



TEST REPORT

Test Report No. : UL-RPT-RP11088562JD03A

Manufacturer : STid
Model No. : ARC-AC3
FCC ID : OVNAC3
Technology : RFID – 13.56 MHz
Test Standard(s) : FCC Parts 15.207, 15.209(a) & 15.225

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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: 29 April 2016

Checked by:

Ian Watch
Senior Engineer, Radio Laboratory

Company Signatory:

Steven White
Service Lead, Radio Laboratory,
UL VS LTD



This laboratory is accredited by UKAS.
The tests reported herein have been
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of accreditation.

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1. Customer Information








| | |
|----------------------|--|
| Company Name: | STid |
| Address: | 20 Parc d'Activités des Pradeaux 13850 Gréasque France |

2. Summary of Testing

2.1. General Information

| | |
|---------------------------------|---|
| Specification Reference: | 47CFR15.225 |
| Specification Title: | Code of Federal Regulations Volume 47 (Telecommunications): Part 15 Subpart C (Radio Frequency Devices) - Section 15.225 |
| 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: | 209735 |
| Location of Testing: | UL VS LTD, Unit 3 Horizon, Wade Road, Kingsland Business Park, Basingstoke, Hampshire, RG24 8AH, United Kingdom |
| Test Dates: | 08 March 2016 to 31 March 2016 |

2.2. Summary of Test Results

| FCC Reference (47CFR) | Measurement | Result |
|---|---|---|
| Part 15.207 | Transmitter AC Conducted Emissions |  |
| Part 15.225(a)(b)(c)(d) | Transmitter Fundamental Field Strength |  |
| Part 15.209(a)/15.225(d) | Transmitter Radiated Emissions |  |
| Part 15.209(a)/15.225(c)(d) | Transmitter Band Edge Radiated Emissions |  |
| Part 15.225(e) | Transmitter Frequency Stability (Temperature & Voltage Variation) |  |
| Key to Results | | |
|  = Complied  = Did not comply | | |

2.3. Methods and Procedures

| | |
|-------------------|---|
| Reference: | ANSI C63.10-2013 |
| Title: | American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices |
| Reference: | FCC KDB Publication Number 174176 Date: June 3, 2015 |
| Title: | AC Power-Line Conducted Emissions Frequently Asked Questions. |
| Reference: | FCC KDB Publication Number 937606 Date: 10/10/2014 |
| Title: | Test Site Requirements for Part 15 and 18 Devices Operating Below 30 MHz |

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: | ARC1 |
| Model Name or Number: | ARC-AC3 |
| Test Sample Serial Number: | G14180432 (<i>Standard unit</i>) |
| Hardware Version: | 03 |
| Software Version: | 02 |
| FCC ID: | OVNAC3 |

| | |
|-----------------------------------|--|
| Brand Name: | ARC1 |
| Model Name or Number: | ARC-AC3 |
| Test Sample Serial Number: | G14180434 (<i>Modified antenna unit</i>) |
| Hardware Version: | 03 |
| Software Version: | 02 |
| FCC ID: | OVNAC3 |

3.2. Description of EUT

The Equipment Under Test was an RFID tag reader operating at 13.56 MHz.

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: | RFID | |
| Category of Equipment: | Transceiver | |
| Channel Spacing: | Single channel device | |
| Transmit Frequency: | 13.559833 MHz | |
| Power Supply Requirement: | Nominal | 12 VDC |
| | Minimum | 10.2 VDC |
| | Maximum | 13.8 VDC |
| Tested Temperature Range: | Minimum | -20°C |
| | Maximum | 50°C |

3.5. Support Equipment

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

| | |
|------------------------------|----------------------|
| Description: | 12 Volt Battery |
| Brand Name: | OPTIMA Batteries |
| Model Name or Number: | 8012-254 |
| Serial Number: | Not marked or stated |

| | |
|------------------------------|--|
| Description: | 100-240 VAC to 12 VDC Switch Mode Power Supply |
| Brand Name: | RS Pro |
| Model Name or Number: | SAW48-12.0-4000 |
| 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):

- Constantly transmitting at full power with a modulated carrier in RFID test mode.

4.2. Configuration and Peripherals

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

- The RFID transmitter test mode was enabled when the EUT was powered.
- AC conducted emissions tests were performed with the EUT connected to an RS Pro SAW48-12.0-4000 power supply. The power supply was connected to a 120 VAC 60 Hz / 240 VDC 60 Hz single phase supply via a LISN.
- Testing at voltage extremes was performed with the EUT connected to a variable voltage, bench power supply.
- Radiated tests on an open field test site were performed with the EUT powered from a fully charged 12 Volt battery.
- For all other tests, EUT was powered from an off-the-shelf unmodified DC power supply.

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 Uncertainties* 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: | Georgios Vrezas | Test Date: | 31 March 2016 |
| Test Sample Serial Numbers: | G14180432 & G14180434 | | |

| | |
|--------------------------|-------------------------|
| FCC Reference: | Part 15.207 |
| Test Method Used: | ANSI C63.10 Section 6.2 |

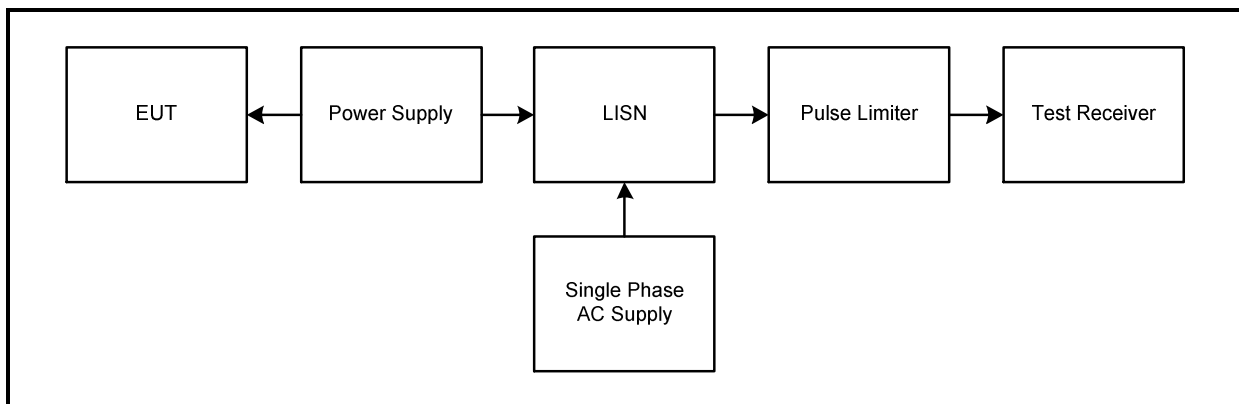
Environmental Conditions:

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

Note(s):

1. The EUT was connected to a power supply. The power supply was connected to 120 VAC 60 Hz single phase supply via a LISN.
2. In accordance with KDB 174176 Q4, tests were also performed with the power supply connected to a 240 VAC 60 Hz single phase supply via a LISN.
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.
5. * Test results prior to modification of the EUT (standard antenna).
6. ** Test results with modified sample Serial No. G14180434 (transmitter terminated into 50 Ohm load in accordance with KDB 174176 Q5)

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 |
|-----------------|------|--------------------|--------------------|-------------|----------|
| 0.182 | Live | 45.6* | 64.4 | 18.8 | Complied |
| 0.240 | Live | 37.8* | 62.1 | 24.3 | Complied |
| 0.303 | Live | 35.0* | 60.2 | 25.2 | Complied |
| 0.425 | Live | 32.3* | 57.4 | 25.1 | Complied |
| 13.560 | Live | 15.8** | 60.0 | 44.2 | Complied |
| 27.119 | Live | 38.3* | 60.0 | 21.7 | Complied |

Results: Live / Average / 120 VAC 60 Hz

| Frequency (MHz) | Line | Level (dB μ V) | Limit (dB μ V) | Margin (dB) | Result |
|-----------------|------|--------------------|--------------------|-------------|----------|
| 0.182 | Live | 29.6* | 54.4 | 24.8 | Complied |
| 0.240 | Live | 28.6* | 52.1 | 23.5 | Complied |
| 0.303 | Live | 23.4* | 50.2 | 26.8 | Complied |
| 0.425 | Live | 23.9* | 47.4 | 23.5 | Complied |
| 13.560 | Live | 11.4** | 50.0 | 38.6 | Complied |
| 27.119 | Live | 30.8* | 50.0 | 19.2 | Complied |

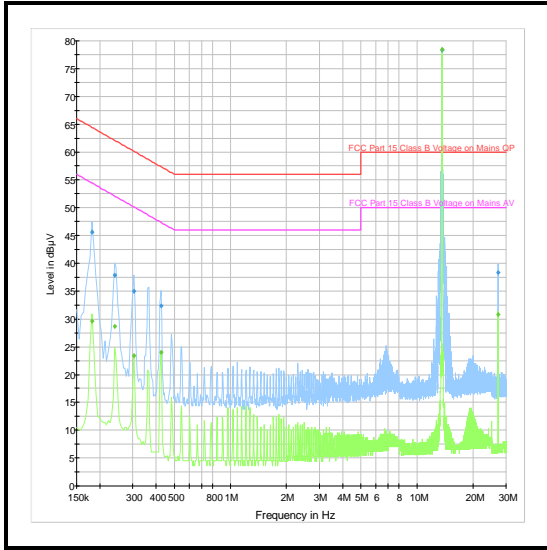
Results: Neutral / Quasi Peak / 120 VAC 60 Hz

| Frequency (MHz) | Line | Level (dB μ V) | Limit (dB μ V) | Margin (dB) | Result |
|-----------------|---------|--------------------|--------------------|-------------|----------|
| 0.182 | Neutral | 46.0* | 64.4 | 18.4 | Complied |
| 0.240 | Neutral | 38.3* | 62.1 | 23.8 | Complied |
| 0.303 | Neutral | 35.6* | 60.2 | 24.6 | Complied |
| 0.425 | Neutral | 32.7* | 57.4 | 24.7 | Complied |
| 13.560 | Neutral | 18.4** | 60.0 | 41.6 | Complied |
| 27.119 | Neutral | 41.0* | 60.0 | 19.0 | Complied |

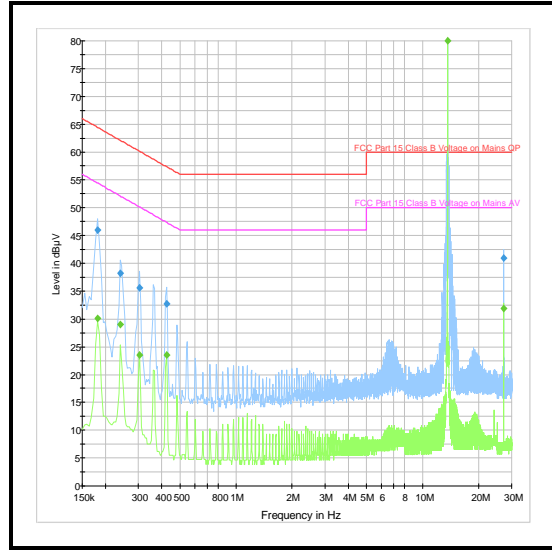
Results: Neutral / Average / 120 VAC 60 Hz

| Frequency (MHz) | Line | Level (dB μ V) | Limit (dB μ V) | Margin (dB) | Result |
|-----------------|---------|--------------------|--------------------|-------------|----------|
| 0.182 | Neutral | 30.1* | 54.4 | 24.3 | Complied |
| 0.240 | Neutral | 29.1* | 52.1 | 23.0 | Complied |
| 0.303 | Neutral | 23.6* | 50.2 | 26.6 | Complied |
| 0.425 | Neutral | 23.5* | 47.4 | 23.9 | Complied |
| 13.560 | Neutral | 14.8** | 50.0 | 35.2 | Complied |
| 27.119 | Neutral | 31.9* | 50.0 | 18.1 | Complied |

Transmitter AC Conducted Spurious Emissions (continued)

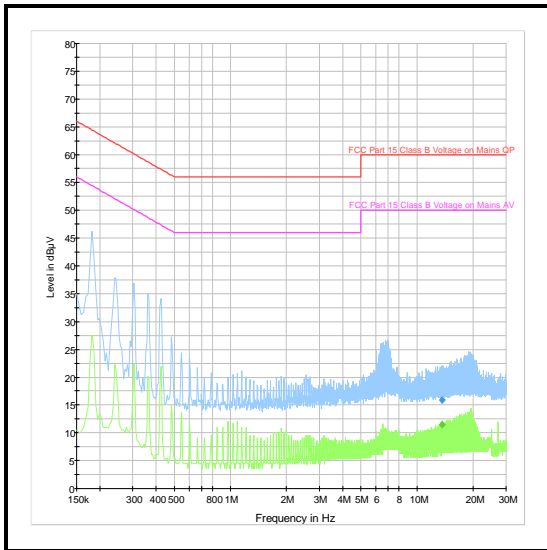


Live / 120 VAC 60 Hz

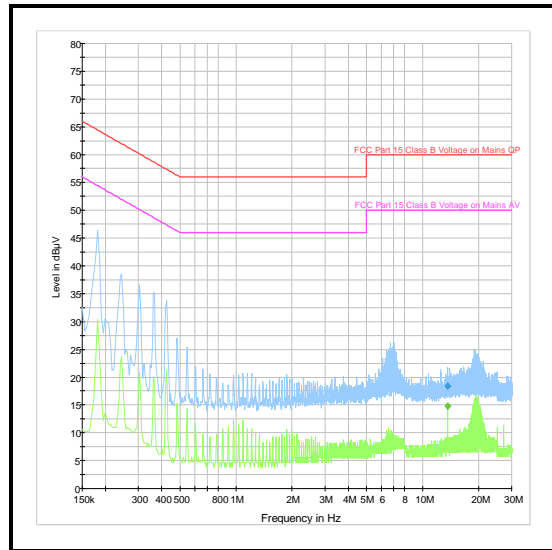


Neutral / 120 VAC 60 Hz

Test results prior to modification of the EUT (standard antenna)



Live / 120 VAC 60 Hz



Neutral / 120 VAC 60 Hz

Test results with modified sample (transmitter terminated into 50 Ohm load)

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 |
|-----------------|------|--------------------|--------------------|-------------|----------|
| 0.182 | Live | 40.4* | 64.4 | 24.0 | Complied |
| 0.375 | Live | 46.1* | 58.4 | 12.3 | Complied |
| 0.497 | Live | 33.3* | 56.1 | 22.8 | Complied |
| 0.663 | Live | 32.3* | 56.0 | 23.7 | Complied |
| 13.560 | Live | 17.2** | 60.0 | 42.8 | Complied |
| 27.119 | Live | 38.7* | 60.0 | 21.3 | Complied |

Results: Live / Average / 240 VAC 60 Hz

| Frequency (MHz) | Line | Level (dB μ V) | Limit (dB μ V) | Margin (dB) | Result |
|-----------------|------|--------------------|--------------------|-------------|----------|
| 0.150 | Live | 32.6* | 56.0 | 23.4 | Complied |
| 0.371 | Live | 45.6* | 48.5 | 2.9 | Complied |
| 0.380 | Live | 30.7* | 48.3 | 17.6 | Complied |
| 0.605 | Live | 27.2* | 46.0 | 18.8 | Complied |
| 13.560 | Live | 14.2** | 50.0 | 35.8 | Complied |
| 27.119 | Live | 31.2* | 50.0 | 18.8 | Complied |

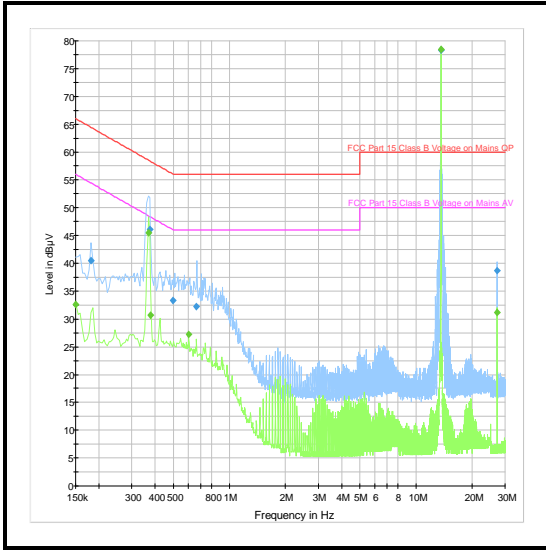
Results: Neutral / Quasi Peak / 240 VAC 60 Hz

| Frequency (MHz) | Line | Level (dB μ V) | Limit (dB μ V) | Margin (dB) | Result |
|-----------------|---------|--------------------|--------------------|-------------|----------|
| 0.182 | Neutral | 40.5* | 64.4 | 23.9 | Complied |
| 0.371 | Neutral | 44.6* | 58.5 | 13.9 | Complied |
| 0.506 | Neutral | 33.6* | 56.0 | 22.4 | Complied |
| 0.717 | Neutral | 33.1* | 56.0 | 22.9 | Complied |
| 13.560 | Neutral | 14.8** | 60.0 | 45.2 | Complied |
| 27.119 | Neutral | 40.3* | 60.0 | 19.7 | Complied |

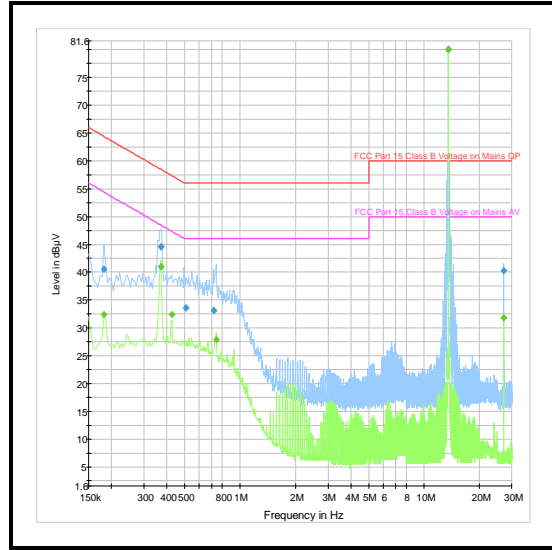
Results: Neutral / Average / 240 VAC 60 Hz

| Frequency (MHz) | Line | Level (dB μ V) | Limit (dB μ V) | Margin (dB) | Result |
|-----------------|---------|--------------------|--------------------|-------------|----------|
| 0.182 | Neutral | 32.4* | 54.4 | 22.0 | Complied |
| 0.371 | Neutral | 41.0* | 48.5 | 7.5 | Complied |
| 0.425 | Neutral | 32.4* | 47.4 | 15.0 | Complied |
| 0.740 | Neutral | 27.9* | 46.0 | 18.1 | Complied |
| 13.560 | Neutral | 15.1** | 50.0 | 34.9 | Complied |
| 27.119 | Neutral | 31.9* | 50.0 | 18.1 | Complied |

Transmitter AC Conducted Spurious Emissions (continued)

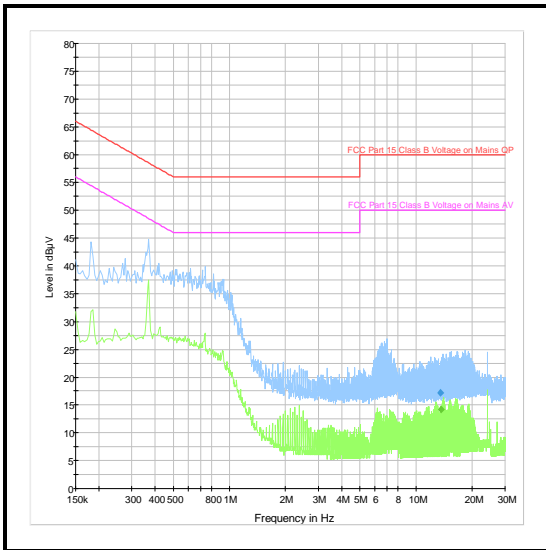


Live / 240 VAC 60 Hz

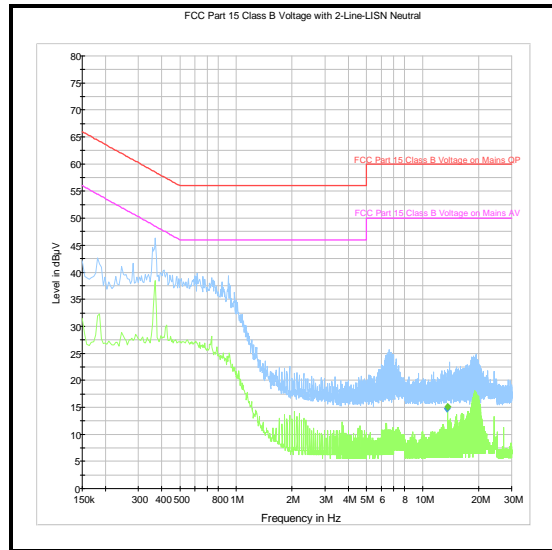


Neutral / 240 VAC 60 Hz

Test results prior to modification of the EUT (standard antenna)



Live / 240 VAC 60 Hz



Neutral / 240 VAC 60 Hz

Test results with modified sample (transmitter terminated into 50 Ohm load)

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

Transmitter AC Conducted Spurious Emissions (continued)**Test Equipment Used:**

| Asset No. | Instrument | Manufacturer | Type No. | Serial No. | Date Calibration Due | Cal. Interval (Months) |
|------------------|--------------------------|---------------------|-----------------|-------------------|-----------------------------|-------------------------------|
| M1625 | Thermohygrometer | JM Handelspunkt | 890603/002 | None stated | 11 Jan 2017 | 12 |
| A067 | LISN | Rohde & Schwarz | ESH3-Z5 | 890603/002 | 27 Aug 2016 | 12 |
| A1830 | Pulse Limiter | Rohde & Schwarz | ESH3-Z2 | 100668 | 08 Mar 2017 | 12 |
| M1263 | Test Receiver | Rohde & Schwarz | ESIB7 | 100265 | 16 Oct 2016 | 12 |
| S0539 | Variable AC Power Supply | Kikusui | PCR 1000L | 13010170 | Calibrated before use | - |
| M1229 | Multimeter | Fluke | 179 | 87640015 | 23 Apr 2016 | 12 |

5.2.2. Transmitter Fundamental Field Strength**Test Summary:**

| | | | |
|-----------------------------------|-----------------|--------------------|----------------------------------|
| Test Engineer: | Georgios Vrezas | Test Dates: | 14 March 2016 & 15 March 2016 |
| Test Sample Serial Number: | G14180432 | | |

| | |
|--------------------------|---|
| FCC Reference: | Part 15.225(a)(b)(c)(d) |
| Test Method Used: | ANSI C63.10 Section 6.4 and Notes below |

Environmental Conditions:

| | |
|-------------------------------|----------|
| Temperature (°C): | 12 to 21 |
| Relative Humidity (%): | 31 to 51 |

Note(s):

1. The limit is specified at a test distance of 30 metres. However, as specified by FCC Section 15.31 (f)(2), measurements may be performed at a closer distance and the measured level corrected to the specified measurement distance by using the square of an inverse linear distance extrapolation factor (40dB/decade).
2. In accordance with FCC KDB 937606, a *bona fide* attempt was made to perform measurements at the distances specified in Part 15.209(a). It was not possible to determine the emission value at the test distances specified below 30 MHz on an open field test site, therefore in accordance with 47 CFR 15.31(f), measurements were made at closer distances. Attempts were made to measure the fundamental at 30 metres on an open field test site on 14 March 2016. Unfortunately, the fundamental could not be seen above the ambient emissions or the noise floor of the measurement system at a distance of 30 metres, therefore the measurement was repeated at a reduced measurement distance of 3 metres using a measurement bandwidth of 10 kHz. Ambient emissions affected the fundamental field strength measurement, therefore the fundamental field strength measurement was repeated using a reduced bandwidth (resolution bandwidth 1 kHz and video bandwidth 3 kHz). The fundamental was visible with these measurement settings.
3. The fundamental field strength level was maximized by rotating the measurement antenna and EUT. A peak level of 67.7 dB μ V/m in a 1 kHz measurement bandwidth, at a measurement distance of 3 metres was recorded and shown on the pre-scan plots below. The measurement was repeated in a semi-anechoic chamber at 3 metres on 15 March 2016. An RF level offset on the test receiver was used to correlate the field strength measurement made in the semi-anechoic chamber to the same measurement performed at 3 metres on the open field test site. Refer to result plot '*Fundamental field strength and spectrum mask / measured at 3 metres in a semi-anechoic chamber with reduced measurement bandwidth of 1 kHz*'. This illustrates that the value of the RF level offset is -4 dB, since the fundamental field strength is 67.7 dB μ V/m at a measurement distance of 3 metres.
4. Further measurements were performed in the semi-anechoic chamber using a spectrum analyser with a peak detector and measurement bandwidth of 10 kHz. An RF level offset of -44 dB was used on the spectrum analyser. This offset includes the -4 dB offset as explained in Note 3 above and a further -40 dB to extrapolate the level measured at 3 metres to the required distance of 30 metres (one decade). The fundamental field strength was maximized by rotating the measurement antenna and EUT. A peak level of 27.6 dB μ V/m at a measurement distance of 3 metres (extrapolated to 30 metres) was recorded and shown on the pre-scan plot below. The spectrum analyser was then switched to test receiver mode and the final measurement on the maximized level was performed. In accordance with ANSI C63.10 Clause 4.1.4.2.1 and CISPR 16-1-1, a quasi-peak detector was used in conjunction with a measurement bandwidth of 9 kHz and 0.2 second sweep time. A quasi-peak level of 27.5 dB μ V/m was recorded.

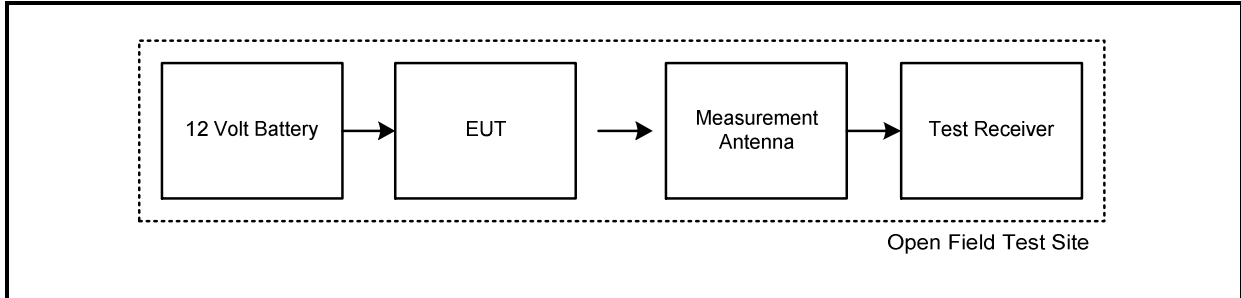
Transmitter Fundamental Field Strength (continued)**Note(s):**

5. A transducer factor was used on the spectrum analyser during open field tests. This factor includes correction between the fixed gain of the magnetic loop antenna and the calibration values. It also includes the insertion loss of the RF cable used to connect the antenna to the spectrum analyser which was incorporated into the annual calibration of the magnetic loop antenna.

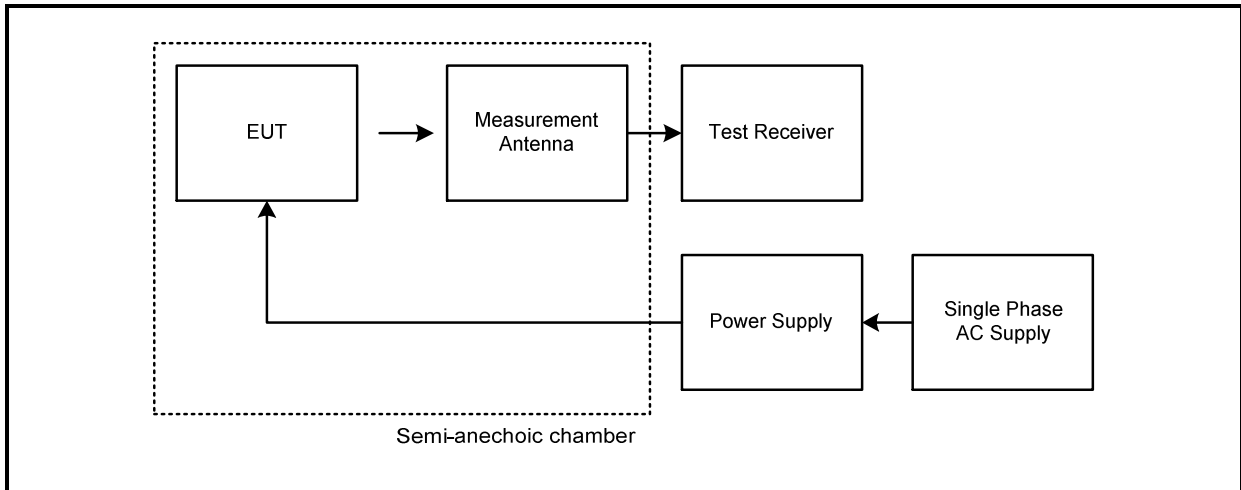
Transmitter Fundamental Field Strength (continued)

Test setup for fundamental field strength measurements:

Measurements on an open field test site



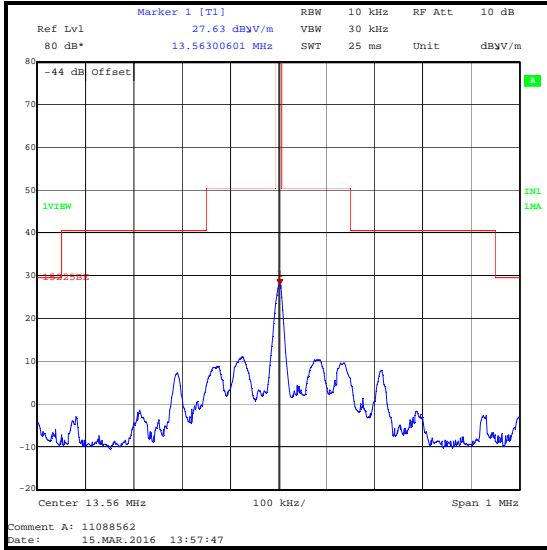
Measurements in a semi-anechoic chamber



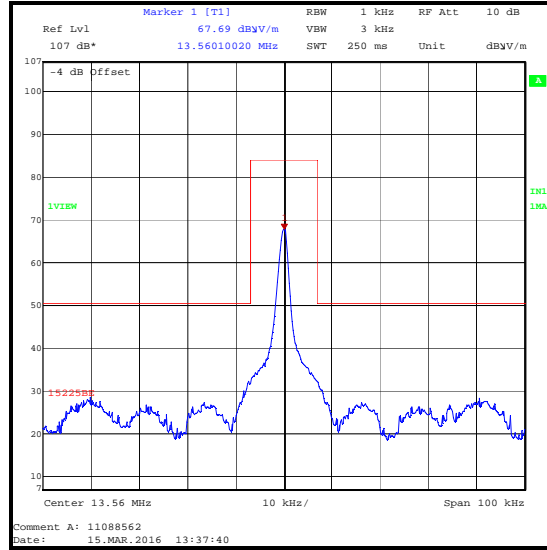
Transmitter Fundamental Field Strength (continued)

Results: Quasi Peak

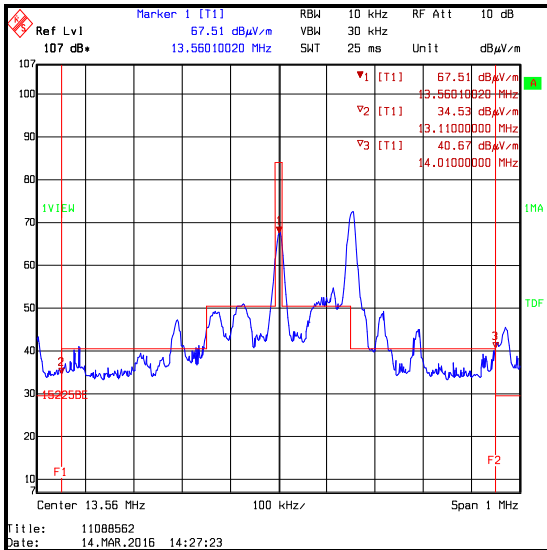
| Frequency (MHz) | Measurement Antenna Position | Level (dB μ V/m) | Limit at 30 m (dB μ V/m) | Margin (dB) | Result |
|-----------------|------------------------------|----------------------|------------------------------|-------------|----------|
| 13.560100 | Tip of antenna 30° from EUT | 27.5 | 84.0 | 56.5 | Complied |



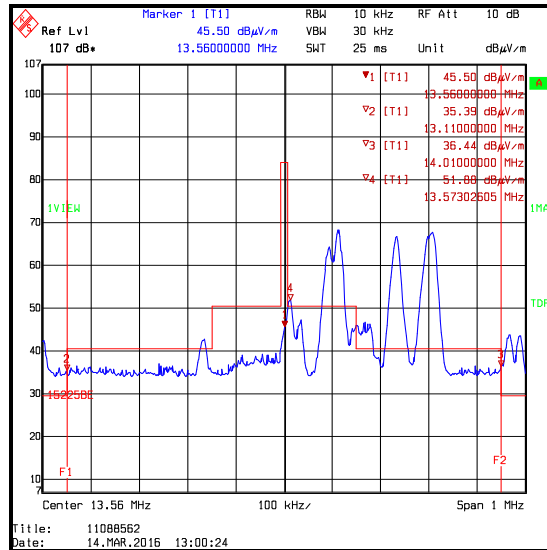
Fundamental field strength and spectrum mask / measured at 3 metres in a semi-anechoic chamber / extrapolated to 30 metres



Fundamental field strength and spectrum mask / measured at 3 metres in a semi-anechoic chamber with reduced measurement bandwidth of 1 kHz



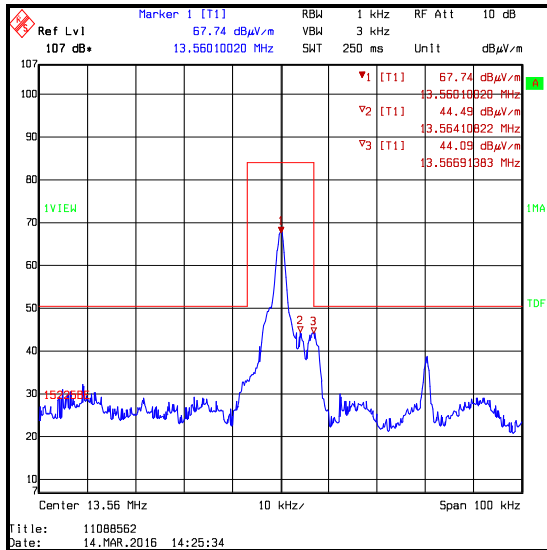
Fundamental field strength / EUT operating / measured at 3 metres / measured on an open field test site with 10 kHz measurement bandwidth (fundamental is affected by an ambient emission)



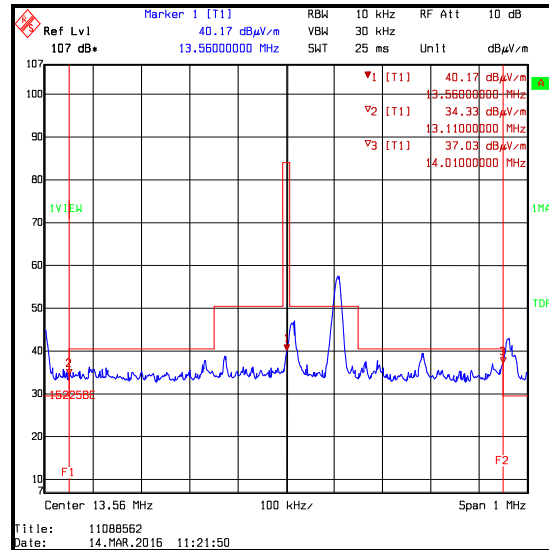
Fundamental field strength / EUT operating / measured at 30 metres / measured on an open field test site with 10 kHz measurement bandwidth (fundamental is below the noise floor / masked by an ambient emission)

Transmitter Fundamental Field Strength (continued)

Results:



Fundamental field strength / EUT operating / measured at 3 metres / measured on an open field test site with reduced measurement bandwidth of 1 kHz



EUT off / Background scan of the open field test site with a 10 kHz measurement bandwidth showing an unwanted ambient emission at approximately 13.56 MHz (Marker 1)

Test Equipment Used:

| Asset No. | Instrument | Manufacturer | Type No. | Serial No. | Date Calibration Due | Cal. Interval (Months) |
|-----------|-----------------------|-----------------|------------|-------------|----------------------|------------------------|
| M1945 | Thermohygrometer | JM Handelspunkt | 30.5015.01 | 0112 | 23 Apr 2016 | 12 |
| K0001 | 5m RSE Chamber | Rainford EMC | N/A | N/A | 12 Jan 2017 | 12 |
| M1273 | Test Receiver | Rohde & Schwarz | ESIB 26 | 100275 | 19 Mar 2016 | 12 |
| M127 | Test Receiver | Rohde & Schwarz | FSEB30 | 842659/016 | 11 Aug 2016 | 12 |
| M1785 | Thermohygrometer | JM Handelspunkt | 30.5015.13 | None stated | 23 Apr 2016 | 12 |
| M1568 | Magnetic Loop Antenna | Rohde & Schwarz | HFH2-Z2 | 879284/2 | 06 May 2016 | 12 |

5.2.3. Transmitter Radiated Spurious Emissions**Test Summary:**

| | | | |
|-----------------------------------|-----------------|--------------------|-----------------------------------|
| Test Engineer: | Georgios Vrezas | Test Dates: | 08 March 2016 to 15 March 2016 |
| Test Sample Serial Number: | G14180432 | | |

| | |
|--------------------------|--|
| FCC Reference: | Parts 15.225(d) & 15.209(a) |
| Test Method Used: | ANSI C63.10 Sections 6.3, 6.4, 6.5 and Notes below |
| Frequency Range: | 9 kHz to 1000 MHz |

Environmental Conditions:

| | |
|-------------------------------|----------|
| Temperature (°C): | 12 to 21 |
| Relative Humidity (%): | 31 to 51 |

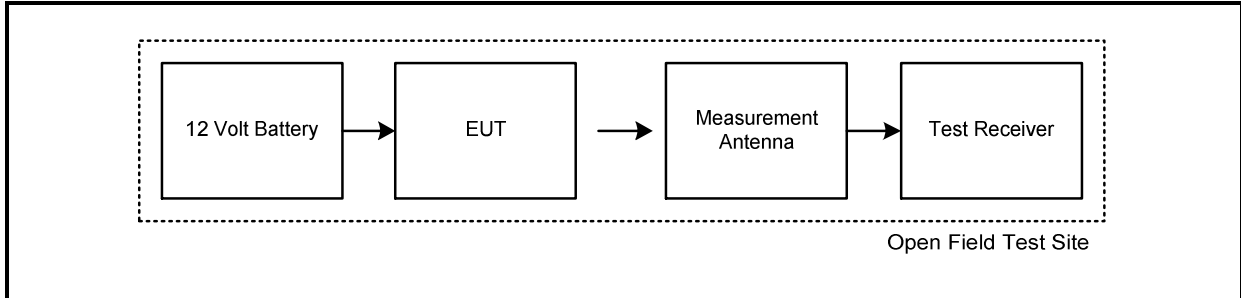
Note(s):

1. In accordance with FCC KDB 937606, a *bona fide* attempt was made to perform measurements at the distances specified in Part 15.209(a) on an open field test site. It was not possible to determine the spurious emission values at the test distances specified below 30 MHz on an open field test site, therefore in accordance with 47 CFR 15.31(f), measurements were made at closer distances. Attempts were made to measure spurious emissions at 3, 30 and 300 metres on an open field test site on 14 March 2016. Unfortunately, spurious emissions from the EUT could not be seen above the ambient emissions present at the open field test site or the noise floor of the measurement system. Final measurement results from the semi-anechoic chamber tests on 15 March 2016 are shown in this section. In addition, the open field test result plots for measurements between 9 kHz and 30 MHz are also shown. These measurement plots are identical to background scan plots of the open field test site. Background scans of the open field test site and further information are shown in Appendix 1 of this test report.
2. The final measured value, for the given emission, in the table below incorporates the calibrated antenna factor and cable loss. Only spurious emissions in the range 30 MHz to 1 GHz were recorded. Markers were placed on the peaks of the pre-scan plot and final measurements were performed using a quasi-peak detector.
3. All other emissions were greater than 20 dB below the applicable limit, below the noise floor of the measurement system or ambient.
4. Measurements on 08 March 2016 were performed in a semi-anechoic chamber (UL VS LTD 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. Between 30 MHz and 1 GHz, maximum emission levels were determined by height searching the measurement antenna over the range 1 metre to 4 metres.
5. Measurement plots in this section for tests between 9 kHz and 30 MHz on an open field test site have markers placed on the highest level ambient emissions. This is for information only.
6. All emissions on the 9 kHz to 150 kHz plot were investigated and found to be radiating from the test site turntable.
7. A transducer factor was used on the spectrum analyser during open field tests. This factor includes correction between the fixed gain of the magnetic loop antenna and the calibration values. It also includes the insertion loss of the RF cable used to connect the antenna to the spectrum analyser which was incorporated into the annual calibration of the magnetic loop antenna.

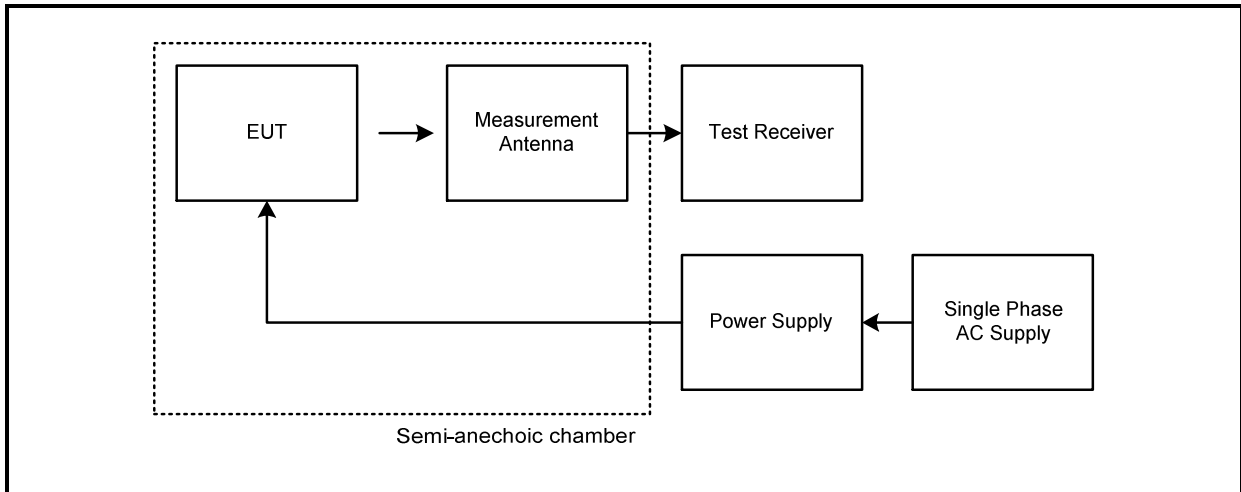
Transmitter Radiated Spurious Emissions (continued)

Test setup for radiated measurements:

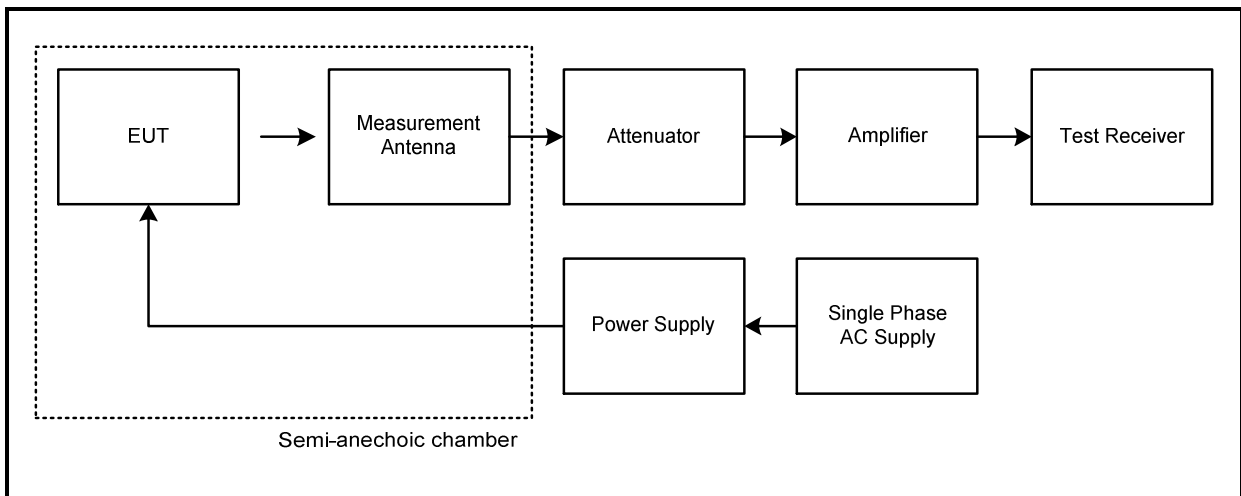
Measurements below 30 MHz on an open field test site



Measurements below 30 MHz in a semi-anechoic chamber



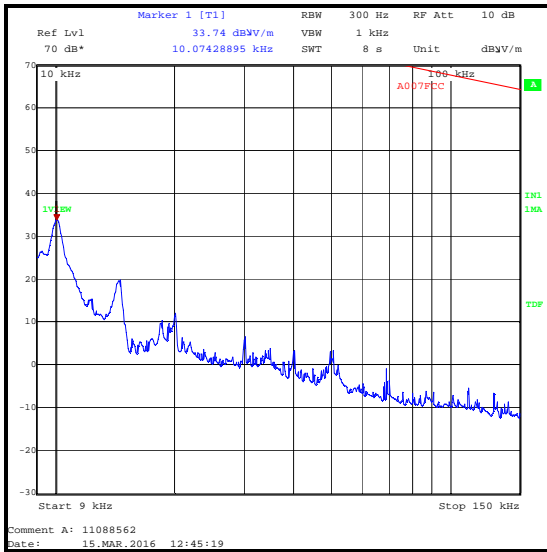
Measurements above 30 MHz in a semi-anechoic chamber.



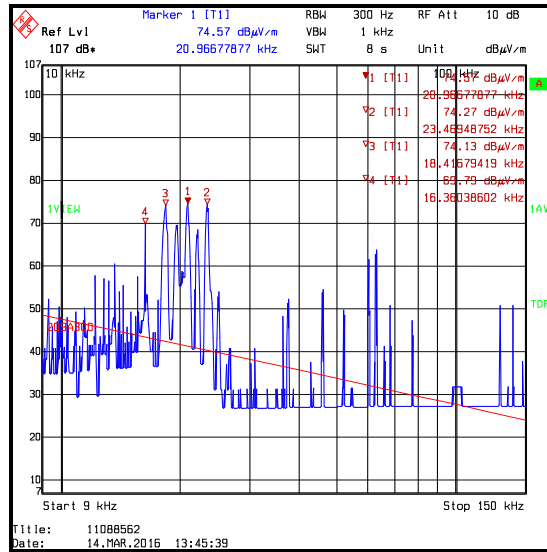
Transmitter Radiated Spurious Emissions (continued)

Results: Quasi Peak

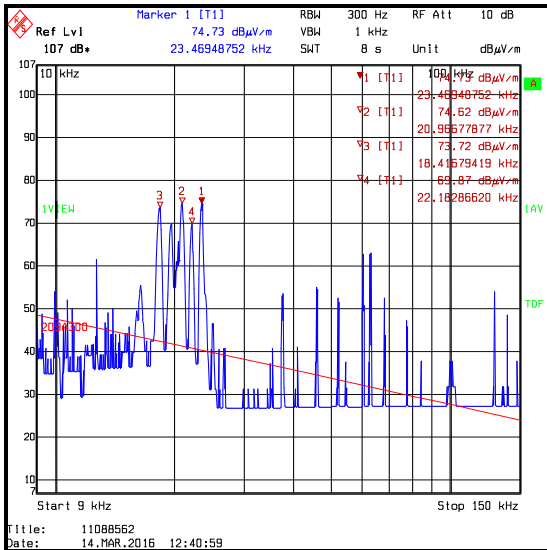
| Frequency (MHz) | Antenna Polarity | Level (dB μ V/m) | Limit (dB μ V/m) | Margin (dB) | Result |
|-----------------|------------------|----------------------|----------------------|-------------|----------|
| 108.460 | Vertical | 36.1 | 43.5 | 7.4 | Complied |
| 162.698 | Vertical | 34.3 | 43.5 | 9.2 | Complied |
| 244.057 | Vertical | 39.2 | 46.0 | 6.8 | Complied |
| 257.628 | Vertical | 35.6 | 46.0 | 10.4 | Complied |



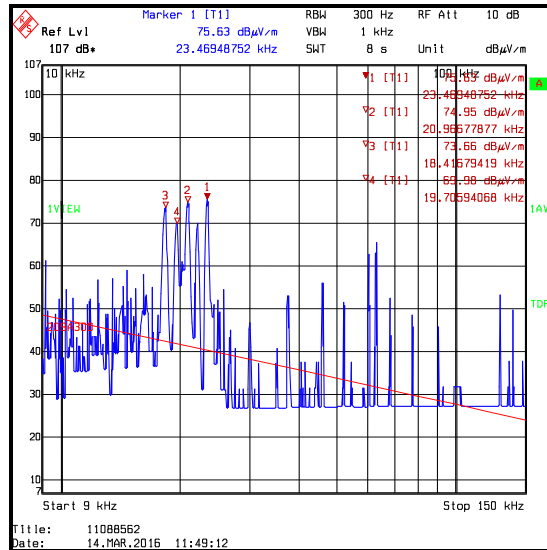
9 kHz to 150 kHz / peak detector / measured at 3 metres extrapolated to 30 metres / measured in a semi-anechoic chamber



9 kHz to 150 kHz / average detector / EUT operating / measured at 3 metres on an open field test site



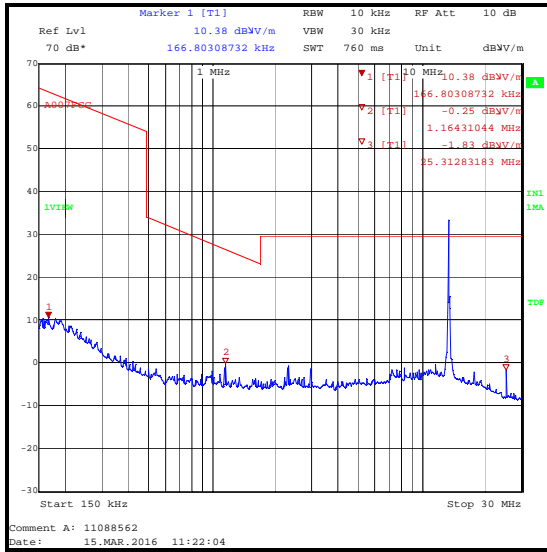
9 kHz to 150 kHz / average detector / EUT operating / measured at 30 metres on an open field test site



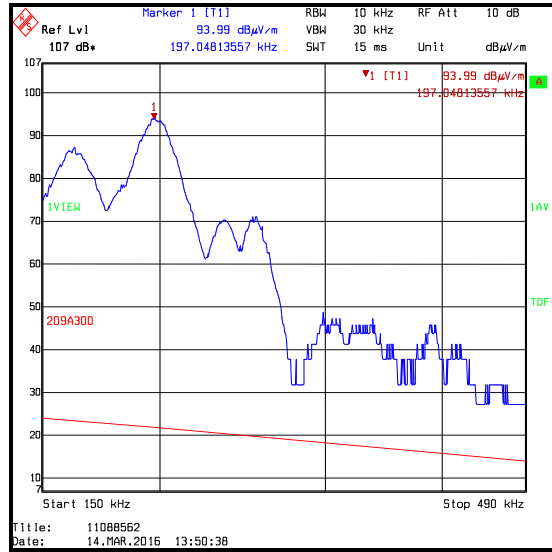
9 kHz to 150 kHz / average detector / EUT operating / measured at 300 metres on an open field test site

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

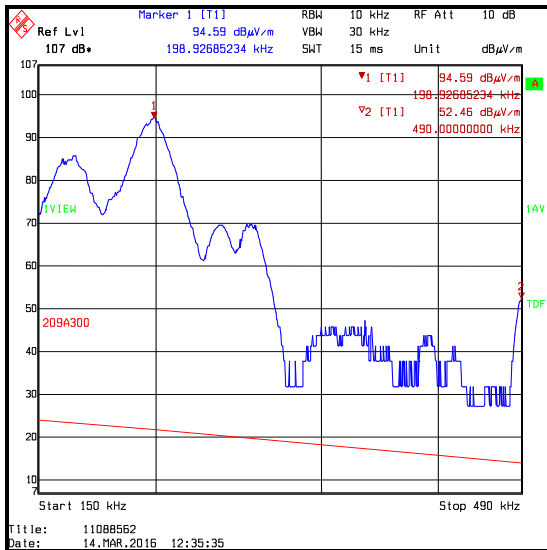
Transmitter Radiated Spurious Emissions (continued)



150 kHz to 30 MHz / peak detector (worst case) / EUT operating / measured at 3 metres extrapolated to 30 metres / measured in a semi-anechoic chamber



150 kHz to 490 kHz / average detector / EUT operating / measured at 3 metres on an open field test site



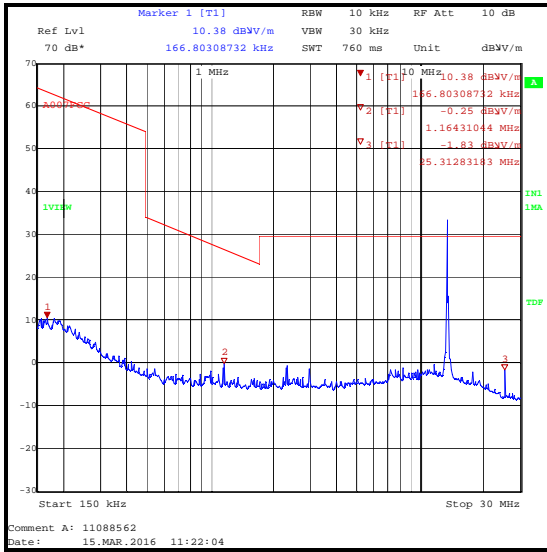
150 kHz to 490 kHz / average detector / EUT operating / measured at 30 metres on an open field test site



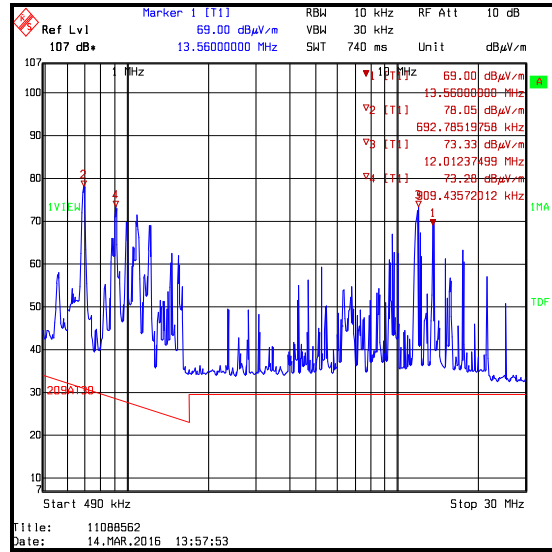
150 kHz to 490 kHz / average detector / EUT operating / measured at 300 metres on an open field test site

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

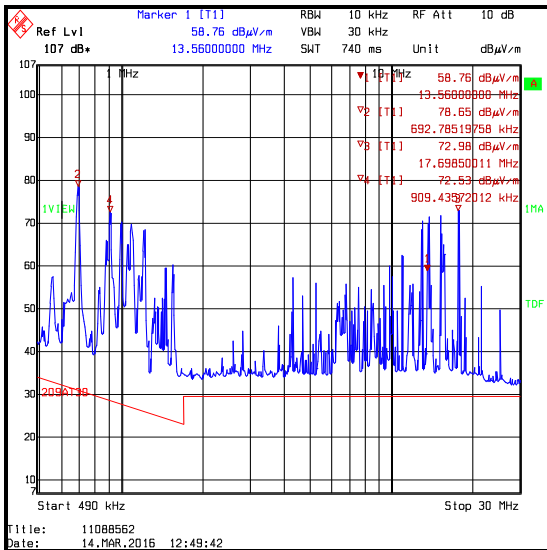
Transmitter Radiated Spurious Emissions (continued)



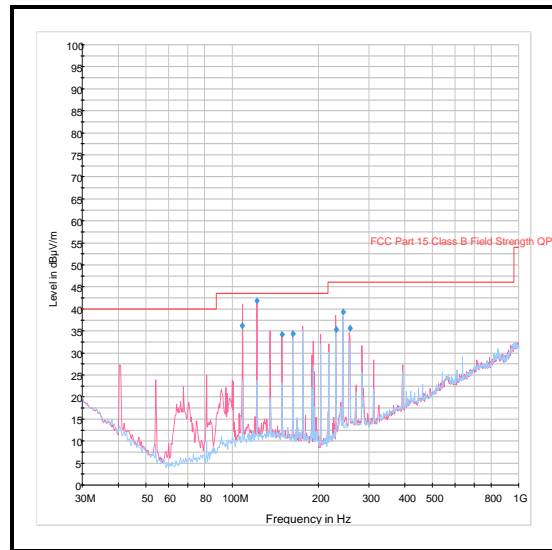
150 kHz to 30 MHz / peak detector / measured at 3 metres extrapolated to 30 metres / measured in a semi-anechoic chamber



490 kHz to 30 MHz / peak detector / EUT operating / measured at 3 metres on an open field test site



490 kHz to 30 MHz / peak detector / EUT operating / measured at 30 metres on an open field test site



30 MHz to 1 GHz / peak detector (worst case) / measured at 3 metres in a semi-anechoic chamber

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

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

| Asset No. | Instrument | Manufacturer | Type No. | Serial No. | Date Calibration Due | Cal. Interval (Months) |
|-----------|-----------------------|-----------------|------------|-------------|-----------------------|------------------------|
| M1945 | Thermohygrometer | JM Handelspunkt | 30.5015.01 | 0112 | 23 Apr 2016 | 12 |
| K0001 | 5m RSE Chamber | Rainford EMC | N/A | N/A | 12 Jan 2017 | 12 |
| M1273 | Test Receiver | Rohde & Schwarz | ESIB 26 | 100275 | 19 Mar 2016 | 12 |
| G0543 | Amplifier | Sonoma | 310N | 230801 | 29 May 2016 | 3 |
| A259 | Antenna | Chase | CBL6111A | 1513 | 09 Apr 2016 | 12 |
| A1834 | Attenuator | Hewlett Packard | 8491B | 10444 | Calibrated before use | - |
| M1124 | Test Receiver | Rohde & Schwarz | ESIB 26 | 100046 | 18 Nov 2016 | 12 |
| M1252 | Signal Generator | Hewlett Packard | 83640A | 3119A00489 | 26 Oct 2017 | 24 |
| M127 | Test Receiver | Rohde & Schwarz | FSEB30 | 842659/016 | 11 Aug 2016 | 12 |
| M1785 | Thermohygrometer | JM Handelspunkt | 30.5015.13 | None stated | 23 Apr 2016 | 12 |
| M1568 | Magnetic Loop Antenna | Rohde & Schwarz | HFH2-Z2 | 879284/2 | 06 May 2016 | 12 |

5.2.4. Transmitter Band Edge Radiated Emissions

Test Summary:

| | | | |
|-----------------------------------|-----------------|-------------------|---------------|
| Test Engineer: | Georgios Vrezas | Test Date: | 15 March 2016 |
| Test Sample Serial Number: | G14180432 | | |

| | |
|--------------------------|---|
| FCC Reference: | Parts 15.225(c)(d) & 15.209(a) |
| Test Method Used: | ANSI C63.10 Section 6.4 and Notes below |

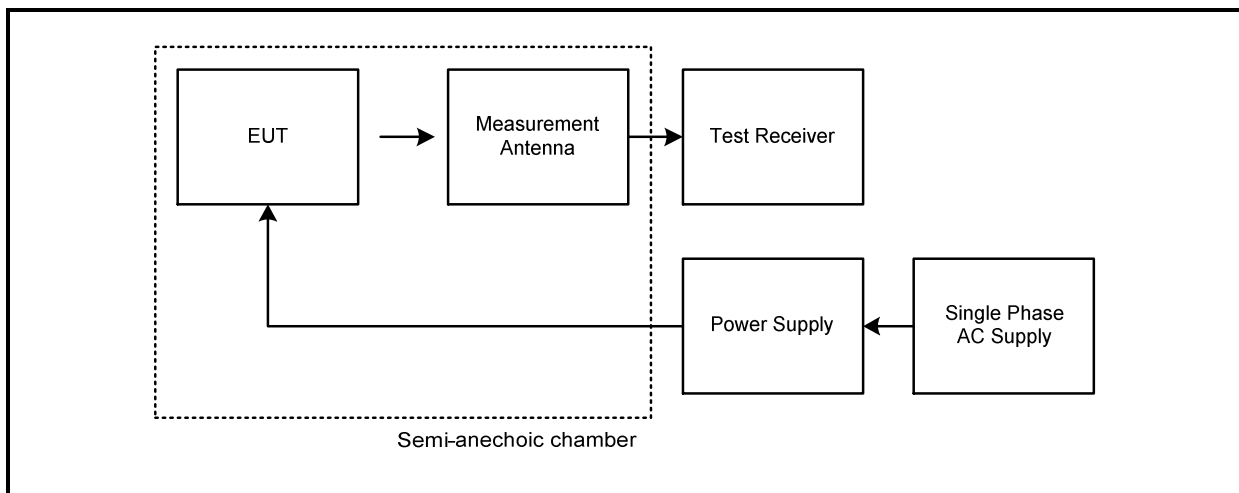
Environmental Conditions:

| | |
|-------------------------------|----|
| Temperature (°C): | 21 |
| Relative Humidity (%): | 36 |

Note(s):

1. In accordance with FCC KDB 937606, a *bona fide* attempt was made to perform measurements at the distances specified in Part 15.209(a). It was not possible to determine the band edge emission values at the test distances specified below 30 MHz on an open field test site due to the presence of ambient emissions, therefore in accordance with 47 CFR 15.31(f), measurements were made at closer distances. Attempts were made to measure the fundamental and band edges at 3 metres on an open field test site on 14 March 2016. Unfortunately the emission could not be seen above the ambient emissions or the noise floor of the measurement system. Therefore the results from the semi-anechoic chamber tests on 15 March 2016 are shown in this section of the test report. Background scans of the open field test site are shown in Appendix 1 of this test report.
2. For the field strength measurements in a semi-anechoic chamber, an offset of -44 dB was used to extrapolate the results at 3 metres to a distance of 30 metres and collate measurements in a semi-anechoic chamber with measurements on an open field test site. For details on the calculations see Notes 3 and 4 in Section 5.2.2 of this test report.
3. The spectrum analyser resolution bandwidth was set to 10 kHz and video bandwidth 30 kHz. A peak detector was used, sweep time was set to auto and the trace mode was Max Hold. The span was set to 1 MHz. Markers were placed at the lower and upper band edges. The results are given in the tables below.

Test setup:



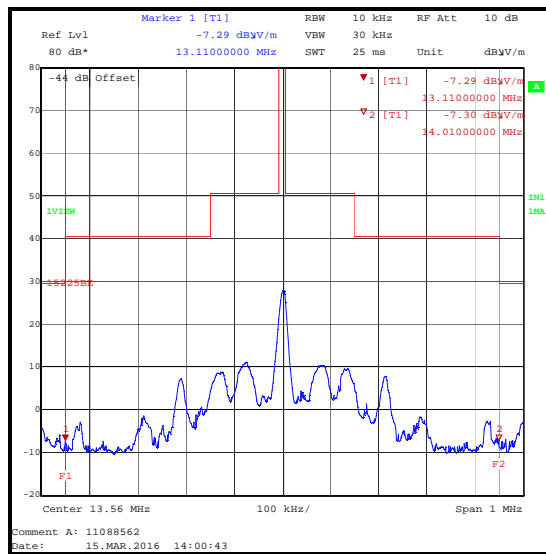
Transmitter Band Edge Radiated Emissions (continued)

Results: Peak / Lower Band Edge

| Frequency (MHz) | Level (dBµV/m) | Limit (dBµV/m) | Margin (dB) | Result |
|-----------------|----------------|----------------|-------------|----------|
| 13.11 | -7.3 | 29.5 | 36.8 | Complied |

Results: Peak / Upper Band Edge

| Frequency (MHz) | Level (dBµV/m) | Limit (dBµV/m) | Margin (dB) | Result |
|-----------------|----------------|----------------|-------------|----------|
| 14.01 | -7.3 | 29.5 | 36.8 | Complied |



Test Equipment Used:

| Asset No. | Instrument | Manufacturer | Type No. | Serial No. | Date Calibration Due | Cal. Interval (Months) |
|-----------|-----------------------|-----------------|------------|------------|----------------------|------------------------|
| M1945 | Thermohygrometer | JM Handelspunkt | 30.5015.01 | 0112 | 23 Apr 2016 | 12 |
| K0001 | 5m RSE Chamber | Rainford EMC | N/A | N/A | 12 Jan 2017 | 12 |
| M1273 | Test Receiver | Rohde & Schwarz | ESIB 26 | 100275 | 19 Mar 2016 | 12 |
| M1568 | Magnetic Loop Antenna | Rohde & Schwarz | HFH2-Z2 | 879284/2 | 06 May 2016 | 12 |

5.2.5. Transmitter Frequency Stability (Temperature & Voltage Variation)**Test Summary:**

| | | | |
|-----------------------------------|-----------------|-------------------|---------------|
| Test Engineer: | Georgios Vrezas | Test Date: | 16 March 2016 |
| Test Sample Serial Number: | G14180432 | | |

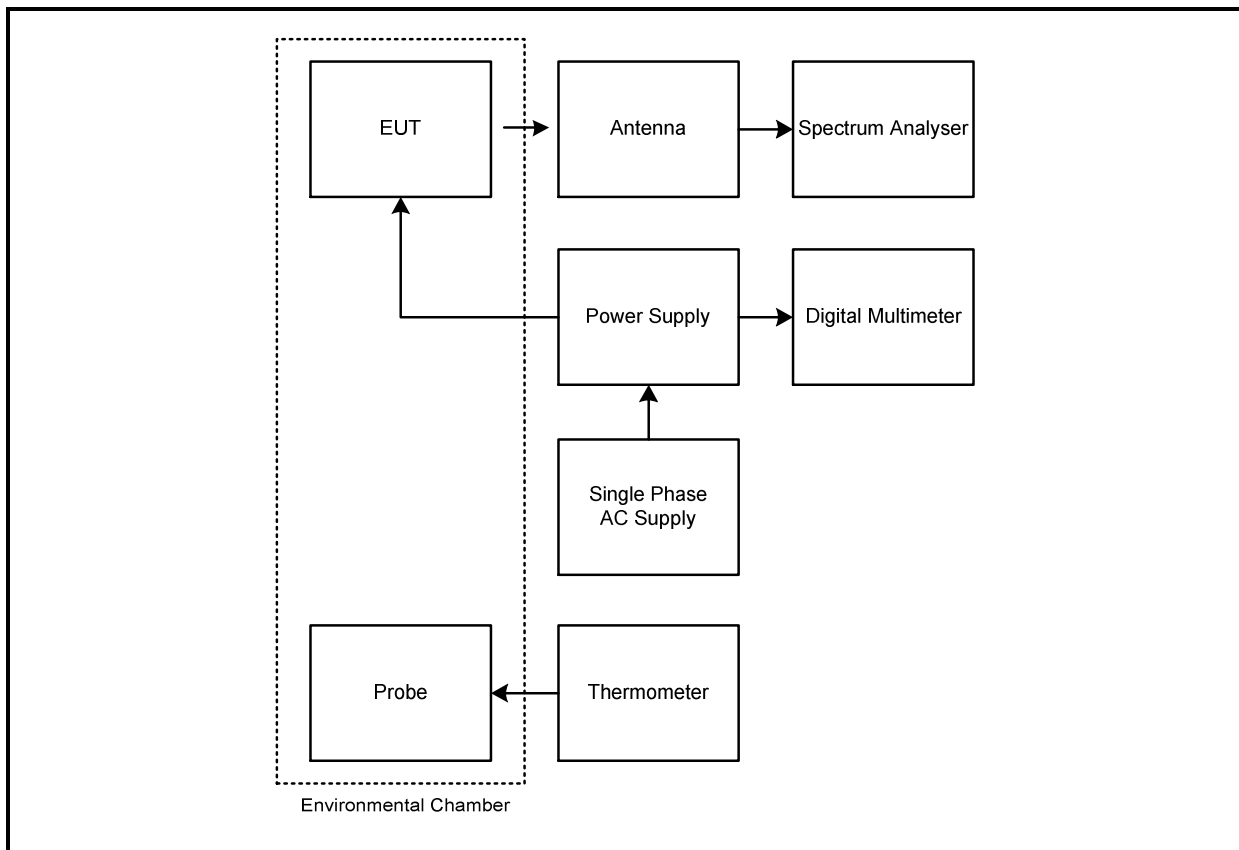
| | |
|--------------------------|-------------------------------------|
| FCC Reference: | Part 15.225(e) |
| Test Method Used: | ANSI C63.10 Section 6.8.1 and 6.8.2 |

Environmental Conditions:

| | |
|---------------------------------------|----|
| Ambient Temperature (°C): | 20 |
| Ambient Relative Humidity (%): | 32 |

Note(s):

1. Testing at voltage extremes was performed with the EUT powered by an external DC power supply.
2. Frequency error was measured using a calibrated Rohde & Schwarz spectrum analyser.
3. Temperature was monitored throughout the test with a calibrated digital thermometer.
4. Voltage was monitored throughout the test with a calibrated digital voltmeter.

Test setup:

Transmitter Frequency Stability (Temperature & Voltage Variation) (continued)**Results: Maximum frequency error of the EUT with variations in ambient temperature**

| Temperature (°C) | Time after Start-up | | | |
|------------------|---------------------|---------------|---------------|---------------|
| | 0 minutes | 2 minutes | 5 minutes | 10 minutes |
| -20 | 13.559918 MHz | 13.559923 MHz | 13.559925 MHz | 13.559925 MHz |
| 20 | 13.559842 MHz | 13.559834 MHz | 13.559833 MHz | 13.559833 MHz |
| 50 | 13.559832 MHz | 13.559840 MHz | 13.559848 MHz | 13.559852 MHz |

| Frequency with Worst Case Deviation (MHz) | Frequency Error (Hz) | Frequency Error (%) | Limit (%) | Margin (%) | Result |
|---|----------------------|---------------------|-----------|------------|----------|
| 13.559925 MHz | 92 | 0.000678 | 0.01 | 0.009322 | Complied |

Results: Maximum frequency error of the EUT with variations in nominal operating voltage at an ambient temperature of 20°C

| Supply Voltage (VDC) | Nominal Frequency (MHz) | Measured Frequency (MHz) | Frequency Error (Hz) | Frequency Error (%) | Limit (%) | Margin (%) | Result |
|----------------------|-------------------------|--------------------------|----------------------|---------------------|-----------|------------|----------|
| 10.2 | 13.559833 | 13.559835 | 2 | 0.000015 | 0.01 | 0.009985 | Complied |
| 12.0 | 13.559833 | 13.559833 | 0 | 0.000000 | 0.01 | 0.010000 | Complied |
| 13.8 | 13.559833 | 13.559838 | 5 | 0.000037 | 0.01 | 0.009963 | Complied |

Test Equipment Used:

| Asset No. | Instrument | Manufacturer | Type No. | Serial No. | Date Calibration Due | Cal. Interval (Months) |
|-----------|-----------------------|-------------------|------------|-------------|-----------------------|------------------------|
| M1659 | Thermohygrometer | JM Handelpunkt | 30.5015.13 | None stated | 23 Apr 2016 | 12 |
| M1674 | Environmental Chamber | Espec Corporation | SU-241 | 92013139 | Calibrated before use | - |
| M127 | Test Receiver | Rohde & Schwarz | FSEB30 | 842659/016 | 11 Aug 2016 | 12 |
| S0557 | DC Power Supply | TTi | EL303R | 395819 | Calibrated before use | - |
| M1229 | Multimeter | Fluke | 179 | 87640015 | 23 Apr 2016 | 12 |
| M1568 | Magnetic Loop Antenna | Rohde & Schwarz | HFH2-Z2 | 879284/2 | 06 May 2016 | 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% | ±4.69 dB |
| Frequency Stability | 13 MHz to 14 MHz | 95% | ±0.92 ppm |
| Radiated Spurious Emissions | 9 kHz to 30 MHz | 95% | ±3.73 dB |
| Radiated Spurious Emissions | 30 MHz to 1000 MHz | 95% | ±5.65 dB |
| Transmitter Fundamental Field Strength | 13 MHz to 14 MHz | 95% | ±3.73 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 |

8. Appendix 1

GPS coordinates of test location

Mag loop location (lower marker on photo)

N51° 08.739' W001° 26.328'

30 metre test point (middle marker on photo)

N51° 08.755' W001° 26.325'

300 metre test point (upper marker on photo)

N51° 08.895' W001° 26.289'



Details of 3 metre and 30 metre open field test site used on 14 March 2016

Temperature: 12°C to 21°C

Relative Humidity: 31% to 51%

Ground conditions: Dry

Measurements at 3 and 30 metres

The test site was free from underground metal objects.

The EUT was powered at its nominal voltage from an external 12 VDC battery.

The EUT was placed on a plastic table at a height of 0.8 metres above ground level. All associated cables and support equipment were arranged according to ANSI C63.10-2013 Section 6.12.

The spectrum analyser used for measurements was located in a vehicle 30 metres from the magnetic loop antenna. Power to the measurement equipment was from a single phase agricultural supply.

The test distance was from the centre of the mag loop antenna to the closest periphery of the EUT. This distance was maintained as the EUT was rotated.

Initially, the EUT was rotated through 360 degrees in 60 degree steps at both measurement distances. The mag loop antenna was rotated through 90 degrees in 30 degree steps at every position the EUT was moved to. The EUT and mag loop antenna were then rotated in small increments in order to maximise emission levels.

Details of 300 metre open field test site used on 14 March 2016

Temperature: 12°C to 21°C

Relative Humidity: 31% to 51%

Ground conditions: Dry

Measurements at 300 metres

The test site was free from underground metal objects.

The EUT was powered at its nominal voltage from an external 12 VDC battery.

The EUT was placed on a plastic table at a height of 0.8 metres above ground level. All associated cables were arranged according to ANSI C63.10-2013 Section 6.12.

The spectrum analyser used for measurements was located in a vehicle 30 metres from the magnetic loop antenna. Power to the measurement equipment was from a single phase agricultural supply.

The test distance was from the centre of the mag loop antenna to the closest periphery of the EUT. This distance was maintained as the EUT was rotated.

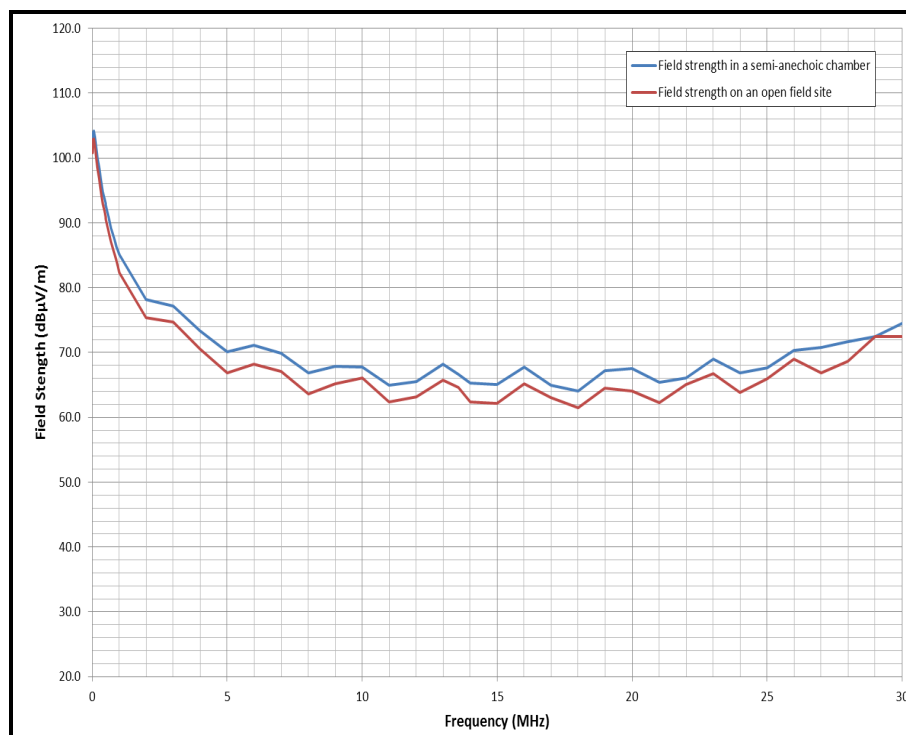
Initially, the EUT was rotated through 360 degrees in 60 degree steps at both measurement distances. The mag loop antenna was rotated through 90 degrees in 30 degree steps at every position the EUT was moved to. The EUT and mag loop antenna were then rotated in small increments in order to maximise emission levels.

Comparison of open field test site with semi-anechoic chamber measurements at 3 metres

Radiated measurements were performed on an open field test site and within a 5 metre semi-anechoic chamber.

For the signal source, a modified loop antenna was connected to a signal generator at the transmit side. A standard active magnetic loop antenna was connected to a spectrum analyser at the receive side. The signal generator was set to its maximum supported output power and the signal was transmitted to the spectrum analyser via the two antennas and associated RF cables.

A sweep in small frequency increments was performed from 9 kHz to 30 MHz. The sweep was repeatedly performed with both antennas rotated about the axis in various orientations. Received levels for all orientations were recorded and the maximum levels for the open field test site and the semi-anechoic chamber are shown on the graph below. Full data for both tests are archived on the UL VS LTD IT server and available for inspection on request.



The conclusion was that the open field test site compares well with the semi-anechoic chamber at a measurement distance of 3 metres. If anything, the semi-anechoic chamber results are generally slightly higher. This means that if the measurement passes in the semi-anechoic chamber, it will pass with a higher margin on an open field test site.

The magnetic loop antenna used to perform these measurements is the same antenna or same type of antenna used during measurements contained in this test report.

Verification of open field test site and semi-anechoic chamber measurements at 3 metres prior to performing measurements

Two reference units are used for verification of the measurement system before testing commences. Both reference units are door entry systems modified by the manufacturer for test purposes only.

One reference unit transmits a continuous, unmodulated signal at a fixed frequency of 125 kHz when a 12 Volt battery is connected. The output power is fixed and known to be stable.

The second transmits a continuous, unmodulated signal at a fixed frequency of 13.56 MHz when a 12 Volt battery is connected. The output power is fixed and known to be stable.

Both frequencies are commonly used RFID frequencies.

A UL VS LTD internal verification document explains the procedure in detail. A brief description is given below.

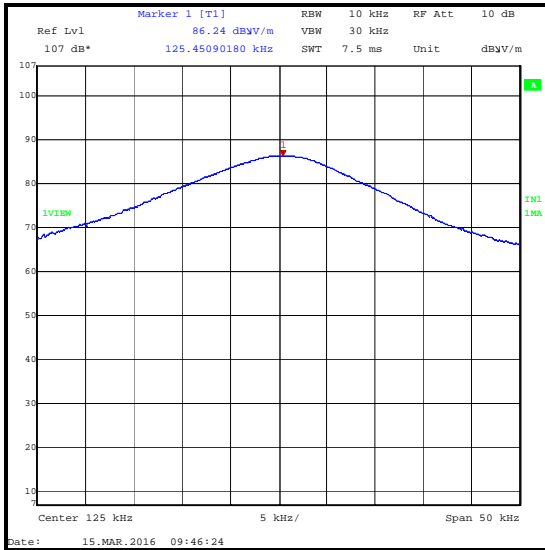
The centre of the magnetic loop antenna is placed exactly 3 metres from the reference unit. The reference unit is placed on a plastic table at a height of 0.8 metres above floor level and the centre of the mag loop antenna is 1 metre above the floor level. The mag loop antenna and reference unit are oriented in certain positions to ensure repeatability.

Each reference unit is connected to a 12 Volt battery and once transmitting, the maximum raw received level at each of the two frequencies is read on the spectrum analyser by using the marker peak function. The measured level has to be within certain levels as specified in the UL VS LTD internal test procedure. The plot of the verification measurement is archived on the UL VS LTD IT server. The peak level of each reference unit is recorded on a spreadsheet which is also archived on the UL VS LTD IT server.

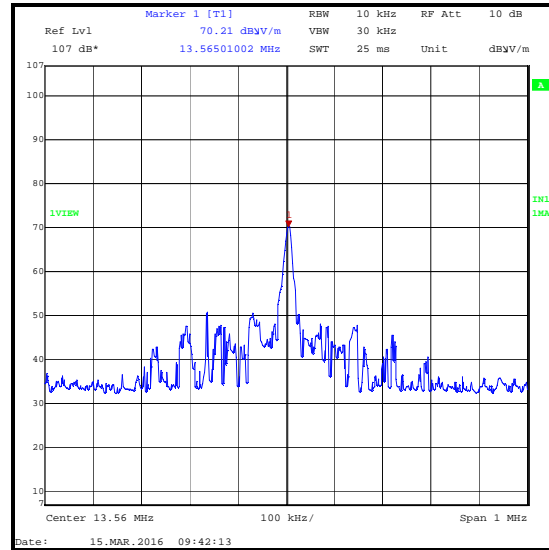
The internal verification procedure and verification plots are available for inspection on request.

Radiated measurements below 30 MHz were performed in a semi-anechoic chamber at a distance of 3 metres.

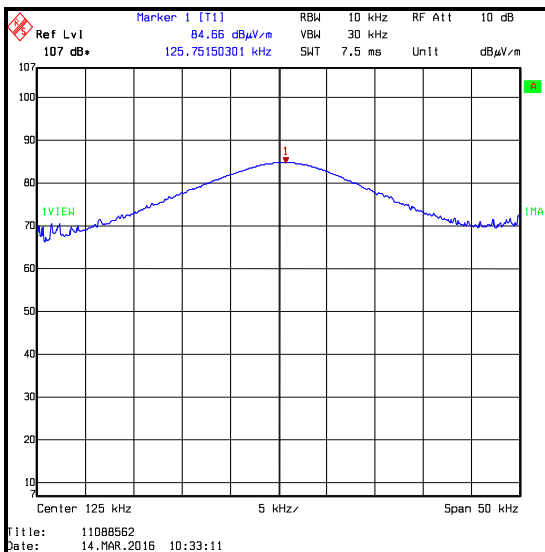
Verification plots of the two reference units at a measurement distance of 3 metres are shown on the following page. Plots were taken on an open field test site (14 March 2016) and in a semi-anechoic chamber (15 March 2016).



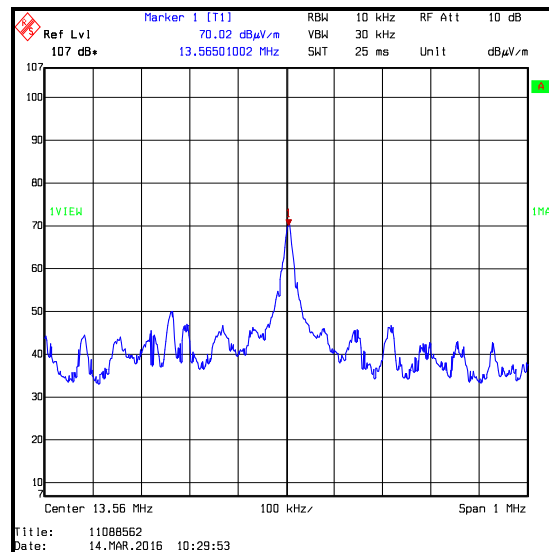
125 kHz reference unit signal at 3 metres in a semi-anechoic chamber on 15 March 2016



13.56 MHz reference unit signal at 3 metres in a semi-anechoic chamber on 15 March 2016



125 kHz reference unit signal at 3 metres on an open field test site on 14 March 2016

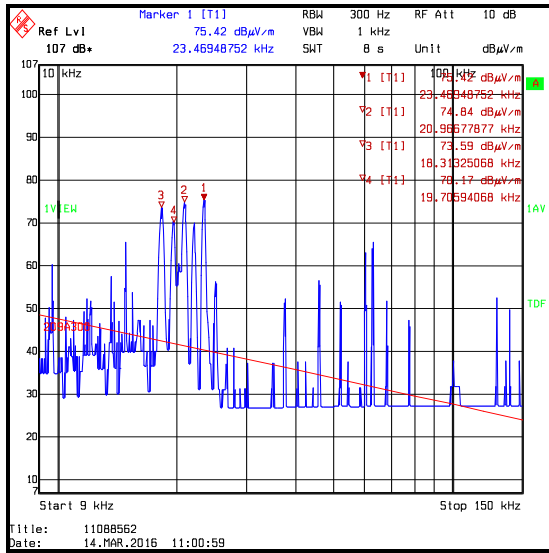


13.56 MHz reference unit signal at 3 metres on an open field test site on 14 March 2016

Note(s):

1. The above plots show comparable measurements of reference units on an open field test site and in a semi-anechoic chamber at spot frequencies.

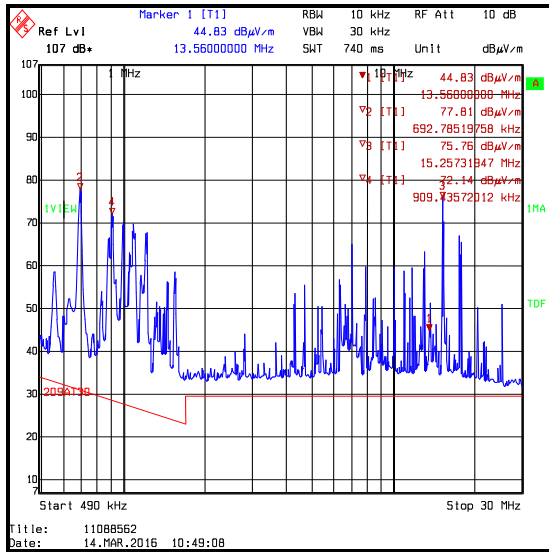
Background scans of the open field test site



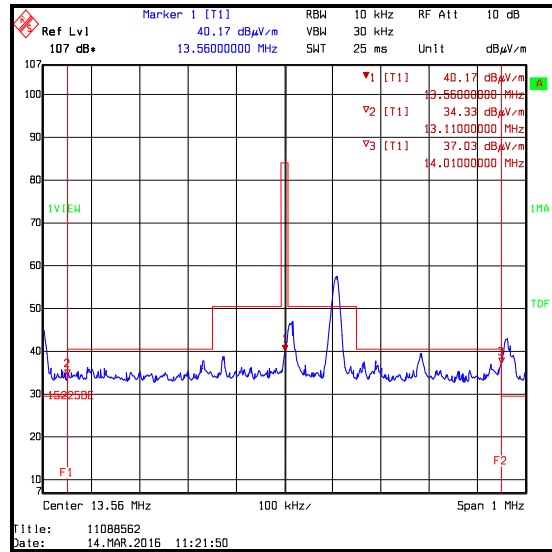
**Frequency range: 9 kHz to 150 kHz
Average detector / background scan**



**Frequency range: 150 kHz to 490 kHz
Average detector / background scan**



**Frequency range: 490 kHz to 30 MHz
Peak detector / background scan**



**Frequency range: 13.06 MHz to 14.06 MHz
/ background scan of the open field test site**

Note(s):

1. The above plots are background scans of the open field test site. The EUT was turned off when the background scans were performed.

--- END OF REPORT ---