Bluetooth 4.0 (Low Energy)

FCC / IC Test Report

FOR:

Honeywell

Model Name: 75eL0N and 75eL00

Product Description: Dolphin 75e Handheld Computer

FCC ID: HD5-75EL0N and HD5-75EL00
IC ID: 1693B-75EL0N and 1693B-75EL00

47 CFR Part 15.247

RSS-210 Issue 8 & RSS-Gen Issue 4

TEST REPORT #: EMC_ HONEY_134_14001_15.247_BTLE_75E
DATE: 2015-Feb-05

ACCREDITED
TESTING LABORATORY
Certificate #2135.01

Bluetooth Qualification Test Facility (BQTF)

CTIA Authorized Test Lab
LAB CODE 20020328-00

FCC listed
A2LA Accredited

IC recognized # 3462B

***CETECOM* Inc.**
411 Dixon Landing Road ◆ Milpitas, CA 95035 ◆ U.S.A.
Phone: + 1 (408) 586 6200 ◆ Fax: + 1 (408) 586 6299 ◆ E-mail: info@cetecomusa.com ◆ http://www.cetecom.com
CETECOM Inc. is a Delaware Corporation with Corporation number: 2113686

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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-210 issue 8, Annex 8 and no deviations were ascertained during the course of the tests performed.

Company	Description	Model #
Honeywell International, Inc	Dolphin 75e Handheld Computer	75eL0N and 75eL00

Responsible for Testing Laboratory:

Date	Section	Name	Signature
2015-02-05	Compliance	Franz Engert (Compliance Manager)	Digitally signed by Franz Engert DN: cn=Franz Engert, c=US, o=CETECOM, ou=Complience, email=franz.engert@cetecom.com Date: 2015.02.05 19:42:19 -08'00'

Responsible for the Report:

Date	Section	Name	Signature
2015-02-05	Compliance	Danh Le (EMC Engineer)	Digitally signed by Danh Le DN: cn=Danh Le, o=Cetecom, ou=Compliance, email=danh.le@cetecom.com, c=US Date: 2015.02.05 19:49:42 -08'00'

The test results of this test report relate exclusively to the test item specified in Section3.
CETECOM Inc. USA does not assume responsibility for any conclusions and generalizations drawn from the test results with regard to other specimens or samples of the type of the equipment represented by the test item. The test report may only be reproduced or published in full. Reproduction or publication of extracts from the report requires the prior written approval of CETECOM Inc. USA.

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:	Danh Le

2.2 Identification of the Client

Applicant's Name:	Honeywell International Inc.
Street Address:	9680 Old Bailes Road
City/Zip Code	Fort Mill SC 29707
Country	USA
Contact Person:	Mandana Salahshour
Phone No.	(803)835-8190; (803)835-8097
Fax:	----------
e-mail:	mandana.salahshour@honeywell.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

Marketing Name / Model No:	75eL0N and 75eL00
HW / SW Revision :	2.0
FCC-ID:	HD5-75EL0N/ HD5-75EL00
IC-ID:	1693B-75EL0N and 1693B-75EL00
Product Description:	Dolphin 75e Handheld Computer
Technology / Type(s) of Modulation:	Bluetooth v4.0, 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 dedicated antenna Documented max antenna gain (2.4GHz) = 2.5dBi
Max. Output Power:	Conducted: 2.31 dBm (1.70 mW)
Rated Operating Voltage Range / Power Supply:	Li-ion Battery Vmin: 3.3V dc/ Vnom: 3.7V dc / Vmax: 4.2V dc
Rated Operating Temperature Range:	-20 ºC to 50 ºC
Other Radios included in the device:	1. BT Basic/EDR (Band of operation: 2.4 GHz) 2. Wi-Fi 802.11b/g/n/ac (Band of operation: 2.4 GHz/5.0 GHz) 3. NFC, 13.56 MHz (only in model 75eL0N)
EUT status	Prototype

Note: For model variants, see section 3 of test report.

3.2 Identification of the Equipment under Test (EUT)

EUT #	Serial Number	HW Version	SW Version	Notes/Comments
1	14269J000A	2.0	54.0	Radiated RF Sample / model 75eL0N
2	14268J0078	2.0	54.0	Conducted RF Sample / model 75eL0N

3.3 Identification of Accessory equipment

STE #	Type	Manufacturer	Model	Serial Number
1	AC/DC Adapter	PhiHong	PSA105R-050Q	P142302633A1
2	Li-ion Battery	BTEC	70e-BTEC	TGMX142071852

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:

10/28/2014 – 12/30/2014

3.6 Testing Notes:

Two model variants are covered from this test report, models 75eL0N and 75eL00. Radiated and conducted testing were performed on model 75eL0N only, based on the manufacturer's declaration that the 75eL00 has identical hardware, software and maximum output power tune up limits and only differ in the addition of the NFC hardware in model 75eL0N.

3.7 Test mode of operation:

Mode	Data rate (Mbps)	Modulation scheme
802.15 BTLE	1.0	GFSK

The device was configured with a manufacturer provided test SW, capable of setting the unit in Bluetooth LE mode / GFSK modulation with duty cycle.

For radiated spurious emissions, the EUT was tested on low, mid and high channels (2.4GHz) in Bluetooth LE mode / GFSK.

4 Subject Of Investigation

The objective of the evaluation documented in this report was to assess if the performance of the EUT meets the relevant requirements specified in FCC rules Part 15.247 of Title 47 of the Code of Federal Regulations and Radio Standard Specification RSS-210 Issue 8, Annex 8 of Industry Canada.

This test report is to support a request for new equipment authorization under the FCC ID **HD5-75EL0N and HD5-75EL00.**

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

During the testing process the EUT was tested with transmitter sets on low, mid and high channels. 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-210 A8.2(b)	Power Spectral Density	Nominal	802.15 (LE)	■	☐	☐	☐	Complies
§15.247(a)(1) RSS-210 A8.2(a)	Emission Bandwidth	Nominal	802.15 (LE)	■	☐	☐	☐	Complies
§15.247(b)(1) RSS-210 A8.4(4)	Maximum Conducted Output Power and EIRP	Nominal	802.15 (LE)	■	☐	☐	☐	Complies
§15.247(d) RSS-210 A8.5	Band edge & Restricted Band Edge compliance	Nominal	802.15 (LE)	■	☐	☐	☐	Complies
§15.247(d) §15.209 RSS-210 A8.5 RSS-Gen 6.13	TX Spurious emissions-Radiated	Nominal	802.15 (LE)	■	☐	☐	☐	Complies
§15.207(a) RSS-Gen 8.8	AC Conducted Emissions	Nominal	802.15 (LE)	■	☐	☐	☐	Complies
§15.205(a) RSS-Gen 8.10	Restricted Bands	Nominal	802.15 (LE)	■	☐	☐	☐	Complies

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

6 Measurements

6.1 Radiated Measurement Procedure

Ref: ANSI C63.10 (2013)

Section 5.4: Measurements around the EUT

Measurements shall be made at a test site that incorporates a turntable allowing EUT rotation of 0° through 360°, except where the EUT is so large that a suitable turntable is not readily available. A remotely controlled turntable shall be installed at the test site to support the EUT and facilitate determination of the direction of maximum radiation for each EUT emission frequency. Continuous azimuth searches shall be made. The maximum field strength at the frequency being measured shall be reported in the test report.32 See ANSI C63.4 for details of the test site, turntable, and antenna positioner. Where a continuous azimuth search cannot be made, as is the case for example where the EUT is so large that a suitable turntable is not readily available, frequency scans of the EUT field strength with both polarizations of the measuring antenna shall be made, starting with a minimum of 16 azimuth angles around the EUT, nominally spaced by 22.5°, in characterizing the EUT radio-noise profile. If directional EUT radiation patterns are suspected, especially above 1 GHz then additional and smaller azimuth angles shall be examined.

Section 5.3.2: Test distance for frequencies below 30 MHz

Radiated emissions limits are usually defined at a specific distance from the EUT. Where possible, measurements shall be made at the distance specified in the limits. This might not be possible in all cases, however, due to the physical limitations of the test facility, physical access problems at the required distance (especially for measurements that must be made in situ or on-site), or levels of ambient noise or other radiated signals present at the time and location where measurements are made. See 6.4.3 for more information about antenna selection, location, and test distance. If measurements cannot practically be made at the EUT limit distance, then they may be made at a different distance (usually closer) and extrapolated to the limit distance using one of the procedures described in 6.4.4, 6.4.5, or 7.7, depending on the EUT source and size.31 The test report shall specify the extrapolation method used to determine compliance of the EUT.

Section 5.3.3: Test distance for frequencies at or above 30 MHz

Measurements may be performed at a distance other than the limit distance provided they are not performed in the near field and the emissions to be measured can be detected by the measurement equipment (see 4.3.4). Measurements shall not be performed at a distance greater than 30 m for frequencies above 30 MHz, unless it can be further demonstrated that measurements at a distance of 30 m or less are impractical. Measurements from 18 GHz to 40 GHz are typically made at distances significantly less than 3 m from the EUT. When performing measurements at a distance other than that specified, the results shall be extrapolated to the specified distance using an extrapolation factor of 20 dB/decade of distance (inverse of linear distance for field-strength measurements or inverse of linear distance-squared for power-density measurements).

ANSI C63.10 (2013)

Section 6.6.4.2: Exploratory radiated emissions measurements

Exploratory radiated measurements shall be performed at the measurement distance or at a closer distance than that specified for compliance to determine the emission characteristics of the EUT and, if applicable, the EUT configuration that produces the maximum level of emissions. The frequencies of maximum emission may be determined by manually positioning the antenna close to the EUT, and then moving the antenna over all sides of the EUT while observing a spectral display. It is advantageous to have prior knowledge of the frequencies of emissions, although this may be determined from such a near-field scan. The near-field scan shall only be used to determine the frequency but not the amplitude of the emissions. Where exploratory measurements are not adequate to determine the worst-case operating modes and are used only to identify the frequencies of the highest emissions, additional preliminary tests can be required.

Preliminary tests shall be performed following the procedures in 6.3 on a site meeting the requirements of 5.2. For emissions from the EUT, the maximum level shall be determined by rotating the EUT and its antenna through 0° to 360°. For each mode of operation required to be tested, the frequency spectrum (based on findings from exploratory measurements) shall be monitored.

Section 6.6.4.3: Final radiated emissions measurements

The final measurements are performed on a site meeting the requirements of 5.2. Using the orientation and equipment arrangement of the EUT based on the measurement results found during the preliminary (exploratory) measurements per 6.6.4.2, the EUT arrangement, appropriate modulation, and modes of operation that produce the emissions that have the highest amplitude relative to the limit shall be selected for the final measurement. The final measurement shall follow all the procedures in 6.3 with the EUT operating on frequencies per 5.6. For each mode selected, record the frequency and amplitude of the highest fundamental emission (if applicable), as well as the frequency and amplitude of the six highest spurious emissions relative to the limit. Emissions more than 20 dB below the limit do not need to be reported.

Measurements are performed with the EUT rotated from 0° to 360°; the antenna height scanned in accordance with 6.6.3.1, 6.6.3.2, or 6.6.3.3, as appropriate; and the antenna rotated to repeat the measurements for both the horizontal and vertical antenna polarizations. Variations in cable or wire placement shall be explored to maximize the measured emissions.

NOTES

1— Where limits are specified by agencies for both average and peak (or quasi-peak) detection, if the peak (or quasi-peak) measured value complies with the average limit, it is unnecessary to perform an average measurement.

2—Use of waveguide and flexible waveguide may be necessary at frequencies above 10 GHz to achieve usable signal-to noise ratios at required measurement distances. If so, it may be necessary to restrict the height search of the antenna, and special care should be taken to ensure that maximum emissions are correctly measured.

3—All presently known devices causing emissions above 10 GHz are physically small compared with the beam-widths of typical horn antennas used for EMC measurements. For such EUTs and frequencies, it may be preferable to vary the height and polarization of the EUT instead of the receiving antenna to maximize the measured emissions.

6.2 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.

Radiated Measurement Uncertainty: ± 3dB

6.3 Conducted Emissions Procedure
Ref: ANSI C63.10 (2013)

Section 6.2: Standard test method for ac power-line conducted emissions from unlicensed wireless devices

Section 6.2.1: General considerations
AC power-line conducted emission measurements shall be made, unless otherwise specified, over the frequency range from 150 kHz to 30 MHz, to determine the line-to-ground radio-noise voltage that is conducted from all of the EUT current-carrying power input terminals that are directly (or indirectly via separate transformers or power supplies) connected to a public power network. These measurements may also be required between 9 kHz and 150 kHz.

If the EUT normally receives power from another device that in turn connects to the public utility ac power lines, measurements shall be made on that device with the EUT in operation to demonstrate that the device continues to comply with the appropriate limits while providing the EUT with power. If the EUT is operated only from internal or dedicated batteries, with no provisions for connection to the public utility ac power lines (600 VAC or less) to operate the EUT (such as an adapter), then ac power-line conducted measurements are not required.

For direct current (dc) powered devices where the ac power adapter is not supplied with the device, an "off-the-shelf" unmodified ac power adapter shall be used. If the device is supposed to be installed in a host (e.g., the device is a module or PC card), then it is tested in a typical compliant host (see also 5.10.3).

Section 6.2.2: Measurement requirements
The LISN housing, measuring instrument case, reference ground plane, vertical conducting plane, if used, shall be bonded together.

Measured levels of ac power-line conducted emission shall be the emission voltages from the voltage probe, where permitted, or across the 50 Ω LISN port (to which the EUT is connected), where permitted, terminated into a 50 Ω measuring instrument. All emission voltage and current measurements shall be made on each current-carrying conductor at the plug end of the EUT power cord by the use of mating plugs and receptacles on the LISN, if used. Equipment shall be tested with power cords that are normally supplied or recommended by the manufacturer and that have electrical and shielding characteristics that are the same as those cords normally supplied or recommended by the manufacturer. For those measurements using a LISN, the 50 Ω measuring port is terminated by a measuring instrument having 50 Ω input impedance. All other ports are terminated in 50 Ω loads.

ANSI C63.10 (2013)

Section 6.2.4: Exploratory ac power-line conducted emission measurements

Exploratory tests shall be run with the modulating signal(s) specified in 5.12 applied to the EUT. Antenna(s) can be integral or detachable. If detachable, the antenna(s) shall be attached during the test. On any one convenient frequency specified in 5.5 and 5.6, exploratory measurements shall be used to identify the frequency of the emission that has the highest amplitude relative to the limit by operating the EUT in a range of typical modes of operation, cable positions, and with a typical system equipment configuration and arrangement. For each mode of operation and for each ac power current-carrying conductor, cable manipulation shall be performed within the range of likely configurations. For this measurement or series of measurements, the frequency spectrum of interest shall be monitored looking for the emission that has the highest amplitude relative to the limit. Once that emission is found for each current-carrying conductor of each power cord associated with the EUT (but not the cords associated with non-EUT equipment in the overall system), the one configuration and arrangement and mode of operation that produces the emission closest to the limit over all of the measured conductors shall be recorded.

Section 6.2.5: Final ac power-line conducted emission measurements

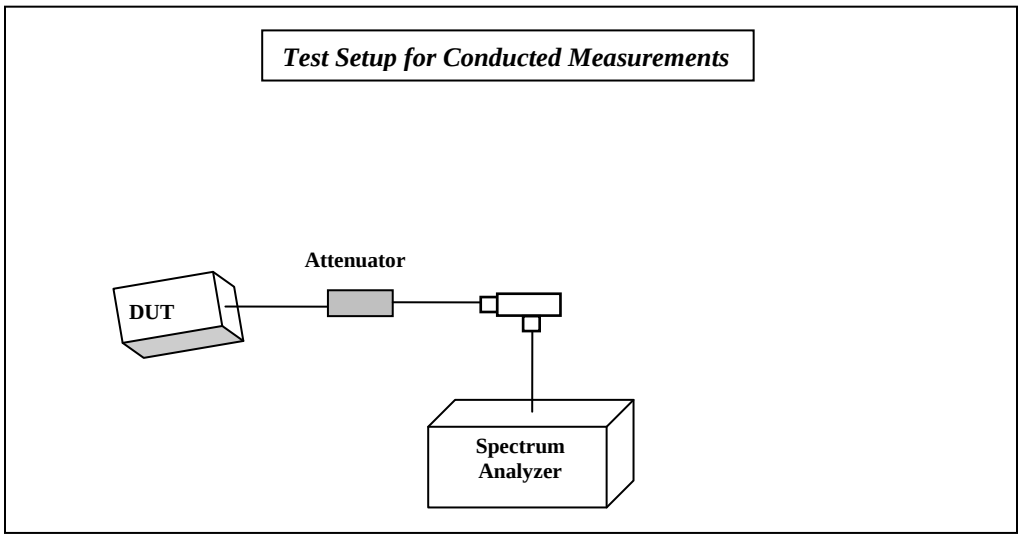
Based on the exploratory tests of the EUT performed in 6.2.4, the one EUT cable configuration and arrangement and mode of operation that produced the emission with the highest amplitude relative to the limit is selected for the final measurement, while applying the appropriate modulating signal to the EUT. If the EUT is relocated from an exploratory test site to a final test site, the highest emissions shall be remaximized at the final test location before final ac power-line conducted emission measurements are performed. The final test on all current-carrying conductors of all of the power cords to the equipment that comprises the EUT (but not the cords associated with other non-EUT equipment in the system) is then performed for the full frequency range for which the EUT is being tested for compliance without further variation of the EUT arrangement, cable positions, or EUT mode of operation. If the EUT is composed of equipment units that have their own separate ac power connections (e.g., floor-standing equipment with independent power cords for each shelf that are able to connect directly to the ac power network), then each current-carrying conductor of one unit is measured while the other units are connected to a second (or more) LISN(s). All units shall be measured separately. If a power strip is provided by the manufacturer, to supply all of the units making up the EUT, only the conductors in the power cord of the power strip shall be measured.

If the EUT operates above 30 MHz and uses a detachable antenna, then these measurements shall be made with a representative antenna connected to the antenna output terminals. These tests shall be made with the antenna connected and, if adjustable, fully extended.

Record the six highest EUT emissions relative to the limit of each of the current-carrying conductors of the power cords of the equipment that comprises the EUT over the frequency range specified by the procuring or regulatory agency.

6.4 RF Conducted Measurement Procedure

Measurement according to FCC KDB 558074 D01 DTS Meas Guidance v03r02:2014
(Guidance for Performing Compliance Measurements on Digital Transmission System (DTS) Operating Under §15.247)



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.

6.5 Measurement Uncertainty

	Uncertainty in dB radiated <30MHz	Uncertainty in dB radiated 30MHz - 1GHz	Uncertainty in dB radiated > 1GHz	Uncertainty in dB Conducted measurement
standard deviation k=1	2.48	1.94	2.16	0.64
95% confidence interval in dB	4.86	3.79	4.24	1.25
95% confidence interval in dB in delta to Result (rounded up to next decimal point)	+-2.5 dB	+-2.0 dB	+- 2.3dB	+-0.7dB

7 Maximum Conducted Output Power and EIRP

7.1 Limits:

Maximum Conducted Output Power:
FCC §15.247 (b)(1): 1W
IC RSS-210 issue 8, annex 8.4(2): 1W
EIRP:
IC RSS-210 issue 8, 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 DTS Meas Guidance v03r02 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 (1/0.62) = 2 dB if the dc is 62 %.

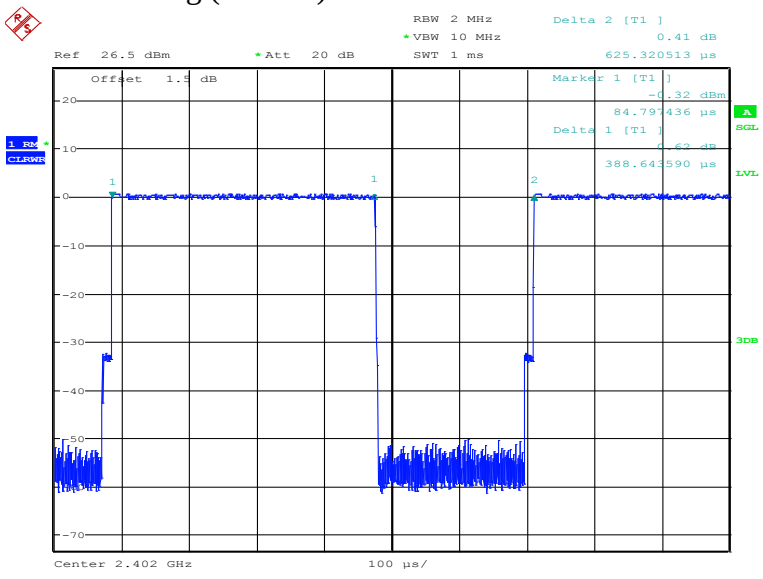
7.4 Test Data

Maximum Conducted Output Power (dBm)							
Limit = 30 dBm		Frequency (MHz)					
		2412 Channel 1		2437 Channel 6		2462 Channel 11	
Mode	Duty Cycle CF (dB)	Measured	Corrected	Measured	Corrected	Measured	Corrected
802.15 (BTLE)	2	-1.95	0.05	0.31	2.31	-1.74	0.26
Calculated Radiated Output Power EIRP (dBm)							
Limit = 36 dBm		Frequency (MHz)					
Mode	Antenna G (dBi)	2412 Channel 1		2437 Channel 6		2462 Channel 11	
802.15 (BTLE)	2.5	2.55		4.81		2.76	

Declared Antenna Gain in the 2.4GHz band: 2.5 dBi

DC = Txon / Txon + Txoff = 0.388 ms / 0.625 ms = 0.621 or 62%

DCCF = 10 log (1/x); x = duty cycle
DCCF = 10 log (1/0.621) = 2 dB



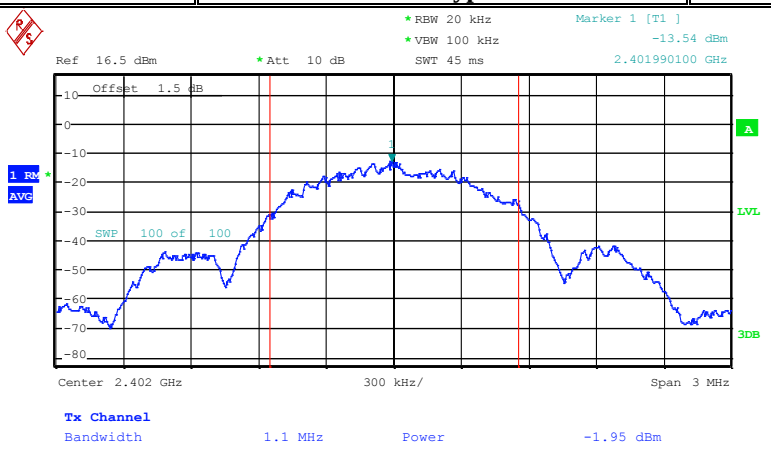
7.5 Measurement Result

Pass.

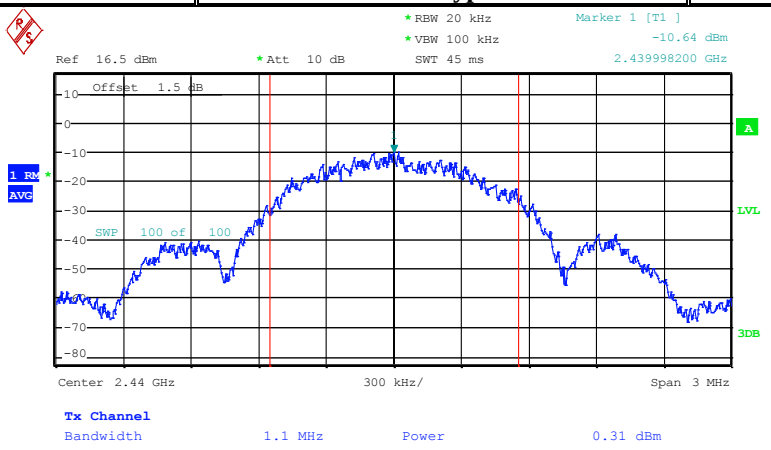
7.6 Measurement Plots:

Maximum Conducted Output Power

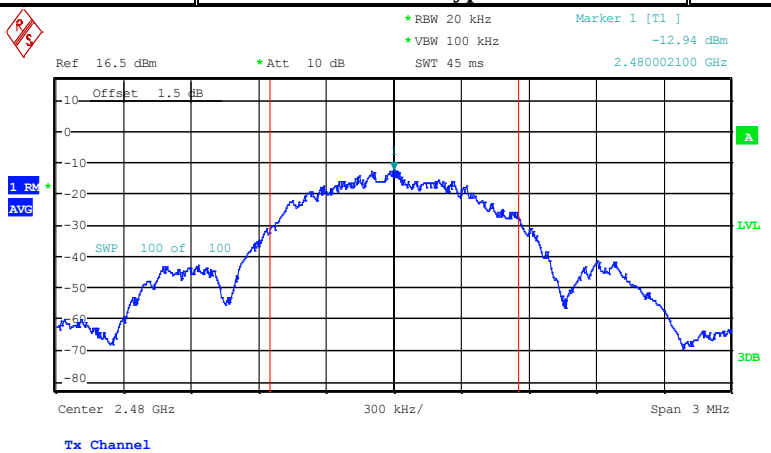
Ch.0 / 2402 MHz	Modulation/Packet Type: GFSK	Data Rate: 1 Mbps



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-210 A8.2 (b)

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 V03R02 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:

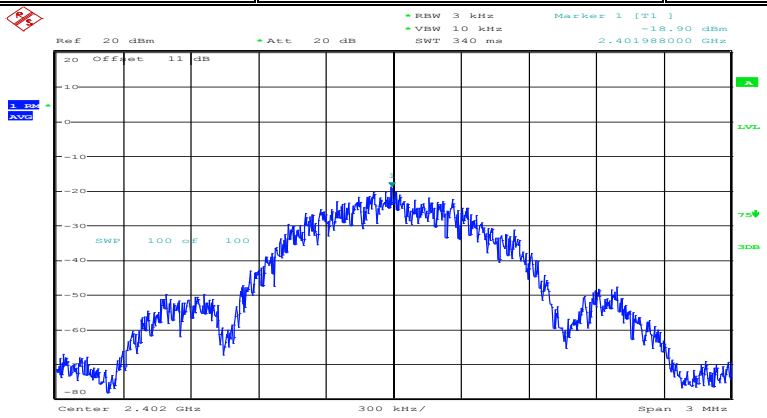
Maximum Power Spectral Density (dBm)							
Limit = 8 dBm / 3KHz		Frequency (MHz)					
		2412 Channel 1		2437 Channel 6		2462 Channel 11	
Mode	Duty Cycle CF	Measured	Corrected	Measured	Corrected	Measured	Corrected
802.15 (BTLE)	2	-18.90	-16.90	-17.12	-15.12	-19.72	-17.72

8.5 Measurement Result:

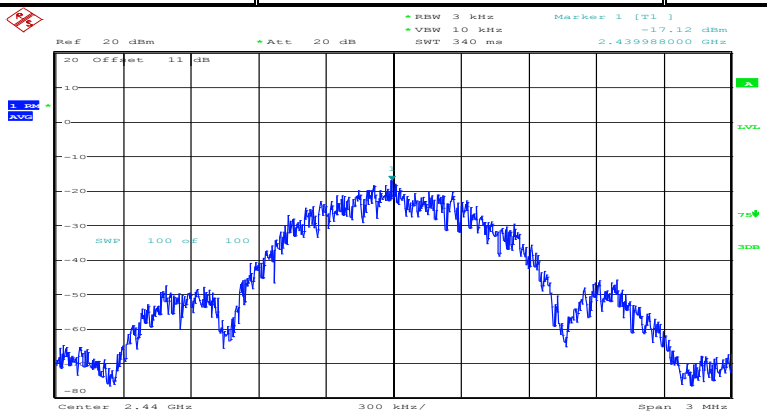
Pass.

8.6 Measurement Plots:

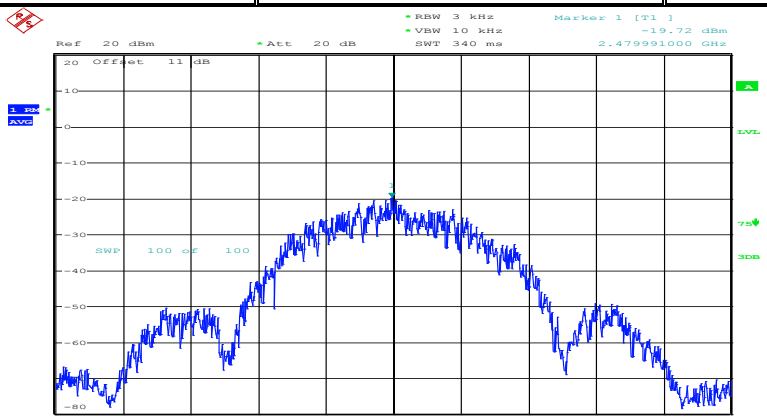
Maximum Power Spectral Density		
Ch.0 / 2402 MHz	**Modulation: GFSK**	**Data Rate: 1 Mbps**



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



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



9 Band Edge Compliance – at restricted and non-restricted band edges

9.1 Limits:

§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.

FCC15.247 (d) / RSS-210 A8.5

In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, as permitted under paragraph (b)(3) of this section, the attenuation required under this paragraph shall be 30 dB instead of 20 dB. Attenuation below the general limits specified in §

15.209(a) is not required. In addition, radiated emissions which fall in the restricted bands, as defined in § 15.205(a), must also comply with the radiated emission limits specified in § 15.209(a).

9.2 Test Conditions:

Tnom: 21°C; Vnom: 3.7V

9.3 Measurement Procedure:

Measurement according to FCC KDB 558074 D01 v03r02 section 11/12

For non-Restricted Band Edge measurement

11.2 Reference level measurement

Establish a reference level by using the following procedure:
Center frequency = band edge
Span ≥ 1.5 times the *DTS bandwidth* or encompass frequency range to be measured.
RBW = 100 kHz
VBW ≥ 3 x RBW
Detector = peak.
Sweep time = auto couple.
Trace mode = max hold.
- Allow trace to fully stabilize.
- 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.

11.3 Emission level measurement

Establish a reference level by using the following procedure:
Center frequency = band edge
Span ≥ 1.5 times the *DTS bandwidth* or encompass frequency range to be measured.
RBW = 100 kHz
VBW ≥ 3 x RBW
Detector = peak.
Sweep time = auto couple.
Trace mode = max hold.
- Allow trace to fully stabilize.
- Use the peak marker function to determine the maximum PSD level.
- Ensure that the band edge and the amplitude of all unwanted emissions outside of the authorized frequency band (excluding restricted frequency bands) are attenuated by least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power and at least 30 dB if measurement based on the use of RMS averaging.

For Restricted Bands measurement

*PEAK LIMIT= 74dBµV/m @ 3m (-21.2 dBm)
*AVG. LIMIT = 54dBµV/m @ 3m (-41.2 dBm)

12.2.4 Peak power measurement procedure

Peak emission levels are measured by setting the instrument as follows:
Start frequency = the beginning of the restricted band
Stop frequency = the end of the restricted band
RBW = 1 MHz
VBW ≥ 3 x RBW
Detector = Peak.
Sweep time = auto.
Trace mode = max hold.
- Allow sweeps to continue until the trace stabilizes.
- Use the peak marker function to determine the maximum amplitude level.
- Add the specified antenna gain to the peak readings.
- Compare to the peak limit (-21.2 dBm) specified above.

12.2.5.2 Average power measurement procedure

Repeat the measurement in average by setting the instrument as follows:
Start frequency = the beginning of the restricted band
Stop frequency = the end of the restricted band
RBW =1 MHz
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
- Use the peak marker function to determine the maximum amplitude level.
- Add the duty cycle correction factor and the specified antenna gain to the maximum readings.
- Compare to the average limit (-41.2 dBm) specified above.

9.4 Measurement Result

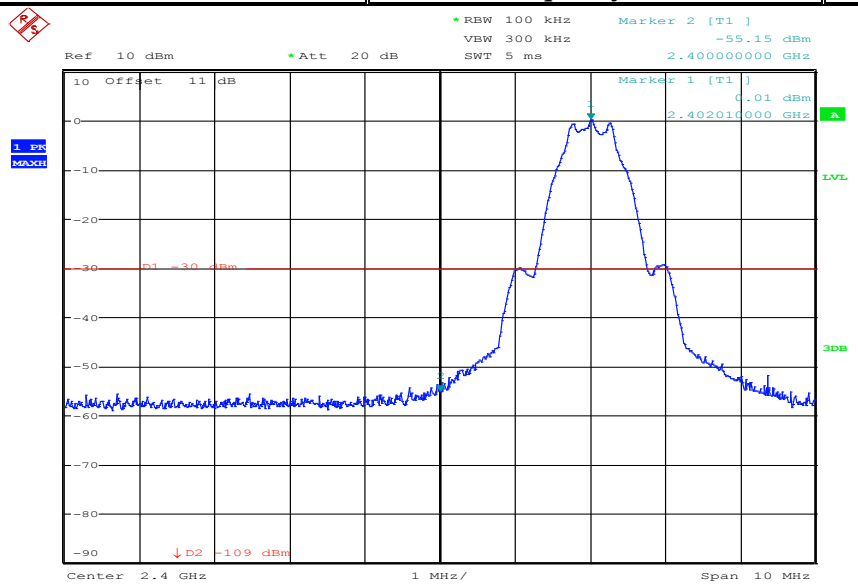
Pass.

9.5 Test Data:

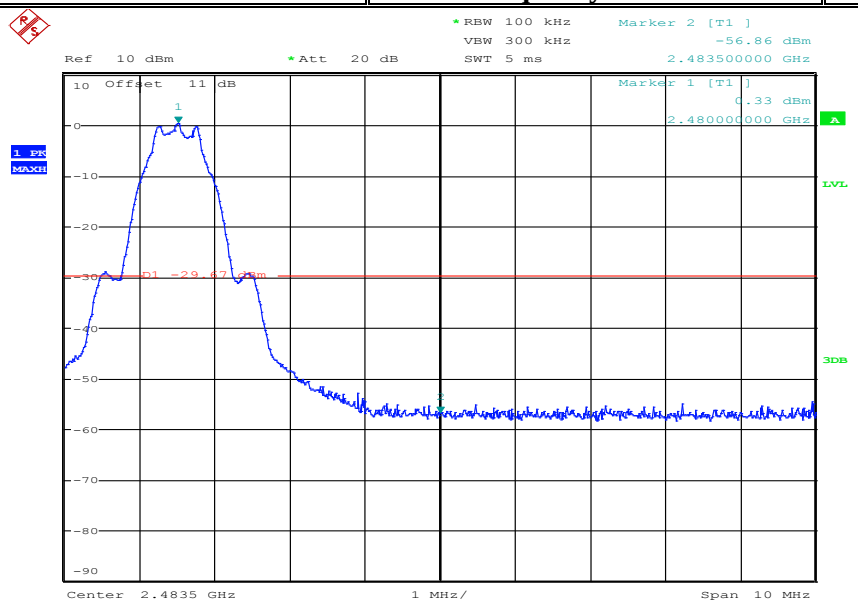
Mode: Bluetooth LE **Modulation: GFSK** **Data Rate: 1 Mbps** **Test Channel: 0**							
Lower Restricted Band / Frequency Range: 2310 MHz – 2390 MHz							
Recorded Frequency (MHz)	**Emission Lvl Peak/Average (dBm)**	**Cable Loss/ ext. attenuator (dB)**	**Duty Cycle C F (dB)**	**Antenna Gain (dBi)**	**Calculated Emission Level (dBm)**	**Limit Peak/Average (dBm)**	**Margin (dB)**
2362.9	-51.34 Pk	Compensated in offset function	n.a.	2.5	-48.84	-21.2	-27.64
2374.8	-59.37 Av	Compensated in offset function	2	2.5	-54.87	-41.2	-13.67
Upper Restricted Band / Frequency Range: 2483.5 MHz – 2500 MHz							
2483.5	-40.50 Pk	Compensated in offset function	n.a.	2.5	-38.0	-21.2	-16.8
2483.5	-50.19Av	Compensated in offset function	2	2.5	-45.69	-41.2	-4.49

9.6 Measurement Plots:

Lower non-restricted Band Edge		
Ch. Low / 2402MHz / Peak	**BE Frequency: 2.4 GHz**	**GFSK**

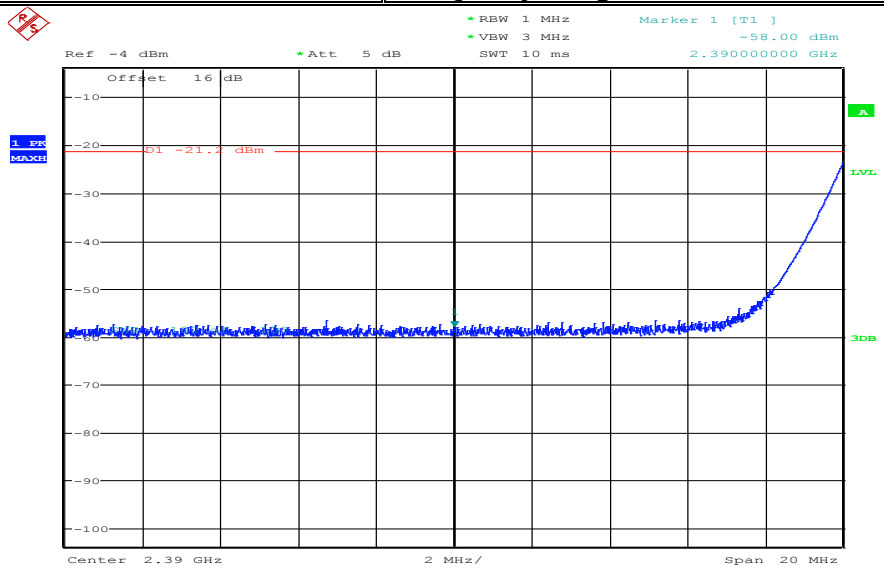


Upper non-restricted Band Edge		
Ch. Low / 2402MHz / Peak	**BE Frequency: 2.4835 GHz**	**GFSK**



Lower Restricted Band Edge - peak

Ch. Low / 2402MHz / Peak	Frequency Range: 2.310 – 2.390 GHz	GFSK

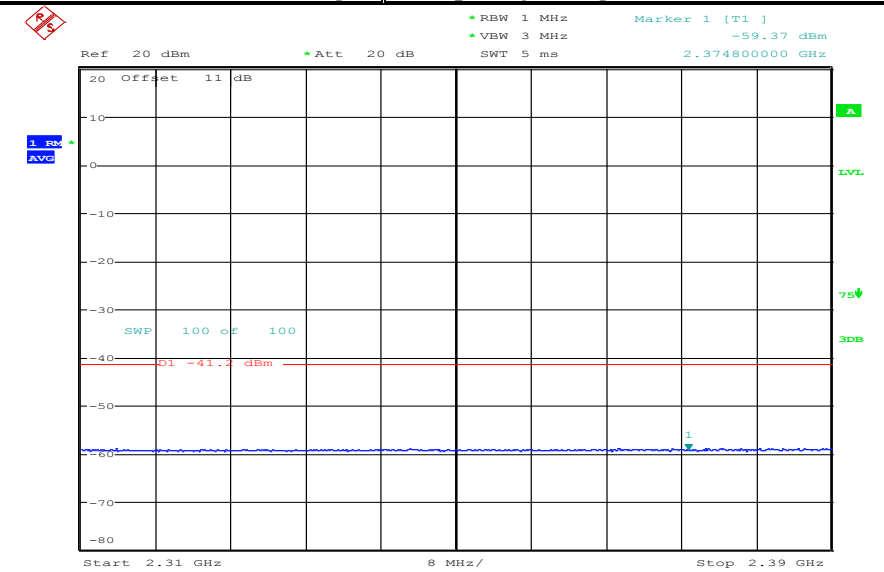


low

Date: 5.FEB.2015 17:49:20

Lower Restricted Band Edge - average

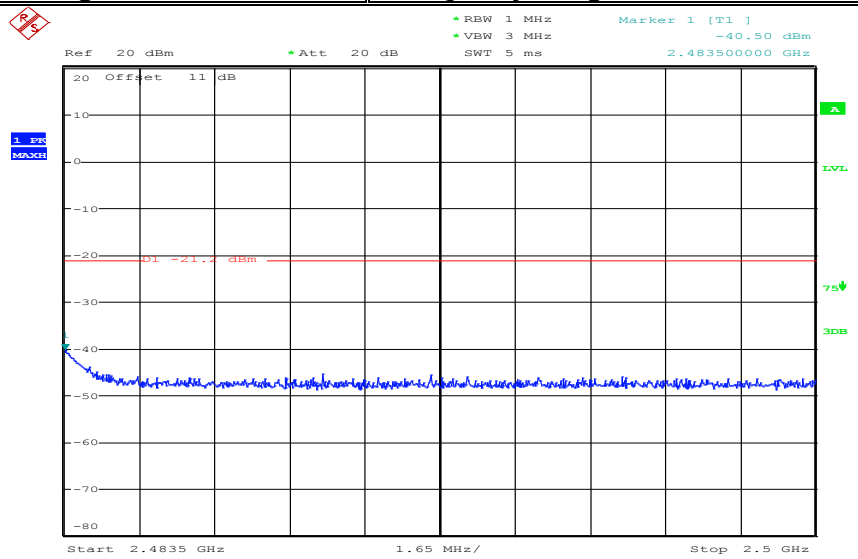
Ch. Low / 2402MHz / Avg	Frequency Range: 2.310 – 2.390 GHz	GFSK



Date: 12.JAN.2015 22:39:11

Upper Restricted Band Edge - peak

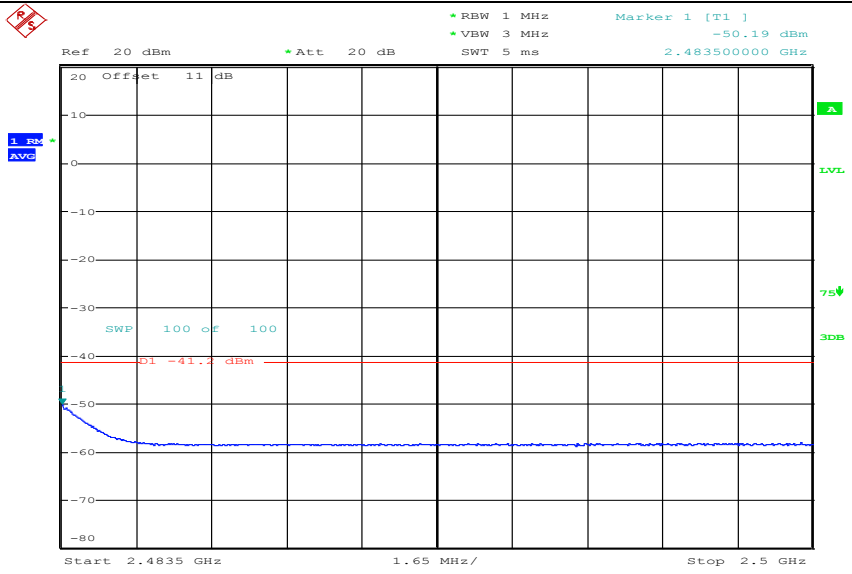
Ch. High / 2480MHz / Peak	Frequency Range: 2.4935 – 2.5 GHz	GFSK



Date: 12.JAN.2015 22:42:27

Upper Restricted Band Edge - average

Ch. High / 2480MHz / Avg	Frequency Range: 2.4935 – 2.5 GHz	GFSK



Date: 12.JAN.2015 22:40:39

10 Occupied Bandwidth (6dB and 99% Bandwidth)

10.1 Limits:

§15.247 (a) (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.

10.2 Test Conditions:

Tnom: 22 °C; Vnom: 3.7 V

10.3 Test Procedure

Measurement according to FCC KDB 558074 D01 v03r02 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%

10.4 Test Data Results:

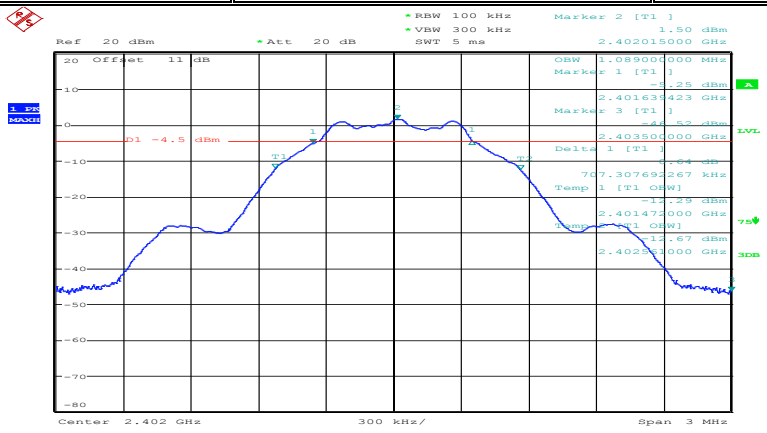
Occupied Bandwidth (MHz)						
Mode	Frequency (MHz)					
	2404 Channel 0		2440 Channel 19		2480 Channel 39	
	6dB (KHz)	99% (MHz)	6dB (KHz)	99% (MHz)	6dB (KHz)	99% (MHz)
802.15 LE	707.3	1.089	711.5	1.086	706.7	1.089

10.5 Measurement Result

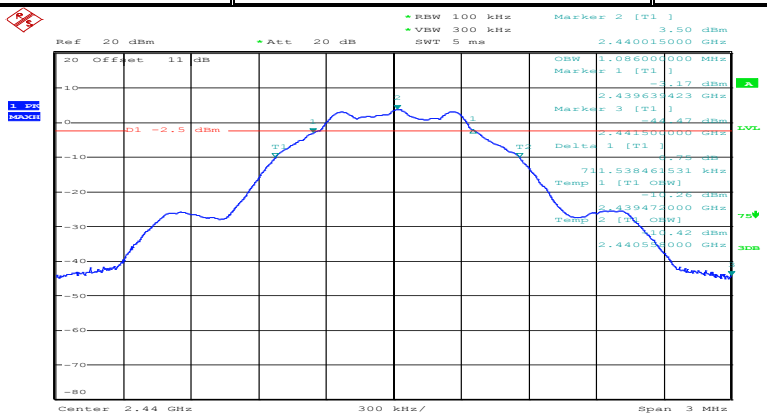
Pass.

10.6 Measurement Plots:

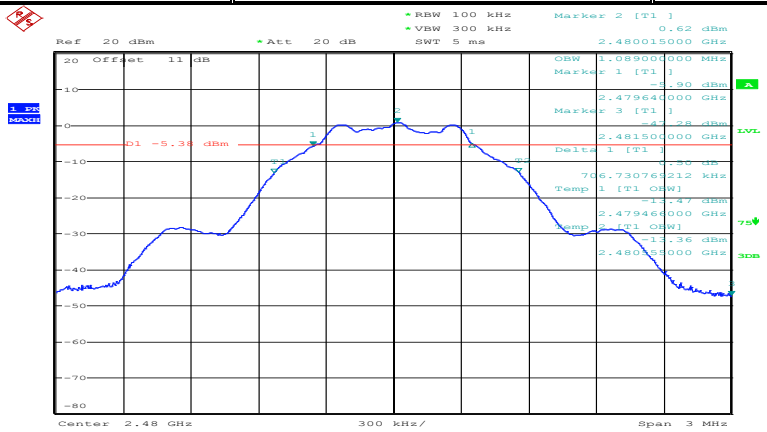
20dB Bandwidth		
Ch.0 / 2402 MHz	**Modulation: GFSK**	**Data Rate: 1 Mbps**



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



Ch.39 / 2480 MHz	**Modulation: GFSK / DH3**	**Data Rate: 1 Mbps**



11 Radiated Transmitter Spurious Emissions - Restricted Bands

11.1 Limits:

§15.247/15.205/15.209 & RSS-210 A8.5 / 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.

11.2 Test Conditions:

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

11.3 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

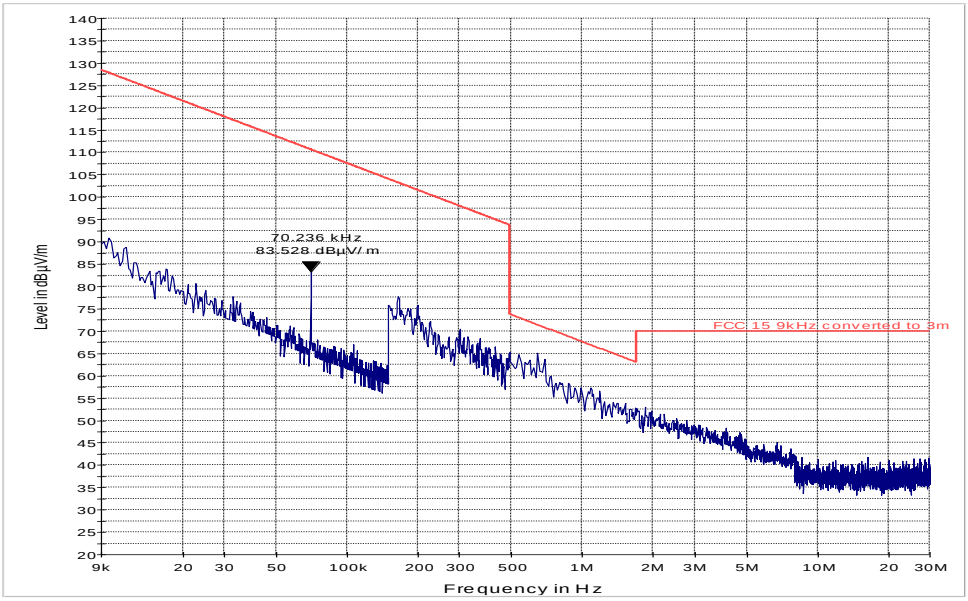
Test mode: *Modulation:* GFSK- the highest conducted output power.
Plots reported here represent the worst case emissions for horizontal and vertical antenna polarizations and for three orientations of the EUT.

11.4 Verdict:

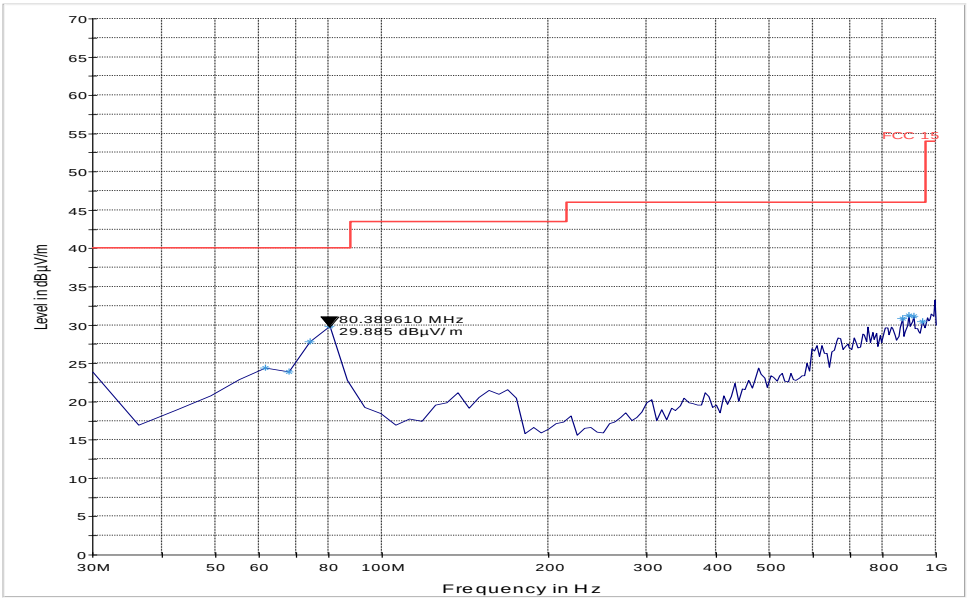
Plots reported here represent the worst case emissions for horizontal and vertical antenna polarizations and for three orientations of the EUT. PASS

11.5 Measurement Plots:

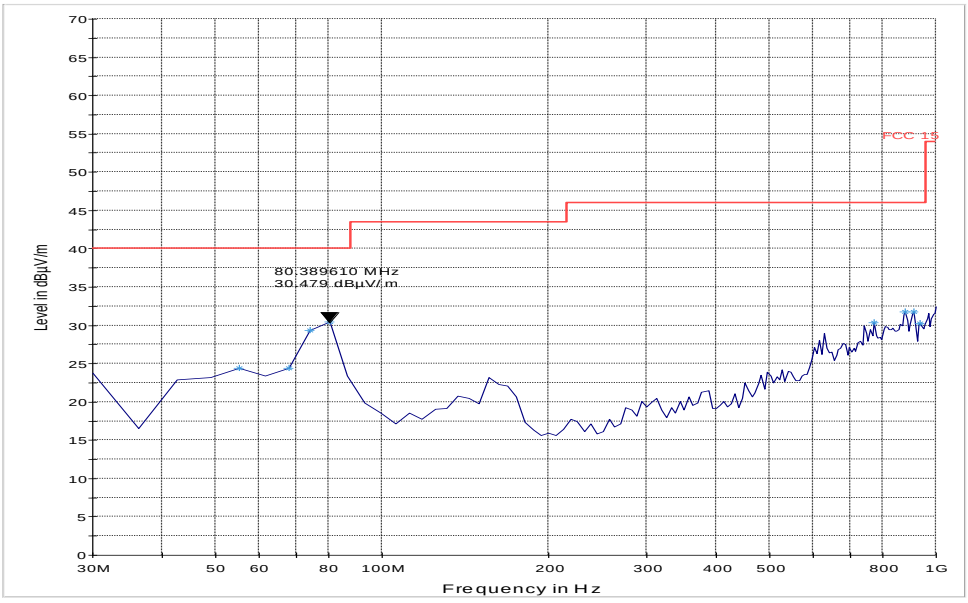
TX Radiated Spurious Emissions: 9kHz – 30MHz			
Ch. Mid	**Mode: Bluetooth LE**	**Modulation: GFSK**	**Data Rate: 1 Mbps**



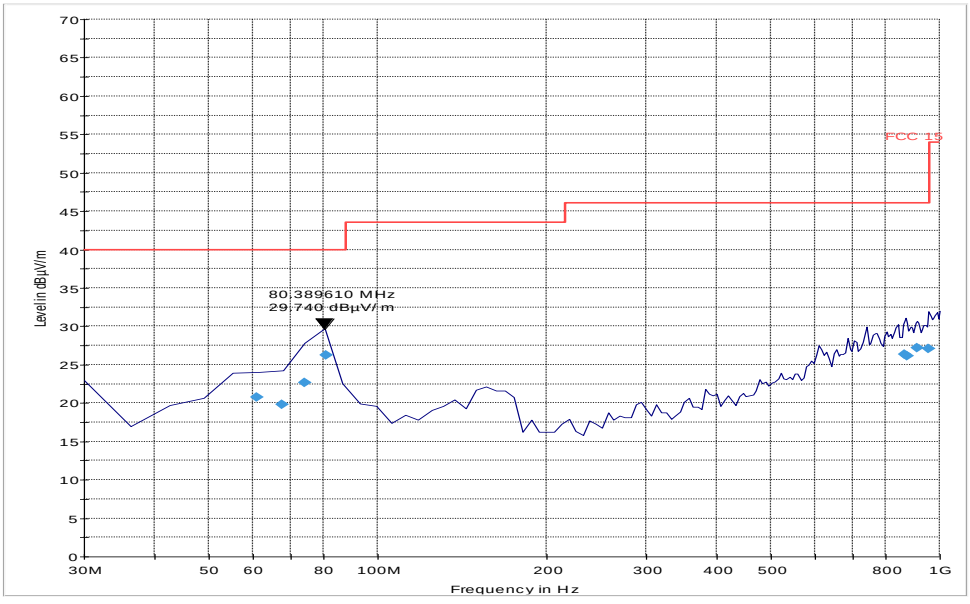
TX Radiated Spurious Emission: 30 MHz – 1GHz			
Ch. Low	**Mode: Bluetooth LE**	**Modulation: GFSK**	**Data Rate: 1 Mbps**



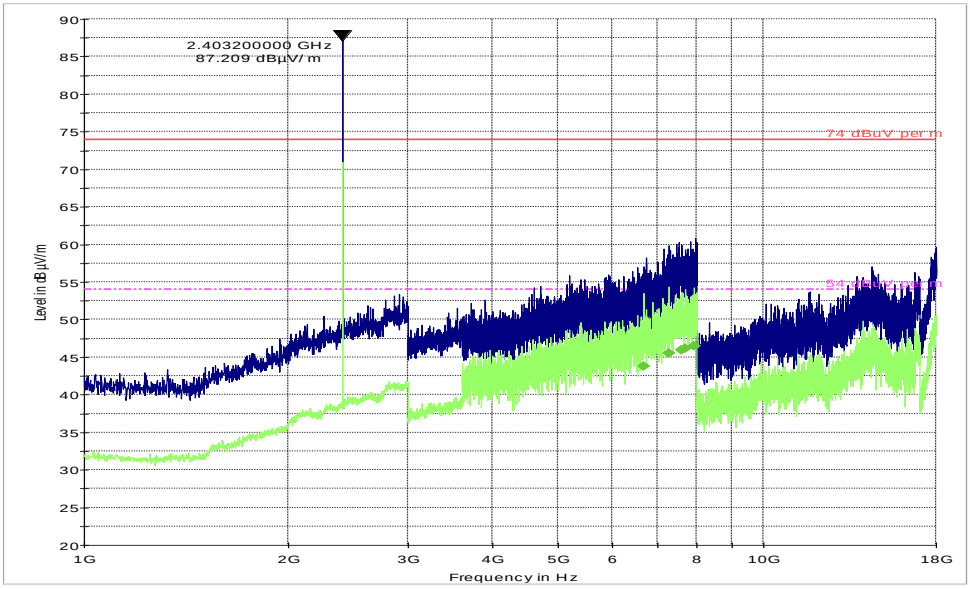
TX Radiated Spurious Emission: 30 MHz – 1GHz			
Ch. Mid	**Mode: Bluetooth LE**	**Modulation: GFSK**	**Data Rate: 1 Mbps**



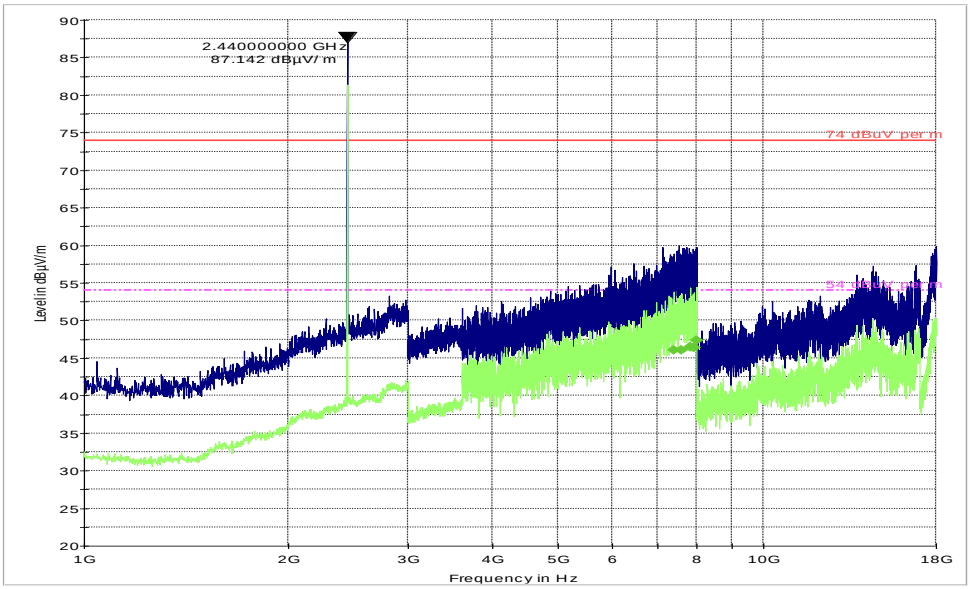
TX Radiated Spurious Emission: 30 MHz – 1GHz			
Ch. High	**Mode: Bluetooth LE**	**Modulation: GFSK**	**Data Rate: 1 Mbps**



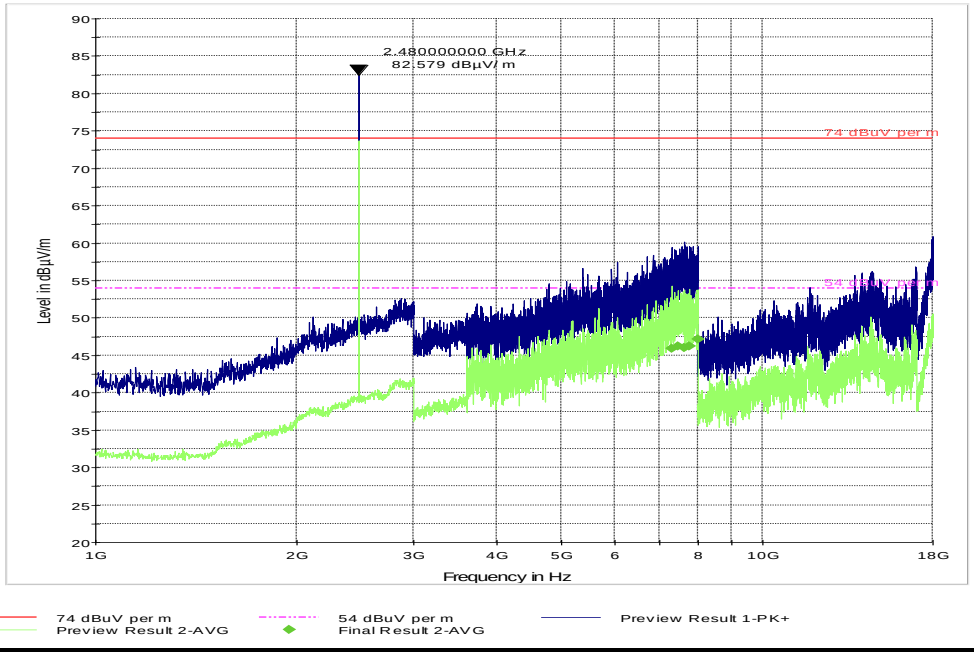
TX Radiated Spurious Emission: 1 GHz – 18 GHz			
Ch. Low	**Mode: Bluetooth LE**	**Modulation: GFSK**	**Data Rate: 1 Mbps**



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



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



12 AC Power Line Conducted Emissions

12.1 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.

12.2 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.

12.3 Test Conditions:

Tnom: 23 °C; Vnom: 3.7V

Receive and transmit mode of operation of operation

12.4 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 = Qusi-peak / Average

12.5 Results

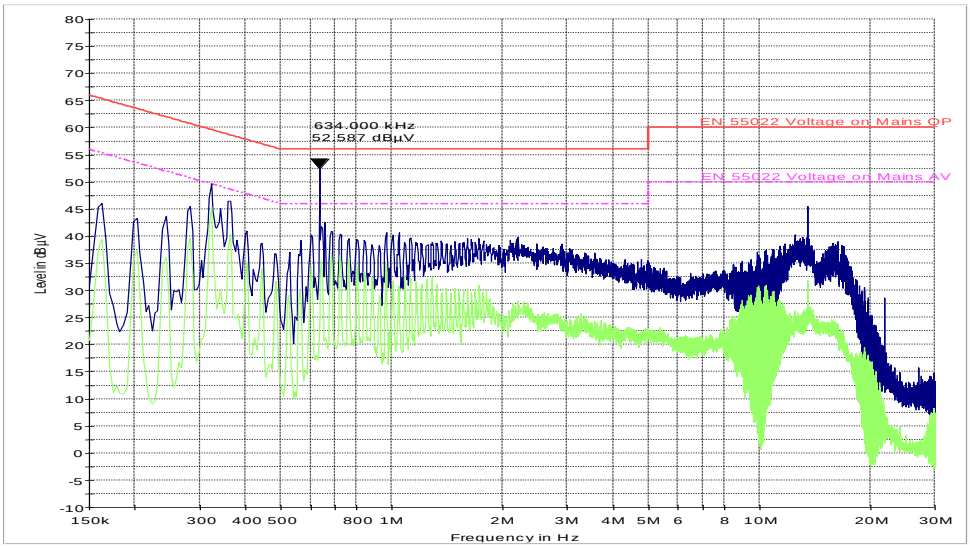
Plots shown here represent the combined worse case emissions for power lines, phases and neutral line.

Pass.

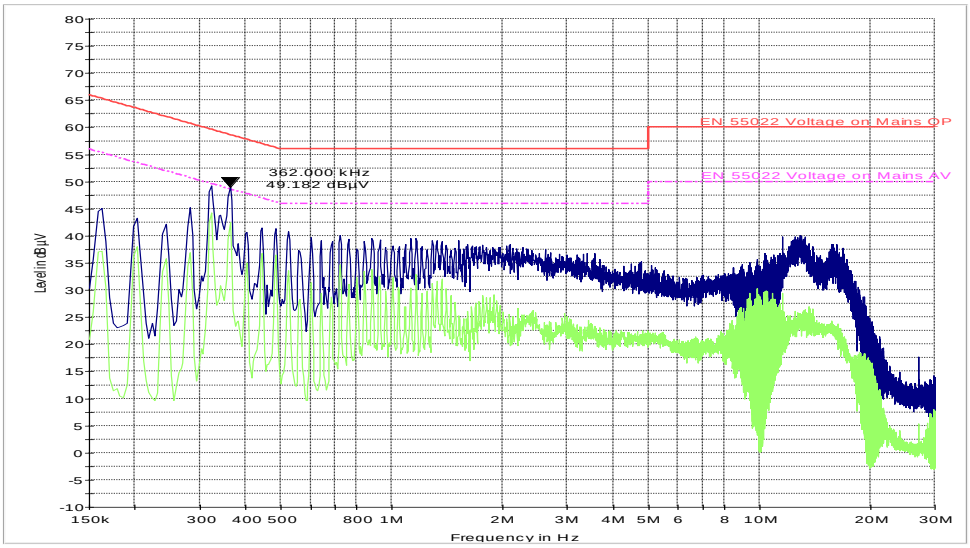
12.6 Measurement Plots:

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**



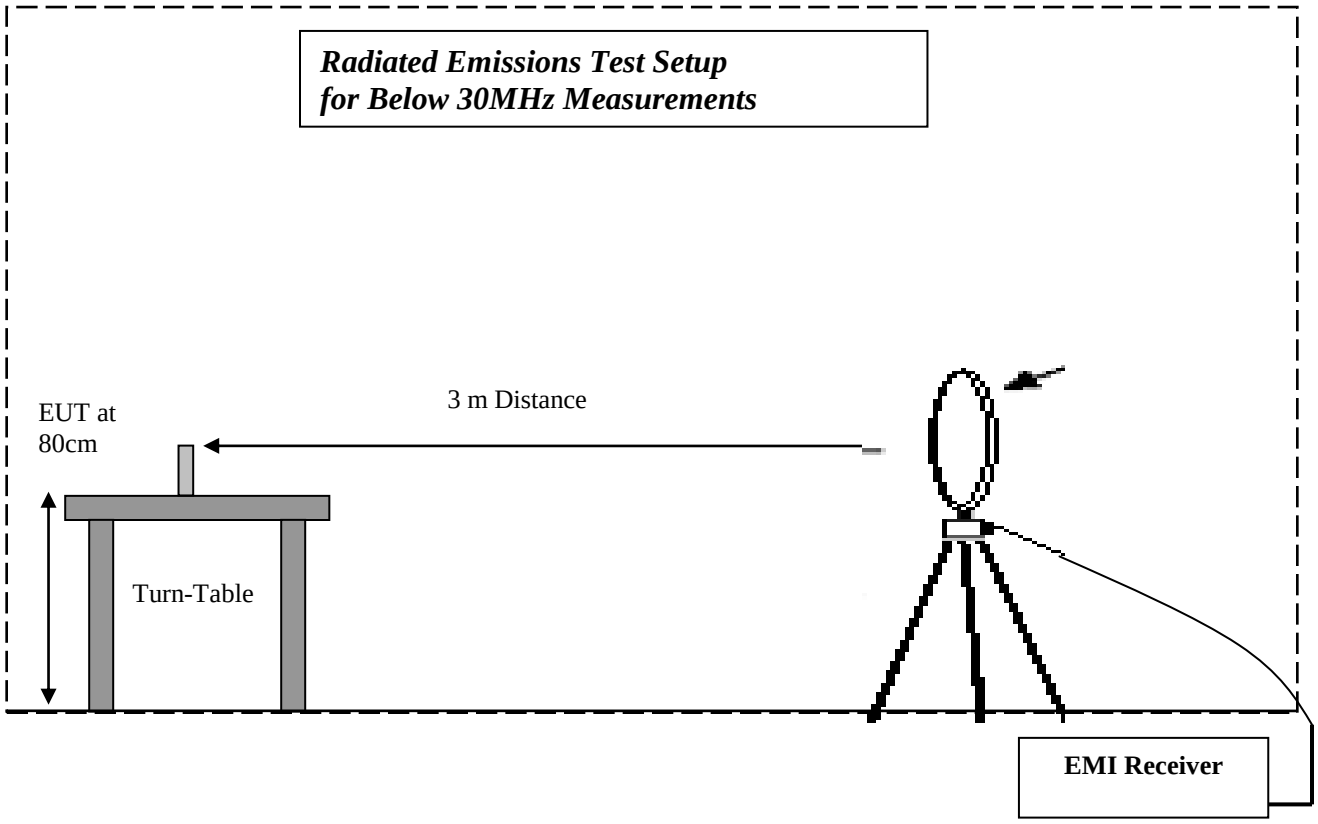
Conducted Emissions: 150 kHz – 30 MHz
RX/Idle mode

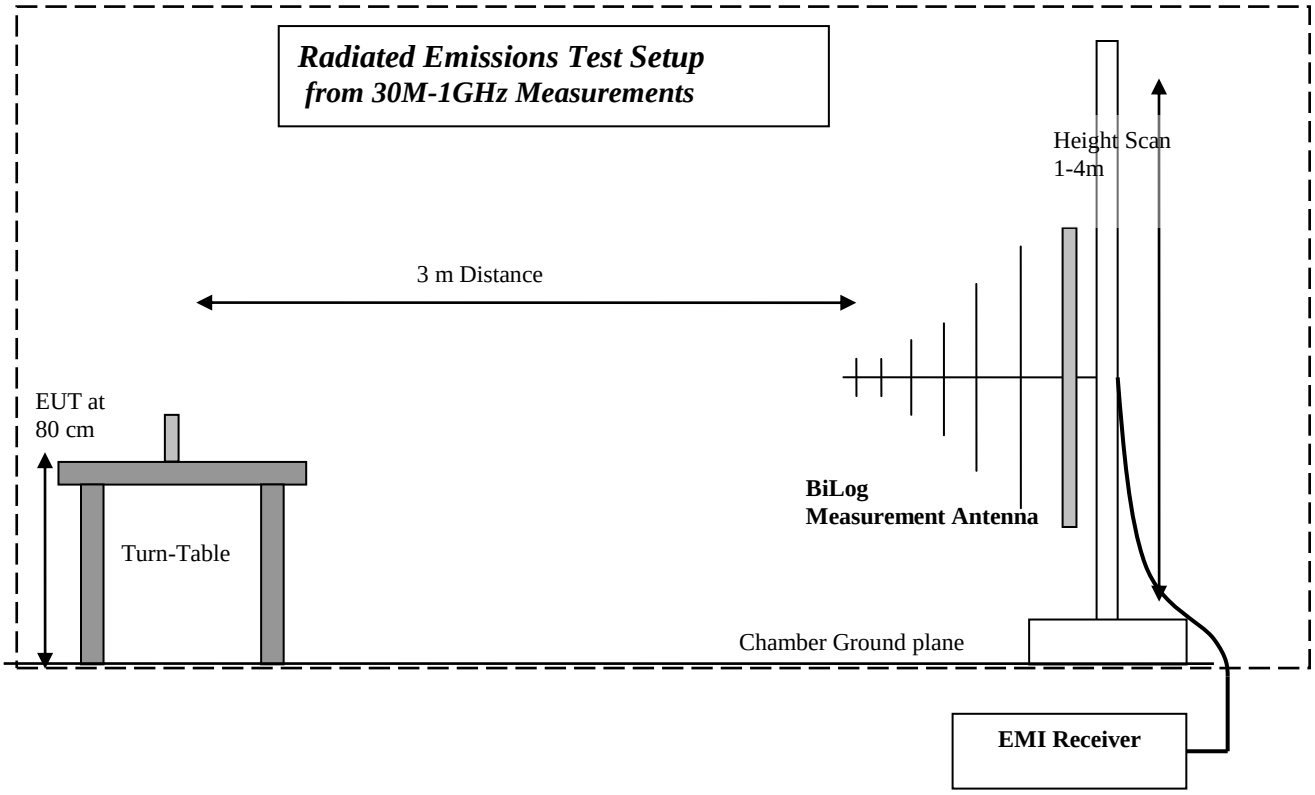


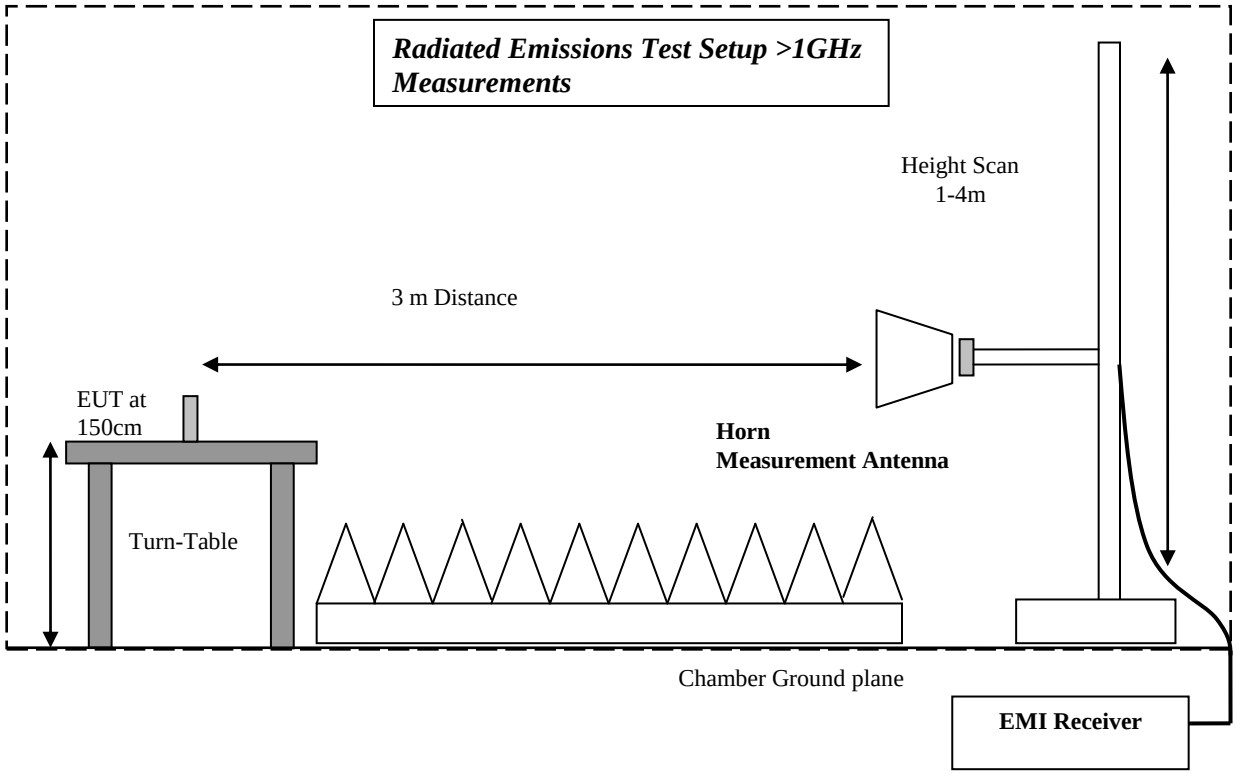
13 Test Equipment and Ancillaries used for tests

No.	Equipment Name	Manufacturer	Type/model	Serial No.	Cal Date	Cal Interval
	Turn table	EMCO	2075	N/A	N/A	N/A
	MAPS Position Controller	ETS Lindgren	2092	0004-1510	N/A	N/A
	Antenna Mast	EMCO	2075	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	
	Relay Switch Unit	Rohde&Schwarz	RSU	338964/001	N/A	N/A
	EMI Receiver/Analyzer	Rohde&Schwarz	ESU 40	100251	Sept 2013	2 Year
	Spectrum Analyzer	Rohde&Schwarz	FSU	200302	Jun 2013	2 Years
	1500MHz HP Filter	Filtek	HP12/1700	14c48	N/A	N/A
	2800 MHZ HP Filter	Filtek	HP12/2800	14C47	N/A	N/A
	Pre-Amplifier	Miteq	JS40010260	340125	N/A	N/A
	Binconilog Antenna	EMCO	3141	0005-1186	Apr 2012	3 Years
	Binconilog Antenna	ETS	3149	J000123908	Feb 2012	3 years
	Horn Antenna	EMCO	3115	35114	Mar 2012	3 Years
	Loop Antenna	EMCO	6512	00049838	Apr 2012	3 years
	LISN	R&S	ESH3-Z5	836679/003	Jun 2013	3 Years

14 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

15 Revision History

Date	Report Name	Changes to the report	Report prepared by
2015-02-05	EMC_INTEL_039_14001_15.247_BTLE_75E	First Revision	Danh Le