

EMC Test Report

Project Number: 4286765 / 5414

Report Number: 4286765 EMC04 **Revision Level:** 1

Client: Sanmina Corp

Equipment Under Test: LoraWAN Sensor

Models: 1006010

FCC ID: 2AMS3WBOX1

IC ID: 5541A-WBOX1

Applicable Standards: ANSI C63.10: 2013

FCC Part 15 Subpart C, § 15.247

RSS-247, Issue 2

RSS-GEN, Issue 4

Report issued on: 30 May 2018

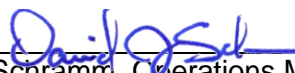
Test Result: Compliant

Tested by:



Jerry Chen, Technical Manager

Reviewed by:



David Schramm, Operations Manager

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

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1 Summary of Test Results

Test Description	Test Specification	Test Result
Occupied Bandwidth	15.247(a) (1) RSS-GEN 6.6 / RSS-247 5.1 b	Compliant
Peak Power Output	15.247(a) (1) RSS-247 5.1 b / 5.4 a	Compliant
Power Spectral Density	15.247(f) RSS-247 5.2 b	NA (1)
Conducted Spurious Emissions	15.247(d) RSS-247 5.5	Compliant
Radiated Spurious Emissions in / out the restricted bands	15.247(d), 15.35(b), 15.205, 15.209 RSS-GEN 8.9/ RSS-247 5.5	Compliant
Dwell time	15.247(f) RSS-247 5.1 c	Compliant
Number of Hopping Frequencies	15.247(a)(1)(i) RSS-247 5.1 c	Compliant
Channel separation	15.247(a)(1)	Compliant
AC Power Line Conducted Emission	15.107, 15.207 & RSS-GEN 8.8	N/A (2)

(1) Not Applicable – The device is FHSS device, not DTS device.

(2) Not Applicable – The device is powered via battery.

1.1 Modifications Required for Compliance

None

2 General Information

2.1 Client Information

Name: Sanmina Corporation
Address: 13000 Memorial Parkway SW
City, State, Zip, Country: Huntsville, AL 35803

2.2 Test Laboratory

Name: SGS North America, Inc.
Address: 620 Old Peachtree Road NW, Suite 100
City, State, Zip, Country: Suwanee, GA 30024, USA

2.3 General Information of EUT

EUT: LoRa WAN sensor
Model Number: 1006010
Serial Number: Not labeled

Frequency Range: 902.3 to 914.9 MHz
Number of channels: 15.247 Frequency Hopping device employing 64 channels
Modulation type: LoRa
Channel spacing: <200 kHz
Antenna: internal Chip, 1dBi

Rated Voltage: 3V battery
Test Voltage: Fully charged 3V battery

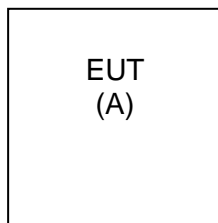
Sample Received Date: March 6, 2018
Dates of testing: 18 April to 24 April, 2018

Operating Modes and Conditions

The EUT was configured to operate in the following modes:

1. Continuously hopping through low, mid and high channels
2. Hopping through all channels

2.4 EUT Connection Block Diagram



2.5 System Configurations

Device reference	Manufacturer	Description	Model Number	Serial Number
A	Sanmina	Whitebox Sensor	1006010	None

2.6 Cable List

None

3 Occupied Bandwidth

3.1 Test Result

Test Description	Basic Standards	Test Result
Bandwidth	15.247(a) (1) RSS-GEN 6.6 / RSS-247 5.1 b	Compliant

3.2 Test Method

The procedures from ANSI C63.10 Clause 6.9.2 and 6.9.3 were used to determine the 20 dB and 99% bandwidths.

- The spectrum analyzer center frequency is set to the nominal EUT channel center frequency. The span range shall be between 2 to 5 times the OBW.
- RBW shall be in the range of 1% to 5% of the OBW and VBW shall be approximately 3 x RBW, unless otherwise specified by the applicable requirement.
- Set the reference level of the instrument as required, keeping the signal from exceeding the maximum input mixer level for linear operation. In general, the peak of the spectral envelope shall be more than $[10 \log (OBW/RBW)]$ below the reference level. Specific guidance is given in 4.1.5.2.
- Steps a) through c) might require iteration to adjust within the specified tolerances.

3.3 Test Site

SGS EMC Laboratory, Suwanee, GA

Environmental Conditions

Temperature: 23.6 °C

Relative Humidity: 44.4 %

3.4 Test Equipment

Test Date: 24-Apr-2018

Tester: JC

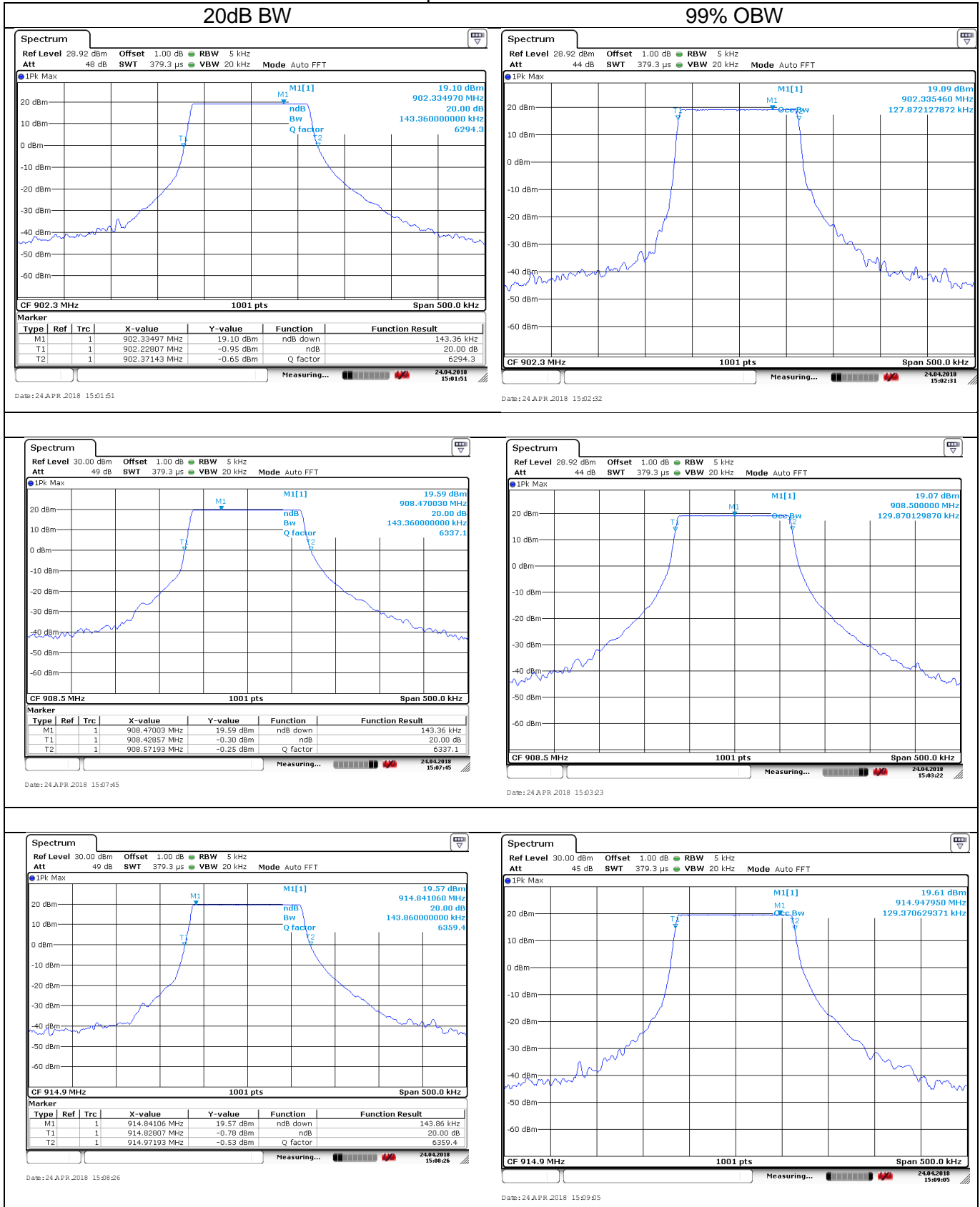
Equipment	Model	Manufacturer	Asset Number	Cal Due Date
SIGNAL ANALYZER	FSV30	ROHDE & SCHWARZ	S/N: 103106	24-Jul-2018
RF Cable	U.FL to SMA	Not Labeled	17026	VBU
NETWORK ANALYZER	ZVL	ROHDE & SCHWARZ	B079799	23-Mar-2019

Note: The equipment calibration period is 1 year.

3.5 Test Data

Frequency (MHz)	20 dB bandwidth (MHz)	99% OBW (MHz)
902.3	0.143	0.128
908.0	0.143	0.130
914.9	0.143	0.129

Representative Plot



4 Peak Output Power

4.1 Test Result

Test Description	Test Specification	Test Result
Peak Output Power	15.247(a) (1) RSS-247 5.1 b / 5.4 a	Compliant

4.2 Test Method

Measurements were recorded using the test methods defined in ANS C63.10, Clause 7.8.5.

a) Use the following spectrum analyzer settings:

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

b) Allow trace to stabilize.

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

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

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

Limit

For hybrid DTS / frequency hopping systems operating in the 902-928 MHz band: 1 watt.

4.3 Test Site

SGS EMC Laboratory, Suwanee, GA

Environmental Conditions

Temperature: 23.6 °C

Relative Humidity: 44.5 %

4.4 Test Equipment

Test Date: 24-Apr-2018

Tester: JC

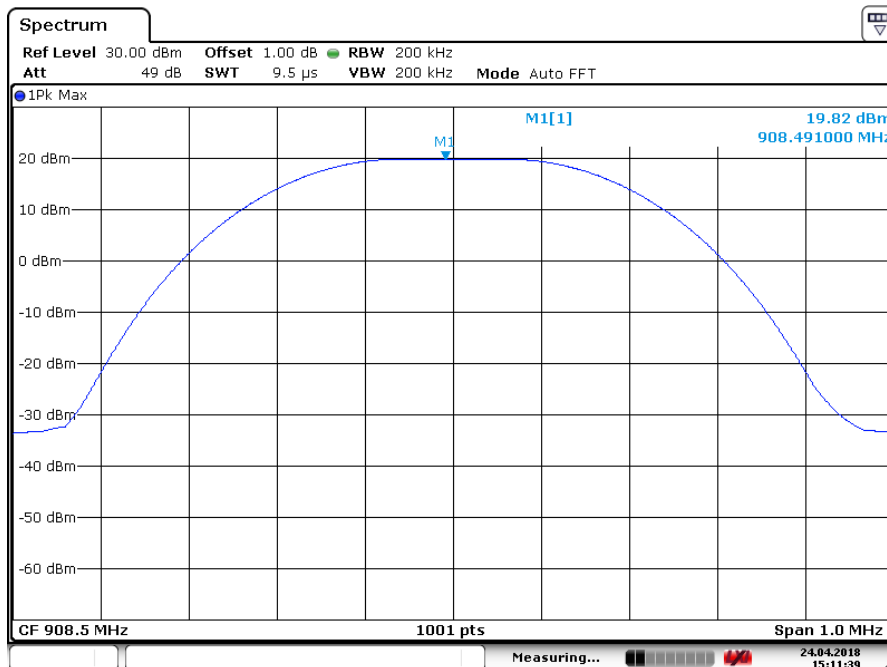
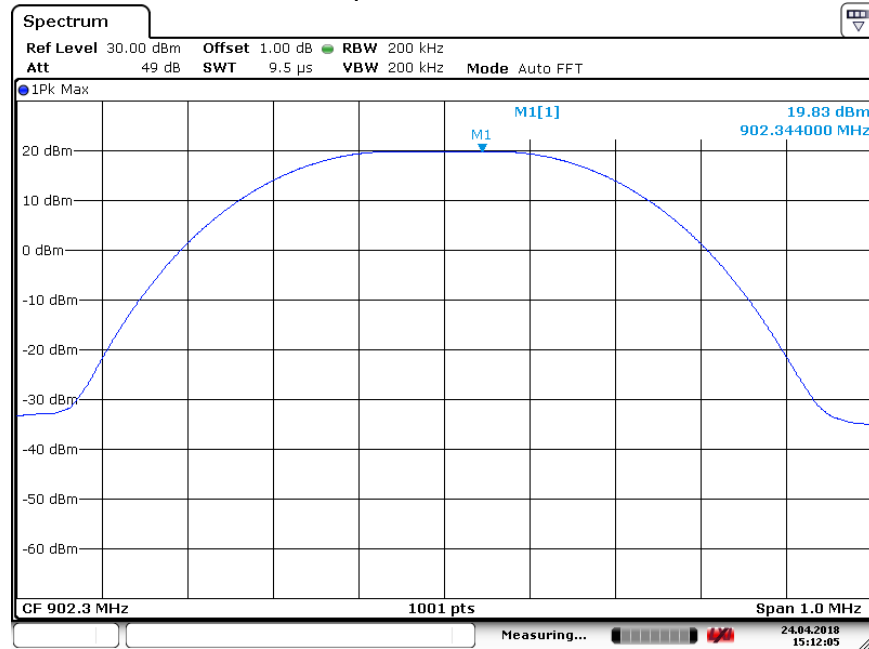
Equipment	Model	Manufacturer	Asset Number	Cal Due Date
SIGNAL ANALYZER	FSV30	ROHDE & SCHWARZ	S/N: 103106	24-Jul-2018
RF Cable	U.FL to SMA	Not Labeled	17026	VBV
NETWORK ANALYZER	ZVL	ROHDE & SCHWARZ	B079799	23-Mar-2019

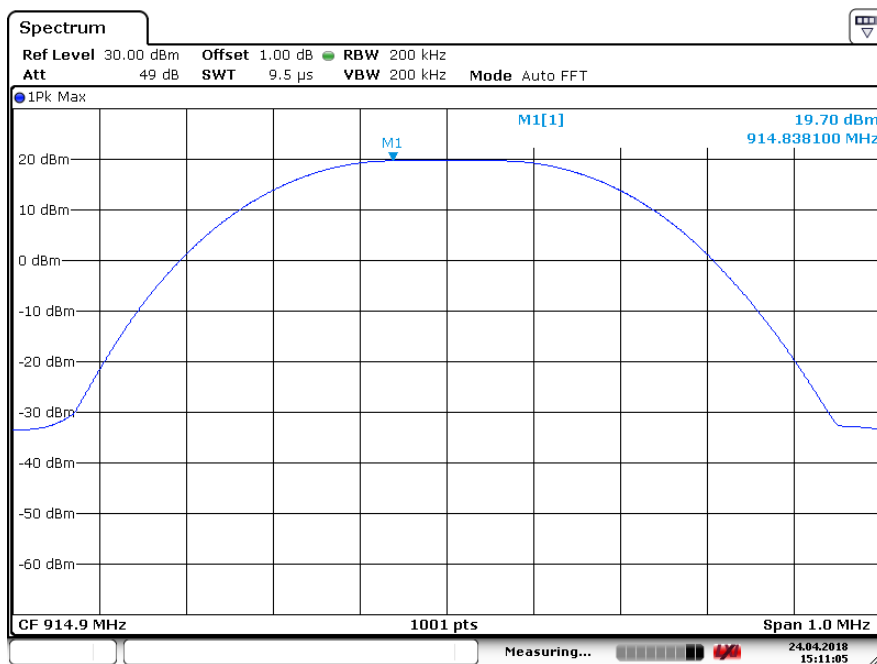
Note: The equipment calibration period is 1 year.

4.5 Test Data

Frequency	Peak Output Power (dBm)	Peak Output Power (W)	Output Power limit (W)
902.3	19.83	0.0962	1
908.0	19.82	0.0959	1
914.9	19.72	0.0938	1

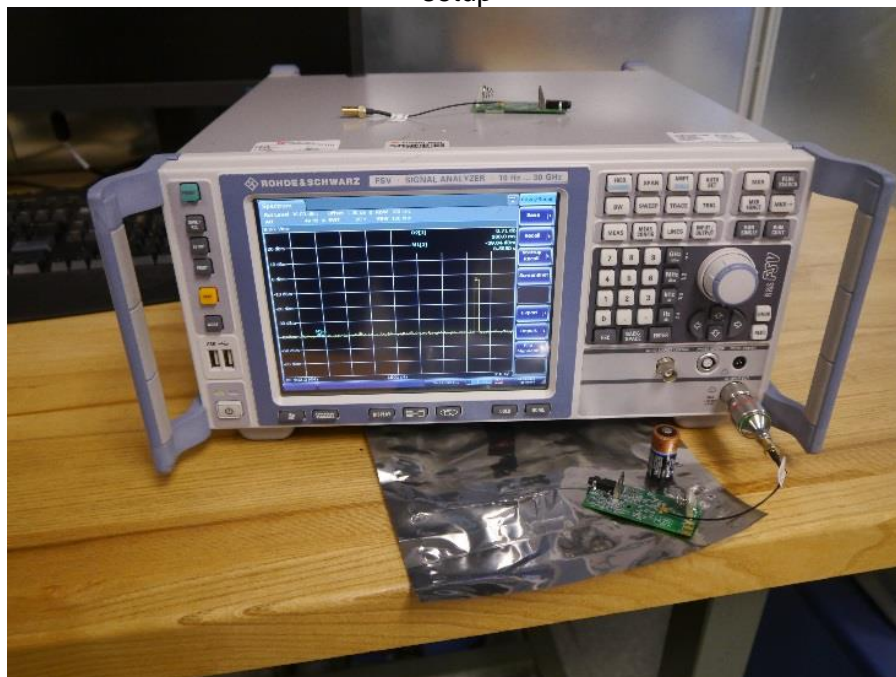
Representative Plot





Date: 24 APR 2018 15:11:05

setup



5 Power Spectral Density

5.1 Test Result

Test Description	Test Specification	Test Result
Power Spectral Density	15.247(f) & RSS-247 5.2 b	Not applicable

6 Conducted Spurious Emissions

6.1 Test Result

Test Description	Test Specification	Test Result
Conducted Spurious Emissions	15.247(d) & RSS-247 5.5	Compliant

6.2 Test Method

Measurements were recorded using the test methods defined in ANS C63.10, Clause 7.8.8. The instrument shall span 30 MHz to 10 times the operating frequency in GHz, with a resolution bandwidth of 100 kHz, video bandwidth of 300 kHz, and a coupled sweep time with a peak detector. The band 30 MHz to the highest frequency may be split into smaller spans, as long as the entire spectrum is covered.

The limit is 20 dB below the measured peak power.

6.3 Test Site

SGS EMC Laboratory, Suwanee, GA

Environmental Conditions

Temperature: 23.6 °C
Relative Humidity: 44.5 %

6.4 Test Equipment

Test Date: 24-Apr-2018

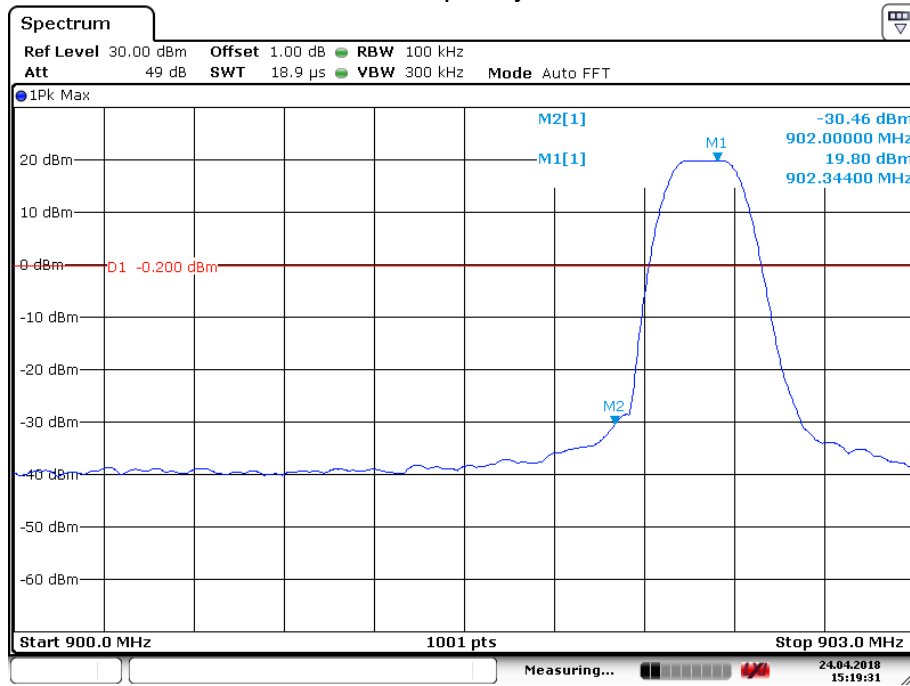
Tester: JC

Equipment	Model	Manufacturer	Asset Number	Cal Due Date
SIGNAL ANALYZER	FSV30	ROHDE & SCHWARZ	S/N: 103106	24-Jul-2018
RF Cable	U.FL to SMA	Not Labeled	17026	VBU
NETWORK ANALYZER	ZVL	ROHDE & SCHWARZ	B079799	23-Mar-2019

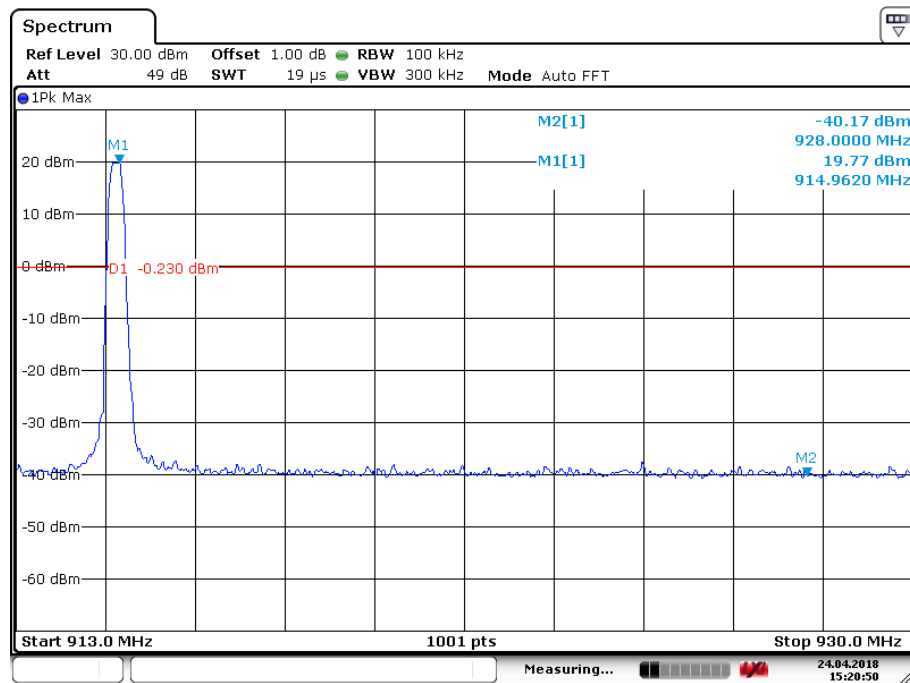
Note: The equipment calibration period is 1 year.

6.5 Test Data (Band-Edge)

Fixed frequency mode

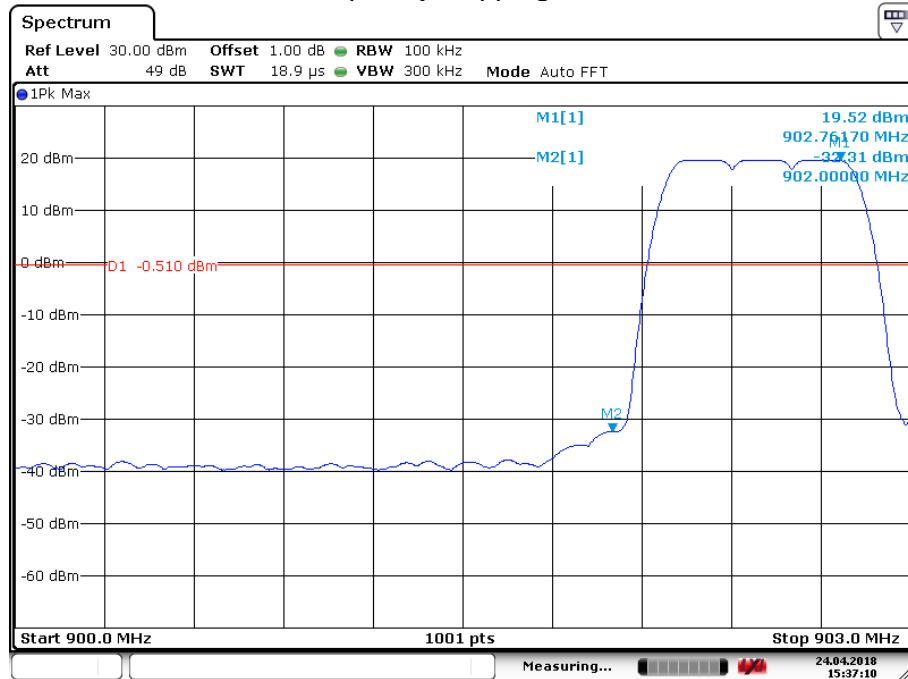


Date: 24 APR 2018 15:19:31

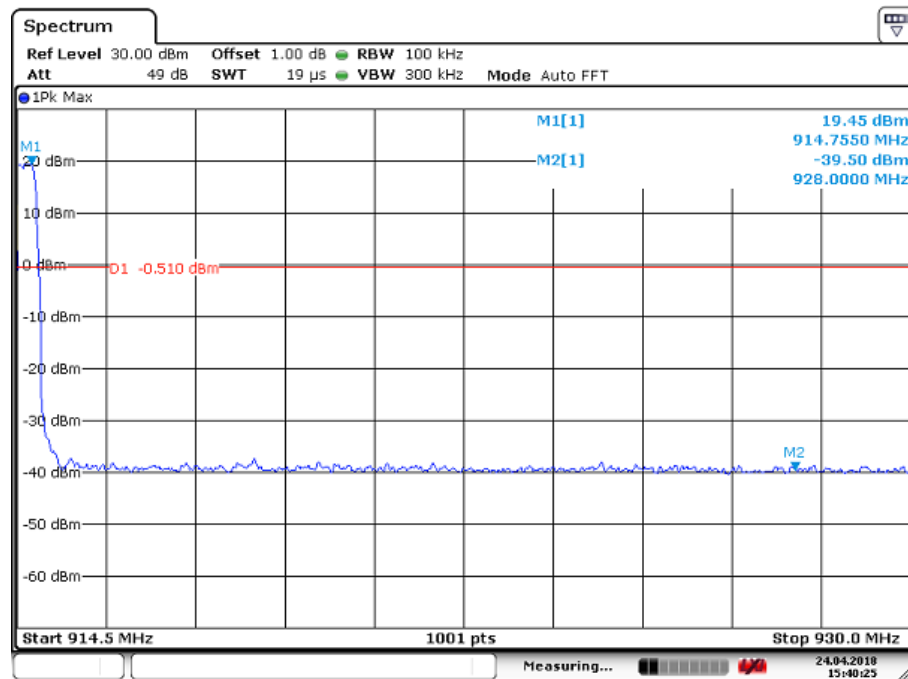


Date: 24 APR 2018 15:20:50

Frequency Hopping Mode



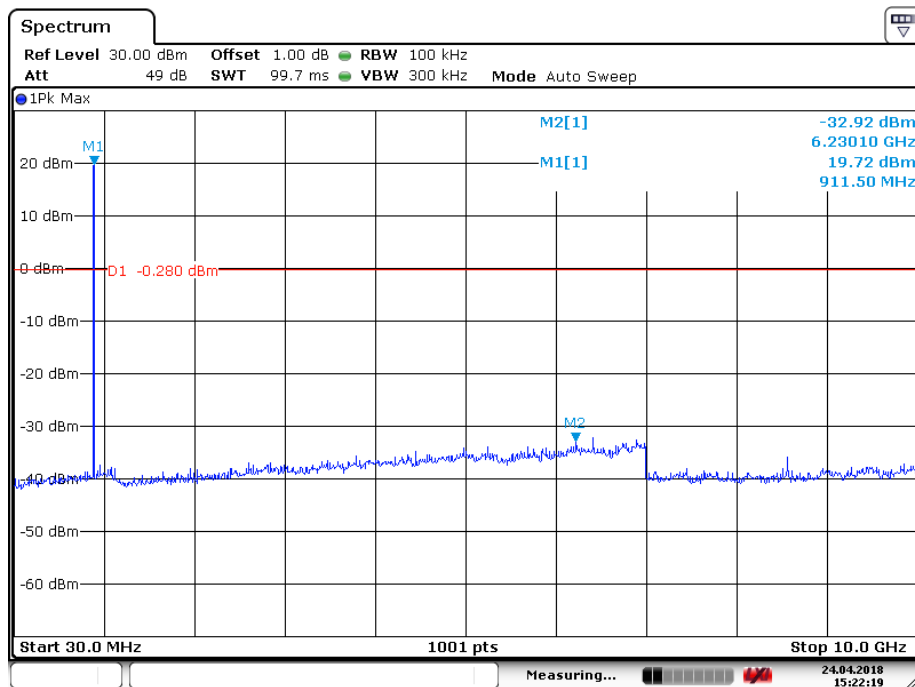
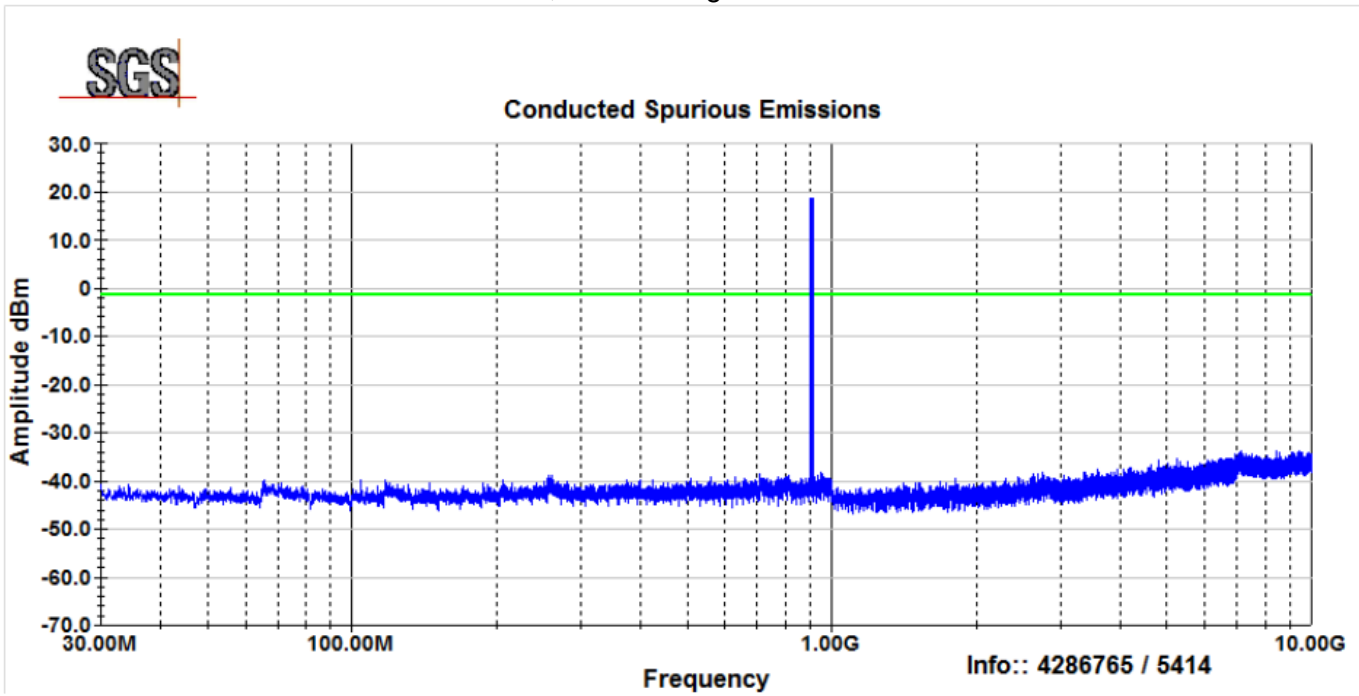
Date: 24 APR 2018 15:37:10



Date: 24 APR 2018 15:40:25

6.6 Test Data (Spurious Emissions)

Low, Mid and High Channels



Date: 24 APR 2018 15:22:19

7 Field Strength of Spurious Radiation

7.1 Test Result

Test Description	Test Specification	Test Result
Field strength of spurious radiation	15.247(d), 15.35(b), 15.205, 15.209 & RSS-GEN 8.9/ RSS-247 5.5	Compliant

7.2 Test Method

Radiated spurious emissions measurements were recorded with the device configured to transmit at the lowest, middle, and highest channels. The frequency range investigated was up through the 10th harmonic of the fundamental transmit frequency. The methods defined in ANSI C63.10: 2013 were used.

For measurements below 1GHz, the device was manipulated through three orthogonal axes. Above 1GHz, the alternative method in Clause 6.6.5 was used.

Test distance:

30 MHz to 1 GHz - The EUT to measurement antenna distance is 3 meters

1 to 18 GHz - The EUT to measurement antenna distance is 3 meters

18 to 40 GHz - The EUT to measurement antenna distance is 1 meter

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

(1) These limits are applicable to emissions within the restricted bands of operation defined in FCC §15.205.

(2) Quasi-peak limit

(3) Average limit

7.3 Test Site

3m Absorber Lined Shielded Enclosure (ALSE), Suwanee, GA

Environmental Conditions

Temperature: 24.4 °C

Relative Humidity: 31.2 %

7.4 Test Equipment

Test End Date: 18-Apr-2018

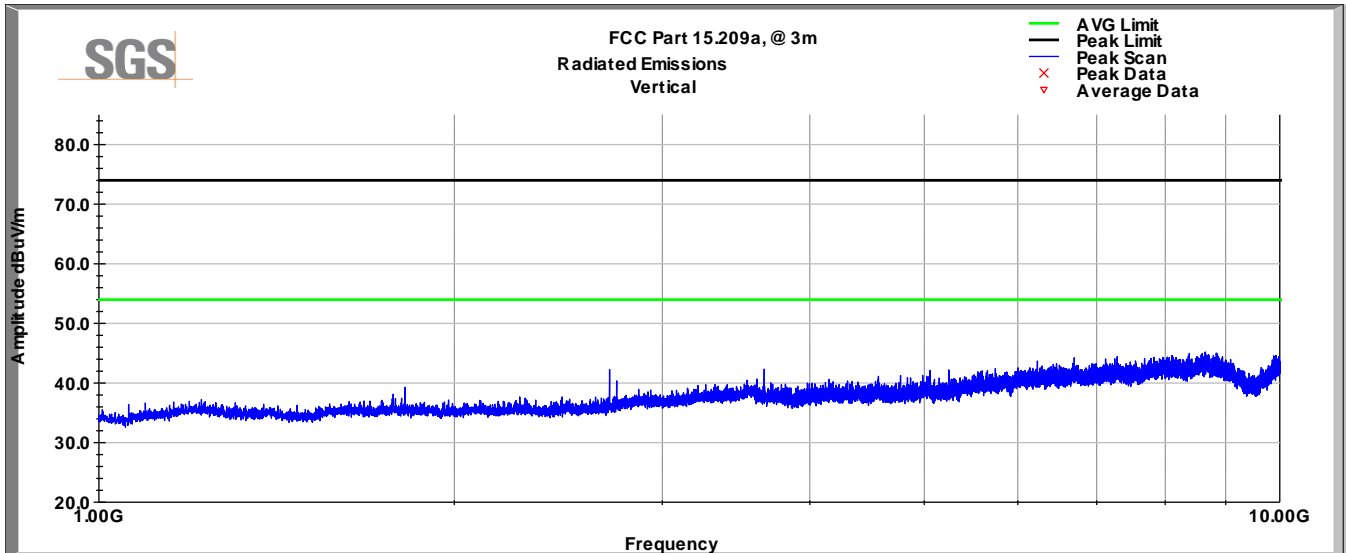
Tester: MT

Equipment	Model	Manufacturer	Asset Number	Cal Due Date
ANTENNA, BILOG	JB6	SUNOL	B079690	29-Nov-2018
ANTENNA, DRG HORN (MEDIUM)	3117	ETS LINDGREN	B079699	16-May-2018
RF CABLE	SF106	HUBER & SUHNER	B079661	25-Jul-2018
RF CABLE	SF106	HUBER & SUHNER	B079713	24-Jul-2018
RF CABLE	SF106	HUBER & SUHNER	B079659	25-Jul-2018
LOW NOISE AMPLIFIER	TS-PR18	ROHDE & SCHWARZ	15003	28-Jul-2018
RF CABLE	SUCOFLEX 100	HUBER & SUHNER	B108523	24-Jul-2018
EMI TEST RECEIVER	ESU40	ROHDE & SCHWARZ	B079629	25-Apr-2018
FILTER, HIGH PASS (>1150MHZ)	HPM50108	MICRO-TRONICS	B079802	27-Jul-2018

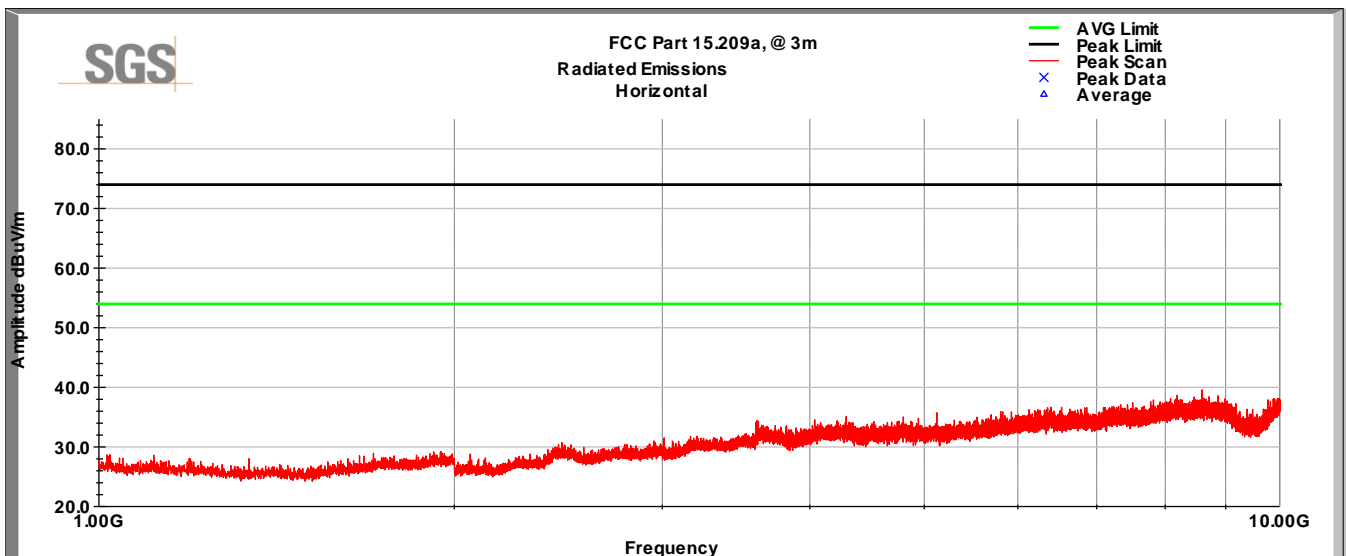
Note: The equipment calibration period is 1 year.

7.5 Test Data – Peak Data

Low, Mid and High Channels, Vertical

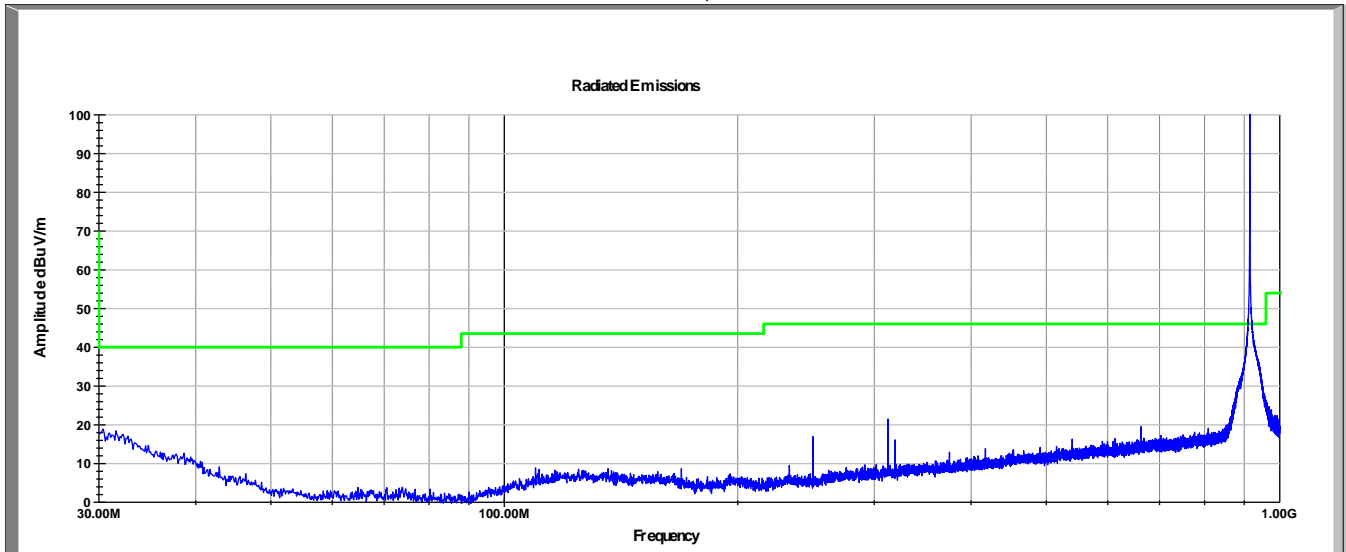


Low, Mid and High Channels, Horizontal

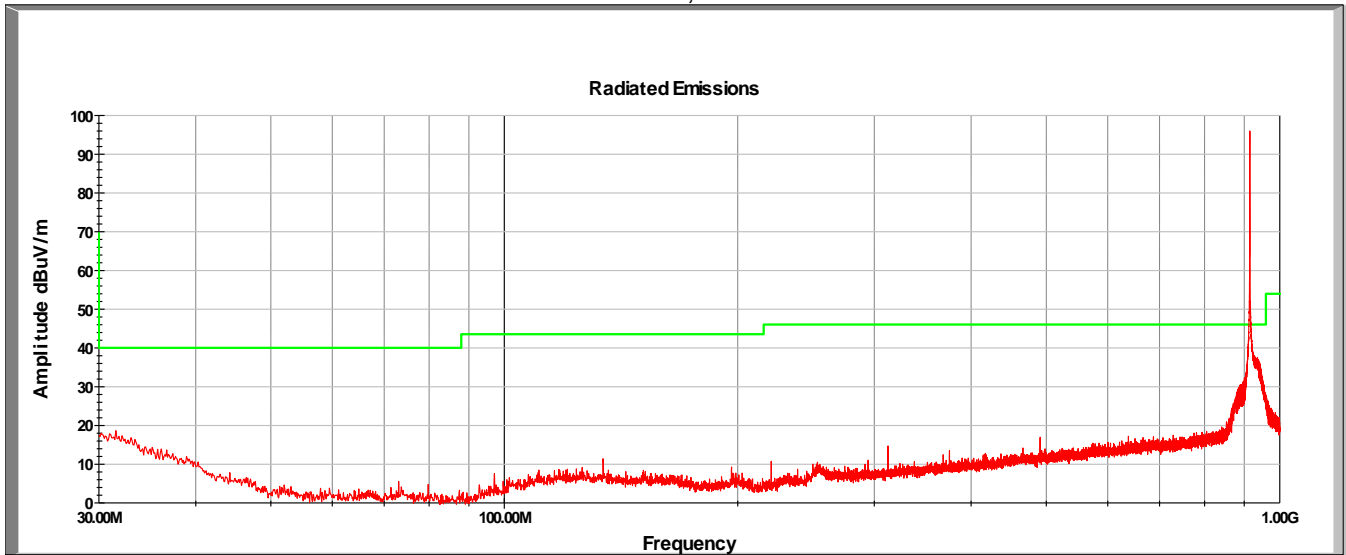


No data is shown as the level is same as background noise except the intentional transmission.

Low, Mid and High Channels
30-1000MHz, Vertical

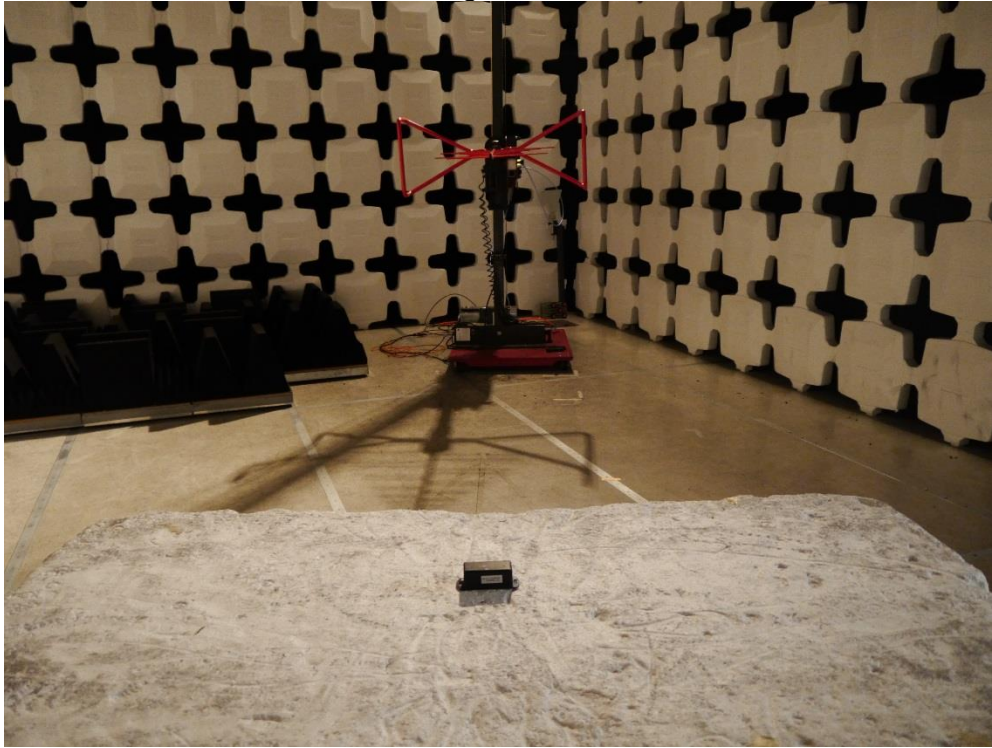


Low, Mid and High Channels
30-1000MHz, Horizontal

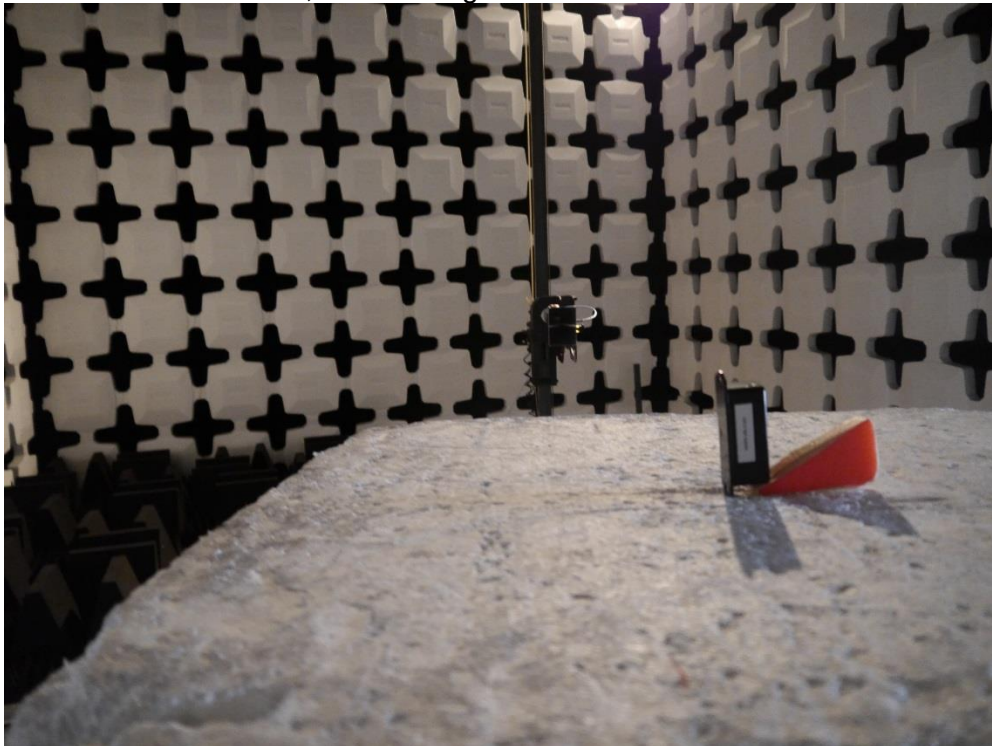


No data is shown as the level is same as background noise except the intentional transmission.

Low, Mid and High Channels 30-1GHz



Low, Mid and High Channels 1-10GHz



8 Pseudo-Random Hop Sequence

8.1 Test Result

Test Description	Test Specification	Test Result
Pseudo-Random Hop Sequence	15.247(d)	Compliant ⁽¹⁾

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

8.2 Test Method

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

Requirement

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

9 Channel Separation

9.1 Test Result

Test Description	Test Specification	Test Result
Channel Separation	15.247(a)(1)	Compliant

9.2 Test Method

Measurements were recorded using the test methods defined in ANSI C63.10, Clause 7.8.2.

Use the following spectrum analyzer settings:

- a) Span: Wide enough to capture the peaks of two adjacent channels.
- b) RBW: Start with the RBW set to approximately 30% of the channel spacing; adjust as necessary to best identify the center of each individual channel.
- c) Video (or average) bandwidth (VBW) \geq RBW.
- d) Sweep: Auto.
- e) Detector function: Peak.
- f) Trace: Max hold.
- g) Allow the trace to stabilize.

Requirement

Frequency hopping systems shall have hopping channel carrier frequencies separated by a minimum of 25 kHz or the 20 dB bandwidth of the hopping channel, whichever is greater. Alternatively, frequency hopping systems operating in the band 2400-2483.5 MHz may have hopping channel carrier frequencies that are separated by 25 kHz or two-thirds of the -20 dB bandwidth of the hopping channel, whichever is greater, provided that the systems operate with an output power no greater than 0.125 W.

9.3 Test Site

SGS EMC Laboratory, Suwanee, GA

Environmental Conditions

Temperature: 23.6 °C
Relative Humidity: 44.5 %

9.4 Test Equipment

Test Date: 24-Apr-2018

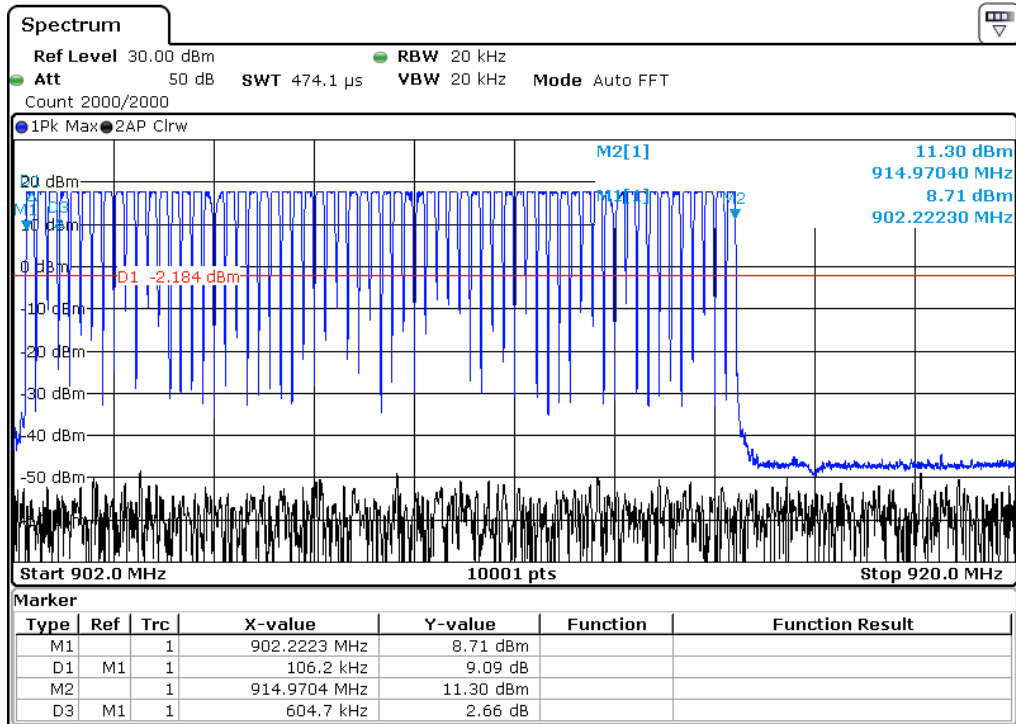
Tester: JC

Equipment	Model	Manufacturer	Asset Number	Cal Due Date
SIGNAL ANALYZER	FSV30	ROHDE & SCHWARZ	S/N: 103106	24-Jul-2018
RF Cable	U.FL to SMA	Not Labeled	17026	VBV
NETWORK ANALYZER	ZVL	ROHDE & SCHWARZ	B079799	23-Mar-2019

Note: The equipment calibration period is 1 year.

9.5 Test Data

The minimum channel separation was $604.7\text{kHz} / 3 = 0.202\text{ MHz}$ which is greater than the worst-case 20dB bandwidth of 0.143 MHz.



10 Number of Hopping Channels

10.1 Test Result

Test Description	Test Specification	Test Result
Number of Hopping Channels	15.247(a)(1)(i) RSS-247 5.1 c	Compliant

10.2 Test Method

Measurements were recorded using the methods defined in ANSI C63.10, Clause 7.8.3.

Use the following spectrum analyzer settings:

- a) Span: The frequency band of operation. Depending on the number of channels the device supports, it may be necessary to divide the frequency range of operation across multiple spans, to allow the individual channels to be clearly seen.
- b) RBW: To identify clearly the individual channels, set the RBW to less than 30% of the channel spacing or the 20 dB bandwidth, whichever is smaller.
- c) VBW \geq RBW.
- d) Sweep: Auto.
- e) Detector function: Peak.
- f) Trace: Max hold.
- g) Allow the trace to stabilize.

Requirement

- ✓ For frequency hopping systems operating in the 902-928 MHz band:
 - if the 20 dB bandwidth of the hopping channel is less than 250 kHz, the system shall use at least 50 hopping frequencies and the average time of occupancy on any frequency shall not be greater than 0.4 seconds within a 20 second period;
- x if the 20 dB bandwidth of the hopping channel is 250 kHz or greater, the system shall use at least 25 hopping frequencies and the average time of occupancy on any frequency shall not be greater than 0.4 seconds within a 10 second period. The maximum allowed 20 dB bandwidth of the hopping channel is 500 kHz.

10.3 Test Site

SGS EMC Laboratory, Suwanee, GA

Environmental Conditions

Temperature: 23.6 °C
Relative Humidity: 44.5 %

10.4 Test Equipment

Test Date: 24-Apr-2018

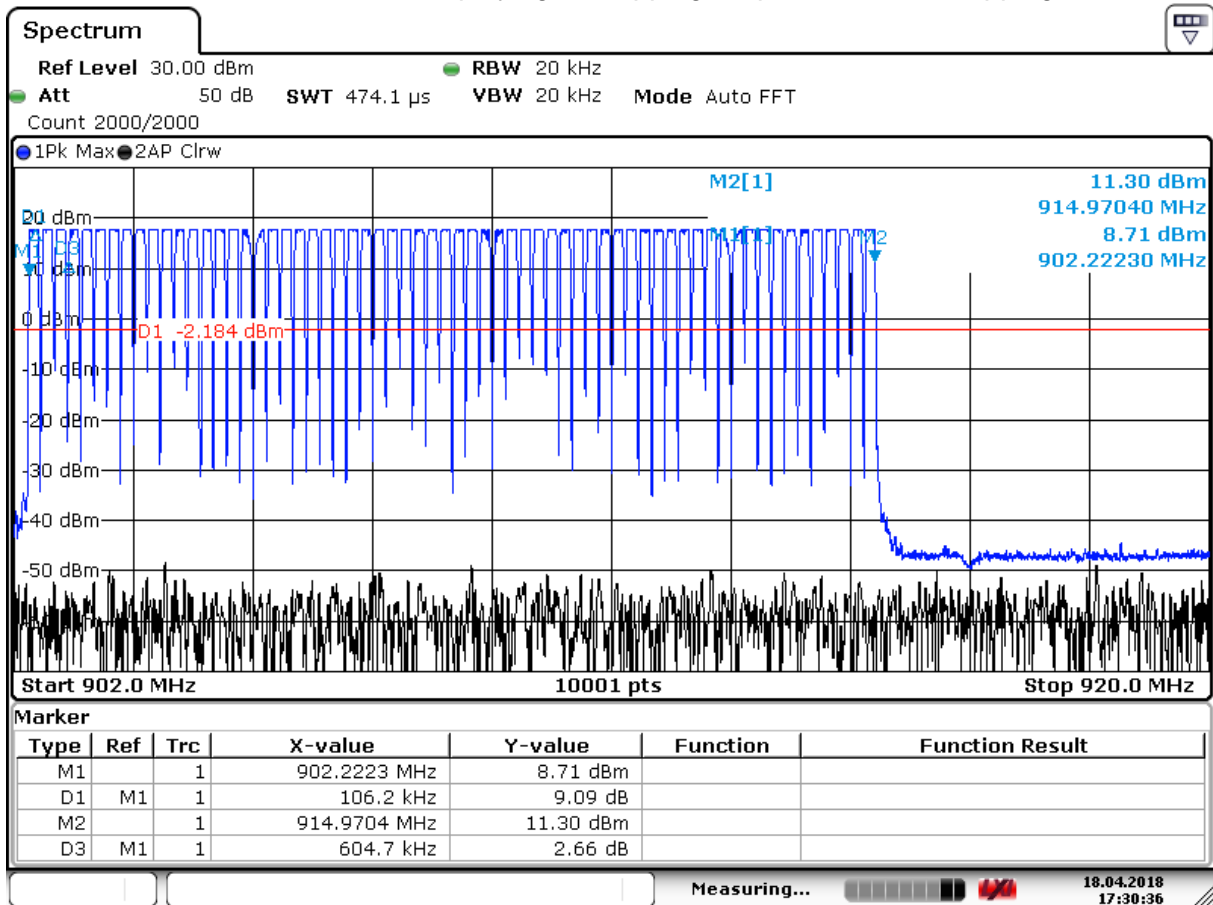
Tester: JC

Equipment	Model	Manufacturer	Asset Number	Cal Due Date
SIGNAL ANALYZER	FSV30	ROHDE & SCHWARZ	S/N: 103106	24-Jul-2018
RF Cable	U.FL to SMA	Not Labeled	17026	VBU
NETWORK ANALYZER	ZVL	ROHDE & SCHWARZ	B079799	23-Mar-2019

Note: The equipment calibration period is 1 year.

10.5 Test Data

The LoRa device is employing 64 hopping frequencies > 50 hopping.



Date: 18 APR 2018 17:30:36

11 Dwell Time

11.1 Test Result

Test Description	Test Specification	Test Result
Dwell Time	15.247(f) RSS-247 5.1 c	Compliant

11.2 Test Method

Measurements were recorded using the methods defined in ANSI C63.10, Clause 7.8.4.

Setting the spectrum analyzer the following:

- a) Span: Zero span, centered on a hopping channel.
- b) RBW shall be \leq channel spacing and where possible RBW should be set $\gg 1 / T$, where T is the expected dwell time per channel.
- c) Sweep: As necessary to capture the entire dwell time per hopping channel; where possible use a video trigger and trigger delay so that the transmitted signal starts a little to the right of the start of the plot. The trigger level might need slight adjustment to prevent triggering when the system hops on an adjacent channel; a second plot might be needed with a longer sweep time to show two successive hops on a channel.
- d) Detector function: Peak.
- e) Trace: Max hold.

Requirement

- ✓ For frequency hopping systems operating in the 902-928 MHz band:
 - if the 20 dB bandwidth of the hopping channel is less than 250 kHz, the system shall use at least 50 hopping frequencies and the average time of occupancy on any frequency shall not be greater than 0.4 seconds within a 20 second period;
- x if the 20 dB bandwidth of the hopping channel is 250 kHz or greater, the system shall use at least 25 hopping frequencies and the average time of occupancy on any frequency shall not be greater than 0.4 seconds within a 10 second period. The maximum allowed 20 dB bandwidth of the hopping channel is 500 kHz.

11.3 Test Site

SGS EMC Laboratory, Suwanee, GA

Environmental Conditions

Temperature: 23.6 °C
Relative Humidity: 44.5 %

11.4 Test Equipment

Test Date: 24-Apr-2018

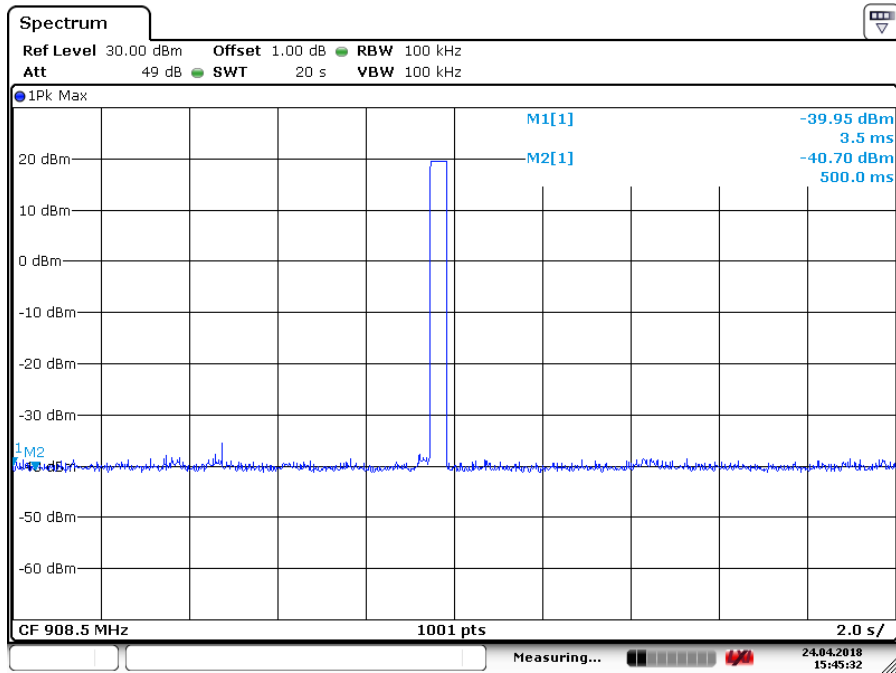
Tester: JC

Equipment	Model	Manufacturer	Asset Number	Cal Due Date
SIGNAL ANALYZER	FSV30	ROHDE & SCHWARZ	S/N: 103106	24-Jul-2018
RF Cable	U.FL to SMA	Not Labeled	17026	VBU
NETWORK ANALYZER	ZVL	ROHDE & SCHWARZ	B079799	23-Mar-2019

Note: The equipment calibration period is 1 year.

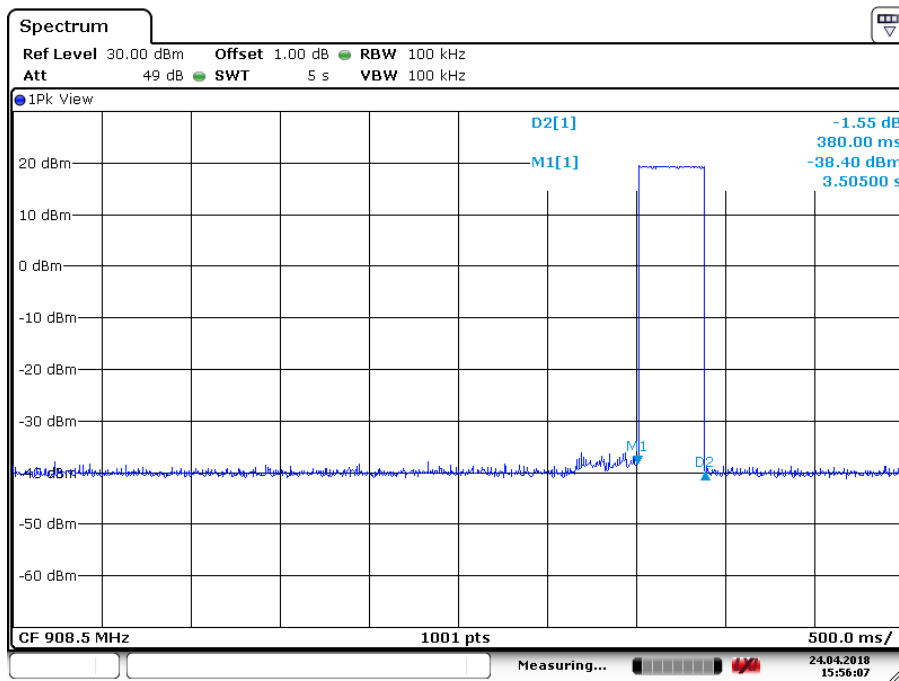
11.5 Test Data

Bursts in 20 s



As per manufacturer declaration, the interval between two pulses will be set to about 20 minutes

Pulse Width = 0.380 ms < 0.4s



12 Revision History

Revision Level	Description of changes	Revision Date
0	Initial release	25 April 2018
1	Updated Section 2.3 to show EUT is a Frequency Hopping device. Throughout report, added U.FL cable used for conducted measurements. Corrected typo in the address.	30 May 2018