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FCC/ISED SIGFOX REPORT

Certification

Applicant Name:
WISOL CO., LTD

Address:
531-7, Gajang-ro, Osan-si Gyeonggi-do, 18103, Korea

Date of Issue:
December 08, 2017

Test Site/Location:
HCT CO., LTD., 74,Seoicheon-ro 578beon-gil,Majang-myeo,Icheon-si, Gyeonggi-do, 17383, Rep. of KOREA

Report No.: HCT-R-1712-F005

ISED Registration Number: 5944A-5

FCC ID	**: 2ABA2SFM60R4**
IC ID	**: 11534A-SFM60R4**
APPLICANT	**: WISOL CO., LTD**

According to the Evaluation report, all of the data contained herein is reused from the reference FCC ID : 2ABA2SFM20R4 / IC ID : 11534A-SFM20R4 report.
[Exceptions : The radiated test was fully test.]

Model(s):	SFM60R4
EUT Type:	Sigfox/BLE/GPS module
Max. RF Output Power:	22.188 dBm (165.50 mW)
Frequency Range:	920.1375 MHz – 922.6625 MHz
Modulation type	DBPSK
FCC Classification:	FCC Part 15 Spread Spectrum Transmitter
FCC Rule Part(s):	Part 15 subpart C 15.247
IC Rule Part(s):	RSS-247 Issue 2 (February 2017), RSS-Gen Issue 4(November 2014)

The measurements shown in this report were made in accordance with the procedures specified in §2.947. I assume full responsibility for the accuracy and completeness of these measurements, and for the qualifications of all persons taking them.

HCT CO., LTD. Certifies that no party to this application has subject to a denial of Federal benefits that includes FCC benefits pursuant to section 5301 of the Anti-Drug Abuse Act of 1998,21 U.S. C.853(a)

Report prepared by : Se Wook Park
Engineer of Telecommunication testing center

Approved by : Jong Seok Lee
Manager of Telecommunication testing center

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Version

TEST REPORT NO.	DATE	DESCRIPTION
HCT-R-1712-F005	December 08, 2017	- First Approval Report

Table of Contents

1. GENERAL INFORMATION 4
2. EUT DESCRIPTION 4
3. TEST METHODOLOGY 5
3.1 EUT CONFIGURATION 5
3.2 EUT EXERCISE 5
3.3 GENERAL TEST PROCEDURES 5
3.4 DESCRIPTION OF TEST MODES 6
4. INSTRUMENT CALIBRATION 6
5. FACILITIES AND ACCREDITATIONS 6
5.1 FACILITIES 6
5.2 EQUIPMENT 6
6. ANTENNA REQUIREMENTS 6
7. MEASUREMENT UNCERTAINTY 7
8. SUMMARY OF TEST RESULTS 8
8.1 FCC Part 8
8.2 ISED Part 9
9. TEST RESULT 10
9.1 PEAK POWER 10
9.2 BAND EDGES 14
9.3 FREQUENCY SEPARATION / OCCUPIED BANDWIDTH (99% BW) 18
9.4 NUMBER OF HOPPING FREQUENCY 25
9.5 TIME OF OCCUPANCY (DWELL TIME) 27
9.6 SPURIOUS EMISSIONS 31
9.6.1 CONDUCTED SPURIOUS EMISSIONS 31
9.6.2 RADIATED SPURIOUS EMISSIONS 36
9.6.3 RECEIVER SPURIOUS EMISSIONS 49
9.7 POWERLINE CONDUCTED EMISSIONS 50
10. LIST OF TEST EQUIPMENT 55
10.1 LIST OF TEST EQUIPMENT(Conducted Test) 55
10.2 LIST OF TEST EQUIPMENT(Radiated Test) 56

1. GENERAL INFORMATION

Applicant: WISOL CO., LTD

Address: 531-7, Gajang-ro, Osan-si Gyeonggi-do, 18103, Korea

FCC ID: 2ABA2SFM60R4

IC ID: 11534A-SFM60R4

EUT Type: Sigfox/BLE/GPS module

Model: SFM60R4

Date(s) of Tests: October 10, 2017 ~ December 05, 2017

Place of Tests: HCT Co., Ltd.

74, Seoicheon-ro 578beon-gil, Majang-myeon, Icheon-si, Gyeonggi-do, Korea

2. EUT DESCRIPTION

Model	SFM60R4
EUT Type	Sigfox/BLE/GPS module
Power Supply	DC 3.3 V
Frequency Range	920.1375 MHz – 922.6625 MHz
Max. RF Output Power:	22.188 dBm (165.50 mW)
Modulation Type	DBPSK
Modulation Technique	Frequency Hopping
Number of Channels	54 Channels (9 Macro channels x 6 Micro channels)
Antenna Specification	Manufacturer: INNO-LINK Antenna type: External dipole antenna Peak Gain : 2.01 dBi

※ 15.247 Requirements for Sigfox transmitter

▪ This Sigfox module has been tested by a Sigfox Qualification Lab, and we confirm the following:

1) This system is hopping pseudo-randomly.

2) Each frequency is used equally on the average by each transmitter.

3) The receiver input bandwidths that match the hopping channel bandwidths of their corresponding transmitters

4) The receiver shifts frequencies in synchronization with the transmitted signals.

▪ 15.247(g): The system, consisting of both the transmitter and the receiver, must be designed to comply with all of the regulations in this Section 15.247 should the transmitter be presented with a continuous data (or information) stream.

▪ 15.247(h): The coordination of frequency hopping systems in any other manner for the express purpose of avoiding the simultaneous occupancy of individual hopping frequencies by multiple transmitters is not permitted.

3. TEST METHODOLOGY

The measurement procedure described in the American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices (ANSI C63.10-2013) is used in the measurement of the test device.

3.1 EUT CONFIGURATION

The EUT configuration for testing is installed on RF field strength measurement to meet the Commissions requirement and operating in a manner that intends to maximize its emission characteristics in a continuous normal application.

3.2 EUT EXERCISE

The EUT was operated in the engineering mode to fix the Tx frequency that was for the purpose of the measurements. According to its specifications, the EUT must comply with the requirements of the Section 15.207, 15.209 and 15.247 under the FCC Rules Part 15 Subpart C / the RSS-Gen issue 4, RSS-247 issue 2.

3.3 GENERAL TEST PROCEDURES

Conducted Emissions

The EUT is placed on the turntable, which is 0.8 m above ground plane. According to the requirements in Section 6.2 of ANSI C63.10. (Version :2013) Conducted emissions from the EUT measured in the frequency range between 0.15 MHz and 30MHz using CISPR Quasi-peak and average detector modes.

Radiated Emissions

The EUT is placed on a turn table, which is 0.8 m above ground plane below 1GHz. Above 1GHz with 1.5m using absorbers between the EUT and receive antenna. The turntable shall rotate 360 degrees to determine the position of maximum emission level. EUT is set 3.75 m away from the receiving antenna, which varied from 1 m to 4 m to find out the highest emission. And also, each emission was to be maximized by changing the polarization of receiving antenna both horizontal and vertical. In order to find out the max. emission, the relative positions of this hand-held transmitter (EUT) was rotated through three orthogonal axes according to the requirements in Section 8 of ANSI C63.10. (Version: 2013). To record the final measurements, the analyzer detector function was set to CISPR quasi-peak mode and the bandwidth of the spectrum analyzer was set to 120 kHz for frequencies below 1 GHz or 1 MHz for frequencies above 1 GHz. For average measurements above 1 GHz, the analyzer was set to peak detector with a reduced VBW setting(RBW = 1 MHz, VBW ≥3*RBW).

Conducted Antenna Terminal

See Section from 7.8.2 to 7.8.8.(ANSI 63.10-2013)

3.4 DESCRIPTION OF TEST MODES

The EUT has been tested under operating condition. Test program used to control the EUT for staying in continuous transmitting and receiving mode is programmed.
Channel low, mid and high with highest data rate (worst case) is chosen for full testing.

4. INSTRUMENT CALIBRATION

The measuring equipment, which was utilized in performing the tests documented herein, has been calibrated in accordance with the manufacturer's recommendations for utilizing calibration equipments, which is traceable to recognized national standards.
Especially, all antenna for measurement is calibrated in accordance with the requirements of C63.5 (Version : 2006).

5. FACILITIES AND ACCREDITATIONS

5.1 FACILITIES

The SAC(Semi-Anechoic Chamber) and conducted measurement facility used to collect the radiated data are located at the 74, Seoicheon-ro 578beon-gil, Majang-myeon, Icheon-si, Gyeonggi-do, Korea. The site is constructed in conformance with the requirements of ANSI C63.4. (Version :2014) and CISPR Publication 22. Detailed description of test facility was submitted to the Commission and accepted dated July 07, 2015 (Registration Number: 90661)

5.2 EQUIPMENT

Radiated emissions are measured with one or more of the following types of Linearly polarized antennas: tuned dipole, bi-conical, log periodic, bi-log, and/or ridged waveguide, horn. Spectrum analyzers with pre-selectors and quasi-peak detectors are used to perform radiated measurements. Conducted emissions are measured with Line Impedance Stabilization Networks and EMI Test Receivers. Calibrated wideband preamplifiers, coaxial cables, and coaxial attenuators are also used for making measurements. All receiving equipment conforms to CISPR Publication 16-1, “Radio Interference Measuring Apparatus and Measurement Methods.”

6. ANTENNA REQUIREMENTS

According to FCC 47 CFR §15.203:

“An intentional radiator antenna shall be designed to ensure that no antenna other than that furnished by the responsible party can 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.”

*This module has SMA type antenna connector, not unique coupling. So it`s subject to Limited singl e-modular transmitter.

*The OEM manufacturer who will install this module into their device must not give an access to an tenna and connector by end-user in compliance with FCC Section 15.203.

7. MEASUREMENT UNCERTAINTY

The measurement uncertainties shown below were calculated in accordance with the requirements of ANSI C63.4:2014.

All measurement uncertainty values are shown with a coverage factor of *k* = 2 to indicate a 95 % level of confidence.

Parameter	Expanded Uncertainty (±dB)
Conducted Disturbance (150 kHz ~ 30 MHz)	1.82
Radiated Disturbance (9 kHz ~ 30 MHz)	3.40
Radiated Disturbance (30 MHz ~ 1 GHz)	4.80
Radiated Disturbance (1 GHz ~ 18 GHz)	5.70

8. SUMMARY OF TEST RESULTS

8.1 FCC Part

Test Description	FCC Part Section(s)	Test Limit	Test Condition	Test Result
20 dB Bandwidth	§15.247(a)(1)(i)	N/A	CONDUCTED	PASS
Occupied Bandwidth	N/A	N/A		N/A
Conducted Maximum Peak Output Power	§15.247(b)(2)	< 1 W if ≥ 50 non-overlapping hopping channels used < 0.25 W if < 50 non-overlapping hopping channels used		PASS
Carrier Frequency Separation	§15.247(a)(1)	>25 kHz or > 20dB BW of hopping channel		PASS
Number of Hopping Frequencies	§15.247(a)(1)(i)	≥ 50		PASS
Time of Occupancy	§15.247(a)(1)(i)	<400 ms		PASS
Conducted Spurious Emissions	§15.247(d)	> 20 dB for all out-of band emissions		PASS
Band Edge(Out of Band Emissions)	§15.247(d)	> 20 dB for all out-of band emissions		PASS
AC Power line Conducted Emissions	§15.207(a)	cf. Section 9.7		PASS
Radiated Spurious Emissions	§15.247(d), 15.205, 15.209	cf. Section 9.6.2	RADIATED	PASS
Radiated Restricted Band Edge	§15.247(d), 15.205, 15.209	cf. Section 9.6.3		PASS

8.2 ISED Part

Test Description	IC Part Section(s)	Test Limit	Test Condition	Test Result
20 dB Bandwidth	RSS-247, 5.1.3	N/A	CONDUCTED	PASS
99 % Bandwidth	RSS-GEN, 6.6	N/A		PASS
Conducted Maximum Peak Output Power	RSS-247, 5.4.1	< 1 W if the hopset uses 50 or more hopping channels < 0.25 W if the hopset uses less than 50 hopping channels		PASS
Carrier Frequency Separation	RSS-247, 5.1.2	>25 kHz or > 20dB BW of hopping channel		PASS
Number of Hopping Frequencies	RSS-247, 5.1.3	≥ 50		PASS
Time of Occupancy	RSS-247, 5.1.3	< 0.4 s		PASS
Conducted Spurious Emissions	RSS-247, 5.5	< 20 dB for all out-of band emissions		PASS
Band Edge(Out of Band Emissions)	RSS-247, 5.5	< 20 dB for all out-of band emissions		PASS
AC Power line Conducted Emissions	RSS-GEN, 8.8	RSS-GEN section 8.8 table 3		PASS
Radiated Spurious Emissions	RSS-GEN, 8.9	RSS-GEN section 8.9 table 4, 5	RADIATED	PASS
Radiated Restricted Band Edge	RSS-GEN, 8.10	RSS-GEN section 8.10 table 6		PASS
Receiver Spurious Emissions	RSS-GEN, 5 RSS-GEN, 7.1.2	RSS-GEN section 7.1.2 table 2		PASS

9. TEST RESULT

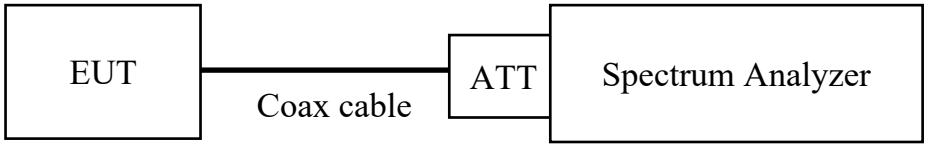
9.1 PEAK POWER

LIMIT

The maximum peak output power of the intentional radiator shall not exceed the following:

1. For frequency hopping systems operating in the 902-928 MHz band: 1 watt (30 dBm) for systems employing at least 50 hopping channels; and, 0.25 watts (24 dBm) for systems employing less than 50 hopping channels, but at least 25 hopping channels, as permitted under paragraph (a)(1)(i) of this section.
2. The conducted output power limit specified in paragraph (b) of this section is based on the use of antennas with directional gains that do not exceed 6 dBi.
3. The e.i.r.p of this module not exceed 4 W because the antenna gain not exceed not 6 dBi.

Test Configuration



TEST PROCEDURE

The transmitter output is connected to the Spectrum Analyzer. The Spectrum Analyzer is set to the peak detector mode. This test is performed with hopping off.

The Spectrum Analyzer is set to (7.8.5 in ANSI 63.10-2013)

1) Span: approximately 5 times the 20 dB bandwidth, centered on a hopping channel
2) RBW > the 20 dB bandwidth of the emission being measured
3) VBW ≥ RBW
4) Sweep = Auto
5) Detector = Peak
6) Trace = Max hold

SAMPLE CALCULATION

Output Power = Spectrum Reading Power + Attanuator loss + Cable loss(1 ea)

= 10 dBm + 10 dB + 0.1dB = 20.1 dBm

Note :

1. The power results in plot is already including the actual values of loss for the attenuator and cable combination.
2. Spectrum offset = Attenuator loss + Cable loss
3. We apply to the offset in the 900 MHz range that was rounded off to the closest tenth dB. Actual value of loss for the Attenuator and cable combination is 10 dB at 900 MHz.

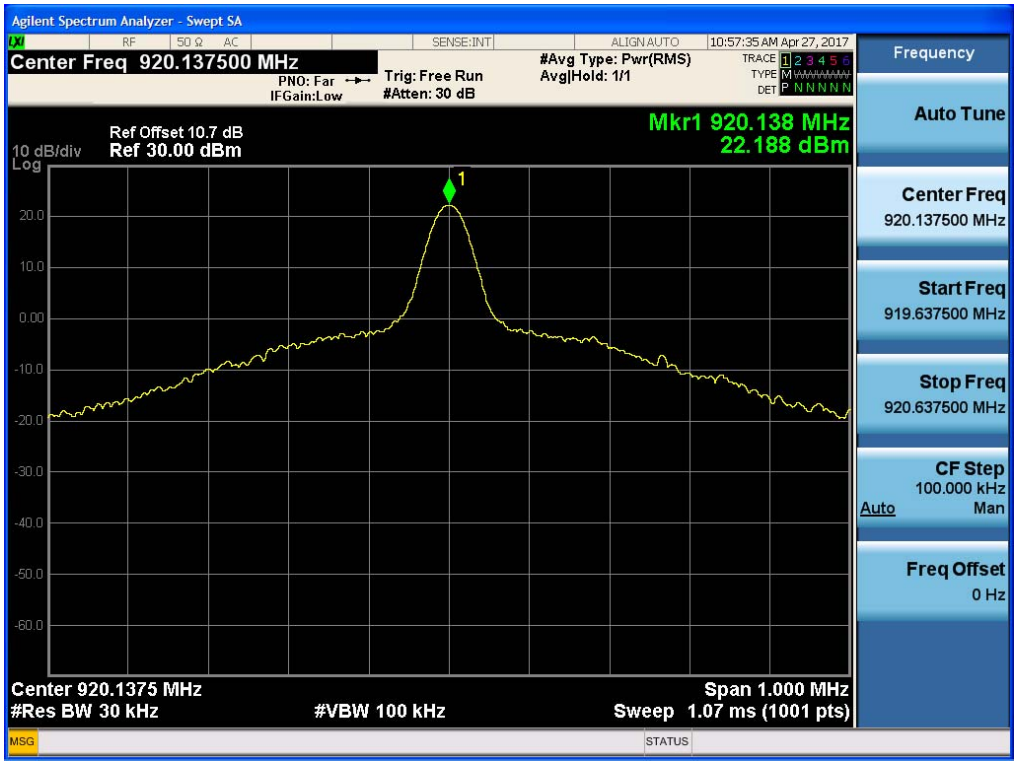
TEST RESULTS

No non-compliance noted

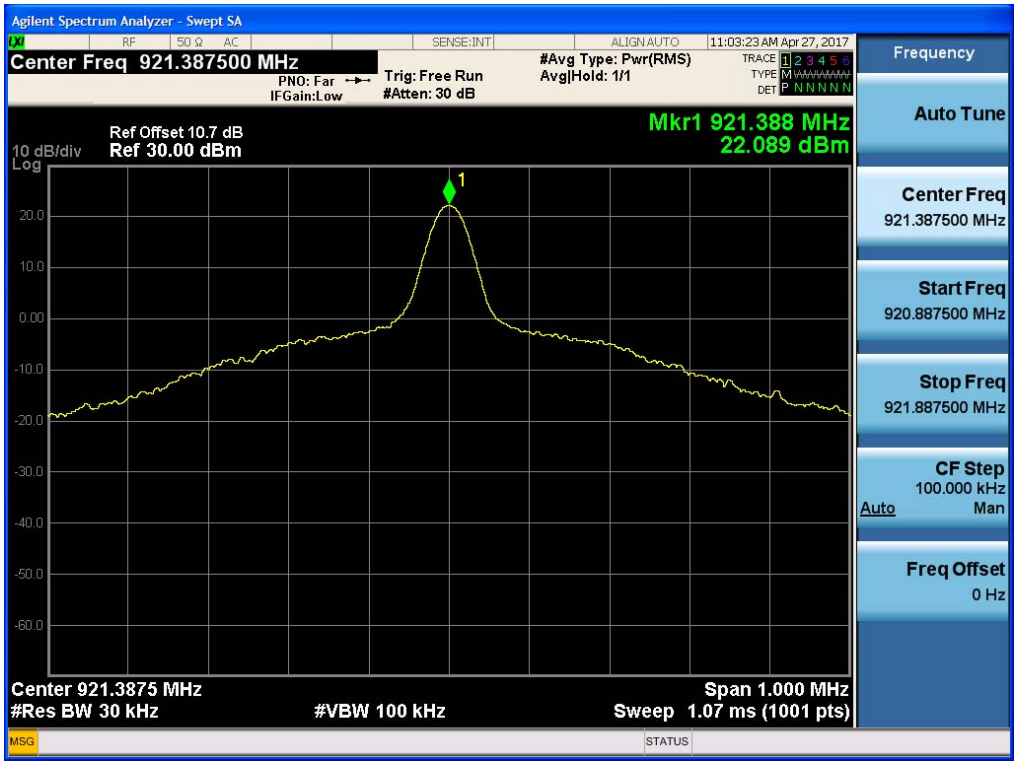
Test Data

Channel	Frequency (MHz)	Output Power (DBPSK)		Limit (mW)	Result
		(dBm)	(mW)		
Low	920.1375	22.188	165.50	1000	PASS
Mid	921.3875	22.089	162.37		PASS
High	922.6625	22.117	162.82		PASS

Test Plots (DBPSK)
Peak Power (Low)

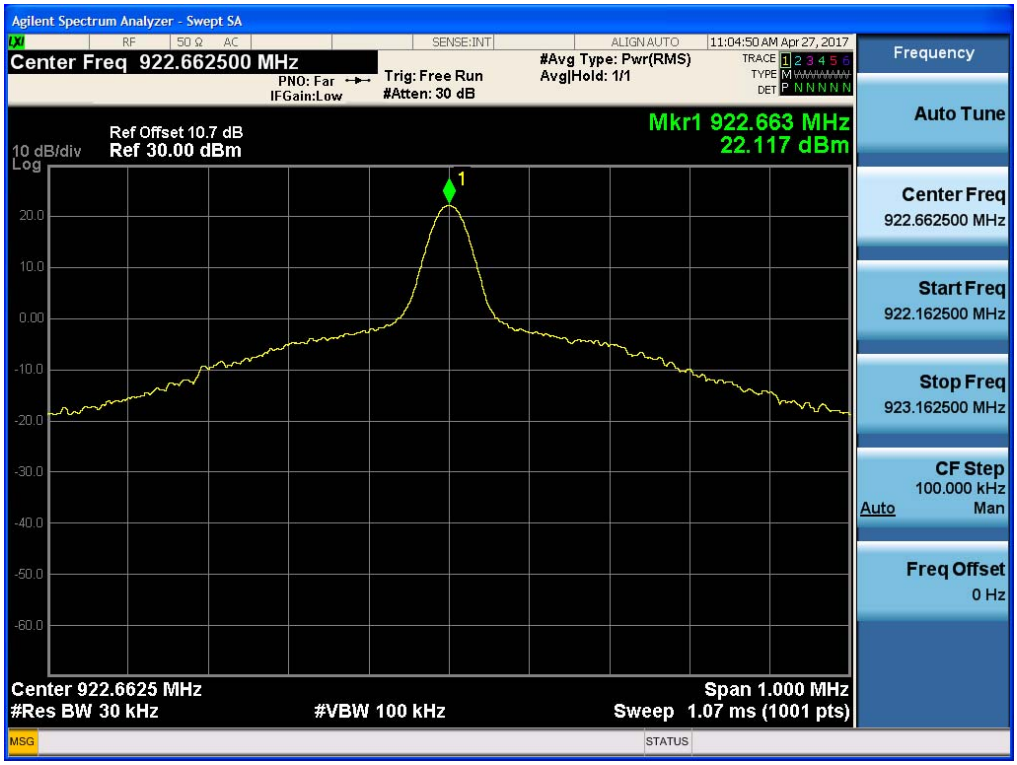


Test Plots (DBPSK)
Peak Power (Mid)



Test Plots (DBPSK)

Peak Power (High)

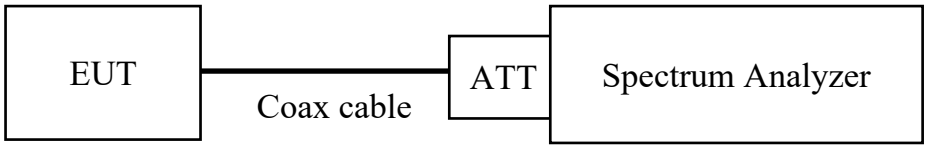


9.2 BAND EDGES

LIMIT

According to §15.247(d) / RSS-247 5.5, 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.

Test Configuration



TEST PROCEDURE

This test is performed with hopping off and hopping on.

The Spectrum Analyzer is set to (6.10.4 in ANSI 63.10-2013)

1) Span: Wide enough to capture the peak level of the emission operating on the channel closest to the band edge, as well as any modulation products which fall outside of the authorized band of operation
2) Reference level: As required to keep the signal from exceeding the maximum instrument input mixer level for linear operation. In general, the peak of the spectral envelope shall be more than [10 log (OBW/RBW)] below the reference level.
3) Attenuation: Auto (at least 10 dB preferred).
4) Sweep time: Coupled.
5) RBW: 100 kHz
6) VBW: 300 kHz
7) Detector: Peak
8) Trace: Max hold

TEST RESULTS

See attached.

Note :

1. The results in plot is already including the actual values of loss for the Attanuator and cable combination.
2. Spectrum offset = Attenuator loss + Cable loss
3. We apply to the offset in the 900 MHz range that was rounded off to the closest tenth dB. Actual value of loss for the Attenuator and cable combination is 10 dB at 900 MHz.

Test Data

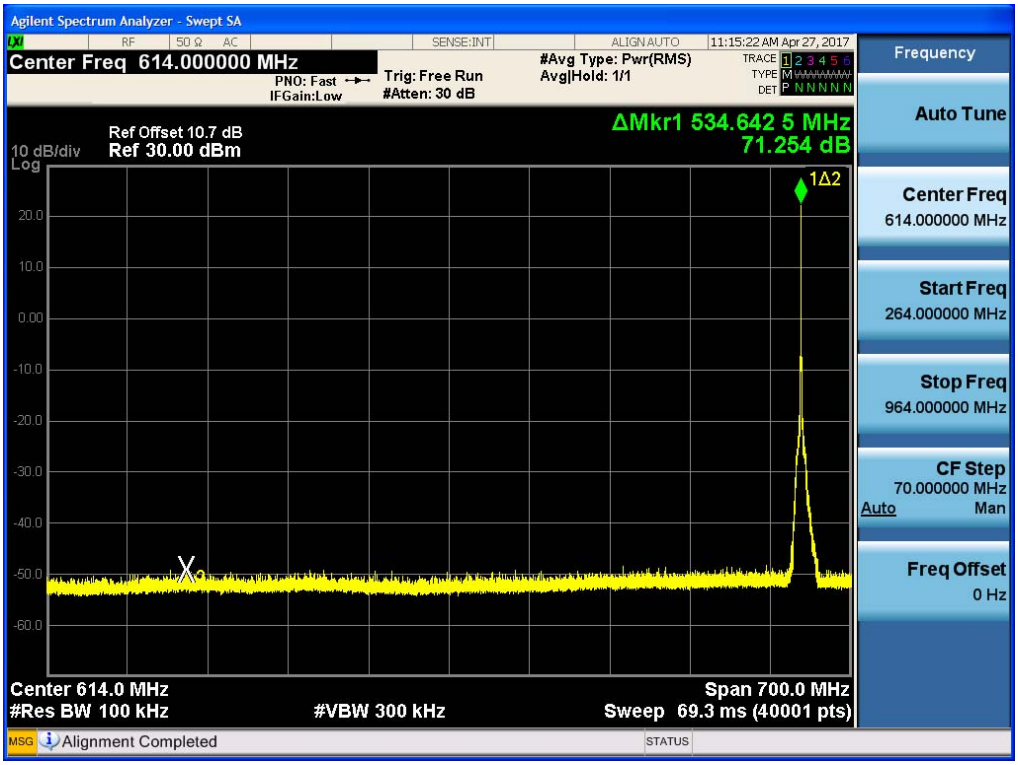
- Without hopping

Frequency (MHz)	Channel	D-BPSK (dB)	Limit (dBc)	Margin D-BPSK (dBc)	Result
920.1375	Low	71.254	20	51.25	Pass
922.6625	Upper	71.024		51.02	Pass

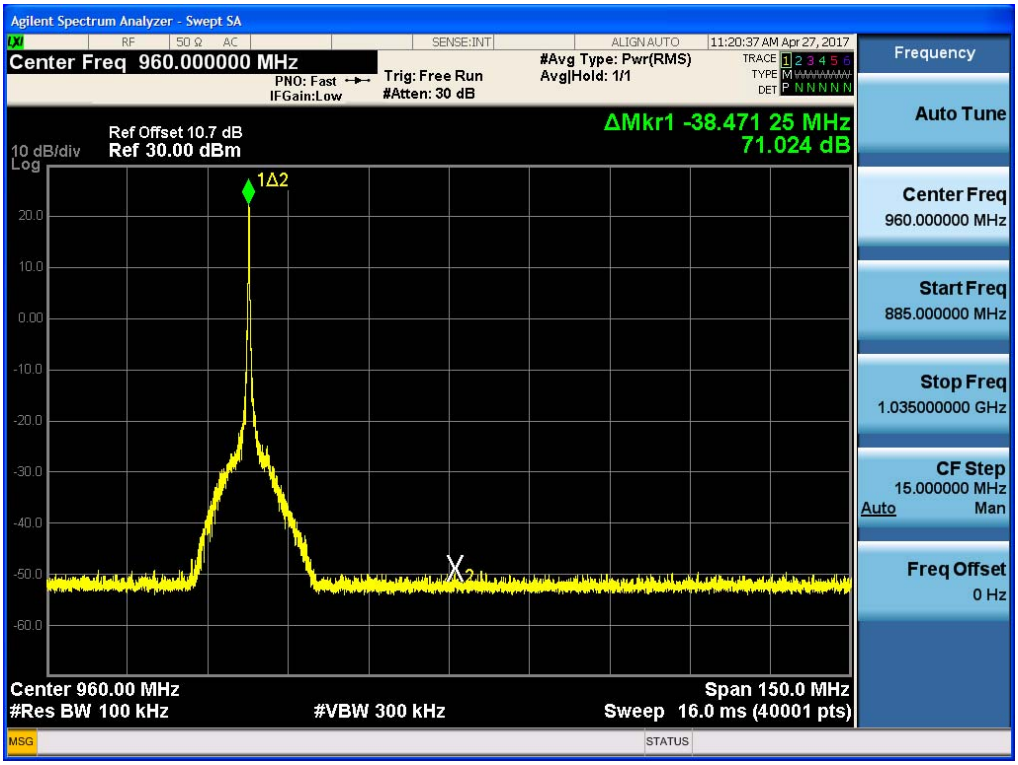
- With hopping

Frequency (MHz)	Channel No.	D-BPSK (dB)	Limit (dBc)	Margin D-BPSK (dBc)	Result
920.1375	Lower	71.265	20	51.27	Pass
922.6625	Upper	70.987		50.99	Pass

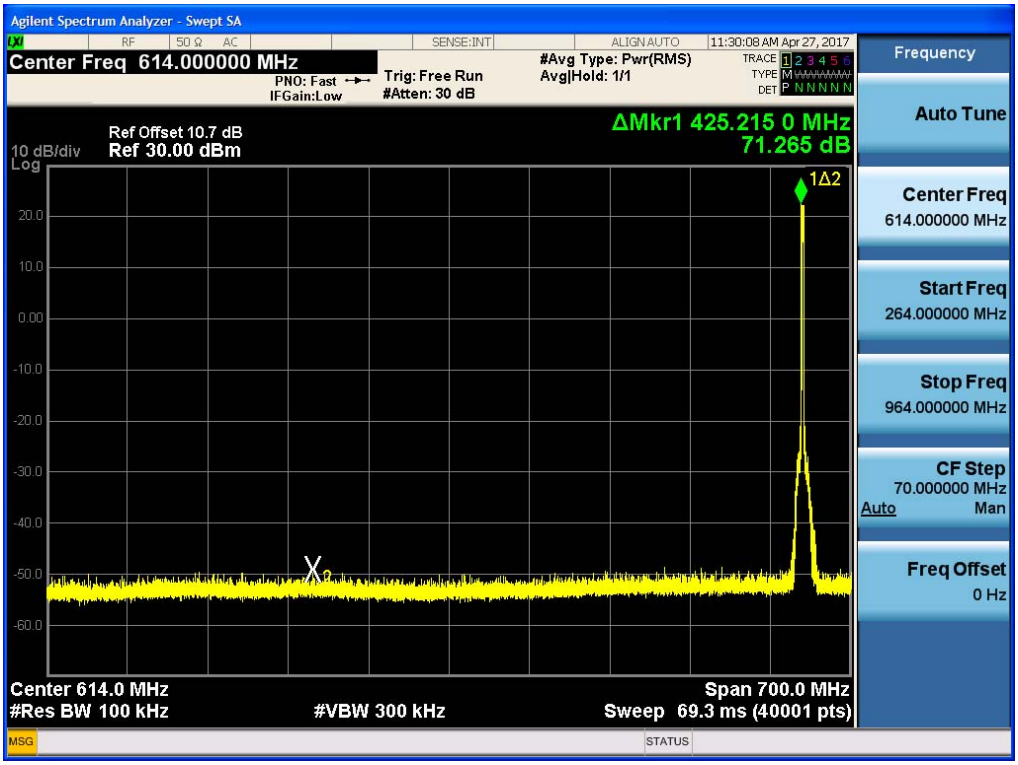
Test Plots without hopping (DBPSK)
Band Edges (Low)



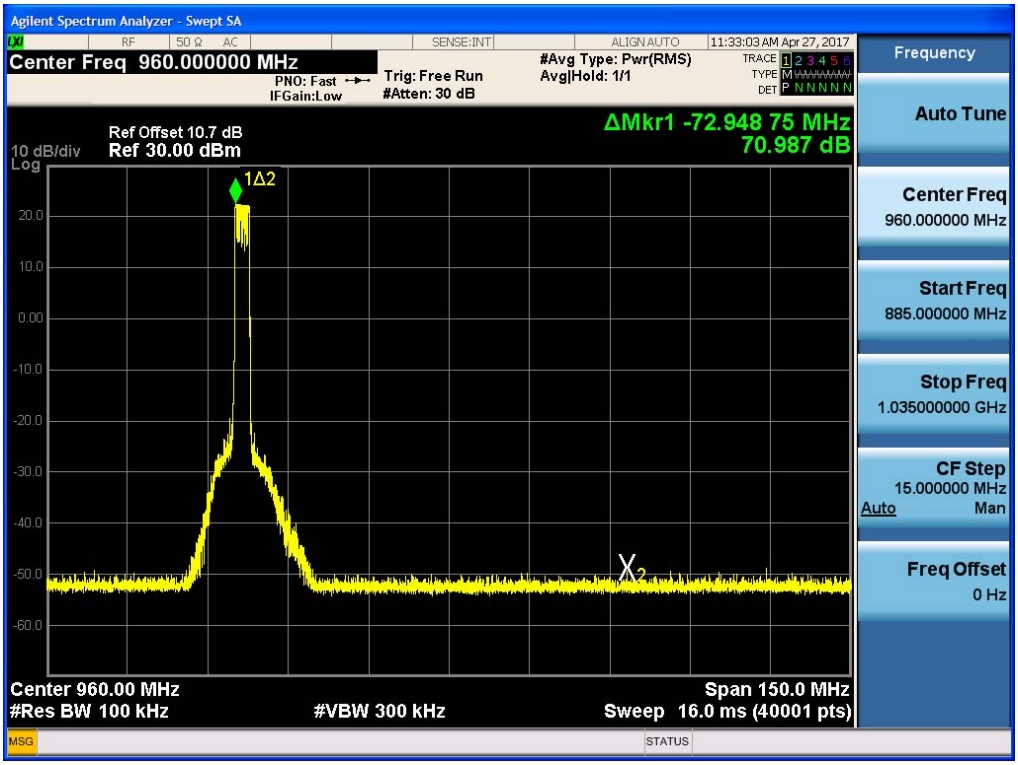
Test Plots without hopping (DBPSK)
Band Edges (High)



Test Plots with hopping (DBPSK)
Band Edges (Low)



Test Plots with hopping (DBPSK)
Band Edges (High)

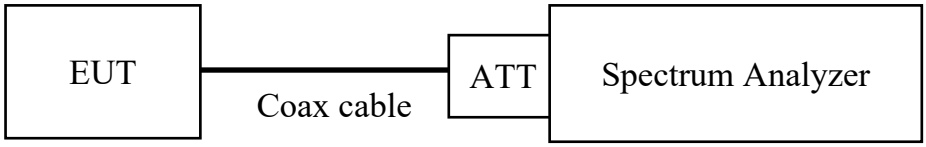


9.3 FREQUENCY SEPARATION / OCCUPIED BANDWIDTH (99% BW)

LIMIT

According to §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.

Test Configuration



TEST PROCEDURE

The Channel Separation test is performed with hopping on. And the 20 dB Bandwidth test is performed with hopping off.

The Spectrum Analyzer is set to (7.8.2 in ANSI 63.10-2013)

1) Span: Wide enough to capture the peaks of two adjacent channels
2) RBW: Start with the RBW set to approximately 30% of the channel spacing; adjust as necessary to best identify the center of each individual channel.
3) VBW ≥ RBW
4) Sweep: Auto
5) Detector: Peak
6) Trace: Max hold
7) All the trace to stabilize.

Use the marker-delta function to determine the separation between the peaks of the adjacent channels. Compliance of an EUT with the appropriate regulatory limit shall be determined. A plot of the data shall be included in the test report.

TEST RESULTS

No non-compliance noted

Test Data

Channel Separation (kHz)	20dB Bandwidth (kHz)		Limit (kHz)	Result
DBPSK	Channel	DBPSK		
25.05	Low	21.70	>25 or >20dB BW of hopping channel	Pass
	Mid	23.35		
	High	23.75		

Occupied Bandwidth (99% BW)

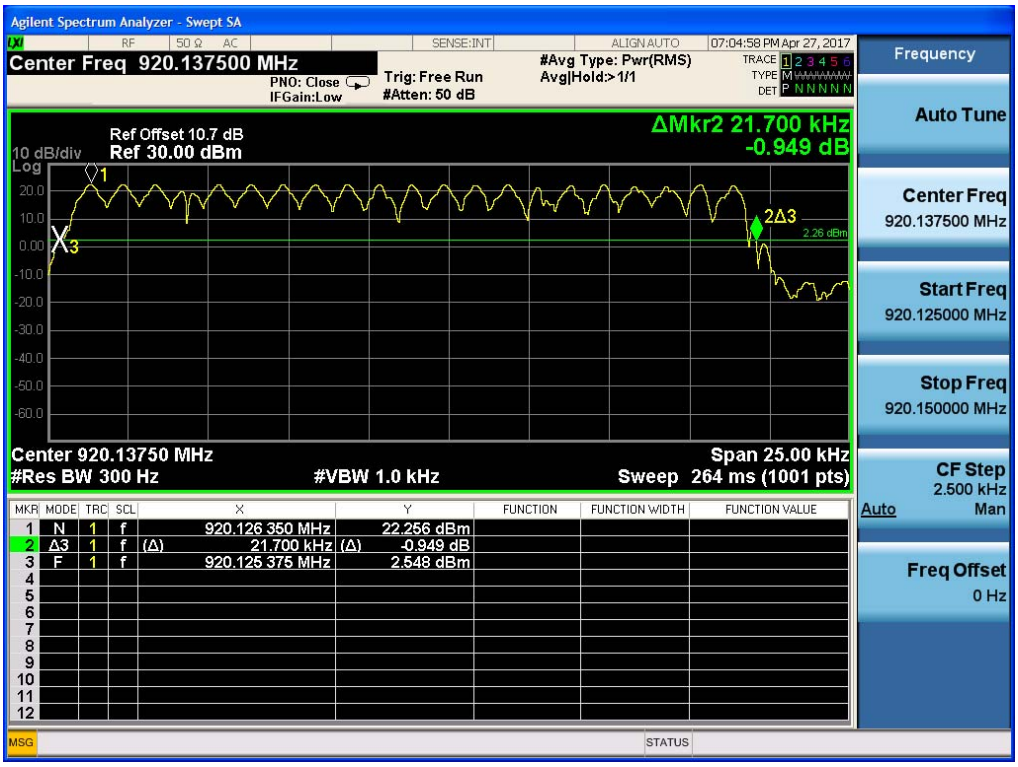
99% BW (kHz)			
Channel	Low	Mid	High
	25.601	25.556	25.575

Test Plots (DBPSK)

Channel Separation

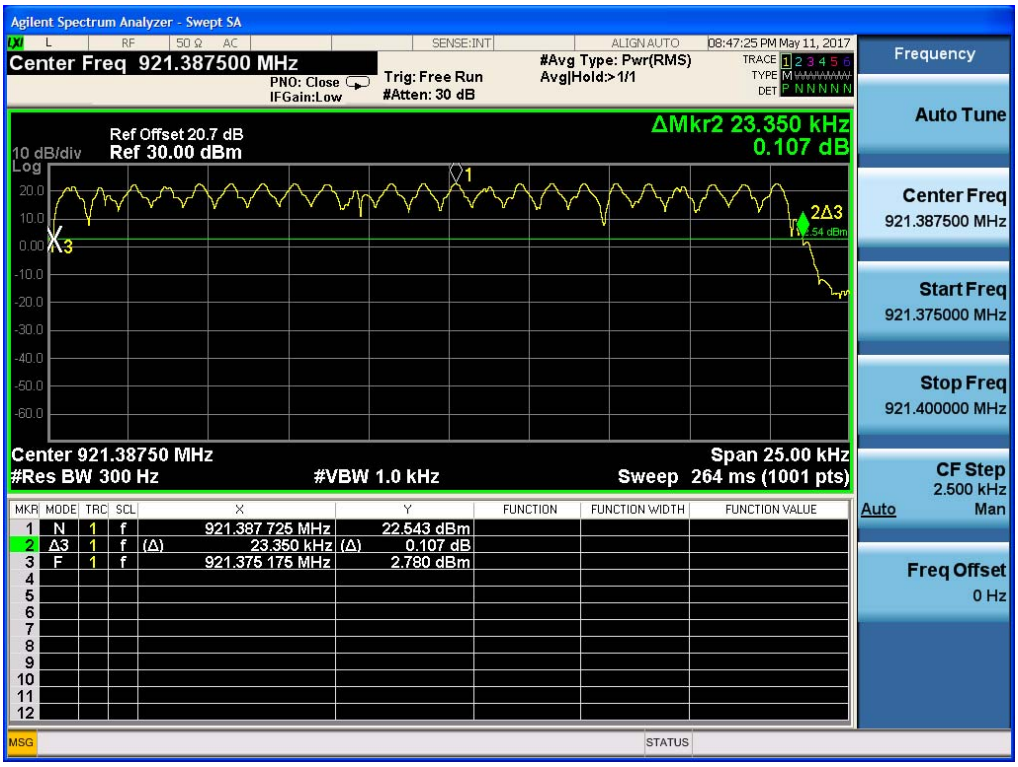
Test Plots (DBPSK)

20 dB Bandwidth (Low)



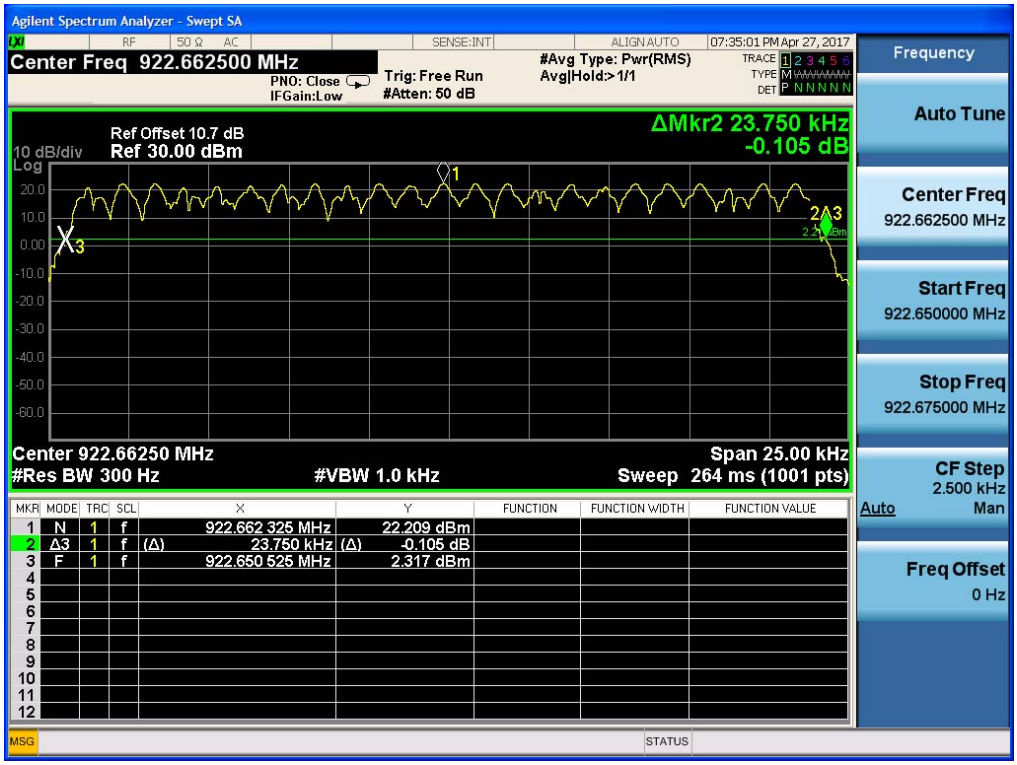
Test Plots (DBPSK)

20 dB Bandwidth (Mid)



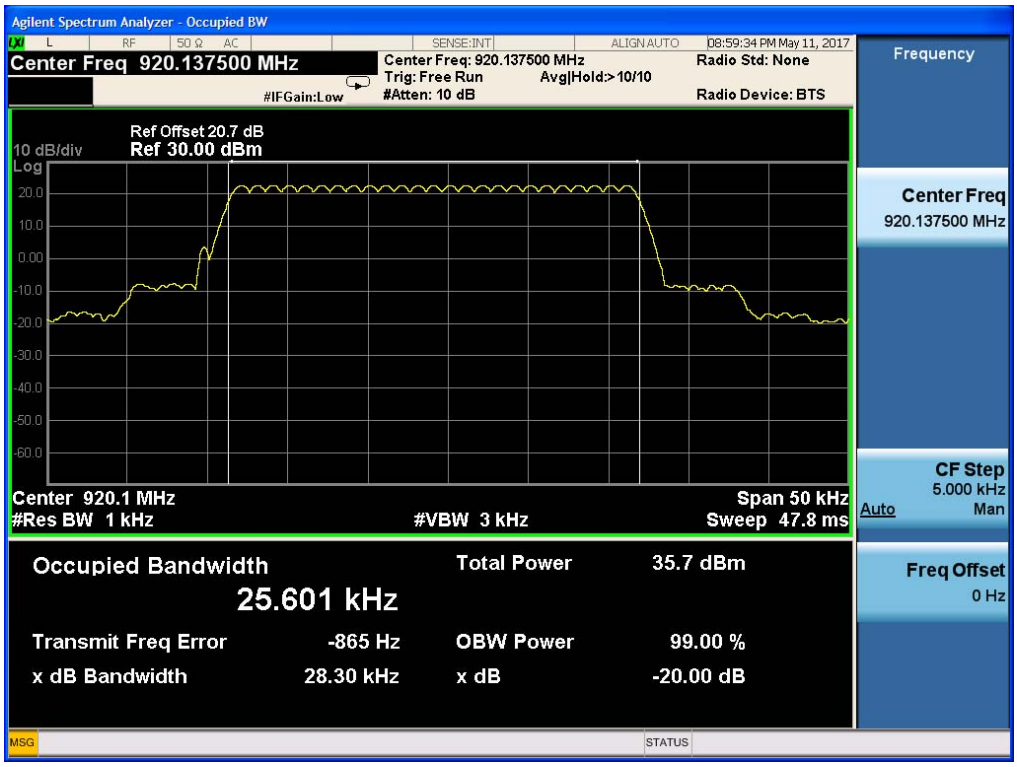
Test Plots (DBPSK)

20 dB Bandwidth (High)



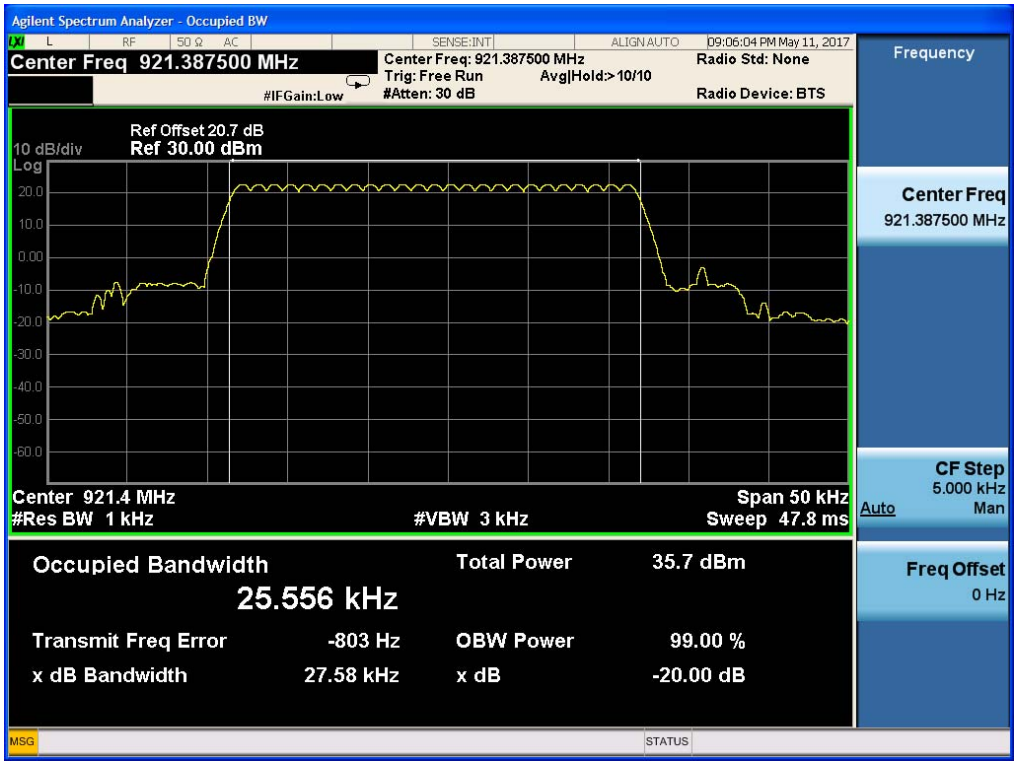
Test Plots (DBPSK)

Occupied Bandwidth (Low)



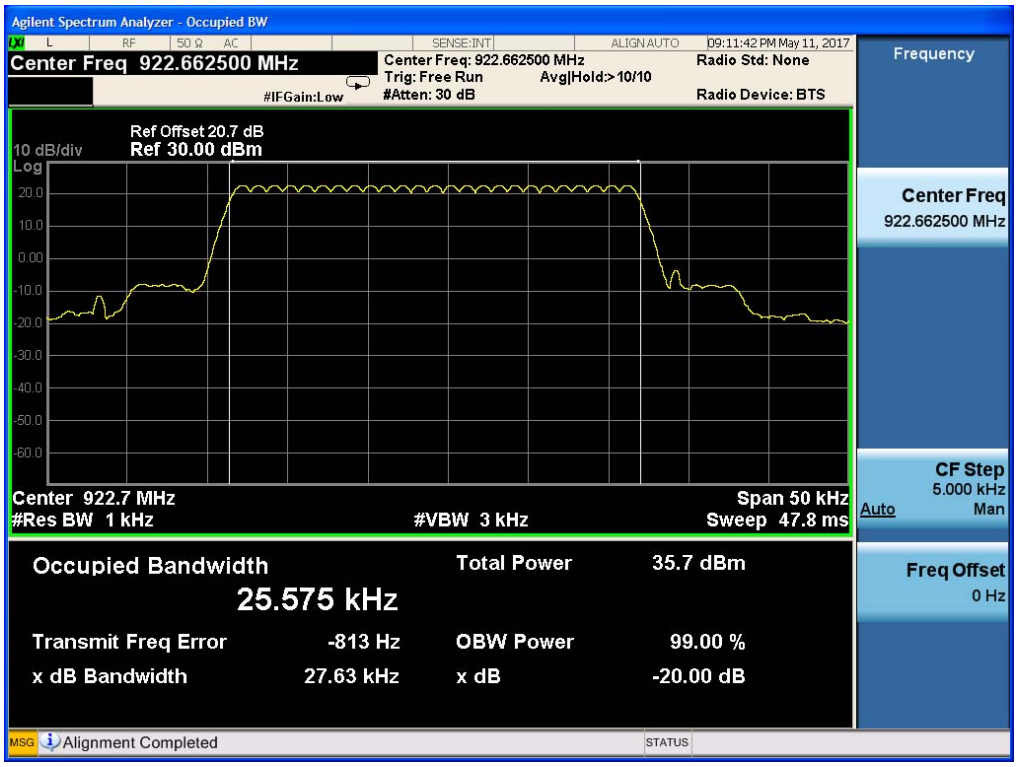
Test Plots (DBPSK)

Occupied Bandwidth (Mid)



Test Plots (DBPSK)

Occupied Bandwidth (High)

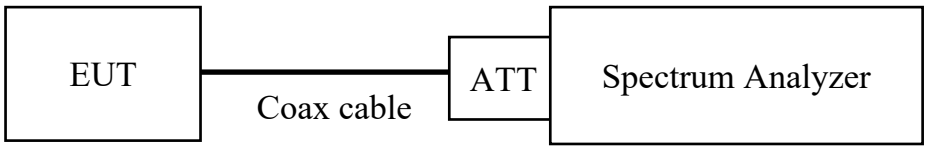


9.4 NUMBER OF HOPPING FREQUENCY

LIMIT

According to §15.247(a)(1)(i) / RSS-247 5.1.3, if the 20 dB bandwidth of the hopping channel is less than 250 kHz, the system shall use at least 50 hopping channels and the average time of occupancy on any channel 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 channels and the average time of occupancy on any channel shall not be greater than 0.4 seconds within a 10-second period. The maximum 20 dB bandwidth of the hopping channel shall be 500 kHz.

Test Configuration



TEST PROCEDURE

The Bluetooth frequency hopping function of the EUT was enabled.

The Spectrum Analyzer is set to (7.8.3 in ANSI 63.10-2013)

1) Span: the frequency band of operation
2) RBW: To identify clearly the individual channels, set the RBW to less than 30% of the channel spacing or the 20 dB bandwidth, whichever is smaller.
3) VBW ≥ RBW
4) Sweep: Auto
5) Detector: Peak
6) Trace: Max hold
7) Allow the trace to stabilize.

TEST RESULTS

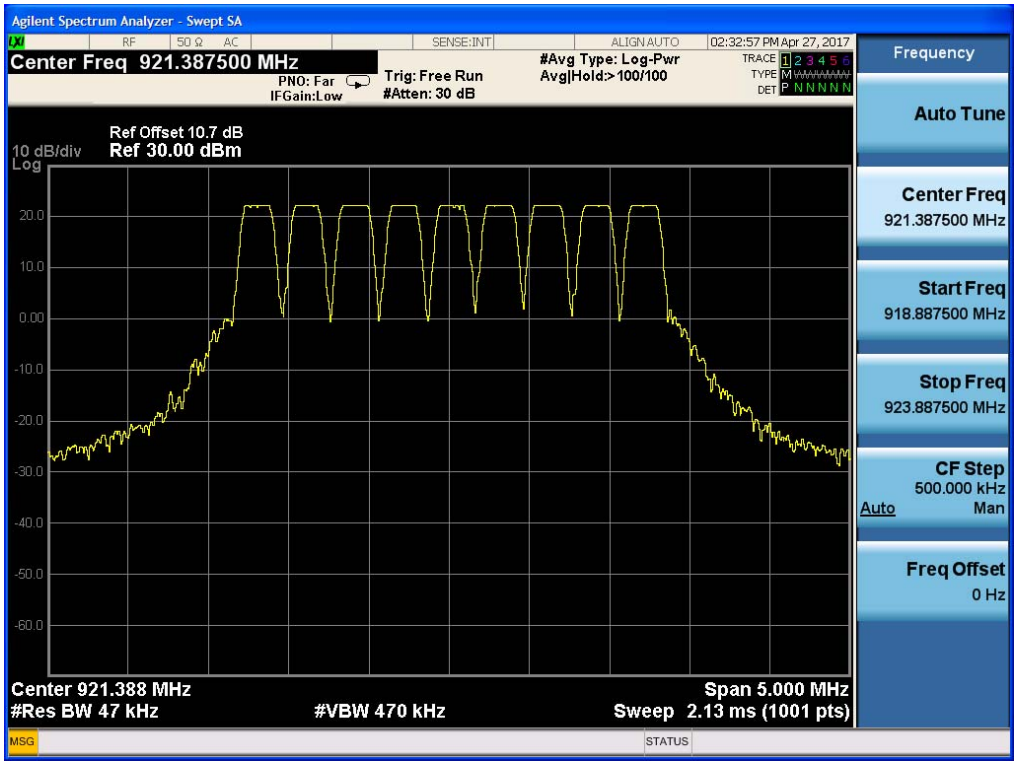
No non-compliance noted

Test Data (Number of Hopping Frequencies : 9 x 6 = 54)

(Number of Macro CH)	(Number of Micro CH)
D-BPSK	D-BPSK
9	6

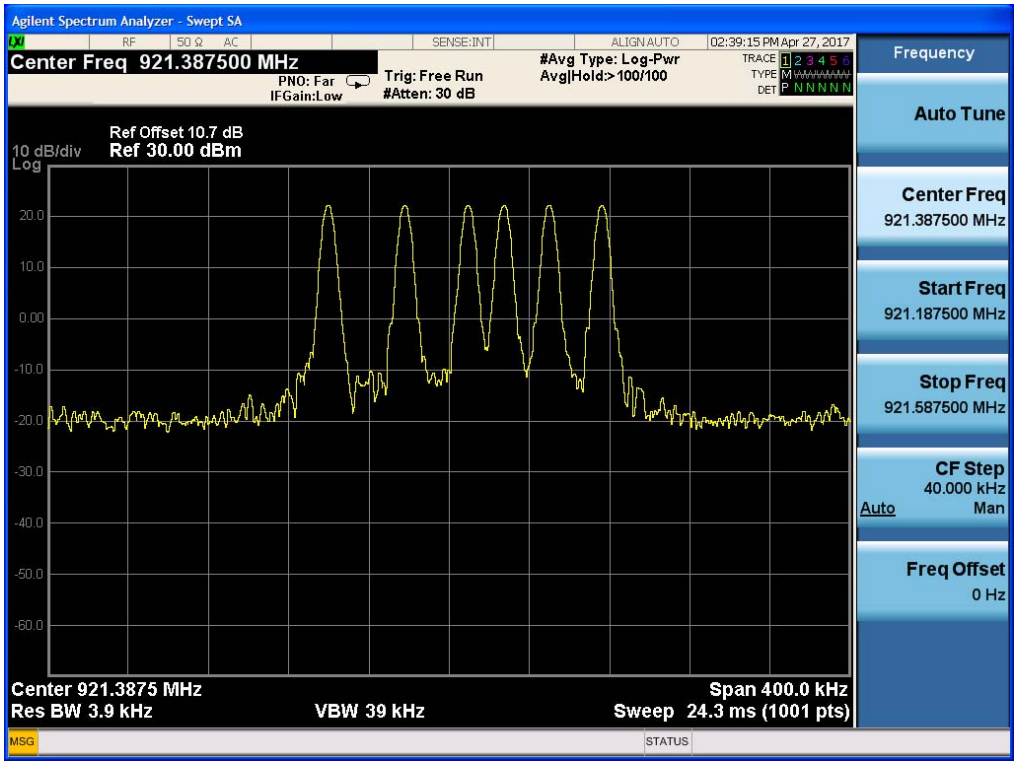
Test Plots

Number of macro channels



Test Plots

Number of micro channels in one single macro channel

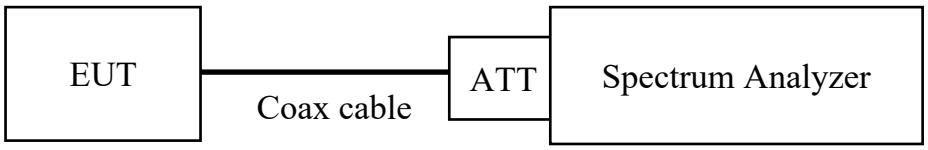


9.5 TIME OF OCCUPANCY (DWELL TIME)

LIMIT

According to §15.247(a)(1)(i) / RSS-247 5.1.3, Frequency hopping systems operating in the 902 MHz ~ 928MHz bands. 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. The maximum allowed 20 dB bandwidth of the hopping channel is 500 kHz.

Test Configuration



TEST PROCEDURE

This test is performed with hopping off.

The Spectrum Analyzer is set to (7.8.4 in ANSI 63.10-2013)

1) Span: Zero span, centered on a hopping channel
2) RBW shall be ≤ channel spacing and where possible RBW should be set >> 1 / T, where T is the expected dwell time per channel.
3) Sweep = as necessary to capture the entire dwell time per hopping channel
4) Detector: Peak
5) Trace: Max hold

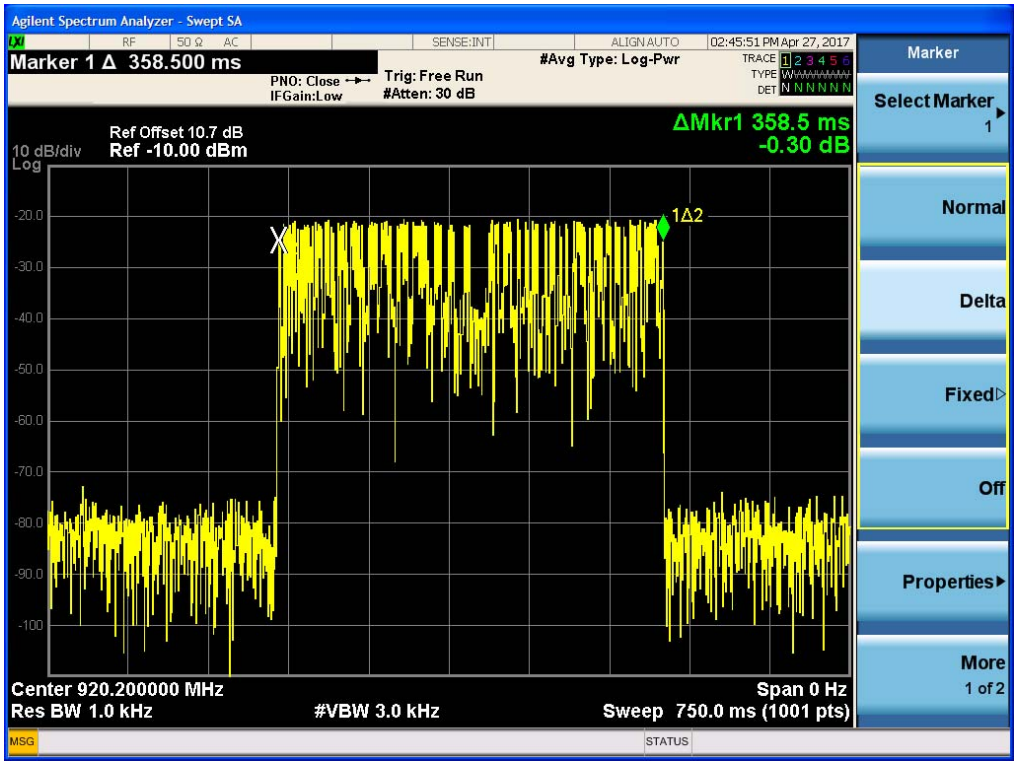
The marker-delta function was used to determine the dwell time.

TEST RESULTS

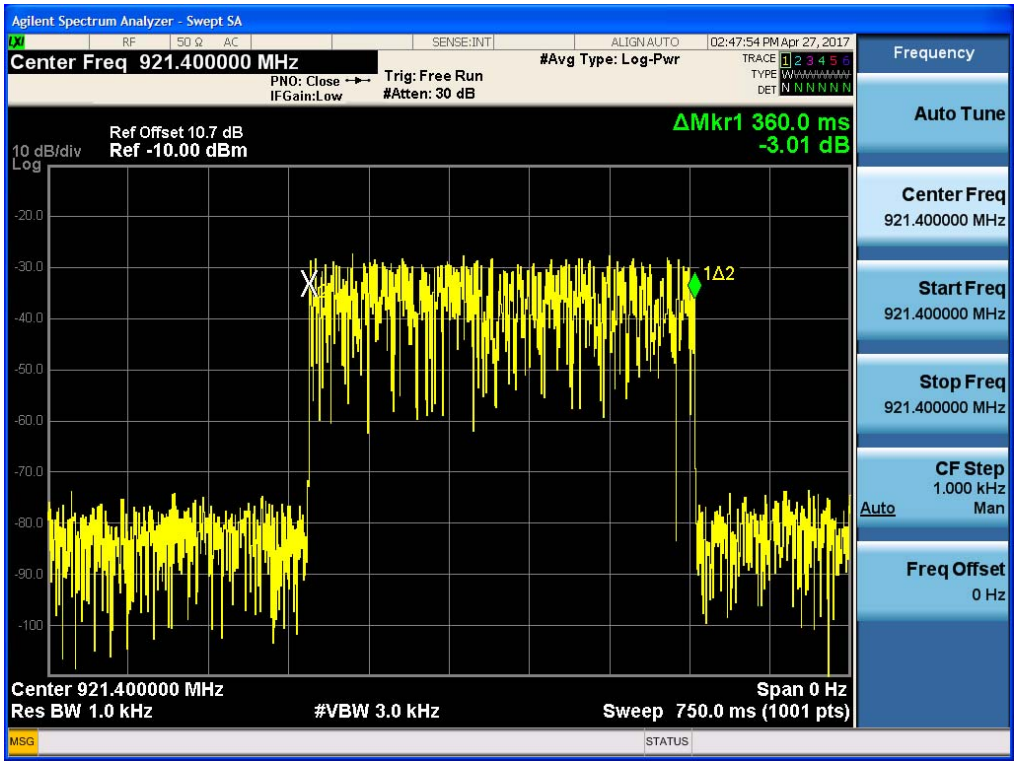
See the table.

	Channel	DBPSK	Limit (ms)	Result
Pulse Time (ms)	Low	358.5 ms	400	PASS
	Mid	360.0 ms		PASS
	High	358.5 ms		PASS

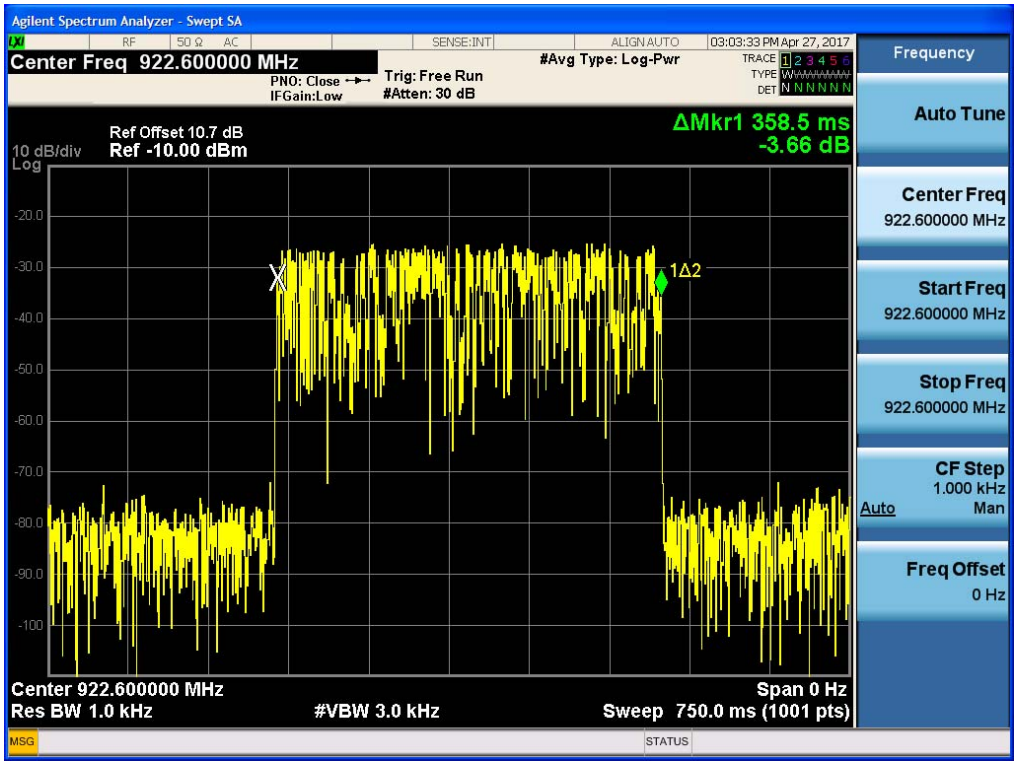
Test Plots (Channel Mid)
Time slot length = 358.5 ms



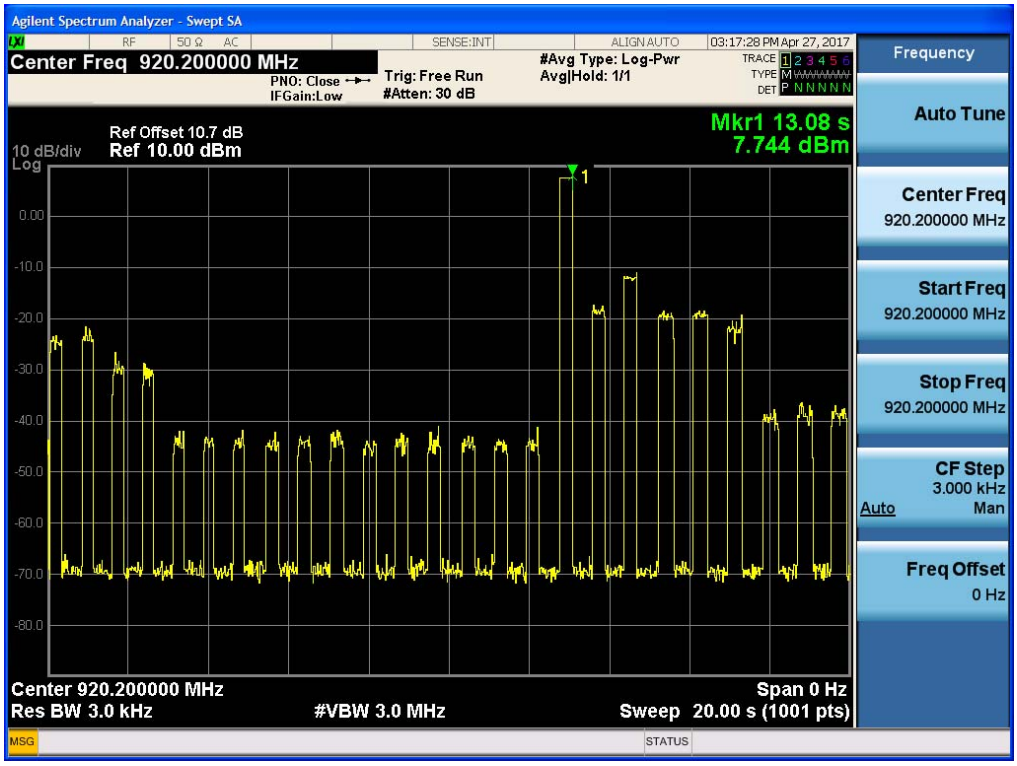
Test Plots (Channel Mid)
Time slot length = 360.0 ms



Test Plots (Channel High)
Time slot length = 358.5 ms



Test Plots
Hops / channel @ 20s = 1 (The highest emission is only relevant)



9.6 SPURIOUS EMISSIONS

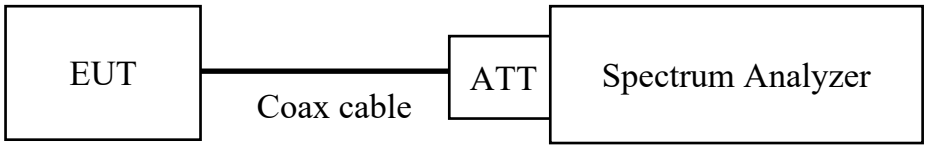
9.6.1 CONDUCTED SPURIOUS EMISSIONS

Test Requirements and limit, §15.247(d) / RSS-247(Issue 2) Section 5.5

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)).

Limit : 20 dBc

Test Configuration



TEST PROCEDURE

Conducted RF measurements of the transmitter output were made to confirm that the EUT antenna port conducted emissions meet the specified limit and to identify any spurious signals that require further investigation or measurements on the radiated emissions site.

The transmitter output is connected to the spectrum analyzer.

The Spectrum Analyzer is set to (7.8.8 in ANSI 63.10-2013)

1) Span: 30 MHz to 10 times the operating frequency in GHz.
2) RBW: 100 kHz
3) VBW: 300 kHz
4) Sweep: Coupled
5) Detector: Peak

Measurements are made over the 30 MHz to 10 GHz range with the transmitter set to the lowest, middle, and highest channels.

This test is performed with hopping off.

TEST RESULTS

No non-compliance noted.

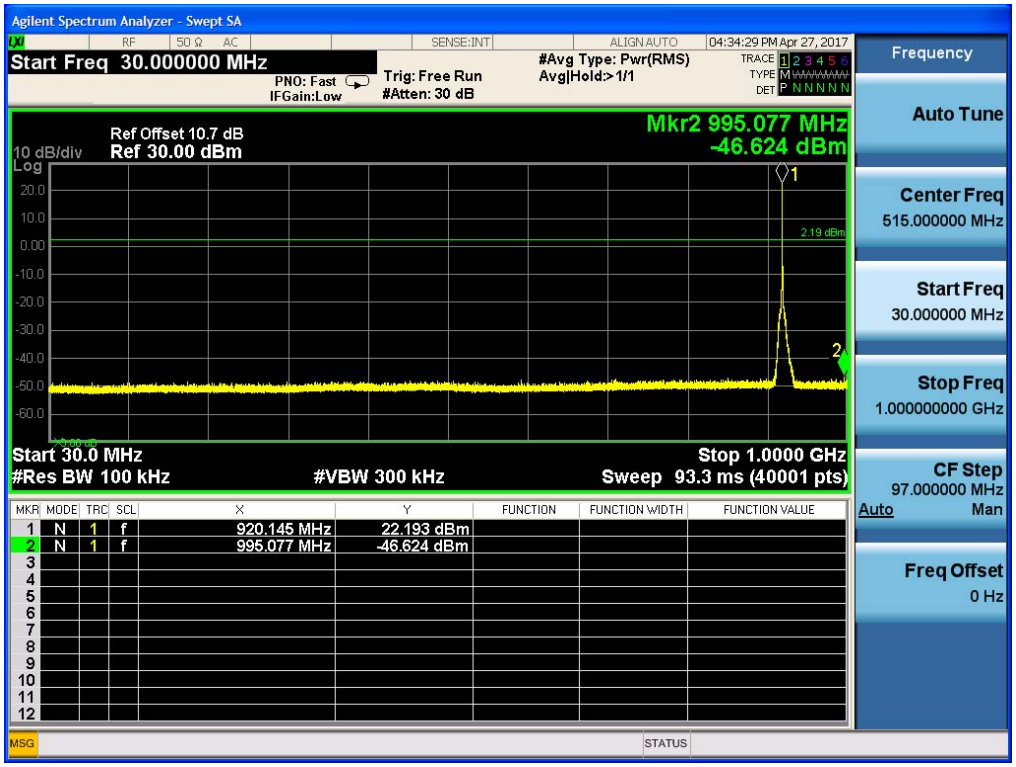
Note : In order to simplify the report, attached plots were only the worst case channel and data rate.

▣ FACTORS FOR FREQUENCY

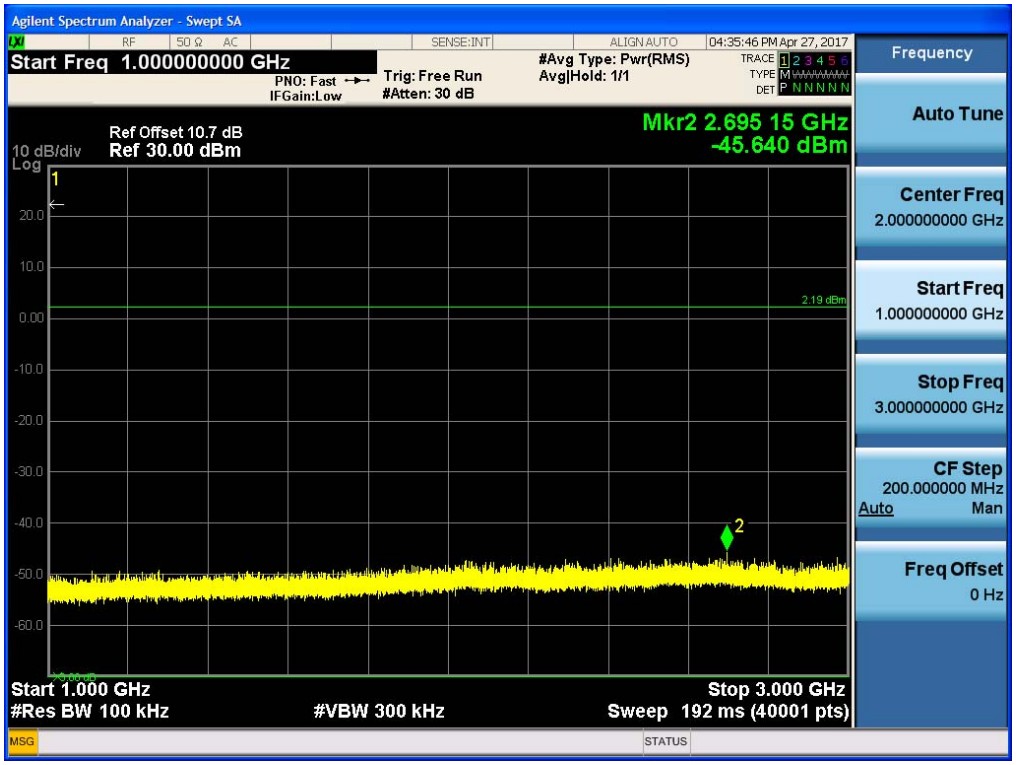
Freq(MHz)	Factor(dB)
30	10.95
100	9.51
200	9.823
300	9.848
400	9.909
500	9.941
600	9.986
700	10.00
800	10.02
900	10.00
1000	10.12
2000	10.32
3000	11.15
4000	10.74
5000	10.63
6000	10.66
7000	10.90
8000	10.82
9000	10.93
10000	11.00

Note : 1. '*' is fundamental frequency range.
2. Factor = Cable loss + Attenuator loss

Test Plots (DBPSK)- 30 MHz - 1 GHz
Spurious Emission

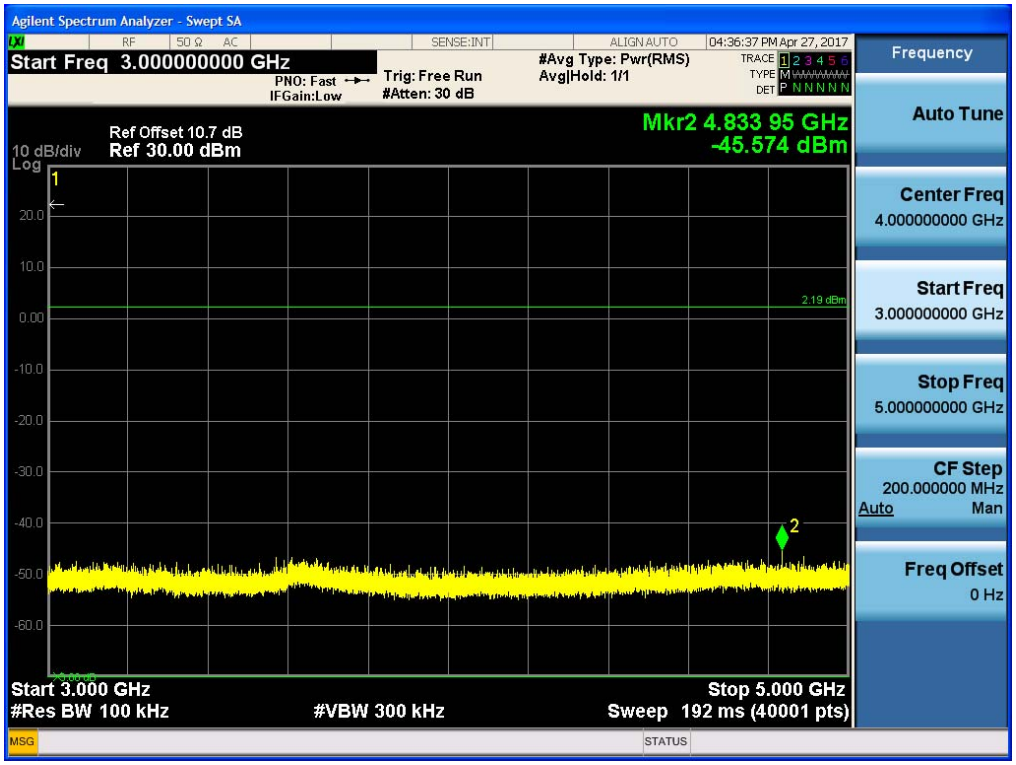


Test Plots (DBPSK)- 1 GHz – 3 GHz
Spurious Emission



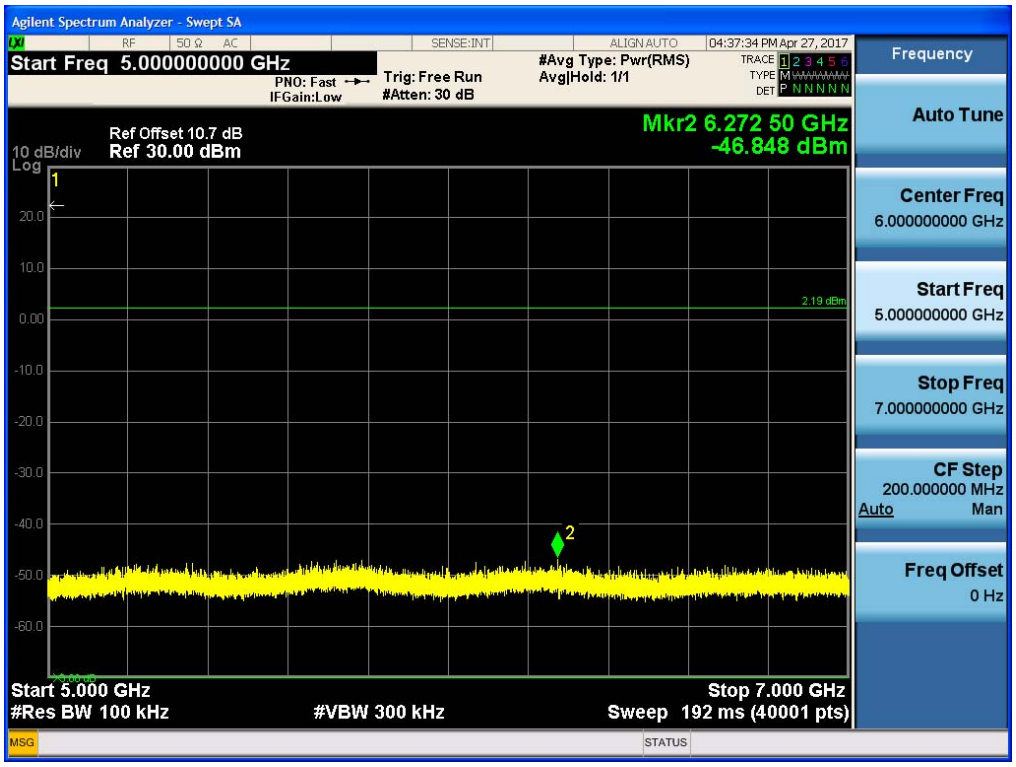
Test Plots (DBPSK)- 3 GHz – 5 GHz

Spurious Emission

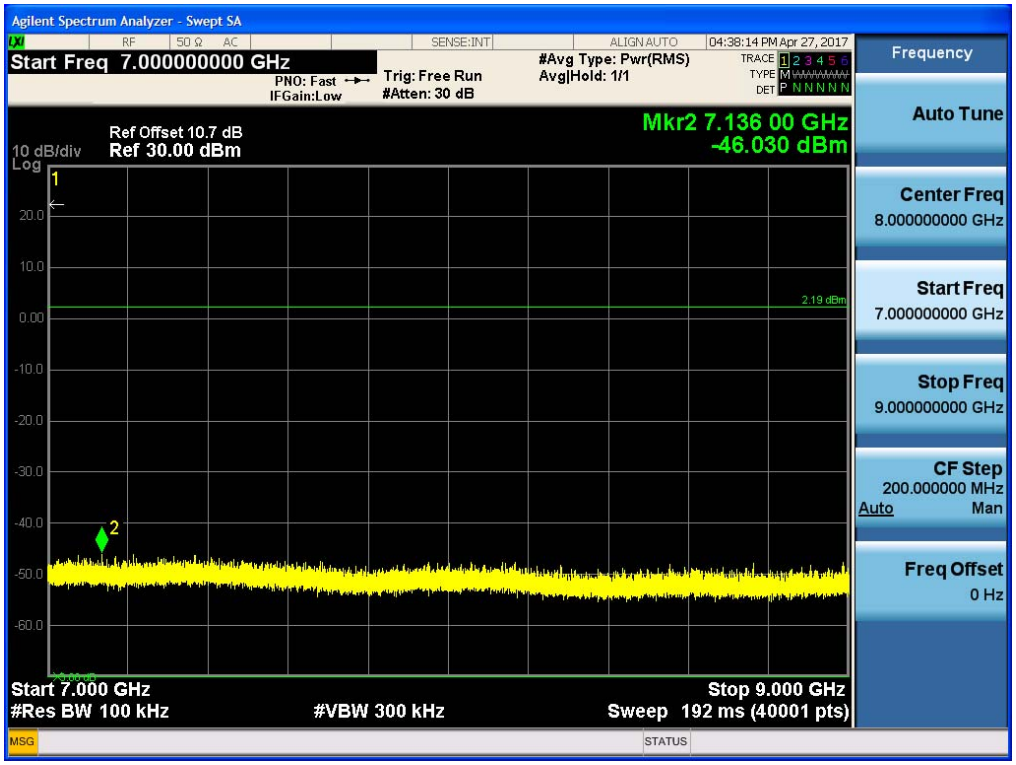


Test Plots(DBPSK)- 5 GHz - 7 GHz

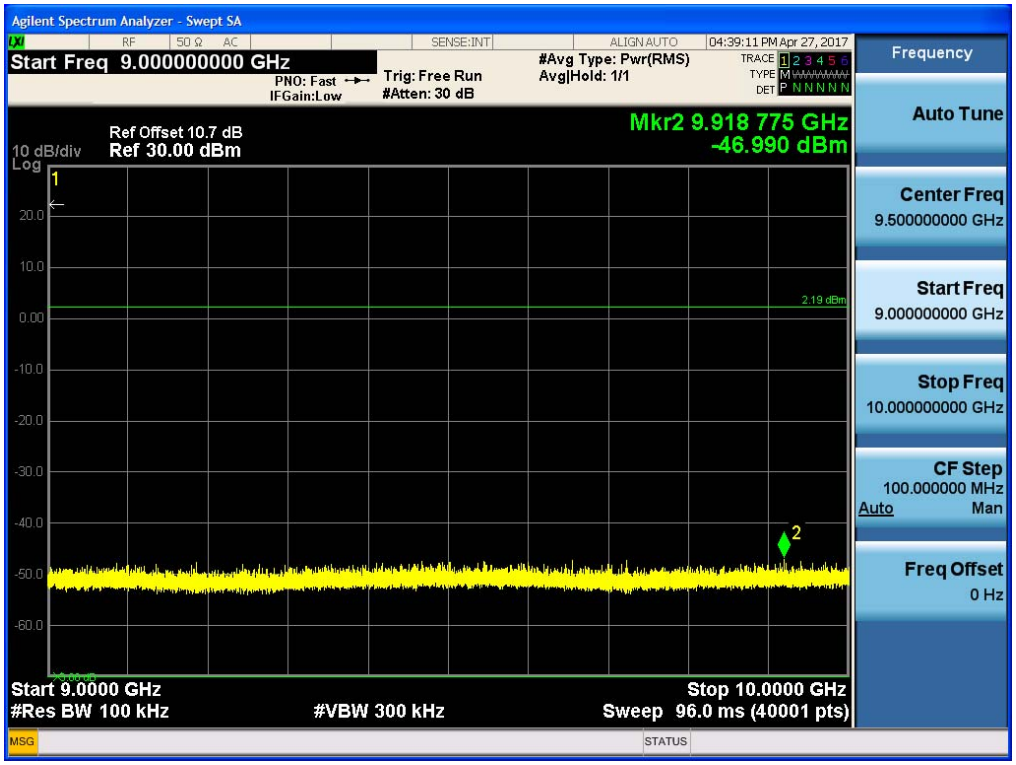
Spurious Emission



Test Plots (DBPSK)- 7 GHz - 9 GHz
Spurious Emission



Test Plots(DBPSK)- 9 GHz - 10 GHz
Spurious Emission



9.6.2 RADIATED SPURIOUS EMISSIONS

LIMIT : §15.247(d), §15.205, §15.209 / RSS-GEN(Issue 4) Section 8.9

20dBc in any 100kHz bandwidth outside the operating frequency band. In case the emission fall within the restricted band specified on 15.205(a), then the 15.209(a) limit in the table below has to be followed.

Frequency (MHz)	Field Strength (uV/m)	Measurement Distance (m)
0.009 – 0.490	2400/F(kHz)	300
0.490 – 1.705	24000/F(kHz)	30
1.705 – 30	30	30
30-88	100	3
88-216	150	3
216-960	200	3
Above 960	500	3

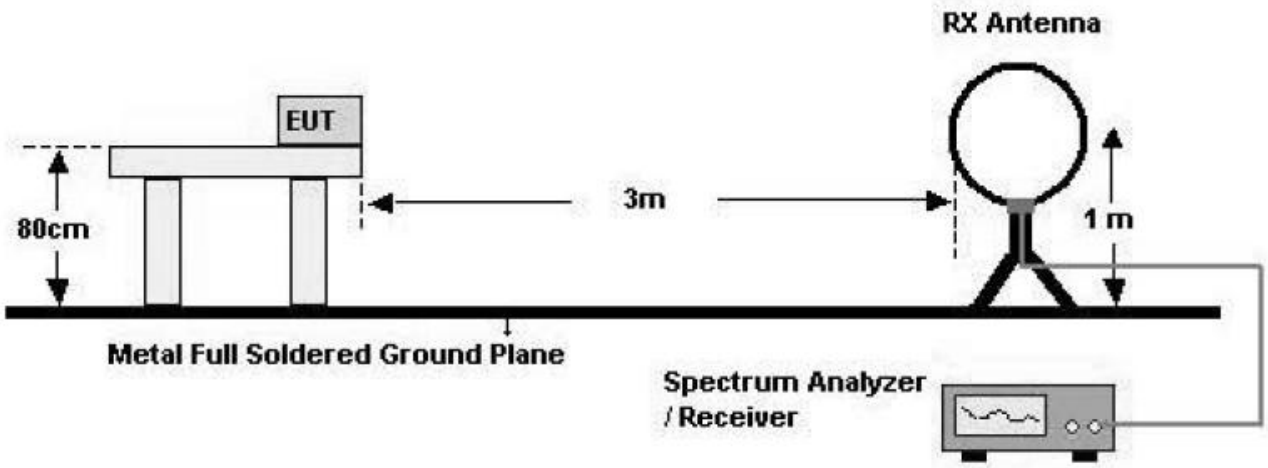
Restricted band of operation : §15.205

(a) Except as shown in paragraph (d) of this section, only spurious emissions are permitted in any of the frequency bands listed below:

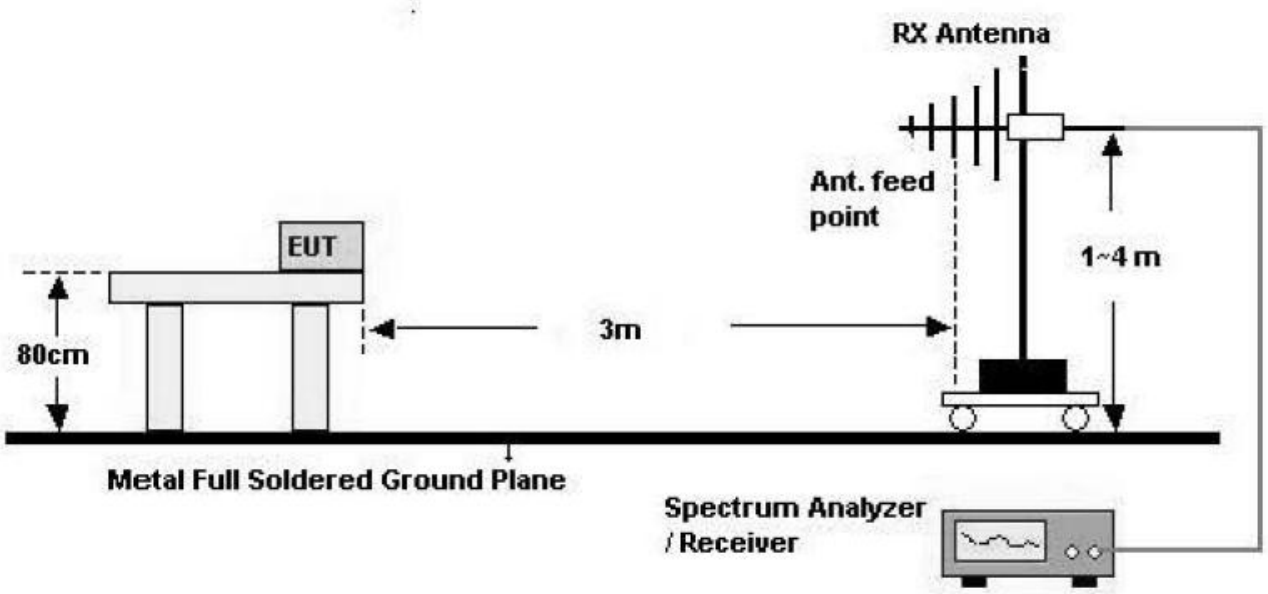
MHz	MHz	MHz	GHz
0.090-0.110	16.42-16.423	399.9-410	4.5-5.15
[1]0.495-0.505	16.69475-16.69525	608-614	5.35-5.46
2.1735-2.1905	16.80425-16.80475	960-1240	7.25-7.75
4.125-4.128	25.5-25.67	1300-1427	8.025-8.5
4.17725-4.17775	37.5-38.25	1435-1626.5	9.0-9.2
4.20725-4.20775	73-74.6	1645.5-1646.5	9.3-9.5
6.215-6.218	74.8-75.2	1660-1710	10.6-12.7
6.26775-6.26825	108-121.94	1718.8-1722.2	13.25-13.4
6.31175-6.31225	123-138	2200-2300	14.47-14.5
8.291-8.294	149.9-150.05	2310-2390	15.35-16.2
8.362-8.366	156.52475-156.52525	2483.5-2500	17.7-21.4
8.37625-8.38675	156.7-156.9	2690-2900	22.01-23.12
8.41425-8.41475	162.0125-167.17	3260-3267	23.6-24.0
12.29-12.293	167.72-173.2	3332-3339	31.2-31.8
12.51975-12.52025	240-285	3345.8-3358	36.43-36.5
12.57675-12.57725	322-335.4	3600-4400	([2])
13.36-13.41			

Test Configuration

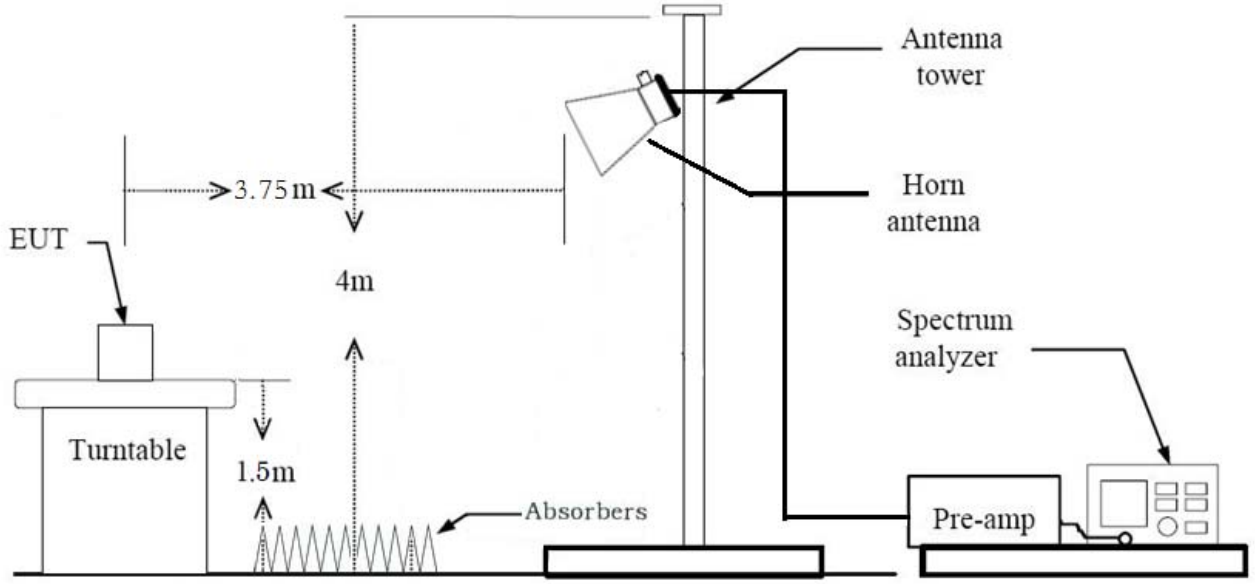
Below 30 MHz



30 MHz - 1 GHz



Above 1 GHz



TEST PROCEDURE

1. The EUT is placed on a turntable, which is 1.5 m above ground plane.
2. The turntable shall be rotated for 360 degrees to determine the position of maximum emission level.
3. EUT is set 3.75 m away from the receiving antenna, which is varied from 1m to 4m to find out the highest emissions.
4. Maximum procedure was performed on the six highest emissions to ensure EUT compliance.
5. And also, each emission was to be maximized by changing the polarization of receiving antenna both horizontal and vertical.
6. Repeat above procedures until the measurements for all frequencies are complete.
7. Spectrum Setting
   a. Peak: 1 GHz – 10 GHz, RBW = 1 MHz, VBW ≥3*RBW
   b. Average (RMS): 1 GHz – 10 GHz, RBW = 1 MHz, VBW ≥3*RBW

Note :

1. We are performed the RSE and radiated band edge using standard radiated method.
2. According to SVSWR requirement in ANSI 63.4-2014, We performed the radiated test at 3.75 m distance from center of turn table. So, we applied the distance factor(reference distance : 3 m).
3. Distance extrapolation factor = 20 log (test distance / specific distance) (dB)

TEST RESULTS

Frequency Range : 9 kHz – 30MHz

Operation Mode: Normal Mode

Frequency	Reading	Ant. factor	Cable loss	Ant. POL	Total	Limit	Margin
MHz	dBuV/m	dBm/m	dBm	(H/V)	dBuV/m	dBuV/m	dB
No Critical peaks found							

Notes:

1. Measuring frequencies from 9 kHz to the 30MHz.
2. The reading of emissions are attenuated more than 20 dB below the permissible limits or the field strength is too small to be measured.
3. Distance extrapolation factor = 40 log (specific distance / test distance) (dB)
4. Limit line = specific Limits (dBuV) + Distance extrapolation factor
5. This test is performed with hopping off.
6. We have done x, y, z planes in EUT and horizontal and vertical polarization in detecting antenna.
7. The test results for below 30 MHz is correlated to an open site.
   The result on OATS is about 2 dB higher than semi-anechoic chamber (10 m chamber)

TEST RESULTS

Frequency Range : Below 1 GHz

Operation Mode: Normal Mode

Frequency	Reading	Ant. factor	Cable loss	Ant. POL	Total	Limit	Margin
MHz	dBuV/m	dBm/m	dBm	(H/V)	dBuV/m	dBuV/m	dB
No Critical peaks found							

Notes:

1. Measuring frequencies from 30 MHz to the 1 GHz.
2. Radiated emissions measured in frequency range from 30 MHz to 1000 MHz were made with an instrument using Quasi peak detector mode.
3. This test is performed with hopping off.
4. We have done x, y, z planes in EUT and horizontal and vertical polarization in detecting antenna.

TEST RESULTS

Frequency Range : Above 1 GHz

Channel : Low

Frequency [MHz]	Reading [dBuV]	※A.F.+C.L.-A.G.+D.F+F.L. [dB]	ANT. POL [H/V]	Total [dBuV/m]	Limit [dBuV/m]	Margin [dB]	Measurement Type
2760.41	61.32	-10.03	V	51.29	73.98	22.69	PK
2760.41	55.41	-10.03	V	45.38	53.98	8.60	AV
3680.55	56.94	-6.36	V	50.58	73.98	23.40	PK
3680.55	50.06	-6.36	V	43.70	53.98	10.28	AV
7361.10	53.27	4.29	V	57.56	73.98	16.42	PK
7361.10	44.54	4.29	V	48.83	53.98	5.15	AV
8281.24	50.92	4.9	V	55.82	73.98	18.16	PK
8281.24	38.54	4.9	V	43.44	53.98	10.54	AV
2760.41	60.48	-10.03	H	50.45	73.98	23.53	PK
2760.41	54.62	-10.03	H	44.59	53.98	9.39	AV
3680.55	55.99	-6.36	H	49.63	73.98	24.35	PK
3680.55	49.84	-6.36	H	43.48	53.98	10.50	AV
4600.69	52.89	-3.3	H	49.59	73.98	24.39	PK
4600.69	43.06	-3.3	H	39.76	53.98	14.22	AV
8281.24	51.31	4.9	H	56.21	73.98	17.77	PK
8281.24	38.99	4.9	H	43.89	53.98	10.09	AV

*A.F. : Antenna Factor / C.L. : Cable Loss / AMP.G. : Amplifier Gain / D.F. : Distance Factor / F.L. : Filter Loss

TEST RESULTS

Frequency Range : Above 1 GHz

Channel : Mid

Frequency [MHz]	Reading [dBuV]	※A.F.+C.L.-A.G.+D.F.+F.L. [dB]	ANT. POL [H/V]	Total [dBuV/m]	Limit [dBuV/m]	Margin [dB]	Measurement Type
2764.16	59.27	-10.56	V	48.71	73.98	25.27	PK
2764.16	54.81	-10.56	V	44.25	53.98	9.73	AV
7371.10	54.50	4.19	V	58.69	73.98	15.29	PK
7371.10	46.21	4.19	V	50.40	53.98	3.58	AV
8292.49	49.58	5.08	V	54.66	73.98	19.32	PK
8292.49	37.84	5.08	V	42.92	53.98	11.06	AV
2764.16	60.45	-10.56	H	49.89	73.98	24.09	PK
2764.16	55.00	-10.56	H	44.44	53.98	9.54	AV
3685.55	59.27	-6.15	H	53.12	73.98	20.86	PK
3685.55	53.84	-6.15	H	47.69	53.98	6.29	AV
4606.94	53.88	-3.27	H	50.61	73.98	23.37	PK
4606.94	44.78	-3.27	H	41.51	53.98	12.47	AV
7371.10	52.37	4.19	H	56.56	73.98	17.42	PK
7371.10	44.28	4.19	H	48.47	53.98	5.51	AV
8292.49	50.43	5.08	H	55.51	73.98	18.47	PK
8292.49	38.07	5.08	H	43.15	53.98	10.83	AV

TEST RESULTS

Frequency Range : Above 1 GHz

Channel : High

Frequency [MHz]	Reading [dBuV]	※A.F.+C.L.-A.G.+D.F.+F.L. [dB]	ANT. POL [H/V]	Total [dBuV/m]	Limit [dBuV/m]	Margin [dB]	Measurement Type
2767.99	62.70	-10.06	V	52.64	73.98	21.34	PK
2767.99	57.19	-10.06	V	47.13	53.98	6.85	AV
4613.31	52.72	-3.02	V	49.70	73.98	24.28	PK
4613.31	42.24	-3.02	V	39.22	53.98	14.76	AV
7381.30	53.75	0.14	V	53.89	73.98	20.09	PK
7381.30	45.54	0.14	V	45.68	53.98	8.30	AV
8303.96	49.27	4.98	V	54.25	73.98	19.73	PK
8303.96	37.84	4.98	V	42.82	53.98	11.16	AV
2767.99	61.99	-10.06	H	51.93	73.98	22.05	PK
2767.99	56.84	-10.06	H	46.78	53.98	7.20	AV
3690.65	59.02	-6.43	H	52.59	73.98	21.39	PK
3690.65	53.19	-6.43	H	46.76	53.98	7.22	AV
4613.31	51.97	-3.02	H	48.95	73.98	25.03	PK
4613.31	41.67	-3.02	H	38.65	53.98	15.33	AV
7381.30	51.69	0.14	H	51.83	73.98	22.15	PK
7381.30	43.28	0.14	H	43.42	53.98	10.56	AV
8303.96	50.52	4.98	H	55.50	73.98	18.48	PK
8303.96	38.25	4.98	H	43.23	53.98	10.75	AV

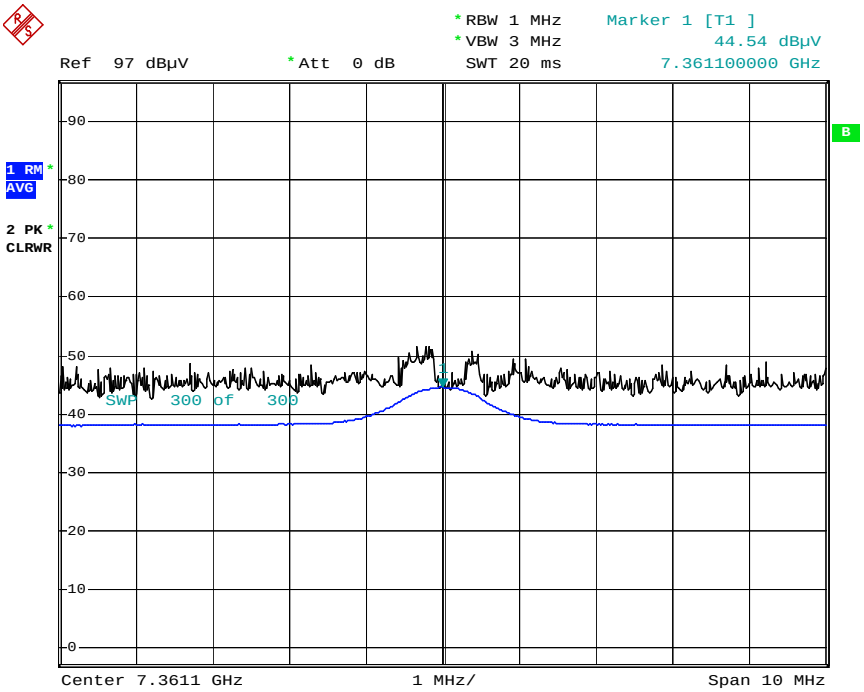
Notes:

1. Measuring frequencies from 1 GHz to the 10th harmonic of highest fundamental frequency.
2. Measurements above show only up to 10 maximum emissions noted, or would be lesser if no specific emissions from the EUT are recorded (ie: margin > 20 dB from the applicable limit) and considered that's already beyond the background noise floor.
3. Radiated emissions measured in frequency above 1000 MHz were made with an instrument using Peak detector mode and average detector mode of the emission shown in Actual FS column.
4. Total = Reading Value + Antenna Factor + Cable Loss - Amp Gain + Distance Factor + Filter Loss
5. Distance extrapolation factor = 20 log (test distance / specific distance) (dB)
6. Spectrum setting:
   a. Peak: 1 GHz – 10 GHz, RBW = 1 MHz, VBW ≥3*RBW
   b. Average (RMS): 1 GHz – 10 GHz, RBW = 1 MHz, VBW ≥3*RBW
7. This test is performed with hopping off.
8. We have done x, y, z planes in EUT and horizontal and vertical polarization in detecting antenna.

▣ RESULT PLOTS

Channel : Low

Radiated Spurious Emissions plot –Average Reading (DBPSK 8th Harmonic, X-V)



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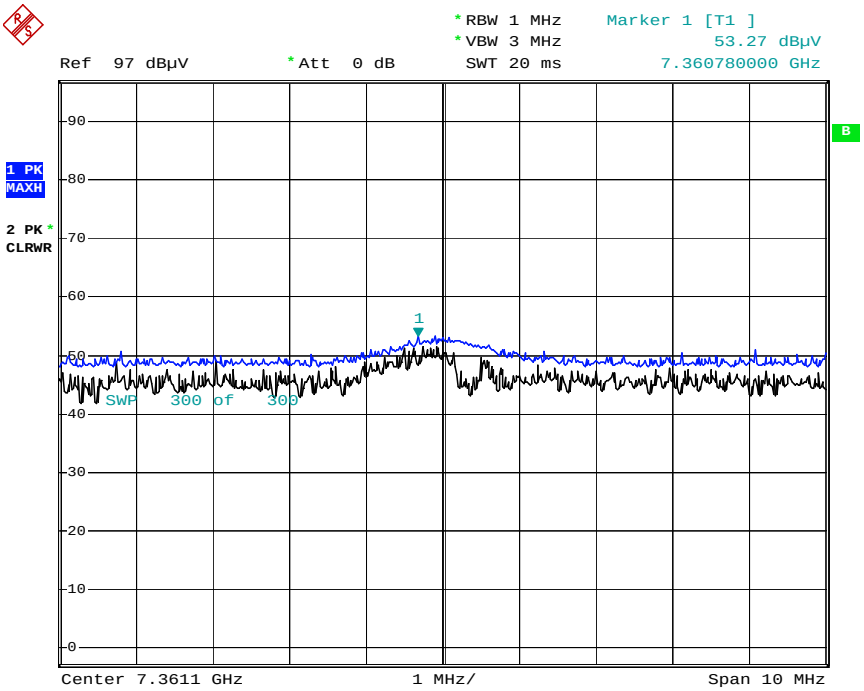
Radiated Spurious Emissions plot – Peak Reading (DBPSK 8th Harmonic, X-V)



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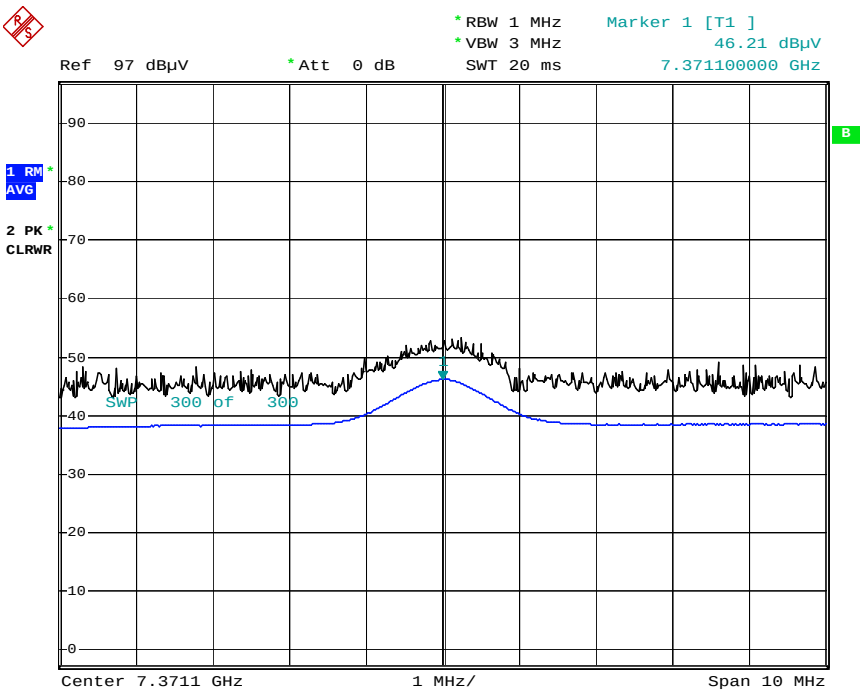
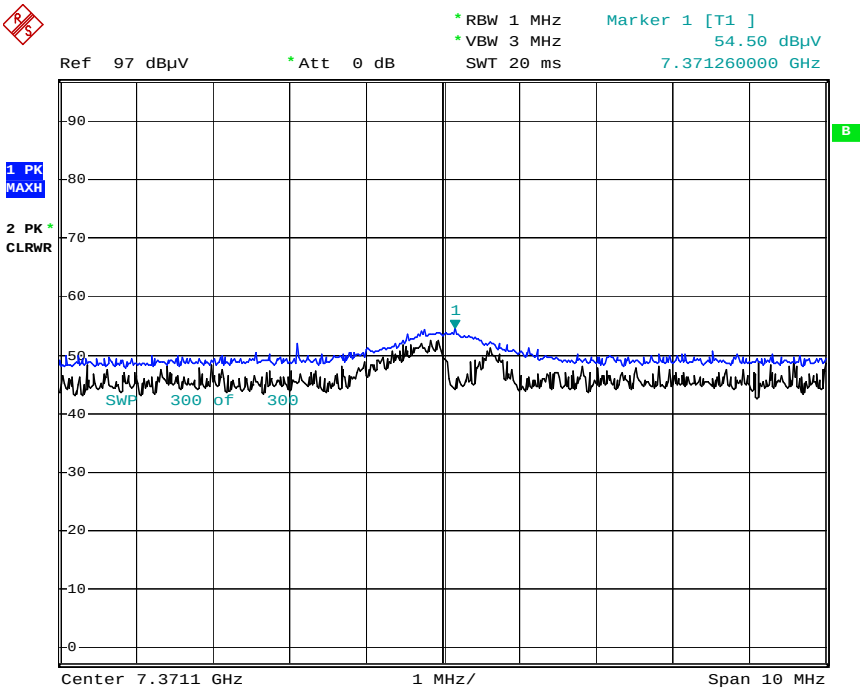
Channel : Mid

Radiated Spurious Emissions plot –Average Reading (DBPSK 8th Harmonic, Y-V)



Date: 29.NOV.2017 03:28:34

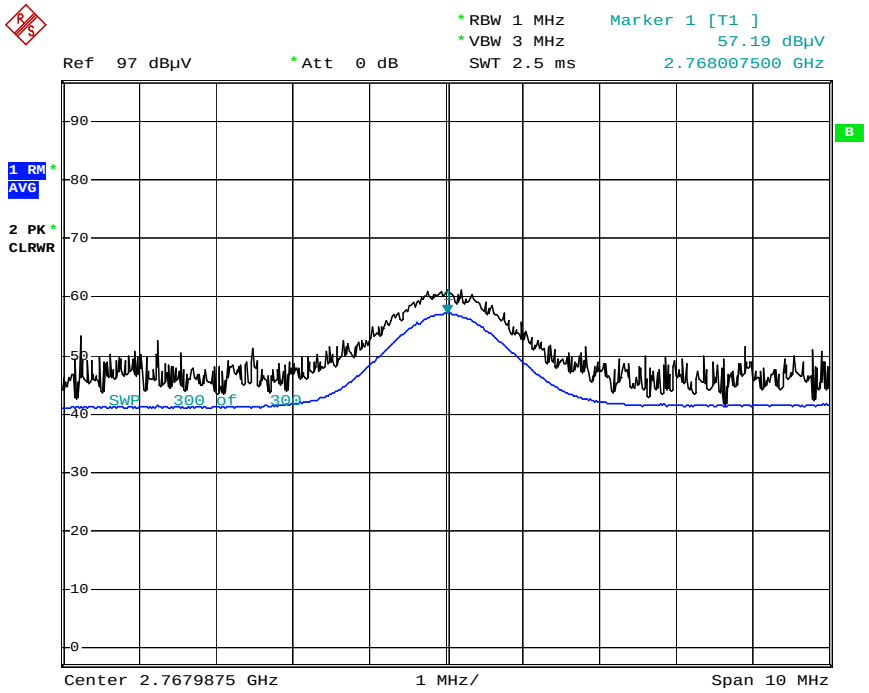
Radiated Spurious Emissions plot – Peak Reading (DBPSK 8th Harmonic, Y-V)



Date: 29.NOV.2017 03:29:00

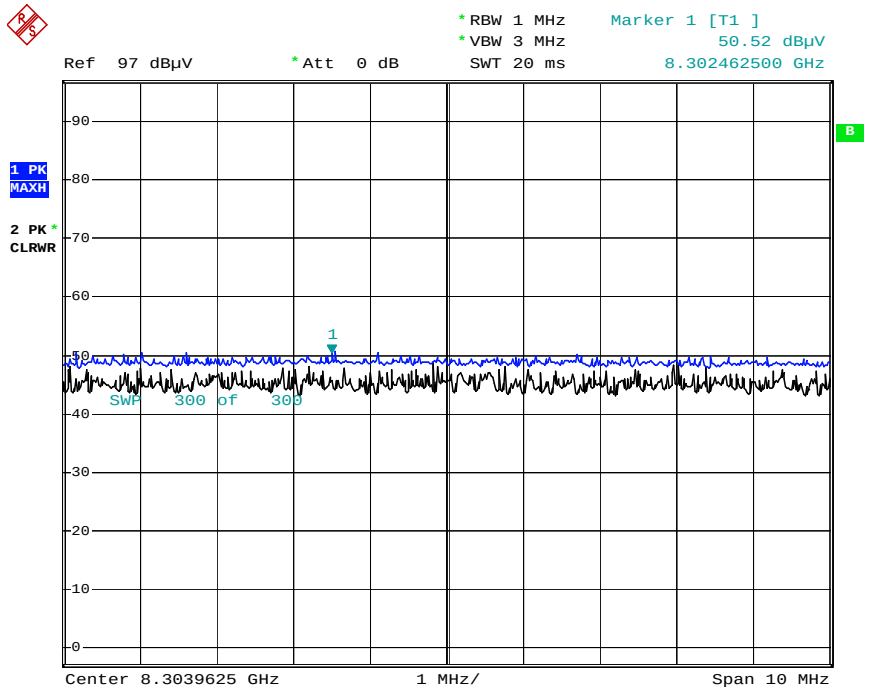
Channel : High

Radiated Spurious Emissions plot –Average Reading (DBPSK 3rd Harmonic, Y-V)



Date: 29.NOV.2017 03:46:03

Radiated Spurious Emissions plot – Peak Reading (DBPSK 9th Harmonic, Y-H)



Date: 29.NOV.2017 04:00:55

Note : Only the worst case plots for Radiated Spurious Emissions.

9.6.3 RECEIVER SPURIOUS EMISSIONS

IC Rule(s)	**RSS-Gen**
Test Requirements:	**Blow the table**
Operating conditions:	**Under normal test conditions**
Method of testing:	**Radiated**
S/A. Settings:	**F < 1 GHz: RBW: 120 kHz, VBW: 300 kHz (Quasi Peak)** **F > 1 GHz: RBW: 1 MHz, VBW: 1 MHz (Peak)**
Mode of operation:	**Receive**

Frequency (MHz)	Field Strength (microvolts/m at 3 meters)
30 – 88	100
88 - 216	150
216 – 960	200
Above 960	500

Operation Mode: Receive:

30 MHz ~ 1 GHz

Frequency	Reading	Ant. factor	Cable loss	Ant. POL	Total	Limit	Margin
MHz	dBμV	dB /m	dB	(H/V)	dBμV/m	dBμV/m	dB
No critical peaks found							

Above 1 GHz

Frequency	Reading	Ant. factor	Cable loss	Ant. POL	Total	Limit	Margin
MHz	dBμV	dB /m	dB	(H/V)	dBμV/m	dBμV/m	dB
No critical peaks found							

9.7 POWERLINE CONDUCTED EMISSIONS

LIMIT : §15.207(a) / RSS-GEN(Issue 4) Section 8.8

For an intentional radiator which 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 250 microvolt (The limit decreases linearly with the logarithm of the frequency in the range 0.15 MHz to 0.50 MHz). The limits at specific frequency range is listed as follows:

Frequency Range (MHz)	Limits (dBµV)	
	Quasi-peak	Average
0.15 to 0.50	66 to 56	56 to 46
0.50 to 5	56	46
5 to 30	60	50

Compliance with this provision shall be based on the measurement of the radio frequency voltage between each power line (LINE and NEUTRAL) and ground at the power terminals.

Test Configuration

See test photographs attached in Appendix 1 for the actual connections between EUT and support equipment.

TEST PROCEDURE

1. The EUT is placed on a wooden table 80 cm above the reference ground plane.
2. The EUT is connected via LISN to a test power supply.
3. The measurement results are obtained as described below:
4. Detectors – Quasi Peak and Average Detector.

Sample Calculation

Quasi-peak(Final Result) = Reading Value + Correction Factor

▣ RESULT PLOTS

Conducted Emissions (Line 1)

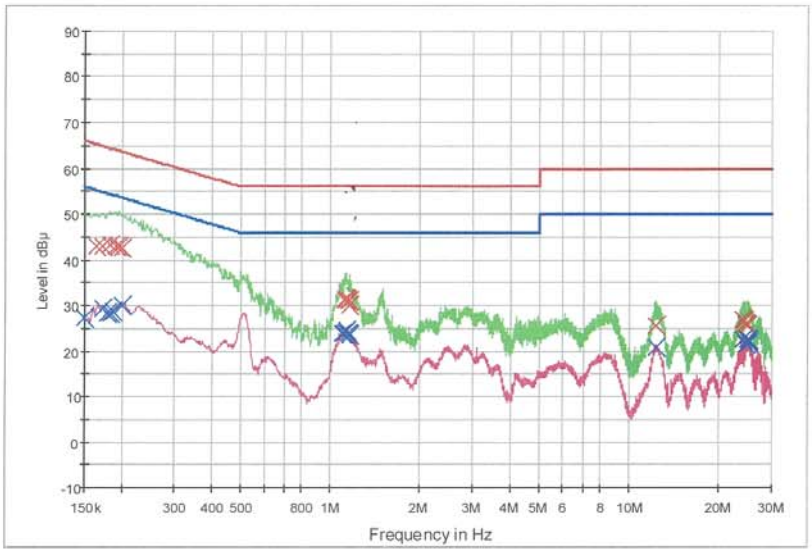
EMI Auto Test(17) 1 / 2

HCT TEST Report

Common Information

EUT:	SFM60R4
Manufacturer:	WISOL
Test Site:	SHIELD ROOM
Operating Conditions:	SIGFOX L1

FCC CLASS B



Final Result 1

Frequency (MHz)	QuasiPeak (dBµV)	Bandwidth (kHz)	Filter	Line	Corr. (dB)	Margin (dB)	Limit (dBµV)
0.164000	43.0	9.000	Off	L1	9.6	22.2	65.3
0.172000	43.0	9.000	Off	L1	9.6	21.8	64.9
0.182000	43.1	9.000	Off	L1	9.6	21.3	64.4
0.192000	43.0	9.000	Off	L1	9.6	21.0	63.9
0.196000	42.8	9.000	Off	L1	9.6	21.0	63.8
0.202000	42.5	9.000	Off	L1	9.6	21.0	63.5
1.116000	31.3	9.000	Off	L1	9.7	24.7	56.0
1.120000	31.2	9.000	Off	L1	9.7	24.8	56.0
1.138000	31.3	9.000	Off	L1	9.7	24.7	56.0
1.146000	31.0	9.000	Off	L1	9.7	25.0	56.0
1.160000	29.9	9.000	Off	L1	9.7	26.1	56.0
1.166000	31.1	9.000	Off	L1	9.7	24.9	56.0
12.354000	25.7	9.000	Off	L1	10.1	34.3	60.0
12.394000	25.7	9.000	Off	L1	10.1	34.3	60.0
24.132000	26.8	9.000	Off	L1	10.3	33.2	60.0
24.350000	26.5	9.000	Off	L1	10.3	33.5	60.0
24.724000	26.1	9.000	Off	L1	10.4	33.9	60.0
24.782000	25.5	9.000	Off	L1	10.4	34.5	60.0

Final Result 2

2017-12-05 오전 10:10:31

EMI Auto Test(17) 2 / 2

Frequency (MHz)	CAverage (dBμV)	Bandwidth (kHz)	Filter	Line	Corr. (dB)	Margin (dB)	Limit (dBμV)
0.150000	27.3	9.000	Off	L1	9.6	28.7	56.0
0.172000	29.3	9.000	Off	L1	9.6	25.5	54.9
0.178000	28.4	9.000	Off	L1	9.6	26.2	54.6
0.182000	28.3	9.000	Off	L1	9.6	26.1	54.4
0.188000	28.8	9.000	Off	L1	9.6	25.3	54.1
0.200000	30.1	9.000	Off	L1	9.6	23.6	53.6
1.098000	23.9	9.000	Off	L1	9.7	22.1	46.0
1.114000	23.8	9.000	Off	L1	9.7	22.2	46.0
1.120000	24.1	9.000	Off	L1	9.7	21.9	46.0
1.138000	24.5	9.000	Off	L1	9.7	21.5	46.0
1.146000	24.0	9.000	Off	L1	9.7	22.0	46.0
1.162000	23.7	9.000	Off	L1	9.7	22.3	46.0
12.354000	21.0	9.000	Off	L1	10.1	29.0	50.0
24.132000	22.5	9.000	Off	L1	10.3	27.5	50.0
24.628000	21.7	9.000	Off	L1	10.4	28.3	50.0
24.832000	22.7	9.000	Off	L1	10.4	27.3	50.0
25.048000	22.5	9.000	Off	L1	10.4	27.5	50.0
25.208000	21.9	9.000	Off	L1	10.4	28.1	50.0

2017-12-05 오전 10:10:31

Conducted Emissions (Line 2)

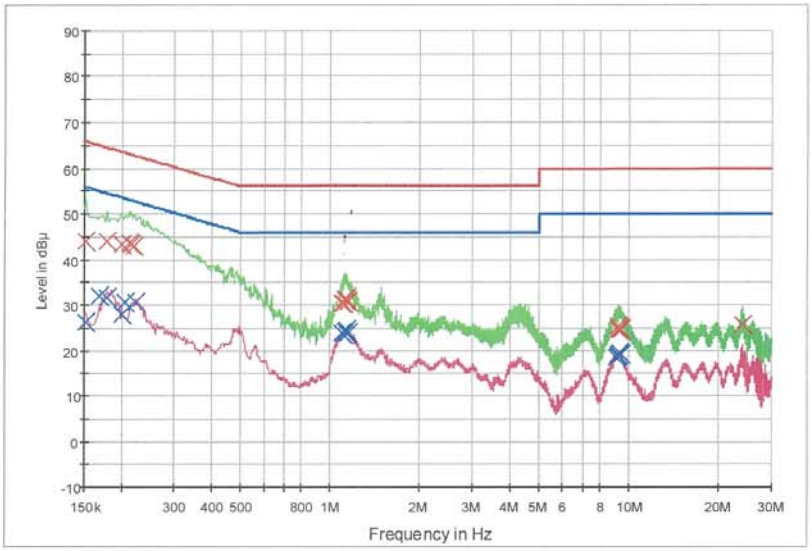
EMI Auto Test(17) 1 / 2

HCT TEST Report

Common Information

EUT:	SFM60R4
Manufacturer:	WISOL
Test Site:	SHIELD ROOM
Operating Conditions:	SIGFOX N

* FCC CLASS B



FCC CLASS B_QP
Preview Result 2-AVG
FCC CLASS B_AV
Final Result 1-QPK
Preview Result 1-PK+
Final Result 2-CAV

Final Result 1

Frequency (MHz)	QuasiPeak (dBµV)	Bandwidth (kHz)	Filter	Line	Corr. (dB)	Margin (dB)	Limit (dBµV)
0.152000	43.9	9.000	Off	N	9.6	22.0	65.9
0.178000	43.8	9.000	Off	N	9.6	20.7	64.6
0.200000	43.2	9.000	Off	N	9.6	20.5	63.6
0.212000	43.4	9.000	Off	N	9.6	19.7	63.1
0.216000	43.3	9.000	Off	N	9.6	19.7	63.0
0.220000	42.9	9.000	Off	N	9.6	20.0	62.8
1.098000	30.3	9.000	Off	N	9.7	25.7	56.0
1.104000	30.4	9.000	Off	N	9.7	25.6	56.0
1.118000	31.2	9.000	Off	N	9.7	24.8	56.0
1.126000	31.1	9.000	Off	N	9.7	24.9	56.0
1.140000	31.2	9.000	Off	N	9.7	24.8	56.0
1.144000	30.6	9.000	Off	N	9.7	25.4	56.0
9.230000	24.6	9.000	Off	N	10.0	35.4	60.0
9.260000	25.2	9.000	Off	N	10.1	34.8	60.0
9.334000	24.9	9.000	Off	N	10.1	35.1	60.0
9.352000	24.7	9.000	Off	N	10.1	35.3	60.0
9.388000	24.5	9.000	Off	N	10.1	35.5	60.0
23.912000	25.4	9.000	Off	N	10.3	34.6	60.0

Final Result 2

2017-12-05 오전 9:28:16

EMI Auto Test(17) 2 / 2

Frequency (MHz)	CAverage (dBµV)	Bandwidth (kHz)	Filter	Line	Corr. (dB)	Margin (dB)	Limit (dBµV)
0.152000	26.2	9.000	Off	N	9.6	29.7	55.9
0.168000	31.9	9.000	Off	N	9.6	23.1	55.1
0.178000	31.6	9.000	Off	N	9.6	23.0	54.6
0.200000	27.8	9.000	Off	N	9.6	25.8	53.6
0.206000	30.8	9.000	Off	N	9.6	22.6	53.4
0.222000	30.7	9.000	Off	N	9.6	22.0	52.7
1.098000	23.8	9.000	Off	N	9.7	22.2	46.0
1.106000	23.5	9.000	Off	N	9.7	22.5	46.0
1.120000	24.1	9.000	Off	N	9.7	21.9	46.0
1.124000	24.3	9.000	Off	N	9.7	21.7	46.0
1.136000	24.4	9.000	Off	N	9.7	21.6	46.0
1.144000	23.9	9.000	Off	N	9.7	22.1	46.0
9.058000	18.4	9.000	Off	N	10.0	31.6	50.0
9.160000	18.9	9.000	Off	N	10.0	31.1	50.0
9.230000	19.2	9.000	Off	N	10.0	30.8	50.0
9.318000	19.6	9.000	Off	N	10.1	30.4	50.0
9.382000	19.2	9.000	Off	N	10.1	30.8	50.0
9.388000	19.2	9.000	Off	N	10.1	30.8	50.0

2017-12-05 오전 9:28:16

10. LIST OF TEST EQUIPMENT

10.1 LIST OF TEST EQUIPMENT(Conducted Test)

Manufacturer	Model / Equipment	Calibration Date	Calibration Interval	Serial No.
Rohde & Schwarz	ENV216 / LISN	12/23/2016	Annual	100073
Rohde & Schwarz	ESCI / Test Receiver	12/23/2016	Annual	100584
Agilent	N9020A / Signal Analyzer	06/13/2017	Annual	MY51110085
Agilent	N9030A / Signal Analyzer	11/22/2017	Annual	MY49431210
Agilent	N1911A / Power Meter	04/17/2017	Annual	MY45100523
Agilent	N1921A / Power Sensor	04/17/2017	Annual	MY52260025
Agilent	87300B / Directional Coupler	11/20/2017	Annual	3116A03621
Hewlett Packard	11667B / Power Splitter	06/12/2017	Annual	05001
Hewlett Packard	E3632A / DC Power Supply	06/30/2017	Annual	KR75303960
Agilent	8493C / Attenuator(10 dB)	07/10/2017	Annual	07560
Rohde & Schwarz	EMC32 / Software	-	-	-

10.2 LIST OF TEST EQUIPMENT(Radiated Test)

Manufacturer	Model / Equipment	Calibration Date	Calibration Interval	Serial No.
Innco system	MA4000-EP / Antenna Position Tower	N/A	N/A	N/A
Innco system	CT0800 / Turn Table	N/A	N/A	N/A
Innco system	CO3000 / Controller(Antenna mast)	N/A	N/A	CO3000-4p
ETS	2090 / Controller(Turn table)	N/A	N/A	1646
Rohde & Schwarz	Loop Antenna	04/19/2017	Biennial	1513-175
Schwarzbeck	VULB 9168 / Hybrid Antenna	04/06/2017	Biennial	760
Schwarzbeck	BBHA 9120D / Horn Antenna	08/01/2017	Biennial	9120D-1151
Schwarzbeck	BBHA9170 / Horn Antenna(15 GHz ~ 40 GHz)	04/25/2017	Biennial	BBHA9170124
Rohde & Schwarz	FSP / Spectrum Analyzer	09/21/2017	Annual	836650/016
Rohde & Schwarz	FSV40-N / Spectrum Analyzer	09/27/2017	Annual	101068-SZ
Wainwright Instruments	WHKX10-2700-3000-18000-40SS / High Pass Filter	08/01/2017	Annual	4
Wainwright Instruments	WHKX8-6090-7000-18000-40SS / High Pass Filter	07/11/2017	Annual	5
Wainwright Instruments	WRCJV2400/2483.5-2370/2520-60/12SS / Band Reject Filter	06/30/2017	Annual	2
Wainwright Instruments	WRCJV5100/5850-40/50-8EEK / Band Reject Filter	01/24/2017	Annual	2
H.P.	8491A / Attenuator(10 dB)	08/01/2017	Annual	18593
CERNEX	CBLU1183540 / Power Amplifier	01/25/2017	Annual	24614
CERNEX	CBL06185030 / Power Amplifier	01/25/2017	Annual	24615
CERNEX	CBL18265035 / Power Amplifier	01/23/2017	Annual	22966
CERNEX	CBL26405040 / Power Amplifier	06/30/2017	Annual	25956