Radio Test Report

Michelin Americas Research Company

MEMS Evolution 3 Sensor

RV1.30

47 CFR Part 15.231
Effective Date 1st October 2014

Test Date: 15th July 2015
Report Number: 07-8129-2-15 Issue 02
Supersedes report: 07-8129-2-15 Issue 01

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Certificate of Test 8129-2

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:	MEMS Evolution 3 Sensor
Model Number:	RV1.30
Unique Serial Number:	21111357
Proposed FCC ID:	F15-RV1-30F
Manufacturer:	Michelin Americas Research Company 515 Michelin Road, PO Box 1987 Greenville USA SC 29605-1987
Full measurement results are detailed in Report Number:	07-8129-2-15 Issue 02
Test Standards:	47 CFR Part 15.231 Effective Date 1st October 2014 Class DSC Intentional radiator

NOTE:
Certain tests were not performed based upon manufacturer's declarations. Certain other requirements are subject to manufacturer declaration only and have not been tested/verified. For details refer to section 3 of this report.

DEVIATIONS:
No deviations from the standard 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 compli ance, 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 confide nce of approximately 95%.

Date Of Test: 15th July 2015

Test Engineer: Digitally signed by: Graham Blake
DN: CN = Graham Blake C = GB O = RN Electronics Ltd
Date: 2016.01.15 09:19:23 +01'00'

Approved By:
Technical Director

Customer
Representative:

1 Contents

2 Equipment under test (EUT)

2.1 Equipment specification

Applicant	Michelin Americas Research Company 515 Michelin Road PO Box 1987 Greenville USA SC 29605-1987	
Manufacturer of EUT	Michelin Americas Research Company	
Brand name of EUT	MEMS Evolution 3 Sensor	
Model Number of EUT	RV1.30	
Serial Number of EUT	21111357	
Proposed FCC ID:	F15-RV1-30F	
Date Received	15th July 2015	
Date of Test:	15th July 2015	
Purpose of Test	To demonstrate design compliance to the relevant rules of Chapter 47 of the Code of Federal Regulations.	
Date Report Created	22nd July 2015	
Visual Description	The EUT is a palm sized plastic unit with four bolt holes for securing the lid.	
Main Function	Tyre Pressure Monitoring	
Information Specification	Height	47 mm
	Width	76 mm
	Depth	78 mm
	Weight	100 g
	Voltage	2.1 - 3.3 VDC (Lithium coin cell)
	Current	not stated

2.2 Configurations for testing

General Parameters	
EUT Normal use position	Mounted in a vehicles wheel (tested as table top)
Choice of model(s) for type tests	Production unit
Antenna details	Integral helical
Antenna port	No
Baseband Data port (yes/no)?	No
Highest Signal generated in EUT	433.92 MHz (RF carrier)
Lowest Signal generated in EUT	125 kHz (RX frequency)
TX Parameters	
Alignment range – transmitter	433.92 MHz (fixed frequency)
EUT Declared Modulation Parameters	FSK
EUT Declared Power level	Level 10 gives 71.6 dBuV/m @ 3m average power (Note: EUT is pulsed).
EUT Declared Signal Bandwidths	+/- 25kHz
EUT Declared Channel Spacing's	Not applicable (single frequency)
EUT Declared Duty Cycle	18ms per minute in normal use
Unmodulated carrier available?	No
Declared frequency stability	Not stated

2.3 Functional description

The MEMS (Michelin Earthmover Management system) Evolution 3 sensor is a battery powered tyre air pressure and air temperature sensor. The sensor is mounted on the interior of the tyre, in the air chamber. The sensor is equipped with a radio transmitter, which sends temperature and pressure measurements to receiving units outside of the tyre. The sensor transmits when the air pressure is above approximately 10 PSI. In normal operating conditions, the temperature and pressure measurements and are transmitted at approximately 1 minute (*) intervals. If the measured air pressure changes significantly the sensor increases the rate of measurement to approximately 16 second (*) intervals for a period of 20 approximately minutes. The sensor operates at 433.92 MHz, and uses FSK modulation.

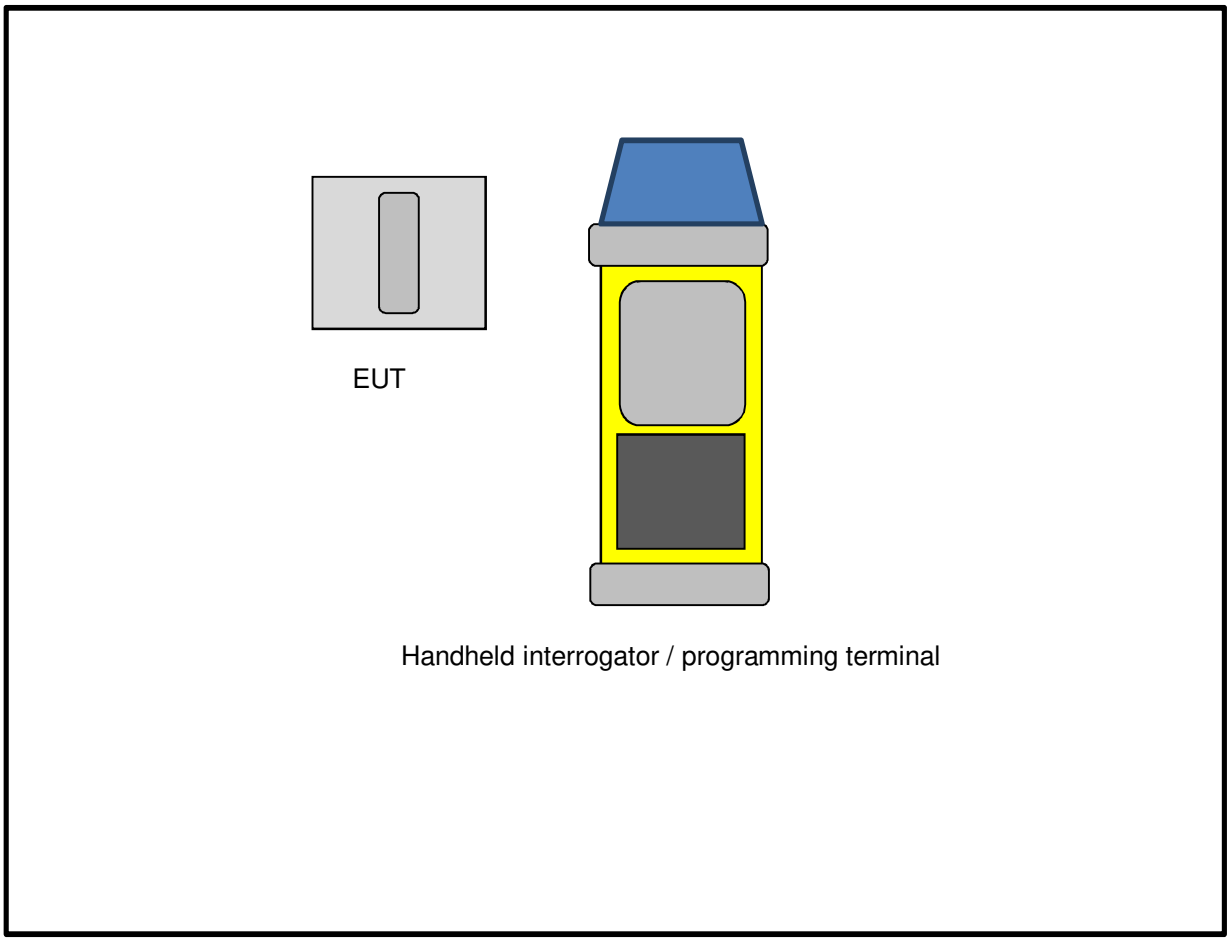
* The timer used for interval measurement is accurate to +/-20% over the full temperature and voltage range.

2.4 Modes of operation

Mode Reference	Description	Used for testing
Normal	Transmission every 60s, approx., when above 10PSI.	No
Continuous	Repeated transmission approximately once per second at 433.92 MHz	Yes
Fast mode	The EUT transmits a burst of data every 16 seconds	Yes

Note: Normal mode not used for tests, Continuous mode provided the same transmit message but at a shorter interval for ease of test.

2.5 Emissions configuration



The unit was powered from a new lithium battery and was positioned in close proximity to the handheld terminal. The unit was configured to transmit approximately once every second using the software on the terminal. The handheld terminal transmitted its commands to the EUT at 125 kHz. Using the handheld terminal, the EUTs' power level was set to 'level 10' and this power level was used throughout the tests included in this test report. No other power levels have been investigated.

The EUTs' test modes were set and controlled by the manufacturers' representative who was in attendance at the time of test. Please refer to section 2.4 of this test report for test modes.

3 Summary of test results

The MEMS Evolution 3 Sensor, RV1.30 was tested for compliance to the following standards :

47 CFR Part 15.231, Effective Date 1st October 2014
DSC intentional radiator

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 kHz - 150 kHz	47 CFR Part 15C Part 15.209 & 15.33(a)	PASSED
3. Radiated emissions - 150 kHz - 30 MHz	47 CFR Part 15C Part 15.209 & 15.33(a)	PASSED
4. Radiated emissions - 30 MHz -1 GHz	47 CFR Part 15C Part 15.231(e) & 15.209	PASSED
5. Radiated emissions - Above 1 GHz	47 CFR Part 15C Part 15.209 & 15.33(a)	PASSED[5]
6. Intentional radiator field strength	47 CFR Part 15C Part 15.231(e)	PASSED
7. Band edge compliance	47 CFR Part 15C Part 15.231(d)/15.205	NOT APPLICABLE[2]
8. Occupied bandwidth	47 CFR Part 15C Part 15.231(c)	PASSED
9. Frequency stability	47 CFR Part 15C Part 15.231(d)	NOT APPLICABLE[2,3]
10. Periodic operation	47 CFR Part 15C Part 15.231(e)	PASSED
Receiver Tests		
11. Antenna Power conducted emissions for receivers	47 CFR Part 15C Part 15.111	NOT APPLICABLE[4]

[1] EUT does not operate from the AC power lines nor contain provisions for operation while connected to AC power lines.
[2] EUT does not operate in the 40.66 - 40.70 MHz band, therefore no limits are specified.
[3] No limits apply, however the requirement to contain the designated bandwidth of the emission within the specified frequency band includes the frequency stability of the transmitter over expected variations in temperature and supply voltage.
[4] No test requirement
[5] Manufacturer declares highest internal source of the EUT to be 433.92 MHz, therefore the requirement for radiated emissions is to verify emissions up to 4.3392 GHz. The measurement has been made up to 5 GHz which is in excess of the requirement.

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	2014	Federal Communications Commission PART 15 – RADIO FREQUENCY DEVICES
4.1.2	ANSI C63.10	2013	American National Standard for Testing 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

R.N. Electronics Ltd site H, is listed with the FCC. Registration Number 293246

4.2 Deviations

No deviations from the standard have been applied.

4.3 Tests at extremes of temperature & voltage

No tests at extremes were required.

5 Tests, methods and results

5.1 AC power line conducted emissions

NOT APPLICABLE: EUT does not operate from the AC power lines nor contain provisions for operation while connected to AC power lines.

5.2 Radiated emissions - 9 kHz - 150 kHz

5.2.1 Test methods

Test Requirements:	47 CFR Part 15C Part 15.209 & 15.33(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 15.209 [Reference 4.1.1 of this report]

5.2.2 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. The EUT was operated in Continuous mode.

5.2.3 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 placed 1m above the ground. The equipment and the antenna were rotated 360 degrees to record the worst case emissions. Tests were performed in Test Site H, which is listed with the FCC.

5.2.4 Test equipment

E533, E534, E535, TMS81
See Section 8 for more details

5.2.5 Test results

Temperature of test environment	24°C
Humidity of test environment	60%
Pressure of test environment	102kPa

Band	433.92 MHz
Power Level	Power Level 10
Channel Spacing	Single Frequency Equipment
Mod Scheme	FSK
Mid channel	433.92 MHz

Plot refs
8129-2 Parallel 9kHz - 150kHz
8129-2 Perpendicular 9kHz - 150kHz

Analyser plots for the Quasi-Peak / Average values as applicable can be found in Section 6 of this report.

There were no emissions within 20dB of the limit.

LIMITS:
15.209 limits are applicable in the restricted bands of 15.205 with the relevant detector.
15.231(e) limits are applicable elsewhere, although 15.209 limits may be used where these allow a higher field strength.

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

Note: EUT tested in a continuous transmit mode for ease of test. Where average limits apply, duty cycle correction was then calculated as per FCC 15.35. TX on time in 100ms period. See section 5.5 Periodic emissions within this report.

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

5.3 Radiated emissions - 150 kHz - 30 MHz

5.3.1 Test methods

Test Requirements:	47 CFR Part 15C Part 15.209 & 15.33(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 15.209 [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 EUT was rotated in all three orthogonal planes. The EUT was operated in Continuous 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. The antenna was placed 1m above the ground. The equipment and the antenna were rotated 360 degrees to record the worst case emissions. Tests were performed in Test Site H, which is listed with the FCC.

5.3.4 Test equipment

E533, E534, E535, TMS81

See Section 8 for more details

5.3.5 Test results

Temperature of test environment	23°C
Humidity of test environment	66%
Pressure of test environment	102kPa

Band	433.92 MHz
Power Level	Power Level 10
Channel Spacing	Single Frequency Equipment
Mod Scheme	FSK
Mid channel	433.92 MHz

Plot refs
8129-2 Perpendicular 150kHz - 30MHz
8129-2 Parallel 150kHz - 30MHz

Analyser plots for the Quasi-Peak / Average values as applicable can be found in Section 6 of this report.

LIMITS:
15.209 limits are applicable in the restricted bands of 15.205 with the relevant detector.
15.231(e) limits are applicable elsewhere, although 15.209 limits may be used where these allow a higher field strength.

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

Note: EUT tested in a continuous transmit mode for ease of test. Where average limits apply, duty cycle correction was then calculated as per FCC 15.35. TX on time in 100ms period. See section 5.5 Periodic emissions within this report.

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 15.231(e) & 15.209 [Reference 4.1.1 of this report]
Test Method:	ANSI C63.10 Clause 6.5 [Reference 4.1.2 of this report]
Limits:	47 CFR Part 15C Clause 15.231(e) & 15.209 [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. The EUT was operated in Continuous 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 equipment was rotated 360 degrees and the antenna scanned 1-4 metres in both horizontal and vertical polarisations to record the worst case emissions. Tests were performed in Test Site H which is listed with the FCC.

5.4.4 Test equipment

LPE364, TMS45, E533, E534, E535

See Section 8 for more details

5.4.5 Test results

Temperature of test environment	24°C
Humidity of test environment	60%
Pressure of test environment	102kPa

Band	433.92 MHz
Power Level	Power Level 10
Channel Spacing	Single Frequency Equipment
Mod Scheme	FSK
Mid channel	433.92 MHz

Plot refs
8129-2 Rad 1 VHF Horiz
8129-2 Rad 1 VHF Vert
8129-2 Rad 1 UHF Horiz
8129-2 Rad 1 UHF Vert

Tables of signals measured for Rad 1 Horizontal Sig List

Signal No.	Freq (MHz)	Peak Amp (dBuV/m)	QP Amp (dBuV/m)	Margin (dB)	Limit Applied
1	165.998	28.4	17.4	-26.1	15.209
2	171.683	37.7	26.3	-17.2	15.209
3	331.685	27.6	21.3	-24.7	15.209

The table above shows emissions within the restricted bands of 15.205, and therefore 15.209 limits apply.

Signal No.	Freq (MHz)	Peak Amp (dBuV/m)	Average (dBuV/m)	Margin (dB)	Limit Applied
5	146.154	37.7	23.5	-29.5	15.231(e)
6	178.041	41.2	27.0	-26.0	15.231(e)
7	181.504	37.8	23.6	-29.4	15.231(e)
8	350.686	27.4	13.2	-39.8	15.231(e)
9	430.670	33.9	19.7	-33.3	15.231(e)
10	437.164	47.9	33.7	-19.3	15.231(e)

The table above shows emissions outside of the restricted bands of 15.205 and therefore 15.231(e) Average limits have been applied. Duty cycle correction as per FCC 15.35 has been applied to convert the peak result into an average result. i.e. 14.2dB reduction. See limit section below for calculation.

Tables of signals measured for Rad 1 Vertical Sig List

Signal No.	Freq (MHz)	Peak Amp (dBuV/m)	QP Amp (dBuV/m)	Margin (dB)	Limit Applied
1	171.710	25.8	11.6	-28.3	15.209

The table above shows emissions within the restricted bands of 15.205, and therefore 15.209 limits apply.

Signal No.	Freq (MHz)	Peak Amp (dBuV/m)	Average (dBuV/m)	Margin (dB)	Limit Applied
2	36.591	25.2	11.0	-42.0	15.231(e)
3	145.012	27.3	13.1	-39.9	15.231(e)
4	160.917	20.4	6.2	-46.8	15.231(e)
5	189.841	21.2	7.0	-46.0	15.231(e)
6	430.666	44.1	29.9	-23.1	15.231(e)
7	437.166	39.1	24.9	-28.1	15.231(e)

The table above shows emissions outside of the restricted bands of 15.205 and therefore 15.231(e) Average limits have been applied. Duty cycle correction as per FCC 15.35 has been applied to convert the peak result into an average result. i.e. 14.2dB reduction. See limit section below for calculation.

Peak detector “Max held” Analyser plots against the Quasi-Peak / Average limit lines and any tables of signals within 20dB of the limit line can be found in Section 6 of this report.

LIMITS:
15.209 limits are applicable in the restricted bands of 15.205 with the relevant detector.
15.231(e) limits are applicable elsewhere, although 15.209 limits may be used where these allow a higher field strength.

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

Note: EUT tested using peak detection and in a continuous transmit mode for ease of test. Where average limits apply, duty cycle correction was then calculated as per FCC 15.35. TX on time in 100ms period. TX on time measured at 19.61ms. Therefore 20Log (100/19.61) = 14.2dB. See section 5.5 Periodic emissions within this report.

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 ±5.1dB

5.5 Radiated emissions - Above 1 GHz

Manufacturer declares highest internal source of the EUT to be 433.92 MHz, therefore the requirement for radiated emissions is to verify emissions up to 4.3392 GHz. The measurement has been made up to 5 GHz which is in excess of the requirement.

5.5.1 Test methods

Test Requirements:	47 CFR Part 15C Part 15.209 & 15.33(a) [Reference 4.1.1 of this report]
Test Method:	ANSI C63.10 Clause 6.6 [Reference 4.1.2 of this report]
Limits:	47 CFR Part 15C Part 15.209/15.231(e) [Reference 4.1.1 of this report]

5.5.2 Configuration of EUT

The EUT was placed on a 1.5 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. The EUT was operated in Continuous mode.

5.5.3 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 with appropriate absorbing material for use in this range. The EUT was raised and antenna was placed 1.5m above the ground in line with the EUT, which was rotated through 360 degrees to record the worst case emissions. Tests were performed in Test Site H which is listed with the FCC.

5.5.4 Test equipment

E534, E535, LPE261, LPE333

See Section 8 for more details

5.5.5 Test results

Temperature of test environment	25°C
Humidity of test environment	55%
Pressure of test environment	102kPa

Setup Table

Band	433.92 MHz
Power Level	Power Level 10
Channel Spacing	Single Frequency Equipment
Mod Scheme	FSK
Single channel	433.92 MHz

Spurious Frequency (MHz)	Peak Amplitude (dBuV/m)	AVG Amplitude (dBuV/m)	Margin (dB)	Antenna Polarisation	EUT Polarisation	Limit Applied
1301.747	42.5	28.3	25.7	Horiz	Upright	15.209
1301.772	40.9	26.7	27.3	Vertical	Flat	15.209
1735.663	42.9	28.7	25.3	Horiz	Upright	15.209
1735.654	42.5	28.3	25.7	Vertical	Flat	15.209
2169.187	51.9	37.7	16.3	Horiz	Upright	15.209
2169.573	46.7	32.5	21.5	Vertical	Flat	15.209
2603.683	46.9	32.7	21.3	Horiz	Upright	15.209
3037.556	46.3	32.1	21.9	Horiz	Upright	15.209
3471.324	46.9	32.7	21.3	Horiz	Upright	15.209
3905.205	51.9	37.7	16.3	Horiz	Upright	15.209
3905.185	43.6	29.4	24.6	Vertical	Flat	15.209

Peak detector “Max held” Analyser plots against the Average limit line can be found in Section 6 of this report.

LIMITS:
15.209 limits are applicable in the restricted bands of 15.205 with the relevant detector.
15.231(e) limits are applicable elsewhere, although 15.209 limits may be used where these allow a higher field strength.

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:

1 – 5 GHz ±3.5dB

5.6 Intentional radiator field strength

5.6.1 Test methods

Test Requirements:	47 CFR Part 15C Part 15.231(e) [Reference 4.1.1 of this report]
Test Method:	ANSI C63.10 Clause 6.5 [Reference 4.1.2 of this report]
Limits:	47 CFR Part 15C Part 15.231(e)/15.35 [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 scanned 1-4m in height in both Horizontal and Vertical polarisations. The EUT was rotated in all three orthogonal planes. The EUT was operated in Continuous 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. Both the equipment and the antenna were rotated 360 degrees to record the maximised emission.

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

5.6.4 Test equipment

E533, E534, E535, LPE364

See Section 8 for more details

5.6.5 Test results

Temperature of test environment	22°C
Humidity of test environment	66%
Pressure of test environment	102kPa

Band	433.92 MHz
Power Level	Power Level 10
Channel Spacing	Single Frequency Equipment
Mod Scheme	FSK
Single channel	433.92 MHz

	Single
Peak Level (dBµV/m)	85.8
Average Level (dBµV/m)	71.6
(uV/m)	3802
Plot reference	8129-2 Field Strength
Antenna Polarisation	Horizontal
EUT Polarisation	Upright

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

LIMITS:
Fc = 433.92MHz
15.231(e) Average = 4,400 uV/m = 72.9 dBuV/m @ 3m.
15.35 Peak = 20dB above the maximum permitted average emission limit = 92.9 dBuV/m @ 3m

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:
<± 3.5 dB

5.7 Band edge compliance

NOT APPLICABLE: EUT does not operate in the 40.66 - 40.70 MHz band, therefore no limits are specified.

5.8 Occupied bandwidth

5.8.1 Test methods

Test Requirements:	47 CFR Part 15C Part 15.231(c) [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 15.231(c) [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 front edge of the EUT was initially positioned facing the antenna. The EUT was measured at a distance of 3 metres. The EUT was operated in Continuous mode.

5.8.3 Test procedure

Tests were made in accordance with FCC Part 15 using the measuring equipment noted below. A 1kHz RBW, 3x VBW, auto sweep time and max hold settings were used for the 20 dB bandwidth test. Tests were performed using Test Site H.

5.8.4 Test equipment

E534, E535, LPE364

See Section 8 for more details

5.8.5 Test results

Temperature of test environment	23°C
Humidity of test environment	66%
Pressure of test environment	102kPa

Band	433.92 MHz
Power Level	Power Level 10
Channel Spacing	Single Frequency Equipment
Mod Scheme	FSK
Mid channel	433.92 MHz

	Mid
20dB Bandwidth (MHz)	0.074
Plot reference	8129-2 FCC OBW 3

Analyser plots for the 20 dB bandwidth can be found in Section 6 of this report.

LIMITS:
15.231(c) must be <0.25% (70-900 MHz fundamentals).

Fc = 433.92MHz = 1.085MHz.

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 %

5.9 Frequency stability

NOT APPLICABLE: No limits apply, however the requirement to contain the designated bandwidth of the emission within the specified frequency band includes the frequency stability of the transmitter over expected variations in temperature and supply voltage.

5.10 Periodic operation

5.10.1 Test methods

Test Requirements:	47 CFR Part 15C Part 15.231(e) [Reference 4.1.1 of this report]
Test Method:	ANSI C63.10 Clause 7.4/7.5/7.6 [Reference 4.1.2 of this report]
Limits:	47 CFR Part 15C Part 15.231(e) [Reference 4.1.1 of this report]

5.10.2 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 operated in Continuous mode.

5.10.3 Test procedure

Tests were made in accordance with FCC Part 15 using the measuring equipment noted below. The centre frequency of the analyser was set to that of the transmitter, and the span set to zero. The sweep time was adjusted so that either the pulse width or the periodic operation could be observed.

Tests were performed using Test Site H.

5.10.4 Test equipment

E534, E535, LPE364

See Section 8 for more details

5.10.5 Test results

Temperature of test environment	23°C
Humidity of test environment	60%
Pressure of test environment	102kPa

Band	433.92 MHz
Power Level	Power Level 10
Channel Spacing	Single Frequency Equipment
Mod Scheme	FSK
Single channel	433.92 MHz

	Single
TX on time (ms)	19.61
TX on Plot filename	Duty Cycle on time
TX repetition time (S)	15.97
TX repetition Plot filename	Duty Cycle rep time
Calculated TX Duty cycle (%)	0.12

Analyser plots for the dwell time and duty cycle can be found in Section 6 of this report.

LIMITS:
15.231(e) Transmitters shall be automatically limited so that the duration of each transmission shall not be greater than 1 second, with any silent period at least 30 times the transmission length but in no case less than 10 seconds.

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:
2.57 ms

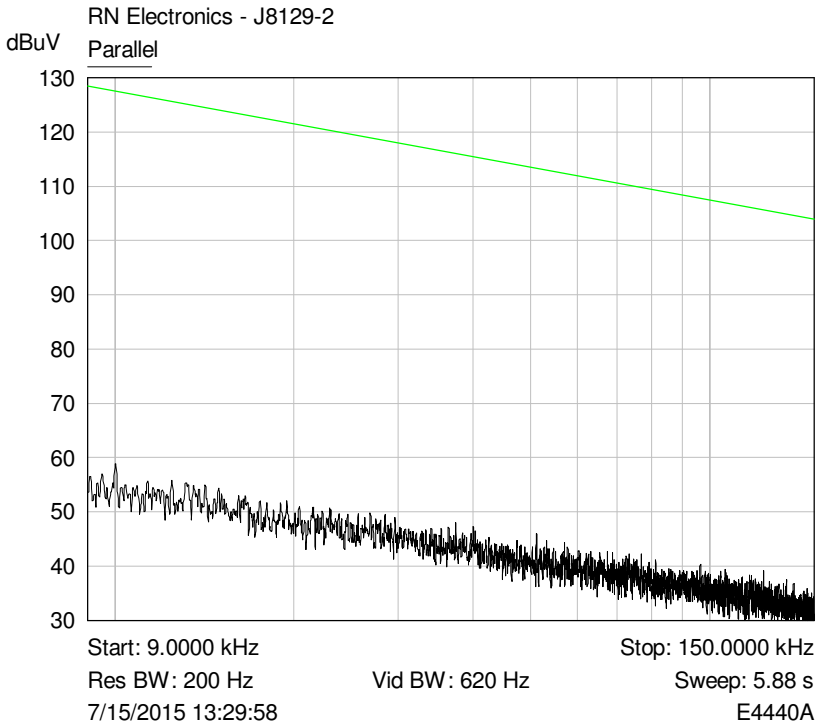
5.11 Antenna Power conducted emissions for receivers

NOT APPLICABLE: No test requirement

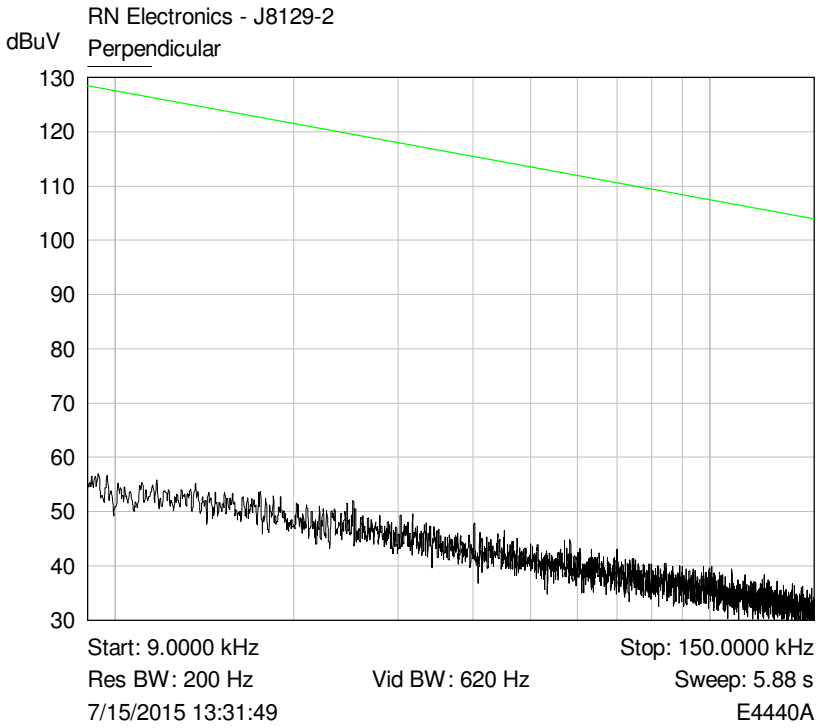
6 Plots/Graphical results

6.1 Radiated emissions - 9 kHz - 150 kHz

RF Parameters: Power Level 10, Modulation FSK, Channel 433.92 MHz



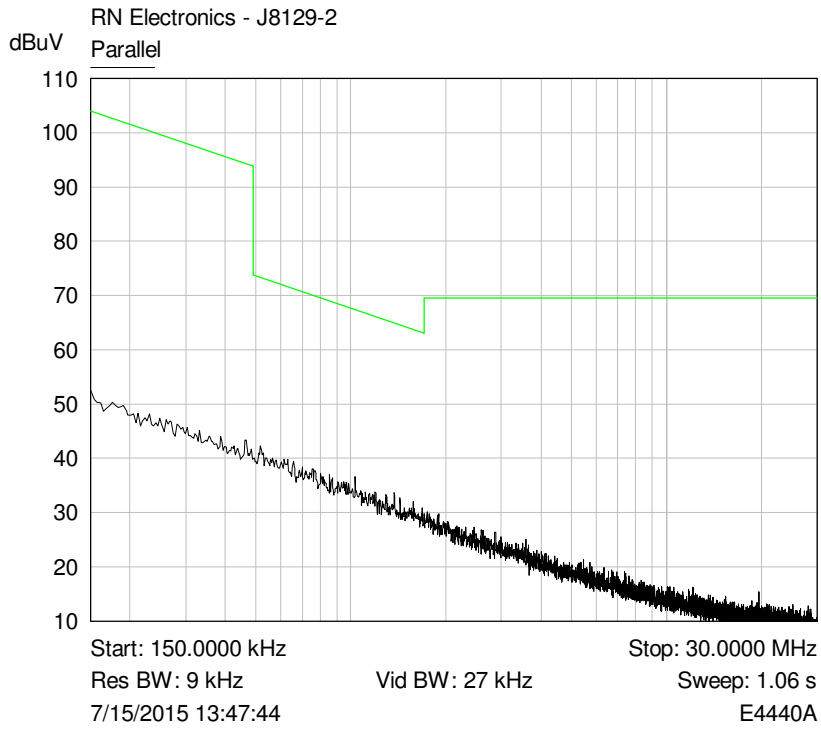
Plot of 9-150kHz Parallel



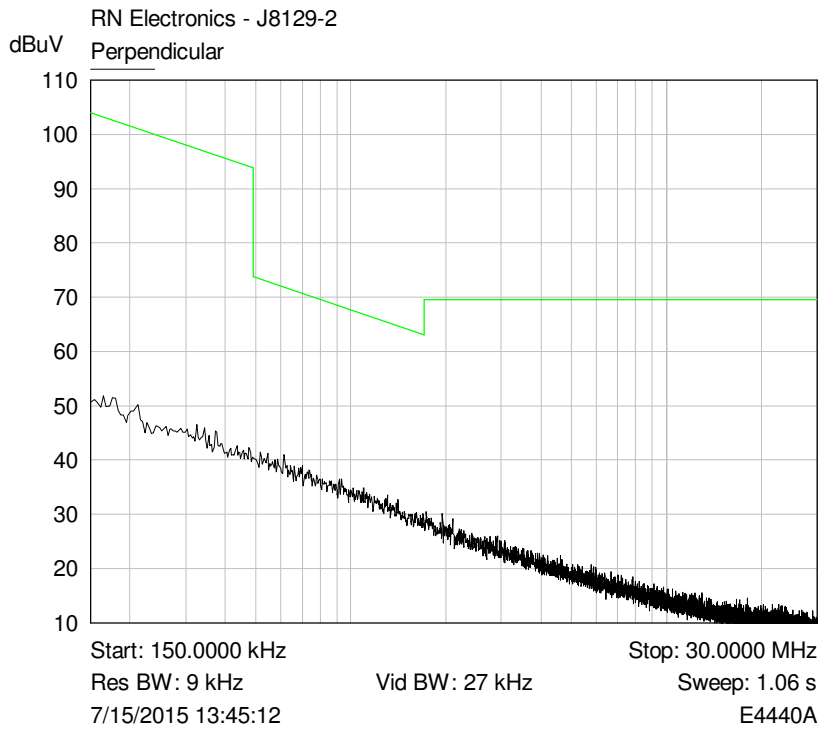
Plot of 9-150kHz Perpendicular

6.2 Radiated emissions 150 kHz - 30 MHz

RF Parameters: Power Level 10, Modulation FSK, Channel 433.92 MHz



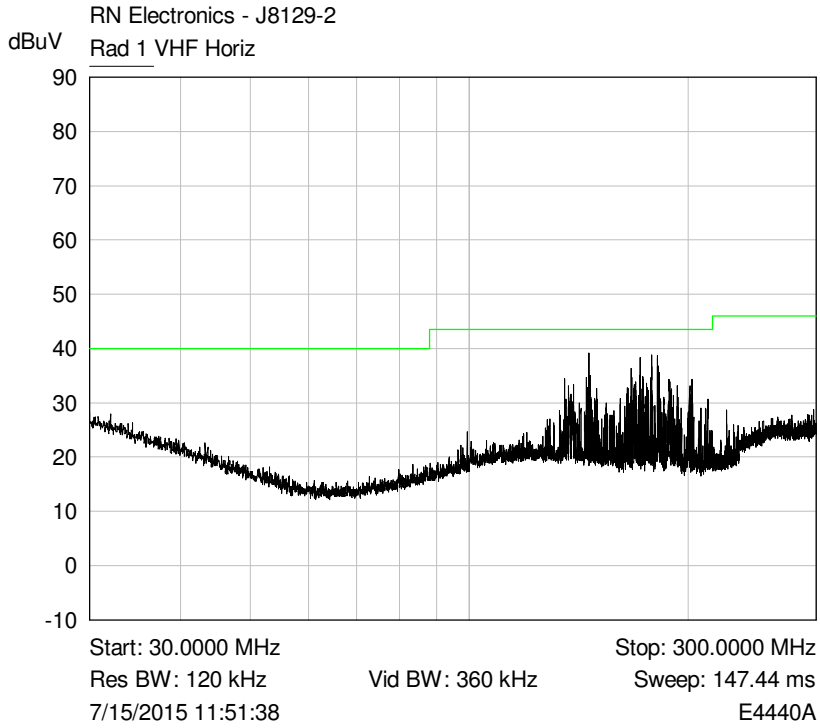
Plot of 150k-30MHz Parallel



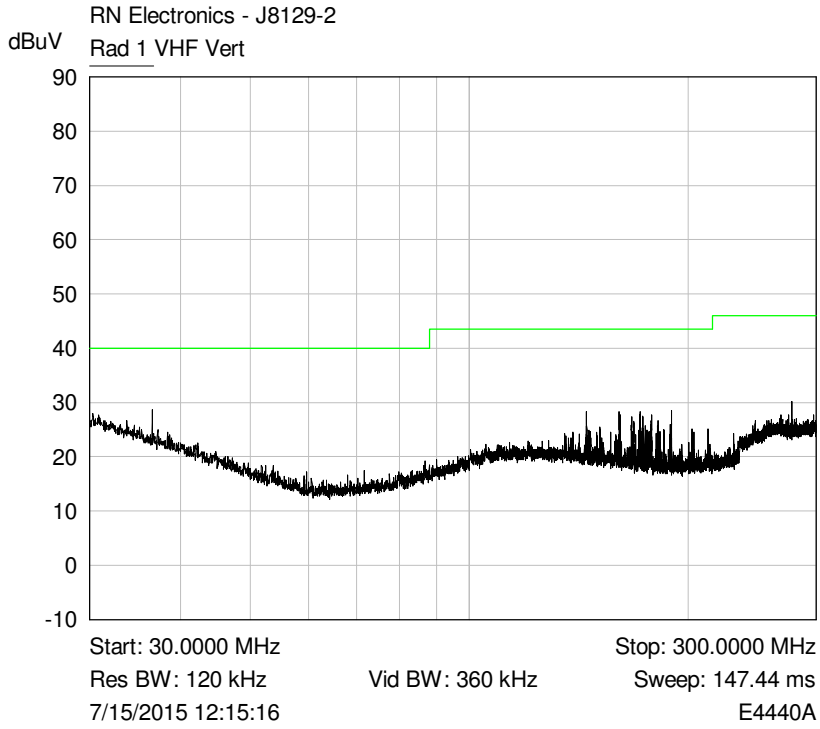
Plot of 150k-30MHz Perpendicular

6.3 Radiated emissions 30 MHz -1 GHz

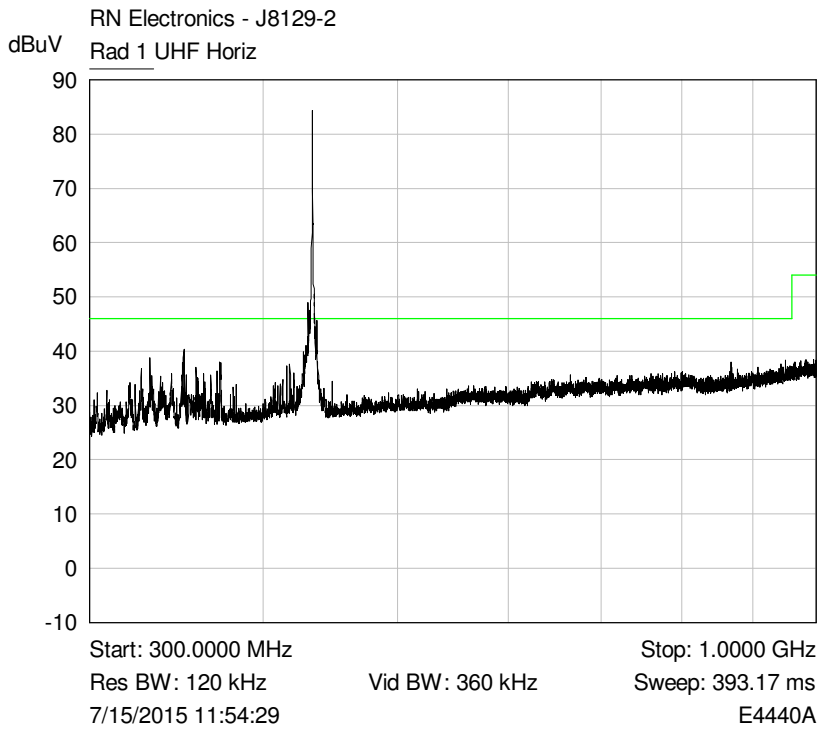
RF Parameters: Power Level 10, Modulation FSK, Channel 433.92 MHz



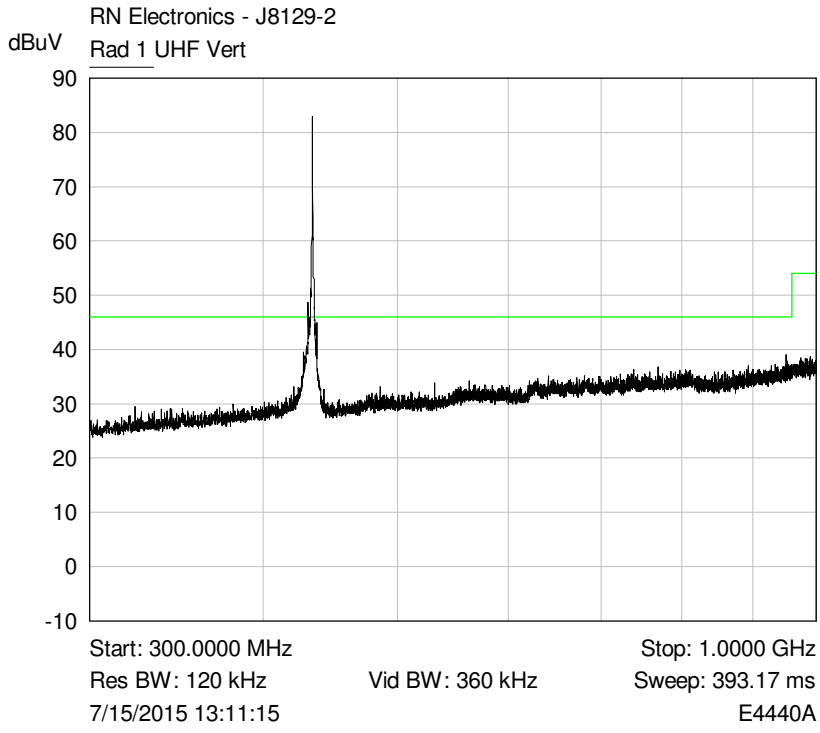
Plot of Horizontal VHF



Plot of Vertical VHF



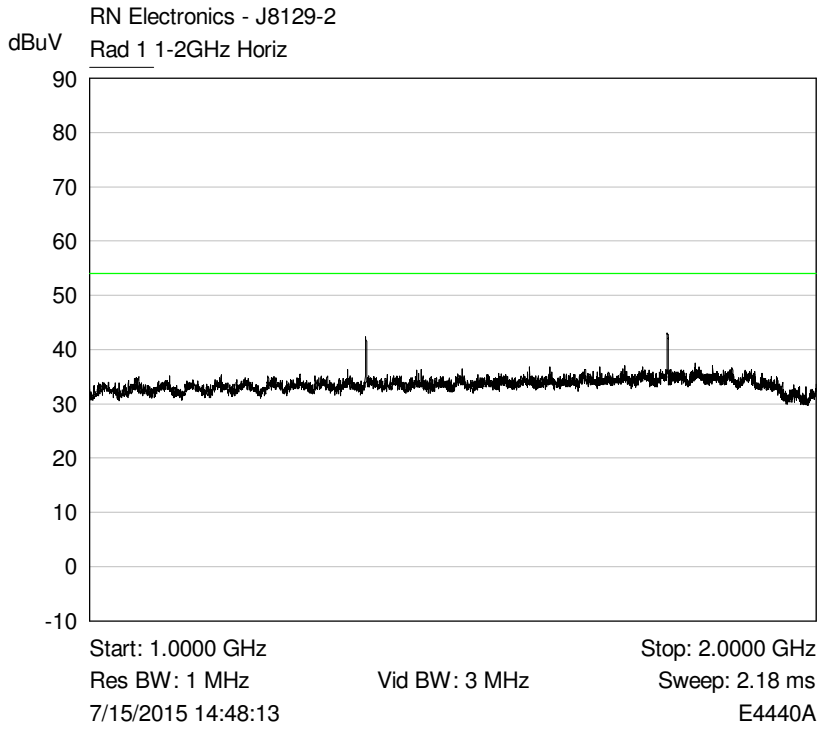
Plot of Horizontal UHF

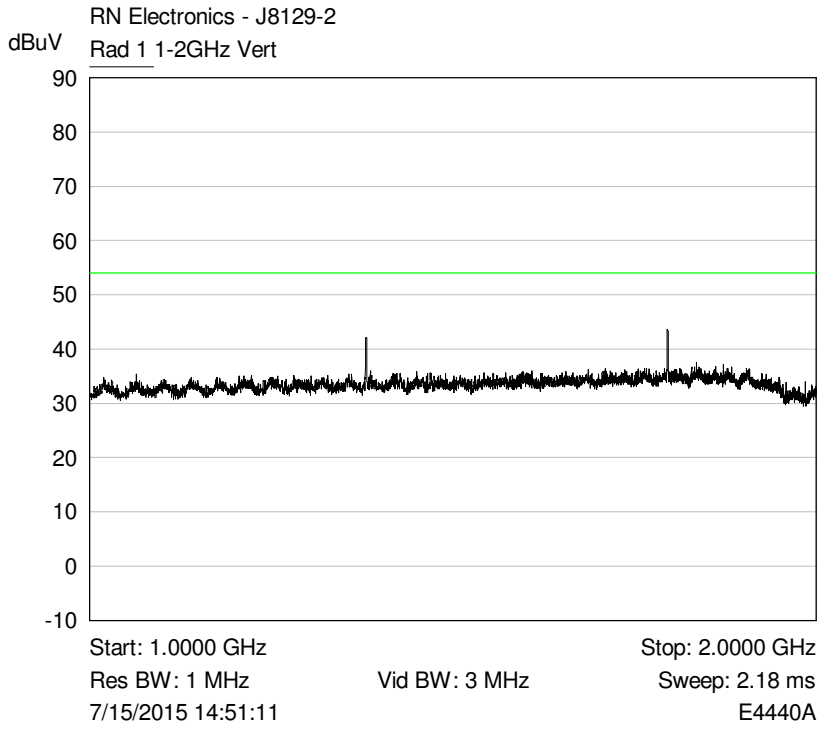


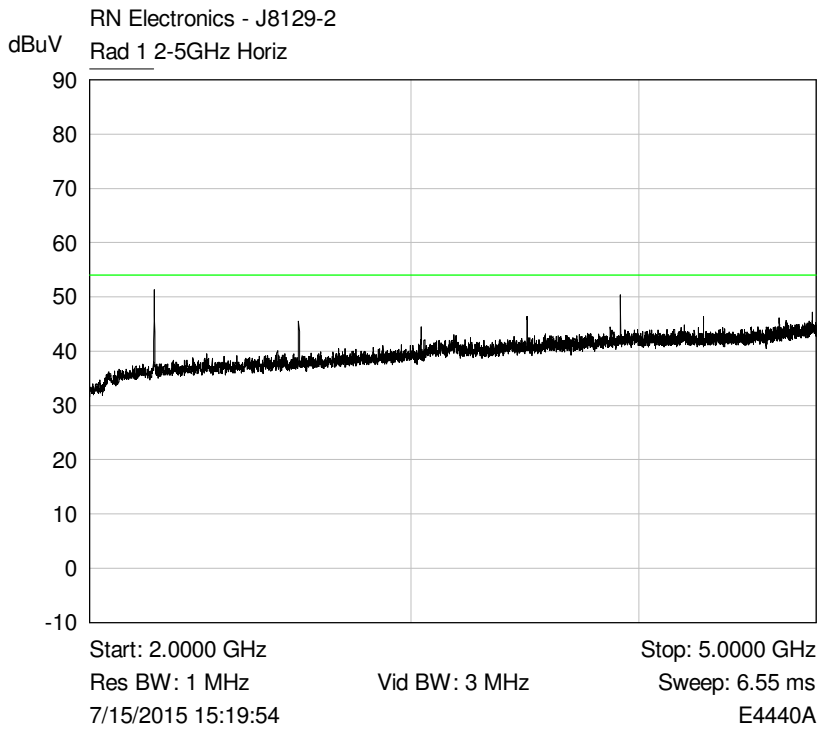
Plot of Vertical UHF

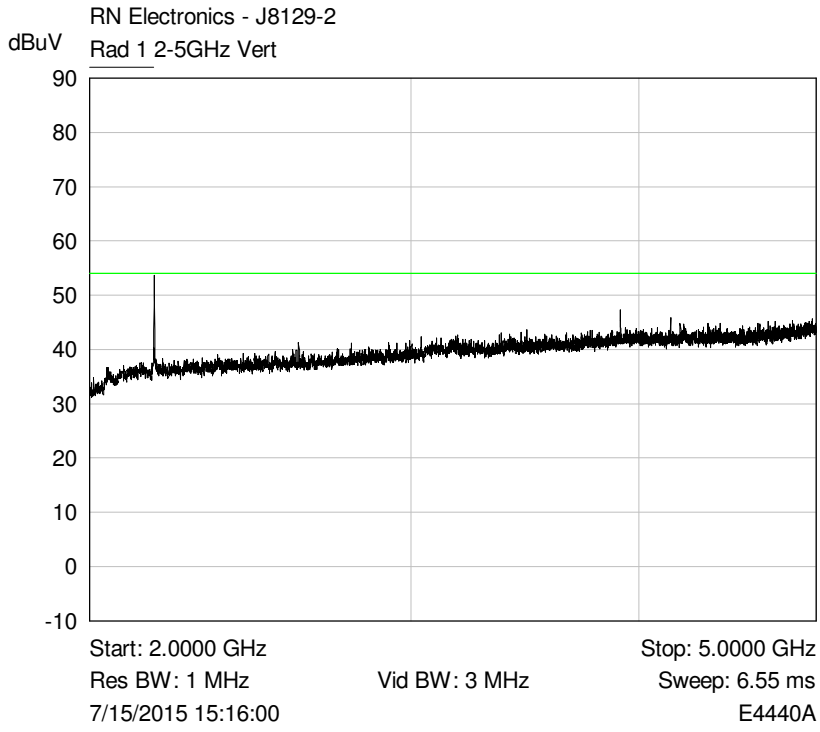
6.4 Radiated emissions Above 1 GHz

RF Parameters: Power Level 10, Modulation FSK, Channel 433.92 MHz



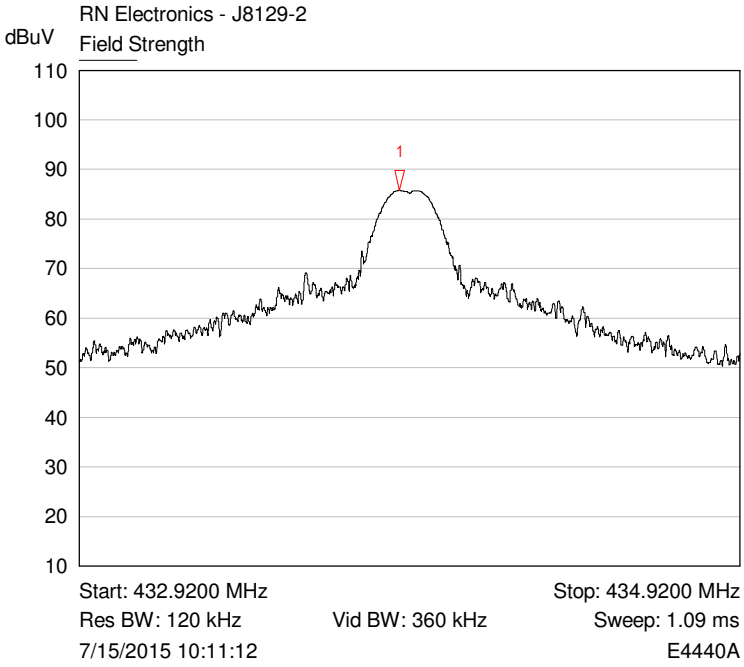



RN Electronics - J8129-2
Rad 1 2-5GHz Horiz
dBuV
90
80
70
60
50
40
30
20
10
0
-10
Start: 2.0000 GHz
Stop: 5.0000 GHz
Res BW: 1 MHz
Vid BW: 3 MHz
Sweep: 6.55 ms
7/15/2015 15:19:54
E4440A


RN Electronics - J8129-2
Rad 1 2-5GHz Vert
dBuV
90
80
70
60
50
40
30
20
10
0
-10
Start: 2.0000 GHz
Stop: 5.0000 GHz
Res BW: 1 MHz
Vid BW: 3 MHz
Sweep: 6.55 ms
7/15/2015 15:16:00
E4440A

6.5 Intentional radiator field strength

RF Parameters: Power Level 10, Modulation FSK, Channel 433.92 MHz

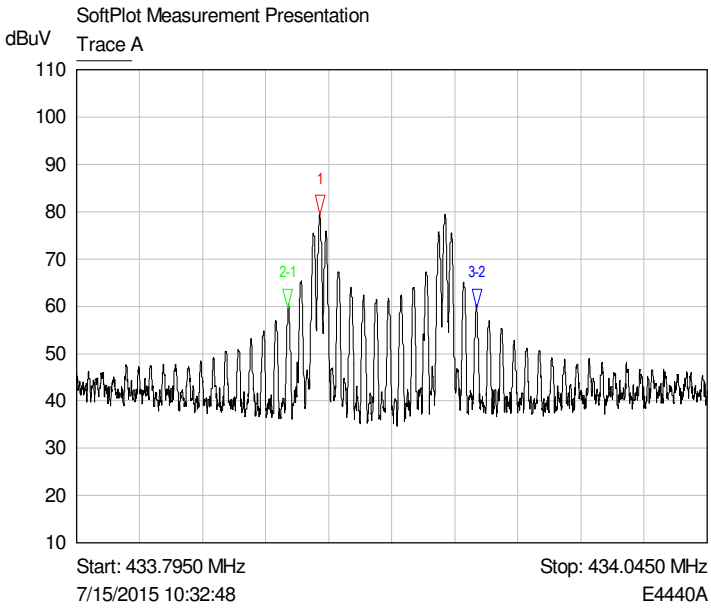


Mkr	Trace	X-Axis	Value	Notes
1 ▽	Field Strength	433.8889 MHz	85.76 dBuV	

Horiz - Upright

6.6 Occupied bandwidth

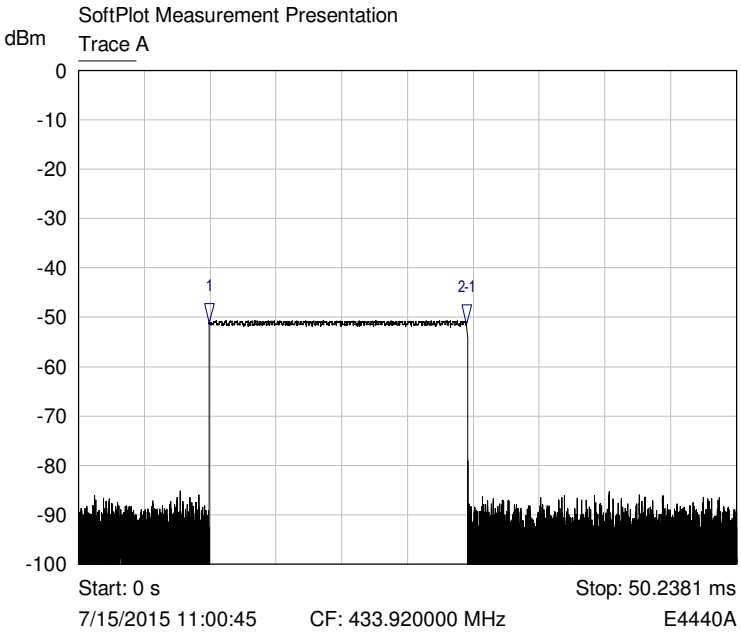
RF Parameters: Power Level 10, Modulation FSK, Channel 433.92 MHz



Mkr	Trace	X-Axis	Value	Notes
1	Trace A	433.8915 MHz	79.58 dBuV	
2-1	Trace A	-12.6358 kHz	-19.93 dB	
3-2	Trace A	74.9603 kHz	-0.04 dB	

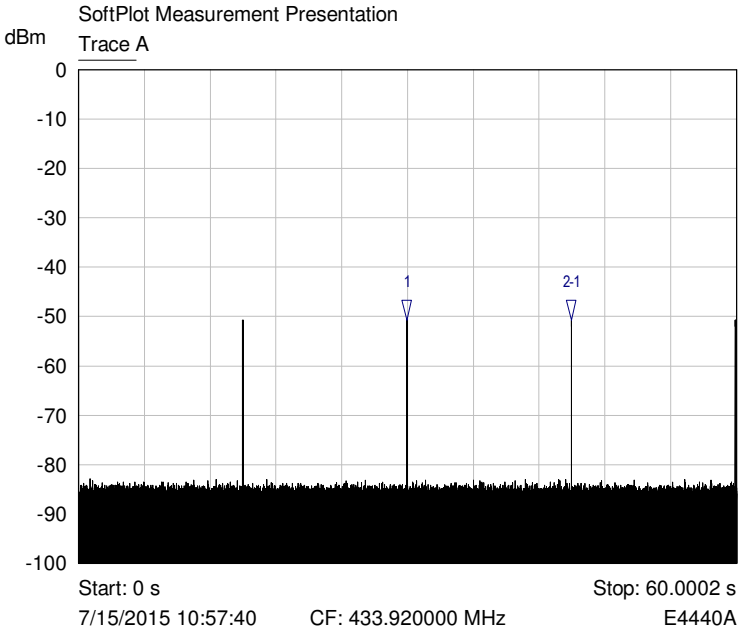
6.7 Periodic operation

RF Parameters: Power Level 10, Modulation FSK, Channel 433.92 MHz



Mkr	Trace	X-Axis	Value	Notes
1 ▽	Trace A	10.0157 ms	-51.22 dBm	
2-1 ▽	Trace A	19.6144 ms	-0.29 dB	

TX on time (ms)



Mkr	Trace	X-Axis	Value	Notes
1 ▽	Trace A	29.9451 s	-50.59 dBm	
2-1 ▽	Trace A	14.9726 s	-0.05 dB	

TX repetition time (S)

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/m)	Pk – Lim 1 (dB)	QP Amp (dBuV/m)	QP - Lim1 (dB)	Av Amp (dBuV/m)	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/m) 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/m) 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/m) 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.

7.1 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
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

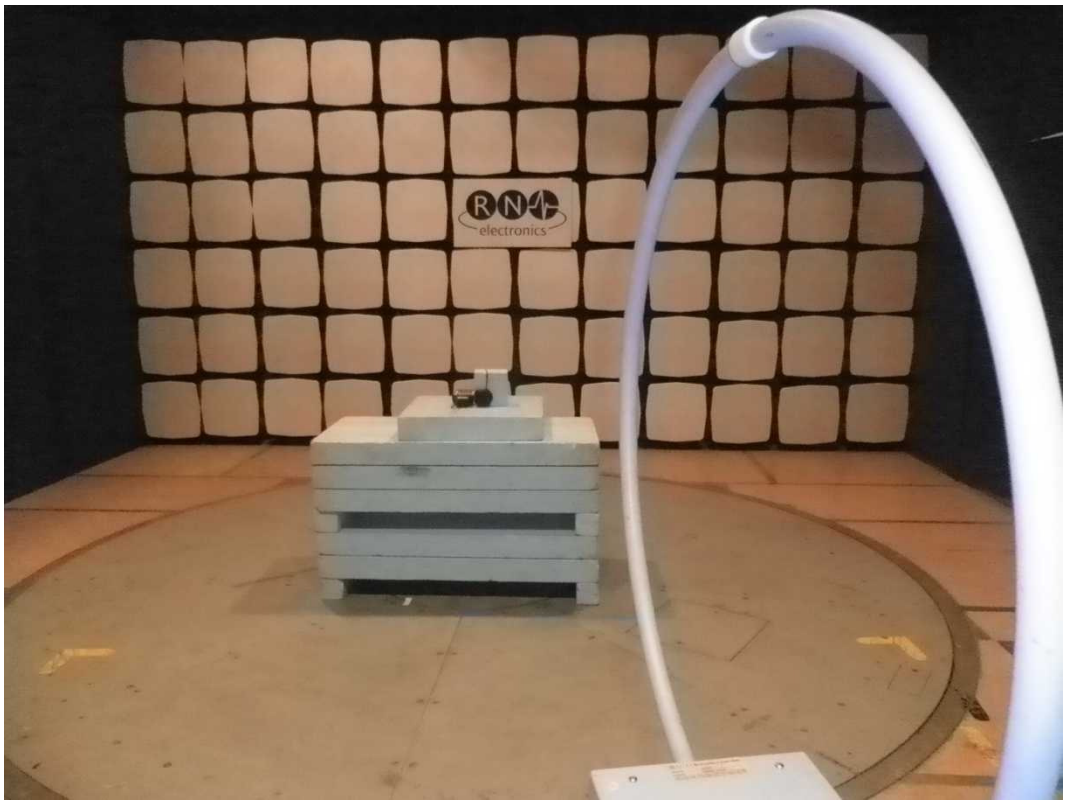
(c) extrapolation factor below 30MHz is 40dB/decade per 15.31(f)(2).

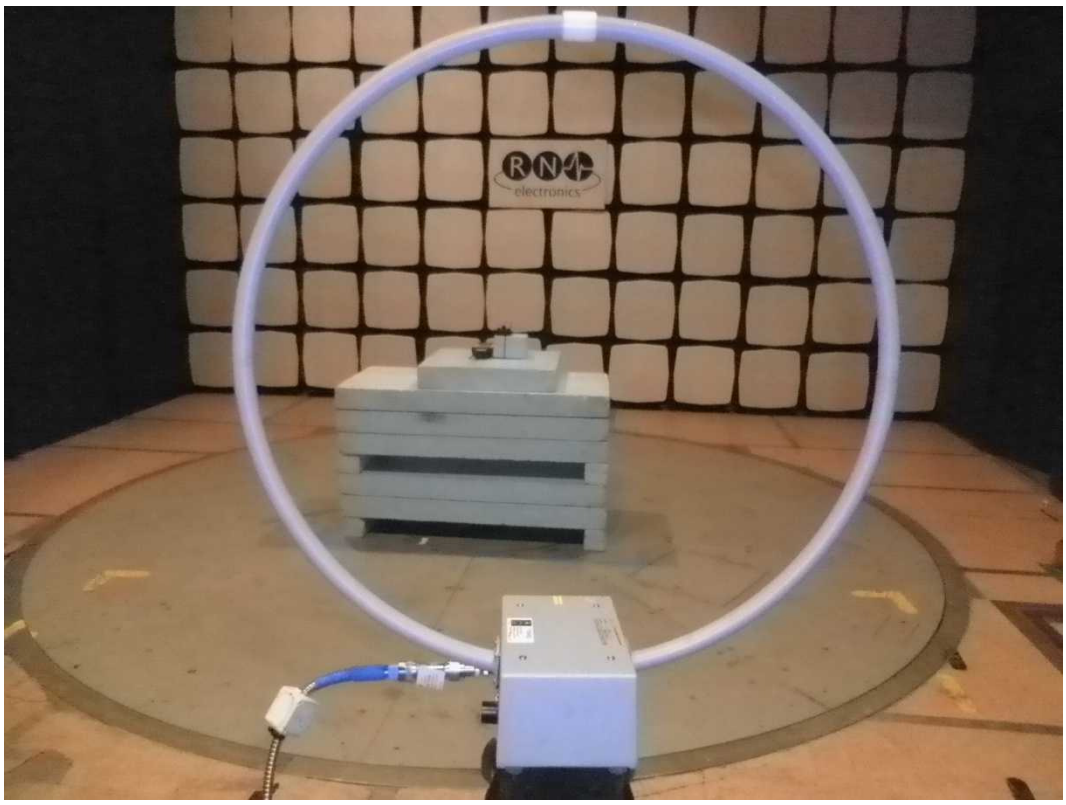
8 Photographs

8.1 EUT Front View

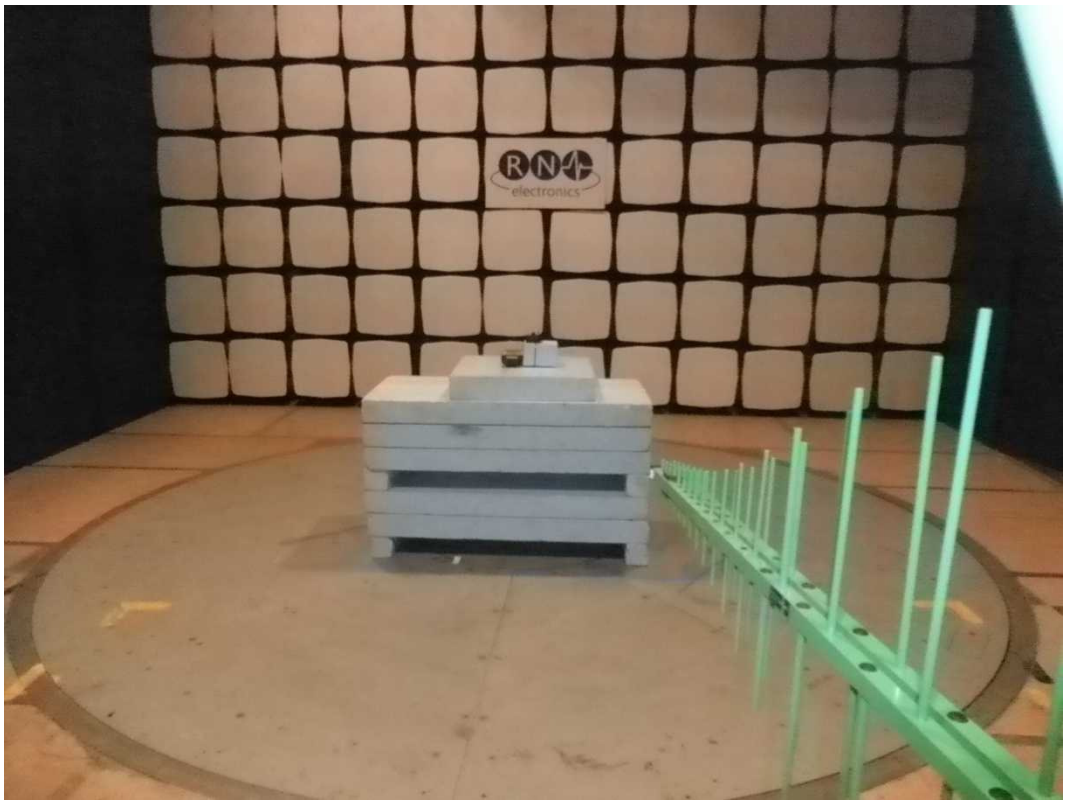
8.2 EUT Reverse Angle

8.3 Radiated emissions - 150 kHz - 30 MHz

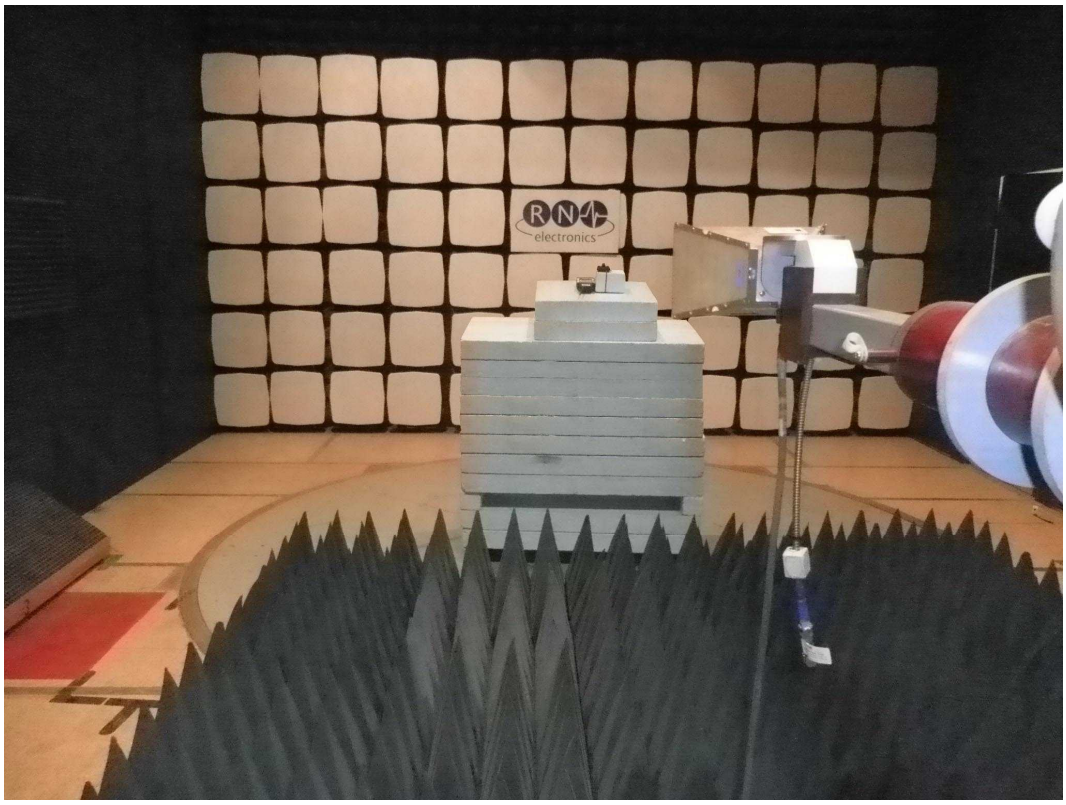




8.4 Radiated emissions - 30 MHz -1 GHz



8.5 Radiated emissions - Above 1 GHz



8.6 Set-up diagrams

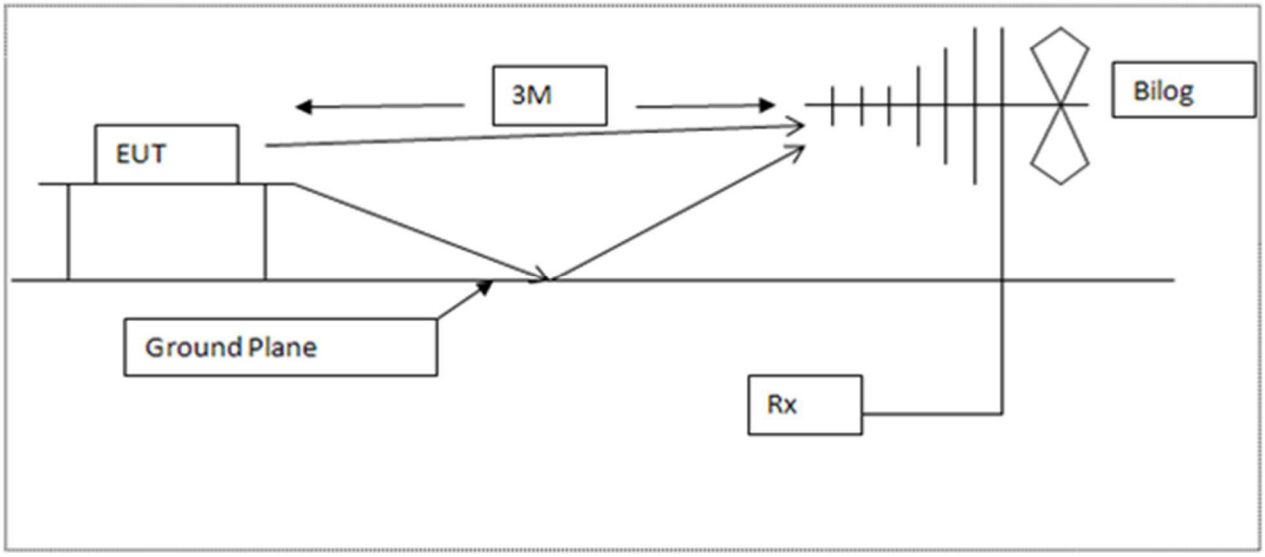


Diagram of the radiated emissions test setup

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
E533	N5182A	6 GHz MXG Signal Generator	Agilent Technologies	26-Feb-2013	36 months
E534	E4440A	3 Hz - 26.5 GHz PSA	Agilent Technologies	26-Feb-2015	24 months
E535	N9039A	9 kHz - 1 GHz RF Filter Section	Agilent Technologies	26-Jan-2015	12 months
LPE261	3115	1-18GHz Horn	EMCO	18-Feb-2014	24 months
LPE333	8449B	Pre-amplifier 1GHz - 26.5GHz	HP	29-Jan-2015	24 months
LPE364	CBL6112A	30MHz - 2GHz Bilog Antenna	Chase Electronics Ltd	02-Dec-2013	24 months
TMS45	Model1	Attenuator	Weinschel	07-Jul-2015	12 months
TMS81	6502	Active Loop Antenna	EMCO	27-Apr-2015	24 months

10 Auxiliary and peripheral equipment

10.1 Customer supplied equipment

Item No.	Model No.	Description	Manufacturer	Serial No.
1	Nomad	Handheld interrogator / programming terminal	Trimble / Raster Vision	S/N 22

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

(EUT serial number 21111357)
In order to meet the intentional radiator field strength limit (72.9 dBuV/m @ 3m average), the EUTs' power level setting was set to 'level 10'. The EUTs' field strength measured 71.6 dBuV/m @ 3m (average) and was therefore within limits.

(Second unit, serial number 2111327)
The field strength of a second production test unit was also measured at power 'level 10' and the measured field strength was 70.9 dBuV/m @ 3m (average), and was therefore within limits.

For full-test serial number 21111357 was used for all tests detailed in this report since it had the highest measured intentional field strength.

No other power level settings were investigated.

Note: It is the manufacturers' responsibility to ensure that power level 10 is suitable for production purposes after allowing for manufacturing variations and component tolerances.

11.2 Modifications during test

No modifications were made during test by RN Electronics Ltd.

12 Compliance information

Products subject to the Declaration of Conformity procedure are required to be supplied with a compliance information statement. A copy of this statement may be included here:

Certified equipment - DoC not required.

13 Description of test sites

Site A Radio / Calibration Laboratory and anechoic chamber

Site B Semi-anechoic chamber

Site B1 Control Room for Site B

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)
VCCI Registration No. C-2823

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 Screened Room

Site K Screened Room (Control Room for Site M)

Site M 3m Semi-anechoic chamber (indoor OATS)
FCC Registration No. 293246

Site Q Fully-anechoic chamber

Site OATS 3m and 10m Open Area Test Site
FCC Registration No. 293246
IC Registration No. 5612A-1
VCCI Registration No. R-2580

Site R Screened Room (Conducted Immunity)

Site S Safety Laboratory

Site T Transient Laboratory

14 Abbreviations and units

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