FCC RF TEST REPORT

ISSUED BY
Shenzhen BALUN Technology Co., Ltd.

FOR

RHF76-052 Module

ISSUED TO
RuiXingHengFang Network (Shenzhen) CO., Ltd

Suite B3019, 3rd Tower of Elite (YiLiDa) Building, NO.1092 Nanshan blvd, Nanshan District, Shenzhen 518054 China

Tested by: Cao Shaodong (Engineer)
Date Nov. 29, 2016

Approved by: Wei Yanquan (Chief Engineer)
Date Nov. 29, 2016

Report No.:	BL-SZ16A0433-601
EUT Type:	RHF76-052 Module
Model Name:	RHF76-052
Brand Name:	RisingHF
Test Standard:	47 CFR Part 15 Subpart C
FCC ID:	2AJUZ76052
Test conclusion:	Pass
Test Date:	Nov. 05, 2016 ~ Nov. 18, 2016
Date of Issue:	Nov. 29, 2016

Block B, 1st FL, Baisha Science and Technology Park, Shahe Xi Road, Nanshan District, Shenzhen, Guangdong, P. R. China 518055
TEL: +86-755-66850100, FAX: +86-755-61824271
Email: info@baluntek.com
www.baluntek.com

Revision History

Version	Issue Date	Revisions Content
Rev. 01	Nov. 23, 2016	Initial Issue
Rev. 02	Nov. 29, 2016	Add Host Device information on page 7.

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1 ADMINISTRATIVE DATA (GENERAL INFORMATION)

1.1 Identification of the Testing Laboratory

Company Name	Shenzhen BALUN Technology Co., Ltd.
Address	Block B, 1st FL, Baisha Science and Technology Park, Shahe Xi Road, Nanshan District, Shenzhen, Guangdong Province, P. R. China
Phone Number	+86 755 6685 0100
Fax Number	+86 755 6182 4271

1.2 Identification of the Responsible Testing Location

Test Location	Shenzhen BALUN Technology Co., Ltd.
Address	Block B, 1st FL, Baisha Science and Technology Park, Shahe Xi Road, Nanshan District, Shenzhen, Guangdong Province, P. R. China
Accreditation Certificate	The laboratory has been listed by Industry Canada to perform electromagnetic emission measurements. The recognition numbers of test site are 11524A-1. The laboratory has been listed by US Federal Communications Commission to perform electromagnetic emission measurements. The recognition numbers of test site are 832625. The laboratory is a testing organization accredited by China National Accreditation Service for Conformity Assessment (CNAS) according to ISO/IEC 17025. The accreditation certificate number is L6791.
Description	All measurement facilities used to collect the measurement data are located at Block B, FL 1, Baisha Science and Technology Park, Shahe Xi Road, Nanshan District, Shenzhen, Guangdong Province, P. R. China 518055

1.3 Laboratory Condition

Ambient Temperature	20 to 25℃
Ambient Relative Humidity	45% - 55%
Ambient Pressure	100 kPa - 102 kPa

1.4 Announce

(1) The test report reference to the report template version v1.0.

(2) The test report is invalid if not marked with the signatures of the persons responsible for preparing and approving the test report.

(3) The test report is invalid if there is any evidence and/or falsification.

(4) The results documented in this report apply only to the tested sample, under the conditions and modes of operation as described herein.

(5) This document may not be altered or revised in any way unless done so by BALUN and all revisions are duly noted in the revisions section.

(6) Content of the test report, in part or in full, cannot be used for publicity and/or promotional purposes without prior written approval from the laboratory.

2 PRODUCT INFORMATION

2.1 Applicant Information

Applicant	RuiXingHengFang Network (Shenzhen) CO., Ltd
Address	Suite B3019, 3rd Tower of Elite (YiLiDa) Building, NO.1092 Nanshan blvd, Nanshan District, Shenzhen 518054 China

2.2 Manufacturer Information

Manufacturer	RuiXingHengFang Network (Shenzhen) CO., Ltd
Address	Suite B3019, 3rd Tower of Elite (YiLiDa) Building, NO.1092 Nanshan blvd, Nanshan District, Shenzhen 518054 China

2.3 Factory Information

Factory	RuiXingHengFang Network (Shenzhen) CO., Ltd
Address	Suite B3019, 3rd Tower of Elite (YiLiDa) Building, NO.1092 Nanshan blvd, Nanshan District, Shenzhen 518054 China

2.4 General Description for Equipment under Test (EUT)

EUT Type	RHF76-052 Module
Model Name Under Test	RHF76-052
Series Model Name	N/A
Description of Model name differentiation	N/A
Hardware Version	V2.0
Software Version	V2.0.3
Dimensions (Approx.)	N/A
Weight (Approx.)	N/A
Network and Wireless connectivity	Lora Spread Spectrum, LoraWAN

2.5 Ancillary Equipment

Ancillary Equipment 1	Host Device	
	Brand Name	RisingHF
	Model No.	RHF1S001
	Product name	RHF1S001 IP64 T&H sensor

2.6 Technical Information

The requirement for the following technical information of the EUT was tested in this report:

Modulation Technology	Frequency hopping system, Hybrid system
Modulation Type	LoRa
Product Type	Mobile and portable
Frequency Range	The frequency range used is 902 MHz to 928 MHz.
Number of channel	64
Tested Channel	0 (902.3 MHz), 32 (908.7 MHz), 63 (914.9 MHz)
Antenna Type	PIFA Antenna
Antenna Gain	-2 dBi (All involve the antenna gain test item, has been included in the final results)
Antenna System(MIMO Smart Antenna)	N/A
About the Product	The EUT is supply the DTS, Frequency hopping system and Hybrid system, only the frequency hopping system and hybrid system were tested in this report.

All channel was listed on the following table:

Channel number	Freq. (MHz)	Channel number	Freq. (MHz)	Channel number	Freq. (MHz)	Channel number	Freq. (MHz)
0	902.3	20	906.3	40	910.3	60	914.3
1	902.5	21	906.5	41	910.5	61	914.5
2	902.7	22	906.7	42	910.7	62	914.7
3	902.9	23	906.9	43	910.9	63	914.9
4	903.1	24	907.1	44	911.1	-	-
5	903.3	25	907.3	45	911.3	-	-
6	903.5	26	907.5	46	911.5	-	-
7	903.7	27	907.7	47	911.7	-	-
8	903.9	28	907.9	48	911.9	-	-
9	904.1	29	908.1	49	912.1	-	-
10	904.3	30	908.3	50	912.3	-	-
11	904.5	31	908.5	51	912.5	-	-
12	904.7	32	908.7	52	912.7	-	-
13	904.9	33	908.9	53	912.9	-	-
14	905.1	34	909.1	54	913.1	-	-
15	905.3	35	909.3	55	913.3	-	-
16	905.5	36	909.5	56	913.5	-	-
17	905.7	37	909.7	57	913.7	-	-
18	905.9	38	909.9	58	913.9	-	-
19	906.1	39	910.1	59	914.1	-	-

2.7 Additional Instructions

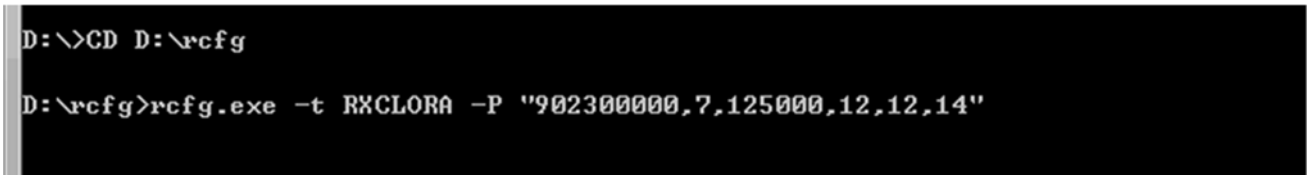
EUT Software Settings:

Mode	☒ Special software is used. The software provided by client to enable the EUT under transmission condition continuously at specific channel frequencies individually.

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

Power level setup in software		
Test Software Version		
Mode	Channel	Soft Set
LoRa	ALL	14

Run Software



3 SUMMARY OF TEST RESULTS

3.1 Test Standards

No.	Identity	Document Title
1	47 CFR Part 15, Subpart C (10-1-15 Edition)	Miscellaneous Wireless Communications Services
2	FCC PUBLIC NOTICE DA 00-705 (Mar. 30, 2000)	Filling and Measurement Guidelines for Frequency Hopping Spread Spectrum Systems
3	ANSI C63.10-2013	American National Standard for Testing Unlicensed Wireless Devices

3.2 Verdict

No.	Description	FCC Part No.	Modulation Technology	Channel	Test Result	Verdict	Remark
1	Antenna Requirement	15.203	N/A	N/A	--	Pass	Note 1
2	Number of Hopping Frequencies	15.247(a)	Frequency hopping system	Hopping	ANNEX A.1	Pass	
3	Peak Output Power	15.247(b)	Frequency hopping system, Hybrid system	Low/Middle/ High	ANNEX A.2	Pass	
4	Occupied Bandwidth	15.247(a)	Frequency hopping system, Hybrid system	Low/Middle/ High	ANNEX A.3	Pass	
5	Carrier Frequency Separation	15.247(a)	Frequency hopping system, Hybrid system	Hopping Mode	ANNEX A.4	Pass	
6	Time of Occupancy (Dwell time)	15.247(a)	Frequency hopping system, Hybrid system	Hopping	ANNEX A.5	Pass	
7	Conducted Spurious Emission & Authorized-band band-edge	15.247(d)	Frequency hopping system, Hybrid system	Low/Middle/ High	ANNEX A.6	Pass	
8	Conducted Emission	15.207	Frequency hopping system, Hybrid system	Low/Middle/ High	ANNEX A.7	N/A	Note 2
9	Radiated Spurious Emission	15.209 15.247(d)	Frequency hopping system, Hybrid system	Hopping, Low/Middle/ High	ANNEX A.8	Pass	
10	Band Edge(Restricted-band band-edge)	15.209 15.247(d)	Frequency hopping system, Hybrid system	Hopping, Low/Middle/ High	ANNEX A.9	Pass	
11	Power spectral density (PSD)	15.247(e)	Hybrid system	Low/Middle/ High	ANNEX A.10	Pass	
Note 1: Please refer to section 5.1 Note 2: The EUT is supply by battery, so the Conducted Emission is not applicable.							

4 GENERAL TEST CONFIGURATIONS

4.1 Test Environments

During the measurement, the normal environmental conditions were within the listed ranges:

Relative Humidity	45% - 55%	
Atmospheric Pressure	100 kPa - 102 kPa	
Temperature	NT (Normal Temperature)	+22℃ to +25℃
Working Voltage of the EUT	NV (Normal Voltage)	3.6 V

4.2 Test Equipment List

Description	Manufacturer	Model	Serial No.	Cal. Date	Cal. Due
Spectrum Analyzer	ROHDE&SCHWARZ	FSV-30	103118	2016.07.13	2017.07.12
Vector Signal Generator	ROHDE&SCHWARZ	SMBV100A	177746	2016.07.13	2017.07.12
Signal Generator	ROHDE&SCHWARZ	SMB100A	260592	2016.07.13	2017.07.12
Switch Unit with OSP-B157	ROHDE&SCHWARZ	OSP120	101270	2016.07.13	2017.07.12
Spectrum Analyzer	AGILENT	E4440A	MY45304434	2016.11.08	2017.11.07
EMI Receiver	ROHDE&SCHWARZ	ESRP	101036	2016.07.05	2017.07.04
LISN	SCHWARZBECK	NSLK 8127	8127-687	2016.07.05	2017.07.04
Bluetooth Tester	ROHDE&SCHWARZ	CBT	101005	2016.07.13	2017.07.12
Power Splitter	KMW	DCPD-LDC	1305003215	--	--
Power Sensor	ROHDE&SCHWARZ	NRP-Z21	103971	2016.07.13	2017.07.12
Attenuator (20 dB)	KMW	ZA-S1-201	110617091	--	--
Attenuator (6 dB)	KMW	ZA-S1-61	1305003189	--	--
DC Power Supply	ROHDE&SCHWARZ	HMP2020	018141664	2016.07.13	2017.07.12
Temperature Chamber	ANGELANTIONI SCIENCE	NTH64-40A	1310	2016.07.13	2017.07.12
Test Antenna-Loop(9 kHz-30 MHz)	SCHWARZBECK	FMZB 1519	1519-037	2015.07.22	2017.07.21
Test Antenna-Bi-Log(30 MHz-3 GHz)	SCHWARZBECK	VULB 9163	9163-624	2015.07.22	2017.07.21
Test Antenna-Horn(1-18 GHz)	SCHWARZBECK	BBHA 9120D	9120D-1148	2015.07.22	2017.07.21
Test Antenna-Horn(15-26.5 GHz)	SCHWARZBECK	BBHA 9170	9170-305	2015.07.22	2017.07.21
Anechoic Chamber	RAINFORD	9m*6m*6m	N/A	2015.02.28	2017.02.27
Shielded Enclosure	ChangNing	CN-130701	130703	--	--

4.3 Measurement Uncertainty

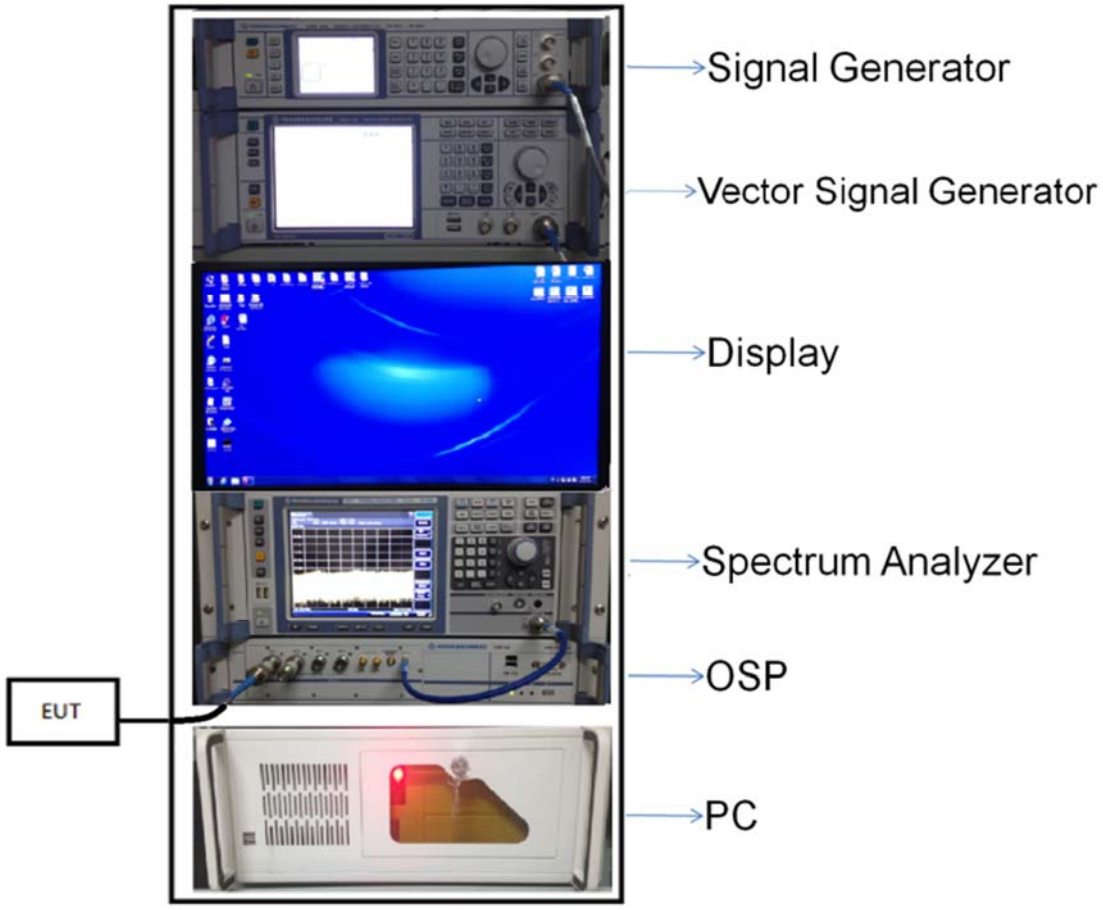
The following measurement uncertainty levels have been estimated for tests performed on the EUT as specified in CISPR 16-4-2.

This uncertainty represents an expanded uncertainty expressed at approximately the 95% confidence level using a coverage factor of k=2.

Measurement	Value
Occupied Channel Bandwidth	±4%
RF output power, conducted	±1.4 dB
Power Spectral Density, conducted	±2.5 dB
Unwanted Emissions, conducted	±2.8 dB
All emissions, radiated	±5.4 dB
Temperature	±1°C
Humidity	±4%

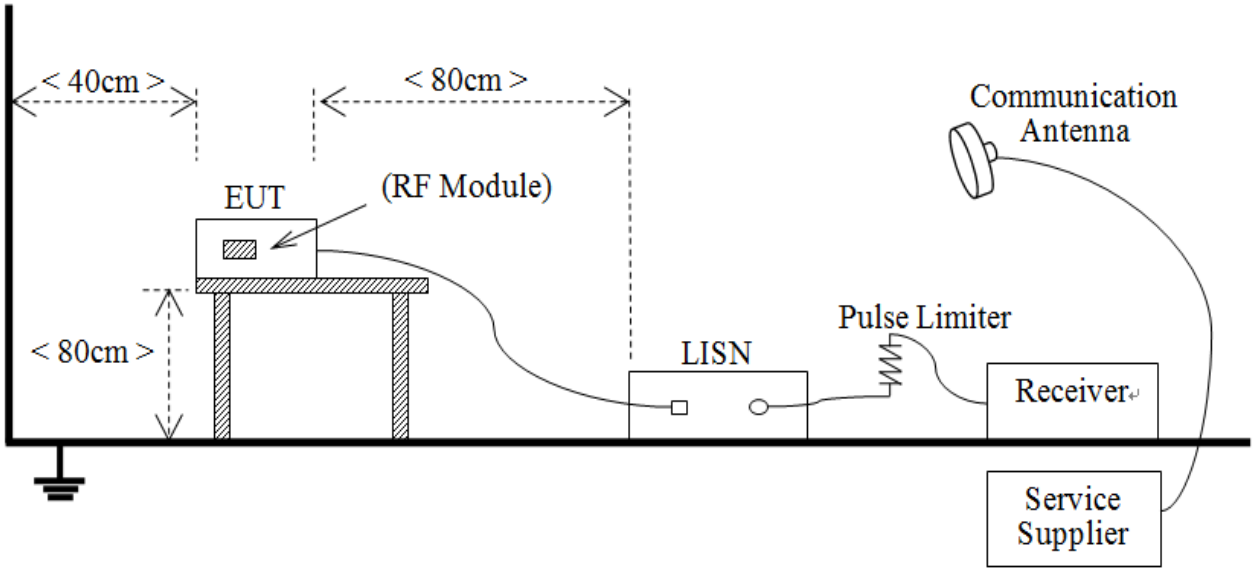
4.4 Description of Test Setup

4.4.1 For Antenna Port Test



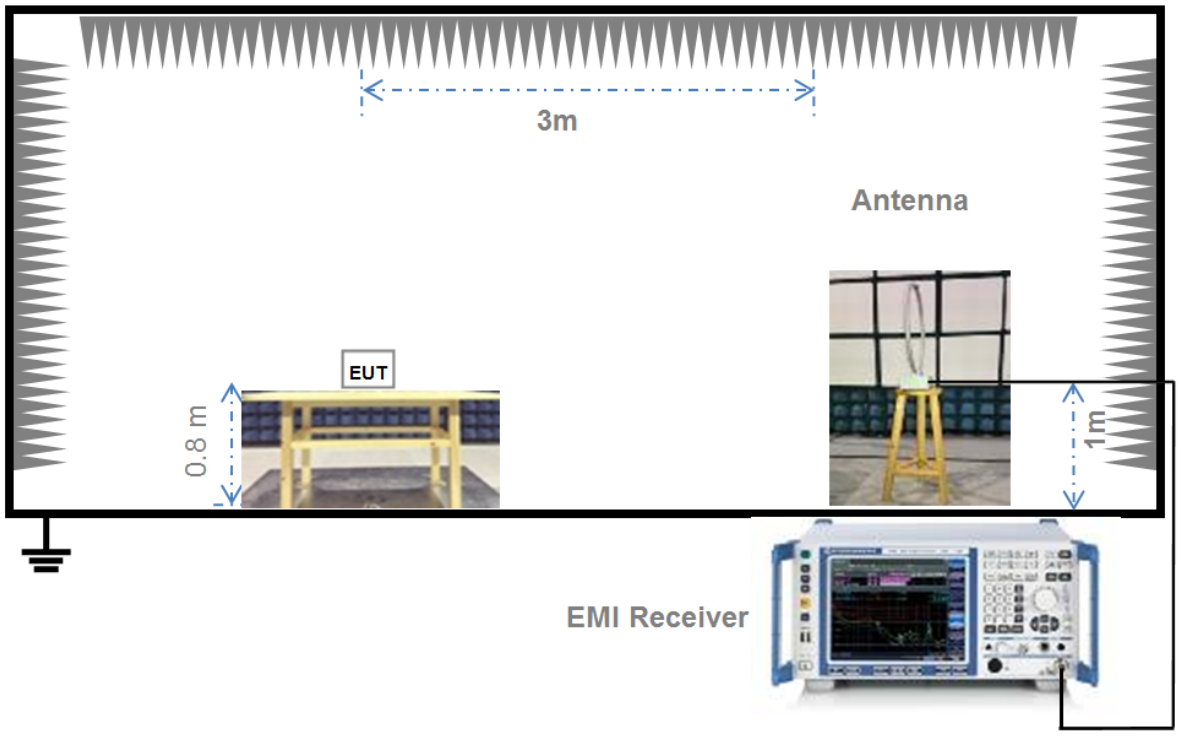
(Diagram 1)

4.4.2 For AC Power Supply Port Test



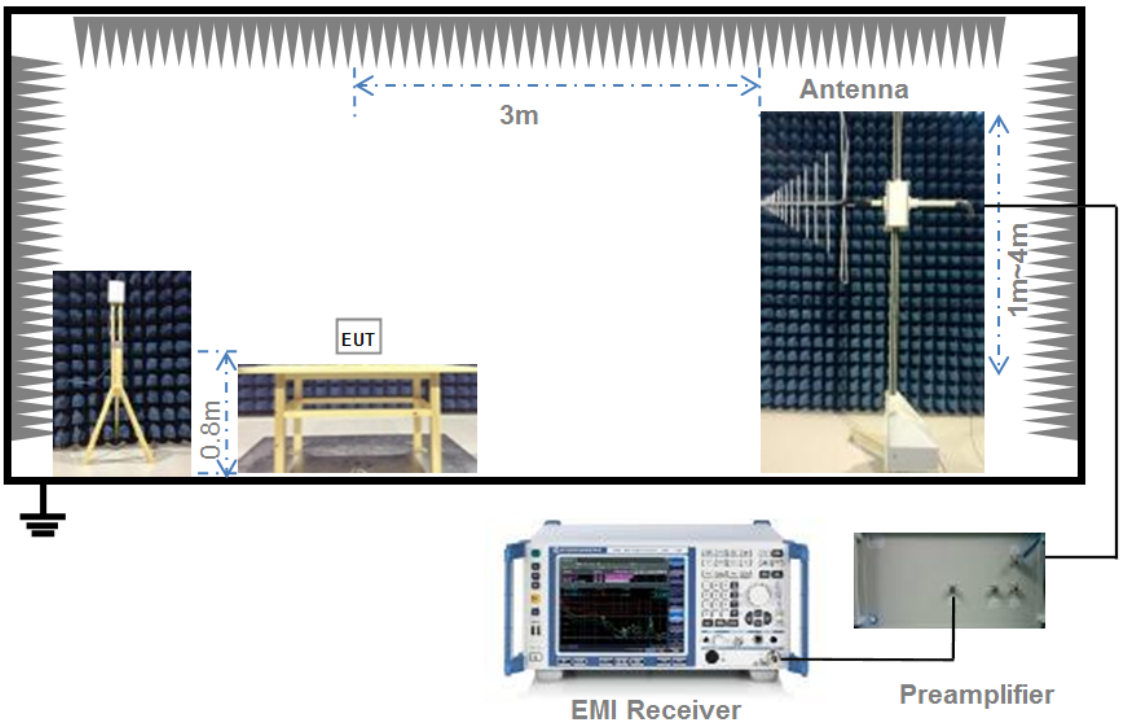
(Diagram 2)

4.4.3 For Radiated Test (Below 30 MHz)



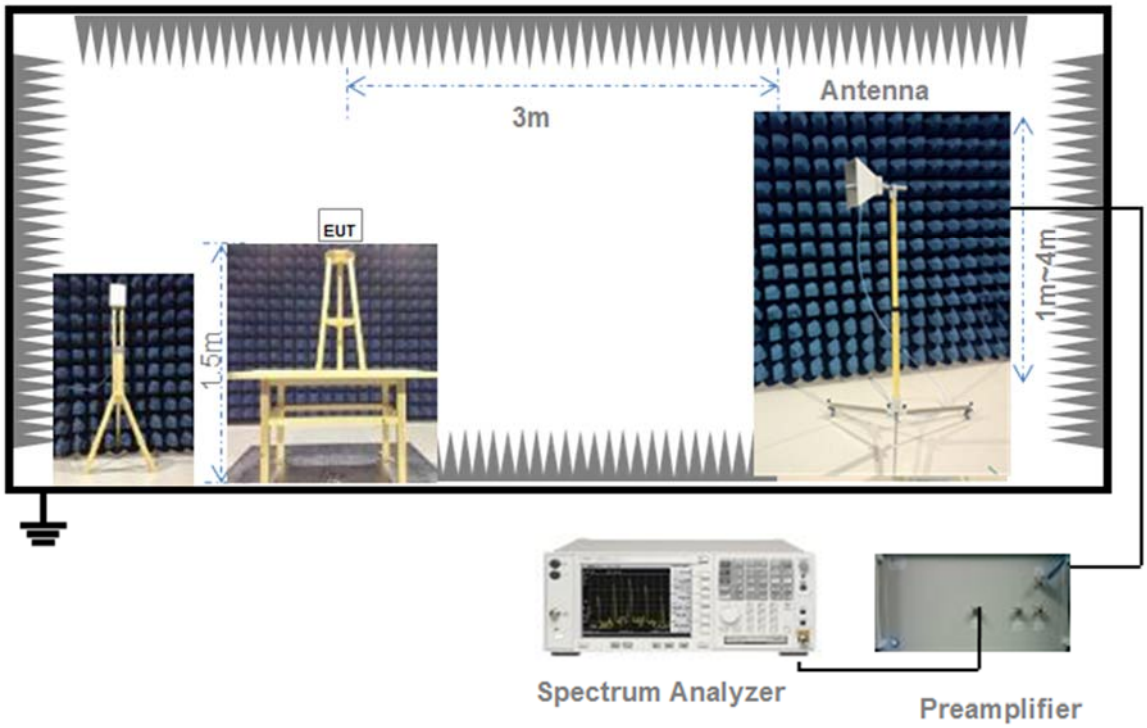
(Diagram 3)

4.4.4 For Radiated Test (30 MHz-1 GHz)



(Diagram 4)

4.4.5 For Radiated Test (Above 1 GHz)



(Diagram 5)

4.5 Measurement Results Explanation Example

4.5.1 For conducted test items:

The offset level is set in the spectrum analyzer to compensate the RF cable loss and attenuator between EUT conducted output port and spectrum analyzer. With the offset compensation, the spectrum analyzer reading level is exactly the EUT RF output level.
The spectrum analyzer offset is derived from RF cable loss and attenuator factor.
Offset = RF cable loss + attenuator factor.

4.5.2 For radiated band edges and spurious emission test:

Per part 15.35(c), the EUT Bluetooth average emission level could be determined by the peak emission level applying duty cycle correction factor, to represent averaging over the whole pulse train.
The average level is derived from the peak level corrected with “Duty cycle correction factor”.
Average Emission Level (dBuV/m) = Peak Emission Level (dBuV/m) + Duty cycle correction factor (dB)
Duty cycle correction factor (dB) = 20 * log (Duty cycle).
Duty cycle = on time / 100 milliseconds
On time = dwell time * hopping number in 100 ms
For example: bluetooth with dwell time 2.9 ms and 3 hops in 100 ms, then
Duty cycle correction factor (dB) = 20 * log ((2.9 * 3) / 100) = -21.21 dB
Following shows an average computation example with duty cycle correction factor = -21.21 dB, and the peak emission level is 45.61 dBuV/m.
Example:
Average Emission Level (dBuV/m) = Peak Emission Level (dBuV/m) + duty cycle correction factor (dB)
= 45.61 + (-21.21) = 24.4 (dBuV/m)

5 TEST ITEMS

5.1 Antenna Requirements

5.1.1 Standard Applicable

FCC §15.203 & 15.247(b); RSS-247, 5.4 (6)

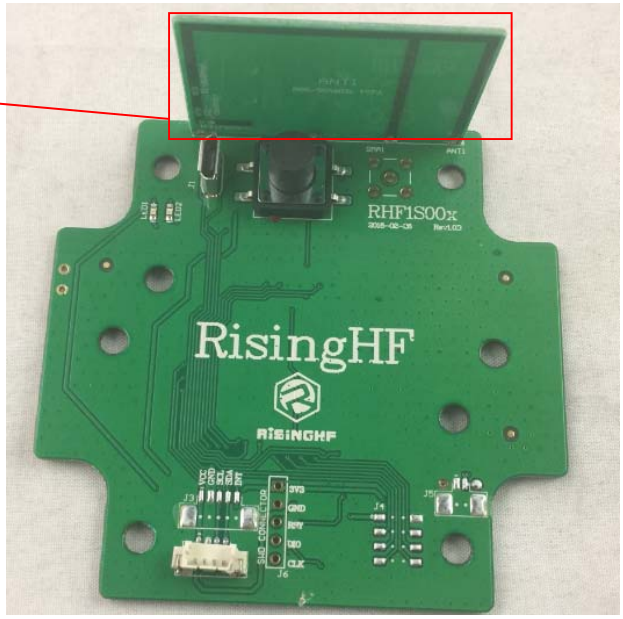
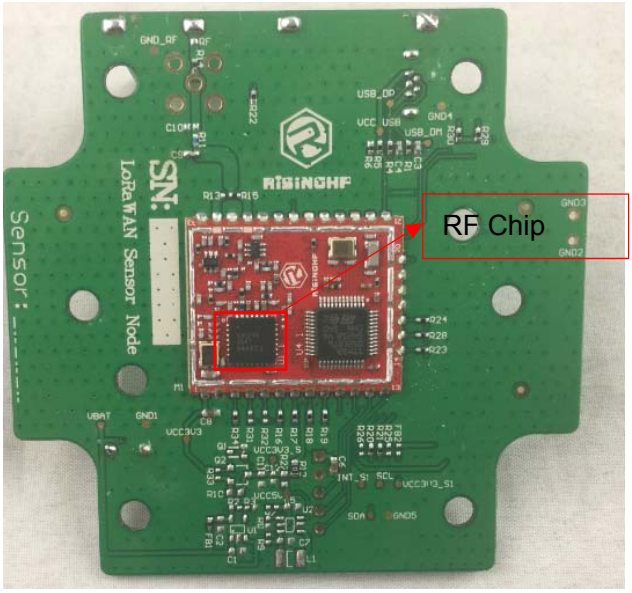
An intentional radiator shall be designed to ensure that no antenna other than that furnished by the responsible party shall be used with the device. The use of a permanently attached antenna or of an antenna that uses a unique coupling to the intentional radiator shall be considered sufficient to comply with the provisions of this section. The manufacturer may design the unit so that a broken antenna can be replaced by the user, but the use of a standard antenna jack or electrical connector is prohibited. This requirement does not apply to carrier current devices or to devices operated under the provisions of § 15.211, § 15.213, § 15.217, § 15.219, or § 15.221. Further, this requirement does not apply to intentional radiators that must be professionally installed, such as perimeter protection systems and some field disturbance sensors, or to other intentional radiators which, in accordance with § 15.31(d), must be measured at the installation site. However, the installer shall be responsible for ensuring that the proper antenna is employed so that the limits in this part are not exceeded.

If directional gain of transmitting antennas is greater than 6 dBi, the power shall be reduced by the same level in dB comparing to gain minus 6 dBi. For the fixed point-to-point operation, the power shall be reduced by one dB for every 3 dB that the directional gain of the antenna exceeds 6 dBi. The use of a permanently attached antenna or of an antenna that uses a unique coupling to the intentional radiator shall be considered sufficient to comply with the FCC rule.

5.1.2 Antenna Anti-Replacement Construction

The Antenna Anti-Replacement as following method:

Protected Method	Description
The antenna is An embedded-in	The antenna is welded on the mainboard, can't be replaced by the consumer

Reference Documents	Item
Photo PIFA Antenna	 

5.1.3 Antenna Gain

The antenna peak gain of EUT is less than 6 dBi. Therefore, it is not necessary to reduce maximum peak output power limit.

5.2 Number of Hopping Frequencies

5.2.1 Limit

FCC §15.247(a) (1) (i); RSS-247, 5.1 (4)

For frequency hopping systems operating in the 902-928 MHz band: the system shall use at least 50 hopping frequencies.

Test Setup

See section 4.4.1 for test setup description for the antenna port. The photo of test setup please refer to ANNEX B.

5.2.2 Test Procedure

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

Span = the frequency band of operation

RBW ≥ 1% of the span

VBW ≥ RBW

Sweep = auto

Detector function = peak

Trace = max hold

Allow the trace to stabilize

5.2.3 Test Result

Please refer to ANNEX A.1.

5.3 Output Power and E.I.R.P

5.3.1 Test Limit

FCC § 15.247(b)(2)

For frequency hopping systems operating in the 902-928 MHz band: 1 watt for systems employing at least 50 hopping channels; and, 0.25 watts for systems employing less than 50 hopping channels, but at least 25 hopping channels, as permitted under paragraph (a)(1)(i) of this section.

FCC § 15.247(b)(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.

RSS-247, 5.4 (2)

For FHSs operating in the band 902-928 MHz, the maximum peak conducted output power shall not exceed 1.0 W and the e.i.r.p. shall not exceed 4 W if the hopset uses 75 or more hopping channels; the maximum peak conducted output power shall not exceed 0.125 W and the e.i.r.p. shall not exceed 0.5 W if the hopset uses less than 75 hopping channels (see Section 5.4(5) for exceptions).

5.3.2 Test Setup

See section 4.4.1 for test setup description for the antenna port. The photo of test setup please refer to ANNEX B.

5.3.3 Test Procedure

For frequency hopping systems:

The Module operates at hopping-off test mode. The lowest, middle and highest channels are selected to perform testing to verify the conducted RF output peak and average power of the Module.

Use the following spectrum analyzer settings:

Span = approximately 5 times the 20 dB bandwidth, centered on a hopping channel

RBW > the 20 dB bandwidth of the emission being measured

VBW ≥ RBW

Sweep = auto

Detector function = peak

Trace = max hold

Allow the trace to stabilize.

For Hybrid systems:

Maximum conducted (average) output powerr

This procedure shall be used when the measurement instrument has available a resolution bandwidth that is greater than the DTS bandwidth.

Set span to at least 1.5 times the OBW.

Set RBW = 1-5% of the OBW, not to exceed 1 MHz.

Set VBW ≥ 3 x RBW.

Sweep points≥ 2 span / RBW.

Sweep time = auto.

Detector = RMS

If transmit duty cycle < 98 %, use a sweep trigger with the level set to enable triggering only on full power pulses. The transmitter shall operate at maximum power control level for the entire duration of every sweep. If the EUT transmits continuously (i.e., with no off intervals) or at duty cycle ≥ 98 %, and if each transmission is entirely at the maximum power control level, then the trigger shall be set to “free run”.

Trace average at least 100 traces in power averaging mode.

Measurements of duty cycle

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.

Set the center frequency of the instrument to the center frequency of the transmission.

Set RBW ≥ OBW if possible; otherwise, set RBW to the largest available value.

Set VBW ≥ RBW. Set detector = peak or average.

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.)

5.3.4 Test Result

Please refer to ANNEX A.2.

5.4 Occupied Bandwidth

5.4.1 Limit

FCC §15.247(a)(1)(i); RSS-247, 5.1 (1)

Measurement of the 20dB bandwidth of the modulated signal. The maximum allowed 20 dB bandwidth of the hopping channel is 500 kHz.

5.4.2 Test Setup

See section 4.4.1 for test setup description for the antenna port. The photo of test setup please refer to ANNEX B.

5.4.3 Test Procedure

Use the following spectrum analyzer settings:

Span = approximately 2 to 3 times the 20 dB bandwidth, centered on a hopping channel

RBW = in the range of 1% to 5% of the OBW

VBW ≥ RBW

Sweep = auto

Detector function = peak

Trace = max hold

The EUT should be transmitting at its maximum data rate, Allow the trace to stabilize.

5.4.4 Test Result

Please refer to ANNEX A.3.

5.5 Carrier Frequency Separation

5.5.1 Limit

FCC §15.247(a)(1); RSS-247, 5.1 (2)

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.

5.5.2 Test Setup

See section 4.4.1 for test setup description for the antenna port. The photo of test setup please refer to ANNEX B.

5.5.3 Test Procedure

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

Span = wide enough to capture the peaks of two adjacent channels

Resolution (or IF) Bandwidth (RBW) ≥ 1% of the span

Video (or Average) Bandwidth (VBW) ≥ RBW

Sweep = auto

Detector function = peak

Trace = max hold

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

5.5.4 Test Result

Please refer to ANNEX A.4.

5.6 Time of Occupancy (Dwell time)

5.6.1 Limit

FCC §15.247(a)(1)(i); RSS-247, 5.1 (4)

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; 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.

5.6.2 Test Setup

See section 4.4.1 for test setup description for the antenna port. The photo of test setup please refer to ANNEX B.

5.6.3 Test Procedure

The lowest, middle and highest channels are selected to perform testing to record the dwell time of each occupation measured in this channel, which is called Pulse Time here.

5.6.4 Test Result

Please refer to ANNEX A.5

5.7 Conducted Spurious Emission & Authorized-band band-edge

5.7.1 Limit

FCC §15.247(d); RSS-247, 5.5

For frequency hopping systems:
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.

For Hybrid systems:
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.

5.7.2 Test Setup

See section 4.4.1 for test setup description for the antenna port. The photo of test setup please refer to ANNEX B.

5.7.3 Test Procedure

Use the following spectrum analyzer settings:

Span = wide enough to capture the peak level of the in-band emission and all spurious emissions (e.g., harmonics) from the lowest frequency generated in the EUT up through the 10th harmonic. Typically, several plots are required to cover this entire span.
RBW = 100 kHz
VBW ≥ RBW
Sweep = auto
Detector function = peak
Trace = max hold
Allow the trace to stabilize

5.7.4 Test Result

Please refer to ANNEX A.6 and A.7

5.8 Conducted Emission

5.8.1 Limit

FCC §15.207; RSS-GEN, 8.8

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 within the band 150 kHz to 30 MHz shall not exceed the limits in the following table, as measured using a 50μH/50Ω line impedance stabilization network (LISN).

Frequency range (MHz)	Conducted Limit (dBμV)	
	Quai-peak	Average
0.15 - 0.50	66 to 56	56 to 46
0.50 - 5	56	46
0.50 - 30	60	50

5.8.2 Test Setup

See section 4.4.2 for test setup description for the AC power supply port. The photo of test setup please refer to ANNEX B.

5.8.3 Test Procedure

The maximum conducted interference is searched using Peak (PK), if the emission levels more than the AV and QP limits, and that have narrow margins from the AV and QP limits will be re-measured with AV and QP detectors. Tests for both L phase and N phase lines of the power mains connected to the EUT are performed. Refer to recorded points and plots below.
Devices subject to Part 15 must be tested for all available U.S. voltages and frequencies (such as a nominal 120 VAC, 50/60 Hz and 240 VAC, 50/60 Hz) for which the device is capable of operation. A device rated for 50/60 Hz operation need not be tested at both frequencies provided the radiated and line conducted emissions are the same at both frequencies.

5.8.4 Test Result

Please refer to ANNEX A.7.

5.9 Radiated Spurious Emission

5.9.1 Limit

FCC §15.209&15.247(d); RSS-247, 5.5

Radiated emission outside the frequency band attenuation below the general limits specified in FCC section 15.209(a) is not required. In addition, radiated emissions which fall in the restricted bands, as defined in FCC section 15.205(a), must also comply with the radiated emission limits specified in FCC section 15.209(a).

According to FCC section 15.209 (a), except as provided elsewhere in this subpart, the emissions from an intentional radiator shall not exceed the field strength levels specified in the following table:

Frequency (MHz)	Field Strength (μV/m)	Measurement Distance (m)
0.009 - 0.490	902/F(kHz)	300
0.490 - 1.705	9020/F(kHz)	30
1.705 - 30.0	30	30
30 - 88	100	3
88 - 216	150	3
216 - 960	200	3
Above 960	500	3

Note:

1. Field Strength (dBμV/m) = 20*log[Field Strength (μV/m)].
2. In the emission tables above, the tighter limit applies at the band edges.
3. For Above 1000 MHz, the emission limit in this paragraph is based on measurement instrumentation employing an average detector, measurement using instrumentation with a peak detector function, corresponding to 20dB above the maximum permitted average limit.
4. For above 1000 MHz, limit field strength of harmonics: 54dBuV/m@3m (AV) and 74dBuV/m@3m (PK).

5.9.2 Test Setup

See section 4.4.3 to 4.4.5 for test setup description for the antenna port. The photo of test setup please refer to ANNEX B.

5.9.3 Test Procedure

The measurement frequency range is from 9 kHz to the 10th harmonic of the fundamental frequency. The Turn Table is actuated to turn from 0° to 360°, and both horizontal and vertical polarizations of the Test Antenna are used to find the maximum radiated power. Mid channels on all channel bandwidth verified. Only the worst RB size/offset presented.

The power of the EUT transmitting frequency should be ignored.

All Spurious Emission tests were performed in X, Y, Z axis direction. And only the worst axis test condition was recorded in this test report.

Use the following spectrum analyzer settings:

Span = wide enough to fully capture the emission being measured

RBW = 1 MHz for f ≥ 1 GHz, 100 kHz for f < 1 GHz
VBW ≥ RBW
Sweep = auto
Detector function = peak
Trace = max hold
For measurement below 1GHz, If the emission level of the EUT measured by the peak detector is 3 dB lower than the applicable limit, the peak emission level will be reported, Otherwise, the emission measurement will be repeated using the quasi-peak detector and reported.

5.9.4 Test Result

Please refer to ANNEX A.8.

5.10 Band Edge (Restricted-band band-edge)

5.10.1 Limit

FCC §15.209&15.247(d)

Radiated emission outside the frequency band attenuation below the general limits specified in FCC section 15.209(a) is not required. In addition, radiated emissions which fall in the restricted bands, as defined in FCC section 15.205(a), must also comply with the radiated emission limits specified in FCC section 15.209(a).

5.10.2 Test Setup

See section 4.4.3 to 4.4.5 for test setup description for the antenna port. The photo of test setup please refer to ANNEX B.

5.10.3 Test Procedure

The measurement frequency range is from 9 kHz to the 10th harmonic of the fundamental frequency. The Turn Table is actuated to turn from 0° to 360°, and both horizontal and vertical polarizations of the Test Antenna are used to find the maximum radiated power. Mid channels on all channel bandwidth verified. Only the worst RB size/offset presented.

The power of the EUT transmitting frequency should be ignored.

All Spurious Emission tests were performed in X, Y, Z axis direction. And only the worst axis test condition was recorded in this test report.

Use the following spectrum analyzer settings:

Span = wide enough to fully capture the emission being measured
RBW = 1 MHz for f ≥ 1 GHz, 100 kHz for f < 1 GHz
VBW ≥ RBW
Sweep = auto
Detector function = peak
Trace = max hold

For measurement below 1GHz, If the emission level of the EUT measured by the peak detector is 3 dB lower than the applicable limit, the peak emission level will be reported, Otherwise, the emission measurement will be repeated using the quasi-peak detector and reported.

5.10.4 Test Result

Please refer to ANNEX A.9.

5.11 Power Spectral density (PSD)

5.11.1 Limit

FCC §15.247(e); RSS-247, 5.2 (2)

The same method of determining the conducted output power shall be used to determine the power spectral density. If a peak output power is measured, then a peak power spectral density measurement is required. If an average output power is measured, then an average power spectral density measurement should be used.

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. This power spectral density shall be determined in accordance with the provisions of Section 5.4(4), (i.e. the power spectral density shall be determined using the same method as is used to determine the conducted output power).

5.11.2 Test Setup

See section 4.4.1 (Diagram 1) for test setup description for the antenna port. The photo of test setup please refer to ANNEX B.

5.11.3 Test Procedure

Set instrument center frequency to DTS channel center frequency.
Set span to at least 1.5 times the OBW.
Set RBW to: 3 kHz ≤ RBW ≤ 100 kHz. .
Set VBW ≥3 x RBW.
Detector = power averaging (RMS).
Ensure that the number of measurement points in the sweep ≥ 2 x span/RBW.
Sweep time = auto couple.
Employ trace averaging (RMS) mode over a minimum of 100 traces.
Use the peak marker function to determine the maximum amplitude level.

5.11.4 Test Result

Please refer to ANNEX A.10.

ANNEX A TEST RESULT

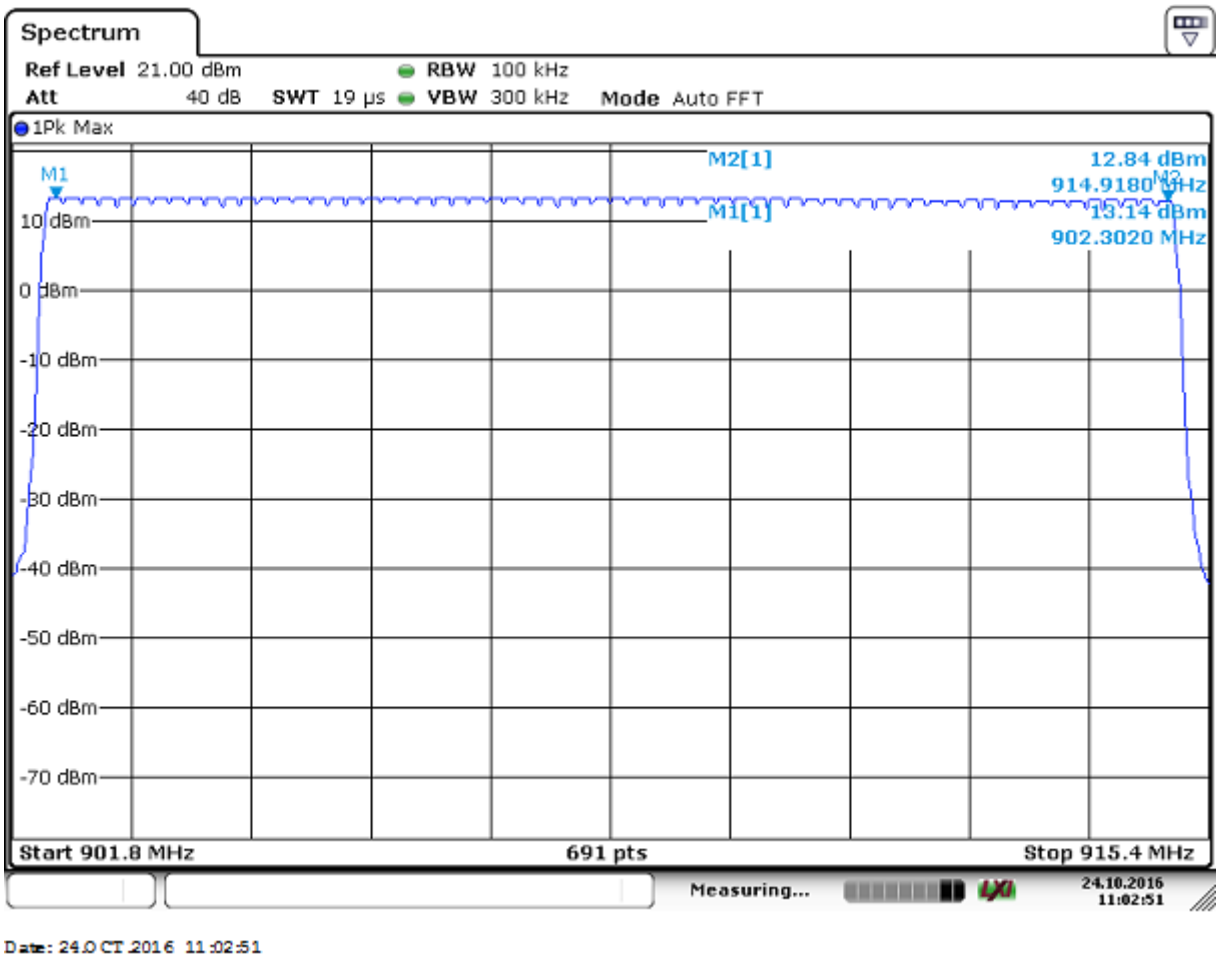
A.1 Number of Hopping Frequency

Test Data

Test Mode	Frequency Block (MHz)	Measured Channel Numbers	Min. Limit	Verdict
LoRa	902-928	64	50	Pass

Test plots

LoRa



A.2 Conducted Output Power

For frequency hopping systems:

Peak Power Test Data

Channel	Measured Output Power		Limit		Verdict
	LoRa		dBm	mW	
	dBm	mW			
Low	13.63	23.07	30	1000	Pass
Middle	13.59	22.86			Pass
High	13.67	23.28			Pass

For Hybrid systems:

Average Power Test Data

Channel	Measured Output Power		Limit		Verdict
	LoRa		dBm	mW	
	dBm	mW			
Low	13.25	21.13	30	1000	Pass
Middle	13.66	23.23			Pass
High	13.74	23.66			Pass

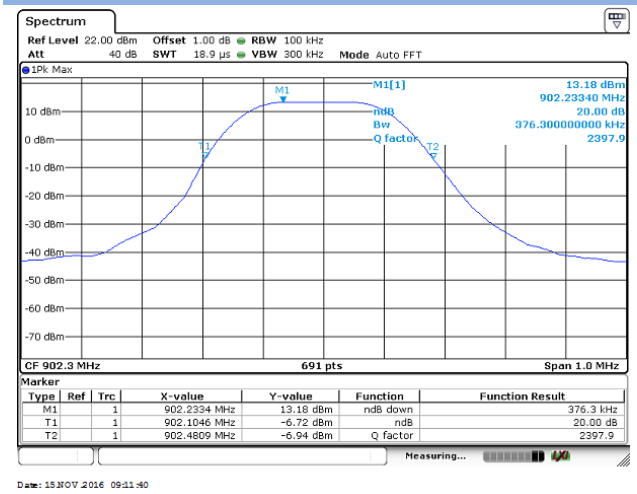
A.3 20 dB and 99% bandwidth

Test Data

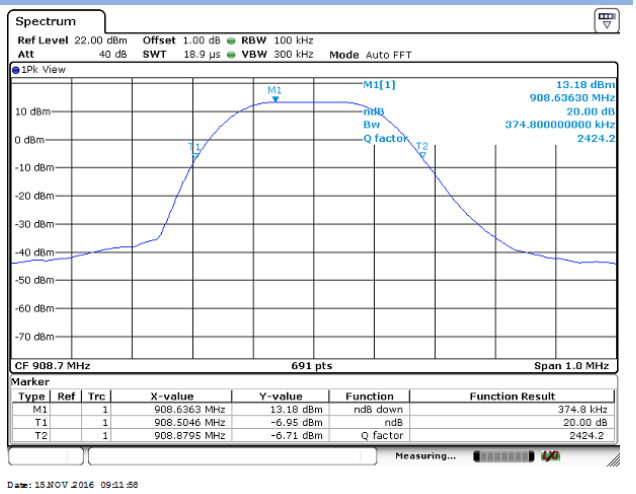
LoRa				
Channel	20 dB Bandwidth (kHz)	99% Bandwidth (kHz)	Limit of 20 dB Bandwidth (kHz)	Verdict
Low	376.3	315.48	500	Pass
Middle	374.8	316.93	500	Pass
High	376.3	316.93	500	Pass

Test plots (20 dB Bandwidth)

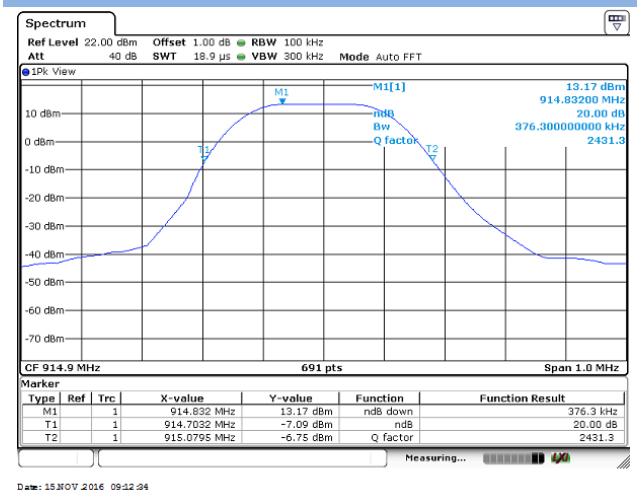
LOW CHANNEL



MIDDLE CHANNEL

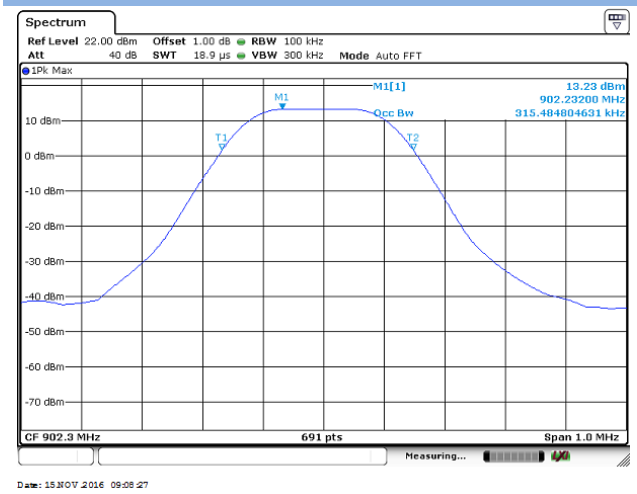


HIGH CHANNEL

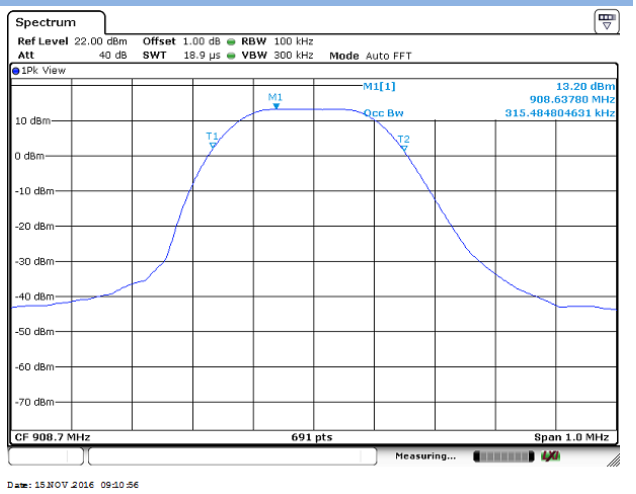


Test plots (99% Bandwidth)

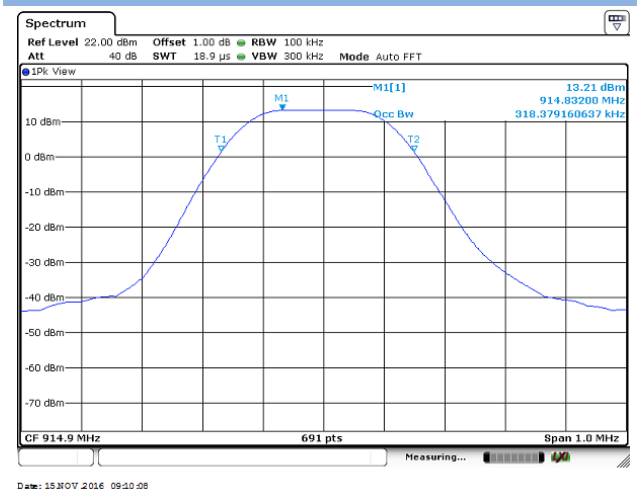
LOW CHANNEL



MIDDLE CHANNEL



HIGH CHANNEL



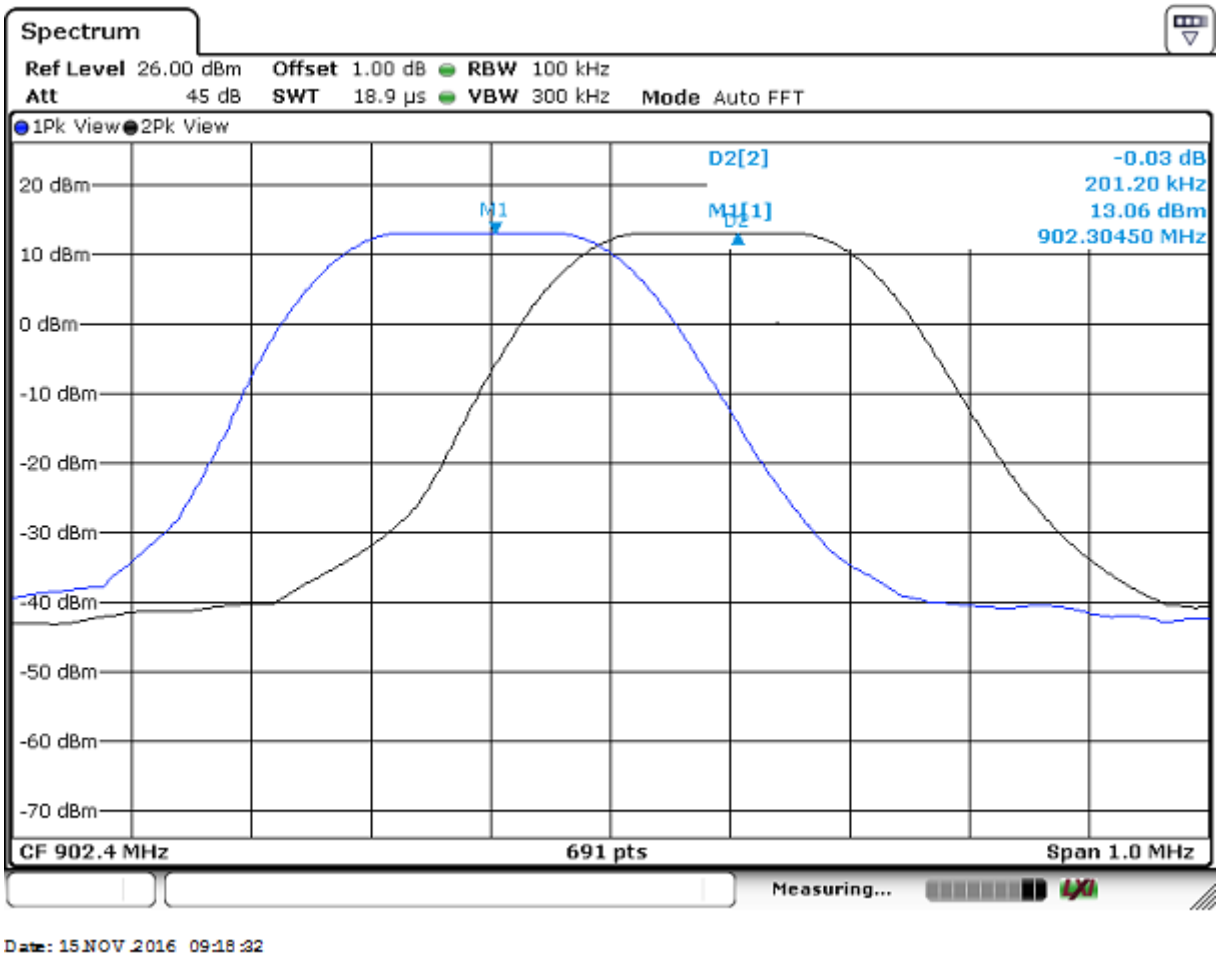
A.4 Hopping Frequency Separation

Test Data

Mode	Frequency separation (MHz)	Max 20 dB Bandwidth (MHz)	Verdict
LoRa	0.201	0.376	Pass

Test Plots

LoRa

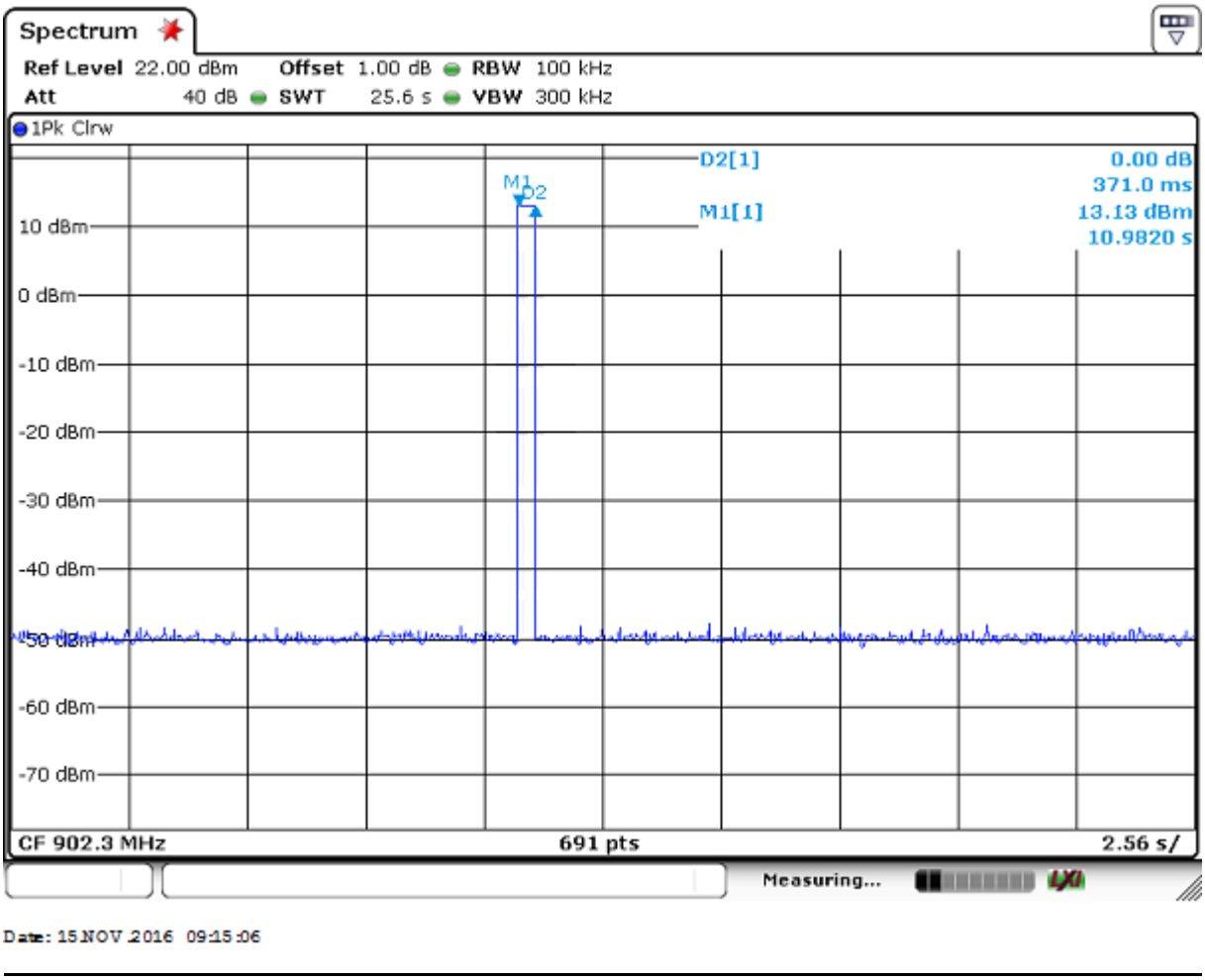


A.5 Average Time of Occupancy

Test Data

Total of Dwell(ms)	Limit (sec)	Verdict
371.0	0.4	Pass

LoRa



A.6 Conducted Spurious Emissions

Test Data

For frequency hopping systems:

LoRa				
Channel	Measured Max. Out of Band Emission (dBm)	Limit (dBm)		Verdict
		Carrier Level	Calculated 20 dBc Limit	
Low	-39.30	13.62	-6.38	Pass
Middle	-38.59	13.64	-6.36	Pass
High	-37.51	13.63	-6.37	Pass

Hopping Mode				
Mode	Measured Max. Out of Band Emission (dBm)	Limit (dBm)		Verdict
		Carrier Level	Calculated 20 dBc Limit	
LoRa	-37.69	12.84	-7.16	Pass

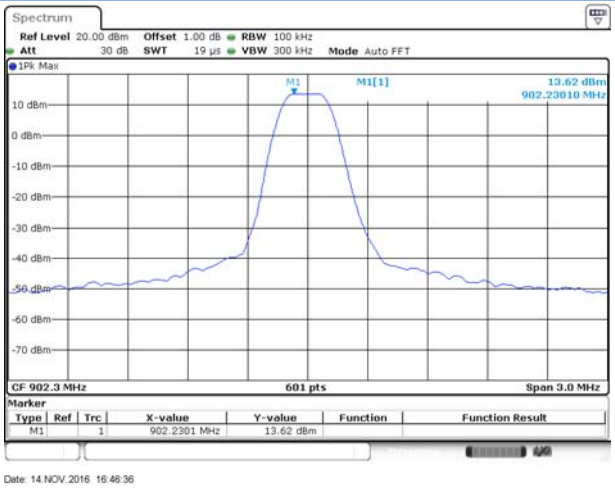
For Hybrid systems:

LoRa				
Channel	Measured Max. Out of Band Emission (dBm)	Limit (dBm)		Verdict
		Carrier Level	Calculated 30 dBc Limit	
Low	-59.56	13.58	-16.42	Pass
Middle	-38.21	13.64	-16.36	Pass
High	-37.45	13.68	-16.32	Pass

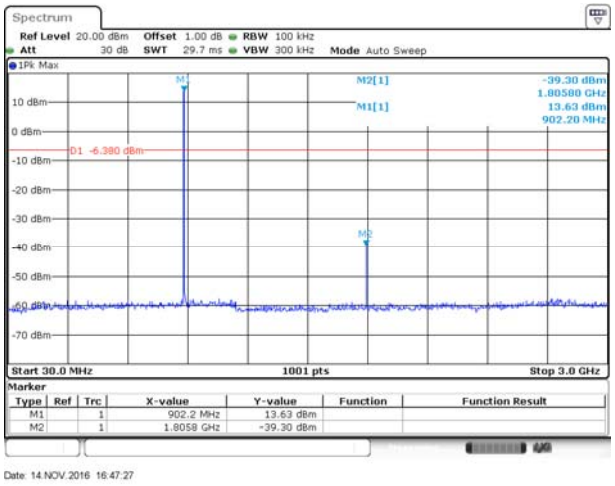
Test Plots

For frequency hopping systems:

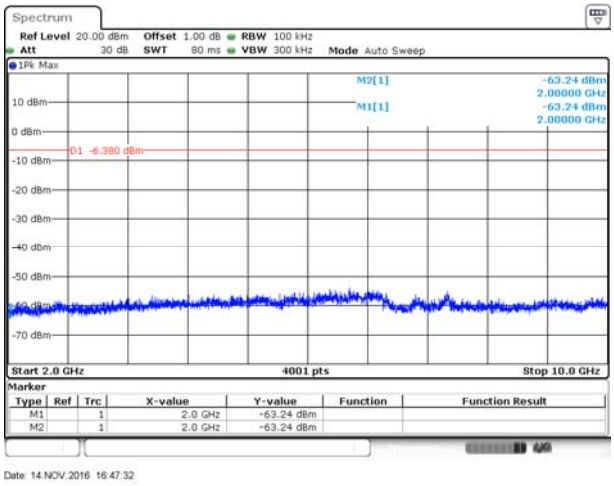
LOW CHANNEL, CARRIER LEVEL



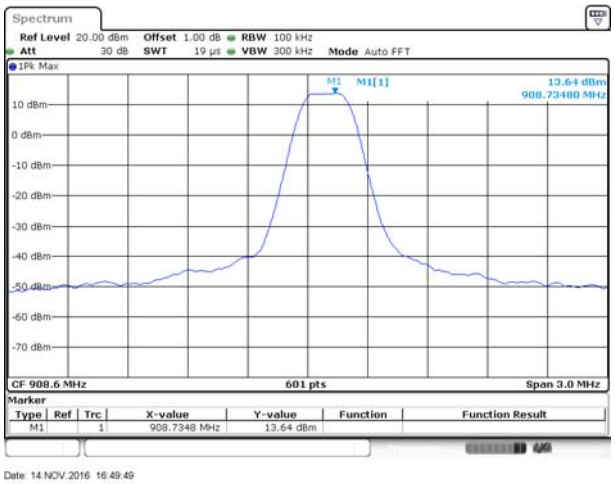
LOW CHANNEL , SPURIOUS 30 MHz ~ 1 GHz



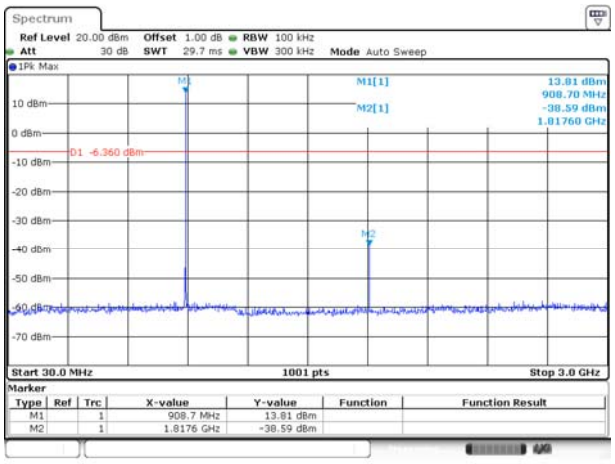
LOW CHANNEL , SPURIOUS 1 GHz ~ 10 GHz



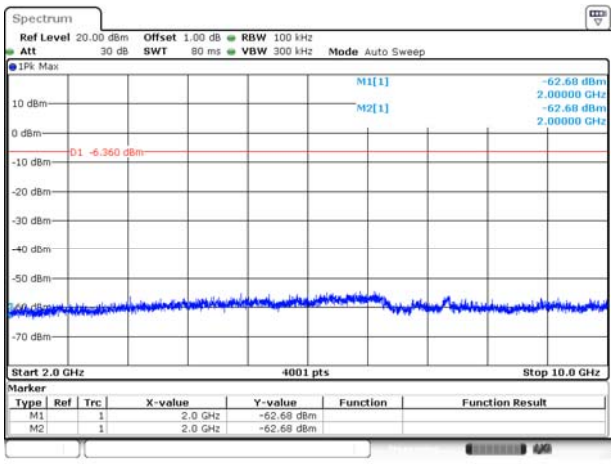
MIDDLE CHANNEL, CARRIER LEVEL



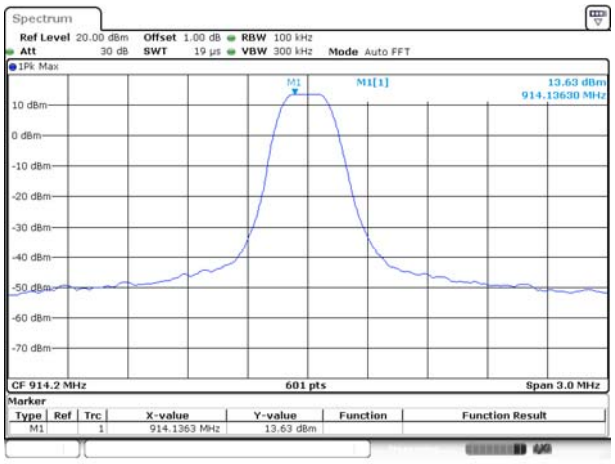
MIDDLE CHANNEL , SPURIOUS 30 MHz ~ 1 GHz



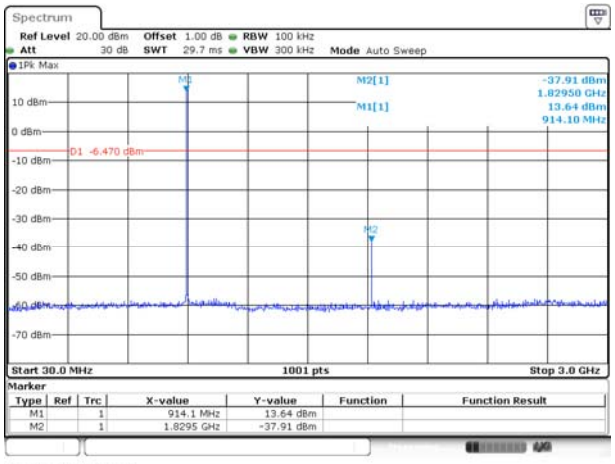
MIDDLE CHANNEL , SPURIOUS 1 GHz ~ 10 GHz



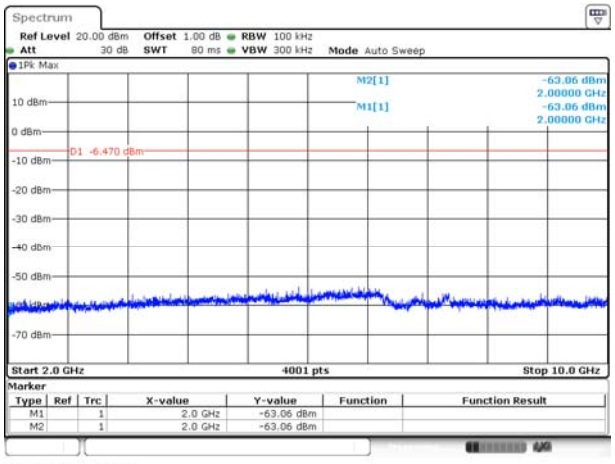
HIGH CHANNEL, CARRIER LEVEL



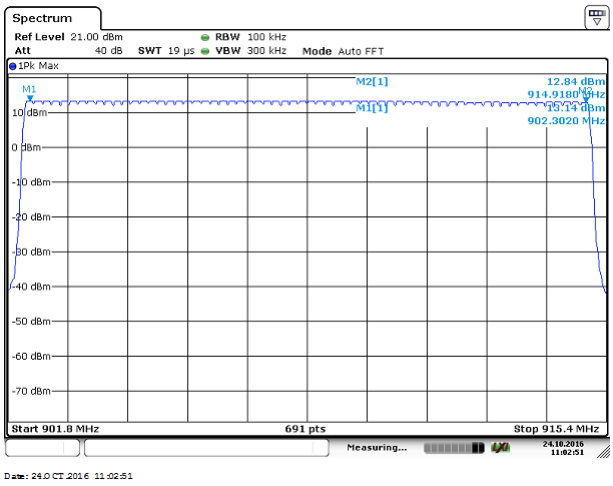
HIGH CHANNEL , SPURIOUS 30 MHz ~ 1 GHz



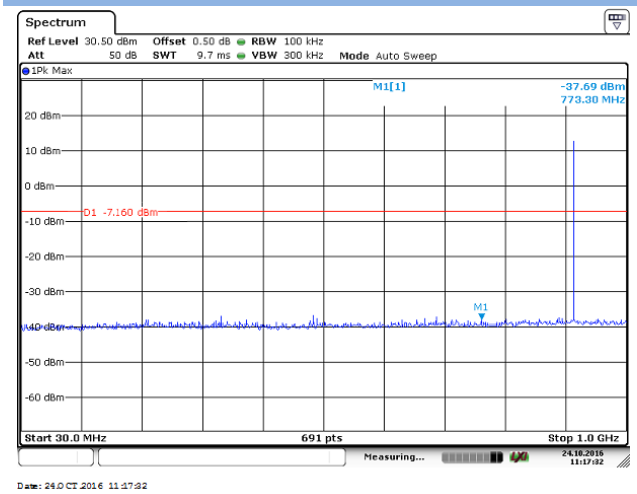
HIGH CHANNEL , SPURIOUS 1 GHz ~ 10 GHz



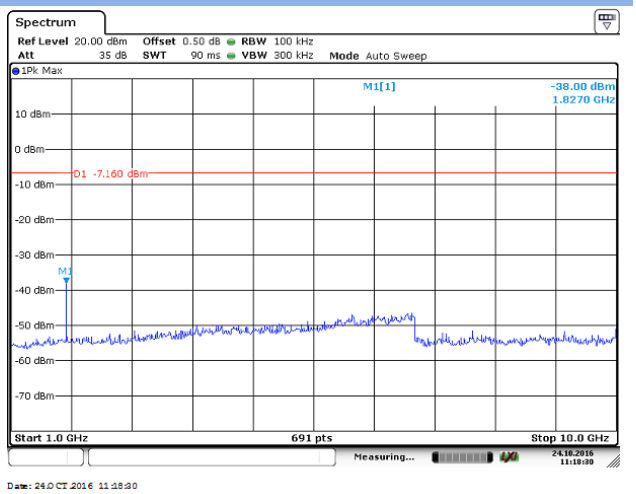
HOPPING, CARRIER LEVEL



Hopping Mode, SPURIOUS 30 MHz ~ 1 GHz

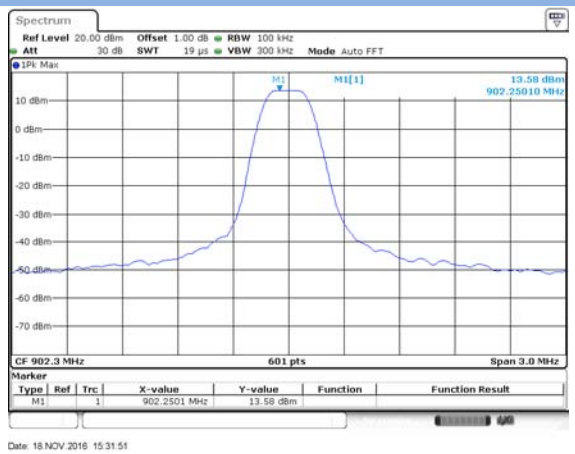


Hopping Mode, SPURIOUS 1GHz ~ 10 GHz

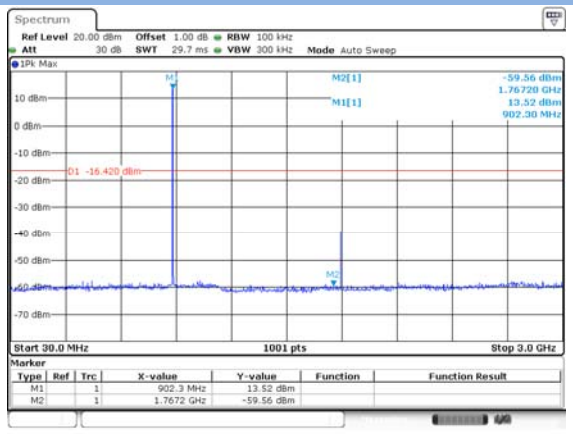


For Hybrib systems:

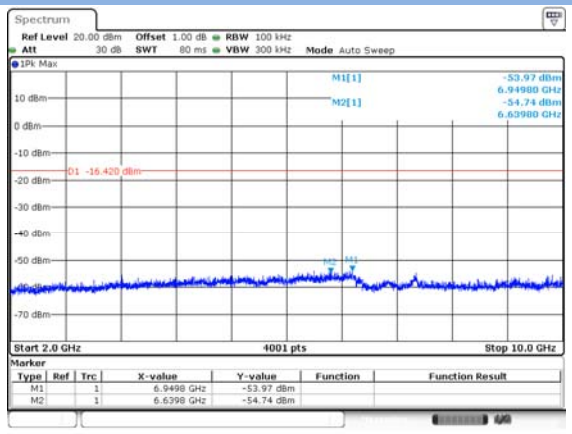
LOW CHANNEL, CARRIER LEVEL



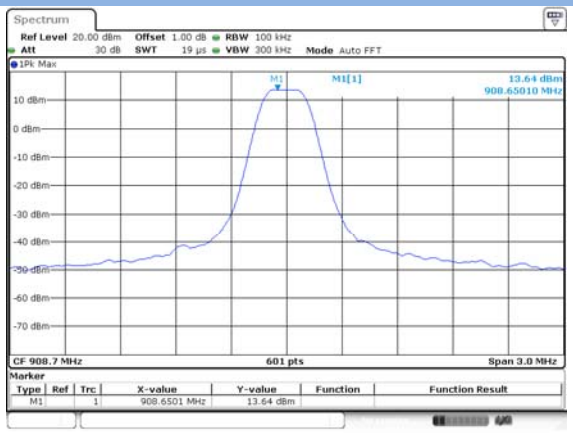
LOW CHANNEL , SPURIOUS 30 MHz ~ 1 GHz



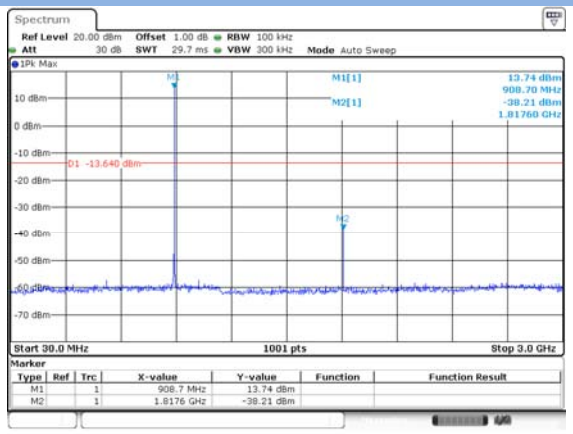
LOW CHANNEL , SPURIOUS 1 GHz ~ 10 GHz



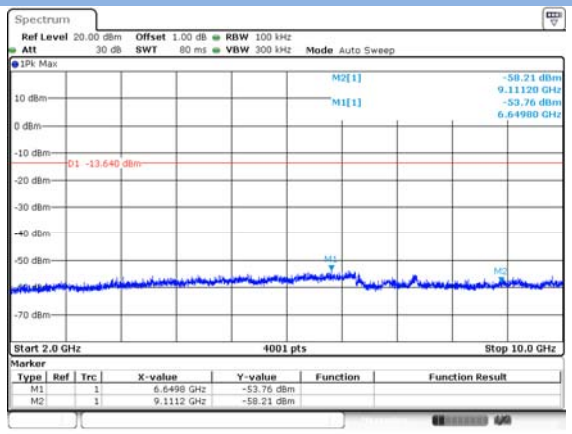
MIDDLE CHANNEL, CARRIER LEVEL



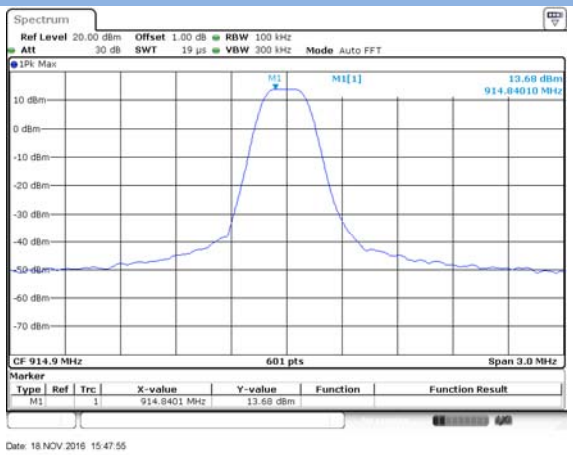
MIDDLE CHANNEL , SPURIOUS 30 MHz ~ 1 GHz



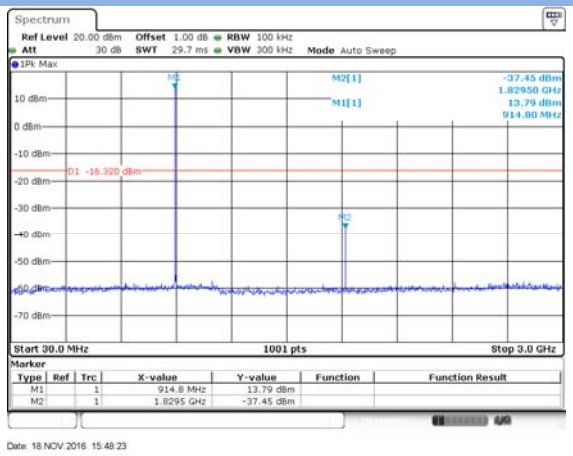
MIDDLE CHANNEL , SPURIOUS 1 GHz ~ 10 GHz



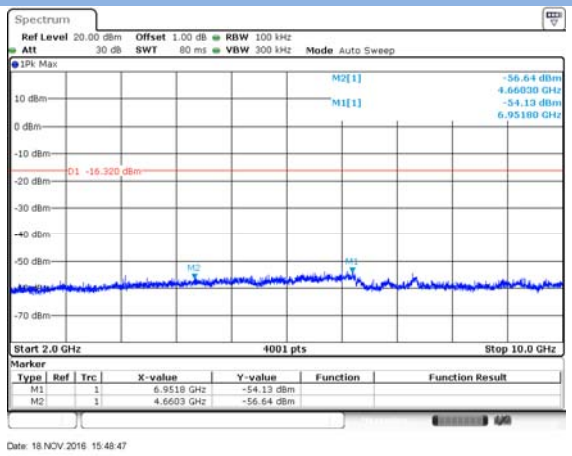
HIGH CHANNEL, CARRIER LEVEL



HIGH CHANNEL , SPURIOUS 30 MHz ~ 1 GHz



HIGH CHANNEL , SPURIOUS 1 GHz ~ 10 GHz



A.7 Band-edge-Authorized-band

Test data

For frequency hopping systems:

Channel	Measured Max. Band Edge Emission (dBm)	Limit (dBm)		Verdict
		Carrier Level	Calculated 20 dBc Limit	
Low Channel	-32.73	13.62	-6.38	Pass
High Channel	-35.96	13.63	-6.37	Pass
Hopping low-channel	-32.64	12.84	-7.16	Pass
Hopping High-channel	-35.26	12.84	-7.16	Pass

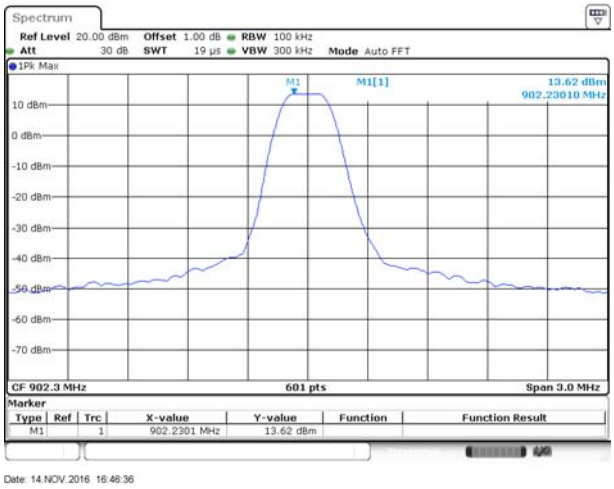
For Hybrid systems:

Channel	Measured Max. Band Edge Emission (dBm)	Limit (dBm)		Verdict
		Carrier Level	Calculated 30 dBc Limit	
Low Channel	-30.95	13.58	-16.42	Pass
High Channel	-33.97	13.68	-16.32	Pass

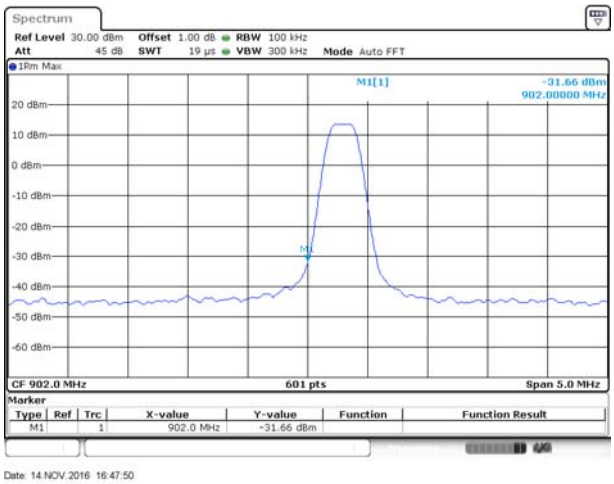
Test Plots

For frequency hopping systems:

LOW CHANNEL, Carrier level

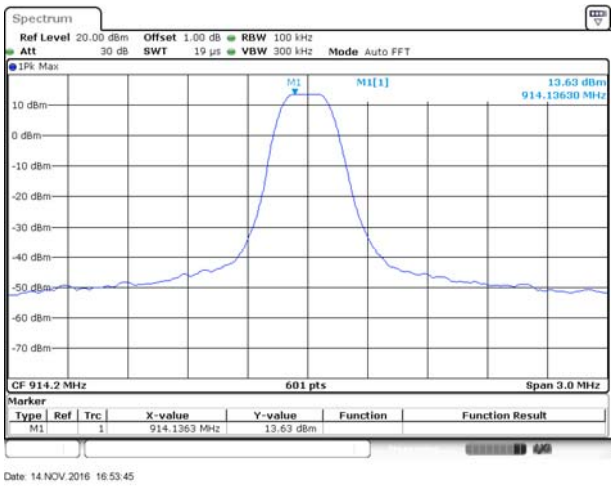


LOW CHANNEL, Reference level

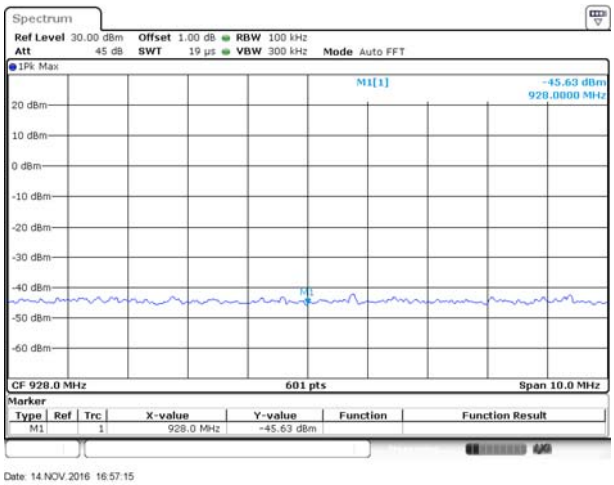


LOW CHANNEL, Band Edge

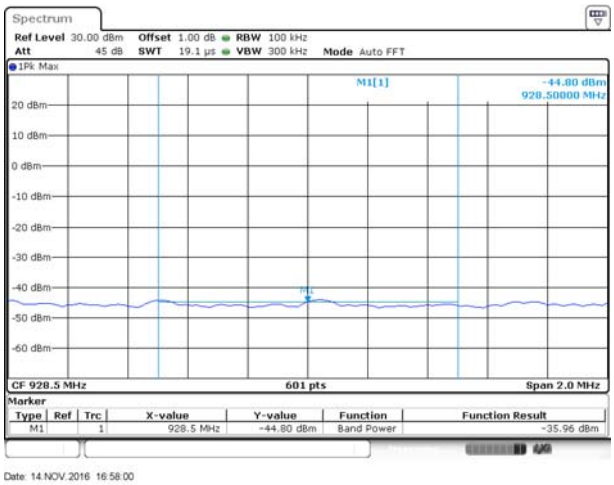
HIGH CHANNEL, Carrier level



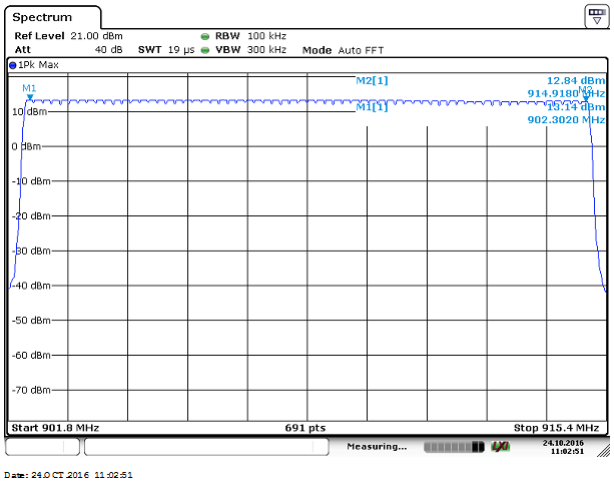
HIGH CHANNEL, Reference level



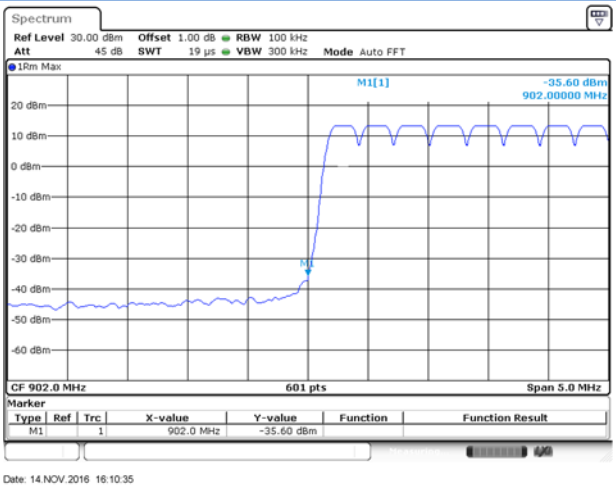
HIGH CHANNEL, Band Edge



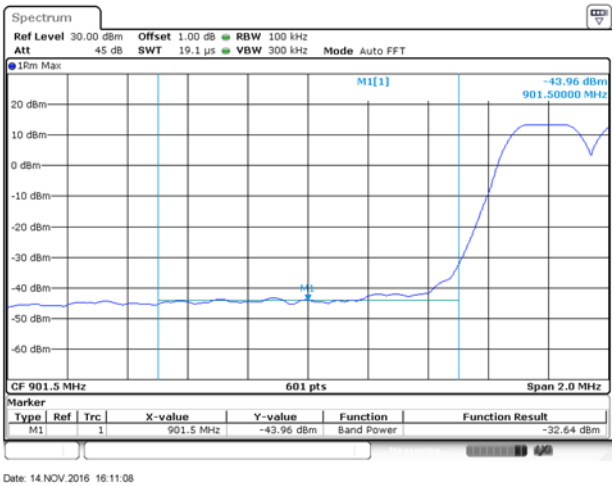
HOPPING LEFT-CHANNEL, Carrier level



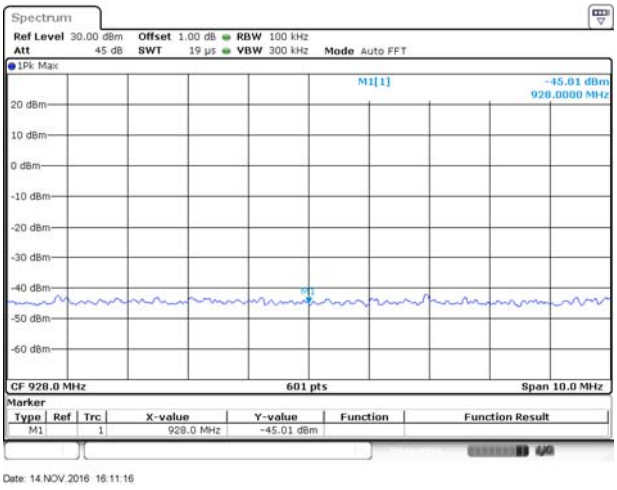
HOPPING LEFT-CHANNEL, Reference level



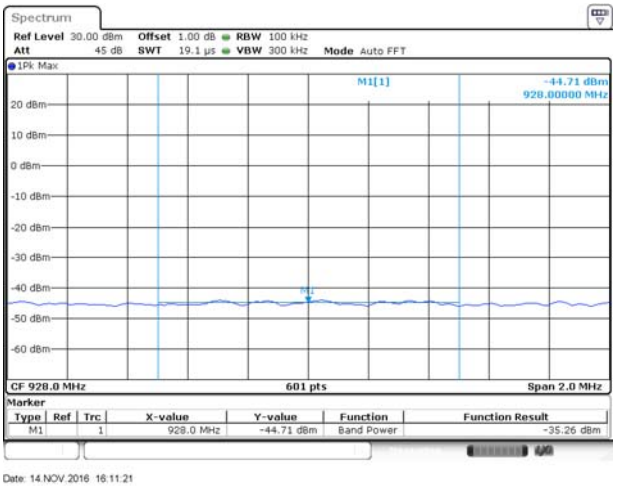
HOPPING LEFT-CHANNEL, Band Edge



HOPPING RIGHT-CHANNEL, Reference level

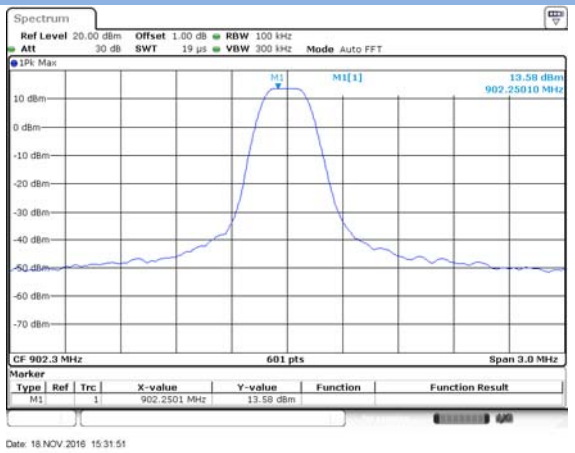


HOPPING RIGHT-CHANNEL, Band Edge



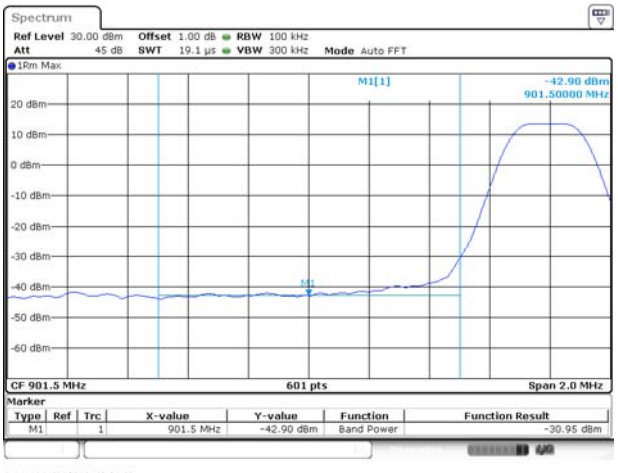
For Hybrid systems:

LOW CHANNEL, Carrier level

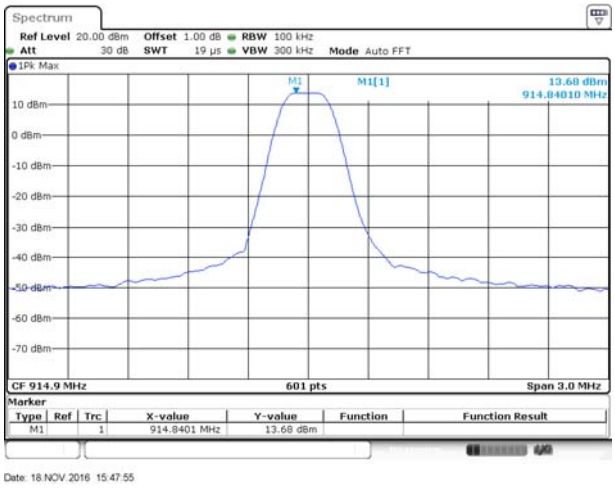


LOW CHANNEL, Reference level

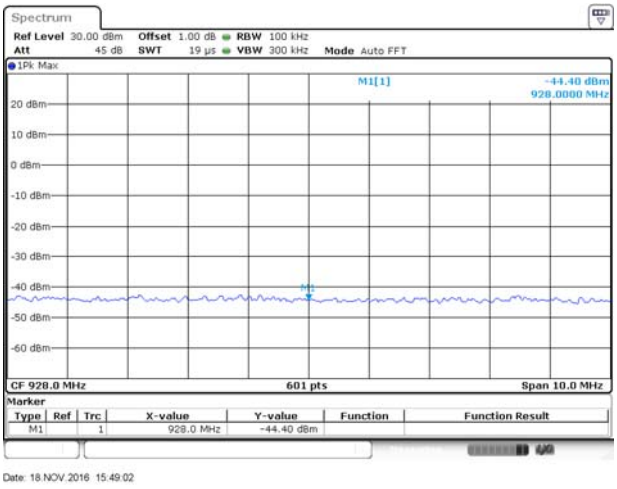
LOW CHANNEL, Band Edge



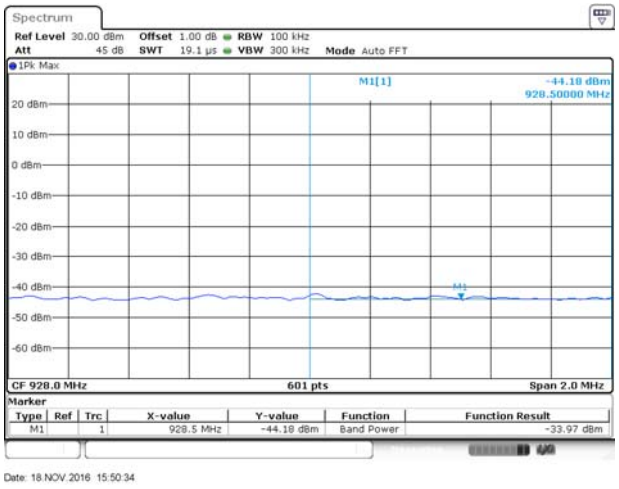
HIGH CHANNEL, Carrier level



HIGH CHANNEL, Reference level



HIGH CHANNEL, Band Edge



A.8 Conducted Emissions

N/A

A.9 Radiated Spurious Emission

Note 1: The symbol of "--" in the table which means not application.

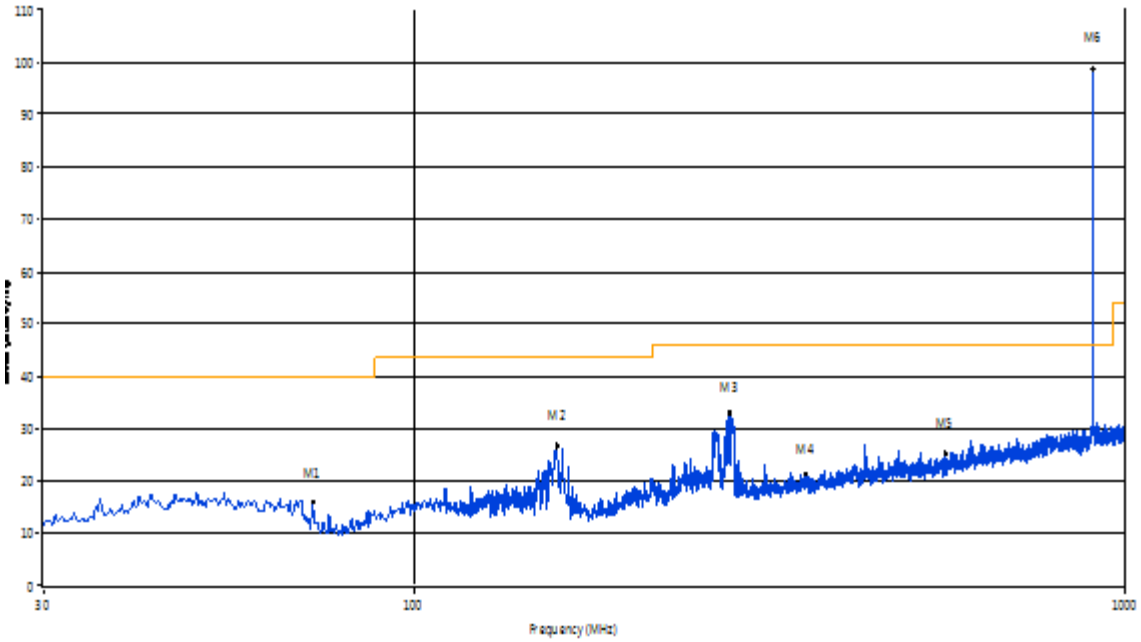
Note 2: For the test data above 1 GHz, according the ANSI C63.10-2013, where limits are specified for both average and peak (or quasi-peak) detector functions, if the peak (or quasi-peak) measured value complies with the average limit, it is unnecessary to perform an average measurement.

Note 3: The low frequency, which started from 9 kHz to 30 MHz, was pre-scanned and the result which was 20 dB lower than the limit line per 15.31(o) was not reported.

Note 4: The worst configurations is below 1 GHz, only the worst configuration (Low Channel) shown here.

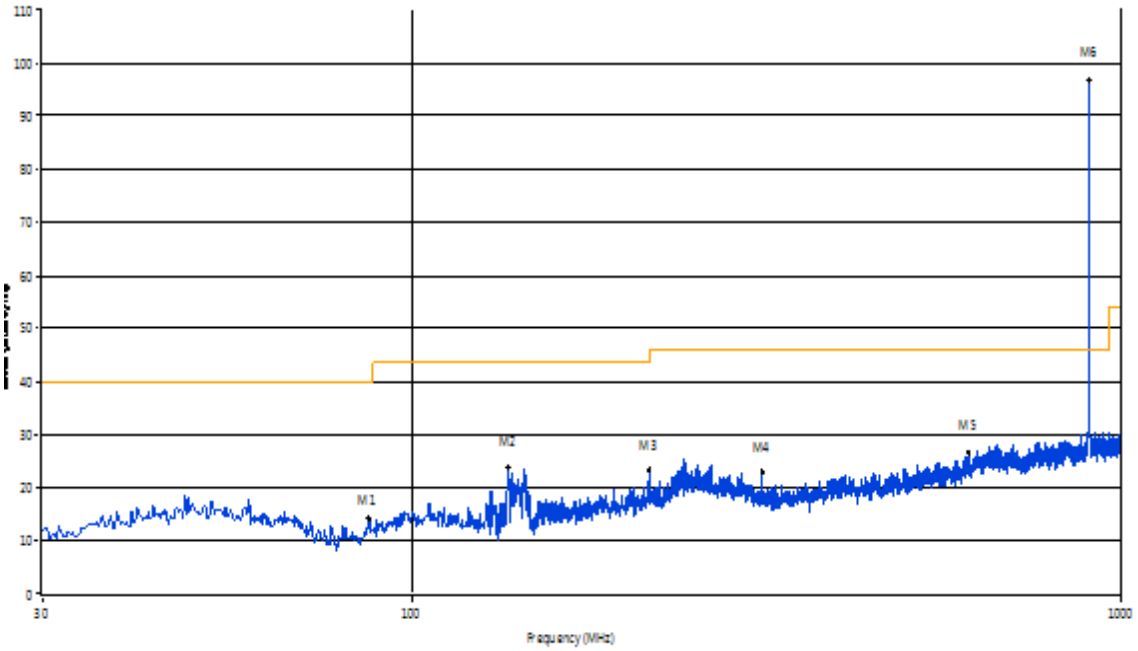
Test Data and Plots

LOW CHANNEL ANT V



No.	Frequency (MHz)	Results (dBuV/m)	Factor (dB)	Limit (dBuV/m)	Margin (dB)	Detector	Table (o)	Height (cm)	ANT	Verdict
1	71.942	15.86	-23.81	40.0	24.14	Peak	32.00	300	Vertical	Pass
2	158.735	26.63	-23.41	43.5	16.87	Peak	238.00	300	Vertical	Pass
3	277.773	32.89	-18.70	46.0	13.11	Peak	197.00	300	Vertical	Pass
4	355.839	21.33	-16.44	46.0	24.67	Peak	182.00	200	Vertical	Pass
5	559.245	25.33	-12.11	46.0	20.67	Peak	4.00	200	Vertical	Pass
6	902.359	97.03	-5.82	46.0	-51.03	Peak	179.00	100	Vertical	N/A

LOW CHANNEL, ANT H



No.	Frequency (MHz)	Results (dBuV/m)	Factor (dB)	Limit (dBuV/m)	Margin (dB)	Detector	Table (o)	Height (cm)	ANT	Verdict
1	86.973	14.36	-23.01	40.0	25.64	Peak	202.00	100	Horizontal	Pass
2	136.673	23.91	-23.85	43.5	19.59	Peak	210.00	200	Horizontal	Pass
3	215.951	23.34	-20.26	43.5	20.16	Peak	2.00	300	Horizontal	Pass
4	311.957	22.88	-17.62	46.0	23.12	Peak	3.00	100	Horizontal	Pass
5	610.400	26.62	-10.79	46.0	19.38	Peak	47.00	100	Horizontal	Pass
6	902.359	96.72	-5.82	46.0	-50.72	Peak	251.00	100	Horizontal	N/A

LOW CHANNEL 1 GHz to 10 GHz, ANT V

No.	Frequency (MHz)	Results (dBuV/m)	Factor (dB)	Limit (dBuV/m)	Margin (dB)	Detector	Table (o)	Height (cm)	ANT	Verdict
1	1021.50	40.47	-6.14	74	33.54	Peak	139.2	150	Vertical	Pass
2	1395.90	44.12	-4.44	74	29.88	Peak	284.1	150	Vertical	Pass
3	1716.82	46.55	-2.99	74	27.45	Peak	217.3	150	Vertical	Pass
4	6179.70	48.31	14.50	74	25.69	Peak	35.8	150	Vertical	Pass
5	7954.24	42.96	9.27	74	31.04	Peak	206.5	150	Vertical	Pass
6	9346.92	44.39	12.42	74	29.61	Peak	318.6	150	Vertical	Pass

LOW CHANNEL 1 GHz to 10 GHz, ANT H

No.	Frequency (MHz)	Results (dBuV/m)	Factor (dB)	Limit (dBuV/m)	Margin (dB)	Detector	Table (o)	Height (cm)	ANT	Verdict
1	1142.46	40.10	-0.27	74	33.90	Peak	65	150	Horizontal	Pass
2	1485.88	46.41	8.95	74	27.59	Peak	121.8	150	Horizontal	Pass
3	1887.78	52.50	13.21	74	21.50	Peak	157.2	150	Horizontal	Pass
4	6325.71	42.75	20.60	74	31.26	Peak	109.3	150	Horizontal	Pass
5	8122.71	48.25	9.04	74	25.75	Peak	331.7	150	Horizontal	Pass
6	8515.81	46.54	10.24	74	27.46	Peak	334.2	150	Horizontal	Pass

MIDDLE CHANNEL 1 GHz to 10 GHz, ANT V

No.	Frequency (MHz)	Results (dBuV/m)	Factor (dB)	Limit (dBuV/m)	Margin (dB)	Detector	Table (o)	Height (cm)	ANT	Verdict
1	1200.00	40.30	-4.64	74	33.70	Peak	201.9	150	Vertical	Pass
2	1547.86	42.17	-4.16	74	31.83	Peak	152.5	150	Vertical	Pass
3	1974.76	42.71	-4.25	74	31.29	Peak	153.1	150	Vertical	Pass
4	6314.48	42.67	16.51	74	31.33	Peak	244.2	150	Vertical	Pass
5	8571.96	45.14	10.23	74	28.86	Peak	314.1	150	Vertical	Pass
6	8571.96	47.79	11.74	74	26.22	Peak	182.8	150	Vertical	Pass

MIDDLE CHANNEL 1 GHz to 10 GHz, ANT H

No.	Frequency (MHz)	Results (dBuV/m)	Factor (dB)	Limit (dBuV/m)	Margin (dB)	Detector	Table (o)	Height (cm)	ANT	Verdict
1	1340.42	41.55	-4.25	74	32.45	Peak	89.5	150	Horizontal	Pass
2	1544.36	44.22	1.11	74	29.78	Peak	192.2	150	Horizontal	Pass
3	1750.81	47.41	10.35	74	26.59	Peak	106.3	150	Horizontal	Pass
4	7347.75	47.31	14.72	74	26.69	Peak	229.3	150	Horizontal	Pass
5	8336.11	44.18	9.03	74	29.82	Peak	355.2	150	Horizontal	Pass
6	8684.28	47.04	9.98	74	26.96	Peak	226	150	Horizontal	Pass

HIGH CHANNEL 1 GHz to 10 GHz, ANT V

No.	Frequency (MHz)	Results (dBuV/m)	Factor (dB)	Limit (dBuV/m)	Margin (dB)	Detector	Table (o)	Height (cm)	ANT	Verdict
1	1163.46	42.48	-4.76	74	31.52	Peak	40.3	150	Vertical	Pass
2	1581.36	43.15	-4.54	74	30.85	Peak	233	150	Vertical	Pass
3	1848.29	42.68	-4.18	74	31.32	Peak	273.3	150	Vertical	Pass
4	7426.37	44.82	14.19	74	29.18	Peak	1.8	150	Vertical	Pass
5	9021.22	42.42	9.13	74	31.58	Peak	358.8	150	Vertical	Pass
6	8875.21	44.64	11.25	74	29.36	Peak	28	150	Vertical	Pass

HIGH CHANNEL 1 GHz to 10 GHz, ANT H

No.	Frequency (MHz)	Results (dBuV/m)	Factor (dB)	Limit (dBuV/m)	Margin (dB)	Detector	Table (o)	Height (cm)	ANT	Verdict
1	1120.97	41.66	-1.00	74	32.34	Peak	356.1	150	Horizontal	Pass
2	1452.39	44.02	8.89	74	29.98	Peak	210.1	150	Horizontal	Pass
3	1892.78	48.22	10.15	74	25.78	Peak	164.7	150	Horizontal	Pass
4	6247.09	47.32	14.80	74	26.68	Peak	105.6	150	Horizontal	Pass
5	8470.88	45.06	10.23	74	28.94	Peak	208.7	150	Horizontal	Pass
6	8953.83	44.71	13.28	74	29.29	Peak	88.4	150	Horizontal	Pass

Hopping Low Channel 1 GHz to 10 GHz, ANT V

No.	Frequency (MHz)	Results (dBuV/m)	Factor (dB)	Limit (dBuV/m)	Margin (dB)	Detector	Table (o)	Height (cm)	ANT	Verdict
1	1051.89	37.49	-8.10	74	32.31	Peak	130.30	150	Vertical	Pass
2	1544.26	41.16	-6.47	74	28.64	Peak	102.40	150	Vertical	Pass
3	1594.25	42.46	-6.16	74	27.34	Peak	43.60	150	Vertical	Pass
4	7794.91	39.55	18.30	74	30.25	Peak	282.00	150	Vertical	Pass
5	8630.20	39.69	6.47	74	30.11	Peak	84.70	150	Vertical	Pass
6	9447.15	42.25	7.33	74	27.56	Peak	138.50	150	Vertical	Pass

Hopping Low Channel 1 GHz to 10 GHz, ANT H

No.	Frequency (MHz)	Results (dBuV/m)	Factor (dB)	Limit (dBuV/m)	Margin (dB)	Detector	Table (o)	Height (cm)	ANT	Verdict
1	1242.34	41.69	-2.69	74	28.11	Peak	4.60	150	Horizontal	Pass
2	1416.30	43.24	0.37	74	26.56	Peak	249.10	150	Horizontal	Pass
3	5630.15	46.04	8.38	74	23.76	Peak	6.20	150	Horizontal	Pass
4	7581.51	42.68	11.47	74	27.12	Peak	9.40	150	Horizontal	Pass
5	6110.21	41.68	7.08	74	28.12	Peak	261.10	150	Horizontal	Pass
6	8727.93	46.12	9.12	74	23.68	Peak	104.70	150	Horizontal	Pass

A.10 Band Edge (Restricted-band band-edge)

PASS

Note: The adjacent to the restricted frequency band (608-614MHz and 960-1240MHz) is far away the fundamental, it is noise only. Please refer to Section A.8 for test data.

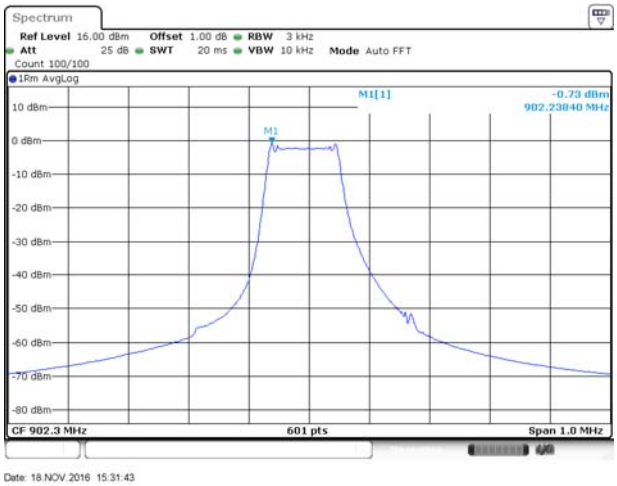
A.11 Power Spectral Density (PSD)

Test Data

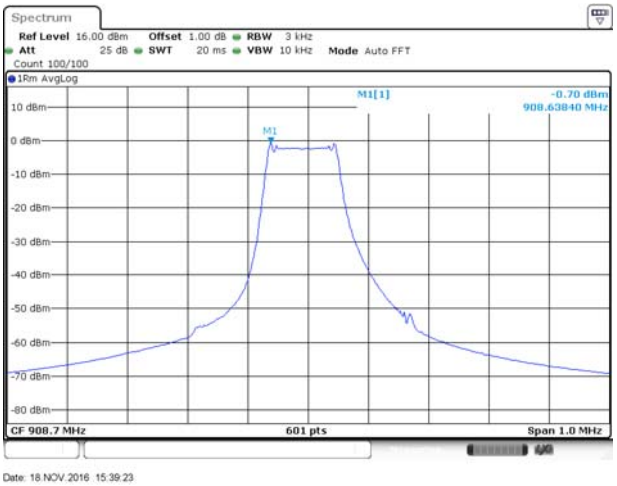
Channel	Spectral power density (dBm/3kHz)	Limit (dBm/3kHz)	Verdict
Low Channel	0.73	8	Pass
Middle Channel	0.70	8	Pass
High Channel	0.67	8	Pass

Test plots

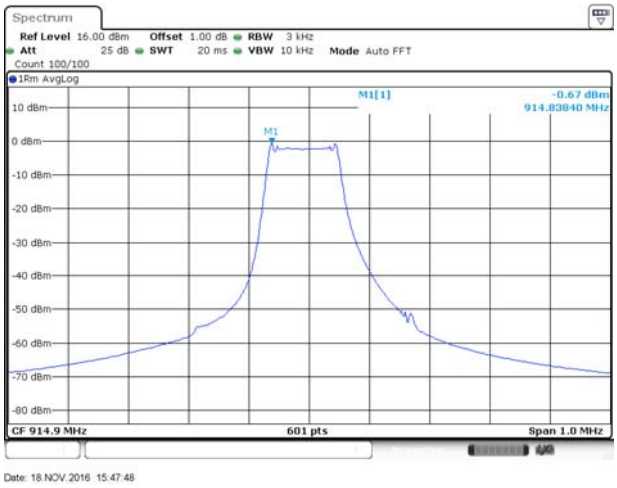
LOW CHANNEL



MIDDLE CHANNEL



HIGH CHANNEL



ANNEX B TEST SETUP PHOTOS

Please refer the document “BL-SZ16A0433-AR.PDF”.

ANNEX C EUT INTERNAL PHOTOS

Please refer the document “BL- SZ16A0433-AI.PDF”.

--END OF REPORT--