



Informe de ensayo nº:
Test report No:

NIE: 45355REM.002A4

Test Report (Modification 4)

FCC Rules and Regulations 47 CFR Chapter I Part 15 Subpart B (10-01-13 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	Wasmote Plug & Sense! 802.15.4
Other identification of the product	S/N: 1
Final HW version	1.0
Final SW version	1.0
FCC ID	XKM-WPS-2400-V1
IC	8472A-WPS2400V1
ANATEL ID.....	0378-15-1209
Features.....	Can transmit with the 802.15.4 protocol in the 2.4 GHz ISM band. Contains an XBee-PRO 802.15.4 radio.
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 (10-01-13 Edition); ICES-003 ISSUE 5 (2012)
Summary	IN COMPLIANCE
Approved by (name / position & signature).....	Francisco Cañas Regulatory LAB Director
Date of issue.....	2016-11-10
Report template No.....	FDT11_18

Index

Competences and Guarantees	3
General conditions	3
Usage of samples	4
Test sample description	4
Identification of the client	4
Testing period	4
Environmental conditions	5
Modifications to the reference test report	6
Remarks and comments	6
Testing verdicts (Legend)	6
List of equipment used during the test	7
Appendix A – Test result	8

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.

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.

IMPORTANT: No parts of this report may be reproduced or quoted out of context, in any form or by any means, except in full, without the previous written permission of AT4 wireless, S.A.

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/02 is composed of the following elements:

Control N°	Description	Model	Serial number	Reception date
45355/001	Sensor node with wireless communications	Plug&Sense	1	2015-12-03
45355/018	Plug&Sense 2.4GHz RF antenna	Plug&Sense	---	2015-12-03
45355/073	Luminosity probe	Plug&Sense	---	2015-12-03
45355/132	Module	Xbee-PRO 802.15.4	---	2015-12-03

Modifications on sample S/02:

Sample S/02 incorporates two ferrites with the code MURATA BLM21AG601SN1, one in the clock input and the other in the clock output. It was added a 50nF capacitor to the DC/DC input. It was added a 50nF capacitor to the DC/DC output. It was added a toroidal ferrite with the code WÜRTH 7427013 with two turns on the mains cable. It was diminished the charge current with R43 to 3,3K. It was added a ferrite with the code WÜRTH 742 712 22 with two turns in the power supply cable. It was added a ferrite with the code WÜRTH7427503 in the positive load cable and it was modified the C15 value to 22µF.

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 2015-11-04 and finished on 2016-02-03

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. = 35 °C
Relative humidity	Min. = 20 % Max. = 80 %
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 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:

- Front page: By client requirement it was modified a typo in the sample model, replacing “Waspote Plug & Sense! 802.15.4 EU” to “Waspote Plug & Sense! 802.15.4”
- Clause “Usage of samples”: Sample 01 is replaced by Sample 02 with the following change: Element 45355/131 (EU module) is replaced by element 45355/132 (rest of the world module).
- Clause “RADIATED EMISSION. ELECTROMAGNETIC FIELD MEASURE”: The measurement graphs and results are updated with the new sample results.
- It was modified a typo in the IC code of 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 45355REM.002, 45355REM.002A1, 45355REM.002A2 and 45355REM.002A3

Remarks and comments

The tests have been performed by the technical personnel: Pedro Manuel Valenzuela.

The total uncertainty of the measurement system for the measured radio disturbance characteristics of EUT from 30 MHz to 1000 MHz is $I = \pm 4,37$ dB for quasi-peak measurements, $I = \pm 4,28$ dB for peak measurements ($k = 2$).

The total uncertainty of the measurement system for the measured radio disturbance characteristics of EUT from 1000 MHz to 26GHz is $I = \pm 2,62$ dB for peaks and average measurements ($k = 2$).

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

CONTENT

DESCRIPTION OF THE OPERATION MODES10

RADIATED EMISSION, ELECTROMAGNETIC FIELD MEASURE11

CONTINUOUS CONDUCTED EMISSION18

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.

The operation modes used by the samples to which the present report refers, are shown in the following table:

OPERATION MODE	DESCRIPTION
OM#01	EUT ON. Equipment in Idle mode. 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.

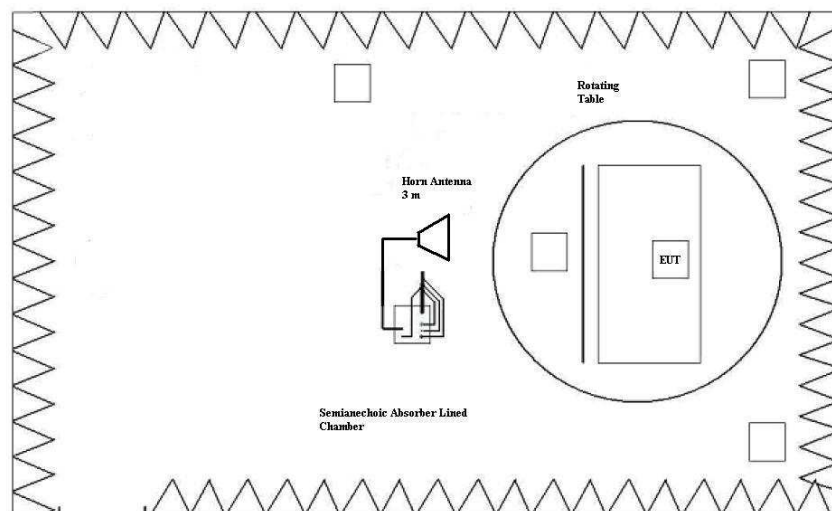
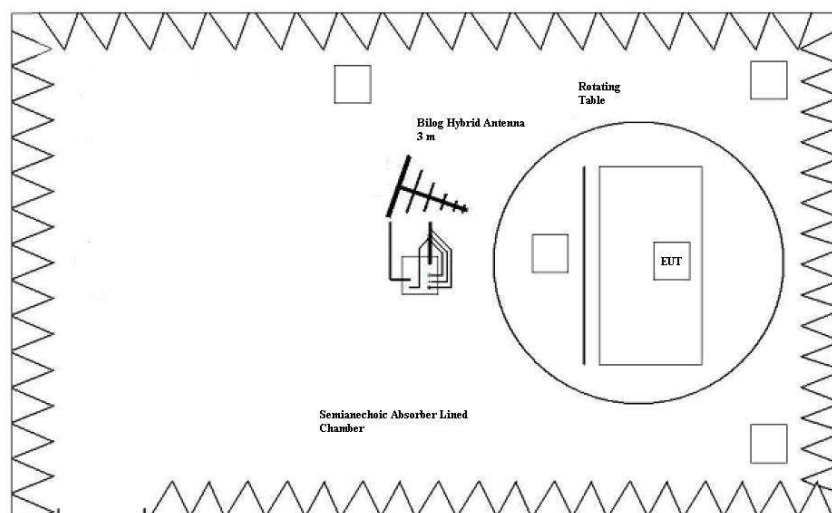
RADIATED EMISSION. ELECTROMAGNETIC FIELD MEASURE

LIMITS:	Product standard:	FCC RULES AND REGULATIONS 47 CFR PART 15, SUBPART B (10-01-13 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)

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 (10-01-13 Edition); ICES-003 ISSUE 5 (2012) & ANSI C63.4-2009 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 $\text{dB}\mu\text{V/m}$



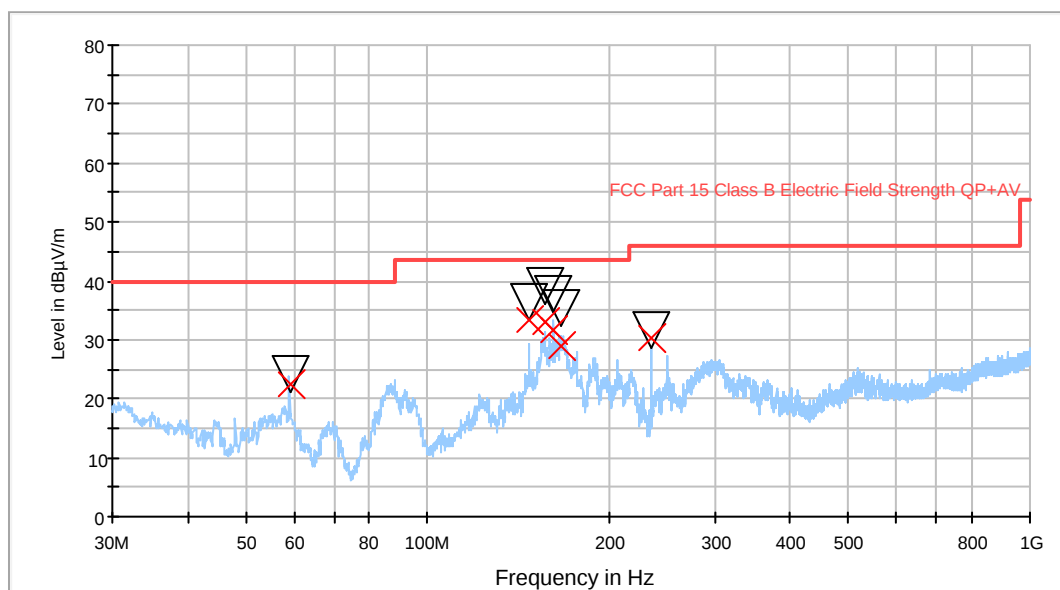
TESTED SAMPLES:	S/02
TESTED OPERATION MODES:	OM#01 & OM#02
TEST RESULTS:	CRmmnn: CR, Radiation Condition; mm: Sample number; nn: Operation mode;

CRmmnn	Description	Result
CR0201RB	Range: 30 MHz - 1000 MHz.	P
CR0201RA_1_PH	Range: 1 GHz - 18 GHz. Horizontal polarization.	P
CR0201RA_1_PV	Range: 1 GHz - 18 GHz. Vertical polarization.	P
CR0201RA_2_PH	Range: 18 GHz - 26 GHz. Horizontal polarization.	P
CR0201RA_2_PV	Range: 18 GHz - 26 GHz. Vertical polarization.	P
CR0202	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. CR0201RB

Project: 45355REM.002
Company: LIBELIUM COMUNICACIONES DISTRIBUIDAS S.L.
Sample: S/02
Operation mode: OM#01
Description: EUT ON. IDLE Mode. Charging battery. 6Vdc.

FCC class B



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

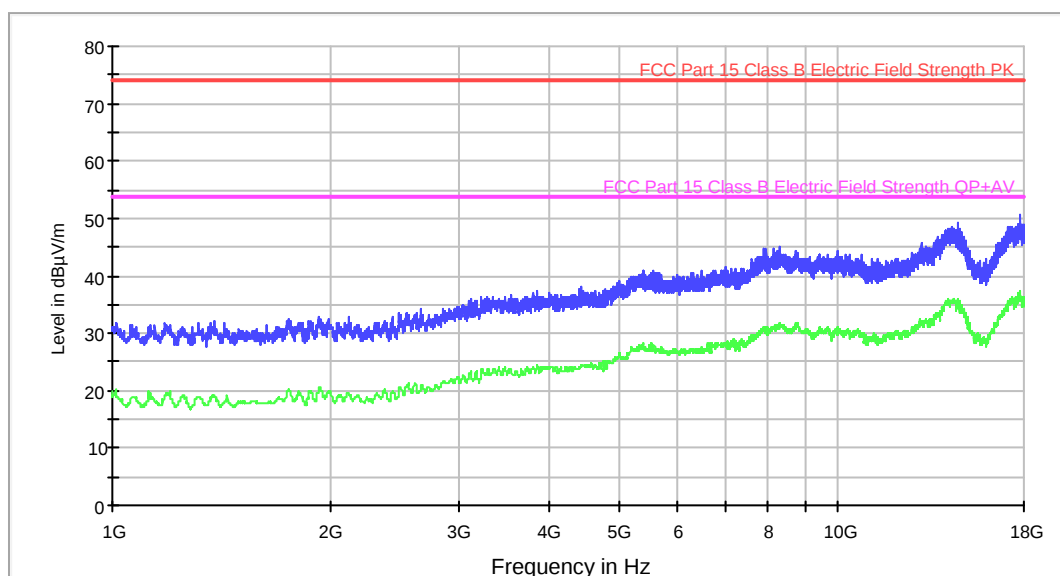
Maximizations

Frequency (MHz)	MaxPeak (dBµV/m)	QuasiPeak (dBµV/m)	Height (cm)	Polarization	Azimuth (deg)
59.146493	24.0	22.5	118.0	H	71.0
147.449098	36.6	33.5	214.0	H	228.0
156.921443	39.3	32.9	251.0	H	251.0
162.201002	37.8	31.5	184.0	H	254.0
167.172545	35.5	29.1	158.0	H	167.0
235.921042	31.5	30.2	138.0	H	210.0

Radiated Emission. CR0201RA_1_PH

Project: 45355REM.002
Company: LIBELIUM COMUNICACIONES DISTRIBUIDAS S.L.
Sample: S/02
Operation mode: OM#01
Description: EUT ON. IDLE Mode. 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

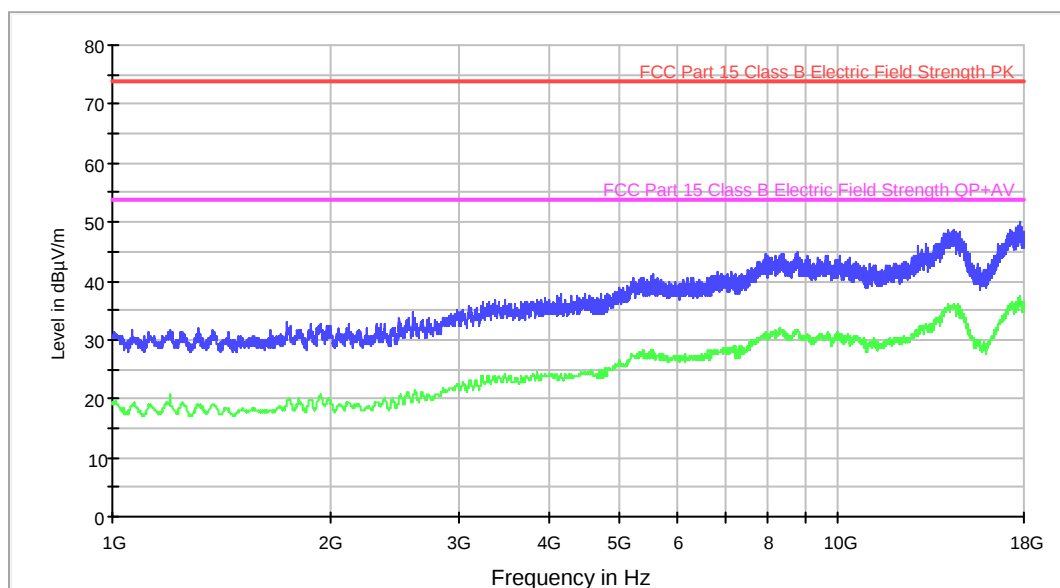
Subrange Maxima

Frequency (MHz)	MaxPeak-ClearWrite (dBµV/m)	Average-ClearWrite (dBµV/m)
1016.000000	31.9	19.0
1750.000000	32.5	20.1
1923.000000	32.7	20.1
3120.000000	36.0	22.6
3855.000000	37.4	24.3
5387.000000	41.0	27.7
6974.000000	41.6	28.0
8312.000000	44.9	31.5
13049.000000	45.9	32.1
17747.000000	50.6	36.9

Radiated Emission. CR0201RA_1_PV

Project: 45355REM.002
Company: LIBELIUM COMUNICACIONES DISTRIBUIDAS S.L.
Sample: S/02
Operation mode: OM#01
Description: EUT ON. IDLE Mode. 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

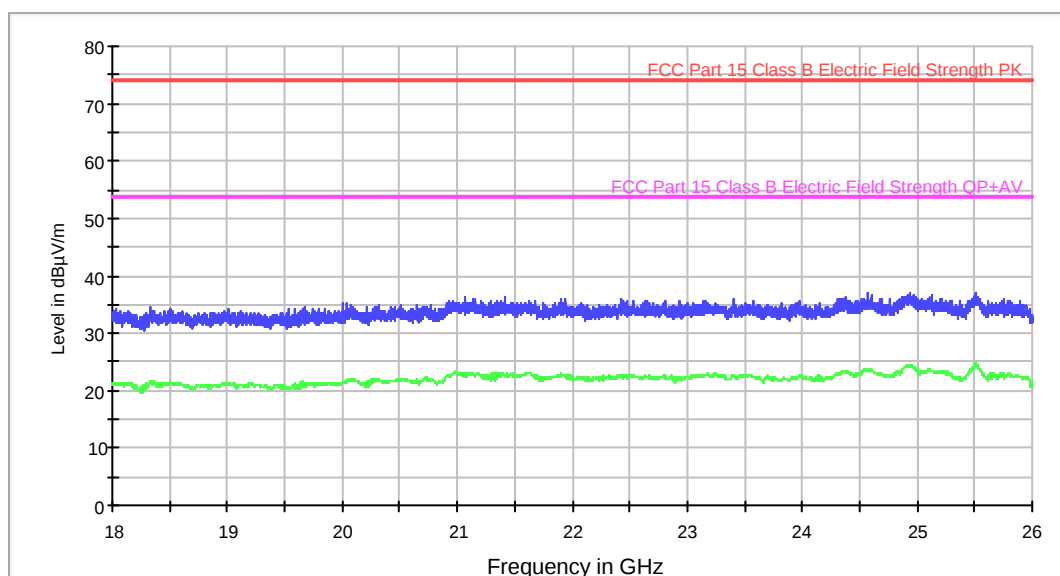
Subrange Maxima

Frequency (MHz)	MaxPeak-ClearWrite (dBµV/m)	Average-ClearWrite (dBµV/m)
1311.000000	32.1	19.0
1739.000000	33.0	19.4
1872.000000	32.7	19.8
3102.000000	35.6	23.0
4141.000000	37.7	23.9
5572.000000	41.0	27.9
7470.000000	41.7	28.2
8754.000000	44.9	31.3
13205.000000	46.4	32.5
17767.000000	50.1	36.2

Radiated Emission. CR0201RA_2_PH

Project: 45355REM.002
Company: LIBELIUM COMUNICACIONES DISTRIBUIDAS S.L.
Sample: S/02
Operation mode: OM#01
Description: EUT ON. IDLE Mode. 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

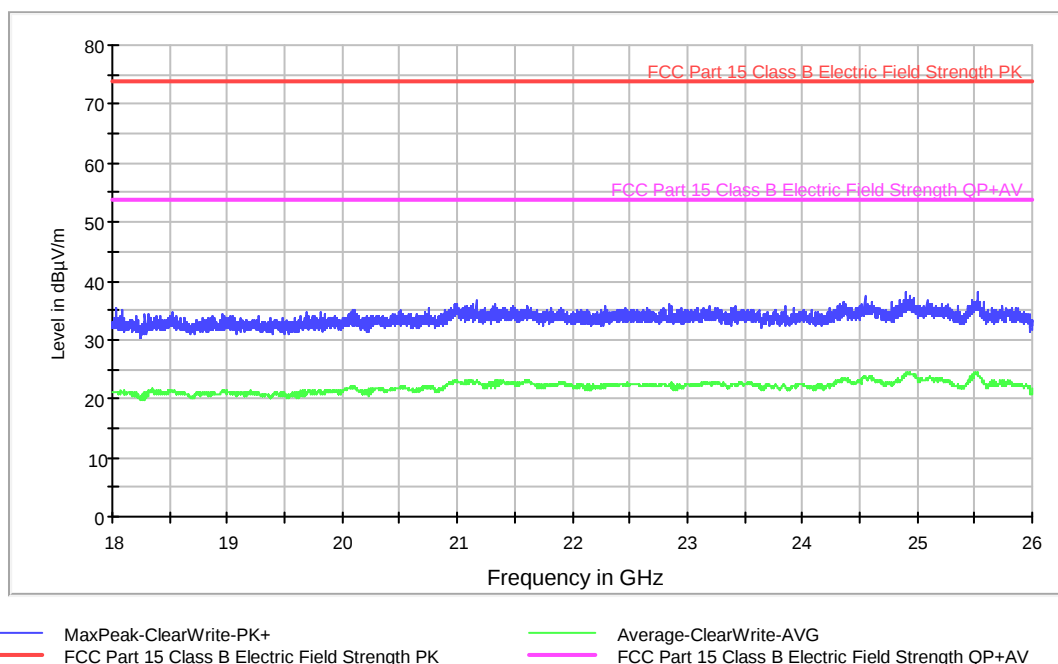
Subrange Maxima

Frequency (MHz)	MaxPeak-ClearWrite (dBµV/m)	Average-ClearWrite (dBµV/m)
18335.000000	34.5	21.5
19005.000000	34.1	21.3
20036.000000	35.5	21.6
20654.000000	35.0	21.9
21069.000000	36.3	22.9
22427.000000	36.0	22.6
22526.000000	35.7	22.4
23402.000000	35.9	22.5
24938.000000	37.0	24.4
25517.000000	37.1	24.6

Radiated Emission. CR0201RA_2_PV

Project: 45355REM.002
Company: LIBELIUM COMUNICACIONES DISTRIBUIDAS S.L.
Sample: S/02
Operation mode: OM#01
Description: EUT ON. IDLE Mode. Charging battery. 6Vdc. Vertical Polarization.

FCC 18-26GHz class B



Subrange Maxima

Frequency (MHz)	MaxPeak-ClearWrite (dBµV/m)	Average-ClearWrite (dBµV/m)
18034.000000	35.4	21.1
18958.000000	34.4	21.3
20099.000000	35.1	21.9
20751.000000	35.3	21.8
21164.000000	36.7	22.8
22288.000000	35.6	21.9
22850.000000	36.1	22.2
23850.000000	35.8	22.2
24904.000000	38.0	24.4
25524.000000	38.3	24.4

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 (10-01-13 Edition), Secs. 15.107, 15.109 and Subpart C (10-1-13 Edition) Secs. 15.207 & ICES-003 Issue 5 (2012), in the frequency range 0,15 to 30 MHz, for Class B equipment was:

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

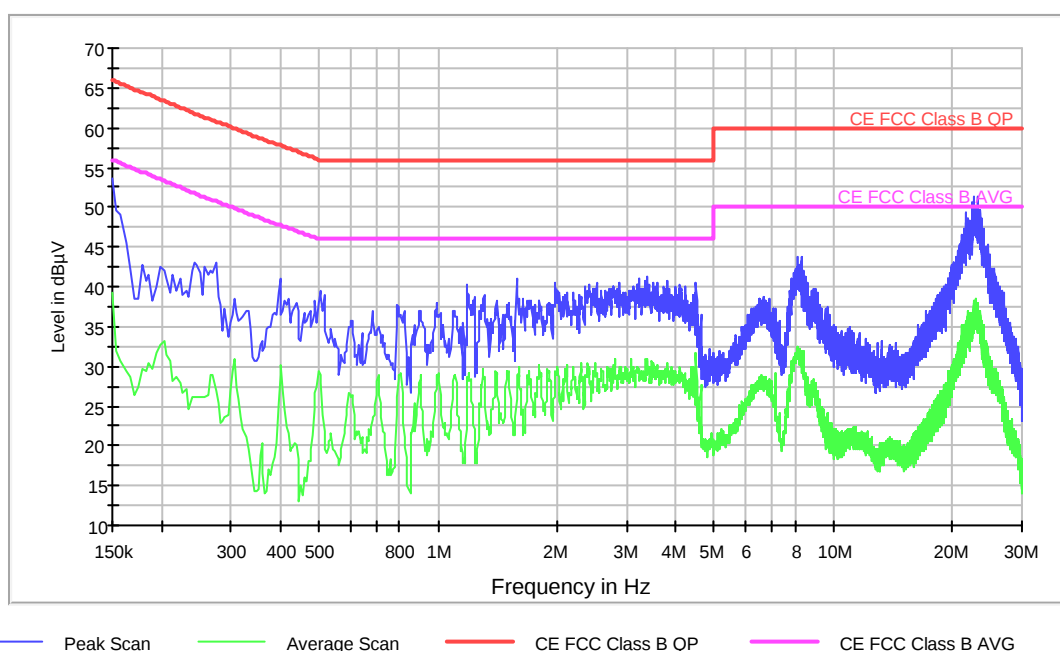
TESTED SAMPLES:	S/02
TESTED OPERATION MODES:	OM#02
TEST RESULTS :	CCmmnnhh: CC, Conducted Condition; mm: Sample number; nn: Operation mode; hh: wire

CCmmnnhh	Description	Result
CC02020N	Neutral wire noise.	P
CC0202L1	Phase wire noise.	P

Conducted Emission. CC02020N

Project: 45355REM.002
Company: LIBELIUM COMUNICACIONES DISTRIBUIDAS S.L.
Sample: S/02
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



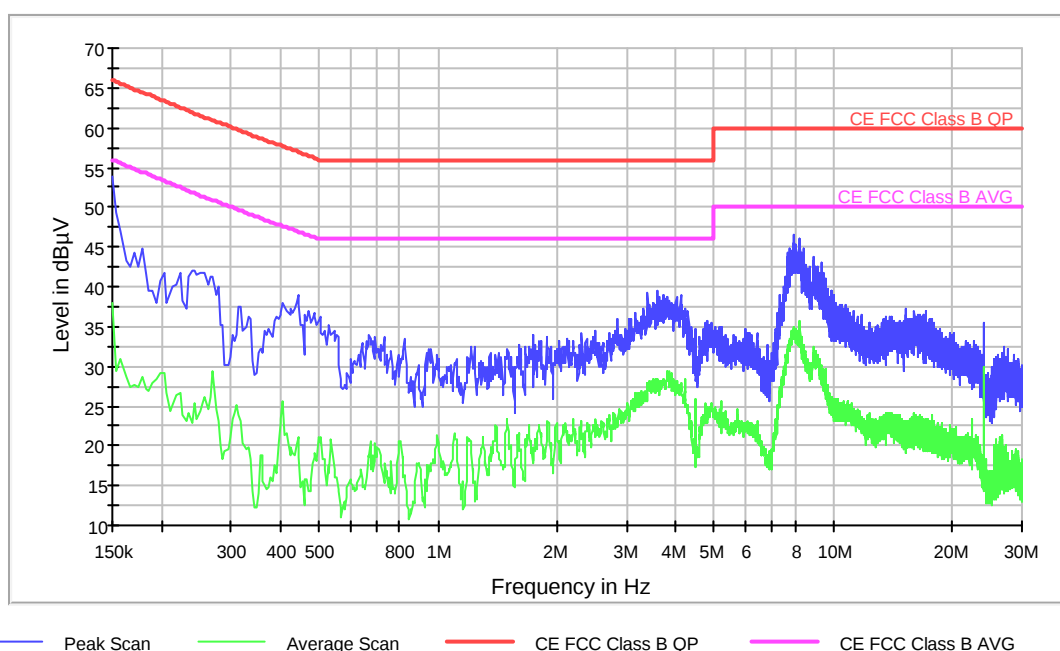
Subrange Maxima

Frequency (MHz)	MaxPeak-ClearWrite (dBµV)	Average-ClearWrite (dBµV)
0.150000	53.7	39.2
0.274000	43.0	26.8
0.502000	39.6	29.0
1.186000	40.1	27.7
1.578000	40.9	25.9
3.398000	41.2	30.9
3.802000	40.8	30.3
8.110000	43.8	32.3
17.610000	37.0	24.3
22.574000	51.3	36.5

Conducted Emission. CC0202L1

Project: 45355REM.002
Company: LIBELIUM COMUNICACIONES DISTRIBUIDAS S.L.
Sample: S/02
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



Subrange Maxima

Frequency (MHz)	MaxPeak-ClearWrite (dBµV)	Average-ClearWrite (dBµV)
0.150000	54.0	38.1
0.258000	41.8	26.1
0.442000	39.0	21.0
0.822000	33.5	16.4
1.734000	33.8	19.6
3.578000	39.4	27.4
4.102000	39.1	27.0
7.938000	46.5	34.5
10.750000	37.8	24.5
17.718000	35.8	23.1