900MHz LoRa Radio Test Report
(DTS)
For

P-LPWA-900 (LoRa Radio)

(Independent of the Host systems)

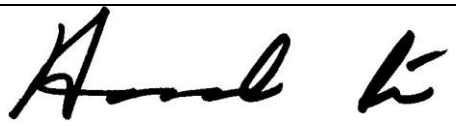
Support Frequency Band
902-928 MHz
FCC ID: LDKLPWA900
IC: 2461A-LPWA900

Against the following Specifications:
47 CFR 15.247, 47 CFR 15.209
47 CFR 15.207
47 CFR 15.205
RSS-Gen issue 5
RSS-247 Issue 2

Cisco Systems
EMC Laboratory
170 West Tasman Drive
San Jose, CA 95134

ACCREDITED
CERTIFICATE #1178.01

Cisco Systems is accredited by the A2LA per ISO/IEC 17025, certificate number 1178.01, to perform the test(s) listed in this report.

Author:	
Tested By: **Title**: Test Engineers	 Danh Le  Farida Rahmanzai
Approved By: Howard Ji **Title**: Compliance Manager	
Revision	2.0

This report replaces any previously entered test report under EDCS – 23252260. This test report has been electronically authorized and
archived using the CISCO Engineering Document Control system. Test Report Template EDCS# 703456

TABLE OF CONTENTS

Section 1: Overview

1.1 Test Summary

Samples were assessed against the tests detailed in section 3 under the requirements of the following specifications:

Specifications
47 CFR Part 15.247 47 CFR Part 15.209 47 CFR Part 15.207 47 CFR Part 15.205
RSS-Gen issue 5 RSS-247 issue 2

Section 2: Assessment Information

2.1 General

This report contains an assessment of an apparatus against Electromagnetic Compatibility Standards based upon tests carried out on the samples submitted. The testing was performed by and for the use of Cisco systems Inc:

With regard to this assessment, the following points should be noted:

a) The results contained in this report relate only to the items tested and were obtained in the period between the date of the initial assessment and the date of issue of the report. Manufactured products will not necessarily give identical results due to production and measurement tolerances.

b) The apparatus was set up and exercised using the configuration and modes of operation defined in this report only.

c) Where relevant, the apparatus was only assessed using the susceptibility criteria defined in this report and the Test Assessment Plan (TAP).

d) All testing was performed under the following environmental conditions:

Temperature	15°C to 35°C (54°F to 95°F)
Atmospheric Pressure	860mbar to 1060mbar (25.4" to 31.3")
Humidity	10% to 75*%

*[Where applicable] For ESD testing the humidity limits used were 30% to 60% and for EFT/B tests the humidity limits used were 25% to 75%.

e) All AC testing was performed at the following supply voltage:
110V 60 Hz (+/-20%)

2.2 Units of Measurement

The units of measurements defined in the appendices are reported in specific terms, which are test dependent. Where radiated measurements are concerned these are defined at a particular distance. Basic voltage measurements are defined in units of [dBuV]

As an example, the basic calculation for all measurements is as follows:

Emission level [dBuV] = Indicated voltage level [dBuV] + Cable Loss [dB] + Other correction factors [dB]

The combinations of correction factors are dependent upon the exact test configurations [see test equipment lists for further details] and may include:-

Antenna Factors, Pre Amplifier Gain, LISN Loss, Pulse Limiter Loss and Filter Insertion Loss..

Note: to convert the results from dBuV/m to uV/m use the following formula:-

Level in uV/m = Common Antilogarithm [(X dBuV/m)/20] = Y uV/m

Measurement Uncertainty Values

voltage and power measurements	± 2 dB
conducted emissions measurements	± 1.4 dB
radiated emissions measurements	± 3.2 dB
frequency measurements	± 2.4 10-7
temperature measurements	± 0.54º.
humidity measurements	± 2.3%
DC and low frequency measurements	± 2.5%.

Where relevant measurement uncertainty levels have been estimated for tests performed on the apparatus. This uncertainty represents an expanded uncertainty expressed at approximately the 95% confidence level using a coverage factor of k=2.

Radiated emissions (expanded uncertainty, confidence interval 95%)

30 MHz – 300 MHz	± 3.8 dB
300 MHz – 1000 MHz	± 4.3 dB
1.0 GHz – 10.0 GHz	± 4.0 dB
10.0 GHz – 18.0 GHz	± 8.2 dB
18.0 GHz – 26.5 GHz	± 4.1 dB
26.5 GHz – 40.0 GHz	± 3.9 dB

Conducted emissions (expanded uncertainty, confidence interval 95%)

30 MHz – 40.0 GHz	± 0.38 dB

A product is considered to comply with a requirement if the nominal measured value is below the limit line. The product is considered to not be in compliance in case the nominal measured value is above the limit line.

2.3 Testing Dates

03-May-2022 – 07-Oct-2022

2.4 Report Issue Date

10-Oct-2022

2.5 Testing facilities

This assessment was performed by:

Testing Laboratory

Cisco Systems, Inc.,
125 West Tasman Drive (Building P)
San Jose, CA 95134,
USA

Headquarters

Cisco Systems, Inc.
170 West Tasman Drive
San Jose, CA 95134
USA

Registration Numbers for Industry Canada

Cisco System Site	Address	Site Identifier
Building P, 10m Chamber	125 West Tasman Dr San Jose, CA 95134 United States	Company #: 2461A
Building P, 5m Chamber	125 West Tasman Dr San Jose, CA 95134 United States	Company #: 2461A
Building 7, 5m Chamber	425 E. Tasman Drive San Jose, California 95134 United States	Company #: 2461N-3

Test Engineer(s)

Danh Le

Farida Rahmanzai

2.6 Equipment Assessed (EUT)

P-LPWA-900

2.7 EUT Description

P-LPWA-900 LoRa radio is a low power wide area network (LPWAN) RF physical layer modulation technology that offers long-distance wireless connectivity, excellent power efficiency, very high receiver sensitivity, and robust spectrum spreading. It operates on unlicensed Industrial, Scientific, and Medical (ISM) frequencies, for which 863 - 870 MHz spectrum and spectrum subsets are available for Europe, the Middle East, Africa, and India, and 902 - 928 MHz spectrum and spectrum subsets can be utilized in the Americas and in Asia-Pacific countries. LoRAWAN is a MAC (Media Access Control) protocol specification defined by the LoRa Alliance that complements the LoRa physical layer. It is supported by an established ecosystem of LoRAWAN compliant devices that are available from multiple vendors, and which can be certified for interoperability by the LoRa Alliance.

900 MHz Lora Radio Specification:

- Operating Frequency Band: 902 MHz – 928 MHz
- Mode: LoRa-DTS
- Nominal Bandwidth: 500kHz
- Data Rate: SF7 – SF 12 (980bps – 21.9Kbps)
- Modulation: Chirp Spread Spectrum (CSS)

Section 3: Result Summary

3.1 Results Summary Table(s)

RF Conducted Emissions		
Standard(s)	**Test Details / Comments**	**Result**
FCC15.247(a)(2) **RSS-247 5.2(a)**	**99%- & 6-dB Bandwidth**: **FCC/RSS**: The 99% 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. There is no limit for 99% OBW. The 6 dB emission bandwidth is the width of the emission that is constrained by the frequencies associated with the two outermost amplitude points (upper and lower frequencies) that are attenuated by 6 dB relative to the maximum level measured in the fundamental emission. **FCC:** Systems using digital modulation techniques may operate in the 902-928 MHz, 2400-2483.5 MHz, and 5725-5850 MHz bands. **RSS:** DTSs include systems that employ digital modulation techniques resulting in spectral characteristics similar to direct sequence systems. The following applies to the bands 902-928 MHz and 2400- 2483.5 MHz: The minimum 6dB bandwidth shall be at least 500 kHz	**Pass**
FCC15.247(b)(3) **FCC15.247(b)(4)**	**Output Power:** The maximum conducted output power is the total transmit power delivered to all antennas and antenna elements averaged across all symbols in the signaling alphabet when the transmitter is operating at its maximum power control level. **FCC:** The maximum peak conducted output power of the intentional radiator shall not exceed the following: For systems using digital modulation in the 902-928 MHz, 2400-2483.5 MHz, and 5725-5850 MHz bands: 1 Watt (30 dBm). As an alternative to a peak power measurement, compliance with the one-Watt limit can be based on a measurement of the maximum conducted output power. The conducted output power limit specified in paragraph (b) of this section is based on the use of antennas with directional gains that do not exceed 6 dBi. Except as shown in paragraph (c) of this section, if transmitting antennas of directional gain greater than 6 dBi are used, the conducted output power from the intentional radiator shall be reduced below the stated values in paragraphs (b)(1), (b)(2), and (b)(3) of this section, as appropriate, by the amount in dB that the directional gain of the antenna exceeds 6 dBi.	**Pass**

RF Conducted Emissions (continue)		
Standard(s)	**Test Details / Comments**	**Result**
RSS-247 5.4(d)	**Output Power (continue):** **RSS:** DTSs include systems that employ digital modulation techniques resulting in spectral characteristics similar to direct sequence systems. The following applies to the bands 902-928 MHz and 2400- 2483.5 MHz: For DTSs employing digital modulation techniques operating in the bands 902-928 MHz and 2400-2483.5 MHz, the maximum peak conducted output power shall not exceed 1W. The e.i.r.p. shall not exceed 4 W, except as provided in section 5.4(e).	**Pass**
FCC15.247(b)(3) **FCC15.247(b)(4)**	**Power Spectral Density** **FCC:** 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. **RSS:** The transmitter power spectral density conducted from the transmitter to the antenna shall not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission.	**Pass**
FCC15.247(d)/ RSS-247 5.5	**Conducted Band-Edge / Out of band emissions / Spurious Emissions:** **FCC/RSS:** In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power. 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. Attenuation below the general limits specified in FCC§15.209(a) & RSS-Gen is not required.	**Pass**

Radiated Emissions		
Basic Standard	**Technical Requirements / Details**	**Result**
FCC 15.209/205 **RSS-Gen6.13(a)/ 8.10**	**TX Spurious Emissions & Restricted Bands** **FCC:** Except as provided elsewhere in this subpart, the emissions from an intentional radiator shall not exceed the field strength levels specified in the field strength limits table in this section. In addition, radiated emissions which fall in the restricted bands as defined in FCC §15.205(a), must also comply with the radiated emission limits specified in Sec. 15.209(a). **RSS**: In measuring unwanted emissions, the spectrum shall be investigated from 30 MHz or the lowest radio frequency signal generated in the equipment, whichever is lower, without going below 9 kHz, up to at least the frequency given below: a) If the equipment operates below 10 GHz; to the tenth harmonic of the highest fundamental frequency or to 40 GHz, whichever is lower. **RSS:** Unwanted emissions falling into restricted bands of Table 6 shall comply with the limits of Table 4 specified in RSS-Gen 8.9.	**Pass**

AC Conducted Emissions		
Basic Standard	**Test Details / Comments**	**Result**
FCC15.207 **RSS-Gen 8.8**	**AC Conducted Emissions** **FCC:** (a) Except as shown in paragraphs (b) and (c) of this section, for an intentional radiator that is designed to be connected to the public utility (AC) power line, the radio frequency voltage that is conducted back onto the AC power line on any frequency or frequencies, within the band 150 kHz to 30 MHz, shall not exceed the limits in the following table, as measured using a 50 μH/50 ohms line impedance stabilization network (LISN). **RSS:** Unless stated otherwise in the applicable RSS, for radio apparatus that are designed to be connected to the public utility AC power network, the radio frequency voltage that is conducted back onto the AC power line on any frequency or frequencies within the range 150 kHz to 30 MHz shall not exceed the limits in table 4, as measured using a 50 μH / 50 Ω line impedance stabilization network.	**Pass**

* MPE calculation to be reported in separate reports

Section 4: Sample Details

Note: Each sample was evaluated to ensure that its condition was suitable to be used as a test sample prior to the commencement of testing. Please also refer to the "Justification for worst Case test Configuration" section of this report for further details on the selection of EUT samples.

4.1 Sample Details

Sample No.	Equipment Details	Manufacturer	Model	HW Rev.	FW Rev.	Serial Number
S01	LoRa Radio	Cisco	P-LPWA-900	01	Diags-1-lnx	FOC25520GAC
S02	Test Jig	Cisco	-	V07	4.4.8-Armada-17.2.2	FCW2543ZQVN
S03	AC/DC adapter	LITEON	PA-1660-2SA2	A0	--	LIT24325DGV
S04	Antenna (5.6dBi)	Cisco	ANT-LPWA-DB-O-N-5	1742	--	----------
S05	Antenna (1.5dBi)	Cisco	ANT-WPAN-OD-OUT-N	-	-	-

4.2 System Details

System #	Description	Samples
1	Radio systems in the test jig for AC conducted EMI with power supply.	S01, S02, S03
2	Radio system in the test jig for RF conducted EMI with power supply.	S01, S02, S03
3	Radio sample in Host System for radiated EMI with power supply and 5.6dBi antenna	S01, S02, S03, S04
4	Radio sample in Host System for radiated EMI with power supply and 1.5dBi antenna	S01, S02, S03, S05

4.3 Mode of Operation Details

Mode#	Description	Comments
1	LoRa-DTS	LoRa radio is set at the maximum output power in a continuous transmitter with ≤98% duty cycle during the test.

4.4 Test Mode, Modulation and Data Rate Description

Test Mode	Modulation	Data Rate
LoRa-DTS	chirp Spread Spectrum (CSS)	SF12 / 980bps

4.5 Software Used for Testing

Tool	Description	Comments
1	EMIsoft Vasona, version 6.0	Vasona is Windows based automated software PC controlled tool kit designed to run radiated emissions.

4.6 Antenna Information

The following antennas are supported by this product series. The data included in this report represent the worst-case data for all antennas. The antenna gain information is referenced from the antenna specification/report included in the application filing.

P-LPWA-900 supports the following antennas:

Antenna	Frequency Supported (MHz)	Peak Gain (dBi)	Radiation Pattern	Antenna Type	Connector	Mounting Style
ANT-LPWA-SMA-D	863 – 928	0.9	Omnidirectional	Dipole	SMA(m)	Direct mount to front panel SMA(f)
ANT-WPAN-OD-OUT-N	863 – 928	1.5	Omnidirectional	Dipole	N(m)	Direct mount to bulkhead N(f)
ANT-LPWA-DB-O-N-5	863 – 928	5.6	Omnidirectional	Dipole	N(f)	Pole/mast mount

Section 5: Modifications

5.1 Sample Modifications Performed During Assessment

No modifications were performed during assessment.

Appendix A: RF Conducted Test Results

Target Maximum Channel Power

The following table details the maximum supported Total Channel Power for the operating mode.

	Maximum Channel Power (dBm)		
	Frequency (MHz)		
Operating Mode	923.3	925.1	927.5
LoRa-DTS	25.44	-----	-----

A.1 Duty Cycle

Ref. ANSI C63.10: 2013, Clause 11.6
B. Duty Cycle (x), Transmission Duration (T) and Maximum Power Control Level

Preferably, all measurements of maximum conducted (average) output power will be performed with the EUT transmitting continuously (i.e., with a duty cycle of greater than or equal to 98%). When continuous operation cannot be realized, then the use of sweep triggering/signal gating techniques can be used to ensure that measurements are made only during transmissions at the maximum power control level. Such sweep triggering/signal gating techniques will require knowledge of the minimum transmission duration (T) over which the transmitter is on and is transmitting at its maximum power control level for the tested mode of operation. Sweep triggering/signal gating techniques can then be used if the measurement/sweep time of the analyzer can be set such that it does not exceed T at any time that data are being acquired (i.e., no transmitter OFF-time is to be considered).

When continuous transmission cannot be achieved and sweep triggering/signal gating cannot be implemented, alternate procedures are provided that can be used to measure the average power; however, they will require an additional measurement of the transmitter duty cycle. Within this guidance document, the duty cycle refers to the fraction of time over which the transmitter is on and is transmitting at its maximum power control level. The duty cycle is constant if variations are less than ± 2 percent, otherwise the duty cycle is considered to be non-constant.

A.1.1 Duty Cycle Test Method

Ref. ANSI C63.10: 2013, Clause 11.6 (b)

Measurements of duty cycle and transmission duration shall be performed using the following technique:

(b) The zero-span mode on a spectrum analyzer or EMI receiver if the response time and spacing between bins on the sweep are sufficient to permit accurate measurements of the on and off times of the transmitted signal.

1) Set the center frequency of the instrument to the center frequency of the transmission.
2) Set RBW ≥ OBW if possible; otherwise, set RBW to the largest available value.
3) Set VBW ≥ RBW. Set detector = peak or average.
4) The zero-span measurement method shall not be used unless both RBW and VBW are > 50/T and the number of sweep points across duration T exceeds 100. (For example, if VBW and/or RBW are limited to 3 MHz, then the zero-span method of measuring duty cycle shall not be used if T ≤ 16.7 microseconds.)

Duty Cycle Correction Factor and Duty Cycle Percentage can be derived by using the following formulas:

DCCF = 10 log **(**1/ (TXon / TXon + TXoff)**)**
DC % = (TXon / TXon + TXoff) * 100

Tested By: Farida Rahmanzai, Danh Le	**Date of testing:** 04-May-2022
Test Result: PASS	

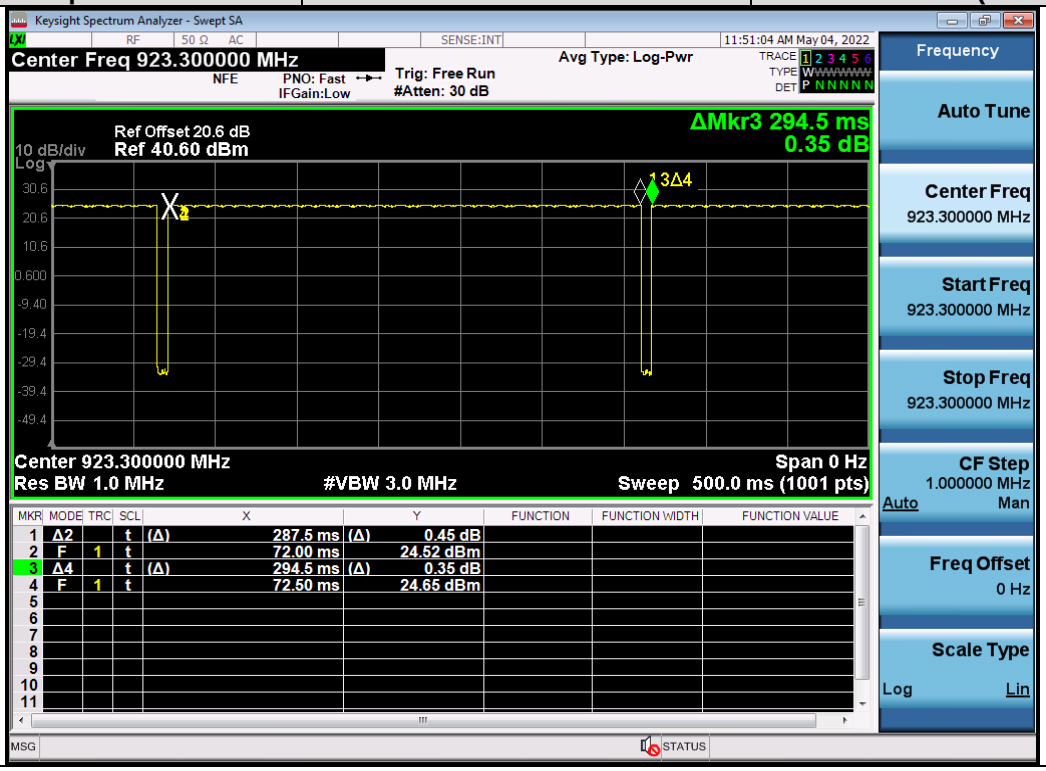
Test Equipment
See Appendix C for list of test equipment

1.2 Duty Cycle Data Table

Mode	Data Rate	On-time (ms)	Total on+off Time (ms)	Duty Cycle (%)	Correction Factor (dB)
LoRa_DTS	SF12	287.5	294.5	97.6	0.1

A.1.3 Duty Cycle Graphical Test results

Freq:923.3 MHz	Mode: LoRa-DTS	Data Rate:SF12 (980 bps)



A.2 99% and 6dB Bandwidth

The 99% 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. There is no limit for 99% OBW.

The 6 dB emission bandwidth is defined as the frequency range between two points, one above and one below the carrier frequency, at which the spectral density of the emission is attenuated 6 dB below the maximum in-band spectral density of the modulated signal.

A.2.1 Limit

FCC 15.247(a) (2); RSS-247 5.2(a)

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

A.2.2 Test Procedure

Ref. ANSI C63.10: 2013, Clause 11.8.2 Option 2

99% BW and EBW (6dB) Test Procedure
1. The radio is configured in the continuous transmitting mode. 2. Allow the trace to stabilize. 3. Setting the x-dB bandwidth mode to -6dB and OBW power function to 99% within the measurement set up function. 4. Select the automatic OBW measurement function of an instrument to perform bandwidth measurement. 5. Capture graphs and record pertinent measurement data.

99% BW and EBW (6dB) Test parameters
Span =Wide enough to capture the entire emission bandwidth RBW =100 kHz VBW ≥ 3 x RBW Detector =Peak Trace = Max. Hold Sweep = Auto couple

A.2.3 99% and 6dB Occupied Bandwidth Data Table

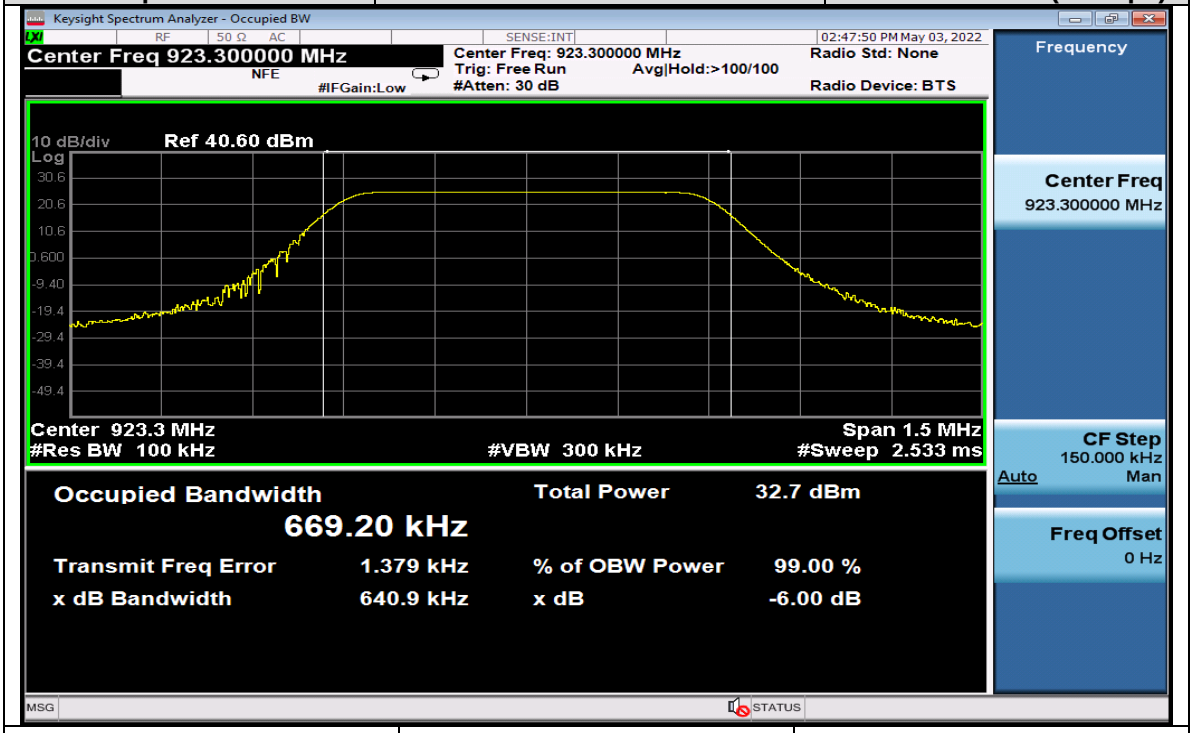
Frequency (MHz)	Data Rate (bps)	99% BW (kHz)	6dB BW (kHz)	6dB BW Limit (kHz)	Result
923.3	980	669.2	640.9	≥ 500	Pass
925.1	980	669.6	642.0	≥ 500	Pass
927.5	980	671.1	642.6	≥ 500	Pass

Tested By: Farida Rahmanzai, Danh Le	**Date of testing:** 03-May-2022
Test Result: PASS	

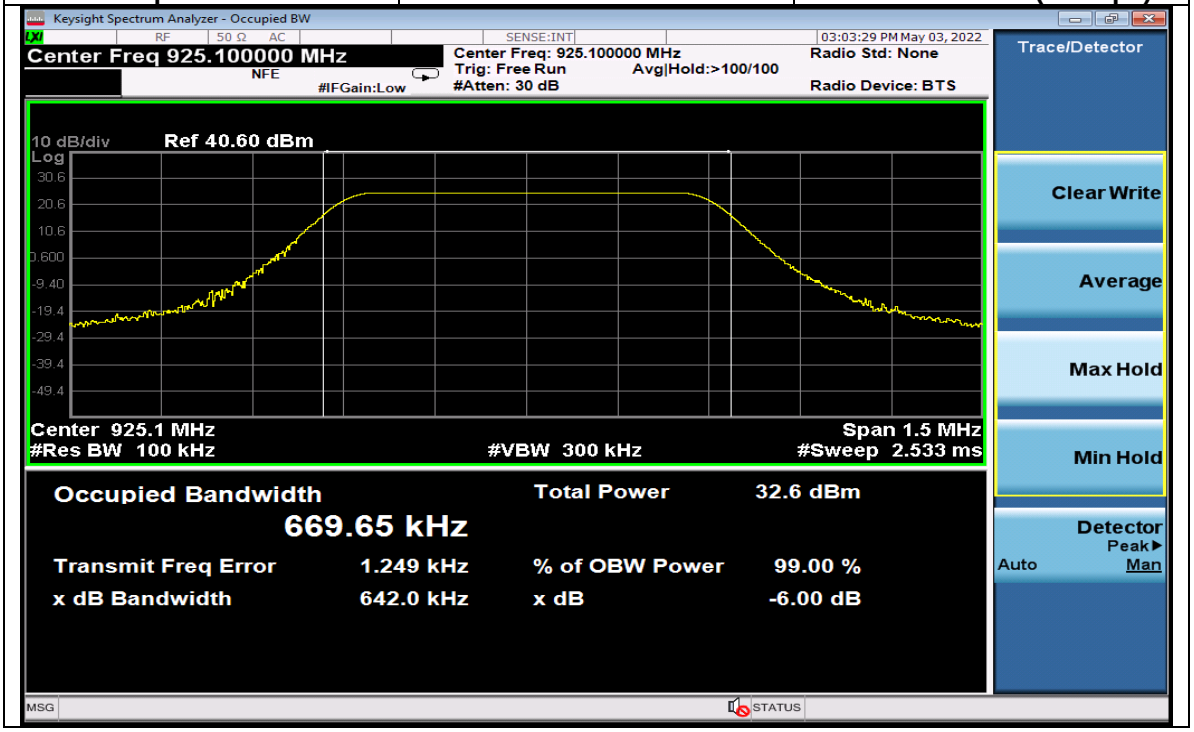
Test Equipment
See Appendix C for list of test equipment

A.2.4 99% and 6dB Occupied Bandwidth Graphical Test Results

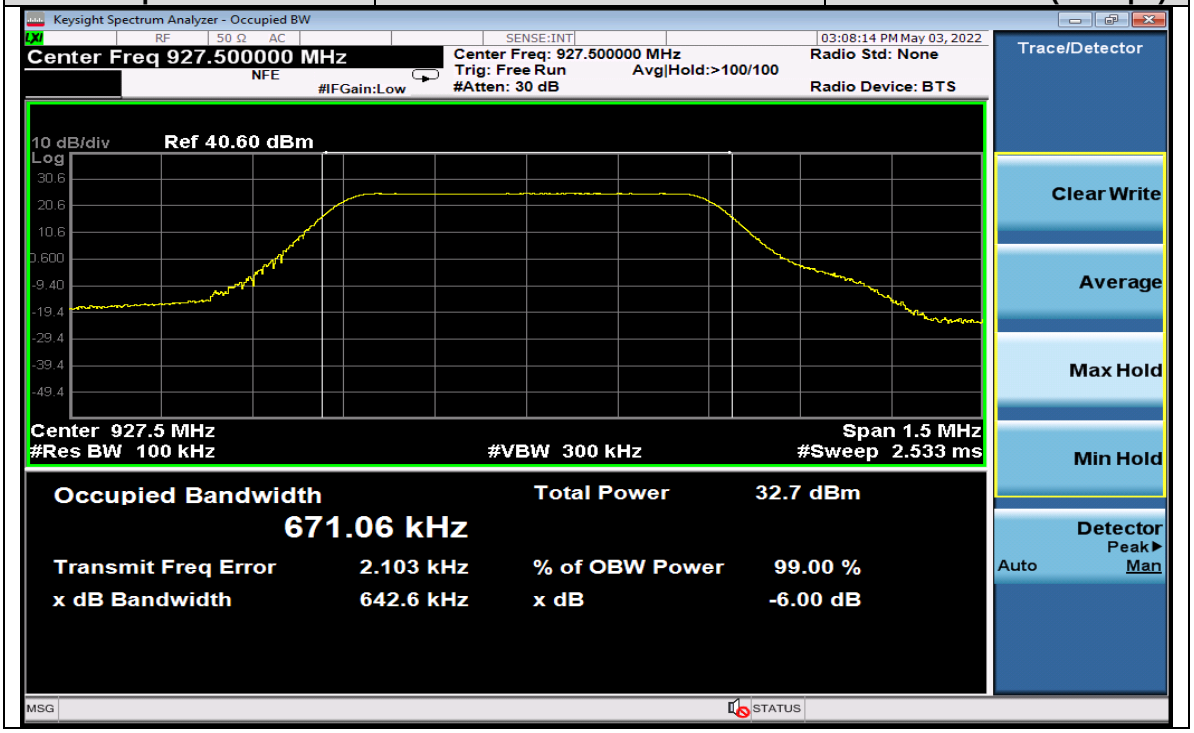
Freq:923.3 MHz	Mode: LoRa-DTS	Data Rate:SF12 (980 bps)



Freq:925.1 MHz	Mode: LoRa-DTS	Data Rate:SF12 (980 bps)



Freq:927.5 MHz	Mode: LoRa-DTS	Data Rate:SF12 (980 bps)



A.3 Maximum Conducted Output power

The maximum conducted output power is the total transmit power delivered to all antennas and antenna elements averaged across all symbols in the signaling alphabet when the transmitter is operating at its maximum power control level.

A.3.1 Limits

FCC 15.247 (b)(3):
The maximum peak conducted output power of the intentional radiator shall not exceed the following:
For systems using digital modulation in the 902-928 MHz, 2400-2483.5 MHz, and 5725-5850 MHz bands: 1 Watt (30 dBm). As an alternative to a peak power measurement, compliance with the one Watt limit can be based on a measurement of the maximum conducted output power.

FCC 15.247 (b)(4):
The conducted output power limit specified in paragraph (b) of this section is based on the use of antennas with directional gains that do not exceed 6 dBi. Except as shown in paragraph (c) of this section, if transmitting antennas of directional gain greater than 6 dBi are used, the conducted output power from the intentional radiator shall be reduced below the stated values in paragraphs (b)(1), (b)(2), and (b)(3) of this section, as appropriate, by the amount in dB that the directional gain of the antenna exceeds 6 dBi.

RSS-247 (5.4) (d):
DTSs include systems that employ digital modulation techniques resulting in spectral characteristics similar to direct sequence systems. The following applies to the bands 902-928 MHz and 2400- 2483.5 MHz:

For DTSs employing digital modulation techniques operating in the bands 902-928 MHz and 2400-2483.5 MHz, the maximum peak conducted output power shall not exceed 1W. The e.i.r.p. shall not exceed 4 W, except as provided in section 5.4(e).

A.3.2 Test Procedure

Ref. KDB 558074 D01 15.247 Meas Guidance v05r02, section 8.3.2.2 (SA)
ANSI C63.10:2013 Clause 11.9.2.2.4 Method AVGSA-2

Max. Conducted Output Power Test Procedure
1. Set the radio in the transmitting mode. 2. Center frequency of interest. 3. Compute power by integrating the spectrum across the OBW of the signal using the instrument's band power measurement function. The integration shall be performed using the spectrum analyzer band-power measurement function with band limits set equal to the OBW band edges. 4. Capture graphs and record pertinent measurement data 5. Add 10 log (1/x), where x is the duty cycle, to the measured power in order to compute the average power during the actual transmission times (because the measurement represents an average over both the on and off times of the transmission).

Test parameters
Span ≥ 1.5 times the OBW RBW = 1 – 5% of the OBW, not to exceed 1 MHz VBW ≥ 3 x RBW Detector = RMS Trace Average ≥ 100 Sweep time = Auto Sweep = free run Sweep Points ≥ 2 x span/ RBW.

A.3.3 Max. Conducted Output Power & EIRP Data Table

Frequency (MHz)	Mode	Tx Path(s)	Correlated Antenna Gain (dBi)	Tx Max Power (dBm)	Duty cycle Correction Factor (dB)	Total TX Channel Power - corrected for duty cycle (dBm)	Total TX Channel Power - corrected for duty cycle (dBm) + Antenna gain	Limit conducted (dBm)	Limit EIRP (dBm)	Result
923.3	LoRa-DTS	1	5.6	25.44	0.1	25.54	31.14	30	36	Pass
925.1	LoRa-DTS	1	5.6	25.01	0.1	25.11	30.71	30	36	Pass
927.5	LoRa-DTS	1	5.6	25.15	0.1	25.25	30.85	30	36	Pass

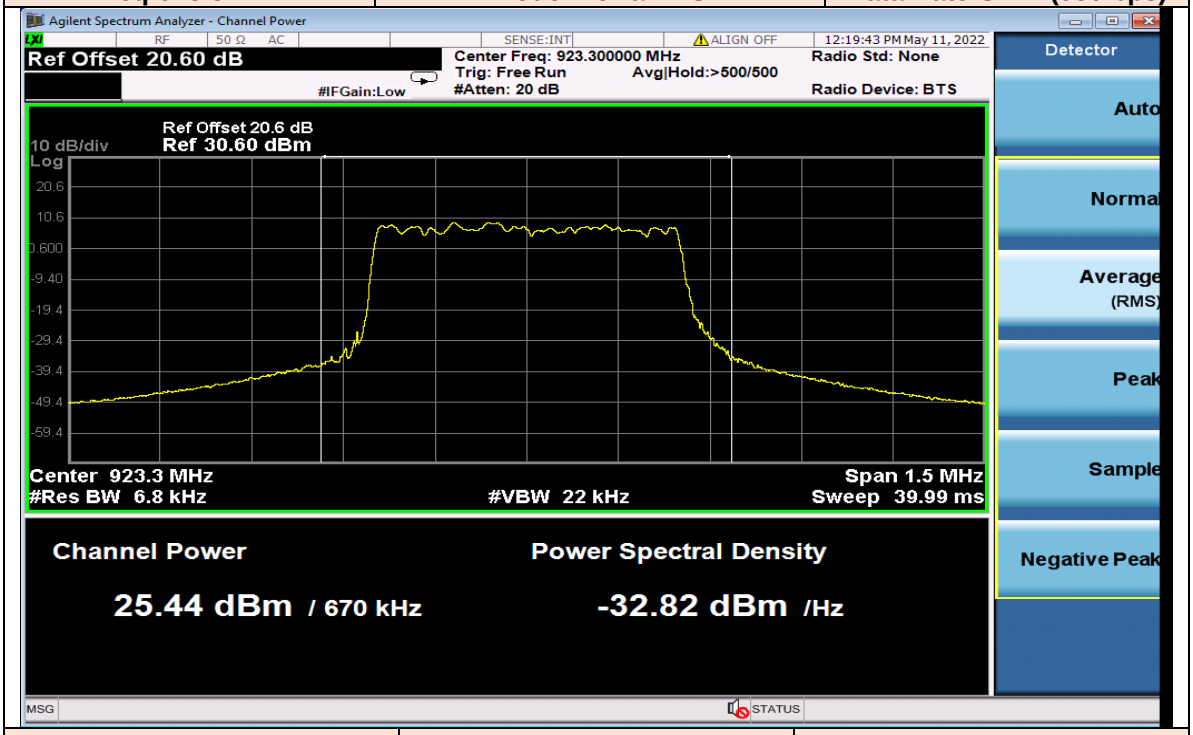
Note: correction factors (ext. attenuation + cable loss) are compensated in the offset function of the Spectrum Analyzer.

Tested By: Farida Rahmanzai, Danh Le	**Date of testing:** 10-May-2022 – 11-May-2022
Test Result: PASS	

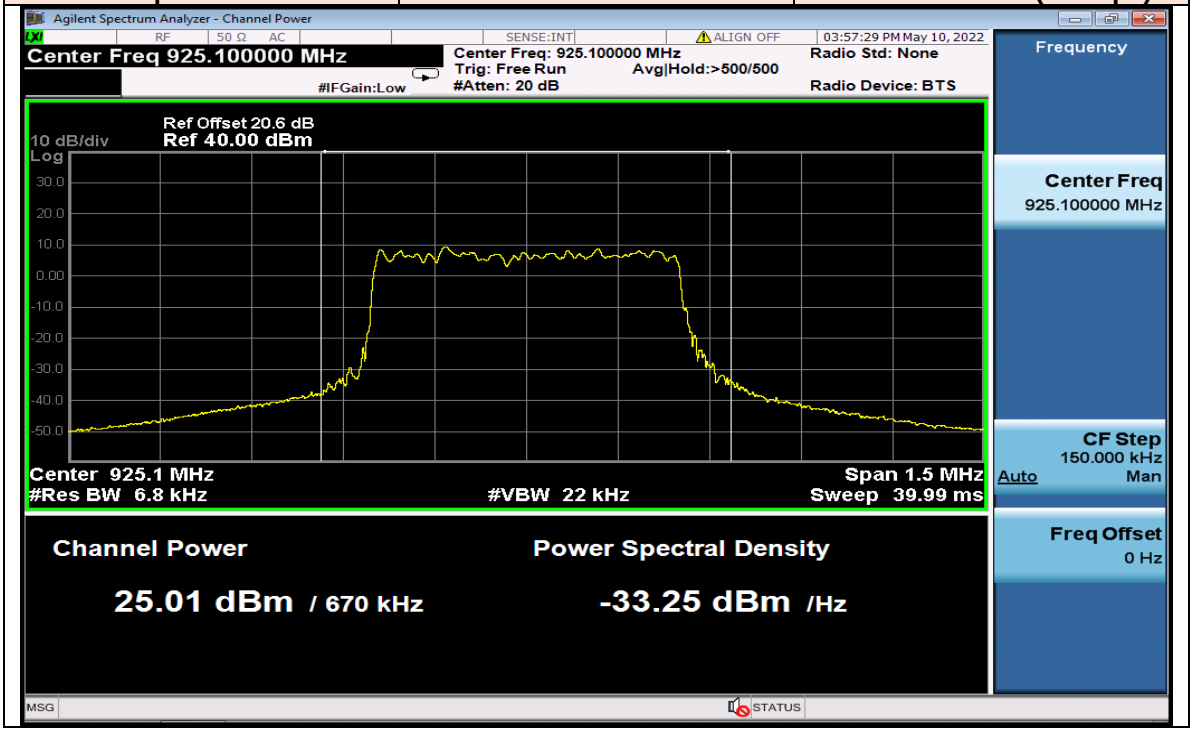
Test Equipment
See Appendix C for list of test equipment

A.3.4 Max. Conducted Output Power Graphical Test Results

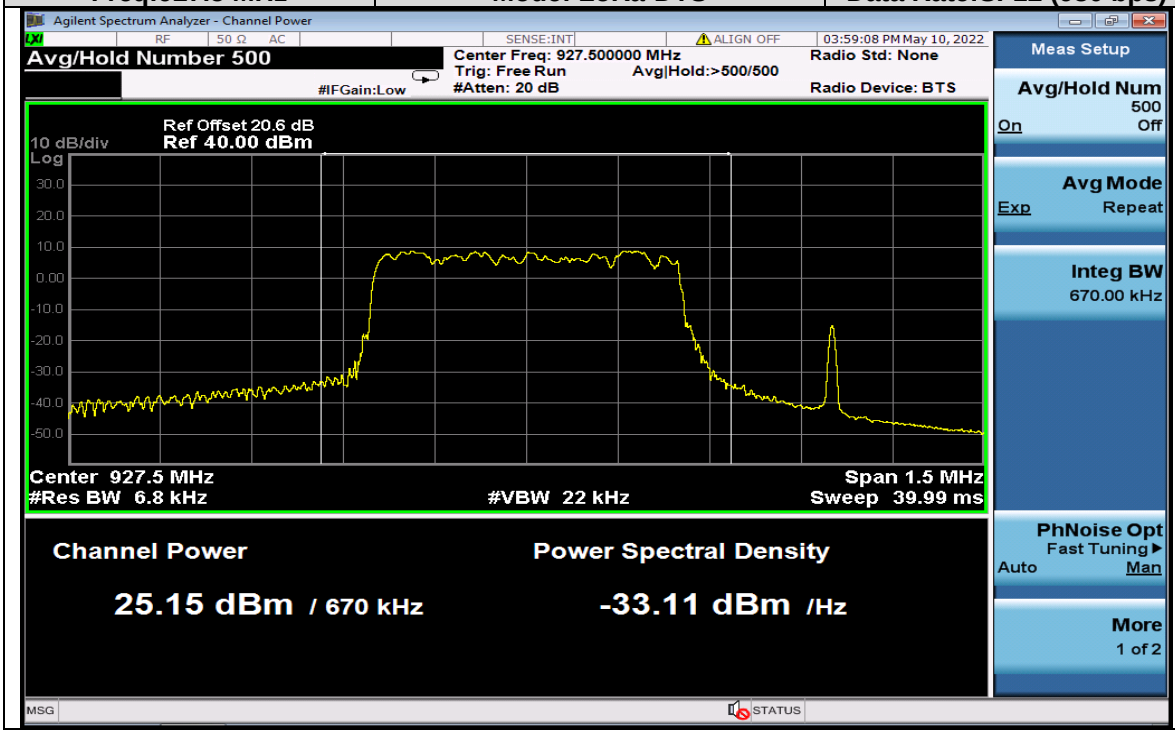
Maximum Conducted Output Power		
Freq:923.3 MHz	Mode: LoRa-DTS	Data Rate:SF12 (980 bps)



Freq:925.1 MHz	Mode: LoRa-DTS	Data Rate:SF12 (980 bps)



Maximum Conducted Output Power		
Freq:927.5 MHz	Mode: LoRa-DTS	Data Rate:SF12 (980 bps)



A.4 Power Spectral Density

The Power Spectral Density is the total energy output per unit bandwidth from a pulse or sequence of pulses for which the transmit power is at its maximum level, divided by the total duration of the pulses, This total time does not include the time between pulses during which the transmit power is off or below its maximum level.

A.4.1 Limits

FCC 15.247(e)/ RSS-247 5.2(b)
The transmitter power spectral density conducted from the transmitter to the antenna shall not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission.

A.4.2 Test Procedure

Ref. ANSI C63.10:2013, Clause 11.10.5 Method AVGPSD-2

Power Spectral Density Test Procedure
1. Set the radio in the continuous transmitting mode. 2. Center frequency of interest. 2. Perform the measurement over a single sweep by using the peak marker function to determine the maximum amplitude level. 3. Capture graphs and record pertinent measurement data

Power Spectral Density Test parameters
Span ≥ 1.5 times the OBW RBW ≥ 3 kHz VBW ≥ 3 x RBW Detector = RMS Trace Average ≥ 100 Sweep time ≥ auto Sweep Points ≥ 2 x span/ RBW

A.4.3 Power Spectral Density Data Table

Frequency (MHz)	Mode	Tx Path(s)	Tx PSD (dBm/3KHz)	Duty cycle Correction Factor (dB)	Total PSD - corrected for duty cycle	PSD Limit	Result
923.3	LoRa-DTS	1	5.99	0.1	6.09	8	Pass
925.1	LoRa-DTS	1	5.76	0.1	5.86	8	Pass
927.5	LoRa-DTS	1	5.68	0.1	5.78	8	Pass

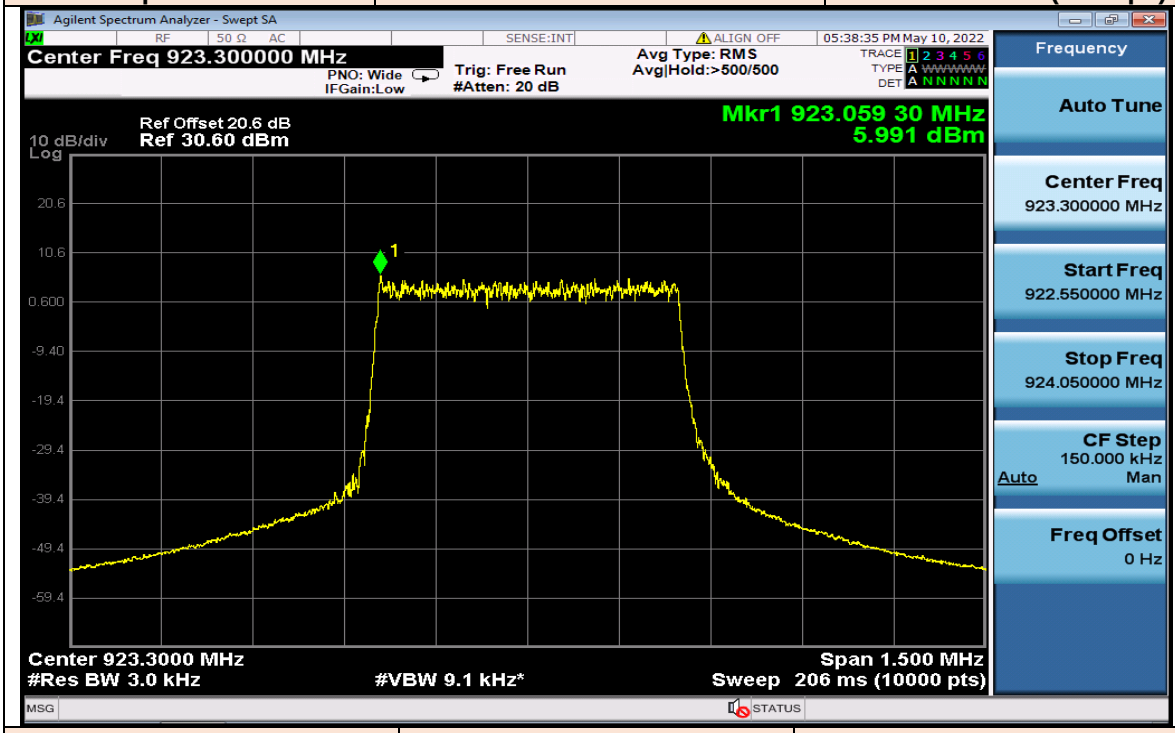
Note: correction factors (ext. attenuation + cable loss) are compensated in the offset function of the Spectrum Analyzer.

Tested By: Farida Rahmanzai, Danh Le	**Date of testing:** 10-May-2022
Test Result: PASS	

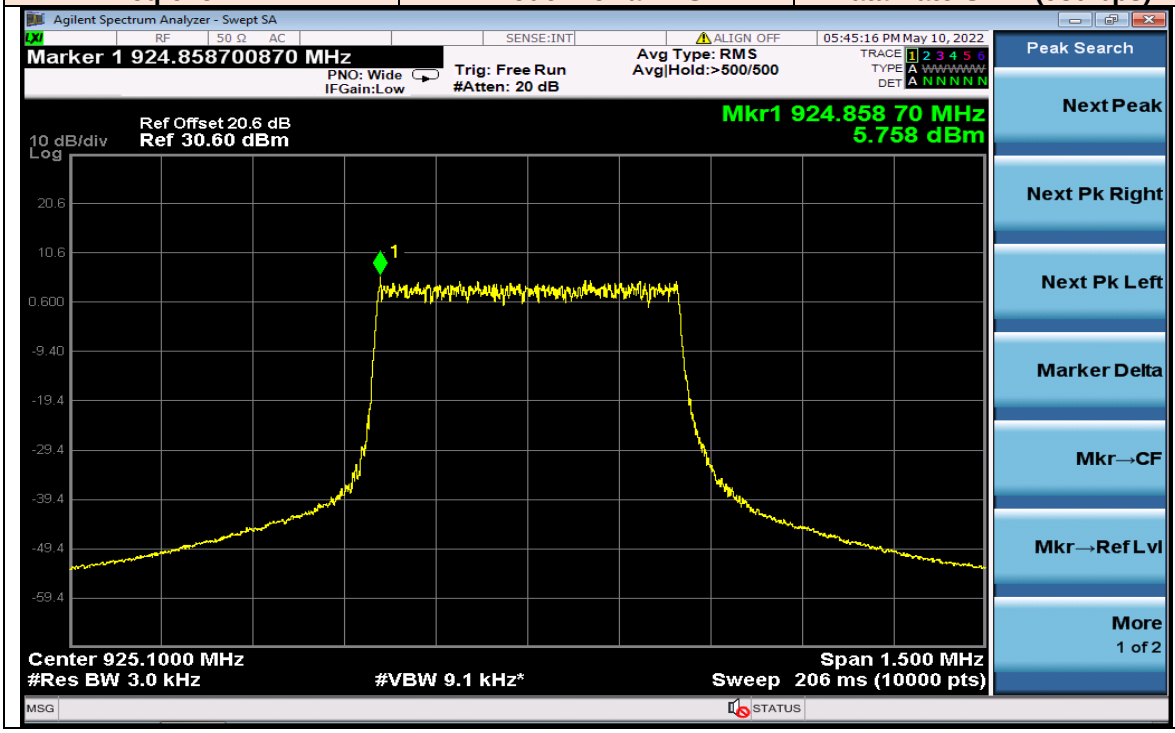
Test Equipment
See Appendix C for list of test equipment

A.4.4 Power Spectral Density Graphical Test Results

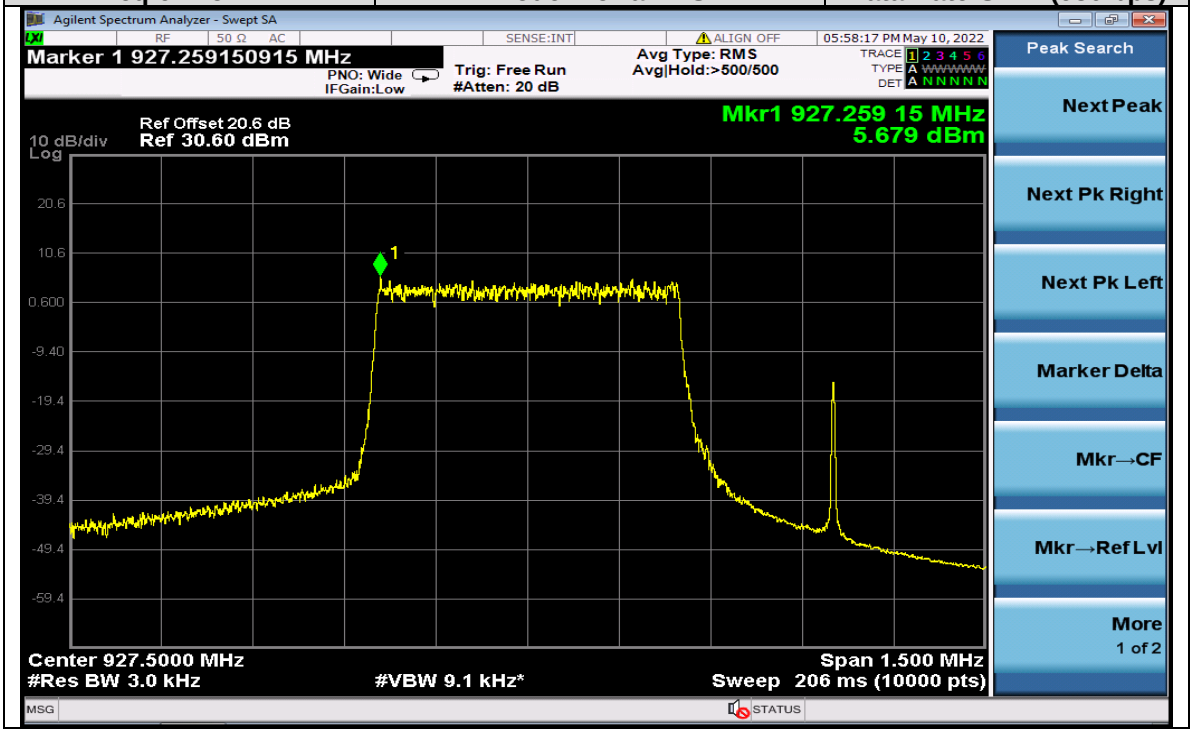
Power Spectral Density		
Freq:923.3 MHz	Mode: LoRa-DTS	Data Rate:SF12 (980 bps)



Freq:925.1 MHz	Mode: LoRa-DTS	Data Rate:SF12 (980 bps)



Power Spectral Density		
Freq:927.5 MHz	Mode: LoRa-DTS	Data Rate:SF12 (980 bps)



A.5 Conducted Band Edge

A.5.1 Limits

FCC 15.247(d)

In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power. 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. Attenuation below the general limits specified in FCC§15.209(a).

RSS-247 5.5

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 radiated measurement, provided that the transmitter demonstrates compliance with 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.

A.5.2 Test Procedure

Ref. ANSI C63.10:2013, Clause 6.10.4

Band-edge Measurement (relative) Test Procedure
1. Turn on the lowest operating channel/frequency that is closest to the lower band edge 2. Set the radio in the continuous transmitting mode with ≥ 98 % duty cycle 3. Allow trace to fully stabilize 4. Set the peak marker function on any unwanted emissions within 2 MHz outside of the authorized band edge. 5. Enable the marker-delta function, and then use the marker-to-peak function to move the marker to the peak of the in-band emission. 6. Turn on the highest operating channel/frequency that is closest to the upper band edge 7. Repeat step 2 – 5 **Note:** The emissions limit is the 30 dB attenuation respects to the peak of the in-band emission. Delta readings must be greater than 30 dB to determine band-edge compliance.

Band-edge Measurement (relative) Test parameters
Span = encompass the 99% OBW of the fundamental signal and 2 MHz outside the band edge Reference level ≥ 10 dB headroom between max. spectrum level and the reference level Int. Attenuation ≥ 10 dB or Auto whichever greater Sweep time = auto RBW = 100 kHz VBW ≥ 3 x RBW Detector = Peak Trace mode = max-hold

A.5.3 Band Edge Recorded Data Table

Operating Frequency (MHz)	Mode	Data Rate (bps)	OOB Unwanted Emission Frequency (MHz)	OOB Unwanted Emission Level (dBm)	Limit -30dBc (dBm)	Results
923.3	LoRa-DTS	SF12 (980)	NF	----	-30.07	Pass
927.5	LoRa-DTS	SF12 (980)	928.01	-17.01	-16.64	Pass

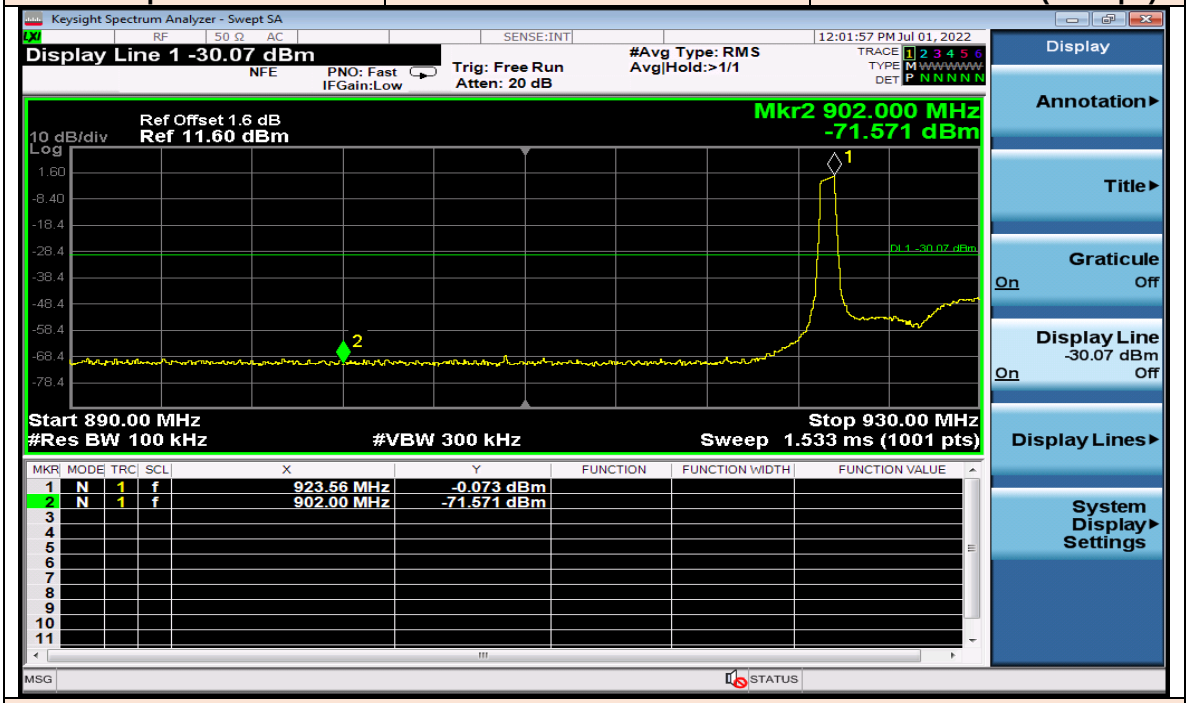
Note1: NF = noise floor
Note2: correction factors (ext. attenuation + cable loss) are compensated in the offset function of the Spectrum Analyzer.

Tested By: Farida Rahmanzai, Danh Le	**Date of testing:** 01-Jul-2022
Test Result: PASS	

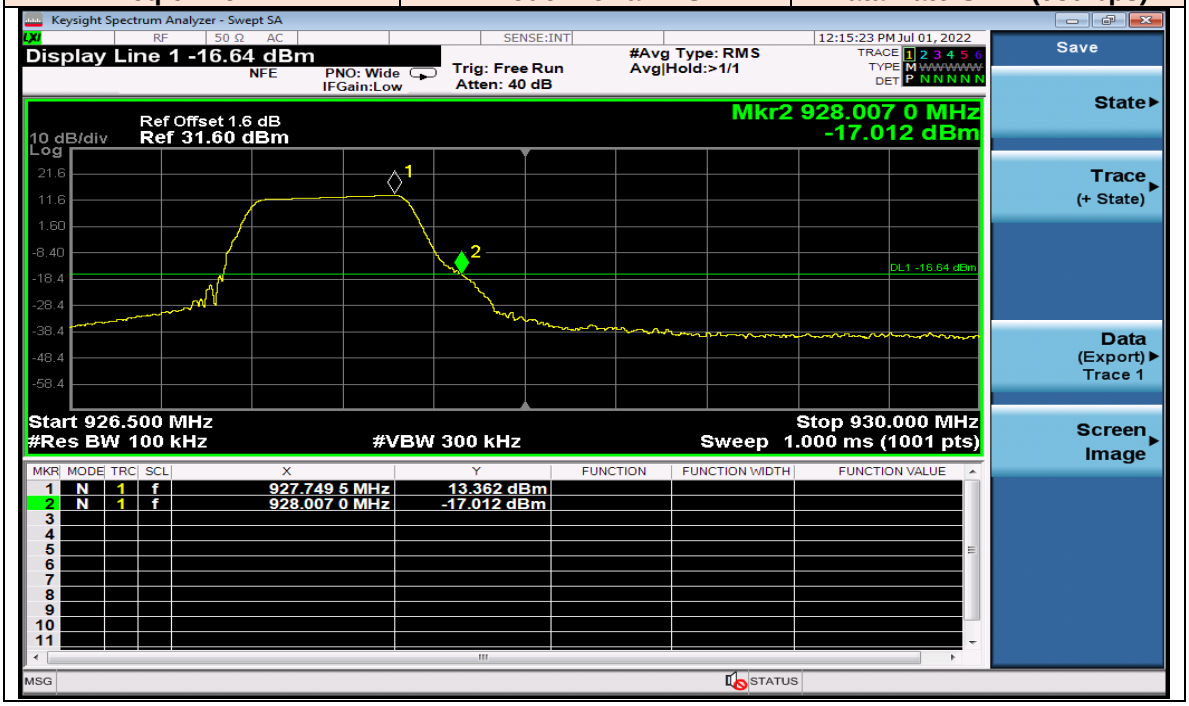
Test Equipment
See Appendix C for list of test equipment

A.5.4 Band Edge Graphical Test Results

Lower Band Edge		
Freq:923.3 MHz	**Mode: LoRa-DTS**	**Data Rate:SF12 (980 bps)**



Upper Band Edge		
Freq:927.5 MHz	**Mode: LoRa-DTS**	**Data Rate:SF12 (980 bps)**



A.6 Conducted Spurious Emissions

In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power. 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. Attenuation below the general limits specified in FCC§15.209(a) & RSS-Gen is not required.
A.6.1 Conducted Spurious Emissions Data Table.

A.6.1 Limits

FCC 15.247(d)

In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power. 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. Attenuation below the general limits specified in FCC§15.209(a).

RSS-247 5.5

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 radiated measurement, provided that the transmitter demonstrates compliance with 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.

A.6.2 Test Procedure

Ref. ANSI C63.10:2013, Clause 11.11.2

Reference Level Setting Test Procedure
1. Turn on the operating channel/frequency of interest 2. Set the radio in the continuous transmitting mode with ≥ 98 % duty cycle 3. Set the span to encompass frequency range to be measured. Note that the frequency range might need to be divided into multiple frequency ranges to retain frequency resolution. 4. Allow trace to fully stabilize 5. Use the peak marker function to set the maximum PSD level of fundamental signal 6. Turn on the display function and set the display line at 30 dBc **Note:** The emissions limit is the 30 dB attenuation respects to the maximum PSD level of the in-band emission.

Reference Level Setting Test parameters
Reference level ≥ 10 dB headroom between max. spectrum level and the reference level Int. Attenuation ≥ 10 dB or Auto whichever greater Set the span to ≥ 1.5 times the DTS bandwidth. RBW = 100 kHz (30MHz - 10GHz) /10KHz ((30KHz – 30MHz) VBW ≥ 3 x RBW Detector = Peak Sweep time = Auto Trace mode = max-hold

Ref. ANSI C63.10:2013, Clause 11.11.3

Conducted Spurious Emissions Measurement in non-restricted bands Test procedure
1. Turn on the lowest operating channel/frequency 2. Set the radio in the continuous transmitting mode with ≥ 98 % duty cycle 3. Allow trace to fully stabilize 4. Use the peak marker function to set the maximum PSD level of unwanted emissions in the spurious domain. 5. Record the maximum PSD level 6. Turn on the middle operating channel/frequency 7. Repeat step 2 – 5 8. Turn on the highest operating channel/frequency 9. Repeat step 2 – 5 **Note:** The emissions limit is the 30 dB attenuation respects to the peak of the in-band emission.

Conducted Spurious Emissions Measurement in non-restricted bands Test parameters
Span = Set the center frequency and span to encompass frequency range to be measured **Note**: that the frequency range might need to be divided into multiple frequency ranges to retain frequency resolution Reference level ≥ 10 dB headroom between max. spectrum level and the reference level Int. Attenuation ≥ 10 dB or Auto whichever greater Sweep time = auto RBW = 100 kHz (30MHz - 10GHz) /10KHz ((30KHz – 30MHz) VBW ≥ 3 x RBW Detector = Peak Sweep time = Auto Trace mode = max-hold

A.6.3 Conducted Spurious Emissions Data Table

Frequency (MHz)	Mode	Data Rate (bps)	Frequency Range (MHz)	Unwanted Emission Frequency (MHz)	Max. Unwanted Emission Level (dBm)	Limit -30dBc (dBm)	Margin (dB)	Result
Channel 0								
923.3	LoRa-DTS	SF12 (980)	30KHz-30MHz	0.032768	-31.9	-3.63	-28.27	Pass
923.3	LoRa-DTS	SF12 (980)	30MHz-1GHz	------	NF	-30.14	-	Pass
923.3	LoRa-DTS	SF12 (980)	1GHz – 5GHz	1846.5	-54.214	-30.14	-24.07	Pass
923.3	LoRa-DTS	SF12 (980)	5GHz – 10 GHz	------	NF	-30.14	-	Pass
Channel 3								
925.1	LoRa-DTS	SF12 (980)	30KHz-30MHz	0.032768	-33.82	-3.75	30.07	Pass
925.1	LoRa-DTS	SF12 (980)	30MHz-1GHz	------	NF	-24.32	-	Pass
925.1	LoRa-DTS	SF12 (980)	1GHz – 5GHz	1850.7	-53.76	-24.32	-29.44	Pass
925.1	LoRa-DTS	SF12 (980)	5GHz – 10 GHz	------	NF	-24.32	-	Pass
Channel 7								
927.5	LoRa-DTS	SF12 (980)	30KHz-30MHz	0.032768	-32.19	-3.84	-28.35	Pass
927.5	LoRa-DTS	SF12 (980)	30MHz-1GHz	------	NF	-16.28		Pass
927.5	LoRa-DTS	SF12 (980)	1GHz – 5GHz	1852.7	-51.42	-16.28	-35.14	Pass
927.5	LoRa-DTS	SF12 (980)	5GHz – 10 GHz	------	NF	-16.28		Pas

Note1: NF = noise floor
Note2: correction factors (ext. attenuation + cable loss) are compensated in the offset function of the Spectrum Analyzer.
Note3: For frequency range from 30kHz - 30MHz, the measurement is performed using a reduced resolution bandwidth (10kHz) less than the rule specifies (100kHz). Correction factor shall be adjusted to the final measurements.

The correction factor (in dB) shall be calculated using the equation below:

CF = 10 log (Specified RBW / Actual measured RBW)

= 10 log (100kHz / 10KHz)

= 10 log (10)

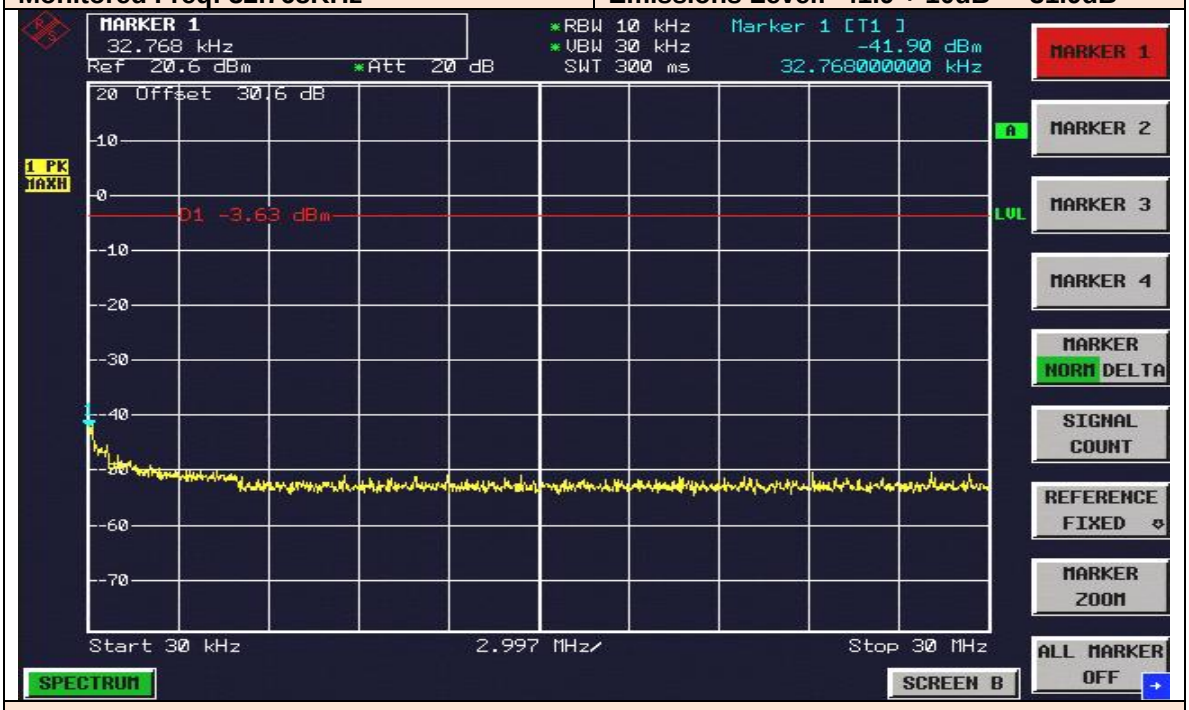
= 10 dB

Tested By: Farida Rahmanzai, Danh Le	**Date of testing:** 30-Jun-2022 & 08-August-2022
Test Result: PASS	

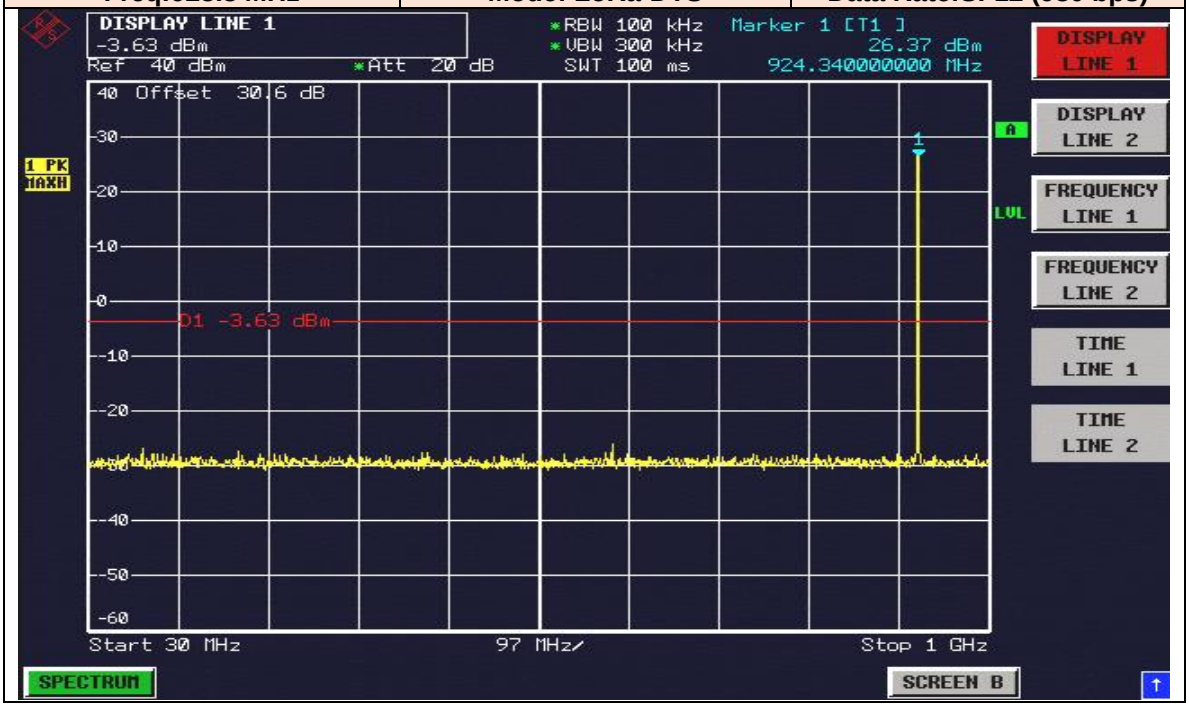
Test Equipment
See Appendix C for list of test equipment

A.6.4 Conducted Spurious Emissions Graphical Test Results

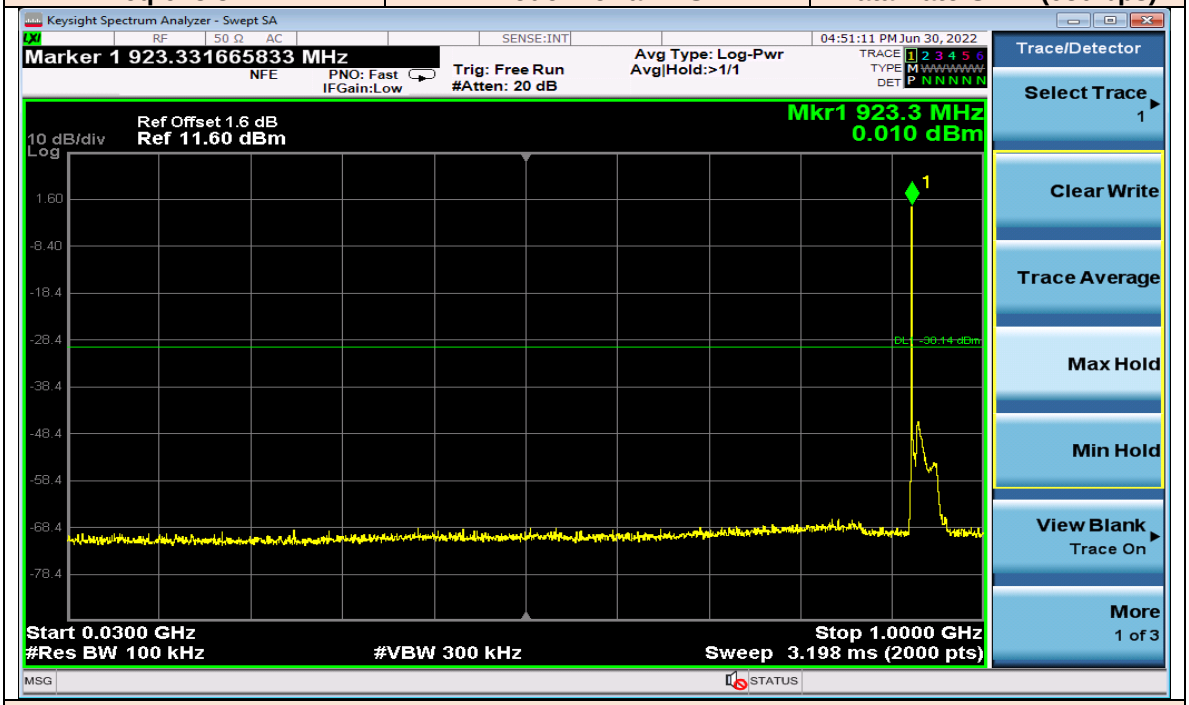
Conducted Spurious Emissions (30KHz – 30MHz)		
Freq:923.3 MHz	**Mode: LoRa-DTS**	**Data Rate:SF12 (980 bps)**
Monitored Freq: 32.768KHz	**Emissions Level: -41.9 + 10dB = -31.9dB**	



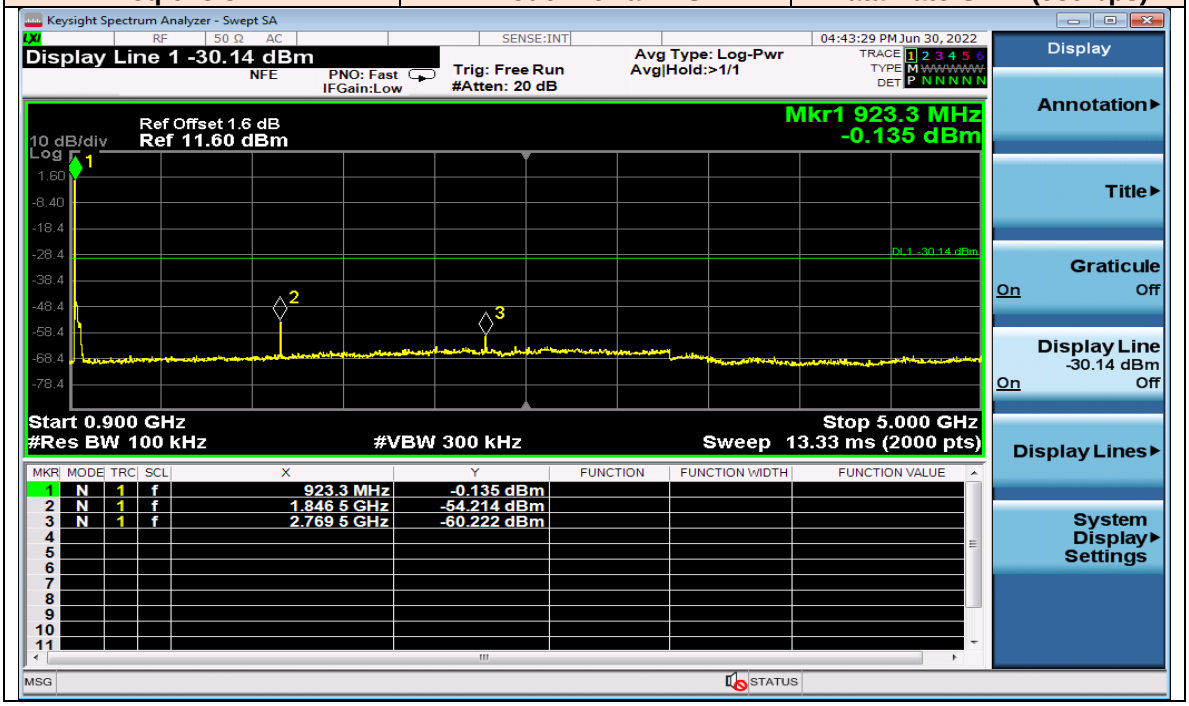
`Conducted Spurious Emissions (30MHz – 1GHz)		
Freq:923.3 MHz	**Mode: LoRa-DTS**	**Data Rate:SF12 (980 bps)**



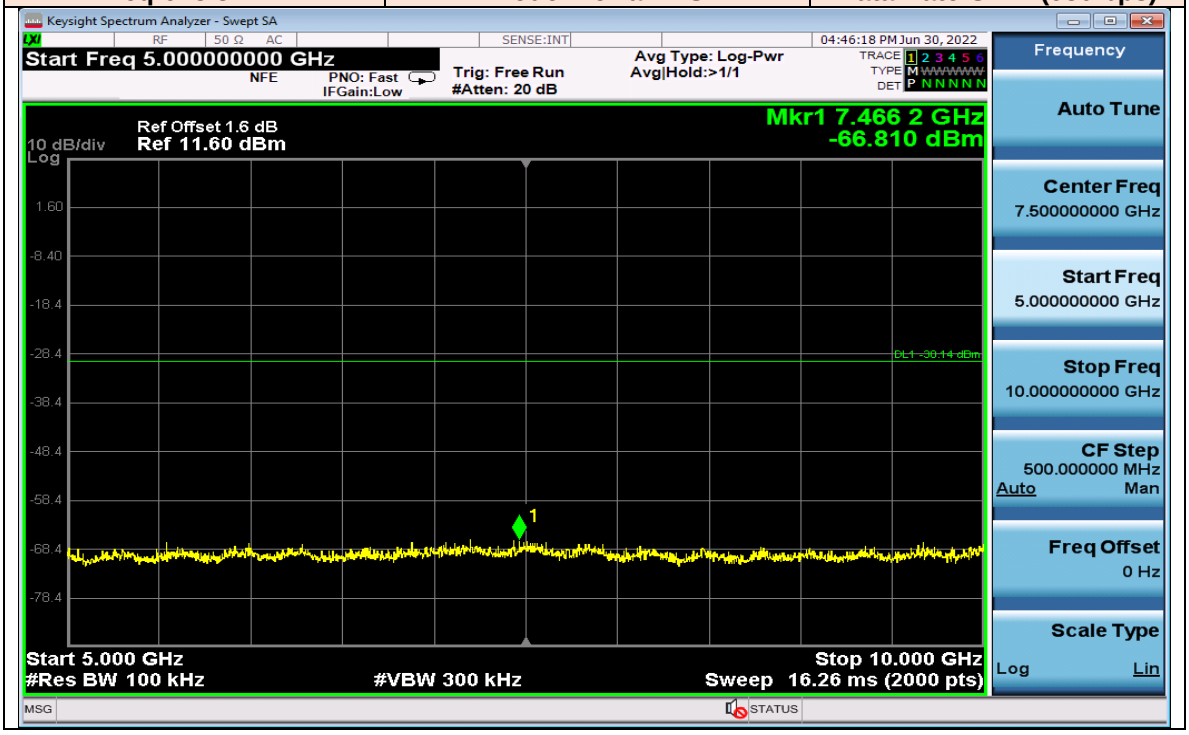
Conducted Spurious Emissions (30MHz – 1GHz)		
Freq:923.3 MHz	**Mode: LoRa-DTS**	**Data Rate:SF12 (980 bps)**



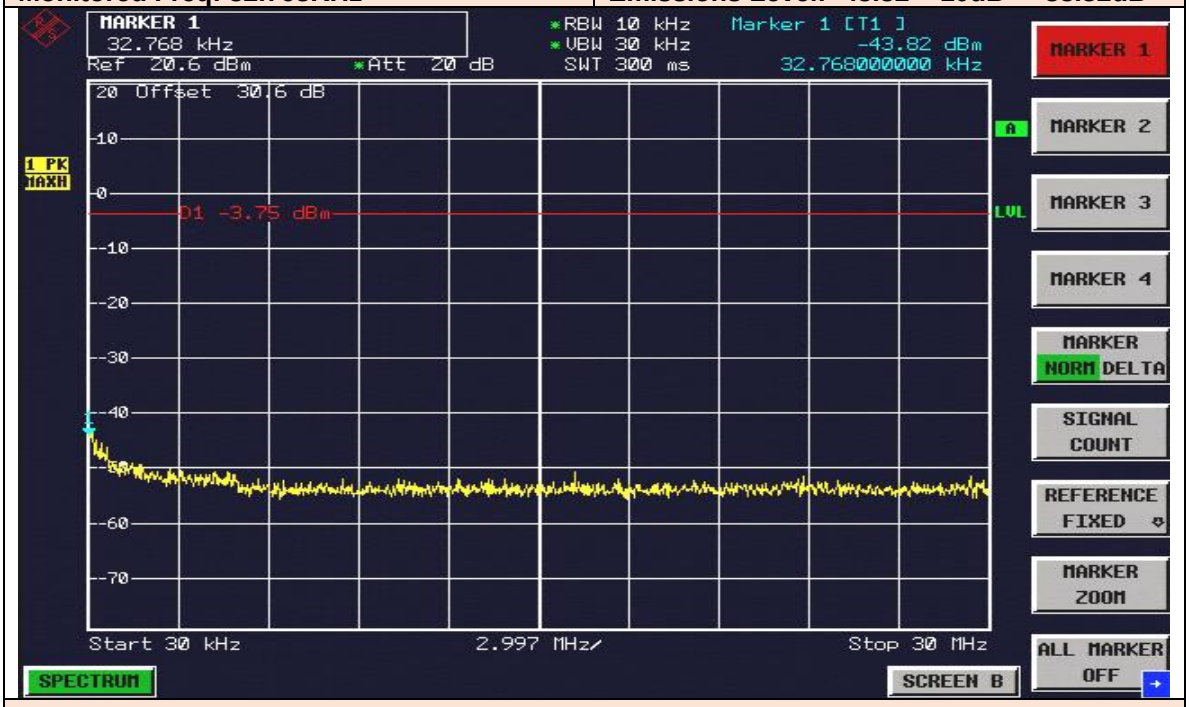
`Conducted Spurious Emissions (1GHz – 5GHz)		
Freq:923.3 MHz	**Mode: LoRa-DTS**	**Data Rate:SF12 (980 bps)**



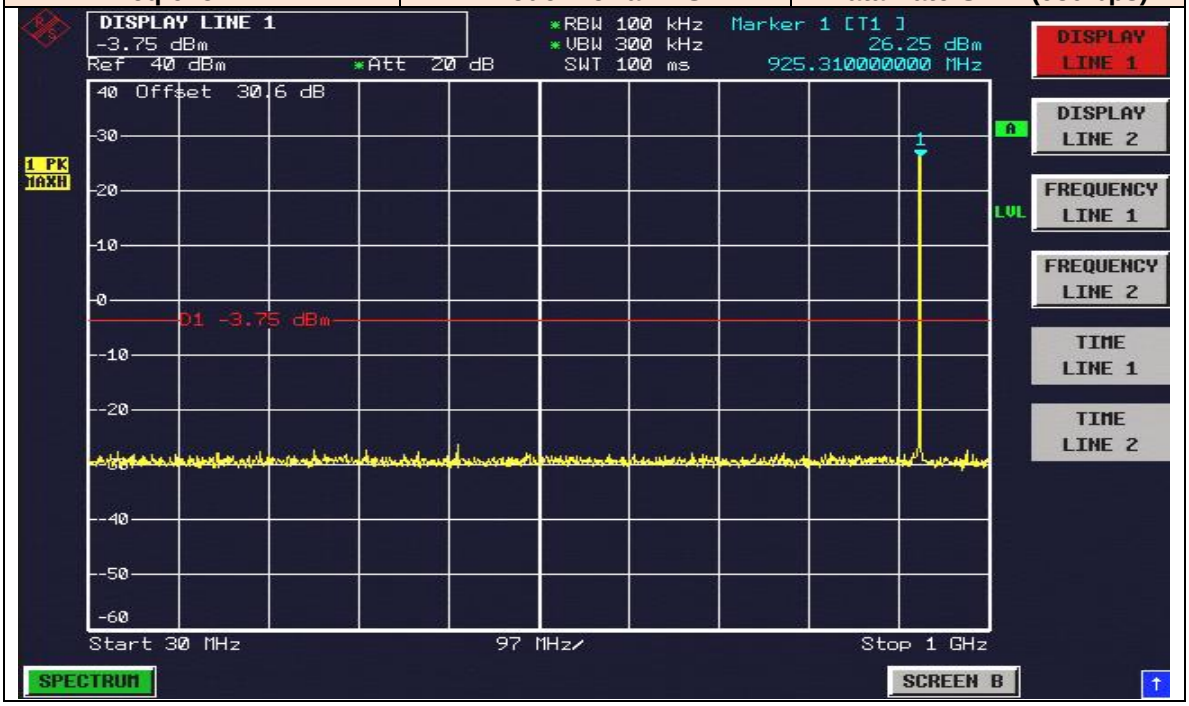
Conducted Spurious Emissions (1GHz – 10GHz)		
Freq:923.3 MHz	**Mode: LoRa-DTS**	**Data Rate:SF12 (980 bps)**



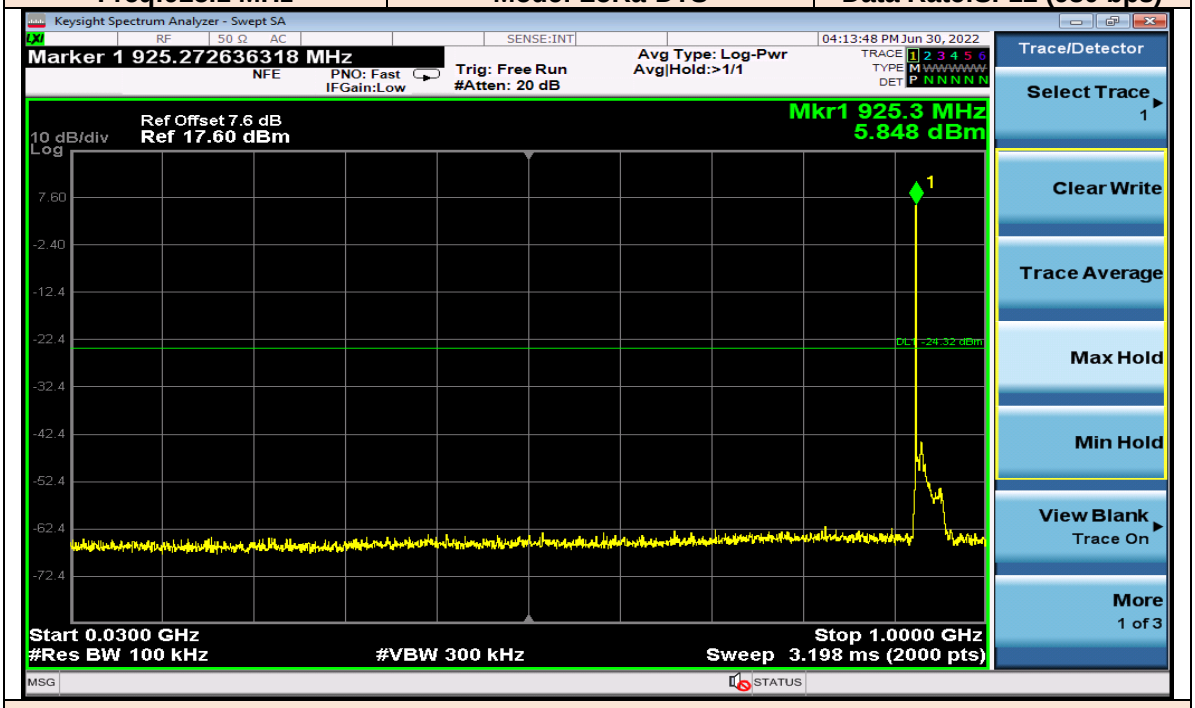
Conducted Spurious Emissions (30KHz – 30MHz)		
Freq:925.1 MHz	**Mode: LoRa-DTS**	**Data Rate:SF12 (980 bps)**
Monitored Freq: 32.768KHz	**Emissions Level: -43.82 + 10dB = -33.82dB**	



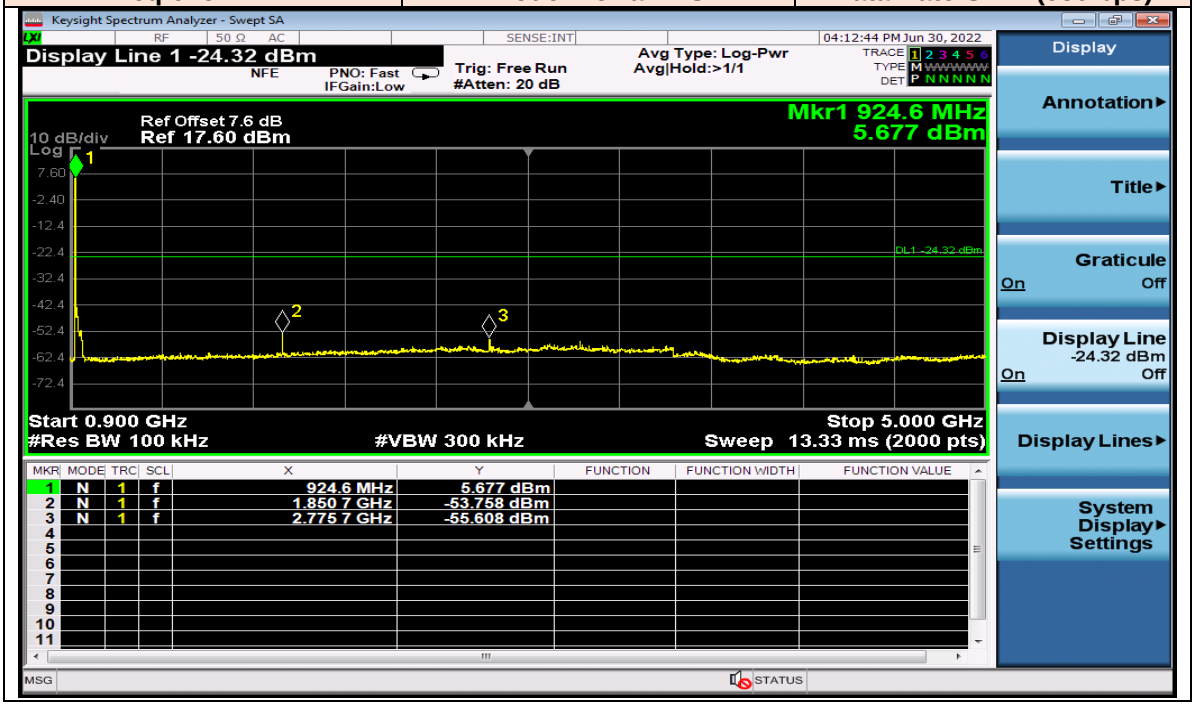
Conducted Spurious Emissions (30MHz – 1GHz)		
Freq:925.1 MHz	**Mode: LoRa-DTS**	**Data Rate:SF12 (980 bps)**



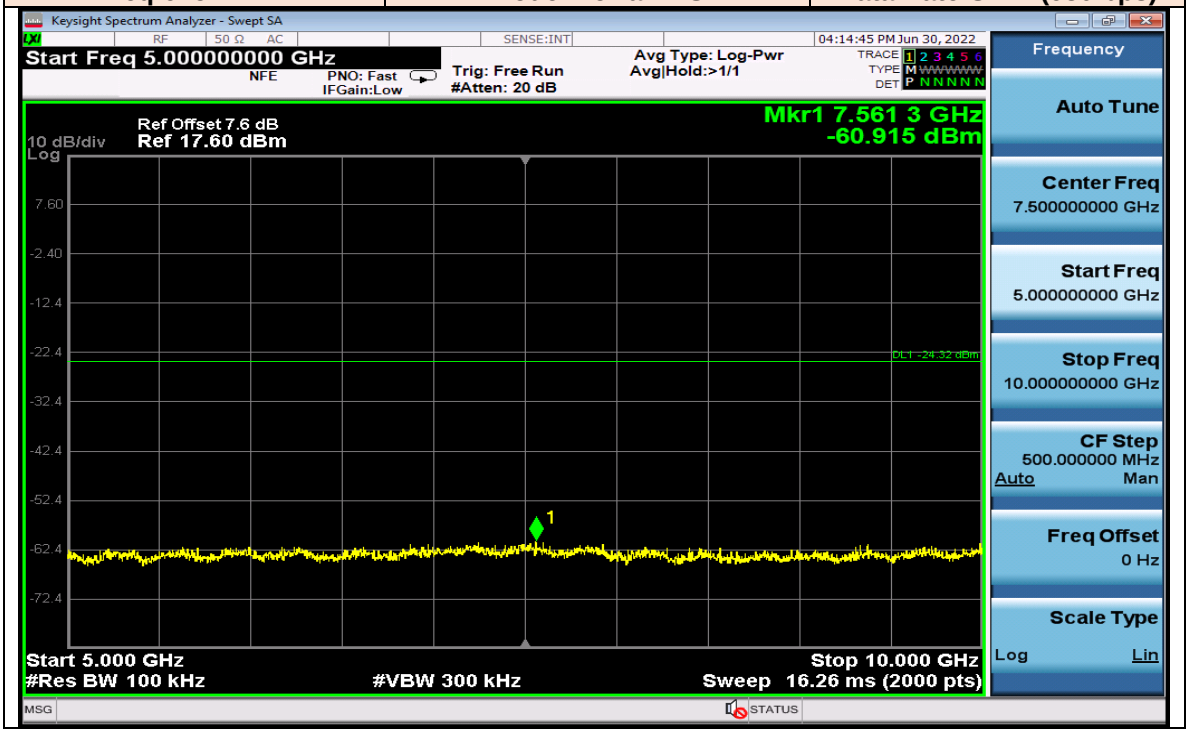
Conducted Spurious Emissions (30MHz – 1GHz)		
Freq:925.1 MHz	**Mode: LoRa-DTS**	**Data Rate:SF12 (980 bps)**



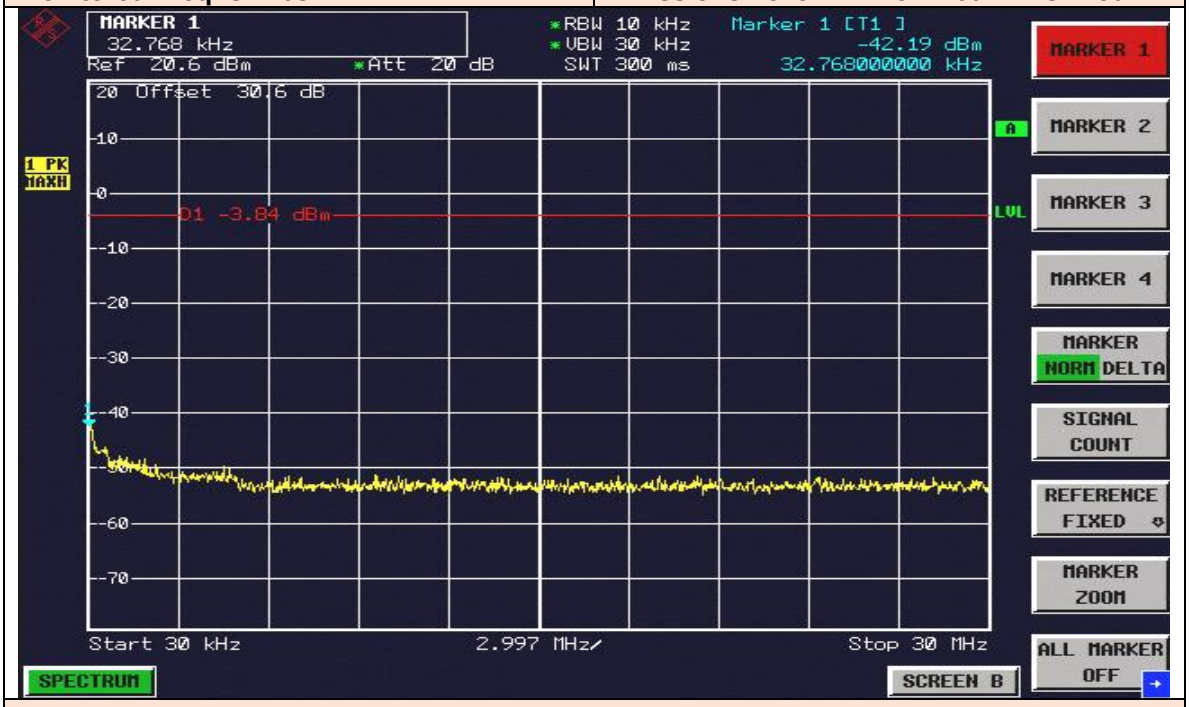
Conducted Spurious Emissions (1GHz – 5GHz)		
Freq:925.1 MHz	**Mode: LoRa-DTS**	**Data Rate:SF12 (980 bps)**



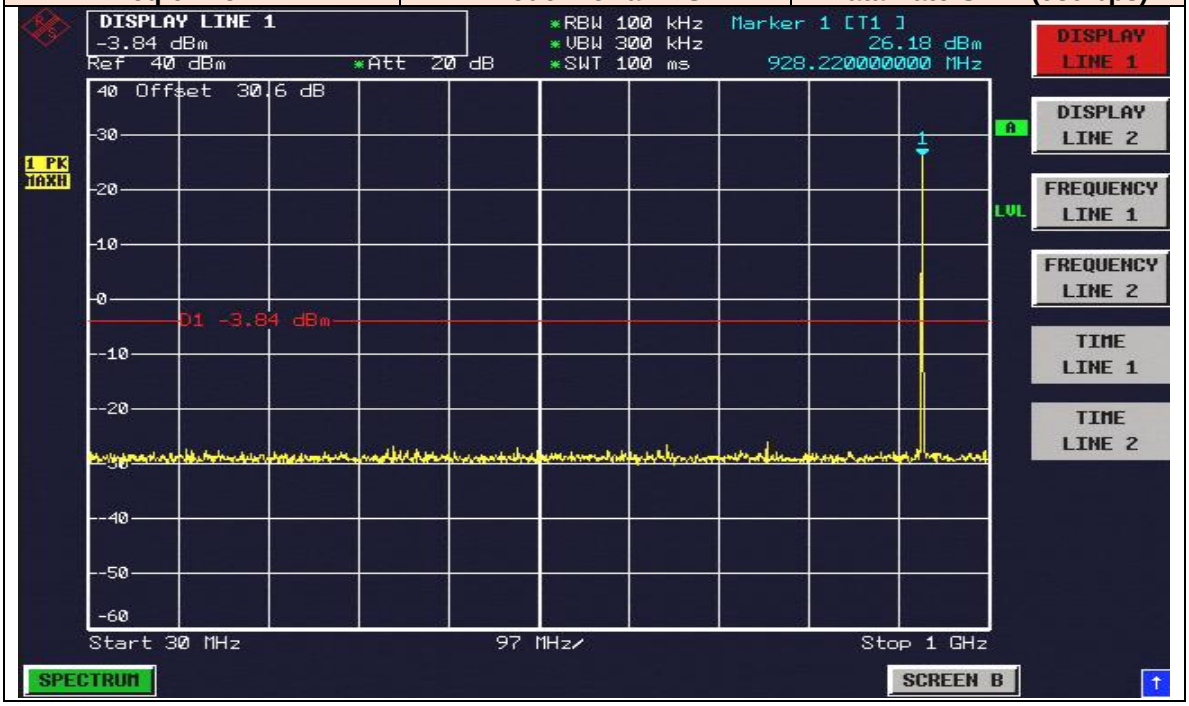
Conducted Spurious Emissions (1GHz – 10GHz)		
Freq:925.1 MHz	**Mode: LoRa-DTS**	**Data Rate:SF12 (980 bps)**



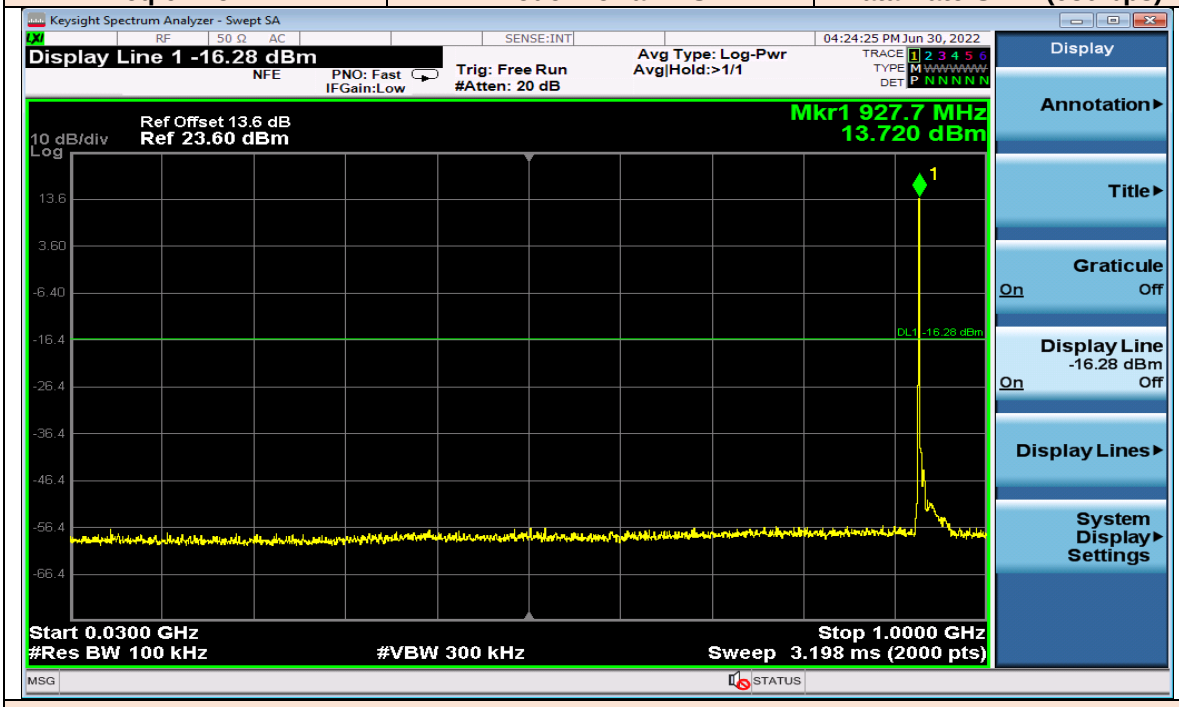
Conducted Spurious Emissions (30KHz – 30MHz)		
Freq:927.5 MHz	**Mode: LoRa-DTS**	**Data Rate:SF12 (980 bps)**
Monitored Freq: 32.768KHz	**Emissions Level: -42.19 + 10dB = -32.19dB**	



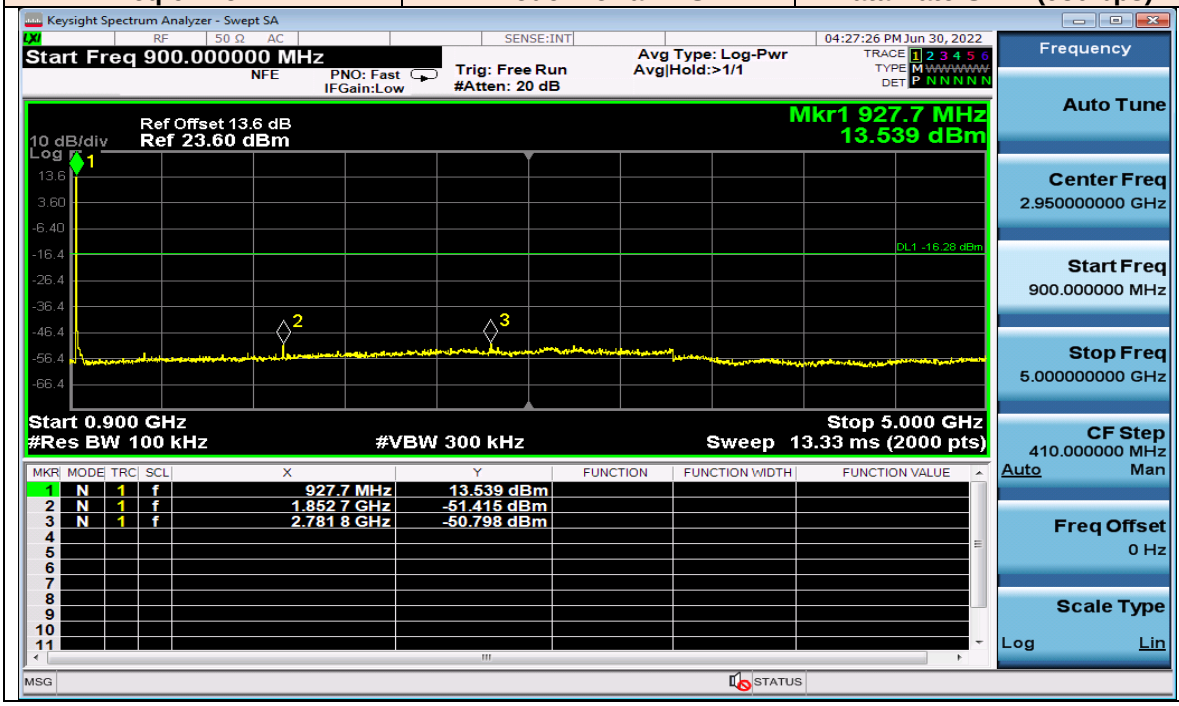
Conducted Spurious Emissions (30MHz – 1GHz)		
Freq:927.5 MHz	**Mode: LoRa-DTS**	**Data Rate:SF12 (980 bps)**



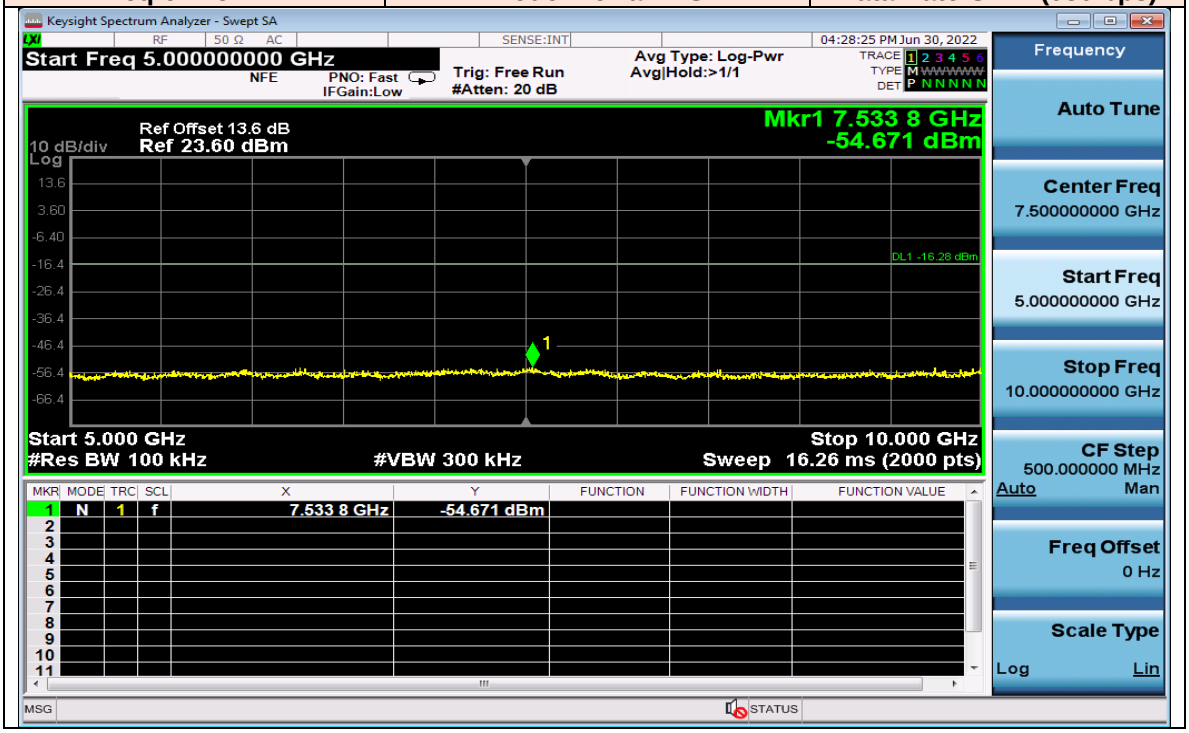
Conducted Spurious Emissions (30MHz – 1GHz)		
Freq:927.5 MHz	**Mode: LoRa-DTS**	**Data Rate:SF12 (980 bps)**



Conducted Spurious Emissions (1GHz – 5GHz)		
Freq:927.5 MHz	**Mode: LoRa-DTS**	**Data Rate:SF12 (980 bps)**



Conducted Spurious Emissions (1GHz – 10GHz)		
Freq:927.5 MHz	**Mode: LoRa-DTS**	**Data Rate:SF12 (980 bps)**



Appendix B: Radiated Test Results

B.1 Transmitter Radiated Spurious Emissions & Restricted Bands

Emissions on a frequency or frequencies which are outside the necessary bandwidth and the level of which may be reduced without affecting the corresponding transmission of information. Spurious emissions include harmonic emissions, parasitic emissions, intermodulation products and frequency conversion products, but exclude out-of-band emissions.

FCC 15.209: The level of any unwanted emissions from an intentional radiator operating under these general provisions shall not exceed the level of the fundamental emission. Except as provided elsewhere in this subpart, the emissions from an intentional radiator shall not exceed the field strength levels specified in the table specified in the table in FCC§15.209(a).

RSS-Gen 6.13**:** In measuring unwanted emissions, the spectrum shall be investigated from 30 MHz or the lowest radio frequency signal generated in the equipment, whichever is lower, without going below 9 kHz, up to at least the frequency given below:

(a) If the equipment operates below 10 GHz: to the tenth harmonic of the highest fundamental frequency or to 40 GHz, whichever is lower.

(b) If the equipment operates at or above 10 GHz: to the fifth harmonic of the highest fundamental frequency or to 100 GHz, whichever is lower.

FCC Restricted Bands

FCC15.247 (d)
FCC: In addition, radiated emissions which fall in the restricted bands, as defined in FCC §15.205(a), must also comply with the radiated emission limits specified in Sec. 15.209(a).

FCC15.205
FCC: Except as provided elsewhere in this subpart, the emissions from an intentional radiator shall not exceed the field strength levels specified in the field strength limits table in this section. In addition, radiated emissions which fall in the restricted bands as defined in FCC §15.205(a), must also comply with the radiated emission limits specified in Sec. 15.209(a).

FCC Restricted Bands Table			
MHz	**MHz**	**MHz**	**GHz**
0.090-0.110	16.42-16.423	399.9-410	4.5-5.15
[1]0.495-0.505	16.69475-16.69525	608-614	5.35-5.46
2.1735-2.1905	16.80425-16.80475	960-1240	7.25-7.75
4.125-4.128	25.5-25.67	1300-1427	8.025-8.5
4.17725-4.17775	37.5-38.25	1435-1626.5	9.0-9.2
4.20725-4.20775	73-74.6	1645.5-1646.5	9.3-9.5
6.215-6.218	74.8-75.2	1660-1710	10.6-12.7
6.26775-6.26825	108-121.94	1718.8-1722.2	13.25-13.4
6.31175-6.31225	123-138	2200-2300	14.47-14.5
8.291-8.294	149.9-150.05	2310-2390	15.35-16.2
8.362-8.366	156.52475-156.52525	2483.5-2500	17.7-21.4
8.37625-8.38675	156.7-156.9	2690-2900	22.01-23.12
8.41425-8.41475	162.0125-167.17	3260-3267	23.6-24.0
12.29-12.293	167.72-173.2	3332-3339	31.2-31.8
12.51975-12.52025	240-285	3345.8-3358	36.43-36.5
12.57675-12.57725	322-335.4	3600-4400	Above 38.6
13.36-13.41			

RSS Restricted Bands

RSS-Gen 8.10 (**b**) Restricted frequency bands, identified in table 7, are designated primarily for safety-of-life services (distress calling and certain aeronautical activities), certain satellite downlinks, radio astronomy and some government uses. Except where otherwise indicated, the following conditions related to the restricted frequency bands apply:

(a) The transmit frequency, including fundamental components of modulation, of licence-exempt radio apparatus shall not fall within the restricted frequency bands listed in table 7 except for apparatus compliant with RSS-287, Emergency Position Indicating Radio Beacons (EPIRB), Emergency Locator Transmitters (ELT), Personal Locator Beacons (PLB), and Maritime Survivor Locator Devices (MSLD).

(b) (b) Unwanted emissions that fall into restricted frequency bands listed in table 7 shall comply with the limits specified in table 5 and table 6.

(c) (c) Unwanted emissions that do not fall within the restricted frequency bands listed in table 7 shall comply either with the limits specified in the applicable RSS or with those specified in table 5 and table 6.

Table 7

RSS-Gen Restricted Bands Table			
MHz	**MHz**	**MHz**	**GHz**
0.090-0.110	13.36-13.41	960-1427	9.0-9.2
0.495 - 0.505	16.42-16.423	1435-1626.5	9.3-9.5
2.1735-2.1905	16.69475-16.69525	1645.5-1646.5	10.6-12.7
3.020-3.026	16.80425-16.80475	1660-1710	13.25-13.4
4.125-4.128	25.5-25.67	1718.8-1722.2	14.47-14.5
4.17725-4.17775	37.5-38.25	2200-2300	15.35-16.2
4.20725-4.20775	73-74.6	2310-2390	17.7-21.4
5.677-5.683	74.8-75.2	2483.5-2500	22.01-23.12
6.215-6.218	108-138	2655-2900	23.6-24.0
6.26775-6.26825	149.9 - 150.05	3260-3267	31.2-31.8
6.31175-6.31225	156.52475-156.52525	3332-3339	36.43-36.5
8.291-8.294	156.7-156.9	3345.8-3358	Above 38.6
8.362-8.366	162.0125 - 167.17	3500-4400	*
8.37625-8.38675	167.72 - 173.2	4500-5150	
8.41425-8.41475	240-285	5350-5460	
12.29-12.293	322-335.4	7250-7750	
12.51975-12.52025	399.9-410	8025-8500	
12.57675-12.57725	608-614	--	

B.1.1 Limits

FCC 15.209; RSS-Gen 8.9 Issue 5

FCC 15.209: The level of any unwanted emissions from an intentional radiator operating under these general provisions shall not exceed the level of the fundamental emission. Except as provided elsewhere in this subpart, the emissions from an intentional radiator shall not exceed the field strength levels specified in the table specified in the table in FCC§15.209(a).

RSS-Gen 8.9**:** Except where otherwise indicated in the applicable RSS, radiated emissions shall comply with the field strength limits shown in table 5 and table 6. Additionally, the level of any transmitter unwanted emission shall not exceed the level of the transmitter's fundamental emission

FCC§15.209(a) / RSS-Gen 8.9 Table

Frequency (MHz)	Field strength (uV/meter)	Field strength (dBuV/meter)	Measurement distance (meters)
30-88	100**	40 Qp	3
88-216	150**	43.5 Qp	3
216-960	200**	46 Qp	3
Above 960	500	54 Av / 74 Pk	3

**Except as provided in paragraph (g), fundamental emissions from intentional radiators operating under this section shall not be located in the frequency bands 54-72 MHz, 76-88 MHz, 174-216 MHz or 470-806 MHz. However, operation within these frequency bands is permitted under other sections of this part, e.g., §§15.231 and 15.241.

The emission limits shown in the above table are based on measurements employing a 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.

B.1.2 Test Procedure

Ref. ANSI C63.10:2013, section 6.5 & 6.6

Test Procedure
1. Using Vasona software, configure the spectrum analyzer as shown below (be sure to enter all losses between the transmitter output and the spectrum analyzer). 2. Place the radio in continuous transmit mode and turn on frequency/channel of interest 3. Scans for both horizontal and vertical polarizations. 4. Maximize Turntable (find worst case table angle) and maximize antenna (find worst case height). 5. Identify all emissions within 20 dB respect to the limits. 6. Use the peak marker function to determine the maximum amplitude level. 7. Center marker frequency and perform final measurement in Quasi-peak (≤ 1Ghz) and Average (above 1 GHz) 8. Record at least 6 highest readings for the worst-case operating mode.

Ref. ANSI C63.10:2013, Clause 4 / **CISPR16**-1-1

Test Parameters
Span = Entire frequency range or segment if necessary. Reference Level ≥ 80 dBuV or 10 dB headroom between max. spectrum level and the reference level RBW = 100 kHz (freq range less than or equal to 1 GHz); 1 MHz (above 1 GHz) VBW ≥ 3 x RBW Detector = Peak & Quasi-Peak (frequency range 30 MHz to 1 GHz); Peak & Average (frequency range above 1 GHz); Sweep Time = Couple

These data represent the worst-case mode data for all supported operating modes and antennas.

- For emissions below 1000 MHz, measurements shall be performed using a CISPR quasi-peak detector and the related measurement bandwidth. As an alternative to CISPR quasi-peak measurement, compliance with the emission limit can be demonstrated using measuring equipment employing a peak detector function properly adjusted for factors such as pulse desensitization as required, with an equal or greater measurement bandwidth relative to the applicable CISPR quasi-peak bandwidth.

- Above 1000 MHz, measurements shall be performed using an average detector with a minimum resolution bandwidth of 1 MHz

Note1: A Notch Filter was used during formal testing from 30MHz – 1GHz to help prevent the front end of the analyzer from over loading. The Notch filters used are designed to suppress TX fundamental frequency but do not effect harmonics of the fundamental frequency from being measured.

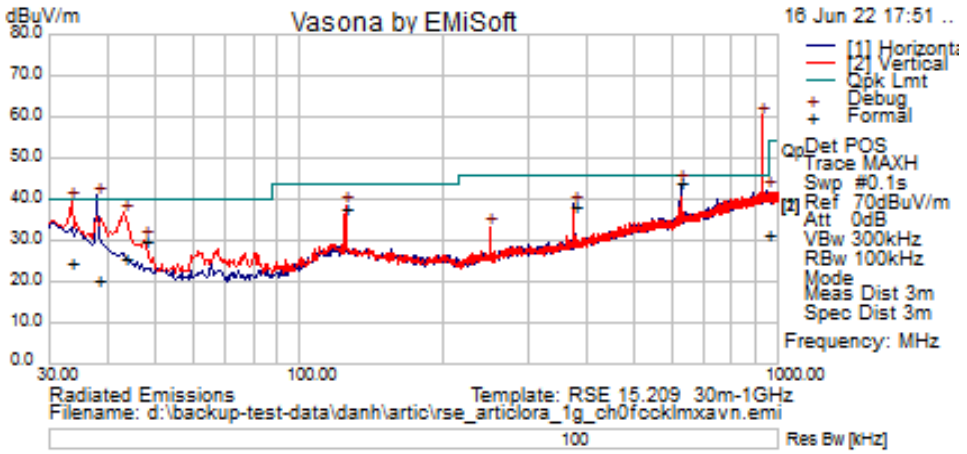
Install an appropriate Notch filter at the input of the measurement system power amplifier. This filter shall attenuate the fundamental emission of the EUT and allow an accurate measurement of the associated harmonics and spurious emissions. The filter shall be characterized, and any attenuation/loss factors shall be accounted for in the measurement results.

Note2: The data displayed on the plots detailed in this appendix were measured using a 'Peak Detector'. Please refer to the results table for the detectors used during formal measurements.

B.1.3 TX Spurious Emissions Test Data and Graphical Test Results

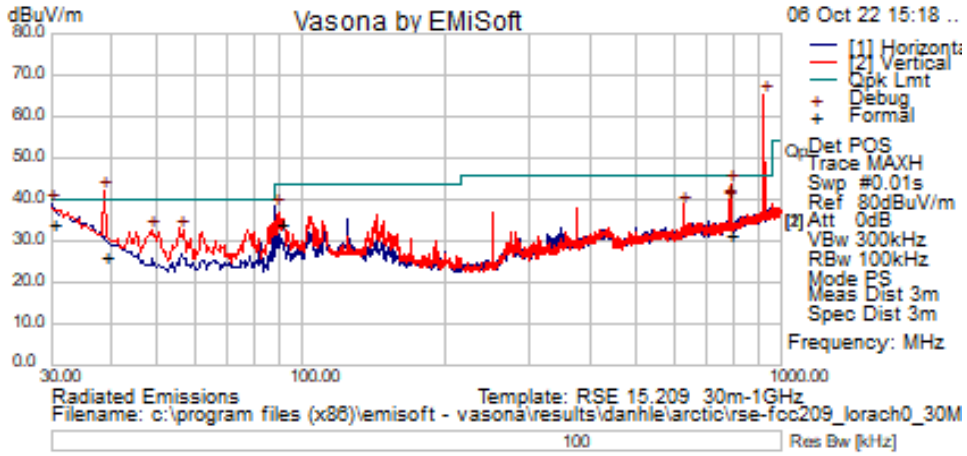
TX Spurious Emissions Test Result Tables for LoRa-DTS

Subtest Date:	16-June-2022
Engineer	Danh Le
Lab Information	Building 7, 5m Anechoic
Subtest Title	Transmitter Spurious Emissions
Frequency Range	30MHz-1GHz
Comments on the above Test Results	TX Channel 0 (923.3 MHz); Mode: LoRa-DTS – SF12
Test System#	**3 (Refer to section 4.2 for system details)**



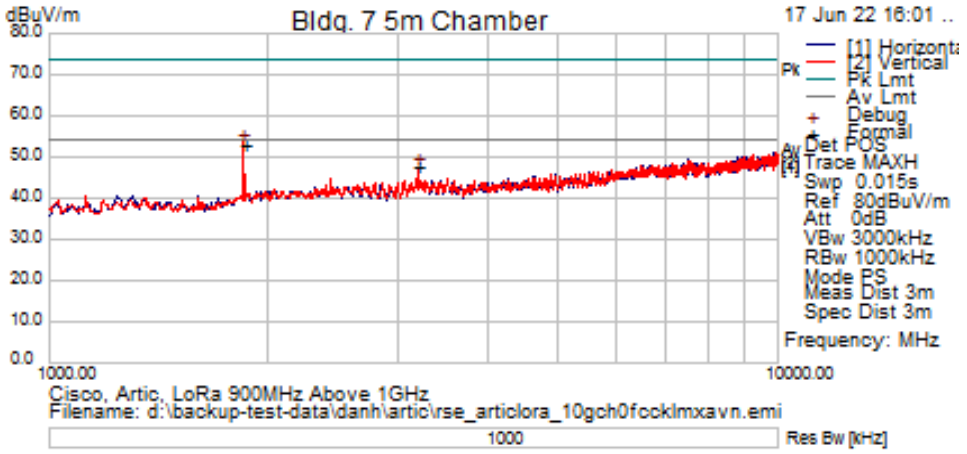
Frequency (MHz)	Raw (dBuV)	Cab Loss (dB)	AF (dB)	Level (dBuV)	Detector	Polarity	Height (cm)	Azt (Deg)	Limit (dBuV)	Margin (dB)	Results Pass /Fail	Comments
923.37	34.23	2.99	23.12	60.33	Peak	V	150	139	-----	NA	Ignored	Fundamental
37.97375	4.38	0.61	15.48	20.46	Quasi-Pk	H	351	333	40	-19.54	Pass	
33.457	5.39	0.58	18.8	24.76	Quasi-Pk	V	299	327	40	-15.24	Pass	
624.995	21.93	2.43	20.03	44.38	Quasi-Pk	H	150	282	46	-1.62	Pass	
43.058	12.89	0.64	12.1	25.64	Quasi-Pk	V	99	40	40	-14.36	Pass	
951.0643	5.31	3.02	23.14	31.47	Quasi-Pk	H	150	84	46	-14.53	Pass	
125	22.8	1.05	14.14	37.99	Quasi-Pk	H	299	12	43.5	-5.51	Pass	
374.99	21.38	1.87	14.95	38.19	Quasi-Pk	H	100	134	46	-7.81	Pass	

Subtest Date:	06-Oct-2022
Engineer	Danh Le
Lab Information	Building P, 5m Anechoic
Subtest Title	Transmitter Spurious Emissions
Frequency Range	30MHz-1GHz
Comments on the above Test Results	TX Channel 0 (923.3 MHz); Mode: LoRa-DTS – SF12
Test System#	**4 (Refer to section 4.2 for system details)**



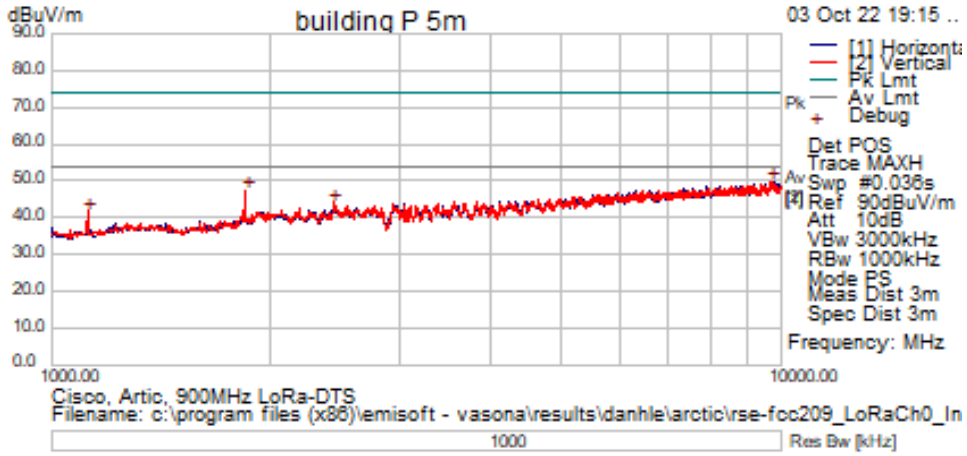
Frequency (MHz)	Raw (dBuV)	Cab Loss (dB)	AF (dB)	Level (dBuV)	Detector	Polarity	Height (cm)	Azt (Deg)	Limit (dBuV)	Margin (dB)	Results Pass /Fail	Comments
923.37	39.93	3.43	22.11	65.47	Peak	V	100	52	-----	NA	Ignored	Fundamental
30.2312	12.49	0.57	21.16	34.22	Quasi-Pk	H	401	280	40	-5.78	Pass	
38.85768	10.4	0.64	15.1	26.14	Quasi-Pk	V	376	85	40	-13.86	Pass	
90.3775	24.92	1.1	7.83	33.85	Quasi-Pk	V	129	341	43.5	-9.65	Pass	
784.5306	7.37	3.16	21	31.54	Quasi-Pk	V	199	309	46	-14.46	Pass	

Subtest Date:	17-June-2022
Engineer	Danh Le
Lab Information	Building 7, 5m Anechoic
Subtest Title	Transmitter Spurious Emissions
Frequency Range	1GHz-10GHz
Comments on the above Test Results	TX Channel 0 (923.3 MHz); Mode: LoRa-DTS – SF12
Test System #	**3 (Refer to section 4.2 for system details)**



Frequency (MHz)	Raw (dBuV)	Cab Loss (dB)	AF (dB)	Level (dBuV)	Detector	Polarity	Height (cm)	Azt (Deg)	Limit (dBuV)	Margin (dB)	Results Pass /Fail	Comments
1843.75	61.12	5.45	-13.08	53.49	Peak	V	250	58	74	-20.51	Pass	2nd harmonic
1846.844	60.75	5.45	-13.05	53.15	Average	V	250	57	54	-0.85	Pass	2nd harmonic
3199.375	50.94	7.34	-10.87	47.41	Peak	V	250	38	74	-26.59	Pass	
3200.156	51.5	7.34	-10.88	47.97	Average	V	250	37	54	-6.03	Pass	

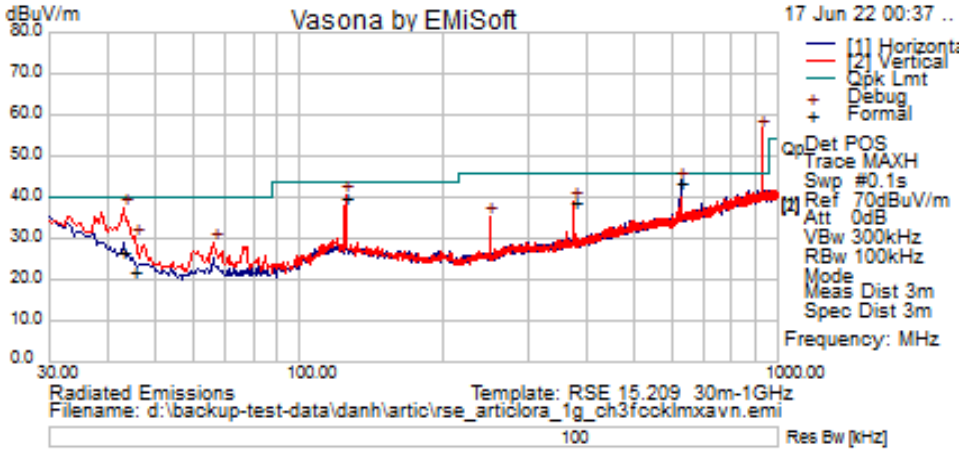
Subtest Date:	03-Oct-2022
Engineer	Danh Le
Lab Information	Building P, 5m Anechoic
Subtest Title	Transmitter Spurious Emissions
Frequency Range	1GHz-10GHz
Comments on the above Test Results	TX Channel 0 (923.3 MHz); Mode: LoRa-DTS – SF12
Test System #	**4 (Refer to section 4.2 for system details)**



Frequency (MHz)	Raw (dBuV)	Cab Loss (dB)	AF (dB)	Level (dBuV)	Detector	Polarity	Height (cm)	Azt (Deg)	Limit (dBuV)	Margin (dB)	Results Pass /Fail	Comments
1121.5	63.79	3.78	-25.81	41.76	Peak	V	175	18	74	-32.24	Pass	
1846	66.55	4.92	-23.88	47.59	Peak	V	175	42	74	-6.41	Pass	2nd harmonic
2440	60.35	5.68	-21.76	44.26	Peak	V	350	191	54	-9.74	Pass	
9676	51.42	12.06	-13.68	49.79	Peak	V	125	346	54	-4.21	Pass	

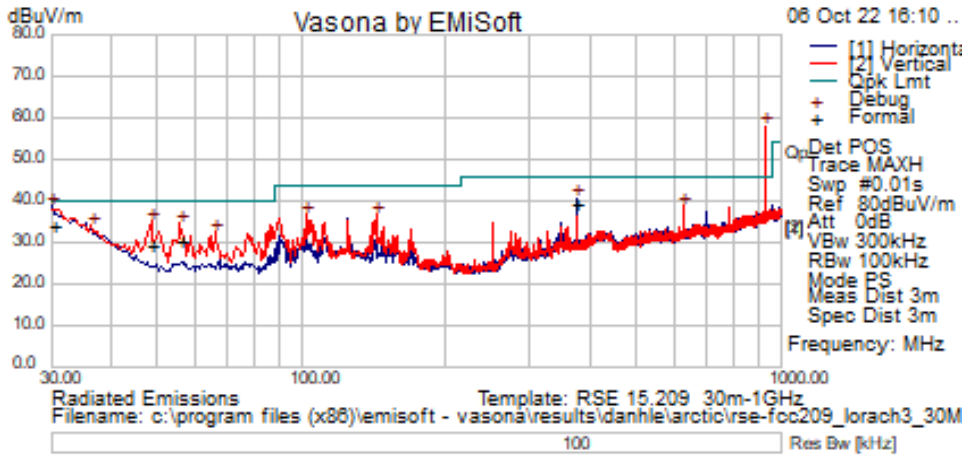
Note: When Peak measurement is 20 dB or more below the peak limit, it's unnecessary to perform final measurement.

Subtest Date:	17-June-2022
Engineer	Danh Le
Lab Information	Building 7, 5m Anechoic
Subtest Title	Transmitter Spurious Emissions
Frequency Range	30MHz-1GHz
Comments on the above Test Results	TX Channel 3 (925.1 MHz); Mode: LoRa-DTS – SF12
Test System#	**3 (Refer to section 4.2 for system details)**



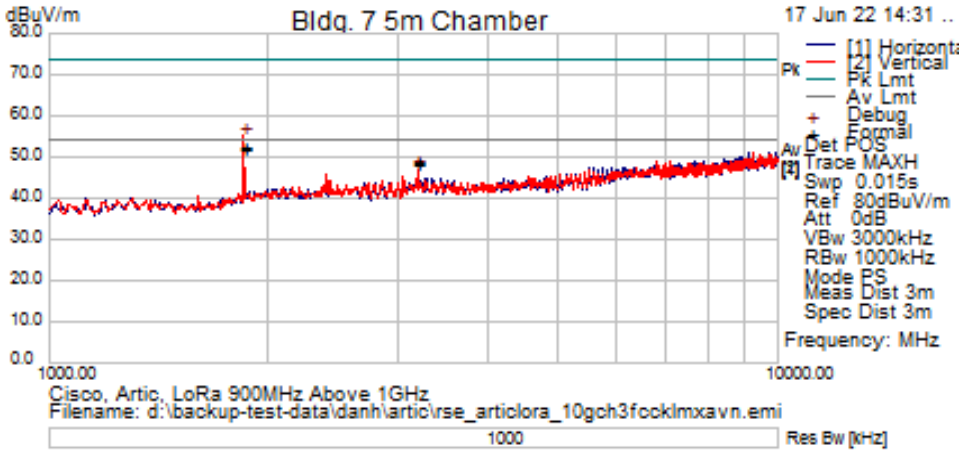
Frequency (MHz)	Raw (dBuV)	Cab Loss (dB)	AF (dB)	Level (dBuV)	Detector	Polarity	Height (cm)	Azt (Deg)	Limit (dBuV)	Margin (dB)	Results Pass /Fail	Comments
925.31	30.56	2.99	23.19	56.74	Peak	V	150	108	-----	NA	Ignored	Fundamental
624.985	21.29	2.43	20.03	43.75	Quasi-Pk	H	141	278	46	-2.25	Pass	
42.923	13.89	0.64	12.19	26.72	Quasi-Pk	V	138	360	40	-13.28	Pass	
124.995	24.47	1.05	14.14	39.66	Quasi-Pk	V	100	345	43.5	-3.84	Pass	
375.003	22.01	1.87	14.95	38.82	Quasi-Pk	V	129	17	46	-7.18	Pass	
45.30575	10.51	0.66	10.81	21.97	Quasi-Pk	V	362	196	40	-18.03	Pass	
250.008	19.3	1.51	11.72	32.53	Quasi-Pk	H	130	320	46	-13.47	Pass	
66.31	18.28	0.77	8.08	27.12	Quasi-Pk	V	103	256	40	-12.88	Pass	

Subtest Date:	06-Oct-2022
Engineer	Danh Le
Lab Information	Building P, 5m Anechoic
Subtest Title	Transmitter Spurious Emissions
Frequency Range	30MHz-1GHz
Comments on the above Test Results	TX Channel 3 (925.1 MHz); Mode: LoRa-DTS – SF12
Test System#	**4 (Refer to section 4.2 for system details)**



Frequency (MHz)	Raw (dBuV)	Cab Loss (dB)	AF (dB)	Level (dBuV)	Detector	Polarity	Height (cm)	Azt (Deg)	Limit (dBuV)	Margin (dB)	Results Pass /Fail	Comments
925.31	32.53	3.43	22.07	58.03	Peak	V	100	357	-----	NA	Ignored	Fundamental
30.21131	12.47	0.57	21.17	34.21	Quasi-Pk	H	131	119	40	-5.79	Pass	
48.45973	20.21	0.7	8.5	29.41	Quasi-Pk	V	114	111	40	-10.59	Pass	
55.86417	22.06	0.88	7.36	30.3	Quasi-Pk	V	188	0	40	-9.7	Pass	
375.0108	22.07	2.22	14.98	39.27	Quasi-Pk	H	99	290	46	-6.73	Pass	

Subtest Date:	17-June-2022
Engineer	Danh Le
Lab Information	Building 7, 5m Anechoic
Subtest Title	Transmitter Spurious Emissions
Frequency Range	1GHz-10GHz
Comments on the above Test Results	TX Channel 3 (925.1 MHz); Mode: LoRa-DTS – SF12
Test System#	**3 (Refer to section 4.2 for system details)**

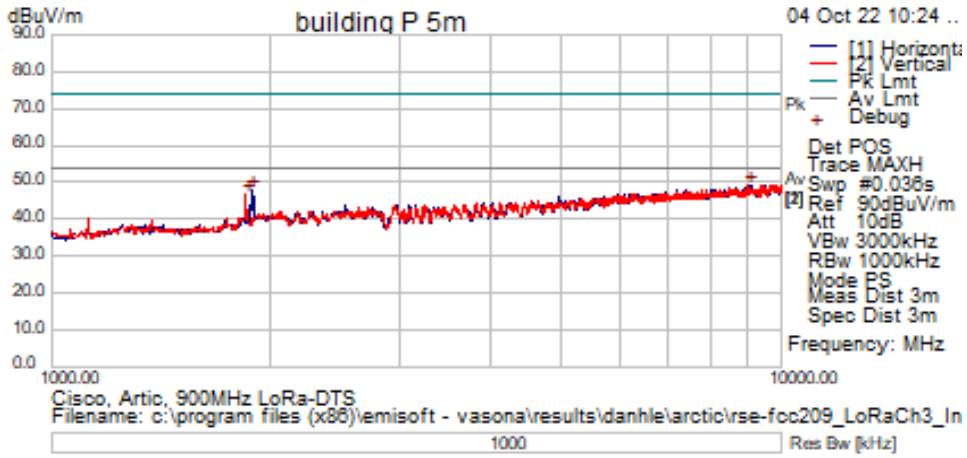


Title: **TX Spurious Emissions from 1-10GHz – Ch1 (2412 MHz) – Peak Trace**

Legend: —— 74dBµV/m (Peak); —— 54 dBµV/m (Average)

Frequency (MHz)	Raw (dBuV)	Cab Loss (dB)	AF (dB)	Level (dBuV)	Detector	Polarity	Height (cm)	Azt (Deg)	Limit (dBuV)	Margin (dB)	Results Pass /Fail	Comments
1850.313	60.28	5.45	-13.01	52.72	Peak	V	235	43	74	-21.28	Pass	2nd harmonic
1850.313	59.82	5.45	-13.01	52.26	Average	V	235	43	54	-1.74	Pass	2nd harmonic
3199.719	52.13	7.34	-10.88	48.6	Peak	V	275	360	74	-25.4	Pass	
3199.719	52.6	7.34	-10.88	49.07	Average	V	275	360	54	-4.94	Pass	

Subtest Date:	04-Oct-2022
Engineer	Danh Le
Lab Information	Building P, 5m Anechoic
Subtest Title	Transmitter Spurious Emissions
Frequency Range	1GHz-10GHz
Comments on the above Test Results	TX Channel 3 (925.1 MHz); Mode: LoRa-DTS – SF12
Test System#	**4 (Refer to section 4.2 for system details)**



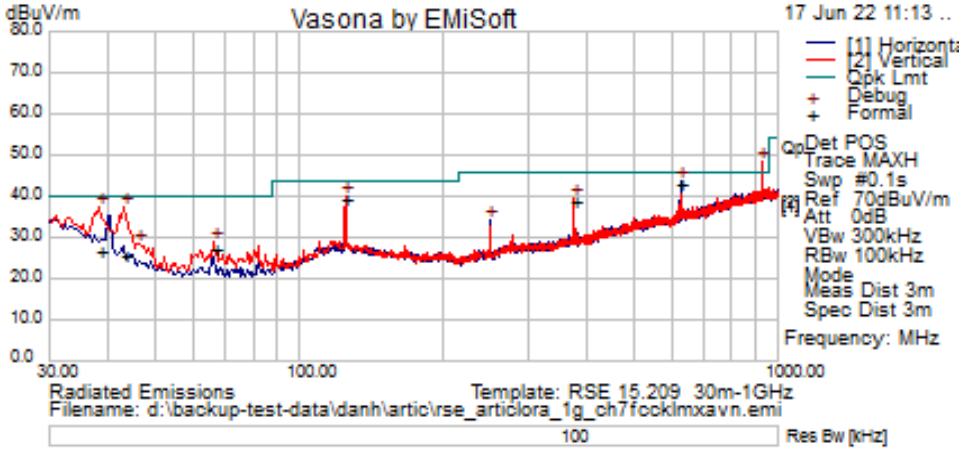
Title: **TX Spurious Emissions from 1-10GHz – Ch1 (2412 MHz) – Peak Trace**

Legend: —— 74dBµV/m (Peak); —— 54 dBµV/m (Average)

Frequency (MHz)	Raw (dBuV)	Cab Loss (dB)	AF (dB)	Level (dBuV)	Detector	Polarity	Height (cm)	Azt (Deg)	Limit (dBuV)	Margin (dB)	Results Pass /Fail	Comments
1850.5	65.65	4.92	-23.83	46.74	Peak	V	175	9	74	-27.26	Pass	2nd harmonic
1877.5	66.54	4.95	-23.4	48.09	Peak	H	100	244	74	-25.91	Pass	
9064	51.48	11.62	-13.78	49.32	Peak	H	225	200	74	-24.68	Pass	

Note: When peak measurement is 20 dB or more below the peak limit, it's unnecessary to perform final measurement.

Subtest Date:	17-June-2022
Engineer	Danh Le
Lab Information	Building 7, 5m Anechoic
Subtest Title	Transmitter Spurious Emissions
Frequency Range	30MHz-1GHz
Comments on the above Test Results	TX Channel 7 (927.5 MHz); Mode: LoRa-DTS – SF12
Test System#	**3 (Refer to section 4.2 for system details)**

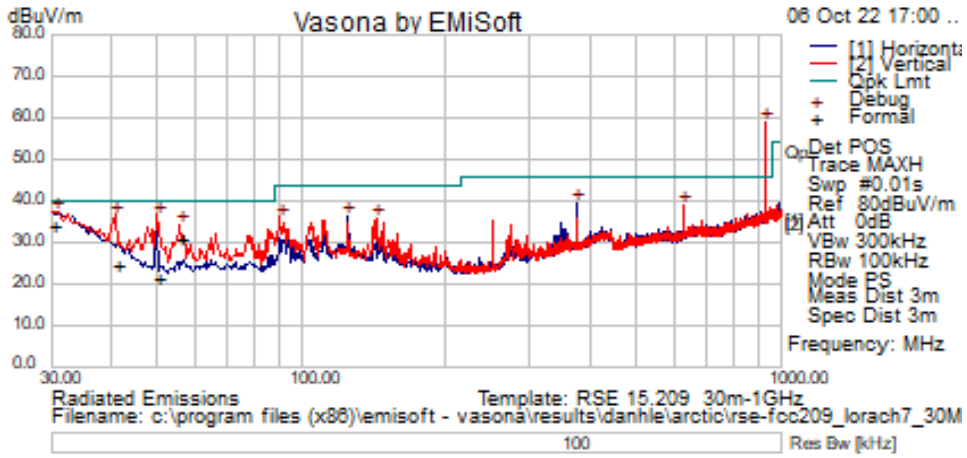


Title: **TX Spurious Emissions from 1-10GHz – Ch6 (2437 MHz) – Peak Trace**

Legend: —— 74dBµV/m (Peak); —— 54dBµV/m (Average)

Frequency (MHz)	Raw (dBuV)	Cab Loss (dB)	AF (dB)	Level (dBuV)	Detector	Polarity	Height (cm)	Azt (Deg)	Limit (dBuV)	Margin (dB)	Results Pass /Fail	Comments
927.735	22.31	2.99	23.25	48.55	Peak	V	150	41	-----	NA	Ignored	Fundamental
625.005	20.84	2.43	20.03	43.29	Quasi-Pk	H	151	295	46	-2.71	Pass	
38.428	10.88	0.61	15.16	26.65	Quasi-Pk	V	151	4	40	-13.35	Pass	
43.06	12.82	0.64	12.1	25.56	Quasi-Pk	V	99	334	40	-14.44	Pass	
124.995	24.36	1.05	14.14	39.55	Quasi-Pk	V	99	354	43.5	-3.95	Pass	
374.998	22.24	1.87	14.95	39.05	Quasi-Pk	V	149	8	46	-6.95	Pass	
66.275	18.63	0.77	8.07	27.48	Quasi-Pk	V	101	247	40	-12.52	Pass	

Subtest Date:	06-Oct-2022
Engineer	Danh Le
Lab Information	Building P, 5m Anechoic
Subtest Title	Transmitter Spurious Emissions
Frequency Range	30MHz-1GHz
Comments on the above Test Results	TX Channel 7 (927.5 MHz); Mode: LoRa-DTS – SF12
Test System#	**4 (Refer to section 4.2 for system details)**

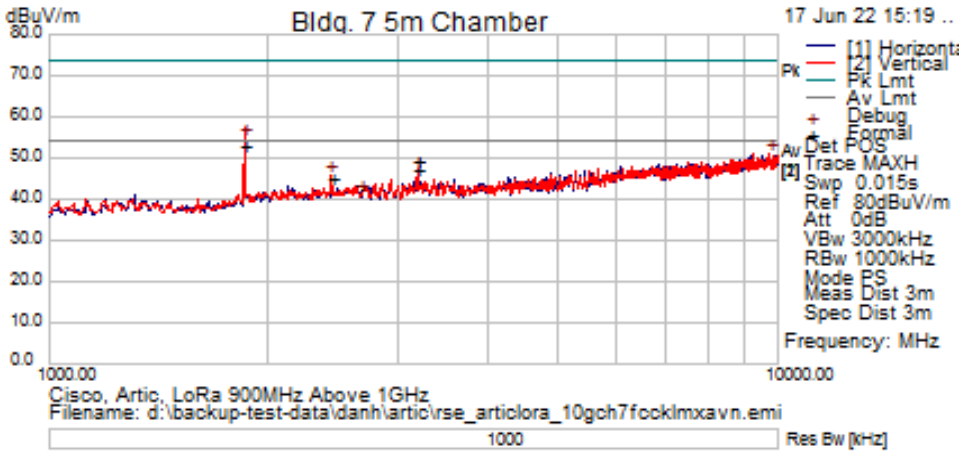


Title: **TX Spurious Emissions from 1-10GHz – Ch6 (2437 MHz) – Peak Trace**

Legend: —— 74dBµV/m (Peak); —— 54dBµV/m (Average)

Frequency (MHz)	Raw (dBuV)	Cab Loss (dB)	AF (dB)	Level (dBuV)	Detector	Polarity	Height (cm)	Azt (Deg)	Limit (dBuV)	Margin (dB)	Results Pass /Fail	Comments
927.735	33.56	3.44	22.15	59.14	Peak	V	100	330	-----	NA	Ignored	Fundamental
30.31184	12.29	0.57	21.12	33.98	Quasi-Pk	V	166	60	40	-6.02	Pass	
41.03932	10.56	0.65	13.48	24.69	Quasi-Pk	V	231	360	40	-15.31	Pass	
50.22159	12.83	0.83	7.87	21.53	Quasi-Pk	V	134	213	40	-18.47	Pass	
55.91615	22.88	0.88	7.37	31.13	Quasi-Pk	V	130	20	40	-8.87	Pass	

Subtest Date:	17-June-2022
Engineer	Danh Le
Lab Information	Building 7, 5m Anechoic
Subtest Title	Transmitter Spurious Emissions
Frequency Range	1GHz-10GHz
Comments on the above Test Results	TX Channel 7 (927.5 MHz); Mode: LoRa-DTS – SF12
Test System#	**3 (Refer to section 4.2 for system details)**

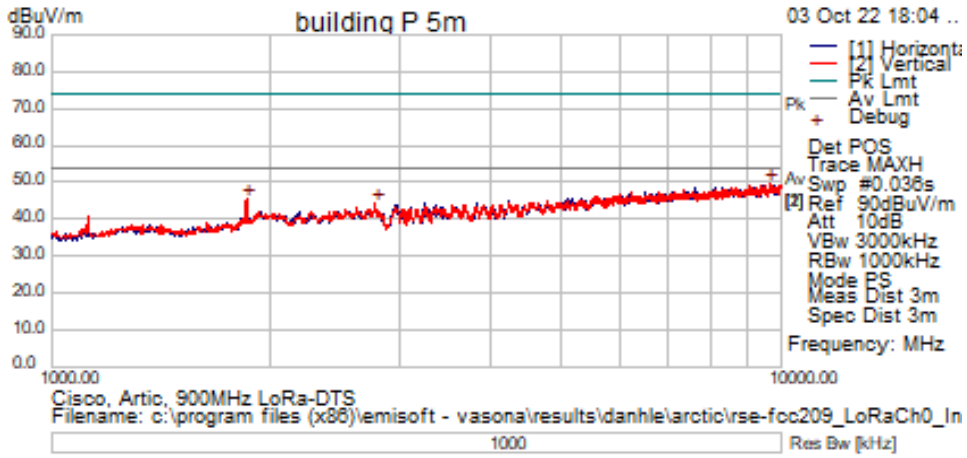


Title: **TX Spurious Emissions from 1-10GHz – Ch11 (2462 MHz) – Peak Trace**

Legend: —— 74dBµV/m (Peak); —— 54 dBµV/m (Average)

Frequency (MHz)	Raw (dBuV)	Cab Loss (dB)	AF (dB)	Level (dBuV)	Detector	Polarity	Height (cm)	Azt (Deg)	Limit (dBuV)	Margin (dB)	Results Pass /Fail	Comments
1855.00	64.7	5.5	-13	57.2	Peak	V	150	62	74	-16.8	Pass	2nd harmonic
1855.063	60.62	5.45	-12.97	53.1	Average	V	249	80	54	-0.9	Pass	2nd harmonic
3199.375	50.63	7.34	-10.87	47.1	Peak	V	275	355	74	-26.9	Pass	
3199.844	53.1	7.34	-10.88	49.57	Average	V	276	356	54	-4.43	Pass	
2434.375	51.59	6.33	-12.03	45.89	Peak	V	225	359	74	-28.11	Pass	Ambient
2434.693	50.74	6.33	-12.03	45.05	Average	V	224	356	54	-8.95	Pass	Ambient

Subtest Date:	03-Oct-2022
Engineer	Danh Le
Lab Information	Building P, 5m Anechoic
Subtest Title	Transmitter Spurious Emissions
Frequency Range	1GHz-10GHz
Comments on the above Test Results	TX Channel 7 (927.5 MHz); Mode: LoRa-DTS – SF12
Test System#	**4 (Refer to section 4.2 for system details)**



Title: **TX Spurious Emissions from 1-10GHz – Ch11 (2462 MHz) – Peak Trace**

Legend: —— 74dBµV/m (Peak); —— 54 dBµV/m (Average)

Frequency (MHz)	Raw (dBuV)	Cab Loss (dB)	AF (dB)	Level (dBuV)	Detector	Polarity	Height (cm)	Azt (Deg)	Limit (dBuV)	Margin (dB)	Results Pass /Fail	Comments
1855	64.34	4.93	-23.8	45.47	Peak	V	150	126	54	-8.53	Pass	2nd harmonic
2782	59.23	6.05	-21	44.27	Peak	V	375	311	54	-9.73	Pass	3rd harmonic
9671.5	51.47	12.05	-13.66	49.86	Peak	V	325	110	54	-4.14	Pass	

B.2 AC Conducted Emissions

B.2.1 Limits.

FCC 15.207 / RSS-Gen 8.8 issue5

FCC 15.207

(23) Except as shown in paragraphs (b) and (c) of this section, for an intentional radiator that is designed to be connected to the public utility (AC) power line, the radio frequency voltage that is conducted back onto the AC power line on any frequency or frequencies, within the band 150 kHz to 30 MHz, shall not exceed the limits in the following table, as measured using a 50 μH/50 ohms line impedance stabilization network (LISN). Compliance with the provisions of this paragraph shall be based on the measurement of the radio frequency voltage between each power line and ground at the power terminal. The lower limit applies at the boundary between the frequency ranges.

RSS-Gen 8.8

Unless stated otherwise in the applicable RSS, for radio apparatus that are designed to be connected to the public utility AC power network, the radio frequency voltage that is conducted back onto the AC power line on any frequency or frequencies within the range 150 kHz to 30 MHz shall not exceed the limits in table 4, as measured using a 50 μH / 50 Ω line impedance stabilization network. This requirement applies for the radio frequency voltage measured between each power line and the ground terminal of each AC power-line mains cable of the EUT.

For an EUT that connects to the AC power lines indirectly, through another device, the requirement for compliance with the limits in table 4 shall apply at the terminals of the AC power-line mains cable of a representative support device, while it provides power to the EUT.

	Conducted Limits	
Frequency of Emission (MHz)	Quasi-Peak	Average
0.15 – 0.5	66 to 56*	56 to 46*
0.5 – 5	56	46
5 – 30	60	50

*Decreases with the logarithm of the frequency

B.2.2 Test Procedure

Ref: ANSI C63.10:2013, Clause 6.2

Section 6.2.2 Measurement requirements

Measured levels of ac power-line conducted emission shall be the emission voltages from the voltage probe or across the 50 Ω LISN port (to which the EUT is connected), where permitted, terminated into a 50 Ω measuring instrument, or where permitted or required, the emission currents on the power line sensed by a current probe. All emission voltage and current measurements shall be made on each current-carrying conductor at the plug end of the EUT power cord by the use of mating plugs and receptacles on the LISN, if used. Equipment shall be tested with power cords that are normally supplied or recommended by the manufacturer, and that have electrical and shielding characteristics that are the same as those cords normally supplied or recommended by the manufacturer. For those measurements, using a LISN, the 50 Ω measuring port is terminated by a measuring instrument having a 50 Ω input impedance. All other ports are terminated in 50 Ω loads. Figure 5, Figure 6, and Figure 7 show typical test setups for ac power-line conducted emissions testing (see 6.13). For information about the use of a RF-shielded (screen) room, vertical conducting plane and voltage probe, see ANSI C63.4.

Tabletop devices shall be placed on a platform of nominal size, 1 m by 1.5 m, raised 80 cm above the reference ground plane. The vertical conducting plane or wall of an RF-shielded (screen) room shall be located 40 cm to the rear of the EUT. Floor-standing devices shall be placed either directly on the reference ground-plane or on insulating material as described in ANSI C63.4. All other surfaces of tabletop or floor standing EUTs shall be at least 80 cm from any other grounded conducting surface, including the case or cases of one or more LISNs.

Section 6.2.4 Exploratory AC power-line conducted emission measurements
Exploratory ac power-line conducted emission measurements Exploratory tests shall be run with the modulating signal(s) specified in 5.12 applied to the EUT. Antenna(s) can be integral or detachable. If detachable, the antenna(s) shall be attached during the test. The EUT shall be operated on the mid channel and in the mode with highest output power unless the fundamental operates in the AC power-line emission test range then the EUT shall be operated in the range of typical modes of operation, cable positions, and with a typical system equipment configuration and arrangement. For each mode of operation and for each ac power current-carrying conductor, cable manipulation shall be performed within the range of likely configurations. For this measurement or series of measurements, the frequency spectrum of interest shall be monitored looking for the emission that has the highest amplitude relative to the limit. Once that emission is found for each current-carrying conductor of each power cord associated with the EUT (but not the cords associated with non EUT equipment in the overall system), the one configuration and arrangement and mode of operation that produces the emission closest to the limit over all of the measured conductors shall be recorded.

Section 6.2.5 Final ac power-line conducted emission measurements
Based on the exploratory tests of the EUT performed in 6.2.4, the one EUT cable configuration and arrangement and mode of operation that produced the emission with the highest amplitude relative to the limit is selected for the final measurement, while applying the appropriate modulating signal to the EUT. If the EUT is relocated from an exploratory test site to a final test site, the highest emissions shall be remaximized at the final test location before final ac power-line conducted emission measurements are performed. The final test on all current-carrying conductors of all of the power cords to the equipment that comprises the EUT (but not the cords associated with other non-EUT equipment in the system) is then performed for the full frequency range for which the EUT is being tested for compliance without further variation of the EUT arrangement, cable positions, or EUT mode of operation. If the EUT is comprised of equipment units that have their own separate ac power connections, e.g., floor-standing equipment with independent power cords for each shelf that are able to connect directly to the ac power network, each current-carrying conductor of one unit is measured while the other units are connected to a second (or more) LISN(s). All units shall be separately measured. If a power strip is provided by the manufacturer, to supply all of the units making up the EUT, only the conductors in the power cord of the power strip shall be measured.

If the EUT operates above 30 MHz and uses a detachable antenna, then these measurements shall be made with a representative antenna connected to the antenna output terminals. These tests shall be made with the antenna connected and, if adjustable, fully extended.

When an EUT operates below 30 MHz it is acceptable to test the device with the antenna connected and if emissions at the fundamental frequency exceed the limit the antenna, detachable or non-detachable, may be replaced with a suitable dummy load and the test repeated in this configuration. Emissions must not exceed the regulatory limit with the dummy load in place.

Record the six highest EUT emissions relative to the limit of each of the current-carrying conductors of the power cords of the equipment that comprises the EUT over the frequency range specified by the procuring or regulatory agency.

Ref. ANSI C63.10:2013, section 6.2

Test Procedure
1. Using Vasona software, configure the spectrum analyzer as shown above (be sure to enter all losses between the transmitter output and the spectrum analyzer). 2. Set the radio in continuous transmit mode. 3. Connect cable end to LISN Hot port and other cable end to the spectrum Analyzer/EMC receiver RF input port. Terminate the LISN neutral port with a 50 Ω impedance terminator. 4. Sweep the frequency range from 150 kHz to 30 MHz (segment if necessary). 5. Use the peak marker function to determine the maximum amplitude level. 6. Center marker frequency and perform final measurement using applicable detector (Quasi-Pk/Average). 7. Record at least 6 highest reading for the worst case operating modes in Quasi-peak/Average. 8. Repeat the test on Neutral lead. 9. Repeat step 3 – 7 with the radio sets in the Receiver mode. 10. Record at least 6 highest reading in Quasi-peak/Average.

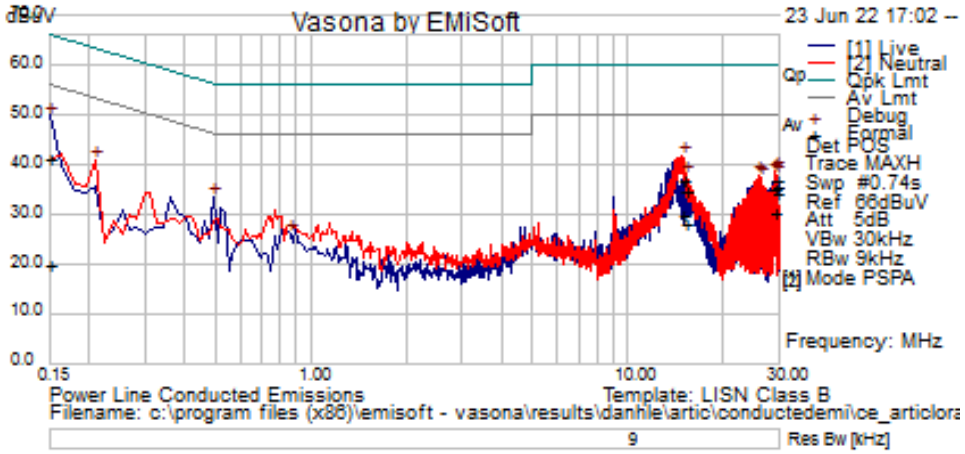
Ref. ANSI C63.10:2013, section 4 / **CISPR16**-1-1

Test Parameters
Span = Entire frequency range or segment if necessary. Reference Level ≥ 70 dBuV or 10 dB headroom between max. spectrum level and the reference level RBW = 9 kHz VBW ≥ 3 x RBW Sweep Time = Couple Detector = Quasi-Peak & Average

Note: The data displayed on the plots detailed in this appendix were measured using a 'Peak Detector'. Please refer to the results table for the detectors used during formal measurements.

B.2.3 AC Conducted Emissions Test Data and Graphical Test Results

Subtest Date:	23-June-2022
Engineer	Danh Le
Lab Information	Building 7, 5m Anechoic
Subtest Title	AC Conducted Emissions
Frequency Range	150kHz-30MHz
Comments on the above Test Results	TX Channel 3 (925.1 MHz); Mode: LoRa-DTS – SF12
Test System#	1 (Refer to section 4.2 for system details)



AC Conducted Emissions Test Result Tables for 802.11b / TX Ch6

Frequency (MHz)	Raw (dBuV)	Cab Loss (dB)	Factors (dB)	Level (dBuV)	Detector	Lines (Live/Neutral)	Limit (dBuV)	Margin (dB)	Results Pass / Fail	Comments
0.15	19.98	21.21	0.18	41.37	Quasi Peak	Live	66	-24.63	Pass	TX / Ch 3
0.15	-1.39	21.21	0.18	20	Average	Live	56	-36	Pass	TX / Ch 3
14.90984	16.44	20.25	0.16	36.86	Quasi Peak	Neutral	60	-23.14	Pass	TX / Ch 3
14.90984	9.24	20.25	0.16	29.66	Average	Neutral	50	-20.34	Pass	TX / Ch 3
29.353	15.97	20.63	0.27	36.86	Quasi Peak	Neutral	60	-23.14	Pass	TX / Ch 3
29.353	14.61	20.63	0.27	35.51	Average	Neutral	50	-14.49	Pass	TX / Ch 3
29.164	14.13	20.62	0.26	35.02	Quasi Peak	Neutral	60	-24.98	Pass	TX / Ch 3
29.164	9.47	20.62	0.26	30.35	Average	Neutral	50	-19.65	Pass	TX / Ch 3
15.27175	14.41	20.27	0.16	34.84	Quasi Peak	Neutral	60	-25.16	Pass	TX / Ch 3
15.27175	7.55	20.27	0.16	27.98	Average	Neutral	50	-22.02	Pass	TX / Ch 3
29.55377	14.76	20.64	0.27	35.66	Quasi Peak	Neutral	60	-24.34	Pass	TX / Ch 3
29.55377	13.41	20.64	0.27	34.32	Average	Neutral	50	-15.68	Pass	TX / Ch 3

Appendix C: List of Test Equipment Used to perform the test

Equip#	Manufacturer/ Model	Description	Last Cal	Next Due	Test Item
Radiated Emissions 30MHz – 1GHz for Test System#3					
CIS008113	Cisco/NSA 5m Chamber	NSA 5m Chamber	27-Jul-2021	27-Jul-2022	B1
CIS042933	Rohde & Schwarz / ESCI	EMI Test Receiver	09-Dec-2021	09-Dec-2022	B1
CIS054013	Sunol Sciences / JB1	Combination Bi-Log Antenna, 30MHz-2GHz	16-Nov-2021	16-Nov-2022	B1
CIS059867	Huber+Suhner /Sucoflex 106PA	Sucoflex 106 RF cable, 8.44m 9kHz-18GHz	25-Aug-2021	25-Aug-2022	B1
CIS025660	Micro-Coax UFB311A-1-0840-504504	RF Coaxial Cable, 84.0 in - 18GHz	22-Jul-2021	22-Jul-2022	B1
CIS025640	Micro-Coax / UFB311A-0-2720-520520	RF Coaxial Cable, 272.0 in. - 18GHz	22-Jul-2021	22-Jul-2022	B1
CIS063056	K&L Microwave/ 4N45-902.5/x2-0/0	SMA band rejecter filter 902MHz – 938MHz	15-Jun-2022	15-Jun-2023	B1
Radiated Emissions 1GHz – 10GHz for Test System#3					
CIS43024	Cisco/NSA 5m Chamber	NSA 5m Chamber Above 1GHz	01-Oct-2021	01-Oct-2022	B1
CIS042015	ETS Lindgren / 3117	Double Ridged Guide Horn Antenna	05-Nov-2021	05-Nov-2022	B1
CIS039125	Cisco / TH0118	Mast Mount Preamplifier Array, 1-18GHz	07-Apr-2022	07-Apr-2023	B1
CIS056098	Keysight / MXA N9020A	MXA Spectrum Analyzer, 10Hz-26.5GHz	13-Jan-2022	13-Jan-2023	B1
CIS059867	Huber+Suhner /Sucoflex 106PA	Sucoflex 106 RF cable, 8.44m 9kHz-18GHz	25-Aug-2021	25-Aug-2022	B1
CIS025660	Micro-Coax UFB311A-1-0840-504504	RF Coaxial Cable, 84.0 in - 18GHz	22-Jul-2021	22-Jul-2022	B1
CIS025640	Micro-Coax / UFB311A-0-2720-520520	RF Coaxial Cable, 272.0 in. - 18GHz	22-Jul-2021	22-Jul-2022	B1
CIS054612	MegaPhase/ RA08-S1S1-12	RF Coaxial SMA cable 1.0mm - 18GHz	15-Feb-2022	15-Feb-2023	B1
CIS054630	MegaPhase/ RA08-S1S1-36	RF Coaxial SMA cable 1.0mm - 18GHz	15-Feb-2022	15-Feb-2023	B1
CIS063056	K&L Microwave/ 4N45-902.5/x2-0/0	SMA band rejecter filter 902MHz – 938MHz	15-Jun-2022	15-Jun-2023	B1

Equip#	Manufacturer/ Model	Description	Last Cal	Next Due	Test Item
Radiated Emissions 30MHz – 1GHz for Test System#4 & Sysytem#5					
CIS008448	Cisco/NSA 5m Chamber	NSA 5m Chamber	23-Aug-2022	23-Aug-2023	B1
CIS058263	Rohde & Schwarz / ESW	EMI Test Receiver	30-Aug-2022	30-Aug-2023	B1
CIS032367	Sunol Sciences / JB1	Combination Bi-Log Antenna, 30MHz-2GHz	18-May-2022	18-May-2023	B1
CIS063069	Huber+Suhner /Sucoflex 104PEA	Sucoflex 106 RF cable, 8.44m 9kHz-18GHz	28-Jul-2022	28-Jul-2023	B1
CIS025650	Micro-Coax UFB311A-1-0840-504504	RF Coaxial Cable, 84.0 in - 18GHz	10-Aug-2022	10-Aug-2023	B1
CIS021117	Micro-Coax / UFB311A-0-2484-520520	RF Coaxial Cable, 272.0 in. - 18GHz	12-Sep-2022	12-Sep-2023	B1
CIS054628	Megaphase/ RA08-S1S1-36	RF Coaxial SMA cable 1.0mm - 18GHz	15-Feb-2022	15-Feb-2023	B1
CIS046379	Micro-Tronics/ BRC16306	SMA band rejecter filter 880MHz – 915MHz	10-May-2022	10-May-2023	B1
CIS062494	Wainwright Ins/ WRCGV8-915-925-960-970-40SS	SMA band rejecter filter 915MHz – 960MHz	11-Mar-2022	11-Mar-2023	B1
Radiated Emissions 1GHz – 10GHz for Test System#5 & Sysytem#4					
CIS40597	Cisco/NSA 5m Chamber	NSA 5m Chamber Above 1GHz	10-Sep-2022	10-Sep-2023	B1
CIS041201	ETS Lindgren / 3117	Double Ridged Guide Horn Antenna	03-Nov-2021	03-Nov-2022	B1
CIS063061	Cisco / TstHd1	External Preamplifier Array, 1-18GHz	06-Jul-2022	06-Jul-2023	B1
CIS058263	Rohde & Schwarz / ESW	EMI Test Receiver	30-Aug-2022	30-Aug-2023	B1
CIS063069	Huber+Suhner /Sucoflex 104PEA	Sucoflex 106 RF cable, 8.44m 9kHz-18GHz	28-Jul-2022	28-Jul-2023	B1
CIS025650	Micro-Coax UFB311A-1-0840-504504	RF Coaxial Cable, 84.0 in - 18GHz	10-Aug-2022	10-Aug-2023	B1
CIS021117	Micro-Coax / UFB311A-0-2484-520520	RF Coaxial Cable, 272.0 in. - 18GHz	12-Sep-2022	12-Sep-2023	B1
CIS054628	Megaphase/ RA08-S1S1-36	RF Coaxial SMA cable 1.0mm - 18GHz	15-Feb-2022	15-Feb-2023	B1
CIS046379	Micro-Tronics/ BRC16306	SMA band rejecter filter 880MHz – 915MHz	10-May-2022	10-May-2023	B1
CIS062494	Wainwright Ins/ WRCGV8-915-925-960-970-40SS	SMA band rejecter filter 915MHz – 960MHz	11-Mar-2022	11-Mar-2023	B1

RF Conducted Emissions for Test System#2					
CIS056098	Keysight / MXA N9020A	MXA Spectrum Analyzer, 10Hz-26.5GHz	13-Jan-2022	13-Jan-2023	A1,A2,A3, A4,A5,A6
CIS032080	ROHDE & SCHWARZ/ FSP-7	SPECTRUM ANALYZER, 7GHZ	04-Mar-2022	04-Mar-2023	A6 (30KHz-30MHz)
CIS054661	MINI-CIRCUITS/BW-S3 0W2 +	30dB SMA Attenuator	25-Mar-2022	25-Mar-2023	A6 (30KHz-30MHz)
CIS054053	Aeroflex/INMET 40AH2W-10	SMA 10 dB Attenuator 2.92mm	28-Mar-2022	28-Mar-2023	A1,A3,A4
CIS055603	Mini-Circuits/ BWS10W2+	SMA 10dB Attenuator	24-Mar-2022	24-Mar-2023	A1,A3,A4
CIS047283	HUBER + SUHNER/Sucoflex 102E	40GHz Cable K Connector	26-May-2022	26-May-2023	A6 (30KHz-30MHz)
CIS054628	MegaPhase/ RA08-S1S1-36	RF Coaxial SMA cable 1.0mm	15-Feb-2022	15-Feb-2023	A1,A2,A3, A4,A5,A6
CIS062412	MegaPhase/ RA08-S1S1-12	RF Coaxial SMA cable 1.0mm	15-Feb-2022	15-Feb-2023	A5,A6
CIS046379	Micro-Tronics/Brc16306	880MHz – 928MHz Notch filter	10-May-2022	10-May-2022	A5,A6
CIS055600	Mini-Circuits/ BWS6W2+	SMA 6dB Attenuator	24-Mar-2022	24-Mar-2023	A6
CIS041998	Mini-Circuits/ BWS6W2+	SMA 6dB Attenuator	24-Mar-2022	24-Mar-2023	A6

AC Conducted Emissions 150KHz – 30MHz for Test System#1					
CIS44908	Rohde & Schwarz / ESCI	EMI Test Receiver 9KHz – 3GHz	29-Nov-2021	29-Nov-2022	B2
CIS062421	TTE / H613-150K-50-21378	High Pass Filter 150KHz	12-Feb-2022	12-Feb-2023	B2
CIS024133	Fisher Custom Com / 50/250-50-2-02	LISN (9kHz-30MHz), 50A, 2-Line	19-May-2022	19-May-2023	B2
CIS024127	Fisher Custom Com / LISN-PA-5-20R	LISN Receptacle Adaptor, Polarized 120VAC	19-May-2022	19-May-2023	B2
CIS024132	Fisher Custom Com / 50/250-50-2-02	LISN (9kHz-30MHz), 50A, 2-Line	20-May-2022	20-May-2023	B2
CIS024126	Fisher Custom Com / LISN-PA-5-20R	LISN Receptacle Adaptor, Polarized 120VAC	20-May-2022	20-May-2023	B2
CIS051661	Bird/5-T-MB	50Ω terminator	23-Feb-2022	23-Feb-2023	B2
CIS040532	Coleman / RG-223	25 ft RF coaxial RG-223 Cable	15-Jul-2021	15-Jul-2022	B2

Appendix D: Abbreviation Key and Definitions

The following table defines abbreviations used within this test report.

Abbreviation	Description	Abbreviation	Description
EMC	Electro Magnetic Compatibility	°F	Degrees Fahrenheit
EMI	Electro Magnetic Interference	°C	Degrees Celsius
EUT	Equipment Under Test	Temp	Temperature
ITE	Information Technology Equipment	S/N	Serial Number
TAP	Test Assessment Schedule	Qty	Quantity
ESD	Electro Static Discharge	Emf	Electromotive force
EFT	Electric Fast Transient	RMS	Root mean square
EDCS	Engineering Document Control System	Qp	Quasi Peak
Config	Configuration	Av	Average
CIS#	Cisco Number (unique identification number for Cisco test equipment)	Pk	Peak
Cal	Calibration	kHz	Kilohertz ($1x10^3$)
EN	European Norm	MHz	MegaHertz ($1x10^6$)
IEC	International Electro technical Commission	GHz	Gigahertz ($1x10^9$)
CISPR	International Special Committee on Radio Interference	H	Horizontal
CDN	Coupling/Decoupling Network	V	Vertical
LISN	Line Impedance Stabilization Network	dB	decibel
PE	Protective Earth	V	Volt
GND	Ground	kV	Kilovolt ($1x10^3$)
L1	Line 1	µV	Microvolt ($1x10^{-6}$)
L2	Line2	A	Amp
L3	Line 3	µA	Micro Amp ($1x10^{-6}$)
DC	Direct Current	mS	Milli Second ($1x10^{-3}$)
RAW	Uncorrected measurement value, as indicated by the measuring device	µS	Micro Second ($1x10^{-6}$)
RF	Radio Frequency	µS	Micro Second ($1x10^{-6}$)
SLCE	Signal Line Conducted Emissions	M	Meter
Meas dist	Measurement distance	Spec dist	Specification distance
N/A or NA	Not Applicable	SL	Signal Line (or Telecom Line)
P	Power Line	L	Live Line
N	Neutral Line	R	Return
S	Supply	AC	Alternating Current

Appendix E: Software Used to Perform Testing

EMIsoft Vasona, version 6.024

Appendix F: Test Procedures

Measurements were made in accordance with:

- ANSI C63.10:2013 Procedure for Compliance Testing of Unlicensed Wireless Devices
- KDB 558074 D01 15.247 Mesa Guidance v05r02
- RSS Gen Issue 5 General Requirements for Compliance of Radio Apparatus

Test procedures are summarized below

FCC part15.247 Conducted Test Procedures	EDCS # 1445042
FCC part15.09/15.247 RSE Test Procedures	EDCS # 1480386

Appendix G: Scope of Accreditation (A2LA certificate number 1178-01)

The scope of accreditation of Cisco Systems, Inc. can be found on the A2LA web page at:

http://www.a2la.org/scopepdf/1178-01.pdf

Note: FCC 15.205, FCC 15.207 and FCC 15.209 are additional requirement not covered under the scope of accreditation

Appendix H: Test Assessment Plan

Compliance Test Plan: EDCS-23252259
Target Power Tables: EDCS-23067411

Appendix I: Worst Case Justification

Conducted Testing:

From below data rate SF12/500KHz supports 980 bps, Higher the spreading factor, lower the speed and further it travels and so better the sensitivity. LoRa is a constant envelope modulation. All data rates use the same transmit power. SF12 is the lowest data rate so packets sent at SF12 have the longest time on air. When transmitting continuously there are small gaps between each packet. When measuring over a duration longer than a single packet, a stream of SF12 packets will have the fewest gaps and therefore a duty cycle slightly closer to 100% than higher data rates.

8	LoRa: SF12 / 500 kHz	980
9	LoRa: SF11 / 500 kHz	1760
10	LoRa: SF10 / 500 kHz	3900
11	LoRa: SF9 / 500 kHz	7000
12	LoRa: SF8 / 500 kHz	12500
13	LoRa: SF7 / 500 kHz	21900

Radiated Testing:

Worst case modes were selected by ANSI C63.10 2013 Section **5.6.2.2, 6.3.1**

All 3 orientations (Z, Y, Z) of the EUT were assessed by performing pre-scan.
The Y orientation was determined to be the worst-case orientation.

Worst Case Orientation		
X-axis	**Y-axis**	**Z-axis**
		
☐	☒	☐