



**DATE: 19 December 2019**

**I.T.L. (PRODUCT TESTING) LTD.  
FCC/IC Radio Test Report  
for  
Munters Israel Ltd**

**Equipment under test:  
Poultry House Monitoring Equipment**

**ECHO**

Tested by:

M. Zohar

Approved by:

D. Shidlowsky

This report must not be reproduced, except in full, without the written  
permission of I.T.L. (Product Testing) Ltd.

This report relates only to items tested.



**Measurement/Technical Report for**  
**Munters Israel Ltd**  
**Poultry House Monitoring Equipment**

**ECHO**

**FCC ID: 2ATJLECHO**  
**IC: 25363-ECHO**

|                       |                                                                                                      |
|-----------------------|------------------------------------------------------------------------------------------------------|
| This report concerns: | Original Grant: X<br>Class I Change:<br>Class II Change:                                             |
| Equipment type:       | FCC: (DTS) Digital Transmission System<br>IC: Spread Spectrum Digital Device (2400-2483.5)           |
| Limits used:          | 47CFR15 Section 15.247<br>RSS 247, Issue 2, February 2017, Section 5<br>RSS-Gen, Issue 5, April 2018 |

Measurement procedure used is KDB 558074 D01 v05r02 and ANSI C63.10:2013 and RSS-Gen, Issue 5, April 2018

|                                               |                                                                                        |
|-----------------------------------------------|----------------------------------------------------------------------------------------|
| Application for Certification<br>prepared by: | Applicant for this device:<br>(different from "prepared by")                           |
| R. Pinchuck                                   | Wouter Claassens                                                                       |
| ITL (Product Testing) Ltd.                    | Munters Israel Ltd                                                                     |
| 1 Bat Sheva St.                               | 2691 Ena Drive                                                                         |
| Lod 7116002                                   | Lansing, MI 48917-8521                                                                 |
| e-mail: Rpinchuck@itlglobal.org               | Tel: +1 517 899 6849                                                                   |
|                                               | e-mail: <a href="mailto:wouter.claassens@munters.com">wouter.claassens@munters.com</a> |

# TABLE OF CONTENTS

|           |                                                                |           |
|-----------|----------------------------------------------------------------|-----------|
| <b>1.</b> | <b>GENERAL INFORMATION</b>                                     | <b>5</b>  |
| 1.1       | Administrative Information                                     | 5         |
| 1.2       | List of Accreditations                                         | 6         |
| 1.3       | Product Description                                            | 7         |
| 1.4       | Test Methodology                                               | 7         |
| 1.5       | Test Facility                                                  | 7         |
| 1.6       | Measurement Uncertainty                                        | 7         |
| <b>2.</b> | <b>SYSTEM TEST CONFIGURATION</b>                               | <b>9</b>  |
| 2.1       | Justification                                                  | 9         |
| 2.2       | EUT Exercise Software                                          | 9         |
| 2.3       | Special Accessories                                            | 10        |
| 2.4       | Equipment Modifications                                        | 10        |
| 2.5       | Configuration of Tested System                                 | 11        |
| <b>3.</b> | <b>CONDUCTED &amp; RADIATED MEASUREMENT TEST SET-UP PHOTOS</b> | <b>12</b> |
| <b>4.</b> | <b>CONDUCTED EMISSION FROM AC MAINS</b>                        | <b>16</b> |
| 4.1       | Test Specification                                             | 16        |
| 4.2       | Test Procedure                                                 | 16        |
| 4.3       | Test Limit                                                     | 16        |
| 4.4       | Test Results                                                   | 17        |
| <b>5.</b> | <b>6 DB MINIMUM BANDWIDTH</b>                                  | <b>23</b> |
| 5.1       | Test Specification                                             | 23        |
| 5.2       | Test Procedure                                                 | 23        |
| 5.3       | Test Limit                                                     | 23        |
| 5.4       | Test Results                                                   | 24        |
| 5.5       | Test Equipment Used; 6dB Bandwidth                             | 28        |
| <b>6.</b> | <b>MAXIMUM CONDUCTED OUTPUT POWER</b>                          | <b>29</b> |
| 6.1       | Test Specification                                             | 29        |
| 6.2       | Test Procedure                                                 | 29        |
| 6.3       | Test Limit                                                     | 29        |
| 6.4       | Test Results                                                   | 30        |
| 6.5       | Test Equipment Used; Maximum Peak Power Output                 | 34        |
| <b>7.</b> | <b>BAND EDGE SPECTRUM</b>                                      | <b>35</b> |
| 7.1       | Test Specification                                             | 35        |
| 7.2       | Test Procedure                                                 | 35        |
| 7.3       | Test Limit                                                     | 35        |
| 7.4       | Test Results                                                   | 36        |
| 7.5       | Test Equipment Used; Band Edge                                 | 39        |
| <b>8.</b> | <b>TRANSMITTED POWER DENSITY</b>                               | <b>40</b> |
| 8.1       | Test Specification                                             | 40        |
| 8.2       | Test Procedure                                                 | 40        |
| 8.3       | Test Limit                                                     | 40        |
| 8.4       | Test Results                                                   | 41        |
| 8.5       | Test Equipment Used; Transmitted Power Density                 | 45        |
| <b>9.</b> | <b>OCCUPIED BANDWIDTH</b>                                      | <b>46</b> |
| 9.1       | Test Specification                                             | 46        |
| 9.2       | Test Procedure                                                 | 46        |
| 9.3       | Test Limit                                                     | 46        |
| 9.4       | Test Results                                                   | 47        |
| 9.5       | Test Equipment Used; Bandwidth                                 | 51        |



|            |                                                                                 |           |
|------------|---------------------------------------------------------------------------------|-----------|
| <b>10.</b> | <b>EMISSIONS IN NON-RESTRICTED FREQUENCY BANDS</b>                              | <b>52</b> |
| 10.1       | Test Specification                                                              | 52        |
| 10.2       | Test Procedure                                                                  | 52        |
| 10.3       | Test Limit                                                                      | 52        |
| 10.4       | Test Results                                                                    | 52        |
| 10.1       | Test Instrumentation Used, Emission in Non Restricted Frequency Bands           | 59        |
| <b>11.</b> | <b>EMISSIONS IN RESTRICTED FREQUENCY BANDS</b>                                  | <b>60</b> |
| 11.1       | Test Specification                                                              | 60        |
| 11.3       | FCC Test Limit                                                                  | 61        |
| 11.4       | IC Test Limit                                                                   | 61        |
| 11.5       | Test Results                                                                    | 62        |
| 11.6       | Test Instrumentation Used; Emissions in Restricted Frequency Bands              | 66        |
| <b>12.</b> | <b>ANTENNA GAIN/INFORMATION</b>                                                 | <b>67</b> |
| <b>13.</b> | <b>R.F EXPOSURE/SAFETY</b>                                                      | <b>68</b> |
| <b>14.</b> | <b>APPENDIX A - CORRECTION FACTORS</b>                                          | <b>69</b> |
| 14.1       | Correction factors for RF OATS Cable 35m                                        | 69        |
| 14.1       | Correction Factors for RF Cable for Anechoic Chamber                            | 70        |
| 14.2       | Correction Factors for Active Loop Antenna                                      | 71        |
| 14.3       | Correction Factors for Biconical Antenna                                        | 72        |
| 14.4       | Correction Factors for Log Periodic Antenna                                     | 73        |
| 14.5       | Correction Factors for Double – Ridged Waveguide Horn ANTENNA 3<br>meter range; | 74        |
| 14.6       | Correction factors for Horn Antenna Model SWH-28 ITL # 1353                     | 75        |



# 1. General Information

## 1.1 Administrative Information

Manufacturer: Munters Israel Ltd

Manufacturer's Address: 2691 Ena Drive  
Lansing, MI 48917-8521  
U.S.A.  
Tel: +1 517 899 6849

Manufacturer's Representative: Wouter Claassens

Equipment Under Test (E.U.T): Poultry House Monitoring Equipment

Equipment PMN: ECHO

Equipment Serial No.: 0519.08928

Equipment HVIN: 2

Date of Receipt of E.U.T: June 12, 2019

Start of Test: June 12, 2019

End of Test: June 30, 2019

Test Laboratory Location: I.T.L (Product Testing) Ltd.  
1 Batsheva St.,  
Lod  
ISRAEL 7120101

Test Specifications: FCC Part 15, Subpart C  
RSS 247, Issue 2, February 2017, Section 5  
RSS-Gen, Issue 5, April 2018



## **1.2 List of Accreditations**

The EMC laboratory of I.T.L. is accredited by the following bodies:

1. The American Association for Laboratory Accreditation (A2LA) (U.S.A.), Certificate No. 1152.01.
2. The Federal Communications Commission (FCC) (U.S.A.), FCC Designation No. IL1005.
3. The Israel Ministry of the Environment (Israel), Registration No. 1104/01.
4. Department of Innovation, Science and Economic Development (ISED) Canada, CAB identifier: IL1002

I.T.L. Product Testing Ltd. is accredited by the American Association for Laboratory Accreditation (A2LA) and the results shown in this test report have been determined in accordance with I.T.L.'s terms of accreditation unless stated otherwise in the report.

### 1.3 Product Description

The Echo is a remote sensing device designed to be installed in poultry houses. It's powered by 24 volts DC and measures a variety of parameters including temperature, humidity, ammonia level, water flow, food flow, and bird weight. The Echo periodically transmits its measurements to a remote server through a dedicated 802.11b WiFi network that's connected to the Internet.

The data collected from the Echo sensors at a farm is used for remote monitoring, detection of alarm conditions, and prediction of future outcomes such as bird weight. The customers for this product are the poultry integrators who use it to insure that the animals are raised according to their standards, and who want better information to improve their planning and scheduling.

|                           |                                                                                                                      |
|---------------------------|----------------------------------------------------------------------------------------------------------------------|
| Working voltage           | 24VDC via AC/DC adapter                                                                                              |
| Mode of operation         | Transceiver                                                                                                          |
| Modulations               | For Wi-Fi/b: DSSS, CCK<br>For Wi-Fi/g: OFDM(BPSK,QPSK,16QAM ,64QAM)<br>For Wi-Fi/n: OFDM(BPSK,QPSK,16QAM ,64QAM)     |
| Assigned Frequency Range  | 2400.0-2483.5MHz                                                                                                     |
| Operating Frequency Range | For Wi-Fi/b/g/n: 2412.0-2462.0MHz                                                                                    |
| Transmit power(conducted) | For Wi-Fi/b/g/n: ~20.0dBm                                                                                            |
| Antenna Gain              | 1.9 dBi chip antenna                                                                                                 |
| Modulation BW             | For Wi-Fi/b/g/n: 20MHz                                                                                               |
| Bit rate (Mbit/s)         | For Wi-Fi/b: 1, 2, 5.5, 11<br>For Wi-Fi/g: 6, 9, 12, 18, 24, 36, 48, 54<br>For Wi-Fi/n: 6.5,13,19.5,26,39,52,58.5,65 |

### 1.4 Test Methodology

Both conducted and radiated testing was performed according to the procedures in KDB 558074 D01 v05r02, ANSI C63.10: 2013 and RSS-Gen, Issue 5. Radiated testing was performed at an antenna to EUT distance of 3 meters.

### 1.5 Test Facility

Emissions tests were performed at I.T.L.'s testing facility in Lod, Israel. I.T.L.'s EMC Laboratory is accredited by A2LA, certificate No. 1152.01, FCC Designation Number is IL1005 and ISED CAB identifier is IL1002.

### 1.6 Measurement Uncertainty

#### Conducted Emission

Conducted Emission (CISPR 11, EN 55011, CISPR 22, EN 55022, ANSI C63.4)

0.15 – 30 MHz:

Expanded Uncertainty (95% Confidence, K=2):  
± 3.44 dB



**Radiated Emission**

Radiated Emission (CISPR 11, EN 55011, CISPR 22, EN 55022, ANSI C63.4)  
for open site:

30-1000MHz:

Expanded Uncertainty (95% Confidence, K=2):  
 $\pm 4.96$  dB

1 GHz to 6 GHz

Expanded Uncertainty (95% Confidence, K=2):  
 $\pm 5.19$  dB

>6 GHz

Expanded Uncertainty (95% Confidence, K=2):  
 $\pm 5.51$  dB

## 2. System Test Configuration

### 2.1 Justification

- 2.1.1 The E.U.T contains an IEEE 802.11b/g/n standard (Wi-Fi/b/g/n) transceiver with only 20MHz CBW.
- 2.1.2 The unit was evaluated while transmitting at the low channel (2412MHz), mid channel (2437MHz) and the high channel (2462MHz).
- 2.1.3 Conducted emission tests were performed with the E.U.T. antenna terminal connected by a RF cable to the Spectrum Analyzer through a 30dB external attenuator.
- 2.1.4 Final radiated emission for Wi-Fi b/g/n modes tests were performed using the lowest and highest bit rates for each different protocol type. The bit rates for each protocol are shown in the table below:

| Protocol Type | "Worst Case" Bit Rate     |
|---------------|---------------------------|
| Wi-Fi/b       | 1,11 Mbit/s               |
| Wi-Fi/g       | 6,54 Mbit/s               |
| Wi-Fi/n       | 6.5,65 Mbit/s (MCS0,MCS7) |

- 2.1.5 Final radiated emission tests were performed after exploratory emission testing that was performed in 3 orthogonal polarities to determine the "worst case" radiation.
- 2.1.6 According to the below screening results, the worst case was the "y axis".

| Orientation | Frequency | 2 <sup>nd</sup> Harmonic | 3 <sup>rd</sup> Harmonic | Band Edge |
|-------------|-----------|--------------------------|--------------------------|-----------|
|             | (MHz)     | (dBuV/m)                 | (dBuV/m)                 | (dBuV/m)  |
| X axis      | 2412.0    | 52.3                     | 45.3                     | 50.1      |
|             | 2437.0    | 51.2                     | 45.4                     | -         |
|             | 2462.0    | 51.6                     | 45.2                     | 50.6      |
| Y axis      | 2412.0    | <b>54.3</b>              | 45.6                     | 50.3      |
|             | 2437.0    | <b>53.5</b>              | 45.5                     | -         |
|             | 2462.0    | <b>52.5</b>              | 45.6                     | 50.7      |
| Z axis      | 2412.0    | 53.0                     | 45.5                     | 49.9      |
|             | 2437.0    | 52.7                     | 45.5                     | -         |
|             | 2462.0    | 52.3                     | 45.4                     | 50.5      |

Figure 1. Screening Results

### 2.2 EUT Exercise Software

TI radio tool GUI.

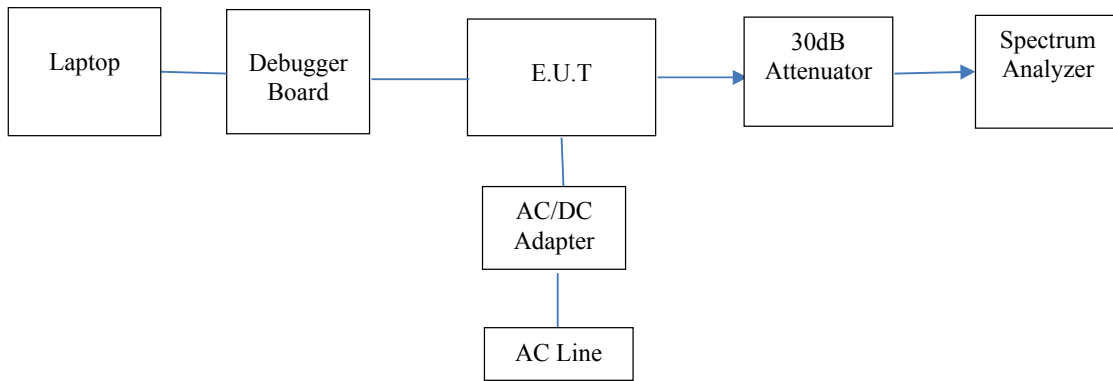
### 2.3 *Special Accessories*

| Equipment     | Manufacturer | Part Number | Serial Number |
|---------------|--------------|-------------|---------------|
| Laptop        | Lenovo       | 20BT-SOMX00 | R9-0JJNAF     |
| AC/DC adapter | MEAN WELL    | APV-16-12   | N/A           |
| Debugger      | TI           | CC3220      | N/A           |

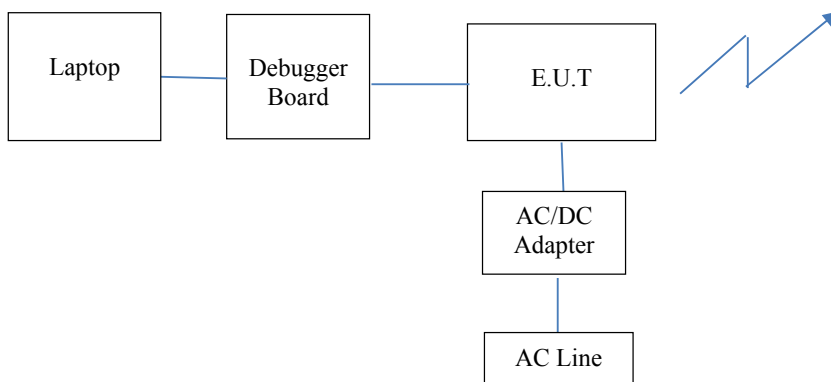
### 2.4 *Equipment Modifications*

No modifications were necessary in order to achieve compliance.

## 2.5 Configuration of Tested System



**Figure 2. Configuration of Tested System Conducted**



**Figure 3. Configuration of Tested System Radiated**

### 3. Conducted & Radiated Measurement Test Set-Up Photos



Figure 4. Conducted Emission from AC Line Test



Figure 5. Radiated Emission Test, 0.009-30MHz



**Figure 6. Radiated Emission Test, 30-200MHz**



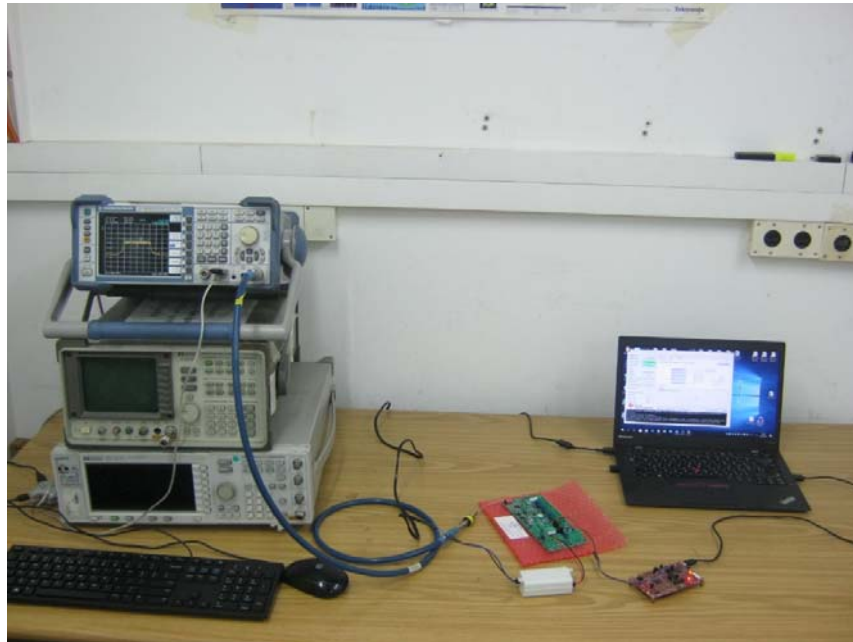
**Figure 7. Radiated Emission Test, 200-1000MHz**



**Figure 8. Radiated Emission Test, 1-18GHz**



**Figure 9. Radiated Emission Test, 18-26.5GHz**



**Figure 10. Conducted Emission Test**

## 4. Conducted Emission From AC Mains

### 4.1 Test Specification

FCC Part 15, Subpart C, Section 15.207

RSS Gen, Issue 5, Clause 8.8

### 4.2 Test Procedure

(Temperature (21°C)/ Humidity (65%RH))

The E.U.T operation mode and test setup are as described in Section 2 of this report. In order to minimize background noise interference, the conducted emission testing was performed inside a shielded room, with the E.U.T placed on a 0.8 meter high wooden table, 0.4 meter from the room's vertical wall. In the case of a floor-standing E.U.T., it was placed on the horizontal ground plane.

The E.U.T was powered from 115 V AC / 60 Hz via 50 Ohm / 50  $\mu$ Hn Line Impedance Stabilization Network (LISN) on the phase and neutral lines. The LISN's were grounded to the shielded room ground plane (floor), and were kept at least 0.8 meters from the nearest boundary of the E.U.T.

The center of the E.U.T.'s AC cable was folded back and forth, in order to form a bundle less than 0.40 meters and a total cable length of 1 meter.

The effect of varying the position of the cables was investigated to find the configuration that produces maximum emission.

The emission voltages at the LISN's outputs were measured using a computerized receiver, complying with CISPR 16 requirements. The specification limits are loaded to the receiver and are displayed on the receiver's spectrum display.

The E.U.T was evaluated in TX operation mode.

A frequency scan between 0.15 and 30 MHz was performed at 9 kHz I.F. band width, using peak detection.

The spectral components having the highest level on each line were measured using a quasi-peak and average detector.

### 4.3 Test Limit

| Frequency of Emission (MHz) | Conducted Limit (dB $\mu$ 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.



#### **4.4 Test Results**

JUDGEMENT: Passed by 14.78 dB

The margin between the emission levels and the specification limit is, in the worst case, 14.85 dB for the phase line at 0.66 MHz and 14.78 dB at 0.66 MHz for the neutral line.

The EUT met the F.C.C. Part 15, Subpart C specification requirements.

The details of the highest emissions are given in *Figure 11* to *Figure 14*.

## Conducted Emission

E.U.T Description      Poultry House  
Monitoring  
Equipment  
Type                      ECHO  
Serial Number:        0519.08928

Specification:            FCC Part 15, Subpart C;  
RSS Gen, Issue 5, Clause 8.8  
Lead:                      Phase  
Detectors: :              Peak, Quasi-peak, Average  
Power Operation        AC/DC Adapter

| EDIT PEAK LIST (Final Measurement Results) |            |            |        |          |
|--------------------------------------------|------------|------------|--------|----------|
| Trace1:                                    | CE22BQP    |            |        |          |
| Trace2:                                    | CE22BAP    |            |        |          |
| Trace3:                                    | ---        |            |        |          |
| TRACE                                      | FREQUENCY  | LEVEL dBμV | DELTA  | LIMIT dB |
| 2 Average                                  | 202 kHz    | 21.32      | -32.20 |          |
| 1 Quasi Peak                               | 250 kHz    | 35.31      | -26.44 |          |
| 1 Quasi Peak                               | 394 kHz    | 38.17      | -19.80 |          |
| 2 Average                                  | 402 kHz    | 24.36      | -23.45 |          |
| 1 Quasi Peak                               | 438 kHz    | 34.39      | -22.70 |          |
| 2 Average                                  | 658 kHz    | 31.14      | -14.85 |          |
| 2 Average                                  | 1.078 MHz  | 16.88      | -29.11 |          |
| 1 Quasi Peak                               | 1.086 MHz  | 28.76      | -27.24 |          |
| 1 Quasi Peak                               | 1.314 MHz  | 30.74      | -25.25 |          |
| 2 Average                                  | 1.314 MHz  | 25.23      | -20.76 |          |
| 1 Quasi Peak                               | 2.63 MHz   | 28.10      | -27.89 |          |
| 2 Average                                  | 2.63 MHz   | 20.97      | -25.02 |          |
| 1 Quasi Peak                               | 3.634 MHz  | 23.45      | -32.54 |          |
| 2 Average                                  | 4.602 MHz  | 16.07      | -29.92 |          |
| 2 Average                                  | 6.574 MHz  | 14.10      | -35.89 |          |
| 1 Quasi Peak                               | 7.238 MHz  | 19.39      | -40.61 |          |
| 2 Average                                  | 15.118 MHz | 14.35      | -35.64 |          |
| 1 Quasi Peak                               | 17.534 MHz | 21.44      | -38.55 |          |
| 1 Quasi Peak                               | 20.422 MHz | 27.97      | -32.02 |          |
| 2 Average                                  | 21.158 MHz | 21.09      | -28.90 |          |

Date: 26.JUN.2019 07:27:17

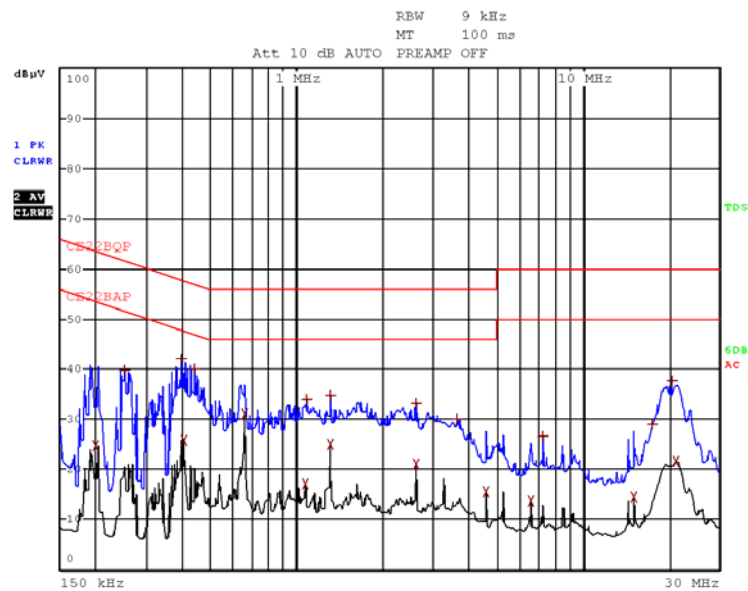
**Figure 11. Detectors: Peak, Quasi-peak, Average**

*Note: QP Delta/Av Delta refers to the test results obtained minus specified requirement; thus a positive number indicates failure, and a negative result indicates that the product passes the test.*

## Conducted Emission

E.U.T Description Poultry House  
Monitoring Equipment  
Type ECHO  
Serial Number: 0519.08928

Specification: FCC Part 15, Subpart C;  
RSS Gen, Issue 5, Clause 8.8  
Lead: Phase  
Detectors: Peak, Quasi-peak, Average  
Power Operation AC/DC Adapter



Date: 26.JUN.2019 07:24:30

Figure 12. Detectors: Peak, Quasi-peak, Average

## Conducted Emission

E.U.T Description Poultry House  
Monitoring Equipment  
Type ECHO  
Serial Number: 0519.08928

Specification: FCC Part 15, Subpart C;  
RSS Gen, Issue 5, Clause 8.8  
Lead: Neutral  
Detectors: Peak, Quasi-peak, Average  
Power Operation AC/DC Adapter

| EDIT PEAK LIST (Final Measurement Results) |            |            |        |          |
|--------------------------------------------|------------|------------|--------|----------|
| Trace1:                                    | CE22BQP    |            |        |          |
| Trace2:                                    | CE22BAP    |            |        |          |
| Trace3:                                    | ---        |            |        |          |
| TRACE                                      | FREQUENCY  | LEVEL dBμV | DELTA  | LIMIT dB |
| 1 Quasi Peak                               | 182 kHz    | 36.51      | -27.87 |          |
| 2 Average                                  | 202 kHz    | 22.58      | -30.94 |          |
| 2 Average                                  | 402 kHz    | 26.20      | -21.60 |          |
| 1 Quasi Peak                               | 406 kHz    | 37.78      | -19.94 |          |
| 1 Quasi Peak                               | 658 kHz    | 36.45      | -19.54 |          |
| 2 Average                                  | 658 kHz    | 31.22      | -14.78 |          |
| 2 Average                                  | 1.082 MHz  | 15.29      | -30.70 |          |
| 1 Quasi Peak                               | 1.154 MHz  | 26.34      | -29.65 |          |
| 2 Average                                  | 1.314 MHz  | 25.79      | -20.20 |          |
| 1 Quasi Peak                               | 1.318 MHz  | 28.41      | -27.58 |          |
| 1 Quasi Peak                               | 2.502 MHz  | 25.28      | -30.71 |          |
| 2 Average                                  | 2.63 MHz   | 21.35      | -24.64 |          |
| 1 Quasi Peak                               | 4.602 MHz  | 24.78      | -31.21 |          |
| 2 Average                                  | 4.602 MHz  | 16.97      | -29.02 |          |
| 2 Average                                  | 6.574 MHz  | 14.42      | -35.57 |          |
| 1 Quasi Peak                               | 7.226 MHz  | 19.67      | -40.33 |          |
| 1 Quasi Peak                               | 17.586 MHz | 24.11      | -35.89 |          |
| 2 Average                                  | 17.614 MHz | 16.27      | -33.72 |          |
| 1 Quasi Peak                               | 19.062 MHz | 30.73      | -29.27 |          |
| 2 Average                                  | 19.59 MHz  | 22.54      | -27.45 |          |

Date: 26.JUN.2019 07:36:46

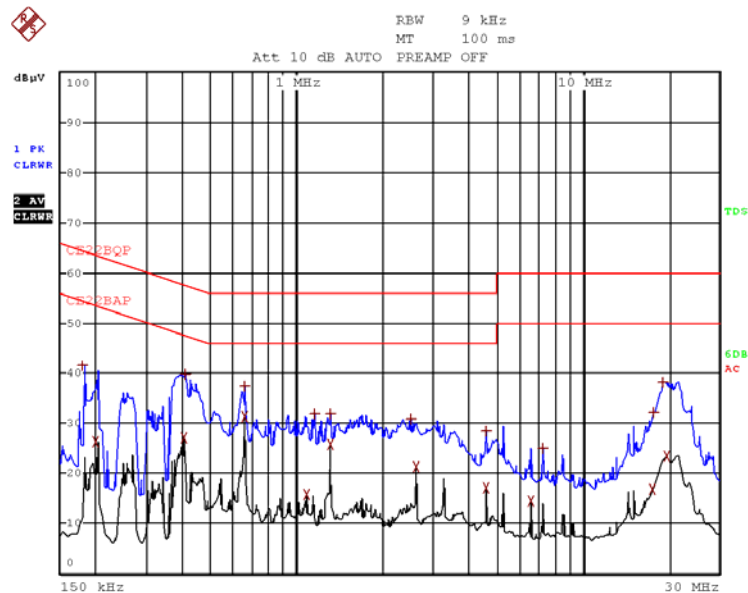
**Figure 13. Detectors: Peak, Quasi-peak, Average**

*Note: QP Delta/Av Delta refers to the test results obtained minus specified requirement; thus a positive number indicates failure, and a negative result indicates that the product passes the test.*

## Conducted Emission

E.U.T Description    Poultry House  
Monitoring Equipment  
Type                    ECHO  
Serial Number:        0519.08928

Specification:        FCC Part 15, Subpart C;  
RSS Gen, Issue 5, Clause 8.8  
Lead:                   Neutral  
Detectors:            Peak, Quasi-peak, Average  
Power Operation      AC/DC Adapter



Date: 26.JUN.2019 07:33:02

Figure 14 Detectors: Peak, Quasi-peak, Average



#### 4.5 Test Equipment Used; Conducted Emission

| Instrument               | Manufacturer        | Model        | Serial No. | Last Calibration Date | Next Calibration Due |
|--------------------------|---------------------|--------------|------------|-----------------------|----------------------|
| LISN                     | Fischer             | FCC-LISN-25A | 127        | July 20, 2017         | July 31, 2019        |
| Transient Limiter        | HP                  | 11947A       | 3107A03042 | June 25, 2018         | June 30, 2019        |
| EMI Receiver             | Rohde & Schwarz     | ESCI7        | 100724     | February 27, 2019     | February 28, 2020    |
| Cable CE Chamber 3M + 3M | Testline 18 + RJ214 | 11556        | -          | March 31, 2019        | March 31, 2020       |

**Figure 15 Test Equipment Used**

## **5. 6 dB Minimum Bandwidth**

### **5.1 Test Specification**

FCC Part 15, Subpart C, Section 247(a)(2)

RSS 247, Issue 2, Section 5.2(a)

### **5.2 Test Procedure**

(Temperature (21°C)/ Humidity (63%RH))

The E.U.T operation mode and test set-up are as described in Section 2 of this report.

The E.U.T. antenna terminal was connected to the Spectrum Analyzer through an external attenuator and an appropriate coaxial cable (total loss=31.0 dB). Special attention was taken to prevent Spectrum Analyzer RF input overload.

The spectrum bandwidth of the E.U.T. at the point of 6 dB below maximum peak power was measured and recorded. The RBW was set to 100 kHz.

### **5.3 Test Limit**

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.

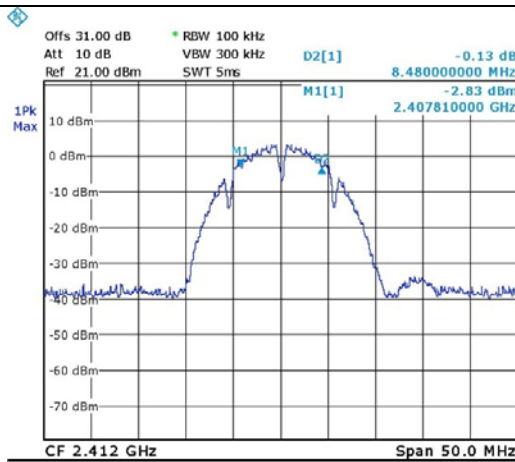
#### 5.4 Test Results

| Protocol Type      | Operating Frequency | Reading  | Limit  |
|--------------------|---------------------|----------|--------|
|                    | (MHz)               | (kHz)    | (kHz)  |
| Wi-fi/b(1Mbit/s)   | 2412.0              | 8480.0   | >500.0 |
|                    | 2437.0              | 8580.0   | >500.0 |
|                    | 2462.0              | 9580.0   | >500.0 |
| Wi-fi/b(11Mbit/s)  | 2412.0              | 8780.0   | >500.0 |
|                    | 2437.0              | 8180.0   | >500.0 |
|                    | 2462.0              | 8280.0   | >500.0 |
| Wi-fi/g(6Mbit/s)   | 2412.0              | 14,970.0 | >500.0 |
|                    | 2437.0              | 14,270.0 | >500.0 |
|                    | 2462.0              | 15,170.0 | >500.0 |
| Wi-fi/g(54Mbit/s)  | 2412.0              | 16,370.0 | >500.0 |
|                    | 2437.0              | 16,370.0 | >500.0 |
|                    | 2462.0              | 16,470.0 | >500.0 |
| Wi-fi/n(6.5Mbit/s) | 2412.0              | 16,470.0 | >500.0 |
|                    | 2437.0              | 14,930.0 | >500.0 |
|                    | 2462.0              | 15,170.0 | >500.0 |
| Wi-fi/n(65Mbit/s)  | 2412.0              | 17,660.0 | >500.0 |
|                    | 2437.0              | 17,610.0 | >500.0 |
|                    | 2462.0              | 17,760.0 | >500.0 |

**Figure 16 6 dB Minimum Bandwidth**

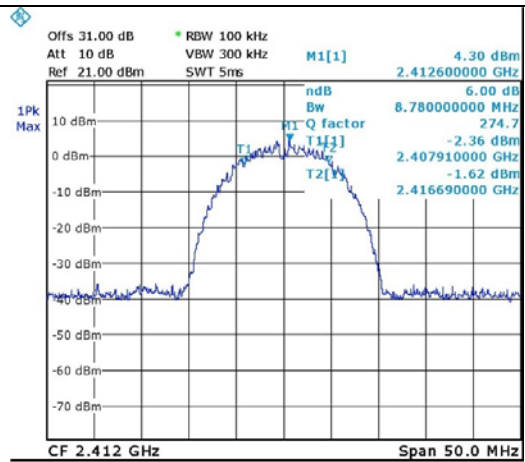
JUDGEMENT: Passed

For additional information see *Figure 17* to *Figure 34*.



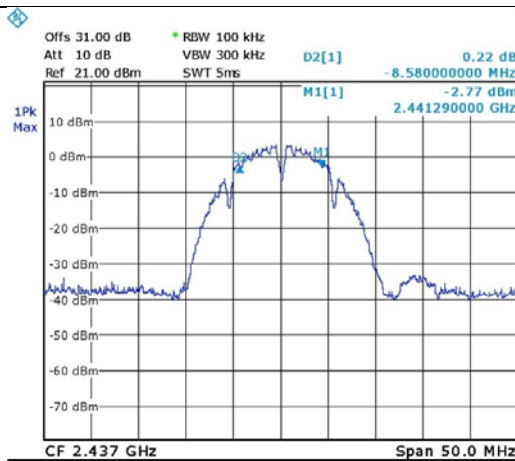
Date: 12.JUN.2019 07:52:25

Figure 17. 2412.0 MHz, Wi-fi/b(1Mbit/s)



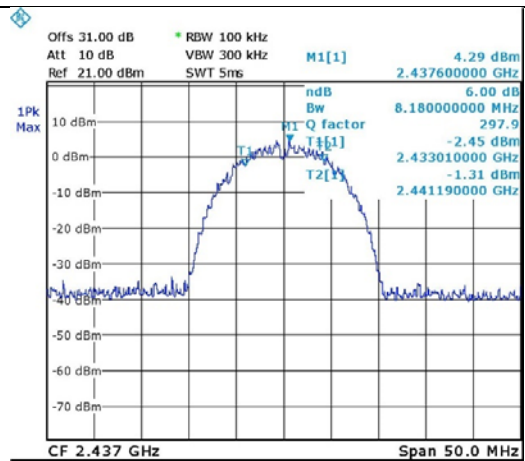
Date: 12.JUN.2019 08:00:19

Figure 18. 2412.0 MHz, Wi-fi/b(11Mbit/s)



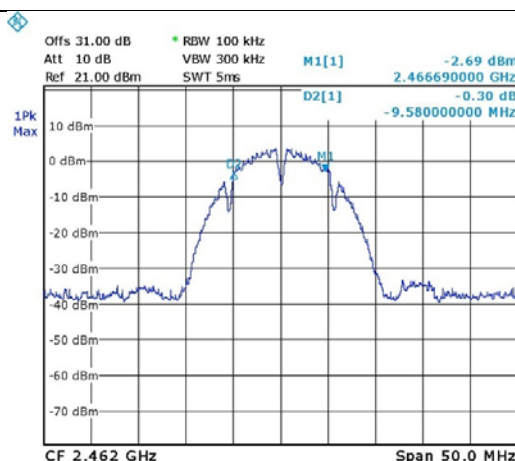
Date: 12.JUN.2019 07:54:08

Figure 19. 2437.0 MHz, Wi-fi/b(1Mbit/s)



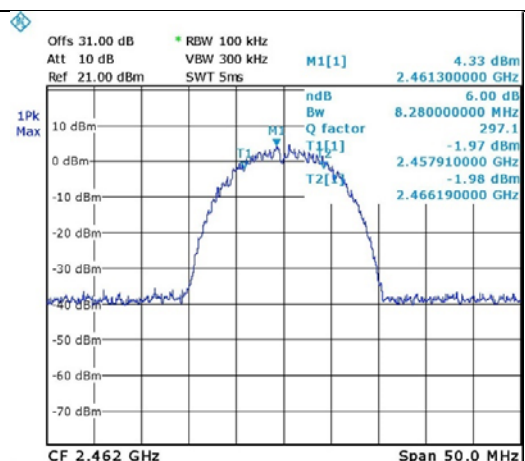
Date: 12.JUN.2019 07:58:58

Figure 20. 2437.0 MHz, Wi-fi/b(11Mbit/s)



Date: 12.JUN.2019 07:56:55

Figure 21. 2462.0 MHz, Wi-fi/b(1Mbit/s)



Date: 12.JUN.2019 07:57:58

Figure 22. 2462.0 MHz, Wi-fi/b(11Mbit/s)

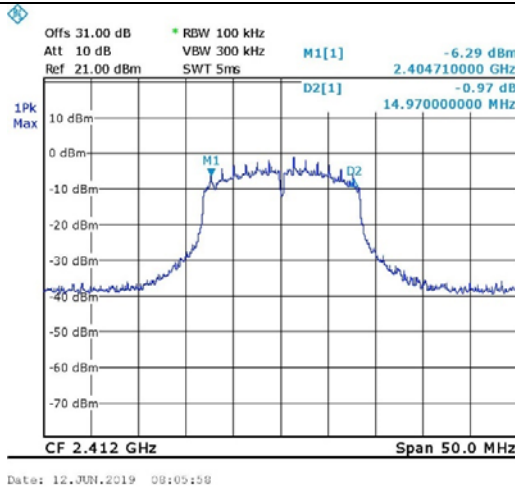


Figure 23. 2412.0 MHz, Wi-fi/g(6Mbit/s)

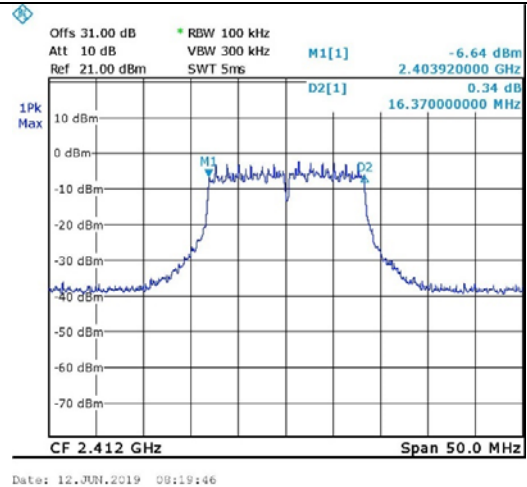


Figure 24. 2412.0 MHz, Wi-fi/g(54Mbit/s)

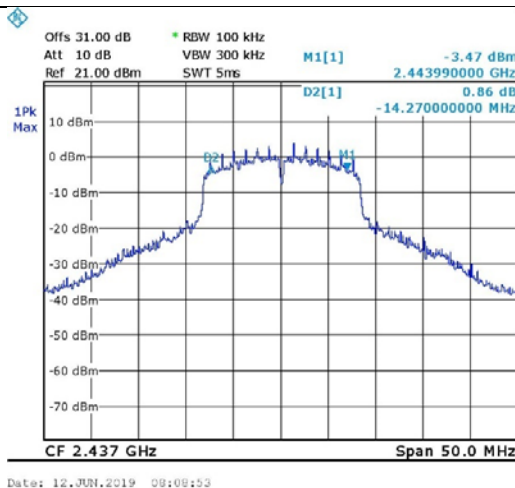


Figure 25. 2437.0 MHz, Wi-fi/g(6Mbit/s)

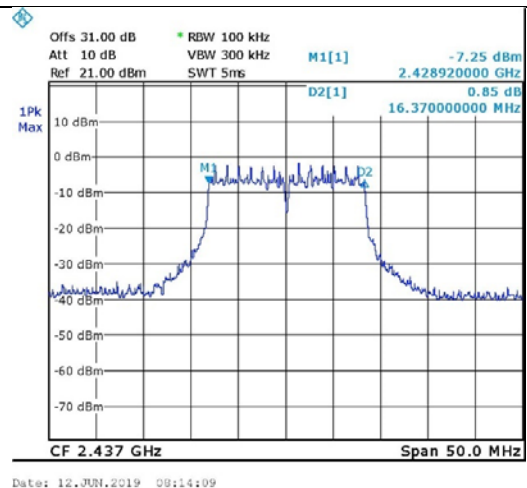


Figure 26. 2437.0 MHz, Wi-fi/g(54Mbit/s)

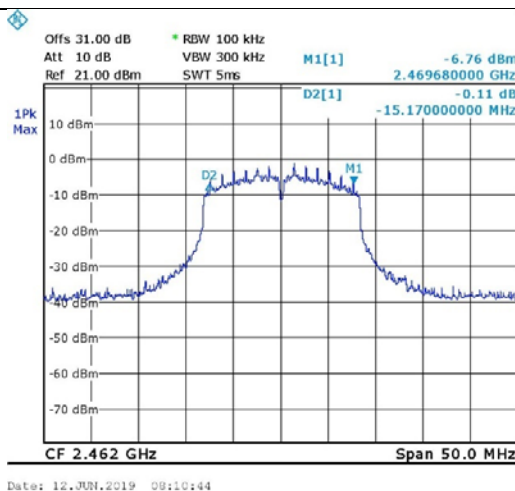


Figure 27. 2462.0 MHz, Wi-fi/g(6Mbit/s)

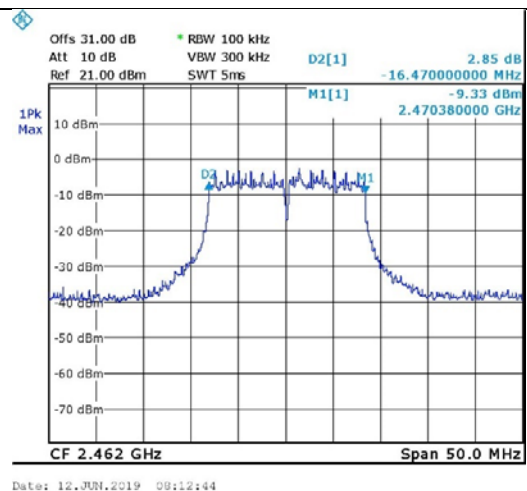
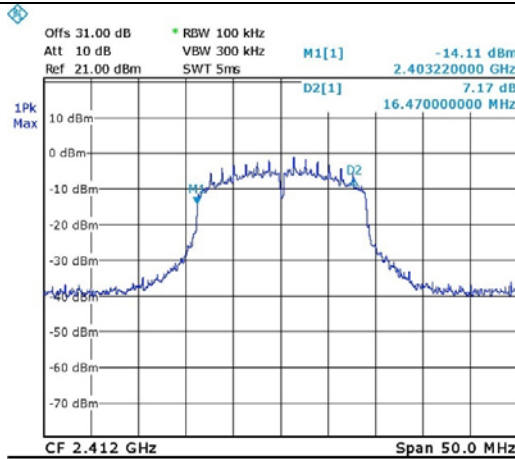
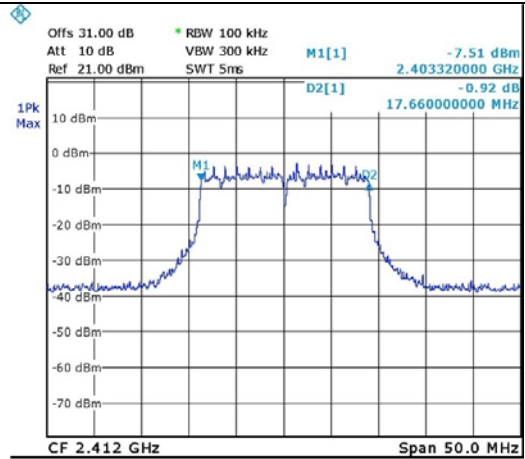


Figure 28. 2462.0 MHz, Wi-fi/g(54Mbit/s)



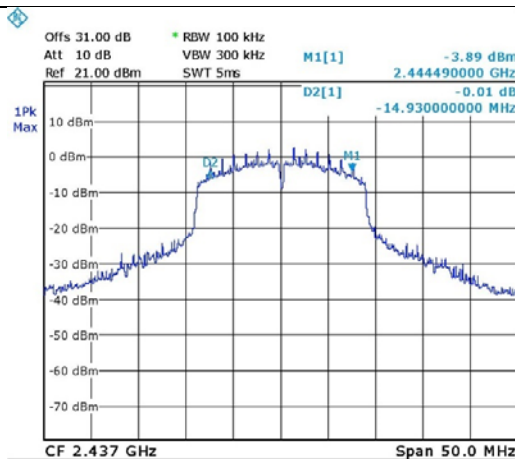
Date: 12.JUN.2019 08:22:04

Figure 29. 2412.0 MHz, Wi-fi/n(6.5Mbit/s)



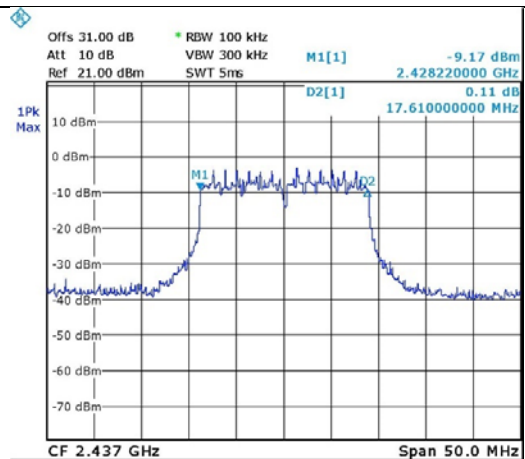
Date: 12.JUN.2019 08:49:02

Figure 30. 2412.0 MHz, Wi-fi/n(65Mbit/s)



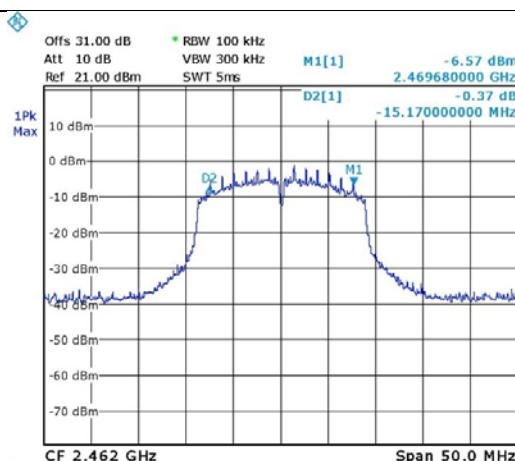
Date: 12.JUN.2019 08:24:29

Figure 31. 2437.0 MHz, Wi-fi/n(6.5Mbit/s)



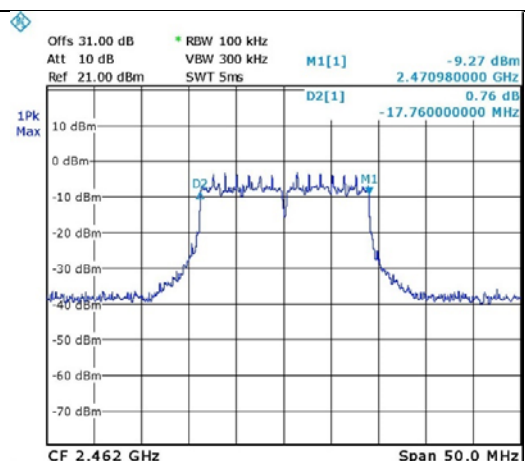
Date: 12.JUN.2019 08:30:33

Figure 32. 2437.0 MHz, Wi-fi/n(65Mbit/s)



Date: 12.JUN.2019 08:26:28

Figure 33. 2462.0 MHz, Wi-fi/n(6.5Mbit/s)



Date: 12.JUN.2019 08:28:33

Figure 34. 2462.0 MHz, Wi-fi/n(65Mbit/s)



### 5.5 Test Equipment Used; 6dB Bandwidth

| Instrument        | Manufacturer | Model     | Serial No. | Last Calibration Date | Next Calibration Due |
|-------------------|--------------|-----------|------------|-----------------------|----------------------|
| Spectrum Analyzer | R&S          | FSL6      | 100194     | March 24, 2019        | March 31, 2020       |
| 30dB Attenuator   | MCL          | BW-S30W5  | 533        | December 24, 2018     | December 31, 2019    |
| RF Cable          | Huber Suner  | Sucofelex | 28239/4PEA | December 24, 2018     | December 31, 2019    |

**Figure 35 Test Equipment Used**

## 6. Maximum Conducted Output Power

### 6.1 Test Specification

FCC, Part 15, Subpart C, Section 247(b)(3)

RSS 247, Issue 2, Section 5.4(d)

### 6.2 Test Procedure

(Temperature (21°C)/ Humidity (63%RH))

The E.U.T operation mode and test set-up are as described in Section 2 of this report.

The E.U.T. antenna terminal was connected to the Spectrum Analyzer through an external attenuator and an appropriate coaxial cable (total loss=31.0 dB). Special attention was taken to prevent Spectrum Analyzer RF input overload.

### 6.3 Test Limit

The maximum peak conducted output power of the intentional radiator for systems using digital modulation in the 902-928 MHz, 2400-2483.5 MHz, and 5725-5850 MHz bands: 1 Watt.

#### 6.4 Test Results

| Protocol Type      | Operation Frequency | Power | Power  | Limit  | Margin   |
|--------------------|---------------------|-------|--------|--------|----------|
|                    | (MHz)               | (dBm) | (mW)   | (mW)   | (mW)     |
| Wi-fi/b(1Mbit/s)   | 2412.0              | 17.9  | 61.66  | 1000.0 | -938.34  |
|                    | 2437.0              | 18.0  | 63.10  | 1000.0 | -936.90  |
|                    | 2462.0              | 18.0  | 63.10  | 1000.0 | -936.90  |
| Wi-fi/b(11Mbit/s)  | 2412.0              | 20.3  | 107.15 | 1000.0 | -892.85  |
|                    | 2437.0              | 20.6  | 114.82 | 1000.0 | -885.18  |
|                    | 2462.0              | 21.0  | 125.89 | 1000.0 | -874.11  |
| Wi-fi/g(6Mbit/s)   | 2412.0              | 15.9  | 38.90  | 1000.0 | -961.10  |
|                    | 2437.0              | 20.5  | 112.20 | 1000.0 | -887.8   |
|                    | 2462.0              | 16.1  | 40.74  | 1000.0 | -959.26  |
| Wi-fi/g(54Mbit/s)  | 2412.0              | 16.1  | 40.74  | 1000.0 | -959.26  |
|                    | 2437.0              | 16.5  | 44.67  | 1000.0 | -955.33  |
|                    | 2462.0              | 16.5  | 44.67  | 1000.0 | -955.33  |
| Wi-fi/n(6.5Mbit/s) | 2412.0              | 15.9  | 38.90  | 1000.0 | -961.10  |
|                    | 2437.0              | 19.3  | 85.11  | 1000.0 | -914.89  |
|                    | 2462.0              | 15.6  | 36.31  | 1000.0 | -963.69  |
| Wi-fi/n(65Mbit/s)  | 2412.0              | 15.2  | 33.11  | 1000.0 | -966.89  |
|                    | 2437.0              | 14.8  | 30.20  | 1000.0 | -969.8.0 |
|                    | 2462.0              | 15.1  | 32.36  | 1000.0 | -967.64  |

**Figure 36 Maximum Peak Power Output**

JUDGEMENT: Passed by 874.11 mW

For additional information see *Figure 37* to *Figure 54*.

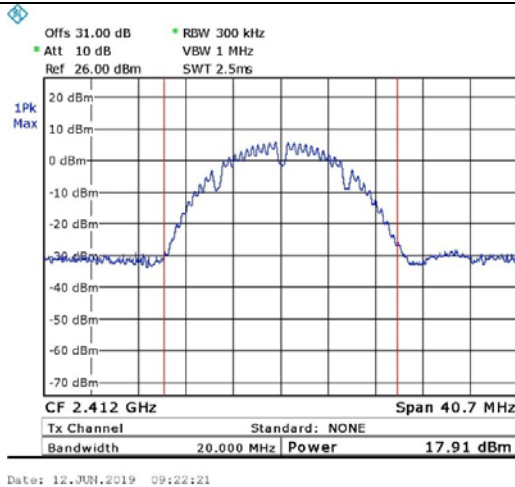


Figure 37. 2412.0 MHz, Wi-fi/b(1Mbit/s)

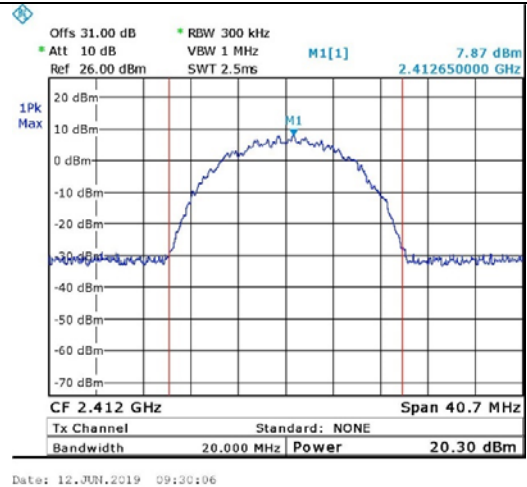


Figure 38. 2412.0 MHz, Wi-fi/b(11Mbit/s)

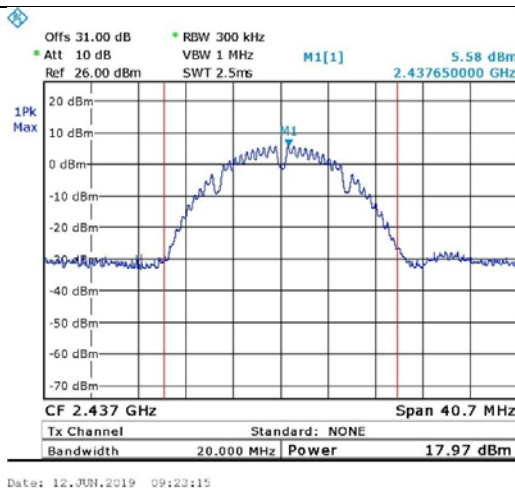


Figure 39. 2437.0 MHz, Wi-fi/b(1Mbit/s)

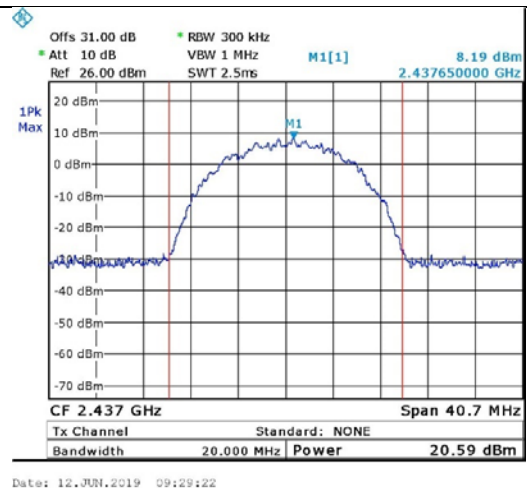


Figure 40. 2437.0 MHz, Wi-fi/b(11Mbit/s)

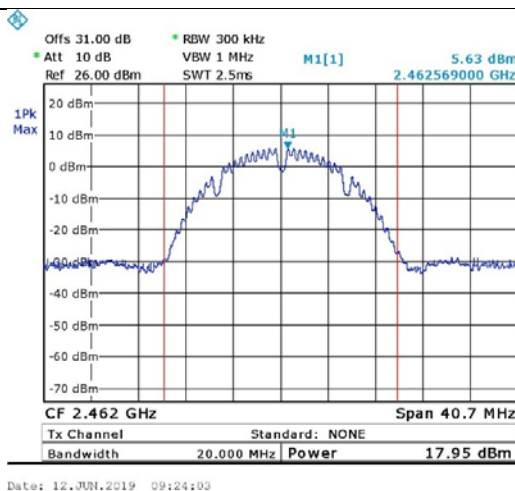


Figure 41. 2462.0 MHz, Wi-fi/b(1Mbit/s)

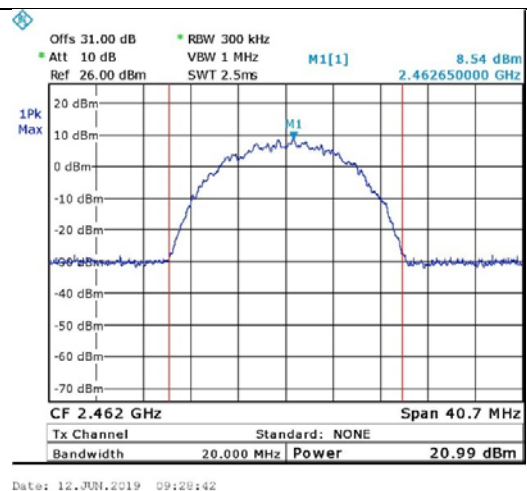


Figure 42. 2462.0 MHz, Wi-fi/b(11Mbit/s)

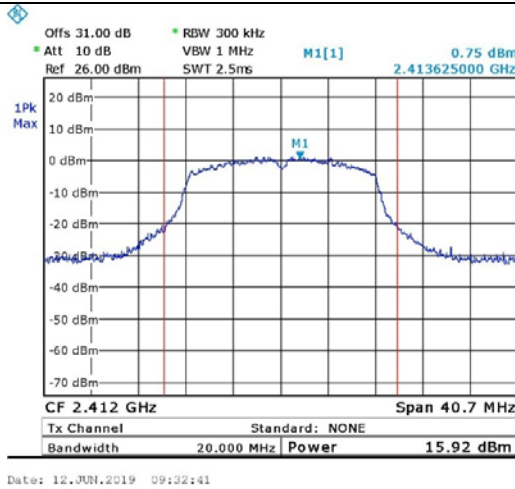


Figure 43. 2412.0 MHz, Wi-fi/g(6Mbit/s)

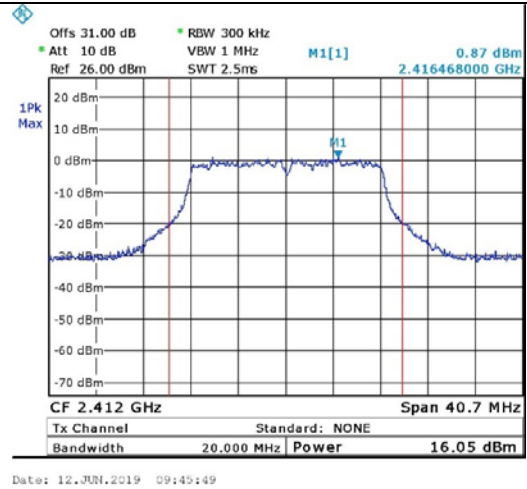


Figure 44. 2412.0 MHz, Wi-fi/g(54Mbit/s)

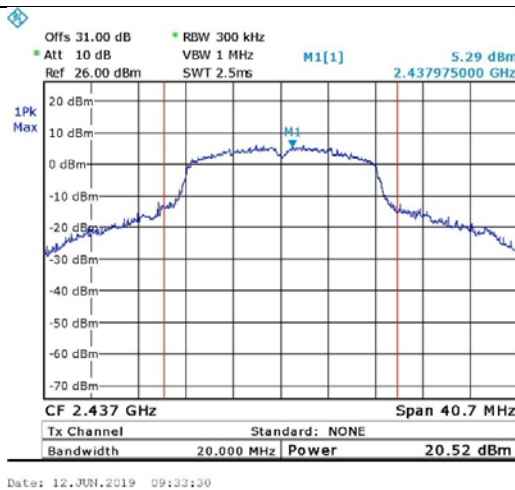


Figure 45. 2437.0 MHz, Wi-fi/g(6Mbit/s)

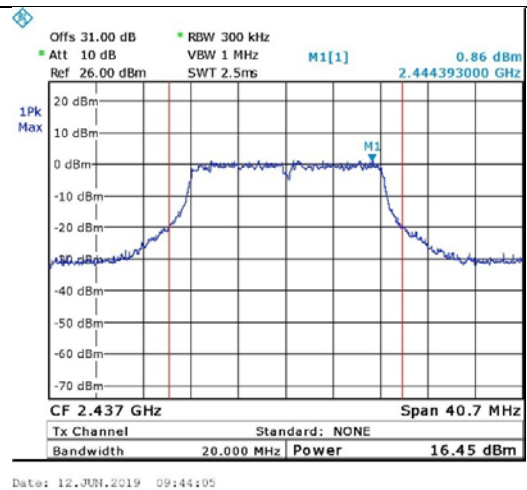


Figure 46. 2437.0 MHz, Wi-fi/g(54Mbit/s)

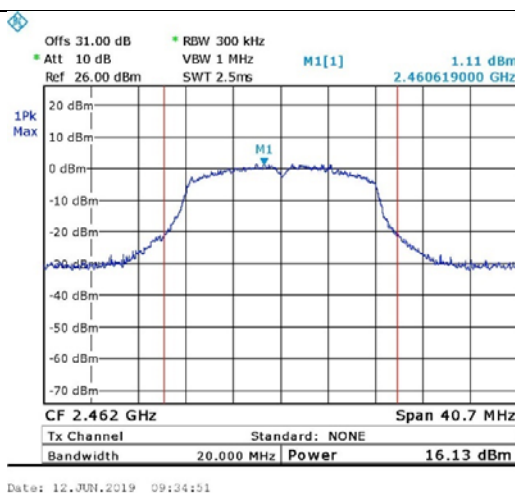


Figure 47. 2462.0 MHz, Wi-fi/g(6Mbit/s)

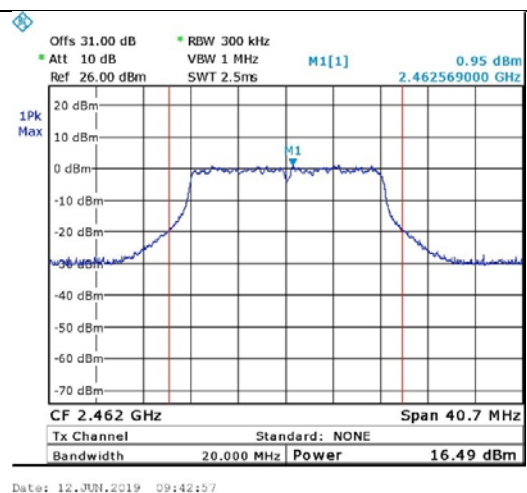
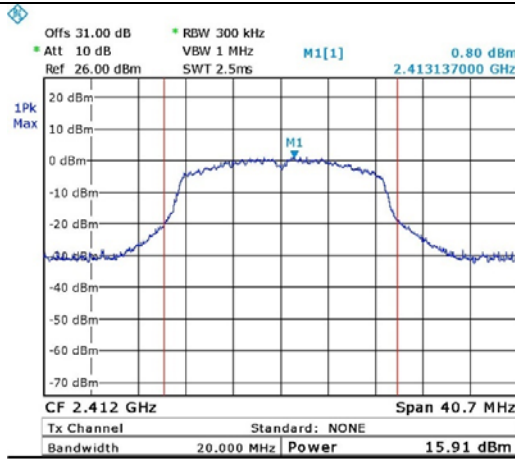
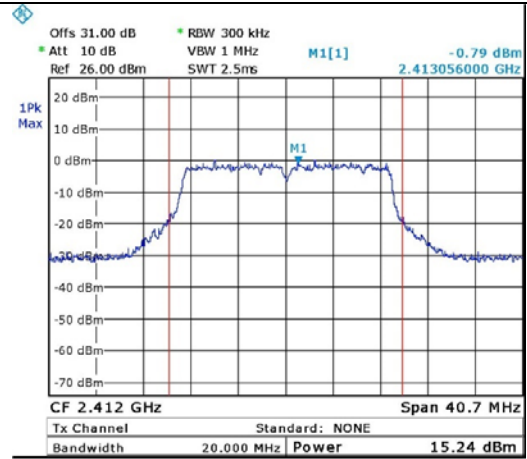


Figure 48. 2462.0 MHz, Wi-fi/g(54Mbit/s)



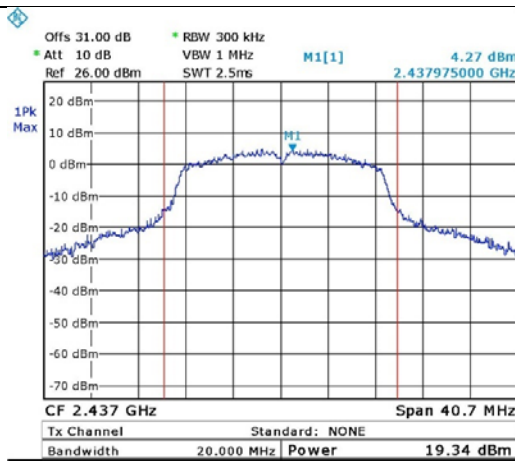
Date: 12.JUN.2019 09:47:26

Figure 49. 2412.0 MHz, Wi-fi/n(6.5Mbit/s)



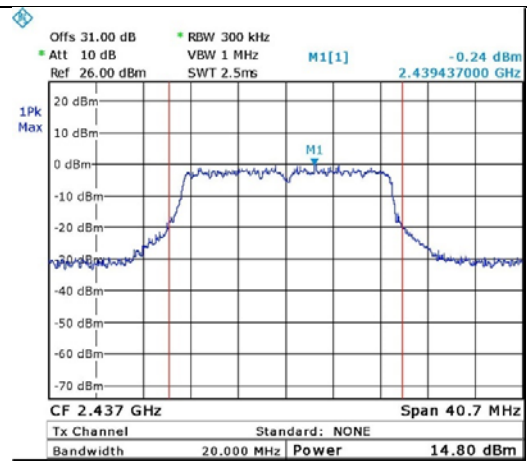
Date: 12.JUN.2019 09:52:41

Figure 50. 2412.0 MHz, Wi-fi/n(65Mbit/s)



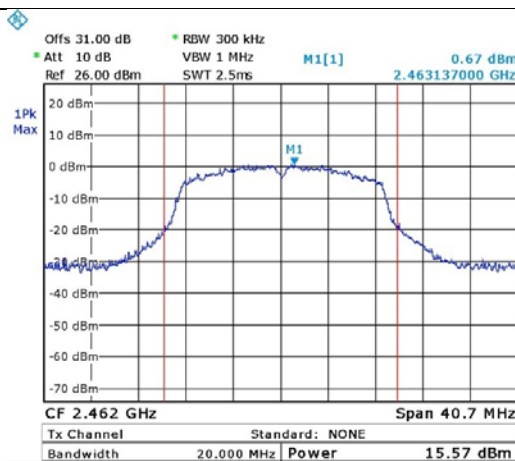
Date: 12.JUN.2019 09:48:08

Figure 51. 2437.0 MHz, Wi-fi/n(6.5Mbit/s)



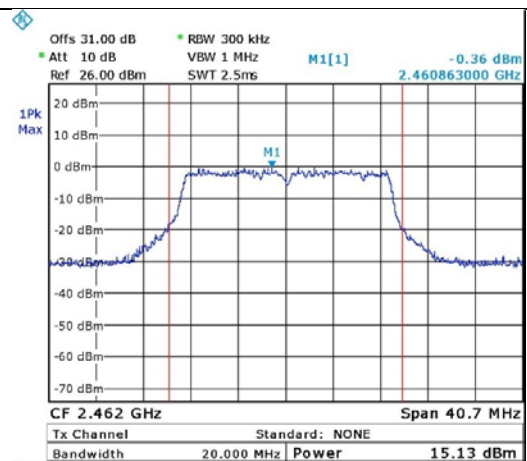
Date: 12.JUN.2019 09:51:14

Figure 52. 2437.0 MHz, Wi-fi/n(65Mbit/s)



Date: 12.JUN.2019 09:48:48

Figure 53. 2462.0 MHz, Wi-fi/n(6.5Mbit/s)



Date: 12.JUN.2019 09:50:21

Figure 54. 2462.0 MHz, Wi-fi/n(65Mbit/s)



### 6.5 Test Equipment Used; Maximum Peak Power Output

| Instrument        | Manufacturer | Model     | Serial No. | Last Calibration Date | Next Calibration Due |
|-------------------|--------------|-----------|------------|-----------------------|----------------------|
| Spectrum Analyzer | R&S          | FSL6      | 100194     | March 24, 2019        | March 31, 2020       |
| 30dB Attenuator   | MCL          | BW-S30W5  | 533        | December 24, 2018     | December 31, 2019    |
| RF Cable          | Huber Suner  | Sucofelex | 28239/4PEA | December 24, 2018     | December 31, 2019    |

Figure 55 Test Equipment Used

## 7. Band Edge Spectrum

### 7.1 Test Specification

FCC, Part 15, Subpart C, Section 247(d)

RSS 247, Issue 2, Section 5.5

### 7.2 Test Procedure

(Temperature (21°C)/ Humidity (63%RH))

The E.U.T operation mode and test set-up are as described in Section 2 of this report.

The E.U.T. antenna terminal was connected to the Spectrum Analyzer through an external attenuator and an appropriate coaxial cable (total loss=31.0 dB). Special attention was taken to prevent Spectrum Analyzer RF input overload.

The RBW was set to 100 kHz.

### 7.3 Test Limit

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.

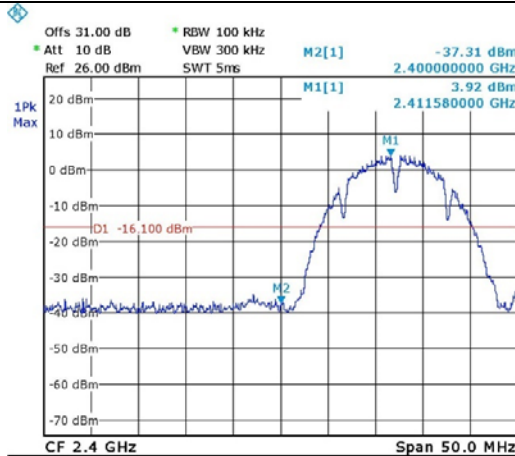
## 7.4 Test Results

| Protocol Type      | Operation Frequency | Band Edge Frequency | Spectrum Level | Limit | Margin |
|--------------------|---------------------|---------------------|----------------|-------|--------|
|                    | (MHz)               | (MHz)               | (dBm)          | (dBm) | (dB)   |
| Wi-fi/b(1Mbit/s)   | 2412.0              | 2400.0              | -37.3          | -16.1 | -21.2  |
|                    | 2462.0              | 2483.5              | -38.7          | -16.3 | -22.4  |
| Wi-fi/b(11Mbit/s)  | 2412.0              | 2400.0              | -38.7          | -15.3 | -23.4  |
|                    | 2462.0              | 2483.5              | -37.8          | -14.9 | -22.9  |
| Wi-fi/g(6Mbit/s)   | 2412.0              | 2400.0              | -33.3          | -21.2 | -12.1  |
|                    | 2462.0              | 2483.5              | -38.8          | -21.2 | -17.6  |
| Wi-Fi/g(54Mbit/s)  | 2412.0              | 2400.0              | -33.5          | -22.5 | -11.0  |
|                    | 2462.0              | 2483.5              | -38.1          | -22.7 | -15.4  |
| Wi-Fi/n(6.5Mbit/s) | 2412.0              | 2400.0              | -33.7          | -21.1 | -12.6  |
|                    | 2462.0              | 2483.5              | -38.0          | -21.2 | -16.8  |
| Wi-fi/n(65Mbit/s)  | 2412.0              | 2400.0              | -33.9          | -23.0 | -10.9  |
|                    | 2462.0              | 2483.5              | -38.3          | -23.3 | -15.0  |

Figure 56 Band Edge Spectrum

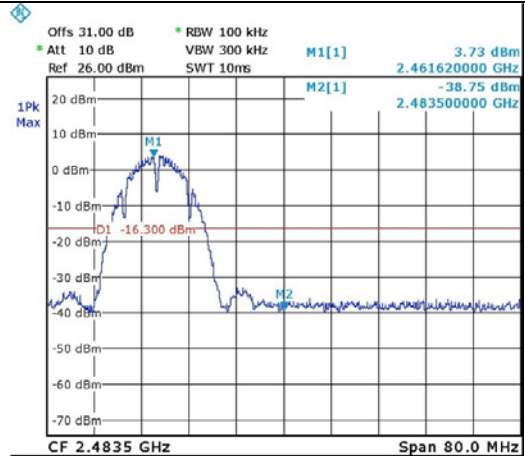
JUDGEMENT: Passed by 10.9 dB

For additional information see *Figure 57* to *Figure 68*.



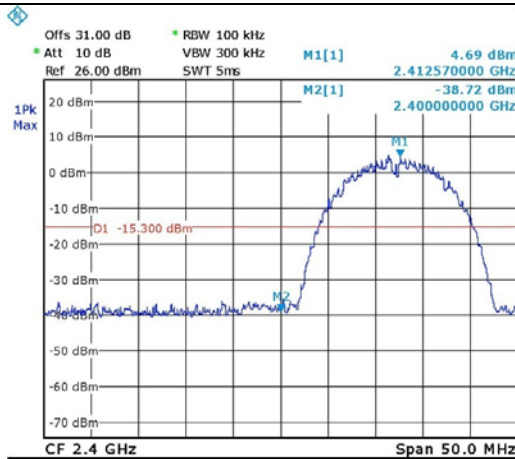
Date: 12.JUN.2019 10:26:46

Figure 57. 2412.0 MHz, Wi-fi/b(1Mbit/s)



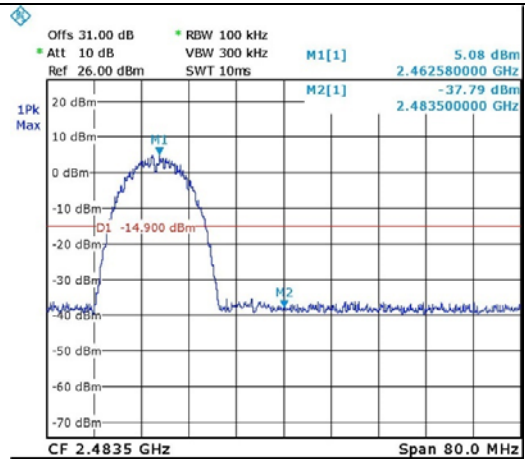
Date: 12.JUN.2019 10:43:37

Figure 58. 2462.0 MHz, Wi-fi/b(1Mbit/s)



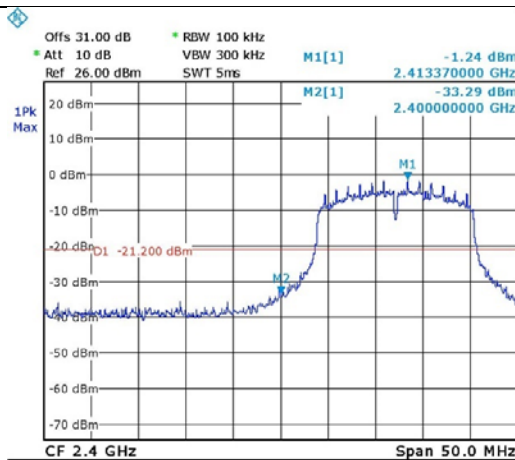
Date: 12.JUN.2019 10:28:10

Figure 59. 2412.0 MHz, Wi-fi/b(11Mbit/s)



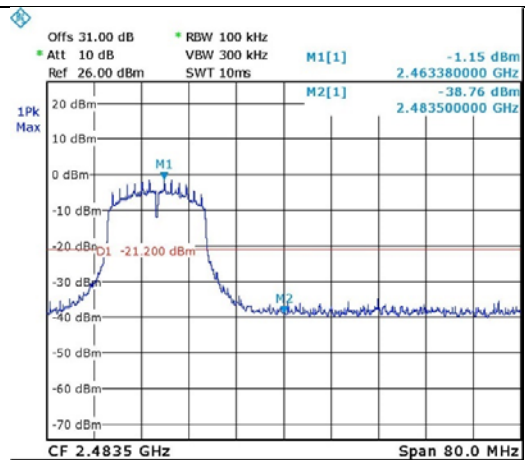
Date: 12.JUN.2019 10:42:34

Figure 60. 2462.0 MHz, Wi-fi/b(11Mbit/s)



Date: 12.JUN.2019 10:29:51

Figure 61. 2412.0 MHz, Wi-fi/g(6Mbit/s)



Date: 12.JUN.2019 10:41:28

Figure 62. 2462.0 MHz, Wi-fi/g(6Mbit/s)

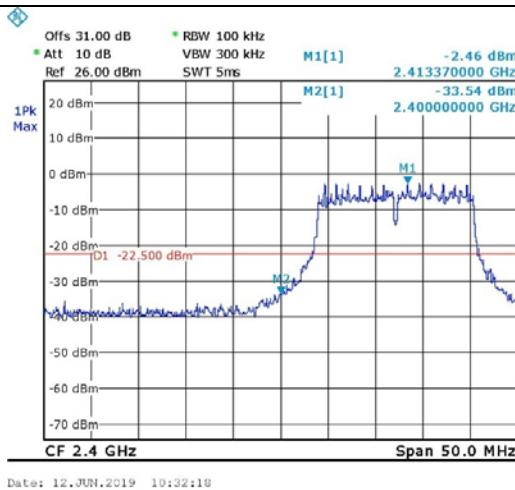


Figure 63. 2412.0 MHz, Wi-fi/g(54Mbit/s)

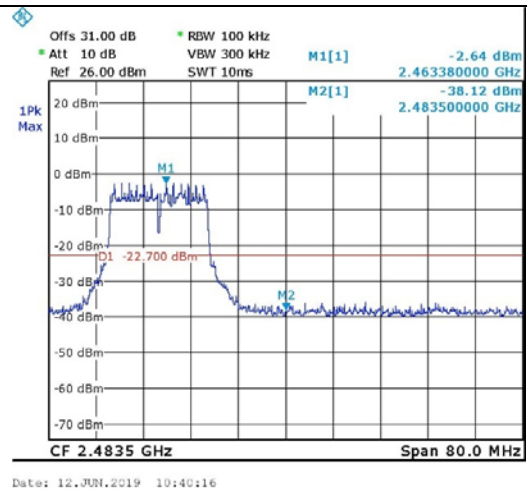


Figure 64. 2462.0 MHz, Wi-fi/g(54Mbit/s)

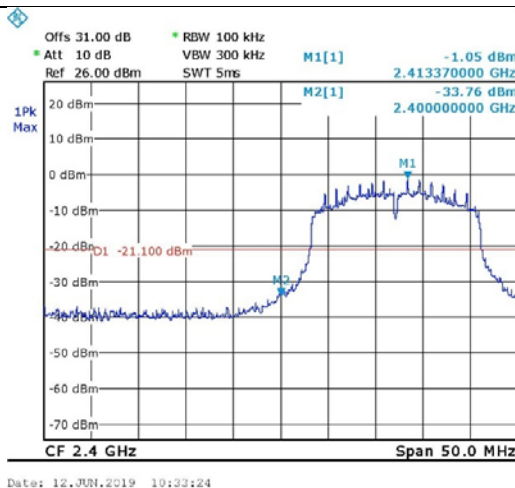


Figure 65. 2412.0 MHz, Wi-fi/n(6.5Mbit/s)

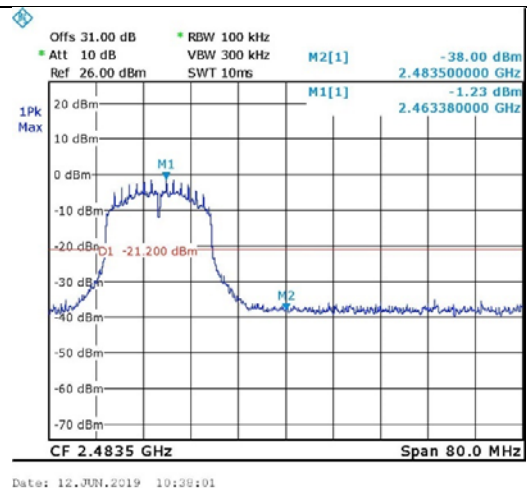


Figure 66. 2462.0 MHz, Wi-fi/n(6.5Mbit/s)

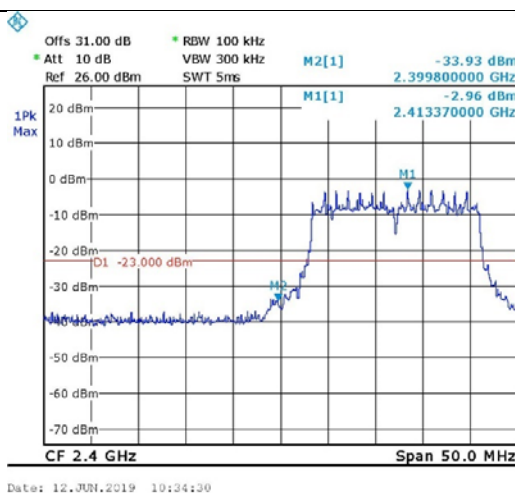


Figure 67. 2412.0 MHz, Wi-fi/n(65Mbit/s)

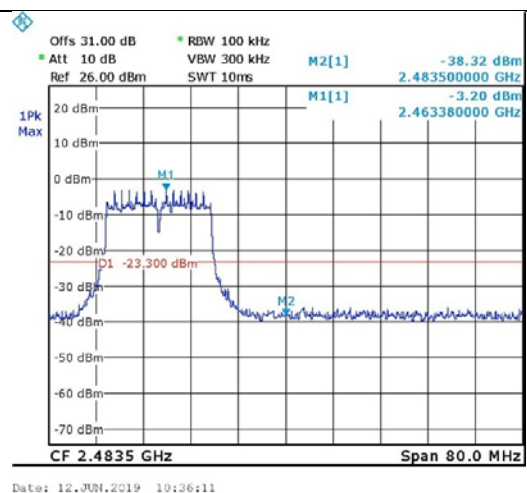


Figure 68. 2462.0 MHz, Wi-fi/n(65Mbit/s)



### 7.5 Test Equipment Used; Band Edge

| Instrument        | Manufacturer | Model     | Serial No.     | Last Calibration Date | Next Calibration Due |
|-------------------|--------------|-----------|----------------|-----------------------|----------------------|
| Spectrum Analyzer | R&S          | FSL6      | 100194         | March 24, 2019        | March 31, 2020       |
| 30dB Attenuator   | MCL          | BW-S30W5  | 533            | December 24, 2018     | December 31, 2019    |
| RF Cable          | Huber Suner  | Sucofelex | 28239/4PE<br>A | December 24, 2018     | December 31, 2019    |

**Figure 69 Test Equipment Used**