2360

Radio Test Report

Geolux d.o.o.

RSS-4

47 CFR Part 15.249 Effective Date 1st October 2019
DXX: Part 15 Low Power Communication Device Transmitter
Test Date: 1st July 2020 to 14th January 2021
Report Number: 08-12156-1-20 Issue 02
Supersedes Report Number: 08-12156-1-20 Issue 01

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Certificate of Test 12156-1

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:	RSS-4
Model Number:	RSS-4
Unique Serial Number:	RSS-0003-1002
Applicant:	Geolux d.o.o. Ljudevita Gaja 62 10430 Samobor Croatia
Proposed FCC ID	2AN9XRSS4001
Full measurement results are detailed in Report Number:	08-12156-1-20 Issue 02
Test Standards:	47 CFR Part 15.249 Effective Date 1st October 2019 DXX: Part 15 Low Power Communication Device Transmitter

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 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: 1st July 2020 to 14th January 2021

Test Engineer: Ian Rose
Digitally signed by: Ian Rose
DN: CN = Ian Rose email = Ian@RNElectronics.com C = GB O = Rn Electronics
Date: 2021.01.29 10:08:10 Z

Approved By:
Radio Approvals Manager
Digitally signed by: Daniel Sims
DN: CN = Daniel Sims C = GB O = RN Electronics Ltd
Date: 2021.01.29 10:02:35 Z

Customer Representative:

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0 Revision History

Issue Number	Revision History	Page Reference(s)
01	First Issue	-
02	Clarified/updated test modes Added results for TX1 mode Update results Add results Added plots for TX1 mode Updated plots where required Changed photo Added set-up photo Added equipment to test equipment list and updated cal dates for some equipment Added AC/DC adaptor to RN Electronics supplied equipment list Added modification photo	Pages 7 and 8 Pages 11 and 12 Pages 18-20, 23, 25-26 Page 21 Pages 28 and 29 Pages 50-90 Pages 69, 76 and 81-82 Page 76 and 82 Page 84, 85 Page 86 Page 88

1 Contents

2 Equipment under test (EUT)

2.1 Equipment specification

Applicant	Geolux d.o.o. Ljudevita Gaja 62 10430 Samobor Croatia	
Manufacturer of EUT	Geolux d.o.o	
Full Name of EUT	RSS-4	
Model Number of EUT	RSS-4	
Serial Number of EUT	RSS-0003-1002	
Date Received	14th July 2020	
Date of Test:	1st July 2020 to 14th January 2021	
Purpose of Test	To demonstrate design compliance to the relevant rules of Chapter 47 of the Code of Federal Regulations.	
Date Report Issued	15th January 2021	
Main Function	Ground Surveillance Radar.	
Information Specification	Height	190 mm
	Width	120 mm
	Depth	50 mm
	Weight	2.5 kg
	Voltage	9-48 V DC
	Current	1.25 A

2.2 Configurations for testing

General Parameters	
EUT Normal use position	Outdoors
Choice of model(s) for type tests	Production sample and engineering sample with sweep stopped
Antenna details	5 internal patch array TX antennas 8 internal patch array RX antennas 14 dBi gain.
Antenna port	No. Integral antenna.
Baseband Data port (yes/no)?	No
Highest Signal generated in EUT	24.25 GHz
Lowest Signal generated in EUT	24.576 MHz
Hardware Version	RevA
Software Version	Not applicable
Firmware Version	6.0.8.
Type of Equipment	Perimeter security systems
Technology Type	Radar
Geo-location (yes/no)	Not used to configure the radio but it is used to report a targets location.
TX Parameters	
Alignment range – transmitter	24.075-24.175 GHz
EUT Declared Modulation Parameters	FMCW
EUT Declared Power level	20 dBm EIRP
EUT Declared Signal Bandwidths	100 MHz
EUT Declared Channel Spacing's	Single channel 24.125 GHz
EUT Declared Duty Cycle	60%
Unmodulated carrier available?	No
Declared frequency stability	35 ppm
RX Parameters	
Alignment range – receiver	24.075-24.175 GHz
EUT Declared RX Signal Bandwidth	1.8 MHz
Receiver Signal Level (RSL)	Not declared
Method of Monitoring Receiver BER	Not declared
FCC Parameters	
FCC Transmitter Class	DXX: Part 15 Low Power Communication Device Transmitter

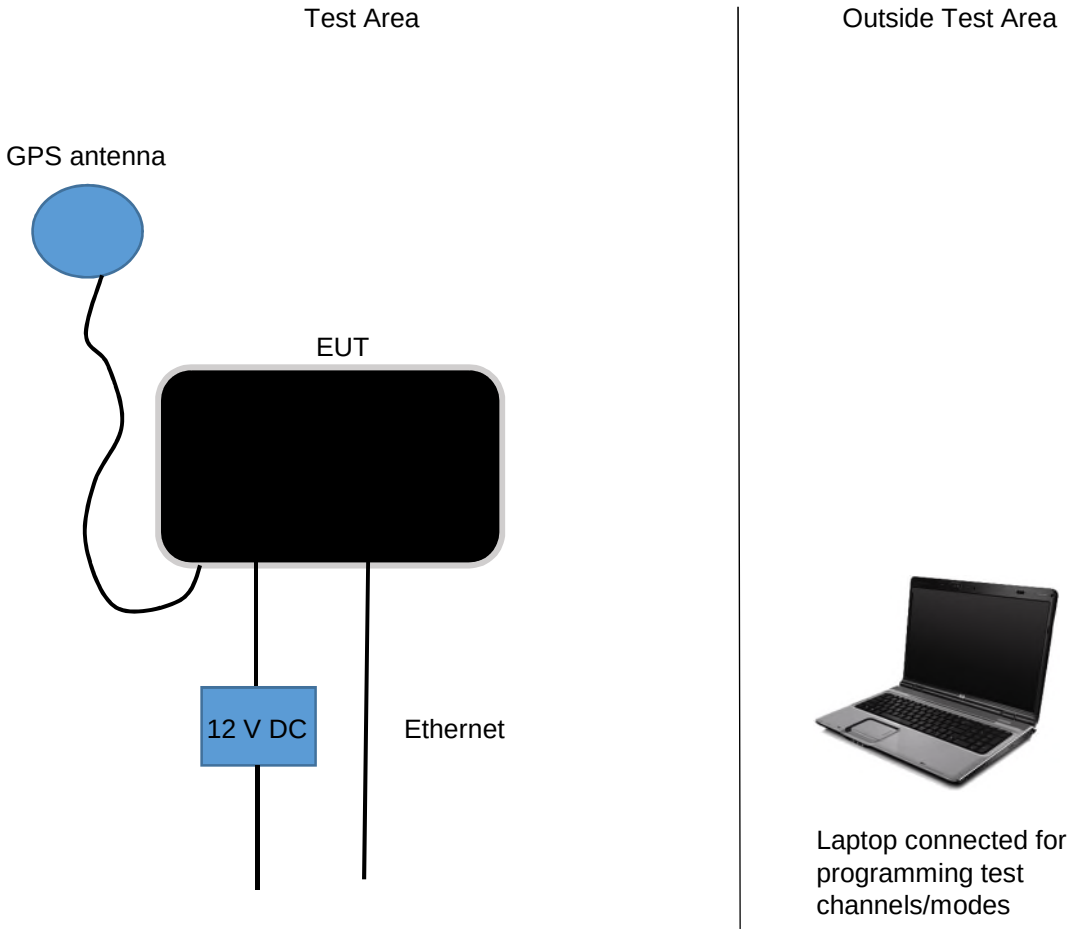
2.3 Functional description

FMCW radar in 24 GHz band for ground surveillance applications. Radar uses MIMO principle and FMCW modulated RF signal to detect and locate targets in front of the sensor. Sensor is capable in detection of multiple targets and of tracking all detected targets. Visualization of detections and setup of the sensor are done using the web-based GUI accessed through Ethernet interface. Sensor is also capable of alerting third party security systems and/or controlling cameras using the same Ethernet interface.

2.4 Modes of operation

Mode Reference	Description	Used for testing
TX1	24.125 GHz 20 dBm FMCW 290us TX time 210 us RX/Idle time. DC powered	Yes
TX2	24.125 GHz 20 dBm FMCW 290us TX time 210 us RX/Idle time. PoE powered	Yes
TX3	24.089 GHz 20 dBm sweep stopped 290us TX time 210 us RX/Idle time. DC powered	Yes
TX4	24.129 GHz 20 dBm sweep stopped 290us TX time 210 us RX/Idle time. DC powered	Yes
TX5	24.170 GHz 20 dBm sweep stopped 290us TX time 210 us RX/Idle time. DC powered	Yes

2.5 Emissions configuration



The unit was powered from a DC power supply via 120 V AC. For conducted AC emissions and radiated emissions the unit was powered from either an off the shelf Power over Ethernet adaptor or an off the shelf AC/DC adaptor. The standard modes (TX1 and TX2) were sweeping in normal operation this allowed repeated transmit and receive modes of device as stated within section 2.4 of this report. In normal mode of operation with frequency sweeping burst transmission and modulation, duty cycle was measured at 58%. The power setting was as stated below:-
Swept frequency mode = Power level setting 20

The unit was also modified by the applicant with extra engineering modes to allow the sweep to be stopped on Low, Mid and High Frequencies of the EUT swept band, as required by the FCC rules. The Frequencies the unit was stopped on and power settings are listed below:

Low Frequency 24.089 GHz, power setting 20
Mid Frequency 24.129 GHz, power setting 20
High Frequency 24.170 GHz, power setting 20

A GPS antenna was provided and connected for tests. This provides a time synchronisation for any reported targets.

2.5.1 Signal leads

Port Name	Cable Type	Connected
J1	M12 circular 12 pin custom cable	Yes
J2	M12 circular 8 pin custom cable	Yes
GPS	SMA	Yes

3 Summary of test results

The RSS-4 was tested for compliance to the following standard :

47 CFR Part 15.249 Effective Date 1st October 2019
DXX: Part 15 Low Power Communication Device Transmitter

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

Title	References	Results
Transmitter Tests		
1. AC power line conducted emissions	47 CFR Part 15C Part 15.207	PASSED
2. Radiated emissions 9 - 150 kHz	47 CFR Part 15C Part 15.209	NOT APPLICABLE[2]
3. Radiated emissions 150 kHz - 30 MHz	47 CFR Part 15C Part 15.209	PASSED
4. Radiated emissions 30 MHz -1 GHz	47 CFR Part 15C Part 15.209	PASSED
5. Radiated emissions above 1 GHz	47 CFR Part 15C Part 15.209	PASSED[3]
6. Intentional radiator field strength	47 CFR Part 15C Part 15.249a	PASSED
7. Band Edge Compliance	47 CFR Part 15C Part (15.215 and 15.249)	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)	PASSED
10. Frequency stability	47 CFR Part 15C Part 15.249(b)(2)	NOT APPLICABLE[1]

[1] Test only applies to equipment intended for fixed, point-to-point operation.
[2] Spectrum below 30MHz started at a frequency of 150 kHz up to a frequency of 30MHz based on the lowest signal generated/used within the equipment of 24.576 MHz as declared by the applicant.
[3] Spectrum investigated up to a frequency of 100 GHz based on 5 times the highest channel/ signal generated in equipment of 24175 MHz.

4 Specifications

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

4.1 Relevant standards

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

4.2 Deviations

No deviations were applied.

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 was placed on a wooden table 0.8m above the ground plane and connected to an off the shelf PoE supply and then an off the shelf AC/DC adaptor 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. No difference was observed between the swept FMCW modes and the frequency stopped modes. For final test the EUT was operated in modes TX1 and TX2.

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

E150, E035, ZSW1, E856, E642

See Section 9 for more details

5.1.5 Test results

Temperature of test environment	20°C
Humidity of test environment	50%
Pressure of test environment	102 kPa

TX1 mode (DC powered)

Band	24-24.25 GHz
Power Level	20 dBm (EIRP)
Channel Spacing	Single Channel
Mod Scheme	FMCW
Single channel	24.125 GHz

Plot refs
12156-1 Cond 2 AC Live 150k-30M Average
12156-1 Cond 2 AC Live 150k-30M Quasi-Peak
12156-1 Cond 2 AC Neutral 150k-30M Average
12156-1 Cond 2 AC Neutral 150k-30M Quasi-Peak

Table of signals measured for Cond 2 AC Live 150k-30M

Signal No.	Freq (MHz)	Peak Amp (dBuV)	QP Amp (dBuV)	QP -Lim (dB)	AV Amp (dBuV)	AV -Lim (dB)
1	0.150	60.4	58.2	-7.8	39.6	-16.4
2	0.177	56.7	53.6	-11.0	33.6	-21.0
3	0.214	51.0	47.9	-15.1	29.4	-23.6
4	0.252	46.0	42.5	-19.2	23.4	-28.3
5	0.301	43.3	38.8	-21.4	21.1	-29.1
6	0.580	43.6	40.7	-15.3	27.9	-18.1

Table of signals measured for Cond 2 AC Neutral 150k-30M

Signal No.	Freq (MHz)	Peak Amp (dBuV)	QP Amp (dBuV)	QP -Lim (dB)	AV Amp (dBuV)	AV -Lim (dB)
1	0.150	60.1	53.4	-12.6	35.3	-20.7
2	0.179	55.7	54.1	-10.4	39.0	-15.5
3	0.214	50.1	48.2	-14.8	34.9	-18.1
4	0.250	46.6	45.0	-16.8	30.3	-21.5
5	0.286	44.1	42.2	-18.4	29.4	-21.2
6	0.386	42.6	39.7	-18.4	27.0	-21.1
7	0.574	45.2	43.1	-12.9	33.7	-12.3

TX2 mode (PoE powered)

Band	24-24.25 GHz
Power Level	20 dBm (EIRP)
Channel Spacing	Single Channel
Mod Scheme	FMCW
Single channel	24.125 GHz

Plot refs
12156-1 Cond 1 AC Live 150k-30M Average
12156-1 Cond 1 AC Live 150k-30M Quasi-Peak
12156-1 Cond 1 AC Neutral 150k-30M Average
12156-1 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	0.175	46.2	44.0	-20.7	40.2	-14.5
2	0.175	46.3	44.1	-20.6	40.4	-14.3
3	0.437	38.5	36.8	-20.3	28.8	-18.3
4	0.524	43.5	41.5	-14.5	31.8	-14.2
5	0.699	44.8	43.4	-12.6	38.5	-7.5
6	0.699	44.5	43.2	-12.8	38.4	-7.6
7	0.786	37.0	36.0	-20.0	31.8	-14.2
8	0.873	37.4	36.0	-20.0	30.5	-15.5
9	0.962	36.0	34.7	-21.3	29.6	-16.4
10	2.274	34.2	32.9	-23.1	25.8	-20.2
11	2.886	33.5	32.3	-23.7	29.9	-16.1
12	3.935	31.2	29.9	-26.1	24.0	-22.0
13	4.460	30.5	29.5	-26.5	25.9	-20.1
14	28.064	32.9	31.1	-28.9	28.1	-21.9
15	28.446	31.6	30.4	-29.6	27.2	-22.8
16	29.687	30.8	29.7	-30.3	24.5	-25.5

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	0.175	46.4	44.0	-20.7	40.2	-14.5
2	0.437	38.9	37.1	-20.0	28.8	-18.3
3	0.525	43.7	41.7	-14.3	31.9	-14.1
4	0.700	44.5	43.2	-12.8	38.5	-7.5

5	0.787	36.8	35.5	-20.5	30.7	-15.3
6	0.875	36.9	35.7	-20.3	30.2	-15.8
7	0.962	36.4	34.8	-21.2	29.6	-16.4
8	1.312	35.1	34.0	-22.0	31.3	-14.7
9	1.749	32.4	31.7	-24.3	28.1	-17.9
10	2.887	33.5	32.4	-23.6	30.0	-16.0
11	3.499	31.5	29.8	-26.2	23.9	-22.1
12	3.937	31.3	29.9	-26.1	25.1	-20.9
13	4.461	30.4	29.6	-26.4	25.9	-20.1
14	27.491	30.7	28.7	-31.3	26.2	-23.8
15	28.159	33.3	31.1	-28.9	27.0	-23.0
16	28.350	31.3	29.7	-30.3	26.0	-24.0
17	29.400	31.4	30.0	-30.0	27.3	-22.7

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 ±3.6dB.

5.2 Radiated emissions 9 - 150 kHz

NOT APPLICABLE: Lowest internally generated frequency of 24.576 MHz.

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 & 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]

5.3.2 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 assessed in its normal use position. Initial scans showed no difference in emissions when powered from the external DC supply or when powered from Power over Ethernet so testing was performed whilst powered from a DC power supply. No difference was observed between the swept FMCW mode and the frequency stopped modes. The EUT was operated in TX1 mode for full test.

5.3.3 Test procedure

Tests were made in accordance with FCC Part 15 using the measuring equipment noted below.
Measurements were made in a semi-anechoic chamber (pre-scan) with any final measurements required performed on an OATS without a ground plane. The antenna was placed 1m above the ground. The equipment was rotated 360 degrees to record the worst case emissions.
At least 6 signals within 20dB and all signals within 10dB of the limit were investigated.
Tests were performed using Test Site M.

5.3.4 Test equipment

TMS81, E642, E856

See Section 9 for more details

5.3.5 Test results

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

Band	24-24.25 GHz
Power Level	20 dBm (EIRP)
Channel Spacing	Single Channel
Mod Scheme	FMCW
Single channel	24.125 GHz

Plot refs
12156-1 Rad 1 150k-30MHz Para
12156-1 Rad 1 150k-30MHz Perp

Note: No signals were observed within 20dB of limits.
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 ±3.9dB.

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. 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 assessed in its normal use position. Initial scans showed worst case to be when powered from the external DC supply rather than when powered from Power over Ethernet. The EUT was operated in TX1, TX3, TX4 and TX5 modes. No difference was observed between swept mode and frequency stopped modes.

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 M.

5.4.4 Test equipment

LPE364, E743, NSA-M, ZSW1, E642, E856

See Section 9 for more details

5.4.5 Test results

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

Band	24-24.25 GHz
Power Level	20 dBm (EIRP)
Channel Spacing	Single Channel
Mod Scheme	FMCW
Single channel	24.125 GHz

Plot refs
12156-1 Rad 1 VHF Horiz
12156-1 Rad 1 VHF Vert
12156-1 Rad 1 UHF Horiz
12156-1 Rad 1 UHF Vert

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	30.443	28.9	23.1	-16.9
2	56.155	24.2	17.9	-22.1
3	374.989	40.7	38.3	-7.7
4	442.367	39.0	36.7	-9.3
5	638.974	39.5	36.1	-9.9

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	32.292	36.9	31.8	-8.2
2	57.793	38.7	33.4	-6.6
3	73.156	37.0	31.5	-8.5
4	442.367	40.7	38.8	-7.2
5	466.943	38.1	35.7	-10.3
6	491.519	40.1	38.1	-7.9
7	540.670	37.6	34.8	-11.2
8	589.822	42.4	40.9	-5.1
9	638.974	43.7	42.2	-3.8
10	933.886	43.8	41.0	-5.0

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:

30MHz - 1000MHz ±6.1dB.

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 assessed in its normal use position. Initial scans showed worst case to be when powered from the external DC supply rather than when powered from Power over Ethernet. The EUT was operated in TX3, TX4 and TX5 modes.

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 with frequency sweep stopped on Low, Middle and High frequencies, was rotated through 360 degrees to record the worst case emissions. Above 26.5GHz Pre scans to identify any point sources of radiation were made using a 100kHz RBW and at a distance of approximately 3cm over the volume of the unit. For final measurements a 1MHz RBW and 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 - 75GHz and 0.1/0.03m was used in the test range 75-100GHz. At least 6 signals within 20dB and all signals within 10dB of the limit were investigated. Tests were performed using test Site M, A.

5.5.4 Test equipment

E136, E296-2, E296-4, E296-5, E296-6, E330, E412, E429, E503, E580, E642, E717, E718, E856, F138, F139, F140, H070, TMS78, TMS79, TMS82

See Section 9 for more details

5.5.5 Test results

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

Setup Table

Band	24-24.25 GHz
Power Level	20 dBm (EIRP)
Channel Spacing	Single Channel
Mod Scheme	FMCW
Single channel	24.089 GHz

Spurious Frequency (MHz)	Measured Peak Level (dBµV/m)	Difference to Peak Limit (dB)	Measured Average Level (dBµV/m)	Difference to Average Limit (dB)	EUT Polarisation	Antenna Polarisation
1155	40.0	-34.0	34.7	-19.3	Normal use position	Vertical
1600	41.2	-32.8	34.8	-19.2	Normal use position	Vertical
48178	68.7	N/A	64.0	-4.0	Normal use position	Volumetric
72267	58.5	N/A	53.8	-14.2	Normal use position	Volumetric

Setup Table

Band	24-24.25 GHz
Power Level	20 dBm (EIRP)
Channel Spacing	Single Channel
Mod Scheme	FMCW
Single channel	24.129 GHz

Spurious Frequency (MHz)	Measured Peak Level (dBµV/m)	Difference to Peak Limit (dB)	Measured Average Level (dBµV/m)	Difference to Average Limit (dB)	EUT Polarisation	Antenna Polarisation
1155	40.0	-34.0	34.7	-19.3	Normal use position	Vertical
1600	41.2	-32.8	34.8	-19.2	Normal use position	Vertical
48259	68.2	N/A	63.5	-4.5	Normal use position	Volumetric
72388	59.6	N/A	54.9	-13.1	Normal use position	Volumetric

Plots
12156-1 1-2GHz hor
12156-1 1-2GHz vert
12156-1 2-2.7GHz hor
12156-1 2-2.7GHz vert
12156-1 2.7-5 GHz hor
12156-1 2.7-5 GHz vert
12156-1 5-6 GHz hor
12156-1 5-6 GHz vert
12156-1 6-7 GHz hor
12156-1 6-7 GHz vert
12156-1 7-10 GHz hor
12156-1 7-10 GHz vert
12156-1 10-12.5 GHz hor
12156-1 10-12.5 GHz vert
12156-1 12.4-15 GHz hor
12156-1 12.4-15 GHz vert
12156-1 15-18 GHz hor
12156-1 15-18 GHz vert
12156-1 18-21 GHz hor
12156-1 18-21 GHz vert
12159-1 21-24 GHz hor
12159-1 21-24 GHz vert
12156-1 24.25-26.5 GHz hor
12156-1 24.25-26.5 GHz vert
12156-1 26.5-30 GHz volumetric
12156-1 30-34 GHz volumetric
12156-1 34-38 GHz volumetric
12156-1 38-40 GHz volumetric
12156-1 40-44 GHz volumetric
12156-1 44-48 GHz volumetric
12156-1 48-50 GHz volumetric
12156-1 50-54 GHz volumetric 3
12156-1 54-58 GHz volumetric 3
12156-1 58-62 GHz volumetric 3
12156-1 62-66 GHz volumetric 3

12156-1 66-70 GHz volumetric 3
12156-1 70-74 GHz volumetric 3
12156-1 74-75 GHz volumetric 3
12156-1 75-79 GHz volumetric 2
12156-1 79-83 GHz volumetric 2
12156-1 83-87 GHz volumetric 2
12156-1 87-91 GHz volumetric 2
12156-1 91-95 GHz volumetric 2
12156-1 95-99 GHz volumetric 2
12156-1 99-100 GHz volumetric 2

Setup Table

Band	24-24.25 GHz
Power Level	20 dBm (EIRP)
Channel Spacing	Single Channel
Mod Scheme	FMCW
Single channel	24.170 GHz

Spurious Frequency (MHz)	Measured Peak Level (dBµV/m)	Difference to Peak Limit (dB)	Measured Average Level (dBµV/m)	Difference to Average Limit (dB)	EUT Polarisation	Antenna Polarisation
1155	40.0	-34.0	34.7	-19.3	Normal use position	Vertical
1600	41.2	-32.8	34.8	-19.2	Normal use position	Vertical
48340	69.1	N/A	64.4	-3.6	Normal use position	Volumetric
72510	60.9	N/A	56.2	-11.8	Normal use position	Volumetric

Analyser plots can be found in Section 6 of this report. Whilst Low, Middle and High frequencies of the sweep were stopped at and measured, only middle frequency stopped sweep plots are shown to minimise report size.

LIMITS:
Emissions radiated outside of the specified frequency bands, except for harmonics, shall be attenuated by at least 50 dB below the level of the fundamental or to the general radiated emission limits in §15.209, whichever is the lesser attenuation. Harmonic emissions limit is 2500uV/m @ 3m (68 dBuV/m @3m) for 24 GHz fundamentals.
The general limits of 15.209 / harmonic limits of 15.249 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 ±3.5dB, 18 – 26.5 GHz ±3.9dB, 26.5 – 60 GHz ±3.9dB, 60 – 100 GHz ±4.4dB.

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 6.3/6.5/6.6 [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 rotated in both Horizontal and Vertical polarisations. The EUT was assessed in its normal use position. The EUT was operated in TX3, TX4 and TX5 modes.

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/span in conjunction with a PK detector. Duty cycle correction was applied (per 15.35) to determine the average field strength.
Measurements were made in a semi-anechoic chamber. Measurements were made at site M.

5.6.4 Test equipment

E642, TMS79, TMS82

See Section 9 for more details

5.6.5 Test results

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

Band	24-24.25 GHz
Power Level	20 dBm (EIRP)
Channel Spacing	Sep
Mod Scheme	FMCW
Low channel	24.089 GHz
Mid channel	24.129 GHz
High channel	24.170 GHz

	All channels
Duty Cycle (%)	58.00
Duty Cycle correction (dB)	4.73

	Low channel	Mid channel	High channel
Peak level (dBµV/m @3m)	108.41	108.33	106.54
Corrected average Level (dBµV/m @3m)	103.68	103.60	101.81
Plot reference	12156-1 ERP vert low	12156-1 ERP vert mid	12156-1 ERP vert high
Antenna Polarisation	Vert		
EUT Polarisation	Upright		

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

LIMITS:
15.249(a) 250 mV/m @ 3m (108 dBµV/m @ 3m) Average.

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: 18 – 26.5 GHz ±3.9dB.

5.7 Band Edge Compliance

5.7.1 Test methods

Test Requirements: 47 CFR Part 15C Part (15.215 and 15.249) [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 [Reference 4.1.1 of this report]

5.7.2 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 operated in TX1 and TX3 to TX5 modes.

5.7.3 Test procedure

Tests were made in accordance with FCC Part 15 using the measuring equipment listed below. The emission from the EUT was maximised before taking the plots. Tests were performed using Test Site M.

5.7.4 Test equipment

E296-2, E330, E412, E642, TMS79, TMS82, VSWR-M, ZSW1

See Section 9 for more details

5.7.5 Test results

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

Band	24-24.25 GHz
Power Level	20 dBm (EIRP)
Channel Spacing	Single Channel
Mod Scheme	FMCW
Low channel	24.125 (lower) GHz
High channel	24.125 (upper) GHz

Restricted Band Edge	Low channel	High channel
Peak Level (dBµV/m)	58.4	55.1
Peak Plot reference	12156-1 Restricted lower band edge peak (not sweeping)	12156-1 Restricted upper band edge peak (not sweeping)
Average Level (dBµV/m)	46.6	42.9
Average Plot reference	12156-1 Restricted lower band edge avg (not sweeping)	12156-1 Restricted upper band edge avg (not sweeping)

Authorised Band Edge	Low channel	High channel
Authorised Band Edge Plot reference	12156-1 Lower authorised band edge	12156-1 Upper authorised band edge
Authorised Band Edge Plot reference (sweeping)	12156-1 Authorised band edges (sweeping)	

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 24 and 24.25 GHz. Restricted band edge plots are also shown in section 6.

The restricted band edges closest to the EUT frequency of 24.125 GHz are 24 and 31.2 GHz.

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.

Further wider span plots have been taken to 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:

18 – 26.5 GHz ±3.9dB

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) [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 assessed in its normal use position. No discernible difference was noted between DC or PoE powered configurations so testing was performed whilst powered from a DC power supply. The EUT was operated in TX1, TX3, TX4 and TX5 modes.

5.8.3 Test procedure

Tests were made in accordance with FCC Part 15 using the measuring equipment listed below. A 1 MHz RBW, 3x VBW, auto sweep time and max hold settings were used for the 20 dB bandwidth. With the EUT frequency sweep stopped at low and high frequencies, the upper and lower frequency 20dBc point were found. Bandwidth was calculated between the outermost 20dBc points. An additional test was performed with the unit in swept mode and the bandwidth calculated between the outermost 20dBc points.
Tests were performed using test Site M.

5.8.4 Test equipment

E642, TMS79, TMS82

See Section 9 for more details

5.8.5 Test results

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

Swept mode

Band	24-24.25 GHz
Power Level	20 dBm (EIRP)
Channel Spacing	Single Channel
Mod Scheme	FMCW
Single channel	24.125 GHz

	Single channel
20 dB Bandwidth (MHz) Nominal Temp & Volts	90.4
Plot for 20 dB Bandwidth (MHz) Nominal Temp & Volts	12156-1 OBW (modified sweeping)

FLOW Worst case (MHz)	24079.9
FHIGH Worst case (MHz)	24170.3

Frequency sweep stopped mode

Band	24-24.25 GHz
Power Level	20 dBm (EIRP)
Channel Spacing	Single Channel
Mod Scheme	FMCW
Low frequency stopped	24.089 GHz
High frequency stopped	24.170 GHz

	Single channel
20 dB Bandwidth (MHz) Nominal Temp & Volts	86.5
Plot for 20 dB Bandwidth (MHz) Nominal Temp & Volts	12156-1 OBW (modified fixed)

FLOW Worst case (MHz)	24085.3
FHIGH Worst case (MHz)	24171.8

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 band of 24.0-24.25GHz are 24.0 & 31.2GHz.

Further wider span plots have been taken to 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:

<± 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 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 operated in TX1 and TX3 to TX5 modes. No difference in duty cycle was noted between modes therefore results for TX1 mode only are shown.

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 M.

5.9.4 Test equipment

E249, E627, TMS79

See Section 9 for more details

5.9.5 Test results

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

Band	24-24.25 GHz
Power Level	20 dBm (EIRP)
Channel Spacing	Single Channel
Mod Scheme	FMCW
Single channel	24.125 GHz

	Single channel
TX on time (ms)	0.29
TX on Plot filename	12156-1 on_time
TX repetition time (ms)	0.5
TX repetition Plot filename	12156-1 cycle_time
Calculated TX Duty cycle (%)	58

These results show that the duty cycle correction factor for peak to average emissions is therefore 20log(58/100) = - 4.7dB.

LIMITS:
Not applicable.

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.

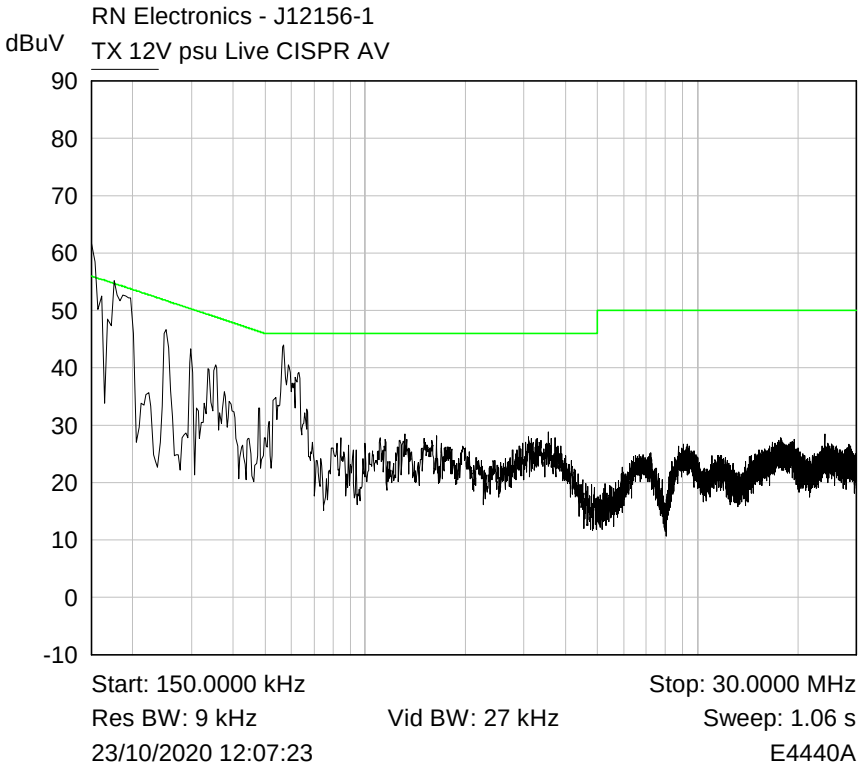
5.10 Frequency stability

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

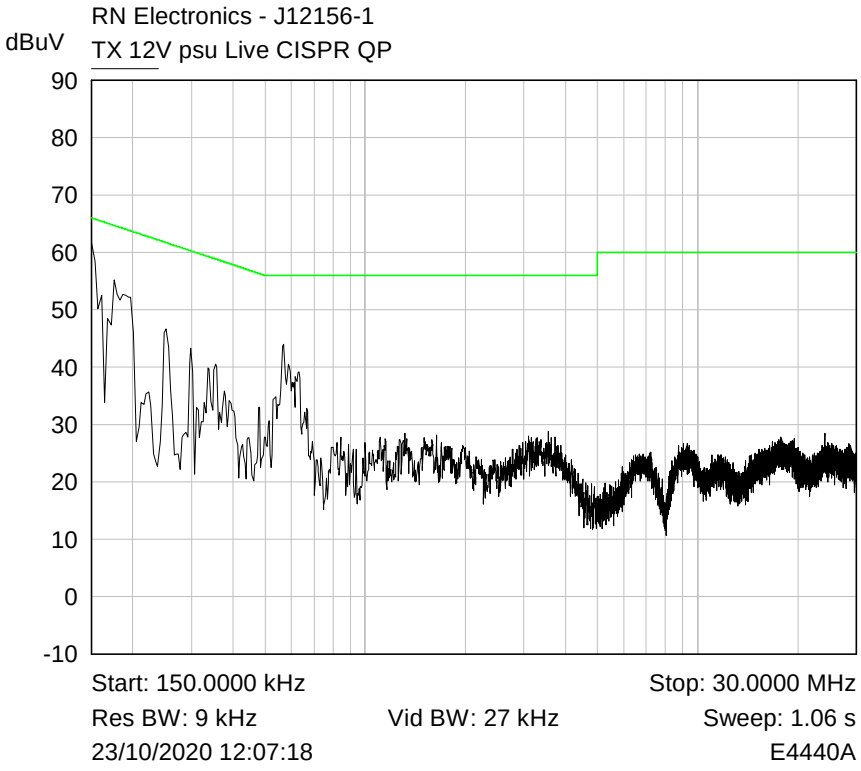
6 Plots/Graphical results

6.1 AC power line conducted emissions

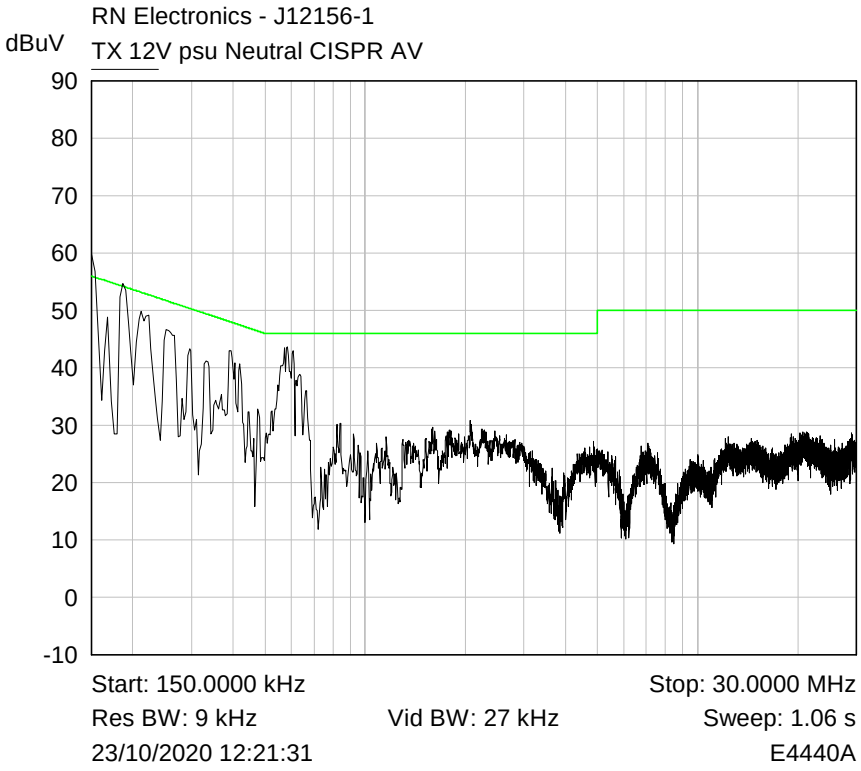
RF Parameters: Band 24-24.25 GHz, Power 20 dBm (EIRP), Channel Spacing Single Channel, Modulation FMCW, Channel 24.125 GHz (TX1 Cond 2)



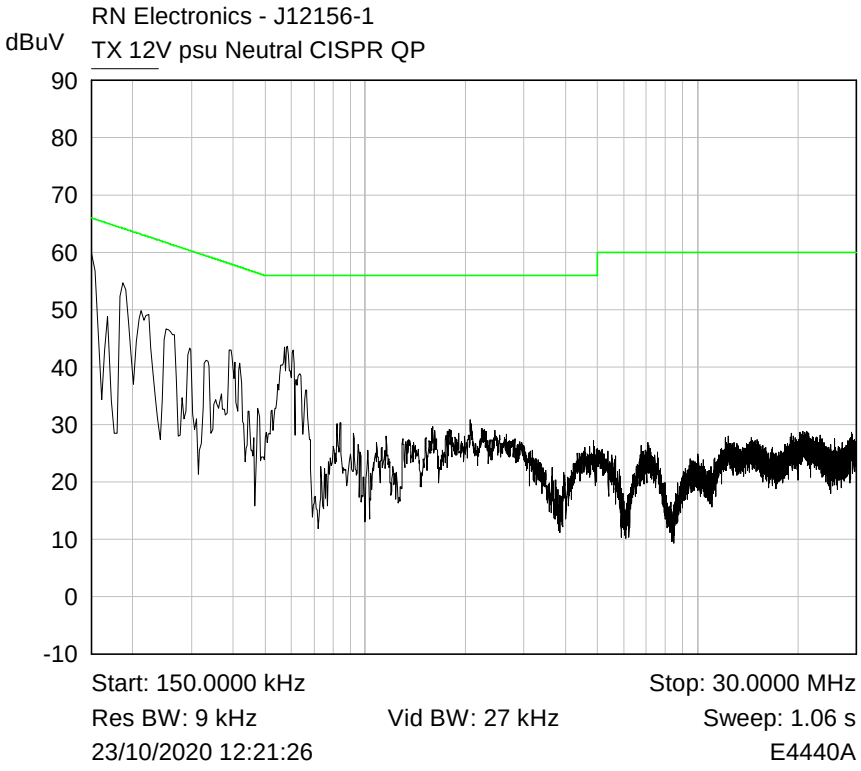
Plot of Live150k-30M Average



Plot of Live150k-30M Quasi-Peak

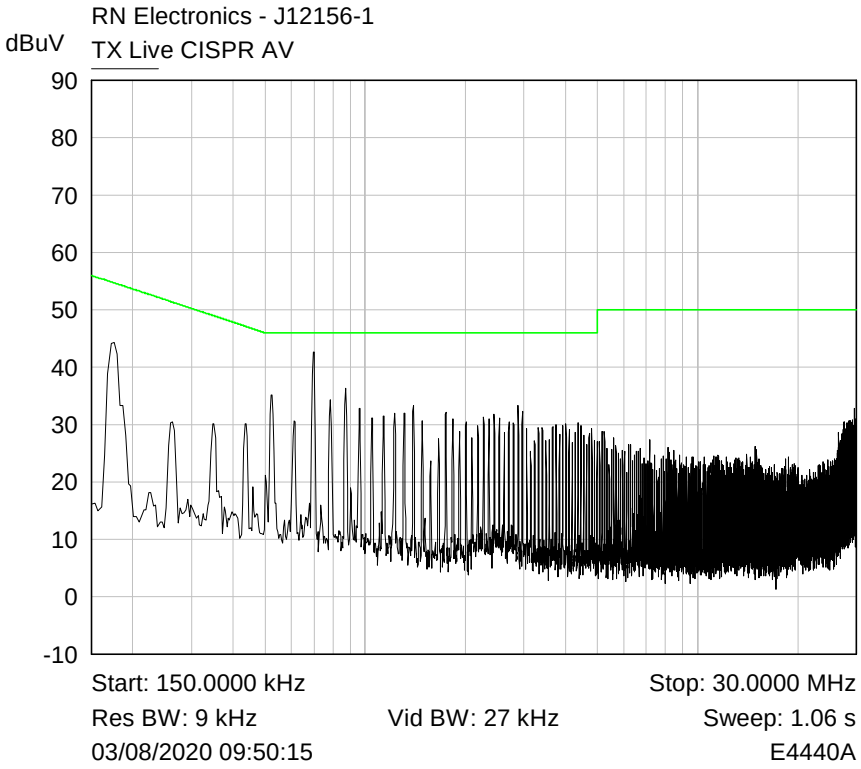


Plot of Neutral150k-30M Average

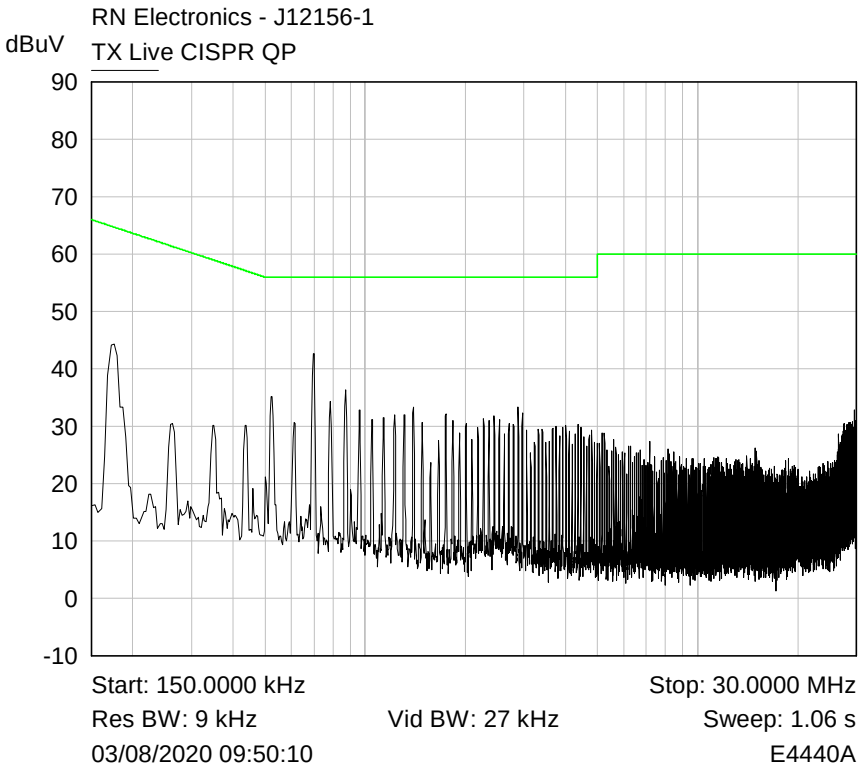


Plot of Neutral150k-30M Quasi-Peak

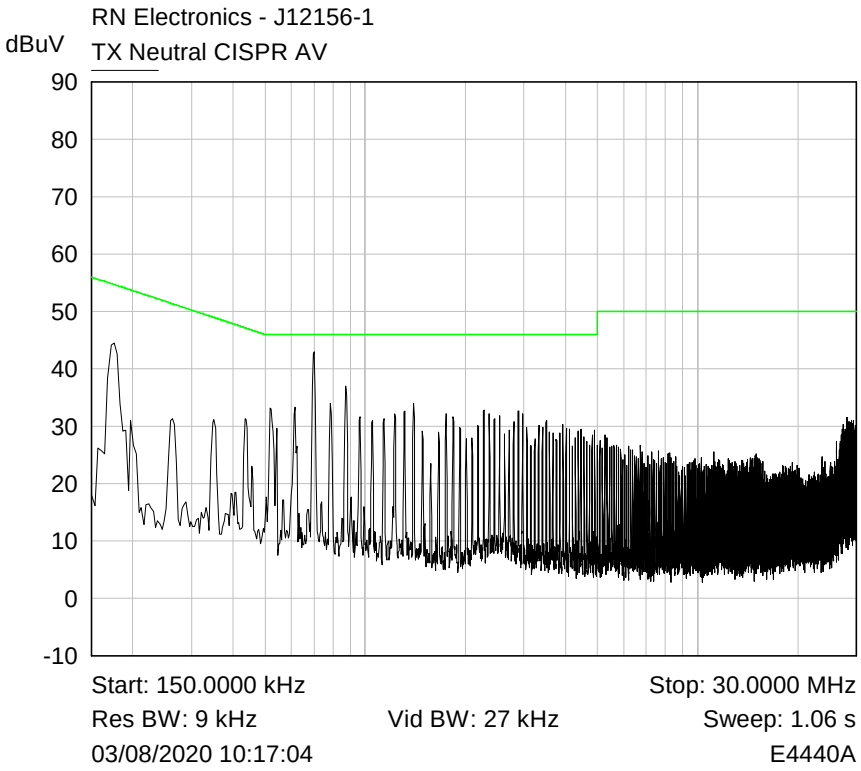
RF Parameters: Band 24-24.25 GHz, Power 20 dBm (EIRP), Channel Spacing Single Channel, Modulation FMCW, Channel 24.125 GHz (TX2 Cond 1)



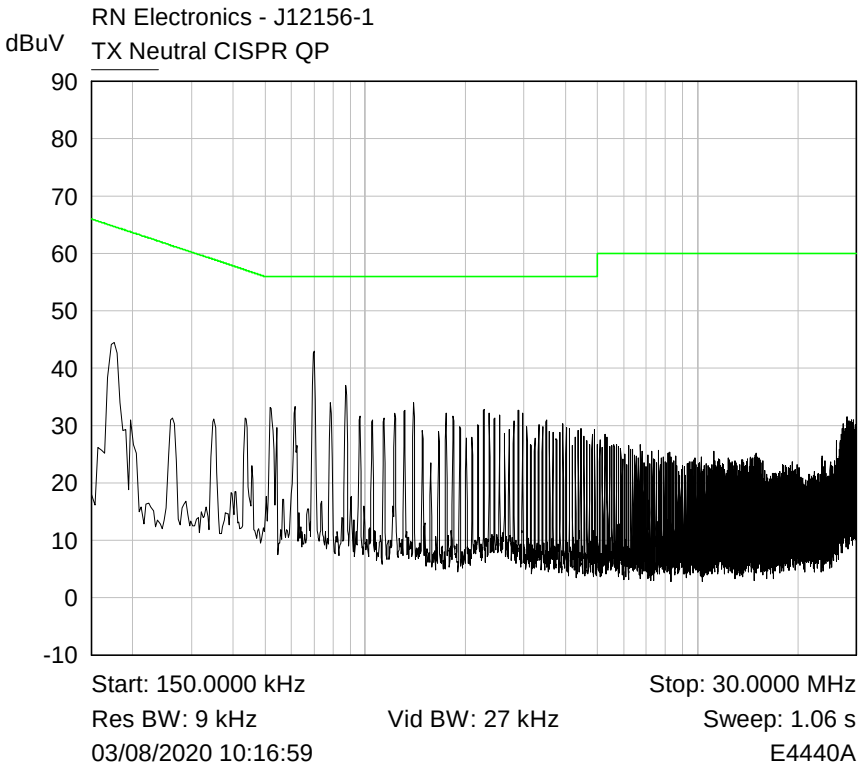
Plot of Live150k-30M Average



Plot of Live150k-30M Quasi-Peak



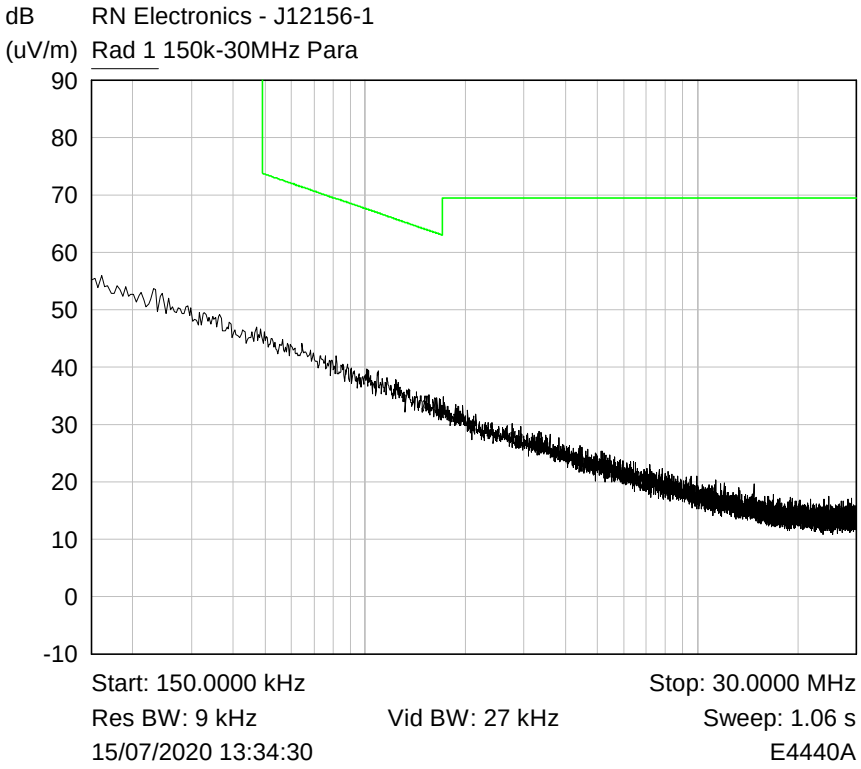
Plot of Neutral150k-30M Average



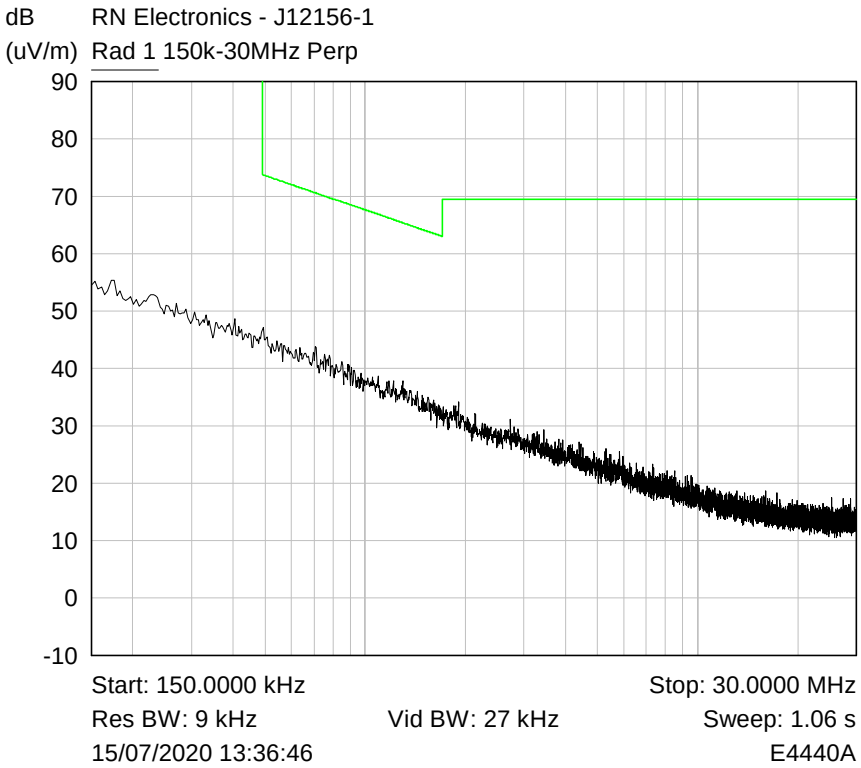
Plot of Neutral150k-30M Quasi-Peak

6.2 Radiated emissions 150 kHz - 30 MHz

RF Parameters: Band 24-24.25 GHz, Power 20 dBm (EIRP), Channel Spacing Single Channel, Modulation FMCW, Channel 24.125 GHz



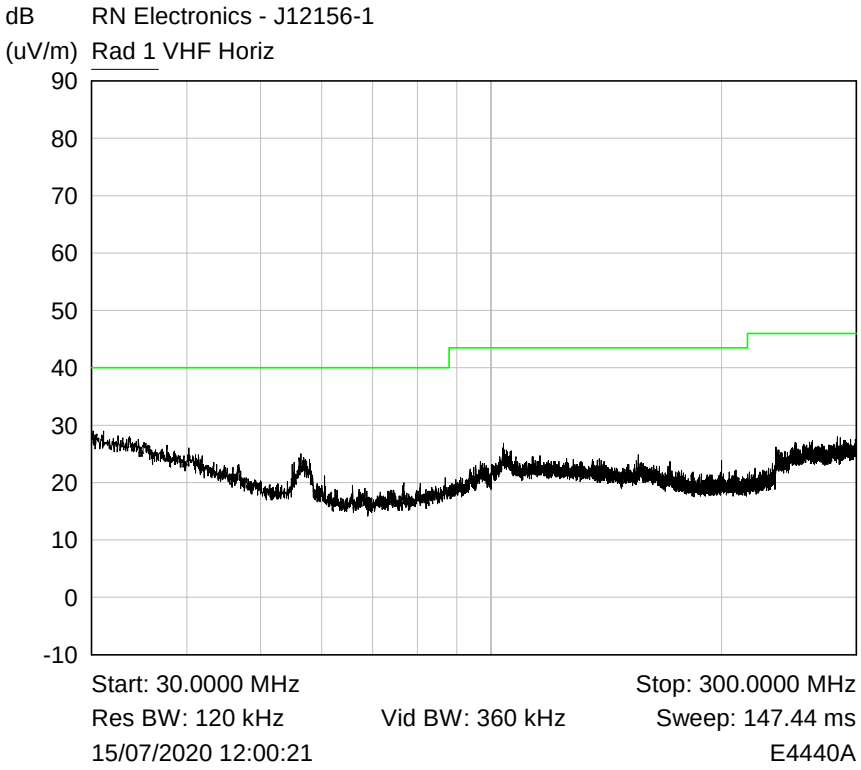
Plot of 150kHz-30MHz Parallel



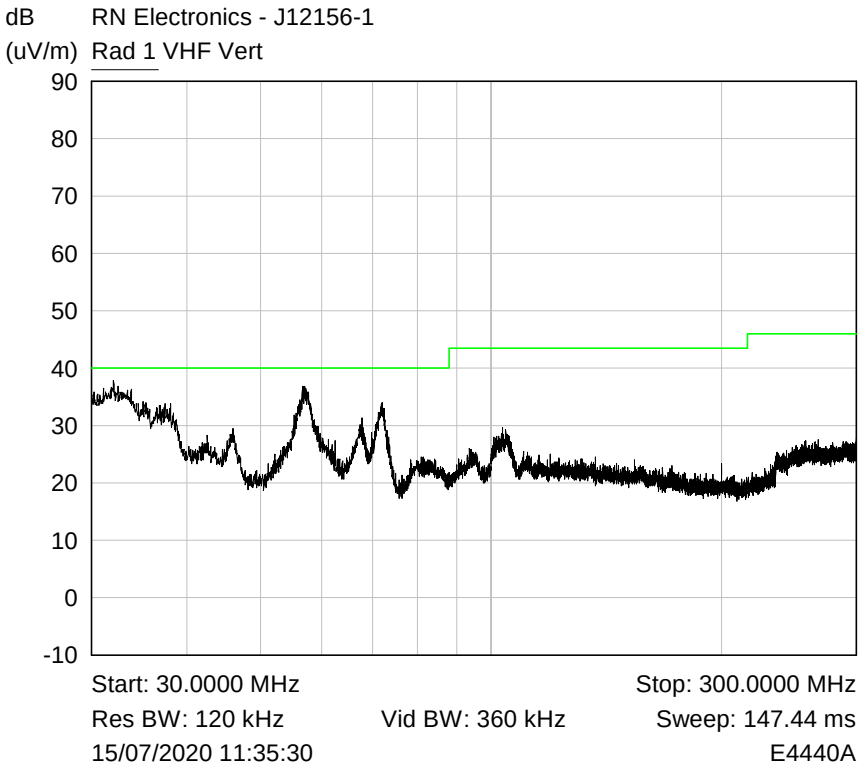
Plot of 150kHz-30MHz Perpendicular

6.3 Radiated emissions 30 MHz -1 GHz

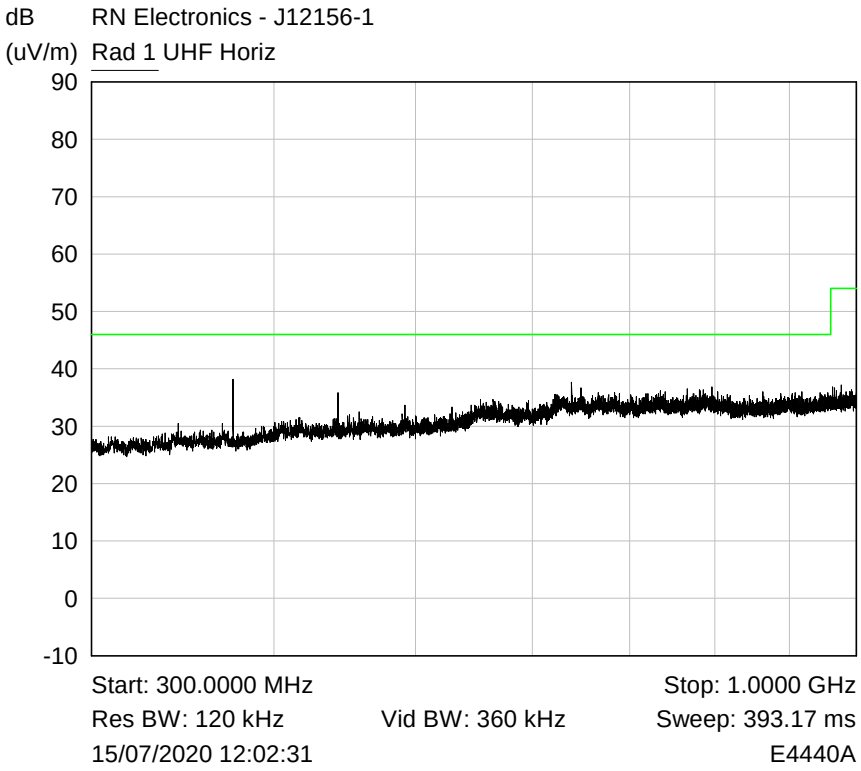
RF Parameters: Band 24-24.25 GHz, Power 20 dBm (EIRP), Channel Spacing Single Channel, Modulation FMCW, Channel 24.125 GHz



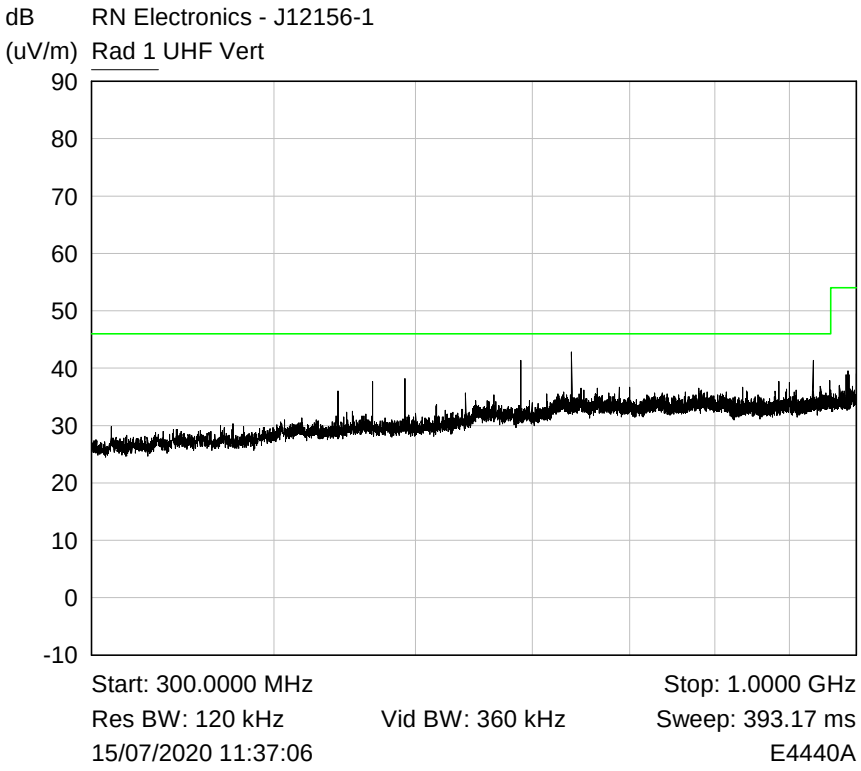
Plot of Peak emissions for VHF Horizontal against the QP limit line.



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



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

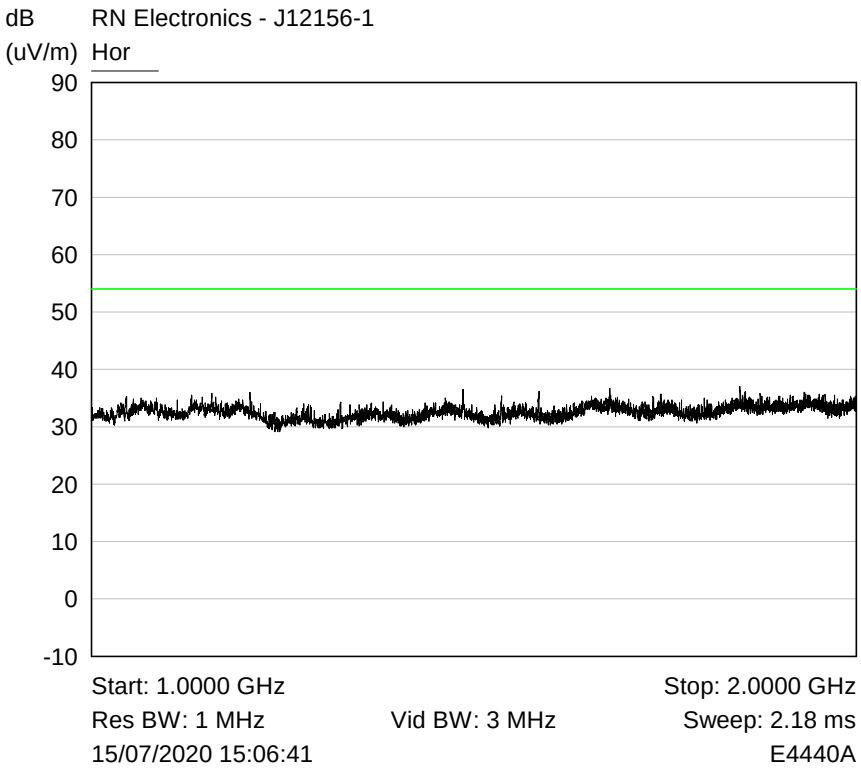


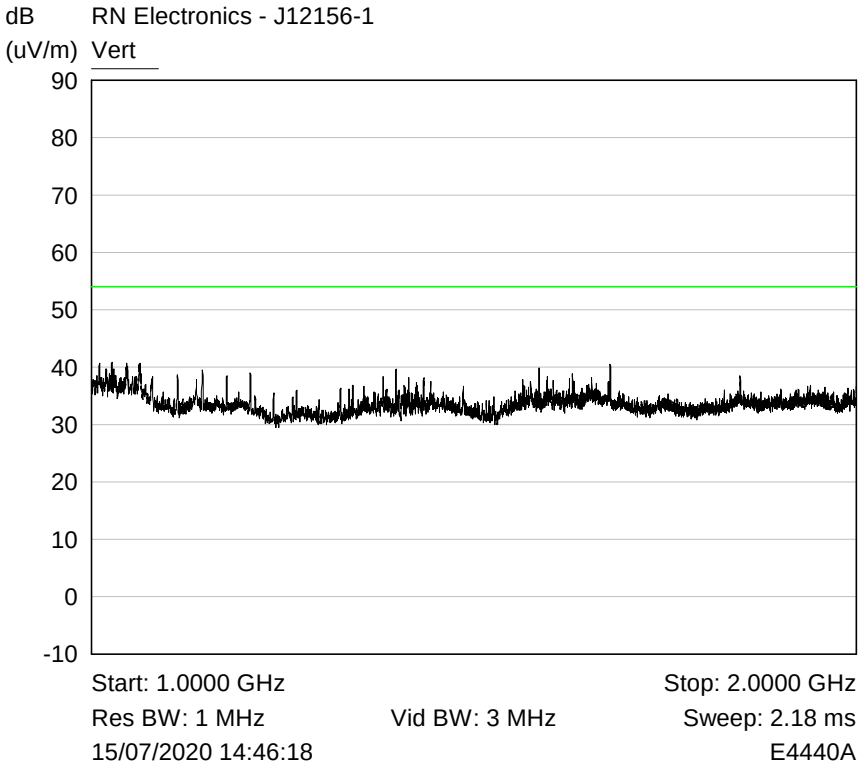
Plot of Peak emissions for UHF Vertical against the QP limit line.

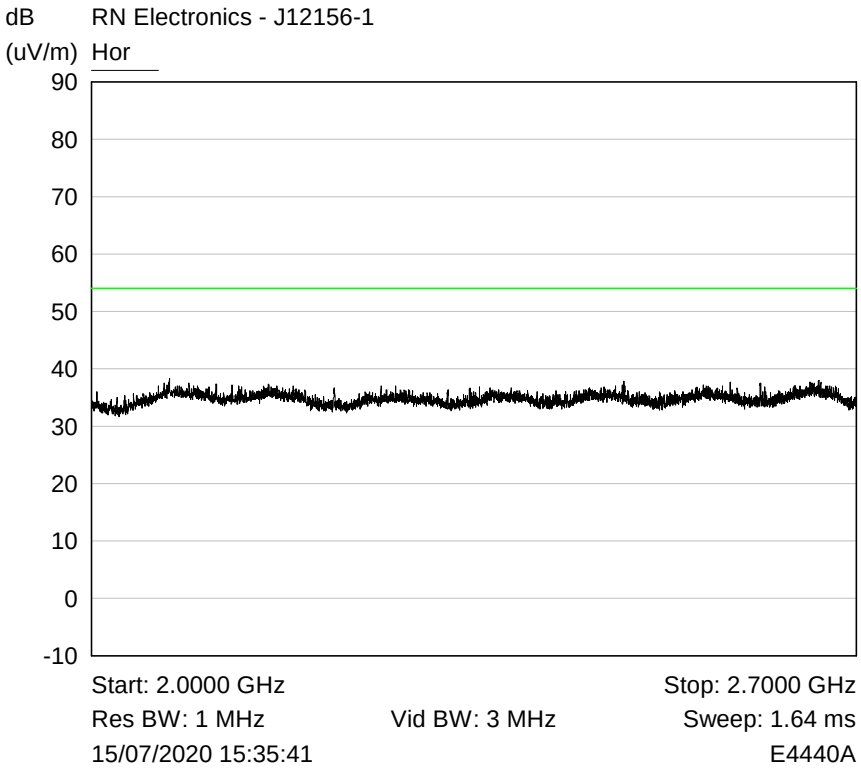
6.4 Radiated emissions above 1 GHz

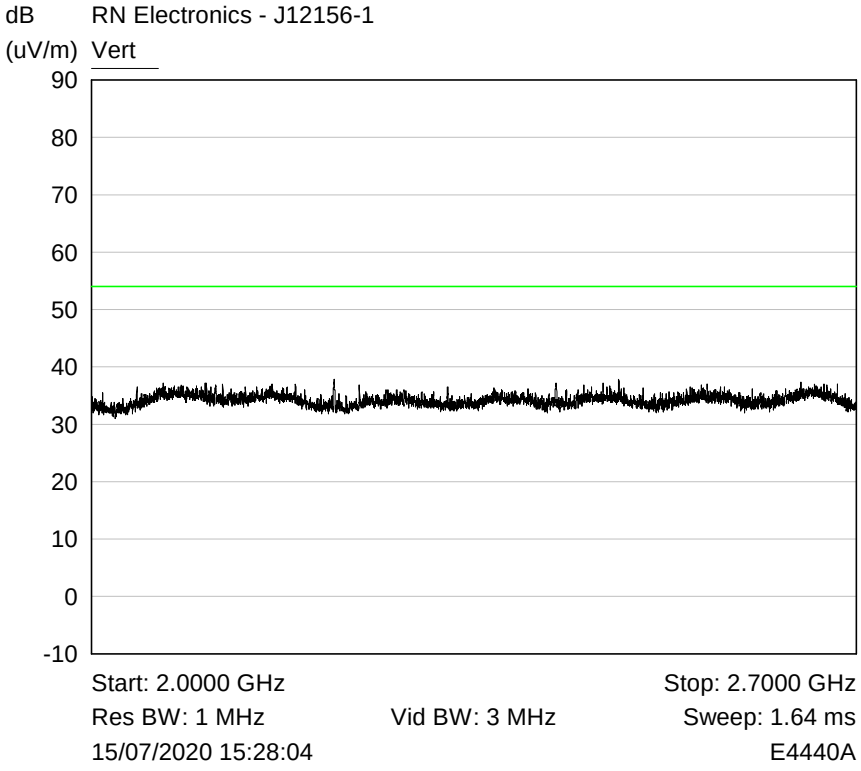
RF Parameters: Band 24-24.25 GHz, Power 20 dBm (EIRP), Channel Spacing Single Channel, Modulation CW, Channel 24.129 GHz

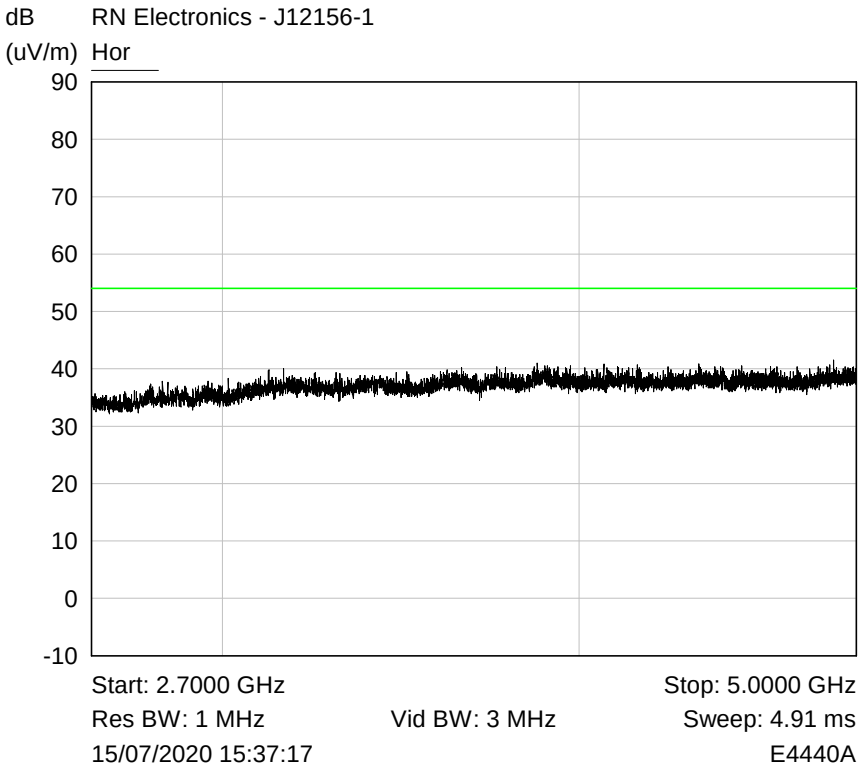
Note: Middle channel plots shown only, to minimise report size.

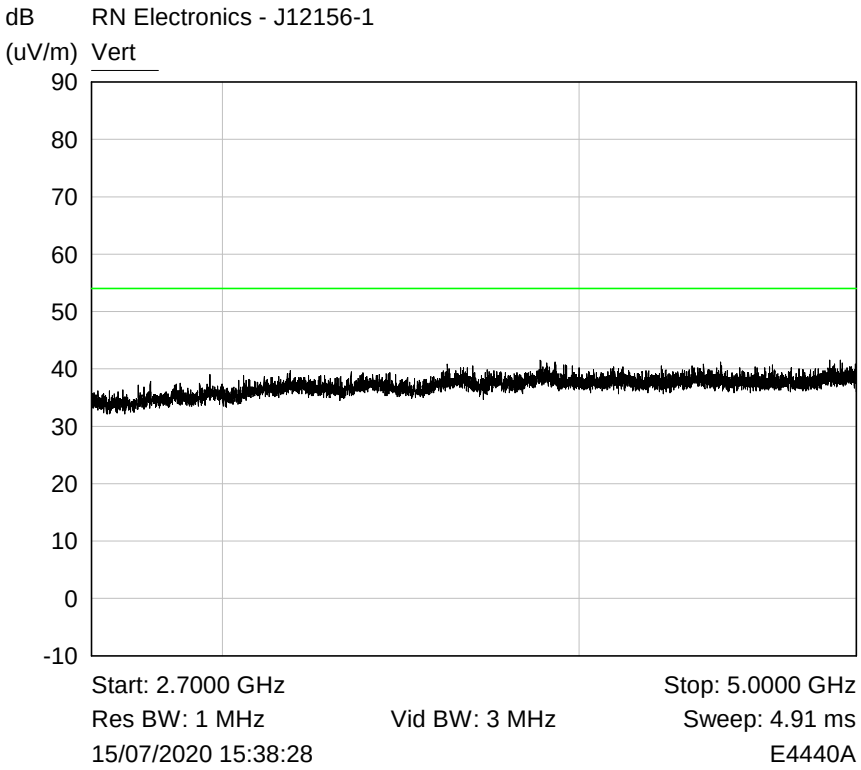


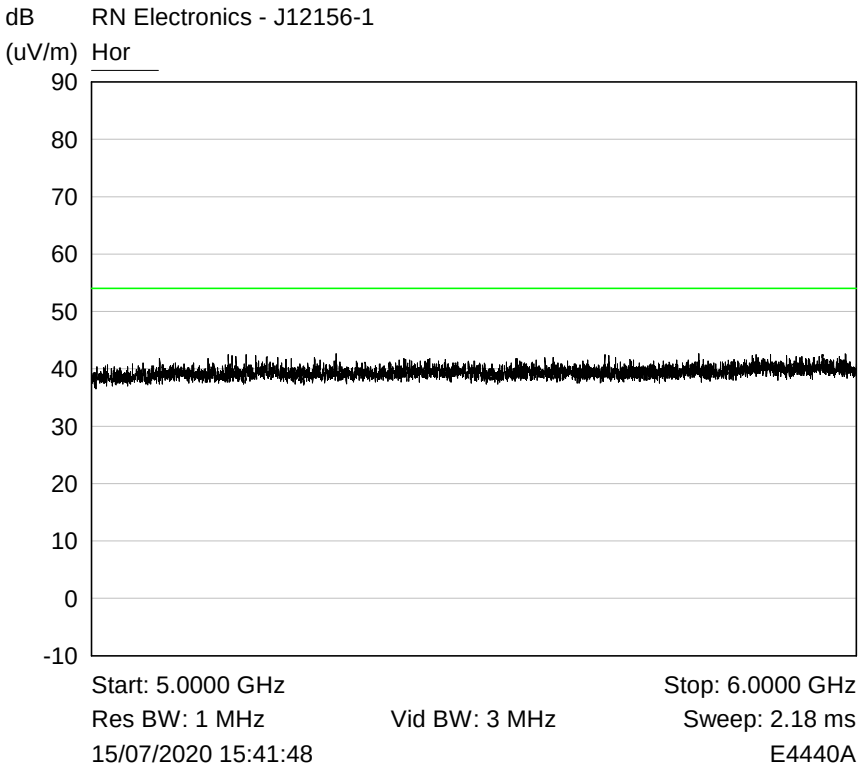


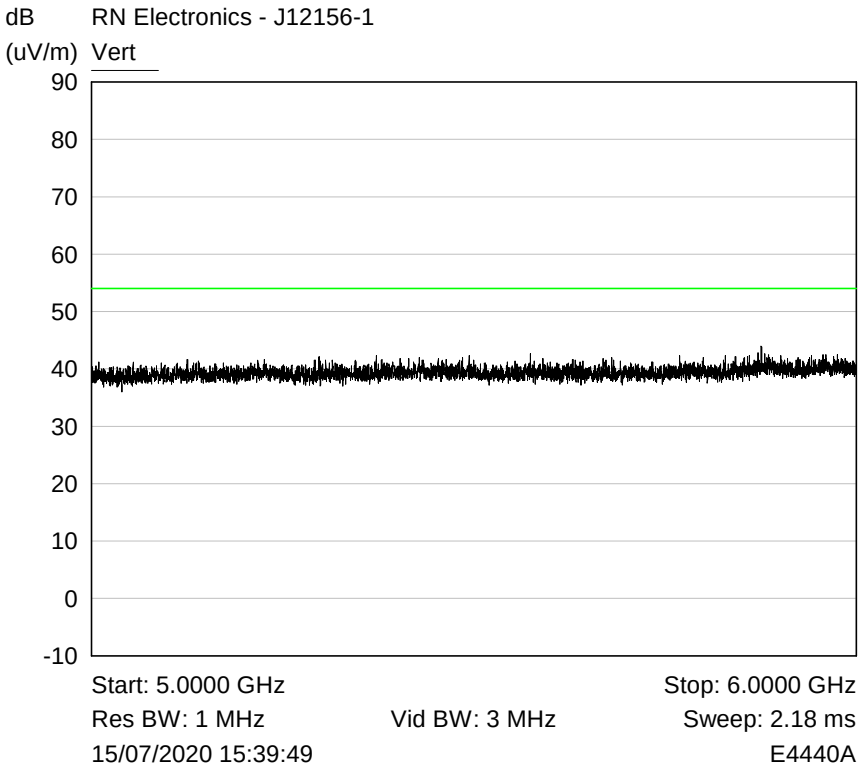

dB
(uV/m)
RN Electronics - J12156-1
Hor
90
80
70
60
50
40
30
20
10
0
-10
Start: 2.0000 GHz
Stop: 2.7000 GHz
Res BW: 1 MHz
Vid BW: 3 MHz
Sweep: 1.64 ms
15/07/2020 15:35:41
E4440A

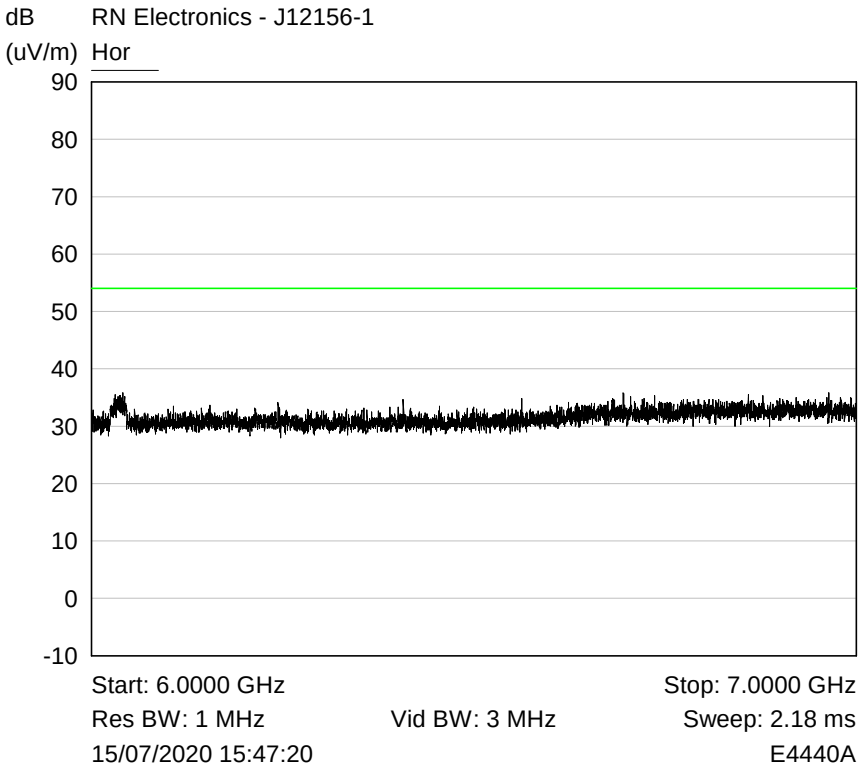

dB
(uV/m)
RN Electronics - J12156-1
Vert
90
80
70
60
50
40
30
20
10
0
-10
Start: 2.0000 GHz
Stop: 2.7000 GHz
Res BW: 1 MHz
Vid BW: 3 MHz
Sweep: 1.64 ms
15/07/2020 15:28:04
E4440A

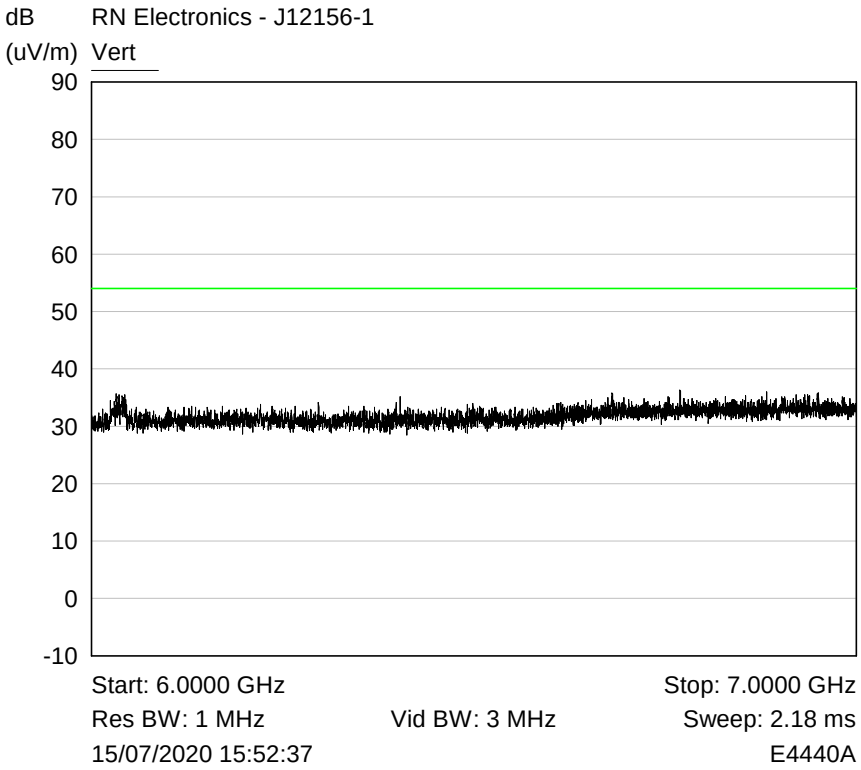


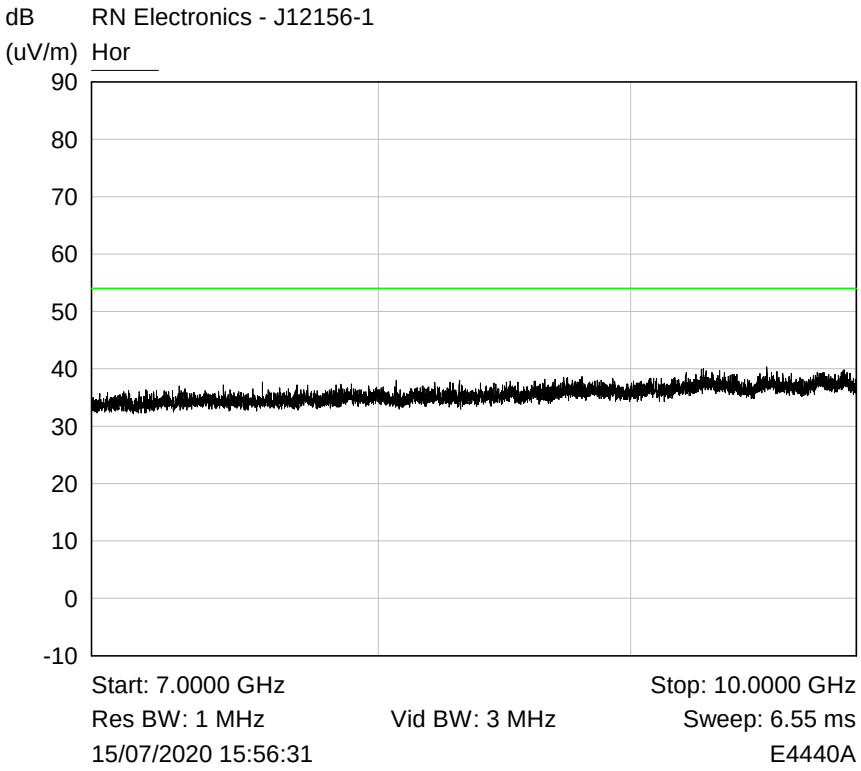


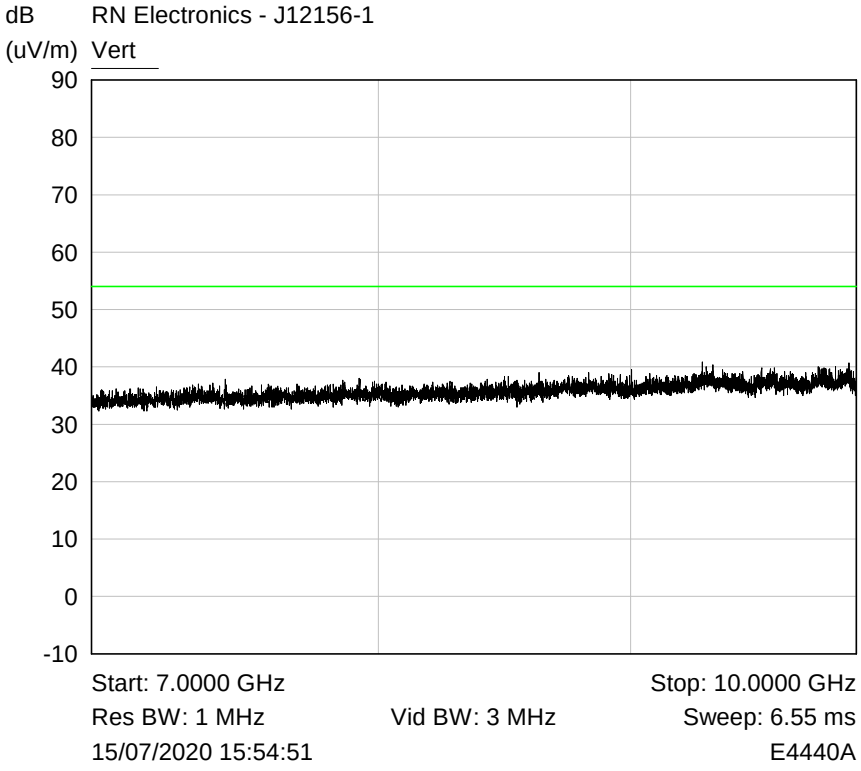

dB
(uV/m)
RN Electronics - J12156-1
Hor
90
80
70
60
50
40
30
20
10
0
-10
Start: 5.0000 GHz
Stop: 6.0000 GHz
Res BW: 1 MHz
Vid BW: 3 MHz
Sweep: 2.18 ms
15/07/2020 15:41:48
E4440A

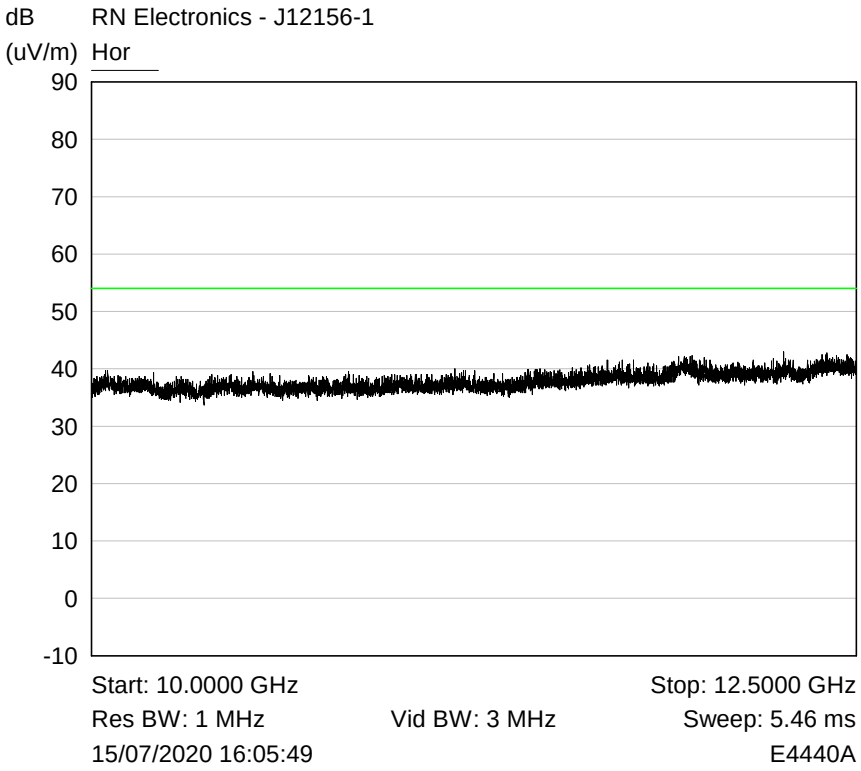

dB
(uV/m)
RN Electronics - J12156-1
Vert
90
80
70
60
50
40
30
20
10
0
-10
Start: 5.0000 GHz
Stop: 6.0000 GHz
Res BW: 1 MHz
Vid BW: 3 MHz
Sweep: 2.18 ms
15/07/2020 15:39:49
E4440A

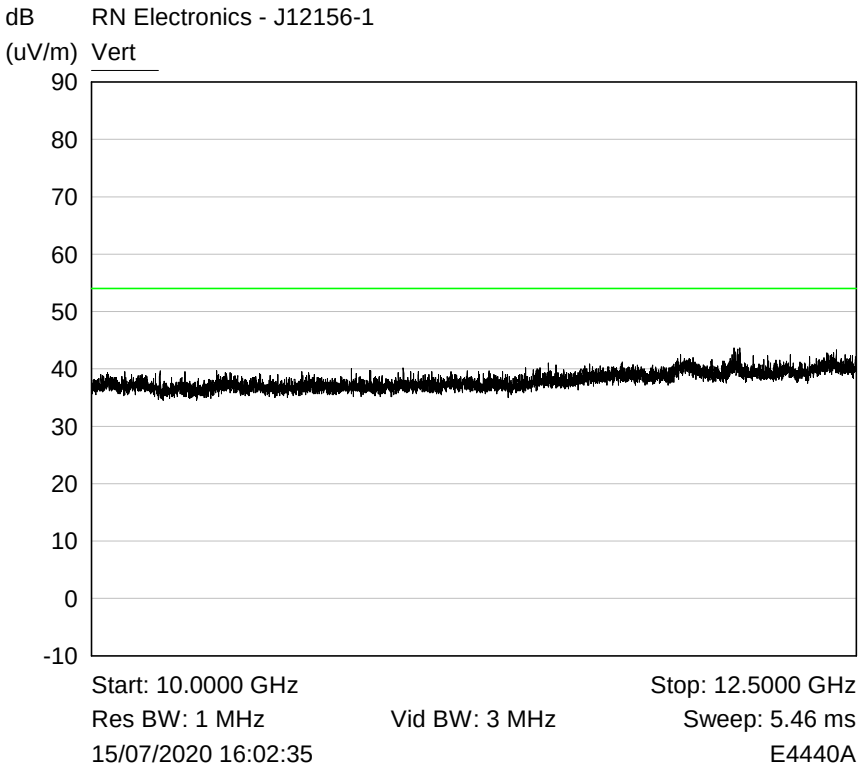


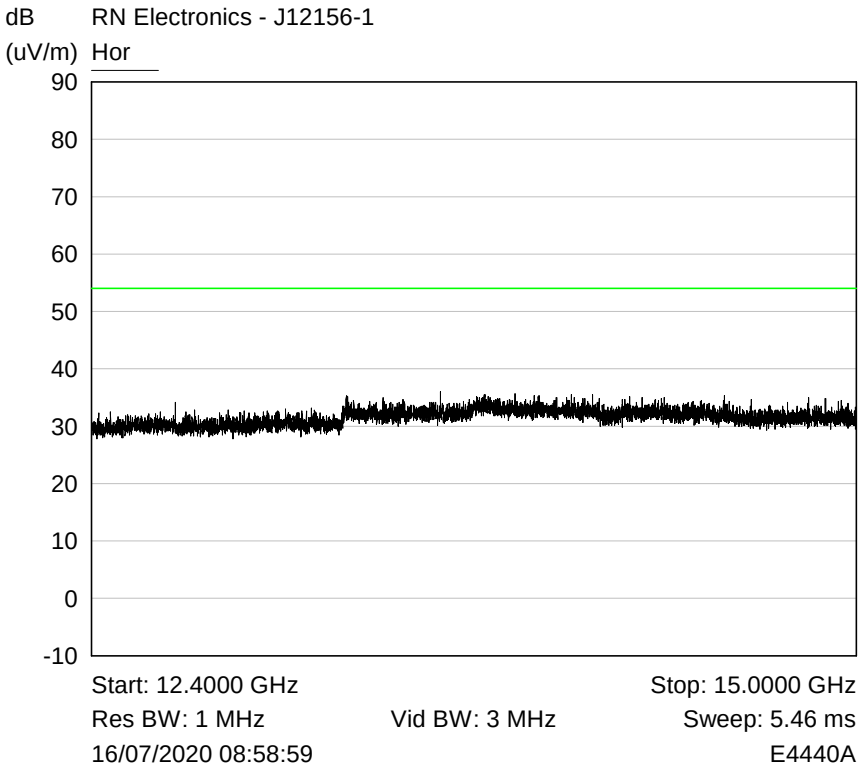


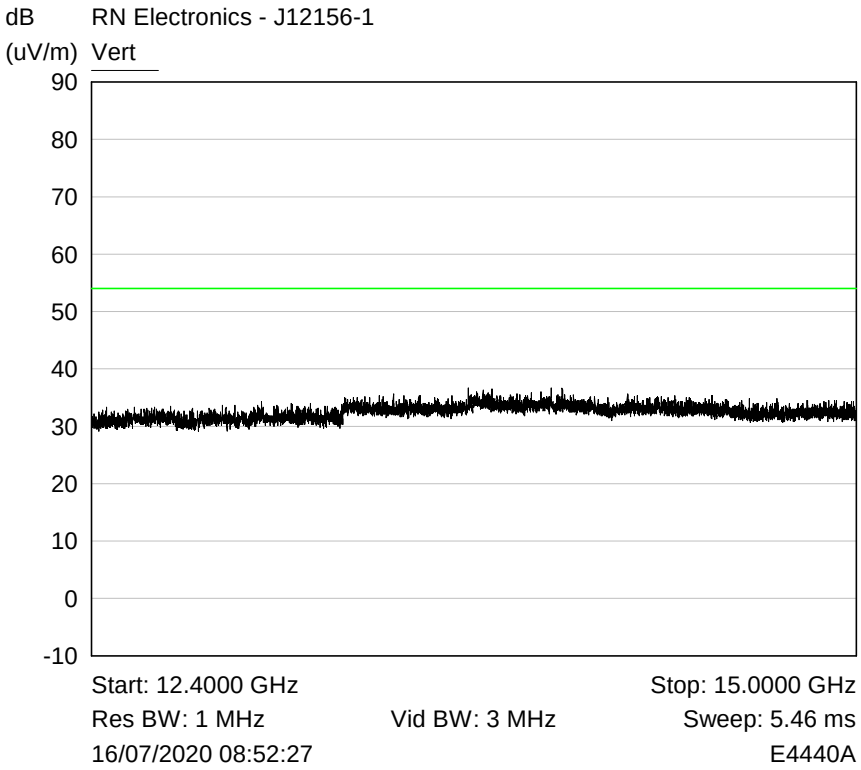


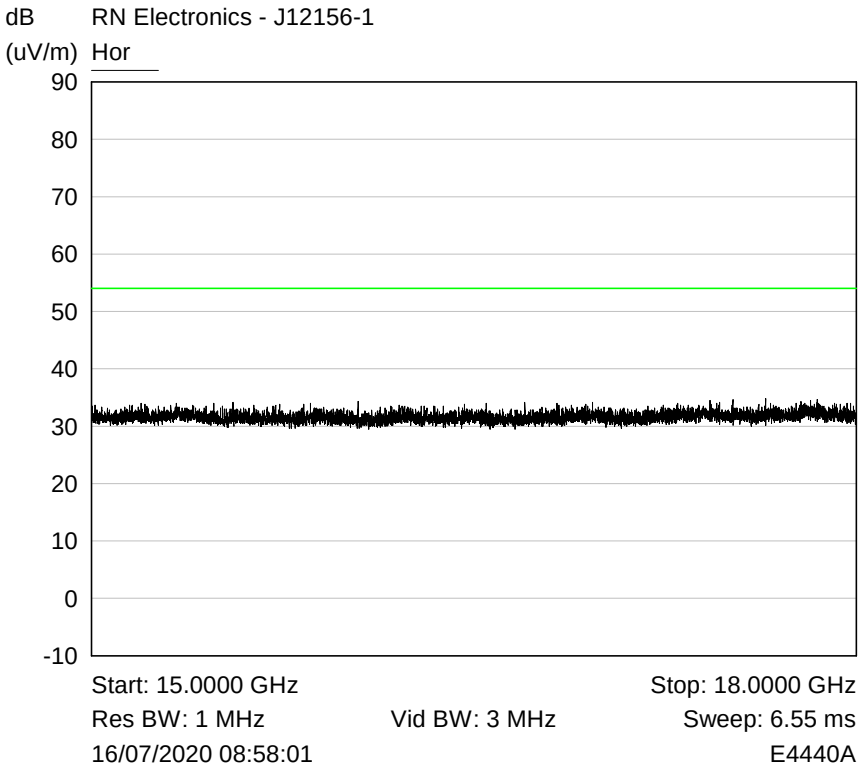


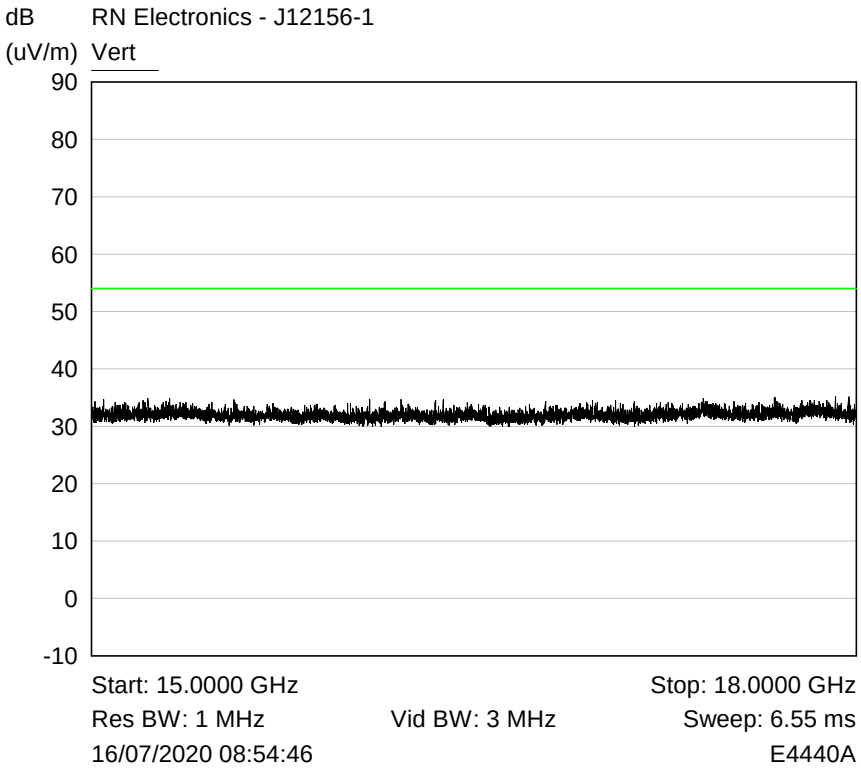

dB
(uV/m)
RN Electronics - J12156-1
Hor
90
80
70
60
50
40
30
20
10
0
-10
Start: 10.0000 GHz
Stop: 12.5000 GHz
Res BW: 1 MHz
Vid BW: 3 MHz
Sweep: 5.46 ms
15/07/2020 16:05:49
E4440A

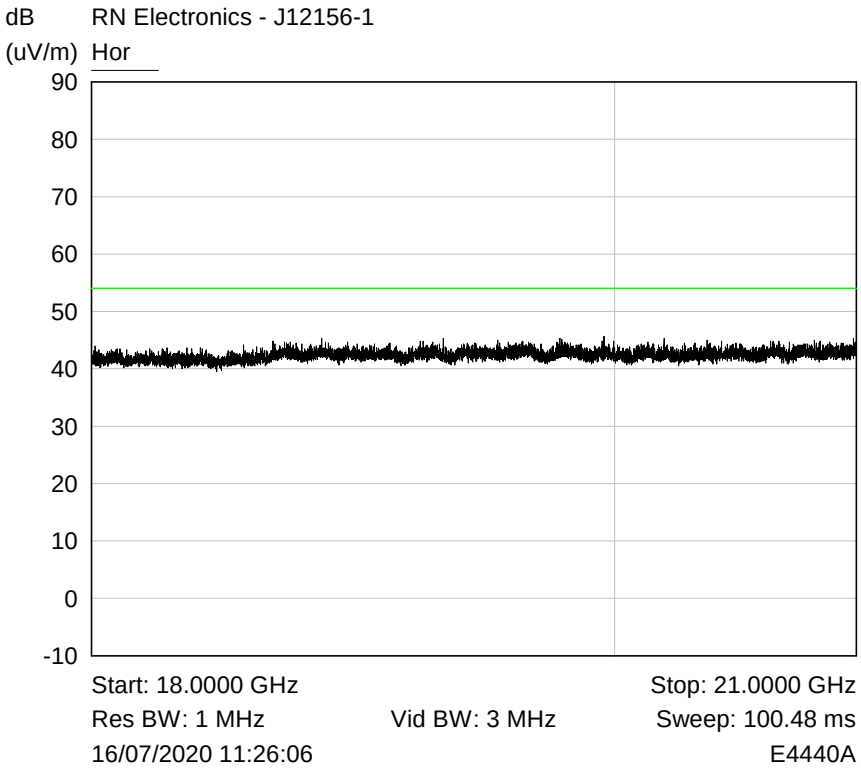

dB
(uV/m)
RN Electronics - J12156-1
Vert
90
80
70
60
50
40
30
20
10
0
-10
Start: 10.0000 GHz
Stop: 12.5000 GHz
Res BW: 1 MHz
Vid BW: 3 MHz
Sweep: 5.46 ms
15/07/2020 16:02:35
E4440A

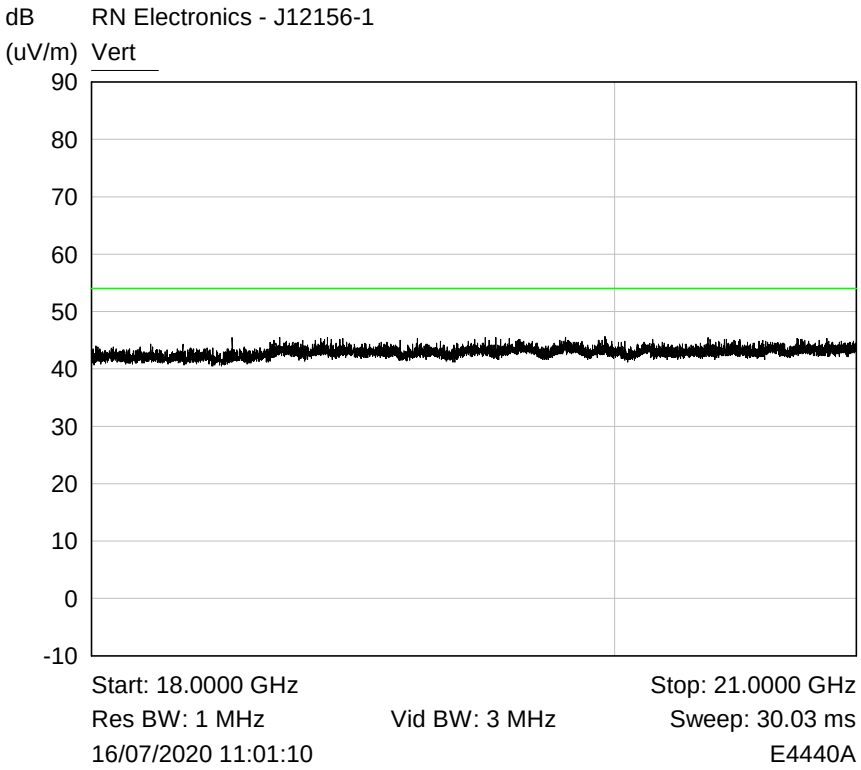


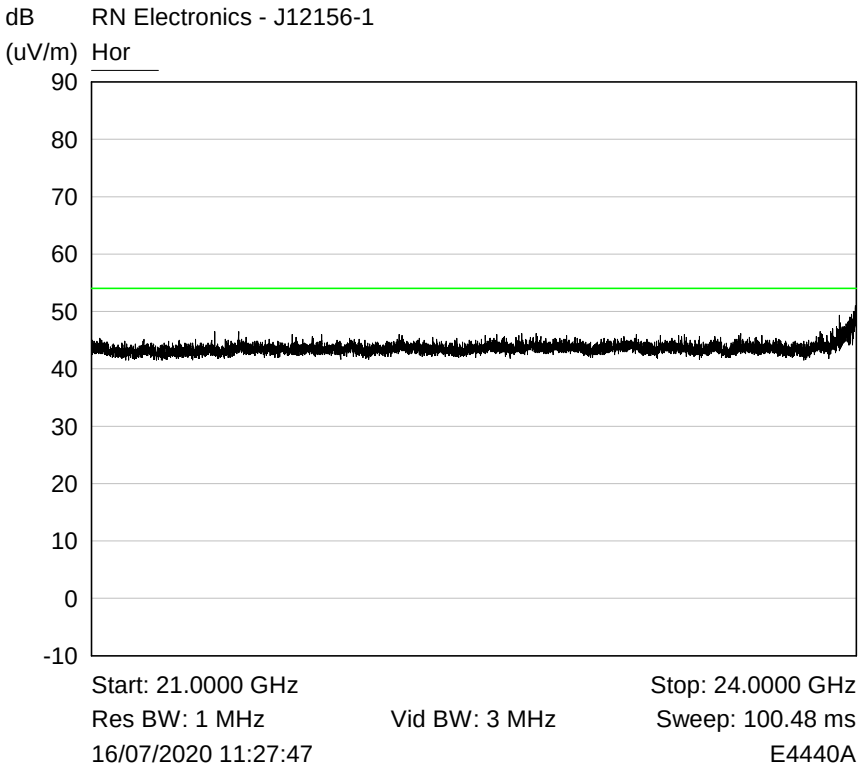


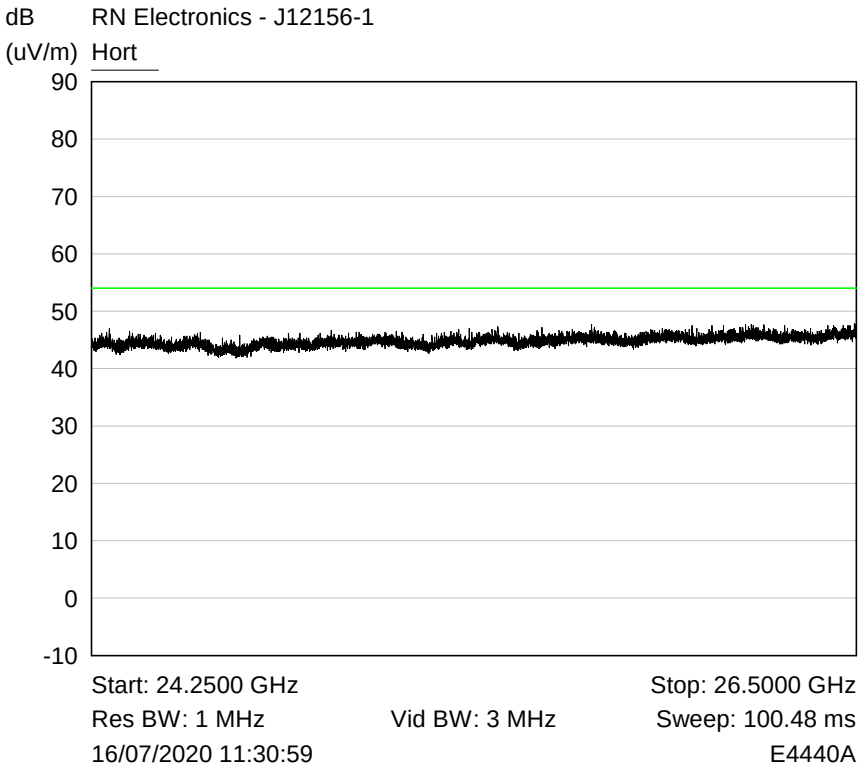


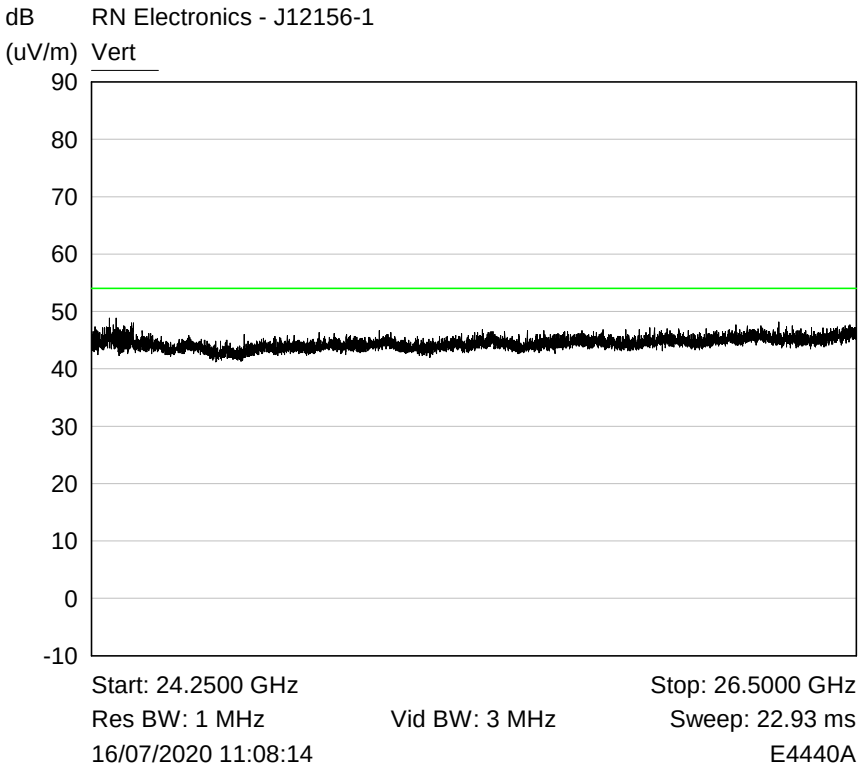


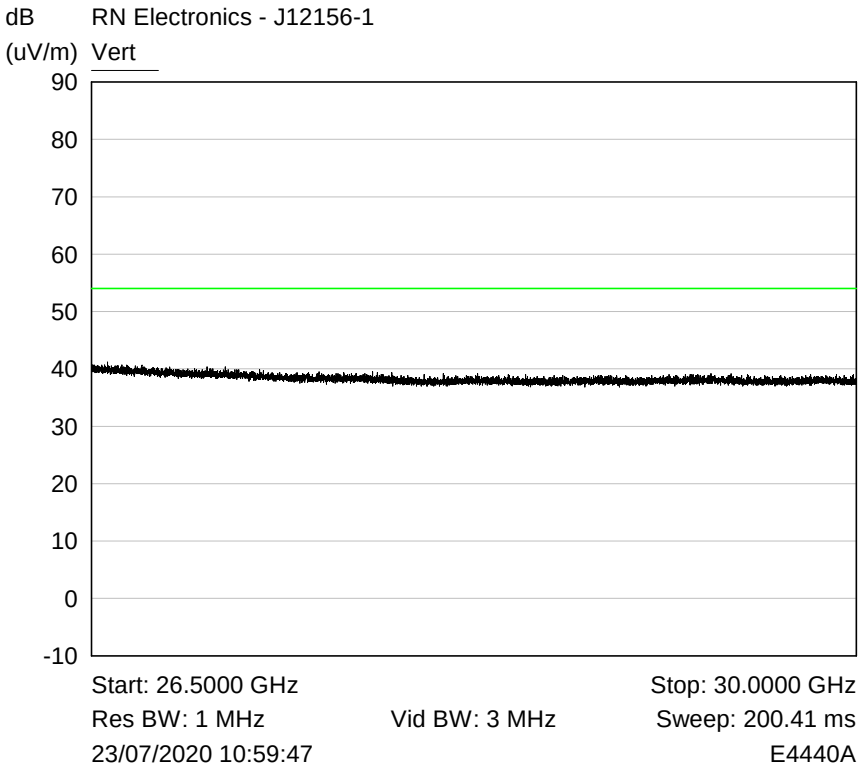


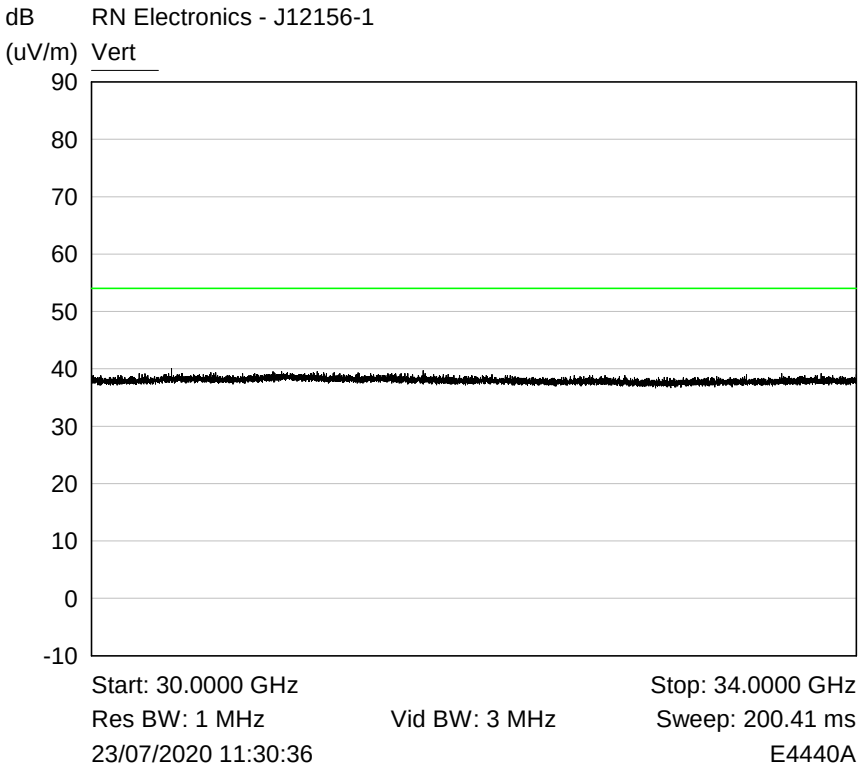


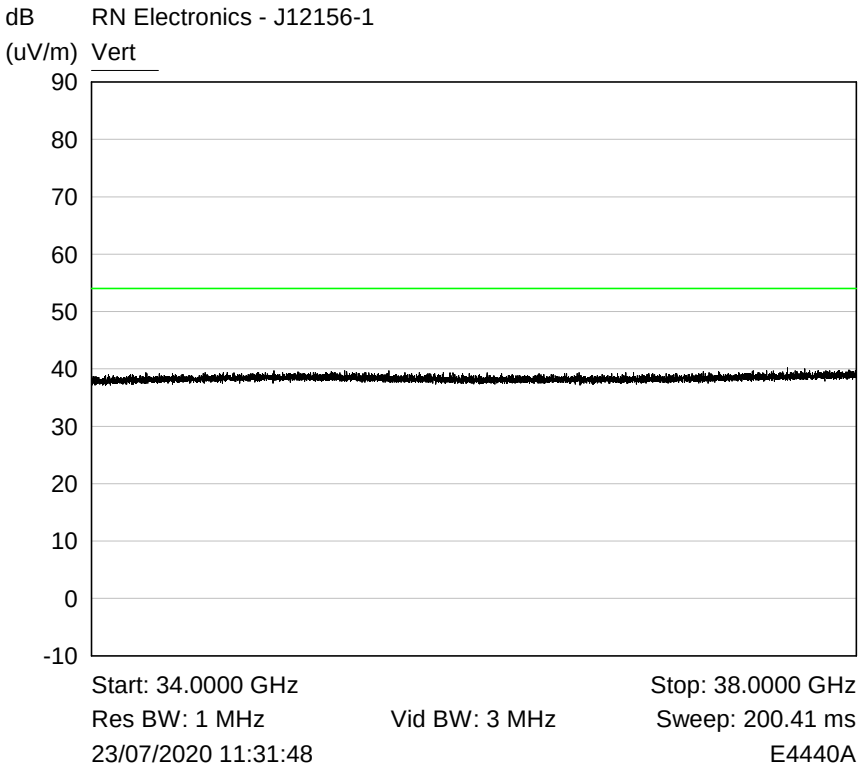

dB
(uV/m)
RN Electronics - J12156-1
Hor
90
80
70
60
50
40
30
20
10
0
-10
Start: 21.0000 GHz
Stop: 24.0000 GHz
Res BW: 1 MHz
Vid BW: 3 MHz
Sweep: 100.48 ms
16/07/2020 11:27:47
E4440A

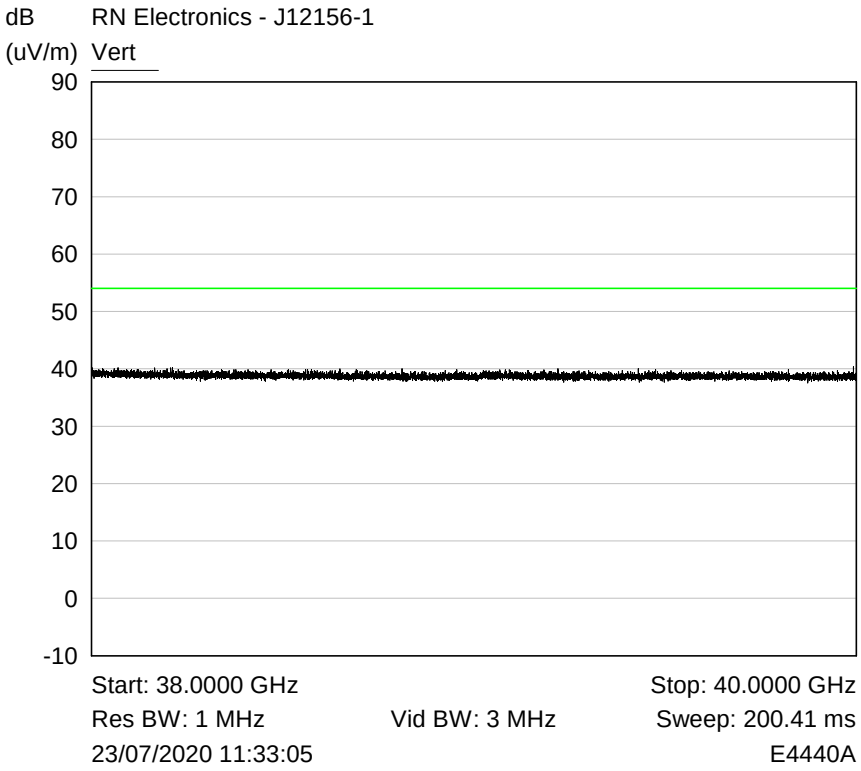

dB
(uV/m)
RN Electronics - J12156-1
Hort
90
80
70
60
50
40
30
20
10
0
-10
Start: 24.2500 GHz
Stop: 26.5000 GHz
Res BW: 1 MHz
Vid BW: 3 MHz
Sweep: 100.48 ms
16/07/2020 11:30:59
E4440A

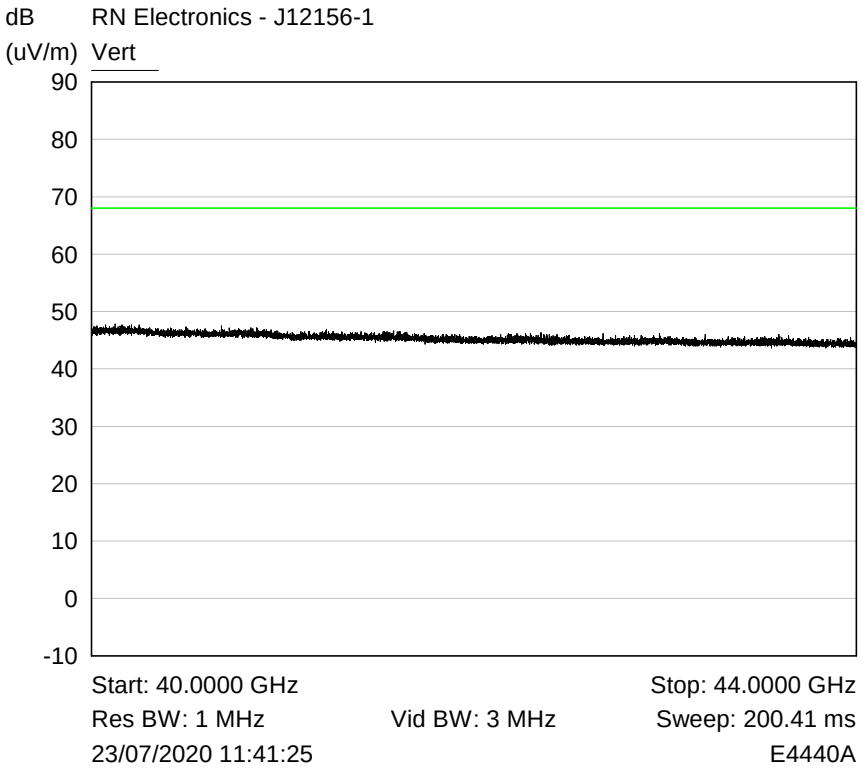


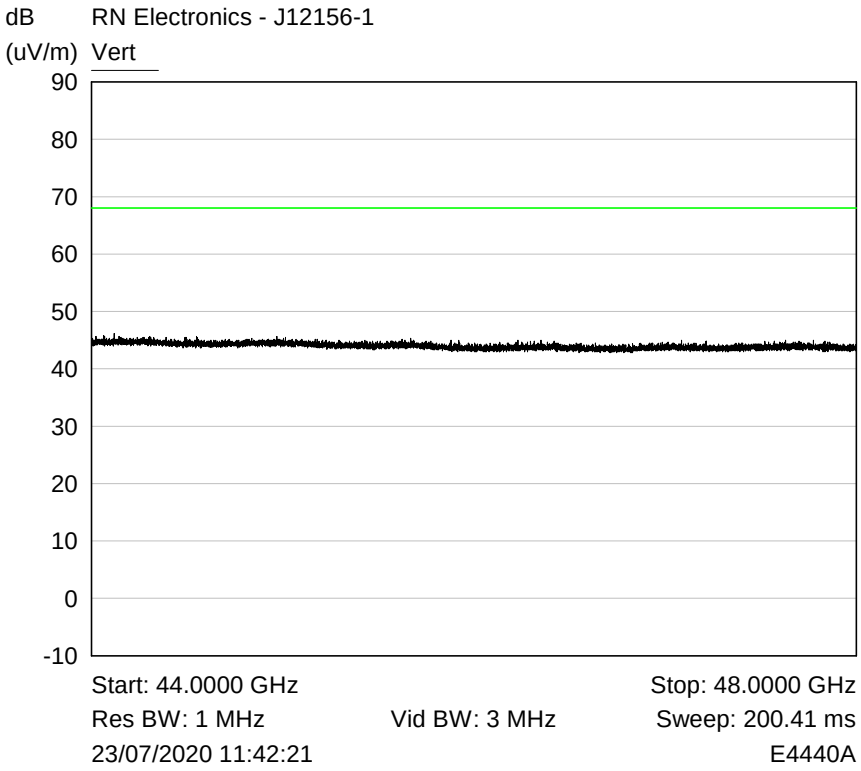


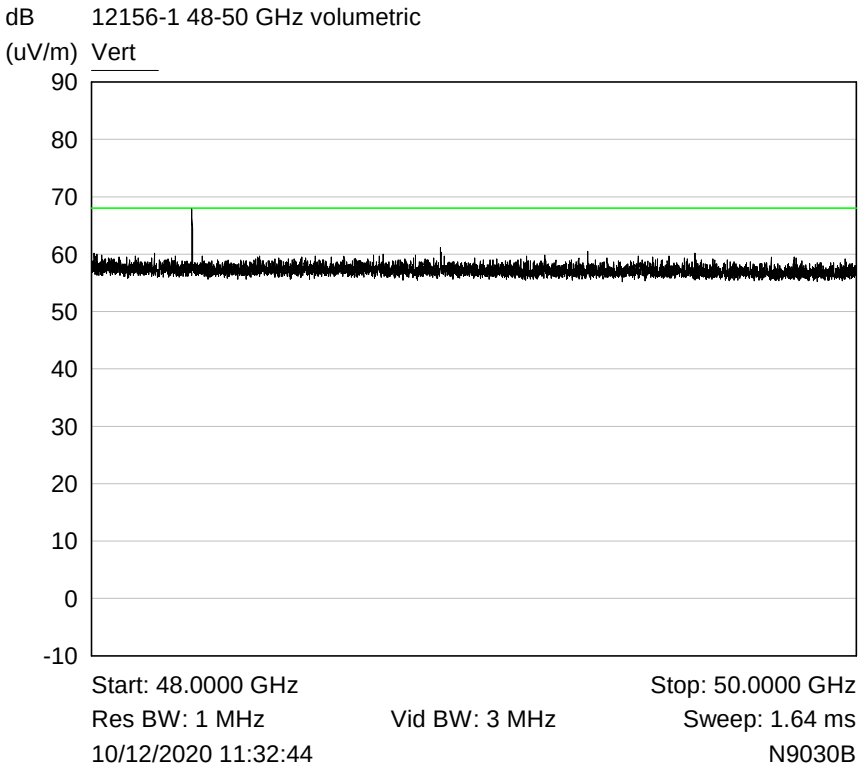


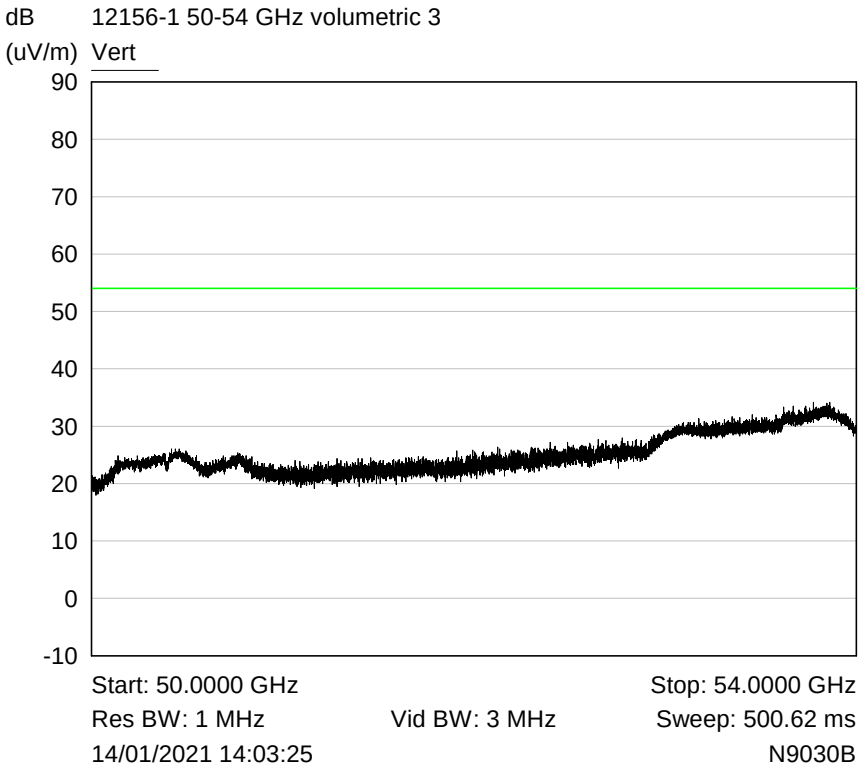


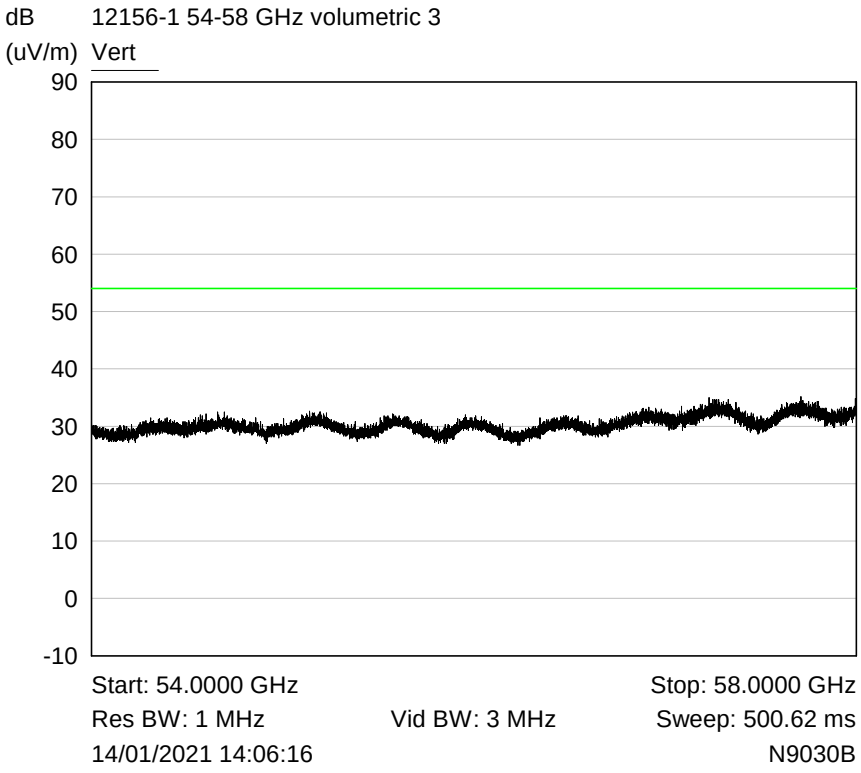


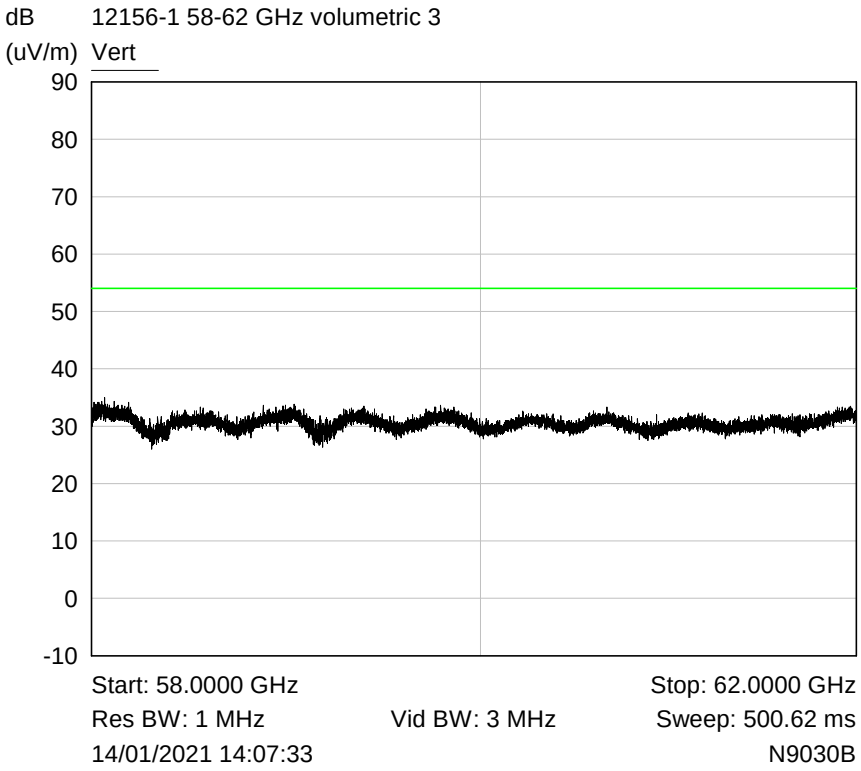


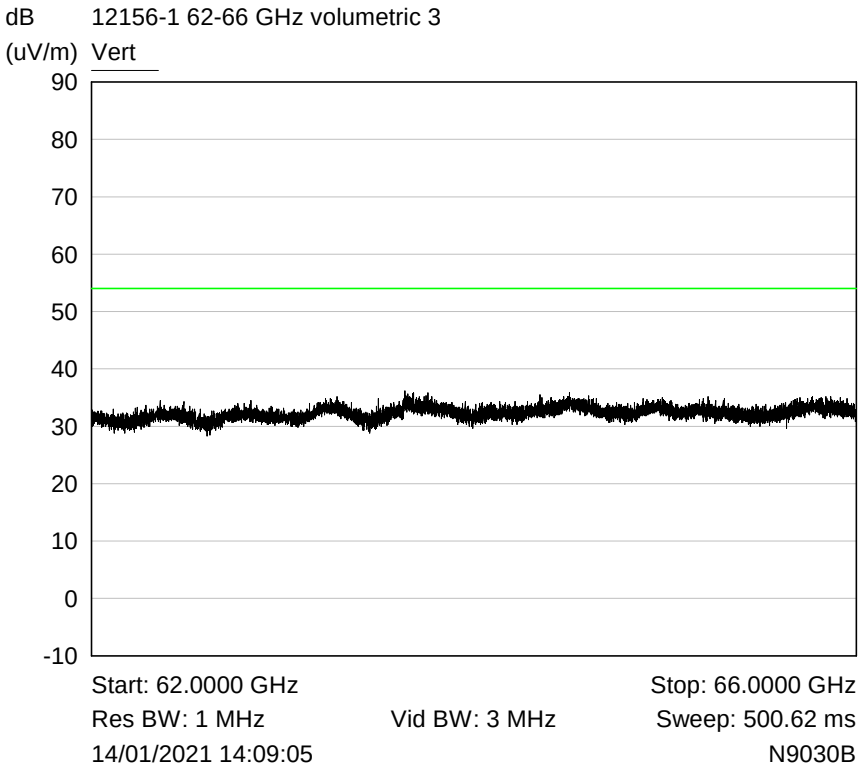


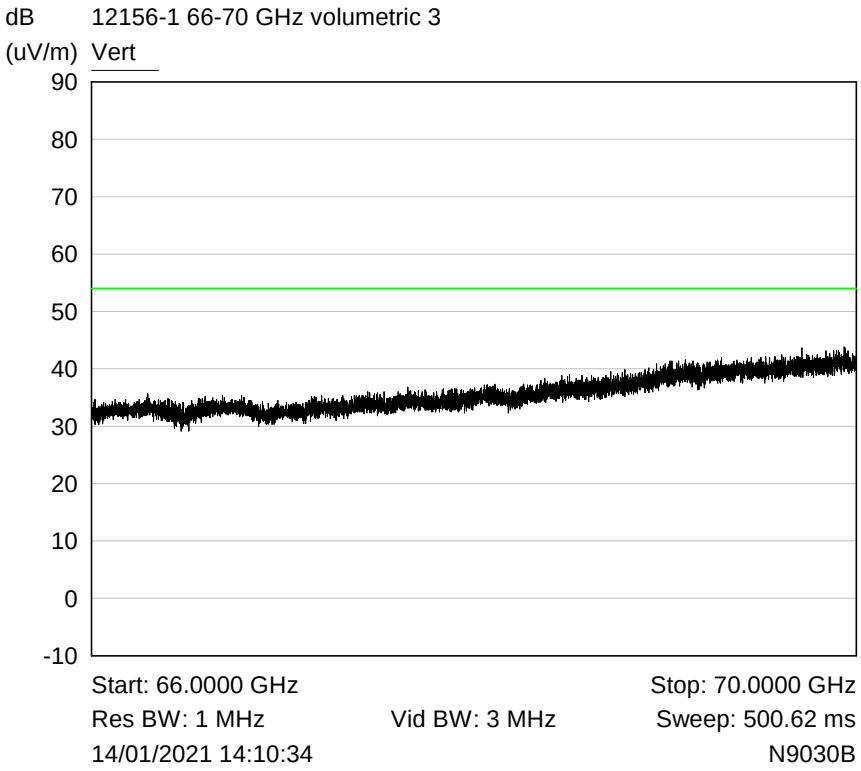


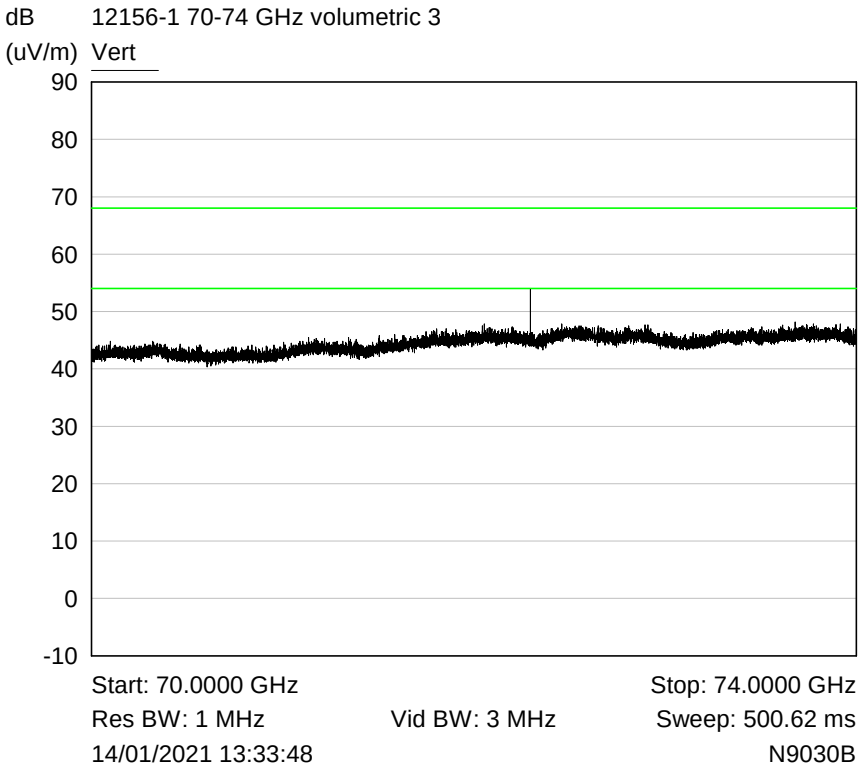

dB
(uV/m)
12156-1 50-54 GHz volumetric 3
Vert
90
80
70
60
50
40
30
20
10
0
-10
Start: 50.0000 GHz
Stop: 54.0000 GHz
Res BW: 1 MHz
Vid BW: 3 MHz
Sweep: 500.62 ms
14/01/2021 14:03:25
N9030B

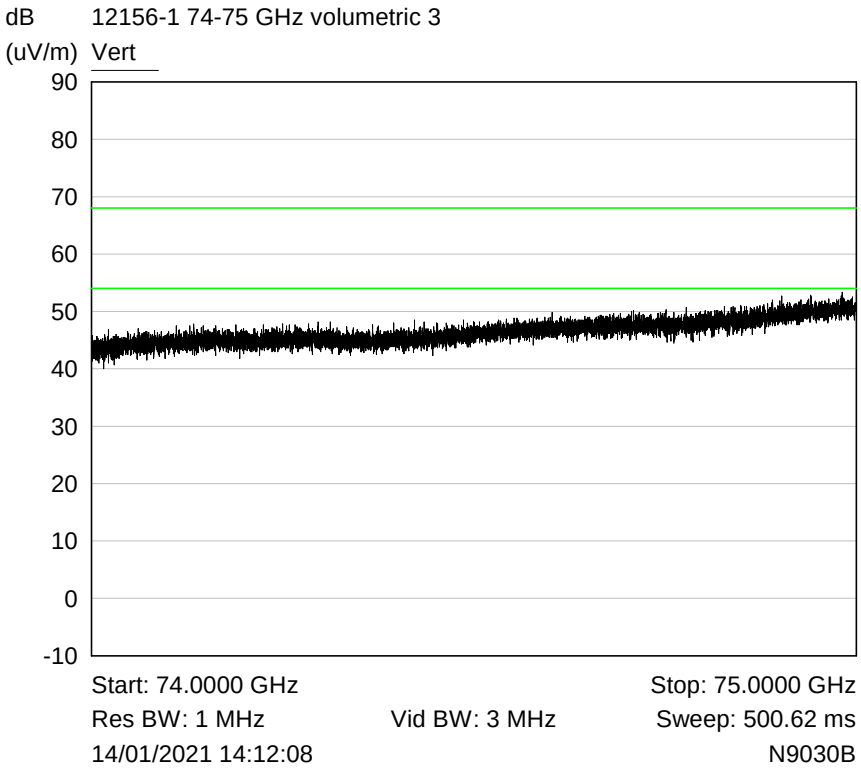

dB
(uV/m)
12156-1 54-58 GHz volumetric 3
Vert
90
80
70
60
50
40
30
20
10
0
-10
Start: 54.0000 GHz
Stop: 58.0000 GHz
Res BW: 1 MHz
Vid BW: 3 MHz
Sweep: 500.62 ms
14/01/2021 14:06:16
N9030B

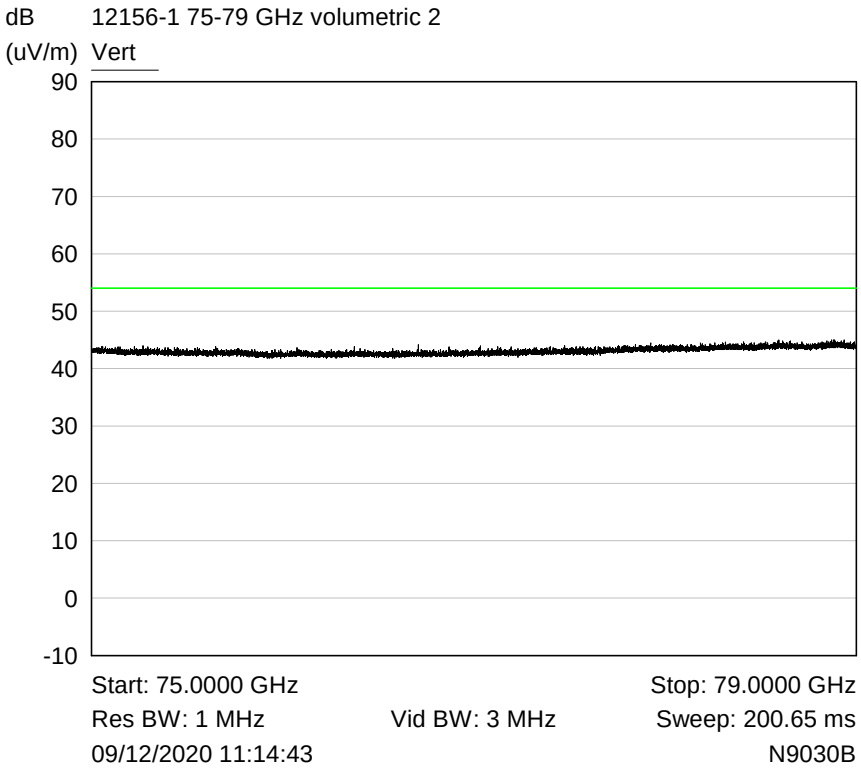


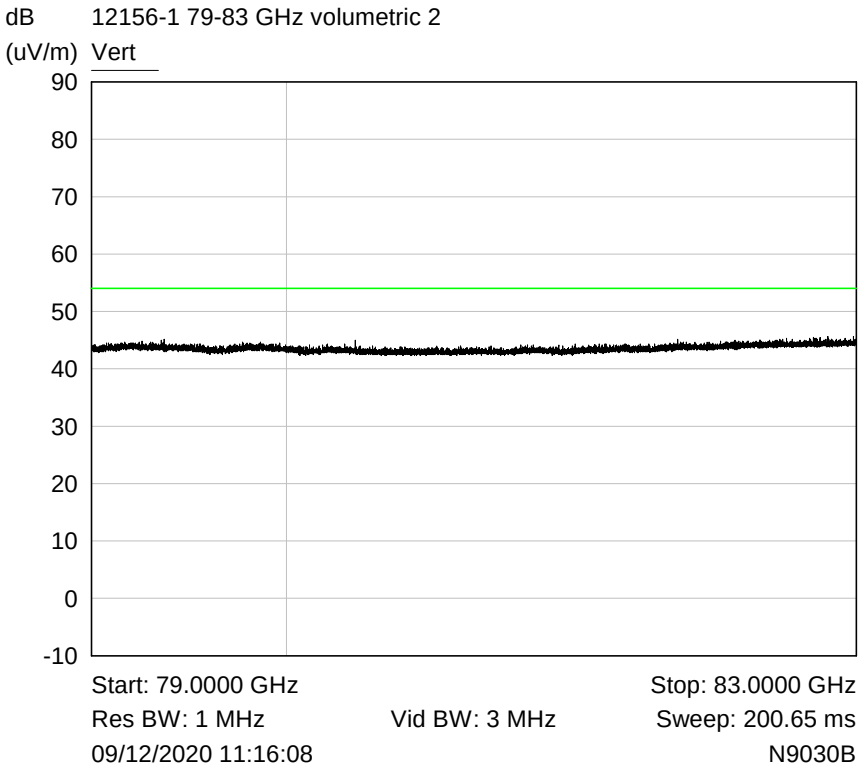


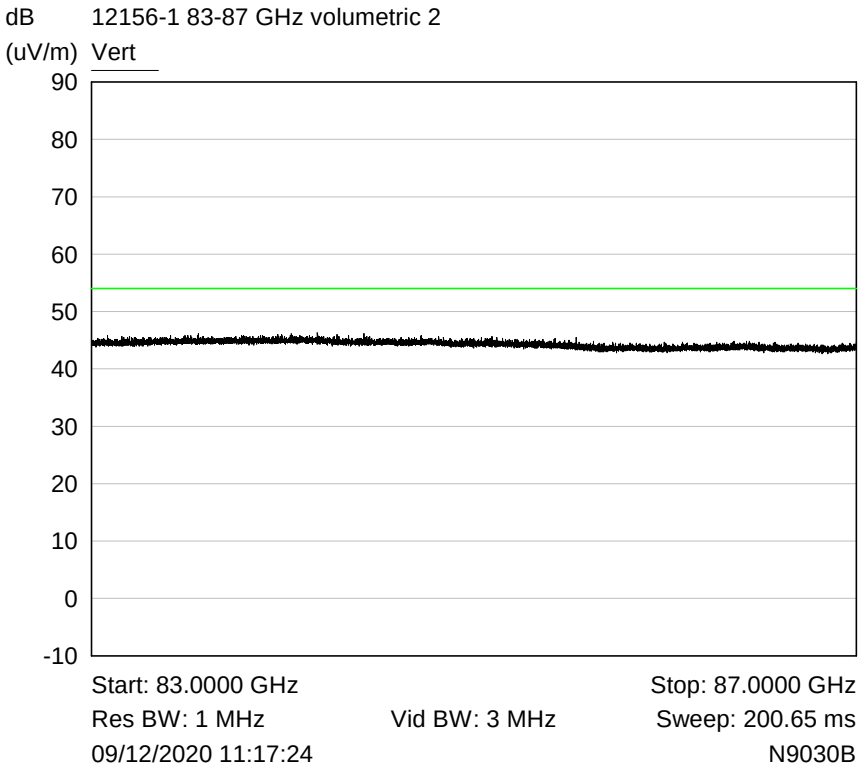


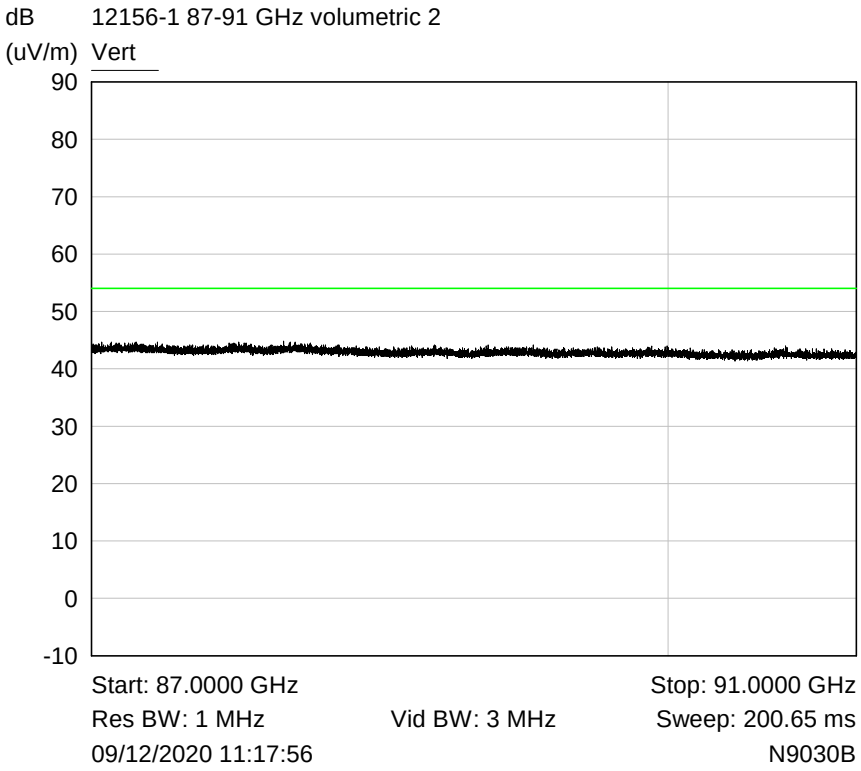


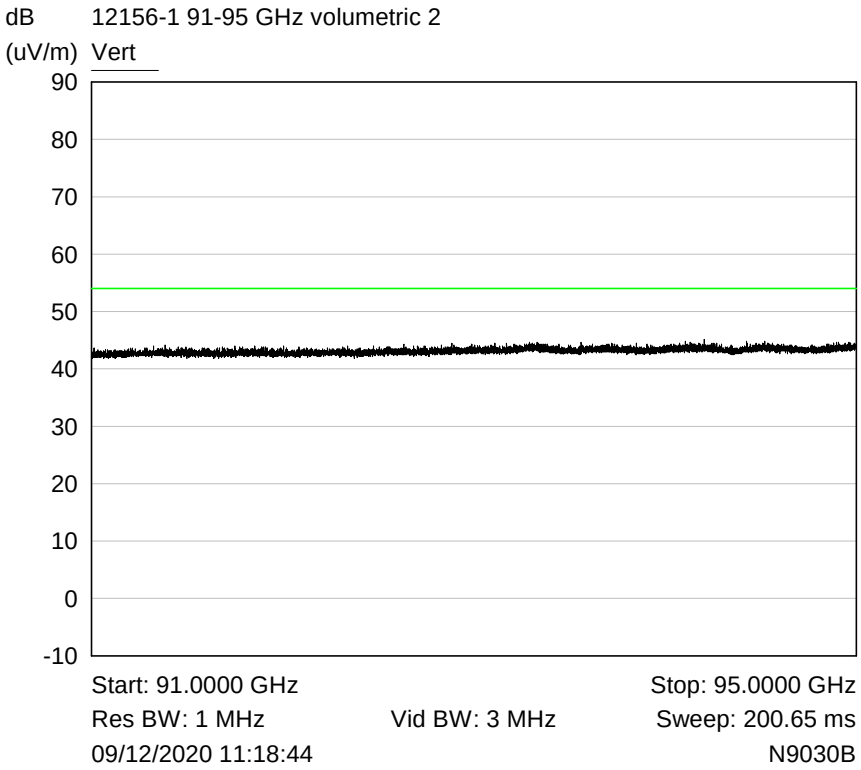

dB
(uV/m)
12156-1 74-75 GHz volumetric 3
Vert
90
80
70
60
50
40
30
20
10
0
-10
Start: 74.0000 GHz
Stop: 75.0000 GHz
Res BW: 1 MHz
Vid BW: 3 MHz
Sweep: 500.62 ms
14/01/2021 14:12:08
N9030B

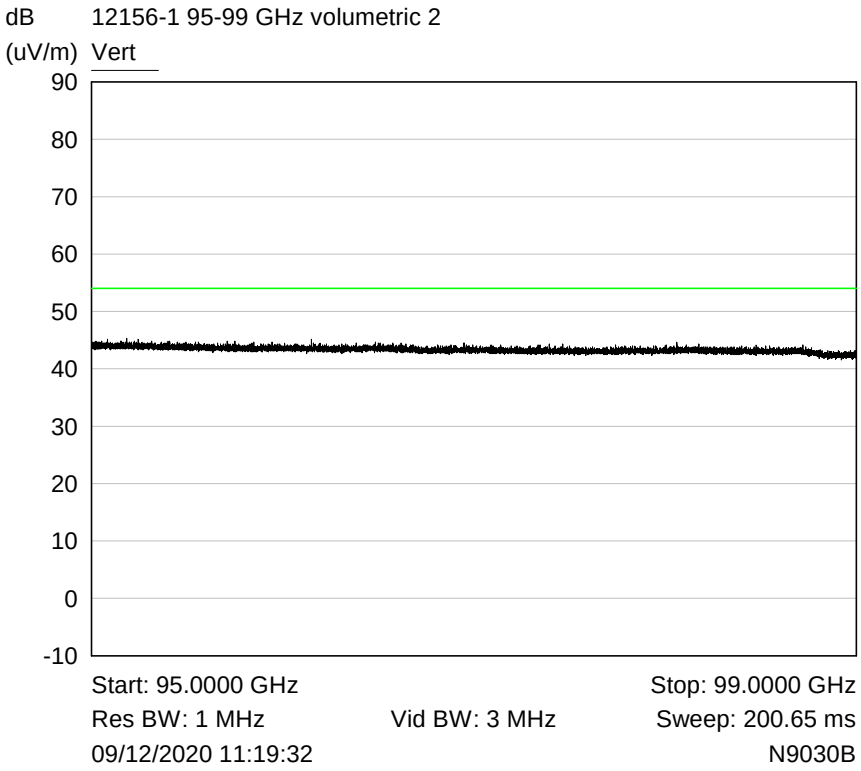

dB
(uV/m)
12156-1 75-79 GHz volumetric 2
Vert
90
80
70
60
50
40
30
20
10
0
-10
Start: 75.0000 GHz
Stop: 79.0000 GHz
Res BW: 1 MHz
Vid BW: 3 MHz
Sweep: 200.65 ms
09/12/2020 11:14:43
N9030B

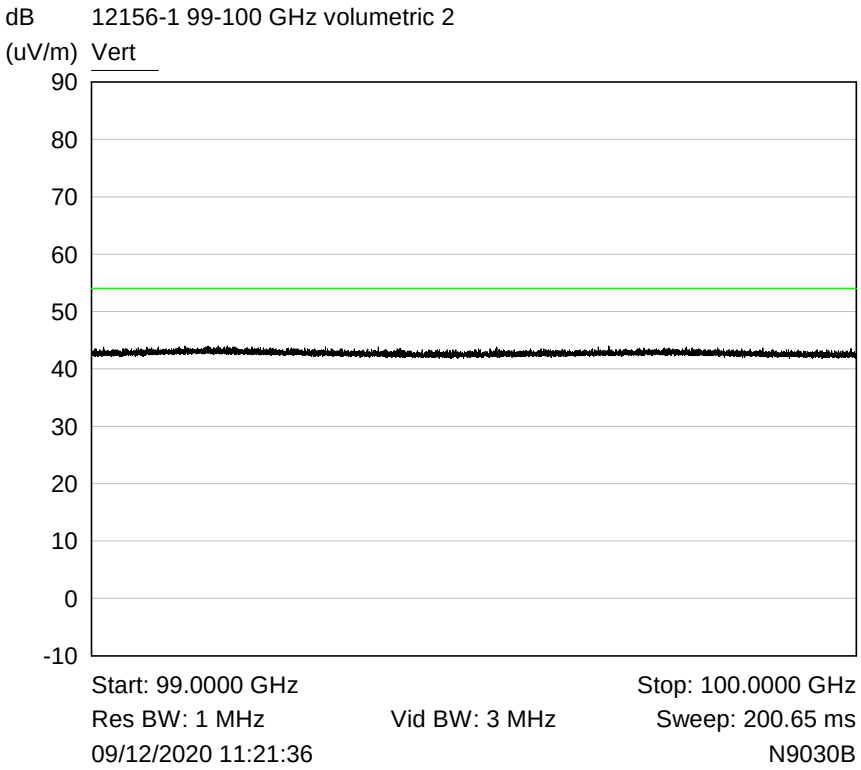

dB
(uV/m)
12156-1 79-83 GHz volumetric 2
Vert
90
80
70
60
50
40
30
20
10
0
-10
Start: 79.0000 GHz
Stop: 83.0000 GHz
Res BW: 1 MHz
Vid BW: 3 MHz
Sweep: 200.65 ms
09/12/2020 11:16:08
N9030B


dB
(uV/m)
12156-1 83-87 GHz volumetric 2
Vert
90
80
70
60
50
40
30
20
10
0
-10
Start: 83.0000 GHz
Stop: 87.0000 GHz
Res BW: 1 MHz
Vid BW: 3 MHz
Sweep: 200.65 ms
09/12/2020 11:17:24
N9030B



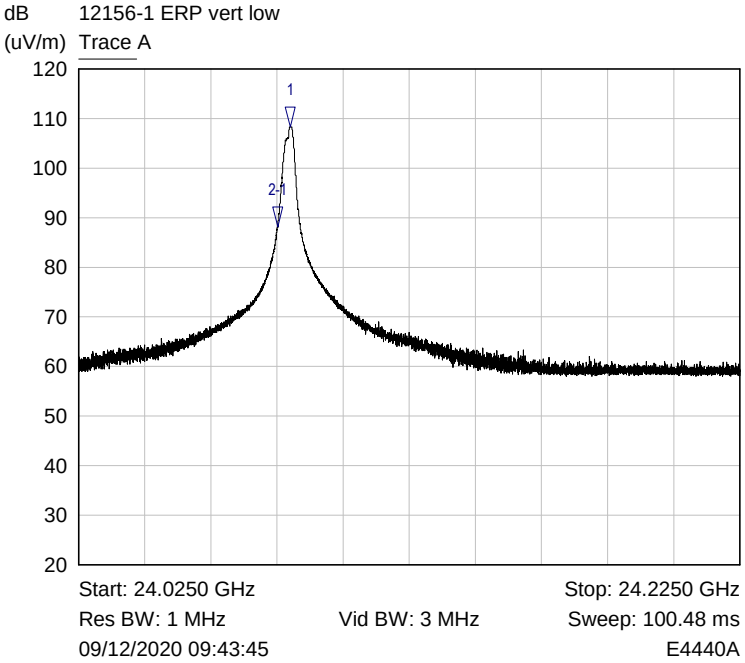






6.5 Intentional radiator field strength

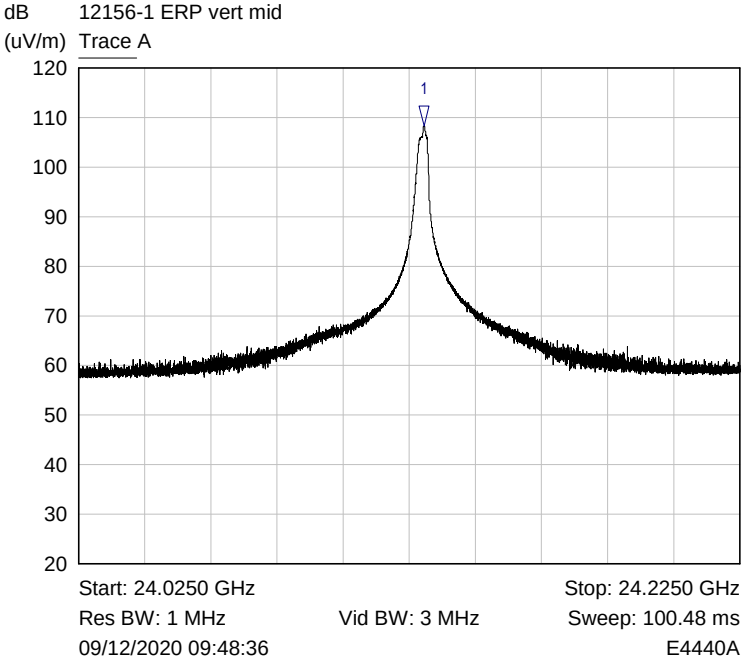
RF Parameters: Band 24-24.25 GHz, Power 20 dBm (EIRP), Channel Spacing Single Channel, Modulation FMCW, Channel 24.089 GHz



Mkr	Trace	X-Axis	Value	Notes
1 ▽	Trace A	24.0891 GHz	108.41 dB(uV/m)	
2-1 ▽	Trace A	24.0852 GHz	-20.20 dB	

Plot ref of Vert polarisation and EUT in Upright position

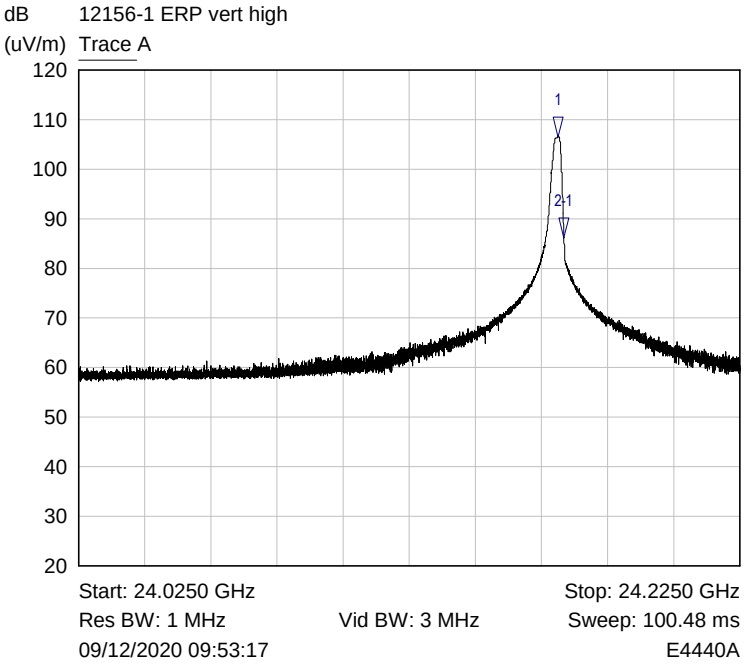
RF Parameters: Band 24-24.25 GHz, Power 20 dBm (EIRP), Channel Spacing Single Channel, Modulation FMCW, Channel 24.129 GHz



Mkr	Trace	X-Axis	Value	Notes
1 ▽	Trace A	24.1295 GHz	108.33 dB(uV/m)	

Plot ref of Vert polarisation and EUT in Upright position

RF Parameters: Band 24-24.25 GHz, Power 20 dBm (EIRP), Channel Spacing Single Channel, Modulation FMCW, Channel 24.170 GHz

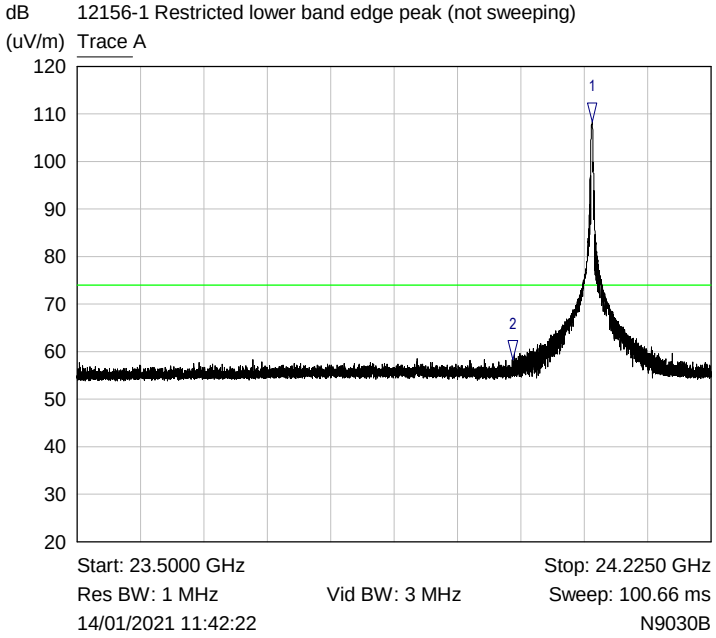


Mkr	Trace	X-Axis	Value	Notes
1 ▽	Trace A	24.1699 GHz	106.54 dB(uV/m)	
2-1 ▽	Trace A	24.1718 GHz	-20.37 dB	

Plot ref of Vert polarisation and EUT in Upright position

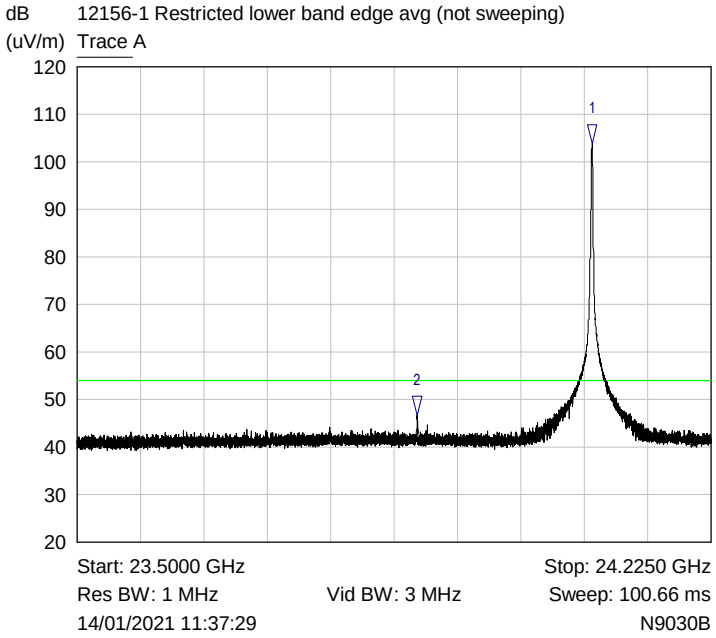
6.6 Band Edge Compliance

RF Parameters: Band 24-24.25 GHz, Power 20 dBm (EIRP), Channel Spacing Single Channel, Modulation FMCW, Channel 24.089 (lower) GHz



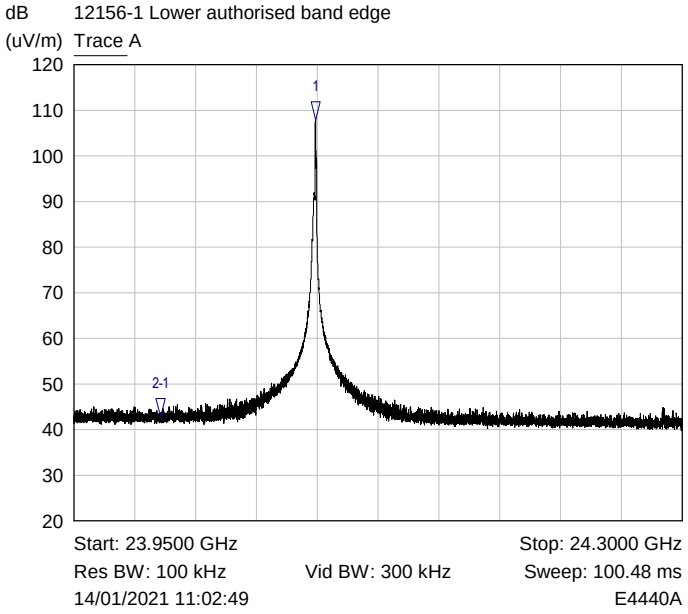
Mkr	Trace	X-Axis	Value	Notes
1 ▽	Trace A	24.0889 GHz	108.28 dB(uV/m)	
2 ▽		23.9982 GHz	58.41 dB(uV/m)	

Lower Restricted band edge Peak Plot



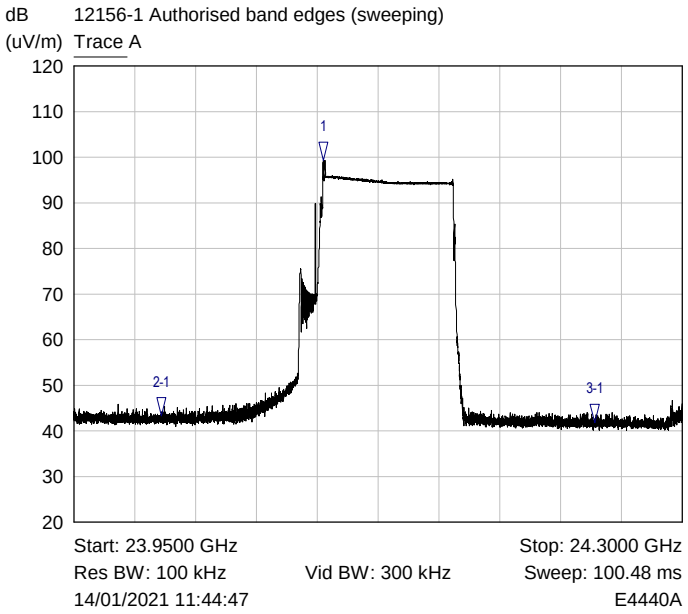
Mkr	Trace	X-Axis	Value	Notes
1 ▽	Trace A	24.0889 GHz	103.82 dB(uV/m)	
2 ▽	Trace A	23.8890 GHz	46.60 dB(uV/m)	

Lower Restricted band edge Average Plot



Mkr	Trace	X-Axis	Value	Notes
1	Trace A	24.0889 GHz	107.76 dB(uV/m)	
2-1	Trace A	24.0000 GHz	-64.94 dB	

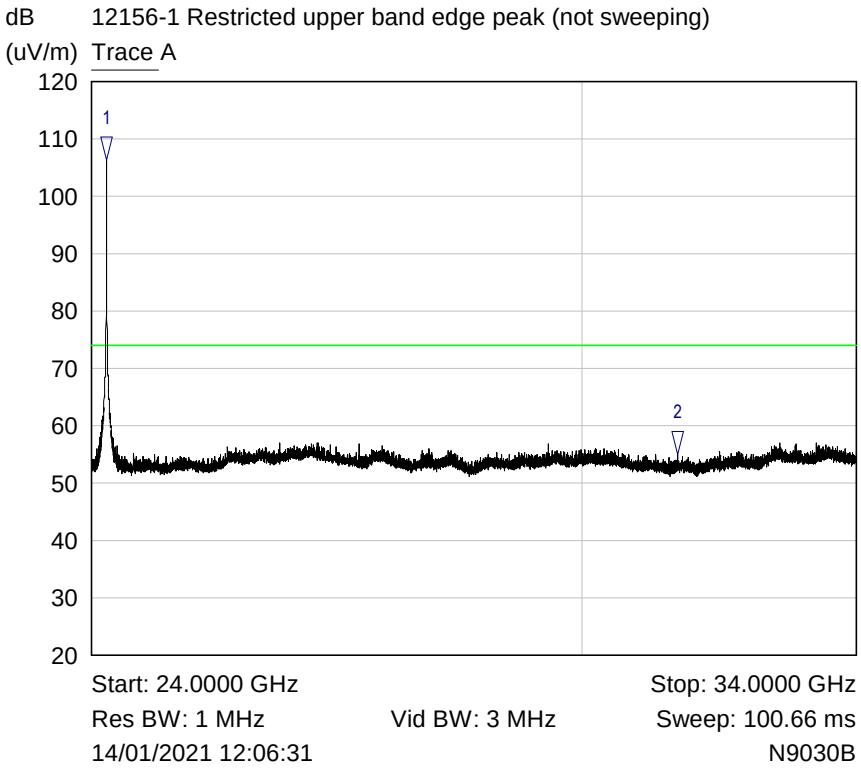
Lower authorised Band Edge Plot



Mkr	Trace	X-Axis	Value	Notes
1	Trace A	24.0934 GHz	99.29 dB(uV/m)	
2-1	Trace A	24.0002 GHz	-55.96 dB	
3-1	Trace A	24.2499 GHz	-57.42 dB	

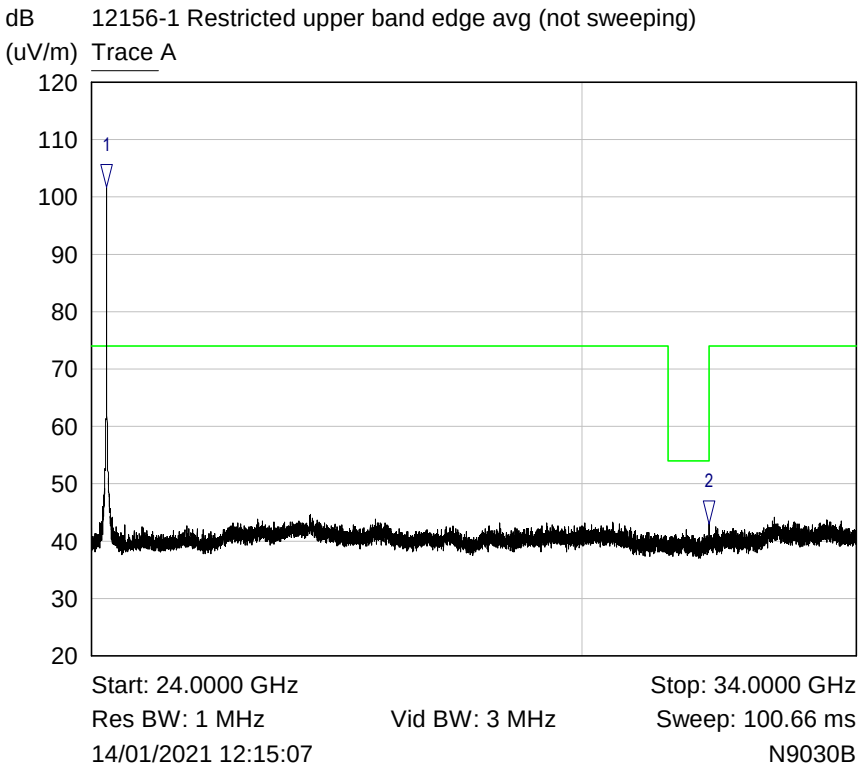
Authorised Band Edges Plot (sweeping)

RF Parameters: Band 24-24.25 GHz, Power 20 dBm (EIRP), Channel Spacing Single Channel, Modulation FMCW, Channel 24.170 (upper) GHz



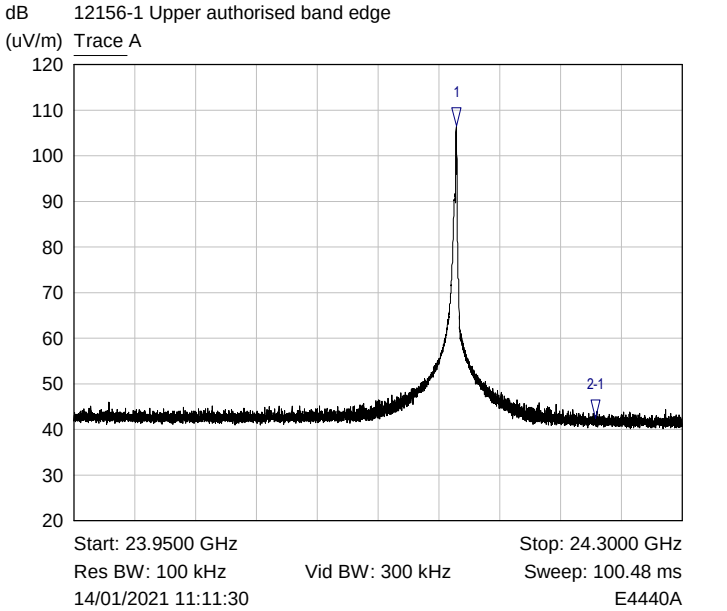
Mkr	Trace	X-Axis	Value	Notes
1 ▽	Trace A	24.1700 GHz	106.36 dB(uV/m)	
2 ▽	Trace A	31.3437 GHz	55.07 dB(uV/m)	

Upper Restricted band edge Peak Plot



Mkr	Trace	X-Axis	Value	Notes
1 ▽	Trace A	24.1700 GHz	101.65 dB(uV/m)	
2 ▽	Trace A	31.7958 GHz	42.93 dB(uV/m)	

Upper Restricted band edge Avg Plot

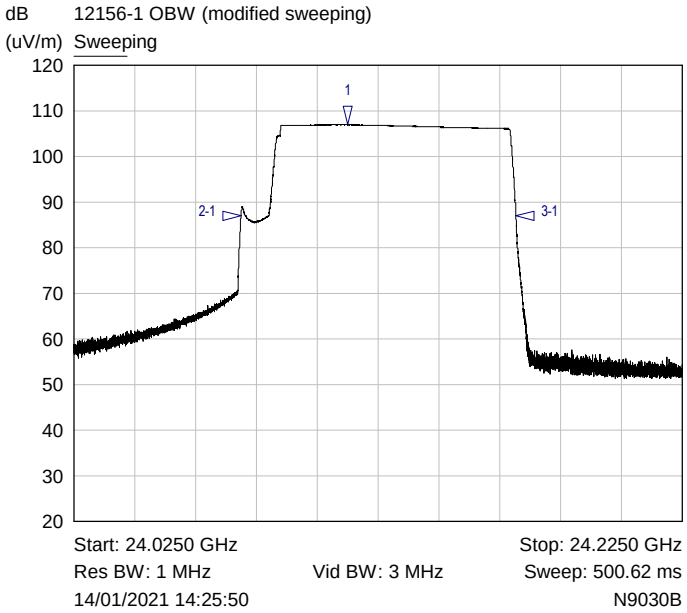


Mkr	Trace	X-Axis	Value	Notes
1 ▽	Trace A	24.1699 GHz	106.51 dB(uV/m)	
2-1 ▽	Trace A	24.2500 GHz	-64.10 dB	

Authorised Band Edge Plot

6.7 Occupied bandwidth

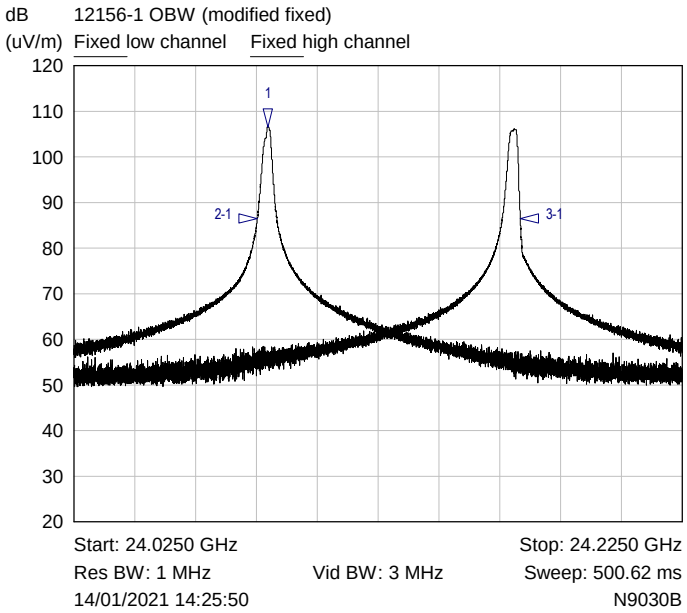
RF Parameters: Band 24-24.25 GHz, Power 20 dBm (EIRP), Channel Spacing Single Channel, Modulation FMCW, Channel 24.125 GHz



Mkr	Trace	X-Axis	Value	Notes
1 ▽	Sweeping	24.1150 GHz	106.96 dB(uV/m)	
2-1 ▽	Sweeping	24.0799 GHz	-19.97 dB	
3-1 ▽	Sweeping	24.1703 GHz	-20.00 dB	

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

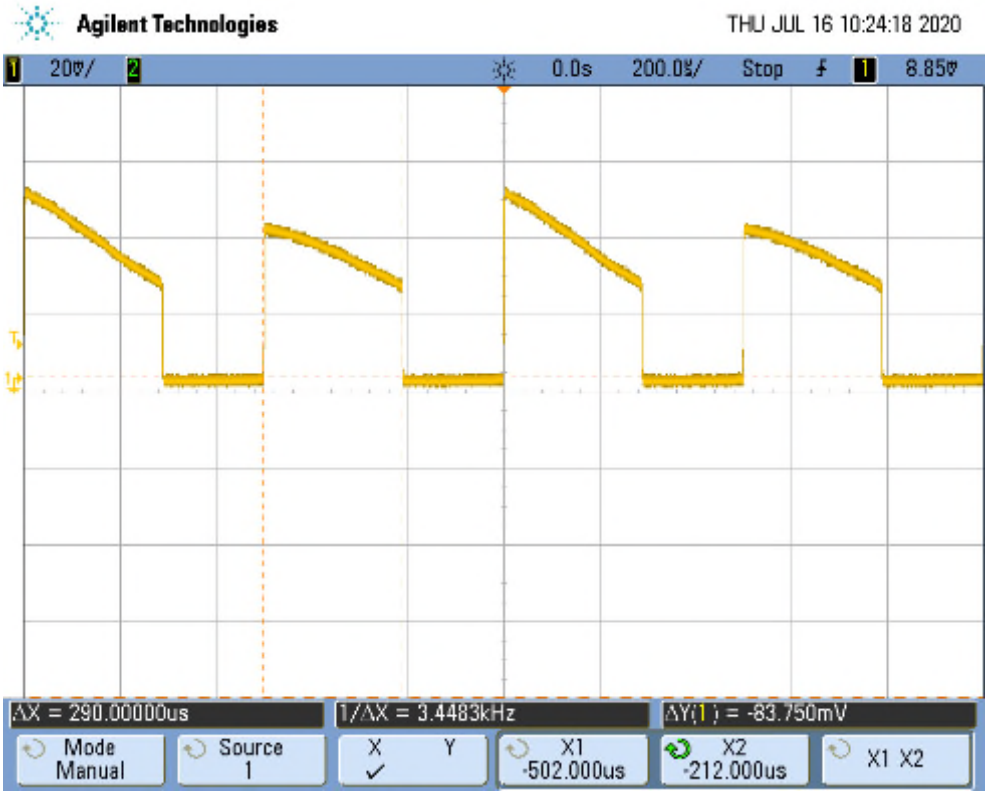
RF Parameters: Band 24-24.25 GHz, Power 20 dBm (EIRP), Channel Spacing Single Channel, Modulation FMCW, Channel, 24.089 GHz and 24.170 GHz



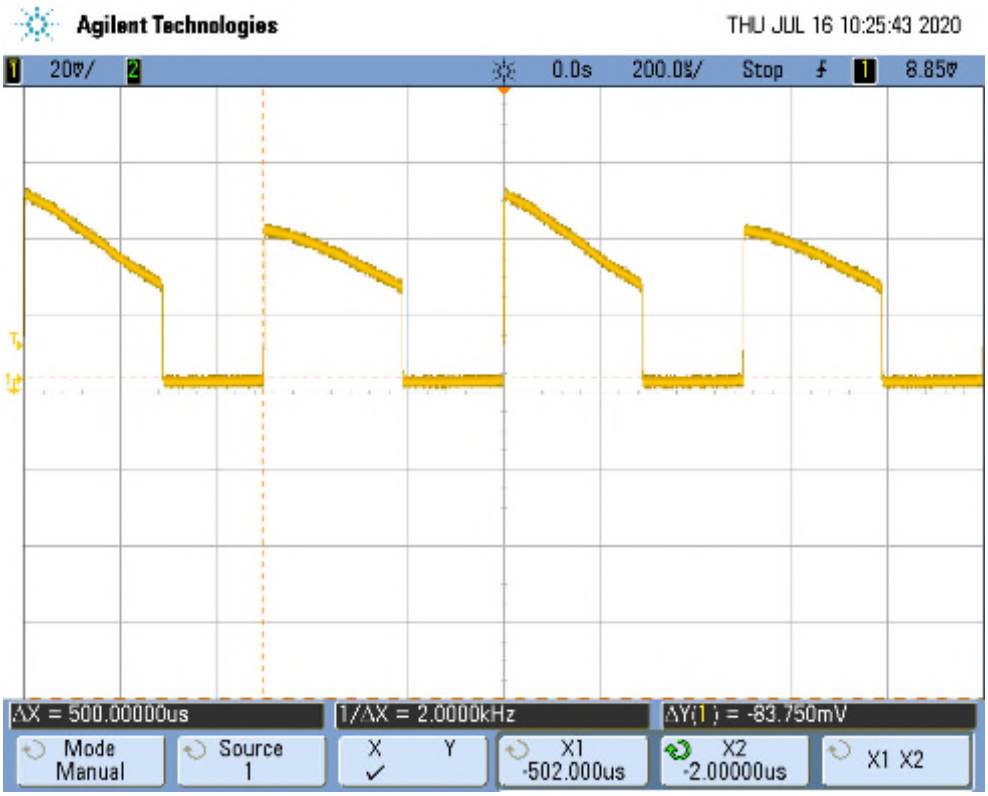
Mkr	Trace	X-Axis	Value	Notes
1 ▽	Fixed low channel	24.0888 GHz	106.53 dB(uV/m)	
2-1 ▽	Fixed low channel	24.0853 GHz	-20.06 dB	
3-1 ▽	Fixed high channel	24.1718 GHz	-19.97 dB	

6.8 Duty cycle

RF Parameters: Band 24-24.25 GHz, Power 20 dBm (EIRP), Channel Spacing Single Channel, Modulation FMCW MHz



TX on time (ms)



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)	Pk – Lim 1 (dB)	QP Amp (dBuV)	QP - Lim1 (dB)	Av Amp (dBuV)	Av - Lim1 (dB)
1	12345	54.9	-10.5	48	-12.6	37.6	-14.4

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

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

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

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

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

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

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

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

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

7.2 Explanation of limit line calculations for radiated measurements

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

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

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

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

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

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

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

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

Equation 21: $E_{Linear} = 10^{((E_{log}-120)/20)}$
And therefore equation 21 transposed is: $E_{Log} = 20xLog(E_{Linear}) +120$
Where:
E_{Linear} is the field strength of the emission in V/m
E_{Log} is the field strength of the emissions in dBµV/m

Equation 22: $EIRP = E_{Meas} + 20log(d_{Meas}) -104.7$
Where:
EIRP is equivalent isotropically radiated power in dBm
E_{Meas} is the field strength of the emission at the measurement distance in dBµV/m
d_{Meas} is the measurement distance in metres

Equation 25: $PD = EIRP_{Linear} / 4\pi d^2$
And therefore equation 25 transposed is: $EIRP_{Linear} = PD \times 4\pi d^2$
Where:
PD is the power density at distance specified by the limit, in W/m^2
$EIRP_{Linear}$ is the equivalent isotropically radiated power in Watts
d is the distance at which the power density limit is specified in metres

Equation 26: $PD = E^2_{Speclimit} / 377$
And therefore equation 26 transposed is: $E_{Spec\ limit} = \sqrt{(PD \times 377)}$
Where:
PD is the power density at distance specified by the limit, in W/m^2
$E_{spec\ limit}$ is the field strength at the distance specified by the limit in V/m

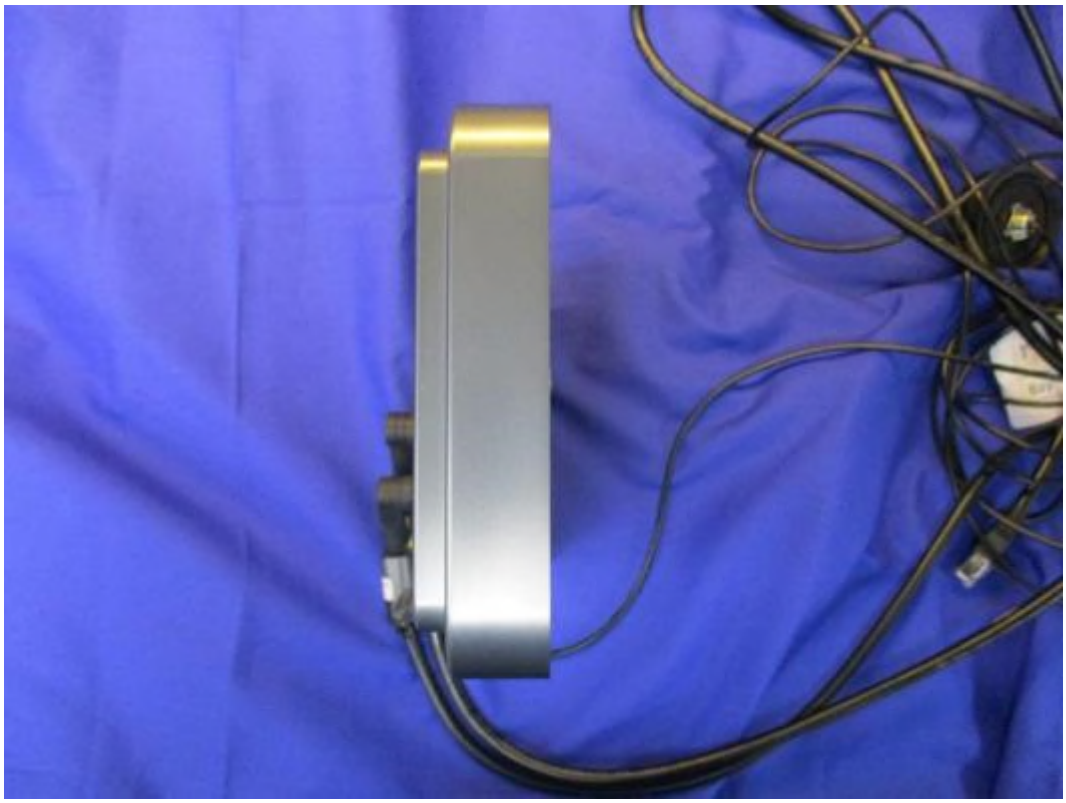
Example:
Radiated spurious emissions limit at 3metres of $90pW/cm^2$.
$90pW/cm^2 \times 100^2 = 0.9\ \mu W/m^2$ = (EIRP Linear)
Equation 25 transposed: $0.9 \times 10^{-6} \times 4 \times \pi \times 3^2 = 0.0001017876$ W
And
Equation 26 transposed: $E_{Spec\ limit} = \sqrt{(0.9x10^{-6} \times 377)} = 0.01842$ V/m.
And
Equation 21 transposed: $E_{Log} = 20Log(0.01842) +120 = 85.3dB\mu V/m$ @ 3m.

8 Photographs

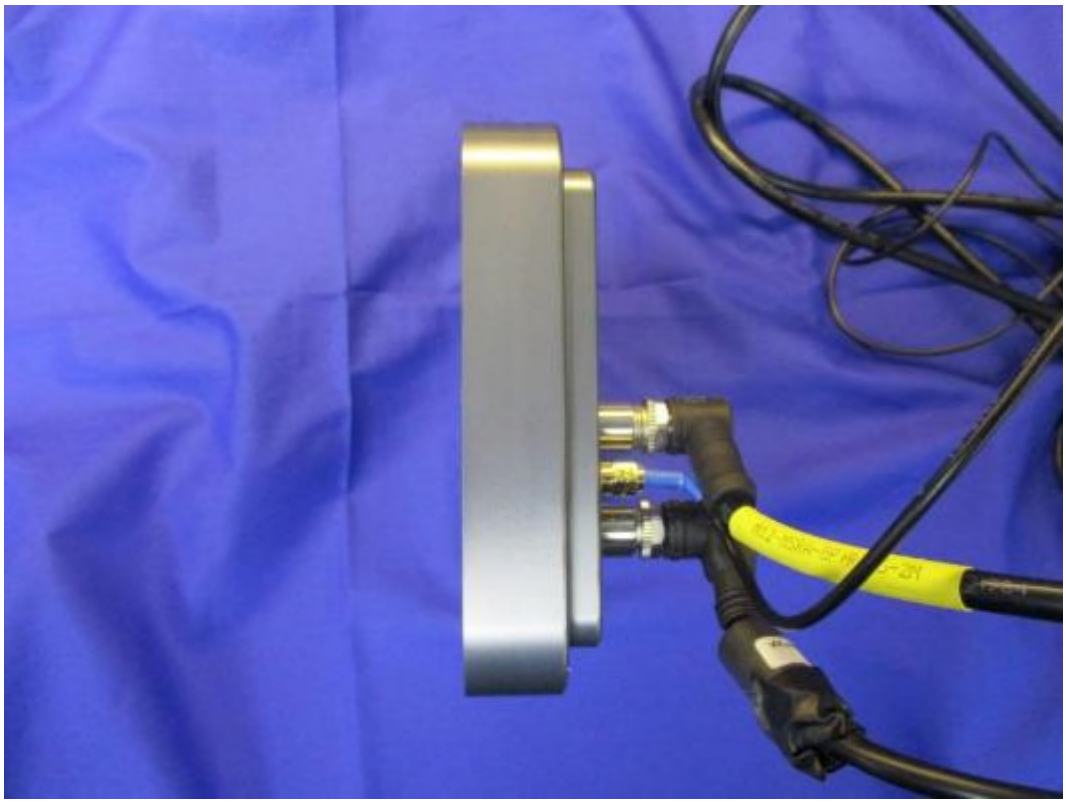
8.1 EUT Front View

8.2 EUT Reverse Angle

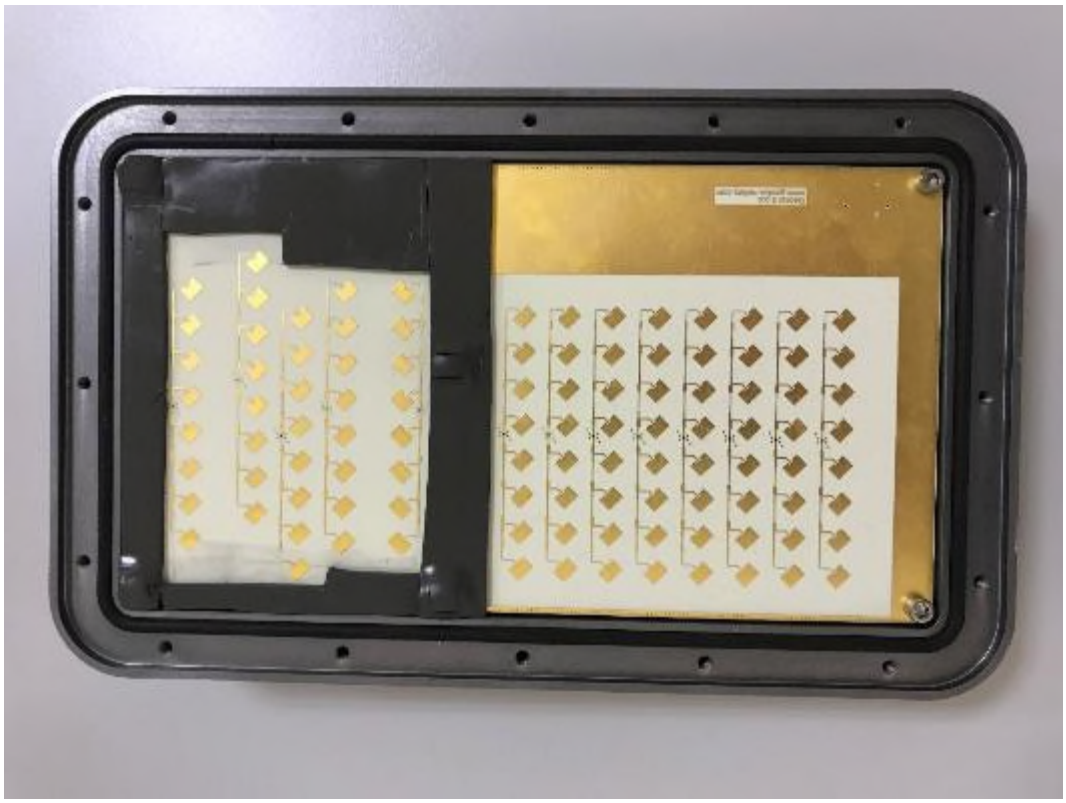
8.3 EUT Left side View



8.4 EUT Right side View



8.5 EUT Antenna

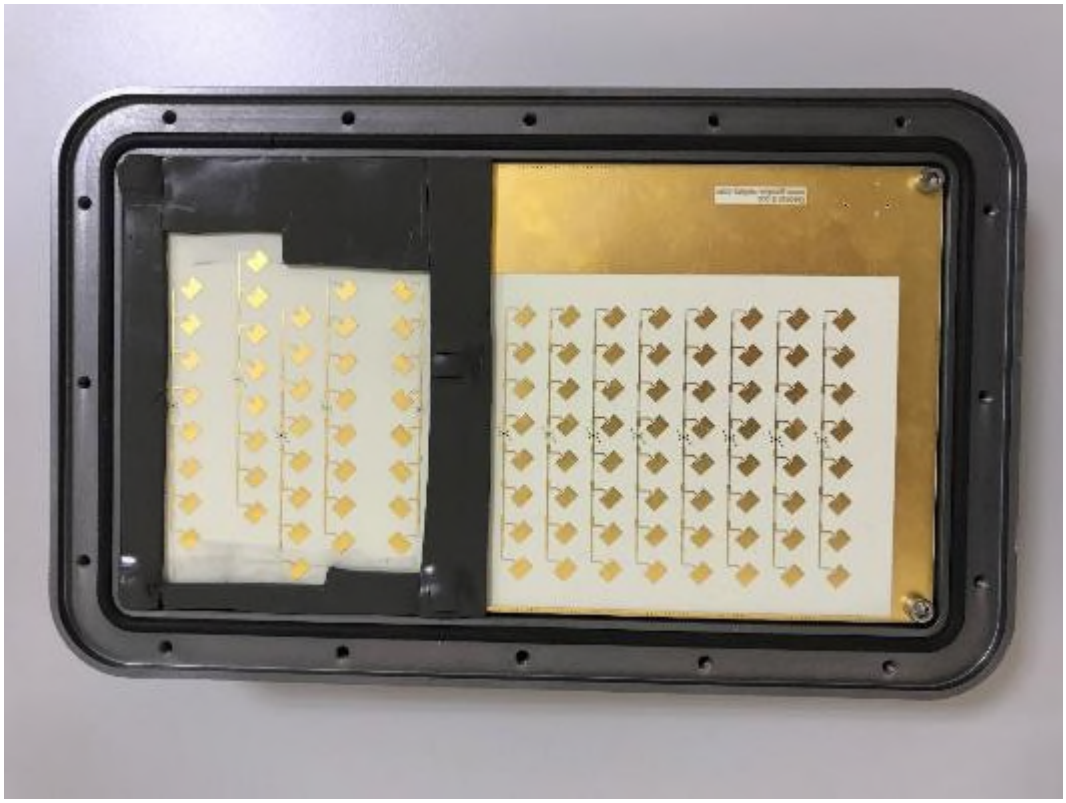


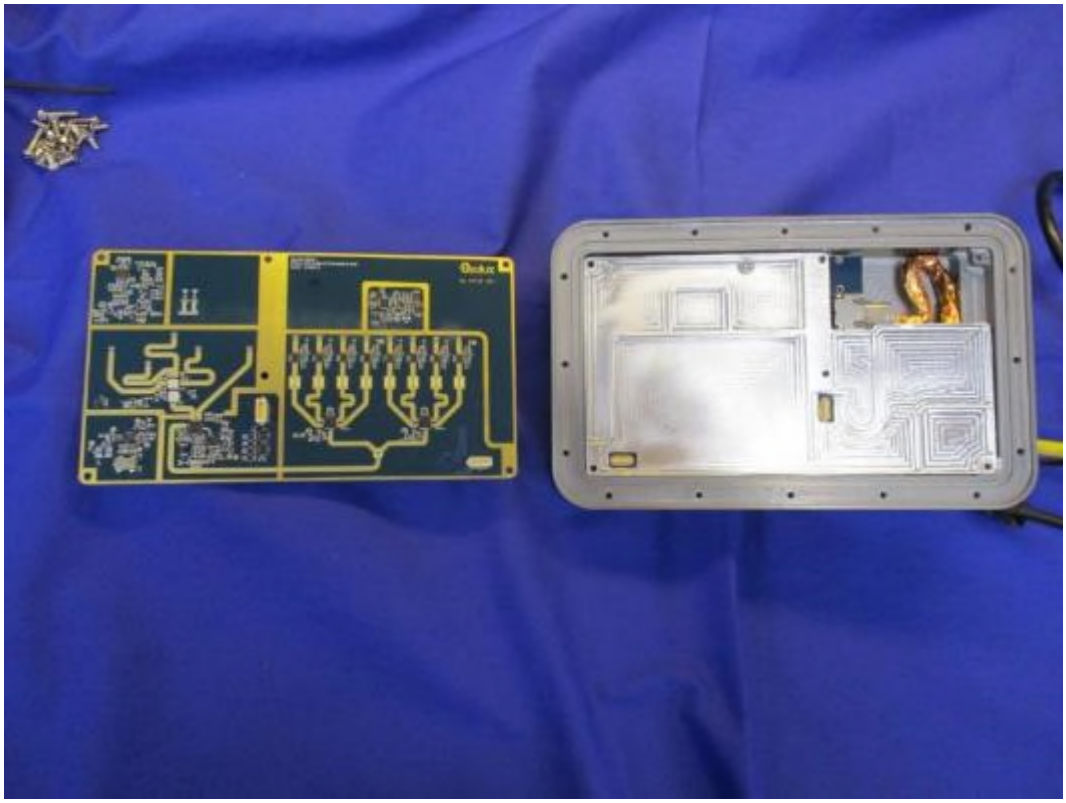
GPS active antenna

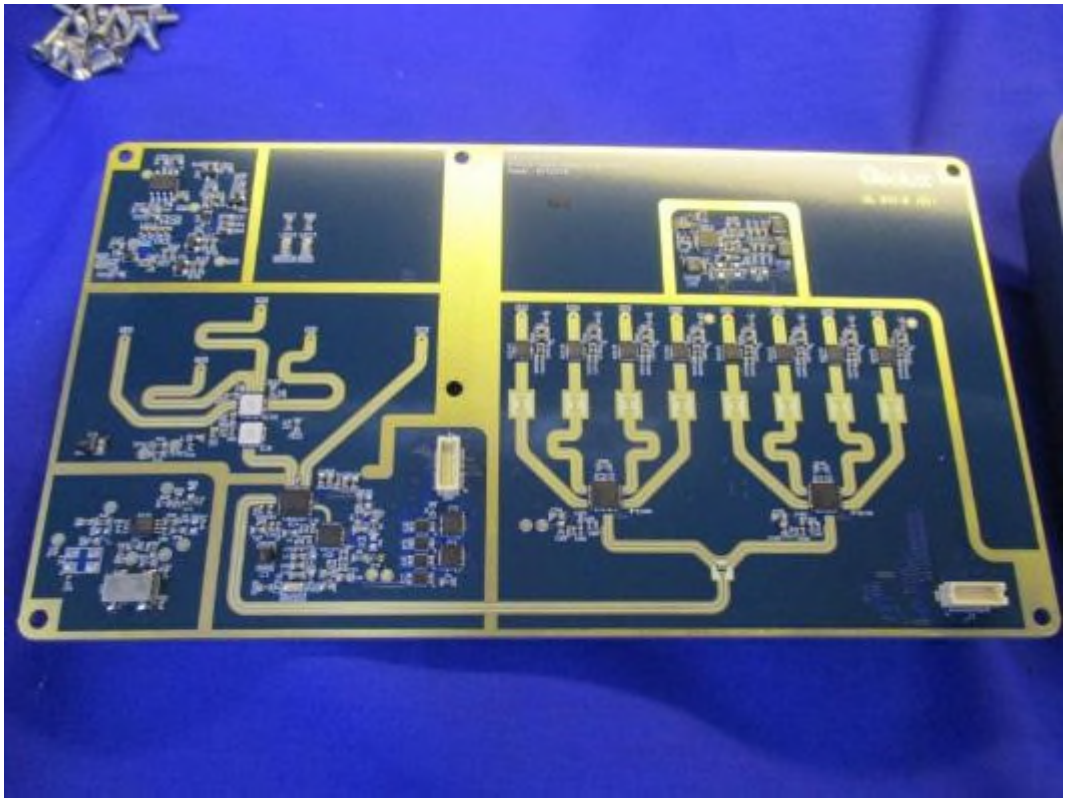
8.6 EUT Display & Controls

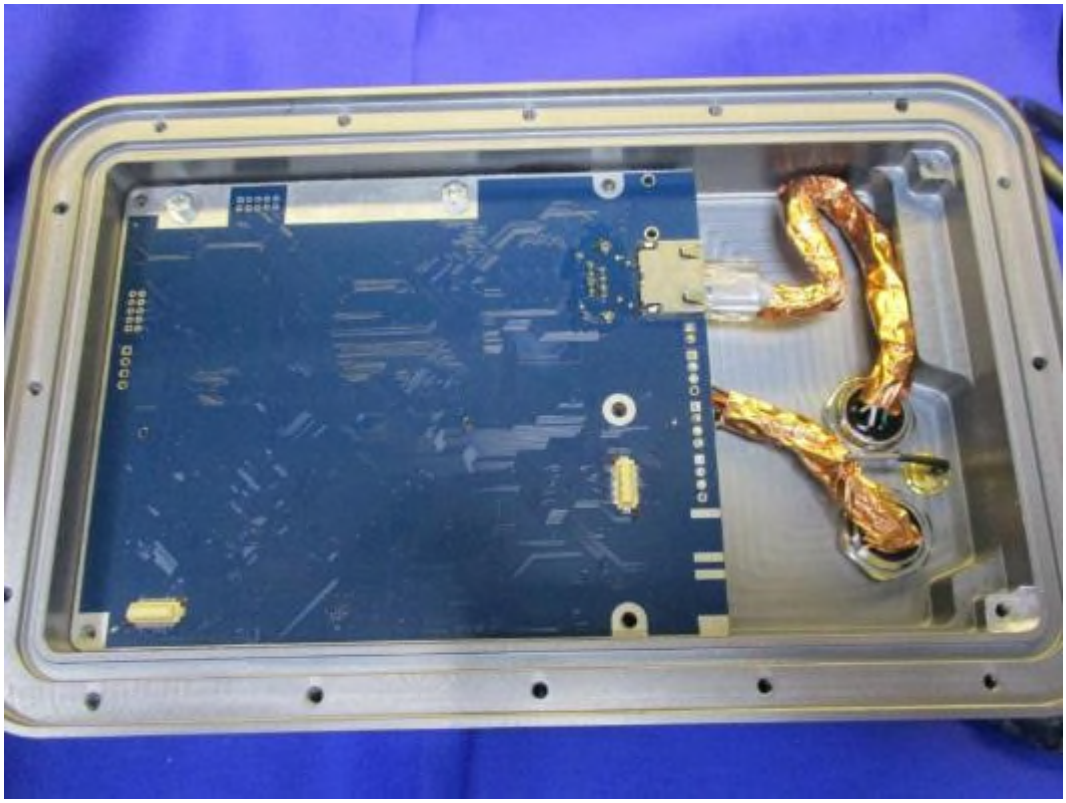
The EUT does not have any displays or controls.

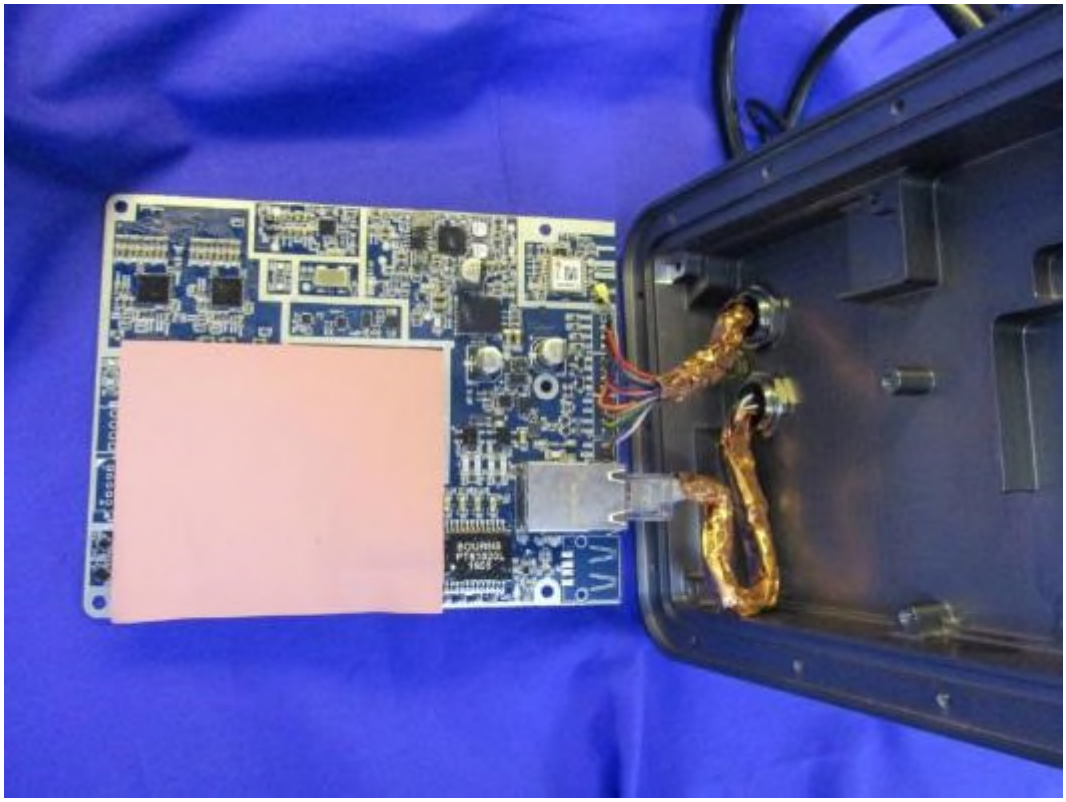
8.7 EUT Internal photos











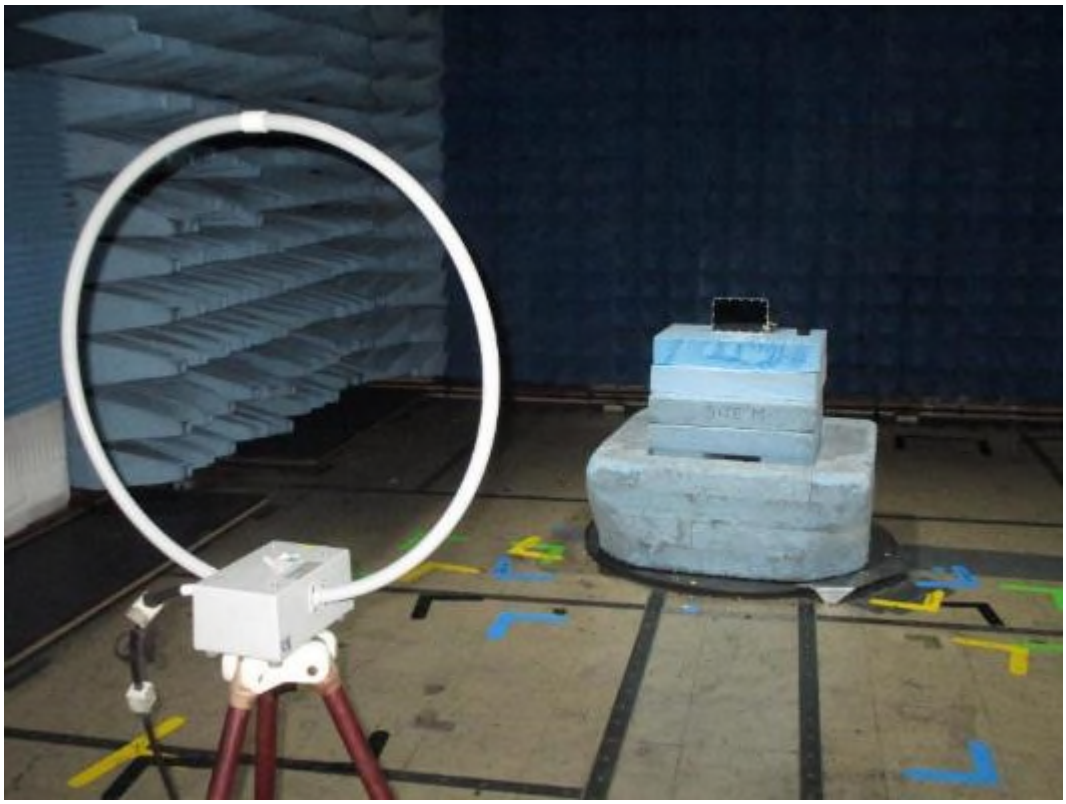
8.8 EUT ID Label

8.9 AC power line conducted emissions

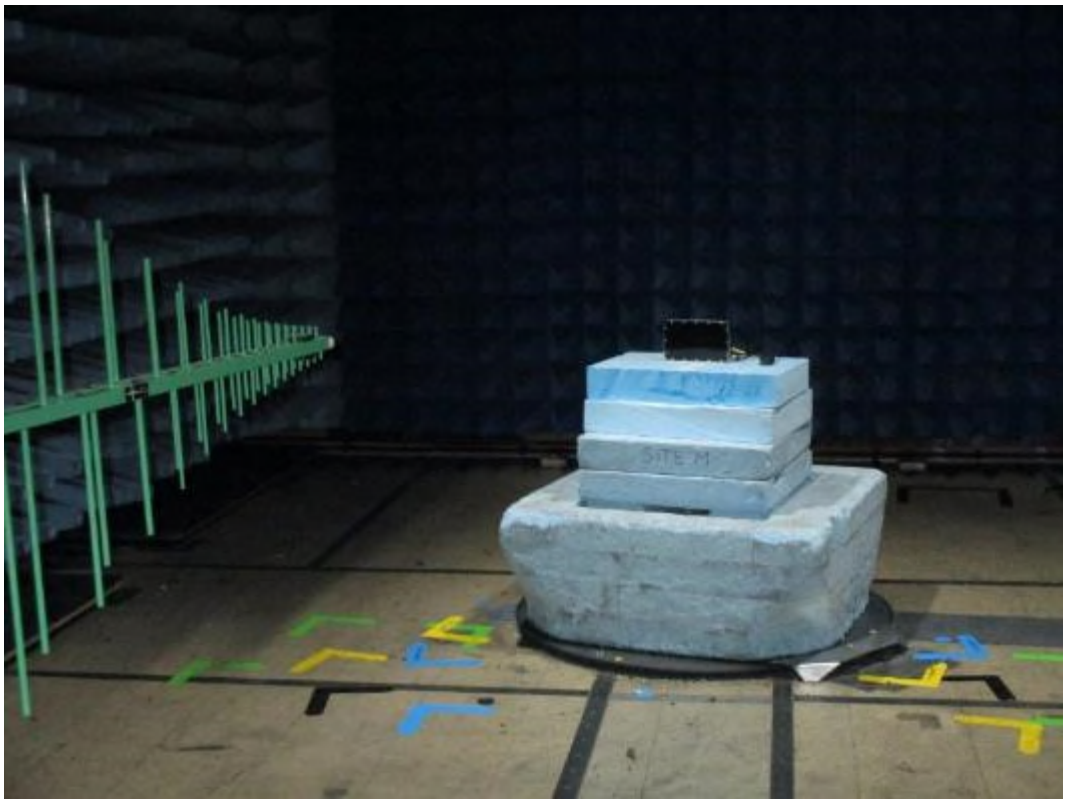
PoE powered

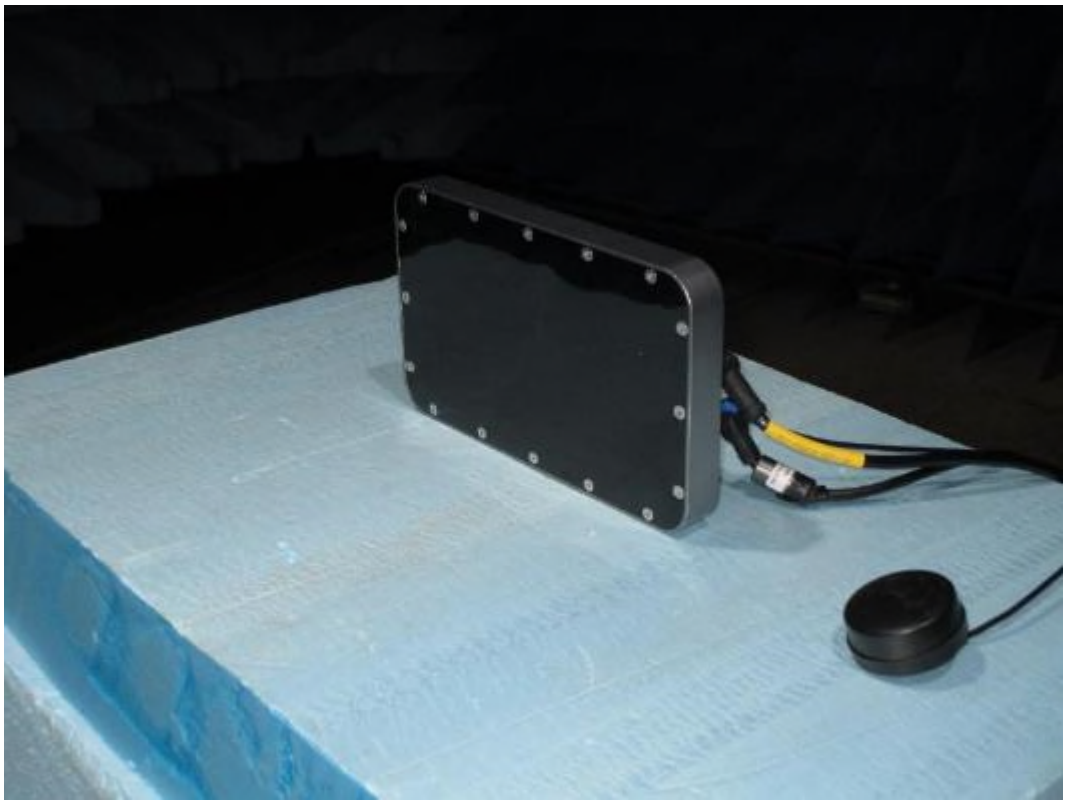
AC/DC adaptor powered

8.10 Radiated emissions 150 kHz - 30 MHz

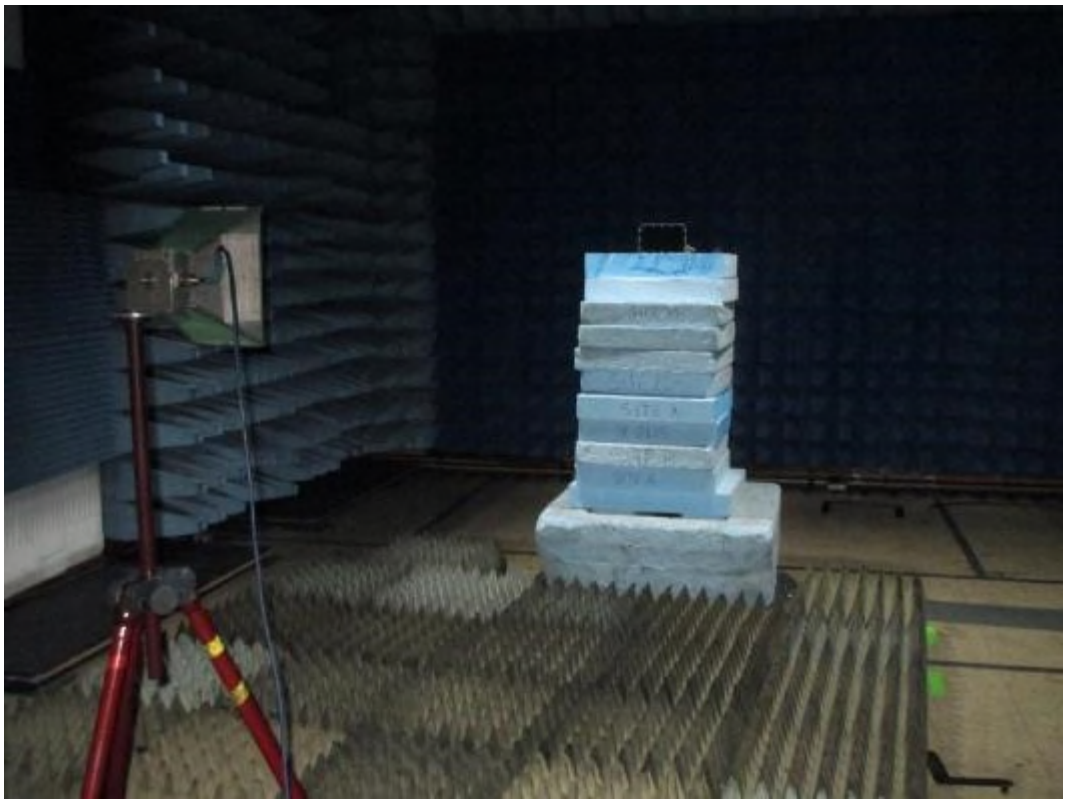


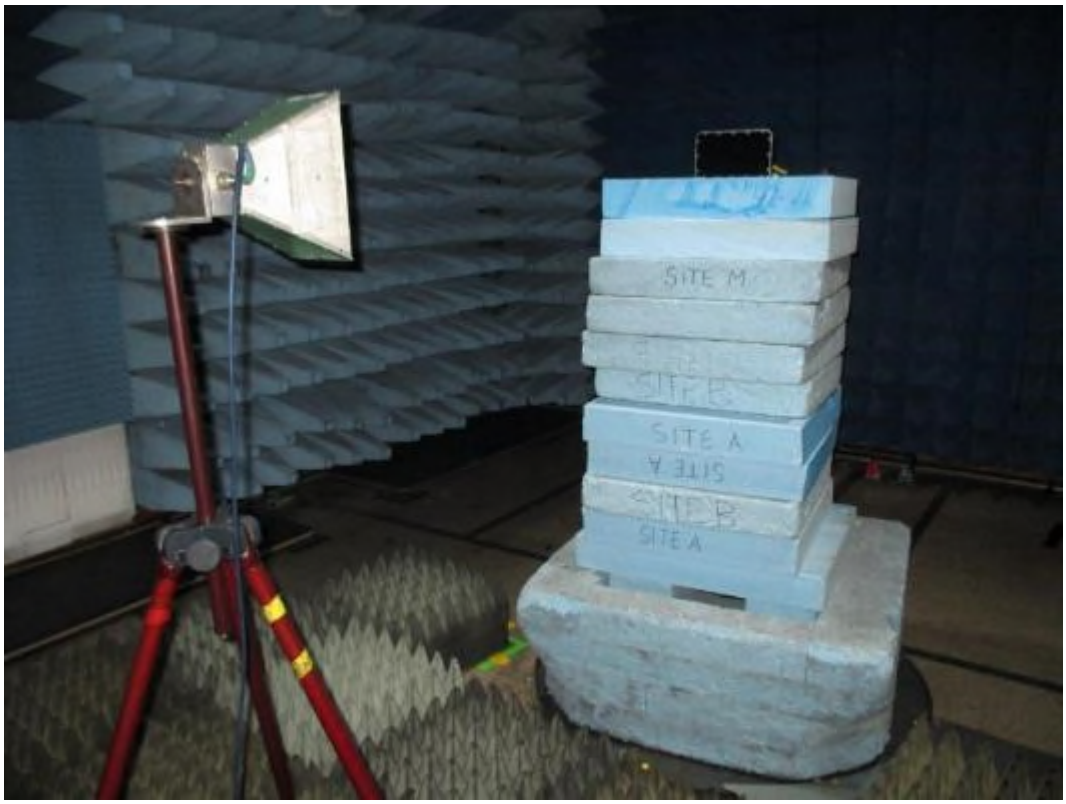
8.11 Radiated emissions 30 MHz -1 GHz

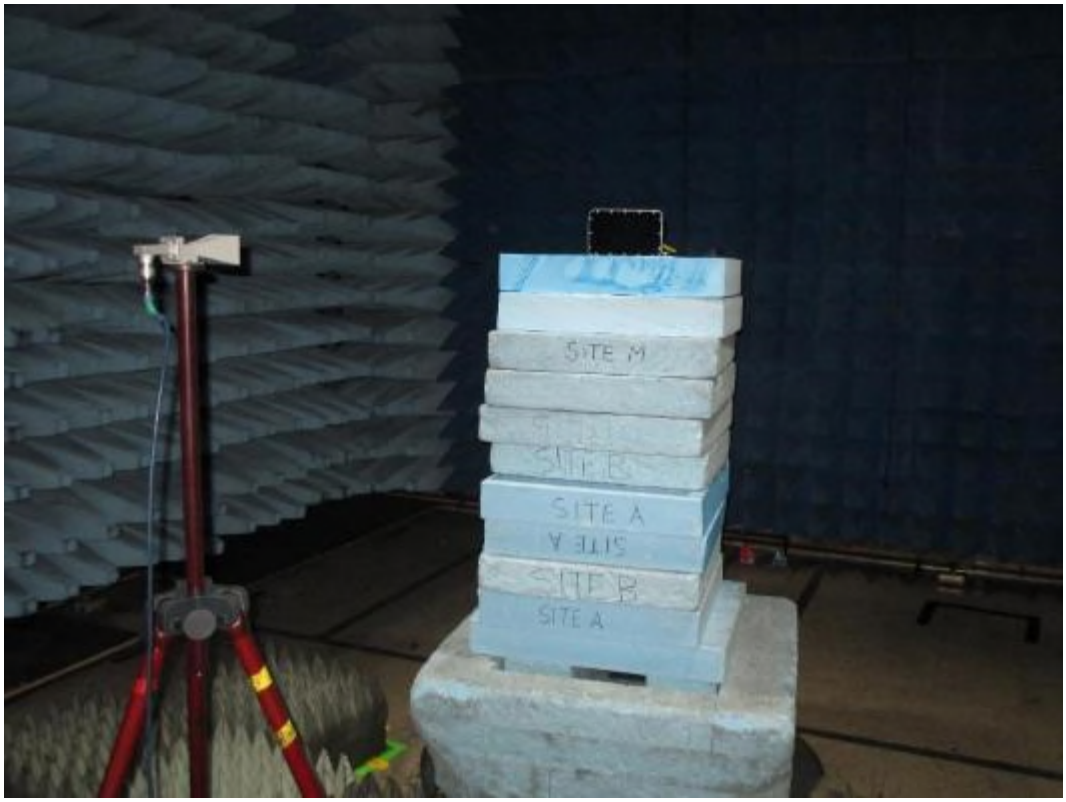




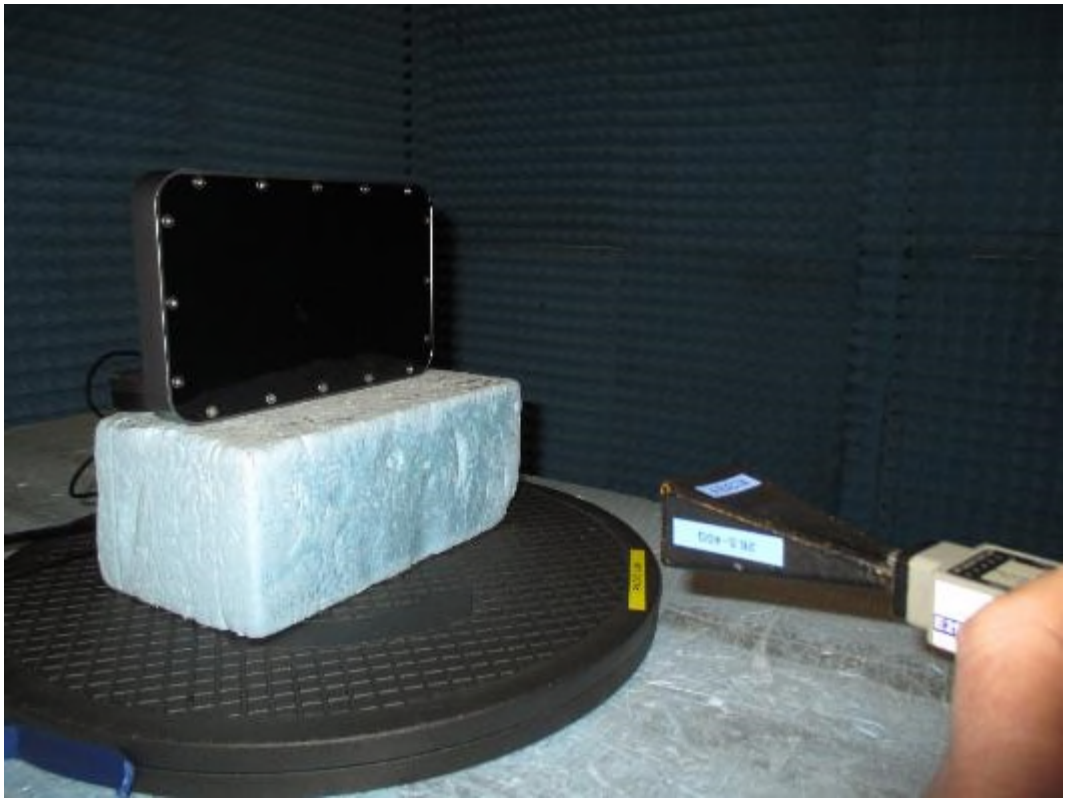
8.12 Radiated emissions above 1 GHz

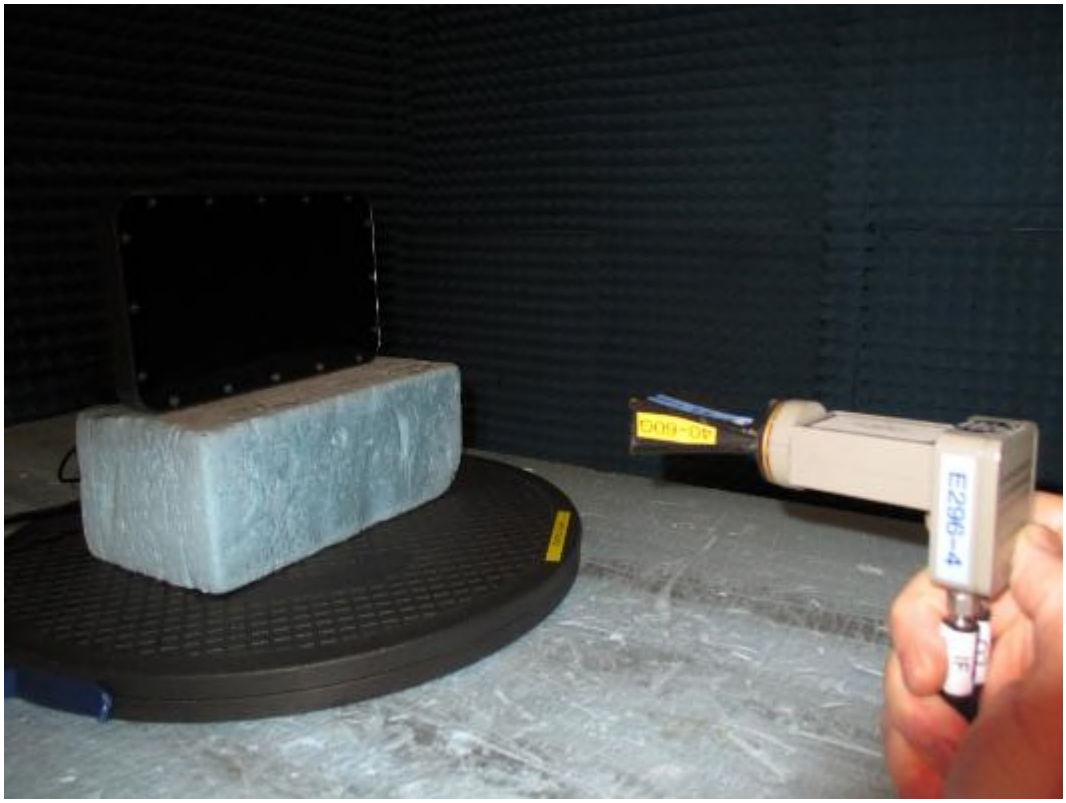


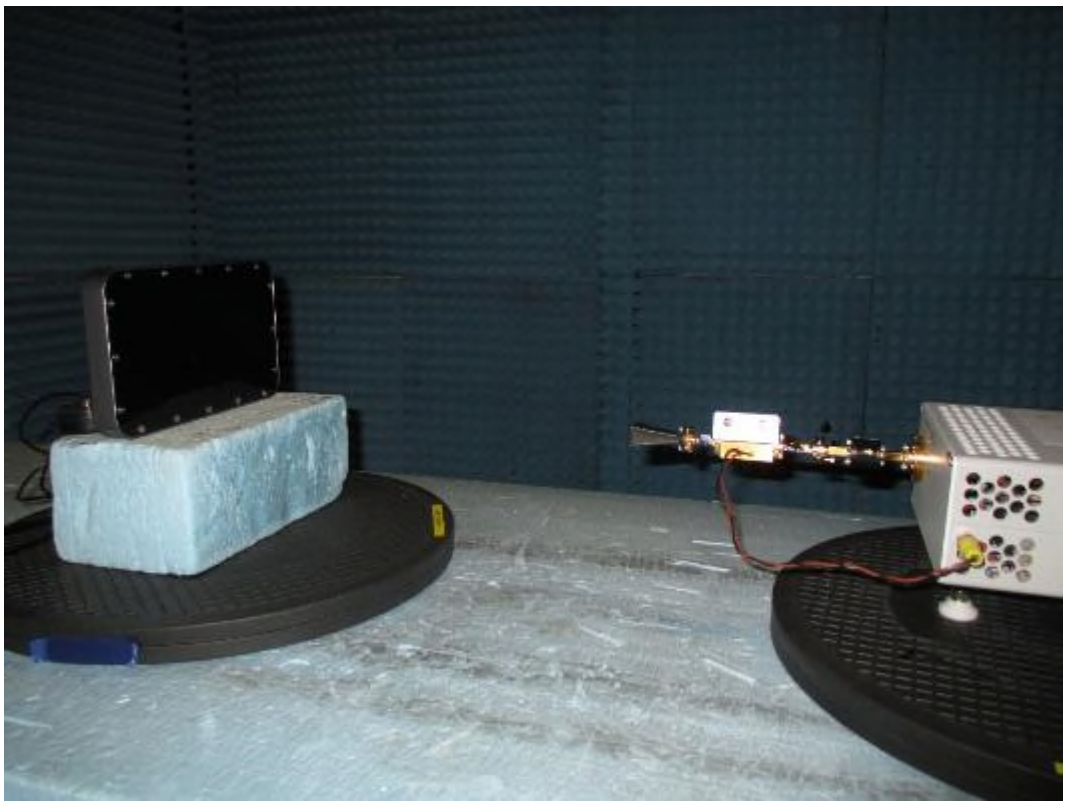


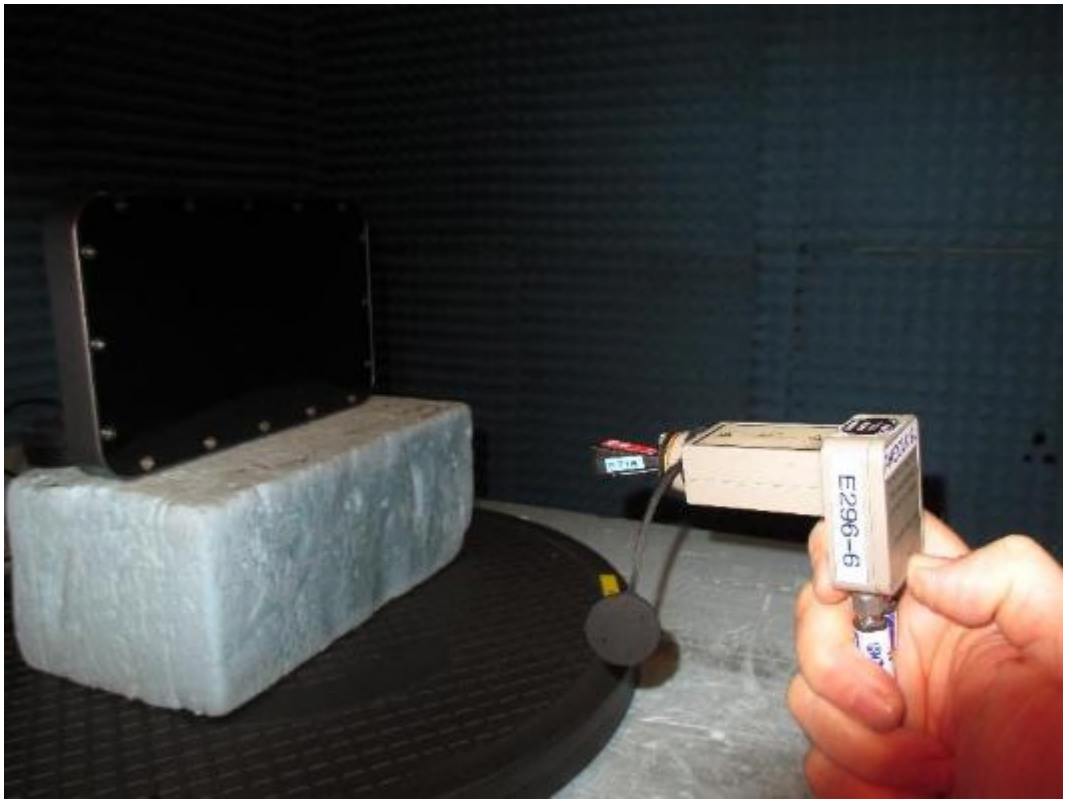

SITE M
SITE A
SITE B
SITE A


SITE M
SITE B
SITE A




E296-4




E296-6

8.13 Radiated emission diagrams

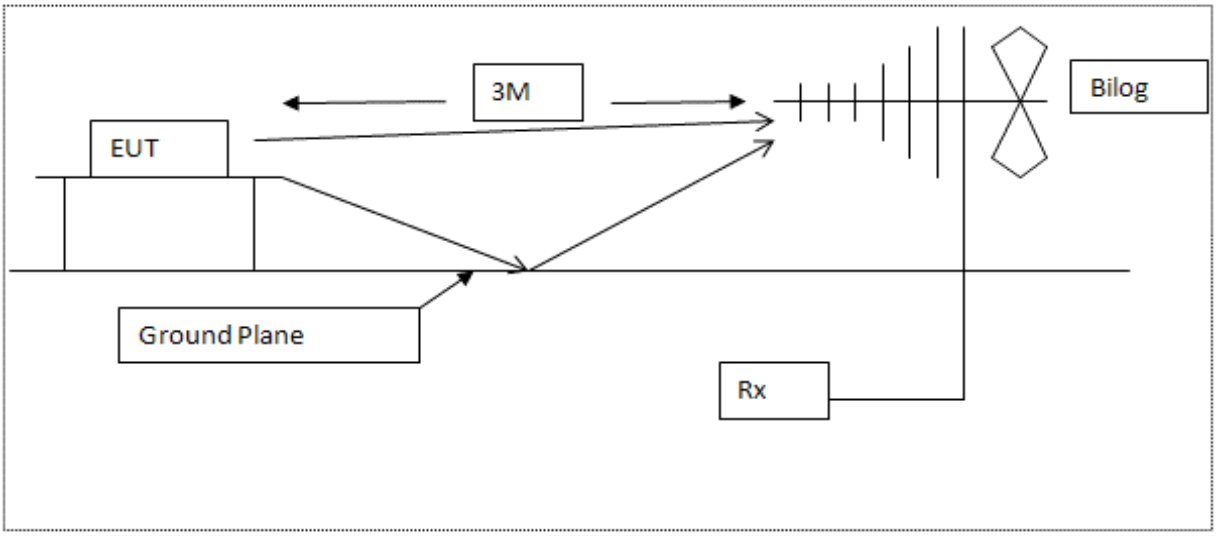


Diagram of the radiated emissions test setup 30 - 1000 MHz

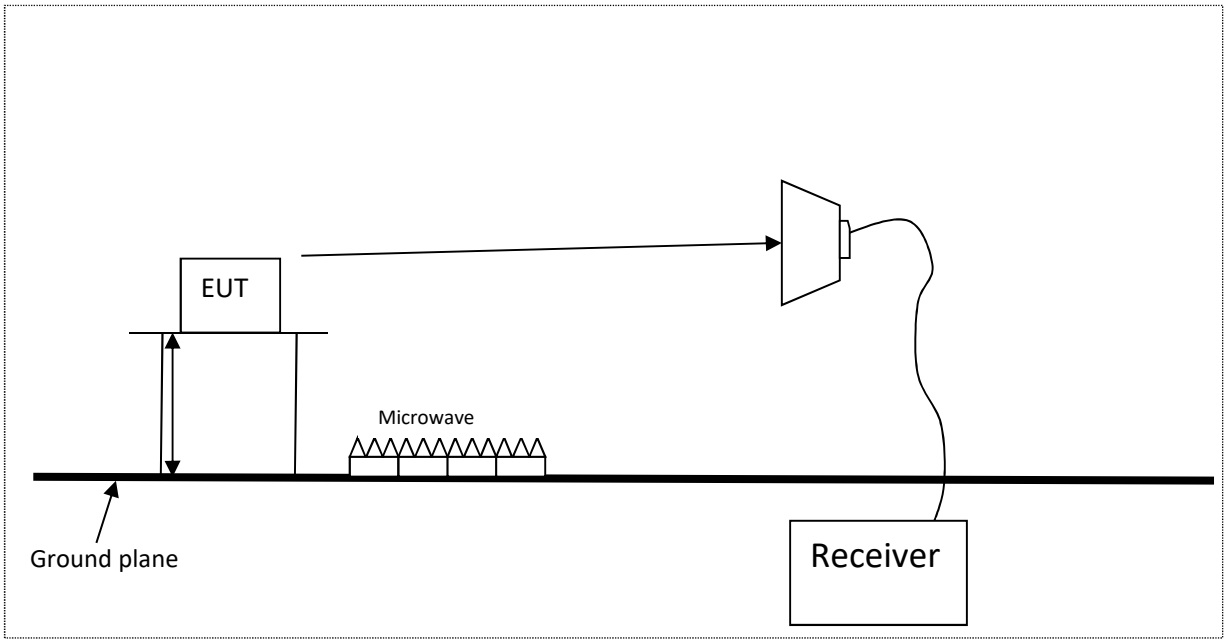


Diagram of the radiated emissions test setup above 1GHz

8.14 AC powerline conducted emission diagram

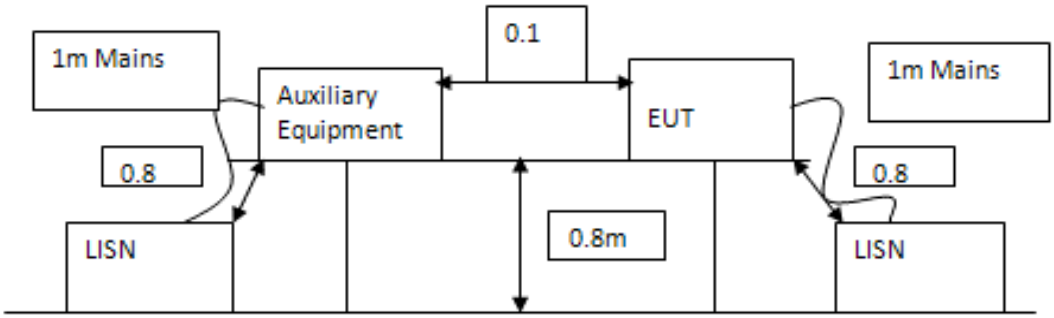


Diagram of the AC conducted emissions test setup

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
E035	11947A	Transient Limiter 9kHz - 200MHz	Hewlett Packard	#15-Dec-2020	12 months
E136	3105	Horn Antenna 1-12.5GHz	EMCO	30-Apr-2020	12 months
E150	MN2050	LISN 13A	Chase	22-Apr-2020	12 months
E249	8471E	Detector 0.01 to 12GHz	Hewlett Packard	12-Mar-2020	12 months
E296-2	11970A	Harmonic Mixer 26.5-40GHz	Hewlett Packard	#02-Jan-2021	3 months
E296-4	11970U	Harmonic Mixer 40-60GHz	Hewlett Packard	04-Dec-2019	24 months
E296-5	11970V	Harmonic Mixer 50-75GHz	Hewlett Packard	25-Nov-2019	24 months
E296-6	11970W	Harmonic Mixer 75-110GHz WR10	Hewlett Packard	#08-Dec-2020	3 months
E330	2224-20	Horn Antenna 26.5-40GHz	Flann (FMI)	28-Apr-2020	12 months
E412	E4440A	PSA 3 Hz - 26.5 GHz	Agilent Technologies	30-Jun-2020	24 months
E429	-	Filter Box 5 Switch Filters 0.91 GHz - 16.3 GHz	RN Electronics	#27-Aug-2020	12 months
E503	2524-20	Horn Antenna 50-75GHz	Flann (FMI)	28-Apr-2020	12 months
E580	24240	Horn Std Gain 40GHz - 60GHz	Flann (FMI)	28-Apr-2020	12 months
E627	DSO5052A	Oscilloscope 500MHz 2CH 4GSa/s	Agilent Technologies	#15-Jul-2020	12 months
E642	E4440A	PSA 3 Hz - 26.5 GHz	Agilent Technologies	11-Dec-2019	24 months
E717		Horn Std Gain 50-75GHz		28-Apr-2020	12 months
E718		Horn Std Gain 75-110GHz		28-Apr-2020	12 months
E743	2017 4/2dB	Attenuator 4/2dB 30-1000MHz	RN Electronics	07-Feb-2020	12 months
E755	N9030B	PXA 3Hz to 50GHz	Keysight Technologies	#04-Aug-2020	12 months
E856	N9039A	9 kHz - 1 GHz RF Filter Section	Agilent Technologies	#02-Dec-2020	12 months
F138	N5152A-H40	Down/Up Convertor WR15	Agilent Technologies/ RN Electronics	#06-Jan-2021	12 months
F139	ALN-62106025-01	Amplifier WR15	Ducommun	#06-Jan-2021	12 months
F140	115V	Isolator WR15	Mi-Wave	#06-Jan-2021	12 months
H070	M1970W	Waveguide harmonic mixer	Keysight Technologies	#09-Jan-2019	24 months
LPE364	CBL6112A	Antenna BiLog 30MHz - 2GHz	Chase Electronics Ltd	07-Mar-2020	24 months
NSA-M	NSA - M	NSA - Site M	RN Electronics	09-Jan-2019	36 months
TMS78	3160-08	Horn Std Gain 12.4-18 GHz	ETS Systems	#25-Aug-2020	12 months
TMS79	3160-09	Horn Std Gain 18-26.5 GHz	ETS Systems	#25-Aug-2020	12 months
TMS81	6502	Antenna Active Loop	EMCO	#24-Jun-2019	24 months
TMS82	8449B	Pre-Amplifier 1GHz - 26.5GHz	Agilent Technologies	#21-Dec-2020	12 months
VSWR-M	VSWR	VSWR 1-18GHz	RN Electronics	09-Jan-2019	36 months
ZSW1	V2.4	Measurement Software Suite	RN Electronics	Not applicable	

Equipment was within calibration dates for tests and/or has been re-calibrated since/during date of tests.

10 Auxiliary and peripheral equipment

10.1 Customer supplied equipment

Item No.	Model No.	Description	Manufacturer	Serial No.
1	-	Active GPS antenna	-	-

10.2 RN Electronics supplied equipment

RN No.	Model No.	Description	Manufacturer	Serial No
P276	D30 4	PSU 30V 4A	Farnell power supply	179
-	FS728TP	Switch with PoE	Netgear	-
-	BYX-1204000	AC/DC adaptor	Atolla	-

11 Condition of the equipment tested

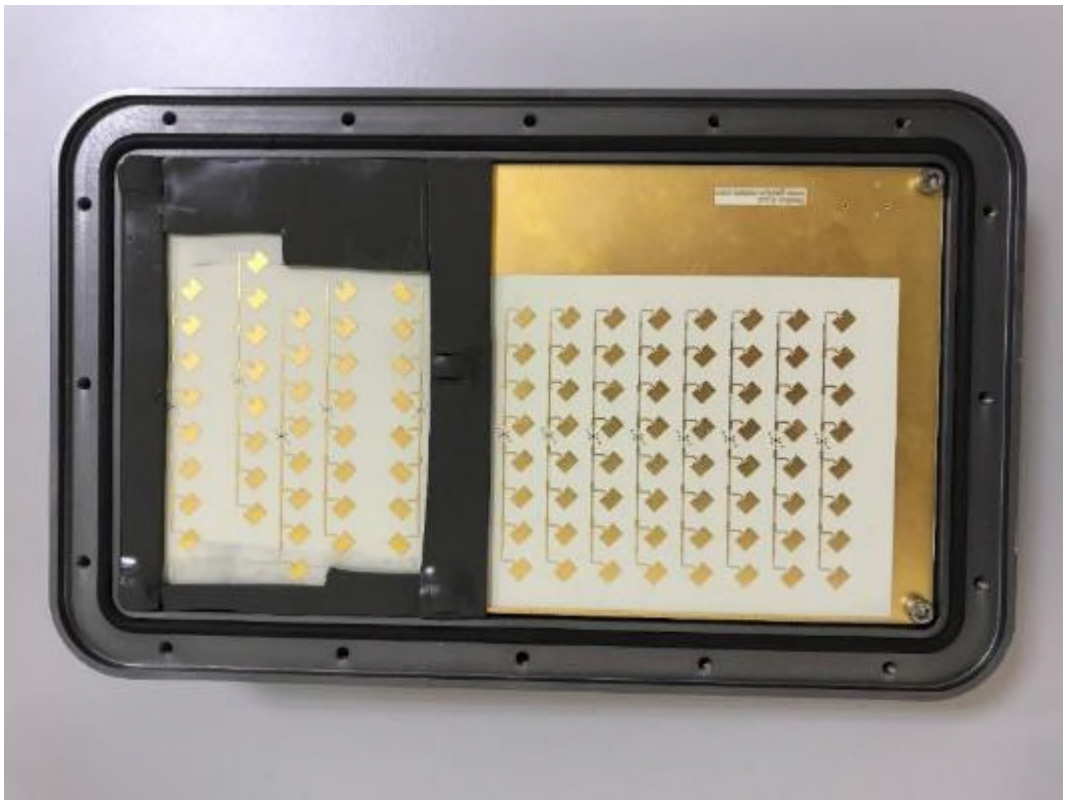
In order for the EUT to produce the results shown within this report the following modifications, if any, were implemented.

11.1 Modifications before test

A ferrite (Wurth Elektronik 742 700 77) was added to the DC power cable at the connector end in order to reduce generic radiated emissions.

11.2 Modifications during test

Additional absorber material (Laird CoolZorb 600) was added in the locations shown in order to reduce the level of the second harmonic of the fundamental.



12 Description of test sites

Site A Radio Laboratory and Anechoic Chamber

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

Site C Transient Laboratory

Site D Screened Room (Conducted Immunity)

Site E Screened Room (Control Room for Site D)

Site F Screened Room (Conducted Emissions)

Site G Screened Room (Control Room for Site H)

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

Site J Transient Laboratory

Site K Screened Room (Control Room for Site M)

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

Site N Radio Laboratory

Site Q Fully-Anechoic Chamber

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

Site R Screened Room (Conducted Immunity)

Site S Safety Laboratory

Site T Transient Laboratory

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

RN Electronics CAB identifier as issued by FCC is UK0015

13 Abbreviations and units

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