Global Product Certification
EMC-EMF Safety Approvals

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RADIO REPORT FOR CERTIFICATION
47 CFR PART 15 SUBPART C (SECTION 15.247)

Client:	**IMAGINASTIX PTY LTD**
Device Under Test / PMN:	**LONE WORKER 2.0 (ANTENNA MODULE)**
Model Number / HVIN:	**LW2 ANTENNA**
FCC ID:	**2AOJ3-LW2ANT-AU-US**
Report Number:	**M170836-1**
Date of Issue:	**28 May 2018**

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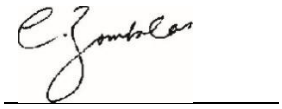
RADIO REPORT
CERTIFICATE OF COMPLIANCE

Device / PMN:	Lone Worker 2.0 (Antenna Module)
Model Number / HVIN:	LW2 Antenna
Manufacturer:	Wavetronics Pty Ltd
Tested for:	Imaginastix Pty Ltd
Address:	57 Crawshaw Crescent, Manning, WA 6152
Phone:	0402 300 800
Contact:	Steve Melitzky
Email:	stevem@imaginastix.com
Standards:	**47 CFR Part 15 –** Radio Frequency Devices **Subpart C –** Intentional Radiators **Section 15.247 –** Operation within the bands 902-928 MHz, 2400-2483.5 MHz, and 5725-5850 MHz
Result:	The Lone Worker 2.0 (Antenna Module) complied with the applicable requirements of 47 CFR Part 15 Subpart C for a Frequency Hopping Spread Spectrum transceiver.
Test Dates:	30 August 2017 to 30 January 2018
Issue Date:	28 May 2018
Issued by:	**EMC TECHNOLOGIES PTY. LTD.,** 176 Harrick Road, Keilor Park, VIC 3042, Australia. Phone: +61 3 9365 1000, Web: www.emctech.com.au

Test Officer: William Alam, Test Engineer; Ian Ng, Test Engineer



Authorised Signatory: Chris Zombolas, Technical Director

Attestation: I hereby certify that the device(s) described herein were tested as described in this report and that the data included is that which was obtained during such testing.

RADIO REPORT FOR CERTIFICATION
to
47 CFR Part 15 Subpart C (section 15.247) and

1.0 INTRODUCTION

Radio tests were performed on the Lone Worker 2.0 (Antenna Module) in accordance with the applicable requirements of 47 CFR, Part 15 Subpart C – Section 15.247 for a Frequency Hopping Spread Spectrum Transceiver (FHSS) operating within the band 902 to 928 MHz.

1.1 Test Procedure

Radio measurements were performed in accordance with the appropriate procedures of ANSI C63.10: 2013.

The measurement instrumentation conformed to the requirements of ANSI C63.2: 2009.

1.2 Summary of 47 CFR Part 15 Subpart C Results

FCC	Test Performed	Results
15.203	Antenna requirement	**Complied**
15.205	Restricted bands of operation	**Complied**
15.207	Conducted limits	**Not Applicable**
15.209	Radiated emissions limits; general requirements	**Complied**
15.247 (a)	Channel Separation	**Complied**
	Number of channels and time of occupancy	**Complied**
15.247 (b)	Peak Output Power	**Complied**
15.247 (c)	Antenna Gain > 6 dBi	**Not Applicable**
15.247 (d)	Out of Band Emissions	**Complied**
15.247 (e)	Peak Power Spectral Density	**Not Applicable**
15.247 (f)	Hybrid Systems	**Not Applicable**
15.247 (g)	FHS with continuous data streams and short bursts	**Complied**
15.247 (h)	Adaptivity	
15.247 (i)	Radio Frequency Hazard	**Complied**
2.1049	Occupied Bandwidth	**Complied**

2.0 GENERAL INFORMATION
(Information supplied by the Client)

2.1 EUT (Transmitter) Details

Radio:	Frequency Hopping Spread Spectrum (FHSS)
Frequency Band:	902 to 928 MHz
Frequency Range:	916 to 927 MHz Ch. Low: 916.175 MHz Ch. Mid: 921.480 MHz Ch. High: 926.780 MHz
Modulation:	FHSS
Emission Designator:	X1D
Antenna type and gain:	PCB Spring Antenna, Antenna gain unknown, assume 0 dBi

2.2 EUT (Host) Details

Device under Test / PMN:	Lone Worker 2.0 (Antenna Module)
Model Number / HVIN:	LW2 Antenna
Manufacturer:	Wavetronics Pty Ltd
Power Supply:	5 VDC external supply

Product is a man-down or lone worker system that primarily includes a Remote worn by a worker that communicates with an Antenna Module in the vehicle to ensure that the user is within range and if required can provide reliable duress scenarios from the worker to the vehicle including GPS position of the worker.

2.3 Test Configuration

The EUT was configured to transmit at lowest, middle, highest frequency and hopping mode.

2.4 Modifications by EMC Technologies

No modifications were performed.

2.5 Test Facility

2.5.1 General

EMC Technologies Pty Ltd has also been accredited as a Conformity Assessment Body (CAB) by Australian Communications and Media Authority (ACMA) under the APECTEL MRA and is designated to perform compliance testing on equipment subject to Declaration of Conformity (DoC) and Certification under Parts 15 and 18 of the FCC Commission's rules – **Registration Number 494713 & Designation number AU0001.**

EMC Technologies indoor open are test site (iOATS) have been accepted by Industry Canada for the performance of radiated measurements in accordance with RSS-Gen, Issue 8 - **Industry Canada iOATS number - IC 3569B**

Measurements in this report were performed at EMC Technologies' laboratory in Keilor Park, Victoria Australia.

2.5.2 NATA Accreditation

EMC Technologies is accredited in Australia by the National Association of Testing Authorities (NATA). All testing in this report has been conducted in accordance with EMC Technologies' scope of NATA accreditation.

NATA is the Australian National laboratory accreditation body and has accredited EMC Technologies to IEC/ISO17025. A major requirement for accreditation is the assessment of the company and its personnel as being technically competent in testing to the standards. This requires documented test procedures, continued calibration of measurement equipment, traceable to the National Standard at the National Measurements Institute (NMI) and an internal quality system to ISO 9002. NATA has mutual recognition agreements with the National Voluntary Laboratory Accreditation Program (NVLAP) and the American Association for Laboratory Accreditation (A^2LA).

The current full scope of accreditation can be found on the NATA website: www.nata.com.au

2.6 Test Equipment Calibration

Measurement instrumentation and transducers were calibrated in accordance with the applicable standards by an independent NATA registered laboratory such as Agilent Technologies (Australia) Pty Ltd or the National Measurement Institute (NMI) or in-house. All equipment calibration is traceable to Australian national standards at the National Measurements Institute.

Equipment Type	Make/Model/Serial Number	Last Cal. dd/mm/yyyy	Due Date dd/mm/yyyy	Cal. Interval
Chamber	Frankonia SAC-10-2 (R-139)	22/03/2017	22/03/2018	1 Year, *1
EMI Receiver	R&S ESW26, 2 Hz – 26.5 GHz Sn: 101306 (R-143)	31/03/2017	31/03/2018	1 Year, *2
Antennas	EMCO 6502 Active Loop 9 kHz – 30 MHz Sn. 9311-2801 (A-231)	20/07/2015	20/07/2018	3 Year, *2
	SUNOL JB6 Biconilog 30 – 6000 MHz Sn. A012312 (A-363)	26/05/2016	26/05/2018	2 Year, *2
	EMCO 3115 Double Ridge Horn 1 – 18 GHz Sn: 8908-3282 (A-004)	15/07/2016	15/07/2019	3 Year, *1
Cables	Room 12 inbuilt cable Panel 1 to 10 m (C-422)	31/05/2017	31/05/2018	1 Year, *1
	Room 12 inbuilt cable Panel 1 to 3 m (C-421)	31/05/2017	31/05/2018	1 Year, *1
	Room 12 Antenna cable (C-437)	31/05/2017	31/05/2018	1 Year, *1
	Sucoflex 104 Huber & Suhner 18 GHz, 5 m cable (C-337)	03/01/2017	03/01/2018	1 Year, *1

Note *1. Internal NATA calibration.
Note *2. External NATA / A2LA calibration

3.0 TEST RESULTS

3.1 §15.203 Antenna Requirement

The antenna was internal to the device ensuring that it could not be replaced.

3.2 §15.207 Conducted Limits

The device did not connect directly or indirectly to the AC mains network.

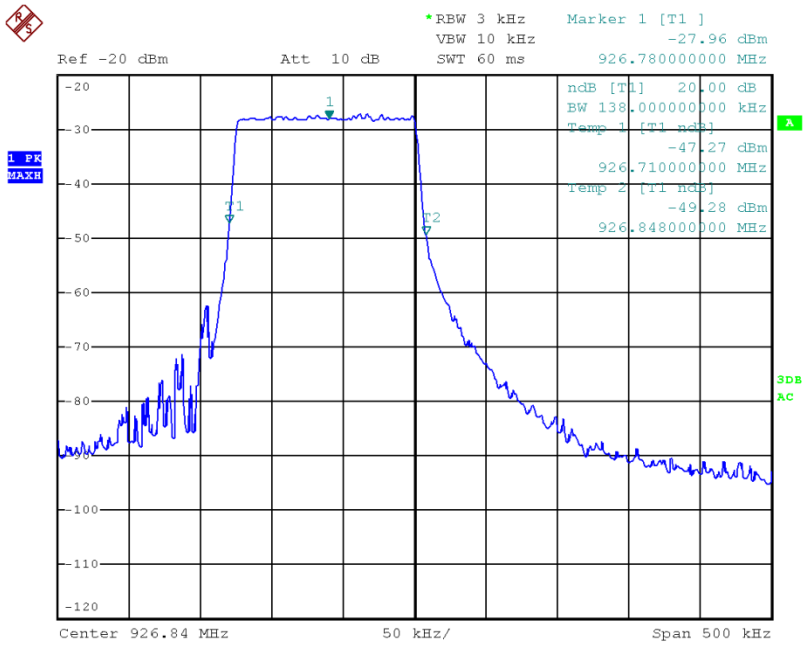
3.3 §15.247(a1) Channel Separation

In the band 902 – 928 MHz, the channel separation must be more than 25 kHz or the 20 dB bandwidth, whichever is greater.

20 dB Emission Bandwidth

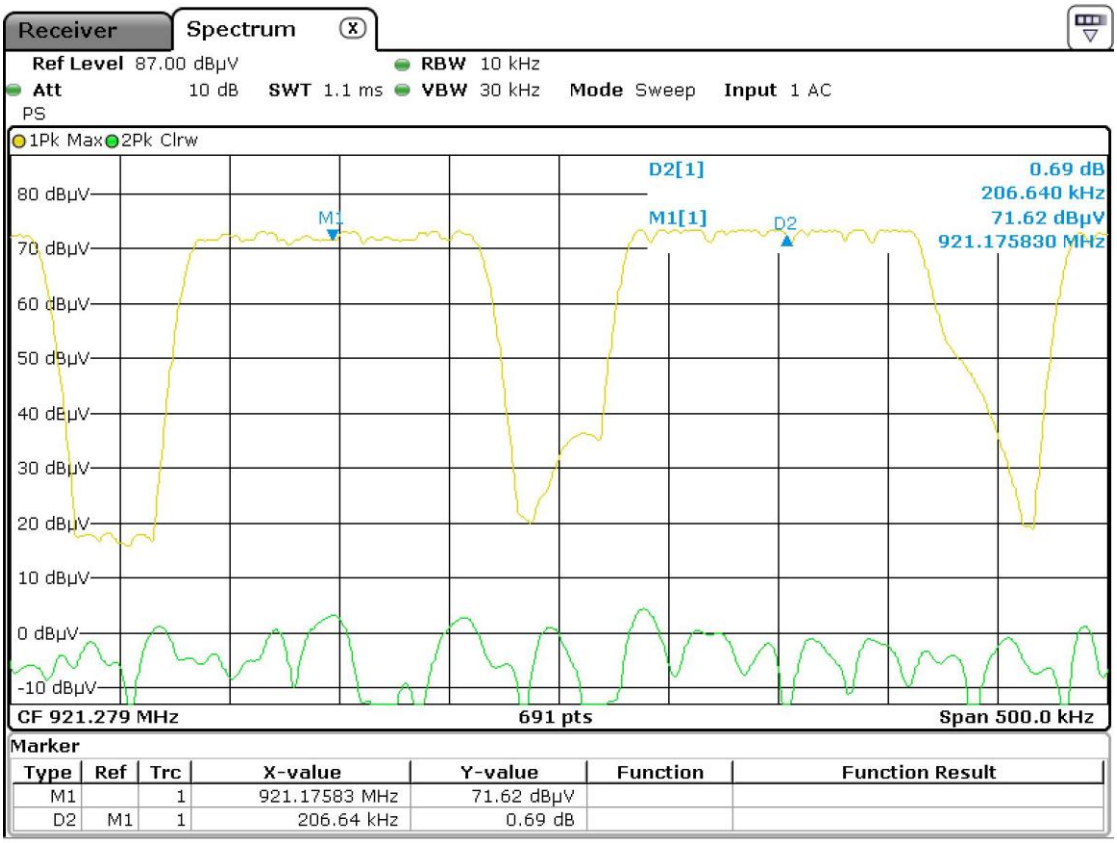
Centre Frequency [MHz]	20 dB Bandwidth [kHz]
916.175	138.0
921.480	137.0
926.780	138.0

The largest 20 dB bandwidth was measured on highest channel:



Channel Separation

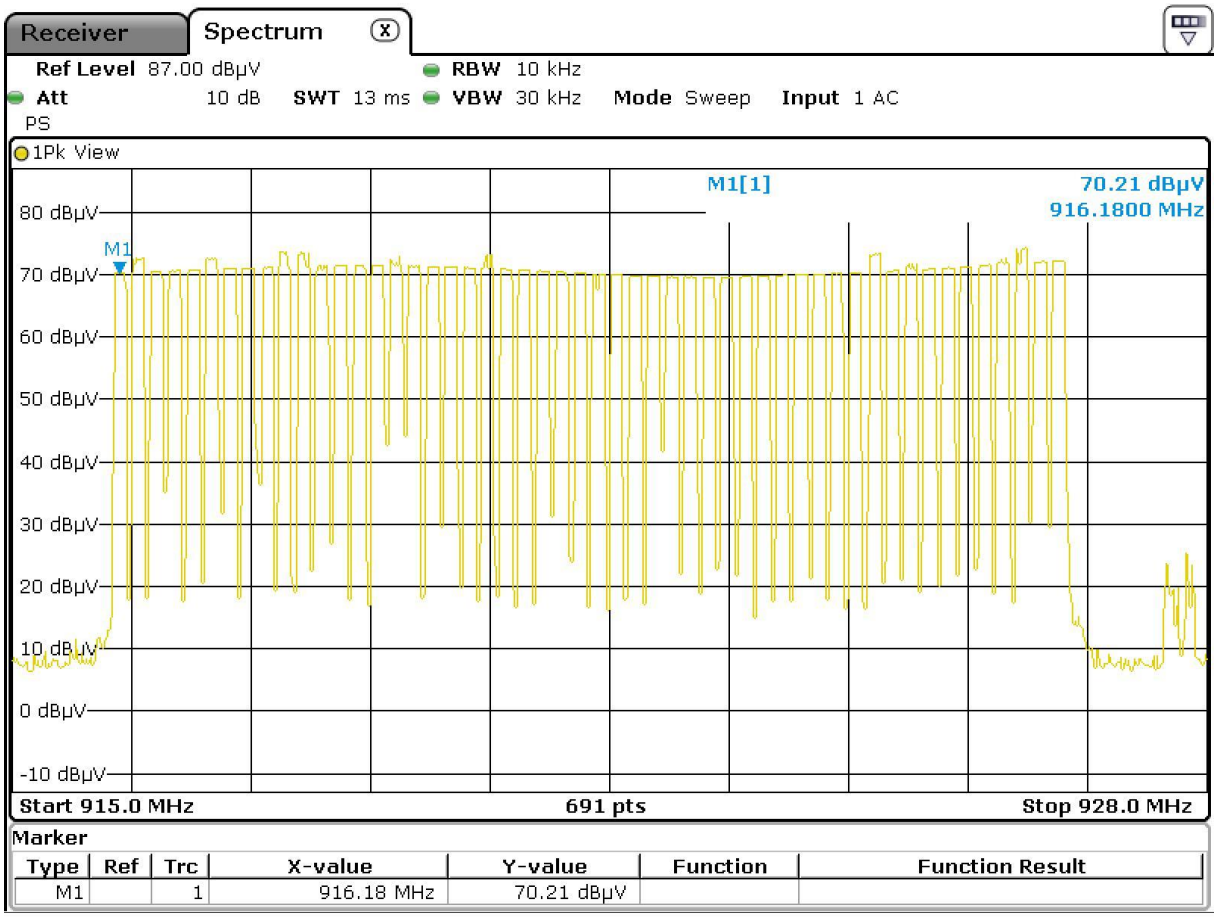
Channel Separation [kHz]	Limit [kHz]	Result
206.64	159.80	Complied



3.4 §15.247(a1) Number of channels and time of occupancy

Number of Channels

There must be at least 50 hopping channels employed by devices operating in the band 902-928 MHz. The Lone Worker 2.0 (Antenna Module) utilised 52 channels:

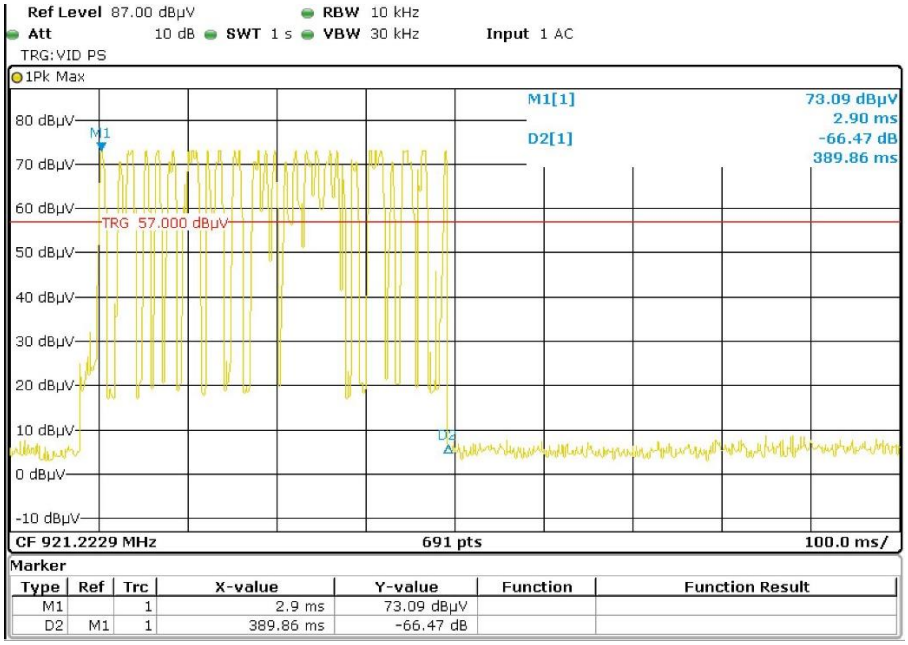


Time of Occupancy

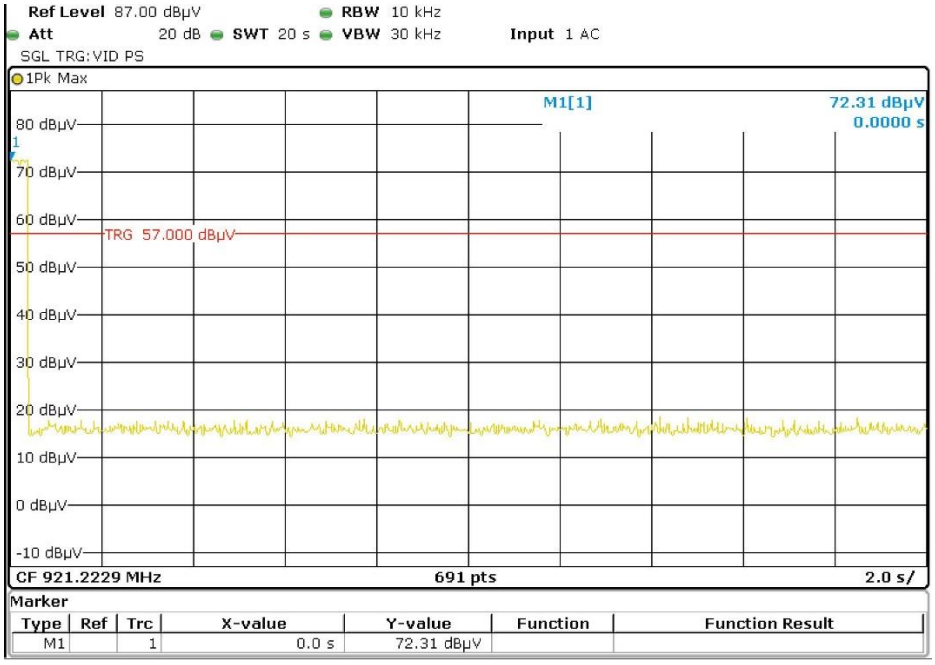
The average time of occupancy on any channel shall not be greater than 0.4 seconds within a 20 seconds period.

On time of one pulse = 389.86 ms
Number of pulses in 20 seconds = 1 pulse
Total on time in 20 seconds = **389.86 ms** (limit = 400 ms)

Duration of one pulse:



Pulses in 20 seconds:



3.5 §15.247(b3) Peak Output power

Testing was performed in a semi-anechoic chamber at a distance of 10 metres. Different configurations of EUT and antenna polarization were investigated to produce highest emission EIRP and the EUT was set to transmit in continuous transmission mode without modulation.

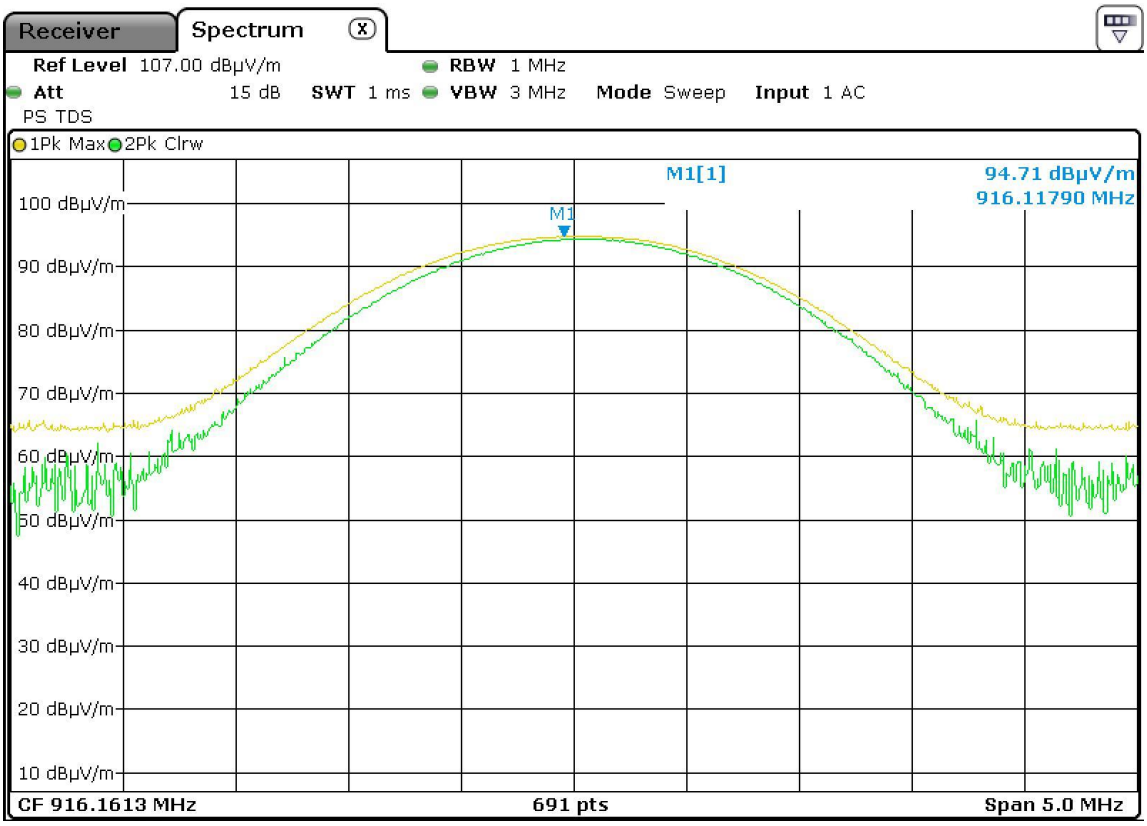
Results:

Freq. (MHz)	10 m Field (dBµV/m)	EIRP		Limit	Ant. Gain (dBi)	Conducted power		Limit	Margin
		(dBm)	(W)	(W)		(dBm)	(W)	(W)	(W)
916.175	94.71	9.94	0.010	4	0	9.94	0.010	1	-0.999
921.480	95.39	10.62	0.012	4	0	10.62	0.012	1	-0.988
926.780	96.18	11.41	0.014	4	0	11.41	0.014	1	-0.986

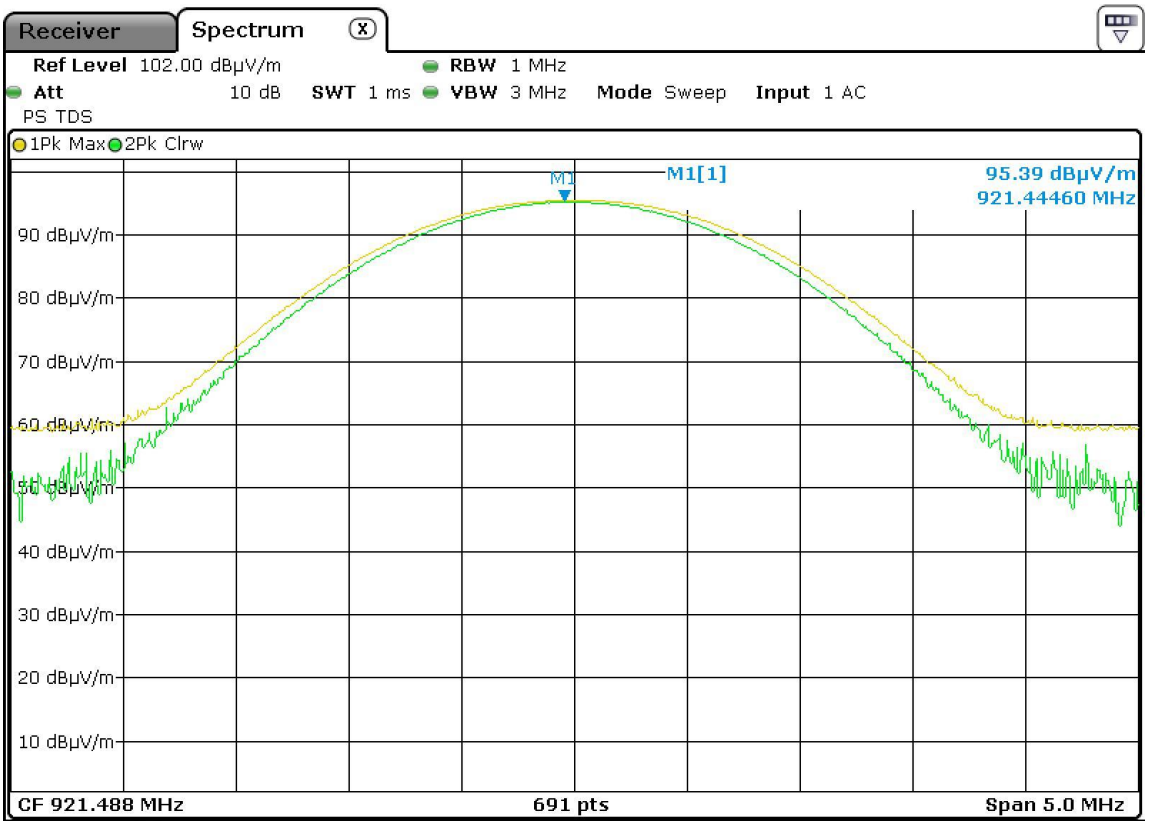
dBµV/m to dBm conversion:

$$E = 20.log\left(\frac{\sqrt{30.P}}{d}\right) + 120$$

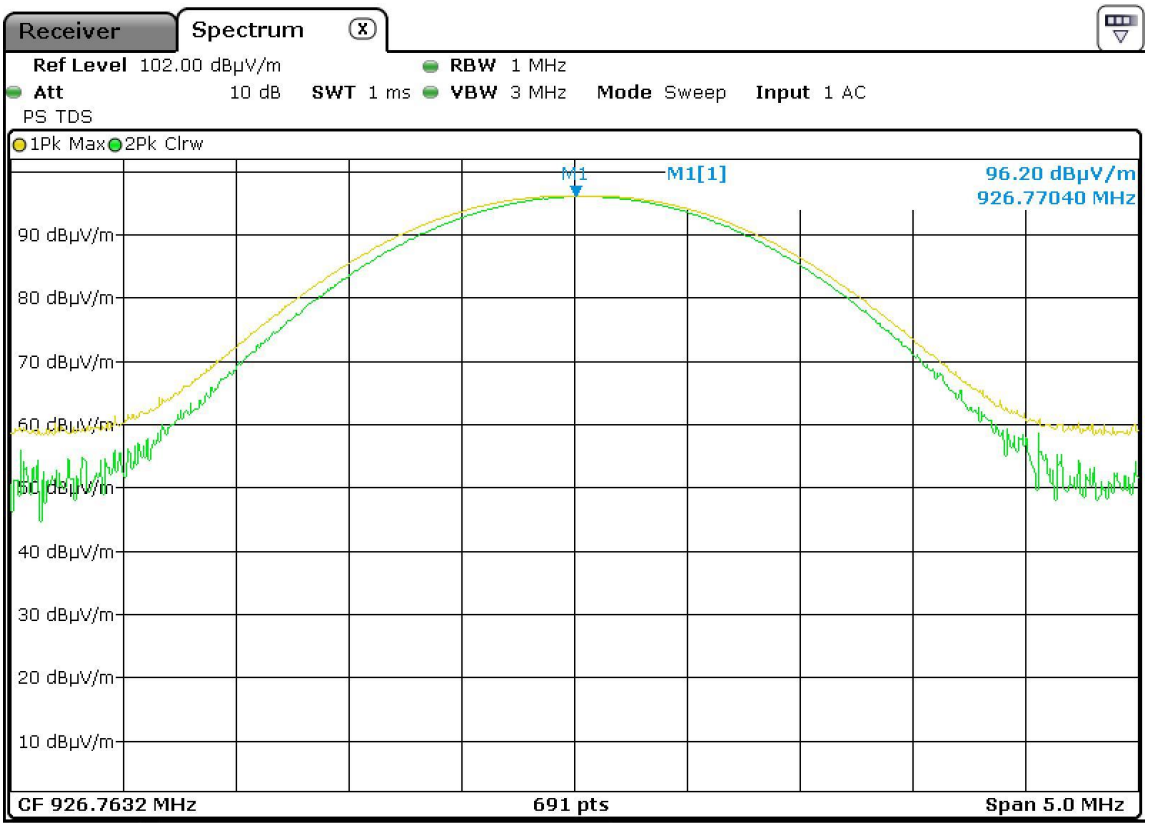
Where: E = electric field strength (dBµV/m)
P = EIRP in Watts
d = measurement distance in metres



Channel 916.175 MHz



Channel 921.480 MHz



Channel 926.780 MHz

3.6 §15.205 Restricted Bands of Operation

The restricted band limits were applied.

3.7 §15.209 Radiated emission limits; general requirements

The limits given in §15.247 applied, however attenuation below the general levels was not required.

3.8 §15.247(d) Out of Band Emissions

3.8.1 Radiated Spurious Measurements

Radiated spurious emission measurements were performed in a semi-anechoic chamber compliant with ANSI C63.4: 2014.

The test frequency range was sub-divided into smaller bands with sufficient frequency resolution to permit reliable display and identification of emissions.

Frequency range [MHz]	Measurement Bandwidth [kHz]	Measurement Distance [m]	Antenna
0.009 to 0.150	0.2	10	0.6 metre loop
0.150 to 30	9	10	
30 to 1000	120	10	Biconilog hybrid
1000 to 18 000	1000	3	Standard gain or broad band horns
18 000 to 40 000	1000	1	

The sample was slowly rotated with the spectrum analyser set to Max-Hold. This was performed for at least two antenna heights. When an emission was located, it was positively identified and its maximum level found by rotating the automated turntable and by varying the antenna height. Devices design for a fixed position were tested in that position, portable devices were tested in three orthogonal orientations.

The measurement data for each frequency range was corrected for cable losses, antenna factors and preamplifier gain. This process was performed for both horizontal and vertical antenna polarisations.

Calculation of field strength

The field strength was calculated automatically by the software using the pre-stored calibration data. The method of calculation is shown below:

$$E = V + AF - G + L$$

Where: E = Radiated Field Strength in dBµV/m.
V = EMI Receiver Voltage in dBµV/m.
AF = Antenna Factor in dB. (stored as a data array)
G = Preamplifier Gain in dB. (stored as a data array)
L = Cable loss in dB. (stored as a data array of Insertion Loss versus frequency)

Field strength conversion over distance

To convert a limit given at a certain distance to a limit at the measurement distance or vice-versa the following equation was applied:

$$E_x = 20 \times \log\left(\frac{d_y \times 10^{E_y/20}}{d_x}\right)$$

Where: E_x = Electric field at x metres (dBµV/m)
E_y = Electric field at y metres (dBµV/m)
d_x = Measurement distance of x metres
d_y = Measurement distance of y metres

3.8.2 Spurious Emission Limit

In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power.

Channel [MHz]	100 kHz BW Power at 10 m [dBµV/m]	Limit		
		10 m [dBµV/m]	3 m [dBµV/m]	1 m [dBµV/m]
926.780	96.1	76.1	86.6	96.1

3.8.3 Radiated Spurious Emission Tabulated Results

Frequency Band: 9 kHz - 30 MHz

Limit 15.209 was applied over the full range, 9 kHz to 30 MHz.

Channel [MHz]	Polarity	Frequency [MHz]	Quasi-Peak [dBµV/m]		Limit [dBµV/m]	Margin [dB]
			10 m (Meas.)	30 m (Calc.)		
916.175	G-Para.	16.656	22.7	13.2	30	-16.8

Frequency Band: 30 - 1000 MHz

Limit 15.209 was applied over the full range, 30 MHz to 1000 MHz.

Channel [MHz]	Polarity	Frequency [MHz]	Quasi-Peak [dBµV/m]		Limit [dBµV/m]	Margin [dB]
			10 m (Meas.)	3 m (Calc.)		
926.780	Vertical	929.00	40.5	51.0	92.2	41.2
	Vertical	211.29	26.0	36.5	92.2	55.7

Frequency Band: 1 000 – 10 000 MHz

Average Detector Results:

Average measurements were determined according to ANSI C63.10:2013 clause 7.5.

Duty cycle correction factor was applied to peak values to determine average values.

$$\delta(dB) = 20\log(\Delta)$$

Where: $\delta(dB)$= -31.14

Δ = 3.11%

Channel [MHz]	Polarity	Frequency [GHz]	3 m Average [dBµV/m]	Limit [dBµV/m]	Margin [dB]
916.175	Vertical	7.320	31.1	54.0	-22.9
921.480	Vertical	7.372	30.6	54.0	-23.4
921.480	Horizontal	2.764	29.2	54.0	-24.8
926.780	Horizontal	2.780	29.0	54.0	-25.0
916.175	Horizontal	2.478	28.6	54.0	-25.4
926.780	Vertical	7.414	28.3	54.0	-25.7
921.480	Vertical	2.764	27.9	54.0	-26.1
916.175	Vertical	2.740	27.9	54.0	-26.1
916.175	Horizontal	8.245	27.4	54.0	-26.6
916.175	Vertical	3.664	27.2	54.0	-26.8
921.480	Vertical	3.686	27.2	54.0	-26.8
921.480	Horizontal	8.294	26.7	54.0	-27.3
916.175	Vertical	9.162	26.7	54.0	-27.3
916.175	Horizontal	7.330	26.5	54.0	-27.5
926.780	Horizontal	7.414	26.2	54.0	-27.8
916.175	Horizontal	3.664	25.6	54.0	-28.4
926.780	Vertical	3.707	24.0	54.0	-30.0
926.780	Horizontal	8.341	23.8	54.0	-30.2
921.480	Horizontal	3.685	23.4	54.0	-30.6
916.175	Horizontal	9.162	23.2	54.0	-30.8
916.175	Vertical	8.246	23.0	54.0	-31.0
926.780	Vertical	8.341	22.7	54.0	-31.3
921.480	Horizontal	4.607	22.6	54.0	-31.4
921.480	Vertical	8.294	21.8	54.0	-32.2
916.175	Vertical	7.320	31.1	54.0	-22.9
921.480	Vertical	7.372	30.6	54.0	-23.4
921.480	Horizontal	2.764	29.2	54.0	-24.8

Peak Detector Results:

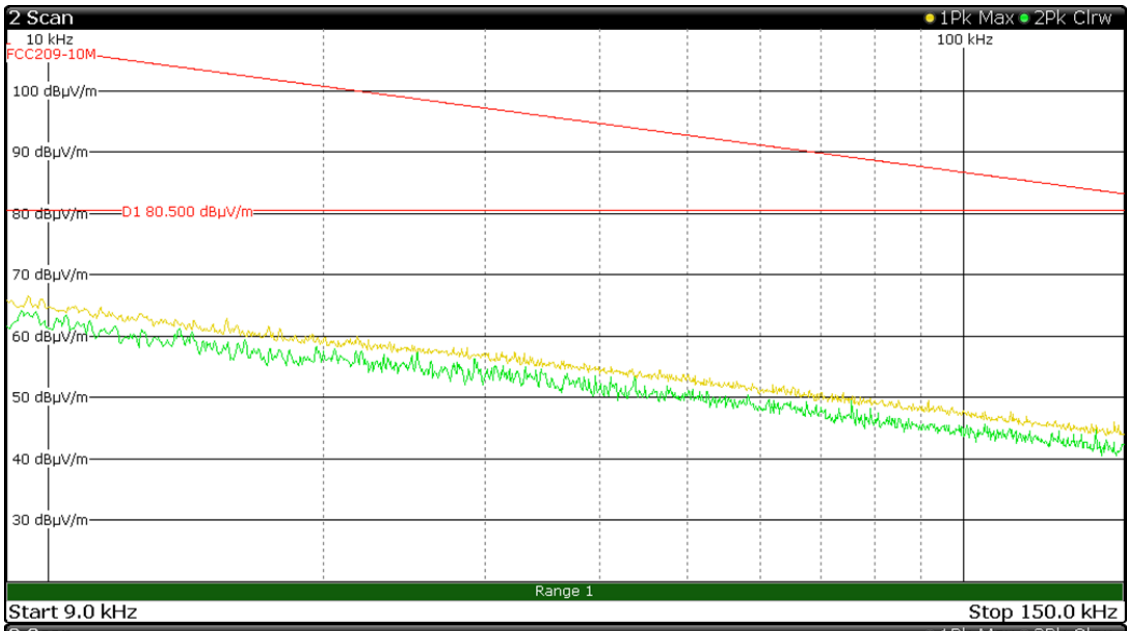
Channel [MHz]	Polarity	Frequency [GHz]	3 m Peak [dBµV/m]	Limit [dBµV/m]	Margin [dB]
916.175	Vertical	7.320	61.2	74.0	-12.8
921.480	Vertical	7.372	60.7	74.0	-13.3
926.780	Vertical	7.414	59.3	74.0	-14.7
916.175	Horizontal	8.245	59.1	74.0	-14.9
916.175	Vertical	9.162	58.7	74.0	-15.3
921.480	Horizontal	8.293	58.4	74.0	-15.6
916.175	Horizontal	9.162	58.0	74.0	-16.0
926.780	Horizontal	8.340	58.0	74.0	-16.0
916.175	Vertical	8.246	57.5	74.0	-16.5
921.480	Vertical	8.294	57.3	74.0	-16.7
926.780	Vertical	8.340	57.3	74.0	-16.7
916.175	Horizontal	7.330	56.8	74.0	-17.2
921.480	Horizontal	2.764	56.8	74.0	-17.2
926.780	Horizontal	2.780	56.6	74.0	-17.4
916.175	Horizontal	2.748	56.3	74.0	-17.7
926.780	Horizontal	7.414	55.7	74.0	-18.3
916.175	Vertical	3.664	54.1	74.0	-19.9
921.480	Vertical	3.686	53.9	74.0	-20.1
921.480	Vertical	2.764	53.5	74.0	-20.5
916.175	Vertical	2.740	53.3	74.0	-20.7
916.175	Horizontal	3.664	53.1	74.0	-20.9
921.480	Horizontal	3.685	52.8	74.0	-21.2
926.780	Vertical	3.707	52.7	74.0	-21.3
921.480	Horizontal	4.607	51.9	74.0	-22.1
916.175	Vertical	7.320	61.2	74.0	-12.8
921.480	Vertical	7.372	60.7	74.0	-13.3
926.780	Vertical	7.414	59.3	74.0	-14.7

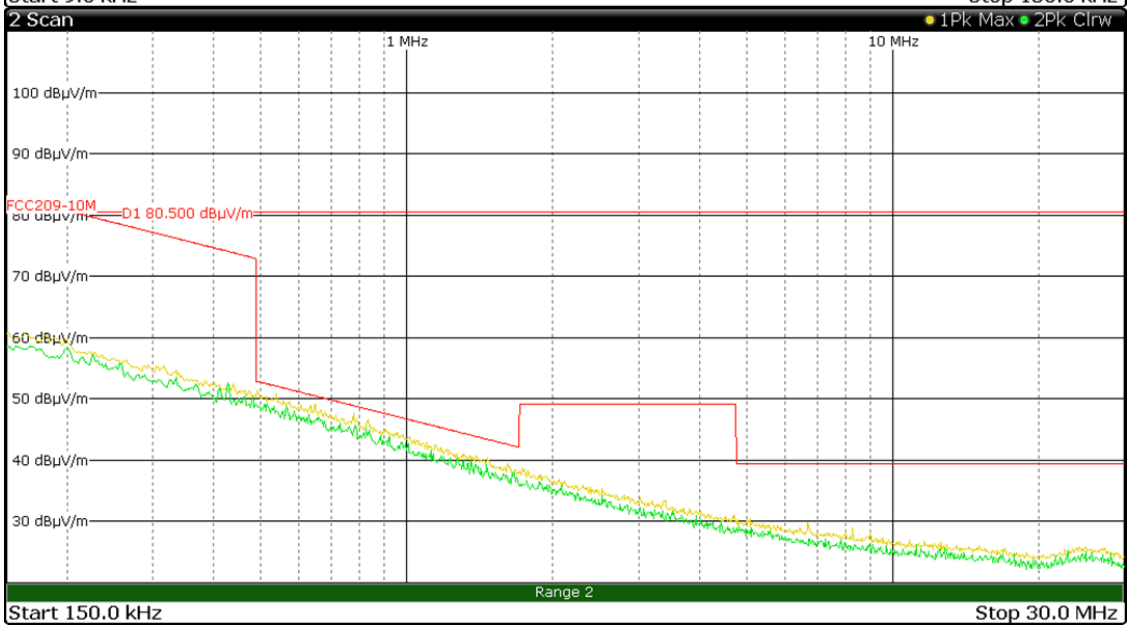
Band-edge measurement results:

Channel [MHz]	Frequency [GHz]	10 m Peak [dBµV/m]	Limit [dBµV/m]	Margin [dB]
916.175	902.000	29.93	76.1	-46.17
926.780	928.000	29.17	76.1	-46.93
926.780	928.000	33.04	76.1	-43.06

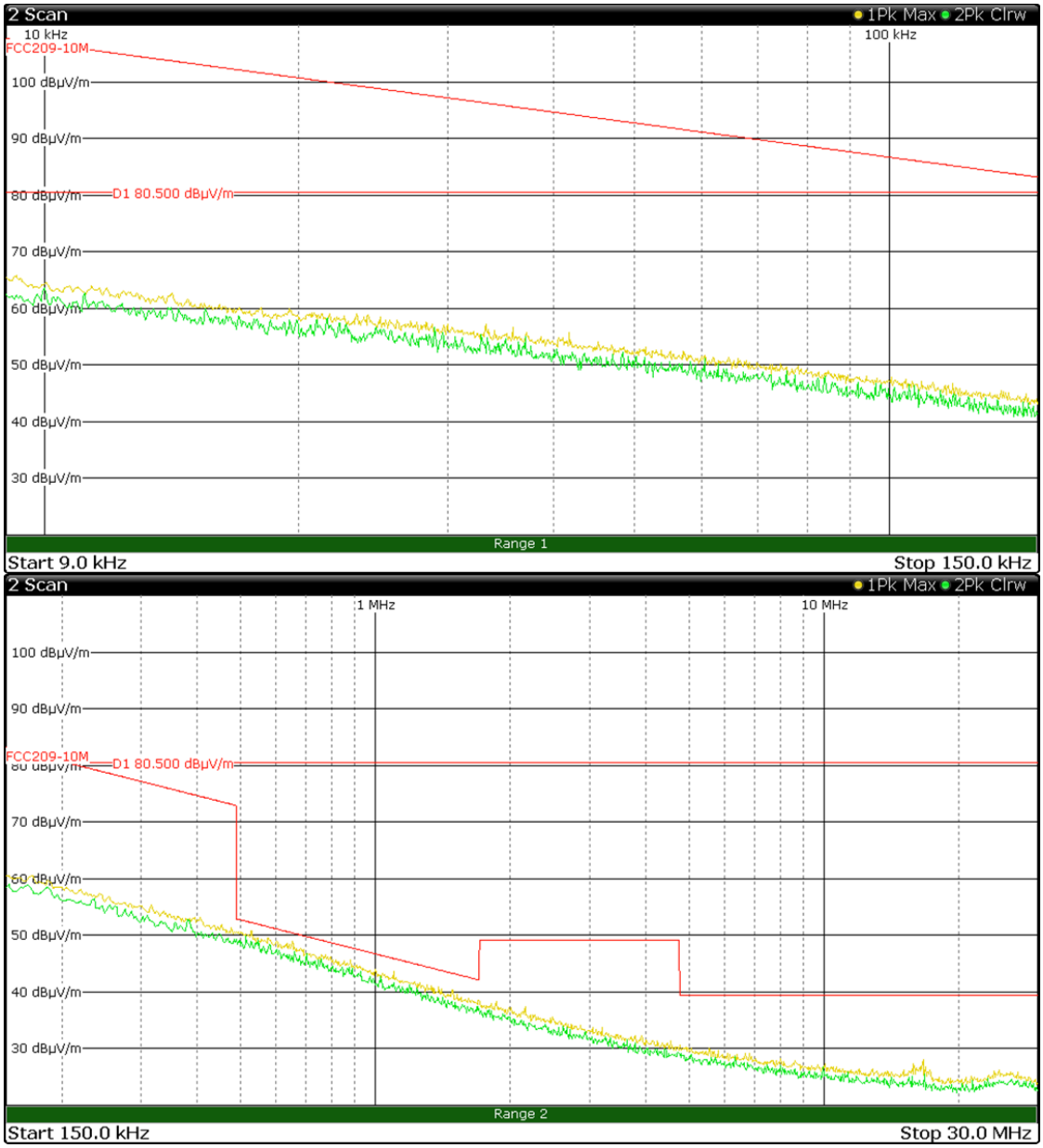
3.8.4 Frequency Band: 9 kHz - 30 MHz

Measurements were made at a distance of 10 metres. The measurement of emissions between 9 kHz – 150 kHz were made with a resolution bandwidth (RBW) of 200 Hz and the video bandwidth (VBW) of 3 kHz, 150 kHz – 30 MHz were measured with the resolution bandwidth (RBW) of 9 kHz and the video bandwidth (VBW) of 30 kHz. Measurements were made with the loop antenna oriented perpendicular, parallel and ground-parallel with respect to the sample. The emissions with the sample transmitting on the lowest, middle and highest channels were measured. Only the graphs of maximum emissions have been reported.

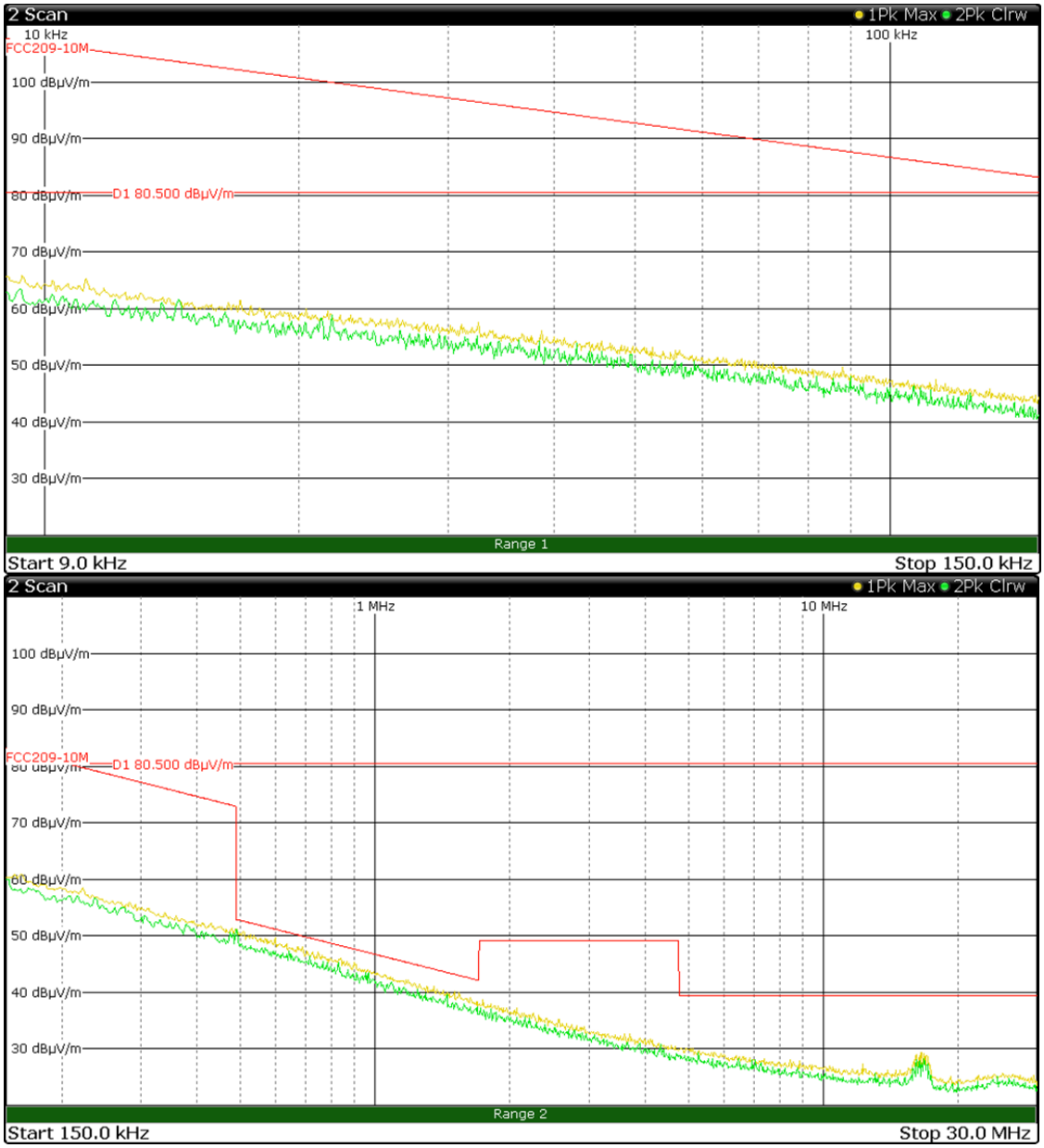




Channel 916.175 MHz – Parallel



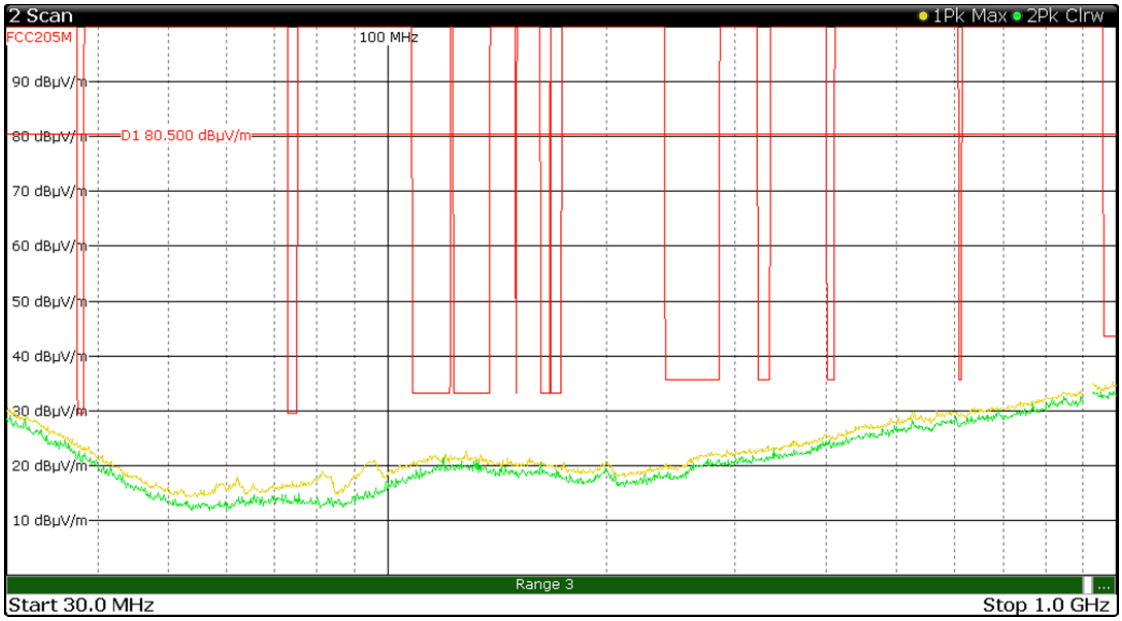
Channel 916.175 MHz – Perpendicular



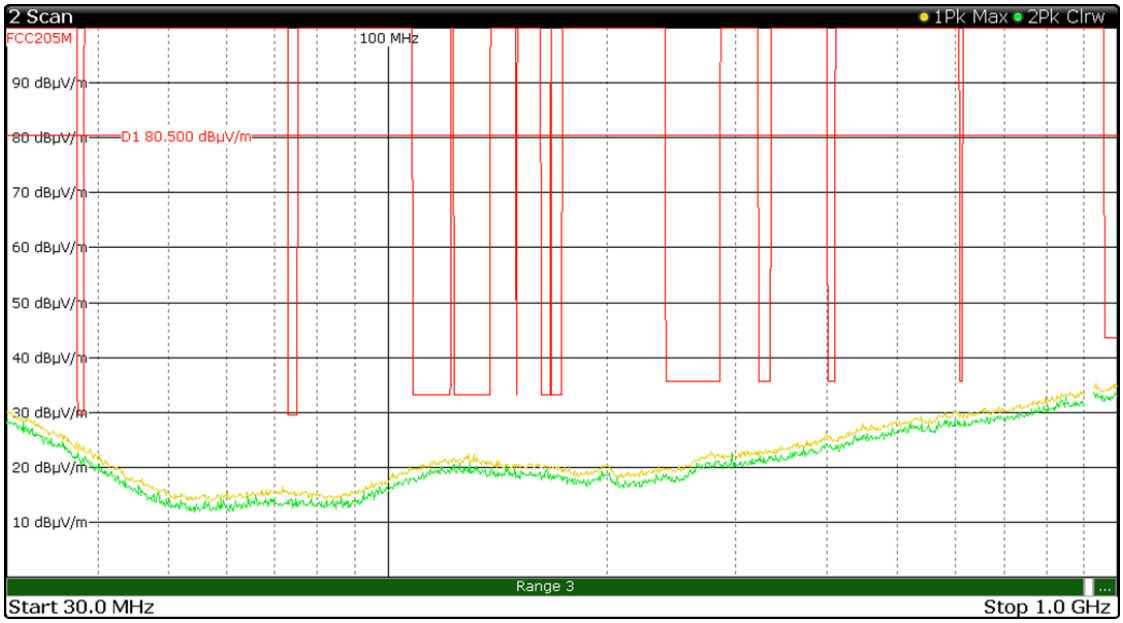
Channel 916.175 MHz – Ground Parallel

3.8.5 Frequency Band: 30 - 1000 MHz

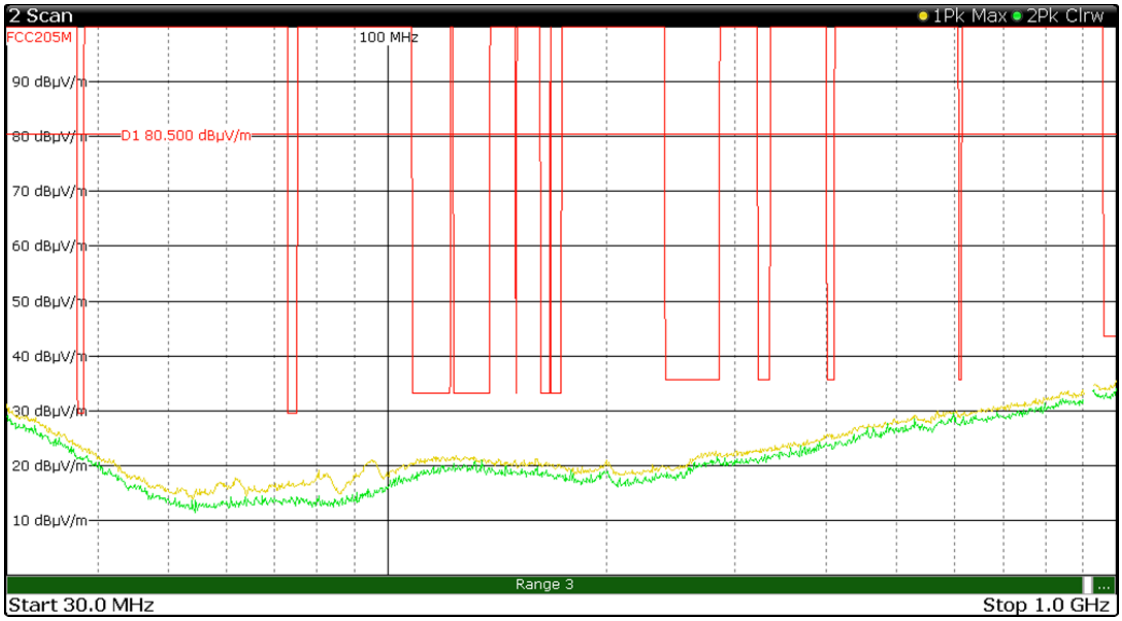
Measurements were made at a distance of 10 metres. The measurement of emissions between 30 - 1000 MHz were made with a resolution bandwidth (RBW) of 120 kHz and the video bandwidth (VBW) of 300 kHz.



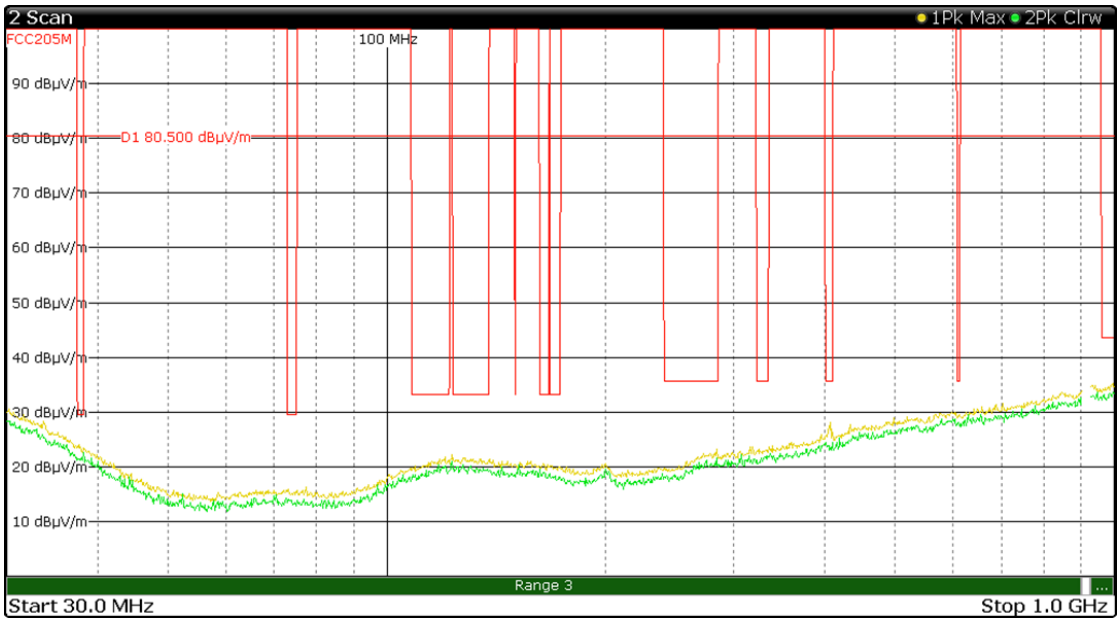
Channel 916.175 MHz - Vertical



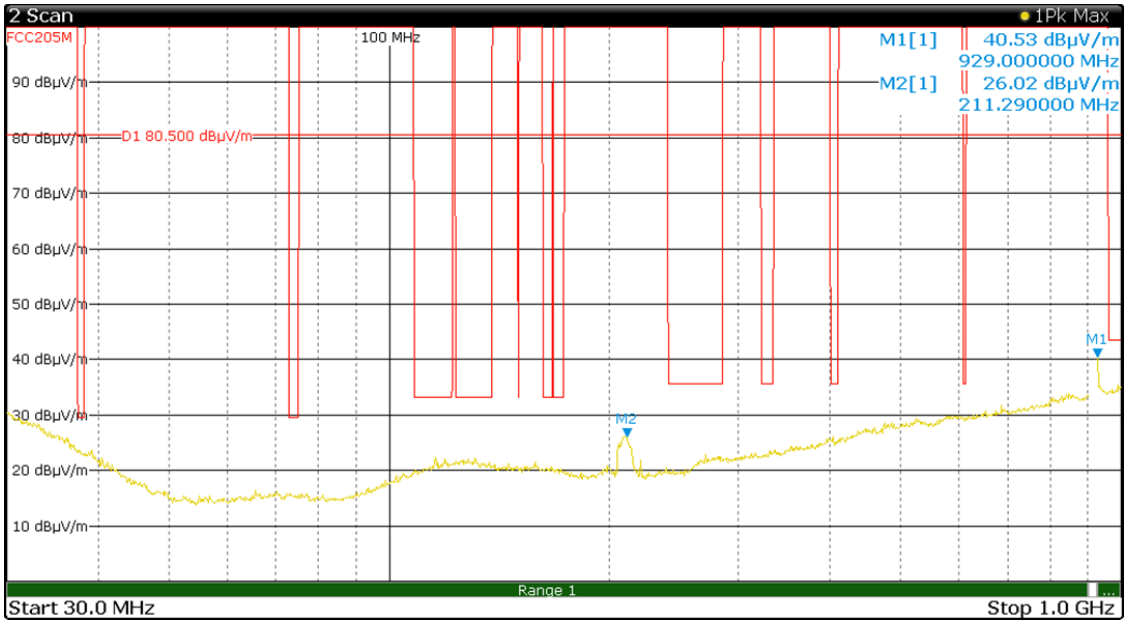
Channel 916.175 MHz - Horizontal



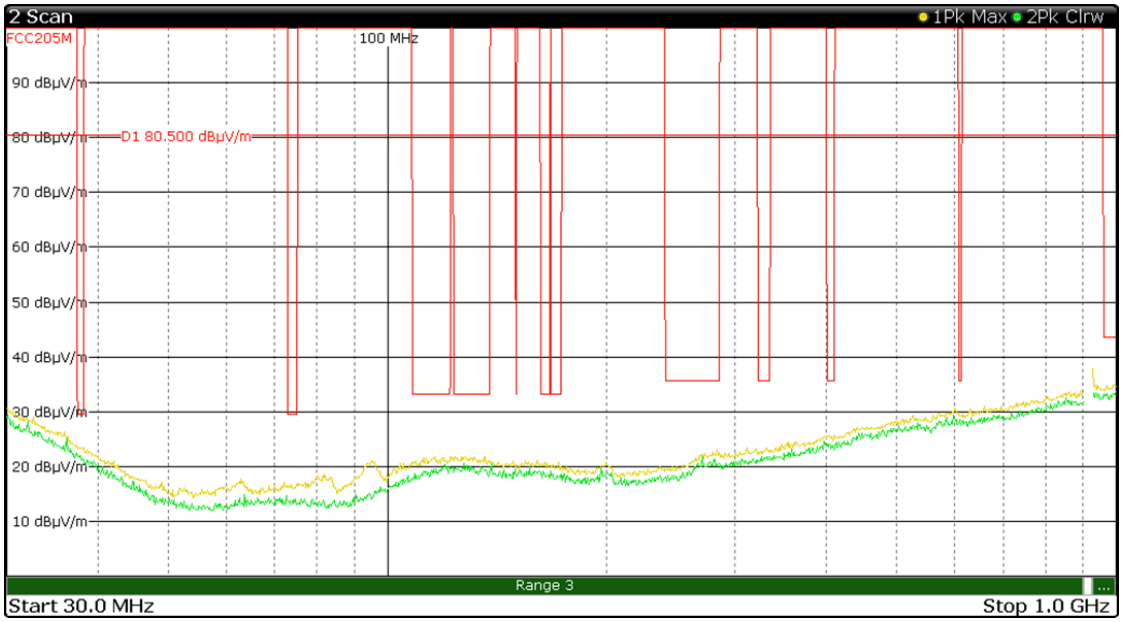
Channel 921.480 MHz - Vertical



Channel 921.480 MHz - Horizontal



Channel 926.780 MHz - Vertical



Channel 926.780 MHz - Horizontal

3.8.6 Frequency Band: 1 000 – 10 000 MHz

Measurements to 10 GHz were made at a distance of 3 metres. The measurements were made with a resolution bandwidth (RBW) of 1000 kHz and the video bandwidth (VBW) of 1000 kHz.

Channel 916.175 - Vertical

Channel 916.175 - Horizontal

Channel 921.480 MHz - Vertical

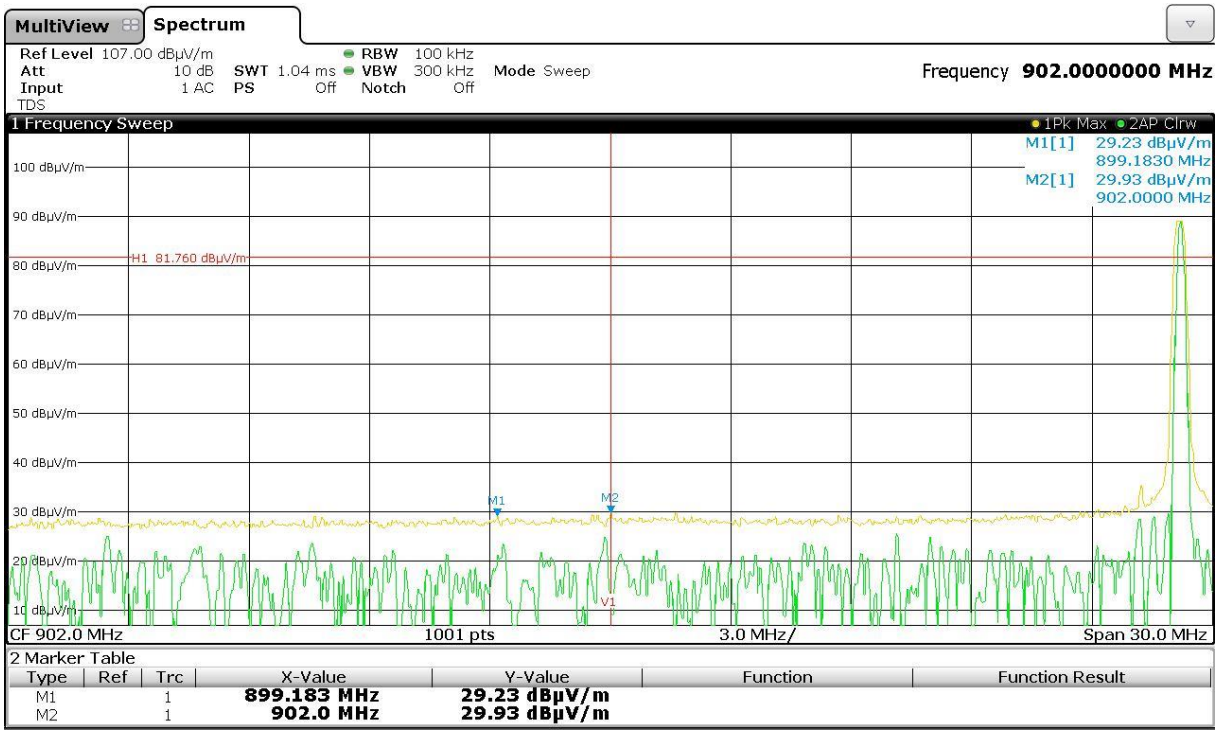
Channel 921.480 MHz - Horizontal

Channel 926.780 MHz - Vertical

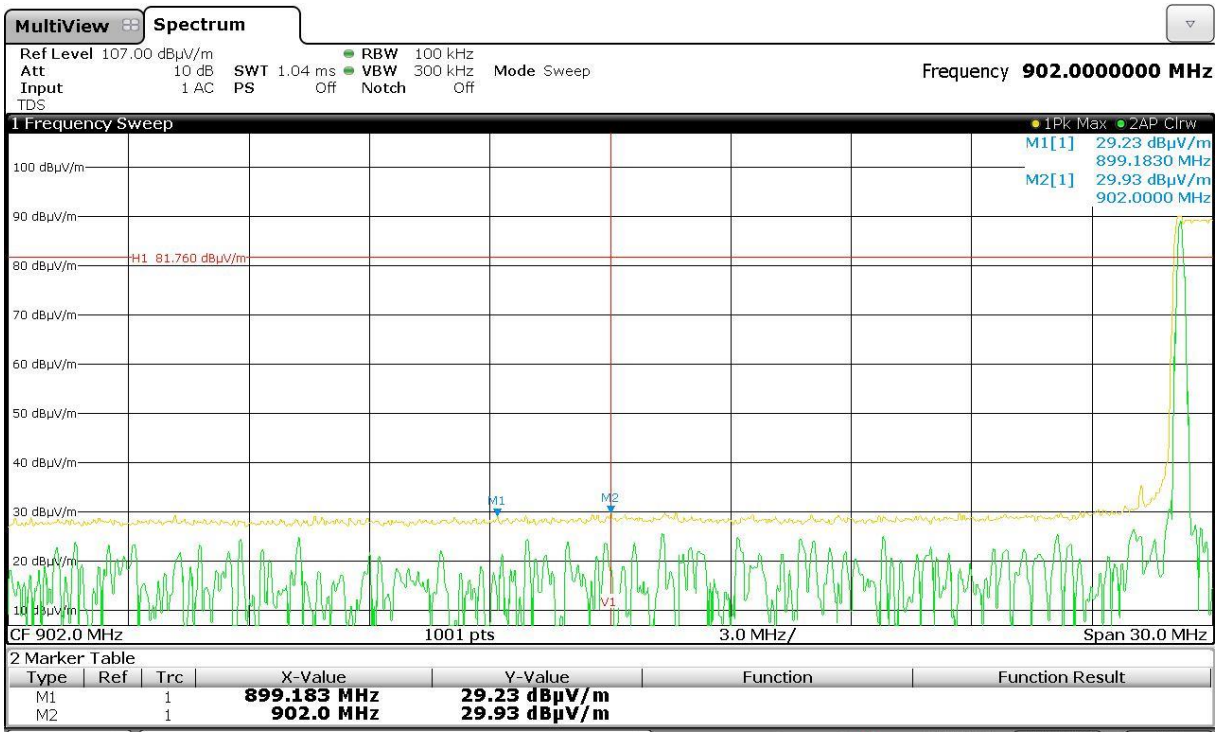
Channel 926.780 MHz - Horizontal

3.8.7 Band-Edge Emission Measurements

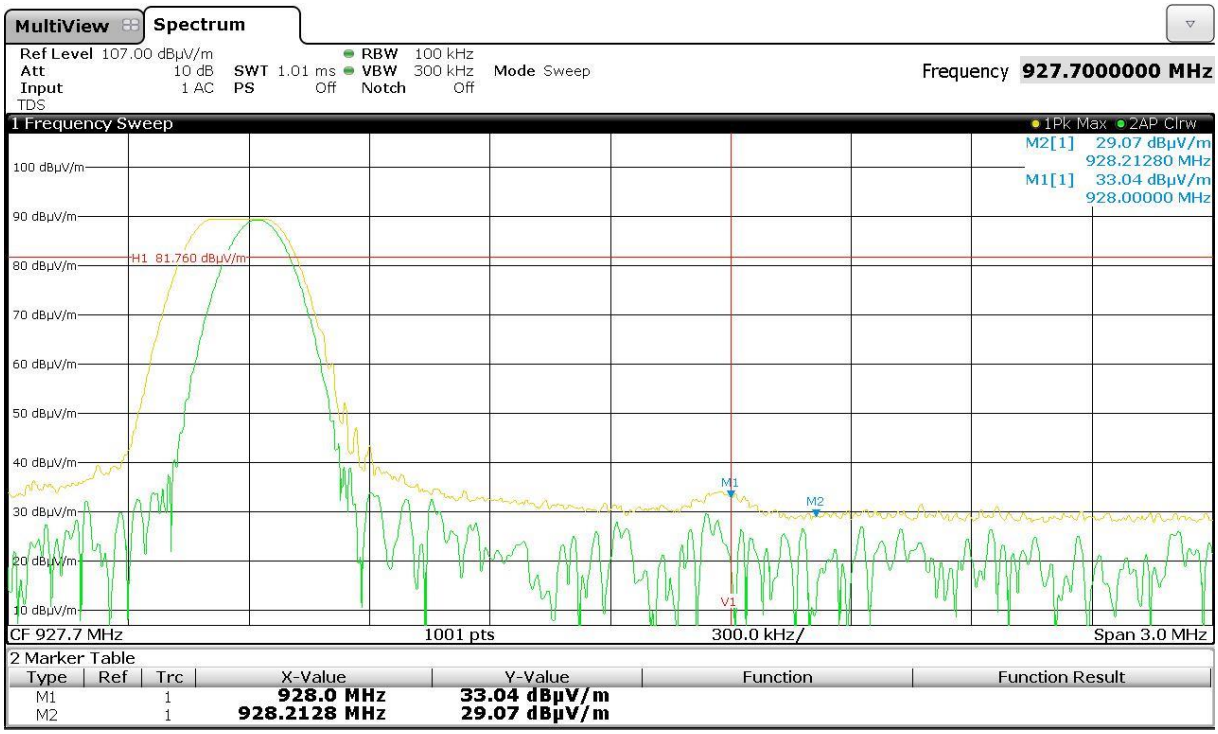
Emissions within 0.5 MHz of an authorised band edge were measured. The measurements were made with the sample and antenna orientated for maximum power level.



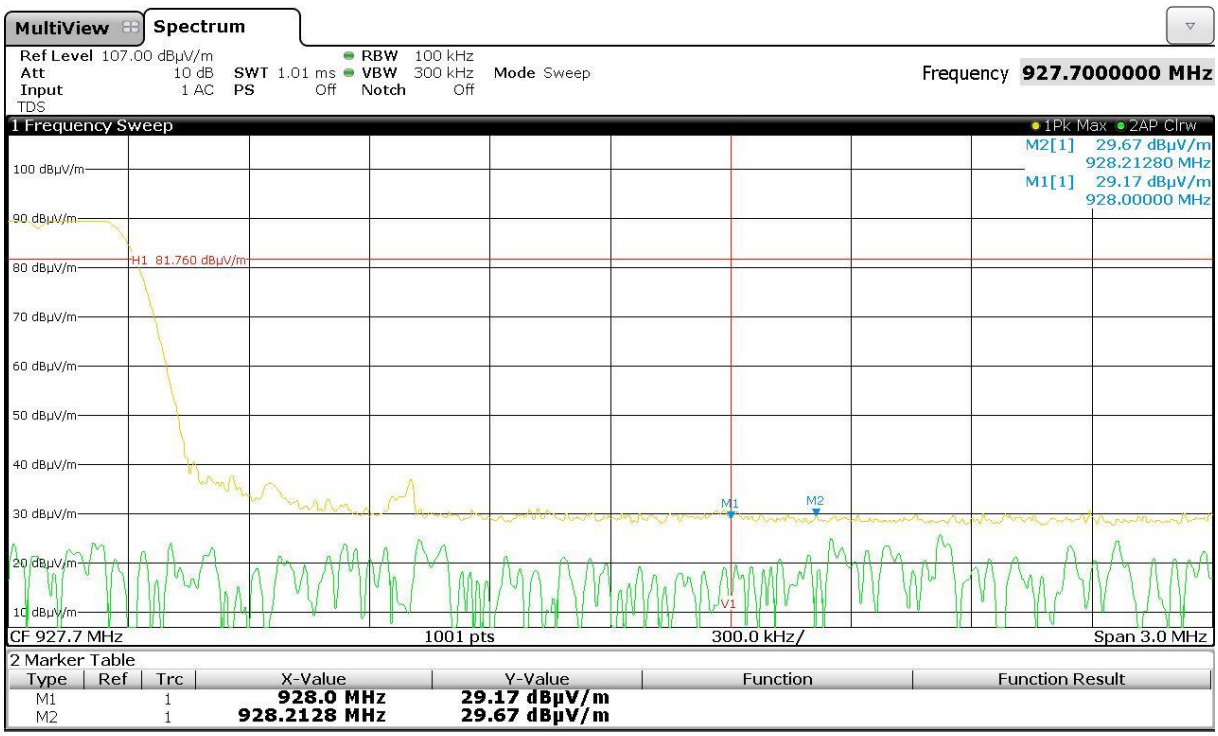
Channel 916.175 MHz, Hopping Off



Channel 916.175 MHz, Hopping On



Channel 926.780 MHz, Hopping Off



Channel 926.780 MHz, Hopping On

3.9 §15.247(i) Maximum Permissible Exposure

The Lone Worker 2.0 (Antenna Module) was considered a portable device and could be operated within 50 mm of the body of a user or nearby person. SAR measurement exclusion requirements of KDB 447498 D01 General RF Exposure Guidance v06 were applied. The following equation was applicable:

1-g Head and Body SAR:

$$\left(\frac{max.channel\ power, mW}{min.separation\ distance, mm}\right) \times \sqrt{f(GHz)} \leq 3.0$$

Maximum measured power, E.I.R.P.	= 51 mW
Time-averaged power	= E.I.R.P. + 10log(duty cycle)
	= 17.1 dBm + 10log(1.4/45)
	= 2.03dBm = 1.59 mW
Minimum separation distance	= 5 mm
Highest frequency	= 0.928 GHz

$$\left({}^{1.59\ mW}/_{5\ mm}\right) \times \sqrt{0.928\ GHz} = 0.31$$

Co-location consideration:

A Bluetooth Low Energy (BLE) transmitter having FCC ID: WAP2005 was incorporated within the device and could transmit simultaneously with the 902-928 MHz transmitter. The BLE details were taken from the module exposure report QuieTek 16A2076C-RF-US-P20V02 downloaded from the FCC website.

SAR test exclusion applies when the sum of the 1g SAR ratios for all simultaneously transmitting antennas incorporated in a host device is ≤ 3.0:

$$\left[\left({}^{1.59\ mW}/_{5\ mm}\right) \times \sqrt{0.928\ GHz}\right] + \left[\left({}^{0.76\ mW}/_{5\ mm}\right) \times \sqrt{2.48\ GHz}\right] = 0.55$$

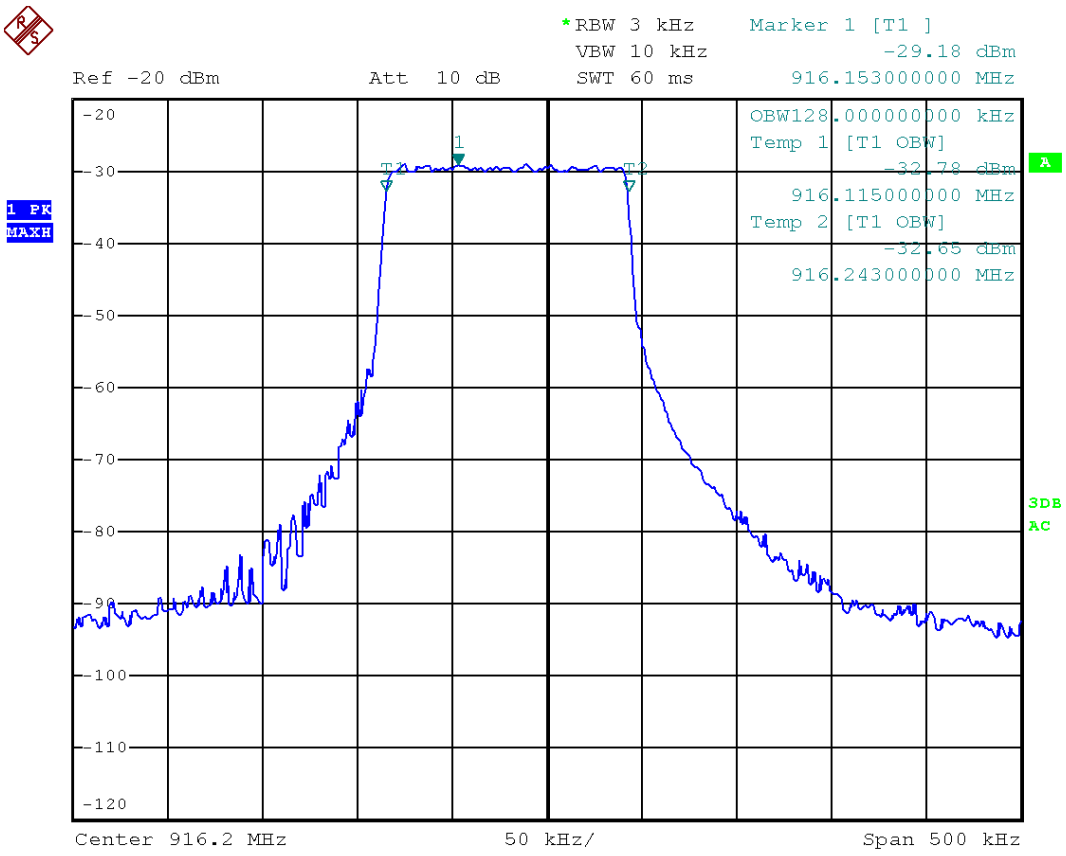
Conclusion:

The Lone Worker 2.0 (Antenna Module) FHSS transceiver complied with the RF exposure requirements of FCC 1.1307.

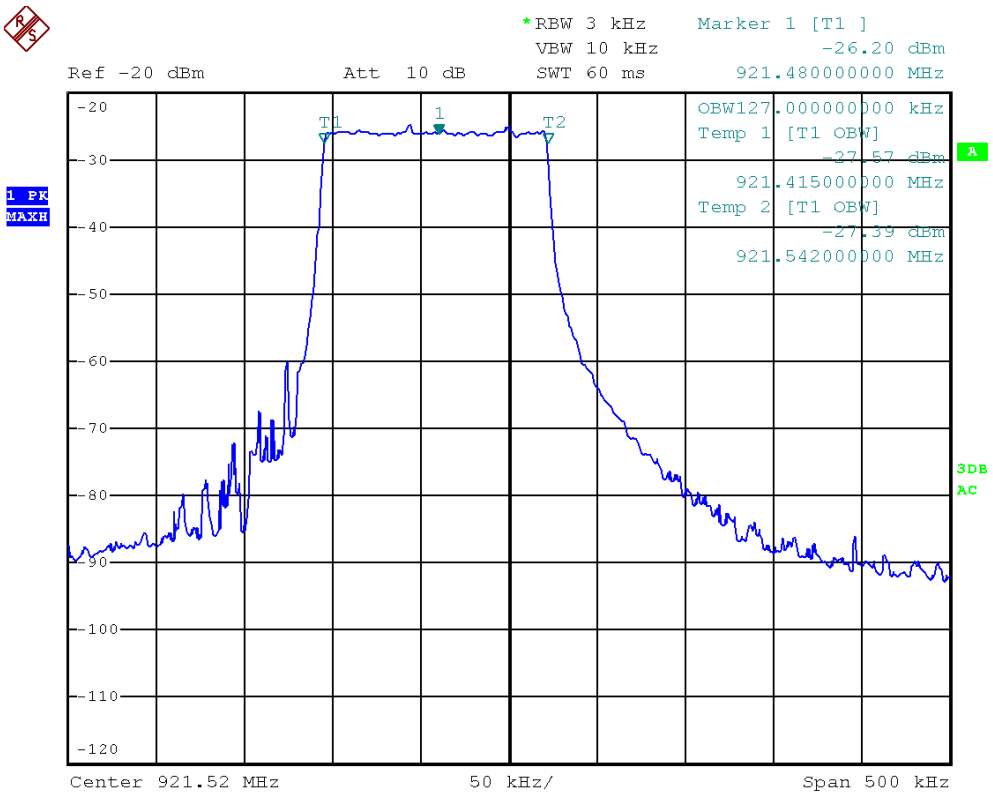
3.10 §2.1049 Occupied bandwidth – 99% power

The bandwidth containing 99% power of the transmitted signal was measured using the procedure from ANSI C63.10 section 6.9.

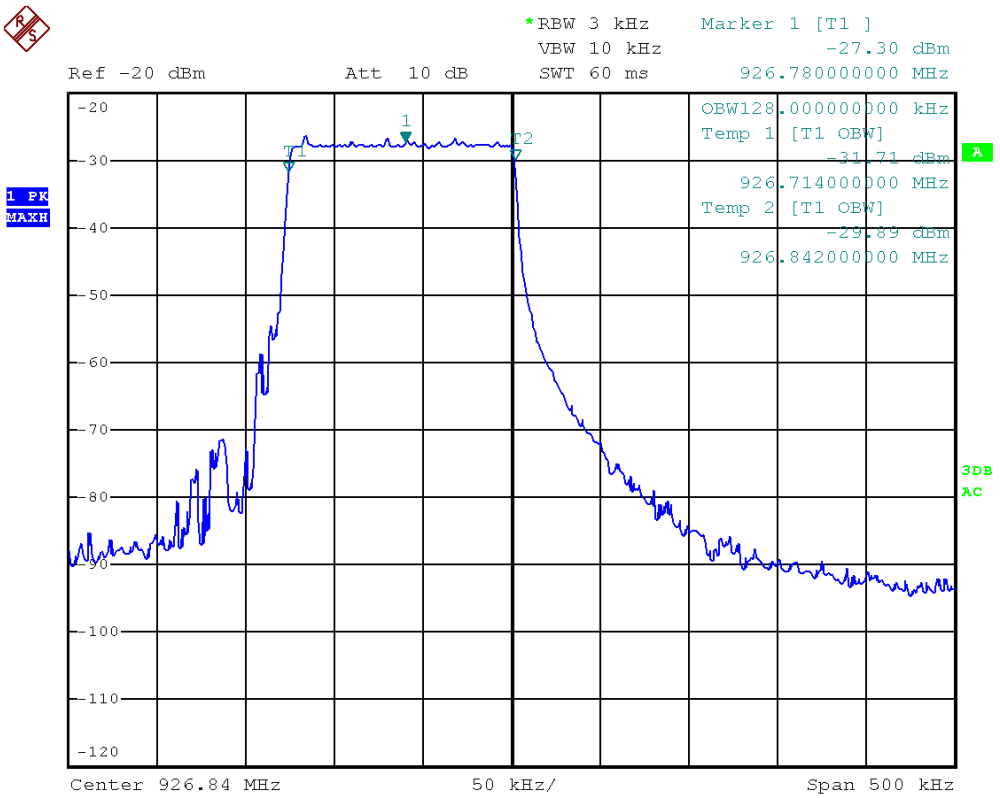
Channel [MHz]	99% Bandwidth [kHz]	Low Frequency [MHz]	High Frequency [MHz]
916.175	128.0	916.115	916.243
921.480	127.0	921.415	921.542
926.780	128.0	926.714	926.842



Channel 916.175 MHz



Channel 921.480 MHz



Channel 926.780 MHz

4.0 COMPLIANCE STATEMENT

The Lone Worker 2.0 (Antenna Module) tested on behalf of Imaginastix Pty. Ltd. **complied** with the requirements of 47 CFR, Part 15 Subpart C - Rules for Radio Frequency Devices (intentional radiators) for a Frequency Hopping Spread Spectrum Transceiver (FHSS) operating within the band: 902 MHz to 928 MHz.

5.0 MEASUREMENT UNCERTAINTY

EMC Technologies has evaluated the equipment and the methods used to perform the emissions testing. The estimated measurement uncertainties for emissions tests shown within this report are as follows:

Conducted Emissions:	9 kHz to 30 MHz	±3.2 dB
Radiated Emissions:	9 kHz to 30 MHz	±4.1 dB
	30 MHz to 300 MHz	±5.1 dB
	300 MHz to 1000 MHz	±4.7 dB
	1 GHz to 18 GHz	±4.6 dB

The above expanded uncertainties are based on standard uncertainties multiplied by a coverage factor of k=2, providing a level of confidence of approximately 95%.