Radio Test Report

Eccel Technology Ltd

RS485 Reader Module

000470

47 CFR Part 15.225 Effective Date 1st October 2019
DXX: Part 15 Low Power Communication Device transmitter
Test Date: 26th May 2020 to 1st June 2020
Report Number: 06-12022-1-20 Issue 01

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Certificate of Test 12022-1

The equipment noted below has been fully tested by R.N. Electronics Limited and, where appropriate, conforms to the relevant subpart of 47 CFR Part 15C. This is a certificate of test only and should not be confused with an equipment authorisation. Other standards may also apply.

Equipment:	RS485 Reader Module
Model Number:	000470
Unique Serial Number:	#1 (27h1 J8B crystal), #2 (25.120M 2012TJ crystal (IQD))
Applicant:	Eccel Technology Ltd 198 Station Road Glenfield Leicester Leicestershire LE3 8GT
Proposed FCC ID:	2ALHY1356NFC-FCC-IC
Full measurement results are detailed in Report Number:	06-12022-1-20 Issue 01
Test Standards:	47 CFR Part 15.225 Effective Date 1st October 2018 DXX: Part 15 Low Power Communication Device transmitter

NOTE:
Certain tests were not performed based upon manufacturer's declarations. Some tests were performed on the 25.120M 2012TJ crystal board to prove there was no difference in performance between the two boards, despite using different crystals, see relevant test section for details. For details refer to section 3 of this report.

DEVIATIONS:
No deviations have been applied.

This certificate relates only to the unit tested as identified by a unique serial number and in the condition at the time it was tested. It does not relate to any other similar equipment and performance of the product before or after the test cannot be guaranteed. Whilst every effort is made to assure quality of testing, type tests are not exhaustive and although no non-conformances may be found, this doesn't exclude the possibility of unit not meeting the intentions of the standard or the requirements of the Federal Regulations, particularly under different conditions to those during testing. Any compliance statements are made reliant on (a) the application of the product and use of the assigned band being acceptable to the FCC and (b) the modes of operation as instructed to us by the Customer based on their specific knowledge of the application and functionality of the EUT. Statements of compliance, where measurements were made, do not include the measurement uncertainty. The measurement uncertainty, where stated, is the expanded uncertainty based on a standard uncertainty multiplied by a coverage factor of k=2, providing a level of confidence of approximately 95%.

Date Of Test:	26th May 2020 to 1st June 2020
Test Engineer:	Digitally signed by: Ben Hodges DN: CN = Ben Hodges email = ben.hodges@rnelectronics.com C = GB O = RNElectronics Ltd OU = RNElectronics Ltd Date: 2020.08.19 15:55:42 Z
Approved By: Radio Approvals Manager	Digitally signed by: Daniel Sims DN: CN = Daniel Sims C = GB O = RN Electronics Ltd Date: 2020.08.19 15:33:33 Z
Customer Representative:	

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1 Contents

2 Equipment under test (EUT)

2.1 Equipment specification

Applicant	Eccel Technology Ltd 198 Station Road Glenfield Leicester Leicestershire LE3 8GT	
Manufacturer of EUT	Eccel Technology Ltd.	
Full Name of EUT	RS485 Reader Module	
Model Number of EUT	000470	
Serial Number of EUT	#1 (27h1 J8B crystal), #2 (25.120M 2012TJ crystal (IQD))	
Date Received	20th May 2020	
Date of Test:	26th May 2020 to 1st June 2020	
Purpose of Test	To demonstrate design compliance to the relevant rules of Chapter 47 of the Code of Federal Regulations.	
Date Report Issued	2nd June 2020	
Main Function	RFIC (NFC) reader writer module	
Information Specification	Height	75 mm
	Width	50 mm
	Depth	5 mm
	Weight	0.03 kg
	Voltage	4.25 - 5.75 VDC
	Current	200 mA

2.2 Configurations for testing

General Parameters	
EUT Normal use position	Module fitted inside host product
Choice of model(s) for type tests	Production Samples
Antenna details	Integral
Antenna port	No
Baseband Data port (yes/no)?	No
Highest Signal generated in EUT	27.12 MHz
Lowest Signal generated in EUT	13.56 MHz
Hardware Version	1
Software Version	Not declared
Firmware Version	1
Type of Equipment	RFID module
Technology Type	13.56 MHz RFID
Geo-location (yes/no)	No
TX Parameters	
Alignment range – transmitter	13.56 MHz (Single frequency)
EUT Declared Modulation Parameters	ISO/IEC 14443A
EUT Declared Power level	< 100mW
EUT Declared Signal Bandwidths	Not specified
EUT Declared Channel Spacing's	Single channel
EUT Declared Duty Cycle	100%
Unmodulated carrier available?	Yes
Declared frequency stability	<20 ppm
RX Parameters	
Alignment range – receiver	13.56 (Single frequency)
EUT Declared RX Signal Bandwidth	Not specified
FCC Parameters	
FCC Transmitter Class	DXX: Part 15 Low Power Communication Device transmitter

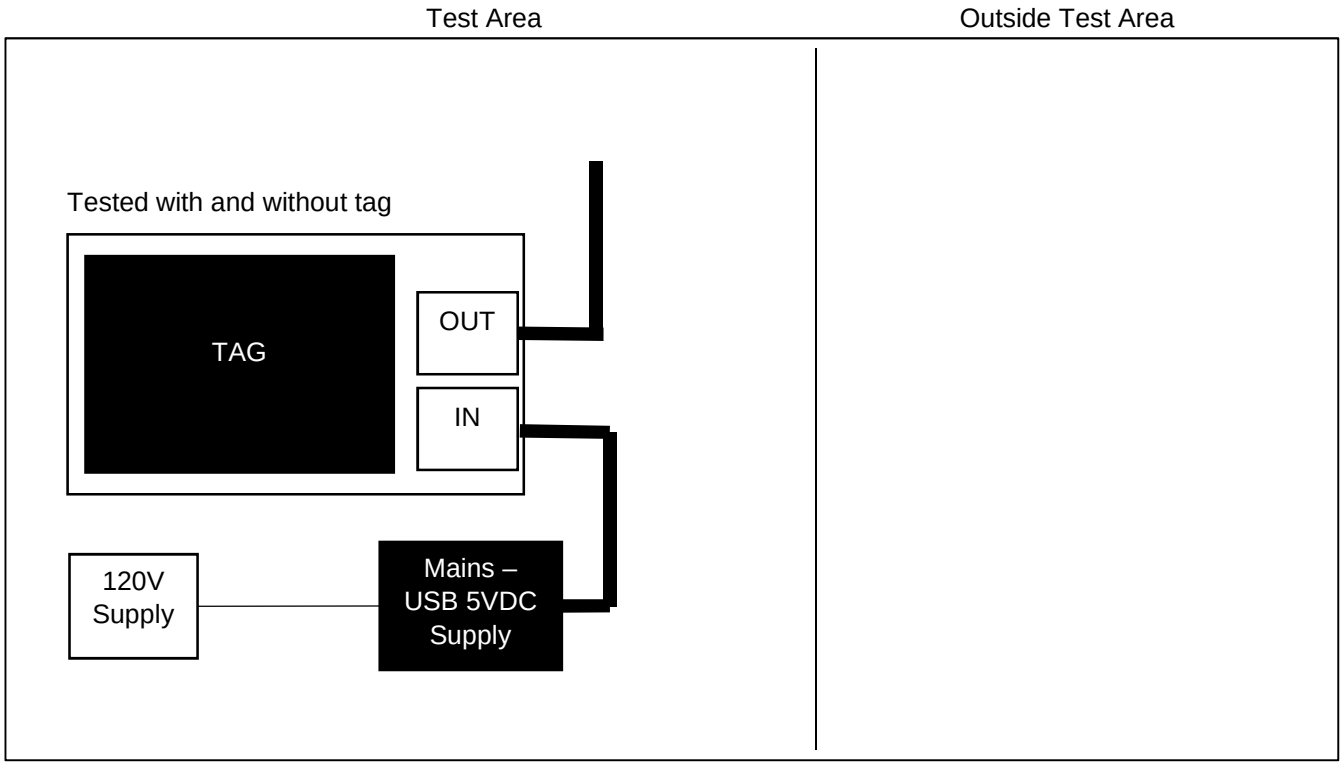
2.3 Functional description

The EUT is a 13.56MHz RFID read write module with RS485 interface. It acts as a slave peripheral within a customer's product. Its function is to read stored data from a passive NTag216 label and write data back to it under the control and direction of a host control unit instructed via a command set via RS485. It is powered by a 5V dc input supplied in the same cable as the RS485 signals. The cable is a twisted pair Ethernet cat 5 cable connecting to the EUT by a standard RJ45 connector.

2.4 Modes of operation

Mode Reference	Description	Used for testing
Tx (No Tag)	The EUT is polling every 10 ms awaiting presentation of an RFID tag	Yes
Tx (Tag Presented)	An RFID tag is presented to the EUT and the tags data is read continuously.	Yes

2.5 Emissions configuration



The EUT is an RFID tag reader intended to be fitted inside a host product. In the final application the host product provides power to the EUT and a connection is made to the data lines via the EUT's combined power / data socket (RJ45). The EUT was powered from a mains to USB adapter which supplied a DC voltage of 5 volts. For testing purposes the EUT was programmed by the manufacturer with engineering firmware. The manufacture also supplied a compatible RFID tag for use in tests. When the EUT was awaiting presentation of the RFID tag, the EUT would continuously transmit and receive at a 10 ms interval, when a tag was presented the EUT would read the tag repeatedly, polling every 35 ms. The EUT operated at a fixed frequency and was supplied by the manufacturer set to the maximum power level which would be available in the final product.

2.5.1 Signal leads

Port Name	Cable Type	Connected
RS485 IN/Power	RJ45 Cat 5	Yes
RS485 OUT/power	RJ45 Cat 5	Yes

3 Summary of test results

The RS485 Reader Module, 000470 was tested for compliance to the following standard(s) :

47 CFR Part 15.225 Effective Date 1st October 2019
DXX: Part 15 Low Power Communication Device Transmitter

Any compliance statements are made reliant on (a) the application of the product and use of the assigned band being acceptable to the FCC and (b) the modes of operation as instructed to us by the Customer based on their specific knowledge of the application and functionality of the EUT. Whilst every effort is made to assure quality of testing, type tests are not exhaustive and although no non-conformances may be found, this doesn't exclude the possibility of equipment not meeting the intentions of the standard or the essential requirements of the directive, particularly under different conditions to those during testing. Statements of compliance, where measurements were made, do not include the measurement uncertainty. The measurement uncertainty, where stated, is the expanded uncertainty based on a standard uncertainty multiplied by a coverage factor of k=2, providing a level of confidence of approximately 95%.

Title	References	Results
Transmitter Tests		
1. AC power line conducted emissions	47 CFR Part 15C Part 15.207	NOT APPLICABLE[1]
2. Radiated emissions 9 - 150 kHz	47 CFR Part 15C Part 15.209	NOT APPLICABLE[2]
3. Radiated emissions 150 kHz - 30 MHz	47 CFR Part 15C Part 15.209	PASSED
4. Radiated emissions 30 MHz -1 GHz	47 CFR Part 15C Part 15.225(d)	PASSED
5. Radiated emissions above 1 GHz	47 CFR Part 15C Part 15.209	NOT APPLICABLE[3]
6. Intentional radiator field strength	47 CFR Part 15C Part 15.225(a)	PASSED
7. Occupied bandwidth	47 CFR Part 15C Part 15.215	PASSED
8. Spectrum mask	47 CFR Part 15C Part 15.225	PASSED
9. Frequency stability	47 CFR Part 15C Part 15.225(e)	PASSED

[1] EUT does not currently have provisions to operate from the AC power lines. However, AC power line conducted emissions should be performed with the EUT in operation in its host product if that host product connects to the AC power lines.

[2] Lowest stated frequency is 13.56 MHz, Therefore this frequency range wasn't investigated.

[3] Radiated emissions measurements above 1 GHz are not required. The highest frequency generated or used within the equipment is 27.12 MHz, the 10th harmonic being 271.2 MHz.

4 Specifications

The tests were performed and operated in accordance with R.N. Electronics Ltd procedures and the relevant standards listed below.

4.1 Relevant standards

Ref.	Standard Number	Version	Description
4.1.1	47 CFR Part 15C	2019	Federal Communications Commission PART 15 – RADIO FREQUENCY DEVICES
4.1.2	ANSI C63.10	2013	American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices
4.1.3	ANSI C63.4	2014	American National Standard for Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz

4.2 Deviations

No deviations were applied.

4.3 Tests at extremes of temperature & voltage

The following test conditions were used to simulate testing at nominal or extremes.

Temperature Test Conditions		Voltage Test Conditions	
T nominal	20 °C	V nominal	5V DC
T minimum	-20 °C	V minimum	4.25V DC
T maximum	50 °C	V maximum	5.75V DC

Extremes of voltage are based on nominal +/- 15 %.
Extremes of temperature are based on FCC 15.225 requirements.
The ambient test conditions of humidity and pressure in the laboratory were as specified in each specific test section within this report

4.4 Test fixtures

In order to measure RF parameters at temperature extremes, the EUT was tested in a temperature controlled chamber as follows:

A test fixture was used for testing.

5 Tests, methods and results

5.1 AC power line conducted emissions

NOT APPLICABLE: EUT does not currently have provisions to operate from the AC power lines. However AC power line conducted emissions should be performed with the EUT in operation in its host product if that host product connects to the AC power lines.

5.2 Radiated emissions 9 - 150 kHz

NOT APPLICABLE: Lowest stated frequency is 13.56 MHz, Therefore this frequency range wasn't investigated.

5.3 Radiated emissions 150 kHz - 30 MHz

5.3.1 Test methods

Test Requirements:	47 CFR Part 15C Part 15.209 [Reference 4.1.1 of this report]
Test Method:	ANSI C63.10 Clause 6.4 [Reference 4.1.2 of this report]
Limits:	47 CFR Part 15C Part 15.225(d) [Reference 4.1.1 of this report]

5.3.2 Configuration of EUT

The EUT was placed on a 0.8 metres high turntable. The front edge of the EUT was initially positioned facing the antenna. The EUT was measured at a distance of 3 metres. The antenna was orientated in both Parallel and Perpendicular polarisations. The EUT was rotated in all three orthogonal planes. Radiated Emissions testing was performed with the EUT powered from AC mains to USB adapter. The EUT was operated in Tx (No Tag) and Tx (Tag Presented) mode.

5.3.3 Test procedure

Tests were made in accordance with FCC Part 15 using the measuring equipment noted below. Measurements were made in a semi-anechoic chamber (pre-scan) with any final measurements required performed on an OATS without a ground plane. The antenna was placed 1m above the ground. The equipment was rotated 360 degrees to record the worst case emissions.

Tests were performed using Test Site H and OATS.

5.3.4 Test equipment

ZSW1, E534, E535, TMS81

See Section 9 for more details

5.3.5 Test results

Temperature of test environment	20°C
Humidity of test environment	55%
Pressure of test environment	102kPa

Band (Single channel)	13.56 MHz
Power Level	Maximum
Channel Spacing	Single channel
Mod Scheme	ISO14443A Tx (No Tag)

Plot refs
12022-1 Rad 1 150k-30MHz Para
12022-1 Rad 1 150k-30MHz Perp

Band (Single channel)	13.56 MHz
Power Level	Maximum
Channel Spacing	Single channel
Mod Scheme	ISO14443A Tx (Tag Presented)

Plot refs
12022-1 Rad 2 150k-30MHz Para
12022-1 Rad 2 150k-30MHz Perp

Peak detector “Max held” Analyser plots against the Quasi-Peak / Average limit line(s) can be found in Section 6 of this report.

Note: A second EUT containing an identical specification crystal oscillator (but different manufacturer) crystal oscillator 25.120M 2012TJ, was checked to prove emissions did not change, there was no difference observed between EUT’s, therefore testing was continued on a single board with the 27h1 J8B crystal.

LIMITS:
15.209 limits are applicable in the restricted bands of 15.205 with the relevant detector.

n.b. the general limits of 15.209 are as drawn on the respective plots.

These results show that the EUT has PASSED this test.

The uncertainty gives a 95% confidence interval in the measurement. Expanded uncertainty (K=2) is as follows:

9kHz - 30MHz ±3.9dB

5.4 Radiated emissions 30 MHz -1 GHz

5.4.1 Test methods

Test Requirements:	47 CFR Part 15C Part 15.225(d) [Reference 4.1.1 of this report]
Test Method:	ANSI C63.10 Clause 6.4 [Reference 4.1.2 of this report]
Limits:	47 CFR Part 15C Part 15.225(d) [Reference 4.1.1 of this report]

5.4.2 Configuration of EUT

The EUT was placed on a 0.8 metres high turntable. The front edge of the EUT was initially positioned facing the antenna. The EUT was measured at a distance of 3 metres. The EUT was rotated in all three orthogonal planes. Radiated Emissions testing was performed with EUT powered from AC mains to USB adapter. The EUT was operated in Tx (No Tag) and Tx (Tag Presented) mode.

5.4.3 Test procedure

Tests were made in accordance with FCC Part 15 using the measuring equipment noted below. Measurements were made in a semi-anechoic chamber. The antenna was height scanned between 1 and 4metres and the equipment was rotated 360 degrees to record the worst case emissions. Both Horizontal and vertical polarisations of measuring antenna were tested.

At least 6 signals within 20dB and all signals within 10dB of the limit were investigated.

Tests were performed in Test Site H

5.4.4 Test equipment

NSA-H, ZSW1, E534, E535, E914, E745

See Section 9 for more details

5.4.5 Test results

Temperature of test environment	19°C
Humidity of test environment	51%
Pressure of test environment	102kPa

Band (Single channel)	13.56 MHz
Power Level	Maximum
Channel Spacing	Single channel
Mod Scheme	ISO14443A Tx (No Tag)

Plot refs
12022-1 Rad 1 VHF Horiz
12022-1 Rad 1 VHF Vert
12022-1 Rad 1 UHF Horiz
12022-1 Rad 1 UHF Vert

Band (Single channel)	13.56 MHz
Power Level	Maximum
Channel Spacing	Single channel
Mod Scheme	ISO14443A Tx (Tag Presented)

Plot refs
12022-1 Rad 2 VHF Horiz
12022-1 Rad 2 VHF Vert
12022-1 Rad 2 UHF Horiz
12022-1 Rad 2 UHF Vert

Table of signals measured for Rad 1 Horizontal Sig List (No Tag)

Signal No.	Freq (MHz)	Peak Amp (dBuV/m)	QP Amp (dBuV/m)	QP -Lim (dB)
No emissions within 20 dB of the limit observed.				

Table of signals measured for Rad 1 Vertical Sig List (No Tag)

Signal No.	Freq (MHz)	Peak Amp (dBuV/m)	QP Amp (dBuV/m)	QP -Lim (dB)
1	46.732	26.6	20.3	-19.7
2	57.517	28.7	21.2	-18.8
3	70.716	24.5	17.9	-22.1
4	80.840	24.2	17.1	-22.9
5	86.481	26.0	18.4	-21.6

Table of signals measured for Rad 2 Horizontal Sig List (Tag)

Signal No.	Freq (MHz)	Peak Amp (dBuV/m)	QP Amp (dBuV/m)	QP -Lim (dB)
1	40.681	32.8	29.9	-10.1
2	67.801	26.9	23.0	-17.0
3	94.917	26.6	23.0	-20.5
4	122.041	25.4	21.7	-21.8
5	149.161	23.7	19.8	-23.7

Table of signals measured for Rad 2 Vertical Sig List (Tag)

Signal No.	Freq (MHz)	Peak Amp (dBuV/m)	QP Amp (dBuV/m)	QP -Lim (dB)
1	40.680	40.4	39.1	-0.9
2	43.179	26.8	19.7	-20.3
3	70.809	23.2	16.4	-23.6
4	80.145	22.4	16.0	-24.0

Peak detector “Max held” Analyser plots against the Quasi-Peak / Average limit line(s) can be found in Section 6 of this report.

Note: A second EUT containing an identical specification crystal oscillator (but different manufacturer), crystal oscillator 25.120M 2012TJ, was checked to prove emissions did not change, there was no difference observed between EUT’s, therefore testing was continued on a single board with the 27h1 J8B crystal.

LIMITS:
15.209 limits are applicable in the restricted bands of 15.205 with the relevant detector.

n.b. the general limits of 15.209 are as drawn on the respective plots.

These results show that the EUT has PASSED this test.

The uncertainty gives a 95% confidence interval in the measurement. Expanded uncertainty (K=2) is as follows:

30MHz - 1000MHz ±6.1dB

5.5 Radiated emissions above 1 GHz

NOT APPLICABLE: Radiated emissions measurements above 1 GHz are not required. The highest frequency generated or used within the equipment is 27.12 MHz, the 10th harmonic being 271.2 MHz

5.6 Intentional radiator field strength

5.6.1 Test methods

Test Requirements: 47 CFR Part 15C Part 15.225(a) [Reference 4.1.1 of this report]
Test Method: ANSI C63.10 Clause 6.4 [Reference 4.1.2 of this report]
Limits: 47 CFR Part 15C Part 15.225(a) [Reference 4.1.1 of this report]

5.6.2 Configuration of EUT

The EUT was placed on a 0.8 metres high turntable. The front edge of the EUT was initially positioned facing the antenna. The EUT was measured at a distance of 3 metres. The antenna was orientated in both Parallel and Perpendicular polarisations. The EUT was rotated in all three orthogonal planes. The EUT was operated in Tx (No Tag) and Tx (Tag Presented) mode.

5.6.3 Test procedure

Tests were made in accordance with FCC Part 15 using the measuring equipment noted below. Measurements were made in a semi-anechoic chamber and on an OATS. This site is listed with the FCC The equipment and the antenna were rotated 360 degrees to record the maximised emission.

Tests were performed using Test Site H and OATS.

5.6.4 Test equipment

ZSW1, E534, E535, TMS81

See Section 9 for more details

5.6.5 Test results

Temperature of test environment	20°C
Humidity of test environment	55%
Pressure of test environment	104kPa

Band (Single channel)	13.56 MHz
Power Level	Maximum
Channel Spacing	Single channel
Mod Scheme	ISO14443A Tx (No Tag)

	Single channel
Peak Level (dBµV/m @3m)	**68.1**
Plot reference	12022-1 Field strength Site OATS Side Parallel No Tag
Antenna Polarisation	Parallel
EUT Polarisation	Side

Highest field strength was measured with EUT in its side position and the loop antenna in the parallel position. 3 metre distance was used. A 40 dB extrapolation factor as per FCC was used to convert the field strength to 30 metres. This gives a field strength result of 28.1 dBuV/m at 30 metres. Any analyser plots can be found in section 6 of this report.

Band (Single channel)	13.56 MHz
Power Level	Maximum
Channel Spacing	Single channel
Mod Scheme	ISO14443A Tx (Tag Presented)

	Single channel
Peak Level (dBµV/m @ 3m)	**65.6**
Plot reference	12022-1 Field strength Site OATS Side Parallel Tag
Antenna Polarisation	Parallel
EUT Polarisation	Side

Highest field strength was measured with EUT in its side position and the loop antenna in the parallel position. 3 metre distance was used. A 40 dB extrapolation factor as per FCC was used to convert the field strength to 30 metres. This gives a field strength result of 25.6dBuV/m at 30 metres. Any analyser plots can be found in section 6 of this report.

Analyser plots can be found in Section 6 of this report.

Note: A second EUT containing an identical specification crystal oscillator (but different manufacturer), crystal oscillator 25.120M 2012TJ, was checked to prove field strength level did not change, there was no difference observed between EUT's, therefore testing was continued on a single board with the 27h1 J8B crystal.

LIMITS:
15.225(a) QP/Peak = the field strength of any emissions within the band 13.553-13.567 MHz shall not exceed 15,848 µV/m @ 30m = 84 dBµV/m @ 30m.

These results show that the EUT has PASSED this test.

The uncertainty gives a 95% confidence interval in the measurement. Expanded uncertainty (K=2) is as follows:
<± 3.9 dB

5.7 Occupied bandwidth

5.7.1 Test methods

Test Requirements:	47 CFR Part 15C Part 15.215 [Reference 4.1.1 of this report]
Test Method:	ANSI C63.10 Clause 6.9 [Reference 4.1.2 of this report]
Limits:	47 CFR Part 15C Part 15.215 [Reference 4.1.1 of this report]

5.7.2 Configuration of EUT

The EUT was placed on a 0.8 metres high turntable. The front edge of the EUT was initially positioned facing the antenna. The EUT was measured at a distance of 3 metres. The EUT was tested whilst connected to the AC mains to USB adapter. The EUT was operated in Tx (No Tag) and Tx (Tag Presented) mode.

5.7.3 Test procedure

Tests were made in accordance with FCC Part 15 using the measuring equipment noted below. A 10 kHz RBW, 3x VBW, auto sweep time and max hold settings were used for the 20 dB bandwidth.
Tests were performed using Test Site H.

5.7.4 Test equipment

ZSW1, E534, E535, TMS81

See Section 9 for more details

5.7.5 Test results

Temperature of test environment	20°C
Humidity of test environment	55%
Pressure of test environment	103kPa

Band (Single channel)	13.56 MHz
Power Level	Maximum
Channel Spacing	Single channel
Mod Scheme	ISO14443A Tx (No Tag)

	Single channel
20 dB Bandwidth (kHz) Nominal Temp & Volts	104.2
Plot for 20 dB Bandwidth (kHz) Nominal Temp & Volts	12022-1 OBW no tag

Band (Single channel)	13.56 MHz
Power Level	Maximum
Channel Spacing	Single channel
Mod Scheme	ISO14443A Tx (Tag Presented)

	Single channel
20 dB Bandwidth (kHz) Nominal Temp & Volts	444.2
Plot for 20 dB Bandwidth (kHz) Nominal Temp & Volts	12022-1 OBW Tag

Analyser plots can be found in Section 6 of this report.

LIMITS:
No limits apply however, per 15.215, the 20dB bandwidth of the emission is to remain within the band over expected variations in temperature and supply voltage. It is recommended that the fundamental emission be kept within at least the central 80% of the permitted band in order to minimise the possibility of out-of-band operation.

These results show that the EUT has PASSED this test.

The uncertainty gives a 95% confidence interval in the measurement. Expanded uncertainty (K=2) is as follows:
<± 1.9 %

5.8 Spectrum mask

5.8.1 Test methods

Test Requirements:	47 CFR Part 15C Part 15.225 [Reference 4.1.1 of this report]
Test Method:	ANSI C63.10 Clause 6.4 [Reference 4.1.2 of this report]
Limits:	47 CFR Part 15C Part 15.225(a)/(b)/(c)/(d) [Reference 4.1.1 of this report]

5.8.2 Configuration of EUT

The EUT was placed on a 0.8 metres high turntable. The EUT was measured at a distance of 3 metres. The EUT and antenna were positioned for maximum field strength and referenced to the field strength measured on the OATS. The EUT was operated in Tx (No Tag) and Tx (Tag Presented) mode.

5.8.3 Test procedure

Tests were made in accordance with FCC Part 15 using the measuring equipment noted below. Plots were taken and results were referenced to limits at 30m by using the extrapolation factor of 40dB/decade, per ANSI C63.10 clause 6.4

Measurements were made at Site H. This site is listed with the FCC.

5.8.4 Test equipment

ZSW1, E534, E535, TMS81

See Section 9 for more details

5.8.5 Test results

Temperature of test environment	20°C
Humidity of test environment	55%
Pressure of test environment	103kPa

Band (Single channel)	13.56 MHz
Power Level	Maximum
Channel Spacing	Single channel
Mod Scheme	ISO14443A Tx (No Tag)

	Single channel
Nominal, Maximised RF Output / field strength dBuV/m @ 30m	28.1
Nominal plot reference	12022-1 Spectrum mask @ 30 metres - No Tag

Band (Single channel)	13.56 MHz
Power Level	Maximum
Channel Spacing	Single channel
Mod Scheme	ISO14443A Tx (Tag Presented)

	Single channel
Nominal, Maximised RF Output / field strength dBuV/m @ 30m	25.6
Nominal plot reference	12022-1 Spectrum mask @ 30 metres - Tag Presented

Analyser plots can be found in Section 6 of this report.

LIMITS:

15.225(a) QP/Peak = the field strength of any emissions within the band 13.553-13.567 MHz shall not exceed 15,848 µV/m @ 30m = 84 dBµV/m @ 30m.
15.225(b) QP/Peak = within the bands 13.410-13.553 MHz and 13.567-13.710 MHz, the field strength of any emissions shall not exceed 334 µV/m @ 30m = 50.5 dBµV/m @ 30m.
15.225(c) QP/Peak = within the bands 13.110-13.410 MHz and 13.710-14.010 MHz the field strength of any emissions shall not exceed 106 µV/m @ 30m = 40.5 dBµV/m @ 30m.
15.225(d) QP/Peak = outside of the 13.110-14.010 MHz band shall not exceed the general radiated emissions limits of 15.209.

These results show that the EUT has PASSED this test.

The uncertainty gives a 95% confidence interval in the measurement. Expanded uncertainty (K=2) is as follows: <± 4.1 dB

5.9 Frequency stability

5.9.1 Test methods

Test Requirements: 47 CFR Part 15C Part 15.225(e) [Reference 4.1.1 of this report]
Test Method: ANSI C63.10 Clause 6.8 [Reference 4.1.2 of this report]
Limits: 47 CFR Part 15C Part 15.225(e) [Reference 4.1.1 of this report]

5.9.2 Configuration of EUT

The EUT's power port was connected to a variable power supply. This allowed the voltage to be set as per the manufacturer's declaration.
The EUT was placed in a temperature controlled chamber. The EUT emissions were observed by means of a test fixture. The EUT was operated in Tx (No Tag) and Tx (Tag Presented) mode.

5.9.3 Test procedure

Tests were made in accordance with FCC Part 15 using the measuring equipment noted below.
Temperature stability was achieved at each test level before taking measurements. A frequency count was made on the peak of the measured signal. At nominal temperature the EUT supply was varied by +/-15% to manufacturer's end points.
A max-held spectrum analyser was used to monitor the frequency of the carrier. The analyser was set with a suitable span, RBW and VBW to allow for a measurement resolution of 1Hz.
Tests were performed using Test Site A.

5.9.4 Test equipment

E227, E642, N579, TMS38

See Section 9 for more details

5.9.5 Test results

Temperature of test environment	23°C
Humidity of test environment	30%
Pressure of test environment	104kPa

Band (Single Channel)	13.56 MHz
Power Level	Maximum
Channel Spacing	Single channel
Mod Scheme	ISO14443A Tx (No Tag)

Test conditions		Frequency Error (MHz) Single channel
-20°C	Volts Nominal (5)	13.560146
-10°C	Volts Nominal (5)	13.560160
0°C	Volts Nominal (5)	13.560153
10°C	Volts Nominal (5)	13.560166
20°C	Volts Minimum (4.25)	13.560125
	Volts Nominal (5)	13.560109
	Volts Maximum (5.75)	13.560086
30°C	Volts Nominal (5)	13.560103
40°C	Volts Nominal (5)	13.560091
50°C	Volts Nominal (5)	13.560071
Max Frequency Error per chan (Hz)		+57 / -38
Max Frequency Error observed (Hz)		57

Note: Error shown is referenced to nominal temp nominal voltage EUT measurement value.

Band (Single channel)	13.56 MHz
Power Level	Maximum
Channel Spacing	Single channel
Mod Scheme	ISO14443A Tx (Tag Presented)

Test conditions		Frequency Error (MHz) Single channel
-20°C	Volts Nominal (5)	13.560149
-20°C	Volts Nominal (5)	13.560149
-10°C	Volts Nominal (5)	13.560139
0°C	Volts Nominal (5)	13.560185
10°C	Volts Nominal (5)	13.560134
20°C	Volts Minimum (4.25)	13.560099
	Volts Nominal (5)	13.560080
	Volts Maximum (5.75)	13.560095
30°C	Volts Nominal (5)	13.560127
40°C	Volts Nominal (5)	13.560120
50°C	Volts Nominal (5)	13.560075
Max Frequency Error per chan (Hz)		+105 / -5
Max Frequency Error observed (Hz)		103

Note: Error shown is referenced to nominal temp nominal voltage EUT measurement value.

Maximum variation observed was 103 Hz

Note: A second EUT containing an identical specification crystal oscillator (but different manufacturer), crystal oscillator 25.120M 2012TJ, was checked to prove frequency error did not change, there was no difference observed between EUT's, therefore testing was continued on a single board with the 27h1 J8B crystal.

LIMITS:
+/- 0.01%. (+/- 1356 Hz)

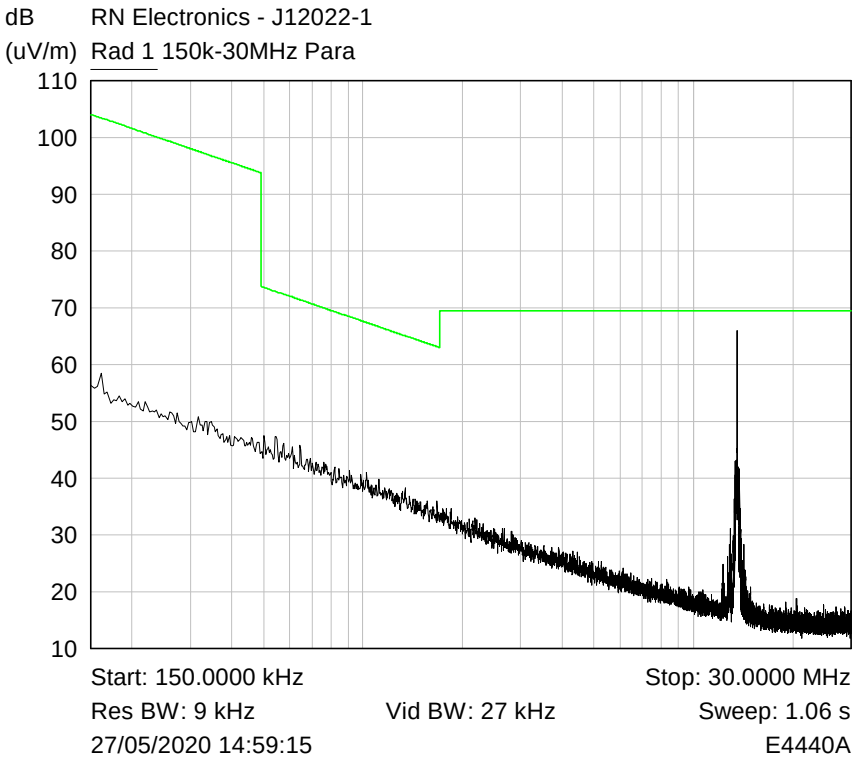
These results show that the EUT has PASSED this test.

The uncertainty gives a 95% confidence interval in the measurement. Expanded uncertainty (K=2) is as follows:
<± 0.7 ppm

6 Plots/Graphical results

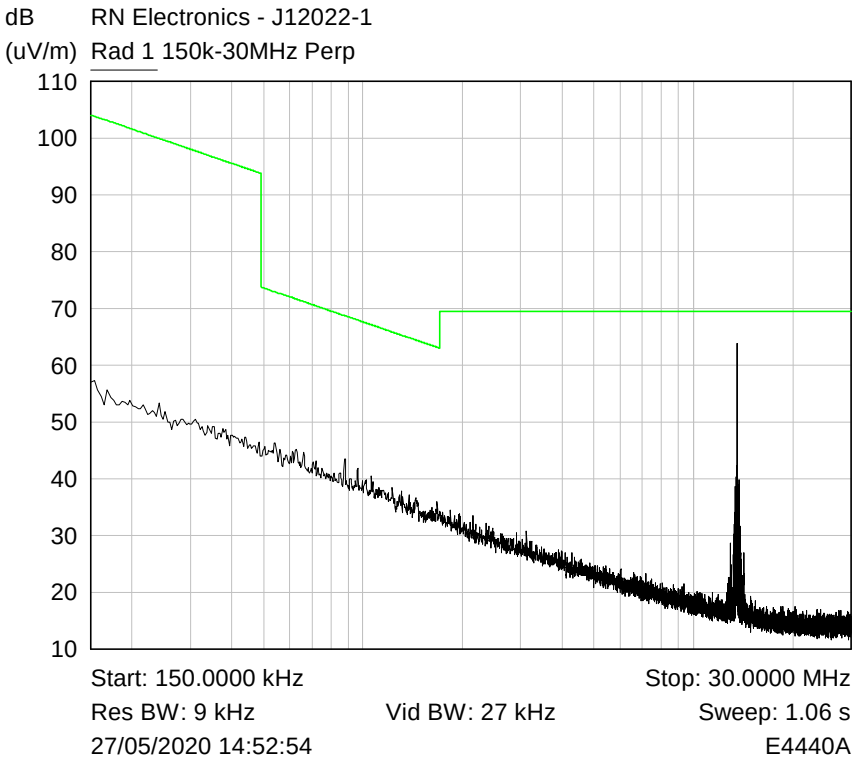
6.1 Radiated emissions 150 kHz - 30 MHz

RF Parameters: Band (Single channel): 13.56 MHz, Power: Maximum, Channel Spacing: Single channel, Modulation: ISO14443A Tx (No Tag), Channel 13.56 MHz



Plot of 150kHz-30MHz Parallel

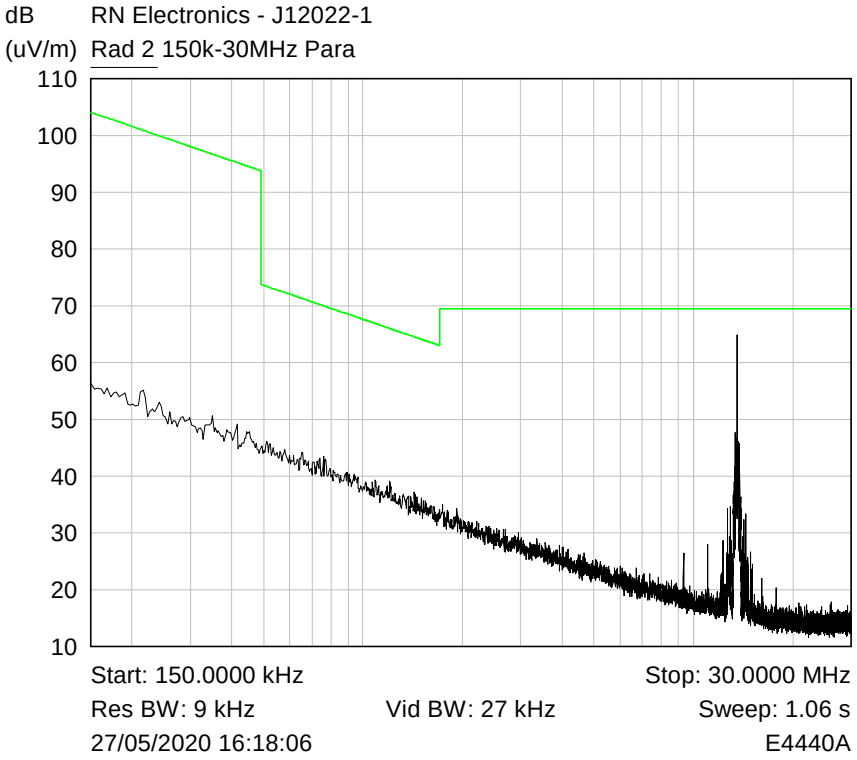
Note: The emission seen is the fundamental and therefore wasn't measured.



Plot of 150kHz-30MHz Perpendicular

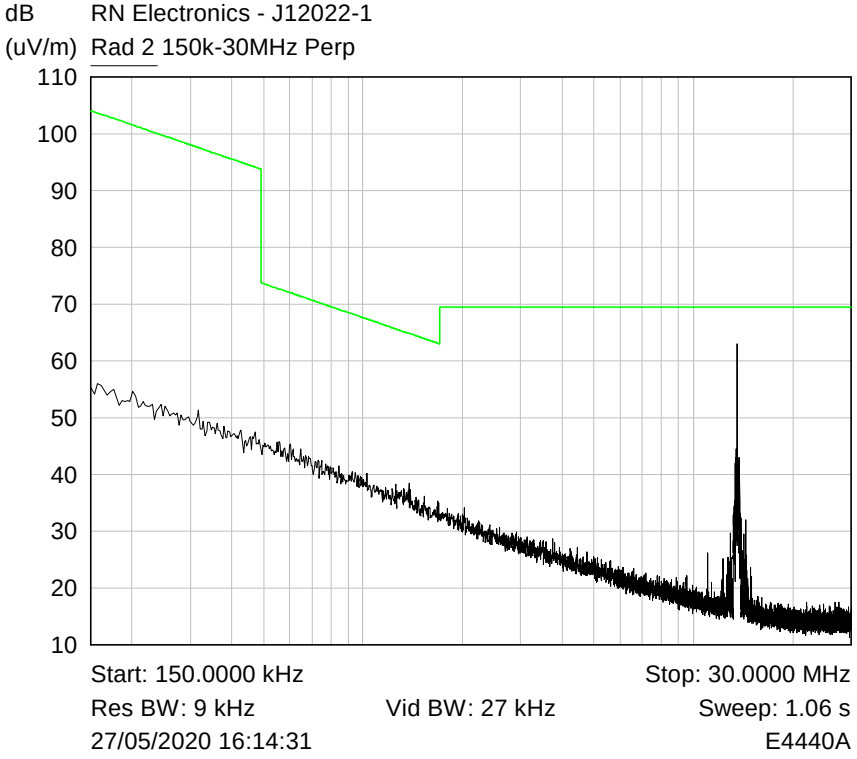
Note: The emission seen is the fundamental and therefore wasn't measured.

RF Parameters: Band (Single channel): 13.56 MHz, Power: Maximum, Channel Spacing: Single channel, Modulation: ISO14443A Tx (Tag Presented), Channel 13.56 MHz



Plot of 150kHz-30MHz Parallel

Note: The emission seen is the fundamental and therefore wasn't measured.

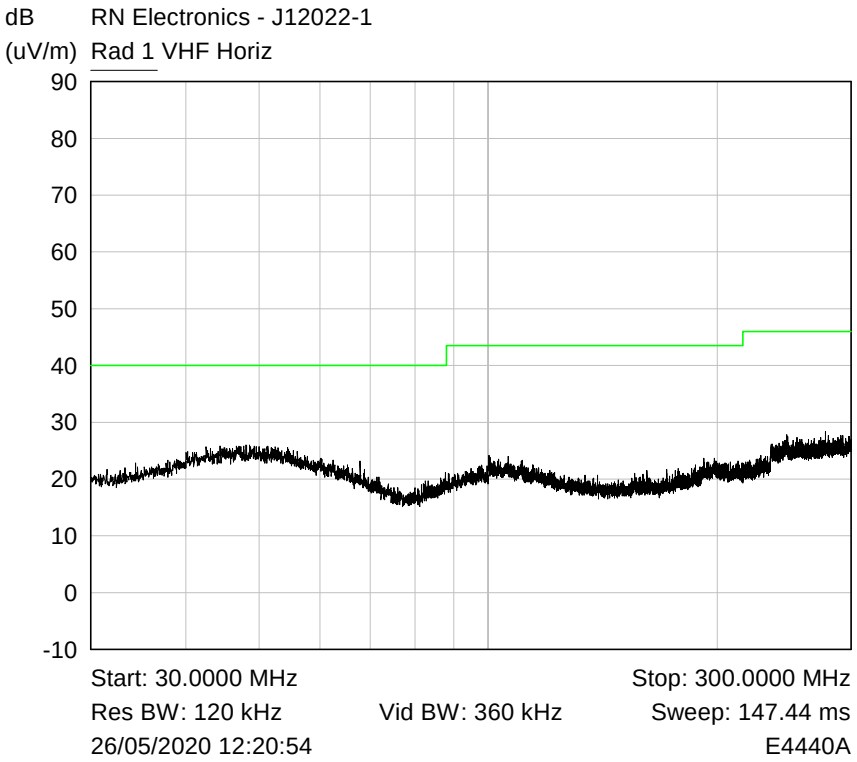


Plot of 150kHz-30MHz Perpendicular

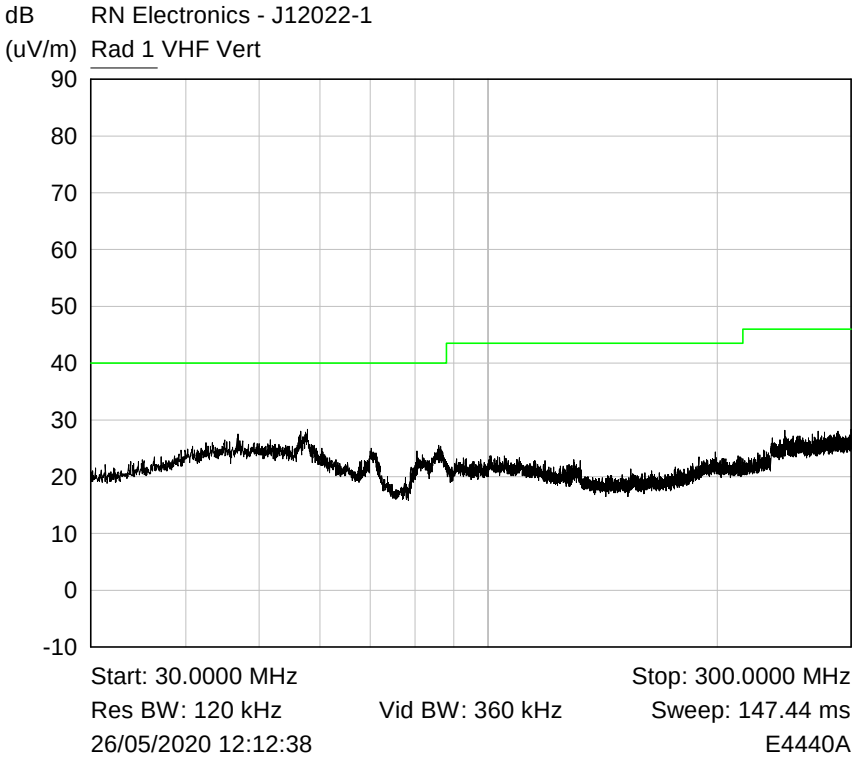
Note: The emission seen is the fundamental and therefore wasn't measured.

6.2 Radiated emissions 30 MHz -1 GHz

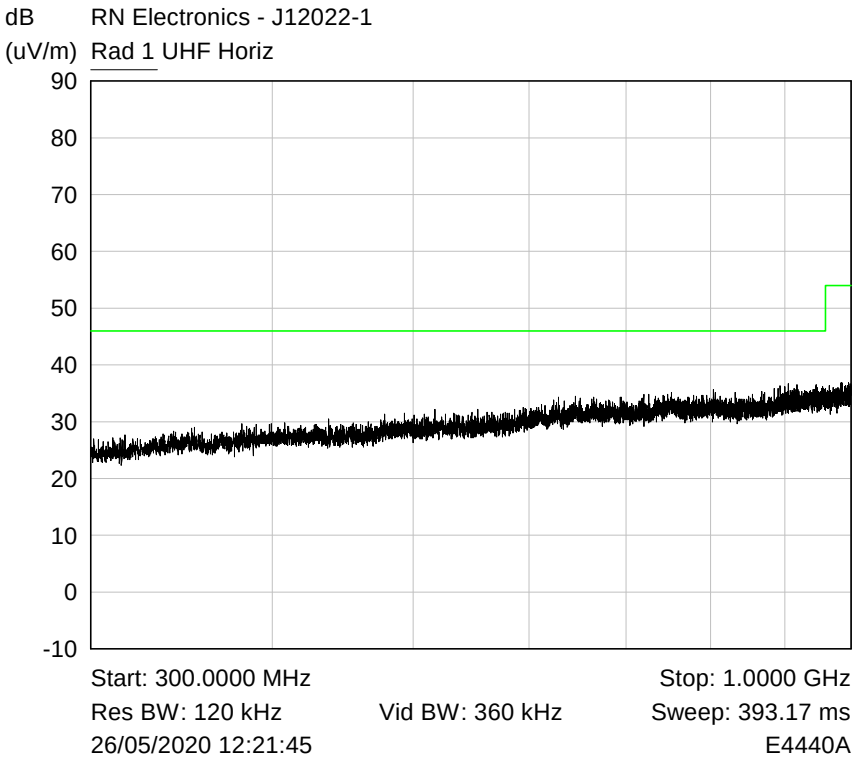
RF Parameters: Band (Single channel): 13.56 MHz, Power: Maximum, Channel Spacing: Single channel, Modulation: ISO14443A Tx (No Tag), Channel 13.56 MHz



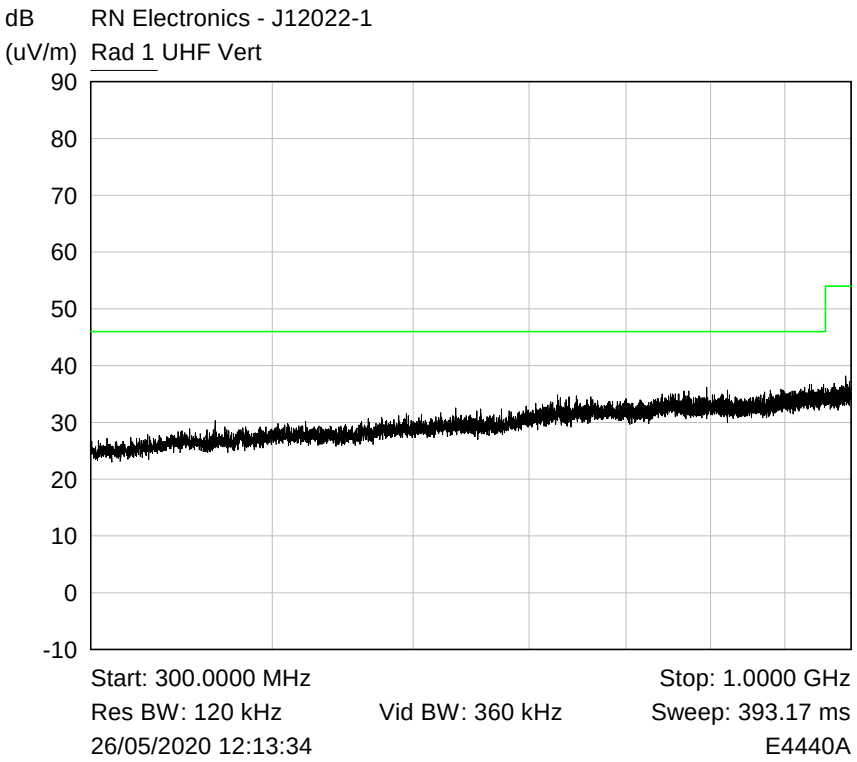
Plot of Peak emissions for VHF Horizontal against the QP limit line.



Plot of Peak emissions for VHF Vertical against the QP limit line.

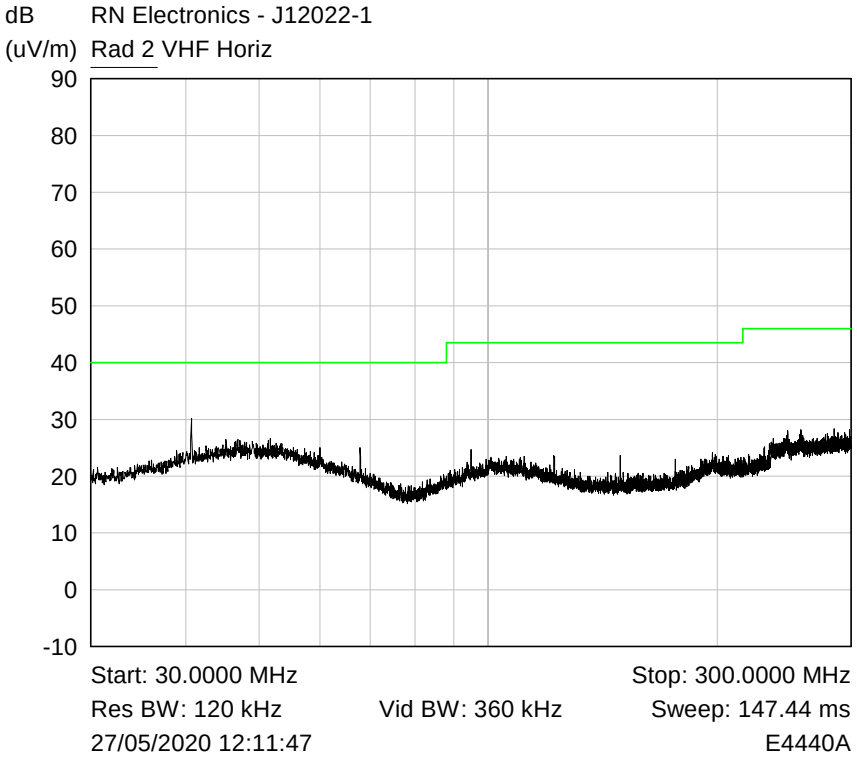


Plot of Peak emissions for UHF Horizontal against the QP limit line.

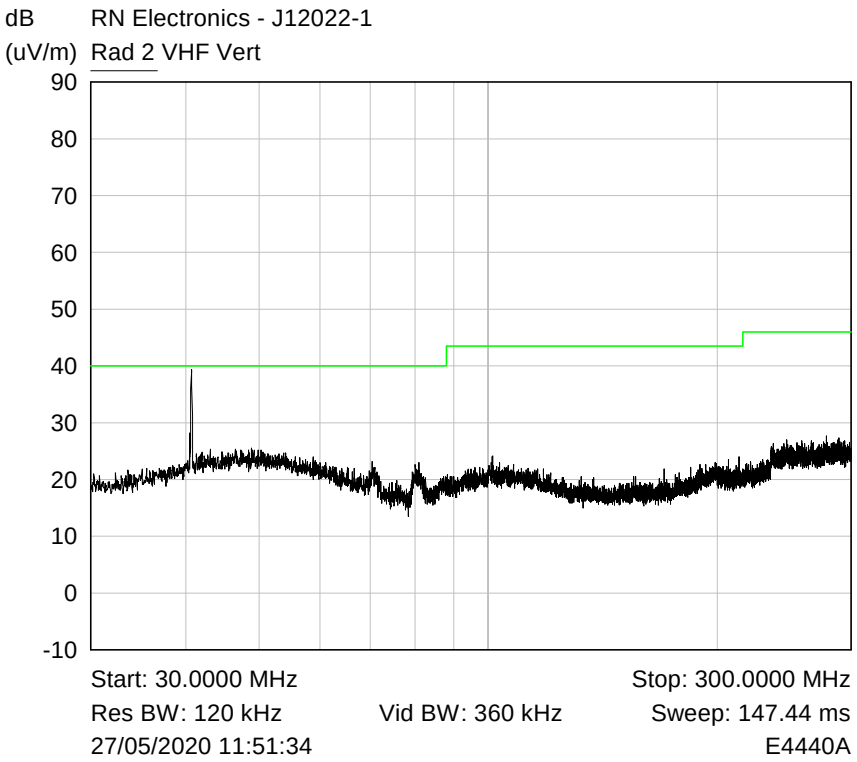


Plot of Peak emissions for UHF Vertical against the QP limit line.

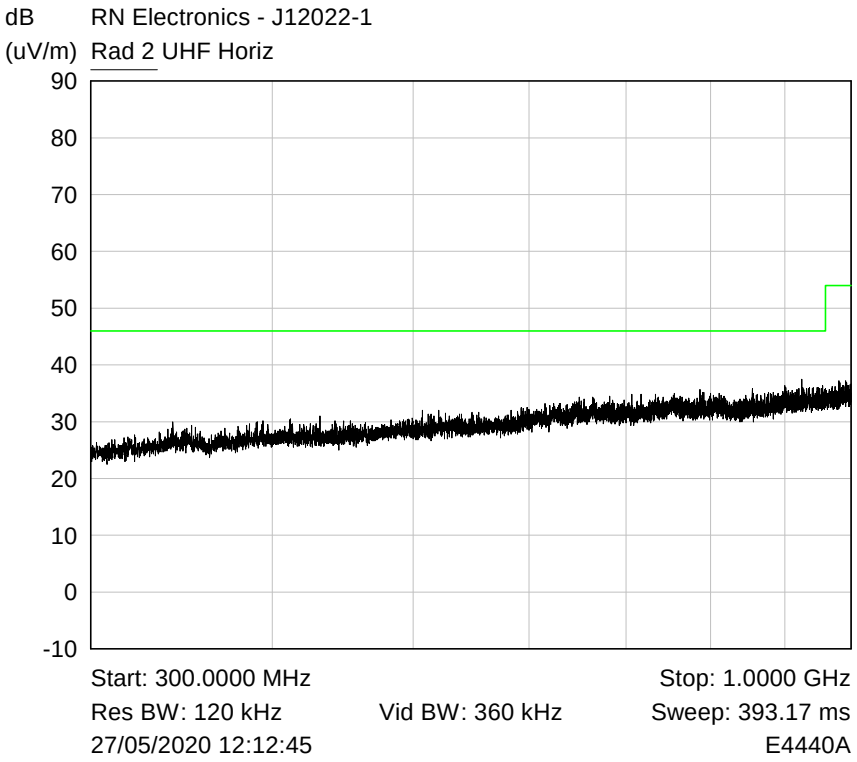
RF Parameters: Band (Single channel): 13.56 MHz, Power: Maximum, Channel Spacing: Single channel, Modulation: ISO14443A Tx (Tag Presented), Channel 13.56 MHz



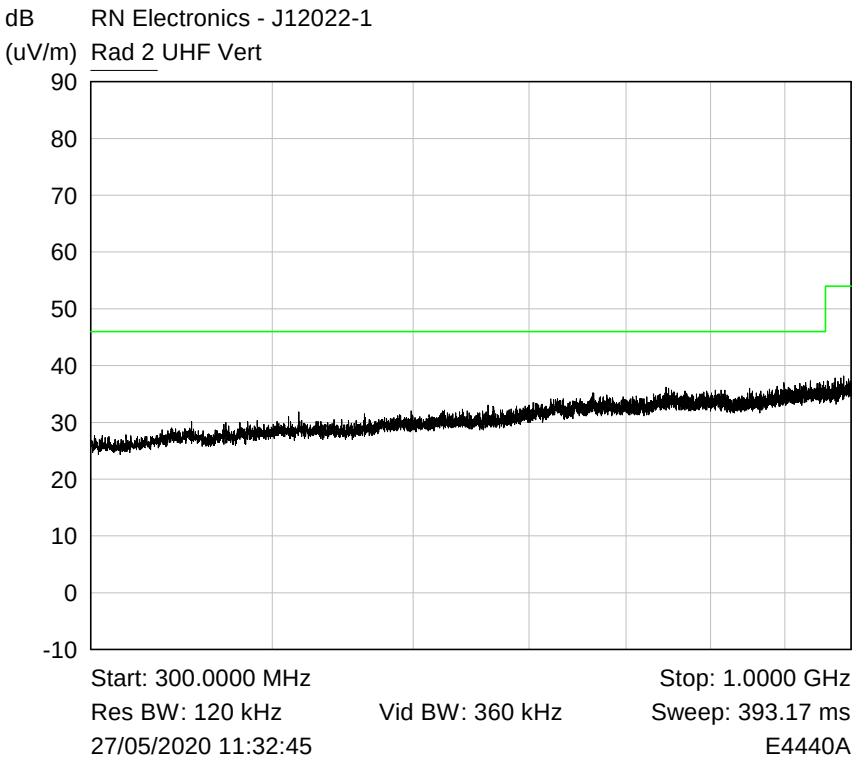
Plot of Peak emissions for VHF Horizontal against the QP limit line.



Plot of Peak emissions for VHF Vertical against the QP limit line.



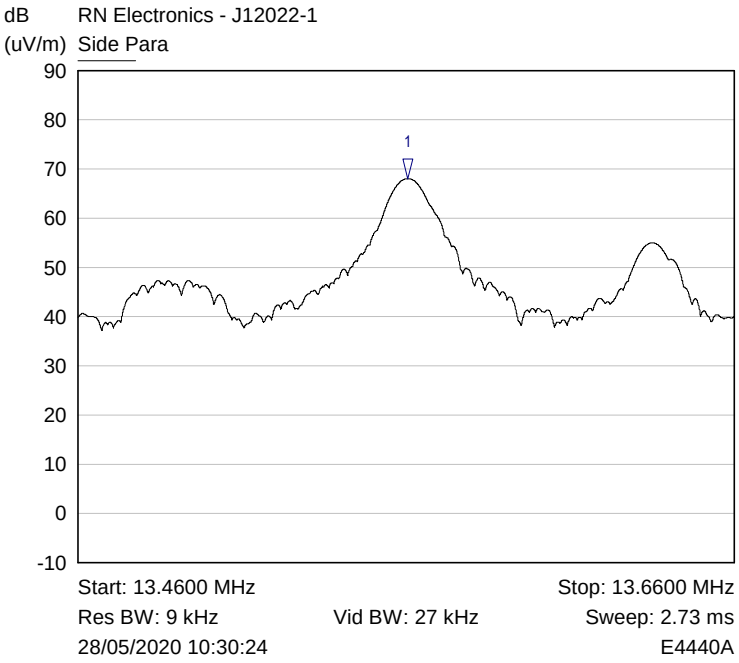
Plot of Peak emissions for UHF Horizontal against the QP limit line.



Plot of Peak emissions for UHF Vertical against the QP limit line.

6.3 Intentional radiator field strength

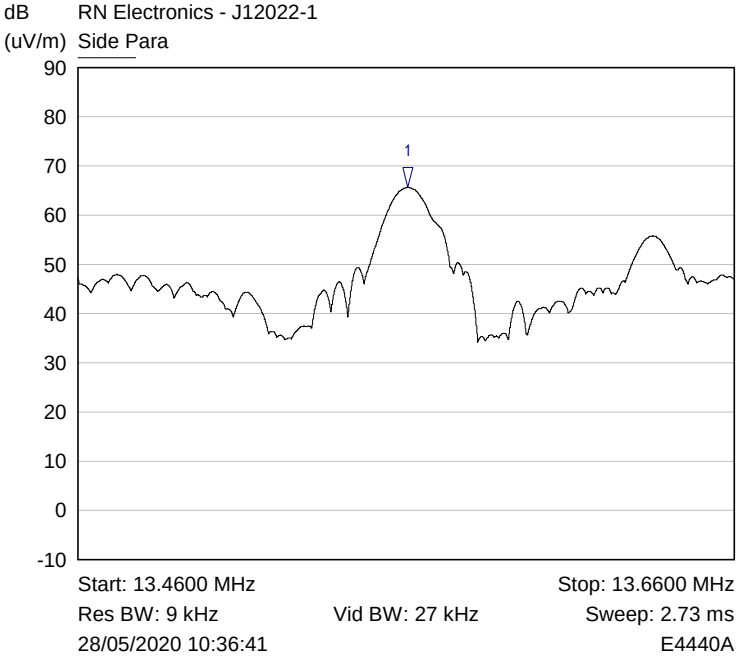
RF Parameters: Band (Single channel): 13.56 MHz, Power: Maximum, Channel Spacing: Single channel, Modulation: ISO14443A Tx (No Tag), Channel 13.56 MHz



Mkr	Trace	X-Axis	Value	Notes
1 ▽	Side Para	13.5601 MHz	68.07 dB(uV/m)	

Plot of Parallel polarisation and EUT in Side position

RF Parameters: Band (Single channel): 13.56 MHz, Power: Maximum, Channel Spacing: Single channel, Modulation: ISO14443A Tx (Tag Presented), Channel 13.56 MHz

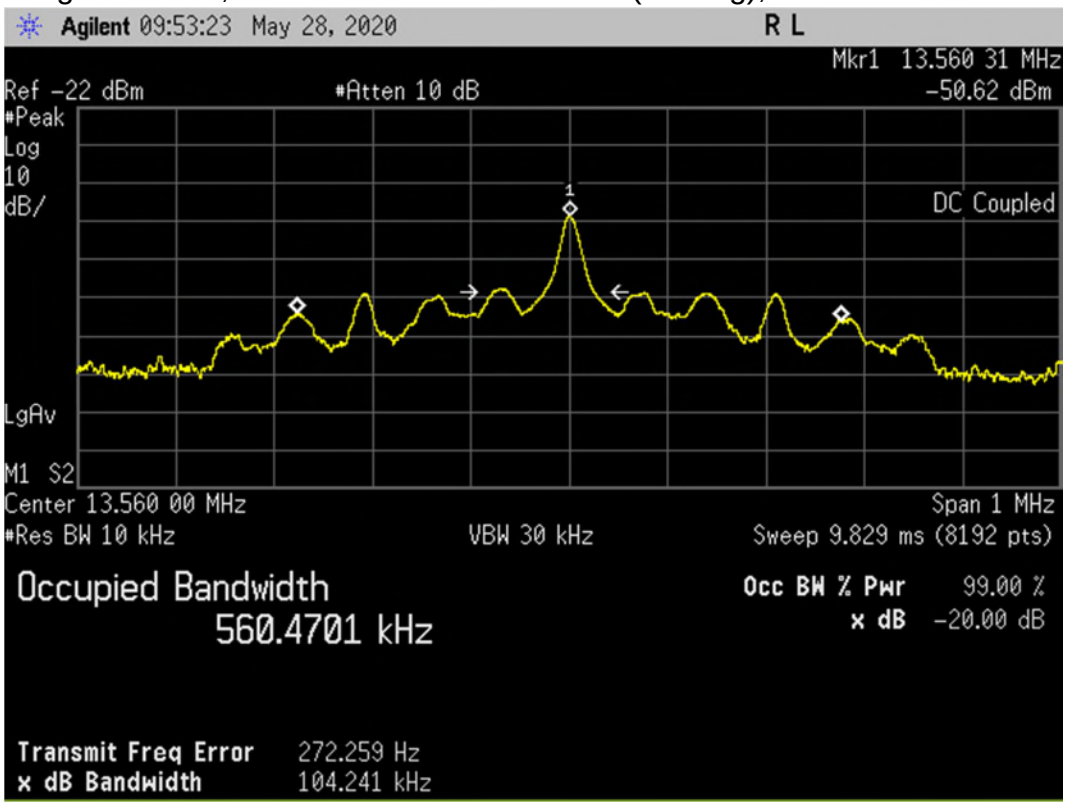


Mkr	Trace	X-Axis	Value	Notes
1 ▽	Side Para	13.5601 MHz	65.63 dB(uV/m)	

Plot of Parallel polarisation and EUT in Side position

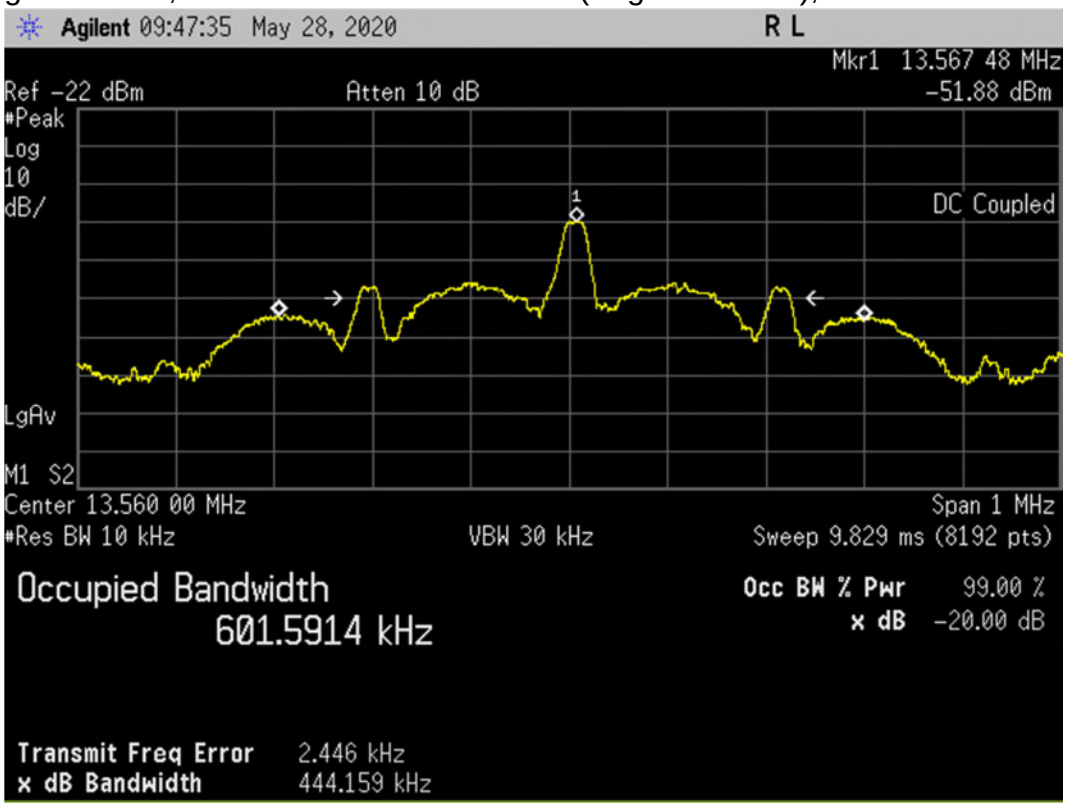
6.4 Occupied bandwidth

RF Parameters: Band (Single channel): 13.56 MHz, Power: Maximum, Channel Spacing: Single channel, Modulation: ISO14443A Tx (No Tag), Channel 13.56 MHz



Plot for 20 dB Bandwidth (kHz) Nominal Temp & Volts

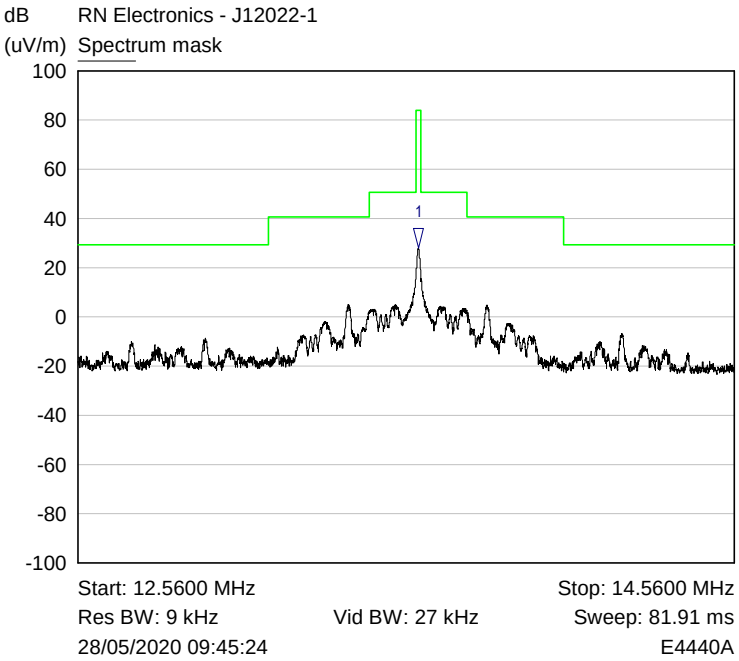
RF Parameters: Band (Single channel): 13.56 MHz, Power: Maximum, Channel Spacing: Single channel, Modulation: ISO14443A Tx (Tag Presented), Channel 13.56 MHz



Plot for 20 dB Bandwidth (kHz) Nominal Temp & Volts

6.5 Spectrum mask

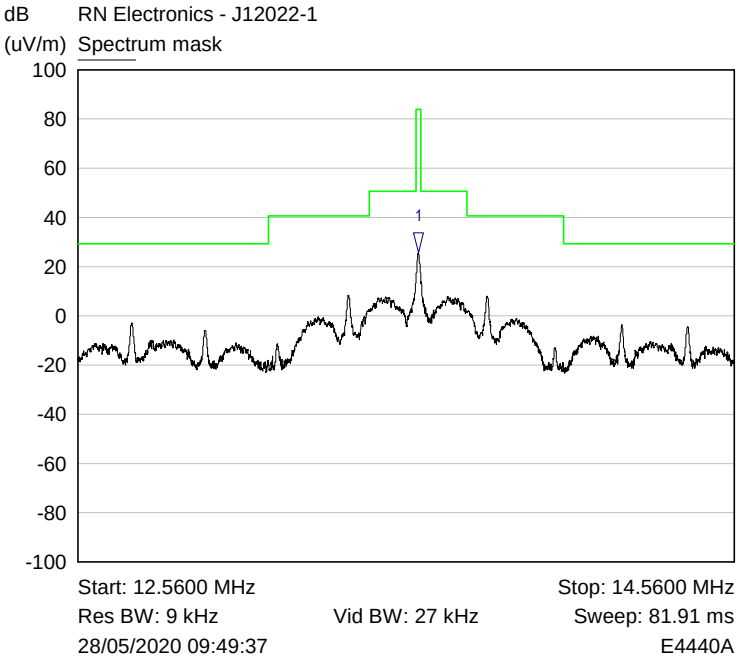
RF Parameters: Band (Single channel): 13.56 MHz, Power: Maximum, Channel Spacing: Single channel, Modulation: ISO14443A Tx (No Tag), Channel 13.56 MHz



Mkr	Trace	X-Axis	Value	Notes
1 ▽	Spectrum mask	13.5601 MHz	28.06 dB(uV/m)	

Nominal Temperature, Nominal Voltage (dBuV/m @ 30m)

RF Parameters: Band (Single channel): 13.56 MHz, Power: Maximum, Channel Spacing: Single channel, Modulation: ISO14443A Tx (Tag Presented), Channel 13.56 MHz



Mkr	Trace	X-Axis	Value	Notes
1 ▽	Spectrum mask	13.5601 MHz	25.63 dB(uV/m)	

Nominal Temperature, Nominal Voltage (dBuV/m @ 30m)

7 Explanatory Notes

7.1 Explanation of Table of Signals Measured

Measurements are made as required by the standard. These measurements are made and recorded using detectors, either peak, quasi peak or average dependant on the test. A table of results has been given following the relevant plots. This table looks similar to the one illustrated below dependant on the measurements required by the test: -

Signal No.	Freq (MHz)	Peak Amp (dBuV)	Pk – Lim 1 (dB)	QP Amp (dBuV)	QP - Lim1 (dB)	Av Amp (dBuV)	Av - Lim1 (dB)
1	12345	54.9	-10.5	48	-12.6	37.6	-14.4

Column One - Labelled Signal No. is an incremental number that the receiver has given to each signal that has been measured.

Column Two - Labelled Freq (MHz) is the approximate frequency of the signal received.

Column Three - Labelled Peak Amp (dBμV) is the level of received signal that was measured in dB above 1μV using the peak detector.

Column Four - Labelled Pk - Lim1 (dB) is the difference in level from the peak signal given to the active limit line. If this column appears in the table the peak detector measurement is required by the standard for this test. The results entered in this column indicate the signal level relative to the compliance limit required. Negative numbers indicate that the product is compliant.

Column Five - Labelled QP Amp (dBμV) is the level of received signal that was measured in dB above 1μV using the quasi-peak detector.

Column Six - Labelled QP - Lim1 (dB) is the difference in level from the quasi-peak signal given to the active limit line. If this column appears in the table the quasi-peak detector measurement is required by the standard for this test. The results entered in this column indicate the signal level relative to the compliance limit required. Negative numbers indicate that the product is compliant.

Column Seven - Labelled Av Amp (dBμV) is the level of received signal that was measured in dB above 1μV using the average detector.

Column Eight - Labelled Av - Lim1 (dB) is the difference in level from the average signal given to the active limit line. If this column appears in the table the average detector measurement is required by the standard for this test. The results entered in this column indicate the signal level relative to the compliance limit required. Negative numbers indicate that the product is compliant.

Only signals highlighted in red are deemed to exceed the limit of the detector required.

7.2 Explanation of limit line calculations for radiated measurements

The limits given in the test standard are normally expressed as absolute values (e.g. in μV/m at a specified distance), whereas the measured values are expressed as peak, quasi peak or average values in dBμV/m referenced to the measuring instrument inputs. RN Electronics calibrate the test set-up to account for any path losses, antenna gains, etc. so that the value read at the receiver relates directly to the absolute value required, except that it is expressed in dB relative to one microVolt and may need to take account of any alternative measuring distance used. Examples:

(a) limit of 500 μV/m equates to 20.log (500) = 54 dB μV/m.

(b) limit of 300 μV/m at 10m equates to 20.log (300 . 10/3) = 60 dB μV/m at 3m

(c) limit of 30 μV/m at 30m, but below 30MHz, equates to 20.log(30) + 40.log(30/3) = 69.5 dBμV/m at 3m, as extrapolation factor below 30MHz is 40dB/decade per 15.31(f)(2).

The measurement receiver used for emissions testing, performs the field strength (FS) calculations automatically. The receiver combines the signal amplitude (RA), Antenna Factor (AF) and Cable Loss (CL) factors for the frequency to be measured.

Example calculation: - FS = RA + AF + CL.

Receiver amplitude (RA)	Antenna factor (3m) (AF)	Cable loss (CL)	Field strength result (3m) (FS)
20dBuV	25 dB	3 dB	48dBuV/m

Additional calculation examples per ANSI C63.10 clause 9.4 – 9.6 equations 21, 22, 25 & 26:

Equation 21: $E_{Linear} = 10^{((E_{log}-120)/20)}$
And therefore equation 21 transposed is: $E_{Log} = 20xLog(E_{Linear}) +120$

Where:
E_{Linear} is the field strength of the emission in V/m
E_{Log} is the field strength of the emissions in dBµV/m

Equation 22: $EIRP = E_{Meas} + 20log(d_{Meas}) -104.7$

Where:
EIRP is equivalent isotropically radiated power in dBm
E_{Meas} is the field strength of the emission at the measurement distance in dBµV/m
d_{Meas} is the measurement distance in metres

Equation 25: $PD = EIRP_{Linear} / 4\pi d^2$
And therefore equation 25 transposed is: $EIRP_{Linear} = PD \times 4\pi d^2$

Where:
PD is the power density at distance specified by the limit, in W/m^2
$EIRP_{Linear}$ is the equivalent isotropically radiated power in Watts
d is the distance at which the power density limit is specified in metres

Equation 26: $PD = E^2_{Speclimit} / 377$
And therefore equation 26 transposed is: $E_{Spec\ limit} = \sqrt{(PD \times 377)}$

Where:
PD is the power density at distance specified by the limit, in W/m^2
$E_{spec\ limit}$ is the field strength at the distance specified by the limit in V/m

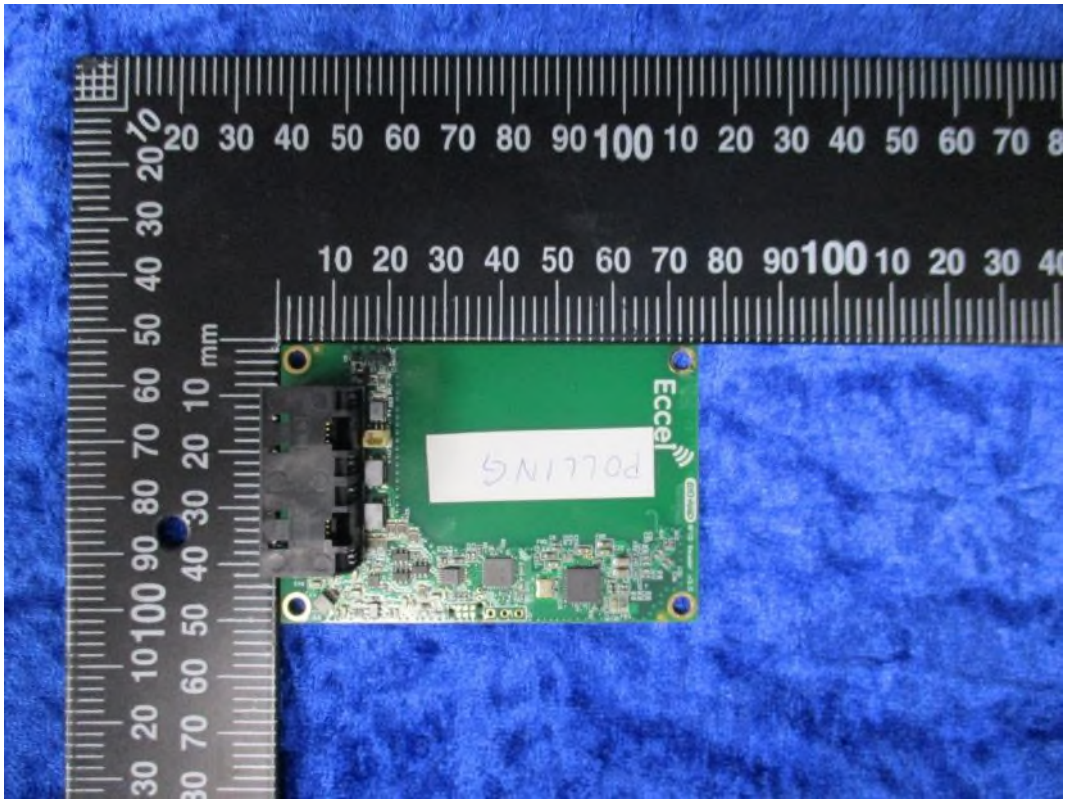
Example:
Radiated spurious emissions limit at 3metres of $90pW/cm^2$.

$90pW/cm^2 \times 100^2 = 0.9\ \mu W/m^2$ = (EIRP Linear)

Equation 25 transposed: $0.9 \times 10^{-6} \times 4 \times \pi \times 3^2 = 0.0001017876$ W
And
Equation 26 transposed: $E_{Spec\ limit} = \sqrt{(0.9x10^{-6} \times 377)} = 0.01842$ V/m.
And
Equation 21 transposed: $E_{Log} = 20Log(0.01842) +120 = 85.3dB\mu V/m$ @ 3m.

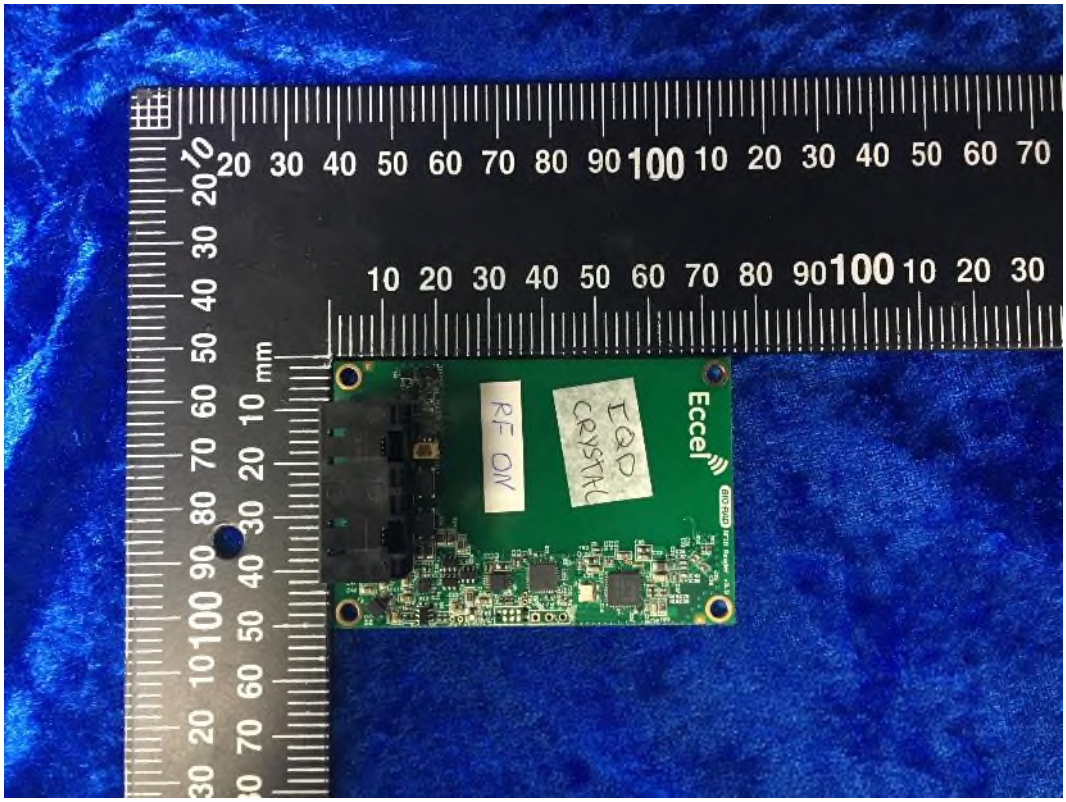
8 Photographs

8.1 EUT Front View



Board containing the 27h1 J8B crystal

Board containing the 27h1 J8B crystal

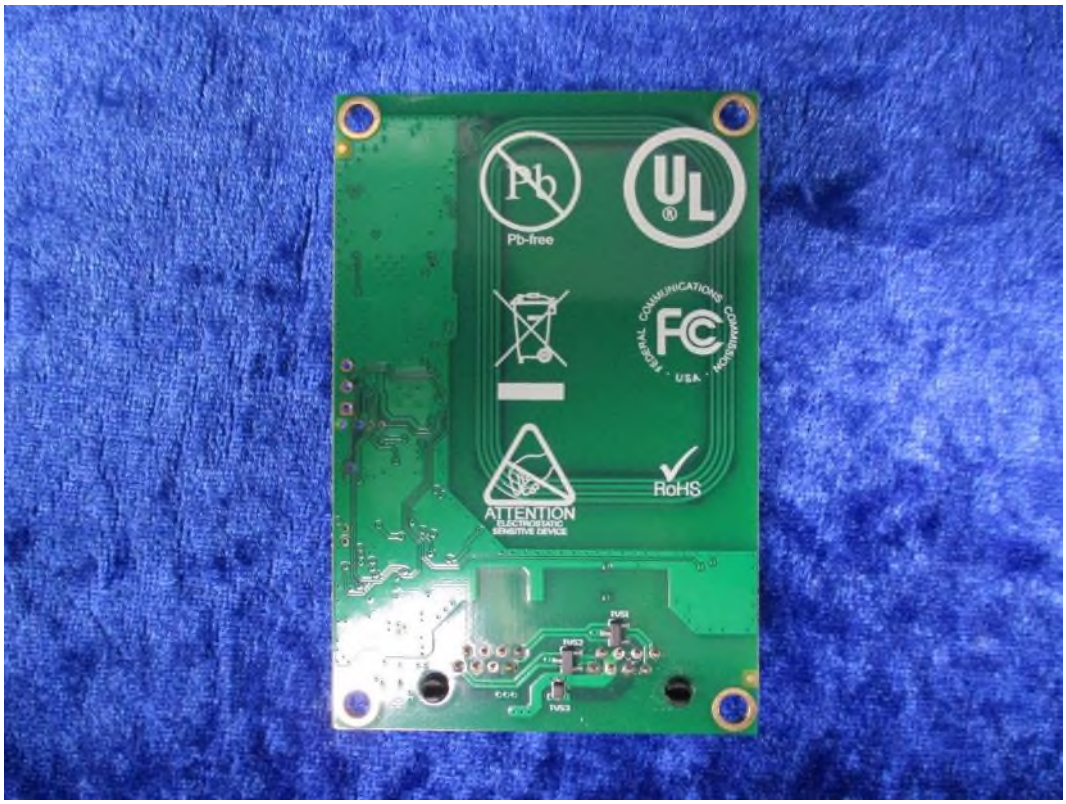


Board containing the 25.120M 2012TJ crystal

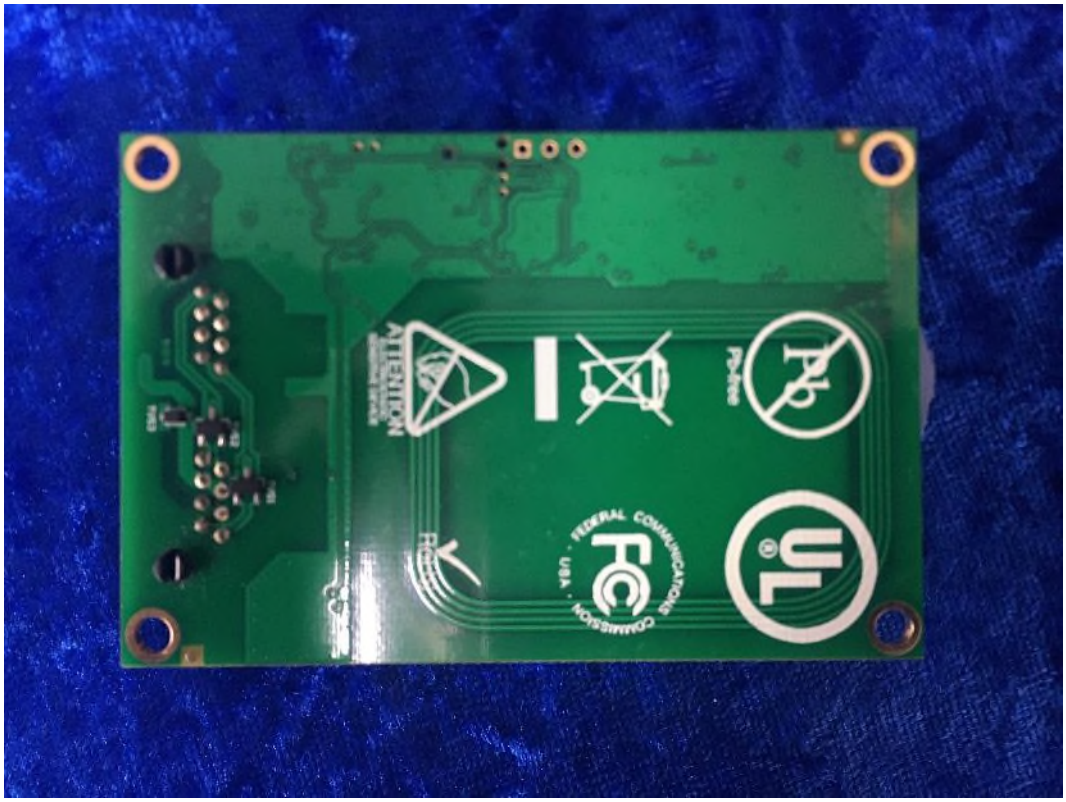
Board containing the 25.120M 2012TJ crystal

Photo of the manufacturer supplied RFID tag

8.2 EUT Reverse Angle

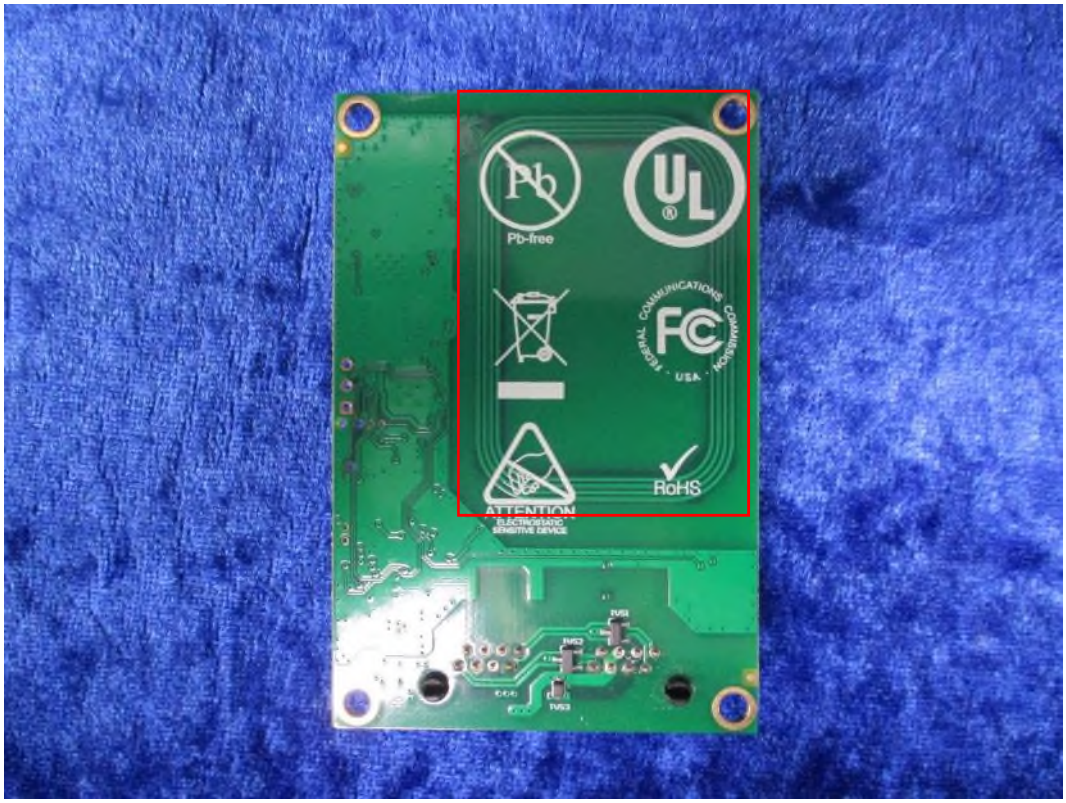


Board containing the 27h1 J8B crystal



Board containing the 25.120M 2012TJ crystal

8.3 EUT Antenna Port



Integral antenna (Outlined in red) this is the same for both of the supplied boards.

8.4 EUT Display & Controls

The EUT has no display or controls

8.5 EUT Internal photos

The EUT is a PCB designed to be fitted inside a host product. Please refer to the previous photos.

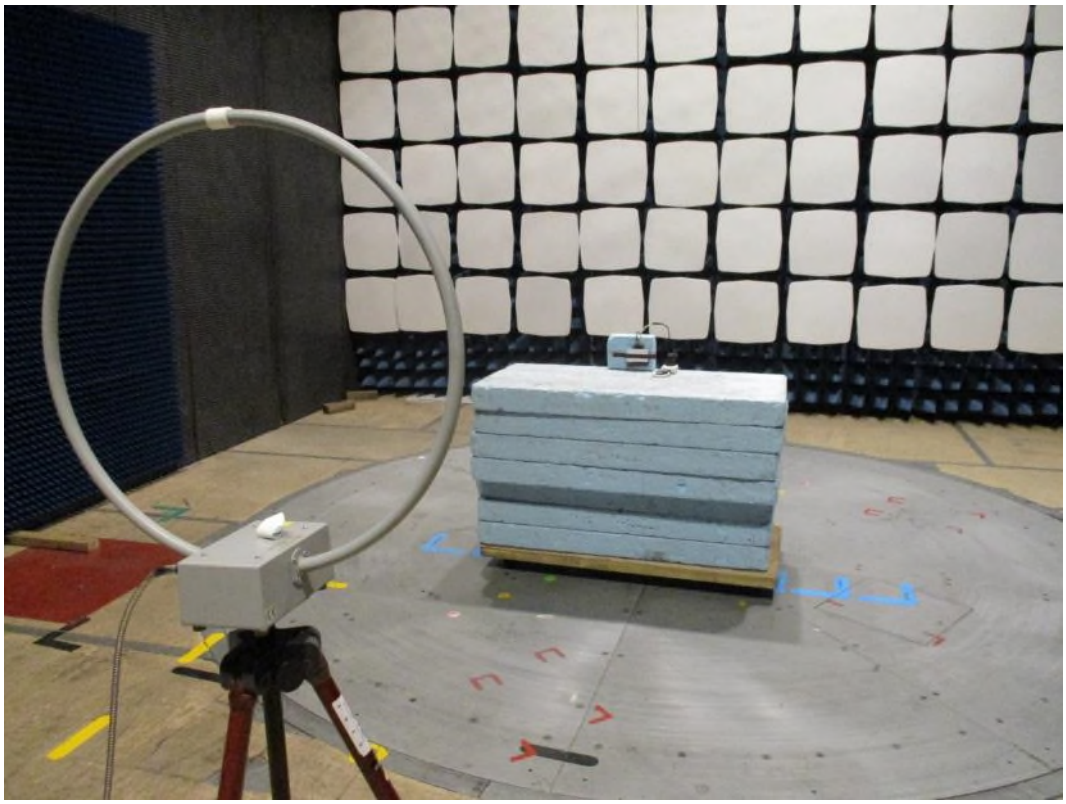
8.6 EUT ID Label

No label was available at the time of test.

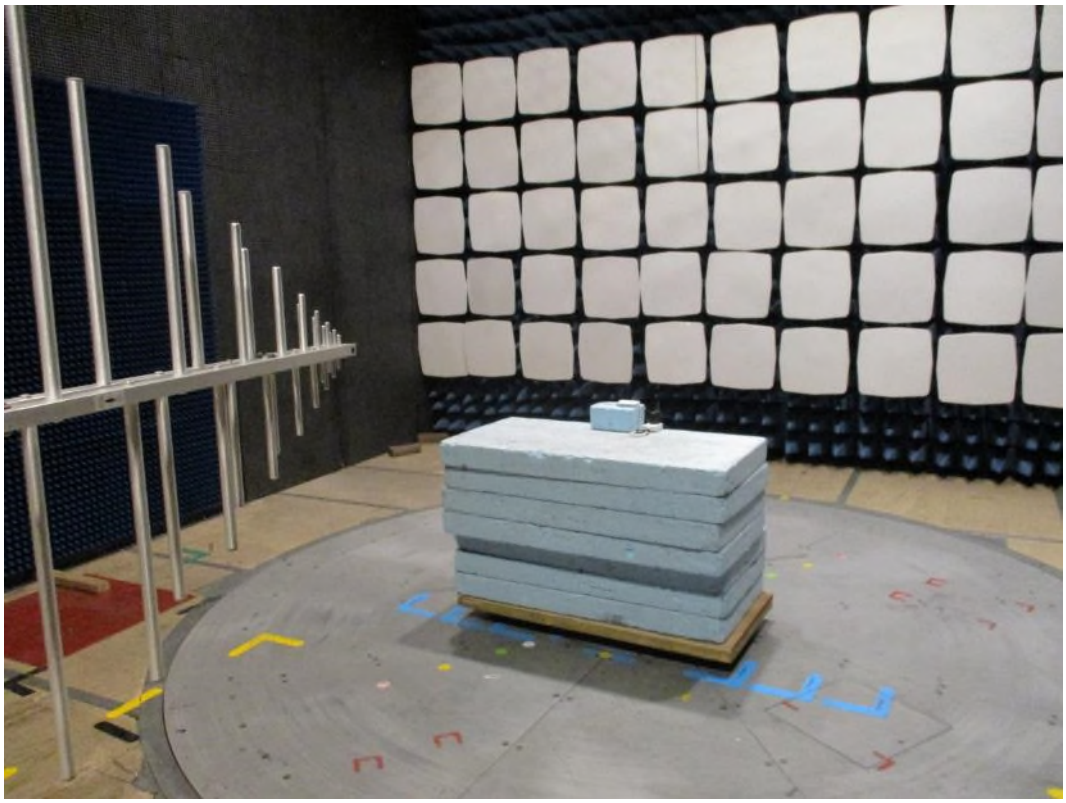
8.7 EUT Chassis

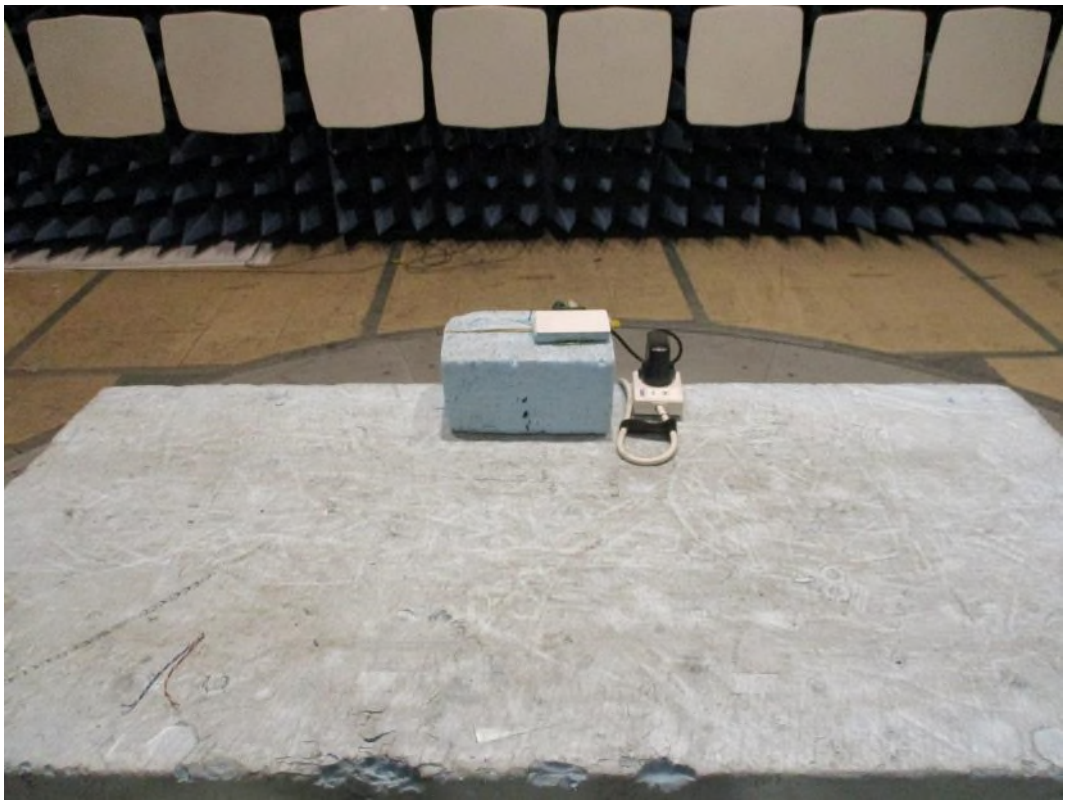
The EUT has no chassis.

8.8 Radiated emissions 150 kHz – 30 MHz



8.9 Radiated emissions 30 MHz – 1 GHz





8.10 Radiated emission diagrams

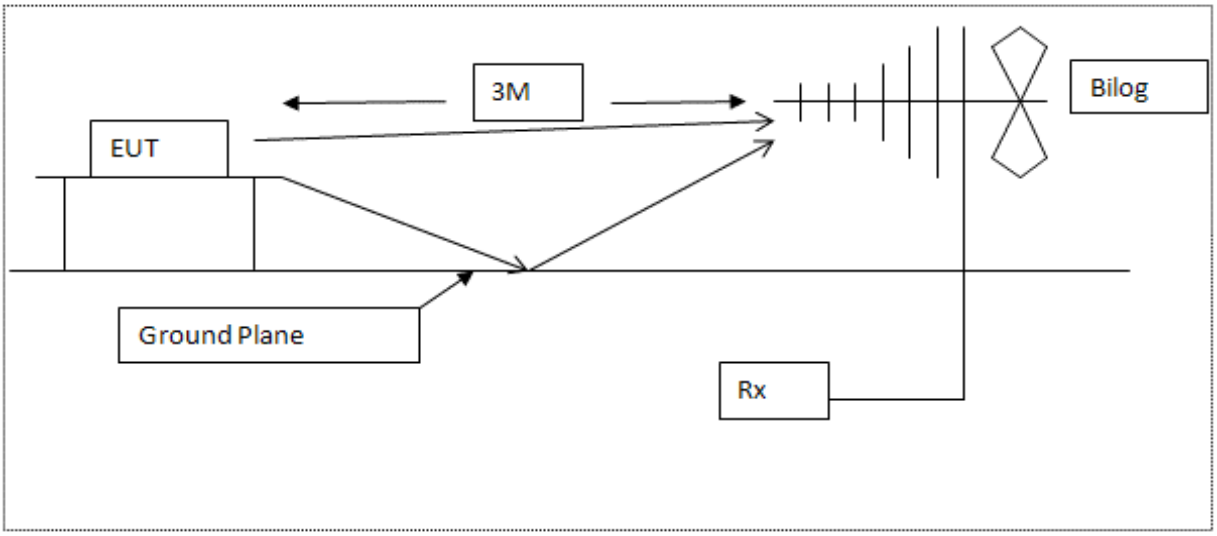


Diagram of the radiated emissions test setup 30 - 1000 MHz

9 Test equipment calibration list

The following is a list of the test equipment used by R.N. Electronics Ltd to test the unit detailed within this report. In line with our procedures, the equipment was within calibration for the period during which testing was carried out.

RN No.	Model No.	Description	Manufacturer	Calibration date	Cal period
E227	6632A	PSU System DC Power Supply	Hewlett Packard	20-Mar-2020	12 months
E534	E4440A	PSA 3 Hz - 26.5 GHz	Agilent Technologies	20-Jan-2020	24 months
E535	N9039A	9 kHz - 1 GHz RF Filter Section	Agilent Technologies	20-Jan-2020	12 months
E642	E4440A	PSA 3 Hz - 26.5 GHz	Agilent Technologies	11-Dec-2019	24 months
E745	2017 4/2dB	Attenuator 4/2dB 30-1000MHz	RN Electronics	07-Feb-2020	12 months
E914	VULB 9163	Antenna BiLog 30MHz to 3GHz	Schwarzbeck	30-Apr-2020	12 months
N579	71043	Frequency Standard Distribution	-	26-Nov-2019	12 months
NSA-H	NSA - H	NSA - Site H	RN Electronics	11-Dec-2019	36 months
TMS38	VMT04/140	Environmental Oven	Heraeus Votsch	N/A	N/A
TMS81	6502	Antenna Active Loop	EMCO	24-Jun-2019	24 months
ZSW1	V2.4	Measurement Software Suite	RN Electronics	N/A	N/A

10 Auxiliary and peripheral equipment

10.1 Customer supplied equipment

Item No.	Model No.	Description	Manufacturer	Serial No.
1	NXP-NTAG213	RFID Tag	Not stated	Not stated

10.2 RN Electronics supplied equipment

No RN Electronics Ltd supplied equipment was used.

11 Condition of the equipment tested

In order for the EUT to produce the results shown within this report the following modifications, if any, were implemented.

11.1 Modifications before test

No modifications were made before test by RN Electronics Ltd.

11.2 Modifications during test

No modifications were made during test by RN Electronics Ltd.

12 Description of test sites

Site A Radio Laboratory and Anechoic Chamber

Site B Semi-Anechoic Chamber and Control Room
FCC Registration No. 293246
IC Registration No. 5612A-4

Site C Transient Laboratory

Site D Screened Room (Conducted Immunity)

Site E Screened Room (Control Room for Site D)

Site F Screened Room (Conducted Emissions)

Site G Screened Room (Control Room for Site H)

Site H 3m Semi-Anechoic Chamber (indoor OATS)
FCC Registration No. 293246
IC Registration No. 5612A-2

Site J Transient Laboratory

Site K Screened Room (Control Room for Site M)

Site M 3m Semi-Anechoic Chamber (indoor OATS)
FCC Registration No. 293246
IC Registration No. 5612A-3

Site N Radio Laboratory

Site Q Fully-Anechoic Chamber

Site OATS 3m and 10m Open Area Test Site
FCC Registration No. 293246
IC Registration No. 5612A-1

Site R Screened Room (Conducted Immunity)

Site S Safety Laboratory

Site T Transient Laboratory

RN Electronics CAB identifier as issued by Innovation, Science and Economic Development Canada is UK0002
RN Electronics CAB identifier as issued by FCC is UK0015

13 Abbreviations and units

%	Percent
µA/m	microAmps per metre
µV	microVolts
µW	microWatts
AC	Alternating Current
ALSE	Absorber Lined Screened Enclosure
AM	Amplitude Modulation
Amb	Ambient
ATPC	Automatic Transmit Power Control
BER	Bit Error Rate
ºC	Degrees Celsius
C/I	Carrier / Interferer
CEPT	European Conference of Postal and Telecommunications Administrations
COFDM	Coherent OFDM
CS	Channel Spacing
CW	Continuous Wave
dB	deciBels
dBµA/m	deciBels relative to 1µA/m
dBµV	deciBels relative to 1µV
dBc	deciBels relative to Carrier
dBm	deciBels relative to 1mW
DC	Direct Current
DTA	Digital Transmission Analyser
EIRP	Equivalent Isotropic Radiated Power
ERP	Effective Radiated Power
EU	European Union
EUT	Equipment Under Test
FM	Frequency Modulation
FSK	Frequency Shift Keying
g	Grams
GHz	GigaHertz
Hz	Hertz
IF	Intermediate Frequency
kHz	kiloHertz
LBT	Listen Before Talk
LO	Local Oscillator
mA	milliAmps
max	maximum
kPa	Kilopascal
Mbit/s	MegaBits per second
MHz	MegaHertz
mic	Microphone
min	minimum
mm	milliMetres
ms	milliSeconds
mW	milliWatts
NA	Not Applicable
nom	Nominal
nW	nanoWatt
OATS	Open Area Test Site
OFDM	Orthogonal Frequency Division Multiplexing
ppm	Parts per million
PRBS	Pseudo Random Bit Sequence
QAM	Quadrature Amplitude Modulation
QPSK	Quadrature Phase Shift Keying
R&TTE	Radio and Telecommunication Terminal Equipment
Ref	Reference
RF	Radio Frequency
RFC	Remote Frequency Control
RSL	Received Signal Level
RTP	Room Temperature and Pressure
RTPC	Remote Transmit Power Control
Rx	Receiver
s	Seconds
SINAD	Signal to Noise And Distortion
Tx	Transmitter
V	Volts