Radio Test Report

FCC ID: 2A2GJ-HTIT

Report No.	:	TBR-C-202202-0173-1
Applicant	:	Heltec Automation Technology Co., Ltd
Equipment Under Test (EUT)		
EUT Name	:	Heltec WiFI Kit LoRa Node
Model No.	:	HTIT-WS
Series Model No.	:	Please see page 5
Brand Name	:	----
Sample ID	:	RW-C-202202-0173-1-1# & RW-C-202202-0173-1-2#
Receipt Date	:	2022-02-24
Test Date	:	2022-02-24 to 2022-03-30
Issue Date	:	2022-04-01
Standards	:	FCC Part 15 Subpart C 15.247
Test Method	:	ANSI C63.10: 2013 KDB 558074 D01 15.247 Meas Guidance v05r02
Conclusions	:	**PASS** In the configuration tested, the EUT complied with the standards specified above.

Witness Engineer	:	Wade. Lv
Engineer Supervisor	:	Ivan Su
Engineer Manager	:	Ray Lai

This report details the results of the testing carried out on one sample. The results contained in this test report do not relate to other samples of the same product. The manufacturer should ensure that all products in series production are in conformity with the product sample detailed in the report.

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Contents

Revision History

Report No.	Version	Description	Issued Date
TBR-C-202202-0173-1	Rev.01	Initial issue of report	2022-04-01

1. General Information about EUT

1.1 Client Information

Applicant	:	Heltec Automation Technology Co., Ltd
Address	:	1st floor, No. 54, 56, 58 zirui North Street, High-tech Zone, Chengdu city, China
Manufacturer	:	Heltec Automation Technology Co., Ltd
Address	:	1st floor, No. 54, 56, 58 zirui North Street, High-tech Zone, Chengdu city, China

1.2 General Description of EUT (Equipment Under Test)

EUT Name	:	Heltec WiFI Kit LoRa Node	
Models No.	:	HTIT-WS, HTIT-WB32LAF, HTIT-WB32, HTIT-WS, HTIT-WSL, HTIT-WSH, HTIT-TB, HTIT-LN151, HTIT-LK151, HITI-WB32LABR, HTIT-W8266, HTIT-WB32G, HT-M00, HT-M01S, HTCC-AB01, HTCC-AB01-S, HTCC-AB02, HTCC-AB02-S, HTCC-AB03, HTCC-AB03-S, HTCC-AC01, HTCC-AC01-S, HTCC-AC02, HTCC-AC02-S, HTCC-AC03, HTCC-AC03-S, HTCC-AM01, HTCC-AM01-S, HTCC-AM02, HTCC-AM02-S, HTCC-AM03, HTCC-AM03-S, HTIT-DIY0051N, HTIT-DIY0031	
Model Different	:	All these models are identical in the same PCB, layout and electrical circuit, the only difference is appearance and color.	
Product Description	:	Operation Frequency:	LoRa(125KHz): 902.3MHz-914.9MHz
		Number of Channel:	64 channels
		Antenna Gain:	3.0dBi Internal Antenna
		Bit Rate of Transmitter:	5.47kbps
Power Rating	:	USB Input: DC 5V	
Software Version	:	V1.0	
Hardware Version	:	V2	

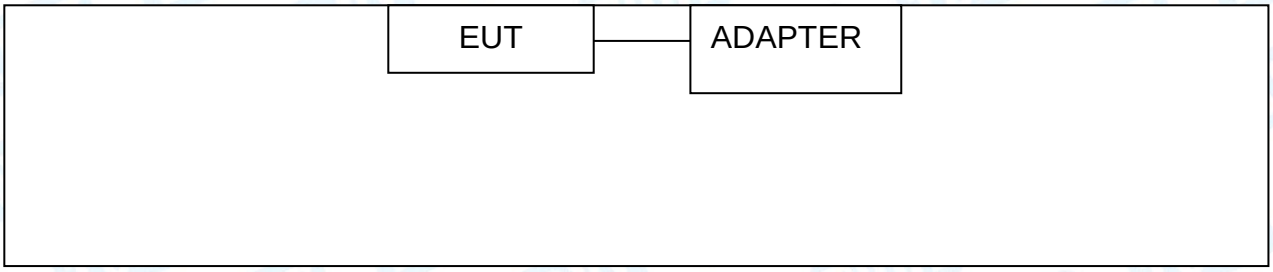
Remark:
(1) The antenna gain and adapter provided by the applicant, the verified for the RF conduction test provided by TOBY test lab.
(2) For a more detailed features description, please refer to the manufacturer's specifications or the User's Manual.
(3) Antenna information provided by the applicant. And the type of antenna please see the external photos.

(4) Channel List:

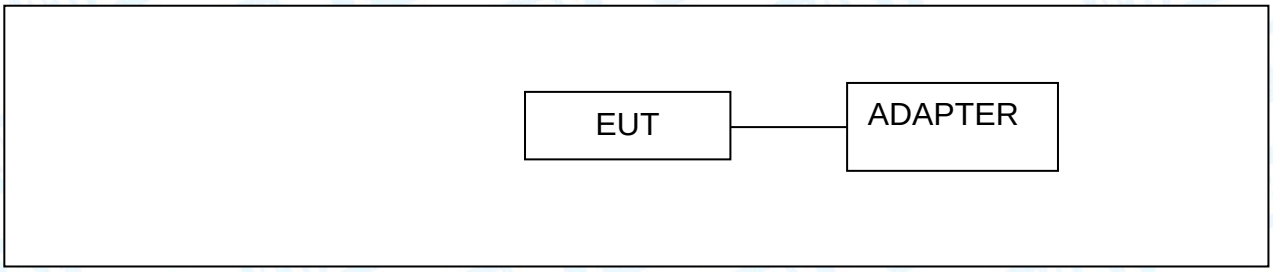
Channel	Frequency (MHz)	Channel	Frequency (MHz)	Channel	Frequency (MHz)
01	902.3	23	906.7	45	911.1
02	902.5	24	906.9	46	911.3
03	902.7	25	907.1	47	911.5
04	902.9	26	907.3	48	911.7
05	903.1	27	907.5	49	911.9
06	903.3	28	907.7	50	912.1
07	903.5	29	907.9	51	912.3
08	903.7	30	908.1	52	912.5
09	903.9	31	908.3	53	912.7
10	904.1	32	908.5	54	912.9
11	904.3	33	908.7	55	913.1
12	904.5	34	908.9	56	913.3
13	904.7	35	909.1	57	913.5
14	904.9	36	909.3	58	913.7
15	905.1	37	909.5	59	913.9
16	905.3	38	909.7	60	914.1
17	905.5	39	909.9	61	914.3
18	905.7	40	910.1	62	914.5
19	905.9	41	910.3	63	914.7
20	906.1	42	910.5	64	914.9
21	906.3	43	910.7		
22	906.5	44	910.9		

1.3 Block Diagram Showing the Configuration of System Tested

Conducted Test



Radiated Test



1.4 Description of Support Units

Equipment Information				
Name	**Model**	**FCC ID/SDOC**	**Manufacturer**	**Used "√"**
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Cable Information				
Number	**Shielded Type**	**Ferrite Core**	**Length**	**Note**
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1.5 Description of Test Mode

To investigate the maximum EMI emission characteristics generates from EUT, the test system was pre-scanning tested base on the consideration of following EUT operation mode or test configuration mode which possible have effect on EMI emission level. Each of these EUT operation mode(s) or test configuration mode(s) mentioned follow was evaluated respectively.

For Conducted Test	
Final Test Mode	**Description**
Mode 1	TX Mode Channel 01
For Radiated Test	
Final Test Mode	**Description**
Mode 1	TX Mode Channel 01
Mode 2	TX Mode Channel 01/34/64
Mode 3	Hopping Mode

Note:

(1) For all test, we have verified the construction and function in typical operation. And all the test modes were carried out with the EUT in transmitting operation in maximum power with all kinds of data rate.
According to ANSI C63.10 standards, the measurements are performed at the highest, middle, lowest available channels.

(2) During the testing procedure, the continuously transmitting with the maximum power mode was programmed by the customer.

(3) The EUT is considered a Mobile unit; in normal use it was positioned on X-plane. The worst case was found positioned on X-plane. Therefore only the test data of this X-plane was used for radiated emission measurement test.

1.6 Description of Test Software Setting

During testing channel& Power controlling software provided by the customer was used to control the operating channel as well as the output power level. The RF output power selection is for the setting of RF output power expected by the customer and is going to be fixed on the firmware of the final end product power parameters of RF setting.

Test Software Version	Windows PowerShell		
Frequency	902.3MHz	908.9MHz	914.9MHz
LoRa	16	16	16

1.7 Measurement Uncertainty

The reported uncertainty of measurement y±U，where expended uncertainty U is based on a standard uncertainty multiplied by a coverage factor of k=2，providing a level of confidence of approximately 95 %.

Test Item	Parameters	Expanded Uncertainty (U_{Lab})
Conducted Emission	Level Accuracy: 9kHz~150kHz 150kHz to 30MHz	±3.50 dB ±3.10 dB
Radiated Emission	Level Accuracy: 9kHz to 30 MHz	±4.60 dB
Radiated Emission	Level Accuracy: 30MHz to 1000 MHz	±4.50 dB
Radiated Emission	Level Accuracy: Above 1000MHz	±4.20 dB

1.8 Test Facility

The testing report were performed by the Shenzhen Toby Technology Co., Ltd., in their facilities located at 1/F.,Building 6, Rundongsheng Industrial Zone, Longzhu, Xixiang, Bao'an District, Shenzhen, Guangdong, China. At the time of testing, the following bodies accredited the Laboratory:

CNAS (L5813)

The Laboratory has been accredited by CNAS to ISO/IEC 17025: 2017 General Requirements for the Competence of Testing and Calibration Laboratories for the competence in the field of testing. And the Registration No.: CNAS L5813.

A2LA Certificate No.: 4750.01

The laboratory has been accredited by American Association for Laboratory Accreditation(A2LA) to ISO/IEC 17025：2017 General Requirements for the Competence of Testing and Calibration Laboratories for the technical competence in the field of Electrical Testing. And the A2LA Certificate No.: 4750.01.FCC Accredited Test Site Number: 854351. Designation Number: CN1223.

IC Registration No.: (11950A)

The Laboratory has been registered by Certification and Engineering Bureau of Industry Canada for radio equipment testing. The site registration: Site# 11950A. CAB identifier: CN0056.

2. Test Summary

Standard Section FCC	Test Item	Test Sample(s)	Judgment	Remark
FCC 15.207(a)	Conducted Emission	RW-C-202202-0173-1-1#	PASS	N/A
FCC 15.209 & 15.247(d)	Radiated Unwanted Emissions	RW-C-202202-0173-1-1#	PASS	N/A
FCC 15.203	Antenna Requirement	RW-C-202202-0173-1-2#	PASS	N/A
FCC 15.247(a)	99% Occupied Bandwidth & 20dB Bandwidth	RW-C-202202-0173-1-2#	PASS	N/A
FCC 15.247(b)(1)	Peak Output Power	RW-C-202202-0173-1-2#	PASS	N/A
FCC 15.247(f)	Power Spectral Density	RW-C-202202-0173-1-2#	PASS	N/A
FCC 15.247(a)(1)	Carrier frequency separation	RW-C-202202-0173-1-2#	PASS	N/A
FCC 15.247(f)	Time of occupancy	RW-C-202202-0173-1-2#	PASS	N/A
FCC 15.247(b)(1)	Number of Hopping Frequency	RW-C-202202-0173-1-2#	PASS	N/A (2)
FCC 15.247(d)	Band Edge	RW-C-202202-0173-1-2#	PASS	N/A
FCC 15.207	Conducted Unwanted Emissions	RW-C-202202-0173-1-2#	PASS	N/A
FCC 15.205	Emissions in Restricted Bands	RW-C-202202-0173-1-2#	PASS	N/A
FCC 15.247(a)(1)	Hopping function Requirements	RW-C-202202-0173-1-2#	PASS	N/A
/	On Time and Duty Cycle	RW-C-202202-0173-1-2#	/	N/A

Note: N/A is an abbreviation for Not Applicable.

3. Test Software

Test Item	Test Software	Manufacturer	Version No.
Conducted Emission	EZ-EMC	EZ	CDI-03A2
Radiation Emission	EZ-EMC	EZ	FA-03A2RE
RF Conducted Measurement	MTS-8310	MWRFtest	V2.0.0.0
RF Test System	JS1120	Tonscend	V2.6.88.0336

4. Test Equipment

Conducted Emission Test					
Equipment	**Manufacturer**	**Model No.**	**Serial No.**	**Last Cal.**	**Cal. Due Date**
EMI Test Receiver	Rohde & Schwarz	ESCI	100321	Jul. 02, 2021	Jul. 01, 2022
RF Switching Unit	Compliance Direction Systems Inc	RSU-A4	34403	Jul. 02, 2021	Jul. 01, 2022
AMN	SCHWARZBECK	NNBL 8226-2	8226-2/164	Jul. 02, 2021	Jul. 01, 2022
LISN	Rohde & Schwarz	ENV216	101131	Jul. 02, 2021	Jul. 01, 2022

Radiation Emission Test (A Site)					
Equipment	**Manufacturer**	**Model No.**	**Serial No.**	**Last Cal.**	**Cal. Due Date**
Spectrum Analyzer	Rohde & Schwarz	FSV40-N	102197	Jul. 02, 2021	Jul. 01, 2022
EMI Test Receiver	Rohde & Schwarz	ESPI	100010/007	Jul. 02, 2021	Jul. 01, 2022
Bilog Antenna	ETS-LINDGREN	3142E	00117537	Feb.27, 2022	Feb.26, 2023
Horn Antenna	ETS-LINDGREN	3117	00143207	Mar. 02, 2022	Mar. 01, 2023
Horn Antenna	SCHWARZBECK	BBHA 9170	1118	May. 20, 2021	May. 19, 2022
Loop Antenna	SCHWARZBECK	FMZB 1519 B	1519B-059	Jul. 06, 2021	Jul. 05, 2022
Pre-amplifier	SONOMA	310N	185903	Feb. 26, 2022	Feb.25, 2023
Pre-amplifier	HP	8449B	3008A00849	Feb. 26, 2022	Feb.25, 2023
HF Amplifier	Tonscend	TAP0184050	AP21C806129	Sep. 03, 2021	Sep. 02, 2022

Radiation Emission Test (B Site)					
Equipment	**Manufacturer**	**Model No.**	**Serial No.**	**Last Cal.**	**Cal. Due Date**
Spectrum Analyzer	KEYSIGT	N9020B	MY60110172	Sep. 03, 2021	Sep. 02, 2022
Spectrum Analyzer	Rohde & Schwarz	FSV40-N	102197	Jul. 02, 2021	Jul. 01, 2022
Bilog Antenna	SCHWARZBECK	VULB 9168	1225	Dec. 05, 2021	Dec. 04, 2023
Horn Antenna	SCHWARZBECK	BBHA 9120 D	2463	May 20, 2021	May 19, 2022
Horn Antenna	SCHWARZBECK	BBHA 9170	1118	May 20, 2021	May 19, 2022
Loop Antenna	SCHWARZBECK	FMZB 1519 B	1519B-059	Jul. 06, 2021	Jul. 05, 2022
HF Amplifier	Tonscend	TAP9E6343	AP21C806117	Sep. 03, 2021	Sep. 02, 2022
HF Amplifier	Tonscend	TAP051845	AP21C806141	Sep. 03, 2021	Sep. 02, 2022
HF Amplifier	Tonscend	TAP0184050	AP21C806129	Sep. 03, 2021	Sep. 02, 2022

Antenna Conducted Emission					
Equipment	**Manufacturer**	**Model No.**	**Serial No.**	**Last Cal.**	**Cal. Due Date**
Spectrum Analyzer	Agilent	E4407B	MY45106456	Jul. 02, 2021	Jul. 01, 2022
Spectrum Analyzer	Rohde & Schwarz	FSV40-N	102197	Jul. 02, 2021	Jul. 01, 2022
MXA Signal Analyzer	Agilent	N9020A	MY49100060	Sep. 03, 2021	Sep. 02, 2022
MXA Signal Analyzer	Agilent	N9020A	MY47380425	Sep. 03, 2021	Sep. 02, 2022
Vector Signal Generator	Agilent	N5182A	MY50141294	Sep. 03, 2021	Sep. 02, 2022
Analog Signal Generator	Agilent	N5181A	MY50141953	Sep. 03, 2021	Sep. 02, 2022
Vector Signal Generator	Agilent	5182B	MY59101429	Sep. 03, 2021	Sep. 02, 2022
Analog Signal Generator	Agilent	5181A	MY48180463	Sep. 03, 2021	Sep. 02, 2022
RF Power Sensor	DARE!! Instruments	RadiPowerRPR3006W	17I00015SNO26	Sep. 03, 2021	Sep. 02, 2022
	DARE!! Instruments	RadiPowerRPR3006W	17I00015SNO29	Sep. 03, 2021	Sep. 02, 2022
	DARE!! Instruments	RadiPowerRPR3006W	17I00015SNO31	Sep. 03, 2021	Sep. 02, 2022
	DARE!! Instruments	RadiPowerRPR3006W	17I00015SNO33	Sep. 03, 2021	Sep. 02, 2022
RF Control Unit	Tonsced	JS0806-1	21C8060380	N/A	N/A
RF Control Unit	Tonsced	JS0806-2	21F8060439	Sep. 03, 2021	Sep. 02, 2022
Band Reject Filter Group	Tonsced	JS0806-F	21D8060414	Jul. 02, 2021	Jul. 01, 2022
Power Control Box	Tonsced	JS0806-4ADC	21C8060387	N/A	N/A
Wideband Radio Comunication Tester	Rohde & Schwarz	CMW500	144382	Sep. 03, 2021	Sep. 02, 2022

5. Conducted Emission

5.1 Test Standard and Limit

5.1.1 Test Standard

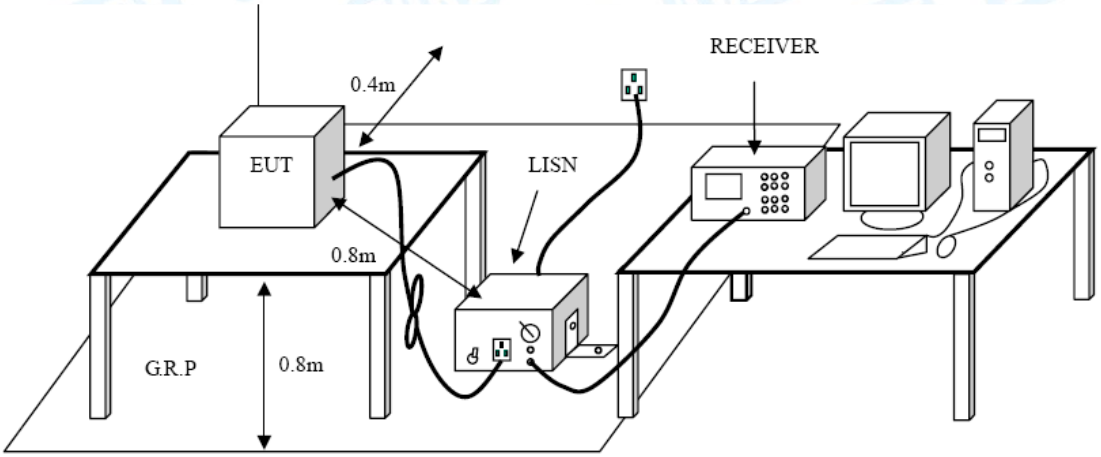
FCC Part 15.207

5.1.2 Test Limit

Frequency	Maximum RF Line Voltage (dBμV)	
	Quasi-peak Level	Average Level
150kHz~500kHz	66 ~ 56 *	56 ~ 46 *
500kHz~5MHz	56	46
5MHz~30MHz	60	50

Notes:
(1) *Decreasing linearly with logarithm of the frequency.
(2) The lower limit shall apply at the transition frequencies.
(3) The limit decrease in line with the logarithm of the frequency in the range of 0.15 to 0.50MHz.

5.2 Test Setup



5.3 Test Procedure

●The EUT was placed 0.8 meters from the horizontal ground plane with EUT being connected to the power mains through a line impedance stabilization network (LISN). All other support equipments powered from additional LISN(s). The LISN provide 50 Ohm/ 50uH of coupling impedance for the measuring instrument.
●Interconnecting cables that hang closer than 40 cm to the ground plane shall be folded back and forth in the center forming a bundle 30 to 40 cm long.
●I/O cables that are not connected to a peripheral shall be bundled in the center. The end of the cable may be terminated, if required, using the correct terminating impedance. The overall length shall not exceed 1 m.
●LISN at least 80 cm from nearest part of EUT chassis.
●The bandwidth of EMI test receiver is set at 9 kHz, and the test frequency band is from 0.15MHz to 30MHz.

5.4 Deviation From Test Standard

No deviation

5.5 EUT Operating Mode

Please refer to the description of test mode.

5.6 Test Data

Please refer to the Attachment A.

6. Radiated and Conducted Unwanted Emissions

6.1 Test Standard and Limit

6.1.1 Test Standard

FCC Part 15.209 & FCC Part 15.247(d)

6.1.2 Test Limit

General field strength limits at frequencies Below 30MHz			
Frequency (MHz)	**Field Strength (μA/m)***	**Field Strength (microvolt/meter)****	**Measurement Distance (meters)**
0.009~0.490	6.37/F (F in kHz)	2400/F(KHz)	300
0.490~1.705	63.7/F (F in kHz)	24000/F(KHz)	30
1.705~30.0	0.08	30	30
Note: 1, The emission limits for the ranges 9-90 kHz and 110-490 kHz are based on measurements employing a linear average detector. 2, ***is for RSS Standard, ****is for FCC Standard.			

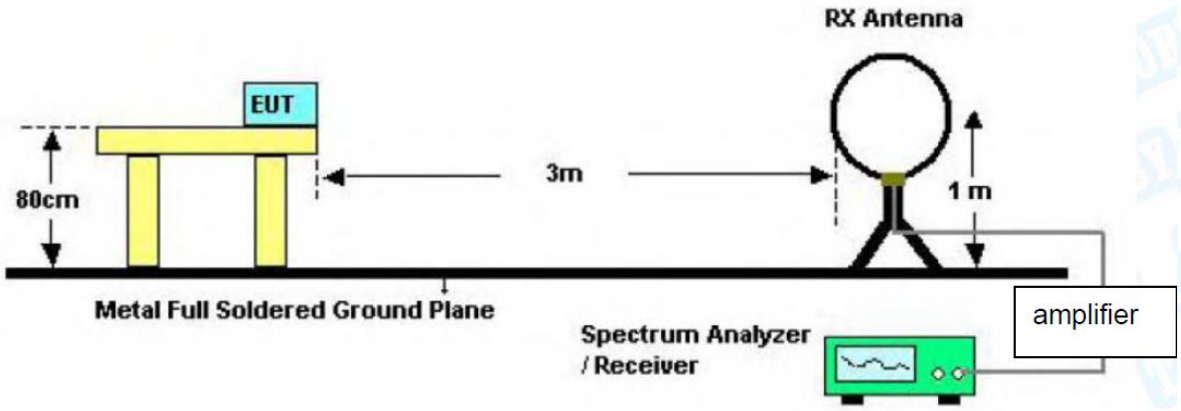
General field strength limits at frequencies above 30 MHz		
Frequency (MHz)	**Field strength (μV/m at 3 m)**	**Measurement Distance (meters)**
30~88	100	3
88~216	150	3
216~960	200	3
Above 960	500	3

General field strength limits at frequencies Above 1000MHz		
Frequency (MHz)	**Distance of 3m (dBuV/m)**	
	Peak	**Average**
Above 1000	74	54
Note: (1) The tighter limit applies at the band edges. (2) Emission Level(dBuV/m)=20log Emission Level(uV/m)		

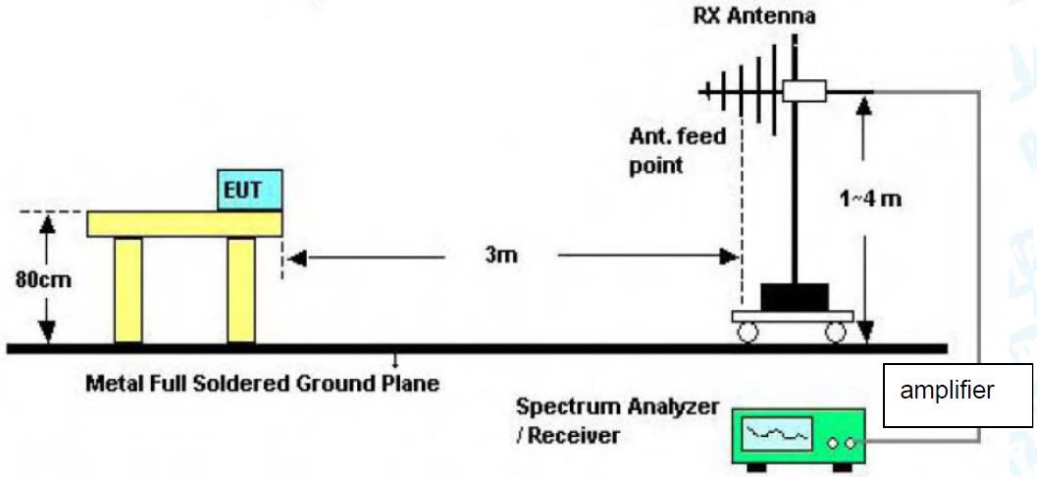
In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated device is operating, the RF power that is produced shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided that the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of root-mean-square averaging over a time interval, as permitted under section 5.4(d), the attenuation required shall be 30 dB instead of 20 dB. Attenuation below the general field strength limits specified in RSS-Gen is not required.

6.2 Test Setup

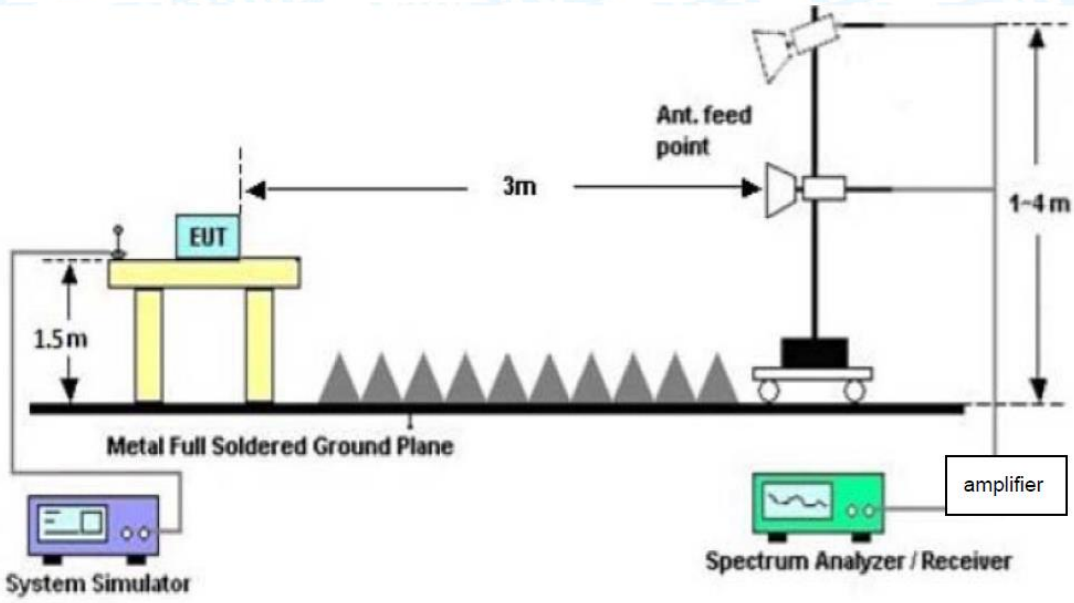
Radiated measurement



Below 30MHz Test Setup

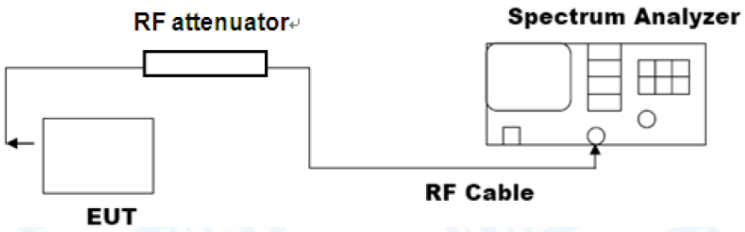


Below 1000MHz Test Setup



Above 1GHz Test Setup

Conducted measurement



6.3 Test Procedure

---Radiated measurement

●The measuring distance of 3m shall be used for measurements at frequency up to 1GHz and above 1 GHz. The EUT was placed on a rotating 0.8m high above ground, the table was rotated 360 degrees to determine the position of the highest radiation.

● Measurements at frequency above 1GHz. The EUT was placed on a rotating 1.5m high above the ground. RF absorbers covered the ground plane with a minimum area of 3.0m by 3.0m between the EUT and measurement receiver antenna. The RF absorber shall not exceed 30cm in high above the conducting floor. The table was rotated 360 degrees to determine the position of the highest radiation.

● The Test antenna shall vary between 1m and 4m, Both Horizontal and Vertical antenna are set to make measurement.

●The initial step in collecting conducted emission data is a spectrum analyzer peak detector mode pre-scanning the measurement frequency range. Significant peaks are then marked and then Quasi Peak detector mode re-measured.

●If the Peak Mode measured value compliance with and lower than Quasi Peak Mode Limit Below 1 GHz, the EUT shall be deemed to meet QP Limits and then no additional QP Mode measurement performed. But the Peak Value and average value both need to comply with applicable limit above 1 GHz.

●Testing frequency range 30MHz-1GHz the measuring instrument use VBW=120 kHz with Quasi-peak detection. Testing frequency range 9KHz-150Hz the measuring instrument use VBW=200Hz with Quasi-peak detection. Testing frequency range 9KHz-30MHz the measuring instrument use VBW=9kHz with Quasi-peak detection.

●Testing frequency range above 1GHz the measuring instrument use RBW=1 MHz and VBW=3 MHz with Peak Detector for Peak Values, and use RBW=1 MHz and VBW=10 Hz with Peak Detector for Average Values.

●For the actual test configuration, please see the test setup photo.

--- Conducted measurement

●Reference level measurement

Establish a reference level by using the following procedure:

a) Set instrument center frequency to DTS channel center frequency.

b) Set the span to≥1.5 times the DTS bandwidth.

c) Set the RBW = 100 kHz.

d) Set the VBW≥[3*RBW].

e) Detector = peak.

f) Sweep time = auto couple.

g) Trace mode = max hold.

h) Allow trace to fully stabilize.

i) Use the peak marker function to determine the maximum PSD level.

Note that the channel found to contain the maximum PSD level can be used to establish the reference level.

●Emission level measurement

Establish an emission level by using the following procedure:

a) Set the center frequency and span to encompass frequency range to be measured.

b) Set the RBW = 100 kHz.

c) Set the VBW≥[3*RBW].

d) Detector = peak.

e) Sweep time = auto couple.

f) Trace mode = max hold.

g) Allow trace to fully stabilize.

h) Use the peak marker function to determine the maximum amplitude level.

Ensure that the amplitude of all unwanted emissions outside of the authorized frequency band (excluding restricted frequency bands) is attenuated by at least the minimum requirements specified in 11.11. Report the three highest emissions relative to the limit.

6.4 Deviation From Test Standard

No deviation

6.5 EUT Operating Mode

Please refer to the description of test mode.

6.6 Test Data

Please refer to the Attachment B.

7. Emissions in nonrestricted frequency bands

7.1 Test Standard and Limit

7.1.1 Test Standard

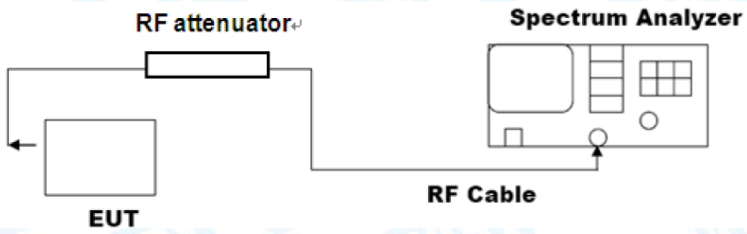
FCC Part 15.205 & FCC Part 15.247(d)

7.1.2 Test Limit

In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated device is operating, the RF power that is produced shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided that the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of root-mean-square averaging over a time interval, as permitted under section 5.4(d), the attenuation required shall be 30 dB instead of 20 dB. Attenuation below the general field strength limits specified in RSS-Gen is not required.

7.2 Test Setup

Conducted measurement



7.3 Test Procedure

Reference level measurement

Establish a reference level by using the following procedure:

a) Set instrument center frequency to DTS channel center frequency.

b) Set the span to ≥1.5 times the DTS bandwidth.

c) Set the RBW = 100 kHz.

d) Set the VBW≥[3*RBW].

e) Detector = peak.

f) Sweep time = auto couple.

g) Trace mode = max hold.

h) Allow trace to fully stabilize.

i) Use the peak marker function to determine the maximum PSD level.

Note that the channel found to contain the maximum PSD level can be used to establish the reference level.

Emission level measurement

Establish an emission level by using the following procedure:

a) Set the center frequency and span to encompass frequency range to be measured.

b) Set the RBW = 100 kHz.

c) Set the VBW≥ [3*RBW].

d) Detector = peak.

e) Sweep time = auto couple.

f) Trace mode = max hold.

g) Allow trace to fully stabilize.

h) Use the peak marker function to determine the maximum amplitude level.

7.4 Deviation From Test Standard

No deviation

7.5 EUT Operating Mode

Please refer to the description of test mode.

7.6 Test Data

Please refer to the Attachment C.

8. 99% Occupied and 20dB Bandwidth

8.1 Test Standard and Limit

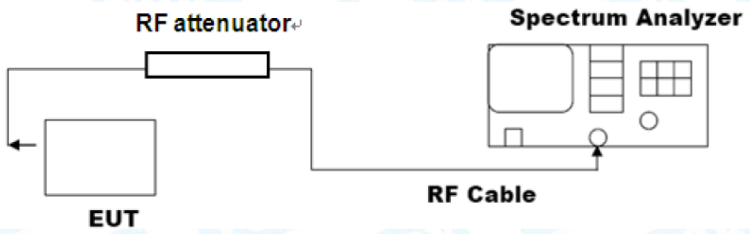
8.1.1 Test Standard

FCC Part 15.205 & FCC Part 15.247(a)

8.1.2 Test Limit

There are no limits for 20dB bandwidth and 99% occupied bandwidth.

8.2 Test Setup



8.3 Test Procedure

●The occupied bandwidth is the frequency bandwidth such that, below its lower and above its upper frequency limits, the mean powers are each equal to 0.5% of the total mean power of the given emission. The following procedure shall be used for measuring 99% power bandwidth:

a) The instrument center frequency is set to the nominal EUT channel center frequency. The frequency span for the spectrum analyzer shall be between 1.5 times and 5.0 times the OBW.

b) The nominal IF filter bandwidth (3 dB RBW) shall be in the range of 1% to 5% of the OBW, and VBW shall be approximately three times the RBW, unless otherwise specified by the applicable requirement.

c) Set the reference level of the instrument as required, keeping the signal from exceeding the maximum input mixer level for linear operation. In general, the peak of the spectral envelope shall be more than [10 log (OBW/RBW)] below the reference level. Specific guidance is given in 4.1.5.2.

d) Step a) through step c) might require iteration to adjust within the specified range.

e) Video averaging is not permitted. Where practical, a sample detection and single sweep mode shall be used. Otherwise, peak detection and max hold mode (until the trace stabilizes) shall be used.

f) Use the 99% power bandwidth function of the instrument (if available) and report the measured bandwidth.

g) If the instrument does not have a 99% power bandwidth function, then the trace data points are recovered and directly summed in linear power terms. The recovered amplitude data points, beginning at the lowest frequency, are placed in a running sum until 0.5% of the total is reached; that frequency is recorded as the lower frequency. The process is repeated until 99.5% of the total is reached; that frequency is recorded as the upper frequency. The 99% power bandwidth is the difference between these two frequencies.

h) The occupied bandwidth shall be reported by providing plot(s) of the measuring

instrument display; the plot axes and the scale units per division shall be clearly labeled. Tabular data may be reported in addition to the plot(s).

8.4 Deviation From Test Standard

No deviation

8.5 EUT Operating Mode

Please refer to the description of test mode.

8.6 Test Data

Please refer to the Attachment D.

9. Peak Output Power Test

9.1 Test Standard and Limit

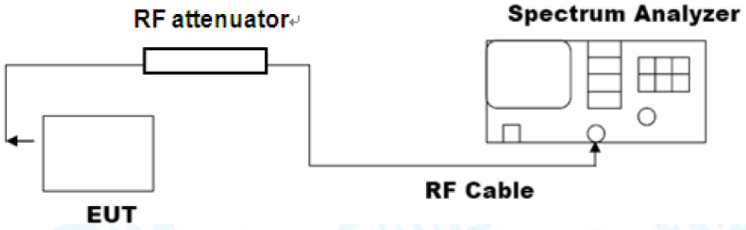
9.1.1 Test Standard

FCC Part 15.247(b)(1)

9.1.2 Test Limit

Test Item	Limit	Frequency Range(MHz)
Peak Output Power	$P_{max\text{-}pk}$ ≤ 1 W N_{ch} ≥ 50 f ≥ MAX { 25 kHz, BW_{20dB} } BW_{20dB} ≤250KHz t_{ch} ≤ 0.4 s for T = 20s	902~928
	$P_{max\text{-}pk}$ ≤ 0.25W 25≤N_{ch} ＜50 f ≥ MAX { 25 kHz, BW_{20dB} } 250KHz＜BW_{20dB} ≤500KHz t_{ch} ≤ 0.4 s for T = 10s	
t_{ch} = average time of occupancy; T = period; N_{ch} = # hopping frequencies; BW = bandwidth; f = hopping channel carrier frequency separation		

9.2 Test Setup



9.3 Test Procedure

●This is an RF-conducted test to evaluate maximum peak output power. Use a direct connection between the antenna port of the unlicensed wireless device and the spectrum analyzer, through suitable attenuation. The hopping shall be disabled for this test:

a) Use the following spectrum analyzer settings:
   1) Span: Approximately five times the 20 dB bandwidth, centered on a hopping channel.
   2) RBW > 20 dB bandwidth of the emission being measured.
   3) VBW≥ RBW.
   4) Sweep: Auto.
   5) Detector function: Peak.
   6) Trace: Max hold.

b) Allow trace to stabilize.

c) Use the marker-to-peak function to set the marker to the peak of the emission.

d) The indicated level is the peak output power, after any corrections for external attenuators and cables.

e) A plot of the test results and setup description shall be included in the test report.

NOTE-A peak responding power meter may be used, where the power meter and sensor system video bandwidth is greater than the occupied bandwidth of the unlicensed wireless device, rather than a spectrum analyzer.

9.4 Deviation From Test Standard

No deviation

9.5 EUT Operating Mode

Please refer to the description of test mode.

9.6 Test Data

Please refer to the Attachment E.

10. Power Spectral Density

10.1 Test Standard and Limit

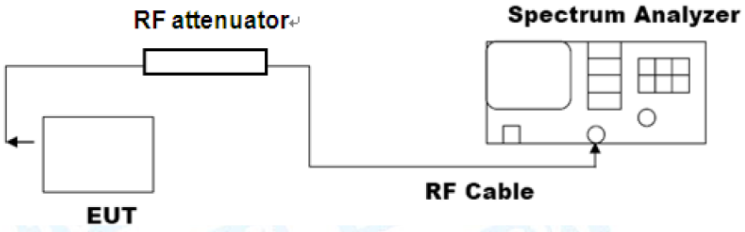
10.1.1 Test Standard

FCC Part 15.247(f)

10.1.2 Test Limit

Test Item	Limit
Power Spectral Density	8dBm(in any 3 kHz)

10.2 Test Setup



10.3 Test Procedure

●The following procedure shall be used if maximum peak conducted output power was used to determine compliance, and it is optional if the maximum conducted (average) output power was used to determine compliance:

a) Set analyzer center frequency to DTS channel center frequency.
b) Set the span to 1.5 times the DTS bandwidth.
c) Set the RBW to 3 kHz≤RBW≤100 kHz.
d) Set the VBW ≥[3*RBW].
e) Detector = peak.
f) Sweep time = auto couple.
g) Trace mode = max hold.
h) Allow trace to fully stabilize.
i) Use the peak marker function to determine the maximum amplitude level within the RBW.
j) If measured value exceeds requirement, then reduce RBW (but no less than 3 kHz) and repeat.

10.4 Deviation From Test Standard

No deviation

10.5 Antenna Connected Construction

Please refer to the description of test mode.

10.6 Test Data

Please refer to the Attachment F.

11. Carrier frequency separation

11.1 Test Standard and Limit

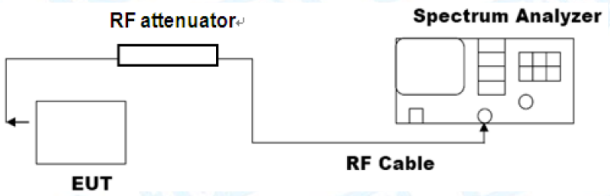
11.1.1 Test Standard

FCC Part 15.247(a)(1)

11.1.2 Test Limit

Test Item	Limit	Frequency Range(MHz)
Carrier frequency separation	$P_{max\text{-}pk}$ ≤ 1 W N_{ch} ≥ 50 f ≥ MAX { 25 kHz, BW_{20dB} } BW_{20dB} ≤250KHz t_{ch} ≤ 0.4 s for T = 20s	902~928
	$P_{max\text{-}pk}$ ≤ 0.25W 25≤N_{ch}＜50 f ≥ MAX { 25 kHz, BW_{20dB} } 250KHz＜BW_{20dB} ≤500KHz t_{ch} ≤ 0.4 s for T = 10s	
t_{ch} = average time of occupancy; T = period; N_{ch} = # hopping frequencies; BW = bandwidth; f = hopping channel carrier frequency separation		

11.2 Test Setup



11.3 Test Procedure

●The EUT shall have its hopping function enabled. Use the following spectrum analyzer settings:

a) Span: Wide enough to capture the peaks of two adjacent channels.

b) RBW: Start with the RBW set to approximately 30% of the channel spacing; adjust as necessary to best identify the center of each individual channel.

c) Video (or average) bandwidth (VBW) ≥ RBW.

d) Sweep: Auto.

e) Detector function: Peak.

f) Trace: Max hold.

g) Allow the trace to stabilize.

Use the marker-delta function to determine the separation between the peaks of the adjacent channels.

Compliance of an EUT with the appropriate regulatory limit shall be determined. A plot of the data shall be included in the test report.

11.4 Deviation From Test Standard

No deviation

11.5 Antenna Connected Construction

Please refer to the description of test mode.

11.6 Test Data

Please refer to the Attachment G.

12. Time of occupancy (Dwell time)

12.1 Test Standard and Limit

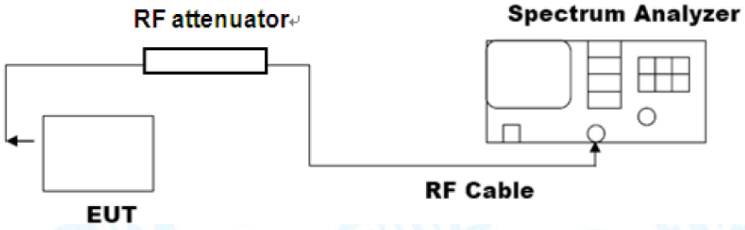
12.1.1 Test Standard

FCC Part 15.247(f)

12.1.2 Test Limit

Test Item	Limit	Frequency Range(MHz)
Time of occupancy (dwell time)	$P_{max\text{-}pk}$ ≤ 1 W N_{ch} ≥ 50 f ≥ MAX { 25 kHz, BW_{20dB} } BW_{20dB} ≤250KHz t_{ch} ≤ 0.4 s for T = 20s	902~928
	$P_{max\text{-}pk}$ ≤ 0.25W 25≤N_{ch} <50 f ≥ MAX { 25 kHz, BW_{20dB} } 250KHz< BW_{20dB} ≤500KHz t_{ch} ≤ 0.4 s for T = 10s	
t_{ch} = average time of occupancy; T = period; N_{ch} = # hopping frequencies; BW = bandwidth; f = hopping channel carrier frequency separation		

12.2 Test Setup



12.3 Test Procedure

●The EUT shall have its hopping function enabled. Use the following spectrum analyzer settings:

a) Span: Zero span, centered on a hopping channel.

b) RBW shall be □ channel spacing and where possible RBW should be set >> 1 / T, where T is the expected dwell time per channel.

c) Sweep: As necessary to capture the entire dwell time per hopping channel; where possible use a video trigger and trigger delay so that the transmitted signal starts a little to the right of the start of the plot. The trigger level might need slight adjustment to prevent triggering when the system hops on an adjacent channel; a second plot might be needed with a longer sweep time to show two successive hops on a channel.

d) Detector function: Peak.

e) Trace: Max hold.

Use the marker-delta function to determine the transmit time per hop. If this value varies with different modes of operation (data rate, modulation format, number of hopping

channels, etc.), then repeat this test for each variation in transmit time.
Repeat the measurement using a longer sweep time to determine the number of hops over the period specified in the requirements. The sweep time shall be equal to, or less than, the period specified in the requirements. Determine the number of hops over the sweep time and calculate the total number of hops in the period specified in the requirements, using the following equation:
(Number of hops in the period specified in the requirements) =
(number of hops on spectrum analyzer)x(period specified in the requirements / analyzer sweep time)
The average time of occupancy is calculated from the transmit time per hop multiplied by the number of hops in the period specified in the requirements. If the number of hops in a specific time varies with different modes of operation (data rate, modulation format, number of hopping channels, etc.), then repeat this test for each variation.
The measured transmit time and time between hops shall be consistent with the values described in the operational description for the EUT.

12.4 Deviation From Test Standard

No deviation

12.5 Antenna Connected Construction

Please refer to the description of test mode.

12.6 Test Data

Please refer to the Attachment H.

13. Number of hopping frequencies

13.1 Test Standard and Limit

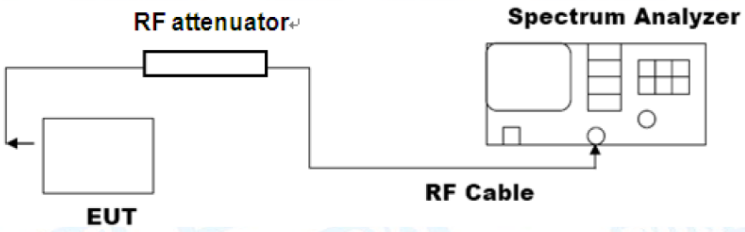
13.1.1 Test Standard

FCC Part 15.247(b)(1)

13.1.2 Test Limit

Test Item	Limit	Frequency Range(MHz)
Carrier frequency separation	P_{max-pk} ≤ 1 W N_{ch} ≥ 50 f ≥ MAX { 25 kHz, BW_{20dB} } BW_{20dB} ≤250KHz t_{ch} ≤ 0.4 s for T = 20s	902~928
	P_{max-pk} ≤ 0.25W 25≤N_{ch} <50 f ≥ MAX { 25 kHz, BW_{20dB} } 250KHz< BW_{20dB} ≤500KHz t_{ch} ≤ 0.4 s for T = 10s	
t_{ch} = average time of occupancy; T = period; N_{ch} = # hopping frequencies; BW = bandwidth; f = hopping channel carrier frequency separation		
There is no minimum number of hopping channels associated with this type of hybrid system. While there is not a specific minimum limit, the hop sequence is required to appear as pseudorandom per Section 15.247(a)(1) (see Section 3 of this document).		

13.2 Test Setup



13.3 Test Procedure

●The EUT shall have its hopping function enabled. Use the following spectrum analyzer settings:

a) Span: The frequency band of operation. Depending on the number of channels the device supports, it may be necessary to divide the frequency range of operation across multiple spans, to allow the individual channels to be clearly seen.

b) 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.

c) VBW ≥ RBW.

d) Sweep: Auto.

e) Detector function: Peak.

f) Trace: Max hold.

g) Allow the trace to stabilize.
It might prove necessary to break the span up into subranges to show clearly all of the hopping frequencies.
Compliance of an EUT with the appropriate regulatory limit shall be determined for the number of hopping channels. A plot of the data shall be included in the test report.

13.4 Deviation From Test Standard

No deviation

13.5 Antenna Connected Construction

Please refer to the description of test mode.

13.6 Test Data

Please refer to the Attachment I.

14. Hopping function Requirements

14.1 Test Standard and Limit

14.1.1 Test Standard

FCC Part 15.247(a)(1)

14.1.2 Test Limit

The 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 hop-ping channel bandwidths of their corresponding transmitters and shall shift frequencies in synchronization with the transmitted signals.

14.4 Deviation From Test Standard

No deviation

14.6 Test Data

The transmitter follows the LoRa alliance protocol which complies with the pseudo-random hop sequence, equal use of each frequency, and receiver matching bandwidth and synchronization requirements.

15. Antenna Requirement

15.1 Test Standard and Limit

15.1.1 Test Standard

FCC Part 15.203

15.1.2 Requirement

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. The manufacturer may design the unit so that a broken antenna can be replaced by the user, but the use of a standard antenna jack or electrical connector is prohibited.

15.2 Deviation From Test Standard

No deviation

15.3 Antenna Connected Construction

The gains of the antenna used for transmitting is 3.0dBi, and the antenna de-signed with Unique connector antenna and consideration of replacement. Please see the EUT photo for details.

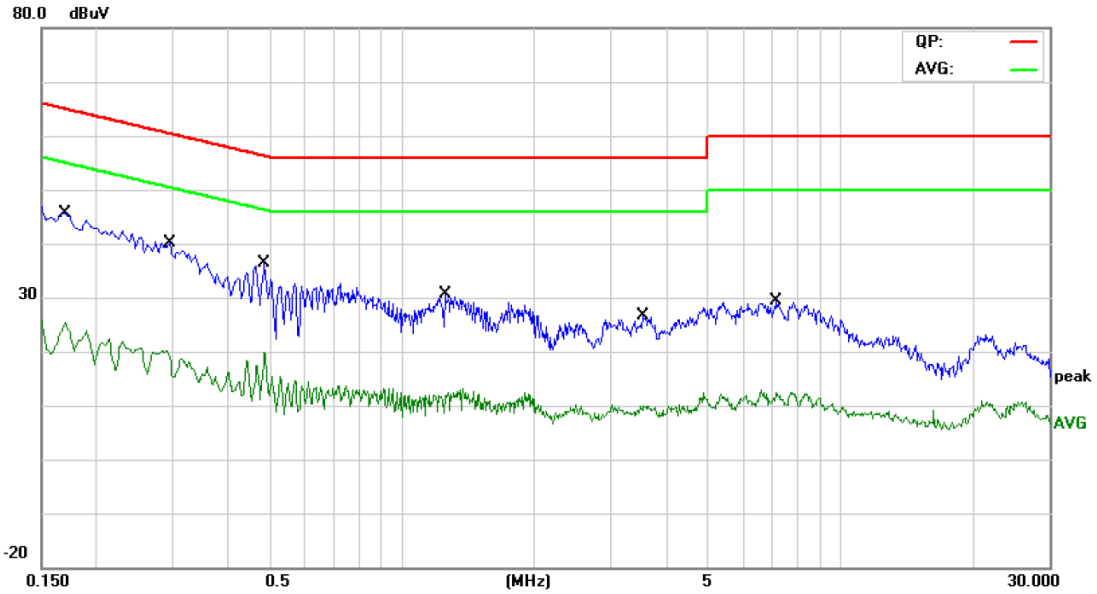
15.4 Test Data

The EUT antenna is a Internal antenna. It complies with the standard requirement.

Antenna Type
☒Permanent attached antenna
☐Unique connector antenna
☐Professional installation antenna

Attachment A-- Conducted Emission Test Data

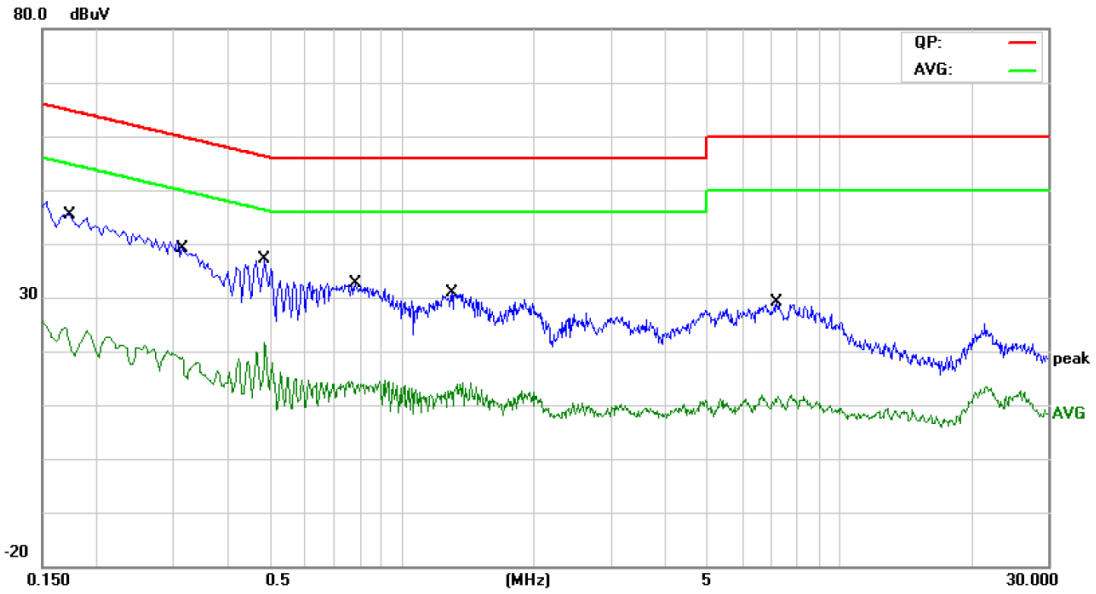
Temperature:	24.5℃	**Relative Humidity:**	45%
Test Voltage:	AC 120V/60Hz		
Terminal:	Line		
Test Mode:	Mode 1		
Remark:	Only worse case is reported.		



No.	Mk.	Freq.	Reading Level	Correct Factor	Measure-ment	Limit	Over	
		MHz	dBuV	dB	dBuV	dBuV	dB	Detector
1		0.1700	30.50	11.62	42.12	64.96	-22.84	QP
2		0.1700	11.64	11.62	23.26	54.96	-31.70	AVG
3		0.2940	24.42	11.59	36.01	60.41	-24.40	QP
4		0.2940	6.29	11.59	17.88	50.41	-32.53	AVG
5	*	0.4860	22.76	11.50	34.26	56.24	-21.98	QP
6		0.4860	8.03	11.50	19.53	46.24	-26.71	AVG
7		1.2540	14.25	11.02	25.27	56.00	-30.73	QP
8		1.2540	-0.09	11.02	10.93	46.00	-35.07	AVG
9		3.5460	10.42	10.14	20.56	56.00	-35.44	QP
10		3.5460	-1.27	10.14	8.87	46.00	-37.13	AVG
11		7.1380	14.45	10.02	24.47	60.00	-35.53	QP
12		7.1380	1.26	10.02	11.28	50.00	-38.72	AVG

Remark:
1. Corr. Factor (dB) = LISN Factor (dB) + Cable Loss (dB)
2. Margin (dB) =QuasiPeak/Average (dBuV)-Limit (dBuV)

Temperature:	24.5℃	**Relative Humidity:**	45%
Test Voltage:	AC 120V/60Hz		
Terminal:	Neutral		
Test Mode:	Mode 1		
Remark:	Only worse case is reported.		



No.	Mk.	Freq.	Reading Level	Correct Factor	Measure-ment	Limit	Over	
		MHz	dBuV	dB	dBuV	dBuV	dB	Detector
1		0.1749	28.43	11.63	40.06	64.72	-24.66	QP
2		0.1749	9.89	11.63	21.52	54.72	-33.20	AVG
3		0.3180	23.51	11.55	35.06	59.76	-24.70	QP
4		0.3180	5.93	11.55	17.48	49.76	-32.28	AVG
5	*	0.4860	23.73	11.50	35.23	56.24	-21.01	QP
6		0.4860	9.98	11.50	21.48	46.24	-24.76	AVG
7		0.7820	16.49	11.38	27.87	56.00	-28.13	QP
8		0.7820	1.44	11.38	12.82	46.00	-33.18	AVG
9		1.2980	14.88	10.98	25.86	56.00	-30.14	QP
10		1.2980	0.37	10.98	11.35	46.00	-34.65	AVG
11		7.1780	13.96	10.02	23.98	60.00	-36.02	QP
12		7.1780	0.41	10.02	10.43	50.00	-39.57	AVG

Remark:
1. Corr. Factor (dB) = LISN Factor (dB) + Cable Loss (dB)
2. Margin (dB) =QuasiPeak/Average (dBuV)-Limit (dBuV)

Attachment B--Unwanted Emissions Data

---Radiated Unwanted Emissions

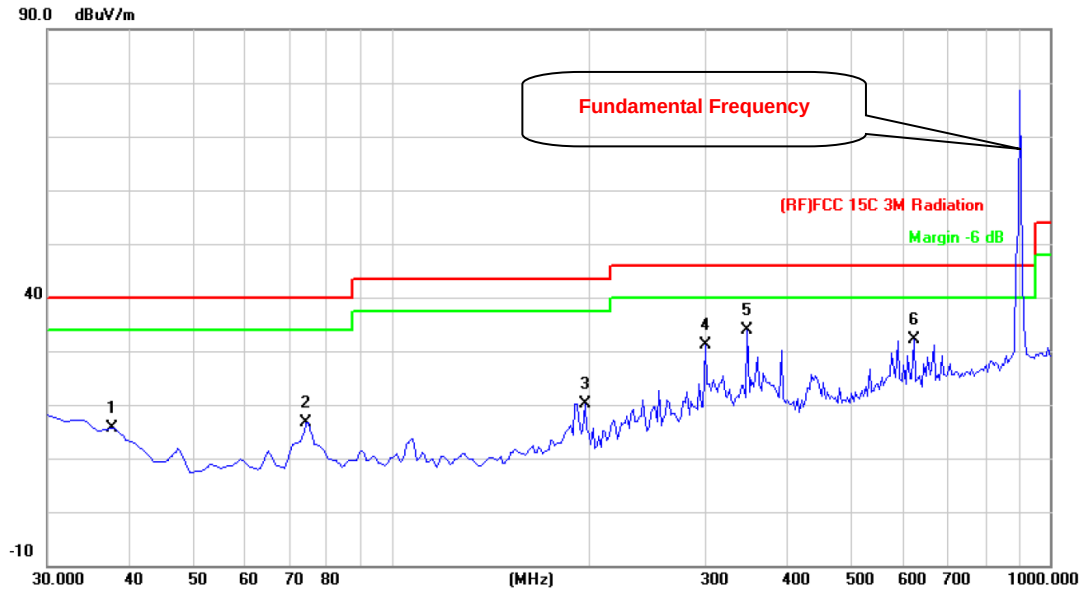
9 KHz~30 MHz

From 9 KHz to 30 MHz: Conclusion: PASS

Note: The amplitude of spurious emissions which are attenuated by more than 20dB Below the permissible value has no need to be reported.

30MHz~1GHz

Temperature:	23.5℃	**Relative Humidity:**	46%
Test Voltage:	AC 120V/60Hz		
Ant. Pol.	Horizontal		
Test Mode:	Mode 2 (902.3MHz)		
Remark:	Only worse case is reported.		



No.	Mk.	Freq.	Reading Level	Correct Factor	Measure-ment	Limit	Over	
		MHz	dBuV	dB/m	dBuV/m	dBuV/m	dB	Detector
1		37.7599	34.10	-18.42	15.68	40.00	-24.32	peak
2		74.6200	39.86	-23.22	16.64	40.00	-23.36	peak
3		196.8400	40.29	-20.06	20.23	43.50	-23.27	peak
4		299.6600	47.43	-16.30	31.13	46.00	-14.87	peak
5	*	348.1600	48.68	-14.76	33.92	46.00	-12.08	peak
6		621.7000	40.29	-8.24	32.05	46.00	-13.95	peak

*:Maximum data x:Over limit !:over margin

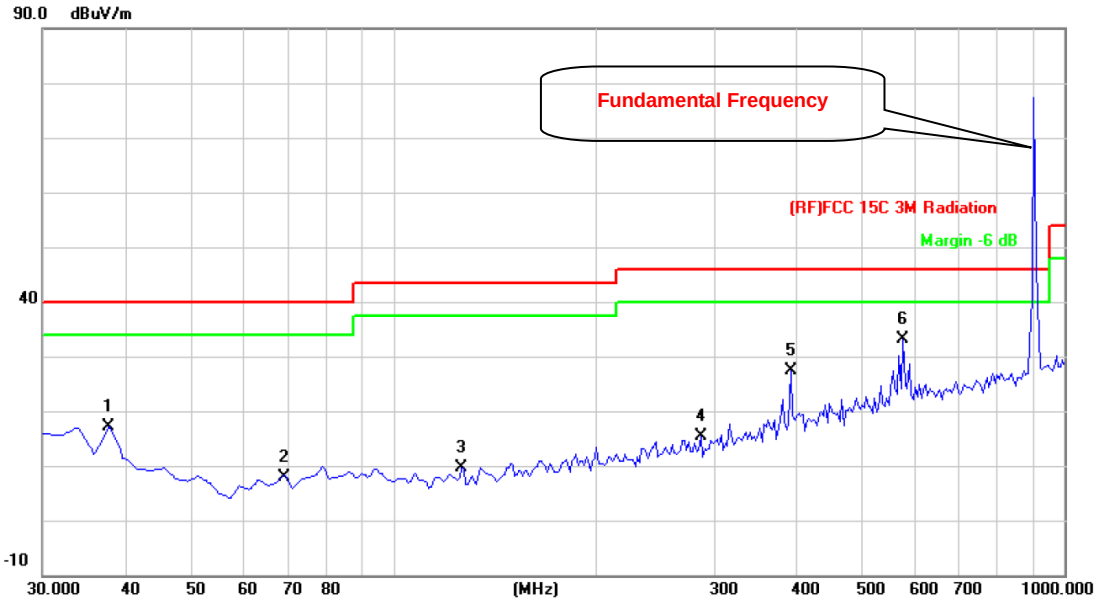
Remark:

1. Corr. = Antenna Factor (dB/m) + Cable Loss (dB)

2. QuasiPeak (dBμV/m)= Corr. (dB/m)+ Read Level (dBμV)

3. Margin (dB) = QuasiPeak (dBμV/m)-Limit QPK(dBμV/m)

Temperature:	23.5℃	**Relative Humidity:**	46%
Test Voltage:	AC 120V/60Hz		
Ant. Pol.	Vertical		
Test Mode:	Mode 2 (902.3MHz)		
Remark:	Only worse case is reported.		

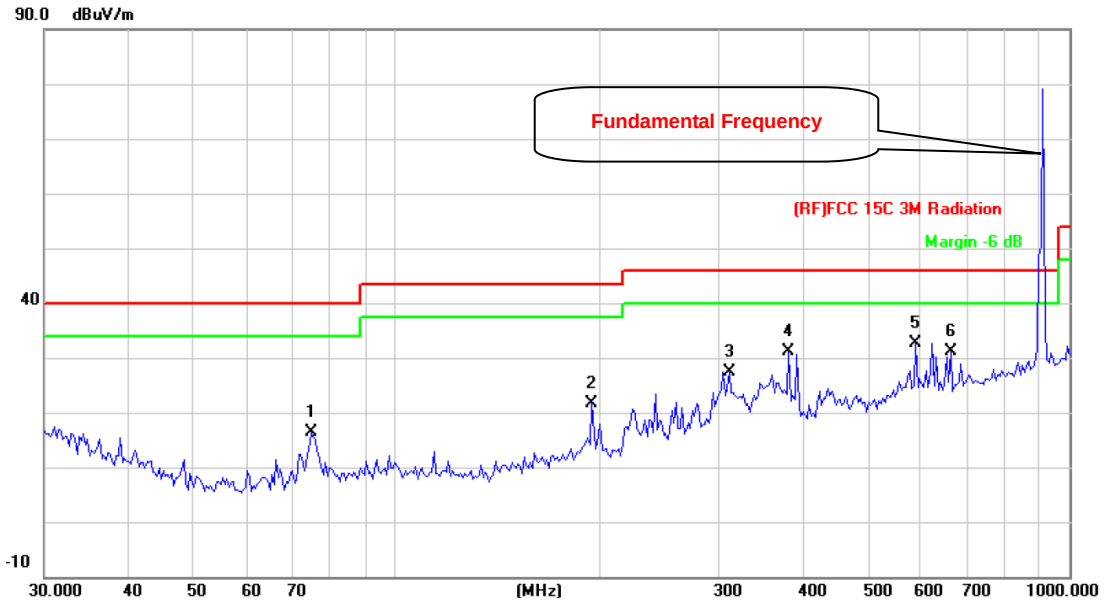


No.	Mk.	Freq.	Reading Level	Correct Factor	Measure-ment	Limit	Over	
		MHz	dBuV	dB/m	dBuV/m	dBuV/m	dB	Detector
1		37.7599	35.62	-18.42	17.20	40.00	-22.80	peak
2		68.1514	31.83	-23.87	7.96	40.00	-32.04	peak
3		127.0000	32.21	-22.54	9.67	43.50	-33.83	peak
4		288.0200	31.88	-16.53	15.35	46.00	-30.65	peak
5		392.7800	40.06	-12.72	27.34	46.00	-18.66	peak
6	*	577.0800	41.75	-8.72	33.03	46.00	-12.97	peak

*:Maximum data x:Over limit !:over margin

Remark:
1. Corr. = Antenna Factor (dB/m) + Cable Loss (dB)
2. QuasiPeak (dBμV/m)= Corr. (dB/m)+ Read Level (dBμV)
3. Margin (dB) = QuasiPeak (dBμV/m)-Limit QPK(dBμV/m)

Temperature:	23.5℃	Relative Humidity:	46%
Test Voltage:	AC 120V/60Hz		
Ant. Pol.	Horizontal		
Test Mode:	Mode 2 (908.9MHz)		
Remark:	Only worse case is reported.		

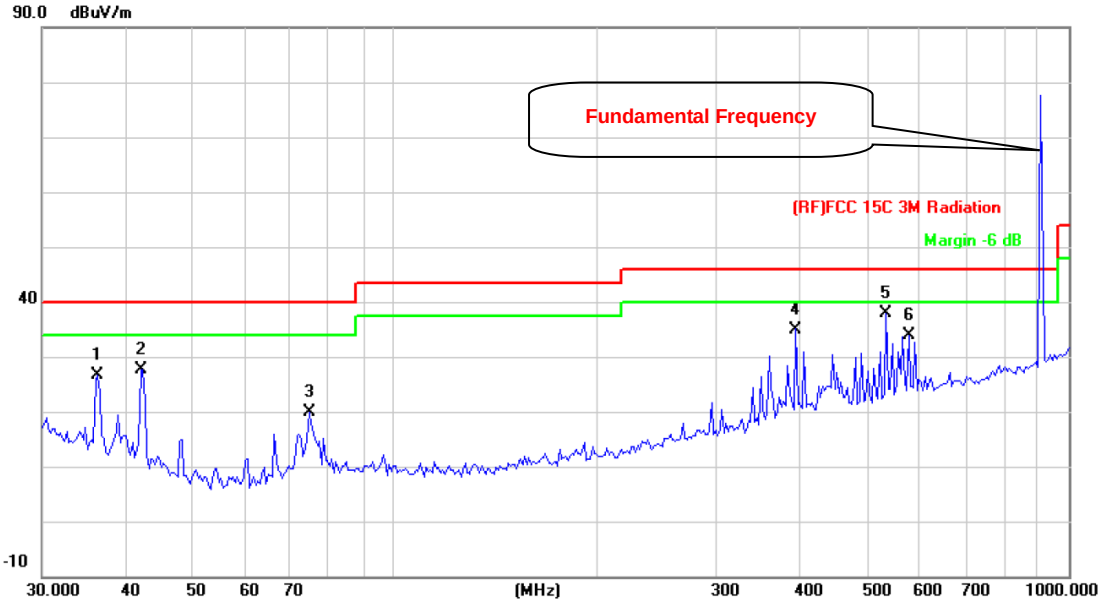


No.	Mk.	Freq.	Reading Level	Correct Factor	Measure-ment	Limit	Over	
		MHz	dBuV	dB/m	dBuV/m	dBuV/m	dB	Detector
1		74.6569	39.58	-23.22	16.36	40.00	-23.64	peak
2		195.1365	41.77	-20.02	21.75	43.50	-21.75	peak
3		312.1794	43.29	-15.89	27.40	46.00	-18.60	peak
4		382.5879	44.34	-13.20	31.14	46.00	-14.86	peak
5	*	590.9737	41.17	-8.53	32.64	46.00	-13.36	peak
6		665.8035	38.83	-7.62	31.21	46.00	-14.79	peak

*:Maximum data x:Over limit !:over margin

Remark:
1. Corr. = Antenna Factor (dB/m) + Cable Loss (dB)
2. QuasiPeak (dBμV/m)= Corr. (dB/m)+ Read Level (dBμV)
3. Margin (dB) = QuasiPeak (dBμV/m)-Limit QPK(dBμV/m)

Temperature:	23.5℃	Relative Humidity:	46%
Test Voltage:	AC 120V/60Hz		
Ant. Pol.	Vertical		
Test Mode:	Mode 2 (908.9MHz)		
Remark:	Only worse case is reported.		

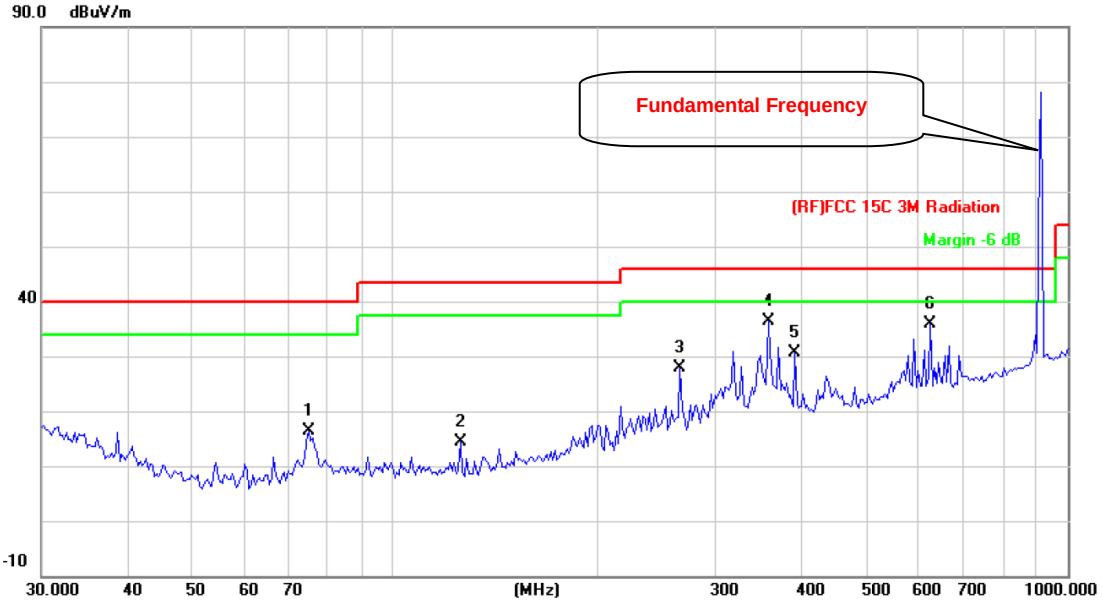


No.	Mk.	Freq.	Reading Level	Correct Factor	Measure-ment	Limit	Over	
		MHz	dBuV	dB/m	dBuV/m	dBuV/m	dB	Detector
1		36.2541	44.26	-17.72	26.54	40.00	-13.46	peak
2		42.0066	48.10	-20.45	27.65	40.00	-12.35	peak
3		74.6569	43.21	-23.22	19.99	40.00	-20.01	peak
4		393.4723	47.69	-12.69	35.00	46.00	-11.00	peak
5	*	535.7073	47.50	-9.54	37.96	46.00	-8.04	peak
6		578.6699	42.64	-8.69	33.95	46.00	-12.05	peak

*:Maximum data x:Over limit !:over margin

Remark:
1. Corr. = Antenna Factor (dB/m) + Cable Loss (dB)
2. QuasiPeak (dBμV/m)= Corr. (dB/m)+ Read Level (dBμV)
3. Margin (dB) = QuasiPeak (dBμV/m)-Limit QPK(dBμV/m)

Temperature:	23.5℃	Relative Humidity:	46%
Test Voltage:	AC 120V/60Hz		
Ant. Pol.	Horizontal		
Test Mode:	Mode 2 (914.9MHz)		
Remark:	Only worse case is reported.		

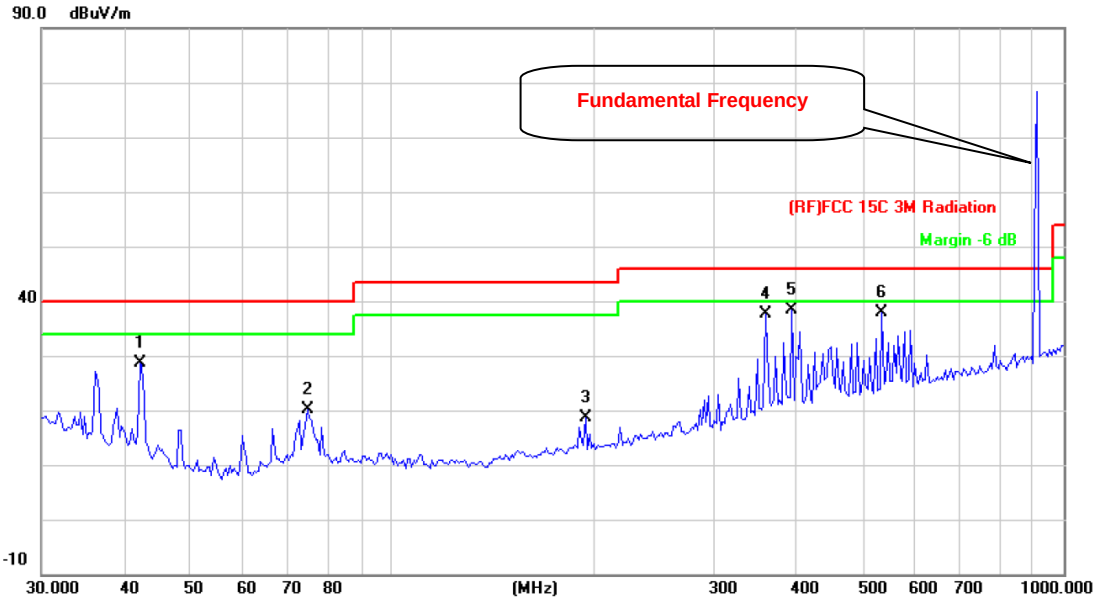


No.	Mk.	Freq.	Reading Level	Correct Factor	Measure-ment	Limit	Over	
		MHz	dBuV	dB/m	dBuV/m	dBuV/m	dB	Detector
1		74.6569	39.63	-23.22	16.41	40.00	-23.59	peak
2		125.4457	36.81	-22.52	14.29	43.50	-29.21	peak
3		265.6757	44.82	-16.98	27.84	46.00	-18.16	peak
4	*	359.1860	50.74	-14.27	36.47	46.00	-9.53	peak
5		393.4723	43.26	-12.69	30.57	46.00	-15.43	peak
6		625.0780	44.19	-8.21	35.98	46.00	-10.02	peak

*:Maximum data x:Over limit !:over margin

Remark:
1. Corr. = Antenna Factor (dB/m) + Cable Loss (dB)
2. QuasiPeak (dBμV/m)= Corr. (dB/m)+ Read Level (dBμV)
3. Margin (dB) = QuasiPeak (dBμV/m)-Limit QPK(dBμV/m)

Temperature:	23.5℃	**Relative Humidity:**	46%
Test Voltage:	AC 120V/60Hz		
Ant. Pol.	Vertical		
Test Mode:	Mode 2 (914.9MHz)		
Remark:	Only worse case is reported.		



No.	Mk.	Freq.	Reading Level	Correct Factor	Measure-ment	Limit	Over	
		MHz	dBuV	dB/m	dBuV/m	dBuV/m	dB	Detector
1		42.0066	48.98	-20.45	28.53	40.00	-11.47	peak
2		74.6569	43.37	-23.22	20.15	40.00	-19.85	peak
3		193.7728	38.62	-20.01	18.61	43.50	-24.89	peak
4		359.1860	51.92	-14.27	37.65	46.00	-8.35	peak
5	*	393.4723	51.12	-12.69	38.43	46.00	-7.57	peak
6		535.7073	47.50	-9.54	37.96	46.00	-8.04	peak

*:Maximum data x:Over limit !:over margin

Remark:
1. Corr. = Antenna Factor (dB/m) + Cable Loss (dB)
2. QuasiPeak (dBμV/m)= Corr. (dB/m)+ Read Level (dBμV)
3. Margin (dB) = QuasiPeak (dBμV/m)-Limit QPK(dBμV/m)

Above 1GHz

Temperature:	23.5℃	**Relative Humidity:**	46%
Test Voltage:	AC 120V/60Hz		
Ant. Pol.	Horizontal		
Test Mode:	TX 902.3MHz		
Remark:	Only worse case is reported.		

No.	Mk.	Freq.	Reading Level	Correct Factor	Measure-ment	Limit	Over	
		MHz	dBuV	dB/m	dBuV/m	dBuV/m	dB	Detector
1		1804.574	58.50	-2.25	56.25	74.00	-17.75	peak
2	*	1804.868	43.89	-2.25	41.64	54.00	-12.36	AVG

Remark:
1. Corr. = Antenna Factor (dB/m) + Cable Loss (dB)
2. Peak/AVG (dBμV/m)= Corr. (dB/m)+ Read Level (dBμV)
3. Margin (dB) = Peak/AVG (dBμV/m)-Limit PK/AVG(dBμV/m)
4. The tests evaluated1-10GHz,The testing has been conformed to the 10th harmonic of the highest fundamental frequency.
5. No report for the emission which more than 20dB below the prescribed limit.

Temperature:	23.5℃	**Relative Humidity:**	46%
Test Voltage:	AC 120V/60Hz		
Ant. Pol.	Vertical		
Test Mode:	TX 902.3MHz		
Remark:	Only worse case is reported.		

No.	Mk.	Freq.	Reading Level	Correct Factor	Measure-ment	Limit	Over	
		MHz	dBuV	dB/m	dBuV/m	dBuV/m	dB	Detector
1		1804.476	59.46	-2.25	57.21	74.00	-16.79	peak
2	*	1804.960	44.01	-2.25	41.76	54.00	-12.24	AVG

Remark:
1. Corr. = Antenna Factor (dB/m) + Cable Loss (dB)
2. Peak/AVG (dBμV/m)= Corr. (dB/m)+ Read Level (dBμV)
3. Margin (dB) = Peak/AVG (dBμV/m)-Limit PK/AVG(dBμV/m)
4. The tests evaluated1-10GHz,The testing has been conformed to the 10th harmonic of the highest fundamental frequency.
5. No report for the emission which more than 20dB below the prescribed limit.

Temperature:	23.5℃	**Relative Humidity:**	46%
Test Voltage:	AC 120V/60Hz		
Ant. Pol.	Horizontal		
Test Mode:	TX 908.9MHz		
Remark:	Only worse case is reported.		

No.	Mk.	Freq.	Reading Level	Correct Factor	Measure-ment	Limit	Over	
		MHz	dBuV	dB/m	dBuV/m	dBuV/m	dB	Detector
1		1817.726	56.33	-2.12	54.21	74.00	-19.79	peak
2	*	1818.202	47.21	-2.10	45.11	54.00	-8.89	AVG

Remark:
1. Corr. = Antenna Factor (dB/m) + Cable Loss (dB)
2. Peak/AVG (dBμV/m)= Corr. (dB/m)+ Read Level (dBμV)
3. Margin (dB) = Peak/AVG (dBμV/m)-Limit PK/AVG(dBμV/m)
4. The tests evaluated1-10GHz,The testing has been conformed to the 10th harmonic of the highest fundamental frequency.
5. No report for the emission which more than 20dB below the prescribed limit.

Temperature:	23.5℃	**Relative Humidity:**	46%
Test Voltage:	AC 120V/60Hz		
Ant. Pol.	Vertical		
Test Mode:	TX 908.9MHz		
Remark:	Only worse case is reported.		

No.	Mk.	Freq.	Reading Level	Correct Factor	Measure-ment	Limit	Over	
		MHz	dBuV	dB/m	dBuV/m	dBuV/m	dB	Detector
1	*	1817.936	42.63	-2.10	40.53	54.00	-13.47	AVG
2		1818.122	58.31	-2.10	56.21	74.00	-17.79	peak

Remark:
1. Corr. = Antenna Factor (dB/m) + Cable Loss (dB)
2. Peak/AVG (dBμV/m)= Corr. (dB/m)+ Read Level (dBμV)
3. Margin (dB) = Peak/AVG (dBμV/m)-Limit PK/AVG(dBμV/m)
4. The tests evaluated1-10GHz,The testing has been conformed to the 10th harmonic of the highest fundamental frequency.
5. No report for the emission which more than 20dB below the prescribed limit.

Temperature:	23.5℃	**Relative Humidity:**	46%
Test Voltage:	AC 120V/60Hz		
Ant. Pol.	Horizontal		
Test Mode:	TX 914.9MHz		
Remark:	Only worse case is reported.		

No.	Mk.	Freq.	Reading Level	Correct Factor	Measure-ment	Limit	Over	
		MHz	dBuV	dB/m	dBuV/m	dBuV/m	dB	Detector
1	*	1830.010	50.71	-1.97	48.74	54.00	-5.26	AVG
2		1830.170	60.48	-1.97	58.51	74.00	-15.49	peak

Remark:
1. Corr. = Antenna Factor (dB/m) + Cable Loss (dB)
2. Peak/AVG (dBμV/m)= Corr. (dB/m)+ Read Level (dBμV)
3. Margin (dB) = Peak/AVG (dBμV/m)-Limit PK/AVG(dBμV/m)
4. The tests evaluated1-10GHz,The testing has been conformed to the 10th harmonic of the highest fundamental frequency.
5. No report for the emission which more than 20dB below the prescribed limit.

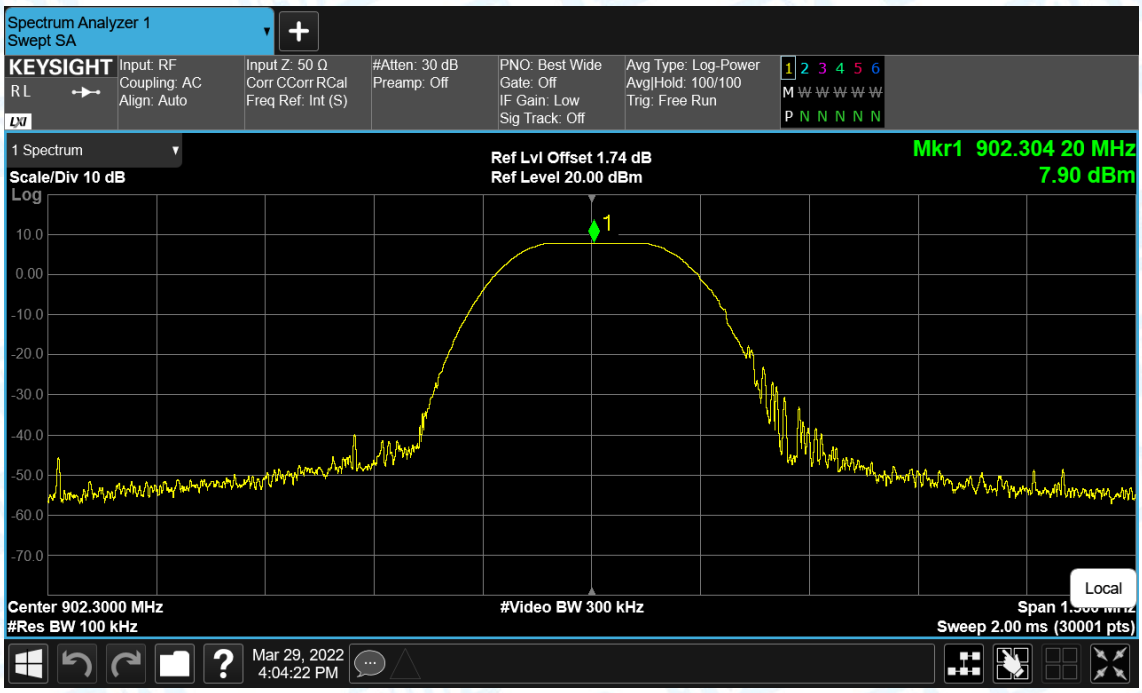
Temperature:	23.5℃	**Relative Humidity:**	46%
Test Voltage:	AC 120V/60Hz		
Ant. Pol.	Vertical		
Test Mode:	TX 914.9MHz		
Remark:	Only worse case is reported.		

No.	Mk.	Freq.	Reading Level	Correct Factor	Measure-ment	Limit	Over	
		MHz	dBuV	dB/m	dBuV/m	dBuV/m	dB	Detector
1		1829.796	56.63	-1.98	54.65	74.00	-19.35	peak
2	*	1830.164	50.94	-1.97	48.97	54.00	-5.03	AVG

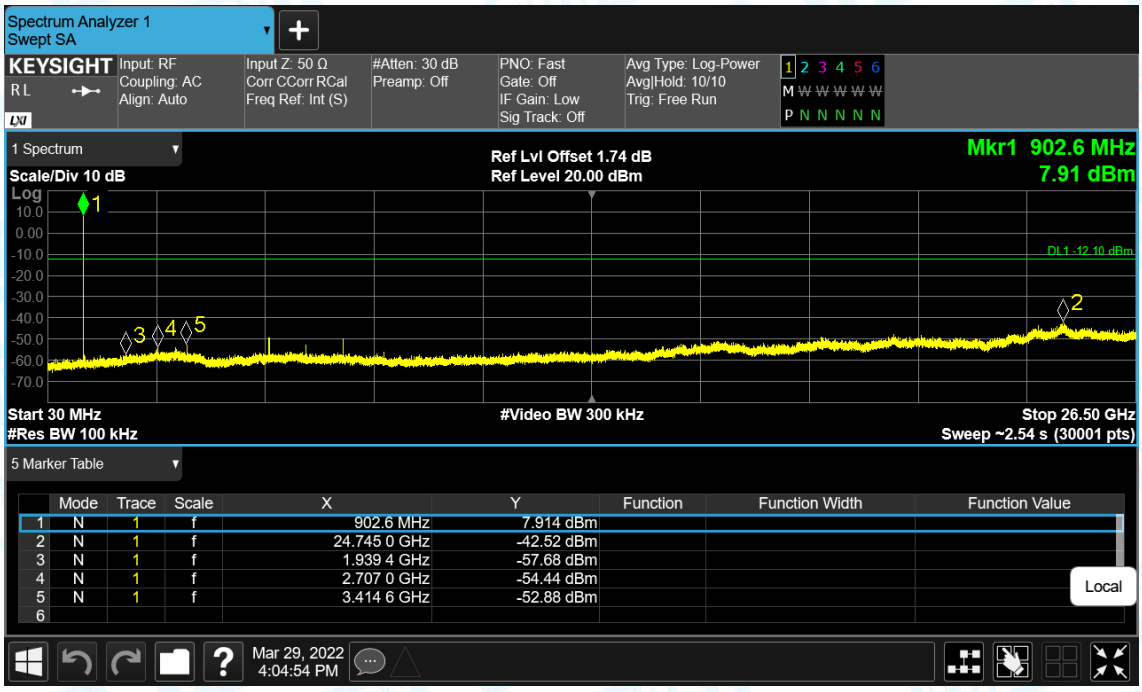
Remark:
1. Corr. = Antenna Factor (dB/m) + Cable Loss (dB)
2. Peak/AVG (dBμV/m)= Corr. (dB/m)+ Read Level (dBμV)
3. Margin (dB) = Peak/AVG (dBμV/m)-Limit PK/AVG(dBμV/m)
4. The tests evaluated1-10GHz,The testing has been conformed to the 10th harmonic of the highest fundamental frequency.
5. No report for the emission which more than 20dB below the prescribed limit.

---Conduction Unwanted Emissions

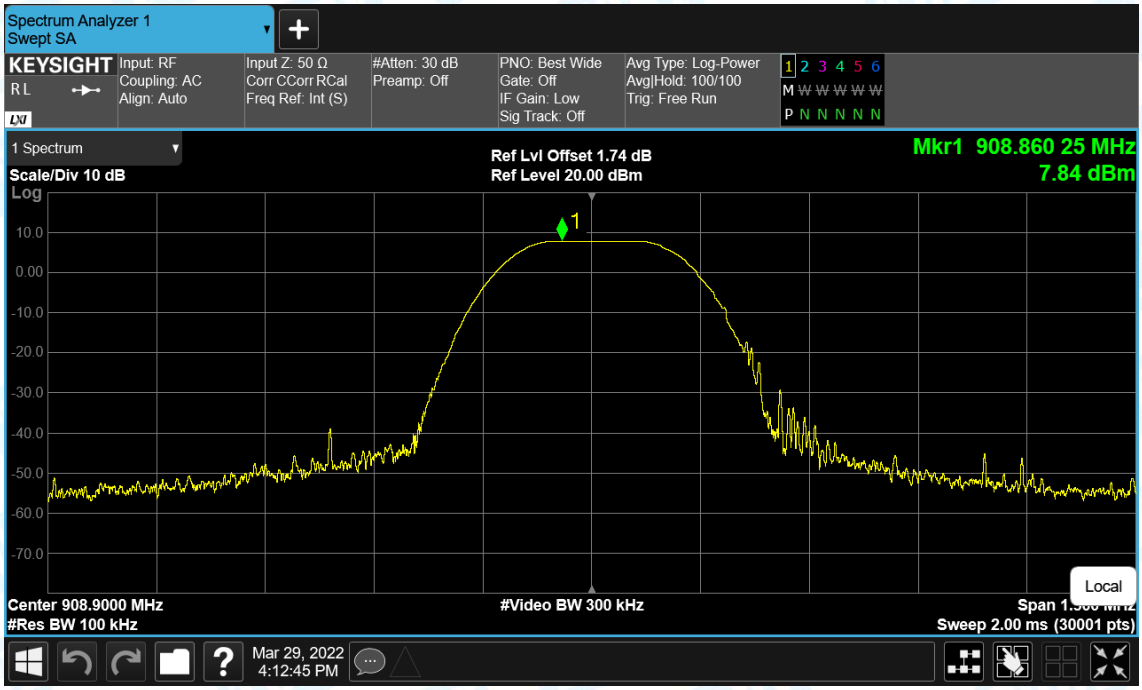
Tx. Spurious NVNT LoRa 902.3MHz Ant1 Ref



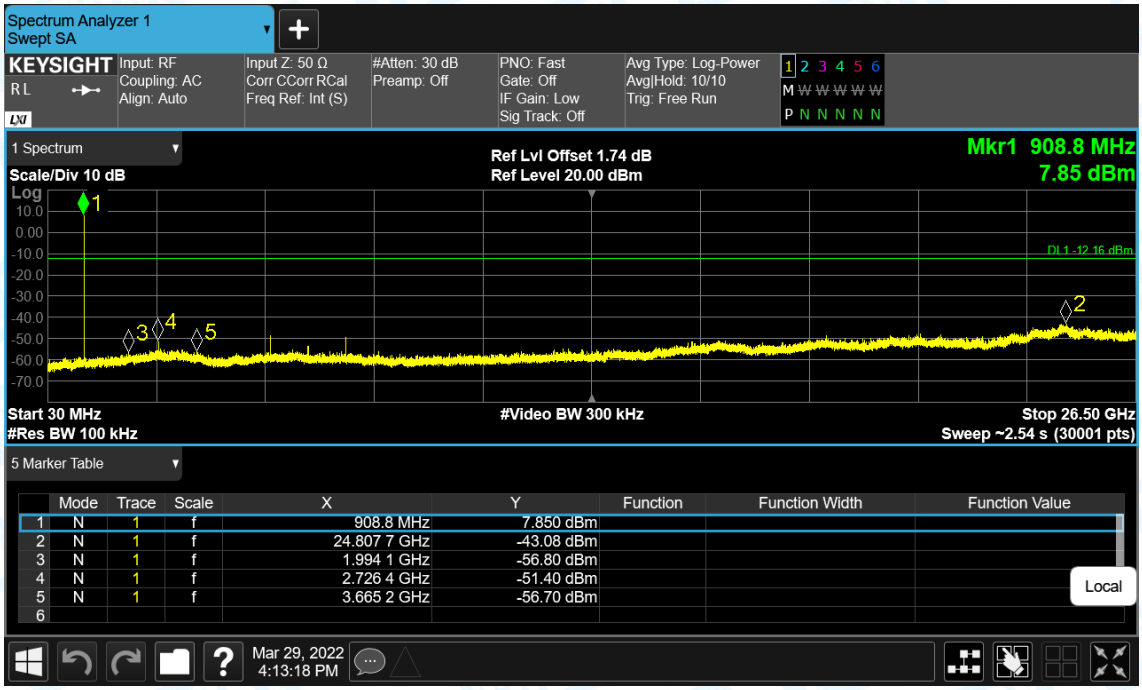
Tx. Spurious NVNT LoRa 902.3MHz Ant1 Emission



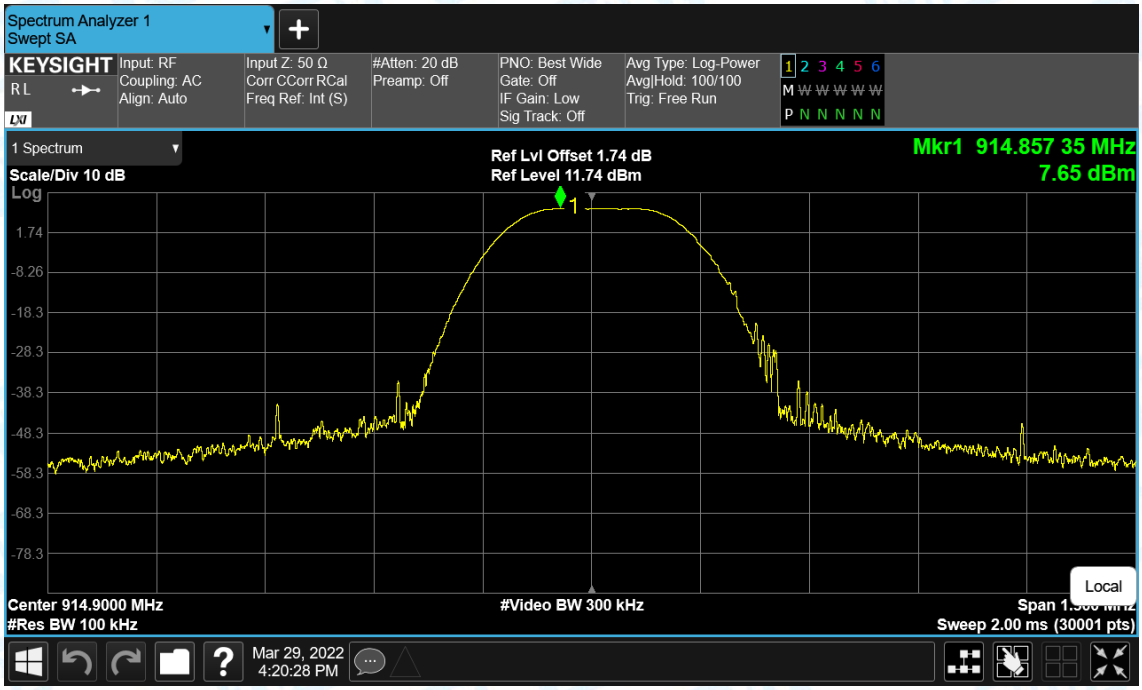
Tx. Spurious NVNT LoRa 908.9MHz Ant1 Ref



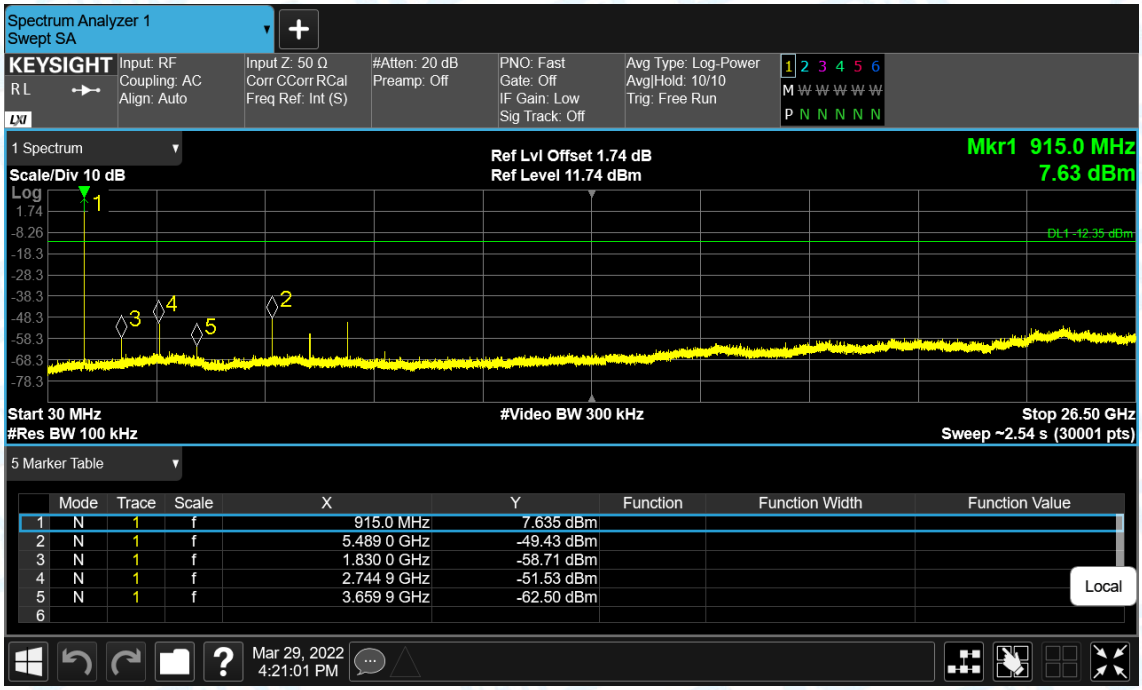
Tx. Spurious NVNT LoRa 908.9MHz Ant1 Emission



Tx. Spurious NVNT LoRa 914.9MHz Ant1 Ref

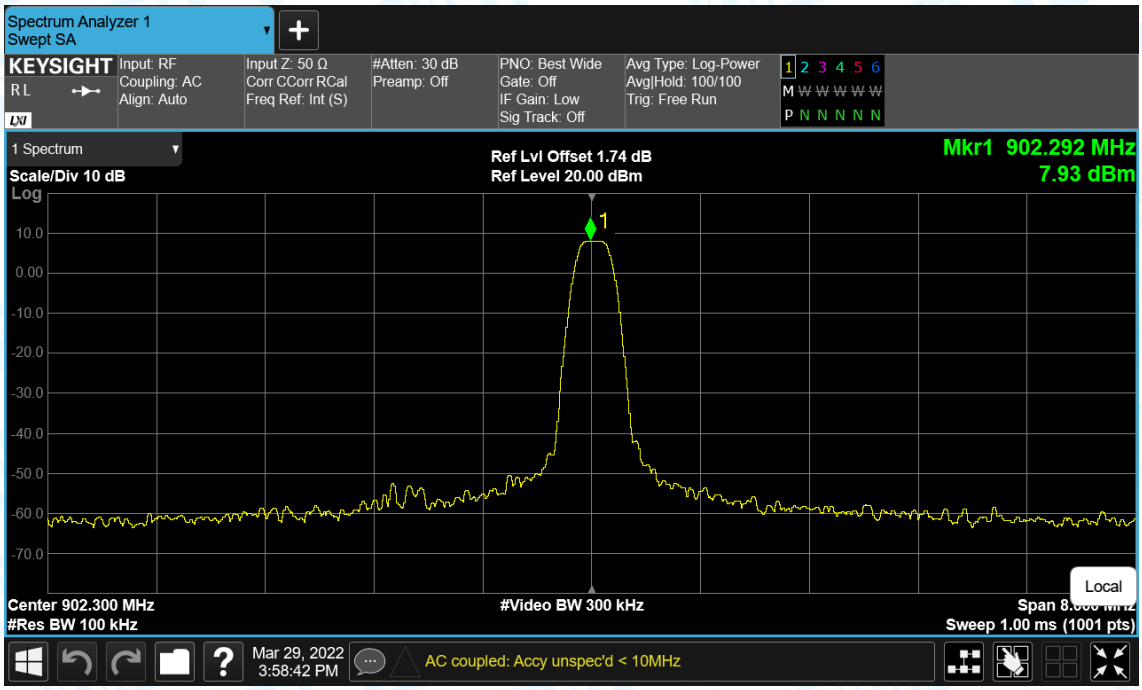


Tx. Spurious NVNT LoRa 914.9MHz Ant1 Emission

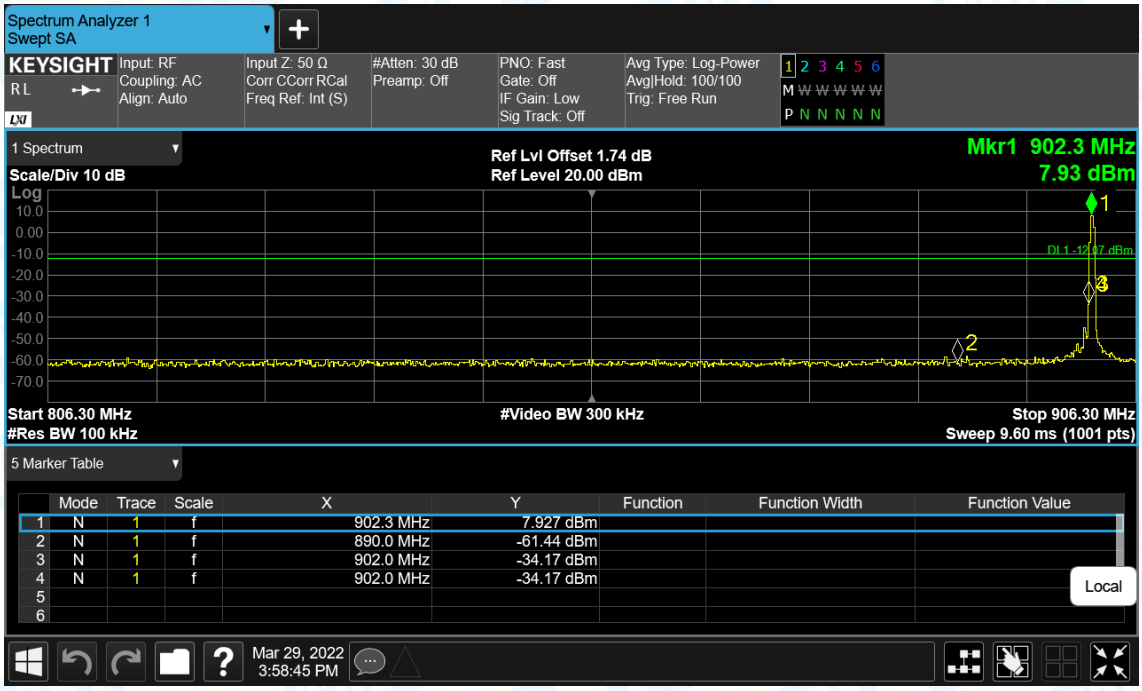


Attachment C—Emissions In Nonrestricted Frequency Data

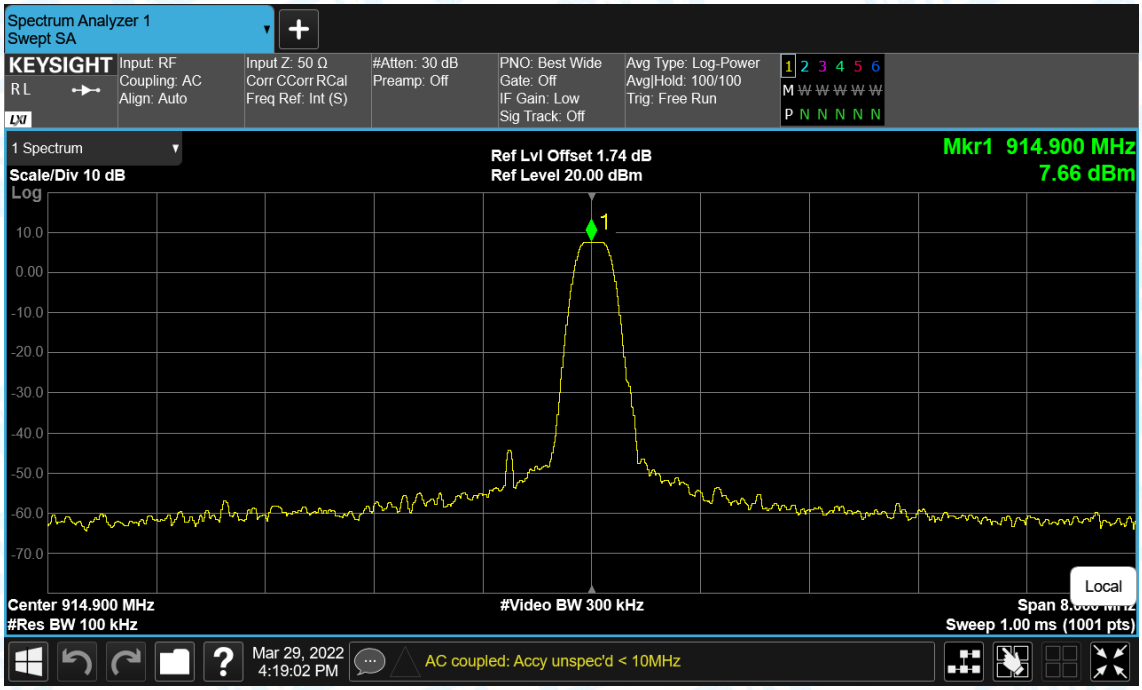
Band Edge NVNT LoRa 902.3MHz Ant1 Ref



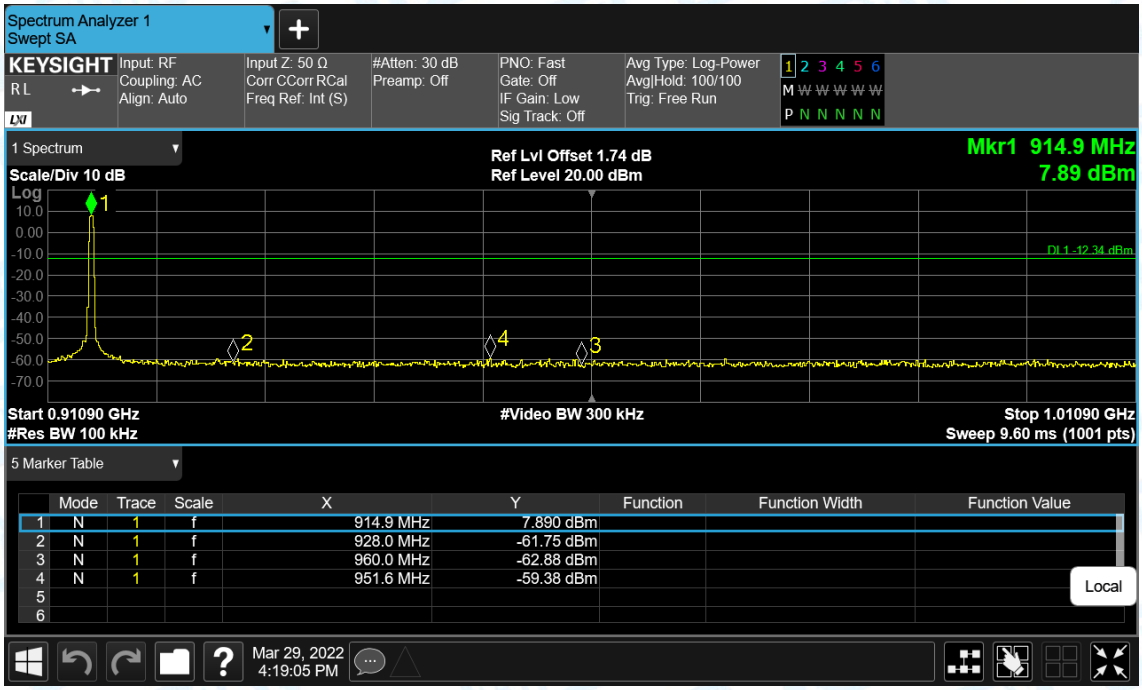
Band Edge NVNT LoRa 902.3MHz Ant1 Emission

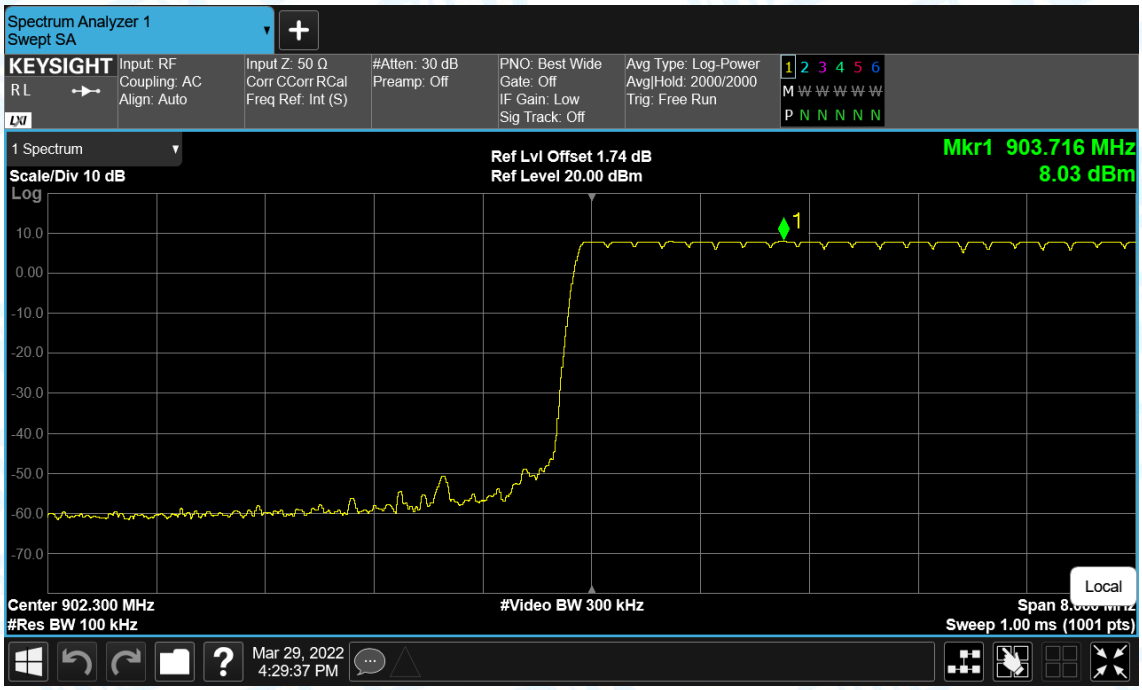


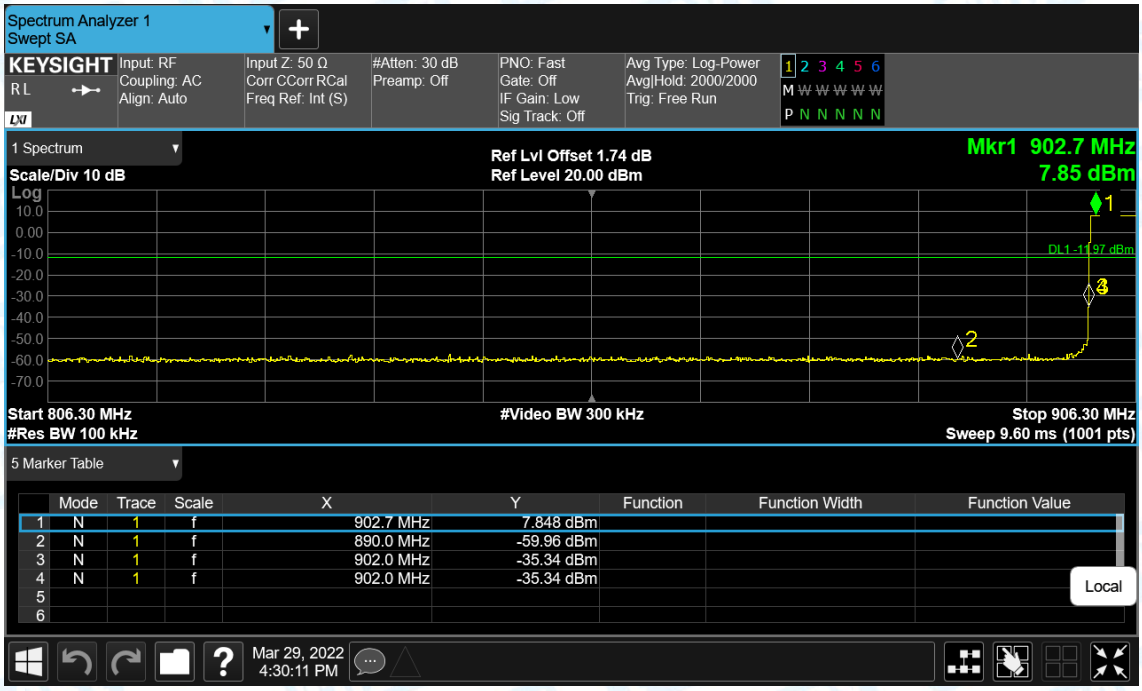
Band Edge NVNT LoRa 914.9MHz Ant1 Ref



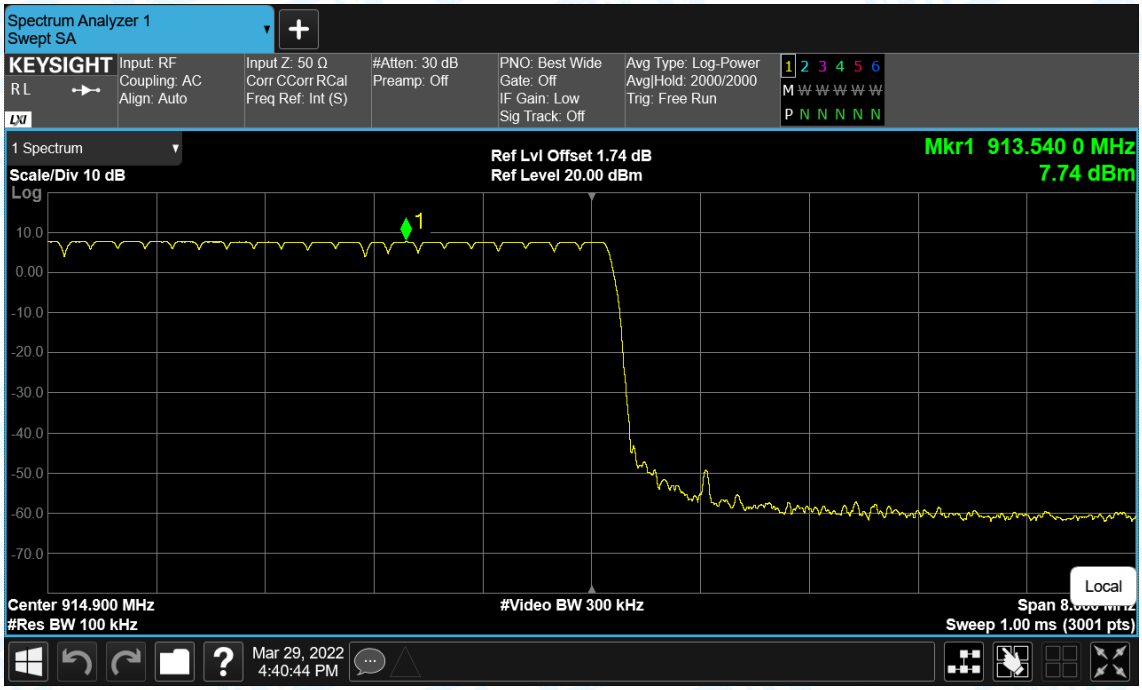
Band Edge NVNT LoRa 914.9MHz Ant1 Emission



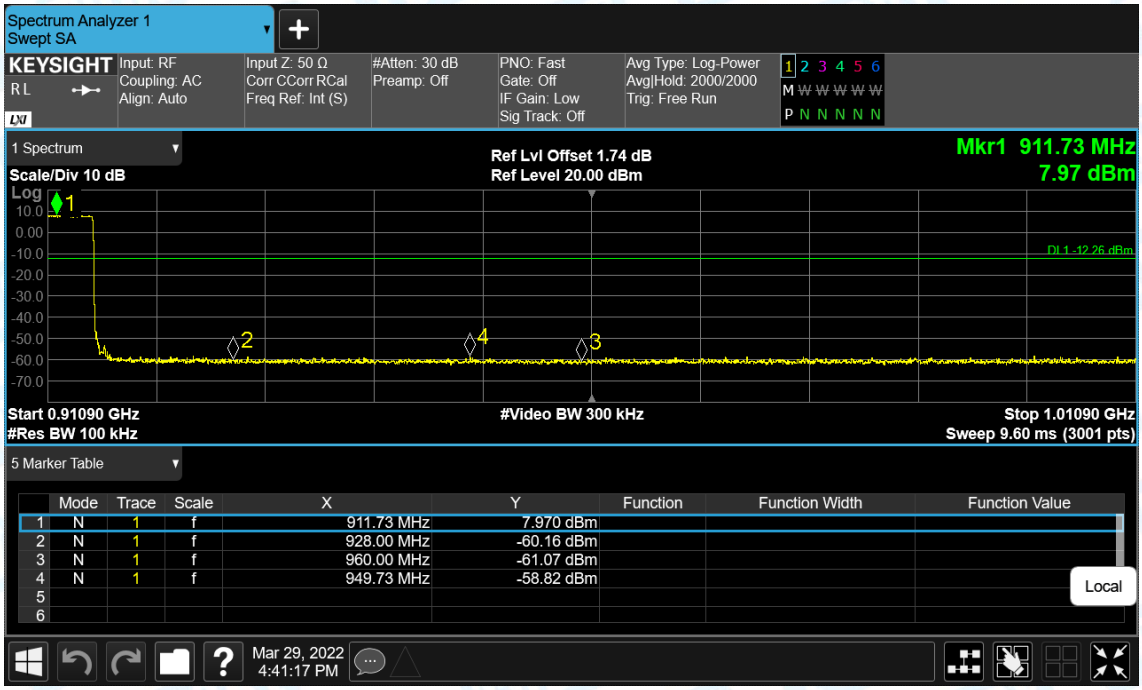
Band Edge (Hopping) NVNT LoRa 902.3MHz Ant1 Ref


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


Band Edge (Hopping) NVNT LoRa 914.9MHz Ant1 Ref



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



Attachment D—99% Occupied and 20dB Bandwidth Data

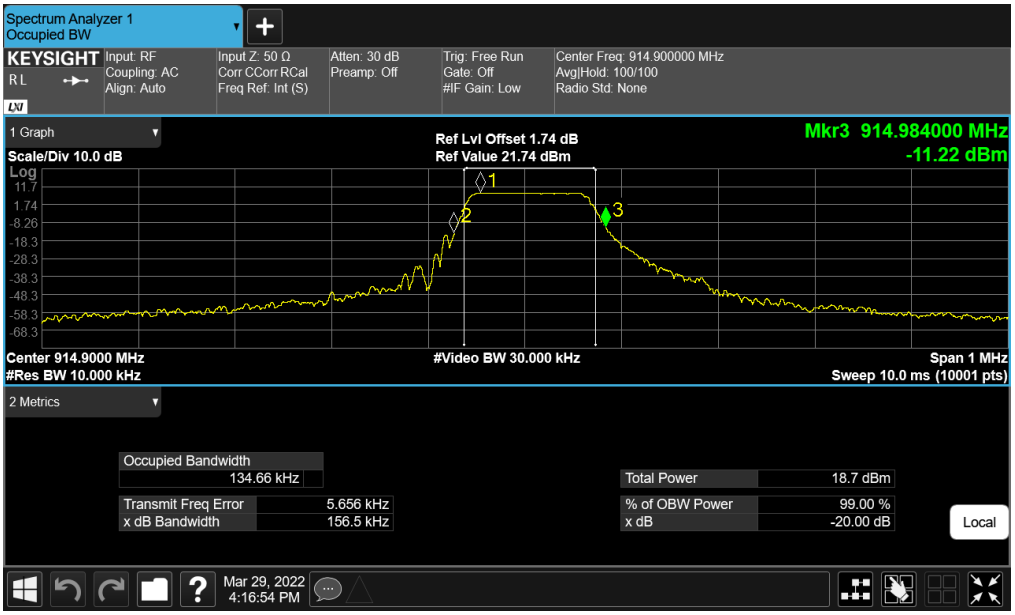
Temperature:	25℃	Relative Humidity:	55%
Test Voltage:	DC 5V		
Test Mode:	TX Mode		

Channel frequency (MHz)	20dB Bandwidth (kHz)	20dB Bandwidth *2/3 (kHz)	Limit (kHz)
902.3	157.7	105.1	/
908.9	158.7	105.8	
914.9	156.5	104.3	

902.3MHz

908.9MHz

914.9MHz

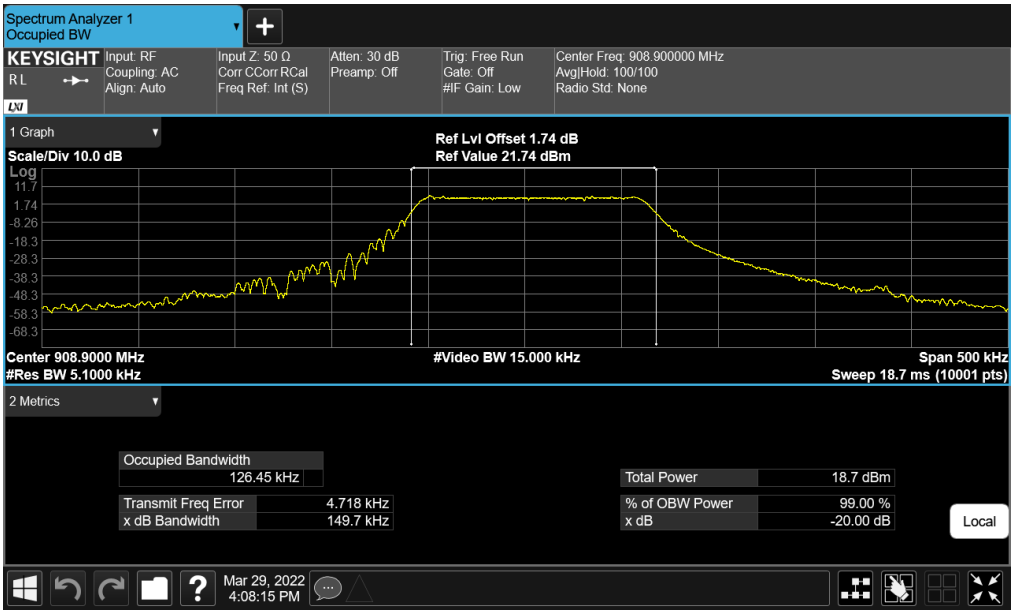


Temperature:	25℃	Relative Humidity:	55%
Test Voltage:	DC 5V		
Test Mode:	TX Mode		

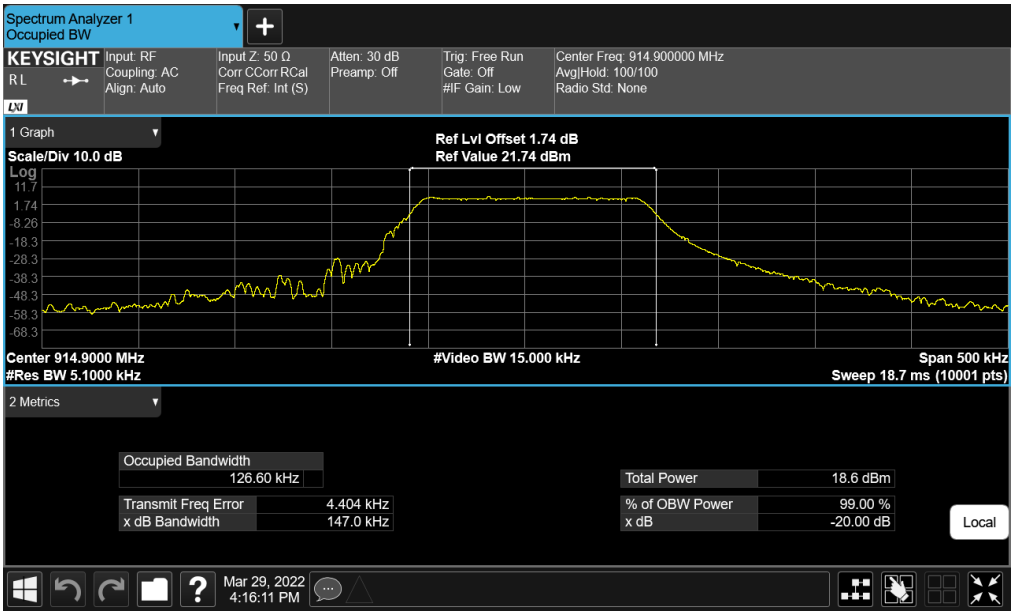
Channel frequency (MHz)	99% Bandwidth (kHz)	Limit (kHz)
902.3	126.39	/
908.9	126.45	
914.9	126.60	

902.3MHz

908.9MHz



914.9MHz



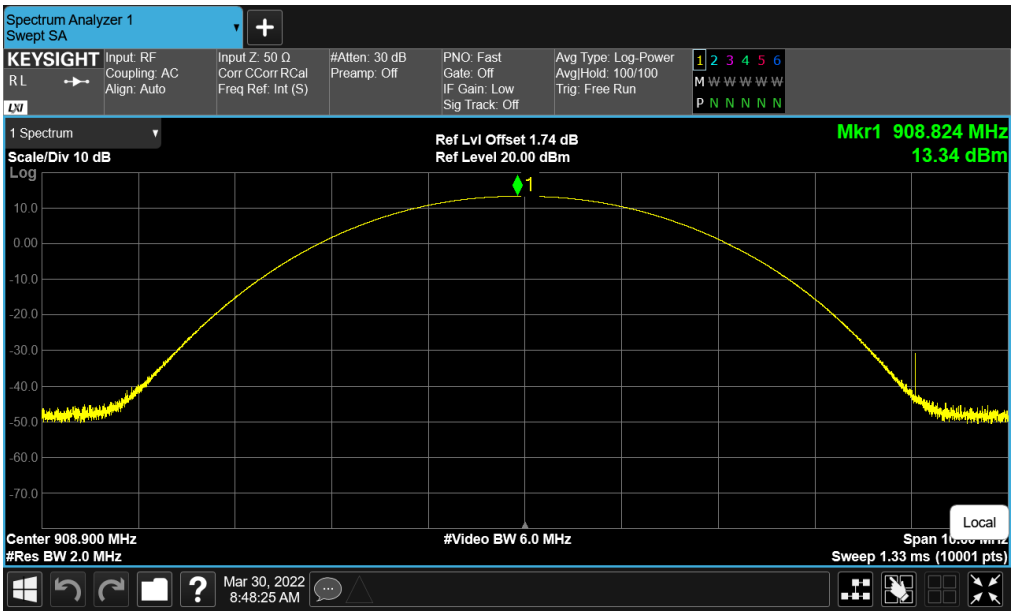
Attachment E—Peak Output Power Data

Temperature:	25℃	Relative Humidity:	55%
Test Voltage:	DC 5V		
Test Mode:	TX Mode		

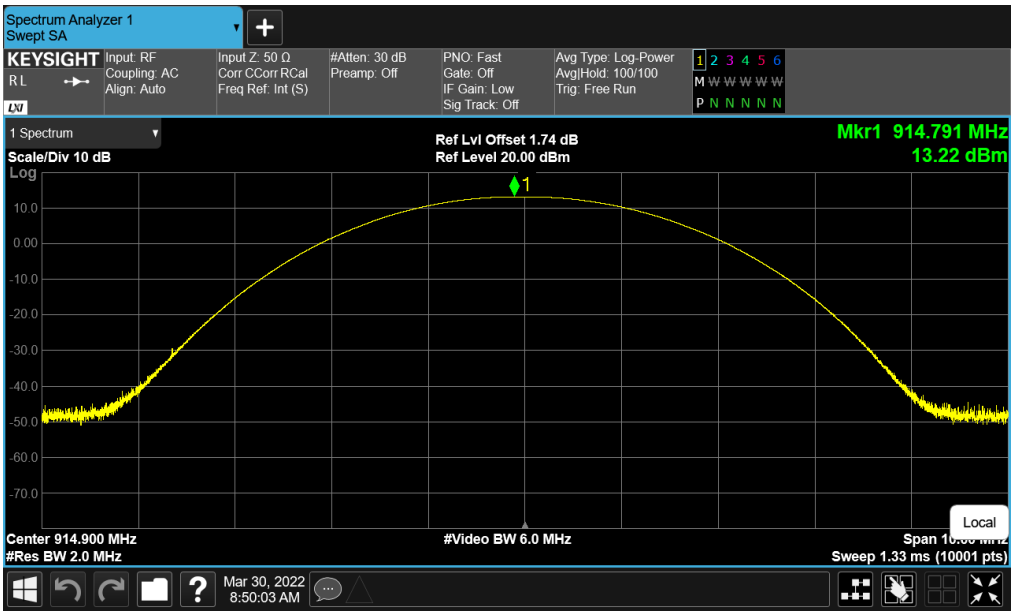
Channel frequency (MHz)	Test Result (dBm)	Limit (dBm)
902.3	13.45	30
908.9	13.34	
914.9	13.22	

902.3MHz

908.9MHz



914.9MHz

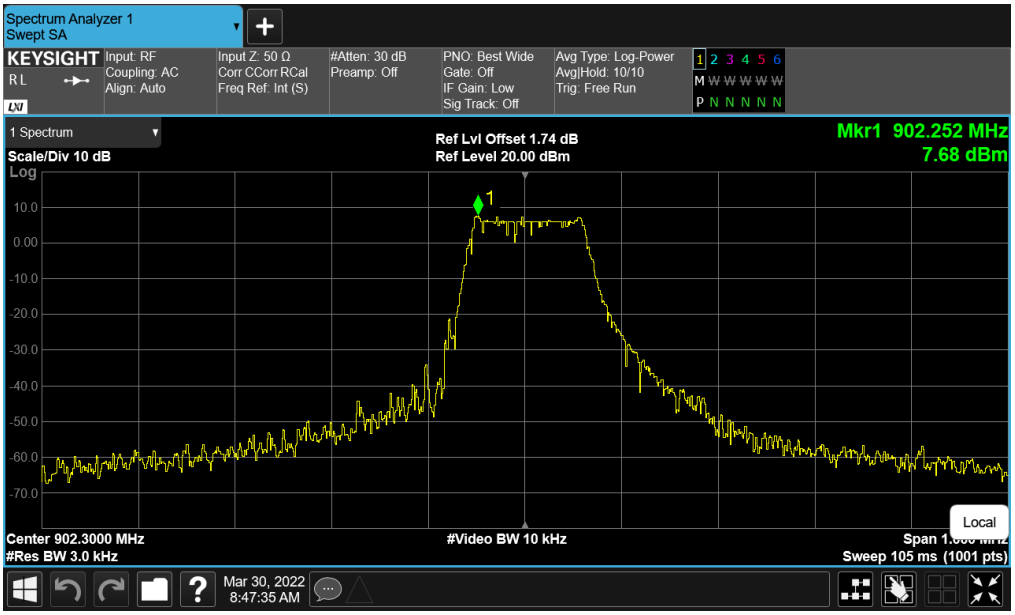


Attachment F—Power Spectral Density Data

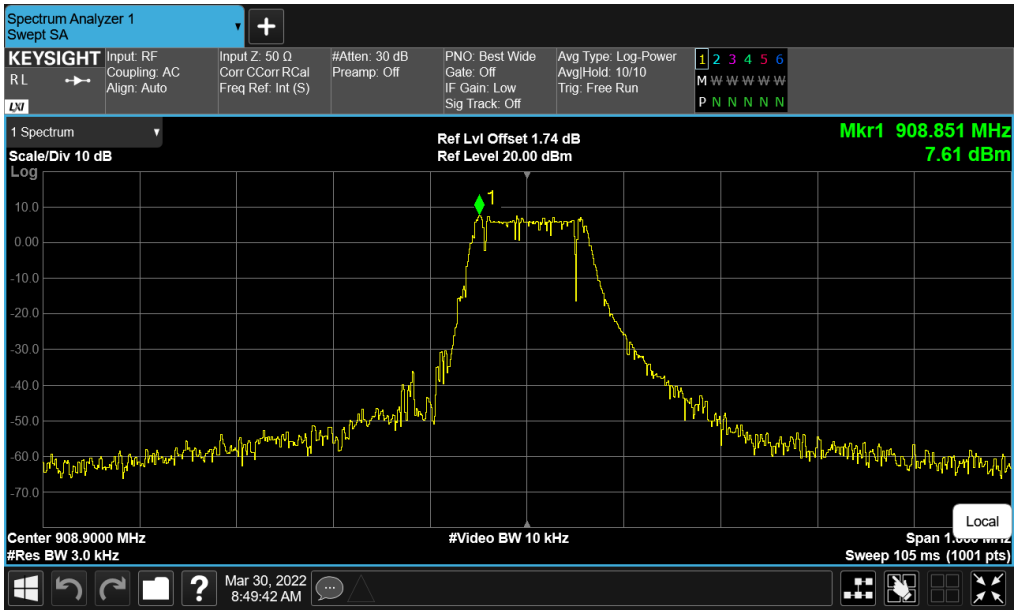
Temperature:	25℃	Relative Humidity:	55%
Test Voltage:	DC 5V		
Test Mode:	TX Mode		

Channel Frequency (MHz)	Power Density (dBm/3kHz)	Limit (dBm/3kHz)	Result
902.3	7.68	8	PASS
908.9	7.61		
914.9	7.95		

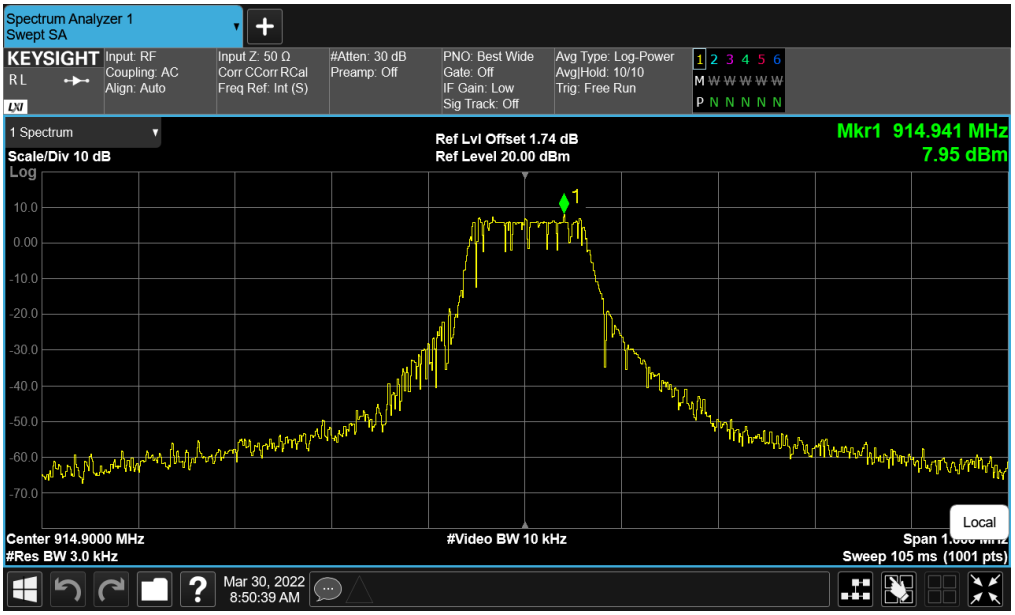
902.3MHz



908.9MHz



914.9MHz



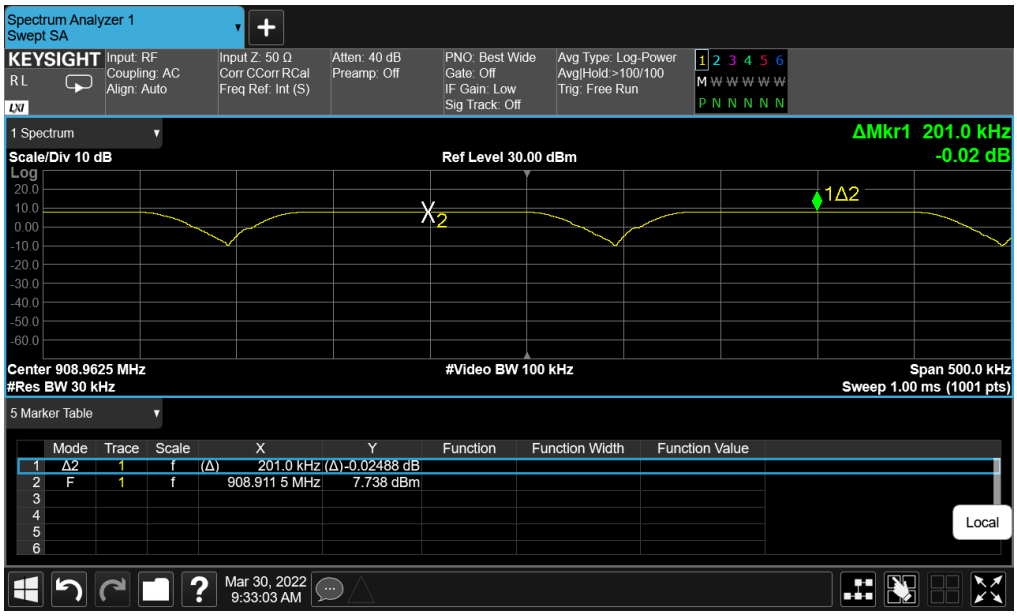
Attachment G—Carrier Frequency Separation Data

Temperature:	25℃	Relative Humidity:	55%
Test Voltage:	DC 5V		
Test Mode:	Hopping Mode		

Channel frequency (MHz)	Separation Read Value (kHz)	Separation Limit (kHz)
908.9	201	105.8

Hopping Mode

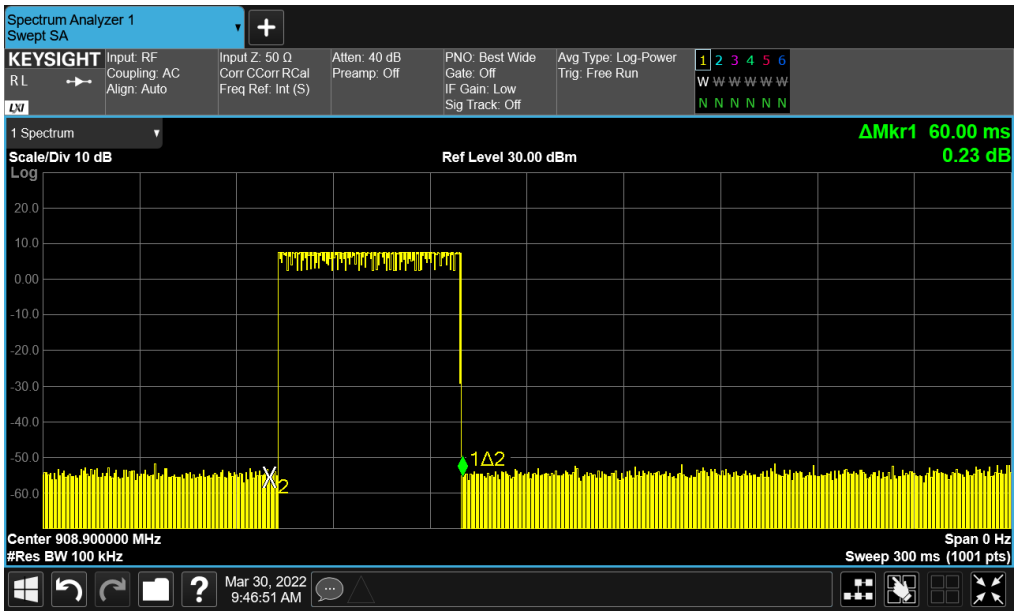
908.9MHz



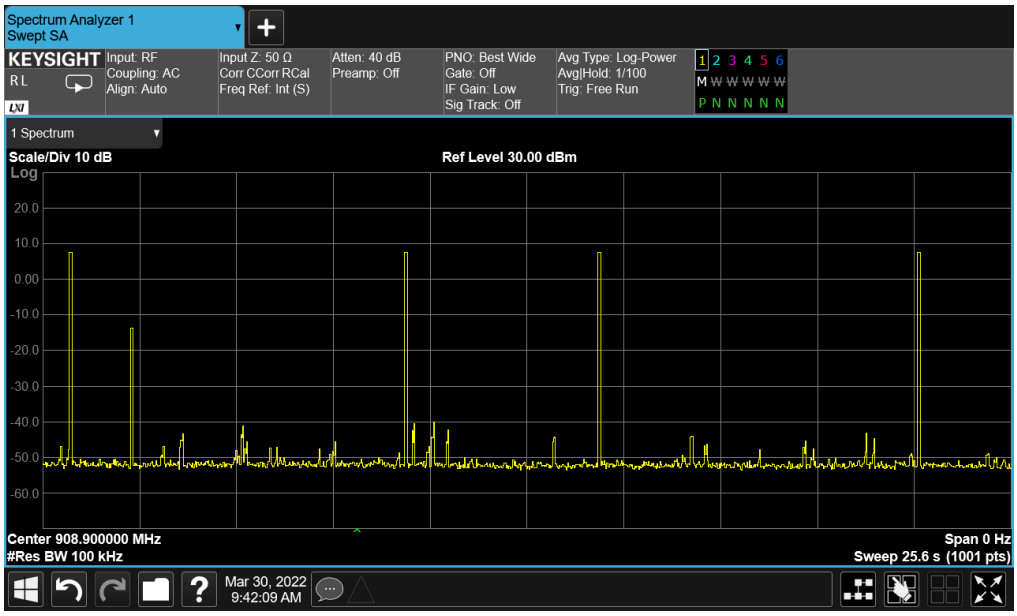
Attachment H—Time of Occupancy(Dwell Time) Data

Test Mode	Number of Channel	Observation Period (0.4s* Number of Channel) (s)	Max. Duration of Each Bust (s)	Number of Burst Repetition During Observation Period	Average Time of Occupancy on any Channel	Limit (s)
Hopping Mode	64	25.6	0.06	4	0.24	0.4

Burst Duration



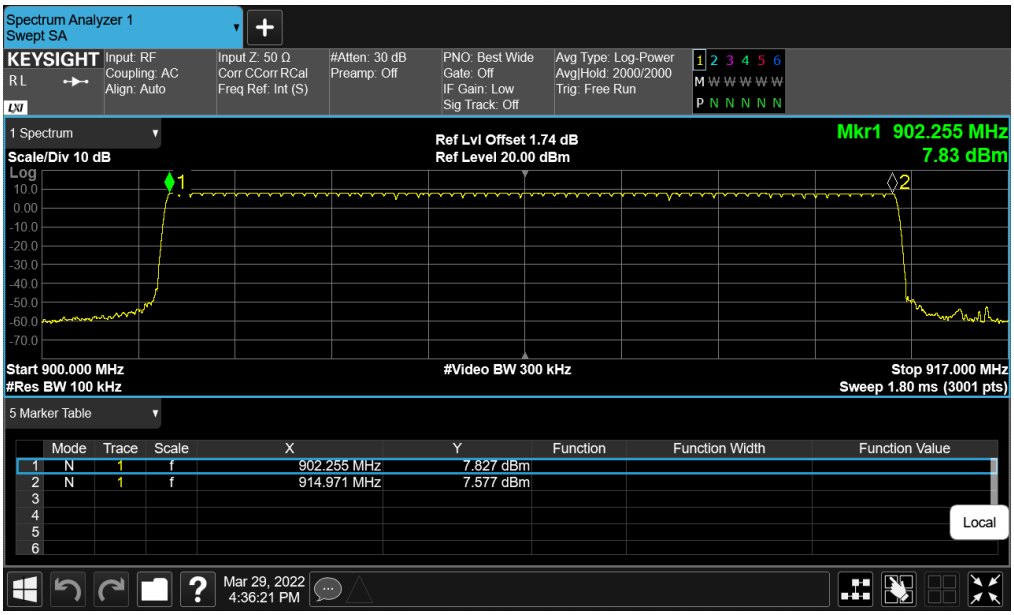
Burst Repetition During Observation Period Duration



Attachment I—Number of Hopping Frequency

Temperature:	25℃	Relative Humidity:	55%
Test Voltage:	DC 3.3V		
Test Mode:	Hopping Mode		

Frequency Range	Test Mode	Quantity of Hopping Channel	Limit
902MHz~928MHz	LoRa	64	**50**



Note: The EUT is hybrid system and there is no minimum number of hopping channels associated with this type of hybrid system.

-----END OF REPORT------