

ISED CABid: ES1909
Lab. Company Number: 4621A

Test Report No:
77596RRF.003A2

Test Report

USA FCC Part 15.247, 15.209
CANADA RSS-247, RSS-Gen

(*) Identification of item tested	Worldsensing LoRa Module LR112X
(*) Trademark	Loadsensing G7
(*) Model and /or type reference	WS-BRD-LR112X
Other identification of the product	FCC ID: 2AHN4-WSBRDLR112X IC: 21260-WSBRDLR112X
(*) Features	LoRa Communication Module at 868, 915, 923 MHz and 2.4 GHz HW version: WS-BRD-LR112X-2 SW version: 3.01
Applicant	Worldsensing S.L C/ Viriat 47, planta 10, 08014, Barcelona, Spain
Test method requested, standard	USA FCC Part 15.247 (10-1-21 Edition): Operation within the bands 902 - 928 MHz, 2400 -2483.5 MHz, and 5725 - 5850 MHz. USA FCC Part 15.209 (10-1-21 Edition): Radiated emission limits; general requirements. CANADA RSS-247 Issue 3 (August 2023). CANADA RSS-Gen Issue 5 amendment 2 (February 2021). Guidance for Performing Compliance Measurements on Digital Transmission System, Frequency Hopping Spread Spectrum System, and Hybrid Systems Devices Operating Under Section 15.247 of the FCC Rules. 558074 D01 Meas Guidance v05r02 dated April 2, 2019. ANSI C63.10-2013: American National Standard for Testing Unlicensed Wireless Devices.
Summary	IN COMPLIANCE
Approved by (name / position & signature)	José Manuel Gómez Galván EMC Consumer & RF Lab. Manager
Date of issue	2024-10-18
Report template No	FDT08_24 (*) "Data provided by the client"

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Acronyms

Acronym ID	Acronym Description
Detector	Detector used
Equipment	Equipment Type
Freq	Frequency
Freq Rng	Frequency Range
MP	Measurement Point
Mod	Modulation
Mode	Mode
Pol	Polarization
Port	Active Port
Unwanted Freq	Unwanted Emissions Frequency
Unwanted Lvl	Unwanted Emissions Level

Competences and guarantees

DEKRA Testing and Certification S.A.U. is a testing laboratory accredited by the National Accreditation Body (ENAC -Entidad Nacional de Acreditación), to perform the tests indicated in the Certificate No. 51/LE 147.

DEKRA Testing and Certification S.A.U. is an FCC-recognized accredited testing laboratory with appropriate scope of accreditation that covers the performed tests in this report.

DEKRA Testing and Certification S.A.U. is an ISED-recognized accredited testing laboratory, CABid: ES1909, Company Number: 4621A, with the appropriate scope of accreditation that covers the performed tests in this report.

In order to assure the traceability to other national and international laboratories, DEKRA Testing and Certification S.A.U. has a calibration and maintenance program for its measurement equipment.

DEKRA Testing and Certification S.A.U. guarantees the reliability of the data presented in this report, which is the result of the measurements and the tests performed to the item under test on the date and under the conditions stated on the report and, it is based on the knowledge and technical facilities available at DEKRA Testing and Certification S.A.U. at the time of performance of the test.

DEKRA Testing and Certification S.A.U. is liable to the client for the maintenance of the confidentiality of all information related to the item under test and the results of the test.

The results presented in this Test Report apply only to the particular item under test established in this document.

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General conditions

1. This report is only referred to the item that has undergone the test.
2. This report does not constitute or imply on its own an approval of the product by the Certification Bodies or competent Authorities.
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4. This test report cannot be used partially or in full for publicity and/or promotional purposes without previous written permission of DEKRA Testing and Certification S.A.U. and the Accreditation Bodies.

Uncertainty

Uncertainty (factor $k=2$) was calculated according to the DEKRA Testing and Certification S.A.U. internal document PODT000.

The total uncertainty of the measurement system for the radiated emissions of EUT from 30 MHz to 1 GHz is:
Measurement uncertainty $\leq \pm 5,35$ dB with factor ($k = 2$).

The total uncertainty of the measurement system for the radiated emissions of EUT from 1 GHz to 17 GHz is:
Measurement uncertainty $\leq \pm 4,32$ dB with factor ($k = 2$).

The total uncertainty of the measurement system for the radiated emissions of EUT from 17 GHz to 26 GHz is:
Measurement uncertainty $\leq \pm 5,51$ dB with factor ($k = 2$).

The total uncertainty of the measurement system for the conducted testing of EUT is:

RF Peak Output Power: Measurement uncertainty $\leq \pm 0,80$ dB

RF Average Output Power: Measurement uncertainty $\leq \pm 0,99$ dB

Power Spectral Density: Measurement uncertainty $\leq \pm 0,99$ dB

6dB Bandwidth: Measurement uncertainty $\leq \pm 2,84$ %

Occupied Channel Bandwidth: Measurement uncertainty $\leq \pm 1,17$ %

Conducted Band-edge spurious emissions: Measurement uncertainty $\leq \pm 1,76$ dB

Data provided by the client

The following data has been provided by the client:

1. Information relating to the description of the sample ("Identification of the item tested", "Trademark", "Model and/or type reference tested").
2. The sample consists of a Worldsensing LoRa Module LR112X. LoRa module with optimized temperature stability for communicating in sub GHz and 2.4 GHz bands.

DEKRA Testing and Certification S.A.U. declines any responsibility with respect to the information provided by the client and that may affect the validity of results.

Usage of samples

Samples undergoing test have been selected by: The client.

Id	Control Number	Description	Model	Serial N°	Date of Reception	Application
S/01	77596_15.1	Module circuit board	WS-BRD-LR112X	-	2023-12-28	Element Under Test
S/01	77596_2.1	SMA cable	-	-	2023-12-05	Element Under Test
S/01	77596_9.1	Antenna	Dipole swivel stick antenna - Pulse W1027	-	2023-12-05	Element Under Test
S/01	77596_8.1	USB cable type C- A	-	-	2023-12-05	Auxiliary Element
S/02	77596_15.1	Module circuit board	WS-BRD-LR112X	-	2023-12-28	Element Under Test
S/02	77596_8.1	USB cable type C- A	-	-	2023-12-05	Auxiliary Element
S/03	77596_15.1	Module circuit board	WS-BRD-LR112X	-	2023-12-28	Element Under Test
S/03	77596_5.1	Antenna sticker	FLEXIANT-AFFINI SRFL064	-	2023-12-05	Element Under Test
S/03	77596_8.1	USB cable type C- A	-	-	2023-12-05	Auxiliary Element
S/04	77596_15.1	Module circuit board	WS-BRD-LR112X	-	2023-12-28	Element Under Test
S/04	77596_8.1	USB cable type C- A	-	-	2023-12-05	Auxiliary Element

Notes referenced to samples during the project:

Id	Type
S/01	Radiated tests for LoRa 2.4 GHz.
S/02	Conducted tests for LoRa 2.4 GHz.
S/03	Radiated tests for AU915-928. Radiated tests for US902-928.
S/04	Conducted tests AU915-928. Conducted tests US902-928.

Test sample description

Ports..... :	Port name and description	Cable					
		Specified max length [m]	Attached during test	Shielded	Coupled to patient ⁽³⁾		
	USB-C for configuration and supply on the host board		[X]	[]	[]		
Supplementary information to the ports..... :							
Rated power supply	Voltage and Frequency		Reference poles				
			L1	L2	L3	N	PE
	[]	AC:	[]	[]	[]	[]	[]
	[X]	DC: 3.6 to 5V DC					
Rated Power	1W maximum required power						
Clock frequencies.....	32MHz and 32.768KHz						
Other parameters							
Software version	3.01						
Hardware version	WS-BRD-LR112X-2						
Dimensions in cm (W x H x D)	24 x 36 x 4 mm (module)						
Mounting position	[X]	Table top equipment					
	[X]	Wall/Ceiling mounted equipment					
	[]	Floor standing equipment					
	[]	Hand-held equipment					
	[]	Other:					
Modules/parts..... :	Module/parts of test item			Type	Manufacturer		
							
Accessories (not part of the test item)	Description			Type	Manufacturer		
							
Documents as provided by the applicant	Description			File name	Issue date		
							

⁽³⁾ Only for Medical Equipment

Identification of the client

Worldsensing S.L
C/ Viriat 47, planta 10, 08014 Barcelona

Testing period and place

Test Location	DEKRA Testing and Certification S.A.U.
Date (start)	2024-01-15
Date (finish)	2024-05-08

Document history

Report number	Date	Description
77596RRF.003	2024-05-21	First release.
77596RRF.003A1	2024-09-19	Second release. It is modified due to some minor typos. This modification test report cancels and replaces the test report 77596RRF.003
77596RRF.003A2	2024-10-18	Third release. It is modified due to a change in declared frequencies and some minor typos. This modification test report cancels and replaces the test report 77596RRF.003A1

Environmental conditions

In the control chamber, the following limits were not exceeded during the test:

Temperature	Min. = 15 °C Max. = 35 °C
Relative humidity	Min. = 20 % Max. = 75 %

In the semianechoic chamber, the following limits were not exceeded during the test.

Temperature	Min. = 15 °C Max. = 35 °C
Relative humidity	Min. = 20 % Max. = 75 %

In the chamber for conducted measurements, the following limits were not exceeded during the test:

Temperature	Min. = 15 °C Max. = 35 °C
Relative humidity	Min. = 20 % Max. = 75 %

Remarks and comments

The tests have been performed by the technical personnel: Rafael Fernández.

Used instrumentation:

Control No.	Equipment	Model	Manufacturer	Next Calibration
07445	DC POWER SUPPLY 30V/5A	U8002A	KEYSIGHT TECHNOLOGIES	N/A
07760	DIGITAL MULTIMETER	175	FLUKE	2024-11
06165	EMI TEST RECEIVER 2Hz-7GHz	ESR7	ROHDE AND SCHWARZ	2025-12
06496	HORN ANTENNA 1-18GHz	BBHA 9120 D	SCHWARZBECK	2026-12
06143	HYBRID BILOG ANTENNA 30MHz-6GHz	3142E	ETS LINDGREN	2027-01
07656	LOW PASS FILTER TEMSTRON/TEMWELL DC - 1 GHZ	ST-1GA3250-LS	TEMSTRON/TEMWELL	2025-02
03783	PRE-AMPLIFIER G>30dB 1GHz-18GHz	BLMA 0118-3A	BONN ELEKTRONIK	2025-03
06142	PRE-AMPLIFIER G>38dB 30MHz-6GHz	BLNA 0360-01N	BONN ELEKTRONIK	2024-06
06144	PRE-AMPLIFIER G>40dB 10MHz-6GHz	BLNA 0160-01N	BONN ELEKTRONIK	2024-07
06791	SEMIANECHOIC ABSORBER LINED CHAMBER IV	FACT 3 200 STP	ETS LINDGREN	N/A
06792	Shielded Room	S101	ETS LINDGREN	N/A
08856	PRE-AMPLIFIER G>30dB 18-40GHz	BLMA 1840-4A	BONN ELEKTRONIK	2025-02
04848	SOFTWARE FOR EMC/RF TESTING	EMC32	ROHDE AND SCHWARZ	N/A
07873	DC Power Supply 30V/5A	U8002A	KEYSIGHT TECHNOLOGIES	N/A
07758	Digital Multimeter	175	FLUKE	2024-11
06157	Signal and Spectrum Analyzer 10 Hz - 40 GHz	FSV40	ROHDE AND SCHWARZ	2025-01
07794	Signal and Spectrum Analyzer 10 Hz - 40 GHz	FSV40	ROHDE AND SCHWARZ	2025-04
03541	Hybrid Bilog Antenna 30MHz-6GHz	JB6	SUNOL SCIENCES CORPORATION	2024-11
08483	TUNABLE NOTCH FILTER 500-1000 MHZ	PE8737	PASTERNAK	2024-05
05850	DIGITAL MULTIMETER	179	FLUKE	2024-11
00922	POWER SUPPLY DC 40 V / 40 A	NGPE 40/40	ROHDE AND SCHWARZ	N/A

Control No.	Equipment	Model	Manufacturer	Next Calibration
08788	PREAMPLIFIER 30dB 500MHz-18GHz	BBV 9718 C	SCHWARZBECK	2025-01
06793	SHIELDED ROOM	S101	ETS LINDGREN	N/A
06668	SIGNAL AND SPECTRUM ANALYZER 10Hz-40GHz	FSV40	ROHDE AND SCHWARZ	2024-12
06794	Shielded Room	S101	ETS LINDGREN	N/A

Testing verdicts

Fail	F
Inconclusive	I
Not applicable	N/A
Not measured	N/M
Pass	P

Summary

Appendix A: LoRa 2.4 GHz.

FCC PART 15 PARAGRAPH / RSS-247			
Requirement – Test case		Verdict	Remark
FCC 15.247 (a)(2) / RSS-247 5.2. (a)	6 dB Bandwidth	P	
FCC 15.247 (b) / RSS-247 5.4. (d)	Maximum output power and antenna gain	P	
FCC 15.247 (d) / RSS-247 5.5.	Band-edge emissions compliance (Transmitter)	P	
FCC 15.247 (e) / RSS-247 5.2. (b)	Power spectral density	P	
FCC 15.247 (d) / RSS-247 5.5.	Emission limitations radiated (Transmitter)	P	
<u>Supplementary information and remarks:</u>			
Note: No FHSS.			

Appendix B: LoRa AU915-928.

FCC PART 15 PARAGRAPH/ RSS-247			
Requirement – Test case		Verdict	Remark
FCC 15.247 (a)(1) / RSS-247 5.1 (b)	20 dB Bandwidth and Carrier frequency separation	P	
FCC 15.247 (a)(1)(i) / RSS-247 5.1 (c)	Number of hopping channels	P	
FCC 15.247 (f) / RSS-247 5.3 (a)	Time of occupancy (Dwell Time)	P	
FCC 15.247 (b) / RSS-247 5.4. (d)	Maximum output power and antenna gain	P	
FCC 15.247 (d) / RSS-247 5.5.	Band-edge emissions compliance (Transmitter)	P	
FCC 15.247 (f) / RSS-247 5.3. (b)	Power spectral density for hybrid systems	P	
FCC 15.247 (d) / RSS-247 5.5.	Emission limitations radiated (Transmitter)	P	
<u>Supplementary information and remarks:</u>			
Note: Hybrid.			

Appendix C: LoRa US902-928.

FCC PART 15 PARAGRAPH/ RSS-247			
Requirement – Test case		Verdict	Remark
FCC 15.247 (a)(1) / RSS-247 5.1 (b)	20 dB Bandwidth and Carrier frequency separation	P	
FCC 15.247 (a)(1)(i) / RSS-247 5.1 (c)	Number of hopping channels	P	
FCC 15.247 (f) / RSS-247 5.3 (a)	Time of occupancy (Dwell Time)	P	
FCC 15.247 (b) / RSS-247 5.4. (d)	Maximum output power and antenna gain	P	
FCC 15.247 (d) / RSS-247 5.5.	Band-edge emissions compliance (Transmitter)	P	
FCC 15.247 (f) / RSS-247 5.3. (b)	Power spectral density for hybrid systems	P	
FCC 15.247 (d) / RSS-247 5.5.	Emission limitations radiated (Transmitter)	P	
<u>Supplementary information and remarks:</u>			
Note: Hybrid.			

Appendix A: Test results. LoRa 2.4 GHz

TEST CONDITIONS	13
<i>Occupied Channel Bandwidth 99%</i>	<i>16</i>
<i>RSS-247 5.2 (a) / FCC 15.247 (a) (2) 6 dB Bandwidth</i>	<i>20</i>
<i>RSS-247 5.2 (b) / FCC 15.247 (e) Power spectral density</i>	<i>24</i>
<i>RSS-247 5.4 (d) / FCC 15.247 (b) (3) Maximum output power and antenna gain</i>	<i>28</i>
<i>RSS-247 5.5 / FCC 15.247 (d) Band-edge emissions compliance (Transmitter)</i>	<i>32</i>
<i>RSS-247 5.5 / FCC 15.247 (d) [RSE] Emission limitations radiated (Transmitter)</i>	<i>35</i>

TEST CONDITIONS

(*): Data provided by the client.

POWER SUPPLY (*):

Vnominal: 5 V
Type of Power Supply: DC (USB-C).

ANTENNA (*):

Type of Antenna LoRa 2.4 GHz: Omnidirectional external antenna.
Maximum Declared External Antenna Gain LoRa 2.4 GHz: 2.0 dBi
Type of Antenna LoRa 2.4 GHz: FPC omnidirectional internal antenna.
Maximum Declared FPC Antenna Gain LoRa 2.4 GHz: 3.9 dBi

According preliminary radiated spurious emissions the External Antenna is a worst case.

TEST FREQUENCIES (*):

Modulation	Low Channel:	Middle Channel	High Channel
LoRa	2403 MHz	2425 MHz	2479 MHz

During transmitter test the EUT was controlled by a SW tool provided by the client to operate in a continuous transmit mode on the modulation schemes and test channels as required.

CONDUCTED MEASUREMENTS:

The equipment under test was set up in a shielded room and it is connected to the TS8997 using a low loss RF cable. The reading of the spectrum analyser is corrected taking into account the cable loss.



RADIATED MEASUREMENTS:

All radiated tests were performed in a semi-anechoic chamber. The measurement antenna (Bilog antenna for the range between 30 MHz to 1000 MHz and 1 GHz-17 GHz Double ridge horn antenna) is situated at a distance of 3 m and at a distance of 1.5 m for the frequency range 17 GHz-26 GHz (17 GHz-40 GHz horn antenna).

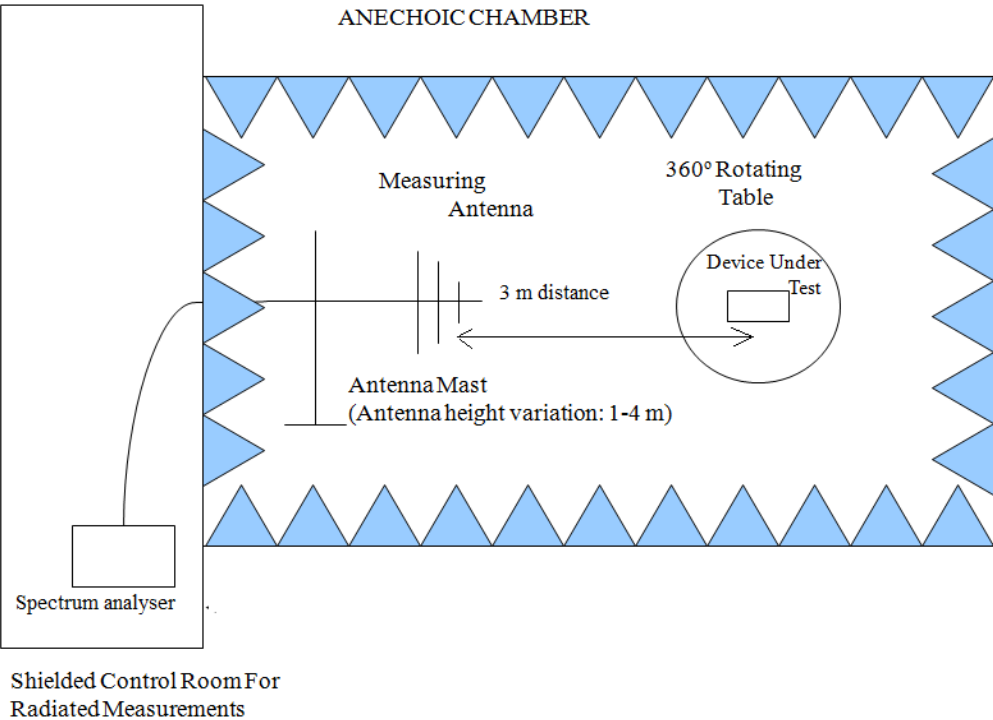
For radiated emissions in the range 17 GHz-26 GHz that is performed at a distance closer than the specified distance, an inverse proportionality factor of 20 dB per decade is used to normalize the measured data for determining compliance.

The equipment under test was set up on a non-conductive platform above the ground plane and the situation and orientation was varied to find the maximum radiated emission. It was also rotated 360° and the antenna height (Bilog antenna and Double ridge horn antenna) was varied from 1 to 4 meters to find the maximum radiated emission.

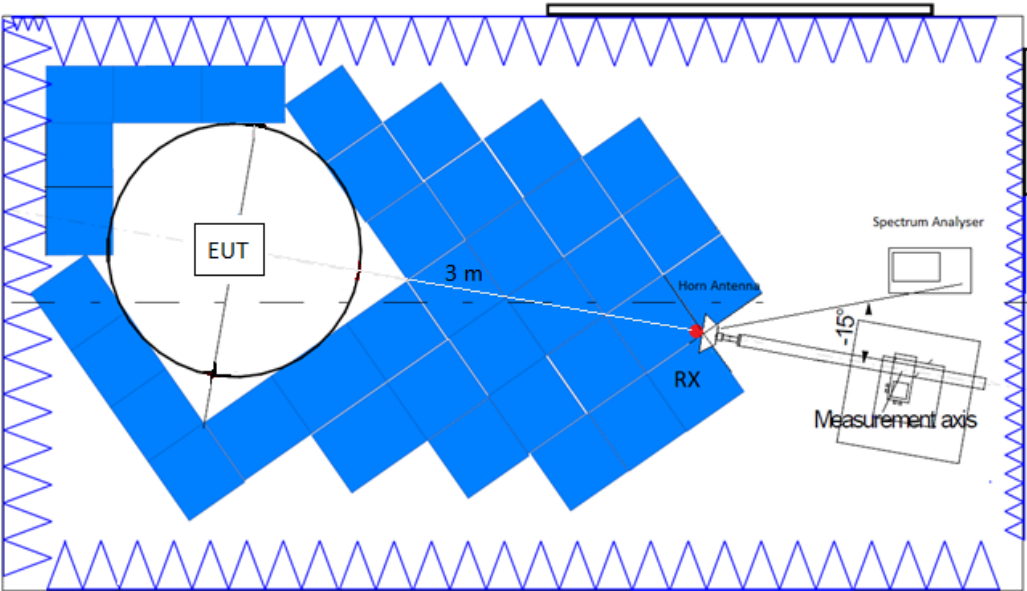
Measurements were made in both horizontal and vertical planes of polarization.

A resolution bandwidth/video bandwidth of 100 kHz / 300 kHz was used for frequencies below 1 GHz and 1 MHz / 3 MHz for frequencies above 1 GHz.

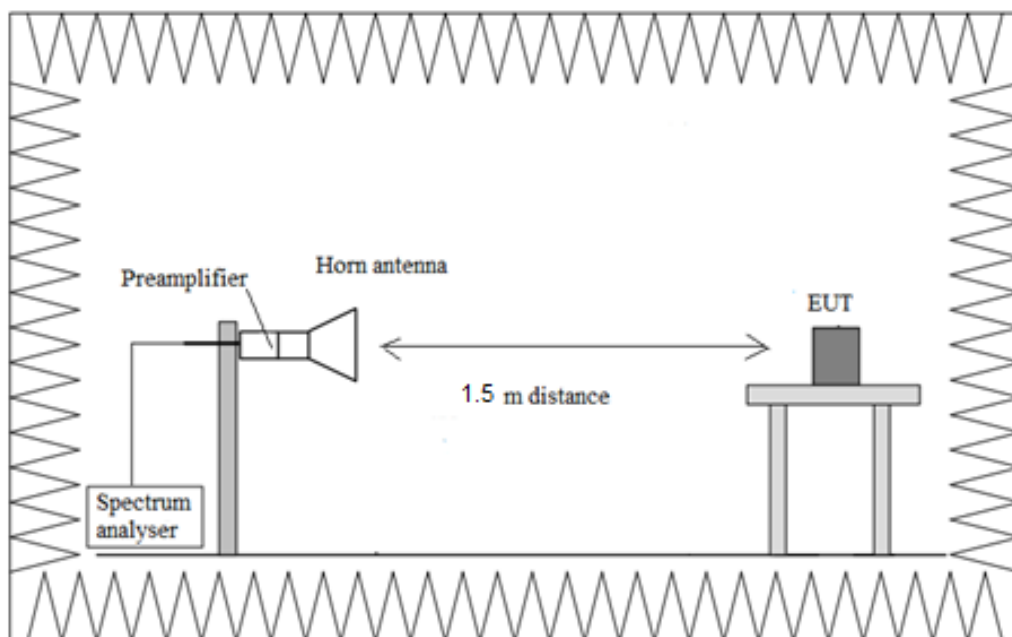
Radiated measurements setup from 30 MHz to 1 GHz:



Radiated measurements setup from 1 GHz to 17 GHz:



Radiated measurements setup $f > 17$ GHz:



Occupied Channel Bandwidth 99%

Limits

* RSS-Gen Clause 6.7:

The transmitter shall be operated at its maximum carrier power measured under normal test conditions.

The span of the spectrum analyzer shall be set large enough to capture all products of the modulation process, including the emission skirts, around the carrier frequency, but small enough to avoid having other emissions (e.g. on adjacent channels) within the span.

The detector of the spectrum analyzer shall be set to “Sample”. However, a peak, or peak hold, may be used in place of the sampling detector since this usually produces a wider bandwidth than the actual bandwidth (worst-case measurement). Use of a peak hold (or “Max Hold”) may be necessary to determine the occupied / x dB bandwidth if the device is not transmitting continuously.

The resolution bandwidth (RBW) shall be in the range of 1% to 5% of the actual occupied / x dB bandwidth and the video bandwidth (VBW) shall not be smaller than three times the RBW value. Video averaging is not permitted.

Modulation: LoRa

Mode: SISO

Results

Freq (MHz)	Occ Ch BW (kHz)
2403	849
2425	848.7
2479	844.5

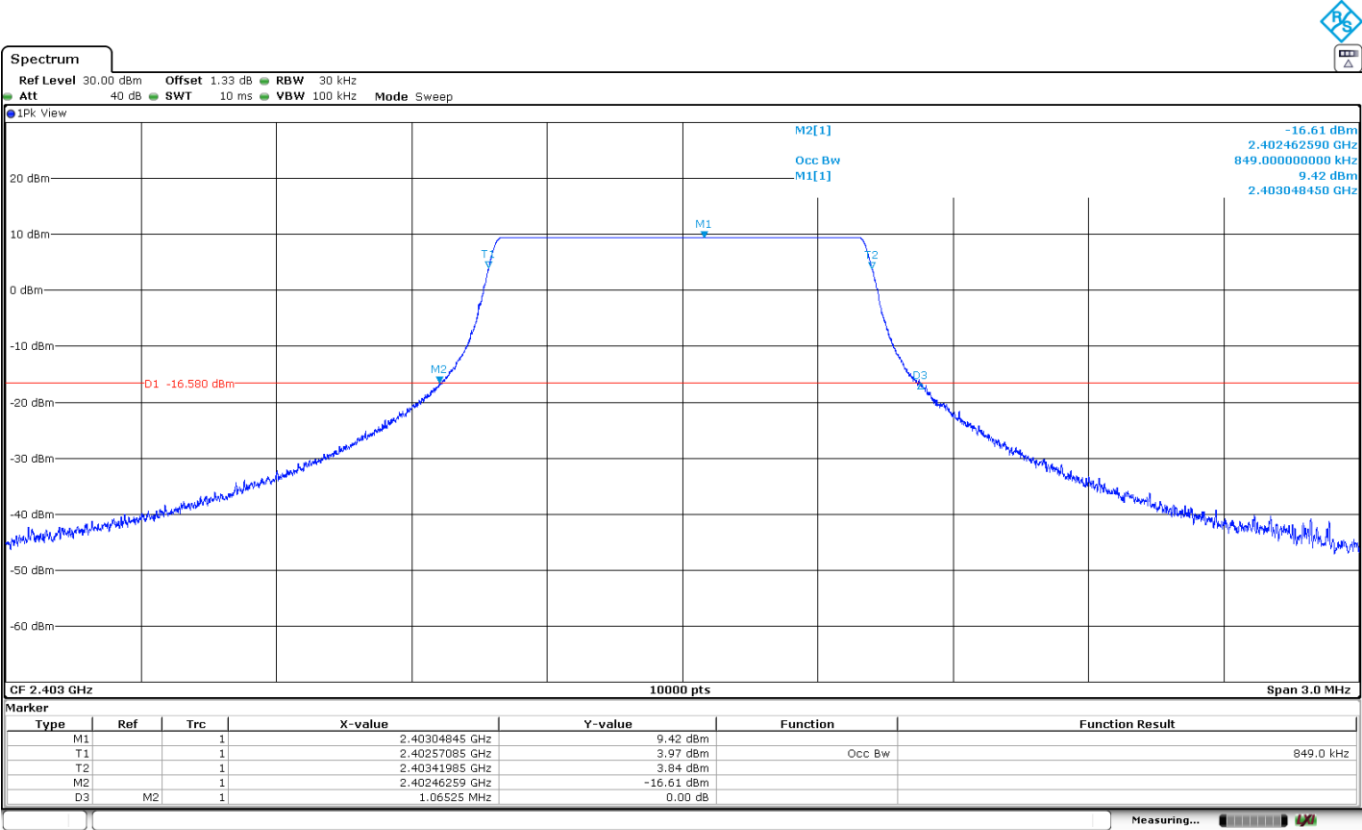
Verdict

Pass

Attachments

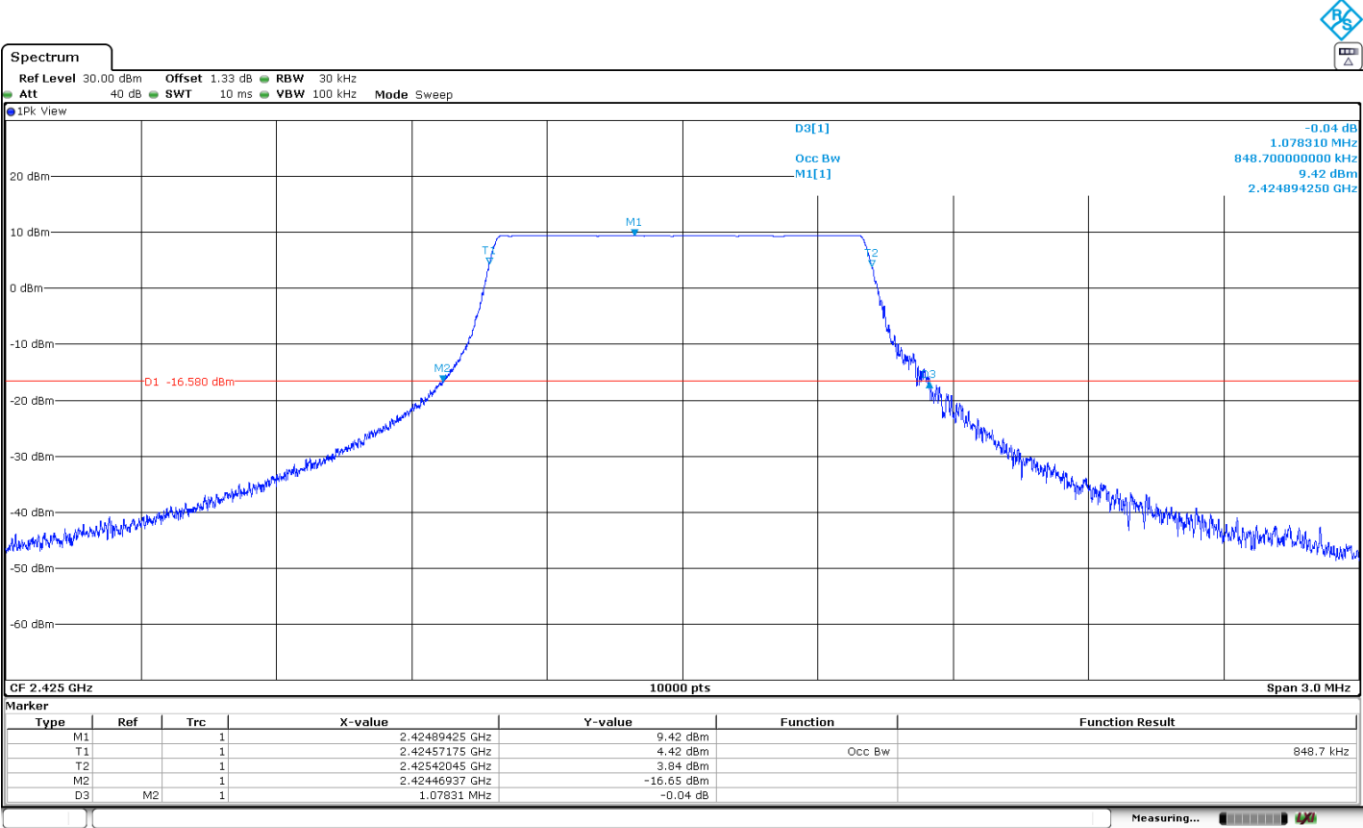
Equipment Type = Digital Transmission System (DTS) Bandwidth MHz = 1
Modulation = LoRa Frequency MHz = 2403
Mode = SISO Active Port = 1

Images:



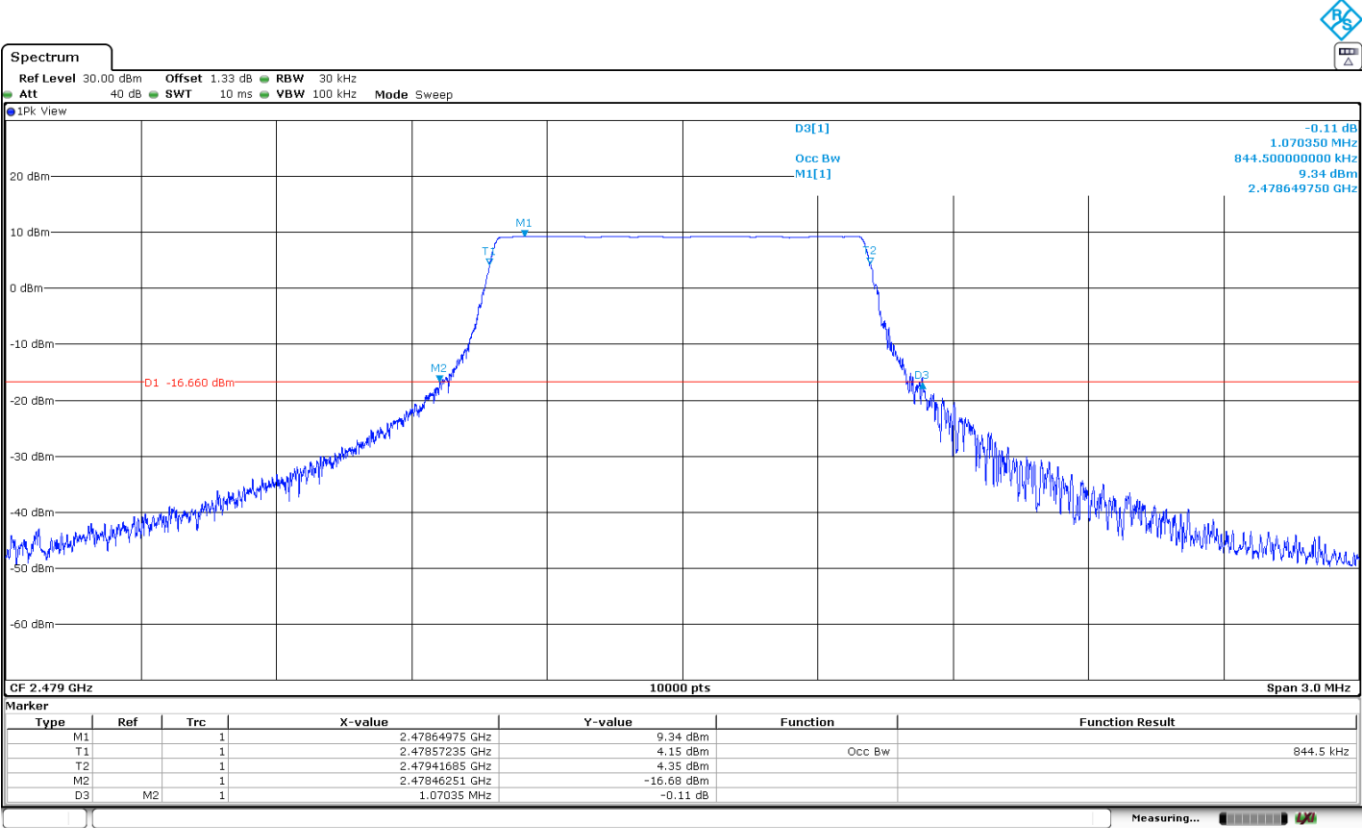
Equipment Type = Digital Transmission System (DTS) Bandwidth MHz = 1
Modulation = LoRa Frequency MHz = 2425
Mode = SISO Active Port = 1

Images:



Equipment Type = Digital Transmission System (DTS) Bandwidth MHz = 1
Modulation = LoRa Frequency MHz = 2479
Mode = SISO Active Port = 1

Images:



RSS-247 5.2 (a) / FCC 15.247 (a) (2) 6 dB Bandwidth

Limits

The minimum 6 dB bandwidth shall be at least 500 kHz.

Modulation: LoRa

Mode: SISO

Results

Freq (MHz)	Ebw (kHz)
2403	851.42
2425	851.52
2479	848.45

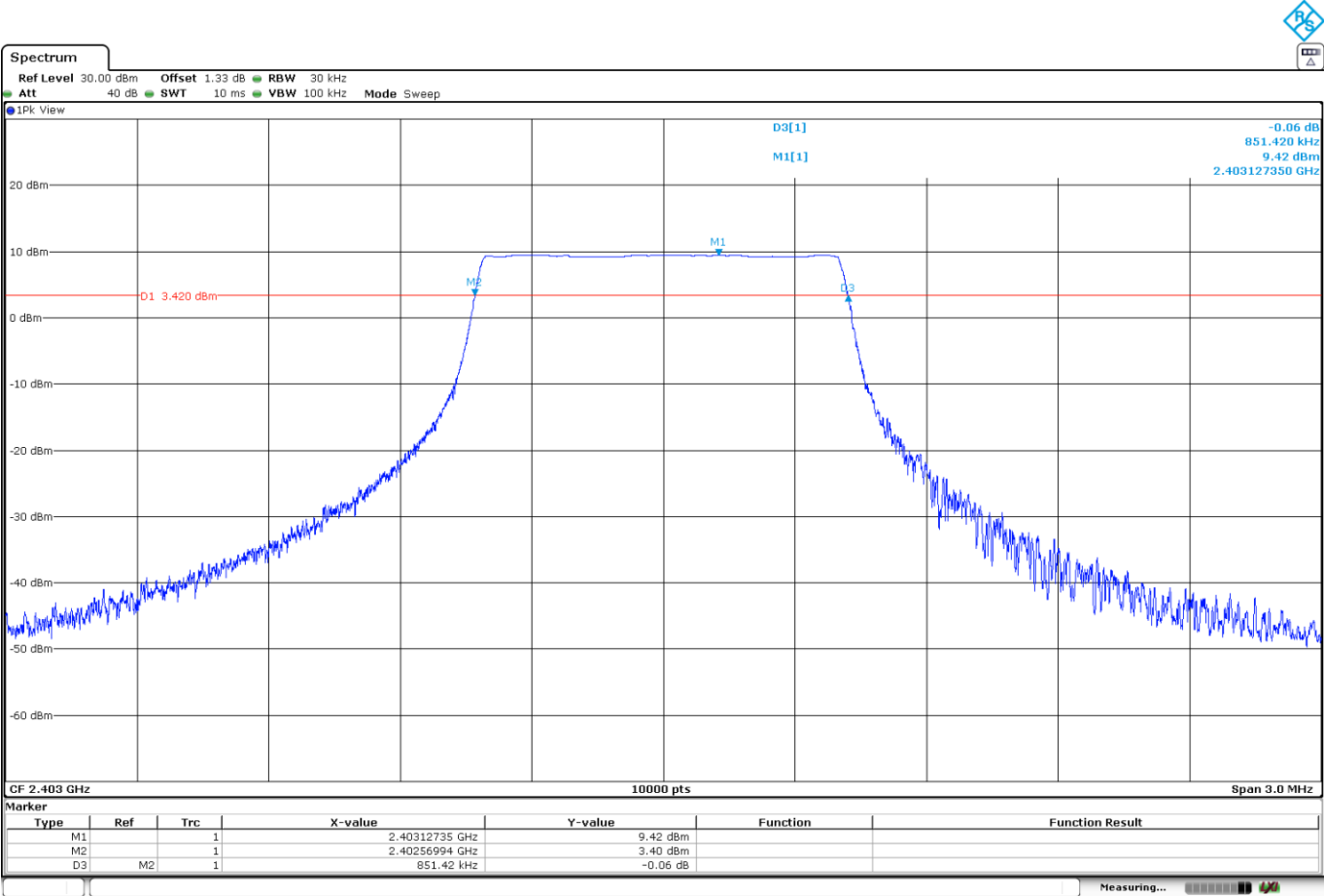
Verdict

Pass

Attachments

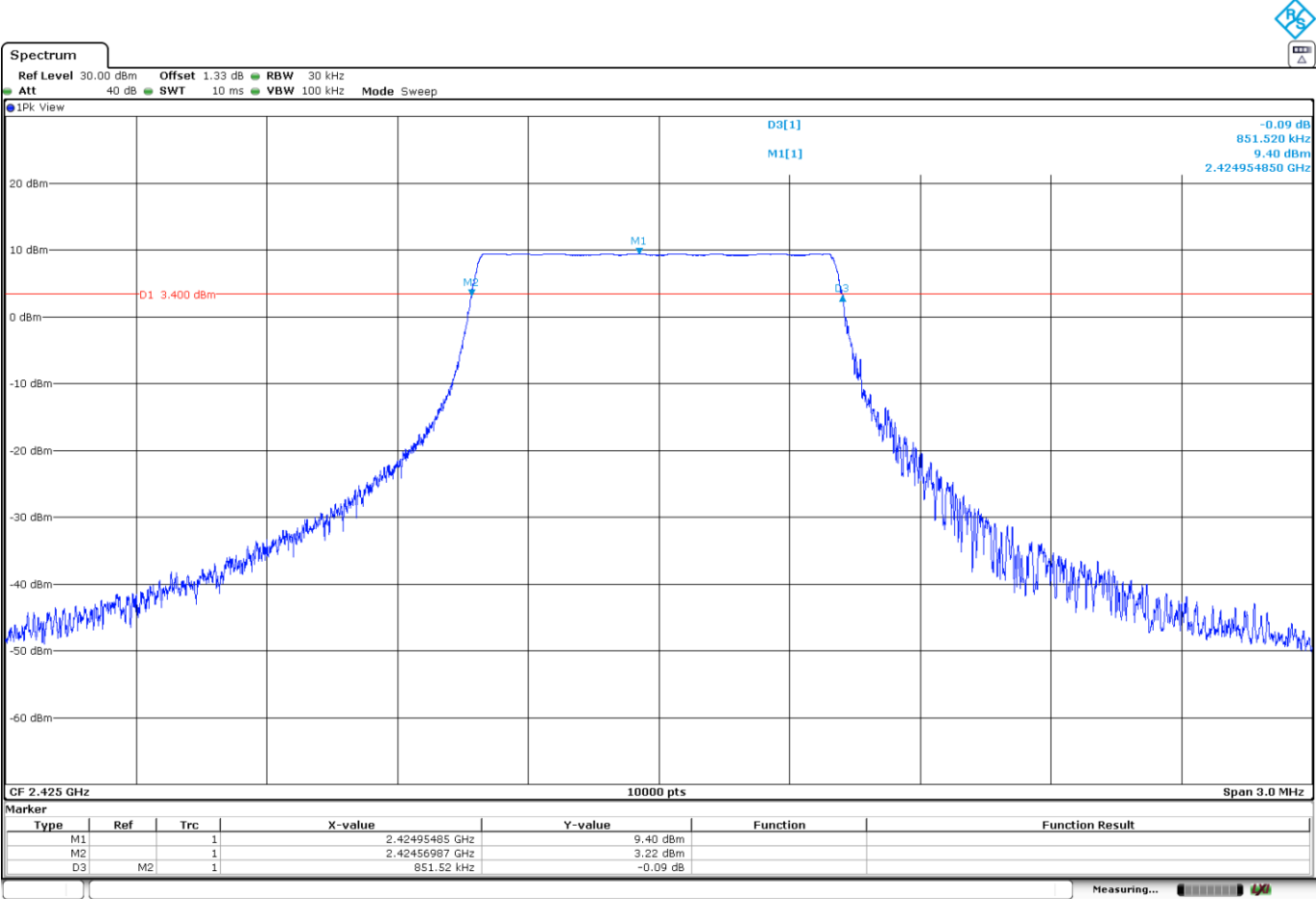
Bandwidth MHz = 1 Modulation = LoRa
Frequency MHz = 2403 Mode = SISO
Active Port = 1

Images:



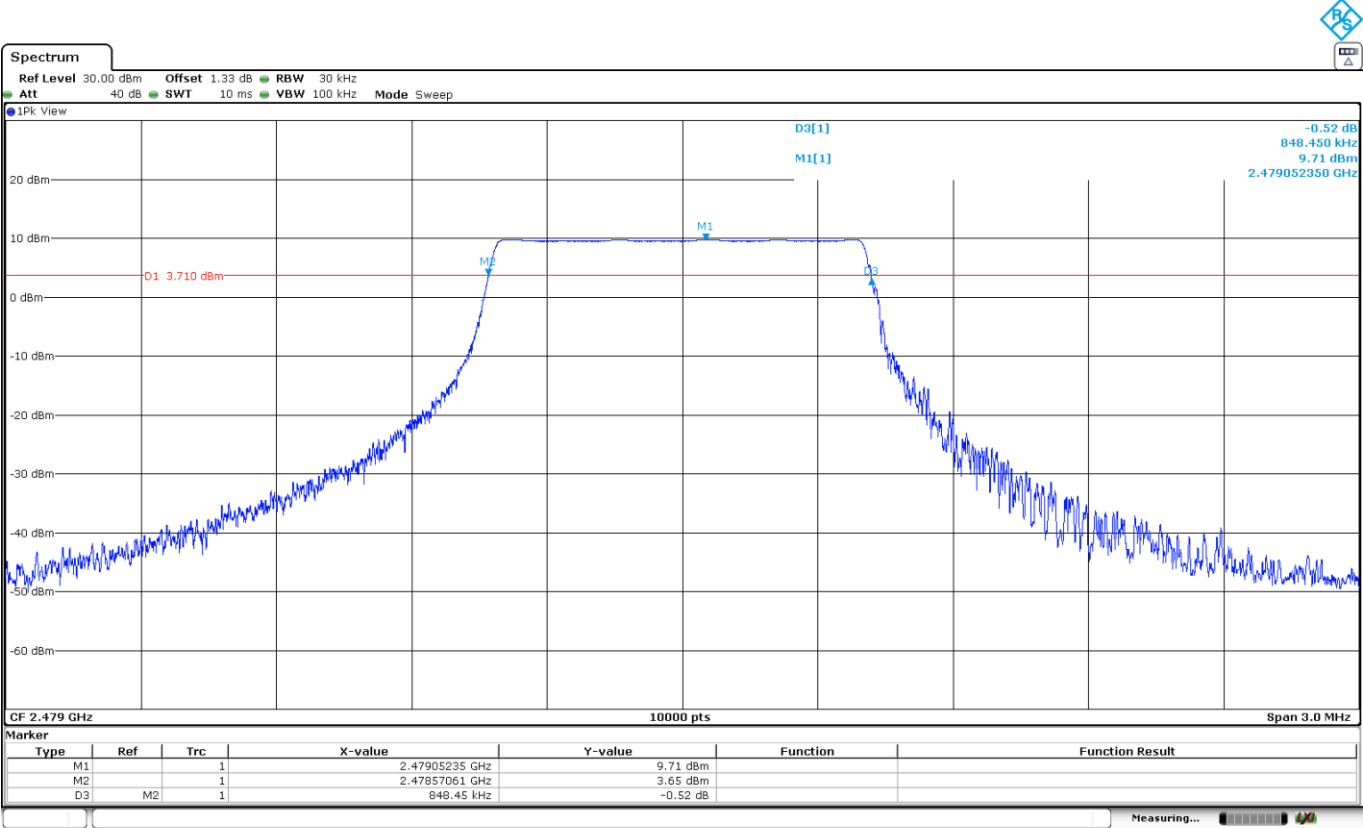
Bandwidth MHz = 1 Modulation = LoRa
Frequency MHz = 2425 Mode = SISO
Active Port = 1

Images:



Bandwidth MHz = 1 Modulation = LoRa
Frequency MHz = 2479 Mode = SISO
Active Port = 1

Images:



RSS-247 5.2 (b) / FCC 15.247 (e) Power spectral density

Limits

For digitally modulated systems, the power spectral density conducted from the intentional radiator to the antenna shall not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission.

Modulation: LoRa

Mode: SISO

Results

Freq (MHz)	PSD (dBm)
2403	2.71
2425	2.84
2479	2.85

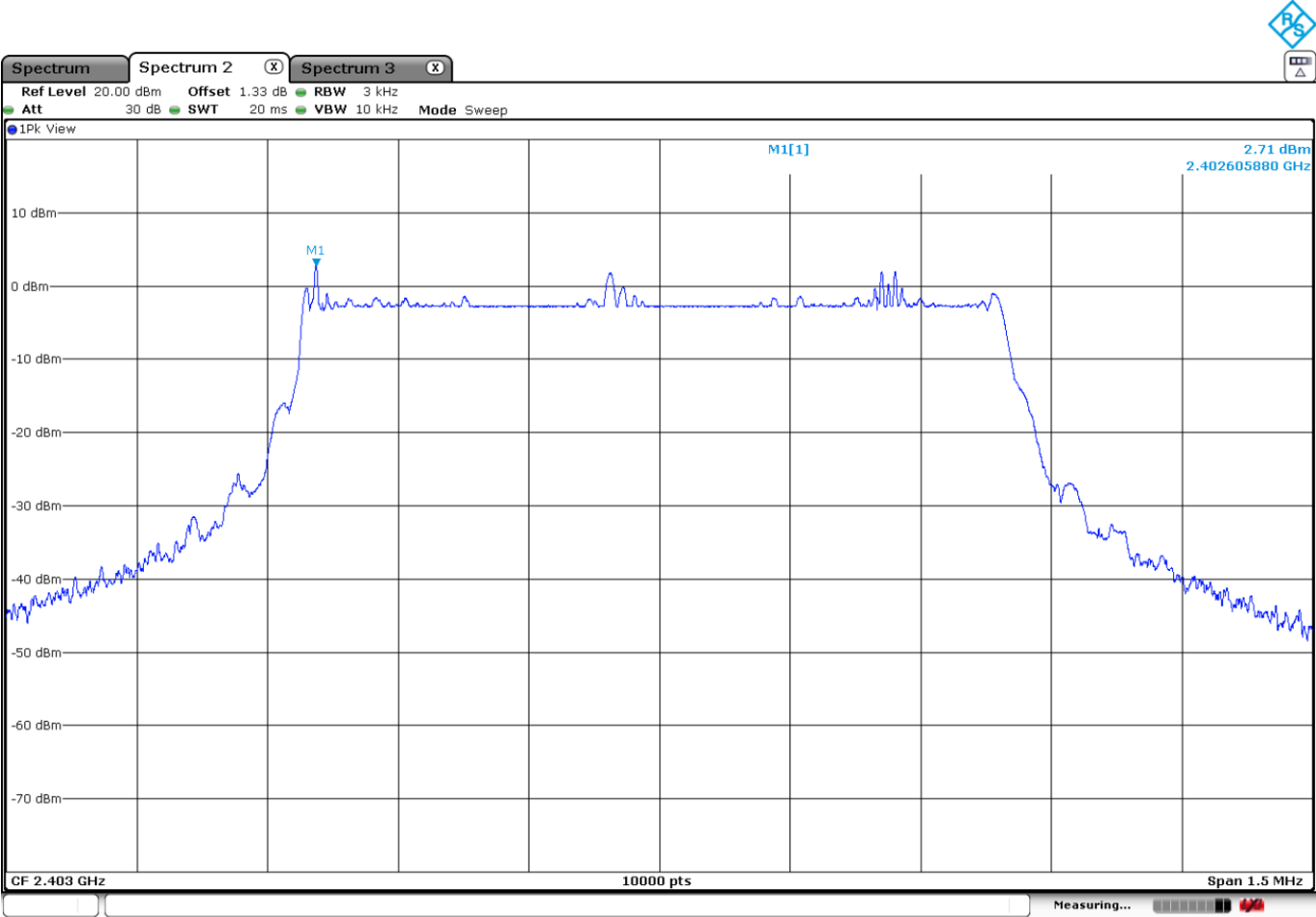
Verdict

Pass

Attachments

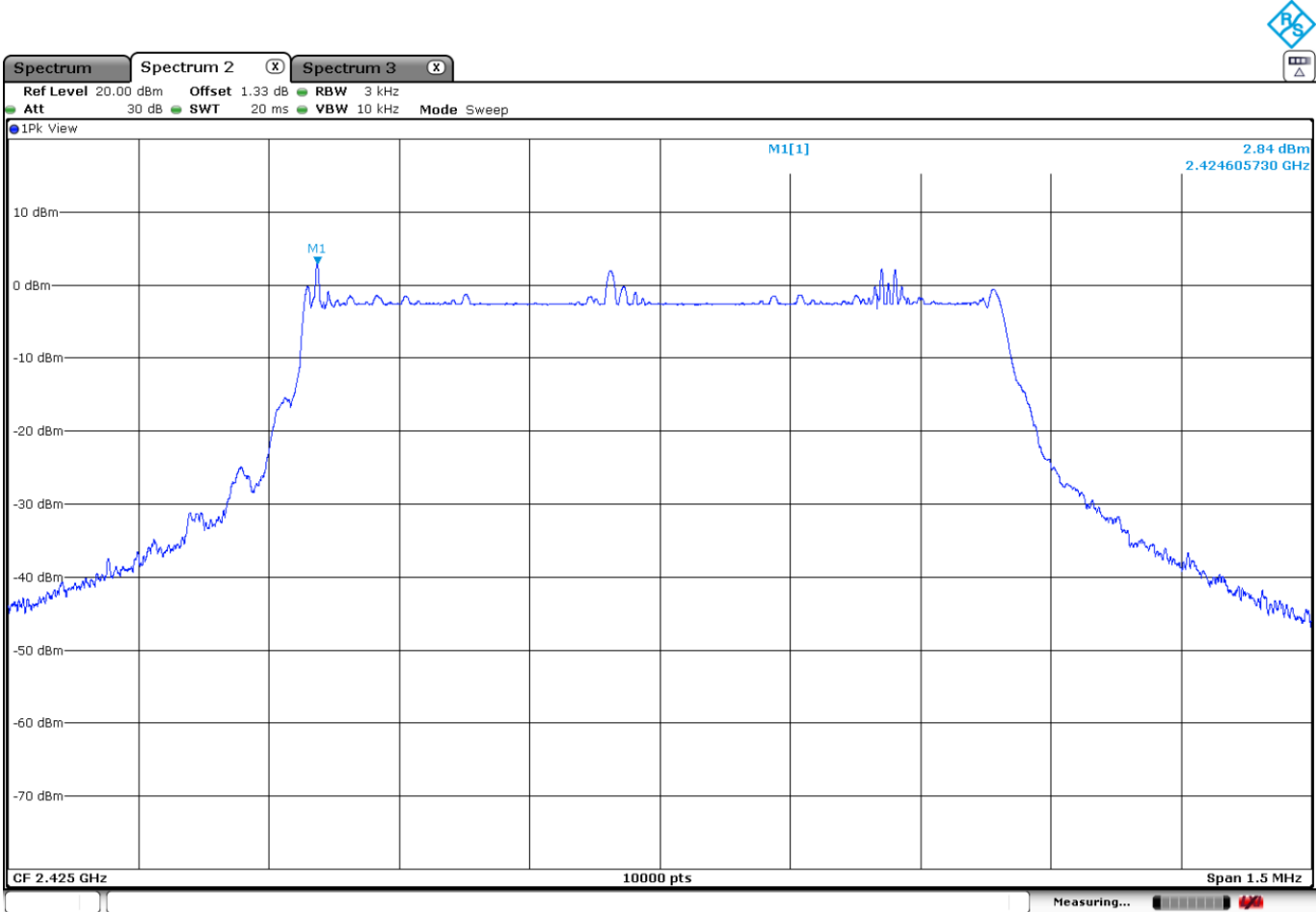
Equipment Type = Digital Transmission System (DTS) Bandwidth MHz = 1
Modulation = LoRa Frequency MHz = 2403
Mode = SISO Active Port = 1

Images:



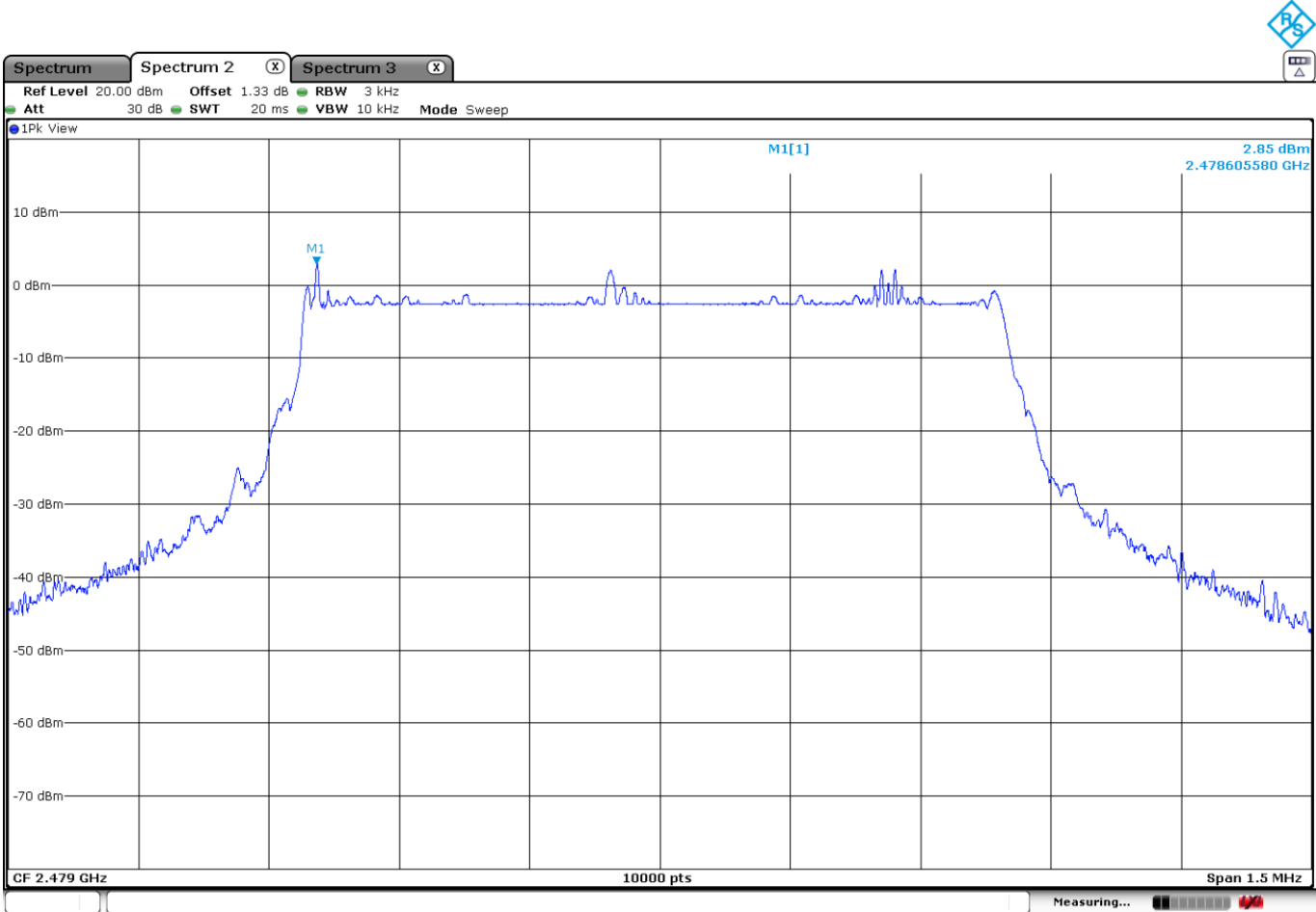
Equipment Type = Digital Transmission System (DTS) Bandwidth MHz = 1
Modulation = LoRa Frequency MHz = 2425
Mode = SISO Active Port = 1

Images:



Equipment Type = Digital Transmission System (DTS) Bandwidth MHz = 1
Modulation = LoRa Frequency MHz = 2479
Mode = SISO Active Port = 1

Images:



RSS-247 5.4 (d) / FCC 15.247 (b) (3) Maximum output power and antenna gain

Limits

For systems using digital modulation in the 2400-2483.5 MHz band: 1 watt (30 dBm).
The e.i.r.p. shall not exceed 4 W (36 dBm) (Canada).

Modulation: LoRa
Mode: SISO

Results

The maximum peak conducted output power level in the fundamental emission was measured using the method according to point 11.9.1.1 "RBW ≥ DTS bandwidth" of ANSI C.63.10-2013.

Measured Duty Cycle: $x = 0.50535$
Duty Cycle Correction: $10 \times \log(1/x) = 2.964 \text{ dB}$

Declared Antenna Gain External: 2 dBi

The maximum directional gain of the antenna is less than 6 dBi and therefore the maximum output power is not required to be reduced from the stated values.

Freq (MHz)	Power (dBm)	Power with Duty Cycle correction (dBm)	E.I.R.P. (dBm)
2403	8.87	11,83	13.83
2425	8.81	11,77	13.77
2479	8.68	11,64	13.64

Declared Antenna Gain FPC: 3.9 dBi

The maximum directional gain of the antenna is less than 6 dBi and therefore the maximum output power is not required to be reduced from the stated values.

Freq (MHz)	Power (dBm)	Power with Duty Cycle correction (dBm)	E.I.R.P. (dBm)
2403	8.87	11,83	15.73
2425	8.81	11,77	15.67
2479	8.68	11,64	15.54

Verdict

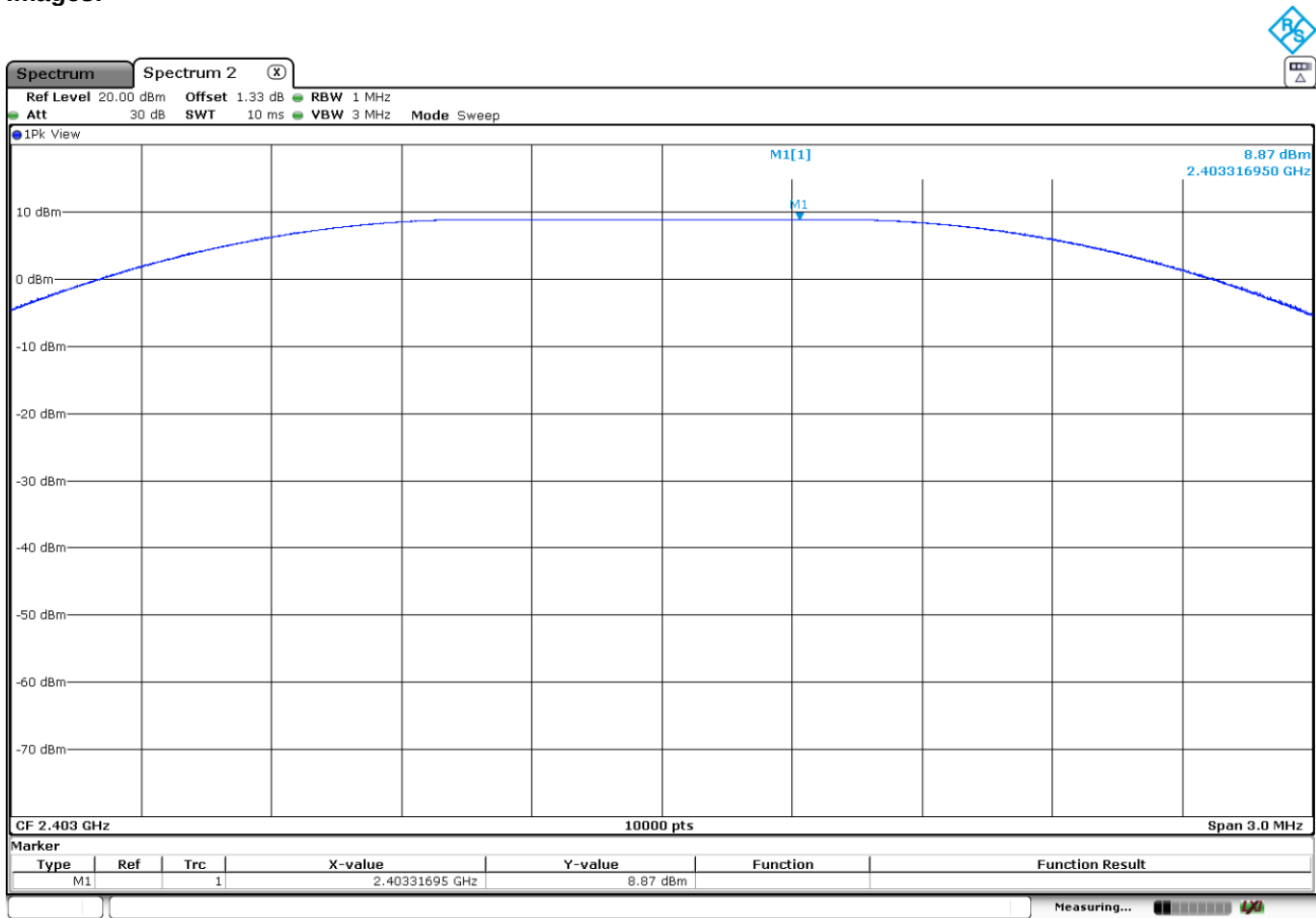
Pass

Maximum Average Output Power:

Attachments

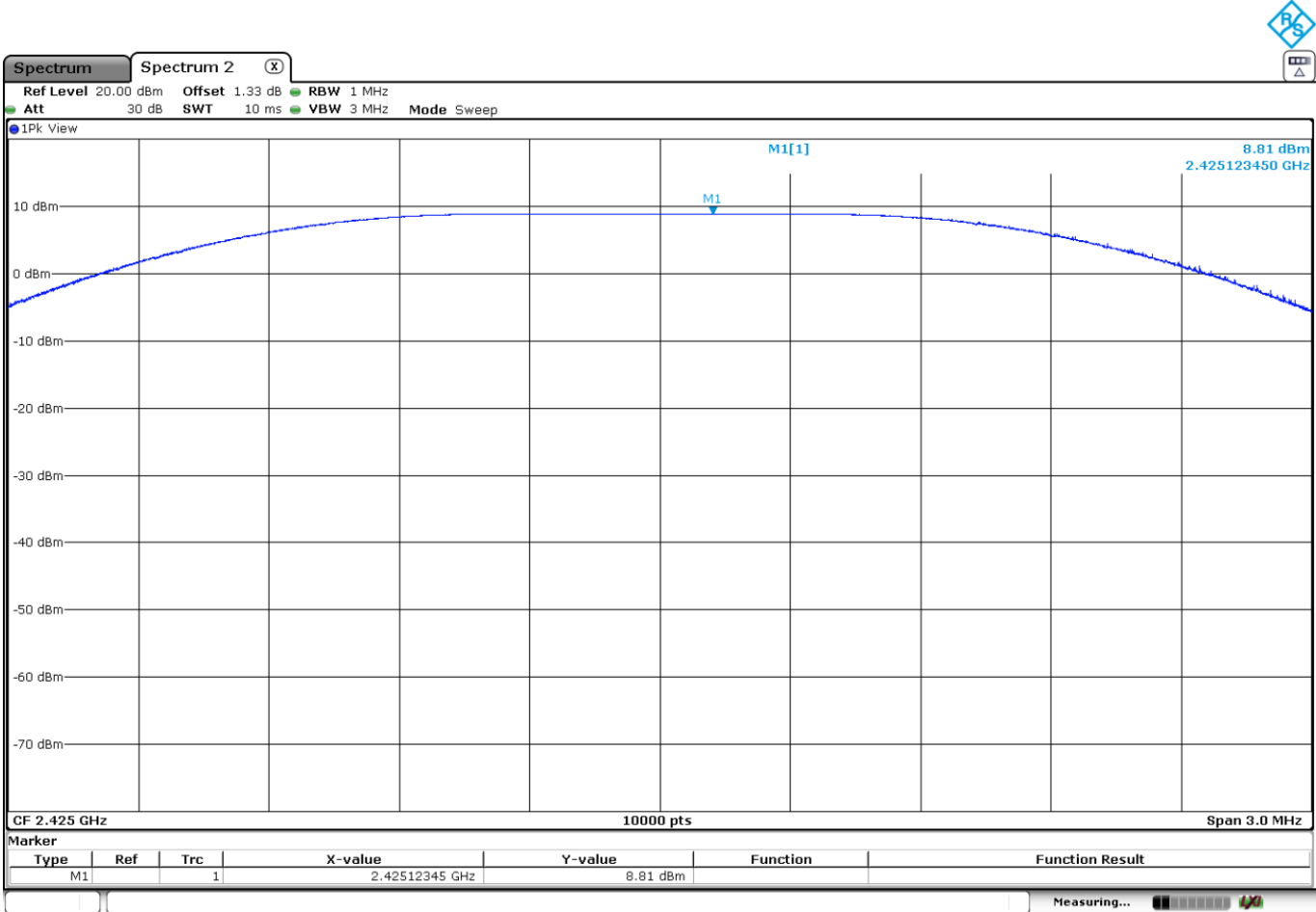
Equipment Type = Digital Transmission System (DTS) Bandwidth MHz = 1
Modulation = LoRa Frequency MHz = 2403
Mode = SISO Active Port = 1

Images:



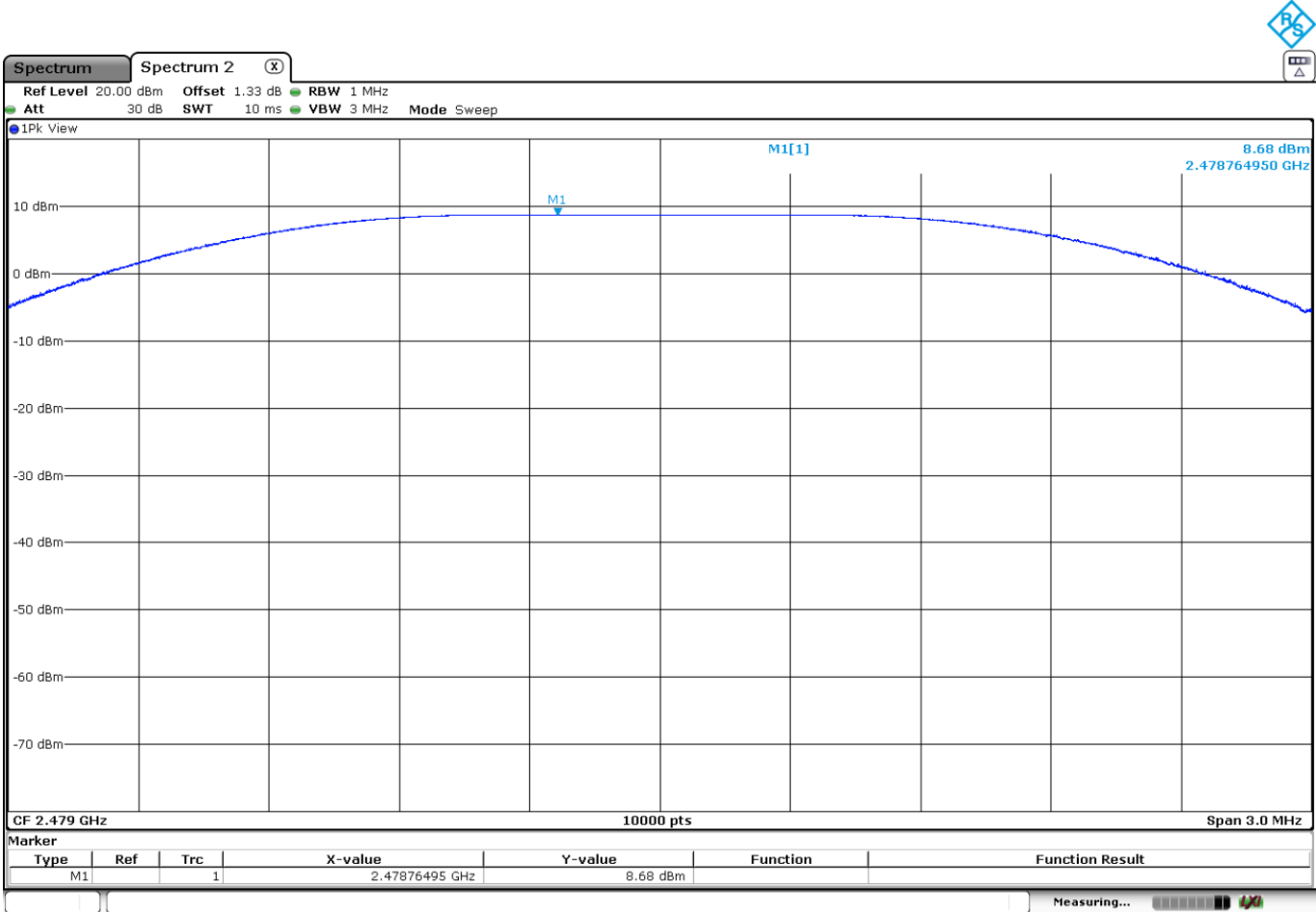
Equipment Type = Digital Transmission System (DTS) Bandwidth MHz = 1
Modulation = LoRa Frequency MHz = 2425
Mode = SISO Active Port = 1

Images:



Equipment Type = Digital Transmission System (DTS) Bandwidth MHz = 1
Modulation = LoRa Frequency MHz = 2479
Mode = SISO Active Port = 1

Images:



RSS-247 5.5 / FCC 15.247 (d) Band-edge emissions compliance (Transmitter)

Limits

In any 100 kHz bandwidths outside the frequency band in which the intentional radiator is operating, the radio frequency power that is produced by the intentional radiator 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 the transmitter demonstrates compliance with the peak conducted power limits.

If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, the attenuation required under this paragraph shall be 30 dB instead of 20 dB.

Modulation: LoRa

Mode: SISO

Results

The attenuation of highest emissions at the band-edge is more than 30 dB respect to the highest level of the desired power.

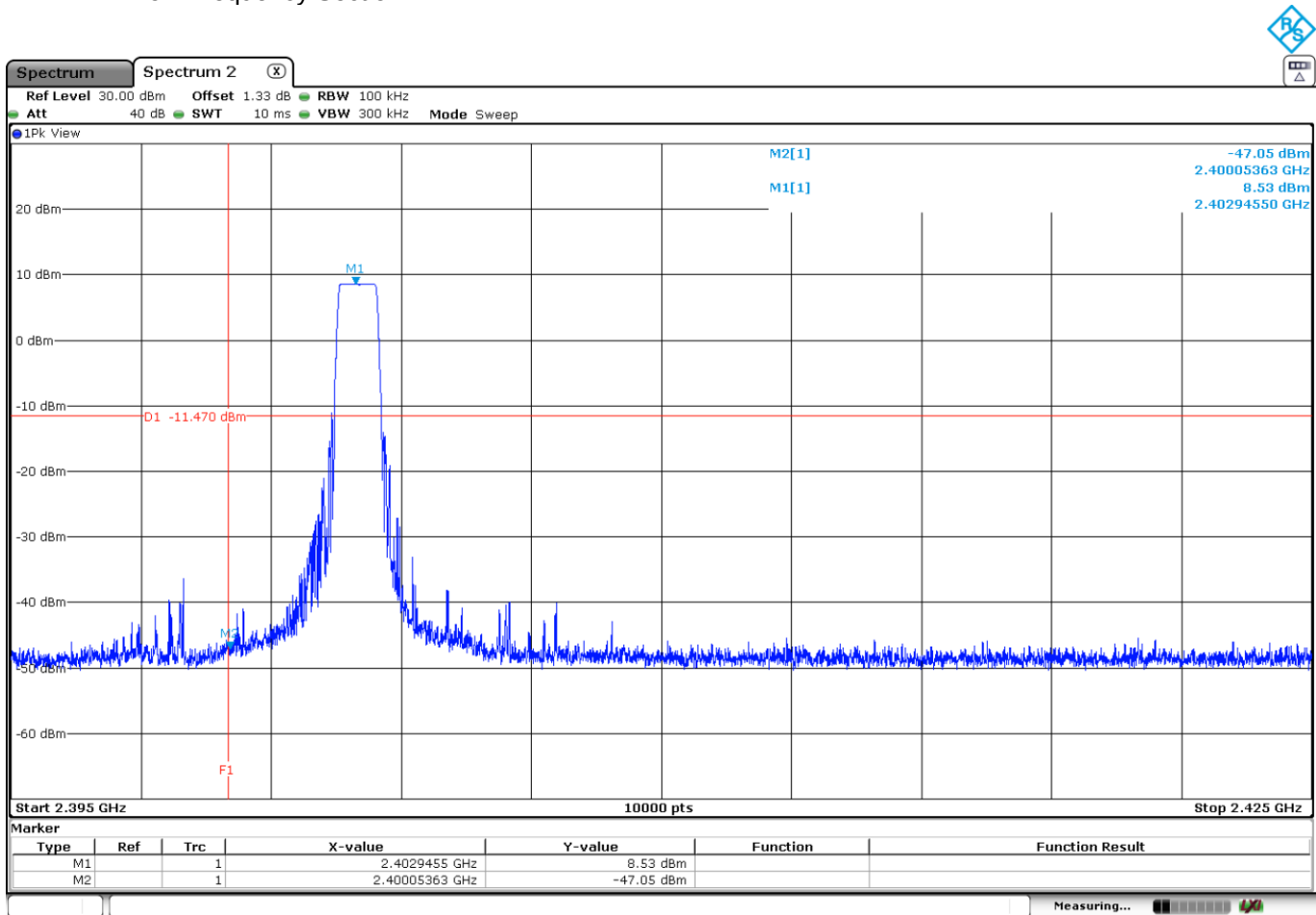
Channel Frequency (MHz)	Frequency (MHz)	Inband Peak Lvl (dBm)
2403	2.4029455	8.53
2479	2.4788541	8.47

Verdict

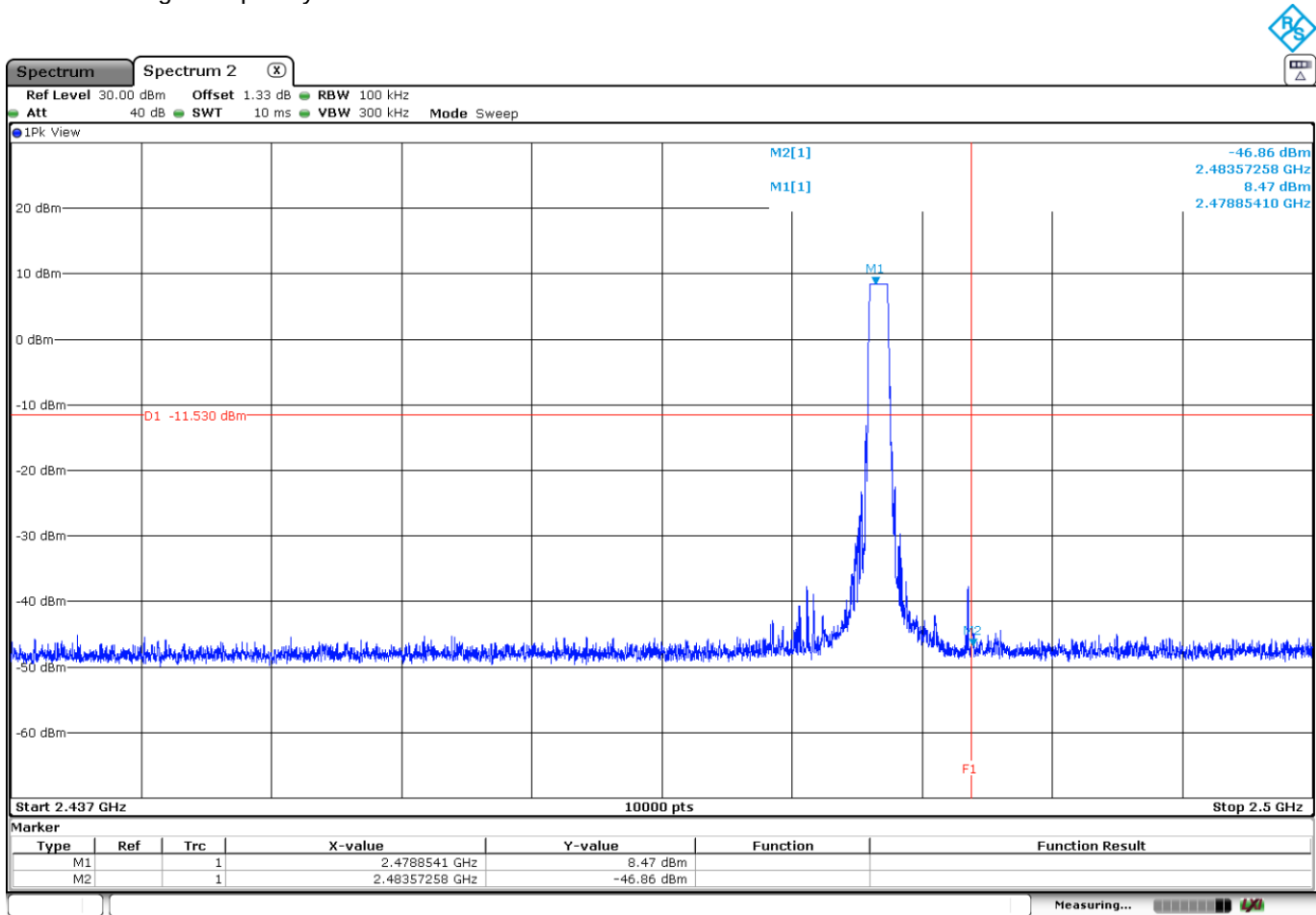
Pass

Attachments

- Low Frequency Section:



- High Frequency Section:



RSS-247 5.5 / FCC 15.247 (d) [RSE] Emission limitations radiated (Transmitter)

Limits

* FCC 15.247:
Radiated emissions which fall in the restricted bands, as defined in Section 15.205(a), must also comply with the radiated emission limits specified in Section 15.209(a) (see Section 15.205(c)/RSS-Gen):

Frequency Range (MHz)	Field strength (µV/m)	Field strength (dBµV/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	40	3
88 - 216	150	43.5	3
216 - 960	200	46	3
Above 960	500	54	3

The emission limits shown in the above table are based on measurements employing CISPR quasi-peak detector except for the frequency bands 9-90 kHz, 110-490 kHz and above 1000 MHz. Radiated emission limits in these three bands are based on measurements employing an average detector.

For average radiated emission measurements above 1000 MHz, there is also a limit corresponding to 20 dB above the indicated values in the table is specified when measuring with peak detector function.

* RSS-247: Attenuation below the general field strength limits specified in RSS-Gen is not required.

Frequency range tested for Radiated emissions

Start frequency: no radiofrequency signal generated in the device found below 10th sub-armonic, no further investigation required.

Stop frequency: it has been performed the radiated spurious emissions until 10th armonic.

Modulation: LoRa

MIMO Mode: SISO

Results

Freq Rng (GHz)	Freq (MHz)	Unwanted Freq (MHz)	Unwanted Lvl (dBµV/m)	Pol	Detector
[0.03, 1]	2403	35.972	28.07	V	QP
[0.03, 1]	2403	39.458	34.25	V	QP
[0.03, 1]	2403	44.035	27.70	V	QP
[0.03, 1]	2403	48.006	30.43	V	QP
[0.03, 1]	2403	59.918	34.51	V	QP
[0.03, 1]	2403	62.737	25.81	V	QP
[0.03, 1]	2403	71.953	25.50	V	QP
[0.03, 1]	2403	83.956	24.78	V	QP
[0.03, 1]	2425	30.303	32.44	V	QP
[0.03, 1]	2425	31.182	34.06	V	QP

Freq Rng (GHz)	Freq (MHz)	Unwanted Freq (MHz)	Unwanted Lvl (dBµV/m)	Pol	Detector
[0.03, 1]	2425	32.728	38.05	H	QP
[0.03, 1]	2425	34.880	30.08	V	QP
[0.03, 1]	2425	36.002	34.75	V	QP
[0.03, 1]	2425	38.972	29.69	H	QP
[0.03, 1]	2425	45.035	27.38	H	QP
[0.03, 1]	2425	50.976	23.75	V	QP
[0.03, 1]	2425	71.983	22.25	H	QP
[0.03, 1]	2479	35.972	27.84	V	QP
[0.03, 1]	2479	40.367	34.66	V	QP
[0.03, 1]	2479	43.368	30.86	V	QP
[0.03, 1]	2479	47.975	30.92	V	QP
[0.03, 1]	2479	59.918	36.71	V	QP
[0.03, 1]	2479	71.922	25.29	V	QP
[0.03, 1]	2479	83.926	23.57	V	QP
[1, 3]	2479	2484.338	68.79	H	PK
[1, 3]	2479	2484.338	49.73	H	AVG
[3, 17]	2403	12015.580	54.54	V	PK
[3, 17]	2403	12015.580	43.80	V	AVG
[3, 17]	2425	7275.740	58.18	H	PK
[3, 17]	2425	7275.740	52.82	H	AVG
[3, 17]	2425	12125.200	57.46	V	PK
[3, 17]	2425	12125.200	48.71	V	AVG
[17, 26]	2403	19224.500	54.58	V	PK
[17, 26]	2403	19224.500	45.85	V	AVG
[17, 26]	2479	19831.700	50.31	V	PK

Verdict

Pass

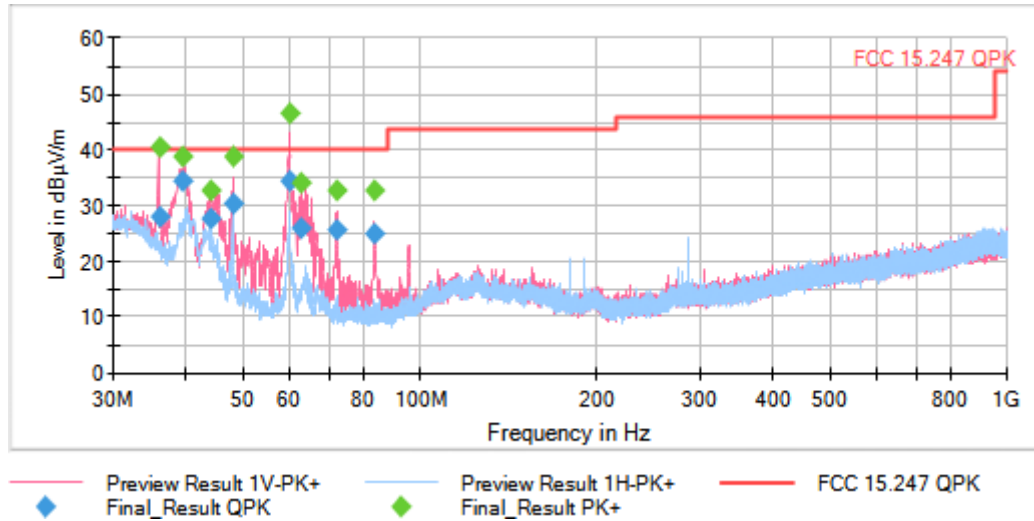
Attachments

Frequency Range GHz = [0.03, 1] Equipment Type = Digital Transmission System (DTS)

Modulation = LoRa Frequency MHz = 2403

MIMO Mode = SISO Active Port = 1

Images:

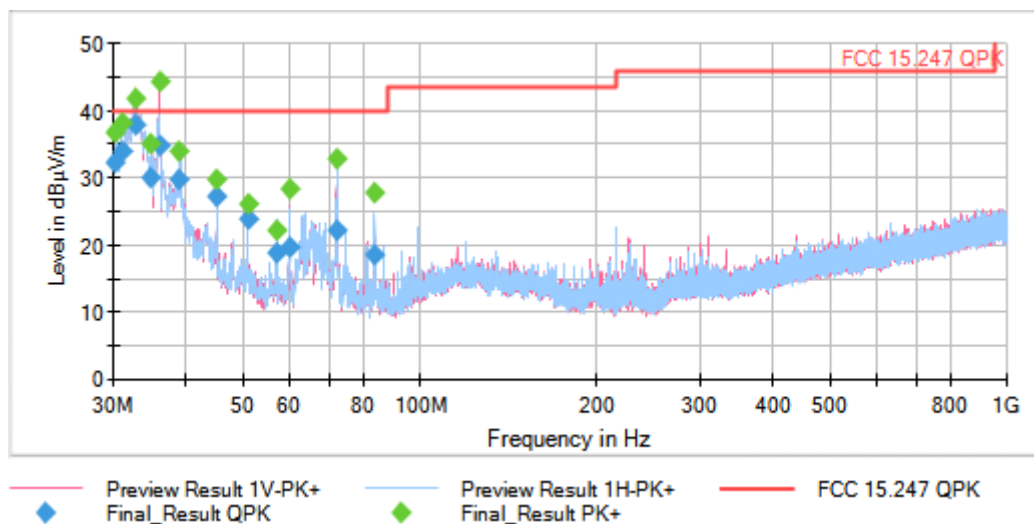


Frequency Range GHz = [0.03, 1] Equipment Type = Digital Transmission System (DTS)

Modulation = LoRa Frequency MHz = 2425

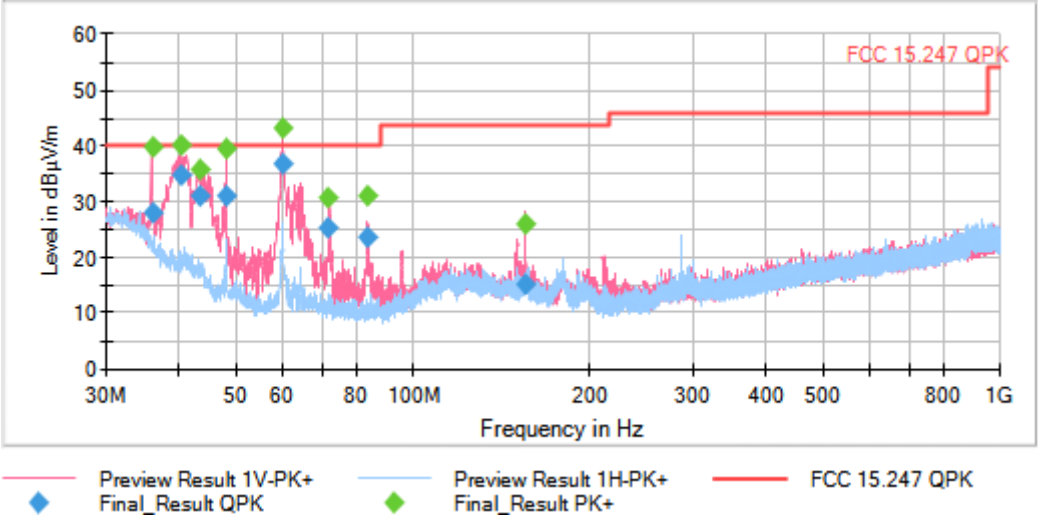
MIMO Mode = SISO Active Port = 1

Images:



Frequency Range GHz = [0.03, 1] Equipment Type = Digital Transmission System (DTS)
Modulation = LoRa Frequency MHz = 2479
MIMO Mode = SISO Active Port = 1

Images:



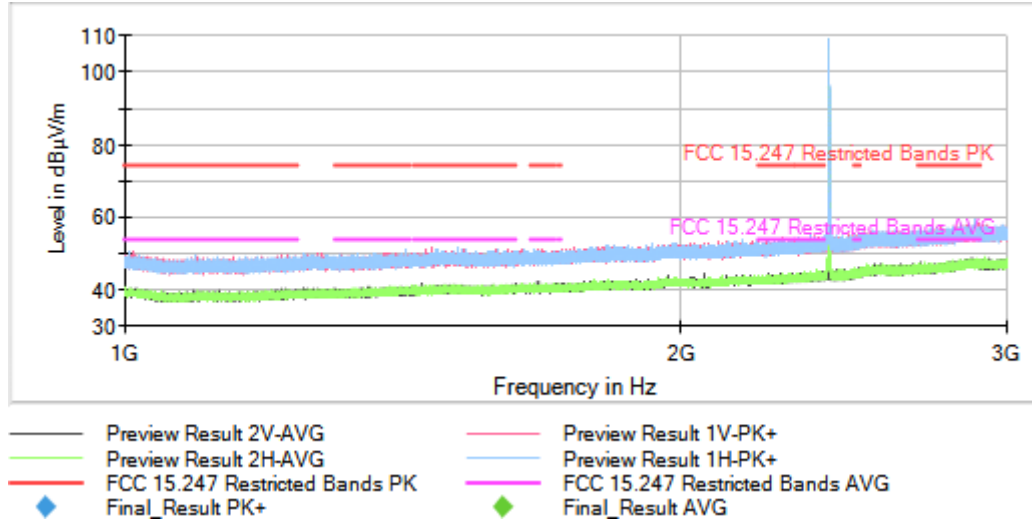
Tables:

Spectrum Analyzer Parameters

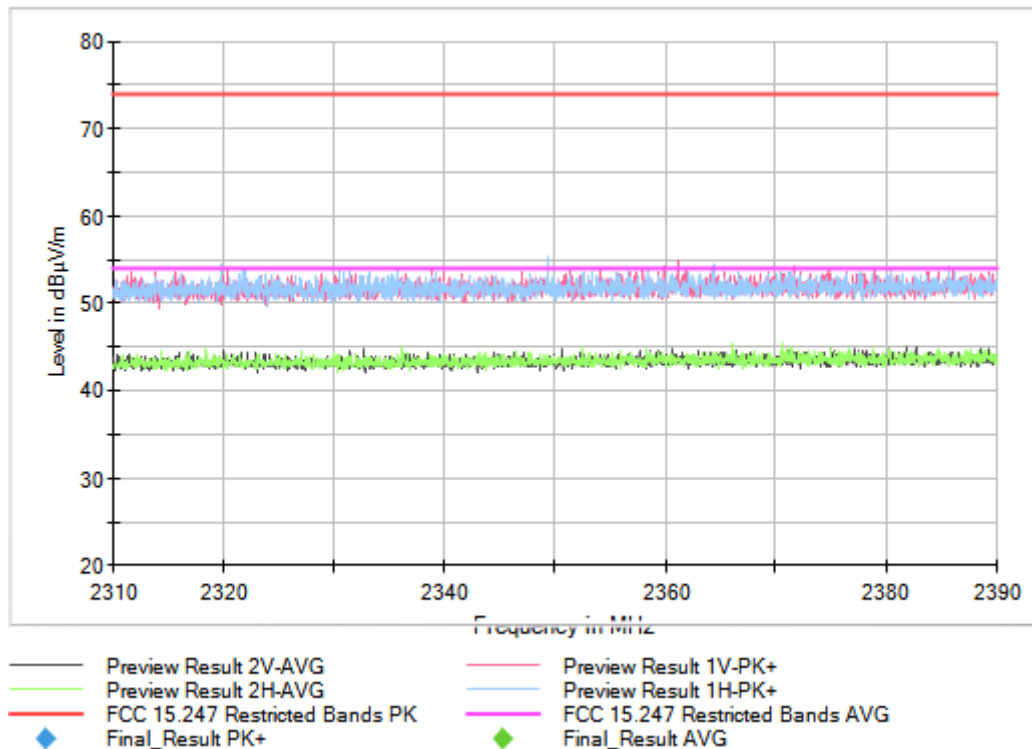
	Subrange	Step Size	Detectors	Bandwidth	Sweep Time	Preamp
	Receiver: [ESR 7]					
	30 MHz - 1 GHz	30,312 kHz	PK+	100 kHz	1 s	0 dB

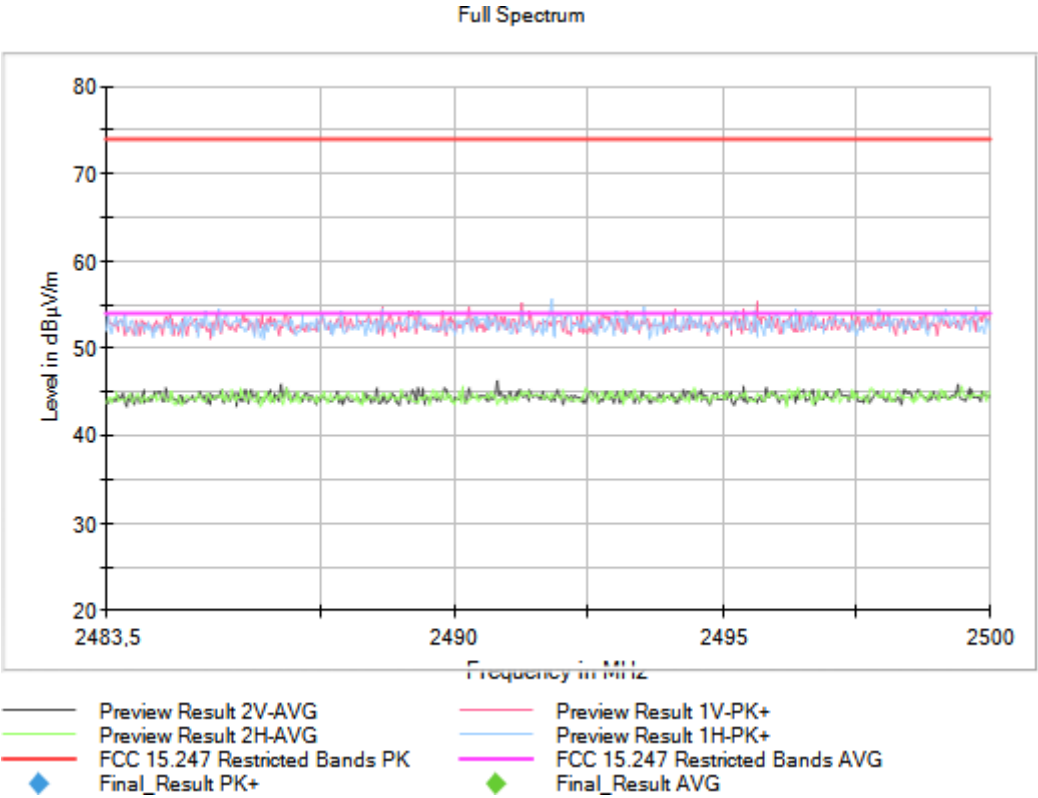
Frequency Range GHz = [1, 3] Equipment Type = Digital Transmission System (DTS)
 Modulation = LoRa Frequency MHz = 2403
 MIMO Mode = SISO Active Port = 1

Images:



Full Spectrum



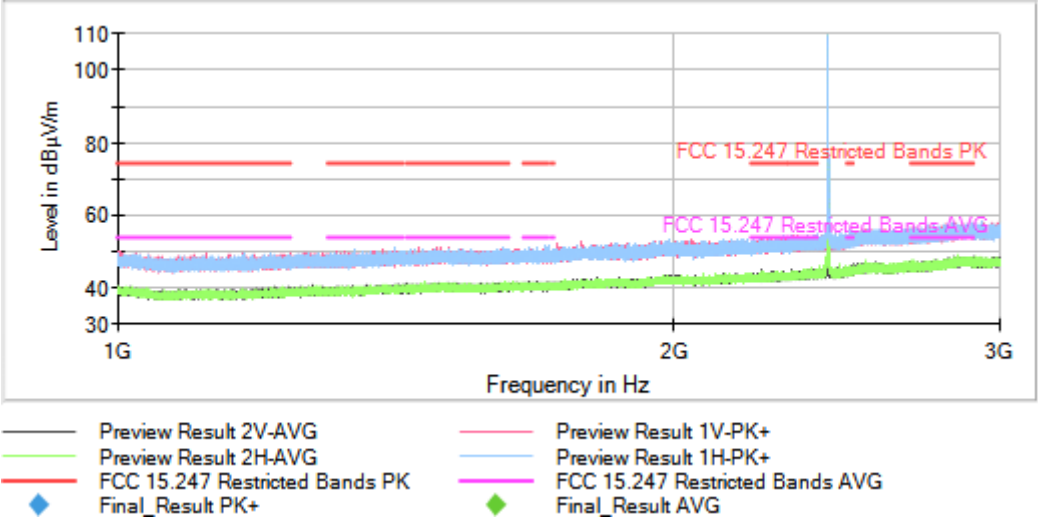


Tables:
Spectrum Analyzer Parameters

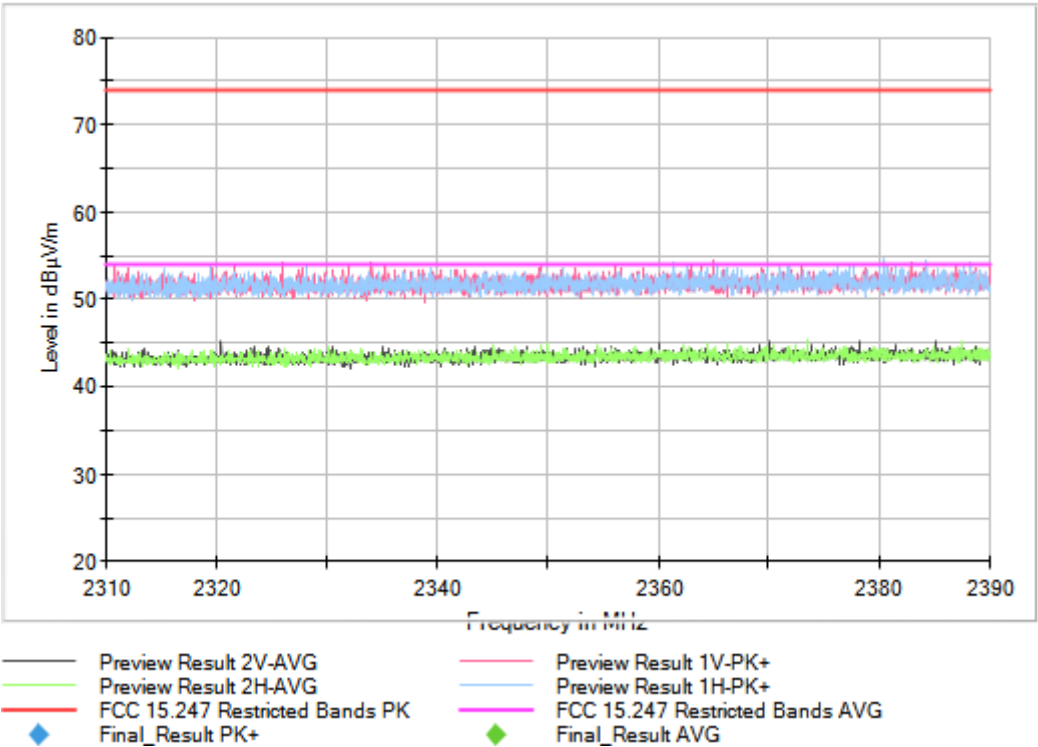
	Subrange	Step Size	Detectors	Bandwidth	Sweep Time	Preamp
	Receiver: [ESR 7]					
	1 GHz - 3 GHz	30,769 kHz	PK+ ; AVG	1 MHz	1 s	0 dB

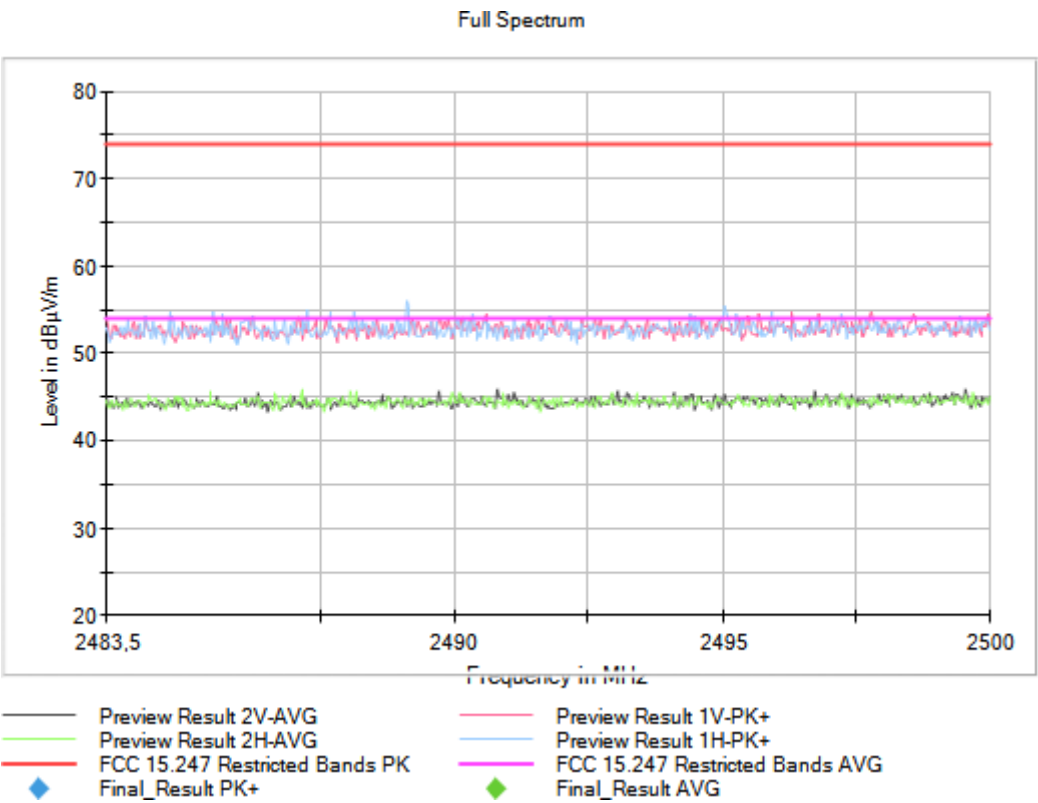
Frequency Range GHz = [1, 3] Equipment Type = Digital Transmission System (DTS)
Modulation = LoRa Frequency MHz = 2425
MIMO Mode = SISO Active Port = 1

Images:



Full Spectrum



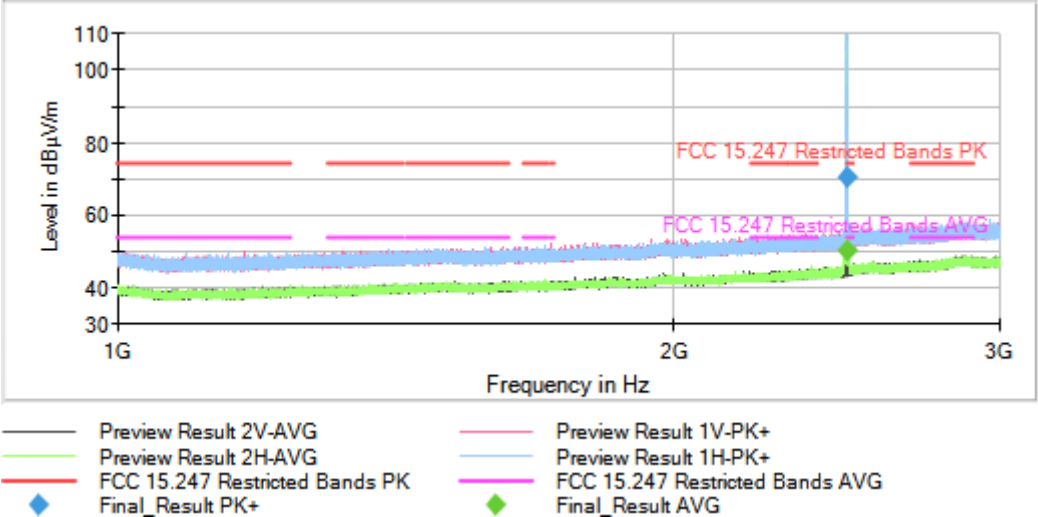


Tables:
Spectrum Analyzer Parameters

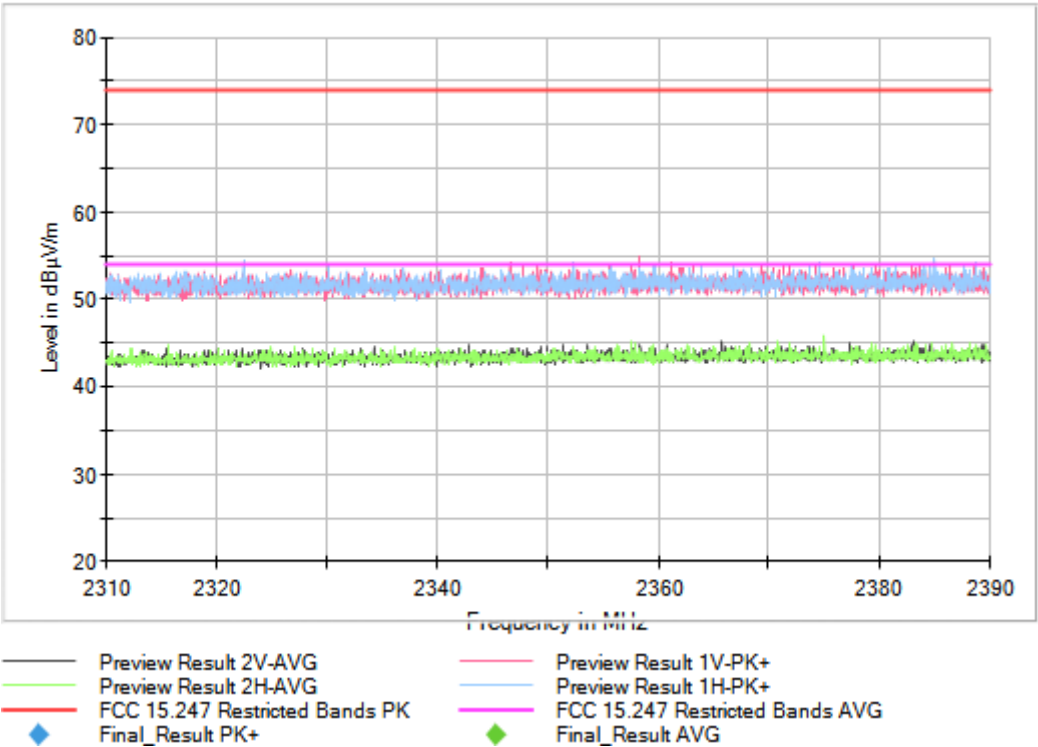
Subrange	Step Size	Detectors	Bandwidth	Sweep Time	Preamp
Receiver: [ESR 7]					
1 GHz - 3 GHz	30,769 kHz	PK+ ; AVG	1 MHz	1 s	0 dB

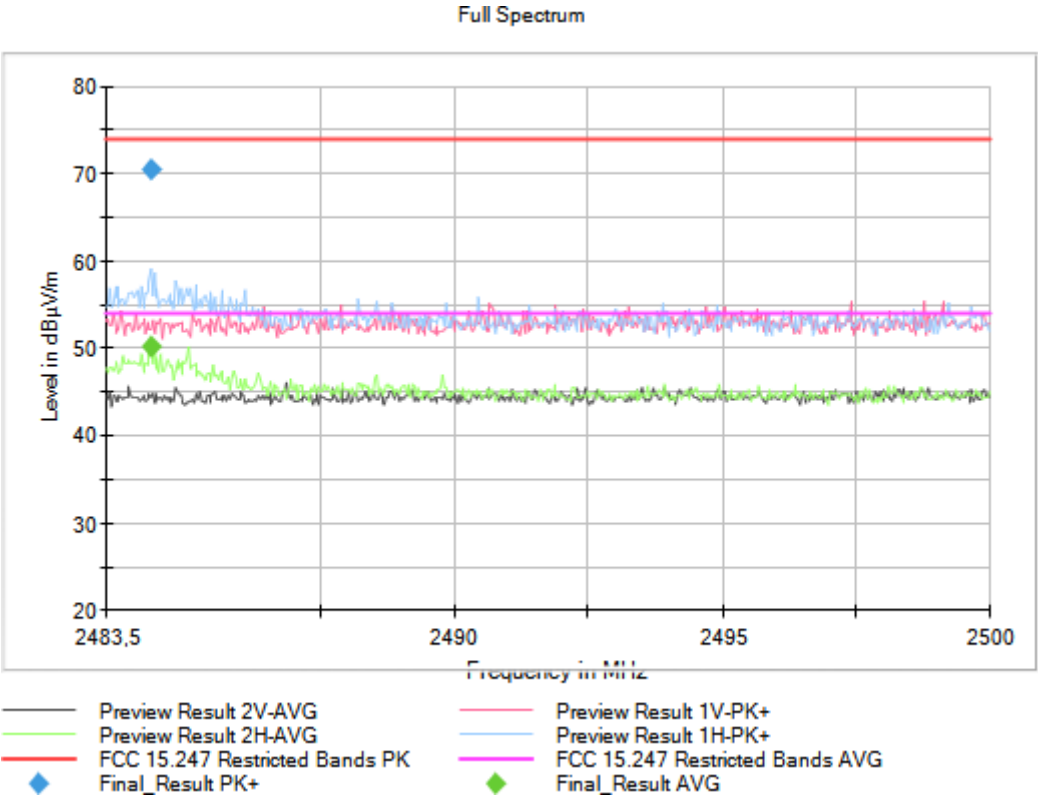
Frequency Range GHz = [1, 3] Equipment Type = Digital Transmission System (DTS)
Modulation = LoRa Frequency MHz = 2479
MIMO Mode = SISO Active Port = 1

Images:



Full Spectrum



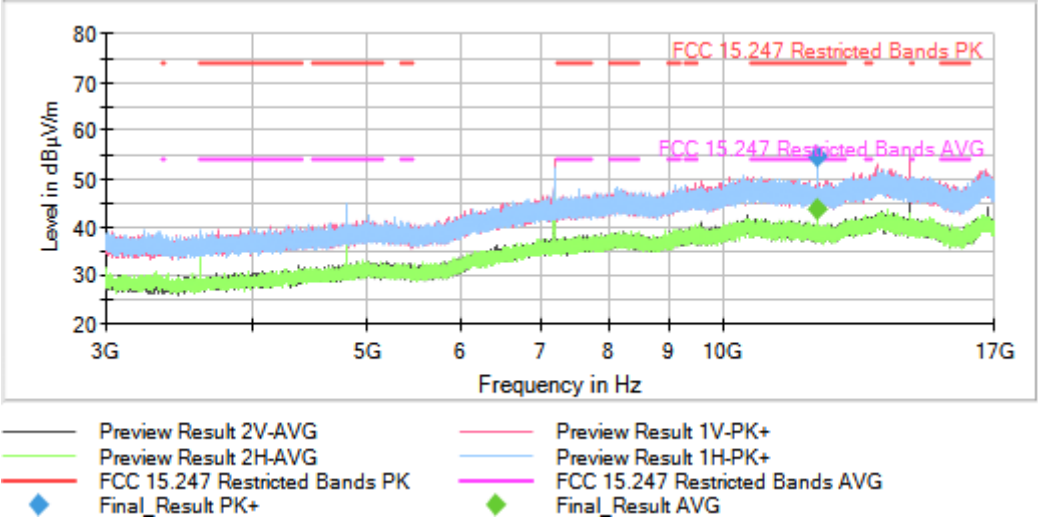


Tables:
Spectrum Analyzer Parameters

	Subrange	Step Size	Detectors	Bandwidth	Sweep Time	Preamp
	Receiver: [ESR 7]					
	1 GHz - 3 GHz	30,769 kHz	PK+ ; AVG	1 MHz	1 s	0 dB

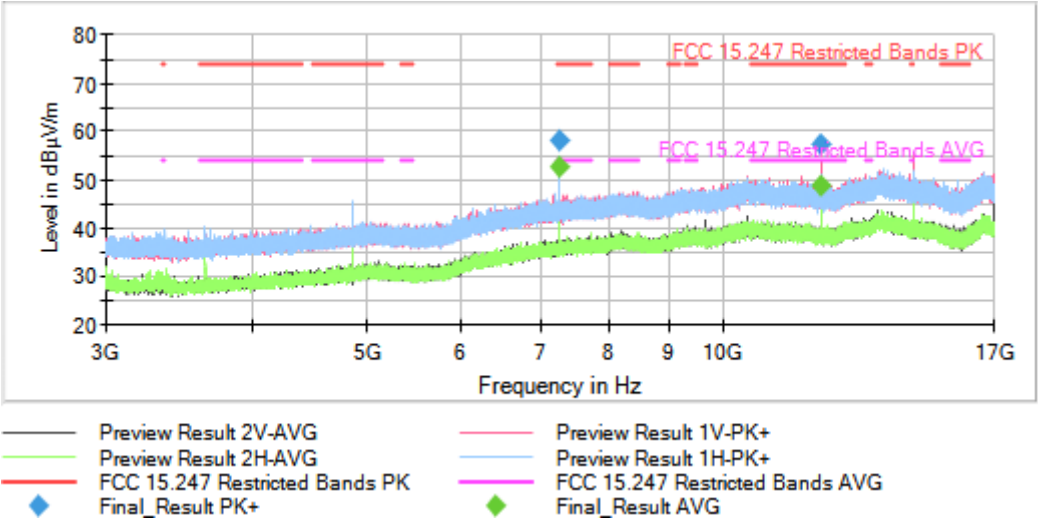
Frequency Range GHz = [3, 17] Equipment Type = Digital Transmission System (DTS)
Modulation = LoRa Frequency MHz = 2403
MIMO Mode = SISO Active Port = 1

Images:



Frequency Range GHz = [3, 17] Equipment Type = Digital Transmission System (DTS)
Modulation = LoRa Frequency MHz = 2425
MIMO Mode = SISO Active Port = 1

Images:



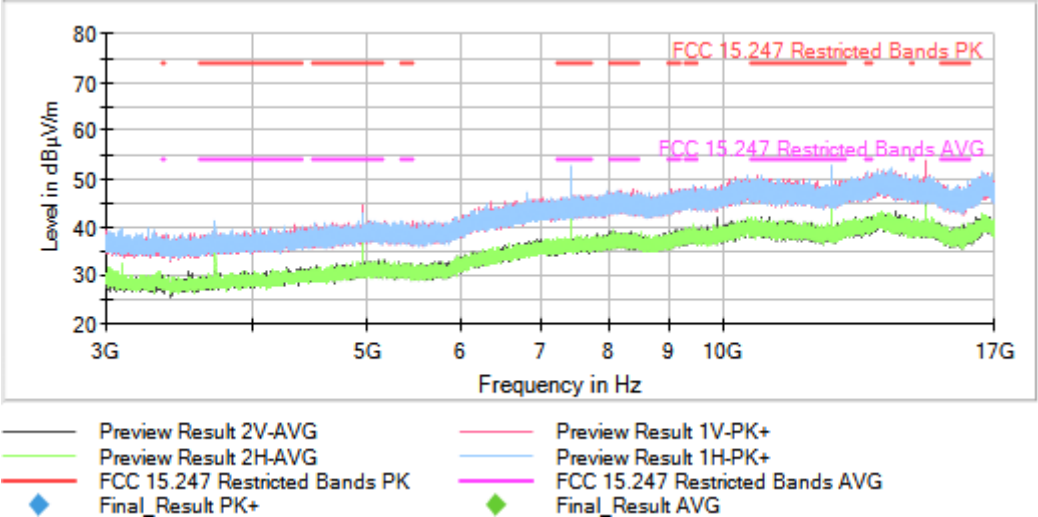
Tables:

Spectrum Analyzer Parameters

Subrange	Step Size	Detectors	Bandwidth	Sweep Time	Preamp
Receiver: [FSV 40]					
3 GHz - 17 GHz	140 kHz	PK+ ; AVG	1 MHz	1 s	30 dB

Frequency Range GHz = [3, 17] Equipment Type = Digital Transmission System (DTS)
Modulation = LoRa Frequency MHz = 2479
MIMO Mode = SISO Active Port = 1

Images:



Tables:

Spectrum Analyzer Parameters

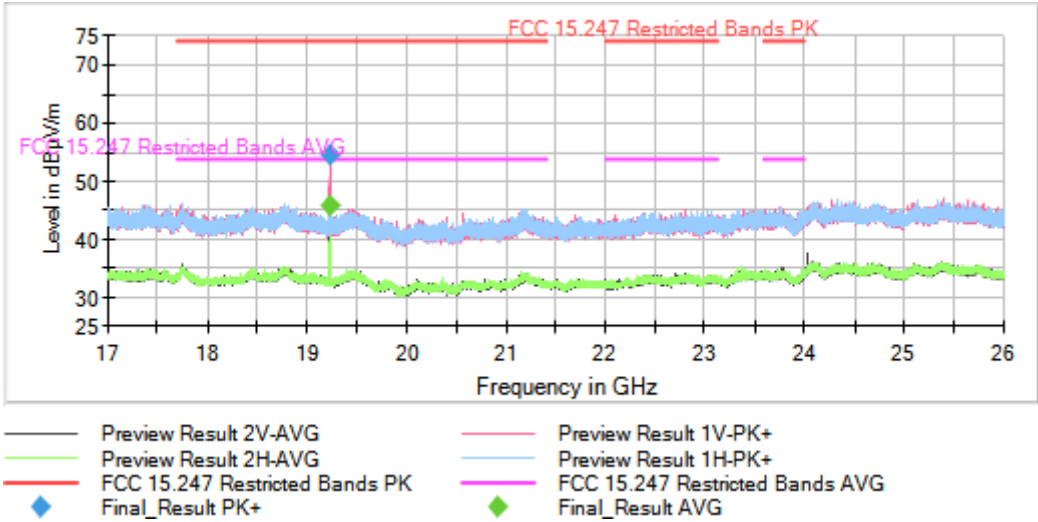
	Subrange	Step Size	Detectors	Bandwidth	Sweep Time	Preamp
	Receiver: [FSV 40]					
	3 GHz - 17 GHz	140 kHz	PK+ ; AVG	1 MHz	1 s	30 dB

Frequency Range GHz = [17, 26] Equipment Type = Digital Transmission System (DTS)

Modulation = LoRa Frequency MHz = 2403

MIMO Mode = SISO Active Port = 1

Images:

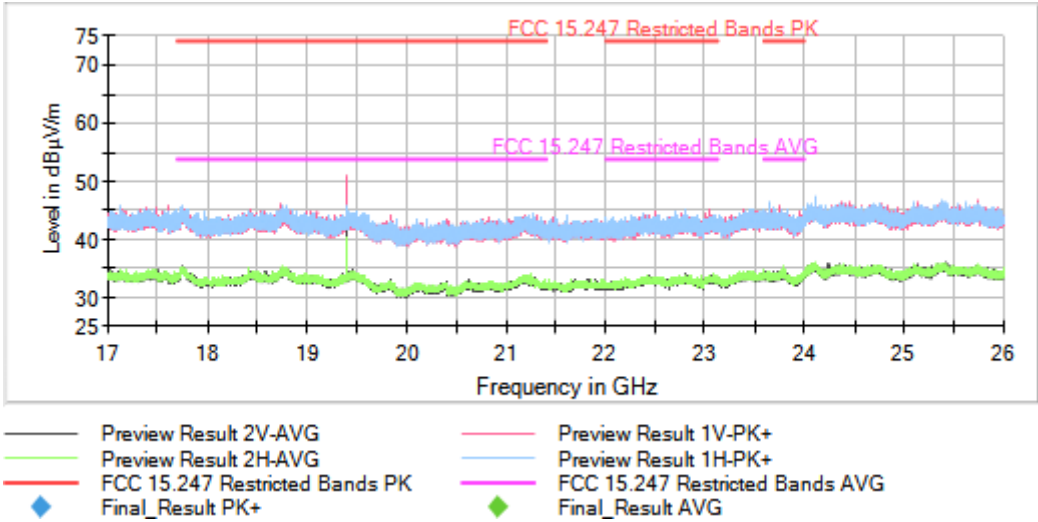


Frequency Range GHz = [17, 26] Equipment Type = Digital Transmission System (DTS)

Modulation = LoRa Frequency MHz = 2425

MIMO Mode = SISO Active Port = 1

Images:

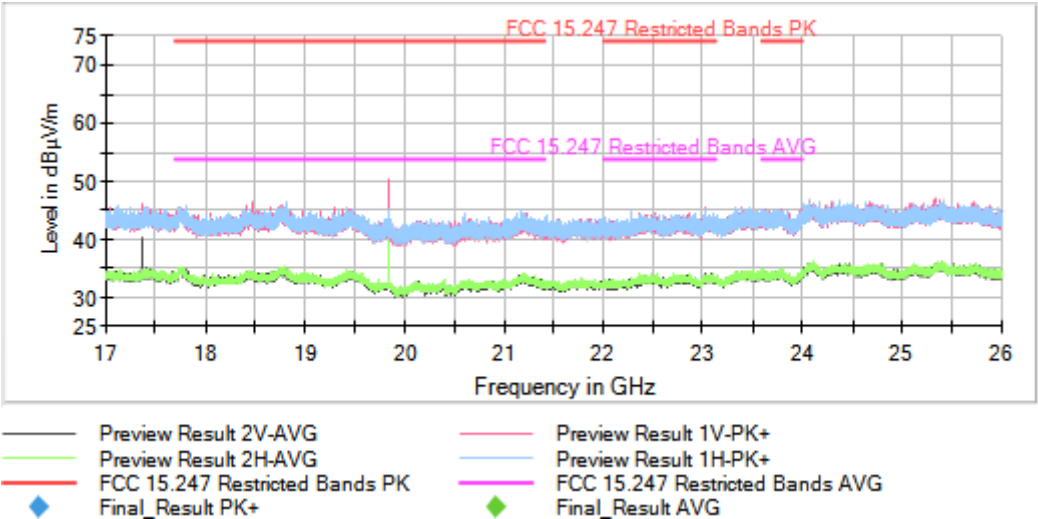


Frequency Range GHz = [17, 26] Equipment Type = Digital Transmission System (DTS)

Modulation = LoRa Frequency MHz = 2479

MIMO Mode = SISO Active Port = 1

Images:



Tables:
Spectrum Analyzer Parameters

	Subrange	Step Size	Detectors	Bandwidth	Sweep Time	Preamp
	Receiver: [FSV 40]					
	17 GHz - 26 GHz	300 kHz	PK+ ; AVG	1 MHz	1 s	0 dB

Appendix B: Test results. LoRa AU915-928

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TEST CONDITIONS51

Occupied Channel Bandwidth 99%53

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TEST CONDITIONS

(*): Data provided by the client.

POWER SUPPLY (*):

Vnominal: 5 V
Type of Power Supply: DC (USB-C).

ANTENNA (*):

Type of Antenna LoRa 900 MHz: Omnidirectional external antenna.
Maximum Declared External Antenna Gain LoRa 900 MHz: -0.2 dBi
Type of Antenna LoRa 900 MHz: FPC omnidirectional internal antenna.
Maximum Declared FPC Antenna Gain LoRa 900 MHz: 1.71 dBi

According preliminary radiated spurious emissions the FPC Antenna is a worst case.

TEST FREQUENCIES (*):

Modulation	Low Channel:	Middle Channel	High Channel
LoRa AU915-928	915.3 MHz	921.5 MHz	927.7 MHz

During transmitter test the EUT was controlled by a SW tool provided by the client to operate in a continuous transmit mode on the modulation schemes and test channels as required.

CONDUCTED MEASUREMENTS:

The equipment under test was set up in a shielded room and it is connected to the TS8997 using a low loss RF cable. The reading of the spectrum analyser is corrected taking into account the cable loss.



RADIATED MEASUREMENTS:

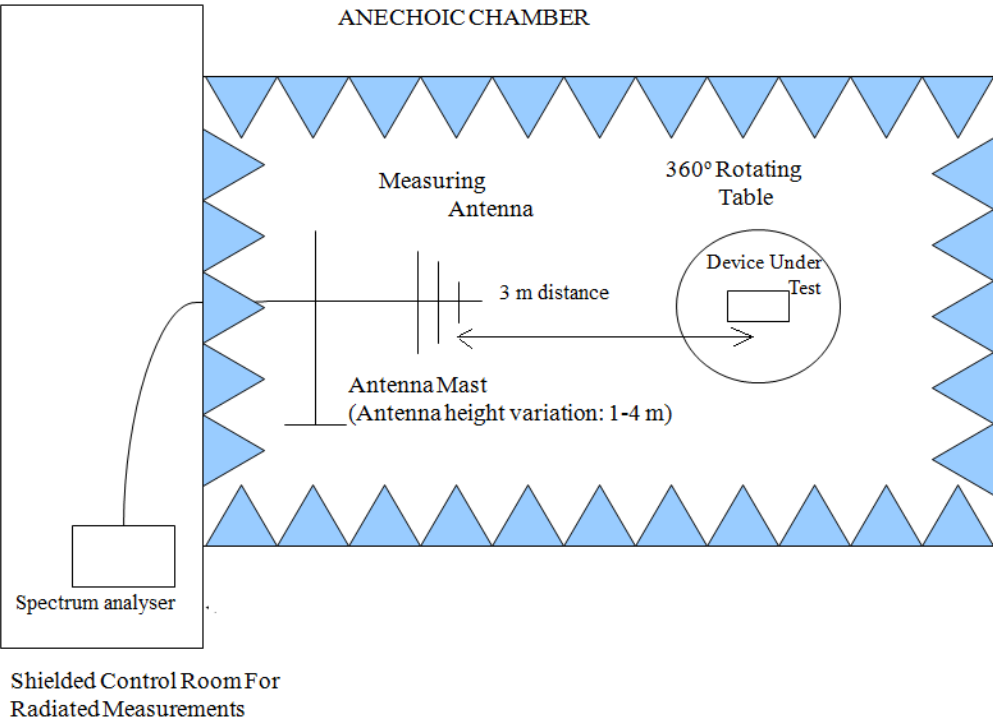
All radiated tests were performed in a semi-anechoic chamber. The measurement antenna (Bilog antenna for the range between 30 MHz to 1000 MHz and 1 GHz-10 GHz Double ridge horn antenna) is situated at a distance of 3 m.

The equipment under test was set up on a non-conductive platform above the ground plane and the situation and orientation was varied to find the maximum radiated emission. It was also rotated 360° and the antenna height (Bilog antenna and Double ridge horn antenna) was varied from 1 to 4 meters to find the maximum radiated emission.

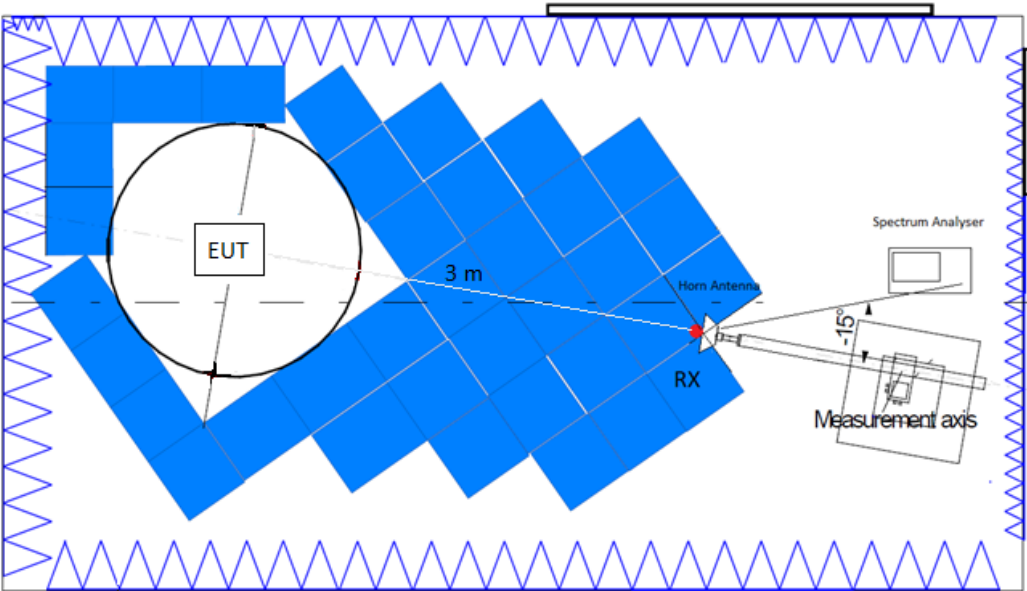
Measurements were made in both horizontal and vertical planes of polarization.

A resolution bandwidth/video bandwidth of 100 kHz / 300 kHz was used for frequencies below 1 GHz and 1 MHz / 3 MHz for frequencies above 1 GHz.

Radiated measurements setup from 30 MHz to 1 GHz:



Radiated measurements setup from 1 GHz to 10 GHz:



Occupied Channel Bandwidth 99%

Limits

* RSS-Gen Clause 6.7:

The transmitter shall be operated at its maximum carrier power measured under normal test conditions.

The span of the spectrum analyzer shall be set large enough to capture all products of the modulation process, including the emission skirts, around the carrier frequency, but small enough to avoid having other emissions (e.g. on adjacent channels) within the span.

The detector of the spectrum analyzer shall be set to “Sample”. However, a peak, or peak hold, may be used in place of the sampling detector since this usually produces a wider bandwidth than the actual bandwidth (worst-case measurement). Use of a peak hold (or “Max Hold”) may be necessary to determine the occupied / x dB bandwidth if the device is not transmitting continuously.

The resolution bandwidth (RBW) shall be in the range of 1% to 5% of the actual occupied / x dB bandwidth and the video bandwidth (VBW) shall not be smaller than three times the RBW value. Video averaging is not permitted.

Modulation: LoRa

Mode: SISO

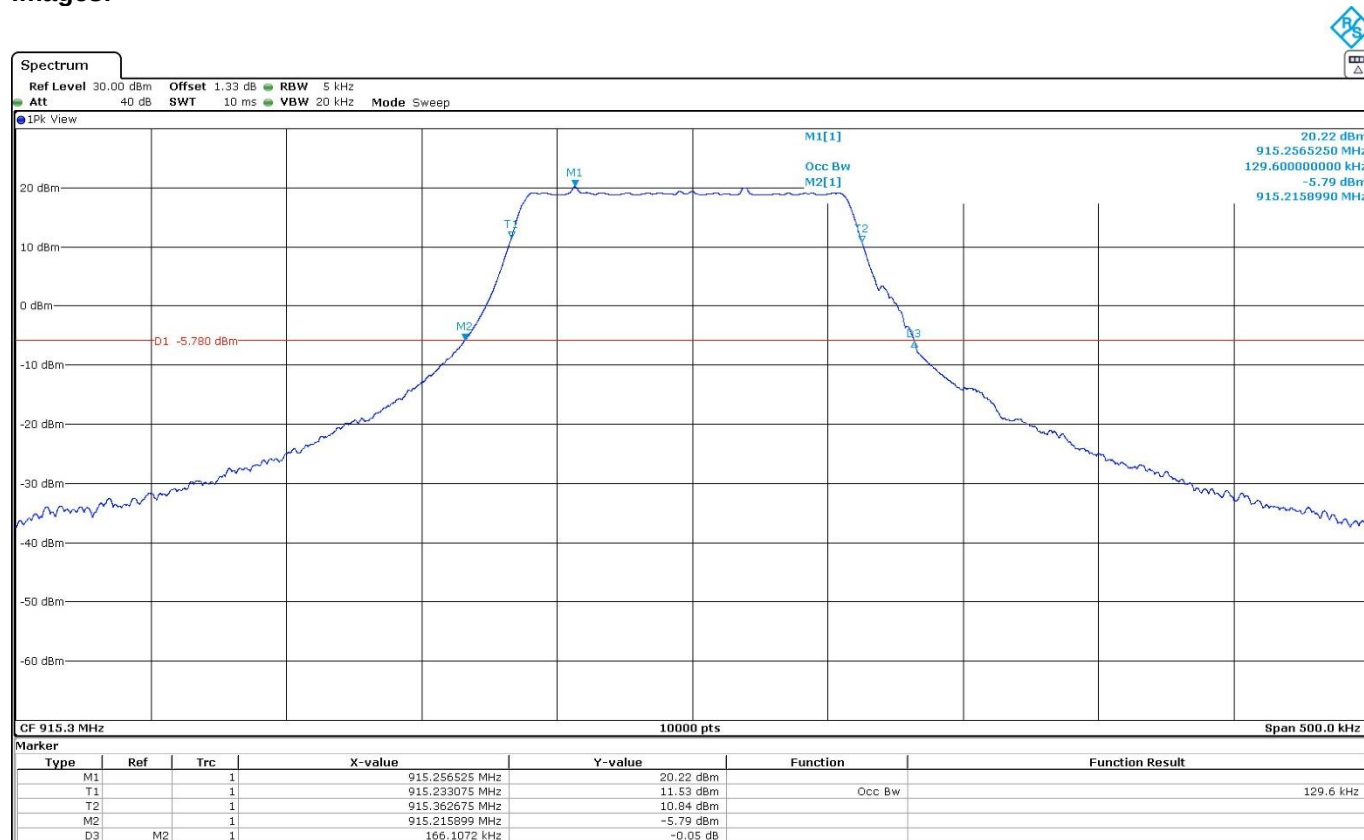
Results

Freq (MHz)	Occ Ch BW (kHz)
915.3	129.6
921.5	129.7
927.7	129.85

Verdict

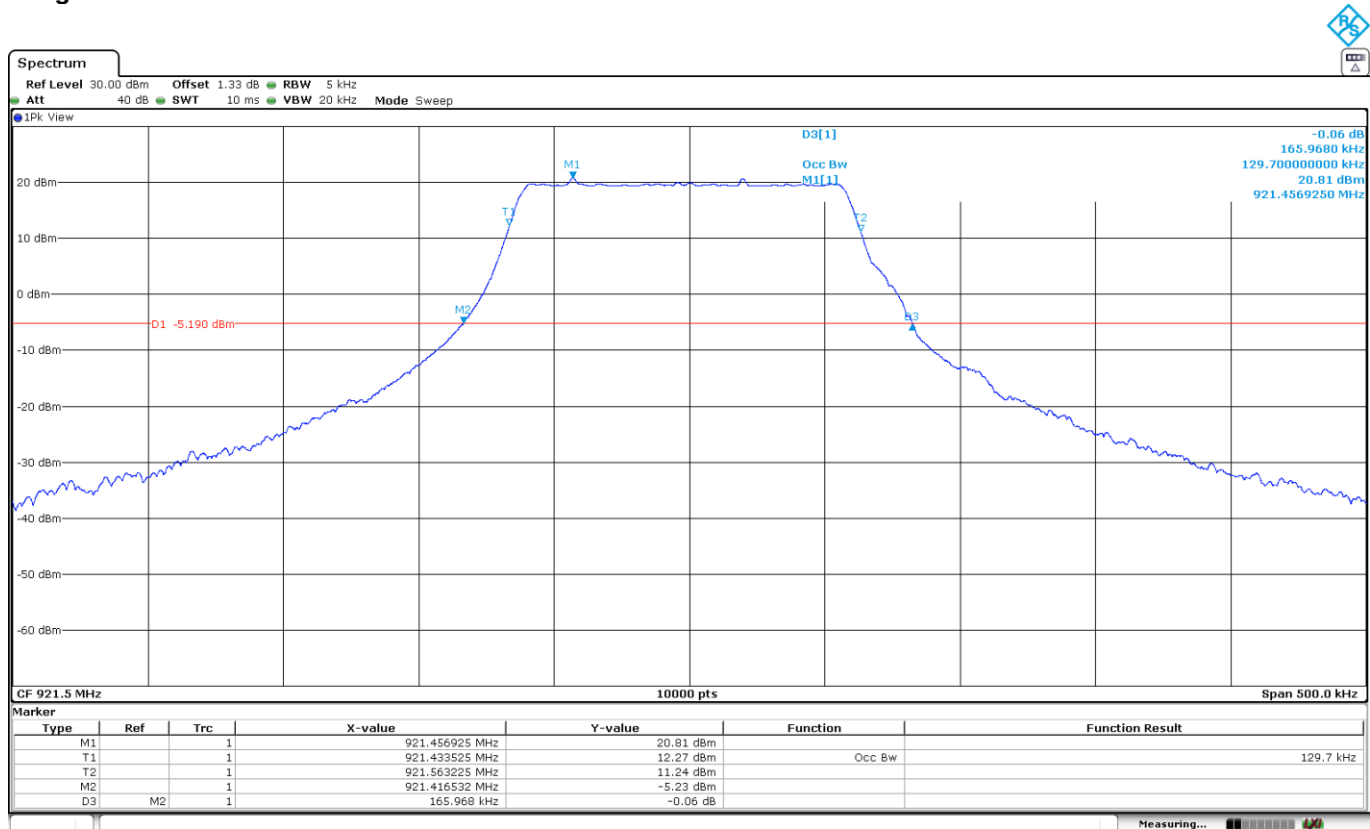
Pass

Equipment Type = Hybrid	Bandwidth MHz = 1
Modulation = LoRa	Frequency MHz = 915.3
Mode = SISO	Active Port = 1



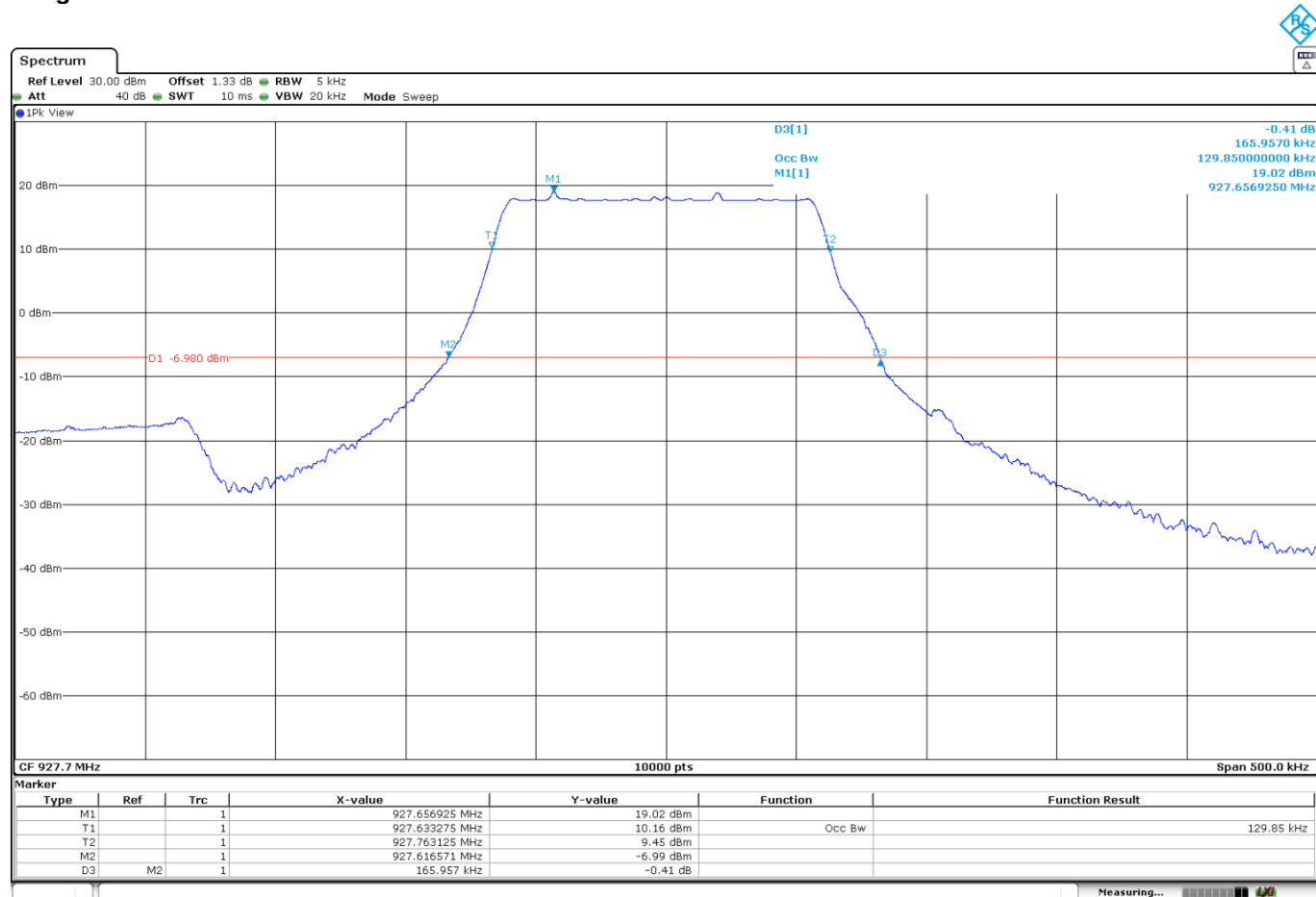
Equipment Type = Hybrid	Bandwidth MHz = 1
Modulation = LoRa	Frequency MHz = 921.5
Mode = SISO	Active Port = 1

Images:



Equipment Type = Hybrid	Bandwidth MHz = 1
Modulation = LoRa	Frequency MHz = 927.7
Mode = SISO	Active Port = 1

Images:



FCC 15.247 (a)(1) / RSS-247 5.1 (b) 20 dB Bandwidth and Carrier frequency separation

Limits

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

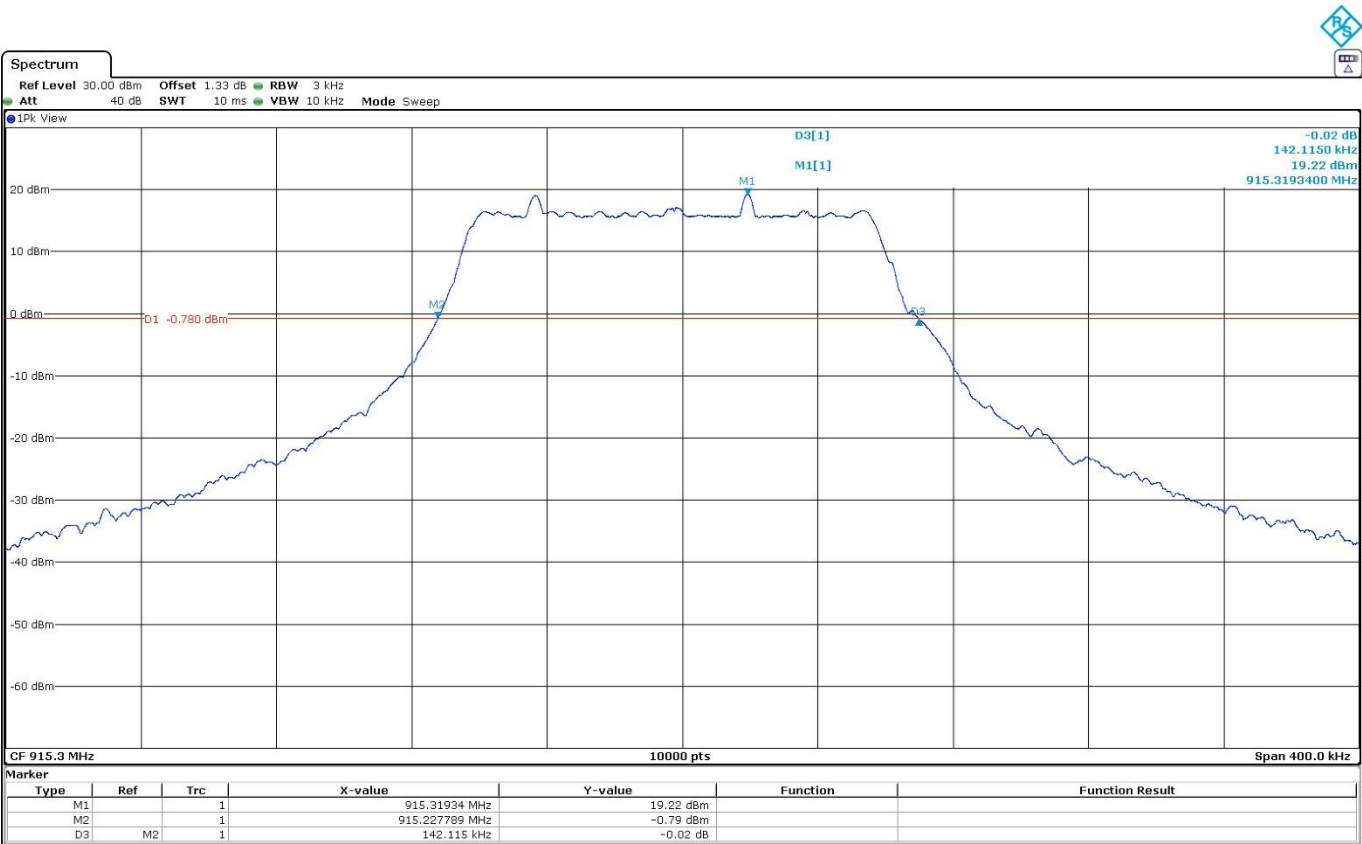
Results

	Low Channel	Middle Channel	High Channel
20 dB Spectrum bandwidth (kHz)	142.115	142.187	142.518

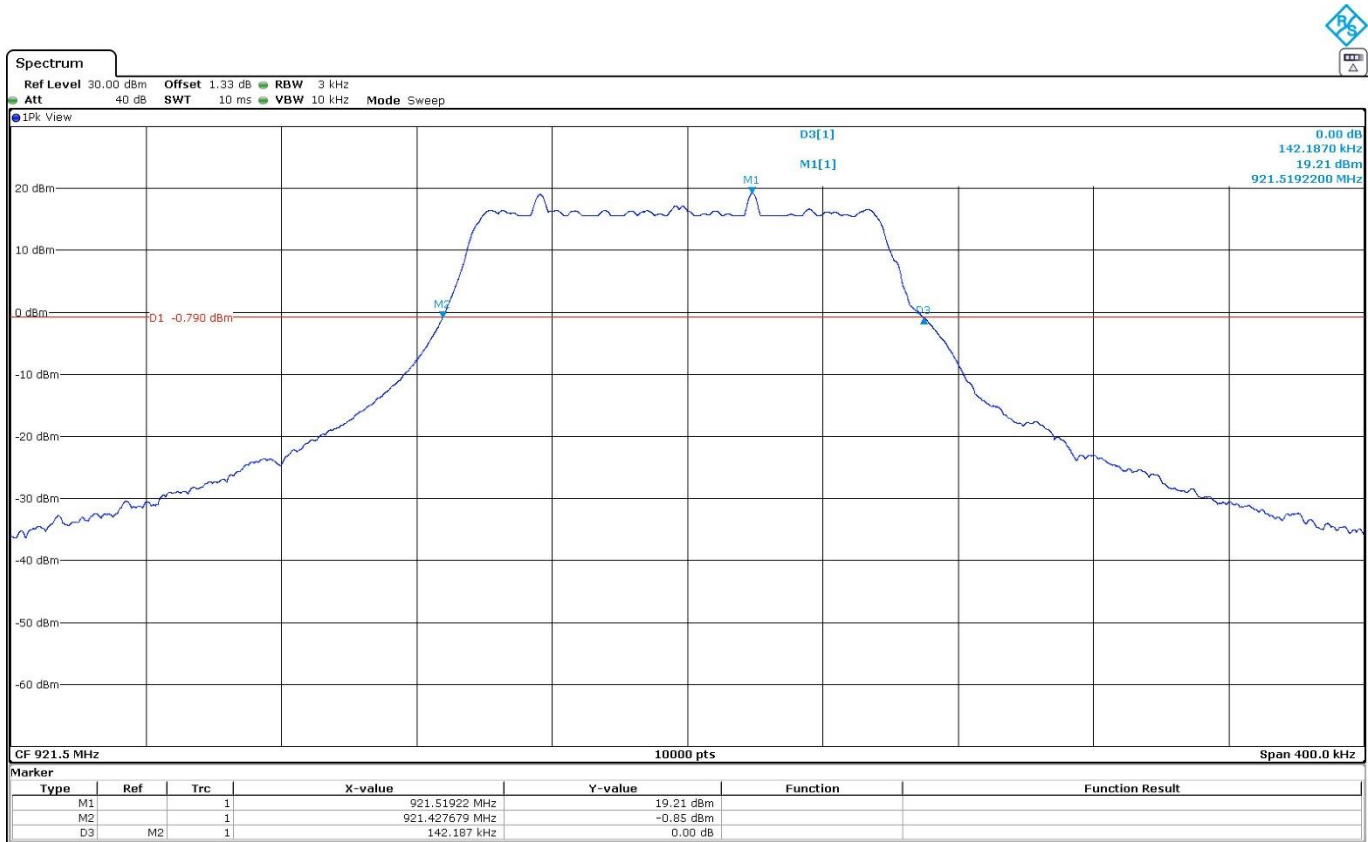
Verdict

PASS

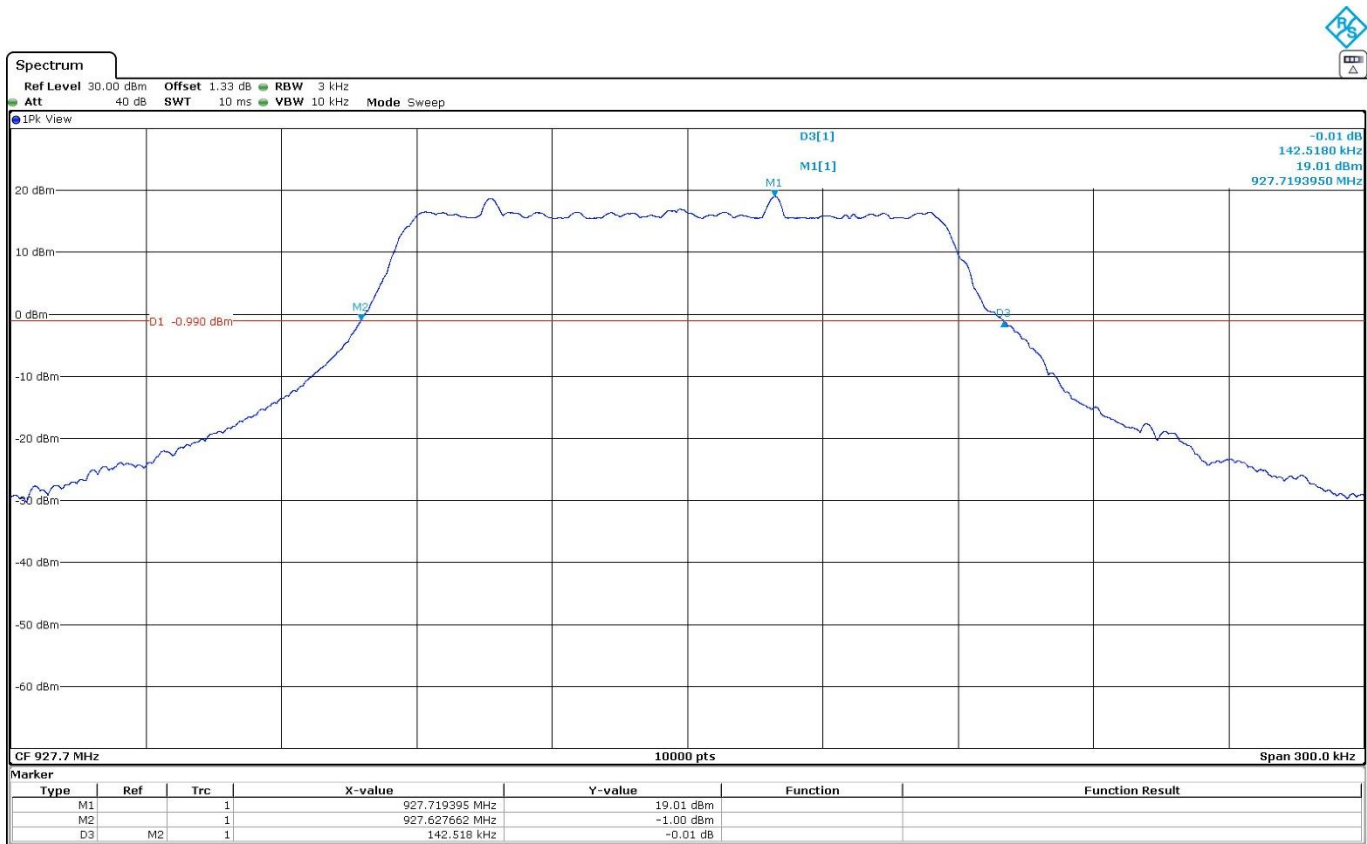
- Low Channel:



- Middle Channel:

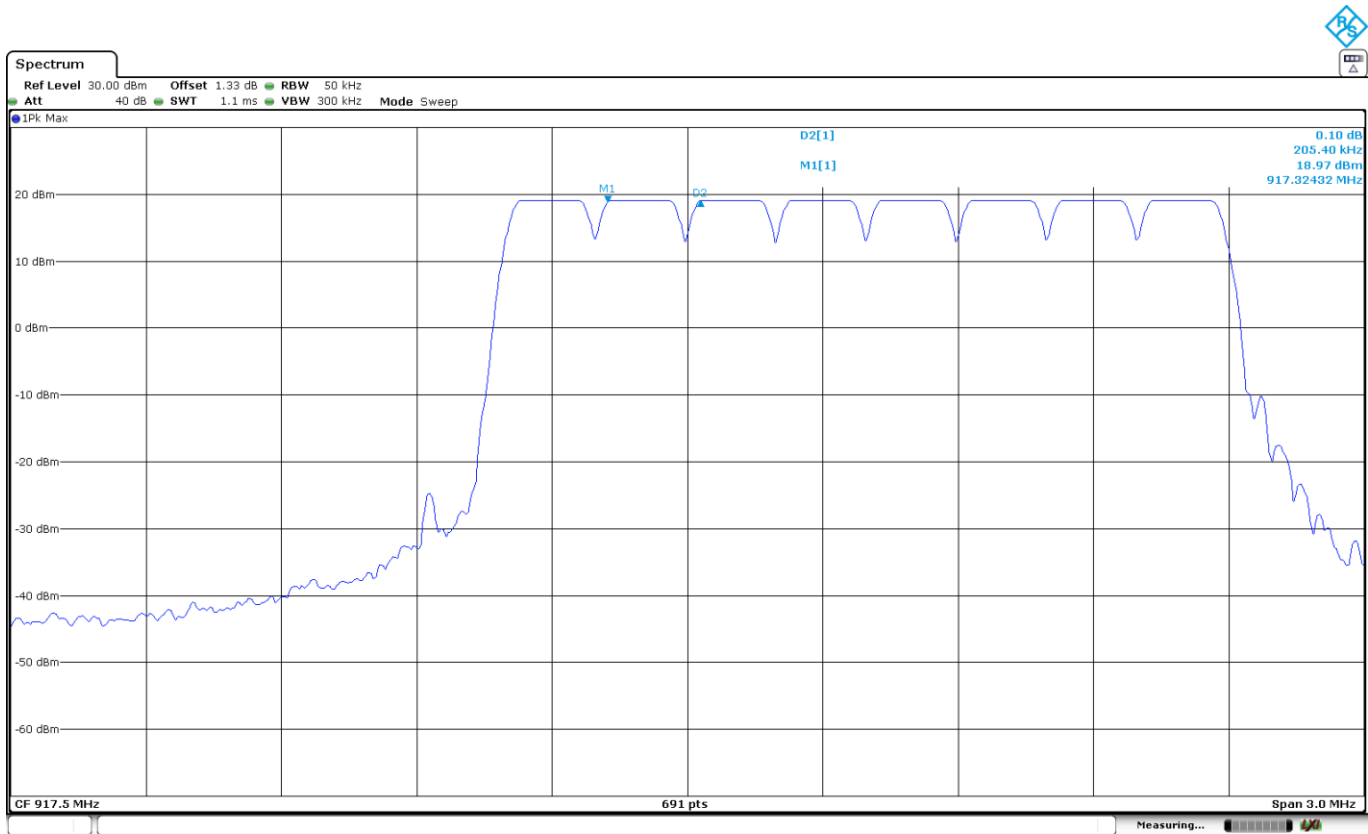


- High Channel:



Carrier frequency separation:

205.4 kHz



The hopping-channel carrier frequencies are separated by a minimum of the 20 dB bandwidth of the hopping channel.

Verdict

PASS

FCC 15.247 (f) / RSS-247 5.3 (a) Time of occupancy (Dwell Time) for hybrid systems

Limits

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

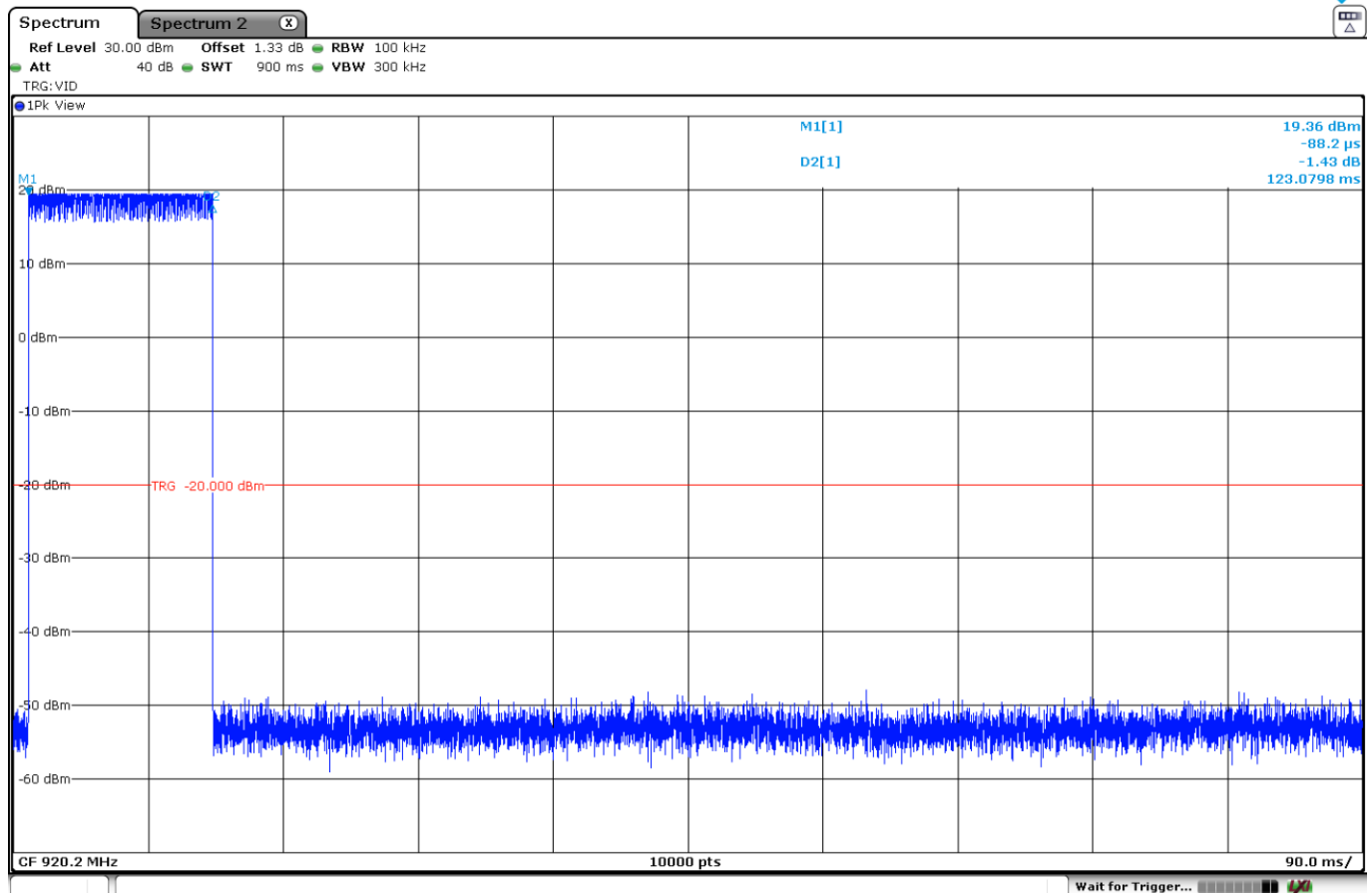
Results

Operation as a frequency hopping system using 8 hopping channels:

- Time period in seconds equal to the number of hopping frequencies employed multiplied by 0.4:
 $8 \text{ hopping channels} \times 0.4 \text{ s} = 3.2 \text{ s}$

Measurement is performed over a period of 0.9 seconds (worst case).

- TX time per hop: 123.0798 ms (see next plots)
- Number of hops over a period of 0.9 s: 1 (see next plots)



- **Average Time of Occupancy** = $123.0798 \text{ ms} \times 1 \text{ hops} = 123.0798 \text{ ms per } 0.9 \text{ s}$.

Average Time of Occupancy is less than 0.4 s per time period in seconds equal to the number of hopping frequencies employed (8) multiplied by 0.4.

Verdict

PASS

RSS-247 5.3 (b) / FCC 15.247 (f) Power spectral density for hybrid systems

Limits

Hybrid systems are those that employ a combination of both frequency hopping and digital modulation techniques.

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

Modulation: LoRa

Mode: SISO

Results

The maximum power spectral density level was measured using the method AVGPST-2 according to clause 11.10.5 (trace averaging across ON and OFF times of the EUT transmissions, followed by duty cycle correction) of ANSI C.63.10-2013.

Measured Duty Cycle: $x = 0.552817986$
Duty Cycle Correction: $10 \times \log(1/x) = 2.574 \text{ dB}$

Freq (MHz)	PSD (dBm)	PSD with Duty Cycle correction (dBm)
915.3	3.92	6.494
921.5	3.67	6.244
927.700000	3.87	6.444

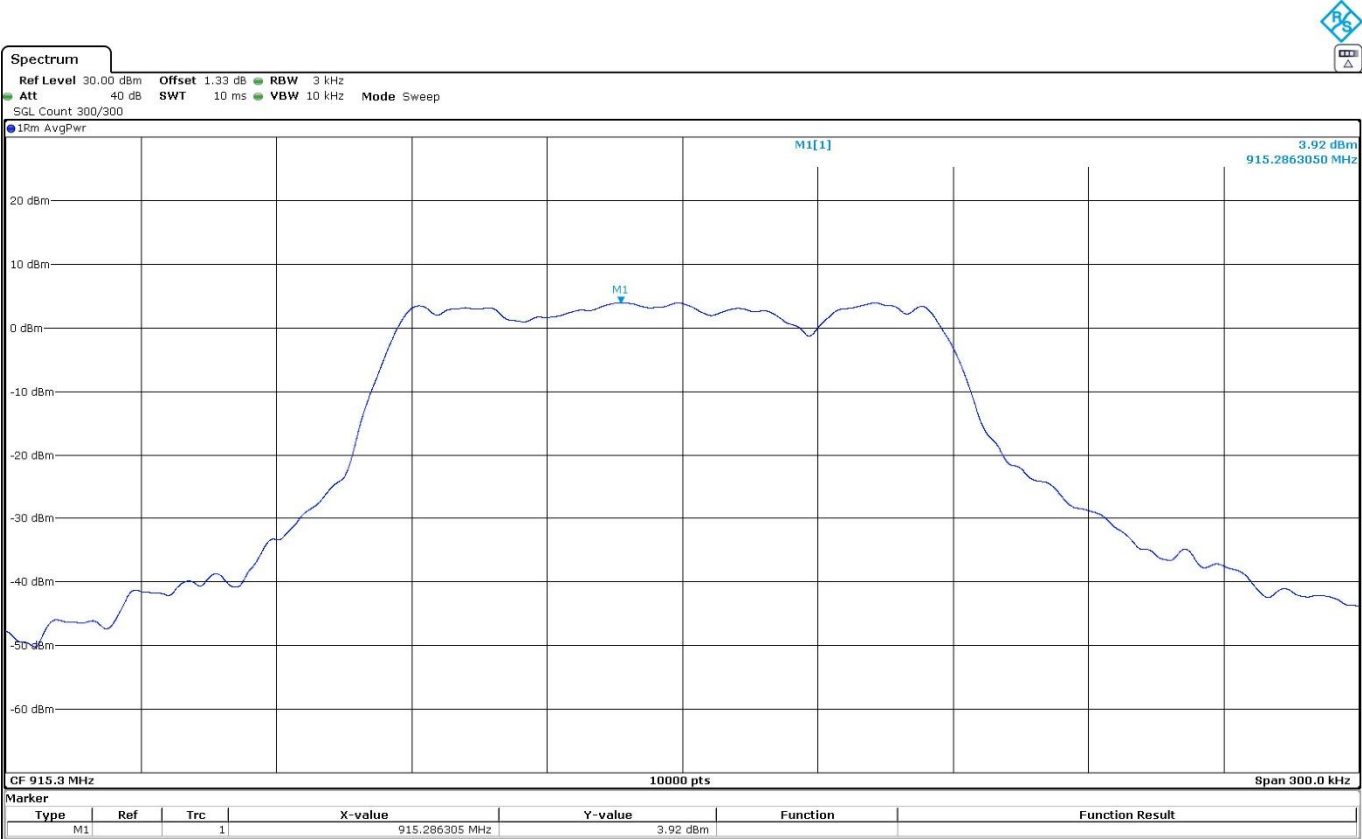
Verdict

Pass

Attachments

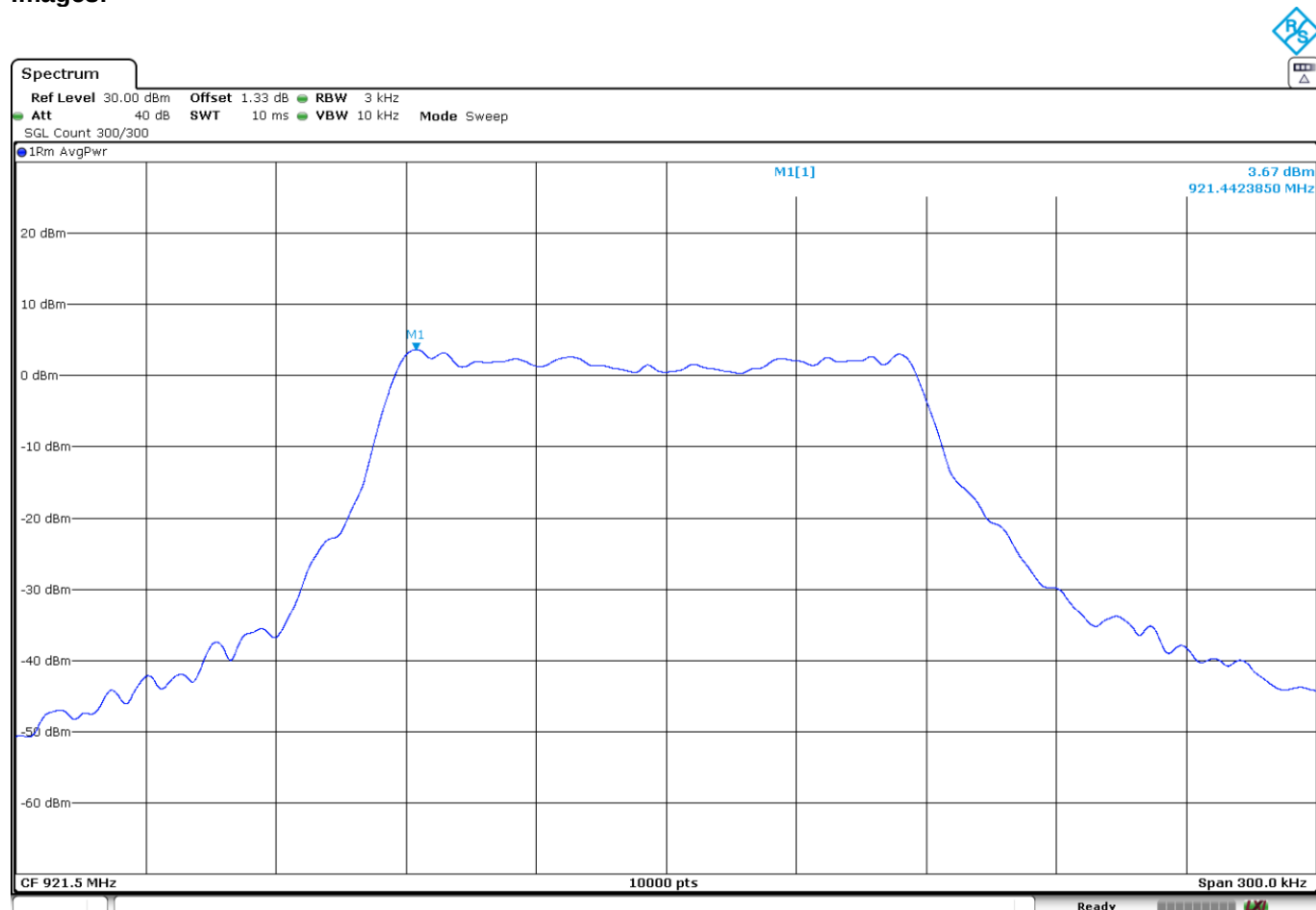
Equipment Type = Hybrid Bandwidth MHz = 1
Modulation = LoRa Frequency MHz = 915.3
Mode = SISO Active Port = 1

Images:



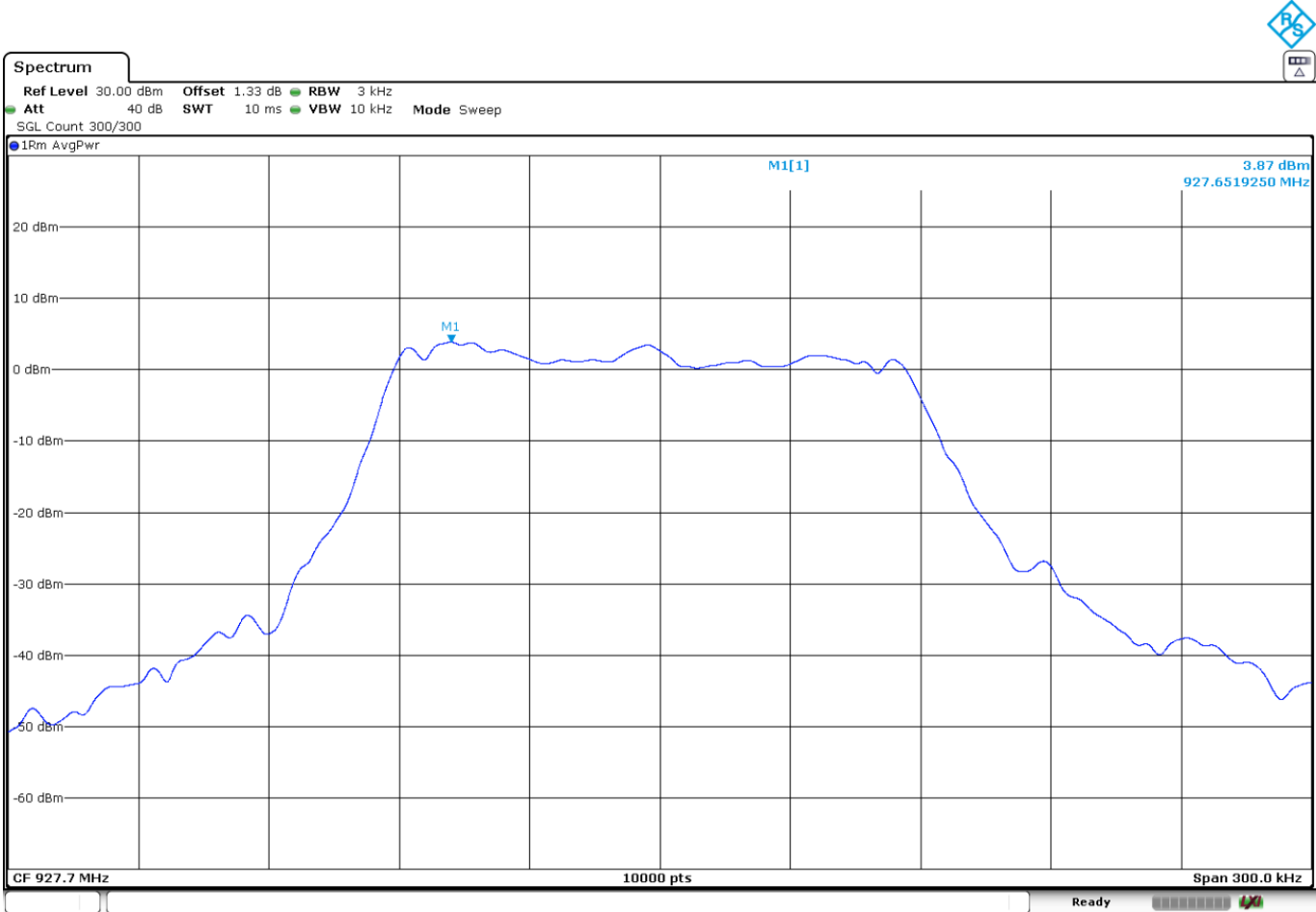
Equipment Type = Hybrid	Bandwidth MHz = 1
Modulation = LoRa	Frequency MHz = 921.5
Mode = SISO	Active Port = 1

Images:



Equipment Type = Hybrid Bandwidth MHz = 1
Modulation = LoRa Frequency MHz = 927.7
Mode = SISO Active Port = 1

Images:



RSS-247 5.4 (d) / FCC 15.247 (b) (3) Maximum output power and antenna gain for hybrid systems

Limits

* FCC 15.247:
For frequency hopping systems operating in the 902-928 MHz band: 1 watt for systems employing at least 50 hopping channels; and, 0.25 watts for systems employing less than 50 hopping channels, but at least 25 hopping channels. Hybrid systems shall comply with the 1 W limit.

* RSS-247:
For FHSS operating in the band 902-928 MHz, the maximum peak conducted output power shall not exceed 1.0 W, and the e.i.r.p. shall not exceed 4 W if the hop set uses 50 or more hopping channels; the maximum peak conducted output power shall not exceed 0.25 W and the e.i.r.p. shall not exceed 1 W if the hop set uses less than 50 hopping channels.
As an alternative to a peak power measurement, compliance can be based on a measurement of the maximum conducted output power.

Modulation: LoRa
Mode: SISO

Results

The maximum conducted (average) output power was measured using the method AVGSA-2 according to clause 11.9.2.2.4 (trace averaging across ON and OFF times of the EUT transmissions, followed by duty cycle correction) of ANSI C.63.10-2013.

The e.i.r.p. power (dBm) is calculated by adding the declared maximum antenna gain to the measured conducted power.

Maximum Declared Antenna Gain: 1.71 dBi

Measured Duty Cycle: $x = 0.5528$
Duty Cycle Correction: $10 \times \log(1/x) = 2.574 \text{ dB}$

The maximum directional gain of the antenna is less than 6 dBi and therefore the maximum output power is not required to be reduced from the stated values.

Freq (MHz)	Power (dBm)	Power with Duty Cycle correction (dBm)	E.I.R.P. (dBm)
915.3	17.76	20.33	22.04
921.5	17.32	19.89	21.60
927.7	17.97	20.54	22.25

Verdict

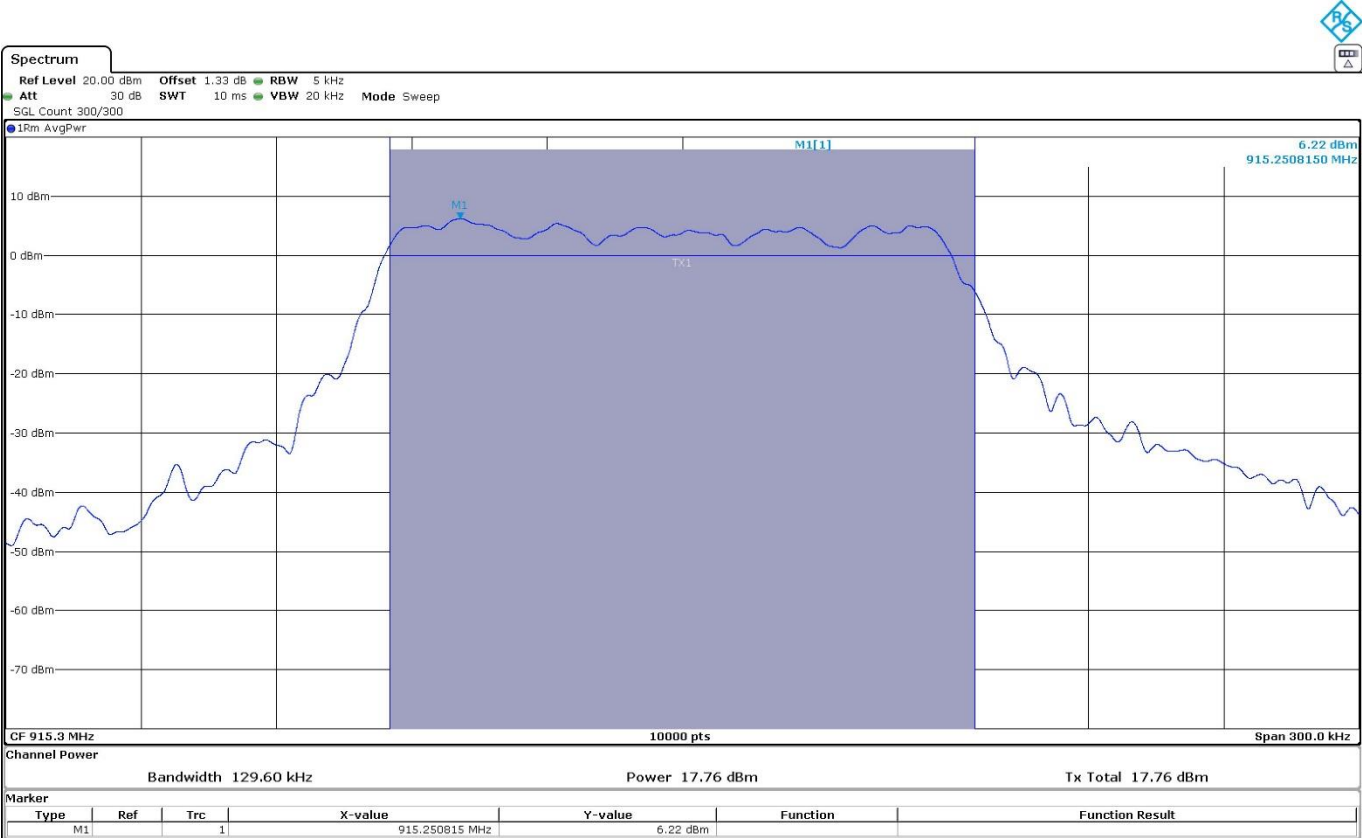
Pass

Maximum Average Output Power:

Attachments

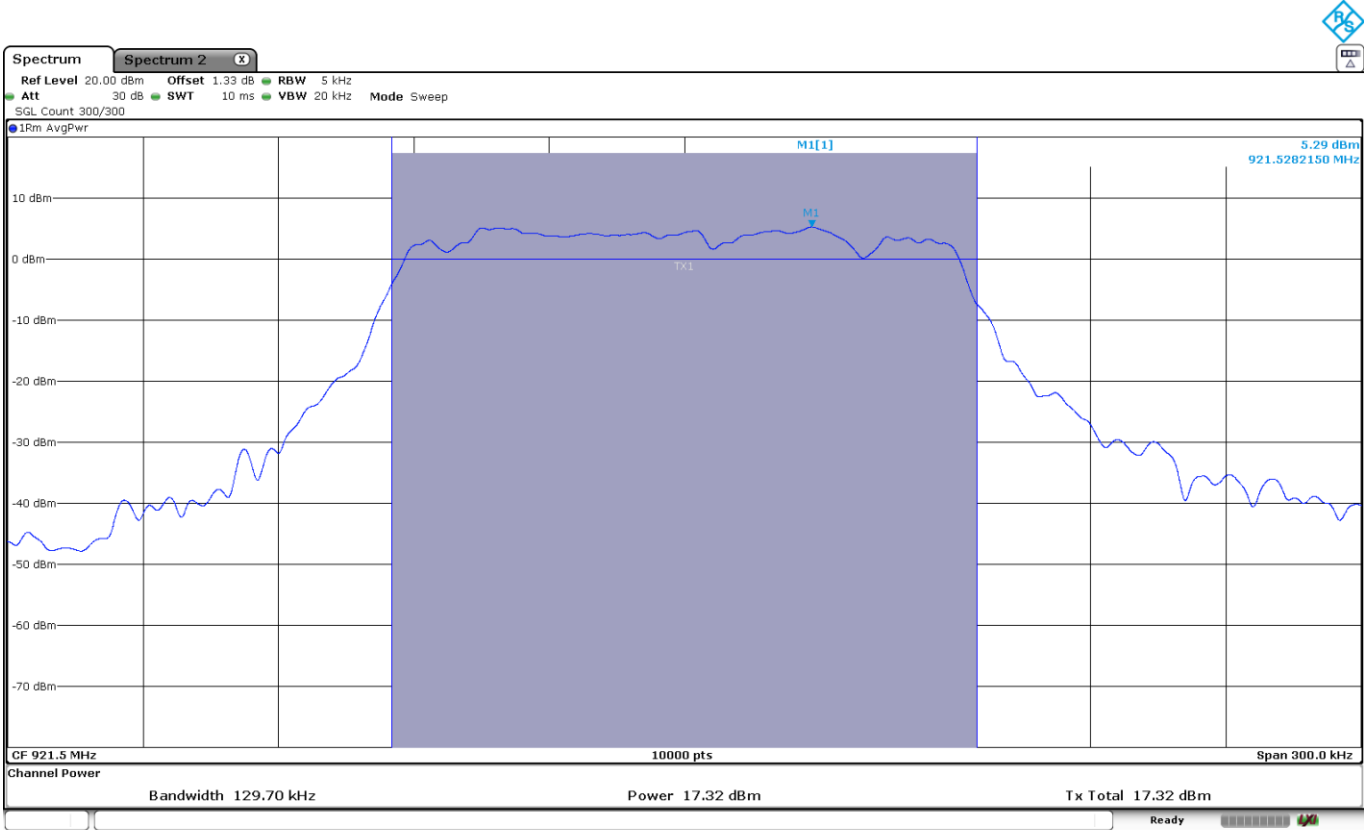
Equipment Type = Hybrid Bandwidth MHz = 1
Modulation = LoRa Frequency MHz = 915.3
Mode = SISO Active Port = 1

Images:



Equipment Type = Hybrid Bandwidth MHz = 1
Modulation = LoRa Frequency MHz = 921.5
Mode = SISO Active Port = 1

Images:



Equipment Type = Hybrid Bandwidth MHz = 1
Modulation = LoRa Frequency MHz = 927.7
Mode = SISO Active Port = 1

Images:

