# FCC / IC Test Report

FOR:

## Moog Inc.

Model Name:

## ILC3000

Product Description:

## asset tracker

**FCC ID:** 2AGRZ-ILC3000
**IC ID:** 20942-ILC3000

**Per:**

47 CFR Part 15.247 (DTS)
RSS-247 Issue 1 (DTS) & RSS-Gen Issue 4

**REPORT #:** EMC_MOOGI-005-15001_15.247_WLAN
**DATE:** January 21, 2015

***CETECOM*** **Inc.**
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*CETECOM* Inc. is a Delaware Corporation with Corporation number: 2905571

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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 IC standard RSS-247.

No deviations were ascertained during the course of testing performed.

| Company | Description | Model # |
|---|---|---|
| Moog Inc. | asset tracker | ILC3000 |

**Responsible for Testing Laboratory:**

| Date | Section | Name | Signature |
|---|---|---|---|
| January 21, 2015 | 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 |

**Responsible for the Report:**

| Date | Section | Name | Signature |
|---|---|---|---|
| January 21, 2015 | Compliance | Yu-Chien Ho (EMC Engineer) | Yu-Chien Ho |

# 2 Administrative Data

## 2.1 Identification of the Testing Laboratory Issuing the EMC Test Report

| | |
|---|---|
| **Company Name:** | CETECOM Inc. |
| **Department:** | Compliance |
| **Address:** | 411 Dixon Landing Road<br>Milpitas, CA 95035<br>U.S.A. |
| **Telephone:** | +1 (408) 586 6200 |
| **Fax:** | +1 (408) 586 6299 |
| **Manager Compliance Services:** | Franz Engert |
| **Project Engineer:** | Yu-Chien Ho |

## 2.2 Identification of the Client

| | |
|---|---|
| **Clients Name:** | Moog Inc. |
| **Clients Address:** | 1421 McCarthy Blvd. |
| **City/Zip Code** | Milpitas, CA 95035 |
| **Country** | USA |

## 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 EUT Specifications

| | |
|---|---|
| **Model #:** | ILC3000 |
| **HW Version :** | 001 |
| **SW Version :** | 3.0.0.1 |
| **FCC-ID :** | 2AGRZ-ILC3000 |
| **IC-ID:** | 20942-ILC3000 |
| **HVIN:** | ILC3000 |
| **PMN:** | ILC 3000 |
| **FVIN:** | NA |
| **Product Description:** | asset tracker |
| **Regulatory Band:** | Lower band edge 2400 MHz – upper band edge 2483.5 MHz |
| **Channels Used:** | 2412(Ch. 1) – 2462(Ch. 1), 11 channels |
| **Type(s) of Modulation:** | 802.11b/g/n with CCK, DQPSK, DBPSK + DSSS<br>QBSK, BPSK, 16 QAM, 64 QAM + OFDM |
| **Modes of Operation:** | Access Point Infrastructure Mode, Group Owner, Station |
| **Antenna Type:** | 2.4GHz High Efficiency Loop Antenna |
| **Max. Declared Antenna Gain:** | 2.5 dBi |
| **Max. Measured Conducted Output** | 18.22 dBm EIRP |
| **Power Supply:** | Li-ion Rechargeable Battery and AC/DC Battery Charger |
| **Rated Operating Voltage Range:** | • Li-ion Rechargeable Battery: Vmin: 3.3V dDC/ Vnom: 3.7V DC / Vmax: 4.2V DC<br>• AC/DC Battery Charger: 110V – 230V AC, 120mA. |
| **Operating Temperature Range:** | T min: -20° C/ T max: 60° C |
| **Other Radios included in the Device:** | Cellular<br>BTLE 4.1<br>GPS |
| **Sample Revision:** | ■Prototype; ☐Production; ☐Pre-Production |

## 3.2 EUT Sample details

| EUT # | Serial Number | HW Version | SW Version | Notes/Comments |
|---|---|---|---|---|
| **1** | 320002 | 001 | 3.0.0.1 | Radiated Sample |
| **2** | 320010 | 001 | 3.0.0.1 | Conducted Sample |

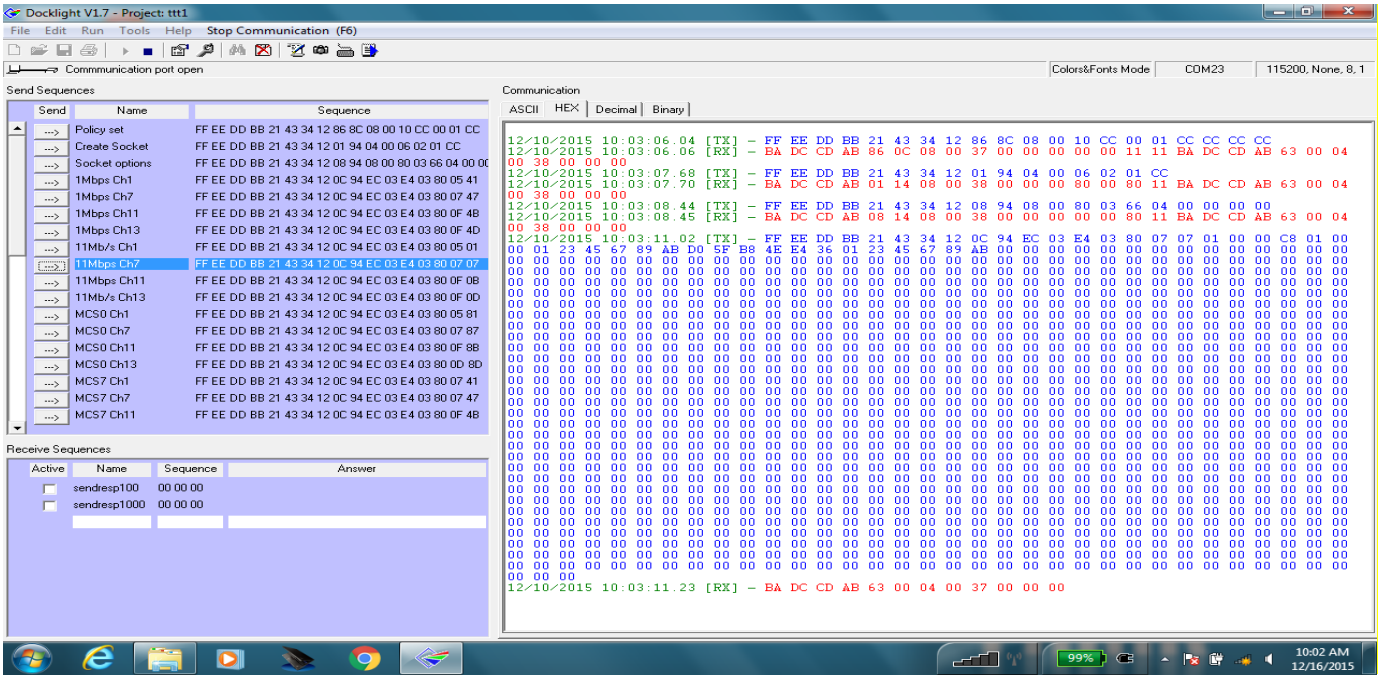
## 3.3 Accessory Equipment (AE) details

| AE # | Type | Model | Manufacturer | Serial Number |
|---|---|---|---|---|
| **1** | AC/DC Power Supply | DCH3-05OUS-0002 | Emerson | 002187 |

## 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 stimulated directly in a test mode not accessible by the end user. The internal antenna was connected. |
| **2** | EUT#2 | The radio of the EUT was stimulated directly in a test mode not accessible by the end user. The measurement equipment was connected to the 50Ohm UFL port of the EUT. |
| **3** | EUT#1 + AE #1 | The radio of the EUT was stimulated directly in a test mode not accessible by the end user. The internal antenna was connected. |

## 3.5 Software tool used to control EUT



## 3.6 Worst case condition for emission measurement

All results are based on the EUT operating at its maximum declared peak envelope power.

To achieve this condition the EUT was set to the following Power Setting / Key value: 15.72 dBm/0.

An analysis over the supported modulations and bandwidths has been carried out on mid channel showing that 802.11b (11Mbps_CCC)/20 MHz has the highest peak envelope power. All emission measurements in this report have been carried out in 802.11 b mode except the band edges restricted which have been tested in 802.11b and 802.11n to also verify conformance of the biggest OBW.

| Modulation | Nominal Bandwidth | Average Power (dBm) | Corrected by Duty Cycle Correction Factor (dBm) | Corrected by Antenna Gain (dBi) | EIRP (dBm) |
|---|---|---|---|---|---|
| 802.11 (1Mbps_DSSS) | 20 MHz | 15 dBm | 0.25 | 2.5 | 17.75 dBm |
| 802.11b (11Mbps_CCK) | 20 MHz | 14.62 dBm | 1.1 | 2.5 | 18.22 dBm |
| 802.11n (MCS0) | 20 MHz | 13.44 dBm | 0.6 | 2.5 | 16.54 dBm |
| 802.11n (MCS7) | 20 MHz | 3.51 dBm | 8.1 | 2.5 | 14.11 dBm |

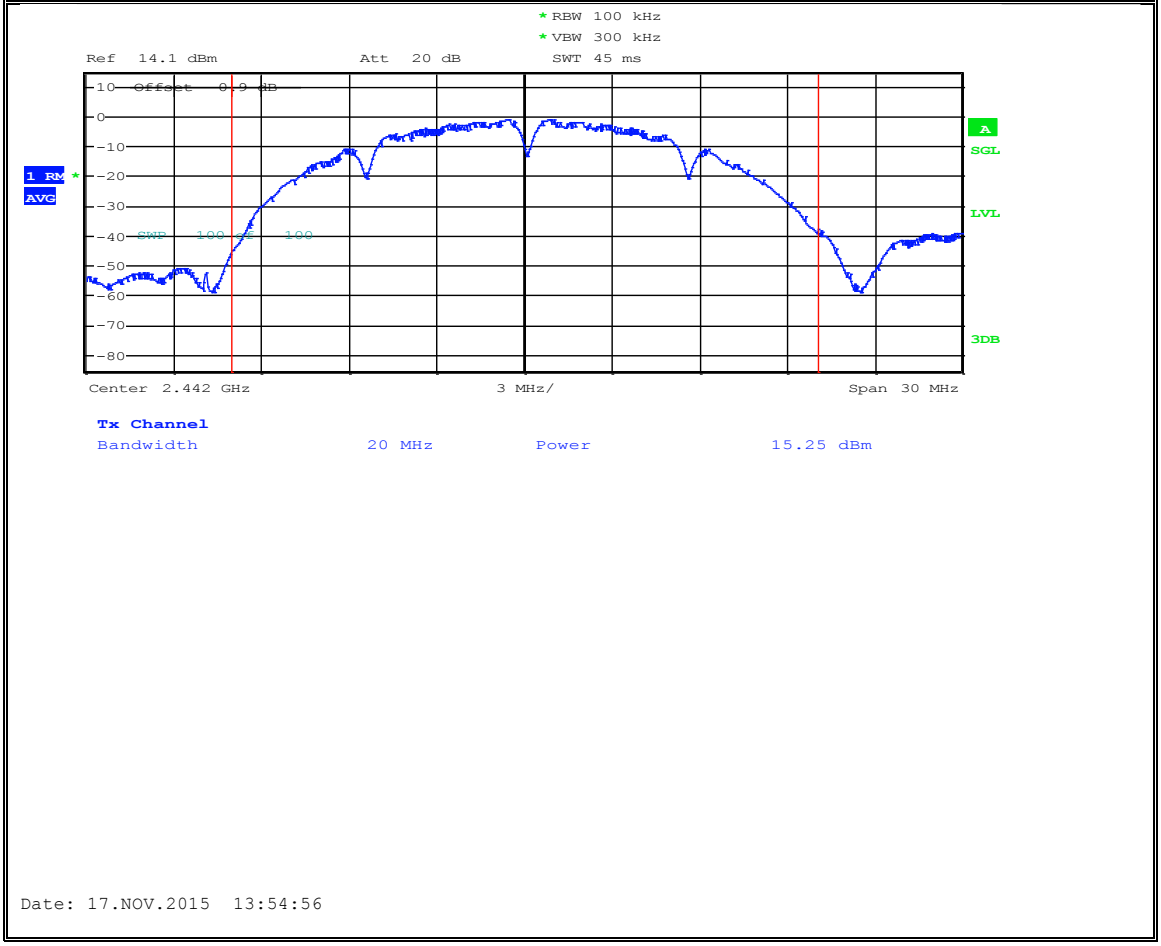
Duty Cycle = 100 (TX ON) / (TX ON +TX OFF)

Duty Cycle Correction Factor = 10 log (TX ON + TX OFF) / TX ON

| Modulation | TX ON + TX OFF (ms) | TX ON (ms) | Duty Cycle | Duty Cycle Correction Factor |
|---|---|---|---|---|
| 802.11 (1Mbps_DSSS) | 8.645 | 8.174 | 94.6% | 0.25dB |
| 802.11b (11Mbps_CCK) | 1.171 | 0.913 | 78% | 1.1dB |
| 802.11n (MCS0) | 1.459 | 1.269 | 87% | 0.6dB |
| 802.11n (MCS7) | 0.954 | 0.147 | 15.4% | 8.1dB |

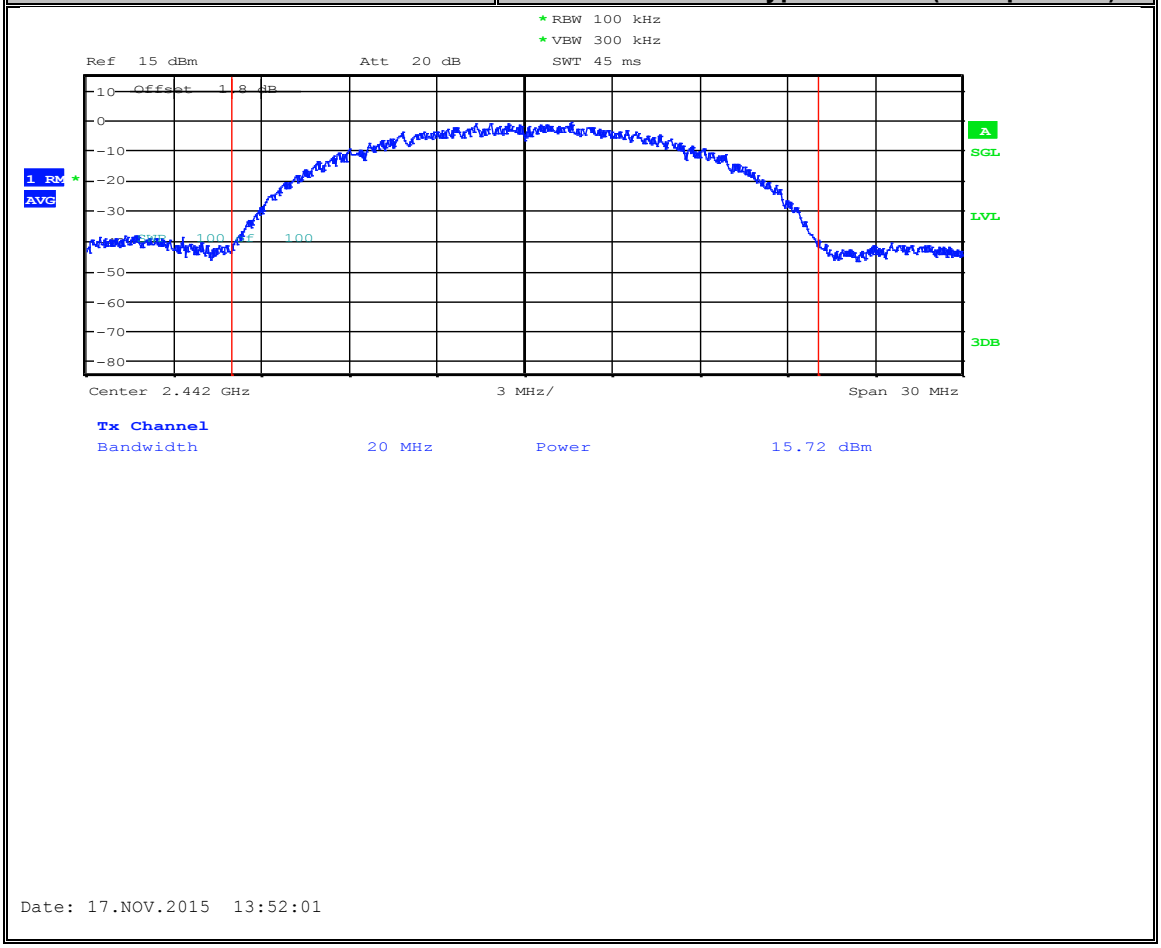
### 3.6.1 Plots

| Plot #1 | |
|---|---|
| Ch. 7 / 2442 MHz | Modulation/Packet Type: 802.11 (1Mbps_DSSS) |




Note: Average output power already compensated for duty cycle correction factor.

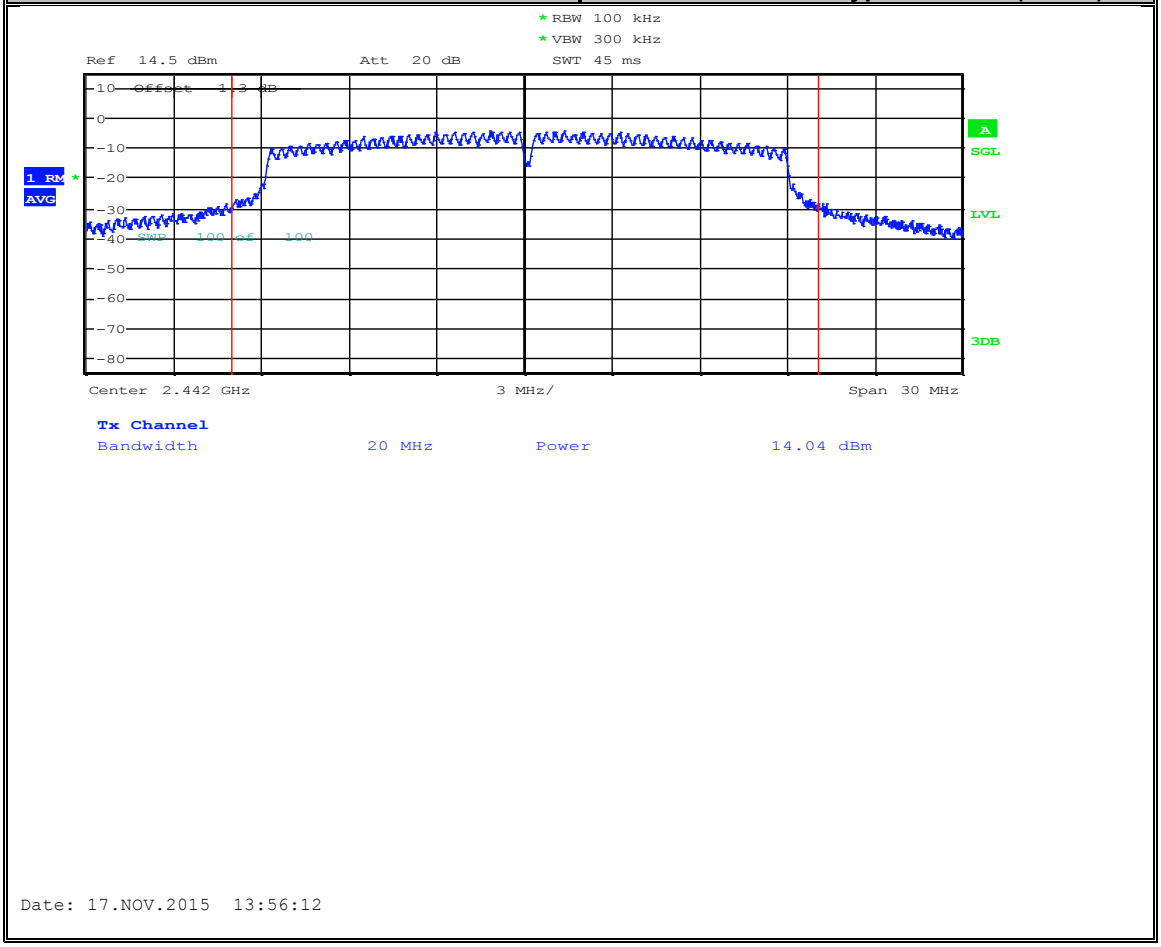
| Plot #2 | |
|---|---|
| Ch. 7 / 2442 MHz | Modulation/Packet Type: 802.11b (11Mbps_CCK) |




Note: Average output power already compensated for duty cycle correction factor.

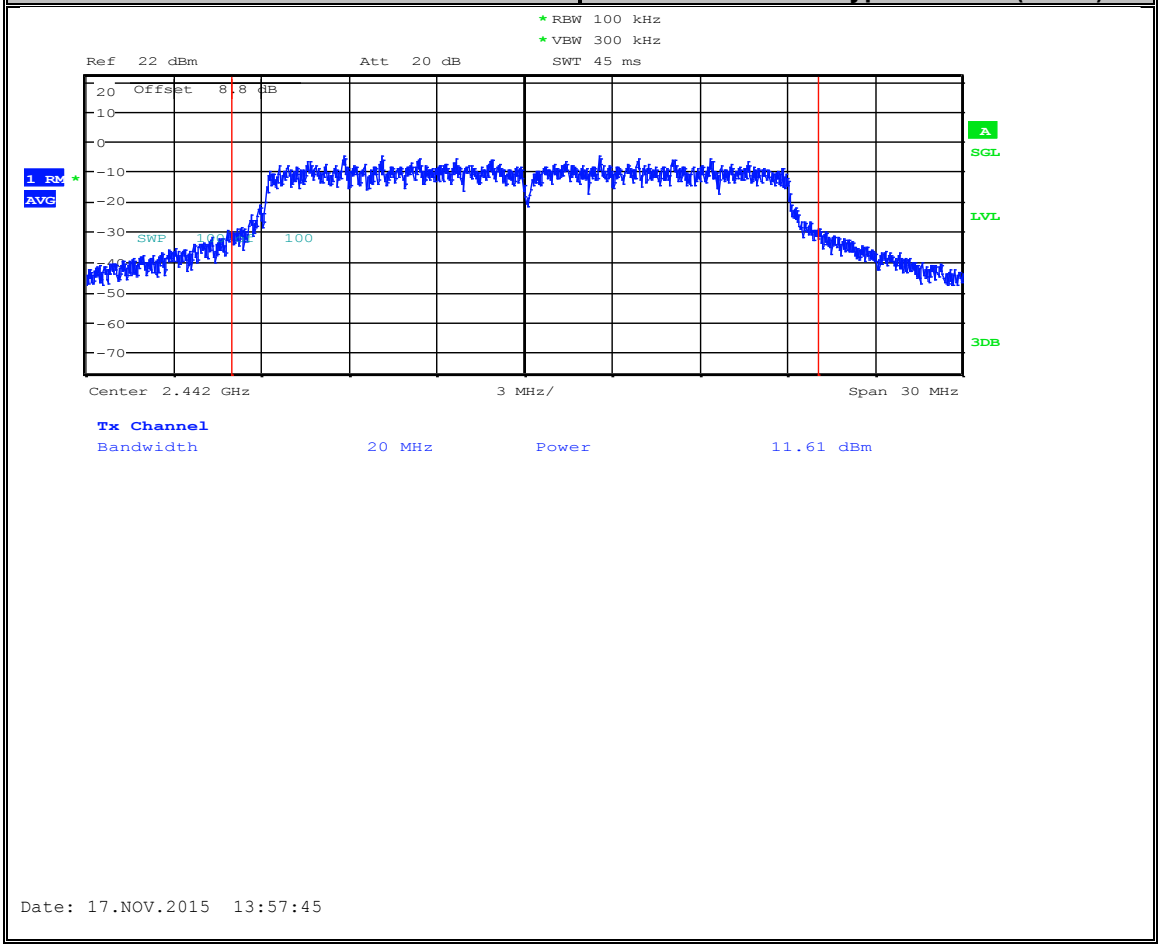
**Plot #3**

| Ch. 7 / 2442 MHz | Modulation/Packet Type: 802.11n (MCS0) |
|---|---|




Note: Average output power already compensated for duty cycle correction factor.

| Plot #4 | |
|---|---|
| Ch. 7 / 2442 MHz | Modulation/Packet Type: 802.11n (MCS7) |



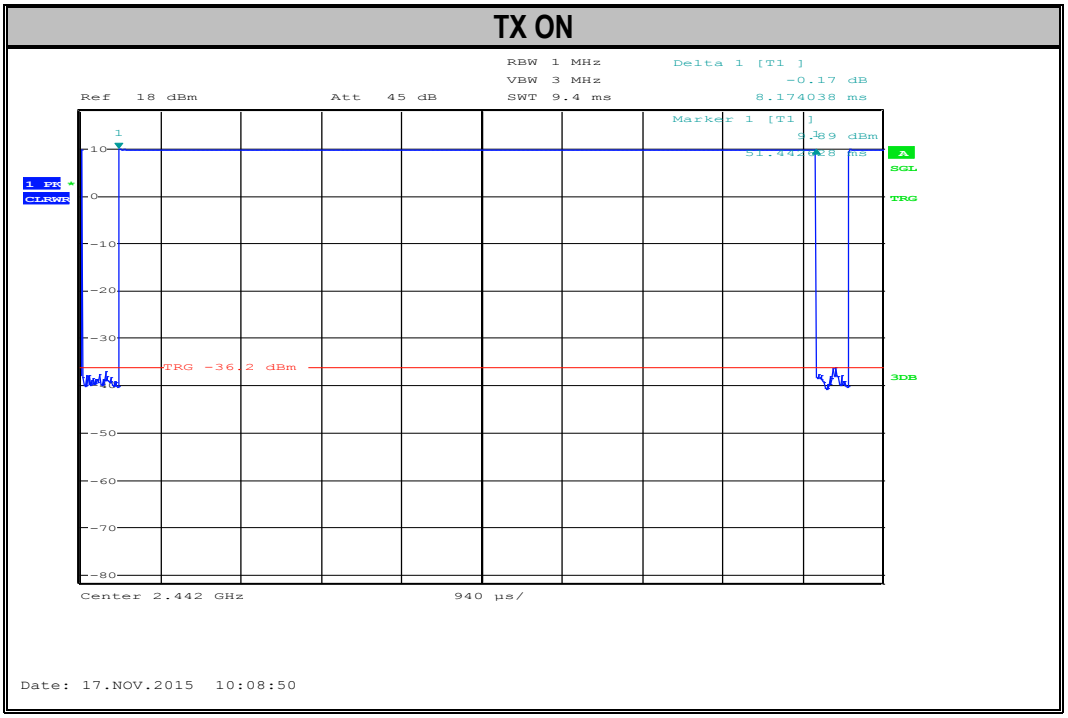

Note: Average output power already compensated for duty cycle correction factor.

## 3.7 Duty Cycle & Duty Cycle Correction Factor

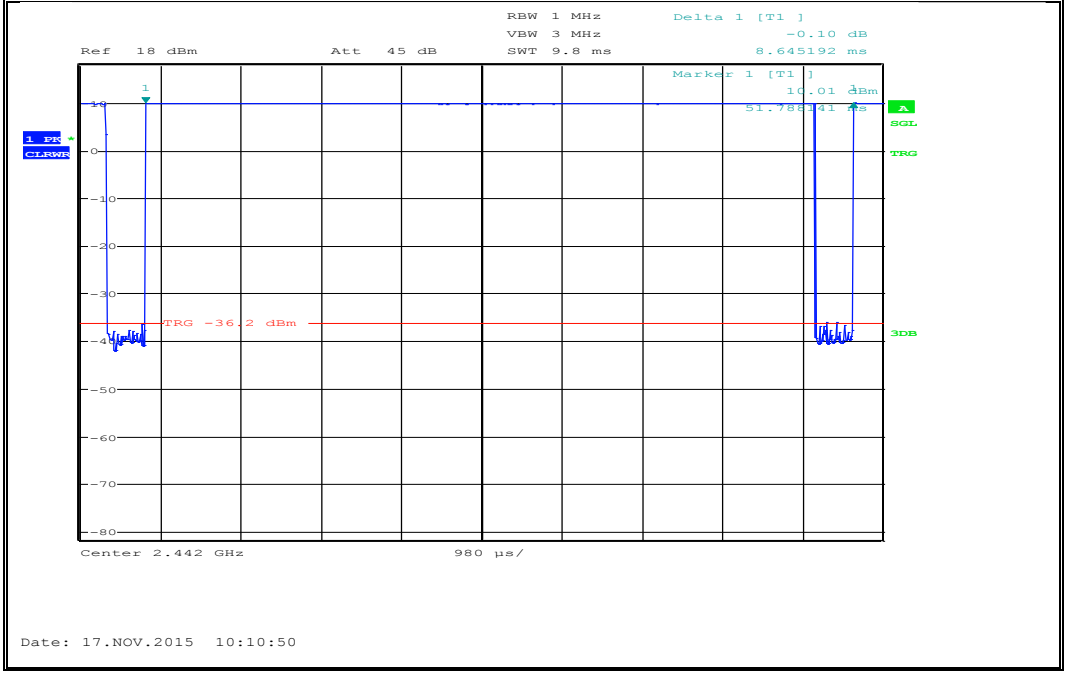
| Mode | Duty Cycle | Correction Factor |
|---|---|---|
| 802.11b 1Mbps_DSSS | 8.2ms / 8.6ms = 95% | 0.2 dB |
| 802.11b 11Mbps_DSSS | 914us / 1171us = 78% | 1.1 dB |
| 802.11n MCS0 | 1.27ms / 1.46ms = 87% | 0.6 dB |
| 802.11n MCS0 | 147.7us / 954.6us = 15.5% | 8.1 dB |

### 3.7.1 802.11b (1Mbps_DSSS)

**TX ON**

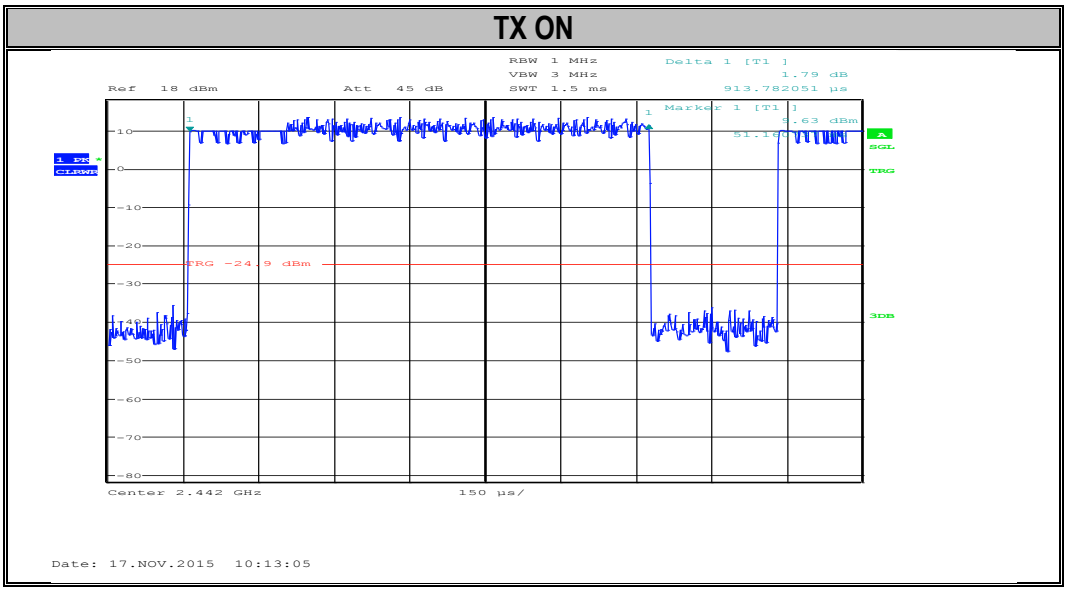


**TX ON / TX OFF**

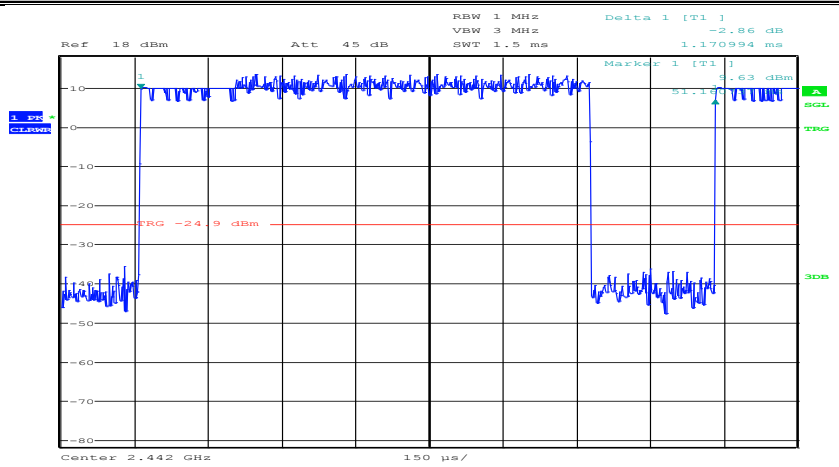



## 3.7.2 802.11b (11Mbps_CCK)

**TX ON**

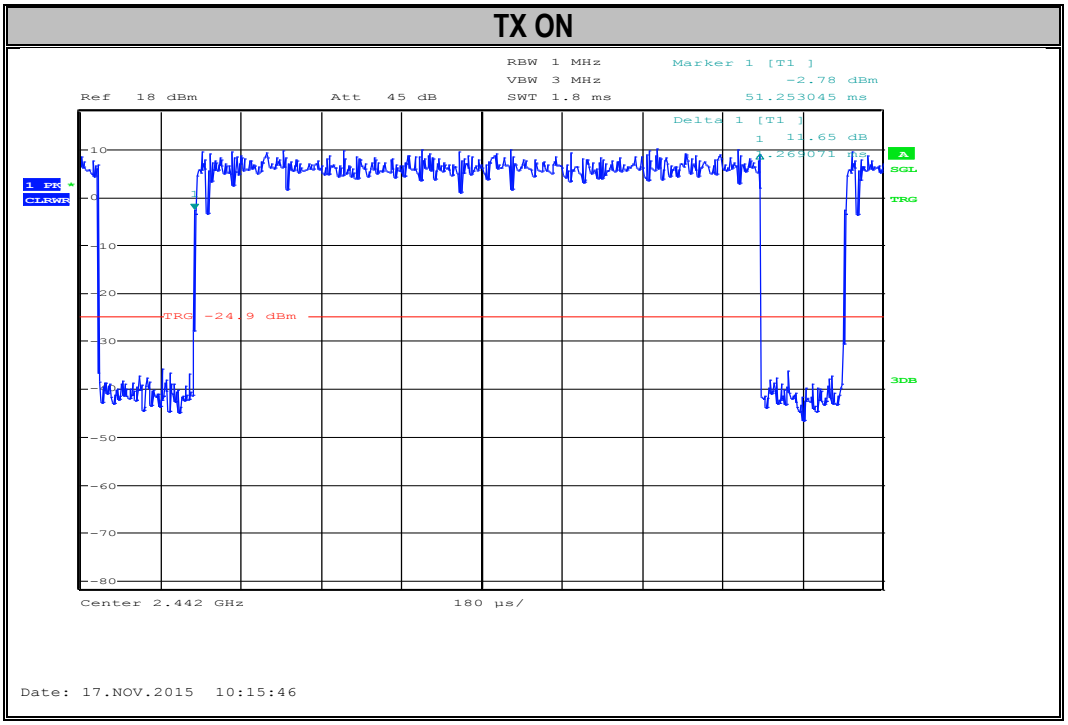


## TX ON / TX OFF

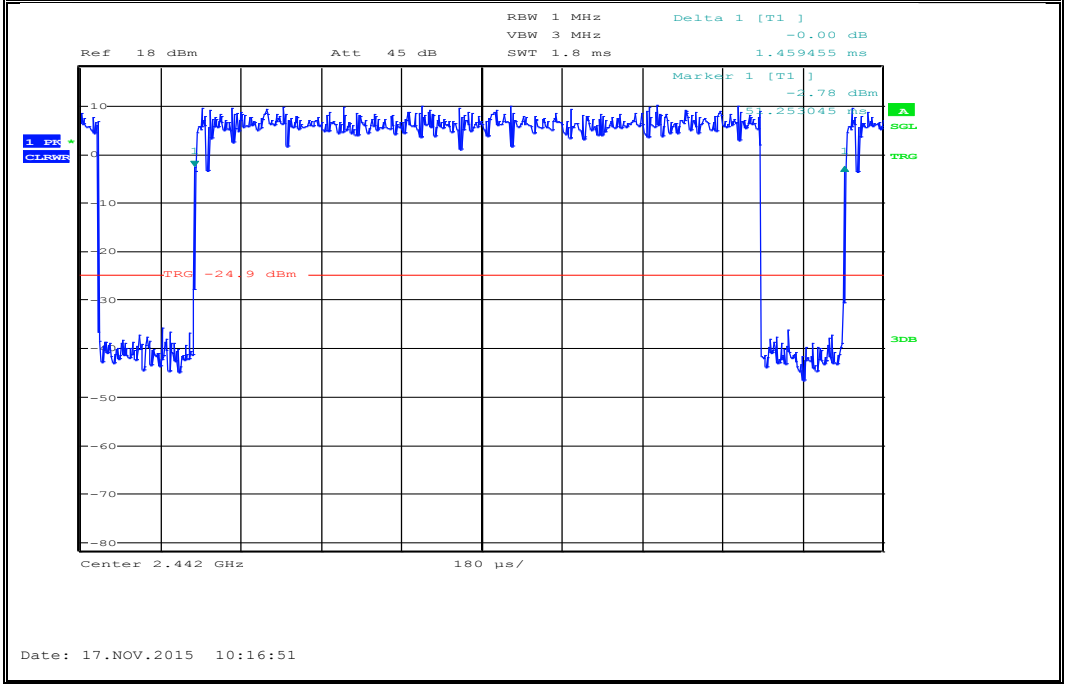

RBW 1 MHz
VBW 3 MHz
SWT 1.5 ms
Delta 1 [T1 ]
-2.86 dB
1.170994 ms
Marker 1 [T1 ]
Ref 18 dBm
Att 45 dB
TRG -24.9 dBm
SGL
TRG
3DB
Center 2.442 GHz
150 µs/
Date: 17.NOV.2015 10:13:48

### 3.7.3 802.11n (MCS0)

**TX ON**

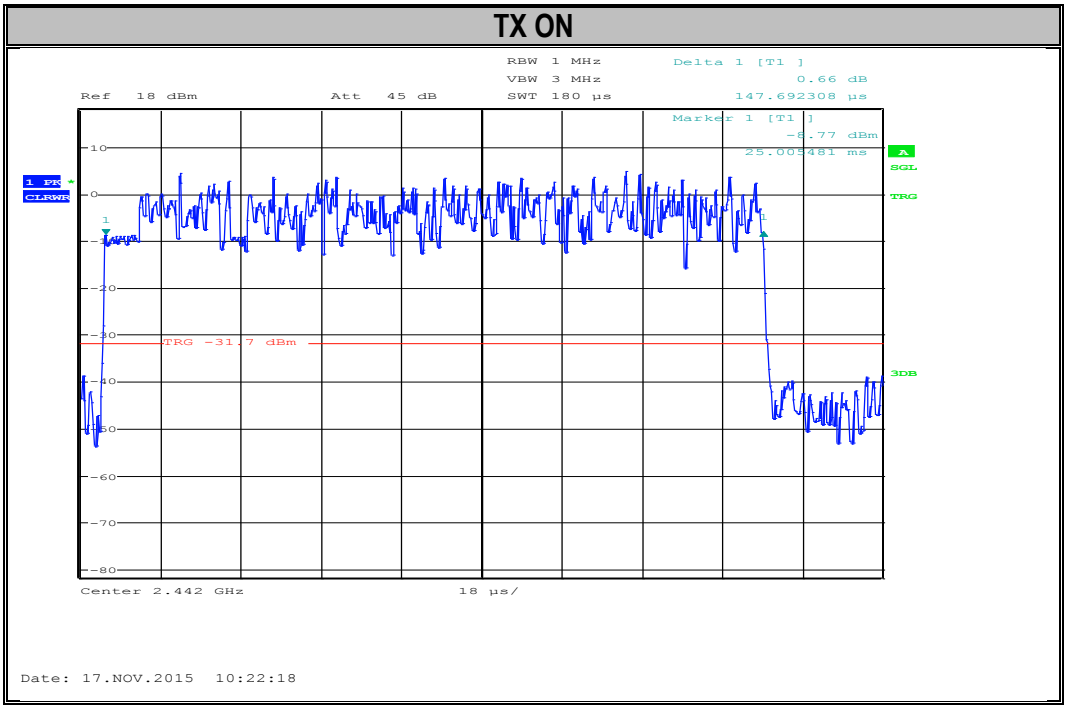



**TX ON / TX OFF**

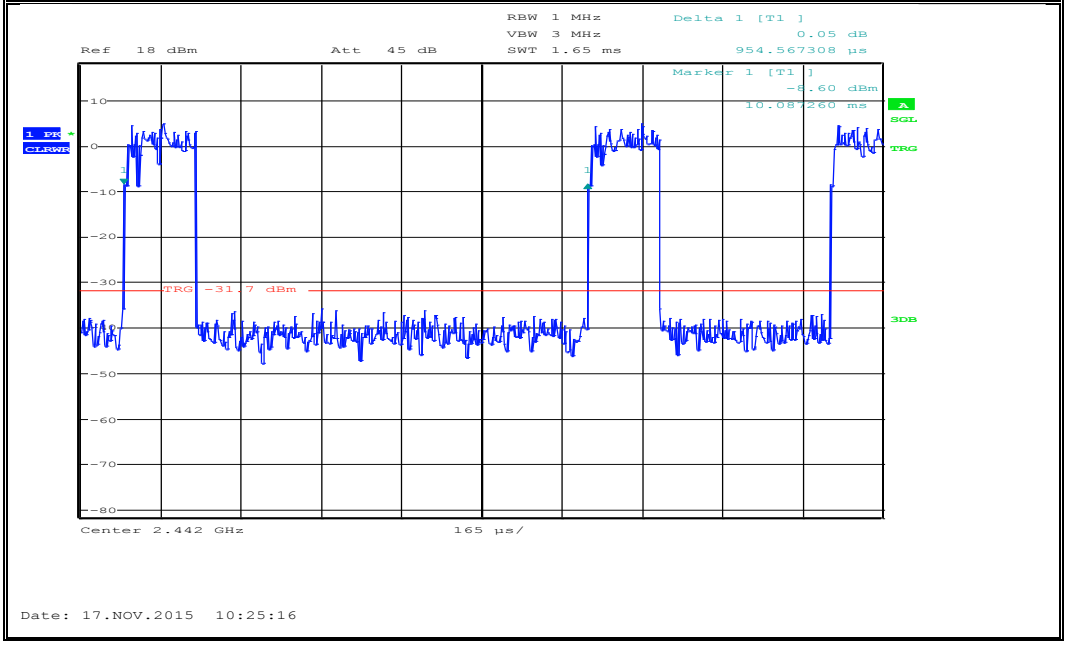


### 3.7.4 802.11n (MCS7)

**TX ON**




**TX ON / TX OFF**



## 4 Subject of Investigation

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

This test report is to support a request for new equipment authorization under the FCC ID: 2AGRZ-ILC3000. IC ID: 20942-ILC3000.

Testing procedures are based on
558074 D01 DTS Meas Guidance v03r03
ANSI C63.10 2013

## 5 Measurement Results Summary

| Test Specification | Test Case | Temperature and Voltage Conditions | Mode | Pass | Fail | NA | NP | Result |
|---|---|---|---|---|---|---|---|---|
| **§15.247(e) RSS247 5.2(2)** | Power Spectral Density | Nominal | Low , Mid, High channel | ■ | ☐ | ☐ | ☐ | Complies |
| **§15.247(a)(1) RSS247 5.2(1)** | Emission Bandwidth | Nominal | All supported modulations Mid channel only | ■ | ☐ | ☐ | ☐ | Complies |
| **§15.247(b)(1) RSS247 5.4(4)** | Maximum Conducted Output Power and EIRP | Nominal | Low , Mid, High channel | ■ | ☐ | ☐ | ☐ | Complies |
| **§15.247/15.209/ 15.205 RSS-Gen 8.9/ 8.10** | Band edge compliance- Restricted Band Edges | Nominal | Low , High channel | ■ | ☐ | ☐ | ☐ | Complies |
| **§15.247(d) RSS247 5.5** | Band edge compliance- Unrestricted Band Edges | Nominal | Low , High channel | ■ | ☐ | ☐ | ☐ | Complies |
| **§15.247(d) §15.209 RSS-Gen 6.13** | TX Spurious emissions- Radiated | Nominal | Low , Mid, High channel | ■ | ☐ | ☐ | ☐ | Complies |
| **§15.207(a) RSS Gen 8.8** | AC Conducted Emissions | Nominal | Mid channel | ■ | ☐ | ☐ | ☐ | Complies |

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

## 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.

| | 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 Environmental Conditions During Testing:

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

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

## 8 Dates of Testing:

November 17, 2015 – December 21, 2015

# 9 Measurement Procedures

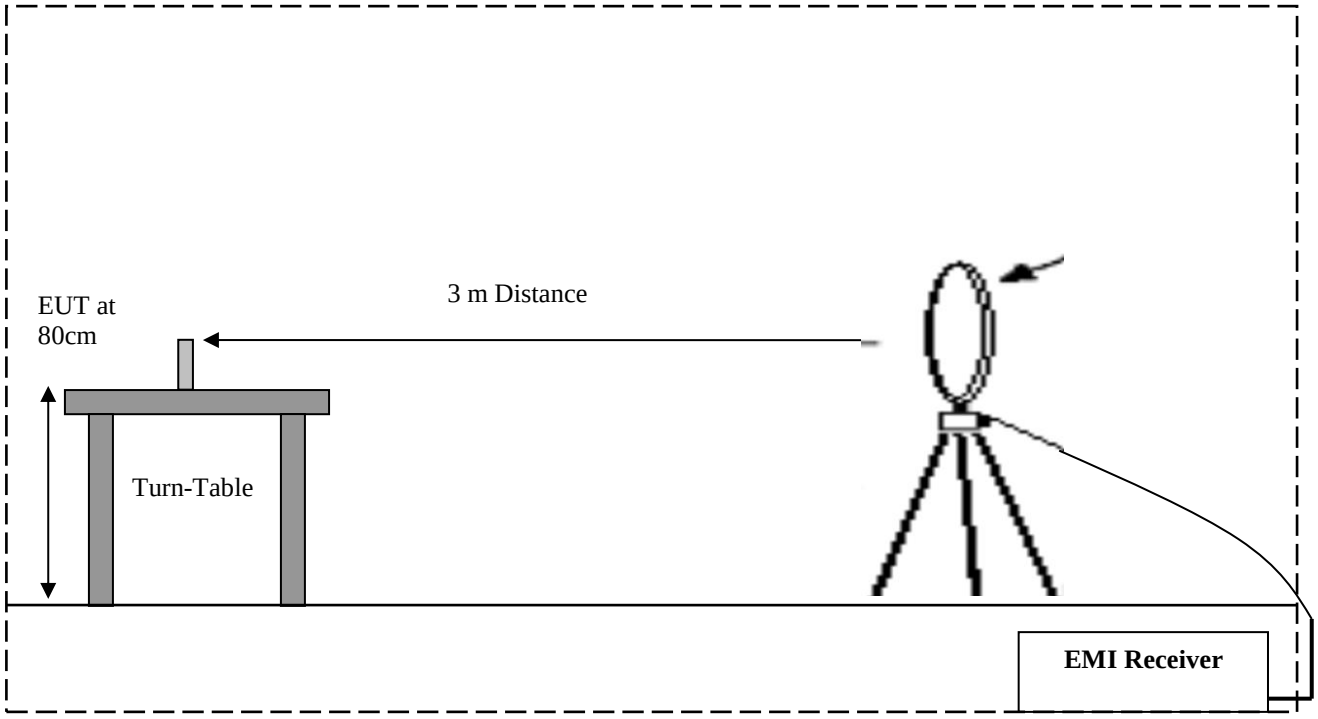
## 9.1 Radiated Measurement

The radiated measurement is performed according to:

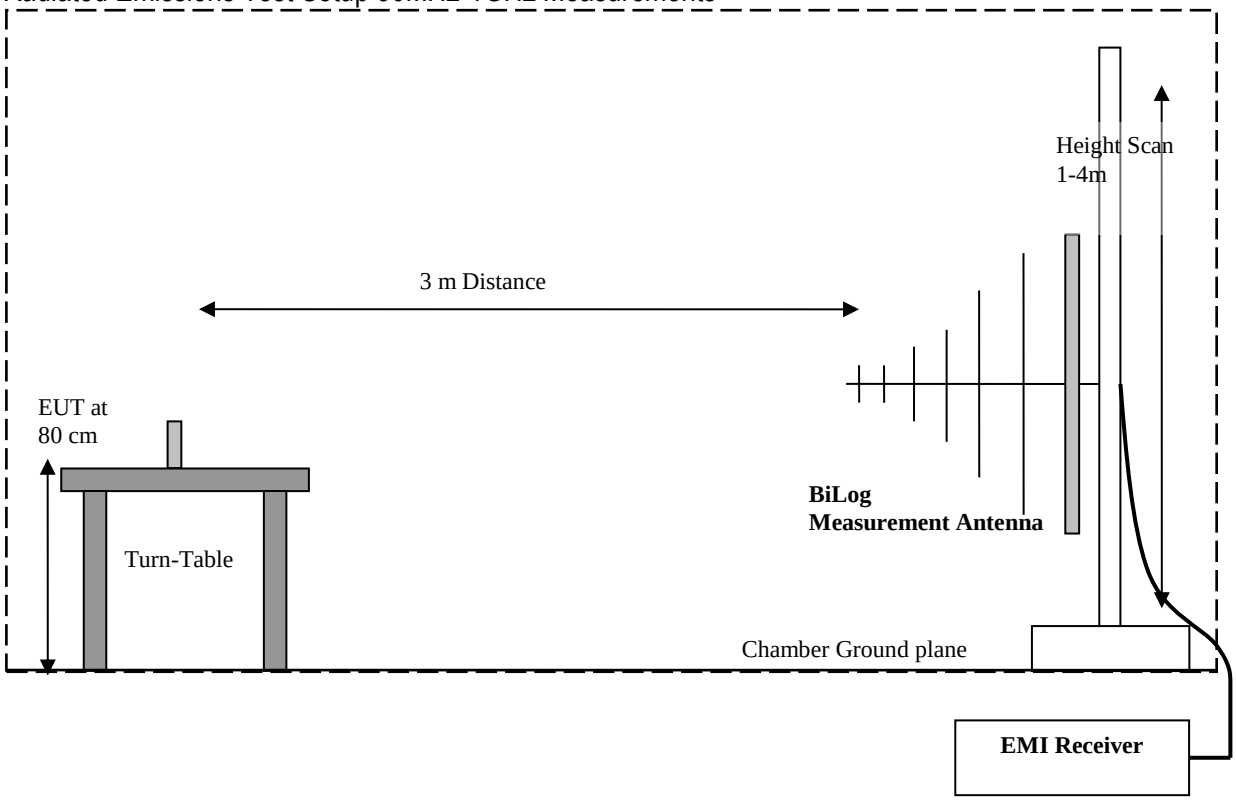
ANSI C63.10 (2013)

- The exploratory measurement is accomplished by running sweeps at 1 and 4m antenna heights over the required frequency range with R&S Test-SW EMC32 for both antenna polarizations. During each frequency scan the turntable rotates by no more than10deg.
- 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 again maximized through a fine search in frequency domain, maximized in the 360deg range of the turntable, and maximized over antenna height between 1m and 4m and for positioning of the EUT.
- The above procedure is repeated for transmission low mid and high channel.
- 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.

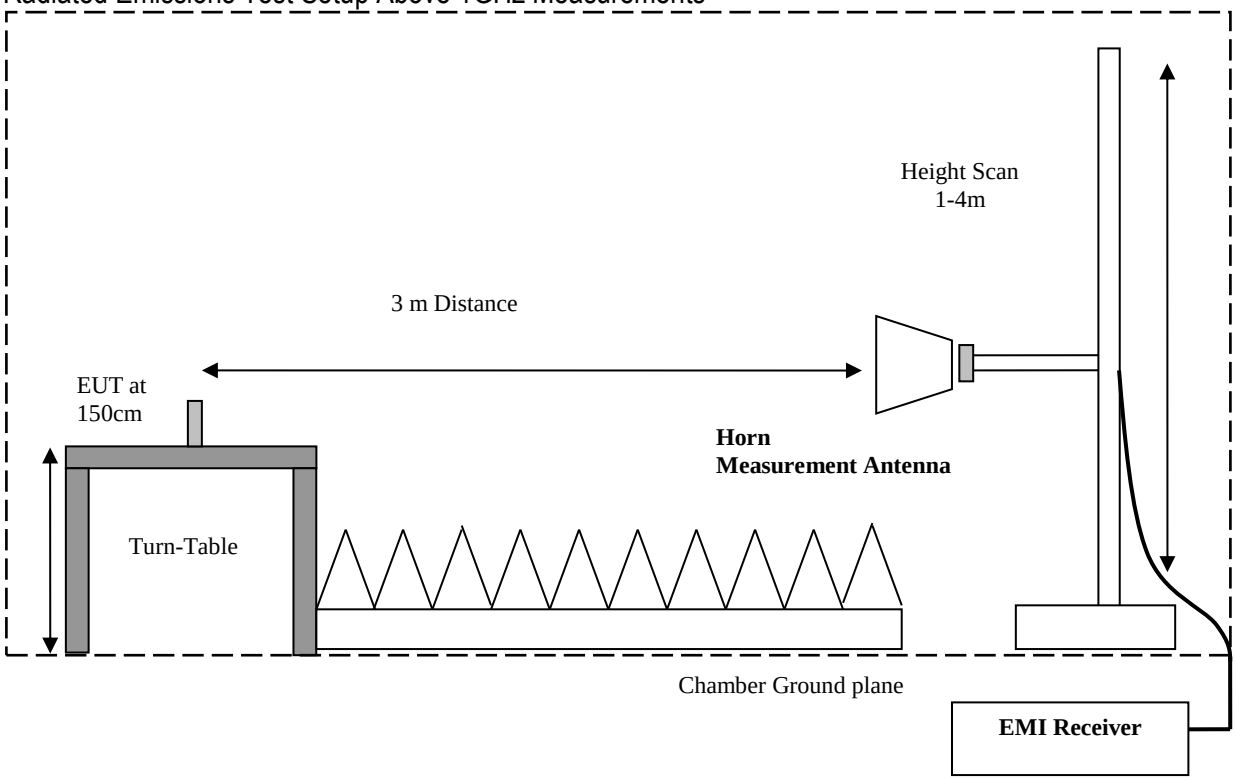
Radiated Emissions Test Setup Below 30MHz Measurements



Radiated Emissions Test Setup 30MHz-1GHz Measurements




Radiated Emissions Test Setup Above 1GHz Measurements



## 9.2 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 dBµV
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 (dBµV/m) = Measured Value on SA (dBµV)- Cable Loss (dB)+ Antenna Factor (dB/m)

Example:

| 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 |

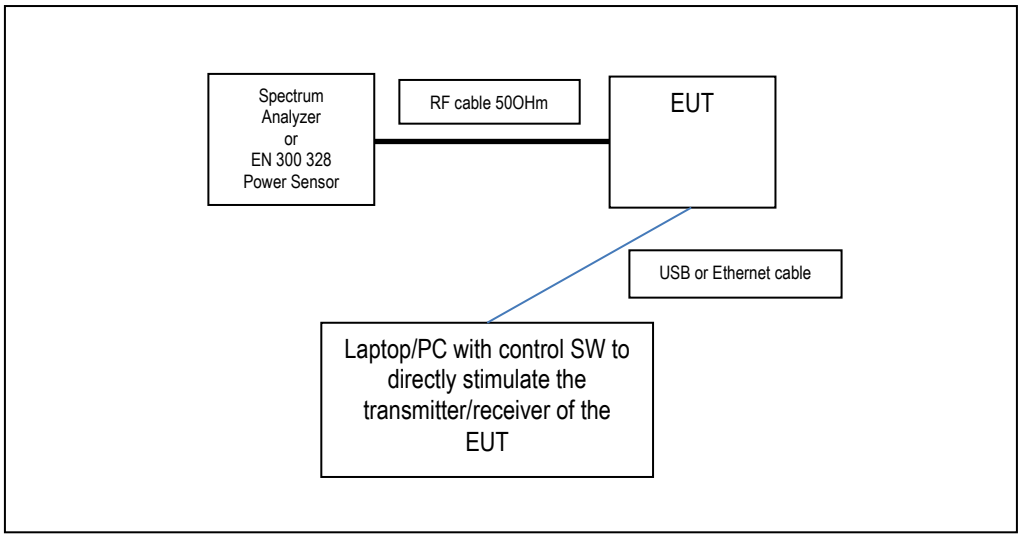
## 9.3 Power Line Conducted Measurement Procedure

AC Power Line conducted emissions measurements performed according to:

ANSI C63.4 (2014)

## 9.4 RF Conducted Measurement Procedure

### 9.4.1 Conducted Measurement Setup without companion device



## 10 Maximum Conducted Average Output Power

### 10.1 Measurement according to FCC KDB 558074 D01 V03R03, Method AVGSA-2 Section 9.2.2.4

**Spectrum Analyzer settings:**

a) Measure the duty cycle, x, of the transmitter output signal as described in 6.0.
b) Set span to at least 1.5 times the OBW.
c) Set RBW = 1-5% of the OBW, not to exceed 1 MHz.
d) Set VBW ≥ 3 x RBW.
e) Number of points in sweep ≥ 2 × span / RBW. (This gives bin-to-bin spacing ≤ RBW/2, so that narrowband signals are not lost between frequency bins.)
f) Sweep time = auto.
g) Detector = RMS (*i.e.*, power averaging), if available. Otherwise, use sample detector mode.
h) Do not use sweep triggering. Allow the sweep to "free run".
i) 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.
j) 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.
k) Add 10 log (1/x), where x is the duty cycle, to the measured power in order to compute the average power during the actual transmission times (because the measurement represents an average over both the on and off times of the transmission). For example, add 10 log (1/0.25) = 6 dB if the duty cycle is 25 %.

### 10.2 Limits:

**Maximum Peak Output Power:**
FCC §15.247 (b)(1): 1W
IC RSS-247: 1W
**EIRP:**
IC RSS-247: 4W

### 10.3 Test conditions and setup:

| Ambient Temperature | EUT Set-Up # | EUT operating mode | Power Input |
|---|---|---|---|
| 23° C | 2 | Tx | Battery, 3.8V DC |

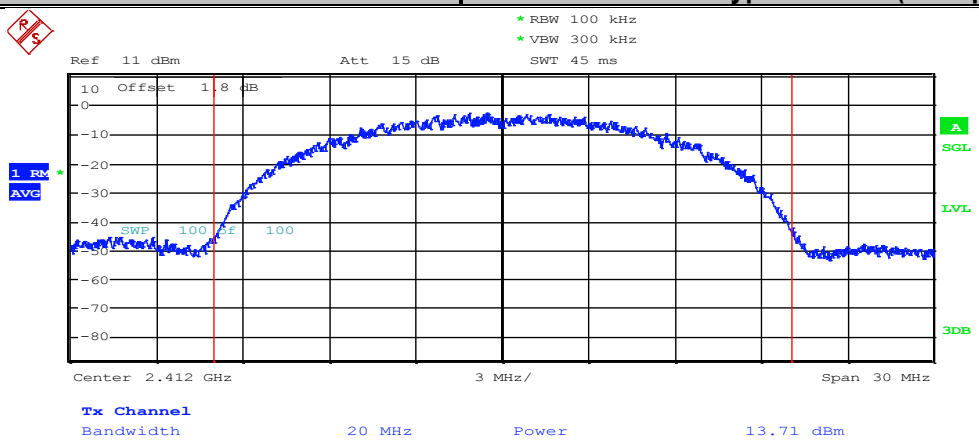
10.4 Measurement result:

| Plot # | Frequency (MHz) | Maximum Average Conducted Output Power (dBm) | Duty Cycle Correction (dB) | Antenna Gain (dBi) | EIRP (dBm) | Limit (dBm) | Result |
|---|---|---|---|---|---|---|---|
| 1 | 2412 | 13.71 | +1.1 | +2.5 | 17.3 | 30(Pk) / 36(EIRP) | Pass |
| 2 | 2442 | 15.72 | +1.1 | +2.5 | 19.3 | 30(Pk) / 36(EIRP) | Pass |
| 3 | 2462 | 14.1 | +1.1 | +2.5 | 17.7 | 30(Pk) / 36(EIRP) | Pass |

## 10.5 Measurement Plots:

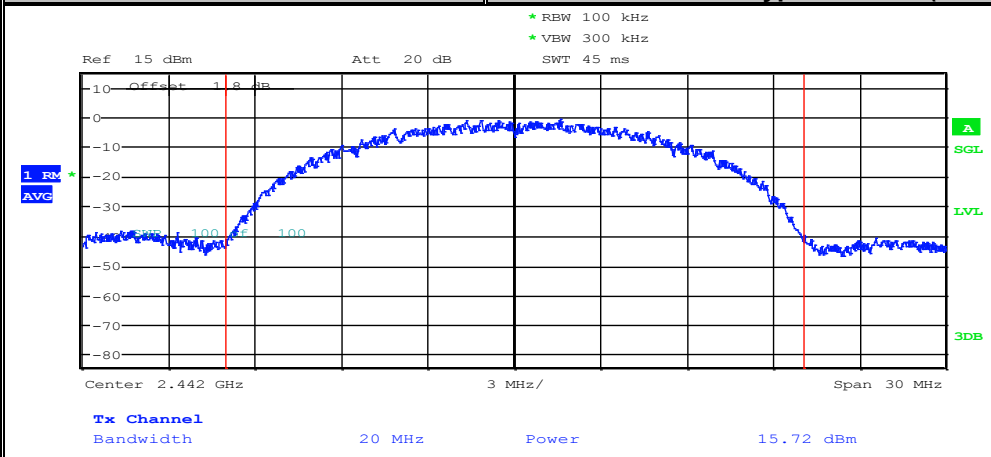
**Plot #1**

**Ch. 1 / 2412 MHz** | **Modulation/Packet Type: 802.11b (11Mbps_CCK)**




Note: Average output power already compensated for duty cycle correction factor.

| Plot #2 | |
|---|---|
| Ch. 7 / 2442 MHz | Modulation/Packet Type: 802.11b (11Mbps_CCK) |

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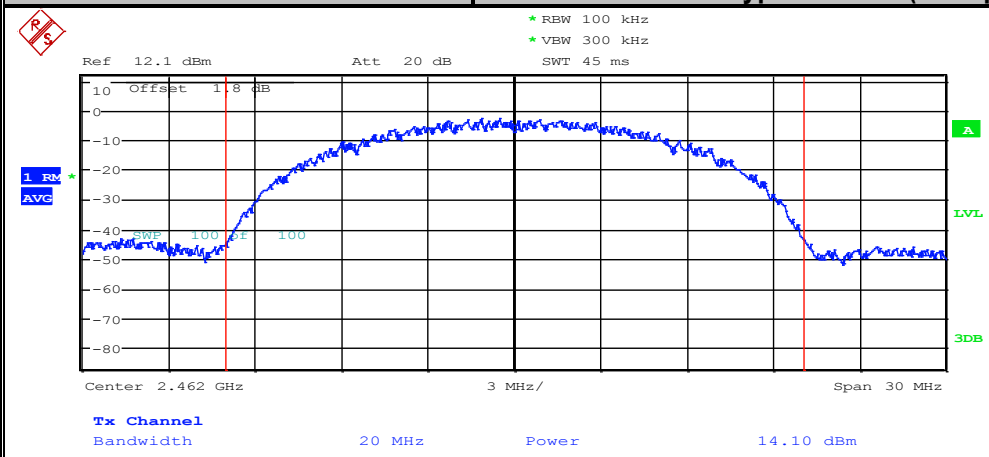
Note: Average output power already compensated for duty cycle correction factor.

**Plot #3**

**Ch. 11 / 2462 MHz** | **Modulation/Packet Type: 802.11b (11Mbps_CCK)**




Note: Average output power already compensated for duty cycle correction factor.

# 11 Power Spectral Density

## 11.1 Measurement according to FCC KDB 558074 D01 V03R03

**Spectrum Analyzer settings for Peak PSD method:**

Set analyzer center frequency to DTS channel center frequency.
Set the span to 1.5 times the DTS bandwidth
Set RBW to: 3 kHz ≤ RBW ≤ 100 kHz.
Set the 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 amplitude level within the RBW.
If measured value exceeds limit, reduce RBW (no less than 3 kHz) and repeat.

## 11.2 Limits: §15.247 & RSS-247

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.

## 11.3 Test conditions and setup:

| Ambient Temperature | EUT Set-Up # | EUT Operating Mode | Power Input |
|---|---|---|---|
| 23° C | 2 | Tx | Battery, 3.8V DC |

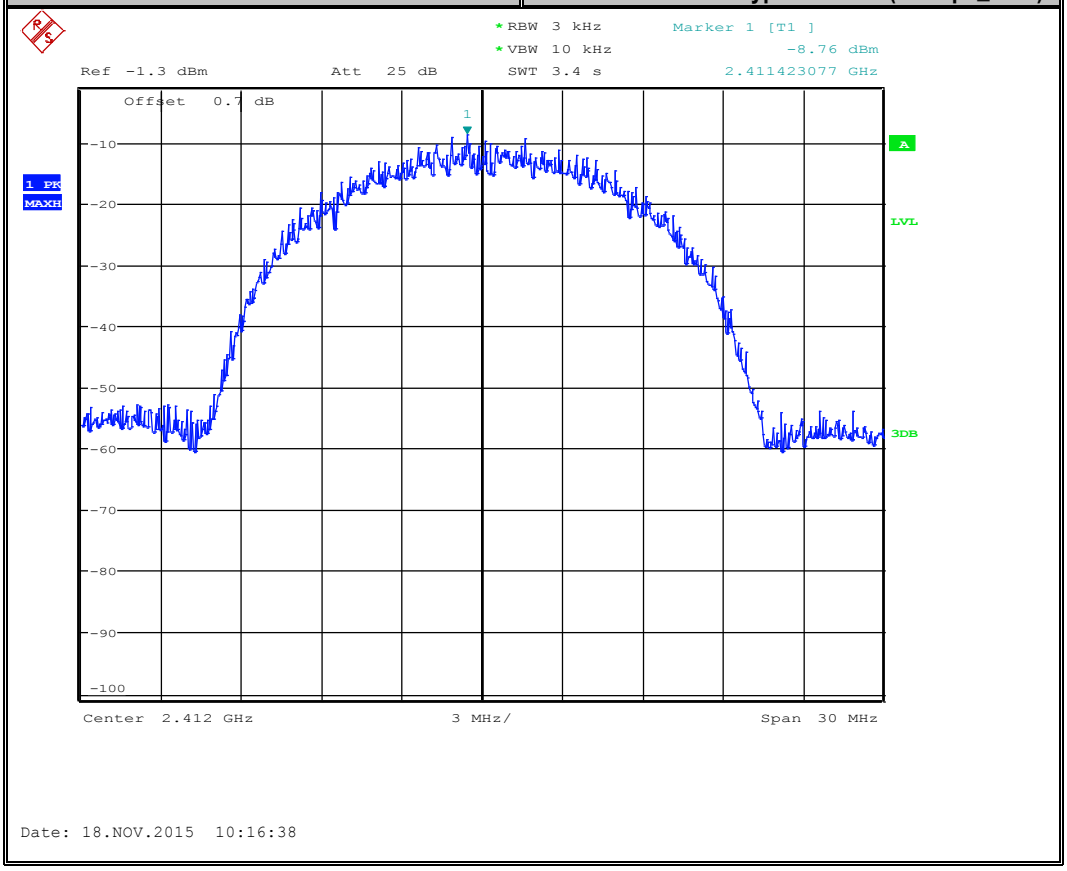
## 11.4 Measurement result:

| Plot # | Frequency (MHz) | Maximum Power Spectral Density (dBm/3kHz) | Limit ( dBm / 3 KHz ) | Result |
|---|---|---|---|---|
| 1 | 2412 | -8.76 | 8 | Pass |
| 2 | 2442 | -7.2 | 8 | Pass |
| 3 | 2462 | -8.68 | 8 | Pass |

## 11.5 Measurement Plots:

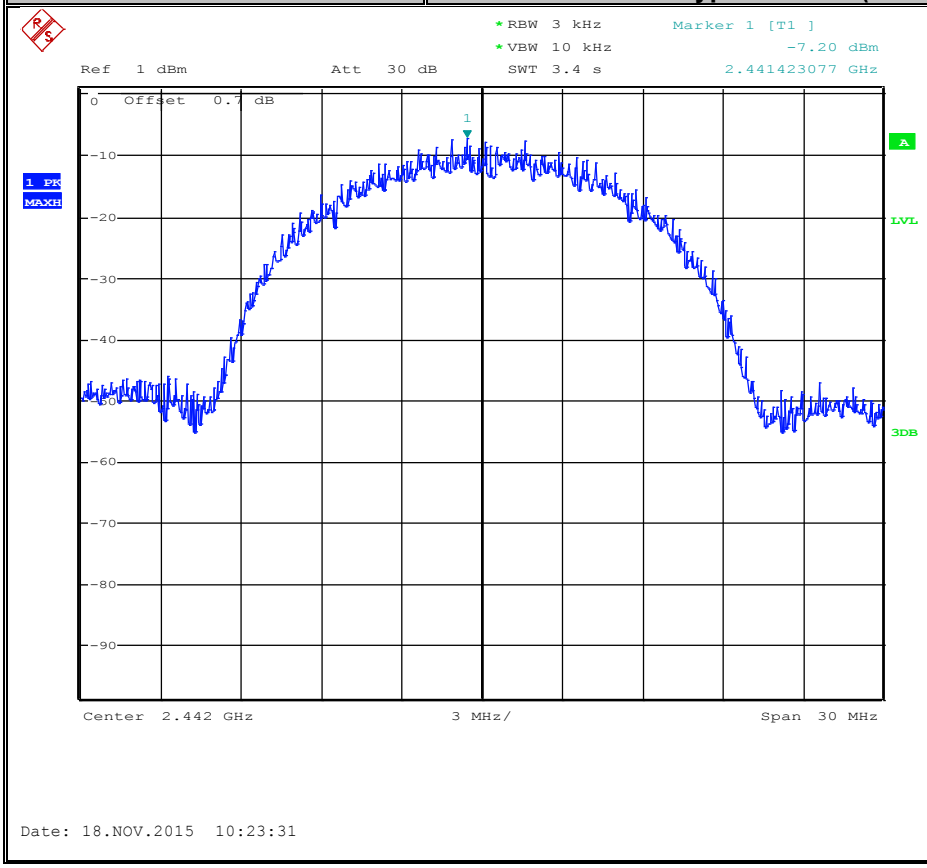
**Plot #1**

**Ch. 1 / 2412 MHz** | **Modulation/Packet Type: 802.11b (11Mbps_CCK)**



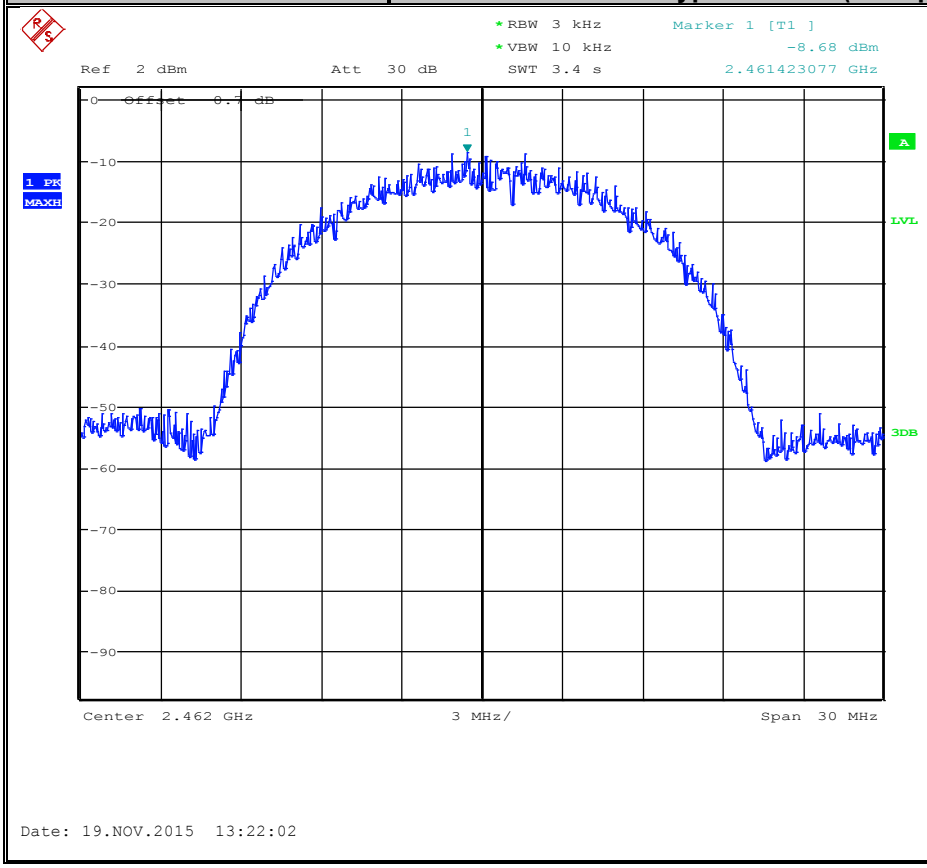
## Plot: 2

### Ch. 7 / 2442 MHz | Modulation/Packet Type: 802.11b (11Mbps_CCK)



## Plot #3

**Ch.11 / 2462 MHz** | **Modulation/Packet Type: 802.11b (11Mbps_CCK)**



## 12 Band Edge Compliance

### 12.1 Measurement according to FCC KDB 558074 D01 v03r03

**Spectrum Analyzer settings for band edge:**
Set the center frequency and span to encompass frequency range to be measured
RBW ≥ 1oo kHz
VBW ≥ RBW
Sweep Time: Auto
Detector = peak
Trace = max hold
Allow trace to fully stabilize
Use the peak marker function to determine the maximum amplitude level
Allow the trace to stabilize. 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.

### 12.2 Limits restricted band §15.205 and RSS-Gen 8.10

*PEAK LIMIT= 74dBµV/m @3m =-21.23dBm
*AVG. LIMIT= 54dBµV/m @3m =-41.23dBm
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:

| 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 | | | |

12.3 Limits non restricted band §15.247 and RSS-247 5.5

**FCC15.247 (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)).

**RSS-247 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 30dB instead of 20dB.

12.4 Test conditions and setup:

| Ambient Temperature | EUT Set-Up # | EUT operating mode | Power Input |
|---|---|---|---|
| 23° C | 2 | Tx | Battery, 3.8V DC |

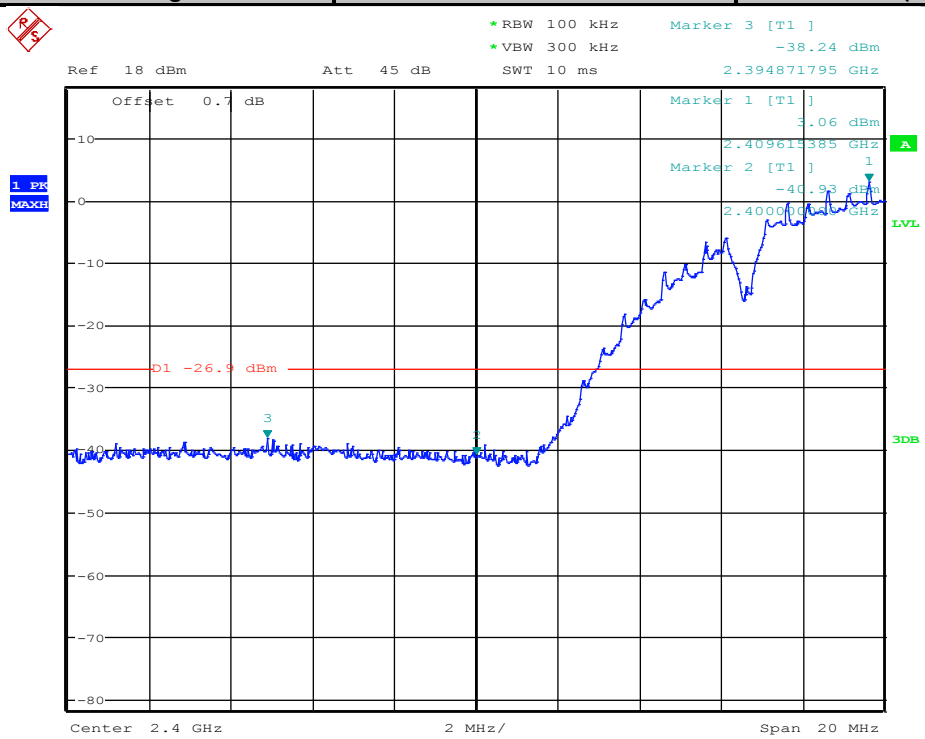
12.5 Measurement result:

| Plot # | EUT operating mode | Band Edge | Band Edge Delta (dBc) | Limit (dBc) in case average output power was measured | Result |
|---|---|---|---|---|---|
| 1 | 802.11b (11Mbps) | Lower, non-restricted | -38.24 | -30 | Pass |
| 2 | 802.11n (MCS7) | Lower, non-restricted | -30.37 | -30 | Pass |

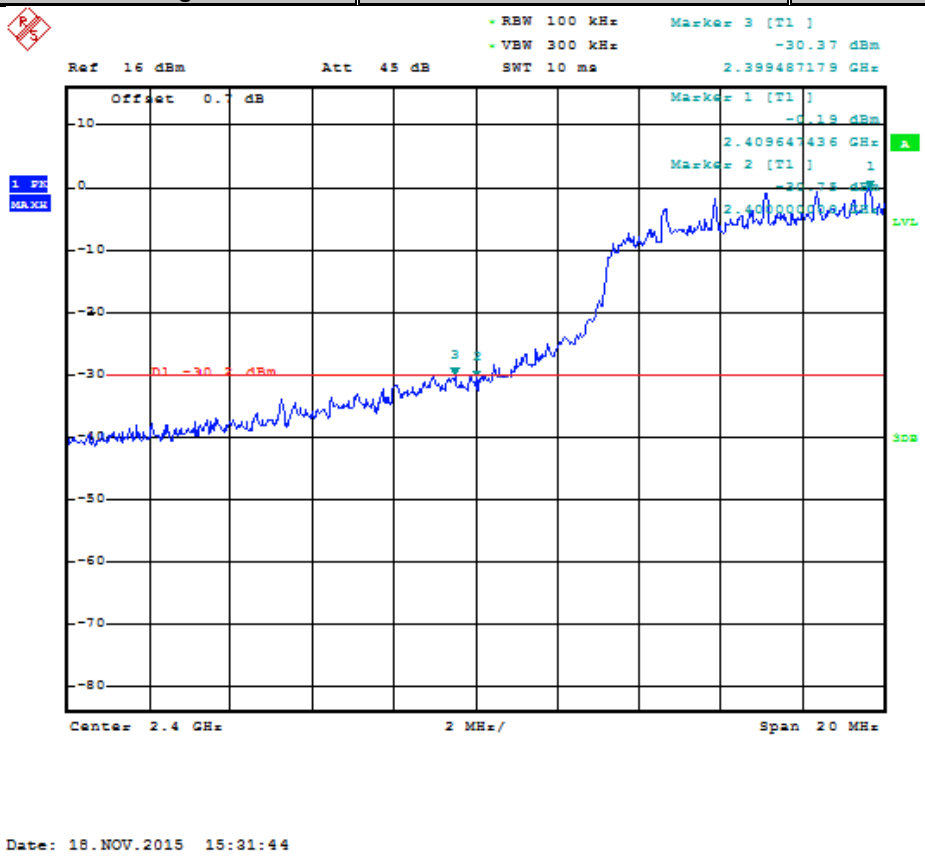
| Plot # | EUT operating mode | Band Edge | Measured value | Corrected by Duty Cycle Correction Factor (dBm) | Corrected by Antenna Gain (dBi) | Limit (dBm) | Result |
|---|---|---|---|---|---|---|---|
| 3 | 802.11b (11Mbps) | Upper restricted peak | -35.22 | 1.1 | 2.5 | -21.23 peak | Pass |
| 4 | 802.11b (11Mbps) | Upper restricted average | -52.96 | 1.1 | 2.5 | -41.23 average | Pass |
| 5 | 802.11n (MCS7) | Upper restricted peak | -36.09 | 8.1 | 2.5 | -21.23 peak | Pass |
| 6 | 802.11n MCS7) | Upper restricted average | -72.08 | 8.1 | 2.5 | -41.23 average | Pass |

## 12.6 Measurement Plots:

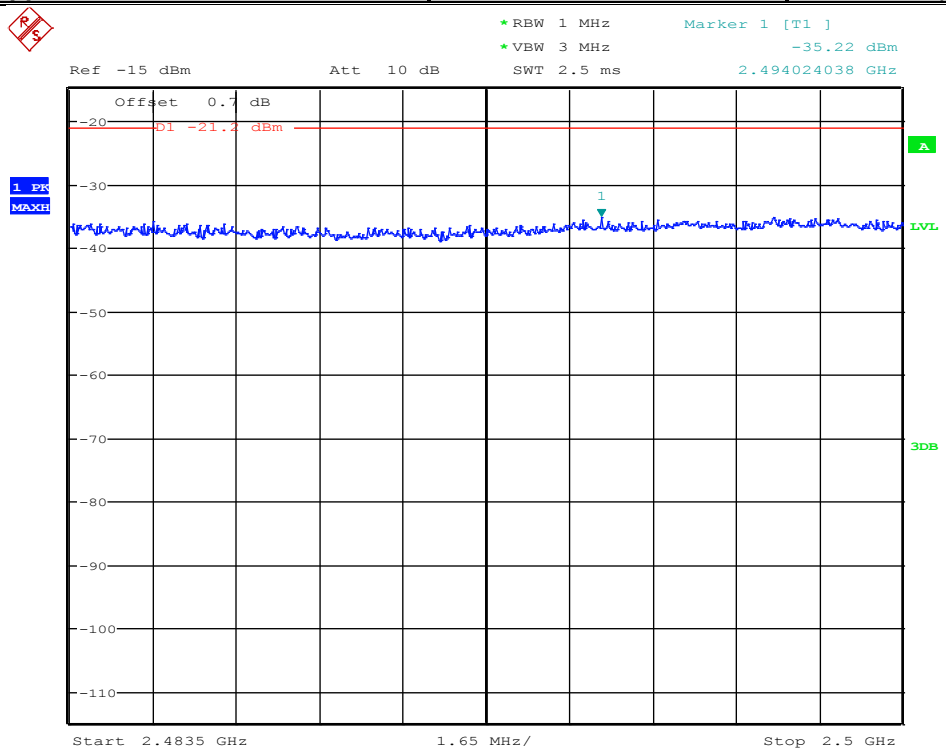
| Plot #1 | | |
|---|---|---|
| **Lower Band Edge, Peak** | **Ch. 1 / 2412MHz** | **802.11b (11Mbps_CCC)** |



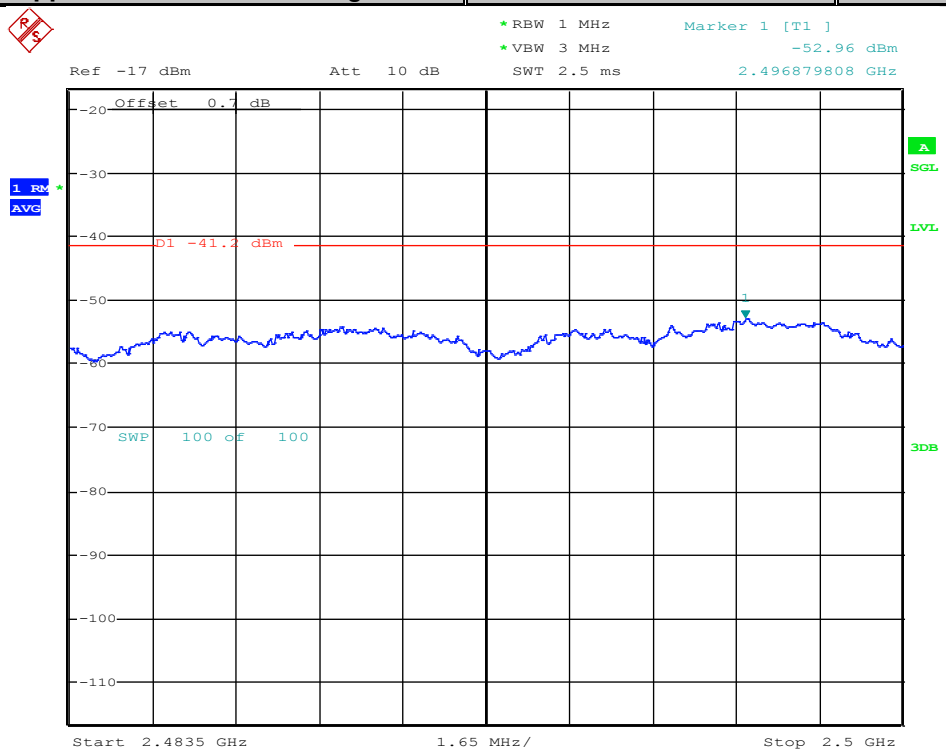
| Plot #2 | | |
|---|---|---|
| **Lower Band Edge, Peak** | **Ch. 1 / 2412MHz** | **802.11n (MCS0)** |



| Plot #3 | | |
|---|---|---|
| Upper Restricted Band, Peak | Ch. 11 / 2462MHz | 802.11b (11Mbps_CCC) |



| Plot #4 | | |
|---|---|---|
| **Upper Restricted Band, Avg** | **Ch. 11 / 2462MHz** | **802.11b (MCS7)** |

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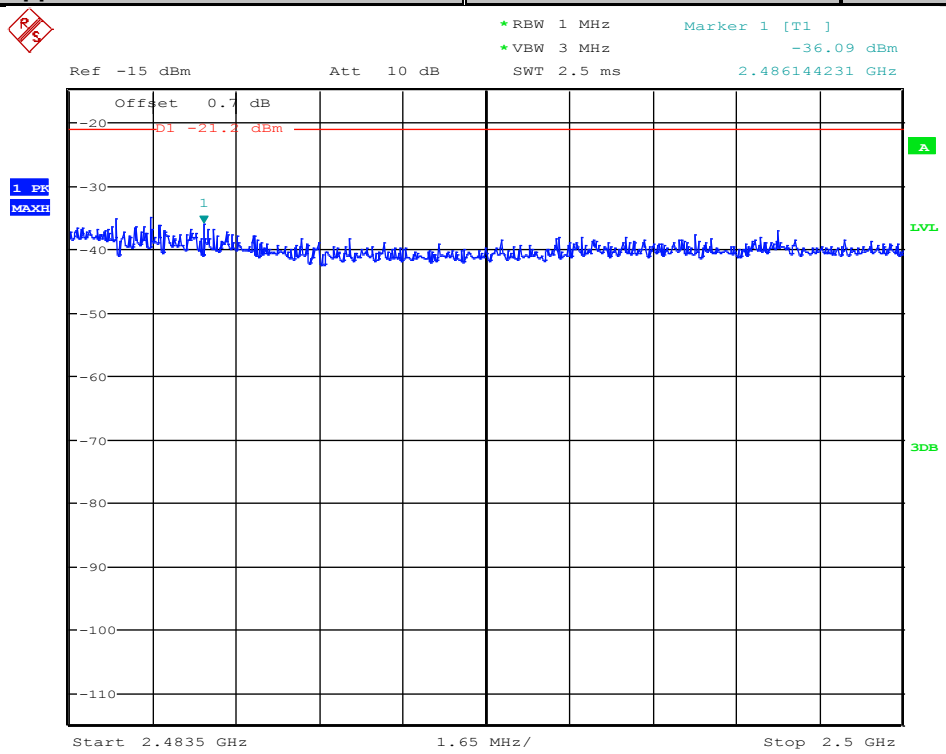
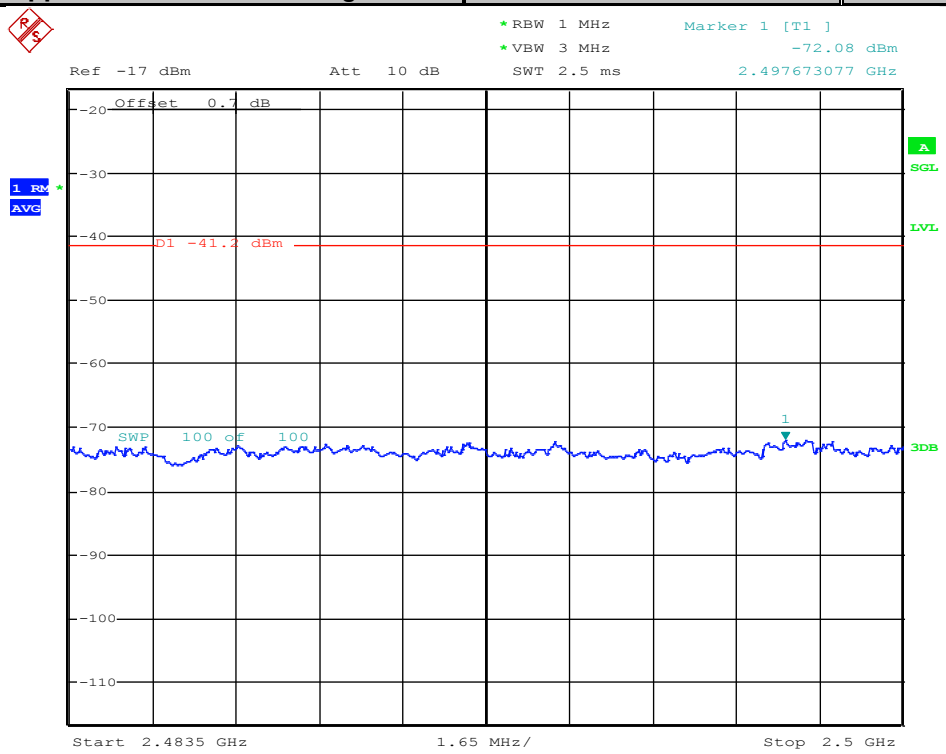
| Plot #5 | | |
|---|---|---|
| **Upper Restricted Band, Peak** | **Ch. 11 / 2462MHz** | **802.11n (MCS7)** |



## Plot #6

| Upper Restricted Band, Avg | Ch. 11 / 2462MHz | 802.11n (MCS7) |
|---|---|---|

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## 13 Emission Bandwidth 6dB and 99% Occupied Bandwidth

### 13.1 Measurement according to FCC KDB 558074 D01 v03r03

**Spectrum Analyzer settings:**
Set RBW = 100 kHz
Set the video bandwidth (VBW) ≥ 3 □ 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.

### 13.2 Limits: §15.247

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.

### 13.3 Test conditions and setup:

| Ambient Temperature | EUT Set-Up # | EUT operating mode | Power Input |
|---|---|---|---|
| 23° C | 2 | Tx | Battery, 3.8V DC |

### 13.4 Measurement result:

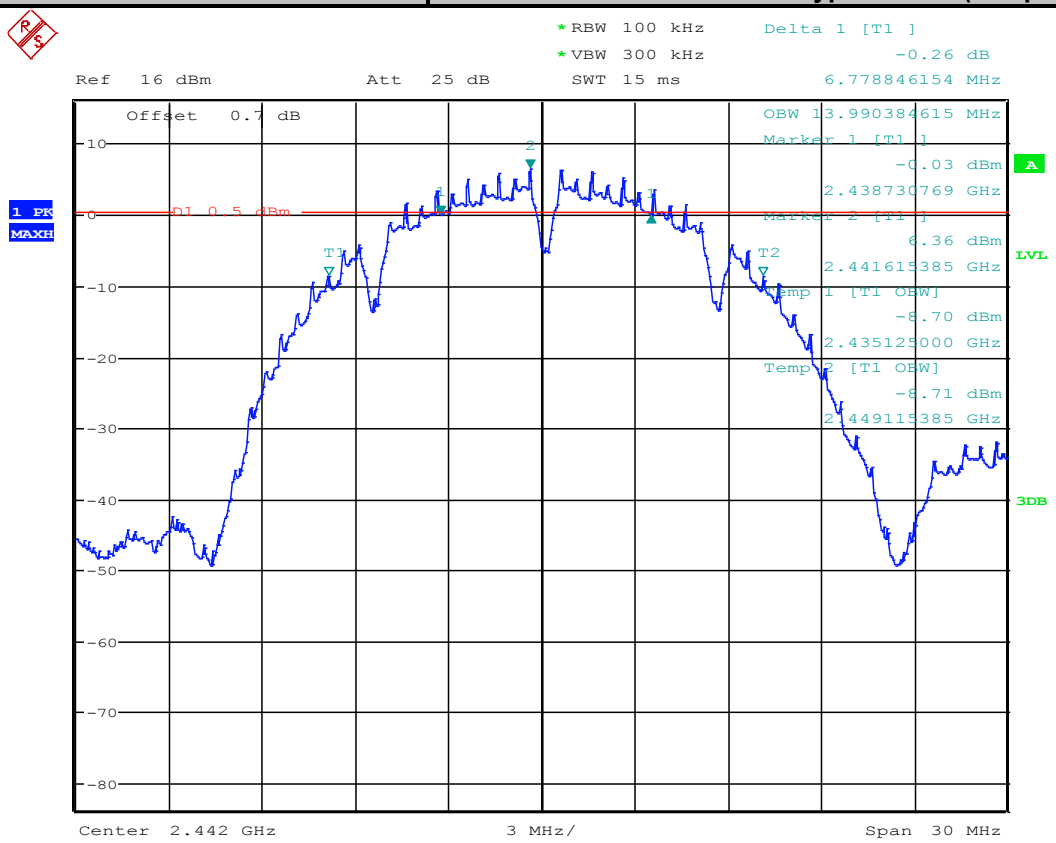
| Plot # | Channel | Frequency (MHz) | Modulation / Bandwidth | 6dB Emissions Bandwidth (MHz) | Limit (MHz) | Result |
|---|---|---|---|---|---|---|
| 1 | Ch. 7 | 2442 | 802.11 (1Mbps_DSSS) | 6.78 | > 0.5 | Pass |
| 2 | Ch. 7 | 2442 | 802.11b (11Mbps_CCK) | 7.88 | > 0.5 | Pass |
| 3 | Ch. 7 | 2442 | 802.11n (MCS0) | 8.46 | > 0.5 | Pass |
| 4 | Ch. 7 | 2442 | 802.11n (MCS7) | 17.74 | > 0.5 | Pass |

| Plot # | Channel | Frequency (MHz) | Modulation / Bandwidth | 99% Occupied Bandwidth (MHz) |
|---|---|---|---|---|
| 1 | Ch. 7 | 2442 | 802.11 (1Mbps_DSSS) | 13.99 |
| 2 | Ch. 7 | 2442 | 802.11b (11Mbps_CCK) | 14.23 |
| 3 | Ch. 7 | 2442 | 802.11n (MCS0) | 17.59 |
| 4 | Ch. 7 | 2442 | 802.11n (MCS7) | 17.69 |

## 13.5 Measurement Plots:

**Plot #1**

**Ch. 7 / 2442 MHz** | **Modulation/Packet Type: 802.11 (1Mbps_DSSS)**

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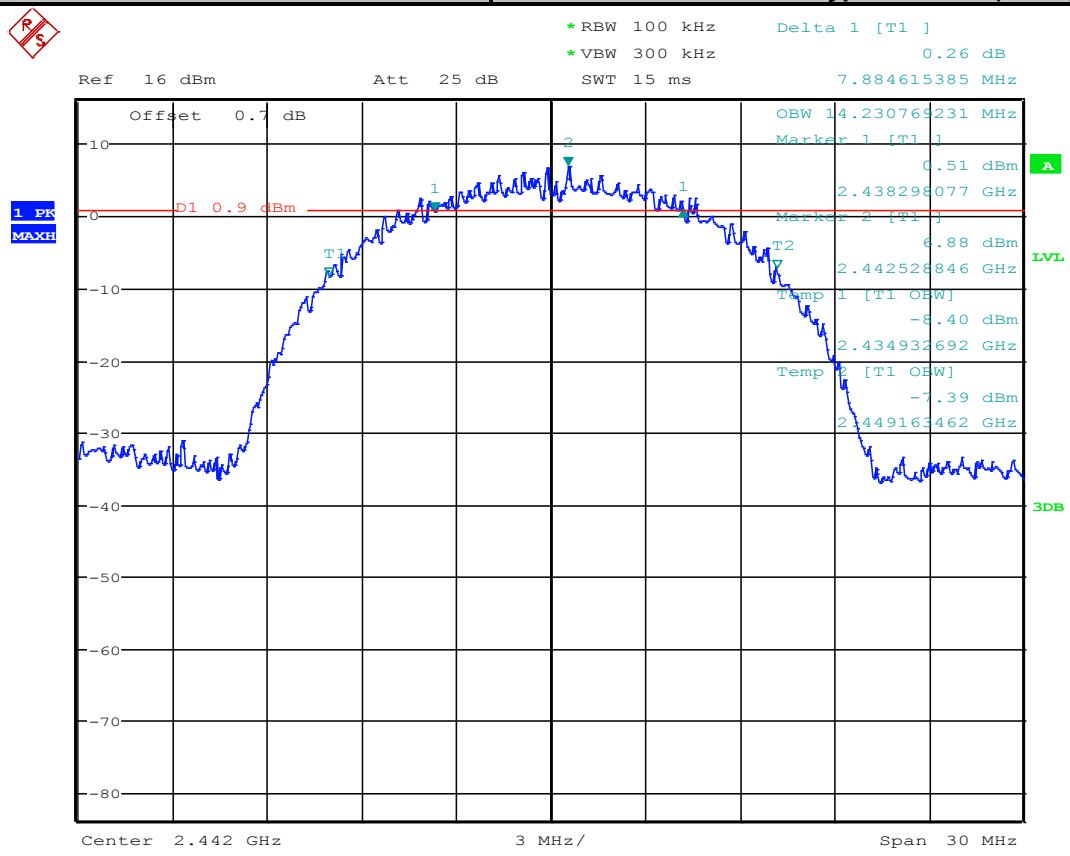
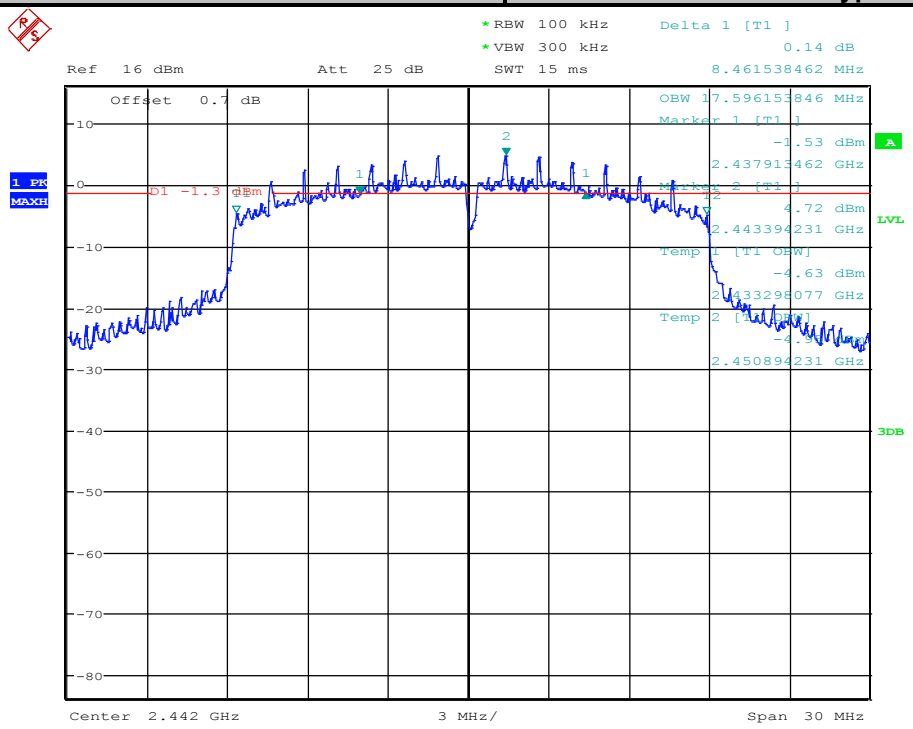
## Plot #2

### Ch. 7 / 2442 MHz | Modulation/Packet Type: 802.11b (11Mbps_CCK)



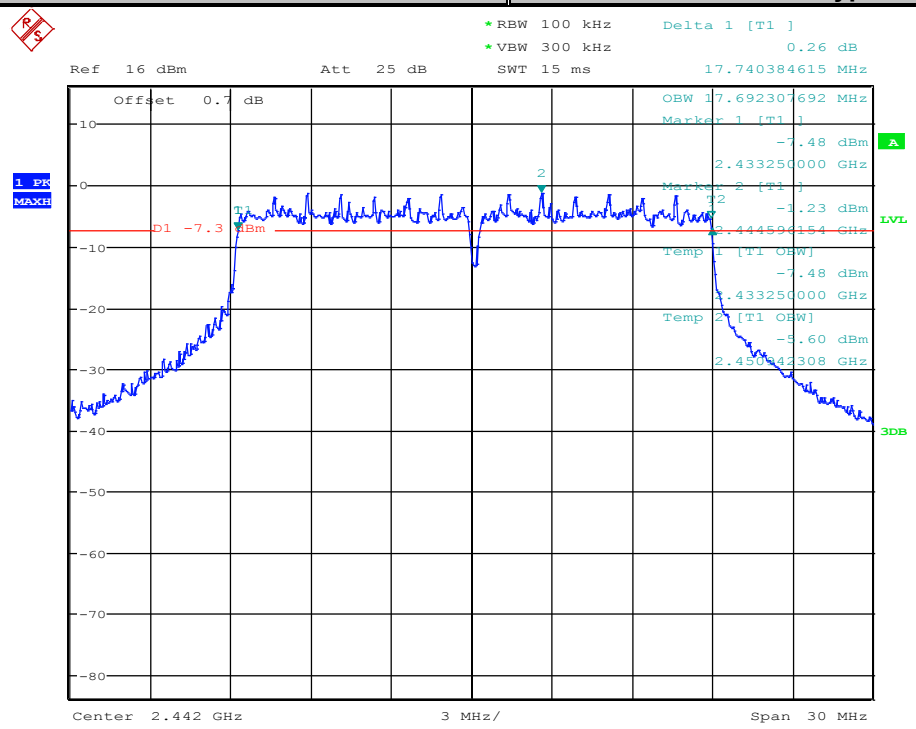
## Plot #3

**Ch. 7 / 2442 MHz** | **Modulation/Packet Type: 802.11n (MCS0)**



## Plot #4

### Ch. 7 / 2442 MHz | Modulation/Packet Type: 802.11n (MCS7)



## 14 Radiated Transmitter Spurious Emissions and Restricted Bands

### 14.1 Measurement according to ANSI C63.10 (2013)

**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= 1MHz

Plots reported here represent the worst case emissions for horizontal and vertical antenna polarizations and for three orientations of the EUT. Unless mentioned otherwise, the emissions outside the limit lines in the plots are from the transmit signal.

### 14.2 Limits: §15.247/15.205/15.209 & RSS-Gen 8.9/ 8.10 (restricted bands)

(a) Except as shown in paragraph (d) of this section, only spurious emissions are permitted in any of the frequency bands listed below:

| MHz | MHz | MHz | GHz |
|---|---|---|---|
| 0.090 - 0.110 | 16.42 - 16.423 | 399.9 - 410 | 4.5 - 5.15 |
| [1]0.495 - 0.505 | 16.69475 - 16.69525 | 608 - 614 | 5.35 - 5.46 |
| 2.1735 - 2.1905 | 16.80425 - 16.80475 | 960 - 1240 | 7.25 - 7.75 |
| 4.125 - 4.128 | 25.5 - 25.67 | 1300 - 1427 | 8.025 - 8.5 |
| 4.17725 - 4.17775 | 37.5 - 38.25 | 1435 - 1626.5 | 9.0 - 9.2 |
| 4.20725 - 4.20775 | 73 - 74.6 | 1645.5 - 1646.5 | 9.3 - 9.5 |
| 6.215 - 6.218 | 74.8 - 75.2 | 1660 - 1710 | 10.6 - 12.7 |
| 6.26775 - 6.26825 | 108 - 121.94 | 1718.8 - 1722.2 | 13.25 - 13.4 |
| 6.31175 - 6.31225 | 123 - 138 | 2200 - 2300 | 14.47 - 14.5 |
| 8.291 - 8.294 | 149.9 - 150.05 | 2310 - 2390 | 15.35 - 16.2 |
| 8.362 - 8.366 | 156.52475 - 156.52525 | 2483.5 - 2500 | 17.7 - 21.4 |
| 8.37625 - 8.38675 | 156.7 - 156.9 | 2690 - 2900 | 22.01 - 23.12 |
| 8.41425 - 8.41475 | 162.0125 - 167.17 | 3260 - 3267 | 23.6 - 24.0 |
| 12.29 - 12.293 | 167.72 - 173.2 | 3332 - 3339 | 31.2 - 31.8 |
| 12.51975 - 12.52025 | 240 - 285 | 3345.8 - 3358 | 36.43 - 36.5 |
| 12.57675 - 12.57725 | 322 - 335.4 | 3600 - 4400 | ([2]) |
| 13.36 - 13.41 | | | |

Radiated emissions which fall in the restricted bands, as defined in §15.205(a), must also comply with the radiated emission limits specified in §15.209(a) (see §15.205(c)).
*PEAK LIMIT= 74dBµV/m

*AVG. LIMIT= 54dBµV/m

**Table 1:**

| Frequency of emission (MHz) | Field strength @ 3m (µV/m) | Field strength @ 3m (dBµV/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:**

| Frequency of emission (MHz) | Field strength (µV/m) / (dBuV/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 / (29.5) | 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.**

For testing at distance other than the specified in the standard, the limit conversion is calculated by using 40 dB/decade extrapolation factors as follow:

Conversion factor (CF) = 40 log (D/d) = 40 log (300m / 3m) = 80dB

14.3 Test conditions and setup:

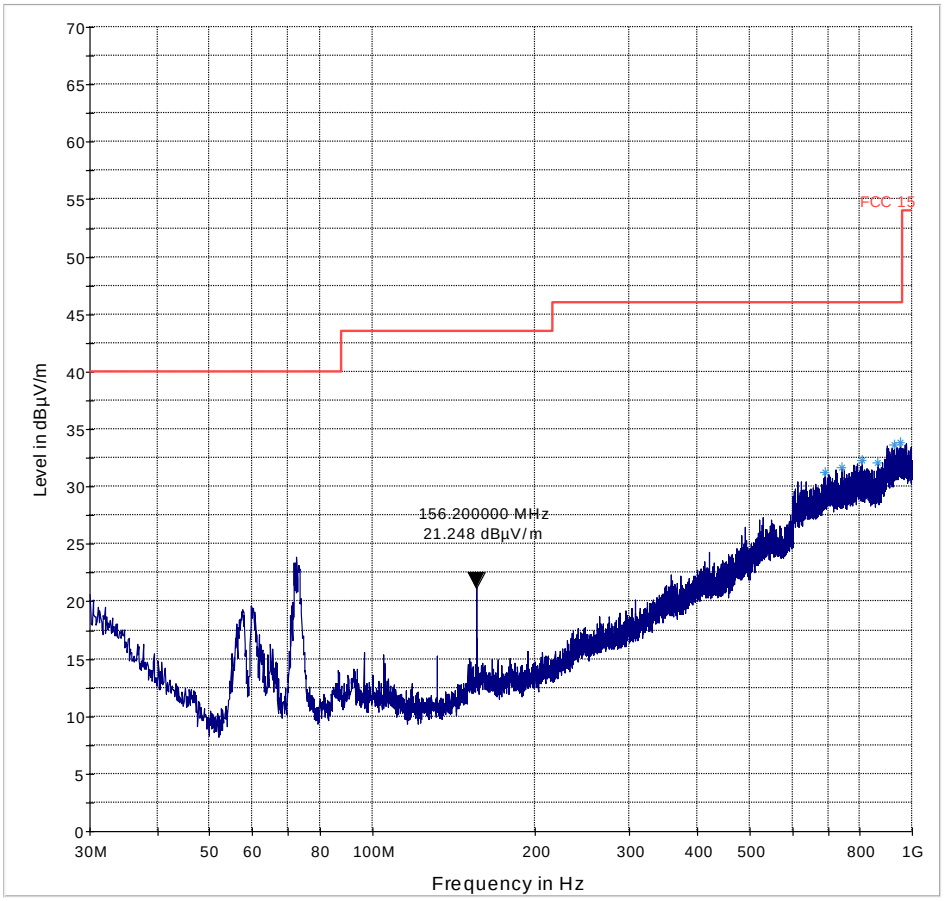
| Ambient Temperature | EUT Set-Up # | EUT operating mode | Power Input |
|---|---|---|---|
| 23° C | 1 | Tx | Battery, 3.8V DC |

14.4 Measurement result:

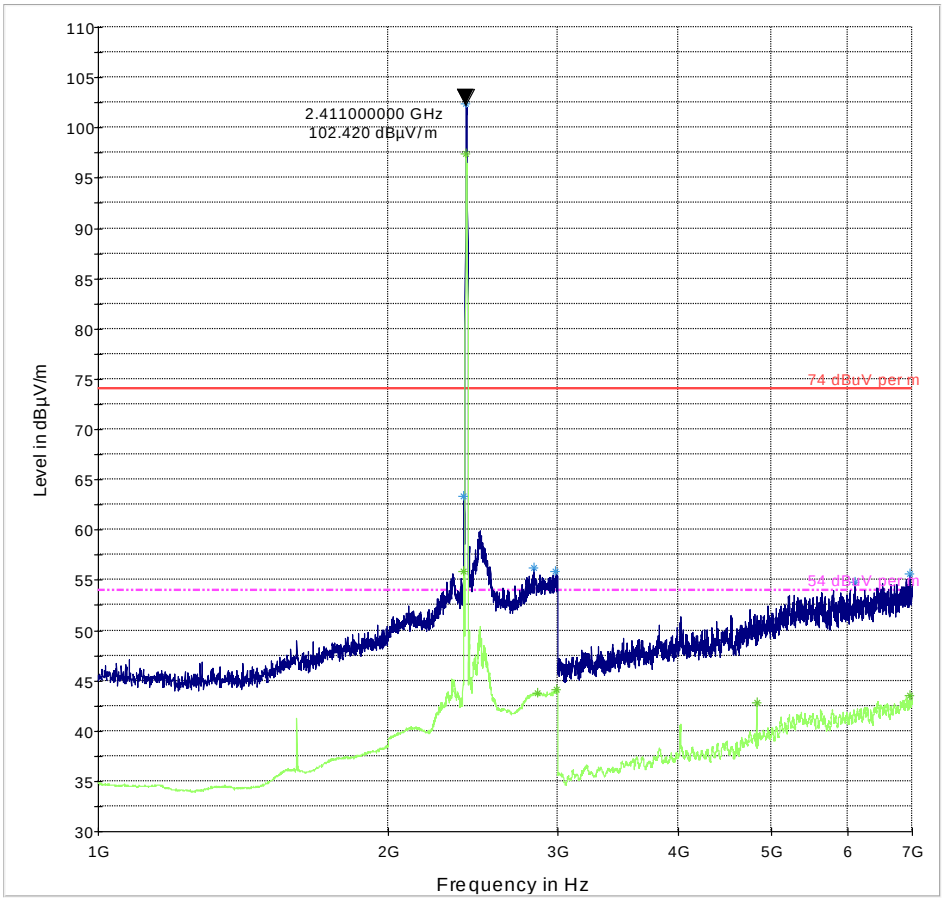
| Plot # | Channel # | Scan Frequency | Limit | Result |
|---|---|---|---|---|
| 1-3 | 1 | 30 MHz – 18 GHz | See section 8.7.2 | Pass |
| 4-8 | 7 | 9 kHz – 26 GHz | See section 8.7.2 | Pass |
| 9-12 | 11 | 30 MHz – 18 GHz | See section 8.7.2 | Pass |

## 14.5 Measurement Plots:

| Plot #1 | | |
|---|---|---|
| **RE: 30 MHz – 1GHz** | **Ch. 1** | **Modulation: 802.11b (11Mbps_CCC)** |

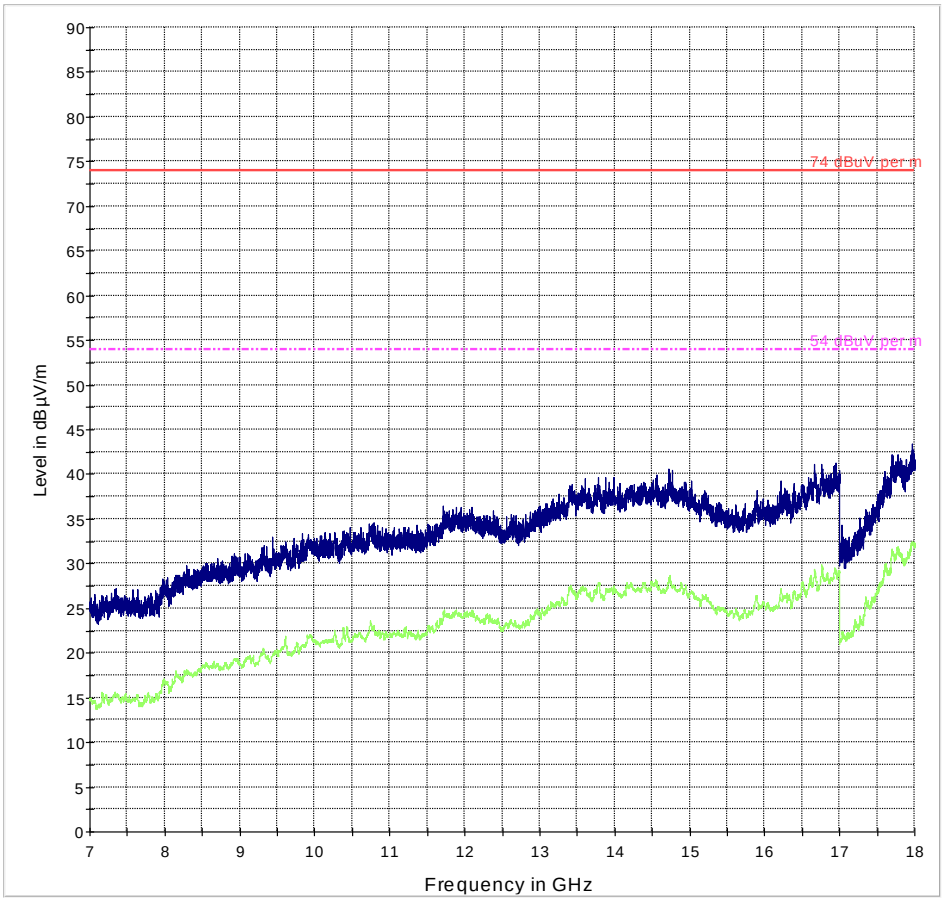


| Plot #2 | | |
|---|---|---|
| **RE: 1 GHz – 7GHz** | **Ch. 1** | **Modulation: 802.11b (11Mbps_CCC)** |

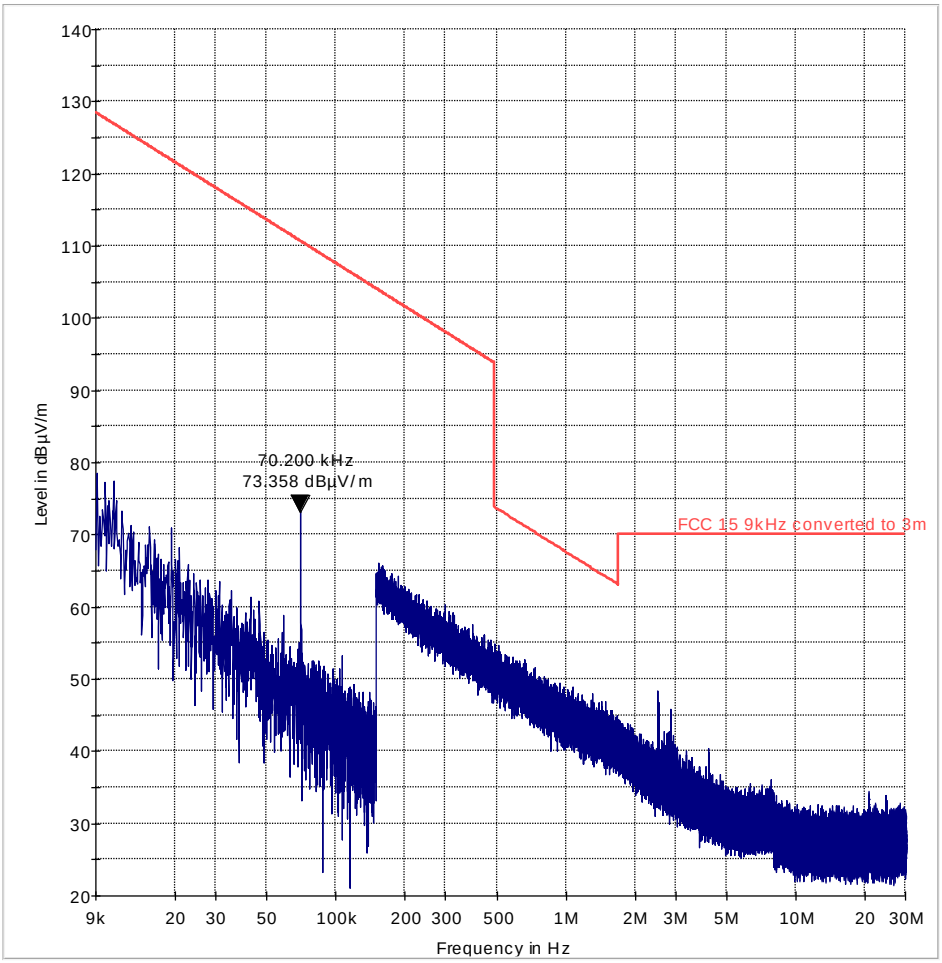



*Note: The peak signal is the Tx channel low.

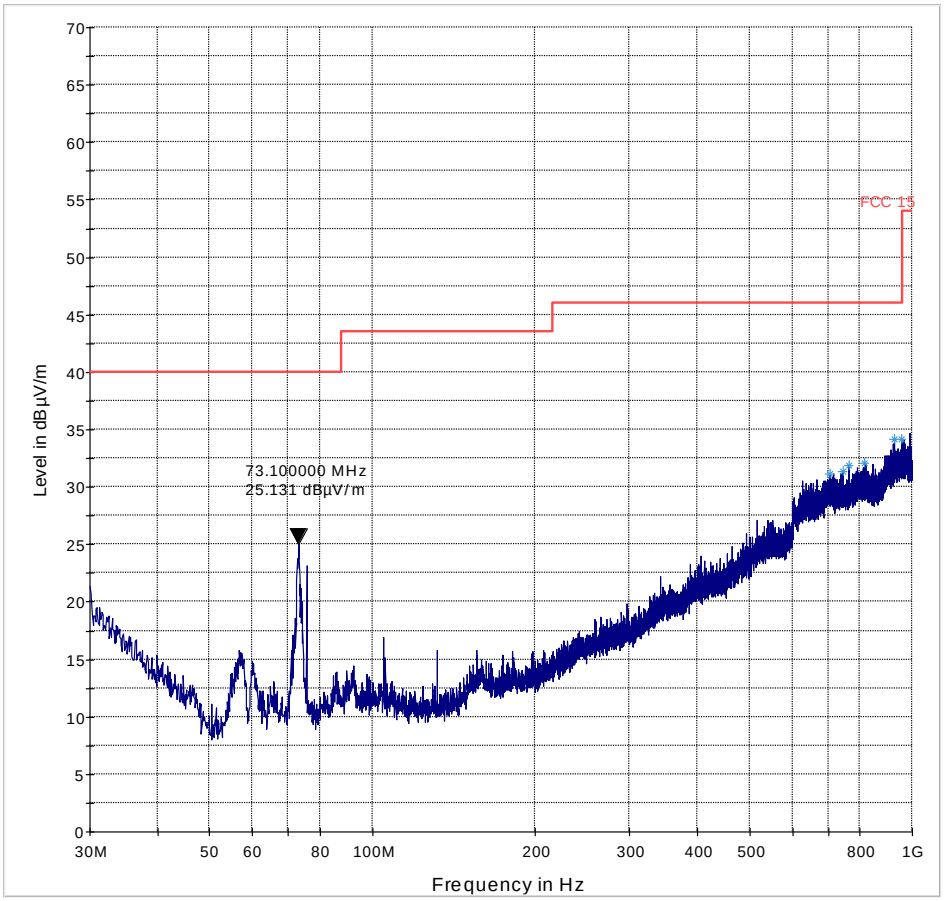
| Plot # 3 | | |
|---|---|---|
| **RE: 7 GHz – 18 GHz** | **Ch. 1** | **Modulation: 802.11b (11Mbps_CCC)** |



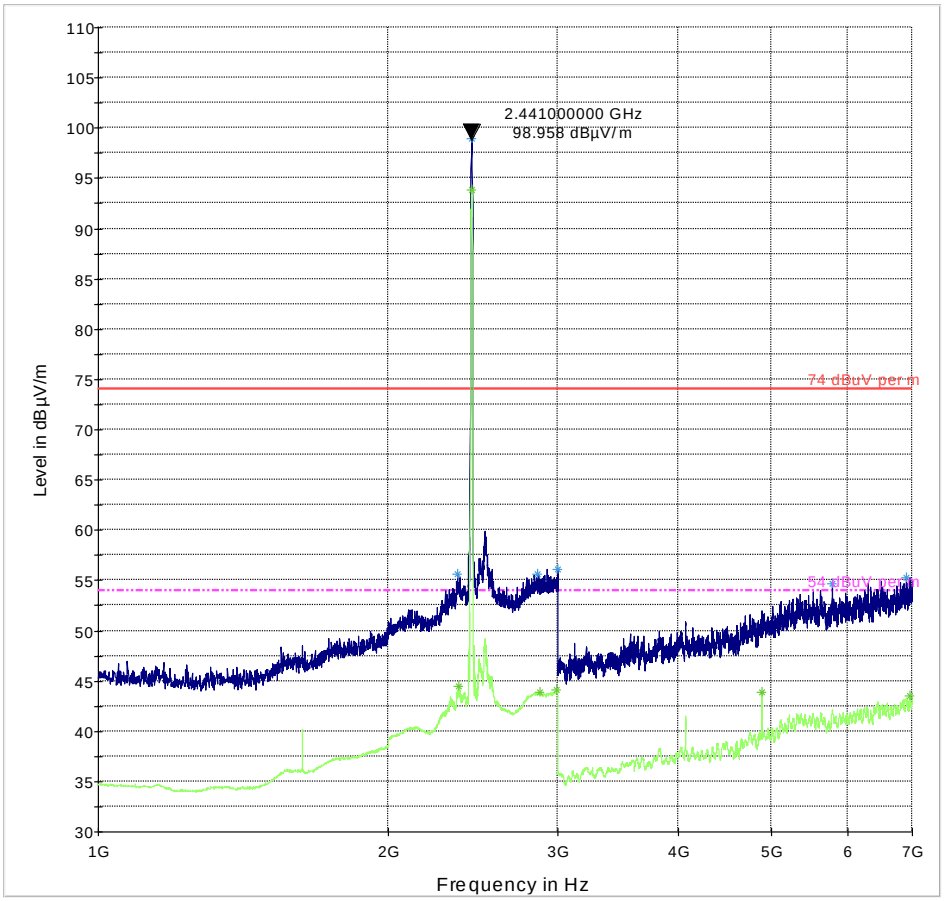
| Plot # 4 | | |
|---|---|---|
| **RE: 9 KHz – 30 MHz** | **Ch. 7** | **Modulation: 802.11b (11Mbps_CCC)** |



| Plot #5 | | |
|---|---|---|
| RE: 30 MHz – 1 GHz | Ch. 7 | Modulation: 802.11b (11Mbps_CCC) |

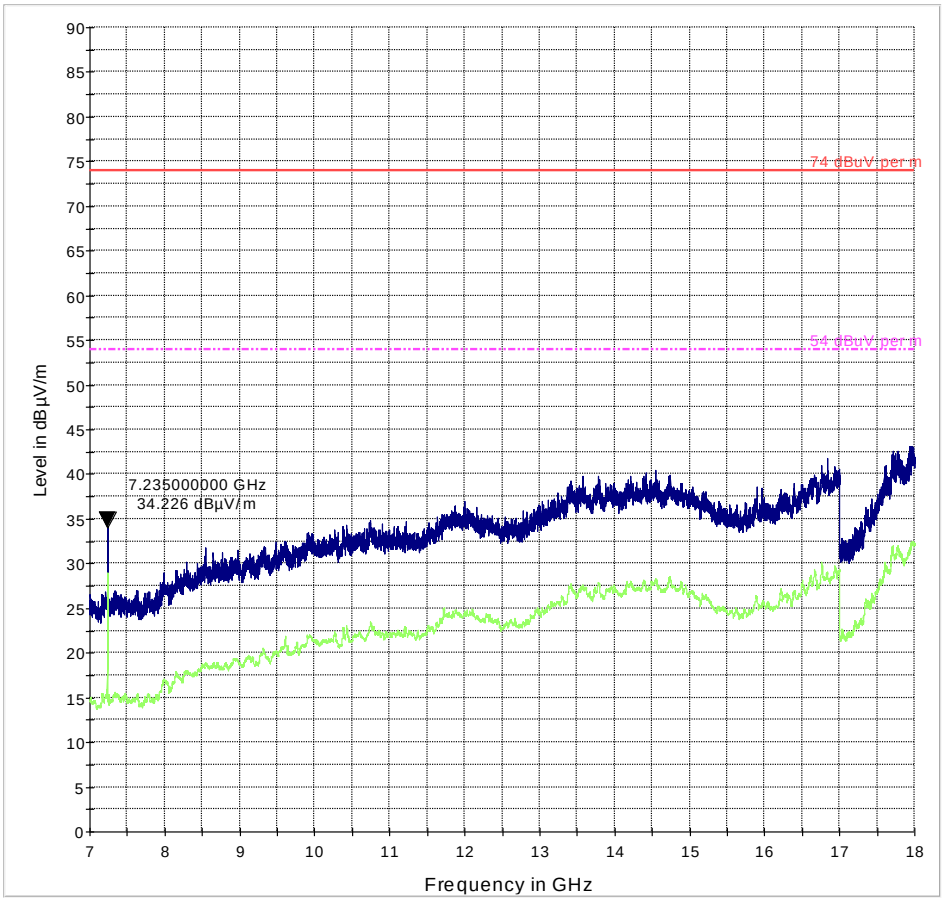


| Plot #6 | | |
|---|---|---|
| RE: 1 GHz – 6 GHz | Ch. 7 | Modulation: 802.11b (11Mbps_CCC) |

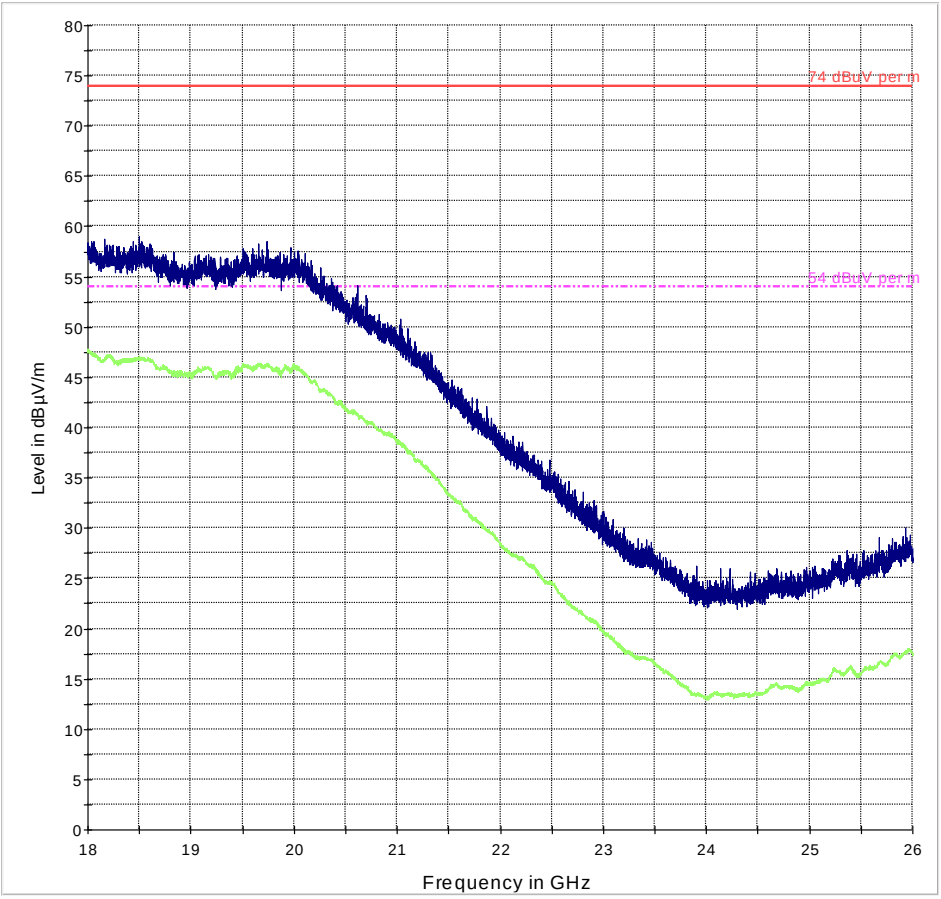



*Note: The peak signal is the Tx Ch.7.

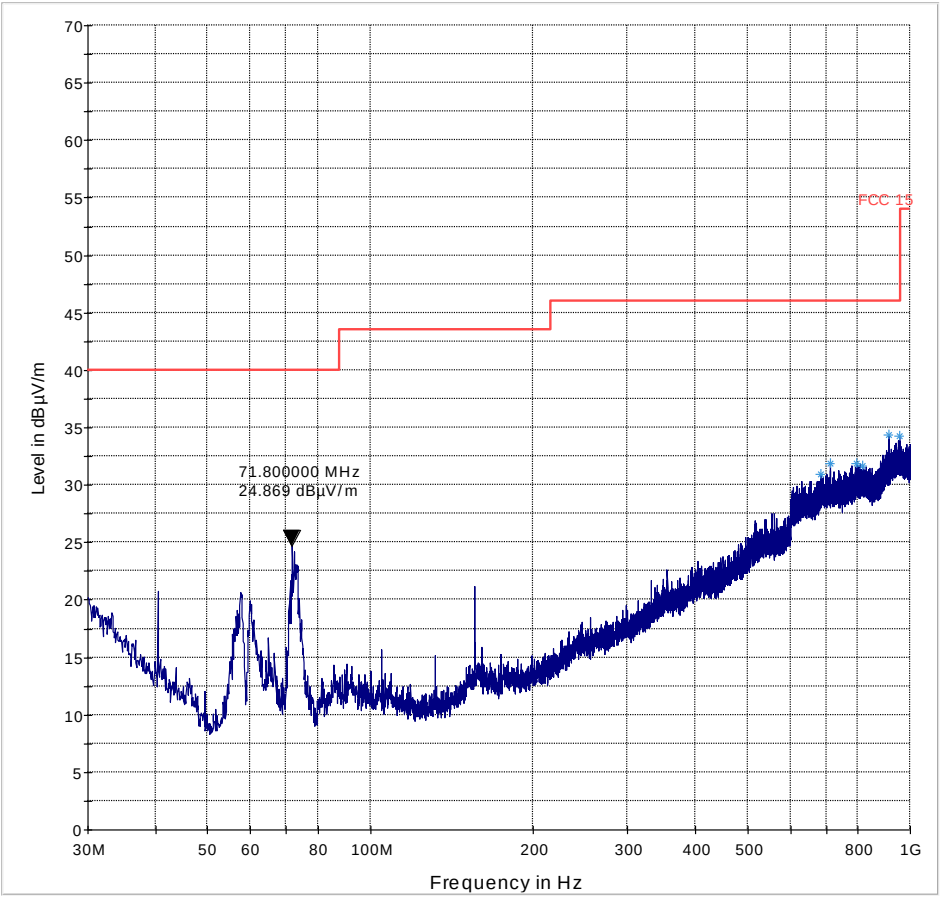
| Plot #7 | | |
|---|---|---|
| RE: 6 GHz – 18 GHz | Ch. 7 | Modulation: 802.11b (11Mbps_CCC) |



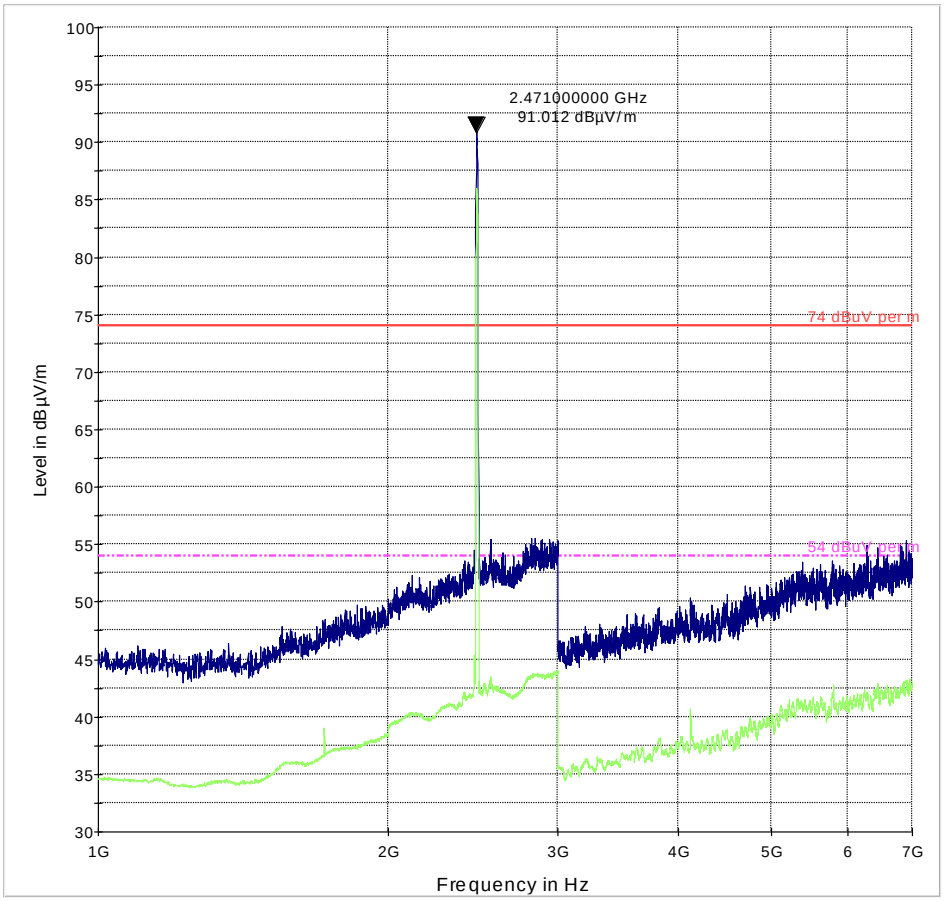
| Plot #8 | | |
|---|---|---|
| **RE: 18 GHz – 26 GHz** | **Ch. 7** | **Modulation: 802.11b (11Mbps_CCC)** |



| Plot #9 | | |
|---|---|---|
| **RE: 30 MHz – 1 MHz** | **Ch. 11** | **Modulation: 802.11b (11Mbps_CCC)** |

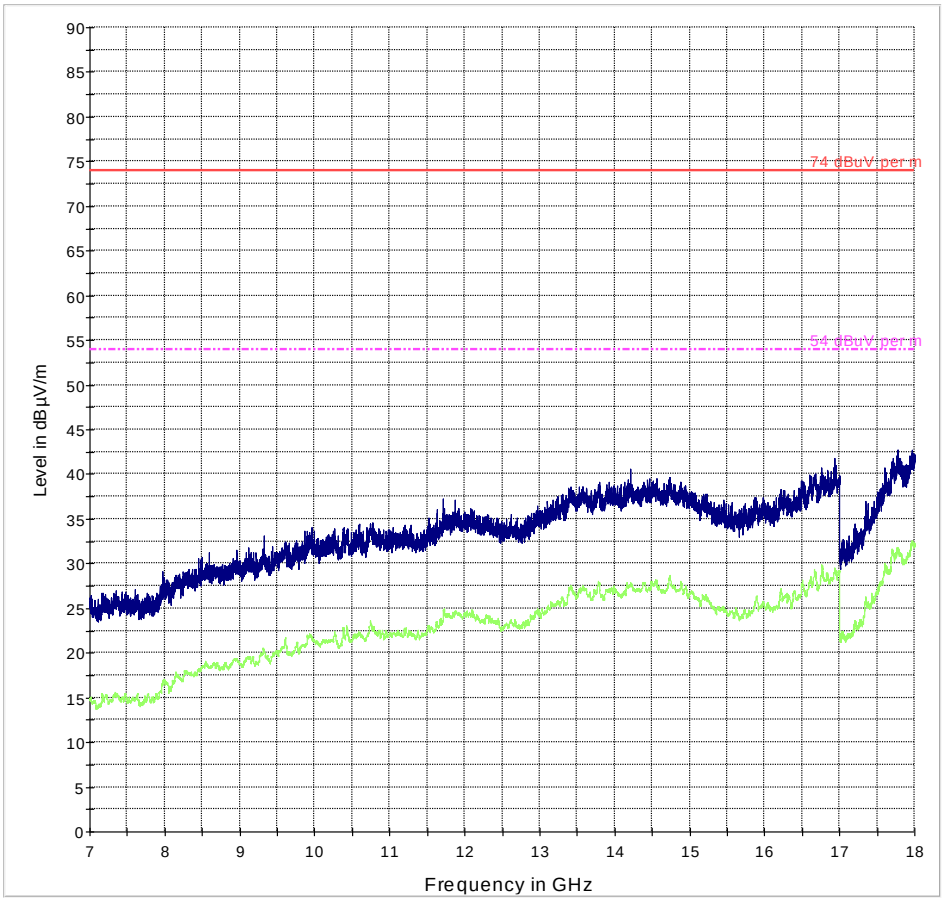


| Plot # 10 | | |
|---|---|---|
| **RE: 1 GHz – 6 GHz** | **Ch. 11** | **Modulation: 802.11b (11Mbps_CCC)** |




*Note: The peak signal is the Tx Ch. 11.

| Plot #11 | | |
|---|---|---|
| **RE: 6 GHz – 18 GHz** | **Ch. 11** | **Modulation: 802.11b (11Mbps_CCC)** |



## 15 AC Power Line Conducted Emissions

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.

15.1 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.

15.2 Test conditions and setup:

| Ambient Temperature | EUT Set-Up # | EUT operating mode | Power Input |
|---|---|---|---|
| 23° C | 3 | Tx | AC/DC Power Supply |

15.3 Test 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:**
**RBW =** 9 KHz (CISPR Bandwidth)
**Detector:** Qusi-Peak / Average

15.4 Results:

Pass

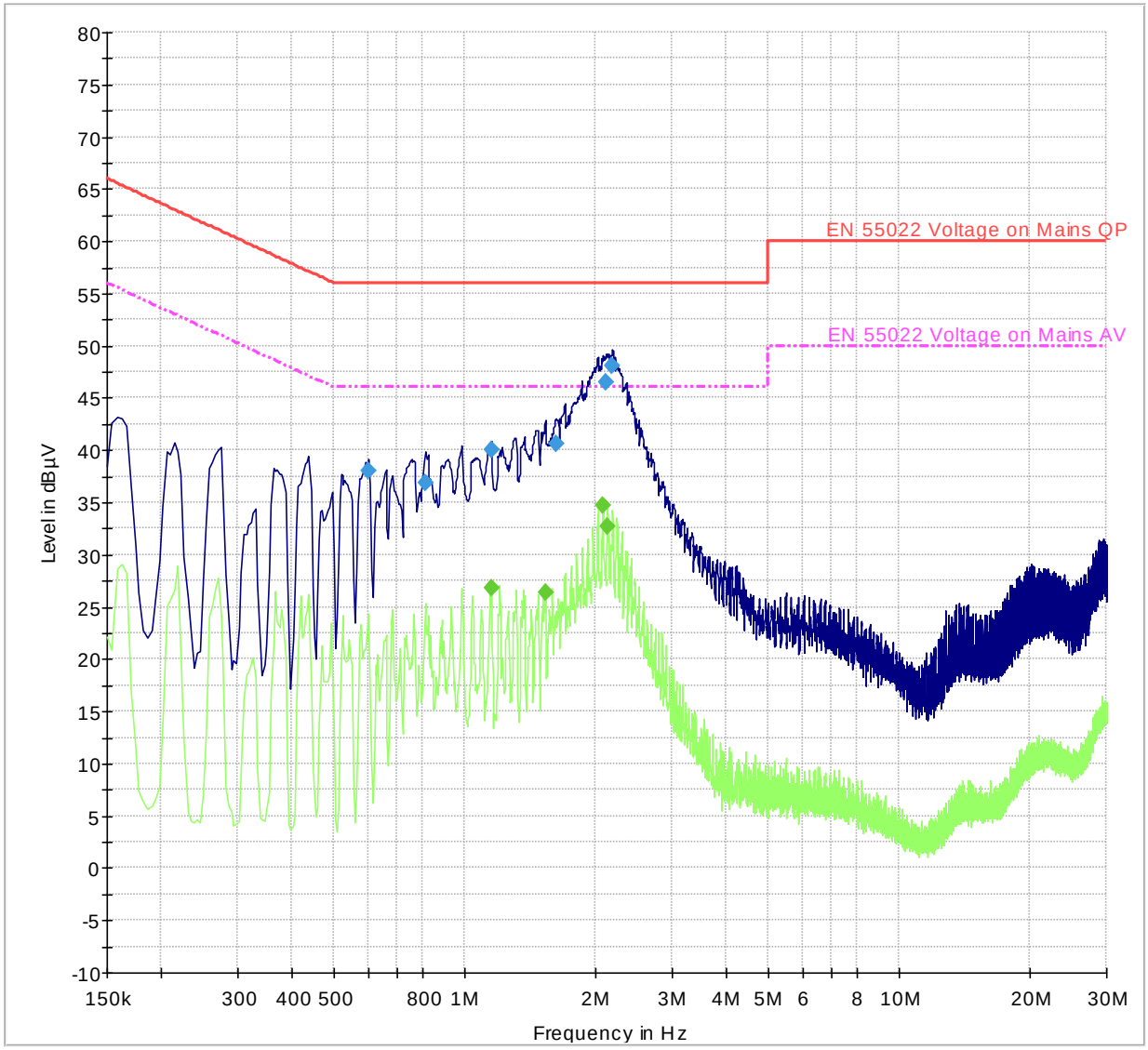
15.5 Test Data:

**Conducted Emissions: 150 KHz – 30 MHz**

| Frequency (MHz) | Quasi-Peak (dBuV) | Meassurement Time (ms) | BW (KHz) | PE | Line | Corr. (dB) | Margin (dB) | Limit (dBuV) | Comments |
|---|---|---|---|---|---|---|---|---|---|
| 0.602000 | 38.0 | 500.0 | 9.000 | GND | N | 0.4 | 18.0 | 56.0 | |
| 0.810000 | 36.9 | 500.0 | 9.000 | GND | L1 | 0.4 | 19.1 | 56.0 | |
| 1.150000 | 40.0 | 500.0 | 9.000 | GND | L1 | 0.4 | 16.0 | 56.0 | |
| 1.618000 | 40.7 | 500.0 | 9.000 | GND | L1 | 0.5 | 15.3 | 56.0 | |
| 2.118000 | 46.2 | 500.0 | 9.000 | GND | L1 | 0.5 | 9.5 | 56.0 | |
| 2.190000 | 48.1 | 500.0 | 9.000 | GND | L1 | 0.5 | 7.9 | 56.0 | |

## 15.6 Measurement Plots:

**Conducted Emissions: 150 KHz – 30 MHz**




**Note:** Plots shown here represent the combined worse case emissions for power lines (phases and neutral line).

## 16 Setup Pictures

Please refer to EMC_MOOGI-005-15001_TestSetupPhotos.pdf

## 17 EUT pictures

Please refer to EMC_MOOGI-005-15001_TestSetupPhotos.pdf

## 18 Test Equipment and Ancillaries Used For Testing

| Item Name | Equipment Type | Manufacturer | Model | Serial # | Calibration Cycle | Last Calibration Date |
|---|---|---|---|---|---|---|
| Antenna Biconilog 3142E | Biconlog Antenna | EMCO | 3142E | 166067 | 3 years | 6/14/2014 |
| Antenna Biconilog 3149 | Biconilog Antenna | EMCO | 3149 | 63983 | 3 years | 4/9/2014 |
| Antenna Horn 3115 SN 35111 | Horn Antenna | EMCO | 3115 | 35111 | 3 years | 7/24/2015 |
| Antenna Horn 3116 | Horn Antenna | ETS Lindgren | 3116 | 70497 | 3 years | 7/22/2015 |
| Antenna Loop 6512 | Loop Antenna | ETS Lindgren | 6512 | 49838 | 3 years | 3/13/2014 |
| Audio Analyzer UPL16 | Audio Analyzer | R&S | UPL16 | 838205/0005 | 3 years | 5/25/2013 |
| Bluetooth Comm. Tester CBT | Bluetooth Comm. Tester | R&S | CBT | 100212 | 3 years | 7/1/2015 |
| CMW500 | CMW 500 | R&S | WIDEB. RADIO COMM. TESTER | 127068 | 3 years | 3/12/2015 |
| Current Probe EZ-17 Immunity | RF Current Probe Conducted Emissions | R&S | EZ-17 | 834613/007 | 3 years | 6/17/2013 |
| Digital Barometer | Compact Digital Barometer | Control Company | 35519-055 | 91119547 | 2 Years | 4/7/2015 |
| Digital Radio Comm. Tester CMU 200 #1 | Digital Radio Comm. Tester | R&S | CMU 200 #1 | 101821 | 2 Years | 7/4/2015 |
| ESD Gun NSG 437 | ESD Gun | Teseq Inc. | NSG 437 | 221 | 2 Years | 2/14/2014 |
| Immunity Tester Generator UCS 500 M4 | Immunity Tester Generator | Amplifier Research | UCS 500 M4 | 28256 | 2 Years | 4/15/2014 |
| Oscilloscope | Oscilloscope | R&S | RTO 1014 | 300087 | 3 years | 7/24/2013 |
| Power Meter NRVD | Power Meter | R&S | NRVD | 836875/020 | 3 years | 6/15/2013 |
| Power Sensor Insertion URV5-Z2 SN 100727 | Power Sensor / 10V Insertion | R&S | URV5-Z2 | 100727 | 3 years | 6/15/2013 |
| Power Sensor Insertion URV5-Z2 SN 836029 | Power Sensor 10V Insertion | R&S | URV5-Z2 | 836029/035 | 3 years | 6/15/2013 |
| Power Sensor NRP - Z22 | Power Sensor | R&S | NRP-Z22 | 100223 | 3 years | 6/17/2013 |
| Power Sensor NRP - Z81 | Power Smart Sensor | R&S | NRP-Z81 | 100161 | 3 years | 6/15/2013 |
| Radiated Immunity Probe HI6005 | Radiated Immunity Probe | ETS Lindgren | HI6005 | 105107 | 2 Years | 3/21/2014 |
| Receiver ESU40 | EMI Receiver | R&S | ESU40 | 100251 | 3 years | 6/29/2015 |
| Signal Generator SME03 | Signal Generator | Amplifier Research | SME 03 | 1038-6002-03 | 3 years | 6/13/2013 |
| Signal Generator SMP04 | Signal Generator | R&S | SMP04 | 100151 | 3 years | 6/17/2013 |
| Spectrum Analyzer FSU08 | Spectrum Analyzer | R&S | FSU-8 | 200256 | 2 Years | 7/5/2015 |
| Spectrum Analyzer FSU26 #1 | FSU 26 | Amplifier Research | FSU 26 | 100189 | 3 years | 6/1/2013 |
| Spectrum Analyzer FSU26 #2 | Spectrum Analyzer | R&S | FSU26 | 200065 | 3 years | 7/4/2015 |

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.

## 19 Revision History

| Date | Report Name | Changes to report | Report prepared by |
|---|---|---|---|
| January 27, 2015 | EMC_MOOGI-005-15001_15.247_WLAN | Initial Version | Franz Engert |
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