# TEST REPORT

## Test Report No. : UL-RPT-RP11456397JD18C

| | | |
|---|---|---|
| **Manufacturer** | : | Neeo AG |
| **Model No.** | : | 6336-BRAIN |
| **FCC ID** | : | 2AKK7-BR633601 |
| **Technology** | : | Digital Transmission System (6LoWPAN / IEEE 802.15.4) |
| **Test Standard(s)** | : | FCC Parts 15.209(a) & 15.247 |

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2. The results in this report apply only to the sample(s) tested.
3. This 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 1.0.

**Date of Issue:** 18 April 2017

**Checked by:**

Ian Watch
Senior Engineer, Radio Laboratory

**Company Signatory:**

Sarah Williams
Senior Engineer, Radio Laboratory
UL VS LTD

0644

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

**UL VS LTD**

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# 1. Customer Information

| | |
|---|---|
| **Company Name:** | Neeo AG |
| **Address:** | Ritterquai 8<br>4500 Solothurn<br>Switzerland |

# 2. Summary of Testing

## 2.1. General Information

| | |
|---|---|
| **Specification Reference:** | 47CFR15.247 |
| **Specification Title:** | Code of Federal Regulations Volume 47 (Telecommunications): Part 15 Subpart C (Intentional Radiators) - Section 15.247 |
| **Specification Reference:** | 47CFR15.209 |
| **Specification Title:** | Code of Federal Regulations Volume 47 (Telecommunications): Part 15 Subpart C (Intentional Radiators) – Section 15.209 |
| **Site Registration:** | 209735 |
| **Location of Testing:** | UL VS LTD, Unit 3 Horizon, Wade Road, Kingsland Business Park, Basingstoke, Hampshire, RG24 8AH, United Kingdom |
| **Test Dates:** | 14 December 2016 to 12 April 2017 |

## 2.2. Summary of Test Results

| FCC Reference (47CFR) | Measurement | Result |
|---|---|---|
| Part 15.247(a)(2) | Transmitter Minimum 6 dB Bandwidth | ✓ |
| Part 15.247(e) | Transmitter Power Spectral Density | ✓ |
| Part 15.247(b)(3) | Transmitter Maximum Peak Output Power | ✓ |
| Part 15.247(d)/15.209(a) | Transmitter Radiated Emissions | ✓ |
| Part 15.247(d)/15.209(a) | Transmitter Band Edge Radiated Emissions | ✓ |
| **Key to Results** ✓ = Complied ✗ = Did not comply | | |

## 2.3. Methods and Procedures

| | |
|---|---|
| **Reference:** | ANSI C63.10-2013 |
| **Title:** | American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices |
| **Reference:** | KDB 558074 D01 DTS Meas Guidance v03r05 April 8, 2016 |
| **Title:** | Guidance for Performing Compliance Measurements on Digital Transmission Systems (DTS) Operating Under §15.247 |

## 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)

| | |
|---|---|
| **Brand Name:** | Neeo |
| **Model Name or Number:** | 6336-BRAIN |
| **Test Sample Serial Number:** | Not marked or stated *(Radiated sample)* |
| **Hardware Version:** | Hardware Rev. 5 |
| **Software Version:** | 0.23.0 |
| **FCC ID:** | 2AKK7-BR633601 |

| | |
|---|---|
| **Brand Name:** | Neeo |
| **Model Name or Number:** | 6336-BRAIN |
| **Test Sample Serial Number:** | Not marked or stated *(Conducted sample with RF port)* |
| **Hardware Version:** | Hardware Rev. 5 |
| **Software Version:** | 0.23.0 |
| **FCC ID:** | 2AKK7-BR633601 |

## 3.2. Description of EUT

The Equipment Under Test was a base station for home automation. It contains Z-Wave, *Bluetooth* BR/EDR/ LE, IEEE 802.15.4 and WLAN transceivers. It is powered from an AC/DC adaptor.

## 3.3. Modifications Incorporated in the EUT

No modifications were applied to the EUT during testing.

## 3.4. Additional Information Related to Testing

| | | | |
|---|---|---|---|
| **Technology Tested:** | IEEE 802.15.4 / 6LoWPAN / Digital Transmission System | | |
| **Type of Unit:** | Transceiver | | |
| **Modulation:** | O-QPSK | | |
| **Data Rate:** | 250 kb/s | | |
| **Power Supply Requirement(s):** | Nominal | 5.2 VDC via 120 VAC 60 Hz adaptor | |
| **Antenna Gain:** | 0.5 dBi | | |
| **Transmit Frequency Range:** | 2405 MHz to 2480 MHz | | |
| **Transmit Channels Tested:** | **Channel ID** | **Channel Number** | **Channel Frequency (MHz)** |
| | Bottom | 11 | 2405 |
| | Middle | 18 | 2440 |
| | Top | 26 | 2480 |

## 3.5. Support Equipment

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

| | |
|---|---|
| **Description:** | Laptop PC |
| **Brand Name:** | Dell |
| **Model Name or Number:** | E5400 |
| **Serial Number:** | 01160 |

| | |
|---|---|
| **Description:** | USB to TTL Serial Cable. Length 1.8 metres |
| **Brand Name:** | FTDI Chip |
| **Model Name or Number:** | TTL-232R-3V3-AJ |
| **Serial Number:** | Not marked or stated |

| | |
|---|---|
| **Description:** | AC/DC Adaptor |
| **Brand Name:** | Liteon |
| **Model Name or Number:** | PA-1100-25 |
| **Serial Number:** | KPO1003005 6088111EPE03 |

| | |
|---|---|
| **Description:** | HDMI Cable. Length 3 metres |
| **Brand Name:** | Not marked or stated |
| **Model Name or Number:** | Not marked or stated |
| **Serial Number:** | Not marked or stated |

| | |
|---|---|
| **Description:** | Now TV Box for HDMI Termination |
| **Brand Name:** | Sky |
| **Model Name or Number:** | 2400SK |
| **Serial Number:** | 1MM4DE006281 |

| | |
|---|---|
| **Description:** | Infra-Red Sensor |
| **Brand Name:** | Neeo |
| **Model Name or Number:** | Not marked or stated |
| **Serial Number:** | Not marked or stated |

# 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 100% duty cycle at maximum power on the bottom, middle and top channels as required.

## 4.2. Configuration and Peripherals

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

- A laptop PC with an open source terminal application Tera Term V4.83 was used to place the EUT into test mode. Operating channels were configured in the test application following instructions provided by the customer. The procedure to set up and control the EUT in 6LoWPAN mode was supplied by the customer in a document titled “userManual-Radio.pdf” dated 12/12/2016. Transmitter power level setting of 3 was used for all tests.
- The EUT was powered from an AC/DC adaptor. The power supply input was connected to a 120 VAC 60 Hz single phase supply.
- Radiated spurious emissions were performed with the EUT in the orientation that produced the highest level emissions. Tests were performed with the EUT connected to the AC/DC adaptor and USB cable. All other ports were terminated with the supplied accessories.
- The EUT radiated sample was used for radiated spurious emissions tests.
- The EUT conducted sample was used for all other 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 Minimum 6 dB Bandwidth

**Test Summary:**

| | | | |
|---|---|---|---|
| **Test Engineer:** | David Doyle | **Test Date:** | 14 December 2016 |
| **Test Sample Serial Number:** | Not marked or stated *(Conducted sample with RF port)* | | |

| | |
|---|---|
| **FCC Reference:** | Part 15.247(a)(2) |
| **Test Method Used:** | FCC KDB 558074 Section 8.1 Option 1 |

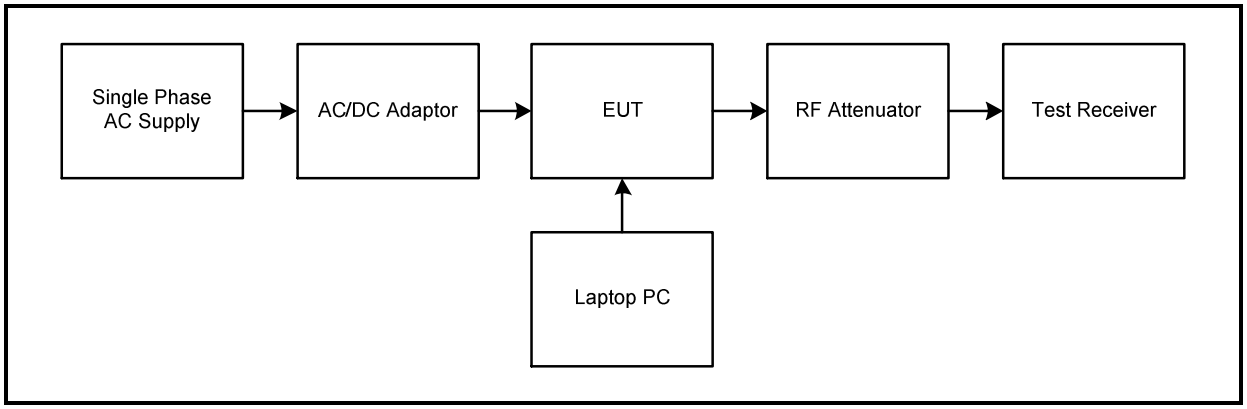
**Environmental Conditions:**

| | |
|---|---|
| **Temperature (°C):** | 23 |
| **Relative Humidity (%):** | 42 |

**Note(s):**

1. 6 dB DTS bandwidth tests were performed using a test receiver in accordance with FCC KDB 558074 Section 8.1 Option 1 measurement procedure. 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 the trace mode was Max Hold. The DTS bandwidth was measured at 6 dB down from the peak of the signal.
2. The test receiver was connected to the RF port on the EUT using suitable attenuation and RF cable.

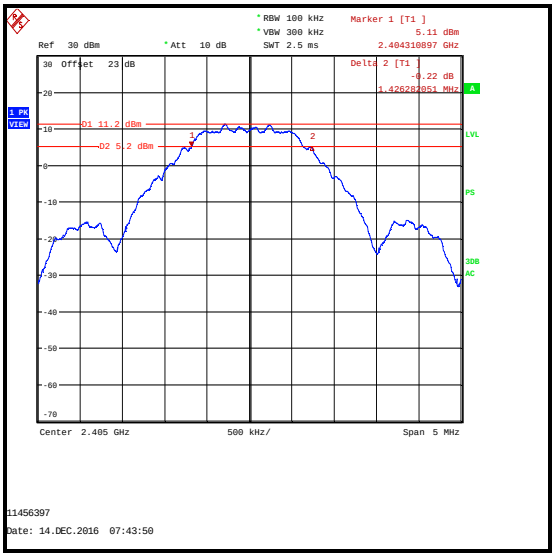
**Test setup:**



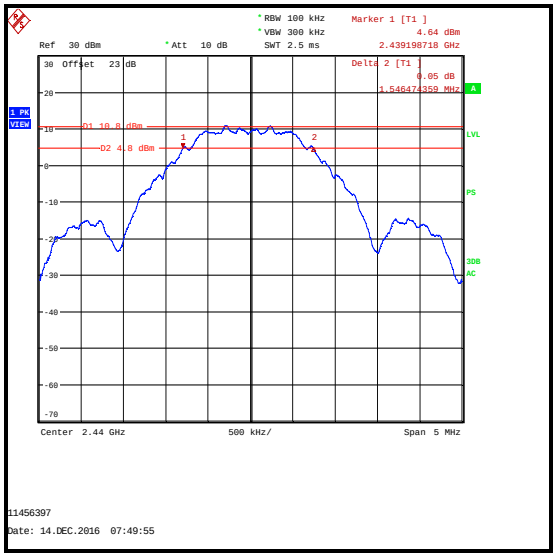
## Transmitter Minimum 6 dB Bandwidth (continued)

## Results:

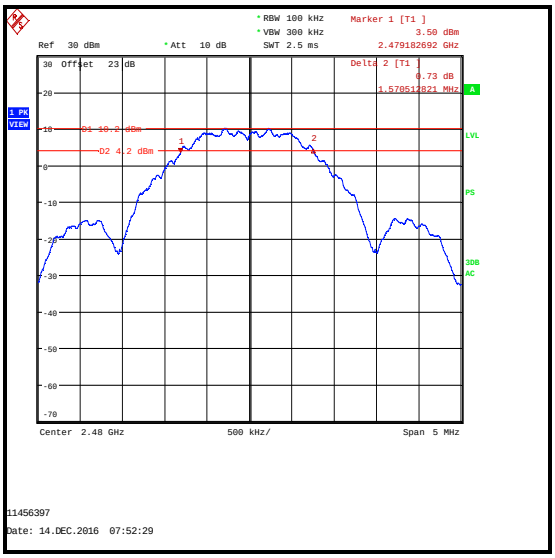
| Channel | 6 dB Bandwidth (kHz) | Limit (kHz) | Margin (kHz) | Result |
|---|---|---|---|---|
| Bottom | 1426.282 | ≥500 | 926.282 | Complied |
| Middle | 1546.474 | ≥500 | 1046.474 | Complied |
| Top | 1570.513 | ≥500 | 1070.513 | Complied |




**Bottom Channel**




**Middle Channel**




**Top Channel**

## Transmitter Minimum 6 dB Bandwidth (continued)

## Test Equipment Used:

| Asset No. | Instrument | Manufacturer | Type No. | Serial No. | Date Calibration Due | Cal. Interval (Months) |
|---|---|---|---|---|---|---|
| M1659 | Thermohygrometer | JM Handelspunkt | 30.5015.13 | Not stated | 02 Apr 2017 | 12 |
| M1874 | Test Receiver | Rohde & Schwarz | ESU26 | 100553 | 28 Oct 2017 | 12 |
| A2526 | Attenuator | AtlanTecRF | AN18W5-20 | 832828#1 | Calibrated before use | - |
| M260 | Signal Generator | Rohde & Schwarz | SMP02 | 829076/008 | 09 May 2017 | 12 |
| M199 | Power Meter | Rohde & Schwarz | NRVS | 827023/075 | 11 Apr 2018 | 24 |
| M1267 | Power Sensor | Rohde & Schwarz | NRV-Z52 | 100155 | 15 Apr 2018 | 24 |

## 5.2.2. Transmitter Power Spectral Density

### Test Summary:

| | | | |
|---|---|---|---|
| **Test Engineer:** | David Doyle | **Test Date:** | 14 December 2016 |
| **Test Sample Serial Number:** | Not marked or stated *(Conducted sample with RF port)* | | |

| | |
|---|---|
| **FCC Reference:** | Part 15.247(e) |
| **Test Method Used:** | FCC KDB 558074 Section 10.2 |

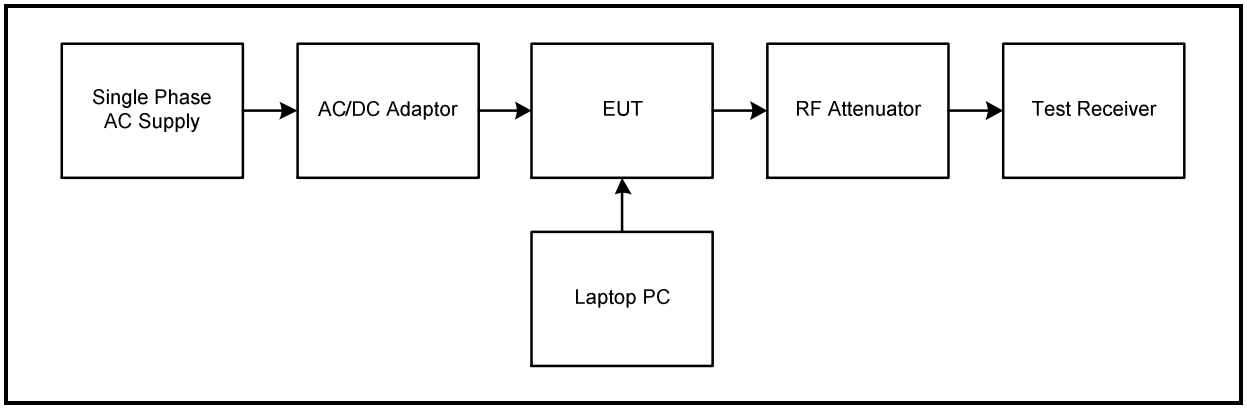
### Environmental Conditions:

| | |
|---|---|
| **Temperature (°C):** | 23 |
| **Relative Humidity (%):** | 42 |

### Note(s):

1. Transmitter Power Spectral Density tests were performed using a test receiver in accordance with FCC KDB 558074 Section 10.2.
2. The signal analyser resolution bandwidth was set to 10 kHz and video bandwidth of 30 kHz. A peak detector was used, sweep time was set to auto and trace mode was Max Hold. The span was set to 1.5 times the measured DTS bandwidth. A marker was placed at the peak of the signal and the results recorded in the table below.
3. The test receiver was connected to the RF port on the EUT using suitable attenuation and RF cable. An RF level offset was entered on the test receiver to compensate for the loss of the attenuator and RF cable.

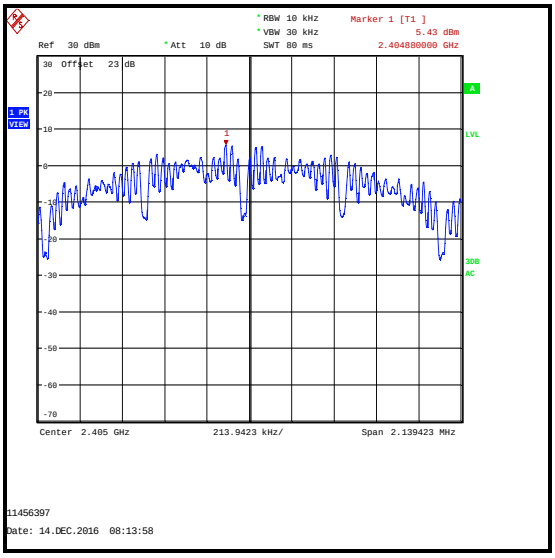
### Test setup:



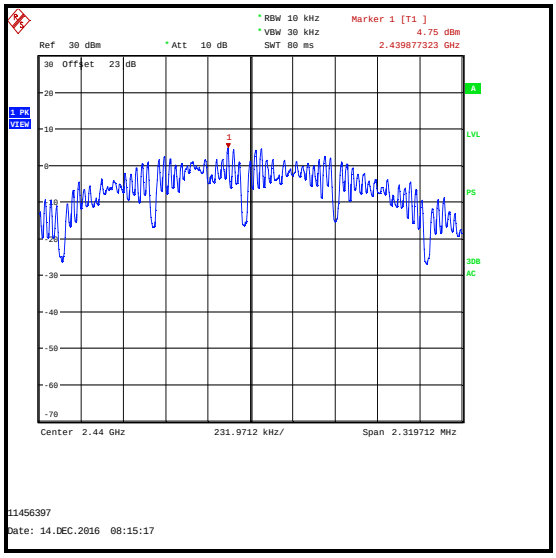
## Transmitter Power Spectral Density (continued)

## Results:

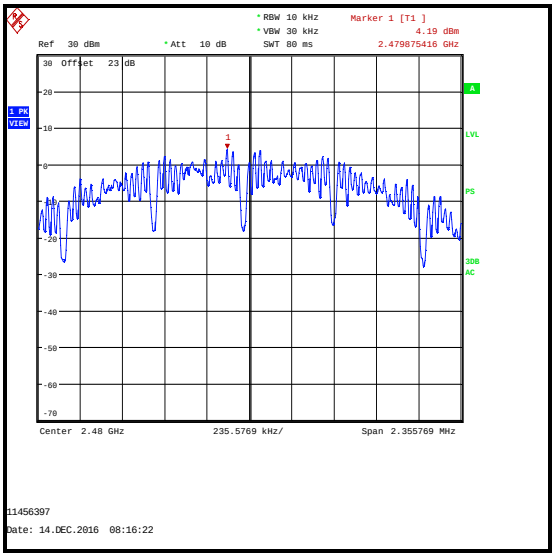
| Channel | Output Power (dBm / 10 kHz) | Limit (dBm / 3 kHz) | Margin (dB) | Result |
|---|---|---|---|---|
| Bottom | 5.4 | 8.0 | 2.6 | Complied |
| Middle | 4.8 | 8.0 | 3.2 | Complied |
| Top | 4.2 | 8.0 | 3.8 | Complied |




**Bottom Channel**




**Middle Channel**




**Top Channel**

## Transmitter Power Spectral Density (continued)

## Test Equipment Used:

| Asset No. | Instrument | Manufacturer | Type No. | Serial No. | Date Calibration Due | Cal. Interval (Months) |
|---|---|---|---|---|---|---|
| M1659 | Thermohygrometer | JM Handelspunkt | 30.5015.13 | Not stated | 02 Apr 2017 | 12 |
| M1874 | Test Receiver | Rohde & Schwarz | ESU26 | 100553 | 28 Oct 2017 | 12 |
| A2526 | Attenuator | AtlanTecRF | AN18W5-20 | 832828#1 | Calibrated before use | - |
| M260 | Signal Generator | Rohde & Schwarz | SMP02 | 829076/008 | 09 May 2017 | 12 |
| M199 | Power Meter | Rohde & Schwarz | NRVS | 827023/075 | 11 Apr 2018 | 24 |
| M1267 | Power Sensor | Rohde & Schwarz | NRV-Z52 | 100155 | 15 Apr 2018 | 24 |

## 5.2.3. Transmitter Maximum Peak Output Power

### Test Summary:

| | | | |
|---|---|---|---|
| **Test Engineer:** | David Doyle | **Test Date:** | 14 December 2016 |
| **Test Sample Serial Number:** | Not marked or stated *(Conducted sample with RF port)* | | |

| | |
|---|---|
| **FCC Reference:** | Part 15.247(b)(3) |
| **Test Method Used:** | FCC KDB 558074 Section 9.1.1 |

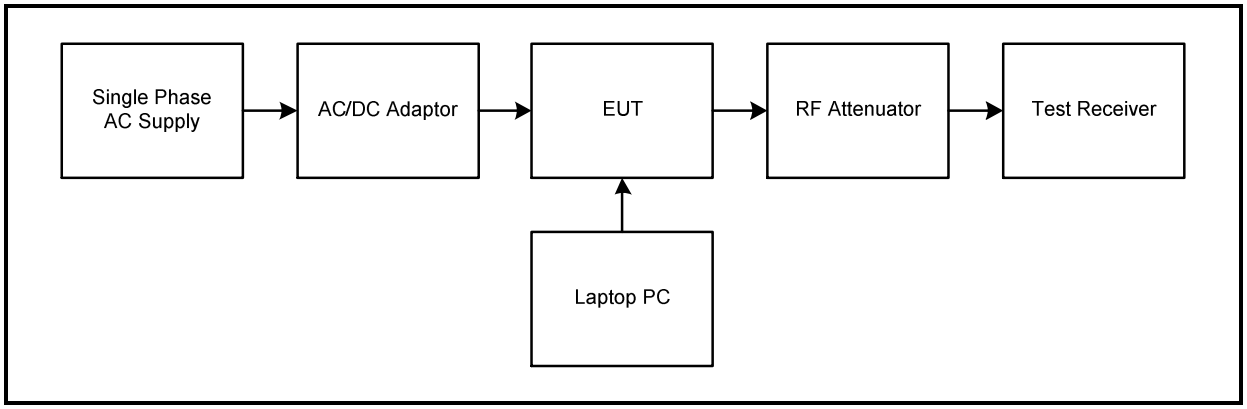
### Environmental Conditions:

| | |
|---|---|
| **Temperature (°C):** | 23 |
| **Relative Humidity (%):** | 42 |

### Note(s):

1. Conducted power tests were performed using a test receiver in accordance with FCC KDB 558074 Section 9.1.1 Measurement Procedure.
2. The test receiver resolution bandwidth was set to 3 MHz and video bandwidth 10 MHz. A peak detector was used, sweep time was set to auto and trace mode was Max Hold. The span was set to 10 MHz. A marker was placed at the peak of the signal and the results recorded in the table below.
3. The test receiver was connected to the RF port on the EUT using suitable attenuation and RF cable. An RF level offset was entered on the test receiver to compensate for the loss of the attenuator and RF cable.
4. The conducted power was added to the declared antenna gain to obtain the EIRP.

### Test setup:



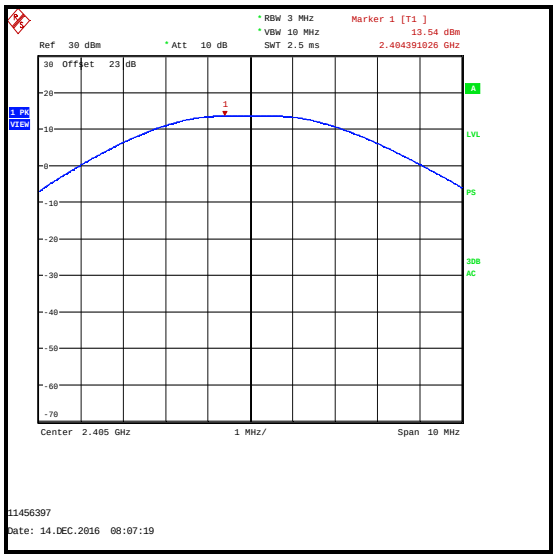
## Transmitter Maximum Peak Output Power (continued)

## Results:

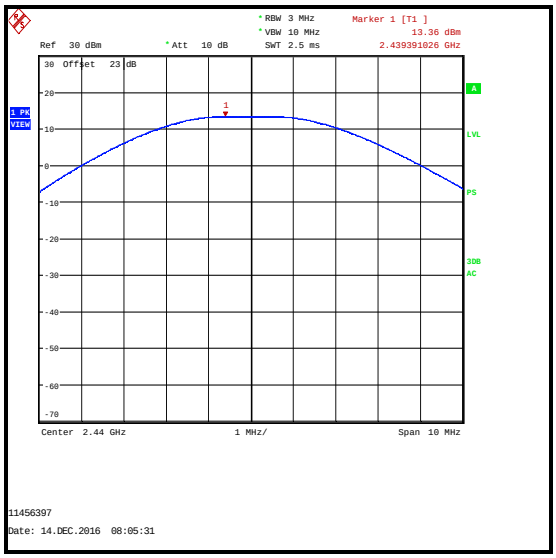
| Channel | Conducted Peak Power (dBm) | Conducted Peak Power Limit (dBm) | Margin (dB) | Result |
|---|---|---|---|---|
| Bottom | 13.5 | 30.0 | 16.5 | Complied |
| Middle | 13.4 | 30.0 | 16.6 | Complied |
| Top | 13.1 | 30.0 | 16.9 | Complied |

| Channel | Conducted Peak Power (dBm) | Declared Antenna Gain (dBi) | EIRP (dBm) | De Facto EIRP Limit (dBm) | Margin (dB) | Result |
|---|---|---|---|---|---|---|
| Bottom | 13.5 | 0.5 | 14.0 | 36.0 | 22.0 | Complied |
| Middle | 13.4 | 0.5 | 13.9 | 36.0 | 22.1 | Complied |
| Top | 13.1 | 0.5 | 13.6 | 36.0 | 22.4 | Complied |

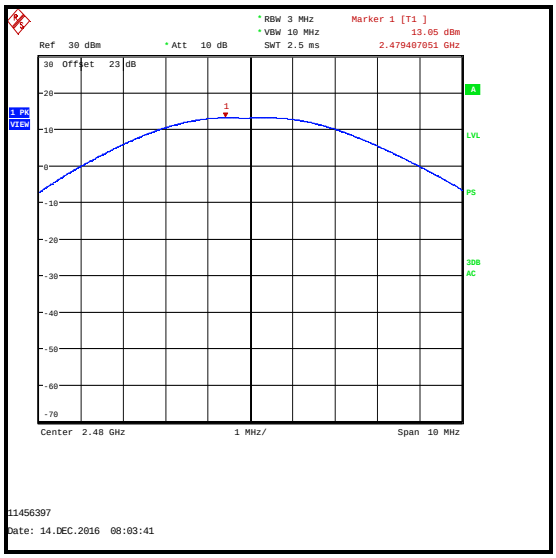
## Transmitter Maximum Peak Output Power (continued)




**Bottom Channel**




**Middle Channel**




**Top Channel**

## Test Equipment Used:

| Asset No. | Instrument | Manufacturer | Type No. | Serial No. | Date Calibration Due | Cal. Interval (Months) |
|---|---|---|---|---|---|---|
| M1659 | Thermohygrometer | JM Handelspunkt | 30.5015.13 | Not stated | 02 Apr 2017 | 12 |
| M1874 | Test Receiver | Rohde & Schwarz | ESU26 | 100553 | 28 Oct 2017 | 12 |
| A2526 | Attenuator | AtlanTecRF | AN18W5-20 | 832828#1 | Calibrated before use | - |
| M260 | Signal Generator | Rohde & Schwarz | SMP02 | 829076/008 | 09 May 2017 | 12 |
| M199 | Power Meter | Rohde & Schwarz | NRVS | 827023/075 | 11 Apr 2018 | 24 |
| M1267 | Power Sensor | Rohde & Schwarz | NRV-Z52 | 100155 | 15 Apr 2018 | 24 |

## 5.2.4. Transmitter Radiated Emissions

### Test Summary:

| | | | |
|---|---|---|---|
| **Test Engineer:** | David Doyle | **Test Date:** | 13 January 2017 |
| **Test Sample Serial Number:** | Not marked or stated *(Radiated sample)* | | |

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

### Environmental Conditions:

| | |
|---|---|
| **Temperature (°C):** | 22 |
| **Relative Humidity (%):** | 30 |

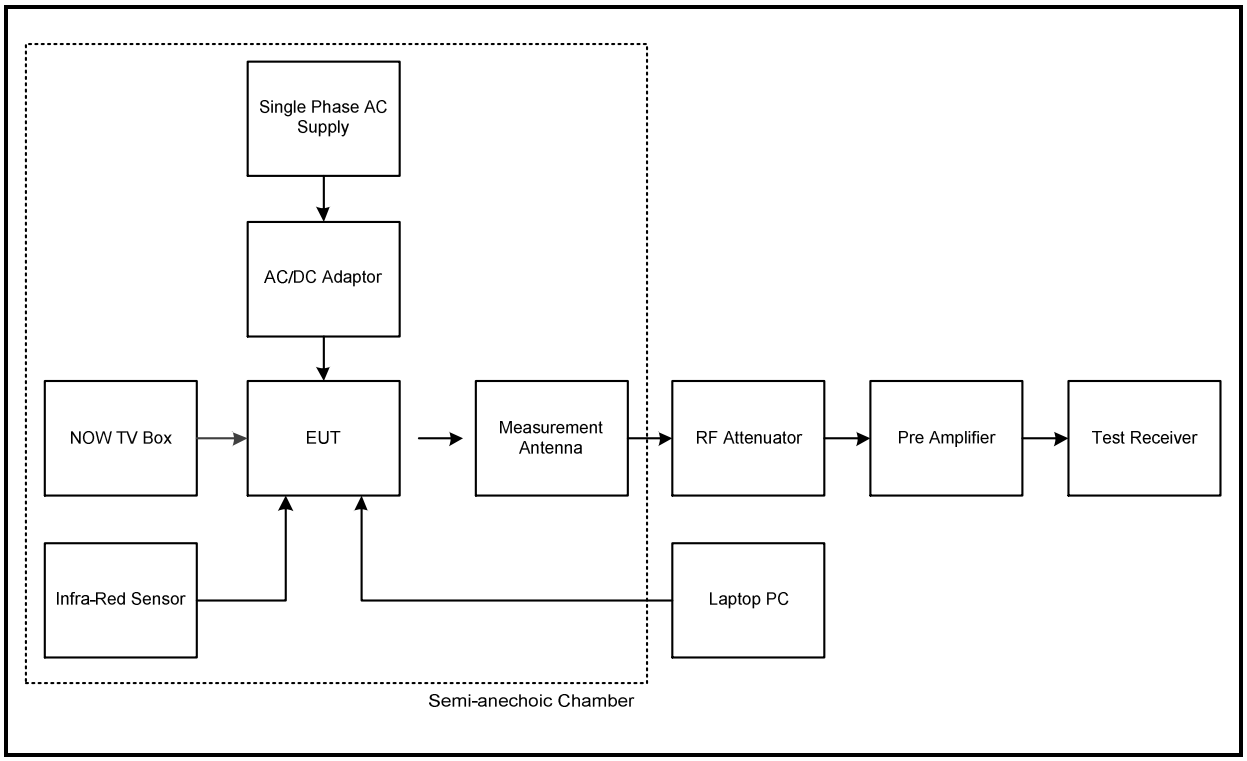
### Note(s):

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 were at least 20 dB below the appropriate limit or below the noise floor of the measurement system.
4. Measurements below 1 GHz were performed in a semi-anechoic chamber (Asset Number K0001) 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 100 kHz and video bandwidth 300 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, using a CISPR quasi-peak detector and span wide enough to see the whole emission.

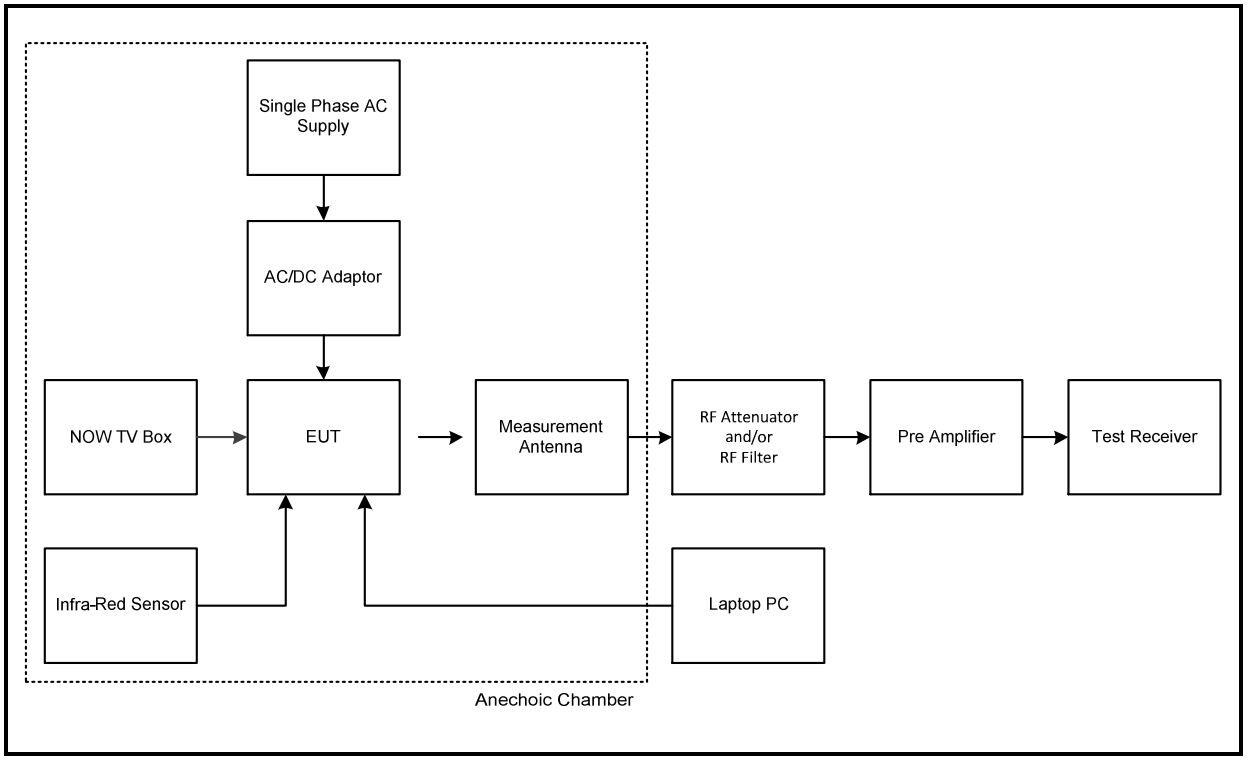
## Transmitter Radiated Emissions (continued)

## Test setup for radiated measurements:

## Semi-anechoic chamber



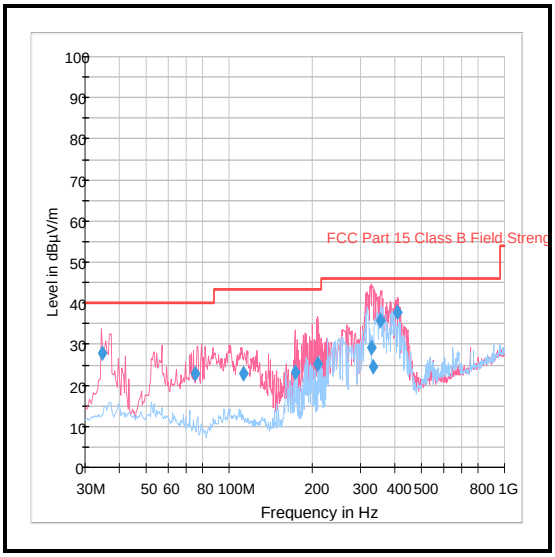

## Anechoic chamber



## Transmitter Radiated Emissions (continued)

## Results: Middle Channel

| Frequency (MHz) | Antenna Polarity | Level (dBµV/m) | Limit (dBµV/m) | Margin (dB) | Result |
|---|---|---|---|---|---|
| 328.905 | Vertical | 29.3 | 46.0 | 16.7 | Complied |
| 408.281 | Vertical | 37.8 | 46.0 | 8.2 | 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) |
|---|---|---|---|---|---|---|
| M2014 | Thermohygrometer | Testo | 608-H1 | 45046246 | 10 Jun 2017 | 12 |
| K0001 | 5m RSE Chamber | Rainford EMC | N/A | N/A | 07 Dec 2017 | 12 |
| G0543 | Amplifier | Sonoma | 310N | 230801 | 09 Jun 2017 | 6 |
| M1273 | Test Receiver | Rohde & Schwarz | ESIB26 | 100275 | 11 Apr 2017 | 12 |
| A2959 | Antenna | Schwarzbeck | VULB 9163 | 9163-967 | 08 Sep 2017 | 12 |
| A1834 | Attenuator | Hewlett Packard | 8491B | 10444 | 30 Mar 2017 | 12 |

## Transmitter Radiated Emissions (continued)

### Test Summary:

| | | | |
|---|---|---|---|
| **Test Engineer:** | David Doyle | **Test Date:** | 12 April 2017 |
| **Test Sample Serial Number:** | Not marked or stated *(Radiated sample)* | | |

| | |
|---|---|
| **FCC Reference:** | Parts 15.247(d) & 15.209(a) |
| **Test Method Used:** | KDB 558074 Sections 11, 12.1, 12.2.4 & 12.2.5.1;<br>ANSI C63.10 Sections 6.3 and 6.6 |
| **Frequency Range** | 1 GHz to 25 GHz |

### Environmental Conditions:

| | |
|---|---|
| **Temperature (°C):** | 24 |
| **Relative Humidity (%):** | 35 |

### Note(s):

1. The final measured value, for the given emission, in the table below incorporates the calibrated antenna factor and cable loss.
2. All other emissions shown on the pre-scan plot were investigated and found to be ambient or >20 dB below the applicable limit or below the measurement system noise floor.
3. The emission shown on the 1 GHz to 3 GHz plot is the EUT fundamental.
4. All measurement above 1 GHz were performed in an anechoic chamber (Asset Number K0017) at a distance of 3 metres. The EUT was placed at a height of 1.5 metres 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 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.
6. *Emissions in restricted bands: In accordance with C63.10 Section 6.6.4.3, Note 1, where the peak detected amplitude was shown to comply with the average limit, an average measurement was not performed.
7. ** -20 dBc limit applies in non-restricted bands as the conducted output power measurements were performed using a peak detector.

## Transmitter Radiated Emissions (continued)

### Results: Peak / Bottom Channel

| Frequency (MHz) | Antenna Polarity | Level (dBµV/m) | Limit (dBµV/m) | Margin (dB) | Result |
|---|---|---|---|---|---|
| 4811.014 | Vertical | 52.6 | 54.0* | 1.4 | Complied |
| 7213.314 | Vertical | 57.5 | 74.8** | 17.3 | Complied |
| 12022.286 | Vertical | 50.3 | 54.0* | 3.7 | Complied |
| 19236.171 | Vertical | 54.3 | 74.0 | 19.7 | Complied |

### Results: Average / Bottom Channel

| Frequency (MHz) | Antenna Polarity | Level (dBµV/m) | Limit (dBµV/m) | Margin (dB) | Result |
|---|---|---|---|---|---|
| 19235.914 | Vertical | 45.0 | 54.0 | 9.0 | Complied |

### Results: Peak / Middle Channel

| Frequency (MHz) | Antenna Polarity | Level (dBµV/m) | Limit (dBµV/m) | Margin (dB) | Result |
|---|---|---|---|---|---|
| 4880.814 | Vertical | 53.3 | 54.0* | 0.7 | Complied |
| 7321.571 | Vertical | 58.0 | 74.0 | 16.0 | Complied |
| 12202.314 | Vertical | 49.0 | 54.0* | 5.0 | Complied |
| 19524.057 | Vertical | 52.2 | 54.0* | 1.8 | Complied |

### Results: Average / Middle Channel

| Frequency (MHz) | Antenna Polarity | Level (dBµV/m) | Limit (dBµV/m) | Margin (dB) | Result |
|---|---|---|---|---|---|
| 7318.600 | Vertical | 51.0 | 54.0 | 3.0 | Complied |

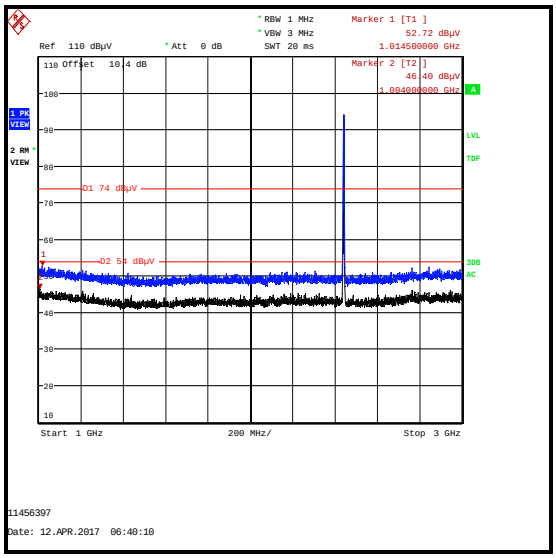
### Results: Peak / Top Channel

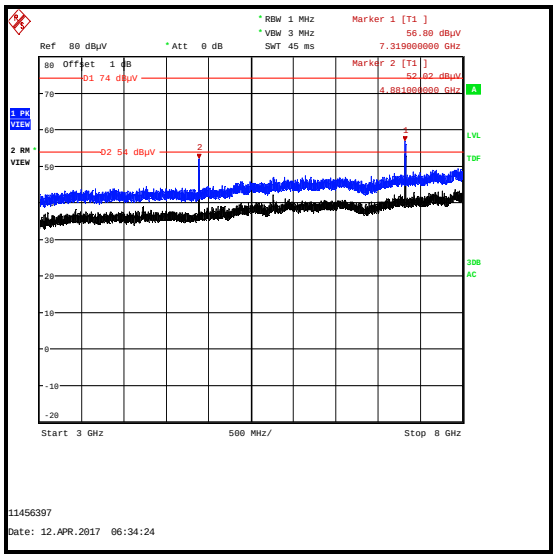
| Frequency (MHz) | Antenna Polarity | Level (dBµV/m) | Limit (dBµV/m) | Margin (dB) | Result |
|---|---|---|---|---|---|
| 4961.000 | Vertical | 57.2 | 74.0 | 16.8 | Complied |
| 7438.586 | Vertical | 59.1 | 74.0 | 14.9 | Complied |
| 12402.271 | Vertical | 51.2 | 54.0* | 2.8 | Complied |
| 19835.457 | Vertical | 50.4 | 54.0* | 3.6 | Complied |

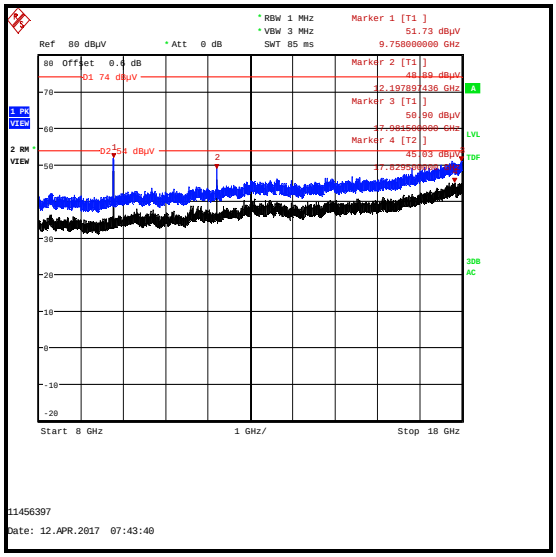
### Results: Average / Top Channel

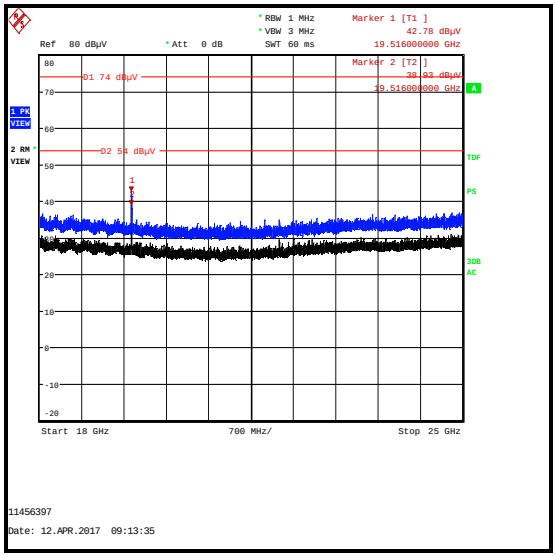
| Frequency (MHz) | Antenna Polarity | Level (dBµV/m) | Limit (dBµV/m) | Margin (dB) | Result |
|---|---|---|---|---|---|
| 4960.814 | Vertical | 51.2 | 54.0 | 2.8 | Complied |
| 7438.500 | Vertical | 52.3 | 54.0 | 1.7 | Complied |

## Transmitter Radiated Emissions (continued)




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

## 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 | 18 May 2017 | 12 |
| M1630 | Test Receiver | Rohde & Schwarz | ESU40 | 100233 | 23 Feb 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 | BBHA 9120 B 653 | 11 Apr 2018 | 12 |
| A2890 | Antenna | Schwarzbeck | HWRD 750 | 014 | 06 May 2017 | 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 | 01 Jun 2017 | 12 |

## 5.2.5. Transmitter Band Edge Radiated Emissions

### Test Summary:

| | | | |
|---|---|---|---|
| **Test Engineer:** | David Doyle | **Test Dates:** | 04 January 2017 & 22 February 2017 |
| **Test Sample Serial Number:** | Not marked or stated *(Radiated sample)* | | |

| | |
|---|---|
| **FCC Reference:** | Parts 15.247(d) & 15.209(a) |
| **Test Method Used:** | KDB 558074 Sections 11, 12.1, 12.2.4 & 12.2.5.1;<br>ANSI C63.10 Sections 6.3 and 6.6 |

### Environmental Conditions:

| | |
|---|---|
| **Temperature (°C):** | 21 to 24 |
| **Relative Humidity (%):** | 36 to 37 |

### 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 maximum peak conducted output power was previously measured. In accordance with FCC KDB 558074 Section 11.1(a), the lower band edge measurement was performed with a peak detector and the -20 dBc limit applied.
3. As the lower band edge is adjacent to 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 peak conducted output power was measured using a peak detector in accordance with FCC KDB 558074 Section 9.1.1 an out-of-band limit line was placed 20 dB below the peak level (FCC KDB 558074 Section 11.1(a)). 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.
4. As the upper band edge is adjacent to 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 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 signal analyser 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.
5. 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.

## Transmitter Band Edge Radiated Emissions (continued)

### Results: Lower Band Edge

| Frequency (MHz) | Level (dBµV/m) | -20 dBc Limit (dBµV/m) | Margin (dB) | Result |
|---|---|---|---|---|
| 2400.000 | 50.8 | 74.6 | 23.8 | Complied |

### Results: Upper Band Edge / Peak

| Frequency (MHz) | Level (dBµV/m) | Limit (dBµV/m) | Margin (dB) | Result |
|---|---|---|---|---|
| 2483.500 | 61.8 | 74.0 | 12.2 | Complied |

### Results: Upper Band Edge / Average

| Frequency (MHz) | Level (dBµV/m) | Limit (dBµV/m) | Margin (dB) | Result |
|---|---|---|---|---|
| 2483.500 | 52.4 | 54.0 | 1.6 | Complied |

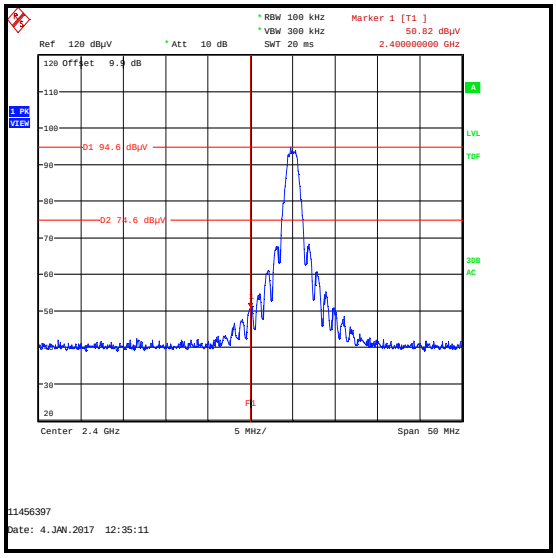
### Results: 2310 to 2390 MHz Restricted Band / Peak

| Frequency (MHz) | Peak Level (dBµV/m) | Peak Limit (dBµV/m) | Margin (dB) | Result |
|---|---|---|---|---|
| 2317.179 | 54.2 | 74.0 | 19.8 | Complied |

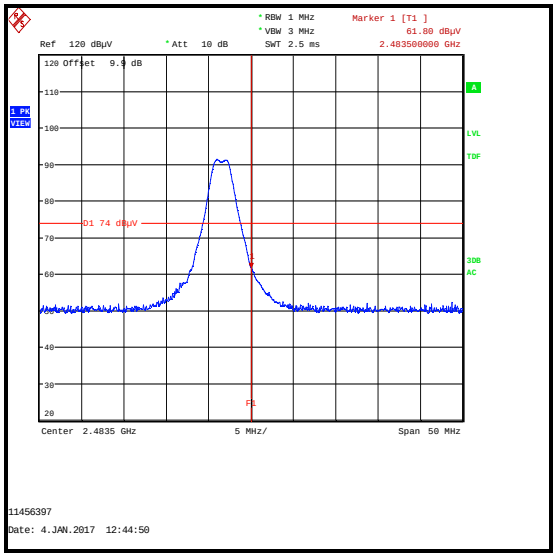
### Results: 2310 to 2390 MHz Restricted Band / Average

| Frequency (MHz) | Level (dBµV/m) | Limit (dBµV/m) | Margin (dB) | Result |
|---|---|---|---|---|
| 2372.949 | 41.7 | 54.0 | 12.3 | Complied |

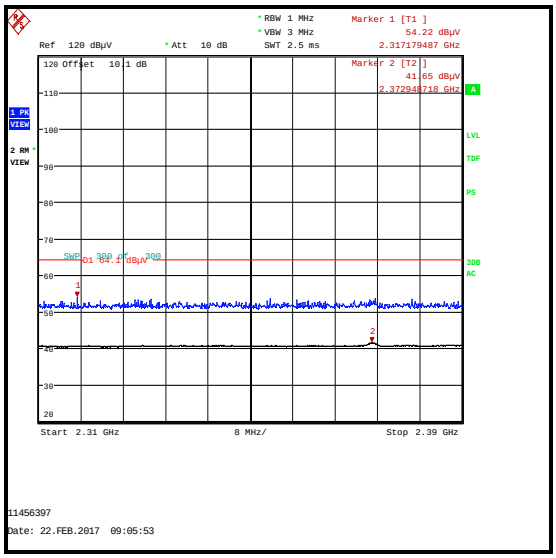
## Transmitter Band Edge Radiated Emissions (continued)



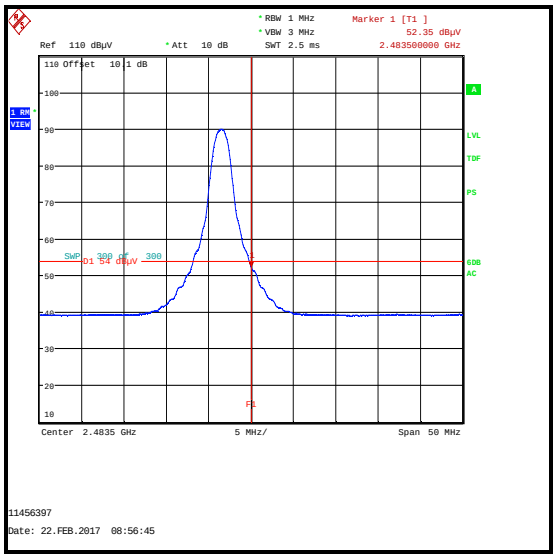

**Lower Band Edge Peak**




**Upper Band Edge Peak**




**2310 MHz to 2390 MHz Restricted Band**




**Upper Band Edge Average**

## 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 Apr 2017 | 12 |
| K0017 | 3m RSE Chamber | Rainford | N/A | N/A | 17 May 2017 | 12 |
| M1995 | Test Receiver | Rohde & Schwarz | ESU40 | 100428 | 21 Mar 2017 | 12 |
| A2863 | Pre-Amplifier | Agilent | 8449B | 3008A02100 | 07 Apr 2017 | 12 |
| A2889 | Antenna | Schwarzbeck | BBHA 9120 B | BBHA 9120 B 653 | 07 Apr 2017 | 12 |
| A2916 | Attenuator | AtlanTecRF | AN18W5-10 | 832827#1 | 19 May 2017 | 12 |
| M1656 | Thermohygrometer | JM Handelspunkt | 30.5015.13 | None stated | 02 Apr 2017 | 12 |
| K0002 | 3m RSE Chamber | Rainford EMC | N/A | N/A | 16 Nov 2017 | 12 |
| M1886 | Test Receiver | Rohde & Schwarz | ESU26 | 100554 | 21 Mar 2017 | 12 |
| A1534 | Pre Amplifier | Hewlett Packard | 8449B | 3008A00405 | 09 Nov 2017 | 12 |
| A1818 | Antenna | EMCO | 3115 | 00075692 | 08 Nov 2017 | 12 |
| A1396 | Attenuator | Huber & Suhner | 6810.17.B | 757987 | 26 Apr 2017 | 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 |
|---|---|---|---|
| Conducted Maximum Peak Output Power | 2.4 GHz to 2.4835 GHz | 95% | ±1.13 dB |
| Spectral Power Density | 2.4 GHz to 2.4835 GHz | 95% | ±1.13 dB |
| Minimum 6 dB Bandwidth | 2.4 GHz to 2.4835 GHz | 95% | ±4.59 % |
| Radiated Spurious Emissions | 30 MHz to 1 GHz | 95% | ±5.65 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 |

**--- END OF REPORT ---**