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Report On

Application for Grant of Equipment Authorization of the
GroGuru Inc
Bud Transceiver GGBUD001 LoRa Module

FCC Part 15 Subpart C §15.247
RSS-247 Issue 2 February 2017

Report No. SD72133339-1117B **March 2018**

REPORT ON	Radio Testing of the GroGuru Inc LoRa Module
TEST REPORT NUMBER	SD72133339-1117B
PREPARED FOR	GroGuru Inc 13377 Cooper Greens San Diego, CA 92129
CONTACT PERSON	Farooq M Anjum CEO (858) 334-3232 fanjum@groguru.com
PREPARED BY	Xiaoying Zhang **Name** Authorized Signatory Title: EMC/Wireless Test Engineer
APPROVED BY	Ferdinand S. Custodio **Name** Authorized Signatory Title: Senior EMC Test Engineer / Wireless Team Lead
DATED	March 06, 2018

TÜV SÜD AMERICA INC 10040 Mesa Rim Road San Diego, CA 92121-2912 Phone: 858 678 1400 FAX: 858 546 0364

Revision History

SD72133339-1117B GroGuru Inc Bud Transceiver GGBUD001 LoRa Module					
DATE	OLD REVISION	NEW REVISION	REASON	PAGES AFFECTED	APPROVED BY
03/06/2018	Initial Release				Ferdinand Custodio

CONTENTS

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SECTION 1

REPORT SUMMARY

Radio Testing of the
GroGuru Inc
LoRa Module

1.1 INTRODUCTION

The information contained in this report is intended to show verification of the GroGuru Inc Bud Transceiver LoRa Module to the requirements of FCC Part 15 Subpart C §15.247 and RSS-247 Issue 2 February 2017.

Objective	To perform Radio Testing to determine the Equipment Under Test's (EUT's) compliance with the Test Specification, for the series of tests carried out.
Manufacturer	GroGuru Inc
Model Name	Bud Transceiver
Model Number(s)	GGBUD001
FCC ID Number	2AO3P-GGBUD001
IC Number	23668-GGBUD001
Serial Number(s)	Unit 1 (STEM-3DS-EXT Host with Battery Powered) Unit 2 (BASE-VZW-EXT Host with 5 VDC AC/DC Power Supply)
Number of Samples Tested	2
Test Specification/Issue/Date	• FCC Part 15 Subpart C §15.247 (October 1, 2017). • RSS-247 Issue 2 February 2017 - Digital Transmission Systems (DTSs), Frequency Hopping Systems (FHSs) and Licence-Exempt Local Area Network (LE-LAN) Devices. • RSS-Gen - General Requirements for Compliance of Radio Apparatus (Issue 4, November 2014). • 558074 D01 DTS Meas Guidance v03r04,(January 07,2016) Guidance for Performing Compliance Measurements on Digital Transmission Systems (DTS) Operating Under §15.247. • ANSI C63.10-2013. American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices
Start of Test	December 12, 2017
Finish of Test	February 05, 2018
Name of Engineer(s)	Xiaoying Zhang
Related Document(s)	GroGuru Device Operating Instructions.pdf

1.2 BRIEF SUMMARY OF RESULTS

A brief summary of the tests carried out in accordance with FCC Part 15 Subpart C §15.247 with cross-reference to the corresponding IC RSS standard is shown below.

Section	§15.247 Spec Clause	RSS	Test Description	Result	Comments/ Base Standard
2.1	§15.247(b)(3)	RSS-247 5.4(d)	Peak Output Power	Compliant	
2.2	§15.207(a)	RSS-Gen 8.8	Conducted Emissions	Compliant	
2.3		RSS-Gen 6.6	99% Emission Bandwidth	Compliant	
2.4	§15.247(a)(2)	RSS-247 5.2(a)	Minimum 6 dB RF Bandwidth	Compliant	
2.5	§15.247(d)	RSS-247 5.5	Out-of-Band Emissions - Conducted	Compliant	
2.6	§15.247(d)	RSS-247 5.5	Band-edge Compliance of RF Conducted Emissions	Compliant	
2.7	§15.247(d)	RSS-Gen 8.9 and 8.10	Spurious Radiated Emissions	Compliant	
-	-	RSS-Gen 7.1	Receiver Spurious Emissions	N/A	
2.8	§15.247(e)	RSS-247 5.2(b)	Power Spectral Density for Digitally Modulated Device	Compliant	

N/A *Not required as per RSS-Gen 5.3. The EUT has no receiver stand-alone mode.*

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1.3 PRODUCT INFORMATION

1.3.1 Technical Description

The Equipment Under Test (EUT) was a GroGuru Inc GGBUD001 LoRa Module. The EUT is an intelligent (CPU enabled) LoaRa Transceiver module that is the heart of GroGuru's agricultural sensor products. It can be integrated into two hosts: the STEM-3DS-EXT and BASE-VZW-EXT. The STEM-3DS-EXT is a battery powered, Field deployed, wireless agricultural device that is used to measure/report various agricultural parameters. It connects with three Demeter Sensors with fixed length Ethernet cables to take the soil metric data from the Demeter Sensors and forward the data to BASE-VZW-EXT. The BASE-VZW-EXT is the wireless collector device that gathers data from the three Demeter Sensors in the Field, and passes the data to the Cloud where the user can monitor Field/Crop conditions. The GGBUD001 LoRa Module is verified Radiated Spurious Emissions with the two hosts.

1.3.2 EUT General Description

EUT Description	LoRa Module
Model Name	Bud Transceiver
Model Number(s)	GGBUD001
Rated Voltage	Host 1: STEM-3DS-EXT (with three Demeter Sensors) Unit: Powered with two 1.5V Size C Alcaline Batteries. Host 2: BASE-VZW-EXT Unit: 5VDC via AC/DC Power Supply
Mode Verified	LoRa 902 – 928 MHz
Capability	LoRa 902 – 928 MHz
Primary Unit (EUT)	☐ Production ☐ Pre-Production ☒ Engineering
Antenna Type	External Rubber Antenna
Antenna Manufacturer	Laird
Antenna Model Number	P/N 0600-00019
Antenna Gain	Max. 2 dBi

1.3.3 Maximum Peak Conducted Output Power

Mode	Frequency Range (MHz)	Output Power (dBm)	Output Power (mW)
LoRa	902-928	18.89	77.45

1.4 EUT TEST CONFIGURATION

1.4.1 Test Configuration Description

Test Configuration	Description
A	Antenna Conducted Port Single Channel Mode. Actual verifications were performed with the GGBUD001 Module in STEM-3DS-EXT Unit Host. EUT connect to a support Laptop via USB Cable. LoRa Transmitter is set to transmit in fixed channel using Tera Term.
B	Case/Cabinet Radiated Emission Single Channel Mode. Actual verifications were performed with the GGBUD001 Module in both STEM-3DS-EXT Unit (with three Demeter Sensors) and BASE-VZW-EXT Hosts. EUT connect to a support Laptop via USB Cable to setup the channel. LoRa Transmitter is set to transmit in fixed channel using Tera Term.

1.4.2 EUT Exercise Software

Tera Term is used to set the transmitter to transmit in fixed channel.

1.4.3 Support Equipment and I/O cables

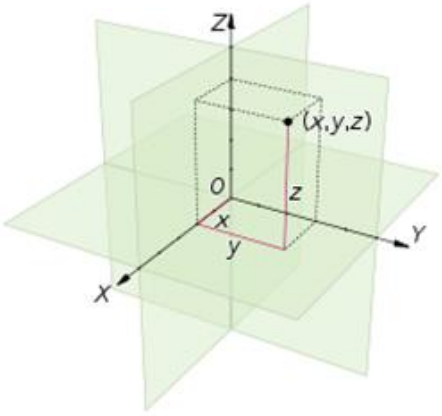
Manufacturer	Equipment/Cable	Description
Dell	Support Laptop	Model Latitude E5500 S/N GRMMMK1
Dell	Support AC Adapter for Laptop	Model HA65NS1-00 S/N CN-0HN662-47890-86G-C9RQ
Triad	AC/DC Power Supply for the BASE-VZW-EXT Unit	Model WS2U050-2000 IP 100-240 VAC 50/60 Hz OP 5.0 VDC 2.0A
Verizon	USB Cellular/WiFi module	Model USB730L FCC ID: PKRNVWMC730

1.4.4 Worst Case Configuration

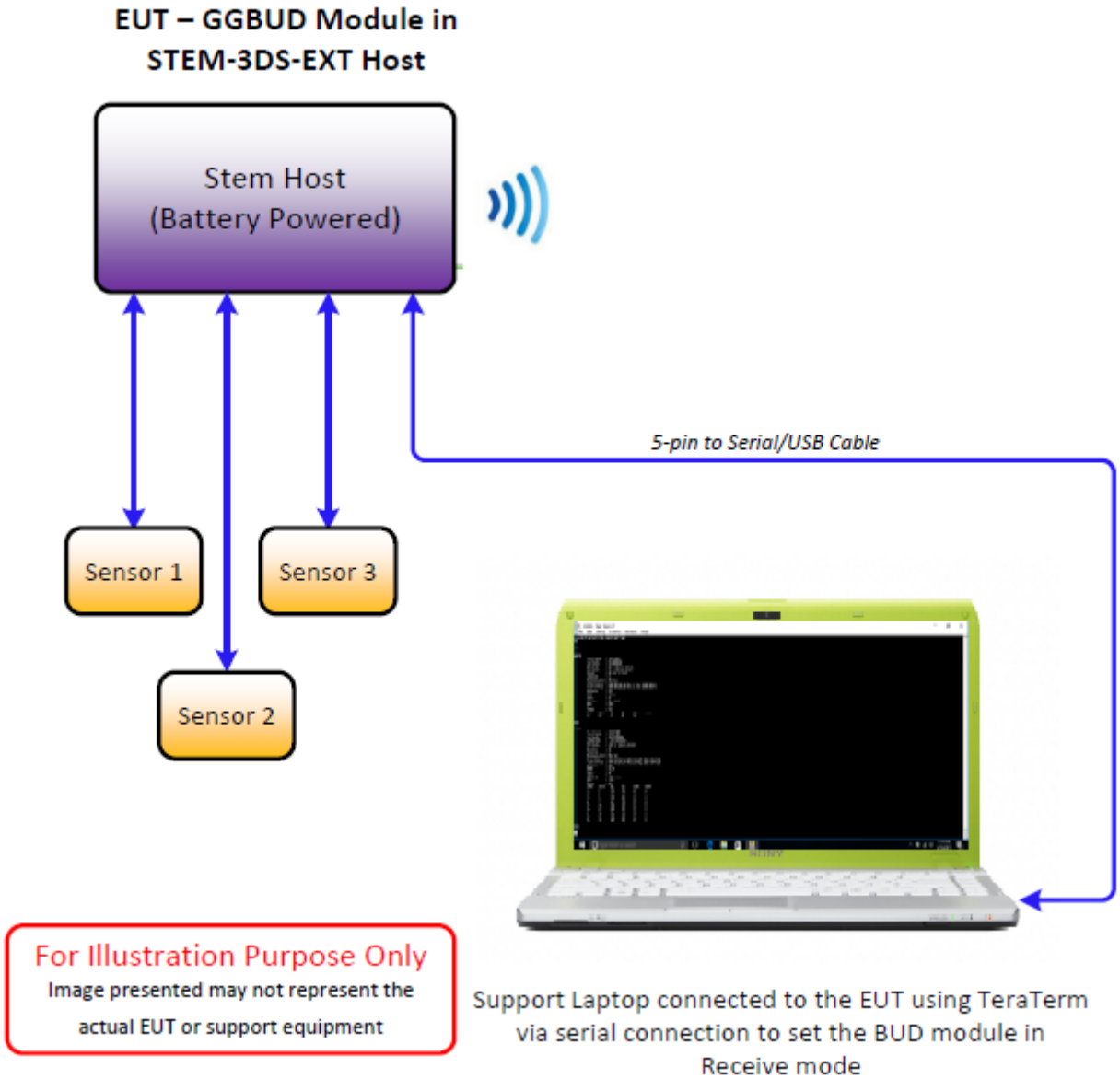
Worst-case configuration used in this test report as per maximum conducted output power measurements:

Mode	Channel	Frequency
LoRa	Mid Channel	915 MHz

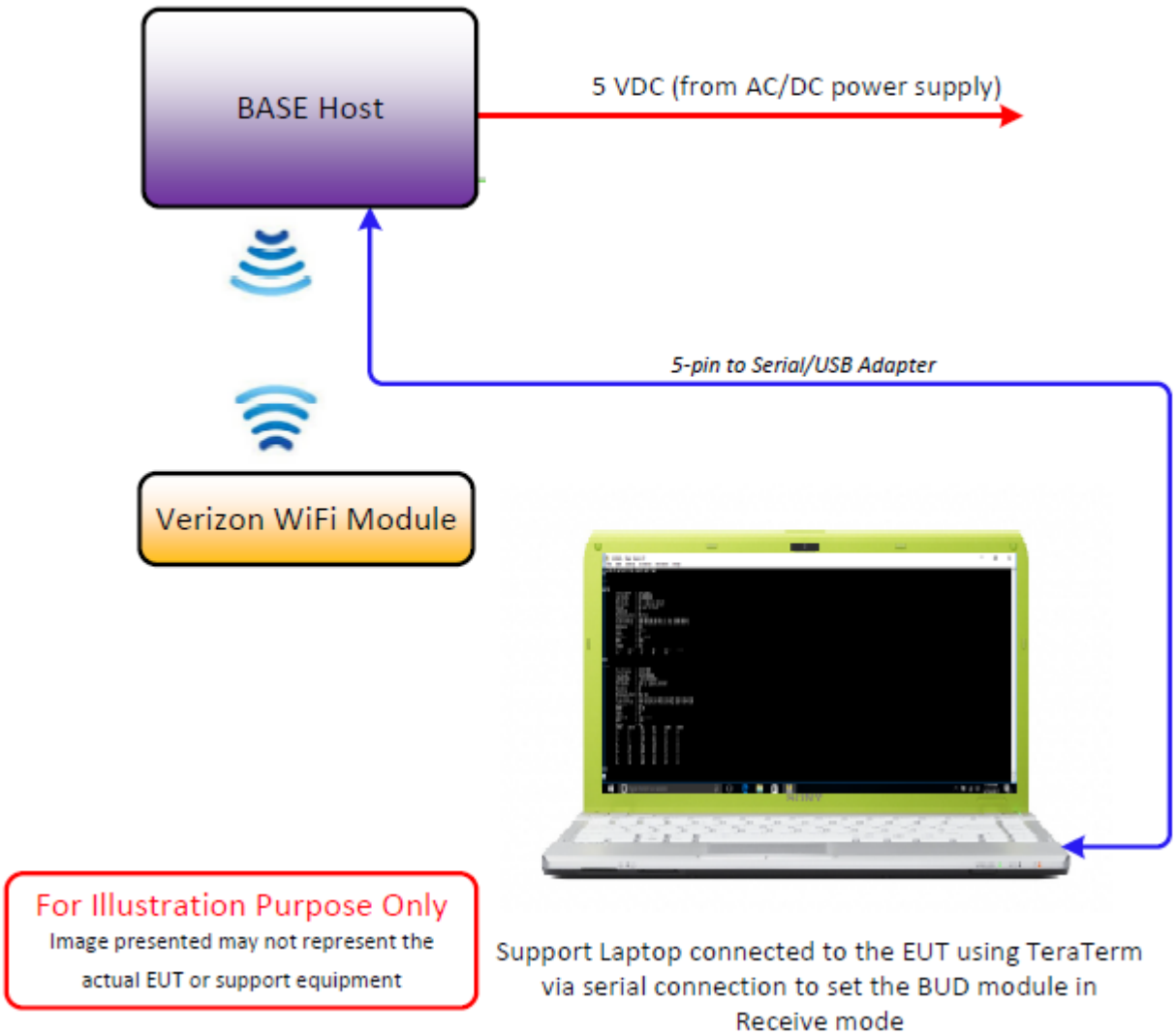
EUT is an RF module. For radiated measurements X, Y and Z orientations were verified. No major variation in emissions observed between the three orientations. Verifications performed using “Z” configuration.



1.4.5 Simplified Test Configuration Diagram



EUT – GGBUD Module in BASE-VZW-EXT Host



Support Laptop connected to the EUT using TeraTerm via serial connection to set the BUD module in Receive mode

1.5 DEVIATIONS FROM THE STANDARD

No deviations from the applicable test standards or test plan were made during testing.

1.6 MODIFICATION RECORD

Description of Modification	Modification Fitted By	Date Modification Fitted
Serial Number Unit 1 and Unit 2		
Modification 1: Change the internal oscillator in Demeter Sensors from 50 MHz to 51.2 MHz.	Weiyang Liu	02/05/2018

The table above details modifications made to the EUT during the test programme. The modifications incorporated during each test (if relevant) are recorded on the appropriate test pages.

1.7 TEST METHODOLOGY

All measurements contained in this report were conducted with ANSI C63.10-2013. American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices.

For conducted and radiated emissions the equipment under test (EUT) was configured to measure its highest possible emission level. This level was based on the maximized cable configuration from exploratory testing per ANSI C63.4-2014. The test modes were adapted according to the Operating Instructions provided by the manufacturer/client.

1.8 TEST FACILITY LOCATION

1.8.1 TÜV SÜD America Inc. (Mira Mesa)

10040 Mesa Rim Road, San Diego, CA 92121-2912 (32.901268,-117.177681). Phone: 858 678 1400 FAX: 858-546 0364

1.8.2 TÜV SÜD America Inc. (Rancho Bernardo)

16936 Via Del Campo, San Diego, CA 92127-1708 (33.018644,-117.092409). Phone: 858 678-1436/65/67 Fax: 858 546 0364.

1.9 TEST FACILITY REGISTRATION

1.9.1 FCC – Designation No.: US1146

TUV SUD America Inc. (San Diego), is an accredited test facility with the site description report on file and has met all the requirements specified in §2.948 of the FCC rules. The acceptance letter from the FCC is maintained in our files and the Designation is US1146.

1.9.2 Innovation, Science and Economic Development Canada (IC) Registration No.: 3067A-1 & 22806-1

The 10m Semi-anechoic chamber of TUV SUD America Inc. (San Diego Rancho Bernardo) has been registered by Certification and Engineering Bureau of Innovation, Science and Economic Development Canada for radio equipment testing with Registration No. 3067A-1.

The 3m Semi-anechoic chamber of TUV SUD America Inc. (San Diego Mira Mesa) has been registered by Certification and Engineering Bureau of Innovation, Science and Economic Development Canada for radio equipment testing with Registration No. 22806-1.

1.9.3 BSMI – Laboratory Code: SL2-IN-E-028R (US0102)

TUV Product Service Inc. (San Diego) is a recognized EMC testing laboratory by the BSMI under the MRA (Mutual Recognition Arrangement) with the United States. Accreditation includes CNS 13438 up to 6GHz.

1.9.4 NCC (National Communications Commission - US0102)

TUV SUD America Inc. (San Diego) is listed as a Foreign Recognized Telecommunication Equipment Testing Laboratory and is accredited to ISO/IEC 17025 (A2LA Certificate No.2955.13) which under APEC TEL MRA Phase 1 was designated as a Conformity Assessment Body competent to perform testing of equipment subject to the Technical Regulations covered under its scope of accreditation including RTTE01, PLMN01 and PLMN08 for TTE type of testing and LP002 for Low-Power RF Device type of testing.

1.9.5 VCCI – Registration No. A-0280 and A-0281

TUV SUD America Inc. (San Diego) is a VCCI registered measurement facility which includes radiated field strength measurement, radiated field strength measurement above 1GHz, mains port interference measurement and telecommunication port interference measurement.

1.9.6 RRA – Identification No. US0102

TUV SUD America Inc. (San Diego) is National Radio Research Agency (RRA) recognized laboratory under Phase I of the APEC Tel MRA.

1.9.7 OFCA – U.S. Identification No. US0102

TUV SUD America Inc. (San Diego) is recognized by Office of the Communications Authority (OFCA) under Appendix B, Phase I of the APEC Tel MRA.

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SECTION 2

TEST DETAILS

Radio Testing of the
GroGuru Inc
LoRa Module

2.1 PEAK OUTPUT POWER

2.1.1 Specification Reference

Part 15 Subpart C §15.247(b)(3) and RSS-247 5.4(d)

2.1.2 Standard Applicable

(3) For systems using digital modulation in the 902–928 MHz, 2400–2483.5 MHz, and 5725–5850 MHz bands: 1 Watt. 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. Maximum Conducted Output Power is defined as 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. Power must be summed across all antennas and antenna elements. The average must not include any time intervals during which the transmitter is off or is transmitting at a reduced power level. If multiple modes of operation are possible (e.g., alternative modulation methods), the maximum conducted output power is the highest total transmit power occurring in any mode.

2.1.3 Equipment Under Test and Modification State

Serial No: Unit 1 (STEM-3DS-EXT) / Test Configuration A

2.1.4 Date of Test/Initial of test personnel who performed the test

December 12, 2016/XYZ

2.1.5 Test Equipment Used

The major items of test equipment used for the above tests are identified in Section 3.1.

2.1.6 Environmental Conditions

Test performed at TÜV SÜD America Inc. Rancho Bernardo facility

Ambient Temperature	25.0 °C
Relative Humidity	14.0 %
ATM Pressure	99.3 kPa

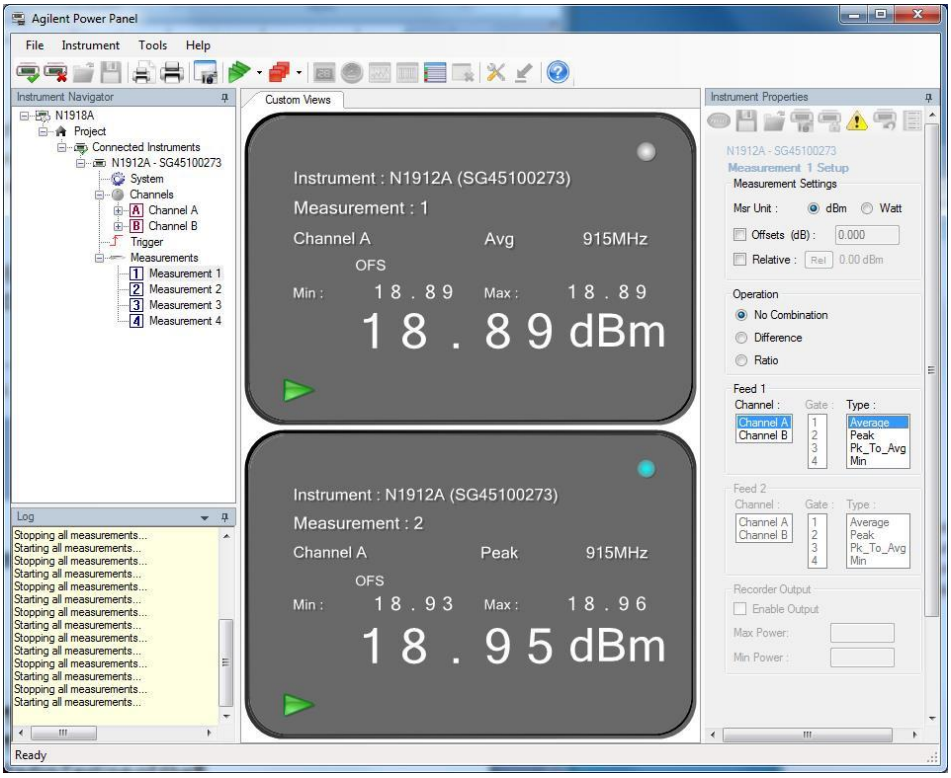
2.1.7 Additional Observations

- This is a conducted test (Maximum peak conducted output power) using direct connection to a broadband power meter with a video bandwidth greater than the DTS bandwidth.
- An offset of 20.6dB was added to compensate for the external attenuator and cable used from the antenna port to the power sensor.
- Test methodology is per Clause 9.1.3 of KDB 558074 D01 DTS Meas Guidance v04 (April 05, 2017) Guidance for Performing Compliance Measurements on Digital Transmission Systems (DTS) Operating Under Section §15.247.
- Both Peak and Average measurements were recorded.

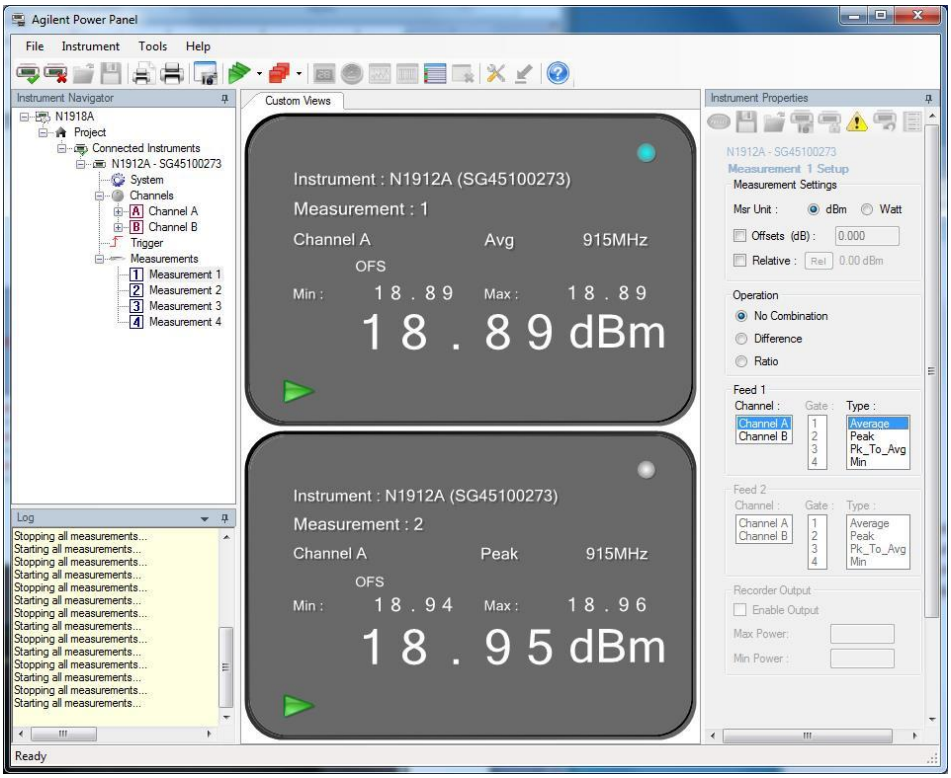
2.1.8 Test Results

Channel	Measured Average Power (dBm)	Measured Peak Power (dBm)
Low Channel (903 MHz)	18.89	18.95
Middle Channel (915 MHz)	18.89	18.95
High Channel (927 MHz)	18.88	18.94

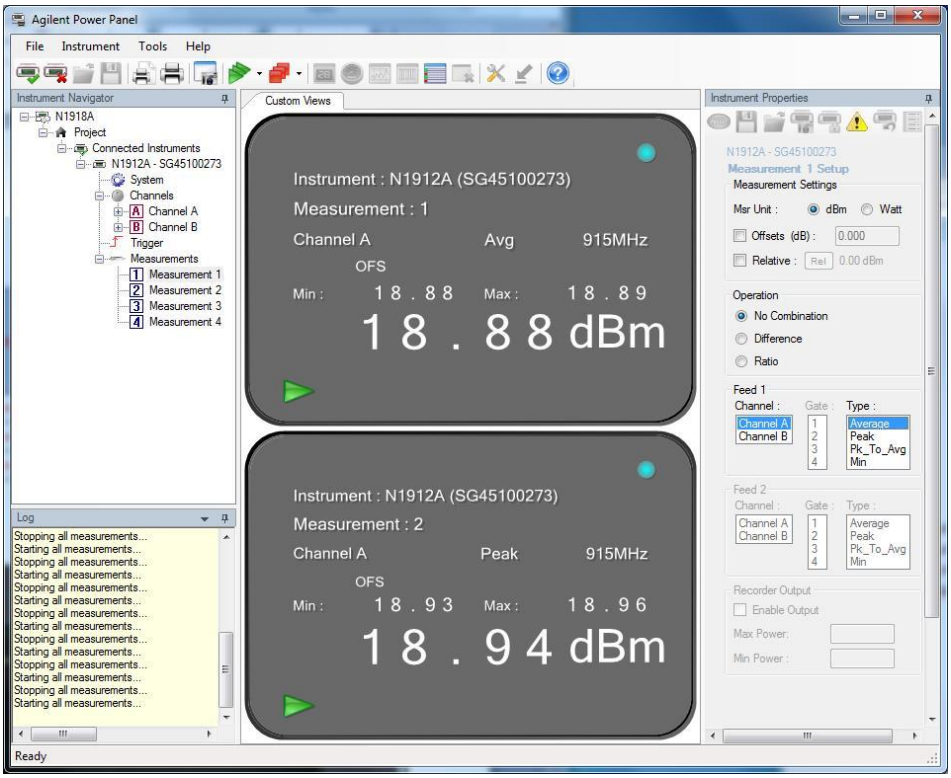
2.1.9 Test Plots



Low Channel 903 MHz

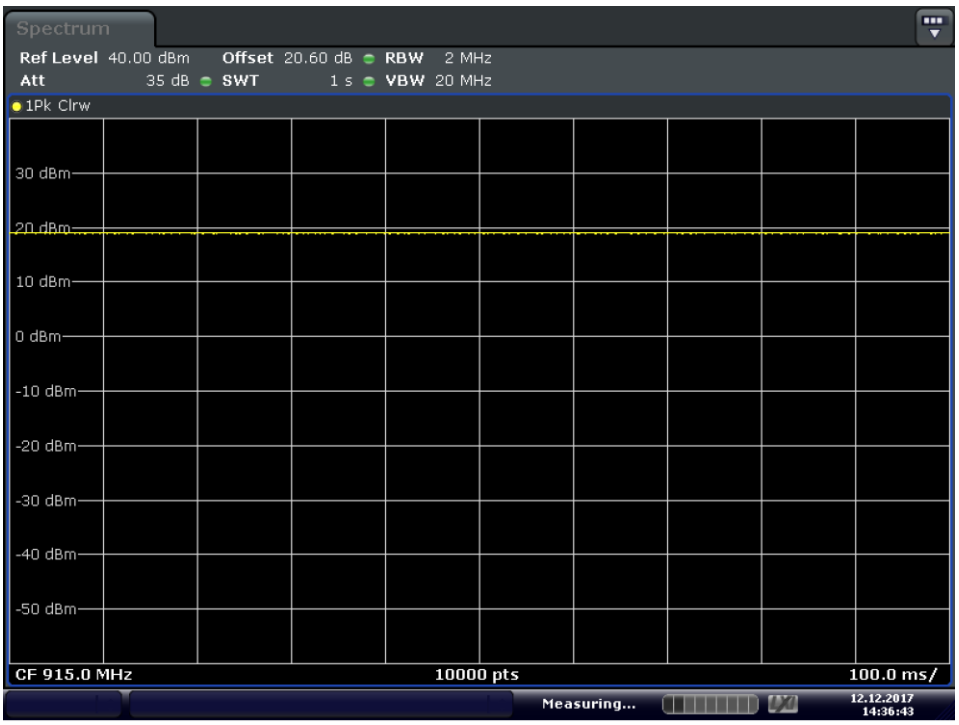


Mid Channel 915 MHz



High Channel 927 MHz

2.1.10 Duty Cycle Verification



Date: 12.DEC.2017 14:36:44

1s sweep plot showing 100% duty cycle (Duty Cycle Measurement Factor calculation not required)

2.2 CONDUCTED EMISSIONS

2.2.1 Specification Reference

Part 15 Subpart C §15.207(a) and RSS-Gen 8.8

2.2.2 Standard Applicable

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).

Frequency of emission (MHz)	Conducted limit (dBµV)	
	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.*

2.2.3 Equipment Under Test and Modification State

Serial No: Unit 2 (BASE-VZW-EXT Unit) / Test Configuration B

2.2.4 Date of Test/Initial of test personnel who performed the test

December 13, 2017 /XYZ

2.2.5 Test Equipment Used

The major items of test equipment used for the above tests are identified in Section 3.1.

2.2.6 Environmental Conditions/ Test Location

Test performed at TÜV SÜD America Inc. Rancho Bernardo facility

Ambient Temperature	24.2 °C
Relative Humidity	12.8 %
ATM Pressure	99.2 kPa

2.2.7 Additional Observations

The test is performed on AC/DC Power Supply of the BASE-VZW-EXT Unit. The STEM-3DS-EXT Unit is not applicable for it is battery powered.

Measurement was done using EMC32 automated software. Reported level is the actual level with all the correction factors factored in. Correction Factor column is for informational purposes only. See Section 2.4.2 for sample computation.

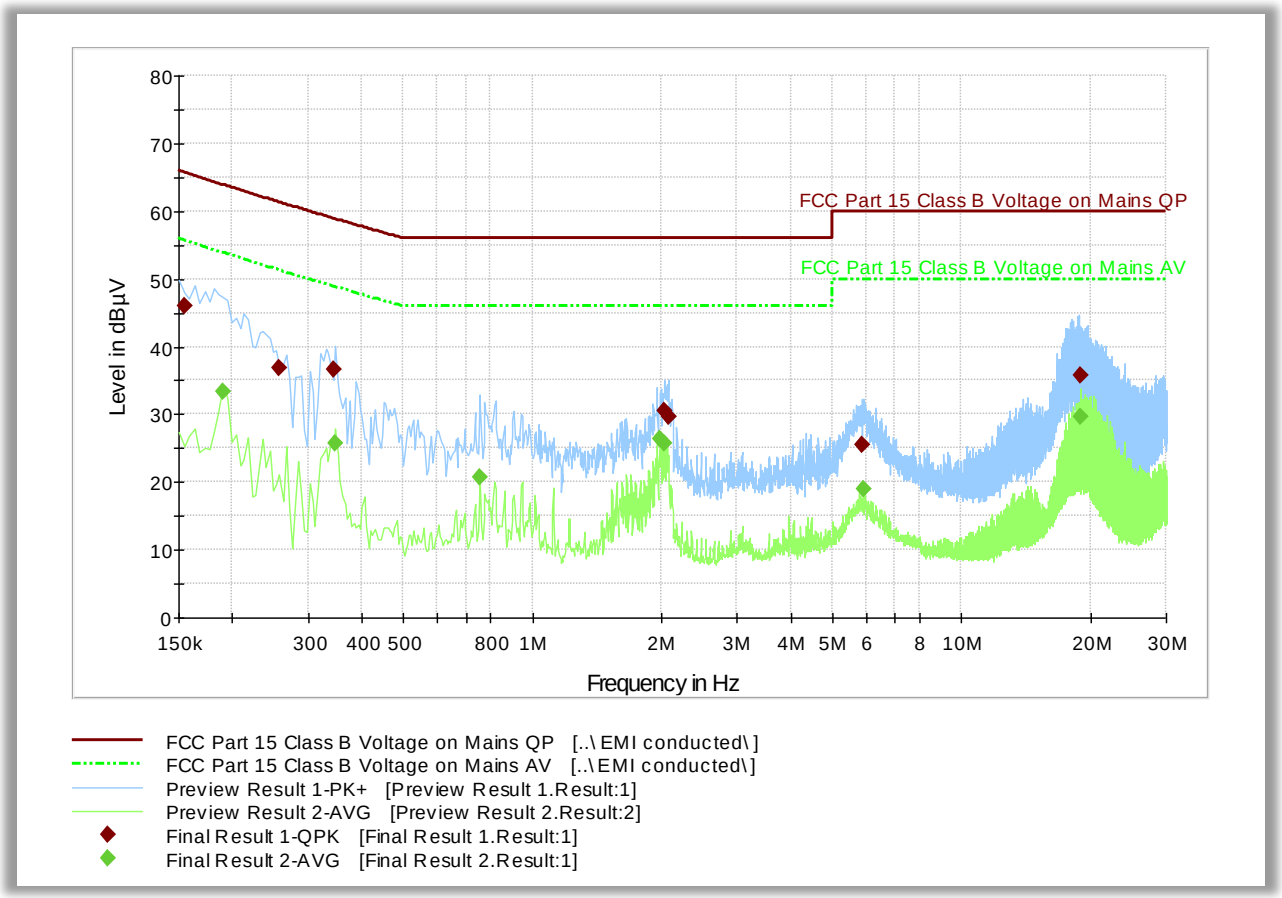
2.2.8 Sample Computation (Conducted Emission – Quasi Peak)

Measuring equipment raw measurement (dbµV) @ 150kHz			5.5
Correction Factor (dB)	Asset# 8607 (20 dB attenuator)	19.9	20.7
	Asset# 1177 (cable)	0.15	
	Asset# 1176 (cable)	0.35	
	Asset# 7568 (LISN)	0.30	
Reported QuasiPeak Final Measurement (dbµV) @ 150kHz			**26.2**

2.2.9 Test Results

Compliant. See attached plots and tables.

2.2.1 120VAC 60Hz (Line 1)



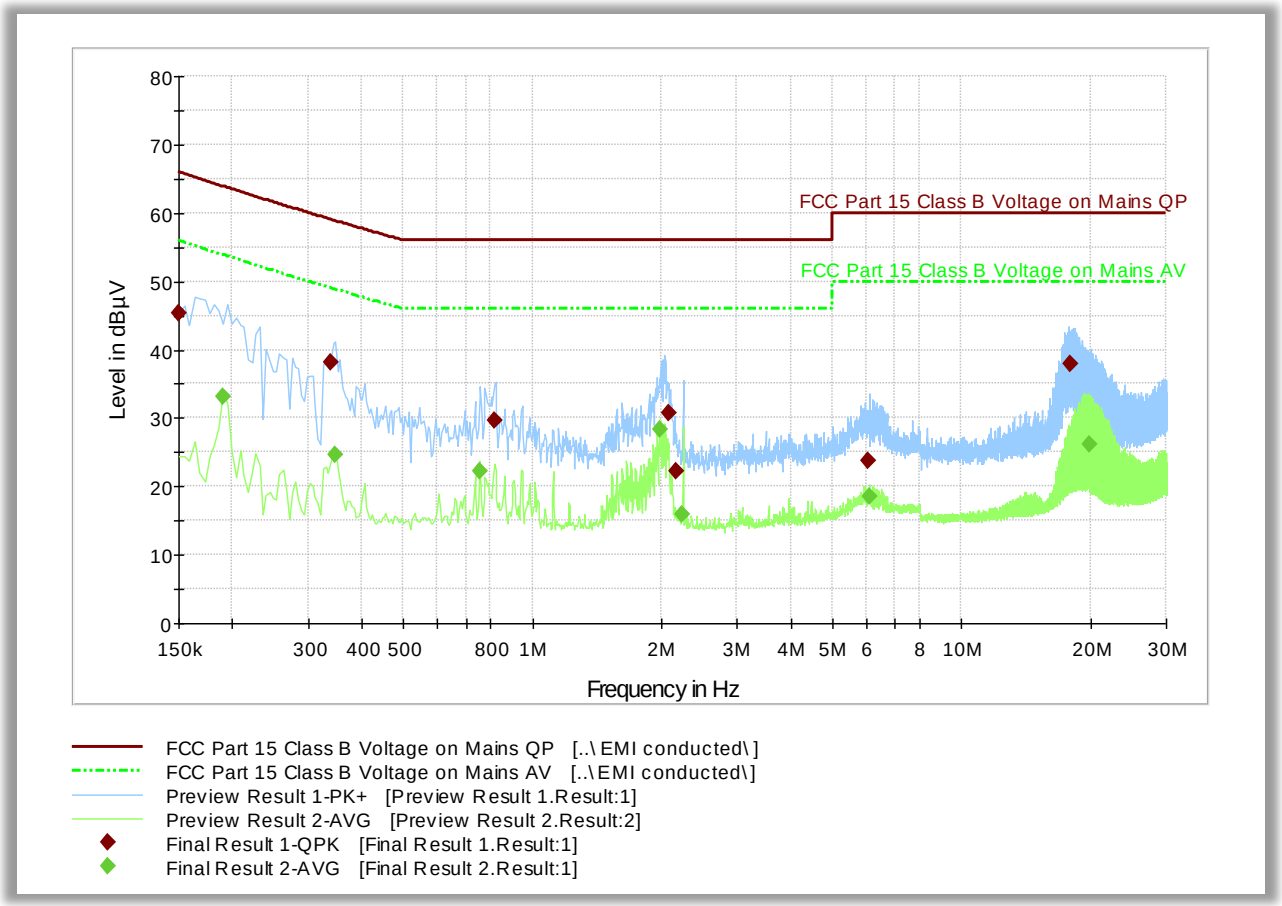
Quasi Peak

Frequency (MHz)	QuasiPeak (dBµV)	Meas. Time (ms)	Bandwidth (kHz)	Filter	Line	Corr. (dB)	Margin - QPK (dB)	Limit - QPK (dBµV)
0.154500	46.1	1000.0	9.000	Off	L1	20.0	19.6	65.7
0.258000	36.9	1000.0	9.000	Off	L1	19.8	24.3	61.3
0.343500	36.7	1000.0	9.000	Off	L1	20.1	22.3	58.9
2.031000	30.4	1000.0	9.000	Off	L1	20.0	25.6	56.0
2.080500	29.6	1000.0	9.000	Off	L1	20.0	26.4	56.0
5.892000	25.4	1000.0	9.000	Off	L1	20.4	34.6	60.0
18.933000	35.7	1000.0	9.000	Off	L1	20.7	24.3	60.0

Average

Frequency (MHz)	Average (dBµV)	Meas. Time (ms)	Bandwidth (kHz)	Filter	Line	Corr. (dB)	Margin - Ave (dB)	Limit - Ave (dBµV)
0.190500	33.4	1000.0	9.000	Off	L1	19.9	20.4	53.9
0.348000	25.7	1000.0	9.000	Off	L1	20.1	23.1	48.8
0.757500	20.7	1000.0	9.000	Off	L1	20.0	25.3	46.0
1.990500	26.3	1000.0	9.000	Off	L1	20.0	19.7	46.0
2.035500	25.7	1000.0	9.000	Off	L1	20.0	20.4	46.0
5.910000	19.1	1000.0	9.000	Off	L1	20.4	30.9	50.0
18.937500	29.5	1000.0	9.000	Off	L1	20.7	20.5	50.0

2.2.2 120VAC 60Hz (Line 2)



Quasi Peak

Frequency (MHz)	QuasiPeak (dBµV)	Meas. Time (ms)	Bandwidth (kHz)	Filter	Line	Corr. (dB)	Margin - QPK (dB)	Limit - QPK (dBµV)
0.150000	45.4	1000.0	9.000	Off	N	20.0	20.6	66.0
0.339000	38.1	1000.0	9.000	Off	N	20.1	21.0	59.0
0.816000	29.7	1000.0	9.000	Off	N	20.1	26.3	56.0
2.080500	30.8	1000.0	9.000	Off	N	20.0	25.2	56.0
2.161500	22.3	1000.0	9.000	Off	N	20.0	33.7	56.0
6.067500	23.8	1000.0	9.000	Off	N	20.4	36.2	60.0
17.907000	38.0	1000.0	9.000	Off	N	20.7	22.0	60.0

Average

Frequency (MHz)	Average (dBµV)	Meas. Time (ms)	Bandwidth (kHz)	Filter	Line	Corr. (dB)	Margin - Ave (dB)	Limit - Ave (dBµV)
0.190500	33.1	1000.0	9.000	Off	N	19.9	20.8	53.9
0.348000	24.6	1000.0	9.000	Off	N	20.1	24.2	48.8
0.757500	22.3	1000.0	9.000	Off	N	20.1	23.7	46.0
1.990500	28.4	1000.0	9.000	Off	N	20.0	17.6	46.0
2.229000	16.0	1000.0	9.000	Off	N	20.1	30.0	46.0
6.130500	18.6	1000.0	9.000	Off	N	20.4	31.4	50.0
19.833000	26.1	1000.0	9.000	Off	N	20.7	23.9	50.0

2.3 99% EMISSION BANDWIDTH

2.3.1 Specification Reference

RSS-Gen Clause 6.6

2.3.2 Standard Applicable

The emission bandwidth (x dB) 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 x dB below the maximum in-band spectral density of the modulated signal. Spectral density (power per unit bandwidth) is to be measured with a detector of resolution bandwidth in the range of 1% to 5% of the anticipated emission bandwidth, and a video bandwidth at least 3x the resolution bandwidth.
When the occupied bandwidth limit is not stated in the applicable RSS or reference measurement method, the transmitted signal bandwidth shall be reported as the 99% emission bandwidth, as calculated or measured.

- The transmitter shall be operated at its maximum carrier power measured under normal test conditions.
- • The span of the analyzer shall be set to capture all products of the modulation process, including the emission skirts.
- • The resolution bandwidth (RBW) shall be in the range of 1% to 5% of the occupied bandwidth (OBW) and video bandwidth (VBW) shall be approximately 3x RBW.

Note: Video averaging is not permitted.
A peak, or peak hold, may be used in place of the sampling detector as this may produce a wider bandwidth than the actual bandwidth (worst-case measurement). Use of a peak hold may be necessary to determine the occupied bandwidth if the device is not transmitting continuously.
The trace data points are recovered and are directly summed in linear power level terms. The recovered amplitude data points, beginning at the lowest frequency, are placed in a running sum until 0.5% of the total is reached and that frequency recorded. The process is repeated for the highest frequency data points (starting at the highest frequency, at the right side of the span, and going down in frequency). This frequency is then recorded.
The difference between the two recorded frequencies is the 99% occupied bandwidth.

2.3.3 Equipment Under Test and Modification State

Serial No: Unit 1 (STEM-3DS-EXT) / Test Configuration A

2.3.4 Date of Test/Initial of test personnel who performed the test

December 12, 2017/XYZ

2.3.5 Test Equipment Used

The major items of test equipment used for the above tests are identified in Section 3.1.

2.3.6 Environmental Conditions/ Test Location

Test performed at TÜV SÜD America Inc. Rancho Bernardo facility

Ambient Temperature	25.0 °C
Relative Humidity	14.0.%
ATM Pressure	99.3 kPa

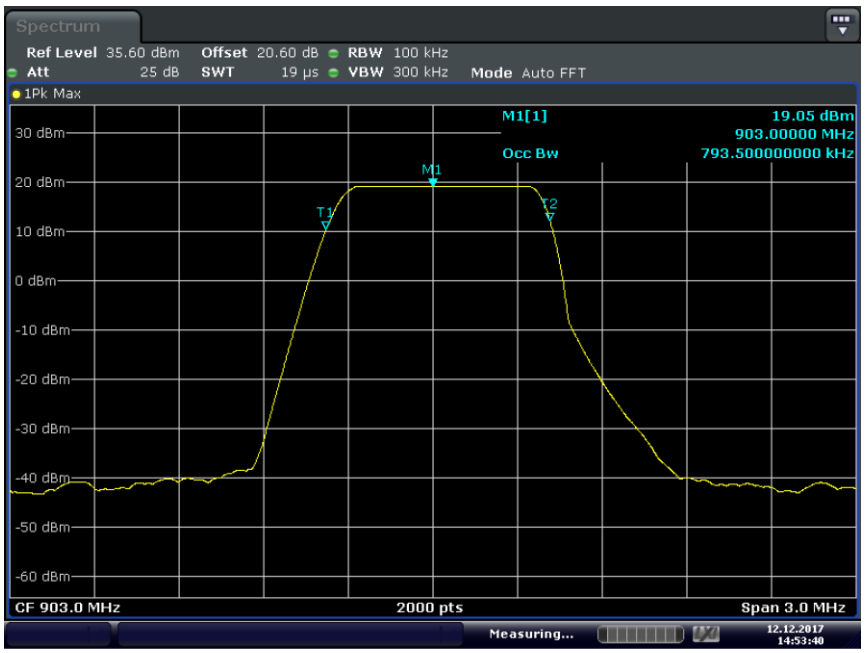
2.3.7 Additional Observations

- This is a conducted test.
- An offset of 20.6dB was added to compensate for the external attenuator and cable used from the antenna port to the spectrum analyzer.
- Span is wide enough to capture the channel transmission.
- RBW is 1% 100 kHz.
- VBW is 3 x RBW.
- Sweep is Auto.
- Detector is Peak.
- Trace mode is Max Hold
- The % Power Bandwidth setting in the spectrum analyzer was set to 99% (default).
- The Channel Bandwidth measurement function of the spectrum analyzer was used for this test.

2.3.8 Test Results (For reporting purposes only)

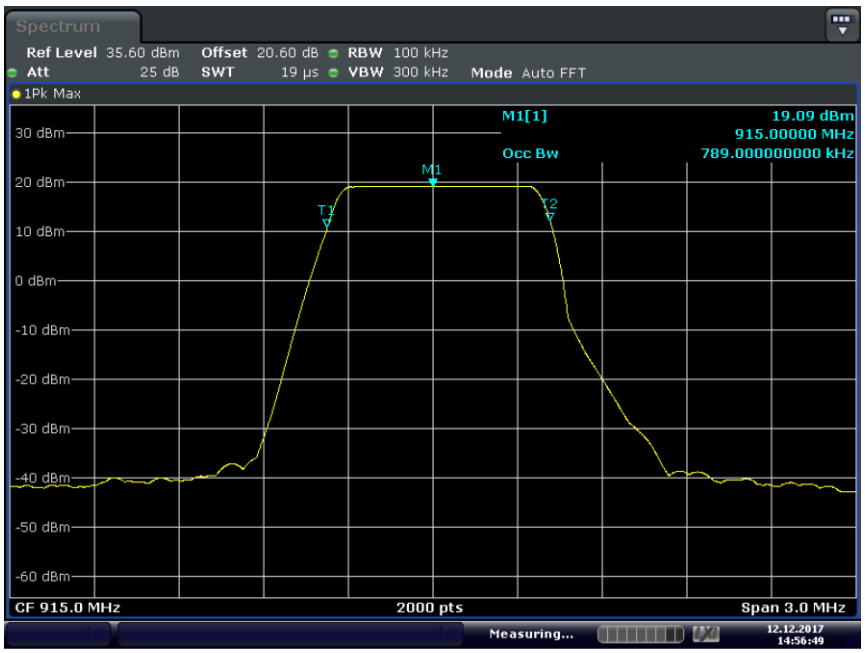
Mode	Channel	Measured 99% Bandwidth (kHz)
LoRA	903 MHz	793.5
	915 MHz	789.0
	927 MHz	793.5

2.3.9 Test Results Plots



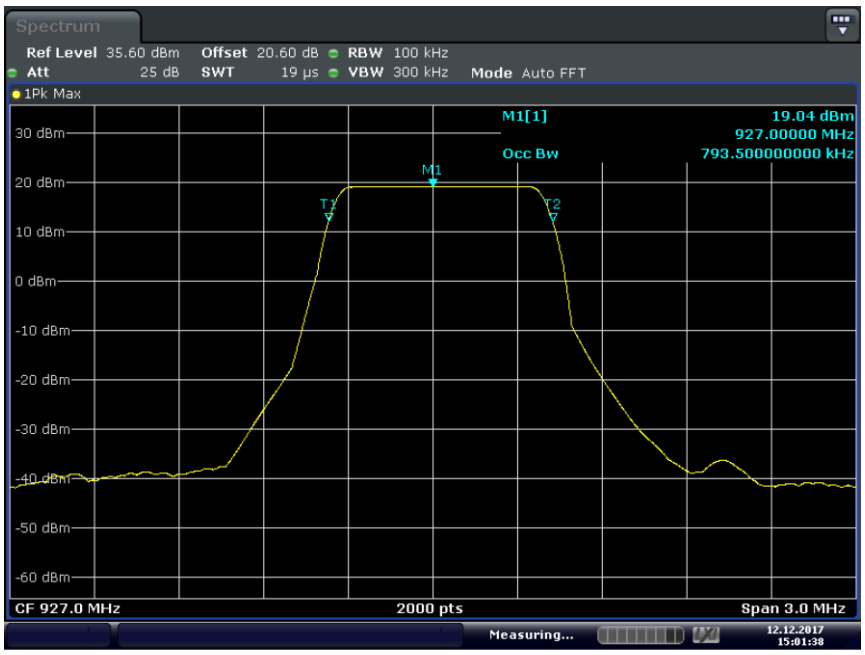
Date: 12.DEC.2017 14:53:40

Low Channel 903 MHz



Date: 12.DEC.2017 14:56:49

Mid Channel 915 MHz



Date: 12.DEC.2017 15:01:38

High Channel 927 MHz

2.4 MINIMUM 6 dB RF BANDWIDTH

2.4.1 Specification Reference

Part 15 Subpart C §15.247(a)(2) and RSS-247 5.2(a)

2.4.2 Standard Applicable

(2) Systems using digital modulation techniques may operate in the 902–928 MHz, 2400–2483.5 MHz, and 5725–5850 MHz bands. The minimum 6 dB bandwidth shall be at least 500 kHz.

2.4.3 Equipment Under Test and Modification State

Serial No: Unit 1 (STEM-3DS-EXT) / Test Configuration A

2.4.4 Date of Test/Initial of test personnel who performed the test

December 12, 2017 / XYZ

2.4.5 Test Equipment Used

The major items of test equipment used for the above tests are identified in Section 3.1.

2.4.6 Environmental Conditions/ Test Location

Test performed at TÜV SÜD America Inc. Rancho Bernardo facility

Ambient Temperature	25.0 °C
Relative Humidity	14.0.%
ATM Pressure	99.3 kPa

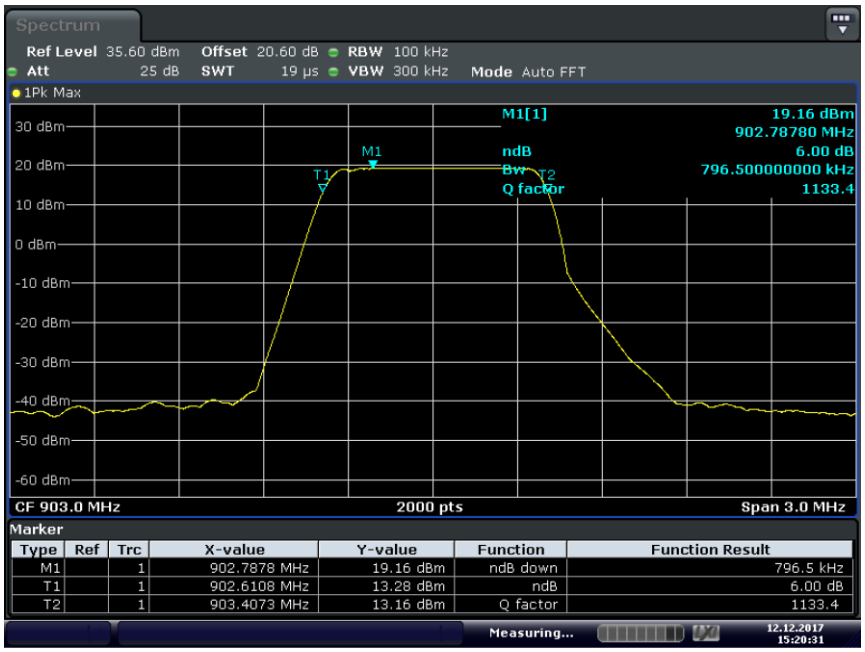
2.4.7 Additional Observations

- This is a conducted test.
- An offset of 20.6dB was added to compensate for the external attenuator and cable used from the antenna port to the spectrum analyzer.
- Span is wide enough to capture the channel transmission.
- RBW was set to 100 kHz while VBW is ≥3 x RBW.
- Sweep is auto while Detector used is Peak.
- Trace mode is Max Hold.
- The “n” dB down marker function of the spectrum analyzer was used for this test.

2.4.8 Test Results

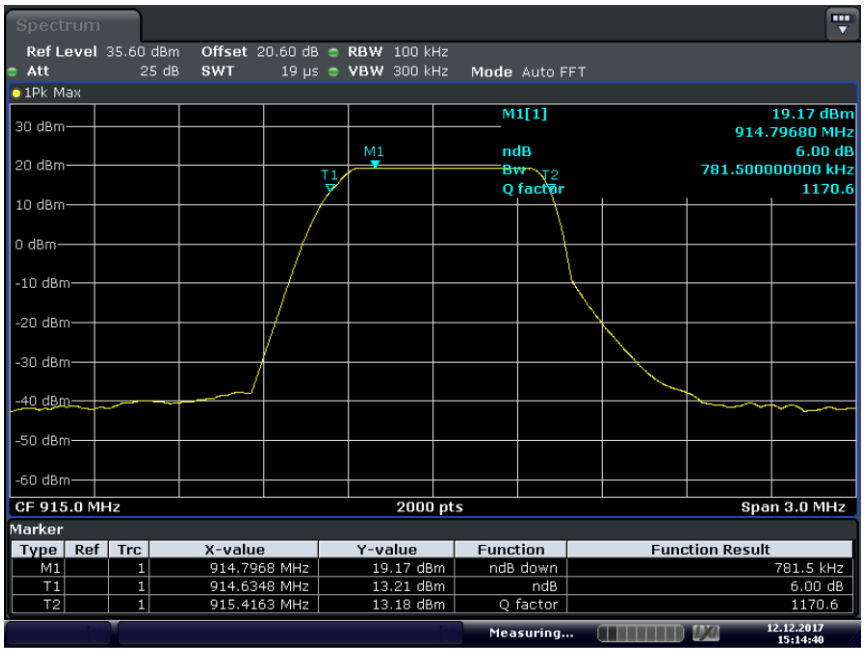
Mode	Channel	Measured Bandwidth (MHz)	Minimum Bandwidth Limit (MHz)	Compliance
LoRa	903 MHz	796.5	0.500	Complies
	915 MHz	781.5	0.500	Complies
	927 MHz	789.0	0.500	Complies

2.4.9 Test Results Plots



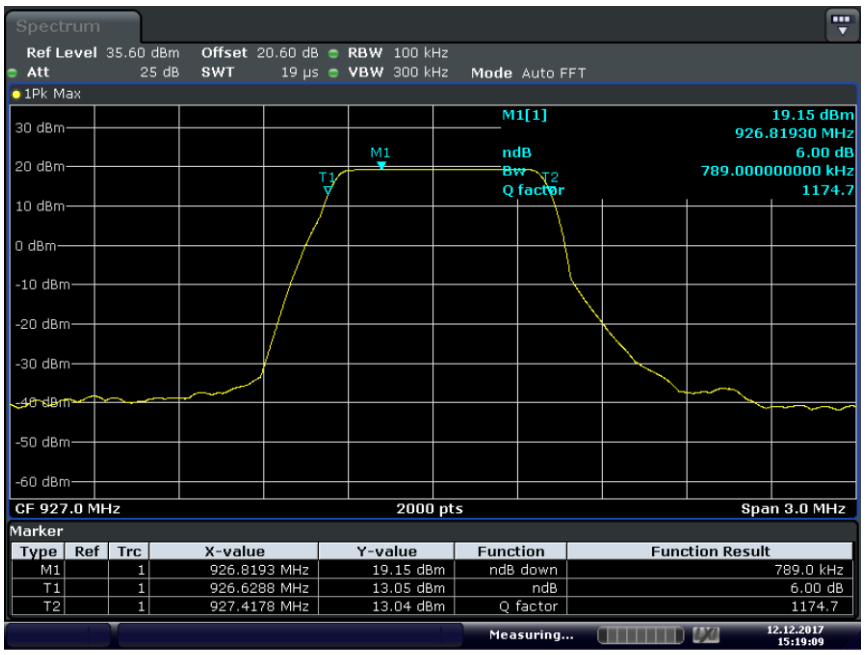
Date: 12.DEC.2017 15:20:30

Low Channel



Date: 12.DEC.2017 15:14:40

Mid Channel 915 MHz



Date: 12.DEC.2017 15:19:10

High Channel 927 MHz

2.5 OUT-OF-BAND EMISSIONS - CONDUCTED

2.5.1 Specification Reference

Part 15 Subpart C §15.247(d) and RSS-247 5.5

2.5.2 Standard Applicable

(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, based on either an RF conducted or a radiated measurement, provided the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, as permitted under paragraph (b)(3) of this section, the attenuation required under this paragraph shall be 30 dB instead of 20 dB. Attenuation below the general limits specified in §15.209(a) is not required. In addition, radiated emissions which fall in the restricted bands, as defined in §15.205(a), must also comply with the radiated emission limits specified in §15.209(a) (see §15.205(c)).

2.5.3 Equipment Under Test and Modification State

Serial No: Unit 1 (STEM-3DS-EXT) / Test Configuration A

2.5.4 Date of Test/Initial of test personnel who performed the test

December 12, 2017 / XYZ

2.5.5 Test Equipment Used

The major items of test equipment used for the above tests are identified in Section 3.1.

2.5.6 Environmental Conditions/ Test Location

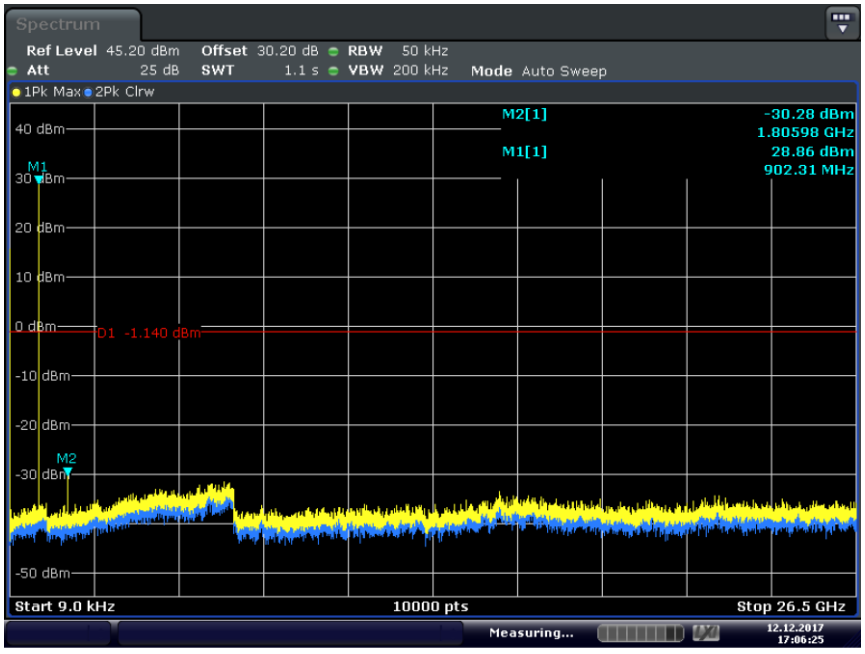
Test performed at TÜV SÜD America Inc. Rancho Bernardo facility

Ambient Temperature	25.0 °C
Relative Humidity	14.0.%
ATM Pressure	99.3 kPa

2.5.7 Additional Observations

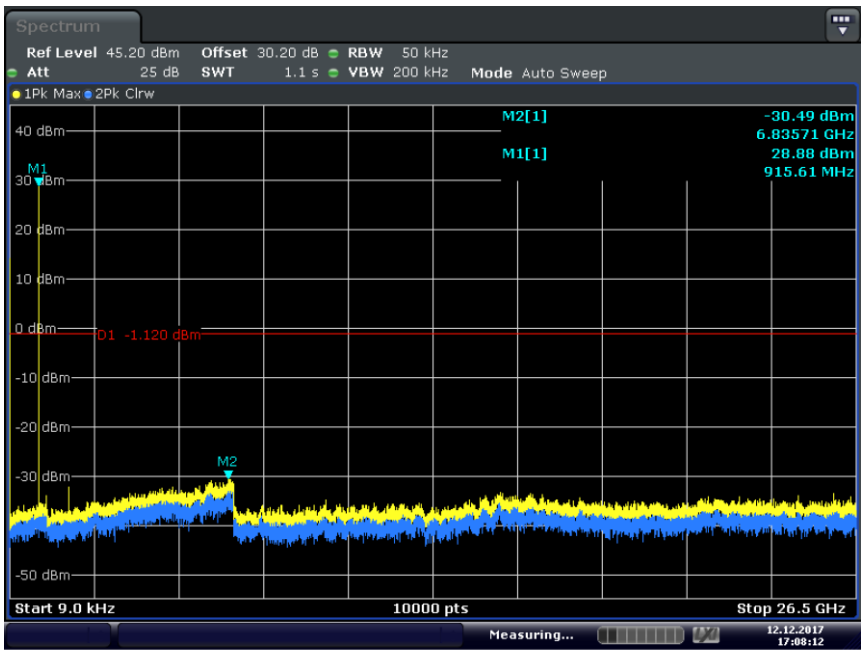
- This is a conducted test.
- An offset of 30.2 dB (worst case attenuation within frequency range 9 kHz to 26.5 GHz) was added to compensate for the external attenuator and cable used from the antenna port to the spectrum analyzer.
- RBW is 100kHz.VBW is 3 x RBW.
- Sweep is Auto. Detector is Peak. Trace is Max Hold.
- Initial scan was performed to determine the highest level of the desired power within the band. Limit (display line) was drawn 30dB below this level (worst case).
- Spectrum was searched from 9 kHz up to 26.5GHz.

2.5.8 Test Results Plots



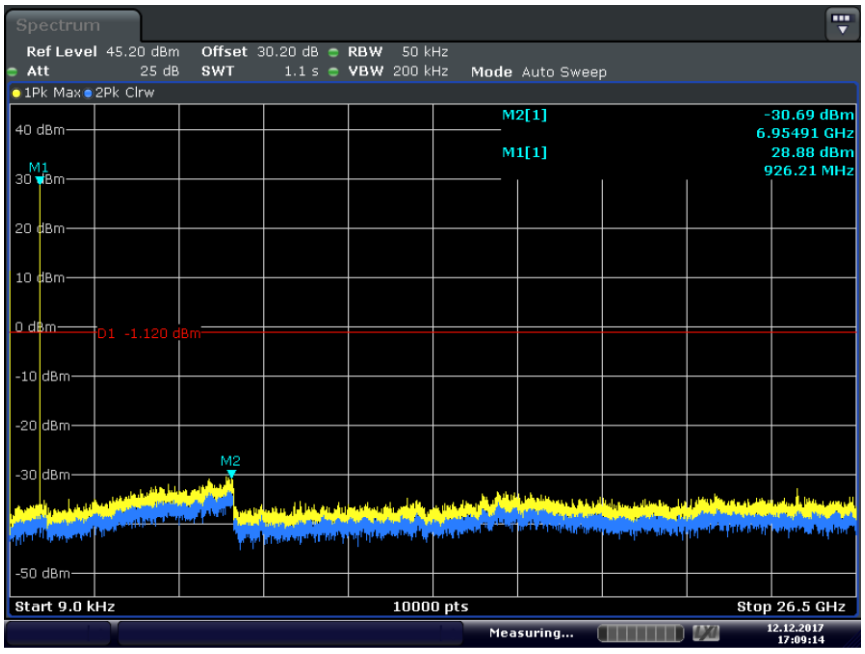
Date: 12.DEC.2017 17:06:26

Low Channel 903 MHz



Date: 12.DEC.2017 17:08:12

Mid Channel 915 MHz



Date: 12.DEC.2017 17:09:14

High Channel 927 MHz

2.6 BAND-EDGE COMPLIANCE OF RF CONDUCTED EMISSIONS

2.6.1 Specification Reference

Part 15 Subpart C §15.247(d) and RSS-247 5.5

2.6.2 Standard Applicable

See previous test.

2.6.3 Equipment Under Test and Modification State

Serial No: Unit 1 (STEM-3DS-EXT) / Test Configuration A

2.6.4 Date of Test/Initial of test personnel who performed the test

December 12, 2017 / XYZ

2.6.5 Test Equipment Used

The major items of test equipment used for the above tests are identified in Section 3.1.

2.6.6 Environmental Conditions/ Test Location

Test performed at TÜV SÜD America Inc. Rancho Bernardo facility

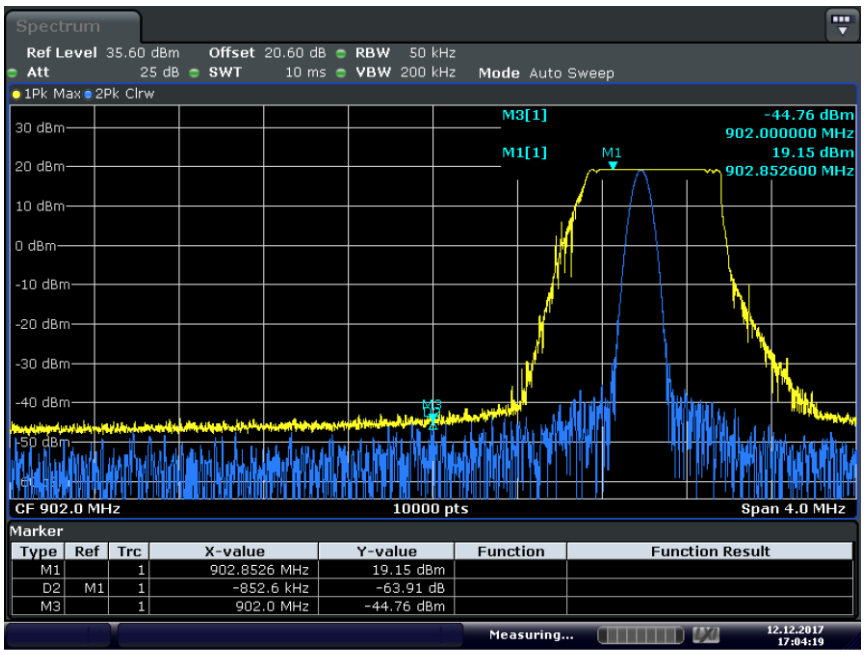
Ambient Temperature	25.0 °C
Relative Humidity	14.0.%
ATM Pressure	99.3 kPa

2.6.7 Additional Observations

- This is a conducted test.
- An offset of 20.6dB was added to compensate for the external attenuator and cable used from the antenna port to the spectrum analyzer.
- RBW is 100kHz.VBW is 3 x RBW.
- Sweep is Auto. Detector is Peak. Trace is Max Hold.
- Trace was centered on the band-edge frequency.
- Span was set to encompass the band-edge frequency and the peak of the emission.
- Using Marker function, peak of the emission was determined and the delta to the band-edge frequency measured (for EUT OBW edge not within 2MHz of the authorized band edge).

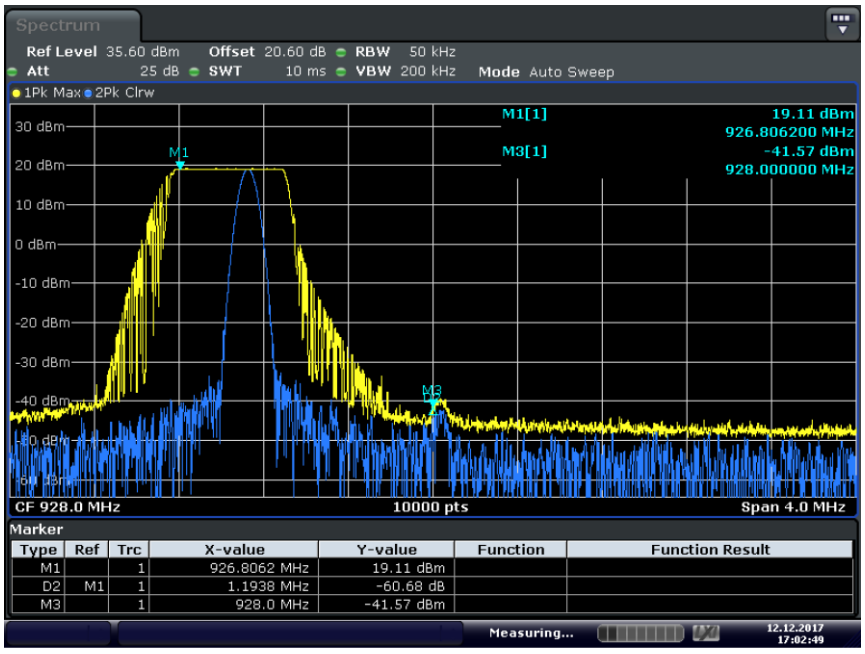
2.6.8 Test Results

Complies. See attached plots.



Date: 12.DEC.2017 17:04:18

Low Channel Band Edge 902 MHz (-63.91 dBc)



Date: 12.DEC.2017 17:02:49

High Channel Band Edge 928 MHz (-60.68 dBc)

2.7 SPURIOUS RADIATED EMISSIONS

2.7.1 Specification Reference

Part 15 Subpart C §15.247(d) and RSS-Gen 8.9 and 8.10

2.7.2 Standard Applicable

(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, based on either an RF conducted or a radiated measurement, provided the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, as permitted under paragraph (b)(3) of this section, the attenuation required under this paragraph shall be 30 dB instead of 20 dB. Attenuation below the general limits specified in §15.209(a) is not required. In addition, radiated emissions which fall in the restricted bands, as defined in §15.205(a), must also comply with the radiated emission limits specified in §15.209(a) (see §15.205(c)).

2.7.3 Equipment Under Test and Modification State

Serial No: Unit 1 (STEM-3DS-EXT) and Unit 2 (BASE-VZW-EXT) / Test Configuration B and Modification 1

2.7.4 Date of Test/Initial of test personnel who performed the test

December 18, 2017 and February 05, 2018/XYZ

2.7.5 Test Equipment Used

The major items of test equipment used for the above tests are identified in Section 3.1.

2.7.6 Environmental Conditions

Test performed at TÜV SÜD America Inc. Rancho Bernardo facility

Ambient Temperature	22.4 - 22.7 °C
Relative Humidity	21.2 - 31.8%
ATM Pressure	99.0 - 99.6 kPa

2.7.7 Additional Observations

- This is a radiated test. The spectrum was searched from 30MHz to the 10th harmonic.
- Test Methodology is per Clause 12.2.7 of Test methodology is per Clause 9.1.3 of KDB 558074 D01 DTS Meas Guidance v04 (April 05, 2017).
- There are no emissions found that do not comply to the restricted bands defined in FCC Part 15 Subpart C, 15.205 or Part 15.247(d).
- Only the worst case channel presented. EUT has an integrated antenna and can't be terminated for this test (cabinet spurious emissions).

- Only noise floor measurements observed above 18GHz.
- Measurement was done using EMC32 automated software. Reported level is the actual level with all the correction factors factored in. Correction Factor column is for informational purposes only. See Section 2.7.8 for sample computation.

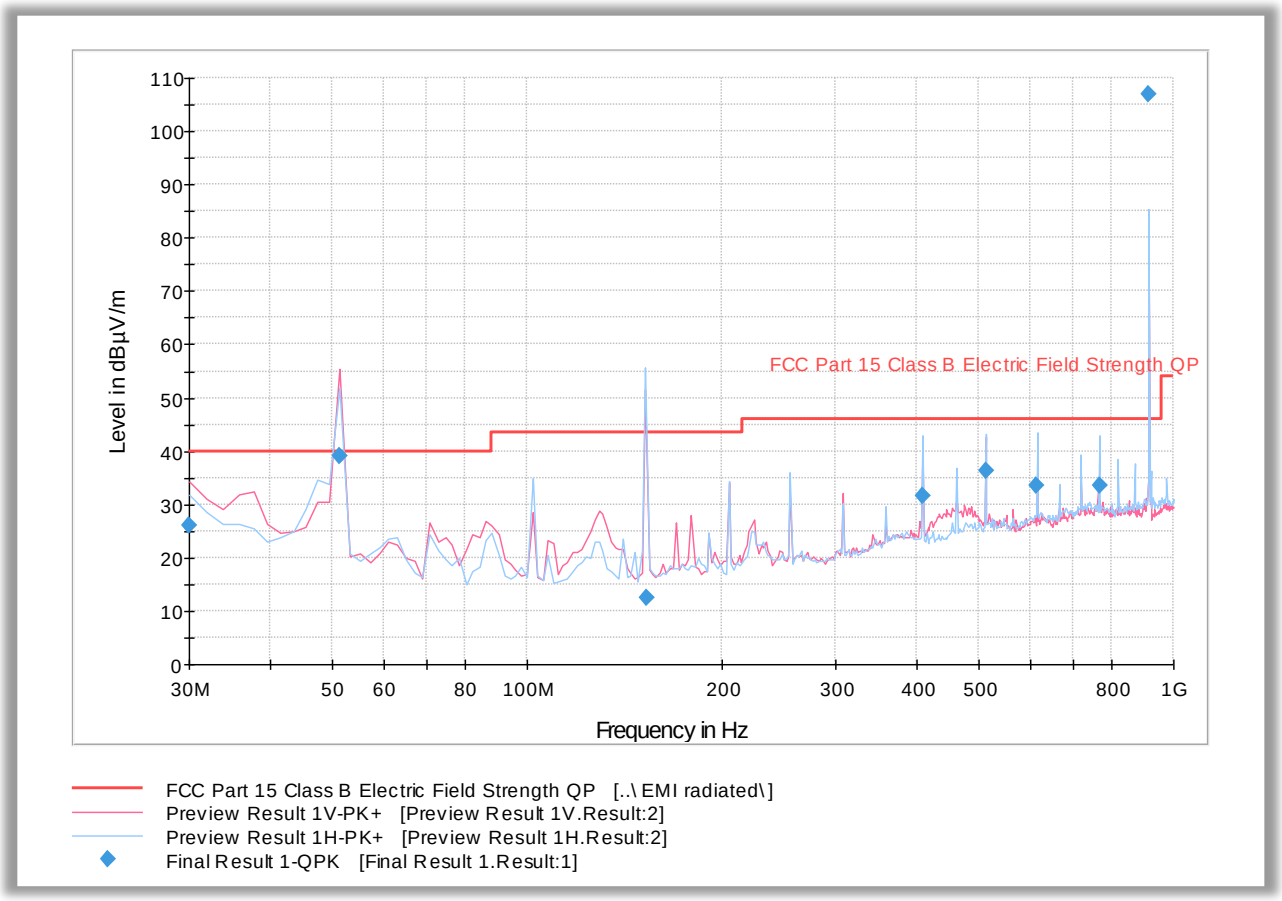
2.7.8 Sample Computation (Radiated Emission)

Measuring equipment raw measurement (dbµV) @ 30 MHz			24.4
Correction Factor (dB)	Asset# 1066 (cable)	0.3	-12.6
	Asset# 1172 (cable)	0.3	
	Asset# 1016 (preamplifier)	-30.7	
	Asset# 1175(cable)	0.3	
	Asset# 1002 (antenna)	17.2	
Reported QuasiPeak Final Measurement (dbµV/m) @ 30MHz			**11.8**

2.7.9 Test Results

See attached plots.

2.7.10 Test Results Below 1GHz (Worst Case Channel – Mid Channel) – STEM-3DS-EXT Unit

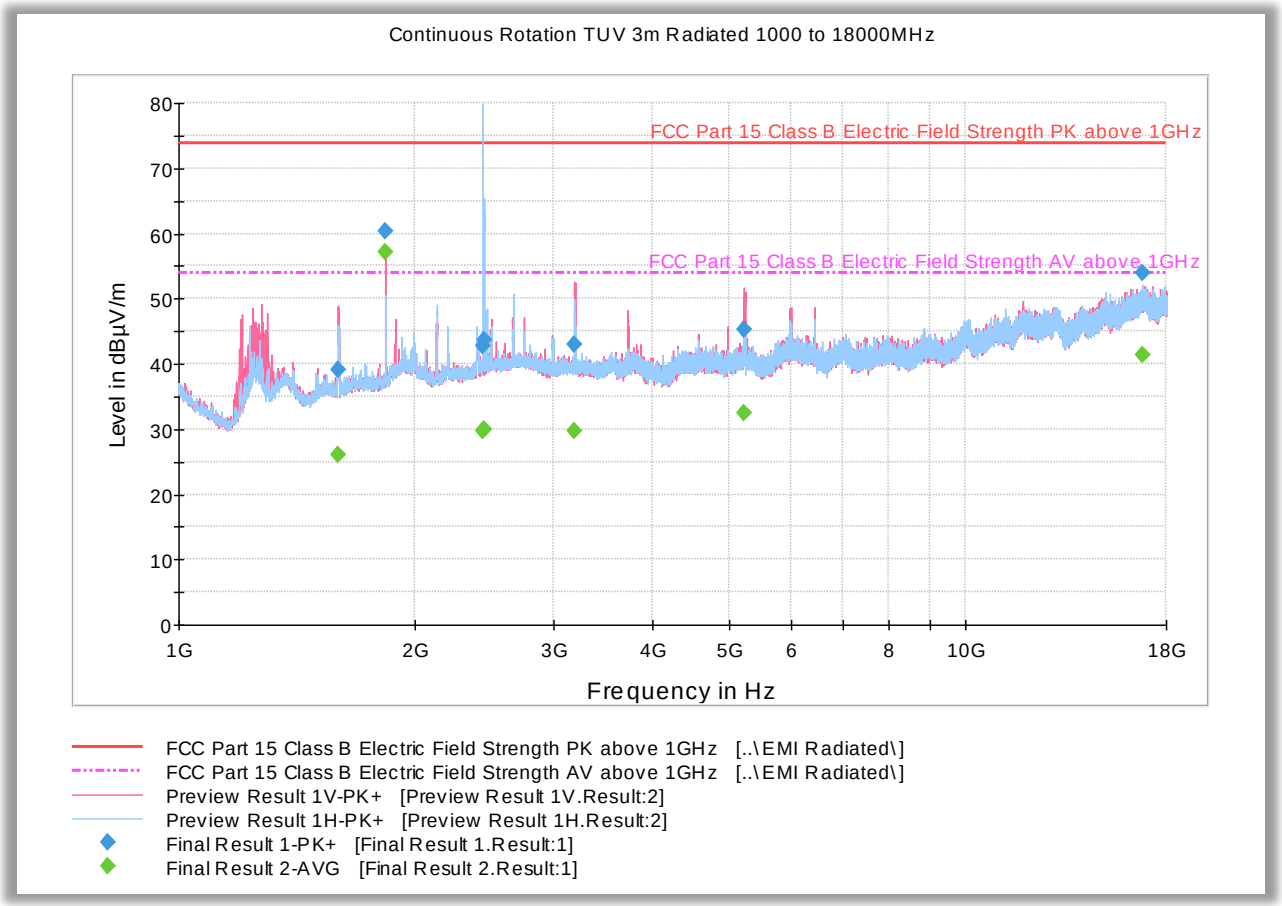


Quasi Peak Data

Frequency (MHz)	QuasiPeak (dBµV/m)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Polarization	Azimuth (deg)	Corr. (dB)	Margin (dB)	Limit (dBµV/m)
30.040000	26.1	1000.0	120.000	100.0	V	-11.0	-5.9	13.9	40.0
51.302766	39.1	1000.0	120.000	100.0	V	23.0	-14.7	0.9	40.0
153.064930	12.5	1000.0	120.000	208.0	H	10.0	-13.3	31.0	43.5
409.618116	31.6	1000.0	120.000	100.0	H	241.0	-4.5	14.4	46.0
511.964168	36.2	1000.0	120.000	219.0	H	228.0	-1.3	9.8	46.0
614.390220	33.5	1000.0	120.000	139.0	H	257.0	1.2	12.5	46.0
768.037355	33.7	1000.0	120.000	123.0	H	208.0	3.9	12.4	46.0
914.812826	106.9	1000.0	120.000	133.0	H	15.0	5.9	Carrier Frequency	

Test Notes: Only worst case channel presented for cabinet spurious emissions. Spurious 153. 06 MHz was verified manually and it does not fall in restricted band, and it complies EIRP – 30dBc Limit (18.89 dBm + 2dBi Antenna Gain – 30 dBc = 86.12 dBµV/m).

2.7.11 Test Results Above 1GHz (Worst Case Channel – Mid Channel) – STEM-3DS-EXT Unit



Peak Data

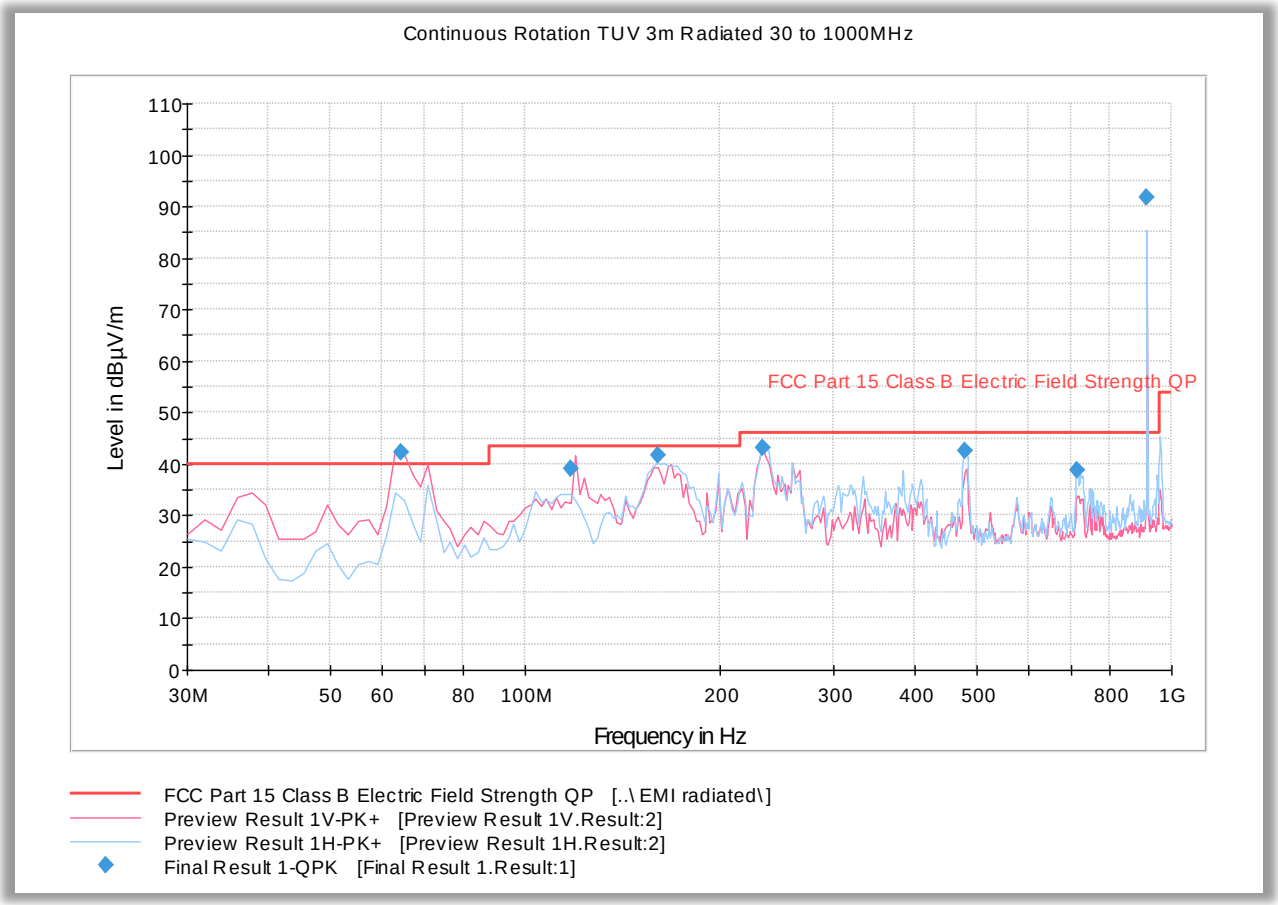
Frequency (MHz)	MaxPeak (dBµV/m)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Polarization	Azimuth (deg)	Corr. (dB)	Margin (dB)	Limit (dBµV/m)
1596.933333	39.1	1000.0	1000.000	117.4	V	344.0	-5.6	34.8	73.9
1830.366667	60.4	1000.0	1000.000	199.3	V	37.0	-3.0	13.5	73.9
2434.100000	42.7	1000.0	1000.000	396.0	H	247.0	-0.6	31.2	73.9
2446.500000	43.6	1000.0	1000.000	397.0	H	240.0	-0.5	30.3	73.9
3186.166667	42.9	1000.0	1000.000	233.2	V	60.0	1.1	31.0	73.9
5227.733333	45.3	1000.0	1000.000	321.1	V	96.0	4.3	28.6	73.9
16776.400000	53.9	1000.0	1000.000	141.4	H	-7.0	19.1	20.0	73.9

Average Data

Frequency (MHz)	Average (dBµV/m)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Polarization	Azimuth (deg)	Corr. (dB)	Margin (dB)	Limit (dBµV/m)
1596.933333	26.0	1000.0	1000.000	117.4	V	344.0	-5.6	27.9	53.9
1830.366667	57.2	1000.0	1000.000	199.3	V	37.0	-3.0	-3.3	53.9
2434.100000	29.7	1000.0	1000.000	396.0	H	247.0	-0.6	24.2	53.9
2446.500000	29.9	1000.0	1000.000	397.0	H	240.0	-0.5	24.0	53.9
3186.166667	29.8	1000.0	1000.000	233.2	V	60.0	1.1	24.1	53.9
5227.733333	32.4	1000.0	1000.000	321.1	V	96.0	4.3	21.5	53.9
16776.400000	41.4	1000.0	1000.000	141.4	H	-7.0	19.1	12.5	53.9

Test Notes: Spurious 1830.366667 MHz does not fall in restricted band, and it complies EIRP – 30dBc Limit (18.89 dBm + 2dBi Antenna Gain – 30 dBc = 86.12 dBµV/m). No significant emissions observed above 18GHz. Measurements above 18GHz were noise floor figures.

2.7.12 Test Results Below 1GHz (Worst Case Channel – Mid Channel) – BASE-VZW-EXT Unit

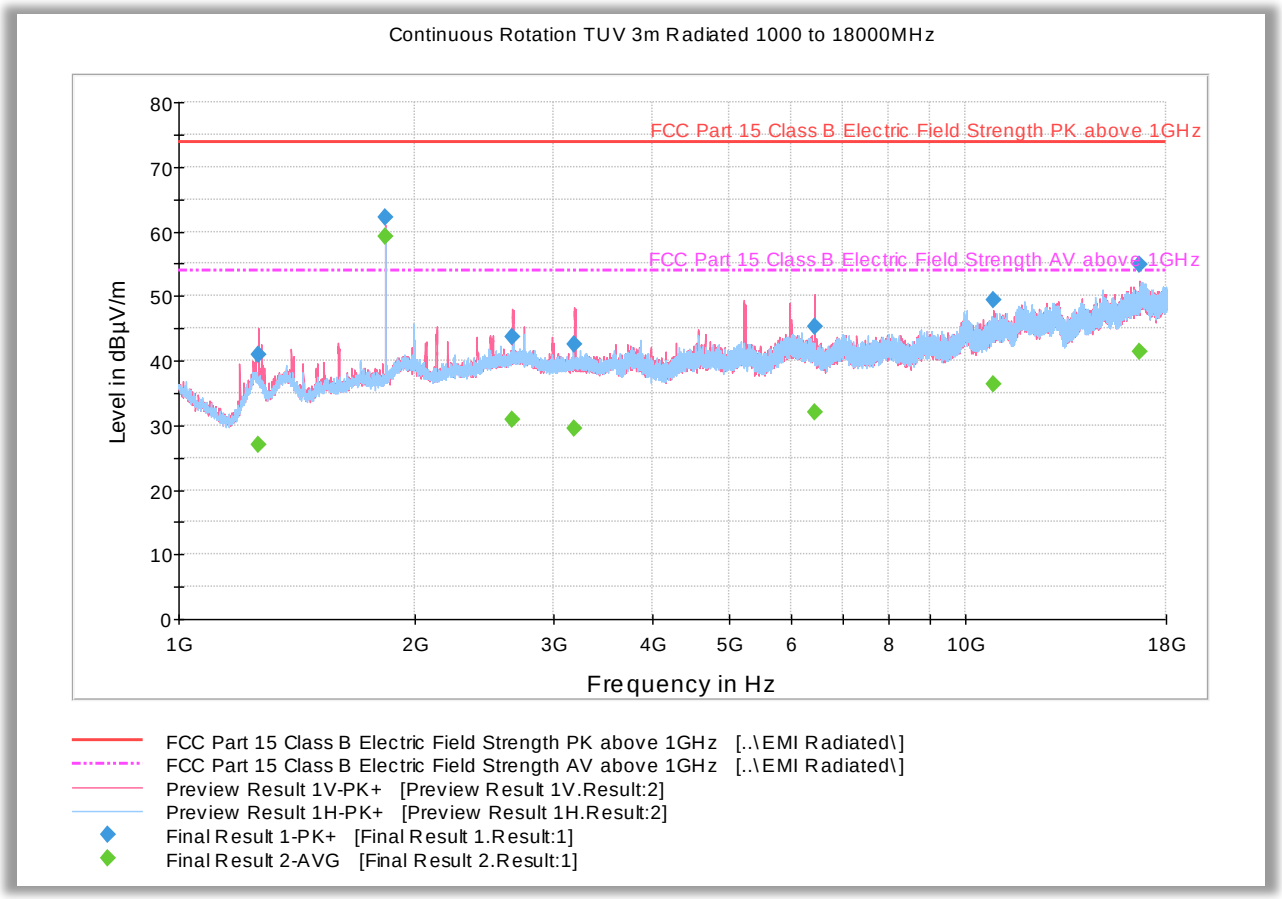


Quasi Peak Data

Frequency (MHz)	QuasiPeak (dBµV/m)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Polarization	Azimuth (deg)	Corr. (dB)	Margin (dB)	Limit (dBµV/m)
64.366092	42.2	1000.0	120.000	110.0	V	289.0	-17.2	-2.2	40.0
117.938838	39.0	1000.0	120.000	109.0	V	127.0	-15.8	4.5	43.5
160.720481	41.6	1000.0	120.000	122.0	H	74.0	-12.8	1.9	43.5
233.468216	43.1	1000.0	120.000	100.0	H	133.0	-9.9	2.9	46.0
478.918076	42.5	1000.0	120.000	100.0	H	349.0	-1.6	3.5	46.0
714.576273	38.8	1000.0	120.000	109.0	H	296.0	3.2	7.2	46.0
915.252826	91.9	1000.0	120.000	400.0	H	-2.0	5.9	Carrier Frequency	

Test Notes: Only worst case channel presented for cabinet spurious emissions. Spurious 64.366092 MHz does not fall in restricted band, and it complies EIRP – 30dBc Limit (18.89 dBm + 2dBi Antenna Gain – 30 dBc = 86.12 dBµV/m).

2.7.13 Test Results Above 1GHz (Worst Case Channel – Mid Channel) – BASE-VZW-EXT Unit



Peak Data

Frequency (MHz)	MaxPeak (dBµV/m)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Polarization	Azimuth (deg)	Corr. (dB)	Margin (dB)	Limit (dBµV/m)
1264.433333	40.8	1000.0	1000.000	145.4	V	249.0	-5.3	33.1	73.9
1830.400000	62.1	1000.0	1000.000	310.1	V	324.0	-3.0	11.8	73.9
2659.433333	43.6	1000.0	1000.000	141.4	V	312.0	-0.1	30.3	73.9
3189.266667	42.6	1000.0	1000.000	131.4	V	313.0	1.1	31.3	73.9
6430.900000	45.2	1000.0	1000.000	100.4	V	82.0	6.4	28.7	73.9
10835.766667	49.3	1000.0	1000.000	100.4	V	246.0	12.1	24.6	73.9
16685.166667	54.8	1000.0	1000.000	352.0	V	283.0	18.9	19.1	73.9

Average Data

Frequency (MHz)	Average (dBµV/m)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Polarization	Azimuth (deg)	Corr. (dB)	Margin (dB)	Limit (dBµV/m)
1264.433333	27.0	1000.0	1000.000	145.4	V	249.0	-5.3	26.9	53.9
1830.400000	59.3	1000.0	1000.000	310.1	V	324.0	-3.0	-5.4	53.9
2659.433333	30.9	1000.0	1000.000	141.4	V	312.0	-0.1	23.0	53.9
3189.266667	29.5	1000.0	1000.000	131.4	V	313.0	1.1	24.4	53.9
6430.900000	32.0	1000.0	1000.000	100.4	V	82.0	6.4	21.9	53.9
10835.766667	36.4	1000.0	1000.000	100.4	V	246.0	12.1	17.5	53.9

Test Notes: Spurious 1830.4 MHz does not fall in restricted band, and it complies EIRP – 30dBc Limit (18.89 dBm + 2dBi Antenna Gain – 30 dBc = 86.12 dBµV/m). No significant emissions observed above 18GHz. Measurements above 18GHz were noise floor figures.

2.8 POWER SPECTRAL DENSITY

2.8.1 Specification Reference

Part 15 Subpart C §15.247(e) and RSS-247 5.2(b)

2.8.2 Standard Applicable

(e) 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. This power spectral density shall be determined in accordance with the provisions of paragraph (b) of this section. The same method of determining the conducted output power shall be used to determine the power spectral density.

2.8.3 Equipment Under Test and Modification State

Serial No: Unit 1 / Test Configuration A

2.8.4 Date of Test/Initial of test personnel who performed the test

December 12, 2017 / XYZ

2.8.5 Test Equipment Used

The major items of test equipment used for the above tests are identified in Section 3.1.

2.8.6 Environmental Conditions/ Test Location

Test performed at TÜV SÜD America Inc. Rancho Bernardo facility

Ambient Temperature	25.0 °C
Relative Humidity	14.0.%
ATM Pressure	99.3 kPa

TÜV SÜD AMERICA INC 10040 Mesa Rim Road San Diego, CA 92121-2912 Phone: 858 678 1400 FAX: 858 546 0364

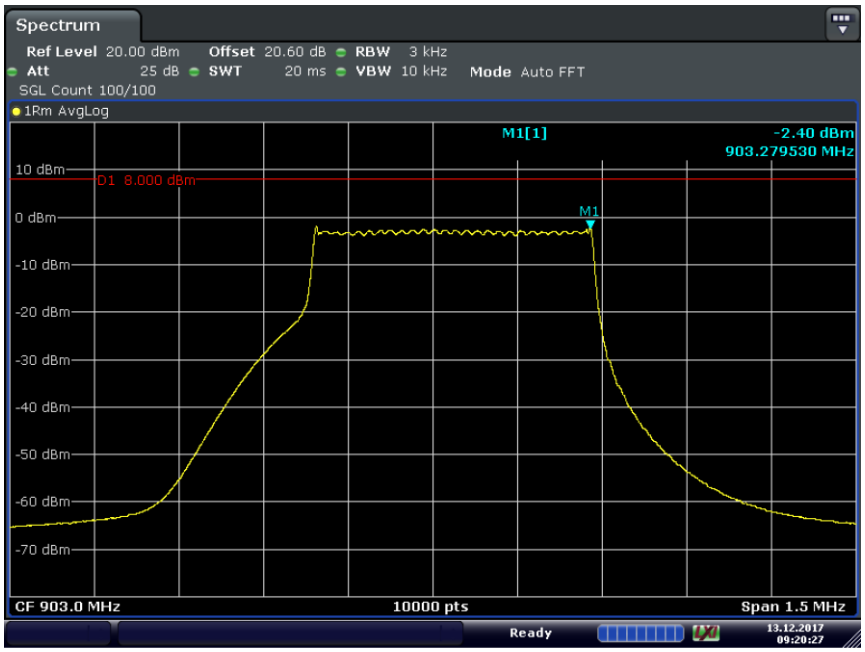
2.8.7 Additional Observations

- This is a conducted test.
- Test procedure is AVGPSD-1 per Section 10.3 of KDB 558074 (April 05, 2017).
- Span is 1.5 times the DTS bandwidth.
- An offset of 20.6dB was added to compensate for the external attenuator and cable used from the antenna port to the spectrum analyzer.
- Set the RBW to: 3 kHz ≤ RBW ≤ 100 kHz
- Set the VBW ≥ 3 x RBW
- Detector is RMS
- Sweep time is Auto Couple.
- Trace mode is averaging (RMS) mode over a minimum of 100 traces.
- Trace allowed to fully stabilize.
- EUT complies with 3 kHz RBW.

2.8.8 Test Results Summary

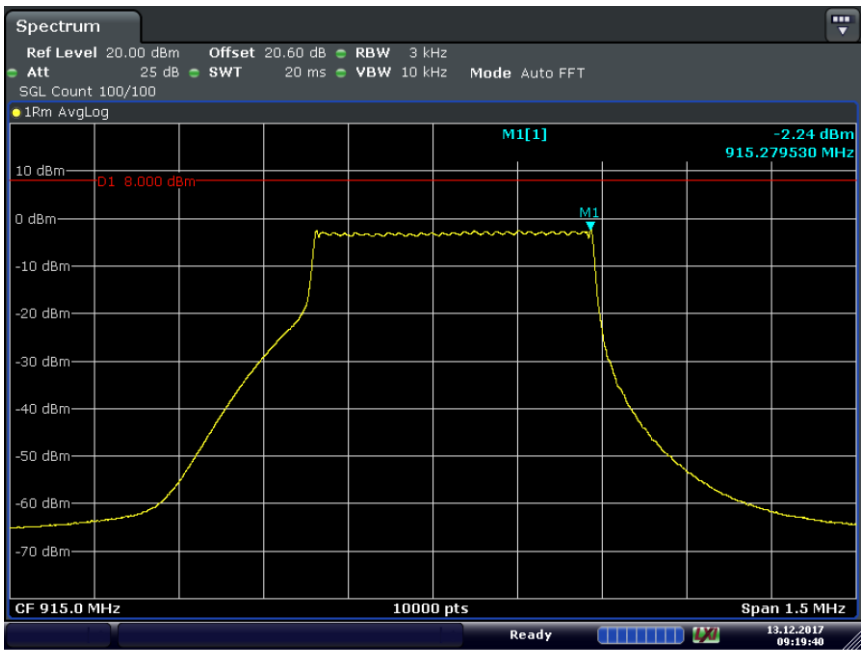
Mode	Channel	Marker Reading using 3 kHz RBW (dBm)	PSD Limit (dBm)	Margin (dB)	Compliance
LoRa	903 MHz	-2.4	8	10.4	Complies
	915 MHz	-2.24	8	10.24	Complies
	927 MHz	-2.5	8	10.5	Complies

2.8.9 Test Results Plots



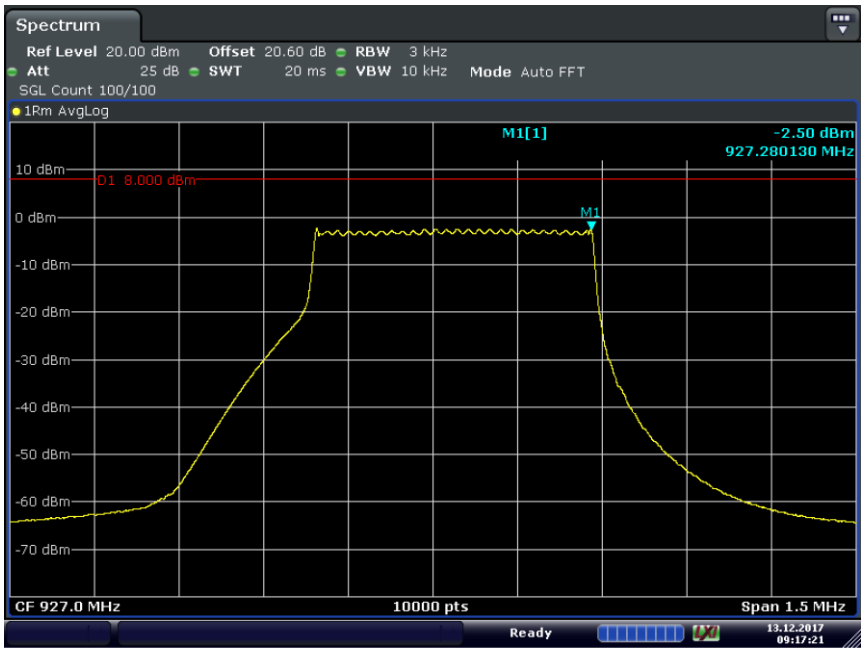
Date: 13.DEC.2017 09:20:27

Low Channel 903 MHz



Date: 13.DEC.2017 09:19:39

Mid Channel 915 MHz



Date: 13.DEC.2017 09:17:20

High Channel

SECTION 3

TEST EQUIPMENT USED

3.1 TEST EQUIPMENT USED

List of absolute measuring and other principal items of test equipment.

ID Number (SDGE/SDRB)	Test Equipment	Type	Serial Number	Manufacturer	Cal Date	Cal Due Date
Antenna Conducted Port Setup						
7604	P-Series Power Meter	N1912A	SG45100273	Agilent	08/14/17	07/27/18
7605	50MHz-18GHz Wideband Power Sensor	N1921A	MY51100054	Agilent	05/19/18	05/19/18
7611	Signal/Spectrum Analyzer	FSW26	102017	Rhode & Schwarz	04/25/17	04/25/18
7643	Signal Analyzer	FSV30	103166	Rhode & Schwarz	03/28/17	03/28/18
7608	Vector Signal Generator	SMBV100A	259021	Rhode & Schwarz	09/19/17	09/19/19
8871	20dB Attenuator	18N10W-20dB	-	INMET	Verified by 7611 and 7608	
Radiated Test Setup						
7611	Signal/Spectrum Analyzer	FSW26	102017	Rhode & Schwarz	04/25/17	04/25/18
7608	Vector Signal Generator	SMBV100A	259021	Rhode & Schwarz	09/19/17	09/19/19
1033	Bilog Antenna	3142C	00044556	EMCO	10/11/16	10/11/18
7575	Double-ridged waveguide horn antenna	3117	00155511	EMCO	06/01/17	06/01/18
1151	Pre-amplifier	TS-PR26	100026	Rhode & Schwarz	Verified by 7611 and 7608	
1153	High-frequency cable	SucoFlex 100 SX	N/A	Suhner	Verified by 7611 and 7608	
8543	High-frequency cable	Micropore 19057793	N/A	United Microwave Products	Verified by 7611 and 7608	
1040	EMI Test Receiver	ESIB40	100292	Rhode & Schwarz	10/25/17	10/25/18
7620	EMI Test Receiver	ESU40	100399	Rhode & Schwarz	10/17/17	10/17/18
1016	Pre-amplifier	PAM-0202	187	PAM	02/06/18	02/06/19
Miscellaneous						
6708	Multimeter	34401A	US36086974	Hewlett Packard	07/05/17	07/05/18
11312	Mini Environmental Quality Meter	850027	CF099-56010-340	Sper Scientific	02/26/28	02/26/19
	Test Software	EMC32	V8.53	Rhode & Schwarz	N/A	

3.2 MEASUREMENT UNCERTAINTY

For a 95% confidence level, the measurement uncertainties for defined systems are:

3.2.1 Radiated Measurements (Below 1GHz)

	Contribution	Probability Distribution Type	Probability Distribution x_i	Standard Uncertainty $u(x_i)$	$[u(x_i)]^2$
1	Receiver/Spectrum Analyzer	Rectangular	0.45	0.26	0.07
2	Cables	Rectangular	0.50	0.29	0.08
3	Preamp	Rectangular	0.50	0.29	0.08
4	Antenna	Rectangular	0.75	0.43	0.19
5	Site	Rectangular	2.70	1.56	2.43
6	EUT Setup	Rectangular	1.00	0.58	0.33
				Combined Uncertainty (u_c):	1.78
				Coverage Factor (k):	2
				Expanded Uncertainty:	3.57

3.2.2 Radiated Emission Measurements (Above 1GHz)

	Contribution	Probability Distribution Type	Probability Distribution x_i	Standard Uncertainty $u(x_i)$	$[u(x_i)]^2$
1	Receiver/Spectrum Analyzer	Rectangular	0.57	0.33	0.11
2	Cables	Rectangular	0.70	0.40	0.16
3	Preamp	Rectangular	0.50	0.29	0.08
4	Antenna	Rectangular	0.37	0.21	0.05
5	Site	Rectangular	2.70	1.56	2.43
6	EUT Setup	Rectangular	1.00	0.58	0.33
				Combined Uncertainty (u_c):	1.78
				Coverage Factor (k):	2
				Expanded Uncertainty:	3.56

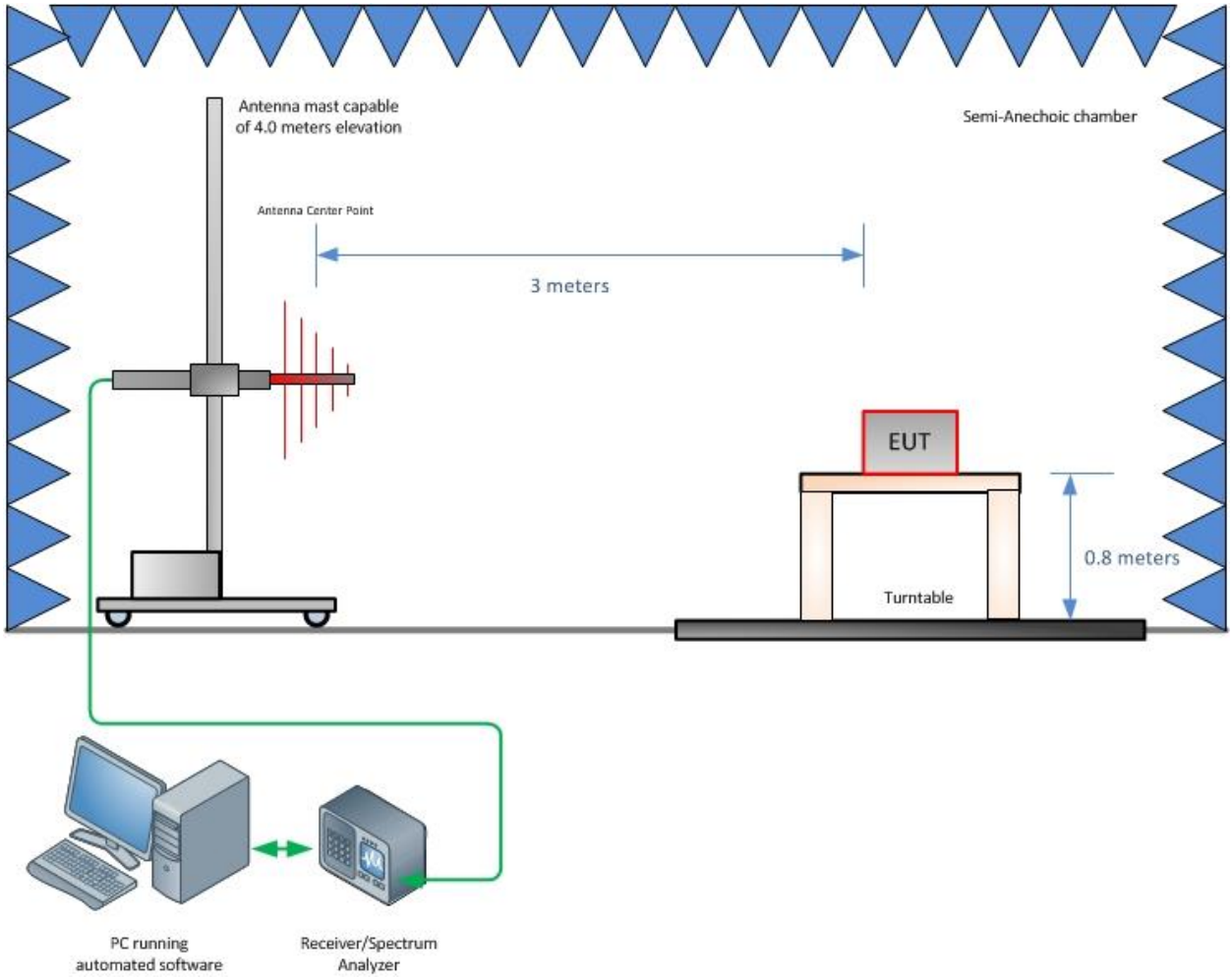
3.2.3 Conducted Antenna Port Measurement

	Contribution	Probability Distribution Type	Probability Distribution x_i	Standard Uncertainty $u(x_i)$	$[u(x_i)]^2$
1	Receiver/Spectrum Analyzer	Rectangular	0.36	0.21	0.04
2	Cables	Rectangular	0.50	0.29	0.08
3	LISN	Rectangular	0.66	0.38	0.15
4	Attenuator	Rectangular	0.30	0.17	0.03
5	EUT Setup	Rectangular	1.00	0.58	0.33
				Combined Uncertainty (u_c):	0.80
				Coverage Factor (k):	2
				Expanded Uncertainty:	1.59

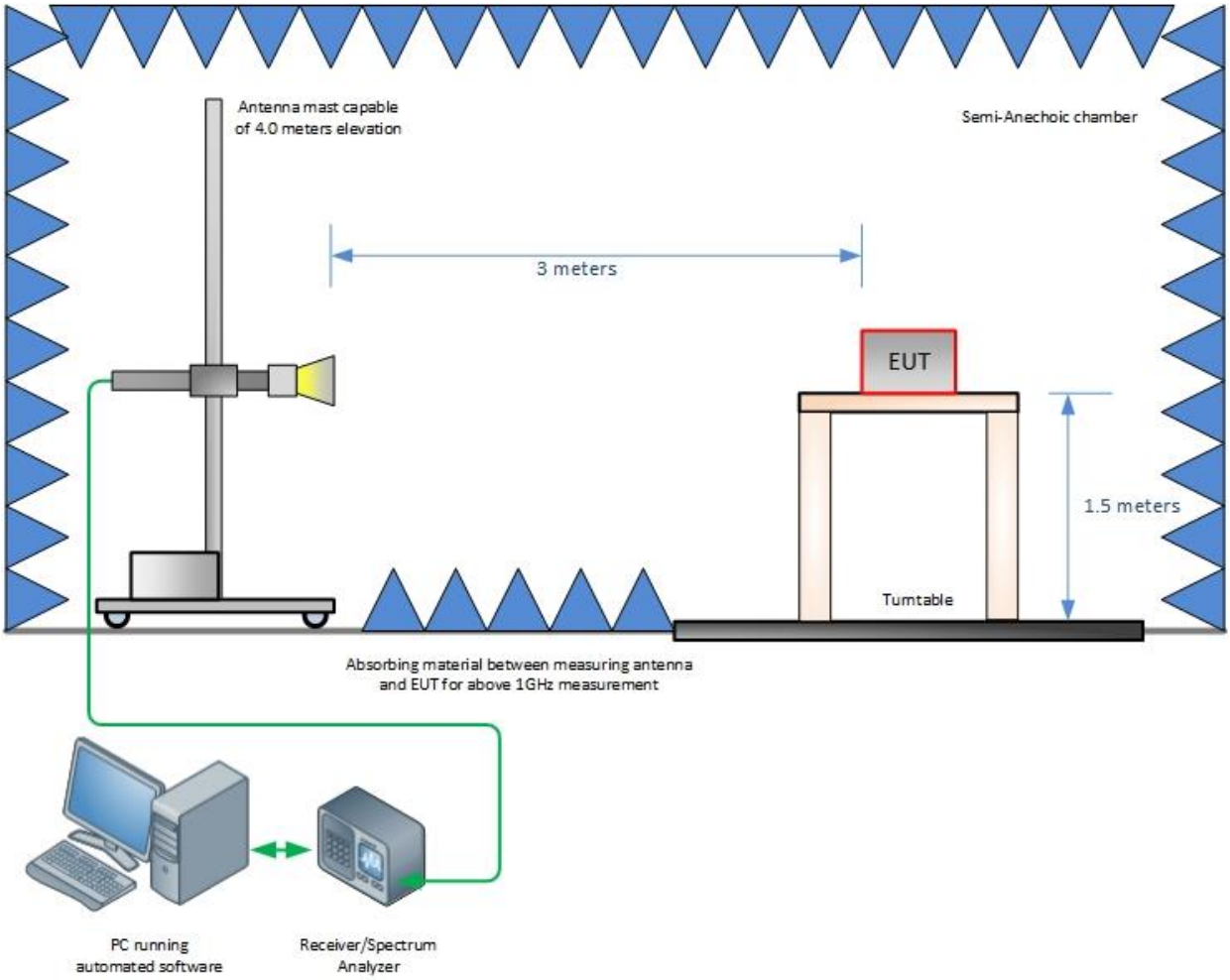
SECTION 4

DIAGRAM OF TEST SETUP

4.1 TEST SETUP DIAGRAM



Radiated Emission Test Setup (Below 1GHz)



Radiated Emission Test Setup (Above 1GHz)

SECTION 5

ACCREDITATION, DISCLAIMERS AND COPYRIGHT

5.1 ACCREDITATION, DISCLAIMERS AND COPYRIGHT

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