



# TEST REPORT

**Test Report No. : UL-RPT-RP11913492-2016A V2.0**

**Manufacturer** : Raspberry Pi (Trading) Ltd  
**Model No.** : Raspberry Pi 3 Model B+  
**FCC ID** : 2ABCB-RPI3BP  
**Technology** : WLAN  
**Test Standard(s)** : FCC Parts 15.207, 15.209(a) & 15.247

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2. The results in this report apply only to the sample(s) tested.
3. The sample tested is in compliance with the above standard(s).
4. The test results in this report are traceable to the national or international standards.
5. Version 2.0 supersedes all previous versions.

**Date of Issue:** 06 March 2018

**Checked by:**

Sarah Williams  
Senior Test Engineer, Radio Laboratory

**Company Signatory:**

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Senior Test Engineer, Radio Laboratory  
UL VS LTD



This laboratory is accredited by UKAS.  
The tests reported herein have been  
performed in accordance with its terms  
of accreditation.

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**1. Customer Information**

|                      |                                                           |
|----------------------|-----------------------------------------------------------|
| <b>Company Name:</b> | Raspberry Pi (Trading) Ltd                                |
| <b>Address:</b>      | 30 Station Road<br>Cambridge<br>CB1 2JH<br>United Kingdom |

## **2. Summary of Testing**

### **2.1. General Information**

|                                 |                                                                                                                                       |
|---------------------------------|---------------------------------------------------------------------------------------------------------------------------------------|
| <b>Specification Reference:</b> | 47CFR15.247                                                                                                                           |
| <b>Specification Title:</b>     | Code of Federal Regulations Volume 47 (Telecommunications):<br>Part 15 Subpart C (Intentional Radiators) - Section 15.247             |
| <b>Specification Reference:</b> | 47CFR15.207 and 47CFR15.209                                                                                                           |
| <b>Specification Title:</b>     | Code of Federal Regulations Volume 47 (Telecommunications):<br>Part 15 Subpart C (Intentional Radiators) - Sections 15.207 and 15.209 |
| <b>Site Registration:</b>       | 209735                                                                                                                                |
| <b>Location of Testing:</b>     | UL VS LTD, Unit 3 Horizon, Wade Road, Kingsland Business Park,<br>Basingstoke, Hampshire, RG24 8AH, United Kingdom                    |
| <b>Test Dates:</b>              | 09 January 2018 to 19 February 2018                                                                                                   |

### **2.2. Summary of Test Results**

| <b>FCC Reference (47CFR)</b>                                                                                                                                                                                                 | <b>Measurement</b>                         | <b>Result</b>                                                                         |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------|---------------------------------------------------------------------------------------|
| Part 15.207                                                                                                                                                                                                                  | Transmitter AC Conducted Emissions         |    |
| Part 15.247(a)(2)                                                                                                                                                                                                            | Transmitter Minimum 6 dB Bandwidth         |   |
| Part 15.35(c)                                                                                                                                                                                                                | Transmitter Duty Cycle                     | Note 1                                                                                |
| Part 15.247(e)                                                                                                                                                                                                               | Transmitter Power Spectral Density         |  |
| Part 15.247(b)(3)                                                                                                                                                                                                            | Transmitter Maximum (Average) Output Power |  |
| Part 15.247(d) & 15.209(a)                                                                                                                                                                                                   | Transmitter Radiated Emissions             |  |
| Part 15.247(d) & 15.209(a)                                                                                                                                                                                                   | Transmitter Band Edge Radiated Emissions   |  |
| <b>Key to Results</b><br> = Complied  = Did not comply |                                            |                                                                                       |

#### **Note(s):**

1. The measurement was performed to assist in the calculation of the level of maximum conducted output power, power spectral density and emissions. The EUT cannot transmit continuously and sweep triggering/signal gating cannot be implemented.

**2.3. Methods and Procedures**

|                   |                                                                                                                      |
|-------------------|----------------------------------------------------------------------------------------------------------------------|
| <b>Reference:</b> | ANSI C63.10-2013                                                                                                     |
| <b>Title:</b>     | American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices                       |
| <b>Reference:</b> | KDB 558074 D01 DTS Meas Guidance v04 April 5, 2017                                                                   |
| <b>Title:</b>     | Guidance for Performing Compliance Measurements on Digital Transmission Systems (DTS) Operating Under Section 15.247 |
| <b>Reference:</b> | KDB 174176 D01 Line Conducted FAQ v01r01 June 3, 2015                                                                |
| <b>Title:</b>     | AC Power-Line Conducted Emissions Frequently Asked Questions                                                         |

**2.4. Deviations from the Test Specification**

For the measurements contained within this test report, there were no deviations from, additions to, or exclusions from the test specification identified above.

### **3. Equipment Under Test (EUT)**

#### **3.1. Identification of Equipment Under Test (EUT)**

|                                   |                                                               |
|-----------------------------------|---------------------------------------------------------------|
| <b>Brand Name:</b>                | Raspberry Pi                                                  |
| <b>Model Name or Number:</b>      | Raspberry Pi 3 Model B+                                       |
| <b>Test Sample Serial Number:</b> | Not marked or stated ( <i>Conducted sample with RF port</i> ) |
| <b>Hardware Version:</b>          | V1.0                                                          |
| <b>Software Version:</b>          | 4.4                                                           |
| <b>FCC ID:</b>                    | 2ABCB-RPI3BP                                                  |

|                                   |                                                    |
|-----------------------------------|----------------------------------------------------|
| <b>Brand Name:</b>                | Raspberry Pi                                       |
| <b>Model Name or Number:</b>      | Raspberry Pi 3 Model B+                            |
| <b>Test Sample Serial Number:</b> | Not marked or stated ( <i>Radiated sample #1</i> ) |
| <b>Hardware Version:</b>          | V1.0                                               |
| <b>Software Version:</b>          | 4.4                                                |
| <b>FCC ID:</b>                    | 2ABCB-RPI3BP                                       |

|                                   |                                                    |
|-----------------------------------|----------------------------------------------------|
| <b>Brand Name:</b>                | Raspberry Pi                                       |
| <b>Model Name or Number:</b>      | Raspberry Pi 3 Model B+                            |
| <b>Test Sample Serial Number:</b> | Not marked or stated ( <i>Radiated sample #2</i> ) |
| <b>Hardware Version:</b>          | V1.1                                               |
| <b>Software Version:</b>          | 4.4                                                |
| <b>FCC ID:</b>                    | 2ABCB-RPI3BP                                       |

#### **3.2. Description of EUT**

The Equipment Under Test was a single board computer. It contains a *Bluetooth* and 2.4 & 5 GHz WLAN module powered from an AC/DC power supply. The antenna is integral.

#### **3.3. Modifications Incorporated in the EUT**

No modifications were applied to the EUT during testing.

**3.4. Additional Information Related to Testing**

|                                        |                                                       |                                    |
|----------------------------------------|-------------------------------------------------------|------------------------------------|
| <b>Technology Tested:</b>              | WLAN (IEEE 802.11b,g,n) / Digital Transmission System |                                    |
| <b>Type of Unit:</b>                   | Transceiver                                           |                                    |
| <b>Modulation Type:</b>                | DBPSK, DQPSK, BPSK, QPSK, 16QAM & 64QAM               |                                    |
| <b>Data Rates:</b>                     | 802.11b                                               | 1, 2, 5.5 & 11 Mbps                |
|                                        | 802.11g                                               | 6, 9, 12, 18, 24, 36, 48 & 54 Mbps |
|                                        | 802.11n HT20                                          | MCS0 to MCS7 (SISO)                |
|                                        | 802.11n HT40                                          | MCS0 to MCS7 (SISO)                |
| <b>Power Supply Requirement(s):</b>    | Nominal                                               | 5.0 VDC                            |
| <b>Maximum Conducted Output Power:</b> | 14.7 dBm                                              |                                    |
| <b>Declared Antenna Gain:</b>          | 3.5 dBi                                               |                                    |
| <b>Channel Spacing:</b>                | 20 MHz                                                |                                    |
| <b>Transmit Frequency Range:</b>       | 2412 MHz to 2462 MHz                                  |                                    |
| <b>Transmit Channels Tested:</b>       | <b>Channel Number</b>                                 | <b>Channel Frequency (MHz)</b>     |
|                                        | 1                                                     | 2412                               |
|                                        | 6                                                     | 2437                               |
|                                        | 11                                                    | 2462                               |
| <b>Channel Spacing:</b>                | 40 MHz                                                |                                    |
| <b>Transmit Frequency Range:</b>       | 2422 MHz to 2452 MHz                                  |                                    |
| <b>Transmit Channels Tested:</b>       | <b>Channel Number</b>                                 | <b>Channel Frequency (MHz)</b>     |
|                                        | 3                                                     | 2422                               |
|                                        | 9                                                     | 2452                               |

**3.5. Support Equipment**

The following support equipment was used to exercise the EUT during testing:

|                              |              |
|------------------------------|--------------|
| <b>Description:</b>          | LCD Monitor  |
| <b>Brand Name:</b>           | Asus         |
| <b>Model Name or Number:</b> | ProArt       |
| <b>Serial Number:</b>        | F4LMTF022693 |

|                              |                              |
|------------------------------|------------------------------|
| <b>Description:</b>          | USB Keyboard                 |
| <b>Brand Name:</b>           | Dell                         |
| <b>Model Name or Number:</b> | KB212-B                      |
| <b>Serial Number:</b>        | CN-0C643N-71616-42B-09XA-A00 |

**Support Equipment (continued)**

|                              |                      |
|------------------------------|----------------------|
| <b>Description:</b>          | USB Mouse            |
| <b>Brand Name:</b>           | Dell                 |
| <b>Model Name or Number:</b> | Not marked or stated |
| <b>Serial Number:</b>        | Not marked or stated |

|                              |                                            |
|------------------------------|--------------------------------------------|
| <b>Description:</b>          | Power Supply. 230 VAC Input / 5 VDC output |
| <b>Brand Name:</b>           | Strontronics Ltd                           |
| <b>Model Name or Number:</b> | DSA-13PFC-05                               |
| <b>Serial Number:</b>        | Not marked or stated                       |

|                              |                      |
|------------------------------|----------------------|
| <b>Description:</b>          | 16 GB Micro SD card  |
| <b>Brand Name:</b>           | SanDisk              |
| <b>Model Name or Number:</b> | HCI                  |
| <b>Serial Number:</b>        | Not marked or stated |

|                              |                                           |
|------------------------------|-------------------------------------------|
| <b>Description:</b>          | HDMI cable. Quantity 1. Length 1.9 metres |
| <b>Brand Name:</b>           | Not marked or stated                      |
| <b>Model Name or Number:</b> | Not marked or stated                      |
| <b>Serial Number:</b>        | Not marked or stated                      |

|                              |                                          |
|------------------------------|------------------------------------------|
| <b>Description:</b>          | USB cable. Quantity 4. Length 3.0 metres |
| <b>Brand Name:</b>           | Not marked or stated                     |
| <b>Model Name or Number:</b> | Not marked or stated                     |
| <b>Serial Number:</b>        | Not marked or stated                     |

|                              |                                               |
|------------------------------|-----------------------------------------------|
| <b>Description:</b>          | Ethernet cable. Quantity 1. Length 8.0 metres |
| <b>Brand Name:</b>           | Not marked or stated                          |
| <b>Model Name or Number:</b> | Not marked or stated                          |
| <b>Serial Number:</b>        | Not marked or stated                          |

|                              |                                               |
|------------------------------|-----------------------------------------------|
| <b>Description:</b>          | Ethernet cable. Quantity 1. Length 3.0 metres |
| <b>Brand Name:</b>           | Not marked or stated                          |
| <b>Model Name or Number:</b> | Not marked or stated                          |
| <b>Serial Number:</b>        | Not marked or stated                          |

**Support Equipment (continued)**

|                              |                                               |
|------------------------------|-----------------------------------------------|
| <b>Description:</b>          | Ethernet cable. Quantity 1. Length 1.0 metres |
| <b>Brand Name:</b>           | Not marked or stated                          |
| <b>Model Name or Number:</b> | Not marked or stated                          |
| <b>Serial Number:</b>        | Not marked or stated                          |

|                              |                      |
|------------------------------|----------------------|
| <b>Description:</b>          | PHF                  |
| <b>Brand Name:</b>           | Samsung              |
| <b>Model Name or Number:</b> | Not marked or stated |
| <b>Serial Number:</b>        | Not marked or stated |

|                              |                                   |
|------------------------------|-----------------------------------|
| <b>Description:</b>          | HDMI Hub                          |
| <b>Brand Name:</b>           | SUMVISION                         |
| <b>Model Name or Number:</b> | Cyclone Micro                     |
| <b>Serial Number:</b>        | SUM091104017 (UL Asset No. A1986) |

|                              |                      |
|------------------------------|----------------------|
| <b>Description:</b>          | USB Hub              |
| <b>Brand Name:</b>           | Belkein              |
| <b>Model Name or Number:</b> | Not marked or stated |
| <b>Serial Number:</b>        | Not marked or stated |

|                              |                 |
|------------------------------|-----------------|
| <b>Description:</b>          | Laptop PC       |
| <b>Brand Name:</b>           | Lenovo          |
| <b>Model Name or Number:</b> | L440            |
| <b>Serial Number:</b>        | R9-019EA1 14/04 |

|                              |               |
|------------------------------|---------------|
| <b>Description:</b>          | Ethernet Hub  |
| <b>Brand Name:</b>           | Netgear       |
| <b>Model Name or Number:</b> | DG834 V4      |
| <b>Serial Number:</b>        | 1PL596BD001A4 |

## **4. Operation and Monitoring of the EUT during Testing**

### **4.1. Operating Modes**

The EUT was tested in the following operating mode(s):

- Continuously transmitting with a modulated carrier at maximum power on the relevant channels as required using the supported data rates/modulation types.

### **4.2. Configuration and Peripherals**

The EUT was tested in the following configuration(s):

- The customer's test application and supplied instructions were used to place the EUT into WLAN test mode. The supplied commands were entered into the console menu on the EUT. Test commands stated in the wlan\_testing\_3.sh file located on the /home/pi drive of the EUT were used to configure the EUT to enable a continuous transmission and to select the test channels, data rates and modulation schemes as required.
- The customer declared the following data rates to be used for all measurements as:
  - o 802.11b - DBPSK / 1 Mbps / SISO
  - o 802.11g - BPSK / 6 Mbps / SISO
  - o 802.11n HT20 - BPSK / MCS0 / SISO
  - o 802.11n HT40 – BPSK / MCS0 / SISO
- Testing was performed using the customer declared power settings:
  - o 802.11b - 1 Mbps / power level 9
  - o 802.11g - 6 Mbps / power level 12
  - o 802.11n HT20 - MCS0 / power level 12
  - o 802.11n HT40 – MCS0 / power level 12
- The EUT was powered via an AC/DC switch mode power supply.
- AC conducted emissions test was tested with the EUT transmitting on the middle channel using a data rate of 6 Mbps (802.11g), as this mode was found to transmit the highest power.
- Transmitter spurious emissions were performed with the EUT transmitting with a data rate of 6 Mbps (802.11g). This was found to be the worst case modulation scheme with regards to emissions after preliminary investigations and as this mode emits the highest output power level, it was deemed to be the worst case.
- Radiated emissions tests pre-scans were initially checked in X,Y& Z orientations, while connected to its power supply. All active ports were terminated with suitable terminations. The worst case orientations were:
  - o Below 1 GHz: Z Axis with the EUT back against the table.
  - o Above 1 GHz & Radiated band edge: Y Axis with the EUT vertically positioned with the Power/HDMI/PHF cables from the bottom of the EUT.
- For radiated emissions the EUT was configured using a test laptop running putty to control the EUT. The test laptop was placed outside of the anechoic chamber. All other terminations apart from PHF were placed underneath the turntable.
- AC conducted tests were performed with all ports terminated, employing all available accessories.
- The conducted sample was used for minimum 6 dB bandwidth, duty cycle, maximum output power and power spectral density tests.

## **5. Measurements, Examinations and Derived Results**

### **5.1. General Comments**

Measurement uncertainties are evaluated in accordance with current best practice. Our reported expanded uncertainties are based on standard uncertainties, which are multiplied by an appropriate coverage factor to provide a statistical confidence level of approximately 95%. Please refer to *Section 6. Measurement Uncertainty* for details.

In accordance with UKAS requirements all the measurement equipment is on a calibration schedule. All equipment was within the calibration period on the date of testing.

## 5.2. Test Results

### 5.2.1. Transmitter AC Conducted Spurious Emissions

#### Test Summary:

|                            |                                                    |            |                 |
|----------------------------|----------------------------------------------------|------------|-----------------|
| Test Engineer:             | Doug Freegard                                      | Test Date: | 23 January 2018 |
| Test Sample Serial Number: | Not marked or stated ( <i>Radiated sample #1</i> ) |            |                 |

|                   |                                                          |
|-------------------|----------------------------------------------------------|
| FCC Reference:    | Part 15.207                                              |
| Test Method Used: | ANSI C63.10 Section 6.2 / FCC KDB 174176 and notes below |

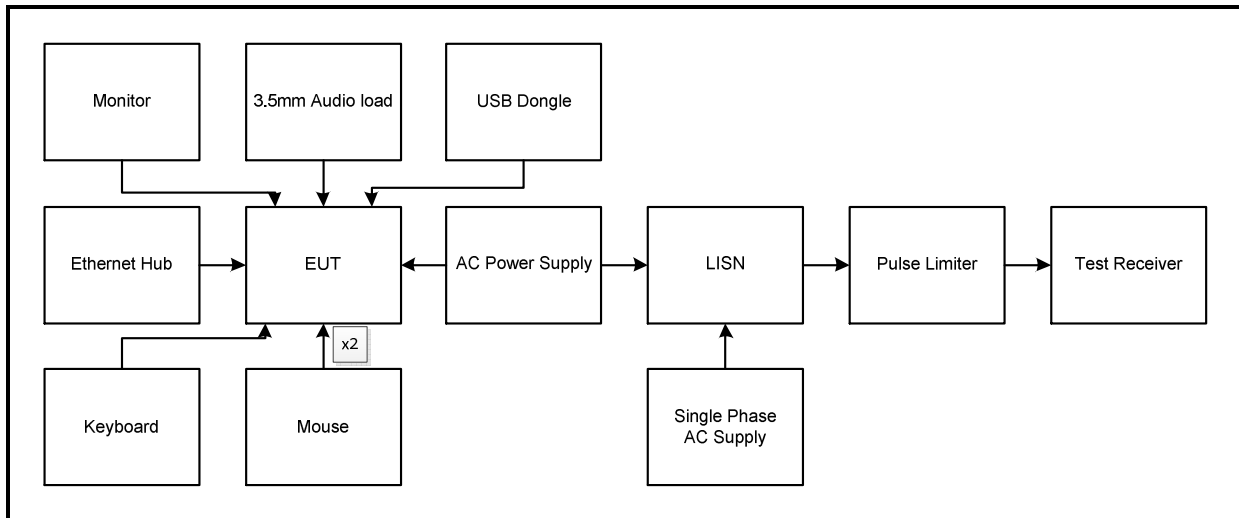
#### Environmental Conditions:

|                        |    |
|------------------------|----|
| Temperature (°C):      | 21 |
| Relative Humidity (%): | 46 |

#### Note(s):

1. The EUT was connected to a DC power supply which supplied the unit with 5.0 VDC. The DC power supply was connected to 120 VAC 60 Hz single phase supply via a LISN.
2. In accordance with FCC KDB 174176 Q4, tests were performed with a 240 VAC 60 Hz single phase supply as this was within the voltage range marked on the 5.0 V DC power supply.
3. A pulse limiter was fitted between the LISN and the test receiver.
4. Pre-scans were performed and markers placed on the highest live and neutral measured levels. Final measurements were performed on the marker frequencies and the results entered into the tables below.

#### Test setup:



**Transmitter AC Conducted Spurious Emissions (continued)****Results: Live / Quasi Peak / 120 VAC 60 Hz**

| Frequency (MHz) | Line | Level (dB $\mu$ V) | Limit (dB $\mu$ V) | Margin (dB) | Result   |
|-----------------|------|--------------------|--------------------|-------------|----------|
| 0.164           | Live | 49.8               | 65.3               | 15.5        | Complied |
| 0.299           | Live | 44.2               | 60.3               | 16.1        | Complied |
| 0.852           | Live | 37.1               | 56.0               | 18.9        | Complied |
| 1.392           | Live | 35.6               | 56.0               | 20.4        | Complied |
| 5.730           | Live | 39.4               | 60.0               | 20.6        | Complied |
| 25.058          | Live | 24.0               | 60.0               | 36.0        | Complied |

**Results: Live / Average / 120 VAC 60 Hz**

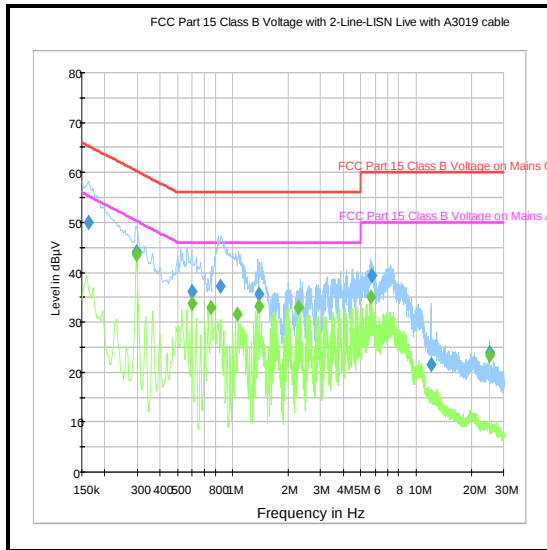
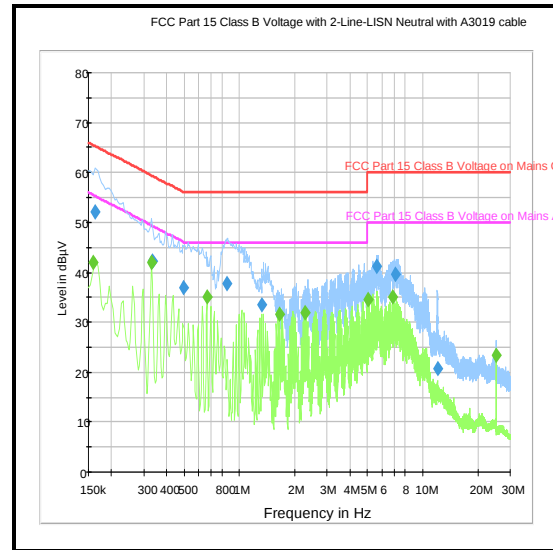
| Frequency (MHz) | Line | Level (dB $\mu$ V) | Limit (dB $\mu$ V) | Margin (dB) | Result   |
|-----------------|------|--------------------|--------------------|-------------|----------|
| 0.299           | Live | 43.5               | 50.3               | 6.8         | Complied |
| 0.596           | Live | 33.8               | 46.0               | 12.2        | Complied |
| 1.059           | Live | 31.7               | 46.0               | 14.3        | Complied |
| 1.392           | Live | 33.3               | 46.0               | 12.7        | Complied |
| 2.283           | Live | 32.9               | 46.0               | 13.1        | Complied |
| 5.658           | Live | 35.2               | 50.0               | 14.8        | Complied |

**Transmitter AC Conducted Spurious Emissions (continued)****Results: Neutral / Quasi Peak / 120 VAC 60 Hz**

| Frequency (MHz) | Line    | Level (dBμV) | Limit (dBμV) | Margin (dB) | Result   |
|-----------------|---------|--------------|--------------|-------------|----------|
| 0.164           | Neutral | 52.1         | 65.3         | 13.2        | Complied |
| 0.335           | Neutral | 42.1         | 59.3         | 17.2        | Complied |
| 0.497           | Neutral | 36.8         | 56.1         | 19.3        | Complied |
| 0.852           | Neutral | 37.8         | 56.0         | 18.2        | Complied |
| 5.618           | Neutral | 41.3         | 60.0         | 18.7        | Complied |
| 7.130           | Neutral | 39.5         | 60.0         | 20.5        | Complied |

**Results: Neutral / Average / 120 VAC 60 Hz**

| Frequency (MHz) | Line    | Level (dBμV) | Limit (dBμV) | Margin (dB) | Result   |
|-----------------|---------|--------------|--------------|-------------|----------|
| 0.159           | Neutral | 41.9         | 55.5         | 13.6        | Complied |
| 0.330           | Neutral | 42.0         | 49.5         | 7.5         | Complied |
| 0.663           | Neutral | 35.2         | 46.0         | 10.8        | Complied |
| 1.653           | Neutral | 31.8         | 46.0         | 14.2        | Complied |
| 2.283           | Neutral | 31.9         | 46.0         | 14.1        | Complied |
| 5.028           | Neutral | 34.5         | 50.0         | 15.5        | Complied |
| 6.878           | Neutral | 35.1         | 50.0         | 14.9        | Complied |

**Transmitter AC Conducted Spurious Emissions (continued)****Results: 120 VAC 60 Hz****Live****Neutral**

*Note: These plots are pre-scans and for indication purposes only. For final measurements, see accompanying tables.*

**Transmitter AC Conducted Spurious Emissions (continued)****Results: Live / Quasi Peak / 240 VAC 60 Hz**

| Frequency (MHz) | Line | Level (dB $\mu$ V) | Limit (dB $\mu$ V) | Margin (dB) | Result   |
|-----------------|------|--------------------|--------------------|-------------|----------|
| 0.155           | Live | 45.6               | 65.8               | 20.2        | Complied |
| 0.893           | Live | 39.0               | 56.0               | 17.0        | Complied |
| 1.428           | Live | 39.3               | 56.0               | 16.7        | Complied |
| 1.982           | Live | 40.0               | 56.0               | 16.0        | Complied |
| 3.129           | Live | 40.5               | 56.0               | 15.5        | Complied |
| 4.862           | Live | 43.1               | 56.0               | 12.9        | Complied |

**Results: Live / Average / 240 VAC 60 Hz**

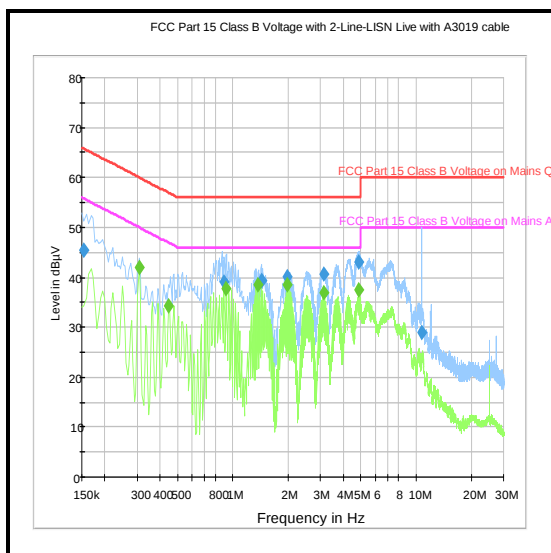
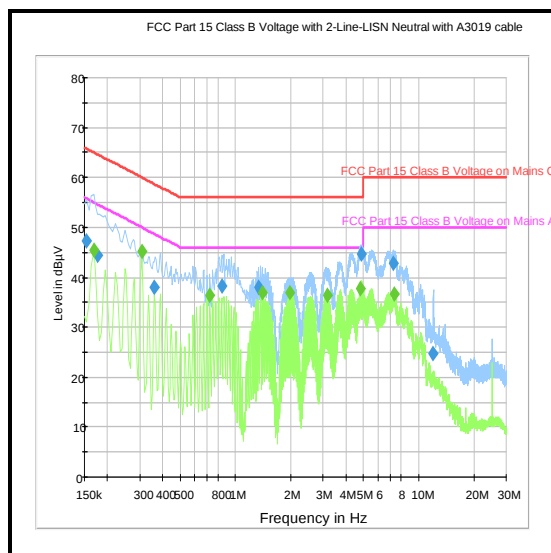
| Frequency (MHz) | Line | Level (dB $\mu$ V) | Limit (dB $\mu$ V) | Margin (dB) | Result   |
|-----------------|------|--------------------|--------------------|-------------|----------|
| 0.308           | Live | 42.0               | 50.0               | 8.0         | Complied |
| 0.447           | Live | 34.2               | 46.9               | 12.7        | Complied |
| 0.920           | Live | 37.8               | 46.0               | 8.2         | Complied |
| 1.370           | Live | 38.6               | 46.0               | 7.4         | Complied |
| 1.982           | Live | 38.4               | 46.0               | 7.6         | Complied |
| 3.129           | Live | 37.1               | 46.0               | 9.0         | Complied |
| 4.830           | Live | 37.4               | 46.0               | 8.6         | Complied |

**Transmitter AC Conducted Spurious Emissions (continued)****Results: Neutral / Quasi Peak / 240 VAC 60 Hz**

| Frequency (MHz) | Line    | Level (dBμV) | Limit (dBμV) | Margin (dB) | Result   |
|-----------------|---------|--------------|--------------|-------------|----------|
| 0.155           | Neutral | 47.3         | 65.8         | 18.5        | Complied |
| 0.177           | Neutral | 44.4         | 64.6         | 20.2        | Complied |
| 0.839           | Neutral | 38.3         | 56.0         | 17.7        | Complied |
| 1.338           | Neutral | 37.9         | 56.0         | 18.1        | Complied |
| 4.862           | Neutral | 44.6         | 56.0         | 11.4        | Complied |
| 7.292           | Neutral | 42.7         | 60.0         | 17.3        | Complied |

**Results: Neutral / Average / 240 VAC 60 Hz**

| Frequency (MHz) | Line    | Level (dBμV) | Limit (dBμV) | Margin (dB) | Result   |
|-----------------|---------|--------------|--------------|-------------|----------|
| 0.168           | Neutral | 45.5         | 55.1         | 9.6         | Complied |
| 0.308           | Neutral | 45.1         | 50.0         | 4.9         | Complied |
| 0.726           | Neutral | 36.5         | 46.0         | 9.5         | Complied |
| 1.397           | Neutral | 36.9         | 46.0         | 9.1         | Complied |
| 1.982           | Neutral | 36.8         | 46.0         | 9.2         | Complied |
| 3.156           | Neutral | 36.4         | 46.0         | 9.6         | Complied |
| 4.803           | Neutral | 37.6         | 46.0         | 8.4         | Complied |
| 7.319           | Neutral | 36.7         | 50.0         | 13.3        | Complied |

**Transmitter AC Conducted Spurious Emissions (continued)****Results: 240 VAC 60 Hz****Live****Neutral**

*Note: These plots are pre-scans and for indication purposes only. For final measurements, see accompanying tables.*

**Test Equipment Used:**

| Asset No. | Instrument       | Manufacturer    | Type No. | Serial No. | Date Calibration Due  | Cal. Interval (Months) |
|-----------|------------------|-----------------|----------|------------|-----------------------|------------------------|
| M2013     | Thermohygrometer | Testo           | 608-H1   | 45046424   | 20 Jun 2018           | 12                     |
| A649      | LISN             | Rohde & Schwarz | ESH3-Z5  | 825562/008 | 09 Aug 2018           | 12                     |
| A1830     | Pulse Limiter    | Rohde & Schwarz | ESH3-Z2  | 100668     | 09 May 2018           | 12                     |
| M1263     | Test Receiver    | Rohde & Schwarz | ESIB7    | 100265     | 13 Nov 2018           | 12                     |
| A2953     | Power Supply     | Tacima          | SC 5467  | Not stated | Calibrated before use | -                      |
| M1229     | Multimeter       | Fluke           | 179      | 87640015   | 12 May 2018           | 12                     |

**5.2.2. Transmitter Minimum 6 dB Bandwidth****Test Summary:**

|                                   |                                                               |                    |                                      |
|-----------------------------------|---------------------------------------------------------------|--------------------|--------------------------------------|
| <b>Test Engineer:</b>             | Stefan Ho                                                     | <b>Test Dates:</b> | 09 January 2018 &<br>10 January 2018 |
| <b>Test Sample Serial Number:</b> | Not marked or stated ( <i>Conducted sample with RF port</i> ) |                    |                                      |

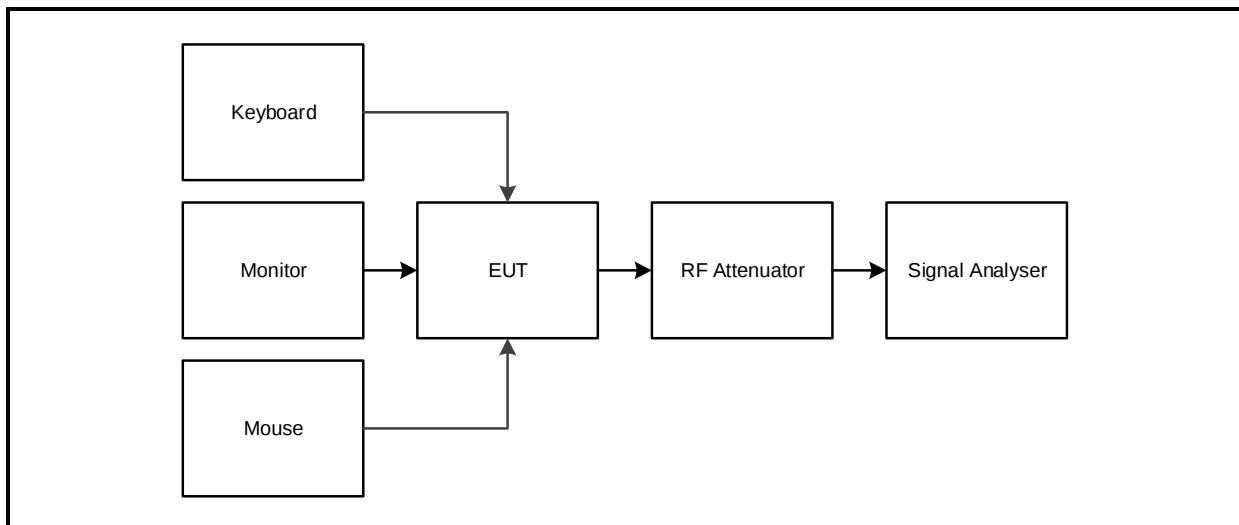
|                          |                            |
|--------------------------|----------------------------|
| <b>FCC Reference:</b>    | Part 15.247(a)(2)          |
| <b>Test Method Used:</b> | FCC KDB 558074 Section 8.1 |

**Environmental Conditions:**

|                               |          |
|-------------------------------|----------|
| <b>Temperature (°C):</b>      | 20 to 21 |
| <b>Relative Humidity (%):</b> | 43 to 46 |

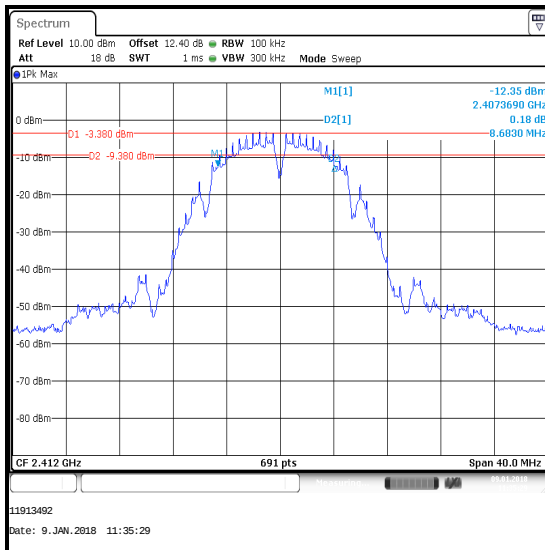
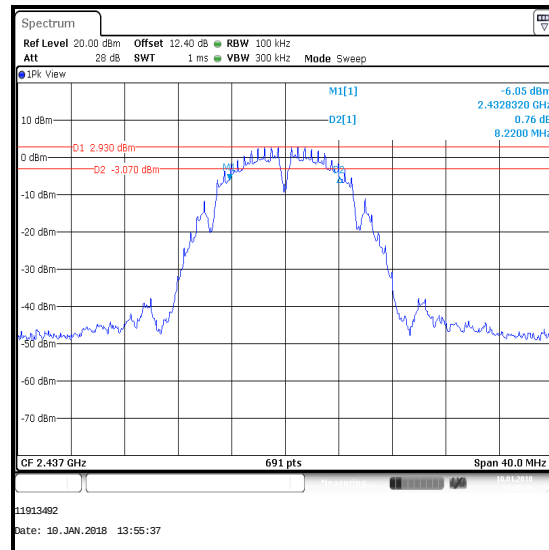
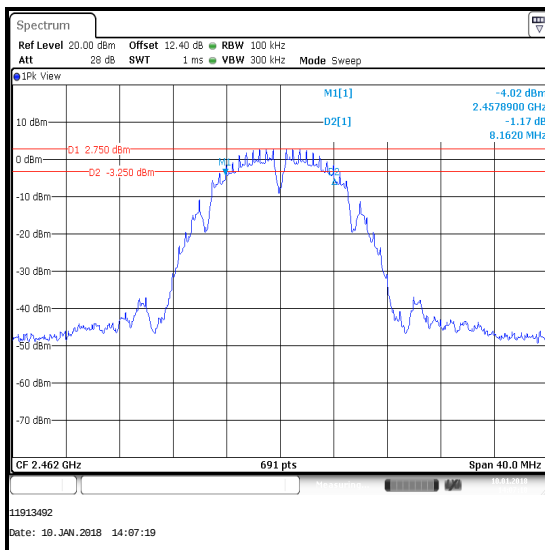
**Note(s):**

1. Tests were performed in accordance with KDB 558074 Section 8.1 Option 1 measurement procedure on bottom, middle and top channels. The signal analyser resolution bandwidth was set to 100 kHz and video bandwidth 300 kHz. A peak detector was used, sweep time was set to auto and the trace mode was Max Hold. The span was set to 40 MHz for 20 MHz channel bandwidths and 80 MHz for 40 MHz channel bandwidths. The DTS bandwidth was measured at 6 dB down from the peak of the signal.
2. The signal analyser was connected to the RF port on the EUT using suitable attenuation and RF cable. An RF level offset was entered on the signal analyser to compensate for the loss of the attenuator and RF cable.

**Test setup:**

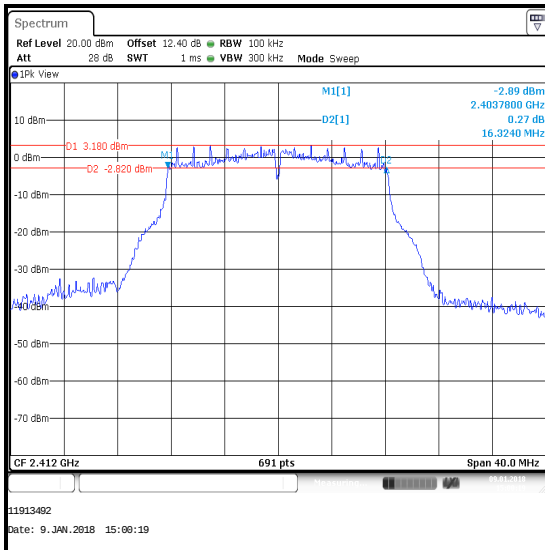
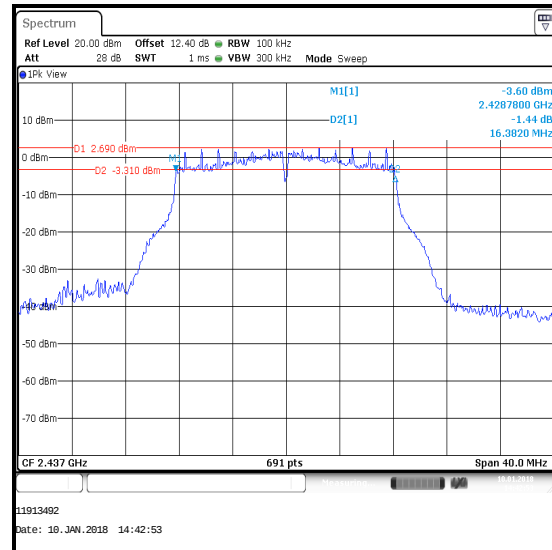
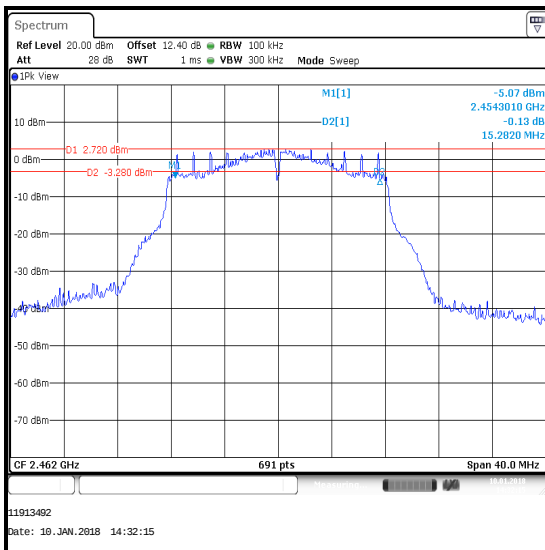
**Transmitter Minimum 6 dB Bandwidth (continued)****Results: 802.11b / 20 MHz / DBPSK / 1 Mbps**

| Channel | 6 dB Bandwidth (kHz) | Limit (kHz) | Margin (kHz) | Result   |
|---------|----------------------|-------------|--------------|----------|
| 1       | 8683                 | ≥500        | 8183         | Complied |
| 6       | 8220                 | ≥500        | 7720         | Complied |
| 11      | 8162                 | ≥500        | 7662         | Complied |

**Channel 1****Channel 6****Channel 11**

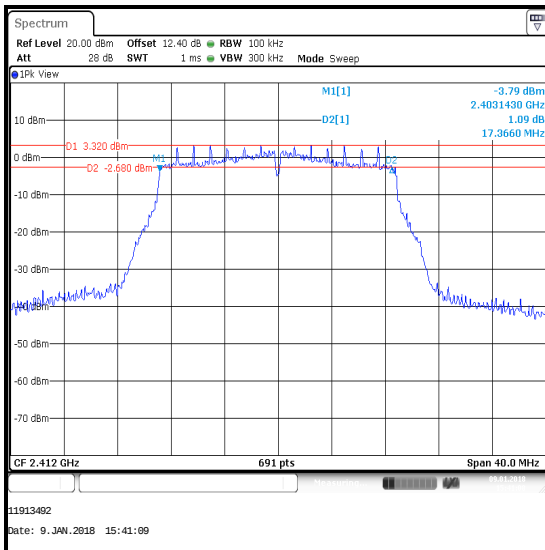
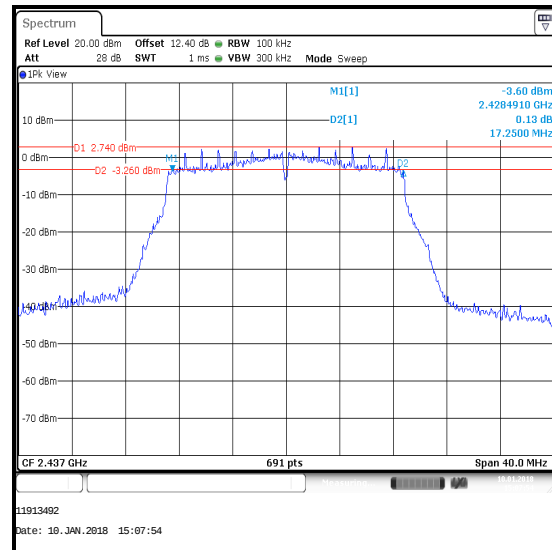
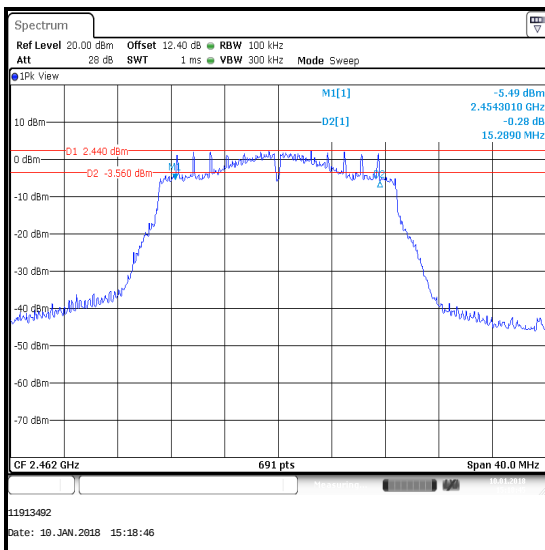
**Transmitter Minimum 6 dB Bandwidth (continued)****Results: 802.11g / 20 MHz / BPSK / 6 Mbps**

| Channel | 6 dB Bandwidth (kHz) | Limit (kHz) | Margin (kHz) | Result   |
|---------|----------------------|-------------|--------------|----------|
| 1       | 16324                | ≥500        | 15824        | Complied |
| 6       | 16382                | ≥500        | 15882        | Complied |
| 11      | 15282                | ≥500        | 14782        | Complied |

**Channel 1****Channel 6****Channel 11**

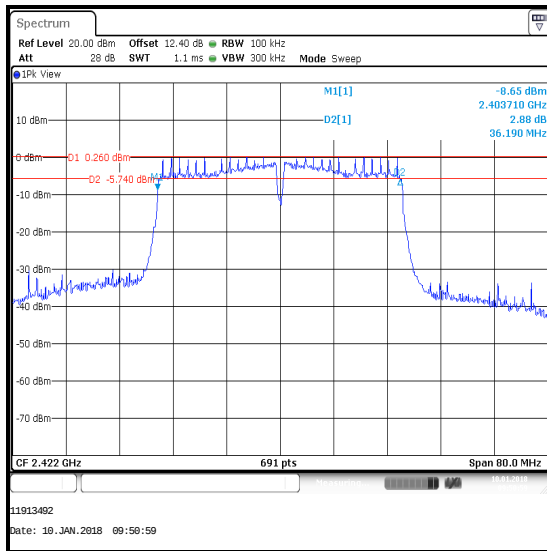
**Transmitter Minimum 6 dB Bandwidth (continued)****Results: 802.11n / 20 MHz / BPSK / MCS0**

| Channel | 6 dB Bandwidth (kHz) | Limit (kHz) | Margin (kHz) | Result   |
|---------|----------------------|-------------|--------------|----------|
| 1       | 17366                | ≥500        | 16866        | Complied |
| 6       | 17250                | ≥500        | 16750        | Complied |
| 11      | 15289                | ≥500        | 14789        | Complied |

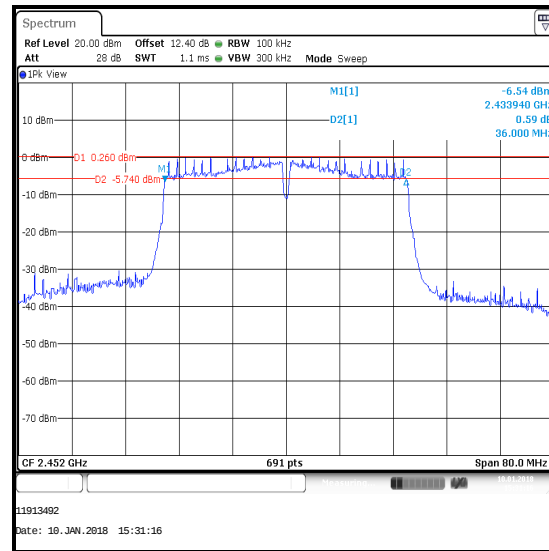
**Channel 1****Channel 6****Channel 11**

**Transmitter Minimum 6 dB Bandwidth (continued)****Results: 802.11n / 40 MHz / BPSK / MCS0**

| Channel | 6 dB Bandwidth (kHz) | Limit (kHz) | Margin (kHz) | Result   |
|---------|----------------------|-------------|--------------|----------|
| 3       | 36190                | ≥500        | 35690        | Complied |
| 9       | 36000                | ≥500        | 35500        | Complied |



Channel 3



Channel 9

**Test Equipment Used:**

| Asset No. | Instrument       | Manufacturer    | Type No.  | Serial No. | Date Calibration Due  | Cal. Interval (Months) |
|-----------|------------------|-----------------|-----------|------------|-----------------------|------------------------|
| M2005     | Thermohygrometer | Testo           | 608-H1    | 45046700   | 22 Feb 2018           | 12                     |
| A2919     | Attenuator       | AtlanTecRF      | AN18W5-20 | 832828#2   | Calibrated before use | -                      |
| M1996     | Signal Analyser  | Rohde & Schwarz | FSV13     | 100975     | 27 Nov 2018           | 12                     |
| M1804     | Signal Generator | Rohde & Schwarz | SMP22     | 100026     | 28 Feb 2019           | 24                     |

**5.2.3. Transmitter Duty Cycle****Test Summary:**

|                                   |                                                               |                    |                                      |
|-----------------------------------|---------------------------------------------------------------|--------------------|--------------------------------------|
| <b>Test Engineers:</b>            | Stefan Ho &<br>Doug Freegard                                  | <b>Test Dates:</b> | 09 January 2018 &<br>10 January 2018 |
| <b>Test Sample Serial Number:</b> | Not marked or stated ( <i>Conducted sample with RF port</i> ) |                    |                                      |

|                          |                            |
|--------------------------|----------------------------|
| <b>FCC Reference:</b>    | Part 15.35(c)              |
| <b>Test Method Used:</b> | FCC KDB 558074 Section 6.0 |

**Environmental Conditions:**

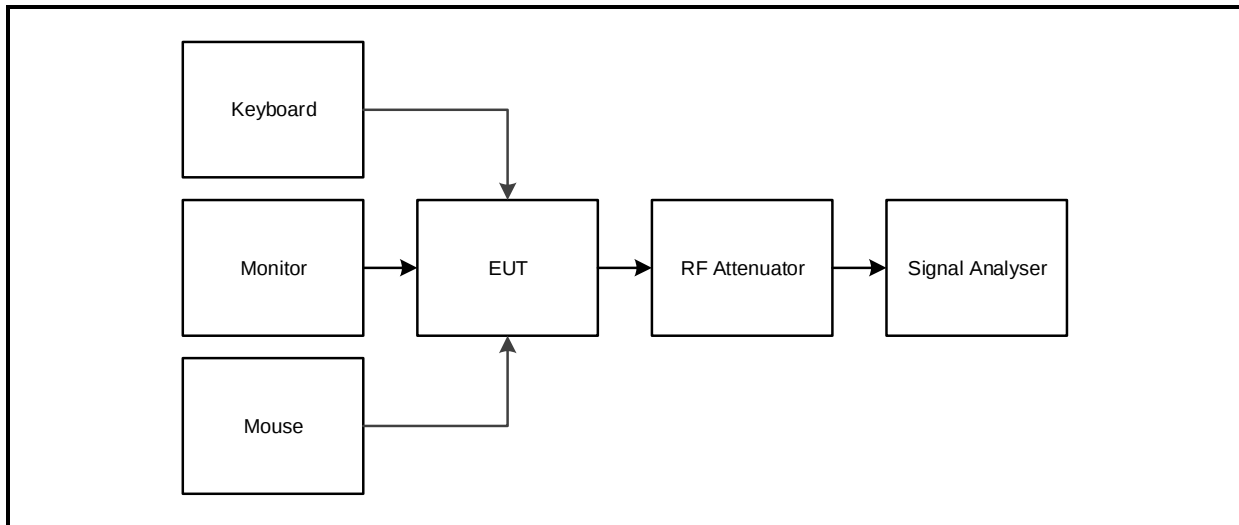
|                               |          |
|-------------------------------|----------|
| <b>Temperature (°C):</b>      | 20 to 21 |
| <b>Relative Humidity (%):</b> | 43 to 46 |

**Note(s):**

1. In order to assist with the determination of the average level of fundamental and spurious emissions field strength, measurements were made of duty cycle to determine the transmission duration and the silent period time of the transmitter. The transmitter duty cycle was measured using a spectrum analyser in the time domain and calculated by using the following calculation:

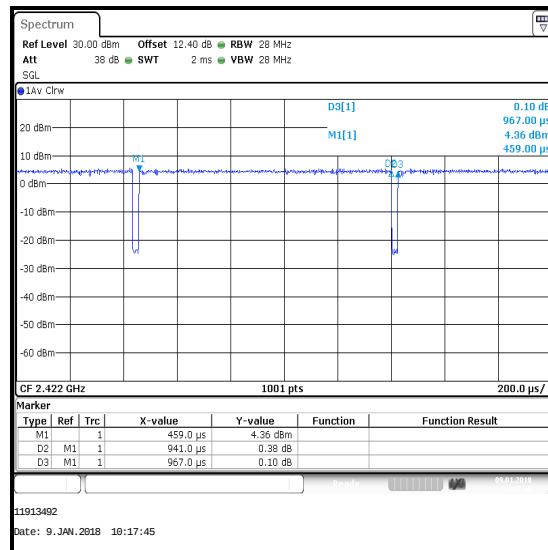
$$10 \log (1 / (\text{On Time} / [\text{Period or } 100 \text{ ms whichever is the lesser}])).$$

2. For 802.11b, 802.11g and 802.11n HT20, the duty cycle was measured to be greater than 98%.

**Test setup:**

**Transmitter Duty Cycle (continued)****Results: 802.11n / 40 MHz / BPSK / MCS0**

| Pulse Duration (ms) | Period (ms) | Duty Cycle % | Duty Cycle Correction factor (dB) |
|---------------------|-------------|--------------|-----------------------------------|
| 0.941               | 0.967       | 97.3         | 0.1                               |

**Test Equipment Used:**

| Asset No. | Instrument       | Manufacturer    | Type No.  | Serial No. | Date Calibration Due  | Cal. Interval (Months) |
|-----------|------------------|-----------------|-----------|------------|-----------------------|------------------------|
| M2005     | Thermohygrometer | Testo           | 608-H1    | 45046700   | 22 Feb 2018           | 12                     |
| A2919     | Attenuator       | AtlanTecRF      | AN18W5-20 | 832828#2   | Calibrated before use | -                      |
| M1996     | Signal Analyser  | Rohde & Schwarz | FSV13     | 100975     | 27 Nov 2018           | 12                     |
| M1804     | Signal Generator | Rohde & Schwarz | SMP22     | 100026     | 28 Feb 2019           | 24                     |

**5.2.4. Transmitter Power Spectral Density****Test Summary:**

|                                   |                                                               |                   |                 |
|-----------------------------------|---------------------------------------------------------------|-------------------|-----------------|
| <b>Test Engineers:</b>            | Stefan Ho &<br>Doug Freegard                                  | <b>Test Date:</b> | 15 January 2018 |
| <b>Test Sample Serial Number:</b> | Not marked or stated ( <i>Conducted sample with RF port</i> ) |                   |                 |

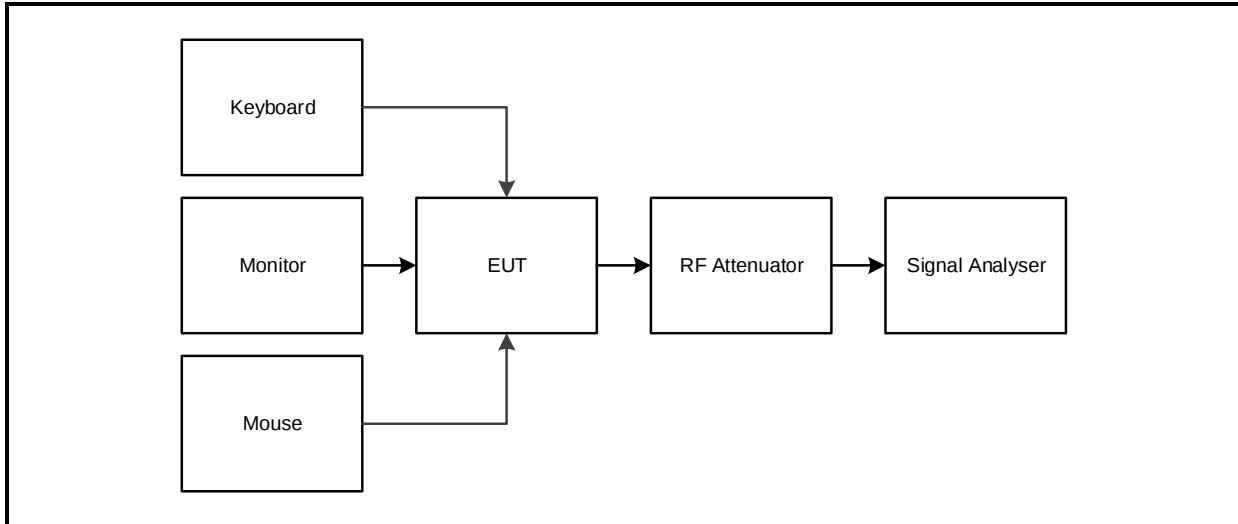
|                          |                                    |
|--------------------------|------------------------------------|
| <b>FCC Reference:</b>    | Part 15.247(e)                     |
| <b>Test Method Used:</b> | FCC KDB 558074 Sections 10.3 &10.5 |

**Environmental Conditions:**

|                               |    |
|-------------------------------|----|
| <b>Temperature (°C):</b>      | 22 |
| <b>Relative Humidity (%):</b> | 42 |

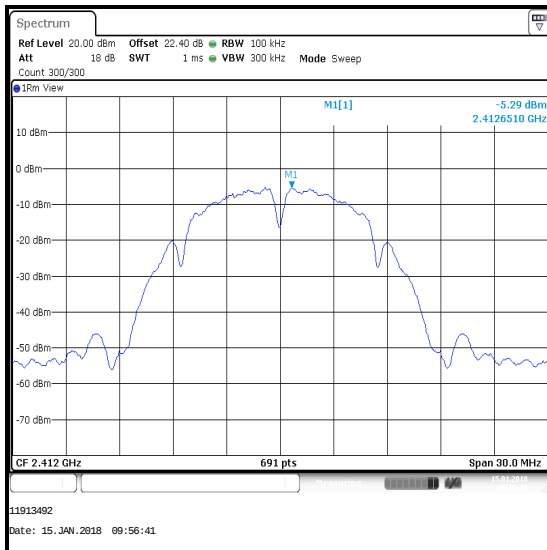
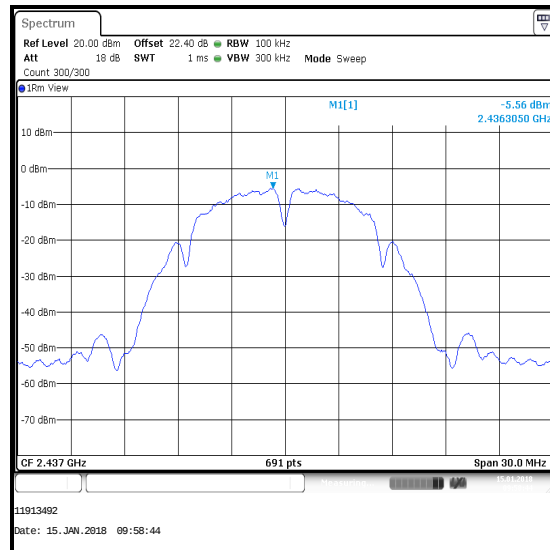
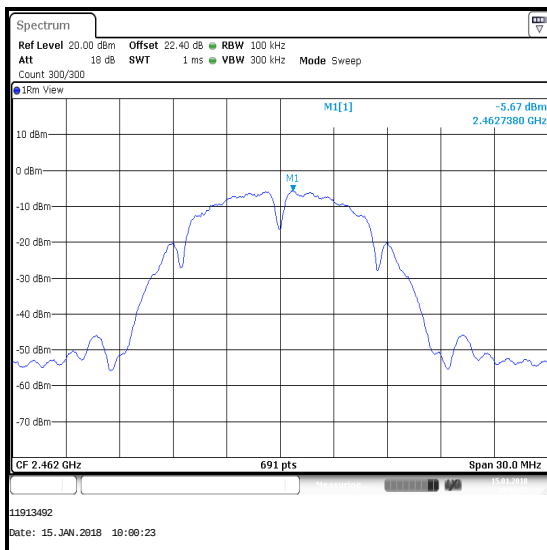
**Note(s):**

1. Final measurements were performed on the bottom, middle and top channels.
2. For 802.11b, 802.11g and 802.11n HT20, the EUT was transmitting at  $\geq 98\%$  duty cycle and testing was performed in accordance with KDB 558074 Section 10.3 Method AVGPS-1. The signal analyser resolution bandwidth was set to 100 kHz and video bandwidth 300 kHz. An RMS detector was used and sweep time set manually to perform trace averaging over 300 traces. The span was set greater than 1.5 times the 99% occupied emission bandwidth (plots for the occupied bandwidth are archived on the company server and available for inspection upon request). The highest peak of the measured signal was recorded.
3. For 802.11n HT40, the EUT was transmitting at  $<98\%$  duty cycle and testing was performed in accordance with KDB 558074 Section 10.5 Method AVGPS-2. The signal analyser resolution bandwidth was set to 100 kHz and video bandwidth 300 kHz. An RMS detector was used and sweep time set manually to perform trace averaging over 300 traces. The span was set greater than 1.5 times the 99% occupied emission bandwidth (plots for the occupied bandwidth are archived on the company server and available for inspection upon request). The highest peak of the measured signal was recorded. The calculated duty cycle in section 5.2.3 was added to the measured average power spectral density in order to compute the average power spectral density during the actual transmission time.
4. The signal analyser was connected to the RF port on the EUT using suitable attenuation and RF cable. An RF level offset was entered on the signal analyser to compensate for the loss of the attenuator and RF cable.

**Transmitter Power Spectral Density (continued)****Test setup:**

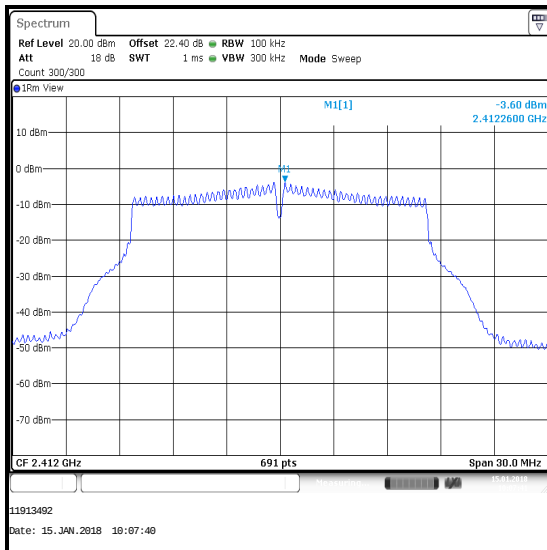
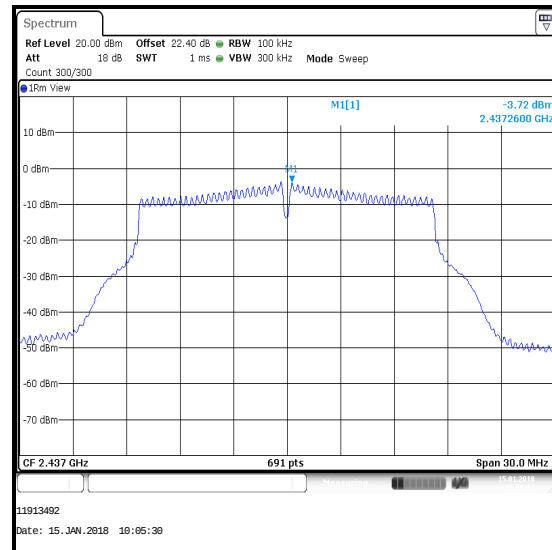
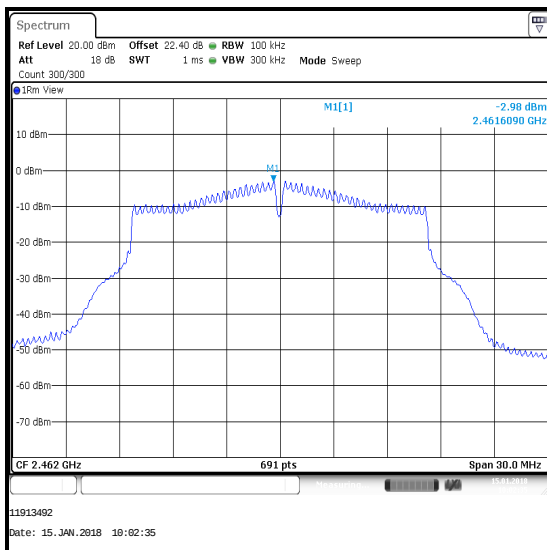
**Transmitter Power Spectral Density (continued)****Results: 802.11b / 20 MHz / DBPSK / 1 Mbps**

| Channel | PSD (dBm/100 kHz) | Limit (dBm/3 kHz) | Margin (dB) | Result   |
|---------|-------------------|-------------------|-------------|----------|
| 1       | -5.3              | 8.0               | 13.3        | Complied |
| 6       | -5.6              | 8.0               | 13.6        | Complied |
| 11      | -5.7              | 8.0               | 13.7        | Complied |

**Channel 1****Channel 6****Channel 11**

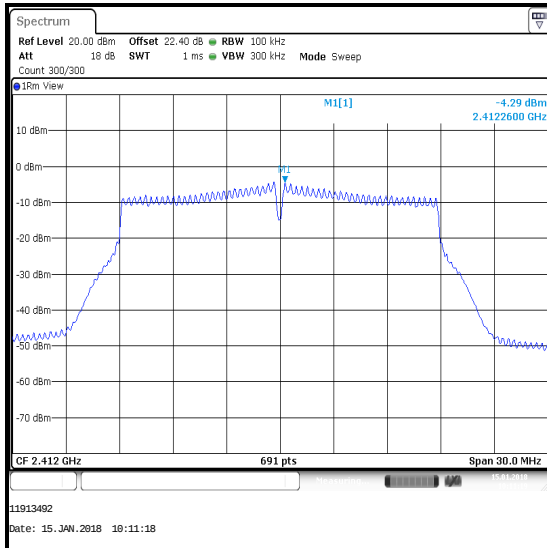
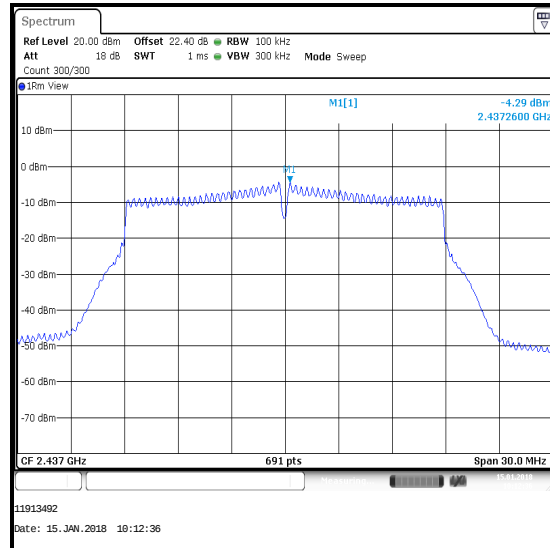
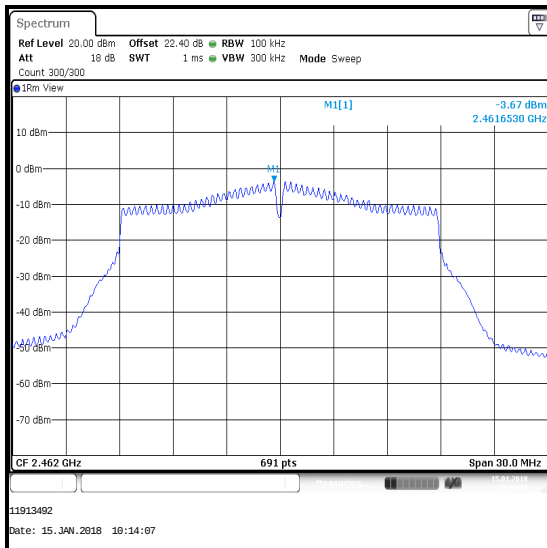
**Transmitter Power Spectral Density (continued)****Results: 802.11g / 20 MHz / BPSK / 6 Mbps**

| Channel | PSD (dBm/100 kHz) | Limit (dBm/3 kHz) | Margin (dB) | Result   |
|---------|-------------------|-------------------|-------------|----------|
| 1       | -3.6              | 8.0               | 11.6        | Complied |
| 6       | -3.7              | 8.0               | 11.7        | Complied |
| 11      | -3.0              | 8.0               | 11.0        | Complied |

**Channel 1****Channel 6****Channel 11**

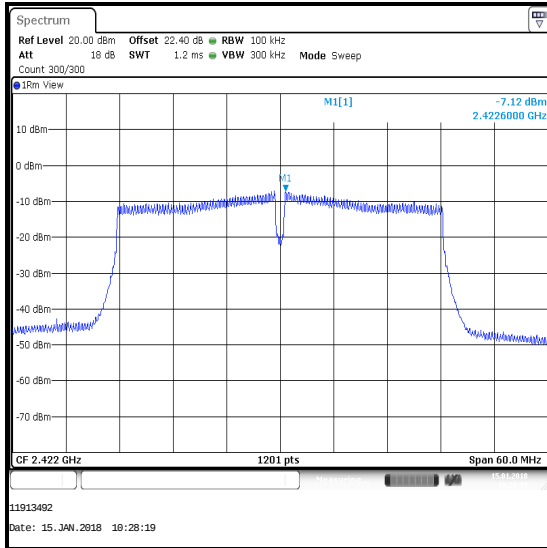
**Transmitter Power Spectral Density (continued)****Results: 802.11n / 20 MHz / BPSK / MCS0**

| Channel | PSD (dBm/100 kHz) | Limit (dBm/3 kHz) | Margin (dB) | Result   |
|---------|-------------------|-------------------|-------------|----------|
| 1       | -4.3              | 8.0               | 12.3        | Complied |
| 6       | -4.3              | 8.0               | 12.3        | Complied |
| 11      | -3.7              | 8.0               | 11.7        | Complied |

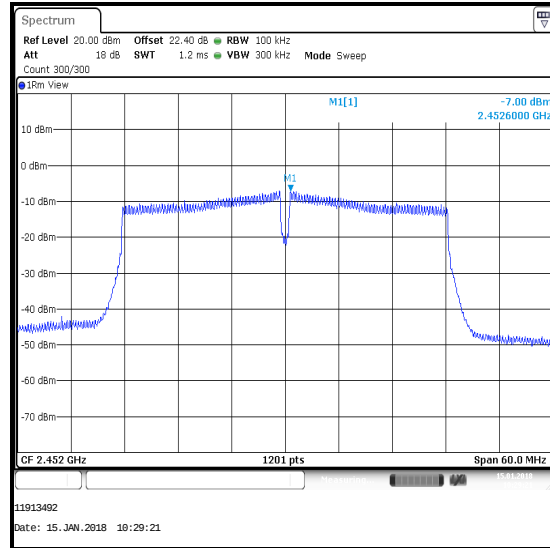
**Channel 1****Channel 6****Channel 11**

**Transmitter Power Spectral Density (continued)****Results: 802.11n / 40 MHz / BPSK / MCS0**

| Channel | PSD (dBm/100 kHz) | Duty Cycle Correction (dB) | Corrected PSD (dBm/3 kHz) | Limit (dBm/3 kHz) | Margin (dB) | Result   |
|---------|-------------------|----------------------------|---------------------------|-------------------|-------------|----------|
| 3       | -7.1              | 0.1                        | -7.0                      | 8.0               | 15.0        | Complied |
| 9       | -7.0              | 0.1                        | -6.9                      | 8.0               | 14.9        | Complied |



Channel 3



Channel 9

**Test Equipment Used:**

| Asset No. | Instrument       | Manufacturer    | Type No.  | Serial No. | Date Calibration Due  | Cal. Interval (Months) |
|-----------|------------------|-----------------|-----------|------------|-----------------------|------------------------|
| M2005     | Thermohygrometer | Testo           | 608-H1    | 45046700   | 22 Feb 2018           | 12                     |
| A2919     | Attenuator       | AtlanTecRF      | AN18W5-20 | 832828#2   | Calibrated before use | -                      |
| M1996     | Signal Analyser  | Rohde & Schwarz | FSV13     | 100975     | 27 Nov 2018           | 12                     |
| M1804     | Signal Generator | Rohde & Schwarz | SMP22     | 100026     | 28 Feb 2019           | 24                     |

**5.2.5. Transmitter Maximum (Average) Output Power****Test Summary:**

|                                   |                                                               |                    |                                       |
|-----------------------------------|---------------------------------------------------------------|--------------------|---------------------------------------|
| <b>Test Engineer:</b>             | Doug Freegard                                                 | <b>Test Dates:</b> | 25 January 2018 &<br>19 February 2018 |
| <b>Test Sample Serial Number:</b> | Not marked or stated ( <i>Conducted sample with RF port</i> ) |                    |                                       |

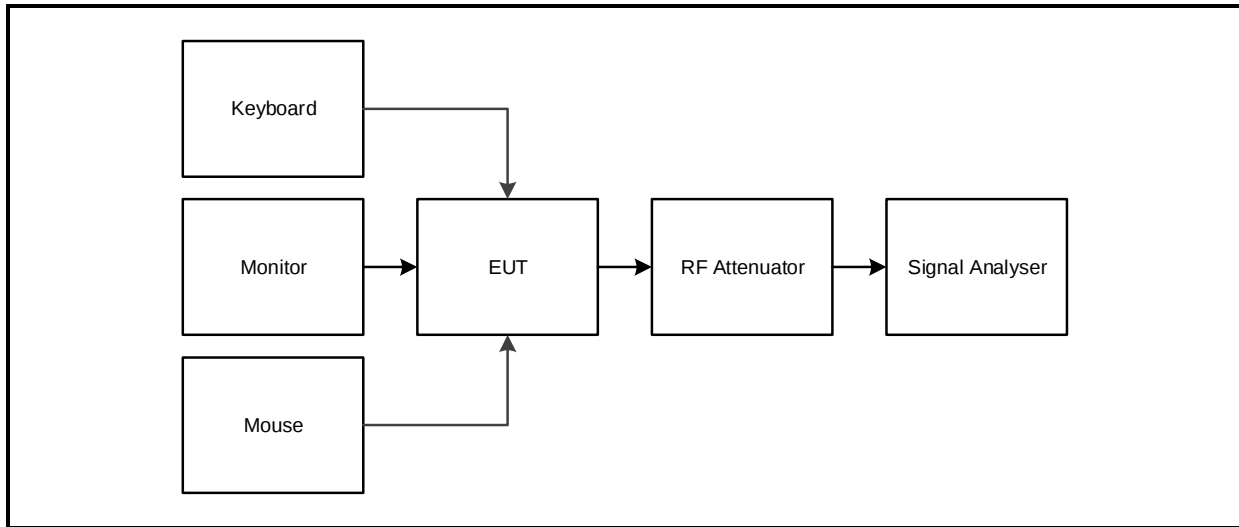
|                          |                                           |
|--------------------------|-------------------------------------------|
| <b>FCC Reference:</b>    | Part 15.247(b)(3)                         |
| <b>Test Method Used:</b> | FCC KDB 558074 Sections 9.2.2.2 & 9.2.2.4 |

**Environmental Conditions:**

|                               |          |
|-------------------------------|----------|
| <b>Temperature (°C):</b>      | 20 to 25 |
| <b>Relative Humidity (%):</b> | 36 to 43 |

**Note(s):**

1. Final measurements were performed on the bottom, middle and top channels. The power has been integrated over the 99% emission bandwidth. Plots for the occupied bandwidth are archived on the company server and available for inspection upon request.
2. For 802.11b, 802.11g and 802.11n HT20 the EUT was transmitting at  $\geq 98\%$  duty cycle and testing was performed in accordance with KDB 558074 Section 9.2.2.2 Method AVGSA-1. The signal analyser's integration function was used to integrate across the 99% occupied bandwidth. The signal analyser resolution bandwidth was set to 200 kHz and video bandwidth 1 MHz. An RMS detector was used and sweep time set manually to perform trace averaging over 300 traces. The span was set greater than 1.5 times the 99% occupied emission bandwidth.
3. For 802.11n HT40, the EUT was transmitting at  $<98\%$  duty cycle and testing was performed in accordance with KDB 558074 Section 9.2.2.4 Method AVGSA-2. The signal analyser's integration function was used to integrate across the 99% occupied bandwidth. The signal analyser resolution bandwidth was set to 500 kHz and video bandwidth 2 MHz. An RMS detector was used and sweep time set manually to perform trace averaging over 300 traces. The span was set greater than 1.5 times the 99% occupied emission bandwidth. The calculated duty cycle in section 5.2.3 was added to the measured power in order to compute the average power during the actual transmission time.
4. The signal analyser was connected to the RF port on the EUT using suitable attenuation and RF cable. An RF level offset was entered on the signal analyser to compensate for the loss of the attenuator and RF cable.
5. Plots for 40 MHz channel bandwidth have an incorrect job number.

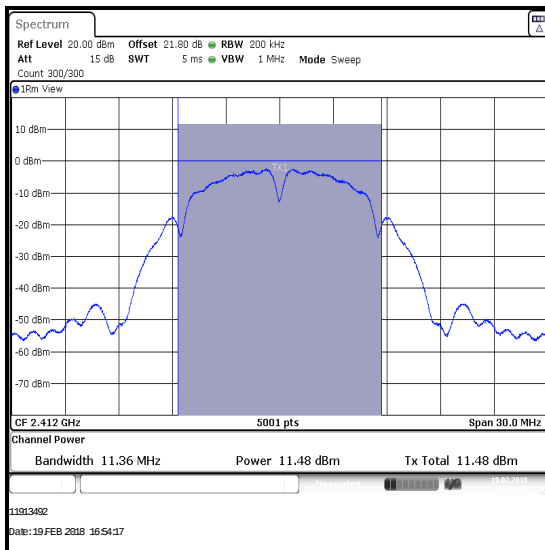
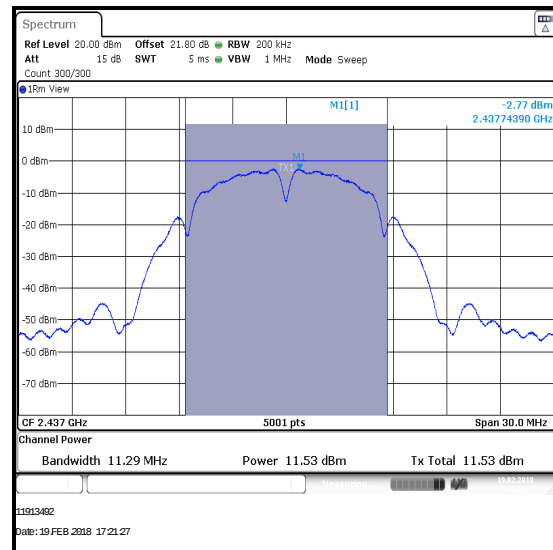
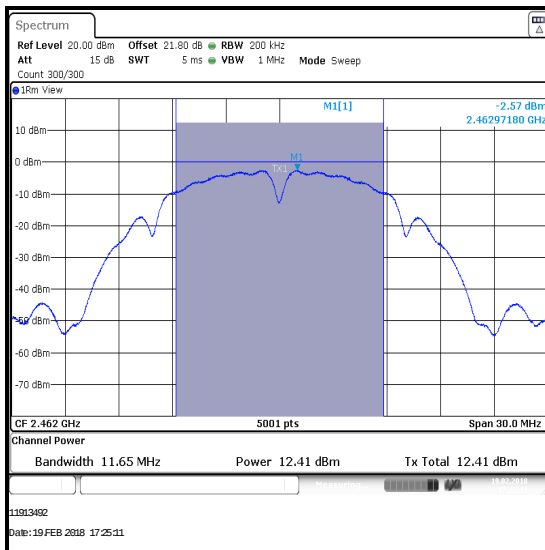
**Transmitter Maximum (Average) Output Power (continued)****Test setup:**

**Transmitter Maximum (Average) Output Power (continued)****Results: 802.11b / 20 MHz / DBPSK / 1 Mbps****Conducted Peak Limit Comparison**

| Channel | Conducted Power (dBm) | Conducted Power Limit (dBm) | Margin (dB) | Result   |
|---------|-----------------------|-----------------------------|-------------|----------|
| 1       | 11.5                  | 30.0                        | 18.5        | Complied |
| 6       | 11.5                  | 30.0                        | 18.5        | Complied |
| 11      | 12.4                  | 30.0                        | 17.6        | Complied |

**De Facto EIRP Limit Comparison**

| Channel | Conducted Power (dBm) | Declared Antenna Gain (dBi) | EIRP (dBm) | De Facto EIRP Limit (dBm) | Margin (dB) | Result   |
|---------|-----------------------|-----------------------------|------------|---------------------------|-------------|----------|
| 1       | 11.5                  | 3.5                         | 15.0       | 36.0                      | 21.0        | Complied |
| 6       | 11.5                  | 3.5                         | 15.0       | 36.0                      | 21.0        | Complied |
| 11      | 12.4                  | 3.5                         | 15.9       | 36.0                      | 20.1        | Complied |

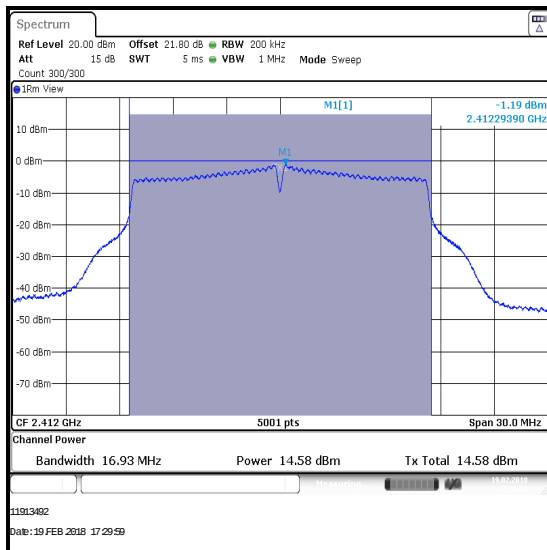
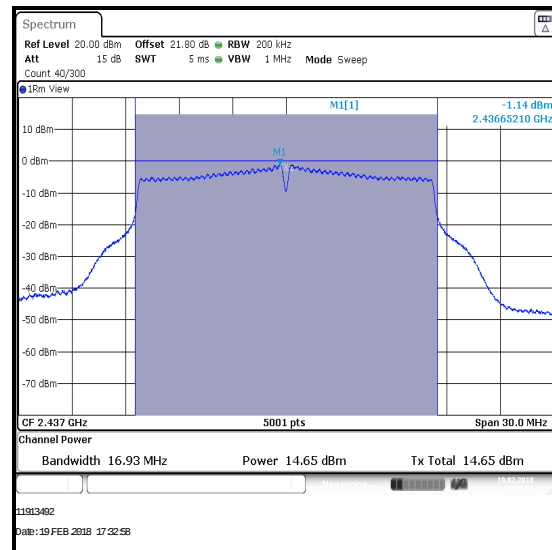
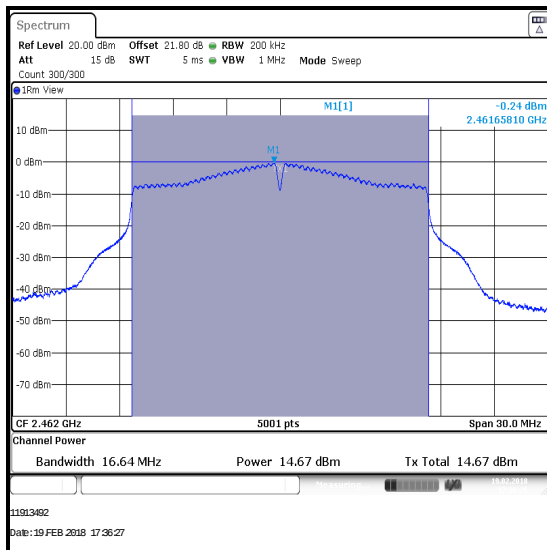
**Transmitter Maximum (Average) Output Power (continued)****Results: 802.11b / 20 MHz / DBPSK / 1 Mbps****Channel 1****Channel 6****Channel 11**

**Transmitter Maximum (Average) Output Power (continued)****Results: 802.11g / 20 MHz / BPSK / 6 Mbps****Conducted Peak Limit Comparison**

| Channel | Conducted Power (dBm) | Conducted Power Limit (dBm) | Margin (dB) | Result   |
|---------|-----------------------|-----------------------------|-------------|----------|
| 1       | 14.6                  | 30.0                        | 15.4        | Complied |
| 6       | 14.7                  | 30.0                        | 15.3        | Complied |
| 11      | 14.7                  | 30.0                        | 15.3        | Complied |

**De Facto EIRP Limit Comparison**

| Channel | Conducted Power (dBm) | Declared Antenna Gain (dBi) | EIRP (dBm) | De Facto EIRP Limit (dBm) | Margin (dB) | Result   |
|---------|-----------------------|-----------------------------|------------|---------------------------|-------------|----------|
| 1       | 14.6                  | 3.5                         | 18.1       | 36.0                      | 17.9        | Complied |
| 6       | 14.7                  | 3.5                         | 18.2       | 36.0                      | 17.8        | Complied |
| 11      | 14.7                  | 3.5                         | 18.2       | 36.0                      | 17.8        | Complied |

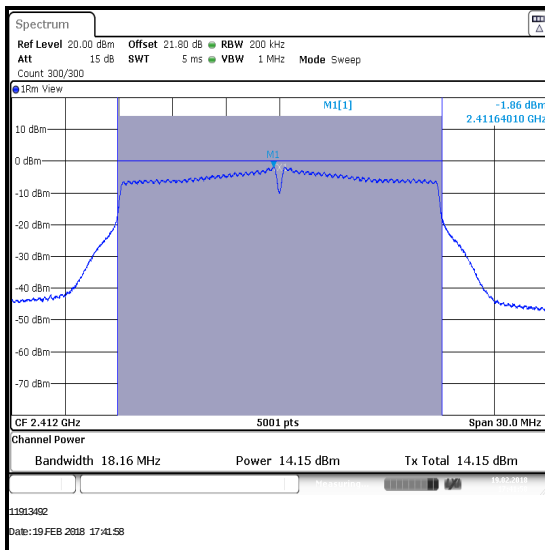
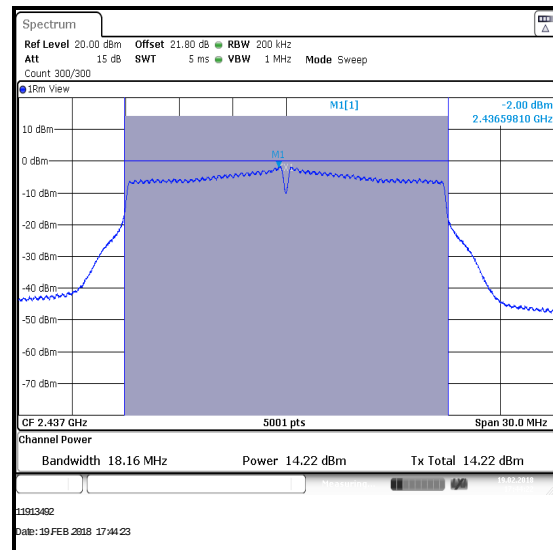
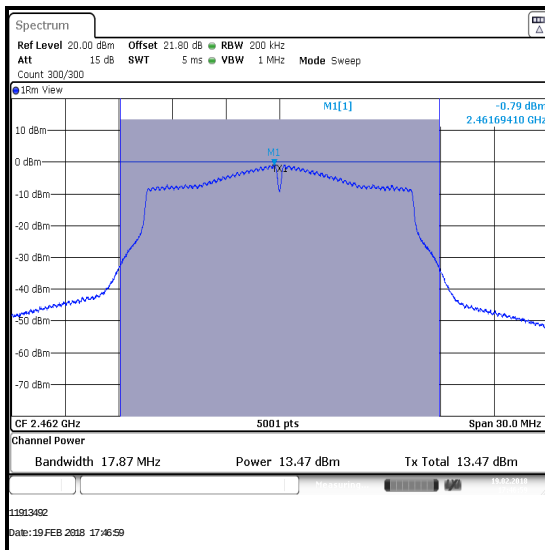
**Transmitter Maximum (Average) Output Power (continued)****Results: 802.11g / 20 MHz / BPSK / 6 Mbps****Channel 1****Channel 6****Channel 11**

**Transmitter Maximum (Average) Output Power (continued)****Results: 802.11n / 20 MHz / BPSK / MCS0****Conducted Peak Limit Comparison**

| Channel | Conducted Power (dBm) | Conducted Power Limit (dBm) | Margin (dB) | Result   |
|---------|-----------------------|-----------------------------|-------------|----------|
| 1       | 14.2                  | 30.0                        | 15.8        | Complied |
| 6       | 14.2                  | 30.0                        | 15.8        | Complied |
| 11      | 13.5                  | 30.0                        | 16.5        | Complied |

**De Facto EIRP Limit Comparison**

| Channel | Conducted Power (dBm) | Declared Antenna Gain (dBi) | EIRP (dBm) | De Facto EIRP Limit (dBm) | Margin (dB) | Result   |
|---------|-----------------------|-----------------------------|------------|---------------------------|-------------|----------|
| 1       | 14.2                  | 3.5                         | 17.7       | 36.0                      | 18.3        | Complied |
| 6       | 14.2                  | 3.5                         | 17.7       | 36.0                      | 18.3        | Complied |
| 11      | 13.5                  | 3.5                         | 17.0       | 36.0                      | 19.0        | Complied |

**Transmitter Maximum (Average) Output Power (continued)****Results: 802.11n / 20 MHz / BPSK / MCS0****Channel 1****Channel 6****Channel 11**

### Transmitter Maximum (Average) Output Power (continued)

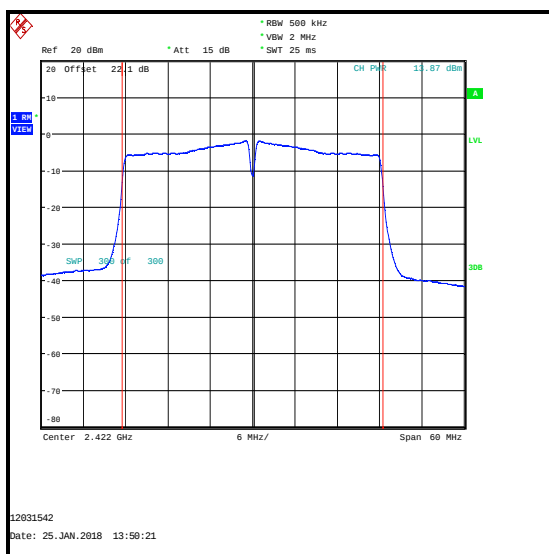
**Results: 802.11n / 40 MHz / BPSK / MCS0**

### Conducted Peak Limit Comparison

| Channel | Conducted Power (dBm) | Duty Cycle Correction (dB) | Corrected Conducted Power (dBm) | Conducted Power Limit (dBm) | Margin (dB) | Result   |
|---------|-----------------------|----------------------------|---------------------------------|-----------------------------|-------------|----------|
| 3       | 13.9                  | 0.1                        | 14.0                            | 30.0                        | 16.0        | Complied |
| 9       | 13.6                  | 0.1                        | 13.7                            | 30.0                        | 16.3        | Complied |

### De Facto EIRP Limit Comparison

| Channel | Corrected Conducted Power (dBm) | Declared Antenna Gain (dBi) | EIRP (dBm) | De Facto EIRP Limit (dBm) | Margin (dB) | Result   |
|---------|---------------------------------|-----------------------------|------------|---------------------------|-------------|----------|
| 3       | 14.0                            | 3.5                         | 17.5       | 36.0                      | 18.5        | Complied |
| 9       | 13.7                            | 3.5                         | 17.2       | 36.0                      | 18.8        | Complied |



### Channel 3



## Channel 9

**Test Equipment Used:**

| Asset No. | Instrument       | Manufacturer    | Type No.  | Serial No. | Date Calibration Due  | Cal. Interval (Months) |
|-----------|------------------|-----------------|-----------|------------|-----------------------|------------------------|
| M2002     | Thermohygrometer | Testo           | 608-H1    | 45041825   | 22 Feb 2018           | 12                     |
| A2946     | Attenuator       | AtlanTecRF      | AN18W5-20 | 832828#2   | Calibrated before use | -                      |
| M1835     | Signal Analyser  | Rohde & Schwarz | FSV30     | 103050     | 06 Mar 2018           | 12                     |
| M1886     | Test Receiver    | Rohde & Schwarz | ESU26     | 100554     | 04 Apr 2018           | 12                     |
| G0615     | Signal Generator | Rohde & Schwarz | SMBV100A  | 260473     | 08 May 2020           | 36                     |

**5.2.6. Transmitter Radiated Emissions****Test Summary:**

|                                   |                                                    |                   |                 |
|-----------------------------------|----------------------------------------------------|-------------------|-----------------|
| <b>Test Engineer:</b>             | Andrew Edwards                                     | <b>Test Date:</b> | 16 January 2018 |
| <b>Test Sample Serial Number:</b> | Not marked or stated ( <i>Radiated sample #1</i> ) |                   |                 |

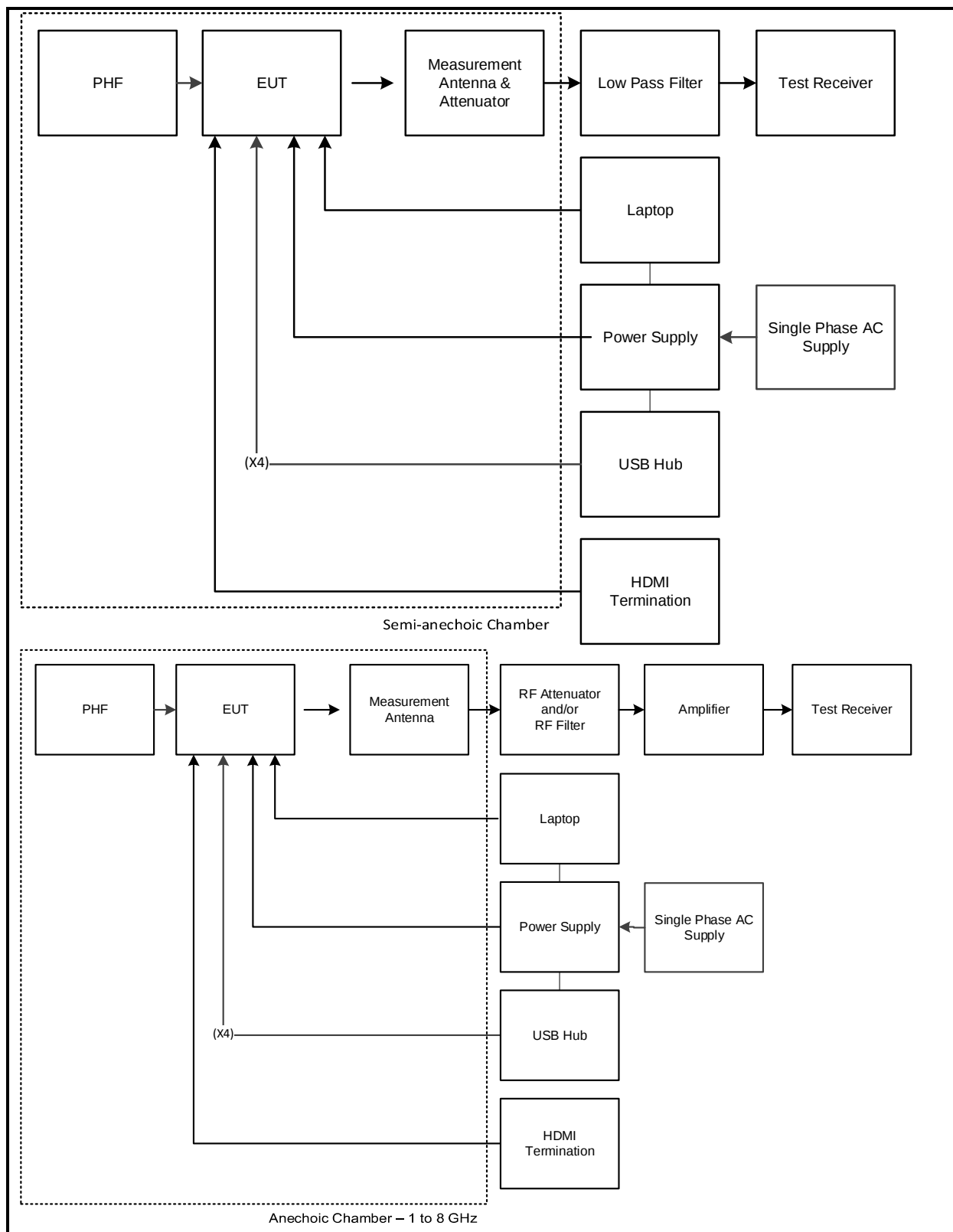
|                          |                                  |
|--------------------------|----------------------------------|
| <b>FCC Reference:</b>    | Parts 15.247(d) & 15.209(a)      |
| <b>Test Method Used:</b> | ANSI C63.10 Sections 6.3 and 6.5 |
| <b>Frequency Range</b>   | 30 MHz to 1000 MHz               |

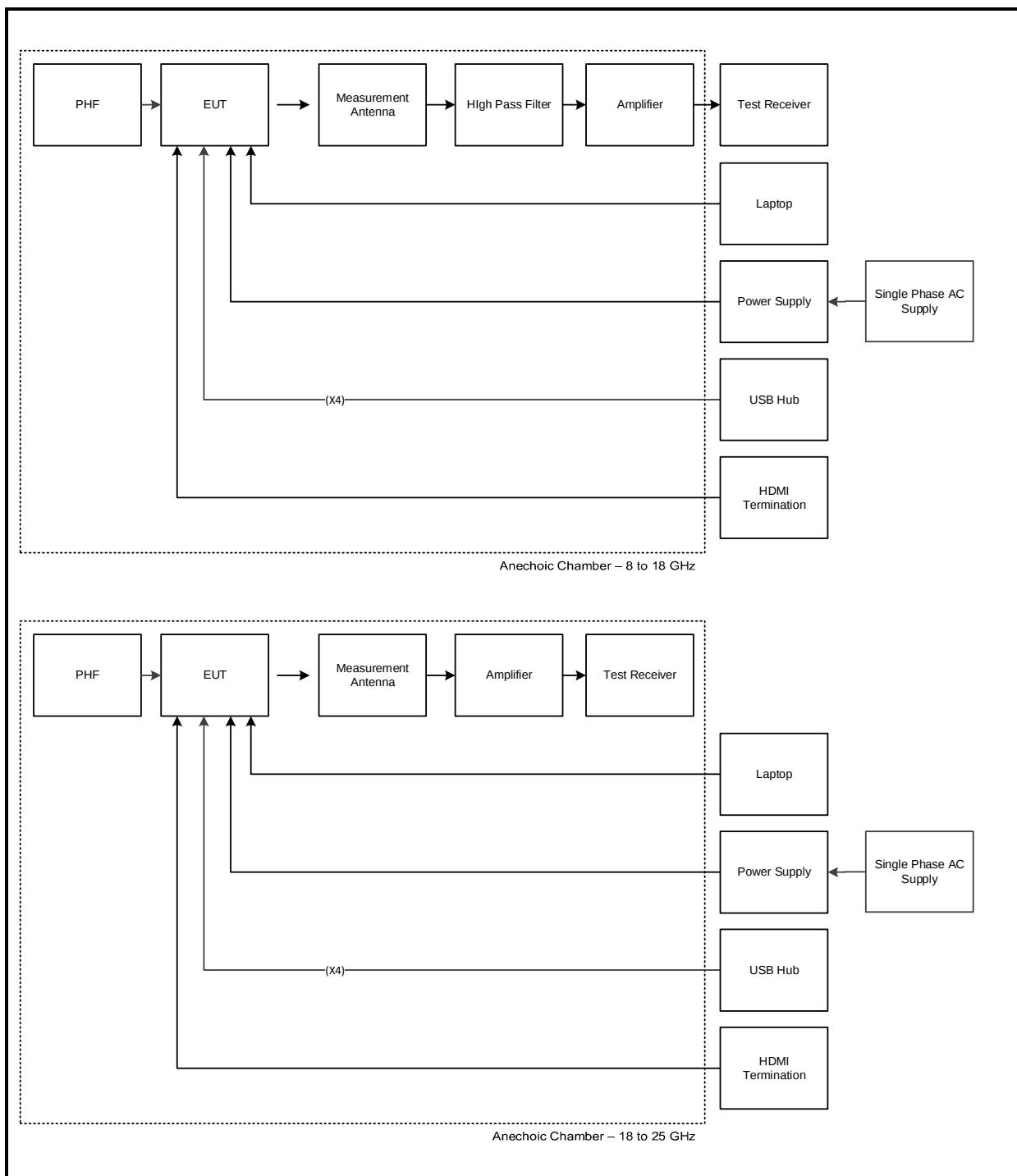
**Environmental Conditions:**

|                               |    |
|-------------------------------|----|
| <b>Temperature (°C):</b>      | 23 |
| <b>Relative Humidity (%):</b> | 40 |

**Note(s):**

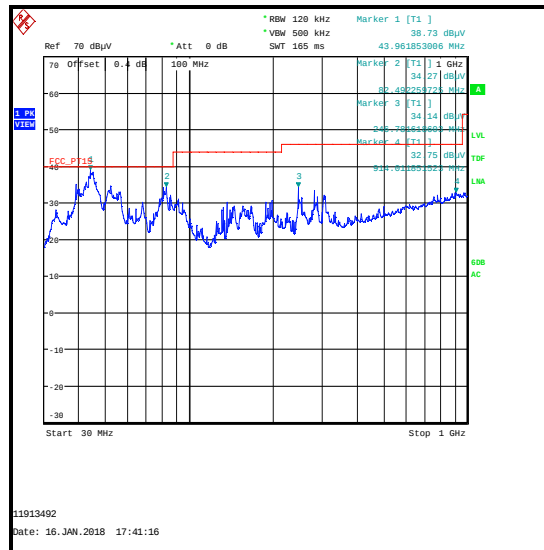
1. The final measured value, for the given emission, in the table below incorporates the calibrated antenna factor and cable loss.
2. The preliminary scans showed similar emission levels below 1 GHz, for each channel of operation. Therefore final radiated emissions measurements were performed with the EUT set to the middle channel only.
3. All other emissions shown on the pre-scans were investigated and found to be ambient, or > 20 dB below the appropriate limit or below the measurement system noise floor and therefore not recorded.
4. Measurements below 1 GHz were performed in a semi-anechoic chamber (Asset Number K0017) at a distance of 3 metres. The EUT was placed at a height of 80 cm above the reference ground plane in the centre of the chamber turntable. Maximum emission levels were determined by height searching the measurement antenna over the range 1 metre to 4 metres.
5. Pre-scans were performed and markers placed on the highest measured levels. The test receiver resolution bandwidth was set to 120 kHz and video bandwidth 500 kHz. A peak detector was used, sweep time was set to auto and trace mode was Max Hold.
6. Final measurements were performed on the marker frequencies and the results entered into the table below. The test receiver resolution bandwidth was set to 120 kHz. A peak detector was used, sweep time was set to auto and trace mode was Max Hold, with the span big enough to see the whole emission.

**Transmitter Radiated Emissions (continued)****Test setup for radiated measurements:**

**Transmitter Radiated Emissions (continued)****Test setup for radiated measurements (continued):**

**Transmitter Radiated Emissions (continued)****Results: Peak / Middle Channel / 802.11g / 6 Mbps**

| Frequency (MHz) | Antenna Polarity | Level (dB $\mu$ V/m) | Limit (dB $\mu$ V/m) | Margin (dB) | Result   |
|-----------------|------------------|----------------------|----------------------|-------------|----------|
| 246.064         | Vertical         | 29.9                 | 46.0                 | 16.1        | Complied |



*Note: This plot is a pre-scan and for indication purposes only. For final measurements, see accompanying table.*

**Test Equipment Used:**

| Asset No. | Instrument       | Manufacturer    | Type No.  | Serial No.   | Date Calibration Due | Cal. Interval (Months) |
|-----------|------------------|-----------------|-----------|--------------|----------------------|------------------------|
| M2003     | Thermohygrometer | Testo           | 608-H1    | 45046641     | 22 Feb 2018          | 12                     |
| K0017     | 3m RSE Chamber   | Rainford EMC    | N/A       | N/A          | 14 Apr 2018          | 12                     |
| M1995     | Test Receiver    | Rohde & Schwarz | ESU40     | 100428       | 13 Apr 2018          | 12                     |
| A2888     | Antenna          | Schwarzbeck     | VULB 9163 | 9163-941     | 25 Apr 2018          | 12                     |
| A2147     | Attenuator       | AtlanTecRF      | AN18-06   | 09020206-06  | 25 Apr 2018          | 12                     |
| A2131     | Low Pass Filter  | AtlanTecRF      | AFL-0200  | JFB 1004-002 | 27 Feb 2018          | 12                     |

**Transmitter Radiated Emissions (continued)****Test Summary:**

|                                   |                                                    |                   |                 |
|-----------------------------------|----------------------------------------------------|-------------------|-----------------|
| <b>Test Engineer:</b>             | Andrew Edwards                                     | <b>Test Date:</b> | 15 January 2018 |
| <b>Test Sample Serial Number:</b> | Not marked or stated ( <i>Radiated sample #1</i> ) |                   |                 |

|                          |                                                                  |
|--------------------------|------------------------------------------------------------------|
| <b>FCC Reference:</b>    | Parts 15.247(d) & 15.209(a)                                      |
| <b>Test Method Used:</b> | ANSI C63.10 Sections 6.3 , 6.6 & FCC KDB 558074 Sections 11 & 12 |
| <b>Frequency Range</b>   | 1 GHz to 25 GHz                                                  |

**Environmental Conditions:**

|                               |    |
|-------------------------------|----|
| <b>Temperature (°C):</b>      | 22 |
| <b>Relative Humidity (%):</b> | 46 |

**Note(s):**

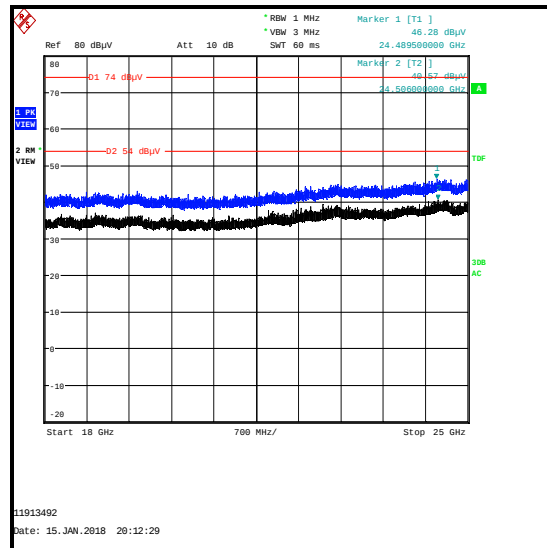
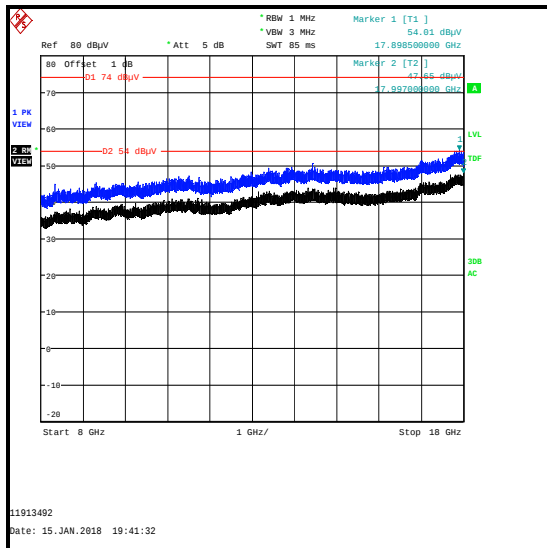
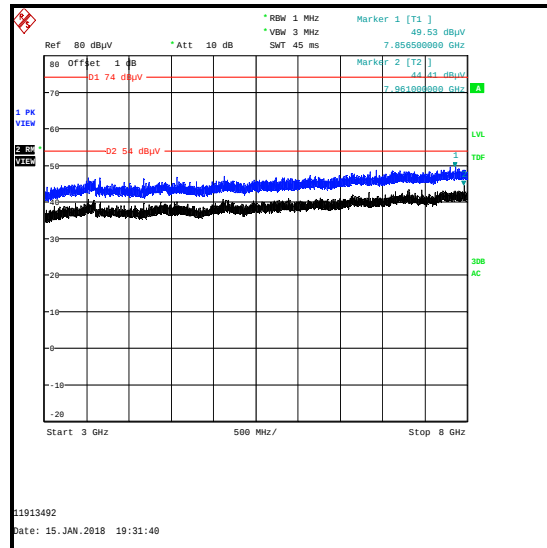
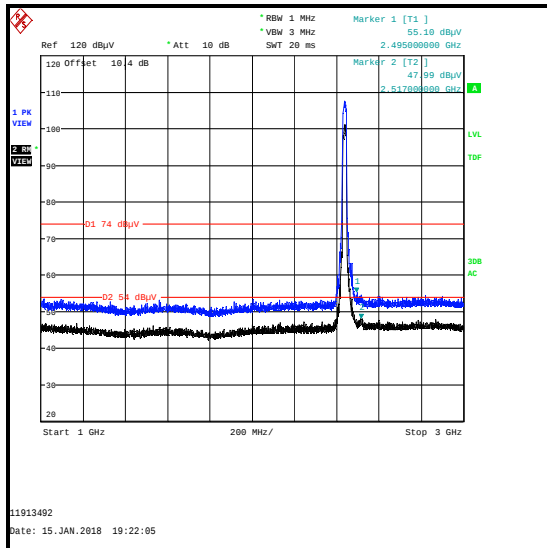
1. The final measured value, for the given emission, in the table below incorporates the calibrated antenna factor and cable loss.
2. No spurious emissions were detected above the noise floor of the measuring receiver therefore the highest peak and average noise floor readings of the measuring receiver were recorded as shown in the tables below.
3. The emission shown on the 1 GHz to 3 GHz plot is the EUT fundamental.
4. Pre-scans above 1 GHz were performed in a fully anechoic chamber (Asset Number K0017) at a distance of 3 metres. The EUT was placed at a height of 1.5 metres above the test chamber floor in the centre of the chamber turntable. All measurement antennas were placed at a fixed height of 1.5 metres above the test chamber floor, in line with the EUT.
5. Pre-scans were performed and a marker placed on the highest measured level of the appropriate plot. The test receiver resolution bandwidth was set to 1 MHz and video bandwidth 3 MHz. The sweep time was set to auto.

**Results: Peak**

| Frequency (MHz) | Antenna Polarity | Peak Level (dBµV/m) | Peak Limit (dBµV/m) | Margin (dB) | Result   |
|-----------------|------------------|---------------------|---------------------|-------------|----------|
| 2495.000        | Vertical         | 55.1                | 74.0                | 18.9        | Complied |

**Results: Average**

| Frequency (MHz) | Antenna Polarity | Average Level (dBµV/m) | Average Limit (dBµV/m) | Margin (dB) | Result   |
|-----------------|------------------|------------------------|------------------------|-------------|----------|
| 2517.000        | Vertical         | 48.0                   | 54.0                   | 6.0         | Complied |

**Transmitter Radiated Emissions (continued)**

**Transmitter Radiated Emissions (continued)****Test Equipment Used:**

| Asset No. | Instrument       | Manufacturer    | Type No.    | Serial No. | Date Calibration Due | Cal. Interval (Months) |
|-----------|------------------|-----------------|-------------|------------|----------------------|------------------------|
| M2003     | Thermohygrometer | Testo           | 608-H1      | 45046641   | 22 Feb 2018          | 12                     |
| K0017     | 3m RSE Chamber   | Rainford EMC    | N/A         | N/A        | 14 Feb 2018          | 12                     |
| M1995     | Test Receiver    | Rohde & Schwarz | ESU40       | 100428     | 13 Apr 2018          | 12                     |
| A2863     | Pre Amplifier    | Agilent         | 8449B       | 3008A02100 | 11 Apr 2018          | 12                     |
| A2891     | Pre Amplifier    | Schwarzbeck     | BBV 9718    | 9718-306   | 11 Apr 2018          | 12                     |
| A2893     | Pre Amplifier    | Schwarzbeck     | BBV 9721    | 9721-021   | 11 Apr 2018          | 12                     |
| A2889     | Antenna          | Schwarzbeck     | BBHA 9120 B | 9120 B 653 | 11 Apr 2018          | 12                     |
| A2890     | Antenna          | Schwarzbeck     | HWRD 750    | 014        | 11 Apr 2018          | 12                     |
| A2892     | Antenna          | Schwarzbeck     | BBHA 9170   | 9170-727   | 11 Apr 2018          | 12                     |
| A2916     | Attenuator       | AtlanTecRF      | AN18W5-10   | 832827#1   | 03 Mar 2018          | 12                     |
| A2914     | High Pass Filter | AtlanTecRF      | AFH-03000   | 2155       | 06 Mar 2018          | 12                     |
| A2947     | High Pass Filter | AtlanTecRF      | AFH-07000   | 1601900001 | 18 May 2018          | 12                     |

**5.2.7. Transmitter Band Edge Radiated Emissions****Test Summary:**

|                                    |                                                              |                    |                                        |
|------------------------------------|--------------------------------------------------------------|--------------------|----------------------------------------|
| <b>Test Engineers:</b>             | Andrew Edwards &<br>John Ferdinand                           | <b>Test Dates:</b> | 15 January 2018 to<br>19 February 2018 |
| <b>Test Sample Serial Numbers:</b> | Not marked or stated ( <i>Radiated samples #1 &amp; #2</i> ) |                    |                                        |

|                          |                                                            |
|--------------------------|------------------------------------------------------------|
| <b>FCC Reference:</b>    | Parts 15.247(d) & 15.209(a)                                |
| <b>Test Method Used:</b> | ANSI C63.10 Section 6.10 & FCC KDB 558074 Sections 11 & 12 |

**Environmental Conditions:**

|                               |          |
|-------------------------------|----------|
| <b>Temperature (°C):</b>      | 22 to 23 |
| <b>Relative Humidity (%):</b> | 34 to 44 |

**Note(s):**

1. The customer declared the following data rates to be used for all measurements as:

- o 802.11b - DBPSK / 1 Mbps
- o 802.11g - BPSK / 6 Mbps
- o 802.11n HT20 - BPSK / MCS0
- o 802.11n HT40 - BPSK / MCS0

Final measurements were performed with the above configurations.

2. The final measured value, for the given emission, in the table below incorporates the calibrated antenna factor and cable loss.
3. The maximum conducted (average) output power was previously measured. In accordance with FCC KDB 558074 Section 11.1(b), the lower band edge measurement should be performed with a peak detector and the -30 dBc limit applied.
4. As the lower band edge falls within a non-restricted band, only peak measurements are required. In accordance with FCC KDB 558074 Section 11.1, the test method in Section 11.3 was followed: the test receiver resolution bandwidth was set to 100 kHz and video bandwidth 300 kHz. A peak detector was used, sweep time was set to auto and trace mode was Max Hold. The test receiver was left to sweep for a sufficient length of time in order to maximise the carrier level and out-of-band emissions. A marker and corresponding reference level line were placed on the peak of the carrier. As the maximum conducted (average) output power was measured using an RMS detector in accordance with FCC KDB 558074 Section 9.2.2.4 an out-of-band limit line was placed 30 dB (FCC KDB 558074 Section 11.1(b)) below the peak level. A marker was placed on the band edge spot frequencies and a second marker placed on the highest emission level in the adjacent non-restricted band of operation (where a higher level emission was present). Marker frequencies and levels were recorded.
5. As the upper band edge falls within a restricted band both peak and average measurements were recorded by placing a marker at the edge of the band. For peak measurements the test receiver resolution bandwidth was set to 1 MHz and the video bandwidth 3 MHz. A peak detector was used, sweep time was set to auto and trace mode was Max Hold. For average measurements the test receiver resolution bandwidth was set to 1 MHz and the video bandwidth 3 MHz. An RMS detector was used, sweep time was set to auto and trace mode was trace averaging over 300 sweeps. A marker was placed on the band edge spot frequencies and a second marker placed on the highest emission level in the adjacent restricted band of operation (where a higher level emission was present). Marker frequencies and levels were recorded.

**Transmitter Band Edge Radiated Emissions (continued)****Note(s):**

6. There is a restricted band 10 MHz below the lower band edge. The test receiver was set up as follows: the RBW set to 1 MHz, the VBW set to 3 MHz, with the sweep time set to auto couple. Peak and average measurements were performed with their respective detectors. Markers were placed on the highest point on each trace.
7. For 802.11n HT40 the EUT was transmitting at <98% duty cycle, in accordance with KDB 558074 Section 12.2.5.2, the calculated duty cycle in section 5.2.3 was added to the measured result for average measurements.
8. \*For 802.11n HT40 modes, the integration method was used in accordance with FCC KDB 558074 Section 13.3.2, in order to meet the average limit. As the EUT had a duty cycle < 98% the duty cycle correction factor has been added to the band edge result.
9. The lower and upper band measurements were performed using a reference level of 130 dB $\mu$ V/m in order to achieve the correct headroom as specified in FCC KDB 558074 Section 5.2.

**Transmitter Band Edge Radiated Emissions (continued)****Results: 802.11b / 20 MHz / DBPSK / 1 Mbps****Results: Lower Band Edge**

| Frequency (MHz) | Level (dB $\mu$ V/m) | -30 dBc Limit (dB $\mu$ V/m) | Margin (dB) | Result   |
|-----------------|----------------------|------------------------------|-------------|----------|
| 2398.878        | 53.0                 | 69.7                         | 16.7        | Complied |
| 2400            | 52.2                 | 69.7                         | 17.5        | Complied |

**Results: Upper Band Edge / Peak**

| Frequency (MHz) | Level (dB $\mu$ V/m) | Limit (dB $\mu$ V/m) | Margin (dB) | Result   |
|-----------------|----------------------|----------------------|-------------|----------|
| 2483.5          | 55.2                 | 74.0                 | 18.8        | Complied |
| 2488.660        | 56.2                 | 74.0                 | 17.8        | Complied |

**Results: Upper Band Edge / Average**

| Frequency (MHz) | Level (dB $\mu$ V/m) | Limit (dB $\mu$ V/m) | Margin (dB) | Result   |
|-----------------|----------------------|----------------------|-------------|----------|
| 2483.5          | 43.3                 | 54.0                 | 10.7        | Complied |

**Results: 2310 MHz to 2390 MHz Restricted Band / Peak**

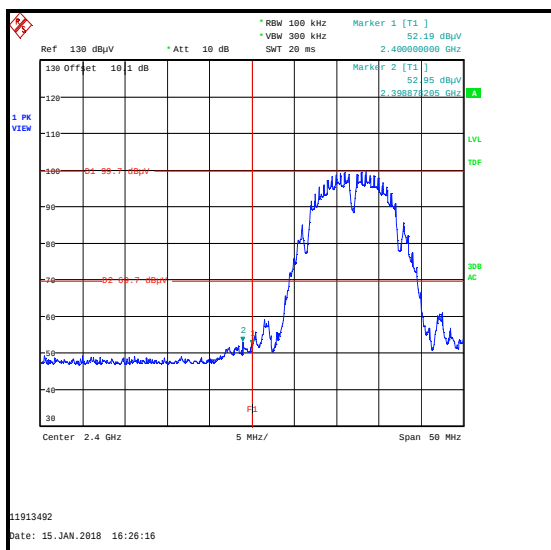
| Frequency (MHz) | Level (dB $\mu$ V/m) | Limit (dB $\mu$ V/m) | Margin (dB) | Result   |
|-----------------|----------------------|----------------------|-------------|----------|
| 2387.051        | 53.4                 | 74.0                 | 20.6        | Complied |

**Results: 2310 MHz to 2390 MHz Restricted Band / Average**

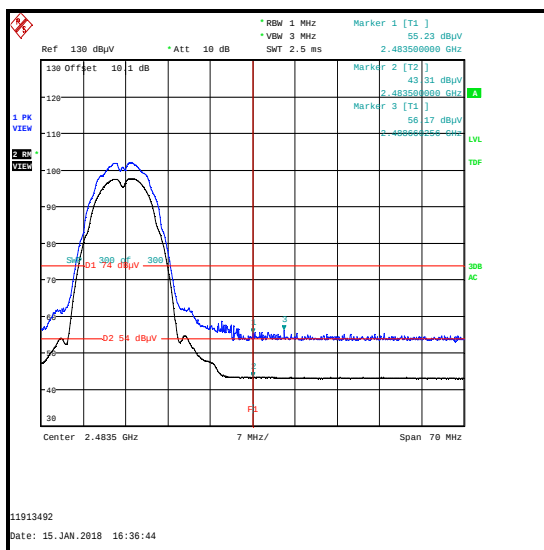
| Frequency (MHz) | Level (dB $\mu$ V/m) | Limit (dB $\mu$ V/m) | Margin (dB) | Result   |
|-----------------|----------------------|----------------------|-------------|----------|
| 2339.103        | 41.6                 | 54.0                 | 12.4        | Complied |

### Transmitter Band Edge Radiated Emissions (continued)

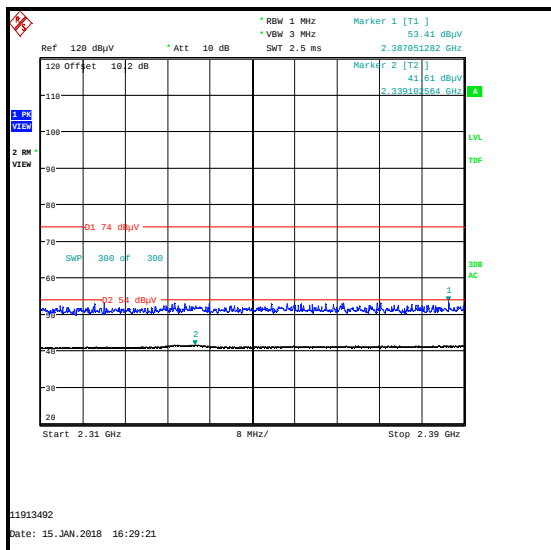
**Results: 802.11b / 20 MHz / DBPSK / 1 Mbps**



### Lower Band Edge



### Upper Band Edge



## 2310 MHz to 2390 MHz Restricted Band

**Transmitter Band Edge Radiated Emissions (continued)****Results: 802.11g / 20 MHz / BPSK / 6 Mbps****Results: Lower Band Edge**

| Frequency (MHz) | Level (dBμV/m) | -30 dBc Limit (dBμV/m) | Margin (dB) | Result   |
|-----------------|----------------|------------------------|-------------|----------|
| 2399.760        | 64.8           | 68.9                   | 4.1         | Complied |
| 2400            | 62.5           | 68.9                   | 6.4         | Complied |

**Results: Upper Band Edge / Peak**

| Frequency (MHz) | Level (dBμV/m) | Limit (dBμV/m) | Margin (dB) | Result   |
|-----------------|----------------|----------------|-------------|----------|
| 2483.5          | 66.6           | 74.0           | 7.4         | Complied |
| 2483.949        | 66.7           | 74.0           | 7.3         | Complied |

**Results: Upper Band Edge / Average**

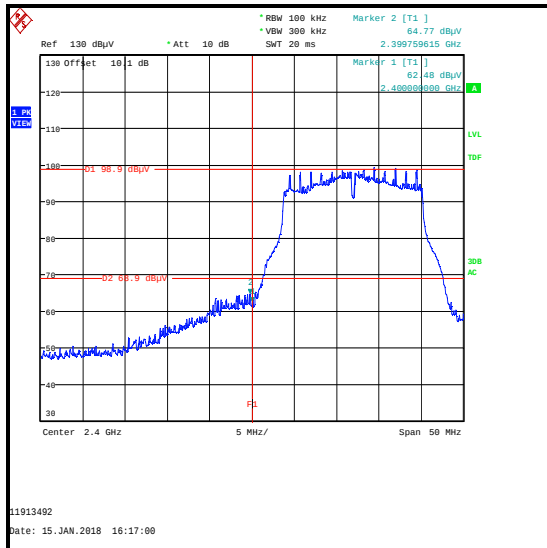
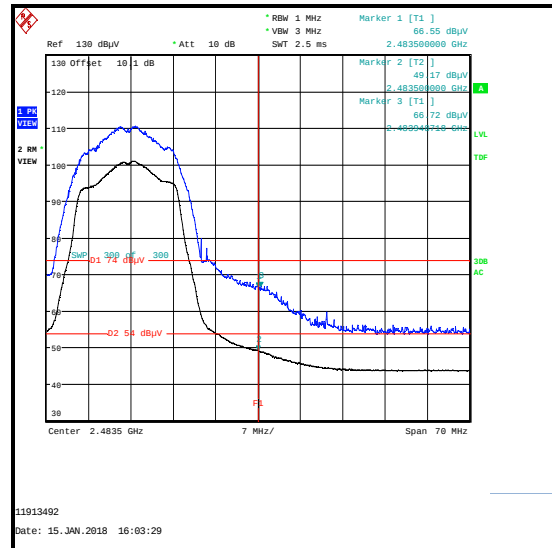
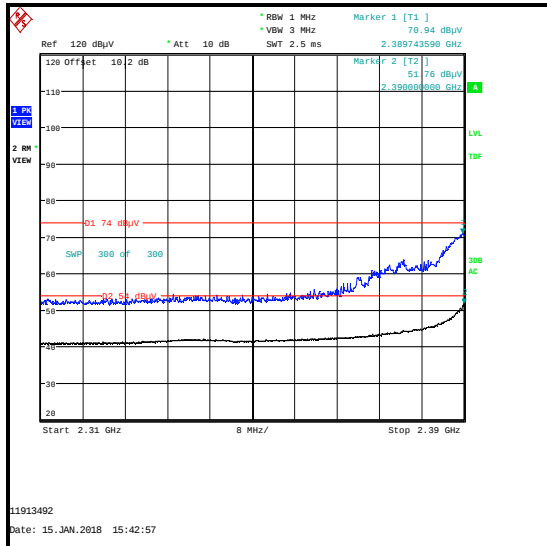
| Frequency (MHz) | Level (dBμV/m) | Limit (dBμV/m) | Margin (dB) | Result   |
|-----------------|----------------|----------------|-------------|----------|
| 2483.5          | 49.2           | 54.0           | 4.8         | Complied |

**Results: 2310 MHz to 2390 MHz Restricted Band / Peak**

| Frequency (MHz) | Level (dBμV/m) | Limit (dBμV/m) | Margin (dB) | Result   |
|-----------------|----------------|----------------|-------------|----------|
| 2389.744        | 70.9           | 74.0           | 3.1         | Complied |

**Results: 2310 MHz to 2390 MHz Restricted Band / Average**

| Frequency (MHz) | Level (dBμV/m) | Limit (dBμV/m) | Margin (dB) | Result   |
|-----------------|----------------|----------------|-------------|----------|
| 2390.000        | 51.8           | 54.0           | 2.2         | Complied |

**Transmitter Band Edge Radiated Emissions (continued)****Results: 802.11g / 20 MHz / BPSK / 6 Mbps****Lower Band Edge****Upper Band Edge****2310 MHz to 2390 MHz Restricted Band**

**Transmitter Band Edge Radiated Emissions (continued)****Results: 802.11n HT20 / BPSK / MCS0****Results: Lower Band Edge**

| Frequency (MHz) | Level (dBμV/m) | -30 dBc Limit (dBμV/m) | Margin (dB) | Result   |
|-----------------|----------------|------------------------|-------------|----------|
| 2399.760        | 64.5           | 68.6                   | 4.1         | Complied |
| 2400            | 63.7           | 68.6                   | 4.9         | Complied |

**Results: Upper Band Edge / Peak**

| Frequency (MHz) | Level (dBμV/m) | Limit (dBμV/m) | Margin (dB) | Result   |
|-----------------|----------------|----------------|-------------|----------|
| 2483.5          | 64.8           | 74.0           | 9.2         | Complied |
| 2483.612        | 67.0           | 74.0           | 7.0         | Complied |

**Results: Upper Band Edge / Average**

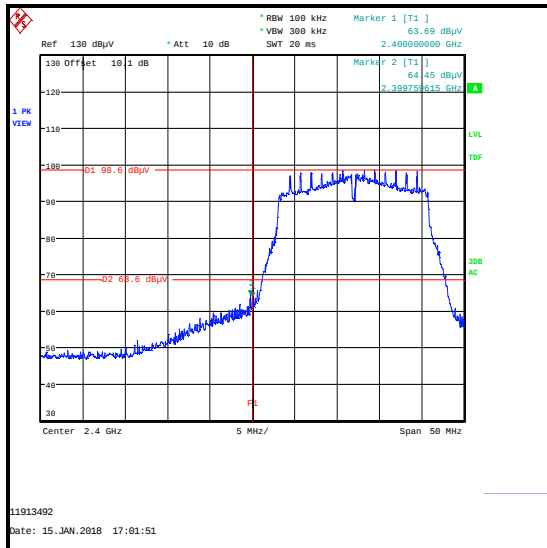
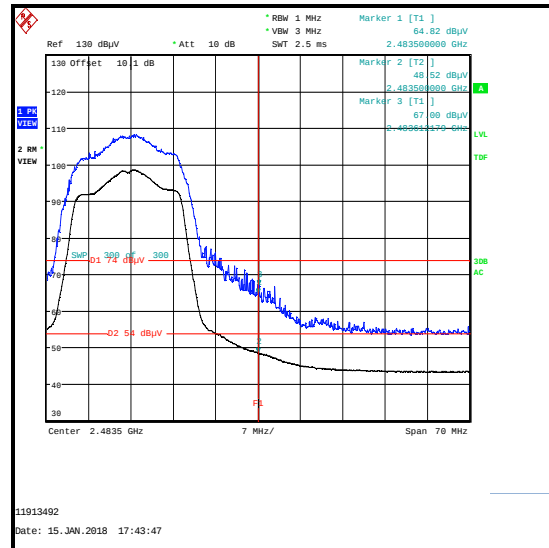
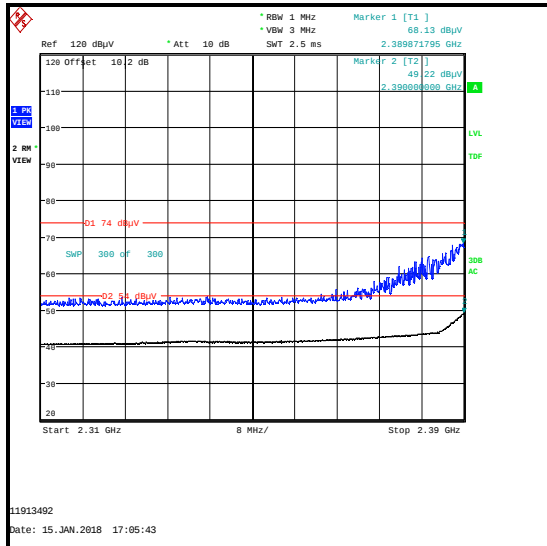
| Frequency (MHz) | Level (dBμV/m) | Limit (dBμV/m) | Margin (dB) | Result   |
|-----------------|----------------|----------------|-------------|----------|
| 2483.5          | 48.5           | 54.0           | 5.5         | Complied |

**Results: 2310 MHz to 2390 MHz Restricted Band / Peak**

| Frequency (MHz) | Level (dBμV/m) | Limit (dBμV/m) | Margin (dB) | Result   |
|-----------------|----------------|----------------|-------------|----------|
| 2389.872        | 68.1           | 74.0           | 5.9         | Complied |

**Results: 2310 MHz to 2390 MHz Restricted Band / Average**

| Frequency (MHz) | Level (dBμV/m) | Limit (dBμV/m) | Margin (dB) | Result   |
|-----------------|----------------|----------------|-------------|----------|
| 2390.000        | 49.2           | 54.0           | 4.8         | Complied |

**Transmitter Band Edge Radiated Emissions (continued)****Results: 802.11n HT20 / BPSK / MCS0****Lower Band Edge****Upper Band Edge****2310 MHz to 2390 MHz Restricted Band**

**Transmitter Band Edge Radiated Emissions (continued)****Results: 802.11n HT40 / BPSK / MCS0****Results: Lower Band Edge**

| Frequency (MHz) | Level (dBμV/m) | -30 dBc Limit (dBμV/m) | Margin (dB) | Result   |
|-----------------|----------------|------------------------|-------------|----------|
| 2396.827        | 64.4           | 65.2                   | 0.8         | Complied |
| 2400            | 62.7           | 65.2                   | 2.5         | Complied |

**Results: Upper Band Edge / Peak**

| Frequency (MHz) | Level (dBμV/m) | Limit (dBμV/m) | Margin (dB) | Result   |
|-----------------|----------------|----------------|-------------|----------|
| 2483.5          | 64.4           | 74.0           | 9.6         | Complied |
| 2483.676        | 67.5           | 74.0           | 6.5         | Complied |

**Results: Upper Band Edge / Average**

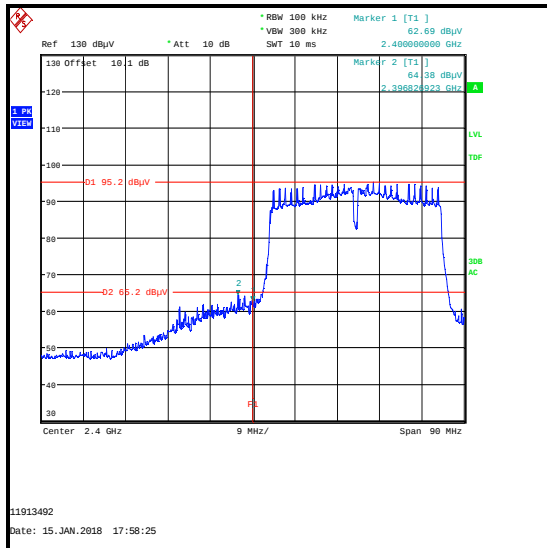
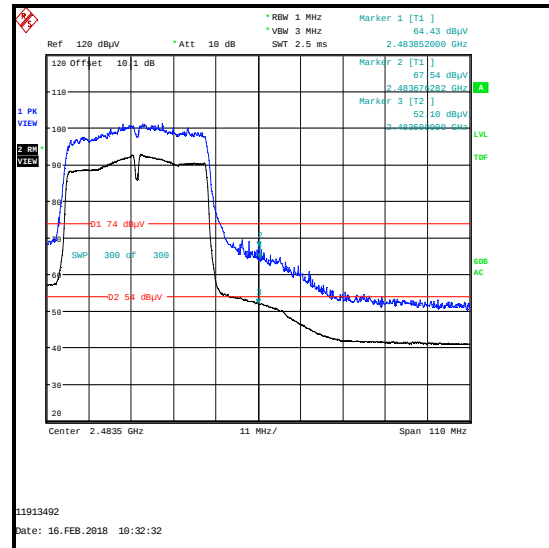
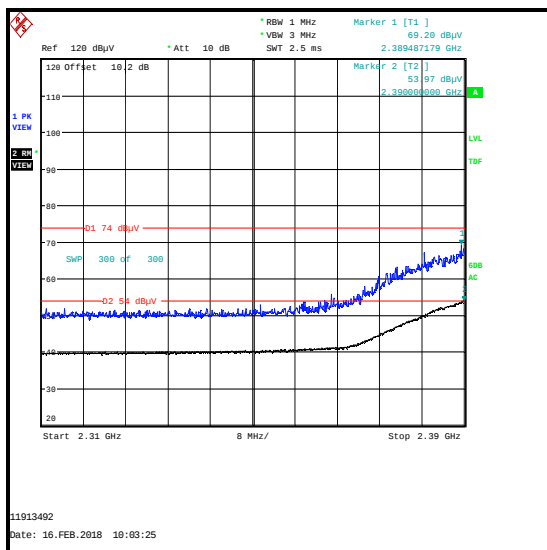
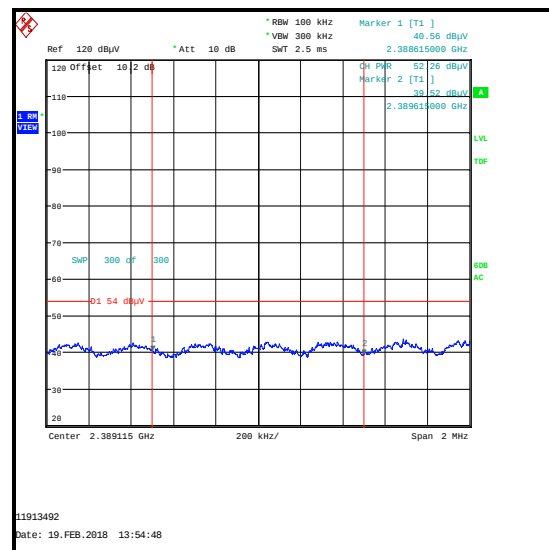
| Frequency (MHz) | Level (dBμV/m) | Duty Cycle Correction (dB) | Corrected Level (dBμV/m) | Limit (dBμV/m) | Margin (dB) | Result   |
|-----------------|----------------|----------------------------|--------------------------|----------------|-------------|----------|
| 2483.5          | 52.1           | 0.1                        | 52.2                     | 54.0           | 1.8         | Complied |

**Results: 2310 MHz to 2390 MHz Restricted Band / Peak**

| Frequency (MHz) | Level (dBμV/m) | Limit (dBμV/m) | Margin (dB) | Result   |
|-----------------|----------------|----------------|-------------|----------|
| 2389.487        | 69.2           | 74.0           | 4.8         | Complied |

**Results: 2310 MHz to 2390 MHz Restricted Band / Average**

| Frequency (MHz) | Level (dBμV/m) | Duty Cycle Correction (dB) | Corrected Level (dBμV/m) | Limit (dBμV/m) | Margin (dB) | Result   |
|-----------------|----------------|----------------------------|--------------------------|----------------|-------------|----------|
| 2389.615        | *52.3          | 0.1                        | 52.4                     | 54.0           | 1.6         | Complied |

**Transmitter Band Edge Radiated Emissions (continued)****Results: 802.11n HT40 / BPSK / MCS0****Lower Band Edge****Upper Band Edge****2310 MHz to 2390 MHz Restricted Band Plot****2310 MHz to 2390 MHz Restricted Band / Average  
– Integration performed 0.5 MHz away from  
2389.615 MHz**

**Transmitter Band Edge Radiated Emissions (continued)****Test Equipment Used:**

| Asset No. | Instrument       | Manufacturer    | Type No.    | Serial No. | Date Calibration Due | Cal. Interval (Months) |
|-----------|------------------|-----------------|-------------|------------|----------------------|------------------------|
| M2003     | Thermohygrometer | Testo           | 608-H1      | 45046641   | 22 Feb 2018          | 12                     |
| K0017     | 3m RSE Chamber   | Rainford EMC    | N/A         | N/A        | 14 Apr 2018          | 12                     |
| M1995     | Test Receiver    | Rohde & Schwarz | ESU40       | 100428     | 13 Apr 2018          | 12                     |
| A2863     | Pre Amplifier    | Agilent         | 8449B       | 3008A02100 | 11 Apr 2018          | 12                     |
| A2889     | Antenna          | Schwarzbeck     | BBHA 9120 B | 9120 B 653 | 11 Apr 2018          | 12                     |
| A2916     | Attenuator       | AtlanTecRF      | AN18W5-10   | 832827#1   | 03 Mar 2018          | 12                     |

## **6. Measurement Uncertainty**

No measurement or test can ever be perfect and the imperfections give rise to error of measurement in the results. Consequently the result of a measurement is only an approximation to the value of the measurand (the specific quantity subject to measurement) and is only complete when accompanied by a statement of the uncertainty of the approximation.

The expression of uncertainty of a measurement result allows realistic comparison of results with reference values and limits given in specifications and standards.

The uncertainty of the result may need to be taken into account when interpreting the measurement results.

The reported expanded uncertainties below are based on a standard uncertainty multiplied by an appropriate coverage factor such that a confidence level of approximately 95% is maintained. For the purposes of this document “approximately” is interpreted as meaning “effectively” or “for most practical purposes”.

| Measurement Type                | Range                 | Confidence Level (%) | Calculated Uncertainty |
|---------------------------------|-----------------------|----------------------|------------------------|
| AC Conducted Spurious Emissions | 0.15 MHz to 30 MHz    | 95%                  | ±2.40 dB               |
| Minimum 6 dB Bandwidth          | 2.4 GHz to 2.4835 GHz | 95%                  | ±4.59 %                |
| Duty Cycle                      | 2.4 GHz to 2.4835 GHz | 95%                  | ±1.14 %                |
| Spectral Power Density          | 2.4 GHz to 2.4835 GHz | 95%                  | ±1.13 dB               |
| Conducted Maximum Output Power  | 2.4 GHz to 2.4835 GHz | 95%                  | ±1.13 dB               |
| Radiated Spurious Emissions     | 30 MHz to 1 GHz       | 95%                  | ±4.65 dB               |
| Radiated Spurious Emissions     | 1 GHz to 25 GHz       | 95%                  | ±2.94 dB               |

The methods used to calculate the above uncertainties are in line with those recommended within the various measurement specifications. Where measurement specifications do not include guidelines for the evaluation of measurement uncertainty the published guidance of the appropriate accreditation body is followed.

**7. Report Revision History**

| Version Number | Revision Details |        |                          |
|----------------|------------------|--------|--------------------------|
|                | Page No(s)       | Clause | Details                  |
| 1.0            | -                | -      | Initial Version          |
| 2.0            | 44               | -      | Test setup diagram added |

--- END OF REPORT ---