



Bluetooth LE
FCC / IC Test Report

FOR:
Apple Inc.

Model Name: A1644

Product Description:
Bluetooth Device with BDR, EDR and LE Support

FCC ID: BCGA1644
IC ID: 579C-A1644

47 CFR Part 15.247 [DTS]

RSS-247 Issue 1 [DTS] & RSS-Gen Issue 4

TEST REPORT #: EMC_APPLE-166-15001_15.247_BTLE_rev2
DATE: 2015-08-13



A2LA Accredited

IC recognized #
3462B

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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 with BDR, EDR and LE Support	A1644

Responsible for Testing Laboratory:

2015-08-13	Compliance	Franz Engert (Compliance Manager)	 Digitally signed by Franz Engert DN: cn=Franz Engert, c=US, o=CETECOM, ou=Compliance, email=franz. engert@cetecom.com
Date	Section	Name	Signature

Responsible for the Report:

2015-08-13	Compliance	Douglas Antioco (EMC Engineer)	Douglas Antioco 2015.08.13 14:50:48 -07'00'
Date	Section	Name	Signature

The test results of this test report relate exclusively to the test item specified in Section 3.

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

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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:	Jacqueline Zhai
Phone No.	(408) 620-0616
Fax:	-----
e-mail:	jacqueline_zhai@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:	A1644
HW Version :	Rev 1.0
SW Version :	STFW 0x0781 (BTFW 0x0048)
FCC-ID:	BCGA1644
IC-ID:	579C-A1644
HVIN:	A1644
PMN:	A1644
Product Description:	Bluetooth Device with BDR, EDR and LE Support
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:	Slot antenna: Documented max antenna gain(2.4GHz) = 6 dBi
Max. Output Power:	Conducted: 3.86 dBm (2.43mW)
Rated Operating Voltage Range / Power Supply:	Li-ion Battery Vmin: 3.0V dc/ Vnom: 3.8V dc / Vmax: 4.3V dc
Rated Operating Temperature Range:	0°C to 35°C
Other Radios included in the device:	1. Bluetooth Version 2.1 + EDR
EUT status	Pre-Production

3.2 Identification of the Equipment under Test (EUT)

EUT #	Serial Number	HW Version	SW Version	Notes/Comments
1	F0T5172006BGJYP18	Rev 1.0	STFW 0x0781 BTFW 0x0048	Radiated and Conducted Emissions (AC power line) Sample
2	F0T5172001ZGJYL14	Rev 1.0	STFW 0x0781 BTFW 0x0048	Conducted RF Sample

3.3 Identification of Ancillary equipment

STE #	Type	Manufacturer	Model	Serial Number	Notes/Comments
1	USB Power Adapter	Phihong	PSAI05R-050Q	P142302633A1	Conducted Emissions
2	USB Power Adapter	Apple	A1357	W010A051	Radiated Emissions

3.4 Environmental conditions during Test:

The following environmental conditions were maintained during the course of testing:

Ambient Temperature: 20-25°C

Relative humidity: 40-60%

3.5 Dates of Testing:

6/3/2015-6/8/2015

3.6 Test mode of operation:

The EUT was set low, mid and high channels with a 100% Duty Cycle using special software that is not available to the end user.

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-247 Issue 1, Section 5 of Industry Canada.

This test report is to support a request for new equipment authorization under the FCC ID: BCGA1644 and IC: 579C-A1644

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

Testing procedures are based on FCC KDB 558074 D01 v03r03, "GUIDANCE FOR PERFORMING COMPLIANCE MEASUREMENTS ON DIGITAL TRANSMISSION SYSTEMS (DTS) OPERATING UNDER §15.247" and ANSI C63.10:2013 for DTS devices.

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.

Note 1: Conducted unwanted emissions testing against non-restricted band limits is not performed, except at the authorized band edge section, since radiated spurious emissions against more stringent restricted band limits over the complete range (9 kHz to 26 GHz) has passed.

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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 dB μ V
2. Cable Loss between the receiving antenna and SA in dB and
3. Antenna Factor in dB/m

FS (dB μ V/m) = Measured Value on SA (dB μ V)+ Cable Loss (dB)+ Antenna Factor (dB/m)

Eg:

Frequency (MHz)	Measured SA (dB μ V)	Cable Loss (dB)	Antenna Factor Correction (dB)	Field Strength Result (dB μ V/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.

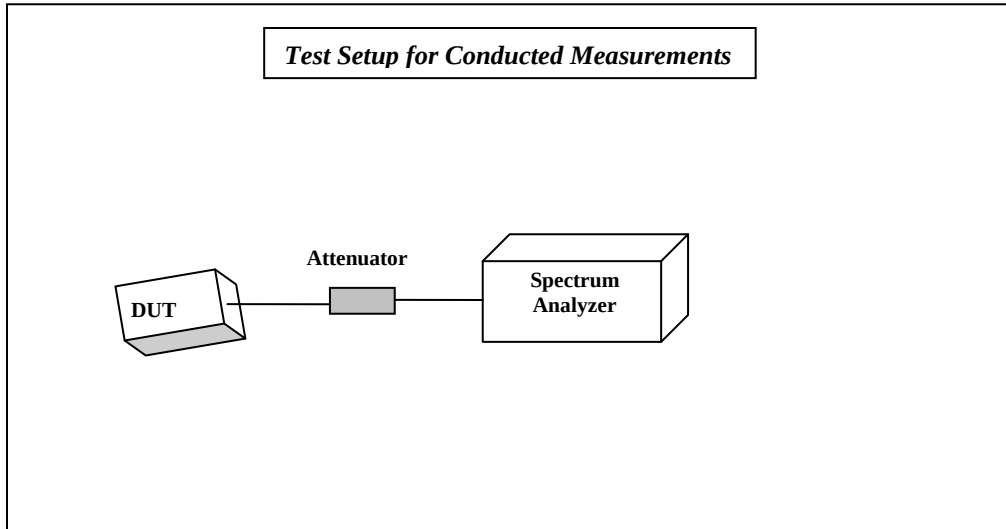
6.2 Conducted Emissions Measurement Procedure (AC Power Line)

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 (Average) Output Power and EIRP

7.1 Limits:

Maximum Peak 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 5.4(4): 4W

7.2 Test Conditions:

Tnom: 21°C; Vnom: 3.8V

EUT set to Transmit with 100% Duty Cycle

7.3 Test Procedure

Duty cycle measurement according to FCC KDB 558074 D01 v03r03 section 6.0 b)

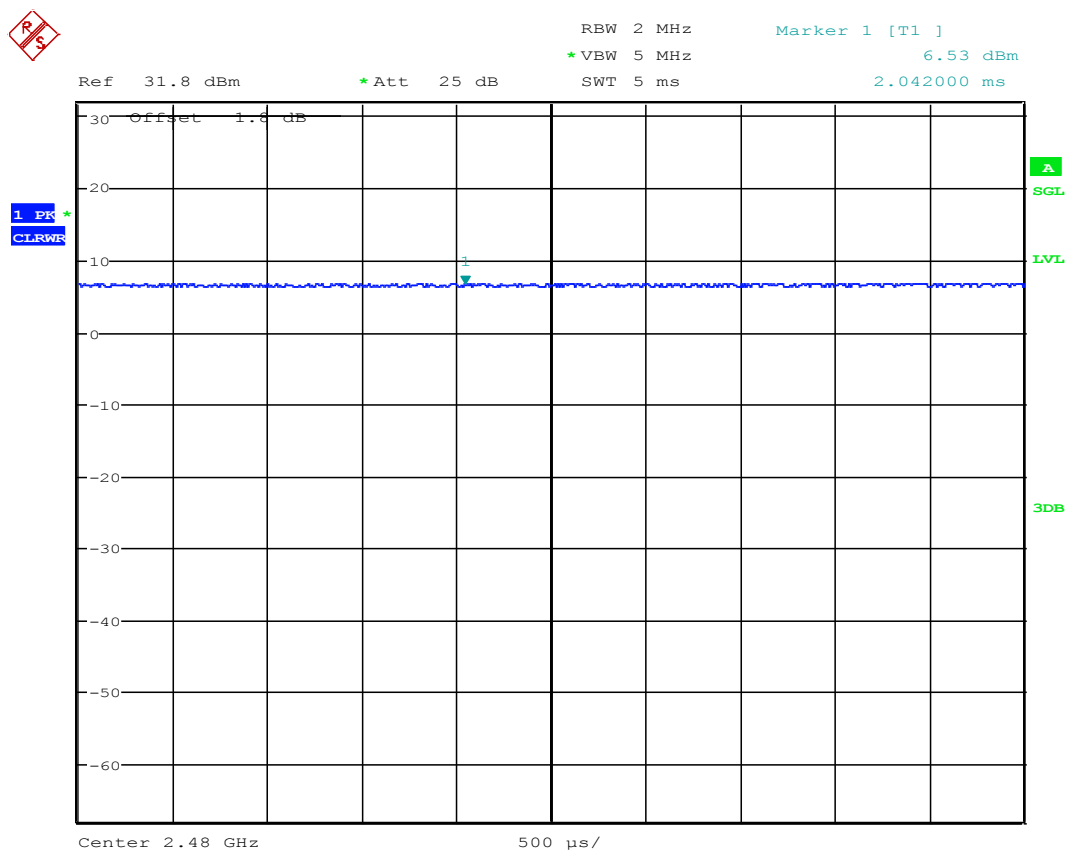
Power measurement according to FCC KDB 558074 D01 v03r03 section 9.2.2.2

9.2.2.2 Method AVGSA-1 (trace averaging with the EUT transmitting at full power throughout each sweep)

- a) Set span to at least 1.5 times the OBW.
- b) Set RBW = 1-5% of the OBW, not to exceed 1 MHz.
- c) Set VBW $\geq 3 \times$ RBW.
- d) Number of points in sweep $\geq 2 \times$ span / RBW. (This gives bin-to-bin spacing $\leq$ RBW/2, so that narrowband signals are not lost between frequency bins.)
- e) Sweep time = auto.
- f) Detector = RMS (*i.e.*, power averaging), if available. Otherwise, use sample detector mode.
- g) If transmit duty cycle < 98 %, use a sweep trigger with the level set to enable triggering only on full power pulses. The transmitter shall operate at maximum power control level for the entire duration of every sweep. If the EUT transmits continuously (*i.e.*, with no off intervals) or at duty cycle ≥ 98 %, and if each transmission is entirely at the maximum power control level, then the trigger shall be set to “free run”.
- h) Trace average at least 100 traces in power averaging (*i.e.*, RMS) mode.
- i) 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. If the instrument does not have a band power function, sum the spectrum levels (in power units) at intervals equal to the RBW extending across the entire OBW of the spectrum.

7.4 Test Data

7.4.1 Duty Cycle Measurement:



Date: 3.JUN.2015 19:58:44

Duty Cycle= 100%

7.4.2 Maximum Conducted (Average) Output Power

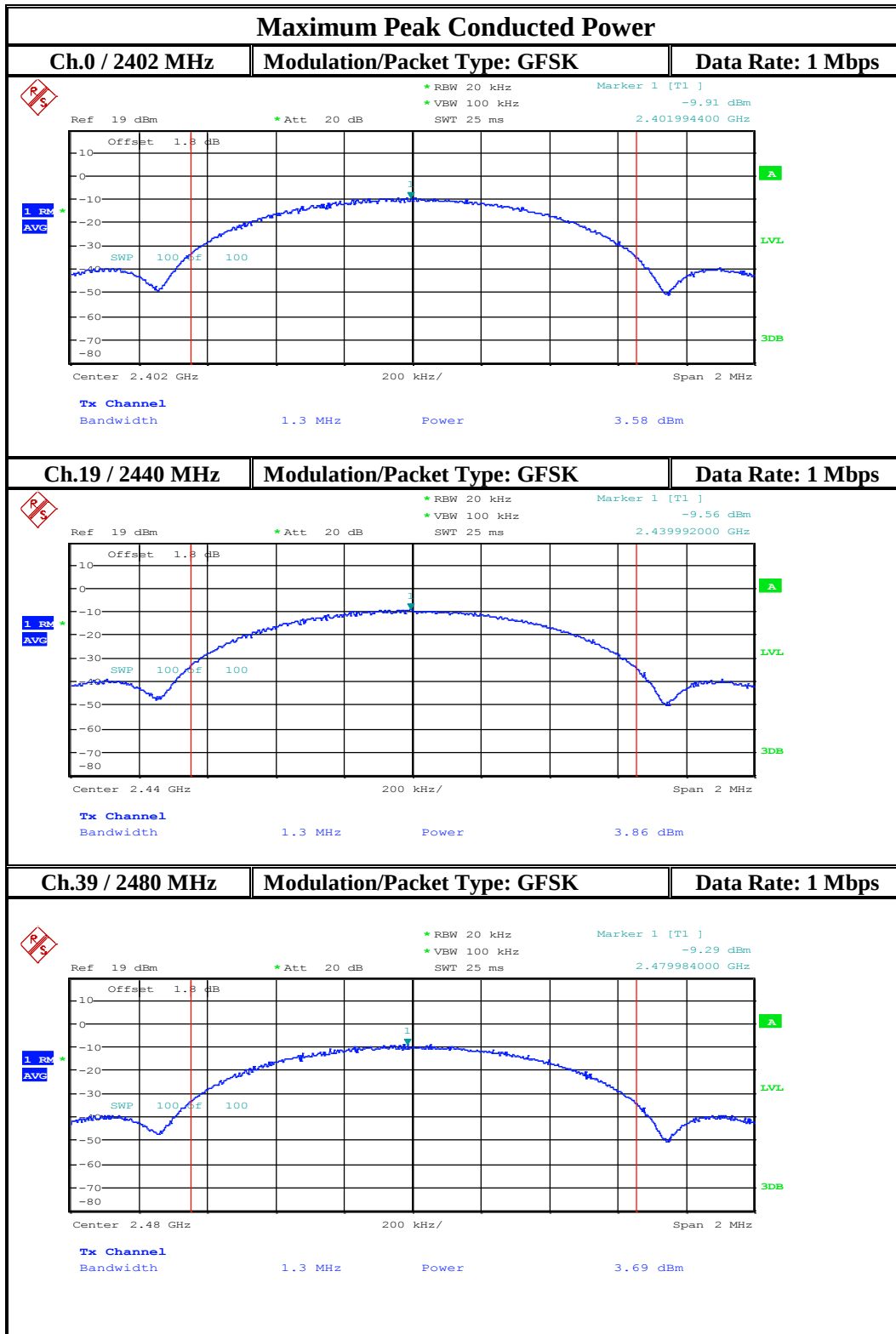
Maximum Conducted (Average) Output Power (dBm)				
Limit = 30 dBm		Frequency (MHz)		
		2402 Channel 0	2440 Channel 19	2480 Channel 39
Bluetooth LE		3.58	3.86	3.69
Calculated Radiated Output Power EIRP (dBm)				
Limit = 36 dBm		Frequency (MHz)		
		2402 Channel 0	2440 Channel 19	2480 Channel 39
Mode	Antenna Gain (dBi)			
Bluetooth LE	6.0	9.58	9.86	9.69

Declared Antenna Gain in the 2.4GHz band: 6.0 dBi

7.5 Measurement Result

Pass.

7.6 Measurement Plots:



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: 3.8V

8.3 Measurement procedure

Measurement according to FCC KDB 558074 D01 V03R03 section 10.3

10.3 Method AVGPSD-1 (trace averaging with EUT transmitting at full power throughout each sweep)

This procedure may be used when the maximum (average) conducted output power was used to demonstrate compliance to the output power limit. This is the baseline method for determining the maximum (average) conducted PSD level. If the instrument has an RMS power averaging detector, it must be used; otherwise, use the sample detector. The EUT must be configured to transmit continuously (duty cycle $\geq 98\%$); otherwise sweep triggering/signal gating must be implemented to ensure that measurements are made only when the EUT is transmitting at its maximum power control level (no transmitter off time is to be considered).

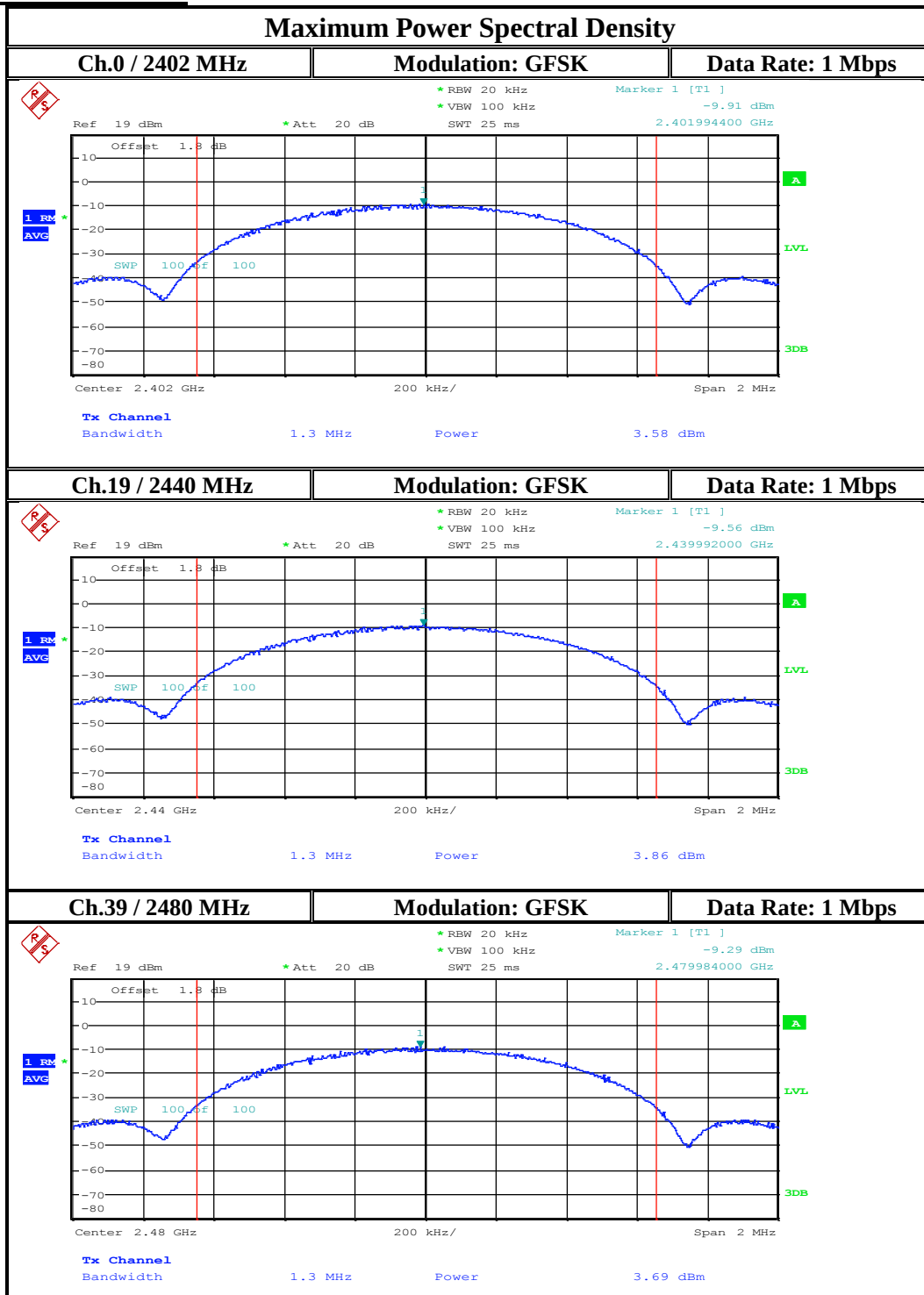
- a) Set instrument center frequency to DTS channel center frequency.
- b) Set span to at least 1.5 times the OBW.
- c) Set RBW to: $3 \text{ kHz} \leq \text{RBW} \leq 100 \text{ kHz}$.
- d) Set VBW $\geq 3 \times \text{RBW}$.
- e) Detector = power averaging (RMS) or sample detector (when RMS not available).
- f) Ensure that the number of measurement points in the sweep $\geq 2 \times \text{span/RBW}$.
- g) Sweep time = auto couple.
- h) Employ trace averaging (RMS) mode over a minimum of 100 traces.
- i) Use the peak marker function to determine the maximum amplitude level.
- j) If measured value exceeds limit, 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)		
	2402 Channel 0	2440 Channel 19	2480 Channel 39
Bluetooth LE	-9.91	-9.56	-9.29

8.4.1 Measurement Result

Pass.

8.5 Measurement Plots:

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) 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: 3.8V

9.3 Measurement Procedure:

Conducted Measurement according to FCC KDB 558074 D01 v03r03 section 11.3

For Band Edge measurement

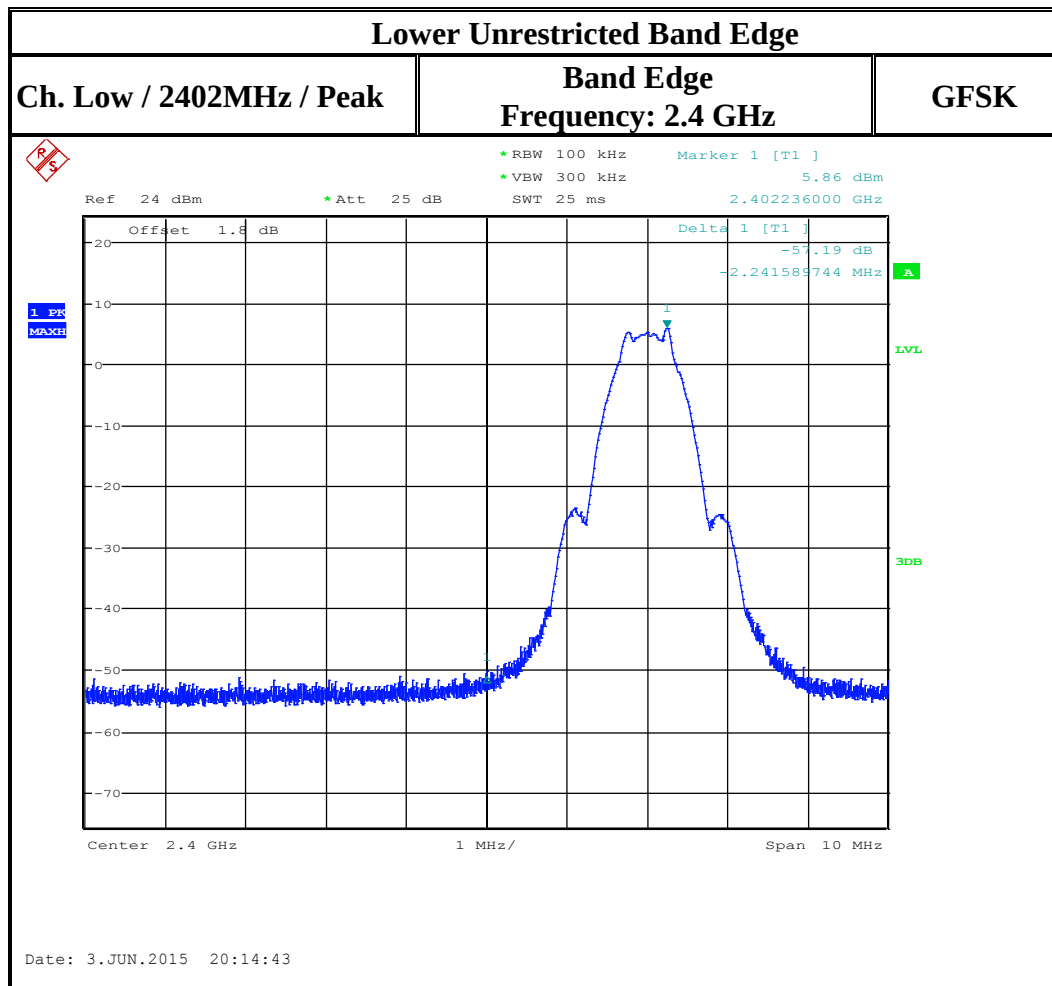
Peak measurements are made using a peak detector and RBW=100 KHz.

*PEAK LIMIT= 30 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power.

9.4 Measurement Result

Pass.

9.4.1 Measurement Plots:



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			

§15.205(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)

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).

At 3 meter distance radiated limits are:

*PEAK LIMIT= 74dB μ V/m

*AVG. LIMIT= 54dB μ V/m

For conducted measurements at the antenna port:

*PEAK LIMIT= -21.2 dBm EIRP

*AVG. LIMIT= -41.2 dBm EIRP

10.2 Test Conditions:

Tnom: 21°C; Vnom: 3.8V

10.3 Measurement Procedure:

Conducted Measurements were performed according to FCC KDB 558074 D01 V03R03 section 12.2, 12.2.4, and 12.2.5.1.

12.2.4 Peak power measurement procedure

Peak emission levels are measured by setting the instrument as follows:

- a) RBW = as specified in Table 1.
- b) $VBW \geq 3 \times RBW$.
- c) Detector = Peak.
- d) Sweep time = auto.
- e) Trace mode = max hold.
- f) Allow sweeps to continue until the trace stabilizes. (Note that the required measurement time may be longer for low duty cycle applications).

Table 1—RBW as a function of frequency

Frequency	RBW
9-150 kHz	200-300 Hz
0.15-30 MHz	9-10 kHz
30-1000 MHz	100-120 kHz
> 1000 MHz	1 MHz

If the peak-detected amplitude can be shown to comply with the average limit, then it is not necessary to perform a separate average measurement.

12.2.5.1 Trace averaging with continuous EUT transmission at full power

If the EUT can be configured or modified to transmit continuously (duty cycle ≥ 98 percent then the average emission levels shall be measured using the following method (with EUT transmitting continuously).

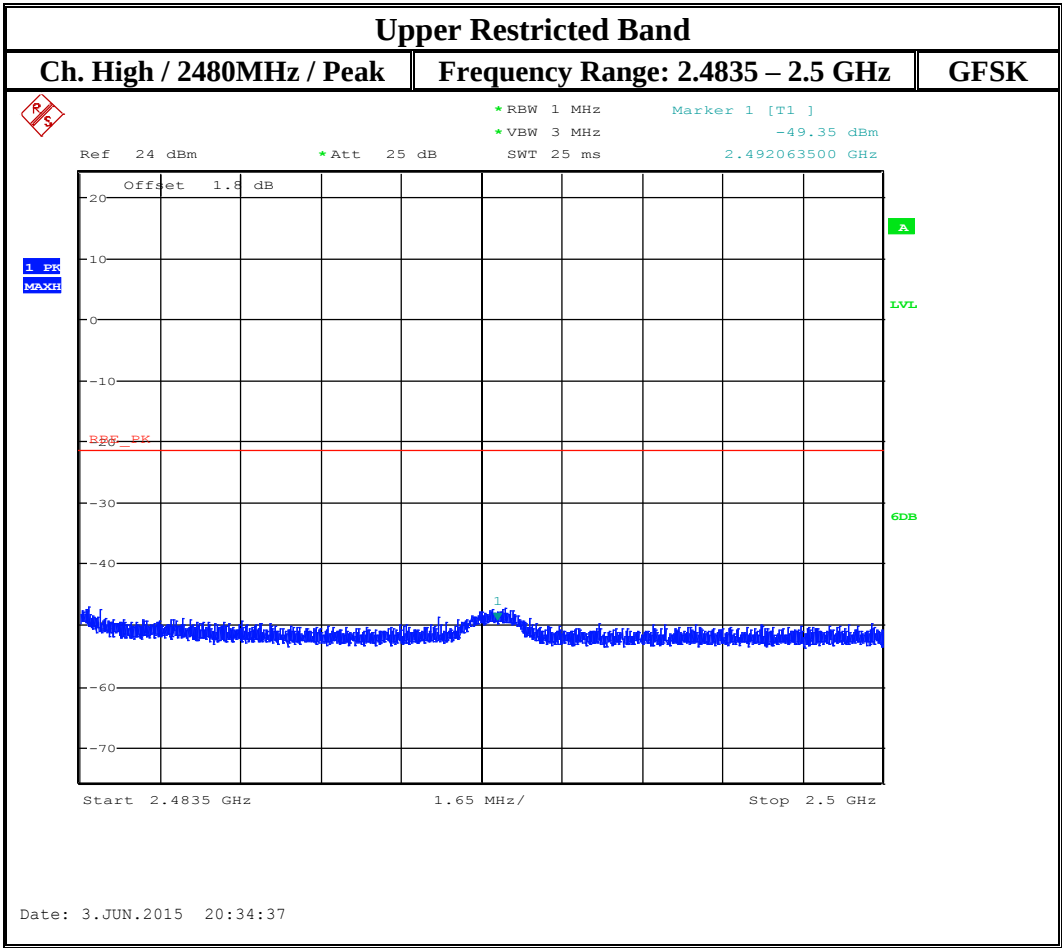
- a) RBW = 1 MHz (unless otherwise specified).
- b) $VBW \geq 3 \times RBW$.
- c) Detector = RMS, if $\text{span}/(\# \text{ of points in sweep}) \leq (RBW/2)$. Satisfying this condition may require increasing the number of points in the sweep or reducing the span. If this condition cannot be satisfied, then the detector mode shall be set to peak.
- d) Averaging type = power (*i.e.*, RMS).

- 1) As an alternative, the detector and averaging type may be set for linear voltage averaging.
- 2) Some instruments require linear display mode in order to use linear voltage averaging. Log or dB averaging shall not be used.
- e) Sweep time = auto.
- f) Perform a trace average of at least 100 traces.

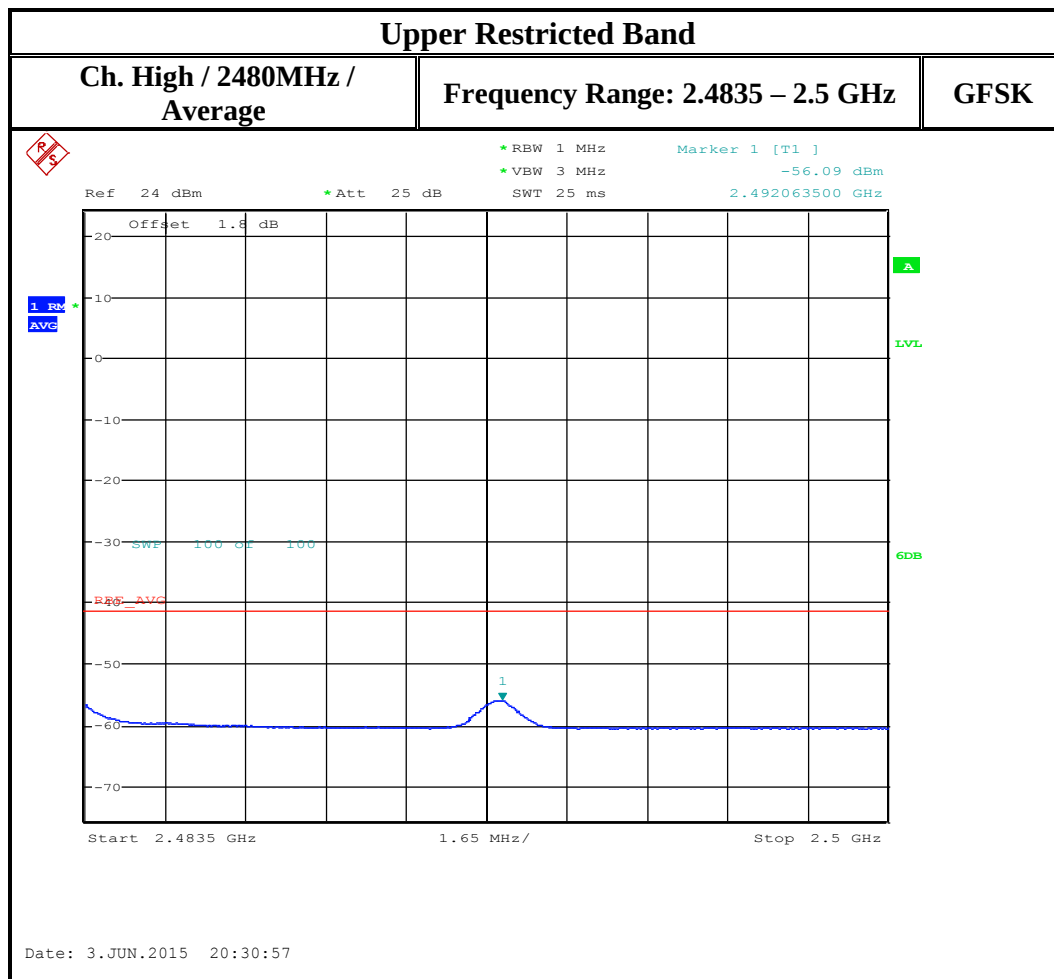
10.4 Measurement Result

Pass.

10.4.1 Measurement Plots:



Note: Antenna gain is not in the offset.



Note: Antenna gain is not in the offset.

11 Occupied Bandwidth (6dB and 99% Bandwidth)

11.1 Limits:

11.1.1.1 §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.

11.2 Test Conditions:

Tnom: 22 °C; Vnom: 3.8V

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 $\geq$ 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:

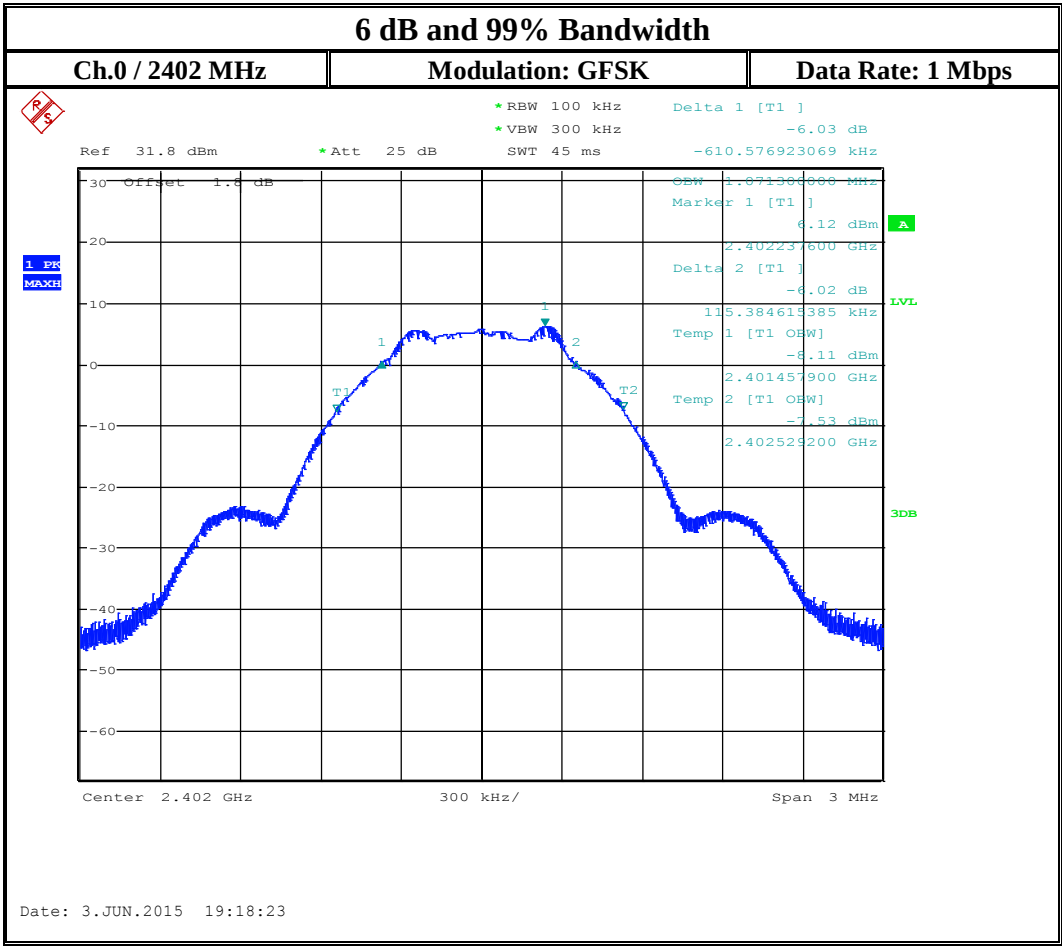
2.4 GHz Band

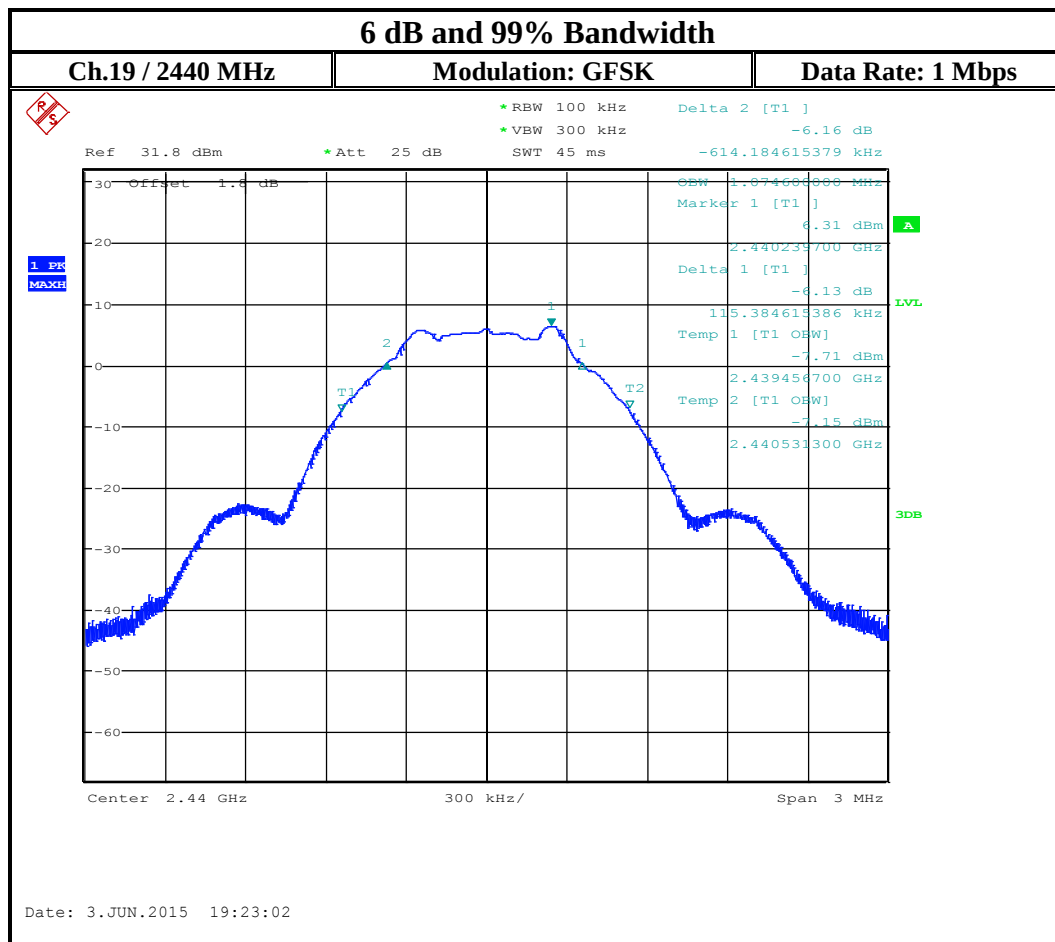
Occupied Bandwidth (MHz)						
Mode	Frequency (MHz)					
	2402 Channel 0		2440 Channel 19		2480 Channel 39	
	6dB (KHz)	99% (MHz)	6dB (KHz)	99% (MHz)	6dB (KHz)	99% (MHz)
Bluetooth LE	726.0	1.07	729.6	1.07	726.0	1.08

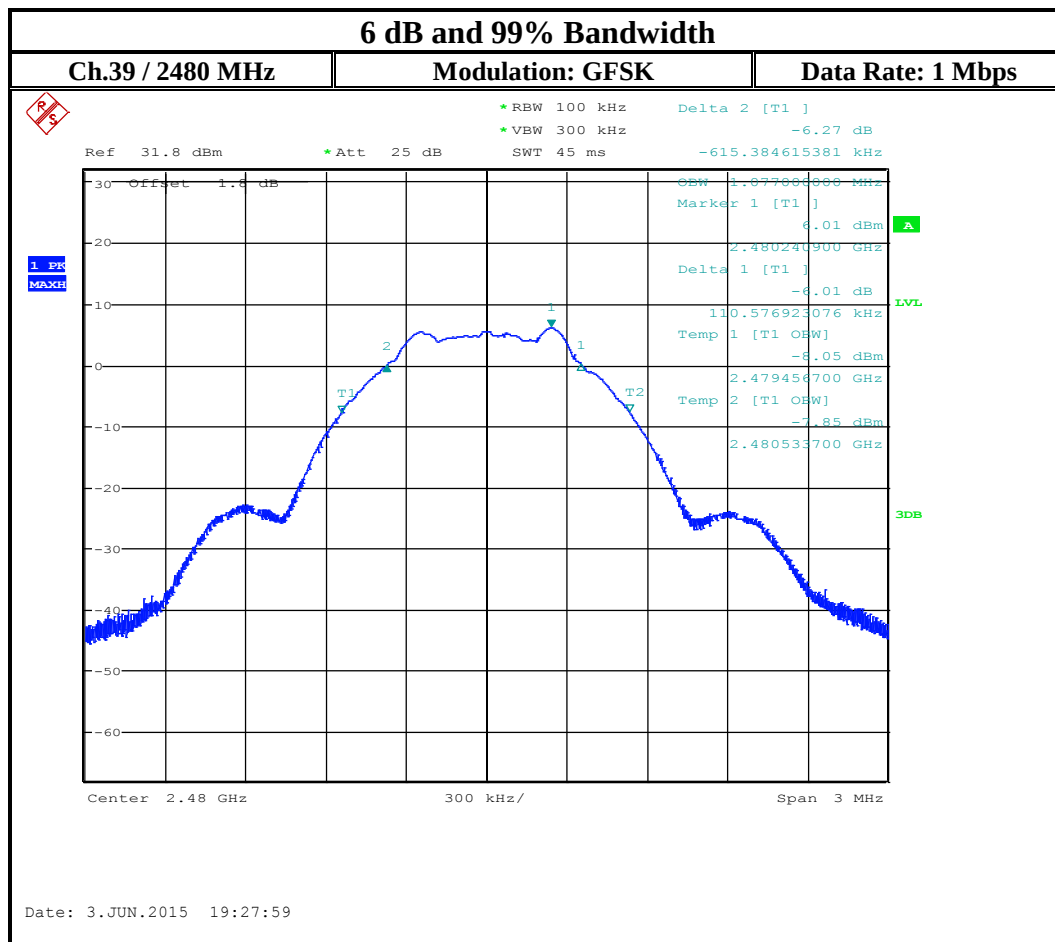
11.5 Measurement Result

Pass.

11.6 Measurement Plots:







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= 74dB μ V/m

*AVG. LIMIT= 54dB μ V/m

Table 1: Field strength limits table above 30 MHz

Frequency of emission (MHz)	Field strength (μ V/m)
30–88	100 (40dB μ V/m)
88–216	150 (43.5 dB μ V/m)
216–960	200 (46 dB μ V/m)
Above 960	500 (54 dB μ V/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: 3.8V

Test mode: Modulation: GFSK

12.3 Measurement procedure:

Measurement according to:

ANSI C63.10 (2013)

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

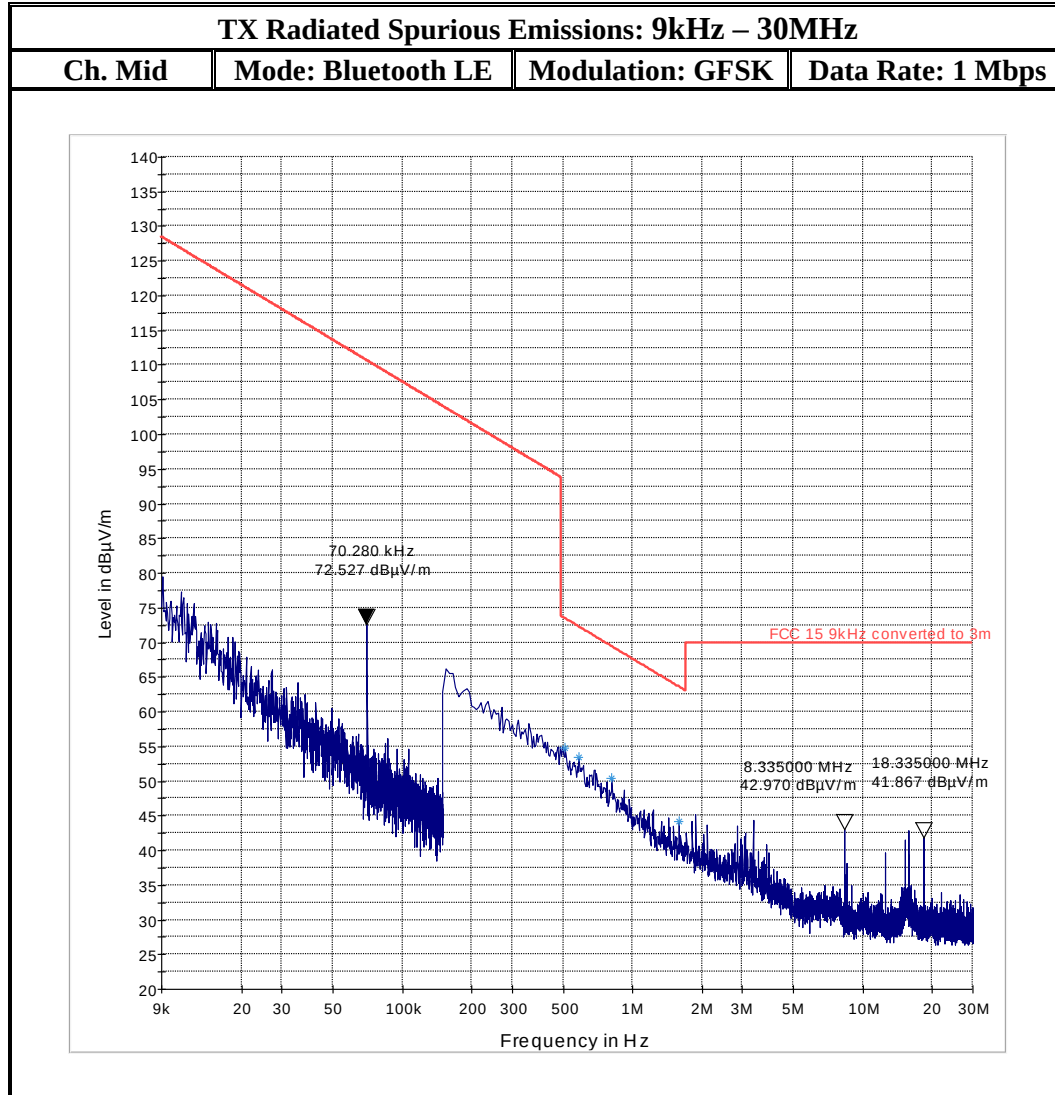
RBW= 1MHz

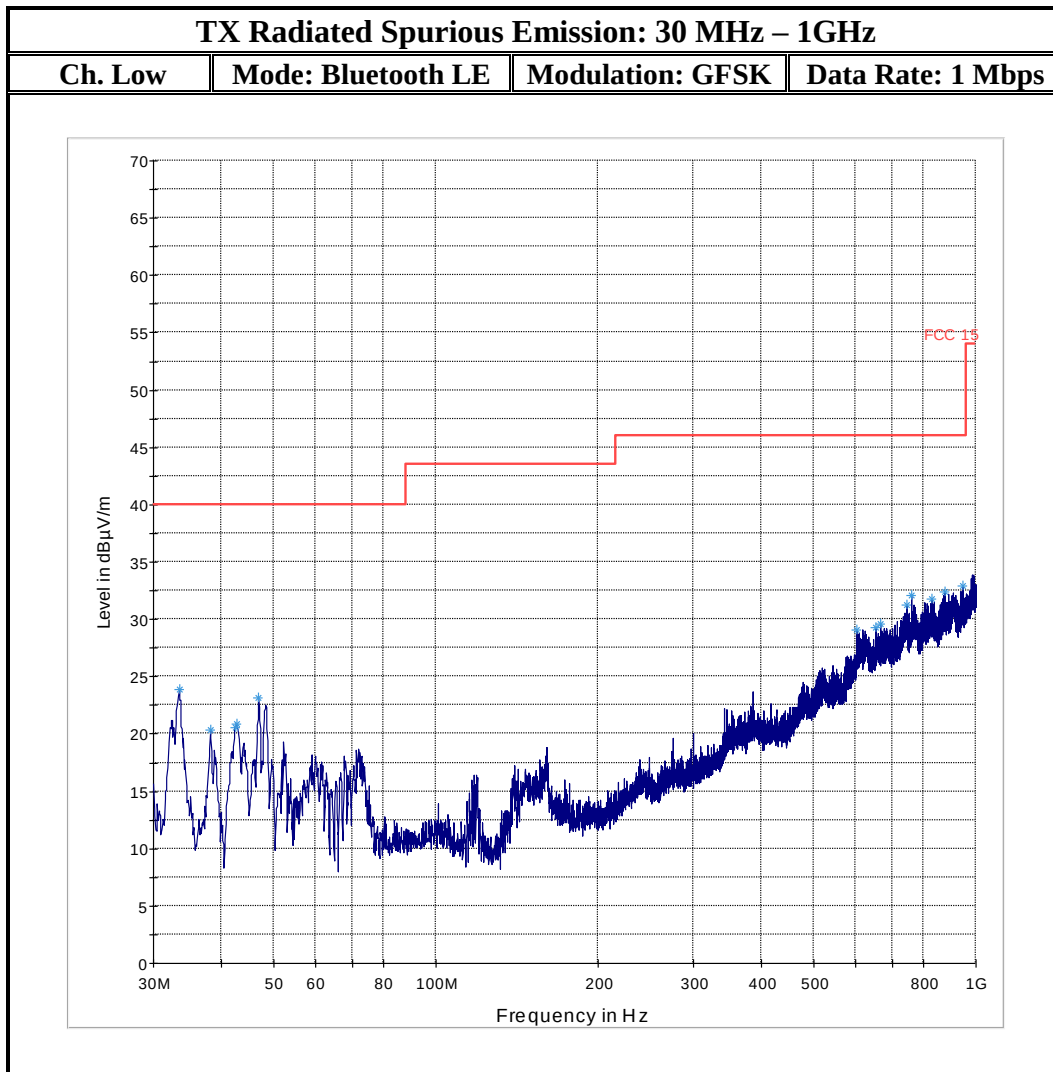
Test mode: Modulation: GFSK

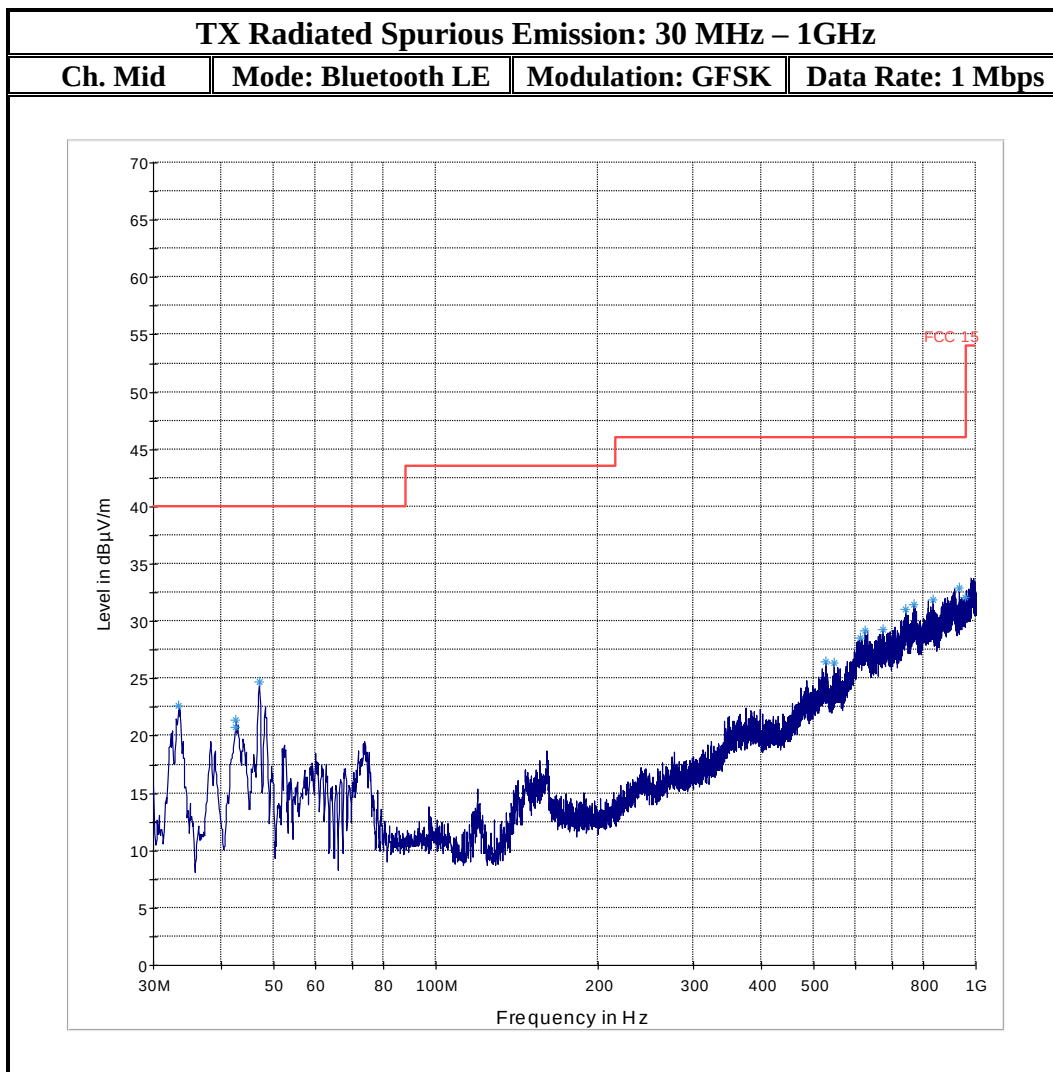
Plots in this report represent the worst case emissions for horizontal and vertical antenna polarizations and for three orientations of the EUT.

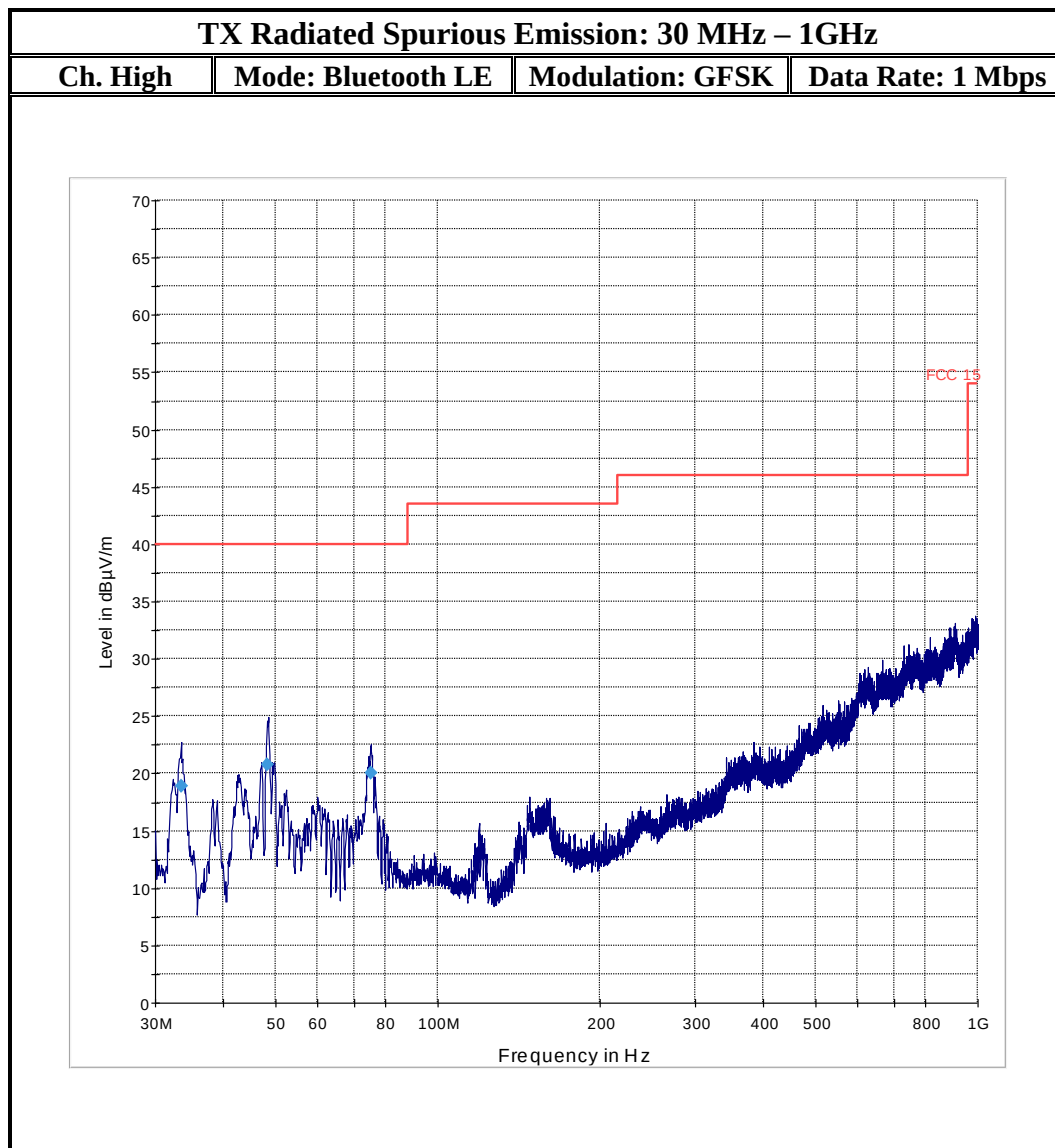
12.4 Measurement Result

Pass.

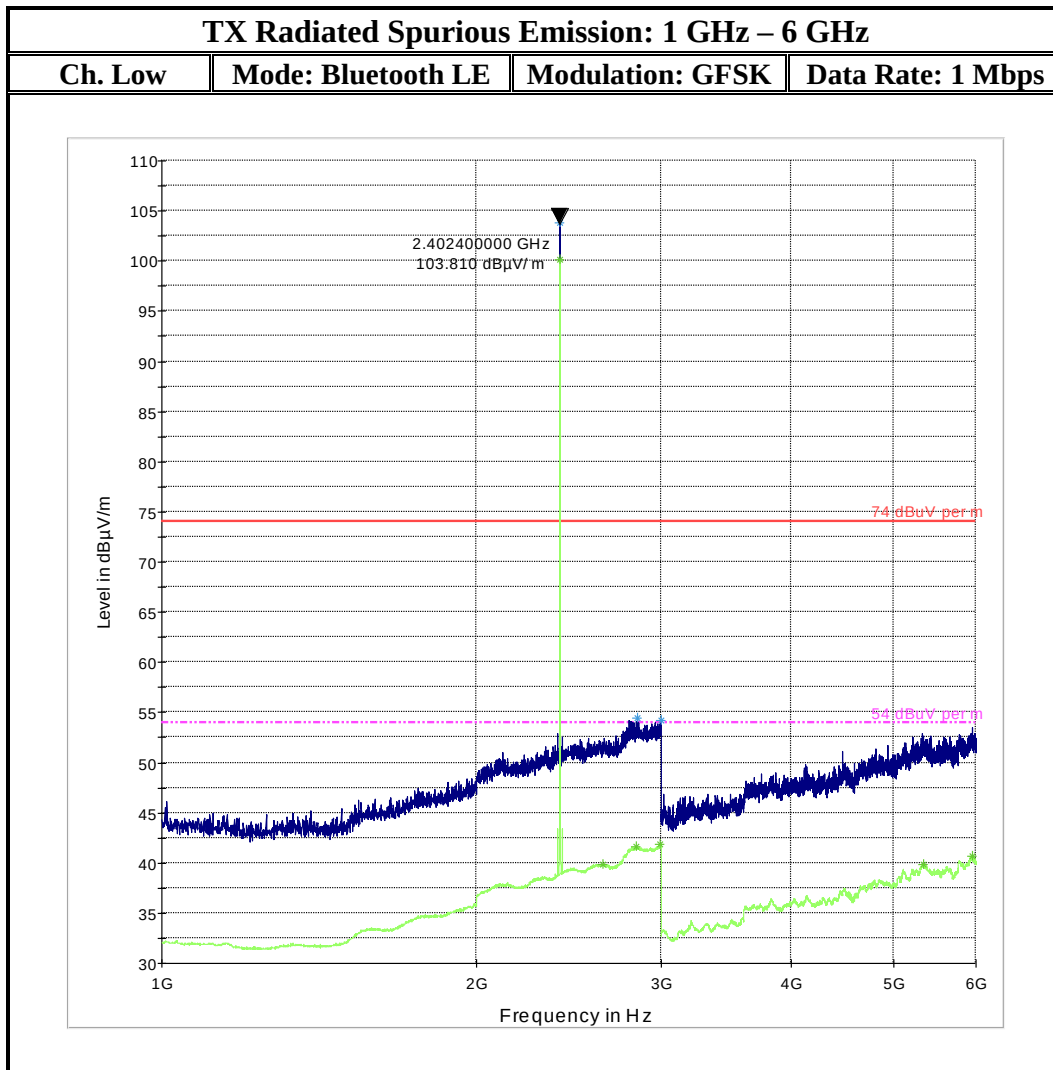
12.5 Measurement Plots:

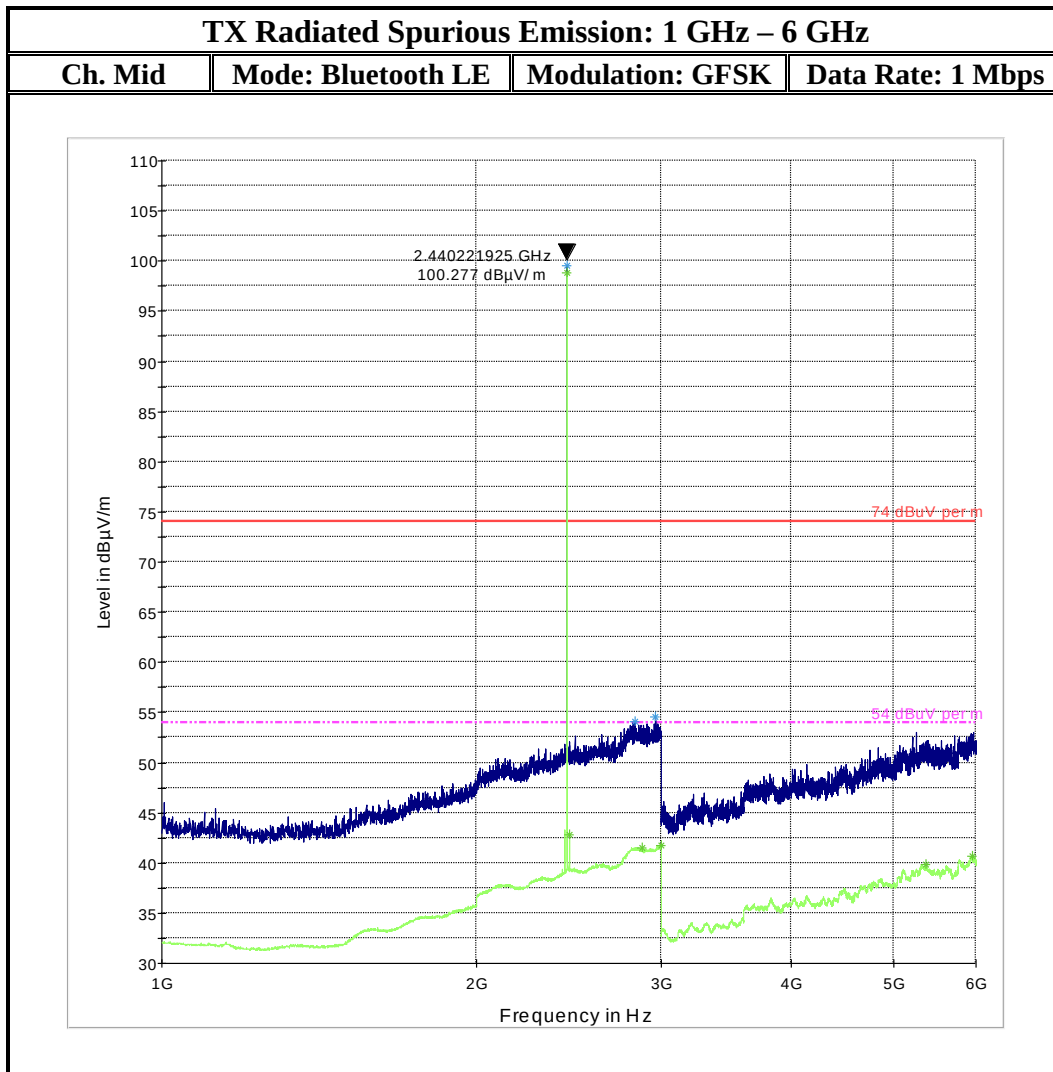


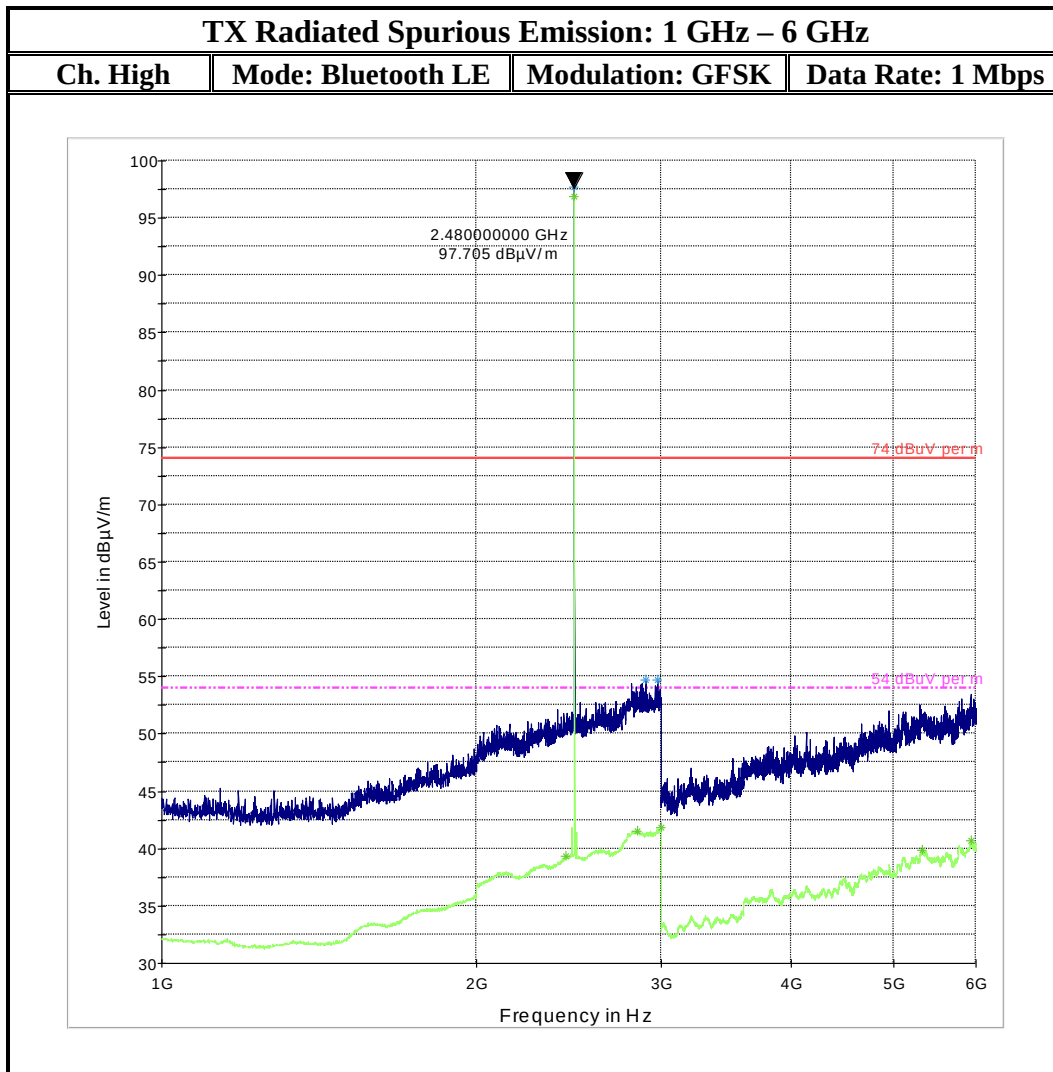


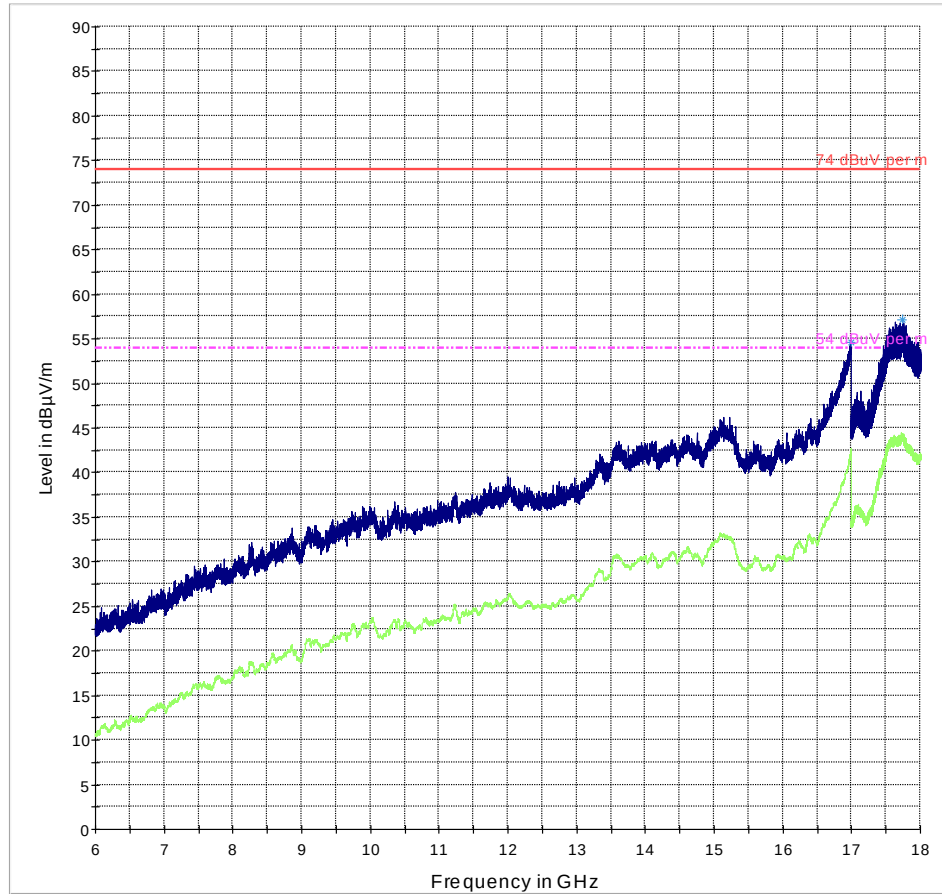


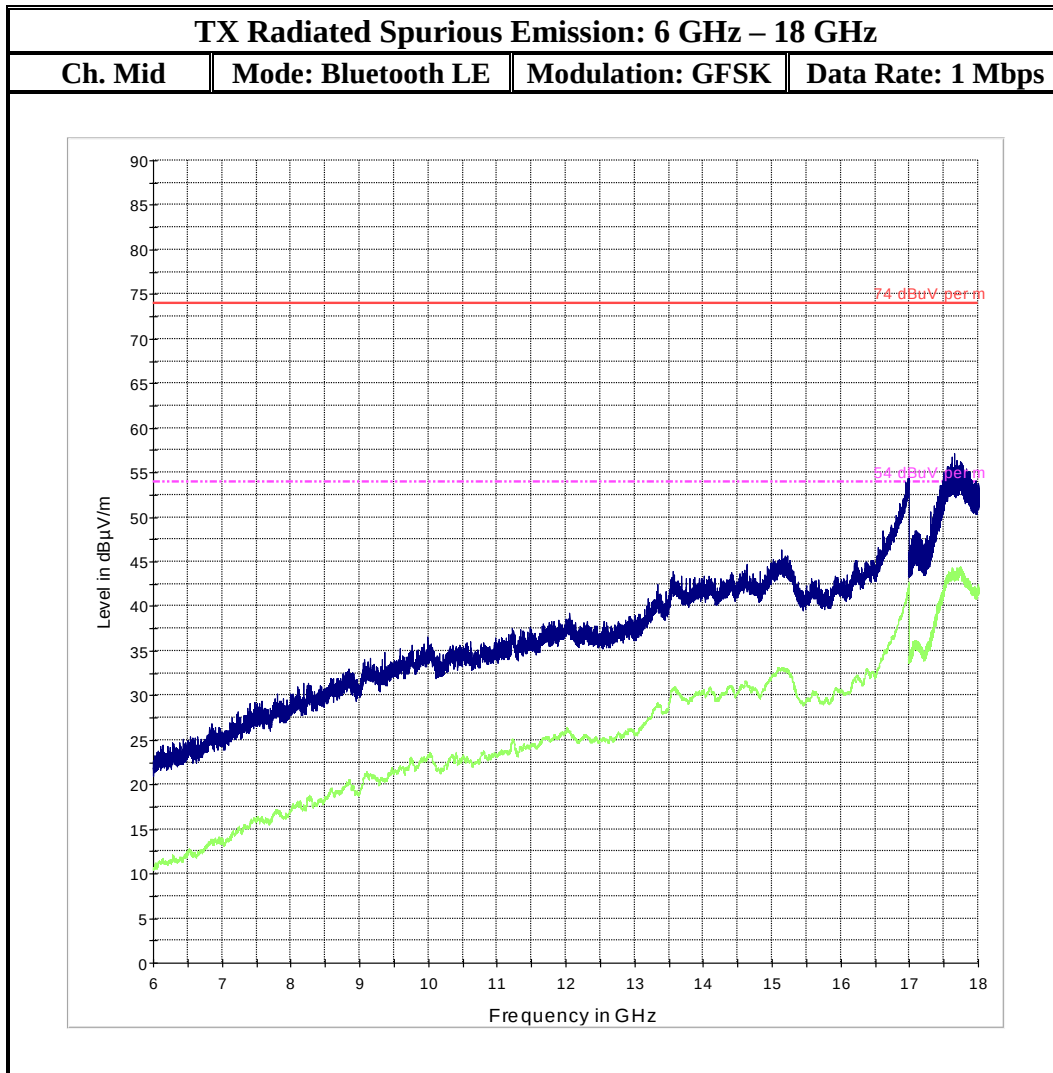
Frequency (MHz)	QuasiPeak (dBµV/m)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Polarization	Azimuth (deg)	Corr. (dB)	Margin (dB)	Limit (dBµV/m)
33.500000	18.9	100.0	120.000	100.0	V	180.0	6.3	21.1	40.0
48.400000	20.8	100.0	120.000	100.0	V	0.0	4.9	19.2	40.0
75.400000	20.0	100.0	120.000	100.0	V	158.0	8.6	20.0	40.0

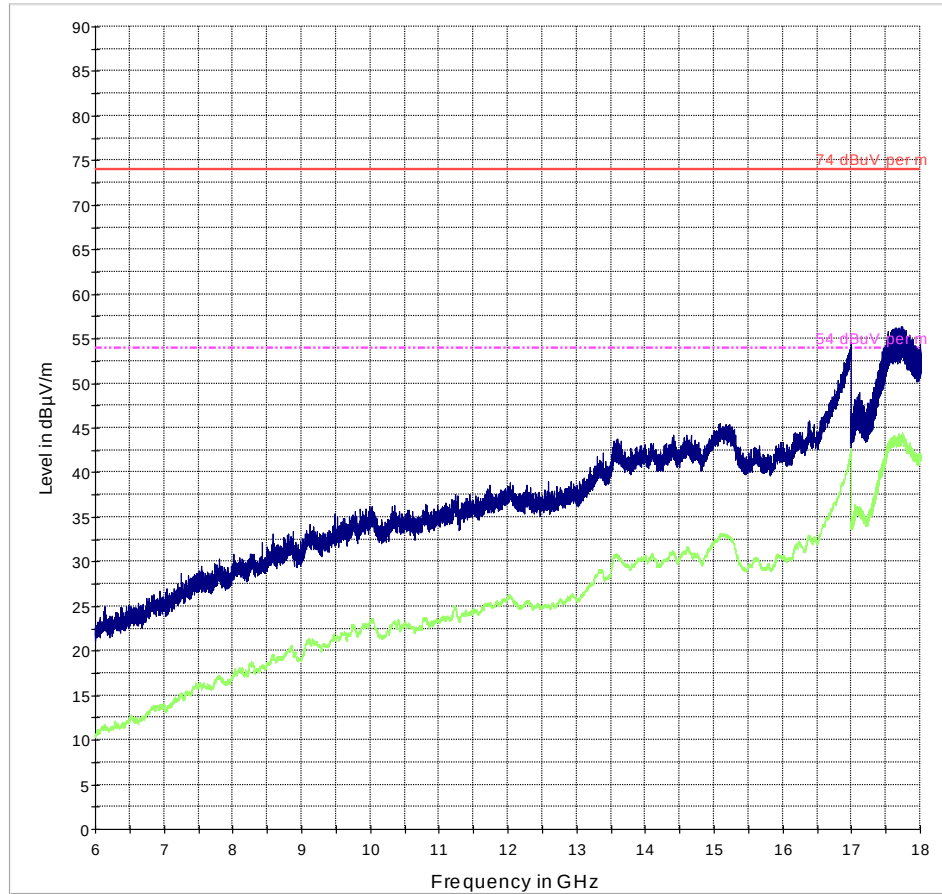


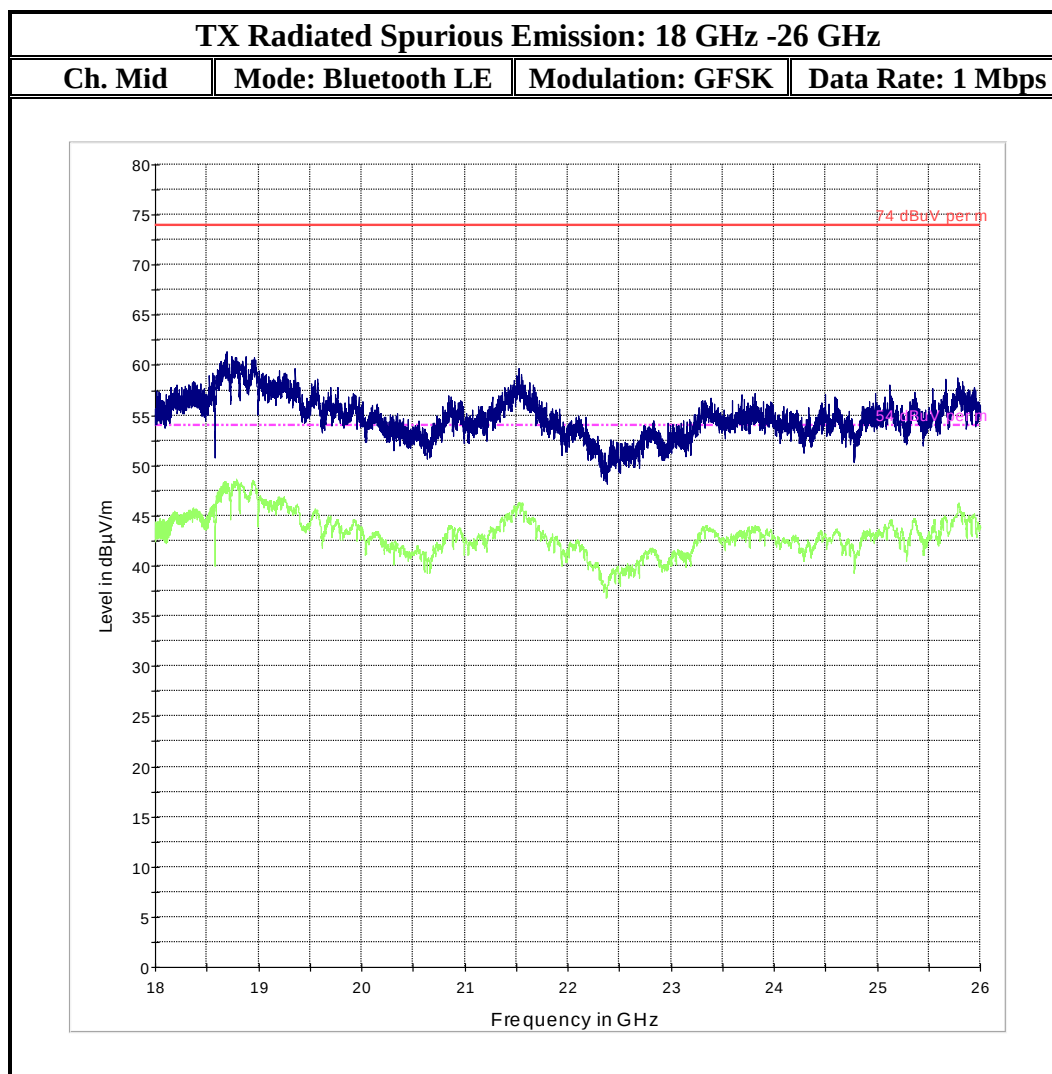




TX Radiated Spurious Emission: 6 GHz – 18 GHz**Ch. Low****Mode: Bluetooth LE****Modulation: GFSK****Data Rate: 1 Mbps**



TX Radiated Spurious Emission: 6 GHz – 18 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 μ H/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 (dB μ V)	
	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: 120 V (AC-DC Charger)

13.4 Measurement procedure:

Measurement according to
ANSI C63.10 (2013)

Analyzer Settings:

CISPR Bandwidth- 9KHz.

Detector = Quasi-peak / Average

Measurement Uncertainty: ± 3.0 dB

13.5 Results

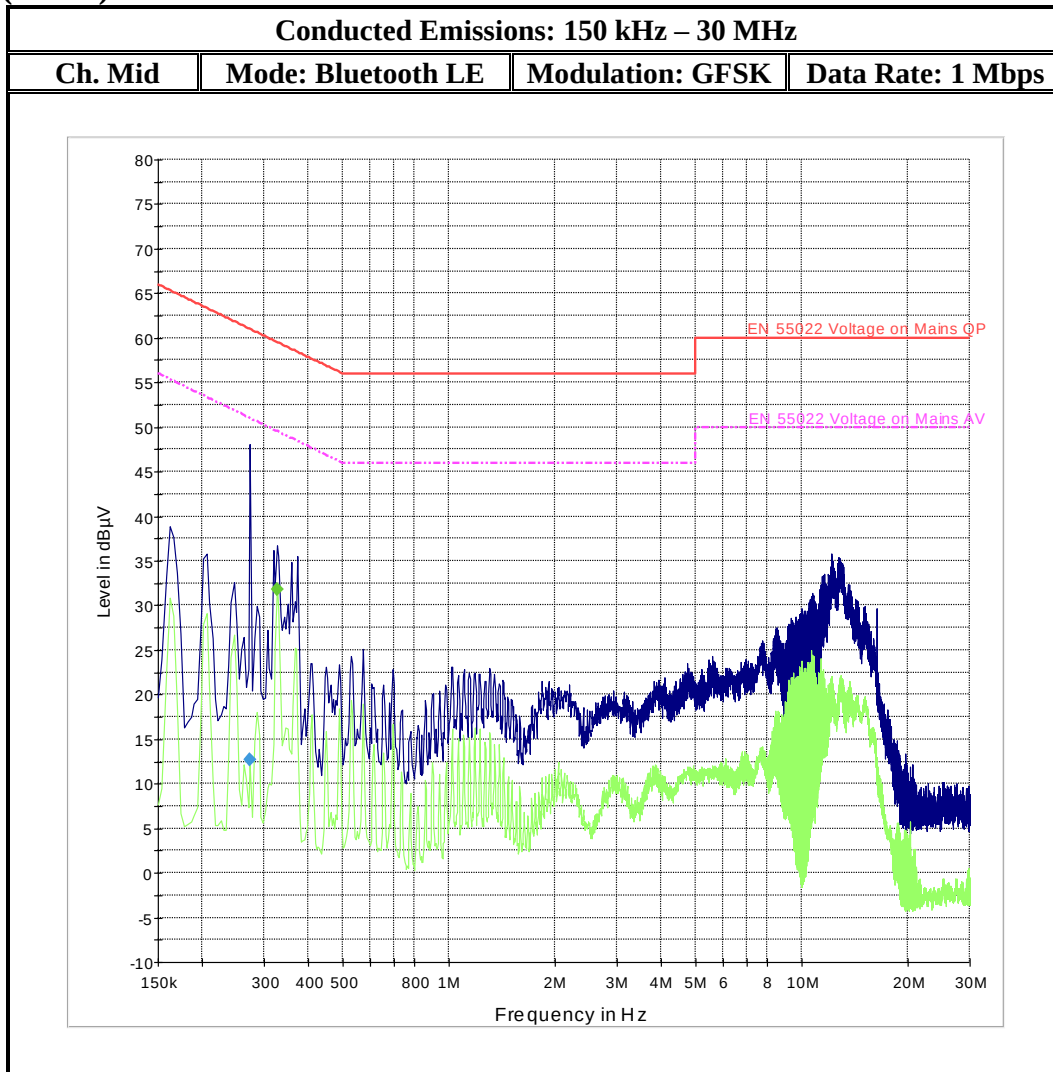
Pass.

13.5.1 Test Data/ Plots

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

Conducted Emissions: 150 KHz – 30 MHz

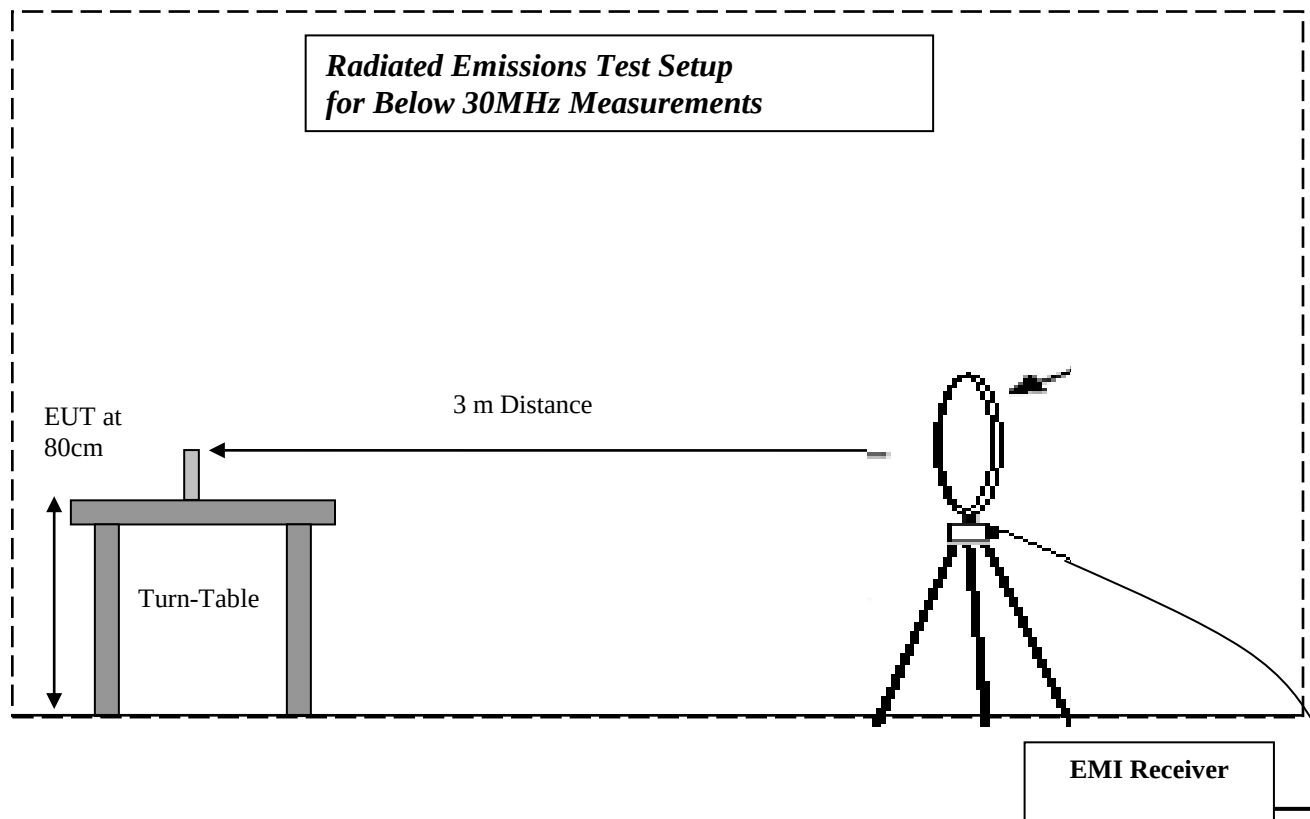
TX Mode (GFSK):

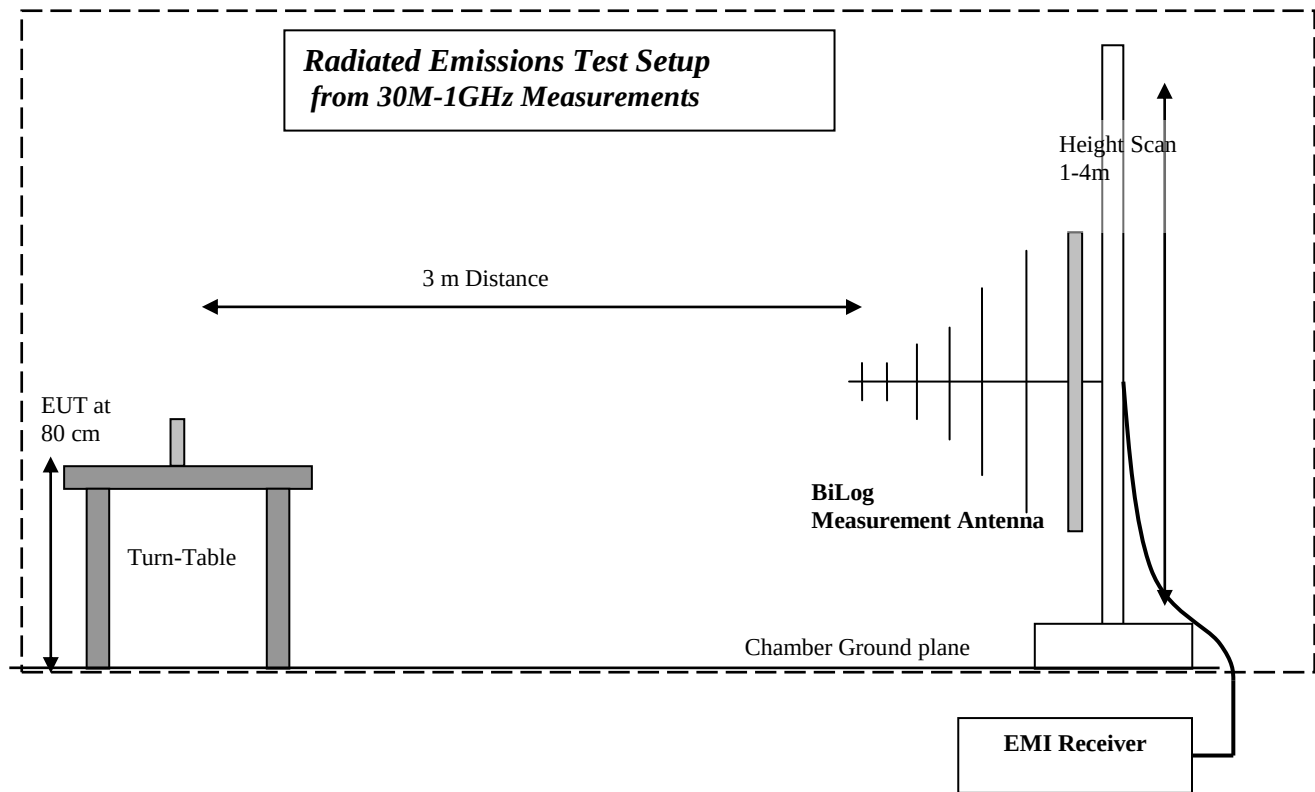


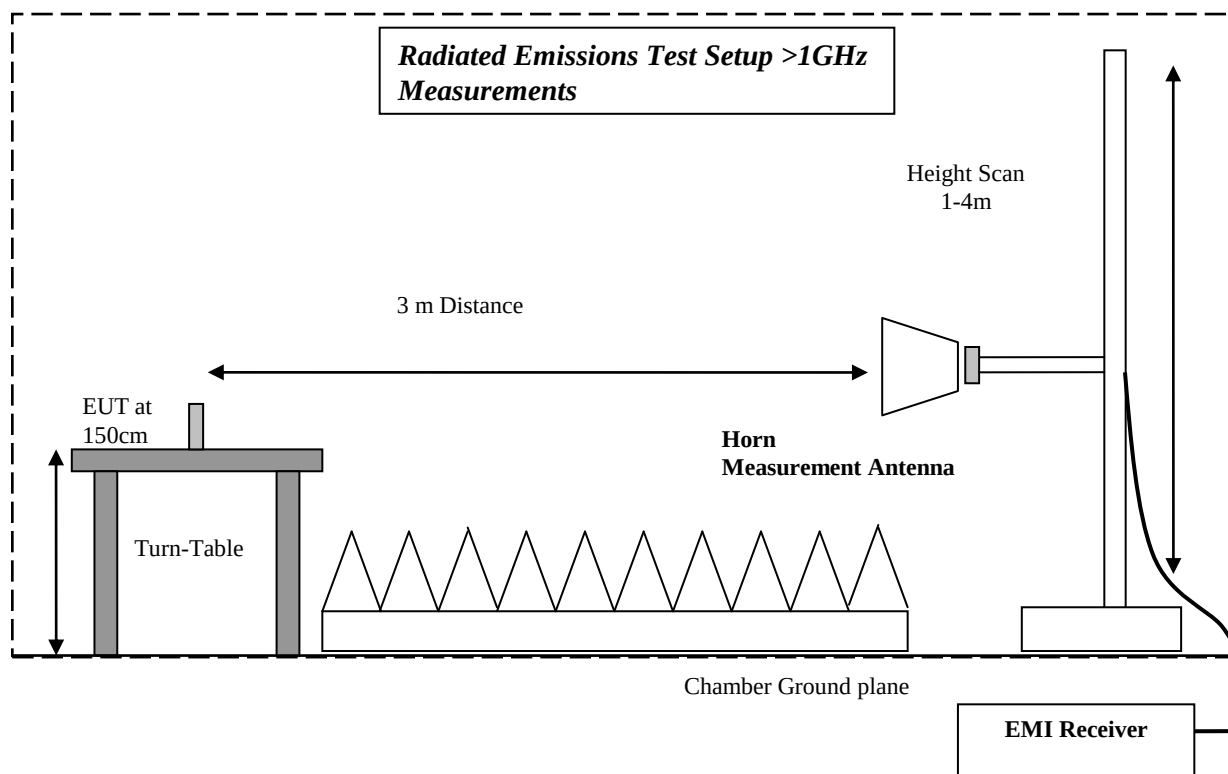
14 Test Equipment and Ancillaries used for tests

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	3.5 Years
	Binconilog Antenna	ETS	3149	J000123908	Feb 2012	3.5 years
	Horn Antenna	EMCO	3115	35114	Mar 2012	3.5 Years
	Loop Antenna	EMCO	6512	00049838	Apr 2012	3 years
	LISN	R&S	ESH3-Z5	836679/003	Jun 2013	3 Years
	Fast Power Detector 5Ms/s	ETS Lindgren	7002-006	00160034	Sep 2014	2 Years

15 Block Diagrams







16 Revision History

Date	Report Name	Changes to the report	Report prepared by
2015-06-15	EMC_APPLE-166-15001_Z11_15.247_BTLE	First Version	Douglas Antioco
2015-08-03	EMC_APPLE-166-15001_15.247_BTLE_rev1	Replaces previous test report number. Replaced relevant references of RSS-210 to relevant references of RSS-247. Model number changed to "A1644." Product Description Changed to "Bluetooth Device. with BDR, EDR and LE support." EUT Status in Section 3.1 changed to "Pre-Production." Measurement Uncertainty in Section 6.2, 6.3 updated.	Douglas Antioco
2015-08-13	EMC_APPLE-166-15001_15.247_BTLE_rev2	Replaces previous test report number. Added FVIN and HVIN in section 3.1. Updated wording in section 4. Updated references in section 7.1, 10.3. Specified limits in section 10.1 with regards to conducted and radiated measurements. Added Average plot to Section 10.4.1.	Douglas Antioco