



2360

Radio Test Report

Roli Ltd

Light Pad Block

LPB01

47 CFR Part 15.249 Effective Date 1st October 2015

DXT: Part 15 Low Power Transceiver

Test Date: 13th September 2016 to 20th September 2016

Report Number: 09-9126-1-16 Issue 02

This report supersedes report: 09-9126-1-16 Issue 01

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Certificate of Test 9126-1

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:	Light Pad Block
Model Number:	LPB01
Unique Serial Number:	PADDVT1666209009
Applicant:	Roli Ltd 2 Glebe Road, Dalston, London E8 4BD
Proposed FCC ID	2AFT3-PB01
Full measurement results are detailed in Report Number:	09-9126-1-16 Issue 02
Test Standards:	47 CFR Part 15.249 Effective Date 1st October 2015 DXT: Part 15 Low Power Transceiver

NOTE:

Certain tests were not performed based upon manufacturer's declarations. 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: 13th September 2016 to 20th September 2016

Test Engineer:

Approved By:
Technical Manager

Customer
Representative:



2360

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2 Equipment under test (EUT)

2.1 Equipment specification

Applicant	Roli Ltd 2 Glebe Road Dalston London E8 4BD	
Manufacturer of EUT	Roli Ltd	
Full Name of EUT	Light Pad Block	
Model Number of EUT	LPB01	
Serial Number of EUT	PADDVT1666209009 (RFtest1)	
Date Received	13th September 2016	
Date of Test:	13th September 2016 to 20th September 2016	
Purpose of Test	To demonstrate design compliance to the relevant rules of Chapter 47 of the Code of Federal Regulations.	
Date Report Created	21st September 2016	
Main Function	Provides a playing surface for creating music in conjunction with an App running on tablet or laptop.	
Information Specification	Height	95mm
	Width	95mm
	Depth	20mm
	Weight	<500g
	Voltage	3.7 V DC nominal from Li internal Battery
	Current	Not specified

2.2 Configurations for testing

General Parameters	
EUT Normal use position	Desktop / handheld
Choice of model(s) for type tests	Production model with engineering test modes
Antenna details	Integral Chip Antenna (Antenova A6111)
Antenna port	No
Baseband Data port (yes/no)?	No
Highest Signal generated in EUT	2480 MHz
Lowest Signal generated in EUT	8MHz
Hardware Version	Not specified
Software Version	Not specified
Firmware Version	Proprietary test firmware v1.0
Type of Equipment	Portable, indoor
Technology Type	Bluetooth LE and Shockburst GFSK
Geo-location (yes/no)	NO
TX Parameters	
Alignment range – transmitter	2402 - 2480 MHz
EUT Declared Modulation Parameters	BT LE ShockBurst (GFSK)
EUT Declared Power level	0dBm
EUT Declared Signal Bandwidths	BTLE: 1MHz ShockBurst : 1MHz and 2MHz
EUT Declared Channel Spacing's	2MHz
EUT Declared Duty Cycle	BT LE approx 66% worst case ShockBurst 15% duty cycle absolute worst case
Unmodulated carrier available?	No
Declared frequency stability	40ppm
RX Parameters	
Alignment range – receiver	2402 - 2480 MHz
EUT Declared RX Signal Bandwidth	2MHz
Receiver Signal Level (RSL)	Not specified
Method of Monitoring Receiver BER	Not applicable
SRD Parameters	
Equipment class	DXT: Part 15 Low Power Transceiver

2.3 Functional description

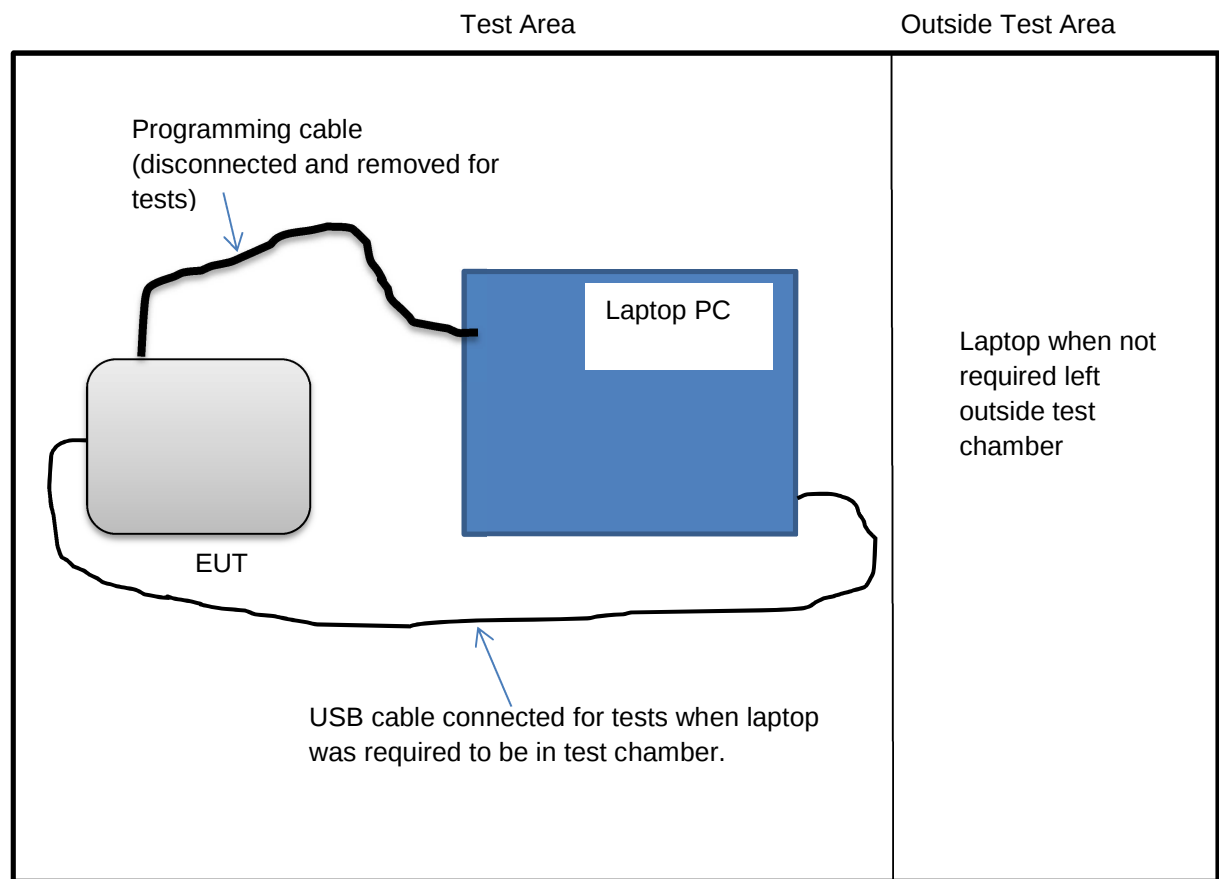
Provides a playing surface for creating music in conjunction with an App running on tablet or laptop, communicating to device over bluetooth. Receives messages from Control block and acknowledges them using proprietary radio.

2.4 Modes of operation

Mode Reference	Description	Used for testing
BTLE Low chan	Bluetooth transmitting packet data repeatedly on 2402MHz.	Yes
BTLE Mid chan	Bluetooth transmitting packet data repeatedly on 2440MHz.	Yes
BTLE High chan	Bluetooth transmitting packet data repeatedly on 2480MHz.	Yes
Shockburst 1MHz Low chan	Shockburst mode 1MHz (GFSK) transmitting packet data repeatedly on 2402MHz.	Yes
Shockburst 1MHz Mid chan	Shockburst mode 1MHz (GFSK) transmitting packet data repeatedly on 2440MHz.	Yes
Shockburst 1MHz High chan	Shockburst mode 1MHz (GFSK) transmitting packet data repeatedly on 2480MHz.	Yes
Shockburst 2MHz Low chan	Shockburst mode 2MHz (GFSK) transmitting packet data repeatedly on 2402MHz.	Yes
Shockburst 2MHz Mid chan	Shockburst mode 2MHz (GFSK) transmitting packet data repeatedly on 2440MHz.	Yes
Shockburst 2MHz High chan	Shockburst mode 2MHz (GFSK) transmitting packet data repeatedly on 2480MHz.	Yes

Note: The following duty cycles for the above modes of operation were confirmed as: BTLE 62.5%, Shockburst 1MHz 16% and Shockburst 2MHz 8.6%. Please see section 5.9 within this report for further details.

2.5 Emissions configuration



The unit was powered from its fully charged internal battery for tests. Where required the unit was also connected back to a laptop PC via its USB port. All tests were performed radiated. The unit was configured via a serial to USB converter lead magnetically coupled to a specific docking port on the unit, which was connected back to an ancillary laptop. This port was provided for test purposes only and allowed access to the specific engineering test modes required for tests via use of a terminal program called “cool term”. Modes set are listed in section 2.4. Low, mid and high channel frequencies were selected, along with the radio type (Bluetooth or Shockburst). Power levels for tests were all left set to the default 0dBm setting. The transmit modes used the following measured duty cycles, and were declared by the manufacturer to be worst case (maximum) duty cycles the equipment could use:

BTLE: 62.5%
Shockburst 1MHz: 16%
Shockburst 2MHz: 8%

For the purposes of radiated emissions between 30-1000MHz worst case emissions were with the unit connected to a laptop via its USB port. For radiated emissions above 1GHz and field strength measurements highest levels were recorded in a stand alone configuration without the laptop connected. Refer to the specific test sections in section 5 for further details.

For the purposes of AC conducted emissions tests an “off the shelf” laptop was used for tests.

2.5.1 Signal leads

Port Name	Cable Type	Connected
USB	USB mini	Yes

3 Summary of test results

The Light Pad Block, LPB01 was tested for compliance to the following standard(s) :

47 CFR Part 15.249 Effective Date 1st October 2015
DXT: Part 15 Low Power Transceiver

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	PASSED
2. Radiated emissions 9 - 150 kHz		NOT APPLICABLE ¹
3. Radiated emissions 150 kHz - 30 MHz	47 CFR Part 15C Part 15.209 & 15.249d	PASSED
4. Radiated emissions 30 MHz -1 GHz	47 CFR Part 15C Part 15.209 & 15.249a,d	PASSED
5. Radiated emissions above 1 GHz	47 CFR Part 15C Part 15.209 & 15.249a,d	PASSED ²
6. Intentional radiator field strength	47 CFR Part 15C Part 15.249a	PASSED
7. Band Edge Compliance	47 CFR Part 15C Part 15.215, 15.209,15.249a,d	PASSED
8. Occupied bandwidth	47 CFR Part 15C Part 15.215	PASSED
9. Duty cycle	47 CFR Part 15C Part 15.35 & 15.249(e)	PERFORMED ³
10. Frequency stability		NOT APPLICABLE ⁴

¹ EUT's lowest generated or used frequency is declared as 8MHz. Therefore tests have only been performed down to 150kHz

² Spectrum investigated up to a frequency of 25GHz based on 10 times the highest channel frequency used in the equipment of 2.48GHz.

³ Test performed to confirm duty cycle of test modes. Results for duty cycle can be used to apply corrections to average emissions measurements where applicable.

⁴ Test only applies to equipment intended for fixed, point-to-point operation.

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	2015	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

5 Tests, methods and results

5.1 AC power line conducted emissions

5.1.1 Test methods

Test Requirements:	47 CFR Part 15C Part 15.207 [Reference 4.1.1 of this report]
Test Method:	ANSI C63.10 Clause 6.2 [Reference 4.1.2 of this report]
Limits:	47 CFR Part 15C Part 15.207 [Reference 4.1.1 of this report]

5.1.2 Configuration of EUT

The EUT and ancillary laptop were placed on a wooden table 0.8m above the ground plane and the laptop supply was connected to a LISN via a 1m mains cable.

Details of the Peripheral and Ancillary Equipment connected for this test are listed in section 10.

During the initial scan, there was no discernible difference noted in emissions between modes listed in section 2.4 of this report. Therefore final tests were performed with the EUT operating in mode **BTLE Mid chan**.

5.1.3 Test procedure

Tests were made in accordance with FCC Part 15 using the measuring equipment listed in the 'Test Equipment' Section. Measurements were made on the live and neutral conductors using both average and quasi-peak detection.

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

Tests were performed in Test Site F.

5.1.4 Test equipment

E010, E035, ZSW1, E411, E624

See Section 9 for more details

5.1.5 Test results

Temperature of test environment	20°C
Humidity of test environment	70%
Pressure of test environment	101kPa

Band	2400-2483.5 MHz
Power Level	0 dBm
Channel Spacing	2 MHz
Mod Scheme	BT LE
Mid channel	2440 MHz

Plot refs
9126-1 Cond 1 AC Live 150k-30M Average
9126-1 Cond 1 AC Live 150k-30M Quasi-Peak
9126-1 Cond 1 AC Neutral 150k-30M Average
9126-1 Cond 1 AC Neutral 150k-30M Quasi-Peak

Table of signals measured for Cond 1 AC Live 150k-30M

Signal No.	Freq (MHz)	Peak Amp (dBuV)	QP Amp (dBuV)	QP Lim (dB)	AV Amp (dBuV)	AV Lim (dB)
1	0.229	51.0	47.6	-14.9	30.0	-22.5
2	0.275	52.4	45.7	-15.3	40.4	-10.6
3	0.354	41.6	38.0	-20.9	24.0	-24.9
4	0.400	46.2	42.4	-15.5	26.8	-21.1
5	0.440	47.4	43.8	-13.3	25.4	-21.7
6	0.465	46.6	43.2	-13.4	21.8	-24.8
7	0.498	44.0	39.1	-16.9	21.9	-24.1
8	0.588	44.6	38.2	-17.8	30.9	-15.1
9	0.588	45.4	41.4	-14.6	32.1	-13.9
10	0.619	44.2	40.3	-15.7	31.7	-14.3
11	0.741	42.4	35.6	-20.4	22.0	-24.0
12	0.841	41.5	35.7	-20.3	23.4	-22.6
13	0.855	42.5	37.1	-18.9	23.0	-23.0
14	0.900	37.0	37.1	-18.9	26.1	-19.9
15	0.908	37.1	33.9	-22.1	20.4	-25.6
16	0.932	38.4	34.4	-21.6	25.1	-20.9
17	0.963	37.1	32.4	-23.6	20.8	-25.2
18	1.039	42.1	32.5	-23.5	21.8	-24.2
19	1.088	39.7	34.1	-21.9	22.0	-24.0

Table of signals measured for Cond 1 AC Neutral 150k-30M

Signal No.	Freq (MHz)	Peak Amp (dBuV)	QP Amp (dBuV)	QP Lim (dB)	AV Amp (dBuV)	AV Lim (dB)
1	0.264	34.7	42.5	-18.8	28.0	-23.3
2	0.290	69.1	42.2	-18.3	21.8	-28.7
3	0.351	37.9	49.8	-9.1	30.9	-18.0
4	0.389	21.8	14.5	-43.6	6.1	-42.0
5	0.400	23.8	21.3	-36.6	19.4	-28.5
6	0.432	58.1	25.0	-32.2	20.5	-26.7
7	0.449	30.6	37.6	-19.3	20.0	-26.9
8	0.487	24.8	27.9	-28.3	20.5	-25.7
9	0.559	22.7	20.6	-35.4	16.8	-29.2
10	0.570	49.5	31.4	-24.6	16.3	-29.7
11	0.582	28.0	37.0	-19.0	21.7	-24.3
12	0.615	29.1	23.4	-32.6	15.7	-30.3
13	0.615	26.1	23.9	-32.1	15.9	-30.1
14	0.646	23.4	22.0	-34.0	17.0	-29.0
15	0.701	24.2	23.7	-32.3	10.5	-35.5
16	0.721	47.6	30.8	-25.2	8.7	-37.3
17	0.786	41.5	31.3	-24.7	18.6	-27.4
18	0.913	27.3	26.6	-29.4	19.0	-27.0
19	0.950	32.9	28.5	-27.5	17.5	-28.5
20	1.048	22.3	19.2	-36.8	12.8	-33.2

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

LIMITS:

15.207: as given in the above tables & 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:

150kHz to 30MHz $\pm 3.6\text{dB}$

5.2 Radiated emissions 9 - 150 kHz

NOT APPLICABLE: EUT's lowest generated or used frequency is declared as 8MHz. Therefore tests have only been performed down to 150kHz.

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 15.209/15.249(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 EUT was rotated in all three orthogonal planes. Radiated Emissions testing was performed with a fully charged battery. During the initial scan, there was no discernible difference noted in emissions between modes listed in section 2.4 of this report. Therefore final tests were performed with the EUT operating in mode **BTLE Mid chan**.

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 final measurements on an OATS without a ground plane. The antenna was placed 1m above the ground. The equipment and the antenna were rotated 360 degrees to record the worst case emissions.

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

Tests were performed using Test Site H and OATS.

5.3.4 Test equipment

TMS81, TMS45, ZSW1, E534, E535

See Section 9 for more details

5.3.5 Test results

Temperature of test environment	24°C
Humidity of test environment	51%
Pressure of test environment	102kPa

Band	2400-2483.5 MHz
Power Level	0 dBm
Channel Spacing	2 MHz
Mod Scheme	BT LE
Mid channel	2440 MHz

Plot refs
9126-1 Rad 1 150k-30MHz Para
9126-1 Rad 1 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.

LIMITS:

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

15.249(d) other emissions, outside the intentional band, must be attenuated by at least 50dB from the level of the fundamental or meet the general limits of 15.209 whichever is the lesser attenuation.

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 $\pm 3.9\text{dB}$

5.4 Radiated emissions 30 MHz -1 GHz

5.4.1 Test methods

Test Requirements:	47 CFR Part 15C Part 15.209 [Reference 4.1.1 of this report]
Test Method:	ANSI C63.10 Clause 6.3 & 6.5 [Reference 4.1.2 of this report]
Limits:	47 CFR Part 15C Part 15.209/15.249(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 along with an ancillary laptop. 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 a fully charged battery and connected to an ancillary laptop. No discernible difference in emissions was noted between mod schemes and channels settings; however, the configuration using the laptop and USB lead did provide worst case radiated emissions results in this test range. The EUT was therefore connected to the laptop via the USB lead for full test and operated in **BTLE Mid chan** mode.

5.4.3 Test procedure

Tests were made in accordance with FCC Part 15 using the measuring equipment listed below.

Measurements were made on a site listed with the FCC. 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.

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

Tests were performed using Test Site H.

5.4.4 Test equipment

LPE364, TMS45, ZSW1, E534, E535

See Section 9 for more details

5.4.5 Test results

Temperature of test environment	24°C
Humidity of test environment	51%
Pressure of test environment	102kPa

Band	2400-2483.5 MHz
Power Level	0 dBm
Channel Spacing	2 MHz
Mod Scheme	BT LE
Single channel	2440 MHz

Plot refs
9126-1 Rad 2 VHF Horiz
9126-1 Rad 2 VHF Vert
9126-1 Rad 2 UHF Horiz
9126-1 Rad 2 UHF Vert

Table of signals measured for Rad 1 Vertical Sig List

Signal No.	Freq (MHz)	Peak Amp (dBuV/m)	QP Amp (dBuV/m)	QP Lim (dB)
1	675.001	45.8	38.5	-7.5

Table of signals measured for Rad 1 Horizontal Sig List

Signal No.	Freq (MHz)	Peak Amp (dBuV/m)	QP Amp (dBuV/m)	QP Lim (dB)
1	200.021	24.8	22.1	-21.4

Note: Only signals measured within 20dB of the limits have been reported.

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

No discernible difference was noted in emissions between channel settings (exploratory measurements), therefore final measurements are presented for TX mid channel mode only for these test ranges.

LIMITS:

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

15.249(d) other emissions, outside the intentional band, must be attenuated by at least 50dB from the level of the fundamental or meet the general limits of 15.209 whichever is the lesser attenuation.

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 ± 6.1 dB

5.5 Radiated emissions above 1 GHz

5.5.1 Test methods

Test Requirements:	47 CFR Part 15C Part 15.209 [Reference 4.1.1 of this report]
Test Method:	ANSI C63.10 Clause 6.3 & 6.6 [Reference 4.1.2 of this report]
Limits:	47 CFR Part 15C Part 15.209/15.249(d) [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. Radiated Emissions testing was performed with a fully charged battery. Small differences in emissions were noted between mod schemes and channels settings. The configuration using the device without the USB lead and laptop provided worst case radiated emissions results for this test range. The EUT was therefore operated in a stand-alone configuration (NOT connected to the laptop via the USB lead) and operated in all the test modes specified in section 2.4 of this report.

5.5.3 Test procedure

Tests were made in accordance with FCC Part 15 using the measuring equipment listed below. Measurements were made in a semi-anechoic chamber with appropriate absorbing material for use in this range. Horn antennas were used at heights where the whole of the EUT was contained within the main beam. The EUT was rotated through 360 degrees to record the worst case emissions. A measurement distance of 3m was used between the test range 1 - 6GHz, 1.2m was used in the test range 6 - 18GHz and 0.3m was used in the test range 18 - 40GHz. Max held sweeps using a Peak detector were used to determine emissions levels.

At least 6 signals within 20dB and all signals within 10dB of the limit were investigated.
Tests were performed using test Site H.

5.5.4 Test equipment

E533, E534, E535, LPE261, LPE333, TMS78, TMS79

See Section 9 for more details

5.5.5 Test results

Temperature of test environment	19-27°C
Humidity of test environment	43-58%
Pressure of test environment	101-102kPa

Setup Table

Band	2400-2483.5 MHz
Power Level	0 dBm
Channel Spacing	2 MHz
Mod Scheme	BT LE
Low channel	2402 MHz

Spurious Frequency (MHz)	Measured Peak Level (dBµV/m)	Difference to Peak Limit (dB)	Difference to Average Limit of Peak level (dB)	EUT Polarisation	Antenna Polarisation
4804	46.7	-27.3	-7.3	side usb up	Vertical
4804	47.9	-26.1	-6.1	side usb on side	Horizontal

Note: Average measurements were not performed as the Peak measurements made were compliant with the average limits.

Setup Table

Band	2400-2483.5 MHz
Power Level	0 dBm
Channel Spacing	2 MHz
Mod Scheme	BT LE
Mid channel	2440 MHz

Spurious Frequency (MHz)	Measured Peak Level (dBμV/m)	Difference to Peak Limit (dB)	Difference to Average Limit of Peak level (dB)	EUT Polarisation	Antenna Polarisation
4880	48	-26.0	-6.0	side usb up	Vertical
4880	49.5	-24.5	-4.5	side usb on side	Horizontal
7320	42.5	-31.5	-11.5	side usb on side	Vertical
7320	47	-27.0	-7.0	side usb on side	Horizontal

Note: Average measurements were not performed as the Peak measurements made were compliant with the average limits.

Plot references
9126-1 Mid channel TX horizontal 1-2.4GHz
9126-1 Mid channel TX vertical 1-2.4GHz
9126-1 Mid channel TX horizontal 2.4-2.4835GHz
9126-1 Mid channel TX vertical 2.4-2.4835GHz
9126-1 Mid channel TX horizontal 2.4835-5GHz
9126-1 Mid channel TX vertical 2.4835-5GHz
9126-1 Mid channel TX horizontal 5-6GHz
9126-1 Mid channel TX vertical 5-6GHz
9126-1 Mid channel TX horizontal 6-10GHz
9126-1 Mid channel TX vertical 6-10GHz
9126-1 Mid channel TX horizontal 10-12GHz
9126-1 Mid channel TX vertical 10-12GHz
9126-1 Mid channel TX horizontal 12-15GHz
9126-1 Mid channel TX vertical 12-15GHz
9126-1 Mid channel TX horizontal 15-18GHz
9126-1 Mid channel TX vertical 15-18GHz
9126-1 Mid channel TX horizontal 18-21.5GHz
9126-1 Mid channel TX vertical 18-21.5GHz
9126-1 Mid channel TX horizontal 21.5-25GHz
9126-1 Mid channel TX vertical 21.5-25GHz

Setup Table

Band	2400-2483.5 MHz
Power Level	0 dBm
Channel Spacing	2 MHz
Mod Scheme	BT LE
High channel	2480 MHz

Spurious Frequency (MHz)	Measured Peak Level (dBμV/m)	Difference to Peak Limit (dB)	Difference to Average Limit of Peak level (dB)	EUT Polarisation	Antenna Polarisation
4960	49.4	-24.6	-4.6	side usb up	Vertical
4960	50.9	-23.1	-3.1	side usb on side	Horizontal
7440	45.5	-28.5	-8.5	side usb on side	Vertical
7440	47.5	-26.5	-6.5	side usb on side	Horizontal

Note: Average measurements were not performed as the Peak measurements made were compliant with the average limits.

Setup Table

Band	2400-2483.5 MHz
Power Level	0 dBm
Channel Spacing	2 MHz
Mod Scheme	Shockburst 1MHz
Low channel	2402 MHz

Spurious Frequency (MHz)	Measured Peak Level (dBμV/m)	Difference to Peak Limit (dB)	Difference to Average Limit of Peak level (dB)	EUT Polarisation	Antenna Polarisation
4802	46.0	-28.0	-8.0	side usb up	Vertical
4802	47.4	-26.6	-8.6	side usb on side	Horizontal
4804	46.0	-28.0	-8.0	side usb up	Vertical
4804	47.0	-27.0	-7.0	side usb on side	Horizontal

Note: Average measurements were not performed as the Peak measurements made were compliant with the average limits.

Setup Table

Band	2400-2483.5 MHz
Power Level	0 dBm
Channel Spacing	2 MHz
Mod Scheme	Shockburst 1MHz
Mid channel	2440 MHz

Spurious Frequency (MHz)	Measured Peak Level (dBμV/m)	Difference to Peak Limit (dB)	Difference to Average Limit of Peak level (dB)	EUT Polarisation	Antenna Polarisation
4878	46.0	-28.0	-8.0	side usb up	Vertical
4878	48.6	-25.4	-7.4	side usb on side	Horizontal
4880	47.0	-27.0	-7.0	side usb up	Vertical
4880	48.4	-25.6	-5.6	side usb on side	Horizontal
7320	43.5	-30.5	-10.5	side usb on side	Horizontal

Note: Average measurements were not performed as the Peak measurements made were compliant with the average limits.

Setup Table

Band	2400-2483.5 MHz
Power Level	0 dBm
Channel Spacing	2 MHz
Mod Scheme	Shockburst 1MHz
High channel	2480 MHz

Spurious Frequency (MHz)	Measured Peak Level (dBμV/m)	Difference to Peak Limit (dB)	Difference to Average Limit of Peak level (dB)	EUT Polarisation	Antenna Polarisation
4958	50.8	-23.2	-3.2	side usb on side	Horizontal
4960	49.0	-25.0	-5.0	side usb up	Vertical
4960	51.0	-23.0	-3.0	side usb on side	Horizontal
7440	45.3	-28.7	-8.7	side usb on side	Horizontal

Note: Average measurements were not performed as the Peak measurements made were compliant with the average limits.

Setup Table

Band	2400-2483.5 MHz
Power Level	0 dBm
Channel Spacing	2 MHz
Mod Scheme	Shockburst 2MHz
Low channel	2402 MHz

Spurious Frequency (MHz)	Measured Peak Level (dBμV/m)	Difference to Peak Limit (dB)	Difference to Average Limit of Peak level (dB)	EUT Polarisation	Antenna Polarisation
4800	46.7	-27.3	-7.3	side usb up	Vertical
4800	48.0	-26.0	-6.0	side usb on side	Horizontal
4804	46.7	-27.3	-7.3	side usb up	Vertical
4804	47.9	-26.1	-6.1	side usb on side	Horizontal

Note: Average measurements were not performed as the Peak measurements made were compliant with the average limits.

Setup Table

Band	2400-2483.5 MHz
Power Level	0 dBm
Channel Spacing	2 MHz
Mod Scheme	Shockburst 2MHz
Mid channel	2440 MHz

Spurious Frequency (MHz)	Measured Peak Level (dBμV/m)	Difference to Peak Limit (dB)	Difference to Average Limit of Peak level (dB)	EUT Polarisation	Antenna Polarisation
4876	47.0	-27.0	-7.0	side usb up	Vertical
4876	48.7	-25.3	-5.3	side usb on side	Horizontal
4880	48.0	-26.0	-6.0	side usb up	Vertical
4880	49.5	-24.5	-4.5	side usb on side	Horizontal

Note: Average measurements were not performed as the Peak measurements made were compliant with the average limits.

Setup Table

Band	2400-2483.5 MHz
Power Level	0 dBm
Channel Spacing	2 MHz
Mod Scheme	Shockburst 2MHz

High channel	2480 MHz
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Spurious Frequency (MHz)	Measured Peak Level (dBμV/m)	Difference to Peak Limit (dB)	Difference to Average Limit (dB)	EUT Polarisation	Antenna Polarisation
4956	51.0	-23.0	-3.0	side usb on side	Horizontal
4960	49.0	-25.0	-5.0	side usb up	Vertical
4960	50.7	-23.3	-3.3	side usb on side	Horizontal

Note: Average measurements were not performed as the Peak measurements made were compliant with the average limits.

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

Note: Whilst Low, Mid and High channels were tested in conjunction with the 3 modulation schemes, plots are for illustrative purposes only and only Mid channel BTLE plots are shown in this report.

LIMITS:

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

15.249(d) other emissions, outside the intentional band, must be attenuated by at least 50dB from the level of the fundamental or meet the general limits of 15.209 whichever is the lesser attenuation.

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 – 18 GHz ± 3.5 dB, 18 – 26.5 GHz ± 3.9 dB

5.6 Intentional radiator field strength

5.6.1 Test methods

Test Requirements:	47 CFR Part 15C Part 15.249a [Reference 4.1.1 of this report]
Test Method:	ANSI C63.10 Clause 6.3 & 6.6 [Reference 4.1.2 of this report]
Limits:	47 CFR Part 15C Part 15.249a [Reference 4.1.1 of this report]

5.6.2 Configuration of EUT

The EUT was placed on a 1.5 metre 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 used in both Horizontal and Vertical polarisations. The EUT was rotated in all three orthogonal planes. Testing was performed with a fully charged battery. The configuration using the device without the USB lead and laptop provided worst case (maximum) radiated fundamental field strength results. The EUT was therefore operated in a stand-alone configuration (NOT connected to the laptop via the USB lead) for full tests and operated in all the test modes specified in section 2.4 of this report.

5.6.3 Test procedure

Tests were made in accordance with FCC Part 15 using the measuring equipment listed below.

Maximum field strength was measured using a spectrum analyser set with the appropriate RBW and span to encompass the entire signal and in conjunction with a PK detector.

Measurements were made in a semi-anechoic chamber. This site is listed with the FCC. Measurements were made at site H.

5.6.4 Test equipment

E533, E534, E535, LPE333, LPE261

See Section 9 for more details

5.6.5 Test results

Temperature of test environment	19-23°C
Humidity of test environment	45-53%
Pressure of test environment	101.5kPa

Band	2400-2483.5 MHz
Power Level	0 dBm
Channel Spacing	2 MHz
Mod Scheme	BT LE
Low channel	2402 MHz
Mid channel	2440 MHz
High channel	2480 MHz

	Low	Mid	High
Peak Level (dBµV/m)	93.30	92.60	90.30
Plot reference	9126-1 BLTE mode, 3M RBW PK field strength Low chan	9126-1 BLTE mode, 3M RBW PK field strength Mid chan	9126-1 BLTE mode, 3M RBW PK field strength high chan
Antenna Polarisation	Horiz	Horiz	Horiz
EUT Polarisation	Side (USB side)	Side (USB side)	Side (USB side)

Band	2400-2483.5 MHz
Power Level	0 dBm
Channel Spacing	2 MHz
Mod Scheme	Shockburst 1MHz
Low channel	2402 MHz
Mid channel	2440 MHz
High channel	2480 MHz

	Low	Mid	High
Peak Level (dBµV/m)	93.30	92.60	90.30
Plot reference	9126-1 prop mode 1MBIT, 3M RBW PK field strength Low chan	9126-1 prop mode 1MBIT, 3M RBW PK field strength Mid chan	9126-1 Prop mode 1MBIT, 3M RBW PK field strength high chan
Antenna Polarisation	Horiz	Horiz	Horiz
EUT Polarisation	Side (USB side)	Side (USB side)	Side (USB side)

Band	2400-2483.5 MHz
Power Level	0 dBm
Channel Spacing	2 MHz
Mod Scheme	Shockburst 2MHz
Low channel	2402 MHz
Mid channel	2440 MHz
High channel	2480 MHz

	Low	Mid	High
Peak Level (dBµV/m)	93.30	92.60	90.30
Plot reference	9126-1 prop mode 2MBIT, 3M RBW PK field strength Low chan	9126-1 prop mode 2MBIT, 3M RBW PK field strength Mid chan	9126-1 Prop mode 2MBIT, 3M RBW PK field strength high chan
Antenna Polarisation	Horiz	Horiz	Horiz
EUT Polarisation	Side (USB side)	Side (USB side)	Side (USB side)

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

LIMITS:

15.249(a) 50 mV/m @ 3m (94 dBµV/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 (1 - 18 GHz)

5.7 Band Edge Compliance

5.7.1 Test methods

Test Requirements:	47 CFR Part 15C Part (15.215 & 15.249d) [Reference 4.1.1 of this report]
Test Method:	ANSI C63.10 Clause 6.10 [Reference 4.1.2 of this report]
Limits:	47 CFR Part 15C Part 15.209 & 15.249 [Reference 4.1.1 of this report]

5.7.2 Configuration of EUT

The EUT was configured exactly the same as for the maximum fundamental field strength results measured in section 5.6.1 of this report. The EUT was operated in Low and High channel modes in modulation schemes, BTLE, Shockburst 1MHz and Shockburst 2MHz for tests.

5.7.3 Test procedure

Tests were made in accordance with FCC Part 15 using the measuring equipment listed below. Appropriate RBW, VBW and spans were set on a spectrum analyser with a peak detector and a Max held display. The emission from the EUT was maximised before taking the plots.

Tests were performed using Test Site H.

5.7.4 Test equipment

E533, E534, E535, LPE261, LPE333

See Section 9 for more details

5.7.5 Test results

Temperature of test environment	22-24°C
Humidity of test environment	48-53%
Pressure of test environment	101.5kPa

Band	2400-2483.5 MHz
Power Level	0 dBm
Channel Spacing	2 MHz
Mod Scheme	BT LE MHz
Low channel	2402 MHz
High channel	2480 MHz

	Low Channel	High Channel
Peak Level (dBµV/m)	40.1	52.1
Peak Plot reference	9126-1 BLTE mode, Low chan restricted band edge PK	9126-1 BLTE mode, High chan restricted band edge PK

Note: Average measurements have not been performed as Peak results show compliance with the Average limits.

	Low Channel	High Channel
Band Edge Plot reference	9126-1 BLTE mode, Low chan authorised band edge PK	9126-1 BLTE mode, High chan authorised band edge PK

Band	2400-2483.5 MHz
Power Level	0 dBm
Channel Spacing	2 MHz
Mod Scheme	Shockburst 1MHz
Low channel	2402 MHz
High channel	2480 MHz

	Low Channel	High Channel
Peak Level (dB μ V/m)	41.4	50.7
Peak Plot reference	9126-1 Prop mode 1MBIT, Low chan restricted band edge PK	9126-1 Prop mode 1MBIT, High chan restricted band edge PK

Note: Average measurements have not been performed as Peak results show compliance with the Average limits.

	Low Channel	High Channel
Band Edge Plot reference	9126-1 Prop mode 1MBIT, Low chan authorised band edge PK	9126-1 Prop mode 1MBIT, High chan authorised band edge PK

Band	2400-2483.5 MHz
Power Level	0 dBm
Channel Spacing	2 MHz
Mod Scheme	Shockburst 2MHz
Low channel	2402 MHz
High channel	2480 MHz

	Low Channel	High Channel
Peak Level (dB μ V/m)	42.7	50.9
Peak Plot reference	9126-1 Prop mode 2MBIT, Low chan restricted band edge PK	9126-1 Prop mode 2MBIT, High chan restricted band edge PK

Note: Average measurements have not been performed as Peak results show compliance with the Average limits.

	Low Channel	High Channel
Band Edge Plot reference	9126-1 Prop mode 2MBIT, Low chan authorised band edge PK	9126-1 Prop mode 2MBIT, High chan authorised band edge PK

Analyser plots for the Band Edge Compliance can be found in Section 6 of this report. These show the 50dBc requirement of 15.249(d) are met at the band edges of 2.4 and 2.4835 GHz. Restricted band edge plots are also shown in section 6. The tables list the field strengths observed in the adjacent restricted bands, which are required to meet the tighter 15.209 limits.

LIMITS:

AV = 54dBuV/m at band edges

PK = 74dBuV/m at band edges

Emissions radiated outside of the specified frequency bands, shall be attenuated by 50dB below the level of the fundamental field strength or to the general emissions limits of 15.209, whichever is the lesser attenuation.

The restricted band edges closest to the EUT frequency band of 2.4-2.4835GHz are 2.39 & 2.4835GHz. Further wider span plots are also shown under radiated emissions above 1GHz (refer to section 5.5), these show the fact that there are no spurious emissions above the restricted 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:
<± 3.5 dB (1 - 18 GHz)

5.8 Occupied bandwidth

5.8.1 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(c)/15.209 [Reference 4.1.1 of this report]

5.8.2 Configuration of EUT

The EUT was placed on a 1.5 metre 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 positioned to maximise emissions. Testing was performed with a fully charged battery. No difference was observed between the configuration using the device with the USB lead and laptop and stand alone configuration without the USB connection. The EUT was therefore operated in a stand-alone configuration (NOT connected to the laptop via the USB lead) for full tests and operated in all the test modes specified in section 2.4 of this report.

5.8.3 Test procedure

Tests were made in accordance with FCC Part 15 using the measuring equipment listed below. A RBW was set between 1-5% of the emission bandwidth, with a span set to 2-5 times the emissions bandwidth. 3 times VBW, auto sweep time and max hold settings were also used. The spectrum was allowed to sweep enough times to capture the full emission. The 20dB bandwidth and 99% power measurement function on the analyser was used for each channel and scheme.

Tests were performed using test Site H.

5.8.4 Test equipment

E533, E534, E535, LPE261, LPE333

See Section 9 for more details

5.8.5 Test results

Temperature of test environment	24°C
Humidity of test environment	53%
Pressure of test environment	102kPa

Band	2400-2483.5 MHz
Power Level	0 dBm
Channel Spacing	2 MHz
Mod Scheme	BT LE
Low channel	2402 MHz
Mid channel	2440 MHz
High channel	2480 MHz

	Low channel	Mid channel	High channel
20dB Bandwidth (MHz)	1.136	1.144	1.148
Plot reference	9126-1 BTLE Low Channel	9126-1 BTLE Mid Channel	9126-1 BTLE High Channel

Band	2400-2483.5 MHz
Power Level	0 dBm
Channel Spacing	2 MHz
Mod Scheme	Shockburst
Low channel	1MHz
Mid channel	2402 MHz
High channel	2440 MHz
	2480 MHz

	Low	Mid	High
20dB Bandwidth (MHz)	0.880	0.899	0.957
Plot reference	9126-1 Proprietary 1MBIT Low Channel	9126-1 Proprietary 1MBIT Mid Channel	9126-1 Proprietary 1MBIT High Channel

Band	2400-2483.5 MHz
Power Level	0 dBm
Channel Spacing	2 MHz
Mod Scheme	Shockburst
Low channel	2MHz
Mid channel	2402 MHz
High channel	2440 MHz
	2480 MHz

	Low	Mid	High
20dB Bandwidth (MHz)	1.655	1.67	1.708
Plot reference	9126-1 Proprietary 2MBIT Low Channel	9126-1 Proprietary 2MBIT Mid Channel	9126-1 Proprietary 2MBIT High Channel

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

LIMITS:

15.215(c) The 20dB bandwidth of the emission must be contained within the designated frequency band. The restricted band edges closest to the EUT frequency of 2400-2483.5MHz are 2390 & 2483.5MHz.

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 Duty cycle

5.9.1 Test methods

Test Requirements: 47 CFR Part 15C Part 15.35 & 15.249(e) [Reference 4.1.1 of this report]
Test Method: ANSI C63.10 Clause 7.5 [Reference 4.1.2 of this report]
Limits: 47 CFR Part 15C Part 15.249(e) [Reference 4.1.1 of this report]

5.9.2 Configuration of EUT

The EUT was checked at the same time and in the same configuration as for the fundamental field strength checks performed in 5.6.1 within this report. No discernible difference in duty cycle during pre-checks were observed between channels, therefore the EUT was operated in BLTE Low chan, Shockburst 1MHz Low chan and Shockburst 2MHz Low chan modes.

5.9.3 Test procedure

Tests were made in accordance with FCC Part 15 using the measuring equipment listed 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.

5.9.4 Test equipment

E533, E534, E535, LPE261, LPE333

See Section 9 for more details

5.9.5 Test results

Temperature of test environment 25°C
Humidity of test environment 51%
Pressure of test environment 102kPa

Band	2400-2483.5 MHz
Power Level	0 dBm
Channel Spacing	2 MHz
Mod Scheme	BT LE
Single channel	2402 MHz

	Low channel
TX on time (ms)	0.391
TX on Plot filename	J9126-1 low channel BTLE burst width
TX repetition time (ms)	0.625
TX repetition Plot filename	J9126-1 low channel BTLE repetition
Calculated TX Duty cycle (%)	62.52

Band	2400-2483.5 MHz
Power Level	0 dBm
Channel Spacing	2 MHz
Mod Scheme	Shockburst 1MHz
Single channel	2402 MHz

	Low channel
TX on time (ms)	0.1518
TX on Plot filename	J9126-1 low channel proprietary 1MBIT burst width
TX repetition time (ms)	0.950
TX repetition Plot filename	J9126-1 low channel proprietary 1MBIT repetition
Calculated TX Duty cycle (%)	15.98

Band	2400-2483.5 MHz
Power Level	0 dBm
Channel Spacing	2 MHz
Mod Scheme	Shockburst 2MHz
Single channel	2402 MHz

	Low channel
TX on time (ms)	0.0816
TX on Plot filename	J9126-1 low channel proprietary 2MBIT burst width
TX repetition time (ms)	0.950
TX repetition Plot filename	J9126-1 low channel proprietary 2MBIT repetition
Calculated TX Duty cycle (%)	8.58

Average duty cycle correction is not required to be applied to any measurements within this report as all Peak emissions met the required average limits, where applicable.

LIMITS:

Not applicable.

Per 15.35, only devices with a TX on time of <100ms are allowed to be considered for duty cycle correction of average emissions.

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

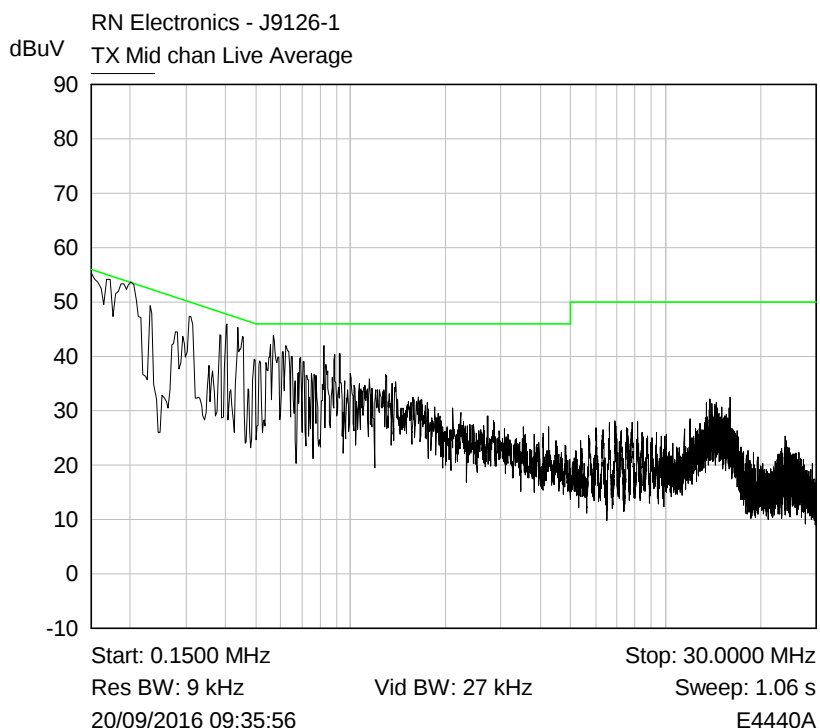
5.10 Frequency stability

NOT APPLICABLE: Test only applies to equipment intended for fixed, point-to-point operation.

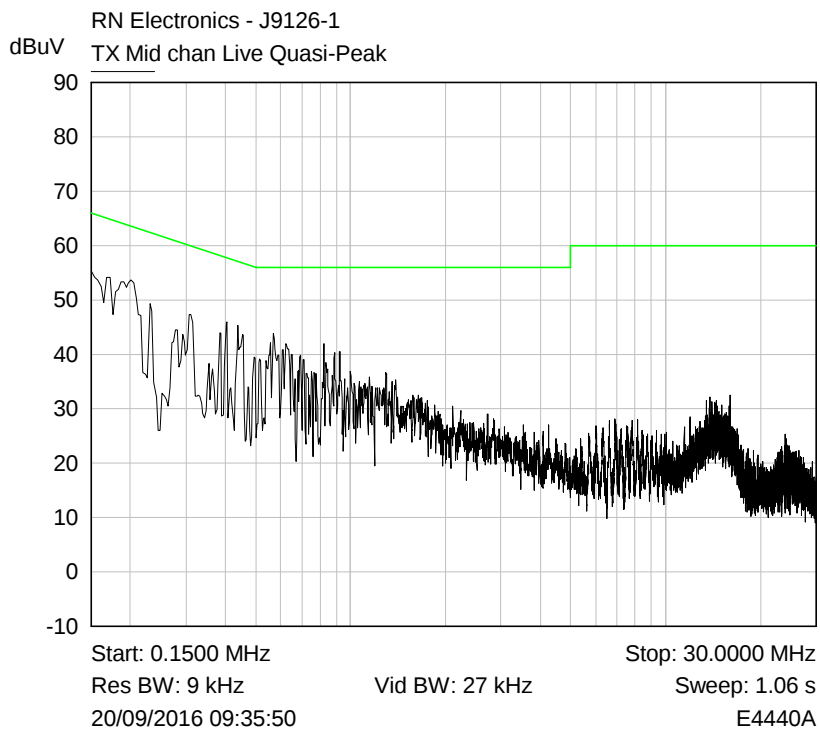
6 Plots/Graphical results

6.1 AC power line conducted emissions

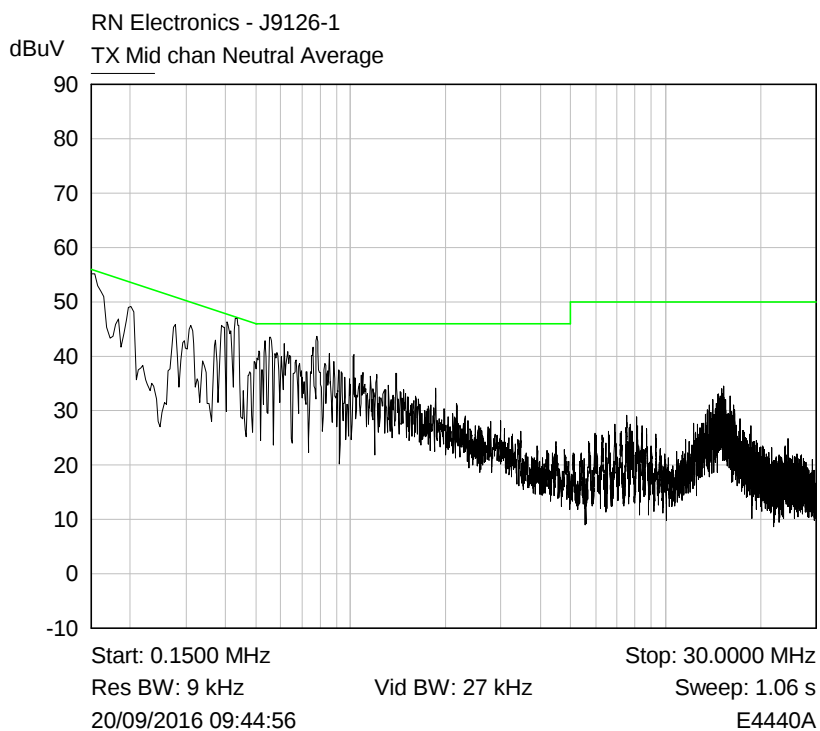
RF Parameters: Band 2400-2483.5 MHz, Power 0 dBm, Channel Spacing 2 MHz, Modulation
BT LE, Channel 2440 MHz



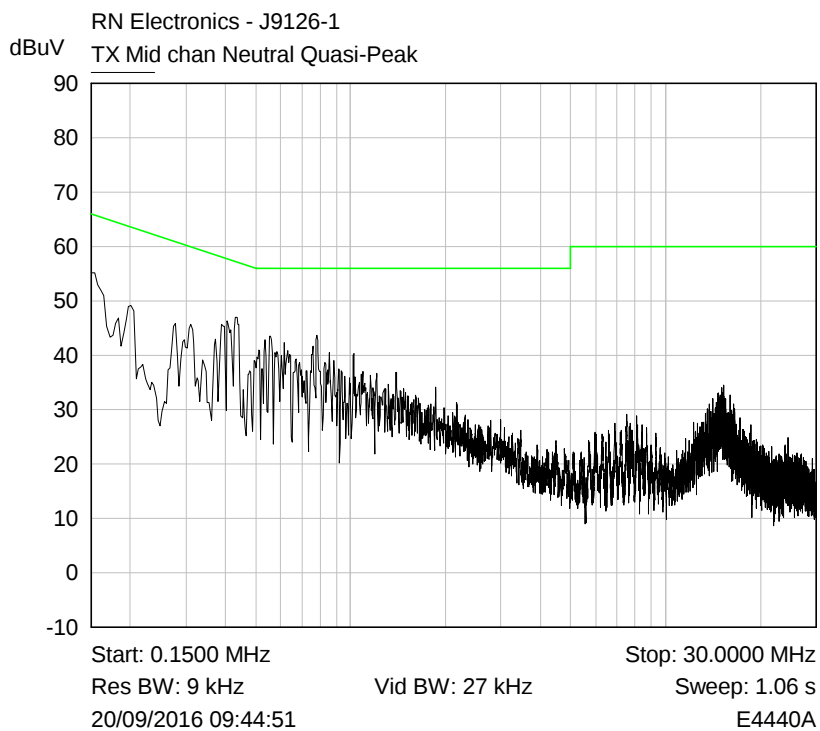
Plot of Live150k-30M Average



Plot of Live150k-30M Quasi-Peak



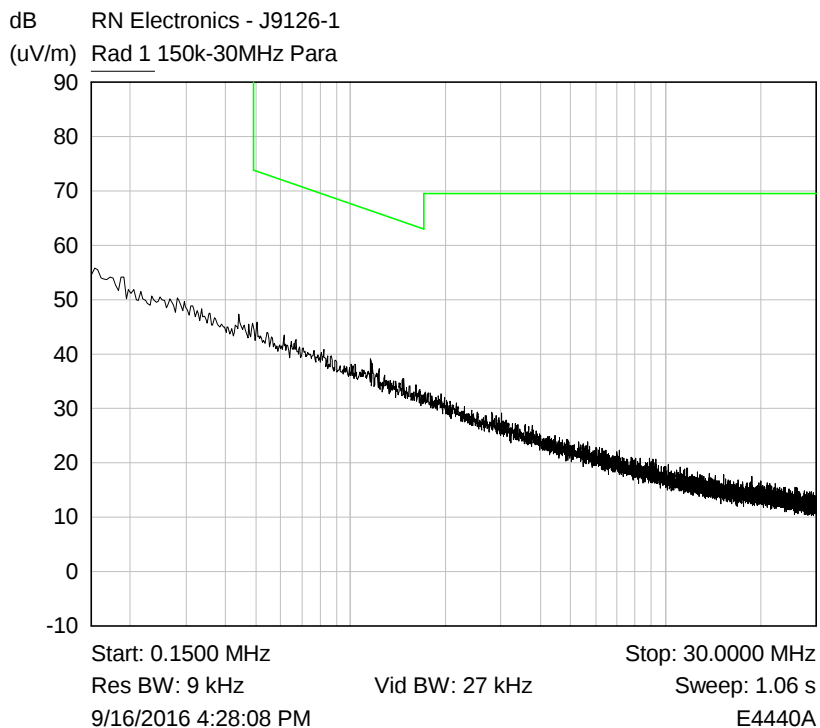
Plot of Neutral150k-30M Average



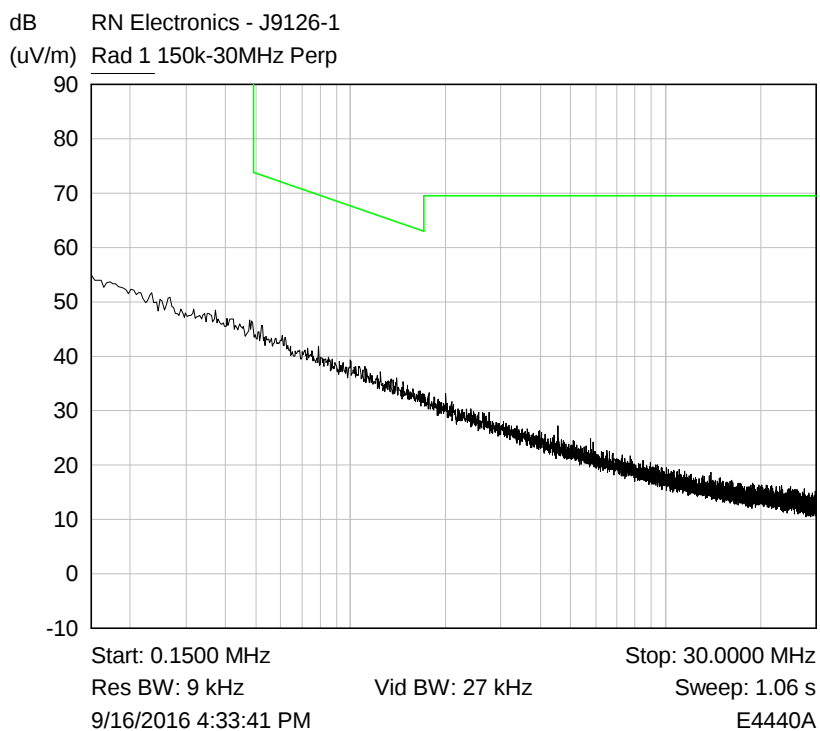
Plot of Neutral150k-30M Quasi-Peak

6.2 Radiated emissions 150 kHz - 30 MHz

RF Parameters: Band 2400-2483.5 MHz, Power 0 dBm, Channel Spacing 2 MHz, Modulation
BT LE, Channel 2440 MHz



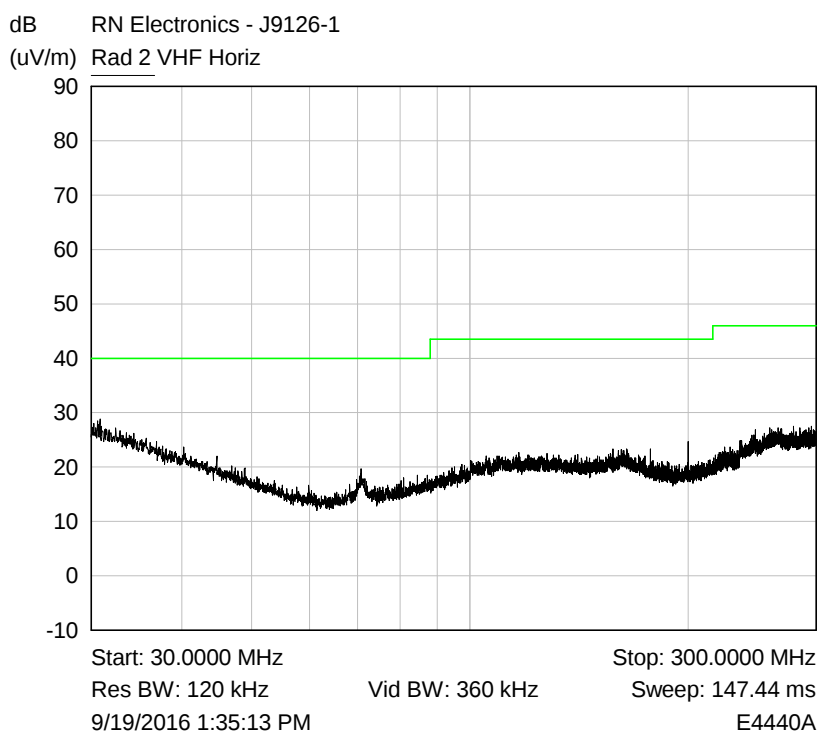
Plot of 150kHz-30MHz Parallel



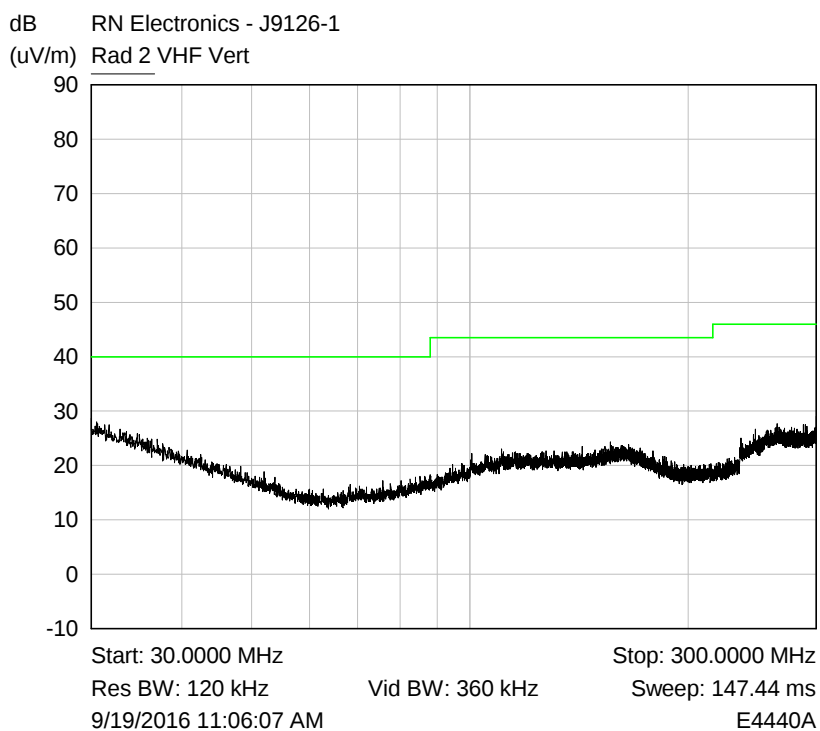
Plot of 150kHz-30MHz Perpendicular

6.3 Radiated emissions 30 MHz -1 GHz

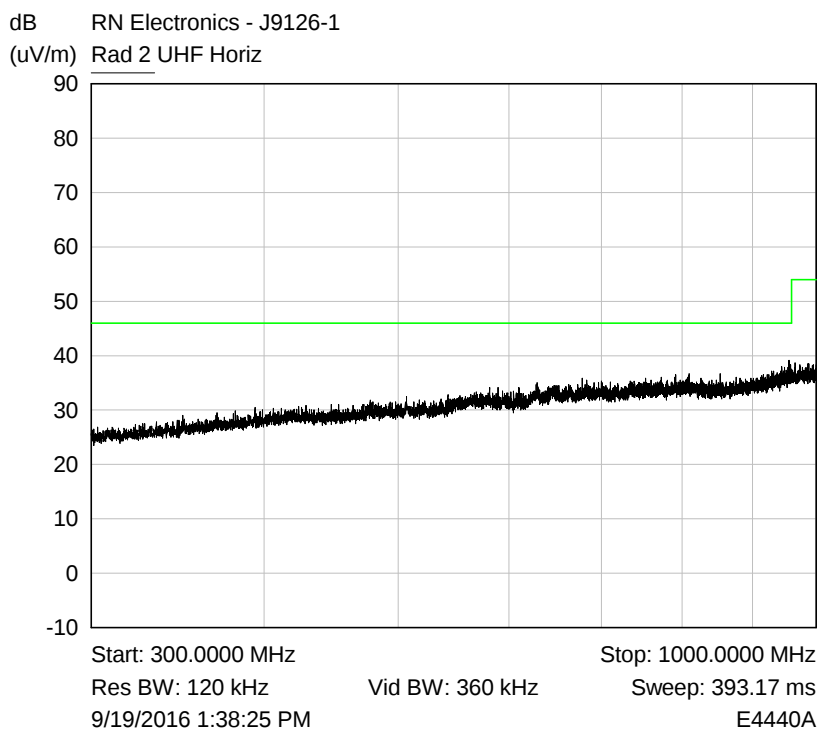
RF Parameters: Band 2400-2483.5 MHz, Power 0 dBm, Channel Spacing 2 MHz, Modulation BT LE, Channel 2440 MHz



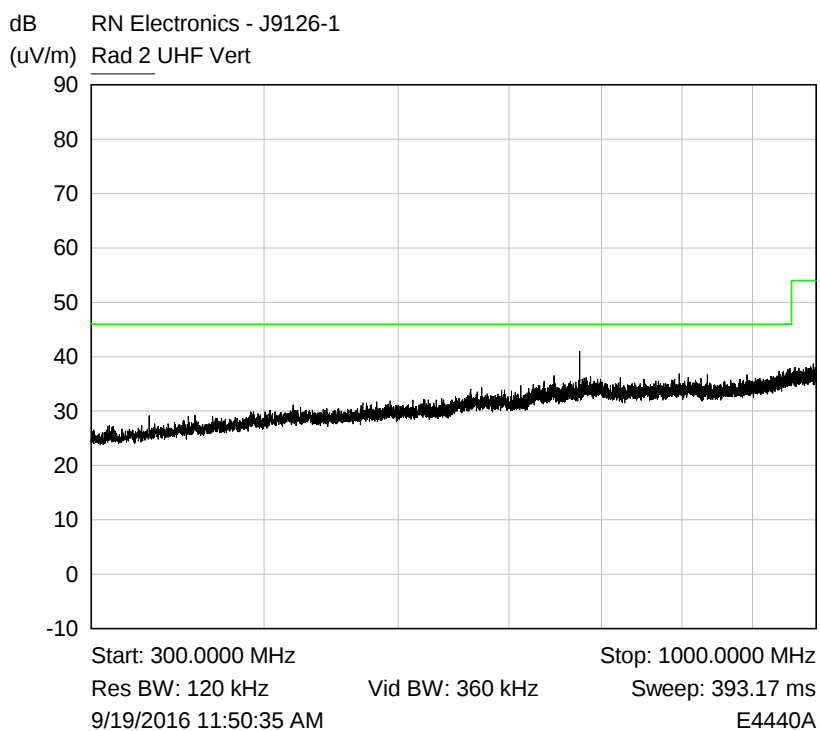
Plot of Peak emissions for VHF Horizontal against the QP limit line.



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



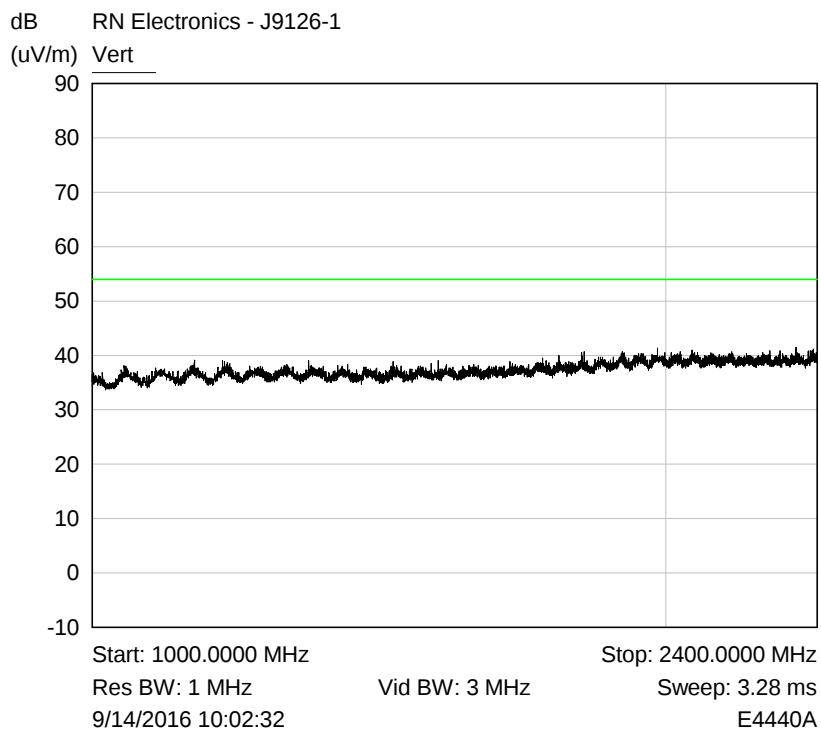
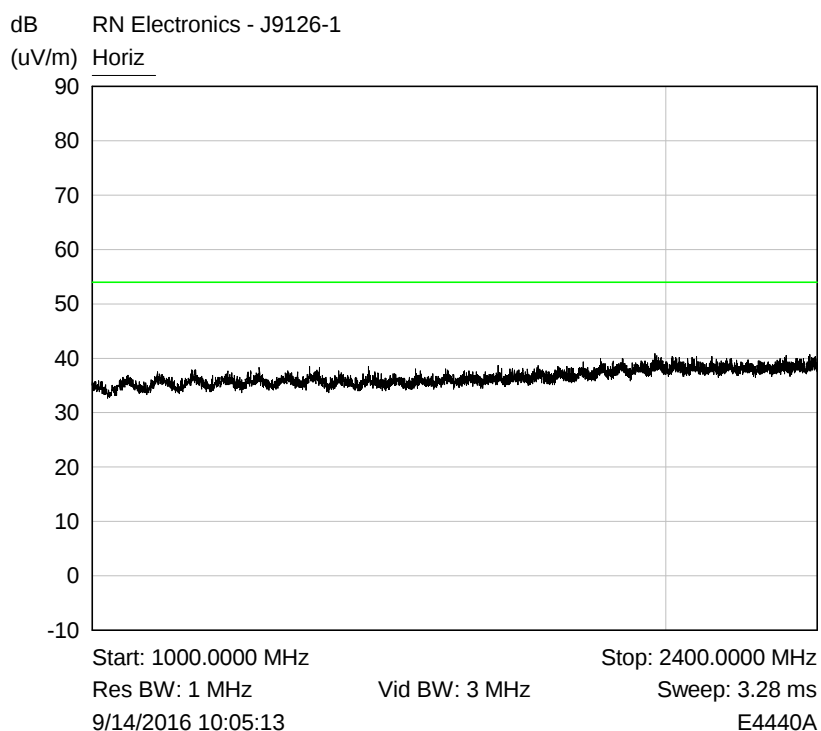
Plot of Peak emissions for UHF Horizontal against the QP limit line.

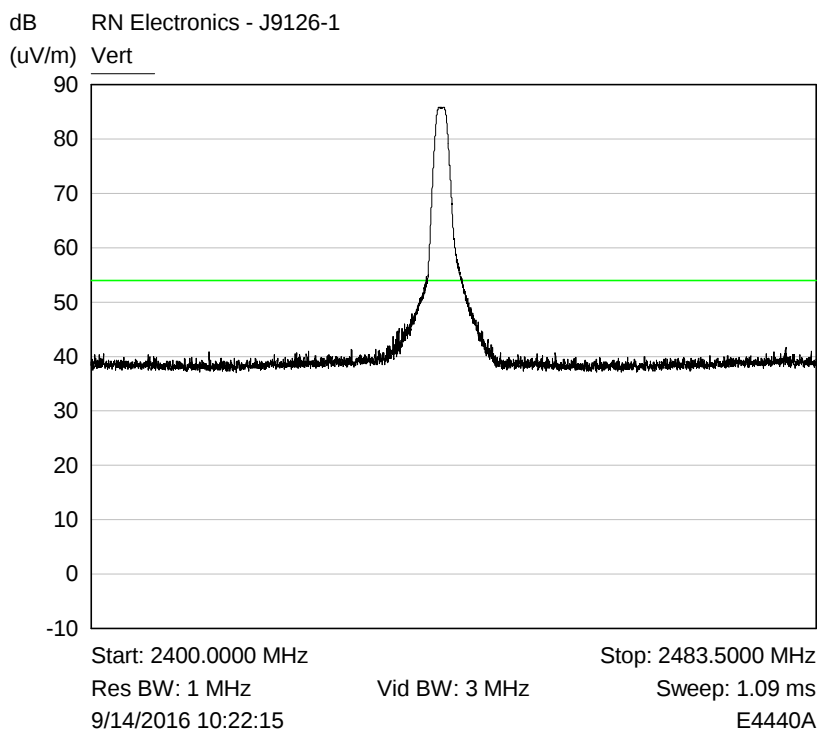
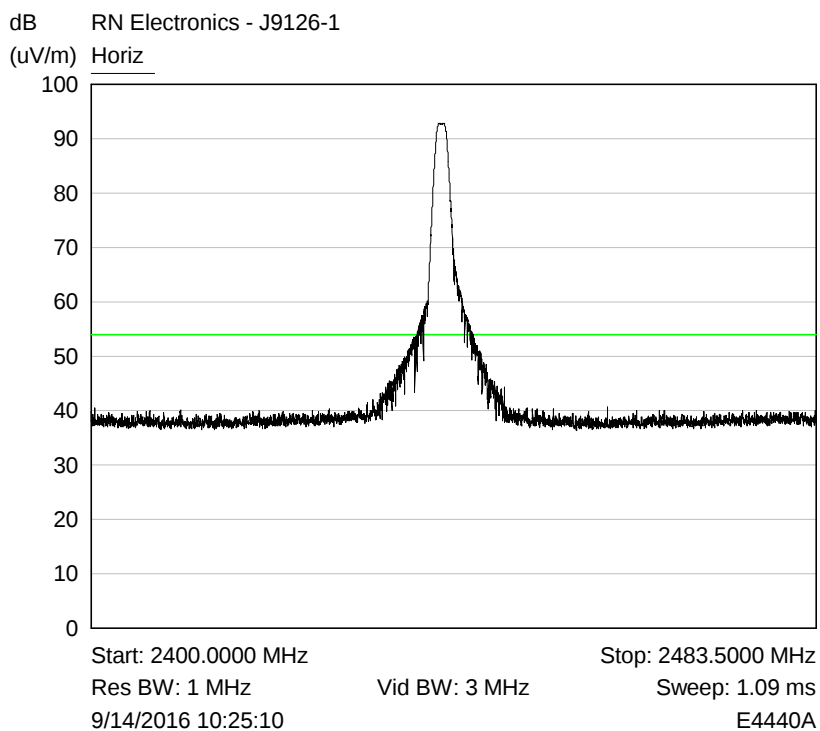


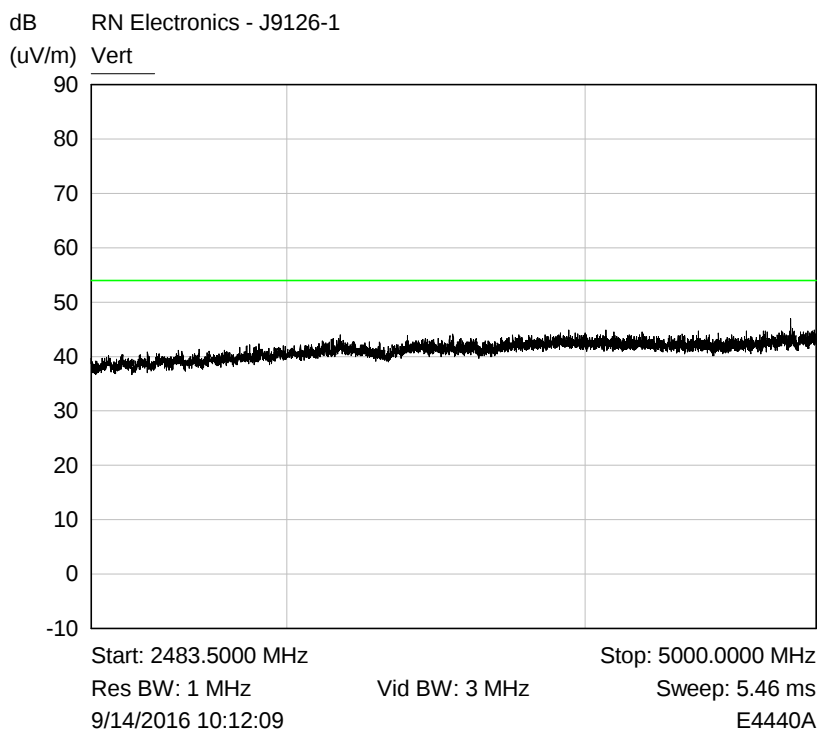
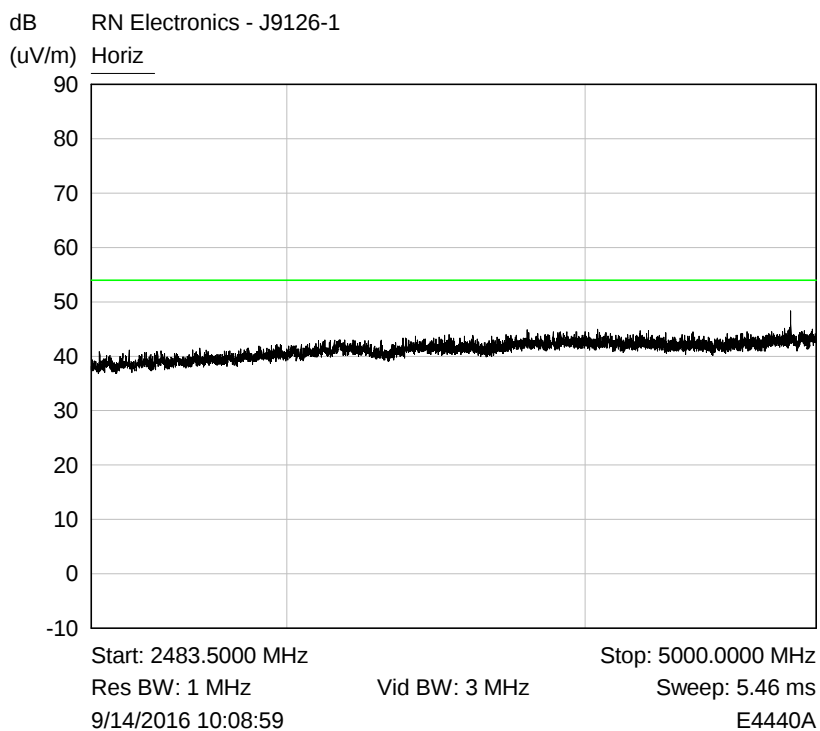
Plot of Peak emissions for UHF Vertical against the QP limit line.

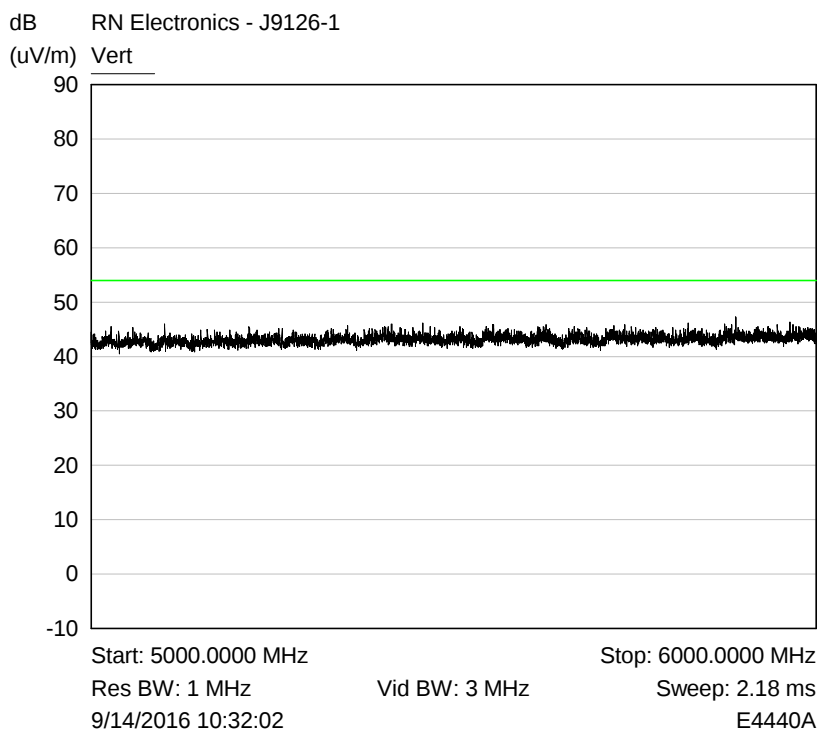
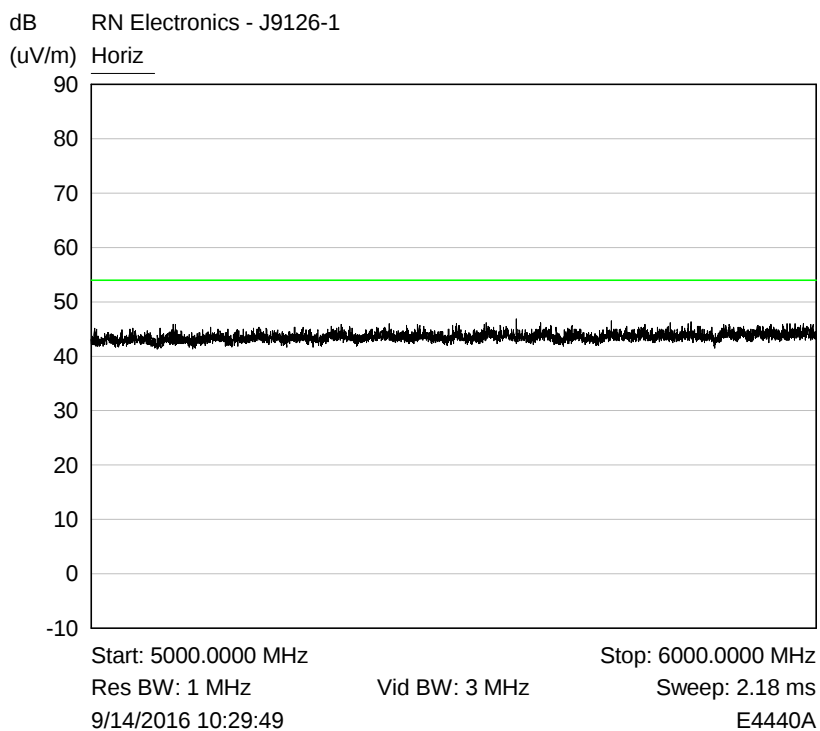
6.4 Radiated emissions above 1 GHz

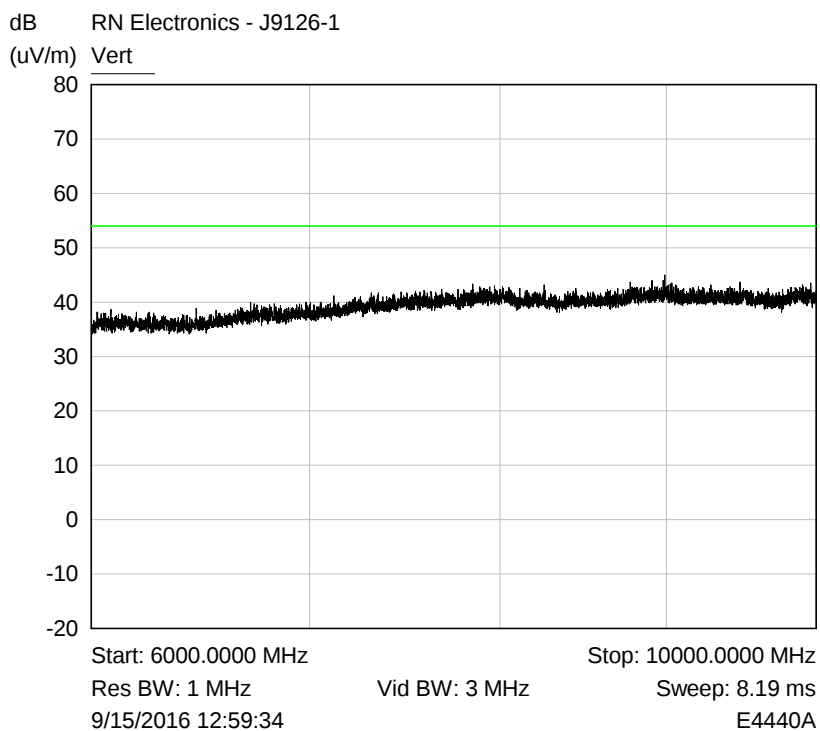
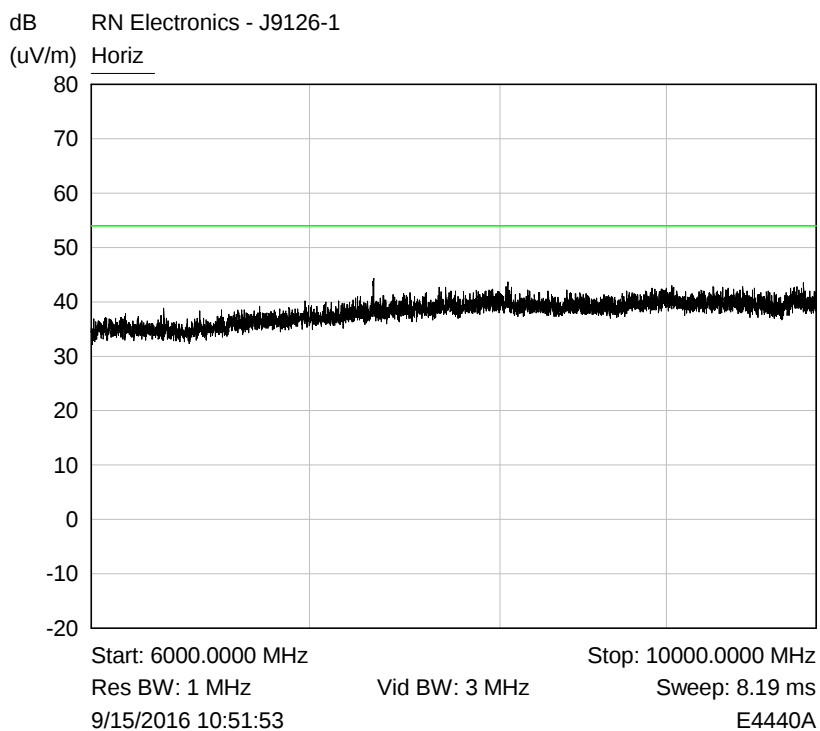
RF Parameters: Band 2400-2483.5 MHz, Power 0 dBm, Channel Spacing 2 MHz, Modulation
BT LE, Channel 2440 MHz

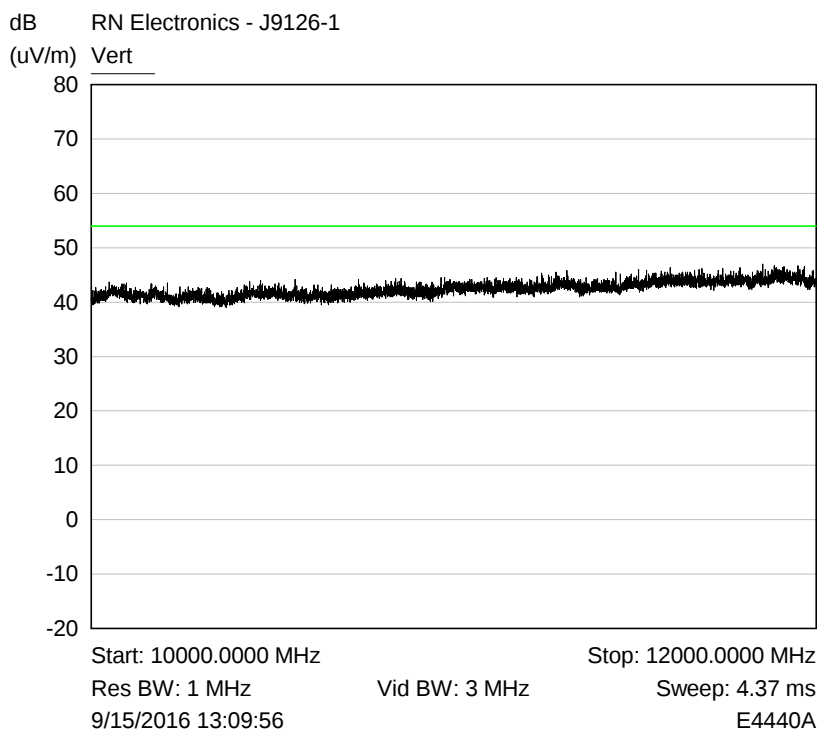
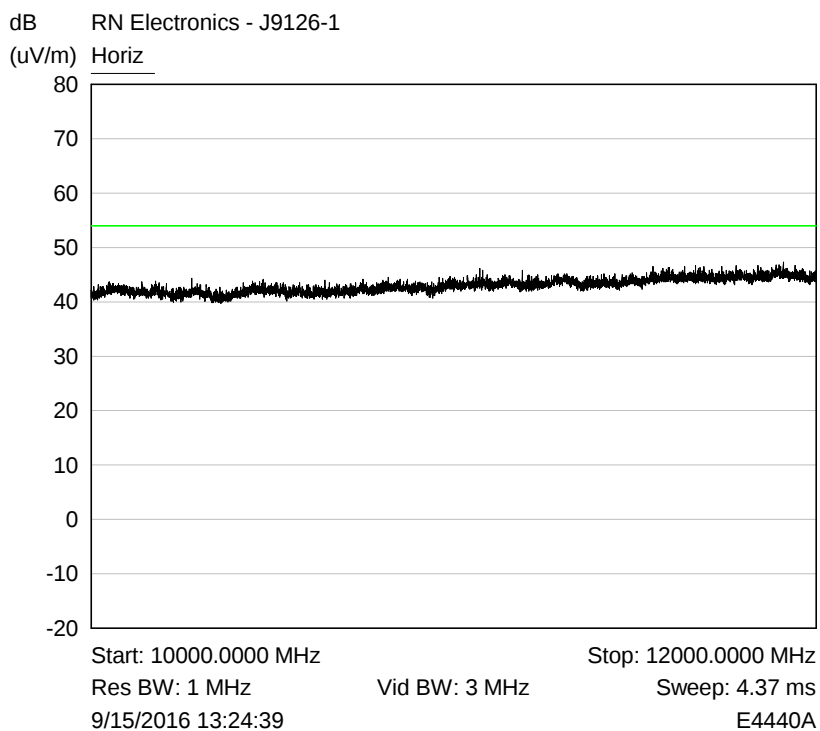


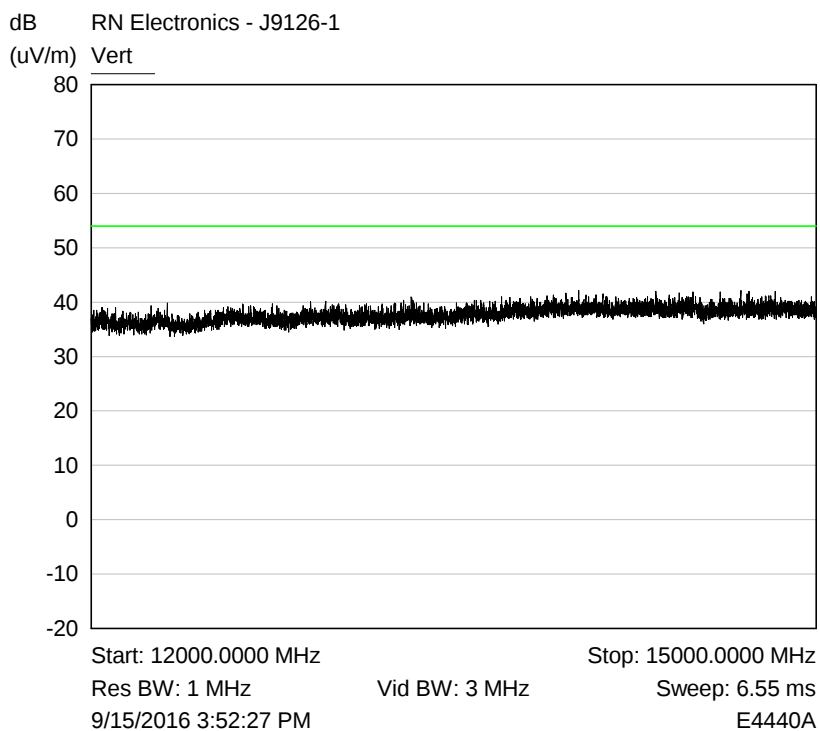
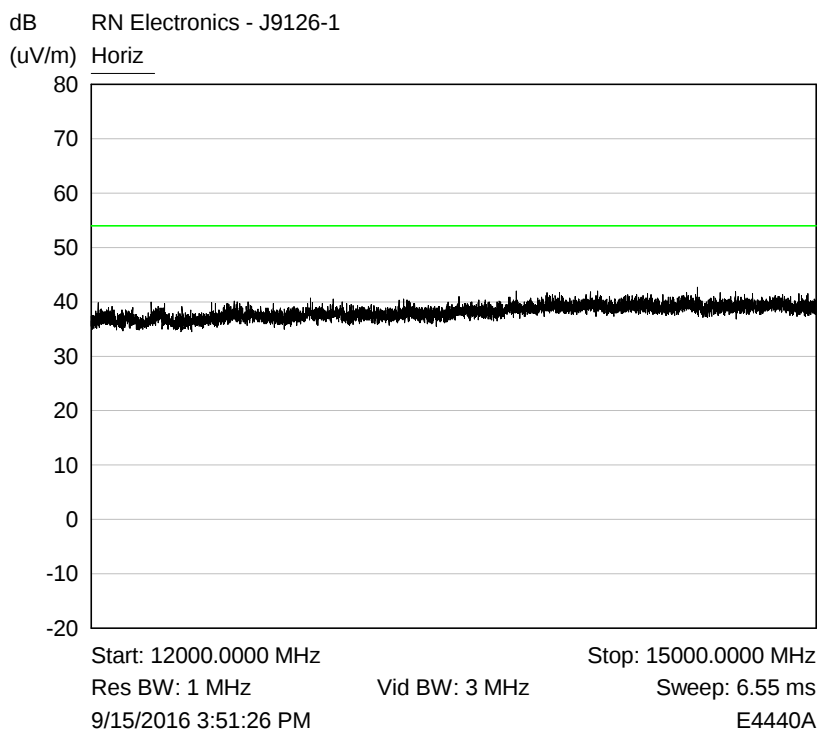


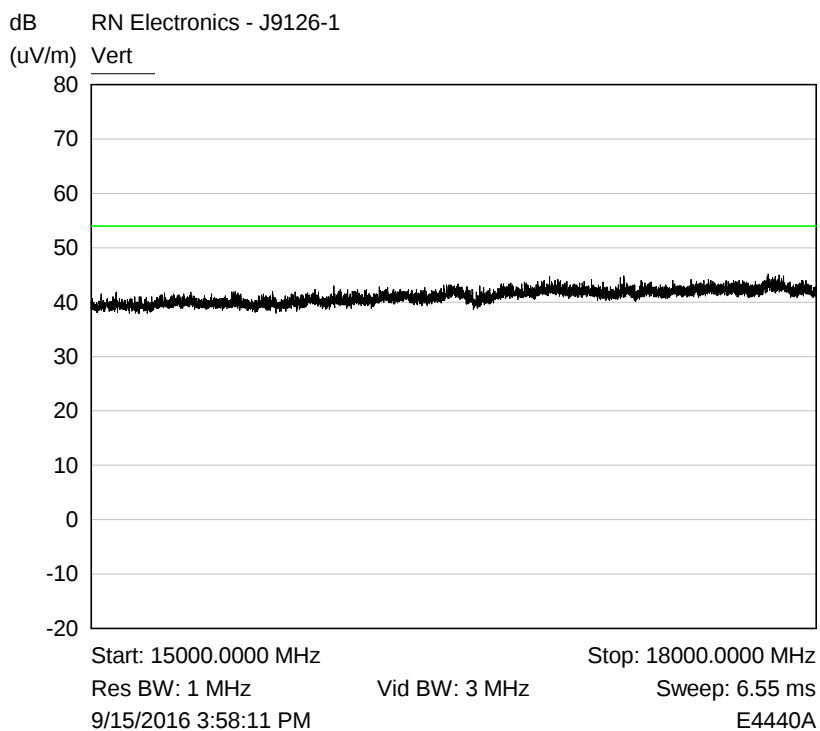
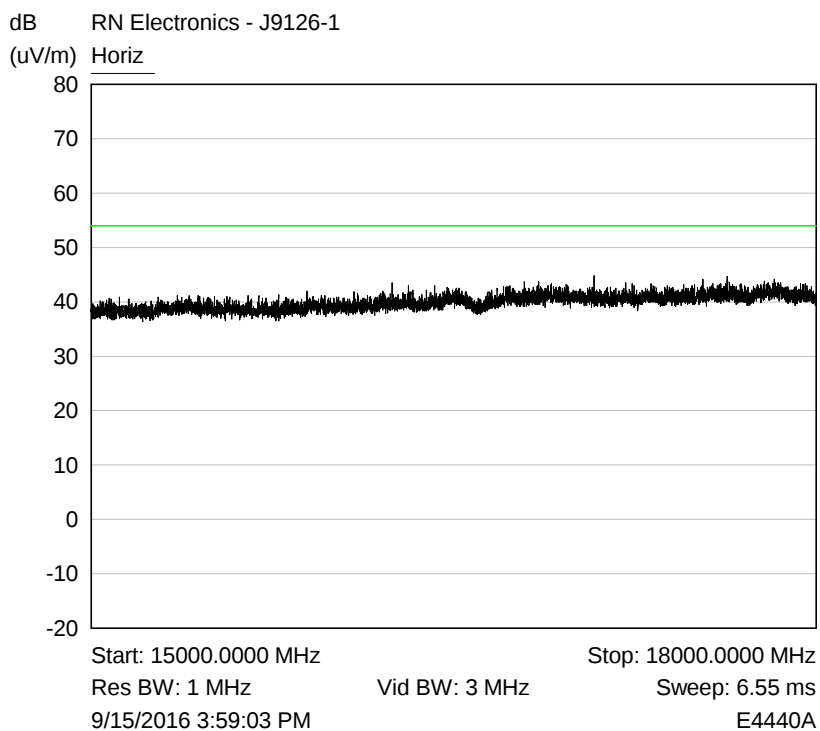


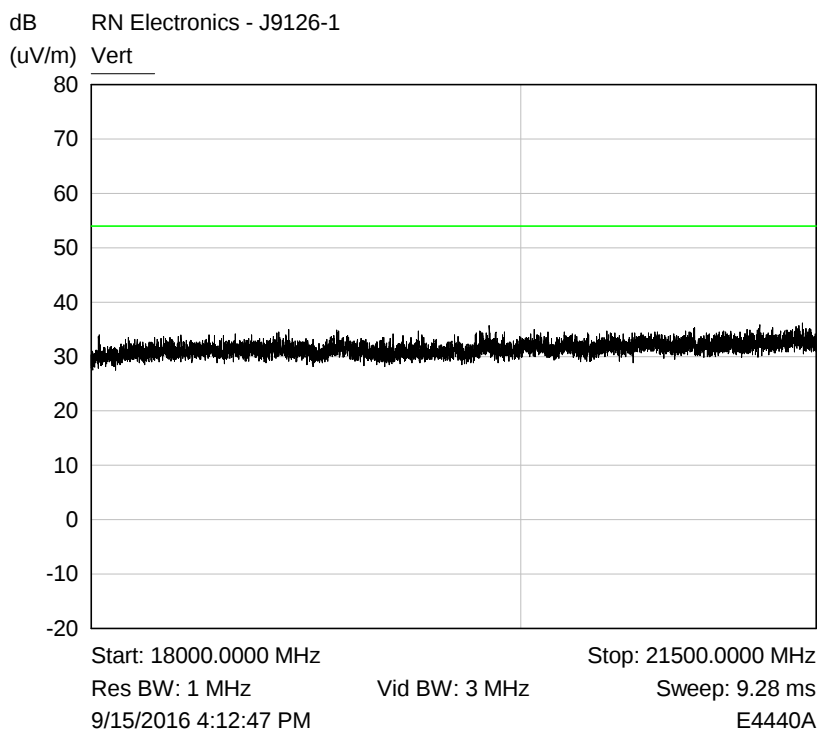
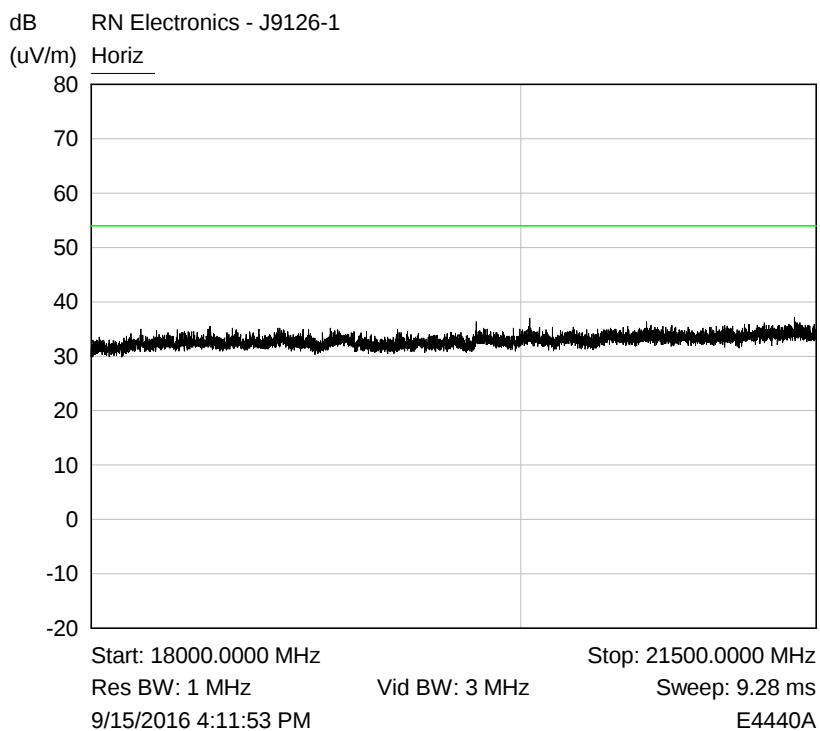


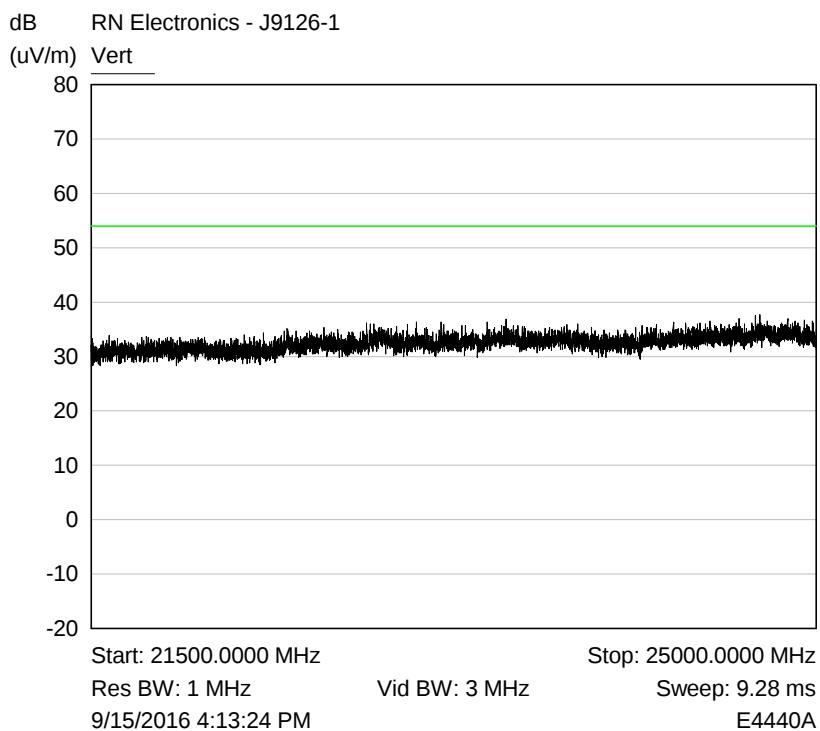
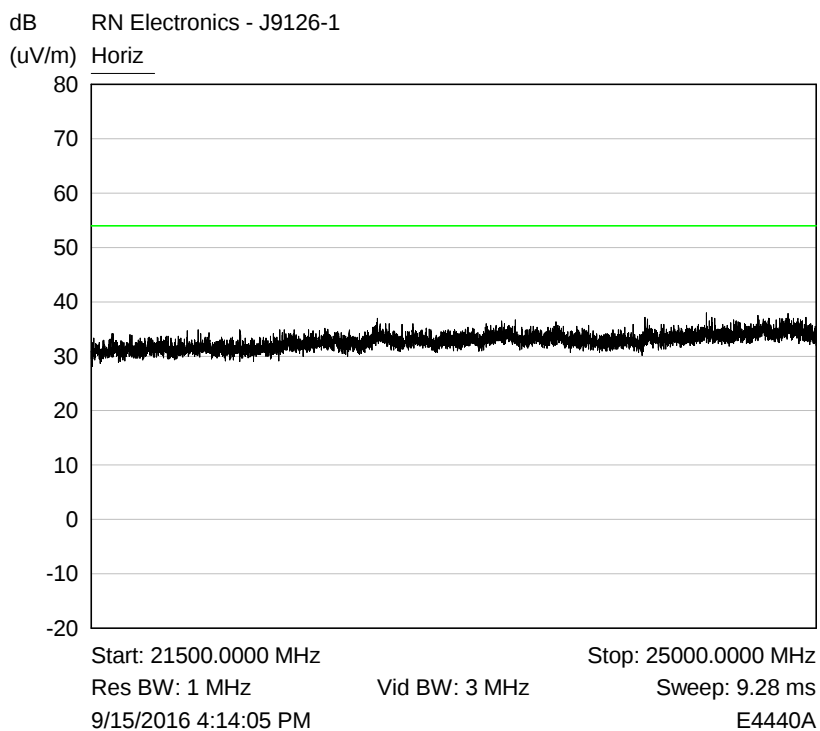






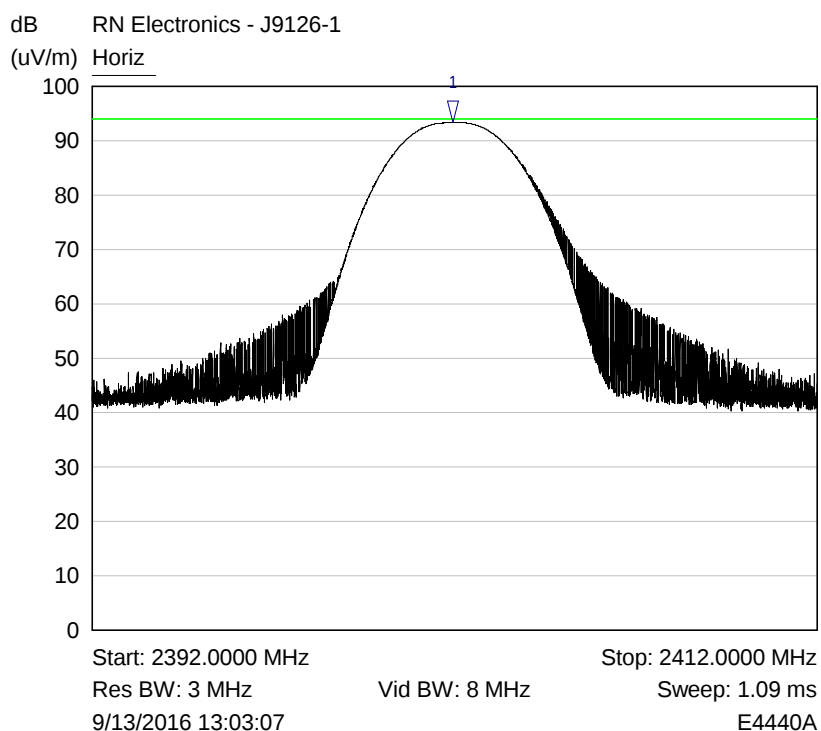






6.5 Intentional radiator field strength

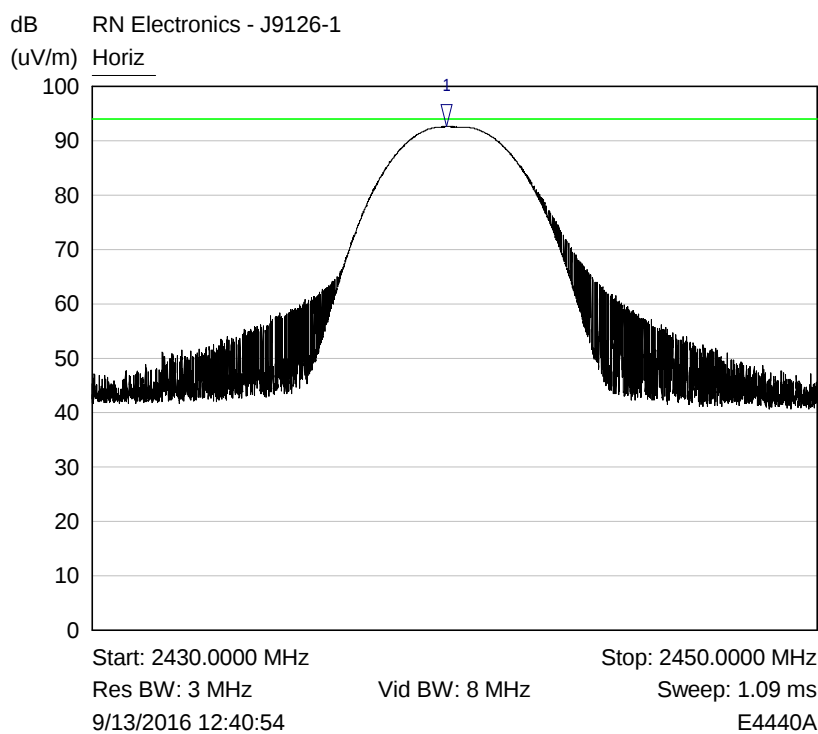
RF Parameters: Band 2400-2483.5 MHz, Power 0 dBm, Channel Spacing 2 MHz, Modulation BT LE, Channel 2402 MHz



Mkr	Trace	X-Axis	Value	Notes
1 ▽	Horiz	2401.9182 MHz	93.30 dB(uV/m)	

Plot of Horiz polarisation and EUT in Side (USB side) position

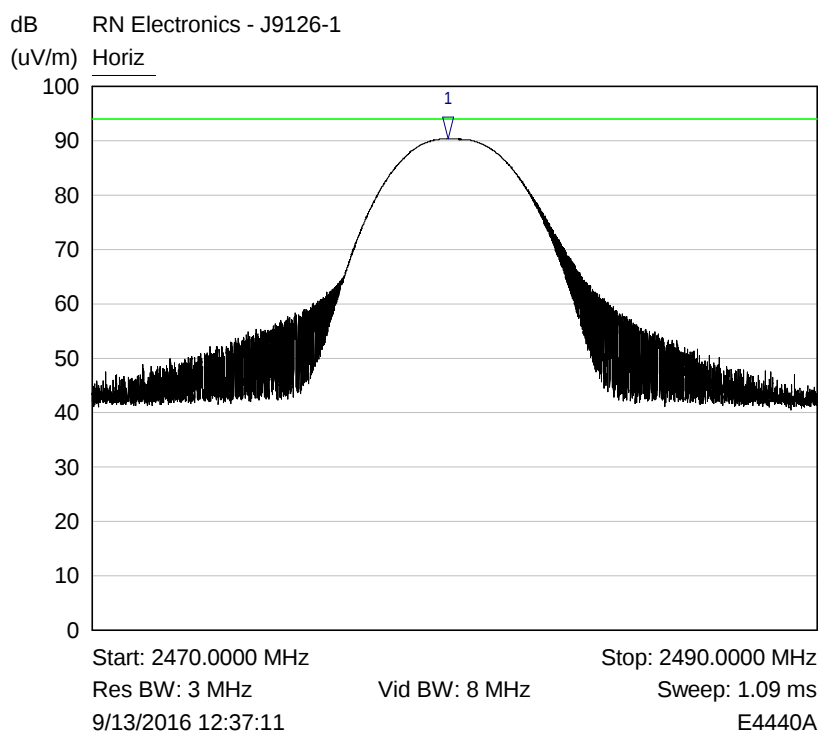
RF Parameters: Band 2400-2483.5 MHz, Power 0 dBm, Channel Spacing 2 MHz, Modulation
BT LE, Channel 2440 MHz



Mkr	Trace	X-Axis	Value	Notes
1 ▽	Horiz	2439.7473 MHz	92.60 dB(uV/m)	

Plot of Horiz polarisation and EUT in Side (USB side) position

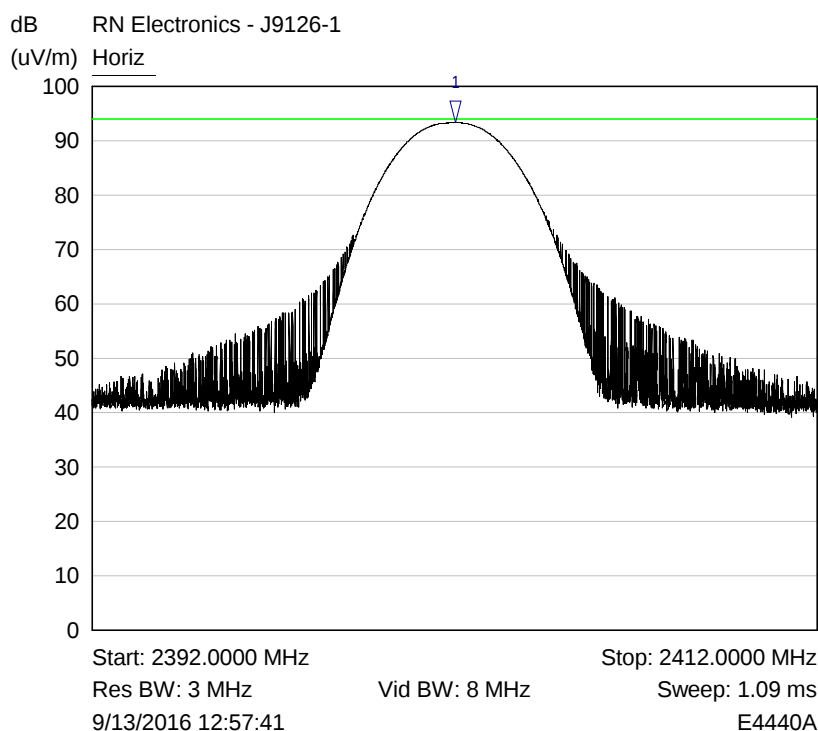
RF Parameters: Band 2400-2483.5 MHz, Power 0 dBm, Channel Spacing 2 MHz, Modulation
BT LE, Channel 2480 MHz



Mkr	Trace	X-Axis	Value	Notes
1 ▽	Horiz	2479.8083 MHz	90.31 dB(uV/m)	

Plot of Horiz polarisation and EUT in Side (USB side) position

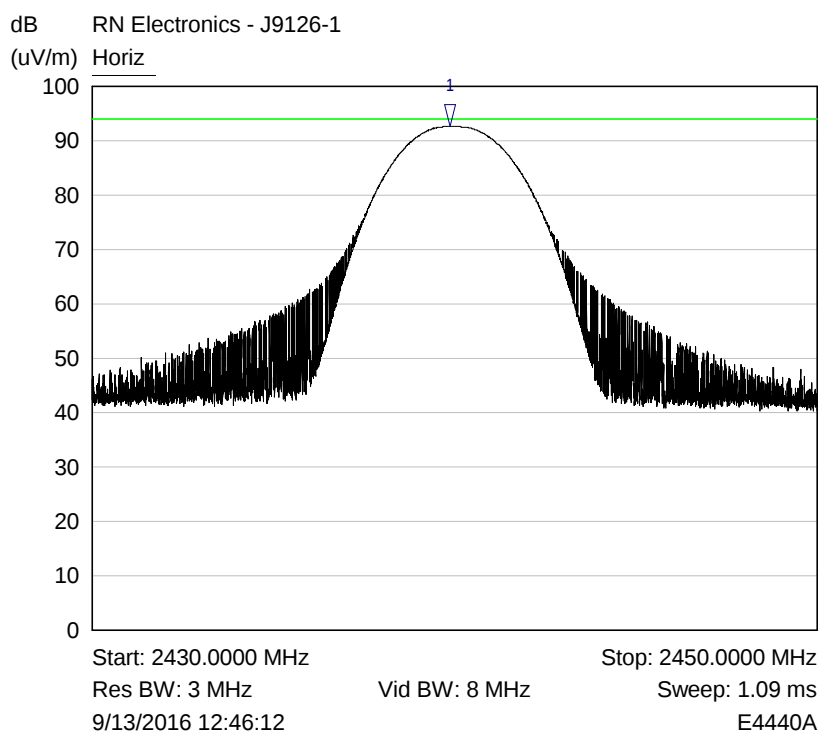
RF Parameters: Band 2400-2483.5 MHz, Power 0 dBm, Channel Spacing 2 MHz, Modulation
Proprietary 1Mbit, Channel 2402 MHz



Mkr	Trace	X-Axis	Value	Notes
1 ▽	Horiz	2402.0012 MHz	93.29 dB(uV/m)	

Plot of Horiz polarisation and EUT in Side (USB side) position

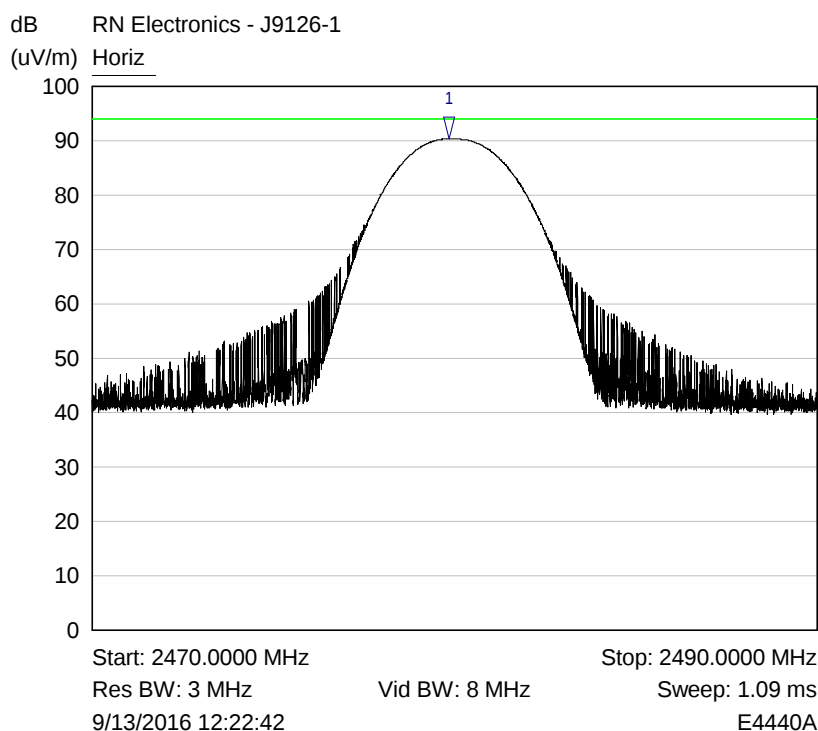
RF Parameters: Band 2400-2483.5 MHz, Power 0 dBm, Channel Spacing 2 MHz, Modulation
Proprietary 1Mbit, Channel 2440 MHz



Mkr	Trace	X-Axis	Value	Notes
1 ▽	Horiz	2439.8547 MHz	92.64 dB(uV/m)	

Plot of Horiz polarisation and EUT in Side (USB side) position

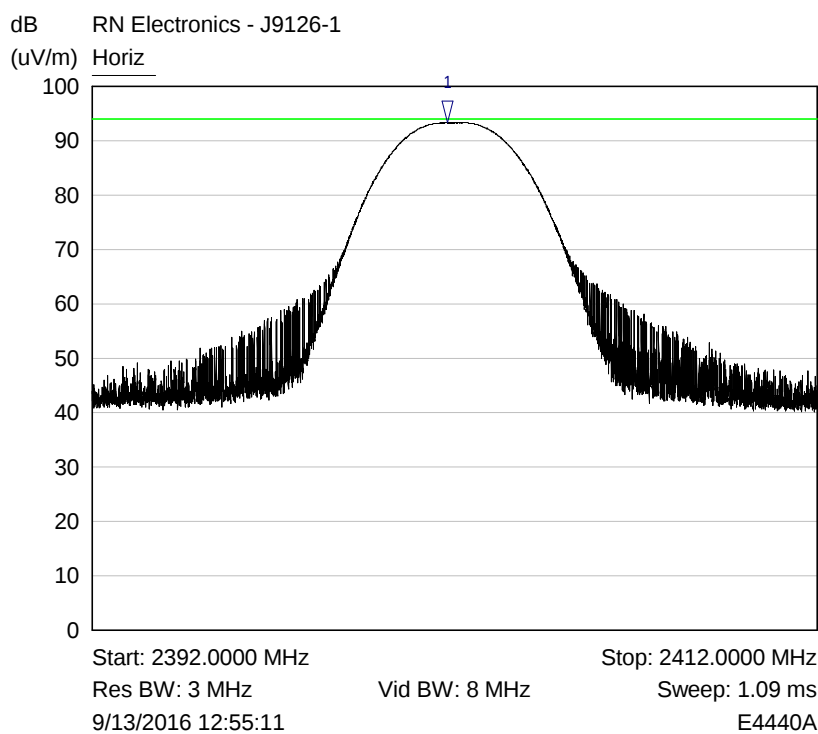
RF Parameters: Band 2400-2483.5 MHz, Power 0 dBm, Channel Spacing 2 MHz, Modulation
Proprietary 1Mbit, Channel 2480 MHz



Mkr	Trace	X-Axis	Value	Notes
1 ▽	Horiz	2479.8352 MHz	90.32 dB(uV/m)	

Plot of Horiz polarisation and EUT in Side (USB side) position

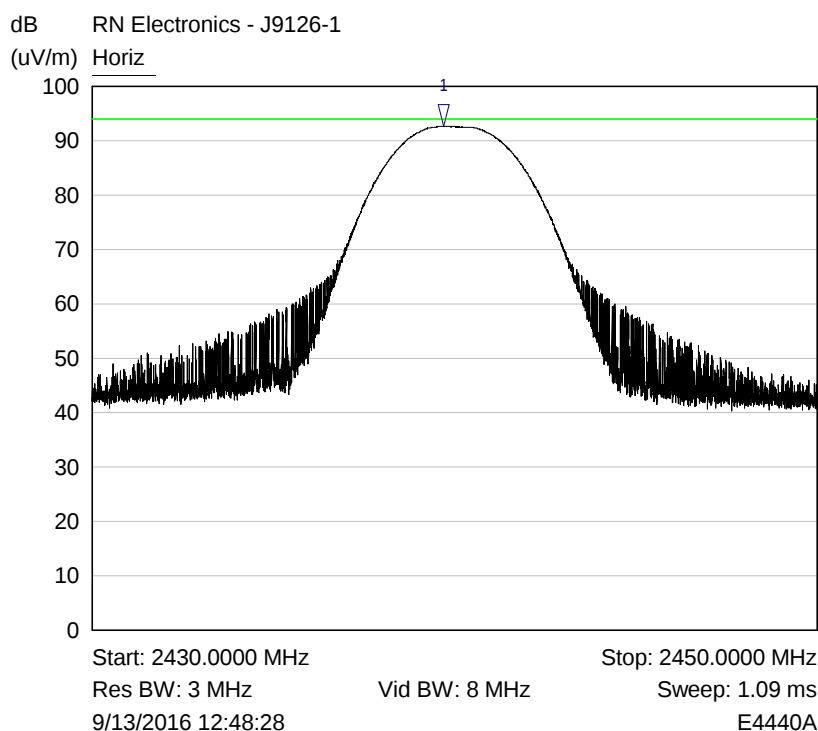
RF Parameters: Band 2400-2483.5 MHz, Power 0 dBm, Channel Spacing 2 MHz, Modulation
Proprietary 2Mbit, Channel 2402 MHz



Mkr	Trace	X-Axis	Value	Notes
1 ▽	Horiz	2401.7815 MHz	93.29 dB(uV/m)	

Plot of Horiz polarisation and EUT in Side (USB side) position

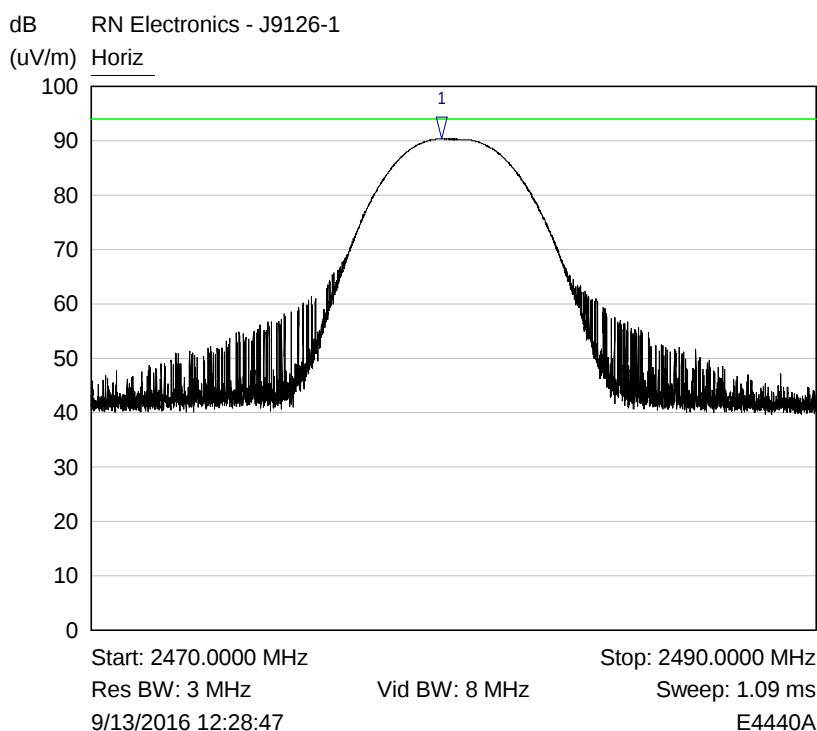
RF Parameters: Band 2400-2483.5 MHz, Power 0 dBm, Channel Spacing 2 MHz, Modulation
Proprietary 2Mbit, Channel 2440 MHz



Mkr	Trace	X-Axis	Value	Notes
1 ▽	Horiz	2439.6691 MHz	92.64 dB(uV/m)	

Plot of Horiz polarisation and EUT in Side (USB side) position

RF Parameters: Band 2400-2483.5 MHz, Power 0 dBm, Channel Spacing 2 MHz, Modulation
Proprietary 2Mbit, Channel 2480 MHz

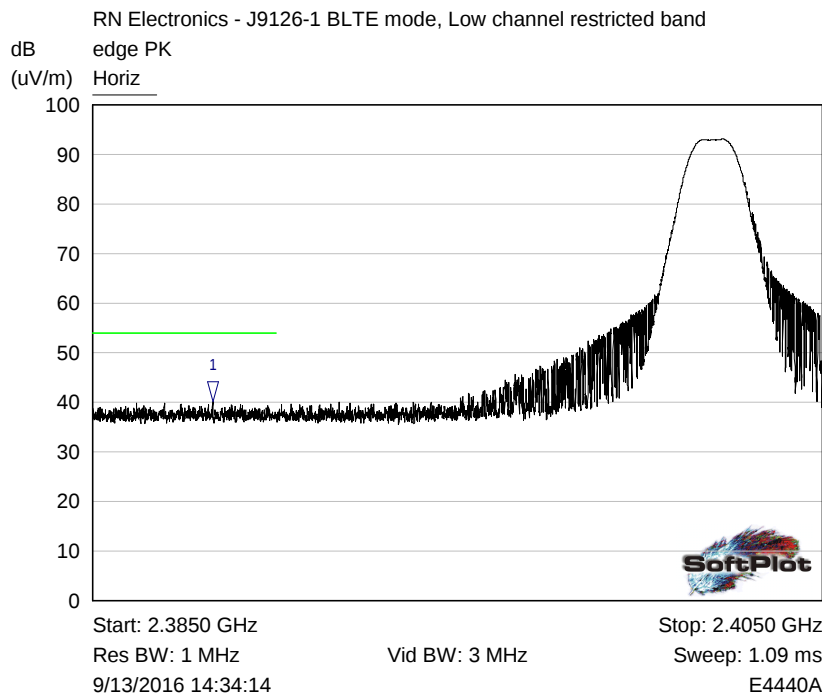


Mkr	Trace	X-Axis	Value	Notes
1 ▽	Horiz	2479.6472 MHz	90.32 dB(uV/m)	

Plot of Horiz polarisation and EUT in Side (USB side) position

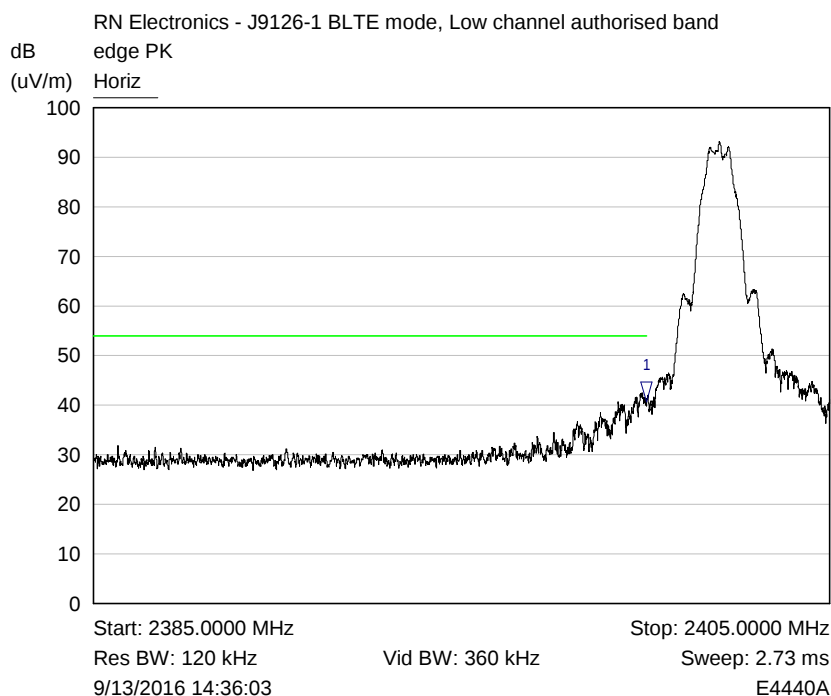
6.6 Band Edge Compliance

RF Parameters: Band 2400-2483.5 MHz, Power 0 dBm, Channel Spacing 2 MHz, Modulation
BT LE MHz, Channel 2402 MHz



Mkr	Trace	X-Axis	Value	Notes
1 ▽	Horiz	2.3883 GHz	40.11 dB(uV/m)	

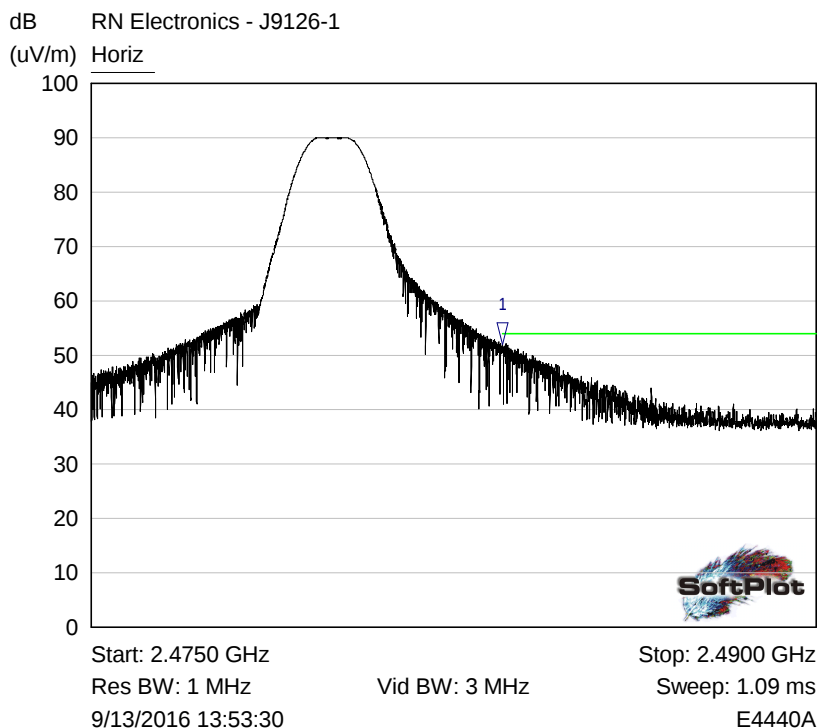
Lower Restricted band Peak Plot



Mkr	Trace	X-Axis	Value	Notes
1 ▽	Horiz	2400.0092 MHz	40.67 dB(uV/m)	

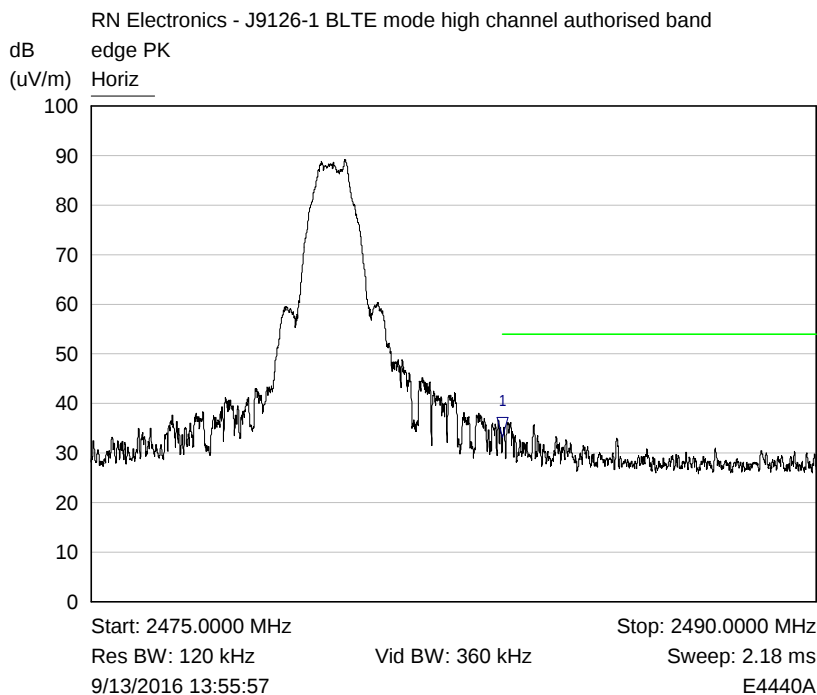
Lower Authorised Band Edge Plot

RF Parameters: Band 2400-2483.5 MHz, Power 0 dBm, Channel Spacing 2 MHz, Modulation
BT LE MHz, Channel 2480 MHz



Mkr	Trace	X-Axis	Value	Notes
1 ▽	Horiz	2.4835 GHz	52.07 dB(uV/m)	

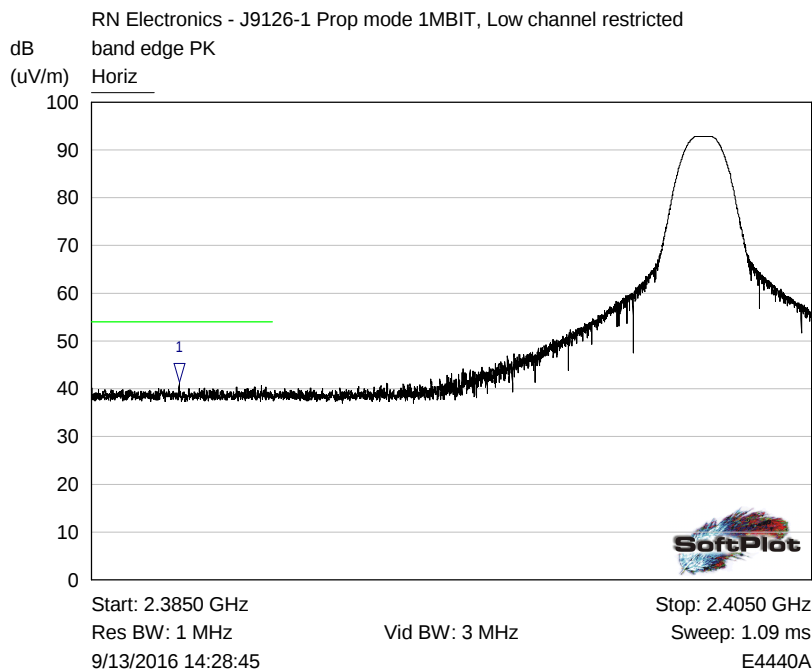
Upper Restricted band Peak Plot



Mkr	Trace	X-Axis	Value	Notes
1 ▽	Horiz	2483.5081 MHz	33.17 dB(uV/m)	

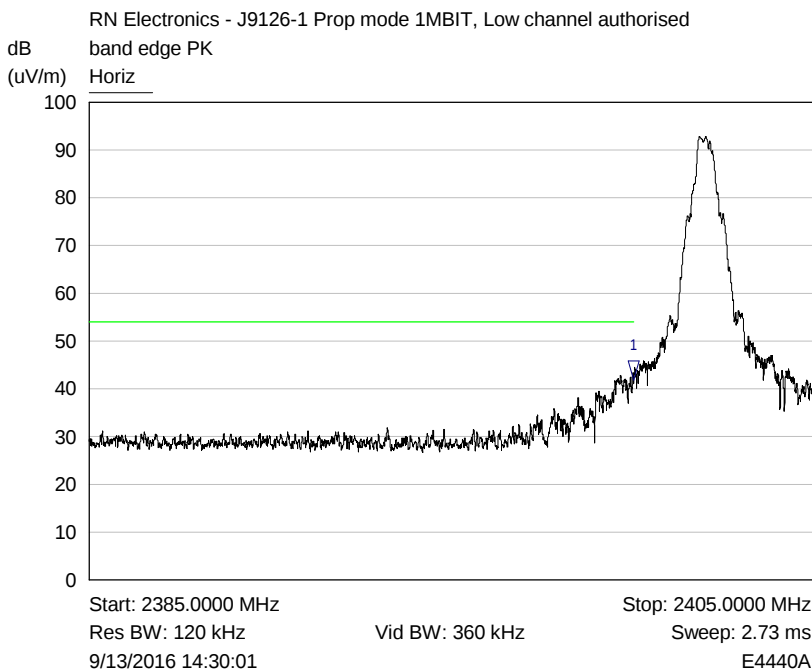
Upper authorised Band Edge Plot

RF Parameters: Band 2400-2483.5 MHz, Power 0 dBm, Channel Spacing 2 MHz, Modulation Shockburst 1MHz, Channel 2402 MHz



Mkr	Trace	X-Axis	Value	Notes
1 ▽	Horiz	2.3874 GHz	41.36 dB(uV/m)	

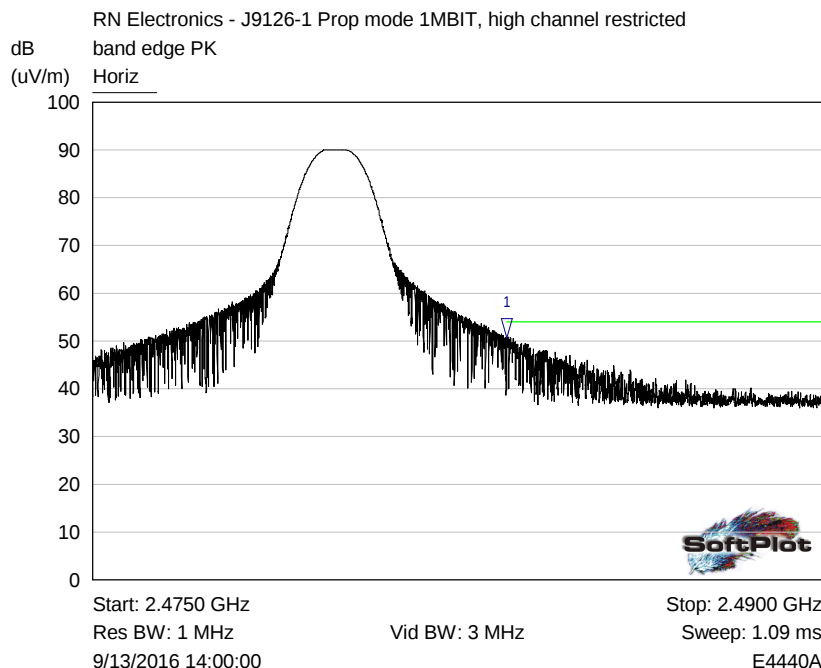
Lower Restricted band Peak Plot



Mkr	Trace	X-Axis	Value	Notes
1 ▽	Horiz	2400.0092 MHz	41.80 dB(uV/m)	

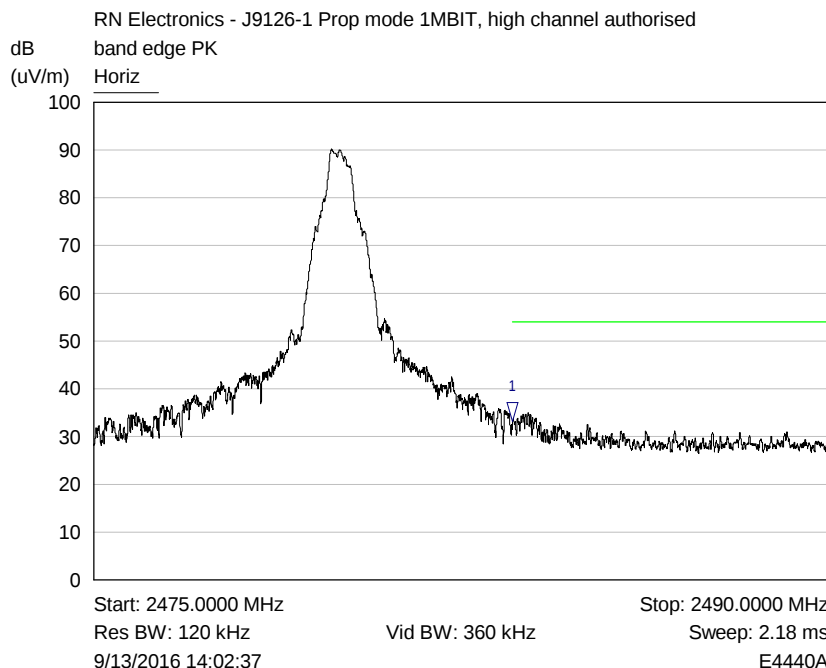
Lower Authorised Band Edge Plot

RF Parameters: Band 2400-2483.5 MHz, Power 0 dBm, Channel Spacing 2 MHz, Modulation Shockburst 1MHz, Channel 2480 MHz



Mkr	Trace	X-Axis	Value	Notes
1 ▽	Horiz	2.4835 GHz	50.67 dB(uV/m)	

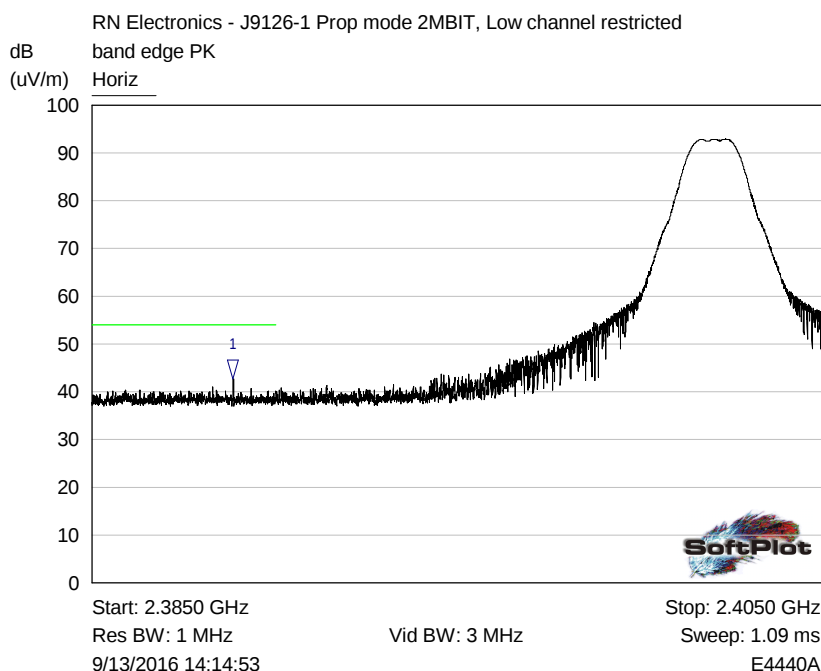
Upper Restricted band Peak Plot



Mkr	Trace	X-Axis	Value	Notes
1 ▽	Horiz	2483.5081 MHz	33.10 dB(uV/m)	

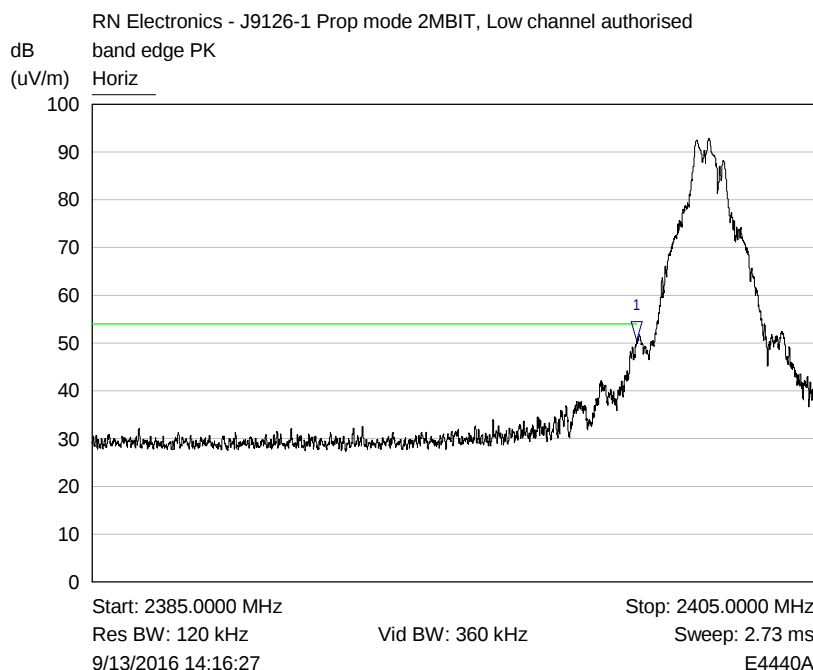
Upper authorised Band Edge Plot

RF Parameters: Band 2400-2483.5 MHz, Power 0 dBm, Channel Spacing 2 MHz, Modulation Shockburst 2MHz, Channel 2402 MHz



Mkr	Trace	X-Axis	Value	Notes
1 ▽	Horiz	2.3888 GHz	42.71 dB(uV/m)	

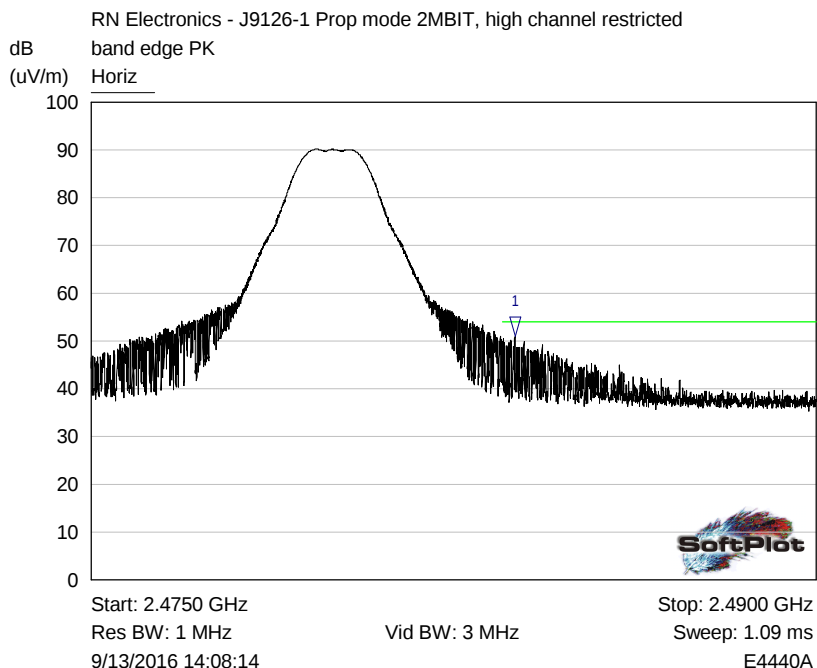
Lower Restricted band Peak Plot



Mkr	Trace	X-Axis	Value	Notes
1 ▽	Horiz	2400.0092 MHz	50.46 dB(uV/m)	

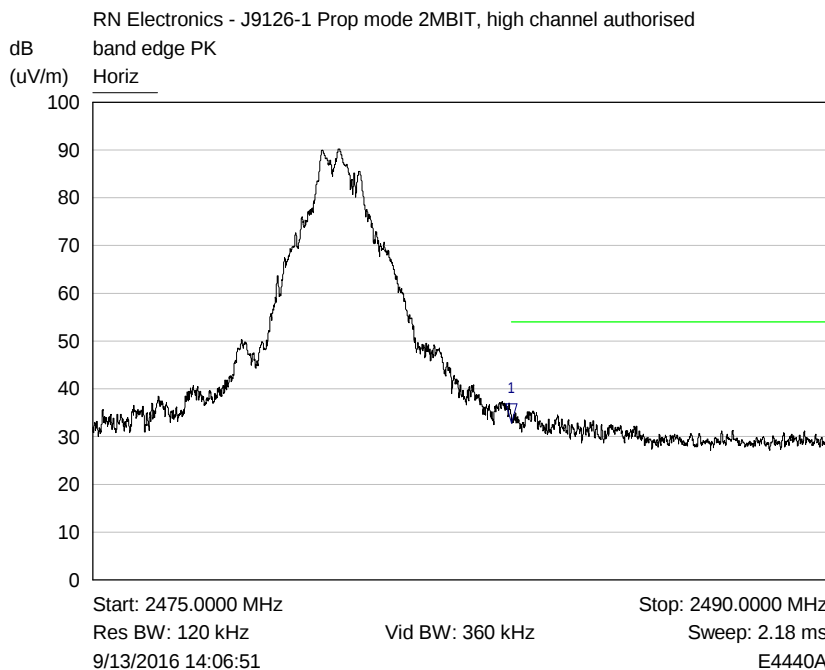
Lower Authorised Band Edge Plot

RF Parameters: Band 2400-2483.5 MHz, Power 0 dBm, Channel Spacing 2 MHz, Modulation Shockburst 2MHz, Channel 2480 MHz



Mkr	Trace	X-Axis	Value	Notes
1 ▽	Horiz	2.4838 GHz	50.92 dB(uV/m)	

Upper Restricted band Peak Plot

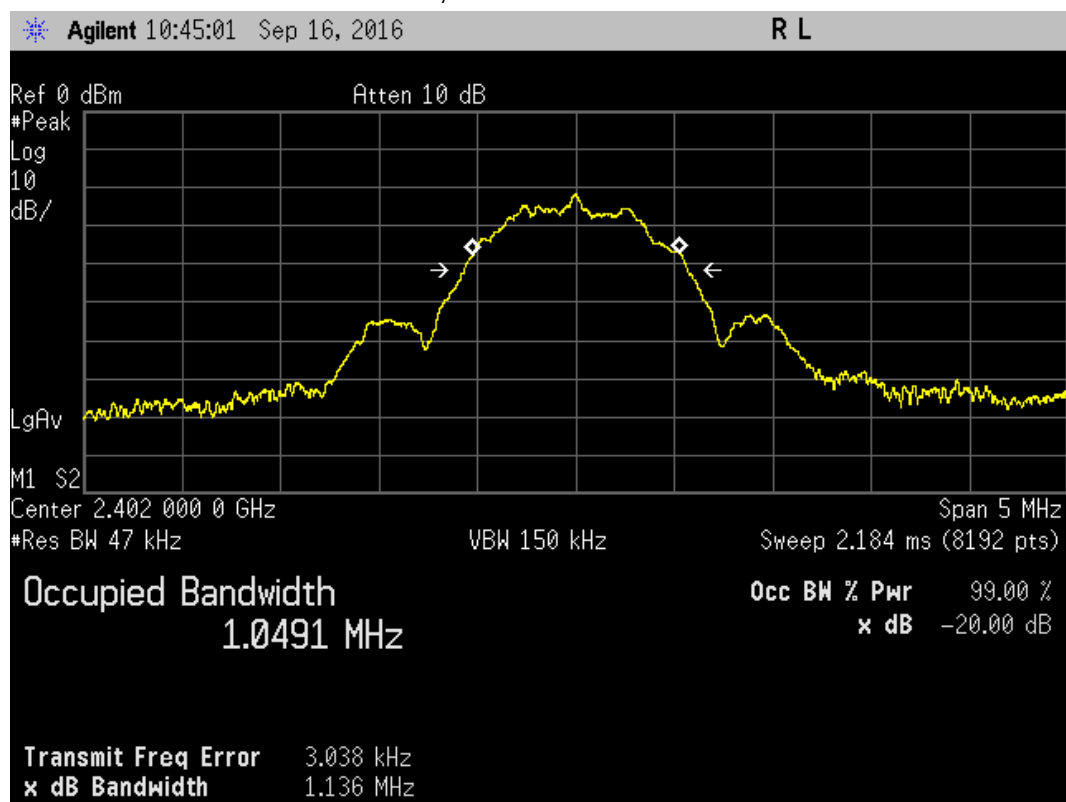


Mkr	Trace	X-Axis	Value	Notes
1 ▽	Horiz	2483.5081 MHz	32.84 dB(uV/m)	

Upper authorised Band Edge Plot

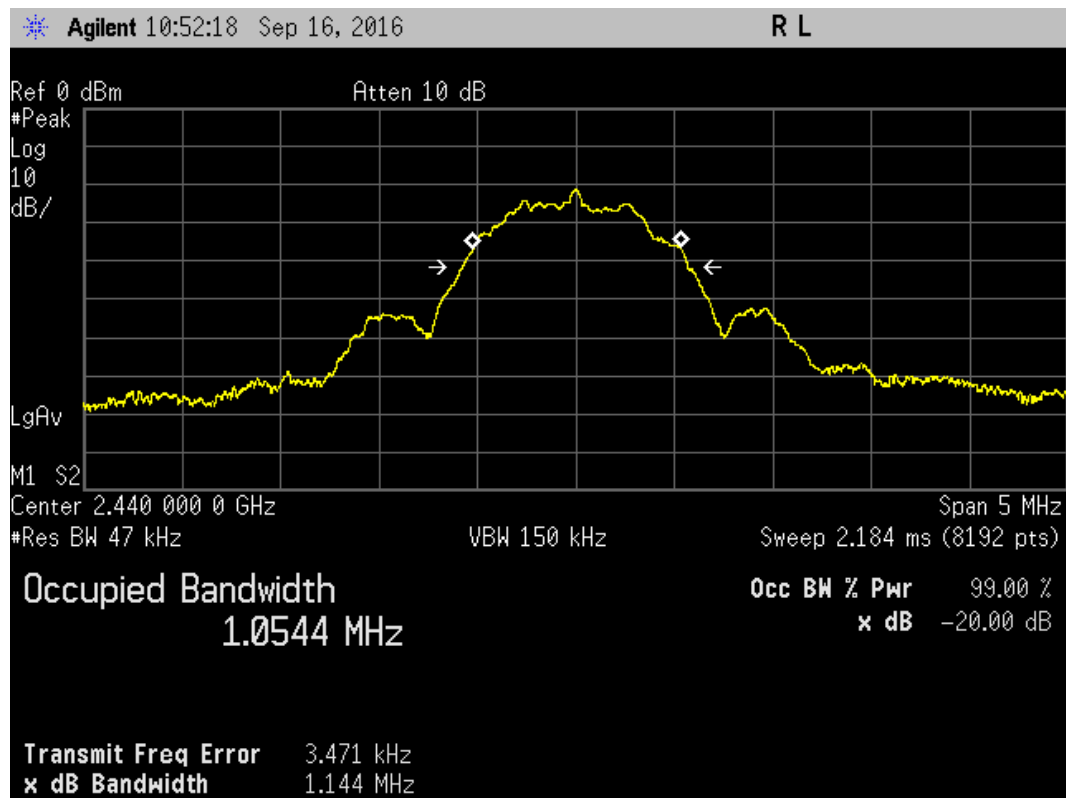
6.7 Occupied bandwidth

RF Parameters: Band 2400-2483.5 MHz, Power 0 dBm, Channel Spacing 2 MHz, Modulation
BT LE, Channel 2402 MHz



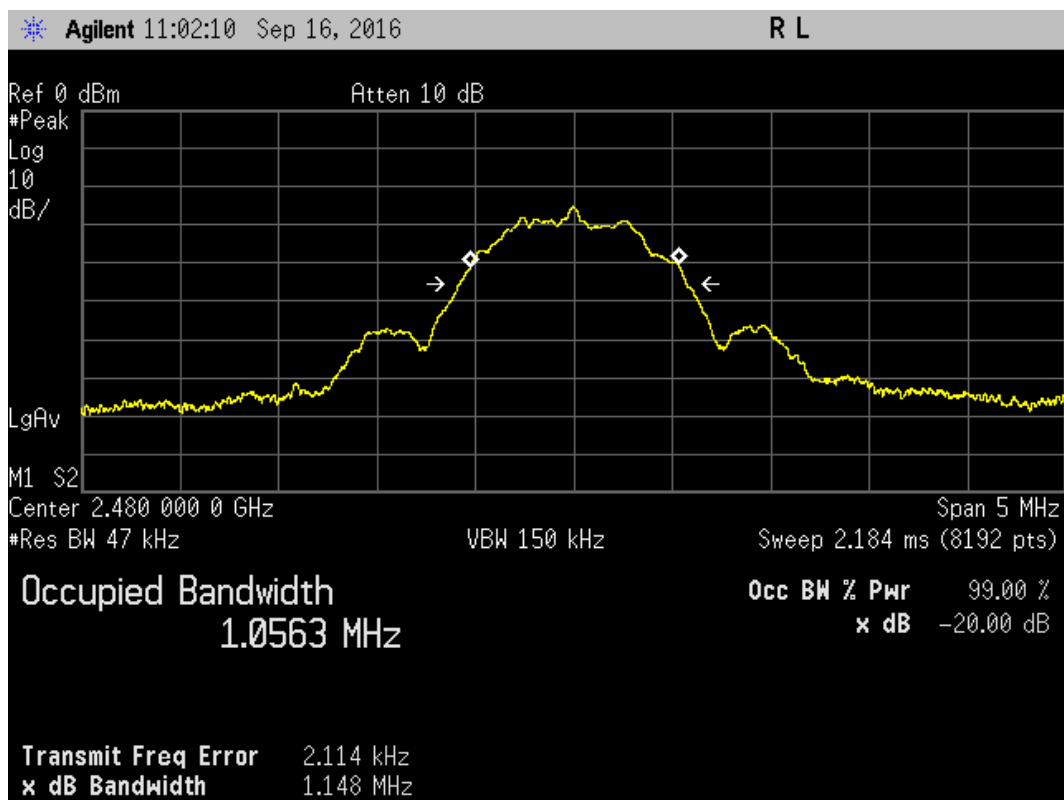
Plot for 20dB Bandwidth (MHz)

RF Parameters: Band 2400-2483.5 MHz, Power 0 dBm, Channel Spacing 2 MHz, Modulation
BT LE, Channel 2440 MHz



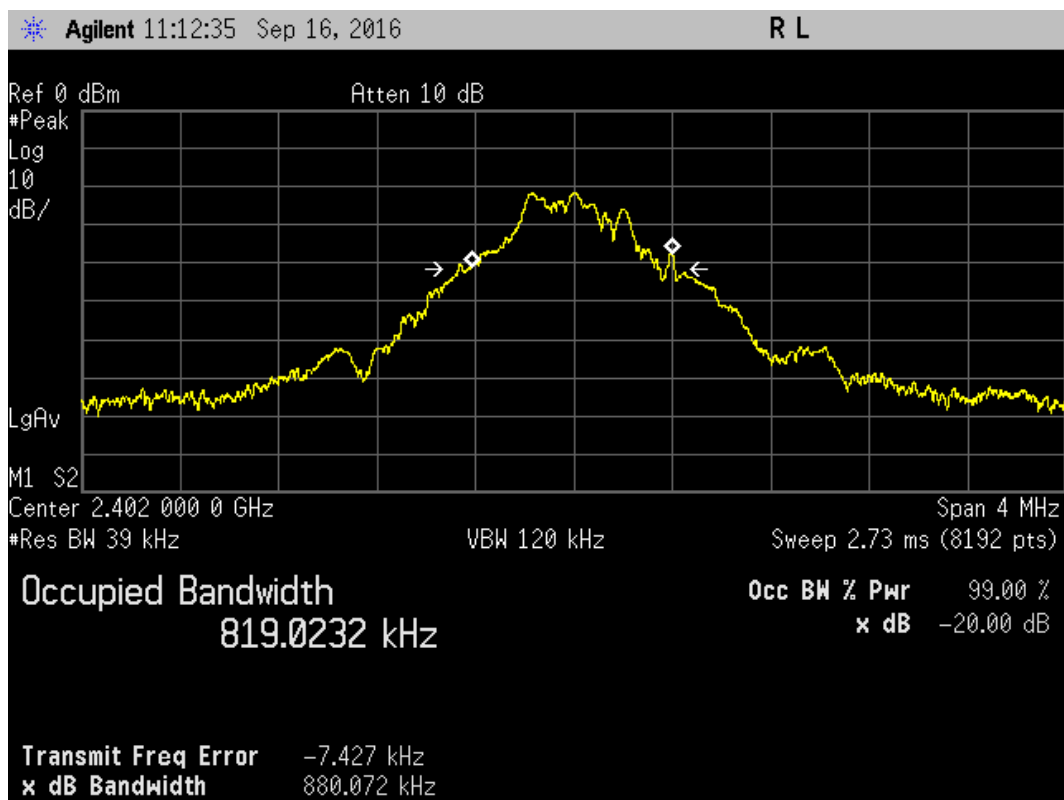
Plot for 20dB Bandwidth (MHz)

RF Parameters: Band 2400-2483.5 MHz, Power 0 dBm, Channel Spacing 2 MHz, Modulation
BT LE, Channel 2480 MHz



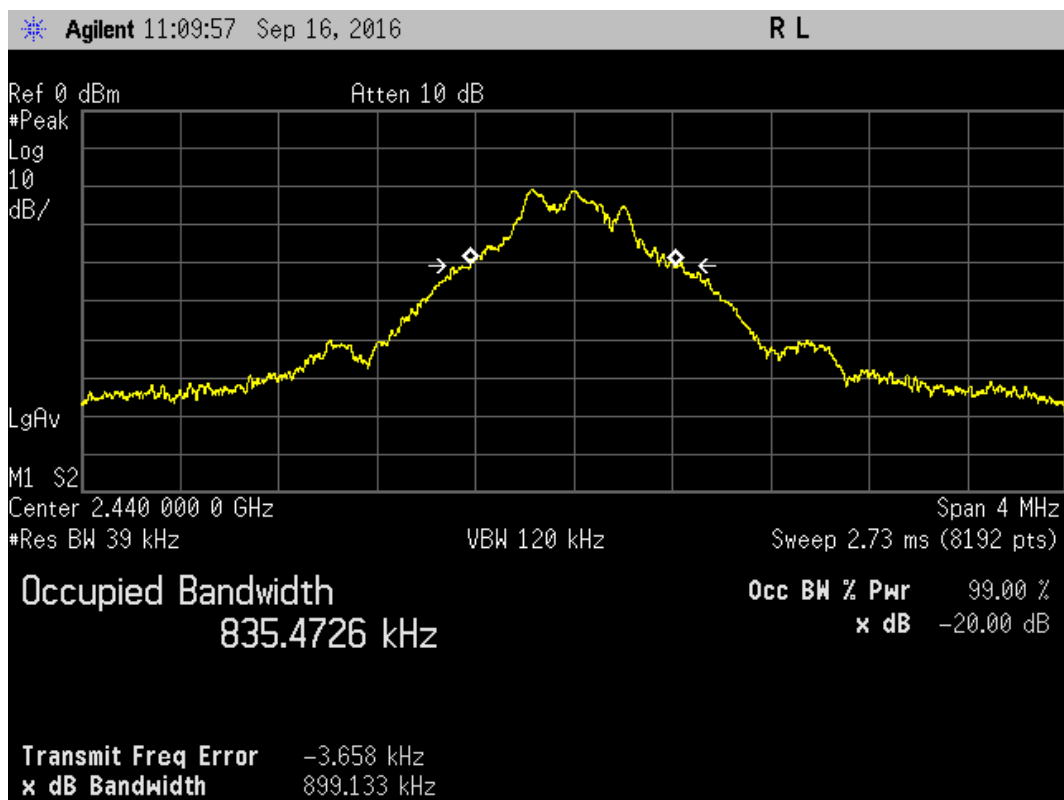
Plot for 20dB Bandwidth (MHz)

RF Parameters: Band 2400-2483.5 MHz, Power 0 dBm, Channel Spacing 2 MHz, Modulation Shockburst 1MHz, Channel 2402 MHz

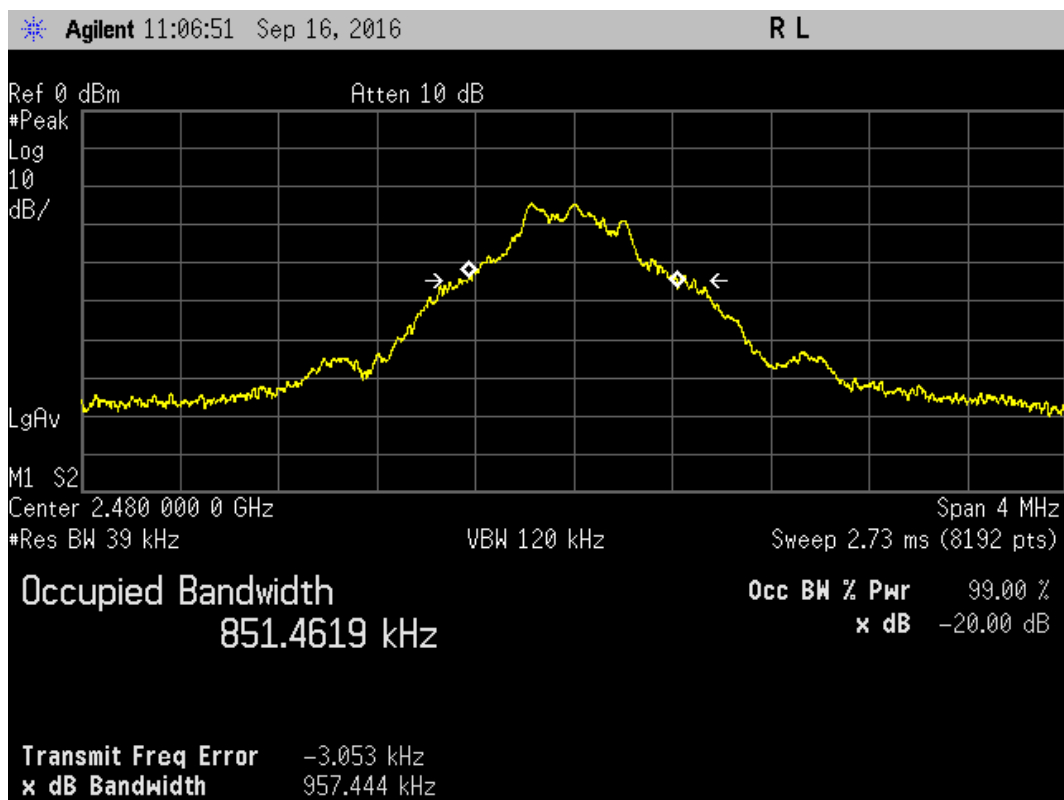


Plot for 20dB Bandwidth (MHz)

RF Parameters: Band 2400-2483.5 MHz, Power 0 dBm, Channel Spacing 2 MHz, Modulation Shockburst 1MHz, Channel 2440 MHz

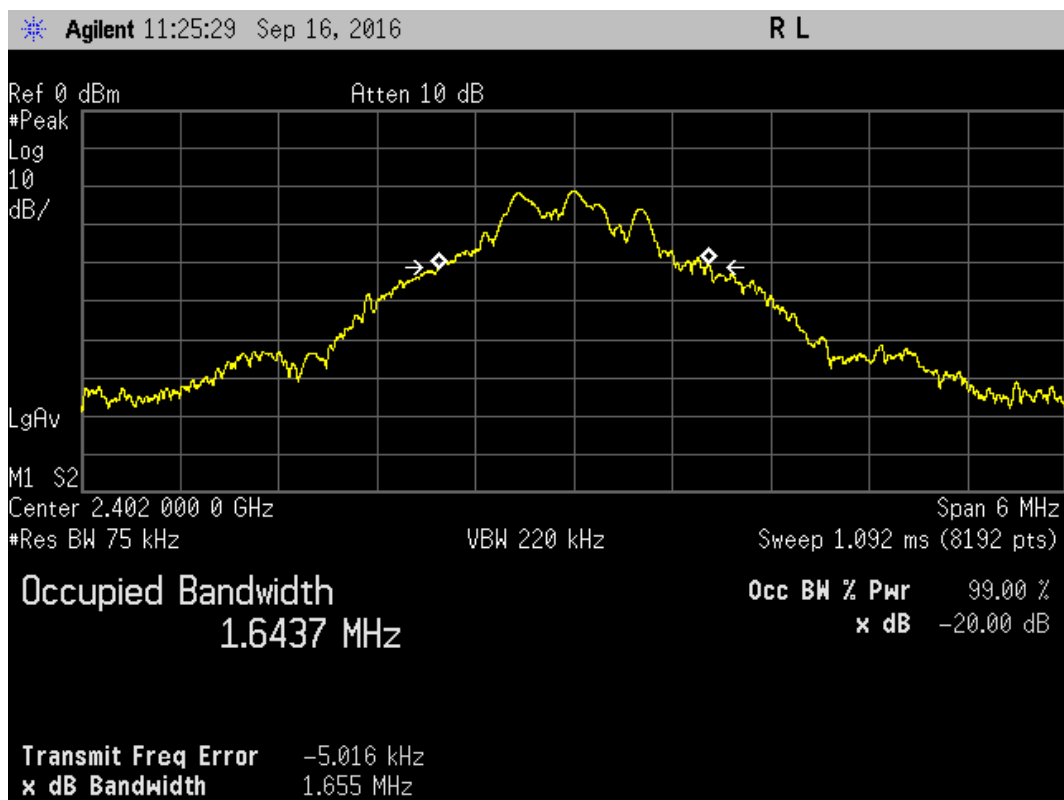


RF Parameters: Band 2400-2483.5 MHz, Power 0 dBm, Channel Spacing 2 MHz, Modulation Shockburst 1MHz, Channel 2480 MHz



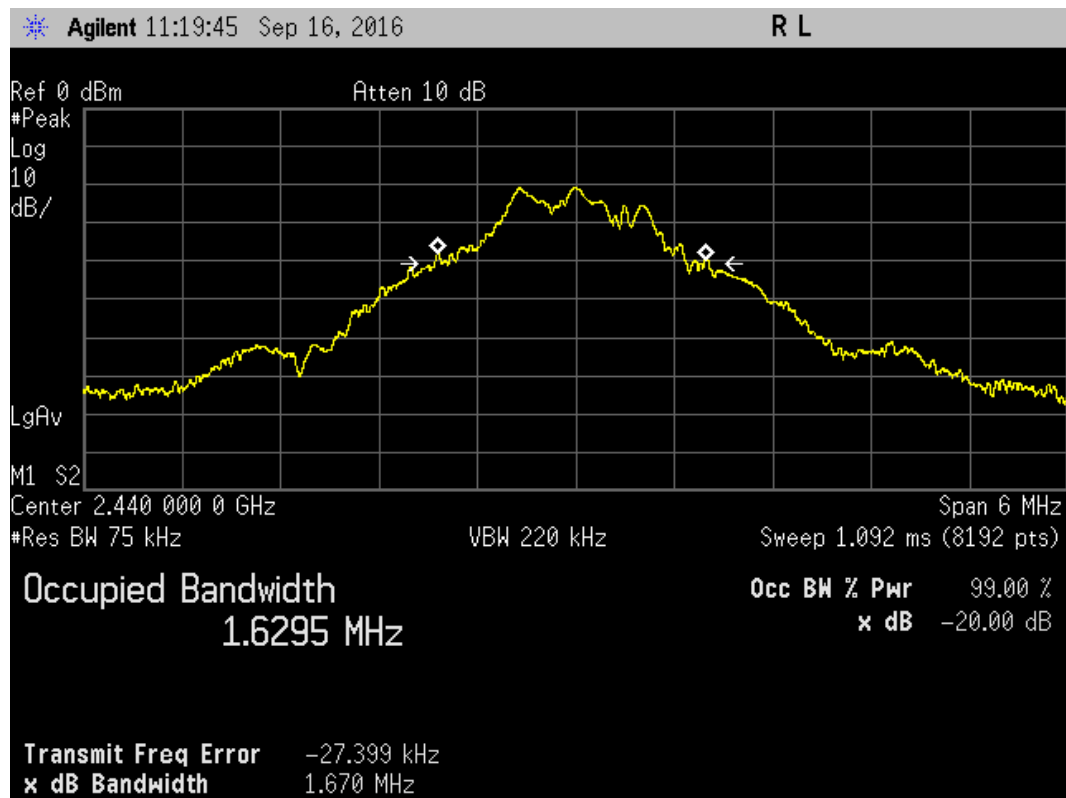
Plot for 20dB Bandwidth (MHz)

RF Parameters: Band 2400-2483.5 MHz, Power 0 dBm, Channel Spacing 2 MHz, Modulation Shockburst 2MHz, Channel 2402 MHz



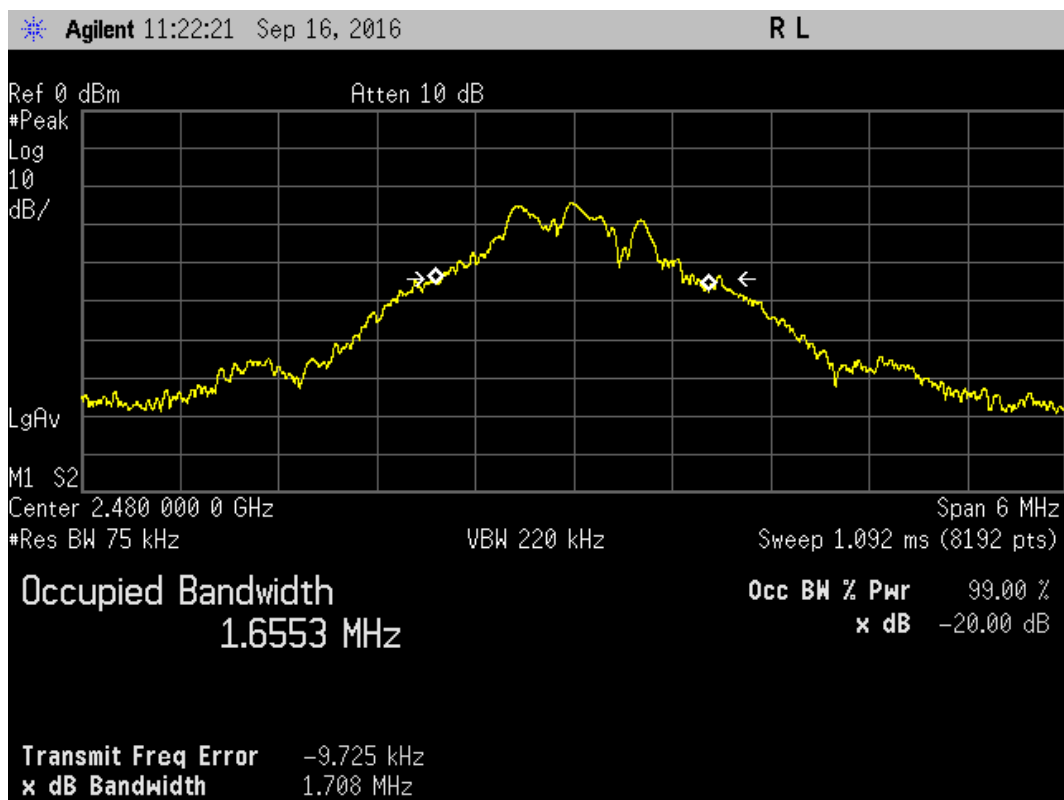
Plot for 20dB Bandwidth (MHz)

RF Parameters: Band 2400-2483.5 MHz, Power 0 dBm, Channel Spacing 2 MHz, Modulation Shockburst 2MHz, Channel 2440 MHz



Plot for 20dB Bandwidth (MHz)

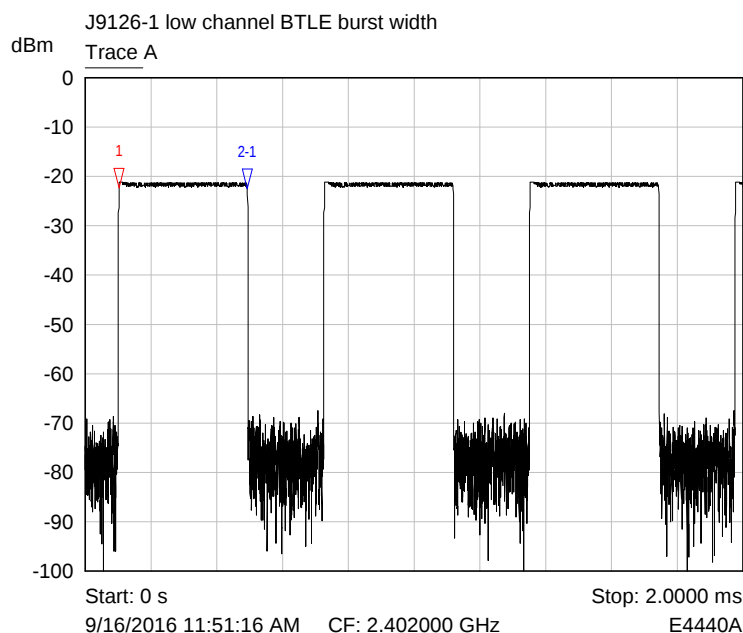
RF Parameters: Band 2400-2483.5 MHz, Power 0 dBm, Channel Spacing 2 MHz, Modulation Shockburst 2MHz, Channel 2480 MHz



Plot for 20dB Bandwidth (MHz)

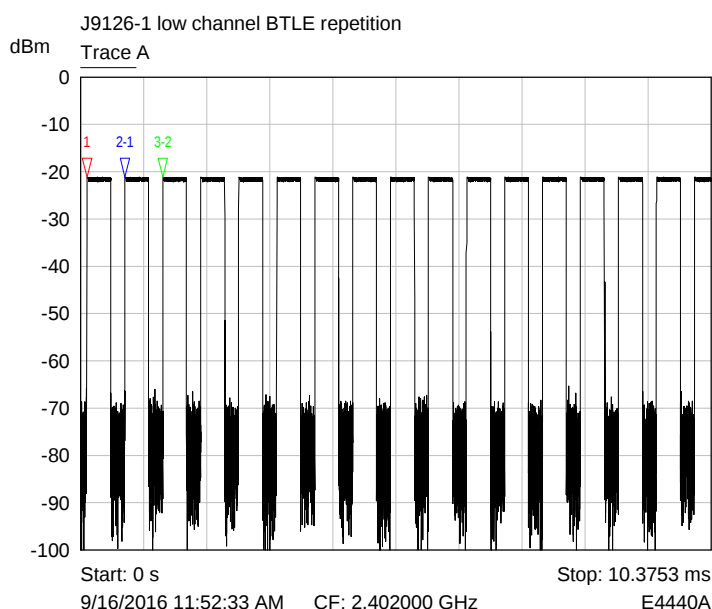
6.8 Duty cycle

RF Parameters: Band 2400-2483.5 MHz, Power 0 dBm, Channel Spacing 2 MHz, Modulation
BT LE



Mkr	Trace	X-Axis	Value	Notes
1 ▽	Trace A	102.3074 us	-22.41 dBm	
2-1 ▽	Trace A	391.1610 us	-0.05 dB	

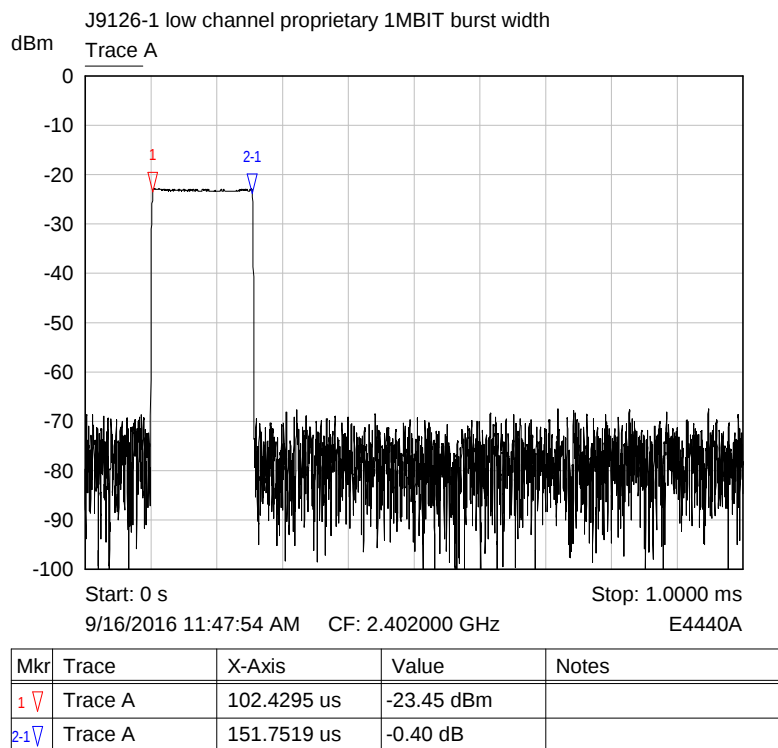
TX on time (us)



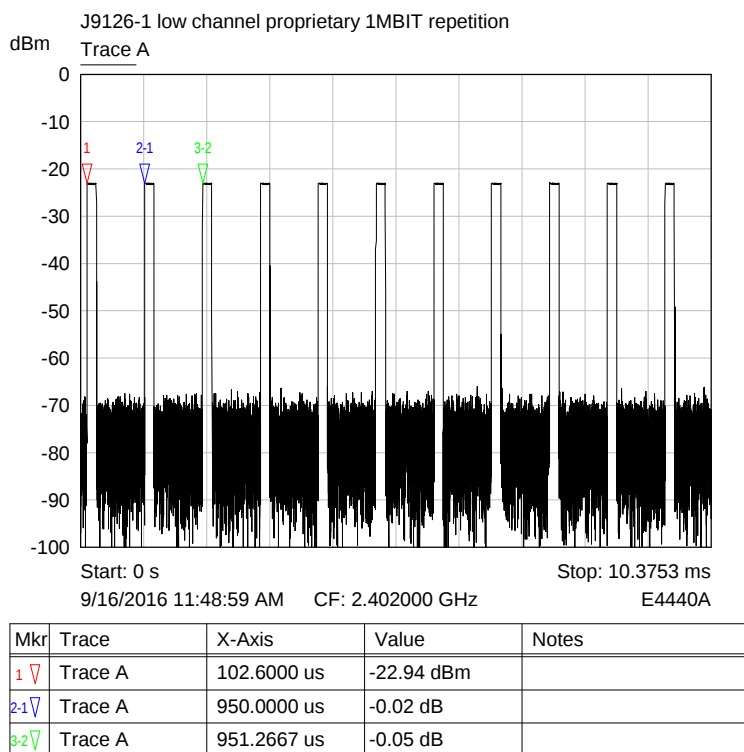
Mkr	Trace	X-Axis	Value	Notes
1 ▽	Trace A	100.0667 us	-21.22 dBm	
2-1 ▽	Trace A	625.7333 us	0.07 dB	
3-2 ▽	Trace A	624.4667 us	-0.05 dB	

TX repetition time (us)

RF Parameters: Band 2400-2483.5 MHz, Power 0 dBm, Channel Spacing 2 MHz, Modulation Shockburst 1MHz

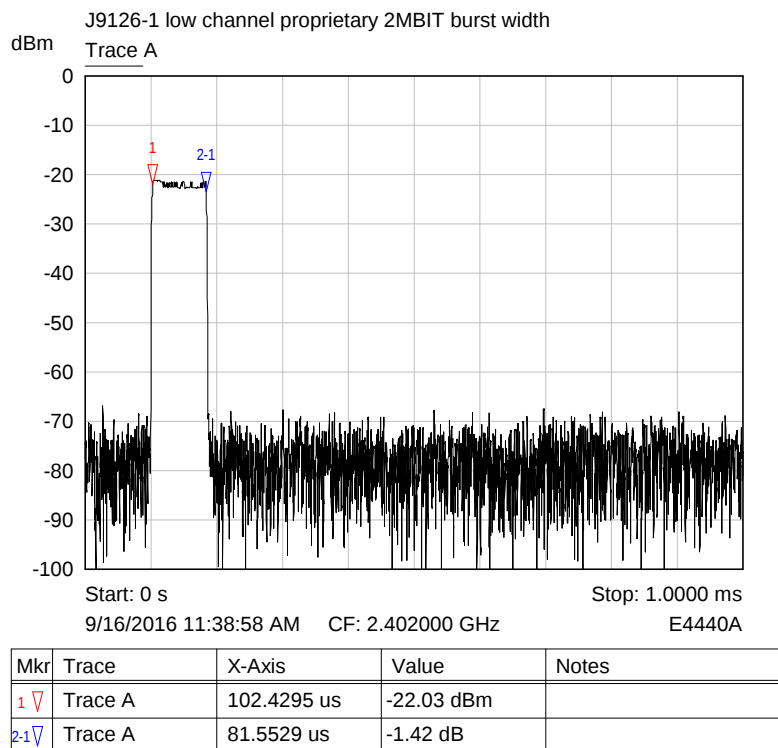


TX on time (us)

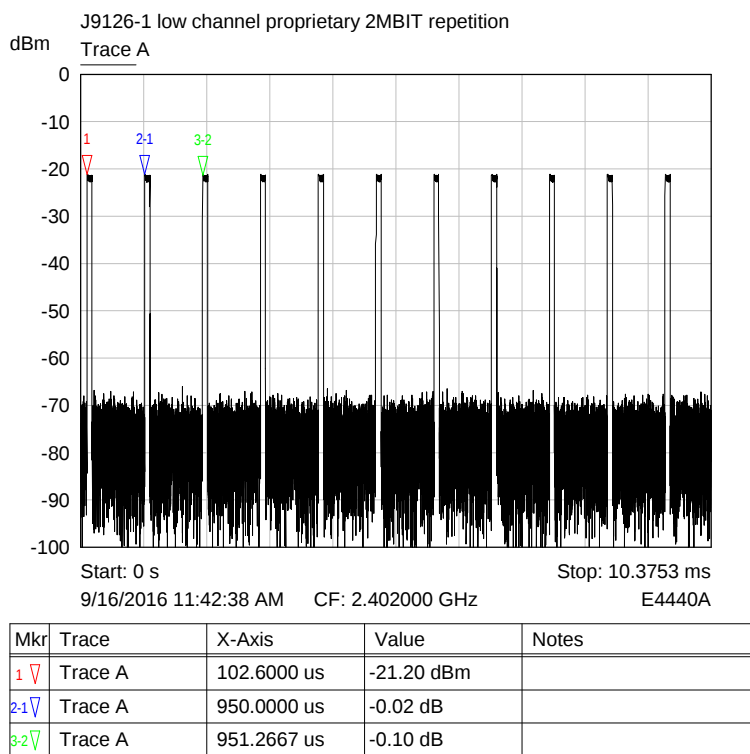


TX repetition time (us)

RF Parameters: Band 2400-2483.5 MHz, Power 0 dBm, Channel Spacing 2 MHz, Modulation Shockburst 2MHz



TX on time (us)



TX repetition time (us)

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 (dBμV)	Pk – Lim 1 (dB)	QP Amp (dBμV)	QP - Lim1 (dB)	Av Amp (dBμV)	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 $20 \cdot \log(500) = 54$ dB μV/m.

(b) limit of 300 $\mu\text{V/m}$ at 10m equates to $20.\log(300 \cdot 10/3) = 60 \text{ dB } \mu\text{V/m}$ at 3m

(c) limit of 30 $\mu\text{V/m}$ at 30m, but below 30MHz, equates to $20.\log(30) + 40.\log(30/3) = 69.5 \text{ dB}\mu\text{V/m}$ 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

8 Photographs

8.1 EUT Front View

Short term confidentiality required, therefore photographs removed at the manufacturer's request.

8.2 EUT Reverse Angle

Short term confidentiality required, therefore photographs removed at the manufacturer's request.

8.3 EUT Antenna

Short term confidentiality required, therefore photographs removed at the manufacturer's request.

8.4 EUT Display & Controls

Short term confidentiality required, therefore photographs removed at the manufacturer's request.

8.5 EUT Internal photos

Short term confidentiality required, therefore photographs removed at the manufacturer's request.

8.6 EUT ID Label

Short term confidentiality required, therefore photographs removed at the manufacturer's request.

8.7 EUT Chassis

Short term confidentiality required, therefore photographs removed at the manufacturer's request.

8.8 Test set up photos

Short term confidentiality required, therefore photographs removed at the manufacturer's request.

8.9 Radiated emission diagram

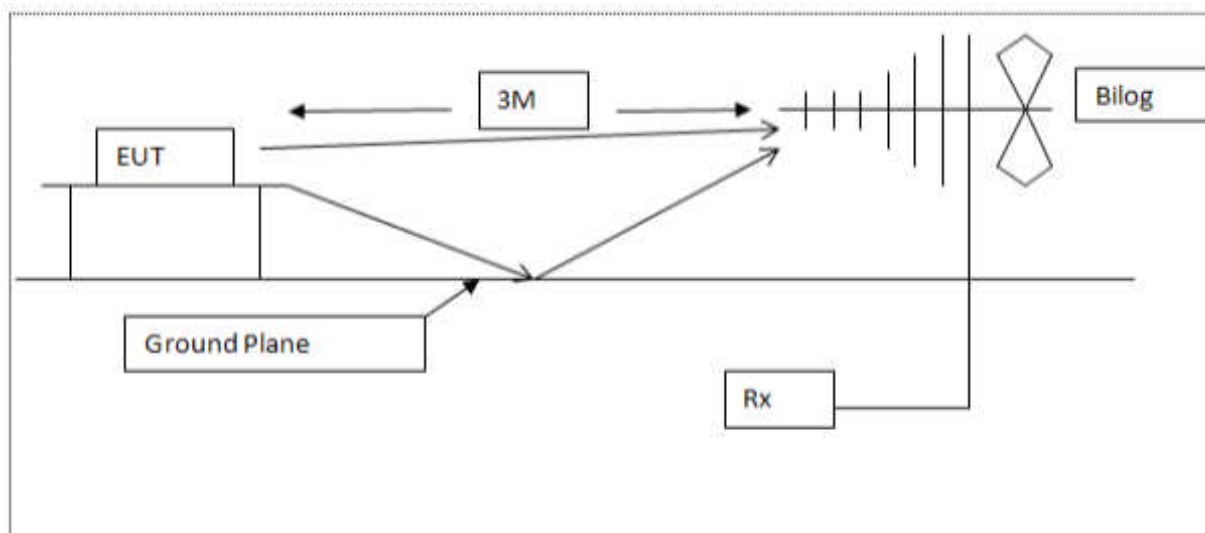


Diagram of the radiated emissions test setup 30 - 1000 MHz

8.10 AC powerline conducted emission diagram

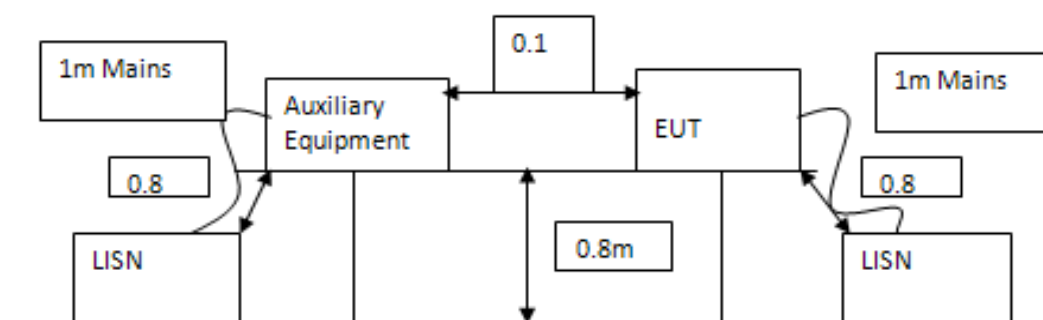


Diagram of the AC conducted emissions test setup

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
E010	MN2050	LISN 13A	Chase	28-Apr-2016	12 months
E035	11947A	Transient Limiter + 10dB Atten.	Hewlett Packard	01-Jun-2016	6 months
E411	N9039A	9 kHz - 1 GHz RF Filter Section	Agilent Technologies	06-Jul-2016	12 months
E533	N5182A	Signal Generator 6 GHz MXG	Agilent Technologies	26-Feb-2016	36 months
E534	E4440A	PSA 3 Hz - 26.5 GHz	Agilent Technologies	26-Feb-2015	24 months
E535	N9039A	9 kHz - 1 GHz RF Filter Section	Agilent Technologies	25-Feb-2016	12 months
E624	E4440A	PSA 3 Hz - 26.5 GHz	Agilent Technologies	22-Dec-2015	24 months
LPE261	3115	1-18GHz Horn	EMCO	04-Apr-2016	24 months
LPE333	8449B	Pre-amplifier 1GHz - 26.5GHz	Hewlett Packard	18-Apr-2016	24 months
LPE364	CBL6112A	30MHz - 2GHz Bilog Antenna	Chase Electronics Ltd	22-Jan-2016	24 months
TMS45	Model1	Attenuator 3dB 12.4GHz	Weinschel	02-Sep-2016	12 months
TMS78	3160-08	Std Gain Horn Antenna 12.4-18 GHz	ETS Systems	03-Jun-2016	12 months
TMS79	3160-09	Std Gain Horn Antenna 18-26.5 GHz	ETS Systems	03-Jun-2016	12 months
TMS81	6502	Active Loop Antenna	EMCO	27-Apr-2015	24 months
ZSW1	V2.0	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	A1502	Macbook Pro	Apple	C17N6HGGG3QH
2	TTL-232R-3V3	USB to serial programming lead	-	-

10.2 RN Electronics supplied equipment

RN No.	Model No.	Description	Manufacturer	Serial No
I034	Precision M60	Laptop	DELL	B17244

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 / 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

13 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
°C	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		