



TEST REPORT

Test Report No. : UL-RPT-RP11456397JD18E

Manufacturer : Neeo AG
Model No. : 6336-BRAIN
FCC ID : 2AKK7-BR633601
Technology : *Bluetooth* – Basic Rate & EDR
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. 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 1.0.

Date of Issue: 10 April 2017

Checked by:

Ian Watch
Senior Engineer, Radio Laboratory

Company Signatory:

Sarah Williams
Senior Engineer, Radio Laboratory
UL VS LTD



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1. Customer Information









| | |
|----------------------|---|
| Company Name: | Neeo AG |
| Address: | Ritterquai 8 4500 Solothurn 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) - Sections 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: | 15 December 2016 to 03 February 2017 |

2.2. Summary of Test Results

| FCC Reference (47CFR) | Measurement | Result |
|--|--|---|
| Part 15.247(a)(1) | Transmitter 20 dB Bandwidth |  |
| Part 15.247(a)(1) | Transmitter Carrier Frequency Separation |  |
| Part 15.247(a)(1)(iii) | Transmitter Number of Hopping Frequencies and Average Time of Occupancy |  |
| Part 15.247(b)(1) | 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 |

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 (<i>Radiated sample</i>) |
| 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 (<i>Conducted sample with RF port</i>) |
| 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

| | | | |
|---------------------------------|----------------------|-----------------------------------|-------------------------|
| Tested Technology: | Bluetooth | | |
| Power Supply Requirement: | Nominal | 5.2 VDC via 120 VAC 60 Hz adaptor | |
| Type of Unit: | Transceiver | | |
| Channel Spacing: | 1 MHz | | |
| Mode: | Basic Rate | Enhanced Data Rate | |
| Modulation: | GFSK | $\pi/4$ -DQPSK | 8DPSK |
| Packet Type: (Maximum Payload) | DH5 | 2DH5 | 3DH5 |
| Data Rate (Mbps): | 1 | 2 | 3 |
| Maximum Conducted Output Power: | 6.0 dBm | | |
| Antenna Gain: | 0.5 dBi | | |
| Transmit Frequency Range: | 2402 MHz to 2480 MHz | | |
| Transmit Channels Tested: | Channel ID | Channel Number | Channel Frequency (MHz) |
| | Bottom | 0 | 2402 |
| | Middle | 39 | 2441 |
| | Top | 78 | 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 at maximum power on bottom, middle and top channels in Basic Rate (DH5 packets) or EDR (2DH5 or 3DH5 packets) as required.
- Continuously transmitting at maximum power in hopping mode on all channels in Basic Rate (DH5 packets) or EDR (2DH5 or 3DH5 packets) 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 *Bluetooth* test mode. Once in *Bluetooth* mode test mode, a link was established to a *Bluetooth* tester which was then used to control the EUT.
- The procedure to set up and control the EUT was supplied by the customer in a document titled "userManual-Radio.pdf" dated 12/12/2016.
- The EUT was powered from an AC/DC power supply. The power supply input was connected to a 120 VAC 60 Hz single phase supply.
- Both EDR/Basic rate modes were compared and tests were performed with the mode that presented the worst case result. For output power, bandwidth, band edge and channel separation, all modes were tested.
- Transmitter radiated spurious emissions tests were performed with the EUT transmitting in 3DH5 mode as this mode was found to transmit the highest power.
- Radiated spurious emissions were performed with the EUT in the worst case position for radiated spurious emissions. Tests were performed with the EUT connected to the AC/DC adaptor and USB cable. All other ports were terminated with suitable terminations.
- 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 20 dB Bandwidth

Test Summary:

| | | | |
|----------------------------|---|------------|------------------|
| Test Engineer: | David Doyle | Test Date: | 15 December 2016 |
| Test Sample Serial Number: | Not marked or stated (<i>Conducted sample with RF port</i>) | | |

| | |
|-------------------|---------------------------|
| FCC Reference: | Part 15.247(a)(1) |
| Test Method Used: | ANSI C63.10 Section 6.9.2 |

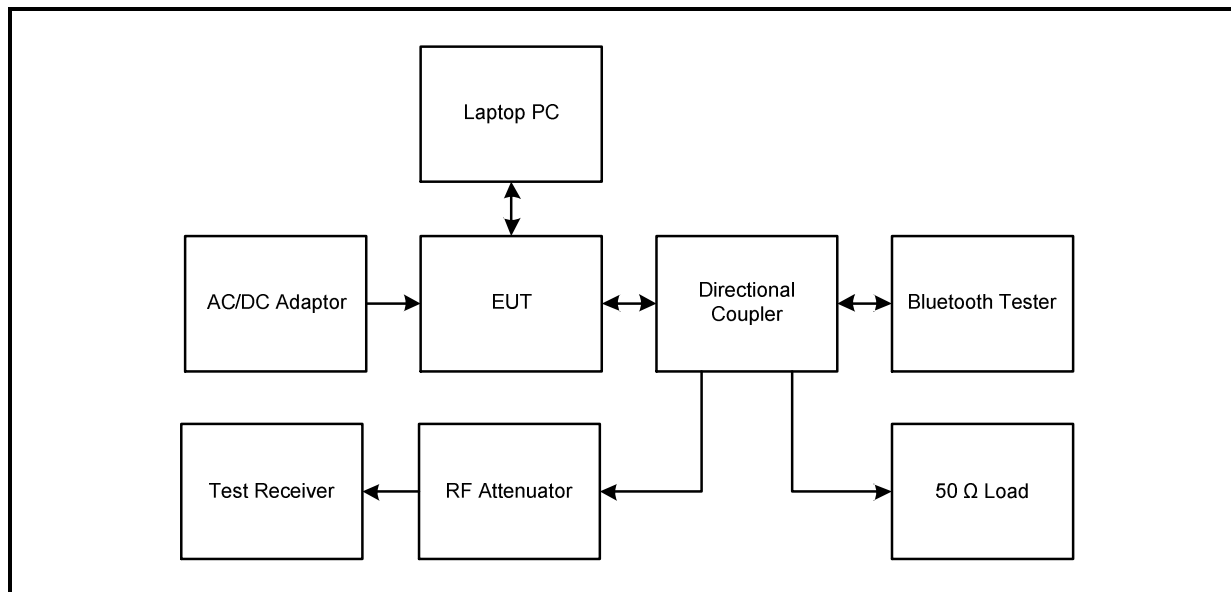
Environmental Conditions:

| | |
|------------------------|----|
| Temperature (°C): | 23 |
| Relative Humidity (%): | 44 |

Note(s):

1. The test receiver resolution bandwidth was set to 30 kHz and video bandwidth 100 kHz. A peak detector was used, sweep time was set to auto and the trace mode was Max Hold. The span was set to 3 MHz. Normal and delta markers were placed 20 dB down from the peak of the carrier. These results are recorded in the table below.
2. The test receiver was connected to the RF port on the EUT via a directional coupler, suitable attenuation and RF cables.

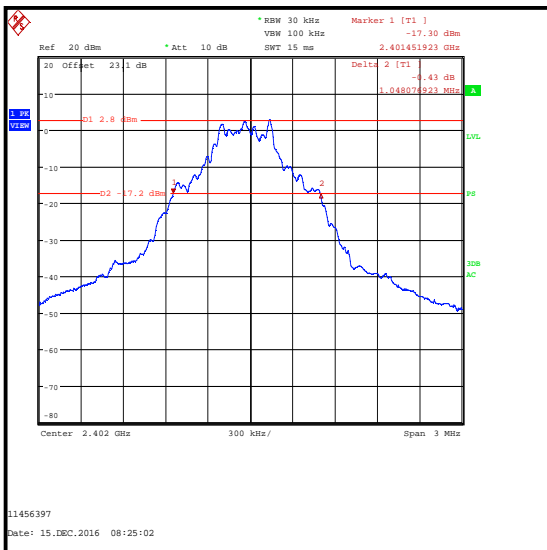
Test setup:



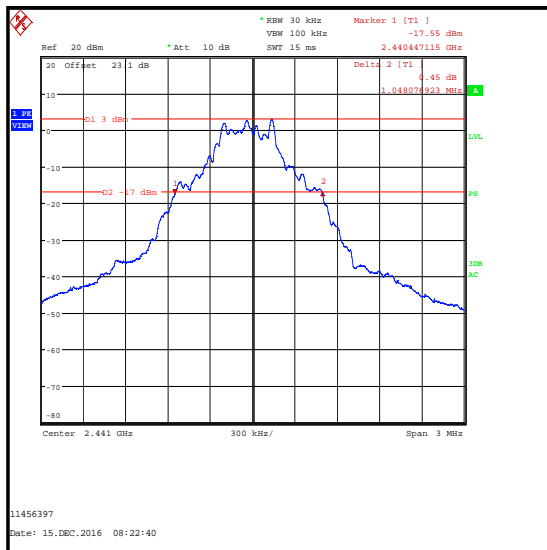
Transmitter 20 dB Bandwidth (continued)

Results DH5:

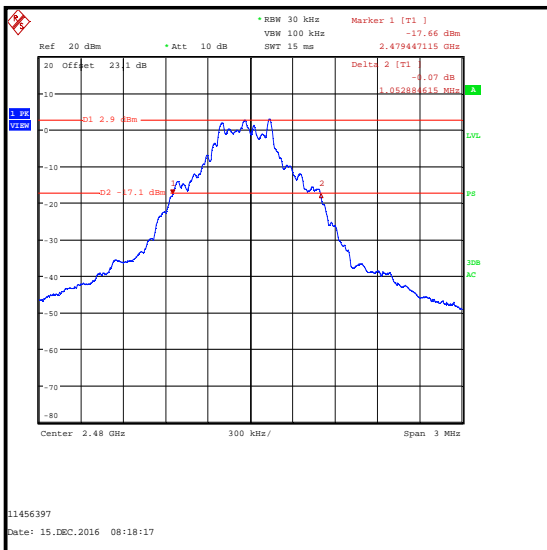
| Channel | 20 dB Bandwidth (kHz) |
|---------|-----------------------|
| Bottom | 1048.077 |
| Middle | 1048.077 |
| Top | 1052.885 |



Bottom Channel



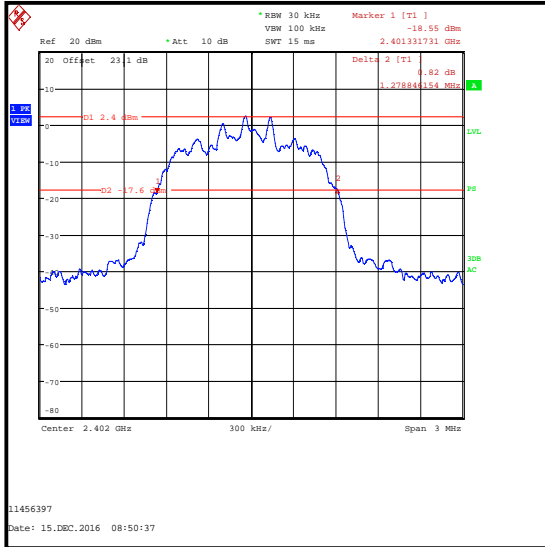
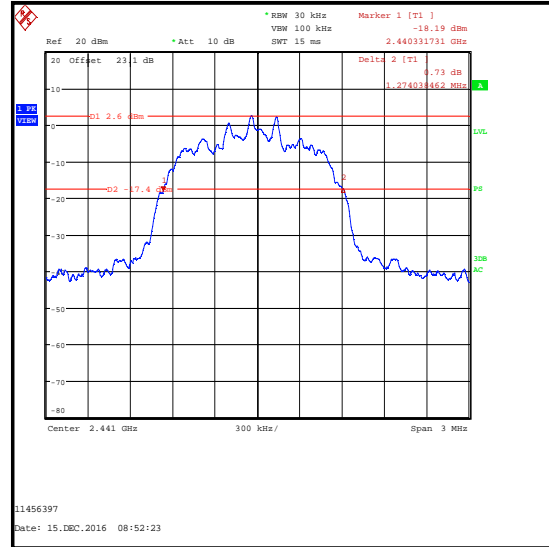
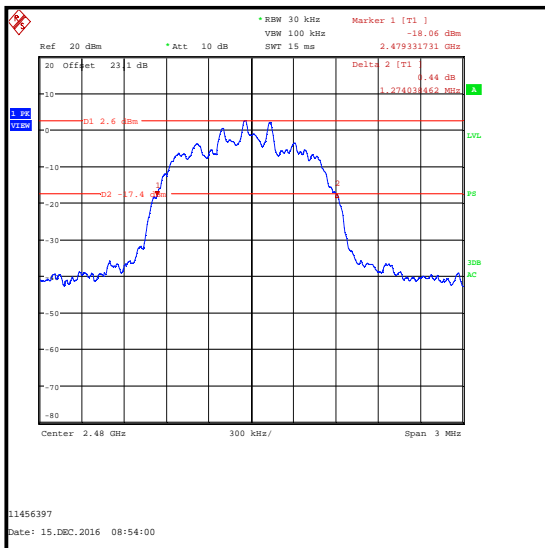
Middle Channel



Top Channel

Transmitter 20 dB Bandwidth (continued)**Results 2DH5:**

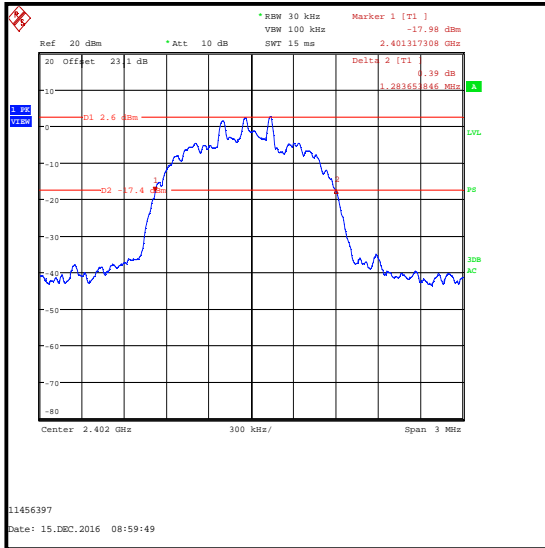
| Channel | 20 dB Bandwidth (kHz) |
|---------|-----------------------|
| Bottom | 1278.846 |
| Middle | 1274.038 |
| Top | 1274.038 |

**Bottom Channel****Middle Channel****Top Channel**

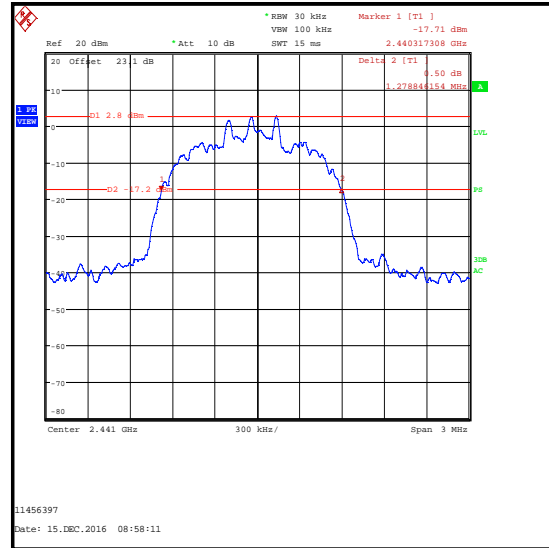
Transmitter 20 dB Bandwidth (continued)

Results 3DH5:

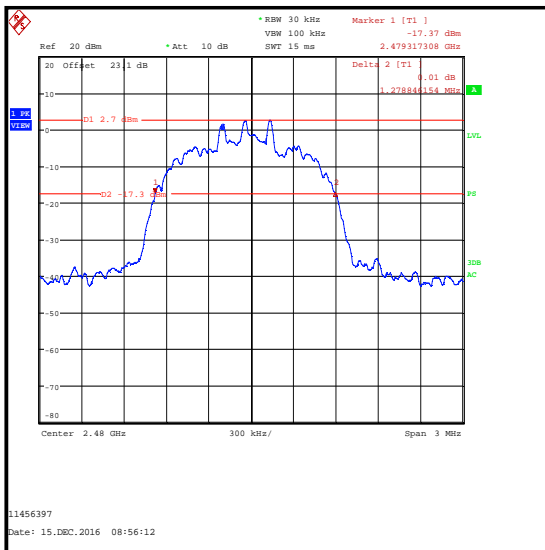
| Channel | 20 dB Bandwidth (kHz) |
|---------|-----------------------|
| Bottom | 1283.654 |
| Middle | 1278.846 |
| Top | 1278.846 |



Bottom Channel



Middle Channel



Top Channel

Transmitter 20 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 |
| A2524 | Attenuator | AtlanTecRF | AN18W5-10 | 832827#2 | Calibrated before use | - |
| A2500 | Directional Coupler | AtlanTecRF | CDC-003060-10 | 13122501835 | Calibrated before use | - |
| M1021 | Signal Generator | Rohde & Schwarz | SMP02 | 833286/004 | 19 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 Carrier Frequency Separation

Test Summary:

| | | | |
|-----------------------------------|---|-------------------|------------------|
| Test Engineer: | David Doyle | Test Date: | 15 December 2016 |
| Test Sample Serial Number: | Not marked or stated (<i>Conducted sample with RF port</i>) | | |

| | |
|--------------------------|---------------------------|
| FCC Reference: | Part 15.247(a)(1) |
| Test Method Used: | ANSI C63.10 Section 7.8.2 |

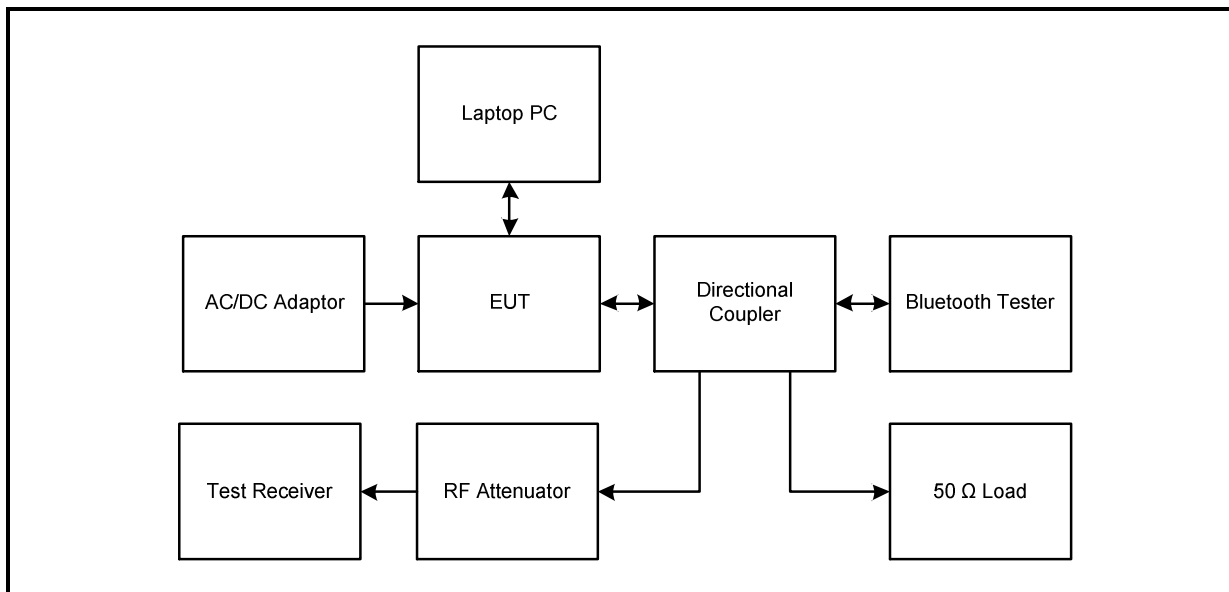
Environmental Conditions:

| | |
|-------------------------------|----|
| Temperature (°C): | 23 |
| Relative Humidity (%): | 44 |

Note(s):

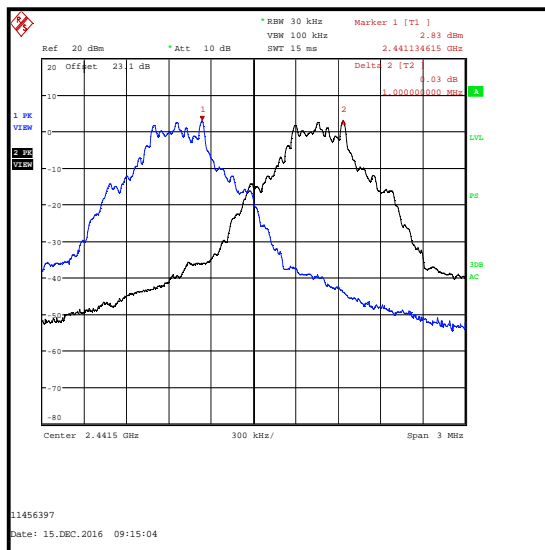
1. The 20 dB bandwidth measured for the middle channel operating at 2441 MHz was used to calculate the limit.
2. The test receiver centre frequency was set at the mid frequency of channels 39 and 40. The resolution bandwidth was set to 30 kHz and video bandwidth of 100 kHz. A peak detector was used, sweep time was set to auto and trace mode was Max Hold. The span was set to 3 MHz. A marker was placed on each of the corresponding peaks of the adjacent channels, with the frequency difference recorded in the tables below for each mode of operation.
3. The test receiver was connected to the RF port on the EUT via a directional coupler, suitable attenuation and RF cables.

Test setup:



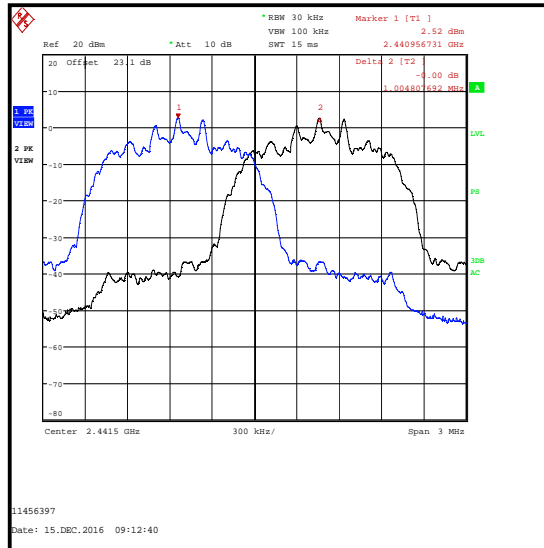
Transmitter Carrier Frequency Separation (continued)**Results: DH5**

| Carrier Frequency Separation (kHz) | Limit ($2/3$ of 20 dB BW) (kHz) | Margin (kHz) | Result |
|------------------------------------|----------------------------------|--------------|----------|
| 1000.000 | 698.718 | 301.282 | Complied |



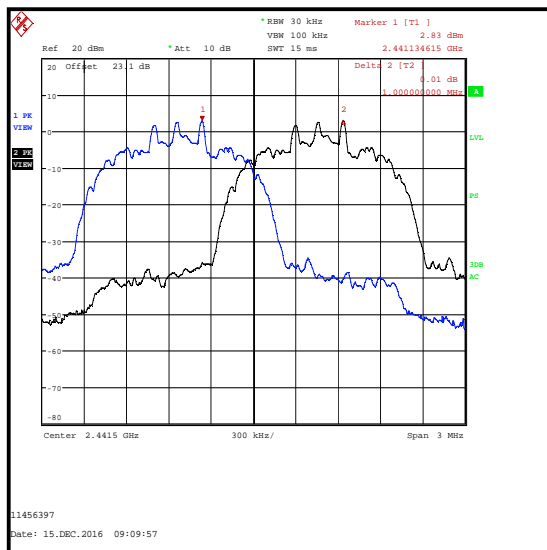
Transmitter Carrier Frequency Separation (continued)**Results: 2DH5**

| Carrier Frequency Separation (kHz) | Limit ($2/3$ of 20 dB BW) (kHz) | Margin (kHz) | Result |
|------------------------------------|----------------------------------|--------------|----------|
| 1004.808 | 849.359 | 155.449 | Complied |



Transmitter Carrier Frequency Separation (continued)**Results: 3DH5**

| Carrier Frequency Separation (kHz) | Limit ($2/3$ of 20 dB BW) (kHz) | Margin (kHz) | Result |
|------------------------------------|----------------------------------|--------------|----------|
| 1000.000 | 852.564 | 147.436 | Complied |

**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 |
| A2524 | Attenuator | AtlanTecRF | AN18W5-10 | 832827#2 | Calibrated before use | - |
| A2500 | Directional Coupler | AtlanTecRF | CDC-003060-10 | 13122501835 | Calibrated before use | - |
| M1021 | Signal Generator | Rohde & Schwarz | SMP02 | 833286/004 | 19 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 Number of Hopping Frequencies and Average Time of Occupancy**Test Summary:**

| | | | |
|-----------------------------------|---|-------------------|------------------|
| Test Engineer: | David Doyle | Test Date: | 15 December 2016 |
| Test Sample Serial Number: | Not marked or stated (<i>Conducted sample with RF port</i>) | | |

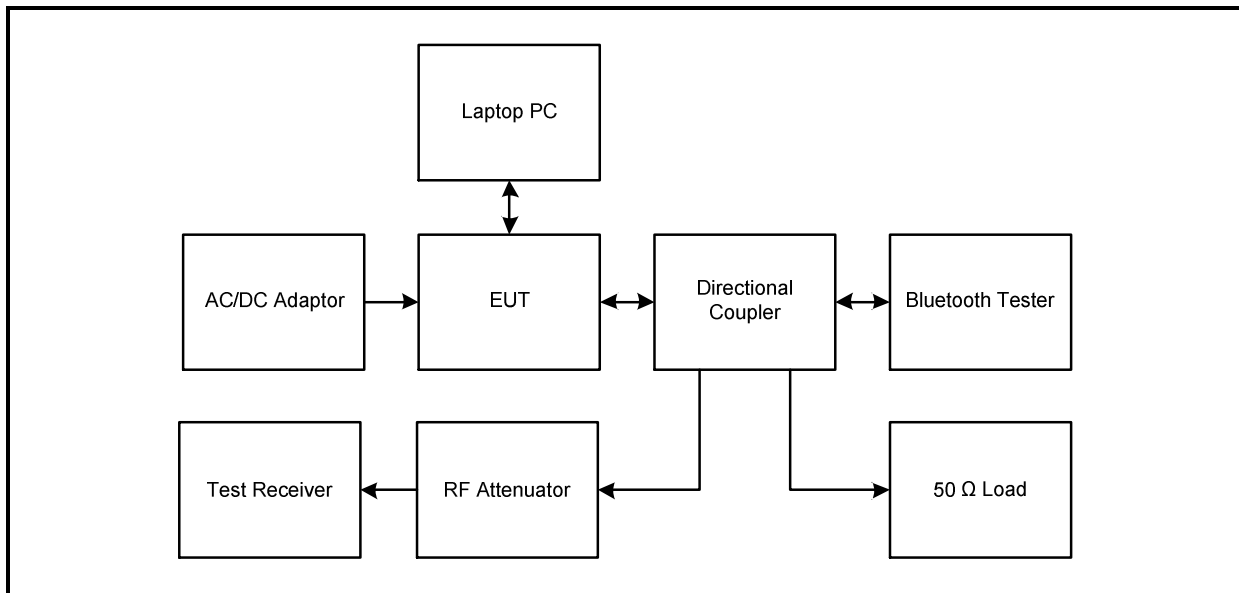
| | |
|--------------------------|------------------------------------|
| FCC Reference: | Part 15.247(a)(1)(iii) |
| Test Method Used: | ANSI C63.10 Sections 7.8.3 & 7.8.4 |

Environmental Conditions:

| | |
|-------------------------------|----|
| Temperature (°C): | 23 |
| Relative Humidity (%): | 44 |

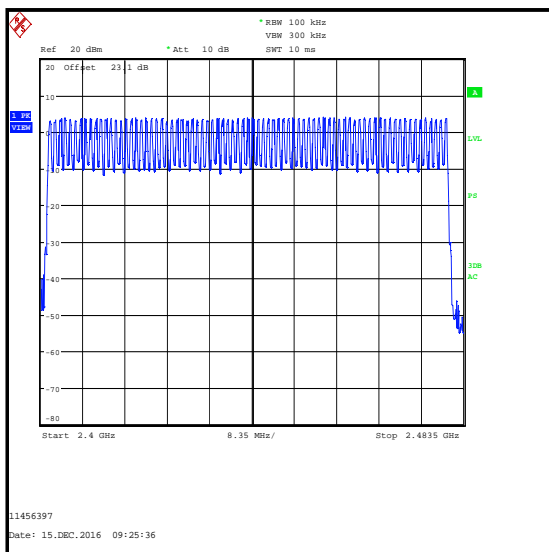
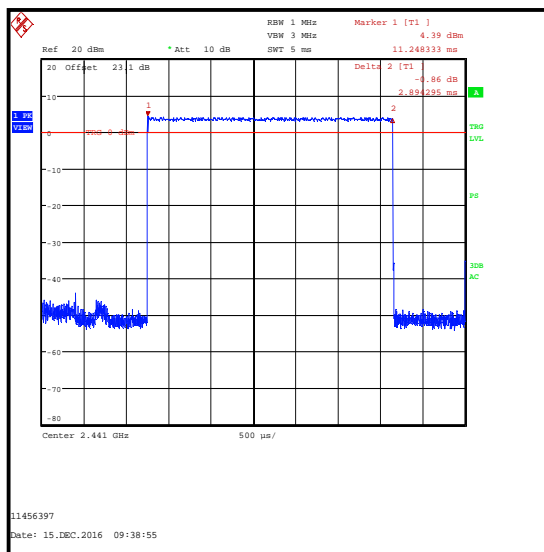
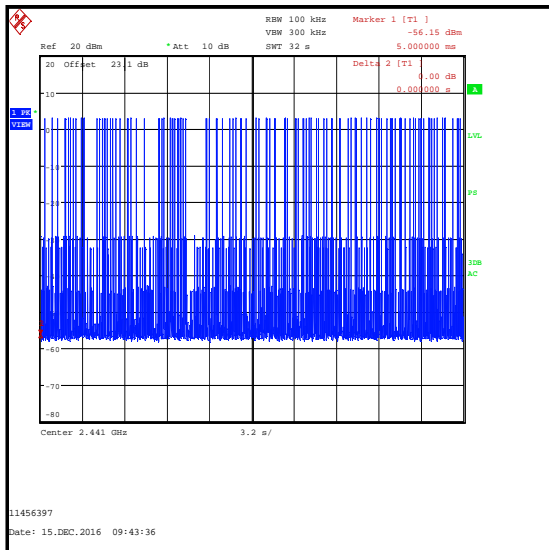
Note(s):

1. Tests were performed to determine the average time of occupancy in number of channels (79) x 0.4 seconds. The calculated period is 31.6 seconds.
2. Number of Hopping Frequencies test: The test receiver resolution bandwidth was set to 100 kHz and video bandwidth of 300 kHz. A peak detector was used, sweep time was set to auto and trace mode was Max Hold. The span was set to 83.5 MHz which covers the frequency band of operation. The number of hopping frequencies was recorded.
3. Emission Width test: The test receiver resolution bandwidth was set to 1 MHz and video bandwidth of 3 MHz. A peak detector was used and sweep time was set to auto with a span of zero Hz. A marker placed at the start of the emission and a delta marked place at the end of the emission. The emission width was recorded.
4. Number of Hops in a 32 second period test: The centre channel was monitored. The test receiver resolution bandwidth was set to 100 kHz and video bandwidth of 300 kHz. A peak detector was used and sweep time was set to 32 seconds. The EUT was set to transmit in a hopping frequency mode. The total number of hops on the centre channel observed in a 32 second period was recorded.
5. The test receiver was connected to the RF port on the EUT via a directional coupler, suitable attenuation and RF cables.

Transmitter Number of Hopping Frequencies and Average Time of Occupancy (continued)**Test setup:**

Transmitter Number of Hopping Frequencies and Average Time of Occupancy (continued)**Results:**

| Emission Width (μ s) | Number of Hops in 31.6 Seconds | Average Time of Occupancy (s) | Limit (s) | Margin (s) | Result |
|---------------------------|--------------------------------|-------------------------------|-----------|------------|----------|
| 2894.295 | 111 | 0.321 | 0.4 | 0.079 | Compiled |

**Number of Hopping Frequencies****Emission Width****Number of Hops in 32 seconds**

Transmitter Number of Hopping Frequencies and Average Time of Occupancy (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 |
| A2524 | Attenuator | AtlanTecRF | AN18W5-10 | 832827#2 | Calibrated before use | - |
| A2500 | Directional Coupler | AtlanTecRF | CDC-003060-10 | 13122501835 | Calibrated before use | - |
| M1021 | Signal Generator | Rohde & Schwarz | SMP02 | 833286/004 | 19 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 Maximum Peak Output Power

Test Summary:

| | | | |
|-----------------------------------|---|-------------------|------------------|
| Test Engineer: | David Doyle | Test Date: | 15 December 2016 |
| Test Sample Serial Number: | Not marked or stated (<i>Conducted sample with RF port</i>) | | |

| | |
|--------------------------|---------------------------|
| FCC Reference: | Part 15.247(b)(1) |
| Test Method Used: | ANSI C63.10 Section 7.8.5 |

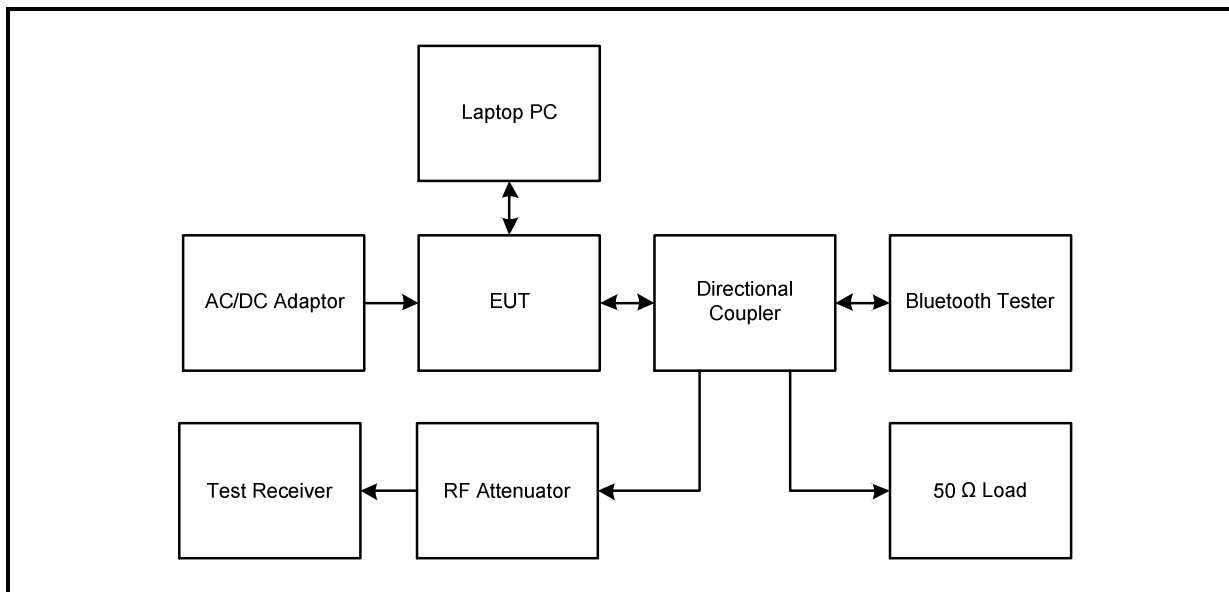
Environmental Conditions:

| | |
|-------------------------------|----|
| Temperature (°C): | 23 |
| Relative Humidity (%): | 44 |

Note(s):

1. The test receiver resolution bandwidth was set to 2 MHz (>20 dB bandwidth) and video bandwidth 5 MHz (\geq RBW). A peak detector was used, sweep time was set to auto and trace mode was Max Hold. The span was set to 5 MHz (approximately five times the 20 dB bandwidth). A marker was placed at the peak of the signal and the results recorded in the tables below.
2. The declared antenna gain was added to the conducted peak power to obtain the EIRP.
3. The test receiver was connected to the RF port on the EUT via a directional coupler, suitable attenuation and RF cables.

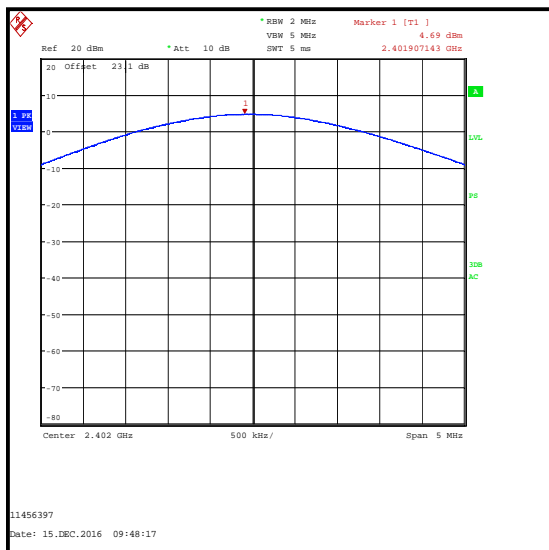
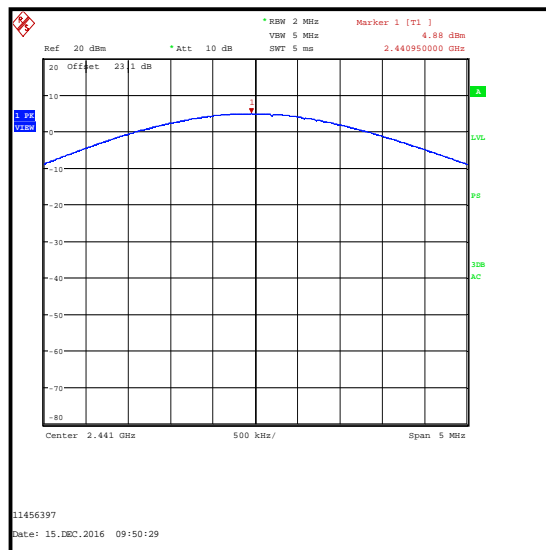
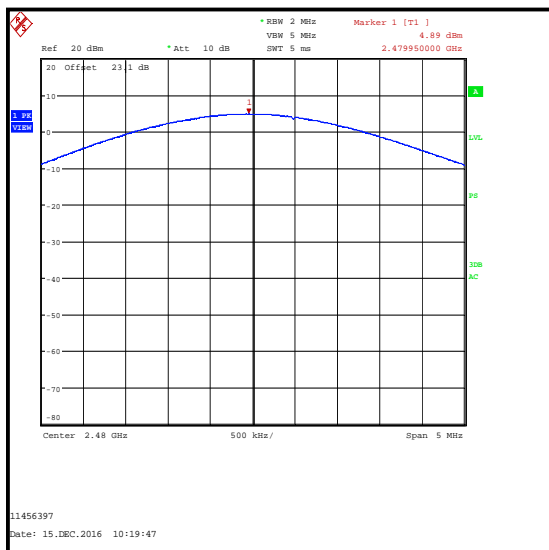
Test setup:



Transmitter Maximum Peak Output Power (continued)**Results: DH5**

| Channel | Conducted Peak Power (dBm) | Conducted Peak Power Limit (dBm) | Margin (dB) | Result |
|---------|----------------------------|----------------------------------|-------------|----------|
| Bottom | 4.7 | 30.0 | 25.3 | Complied |
| Middle | 4.9 | 30.0 | 25.1 | Complied |
| Top | 4.9 | 30.0 | 25.1 | Complied |

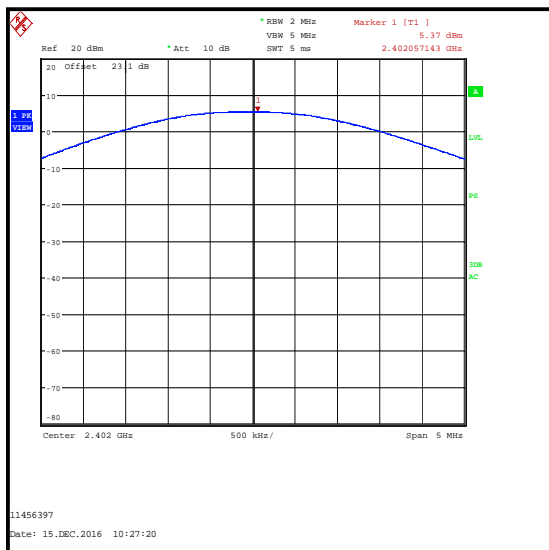
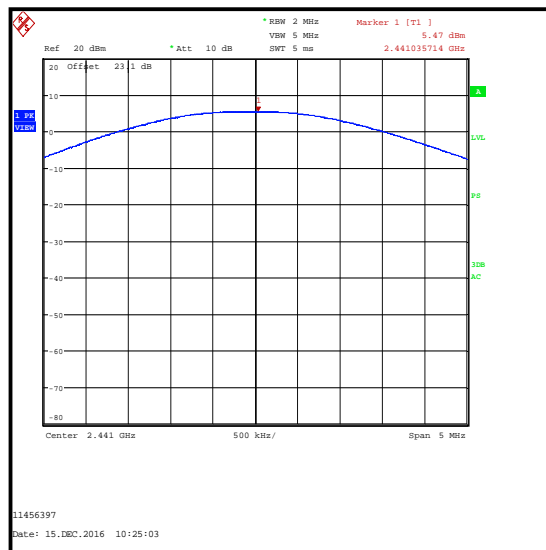
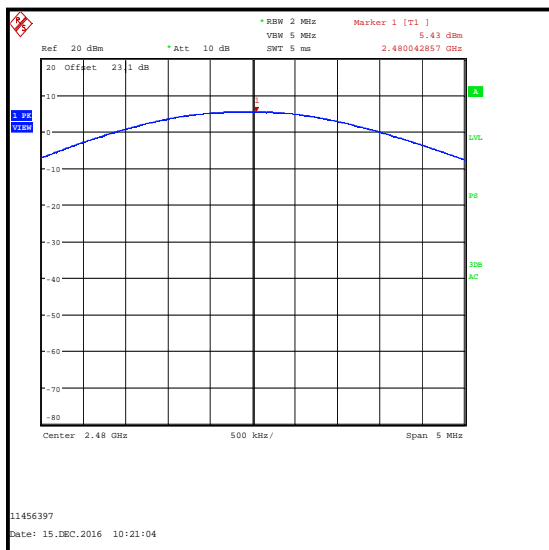
| Channel | Conducted Peak Power (dBm) | Declared Antenna Gain (dBi) | EIRP (dBm) | De Facto EIRP Limit (dBm) | Margin (dB) | Result |
|---------|----------------------------|-----------------------------|------------|---------------------------|-------------|----------|
| Bottom | 4.7 | 0.5 | 5.2 | 36.0 | 30.8 | Complied |
| Middle | 4.9 | 0.5 | 5.4 | 36.0 | 30.6 | Complied |
| Top | 4.9 | 0.5 | 5.4 | 36.0 | 30.6 | Complied |

Transmitter Maximum Peak Output Power (continued)**Results: DH5****Bottom Channel****Middle Channel****Top Channel**

Transmitter Maximum Peak Output Power (continued)**Results: 2DH5**

| Channel | Conducted Peak Power (dBm) | Conducted Peak Power Limit (dBm) | Margin (dB) | Result |
|---------|----------------------------|----------------------------------|-------------|----------|
| Bottom | 5.4 | 21.0 | 15.6 | Complied |
| Middle | 5.5 | 21.0 | 15.5 | Complied |
| Top | 5.4 | 21.0 | 15.6 | Complied |

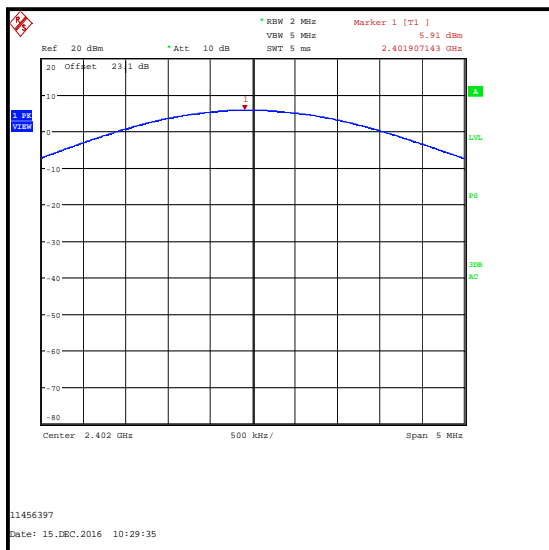
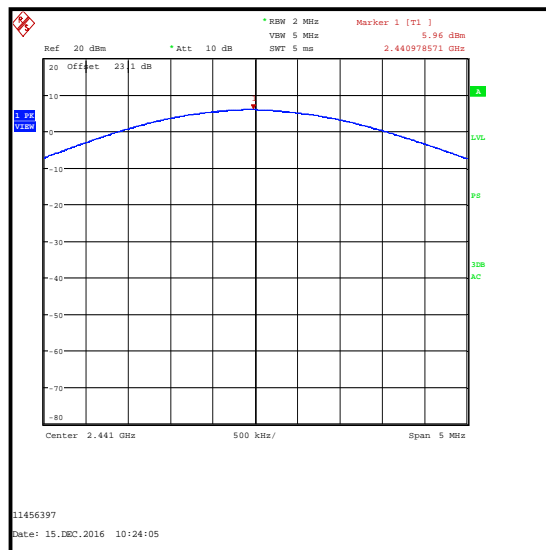
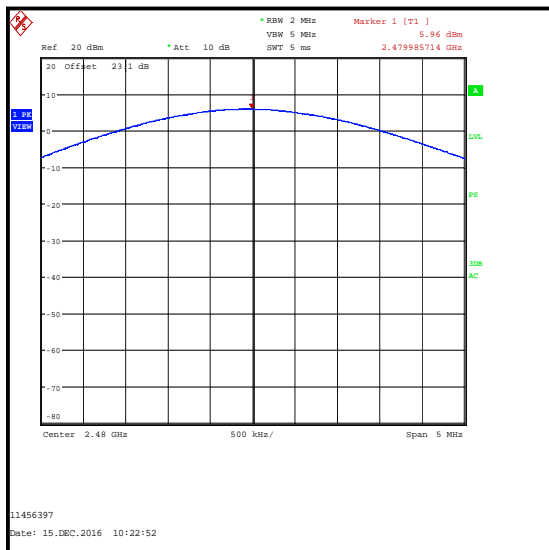
| Channel | Conducted Peak Power (dBm) | Declared Antenna Gain (dBi) | EIRP (dBm) | De Facto EIRP Limit (dBm) | Margin (dB) | Result |
|---------|----------------------------|-----------------------------|------------|---------------------------|-------------|----------|
| Bottom | 5.4 | 0.5 | 5.9 | 27.0 | 21.1 | Complied |
| Middle | 5.5 | 0.5 | 6.0 | 27.0 | 21.0 | Complied |
| Top | 5.4 | 0.5 | 5.9 | 27.0 | 21.1 | Complied |

Transmitter Maximum Peak Output Power (continued)**Results: 2DH5****Bottom Channel****Middle Channel****Top Channel**

Transmitter Maximum Peak Output Power (continued)**Results: 3DH5**

| Channel | Conducted Peak Power (dBm) | Conducted Peak Power Limit (dBm) | Margin (dB) | Result |
|---------|----------------------------|----------------------------------|-------------|----------|
| Bottom | 5.9 | 21.0 | 15.1 | Complied |
| Middle | 6.0 | 21.0 | 15.0 | Complied |
| Top | 6.0 | 21.0 | 15.0 | Complied |

| Channel | Conducted Peak Power (dBm) | Declared Antenna Gain (dBi) | EIRP (dBm) | De Facto EIRP Limit (dBm) | Margin (dB) | Result |
|---------|----------------------------|-----------------------------|------------|---------------------------|-------------|----------|
| Bottom | 5.9 | 0.5 | 6.4 | 27.0 | 20.6 | Complied |
| Middle | 6.0 | 0.5 | 6.5 | 27.0 | 20.5 | Complied |
| Top | 6.0 | 0.5 | 6.5 | 27.0 | 20.5 | Complied |

Transmitter Maximum Peak Output Power (continued)**Results: 3DH5****Bottom Channel****Middle Channel****Top Channel**

Transmitter Maximum Peak Output Power (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 |
| A2524 | Attenuator | AtlanTecRF | AN18W5-10 | 832827#2 | Calibrated before use | - |
| A2500 | Directional Coupler | AtlanTecRF | CDC-003060-10 | 13122501835 | Calibrated before use | - |
| M1021 | Signal Generator | Rohde & Schwarz | SMP02 | 833286/004 | 19 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 |

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

| | | | |
|-----------------------------------|---|-------------------|------------------|
| Test Engineer: | David Doyle | Test Date: | 03 February 2017 |
| Test Sample Serial Number: | Not marked or stated (<i>Radiated sample</i>) | | |

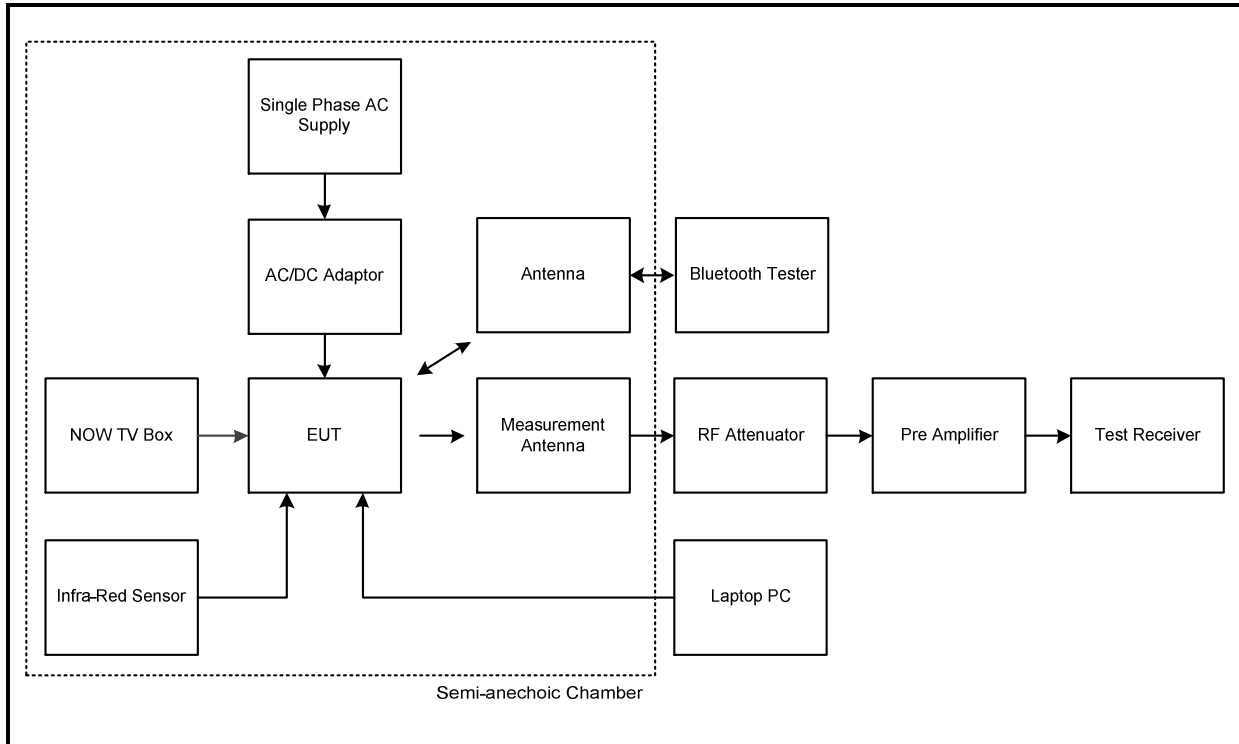
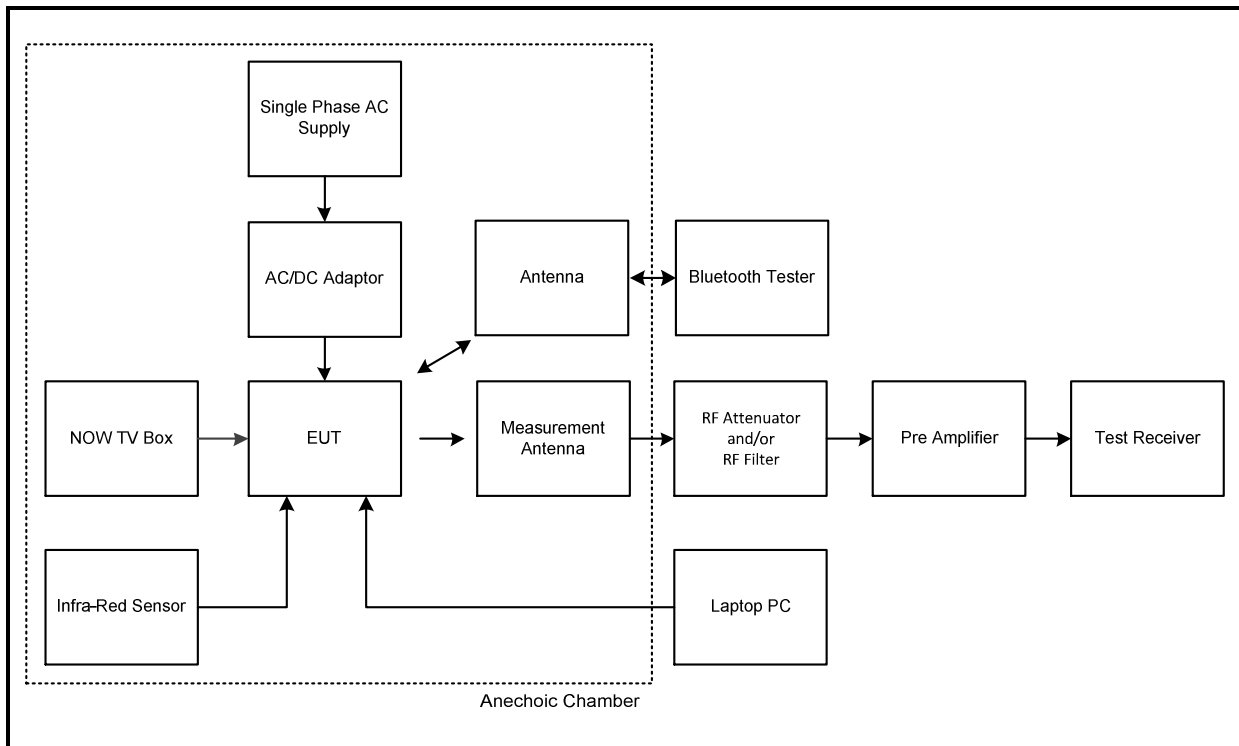
| | |
|--------------------------|----------------------------------|
| FCC Reference: | Parts 15.247(d) & 15.209(a) |
| Test Method Used: | ANSI C63.10 Sections 6.3 and 6.5 |
| Frequency Range | 30 MHz to 1000 MHz |

Environmental Conditions:

| | |
|-------------------------------|----|
| Temperature (°C): | 23 |
| Relative Humidity (%): | 39 |

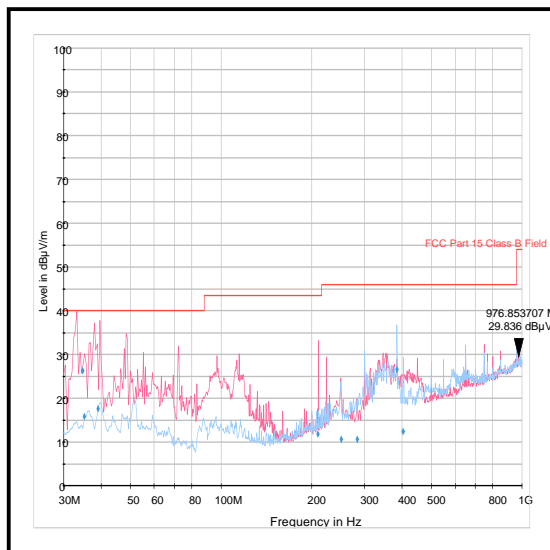
Note(s):

1. Transmitter radiated spurious emissions tests were performed with the EUT transmitting in 3DH5 mode as this was found to transmit the highest power and therefore deemed worst case.
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 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. Therefore the highest peak noise floor reading of the measuring receiver was recorded in the table below.
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. The sweep time was set to auto. A peak detector was used, sweep time was set to auto and trace mode was Max Hold.

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 (dB μ V/m) | Limit (dB μ V/m) | Margin (dB) | Result |
|-----------------|------------------|----------------------|----------------------|-------------|----------|
| 976.854 | Vertical | 29.8 | 54.0 | 24.2 | Complied |

**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 | 5 m RSE Chamber | Rainford EMC | N/A | N/A | 07 Dec 2017 | 12 |
| M1273 | Test Receiver | Rohde & Schwarz | ESIB26 | 100275 | 11 Apr 2017 | 12 |
| A2959 | Antenna | Schwarzbeck | VULB 9163 | 9163-967 | 08 Sep 2017 | 12 |
| G0543 | Amplifier | Sonoma | 310N | 230801 | 09 Jun 2017 | 6 |
| A1834 | Attenuator | Hewlett Packard | 8491B | 10444 | 30 Mar 2017 | 12 |

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

| | | | |
|-----------------------------------|---|-------------------|-----------------|
| Test Engineer: | David Doyle | Test Date: | 04 January 2017 |
| Test Sample Serial Number: | Not marked or stated (<i>Radiated sample</i>) | | |

| | |
|--------------------------|----------------------------------|
| FCC Reference: | Parts 15.247(d) & 15.209(a) |
| Test Method Used: | ANSI C63.10 Sections 6.3 and 6.6 |
| Frequency Range | 1 GHz to 25 GHz |

Environmental Conditions:

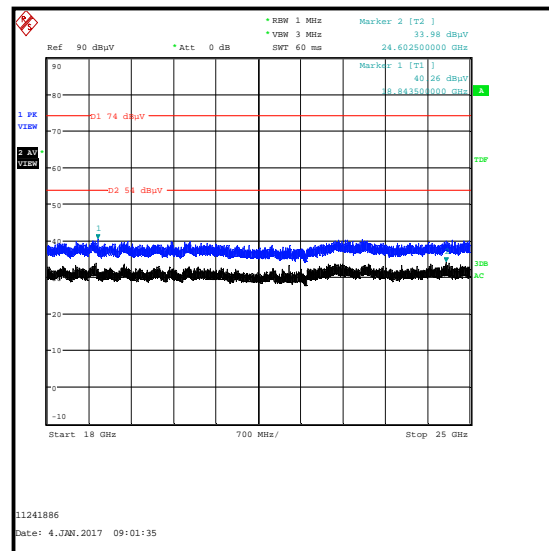
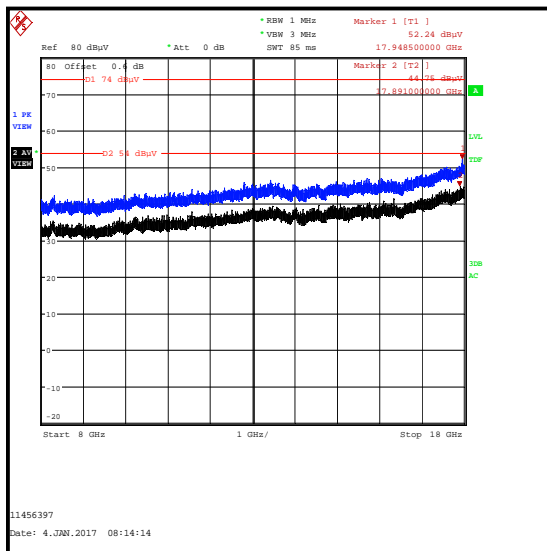
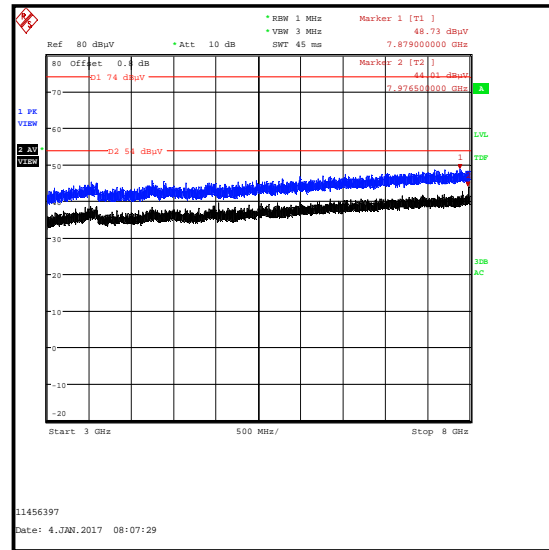
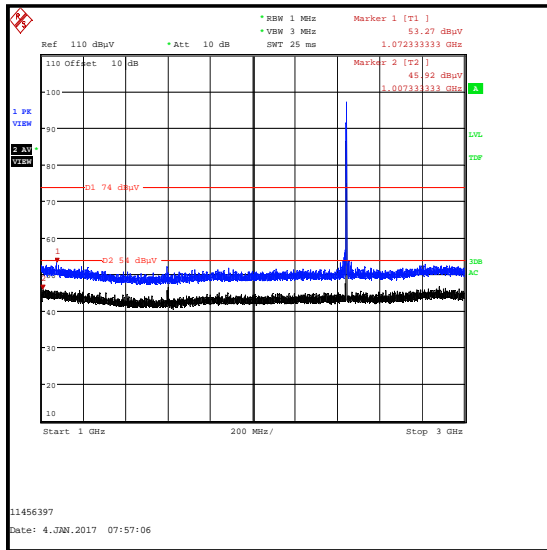
| | |
|-------------------------------|----|
| Temperature (°C): | 21 |
| Relative Humidity (%): | 37 |

Note(s):

1. Transmitter radiated spurious emissions tests were performed with the EUT transmitting in 3DH5 mode as this was found to transmit the highest power and therefore deemed worst case.
2. The final measured value, for the given emission, in the table below incorporates the calibrated antenna factor and cable loss.
3. No spurious emissions were detected above the noise floor of the measuring receiver therefore the highest peak noise floor reading of the measuring receiver was recorded as shown in the table below. The peak level was compared to the average limit as opposed to being compared to the peak limit because this is the more onerous limit.
4. The emission shown on the 1 GHz to 3 GHz plot is the EUT fundamental at 2441 MHz.
5. Measurements 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 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.
6. 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. Peak and average measurements were performed with their own appropriate detectors during the pre-scan measurements.

Results: 3DH5 / Peak

| Frequency (MHz) | Antenna Polarity | Level (dBμV/m) | Limit (dBμV/m) | Margin (dB) | Result |
|-----------------|------------------|----------------|----------------|-------------|----------|
| 1072.333 | Horizontal | 53.3 | 54.0 | 0.7 | 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 Apr 2017 | 12 |
| K0017 | 3m RSE Chamber | Rainford EMC | N/A | N/A | 17 May 2017 | 12 |
| M1995 | Test Receiver | Rohde & Schwarz | ESU40 | 100428 | 21 Mar 2017 | 12 |
| A2889 | Antenna | Schwarzbeck | BBHA 9120 B | BBHA 9120 B 653 | 07 Apr 2017 | 12 |
| A2890 | Antenna | Schwarzbeck | HWRD 750 | 014 | 06 May 2017 | 12 |
| A2892 | Antenna | Schwarzbeck | BBHA 9170 | 9170-727 | 07 Apr 2017 | 12 |
| A2863 | Pre-Amplifier | Agilent | 8449B | 3008A02100 | 07 Apr 2017 | 12 |
| A2891 | Pre-Amplifier | Schwarzbeck | BBV 9718 | 9718-306 | 07 Apr 2017 | 12 |
| A2893 | Pre-Amplifier | Schwarzbeck | BBV 9721 | 9721-021 | 07 Apr 2017 | 12 |
| A2914 | High Pass Filter | AtlanTecRF | AFH-03000 | 2155 | 19 May 2017 | 12 |
| A2947 | High Pass Filter | AtlanTecRF | AFH-07000 | 1601900001 | 01 Jun 2017 | 12 |
| A2916 | Attenuator | AtlanTecRF | AN185W-10 | 832827#1 | 19 May 2017 | 12 |

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

| | | | |
|-----------------------------------|---|-------------------|-----------------|
| Test Engineer: | David Doyle | Test Date: | 04 January 2017 |
| Test Sample Serial Number: | Not marked or stated (<i>Radiated sample</i>) | | |

| | |
|--------------------------|-----------------------------|
| FCC Reference: | Parts 15.247(d) & 15.209(a) |
| Test Method Used: | ANSI C63.10 Section 6.10 |

Environmental Conditions:

| | |
|-------------------------------|----|
| Temperature (°C): | 21 |
| Relative Humidity (%): | 37 |

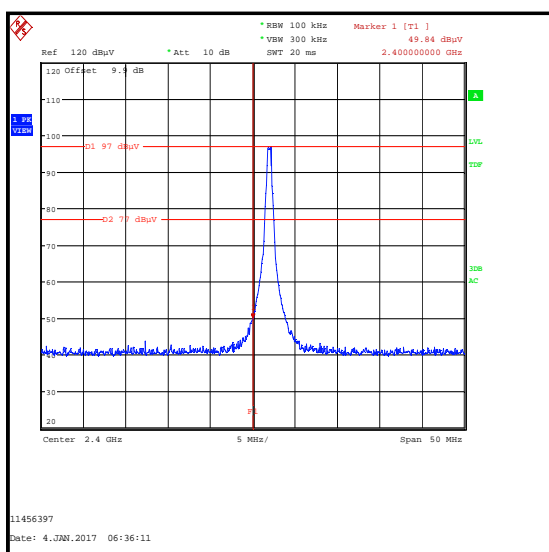
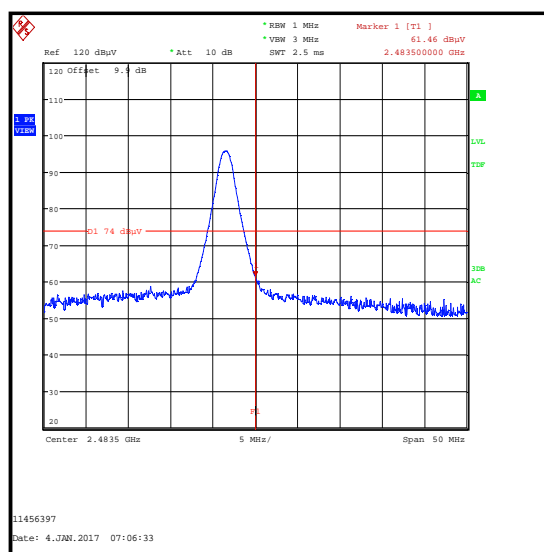
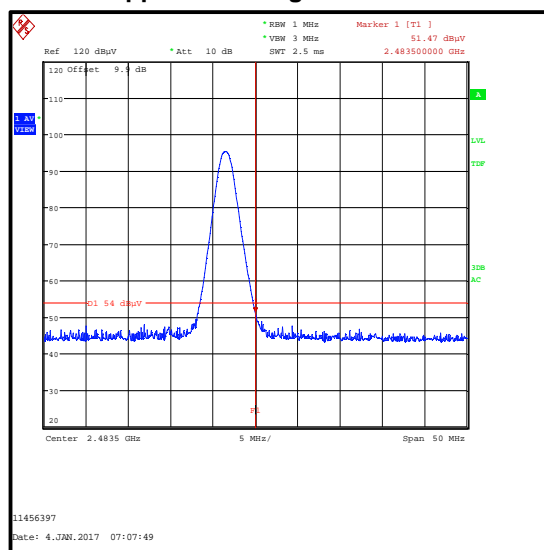
Note(s):

1. The final measured value, for the given emission, in the table below incorporates the calibrated antenna factor and cable loss.
2. The lower band edge is adjacent to a non-restricted band. 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. A marker was placed on the band edge spot frequencies and a second marker placed on the highest emission level in the adjacent band (where a higher level emission was present). Marker frequencies and levels were recorded.
3. The upper band edge falls adjacent to a restricted band. The test receiver resolution bandwidth was set to 1 MHz and video bandwidth 3 MHz. Peak and average measurements were performed with their respective detectors, 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 was placed on the band edge spot frequencies and a second marker placed on the highest emission level in the adjacent band (where a higher level emission was present). Marker frequencies and levels were recorded.
4. 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.
5. The restricted band plot for 2310 MHz to 2390 MHz can be found under the results for 3DH5 static as this mode had the highest output power and was therefore deemed worst case.
6. * -20 dBc limit.

Transmitter Band Edge Radiated Emissions (continued)**Results: Static Mode / DH5**

| Frequency (MHz) | Antenna Polarity | Peak Level (dB μ V/m) | Limit (dB μ V/m) | Margin (dB) | Result |
|-----------------|------------------|---------------------------|----------------------|-------------|----------|
| 2400.000 | Horizontal | 49.8 | 77.0* | 27.2 | Complied |
| 2483.500 | Horizontal | 61.5 | 74.0 | 12.5 | Complied |

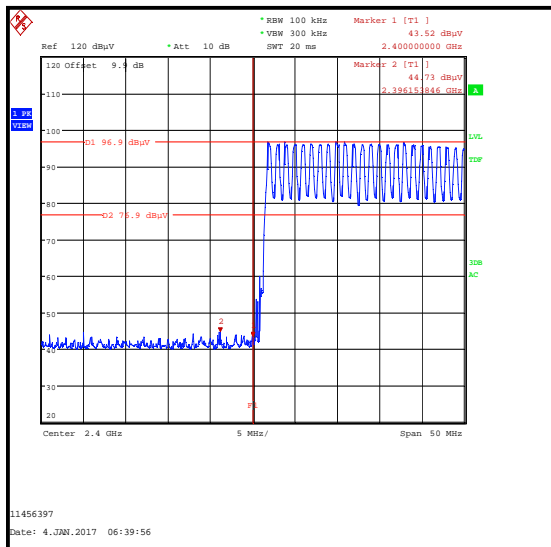
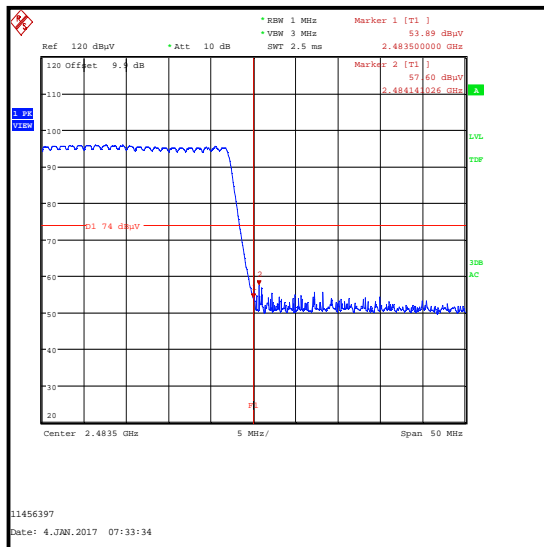
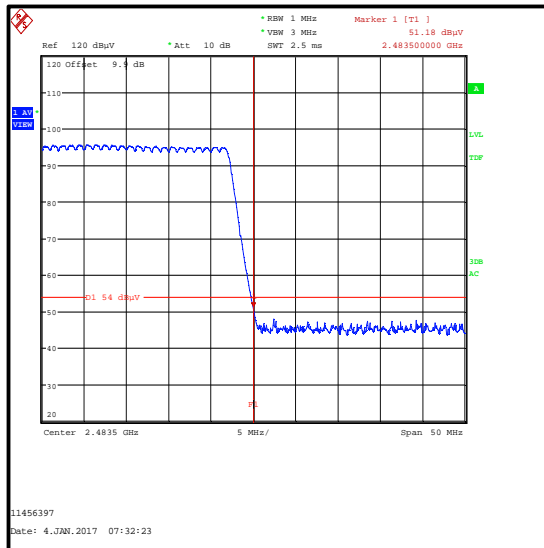
| Frequency (MHz) | Antenna Polarity | Average Level (dB μ V/m) | Limit (dB μ V/m) | Margin (dB) | Result |
|-----------------|------------------|------------------------------|----------------------|-------------|----------|
| 2483.500 | Horizontal | 51.5 | 54.0 | 2.5 | Complied |

**Lower Band Edge Peak Static****Upper Band Edge Peak Static****Upper Band Edge Average Static**

Transmitter Band Edge Radiated Emissions (continued)**Results: Hopping Mode / DH5**

| Frequency (MHz) | Antenna Polarity | Peak Level (dB μ V/m) | Limit (dB μ V/m) | Margin (dB) | Result |
|-----------------|------------------|---------------------------|----------------------|-------------|----------|
| 2396.154 | Horizontal | 44.7 | 76.9* | 32.2 | Complied |
| 2400.000 | Horizontal | 43.5 | 76.9* | 33.4 | Complied |
| 2483.500 | Horizontal | 53.9 | 74.0 | 20.1 | Complied |
| 2484.141 | Horizontal | 57.6 | 74.0 | 16.4 | Complied |

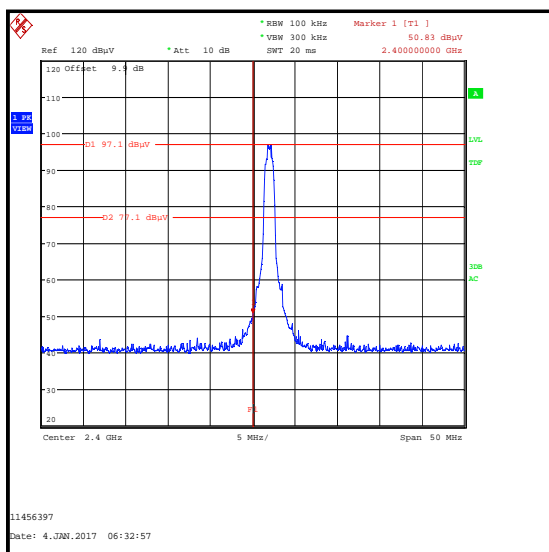
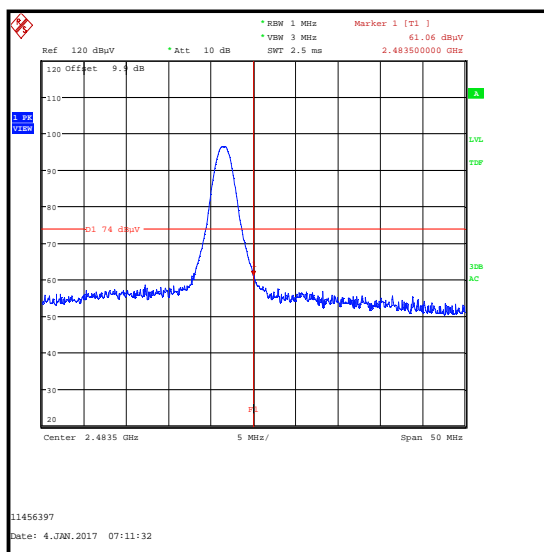
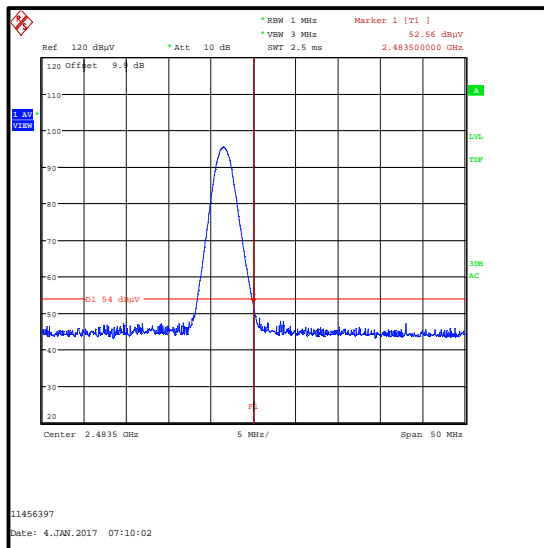
| Frequency (MHz) | Antenna Polarity | Average Level (dB μ V/m) | Limit (dB μ V/m) | Margin (dB) | Result |
|-----------------|------------------|------------------------------|----------------------|-------------|----------|
| 2483.500 | Horizontal | 51.2 | 54.0 | 2.8 | Complied |

Transmitter Band Edge Radiated Emissions (continued)**Results: Hopping Mode / DH5****Lower Band Edge Peak Hopping****Upper Band Edge Peak Hopping****Upper Band Edge Average Hopping**

Transmitter Band Edge Radiated Emissions (continued)**Results: Static Mode / 2DH5**

| Frequency (MHz) | Antenna Polarity | Peak Level (dB μ V/m) | Limit (dB μ V/m) | Margin (dB) | Result |
|-----------------|------------------|---------------------------|----------------------|-------------|----------|
| 2400.000 | Horizontal | 50.8 | 77.1* | 26.3 | Complied |
| 2483.500 | Horizontal | 61.1 | 74.0 | 12.9 | Complied |

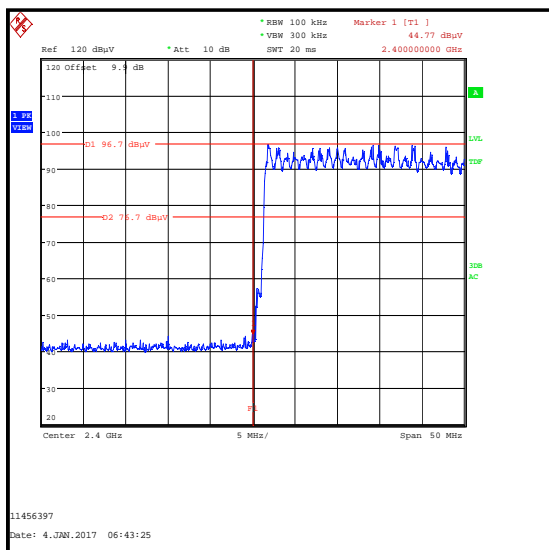
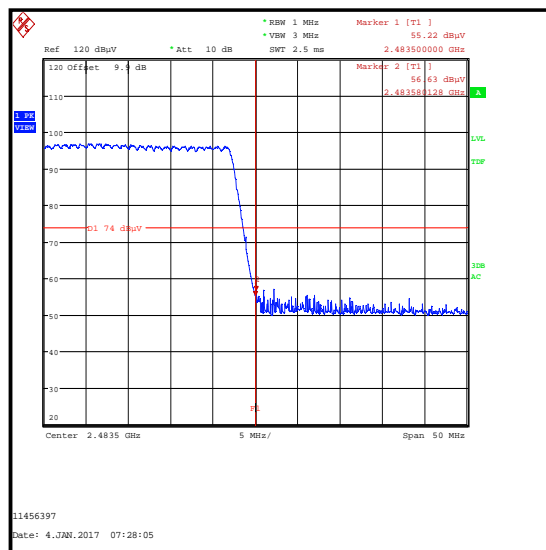
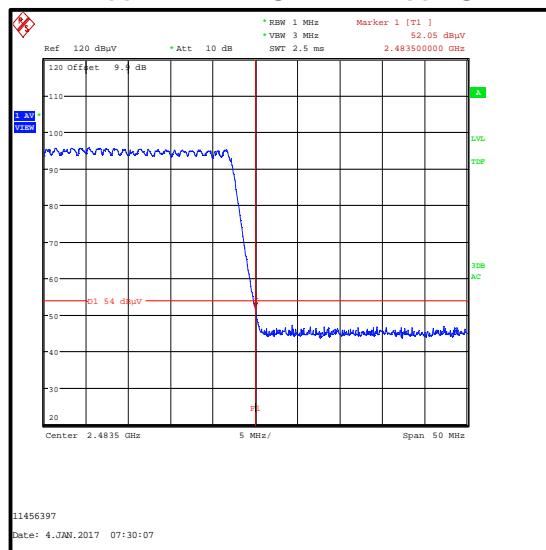
| Frequency (MHz) | Antenna Polarity | Average Level (dB μ V/m) | Limit (dB μ V/m) | Margin (dB) | Result |
|-----------------|------------------|------------------------------|----------------------|-------------|----------|
| 2483.500 | Horizontal | 52.6 | 54.0 | 1.4 | Complied |

**Lower Band Edge Peak Static****Upper Band Edge Peak Static****Upper Band Edge Average Static**

Transmitter Band Edge Radiated Emissions (continued)**Results: Hopping Mode / 2DH5**

| Frequency (MHz) | Antenna Polarity | Peak Level (dB μ V/m) | Limit (dB μ V/m) | Margin (dB) | Result |
|-----------------|------------------|---------------------------|----------------------|-------------|----------|
| 2400.000 | Horizontal | 44.8 | 76.7* | 31.9 | Complied |
| 2483.500 | Horizontal | 55.2 | 74.0 | 18.8 | Complied |
| 2483.580 | Horizontal | 56.6 | 74.0 | 17.4 | Complied |

| Frequency (MHz) | Antenna Polarity | Average Level (dB μ V/m) | Limit (dB μ V/m) | Margin (dB) | Result |
|-----------------|------------------|------------------------------|----------------------|-------------|----------|
| 2483.500 | Horizontal | 52.1 | 54.0 | 1.9 | Complied |

**Lower Band Edge Peak Hopping****Upper Band Edge Peak Hopping****Upper Band Edge Average Hopping**

Transmitter Band Edge Radiated Emissions (continued)**Results: Static Mode / 3DH5**

| Frequency (MHz) | Antenna Polarity | Peak Level (dB μ V/m) | Limit (dB μ V/m) | Margin (dB) | Result |
|-----------------|------------------|---------------------------|----------------------|-------------|----------|
| 2400.000 | Horizontal | 50.0 | 77.1* | 27.1 | Complied |
| 2483.500 | Horizontal | 61.8 | 74.0 | 12.2 | Complied |

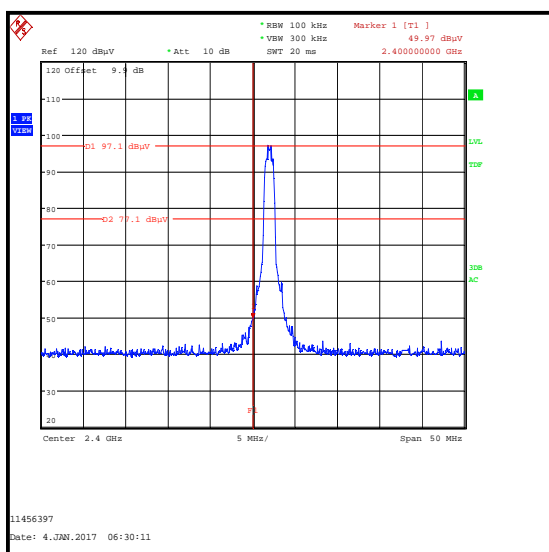
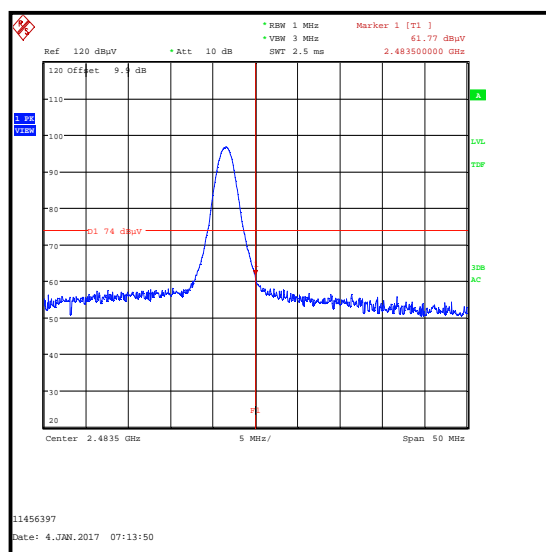
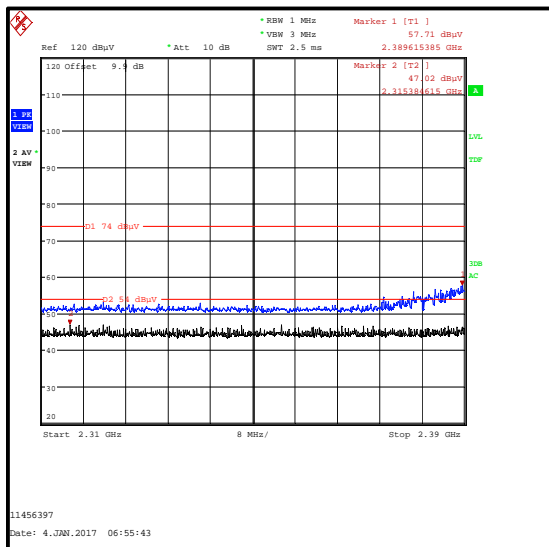
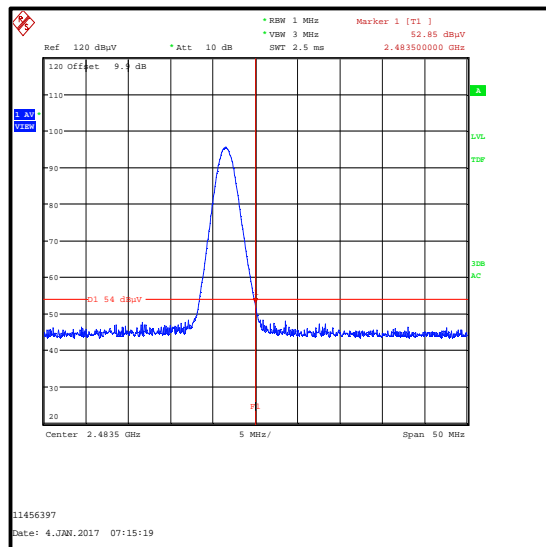
| Frequency (MHz) | Antenna Polarity | Average Level (dB μ V/m) | Limit (dB μ V/m) | Margin (dB) | Result |
|-----------------|------------------|------------------------------|----------------------|-------------|----------|
| 2483.500 | Horizontal | 52.9 | 54.0 | 1.1 | Complied |

Results: 2310 MHz to 2390 MHz Restricted Band / Peak

| Frequency (MHz) | Antenna Polarity | Peak Level (dB μ V/m) | Limit (dB μ V/m) | Margin (dB) | Result |
|-----------------|------------------|---------------------------|----------------------|-------------|----------|
| 2389.615 | Horizontal | 57.7 | 74.0 | 16.3 | Complied |

Results: 2310 MHz to 2390 MHz Restricted Band / Average

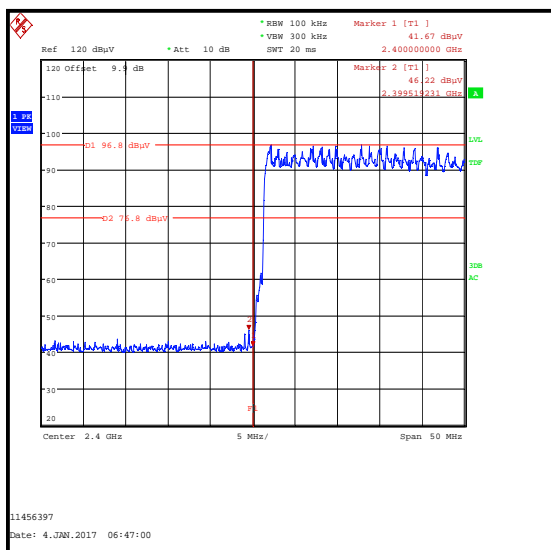
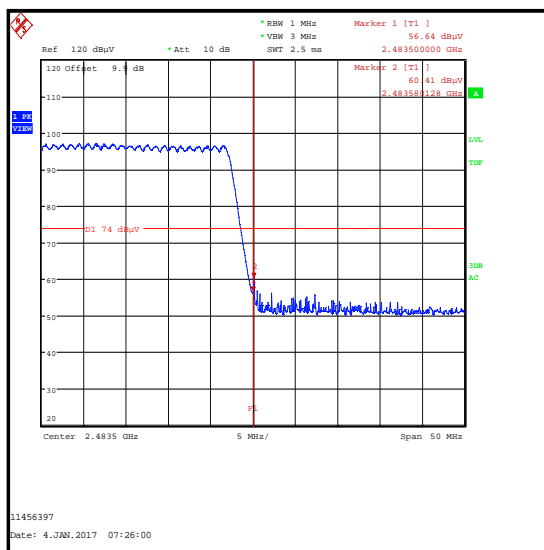
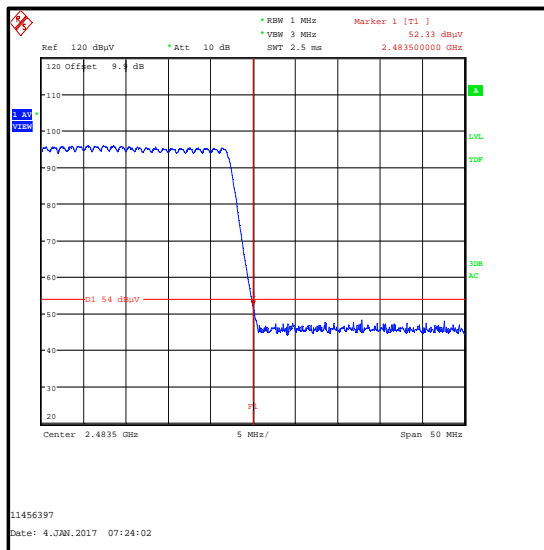
| Frequency (MHz) | Antenna Polarity | Average Level (dB μ V/m) | Limit (dB μ V/m) | Margin (dB) | Result |
|-----------------|------------------|------------------------------|----------------------|-------------|----------|
| 2315.385 | Horizontal | 47.0 | 54.0 | 7.0 | Complied |

Transmitter Band Edge Radiated Emissions (continued)**Results: Static Mode / 3DH5****Lower Band Edge Peak Static****Upper Band Edge Peak Static****2310 MHz to 2390 MHz Restricted Band Plot****Upper Band Edge Average Static**

Transmitter Band Edge Radiated Emissions (continued)**Results: Hopping Mode / 3DH5**

| Frequency (MHz) | Antenna Polarity | Peak Level (dB μ V/m) | Limit (dB μ V/m) | Margin (dB) | Result |
|-----------------|------------------|---------------------------|----------------------|-------------|----------|
| 2399.519 | Horizontal | 46.2 | 76.8* | 30.6 | Complied |
| 2400.000 | Horizontal | 41.7 | 76.8* | 35.1 | Complied |
| 2483.500 | Horizontal | 56.6 | 74.0 | 17.4 | Complied |
| 2483.580 | Horizontal | 60.4 | 74.0 | 13.6 | Complied |

| Frequency (MHz) | Antenna Polarity | Average Level (dB μ V/m) | Limit (dB μ V/m) | Margin (dB) | Result |
|-----------------|------------------|------------------------------|----------------------|-------------|----------|
| 2483.500 | Horizontal | 52.3 | 54.0 | 1.7 | Complied |

Transmitter Band Edge Radiated Emissions (continued)**Results: Hopping Mode / 3DH5****Lower Band Edge Peak Hopping****Upper Band Edge Peak Hopping****Upper Band Edge Average Hopping**

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 EMC | 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 |

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 |
| Carrier Frequency Separation | 2.4 GHz to 2.4835 GHz | 95% | ±4.59 % |
| Average Time of Occupancy | 2.4 GHz to 2.4835 GHz | 95% | ±3.53 ns |
| 20 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 ---