



TEST REPORT

Test Report No. : UL-RPT-RP11406740JD01A V2.0

Manufacturer : EBS Ink-Jet Systems Poland Sp. z o. o.
Model No. : 4500
FCC ID : 2AKBZEMI45A
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 2.0 supersedes all previous versions.

Date of Issue: 26 April 2018

Checked by:

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Senior Test Engineer, Radio Laboratory

Company Signatory:

Sarah Williams
Senior Test Engineer, Radio Laboratory
UL VS LTD



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

UL VS LTD

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1. Customer Information








Company Name:	EBS Ink-Jet Systems Poland Sp. z o. o.
Address:	Tarnogajska 13 50-512 Wroclaw Poland

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:	26 October 2016 to 02 December 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 937606 Date: 10/10/2014
Title:	Test Site Requirements for Part 15 and 18 Devices Operating Below 30 MHz
Reference:	FCC KDB 174176 D01 Line Conducted FAQ v01r01 June 3, 2015
Title:	AC Power-Line Conducted Emissions Frequently Asked Questions

NOTE: FCC KDB 937606 was superseded by KDB 414788 on 18 April 2017. The test sites used during this testing conformed with the requirements of KDB 414788.

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:	Markem-Imaje Industries
Model Name or Number:	4500
Test Sample Serial Number:	Y21634C009 (<i>Standard unit</i>)
Hardware Version:	Printer: Rev A / Screen: Rev B
Firmware Version:	System: 1.03.10 User Interface: 1.01.04 Printer Driver: 1.1.5-04 Editor: 1.09.15_T Head Firmware: 2.43.b0707 B02.3
FCC ID:	2AKBZEMI45A

Brand Name:	Markem-Imaje Industries
Model Name or Number:	4500
Test Sample Serial Number:	Y21647C010 (<i>Unit with antenna dummy load</i>)
Hardware Version:	Printer: Rev A / Screen: Rev B
Firmware Version:	System: 1.03.10 User Interface: 1.01.04 Printer Driver: 1.1.5-04 Editor: 1.09.15_T Head Firmware: 2.43.b0707 B02.3
FCC ID:	2AKBZEMI45A

3.2. Description of EUT

The EUT was a specialised printer used for printing onto boxes travelling down a conveyor belt. The printer incorporates an LCD control panel and a 13.56 MHz RFID reader for reading ink jet cartridge information. It is powered from a single phase AC power supply.

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 Range:	13.56 MHz	
Power Supply Requirement:	Nominal	120 VAC 60 Hz
	Minimum	102 VAC 60 Hz
	Maximum	138 VAC 60 Hz
Tested Temperature Range:	Minimum	5 °C
	Maximum	45 °C

3.5. Support Equipment

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

Description:	Status Beacon. Cable length 5 metres. Connected to black M12 port.
Brand Name:	PATLITE
Model Name or Number:	A51840 Alarm tower 24V BYG M12-4
Serial Number:	Not marked or stated

Description:	Cable with 4 pin plug terminated in 500 Ω load. Cable length 10 metres. Connected to red M12 conveyor stoppage output port.
Brand Name:	Markem-Imaje
Model Name or Number:	10061735 AA
Serial Number:	Not marked or stated

Description:	USB Flash Drive
Brand Name:	SanDisk
Model Name or Number:	SDCZ43-064G-G46
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 using instructions provided by the customer in document '*MI4500_RFID_test EMC&Radio(EN).pdf*' dated 12 October 2016.
- Frequency stability tests were performed with the EUT connected to a variable power supply. Temperature range tested was as stated in the User Manual, 5° C to 45° C.
- A USB Flash Drive was used to terminate the USB port. A Status Beacon was connected to the black M12 port during emissions tests. A multicore cable with 4 pin plug terminated in 50 Ω load was connected to red M12 conveyor stoppage output port during emissions tests.
- Refer to Appendix 1 of this test report for details of radiated tests on an open field test site.
- The sample with serial number Y21634C009 was used for all tests. The sample with serial number Y21647C010 was also used for AC conducted emissions tests.

5. Measurements, Examinations and Derived Results

5.1. General Comments

Measurement uncertainties are evaluated in accordance with current best practice. Our reported expanded uncertainties are based on standard uncertainties, which are multiplied by an appropriate coverage factor to provide a statistical confidence level of approximately 95%. Please refer to *Section 6: Measurement 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:	Stefan Ho	Test Dates:	10 November 2016 to 02 December 2016
Test Sample Serial Numbers:	Y21634C009 & Y21647C010		

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

Environmental Conditions:

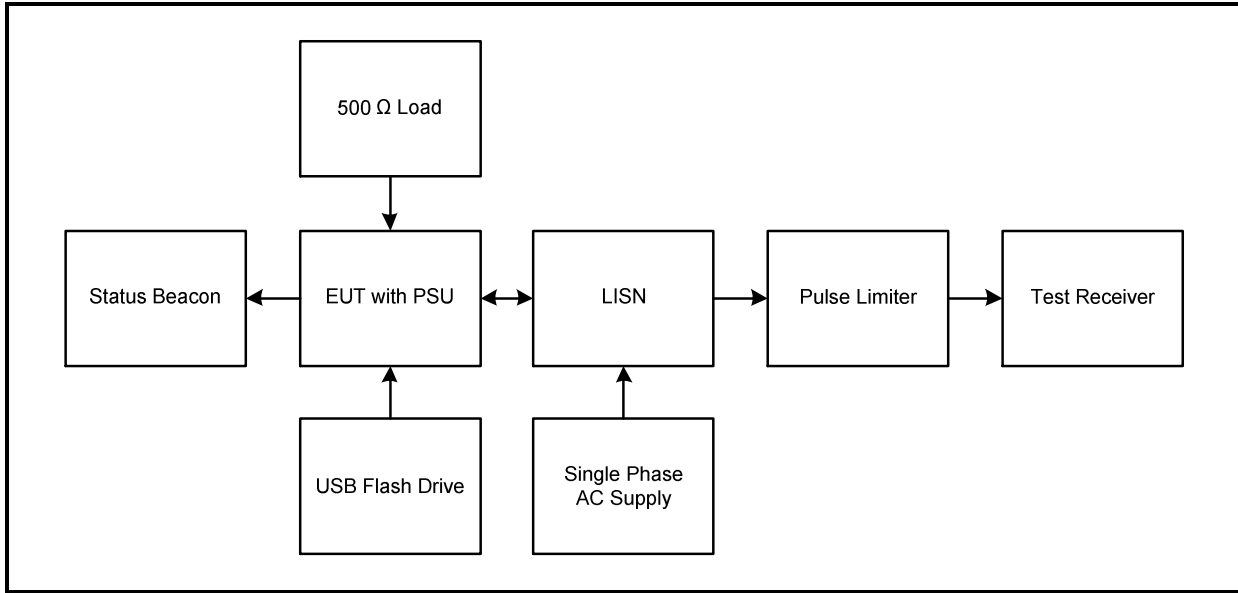
Temperature (°C):	20
Relative Humidity (%):	43

Note(s):

1. The EUT was connected to a 120 VAC 60 Hz single phase supply single phase supply via a LISN.
2. A pulse limiter was fitted between the LISN and the test receiver.
3. 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.
4. In accordance with FCC KDB 174176 Q4, tests were also performed with a 240 VAC 60 Hz single phase supply as this was within the voltage range marked on the EUT.
5. The EUT was initially tested with the standard antenna connected (Test sample serial number Y21634C009) and using a 120 VAC 60 Hz single phase supply. An emission at the approximate carrier frequency of 13.56 MHz was found to be non-compliant as it exceeded the limit. The customer supplied a second, modified sample (Test sample serial number Y21647C010). The standard antenna on this sample was disconnected and a dummy load fitted in accordance with FCC KDB 174176 Q5. The test was repeated and the EUT was found to be compliant.
6. * Test results with standard EUT sample (standard antenna).
7. ** Test results with EUT sample incorporating antenna dummy load.

Transmitter AC Conducted Spurious Emissions (continued)

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
0.150	Live	49.3*	66.0	16.7	Complied
0.537	Live	47.9*	56.0	8.1	Complied
1.077	Live	33.7*	56.0	22.3	Complied
12.768	Live	45.5*	60.0	14.5	Complied
13.560	Live	29.0**	60.0	31.0	Complied
14.406	Live	48.3*	60.0	11.7	Complied

Results: Live / Average / 120 VAC 60 Hz

Frequency (MHz)	Line	Level (dB μ V)	Limit (dB μ V)	Margin (dB)	Result
0.150	Live	38.9*	56.0	17.1	Complied
0.537	Live	41.5*	46.0	4.5	Complied
1.073	Live	26.2*	46.0	19.8	Complied
12.705	Live	28.7*	50.0	21.3	Complied
13.560	Live	22.7**	50.0	27.3	Complied
14.388	Live	25.3*	50.0	24.7	Complied

Results: Neutral / Quasi Peak / 120 VAC 60 Hz

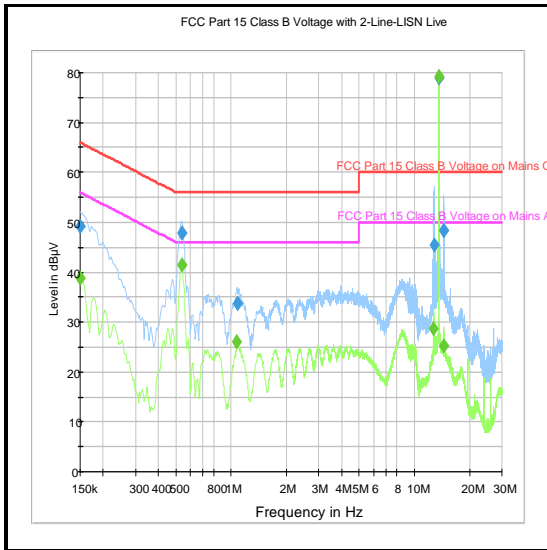
Frequency (MHz)	Line	Level (dB μ V)	Limit (dB μ V)	Margin (dB)	Result
0.150	Neutral	51.3*	66.0	14.7	Complied
0.533	Neutral	48.9*	56.0	7.1	Complied
1.077	Neutral	36.0*	56.0	20.0	Complied
12.714	Neutral	53.6*	60.0	6.4	Complied
13.560	Neutral	29.6**	60.0	30.4	Complied
14.366	Neutral	40.7*	60.0	19.3	Complied

Results: Neutral / Average / 120 VAC 60 Hz

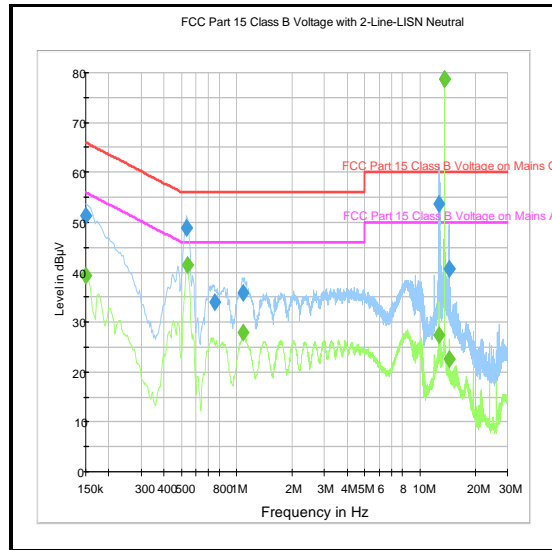
Frequency (MHz)	Line	Level (dB μ V)	Limit (dB μ V)	Margin (dB)	Result
0.150	Neutral	39.3*	56.0	16.7	Complied
0.537	Neutral	41.3*	46.0	4.7	Complied
1.077	Neutral	27.9*	46.0	18.1	Complied
12.692	Neutral	27.4*	50.0	22.6	Complied
13.560	Neutral	24.0**	50.0	26.0	Complied
14.397	Neutral	22.7*	50.0	27.3	Complied

Transmitter AC Conducted Spurious Emissions (continued)

Results: 120 VAC 60 Hz with unmodified sample (antenna present)

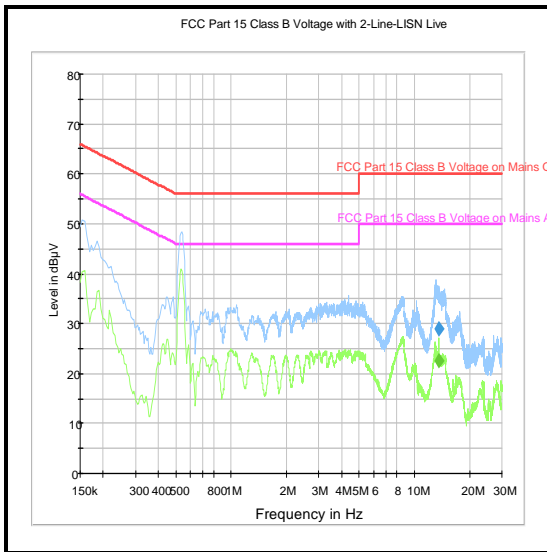


Live

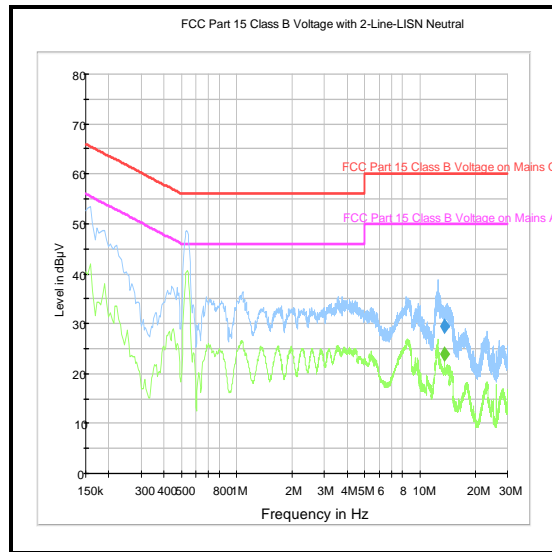


Neutral

Results: 120 VAC 60 Hz with modified sample (transmitter terminated into a dummy load)



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
0.546	Live	48.6*	56.0	7.4	Complied
0.906	Live	38.4*	56.0	17.6	Complied
2.891	Live	35.6*	56.0	20.4	Complied
12.768	Live	45.9*	60.0	14.1	Complied
13.560	31.8**	60.0	28.2	31.8**	Complied
14.388	Live	41.2*	60.0	18.8	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	38.5	56.0	17.5	Complied
0.551	Live	40.6	46.0	5.4	Complied
0.911	Live	29.6	46.0	16.4	Complied
2.243	Live	30.0	46.0	16.0	Complied
4.088	Live	30.2	46.0	15.8	Complied
13.560	Live	25.2**	50.0	24.8	Complied

Results: Neutral / Quasi Peak / 240 VAC 60 Hz

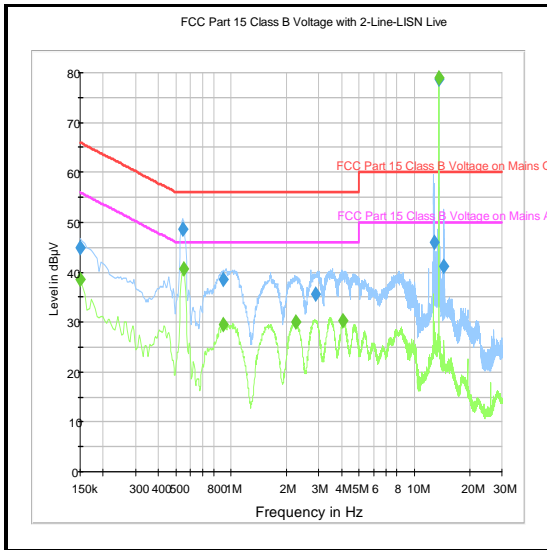
Frequency (MHz)	Line	Level (dB μ V)	Limit (dB μ V)	Margin (dB)	Result
0.150	Neutral	49.5*	66.0	16.5	Complied
0.546	Neutral	49.3*	56.0	6.7	Complied
1.046	Neutral	40.1*	56.0	15.9	Complied
12.692	Neutral	46.9*	60.0	13.1	Complied
13.560	Neutral	30.3**	60.0	29.7	Complied
14.406	Neutral	47.2*	60.0	12.8	Complied

Results: Neutral / Average / 240 VAC 60 Hz

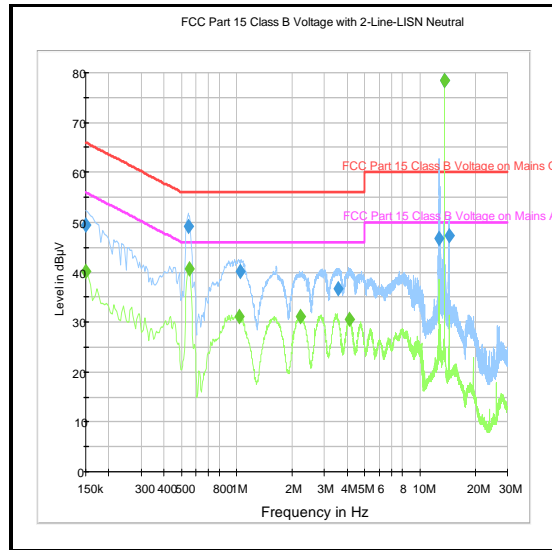
Frequency (MHz)	Line	Level (dB μ V)	Limit (dB μ V)	Margin (dB)	Result
0.150	Neutral	40.2*	56.0	15.8	Complied
0.551	Neutral	40.6*	46.0	5.4	Complied
1.028	Neutral	31.2*	46.0	14.8	Complied
2.216	Neutral	31.0*	46.0	15.0	Complied
4.092	Neutral	30.5*	46.0	15.5	Complied
13.560	Neutral	23.8**	50.0	26.2	Complied

Transmitter AC Conducted Spurious Emissions (continued)

Results: 240 VAC 60 Hz with unmodified sample (antenna present)

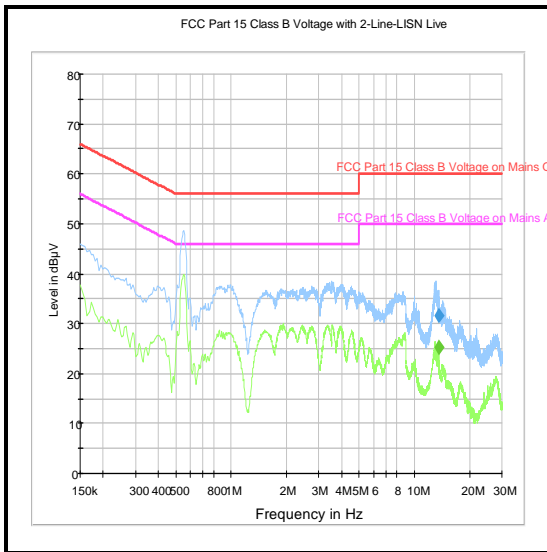


Live

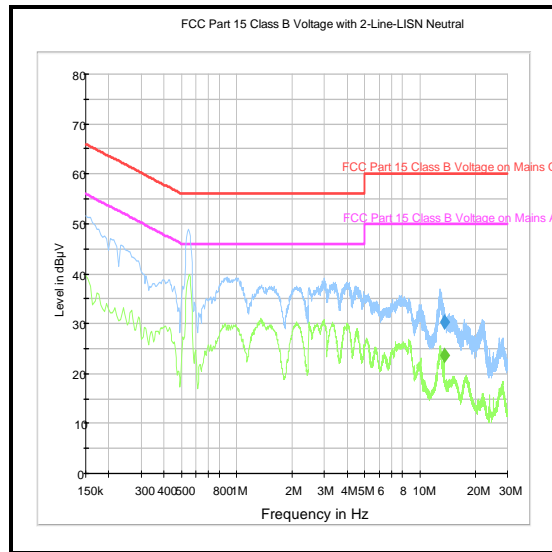


Neutral

Results: 240 VAC 60 Hz with modified sample (transmitter terminated into a dummy load)



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)**Test Equipment Used:**

Asset No.	Instrument	Manufacturer	Type No.	Serial No.	Date Calibration Due	Cal. Interval (Months)
M2015	Thermohygrometer	Testo	608-H1	45046424	10 Jun 2017	12
A649	LISN	Rohde & Schwarz	ESH3-Z5	825562/008	09 Aug 2017	12
A1830	Pulse Limiter	Rohde & Schwarz	ESH3-Z2	100668	08 Mar 2017	12
M1379	Test Receiver	Rohde & Schwarz	ESIB7	100330	13 Dec 2016	12
A2953	Power Supply	Tacima	SC 5467	Not stated	Calibrated before use	-
M1229	Multimeter	Fluke	179	87640015	21 Apr 2017	12

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

Test Engineers:	Georgios Vrezas & Stefan Ho	Test Dates:	26 October 2016 & 09 November 2016
Test Sample Serial Number:	Y21634C009		

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):	15 to 20
Relative Humidity (%):	38 to 74

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) on an open field site. 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 26 October 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.
3. The fundamental field strength level was maximized by rotating the measurement antenna and EUT. A peak level of 53.9 dBµV/m in a 10 kHz measurement bandwidth, at a measurement distance of 3 metres was recorded and shown on the pre-scan plots below.
4. Further measurements were performed in the semi-anechoic chamber using a test receiver with a peak detector and measurement bandwidth of 10 kHz. An RF level offset of -1.5 dB was used on the test receiver. Refer to results plots '*Fundamental field strength and spectrum mask / measured at 3 metres in a semi-anechoic chamber*'. This illustrates that the value of the RF level offset is -1.5 dB and the peak fundamental field strength is 53.9 dBµV/m at a measurement distance of 3 metres.
5. Final measurements were performed in the semi-anechoic chamber 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 level of 53.8 dBµV/m at a measurement distance of 3 metres was recorded. A further 40 dB was subtracted to extrapolate the level measured at 3 metres to the required distance of 30 metres:

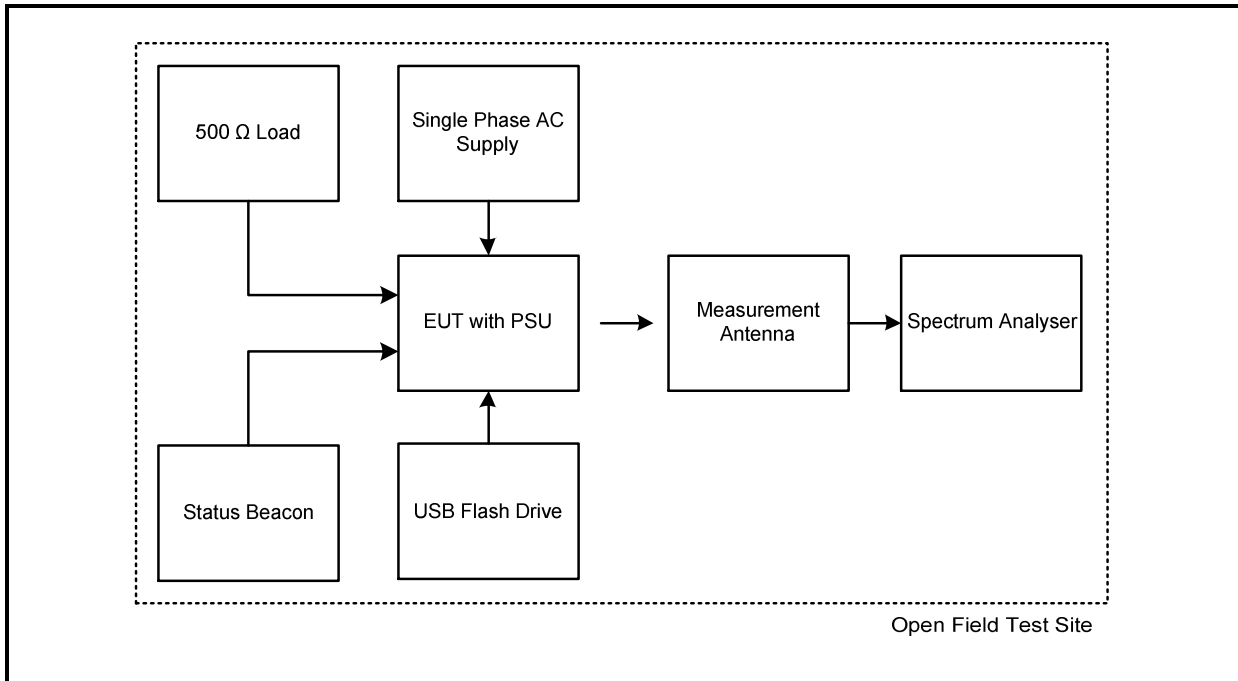
Corrected level 53.8 – 40 = 13.8 dBµV/m at 30 metres.

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

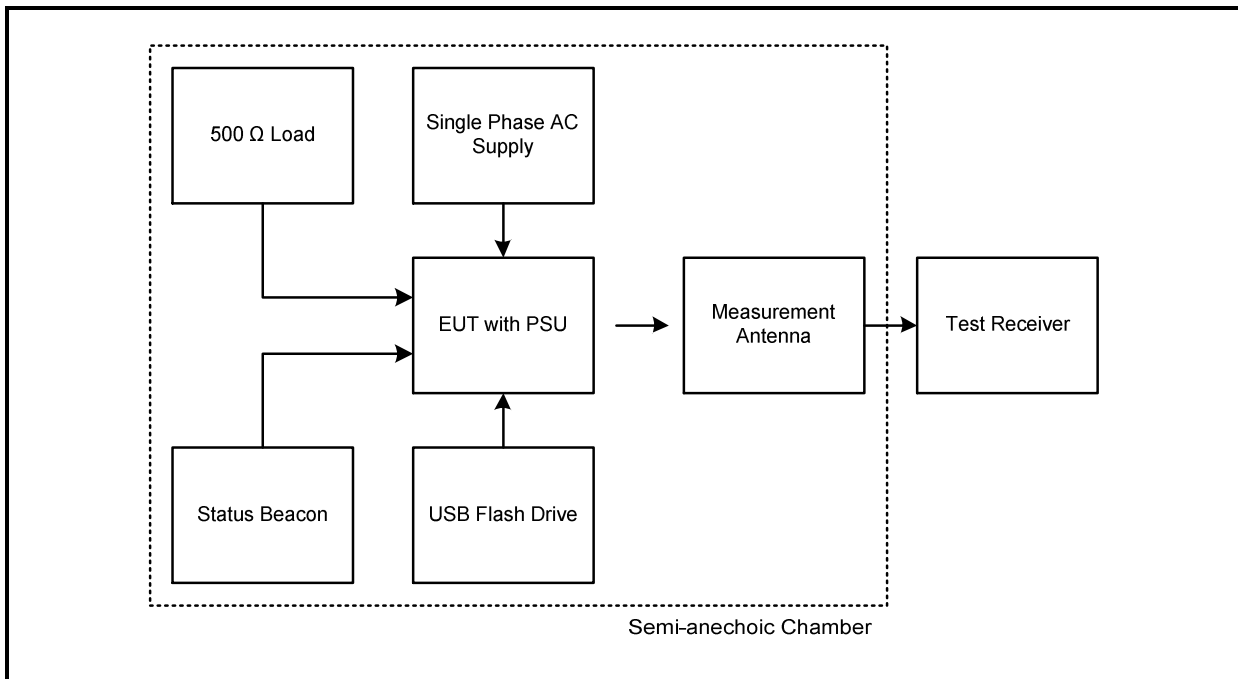
6. Due to the ambient emissions present on the open field test site, compliance with the spectrum mask is shown by measurements performed in a semi-anechoic chamber. For the field strength measurements in a semi-anechoic chamber, an RF level offset was used to replicate the measurement at 30 metres on 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.
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.
8. For compliance with the spectrum mask, refer to Section 5.2.4 of this test report.
9. Assets M1956 Steel Rule, A2686 Measuring Wheel and A2955 Protractor, were used to support offsite measurements. The calibrated steel rule was used to verify the accuracy of the measuring wheel and the protractor used to ensure the accuracy of the EUT position during testing.

Test setup for fundamental field strength measurements:

Measurements on an open field test site



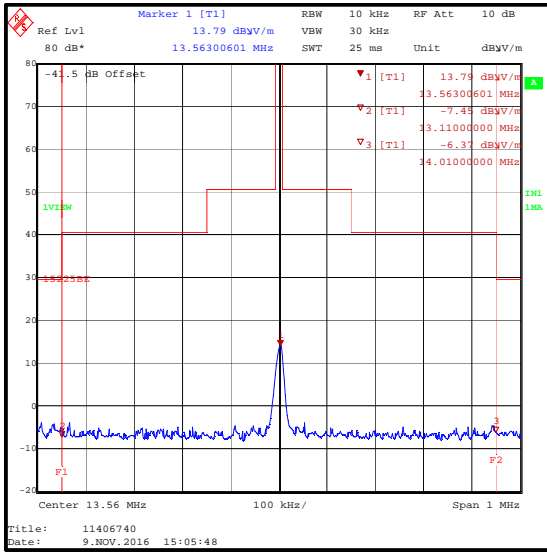
Measurements in a semi-anechoic chamber



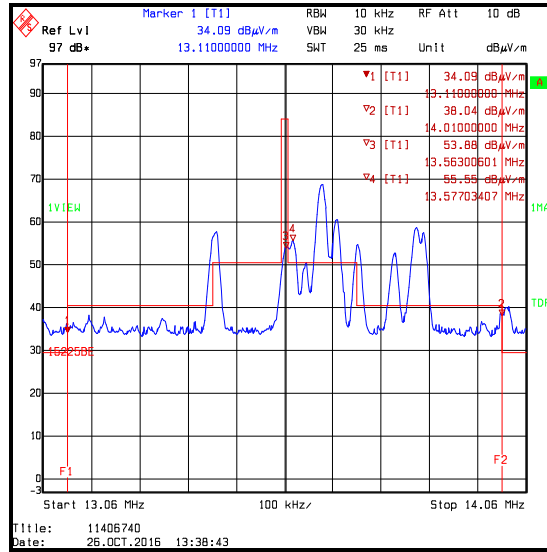
Transmitter Fundamental Field Strength (continued)

Results: Quasi Peak

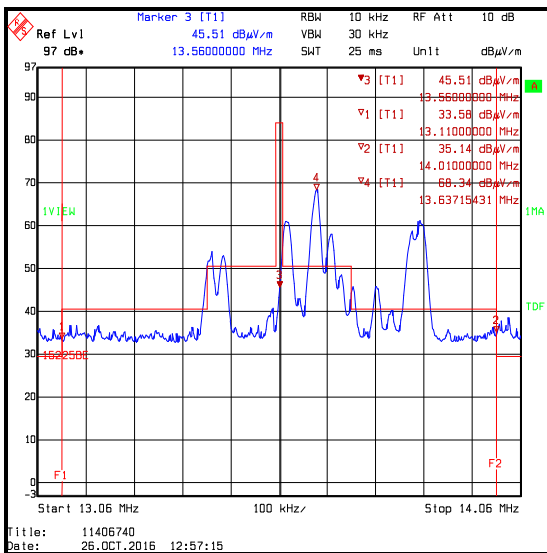
Frequency (MHz)	Measurement Antenna Position	Level (dB μ V/m)	Limit at 30 m (dB μ V/m)	Margin (dB)	Result
13.56	Tip of antenna facing EUT	13.8	84.0	70.2	Complied



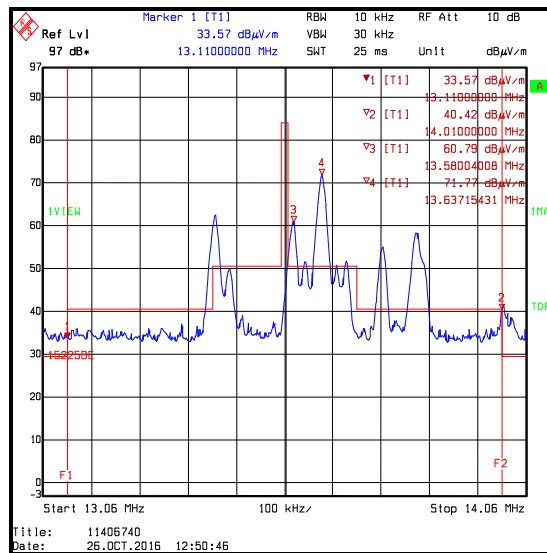
Fundamental field strength at 3 metres in a semi-anechoic chamber / extrapolated to 30 metres



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)



EUT off / Background scan of the open field test site with a 10 kHz measurement bandwidth showing ambient emissions

Transmitter Fundamental Field Strength (continued)**Test Equipment Used:**

Asset No.	Instrument	Manufacturer	Type No.	Serial No.	Date Calibration Due	Cal. Interval (Months)
M1659	Thermohygrometer	JM Handelspunkt	30.5015.13	Not stated	02 Apr 2017	12
K0001	RSE Chamber	Rainford EMC	N/A	N/A	12 Jan 2017	12
M1568	Magnetic Loop Antenna	Rohde & Schwarz	HFH2-Z2	879284/2	23 May 2017	12
M1273	Test Receiver	Rohde & Schwarz	ESIB 26	100275	11 Apr 2017	12
M1659	Thermohygrometer	JM Handelspunkt	30.5015.13	Not stated	02 Apr 2017	12
M127	Spectrum Analyser	Rohde & Schwarz	FSEB30	842659/016	08 Sep 2017	12
M1956	Precision Steel Rule	Rabone	(64SR) 0-35-406	4501361/2204	22 Apr 2020	60
A2686	Distance Measuring Wheel	Rolson Quality Tools	50799	Not stated	Calibrated before use	-
A2955	Protractor	Not marked or stated	978190755 0980	#1	Calibration not required	-

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

Test Engineers:	Georgios Vrezas & Stefan Ho	Test Dates:	26 October 2016 & 09 November 2016
Test Sample Serial Number:	Y21634C009		

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

Environmental Conditions:

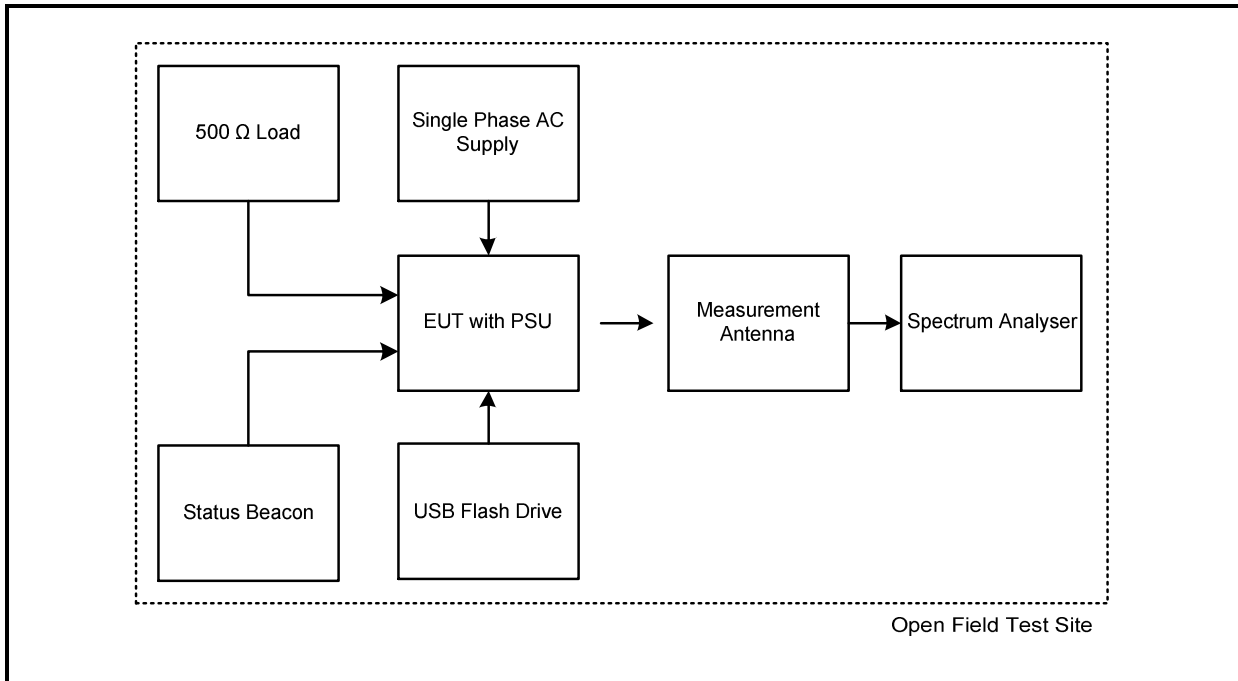
Temperature (°C):	15 to 20
Relative Humidity (%):	38 to 74

Note(s):

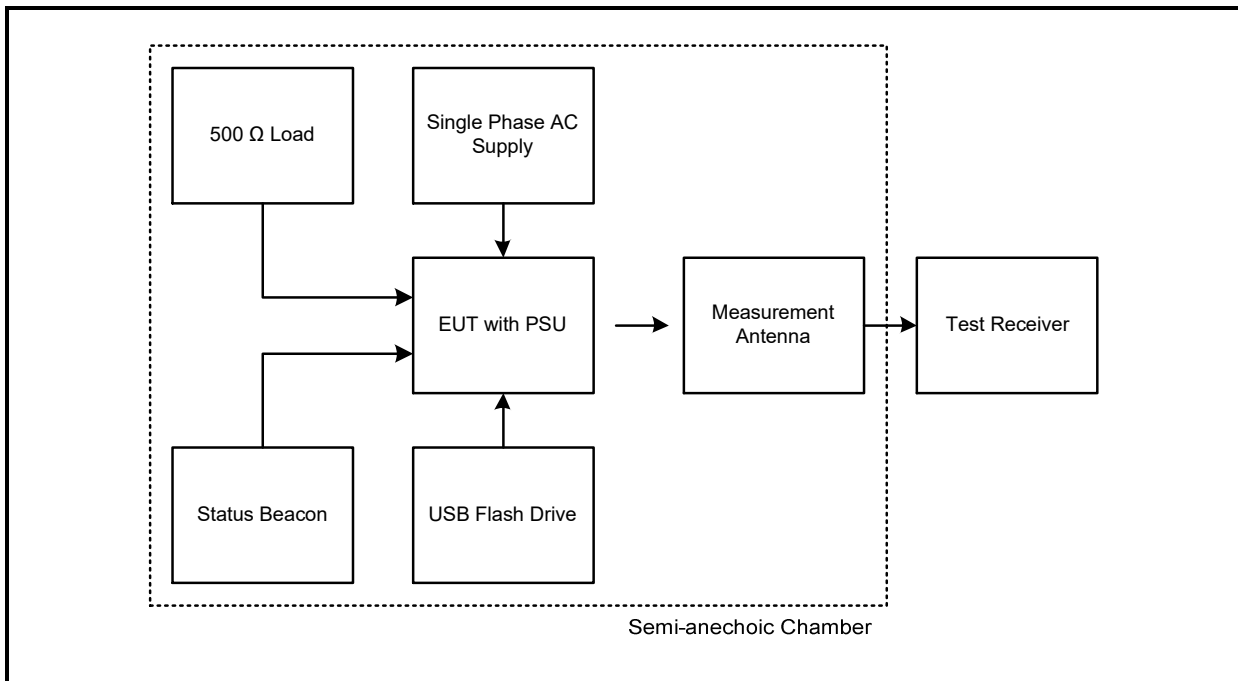
1. In accordance with FCC KDB 937606, a *bona fide* attempt was made to perform measurements at the distances specified in Part 15.209(a) on an open field test site. It was not possible to determine the spurious emission values at the test distances specified below 30 MHz on an open field test site, 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 26 October 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 09 November 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 09 November 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. Limit lines shown on open field test site plots from 9 kHz to 490 kHz have been extrapolated using a factor of 40 dB/decade to a test distance of 30 metres and are for indication only.
7. All other emissions shown on the pre-scan plots were investigated and found to be >20 dB below the applicable limit or below the measurement system noise floor.
8. 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 value 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 spurious emissions measurements on an open field test site:



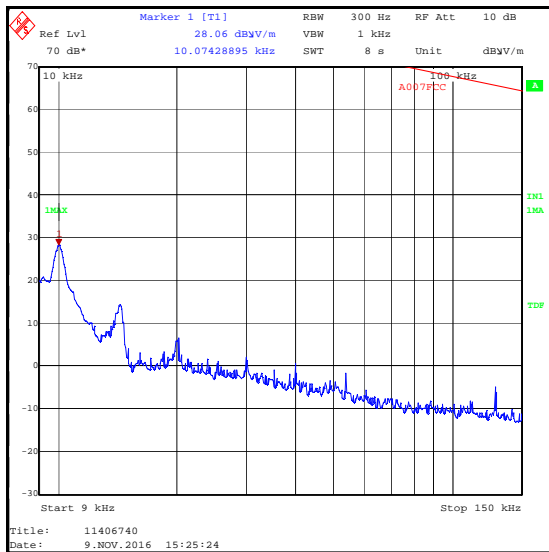
Test setup for radiated spurious emissions measurements in a semi-anechoic chamber:



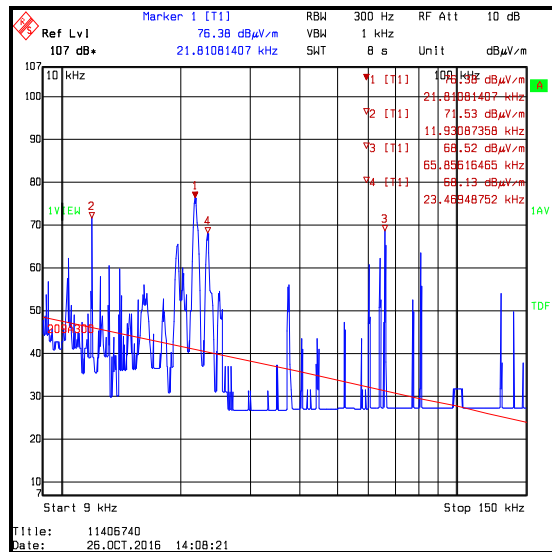
Transmitter Radiated Spurious Emissions (continued)**Results: Quasi Peak**

Frequency (MHz)	Antenna Polarity	Level (dB μ V/m)	Limit (dB μ V/m)	Margin (dB)	Result
33.690	Vertical	37.9	40.0	2.1	Complied
57.067	Vertical	23.5	40.0	16.5	Complied
68.517	Vertical	28.7	40.0	11.3	Complied
100.210	Vertical	29.4	43.5	14.1	Complied
271.184	Horizontal	41.0	46.0	5.0	Complied
298.311	Horizontal	42.2	46.0	3.8	Complied
325.430	Vertical	42.9	46.0	3.1	Complied
352.542	Horizontal	42.7	46.0	3.3	Complied

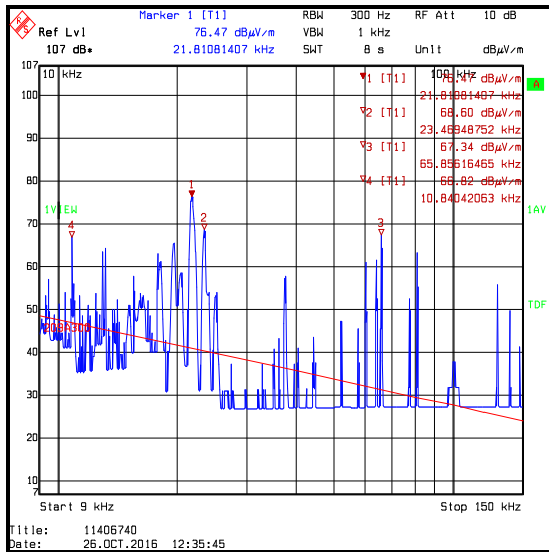
Transmitter Radiated Spurious Emissions (continued)



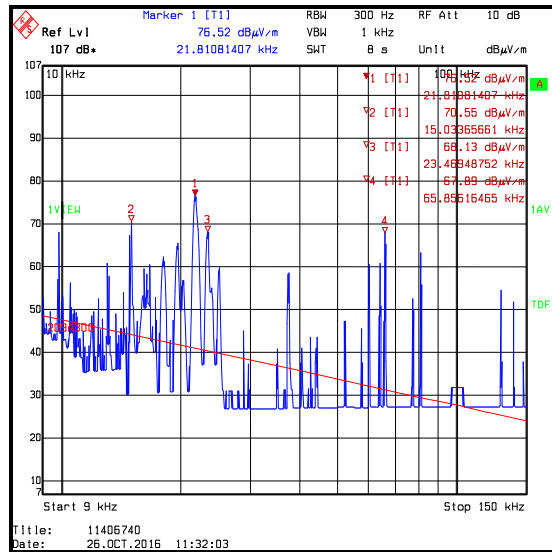
9 kHz to 150 kHz / peak detector / measured at 3 metres extrapolated to 30 metres / measured in a semi-anechoic chamber



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



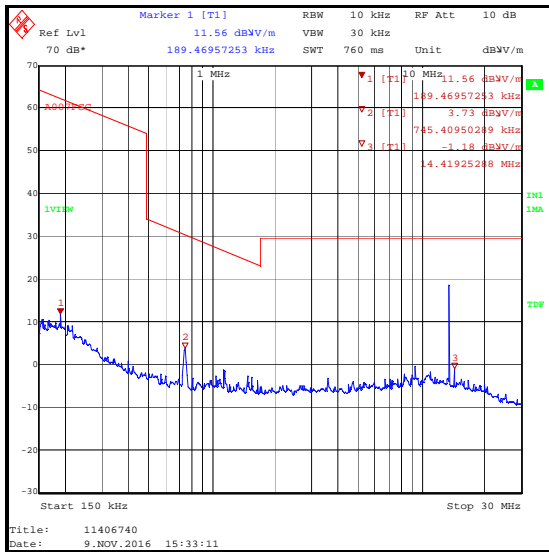
9 kHz to 150 kHz / average detector / EUT operating / measured at 30 metres on an open field test site



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.

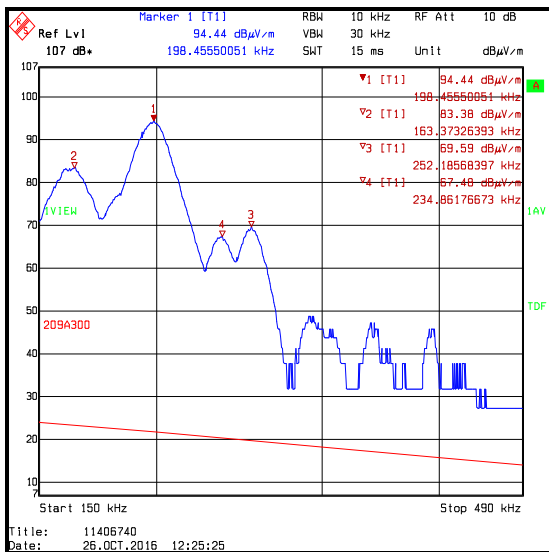
Transmitter Radiated Spurious Emissions (continued)



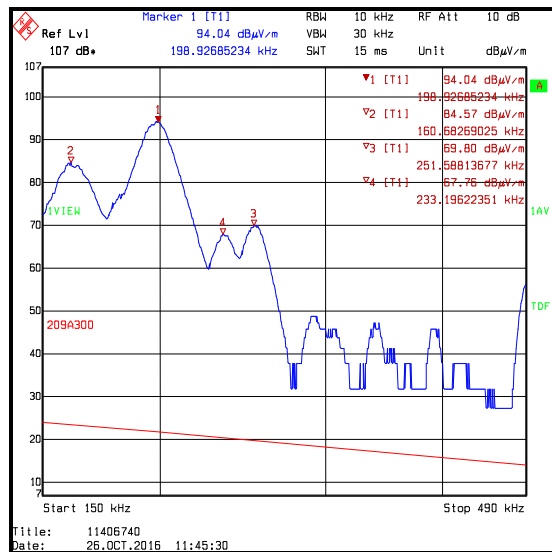
150 kHz to 30 MHz / peak detector (worst case) / EUT operating / measured at 3 metres extrapolated to 30 metres / measured in a semi-anechoic chamber



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



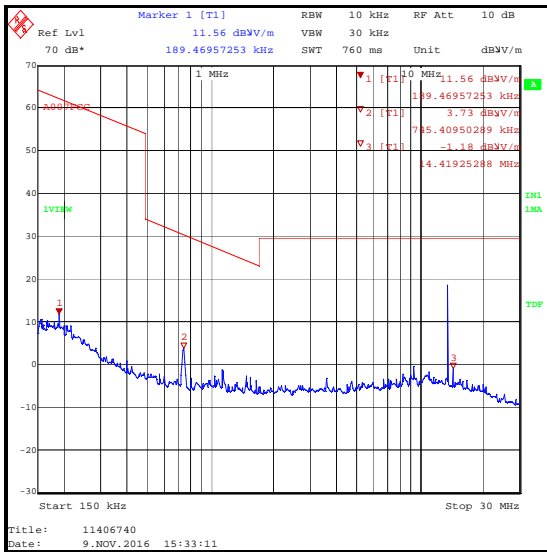
150 kHz to 490 kHz / average detector / EUT operating / measured at 30 metres on an open field test site



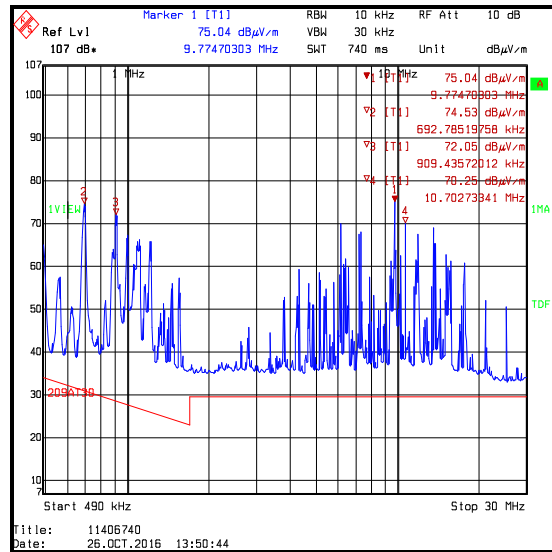
150 kHz to 490 kHz / average detector / EUT operating / measured at 300 metres on an open field test site

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

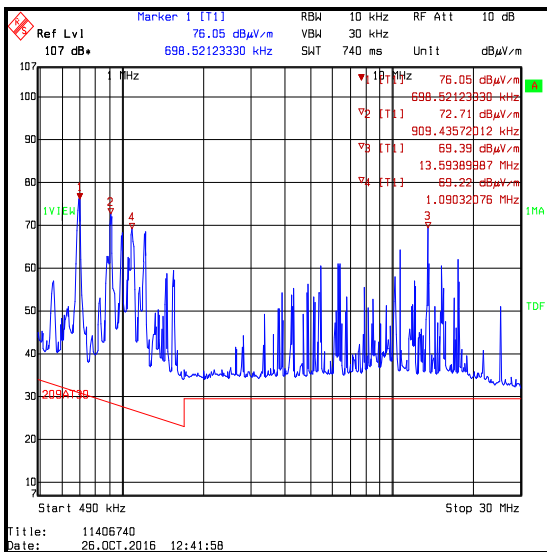
Transmitter Radiated Spurious Emissions (continued)



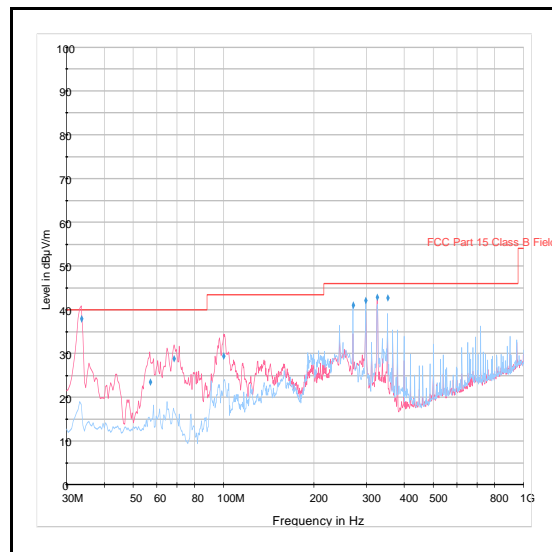
150 kHz to 30 MHz / peak detector / measured at 3 metres extrapolated to 30 metres / measured in a semi-anechoic chamber



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)
K0001	RSE Chamber	Rainford EMC	N/A	N/A	12 Jan 2017	12
A1834	Attenuator	Hewlett Packard	8491B	10444	30 Mar 2017	12
G0543	Amplifier	Sonoma	310N	230801	09 Dec 2016	6
M1273	Test Receiver	Rohde & Schwarz	ESIB26	100275	11 Apr 2017	12
A2903	Antenna	Schwarzbeck	VULB 9163	9163-944	06 May 2017	12
M1659	Thermohygrometer	JM Handelspunkt	30.5015.1 3	Not stated	02 Apr 2017	12
M127	Spectrum Analyser	Rohde & Schwarz	FSEB30	842659/016	08 Sep 2017	12
M1568	Magnetic Loop Antenna	Rohde & Schwarz	HFH2-Z2	879284/2	23 May 2017	12
M1956	Precision Steel Rule	Rabone	(64SR) 0- 35-406	4501361/2204	22 Apr 2020	60
A2686	Distance Measuring Wheel	Rolson Quality Tools	50799	Not stated	Calibrated before use	-
A2955	Protractor	Not marked or stated	97819075 50980	#1	Calibration not required	-

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

Test Engineer:	Stefan Ho	Test Date:	09 November 2016
Test Sample Serial Number:	Y21634C009		

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

Environmental Conditions:

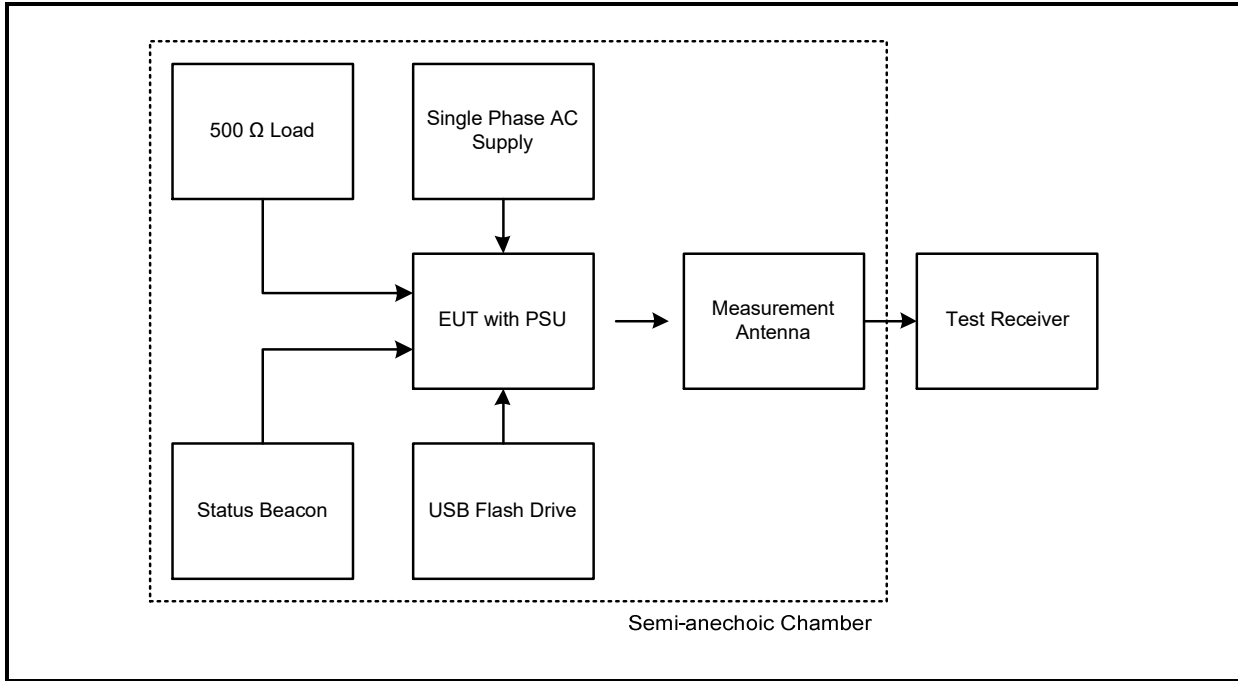
Temperature (°C):	20
Relative Humidity (%):	38

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 26 October 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 09 November 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. The measurement was performed in a semi-anechoic chamber at a distance of 3 metres. An RF level offset on the test receiver was used to replicate the fundamental field strength level measured at 3 metres and an additional -40 dB was incorporated to extrapolate the measured level to the required measurement distance of 30 metres.
3. The test receiver 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.

Transmitter Band Edge Radiated Emissions (continued)

Test setup:



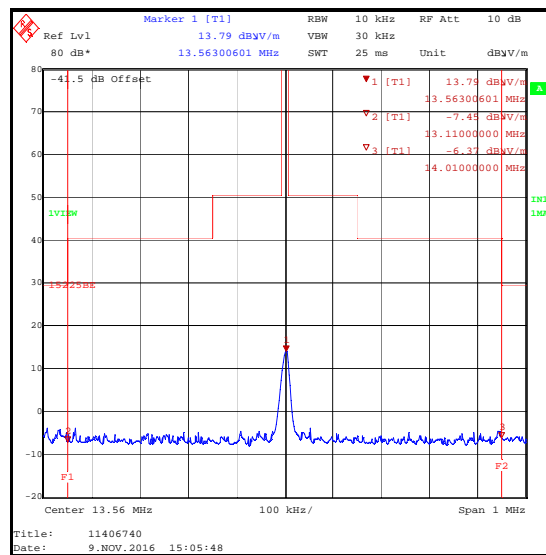
Transmitter Band Edge Radiated Emissions (continued)

Results: Peak / Lower Band Edge

Frequency (MHz)	Level (dB μ V/m)	Limit (dB μ V/m)	Margin (dB)	Result
13.11	-7.4	29.5	36.9	Complied

Results: Peak / Upper Band Edge

Frequency (MHz)	Level (dB μ V/m)	Limit (dB μ V/m)	Margin (dB)	Result
14.01	-6.4	29.5	35.9	Complied



Test Equipment Used:

Asset No.	Instrument	Manufacturer	Type No.	Serial No.	Date Calibration Due	Cal. Interval (Months)
M2014	Thermohygrometer	Testo	608-H1	45046246	10 Jun 2017	12
K0001	RSE Chamber	Rainford EMC	N/A	N/A	12 Jan 2017	12
M1568	Magnetic Loop Antenna	Rohde & Schwarz	HFH2-Z2	879284/2	23 May 2017	12
M1273	Test Receiver	Rohde & Schwarz	ESIB 26	100275	11 Apr 2017	12

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

Test Engineer:	Stefan Ho	Test Date:	28 October 2016
Test Sample Serial Number:	Y21634C009		

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

Environmental Conditions:

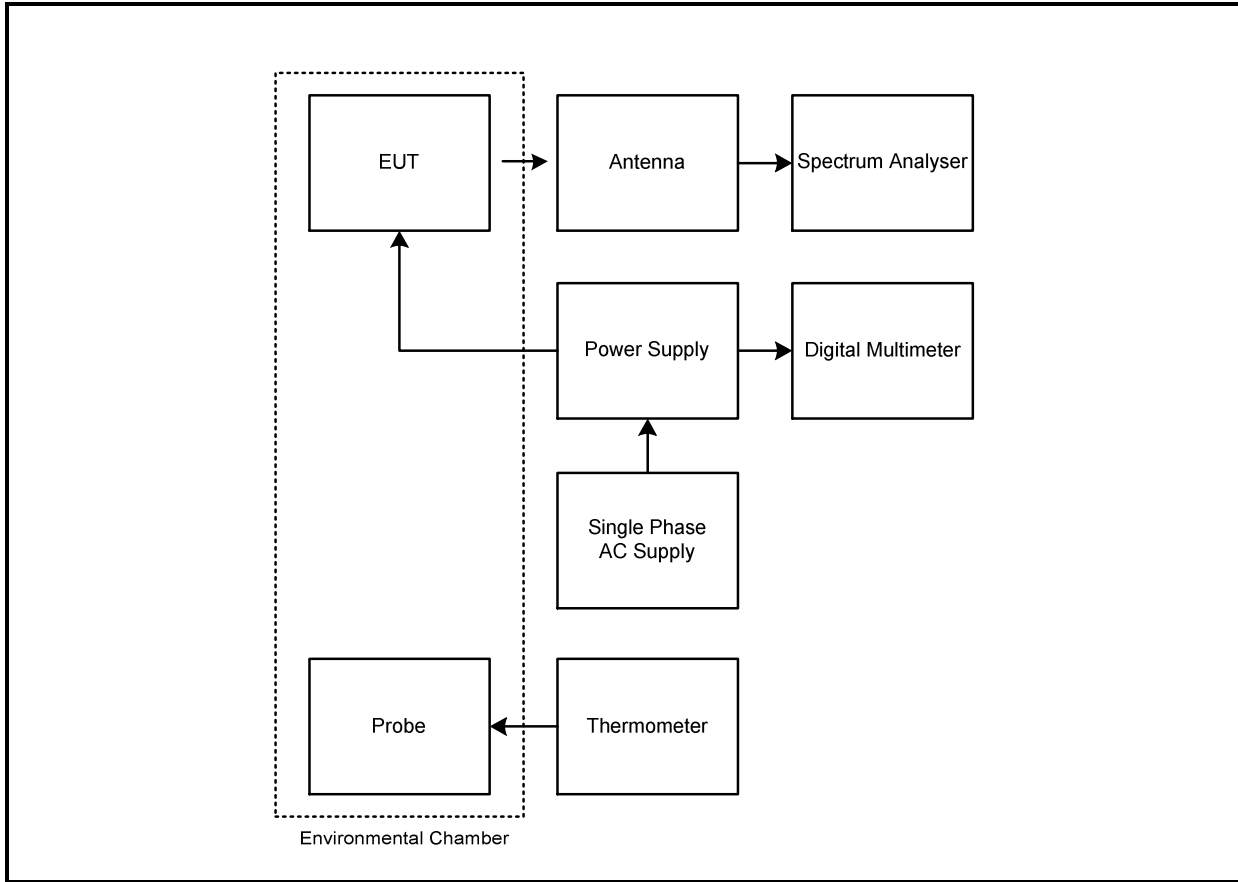
Ambient Temperature (°C):	26
Ambient Relative Humidity (%):	35

Note(s):

1. Testing at voltage extremes was performed with the EUT powered by a variable AC power supply. Temperature range tested was as stated in the User Manual, 5 °C to 45 °C.
2. Frequency stability measurements were performed with a modulated carrier. The measurements were performed using the spectrum analyser marker counter function. The marker counter function was set to 1 Hz before any measurements were performed.
3. Frequency error was measured using a calibrated Rohde & Schwarz spectrum analyser.
4. Temperature was monitored throughout the test with a calibrated digital thermometer.
5. Voltage was monitored throughout the test with a calibrated digital voltmeter.

Transmitter Frequency Stability (Temperature & Voltage Variation) (continued)

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
5	13.560002 MHz	13.560003 MHz	13.560003 MHz	13.560003 MHz
20	13.560030 MHz	13.560030 MHz	13.560065 MHz	13.560069 MHz
45	13.560087 MHz	13.560118 MHz	13.560141 MHz	13.560019 MHz

Frequency with Worst Case Deviation (MHz)	Frequency Error (Hz)	Frequency Error (%)	Limit (%)	Margin (%)	Result
13.560141	141	0.001040	0.01	0.008960	Complied

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

Supply Voltage (V)	Nominal Frequency (MHz)	Measured Frequency (MHz)	Frequency Error (Hz)	Frequency Error (%)	Limit (%)	Margin (%)	Result
102	13.56	13.560071	71	0.000524	0.01	0.009476	Complied
120	13.56	13.560030	30	0.000221	0.01	0.009779	Complied
138	13.56	13.560073	73	0.000538	0.01	0.009462	Complied

Test Equipment Used:

Asset No.	Instrument	Manufacturer	Type No.	Serial No.	Date Calibration Due	Cal. Interval (Months)
M1659	Thermohygrometer	JM Handelspunkt	30.5015.13	None stated	02 Apr 2017	12
E0513	Environmental Chamber	TAS	LT600	23900506	Calibrated before use	-
M1249	Thermometer	Fluke	52II	88800049	27 May 2017	12
S0539	Variable AC Power Supply	Kikusui	PCR 1000L	13010170	Calibrated before use	-
M1229	Multimeter	Fluke	179	87640015	21 Apr 2017	12
M127	Spectrum Analyser	Rohde & Schwarz	FSEB30	842659/016	08 Sep 2017	12
M1568	Magnetic Loop Antenna	Rohde & Schwarz	HFH2-Z2	879284/2	23 May 2017	12

6. Measurement Uncertainty

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

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

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

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

Measurement Type	Range	Confidence Level (%)	Calculated Uncertainty
AC Conducted Spurious Emissions	0.15 MHz to 30 MHz	95%	±4.69 dB
Frequency Stability	13 MHz to 14 MHz	95%	±1.62 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
2.0	5, 17, 22 & 29	-	Inserted references to FCC KDB 937606. Inserted Note in Section 2.3, Page 5

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 26 October 2016

Temperature: 14 °C to 18 °C

Relative Humidity: 60% to 74%

Ground conditions: Wet

Measurements at 3 and 30 metres

The test site was free from underground metal objects.

The EUT was powered at its nominal voltage from its power supply. The power supply was connected to a single phase supply from a portable generator. A power cable was run across the field to the EUT. An RCD was fitted to the power source. The generator was located 50 metres from the EUT and surrounded by radio absorbent material. For safety purposes, an RCD was fitted to the generator output.

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 test equipment was from a single phase 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 26 October 2016

Temperature: 14 °C to 18 °C

Relative Humidity: 60% to 74%

Ground conditions: Wet

Measurements at 300 metres

The test site was free from underground metal objects.

The EUT was powered at its nominal voltage from its power supply. The power supply was connected to a single phase supply from a portable generator. A power cable was run across the field to the EUT. An RCD was fitted to the power source. The generator was located 50 metres from the EUT and surrounded by radio absorbent material. For safety purposes, an RCD was fitted to the generator output.

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 test 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.

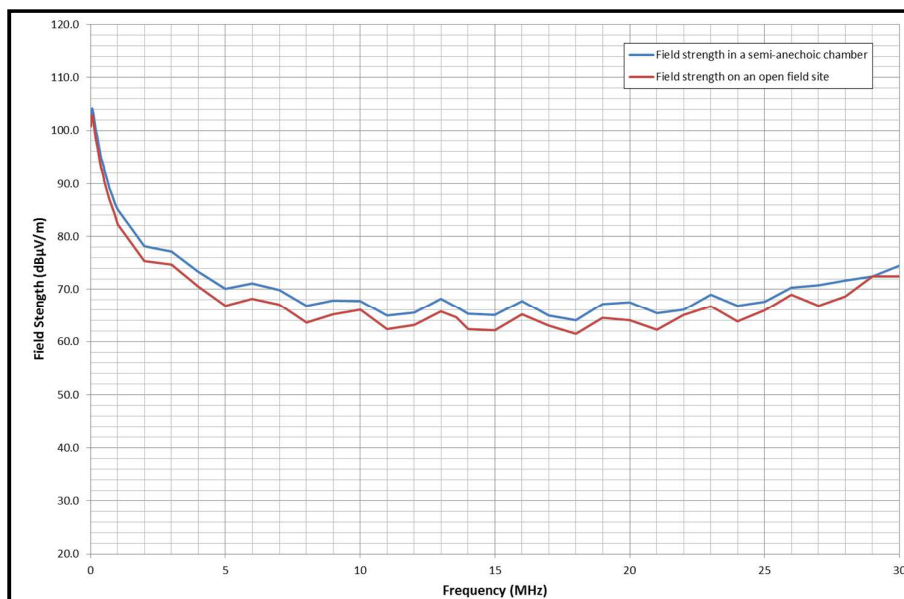
Initially, The EUT was rotated through 360 degrees in 60 degree steps at both measurement distances. The mag loop antenna was rotated through 90 degrees in 30 degree steps at every position the EUT was moved to. The EUT and mag loop antenna were then rotated in small increments in order to maximise emission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

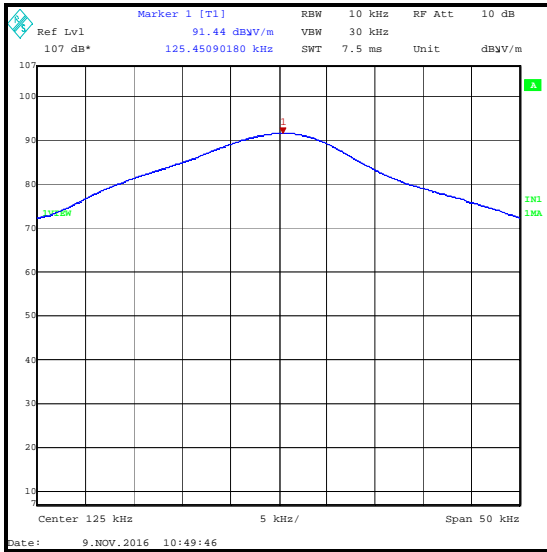
The centre of the magnetic loop antenna is placed exactly 3 metres from the reference unit. The reference unit is placed on a plastic table at a height of 0.8 metres above floor level and the centre of the mag loop antenna is 1 metre above the floor level. The mag loop antenna and reference unit are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

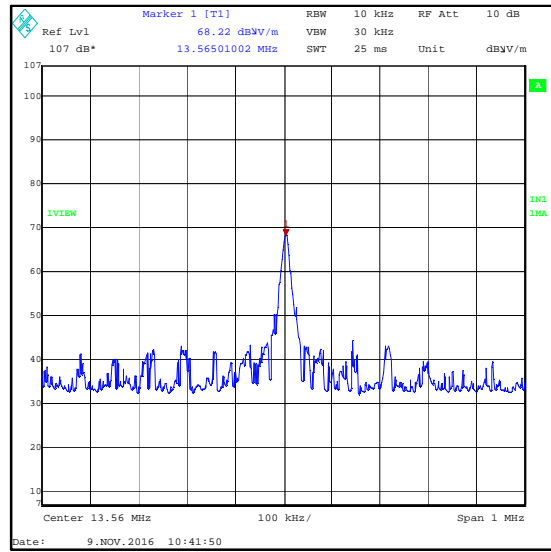
The internal verification procedure and verification plots are available for inspection on request.

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

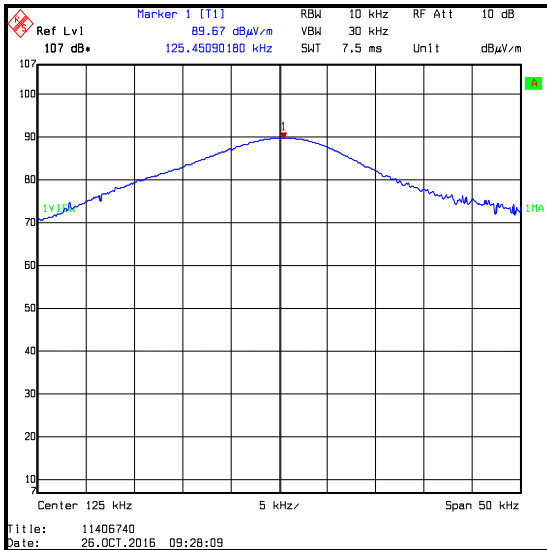
Verification plots of the two reference units at a measurement distance of 3 metres are shown on the following page. Plots were taken on an open field test site (26 October 2016) and in a semi-anechoic chamber (09 November 2016).



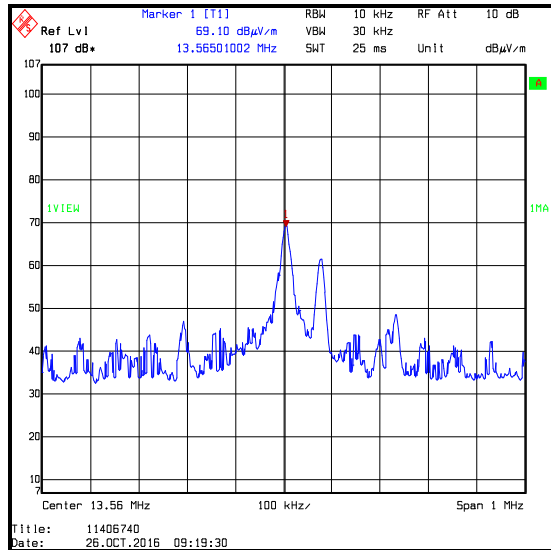
125 kHz reference unit signal at 3 metres in a semi-anechoic chamber on 09 November 2016



13.56 MHz reference unit signal at 3 metres in a semi-anechoic chamber on 09 November 2016



125 kHz reference unit signal at 3 metres on an open field test site on 26 October 2016

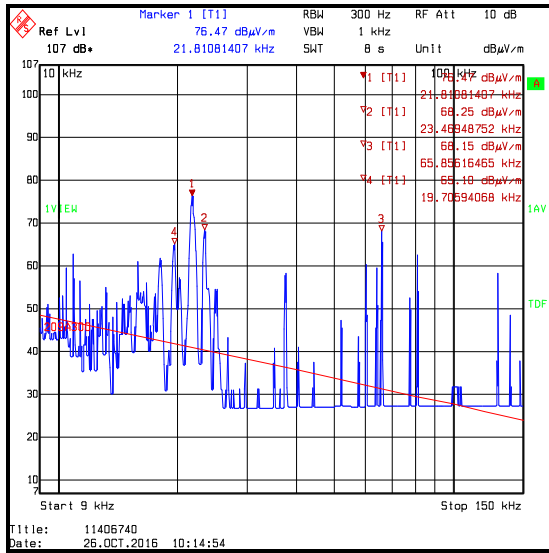


13.56 MHz reference unit signal at 3 metres on an open field test site on 26 October 2016

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.

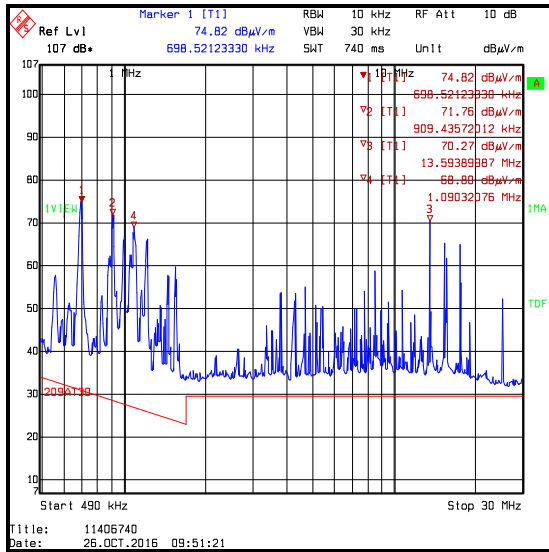
Background scans of the open field test site



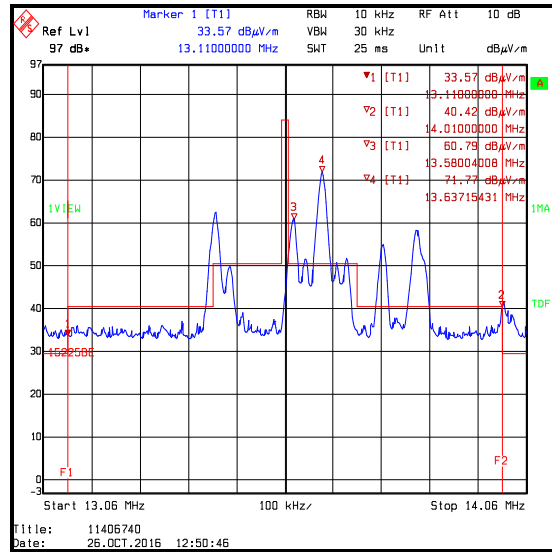
**Frequency range: 9 kHz to 150 kHz
Average detector / background scan**



**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 and generator (when used) were turned off when the background scans were performed.

--- END OF REPORT ---