



Test report No:

NIE: 48668REM.002A2

Test report (Modification 2)

FCC Rules and Regulations 47 CFR Chapter I Part 15 Subpart B (10-01-14 Edition) & ICES-003 ISSUE 5 (2012)

Identification of item tested.....:	Wireless sensor node for the Internet of Things
Trademark	Libelium
Model and /or type reference.....:	Waspmote Plug & Sense! 4G US
Other identification of the product	S/N: Prototype
Final HW version	1.0
Final SW version	1.0
FCC ID	Chipset's FCC ID: RI7LE910NA Libelium's product FCC ID: XKM-WPS-4G-V1
IC	Chipset's IC: 5131A-LE910NA Libelium's product IC: 8472A-WPS4GV1
IMEI TAC	35894205
Features	Can communicate with 2G, 3G and 4G/LTE networks. GNSS (A-GPS) receiver. USA and Canada version, AT&T. Contains a LE910 NAG chipset. Includes 2 cellular antennas for diversity gain.
Manufacturer	LIBELIUM COMUNICACIONES DISTRIBUIDAS, S.L. C/ Escatrón 16 (Edificio Libelium), C.P.: 50014. Zaragoza. Spain.
Test method requested, standard.....:	FCC Rules and Regulations 47 CFR Chapter I Part 15 Subpart B (10-01-14 Edition) & ICES-003 ISSUE 5 (2012)
Summary	IN COMPLIANCE
Approved by (name / position & signature).....:	Rafael López EMC LAB Manager P.A.
Date of issue.....:	2016-11-10
Report template No.....:	FDT11_18

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Competences and guarantees

AT4 wireless is a testing laboratory accredited by the National Accreditation Body (ENAC - Entidad Nacional de Acreditación), to perform the tests indicated in the Certificate No. 51/LE 147.

This certificate of conformity was issued in accordance with the decision Nº 3/2000 of the Joint Committee established under the Agreement on Mutual Recognition between the European Community and the United States of America. By this decision, AT4 wireless can act as Conformity Assessment Body (CAB) on Electromagnetic Compatibility. This Certificate applies to the samples listed at technical reports.

This laboratory is designed by the Federal Communications Commission (ES0004)

AT4 wireless is a testing laboratory competent to carry out the tests described in this report.

In order to assure the traceability to other national and international laboratories, AT4 wireless has a calibration and maintenance program for its measurement equipment.

AT4 wireless guarantees the reliability of the data presented in this report, which is the result of the measurements and the tests performed to the item under test on the date and under the conditions stated on the report and, it is based on the knowledge and technical facilities available at AT4 wireless at the time of performance of the test.

AT4 wireless is liable to the client for the maintenance of the confidentiality of all information related to the item under test and the results of the test.

The results presented in this Test Report apply only to the particular item under test established in this document.

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General conditions

1. This report is only referred to the item that has undergone the test.
2. This report does not constitute or imply on its own an approval of the product by the Certification Bodies or competent Authorities.
3. This document is only valid if complete; no partial reproduction can be made without previous written permission of AT4 wireless.
4. This test report cannot be used partially or in full for publicity and/or promotional purposes without previous written permission of AT4 wireless and the Accreditation Bodies.

Uncertainty

Uncertainty (factor $k=2$) was calculated according to the AT4 wireless internal document PODT000.

Usage of samples

Samples under test have been selected by: The client.

Sample S/01 is composed of the following elements:

Control Nº	Description	Model	Serial number	Reception date
45355E/068	Luminosity probe	Plug&Sense	---	2015-10-26
45355E/175	Antenna	---	---	2016-02-01
45355E/176	Antenna	---	---	2016-02-01
45355E/181	Antenna	---	---	2016-02-01
45355E/184	Dummy battery connector	---	---	2016-02-01
45355E/185	Sensor node with wireless communication	Plug & Sense 4G EU	23	2016-02-01
45355E/190	Module	4G USA	358942051019843	2016-02-01

Sample S/01 incorporates a MURATA ferrite with the code BLM21AG601SN1 in the clock input; It was added another ferrite with the same code to the clock output and two 50nF capacitors, one on the DC/DC input and another one in the output; It was added a toroidal ferrite with the code WÜRTH 742 70 13 with two turns on the power supply cable. It was reduced the load current with R43 at 3.3K. It was added a ferrite with the code WÜRTH 7427503 in the positive load cable and it was replaced C15 to 22µF and it was added a 330µF capacitor in the DC power supply cable.

Auxiliary PC for Operation Mode 02: Dell Latitude E6440 (CTC-1230-D)

Test sample description

This device receives data from sensors and sends information with its wireless radio. It is battery powered and can be easily programmed.

Identification of the client

LIBELIUM COMUNICACIONES DISTRIBUIDAS, S.L.

C/ Escatrón 16 (Edificio Libelium), C.P.: 50014. Zaragoza. Spain.

Testing period

The performed test started on 2016-02-01 and finished on the same day.

The tests have been performed at AT4 wireless.

Environmental conditions

In the control chamber, the following limits were not exceeded during the test:

Temperature	Min. = 15 °C Max. = 30 °C
Relative humidity	Min. = 45 % Max. = 60 %
Shielding effectiveness	> 100 dB
Reference resistance to earth	< 1 Ω

In the semianechoic chamber, the following limits were not exceeded during the test.

Temperature	Min. = 15 °C Max. = 30 °C
Relative humidity	Min. = 45 % Max. = 60 %
Air pressure	Min. = 860 mbar Max. = 1060 mbar
Shielding effectiveness	> 100 dB
Reference resistance to earth	< 1 Ω
Normal site attenuation (NSA)	< ± 4 dB at 10 m & 3m distance between item under test and receiver antenna, (30 MHz to 1000 MHz)
Site VSWR	< ± 6 dB at 3m distance between item under test and receiver antenna, (1 GHz to 18 GHz)
Field homogeneity	More than 75% of illuminated surface is between 0 and 6 dB (26 MHz to 18 GHz).

In the chamber for conducted measurements, the following limits were not exceeded during the test:

Temperature	Min. = 15 °C Max. = 30 °C
Relative humidity	Min. = 45 % Max. = 60 %
Air pressure	Min. = 860 mbar Max. = 1060 mbar
Shielding effectiveness	> 100 dB
Reference resistance to earth	< 1 Ω

Modifications to the reference test report

The following modifications in respect to the test report number 45355REM.002 were included in the next clauses and sub-clauses:

- It was modified a typo in the IC code indicated on the page 1.
- The Operation Mode 02 defined as “programming mode connected by USB cable to an auxiliary PC” is included in the report. The measurement results for this mode are added.

This modification test report cancels and replaces the test report 48668REM.002 and 48668REM.002A1.

Remarks and comments

The tests have been realized by the technical personnel: José Manuel Márquez.

The total uncertainty of the measurement system for the measured radio disturbance characteristics of EUT from 150 kHz to 30 MHz is $I = \pm 3,60$ dB for quasi-peak measurements, $I = \pm 3,48$ dB for peak measurements ($k = 2$).

The total uncertainty of the measurement system for the measured radio disturbance characteristics of EUT from 30 MHz to 1 GHz is $I = \pm 4,57$ dB for quasi-peak measurements, $I = \pm 4,48$ dB for peak measurements ($k = 2$) and from 1 to 12,75 GHz is $I = \pm 3,43$ dB for average and peak measurements.

The total uncertainty of the measurement system for the measured radio disturbance characteristics of EUT from 12,75 GHz to 26 GHz is $I = \pm 4,09$ dB for average and peak measurements.

The conducted emission test does not apply according to the standard on DC power supply.

The operation mode used has been chosen as a worst case mode.

Testing verdicts (Legend)

Not applicable	N/A
Pass	P
Fail	F
Not measured	N/M

List of equipment used during the test

CONTROL NUMBER	DESCRIPTION	MANUFACTURER	MODEL	LAST CALIBRATION	NEXT CALIBRATION
1999	EMI Receptor	ROHDE & SCHWARZ	ESIB 26	2015-06-16	2017-06-16
2932	Bilog Hybrid Antenna	SUNOL	JB6	2014-05-11	2017-05-11
4612	Horn Antenna	SCHWARZBECK MESS- ELEKTRONIK	BBHA 9120D	2013-12-29	2016-12-29
4658	RF Amplifier	SCHWARZBECK	BBV9743	2015-03-19	2016-03-19
4662	Transient limiter	SCHWARZBECK	VTSD 9561-D	2014-02-12	2016-02-12
4659	RF Amplifier	SCHWARZBECK	BBV 9718	2015-09-29	2016-09-29
4729	RF Amplifier	BONN ELEKTRONIK	BLMA 1840-1M	2015-12-02	2017-12-02
3545	Temperature and humidity probe	PICO TECHNOLOGY	HUMIDIPROBE	2015-03-04	2016-03-04
3556	Digital termohigrometer	T&D	TR-72W	2015-04-16	2016-04-16
4657	Horn Antenna	SCHWARZBECK	BBHA 9170	2014-03-28	2017-03-28
0224	Artificial network	ROHDE & SCHWARZ	ESH2-Z5	2015-02-06	2017-02-06

Appendix A – Test result

APPENDIX A CONTENT:

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DESCRIPTION OF THE OPERATION MODES

The operation modes described in this paragraph constitute a functionality of the sample under test for itself. Every operation mode takes a failure criteria for the immunity test that they were applying to it and a monitoring to guarantee performance of the same ones.

In the following table appears the operation modes used by the samples tested to that it refers the present test report.

OPERATION MODE	DESCRIPTION
OM#01	EUT ON. IDLE LTE Band 2. GPS ON. Charging battery : 6Vdc.
OM#02	EUT ON. Equipment in programming mode connected by USB cable to an auxiliary PC. Charging battery: 6Vdc. PC power supply: 115Vac.

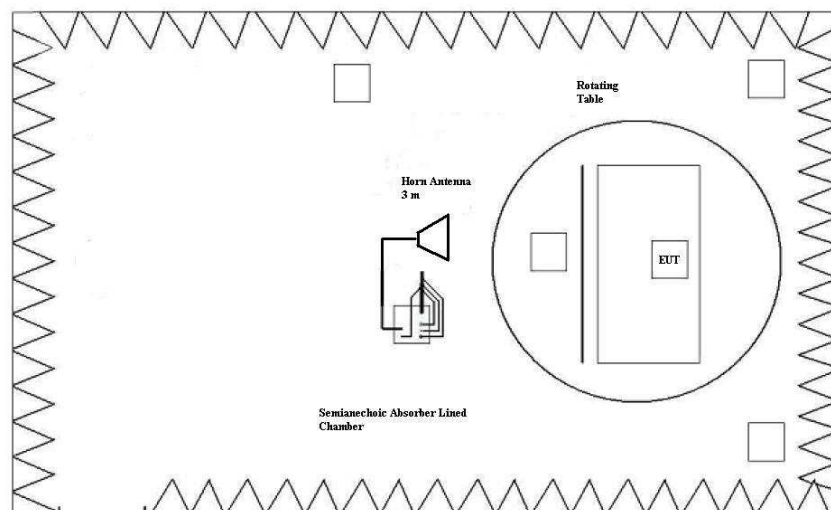
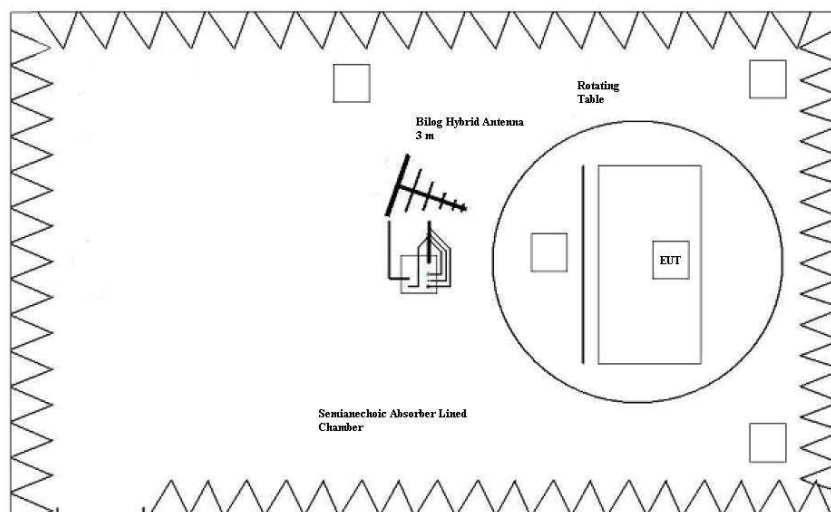
RADIATED EMISSION. ELECTROMAGNETIC FIELD MEASURE.

LIMITS:	Product standard:	FCC RULES AND REGULATIONS 47 CFR PART 15, SUBPART B (10-01-14 Edition) & ICES-003 ISSUE 5 (2012)
	Test standard:	FCC RULES AND REGULATIONS 47 CFR PART 15, SUBPART B (10-01-14 Edition) & ICES-003 ISSUE 5 (2012)

LIMITS OF INTERFERENCE CLASS B

The applied limit for radiated emissions, 3 m distance, according with the requirements of FCC Rules and Regulations 47 CFR Part 15.109, Subpart B (10-01-14 Edition) & ICES-003 ISSUE 5 (2012) in the frequency range 30 MHz to 26 GHz, for Class B equipment, which is a transmitter in a band over 500 MHz, was:

Frequency range (MHz)	QP Limit for 3 m ($\mu\text{V/m}$)	QP Limit for 3 m ($\text{dB}\mu\text{V/m}$)
30 to 88	100	40
88 to 216	150	43.52
216 to 960	200	46.02
Above 960	500	53.98
Above 1000	Limit for 3m AVG	Limit for 3m PK
	53.98 $\text{dB}\mu\text{V/m}$	73.98 $\text{dB}\mu\text{V/m}$



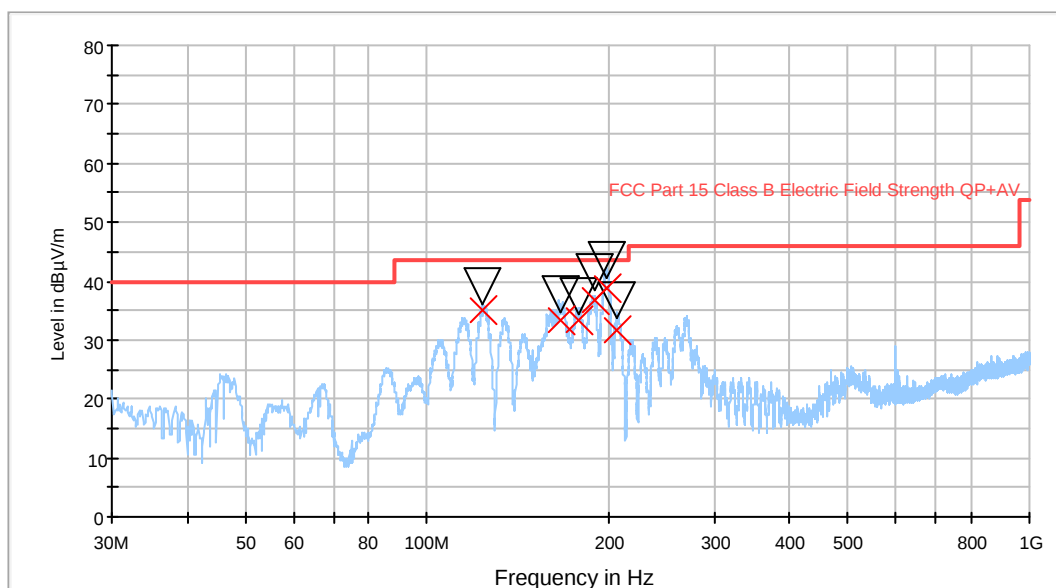
TESTED SAMPLES:	S/01
TESTED OPERATION MODES:	OM#01 & OM#02
TEST RESULTS :	CRmmnnxxyy: CR, Radiation Condition; mm: Sample number; nn: Operation mode ; xx: Measured range; yy: Polarisation.

CRmmnnxxyy	Description	Result
CR0101_RB	Range 30-1000 MHz.	P
CR0101_RA1_PH	Range 1-18 GHz. Horizontal pol.	P
CR0101_RA1_PV	Range 1-18 GHz. Vertical pol.	P
CR0101_RA2_PH	Range 18-26 GHz. Horizontal pol.	P
CR0101_RA2_PV	Range 18-26 GHz. Vertical pol.	P
CR0102	The programming USB mode (02) is previewed and compared with normal mode (01). It is checked that the normal operation mode is the worst case, so the final measurements are performed on operation mode 01.	P

Radiated Emission: CR0101_RB (30MHz to 1GHz)

Project: 48668rem002
Company: Libelium
Sample: S/01
Operation mode: OM#01
Description: EUT ON. IDLE LTE Band II. GPS ON. Charging battery. 6Vdc

FCC class B



▽ FCC Part 15 Class B Electric Field Strength QP+AV MaxPeak
× Preview Result 1-PK+ QuasiPeak

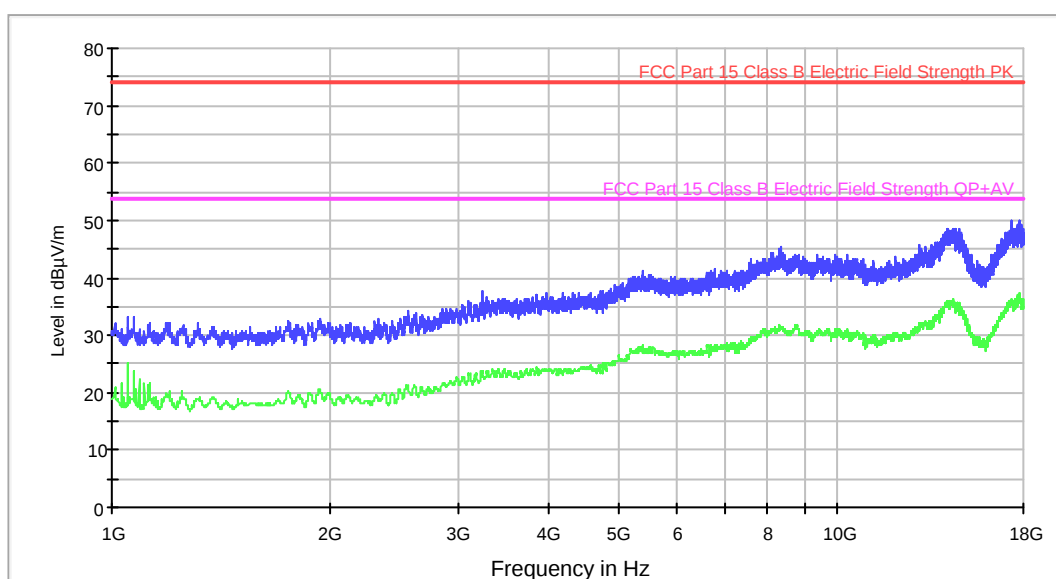
Maxizations

Frequency (MHz)	MaxPeak (dBµV/m)	QuasiPeak (dBµV/m)	Height (cm)	Polarization	Azimuth (deg)
123.752705	39.2	35.0	98.0	V	316.0
166.233868	37.8	33.3	140.0	H	150.0
178.468337	37.5	33.4	98.0	V	292.0
189.248898	41.4	36.8	185.0	H	111.0
198.990982	43.6	38.9	130.0	H	97.0
207.023447	36.6	31.8	138.0	H	107.0

Radiated Emission: CR0101_RA1_PH (1 – 18 GHz)

Project: 48668rem002
Company: Libelium
Sample: S/01
Operation mode: OM#01
Description: EUT ON. IDLE LTE Band II. GPS ON. Charging battery. 6Vdc.
Horizontal polarization.

FCC 1-18GHz class B



— MaxPeak-ClearWrite-PK+ — Average-ClearWrite-AVG
— FCC Part 15 Class B Electric Field Strength PK — FCC Part 15 Class B Electric Field Strength QP+AV

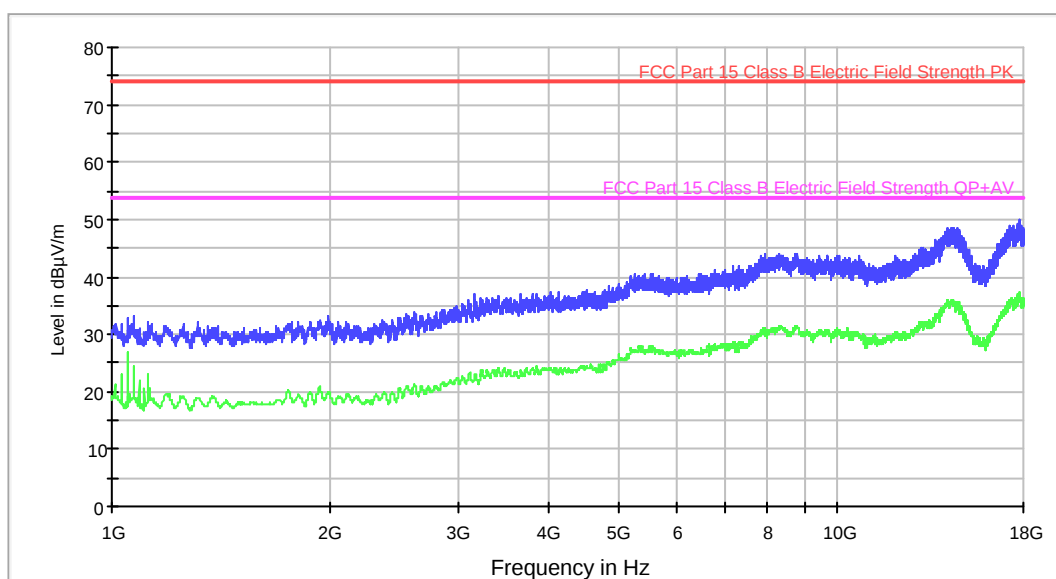
Subrange Maxima

Frequency (MHz)	MaxPeak-ClearWrite (dBµV/m)	Average-ClearWrite (dBµV/m)	Polarization
1050.000000	33.2	25.2	H
1745.000000	32.5	20.0	H
2332.000000	33.0	18.8	H
3101.000000	35.9	23.0	H
3239.000000	37.6	23.5	H
5376.000000	41.2	28.1	H
7559.000000	42.5	29.2	H
8340.000000	45.3	31.3	H
13423.000000	45.8	32.4	H
17331.000000	50.0	36.2	H

Radiated Emission: CR0101_RA1_PV (1 – 18 GHz)

Project: 48668rem002
Company: Libelium
Sample: S/01
Operation mode: OM#01
Description: EUT ON. IDLE LTE Band II. GPS ON. Charging battery. 6Vdc.
Vertical polarization.

FCC 1-18GHz class B



— MaxPeak-ClearWrite-PK+ — Average-ClearWrite-AVG
— FCC Part 15 Class B Electric Field Strength PK — FCC Part 15 Class B Electric Field Strength QP+AV

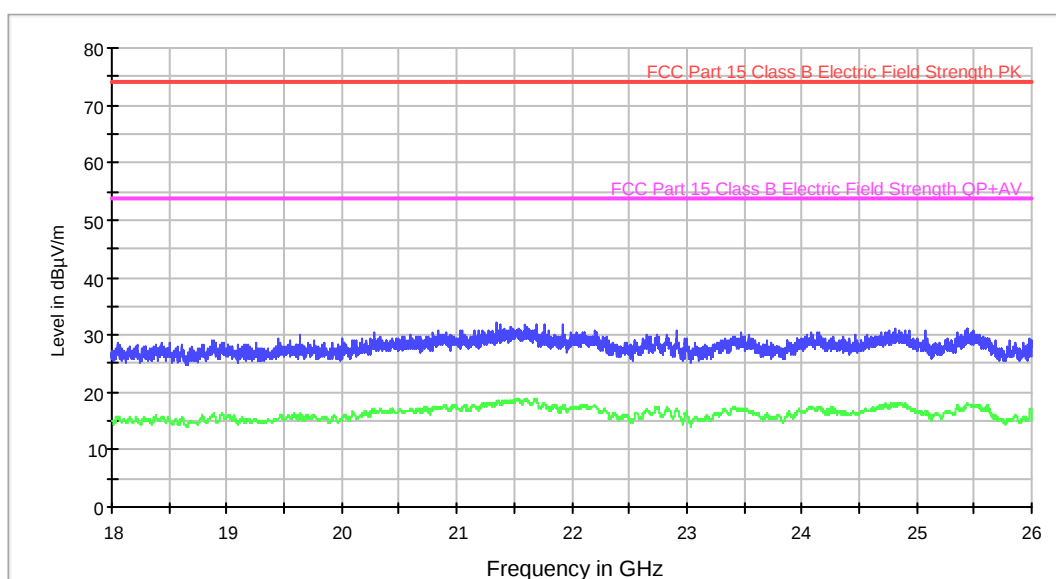
Subrange Maxima

Frequency (MHz)	MaxPeak-ClearWrite (dBμV/m)	Average-ClearWrite (dBμV/m)	Polarization
1070.000000	33.1	24.3	V
1770.000000	32.1	18.5	V
1991.000000	33.3	19.8	V
3154.000000	37.1	22.4	V
4014.000000	37.5	24.0	V
5558.000000	40.6	27.7	V
7322.000000	42.0	28.6	V
8783.000000	44.1	31.4	V
13140.000000	45.2	31.8	V
17752.000000	49.9	37.1	V

Radiated Emission: CR0101_RA2_PH (18 – 26 GHz)

Project: 48668rem002
Company: Libelium
Sample: S/01
Operation mode: OM#01
Description: EUT ON. IDLE LTE Band II. GPS ON. Charging battery. 6Vdc.
Horizontal polarization.

FCC 18-26GHz class B



— MaxPeak-ClearWrite-PK+ — Average-ClearWrite-AVG
— FCC Part 15 Class B Electric Field Strength PK — FCC Part 15 Class B Electric Field Strength QP+AV

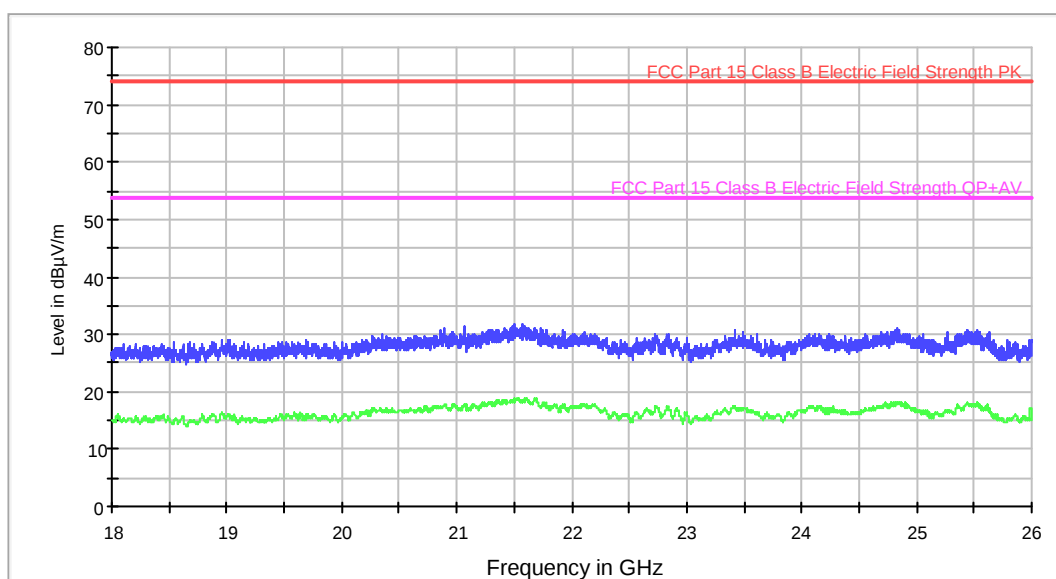
Subrange Maxima

Frequency (MHz)	MaxPeak-ClearWrite (dBμV/m)	Average-ClearWrite (dBμV/m)	Polarization
18055.000000	28.6	15.9	H
18872.000000	29.1	15.9	H
19642.000000	29.9	16.2	H
20839.000000	30.7	17.4	H
21352.000000	32.0	18.4	H
21924.000000	31.8	18.0	H
22917.000000	30.7	16.9	H
24087.000000	30.6	17.4	H
24814.000000	30.9	18.3	H
25442.000000	31.0	18.0	H

Radiated Emission: CR0101_RA2_PV (18 – 26 GHz)

Project: 48668rem002
Company: Libelium
Sample: S/01
Operation mode: OM#01
Description: EUT ON. IDLE LTE Band II. GPS ON. Charging battery. 6Vdc.
Vertical polarization.

FCC 18-26GHz class B



— MaxPeak-ClearWrite-PK+ — Average-ClearWrite-AVG
— FCC Part 15 Class B Electric Field Strength PK — FCC Part 15 Class B Electric Field Strength QP+AV

Subrange Maxima

Frequency (MHz)	MaxPeak-ClearWrite (dBμV/m)	Average-ClearWrite (dBμV/m)	Polarization
18545.000000	28.5	14.9	V
18958.000000	28.9	16.4	V
19683.000000	29.0	15.3	V
20852.000000	30.8	17.3	V
21576.000000	31.7	18.4	V
21723.000000	31.2	17.4	V
22836.000000	30.1	17.2	V
23416.000000	30.6	17.4	V
24833.000000	31.1	17.7	V
25526.000000	30.8	17.7	V

CONTINUOUS CONDUCTED EMISSION

LIMITS:	Product standard :	FCC RULES AND REGULATIONS 47 CFR PART 15, SUBPART B (10-01-13 Edition); ICES-003 ISSUE 5 (2012)
	Test standard :	FCC RULES AND REGULATIONS 47 CFR PART 15, SUBPART B (10-01-13 Edition); ICES-003 ISSUE 5 (2012)

CLASS B

The applied limit for continuous conducted emissions in power leads, according with the requirements of FCC Rules and Regulations 47 CFR Part 15, Subpart B (10-01-15 Edition), Secs. 15.107, 15.109 and Subpart C (10-1-15 Edition) Secs. 15.207 & ICES-003 Issue 6 (2016), in the frequency range 0,15 to 30 MHz, for Class B equipment was:

Frequency range (MHz)	Limit (dBμV)	
	Quasi-peak	Average
0,15 to 0,5	66-56	56-46
0,5 to 5	56	46
5 to 30	60	50

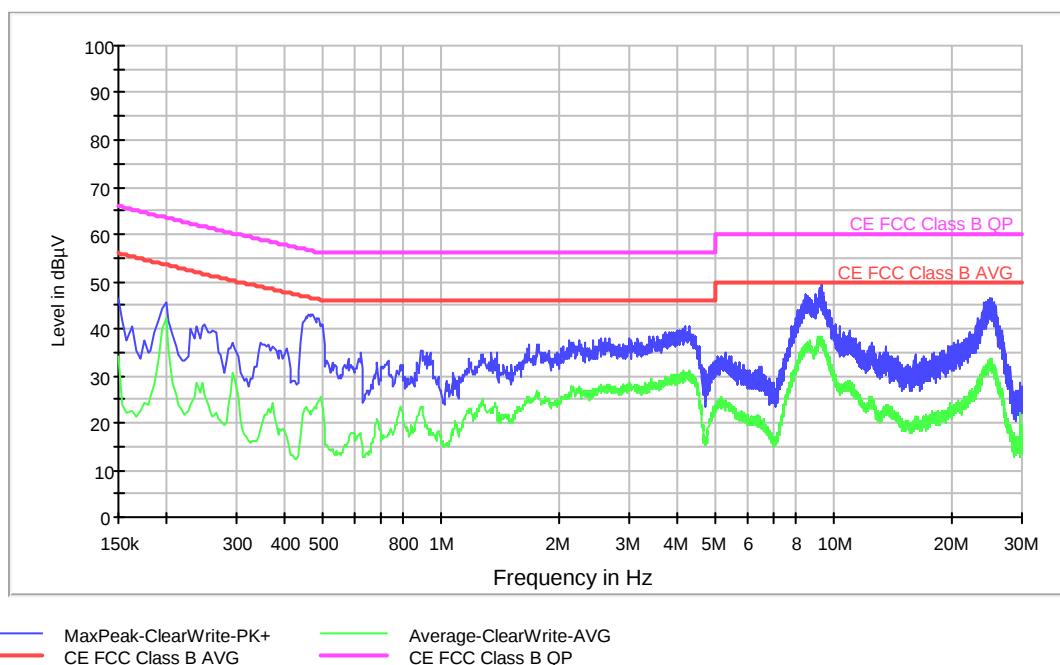
TESTED SAMPLES:	S/01
TESTED OPERATION MODES:	OM#02
TEST RESULTS :	CCmmnnhh: CC, Conducted Condition; mm: Sample number; nn: Operation mode; hh: wire

CCmmnnhh	Description	Result
CC01020N	Neutral wire noise.	P
CC0102L1	Phase wire noise.	P

Conducted Emission. CC01020N

Project: 48668REM.002
Company: Libelium
Sample: S/01
Operation mode: OM#02
Description: EUT ON. Equipment in programming mode connected by USB cable to an auxiliary PC. Charging battery: 6Vdc. PC power supply: 115Vac. Neutral wire noise.

EC FCC Class B



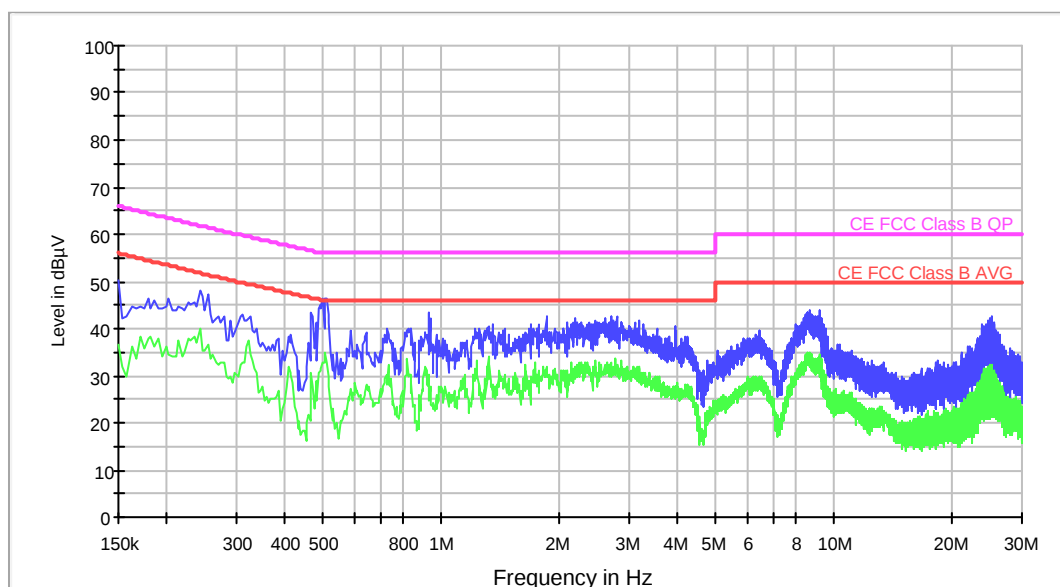
Subrange Maxima

Frequency (MHz)	MaxPeak-ClearWrite (dBµV)	Average-ClearWrite (dBµV)
0.150000	46.2	34.0
0.262000	39.6	21.3
0.458000	43.1	22.6
0.882000	35.2	23.3
2.106000	37.6	26.4
3.530000	38.2	28.2
4.170000	40.5	30.2
9.234000	49.2	37.5
10.866000	39.4	28.7
25.010000	46.5	33.5

Conducted Emission. CC0102L1

Project: 48668REM.002
Company: Libelium
Sample: S/01
Operation mode: OM#02
Description: EUT ON. Equipment in programming mode connected by USB cable to an auxiliary PC. Charging battery: 6Vdc. PC power supply: 115Vac. Phase wire noise.

EC FCC Class B



— MaxPeak-ClearWrite-PK+ — Average-ClearWrite-AVG
— CE FCC Class B AVG — CE FCC Class B QP

Subrange Maxima

Frequency (MHz)	MaxPeak-ClearWrite (dBµV)	Average-ClearWrite (dBµV)
0.150000	50.1	36.5
0.310000	43.0	32.9
0.510000	46.6	32.9
0.926000	43.3	30.0
1.854000	42.6	31.5
2.782000	42.6	31.8
3.934000	40.6	26.7
8.630000	43.9	33.6
11.022000	35.2	23.7
25.078000	42.7	32.2