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Report On

Application for Grant of Equipment Authorization of the
Federal Express Corporation
FedEx ID Node

FCC Part 15 Subpart C § 15.247
RSS 247 Issue 2, February 2017
RSS-Gen Issue 4, November 2014

Report No. TP72122363.100 **March 2017**

REPORT ON	Radio Testing of the Federal Express Corporation Fedex ID Node
TEST REPORT NUMBER	TP72122363.100
PREPARED FOR	Federal Express Corporation 920 W. Poplar Ave. Suite 101 Collierville, TN 38017
CONTACT PERSON	Robert Laster Blaster@fedex.com
PREPARED BY	 Steven Hoke Title: Senior EMC Engineer
APPROVED BY	 Pete Walsh, NCE Authorized Signatory Title: Service Line Manager
DATED	23. March 2017

TÜV SÜD AMERICA INC 5610 W. Sligh Ave., Suite 100, Tampa, FL 33634 Phone: 813-284-2715 FAX: 813-413-3813

Revision History

TP72122363.100 Federal Express Fedex ID Node					
DATE	OLD REVISION	NEW REVISION	REASON	PAGES AFFECTED	APPROVED BY
23. March 2017	Initial Release				Pete Walsh

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REPORT SUMMARY

Radio Testing of the
Federal Express Corporation
Fedex ID Node

TÜV SÜD AMERICA INC 5610 W. Sligh Ave., Suite 100, Tampa, FL 33634 Phone: 813-284-2715 FAX: 813-413-3813

1.1 INTRODUCTION

The information contained in this report is intended to show verification of the Telkonet EcoInsight to the requirements of FCC Part 15 Subpart C § 15.247, RSS-Gen, Issue 4, November 2014 and RSS 247 Issue 2, February 2017.

Objective	To perform Radio Testing to determine the Equipment Under Test's (EUT's) compliance with the Test Specification, for the series of tests carried out.
Manufacturer	Federal Express
Model Number(s)	Fedex ID Node
FCC ID Number	2AKUX-ID1
IC Number	22325-ID1
Serial Number(s)	None.
Number of Samples Tested	3
Test Specification/Issue/Date	• FCC Part 15 Subpart C § 15.247 • RSS 247 Issue 2, February 2017 Digital Transmission Systems (DTSs), Frequency Hopping Systems (FHSs) and Licence-Exempt Local Area Network (LE-LAN) Devices. • RSS-Gen, Issue 4, November 2014 General Requirements for Compliance of Radio Apparatus. • 558074 D01 DTS Meas Guidance v03r03, (June 09, 2015) Guidance for Performing Compliance Measurements on Digital Transmission Systems (DTS) Operating Under §15.247.
Start of Test	16. December 2016
Finish of Test	28. December 2016
Name of Engineer(s)	David "Chip" Foerstner
Related Document(s)	Supporting documents for EUT certification are separate exhibits.

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1.2 BRIEF SUMMARY OF RESULTS

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

Section	§15.247 Spec Clause	RSS	Test Description	Result	Comments/ Base Standard
2.1	§15.247(b)(3)	RSS-210 A8.4 (4)	Peak Output Power	Compliant	
2.2	§15.207(a)	RSS-Gen 8.8	Conducted Emissions	NA	NP
2.3		RSS-Gen 6.6	99% Emission Bandwidth	Compliant	
2.4	§15.247(a)(2)	RSS-210 A8.2(a)	Minimum 6 dB RF Bandwidth	Compliant	
2.5	§15.247(d)	RSS-210 A8.5	Out-of-Band Emissions - Conducted	NA	NP
2.6	§15.247(d)	RSS-210 A8.5	Band-edge Compliance of RF Conducted Emissions	Compliant	
2.7	§15.247(d)	RSS-210 A8.5	Spurious Radiated Emissions	Compliant	
2.7		RSS-Gen 7.1	Receiver Spurious Emissions	Compliant	
2.8	§15.247(d)	RSS-210 A8.5	Radiated Band Edge Measurements	Compliant	
2.9	§15.247(e)	RSS-210 A8.2(b)	Power Spectral Density for Digitally Modulated Device	Compliant	

NA – Not applicable NP – Not performed

1.3 PRODUCT INFORMATION

1.3.1 Technical Description

The Equipment Under Test (EUT) is a Federal Express, Fedex ID Node as shown in the photograph below.

Equipment Under Test

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1.3.2 EUT General Description

EUT Description	Bluetooth LE Transmitter
Model Name	Fedex ID Node
Model Number(s)	none
Mode Verified	BT LE
Capability	BT LE
Primary Unit (EUT)	☐ Production
	☒ Pre-Production
	☐ Engineering
Antenna Type	Embedded
Antenna Gain	-0.57 dBi (2.4GHz)

1.3.3 Maximum Conducted Output Power (Peak)

Mode	Frequency Range (MHz)	Output Power (dBm)	Output Power (mW)
Bluetooth LE	2402-2480	6.5	4.47

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1.4 EUT TEST CONFIGURATION

1.4.1 Test Configuration Description

Test Configuration	Description
A	Radiated emissions test configuration. EUT transmitting through the integral antenna.

1.4.2 EUT Exercise Software

EUT is configured by manufacturer to operate on a single channel per sample. There were a total of (3) samples and the frequencies they used were 2402, 2426, 2480 MHz. These were the normal advertising channels and the duty cycle was increased to 1.5 %.

1.4.3 Support Equipment and I/O cables

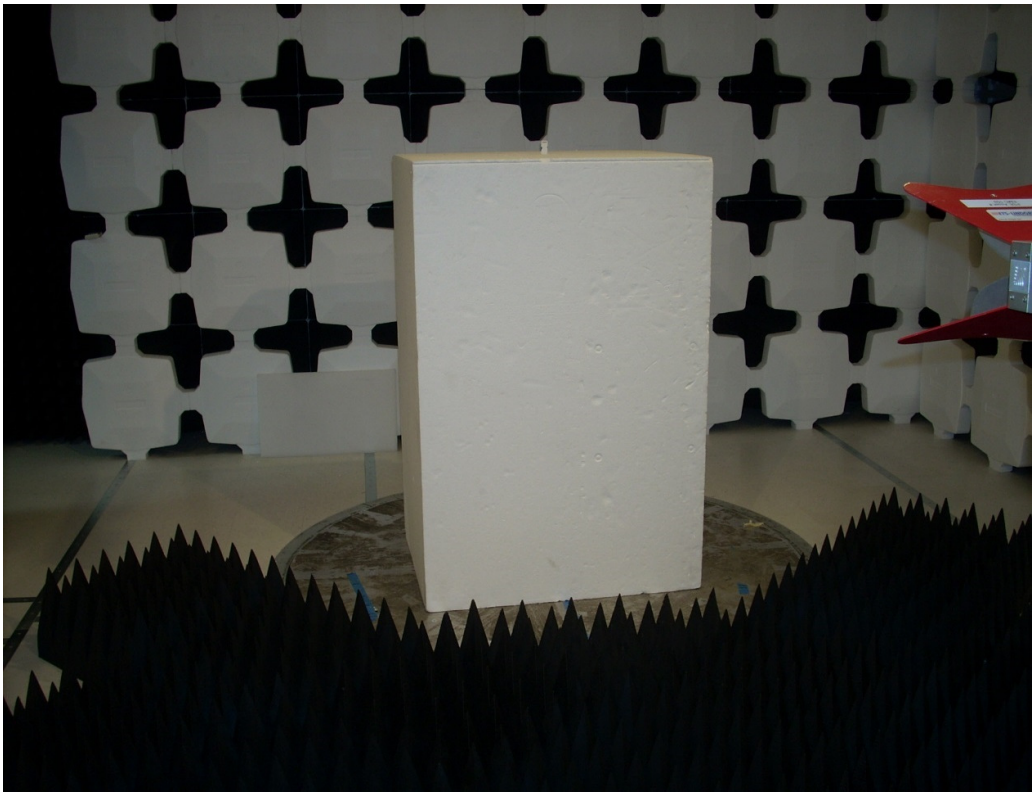
None were required.

1.4.4 Worst Case Configuration

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

Mode	Channel	Data Rate
Bluetooth LE	37 (Low Channel)	1Mbps

EUT is a portable device. For radiated measurements, the EUT was investigated in all orthogonal directions.



1.5 DEVIATIONS FROM THE STANDARD

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

1.6 MODIFICATION RECORD

Description of Modification	Modification Fitted By	Date Modification Fitted
Serial Number: None		
N/A		

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

1.7 TEST METHODOLOGY

All measurements contained in this report were conducted with ANSI C63.10-2013, American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices. All three orthogonal positions were investigated and the test data reflects the worst case.

For conducted and radiated emissions the equipment under test (EUT) was configured to measure its highest possible emission level. This level was based on the maximized cable configuration from exploratory testing per ANSI C63.10-2013.

1.8 TEST FACILITY LOCATION

1.8.1 TÜV SÜD America Inc. (Tampa)

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1.9 TEST FACILITY REGISTRATION

1.9.1 FCC – Registration No

The TUV SUD America Inc. (Tampa), test facility has been registered with the Federal Communication Commission as an ISO/IEC 17025 accredited test laboratory and assigned the designation number US1063.

1.9.2 Innovation, Science and Economic Development Canada Registration

The TUV SUD America Inc. (Tampa), test facility has been registered with Innovation, Science and Economic Development Canada and assigned the site number 2087A-2.

SECTION 2

TEST DETAILS

Radio Testing of the
Federal Express
Fedex ID Node

TÜV SÜD AMERICA INC 5610 W. Sligh Ave., Suite 100, Tampa, FL 33634 Phone: 813-284-2715 FAX: 813-413-3813

2.1 PEAK OUTPUT POWER

2.1.1 Specification Reference

Part 15 Subpart C §15.247(b)(3)

2.1.2 Standard Applicable

(3) For systems using digital modulation in the 902–928 MHz, 2400–2483.5 MHz, and 5725–5850 MHz bands: 1 Watt. As an alternative to a peak power measurement, compliance with the one watt limit can be based on a measurement of the maximum conducted output power. Maximum conducted output power is defined as the total transmit power delivered to all antennas and antenna elements averaged across all symbols in the signaling alphabet when the transmitter is operating at its maximum power control level. Power must be summed across all antennas and antenna elements. The average must not include any time intervals during which the transmitter is off or is transmitting at a reduced power level. If multiple modes of operation are possible (e.g., alternative modulation methods), the maximum conducted output power is the highest total transmit power occurring in any mode.

2.1.3 Equipment Under Test and Modification State

Serial No: None / Test Configuration A

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

16. December 2016/DF

2.1.5 Test Equipment Used

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

2.1.6 Environmental Conditions

Test performed at TÜV SÜD America Inc. Tampa facility

Ambient Temperature	22 – 24 °C
Relative Humidity	48 – 52%

2.1.7 Additional Observations

- This is a radiated test at a 3-meter distance that was used to calculate the (Maximum [peak] conducted output power.
- Test methodology is per Clause 9.1.1 of KDB 558074 D01 (DTS Meas Guidance v03r05, April 08, 2016). All conditions under this Clause were satisfied.
- Radiated emissions measurements are allowed for demonstrating compliance to the conducted emission requirements per section 3.0 of KDB 558074 D01 (DTS Meas Guidance v03r05, April 08, 2016).

2.1.8 Test Results

Channel	Modulation	Measured Peak Field Strength dBuV/m @ 3M	Calculated EIRP (dBm)	Calculated EIRP (mW)
37 (2402 MHz)	GFSK @ 1Mbps	101.7	6.5	4.47
38 (2426 MHz)		99.6	4.4	2.75
39 (2480 MHz)		100.5	5.3	3.39

Equivalent conducted output power = EIRP = FS + (20 log d) – 104.7

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2.1.9 Sample Test Plots – Amplitudes are in dBuV/m at a (3) meter distance

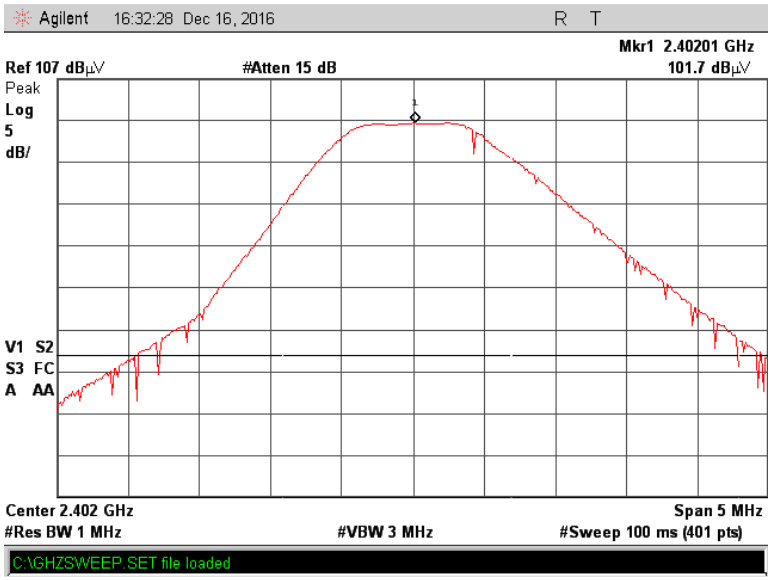

Figure 2.1.9-1 - Low Channel Peak Power

Notes:

ANSI C63.10:2013 clause 9.5

EIRP = E + (20 log d) – 104.7
EIRP = 101.7 + 9.54 – 104.7
EIRP = 6.54 dBm

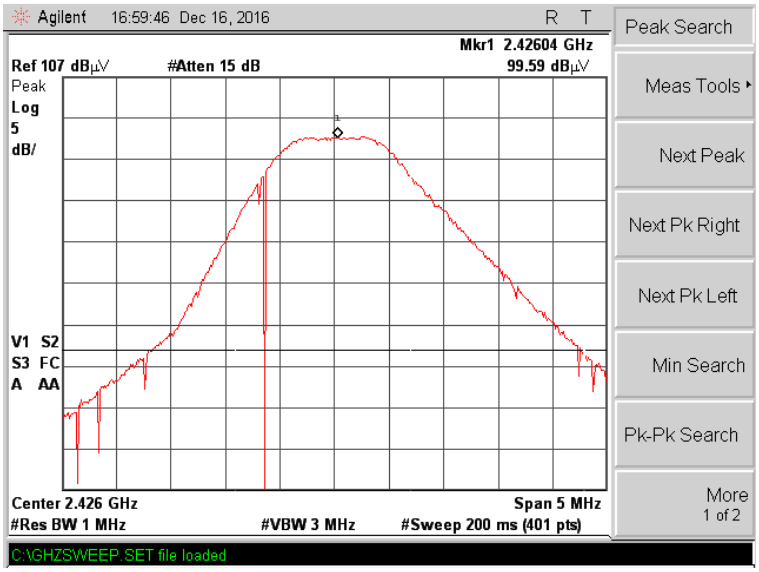

Figure 2.1.9-2 - Mid Channel Peak Power

Notes:

ANSI C63.10:2013 clause 9.5

EIRP = E + (20 log d) – 104.7
EIRP = 99.6 + 9.54 – 104.7
EIRP = 4.44 dBm

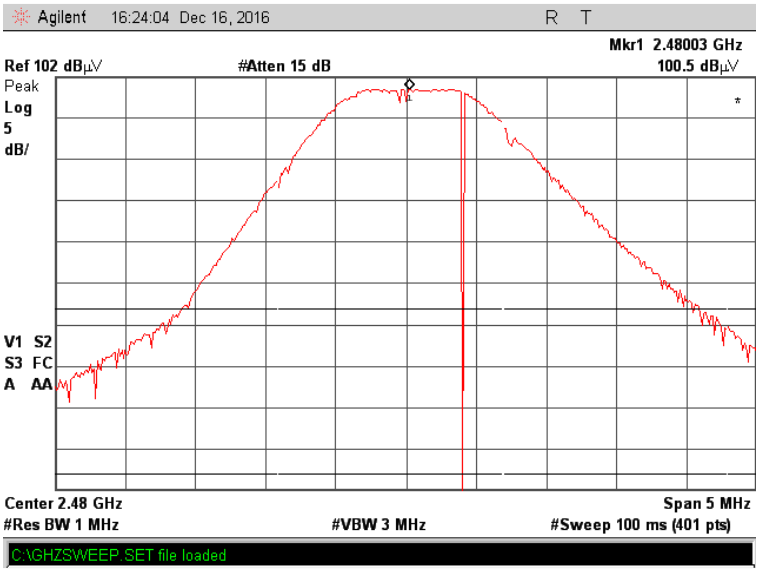

Figure 2.1.9-3 - High Channel Peak Power

Notes:

ANSI C63.10:2013 clause 9.5

EIRP = E + (20 log d) – 104.7
EIRP = 100.5 + 9.54 – 104.7
EIRP = 5.34 dBm

2.2 CONDUCTED EMISSIONS

2.2.1 Specification Reference

Part 15 Subpart C §15.207(a)

2.2.2 Standard Applicable

An intentional radiator that is designed to be connected to the public utility (AC) power line, the radio frequency voltage that is conducted back onto the AC power line on any frequency or frequencies, within the band 150 kHz to 30 MHz, shall not exceed the limits in the following table, as measured using a 50 µH/50 ohms line impedance stabilization network (LISN).

Frequency of emission (MHz)	Conducted limit (dBµV)	
	Quasi-peak	Average
0.15–0.5	66 to 56*	56 to 46*
0.5–5	56	46
5–30	60	50

**Decreases with the logarithm of the frequency.*

2.2.3 Equipment Under Test and Modification State

Serial No: none /Test Configuration B

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

Not applicable – battery operated

2.2.5 Test Equipment Used

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

2.2.6 Environmental Conditions

Test performed at TÜV SÜD America Inc. Tampa facility

Ambient Temperature	22 – 24 °C
Relative Humidity	48 – 52%

2.2.7 Additional Observations

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2.2.1 Sample Computation (Conducted Emission – Quasi Peak)

Measuring equipment raw measurement (dBµV) @ 150kHz			30.0
Correction Factor (dB)	TEMC00002 - LISN	0.03	0.11
	Cable 1	0.08	
Reported QuasiPeak Final Measurement (dbµV) @ 150kHz			**30.11**

2.2.2 Test Results

Not applicable – battery operated

2.3 99% Emission Bandwidth

2.3.1 Specification Reference

RSS-Gen Clause 6.6

2.3.2 Standard Applicable

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

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

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

2.3.3 Equipment Under Test and Modification State

Serial No: none / Test Configuration A

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

19. December 2016/DF

2.3.5 Test Equipment Used

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

2.3.6 Environmental Conditions

Test performed at TÜV SÜD America Inc. Tampa facility

Ambient Temperature	22 – 24 °C
Relative Humidity	48 – 52%

2.3.7 Additional Observations

- This is a radiated test.
- Span is wide enough to capture the channel transmission.
- RBW is 5% of the span.
- VBW is 3X RBW.
- Sweep is auto.
- Detector is peak.

2.3.8 Test Results (For reporting purposes only)

Mode	Channel	Measured 99% Bandwidth (MHz)
Bluetooth LE	37 (2402 MHz)	1.435
	38 (2446 MHz)	1.068
	39 (2480 MHz)	1.205

2.3.9 Test Results Plots

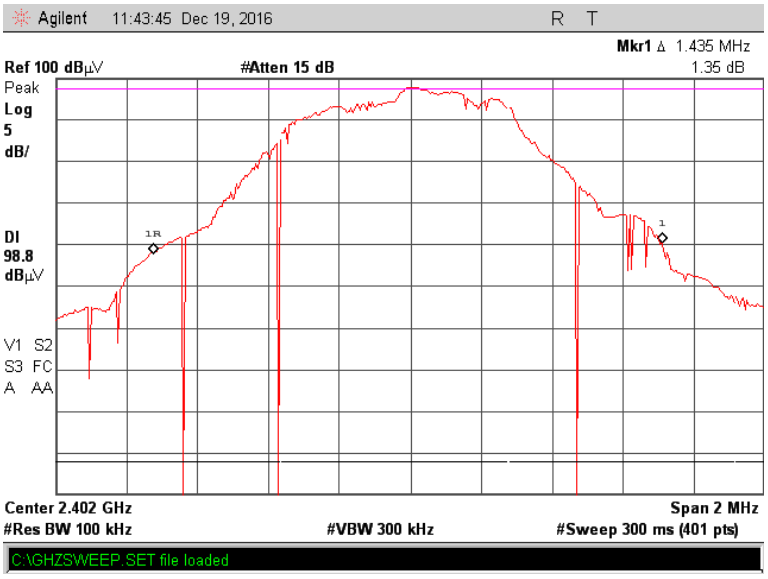

Figure 2.3.9-1 - Low Channel Bandwidth

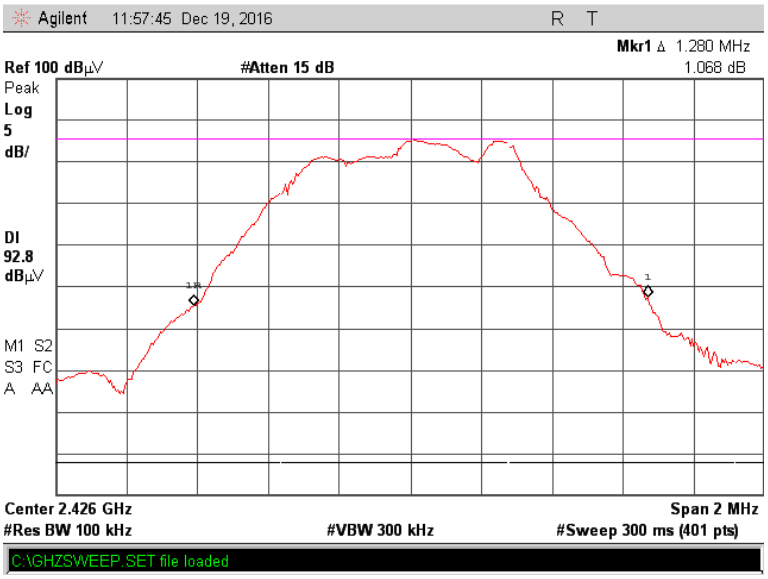

Figure 2.3.9-2 - Mid Channel Bandwidth

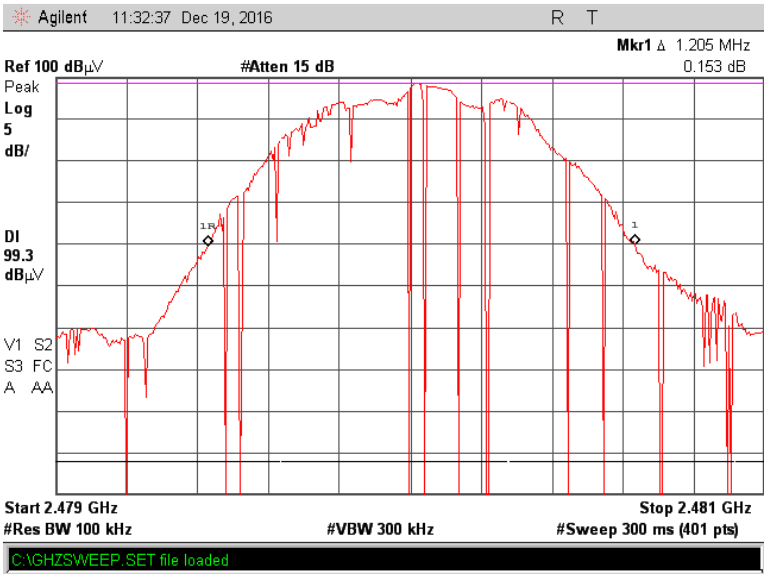

Figure 2.3.9-3 - High Channel Bandwidth

2.4 MINIMUM 6 dB RF BANDWIDTH

2.4.1 Specification Reference

Part 15 Subpart C §15.247(a)(2)

2.4.2 Standard Applicable

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

2.4.3 Equipment Under Test and Modification State

Serial No: none / Test Configuration A

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

19. December 2016 /DF

2.4.5 Test Equipment Used

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

2.4.6 Environmental Conditions

Test performed at TÜV SÜD America Inc. Tampa facility

Ambient Temperature	22 – 24 °C
Relative Humidity	48 – 52%

2.4.7 Additional Observations

- This is a radiated test.
- Span is wide enough to capture the channel transmission.
- RBW is set to 100 kHz
- VBW is ≥3X RBW.
- Sweep is auto.
- Detector is peak.

2.4.8 Test Results

Mode	Channel	Measured Bandwidth (MHz)	Minimum Bandwidth (MHz)	Compliance
Bluetooth LE	37 (2402 MHz)	0.705	0.500	Complies
	38 (2426 MHz)	0.695	0.500	Complies
	39 (2480 MHz)	0.695	0.500	Complies

2.4.9 Test Results Plots

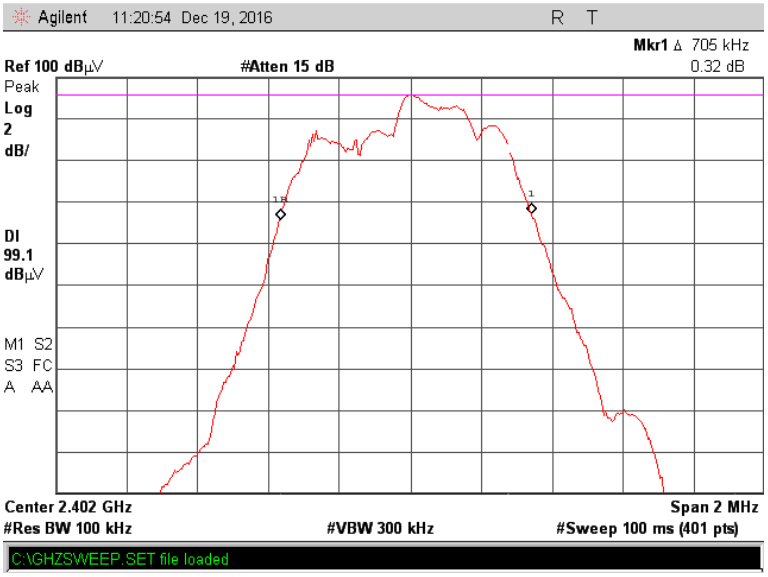

Figure 2.4.9-1 - Low Channel 6 dB Bandwidth

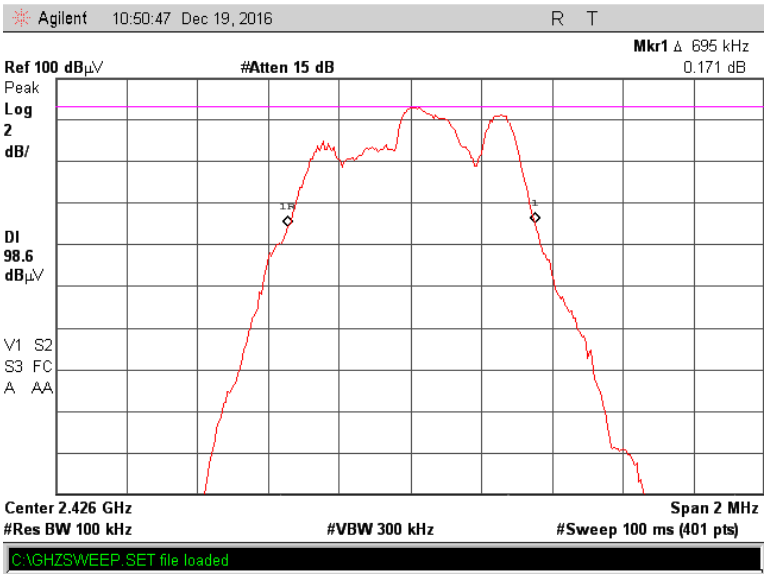

Figure 2.4.9-2 - Mid Channel 6 dB Bandwidth

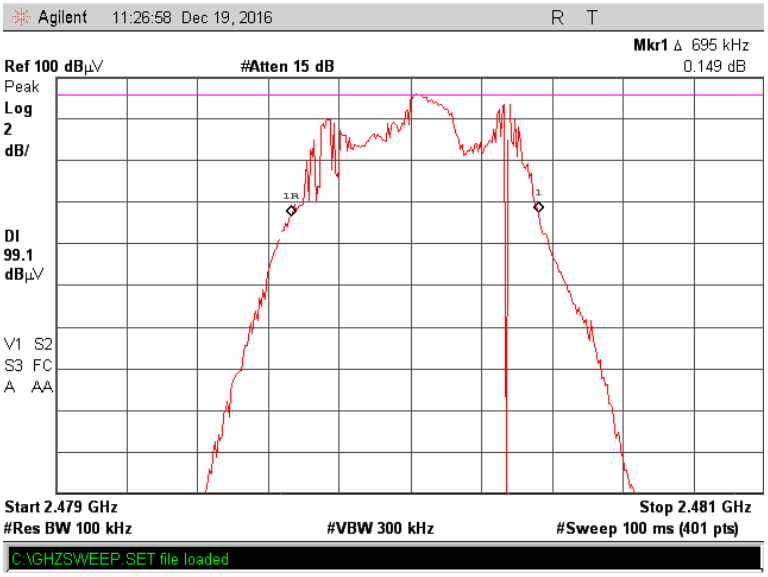

Figure 2.4.9-3 - High Channel 6 dB Bandwidth

2.5 BAND-EDGE COMPLIANCE OF RF CONDUCTED EMISSIONS

2.5.1 Specification Reference

Part 15 Subpart C §15.247(d)

2.5.2 Standard Applicable

(d) In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, as permitted under paragraph (b)(3) of this section, the attenuation required under this paragraph shall be 30 dB instead of 20 dB. Attenuation below the general limits specified in §15.209(a) is not required. In addition, radiated emissions which fall in the restricted bands, as defined in §15.205(a), must also comply with the radiated emission limits specified in §15.209(a) (see §15.205(c)).

2.5.3 Equipment Under Test and Modification State

Serial No: None / Test Configuration A

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

Not performed – this product has an integral antenna only.

2.5.5 Test Equipment Used

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

2.5.6 Environmental Conditions

Test performed at TÜV SÜD America Inc. Tampa facility

Ambient Temperature	22 – 24 °C
Relative Humidity	48 – 52%

2.5.7 Additional Observations

- This is a radiated test.
- RBW is 100kHz.VBW is 3X RBW.
- Sweep is auto. Detector is peak. Trace is max hold.
- Sweep points set to maximum.
- Spectrum was searched from 30 MHz up to 26.5GHz.

2.5.8 Test Results Plots

None taken as the alternative radiated spurious emissions test was performed. See results in Section 2.7.

2.6 BAND-EDGE COMPLIANCE OF RF CONDUCTED EMISSIONS

2.6.1 Specification Reference

Part 15 Subpart C §15.247(d)

2.6.2 Standard Applicable

See 2.7.2.

2.6.3 Equipment Under Test and Modification State

Serial No: none / Test Configuration A

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

19. December 2016/ DF

2.6.5 Test Equipment Used

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

2.6.6 Environmental Conditions

Test performed at TÜV SÜD America Inc. Tampa facility

Ambient Temperature	22 – 24 °C
Relative Humidity	48 – 52%

2.6.7 Additional Observations

- This is a radiated test.
- RBW is 100kHz. VBW is 3X RBW.
- Sweep is auto. Detector is peak. Trace is max hold.
- Span was set to encompass the band-edge frequency and the peak of the emission.
- Using Marker function, peak of the emission was determined and the delta to the band-edge frequency measured.
- Band-edges were verified ≤ 30 dBc (worst-case).

2.6.8 Test Results

Complies. See attached plots.

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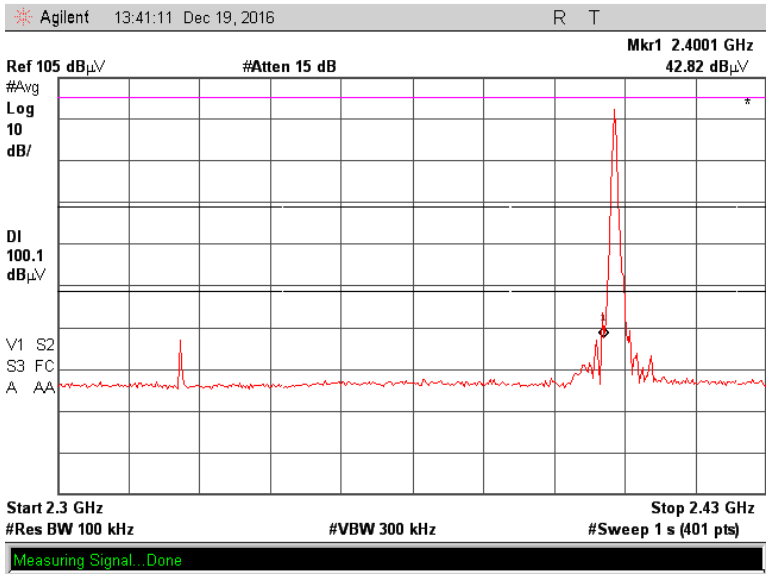


Figure 2.6.8-1 - Bluetooth LE Low Channel (2402 MHz)

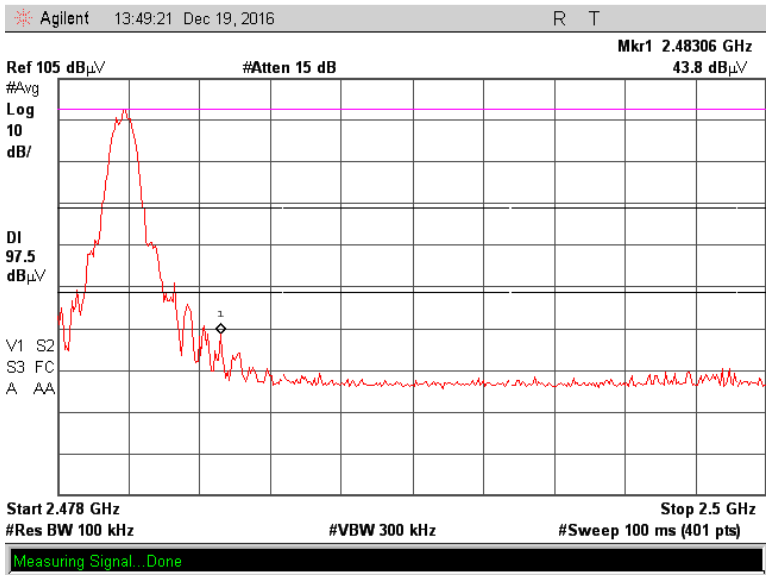


Figure 2.6.8-2 - Bluetooth LE High Channel (2480 MHz)

2.7 SPURIOUS RADIATED EMISSIONS

2.7.1 Specification Reference

Part 15 Subpart C §15.247(d)

2.7.2 Standard Applicable

(d) In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, as permitted under paragraph (b)(3) of this section, the attenuation required under this paragraph shall be 30 dB instead of 20 dB. Attenuation below the general limits specified in §15.209(a) is not required. In addition, radiated emissions which fall in the restricted bands, as defined in §15.205(a), must also comply with the radiated emission limits specified in §15.209(a) (see §15.205(c)).

2.7.3 Equipment Under Test and Modification State

Serial No: None / Test Configuration B

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

20. December 2016/DF

2.7.5 Test Equipment Used

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

2.7.6 Environmental Conditions

Test performed at TÜV SÜD America Inc. Tampa facility

Ambient Temperature	22 – 24 °C
Relative Humidity	48 – 52%

2.7.7 Additional Observations

- This is a radiated test at a 3-meter distance. The spectrum was searched from 30MHz to the 10th harmonic.
- There are no emissions found that do not comply to the restricted bands defined in FCC Part 15 Subpart C, 15.205 or Part 15.247(d).

- Only noise floor measurements observed above 13 GHz.
- Measurement was done using EMC32 automated software. Reported level is the actual level with all the correction factors factored in. Correction Factor column is for informational purposes only. See Section 2.7.8 for sample computation.

2.7.8 Sample Computation (Radiated Emission)

Measuring equipment raw measurement (dbµV) @ 30 MHz			20.0
Correction Factor (dB)	Cable 2	0.24	18.94
	TEMC00011 (antenna)	18.70	
Reported QuasiPeak Final Measurement (dbµV/m) @ 30MHz			**38.94**

2.7.9 Test Results

See attached plots.

2.7.10 Test Results Below 1GHz (Receive Mode)

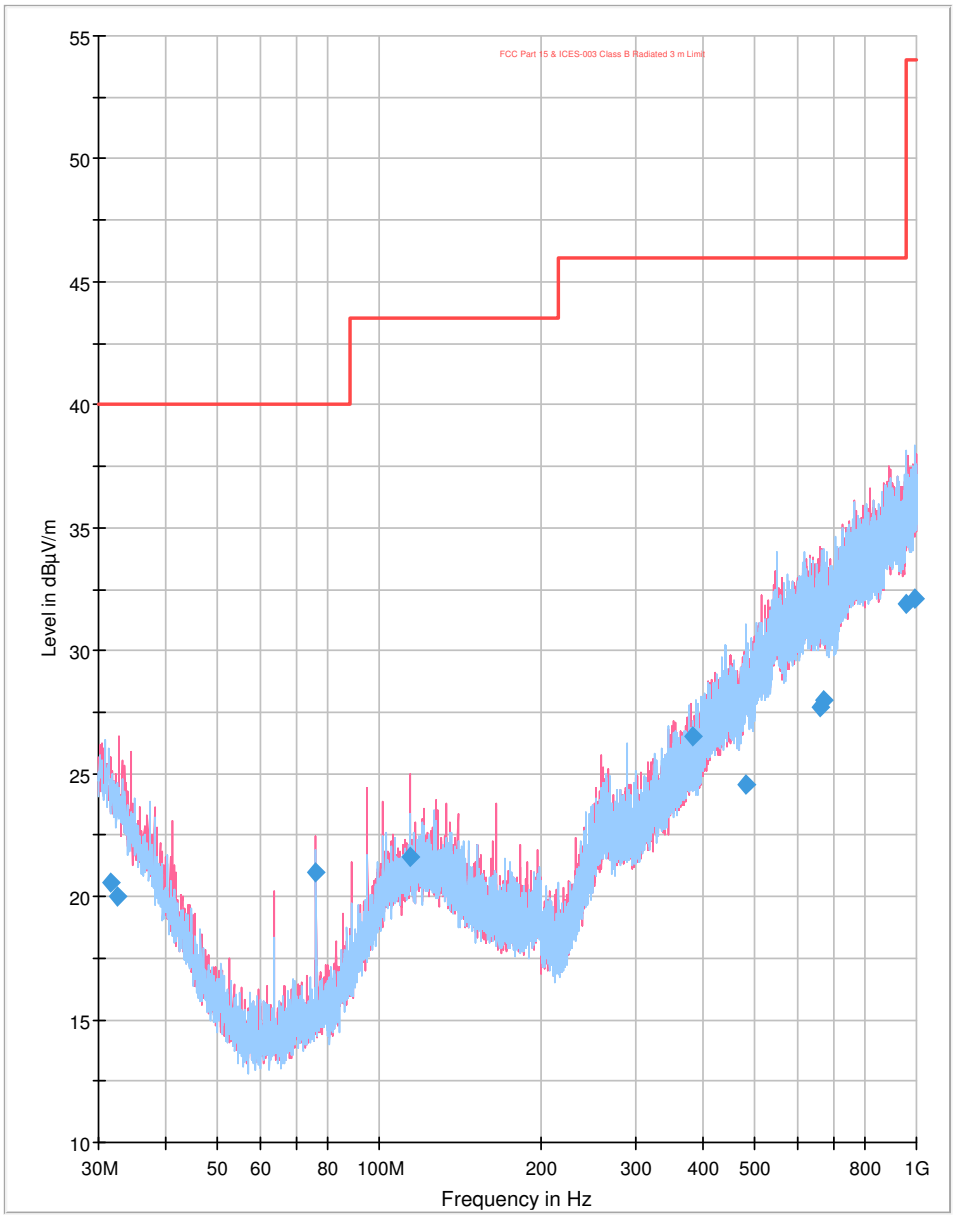


Figure 2.7.10-1 – Receive Mode Radiated Emissions Plot

Table 2.7.10-1 - Quasi Peak Detector Data

Frequency (MHz)	MaxPeak (dBµV/m)	Height (cm)	Polarization	Azimuth (deg)	Corr. (dB)	Margin (dB)	Limit (dBµV/m)
31.560000	20.6	362.0	V	46.0	24.0	19.4	40.0
32.640000	20.0	149.0	H	265.0	23.4	20.0	40.0
76.280000	21.0	283.0	V	238.0	13.2	19.0	40.0
114.440000	21.6	222.0	V	226.0	19.0	21.9	43.5
383.560000	26.5	167.0	V	102.0	23.5	19.5	46.0
480.760000	24.6	161.0	V	45.0	25.8	21.4	46.0
661.320000	27.7	284.0	H	251.0	28.3	18.3	46.0
669.640000	28.0	344.0	V	91.0	28.5	18.0	46.0
957.360000	31.9	143.0	H	250.0	31.5	14.1	46.0
989.120000	32.1	217.0	H	46.0	31.5	21.9	54.0

2.7.11 Test Results Above 1GHz (Receive Mode)

Table 2.7.11-1 - Peak Detector Data

Frequency (MHz)	MaxPeak (dBµV/m)	Height (cm)	Polarization	Azimuth (deg)	Corr. (dB)	Margin (dB)	Limit (dBµV/m)
1733.000000	39.5	226.0	H	120.0	-1.7	34.5	74.0
6721.000000	53.1	260.0	H	281.0	9.2	20.9	74.0
9052.200000	55.1	358.0	V	43.0	14.0	18.9	74.0
9069.400000	55.1	98.0	V	0.0	14.0	18.9	74.0
10702.600000	59.0	375.0	H	239.0	19.3	15.0	74.0
10806.600000	58.6	220.0	H	30.0	19.9	15.4	74.0
12105.000000	63.6	333.0	H	314.0	22.6	10.4	74.0
12123.000000	63.0	244.0	V	17.0	22.6	11.0	74.0
14665.000000	64.0	252.0	V	240.0	23.3	10.0	74.0
14763.000000	65.8	142.0	H	270.0	23.7	8.2	74.0

Table 2.7.11-2 - Average Detector Data

Frequency (MHz)	Average (dBµV/m)	Height (cm)	Polarization	Azimuth (deg)	Corr. (dB)	Margin (dB)	Limit (dBµV/m)
1733.000000	19.5	226.0	H	120.0	-1.7	34.5	54.0
6721.000000	33.1	260.0	H	281.0	9.2	20.9	54.0
9052.200000	35.1	358.0	V	43.0	14.0	18.9	54.0
9069.400000	35.1	98.0	V	0.0	14.0	18.9	54.0
10702.600000	39.0	375.0	H	239.0	19.3	15.0	54.0
10806.600000	38.6	220.0	H	30.0	19.9	15.4	54.0
12105.000000	43.6	333.0	H	314.0	22.6	10.4	54.0
12123.000000	43.0	244.0	V	17.0	22.6	11.0	54.0
14665.000000	44.0	252.0	V	240.0	23.3	10.0	54.0
14763.000000	45.8	142.0	H	270.0	23.7	8.2	54.0

2.7.12 Test Results Above 1GHz (Bluetooth Mode)

Table 2.7.12-1 – Radiated Emissions Results for the Low Channel

Transmit Frequency 2402 MHz						
Freq.		Field Strength		Delta	Restricted	POL
	AVG/PEAK	3 Meter Distance	Limit		Band	H/V
MHz	Detector	dBuV/m	dBuV/m	dB	Yes/No	
2402	PEAK	101.7	NA	NA	NO	Horz
4808	AVG	27.8	54	-26.2	**YES**	Vert
4808	PEAK	47.8	74	-26.2	**YES**	Vert
7206	AVG	34.5	81.7	-47.2	NO	Horz
7206	PEAK	54.5	81.7	-27.2	NO	Horz
9608	AVG	38.2	81.7	-43.5	NO	Vert
9608	PEAK	58.2	81.7	-23.5	NO	Vert
12010	AVG	43.8	54	-10.2	**YES**	Vert
12010	PEAK	63.8	74	-10.2	**YES**	Vert
* Low Loss setup includes: 1 Meter Measurement Distance and Very Low loss cables						
Low Loss setup confirms harmonics above 13 GHz are > 20 dB below Peak & Average Limits						
RBW=1 MHz, VBW=3 MHz						

Table 2.7.12-2 – Radiated Emissions Results for the Mid Channel

Transmit Frequency 2426 MHz						
Freq.		Field Strength		Delta	Restricted	POL
		3 Meter Distance	Limit		Band	H/V
MHz		dBuV/m	dBuV/m	dB	Yes/No	
2426	PEAK	99.6	NA	NA	NO	Horz
4852	AVG	26.5	54	-27.5	**YES**	Vert
4852	PEAK	46.5	74	-27.5	**YES**	Vert
7278	AVG	33.1	54	-20.9	**YES**	**Horz**
7278	PEAK	53.1	74	-20.9	**YES**	Horz
9704	AVG	36.6	81.7	-45.1	NO	Vert
9704	PEAK	56.6	81.7	-25.1	NO	Vert
12130	AVG	43.4	54	-10.6	**YES**	vert
12130	PEAK	63.4	74	-10.6	**YES**	vert
* Low Loss setup includes: 1 Meter Measurement Distance and Very Low loss cables						
Low Loss setup confirms harmonics above 13 GHz are > 20 dB below Peak & Average Limits						
RBW=1 MHz, VBW=3 MHz						

Table 2.7.12-3 – Radiated Emissions Results for the High Channel

Transmit Frequency 2480 MHz						
Freq.		Field Strength		Delta	Restricted	POL
		3 Meter Distance	Limit		Band	H/V
MHz		dBuV/m	dBuV/m	dB	Yes/No	
2480	PEAK	100.5	NA	NA	NO	Horz
4960	AVG	29	54	-25	**YES**	Vert
4960	PEAK	49	74	-25	**YES**	Vert
7440	AVG	35.6	54	-18.4	**YES**	Horz
7440	PEAK	55.6	74	-18.4	**YES**	Horz
9920	AVG	39.9	81.7	-41.8	NO	Horz
9920	PEAK	59.9	81.7	-21.8	NO	Horz
12400	AVG	44.1	54	-9.9	**YES**	Vert
12400	PEAK	64.1	74	-9.9	**YES**	Vert
* Low Loss setup includes: 1 Meter Measurement Distance and Very Low loss cables						
Low Loss setup confirms harmonics above 13 GHz are > 20 dB below Peak & Average Limits						
RBW=1 MHz, VBW=3 MHz						

2.8 RADIATED BAND EDGE MEASUREMENTS AND IMMEDIATE RESTRICTED BANDS

2.8.1 Specification Reference

Part 15 Subpart C §15.247(d)

2.8.2 Standard Applicable

(d) In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, as permitted under paragraph (b)(3) of this section, the attenuation required under this paragraph shall be 30 dB instead of 20 dB. Attenuation below the general limits specified in §15.209(a) is not required. In addition, radiated emissions which fall in the restricted bands, as defined in §15.205(a), must also comply with the radiated emission limits specified in §15.209(a) (see §15.205(c)).

2.8.3 Equipment Under Test and Modification State

Serial No: none / Test Configuration A

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

19. December 2016 /DF

2.8.5 Test Equipment Used

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

2.8.6 Environmental Conditions

Test performed at TÜV SÜD America Inc. Tampa facility

Ambient Temperature	22 – 24 °C
Relative Humidity	48 – 52%

2.8.7 Additional Observations

- This is a radiated test at a 3-meter distance. The spectrum was searched from 2310MHz to 2390MHz for lower immediate restricted band and 2483.5MHz to 2500MHz for the upper immediate restricted band.
- There are no emissions found that do not comply with the restricted bands defined in FCC Part 15 Subpart C, 15.205.

- Measurement was done using Agilent E7405A spectrum analyzer. Correction Factor column is for informational purposes only. See Section 2.8.8 for sample computation.

2.8.8 Sample Computation (Radiated Emission)

Measuring equipment raw measurement (dbµV) @ 30 MHz			20.0
Correction Factor (dB)	Cable 2	0.24	18.94
	TEMC00011 (antenna)	18.70	
Reported QuasiPeak Final Measurement (dbµV/m) @ 30MHz			**38.94**

2.8.9 Test Results

See attached plots.

2.8.10 Test Results Restricted Band 2310MHz to 2390MHz (Bluetooth LE Low Channel)

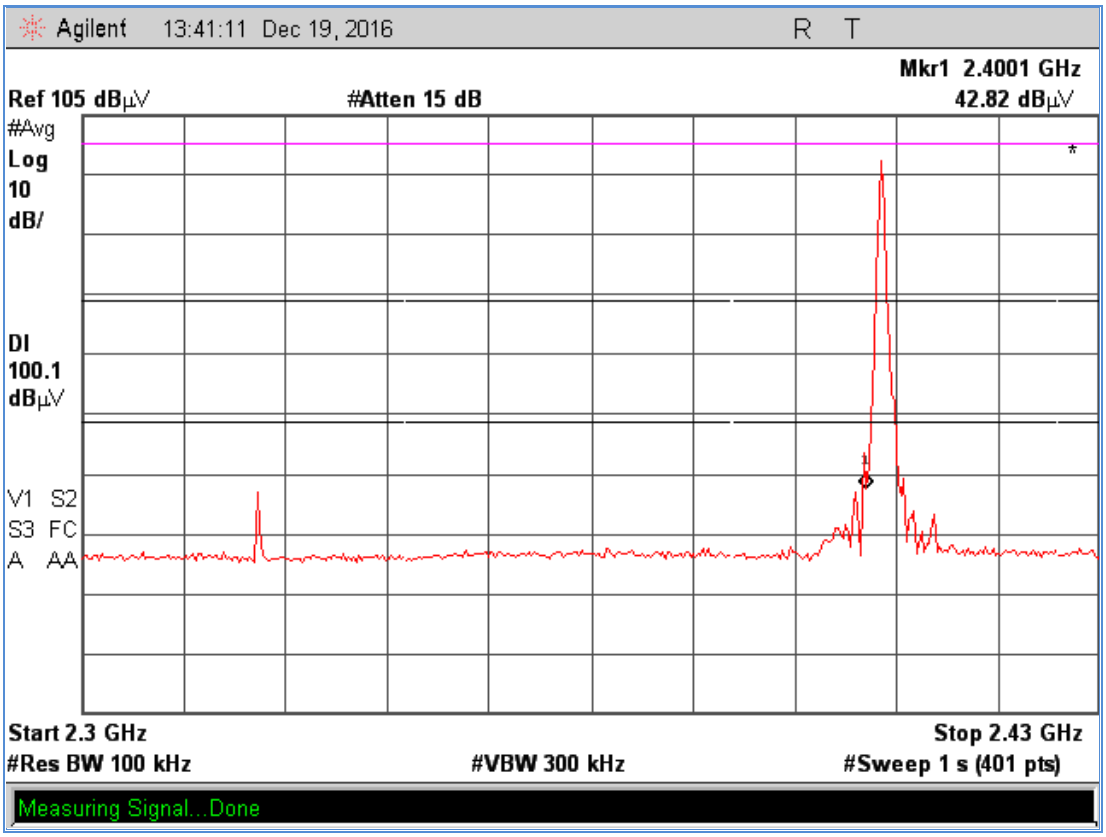


Figure 2.8.10-1 – Lower Frequency Restricted Band

2.8.11 Test Results Restricted Band 2483.5MHz to 2500MHz (Bluetooth LE High Channel)

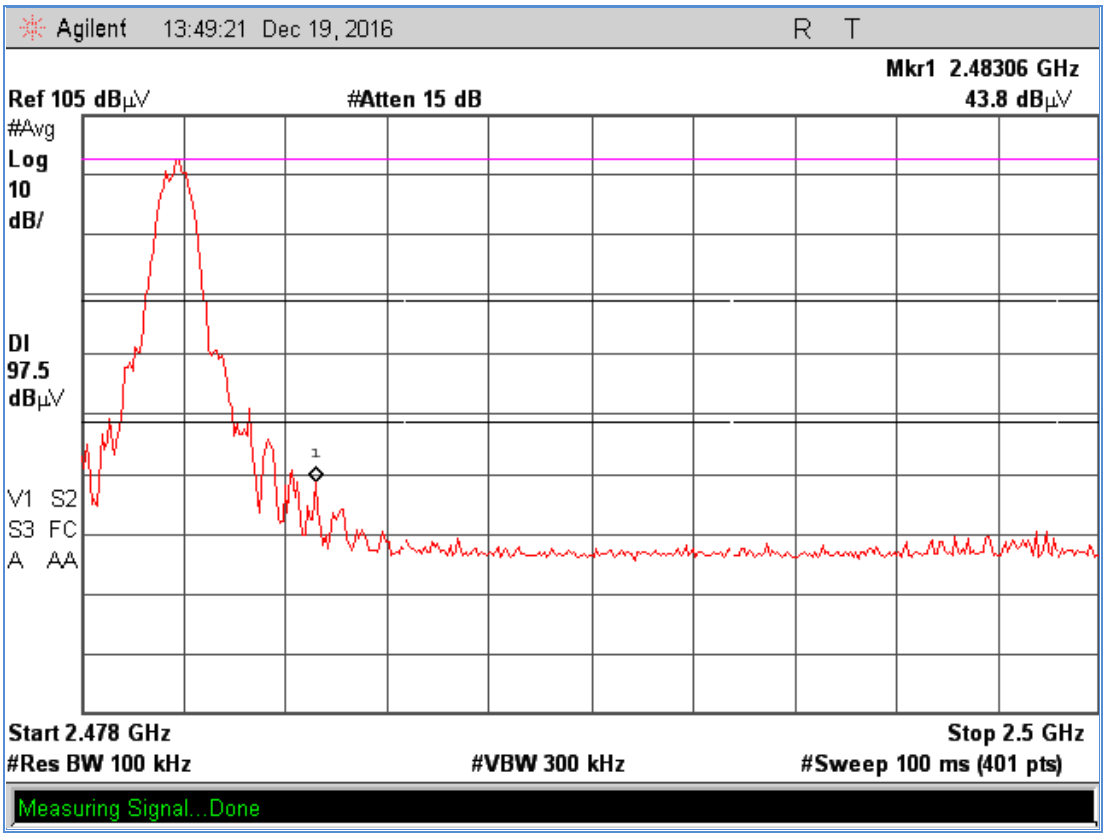


Figure 2.8.10-2 – Upper Frequency Restricted Band

2.9 POWER SPECTRAL DENSITY

2.9.1 Specification Reference

Part 15 Subpart C §15.247(e)

2.9.2 Standard Applicable

(e) For digitally modulated systems, the power spectral density conducted from the intentional radiator to the antenna shall not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission. This power spectral density shall be determined in accordance with the provisions of paragraph (b) of this section. The same method of determining the conducted output power shall be used to determine the power spectral density.

2.9.3 Equipment Under Test and Modification State

Serial No: none / Test Configuration A

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

19. December 2016 / DF

2.9.5 Test Equipment Used

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

2.9.6 Environmental Conditions

Test performed at TÜV SÜD America Inc. Tampa facility

Ambient Temperature	22 – 24 °C
Relative Humidity	48 – 52%

2.9.7 Additional Observations

- This is a radiated test at a 3-meter distance.
- Test procedure is per Section 10.2 of KDB 558074 (April 08, 2016).
- Detector is Peak.
- Max hold
- Sweep time is Auto Couple.
- EUT complies with 3 kHz RBW Bluetooth LE.

2.9.8 Test Results Summary

Mode	Channel	Marker Reading using 3 kHz RBW (dBm)	Antenna Gain (dB)	Calculated PSD (dBm)	PSD Limit (dBm)	Compliance
Bluetooth LE	37 (2402 MHz)	-8.66	-0.57	--8.09	8	Complies
	38 (2426 MHz)	-6.96		-6.39	8	Complies
	39 (2480 MHz)	-8.32		-7.75	8	Complies

2.9.9 Test Results Plots – Amplitudes are in dBuV/m at a (3) meter distance

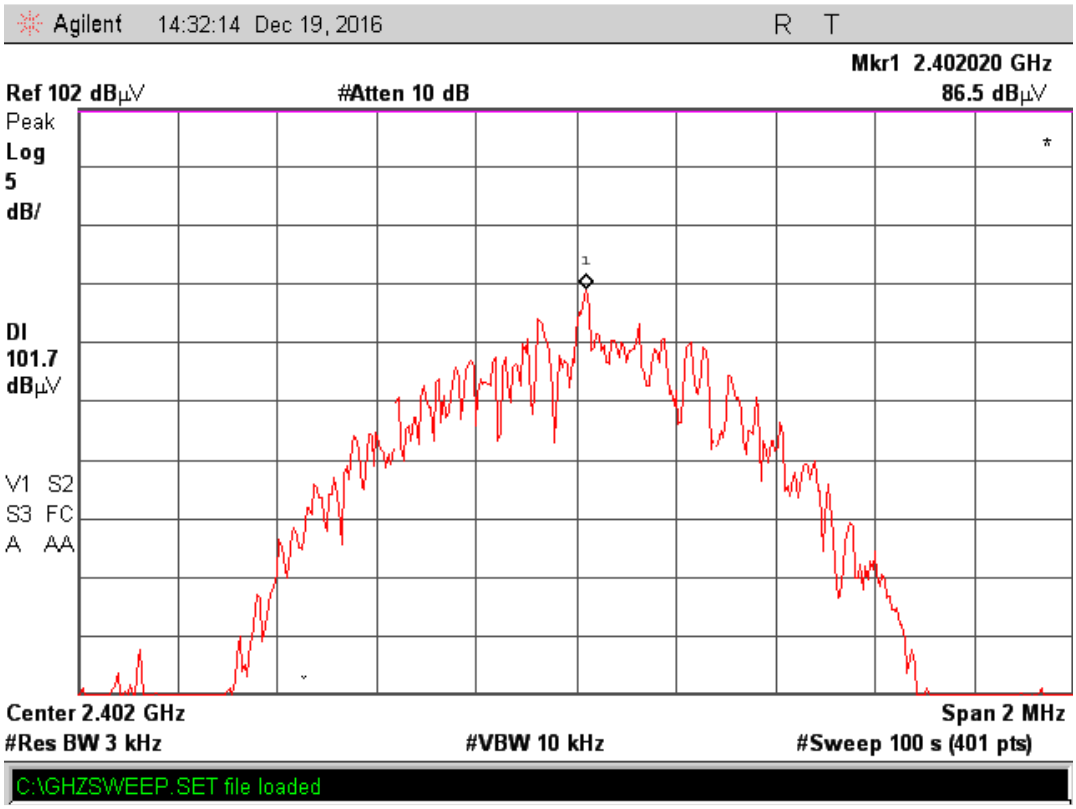


Figure 2.9.9-1 - Power Spectral Density – Low Channel

Notes:

ANSI C63.10:2013 clause 9.5

EIRP = E + (20 log d) – 104.7
EIRP = 86.5 + 9.54 – 104.7
EIRP = -8.66 dBm

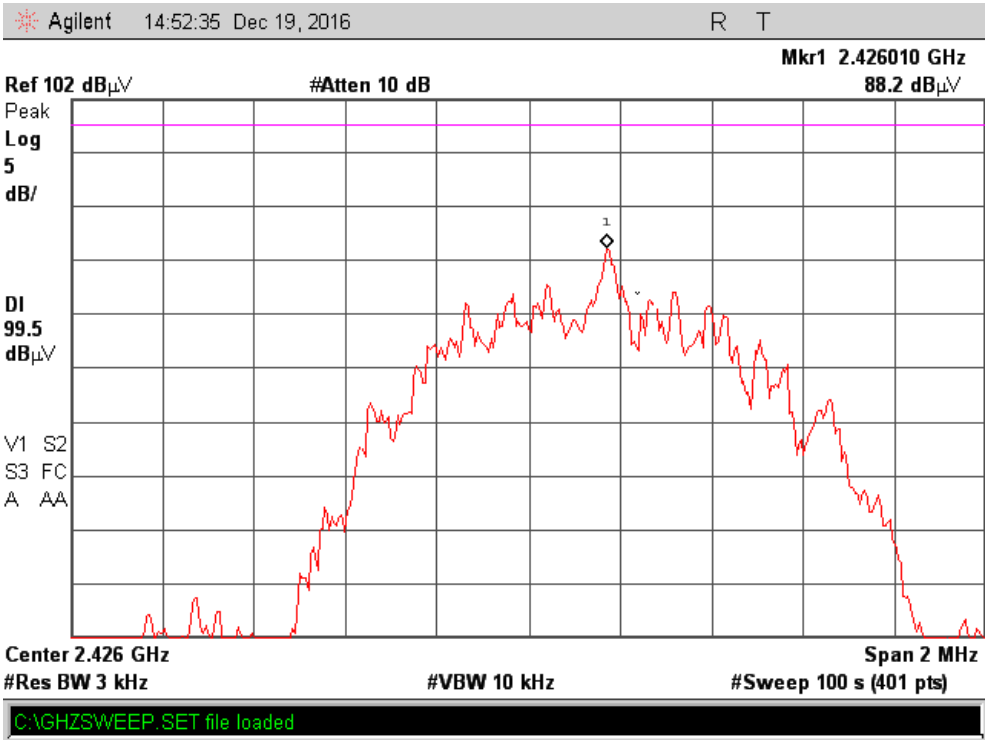


Figure 2.9.9-2 - Power Spectral Density – Mid Channel

Notes:

ANSI C63.10:2013 clause 9.5

EIRP = E + (20 log d) – 104.7
EIRP = 88.2 + 9.54 – 104.7
EIRP = -6.96 dBm

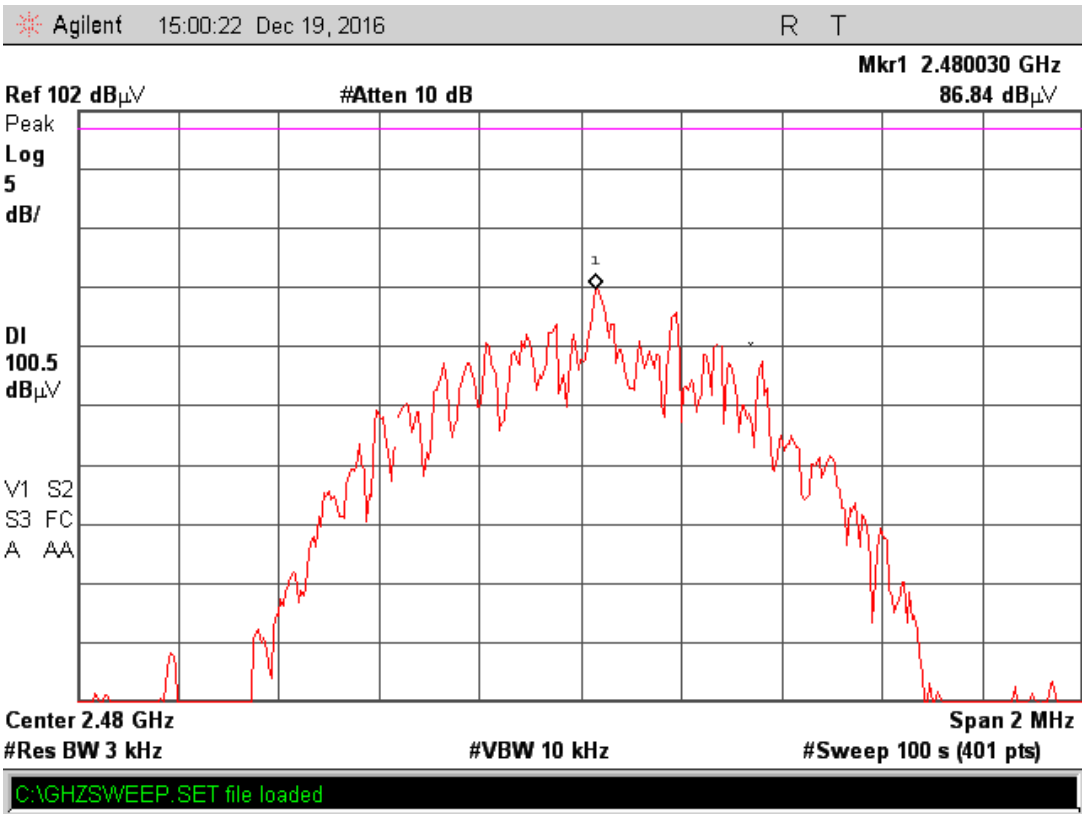


Figure 2.9.9-3 - Power Spectral Density – High Channel

Notes:

ANSI C63.10:2013 clause 9.5

EIRP = E + (20 log d) – 104.7
EIRP = 86.84 + 9.54 – 104.7
EIRP = -8.32 dBm

SECTION 3

TEST EQUIPMENT USED

3.1 TEST EQUIPMENT USED

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

ID Number (SDGE/SDRB)	Test Equipment	Type	Serial Number	Manufacturer	Cal Date	Cal Due Date
Antenna Conducted Port Setup						
Radiated Test Setup						
TEMC00005	Bilog Antenna	6112B	2579	Chase EMC	12/17/2015	12/17/2017
TEMC00061	Double-ridged waveguide horn antenna	3117	00109296	ETS Lindgren	2/3/2016	2/3/2018
TEMC00128	EMI Test Receiver	ESIB 40	100255/040	Rhode & Schwarz	11/7/2016	11/7/2017
TEMC00012	Spectrum Analyzer	E7404A	MY42000055	Agilent	4/10/2015	4/10/2017
TEMC00013	Pre-amplifier	PA-122	181925	Compower	10/3/2016	10/3/2017
	High-frequency cable					
	High-frequency cable					
Conducted Emissions						
Miscellaneous						
	Test Software	EMC32	V8.54	Rhode & Schwarz	N/A	

3.2 MEASUREMENT UNCERTAINTY

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

3.2.1 Radiated Emission Measurements (Below 1GHz)

Radiated Measurement 30 - 1000 MHz at a distance of 3 m

	Input Quantity (Contribution) X_i	Value		Prob. Dist.	Divisor	$u_i(x)$	$u_i(x)^2$
1	Receiver reading	0.10	dB	Normal, k=1	1.000	0.10	0.01
2	Attenuation: antenna-receiver	0.20	dB	Normal, k=2	2.000	0.10	0.01
3	Antenna factor AF	0.58	dB	Normal, k=2	2.000	0.29	0.08
4	Receiver sinewave accuracy	0.40	dB	Normal, k=2	2.000	0.20	0.04
5	Receiver pulse amplitude	1.50	dB	Rectangular	1.732	0.87	0.75
6	Receiver pulse repetition rate	1.50	dB	Rectangular	1.732	0.87	0.75
7	Noise floor proximity	0.50	dB	Rectangular	1.732	0.29	0.08
8	Mismatch: antenna-receiver	0.95	dB	U-shaped	1.414	0.67	0.45
9	AF frequency interpolation	0.30	dB	Rectangular	1.732	0.17	0.03
10	AF height deviations	0.10	dB	Rectangular	1.732	0.06	0.00
11	Directivity difference at 3 m	3.12	dB	Rectangular	1.732	1.80	3.24
12	Phase center location at 3 m	1.00	dB	Rectangular	1.732	0.58	0.33
13	Cross-polarisation	0.90	dB	Rectangular	1.732	0.52	0.27
14	Balance	0.00	dB	Rectangular	1.732	0.00	0.00
15	Site imperfections	3.85	dB	Triangular	2.449	1.57	2.47
16	Separation distance at 3 m	0.30	dB	Rectangular	1.732	0.17	0.03
17	Effect of setup table material	0.77	dB	Rectangular	1.732	0.44	0.20
18	Table height at 3 m	0.10	dB	Normal, k=2	2.000	0.05	0.00
19	Near-field effects	0.00	dB	Triangular	2.449	0.00	0.00
20	Effect of ambient noise on OATS	0.00	dB				0.00

Combined standard uncertainty	Normal	2.96	dB
Expanded uncertainty	Normal, k=2	**5.92**	**dB**

3.2.2 Radiated Emission Measurements (Above 1GHz)

Radiated Measurement Above 1 GHz at a distance of 3 m

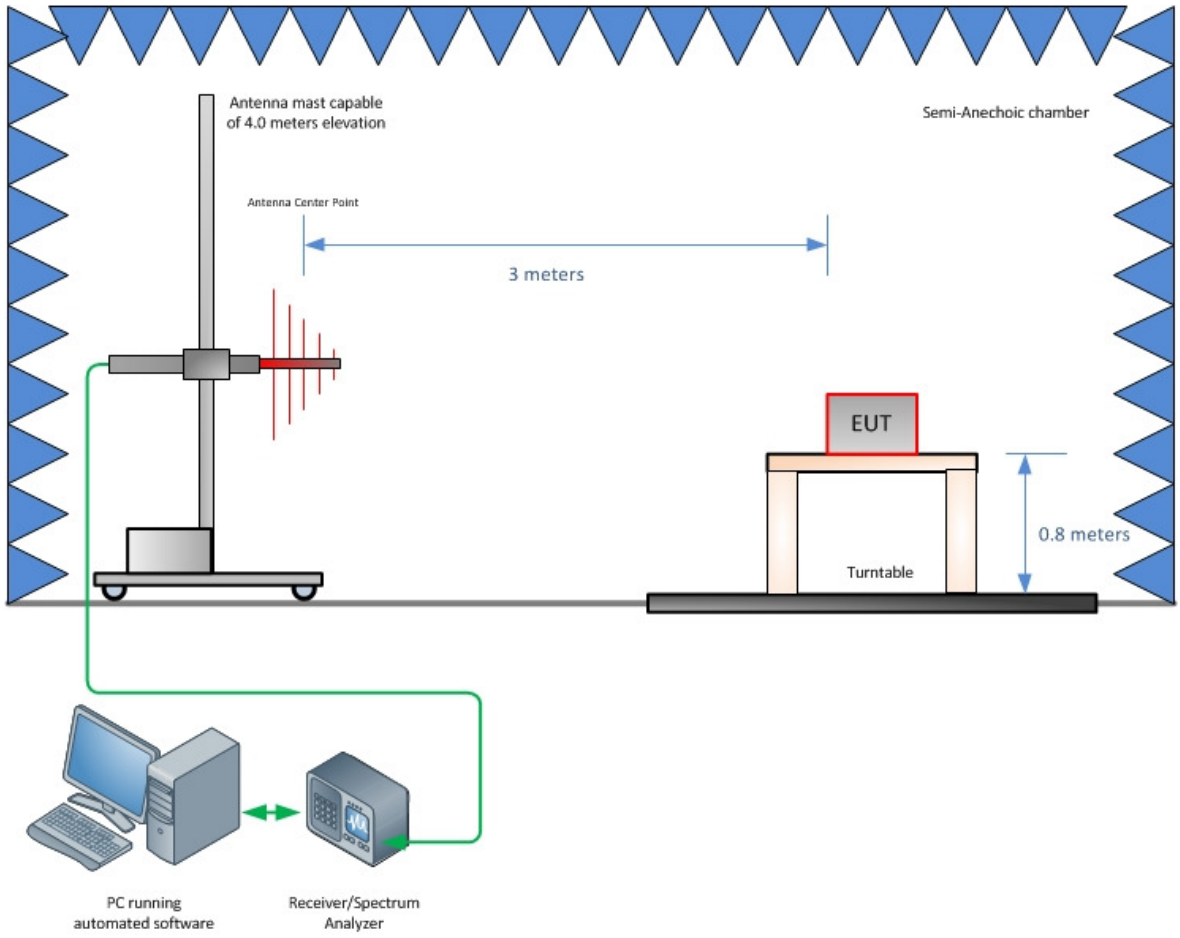
	Input Quantity (Contribution) X_i	Value		Prob. Dist.	Divisor	$u_i(x)$	$u_i(x)^2$
1	Receiver reading	0.10	dB	Normal, k=1	1.000	0.10	0.01
2	Attenuation: antenna-receiver	0.30	dB	Normal, k=2	2.000	0.15	0.02
3	Preamplifier Gain	0.20	dB	Normal, k=2	2.000	0.10	0.01
4	Antenna factor AF	0.75	dB	Normal, k=2	2.000	0.38	0.14
5	Sinewave accuracy	0.20	dB	Normal, k=2	2.000	0.10	0.01
6	Instability of preamp gain	1.21	dB	Rectangular	1.732	0.70	0.49
7	Noise floor proximity	0.70	dB	Rectangular	1.732	0.40	0.16
8	Mismatch: antenna-preamplifier	1.41	dB	U-shaped	1.414	1.00	0.99
9	Mismatch: preamplifier-receiver	1.30	dB	U-shaped	1.414	0.92	0.85
10	AF frequency interpolation	0.30	dB	Rectangular	1.732	0.17	0.03
11	Directivity difference at 3 m	1.50	dB	Rectangular	1.732	0.87	0.75
12	Phase center location at 3 m	0.30	dB	Rectangular	1.732	0.17	0.03
13	Cross-polarisation	0.90	dB	Rectangular	1.732	0.52	0.27
14	Site imperfections VSWR (Method 2)	2.25	dB	Triangular	2.449	0.92	0.84
15	Effect of setup table material	2.90	dB	Rectangular	1.732	1.67	2.80
16	Separation distance at 3 m	0.30	dB	Rectangular	1.732	0.17	0.03
17	Table height at 3 m	0.00	dB	Normal, k=2	2.000	0.00	0.00

Combined standard uncertainty	Normal	2.73	dB
Expanded uncertainty	Normal, k=2	**5.46**	**dB**

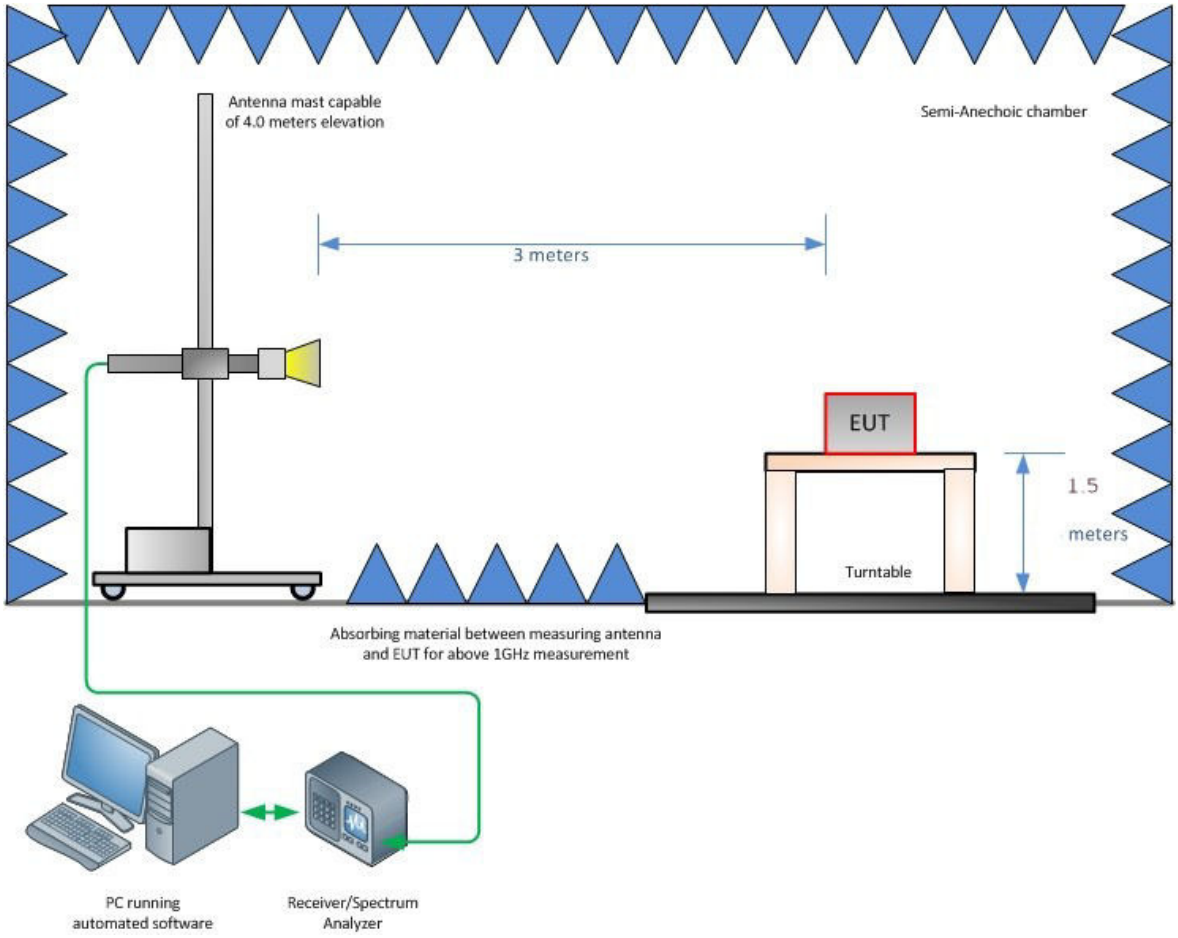
SECTION 4

DIAGRAM OF TEST SETUP

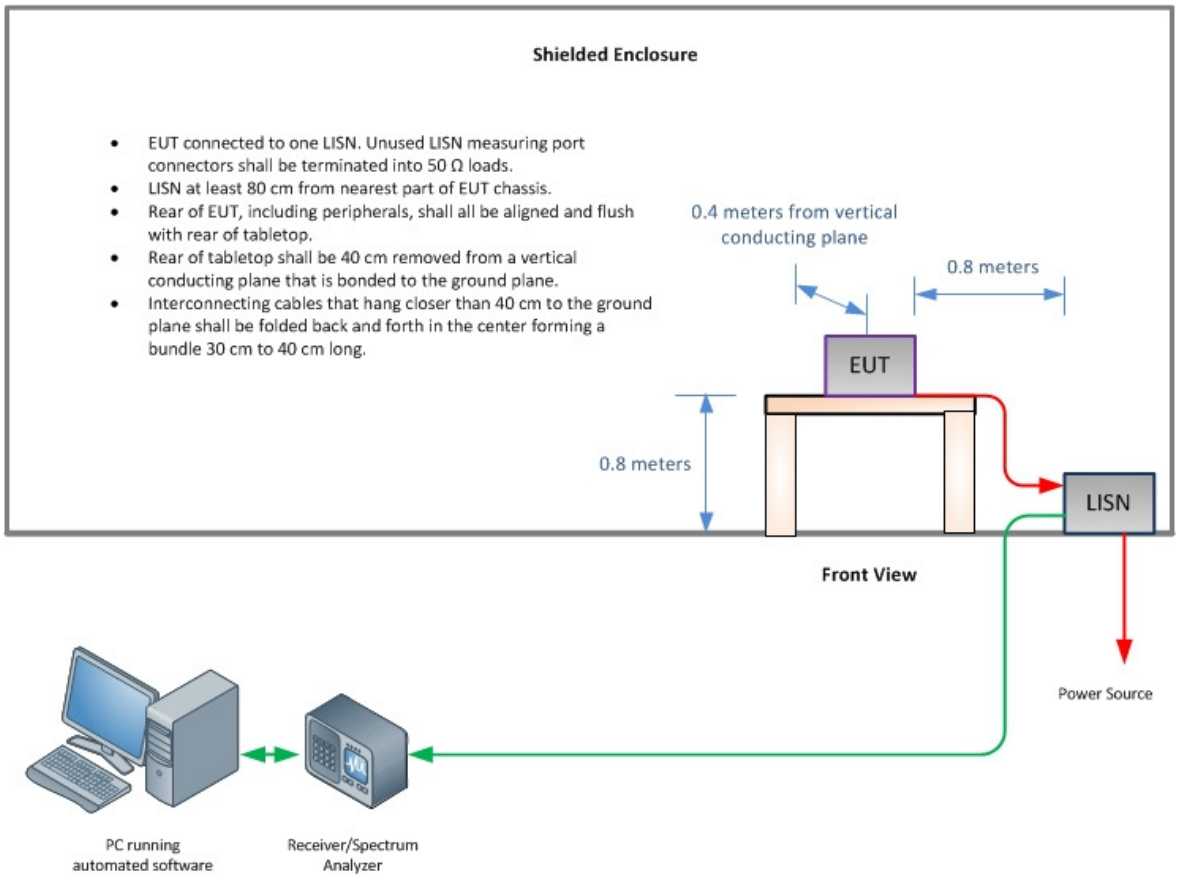
4.1 TEST SETUP DIAGRAM



Radiated Emission Test Setup (Below 1GHz)



Radiated Emission Test Setup (Above 1GHz)



Conducted Emission Test Setup

SECTION 5

ACCREDITATION, DISCLAIMERS AND COPYRIGHT

5.1 ACCREDITATION, DISCLAIMERS AND COPYRIGHT

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