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Global Product Certification
EMC-EMF Safety Approvals

RADIO TEST REPORT FOR CERTIFICATION
to
FCC Part 15 Subpart C (Section 15.247)

FCC ID: 2AK7Z-DN01C011F9

Manufacturer: LX Design House Pty Ltd
Test Sample: Weir Sensor Node
Model Number: DN-1-SC-1.1-915

Test Report Number: T161214-2R1_F
Issue Date: 23 May 2017

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CONTENTS

RADIO TEST REPORT FOR CERTIFICATION

Test Sample Name:	Weir Sensor Node
Model Number:	DN-1-SC-1.1-915
Manufacturer:	LX Design House Pty Ltd Suite 101, 4 Cornwallis Street, Cicada Innovations Building, Eveleigh, NSW 2015, AUSTRALIA
FCC ID:	2AK7Z-DN01C011F9
Equipment Type:	Intentional Radiator (Transceiver)
Tested For:	Weir Minerals Australia Ltd
Address:	1 Marden Street Artarmon, NSW, 2064
Phone Number:	+61 (0)2 9934 5100
Fax Number:	+61 (0)2 9934 5201
Responsible Party:	Mr Ben Baker
Test Standards:	FCC Part 15 – *Radio Frequency Devices* FCC Part 15 Subpart C – *Intentional Radiators* Section 15.247: 902 – 928 MHz *Operation Bands* ANSI C63.10 – 2013 *American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices* KDB 558074 – *Guidance for Performing Compliance Measurements on Digital Transmission Systems (DTS) Operating Under §15.247*
Test Dates:	13th December 2016 to 13th January 2017
Testing Officer:	**James Guo**
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.*
Authorised Signature:	**Jason Cameron** **Facility Manager** **EMC Technologies Pty Ltd**

RADIO TEST REPORT FOR CERTIFICATION
to
FCC Part 15 Subpart C (Section 15.247)

1.0 INTRODUCTION

Radio testing was performed on the DN-1-SC-1.1-915 Weir Sensor Node.

Test results and procedures were performed in accordance with the following Federal Communications Commission (FCC) standards/regulations:

47 CFR, Part 15, Subpart C:	Rules for intentional radiators (particularly section 15.247)
Section 15.203:	Antenna requirements
Section 15.205:	Restricted bands of operation
Section 15.207:	Conducted Emission Limits
Section 15.209:	Radiated Emission Limits (General requirements)
Section 15.247:	Operation in the bands 902-928 MHz, 2400-2483.5 MHz, 5725-5850 MHz

The sample **complied** with the requirements of 47 CFR, Part 15 Subpart C - Section 15.247.

The measurement procedure used was in accordance with ANSI C63.10: 2013. The instrumentation conformed to the requirements of ANSI C63.2: 2009.

1.1 Summary of Results

FCC Part 15 Subpart C	Test Performed	Results
15.203	Antenna Requirement	**Complied**
15.205	Operation in Restricted Band	**Complied**
15.207	Conducted Emissions	**Not Applicable**
15.209	Radiated Emissions	**Complied**
15.247 (a)(2)	Channel Bandwidth	**Complied**
15.247 (b)(3)	Peak Output Power	**Complied**
15.247 (c)	Antenna Gain > 6 dBi	**Not Applicable.** Antenna gain < 6 dBi
15.247 (d)	Out of Band Emissions	**Complied**
15.247 (e)	Peak Power Spectral Density	**Complied**
15.247 (f)	*Hybrid Systems	**Not Applicable.** EUT does not employ a hybrid system
15.247 (g)	Frequency Hopping System with Transmitter and Receiver	**Not Applicable.** EUT does not employ frequency hopping
15.247 (h)	Simultaneous occupancy of individual hopping frequencies	**Not Applicable.** EUT does not employ frequency hopping
15.247 (i)	Radio Frequency Hazard	**Complied**
2.1049	Occupied Bandwidth	**632 kHz**

*Hybrid systems are those that employ a combination of both frequency hopping and digital modulations technique.

1.2 Modifications by EMC Technologies

No modifications were performed in order for the EUT to comply with the standard.

2.0 GENERAL INFORMATION

2.1 General Description of Test Sample

Test Sample:	Weir Sensor Node
Model Number:	DN-1-SC-1.1-915
Part Number	DN-1-SC-1.1-915
Operating Frequency Band:	902 to 928 MHz
Frequency Range:	918 to 926 MHz
Modulation:	LoRa™
Number of Channels:	8
Nominal Output Power:	+27 dBm
Antenna:	LoRa Straight RF Antenna 900 MHz – 935 MHz
Antenna Assembly Gain:	1.3 dBi
Power Supply:	Li-ion battery, 3.7 V, 150 mA peak

2.2 Test Sample Description

The Sensor Node samples the impedance across 2 terminals, as well as the ID from a 1-wire ID device on one of the 2 terminals. The sample interval is configurable from 60 minutes to 1440 minutes. A 3rd terminal is used to provide the GND reference for the 1-wire ID device. The impedance measured is from a wear detection mechanism embedded into slurry hoses deployed on mine sites.

The sampled data is transmitted to a LoRa Base Station, which passes the data onto a computer system via RS485.

2.3 Technical Specifications and System Overview

Microprocessor	:	STM32L152RET6
Crystal Frequencies	:	32.7468 kHz and 8 MHz
Highest Operating Freq	:	32 MHz (non-radio)

2.4 EUT Configurations

The Sensor Node needs the interface cable attached to the 10-way circular connector, after it will start up and function normally. No configuration is required. The unit will operate its radio at near 100% duty cycle. Similarly the Base Station needs DC power source, and will operate in “test” mode without any configuration.

2.5 Test Sample Support Equipment

The Base Station needs a DC power Source. A pair of unterminated wires will be exposed.
A 2 m RS485 cable will also connected to the Base Station.
The Sensor Node will have a 6-wire cable attached to a 10-way circular connector.
The 6 wires provide for long range I2C (not connected: 5V,GND, SCL, SDA) and 1 pair of wires for analogue measurement of impedance.
No other support equipment is required.

2.6 EUT Operation Conditions

The EUT was operated in accordance with the standard and the customer’s requirements.

2.7 Test Facility

2.7.1 General

Measurements performed at EMC Technologies Laboratory in Seven Hills, New South Wales, Australia. Radiated Emission measurements in the ranges 9 kHz to 18 000 MHz were performed at EMC Technologies' Semi anechoic chamber

The above site has been fully described in a report submitted to the FCC office. EMC Technologies Pty Ltd has FCC registration number 411703 and we have been designated by the Australian Communications and Media Authority under the APAC TELMRA. The designation number is AU0002 which will expire on the 4th July 2018.

Spurious emission measurements over the range 9 kHz to 30 MHz in this report were performed at EMC Technologies' laboratory in Keilor Park, Victoria Australia having the following registration:

EMC Technologies Pty Ltd is listed by the FCC as a test laboratory able to perform compliance testing for the public. EMC Technologies is listed as an FCC part 47CFR2.948 test lab and may perform the testing required under Parts 15 and 18 – **FCC Registration Number 90560**

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**

2.7.2 NATA Accreditation

EMC Technologies is accredited in Australia to test to the following standards by the National Association of Testing Authorities (NATA).

"FCC Part 15 unintentional and intentional emitters in the frequency range 9kHz to 18GHz excluding TV receivers (15.117 and 15.119), TV interface devices (15.115), cable ready consumer electronic equipment (15.118), cable locating equipment (15.213) and unlicensed national information infrastructure devices (Sub part E)."

The current full scope of accreditation can be found on the NATA website: www.nata.asn.au
It also includes a large number of emission, immunity, EMR and Safety standards.

NATA is the Australian national laboratory accreditation body and has accredited EMC Technologies to operate to the IEC/ISO17025 requirements. 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 fully documented test procedures, continued calibration of all equipment 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).

2.8 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	Make/ Model/ Serial Number	Due Date dd/mm/yyyy	Calibration Interval
EMI Receiver	R&S ESU40 Sn: 100183 (R-038)	07/03/2017	1 Year
Antenna	EMCO 3115 (A324) 1 – 18 GHz Sn: 3823	27/01/2018	3 Year
	ETS-Lindgren 3160-07 (A-260) 8.2 – 12.4 GHz Sn: 228162	29/01/2019	3 Year
	ETS-Lindgren 3160-08 (A-262) 12.4 - 18 GHz Sn: 28245	29/01/2019	3 Year
Pre-Amplifier	HP 8449B 1-26.5 GHz, 30 dB Gain Sn: 3008A01113(A138)	08/08/2017	1 Year

Equipment	Make/ Model/ Serial Number	Due Date dd/mm/yyyy	Calibration Interval
Chamber	Frankonia SAC-10-2 (R-139)	11/05/2017	1 Year, *1
EMI Receiver	R&S ESR7 9 kHz – 7 GHz Sn: 101804 (R-142)	10/04/2018	1 Year, *2
Antennas	EMCO 6502 Active Loop 9 kHz – 30 MHz Sn. 9311-2801 (A-231)	20/07/2018	3 Year, *2
Cables	Room 12 inbuilt cable Panel 1 to 10 m (C-422)	09/05/2017	1 Year, *1
	Room 12 Antenna cable (C-437)	09/05/2017	1 Year, *1

3.0 TEST RESULTS

3.1 §15.203 Antenna Requirement

The Wireless Hose Wear Monitoring System was intended to be installed professionally, thereby ensuring proper antenna will be used.

3.2 §15.205 Restricted Bands of Operation

The restricted bands of operation limits were applied during testing of the spurious emissions. The DN-1-SC-1.1-915 emissions did not exceed these limits. Refer to 3.8 for emission test results.

3.3 §15.207 Conducted Limits

Not applicable as the EUT had no direct or in-direct AC Mains connection.

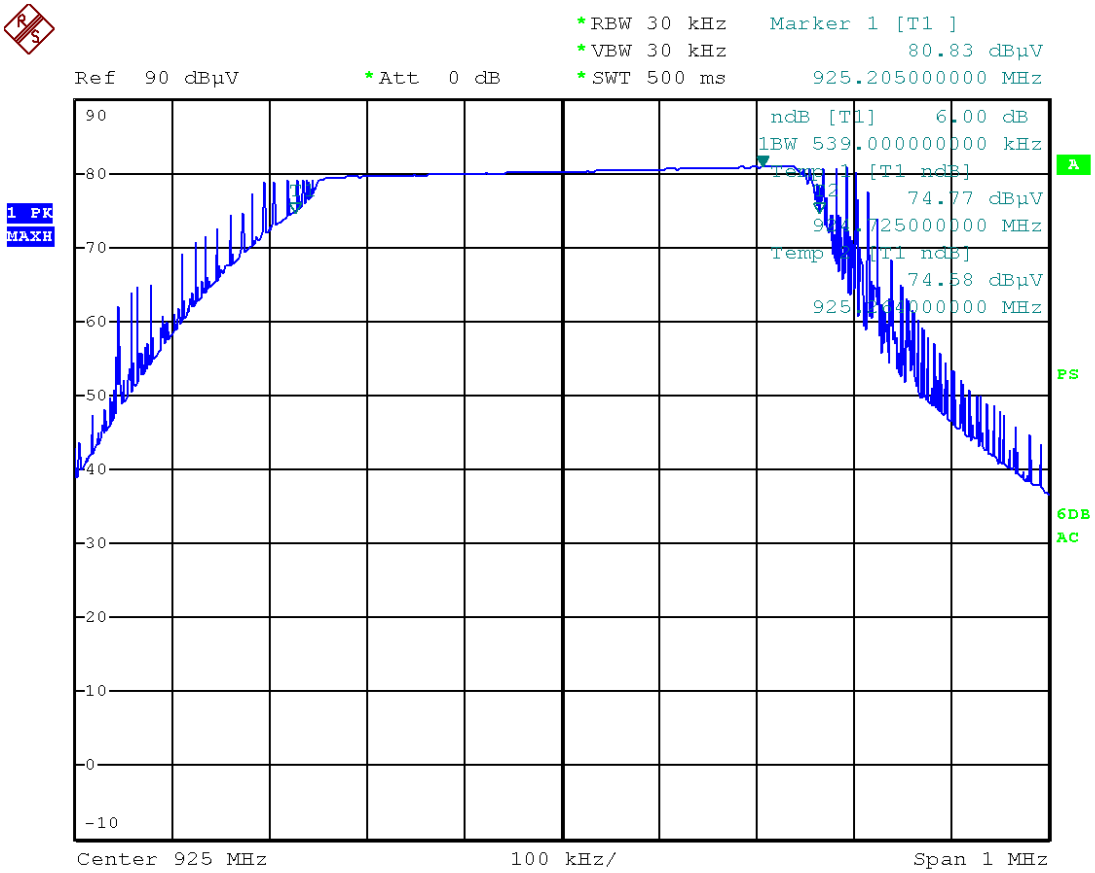
3.4 §15.209 Radiated emission limits; general requirements

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

3.5 §15.247(a) Channel Bandwidth

In the 902 - 928 MHz band the minimum 6 dB bandwidth is to be at least 500 kHz. The 6 dB bandwidth was measured while the device was transmitting with typical modulation.

The lower, middle and upper channel 6 dB bandwidths were measured. The bandwidth closest to the limit was **539 kHz**.



6 dB bandwidth

3.6 §15.247(b) Peak Output Power

The peak power from the transmitter was measured at the antenna port. The lower, middle and upper channel powers were measured. The following was the highest recorded.

Frequency [MHz]	Conducted Power [dBm]	Correction factor [dB]	Actual Power [dBm]	Actual Power [W]	Limit [W]	Margin [W]
919	-7.8	30.1	22.3	0.170	1.000	0.786

EIRP = Conducted power + Antenna gain
= 22.3 dBm + 1.3 dBi
= 23.6 dBm = 0.229 W

3.7 §15.247(c) Directional Antenna with gain > 6dBi

Not applicable.

3.8 §15.247(d) Out of Band Emissions

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, based on either an RF conducted or a radiated measurement, provided the transmitter demonstrates compliance with the peak conducted power limits.

Radiated emissions which fall in the restricted bands, as defined in §15.205(a), must also comply with the radiated emission limits specified in §15.209(a).

The limits of §15.209(a) were applied over the spurious emission domain ensuring compliance with all out of band requirements.

3.8.1 Spurious Emissions

Radiated EMI tests were performed inside a fully compliant CISPR16-1-4 semi-anechoic chamber for a 2m x 2m x 2m test volume up to 18 GHz, at a test distance of 3 metres. The EUT was set up on the table top (placed on turntable) of total height 80 cm above the ground plane and operated as described in section 2 of this report. The test frequency range was sub-divided into smaller bands with sufficient frequency resolution to permit reliable display and identification of possible EMI peaks while also permitting fast frequency scan times. A calibrated Biconilog antenna was used for measurements between 30 MHz and 1000 MHz. Calibrated EMCO 3115, EMCO 3116 and ETS standard gain horn antennas were used for measurements between 1 to 25 GHz.

The EUT was slowly rotated with the Peak Detector set to Max-Hold. This was performed for 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. The procedure was repeated with the device orientated in three orthogonal axis to further maximise the emission.

Each significant peak was investigated with the Peak/Average Detectors. 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.

3.8.2 Calculation of field strength

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

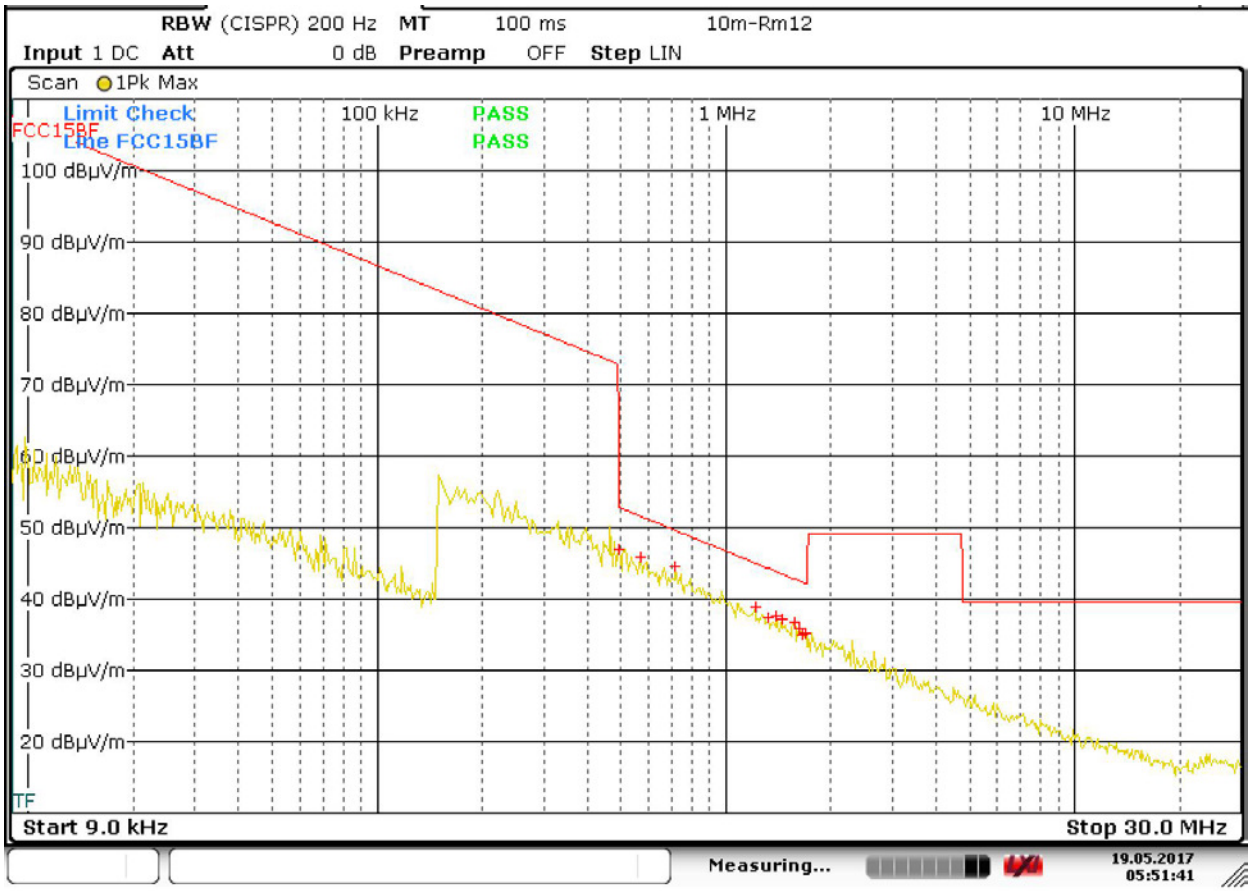
E = V + AF - G + L

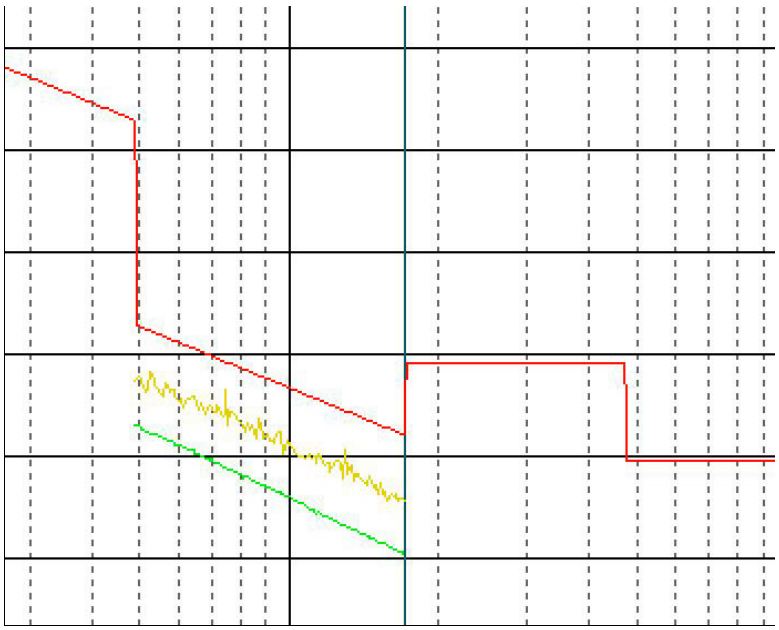
Where:

E	=	Radiated Field Strength in dBµV/m.
V	=	EMI Receiver Voltage in dBµV. (measured value)
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)

3.8.3 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.





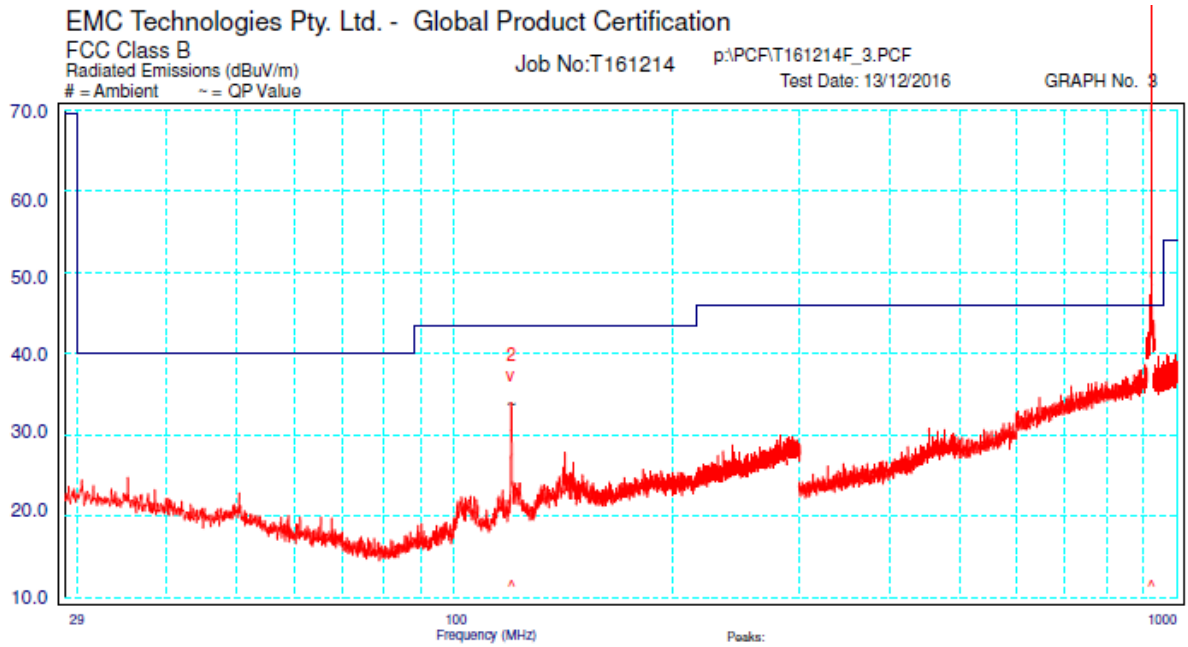
(Green trace = Quasi-Peak detector)

No emissions were detected above the noise floor of the measuring system and therefore complied with the FCC §15.205 and §15.209 average and quasi-peak limits.

3.8.4 Frequency Band: 30 - 1000 MHz

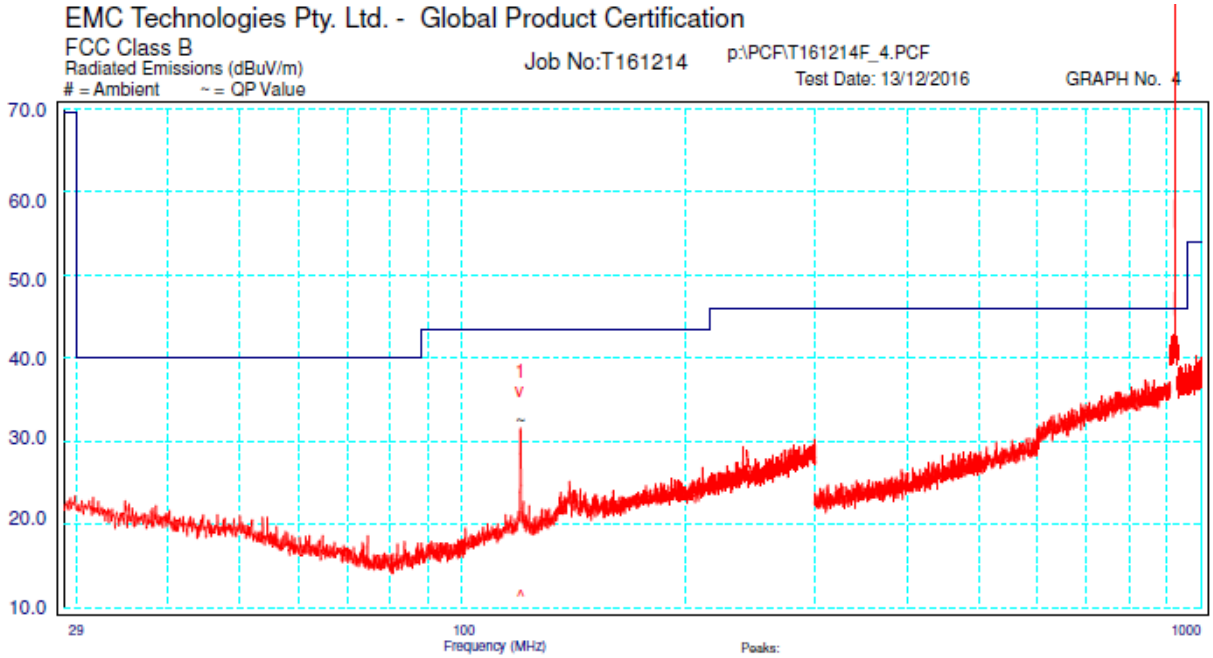
Testing was performed at a distance of 3 metres. The measurement of emissions between 30 - 1000 MHz was measured with the resolution bandwidth (RBW) of 120 kHz and the video bandwidth (VBW) of 300 kHz. Worst case emissions from the sample when transmitting on either low, middle or high channels are reported.

Vertical emissions:



Point	Frequency [MHz]	Quasi-Peak Emission [dBµV/m]	Quasi-Peak Limit [dBµV/m]	Delta [dB]
1	Fundamental	113.1	-	-
2	120.00	33.7	43.5	-9.8

Horizontal emissions:



Point	Frequency [MHz]	Quasi-Peak Emission [dBµV/m]	Quasi-Peak Limit [dBµV/m]	Delta [dB]
1	120.00	34.8	43.5	-11.5

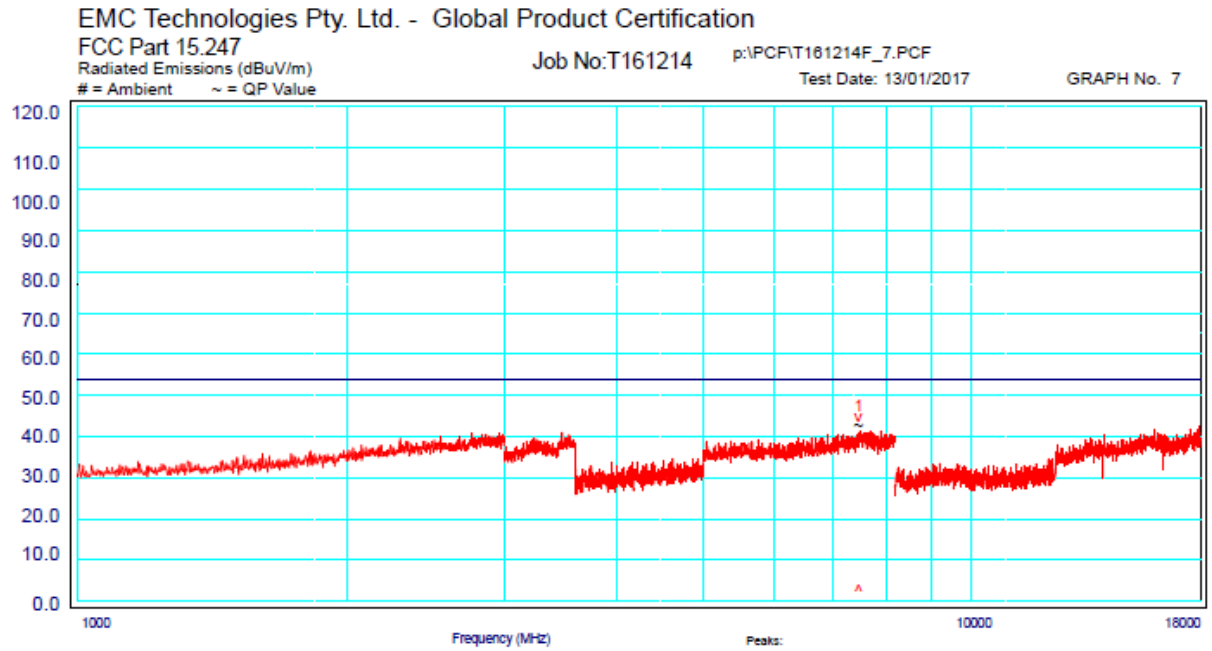
3.8.5 Frequency Band: 1 – 18 GHz

The upper frequency range was 10 times the highest operating frequency:
10 x 928 GHz = 9.28 GHz (Measurements were taken to 18 GHz)

Testing was performed at a distance of 3 metres. The measurement of emissions above 1000 MHz was measured using the following setting: Average measurement setting: RBW = 1 MHz and VBW = 10 Hz.

Worst case emissions from the sample when transmitting on either low, middle or high channels are reported.

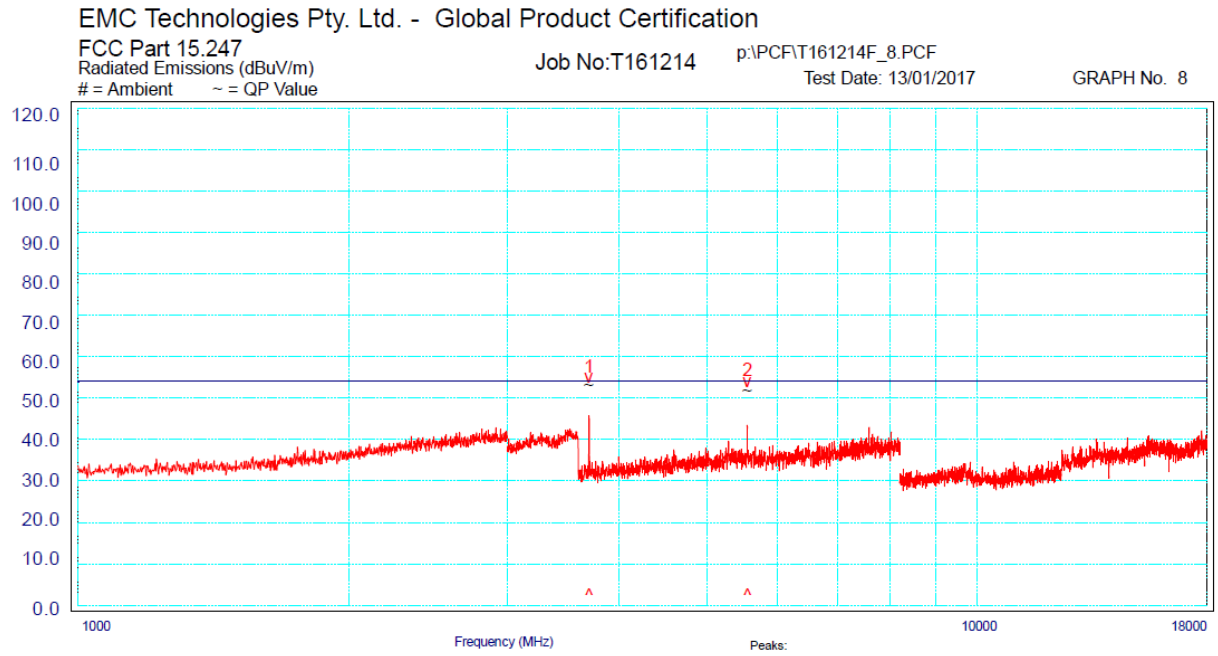
3.8.5.1 Vertical emissions



Point	Frequency [MHz]	Average Emission [dBµV/m]	Average Limit [dBµV/m]	Margin [dB]
1	7468.410	42.7	54.0	-11.3

No peak emissions exceeded the average limits by 20 dB.

3.8.5.2 Horizontal emissions



Point	Frequency [MHz]	Average Emission [dBµV/m]	Average Limit [dBµV/m]	Margin [dB]
1	3700.130	53.0	54.0	-1.0
2	5548.650	51.8	54.0	-2.2

No peak emissions exceeded the average limits by 20 dB.

3.9 §15.247(e) Power Spectral Density

The power spectral density was measured conductively with the transmitter set to the channel having the highest power output and with normal modulation applied. The following was the highest recorded.

Result:

Channel	Power Spectral Density [dBm/3kHz]	Correction Factor [dB]	Actual PSD [dBm/3kHz]	Limit [dBm/3kHz]	Margin [dB]
922 MHz	-28.4	30	1.6	8	6.4

3.10 §15.247(f) Hybrid systems

Not applicable.

3.11 §15.247(g) Frequency Hopping System with Transmitter and Receiver

Not applicable.

3.12 §15.247(h) Simultaneous occupancy of individual hopping frequencies

Not applicable.

3.13 §15.247(i) Radio Frequency Exposure (Hazard) Information

Transmitters operating under part 15.247 are required to be operated in a manner that ensures that the public is not exposed to RF energy levels in accordance with CFR 47, Section 1.1307(b)(1).

The DN-1-SC-1.1-915 was considered a mobile device and not intended to be operated within 20 cm of user or nearby person.

The Maximum Permissible Exposure (MPE) limit defined in §1.1310 for a transmitter operating at 918 MHz is:

MPE limit = $[f_{(MHz)}] \div 1500$ mW/cm^2
= $918 \div 1500$ mW/cm^2
= **0.61 mW/cm^2 = 48.0 V/m** (V/m) = $\sqrt{(1200 \times \pi \times (\text{mW/cm}^2))}$

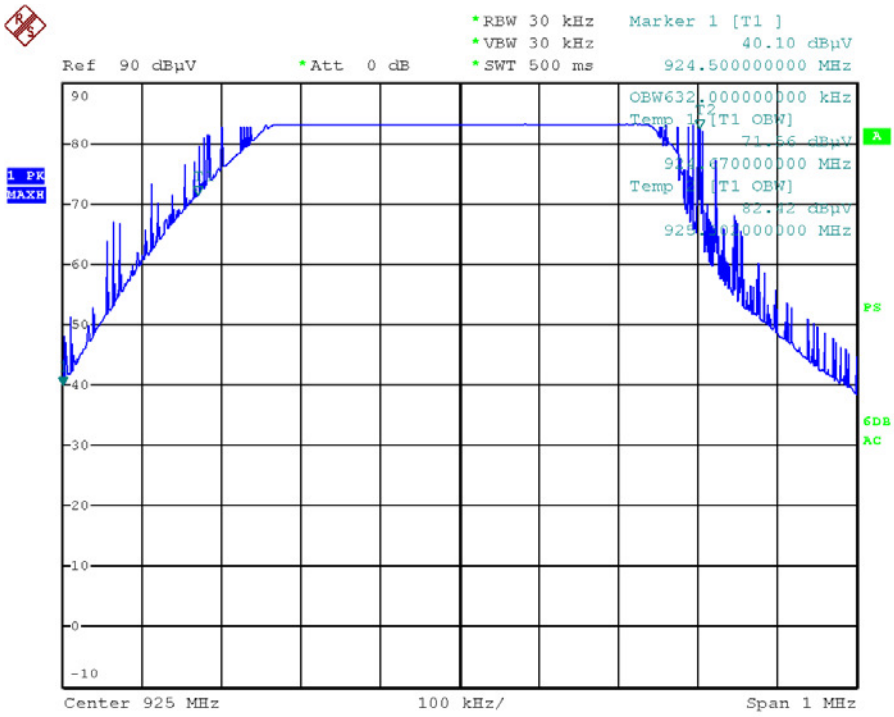
Field strength = [$\sqrt{}$(30× transmitter EIRP)] ÷ [minimum separation distance in metres] V/m
= [$\sqrt{(30 \times 0.229)}$] ÷ 0.2 V/m
= **13.1 V/m = 0.05 mW/cm^2** (mW/cm^2) = (V/m)$^2 \div (1200 \times \pi)$

As the calculated field strength generated by the transmitter is less than the limit, the DN-1-SC-1.1-915 is deemed to comply with the radio frequency exposure requirements.

3.14 §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.

The 99% power bandwidth was **632 kHz**.



4.0 COMPLIANCE STATEMENT

The DN-1-SC-1.1-915, tested on behalf of LX Design House Pty Ltd **complied** with the requirements of 47 CFR, Part 15 Subpart C - Rules for Radio Frequency Devices (intentional radiators), Section 15.247 - Operation in the frequency band 902 to 928 MHz.

Results were as follows:

FCC Part 15 Subpart C	Test Performed	Results
15.203	Antenna Requirement	**Complied**
15.205	Operation in Restricted Band	**Complied**
15.207	Conducted Emissions	**Not Applicable**
15.209	Radiated Emissions	**Complied**
15.247 (a)(2)	Channel Bandwidth	**Complied**
15.247 (b)(3)	Peak Output Power	**Complied**
15.247 (c)	Antenna Gain > 6 dBi	**Not Applicable.** Antenna gain < 6 dBi
15.247 (d)	Out of Band Emissions	**Complied**
15.247 (e)	Peak Power Spectral Density	**Complied**
15.247 (f)	*Hybrid Systems	**Not Applicable.** EUT did not employ a hybrid system
15.247 (g)	Frequency Hopping System with Transmitter and Receiver	**Not Applicable.** EUT did not employ frequency hopping
15.247 (h)	Simultaneous occupancy of individual hopping frequencies	**Not Applicable.** EUT did not employ frequency hopping
15.247 (i)	Radio Frequency Hazard	**Complied**
2.1049	Occupied Bandwidth	**632 kHz**

*Hybrid systems are those that employ a combination of both frequency hopping and digital modulations technique.

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
Peak Output Power:		±1.5 dB
Peak Power Spectral Density:		±1.5 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%.