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Rapport d'essai / *Test report*

N° 249987-R1-E **JDE : 110606**

DELIVRE A / *ISSUED TO* : **INGENICO**
9 Avenue de la Gare
Rovaltain TGV - BP 25156
26958 VALENCE Cedex 9

Objet / *Subject* : Essais de compatibilité électromagnétique conformément aux normes
FCC CFR 47 Part 15, Subpart B et C
RSS-210 Issue 8
Electromagnetic compatibility tests according to the standards
FCC CFR 47 Part 15, Subpart B and C
RSS-210 Issue 8

Matériel testé / *Apparatus under test* :

- Produit / *Product* : **Clavier pour automate banquaire / Bank automate keyboard**
- Marque / *Trade mark* : **INGENICO**
- Constructeur / *Manufacturer* : **INGENICO**
- Type / *Model* : **IUP250-01T1869**
- N° de série / *serial number* : **1293IU0000041**
- FCC ID : **XKB-IUP250-RF**
- IC : **2586D-IUP250**

Date des essais / *Test date* : Du 31 Janvier au 8 Février 2012 / *From January 31st to February 8th , 2012*

Lieu d'essai / *Test location* : **LCIE SUD-EST**
ZI Centr'Alp – 170 rue de Chatagnon
38430 MOIRANS - FRANCE

Test réalisé par / *Test performed by* : Jonathan PAUC

Ce document comporte /*Composition of document :* 47 pages.

MOIRANS, LE 19 JUILLET 2012 / *JULY 19TH, 2012*

Ecrit par / *Written by,*
Anthony MERLIN

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SUMMARY

1. TEST PROGRAM

Standard:
- **FCC Part 15, Subpart C 15.247**
- **ANSI C63.4 (2003)**
- **RSS-210 Issue 8 – Dec 2010**
- **RSS-Gen Issue 3 – Dec 2010**

EMISSION TEST	LIMITS			RESULTS (Comments)
Limits for conducted disturbance at mains ports 150kHz-30MHz	**Frequency**	**Quasi-peak value (dBµV)**	**Average value (dBµV)**	**COMPLY**
	150-500kHz	66 to 56	56 to 46	
	0.5-5MHz	56	46	
	5-30MHz	60	50	
Radiated emissions 9kHz-30MHz *CFR 47 §15.209 (a)* *CFR 47 §15.247 (d)* *RSS-210 §A8.5*	**Measure at 300m** 9kHz-490kHz : 67.6dBµV/m /F(kHz) **Measure at 30m** 490kHz-1.705MHz : 87.6dBµV/m /F(kHz) 1.705MHz-30MHz : 29.5 dBµV/m			**COMPLY**
Radiated emissions 30MHz-25GHz* *CFR 47 §15.209 (a)* *CFR 47 §15.247 (d)* *RSS-210 §A8.5*	**Measure at 3m** 30MHz-88MHz : 40 dBµV/m 88MHz-216MHz : 43.5 dBµV/m 216MHz-960MHz : 46.0 dBµV/m Above 960MHz : 54.0 dBµV/m			**COMPLY**
Maximum Peak Output Power *CFR 47 §15.247 (b)* *RSS-210 §A8.4(1)*	**Limit: 21dBm** Conducted or Radiated measurement			**COMPLY**
Hopping Channel Separation *CFR 47 §15.247 (a) (1)* *RSS-210 §A8.1(b)*	**Minimum between:** Two-third 20dB Bandwidth or 25kHz Whichever is greater			**COMPLY**
Number of Hopping Frequencies *CFR 47 §15.247 (a) (1) (iii)* *RSS-210 §A8.1(d)*	**At least 15 channels used**			**COMPLY**
Time of Occupancy (Dwell Time) *CFR 47 §15.247 (a) (1) (iii)* *RSS-210 §A8.1(d)*	**Maximum 0.4 sec within 31.6sec**			**COMPLY**
Band Edge Measurement *CFR 47 §15.209 (a)* *CFR 47 §15.247 (d)* *RSS-210 §A8.5*	**Limit: -20dBc**			**COMPLY**
Occupied bandwidth *RSS-Gen §4.6.1*	**No limit**			**COMPLY**
Transmitter Frequency Stability *RSS-Gen §4.7*	**+/-0.01% of the operating frequency**			**N/A**
Receiver Spurious Emission** *RSS-Gen §4.10*	**See RSS-Gen §4.10**			**COMPLY**

***§15.33:** The highest internal source of a testing device is defined like more the highest frequency generated or used in the testing device or on which the testing device works or agrees.
- If the highest frequency of the internal sources of the testing device is lower than 108 MHz, measurement must be only performed until 1GHz.
- If the highest frequency of the internal sources of the testing device ranges between 108 MHz and 500 MHz, measurement must be only performed until 2GHz.
- If the highest frequency of the internal sources of the testing device ranges between 500 MHz and 1 GHz, measurement must be only performed until 5GHz.

If the highest frequency of the internal sources of the testing device is above 1 GHz, measurement must be only performed until 5 times the highest frequency or 40 GHz, while taking smallest of both. ****Testing covered the receive mode, and receiver spurious emissions are considered to be the same as transmitter.

N/A : Not Applicable

2. SYSTEM TEST CONFIGURATION

2.1. JUSTIFICATION

The system was configured for testing in a typical fashion (as a customer would normally use it).
The equipment IUP250 can be used with several internal option cards:

- COM2 + MDB + Bluetooth Configuration n°1 – IUP250-01T1998
- COM2 + MDB + Bluetooth + GPRS modular approval Configuration n°2 – IUP250-01T1869

The Equipment Under Test will be the configuration n°2 to represent others configurations (Worst case)
IUP250 has to be is integrated in unattended devices. The test configuration is given by the manufacturer

2.2. HARDWARE IDENTIFICATION

- **Equipment under test (EUT):**

IUP250-01T1869 Serial number: 1293IU0000041

- Internal max frequencies: 400MHz

- **Modular Approval contained:**

- 1 x GPRS module, SAGEMCOM , HILO V2 INGENICO, FCC ID: VW3HILOV2

- **Power supply: 12-30Vdc**

EUT is not sold with any power supply, an AC/DC power supply adapter is used to provide **12VDC (worst case)** during whole tests.(worst case)

- **Input/output:**

- 1 x MDB slave port “DC power input (12VDC – 30VDC)“
- 2 x Serial link (COM0 & COM 2)
- 1 x Ethernet line
- 1 x USB port (Slave)
- 4 x USB ports (Host)
- 1 x MDB Master (4 wires).
- 1 x 5V output port
- 2 x SAMs slot
- 1 x SIM slot
- 1 x MicroSD slot
- 2 x SMA connectors, (GSM & Bluetooth)

- **Cables:**

- 1 x AC power cord, 2 wires, unshielded: 2m
- 1 x DC power supply cable (fixed on mains power unit), unshielded: 1.75m
- 1 x Ethernet cable Type: STP Cat 5e, shielded: 2m
- 5 x USB cables,shielded, (4 x spiraled: 1m & 1x non spiraled: 1m)
- 2 x RS232 Com cables, RJ11, unshielded, 1.5m (COM 0 & Com 2)
- 1 x MdB-slave ‘6 pins’ <-> MdB-master ‘8 pins’ cable, unshielded
- 1 x Jack cable , unshielded, length: 0.3cm
- 1 x GPRS Antenna type GC300M-011-2500, length: 2m

- **Auxiliaries equipment used during test:**

- 1 x Laptop TOSHIBA SATELLITE PS141E-04YC sn : 13594938G
- 1 x AC/DC Power supply adapter PHIHONG PSM36W-120TW, 100-240VAC / 1.5A / 50-60Hz, output 12VDC / 3A

- **Functions:**

- 1 x SAM card reader
- 1 x Serial link communication (COM0 & COM2)
- 1 x µSD card reader (SAM1 & SAM2)
- 1 x Bluetooth at 2400-2483.5MHz, always ON

- **Equipment information:**

- Type:	☒Bluetooth		☐Other:
- Frequency band:	[2400.0 – 2483.5] MHz		
- Number of channel:	79		
- Channel tested:	Full test on 2402MHz / 2441MHZ / 2480MHz		
- Modulation Technology:	☒FHSS		☐DSSS
- Modulation type:	☒GFSK	☒ Pi/4 DQPSK	☒8DPSK
Packet type:	DH1	DH3	DH5
Transfert data rate:	1Mbps	2Mbps	3Mbps
- RF mode:	☒TX/RX	☐RX	☐Standby
- Antenna type:	SMA connector + Whip antenna (EAD, FBTS35024-SM-ST, 0dBi)		
- Antenna connector:	☒Permanent external		☐Permanent internal
	☐None		☐Temporary (only for tests)
- Normal power source:	12VDC (host)		
- Extreme temperature range:	-30°C to +55°C		
- Extreme test source voltage:	☒12VDC ±10%	☐other:	

2.3. EUT CONFIGURATION

Configuration n°1:

A generic program test is loaded on EUT, in order to perform in loop following functions:
- Reading / writing SAM card (SAM1 & SAM2)
- Reading / writing µSD card (MMC)
- RX/TX on Serial port (COM0 & COM2)
- RX/TX between MDB master and slave

With laptop: Continuous Ethernet communication is performed from EUT to Laptop (Ping)

Configuration n°2:

A Bluetooth communication link is performed between CMU 200 and EUT.
EUT program wich performed Bluetooth communication is loaded from a terminal application on laptop, through USB link.

This running mode allowed to monitor the correct communication between EUT and an external device (Laptop in this test report) through USB link.

With Laptop : Continous Ethernet communication is performed from EUT to Laptop (Ping)

Configuration n°3:

With a special mode of EUT a communication is performed with CMU, a permanent link with followings parameters is tested (worst case):
- Lowest, middle, highest channel
- Max power
- EDR / DH5
- Hopping mode: ON or OFF following test

2.4. EQUIPMENT MODIFICATIONS

A ferrite (integrated secondary power supply PHIHONG PSM36W-120TW) is set on two wires which provided 12Vdc (MDm slave connector side).
A ferrite type WE 74271222(Two turns) is set on others MdBm slave wires

2.5. SPECIAL ACCESSORIES

None

3. CONDUCTED EMISSION DATA

3.1. CLIMATIC CONDITIONS

Date of test : February 2nd , 2012
Test performed by : J.PAUC
Atmospheric pressure : 990mb
Relative humidity : 31%
Ambient temperature : 21°C

3.2. SETUP FOR CONDUCTED EMISSIONS MEASUREMENT

The product has been tested according to ANSI C63.4-(2003) and FCC Part 15 subpart B and C.

The product has been tested with 120V/60Hz power line voltage and compared to the FCC Part 15 subpart B §15.107 and C §15.207 limits. Measurement bandwidth was 9kHz from 150 kHz to 30 MHz.

Measurement is made with a Rohde & Schwarz ESU8 receiver in peak mode. This was followed by a Quasi-Peak, i.e. CISPR measurement for any strong signal. If the average limit is met when using a Quasi-Peak detector, the EUT shall be deemed to meet both limits and measurement with the average detector is unnecessary. The LISN (measure) is 50Ω / 50µH.

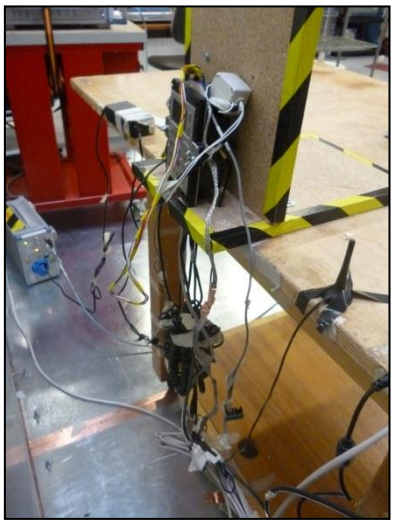
The Peak data are shown on plots in annex 1. Quasi-Peak and Average measurements are detailed in a table with frequencies and levels measured.

Interconnecting cables and equipment's were moved to position that maximized emission. A summary of the worst case emissions found in all test configurations and modes is shown on the following page.

3.3. TEST SETUP

The EUT is placed on the ground reference plane, at 80cm from the LISN. The distance between the EUT and the vertical ground plane is 40cm.
Auxiliaries are powered by another LISN.
The cable has been shorted to 1meter length. The EUT is powered trough the LISN (measure).





Conducted emission test setup

3.4. TEST EQUIPMENT LIST

DESCRIPTION	MANUFACTURER	MODEL	N° LCIE
Cable	-	-	A5329198
Direct Injection Module 100 Ohms	LUTHI	CR100A	A7156004
LISN	RHODE & SCHWARZ	ENV216	C2320123
Receiver 20Hz – 8GHz	ROHDE & SCHWARZ	ESU8	A2642019
Thermo-hygrometer	HUGER	-	B4204052
Attenuator 10dB	RHODE & SCHWARZ	ESH3-Z2	A7122204

3.5. DIVERGENCE, ADDITION OR SUPPRESSION ON THE TEST SPECIFICATION

None

3.6. TEST SEQUENCE AND RESULTS

Measurements are performed on the phase (L1) and neutral (N) of power line voltage.
Graphs are obtained in PEAK detection.
Measures are also performed in Quasi-Peak and Average for any strong signal.

Configuration n°1 :

Measure on L:	graph Emc#1	(see annex 1)
Measure on N:	graph Emc#2	(see annex 1)

Configuration n°2 :

Measure on L:	graph Emc#3	(see annex 1)
Measure on N:	graph Emc#4	(see annex 1)

RESULT: PASS

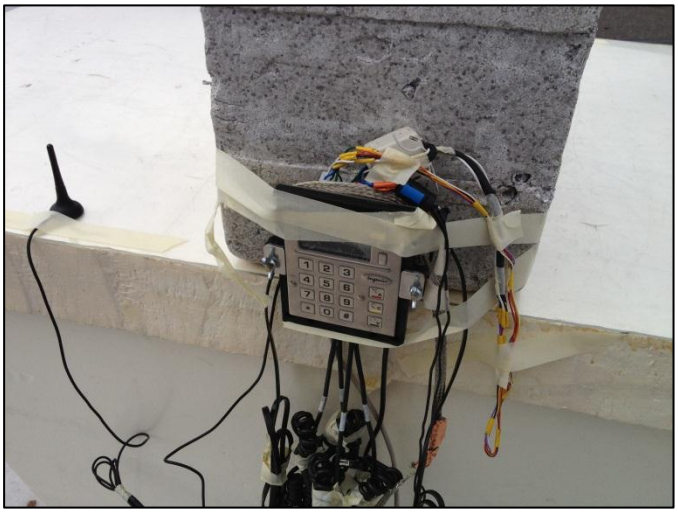
4. RADIATED EMISSION DATA

4.1. CLIMATIC CONDITIONS

Date of test	: January 31st ,2012	February 2nd, 2012	February 8th , 2012
Test performed by	: J.PAUC / A.MERLIN	J.PAUC / A.MERLIN	J.PAUC / A.MERLIN
Atmospheric pressure	: 1001mB	990mB	1002mB
Relative humidity	: 34%	31%	32%
Ambient temperature	: 22°C	21°C	21°C

4.2. TEST SETUP

The installation of EUT is identical for pre-characterization measurement in a 3 meters semi anechoic chamber and for measures on a 10 meters Open site.



Radiated emission test setup

4.1. DIVERGENCE, ADDITION OR SUPPRESSION ON THE TEST SPECIFICATION

None

4.2. TEST EQUIPMENT LIST

DESCRIPTION	MANUFACTURER	MODEL	N° LCIE
Adapter quasi-peak	HEWLETT PACKARD	HP85650A	A4049060
Amplifier 0.1MHz – 1300 MHz	HEWLETT PACKARD	8447F	A7486006
Amplifier 1-8GHz	HEROTEK	A1080304A	A7102024
Antenna Bi-Log XWing	TESEQ	CBL6144	C2040146
Antenna Bi-lo	CHASE	CBL6111A	C2040051
Antenna Horn	EMCO	3115	C2042027
Cable	-	-	A5329045
Cable	-	-	A5329056
Cable	-	-	A5329057
Cable			A5329089
Cable			A5329083
Cable			A5329061
Cable OATS (Turn table)	UTIFLEX		A5329187
Cable OATS (Mast at 10m)	UTIFLEX		A5329188
Cable OATS (Mast at 10m)	UTIFLEX		A5329199
Radiated emission comb generator	BARDET		A3169050
Semi-Anechoic chamber #2	SIEPEL	-	D3044015
Semi-Anechoic chamber #1	SIEPEL		D3044016
Spectrum analyzer display	HEWLETT PACKARD	HP85662A	A4060028
Thermo-hygrometer	HUGER	-	B4204052
Turntable controller (Cage#2-3)	ETS Lingren	Model 2066	F2000393
Table	LCIE	-	F2000438
Receiver 20Hz – 8GHz	ROHDE & SCHWARZ	ESU8	A2642019
OATS			F2000409

4.3. TEST SEQUENCE AND RESULTS

4.3.1. Pre-characterization at 3 meters [9kHz-30MHz]

A pre-scan of all the setup has been performed in a 3 meters semi anechoic chamber.
The distance between EUT and antenna is 3 meters. For Pre-characterization, the loop antenna was rotated during the test for maximized the emission measurement. Measurement performed on 3 axis of EUT.
Frequency band investigated is 9kHz to 30MHz.

The pre-characterization graphs are obtained in PEAK detection.

No significative frequency observed

4.3.2. Pre-characterization [30MHz-25GHz]

For frequency band 30MHz to 1GHz, a pre-scan of all the setup has been performed in a 3 meters semi anechoic chamber.
The distance between EUT and antenna is 3 meters. Test is performed in horizontal (H) and vertical (V) polarization with a log-periodic antenna. The EUT is being rotated on 360° and on 3 axis during the measurement. The pre-characterization graphs are obtained in PEAK detection.
For frequency band 1GHz to 25GHz, a search is performed in the semi-anechoic chamber in order to determine frequencies radiated by the EUT (Measuring distance reduced to 1m and 20cm for frequencies from 12GHz to 25GHz).

See graphs for 30MHz-1GHz:

H polarization	**Emr#1**	(See annex 1)
V polarization	**Emr#2**	(See annex 1)

4.3.3. Characterization on 10 meters open site below 30 MHz

The product has been tested according to ANSI C63.4 (2003), FCC part 15 subpart C. Radiated Emissions were measured on an open area test site. A description of the facility is on file with the FCC.
The product has been tested at a distance of **10 meters** from the antenna and compared to the FCC part 15 subpart C §15.109 limits and C §15.209.
Antenna height was 1m for both horizontal and vertical polarization.
Antenna was rotated around its vertical axis.
Continuous linear turntable azimuth search was performed with 360 degrees range. Measurement performed on 3 axis of EUT. A summary of the worst case emissions found in all test configurations and modes is shown in following tables.

Frequency (MHz)	QPeak Limit (dBµV/m) @ 30m	Qpeak (dBµV/m)	Qpeak-Limit (Margin dB)	Turntable Angle (deg)	Ant. Pol./ Angle (deg)	Tot Corr (dB)
No significative frequency observed						

*: Measure have been done at 10m distance and corrected according to requirements of 15.209.e)
(M@30m = M@10m-19.1dB)

4.3.4. Characterization on 10 meters open site from 30MHz to 26GHz

The product has been tested at a distance of **10 meters** from the antenna and compared to the FCC part 15 subpart B §15.109 limits and C §15.209 limits. Measurement bandwidth was 120kHz from 30 MHz to 1GHz and 1MHz from 1GHz to 2GHz.
Antenna height search was performed from 1m to 4m for both horizontal and vertical polarization. Continuous linear turntable azimuth search was performed with 360 degrees range. Measurement performed on 3 axis of EUT.
A summary of the worst case emissions found in all test configurations and modes is shown on clause 2.3

Worst case final data result:

No	Frequency (MHz)	QPeak Limit (dBµV/m)	Qpeak * (dBµV/m)	Qpeak-Limit (Margin, dB)	Angle (deg)	Pol	Hgt (cm)	Tot Corr (dB)
1	38.424	40	36.4	**-3.6**	125	V	150	13.9
2	60.2124	40	37.0	**-3.0**	0	V	200	6.5
3	193.528	43.5	40.0	**-3.5**	180	V	100	12.0
4	217.718	46	39.9	**-6.1**	175	V	150	13.2
5	249.999	46	37.7	**-8.3**	325	V	100	15.2
6	387.123	46	44.0	**-2.0**	270	V	100	18.5
7	499.999	46	38.0	**-8.0**	280	H	150	21.6
8	875.087	46	42.8	**-3.2**	330	V	200	27.0
9	999.999	54	44.2	**-9.8**	30	V	150	28.5

*: Measure have been done at 10m distance and corrected according to requirements of 15.209.e)
(M@3m = M@10m+10.5dB)

Frequency band 1GHz to 26GHz

Configuration n°1 :

Measurements are performed using a PEAK and Average detection. (RBW = 1MHz)

No	Frequency (MHz)	Limit Peak @3m (dBµV/m)	Measure Peak @3m (dBµV/m)	Margin (Mes-Lim) (dB)	Angle Table (deg)	Pol Ant.	Ht Ant. (cm)	Correc. factor (dB)
1	1.097.88	74	40.2	**-33.8**	75	V	100	25.3
2	1.104.89	74	37.9	**-36.1**	80	V	100	25.3
3	1.199.69	74	46.5	**-27.5**	85	V	100	26.1
4	1.394.71	74	50	**-24.0**	85	V	100	27.0
5	1.619.85	74	43	**-31.0**	90	V	100	27.9

Note: Measures have been done at 3m distance.

No	Frequency (MHz)	Limit Avg @3m (dBµV/m)	Measure Avg @3m (dBµV/m)	Margin (Mes-Lim) (dB)	Angle Table (deg)	Pol Ant.	Ht Ant. (cm)	Correc. factor (dB)
1	1097.88	54	30.0	**-24.0**	75	V	100	25.3
2	1104.89	54	23.0	**-31.0**	80	V	100	25.3
3	1199.69	54	35.3	**-18.7**	85	V	100	26.1
4	1394.71	54	26.0	**-28.0**	85	V	100	27.0
5	1619.85	54	37.0	**-17.0**	90	V	100	27.9

Note: Measures have been done at 3m distance.

RESULTS: PASS

Configuration n°2 :

Measurements are performed using a PEAK and Average detection. (RBW = 1MHz)

Bluetooth module set at channel 0 : 2402MHz

No	Frequency (MHz)	Limit Peak (dBµV/m)	Measure Peak (dBµV/m)	Margin (Mes-Lim) (dB)	Angle Table (deg)	Pol Ant.	Ht Ant. (cm)	Correc. factor (dB)
1	2350.37	74	37.0	**-37.0**	110	V	100	31.2
2	2375.99	74	39.0	**-35.0**	150	V	100	31.2
3	2398.32	74	48.2	**-25.8**	200	V	100	31.2
4	2399.01	74	49.6	**-24.4**	300	V	100	31.2
5	4804.00	74	63.0	**-11.0**	200	H	100	37.0
6	7206.00	74	48.0	**-26.0**	180	H	100	39.9

Note: Measures have been done at 3m distance.

No	Frequency (MHz)	Limit Avg (dBµV/m)	Measure Avg (dBµV/m)	Margin (Mes-Lim) (dB)	Angle Table (deg)	Pol Ant.	Ht Ant. (cm)	Correc. factor (dB)
1	2350.37	54	28.3	**-25.7**	110	V	100	31.2
2	2375.99	54	26.4	**-27.6**	150	V	100	31.2
3	2398.32	54	30.3	**-23.7**	200	V	100	31.2
4	2399.01	54	26.6	**-27.4**	300	V	100	31.2
5	4804.00	54	41.2	**-12.8**	200	H	100	37.0
6	7206.00	54	30.0	**-24.0**	180	H	100	39.9

Note: Measures have been done at 3m distance.

RESULTS: PASS

Bluetooth module set at channel 39 : 2441MHz

No	Frequency (MHz)	Limit Peak (dBµV/m)	Measure Peak (dBµV/m)	Margin (Mes-Lim) (dB)	Angle Table (deg)	Pol Ant.	Ht Ant. (cm)	Correc. factor (dB)
1	4882.00	74	61.2	**-12.8**	200	H	100	37.0
2	7323.00	74	45.3	**-28.7**	180	H	100	39.9

Note: Measures have been done at 3m distance.

No	Frequency (MHz)	Limit Avg (dBµV/m)	Measure Avg (dBµV/m)	Margin (Mes-Lim) (dB)	Angle Table (deg)	Pol Ant.	Ht Ant. (cm)	Correc. factor (dB)
1	4882.00	54	38.0	**-16.0**	200	H	100	37.0
2	7323.00	54	32.0	**-22.0**	180	H	100	39.9

Note: Measures have been done at 3m distance.

RESULTS: PASS

Bluetooth module set at channel 78 : 2480 MHz

No	Frequency (MHz)	Limit Peak (dBµV/m)	Measure Peak (dBµV/m)	Margin (Mes-Lim) (dB)	Angle Table (deg)	Pol Ant.	Ht Ant. (cm)	Correc. factor (dB)
1	1620.13	74	50.0	-24.0	180	H	100	27.9
2	2488.56	74	35.0	-39.0	190	H	100	31.2
3	4960.00	74	61.5	-12.5	180	H	100	37.0
4	7440.00	74	46.0	-28.0	200	H	100	39.9

Note: Measures have been done at 3m distance.

No	Frequency (MHz)	Limit Avg (dBµV/m)	Measure Avg (dBµV/m)	Margin (Mes-Lim) (dB)	Angle Table (deg)	Pol Ant.	Ht Ant. (cm)	Correc. factor (dB)
1	1620.13	54	45.2	-8.8	150	H	100	27.9
2	2488.56	54	30.0	-24.0	190	H	100	31.2
3	4960.00	54	39.0	-15.0	180	H	100	37.0
4	7440.00	54	33.0	-21.0	200	H	100	39.9

Note: Measures have been done at 3m distance.

RESULTS: PASS

4.4. FIELD STRENGTH CALCULATION

The field strength is calculated by adding the Antenna Factor and Cable Factor, and subtracting the Amplifier Gain (if any) from the measured reading. The basic equation with a sample calculation is as follow:

FS = RA + AF + CF – AG

Where FS = Field Strength
RA = Receiver Amplitude
AF = Antenna Factor
CF = Cable Factor
AG = Amplifier Gain

Assume a receiver reading of 52.5dBµV is obtained. The antenna factor of 7.4 and a cable factor of 1.1 are added. The amplifier gain of 29dB is subtracted, giving a field strength of 32 dBµV/m.
FS = 52.5 + 7.4 + 1.1 – 29 = 32 dBµV/m
The 32 dBµV/m value can be mathematically converted to its corresponding level in µV/m.
Level in µV/m = Common Antilogarithm [(32dBµV/m)/20] = 39.8 µV/m.

5. MAXIMUM PEAK OUTPUT POWER (15.247)

5.1. TEST CONDITIONS

Date of test : February 7th , 2012
Test performed by : J.PAUC / A.MERLIN
Atmospheric pressure : 1002mb
Relative humidity : 32%
Ambient temperature : 21°C

5.2. EQUIPMENT CONFIGURATION

Worst case presented:
Modulation: 8DPSK
Packet Type: DH5
Hopping sequence: NO

5.3. SETUP

Conducted measurement:
The EUT is turned ON and connected to measurement instrument; the center frequency of the spectrum analyzer is set to the fundamental frequency and using 3MHz RBW and 10MHz VBW.
The captured power is measured and recorded; the measurement is repeated until all frequencies required were complete.

Radiated measurement:
The product has been tested at a distance of 3 meters from the antenna and using 3MHz RBW and 10MHz VBW.
Antenna height search was performed from 1m to 4m for both horizontal and vertical polarization. Continuous linear turntable azimuth search was performed with 360 degrees range. Measurement performed on 3 axis of EUT.
A summary of the worst case emissions found in all test configurations and modes is shown on following table.
The captured power is measured and recorded; the measurement is repeated until all frequencies required were complete.
To demonstrate compliance with peak output power requirement of section 15.247 (b), the transmitter's peak output power is calculated using the following equation:

$$E = \frac{\sqrt{30PG}}{d}$$

Where:
- E is the measured maximum fundamental field strength in V/m, utilizing a RBW ≥ the 20 dB bandwidth of the emission, VBW > RBW, peak detector function. Follow the procedures in C63.4-1992 with respect to maximizing the emission.
- G is the numeric gain of the transmitting antenna with reference to an isotropic radiator.
- d is the distance in meters from which the field strength was measured.
- P is the power in watts for which you are solving:

$$P = \frac{(E\,d)^2}{30G}$$

5.4. TEST EQUIPMENT LIST

DESCRIPTION	MANUFACTURER	MODEL	N° LCIE
Receiver 20Hz – 8GHz	ROHDE & SCHWARZ	ESU8	A2642019
Attenuator 10dB	PASTERNACK	PE7014-10	A7122126

5.5. DIVERGENCE, ADDITION OR SUPPRESSION ON THE TEST SPECIFICATION

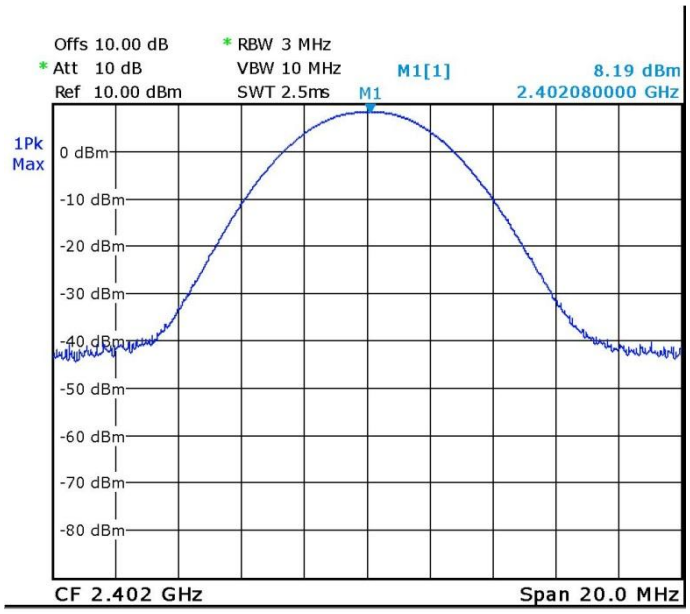
None

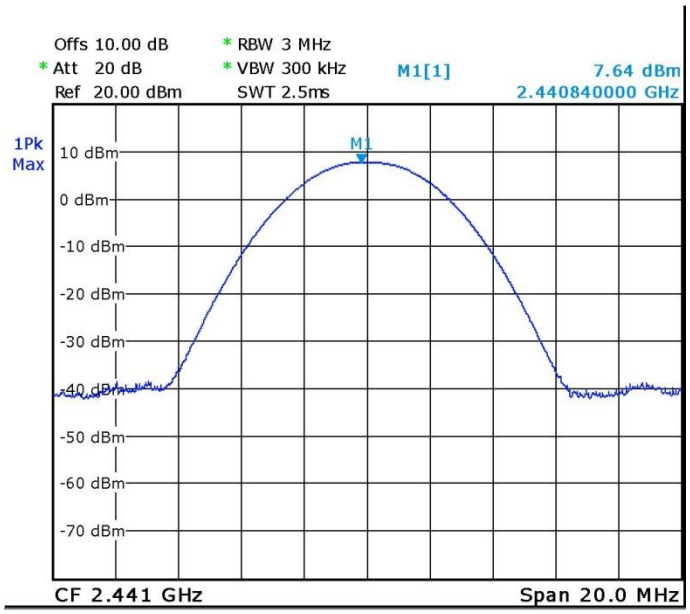
Conducted Measurement :

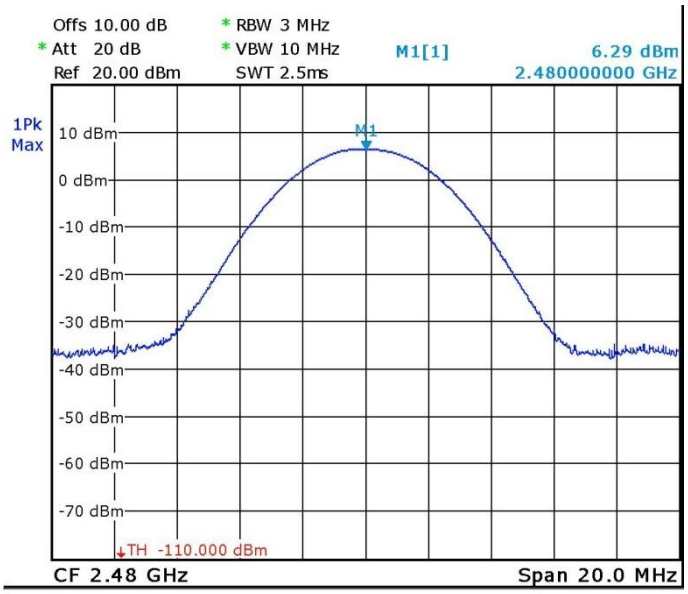
Modulation:

Channel	Channel Frequency (MHz)	Peak Output Power (dBm)	Power Limit (dBm)	PASS / FAIL
0	2402	8.2	21	P
39	2441	7.7	21	P
78	2480	6.3	21	P

Graph:







6. HOPPING CHANNEL SEPARATION (15.247)

6.1. TEST CONDITIONS

Date of test : February 8th , 2012
Test performed by : J.PAUC / A.MERLIN
Atmospheric pressure : 1001mb
Relative humidity : 30%
Ambient temperature : 21°C

6.2. LIMIT

For frequency hopping system operating in the 2400-2483.5MHz, if the 20dB bandwidth of hopping channel is greater than 25kHz, two-thirds 20dB Bandwidth of hopping channel shell be a minimum limit for the hopping channel separation.

6.3. EQUIPMENT CONFIGURATION

Configuration n°3

Modulation type:	☒GFSK	☒ Pi/4 DQPSK	☒8DPSK
Packet type:	DH1	DH3	DH5
Transfert data rate:	1Mbps	2Mbps	3Mbps

Channel frequency: 2402MHz / 2441MHz / 2480MHz
Hopping sequence: ON

6.4. SETUP – 20DB BANDWIDTH

The EUT is placed in an anechoic chamber; levels have been corrected to be in compliant with the Peak Output Power measured. The EUT is turn ON and using the MaxHold function, the frequency separation of two frequencies that were attenuated 20dB from the Peak Output Power level. A delta marker is used to measure the frequency difference as the emission bandwidth.

6.5. SETUP – ADJACENT CHANNEL SEPARATION

The EUT is placed in an anechoic chamber; levels have been corrected to be in compliant with the Peak Output Power measured. The EUT is turn ON and using the MaxHold function, the separation of two adjacent channels is recorded. A delta marker is used to measure the frequency difference.

6.6. TEST EQUIPMENT LIST

DESCRIPTION	MANUFACTURER	MODEL	N° LCIE
Receiver 20Hz – 8GHz	ROHDE & SCHWARZ	ESU8	A2642019
Attenuator 10dB	PASTERNACK	PE7014-10	A7122126

6.7. DIVERGENCE, ADDITION OR SUPPRESSION ON THE TEST SPECIFICATION

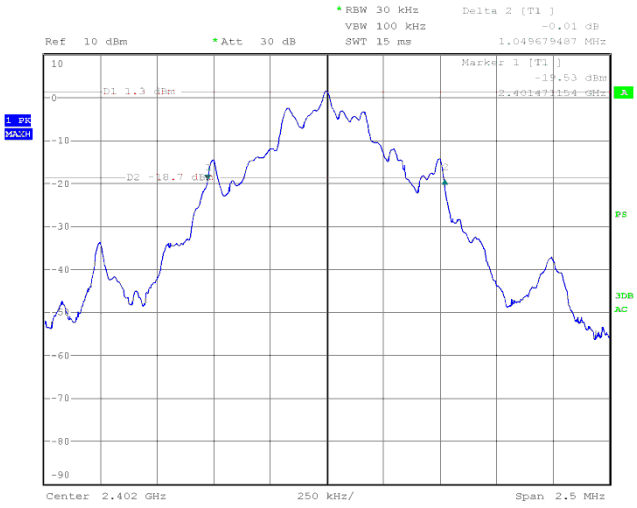
None

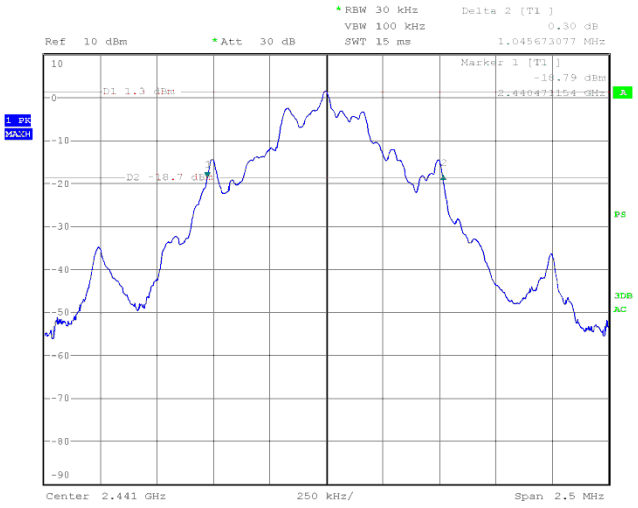
6.8. RESULTS – 20DB BANDWIDTH

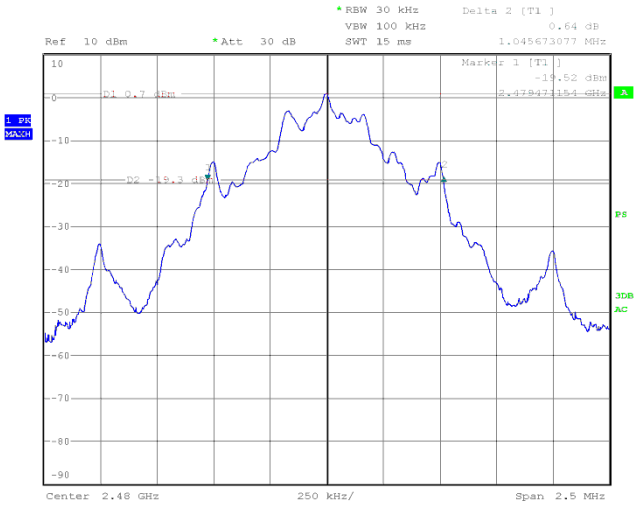
DH1 Measurements:

Channel Frequency (MHz)	20dB Bandwidth (MHz)
2402	1.050
2441	1.046
2480	1.046

Graph:



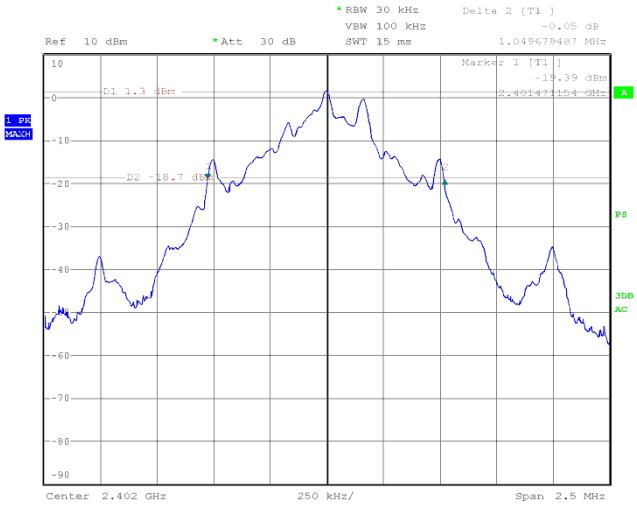


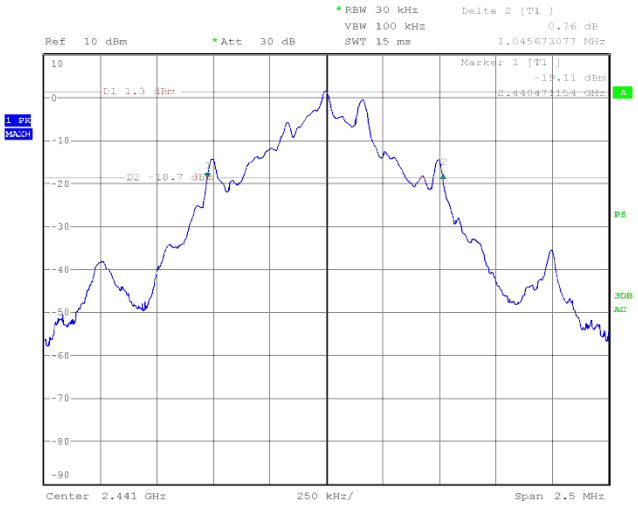


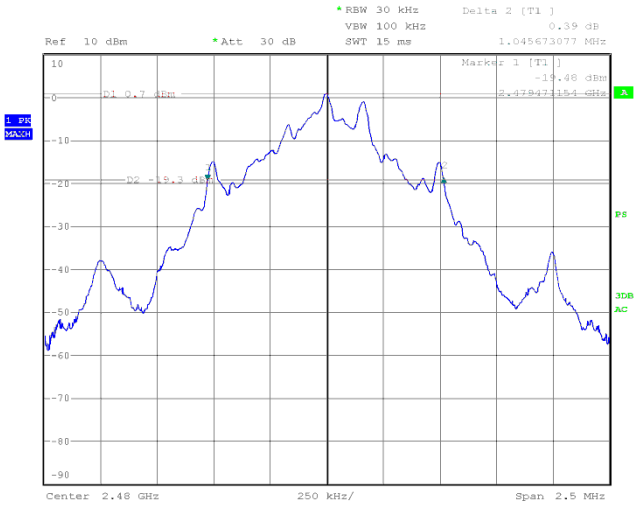
DH3 Measurements:

Channel Frequency (MHz)	20dB Bandwidth (MHz)
2402	1.050
2441	1.046
2480	1.046

Graph:



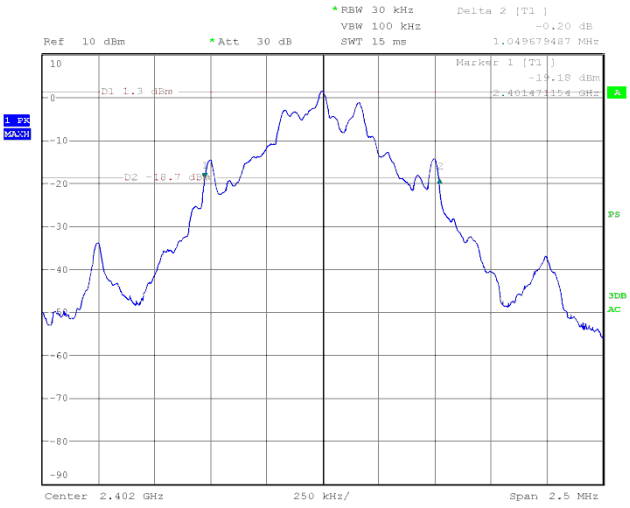


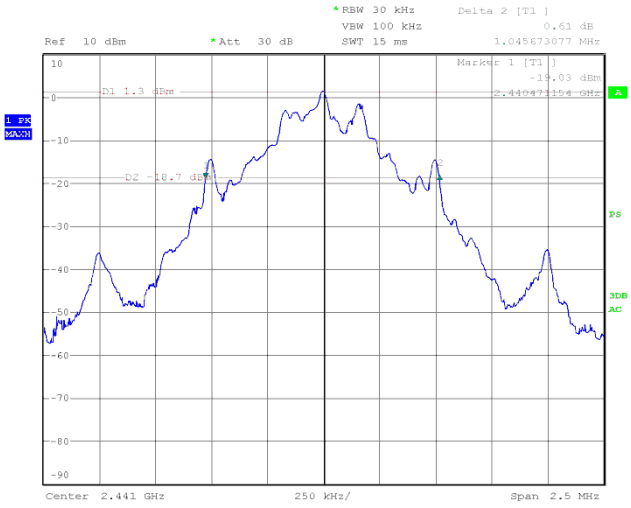


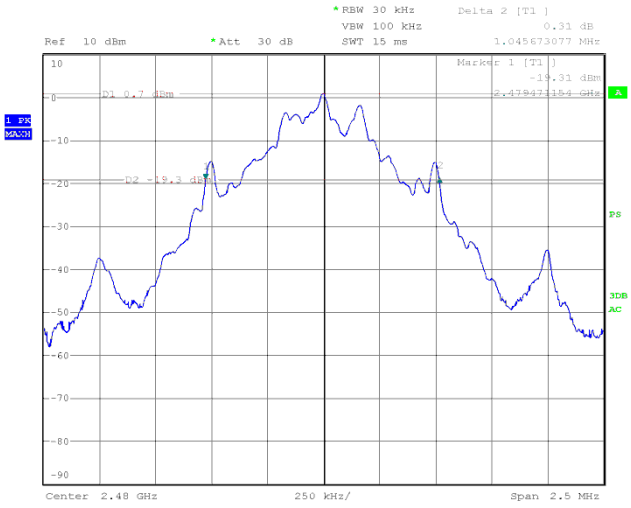
DH5 Measurements:

Channel Frequency (MHz)	20dB Bandwidth (MHz)
2402	1.049
2441	1.046
2480	1.046

Graph:





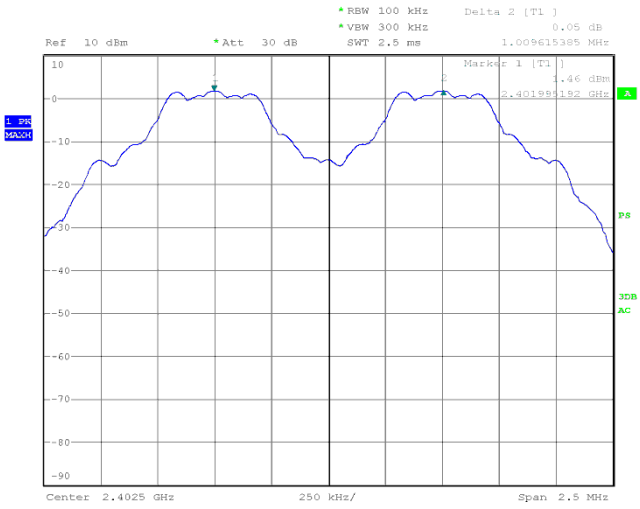


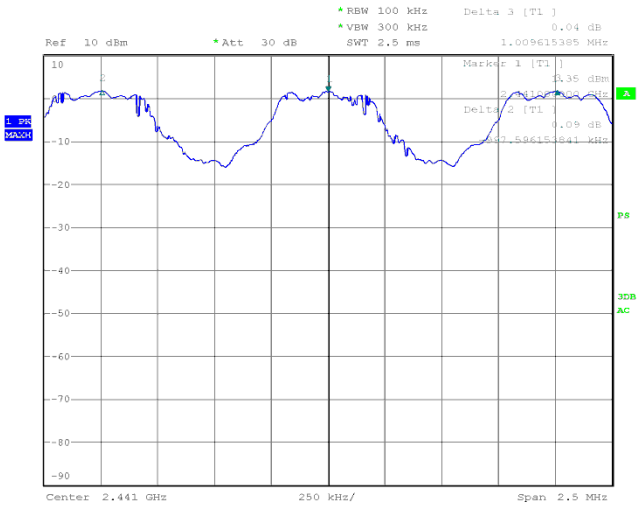
6.9. SETUP – ADJACENT CHANNEL SEPARATION

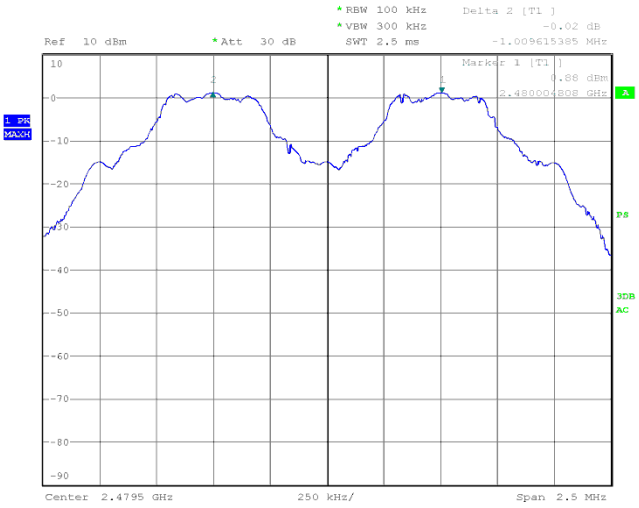
DH1 Measurements:

Channel Frequency (MHz)	Adjacent Channel Separation (MHz)	Minimum Limit (MHz)	PASS / FAIL
2402	1.010	0.698	P
2441	0.998	0.698	P
2480	1.010	0.698	P

Graph:



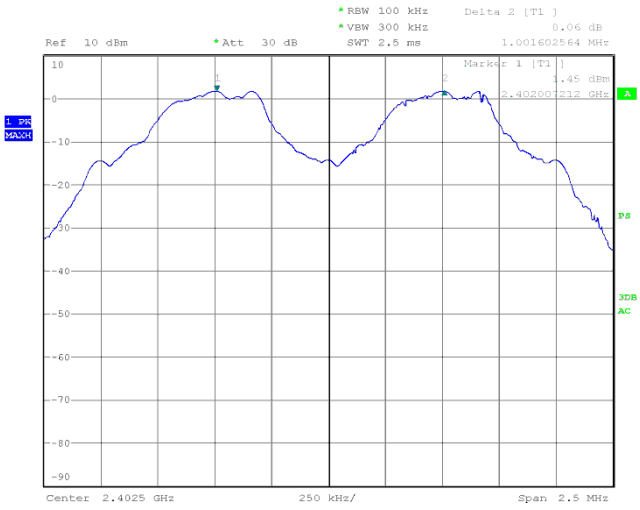


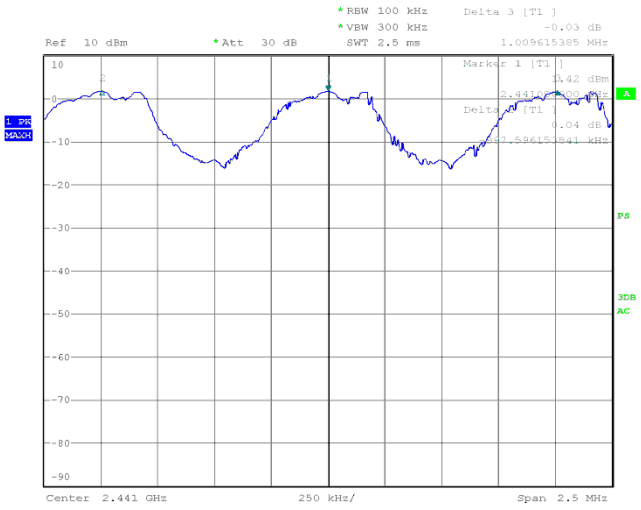


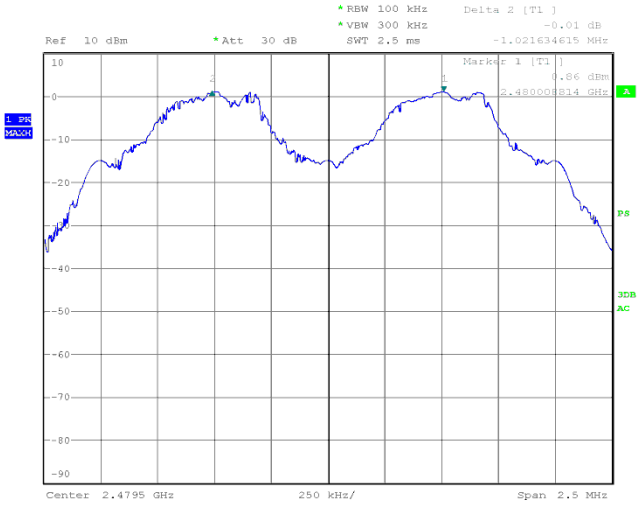
DH3 Measurements:

Channel Frequency (MHz)	Adjacent Channel Separation (MHz)	Minimum Limit (MHz)	PASS / FAIL
2402	1.002	0.698	P
2441	1.010	0.698	P
2480	1.022	0.698	P

Graph:



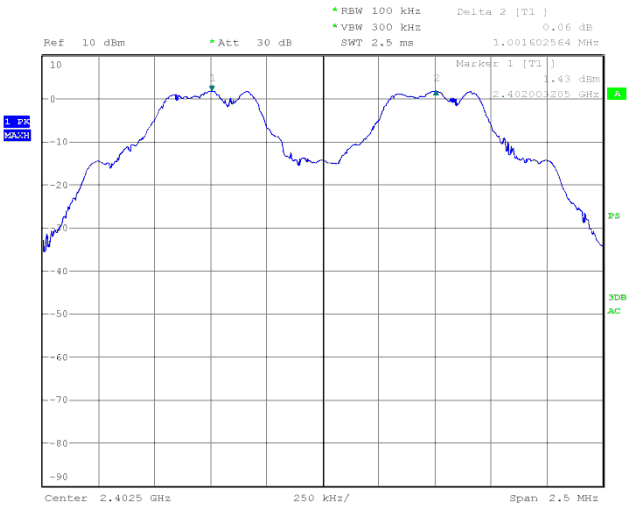


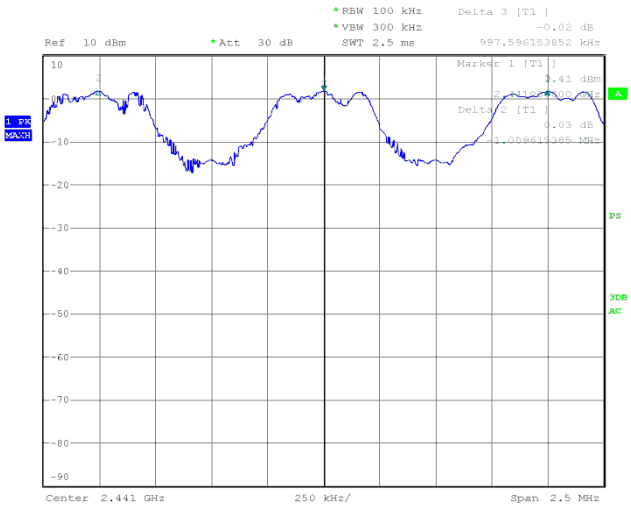


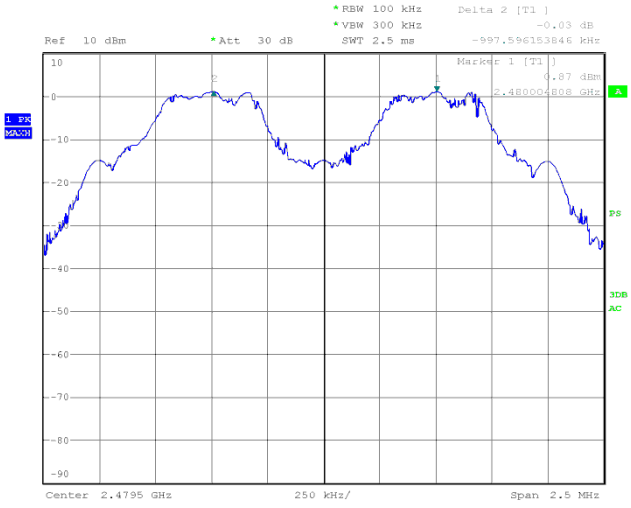
DH5 Measurements:

Channel Frequency (MHz)	Adjacent Channel Separation (MHz)	Minimum Limit (MHz)	PASS / FAIL
2402	1.002	0.698	P
2441	0.998	0.698	P
2480	0.998	0.698	P

Graph:







7. NUMBER OF HOPPING FREQUENCIES (15.247)

7.1. TEST CONDITIONS

Date of test : February 8th , 2012
Test performed by : J.PAUC / A.MERLIN
Atmospheric pressure : 1001mb
Relative humidity : 30%
Ambient temperature : 21°C

7.2. LIMIT

For frequency hopping system operating in the 2400-2483.5MHz, at least 15 channels frequencies must be used and should be equally spaced.

7.3. EQUIPMENT CONFIGURATION

Same results following parameters of modulation
Modulation: 8DPSK
Packet Type: DH5
Hopping sequence: YES

7.4. SETUP

The EUT is placed in an anechoic chamber. The EUT is turn ON and using the MaxHold function and a delta marker the number of frequencies used for this FHSS system is recorded, see following graphs.
RBW: 100kHz
VBW: 300kHz

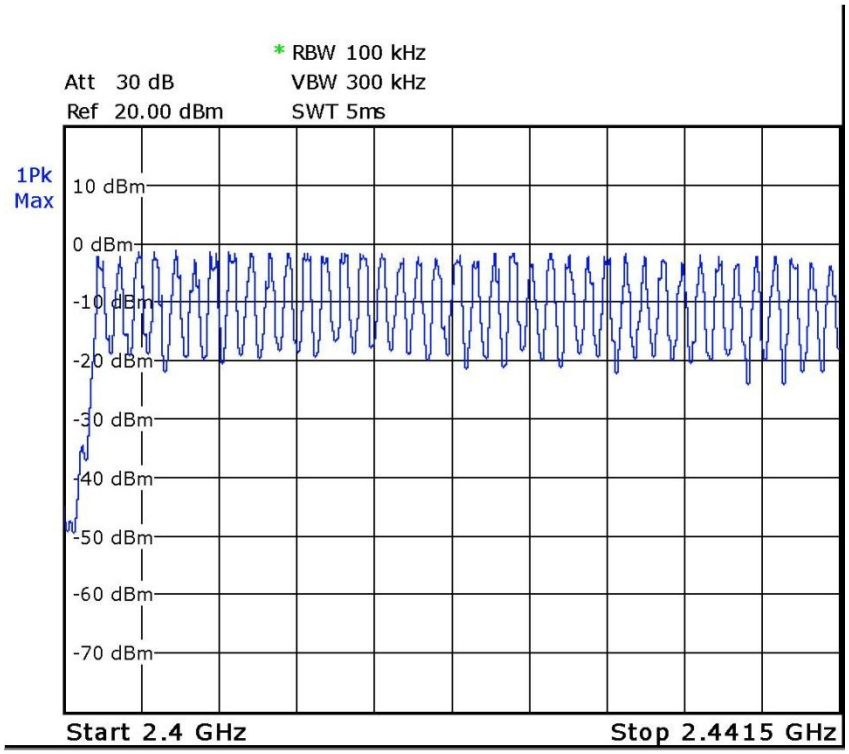
7.5. TEST EQUIPMENT LIST

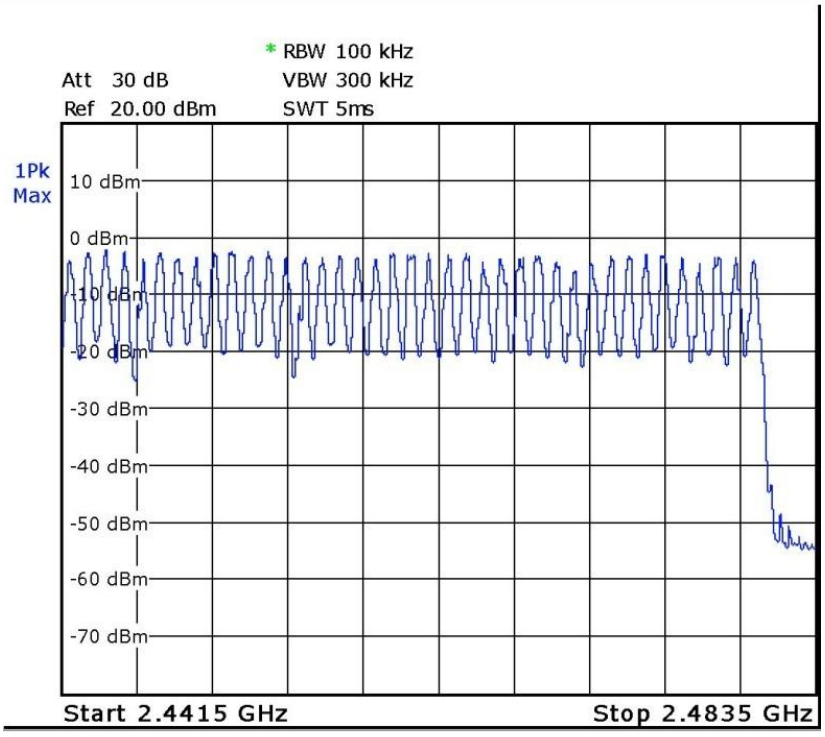
DESCRIPTION	MANUFACTURER	MODEL	N° LCIE
Receiver 20Hz – 8GHz	ROHDE & SCHWARZ	ESU8	A2642019
Attenuator 10dB	PASTERNACK	PE7014-10	A7122126

7.6. DIVERGENCE, ADDITION OR SUPPRESSION ON THE TEST SPECIFICATION

None

7.7. RESULTS





Number of frequency used in the hopping sequence: 79 channels

8. TIME OF OCCUPANCY (DWELL TIME) (15.247)

8.1. TEST CONDITIONS

Date of test : February 8th , 2012
Test performed by : J.PAUC / A.MERLIN
Atmospheric pressure : 1001mb
Relative humidity : 30%
Ambient temperature : 21°C

8.2. LIMIT

The average time of occupancy on any channel shall not be greater than 0.4 seconds within period of 0.4 seconds multiplied by the number of hopping channels employed.

8.3. EQUIPMENT CONFIGURATION

Configuration n°3

Modulation type:	☒GFSK	☒ Pi/4 DQPSK	☒8DPSK
Packet type:	DH1	DH3	DH5
Transfert data rate:	1Mbps	2Mbps	3Mbps

Channel frequency: 2402MHz
Hopping sequence: ON

8.4. SETUP

The EUT is placed in an anechoic chamber. The EUT is turn ON; the Dwell Time is measured and calculated using the zero SPAN mode on a channel frequency and a SWEEP with an adapter value to measure the number of transmission within a period and the time of transmission
RBW: 100kHz
VBW: 300kHz

8.5. TEST EQUIPMENT LIST

DESCRIPTION	MANUFACTURER	MODEL	N° LCIE
Receiver 20Hz – 8GHz	ROHDE & SCHWARZ	ESU8	A2642019
Attenuator 10dB	PASTERNACK	PE7014-10	A7122126

8.6. DIVERGENCE, ADDITION OR SUPPRESSION ON THE TEST SPECIFICATION

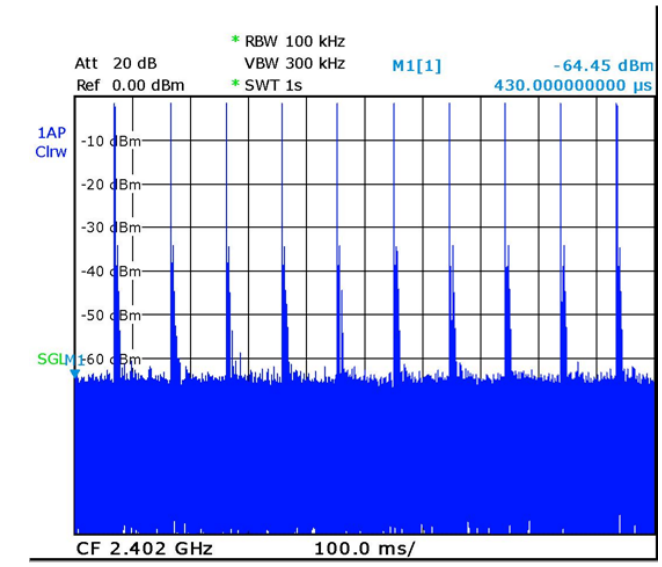
None

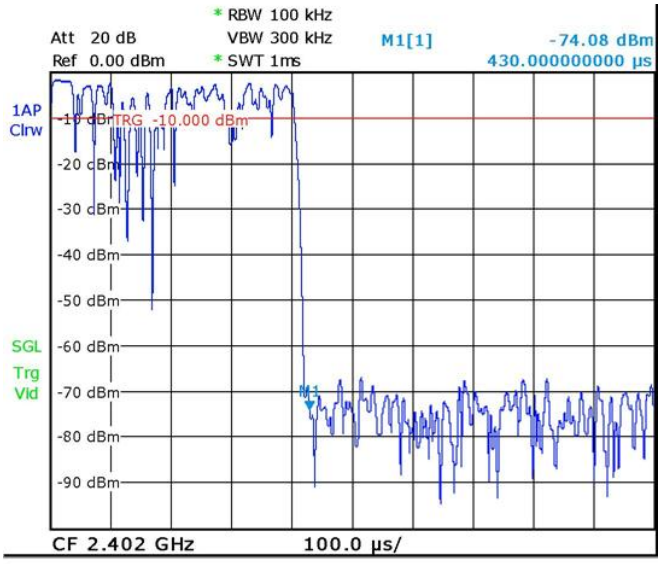
8.7. RESULTS

DH1 Measurements:

Number of transmission in the period	Length of transmission time (ms)	Result (ms)	Limit (ms)	PASS / FAIL
10 (times/ 1 sec) * 31.6	**0.430**	**136**	**400**	**P**

Note: Period of 31.6 seconds (79 channels x 0.4)

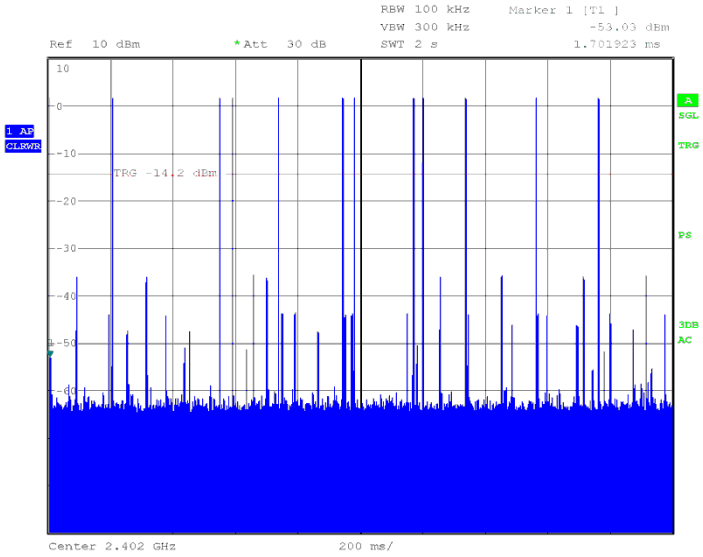


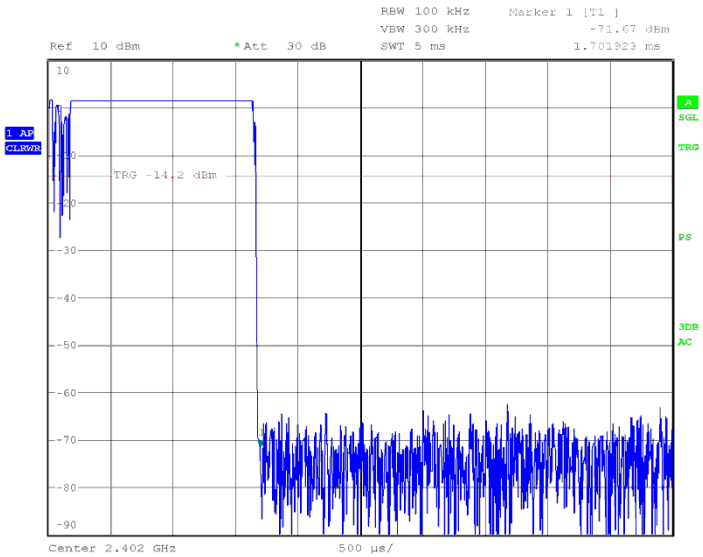


DH3 Measurements:

Number of transmission in the period	Length of transmission time (ms)	Result (ms)	Limit (ms)	PASS / FAIL
12 (times / 2sec) * 15.8	**1.702**	**323**	**400**	**PASS**

Note: Period of 31.6 seconds (79 channels x 0.4)

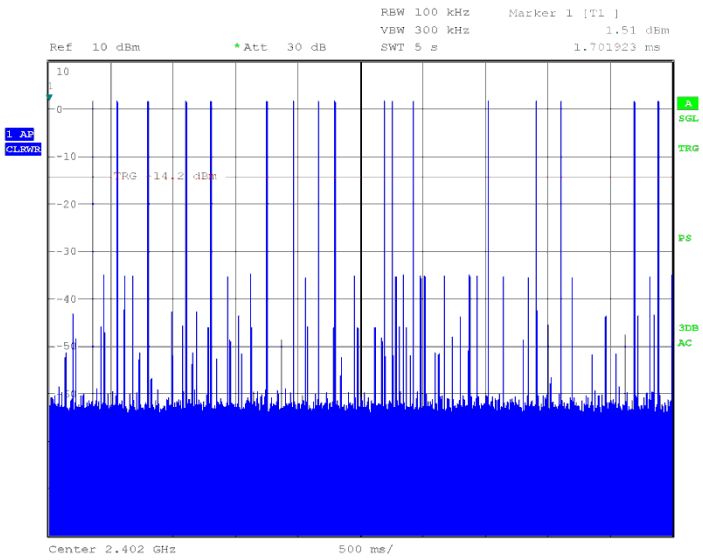


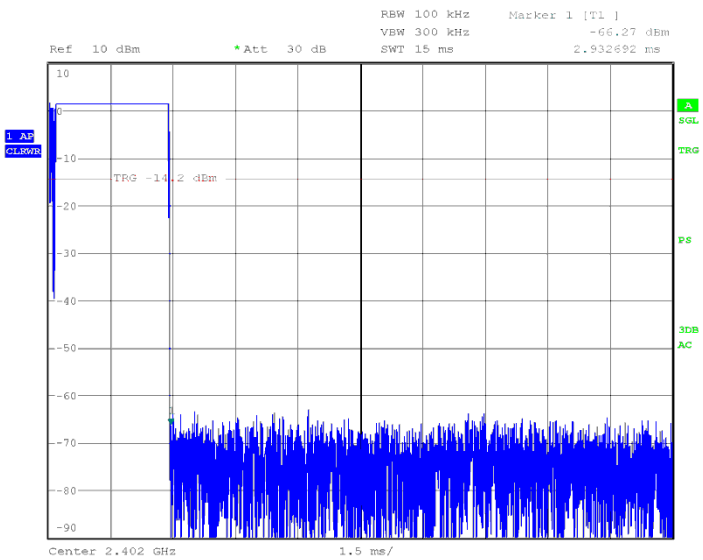


DH5 Measurements:

Number of transmission in the period	Length of transmission time (ms)	Result (ms)	Limit (ms)	PASS / FAIL
18 (times / 5sec) * 6.32	**2.933**	**333**	**400**	**PASS**

Note: Period of 31.6 seconds (79 channels x 0.4)





9. BAND EDGE MEASUREMENT (15.247)

9.1. TEST CONDITIONS

Date of test : February 8th , 2012
Test performed by : J.PAUC / A.MERLIN
Atmospheric pressure : 1001mb
Relative humidity : 30%
Ambient temperature : 21°C

9.2. LIMIT

In Bandedge, the limit of spurious emissions are below -20dB of the highest emission level of operating band (in 100kHz RBW).
In the restrict band (1435-1626.5MHz) (2310-2390MHz) (2483.5-2500MHz) and (4500-5150MHz) including bandedge, the limit of spurious emissions are 15.209. (RBW:1MHz / VBW:1MHz)

9.3. EQUIPMENT CONFIGURATION

Configuration n°3

Modulation: GFSK
Packet: DH5 (Worst case) –
Hopping sequence: ON

9.4. SETUP

The EUT is placed in an anechoic chamber; levels have been corrected to be in compliant with Peak Output Power measurement. The EUT is turn ON; the graphs of the restrict frequency band are recorded with a display line indicating the highest level and other the 20dB offset below to show compliance with 15.247 (d) and 15.205. The emissions in restricted bands are compared to 15.209 limits.
RBW: 100kHz
VBW: 300kHz

9.5. TEST EQUIPMENT LIST

DESCRIPTION	MANUFACTURER	MODEL	N° LCIE
Receiver 20Hz – 8GHz	ROHDE & SCHWARZ	ESU8	A2642019
Attenuator 10dB	PASTERNACK	PE7014-10	A7122126

9.6. DIVERGENCE, ADDITION OR SUPPRESSION ON THE TEST SPECIFICATION

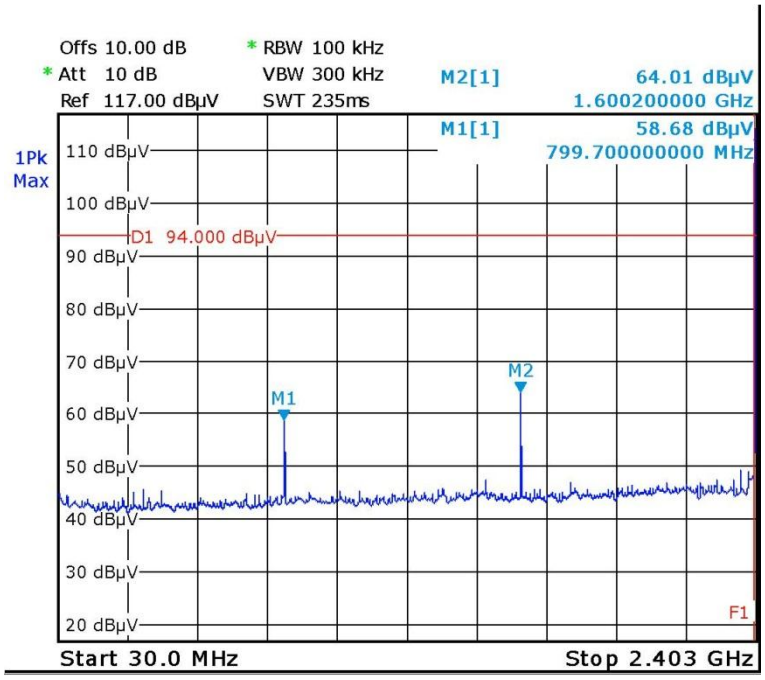
None

9.7. RESULTS

GRAPH / MODULATION.

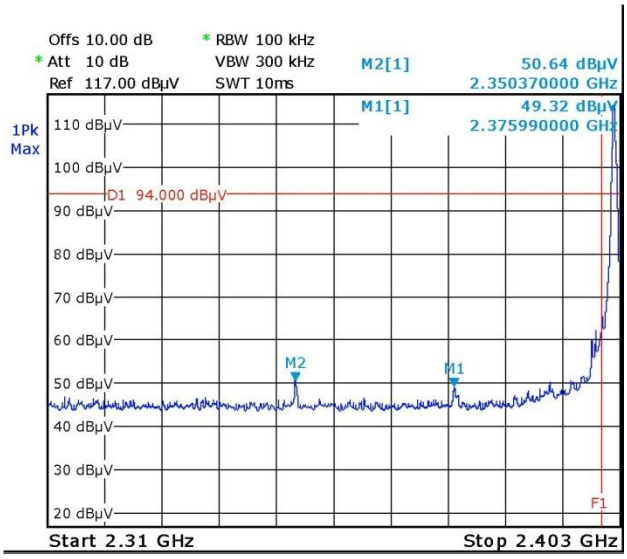
Restricted Band (1435-1626.5) MHz

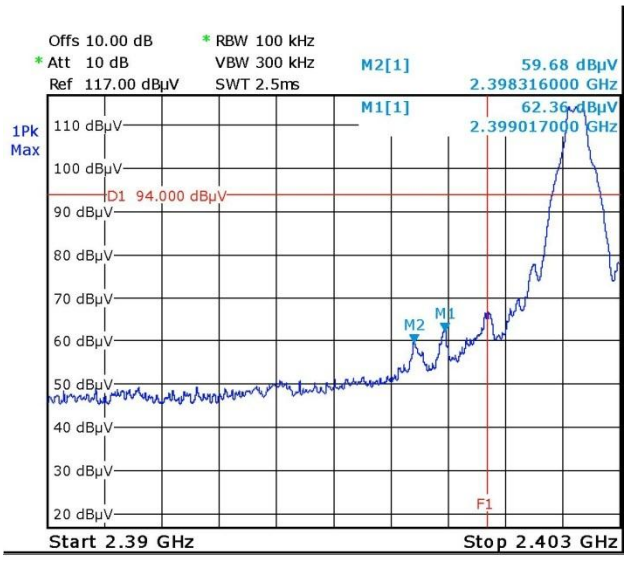
Frequency (MHz)	Maximum field strength in restrict band (dBµV/m)	Limit (dBµV/m)	Detector
1620.13	50	74	PK
1620.13	45.2	54	AV



Restricted Band (2310-2390) MHz

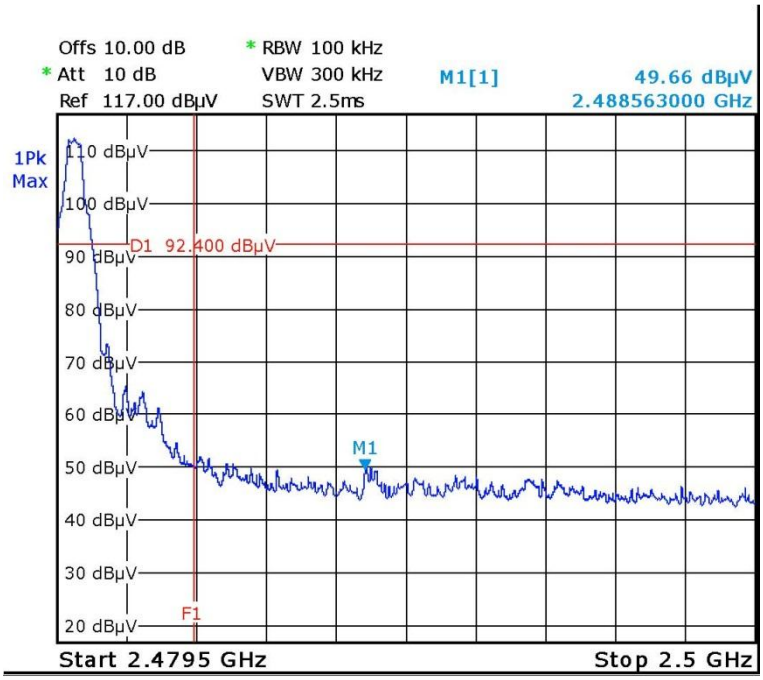
Frequency (MHz)	Maximum field strength in restrict band (dBµV/m)	Limit (dBµV/m)	Detector
2350.37	37.0	74	PK
2350.37	28.3	54	AV
2375.99	39.0	74	PK
2375.99	26.4	54	AV
2398.31	48.2	74	PK
2398.31	30.3	54	AV
2399.01	49.6	74	PK
2399.01	26.6	54	AV





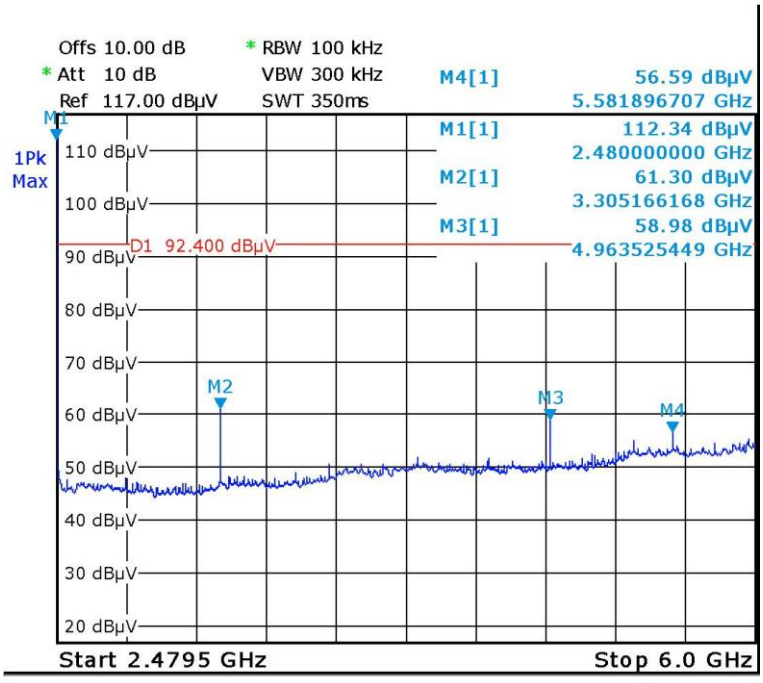
Restricted Band (2483.5-2500) MHz

Frequency (MHz)	Maximum field strength in restrict band (dBµV/m)	Limi (dBµV/m)	Detector
2488.563	**35**	**74**	**PK**
2488.563	**30**	**54**	**AV**



Restricted Band (4500-5150) MHz

Frequency (MHz)	Maximum field strength in restrict band (dBµV/m)	Limi (dBµV/m)	Detector
4960	61.5	74	PK
4960	39.0	54	AV



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NOTE:

1. Average value =Peak value + 20 Log (duty cycle) = Peak value – 30.1dB.
2. The DH5 packet was the worse case duty cycle for a transmit dwell time on a channel, based upon Bluetooth theory the transmitter is on 0.625 * 5 per 296.25 ms per channel. Therefore, the duty cycle correction factor be equal to: 20log (3.125/100) = -30.1 dB.

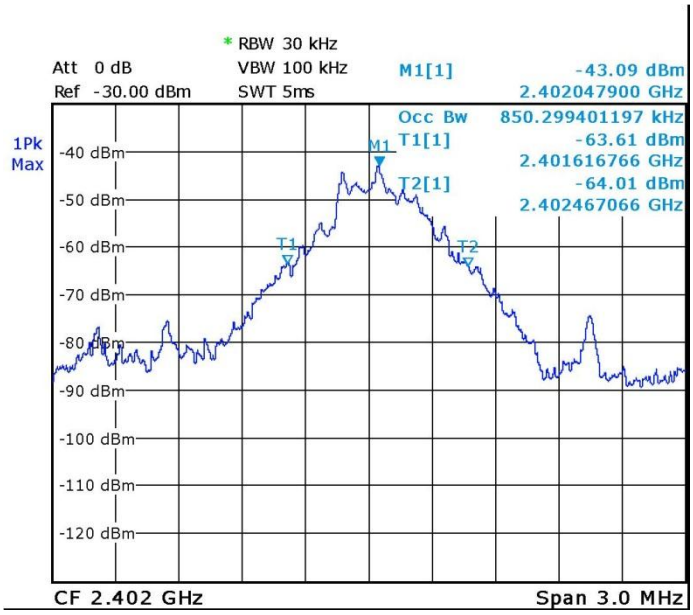
10. OCCUPIED BANDWIDTH

10.1. CLIMATIC CONDITIONS

Date of test : February 8th , 2012
Test performed by : J.PAUC / A.MERLIN
Atmospheric pressure : 1001mb
Relative humidity : 30%
Ambient temperature : 21°C

10.2. TEST RESULTS

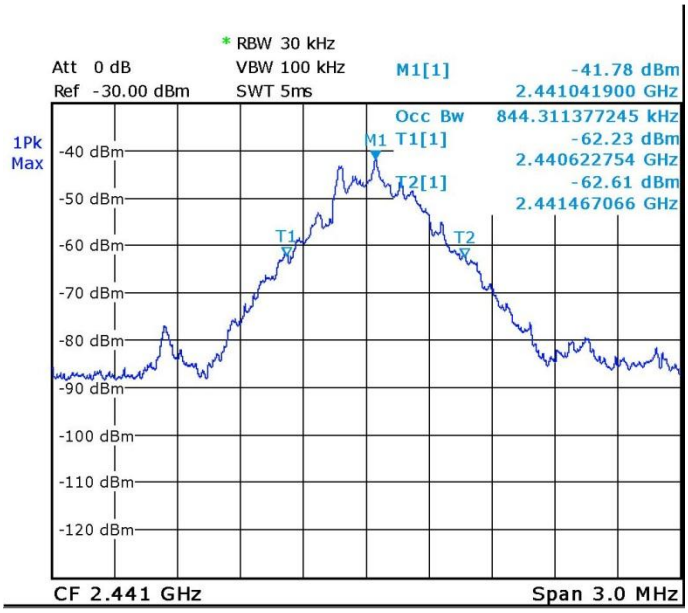
Carrier frequency – Bluetooth: 2402MHz



Measured occupied bandwidth is **850.3 kHz**

Measurement settings:
RBW = 30kHz / Video BW = 100kHz / SPAN = 3MHz

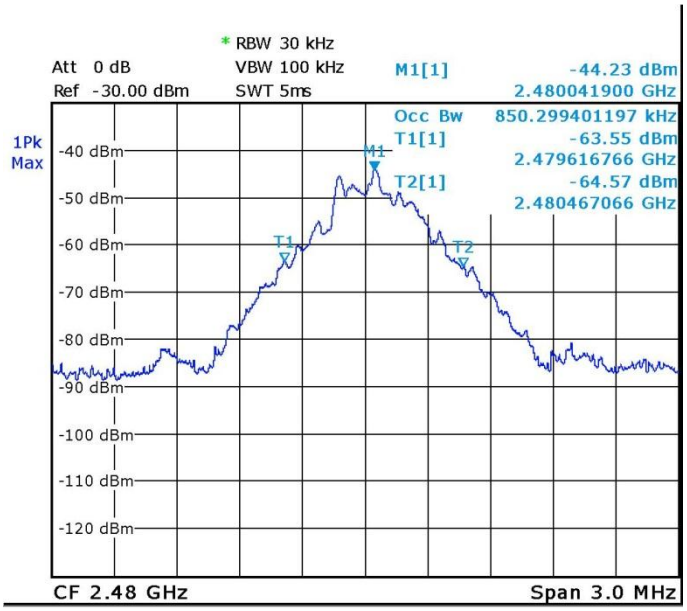
Carrier frequency – Bluetooth: 2441MHz



Measured occupied bandwidth is **844.3 kHz**

Measurement settings:
RBW = 30kHz / Video BW = 100kHz / SPAN = 3MHz

Carrier frequency – Bluetooth: 2480 MHz



Measured occupied bandwidth is **850.3 kHz**

Measurement settings:
RBW = 30kHz / Video BW = 100kHz / SPAN = 3MHz

10.3. TEST EQUIPMENT LIST

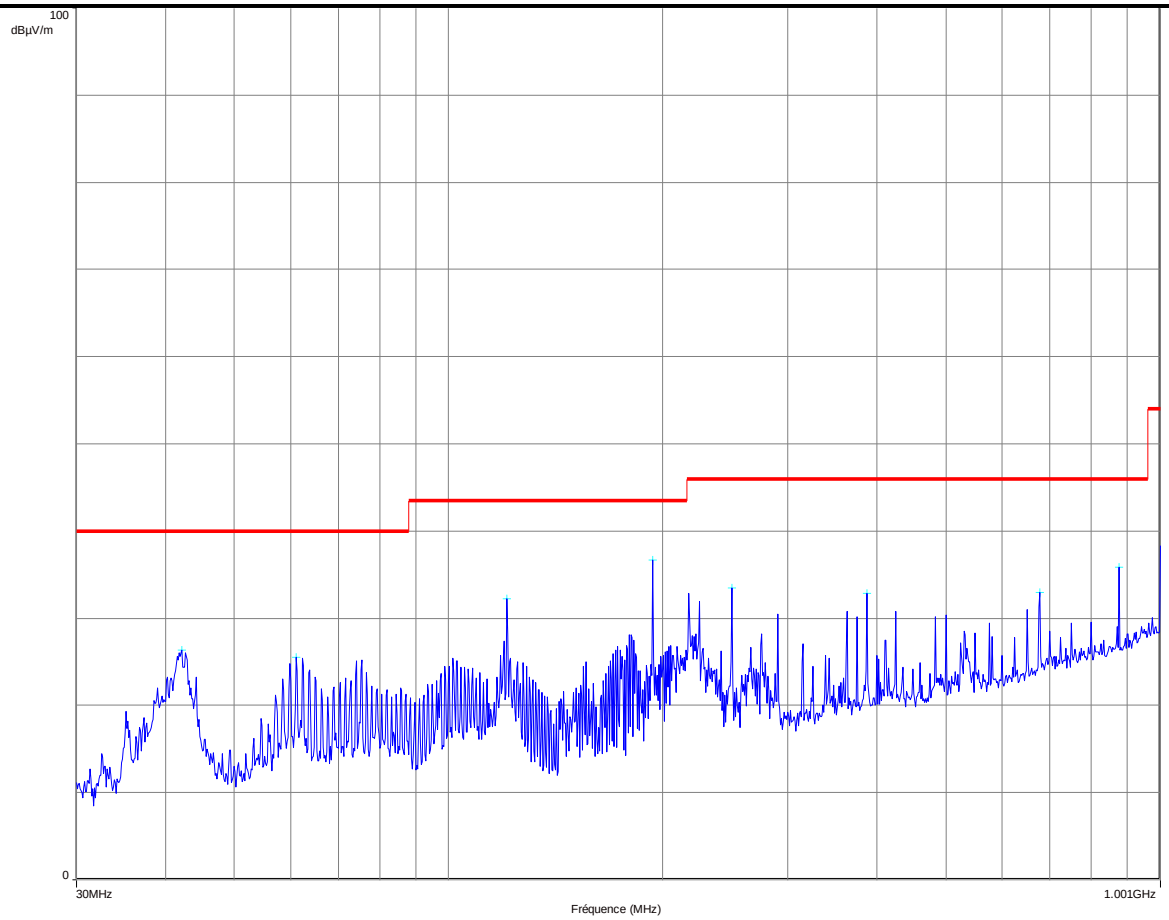
DESCRIPTION	MANUFACTURER	MODEL	N° LCIE
Receiver 20Hz – 8GHz	ROHDE & SCHWARZ	ESU8	A2642019
Attenuator 10dB	PASTERNACK	PE7014-10	A7122126

10.4. DIVERGENCE, ADDITION OR SUPPRESSION ON THE TEST SPECIFICATION

None

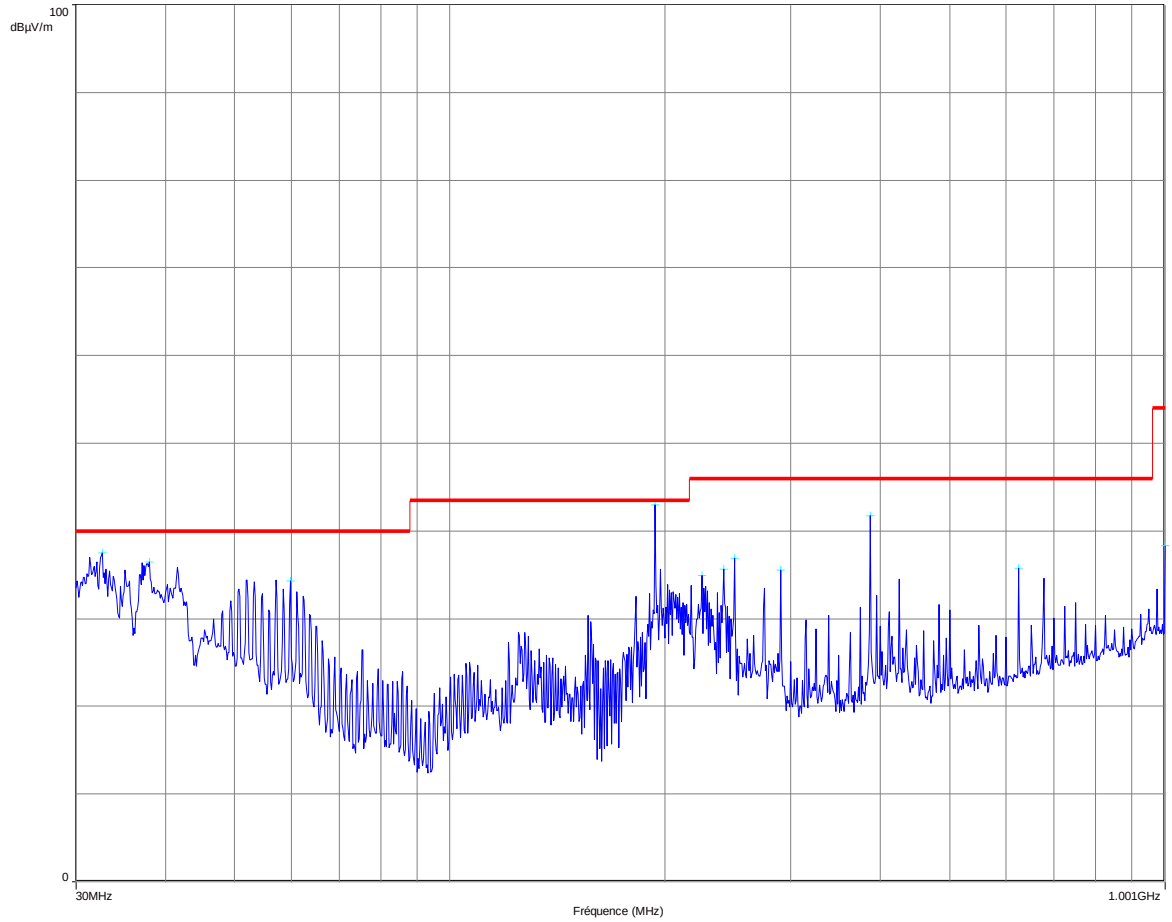
11. ANNEX 1 (GRAPHS)

RADIATED EMISSIONS			
Graph name :	Emr#1	**Test configuration:**	
Limit :	Part 15 Subpart B & C	Configuration n°1	
Class :	B		
PARAMETERS			
Antenna polarization:	Horizontal	**Legend:**	
Azimuth :	0° - 360°		**Peak Measure**
RBW :	100kHz		
VBW :	300kHz		**QPeak Limit@3m**
Frequency :	30MHz- 1.001GHz		



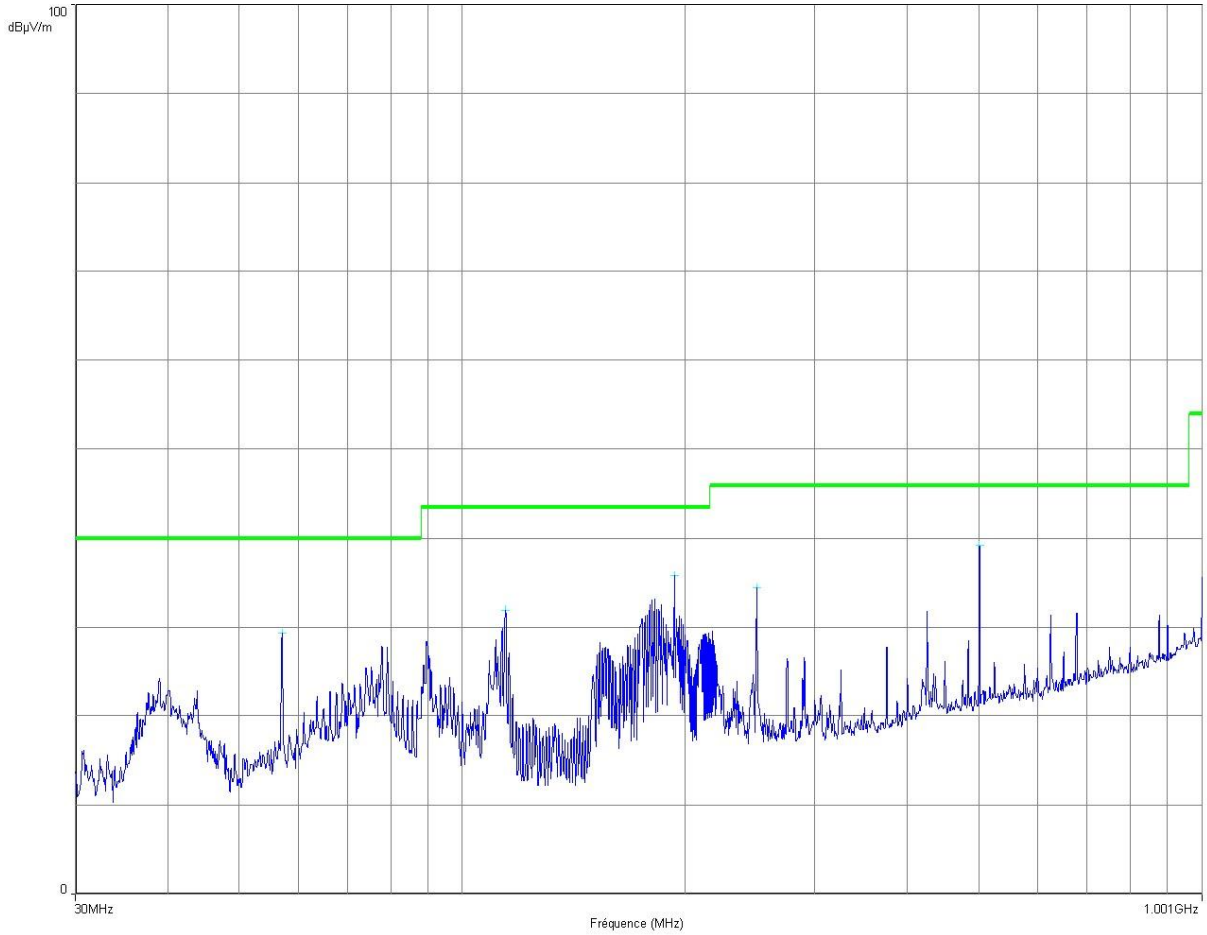
Frequency (MHz)	Level (dBµV/m)
61.08	25.54
120.88	32.21
193.6	36.7
249.88	33.51
387.04	32.81
677.36	32.96
875	35.9

RADIATED EMISSIONS			
Graph name :	Emr#2	**Test configuration:**	
Limit :	Part 15 Subpart B & C	Configuration n°1	
Class :	B		
PARAMETERS			
Antenna polarization:	Verticale	**Legend:**	
Azimuth :	0° - 360°		**Peak Measure**
RBW :	100kHz		
VBW :	300kHz		**QPeak Limit@3m**
Frequency :	30MHz- 1.001GHz		



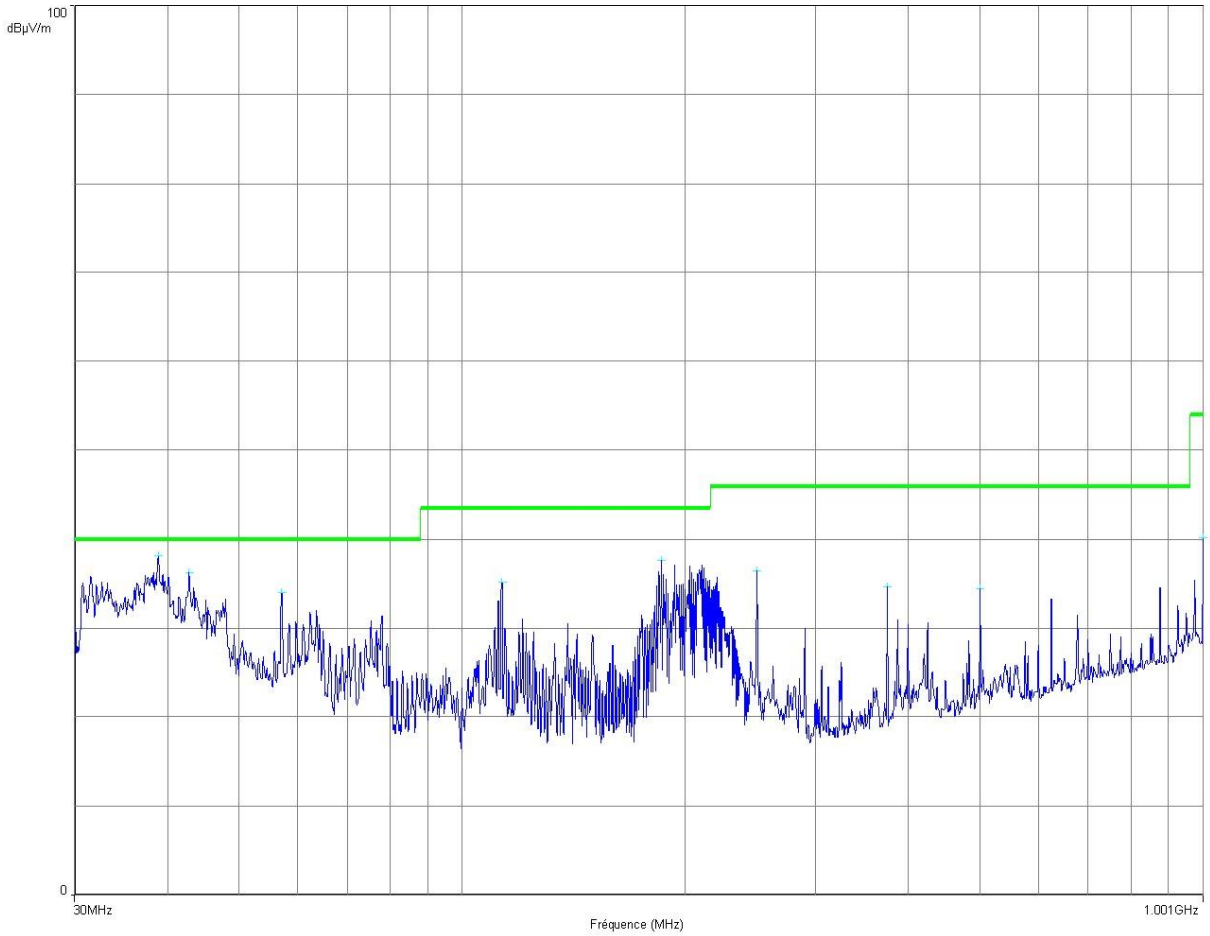
Frequency (MHz)	Level (dBµV/m)
38.04	36.48
59.8	34.30
193.6	43.00
224.96	34.97
241.8	35.66
249.88	36.91
290.24	35.57
387.04	41.71
624.96	35.76
999.96	38.29

RADIATED EMISSIONS			
Graph name :	Emr#3	**Test configuration:**	
Limit :	Part 15 Subpart B & C	Configuration n°2	
Class :	B		
PARAMETERS			
Antenna polarization:	Horizontale	**Legend:**	
Azimuth :	0° - 360°		**Peak Measure**
RBW :	100kHz		
VBW :	300kHz		**QPeak Limit@3m**
Frequency :	30MHz- 1.001GHz		



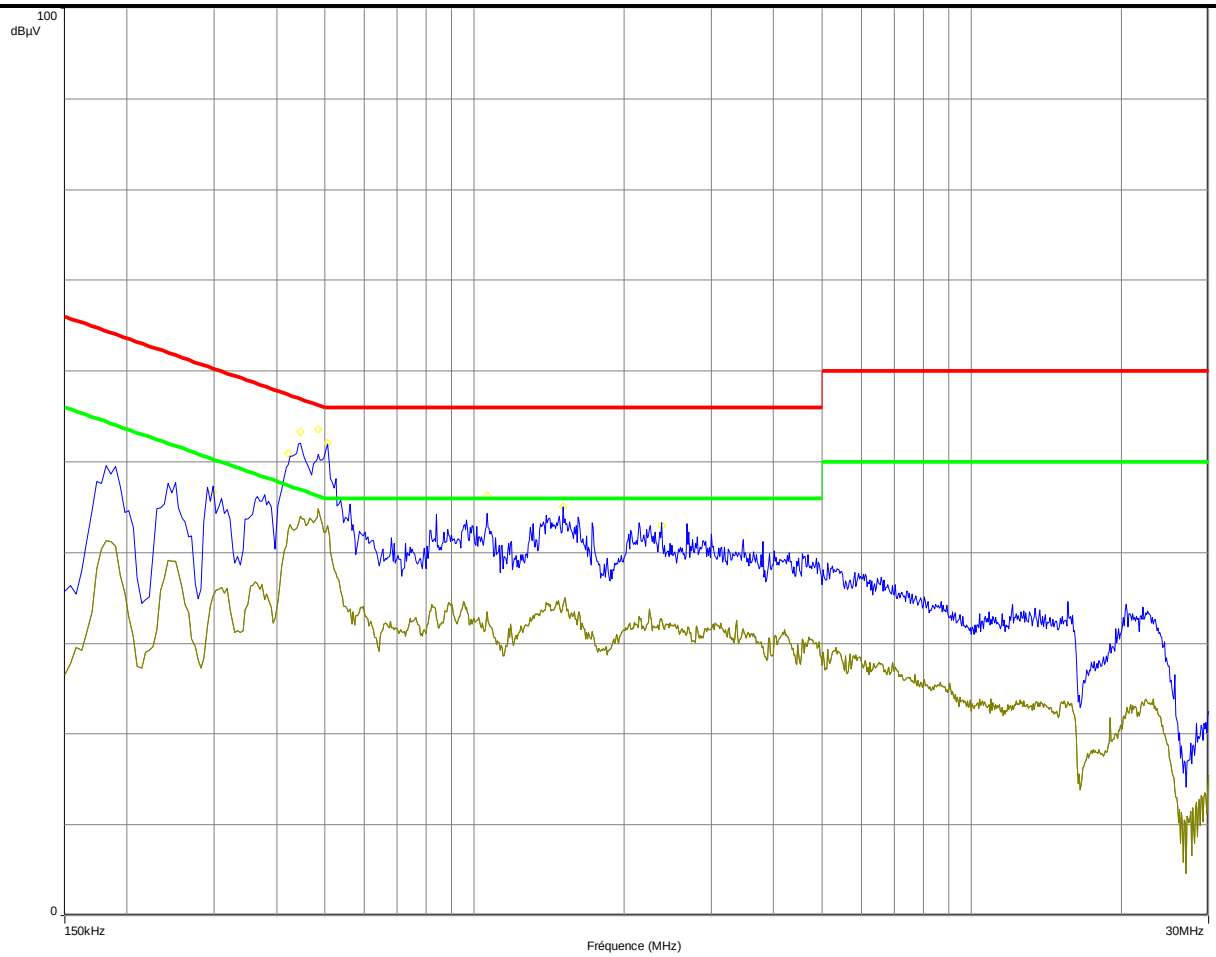
Frequency (MHz)	Level (dBµV/m)
57.08	29.32
114.4	31.92
193.6	35.8
249.88	34.41
499.92	39.12

RADIATED EMISSIONS			
Graph name :	Emr#4	**Test configuration:**	
Limit :	Part 15 Subpart B & C	Configuration n°2	
Class :	B		
PARAMETERS			
Antenna polarization:	Verticale	**Legend:**	
Azimuth :	0° - 360°		**Peak Measure**
RBW :	100kHz		
VBW :	300kHz		**QPeak Limit@3m**
Frequency :	30MHz- 1.001GHz		



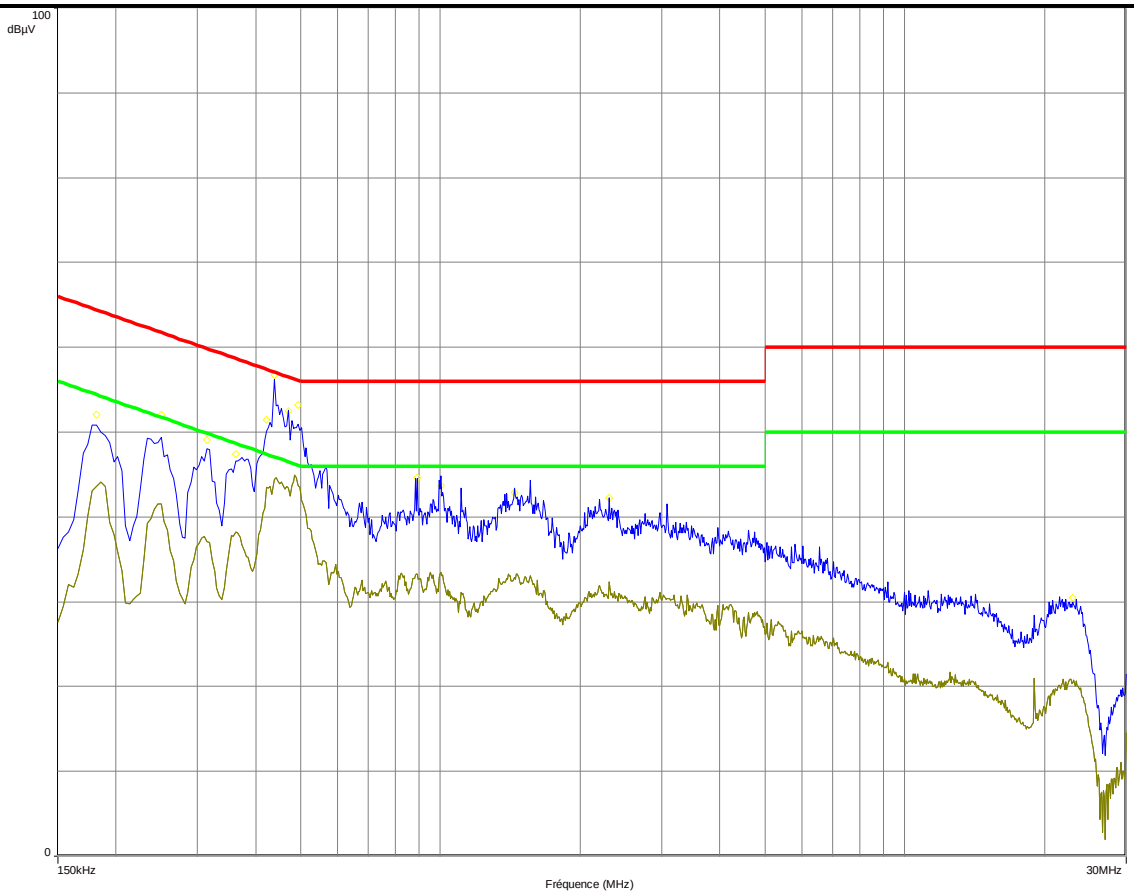
Frequency (MHz)	Level (dBµV/m)
38.88	38.12
42.84	36.3
57.08	34.02
113.12	35.15
185.76	37.55
249.88	36.51
374.88	34.6
499.92	34.42
999.92	40.19

CONDUCTED EMISSIONS					
Graph name :	Emc#1	**Test configuration:**			
Limit :	Part 15 Subpart B & C	Configuration n°1			
Class :	B	Primary of AC/DC power supply converter			
PARAMETERS					
Voltage / Frequency :	120VAC / 60Hz	**Legend:**			
Line :	Phase		**Peak Measure**		**Average Measure**
RBW :	9kHz				
VBW :	30kHz		**QPeak Limit**		**Average Limit**
Frequency :	150kHz- 30MHz				



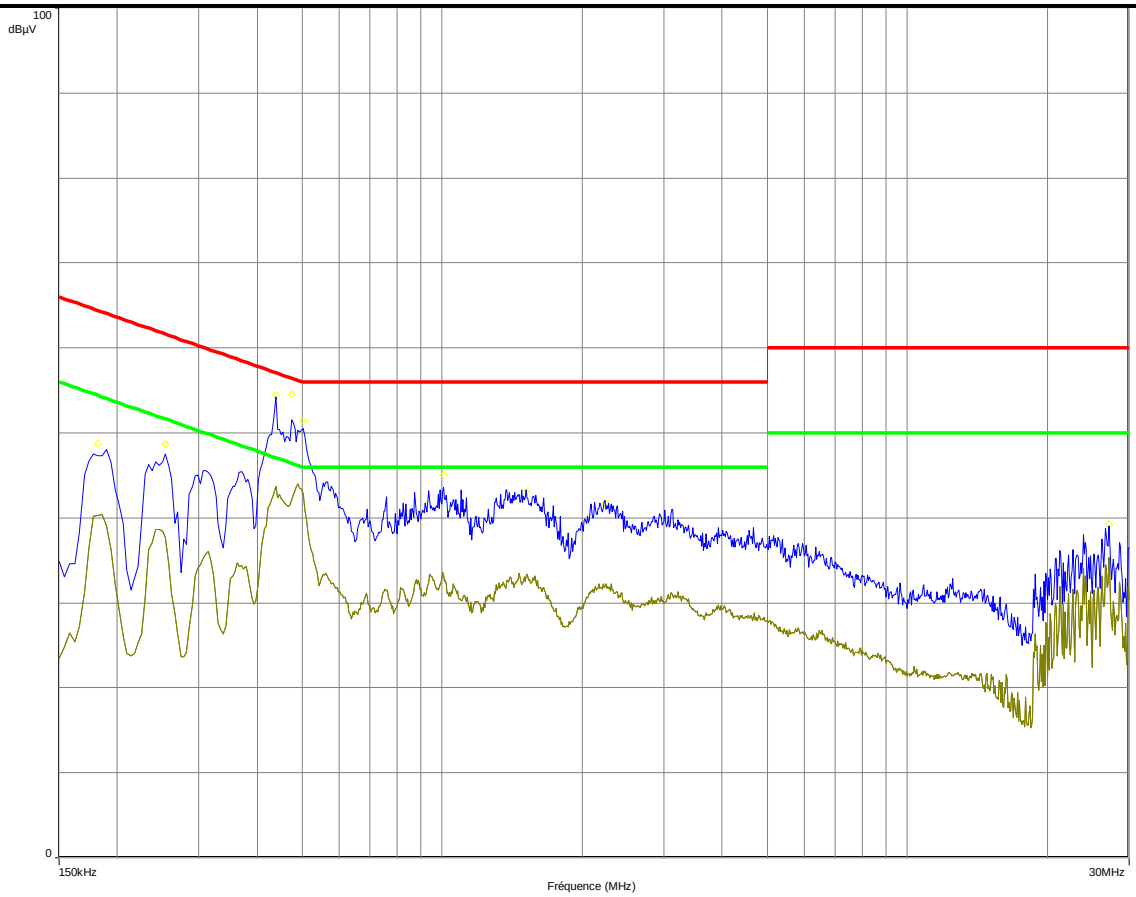
Frequency (MHz)	Avg (dBµV)	Lim Avg (dBµV)	Avg-LimAvg (dBµV)	QPeak (dBµV)	LimQPeak (dBµV)	QPeak-LimQPeak (dBµV)
0.298	34.43	50.3	-15.87	41.85	60.3	-18.45
0.422	42.45	47.41	-4.96	47.5	57.41	-9.91
0.446	43.9	46.95	-3.05	48.91	56.95	-8.04
0.486	44.82	46.24	-1.41	49.03	56.24	-7.21
0.506	41.9	46	-4.1	47.07	56	-8.93
1.062	31.51	46	-14.49	38.47	56	-17.53
1.51	33.55	46	-12.45	39.89	56	-16.11
2.378	31.8	46	-14.2	37.45	56	-18.55

CONDUCTED EMISSIONS					
Graph name :	Emc#2	**Test configuration:**			
Limit :	Part 15 Subpart B & C	Configuration n°1			
Class :	B	Primary of AC/DC power supply converter			
PARAMETERS					
Voltage / Frequency :	120VAC / 60Hz	**Legend:**			
Line :	Neutral		**Peak Measure**		**Average Measure**
RBW :	9kHz				
VBW :	30kHz		**QPeak Limit**		**Average Limit**
Frequency :	150kHz- 30MHz				



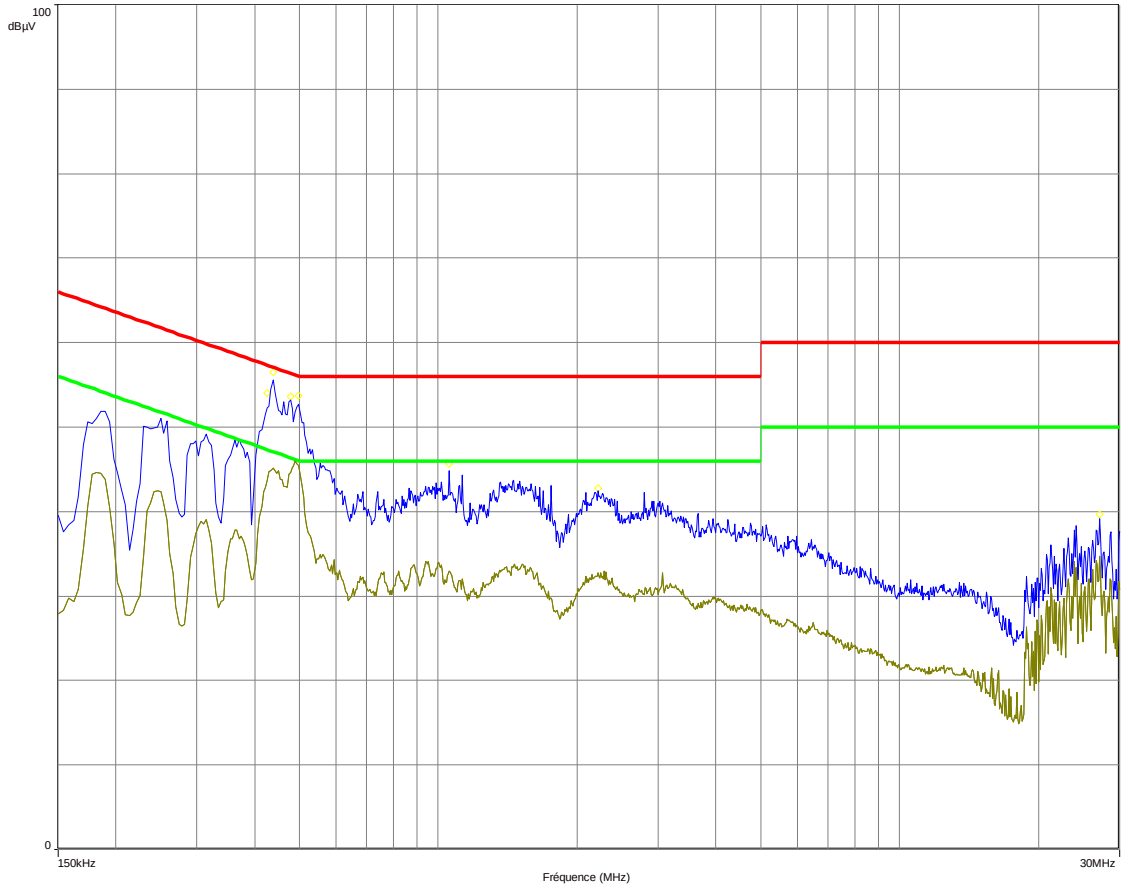
Frequency (MHz)	Avg (dBµV)	Lim Avg (dBµV)	Avg-LimAvg (dBµV)	QPeak (dBµV)	LimQPeak (dBµV)	QPeak-LimQPeak (dBµV)
0.182	43.63	54.39	-10.76	48.75	64.39	-15.64
0.25	41.21	51.76	-10.55	47.52	61.76	-14.24
0.314	37.56	49.86	-12.31	44.78	59.86	-15.08
0.362	37.98	48.68	-10.71	44.63	58.68	-14.05
0.422	42.97	47.41	-4.44	48.04	57.41	-9.37
0.438	43.48	47.1	-3.62	49.8	57.1	-7.3
0.47	43.17	46.51	-3.34	47.16	56.51	-9.35
0.494	43.85	46.1	-2.25	48.4	56.1	-7.7
0.89	33.55	46	-12.45	38.96	56	-17.04
1.002	31.84	46	-14.16	38.66	56	-17.34

CONDUCTED EMISSIONS					
Graph name :	Emc#3	**Test configuration:**			
Limit :	Part 15 Subpart B & C	Configuration n°2			
Class :	B	Primary of AC/DC power supply converter			
PARAMETERS					
Voltage / Frequency :	120VAC / 60Hz	**Legend:**			
Line :	Phase		**Peak Measure**		**Average Measure**
RBW :	9kHz				
VBW :	30kHz		**QPeak Limit**		**Average Limit**
Frequency :	150kHz- 30MHz				



Frequency (MHz)	Avg (dBµV)	Lim Avg (dBµV)	Avg-LimAvg (dBµV)	QPeak (dBµV)	LimQPeak (dBµV)	QPeak-LimQPeak (dBµV)
0.182	40.29	54.39	-14.1	45.64	64.39	-18.75
0.254	37.8	51.63	-13.83	45.53	61.63	-16.09
0.438	42.96	47.1	-4.14	48.85	57.1	-8.25
0.474	42.23	46.44	-4.22	48.66	56.44	-7.78
0.502	42.75	46	-3.25	47.98	56	-8.02
1.006	32.95	46	-13.05	39.7	56	-16.3
1.514	32.77	46	-13.23	39.34	56	-16.66
2.242	31.83	46	-14.17	37.9	56	-18.1
27.198	34.35	50	-15.65	37.56	60	-22.44

CONDUCTED EMISSIONS					
Graph name :	Emc#4	**Test configuration:**			
Limit :	Part 15 Subpart B & C	Configuration n°2			
Class :	B	Primary of AC/DC power supply converter			
PARAMETERS					
Voltage / Frequency :	120VAC / 50Hz	**Legend:**			
Line :	Neutral		**Peak Measure**		**Average Measure**
RBW :	9kHz				
VBW :	30kHz		**QPeak Limit**		**Average Limit**
Frequency :	150kHz- 30MHz				



Frequency (MHz)	Avg (dBµV)	Lim Avg (dBµV)	Avg-LimAvg (dBµV)	QPeak (dBµV)	LimQPeak (dBµV)	QPeak-LimQPeak (dBµV)
0.426	43.82	47.33	-3.51	49.71	57.33	-7.62
0.438	45.05	47.1	-2.05	50.5	57.1	-6.6
0.478	44.73	46.37	-1.64	50.49	56.37	-5.89
0.498	45.39	46.03	-0.65	50.56	56.03	-5.47
1.054	32.64	46	-13.36	40.03	56	-15.97
2.218	32.19	46	-13.81	38.85	56	-17.15
27.198	34.61	50	-15.39	37.87	60	-22.13

12. UNCERTAINTIES CHART

Type de mesure / *Kind of measurement*	**Incertitude élargie laboratoire / *Wide uncertainty laboratory* (k=2) ± x**	**Incertitude limite du CISPR / *CISPR uncertainty limit* ± y**
Mesure des perturbations conduites en tension sur le réseau d'énergie *Measurement of conducted disturbances in voltage on the power port*	3.57 dB	3.6 dB
Mesure des perturbations conduites en tension sur le réseau de télécommunication *Measurement of conducted disturbances in voltage on the telecommunication port.*	3.28 dB	A l'étude / Under consid.
Mesure des perturbations discontinues conduites en tension *Measurement of discontinuous conducted disturbances in voltage*	3.47 dB	3.6 dB
Mesure des perturbations conduites en courant *Measurement of conducted disturbances in current*	2.90 dB	A l'étude / Under consid.
Mesure du champ électrique rayonné sur le site en espace libre de Moirans *Measurement of radiated electric field on the Moirans open area test site*	5.07 dB	5.2 dB

Les valeurs d'incertitudes calculées du laboratoire étant inférieures aux valeurs d'incertitudes limites établies par la norme, la conformité de l'échantillon est établie directement par les niveaux limites applicables. / *The uncertainty values calculated by the laboratory are lower than limit uncertainty values defined by the standard. The conformity of the sample is directly established by the applicable limits values.*