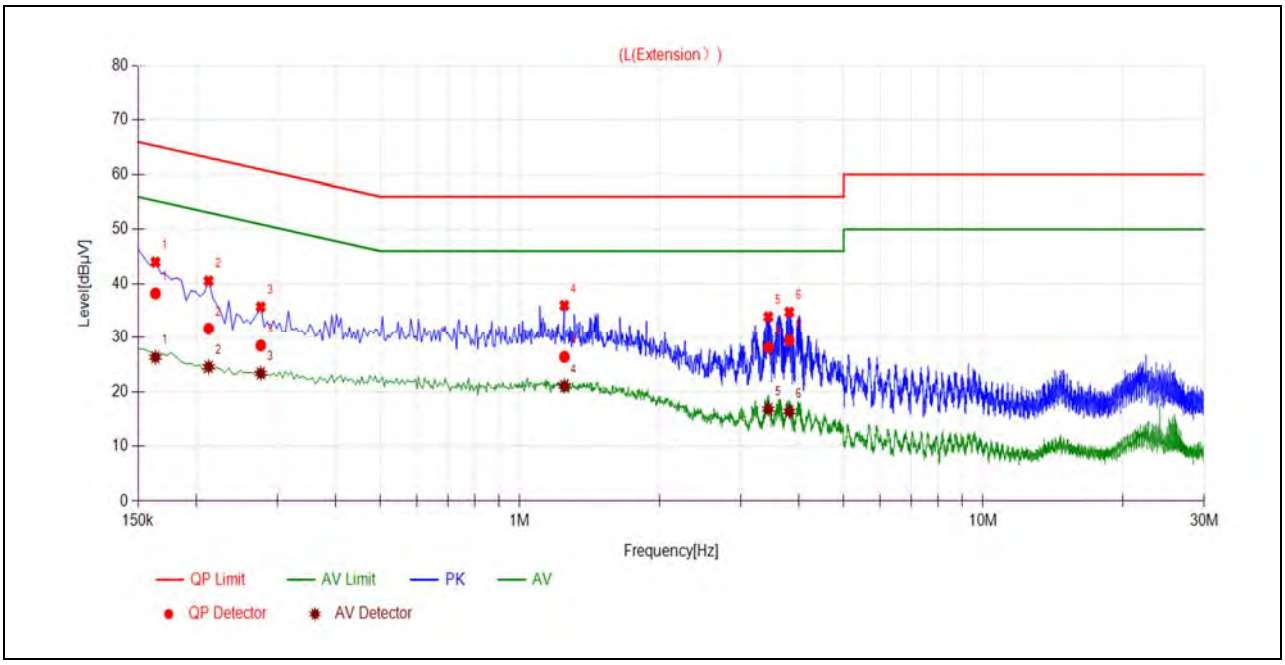
The measurement results are obtained as below:

$E\ [dB\mu V] = U_R + L_{Cable\ loss}\ [dB] + A_{Factor}$

U_R: Receiver Reading

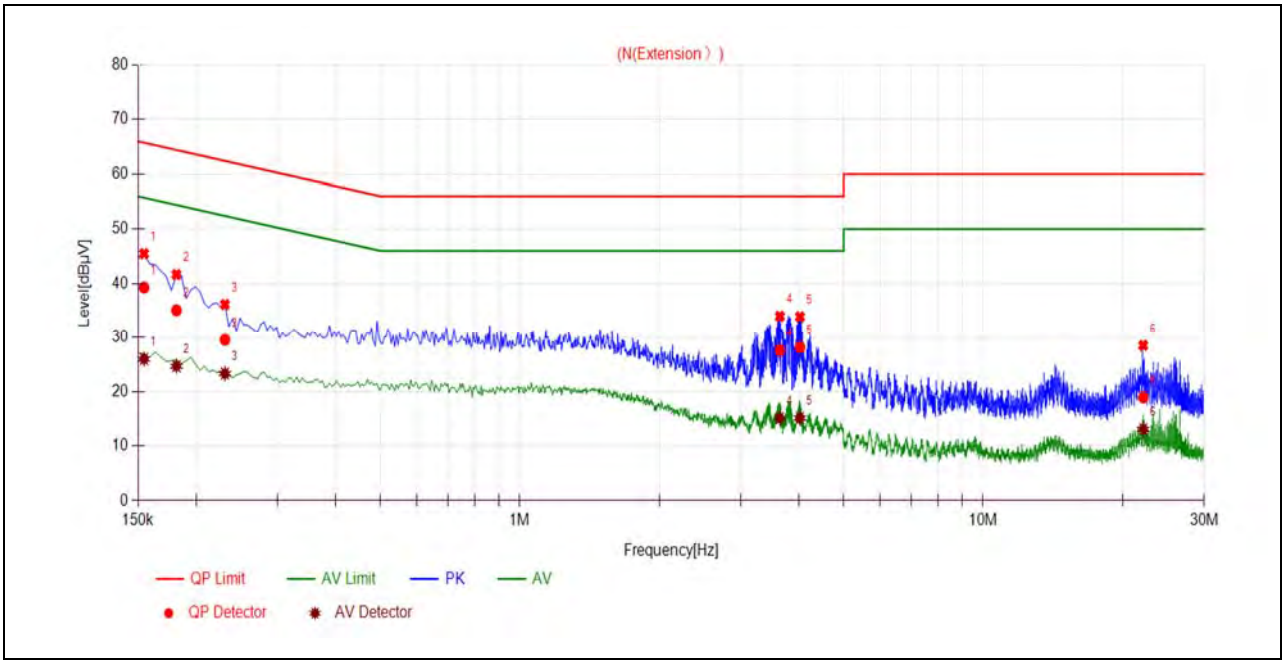
A_{Factor}: Voltage division factor of LISN

B. Test Plot:



(L Phase)

No.	Fre. (MHz)	Emission Level (dBµV)		Limit (dBµV)		Power-line	Verdict
		Quai-peak	Average	Quai-peak	Average		
1	0.1635	38.20	26.31	65.29	55.29	Line	PASS
2	0.2130	31.66	24.54	63.09	53.09		PASS
3	0.2760	28.49	23.36	60.93	50.93		PASS
4	1.2480	26.37	21.03	56.00	46.00		PASS
5	3.4393	28.11	16.79	56.00	46.00		PASS
6	3.8178	29.41	16.37	56.00	46.00		PASS



(N Phase)

No.	Fre. (MHz)	Emission Level (dBµV)		Limit (dBµV)		Power-line	Verdict
		Quai-peak	Average	Quai-peak	Average		
1	0.1545	39.29	25.98	65.75	55.75	Neutral	PASS
2	0.1815	35.09	24.66	64.42	54.42		PASS
3	0.2310	29.54	23.31	62.41	52.41		PASS
4	3.6418	27.61	15.08	56.00	46.00		PASS
5	4.0248	28.16	15.11	56.00	46.00		PASS
6	22.1651	18.91	13.04	60.00	50.00		PASS

A.11. Radiated Emission

According to ANSI C63.10, because of peak detection will yield amplitudes equal to or greater than amplitudes measured with the quasi-peak (or average) detector, the measurement data from a spectrum analyzer peak detector will represent the worst-case results, if the peak measured value complies with the quasi-peak (or average) limit, it is unnecessary to perform an quasi-peak measurement (or average).

The measurement results are obtained as below:

$E\ [dB\mu V/m] = U_R + A_T + A_{Factor}\ [dB]$; $A_T = L_{Cable\ loss}\ [dB] - G_{preamp}\ [dB]$

A_T: Total correction Factor except Antenna

U_R: Receiver Reading

G_{preamp}: Preamplifier Gain

A_{Factor}: Antenna Factor at 3m

During the test, the total correction Factor A_T and A_{Factor} were built in test software.

Note1: All radiated emission tests were performed in X, Y, Z axis direction. And only the worst axis test condition was recorded in this test report.

Note2: For the frequency, which started from 9kHz to 30MHz, was pre-scanned and the result which was 20dB lower than the limit was not recorded.

Note3: For the frequency, which started from 18GHz to 10th harmonic of the highest frequency, was pre-scanned and the result which was 20dB lower than the limit was not recorded.

Note4: All test modes and bandwidth were considered and evaluated respectively by performing full test, only the worst data were recorded for each bandwidth.

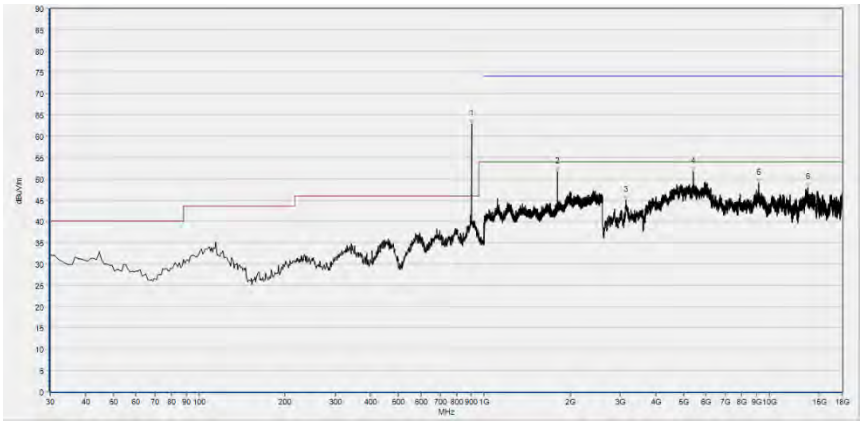
Field strength of fundamental:

Frequency (MHz)	Reading_Peak (dBμV/m)	Antenna Factor (dB)	Path Loss (dB)	Final_Peak (dBμV/m)	Antenna Polarity
902.085	65.11	22.2	4.97	92.28	Vertical
902.175	64.99	22.2	4.97	92.16	Horizontal

The field strength(the lowest) of fundamenta is more than 20dB higher than the unwanted emissions, in accordance with FCC part 15.215(b).

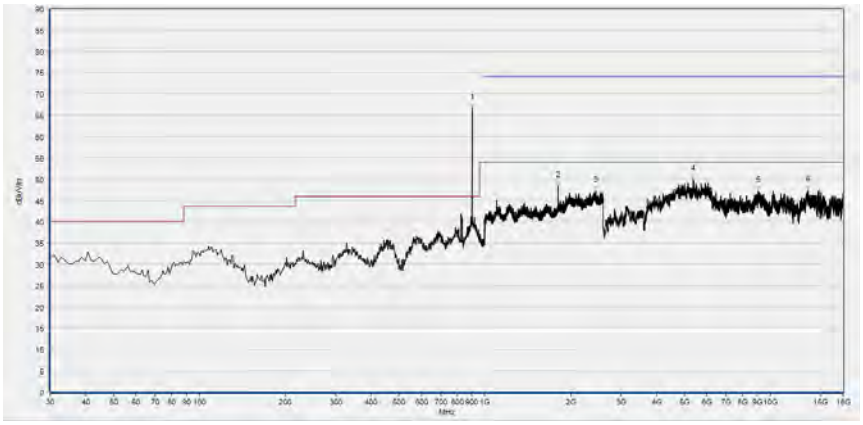
LoRa FHSS_SF7

Plots for Channel 1



Fre. (MHz)	PK (dBμV/m)	QP (dBμV/m)	AV (dBμV/m)	Limit-PK (dBμV/m)	Limit-QP (dBμV/m)	Limit-AV (dBμV/m)	Antenna	Verdict
902.030	62.90	N/A	N/A	N/A	46.00	N/A	Horizontal	N/A
1804.598	51.61	N/A	47.69	74.00	N/A	54.00	Horizontal	PASS
3145.160	44.87	N/A	N/A	74.00	N/A	54.00	Horizontal	PASS
5413.616	51.56	N/A	46.93	74.00	N/A	54.00	Horizontal	PASS
9154.240	48.87	N/A	N/A	74.00	N/A	54.00	Horizontal	PASS
13660.280	47.98	N/A	N/A	74.00	N/A	54.00	Horizontal	PASS

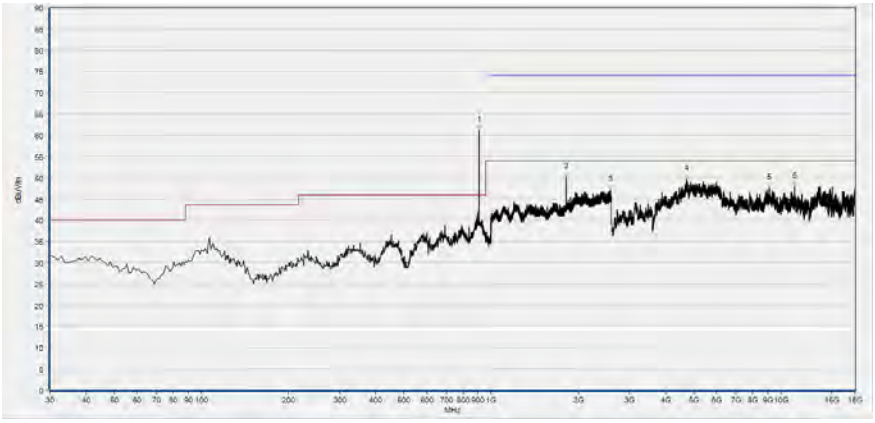
(Antenna Horizontal, 30MHz to 18GHz)



Fre. (MHz)	PK (dBμV/m)	QP (dBμV/m)	AV (dBμV/m)	Limit-PK (dBμV/m)	Limit-QP (dBμV/m)	Limit-AV (dBμV/m)	Antenna	Verdict
902.030	66.71	N/A	N/A	N/A	46.00	N/A	Vertical	N/A
1804.267	48.42	N/A	N/A	74.00	N/A	54.00	Vertical	PASS
2444.267	47.24	N/A	N/A	74.00	N/A	54.00	Vertical	PASS
5381.240	49.97	N/A	N/A	74.00	N/A	54.00	Vertical	PASS
9080.320	47.21	N/A	N/A	74.00	N/A	54.00	Vertical	PASS
13549.400	47.45	N/A	N/A	74.00	N/A	54.00	Vertical	PASS

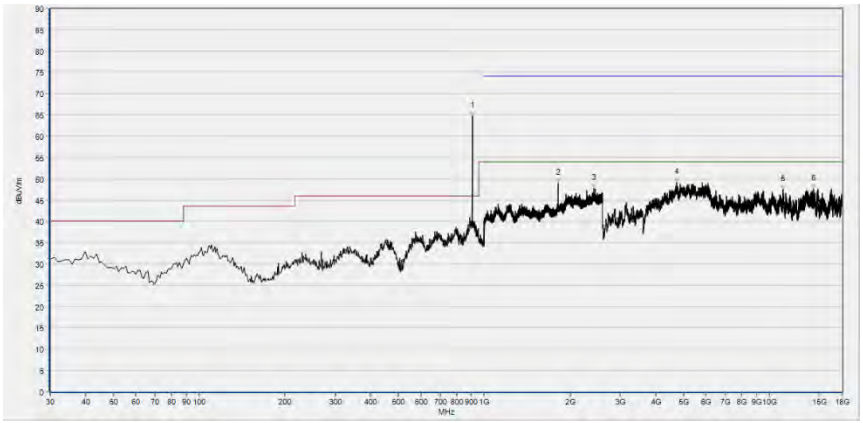
(Antenna Vertical, 30MHz to 18GHz)

Plot for Channel 32



Fre. (MHz)	PK (dBμV/m)	QP (dBμV/m)	AV (dBμV/m)	Limit-PK (dBμV/m)	Limit-QP (dBμV/m)	Limit-AV (dBμV/m)	Antenna	Verdict
908.820	61.23	N/A	N/A	N/A	46.00	N/A	Horizontal	N/A
1816.533	50.07	N/A	N/A	74.00	N/A	54.00	Horizontal	PASS
2581.333	47.10	N/A	N/A	74.00	N/A	54.00	Horizontal	PASS
4715.960	49.62	N/A	N/A	74.00	N/A	54.00	Horizontal	PASS
9141.920	47.57	N/A	N/A	74.00	N/A	54.00	Horizontal	PASS
11147.000	47.95	N/A	N/A	74.00	N/A	54.00	Horizontal	PASS

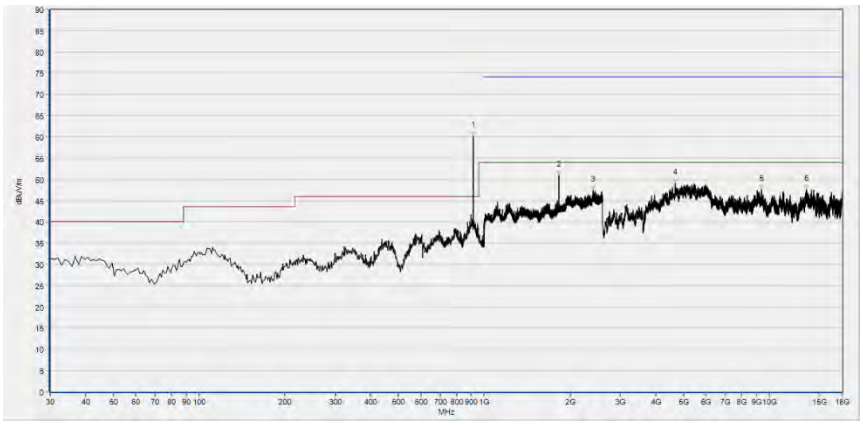
(Antenna Horizontal, 30MHz to 18GHz)



Fre. (MHz)	PK (dBμV/m)	QP (dBμV/m)	AV (dBμV/m)	Limit-PK (dBμV/m)	Limit-QP (dBμV/m)	Limit-AV (dBμV/m)	Antenna	Verdict
908.820	64.67	N/A	N/A	N/A	46.00	N/A	Horizontal	N/A
1817.067	48.96	N/A	N/A	74.00	N/A	54.00	Horizontal	PASS
2423.467	47.72	N/A	N/A	74.00	N/A	54.00	Horizontal	PASS
4740.600	49.09	N/A	N/A	74.00	N/A	54.00	Horizontal	PASS
11150.080	47.35	N/A	N/A	74.00	N/A	54.00	Horizontal	PASS
14285.520	47.64	N/A	N/A	74.00	N/A	54.00	Horizontal	PASS

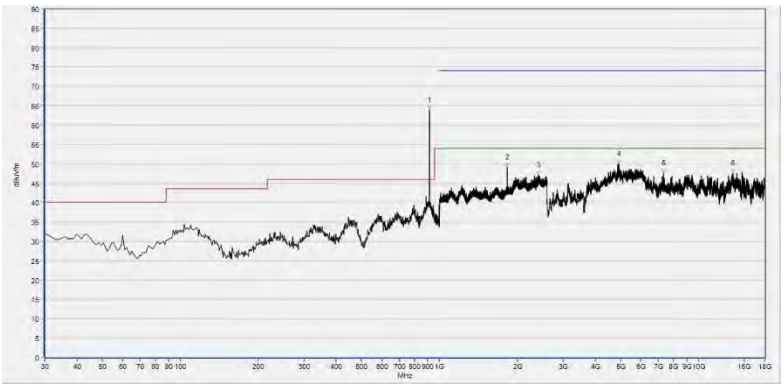
(Antenna Vertical, 30MHz to 18GHz)

Plot for Channel 64



Fre. (MHz)	PK (dBμV/m)	QP (dBμV/m)	AV (dBμV/m)	Limit-PK (dBμV/m)	Limit-QP (dBμV/m)	Limit-AV (dBμV/m)	Antenna	Verdict
914.640	60.12	N/A	N/A	N/A	46.00	N/A	Horizontal	N/A
1829.333	50.93	N/A	N/A	74.00	N/A	54.00	Horizontal	PASS
2408.000	47.49	N/A	N/A	74.00	N/A	54.00	Horizontal	PASS
4672.840	49.06	N/A	N/A	74.00	N/A	54.00	Horizontal	PASS
9406.800	47.58	N/A	N/A	74.00	N/A	54.00	Horizontal	PASS
13469.320	47.61	N/A	N/A	74.00	N/A	54.00	Horizontal	PASS

(Antenna Horizontal, 30MHz to 18GHz)



Fre. (MHz)	PK (dBμV/m)	QP (dBμV/m)	AV (dBμV/m)	Limit-PK (dBμV/m)	Limit-QP (dBμV/m)	Limit-AV (dBμV/m)	Antenna	Verdict
914.640	63.81	N/A	N/A	N/A	46.00	N/A	Vertical	N/A
1829.333	49.15	N/A	N/A	74.00	N/A	54.00	Vertical	PASS
2403.733	47.14	N/A	N/A	74.00	N/A	54.00	Vertical	PASS
4931.560	49.91	N/A	N/A	74.00	N/A	54.00	Vertical	PASS
7333.960	47.60	N/A	N/A	74.00	N/A	54.00	Vertical	PASS
13592.520	47.61	N/A	N/A	74.00	N/A	54.00	Vertical	PASS

(Antenna Vertical, 30MHz to 18GHz)

END OF REPORT