



FCC / IC Test Report

FOR:

Smart Armor Protected, LLC

Product Name:

Smart Cube

Product Description:

Bluetooth Enabled Mechanical Locking System

FCC ID: 2ANAB-090

IC ID: 23092-090

Applied Rules and Standards:

47 CFR Part 15.247 (DTS)

RSS-247 Issue 1 (DTS) & RSS-Gen Issue 4

REPORT #: EMC_SMART-001-17001_15.247_BT_DTS

DATE: 03/02/2018



A2LA Accredited

IC recognized #
3462B-2

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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 the relevant ISSED Canada standard RSS-247.

No deviations were ascertained.

| Company | Description | Model # |
|----------------------------|---|------------|
| Smart Armor Protected, LLC | Bluetooth enabled mechanical locking system | Smart Cube |

Responsible for Testing Laboratory:

| 03/02/2018 | Compliance | James Donnellan (Lab Manager) | |
|------------|------------|----------------------------------|-----------|
| Date | Section | Name | Signature |

Responsible for the Report:

| 03/02/2018 | Compliance | Cindy Li (EMC Engineer) | |
|------------|------------|----------------------------|-----------|
| 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 EMC Test Report

| | |
|------------------------------|------------------------|
| Company Name: | CETECOM Inc. |
| Department: | Compliance |
| Street Address: | 411 Dixon Landing Road |
| City/Zip Code | Milpitas, CA 95035 |
| Country | USA |
| Telephone: | +1 (408) 586 6200 |
| Fax: | +1 (408) 586 6299 |
| Director Radio Com. and EMC: | Peter Nevermann |
| Responsible Project Leader: | Cindy Li |

2.2 Identification of the Client

| | |
|-------------------|---|
| Applicant's Name: | Smart Armor Protected,LLC |
| Street Address: | 19 Kris Court |
| City/Zip Code: | Newark DE |
| Country: | USA |
| Contact Person: | Eric Young |
| Phone No. | 858-231-3184 / 858-405-5767 |
| e-mail: | eyoung@artifexrde.com / luke@smartarmortech.com |

2.3 Identification of the Manufacturer

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

3 Equipment Under Test (EUT)

3.1 EUT Specifications

| | |
|--|---|
| Model No: | Smart Cube |
| HW Version : | 03 |
| SW Version : | 1.1.3 |
| FCC ID: | 2ANAB-090 |
| IC ID: | 23090-090 |
| PMN: | SmartCube |
| HVIN: | SmartCube |
| FVIN: | N/A |
| Product Description: | Bluetooth enabled mechanical locking system |
| Frequency Range / number of channels: | Nominal band: 2400 MHz – 2483.5 MHz; Center to center: 2402 MHz (ch 0) – 2480 MHz (ch 39), 40 channels |
| Type(s) of Modulation: | Bluetooth version 4.0, Low Energy, using Dynamic Sequence Spread Spectrum with GFSK modulation. |
| Modes of Operation: | Bluetooth LE in both advertising and connected mode of operation. Base on ST Micro BlueNRG chip |
| Antenna Information as declared: | W3008C chip antenna, gain 2.2 dBi |
| Max. Peak Output Power: | Conducted Power 2.94 dBm |
| Power Supply/ Rated Operating Voltage Range: | Battery. Vnom: 3.0 VDC / Vmax: 3.5 VDC |
| Operating Temperature Range: | +5 °C to +35 °C |
| Other Radios included in the device: | None |
| Sample Revision: | <input type="checkbox"/> Prototype Unit; <input checked="" type="checkbox"/> Production Unit; <input type="checkbox"/> Pre-Production |

3.2 EUT Sample details

| EUT # | Serial Number | HW Version | SW Version | Notes/Comments |
|-------|---------------|------------|------------|--------------------|
| 1 | N/A | 03 | 1.1.3 | Conducted RF |
| 2 | ZZZZW5 | 03 | 1.1.3 | Radiated Emissions |

3.3 Accessory Equipment (AE) details

| AE # | Type | Model | Manufacturer | Serial Number |
|------|------|-------|--------------|---------------|
| 1 | - | - | - | - |

3.4 Test Sample Configuration

| EUT Set-up # | Combination of AE used for test set up | Comments |
|--------------|--|---|
| 1 | EUT#1 | The radio of the EUT was configured to a fixed channel transmission with highest duty cycle using software that is not available to the end user. The measurement equipment was connected to the 50 ohm RF port of the EUT. |
| 2 | EUT#2 | The EUT was configured to transmit a tone at fixed channel with fixed power level. The internal antenna was integrated. |

3.5 Justification for Worst Case Mode of Operation

During the testing process, the EUT was tested with transmitter sets on low, mid and high channels, and highest duty cycle. 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.

For conducted measurements, the EUT were configured by using diagnostic software "BlueNRG GUI" (not available to the end user), and the transmitter output power was measured using spectrum analyzer (Peak Power). Output power was set to +4 dBm which is the maximum power used according to customer declaration.

For radiated testing, application software "Bluetooth LE Lab" was used to configure the EUT to low, mid and high channels and +4dBm power level following the instruction provide by cinet

These settings are considered worst case for all measurements in scope of this report.

BlueNRG GUI:

The screenshot displays the BlueNRG GUI v2.6.0 interface. At the top, there is a menu bar with 'File', 'Tools', 'Settings', and 'Help'. Below the menu bar, the 'Port' is set to 'COM13', with 'Close' and 'HW Reset' buttons. A status box on the right indicates: 'BlueNRG-1 HW v1.1', 'BlueNRG-1 FW v2.0 - DTM UART v2.0', and 'Motherboard FW v1.6'. The main area has tabs for 'ACI Commands', 'ACI Utilities', 'Scripts', 'Beacon', and 'RF Test'. The 'RF Test' tab is active, showing a 'Test' section with 'TRANSMITTER' and 'RECEIVER' settings. The 'TRANSMITTER' section includes a 'High Power' checkbox (checked), 'TX Frequency' set to '2402 MHz (Channel 0)', 'Length of Data' set to '0x25', and 'Packet Payload' set to '0x00 - Pseudo-Random bit sequence'. It also shows '# Packet Transmitt' as 250 and buttons for 'Start Transmitter' and 'Start Tone'. The 'RECEIVER' section shows 'RX Frequency' set to '2402 MHz (Channel 0)', '# Packet Received' as 0, and a 'Start Receiver' button. Below these are 'PER' settings: 'Packet Transmitted' (0), 'Packet Received' (0), and 'Packet Error Rate (P)' (0%). At the bottom, there are checkboxes for 'Clear List', 'Update', and 'Autoscroll', and a 'Send' button. A 'Sent/Received Packets' table is visible, showing a list of packets with columns for 'N.', 'Time', and 'Type'. The table contains the following data:

| N. | Time | Type |
|----|------------|----------------------------|
| 58 | 17:38:2... | Job start |
| 59 | 17:38:2... | HCI_LE_TEST_END |
| 60 | 17:38:2... | HCI_COMMAND_COMPLET... |
| 61 | 17:38:2... | ACI_HAL_LE_TX_TEST_PACK... |
| 62 | 17:38:2... | HCI_COMMAND_COMPLET... |
| 63 | 17:38:2... | Job finished |

To the right of the table is a 'Packet Details' section with columns for 'Parameter', 'Value', 'Literal', and 'Info'.

4 Subject of Investigation

The objective of the measurements done by CETECOM Inc. was to assess the performance of the EUT according to 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 of ISSED Canada.

Testing procedures are based on 558074 D01 DTS Meas Guidance v04 – “GUIDANCE FOR PERFORMING COMPLIANCE MEASUREMENTS ON DIGITAL TRANSMISSION SYSTEMS (DTS) OPERATING UNDER SECTION 15.247” - April 5, 2017, by the Federal Communications Commission, Office of Engineering and Technology, Laboratory Division.

5 Measurement Results Summary

| Test Specification | Test Case | Temperature and Voltage Conditions | Mode | Pass | NA | NP | Result |
|--|---|------------------------------------|------|------|----|----|--------------|
| §15.247(a)(1) RSS-247 5.2(1) | Emission Bandwidth | Nominal | BTLE | ■ | □ | □ | Complies |
| §15.247(e) RSS-247 5.2(2) | Power Spectral Density | Nominal | BTLE | ■ | □ | □ | Complies |
| §15.247(b)(1) RSS-247 5.4(4) | Maximum Conducted Output Power and EIRP | Nominal | BTLE | ■ | □ | □ | Complies |
| §15.247(d) RSS-247 5.5 | Band edge compliance Unrestricted Band Edges | Nominal | BTLE | ■ | □ | □ | Complies |
| §15.247; 15.209; 15.205 RSS-Gen 8.9; 8.10 | Band edge compliance Restricted Band Edges | Nominal | BTLE | ■ | □ | □ | Complies |
| §15.247(d); §15.209 RSS-Gen 6.13 | TX Spurious emissions- Radiated | Nominal | BTLE | ■ | □ | □ | Complies |
| §15.207(a) RSS Gen 8.8 | AC Conducted Emissions | Nominal | BTLE | □ | ■ | □ | See note2 |

Note1: NA= Not Applicable; NP= Not Performed.

Note2: Device is battery powered.

6 Measurement Uncertainty

Where relevant, the following measurement uncertainty levels have been estimated for tests performed on the apparatus, with 95% confidence interval (in dB delta to result), based on a coverage factor $k=1$.

Radiated measurement

| | |
|--------------------|--------------------------------------|
| 9 kHz to 30 MHz | ± 2.5 dB (Magnetic Loop Antenna) |
| 30 MHz to 1000 MHz | ± 2.0 dB (Biconilog Antenna) |
| 1 GHz to 40 GHz | ± 2.3 dB (Horn Antenna) |

Conducted measurement

| | |
|-------------------|---------------------|
| 150 kHz to 30 MHz | ± 0.7 dB (LISN) |
|-------------------|---------------------|

| | |
|--------------------------|--------------|
| RF conducted measurement | ± 0.5 dB |
|--------------------------|--------------|

According to TR 102 273 a multiplicative propagation of error is assumed for RF measurement systems. For this reason the RMS method is applied to dB values and not to linear values as appropriate for additive propagation of error. Also used: <http://physics.nist.gov/cuu/Uncertainty/typeb.html>. The above calculated uncertainties apply to direct application of the Substitution method. The Substitution method is always used when the EUT comes closer than 3 dB to the limit.

6.1 Environmental Conditions During Testing:

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

- Ambient Temperature: 20-25°C
- Relative humidity: 40-60%

6.2 Dates of Testing:

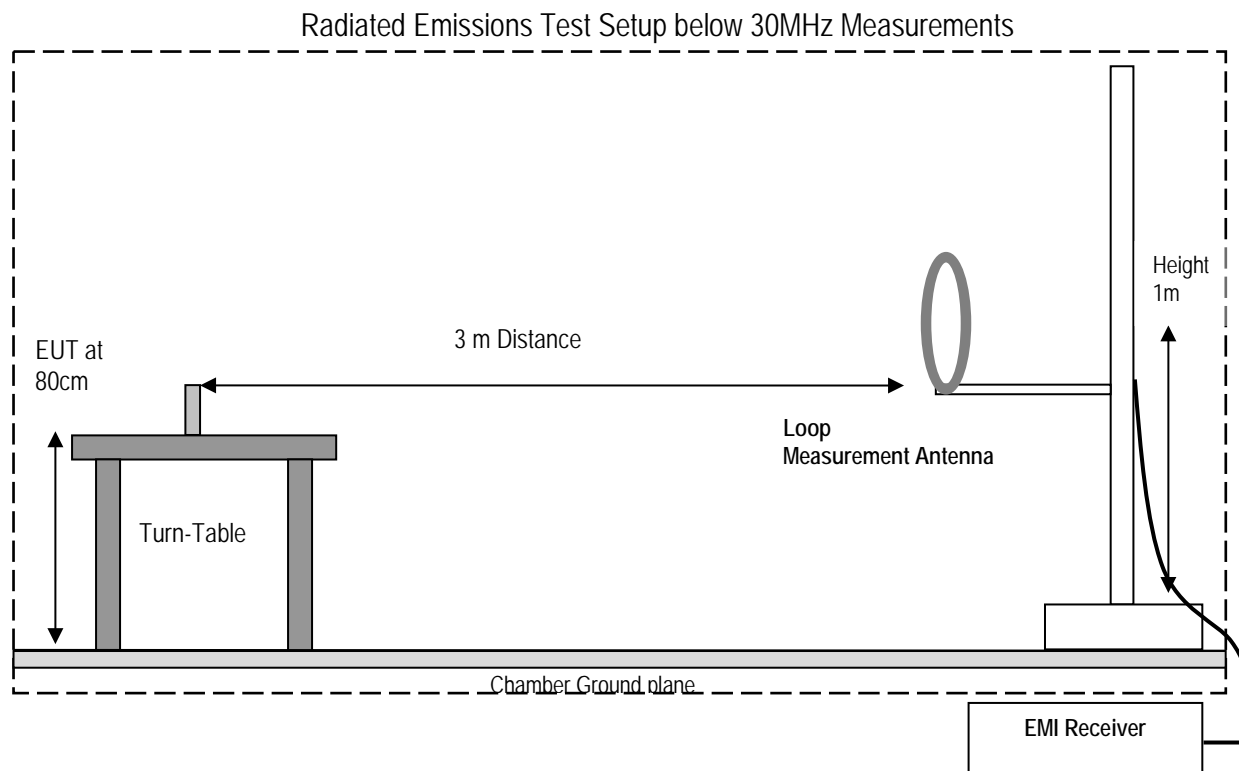
02/16/2018 - 02/23/2018

7 Measurement Procedures

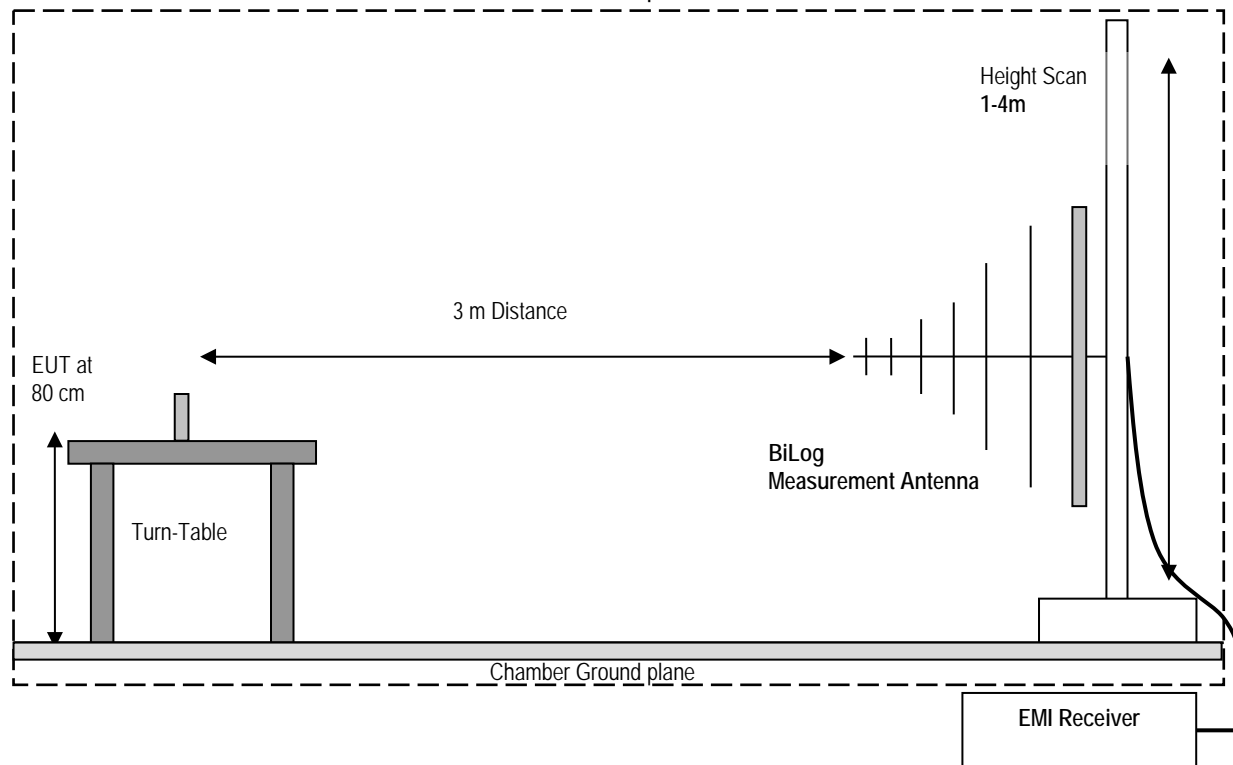
7.1 Radiated Measurement

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

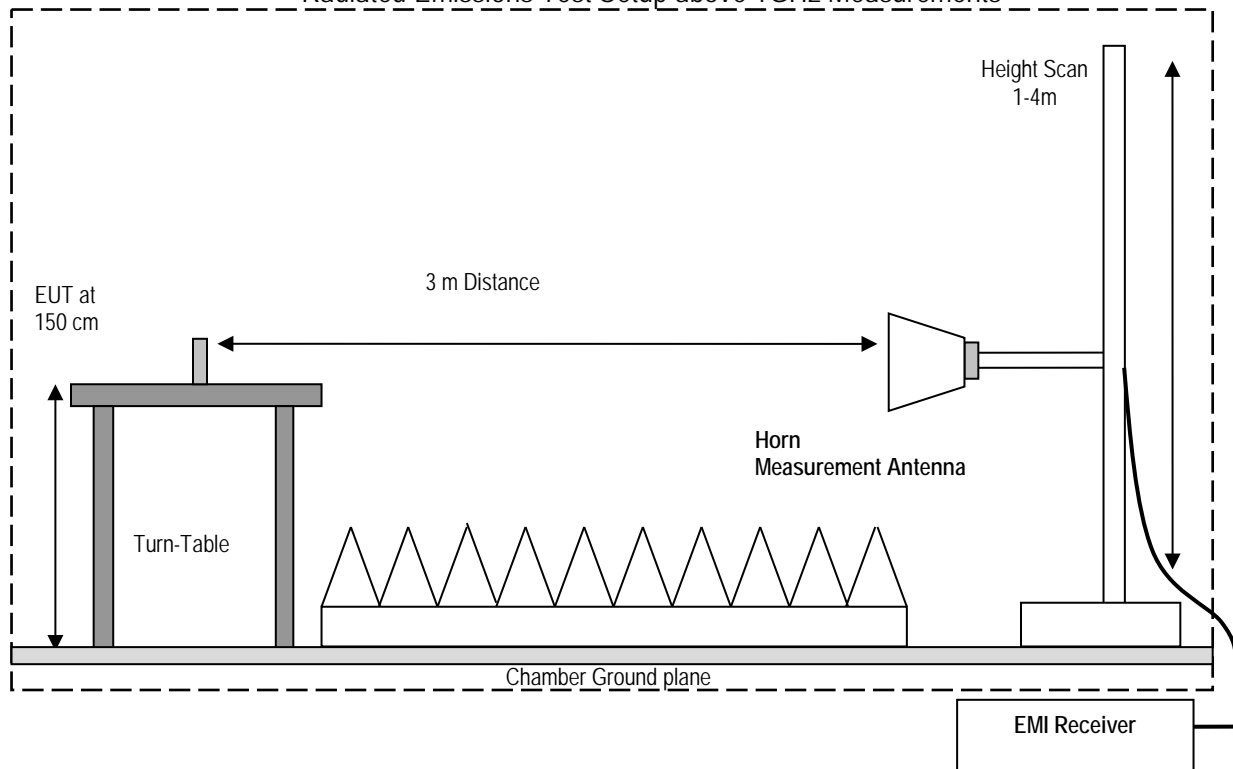
- The exploratory measurement is accomplished by running a matrix of 16 sweeps over the required frequency range with R&S Test-SW EMC32 for 4 positions of the turntable, two orthogonal positions of the EUT and both antenna polarizations. This procedure exceeds the requirement of the above standards to 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 9 kHz to 30 MHz, a Biconilog antenna is used from 30 MHz to 1 GHz, and two different horn antennas are used to cover frequencies up to 40 GHz.



Radiated Emissions Test Setup 30MHz-1GHz Measurements



Radiated Emissions Test Setup above 1GHz Measurements



7.1.1 Sample Calculations for Field Strength Measurements

Field Strength is calculated from the Spectrum Analyzer/ Receiver readings, 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

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

$$FS \text{ (dB}\mu\text{V/m)} = \text{Measured Value on SA (dB}\mu\text{V)} - \text{Cable Loss (dB)} + \text{Antenna Factor (dB/m)}$$

Example:

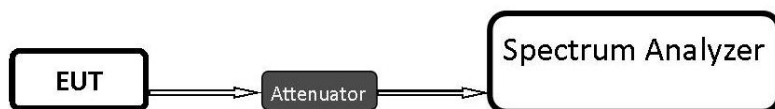
| Frequency (MHz) | Measured SA (dB μ V) | Cable Loss (dB) | Antenna Factor Correction (dB) | Field Strength Result (dB μ V/m) |
|-----------------|--------------------------|-----------------|--------------------------------|--------------------------------------|
| 1000 | 80.5 | 3.5 | 14 | 98.0 |

7.2 Power Line Conducted Measurement Procedure

AC Power Line conducted emissions measurements performed according to: ANSI C63.10 (2013)

7.3 RF Conducted Measurement Procedure

Testing procedures are based on 558074 D01 DTS Meas Guidance v04 – “GUIDANCE FOR PERFORMING COMPLIANCE MEASUREMENTS ON DIGITAL TRANSMISSION SYSTEMS (DTS) OPERATING UNDER SECTION 15.247” - April 5, 2017, by the Federal Communications Commission, Office of Engineering and Technology, Laboratory Division.



- Connect the equipment as shown in the above diagram.
- Adjust the settings of the SA (Rohde-Schwarz Spectrum Analyzer) to connect the EUT at the required mode of test.
- Measurements are to be performed with the EUT set to the low, middle and high channels and for worst case modulation schemes.
- Calculate the conducted power by taking into account attenuation of the cable and the attenuator

8 Test Result Data

8.1 Maximum Peak Conducted Output Power

8.1.1 Measurement according to FCC 558074 D01 DTS Meas Guidance v04

Spectrum Analyzer settings:

- $RBW \geq$ DTS bandwidth
- $VBW \geq 3 \times RBW$
- $Span \geq 3 \times RBW$
- Sweep = Auto couple
- Detector function = Peak
- Trace = Max hold
- Use peak marker function to determine the peak amplitude level

8.1.2 Limits:

Maximum Peak Output Power:

- FCC §15.247 (b)(1): 1 W
- IC RSS-247: 1 W

8.1.3 Test conditions and setup:

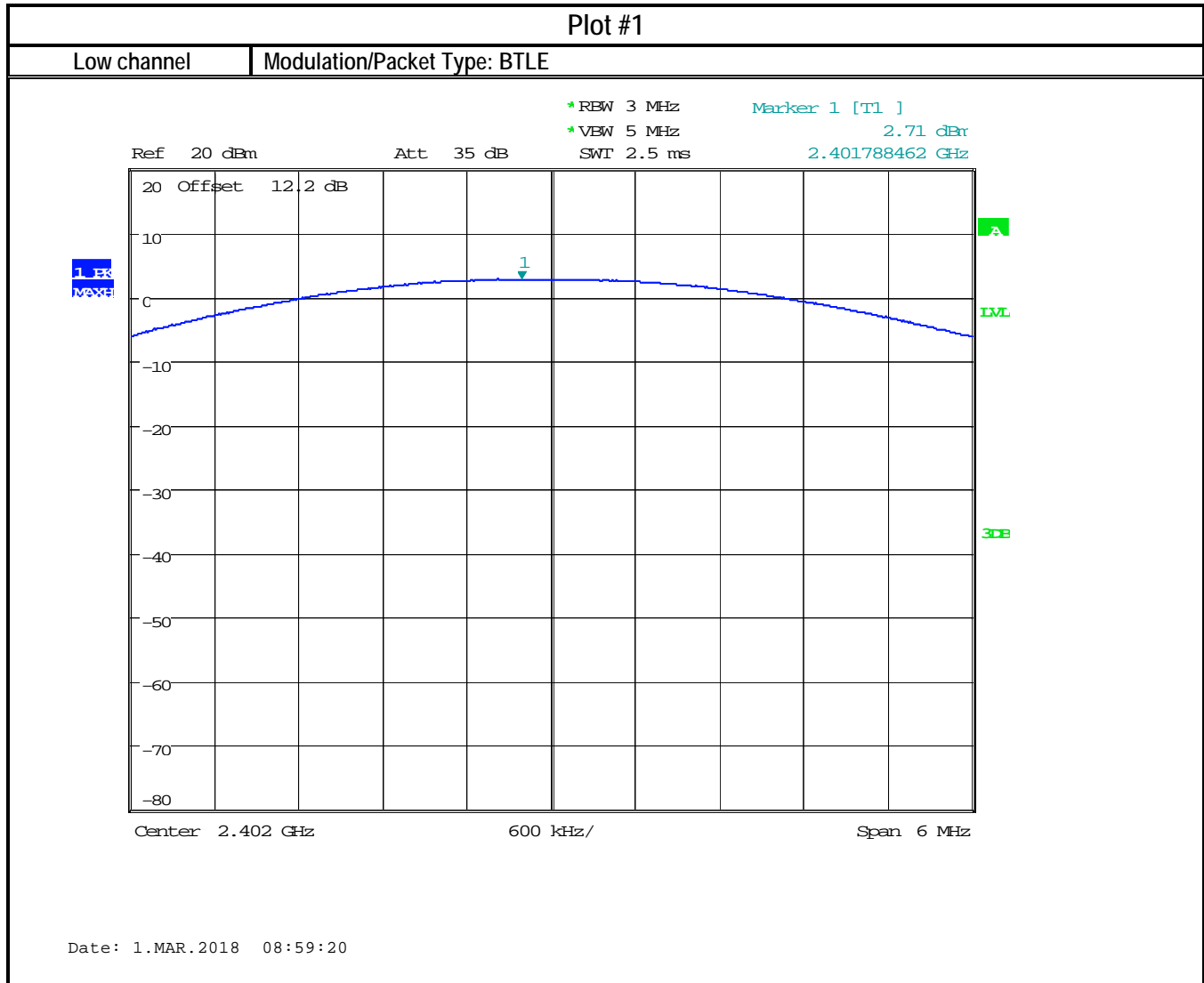
| Ambient Temperature | EUT Set-Up # | EUT operating mode | Power Input | Antenna Gain |
|---------------------|--------------|--------------------|-------------|--------------|
| 23° C | 1 | GFSK fixed channel | 3.3 VDC | 2.2dBi |

8.1.4 Measurement result:

Attenuation of cable and attenuator (already taken into account): 12.2 dB

| Plot # | Frequency (MHz) | Maximum Peak Conducted Output Power (dBm) | EIRP (dBm) | Limit (dBm) | Result |
|--------|-----------------|---|------------|---------------------|--------|
| 1 | 2402 | 2.71 | 4.91 | 30 (Pk) / 36 (EIRP) | Pass |
| 2 | 2442 | 2.94 | 5.14 | 30 (Pk) / 36 (EIRP) | Pass |
| 3 | 2480 | 2.8 | 5 | 30 (Pk) / 36 (EIRP) | Pass |

8.1.5 Measurement Plots:



Plot #2

Mid channel

Modulation/Packet Type: BTLE



*RBW 2 MHz

Marker 1 [T1]

*VBW 5 MHz

2.94 dBm

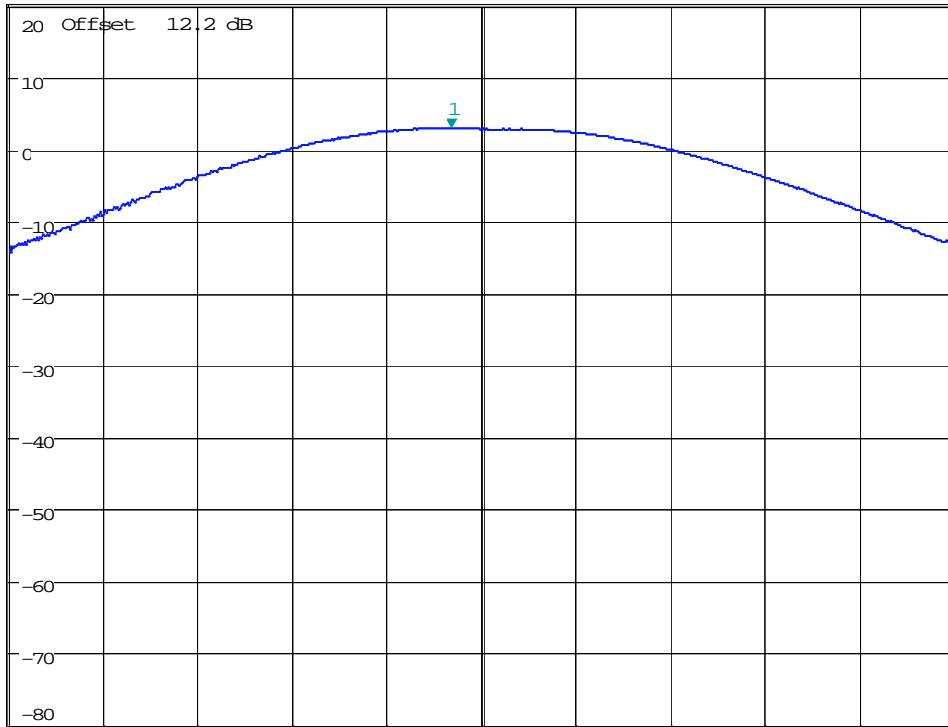
SWT 2.5 ms

2.441807692 GHz

Ref 20 dBm

Att 35 dB

20 Offset 12.2 dB

1. EK
MAGN

Center 2.442 GHz

600 kHz/

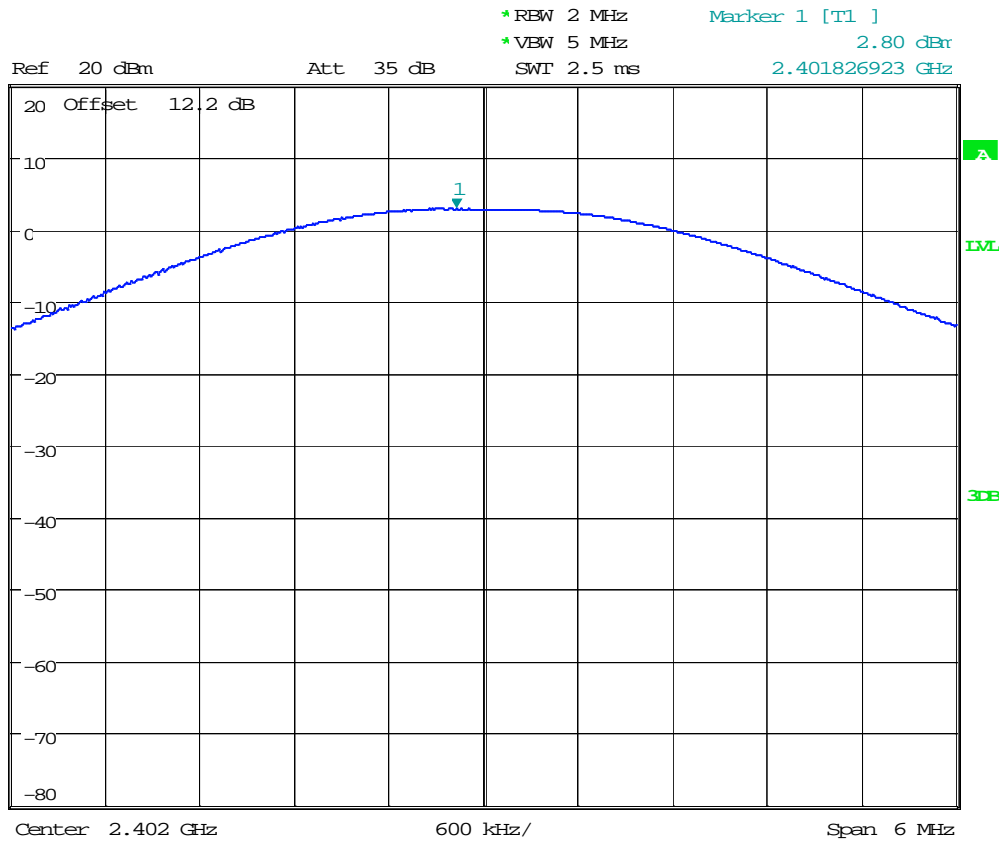
Span 6 MHz

Date: 13.FEB.2018 16:58:22

Plot #3

High channel

Modulation/Packet Type: BTLE

1.038
MAX

Date: 13.FEB.2018 16:59:08

8.2 Power Spectral Density

8.2.1 Measurement according to FCC 558074 D01 DTS Meas Guidance v04

Spectrum Analyzer settings for Peak PSD method:

- Set analyzer center frequency to DTS channel center frequency
- Set the span to 1.5 x DTS bandwidth
- Set RBW to: $3 \text{ kHz} \leq \text{RBW} \leq 100 \text{ kHz}$
- Set the VBW $\geq 3 \times \text{RBW}$
- Detector = Peak
- Sweep time = Auto couple
- Trace mode = Max hold
- Allow trace to fully stabilize
- Use the peak marker function to determine the maximum amplitude level within the RBW
- If measured value exceeds limit, reduce RBW (no less than 3 kHz) and repeat

8.2.2 Limits:

FCC§15.247(e) & RSS-247 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.

8.2.3 Test conditions and setup:

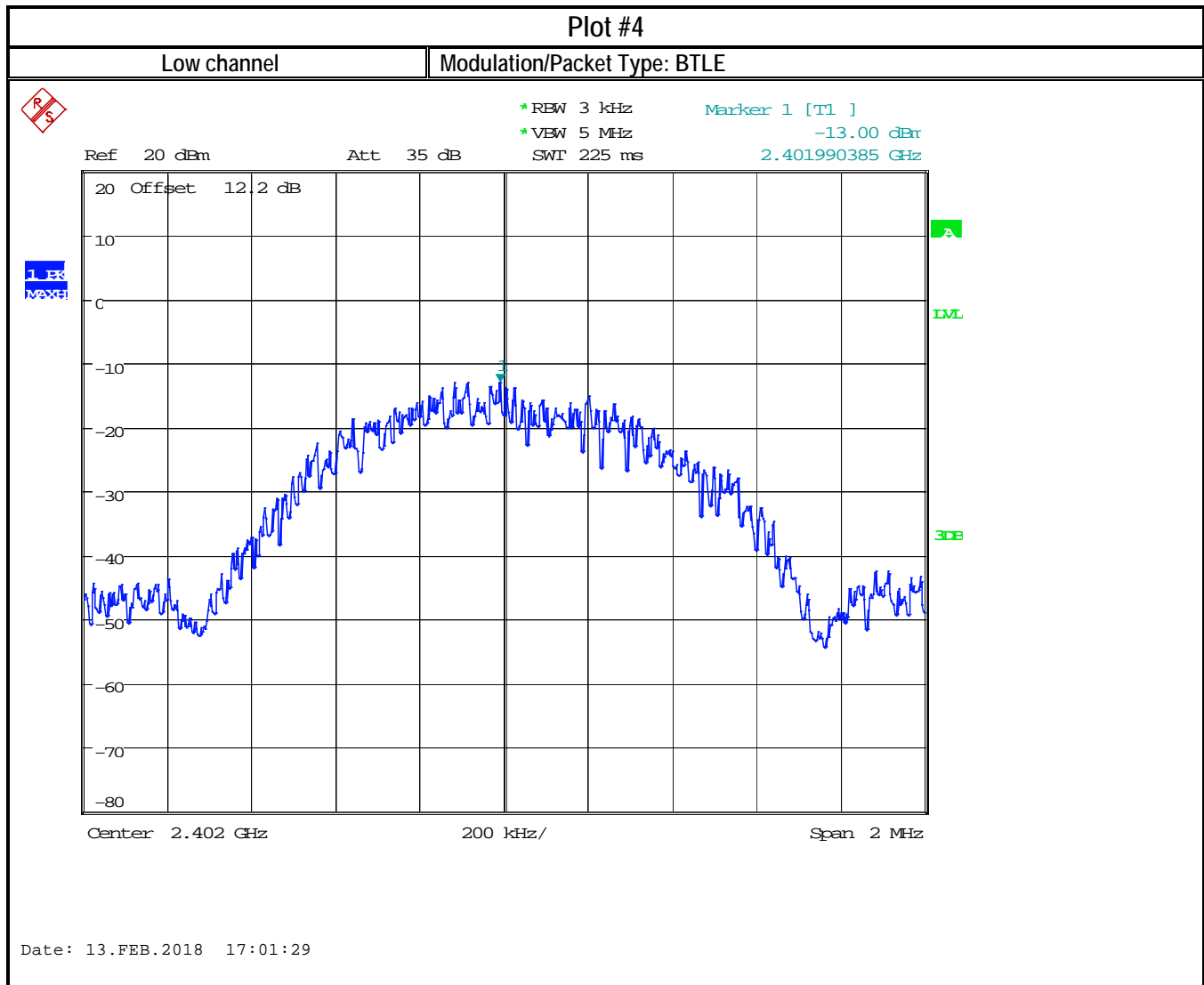
| Ambient Temperature | EUT Set-Up # | EUT operating mode | Power Input | Antenna Gain |
|---------------------|--------------|--------------------|-------------|--------------|
| 23° C | 1 | GFSK fixed channel | 3.3 VDC | 2.2dBi |

8.2.4 Measurement result:

Attenuation of cable and attenuator (already taken into account): 12.2 dB

| Plot # | Frequency (MHz) | Maximum Power Spectral Density (dBm/3 kHz) | PSD Adjusted for Antenna Gain (dBm/3 kHz) | Limit (dBm / 3 kHz) | Result |
|--------|-----------------|--|---|---------------------|--------|
| 4 | 2402 | -13 | -10.8 | 8 | Pass |
| 5 | 2442 | -12.87 | -10.67 | 8 | Pass |
| 6 | 2480 | -12.9 | -10.7 | 8 | Pass |

8.2.5 Measurement Plots:



8.3 Band Edge Compliance

8.3.1 Measurement according to FCC 558074 D01 DTS Meas Guidance v04

Spectrum Analyzer settings for band edge:

- Set the center frequency and span to encompass frequency range to be measured
- RBW = 100 kHz
- VBW $\geq 3 \times$ RBW
- Sweep Time: Auto couple
- Detector = Peak
- Trace = Max hold
- Allow trace to fully stabilize
- Use the peak marker function to determine the maximum amplitude level
- Set the marker on the emission at the band edge, or on the highest modulation product outside of the band, if this level is greater than that at the band edge

8.3.2 Limits non restricted band:

FCC§15.247 (d)

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

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- 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 30dB instead of 20dB.

Spectrum Analyzer settings for restricted band:

- Peak measurements are made using a peak detector and RBW=1 MHz

8.3.3 Limits restricted band §15.247/15.209/15.205 and RSS-Gen 8.9/8.10

- *PEAK LIMIT= 74 dB μ V/m @3m =-21.23 dBm
 - *AVG LIMIT= 54 dB μ V/m @3m =-41.23 dBm
 - Start frequency & stop frequency according to frequency range specified in the restricted band table in FCC section 15.205 & RSS-Gen 8.10
 - Measurements with a peak detector were used to show compliance to average limits, thus showing compliance to both peak and average limits.
- (a) Except as shown in paragraph (d) of this section, only spurious emissions are permitted in any of the frequency bands listed below:

(b)

| MHz | MHz | MHz | GHz |
|-------------------|---------------------|---------------|-------------|
| 0.090-0.110 | 16.42-16.423 | 399.9-410 | 4.5-5.15 |
| 10.495-0.505 | 16.69475-16.69525 | 608-614 | 5.35-5.46 |
| 2.1735-2.1905 | 16.80425-16.80475 | 960-1240 | 7.25-7.75 |
| 4.125-4.128 | 25.5-25.67 | 1300-1427 | 8.025-8.5 |
| 4.17725-4.17775 | 37.5-38.25 | 1435-1626.5 | 9.0-9.2 |
| 4.20725-4.20775 | 73-74.6 | 1645.5-1646.5 | 9.3-9.5 |
| 6.215-6.218 | 74.8-75.2 | 1660-1710 | 10.6-12.7 |
| 6.26775-6.26825 | 108-121.94 | 1718.8-1722.2 | 13.25-13.4 |
| 6.31175-6.31225 | 123-138 | 2200-2300 | 14.47-14.5 |
| 8.291-8.294 | 149.9-150.05 | 2310-2390 | 15.35-16.2 |
| 8.362-8.366 | 156.52475-156.52525 | 2483.5-2500 | 17.7-21.4 |
| 8.37625-8.38675 | 156.7-156.9 | 2690-2900 | 22.01-23.12 |
| 8.41425-8.41475 | 162.0125-167.17 | 3260-3267 | 23.6-24.0 |
| 12.29-12.293 | 167.72-173.2 | 3332-3339 | 31.2-31.8 |
| 12.51975-12.52025 | 240-285 | 3345.8-3358 | 36.43-36.5 |
| 12.57675-12.57725 | 322-335.4 | 3600-4400 | Above 38.6 |
| 13.36-13.41 | | | |

8.3.4 Test conditions and setup:

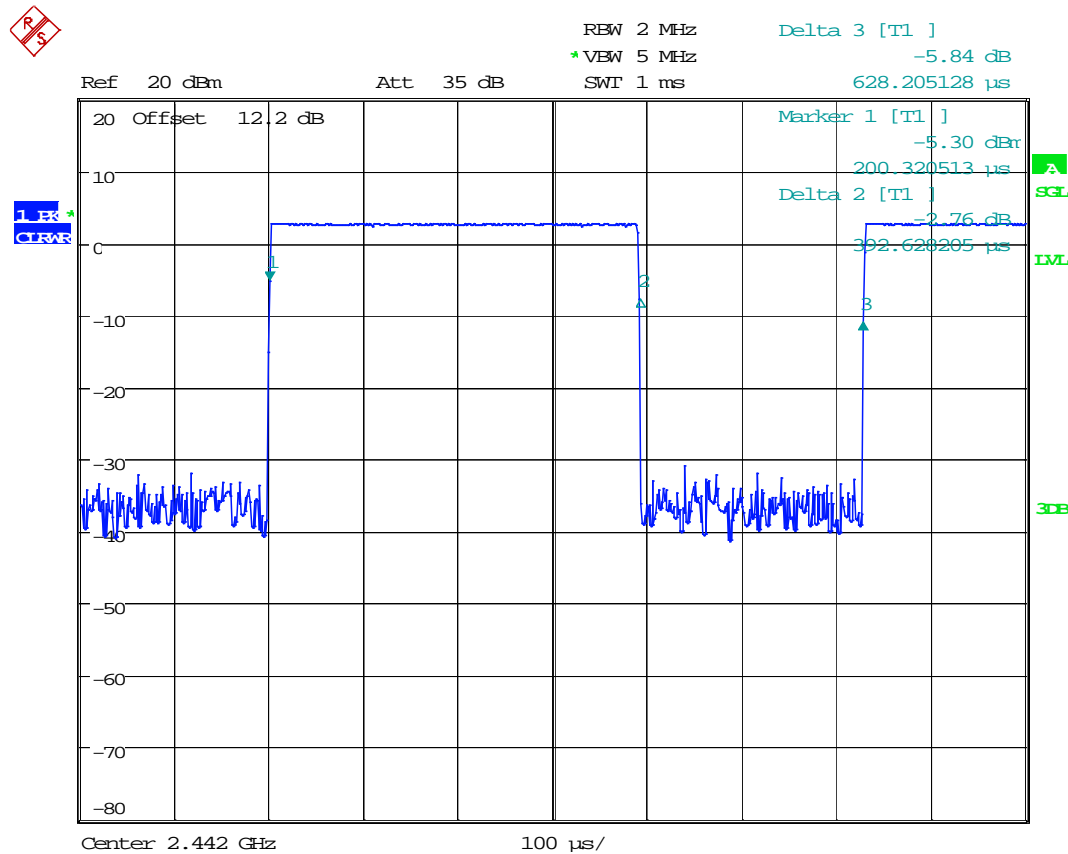
| Ambient Temperature | EUT Set-Up # | EUT operating mode | Power Input | Antenna Gain |
|---------------------|--------------|--------------------|-------------|--------------|
| 23° C | 1 | GFSK fixed channel | 3.3 VDC | 2.2 dBi |

8.3.5 Measurement result:

| Plot # | EUT operating mode | Band Edge | Band Edge Delta (dBc) | Limit (dBc) | Result |
|--------|--------------------|-----------------------|-----------------------|-------------|--------|
| 7 | GFSK fixed channel | Lower, Non-restricted | -39.82 | -20 | Pass |

| Plot # | EUT operating mode | Band Edge | Measured Peak Value (dBm) | Corrected by duty cycle | Corrected by Antenna Gain (dBm) | Limit (dBm) | Result |
|--------|--------------------|--------------------------|---------------------------|-------------------------|---------------------------------|-------------|--------|
| 8 | GFSK fixed channel | Upper Restricted peak | -29.79 | NA | -27.59 | -21.23 Peak | Pass |
| 9 | GFSK fixed channel | Upper Restricted Average | -58.11 | NA | -55.91 | -41.23 AVG | Pass |

8.3.6 Measured Duty Cycle

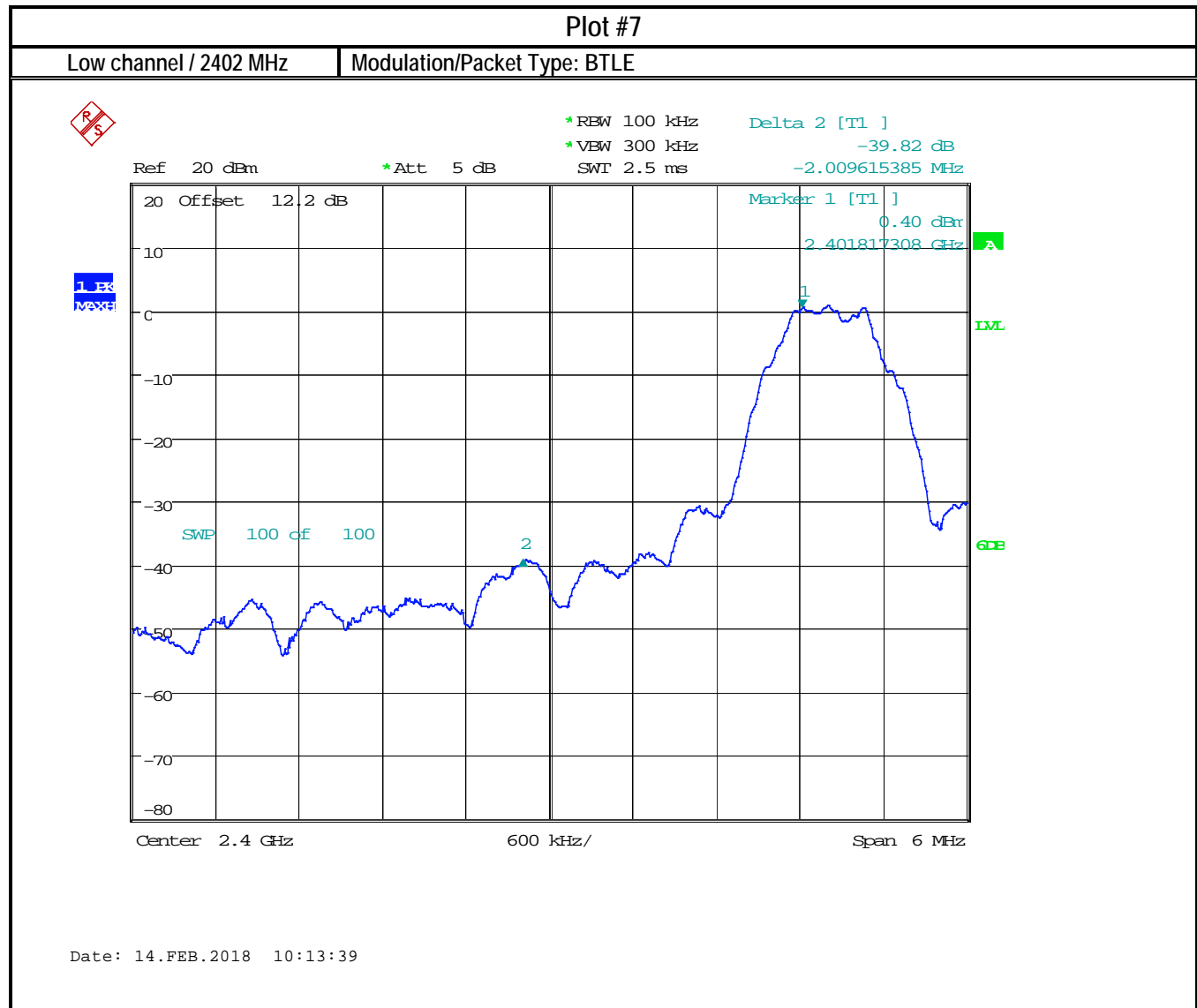


Date: 13.FEB.2018 16:45:55

Duty Cycle = $392.6/628.2 = 62.5\%$

Duty Cycle Correction Factor = $10 \cdot \log(1/0.625) = 2\text{dB}$

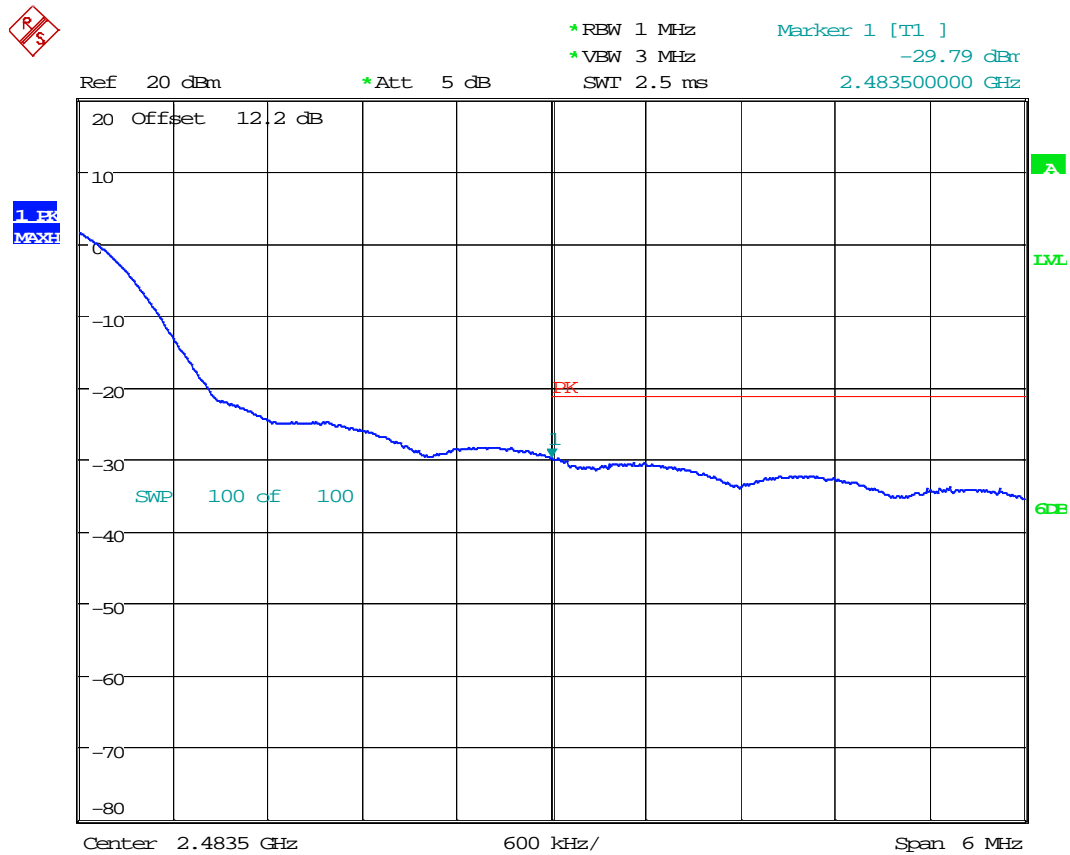
8.3.7 Measurement Plots:



Plot #8

High channel 2480 MHz

Modulation/Packet Type: BTLE

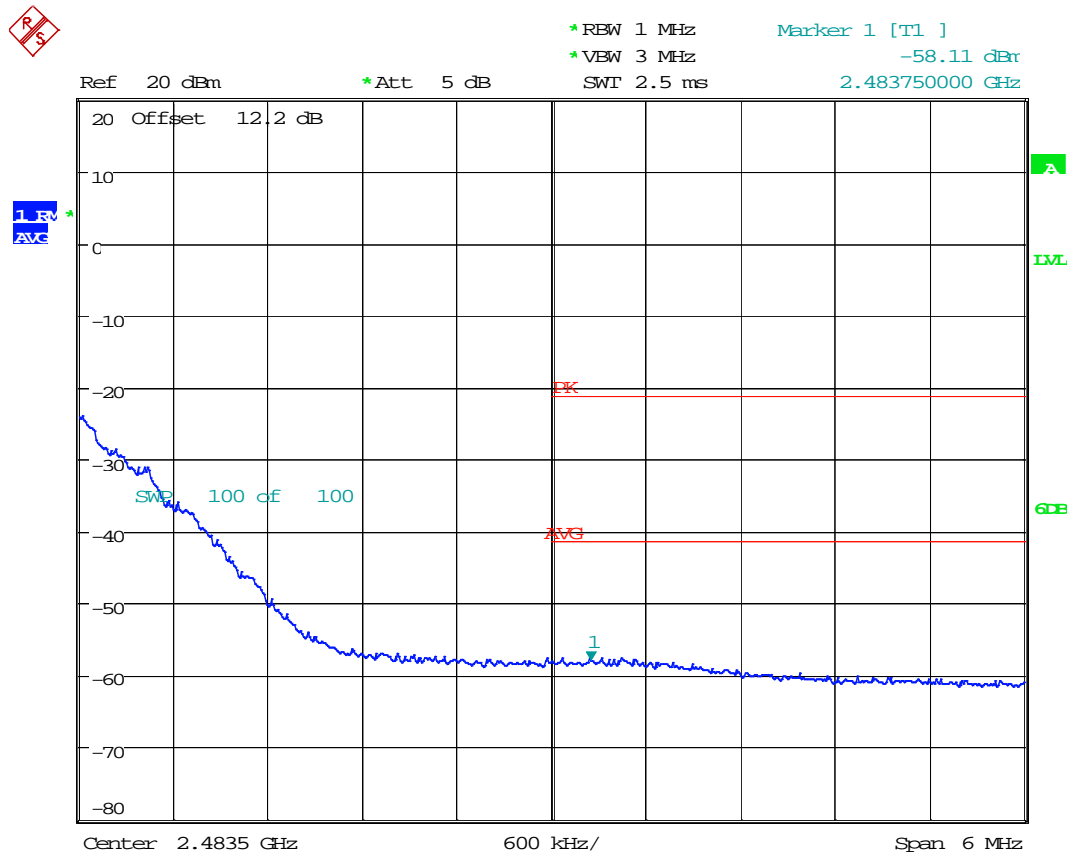


Date: 14.FEB.2018 10:18:18

Plot #9

High channel 2480 MHz

Modulation/Packet Type: BTLE



Date: 14.FEB.2018 10:21:36

8.4 Emission Bandwidth 6 dB and 99% Occupied Bandwidth

8.4.1 Measurement according to FCC 558074 D01 DTS Meas Guidance v04

Spectrum Analyzer settings:

- Set RBW = 100 kHz
- Set the video bandwidth (VBW) $\geq 3 \times$ RBW
- Detector = Peak
- Trace mode = Max hold
- Sweep = Auto couple
- Allow the trace to stabilize
- 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 maximum level measured in the fundamental emission.

8.4.2 Limits:

FCC §15.247(a)(1) and RSS-247 5.2(1)

- 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.

8.4.3 Test conditions and setup:

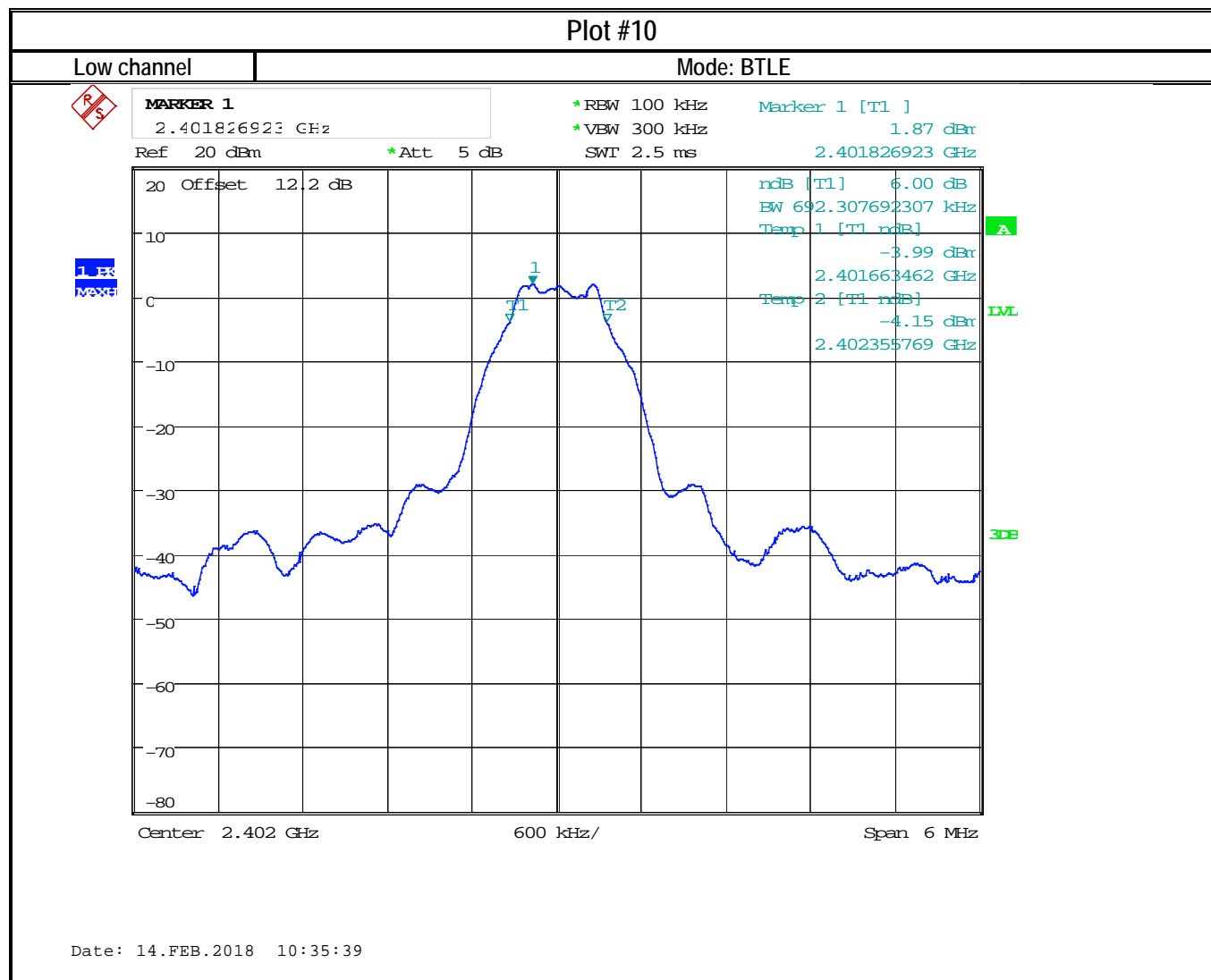
| Ambient Temperature | EUT Set-Up # | EUT operating mode | Power Input |
|---------------------|--------------|--------------------|-------------|
| 22° C | 1 | GFSK fixed channel | 3.3 VDC |

8.4.4 Measurement result:

| Plot # | Frequency (MHz) | 6 dB Emissions Bandwidth (MHz) | Limit (MHz) | Result |
|--------|-----------------|--------------------------------|-------------|--------|
| 10 | 2402 | 0.692 | > 0.5 | Pass |
| 11 | 2442 | 0.692 | > 0.5 | Pass |
| 12 | 2480 | 0.702 | > 0.5 | Pass |

| Plot # | Frequency (MHz) | 99% Occupied Bandwidth (MHz) | Limit (MHz) | Result |
|--------|-----------------|------------------------------|-------------|--------|
| 13 | 2402 | 1.05 | > 0.5 | Pass |
| 14 | 2441 | 1.058 | > 0.5 | Pass |
| 15 | 2480 | 1.058 | > 0.5 | Pass |

8.4.5 Measurement Plots:



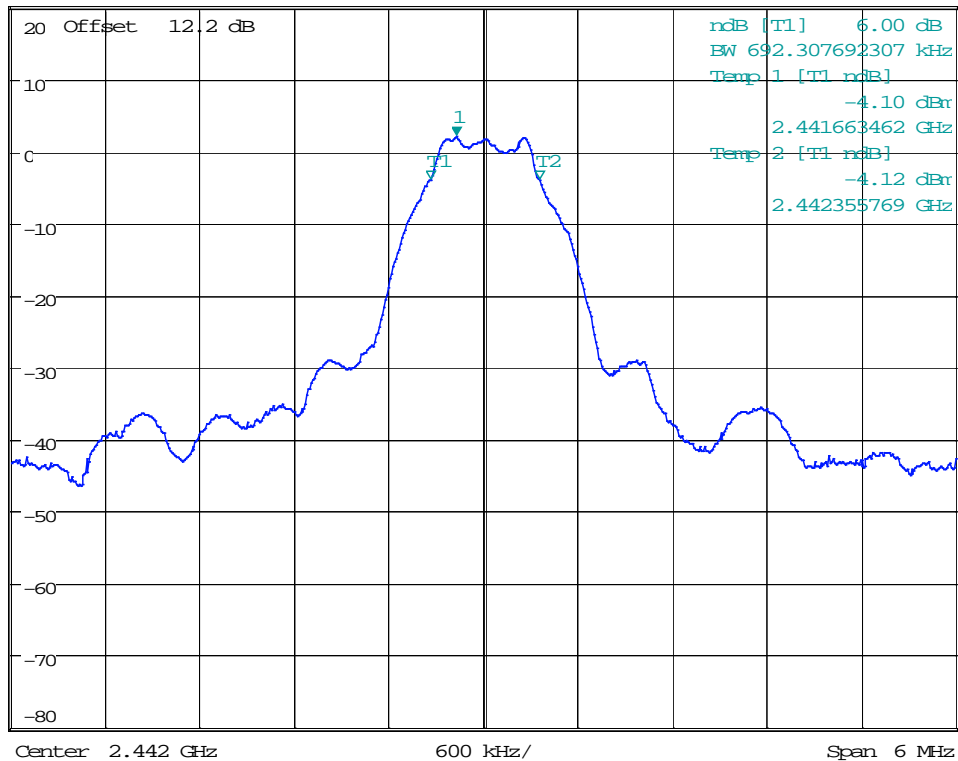
Plot #11

Mid channel

Mode: BTLE



Ref 20 dBm *Att 5 dB *RBW 100 kHz *VBW 300 kHz Marker 1 [T1] 1.95 dBm
SWI 2.5 ms 2.441826923 GHz



Date: 14.FEB.2018 10:36:44

Plot #12

High channel

Mode: BTLE



MARKER 1

2.479807692 GHz

*RBW 100 kHz

Marker 1 [T1]

*VBW 300 kHz

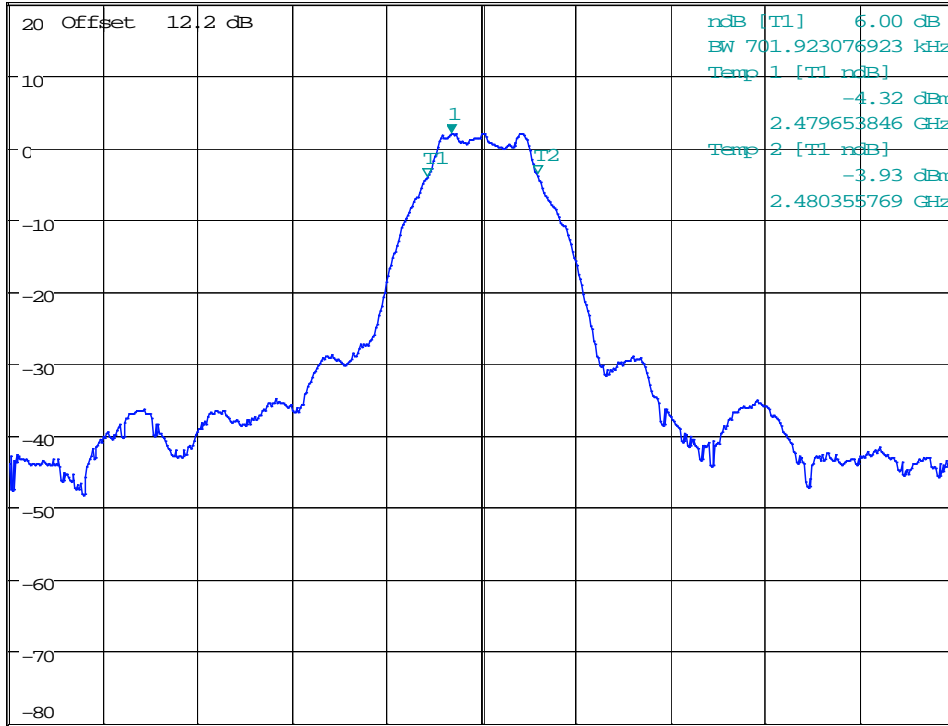
1.87 dBm

Ref 20 dBm

*Att 5 dB

SWI 2.5 ms

2.479807692 GHz

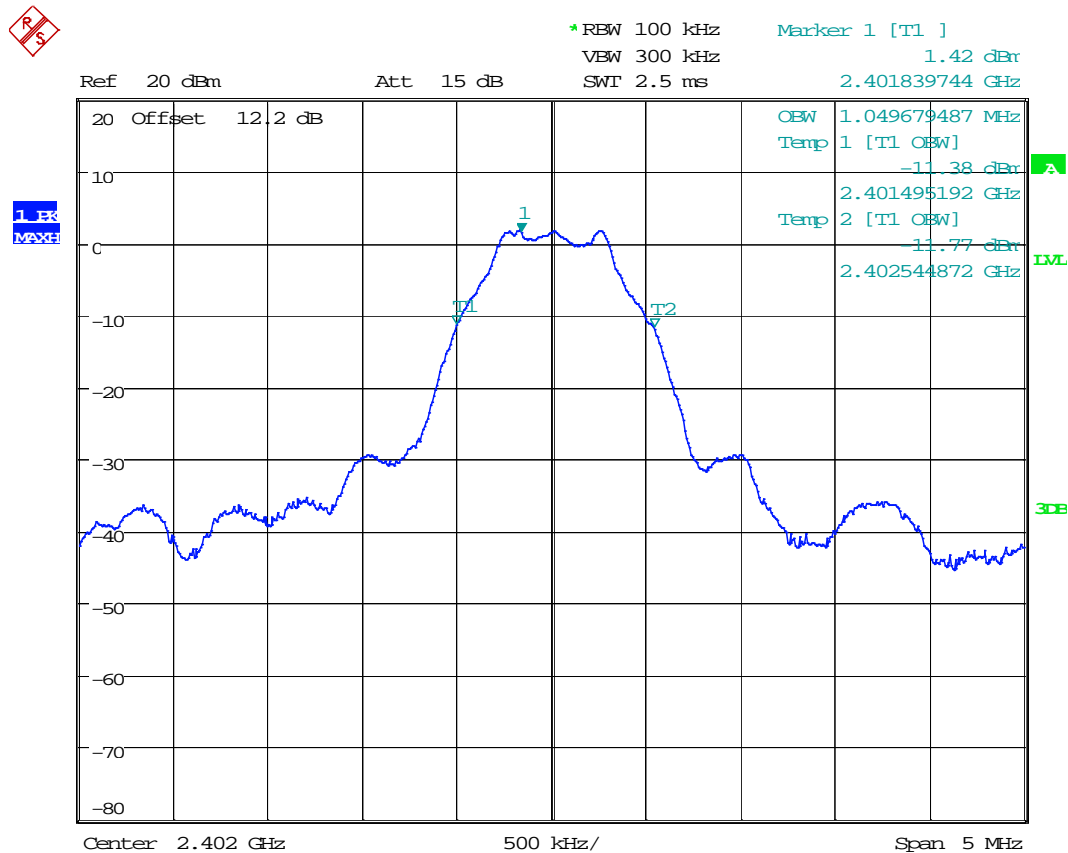
1.038
MAX

Date: 14.FEB.2018 10:37:49

Plot #13

Low channel

Mode: BTLE



Date: 14.FEB.2018 09:56:01

Plot #14

Mid channel

Mode: BTLE



*RBW 100 kHz

Marker 1 [T1]

VBW 300 kHz

1.76 dBm

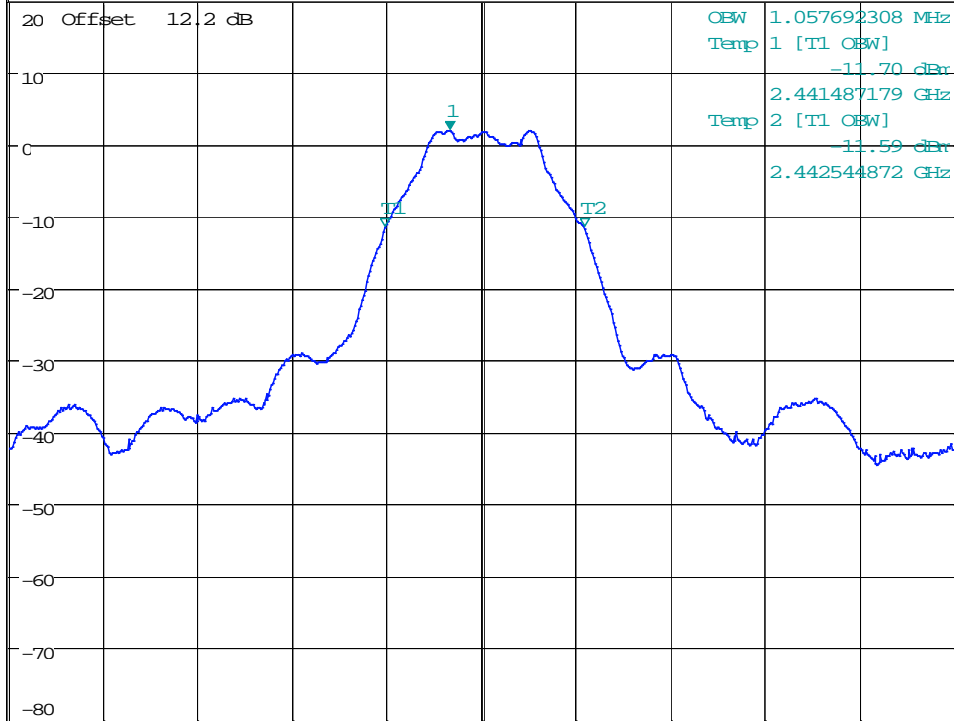
SWT 2.5 ms

2.441831731 GHz

Ref 20 dBm

Att 15 dB

20 Offset 12.2 dB

1.83
MAX

Center 2.442 GHz

500 kHz/

Span 5 MHz

Date: 14.FEB.2018 09:55:19

Plot #15

High channel

Mode: BTLE



*RBW 100 kHz

Marker 1 [T1]

VBW 300 kHz

1.81 dBm

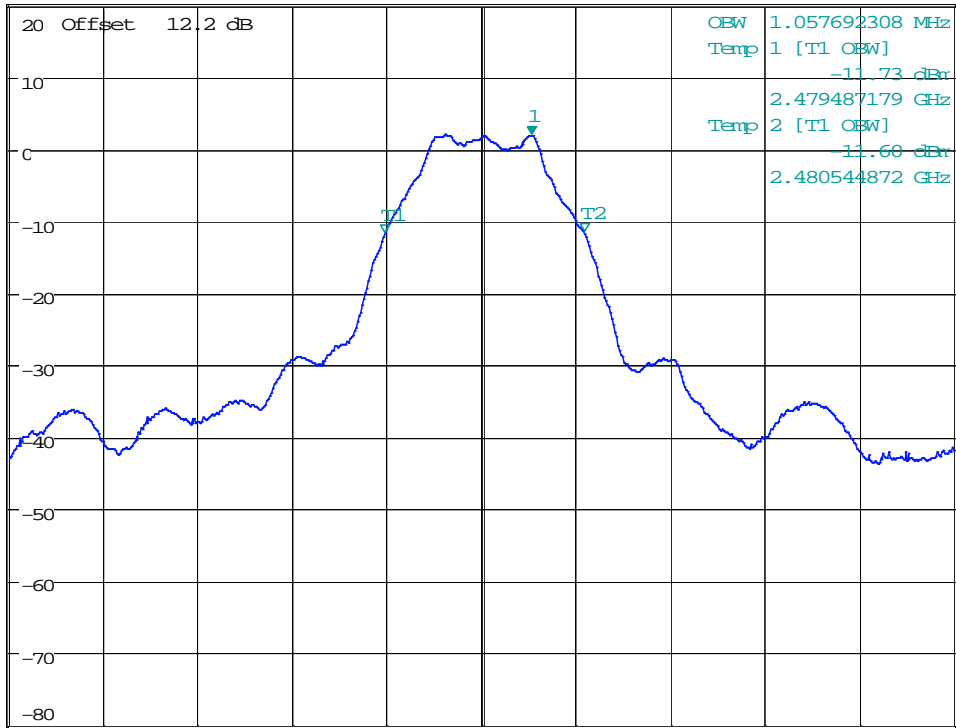
SWT 2.5 ms

2.480264423 GHz

Ref 20 dBm

Att 15 dB

20 Offset 12.2 dB

1.53
MAX

Center 2.48 GHz

500 kHz/

Span 5 MHz

Date: 14.FEB.2018 09:53:33

8.5 Radiated Transmitter Spurious Emissions and Restricted Bands

8.5.1 Measurement according to ANSI C63.10 (2013)

Spectrum Analyzer Settings:

- Frequency = 9 KHz – 30 MHz
- RBW = 9 KHz
- Detector: Peak

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

- Frequency > 1 GHz
- Detector = Peak / Average
- RBW = 1 MHz

- 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.
- The highest (or worst-case) data rate shall be recorded for each measurement.
- For testing at distance other than the specified in the standard, the limit conversion is calculated by using 40 dB/decade extrapolation factor as follow: Conversion factor (CF) = $40 \log (D/d) = 40 \log (300m / 3m) = 80dB$

8.5.2 Limits:

FCC §15.247

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

FCC §15.209 & RSS-Gen 8.9

- Except as provided elsewhere in this subpart, the emissions from an intentional radiator shall not exceed the field strength levels specified in the following table:

| Frequency of emission (MHz) | Field strength (μV/m) | Measurement Distance (m) | Field strength @ 3m (dBμV/m) |
|-----------------------------|-----------------------|--------------------------|------------------------------|
| 0.009–0.490 | 2400/F(kHz) / ----- | 300 | - |
| 0.490–1.705 | 24000/F(kHz) / ----- | 30 | - |
| 1.705–30.0 | 30 / (29.5) | 30 | - |
| 30–88 | 100 | 3 | 40 dBμV/m |
| 88–216 | 150 | 3 | 43.5 dBμV/m |
| 216–960 | 200 | 3 | 46 dBμV/m |
| Above 960 | 500 | 3 | 54 dBμV/m |

FCC §15.205 & RSS-Gen 8.10

- 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 |
| 10.495-0.505 | 16.69475-16.69525 | 608-614 | 5.35-5.46 |
| 2.1735-2.1905 | 16.80425-16.80475 | 960-1240 | 7.25-7.75 |
| 4.125-4.128 | 25.5-25.67 | 1300-1427 | 8.025-8.5 |
| 4.17725-4.17775 | 37.5-38.25 | 1435-1626.5 | 9.0-9.2 |
| 4.20725-4.20775 | 73-74.6 | 1645.5-1646.5 | 9.3-9.5 |
| 6.215-6.218 | 74.8-75.2 | 1660-1710 | 10.6-12.7 |
| 6.26775-6.26825 | 108-121.94 | 1718.8-1722.2 | 13.25-13.4 |
| 6.31175-6.31225 | 123-138 | 2200-2300 | 14.47-14.5 |
| 8.291-8.294 | 149.9-150.05 | 2310-2390 | 15.35-16.2 |
| 8.362-8.366 | 156.52475-156.52525 | 2483.5-2500 | 17.7-21.4 |
| 8.37625-8.38675 | 156.7-156.9 | 2690-2900 | 22.01-23.12 |
| 8.41425-8.41475 | 162.0125-167.17 | 3260-3267 | 23.6-24.0 |
| 12.29-12.293 | 167.72-173.2 | 3332-3339 | 31.2-31.8 |
| 12.51975-12.52025 | 240-285 | 3345.8-3358 | 36.43-36.5 |
| 12.57675-12.57725 | 322-335.4 | 3600-4400 | Above 38.6 |
| 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= 74 dBμV/m

*AVG. LIMIT= 54 dBμV/m

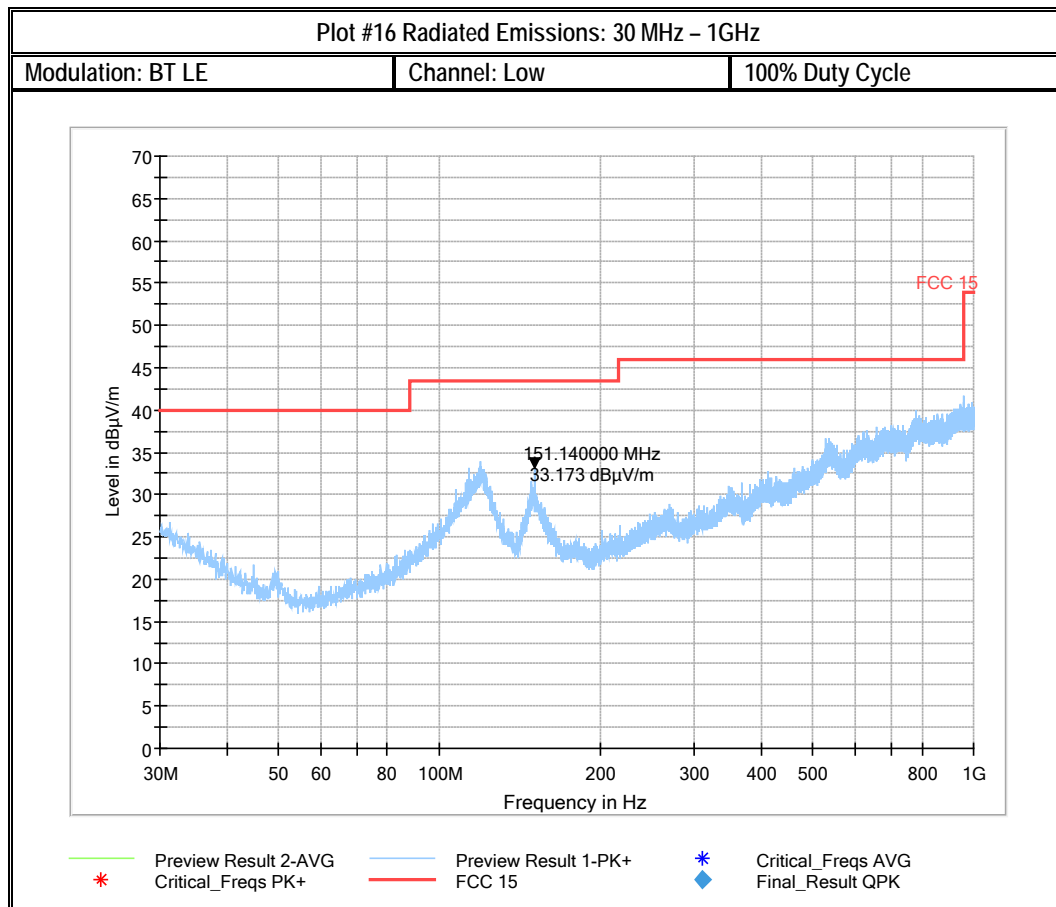
8.5.3 Test conditions and setup:

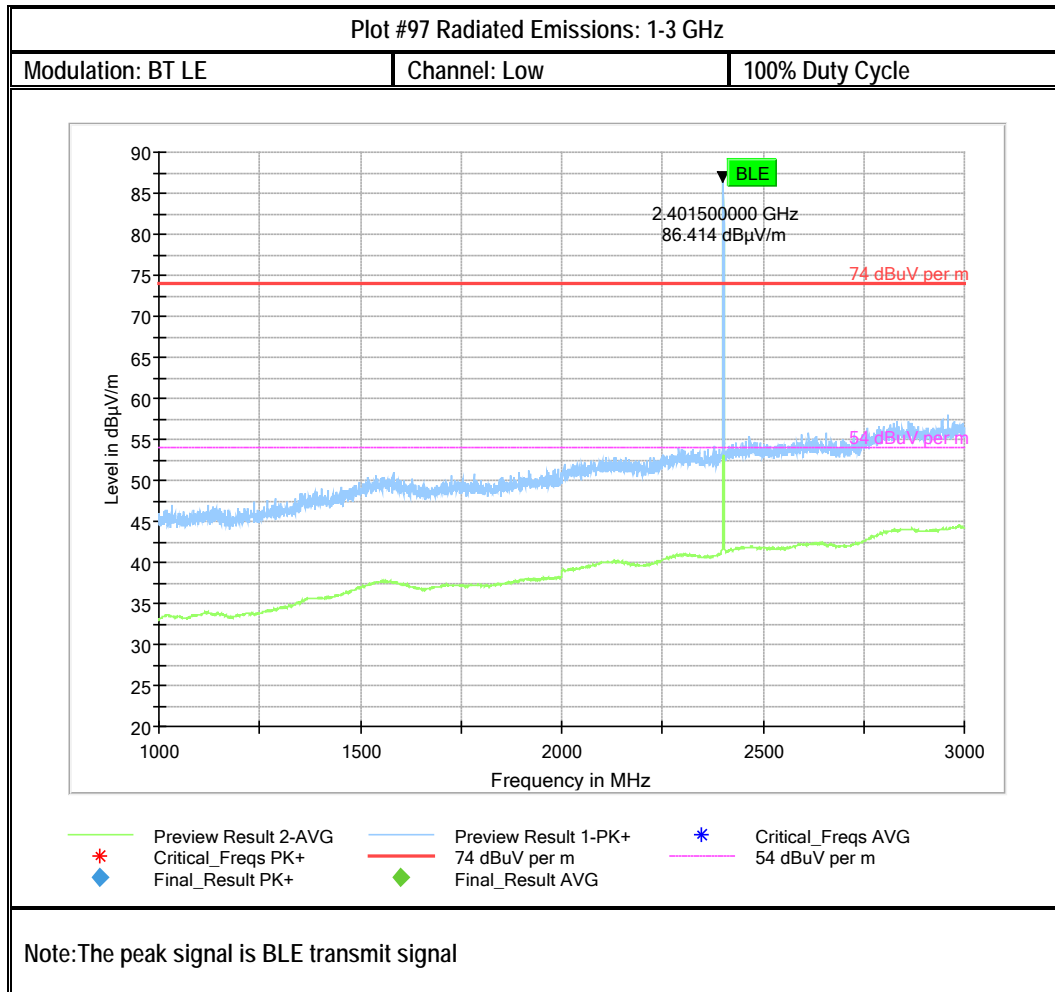
| Ambient Temperature | EUT Set-Up # | EUT operating mode | Power Input |
|---------------------|--------------|--------------------------------------|-----------------|
| 23° C | 2 | Continuous transmit at fixed channel | Battery. 3.0VDC |

8.5.4 Measurement result:

| Plot # | Channel # | Scan Frequency | Limit | Result |
|--------|-----------|-----------------|-------------------|--------|
| 16-18 | Low | 30 MHz – 18 GHz | See section 8.5.2 | Pass |
| 19-23 | Mid | 9 kHz – 26 GHz | See section 8.5.2 | Pass |
| 24-26 | High | 30 MHz – 18 GHz | See section 8.5.2 | Pass |

8.5.5 Measurement Plots:



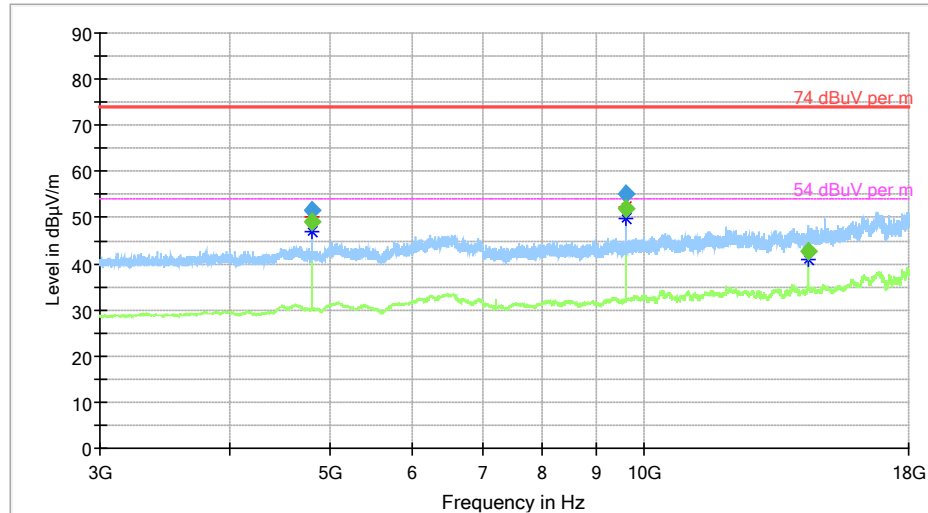


Plot #18 Radiated Emissions: 3-18 GHz

Modulation: BT LE

Channel: Low

100% Duty Cycle



Preview Result 2-AVG
 Critical_Freqs PK+
 Final_Result PK+

Preview Result 1-PK+
 74 dBuV per m
 Final_Result AVG

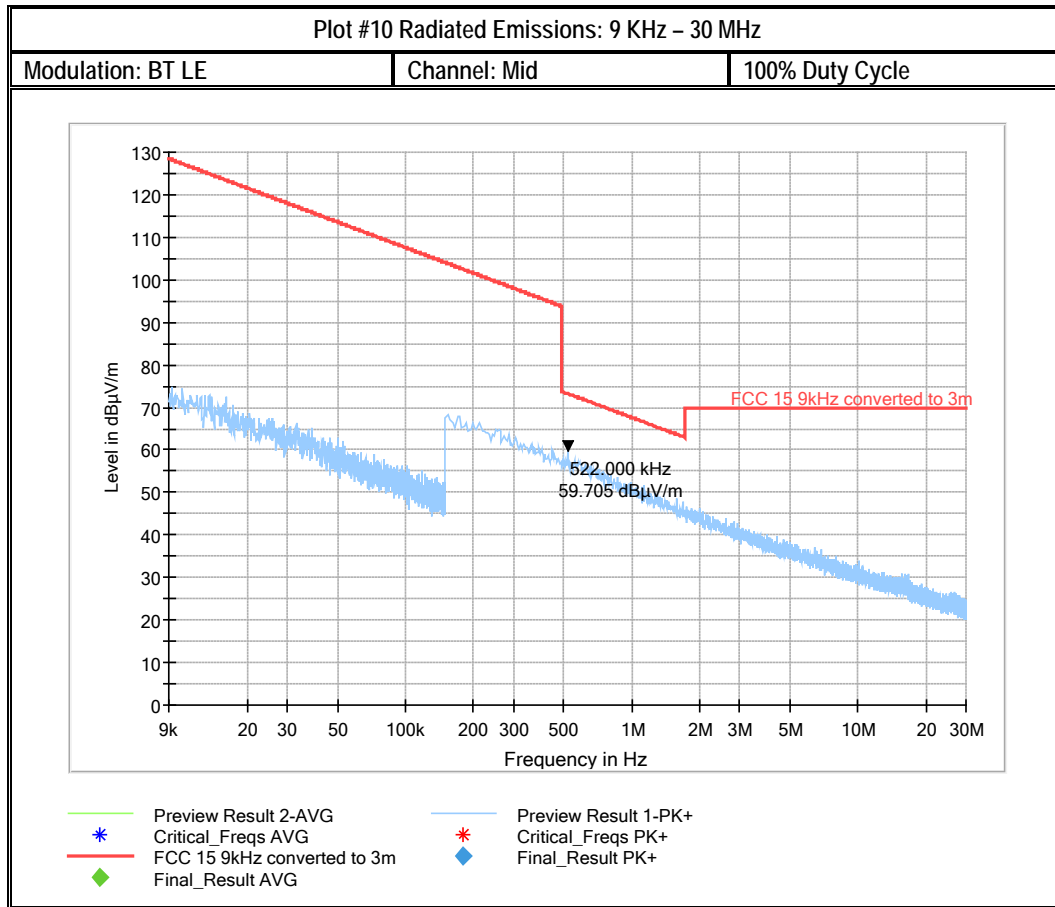
Critical_Freqs AVG
 54 dBuV per m

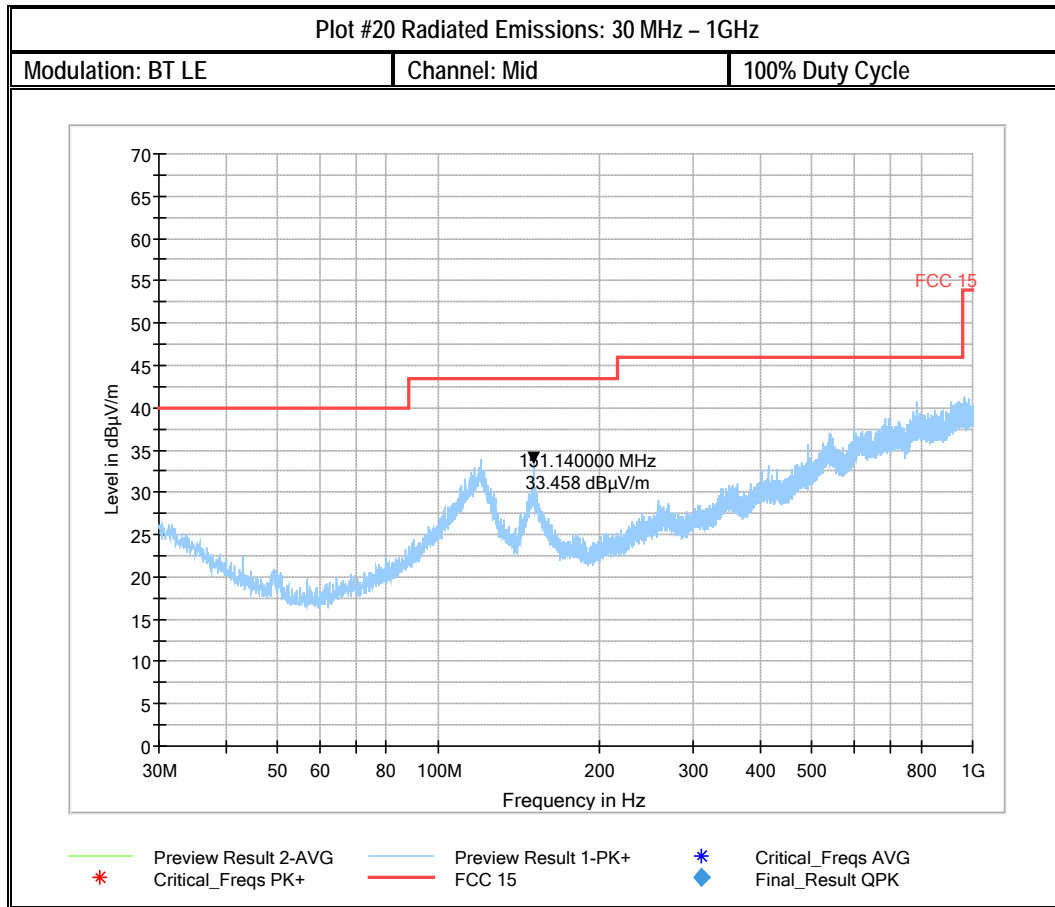
Final Result

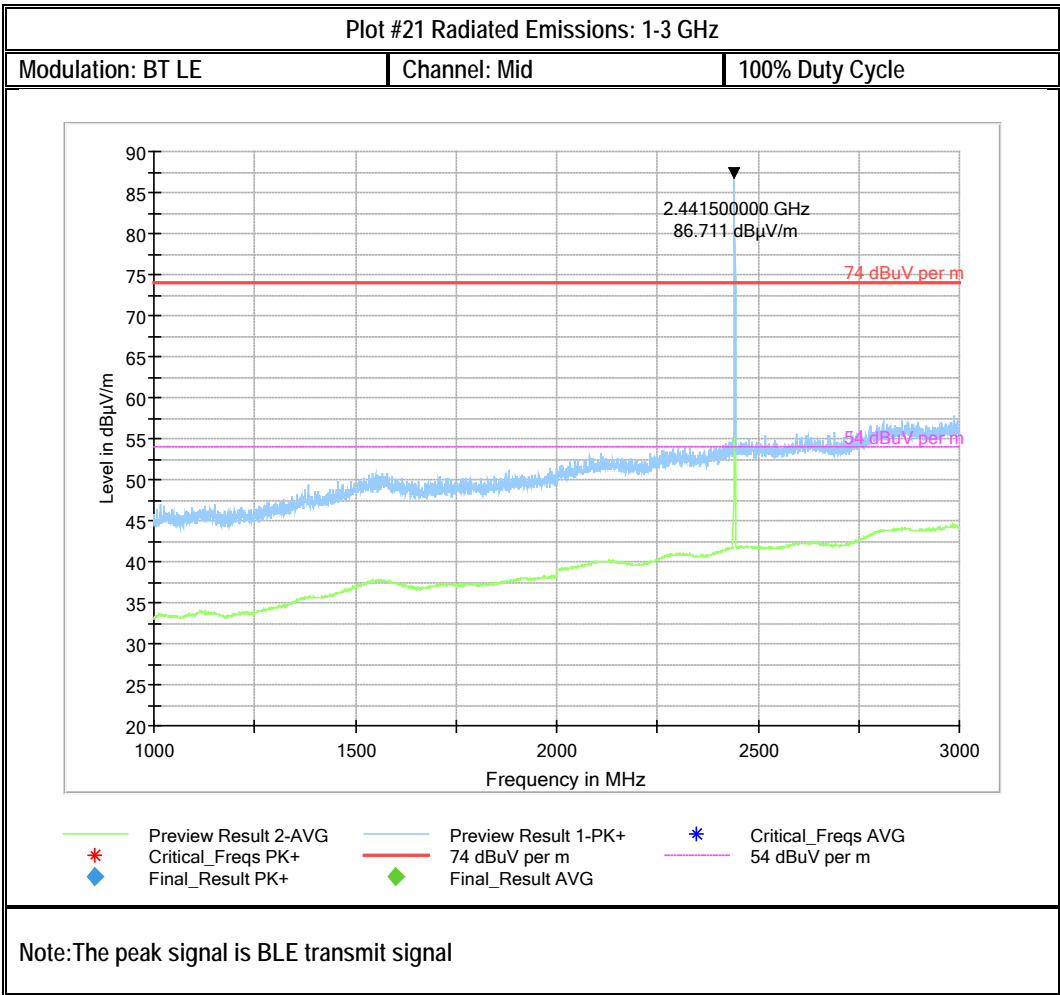
| Frequency (MHz) | MaxPeak (dBuV/m) | Average (dBuV/m) | Limit (dBuV/m) | Margin (dB) | Meas. Time (ms) | Bandwidth (kHz) | Height (cm) | Pol | Azimuth (deg) |
|-----------------|------------------|------------------|----------------|-------------|-----------------|-----------------|-------------|-----|---------------|
| 4803.500000 | --- | 49.24 | 54.00 | 4.76 | 100.0 | 1000.000 | 165.0 | V | 114.0 |
| 4803.540000 | 51.55 | --- | 74.00 | 22.45 | 100.0 | 1000.000 | 186.0 | V | 109.0 |
| 9607.000000 | --- | 52.09 | 54.00 | 1.91 | 100.0 | 1000.000 | 164.0 | H | -33.0 |
| 9607.080000 | 55.01 | --- | 74.00 | 18.99 | 100.0 | 1000.000 | 140.0 | H | -34.0 |
| 14410.500000 | --- | 42.75 | 54.00 | 11.25 | 100.0 | 1000.000 | 140.0 | V | 9.0 |

(continuation of the "Final_Result" table from column 15 ...)

| Frequency (MHz) | Corr. (dB) | Comment |
|-----------------|------------|------------------------|
| 4803.500000 | -5.1 | 4:01:23 PM - 2/23/2018 |
| 4803.540000 | -5.1 | 3:58:51 PM - 2/23/2018 |
| 9607.000000 | 1.8 | 4:02:40 PM - 2/23/2018 |
| 9607.080000 | 1.8 | 4:00:12 PM - 2/23/2018 |
| 14410.500000 | 5.6 | 4:03:47 PM - 2/23/2018 |





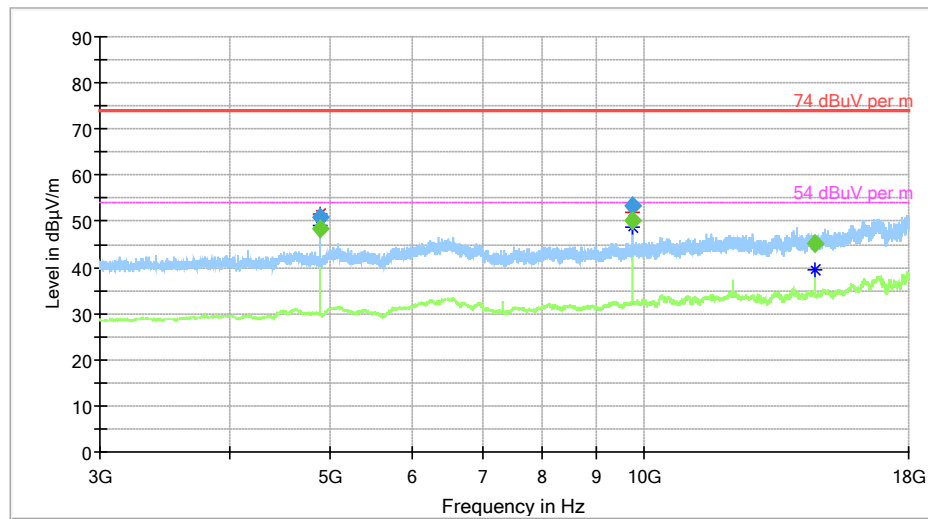


Plot #22 Radiated Emissions: 3-18 GHz

Modulation: BT LE

Channel: Mid

100% Duty Cycle



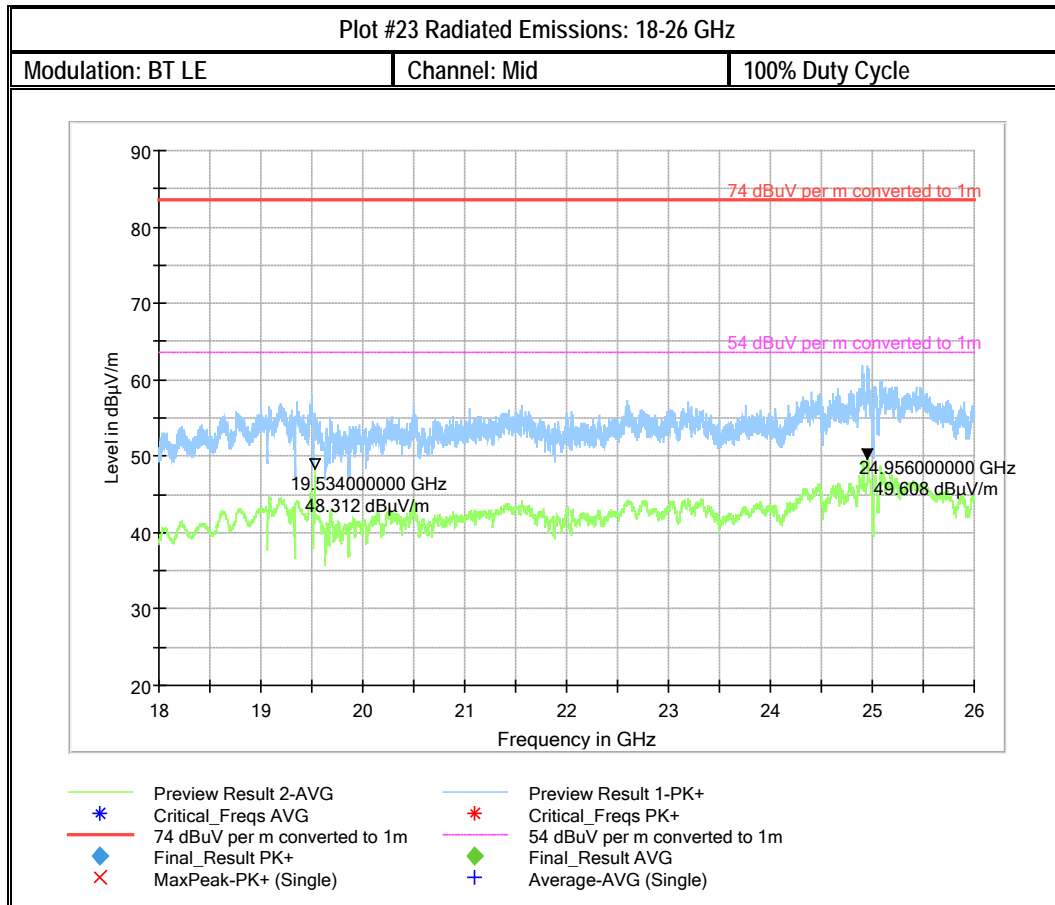
Preview Result 2-AVG Preview Result 1-PK+ * Critical_Freqs AVG
* Critical_Freqs PK+ 74 dBµV per m 54 dBµV per m
◆ Final_Result PK+ ◆ Final_Result AVG

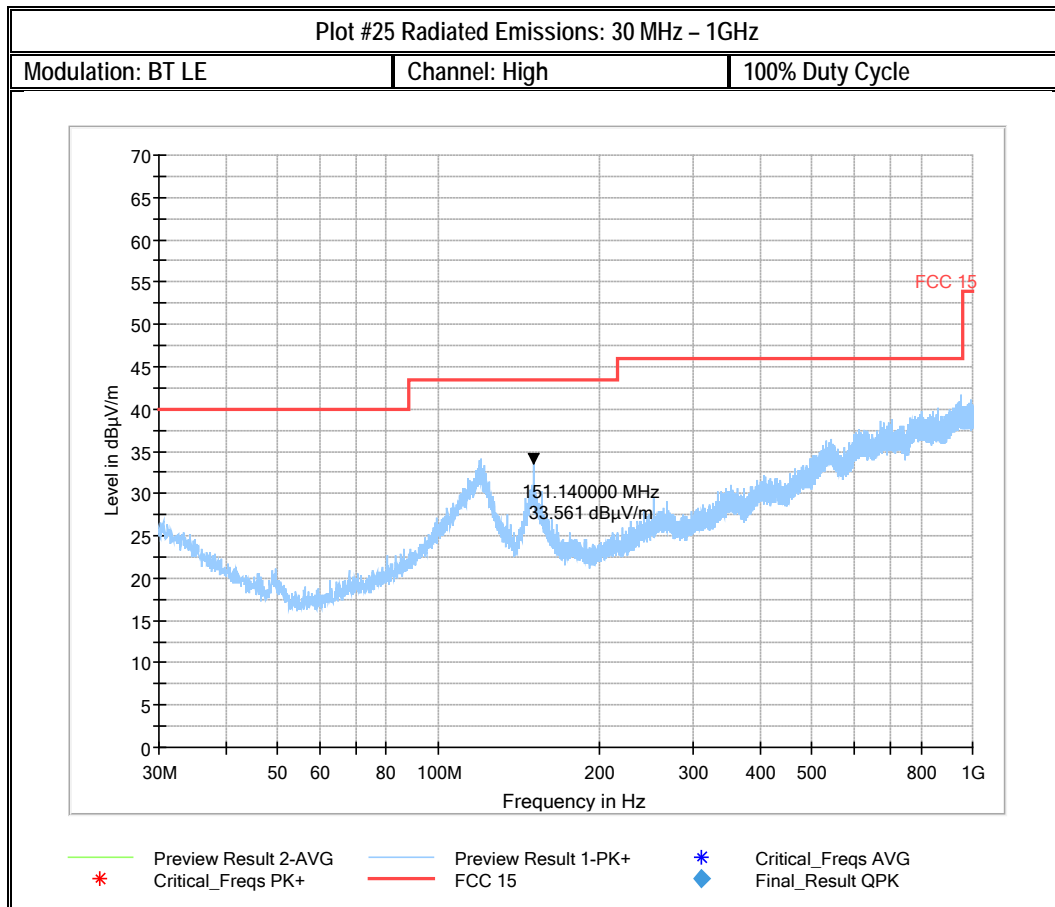
Final_Result

| Frequency (MHz) | MaxPeak (dBµV/m) | Average (dBµV/m) | Limit (dBµV/m) | Margin (dB) | Meas. Time (ms) | Bandwidth (kHz) | Height (cm) | Pol | Azimuth (deg) |
|-----------------|------------------|------------------|----------------|-------------|-----------------|-----------------|-------------|-----|---------------|
| 4883.500000 | --- | 48.41 | 54.00 | 5.59 | 100.0 | 1000.000 | 168.0 | V | 101.0 |
| 4883.540000 | 50.84 | --- | 74.00 | 23.16 | 100.0 | 1000.000 | 165.0 | V | 103.0 |
| 9767.000000 | --- | 50.19 | 54.00 | 3.81 | 100.0 | 1000.000 | 195.0 | H | -22.0 |
| 9767.080000 | 53.34 | --- | 74.00 | 20.66 | 100.0 | 1000.000 | 160.0 | H | -21.0 |
| 14650.500000 | --- | 45.17 | 54.00 | 8.83 | 100.0 | 1000.000 | 140.0 | H | -40.0 |

(continuation of the "Final_Result" table from column 15 ...)

| Frequency (MHz) | Corr. (dB) | Comment |
|-----------------|------------|------------------------|
| 4883.500000 | -5.4 | 5:00:25 PM - 2/23/2018 |
| 4883.540000 | -5.4 | 4:56:47 PM - 2/23/2018 |
| 9767.000000 | 2.3 | 4:58:01 PM - 2/23/2018 |
| 9767.080000 | 2.3 | 4:55:30 PM - 2/23/2018 |
| 14650.500000 | 4.9 | 4:59:08 PM - 2/23/2018 |



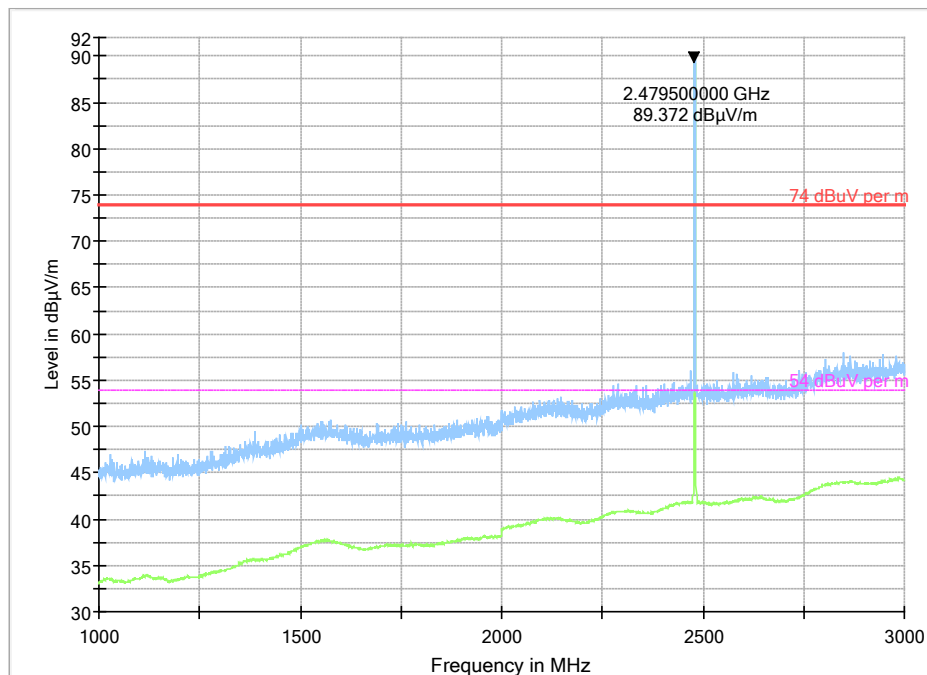


Plot #25 Radiated Emissions: 1-3 GHz and Restricted Bands

Modulation: BT LE

Channel: High

100% Duty Cycle



Preview Result 2-AVG Preview Result 1-PK+ * Critical_Freqs AVG
Critical_Freqs PK+ 74 dBuV per m 54 dBuV per m
Final_Result PK+ Final_Result AVG

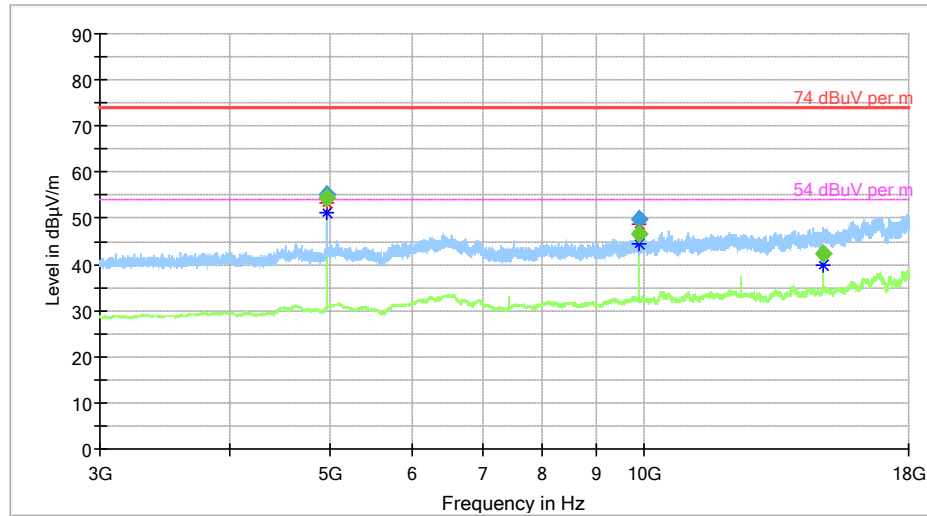
Note: The peak signal is BLE transmit signal

Plot #26 Radiated Emissions: 3-18 GHz

Modulation: GFSK

Channel: High

100% Duty Cycle



Preview Result 2-AVG Preview Result 1-PK+ * Critical_Freqs AVG
Critical_Freqs PK+ 74 dBµV per m Final_Result PK+ 54 dBµV per m
Final_Result AVG

Final Result

| Frequency (MHz) | MaxPeak (dBµV/m) | Average (dBµV/m) | Limit (dBµV/m) | Margin (dB) | Meas. Time (ms) | Bandwidth (kHz) | Height (cm) | Pol | Azimuth (deg) |
|-----------------|------------------|------------------|----------------|-------------|-----------------|-----------------|-------------|-----|---------------|
| 4959.500000 | --- | 54.42 | 54.00 | -0.42 | 100.0 | 1000.000 | 155.0 | H | -45.0 |
| 4959.540000 | 55.04 | --- | 74.00 | 18.96 | 100.0 | 1000.000 | 156.0 | H | -43.0 |
| 9919.000000 | --- | 46.51 | 54.00 | 7.49 | 100.0 | 1000.000 | 173.0 | H | -14.0 |
| 9919.080000 | 49.82 | --- | 74.00 | 24.18 | 100.0 | 1000.000 | 212.0 | H | -9.0 |
| 14878.500000 | --- | 42.39 | 54.00 | 11.61 | 100.0 | 1000.000 | 140.0 | H | 97.0 |

(continuation of the "Final_Result" table from column 15 ...)

| Frequency (MHz) | Corr. (dB) | Comment |
|-----------------|------------|------------------------|
| 4959.500000 | -4.8 | 4:19:42 PM - 2/23/2018 |
| 4959.540000 | -4.8 | 4:17:28 PM - 2/23/2018 |
| 9919.000000 | 2.3 | 4:20:47 PM - 2/23/2018 |
| 9919.080000 | 2.3 | 4:18:34 PM - 2/23/2018 |
| 14878.500000 | 6.0 | 4:21:58 PM - 2/23/2018 |

Note: According to FCC15.35(c), a correction factor is applied here.

From calculation, the maximum data rate of BTLE is 128kbps from a 1Mbps raw tech, thus a correction factor of 17.9dB at least could be applied. Hence this margin could cover the highest spurious above.

9 Test setup photos

Setup photos are included in supporting file name: "EMC_SMART_001_17001_15.247_BT_Setup_Photos.pdf"

10 Test Equipment And Ancillaries Used For Testing

| Equipment Type | Manufacturer | Model | Serial # | Calibration Cycle | Last Calibration Date |
|---------------------------|-----------------|--------------|------------------------|-------------------|-----------------------|
| Biconlog Antenna | EMCO | 3142E | 166067 | 3 years | 6/28/2017 |
| Loop Antenna | ETS Lindgren | 6507 | 161344 | 3 years | 10/26/2017 |
| Horn Antenna | EMCO | 3115 | 35111 | 3 years | 11/17/2015 |
| Horn Antenna | ETS Lindgren | 3116 | 70497 | 3 years | 10/31/2017 |
| Compact Digital Barometer | Control Company | 35519-055 | 91119547 | 2 Years | 6/20/2017 |
| EMI Receiver | R&S | ESU | 1302.6005K40-100251-KB | 3 years | 7/10/2017 |
| Spectrum Analyzer | R&S | FSU26 | 200302 | 3 years | 7/5/2017 |
| Thermometer Humidity | Dickson | TM320 AY1072 | 0528 | 1 Year | 11/2/2016 |

Note: Equipment used meets the measurement uncertainty requirements as required per applicable standards for 95% confidence levels. Calibration due dates, unless defined specifically, falls on the last day of the month. Items indicated "N/A" for cal status either do not specifically require calibration or is internally characterized before use.

11 Revision History

| Date | Report Name | Changes to report | Report prepared by |
|------------|-----------------------------------|-------------------|--------------------|
| 03/02/2018 | EMC_SMART-001-17001_15.247_BT_DTS | Initial version | Cindy Li |