

ELECTROMAGNETIC COMPATIBILITY TEST REPORT

PREPARED FOR TANTALUS SYSTEMS CORP.
BY QAI LABORATORIES



Report Reference Number: E10402-1705_Tantalus-LC-2300_Rev1.4
Total Number of Pages: 59
Date of Issue: October 25, 2017

EMC Test Laboratory: **QAI Laboratories Inc.**
Address: 3980 North Fraser Way, Burnaby, BC, V5J 5K5 Canada
Phone: (604) 527-8378
Fax: (604) 527-8368

Laboratory Accreditations (per ISO/IEC 17025:2005):



American Association for Laboratory Accreditation Certificate Number: 3657.02

This report has been completed in accordance with the requirements of ISO/IEC 17025. Test results contained in this report are within QAI Laboratories ISO/IEC 17025 accreditation. QAI Laboratories authorizes the applicant to reproduce this report, provided it is reproduced in its entirety and for the use by the company's employees only.

EMC Client: Tantalus Systems Corp.
Address: 200-3555 Gilmore Way
Burnaby, BC, Canada, V5G 0B3
Phone: (604) 299-0458

Applicable Test Standards: FCC Title 47 CFR Part 15: Subpart B
FCC Title 47 CFR Part 15: Subpart C - § 15.247
RSS-247 Issue 2
RSS-Gen Issue 4

Equipment Tested/PMN: LC-23NIC
Model Name/HVIN: LC-23NIC
Tantalus Part Number : 100-0208
FCC ID: OZFLC2300
IC Certification Number: 3669A-LC2300
Manufacturer: Tantalus Systems Corp.



REVISION HISTORY

Date	Report Number	Rev #	Details	Author's Initials
Oct 6, 2017	E10402-1705_Tantalus-LC-2300	0.0	Initial Release	HZ
Oct 10, 2017	E10402-1705_Tantalus-LC-2300	1.0	Signed Release	HZ
Oct 13, 2017	E10402-1705_Tantalus-LC-2300	1.1	Test setup photos update	HZ
Oct 23, 2017	E10402-1705_Tantalus-LC-2300	1.2	Test setup photos update	HZ
Oct 24, 2017	E10402-1705_Tantalus-LC-2300	1.3	Test setup photos update	HZ
Oct 25, 2017	E10402-1705_Tantalus-LC-2300	1.4	Standard update EUT info update	HZ

All previous versions of this report have been superseded by the latest dated revision as listed in the above table. Please dispose of all previous electronic and paper printed revisions accordingly.

REPORT AUTHORIZATION

The data documented in this report is for the test equipment provided by Tantalus Systems Corp. Tests were conducted on the sample equipment as requested by Tantalus Systems Corp. for the purpose of demonstrating compliance with FCC Title 47 CFR Part 15: Subpart B & C and RSS-247 Issue 2 as agreed upon by Tantalus Systems Corp. as per Quote 17SH09081.

Tantalus Systems Corp. is responsible for the tested product configuration, continued product compliance, and for the appropriate auditing of subsequent products as required. This report may comprise partial list of tests that are required for FCC Declaration of Conformity and can only be produced by the manufacturer.

This is to certify that the following report is true and correct to the best of our knowledge.



Report Prepared by HP Enriquez
EMC Technical Writer



Reviewed by Aman Jathaul
EMC Engineering Manager



Approved by Parminder Singh
Director for the EMC Department

QAI FACILITIES

Founded in 1994 by a group of experienced certification and testing experts, QAI is an independent third-party testing, inspection and certification organization which serves the building industry, government and individuals with cost effective solutions through our in-house capabilities / services, and an established world-wide network of qualified affiliates. To help get your product to market, trust the provider that many leading global manufacturers do: QAI.

British Columbia

QAI Laboratories Inc.
Main Laboratory/Headquarters
3980 North Fraser Way,
Burnaby, BC V5J Canada

Ontario

QAI Laboratories Inc.
1081 Meyerside Drive, Unit #14
Mississauga, ON L5T 1M4 Canada

Virginia

QAI Laboratories Ltd.
1047 Zachary Taylor Hwy,
Suite A Huntly, VA 22640 USA

California

QAI Laboratories Ltd.
8385 White Oak Avenue Rancho
Cucamonga, CA 91730 USA

Oklahoma

QAI Laboratories Ltd.
108th East Avenue,
Tulsa, OK 74116 USA

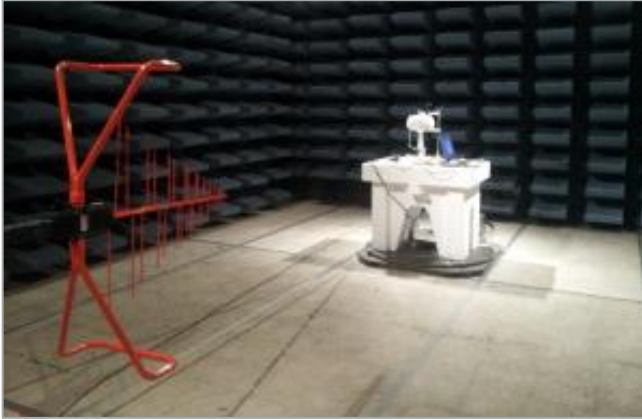
QAI EMC ACCREDITATION

QAI EMC is your one-stop regulatory compliance partner for electromagnetic compatibility (EMC) and electromagnetic interference (EMI). Products are tested to the latest and applicable EMC/EMI requirements for domestic and international markets. QAI EMC goes above and beyond being a testing facility—we are your regulatory compliance partner. QAI EMC has the capability to perform RF Emissions and Immunity for all types of electronics manufacturing including Industrial, Scientific, Medical, Information Technology, Telecom, Wireless, Automotive, Marine and Avionics.

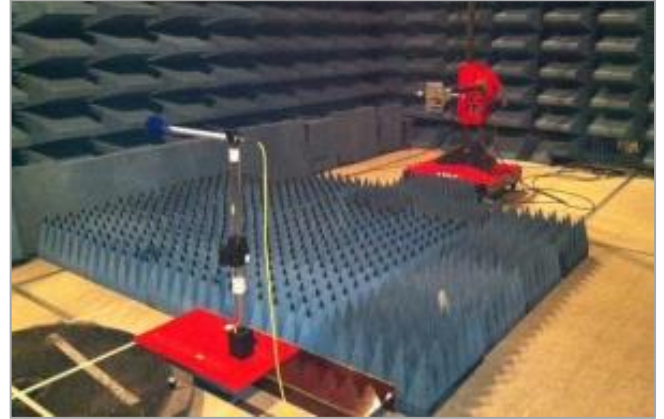
EMC Laboratory Location	FCC Designation (3m SAC)	IC Registration (3m SAC)	A2LA Certificate
Burnaby, BC, Canada	CA9543	21146-1	3657.02



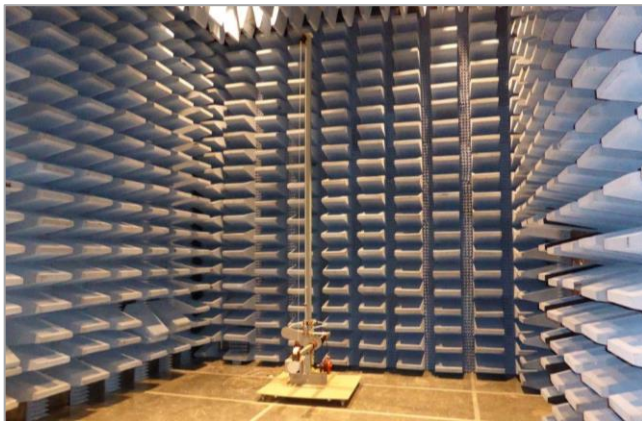
**Headquarters & EMC Laboratory in
Burnaby, BC**



Chamber 1- 3m Semi-Anechoic Chamber (SAC) in Burnaby, BC



Chamber 1- 3m Semi-Anechoic Chamber (SAC) in Burnaby, BC



Chamber 2- 3m Semi-Anechoic Chamber (SAC) in Burnaby, BC



Chamber 2- 3m Semi-Anechoic Chamber (SAC) in Burnaby, BC



10m Open Area Test Site (OATS) in British Columbia, Canada

TABLE OF CONTENTS

REVISION HISTORY	2
REPORT AUTHORIZATION	3
QAI FACILITIES	4
QAI EMC ACCREDITATION	4
TABLE OF CONTENTS	6
Section I: EXECUTIVE SUMMARY	7
1.1 Purpose	7
1.2 Scope.....	7
1.3 Summary of Results	8
Section II: GENERAL INFORMATION	9
2.1 Product Description	9
2.2 Environmental Conditions	10
2.3 Measurement Uncertainty	10
2.4 Worst Test Case	10
2.5 Sample Calculations of Emissions Data	10
2.6 Test Equipment List.....	12
Section III: TEST RESULTS.....	13
4.1 Antenna Requirements.....	13
4.2 RF Peak Power Output.....	14
4.3 20dB Bandwidth	17
4.4 Out of Band Emissions (Band Edge)	24
4.5 Channel Separation	28
4.6 Number of Hopping Channels	32
4.7 Dwell Time and Time Occupancy Per Frequency	41
4.8 Intentional Spurious Emissions.....	45
4.9 Unintentional Radiated Emissions	49
4.10 AC Mains Conducted Emissions	51
Appendix A: TEST SETUP PHOTOS.....	54
Appendix B: ABBREVIATIONS	58

Section I: EXECUTIVE SUMMARY

1.1 Purpose

The purpose of this report is to demonstrate and document the compliance of “LC-2300” as per Sections 1.2 & 1.3.

1.2 Scope

The information documented in this report is based on the test methods and levels as per Quote 17SH09081:

- **FCC Title 47 CFR Part 15** – Radio Frequency Devices, Subpart **B** - Unintentional Radiators.
 - o § 15.107 – Conducted Emissions
 - o § 15.109 – Radiated Emissions
- **FCC Title 47 CFR Part 15** – Radio Frequency Devices, Subpart **C** - Intentional Radiators.
 - o § 15.201 – Antenna Requirement
 - o § 15.205 – Restricted Bands
 - o § 15.207 – Conducted Emissions
 - o § 15.209 – Radiated Emissions
 - o § 15.247 – Operation within the bands 902-928 MHz, 2400-2483.5 MHz, and 5725-5850 MHz.
- **RSS-247 Issue 2** – Digital Transmission Systems (DTSs), Frequency Hopping Systems (FHSs) and Licence-Exempt Local Area Network (LE-LAN) Devices
- **RSS-Gen Issue 4** – General Requirements for Compliance of Radio Apparatus

The tests documented in this report were performed in accordance with ANSI C63.4-2014, ANSI C63.10-2013, and FCC KDB 558074 D01 DTS Meas Guidance v04.

1.3 Summary of Results

The following tests demonstrate the testimony to “FCC” Mark Electromagnetic compatibility testing for “LC-2300” manufactured by Tantalus Systems Corp.

The following tests were performed pursuant to the FCC Unintentional Radiated Emissions, Intentional Radiated Emissions, and Radio Testing Standards:

No.	Test Description	FCC Part 15B & C Standard Clause	RSS-247 Issue 2 Standard Clause	RSS-Gen Issue 4 Standard Clause	Result
1	Antenna Requirement	§15.203	-	8.3	Complies
2	RF Peak Power Output	§15.247 (b)(2)	5.4 (1)	-	Complies
3	20 dB Bandwidth	§15.247 (a)(1)(i)	5.1 (3)	-	Complies
4	Out-of-Band Emissions (Band Edge)	§15.247 (d)	5.5	-	Complies
5	Channel Separation	§15.247 (a)(1)	5.1 (2)	-	Complies
6	Number of Hopping Channels	§15.247 (a)(1)(i)	5.1 (3)	-	Complies
7	Dwell Time	§15.247 (a)(1)(i)	5.1 (3)	-	Complies
8	Time Occupancy	§15.247 (a)(1)(i)	5.1 (3)	-	Complies
9	Intentional Radiated Spurious Emissions	§15.209 §15.205	-	8.9 8.10	Complies
10	AC Mains Conducted Emissions	§15.107 §15.207	-	8.8	Complies
11	Unintentional Radiated Spurious Emissions	§15.109	-	7.1	Complies

Section II: GENERAL INFORMATION

2.1 Product Description

The information provided in this section is for the Equipment Under Test (EUT) and the corresponding Auxiliary Equipment needed to perform the tests as a complete system.

Equipment Under Test (EUT) Information

EUT/PMN	LC-23NIC
Model Name/HVIN	LC-23NIC
Functional Description	Load Control Switch
Operating Frequency	902.17MHz to 927.83MHz
FCC ID	OZFLC2300
IC Certification Number	3669A-LC2300
Manufacturer	Tantalus Systems Corp.
Tantalus Part No.	100-0208
Serial No.	002602DC46

2.2 Environmental Conditions

The equipment under test was operated and tested under the following environmental conditions:

Parameter	Conditions
Location	Indoors
Temperature	22-28°C
Relative Humidity	39.7 - 54.4%

2.3 Measurement Uncertainty

Parameter	Uncertainty
Radiated Emissions, 30MHz-1GHz	± 2.40 dB
Radiated Emissions, 1GHz-40GHz	± 2.48 dB
Radio Frequency	±1.5 x 10 ⁻⁵ MHz
Total RF Power Conducted	±1.36 dB
Spurious Emissions, Conducted	±1.36 dB
RF Power Density, Conducted	±1.36 dB
Temperature	±1°C
Humidity	±5 %
DC and low frequency voltages	±3 %

2.4 Worst Test Case

Worst-case orientation was determined during the preliminary testing. The final radiated emissions were performed in the worst-case orientation.

2.5 Sample Calculations of Emissions Data

Radiated and conducted emissions were performed using EMC32 software developed by Rohdes & Schwarz. Transducer factors like Antenna factors, Cable Losses and Amplifier gains were stored in the test templates which are used to perform the emissions measurements. After test is finished, data is generated from the EMC32 consisting of product details, emission plots and final data tables as shown below.

Frequency (MHz)	QPeak (dBµV/m)	Meas. Time (ms)	Bandwidth (kHz)	Ant. Ht. (cm)	Pol	Turntable position (deg)	Corr. (dB)	Margin (dB)	Limit (dBµV/m)
42.663900	33.0	1000.000	120.000	100.0	H	70.0	13.2	7.5	40.5

Quasi Peak reading shown in the table above is already corrected by the software using correction factor shown in column “Corr.” The correction factor listed under “Corr.” table calculated as:

$$\text{Corr. (dB)} = \text{Antenna factor} + \text{Cable loss}$$

Or

$$\text{Corr. (dB)} = \text{Antenna factor} + \text{Cable Loss} - \text{Amp gain (if pre-amplifier was used)}$$

The final Quasi peak reading shown in the data is calculated by the software using following equation:

$$\text{Corrected Quasi Peak (dBµV/m)} = \text{Raw Quasi Peak Reading} + \text{Antenna factor} + \text{Cable loss}$$

To obtain the final Quasi-Peak or Average reading during power line conducted emissions, transducer factors are included in the final measurement as shown below.

Frequency (MHz)	QPeak (dBµV)	Meas. Time (ms)	Bandwidth (kHz)	PE	Corr. (dB)	Margin (dB)	Limit (dBµV)
0.150	44.3	1000.000	9.000	GND	0.6	21.7	66.0

Frequency (MHz)	QPeak (dBµV)	Meas. Time (ms)	Bandwidth (kHz)	PE	Corr. (dB)	Margin (dB)	Limit (dBµV)
0.150	27.2	1000.000	9.000	GND	0.6	28.8	56.0

Quasi Peak or Average reading shown in above table is already corrected by the software using the correction factor shown in column "Corr." The correction factor listed under "Corr." table calculated as:

$$\text{Corr. (dB)} = \text{Antenna factor} + \text{Cable loss}$$

The final Quasi peak or Average reading shown in the data is calculated by the software using following equation:

$$\text{Corr. Quasi Peak/Average Reading (dBµV)} = \text{Raw Quasi Peak/Average Reading} + \text{Antenna factor} + \text{Cable loss}$$

The allowable margin from the limits, as per the standards, were calculated for both radiated and conducted emissions:

$$\text{Margin (dB)} = \text{Limit} - \text{Quasi-Peak or Average reading}$$

2.6 Test Equipment List

The tables below contain all the equipment used by QAI Laboratories in conducting all tests on the Equipment Under Test (EUT) as per Section 1.3.

Emissions Test Equipment

Manufacturer	Model	Description	Serial No.	Calibration Due Date
Sunol Sciences	SM46C	Turntable	051204-2	N/A
Sunol Sciences	TWR95	Mast	TREML0001	N/A
ETS Lindgren	6502	Active Loop Antenna 10kHz – 30MHz	2178	2020-Aug-21
Sunol Sciences	JB3	Biconilog Antenna 30MHz – 3GHz	A120106	2020-Sep-24
Sunol Sciences	DRH-118	Horn Antenna 1GHz-18GHz	A050905	2019-Mar-10
ETS Lindgren	2165	Turntable	00043677	N/A
ETS Lindgren	2125	Mast	00077487	N/A
Rohde & Schwarz	ESU40	EMI Receiver	100011	2017-Nov-20
Fischer	FCC-LISN-50-25-2-08	LISN (150kHz-30MHz)	2041	2018-Nov-19
ETS Lindgren	S201	5-meter Semi-Anechoic Chamber	1030	N/A
AH Systems	PAM118	Amplifier 10KHz-18GHz	189	Conditional Use

Note: Equipment listed above have 3 years calibration interval.

Measurement Software List

Manufacturer	Model	Version	Description
Rhode & Schwarz	EMC 32	6.20.0	Emissions Test Software
ETS-Lindgren	Tile7	7.3.15	Emissions Test Software

Section III: TEST RESULTS

4.1 Antenna Requirements

Date Performed:

September 25, 2017

Test Standard:

- FCC Title 47 CFR Part 15: Subpart C §15.203
- RSS-Gen Issue 4 Clause 8.3

Applicable Regulation:

The purpose of this requirement is to make certain that no other antenna, except for that provided by the responsible party, shall be used with the Equipment-Under-Test (EUT) as defined in FCC CFR 47 Part 15.203 & RSS-Gen Issue 4:

“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 the user can replace a broken antenna, but the use of a standard antenna jack or electrical connector is prohibited.” ... “the installer shall be responsible for ensuring that the proper antenna is employed so that the limits in this Part are not exceeded.”

Modifications:

No modification was required to comply for this test.

Result:

An integrated antenna is used on this product and it is not field replaceable.

4.2 RF Peak Power Output

Date Performed:

September 28, 2017

Test Standard:

- FCC Title 47 CFR Part 15: Subpart C - §15.247 (b)(2)
- RSS-247 Issue 2 Clause 5.4 (1)

Test Method:

- FCC KDB 558074 D01 DTS Meas Guidance v04

Test Requirement:

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 50 or more hopping channels; the maximum peak conducted output power shall not exceed 0.25 W and the e.i.r.p. shall not exceed 1 W if the hopset uses less than 50 hopping channels.

Test Setup:

The antenna port of EUT was directly connected to a spectrum analyzer.

Measurement Method:

As called in FCC KDB 558074 D01 DTS Meas Guidance v04.

Modifications:

No modification was required to comply for this test.

Result:

The EUT complies with the applicable standard.

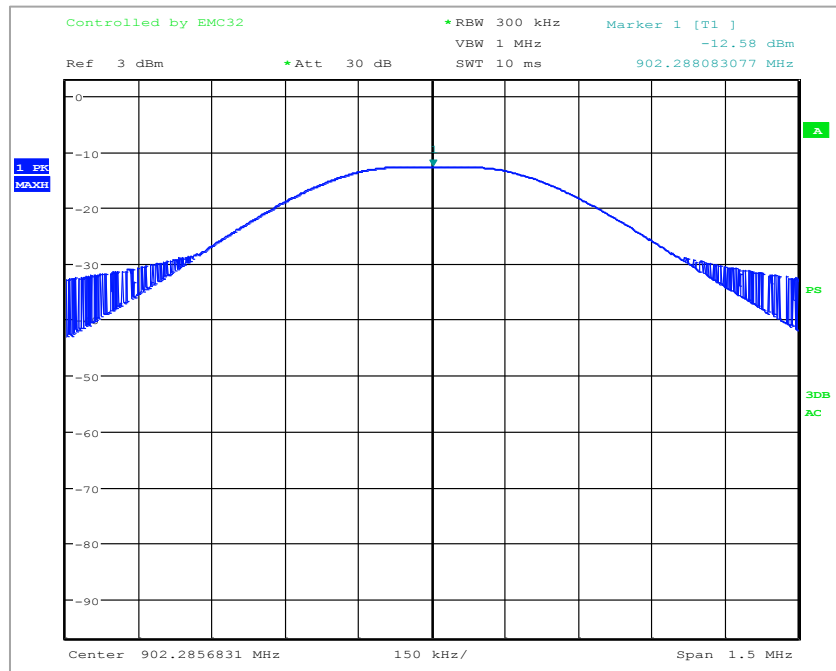
Measurement Data and Plot:

Table 1: E.I.R.P measurements

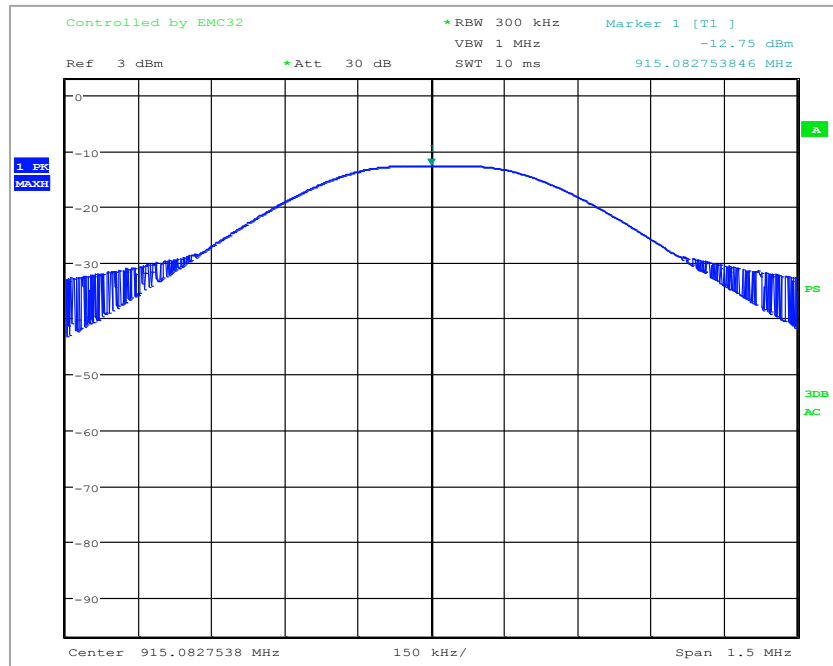
Channel	Freq. (MHz)	Raw Peak (dBμV)	Pol (V or H)	Turn Table (deg)	Ant. Ht. (cm)	Ant. Factors (dBμV)	Cable Loss (dB)	Atten. (dB)	Corr. Peak (dBμV)	EIRP (dBm)	Limit (dBm)	Margin (dB)
Low	902.3	80.2	V	221.4	100.0	22.2	3.3	16.0	121.7	26.4	36	9.6
	902.3	81.6	H	0.0	100.0	22.2	3.3	16.0	123.1	27.8	36	8.2
Middle	914.9	82.7	V	210.9	100.0	22.4	3.3	16.0	124.4	29.1	36	6.9
	915.1	82.9	H	12.7	119.0	22.4	3.3	16.0	124.6	29.3	36	6.7
High	927.7	83.6	V	214.6	100.0	22.5	3.3	16.0	125.4	30.2	36	5.8
	927.7	84.2	H	5.0	104.6	22.5	3.3	16.0	126.0	30.8	36	5.2

Table 2: Conducted output power measurements

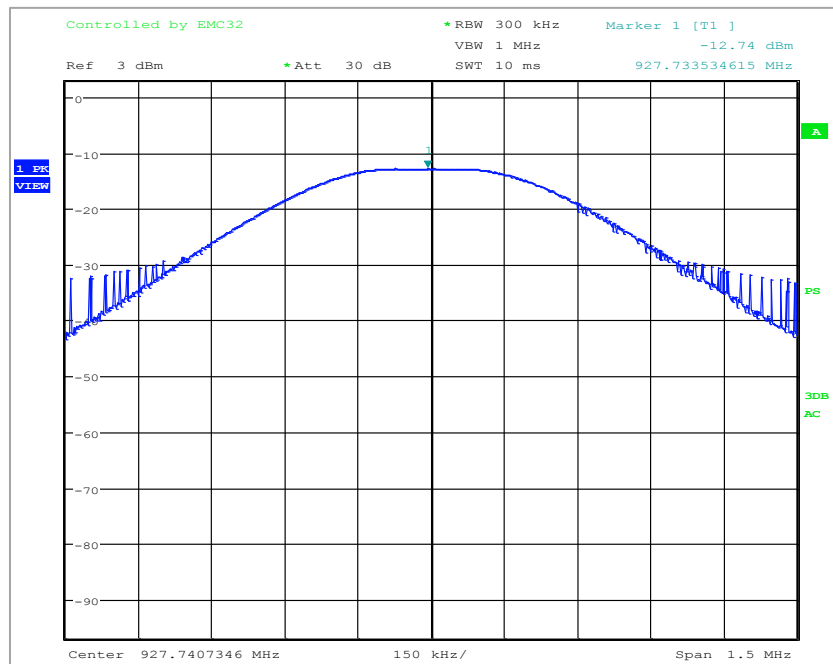
Channel	Freq. (MHz)	Measured Output Power (dBm)	Correction Factor (dB)	Corrected Output Power (dBm)	Limit (dBm)	Margin (dB)
Low	902.2	-12.58	42	29.42	30	0.58
Middle	915.1	-12.75	42	29.25	30	0.75
High	927.7	-12.74	42	29.26	30	0.74



Plot 1: RF Peak Conducted Power Output (Low Channel ~902.2 MHz)



Plot 2: RF Peak Conducted Power Output (Mid Channel ~ 915.1 MHz)



Plot 3: RF Peak Conducted Power Output (High Channel ~ 927.7 MHz)

4.3 20dB Bandwidth

Date Performed:

September 28, 2017

Test Standard:

- FCC Title 47 CFR Part 15: Subpart C - §15.247 (a)(1)(i)
- RSS-247 Issue 2 Clause 5.1 (3)

Test Method:

- ANSI C63.10:2013

Test Requirement:

For FHSs in the band 902-928 MHz: if the 20dB 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 20dB 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 Setup:

The antenna port of EUT was directly connected to a spectrum analyzer.

Measurement Method:

As called in ANSI C63.10-2013.

Modifications:

No modification was required to comply for this test.

Result:

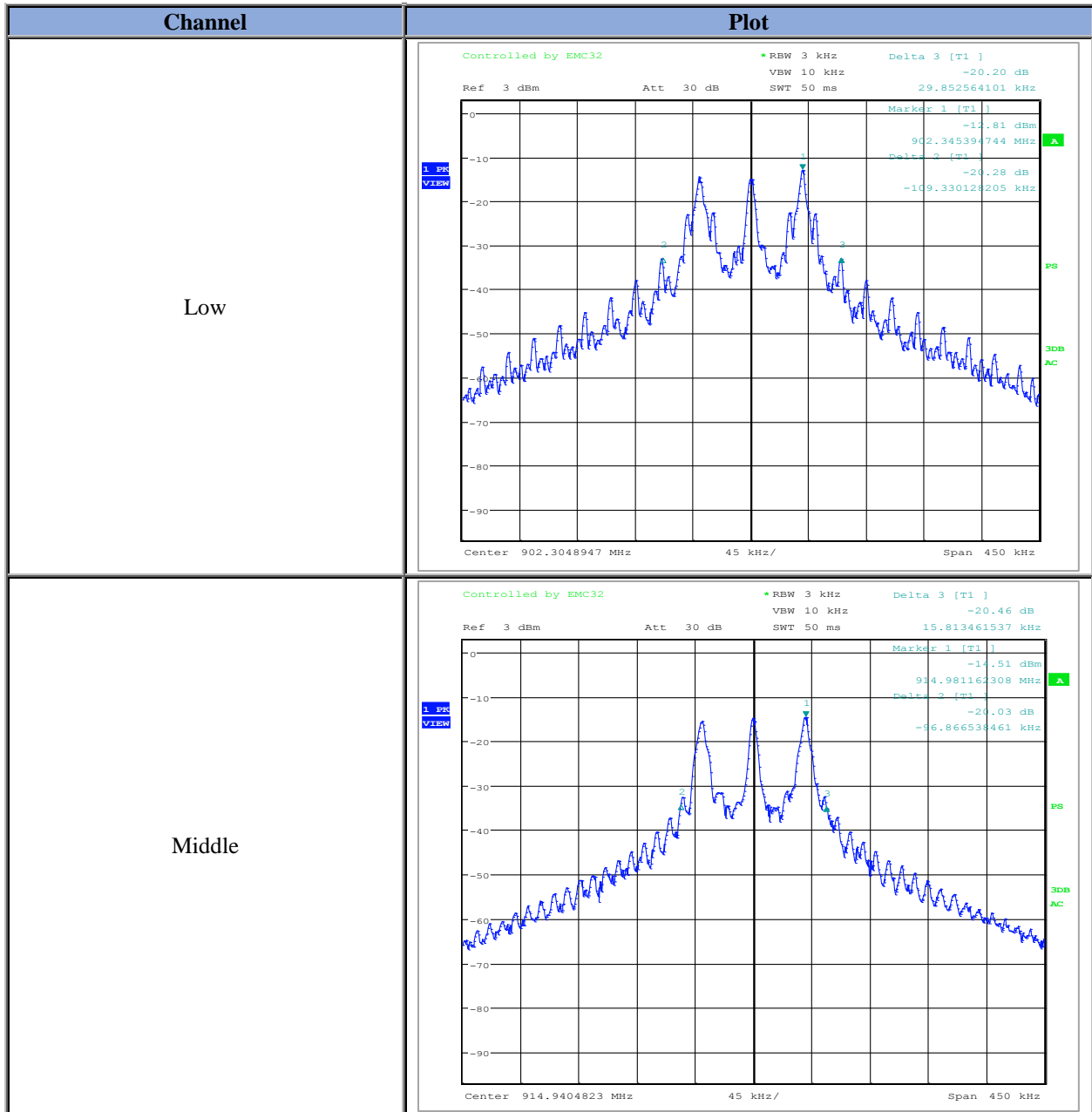
The EUT complies with the applicable standard.

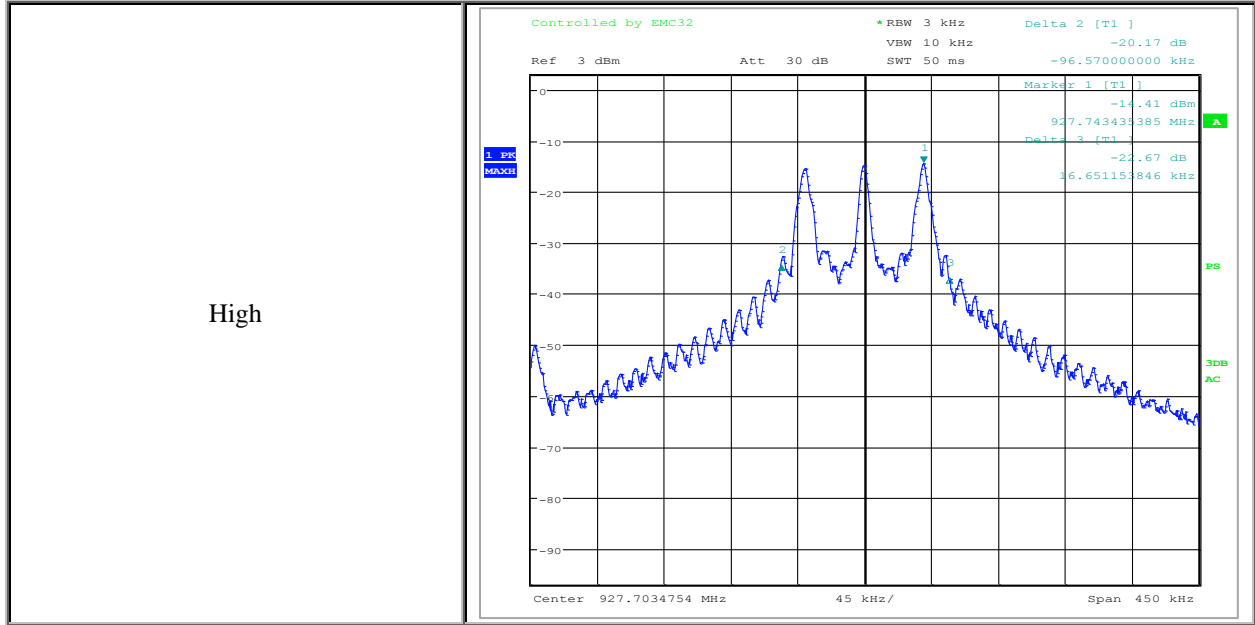
Measurement Data and Plot:

Low Data Rate

Table 3: 20dB Bandwidth Data on Low Data Rate

Channel	Frequency (MHz)	20dB Bandwidth (kHz)
Low	902.3	139.2
Middle	915.0	112.7
High	927.7	113.2



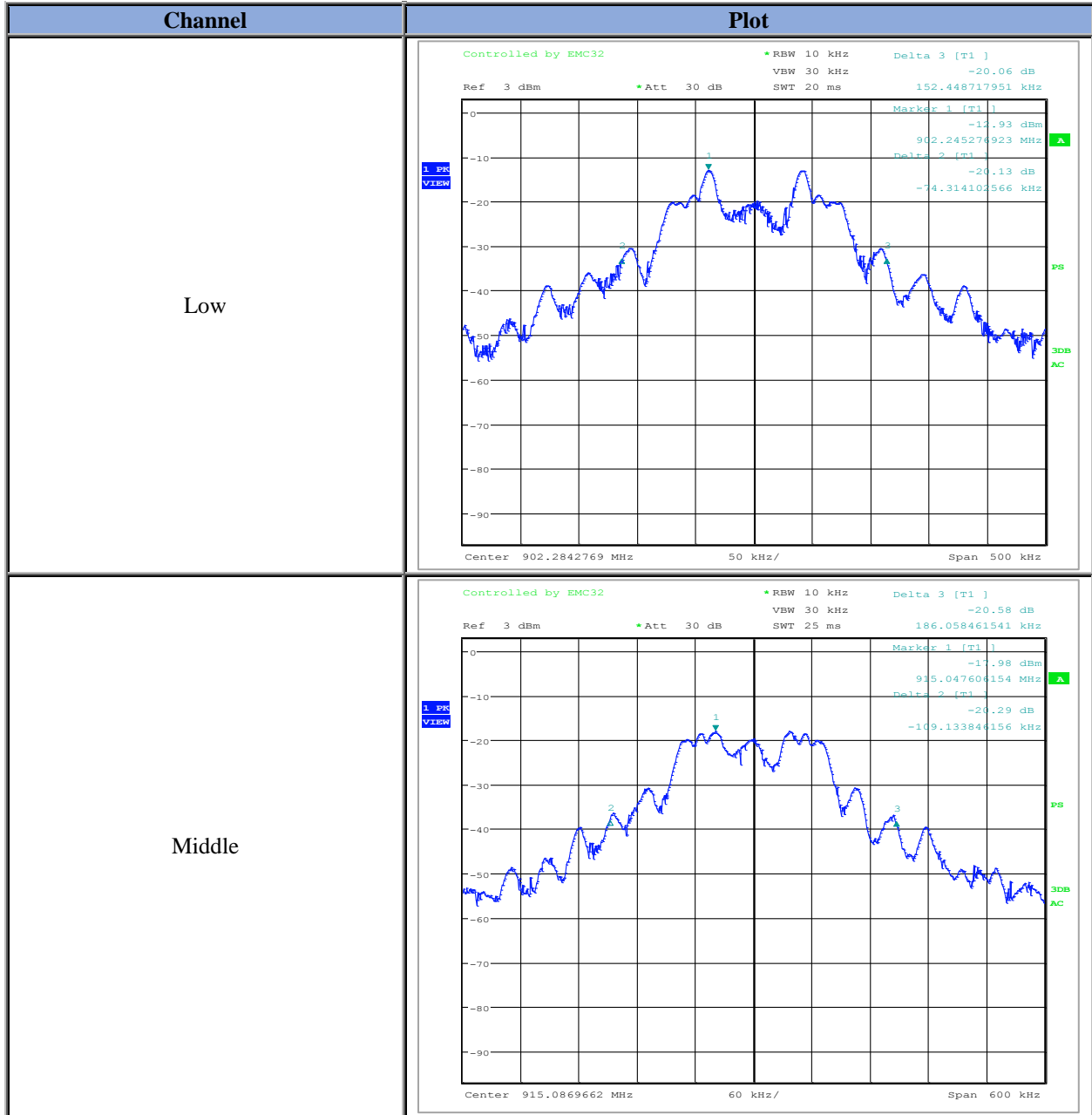


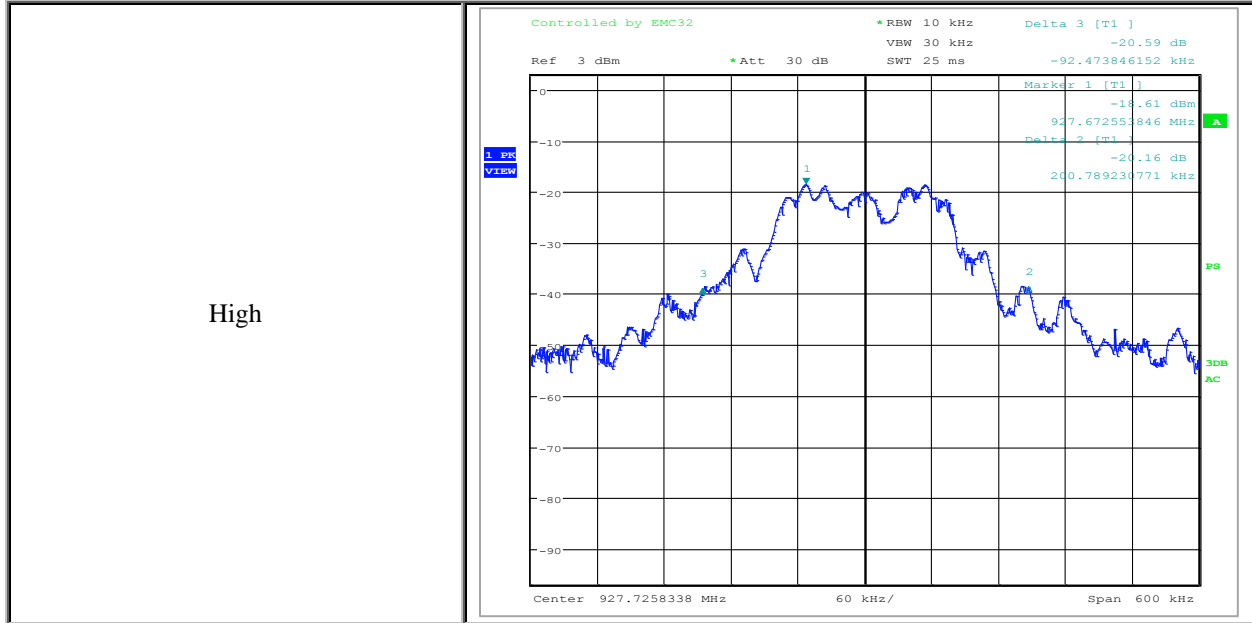
Plot 4: 20dB Bandwidth Plot (Low Data Rate)

High Data Rate

Table 4: 20dB Bandwidth Data on High Data Rate

Channel	Frequency (MHz)	20dB Bandwidth (kHz)
Low	902.2	226.8
Middle	915.0	295.2
High	927.7	293.3





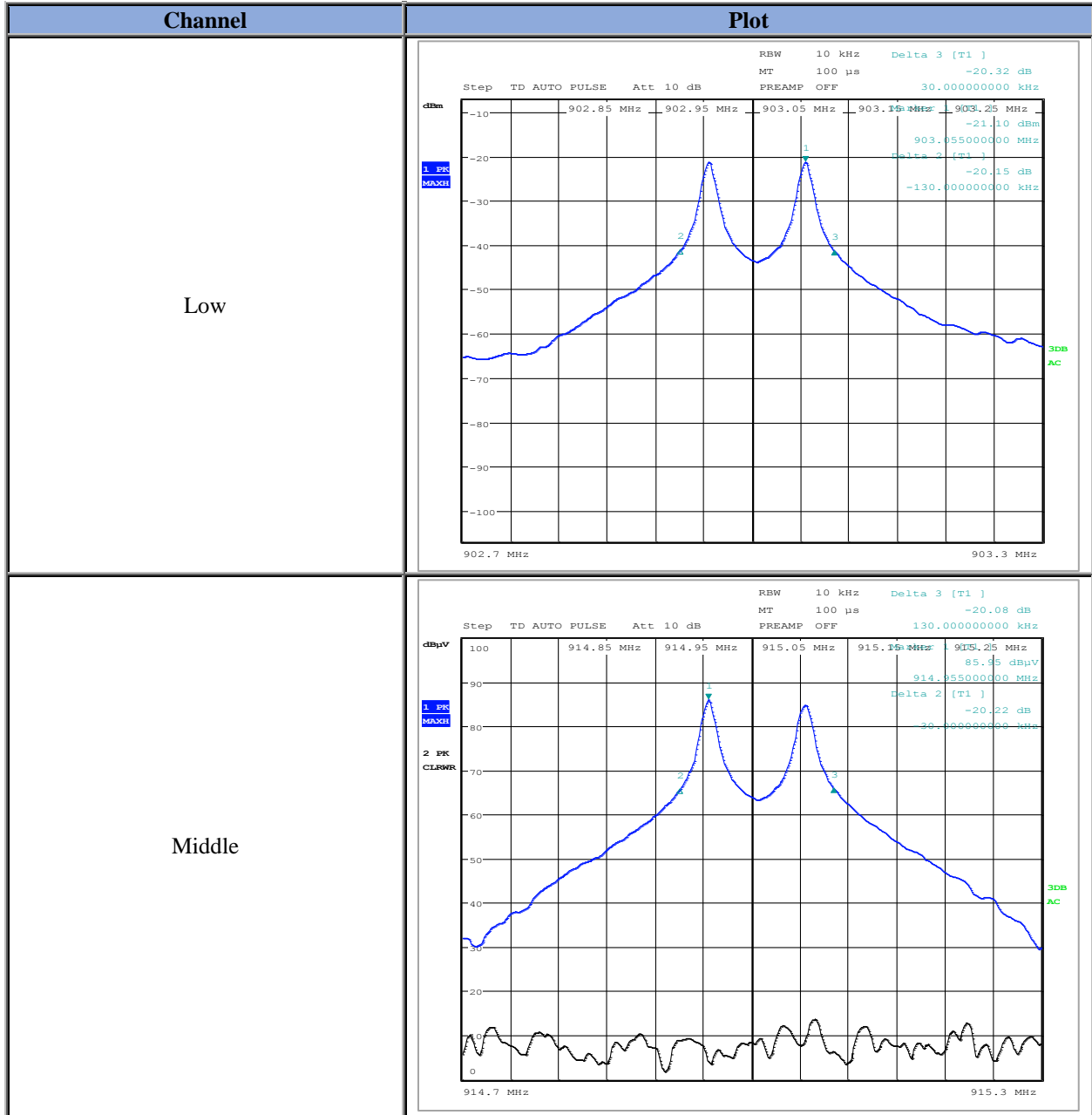
High

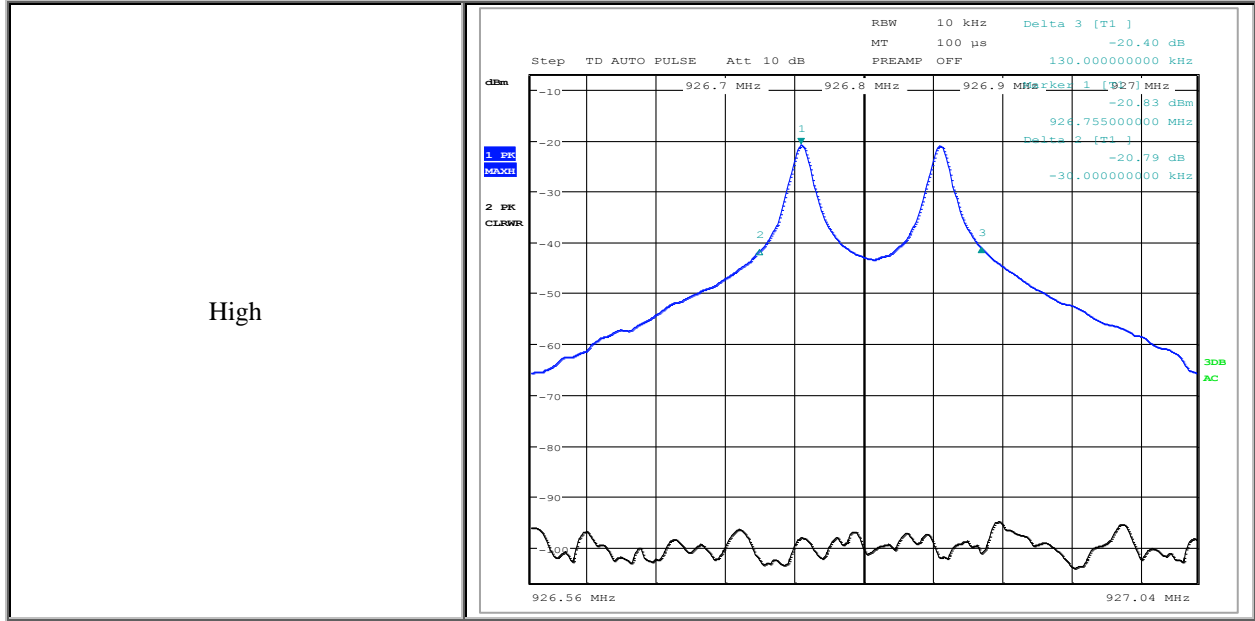
Plot 5: 20dB Bandwidth Plot (High Data Rate)

Data rate for communication to approved Part 15 device

Table 5: 20dB Bandwidth Data on High Data Rate

Channel	Frequency (MHz)	20dB Bandwidth (kHz)
Low	903.1	160
Middle	915.0	160
High	926.8	160





Plot 6: 20dB Bandwidth Plot (Data rate for communication to approved Part 15 device)

4.4 Out of Band Emissions (Band Edge)

Date Performed:

September 28, 2017

Test Standard:

- FCC Title 47 CFR Part 15: Subpart C - §15.247 (d)
- RSS-247 Issue 2 Clause 5.5

Test Method:

- ANSI C63.10:2013

Test Requirement:

In any 100kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated device is operating, the RF power that is produced shall be at least 20 dB below that in the 100kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided that the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of root-mean-square averaging over a time interval, as permitted under Section A8.4 (4), the attenuation required shall be 30 dB instead of 20dB. Attenuation below the general field strength limits specified in RSS-Gen Issue 4 is not required.

Test Setup:

The antenna port of EUT was directly connected to a spectrum analyzer.

Measurement Method:

The measurement method used for both radios was Section 6.10.6.2 Marker-delta Method of ANSI C63.10-2013 standard.

Modifications:

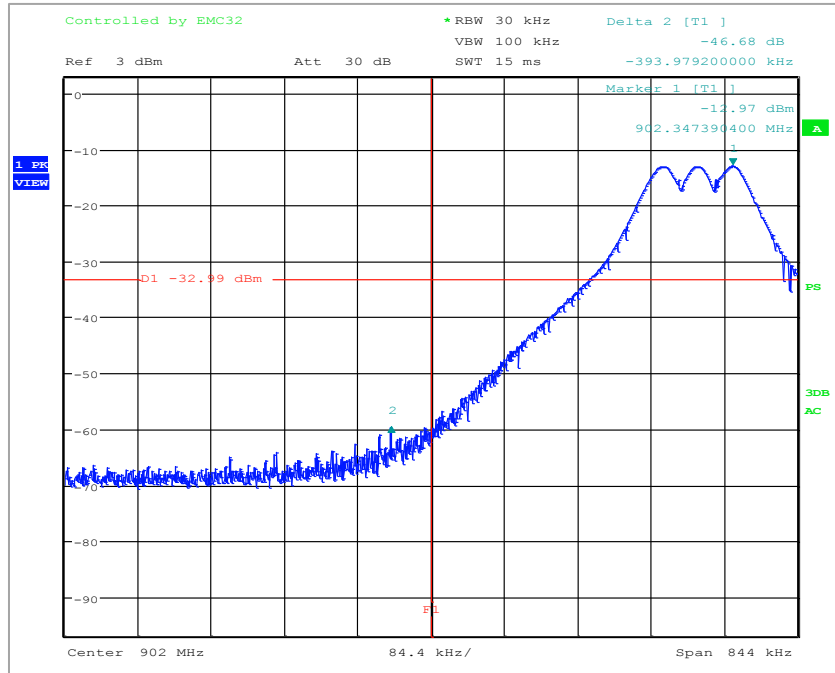
No modification was required to comply for this test.

Result:

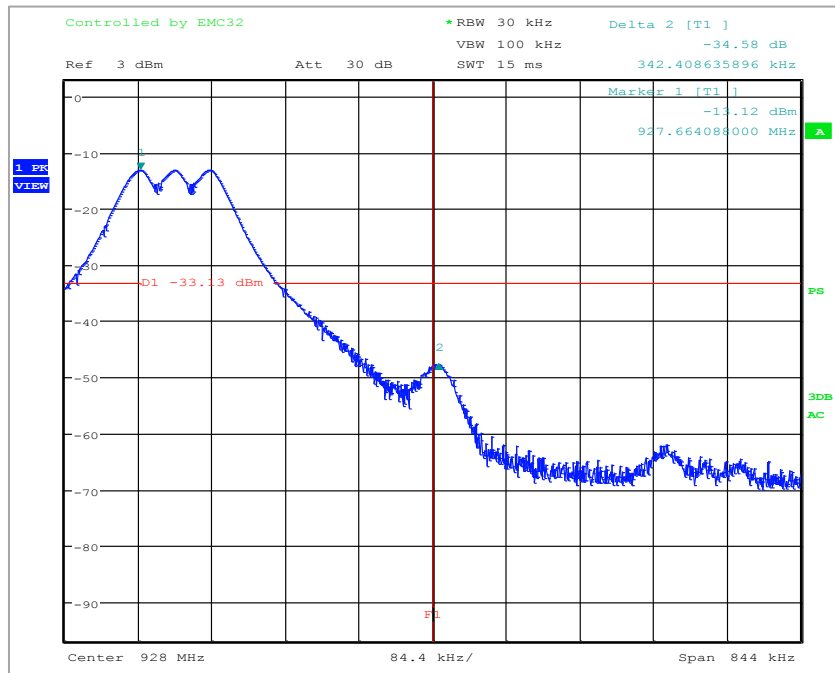
The EUT complies with the applicable standard.

Measurement Data and Plot:

Low Data Rate

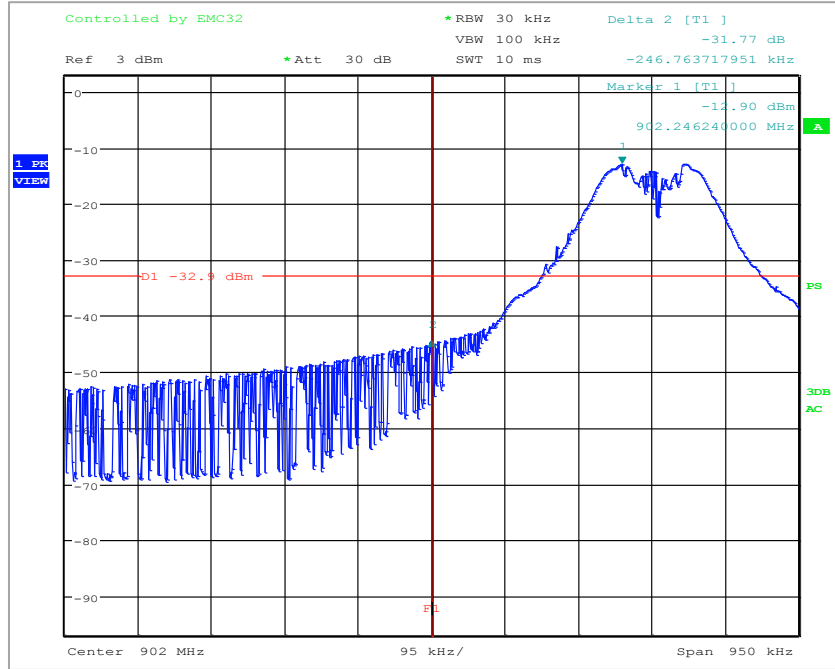


Plot 7: Band Edge Plot (Low Channel ~902.3MHz)

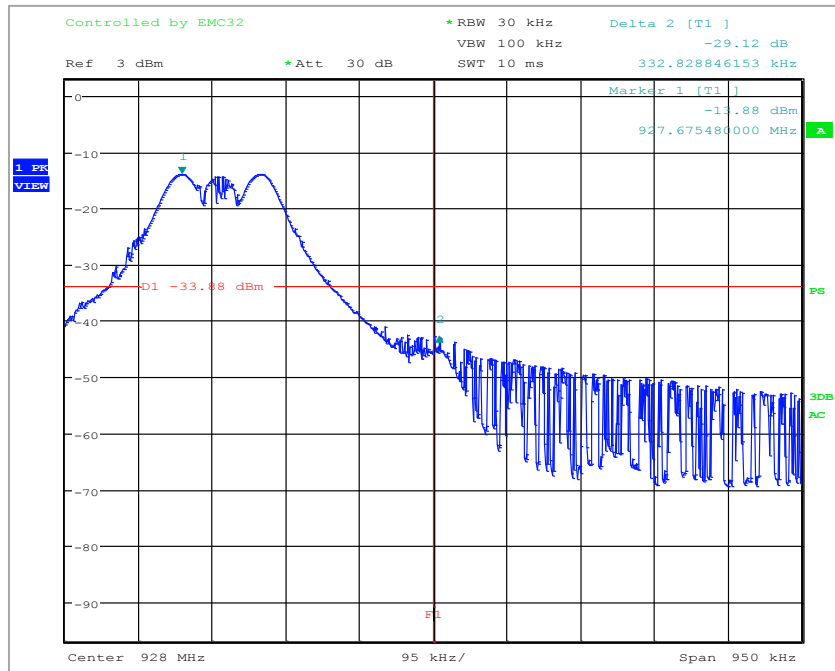


Plot 8: Band Edge Plot (High Channel ~927.7MHz)

High Data Rate

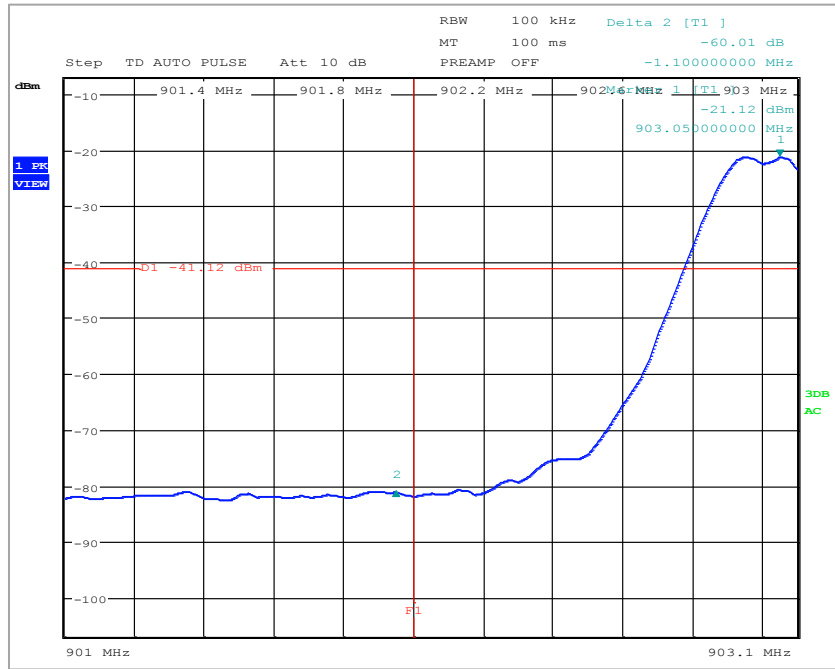


Plot 9: Band Edge Plot (Low Channel ~902.2MHz)

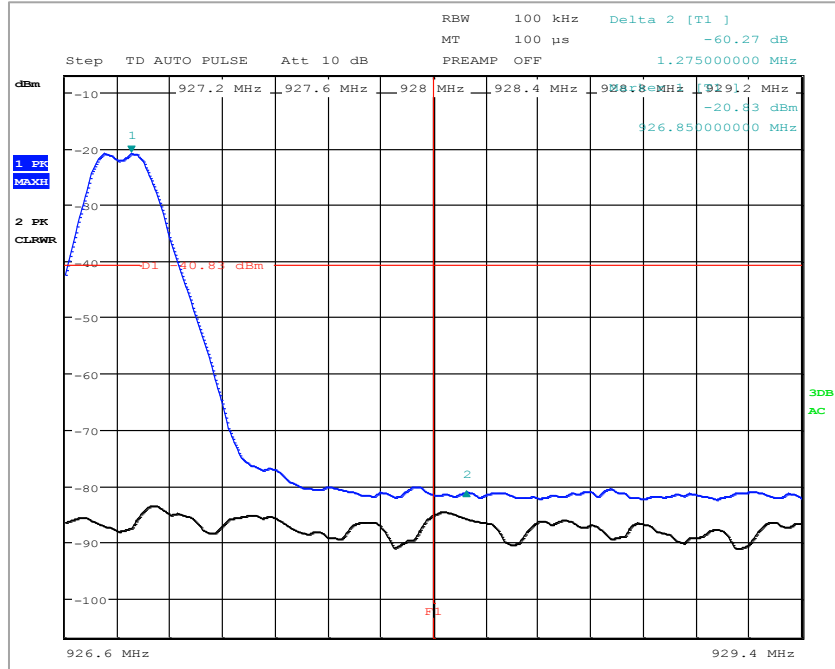


Plot 10: Band Edge Plot (High Channel ~927.7MHz)

Data rate for communication to approved Part 15 device



Plot 11: Band Edge Plot (Low Channel ~903MHz)



Plot 12: Band Edge Plot (High Channel ~926.8MHz)

4.5 Channel Separation

Date Performed:

September 28, 2017

Test Standard:

- FCC Title 47 CFR Part 15: Subpart C - §15.247 (a)(1)
- RSS-247 Issue 2 Clause 5.1 (2)

Test Method:

- ANSI C63.10:2013

Test Requirement:

Frequency hopping systems shall have hopping channel carrier frequencies separated by a minimum of 25 kHz or the 20 dB bandwidth of the hopping channel, whichever is greater. The system shall hop to channel frequencies that are selected at the system hopping rate from a pseudo randomly ordered list of hopping frequencies. Each frequency must be used equally on the average by each transmitter. The system receivers shall have input bandwidths that match the hopping channel bandwidths of their corresponding transmitters and shall shift frequencies in synchronization with the transmitted signals.

Test Setup:

The antenna port of EUT was directly connected to a spectrum analyzer.

Measurement Method:

As called in ANSI C63.10-2013.

Modifications:

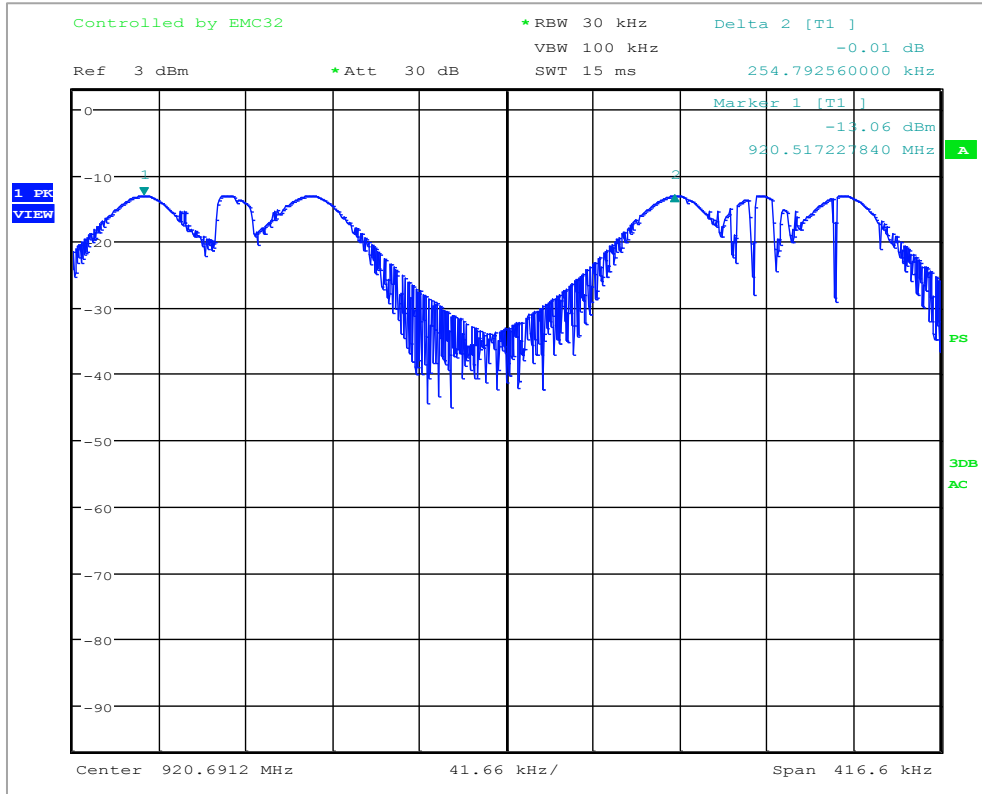
No modification was required to comply for this test.

Result:

The EUT complies with the applicable standard.

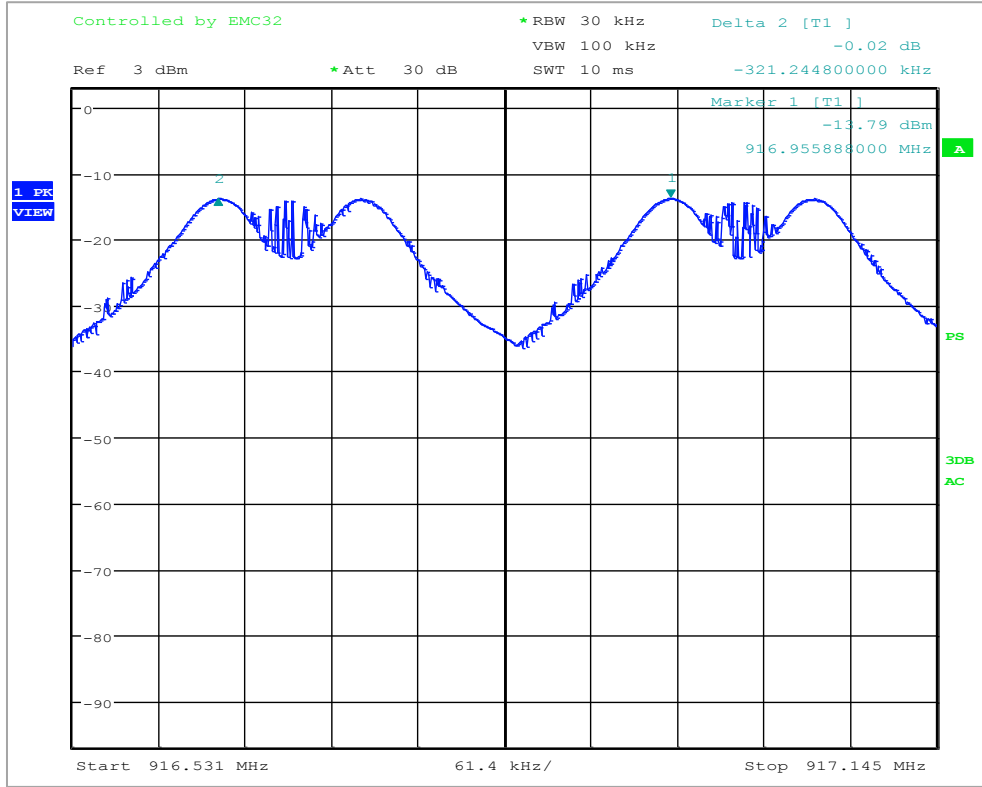
Measurement Data and Plot:

Low Data Rate



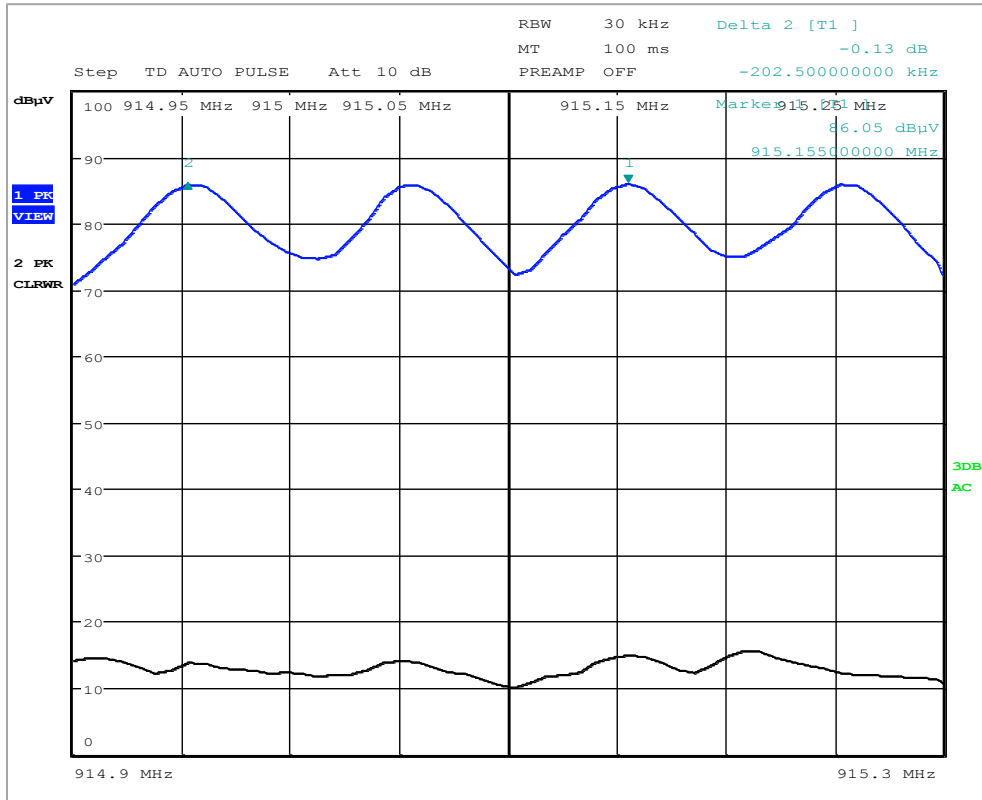
Plot 13: Channel Separation → 254.8 kHz

High Data Rate



Plot 14: Channel Separation → 321.2 kHz

Data rate for communication to approved Part 15 device



Plot 15: Channel Separation → 202.50 kHz

4.6 Number of Hopping Channels

Date Performed:

September 28, 2017

Test Standard:

- FCC Title 47 CFR Part 15: Subpart C - §15.247 (a)(1)(i)
- RSS-247 Issue 2 Clause 5.1 (3)

Test Method:

- ANSI C63.10:2013

Test Requirement:

For FHSs in the band 902-928 MHz: if the 20dB 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 20dB 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 Setup:

The antenna port of EUT was directly connected to a spectrum analyzer.

Measurement Method:

As called in ANSI C63.10-2013.

Modifications:

No modification was required to comply for this test.

Result:

The EUT complies with the applicable standard.

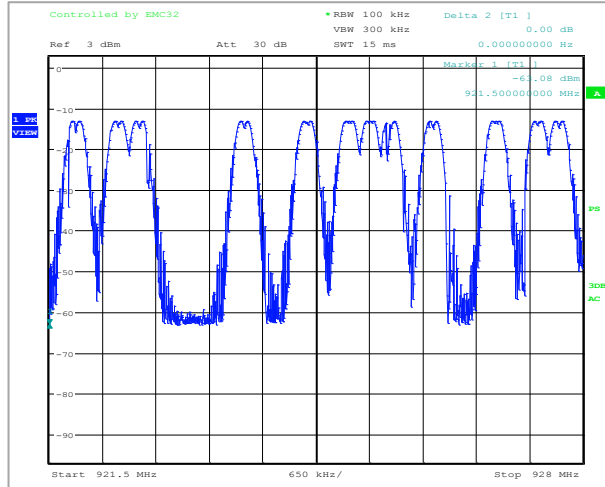
Data Rate	Frequency Range	Number of Hopping Frequencies
Low Data Rate	902MHz to 908MHz	14
	908MHz to 915MHz	14
	915MHz to 921MHz	10
	921MHz to 928MHz	12
High Data Rate	902MHz to 908MHz	14
	908MHz to 915MHz	12
	915MHz to 921MHz	13
	921MHz to 928MHz	11
Data rate for communication to approved Part 15 device	902MHz to 905MHz	11
	905MHz to 908MHz	15
	908MHz to 911MHz	15
	911MHz to 914MHz	15
	914MHz to 917MHz	15
	917MHz to 920MHz	15
	920MHz to 923MHz	15
	923MHz to 926MHz	15
926MHz to 928MHz	4	

Measurement Data and Plot:

Low Data Rate

Number of Hopping Channels	Plot
<p>902MHz to 908MHz ~14 frequencies</p>	<p>Controlled by EMC32 *RBW 100 kHz Delta 2 [T1] Ref 3 dBm Att 30 dB VBW 300 kHz SWT 15 ms -48.97 dB -1.96 dBm 902.347394000 MHz Start 902 MHz 650 kHz/ Stop 908.5 MHz</p>
<p>908MHz to 915MHz ~14 frequencies</p>	<p>Controlled by EMC32 *RBW 100 kHz Delta 2 [T1] Ref 3 dBm Att 30 dB VBW 300 kHz SWT 15 ms 0.00 dB -1.31 dBm 908.500000000 MHz Start 908.5 MHz 650 kHz/ Stop 915 MHz</p>
<p>915MHz to 921MHz ~10 frequencies</p>	<p>Controlled by EMC32 *RBW 100 kHz Delta 2 [T1] Ref 3 dBm Att 30 dB VBW 300 kHz SWT 15 ms 0.00 dB -62.54 dBm 915.000000000 MHz Start 915 MHz 650 kHz/ Stop 921.5 MHz</p>

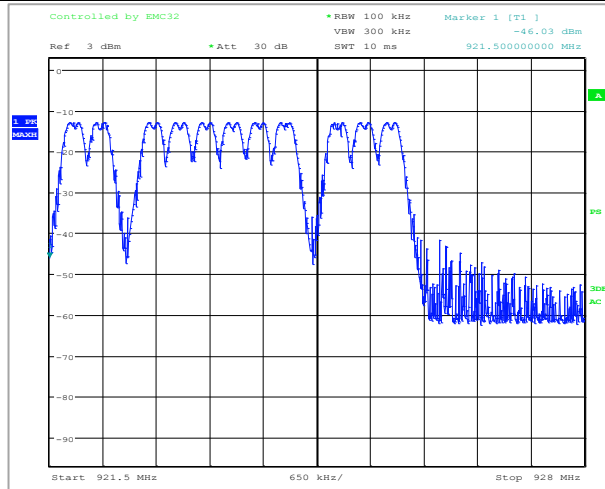
921MHz to 928MHz ~12 frequencies



High Data Rate

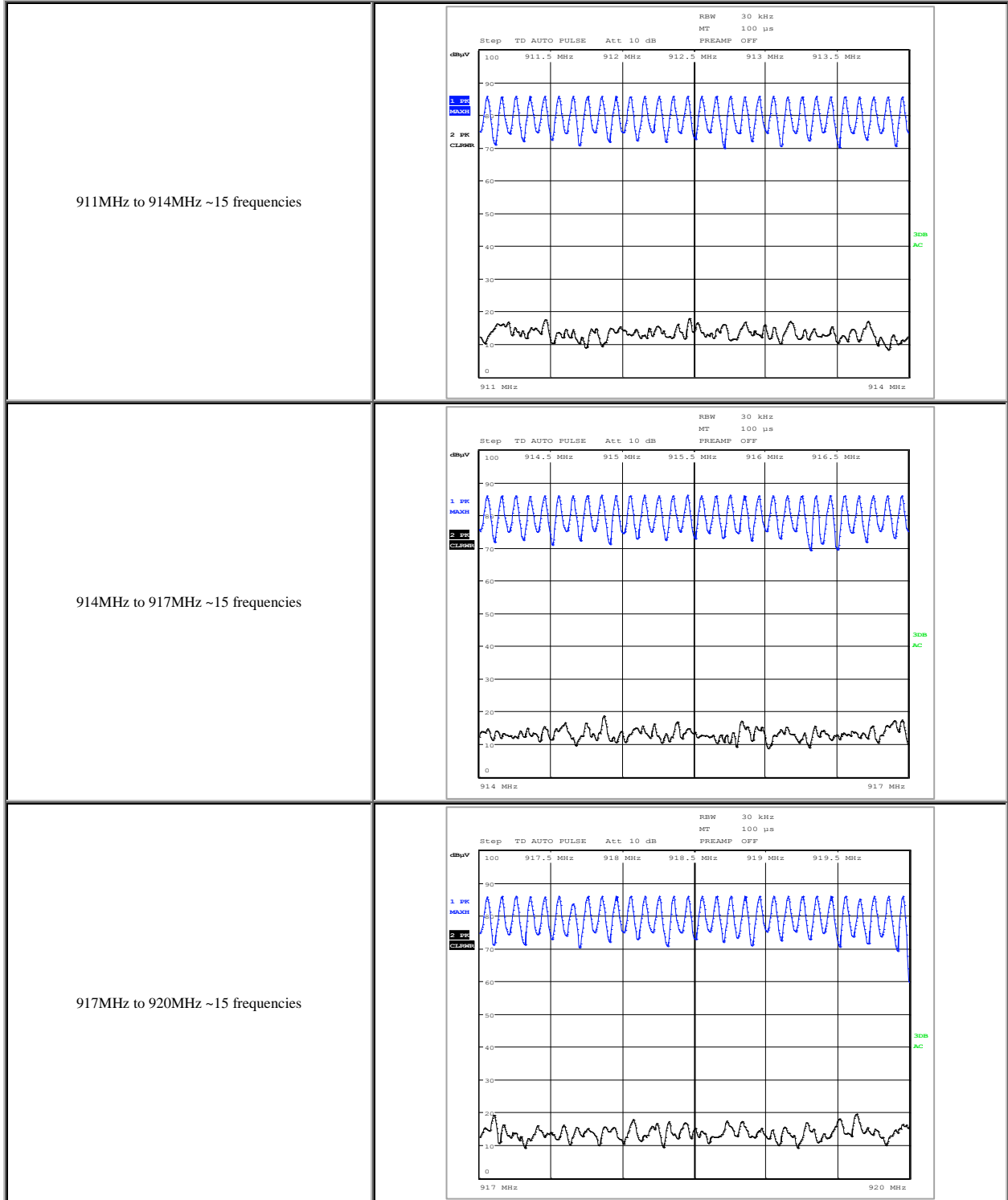
Number of Hopping Channels	Plot
<p>902MHz to 908MHz ~14 frequencies</p>	
<p>908MHz to 915MHz ~12 frequencies</p>	
<p>915MHz to 921MHz ~13 frequencies</p>	

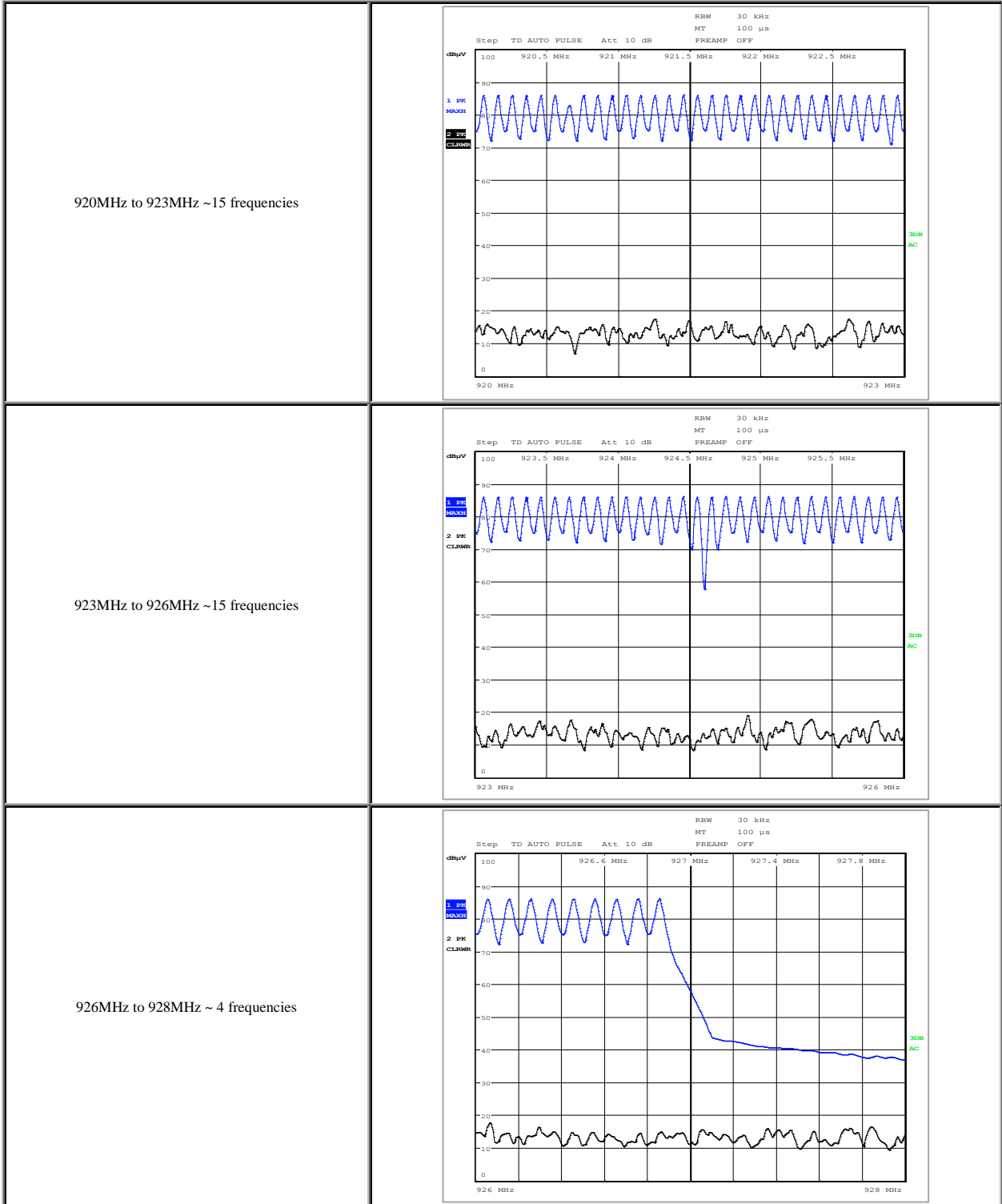
921MHz to 928MHz ~11 frequencies



Data rate for communication to approved Part 15 device

Number of Hopping Channels	Plot
<p>902MHz to 905MHz ~11 frequencies</p>	
<p>905MHz to 908MHz ~15 frequencies</p>	
<p>908MHz to 911MHz ~15 frequencies</p>	





4.7 Dwell Time and Time Occupancy Per Frequency

Date Performed:

September 28, 2017

Test Standard:

- FCC Title 47 CFR Part 15: Subpart C - §15.247 (a)(1)(i)
- RSS-247 Issue 2 Clause 5.1 (3)

Test Method:

- ANSI C63.10:2013

Test Requirement:

For FHSs in the band 902-928 MHz: if the 20dB 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 20dB 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 Setup:

The antenna port of EUT was directly connected to a spectrum analyzer.

Measurement Method:

As called in ANSI C63.10-2013.

Modifications:

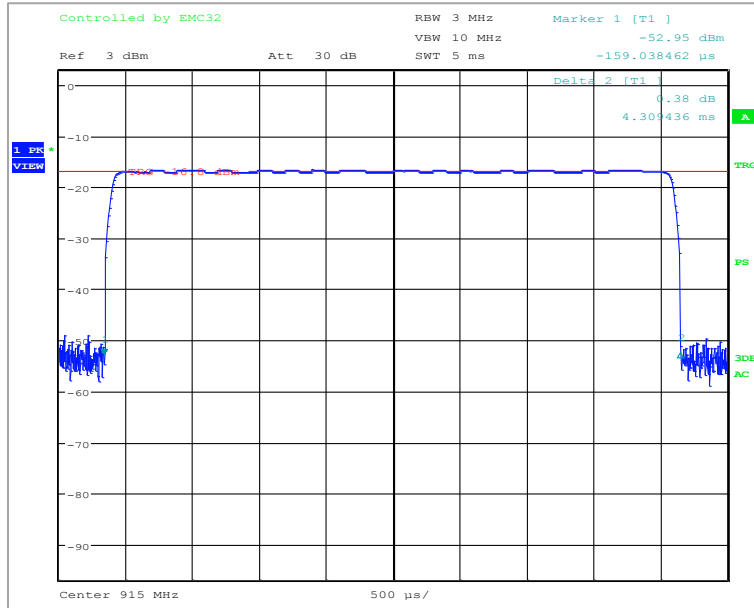
No modification was required to comply for this test.

Result:

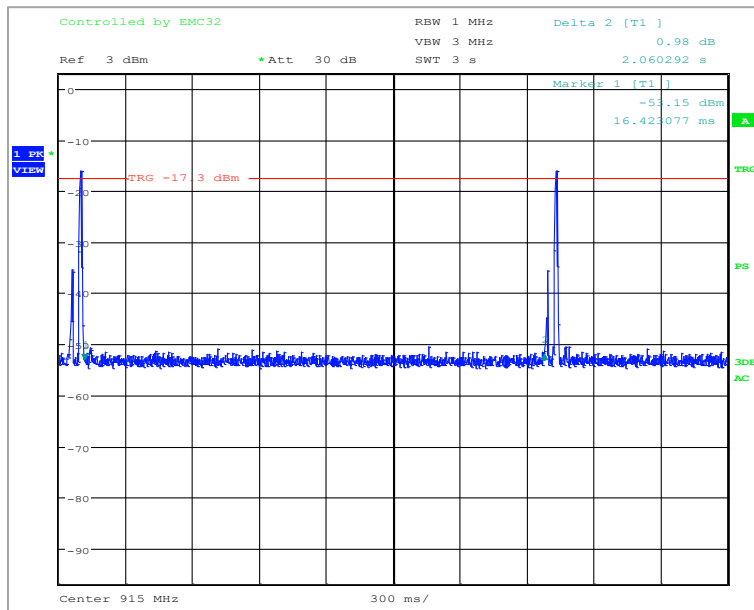
The EUT complies with the applicable standard.

Measurement Data and Plot:

Low Data Rate



Plot 16: Dwell Time → 4.309ms



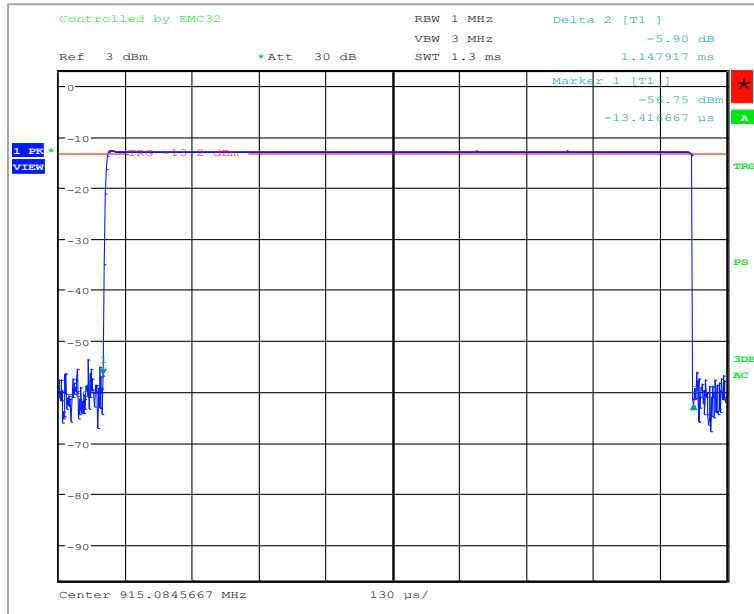
Plot 17: Time Occupancy Per Frequency → 48.83ms

Time between 2 consecutive transmissions on the same frequency is 2.06s

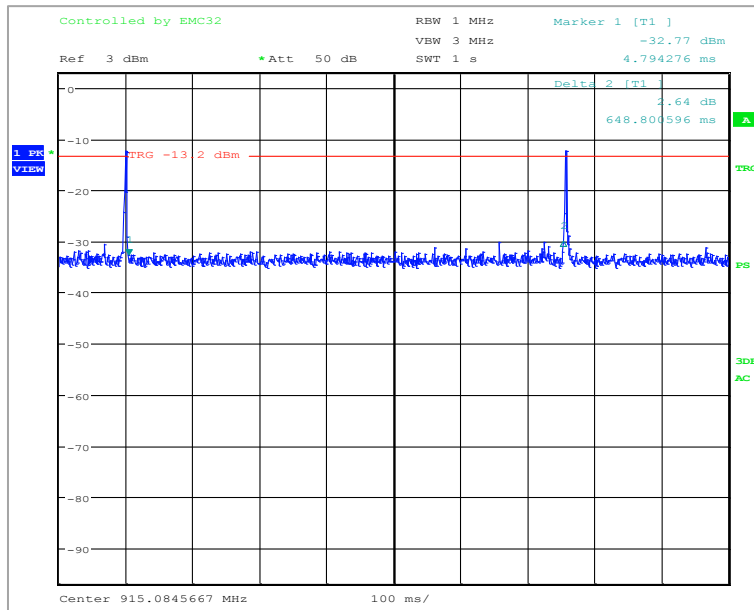
Dwell time per frequency is 4.309ms

Therefore, occupancy time per frequency within 20 seconds' period is $\frac{0.004309s \times 20s}{2.06s} = 48.83ms$

High Data Rate



Plot 18: Dwell Time → 1.148ms



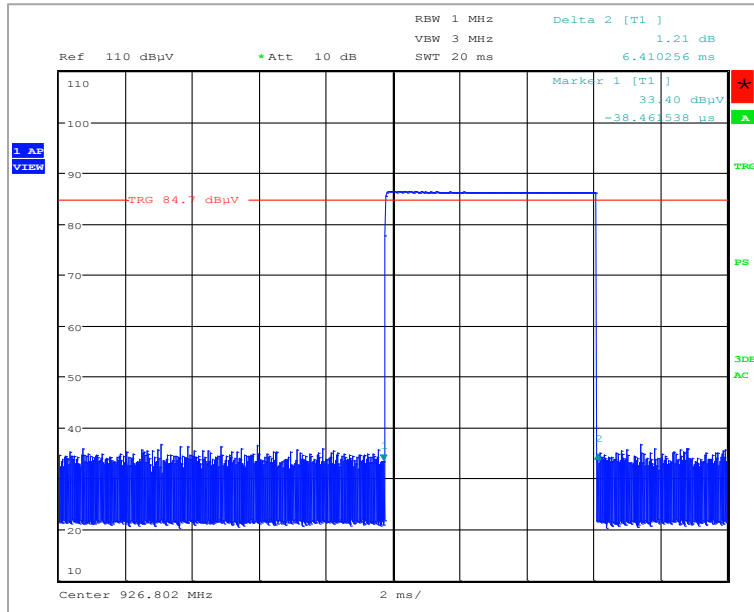
Plot 19: Time Occupancy Per Frequency → 35.4ms

Time between 2 consecutive transmissions on the same frequency is 0.649s

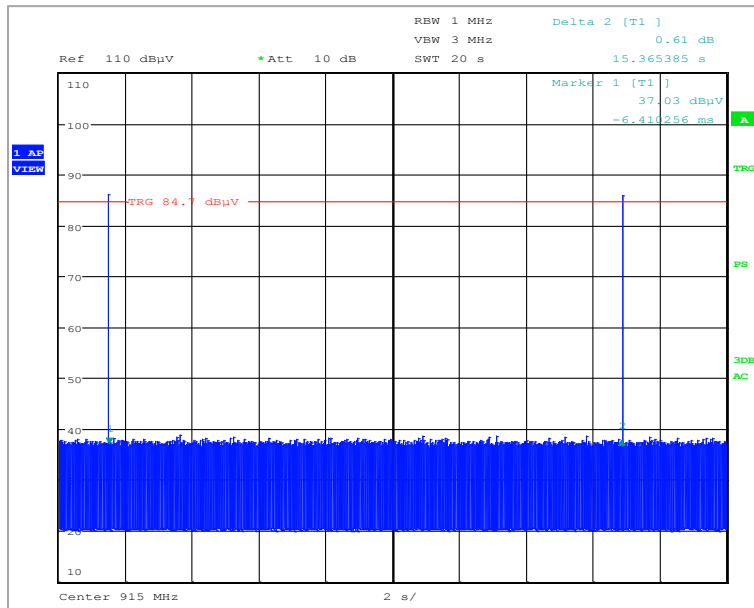
Dwell time per frequency is 1.148ms

Therefore, occupancy time per frequency within 20 seconds' period is $\frac{0.001148s \times 20s}{0.649s} = 35.4ms$

Data rate for communication to approved Part 15 device



Plot 20: Dwell Time → 6.41ms



Plot 21: Time Occupancy Per Frequency → 1.068ms

There are 120 channels in the pseudo random sequence when EUT is communicating to OEM Part 15 approved device, therefore, next same channel will be used is in 120s

Dwell time per frequency is 6.41ms

Therefore, occupancy time per frequency within 20 seconds' period is $\frac{0.00641s \times 20s}{120s} = 1.068ms$

4.8 Intentional Spurious Emissions

Date Performed:

September 25-28, 2017

Test Standard:

- FCC Title 47 CFR Part 15: Subpart C - §15.209
- FCC Title 47 CFR Part 15: Subpart C - §15.205
- RSS-Gen Issue 4 Clause 8.9
- RSS-Gen Issue 4 Clause 8.10

Test Method:

- ANSI C63.10-2013

Required Limit(s):

The limits on the field strength of the spurious emissions in the above table are based on the fundamental frequency of the intentional radiator. Spurious emissions shall be attenuated to the average (or, alternatively, CISPR quasi-peak) limits shown in this table or to the general limits shown in §15.209, whichever limit permits a higher field strength.

Frequency, <i>f</i> (MHz)	Field strength (dBμV/m)
0.009 – 0.490	(20*log(2400/ <i>f</i> (kHz))) + 40 dB
0.490 – 1.705	(20*log(24000/ <i>f</i> (kHz))) + 20 dB
1.705 – 30.0	49.5
30 – 88	40.0
88 – 216	43.5
216 – 960	46.0
above 960	54.0

Note 1: The above field strength limits are specified at a distance of 3 meters. The tighter limits apply at the band edges.

Note 2: The emissions limits shown in the above table are based on measurements employing a CISPR quasi-peak detector except for the frequency bands 9-90 kHz, 110-490 kHz and above 1000 MHz. Radiated emission limits in these three bands are based on measurements employing an average detector.

Unwanted emissions that fall into the restricted bands specified on the table below shall comply with the limits specified on the table limits above as per §15.209 and Clause 8.9 of RSS-Gen.

FCC Restricted Bands:

MHz	MHz	MHz	GHz
0.090-0.110	16.42-16.423	399.9-410	4.5-5.15
10.495-0.505	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			

Method of Measurement:

The EUT was tested in our 3 m SAC and was positioned on the center of the turntable. The transmitter was set for continuous transmission. The operating frequency of the device was measured for all radiated emissions 10 kHz to 4 GHz up to the 10th harmonic of the highest fundamental frequency. The EUT was pre-scanned in 3 different orthogonal orientations and was found to radiate highest when placed flat on the table top as indicated in the test photos.

Modifications:

No modification was required to comply for this test.

Result:

The EUT complies with the applicable standard.

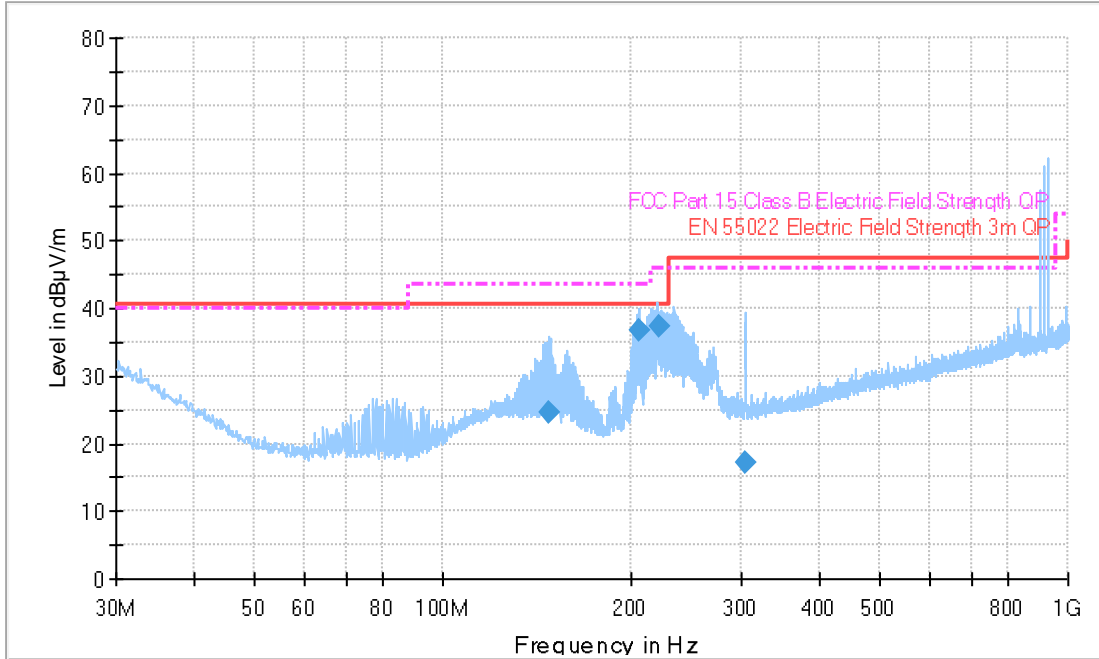
Data/Plot:

Test Mode/Configuration/Operation:

- TX Mode

Frequency Range:

- 30 MHz ↔ 1000 MHz



Plot 22: Radiated Emissions (below 1GHz) scanned at 3m SAC

Table 6: Intentional radiated spurious emissions measurement data

Frequency (MHz)	QuasiPeak (dBµV/m)	Meas. Time (ms)	Bandwidth (kHz)	Antenna height (cm)	Polarity	Turntable position (deg)	Corr. (dB)	Margin (dB)	Limit (dBµV/m)
150.712500	27.9	1000.000	120.000	100.0	V	360.0	19.7	15.6	43.5
205.303200	36.7	1000.000	120.000	100.0	V	26.6	19.1	6.8	43.5
220.203200	38.1	1000.000	120.000	100.0	V	1.0	18.4	7.9	46.0
304.150700	18.0	1000.000	120.000	100.0	V	319.4	20.9	28	46.0

Note: Frequencies around the 900 MHz band are fundamental frequencies of the radio device and the limits specified on this section do not apply. Only harmonics and spurious emissions while the device is on transmit mode are measured on this section.

Table 7: Fundamental frequency measurements data

Freq.	Uncorr. Pk	Pol	Angle	Ht.	Ant. factor	Cable Loss	Atten.	Corr. Peak
MHz	dBµV/m	V or H	°	cm	dB	dB	dB	dBµV/m
902.3	80.2	V	221.4	100.0	22.2	3.3	16.0	121.7
902.3	81.6	H	0.0	100.0	22.2	3.3	16.0	123.1
914.9	82.7	V	210.9	100.0	22.4	3.3	16.0	124.4
915.1	82.9	H	12.7	119.0	22.4	3.3	16.0	124.6
927.7	83.6	V	214.6	100.0	22.5	3.3	16.0	125.4
927.7	84.2	H	5.0	104.6	22.5	3.3	16.0	126.0

Note: Corr. Peak Measurements above are used as limits that do not fall into the Restricted Bands on the measurements data below.

Table 8: Harmonics spurious emissions measurement data – Operating Frequency: 902 MHz

Freq.	Uncorr. Pk	Uncorr. Avg	Angle	Ht.	Pol	Ant. factor	Gain	Corr. Pk	Corr. Avg.	Limit Pk	Limit Avg.	Margin Pk	Margin Avg.
MHz	dBµV/m	dBµV/m	°	cm	V or H	dB	dB	dBµV/m	dBµV/m	dBµV/m	dBµV/m	dB	dB
1805.1	61	58.2	159.2	134.6	V	30.3	-32.1	59.2	56.4	101.7	81.7	40.7	23.5
1805.1	62.6	60.3	214.8	187.3	H	30.3	-32.1	60.8	58.5	101.7	81.7	39.1	21.4
*2706.8	50.8	45.7	51.8	100	V	32.6	-30.4	53.0	47.9	74	54	23.2	8.3
*2706.8	53.4	49.1	185.1	100	H	32.6	-30.4	55.6	51.3	74	54	20.6	4.9
*3609.3	44.1	37.2	234	100	V	33.03	-28.7	48.43	41.5	74	54	29.9	16.8
*3609.3	46.2	41.3	139.6	100	H	33.03	-28.7	50.53	45.6	74	54	27.8	12.7
*4511.5	42	34.0	202.5	100	V	33.9	-26.9	49	41.0	74	54	32	20
*4511.5	46.8	41.4	146.8	142.3	H	33.9	-26.9	53.8	48.4	74	54	27.2	12.6
*5413.9	42.4	34.4	343.1	100	V	34.4	-25.6	51.2	43.2	74	54	31.6	19.6
*5413.9	39.2	29.4	49.6	100	H	34.4	-25.6	48	38.2	74	54	34.8	24.6

* - frequencies that fall into the Restricted Bands

Table 9: Harmonics spurious emissions measurement data – Operating Frequency: 915 MHz

Freq.	Uncorr. Pk	Uncorr. Avg	Angle	Ht.	Pol	Ant. factor	Gain	Corr. Pk	Corr. Avg.	Limit Pk	Limit Avg.	Margin Pk	Margin Avg.
MHz	dBµV/m	dBµV/m	°	cm	V or H	dB	dB	dBµV/m	dBµV/m	dBµV/m	dBµV/m	dB	dB
1829.8	59	56.7	128.9	100	V	30.4	-31.7	57.7	55.4	104.6	84.6	45.6	27.9
1829.8	61.4	53.2	107.4	100	H	30.4	-31.7	60.1	51.9	104.6	84.6	43.2	31.4
*2745.4	51	45.2	41.2	100.0	V	32.6	-30.8	52.8	47.0	74	54	23	8.8
*2744.8	52.5	45.6	132.3	151.2	H	32.6	-30.8	54.3	47.4	74	54	21.5	8.4
*3659.7	38.6	31.6	91.4	146.0	V	33.1	-28.2	43.5	36.5	74	54	35.4	22.4
*3659.7	38	32	243.9	100	H	33.1	-28.2	42.9	36.9	74	54	36	22
*4574.3	40.7	33.3	209.9	133.5	V	33.96	-26.8	47.86	40.5	74	54	33.3	20.7
*4574.3	42.3	35.7	129.4	120.7	H	33.96	-26.8	49.46	42.9	74	54	31.7	18.3
5490	37.6	28.7	232	100.0	V	34.5	-25.9	46.2	37.3	104.6	84.6	67	55.9
5490	38.2	30.4	152.9	130.4	H	34.5	-25.9	46.8	39.0	104.6	84.6	66.4	54.2

* - frequencies that fall into the Restricted Bands

Table 10: Harmonics spurious emissions measurement data – Operating Frequency: 928 MHz

Freq.	Uncorr. Pk	Uncorr. Avg	Angle	Ht.	Pol	Ant. factor	Gain	Corr. Pk	Corr. Avg.	Limit Pk	Limit Avg.	Margin Pk	Margin Avg.
MHz	dBµV/m	dBµV/m	°	cm	V or H	dB	dB	dBµV/m	dBµV/m	dBµV/m	dBµV/m	dB	dB
1855.4	52.1	46	36.5	143.7	V	30.6	-30.6	52.1	46.0	105.4	85.4	53.3	39.4
1855.4	58.5	51.9	115.3	173.9	H	30.6	-30.6	58.5	51.9	105.4	85.4	46.9	33.5
*2783.1	51.2	44.8	222	100.0	V	32.6	-30.2	53.6	47.2	74	54	22.8	9.2
*2783.1	55.4	48.2	97.1	100.0	H	32.6	-30.2	57.8	50.6	74	54	18.6	5.8
*3711.5	41.8	34.7	218.8	100.0	V	33.2	-28	47	39.9	74	54	32.2	19.3
*3710.9	45.8	39.7	222	100.0	H	33.2	-28	51	44.9	74	54	28.2	14.3
*4638.5	40.5	29.9	178.9	100.0	V	34.01	-26.4	48.11	37.5	74	54	33.5	24.1
*4638.7	41.1	30.5	138.9	100.0	H	34.01	-26.4	48.71	38.1	74	54	32.9	23.5
*5565.9	36.2	23.2	41.4	100.0	V	34.5	-25.1	45.4	31.7	74	54	37.8	30.8
*5565.9	36	22.3	162.9	100.0	H	34.5	-25.1	9.4	9.4	74	54	38	31.7
7421.7	38.6	27.5	152.7	205.3	V	35.6	-18.9	55.3	44.2	105.4	85.4	66.8	57.9
7421.7	39.9	27.8	114.5	194.6	H	35.6	-18.9	56.6	44.5	105.4	85.4	65.5	57.6

* - frequencies that fall into the Restricted Bands

Note: Data measured above 1 GHz were manually measured therefore no plots generated.

4.9 Unintentional Radiated Emissions

Date Performed:

September 25-28, 2017

Test Standard:

- FCC Title 47 CFR Part 15: Subpart B - §15.109
- RSS-Gen Issue 4 Clause 7.1

Test Method:

- ANSI C63.4-2014

Test Requirement:

The field strength of radiated emissions from unintentional radiators at a distance of 3 meters shall not exceed the following values:

Frequency, <i>f</i> (MHz)	Field strength (dB μ V/m)
30 – 88	40.0
88 – 216	43.5
216 – 960	46.0
above 960	54.0

Note 1: The above field strength limits are specified at a distance of 3 meters. The tighter limits apply at the band edges.

Note 2: The emissions limits shown in the above table are based on measurements employing a CISPR quasi-peak detector except for the frequency bands 9-90 kHz, 110-490 kHz and above 1000 MHz. Radiated emission limits in these three bands are based on measurements employing an average detector.

Method of Measurement:

The EUT was positioned in the center of the turntable in the SAC. The EUT was then measured for all the radiated emissions in the frequency range of 30MHz – 1GHz. Measurements were made using the spectrum analyzer and receiver using the appropriate antennas, amplifiers, attenuators, and filters.

The required Quasi-Peak CISPR bandwidth shall be 120 kHz for the range 30 – 1000 MHz. A 1 MHz Resolution Bandwidth (RBW, CISPR Band E) shall be used and a 10 Hz Video Bandwidth (VBW). The ANSI C63.4:2014 requirement for the placement of RF Absorber on the turntable Ground Plane shall be satisfied.

Emissions in both horizontal and vertical polarizations were measured while rotating the Equipment Under Test (EUT) on the turntable to maximize signal strength. In the case of high ambient noises, the measurements are performed at a closer distance and the limit is adjusted per the equation below. The result is added or subtracted to the required emission level to ensure compliance at the new distance.

$$20 \log \left(\frac{D1}{D2} \right); \quad \text{Where } \begin{array}{l} D1 = \text{Current Distance} \\ D2 = \text{Required Distance} \end{array}$$

Modifications:

No modification was required to comply for this test.

Result:

The EUT complies with the applicable standard.

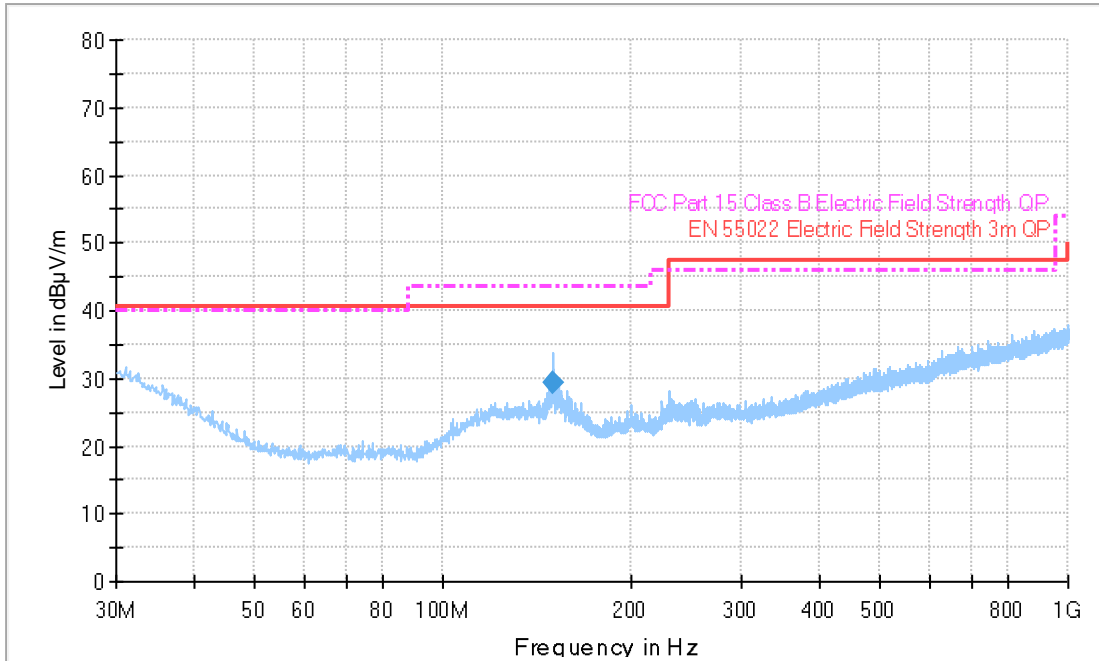
Measurement Data and Plot:

EUT Test Mode:

- Run Mode, No TX

Frequency Range:

- 30 MHz ↔ 1000 MHz



Plot 23: Radiated Emissions scanned at 3m SAC

Table 11: Unintentional radiated spurious emissions measurement data

Frequency (MHz)	QuasiPeak (dBµV/m)	Meas. Time (ms)	Bandwidth (kHz)	Antenna height (cm)	Polarity	Turntable position (deg)	Corr. (dB)	Margin (dB)	Limit (dBµV/m)
149.906650	29.3	1000.000	120.000	100.0	V	0.0	19.7	14.2	43.5

4.10 AC Mains Conducted Emissions

Date Performed:

September 25-28, 2017

Test Standard:

- FCC Title 47 CFR Part 15: Subpart B - §15.107
- FCC Title 47 CFR Part 15: Subpart C - §15.207
- RSS-Gen Issue 4 Clause 8.8

Test Method:

- ANSI C63.4-2014

Required Limit:

The radio frequency voltage that is conducted back onto the AC power line on any frequency or frequencies within the band 150 kHz to 30 MHz shall not exceed the following limits

Frequency (MHz)	Conducted Limit (dB μ V)	
	Quasi-Peak	Average
0.15 – 0.50	66 to 56	56 to 46
0.50 – 5	56	46
5.0 – 30.0	60	50

Note 1: The lower limit shall apply at the transition frequencies.

Method of Measurement:

Measurements were made using a test receiver with 9kHz bandwidth, CISPR Quasi-Peak and Average detector.

Modifications:

No modification was required to comply for this test.

Result:

The EUT complies with the applicable standard.

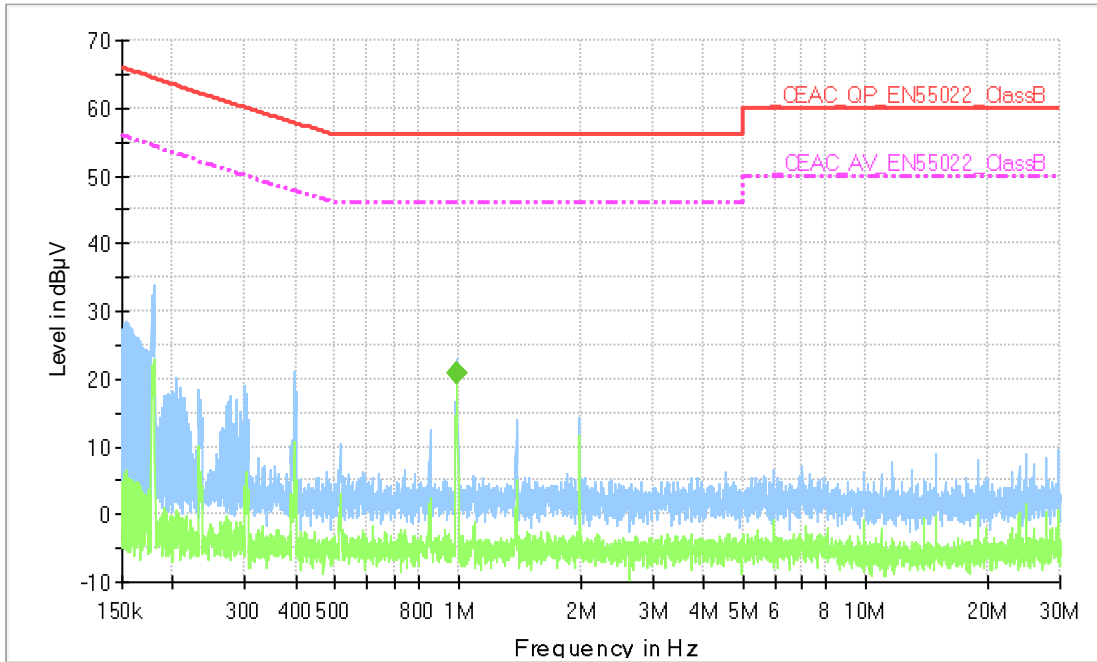
Measurement Data and Plot:

Test Voltage Used:

- Line 1, 240Vac/60Hz

Frequency Range:

- 0.150 MHz ↔ 30 MHz



Plot 24: Conducted Emissions – Line 1, 240Vac/60Hz

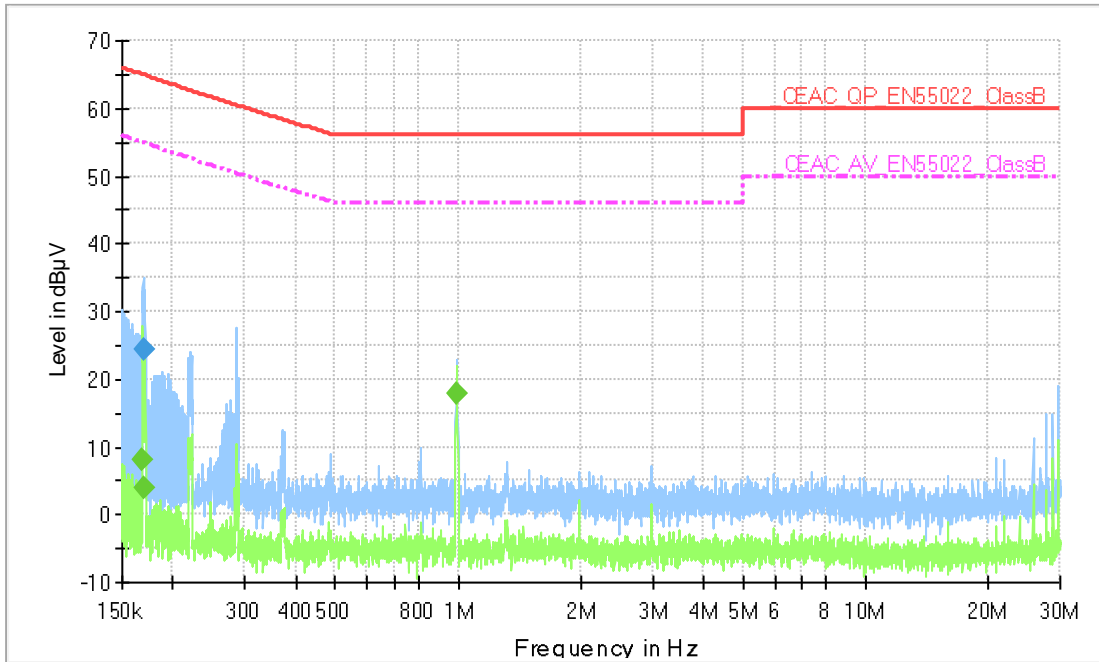
Note: *FCC §15.31(o)* - The amplitude of spurious emissions from intentional radiators and emissions from unintentional radiators which are attenuated more than 20 dB below the permissible value need not be reported unless specifically required elsewhere in the FCC part or other standards.

Test Voltage Used:

- Line 2, 240Vac/60Hz

Frequency Range:

- 0.150 MHz ↔ 30 MHz



Plot 25: Conducted Emissions – Line 2, 240Vac/60Hz

Note: *FCC §15.31(o)* - The amplitude of spurious emissions from intentional radiators and emissions from unintentional radiators which are attenuated more than 20 dB below the permissible value need not be reported unless specifically required elsewhere in the FCC part or other standards.

Appendix A: TEST SETUP PHOTOS



Figure 1: Radiated Emissions below 30 MHz performed at the SAC Test Setup

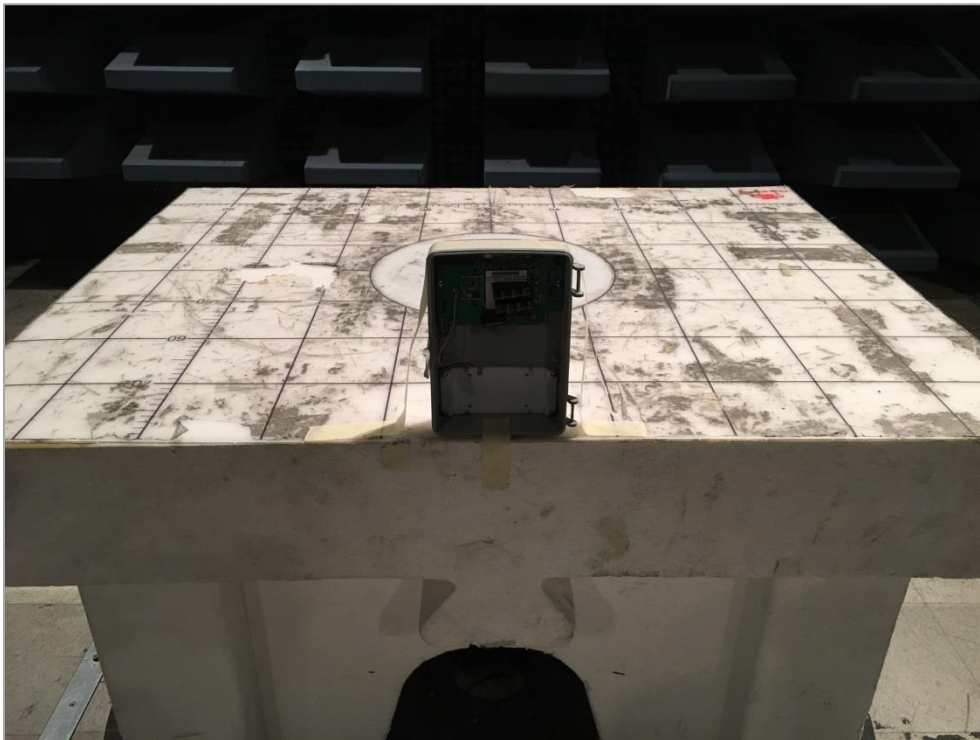


Figure 2: Radiated Emissions below 30 MHz performed at the SAC (close-up view) Test Setup

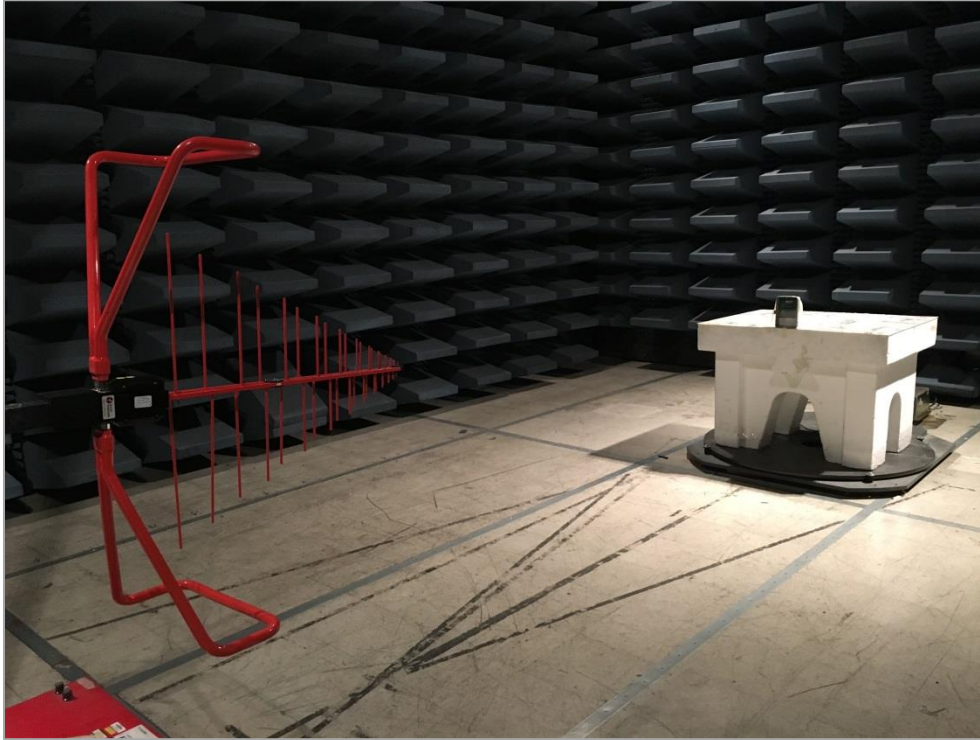


Figure 3: Radiated Emissions 30 MHz to 1 GHz performed at the SAC Test Setup

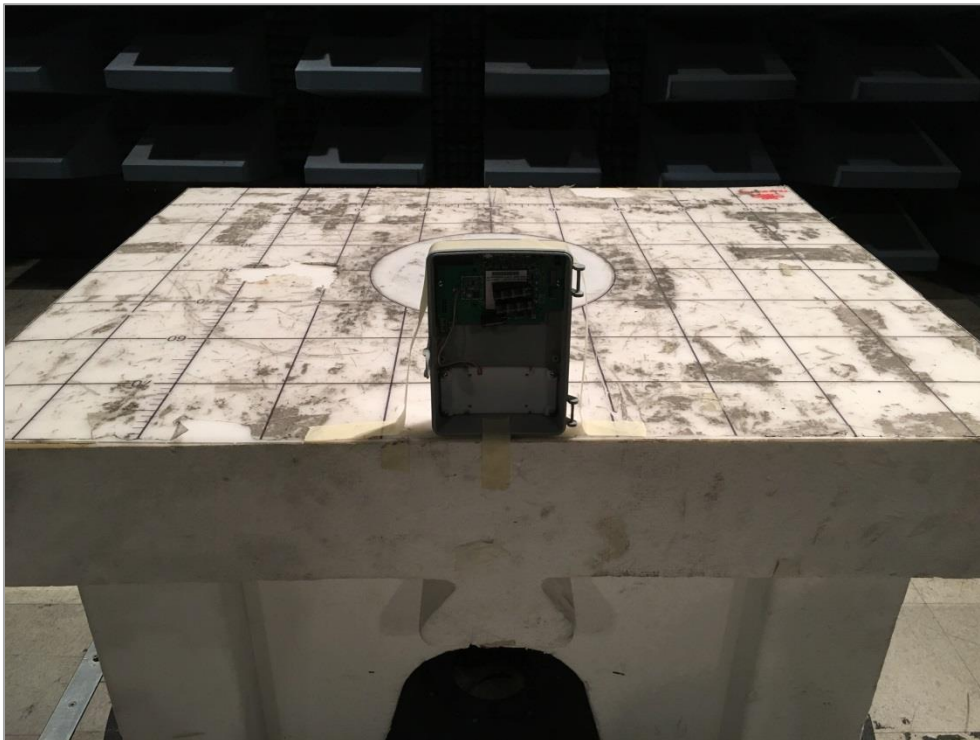


Figure 4: Radiated Emissions 30 MHz to 1 GHz performed at the SAC (close-up view) Test Setup

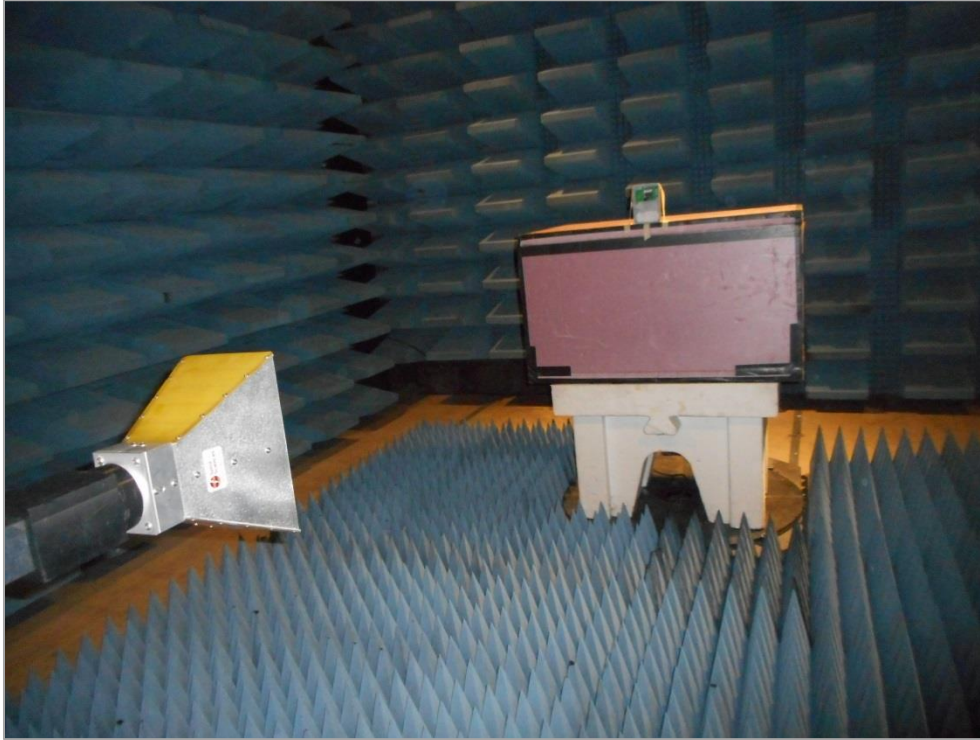


Figure 5: Radiated Emissions above 1 GHz performed at the SAC Test Setup



Figure 6: Radiated Emissions above 1 GHz performed at the SAC (close-up view) Test Setup

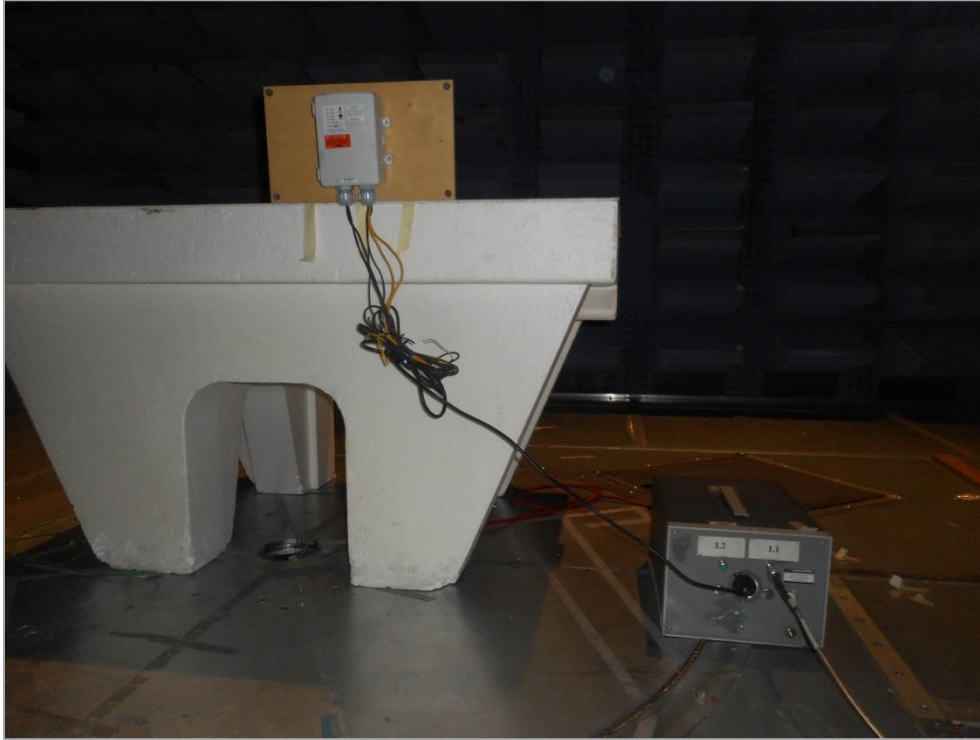


Figure 7: Conducted Emissions Test Setup

Appendix B: ABBREVIATIONS

Abbreviation	Definition
AC	Alternating Current
AM	Amplitude Modulation
CISPR	Comité International Spécial des Perturbations Radioélectriques
DC	Direct Current
EMC	ElectroMagnetic Compatibility
EMI	ElectroMagnetic Interference
EUT	Equipment Under Test
FCC	Federal Communications Commission
IC	Industry Canada
ICES	Interference Causing Equipment Standard
IEC	International Electrotechnical Commission
LISN	Line Impedance Stabilizing Network
OATS	Open Area Test Site
RF	Radio Frequency
RMS	Root-Mean-Square
SAC	Semi-Anechoic Chamber

END OF REPORT