



TEST REPORT

Test Report No. : UL-RPT-RP12592099-2516A

Manufacturer : Plugwise B.V.
Model No. : Stealth HA
FCC ID : ZB9-16201
Technology : Zigbee (IEEE 802.15.4)
Test Standard(s) : FCC Parts 15.207, 15.209(a) & 15.247

1. This test report shall not be reproduced except in full, without the written approval of UL VS LTD.
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 2.0 supersedes all previous versions.

Date of Issue: 04 December 2019

Checked by:

Ben Mercer
Senior Engineer, Radio Laboratory

**Company
Signatory:**

Sarah Williams
Senior 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.

UL VS LTD

Unit 1-3 Horizon, Wade Road, Kingsland Business Park, Basingstoke, Hampshire, RG24 8AH, UK
Telephone: +44 (0)1256 312000
Facsimile: +44 (0)1256 312001

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1. Customer Information








| | |
|----------------------|---|
| Company Name: | Plugwise B.V. |
| Address: | Wattstraat 56 2171TR Sassenheim The Netherlands |

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: | 47CFR15.207 and 47CFR15.209 |
| Specification Title: | Code of Federal Regulations Volume 47 (Telecommunications): Part 15 Subpart C (Intentional Radiators) - Sections 15.207 and 15.209 |
| Site Registration: | 621311 |
| Location of Testing: | UL VS LTD, Unit 3 Horizon, Wade Road, Kingsland Business Park, Basingstoke, Hampshire, RG24 8AH, United Kingdom |
| Test Dates: | 06 February 2019 to 02 December 2019 |

2.2. Summary of Test Results

| FCC Reference (47CFR) | Measurement | Result |
|--|--|---|
| Part 15.207 | Transmitter AC Conducted Emissions |  |
| Part 15.247(a)(2) | Transmitter Minimum 6 dB Bandwidth |  |
| Part 15.247(e) | Transmitter Power Spectral Density | Note 1 |
| 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 | | |

Note(s):

1. In accordance with ANSI C63.10 Section 11.10.1, PSD measurements are not required if the maximum conducted output power is less than the PSD limit of 8 dBm / 3 kHz. The PSD level is therefore deemed to be equal to the measured output power.

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 v05r02 April 2, 2019 |
| Title: | Guidance for Compliance Measurements on Digital Transmission Systems, Frequency Hopping Spread Spectrum System, and Hybrid System Devices Operating Under Section 15.247 of the FCC rules |
| Reference: | KDB 174176 D01 Line Conducted FAQ v01r01 June 3, 2015 |
| Title: | 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)

| | |
|-----------------------------------|---|
| Brand Name: | Plugwise |
| Model Name or Number: | Stealth HA |
| Test Sample Serial Number: | B19ABA (<i>Conducted Sample #1</i>) |
| Hardware Version: | 162-01 |
| Software Version: | ETRX_PLUG_R0004 / 2016-11-21T02:00:00+02:00 |
| FCC ID: | ZB9-16201 |

| | |
|-----------------------------------|---|
| Brand Name: | Plugwise |
| Model Name or Number: | Stealth HA |
| Test Sample Serial Number: | 13CAD4 (<i>Conducted Sample #2</i>) |
| Hardware Version: | 162-01 |
| Software Version: | ETRX_PLUG_R0004 / 2016-11-21T02:00:00+02:00 |
| FCC ID: | ZB9-16201 |

| | |
|-----------------------------------|---|
| Brand Name: | Plugwise |
| Model Name or Number: | Stealth HA |
| Test Sample Serial Number: | B15549 (<i>Radiated Sample</i>) |
| Hardware Version: | 162-01 |
| Software Version: | ETRX_PLUG_R0004 / 2016-11-21T02:00:00+02:00 |
| FCC ID: | ZB9-16201 |

3.2. Description of EUT

The equipment under test was an energy measuring and switching device which incorporated Zigbee (IEEE802.15.4) functionality.

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 (Digital Transmission System) | | |
| Type of Unit: | Transceiver | | |
| Modulation: | O-QPSK | | |
| Data Rate: | 250 kb/s | | |
| Power Supply Requirement(s): | Nominal | 100 to 230 VAC | |
| Maximum Conducted Output Power: | 6.7 dBm | | |
| Antenna Gain: | 5.1 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: | Acer |
| Model Name or Number: | Aspire N17Q4 |
| Serial Number: | NXGVEH003820005157600 |

| | |
|-----------------------|------------------|
| Description: | USB Zigbee Stick |
| Brand Name: | Plugwise |
| Model Name or Number: | Zigbee Stick |
| Serial Number: | 2B11BB |

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 the bottom, middle and top channels as required.

4.2. Configuration and Peripherals

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

- Controlled wirelessly over Zigbee using a bespoke application on the laptop PC supplied by the customer and a USB Zigbee stick. The application was used to enable continuous transmission and idle mode (enabled but not transmitting) and to select the test channels as required. Following test document sent from customer, "*Readme-RF-test mode instructions.pdf*".
- Radiated spurious emissions were performed with the EUT in its worst case orientation/position.
- There were no ports to terminate during radiated emissions testing.
- The EUT was powered from a 120 VAC 60 Hz single phase mains supply.
- The customer supplied an RF cable to the EUT in order to perform conducted measurements. The respective path loss was accounted for as an RF level offset.

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: | Stefan Ho | Test Date: | 08 February 2019 |
| Test Sample Serial Number: | B15549 | | |

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

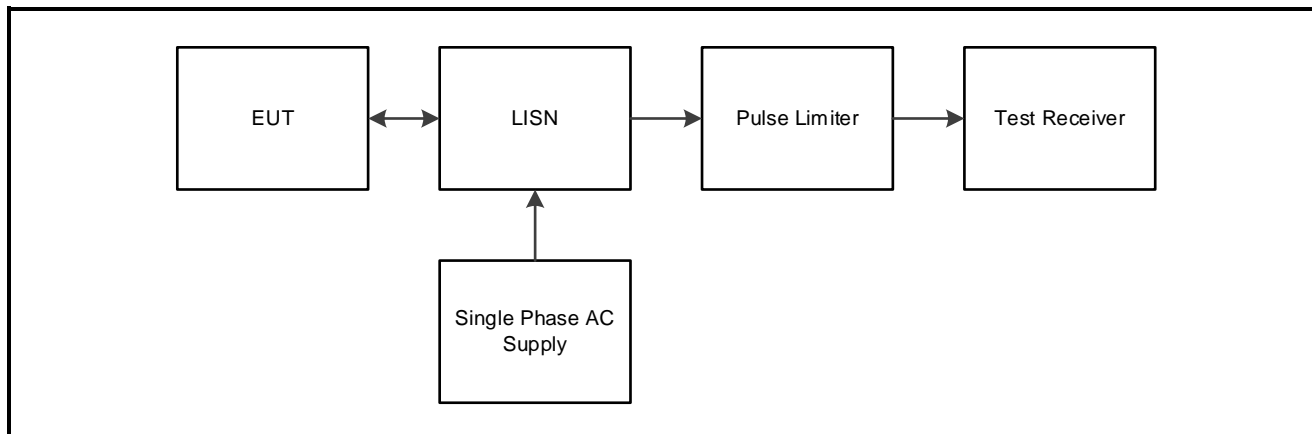
Environmental Conditions:

| | |
|------------------------|----|
| Temperature (°C): | 20 |
| Relative Humidity (%): | 39 |

Note(s):

1. The EUT was connected to a 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 EUT 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 μ V) | Limit (dB μ V) | Margin (dB) | Result |
|-----------------|------|--------------------|--------------------|-------------|----------|
| 0.1995 | Live | 52.7 | 63.6 | 10.9 | Complied |
| 0.2580 | Live | 49.9 | 61.5 | 11.6 | Complied |
| 0.3255 | Live | 46.7 | 59.6 | 12.9 | Complied |
| 0.4560 | Live | 42.0 | 56.8 | 14.8 | Complied |
| 0.6000 | Live | 38.1 | 56.0 | 17.9 | Complied |
| 0.8430 | Live | 31.7 | 56.0 | 24.3 | Complied |

Results: Live / Average / 120 VAC 60 Hz

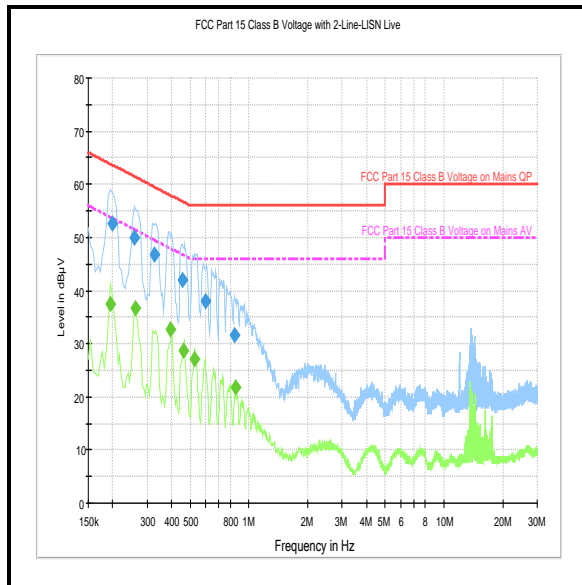
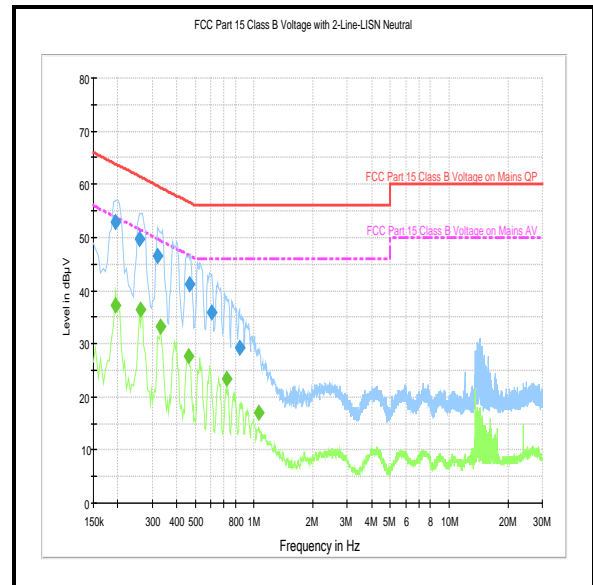
| Frequency (MHz) | Line | Level (dB μ V) | Limit (dB μ V) | Margin (dB) | Result |
|-----------------|------|--------------------|--------------------|-------------|----------|
| 0.1950 | Live | 37.4 | 53.8 | 16.4 | Complied |
| 0.2625 | Live | 36.7 | 51.4 | 14.7 | Complied |
| 0.3975 | Live | 32.8 | 47.9 | 15.1 | Complied |
| 0.4605 | Live | 28.6 | 46.7 | 18.1 | Complied |
| 0.5280 | Live | 27.1 | 46.0 | 18.9 | Complied |
| 0.8565 | Live | 21.9 | 46.0 | 24.1 | Complied |

Results: Neutral / Quasi Peak / 120 VAC 60 Hz

| Frequency (MHz) | Line | Level (dB μ V) | Limit (dB μ V) | Margin (dB) | Result |
|-----------------|---------|--------------------|--------------------|-------------|----------|
| 0.195000 | Neutral | 53.0 | 63.8 | 10.8 | Complied |
| 0.258000 | Neutral | 49.8 | 61.5 | 11.7 | Complied |
| 0.321000 | Neutral | 46.5 | 59.7 | 13.2 | Complied |
| 0.469500 | Neutral | 41.3 | 56.5 | 15.2 | Complied |
| 0.609000 | Neutral | 35.9 | 56.0 | 20.1 | Complied |
| 0.843000 | Neutral | 29.3 | 56.0 | 26.7 | Complied |

Results: Neutral / Average / 120 VAC 60 Hz

| Frequency (MHz) | Line | Level (dB μ V) | Limit (dB μ V) | Margin (dB) | Result |
|-----------------|---------|--------------------|--------------------|-------------|----------|
| 0.195000 | Neutral | 37.1 | 53.8 | 16.7 | Complied |
| 0.262500 | Neutral | 36.5 | 51.4 | 14.9 | Complied |
| 0.330000 | Neutral | 33.3 | 49.5 | 16.2 | Complied |
| 0.460500 | Neutral | 27.7 | 46.7 | 19.0 | Complied |
| 0.726000 | Neutral | 23.4 | 46.0 | 22.6 | Complied |
| 1.059000 | Neutral | 17.0 | 46.0 | 29.0 | 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 μ V) | Limit (dB μ V) | Margin (dB) | Result |
|-----------------|------|--------------------|--------------------|-------------|----------|
| 0.1905 | Live | 48.4 | 64.0 | 15.6 | Complied |
| 0.2580 | Live | 45.3 | 61.5 | 16.2 | Complied |
| 0.3210 | Live | 42.7 | 59.7 | 17.0 | Complied |
| 0.4020 | Live | 38.2 | 57.8 | 19.6 | Complied |
| 0.5910 | Live | 35.1 | 56.0 | 20.9 | Complied |
| 0.8565 | Live | 30.3 | 56.0 | 25.7 | Complied |

Results: Live / Average / 240 VAC 60 Hz

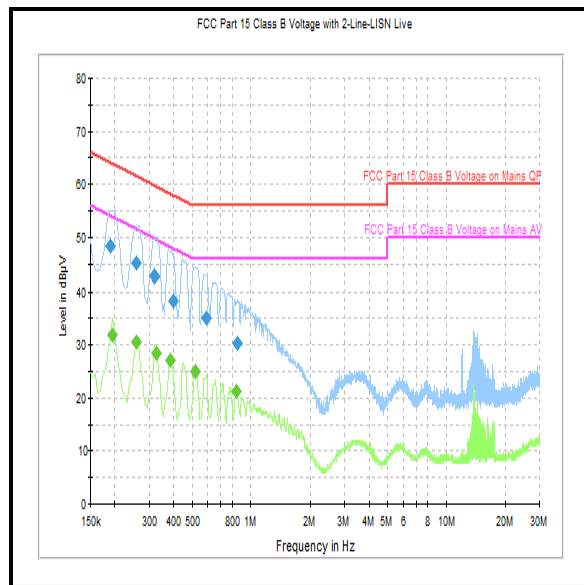
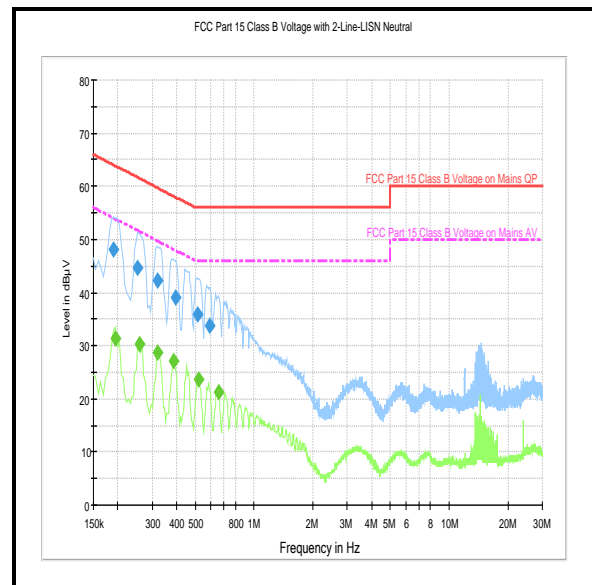
| Frequency (MHz) | Line | Level (dB μ V) | Limit (dB μ V) | Margin (dB) | Result |
|-----------------|------|--------------------|--------------------|-------------|----------|
| 0.1950 | Live | 31.9 | 53.8 | 21.9 | Complied |
| 0.2580 | Live | 30.6 | 51.5 | 20.9 | Complied |
| 0.3255 | Live | 28.4 | 49.6 | 21.2 | Complied |
| 0.3885 | Live | 27.2 | 48.1 | 20.9 | Complied |
| 0.5190 | Live | 24.9 | 46.0 | 21.1 | Complied |
| 0.8385 | Live | 21.4 | 46.0 | 24.6 | Complied |

Results: Neutral / Quasi Peak / 240 VAC 60 Hz

| Frequency (MHz) | Line | Level (dB μ V) | Limit (dB μ V) | Margin (dB) | Result |
|-----------------|---------|--------------------|--------------------|-------------|----------|
| 0.1905 | Neutral | 48.2 | 64.0 | 15.8 | Complied |
| 0.2535 | Neutral | 44.7 | 61.6 | 16.9 | Complied |
| 0.3210 | Neutral | 42.2 | 59.7 | 17.5 | Complied |
| 0.3975 | Neutral | 38.9 | 57.9 | 19.0 | Complied |
| 0.5145 | Neutral | 35.9 | 56.0 | 20.1 | Complied |
| 0.5910 | Neutral | 33.7 | 56.0 | 22.3 | Complied |

Results: Neutral / Average / 240 VAC 60 Hz

| Frequency (MHz) | Line | Level (dB μ V) | Limit (dB μ V) | Margin (dB) | Result |
|-----------------|---------|--------------------|--------------------|-------------|----------|
| 0.1950 | Neutral | 31.4 | 53.8 | 22.4 | Complied |
| 0.2580 | Neutral | 30.3 | 51.5 | 21.2 | Complied |
| 0.3210 | Neutral | 28.8 | 49.7 | 20.9 | Complied |
| 0.3885 | Neutral | 27.2 | 48.1 | 20.9 | Complied |
| 0.5190 | Neutral | 23.7 | 46.0 | 22.3 | Complied |
| 0.6540 | Neutral | 21.2 | 46.0 | 24.8 | 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) |
|-----------|-------------------|-----------------|----------|------------|----------------------|------------------------|
| M2037 | Thermohygrometer | Testo | 608-H1 | 45124925 | 27 Mar 2019 | 12 |
| M1273 | Test Receiver | Rohde & Schwarz | ESIB26 | 100275 | 18 Dec 2019 | 12 |
| A1830 | Pulse Limiter | Rohde & Schwarz | ESH3-Z2 | 100668 | 06 Apr 2019 | 12 |
| A649 | Single Phase LISN | Rohde & Schwarz | ESH3-Z5 | 825562/008 | 23 Aug 2019 | 12 |

Test Measurement Software/Firmware Used

| Name | Version | Release Date |
|-----------------------|---------|--------------|
| Rohde & Schwarz EMC32 | 6.30.0 | 2008 |

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

| | | | |
|-----------------------------------|-----------|-------------------|------------------|
| Test Engineer: | Stefan Ho | Test Date: | 07 February 2019 |
| Test Sample Serial Number: | B19ABA | | |

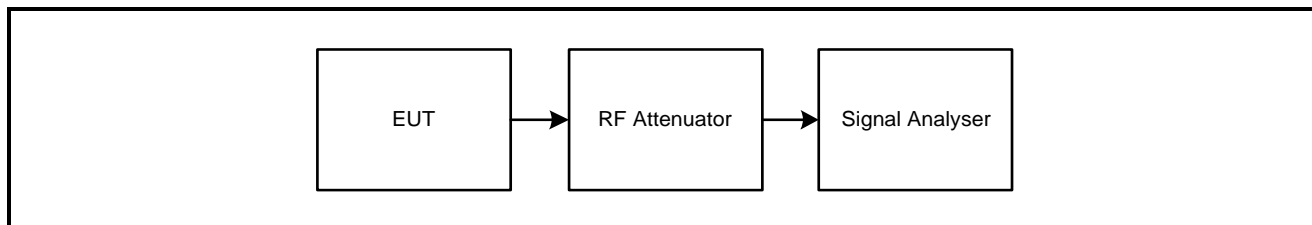
| | |
|--------------------------|--|
| FCC Reference: | Part 15.247(a)(2) |
| Test Method Used: | FCC KDB 558074 Section 8.2 referencing ANSI C63.10 Section 11.8.1 |

Environmental Conditions:

| | |
|-------------------------------|----|
| Temperature (°C): | 22 |
| Relative Humidity (%): | 39 |

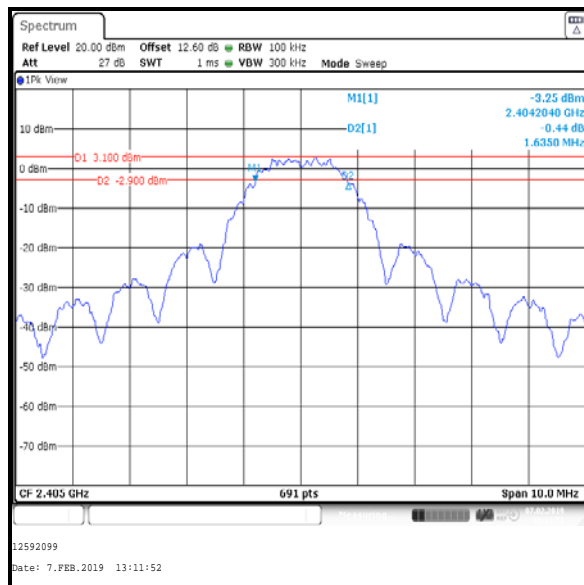
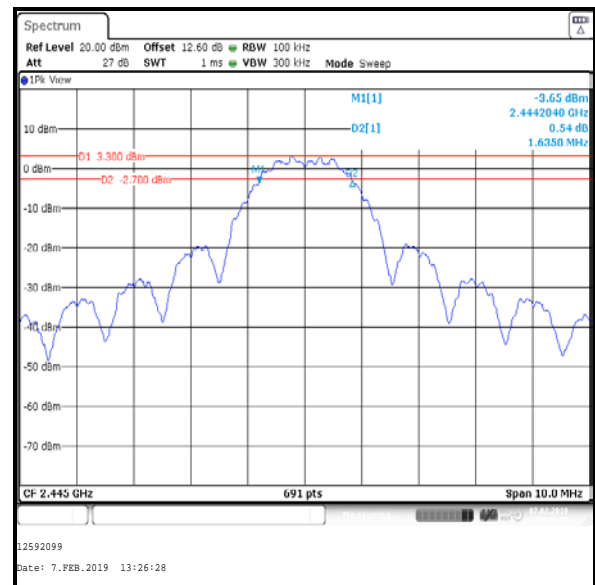
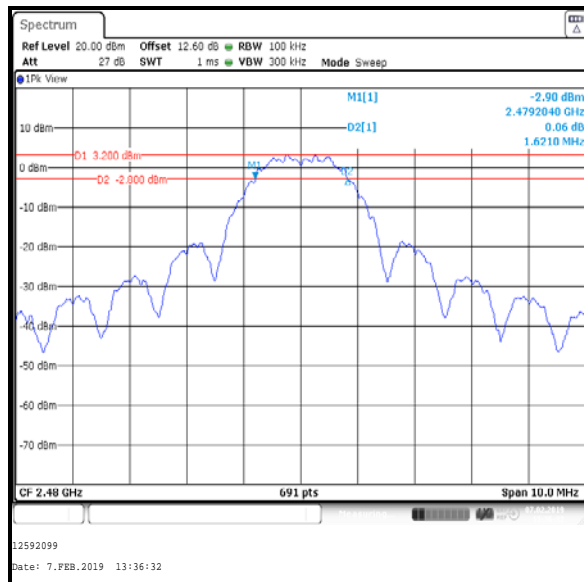
Note(s):

1. 6 dB DTS bandwidth tests were performed using a signal analyser in accordance with ANSI C63.10 Section 11.8.1 Option 1 measurement procedure. The signal analyser resolution bandwidth was set to 100 kHz and video bandwidth to 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 signal analyser 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 | 1635.000 | ≥500 | 1135.000 | Complied |
| Middle | 1635.000 | ≥500 | 1135.000 | Complied |
| Top | 1621.000 | ≥500 | 1121.000 | 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) |
|-----------|-------------------------|-----------------|-----------|------------|-----------------------|------------------------|
| M2005 | Thermohygrometer | Testo | 608-H1 | 45046700 | 06 Jan 2020 | 12 |
| M2036 | Signal Analyser | Rohde & Schwarz | FSV30 | 101791 | 20 Apr 2019 | 12 |
| G0628 | Vector Signal Generator | Rohde & Schwarz | SMBV100A | 261847 | 28 Sep 2020 | 36 |
| A2524 | Attenuator | AtlanTecRF | AN18W5-10 | 832827#2 | Calibrated before use | - |

5.2.3. Transmitter Maximum Peak Output Power**Test Summary:**

| | | | |
|-----------------------------------|-----------|-------------------|--------------|
| Test Engineer: | Stefan Ho | Test Date: | 16 July 2019 |
| Test Sample Serial Number: | 13CAD4 | | |

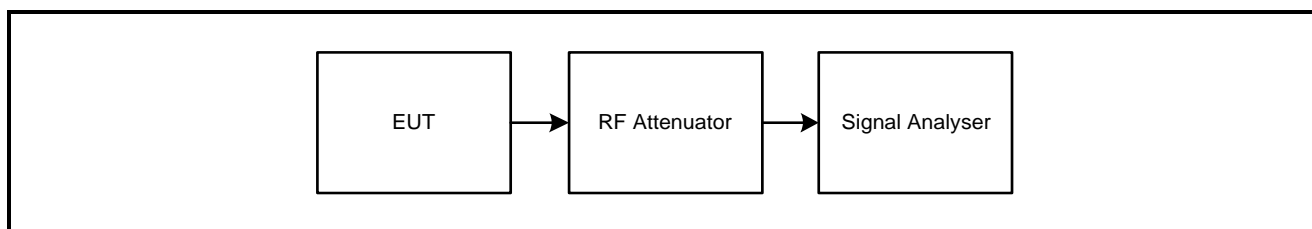
| | |
|--------------------------|--|
| FCC Reference: | Part 15.247(b)(3) |
| Test Method Used: | FCC KDB 558074 Section 8.3.1.1 referencing ANSI C63.10 Section 11.9.1.1 |

Environmental Conditions:

| | |
|-------------------------------|----|
| Temperature (°C): | 22 |
| Relative Humidity (%): | 39 |

Note(s):

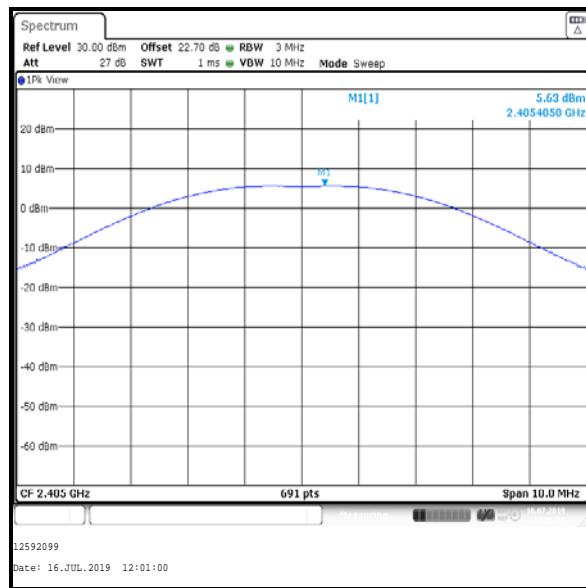
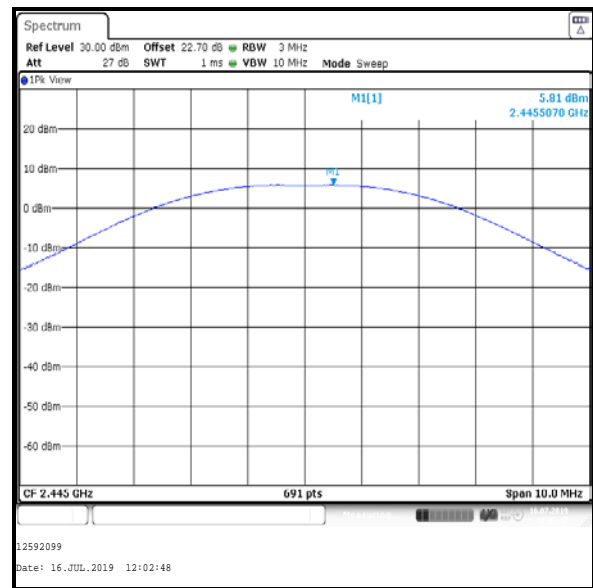
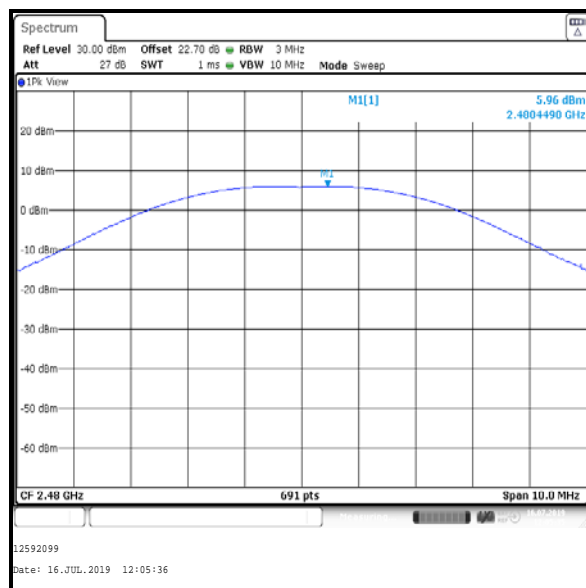
1. Conducted power tests were performed using a signal analyser in accordance with ANSI C63.10 Section 11.9.1.1 RBW \geq DTS bandwidth procedure.
2. The signal analyser resolution bandwidth was set to 3 MHz and video bandwidth of 10 MHz. A peak detector was used, sweep time was set to auto and trace 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 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 spectrum analyser 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 | 5.6 | 30.0 | 24.4 | Complied |
| Middle | 5.8 | 30.0 | 24.2 | Complied |
| Top | 6.0 | 30.0 | 24.0 | Complied |

| Channel | Conducted Peak Power (dBm) | Declared Antenna Gain (dBi) | EIRP (dBm) | De Facto EIRP Limit (dBm) | Margin (dB) | Result |
|---------|----------------------------|-----------------------------|------------|---------------------------|-------------|----------|
| Bottom | 5.6 | 5.1 | 10.7 | 36.0 | 25.3 | Complied |
| Middle | 5.8 | 5.1 | 10.9 | 36.0 | 25.1 | Complied |
| Top | 6.0 | 5.1 | 11.1 | 36.0 | 24.9 | 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) |
|-----------|-------------------------|-----------------|-----------|------------|-----------------------|------------------------|
| M2005 | Thermohyrometer | Testo | 608-H1 | 45046700 | 06 Jan 2020 | 12 |
| M2036 | Signal Analyser | Rohde & Schwarz | FSV30 | 101791 | 07 May 2020 | 12 |
| G0628 | Vector Signal Generator | Rohde & Schwarz | SMBV100A | 261847 | 28 Sep 2020 | 36 |
| A2946 | Attenuator | AtlanTecRF | AN18W5-20 | 208146#1 | Calibrated before use | - |

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

| | | | |
|-----------------------------------|-----------------------------------|--------------------|-------------------------------------|
| Test Engineers: | Mohamed Toubella & Andrew Edwards | Test Dates: | 07 February 2019 & 02 December 2019 |
| Test Sample Serial Number: | B15549 | | |

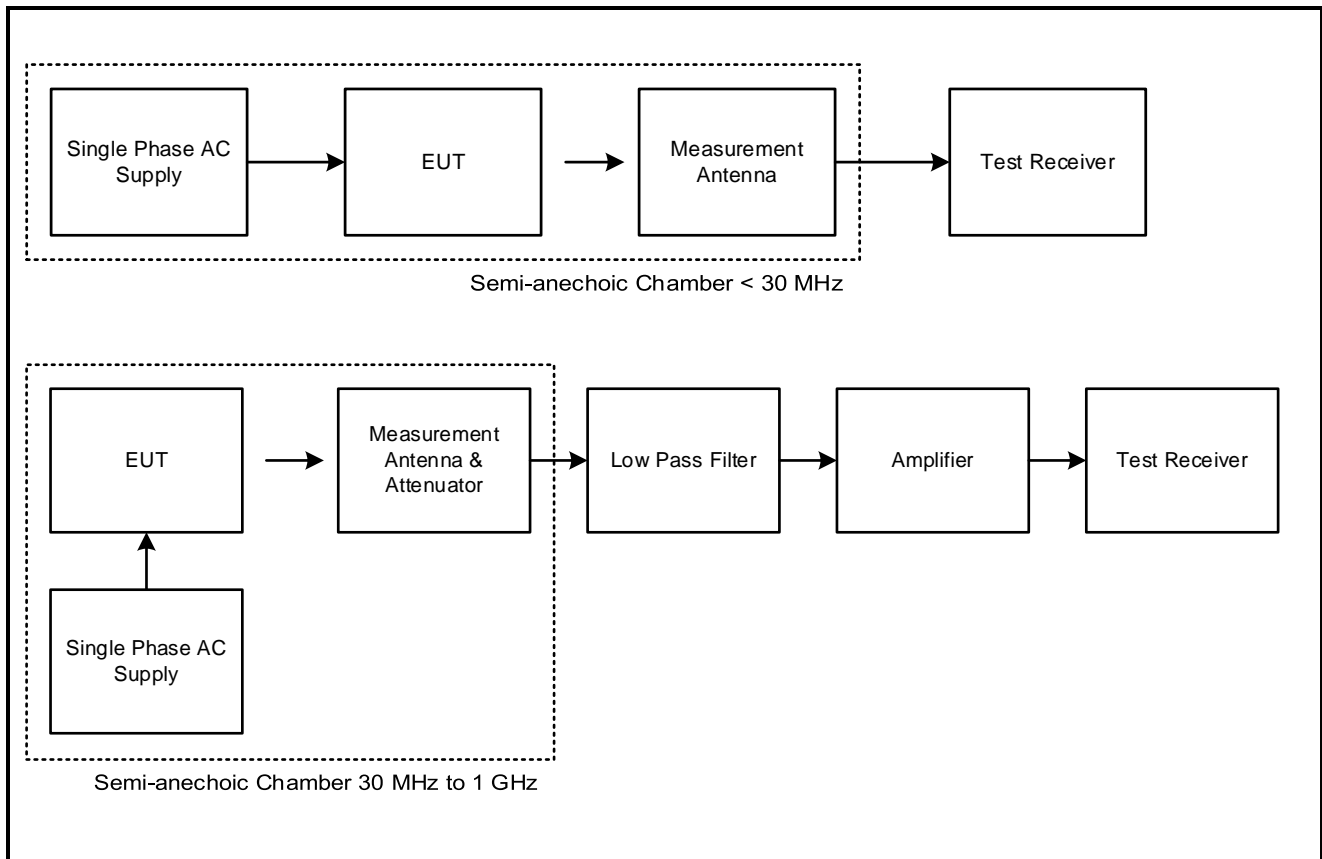
| | |
|--------------------------|---------------------------------------|
| FCC Reference: | Parts 15.247(d) & 15.209(a) |
| Test Method Used: | ANSI C63.10 Sections 6.3, 6.4 and 6.5 |
| Frequency Range | 9 kHz to 1000 MHz |

Environmental Conditions:

| | |
|-------------------------------|----------|
| Temperature (°C): | 21 to 23 |
| Relative Humidity (%): | 35 to 38 |

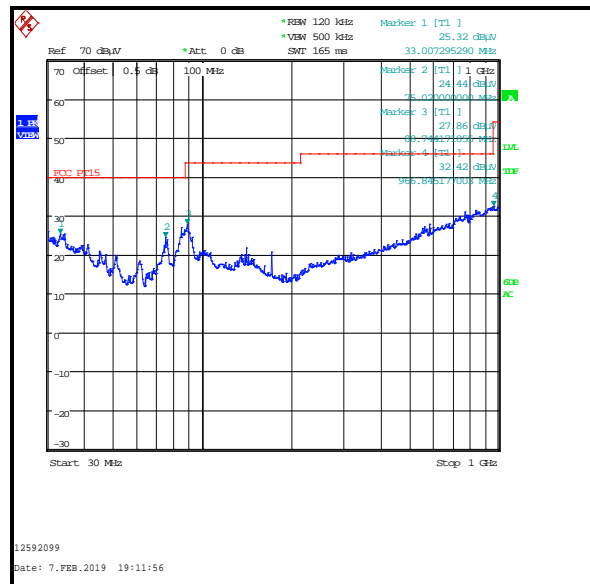
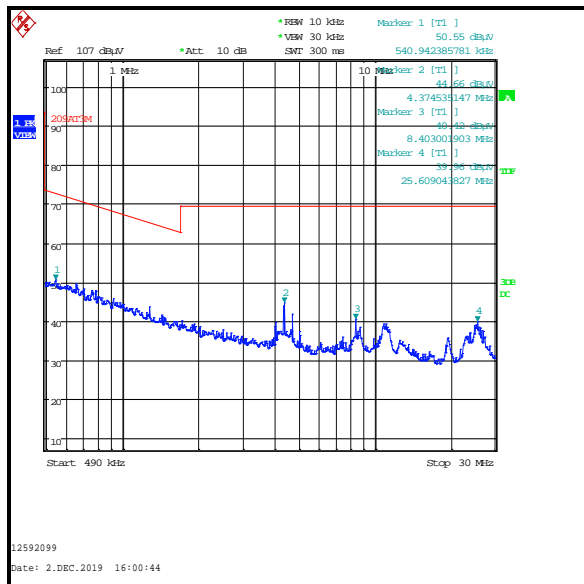
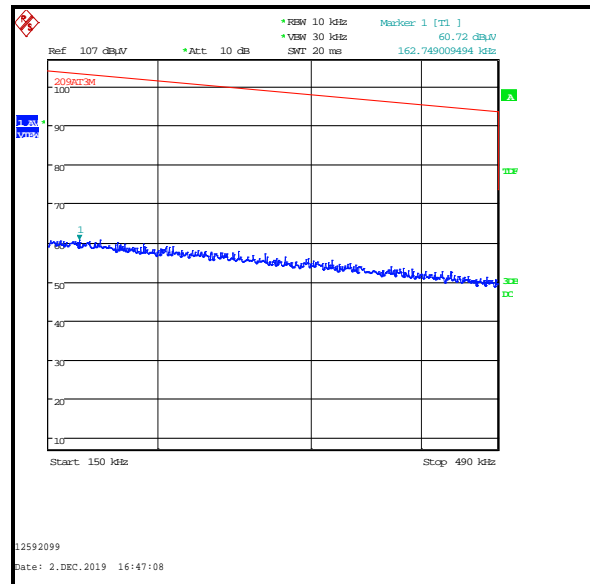
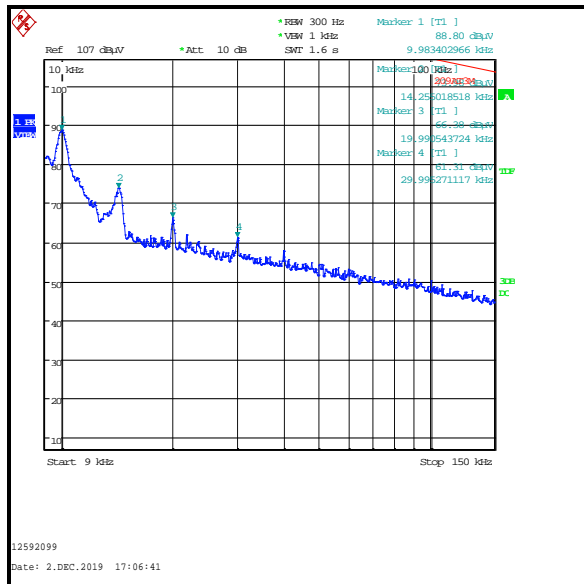
Note(s):

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. There are ambient emissions seen between 2 to 30 MHz on the pre-scan plot for 490 kHz to 30 MHz performed in the semi-anechoic chamber. A background scan between 490 kHz to 30 MHz is stored on the company server and is available for inspection upon request.
5. Measurements below 30 MHz were performed in a semi-anechoic chamber (Asset Number K0001) at 3 metres. The EUT was placed at a height of 80 cm above the reference ground plane in the centre of the chamber turntable. The limit was extrapolated to 3 metres in accordance with ANSI C63.10 Section 6.4.4.2. Correlation data between the semi-anechoic chamber and an open-field test site is available upon request.
6. Measurements between 30 MHz to 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.
7. Pre-scans were performed, and markers placed on the highest measured levels. For measurements below 150 kHz: The test receiver resolution bandwidth was set to 300 Hz and video bandwidth 1 kHz. A peak detector was used, sweep time was set to auto and trace mode was Max Hold. For measurements between 150 to 490 kHz: The test receiver resolution bandwidth was set to 10 kHz and video bandwidth 30 kHz. An average detector was used, sweep time was set to auto and trace mode was Max Hold. For measurements between 490 kHz to 30 MHz: The test receiver resolution bandwidth was set to 10 kHz and video bandwidth 30 kHz. A peak detector was used, sweep time was set auto and trace mode was Max Hold. For measurements between 30 MHz to 1 GHz: The test receiver resolution bandwidth was set to 120 kHz and video bandwidth 500 kHz. A peak detector was used, sweep time was set auto and trace mode was Max Hold.
8. 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 peak detector and Max hold enabled and span big enough to see the whole emission.

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

Transmitter Radiated Emissions (continued)**Results: Middle Channel**

| Frequency (MHz) | Antenna Polarity | Level (dB μ V/m) | Limit (dB μ V/m) | Margin (dB) | Result |
|-----------------|------------------|----------------------|----------------------|-------------|----------|
| 75.058 | Horizontal | 26.1 | 40.0 | 13.9 | Complied |



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

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

| Asset No. | Instrument | Manufacturer | Type No. | Serial No. | Date Calibration Due | Cal. Interval (Months) |
|-----------|-----------------------|-----------------|-----------|-------------|----------------------|------------------------|
| M2040 | Thermohygrometer | Testo | 608-H1 | 45124934 | 06 Jan 2020 | 12 |
| K0001 | 5m RSE Chamber | Rainford EMC | N/A | N/A | 16 Oct 2020 | 12 |
| M2044 | Test Receiver | Rohde & Schwarz | ESU26 | 100122 | 01 Apr 2020 | 12 |
| A3154 | Pre-Amplifier | Com-Power | PAM-103 | 18020012 | 14 Sep 2019 | 12 |
| A3198 | Magnetic Loop Antenna | ETS-Lindgren | 6502 | 00221887 | 27 Mar 2020 | 12 |
| A553 | Antenna | Chase | CBL6111A | 1593 | 08 Oct 2019 | 12 |
| A3112 | Attenuator | AtlanTechRF | AN18-06 | 219706#2 | 08 Oct 2019 | 12 |
| A3085 | Low Pass Filter | AtlanTechRF | AFL-02000 | 18051600014 | 29 Jun 2019 | 12 |

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

| | | | |
|-----------------------------------|-----------------------------------|-------------------|-----------------------------------|
| Test Engineer: | Mohamed Toubella & Andrew Harding | Test Date: | 06 February 2019 to 11 March 2019 |
| Test Sample Serial Number: | B15549 | | |

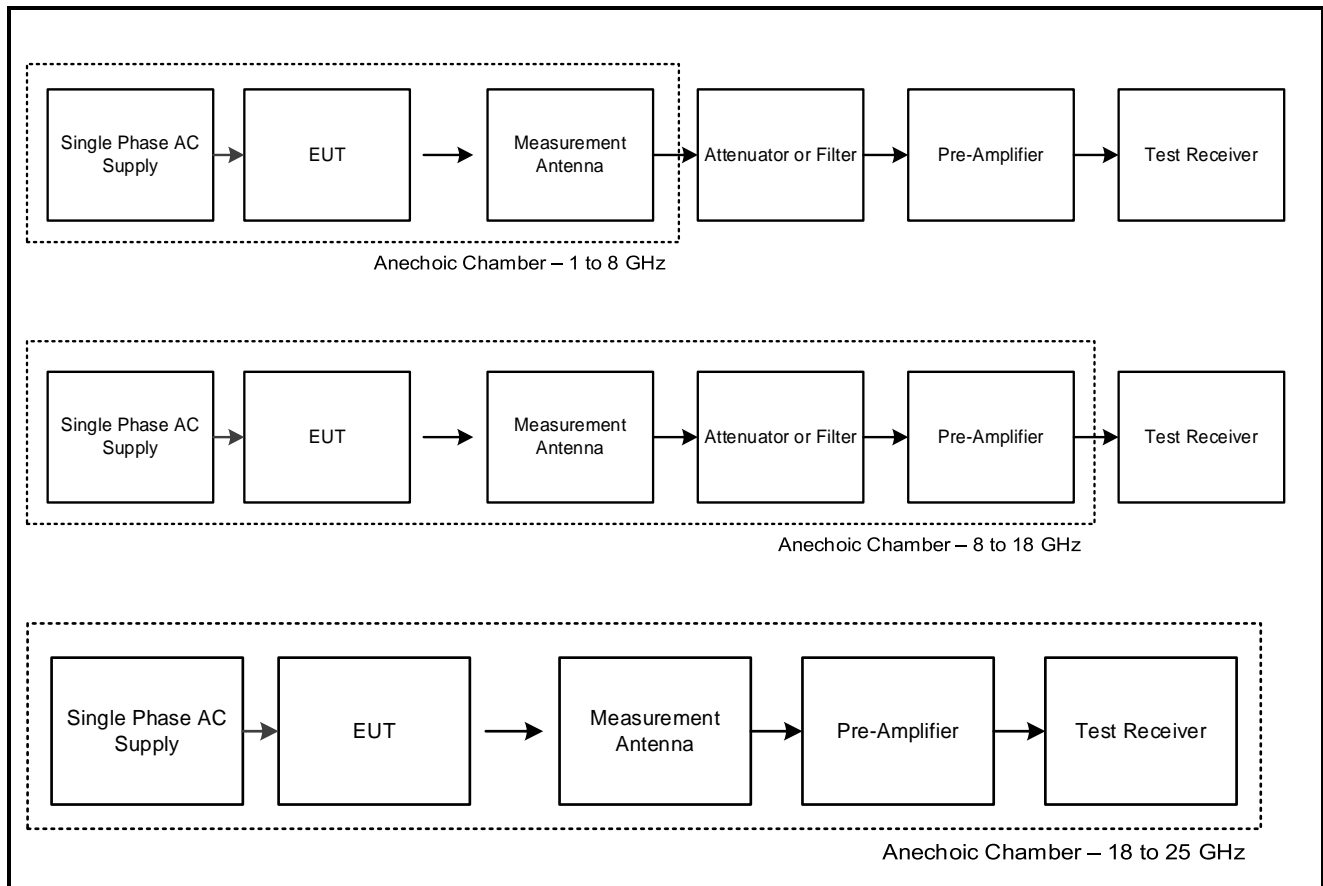
| | |
|--------------------------|--|
| FCC Reference: | Parts 15.247(d) & 15.209(a) |
| Test Method Used: | FCC KDB 558074 Sections 8.1 c)3), 8.5 & 8.6 referencing ANSI C63.10 Sections 6.3, 6.6, 11.11 & 11.12 |
| Frequency Range | 1 GHz to 25 GHz |

Environmental Conditions:

| | |
|-------------------------------|----------|
| Temperature (°C): | 23 to 24 |
| Relative Humidity (%): | 35 to 39 |

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. Pre-scans above 1 GHz were performed in a fully anechoic chamber (Asset Number K0001) 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. Final measurements above 1 GHz were performed in a fully anechoic chamber (Asset Number K0001) at a distance of 3 metres. The EUT was placed at a height of 1.5 m 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 was set up as followed: a RBW set to 1 MHz, the VBW set to 3, with the sweep time set to auto couple. Peak and average measurements were performed with their own appropriate detectors during the pre-scan measurements.
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. The reference level for the emission in the non-restricted band was established by following ANSI C63.10 Section 11.11.2 procedure.
8. ** -20 dBc limit applies in non-restricted bands as the conducted output power measurements were performed using a peak detector.

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

Transmitter Radiated Emissions (continued)**Results: Peak / Bottom Channel**

| Frequency (MHz) | Antenna Polarity | Level (dB μ V/m) | Limit (dB μ V/m) | Margin (dB) | Result |
|-----------------|------------------|----------------------|----------------------|-------------|----------|
| 4811.240 | Vertical | 51.6 | 54.0* | 2.4 | Complied |
| 7216.426 | Vertical | 56.7 | 74.0 | 17.3 | Complied |
| 9622.005 | Vertical | 52.3 | 73.0** | 20.7 | Complied |

Results: Average / Bottom Channel

| Frequency (MHz) | Antenna Polarity | Level (dB μ V/m) | Limit (dB μ V/m) | Margin (dB) | Result |
|-----------------|------------------|----------------------|----------------------|-------------|----------|
| 7213.542 | Vertical | 48.9 | 54.0 | 5.1 | Complied |

Results: Peak / Middle Channel

| Frequency (MHz) | Antenna Polarity | Level (dB μ V/m) | Limit (dB μ V/m) | Margin (dB) | Result |
|-----------------|------------------|----------------------|----------------------|-------------|----------|
| 4889.080 | Vertical | 55.6 | 74.0 | 18.4 | Complied |
| 7333.840 | Vertical | 56.2 | 74.0 | 17.8 | Complied |
| 9781.984 | Vertical | 43.9 | 73.0** | 29.1 | Complied |

Results: Average / Middle Channel

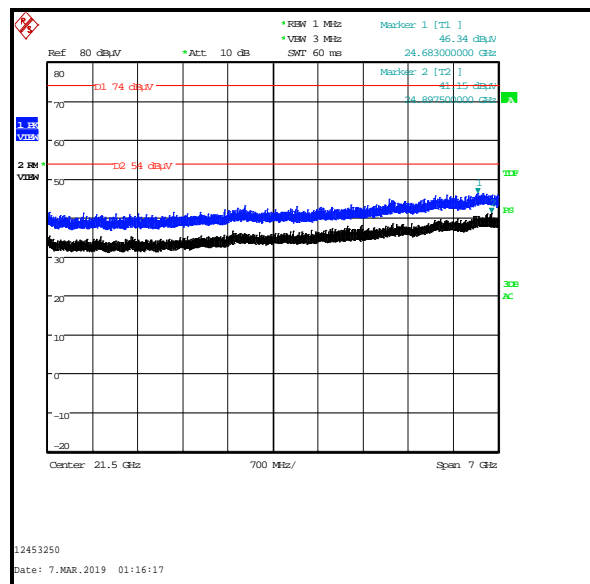
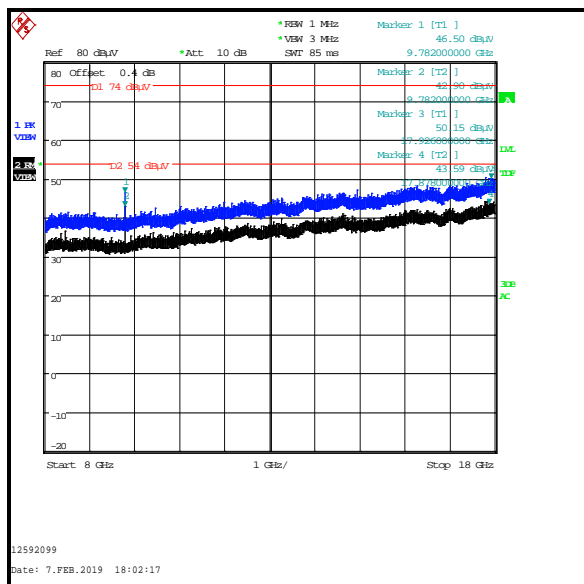
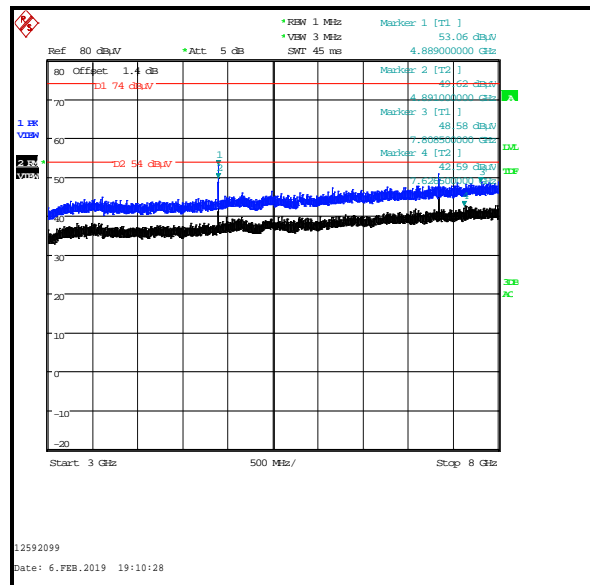
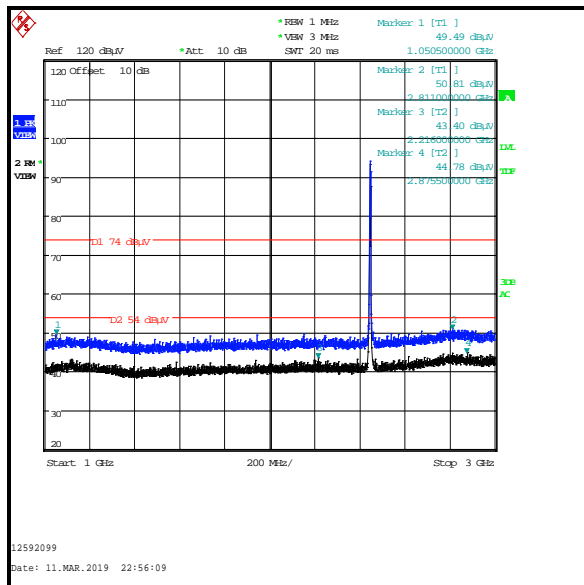
| Frequency (MHz) | Antenna Polarity | Level (dB μ V/m) | Limit (dB μ V/m) | Margin (dB) | Result |
|-----------------|------------------|----------------------|----------------------|-------------|----------|
| 4889.080 | Vertical | 48.8 | 54.0 | 5.2 | Complied |
| 7333.840 | Vertical | 47.8 | 54.0 | 6.2 | Complied |

Results: Peak / Top Channel

| Frequency (MHz) | Antenna Polarity | Level (dB μ V/m) | Limit (dB μ V/m) | Margin (dB) | Result |
|-----------------|------------------|----------------------|----------------------|-------------|----------|
| 4960.994 | Vertical | 59.4 | 74.0 | 14.6 | Complied |
| 7441.442 | Vertical | 46.4 | 54.0* | 7.6 | Complied |
| 9926.504 | Vertical | 44.3 | 73.0** | 28.7 | Complied |

Results: Average / Top Channel

| Frequency (MHz) | Antenna Polarity | Level (dB μ V/m) | Limit (dB μ V/m) | Margin (dB) | Result |
|-----------------|------------------|----------------------|----------------------|-------------|----------|
| 4960.994 | Vertical | 48.6 | 54.0 | 5.4 | Complied |
| 7441.571 | Vertical | 36.0 | 54.0 | 18.0 | 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) |
|-----------|------------------|-----------------|-------------|-------------|----------------------|------------------------|
| M2040 | Thermohygrometer | Testo | 608-H1 | 45124934 | 06 Jan 2020 | 12 |
| K0001 | 5m RSE Chamber | Rainford EMC | N/A | N/A | 04 Oct 2019 | 12 |
| M2044 | Test Receiver | Rohde & Schwarz | ESU26 | 100122 | 17 Apr 2019 | 12 |
| A3155 | Amplifier | Com-Power | PAM-118A | 18040037 | 14 Sep 2019 | 12 |
| A3138 | Antenna | Schwarzbeck | BBHA 9120 B | 00702 | 03 Oct 2019 | 12 |
| A2523 | Attenuator | AtlanTechRF | AN18W5-10 | 832827#1 | 23 Nov 2019 | 12 |
| A3093 | High Pass Filter | AtlanTechRF | AFH-03000 | 18051800077 | 29 Jun 2019 | 12 |
| A3139 | Antenna | Schwarzbeck | HWRD750 | 00027 | 04 Oct 2019 | 12 |
| A3095 | High Pass Filter | AtlanTechRF | AFH-07000 | 18051600012 | 29 Jun 2019 | 12 |
| A3141 | Pre Amplifier | Schwarzbeck | BBV 9718 B | 00021 | 21 Nov 2019 | 12 |
| A2896 | Pre Amplifier | Schwarzbeck | BBV 9721 | 9721 – 023 | 08 Feb 2020 | 12 |
| A2895 | Antenna | Schwarzbeck | BBHA 9170 | 9170-728 | 08 Feb 2020 | 12 |
| M2040 | Thermohygrometer | Testo | 608-H1 | 45124934 | 06 Jan 2020 | 12 |

5.2.5. Transmitter Band Edge Radiated Emissions

Test Summary:

| | | | |
|-----------------------------------|-----------------------------------|--------------------|-------------------------------------|
| Test Engineer: | Mohamed Toubella & Andrew Harding | Test Dates: | 06 February 2019 & 07 February 2019 |
| Test Sample Serial Number: | 000D6F0005-B15549 | | |

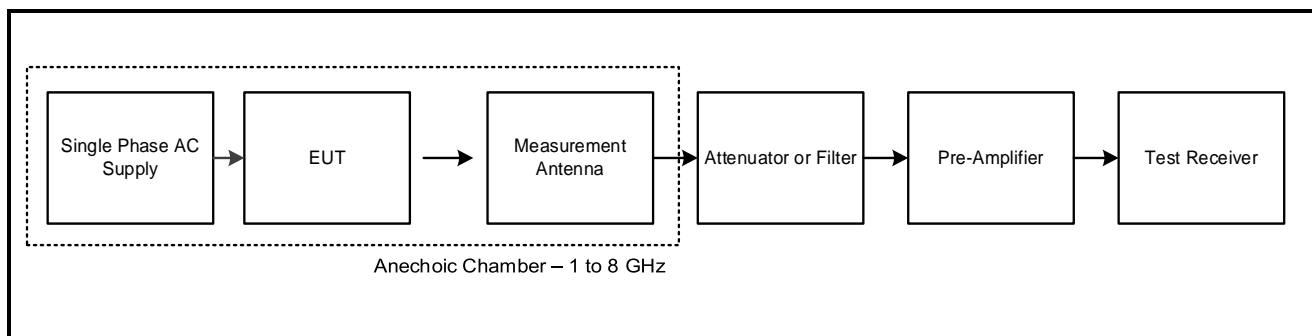
| | |
|--------------------------|---|
| FCC Reference: | Parts 15.247(d) & 15.209(a) |
| Test Method Used: | KDB 558074 Section 8.7 referencing ANSI C63.10 Section 11.11, 11.12 & 11.13 |

Environmental Conditions:

| | |
|-------------------------------|----------|
| Temperature (°C): | 23 to 24 |
| Relative Humidity (%): | 38 to 39 |

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 ANSI C63.10 Section 11.11.1(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 ANSI C63.10 Section 11.11.1, the test method in Section 11.11.3 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 ANSI C63.10 Section 11.9.1.1 an out-of-band limit line was placed 20 dB (ANSI C63.10 Section 11.11.1(a)) below the peak level. A marker was placed on the band edge spot frequencies. Marker frequency 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 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
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.
6. * -20 dBc limit.
7. ** For improved accuracy the upper band edge average measurement was tested using the integration method stated in ANSI C63.10 Section 11.13.3.

Transmitter Band Edge Radiated Emissions (continued)**Test setup for radiated measurements:****Results: Peak**

| Frequency (MHz) | Antenna Polarity | Level (dB μ V/m) | Limit (dB μ V/m) | Margin (dB) | Result |
|-----------------|------------------|----------------------|----------------------|-------------|----------|
| 2400.000 | Vertical | 51.5 | 73.0* | 21.5 | Complied |
| 2483.500 | Vertical | 62.7 | 74.0 | 11.3 | Complied |

Results: Average

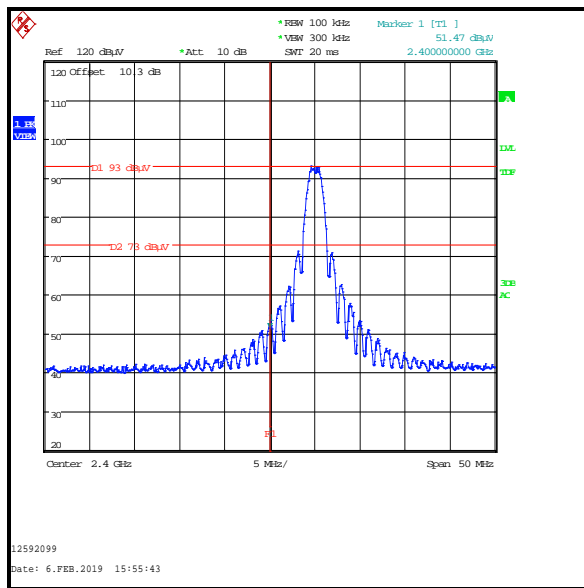
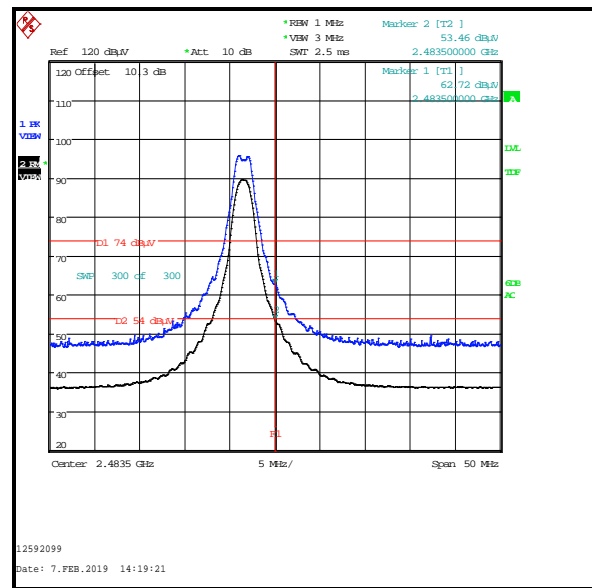
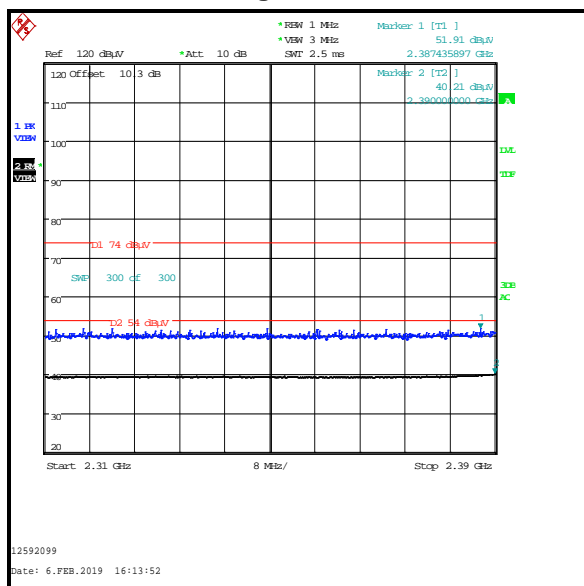
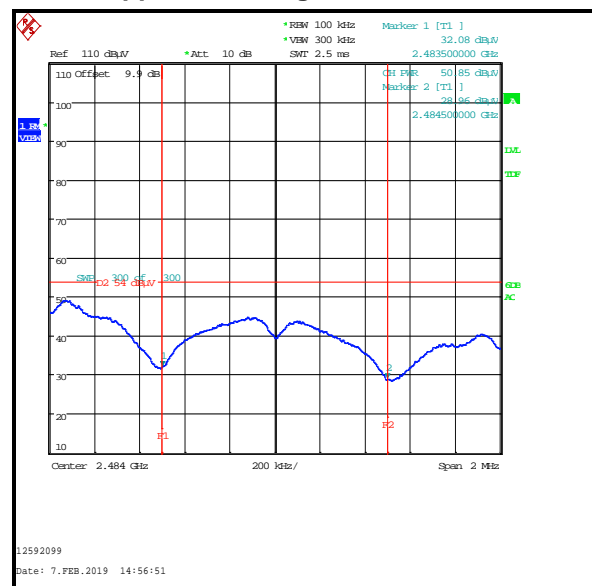
| Frequency (MHz) | Antenna Polarity | Level (dB μ V/m) | Limit (dB μ V/m) | Margin (dB) | Result |
|-----------------|------------------|----------------------|----------------------|-------------|----------|
| 2483.500 | Vertical | 50.9** | 54.0 | 3.1 | Complied |

Results: 2310 MHz to 2390 MHz Restricted Band / Peak

| Frequency (MHz) | Antenna Polarity | Level (dB μ V/m) | Limit (dB μ V/m) | Margin (dB) | Result |
|-----------------|------------------|----------------------|----------------------|-------------|----------|
| 2387.436 | Vertical | 51.9 | 74.0 | 22.1 | Complied |

Results: 2310 MHz to 2390 MHz Restricted Band / Average

| Frequency (MHz) | Antenna Polarity | Level (dB μ V/m) | Limit (dB μ V/m) | Margin (dB) | Result |
|-----------------|------------------|----------------------|----------------------|-------------|----------|
| 2390.00 | Vertical | 40.2 | 54.0 | 13.8 | Complied |

Transmitter Band Edge Radiated Emissions (continued)**Lower Band Edge Peak Measurement****Upper Band Edge Measurement****2310 MHz to 2390 MHz Restricted Band Plot****Upper Band Edge Average Measurement – Integration Method****Test Equipment Used:**

| Asset No. | Instrument | Manufacturer | Type No. | Serial No. | Date Calibration Due | Cal. Interval (Months) |
|-----------|------------------|-----------------|-------------|------------|----------------------|------------------------|
| M2040 | Thermohygrometer | Testo | 608-H1 | 45124934 | 06 Jan 2020 | 12 |
| K0001 | 5m RSE Chamber | Rainford EMC | N/A | N/A | 04 Oct 2019 | 12 |
| M2044 | Test Receiver | Rohde & Schwarz | ESU26 | 100122 | 17 Apr 2019 | 12 |
| A3155 | Pre-Amplifier | Com-Power | PAM-118A | 18040037 | 14 Sep 2019 | 12 |
| A3138 | Antenna | Schwarzbeck | BBHA 9120 B | 00702 | 03 Oct 2019 | 12 |
| A2523 | Attenuator | AtlanTechRF | AN18W5-10 | 832827#1 | 23 Nov 2019 | 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% | ±1.96 dB |
| 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 | 9 kHz to 30 MHz | 95% | ±4.39 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 | - | 5.2.4 | 9 kHz to 30 MHz measurements added. |
| | - | - | Editorial updates. |

--- END OF REPORT ---