Bluetooth LE

FCC / IC Test Report

FOR:

Apple Inc.

Model Name: A1513

Product Description: Bluetooth Device

FCC ID: BCGA1513
IC ID: 579C-A1513

47 CFR Part 15.247

RSS-247 Issue 1 & RSS-Gen Issue 4

TEST REPORT #: EMC_ APPLE-144-14002_15.247_BTLE_rev2
DATE: 2015-08-26

A2LA Accredited

IC recognized # 3462B

***CETECOM* Inc.**
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1 Assessment

The following device was evaluated against the applicable criteria specified in FCC rules Parts 15.247 of Title 47 of the Code of Federal Regulations and IC standard RSS-247 Issue 1, Section 5 and no deviations were ascertained during the course of the tests performed.

Company	Description	Model #
Apple Inc.	Bluetooth Device	A1513

Responsible for Testing Laboratory:

Date	Section	Name	Signature
2015-08-26	Compliance	Josie Sabado (Test Lab Manager)	Signing on behalf of Franz Engert (Compliance Manager)

Responsible for the Report:

Date	Section	Name	Signature
2015-08-26	Compliance	Douglas Antioco (EMC Engineer)	Douglas Antioco 2015.08.26 17:43:52 -07'00'

2 Administrative Data

2.1 Identification of the Testing Laboratory Issuing the Test Report

Company Name:	CETECOM Inc.
Department:	Compliance
Address:	411 Dixon Landing Road Milpitas, CA 95035 U.S.A.
Telephone:	+1 (408) 586 6200
Fax:	+1 (408) 586 6299
Compliance Manager:	Franz Engert
Responsible Project Leader:	Douglas Antioco

2.2 Identification of the Client

Applicant's Name:	Apple Inc.
Street Address:	1 Infinite Loop
City/Zip Code	Cupertino, CA 95014
Country	USA
Contact Person:	Richard Lee
Phone No.	(415)728-7644
Fax:	----------
e-mail:	richard.lee@apple.com

2.3 Identification of the Manufacturer

Manufacturer's Name:	Same as Applicant
Manufacturers Address:	---
City/Zip Code	---
Country	---

3 Equipment under Test (EUT)

3.1 Specification of the Equipment under Test

Model No:	A1513
HW / SW Revision :	Rev 1.0/v0095
FCC-ID:	BCGA1513
IC-ID:	579C-A1513
HVIN	A1513
PMN	A1513
Product Description:	Bluetooth Device
Technology / Type(s) of Modulation:	Bluetooth v4.2, LE, using FHSS with GFSK
Operating Frequency Ranges (MHz) / Channels:	Nominal band: 2400 – 2483.5; Center to center: 2402(ch 0) – 2480(ch 39), 40 channels
Antenna info:	Internal, Patch Antenna Documented max antenna gain(2.4GHz) = 3.5 dBi
Max. Output Power:	**Conducted (Measured):** 6.55 dBm (4.52 mW) **Radiated –EIRP (Calculated with documented max antenna gain):** 10.05 dBm (10.12 mW)
Rated Operating Voltage Range / Power Supply:	Battery Vmin: 3.0V dc/ Vnom: 3.7V dc / Vmax: 4.3V dc
Rated Operating Temperature Range:	0ºC to 35ºC
Other Radios included in the device:	None
EUT status	Hardware Version Rev 1.0

3.2 Identification of the Equipment under Test (EUT)

EUT #	Serial Number	HW Version	SW Version	Notes/Comments
1	C08M401BFY8F	Rev 1.0	v0095	Radiated Sample
2	C08NW06AGH16	Rev 1.0	v0095	Conducted Emissions (AC Power line) Sample
3	C08NN004GDDY	Rev 1.0	v0095	Conducted RF Sample

3.3 Identification of Accessory equipment

AE #	Type	Manufacturer	Model	Serial Number
1	USB Power Adapter	Apple	A1357	0010ADU00
2	Dummy Battery	Apple	N/A	N/A

3.4 Environmental conditions during Test:

The following environmental conditions were maintained during the course of testing:
Ambient Temperature: 20-25^{o}C
Relative humidity: 40-60%

3.5 Dates of Testing:

4/11/2014, 1/29/2015

3.6 Test mode of operation:

Mode	Data rate (Mbps)	Modulation scheme
Bluetooth LE	1.0	GFSK

4 Subject Of Investigation

The objective of the measurements done by Cetecom Inc. was to establish compliance with the requirements listed in FCC rules Part 15.247 of Title 47 of the Code of Federal Regulations and Radio Standard Specification RSS-247 Issue 1, Section 5 of Industry Canada.

This test report is to support a request for new equipment authorization under the FCC ID: **BCGA1513.**

All testing was applied to the product referred to in Section 3 as the EUT.

The EUT was tested on the lowest, middle and highest channel of its specified operating range. For radiated measurements, all data in this report shows the worst case between horizontal and vertical antenna polarizations and for all orientations of the EUT.

5 Summary of Measurement Results

Test Specification	Test Case	Temperature and Voltage Conditions	Mode	Pass	Fail	NA	NP	Result
§15.247(e) RSS-247 5.2(1)	Power Spectral Density	Nominal	Bluetooth LE	■	☐	☐	☐	Complies
§15.247(a)(1) RSS-247 5.2(2)	Emission Bandwidth	Nominal	Bluetooth LE	■	☐	☐	☐	Complies
§15.247(b)(1) RSS-247 5.4(4)	Maximum Conducted Output Power and EIRP	Nominal	Bluetooth LE	■	☐	☐	☐	Complies
§15.247(d) RSS-247 5.5	Band edge compliance-Unrestricted Band Edges	Nominal	Bluetooth LE	■	☐	☐	☐	Complies
§15.247/15.209/15.205 RSS-Gen 8.9/ 8.10	Band edge compliance-Restricted Band Edges	Nominal	Bluetooth LE	■	☐	☐	☐	Complies
§15.247(d) §15.209	TX Spurious emissions-Conducted	Nominal	Bluetooth LE	☐	☐	☐	■	See Note 1
§15.247(d) §15.209 RSS-Gen 6.13	TX Spurious emissions-Radiated	Nominal	Bluetooth LE	■	☐	☐	☐	Complies
§15.207(a) RSS Gen 8.8	AC Conducted Emissions	Nominal	Bluetooth LE	■	☐	☐	☐	Complies

Note: NA= Not Applicable; NP= Not Performed.

1. Conducted unwanted emissions test against non-restricted band limits is NOT PERFORMED except at the authorized band edge (see band edge compliance test) since radiated spurious emissions is tested against more stringent restricted band limits over the complete measurement range (9kHz to 26GHz) has passed.

6 Measurements

6.1 Radiated Measurement Procedure

The radiated measurement is performed according to:
ANSI C63.10 (2013)

- The exploratory measurement is accomplished by running a matrix of 16 sweeps over the required frequency range with R&S Test-SW EMC32 for 4 positions of the turntable, two orthogonal positions of the EUT and both antenna polarizations. This procedure exceeds the requirement of the above standards to cover the 3 orthogonal axis of the EUT. A max peak detector is utilized during the exploratory measurement. The Test-SW creates an overall maximum trace for all 12 sweeps and saves the settings for each point of this trace. The maximum trace is part of the test report.
- The 10 highest emissions are selected with an automatic algorithm of EMC32 searching for peaks in the noise floor and ensuring that broadband signals are not selected multiple times.
- The maxima are then put through the final measurement and again maximized in a 90deg range of the turntable, fine search in frequency domain and height scan between 1m and 4m.
- The above procedure is repeated for all possible ways of power supply to EUT and for all supported modulations.
- In case there are no emissions above noise floor level only the maximum trace is reported as described above.
- The results are split up into up to 4 frequency ranges due to antenna bandwidth restrictions. A magnetic loop is used from 9kHz to 30MHz, a Biconlog antenna is used from 30MHz to 1GHz, two different horn antennas are used to cover frequencies up to 40GHz.

Radiated Measurement Uncertainty:

	Uncertainty in dB Radiated <30MHz	**Uncertainty in dB Radiated 30MHz - 1GHz**	**Uncertainty in dB Radiated > 1GHz**
Standard Deviation k=1	**2.48**	**1.94**	**2.16**
95% Confidence Interval in dB	**4.86**	**3.79**	**4.24**
95% Confidence Interval in dB in Delta to Result	**+/-2.5 dB**	**+/-2.0 dB**	**+/- 2.3dB**

6.1.1 Sample Calculations for Radiated Measurements

Measurements from the Spectrum Analyzer/ Receiver are used to calculate the Field Strength, taking into account the following parameters:

1. Measured reading in dBµV
2. Cable Loss between the receiving antenna and SA in dB and
3. Antenna Factor in dB/m

FS (dBµV/m) = Measured Value on SA (dBµV)+ Cable Loss (dB)+ Antenna Factor (dB/m)
Eg:

Frequency (MHz)	Measured SA (dBµV)	Cable Loss (dB)	Antenna Factor Correction (dB)	Field Strength Result (dBµV/m)
1000	80.5	3.5	14	98.0

All radiated measurement plots in this report are taken from a test SW that calculates the Field Strength based on the above equation.

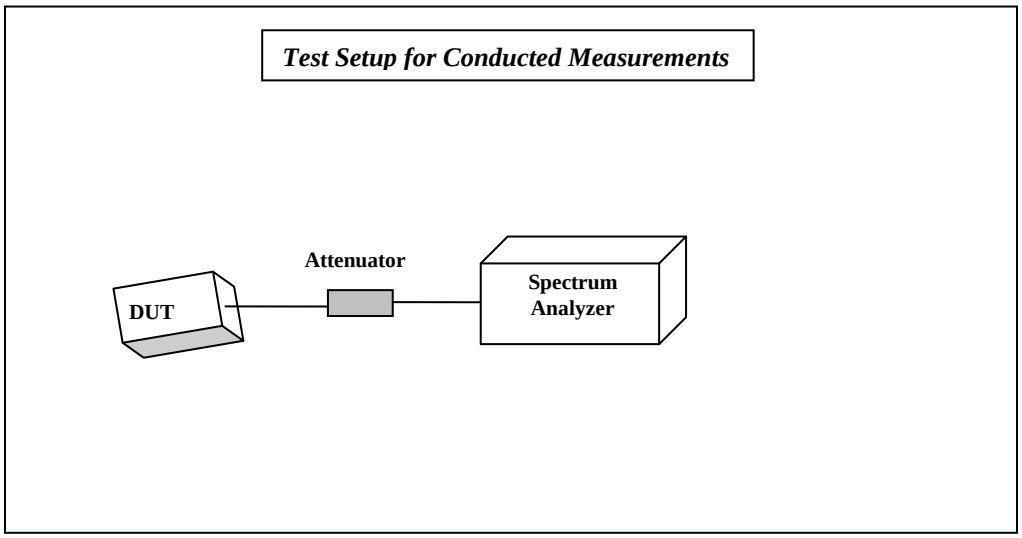
6.2 Conducted Emissions Measurement Procedure (AC Power Line)

Conducted Emissions measurements done according to:

ANSI C63.10 (2013)

6.3 RF Conducted Measurement Procedure

Measurement according to FCC KDB 558074 D01 v03r03 (DTS Meas Guidance)



1. Connect the equipment as shown in the above diagram.
2. Adjust the settings by entering test commands for TX/RX mode on/off, changing channels, modulations and data rates.
3. Measurements are to be performed with the EUT set to the low, middle and high channels.

Measurement Uncertainty:

	Uncertainty in dB Conducted measurement
standard deviation k=1	0.63
95% confidence interval in dB	1.24
95% confidence interval in dB in delta to Result	+-0.7dB

7 Maximum Conducted Output Power and EIRP

7.1 Limits:

Maximum Output Power:
FCC §15.247 (b)(3): 1W
IC RSS-247 issue 1, Section 5.4(4): 1W
EIRP:
IC RSS-247 issue 1, annex 8.4(2): 4W

7.2 Test Conditions:

Tnom: 21°C; Vnom: 3.7V

7.3 Test Procedure

Measurement according to FCC KDB 558074 D01 v03r03 section 9.2.2.4

Maximum conducted (average) output power
Method AVGSA-2 (trace averaging across on and off times of the EUT transmissions, followed by duty cycle correction)

Span ≥ 1.5 times the OBW.
RBW = 1-5% of the OBW, not to exceed 1 MHz.
VBW ≥ 3 x RBW
Sweep points ≥ 2 × span / RBW. (This gives bin-to-bin spacing ≤ RBW/2, so that narrowband signals are not lost between frequency bins.)
Sweep time = auto.
Detector = RMS (*i.e.*, power averaging), if available. Otherwise, use sample detector mode.
Trace = average at least 100 traces in power averaging (*i.e.*, RMS) mode; however, the number of traces to be averaged shall be increased above 100 as needed such that the average accurately represents the true average over the on and off periods of the transmitter.
- Do not use sweep triggering. Allow the sweep to "free run".
- Compute power by integrating the spectrum across the OBW of the signal using the instrument's band power measurement function with band limits set equal to the OBW band edges..
- Add 10 log (1/x), where x is the duty cycle, to the measured power in order to compute the average power during the actual transmission times (because the measurement represents an average over both the on and off times of the transmission). For example, add 10 log (1/0.25) = 6 dB if the duty cycle is 25 %.

7.4 Test Data

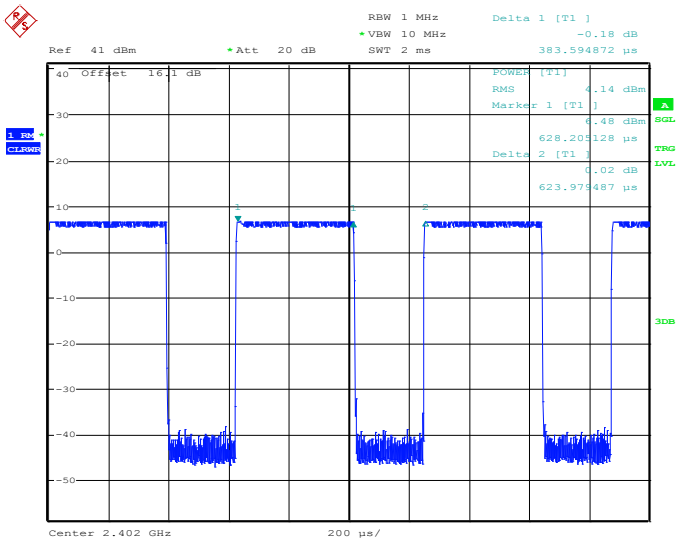
Maximum Conducted Output Power (dBm)							
Limit = 30 dBm		Frequency (MHz)					
		2412 Channel 1		2437 Channel 6		2462 Channel 11	
Mode	Duty Cycle CF	Measured	Corrected	Measured	Corrected	Measured	Corrected
Bluetooth LE	2.11	4.44	6.55	4.23	6.34	4.13	6.24

Calculated Radiated Output Power EIRP (dBm)				
Limit = 36 dBm		Frequency (MHz)		
Mode	Antenna Gain (dBi)	2412 Channel 1	2437 Channel 6	2462 Channel 11
Bluetooth LE	3.5	10.05	9.84	9.74

Declared Antenna Gain in the 2.4GHz band: 3.5 dBi

DC = Txon / Txon + Txoff = 0.3836 ms / 0.6240 ms = 0.615 or 61.5%

DCCF = 10 log (1/x); x = duty cycle
DCCF = 10 log (1/0.615) = 2.11



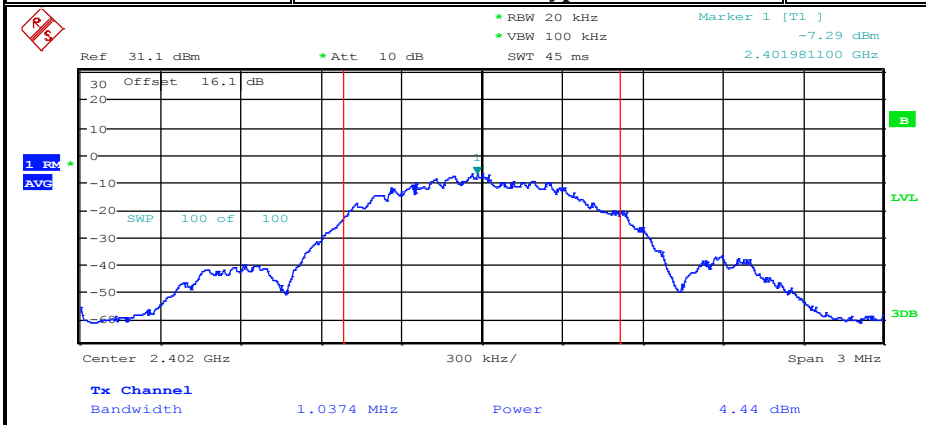
Date: 29.JAN.2015 17:28:16

7.5 Measurement Result

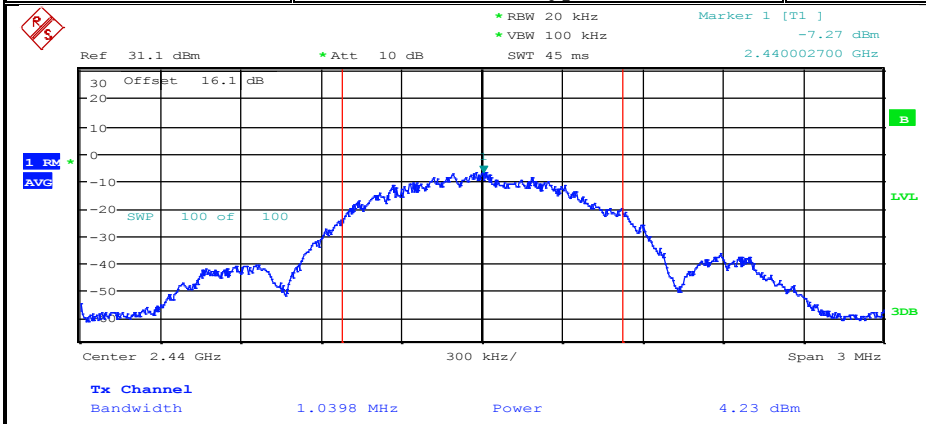
Pass.

7.6 Measurement Plots:

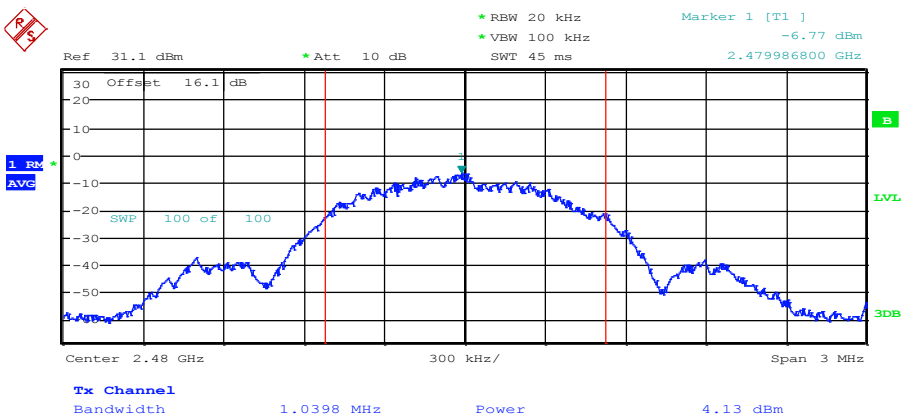
Maximum Peak Conducted Power		
Ch.0 / 2402 MHz	**Modulation/Packet Type: GFSK**	**Data Rate: 1 Mbps**



Ch.19 / 2440 MHz	Modulation/Packet Type: GFSK	Data Rate: 1 Mbps



Ch.39 / 2480 MHz	Modulation/Packet Type: GFSK	Data Rate: 1 Mbps



8 Power Spectral Density

8.1 Limits:

§ 15.247 (e) & RSS-247 Section 5.2 (2)

For digitally modulated systems, the peak 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.

8.2 Test Conditions:

Tnom: 21°C; Vnom: 3.7V

8.3 Measurement procedure

Measurement according to FCC KDB 558074 D01 V03R03 section 10.5

Maximum power spectral density
Method AVGPSD-2 (trace averaging across on and off times of the EUT transmissions, followed by duty cycle correction)
Center Frequency = DTS channel center frequency.
Span ≥ 1.5 times the OBW.
RBW = 3 kHz ≤ RBW ≤ 100 kHz.
VBW ≥ 3 x RBW
Detector = power averaging (RMS) or sample detector (when RMS not available)
Sweep time = auto couple
Trace = averaging (RMS) mode over a minimum of 100 traces
- Ensure that the number of measurement points in the sweep ≥ 2 x span/RBW.
- Do not use sweep triggering. Allow sweep to "free run".
- Use the peak marker function to determine the maximum amplitude level.
- Add 10 log (1/x), where x is the duty cycle measured in step (a, to the measured PSD to compute the average PSD during the actual transmission time.
- If resultant value exceeds the limit, then reduce RBW (no less than 3 kHz) and repeat (note that this may require zooming in on the emission of interest and reducing the span in order to meet the minimum measurement point requirement as the RBW is reduced).

8.4 Test Data Results:

Maximum Power Spectral Density (dBm)							
Limit = 8 dBm in any 3 KHz band		**Frequency (MHz)**					
		2412 Channel 1		**2437 Channel 6**		**2462 Channel 11**	
Mode	**Duty Cycle CF**	Measured	Corrected	Measured	Corrected	Measured	Corrected
Bluetooth LE	**2.11**	-7.29	-5.18	-7.27	-5.16	-6.77	-4.66

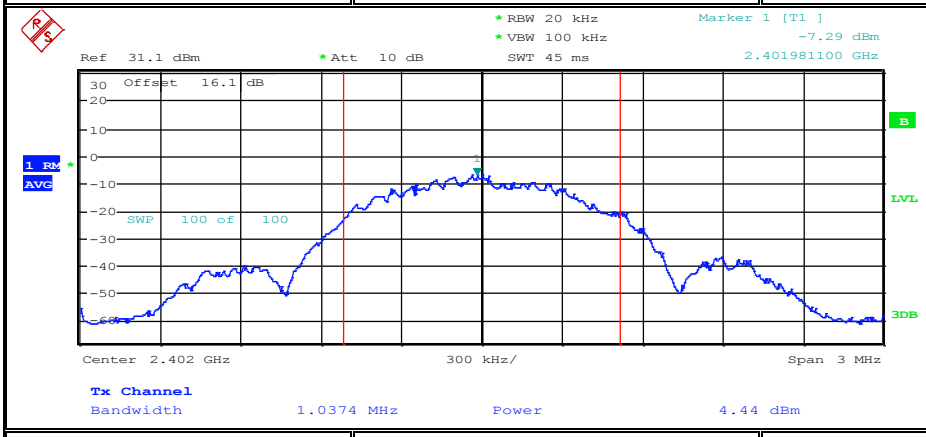
8.4.1 Measurement Result

Pass.

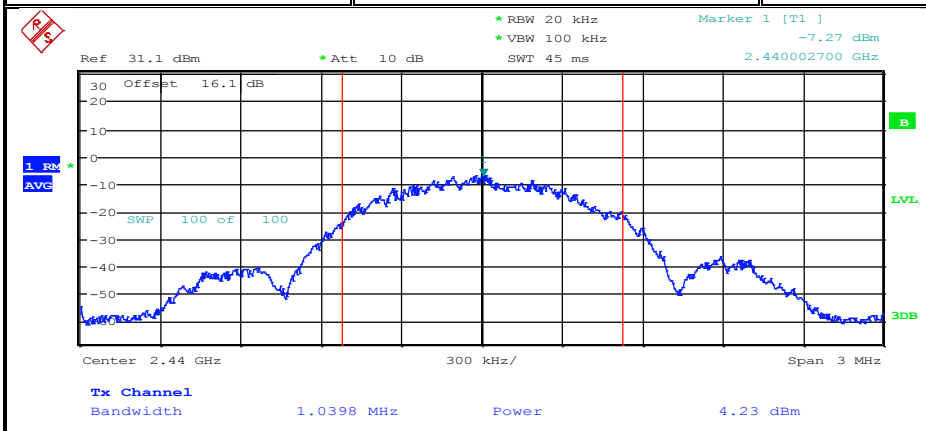
8.5 Measurement Plots:

Maximum Power Spectral Density

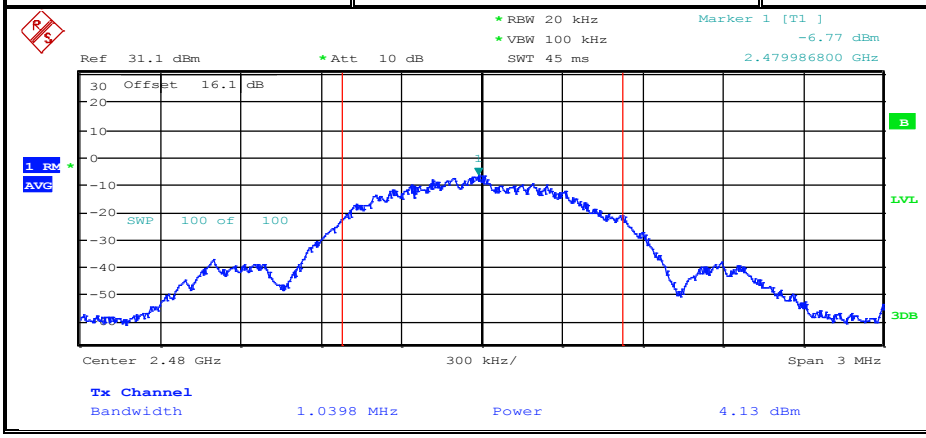
Ch.0 / 2402 MHz	Modulation: GFSK	Data Rate: 1 Mbps



Ch.19 / 2440 MHz	Modulation: GFSK	Data Rate: 1 Mbps



Ch.39 / 2480 MHz	Modulation: GFSK	Data Rate: 1 Mbps



9 Band Edge Compliance – Unrestricted Band Edges

9.1 Limits: § FCC15.247 (d) / RSS-247 Section 5.5

FCC15.247 (d) / RSS-247 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) or RSS-Gen 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).

9.2 Test Conditions:

Tnom: 21°C; Vnom: 3.7V

9.3 Measurement Procedure:

Conducted Measurement according to FCC KDB 558074 D01 v03r03 section 11

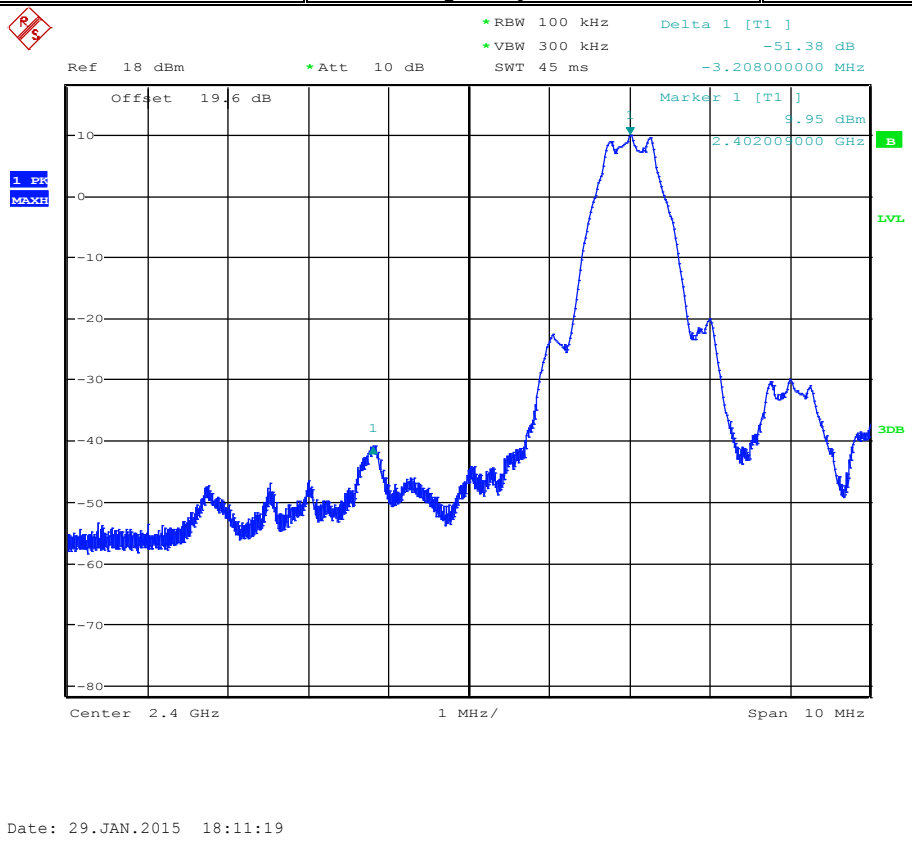
Establish a reference level by using the following procedure:
a)Set instrument center frequency to DTS channel center frequency.
b)Set the span to ≥1.5 times the DTS bandwidth.
c)Set the RBW = 100 kHz.
d)Set the VBW ≥3 x RBW.
e)Detector = peak.
f)Sweep time = auto couple.
g)Trace mode = max hold.
h)Allow trace to fully stabilize.
i)Use the peak marker function to determine the maximum PSD level. Note that the channel found to contain the maximum PSD level can be used to establish the reference level.
Emission level measurement
a)Set the center frequency and span to encompass frequency range to be measured.
b)Set the RBW = 100 kHz.
c)Set the VBW ≥3 x RBW.
d)Detector = peak.
e)Sweep time = auto couple.
f)Trace mode = max hold.
g)Allow trace to fully stabilize.
h)Use the peak marker function to determine the maximum amplitude level.

9.4 Measurement Result

Pass.

9.4.1 Measurement Plots:

Lower Unrestricted Band Edge		
Ch. Low / 2402MHz / Peak	**Band Edge Frequency: 2.4 GHz**	**GFSK**



The peak power in 100 KHz bandwidth outside the authorized frequency band is attenuated by more than 30 dB relative to the in-band peak power spectral density level in 100 KHz, as shown by the delta marker in this plot.

10 Band Edge Compliance – Restricted Band Edges

10.1 Limits: §15.247/15.209/15.205 & RSS-Gen 8.9/ 8.10

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			

(b) Except as provided in paragraphs (d) and (e) of this section, the field strength of emissions appearing within these frequency bands shall not exceed the limits shown in § 15.209. At frequencies equal to or less than 1000 MHz, compliance with the limits in § 15.209 shall be demonstrated using measurement instrumentation employing a CISPR quasi-peak detector. Above 1000 MHz, compliance with the emission limits in § 15.209 shall be demonstrated based on the average value of the measured emissions. The provisions in § 15.35 apply to these measurements.

*PEAK LIMIT= 74dBµV/m

*AVG. LIMIT= 54dBµV/m

10.2 Test Conditions:

Tnom: 21°C; Vnom: 3.7V

10.3 Measurement Procedure:

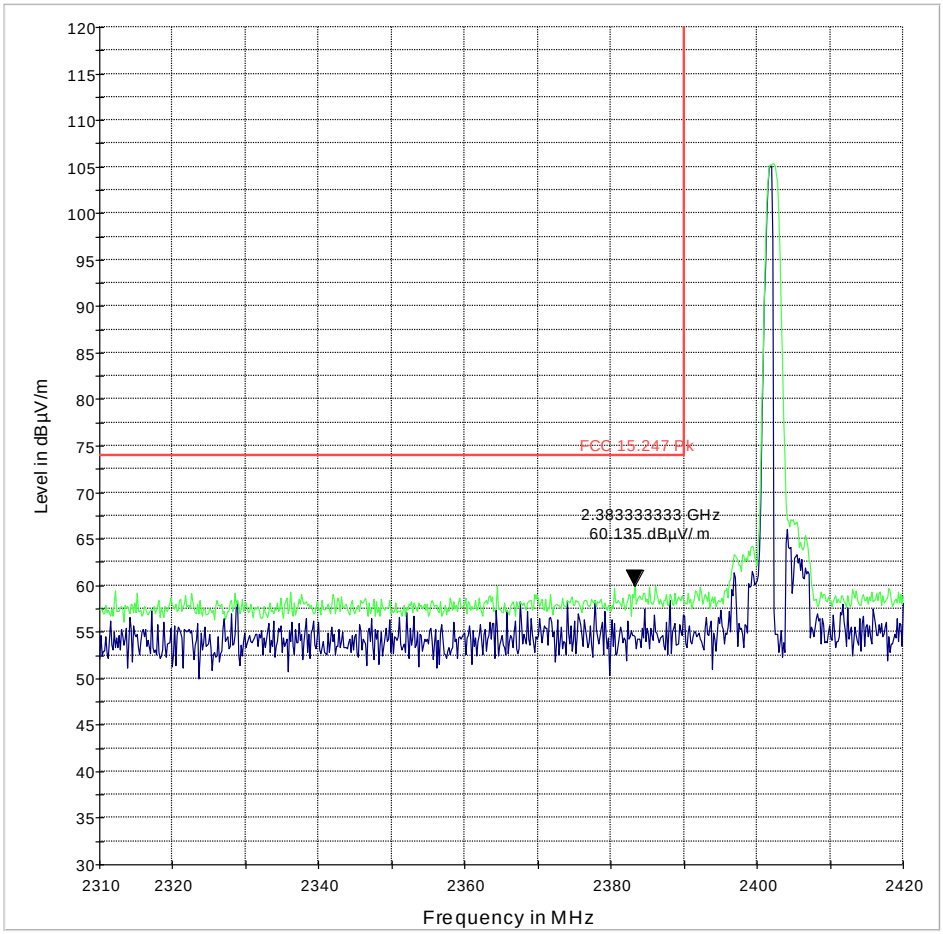
Radiated Measurements were performed according to FCC KDB 558074 D01 V03R03 section 12.1

10.4 Measurement Result

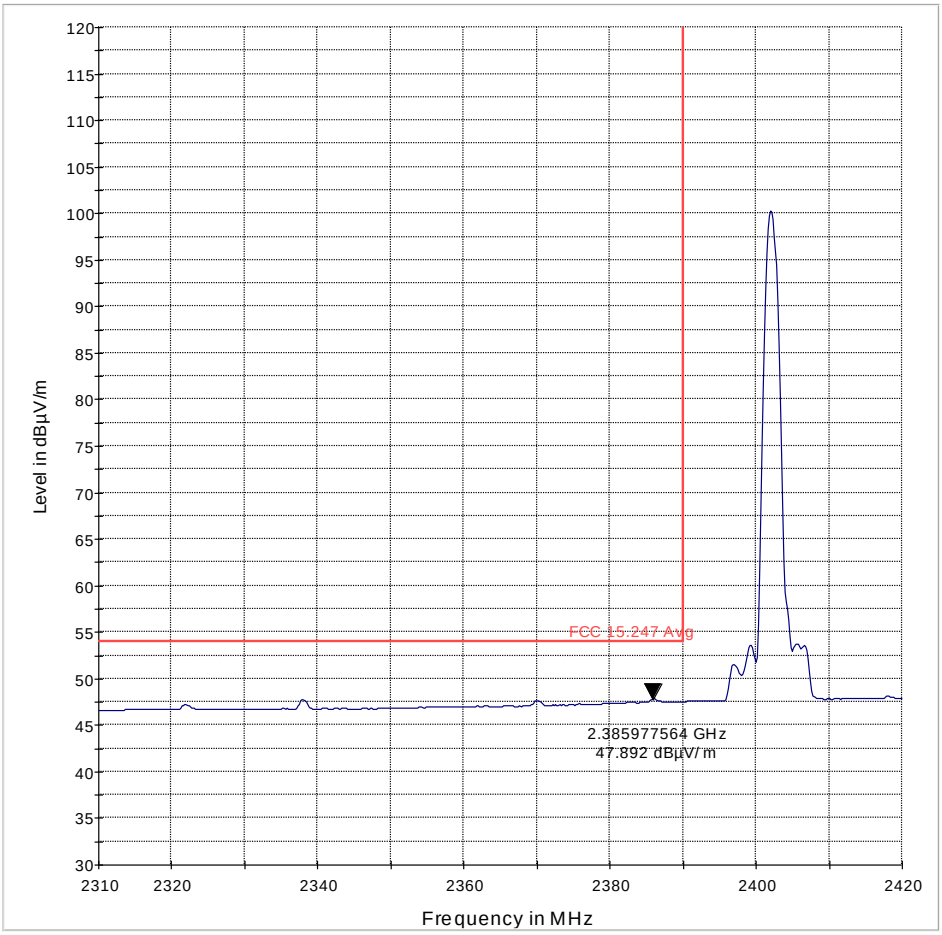
Pass.

10.4.1 Measurement Plots:

Lower Band Edge		
Ch. Low / 2402MHz / Peak	**Restricted Bandedge Frequency: 2.39 GHz**	**GFSK**

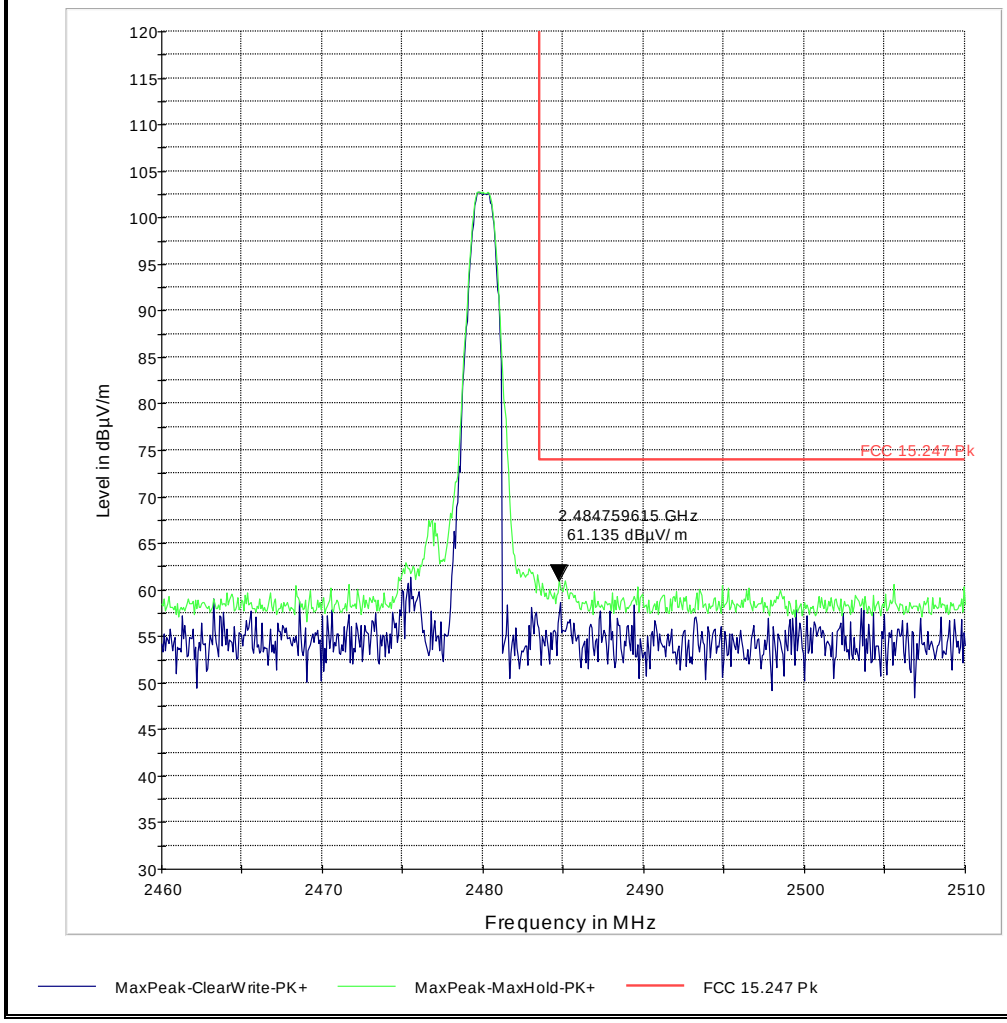


Lower Band Edge		
Ch. Low / 2402MHz / Average	**Restricted Band Edge Frequency: 2.39 GHz**	**GFSK**

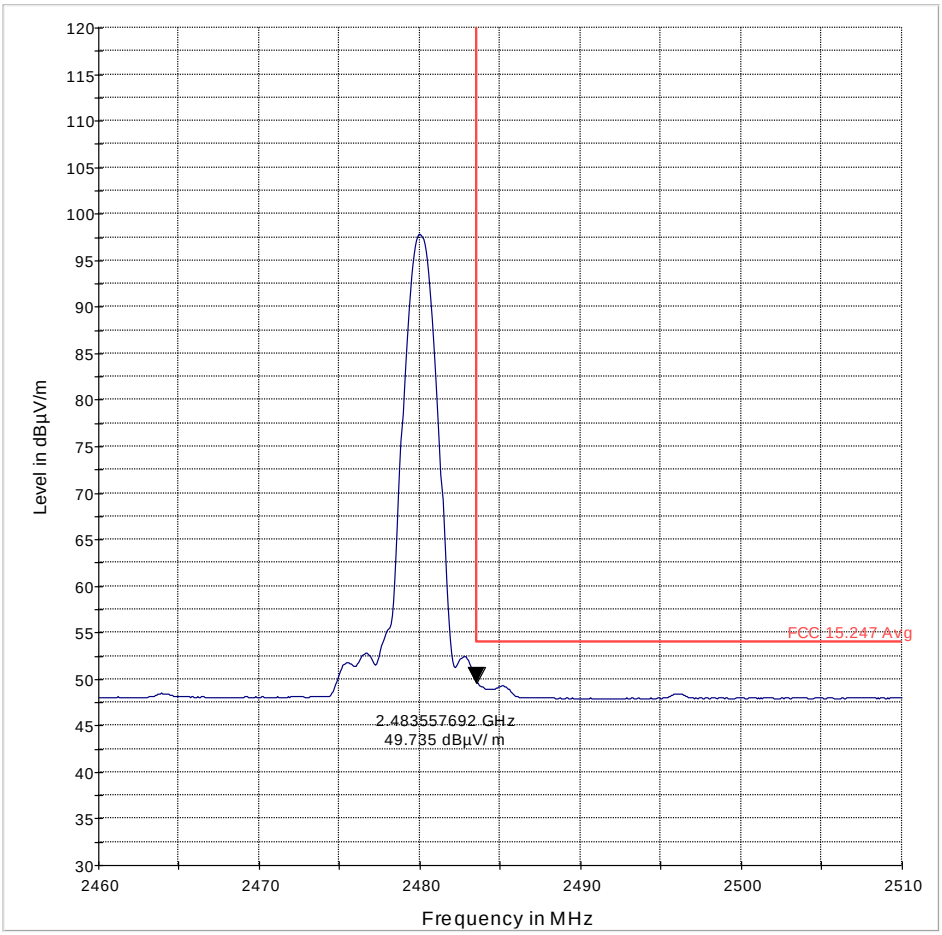


Measurement Plots

Upper Restricted Band		
Ch. High / 2480MHz / Peak	**Frequency Range: 2.4835 – 2.5 GHz**	**GFSK**



Upper Restricted Band		
Ch. High / 2480MHz / Avg	**Frequency Range: 2.4835 – 2.5 GHz**	**GFSK**



11 Occupied Bandwidth (6dB and 99% Bandwidth)

11.1 Limits:

§15.247 (a)(2)
Systems using digital modulation techniques may operate in the 2400–2483.5 MHz band. The minimum 6 dB bandwidth shall be at least 500 kHz.

RSS-247 Section 5.2 (1)
The minimum 6 dB bandwidth shall be 500 kHz.

11.2 Test Conditions:

Tnom: 22 °C; Vnom: 3.7V

11.3 Test Procedure

Measurement according to FCC KDB 558074 D01 v03r03 section 8.1

For 6 dB bandwidth:
Spectrum Analyzer settings:
Span= Wide enough to capture the entire emission bandwidth
RBW= 100 KHz
VBW≥ 3xRBW
Detector: Peak-
Sweep Time: Auto
Trace = Max Hold
Measure the maximum width of the emission that is constrained by the frequencies associated with the two outermost amplitude points (upper and lower frequencies) that are attenuated by 6 dB relative to the peak level measured in the fundamental emission.

For 99% bandwidth:
Use the occupied bandwidth in the measurement function of the spectrum analyzer with power bandwidth setting at 99%

11.4 Test Data Results:

2.4 GHz Band

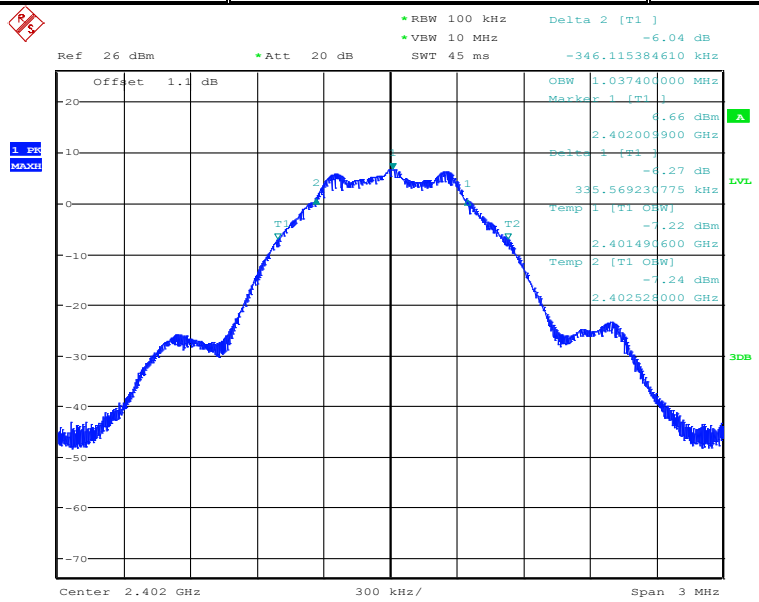
Occupied Bandwidth (MHz)						
Mode	Frequency (MHz)					
	2404 Channel 0		2440 Channel 19		2480 Channel 39	
	6dB (KHz)	99% (MHz)	6dB (KHz)	99% (MHz)	6dB (KHz)	99% (MHz)
Bluetooth LE	681.69	1.0374	682.26	1.0395	692.5	1.0398

11.5 Measurement Result

Pass.

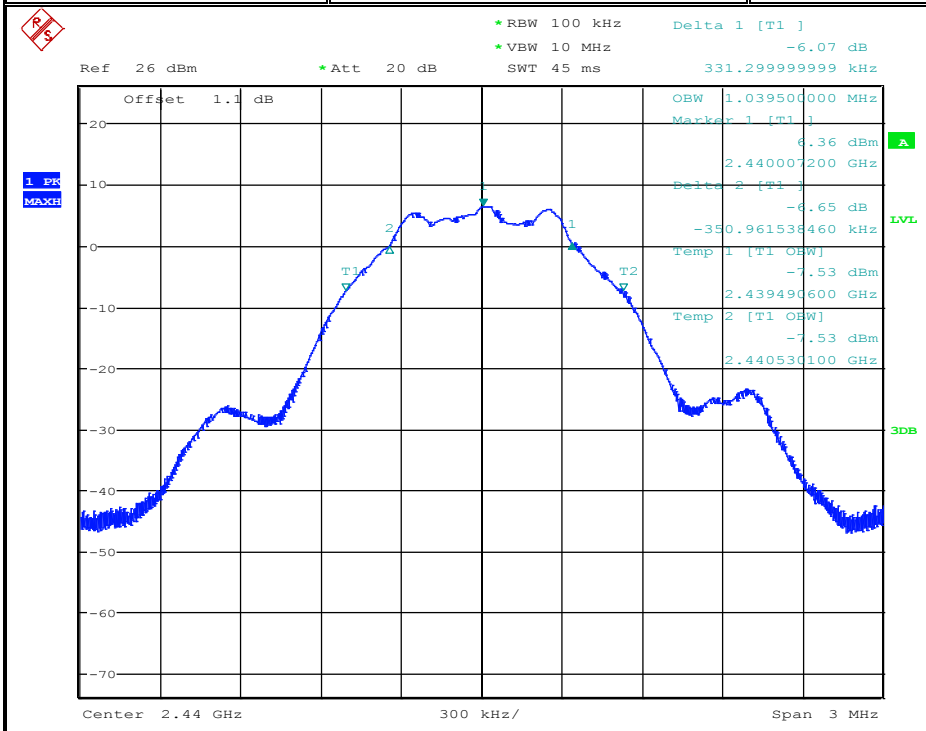
11.6 Measurement Plots:

6 dB and 99% Bandwidth		
Ch.0 / 2402 MHz	Modulation: GFSK	Data Rate: 1 Mbps



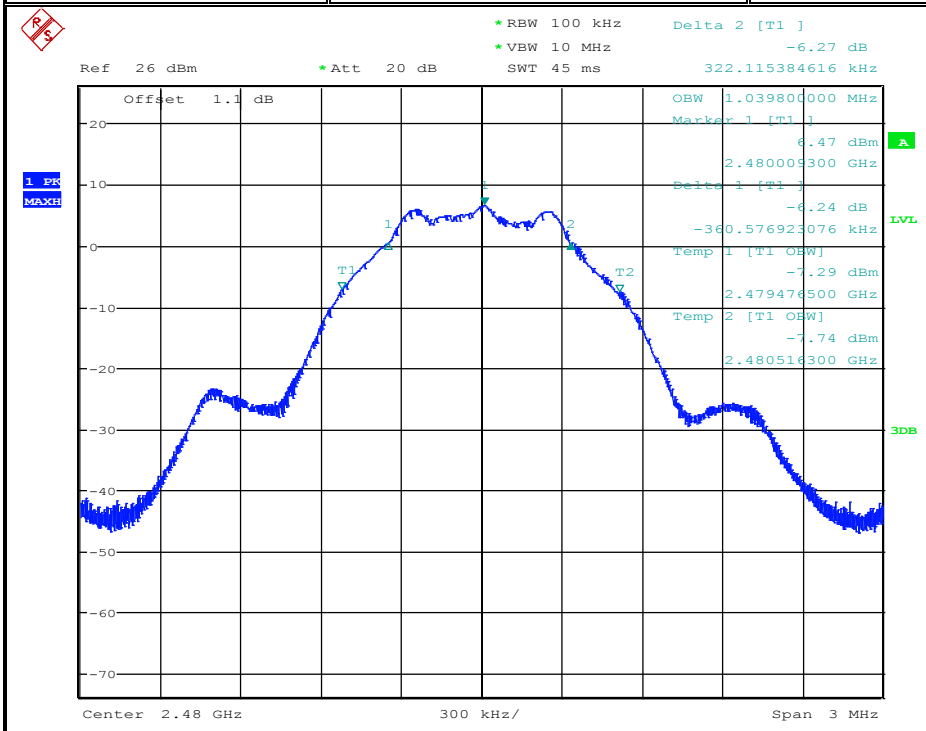
6 dB and 99% Bandwidth

Ch.19 / 2440 MHz	Modulation: GFSK	Data Rate: 1 Mbps



6 dB and 99% Bandwidth

Ch.39 / 2480 MHz	Modulation: GFSK	Data Rate: 1 Mbps



12 Radiated Transmitter Spurious Emissions - Restricted Bands

12.1 Limits:

§15.247/15.205/15.209 & RSS-Gen 8.9/ 8.10 (restricted bands)
(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			

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)).

*PEAK LIMIT= 74dBµV/m
*AVG. LIMIT= 54dBµV/m

Table 1: Field strength limits table above 30 MHz

Frequency of emission (MHz)	Field strength (µV/m)
30–88	100 (40dBµV/m)
88–216	150 (43.5 dBµV/m)
216–960	200 (46 dBµV/m)
Above 960	500 (54 dBµV/m)

Table 2: Field strength limits table below 30 MHz

Frequency of emission (MHz)	Field strength (µV/m)	Measurement Distance (m)
0.009–0.490	2400/F(kHz)	300
0.490–1.705	24000/F(kHz)	30
1.705–30.0	30	30

Radiated spurious emissions shall be measured for the transmit frequencies, transmit power, and data rate for the lowest, middle and highest channel in each frequency band of operation and for the highest gain antenna for each antenna type, and using the appropriate parameters and test requirements described in 5.4.
The highest (or worst-case) data rate shall be recorded for each measurement.

12.2 Test Conditions:

Tnom: 23 °C; Vnom: 3.7V
Test mode: *Modulation:* GFSK

12.3 Measurement procedure:

Measurement according to ANSI C63.10:2013 (also refer to section 6.1 in this test report)

Analyzer Settings:
From 9 KHz – 30 MHz
RBW = 9 KHz
Detector: Peak

From 30 MHz – 1 GHz
Detector = Peak / Quasi-Peak
RBW=120 KHz (<1GHz)

Above 1 GHz
Detector = Peak / Average
RBW= 1MHz

Test mode: *Modulation:* GFSK- the highest conducted output power.
Plots in this report represent the worst case emissions for horizontal and vertical antenna polarizations and for three orientations of the EUT.

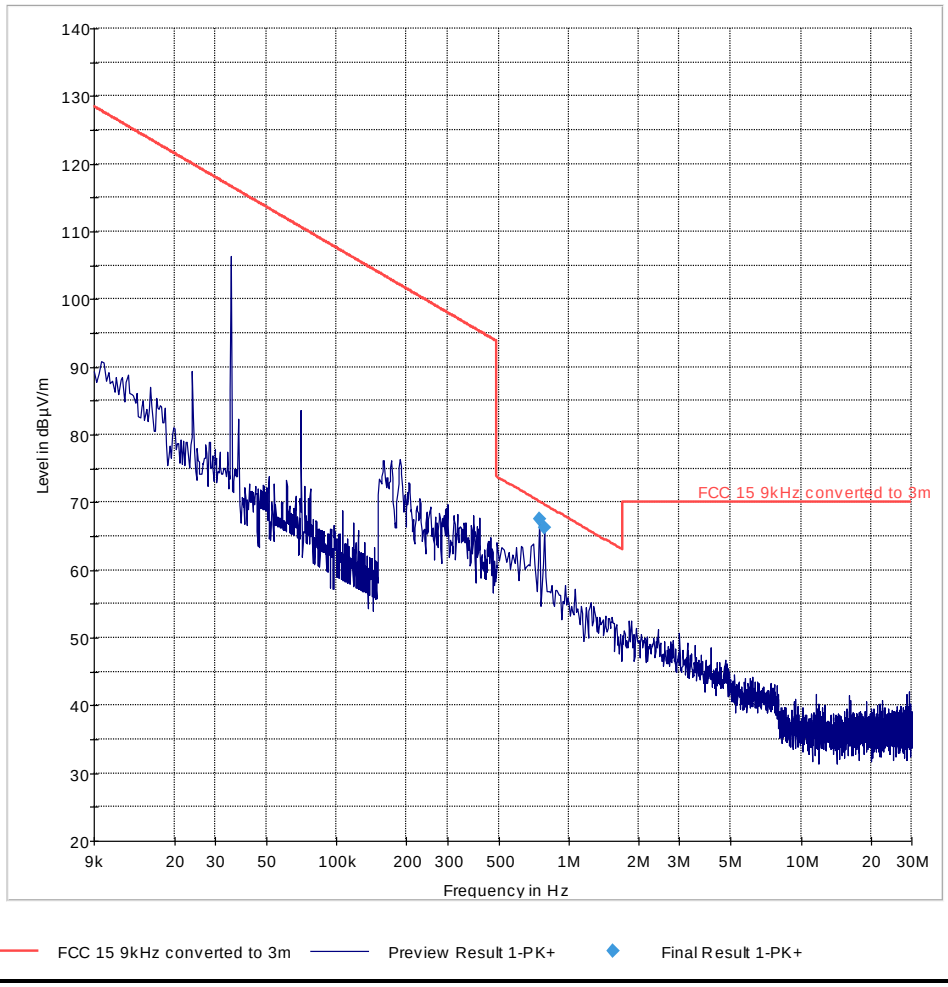
12.3.1 Measurement Result

Pass.

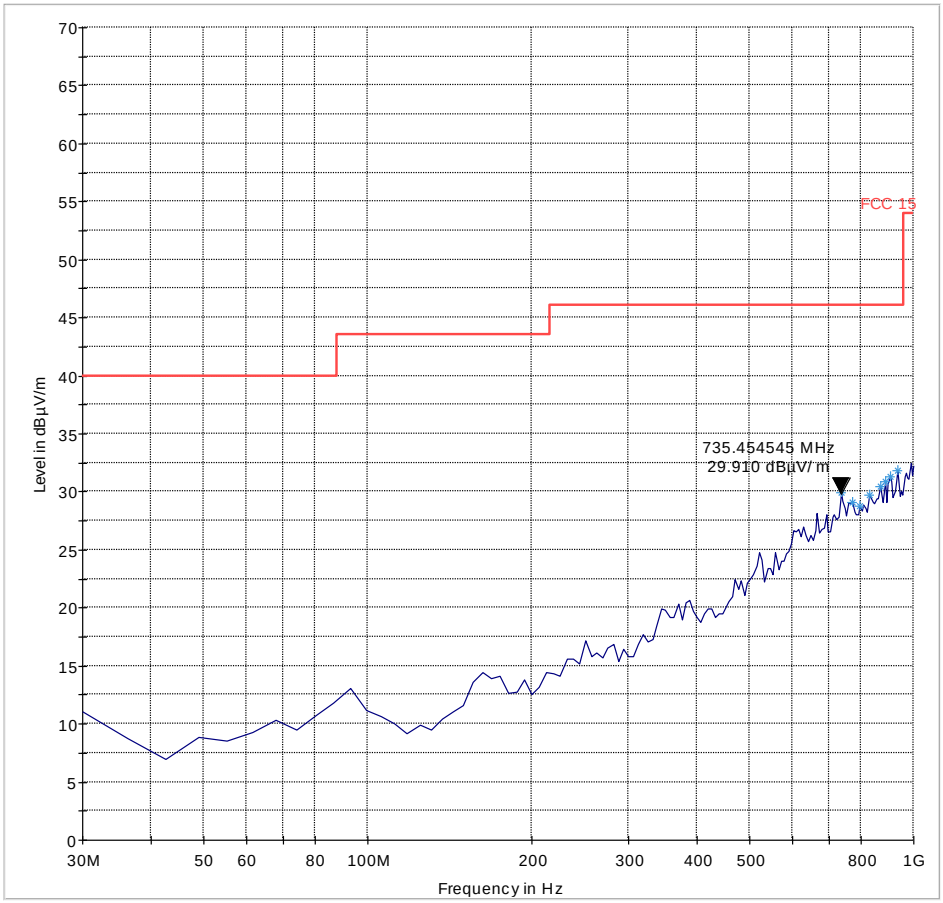
12.3.2 Measurement Plots:

Plots reported here represent the worst case emissions for horizontal and vertical antenna polarizations and for three orientations of the EUT.

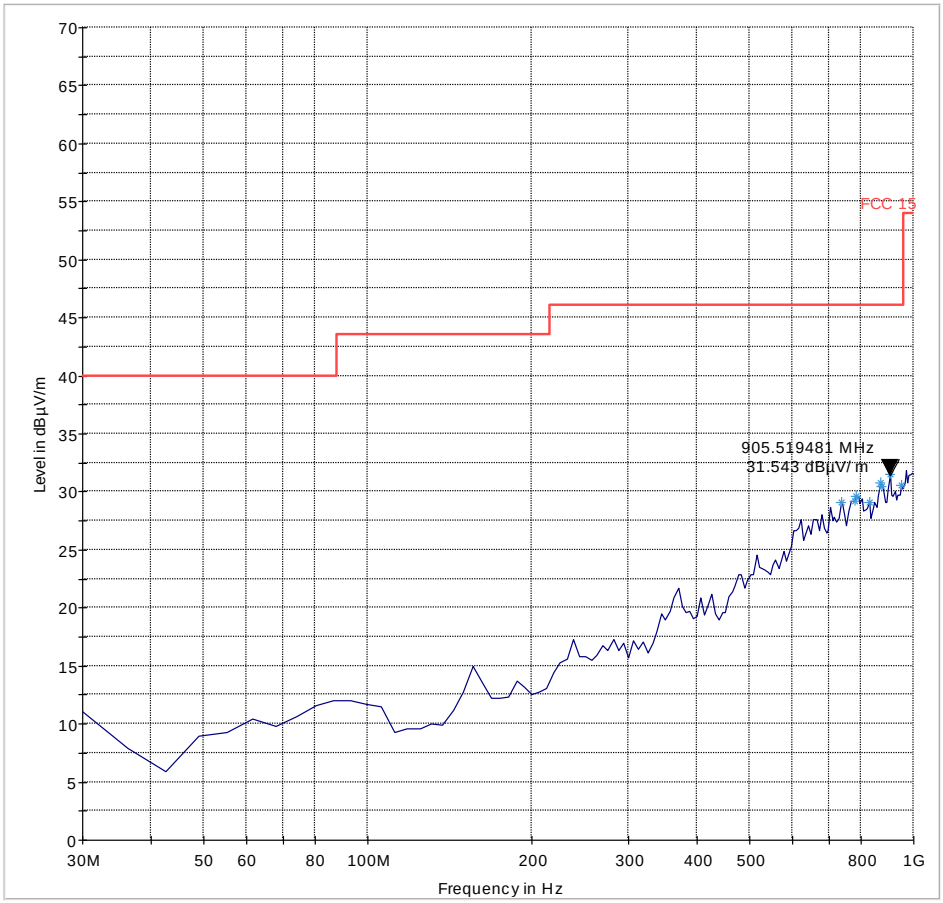
TX Radiated Spurious Emissions: 9kHz – 30MHz			
Ch. Mid	**Mode: Bluetooth LE**	**Modulation: GFSK**	**Data Rate: 1 Mbps**



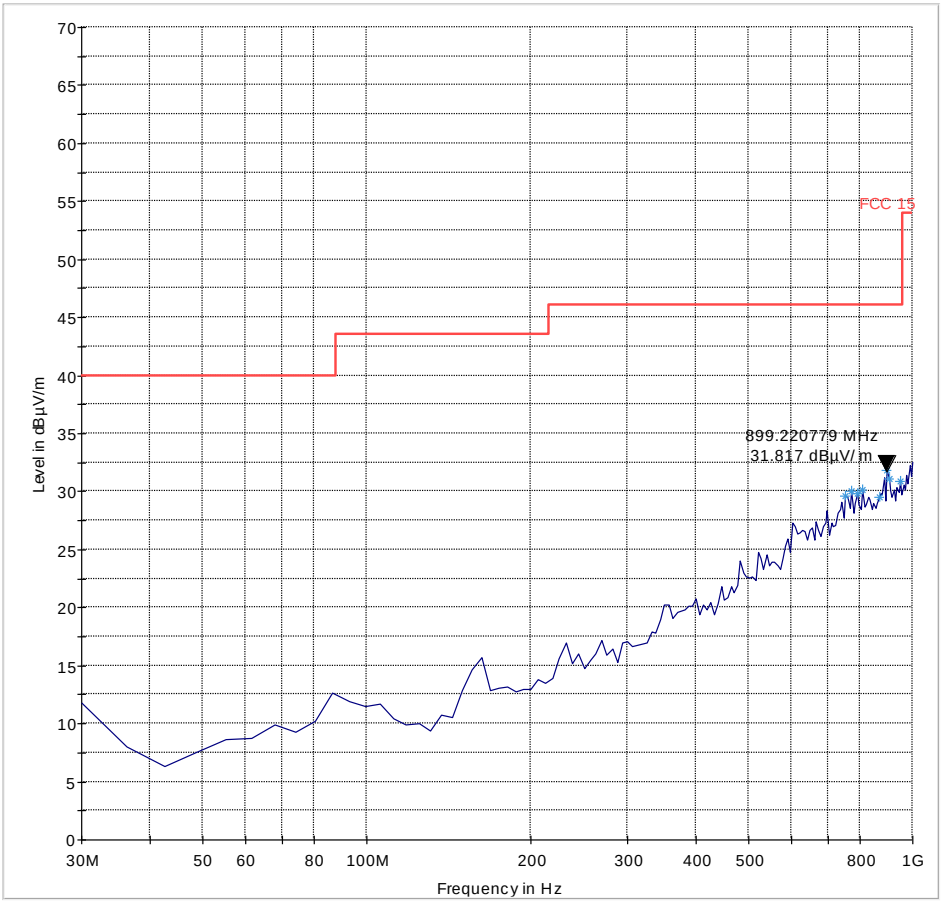
TX Radiated Spurious Emission: 30 MHz – 1GHz			
Ch. Low	**Mode: Bluetooth LE**	**Modulation: GFSK**	**Data Rate: 1 Mbps**



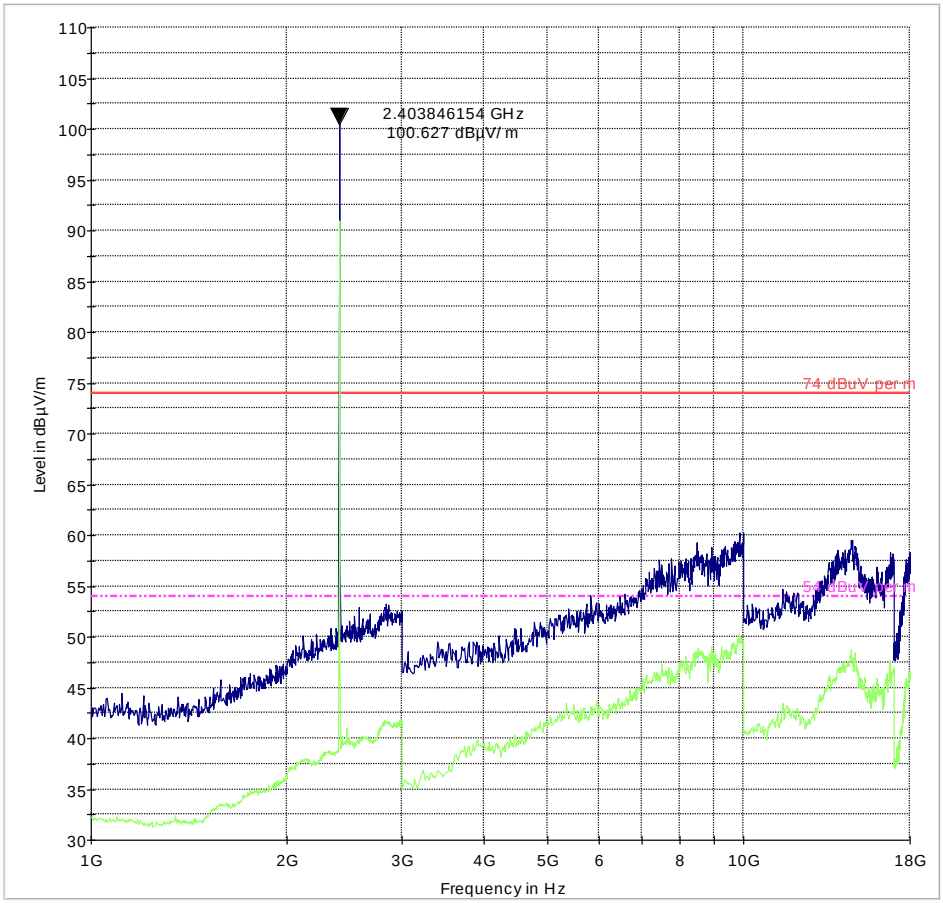
TX Radiated Spurious Emission: 30 MHz – 1GHz			
Ch. Mid	**Mode: Bluetooth LE**	**Modulation: GFSK**	**Data Rate: 1 Mbps**



TX Radiated Spurious Emission: 30 MHz – 1GHz			
Ch. High	**Mode: Bluetooth LE**	**Modulation: GFSK**	**Data Rate: 1 Mbps**

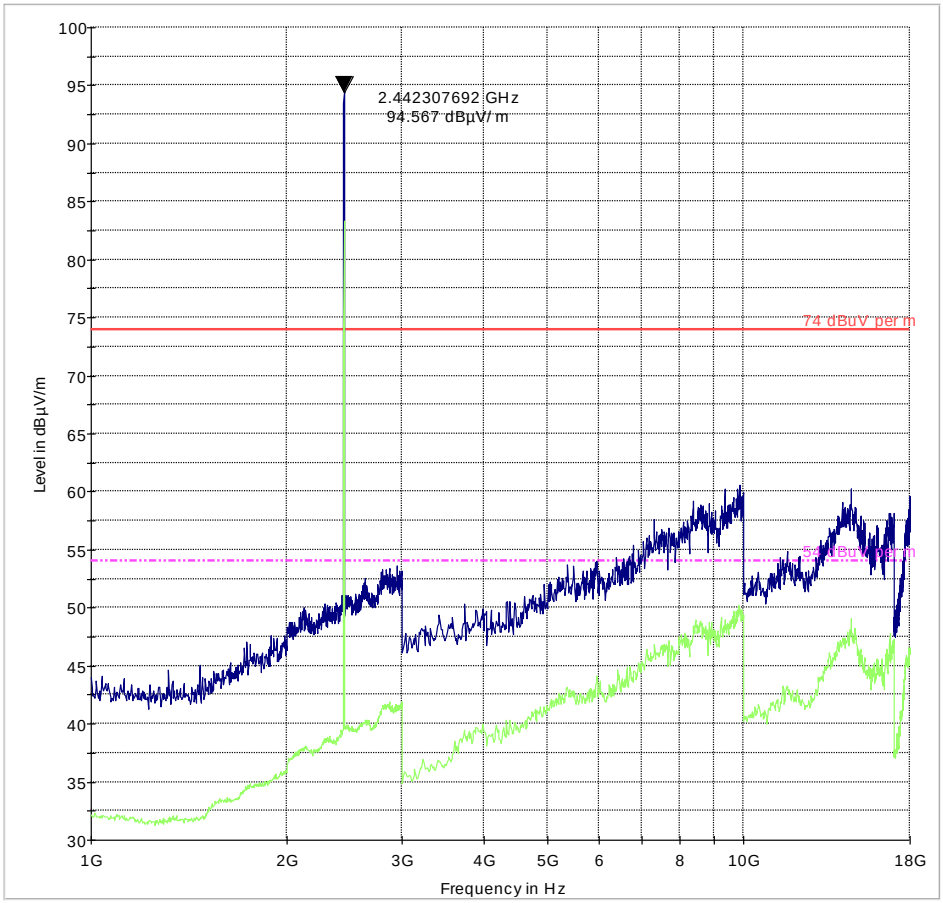


TX Radiated Spurious Emission: 1 GHz – 18 GHz			
Ch. Low	**Mode: Bluetooth LE**	**Modulation: GFSK**	**Data Rate: 1 Mbps**



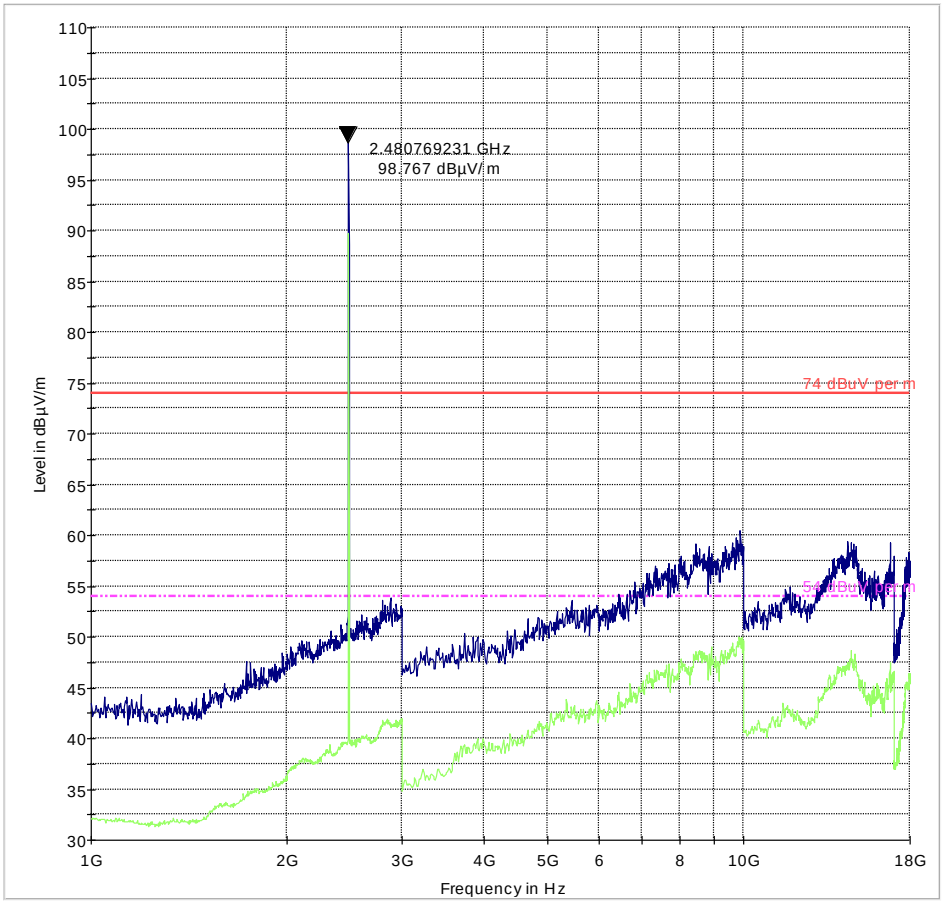
Note: Emission above limit is Tx Signal

TX Radiated Spurious Emission: 1 GHz – 18 GHz			
Ch. Mid	**Mode: Bluetooth LE**	**Modulation: GFSK**	**Data Rate: 1 Mbps**



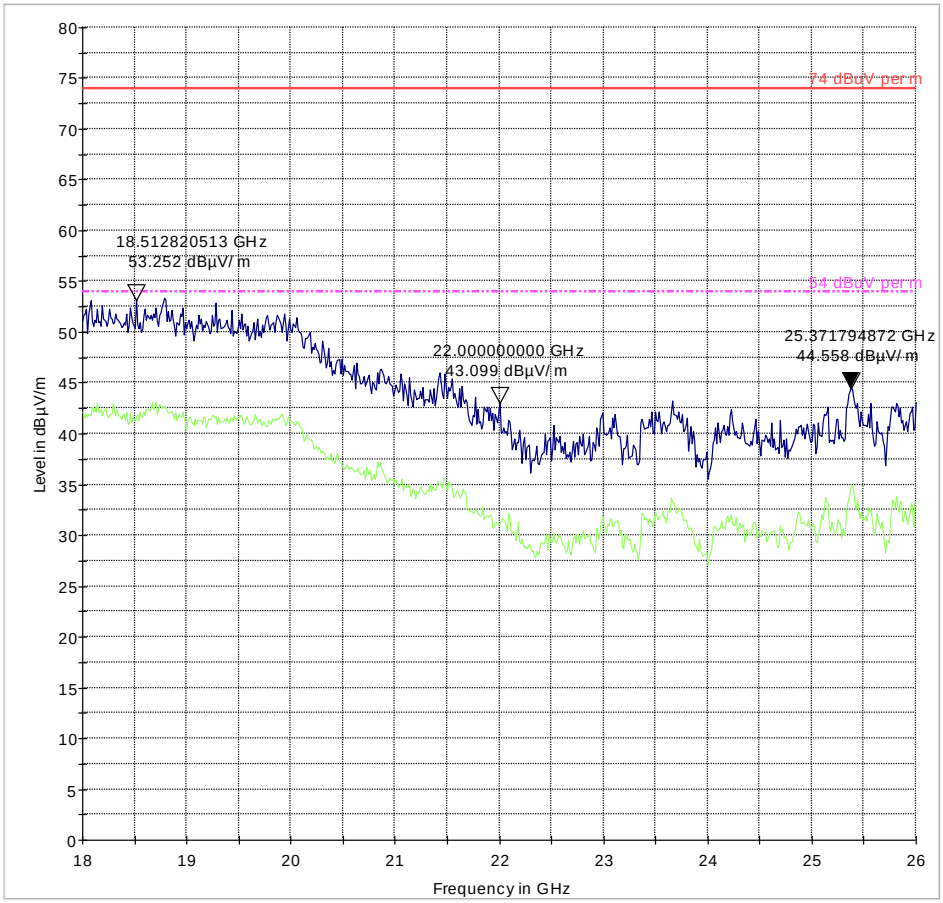
Note: Emission above limit is Tx Signal

TX Radiated Spurious Emission: 1 GHz – 18 GHz			
Ch. High	**Mode: Bluetooth LE**	**Modulation: GFSK**	**Data Rate: 1 Mbps**



Note: Emission above limit is Tx Signal

TX Radiated Spurious Emission: 18 GHz – 26 GHz			
Ch. High	**Mode: Bluetooth LE**	**Modulation: GFSK**	**Data Rate: 1 Mbps**



13 AC Power Line Conducted Emissions

13.1 References:

FCC: CFR Part 15.207/ RSS-Gen 8.8
The purpose of this test is to measure unwanted radio frequency currents induced in any AC conductor external to the equipment which could conduct interference to other equipment via the AC electrical network.

13.2 Limits:

§15.207 & RSS-Gen 8.8

(a) Except as shown in paragraphs (b) and (c) of this section of the CFR, for an intentional radiator that is designed to be connected to the public utility (AC) power line, the radio frequency voltage that is conducted back onto the AC power line on any frequency or frequencies, within the band 150 kHz to 30 MHz, shall not exceed the limits in the following table (1), as measured using a 50 μH/50 ohms line impedance stabilization network (LISN). Compliance with the provisions of this paragraph shall be based on the measurement of the radio frequency voltage between each power line and ground at the power terminal. The lower limit applies at the boundary between the frequency ranges.

Table 1:

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.

13.3 Test Conditions:

Tnom: 23 °C; Vnom: 3.7V
Receive and transmit mode of operation of operation

13.4 Measurement procedure:

Measurement according to ANSI C63.10:2013 section 6.2 and 4.1 (also refer to section 6, 6.3 in this test report)

Analyzer Settings:
CISPR Bandwidth- 9KHz.
Detector = Quasi-peak / Average
Measurement Uncertainty: ±3.0dB

13.5 Results

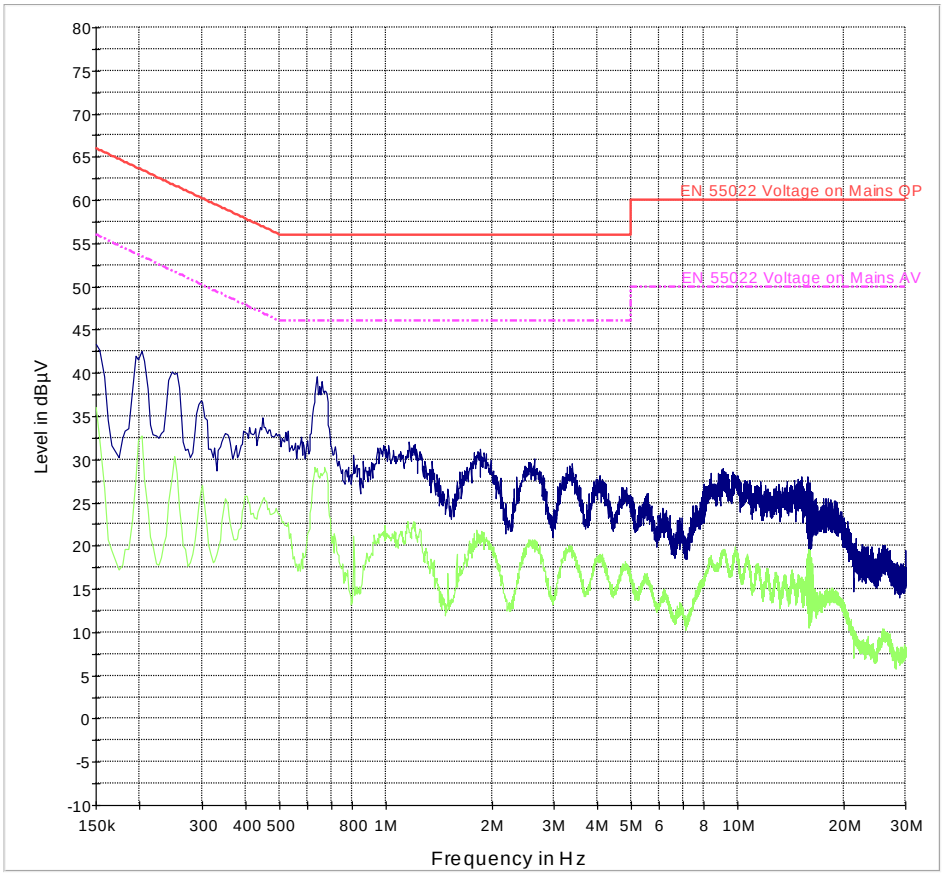
Pass.

13.5.1 Test Data/ Plots

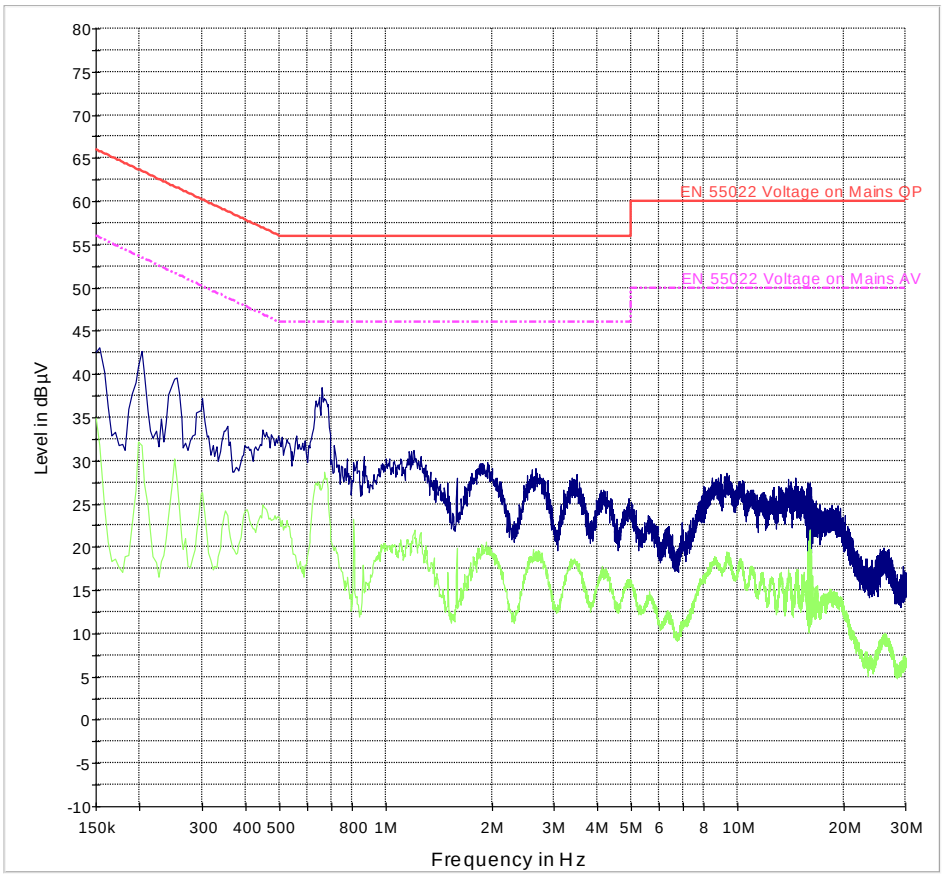
Plots shown here represent the combined worse case emissions for phase and neutral lines.

Conducted Emissions: 150 KHz – 30 MHz
TX Mode (GFSK):

Conducted Emissions: 150 kHz – 30 MHz			
Ch. Mid	**Mode: Bluetooth LE**	**Modulation: GFSK**	**Data Rate: 1 Mbps**



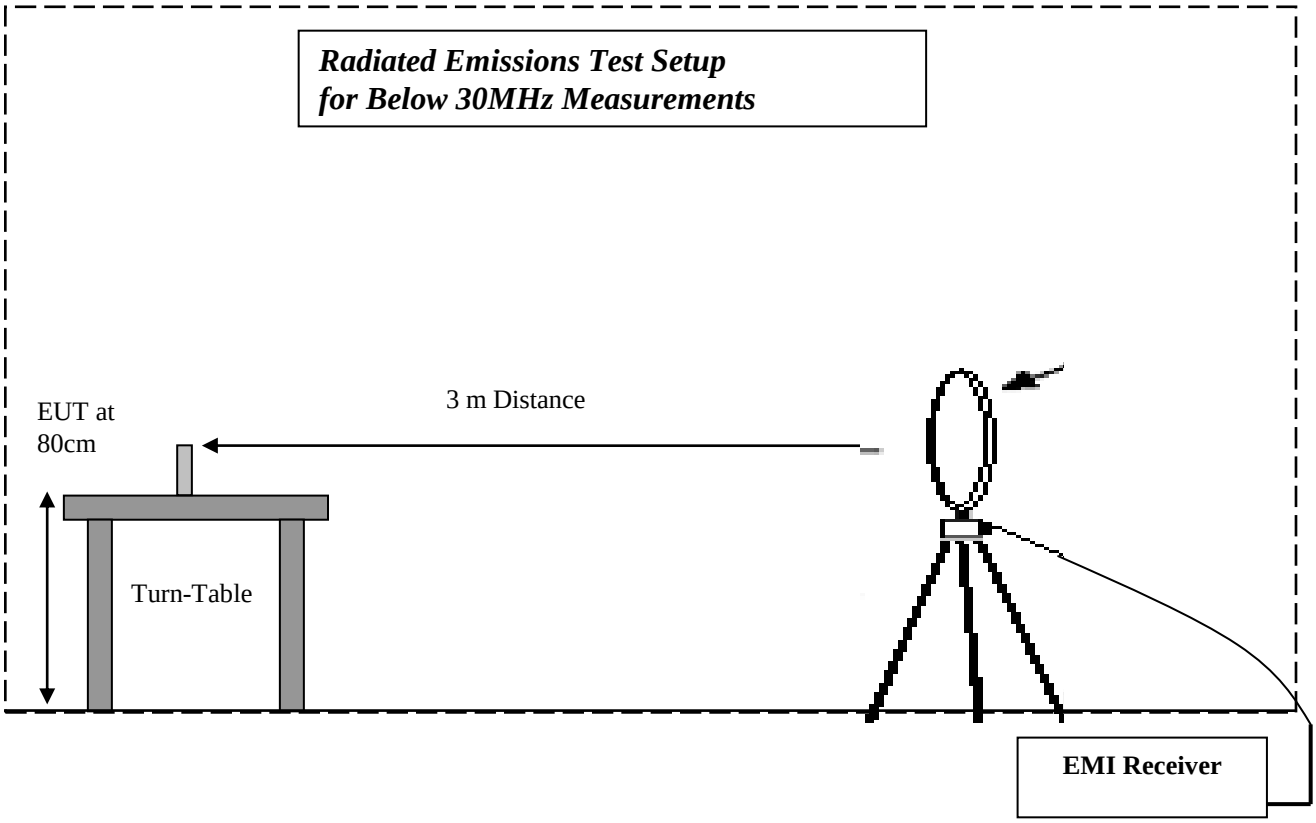
Conducted Emissions: 150 kHz – 30 MHz
RX/Idle mode

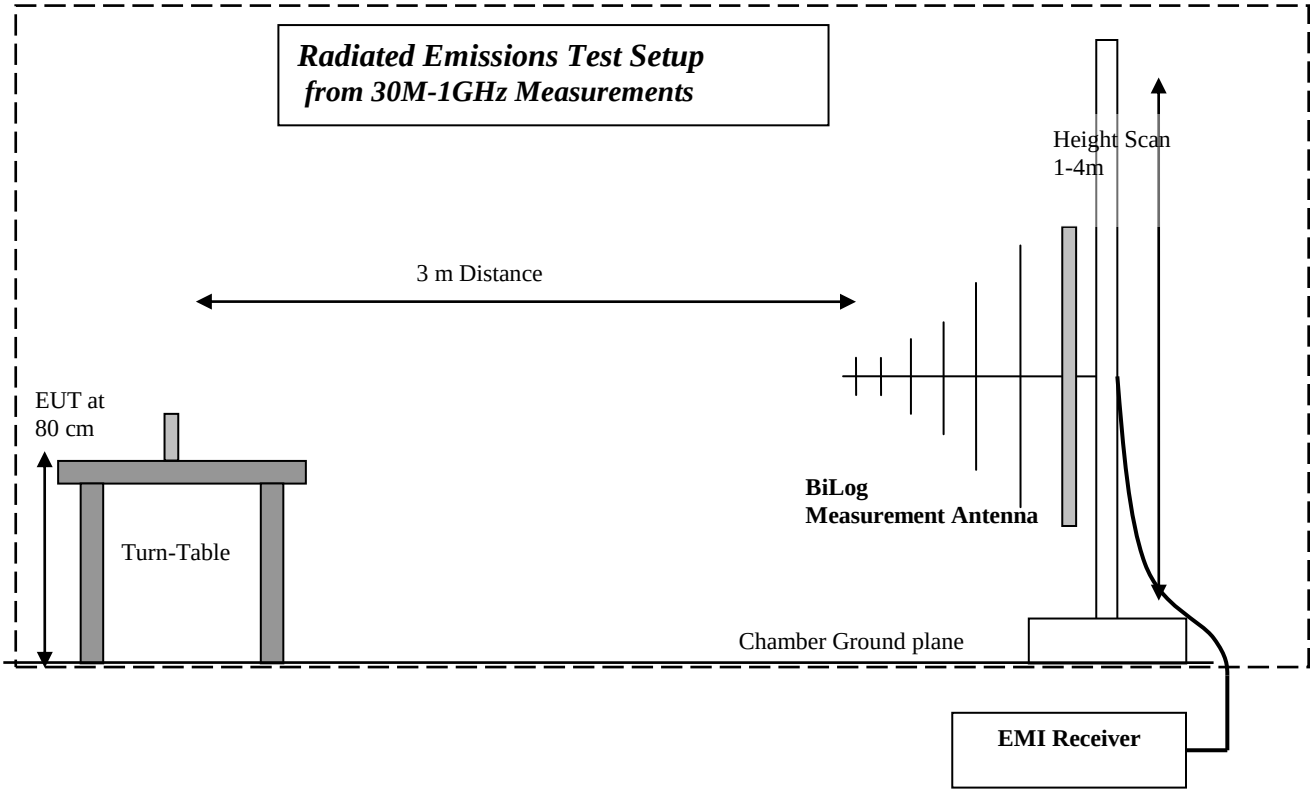


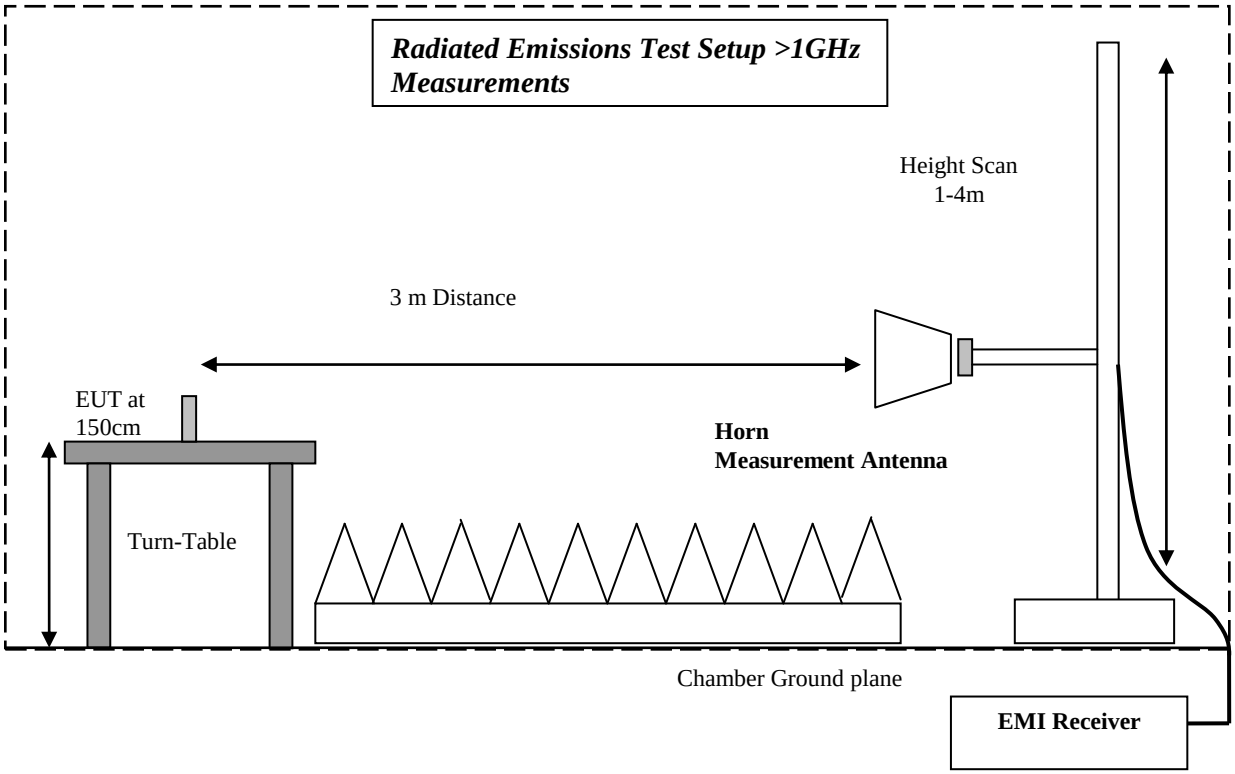
14 Test Equipment and Ancillaries used for tests

Instrument/Ancillary	Model	Manufacturer	Serial No.	Cal Date	Cal Interval
EMI Receiver/Analyzer	ESU 40	Rohde & Schwarz	100251	Sept 2013	2 Years
Spectrum Analyzer	FSU	Rohde & Schwarz	200302	Jun 2013	2 Years
Pre-Amplifier	Miteq	JS40010260	340125	N/A	N/A
Binconilog Antenna	EMCO	3141	0005-1186	Apr 2012	3 Years
Horn Antenna	EMCO	3115	35114	Mar 2012	3 Years
Loop Antenna	EMCO	6512	00049838	Apr 2012	3 years
Communication Antenna	IBP5-900/1940	Kathrein	n/a	n/a	n/a
High Pass Filter	5HC2700	Trilithic Inc.	9926013	Part of system calibration	
High Pass Filter	4HC1600	Trilithic Inc.	9922307	Part of system calibration	
6GHz High Pass Filter	HPM50106	Microtronics	001	Part of system calibration	
Pre-Amplifier	JS4-00102600	Miteq	00616	Part of system calibration	
LISN	R&S	ESH3-Z5	836679/003	Jun 2013	3 Years
Spectrum Analyzer	Rohde&Schwarz	FSU	200302	Jun 2013	2 Years

15 Block Diagrams






Radiated Emissions Test Setup >1GHz Measurements
Height Scan
1-4m
3 m Distance
EUT at
150cm
Horn
Measurement Antenna
Turn-Table
Chamber Ground plane
EMI Receiver

16 Revision History

Date	Report Name	Changes to the report	Report prepared by
2015-03-11	EMC_ APPLE-144-14002_15.247_BTLE	First Revision	Douglas Antioco
2015-08-20	EMC_ APPLE-144-14002_15.247_BTLE_rev1	Replaced relevant references of RSS-210 to relevant references of RSS-247. Replace "Bluetooth v4.0" with "Bluetooth v4.2," added HVIN, PMN in section 3.1. Updated SW Version, EUT status. Deleted references to Peak power in Sections 5 and 7. Replaced References of "802.15" with "Bluetooth LE."	Douglas Antioco
2015-08-26	EMC_ APPLE-144-14002_15.247_BTLE_rev2	Replaces previous test report number. Updated Antenna and Rated Operating Voltage Range/Power Supply in section 3.1.	Douglas Antioco