RR051-15-102192-5-A Ed. 0

Certification Radio test report

According to the standard:
CFR 47 FCC PART 15

Equipment under test:
Seismic data acquisition box for radio system – WTU-518

FCC ID: KQ9-0500A

Company:
SERCEL NANTES

DISTRIBUTION: Mr LE MOINE **(Company: SERCEL NANTES)**

Number of pages: 70 with 9 appendixes

Ed.	Date	Modified pages	Written by Name	Written by Visa	Technical Verification and Quality Approval Name	Technical Verification and Quality Approval Visa
0	10-AUG-2015	Creation	T. LEDRESSEUR	T.L	DUMESNIL M.	

Duplication of this test report is only permitted for an integral photographic facsimile. It includes the number of pages referenced here above.
This document is the result of testing a specimen or a sample of the product submitted. It does not imply an assessment of the conformity of the whole manufactured products of the tested sample.

DESIGNATION OF PRODUCT:	**Seismic data acquisition box for radio system**
Serial number (S/N):	1392
Reference / model (P/N):	WTU-518
Software version:	Not communicated
MANUFACTURER:	SERCEL NANTES

COMPANY SUBMITTING THE PRODUCT:

Company:	SERCEL NANTES
Address:	ZI 16 RUE DE BEL AIR BP 30439 44474 CARQUEFOU CEDEX
Responsible:	Mr LE MOINE
Persons presents during the tests:	Mr LE MOINE
DATES OF TEST:	Between 23-SEP-2014 from 23-JUN-2015
TESTING LOCATION:	EMITECH ANGERS laboratory at JUIGNE SUR LOIRE (49) FRANCE 21 rue de la Fuye 49610 Juigne sur Loire France FCC 2.948 Listed Site Registration Number: 90469 FCC Accredited under US-EU MRA Designation Number: FR0009 Test Firm Registration Number: 873677
TESTED BY:	T. LEDRESSEUR

CONTENTS

1. INTRODUCTION

This document presents the result of RADIO test carried out on the following equipment: **Seismic data acquisition box for radio system**, in accordance with normative reference.

The device under test integrates a FHSS proprietary module not approved, WIFI module already approved and a GPS receiver.
The host device of certified module shall be properly labeled to identify the module within.

This radio test report concerns only the FHSS module for the certification procedure.

2. PRODUCT DESCRIPTION

Class:	B
Utilization:	The product is destined to be used on a professional environment, but It was tested to respect the class B limits
Antenna type and gain:	The product possesses two identical internal antennas with the same orientation. The emission is alternate between each antenna, the product can't emit simultaneously on the two antennas. Gain: 3 dBi
Operating frequency range:	2400 to 2483.5MHz
Frequency tested:	2405 MHz (low channel) 2437 MHz (central channel) 2469 MHz (high channel)
Number of channels:	17 maximum
Channel spacing:	1 MHz is the minimum adjustable for 100 kbps, 2MHz for 500 kbps
Modulation:	MSK
Power source:	7.2 Vdc internal battery or 12 Vdc by external power supply.

Power level, frequency range and channels characteristics are not user adjustable.
The details pictures of the product and the circuit boards are joined with this file.

The product support 2 different data rate 100 kbps and 500 kpbs. The tests are repeated for each.

3. NORMATIVE REFERENCE

The standards and testing methods related throughout this report are those listed below.
They are applied on the whole test report even though the extensions (version, date and amendment) are not repeated.

CFR 47 FCC Part 15 (2014)	Radio Frequency Devices
ANSI C63.4	2009 Methods of measurement of Radio-Noise Emissions from low-voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz.
ANSI C63.10	2009 Testing Unlicensed Wireless Devices.
Public Notice DA 00-705	Filing and Measurement Guideline for Frequency Hopping Spread Spectrum Systems.

4. TEST METHODOLOGY

Radio performance tests procedures given in CFR 47 part 15:

Subpart A –General
- Paragraph 19: labelling requirements
- Paragraph 21: information to user

Subpart B –Unintentional Radiators
- Paragraph 105: information to the user
- Paragraph 107: Conducted limits
- Paragraph 109: Radiated emission limits

Subpart C – Intentional Radiators
- Paragraph 203: Antenna requirement
- Paragraph 205: Restricted bands of operation
- Paragraph 207: Conducted limits
- Paragraph 209: Radiated emission limits; general requirements
- Paragraph 212: Modular transmitter
- Paragraph 215: Additional provisions to the general radiated emission limitations
- Paragraph 247: Operation within the bands 902-928 MHZ, 2400-2483.5 MHz and 5725-5850 MHz

5. TEST EQUIPMENT CALIBRATION DATES

Equipment	Model	Type	Last verification	Next verification	Validity
0000	BAT-EMC	Software	/	/	/
1406	EMCO 6502	Loop antenna	27/01/2015	27/01/2017	27/03/2017
1922	Microwave DB C020180F-4B1	Low-noise amplifier	20/08/2014	20/08/2015	20/10/2015
1939	IMC WR42	Horn antenna	20/04/2012	20/04/2016	20/06/2016
1940	IMC WR42	Horn antenna	20/04/2012	20/04/2016	20/06/2016
3036	ALC Microwave ALN02-0102	Low-noise amplifier	14/05/2014	14/05/2015	14/07/2015
4088	R&S FSP40	Spectrum Analyzer	22/08/2013	22/08/2015	22/10/2015
7299	Microtronics BRM50702	reject band filter	25/10/2013	25/10/2015	25/12/2015
8508	California instruments 1251RP	Power source	22/08/2014	22/08/2015	22/10/2015
8511	HP 8447D	Low noise preamplifier	20/08/2014	20/08/2015	20/10/2015
8524	HP 8591EM	Test receiver	30/07/2013	30/07/2015	30/09/2015
8526	Schwarzbeck VHBB 9124	Biconical antenna	12/06/2012	12/06/2016	12/08/2016
8528	Schwarzbeck VHA 9103	Biconical antenna	24/09/2013	24/09/2017	24/11/2017
8535	Emco 3115	Horn antenna	29/10/2012	29/10/2016	29/12/2016
8543	Schwarzbeck UHALP 9108A	Log periodic antenna	12/06/2012	12/06/2016	12/08/2016
8593	SIDT Cage 2	Full anechoic room	/	/	/
8641	SECRE ETP232	High-pass filter	14/04/2015	14/04/2017	14/06/2017
8671	HUGER	Meteo station	04/09/2014	04/09/2016	04/11/2016
8675	AOIP MN5102B	Multimeter	23/02/2015	23/02/2017	23/04/2017
8707	R&S ESI7	Test receiver	11/12/2014	11/12/2016	11/02/2017
8719	Thurbly Thandar Instruments 1600	LISN	23/06/2014	23/06/2016	23/08/2016
8732	Emitech	OATS	23/08/2013	23/08/2016	23/10/2016
8750	La Crosse Technology WS-9232	Meteo station	03/09/2014	03/09/2016	03/11/2016
8893	Emitech	Outside room	/	/	/
8896	ACQUISYS GPS8	Satellite synchronized frequency standard	/	/	/
9489	Absorber sheath current	Emitech	08/10/2014	08/10/2016	08/12/2016

6. TESTS AND CONCLUSIONS

6.1 general (subpart A)

Test procedure	Description of test	Respected criteria?				Comment
		Yes	No	NAp	NAs	
FCC Part 15.19	LABELLING REQUIREMENTS				X	*See certification documents*
FCC Part 15.21	INFORMATION TO USER				X	*See certification documents*

NAp: Not Applicable NAs: Not Asked

LABEL SHALL CONTAIN

The label shall be located in a conspicuous location on the device
The label shall not be a stick-on, paper label. The label on these products shall be permanently affixed to the product and shall be readily visible to the purchaser at the time of purchase

§15.19: (can be placed in the user manual if the product is too small)

This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) this device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

USER NOTICE SHALL CONTAIN

The user notice shall include the following information's:

§15.21:

Any changes or modifications to this equipment not expressly approved by SERCEL NANTES may cause, harmful interference and void the FCC authorization to operate this equipment

6.2 unintentional radiator (subpart B)

Test procedure	Description of test	Respected criteria?				Comment
		Yes	No	NAp	NAs	
FCC Part 15.105	INFORMATION TO THE USER				X	*See certification documents*
FCC Part 15.107	CONDUCTED LIMITS	X				*Class B*
FCC Part 15.109	RADIATED EMISSION LIMITS	X				*Class B*

NAp: Not Applicable NAs: Not Asked

USER NOTICE SHALL CONTAIN

The user notice shall include the following informations:

§ 15.105:

NOTE: This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference's by one or more of the following measures:
-Reorient or relocate the receiving antenna.
-Increase the separation between the equipment and the receiver.
-Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
-Consult the dealer or an experienced radio/TV technician for help.

6.3 intentional radiator (subpart C)

Test procedure	Description of test	Respected criteria?				Comment
		Yes	No	NAp	NAs	
FCC Part 15.203	ANTENNA REQUIREMENT	X				*Note 1*
FCC Part 15.205	RESTRICTED BANDS OF OPERATION	X				
FCC Part 15.207	CONDUCTED LIMITS	X				
FCC Part 15.209	RADIATED EMISSION LIMITS; general requirements	X				*Note 2*
FCC Part 15.212	MODULAR TRANSMITTERS	X				*Note 3*
FCC part 15.215	ADDITIONAL PROVISIONS TO THE GENERAL RADIATED EMISSION LIMITATIONS					
	(a) Alternative to general radiated emission limits	X				
	(b) Unwanted emissions outside of §15.247 frequency bands	X				*Note 4*
	(c) 20 dB bandwidth and band-edge compliance	X				
FCC Part 15.247	OPERATION WITHIN THE BANDS 902-928 MHZ, 2400-2483.5 MHz and 5725-5850 MHz					
	(a) (1) Hopping systems	X				*Note 5*
	(a) (2) Digital modulation techniques			X		*Note 6*
	(b) Maximum peak output power	X				*Note 7*
	(c) Operation with directional antenna gains > 6 dBi			X		
	(d) Intentional radiator	X				
	(e) Peak power spectral density			X		
	(f) Hybrid system			X		
	(g) Frequency hopping requirements	X				
	(h) Frequency hopping intelligence	X				
	(i) RF exposure compliance	X				*Note 8*

NAp: Not Applicable NAs: Not Asked

Note 1: Integral antennas.

Note 2: See FCC part 15.247 (d).

Note 3: The host devices of the certified modules shall be properly labeled to identify the module within. (see label)

Note 4: See FCC part 15.209. Unwanted emissions levels are all below the fundamental emission field strength level.

Note 5:

- *For data rates of 100 kbps:*

  The system hops to channel frequencies from a pseudo randomly ordered list of hopping frequencies. Each frequency is used equally on the average by the transmitter, and separated by a minimum of 20 dB bandwidth of the hopping channel (980 kHz; see appendix 5)

  The frequency hopping system uses 17 channels (see appendix 8).

  The timing by channel is 22.3 ms (see appendix 7).

  17 channels × 0.4 s = 6.8 s, any channel is used 14 times (see appendix 7),
  Then 22.3 x 14 = 312.2 ms, thus the average time of occupancy on any channel is less than 400 ms within a period of 0.4 seconds multiplied by the number of hopping channels employed, in normal operating mode.

Number of channels	Observation period (0.4s * Nbr of channel) (s)	Maximal Duration of each burst (ms)	Number of burst repetition during observation period	average time of occupancy on any channel (s)	Limits (s)
17	6.8	22.3	14	312.2	0.4

- *For data rates of 500 kbps:*

  The system hops to channel frequencies from a pseudo randomly ordered list of hopping frequencies. Each frequency is used equally on the average by the transmitter, and separated by a minimum of 20 dB bandwidth of the hopping channel (1102 kHz; see appendix 5)

  The frequency hopping system uses 17 channels (see appendix 8).

  The timing by channel is 8.43 ms (see appendix 7).

  17 channels × 0.4 s = 6.8 s, any channel is used 29 times (see appendix 7),
  Then 8.43 x 28 = 244.47 ms, thus the average time of occupancy on any channel is less than 400 ms within a period of 0.4 seconds multiplied by the number of hopping channels employed, in normal operating mode.

Number of channels	Observation period (0.4s * Nbr of channel) (s)	Maximal Duration of each burst (ms)	Number of burst repetition during observation period	average time of occupancy on any channel (s)	Limits (s)
17	6.8	8.43	29	244.47	0.4

Note 6: For data rate of 100 kbps the maximum 6 dB bandwidth of the equipment is 312 kHz (see appendix 4).
For data rate of 500 kbps the maximum 6 dB bandwidth of the equipment is 498 kHz (see appendix 4).

Note 7: Conducted measurement is not possible (integral antenna), so we used the radiated method in open field.

RF EXPOSURE:

Note 8 : In accordance with KDB 447498 D01 General RF Exposure Guidance v05r02, Paragraph 4.3.1.

The product must respect the exclusion limit for 10-g extremity SAR:

*[(max. power of channel, including tune-up tolerance, mW)/(min. test separation distance, mm)] * [√f(GHz)] ≤ 7.5*

*min. test separation distance, mm ≥ [(max. power of channel, including tune-up tolerance, mW)] * [√f(GHz) / 7.5]*
*min. test separation distance, mm ≥ 47.5 (mW) *[√(2.469)/7.5]*
min. test separation distance, mm ≥ ***9.96 mm***

The minimum distance between the user and the antenna is more than 10 mm

« To declare, or not, the compliance with the specifications, it was not explicitly taken into account of uncertainty associated with the results »

7. MEASUREMENT OF THE CONDUCTED DISTURBANCES

Standard: FCC Part 15

Test procedure: Paragraph 15.107

Limits: Class B

Software used: BAT-EMC V3.6.0.32

Test set up:

The EUT is isolated and placed on a wooden table, 0.8 m over a horizontal reference plane and 0.4 m from a vertical reference plane. It is powered by an artificial main network placed on the ground reference plane.
The equipment is powered with the AC power operating voltage of 120 V / 60 Hz.

See photos in appendix 2

Frequency range: 150 kHz - 30 MHz

Detection mode: Peak

Bandwidth: 10 kHz

Equipment under test operating condition:

The equipment is blocked in reception mode.

Results:

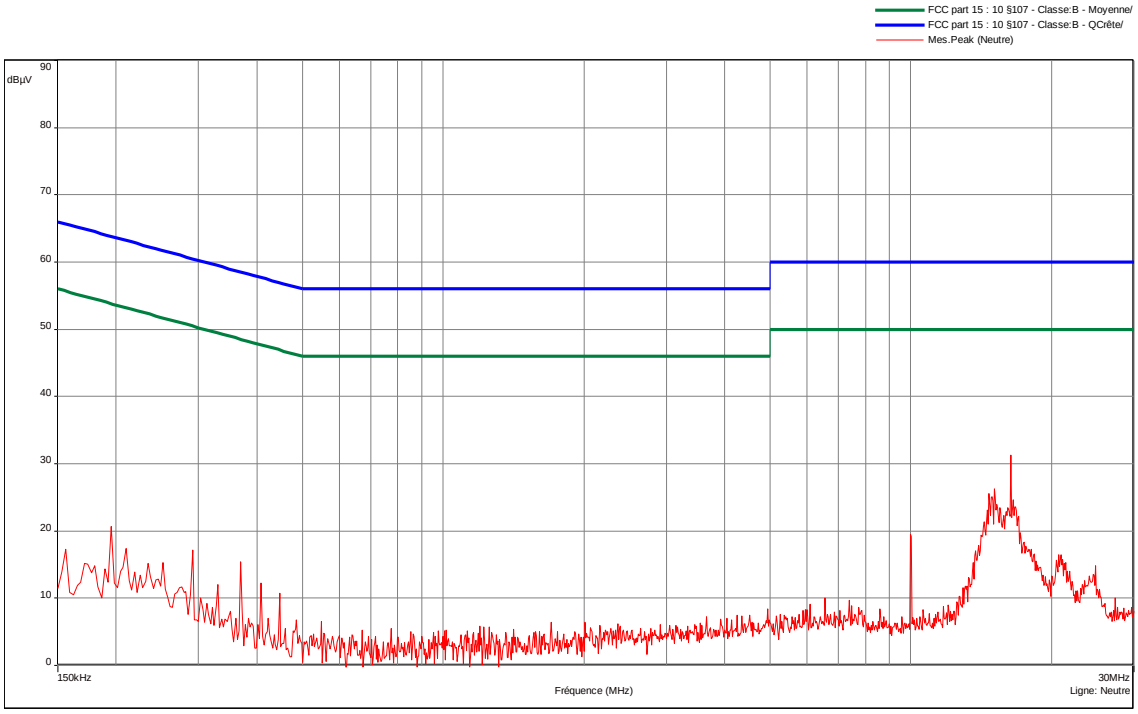
Ambient temperature (°C):	21
Relative humidity (%):	63

Sample N° 1:

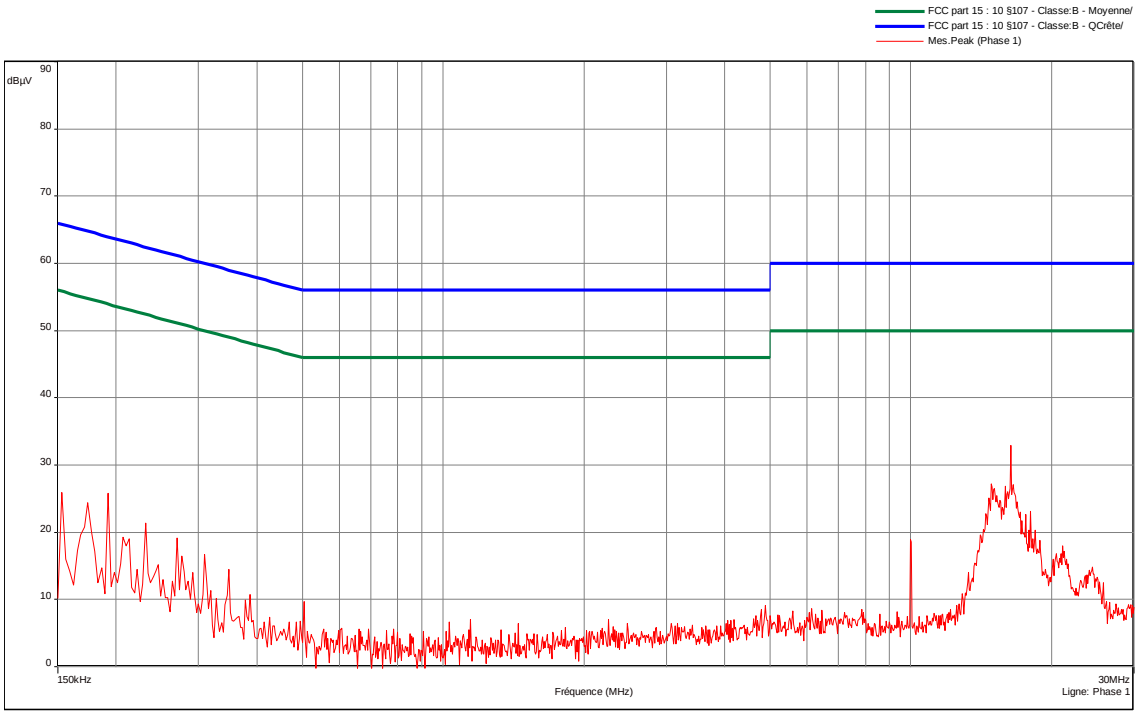
Measurement on the mains power supply:

The measurement is realized with Peak detector.

Curve N° 1: measurement on the Neutral with peak detector



Curve N° 2: measurement on the Line with peak detector



Test conclusion:

RESPECTED STANDARD

8. RADIATED EMISSION LIMITS

Standard: FCC Part 15

Test procedure: paragraph 109

Limit class: Class B

Test set up:

First an exploratory radiated measurement was performed. During this phase the product is oriented in three orthogonal planes.

Then the final measurement is realized with the product on the most critical orientation.

The measure is realized on open area test site under 1 GHz and in anechoic chamber above 1 GHz.

When the system is tested in an open area test site (OATS), the EUT is placed on a rotating table, 0.8m from a ground plane.

When the system is tested in anechoic chamber, the EUT is placed on a rotating table, 1.5m from a ground plane.

Zero degree azimuths correspond to the front of the device under test.

See photos in appendix 2.

Frequency range: From 9 kHz to 5th harmonic of the highest frequency used (12.5 GHz)

Detection mode: Quasi-peak (F < 1 GHz) Average (F > 1 GHz)

Bandwidth: 120 kHz (F < 1 GHz) 1 MHz (F > 1 GHz)

Distance of antenna: 10 meters (in open area test site) / 3 meters (in anechoic room)

Antenna height: 1 to 4 meters (in open area test site) / 1.5 meter (in anechoic room)

Antenna polarization: vertical and horizontal (only the highest level is recorded)

Equipment under test operating condition:

The equipment is blocked in reception mode.

Results:

Ambient temperature (°C): 21
Relative humidity (%): 63

Power source: 12 Vdc by another equipment

Sample N° 1

FREQUENCIES (MHz)	Detector P: Peak QP: Quasi-Peak	Antenna height (cm)	Azimuth (degree)	Polarization H: Horizontal V: Vertical	Field strength (dBµV/m)	Limits (dBµV/m)	Margin (dB)
32.230	QP	327	358	V	25.77	40	14.23
43.802	QP	99	0	V	26.67	40	13.33
62.726	QP	100	92	V	23.59	40	16.41
80.002	QP	192	89	V	28.40	40	11.60
125.002	QP	100	341	V	29.93	43.5	13.57
148.117	QP	400	266	H	26.79	43.5	16.71
320.001	QP	288	347	H	35.67	46	10.33

Note: any spurious which has more than 20 dB of margin compared to the applicable limit is not necessarily reported.

Test conclusion:

RESPECTED STANDARD

9. MEASUREMENT OF THE CONDUCTED DISTURBANCES

Standard: FCC Part 15

Test procedure: Paragraph 15.207

Software used: BAT-EMC V3.6.0.32

Test set up:

The EUT is isolated and placed on a wooden table, 0.8 m over a horizontal reference plane and 0.4 m from a vertical reference plane. It is powered by an artificial main network placed on the ground reference plane.
The equipment is powered with the AC power operating voltage of 120 V / 60 Hz.

See photos in appendix 2

Frequency range: 150 kHz - 30 MHz

Detection mode: Peak

Bandwidth: 10 kHz

Equipment under test operating condition:

The equipment under test is blocked in continuous modulated transmission mode, at the highest output power level at which the transmitter is intended to operate.

Results:

Ambient temperature (°C): 21
Relative humidity (%): 63

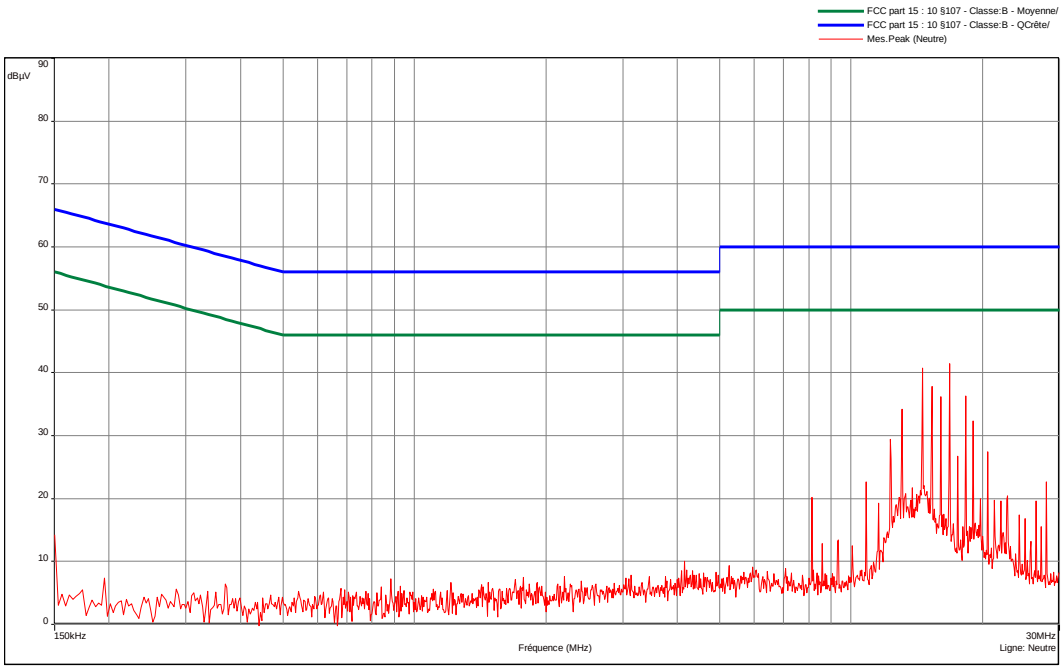
Sample N° 1:

Measurement on the mains power supply:

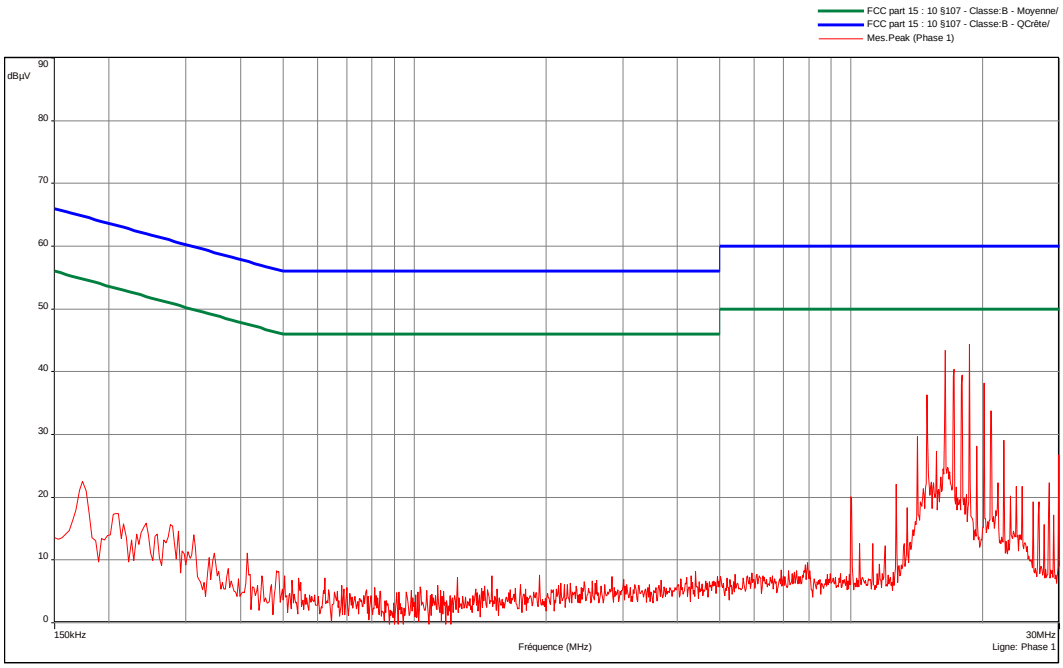
The measurement is realized with Peak detector.

Data rate 100 kbps:

Curve N° 3: measurement on the Neutral with peak detector

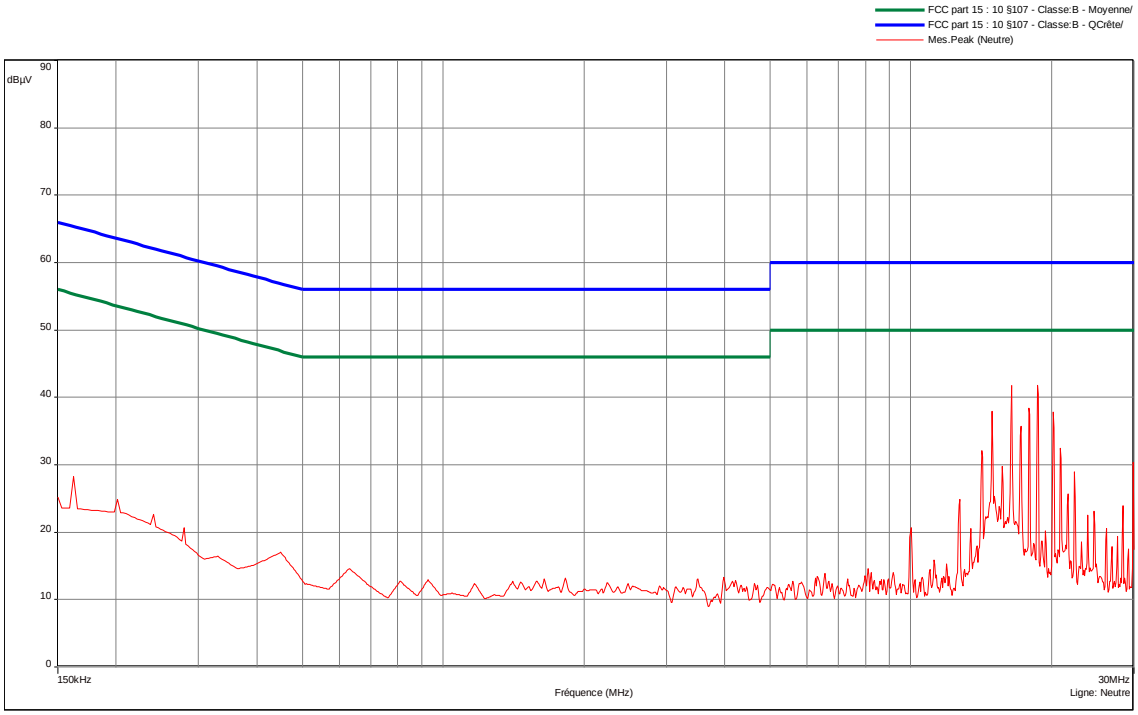


Curve N° 4: measurement on the Line with peak detector

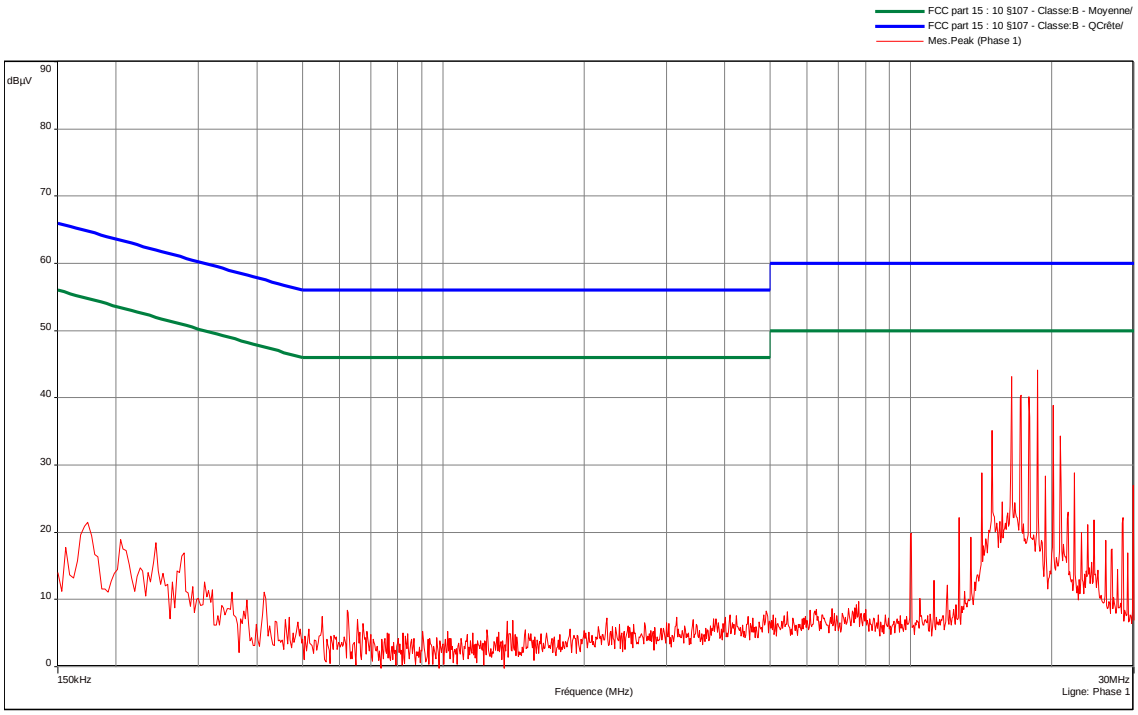


Data rate 500 kbps:

Curve N° 5: measurement on the Neutral with peak detector



Curve N° 6: measurement on the Line with peak detector



Test conclusion:

RESPECTED STANDARD

10. ADDITIONAL PROVISIONS TO THE GENERAL RADIATED EMISSION LIMITATIONS

Standard: FCC Part 15

Test procedure: Paragraph 15.215

Test set up:

Test realized in near field. All field strength measurements are correlated with the radiated maximum peak output power

Test operating condition of the equipment:

The equipment under test is blocked in continuous transmission mode, modulated by internal data signal, at the highest output power level which the transmitter is intended to operate.
The measure is first realized with in hopping off mode and repeated with hopping on mode. Only the worst case for each data rate is reported.

Results:

Ambient temperature (°C): 23.8
Relative humidity (%): 47

Power source: 12 Vdc by another equipment

Lower Band Edge: 2398 to 2400 MHz
Upper Band Edge: 2483.5 to 2485.5 MHz

Sample N° 1: in hopping on mode
Data rate 100 kbps:

Fundamental frequency (MHz)	Field Strength Level of fundamental (dBµV/m)	Detector (Peak or Average)	Frequency of maximum Band-edges Emission (MHz)	Delta Marker (dB)*	Calculated Max Out-of-Band Emission Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)
2405	111	Pk	2399.8	-45.3	65.7	91	25.3
2469	112	Pk	2483.7	-50.7	61.3	74	12.7
2469	112	Av	2483.7	-64.1	47.9	54	6.1

* *Marker-Delta method*

20 dB bandwidth curves are given in appendix 5; band-edge curves are given in appendix 6.

Sample N° 1: in hopping on mode
Data rate 100 kbps:

Fundamental frequency (MHz)	Field Strength Level of fundamental (dBµV/m)	Detector (Peak or Average)	Frequency of maximum Band-edges Emission (MHz)	Delta Marker (dB)*	Calculated Max Out-of-Band Emission Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)
2405	111	Pk	2399.82	-44.3	66.7	91	24.3
2469	111	Pk	2483.6	-53.1	57.9	74	16.1
2469	111	Av	2483.6	-64.3	46.7	54	7.3

* *Marker-Delta method*

20 dB bandwidth curves are given in appendix 5; band-edge curves are given in appendix 6.

Sample N° 1: in hopping off mode
Data rate 100 kbps:

Fundamental frequency (MHz)	Field Strength Level of fundamental (dBµV/m)	Detector (Peak or Average)	Frequency of maximum Band-edges Emission (MHz)	Delta Marker (dB)*	Calculated Max Out-of-Band Emission Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)
2405	111	PEAK	2399.643	-50.37	60.63	91	30.37
2469	111	PEAK	2483.794	-54.58	56.42	74	17.58
2469	112	AVERAGE	2483.535	-67.20	44.80	54	9.20

* *Marker-Delta method*

20 dB bandwidth curves are given in appendix 5; band-edge curves are given in appendix 6.

Sample N° 1: in hopping off mode
Data rate 500 kbps:

Fundamental frequency (MHz)	Field Strength Level of fundamental (dBµV/m)	Detector (Peak or Average)	Frequency of maximum Band-edges Emission (MHz)	Delta Marker (dB)*	Calculated Max Out-of-Band Emission Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)
2405	111	PEAK	2399.744	-50.52	60.48	91	30.52
2469	111	PEAK	2484.282	-53.20	57.80	74	16.20
2469	111	AVERAGE	2483.689	-67.17	43.83	54	10.17

* *Marker-Delta method*

20 dB bandwidth curves are given in appendix 5; band-edge curves are given in appendix 6.

Test conclusion:

RESPECTED STANDARD

11. MAXIMUM PEAK OUTPUT POWER

Standard: FCC Part 15

Test procedure: paragraph 15.247 (b)

Test set up:

First an exploratory radiated measurement was performed. During this phase the product is oriented in three orthogonal planes.

Then the final measurement is realized with the product on the most critical orientation.

The measure is realized in anechoic chamber above 1 GHz.

When the system is tested in anechoic chamber, the EUT is placed on a rotating table, 1.5m from a ground plane.

Zero degree azimuths correspond to the front of the device under test.

See photos in appendix 2.

The measurement of the electro-magnetic field is realized, with a resolution bandwidth adjusted at 10 MHz and video bandwidth at 10 MHz.

Distance of antenna: 3 meters

Antenna height: 1.5 meter

Antenna polarization: vertical and horizontal (only the highest level is recorded)

Equipment under test operating condition:

The equipment under test is blocked in continuous modulated transmission mode, at the highest output power level at which the transmitter is intended to operate.

Results:

Ambient temperature (°C): 22.1
Relative humidity (%): 58

Power source: 12 Vdc by another equipment

Data rate 100 kbps:

Sample N° 1 Low channel

	Electro-magnetic field (dBµV/m):	Conducted power * (mW)	Limit (mW)
Nominal supply voltage: 12V	111	18.9	125

Polarization of test antenna: Vertical (height: 150 cm)
Position of equipment: see photos in appendix 2 (azimuth: 268 degrees)

Sample N° 1 Central channel

	Electro-magnetic field (dBµV/m):	Conducted power * (mW)	Limit (mW)
Nominal supply voltage:12V	111	18.9	125

Polarization of test antenna: Vertical (height: 150 cm)
Position of equipment: see photos in appendix 2 (azimuth: 254 degrees)

Sample N° 1 High channel

	Electro-magnetic field (dBµV/m):	Conducted power * (mW)	Limit (mW)
Nominal supply voltage:12V	112	23.8	125

Polarization of test antenna: Vertical (height: 150 cm)
Position of equipment: see photos in appendix 2 (azimuth: 282 degrees)

** $P = (E \times d)^2 / (30 \times Gp)$ with d = 3 m and Gp = 2.0*
Antenna gain: 3 dBi

Data rate 500 kbps:

Sample N° 1 Low channel

	Electro-magnetic field (dBµV/m):	Conducted power * (mW)	Limit (mW)
Nominal supply voltage: 12V	111	18.9	125

Polarization of test antenna: Vertical (height: 150 cm)
Position of equipment: see photos in appendix 2 (azimuth: 268 degrees)

Sample N° 1 Central channel

	Electro-magnetic field (dBµV/m):	Conducted power * (mW)	Limit (mW)
Nominal supply voltage:12V	111	18.9	125

Polarization of test antenna: Vertical (height: 150 cm)
Position of equipment: see photos in appendix 2 (azimuth:254 degrees)

Sample N° 1 High channel

	Electro-magnetic field (dBµV/m):	Conducted power * (mW)	Limit (mW)
Nominal supply voltage:12V	111	18.9	125

Polarization of test antenna: Vertical (height: 150 cm)
Position of equipment: see photos in appendix 2 (azimuth: 282 degrees)

** $P = (E \times d)^2 / (30 \times Gp)$ with d = 3 m and Gp = 2.0*
Antenna gain: 3 dBi

Test conclusion:

RESPECTED STANDARD

12. INTENTIONAL RADIATOR

Standard: FCC Part 15

Test procedure: paragraph 15.205, paragraph 15.209, paragraph 15.247 (d)

Test set up:

First an exploratory radiated measurement was performed. During this phase the product is oriented in three orthogonal planes.

Then the final measurement is realized with the product on the most critical orientation.

The measure is realized on open area test site under 1 GHz and in anechoic chamber above 1 GHz.

When the system is tested in an open area test site (OATS), the EUT is placed on a rotating table, 0.8m from a ground plane.

When the system is tested in anechoic chamber, the EUT is placed on a rotating table, 1.5m from a ground plane.

Zero degree azimuths correspond to the front of the device under test.

See photos in appendix 2.

Frequency range: From 9 kHz to 10th harmonic of the highest fundamental frequency (25GHz).

Detection mode: Quasi-peak (F < 1 GHz) Peak / Average (F > 1 GHz)

Bandwidth: 200Hz (9 kHz < F < 150kHz)
9 kHz (150 kHz < F < 30MHz)
120 kHz (30 MHz < F < 1 GHz)
100 kHz / 1 MHz (F > 1 GHz)

Distance of antenna: 10 meters (in open area test site) / 3 meters (in anechoic room)

Antenna height: 1 to 4 meters (in open area test site) / 1.5 meter (in anechoic room)

Antenna polarization: vertical and horizontal (only the highest level is recorded)

Equipment under test operating condition:

The equipment under test is blocked in continuous modulated transmission mode, at the highest output power level at which the transmitter is intended to operate.

Results:

Ambient temperature (°C): 21
Relative humidity (%): 53

Power source: 12 Vdc by another equipment

Data rate 100 kbps:

Sample N° 1 Low Channel

FREQUENCIES (MHz)	Detector P: Peak QP: Quasi-Peak Av: Average	Antenna height (cm)	Resolution bandwidth (kHz)	Polarization H: Horizontal V: Vertical	Field strength (dBµV/m)	Limits (dBµV/m)	Margin (dB)
32.230	QP	327	120	V	25.77	40	14.23
43.802	QP	99	120	V	26.67	40	13.33
62.726	QP	100	120	V	23.59	40	16.41
80.002	QP	192	120	V	28.40	40	11.60
125.002	QP	100	120	V	29.93	43.5	13.57
148.117	QP	400	120	H	26.79	43.5	16.71
320.001	QP	288	120	H	35.67	46	10.33
4810*	Pk	150	1000	H	62.57	74	11.43
4810*	Av	150	1000	H	53.1	54	0.9
7215	Pk	150	100	H	70.2	90	19.8
9620	Pk	150	100	H	59.4	90	30.6
12025*	Pk	150	1000	H	56.1	74	17.9
12025*	Av	150	1000	H	50	54	4

* restricted bands of operation in 15.205

Applicable limits: 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.

The highest level recorded in a 100 kHz bandwidth is 110 dBµV/m.
So the applicable limit is 90 dBµV/m.
In addition, radiated emissions which fall in the restricted band, as defined in section 15.205 (a), must also comply with the radiated emission limits specified in section 15.209 (a) (see section 15.205 (c).

Sample N° 1 Central channel

FREQUENCIES (MHz)	Detector P: Peak QP: Quasi-Peak Av: Average	Antenna height (cm)	Resolution bandwidth (kHz)	Polarization H: Horizontal V: Vertical	Field strength (dBµV/m)	Limits (dBµV/m)	Margin (dB)
32.230	QP	327	120	V	25.77	40	14.23
43.802	QP	99	120	V	26.67	40	13.33
62.726	QP	100	120	V	23.59	40	16.41
80.002	QP	192	120	V	28.40	40	11.60
125.002	QP	100	120	V	29.93	43.5	13.57
148.117	QP	400	120	H	26.79	43.5	16.71
320.001	QP	288	120	H	35.67	46	10.33
4874*	Pk	150	1000	H	61.2	74	12.8
4874*	Av	150	1000	H	50.1	54	3.9
7311*	Pk	150	1000	H	65	74	9
7311*	Av Corrected with "duty cycle correction factor"(1)	150	1000	H	45.3	54	8.7
9748	Pk	150	100	H	54.1	90	35.9
12185*	Pk	150	1000	H	55.5	74	18.5
12185*	Av	150	1000	H	45.4	54	8.6

* restricted bands of operation in 15.205

(1) "Duty cycle correction factor": 20 log (dwell time/100ms) => 20 log (22.3 /100) = -13dB

Applicable limits: 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.

The highest level recorded in a 100 kHz bandwidth is 110 dBµV/m.
So the applicable limit is 90 dBµV/m.
In addition, radiated emissions which fall in the restricted band, as defined in section 15.205 (a), must also comply with the radiated emission limits specified in section 15.209 (a) (see section 15.205 (c).

Sample N° 1 High channel

FREQUENCIES (MHz)	Detector P: Peak QP: Quasi-Peak Av: Average	Antenna height (cm)	Resolution bandwidth (kHz)	Polarization H: Horizontal V: Vertical	Field strength (dBµV/m)	Limits (dBµV/m)	Margin (dB)
32.230	QP	327	120	V	25.77	40	14.23
43.802	QP	99	120	V	26.67	40	13.33
62.726	QP	100	120	V	23.59	40	16.41
80.002	QP	192	120	V	28.40	40	11.60
125.002	QP	100	120	V	29.93	43.5	13.57
148.117	QP	400	120	H	26.79	43.5	16.71
320.001	QP	288	120	H	35.67	46	10.33
4938*	Pk	150	1000	H	63.3	74	10.7
4938*	Av	150	1000	H	47.1	54	6.9
7407*	Pk	150	1000	H	68.8	74	5.2
7407*	Av Corrected with "duty cycle correction factor"(1)	150	1000	H	47.1	54	6.9
9876	Pk	150	100	H	56.6	90	33.4
12345*	Pk	150	1000	H	56.3	74	17.7
12345*	Av	150	1000	H	49	54	5

* restricted bands of operation in 15.205

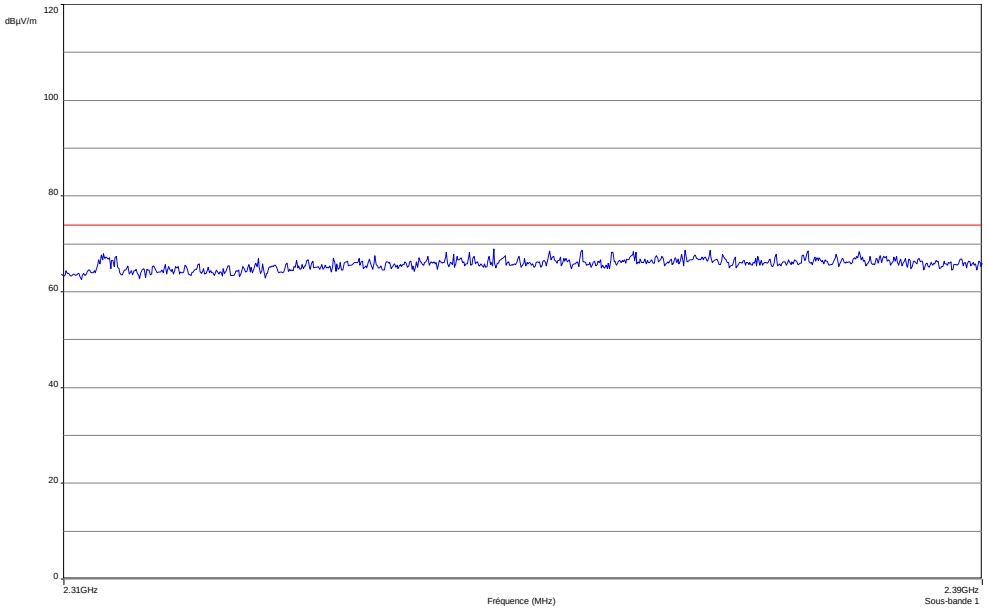
(1) "Duty cycle correction factor": 20 log (dwell time/100ms) => 20 log (22.3 /100) = -13dB

Applicable limits: 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.

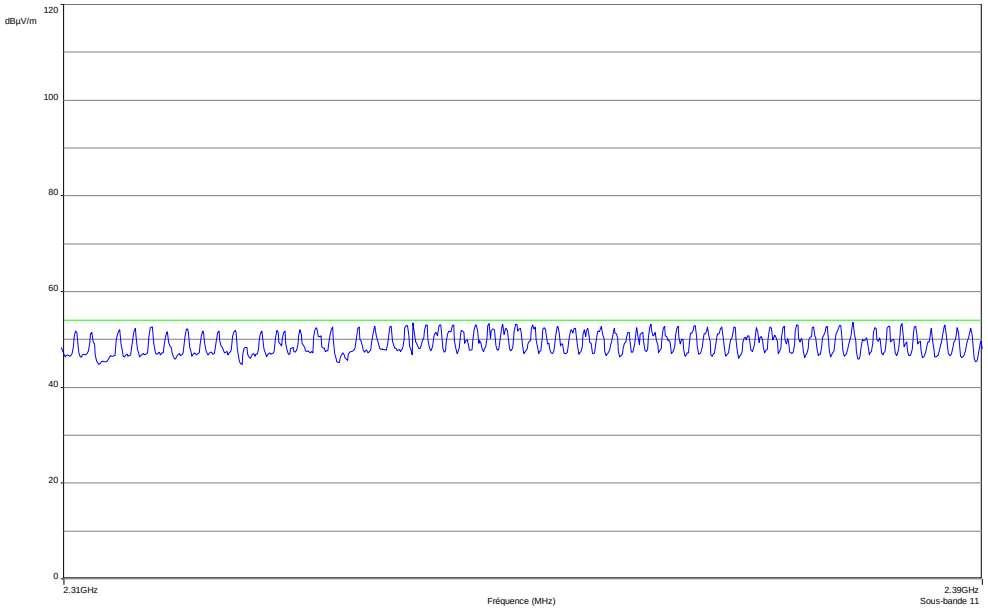
The highest level recorded in a 100 kHz bandwidth is 110 dBµV/m.
So the applicable limit is 90 dBµV/m.
In addition, radiated emissions which fall in the restricted band, as defined in section 15.205 (a), must also comply with the radiated emission limits specified in section 15.209 (a) (see section 15.205 (c)).

Low band edge measurements: Hopping mode on

Peak detector



Average detector



Data rate 500 kbps:

Sample N° 1 Low Channel

FREQUENCIES (MHz)	Detector P: Peak QP: Quasi-Peak Av: Average	Antenna height (cm)	Resolution bandwidth (kHz)	Polarization H: Horizontal V: Vertical	Field strength (dBµV/m)	Limits (dBµV/m)	Margin (dB)
32.230	QP	327	120	V	25.77	40	14.23
43.802	QP	99	120	V	26.67	40	13.33
62.726	QP	100	120	V	23.59	40	16.41
80.002	QP	192	120	V	28.40	40	11.60
125.002	QP	100	120	V	29.93	43.5	13.57
148.117	QP	400	120	H	26.79	43.5	16.71
320.001	QP	288	120	H	35.67	46	10.33
4810*	Pk	150	1000	H	61.4	74	12.6
4810*	Av	150	1000	H	42.1	54	11.9
7215*	Pk	150	100	H	68.2	90	21.8
9620	Pk	150	100	H	51.8	90	38.2
12025*	Pk	150	1000	H	54.6	74	19.4
12025*	Av	150	1000	H	40.5	54	13.5

* restricted bands of operation in 15.205

Applicable limits: 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.

The highest level recorded in a 100 kHz bandwidth is 110 dBµV/m.
So the applicable limit is 90 dBµV/m.
In addition, radiated emissions which fall in the restricted band, as defined in section 15.205 (a), must also comply with the radiated emission limits specified in section 15.209 (a) (see section 15.205 (c)).

Sample N° 1 Central channel

FREQUENCIES (MHz)	Detector P: Peak QP: Quasi-Peak Av: Average	Antenna height (cm)	Resolution bandwidth (kHz)	Polarization H: Horizontal V: Vertical	Field strength (dBµV/m)	Limits (dBµV/m)	Margin (dB)
32.230	QP	327	120	V	25.77	40	14.23
43.802	QP	99	120	V	26.67	40	13.33
62.726	QP	100	120	V	23.59	40	16.41
80.002	QP	192	120	V	28.40	40	11.60
125.002	QP	100	120	V	29.93	43.5	13.57
148.117	QP	400	120	H	26.79	43.5	16.71
320.001	QP	288	120	H	35.67	46	10.33
4874*	Pk	150	1000	H	59.7	74	14.3
4874*	Av	150	1000	H	42.3	54	11.7
7311*	Pk	150	1000	H	64	74	10
7311*	Av Corrected with "duty cycle correction factor"(1)	150	1000	H	46.5	54	7.5
9748	Pk	150	100	H	49.2	90	40.8
12185*	Pk	150	1000	H	58.6	74	15.4
12185*	Av	150	1000	H	42.3	54	11.7

* restricted bands of operation in 15.205

(1) "Duty cycle correction factor": 20 log (dwell time/100ms) => 20 log (8.43/100) = -21.5dB

Applicable limits: 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.

The highest level recorded in a 100 kHz bandwidth is 110 dBµV/m.
So the applicable limit is 90 dBµV/m.
In addition, radiated emissions which fall in the restricted band, as defined in section 15.205 (a), must also comply with the radiated emission limits specified in section 15.209 (a) (see section 15.205 (c)).

Sample N° 1 High channel

FREQUENCIES (MHz)	Detector P: Peak QP: Quasi-Peak Av: Average	Antenna height (cm)	Resolution bandwidth (kHz)	Polarization H: Horizontal V: Vertical	Field strength (dBµV/m)	Limits (dBµV/m)	Margin (dB)
32.230	QP	327	120	V	25.77	40	14.23
43.802	QP	99	120	V	26.67	40	13.33
62.726	QP	100	120	V	23.59	40	16.41
80.002	QP	192	120	V	28.40	40	11.60
125.002	QP	100	120	V	29.93	43.5	13.57
148.117	QP	400	120	H	26.79	43.5	16.71
320.001	QP	288	120	H	35.67	46	10.33
4938*	Pk	150	1000	H	59.5	74	14.5
4938*	Av	150	1000	H	44	54	10
7407*	Pk	150	1000	H	69.3	74	4.7
7407*	Av Corrected with "duty cycle correction factor"(1)	150	1000	H	48.1	54	5.9
9876	Pk	150	100	H	51.2	90	38.8
12345*	Pk	150	1000	H	53.2	74	20.8
12345*	Av	150	1000	H	42.1	54	11.9

* restricted bands of operation in 15.205

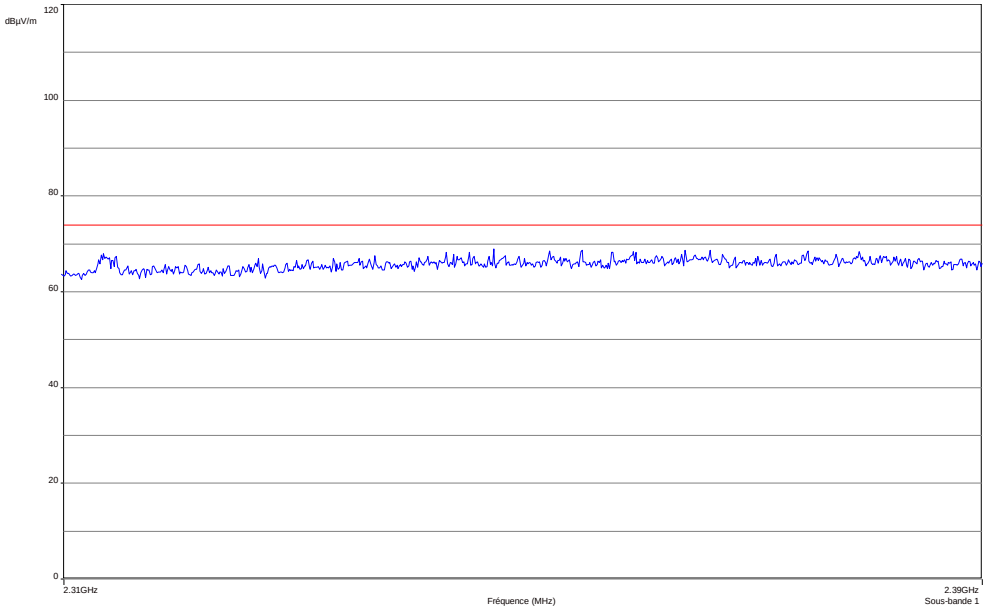
(1) "Duty cycle correction factor": 20 log (dwell time/100ms) => 20 log (8.43/100) = -21.5dB

Applicable limits: 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.

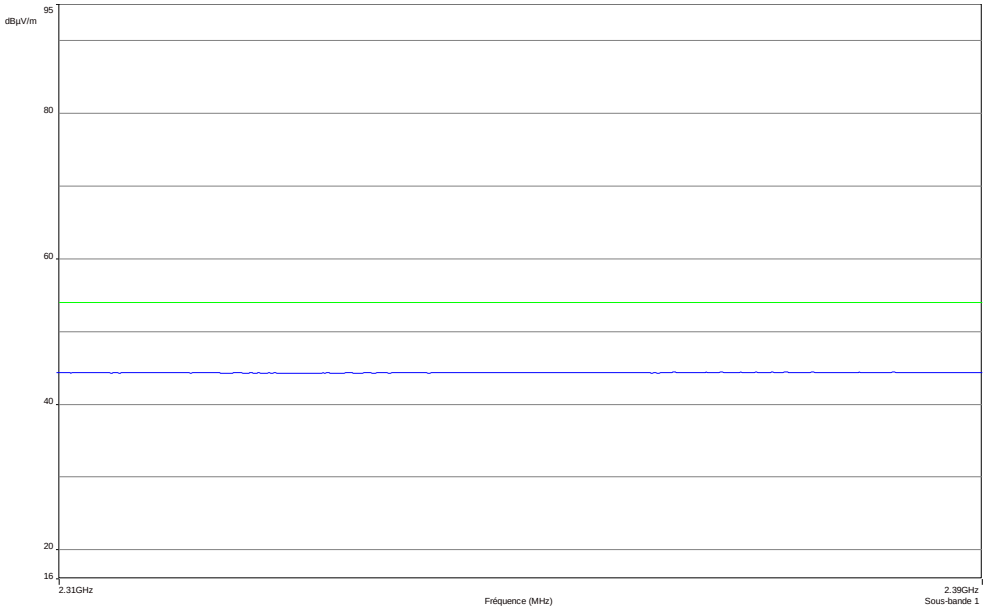
The highest level recorded in a 100 kHz bandwidth is 110 dBµV/m.
So the applicable limit is 90 dBµV/m.
In addition, radiated emissions which fall in the restricted band, as defined in section 15.205 (a), must also comply with the radiated emission limits specified in section 15.209 (a) (see section 15.205 (c).

Low band edge measurements: Hopping mode on

Peak detector



Average detector



Test conclusion:

RESPECTED STANDARD

End of report, 8 appendixes to be forwarded

APPENDIX 1: Photos of the equipment under test

CONFIDENTIAL

APPENDIX 2: Test set up

CONFIDENTIAL

APPENDIX 3: Test equipment list

Measurement of the conducted disturbances

TYPE	MANUFACTURER	EMITECH NUMBER
Outside room Hors cage	Emitech	8893
Satellite synchronized frequency standard GPS8	ACQUISYS	8896
Test receiver HP 8591EM	Hewlett Packard	8524
Transient limiter 11947A	Hewlett Packard	8763
LISN 1600	Rohde & Schwarz	8719
Absorber sheath current	Emitech	9489
Power source 1251RP	California instruments	8508
Multimeter MN5102B	AOIP	8675
Meteo station	HUGER	8671
Software	BAT-EMC V3.6.0.32	0000

Radiated emission limits

TYPE	MANUFACTURER	EMITECH NUMBER
Open test site	EMITECH	8732
Anechoic Chamber	EMITECH	8593
Satellite synchronized frequency standard GPS8	ACQUISYS	8896
Test receiver ESI7	Rohde & Schwarz	8707
Spectrum Analyzer FSP40	Rohde & Schwarz	4088
Biconical antenna VHBB 9124	Schwarzbeck	8526
Biconical antenna VHA 9103	Schwarzbeck	8528
Log periodic antenna UHALP 9108A	Schwarzbeck	8543
Log periodic antenna 3147	EMCO	8783
Antenna 3115	EMCO	8535
Antenna WR42	IMC	1939
Antenna WR42	IMC	1940
Low-noise amplifier 8447D	Hewlett Packard	8511
Low-noise amplifier C020180F-4B1	Microwave DB	1922
Low-noise amplifier ALN02-0102	ALC Microwave	3036
Multimeter MN5102B	AOIP	8675
Meteo station WS-9232	La Crosse Technology	8749
Meteo station WS-9232	La Crosse Technology	8750
Software	BAT-EMC V3.6.0.32	0000
Software	Champ libre Juigné. V3.4	8864

Additional provisions to the general radiated emission limitations

TYPE	MANUFACTURER	EMITECH NUMBER
Outside room Hors cage	Emitech	8893
Anechoic Chamber	EMITECH	8593
Satellite synchronized frequency standard GPS8	ACQUISYS	8896
Spectrum Analyzer FSP40	Rohde & Schwarz	4088
Spectrum Analyzer FSEM30	Rohde & Schwarz	8523
Antenna 3115	EMCO	8535
Multimeter MN5102B	AOIP	8675
Meteo station WS-9232	La Crosse Technology	8750
Software	GPIBShot V2.4	-

Maximum peak output power

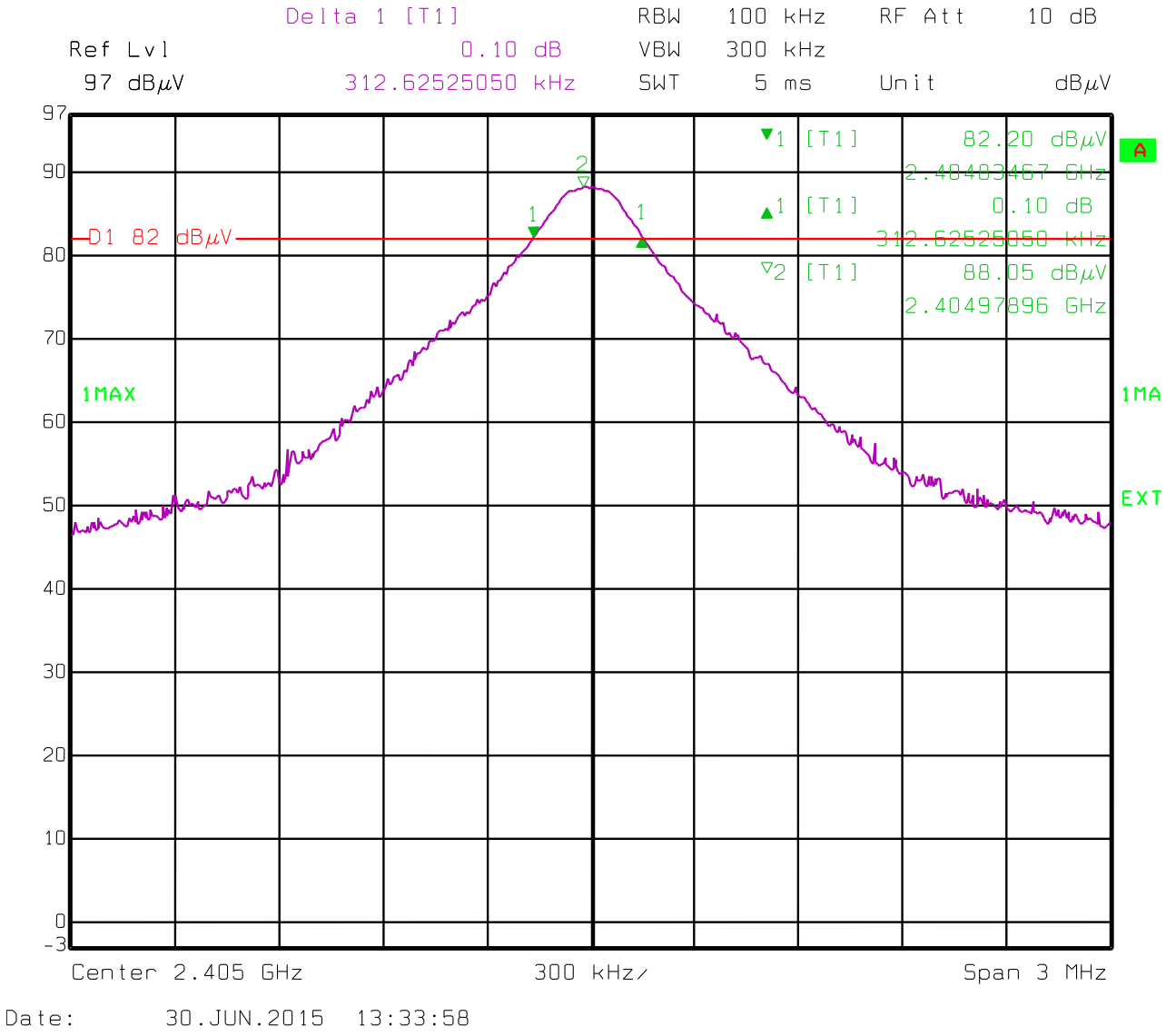
TYPE	MANUFACTURER	EMITECH NUMBER
Anechoic Chamber	EMITECH	8593
Satellite synchronized frequency standard GPS8	ACQUISYS	8896
Spectrum Analyzer FSP40	Rohde & Schwarz	4088
Antenna 3115	EMCO	8535
Multimeter MN5102B	AOIP	8675
Meteo station WS-9232	La Crosse Technology	8750
Software	BAT-EMC V3.6.0.32	0000

Intentional radiator

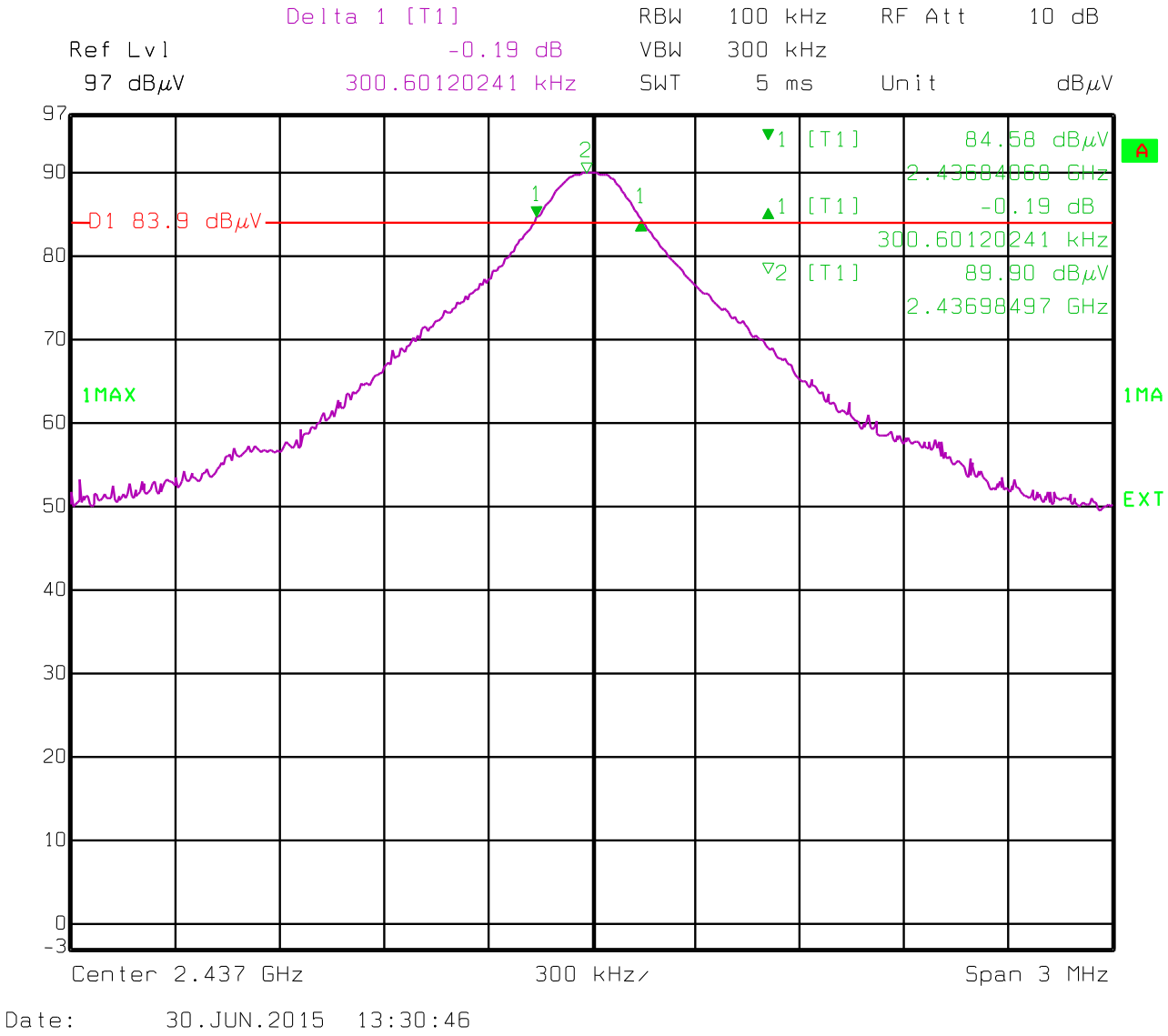
TYPE	MANUFACTURER	EMITECH NUMBER
Open test site	EMITECH	8732
Anechoic Chamber	EMITECH	8593
Satellite synchronized frequency standard GPS8	ACQUISYS	8896
Test receiver ESI7	Rohde & Schwarz	8707
Spectrum Analyzer FSP40	Rohde & Schwarz	4088
Loop antenna 6502	EMCO	1406
Biconical antenna VHBB 9124	Schwarzbeck	8526
Biconical antenna VHA 9103	Schwarzbeck	8528
Log periodic antenna UHALP 9108A	Schwarzbeck	8543
Log periodic antenna 3147	EMCO	8783
Antenna 3115	EMCO	8535
Antenna WR42	IMC	1939
Antenna WR42	IMC	1940
Low-noise amplifier 8447D	Hewlett Packard	8511
Low-noise amplifier C020180F-4B1	Microwave DB	1922
Low-noise amplifier ALN02-0102	ALC Microwave	3036
Low pass filter LP03/1000-7GH	Filtek	4087
Reject band filter BRM50702	Microtronics	7299
Multimeter MN5102B	AOIP	8675
Meteo station WS-9232	La Crosse Technology	8749
Meteo station WS-9232	La Crosse Technology	8750
Software	BAT-EMC V3.6.0.32	0000
Software	Champ libre Juigné. V3.4	8864

APPENDIX 4: 6 dB bandwidth

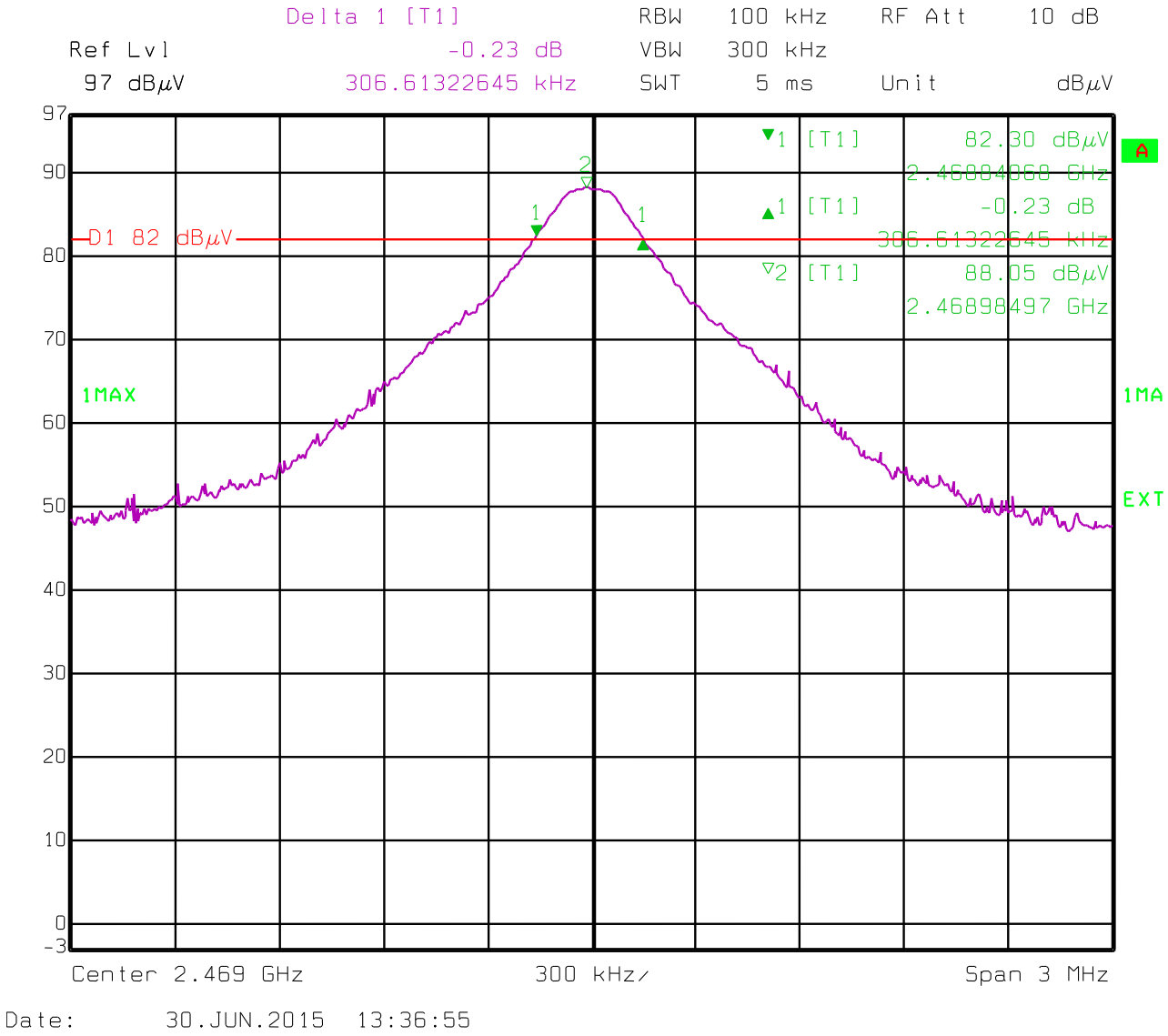
Low Channel – 100Kbit/s



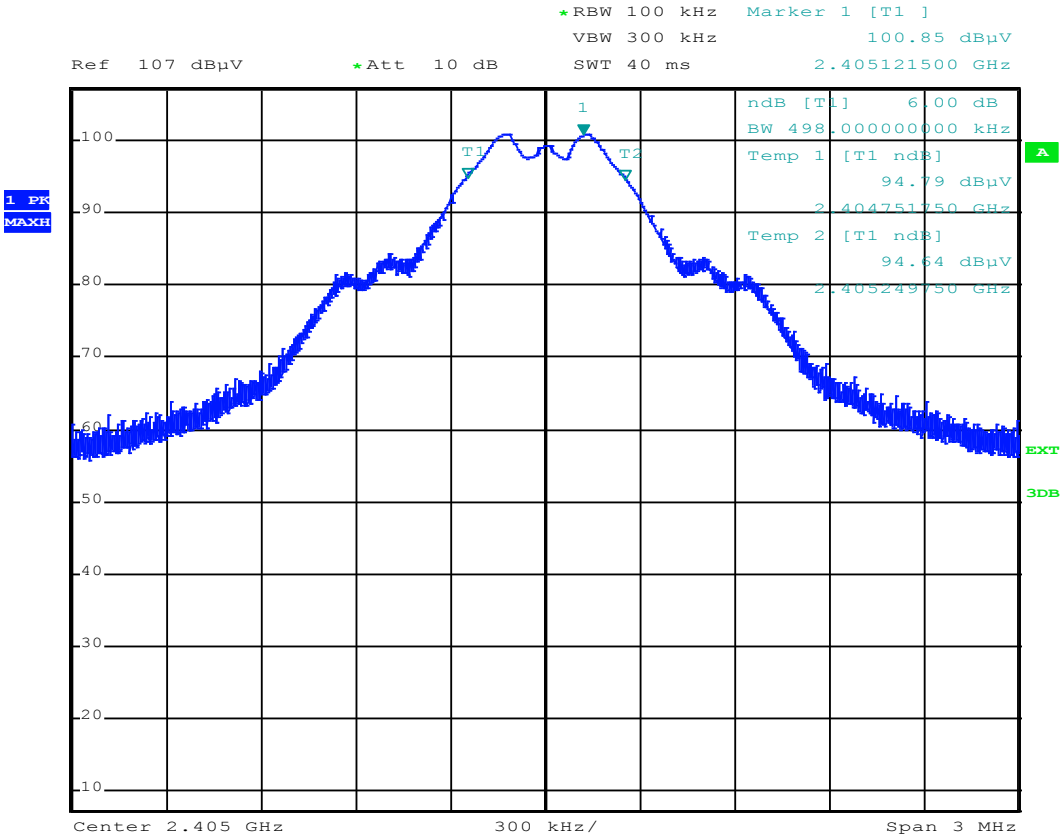
Central Channel – 100Kbit/s



High Channel – 100Kbit/s

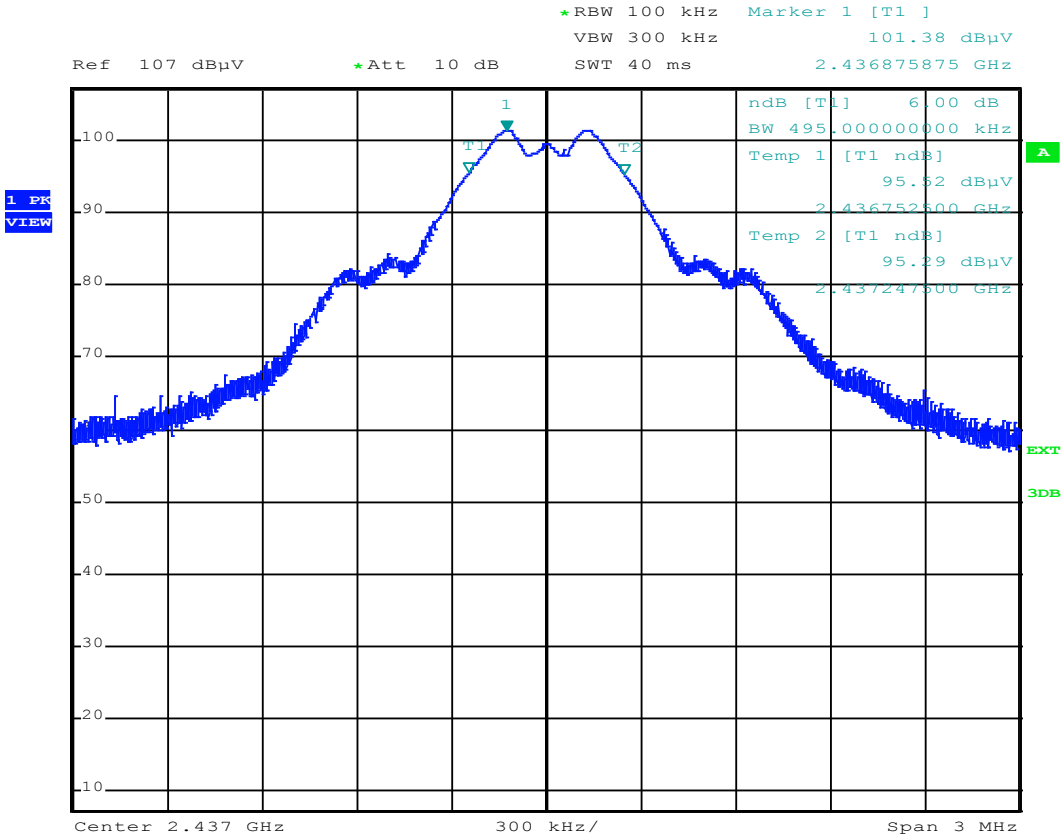


Low Channel – 500Kbit/s



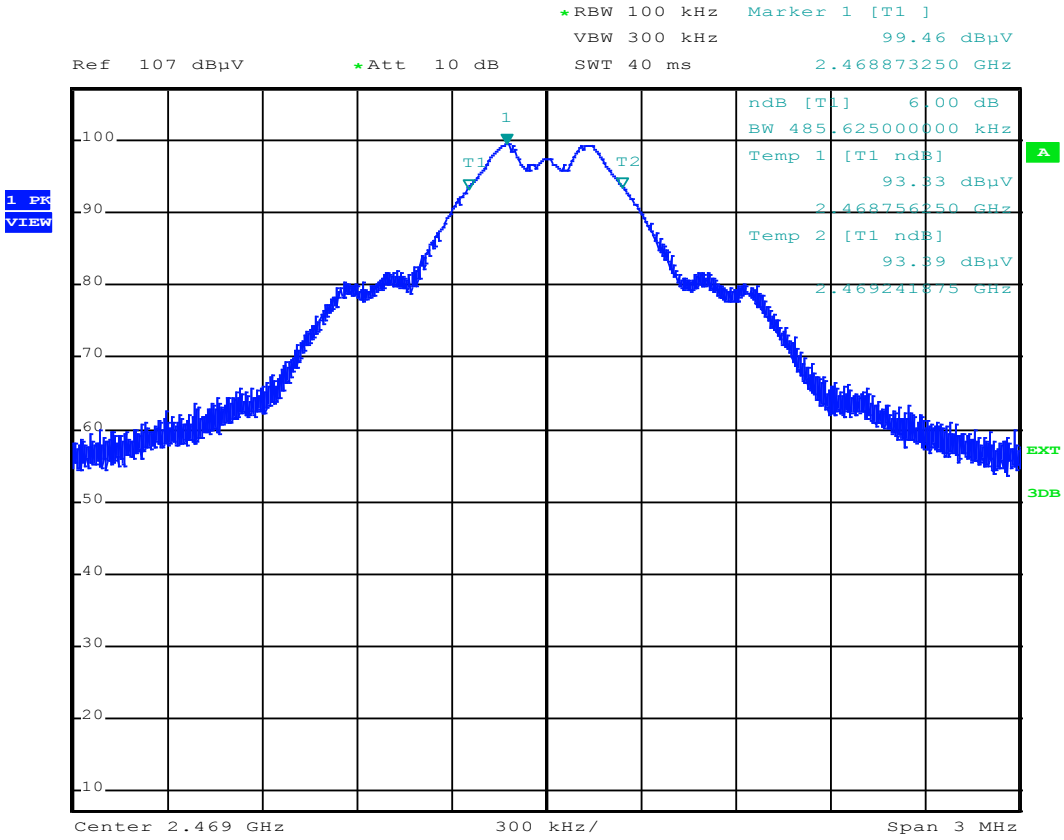
Date: 22.SEP.2014 10:00:36

Central Channel – 500Kbit/s



Date: 22.SEP.2014 10:04:26

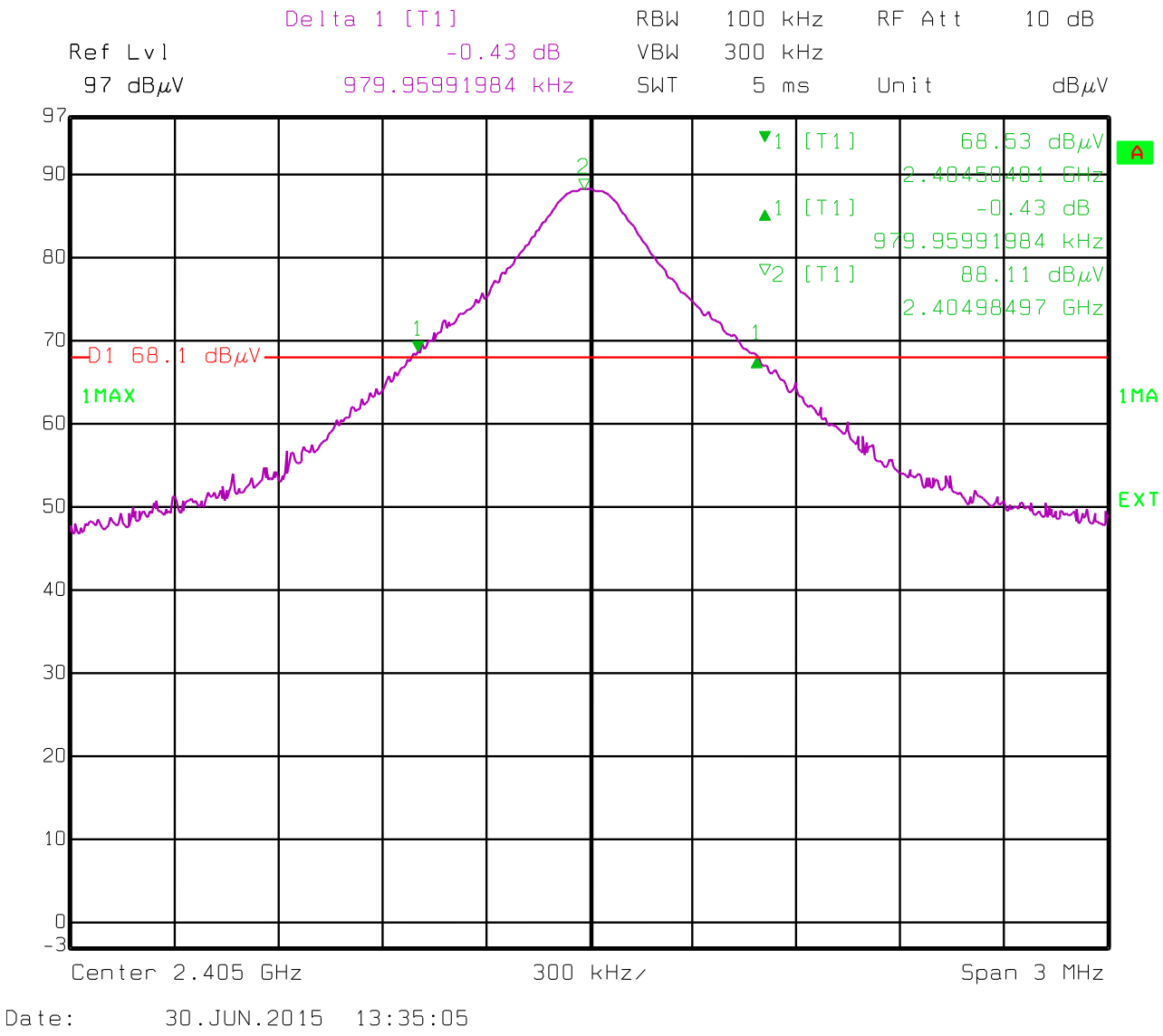
High Channel – 500Kbit/s



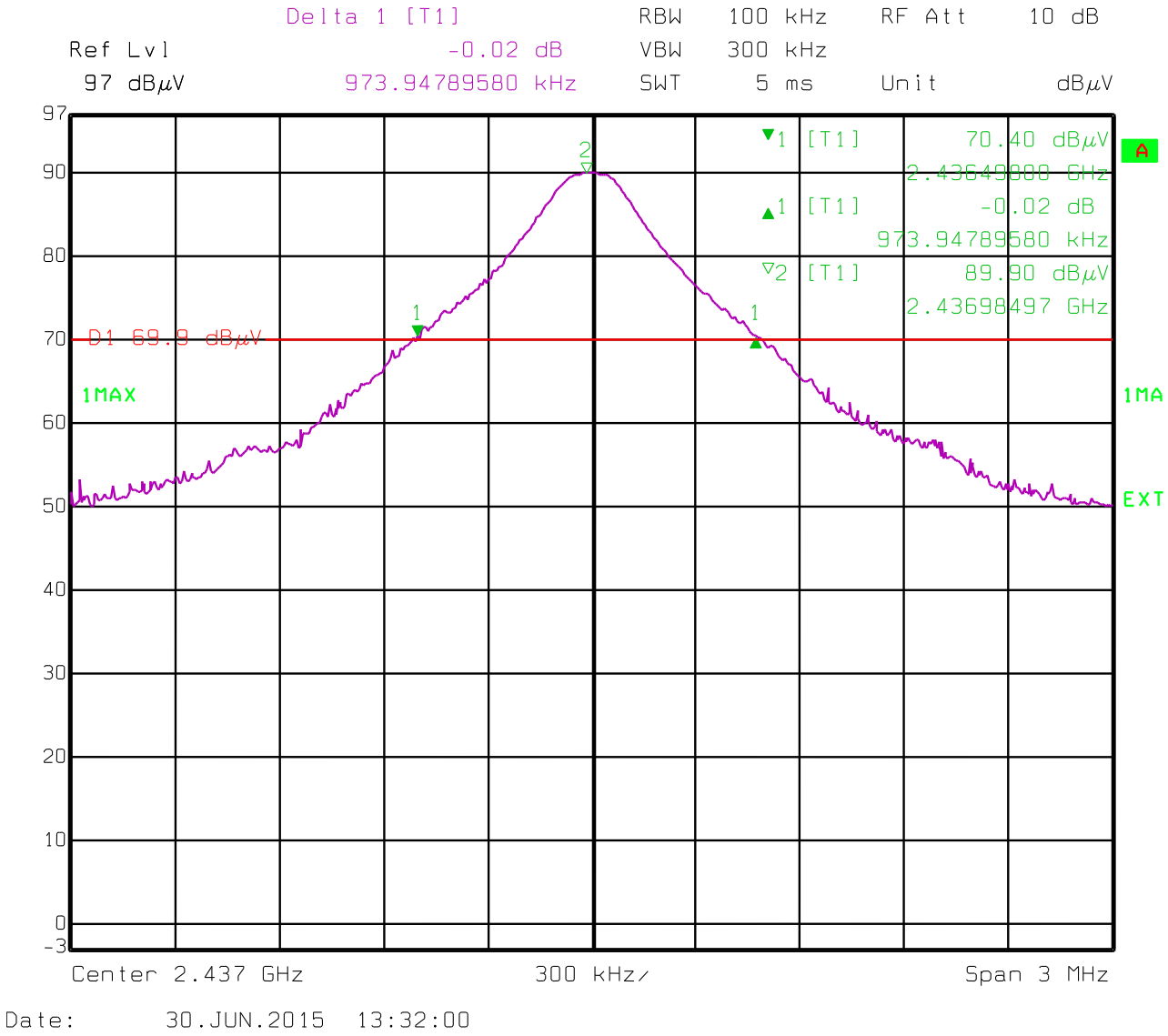
Date: 22.SEP.2014 10:06:02

APPENDIX 5: 20 dB bandwidth

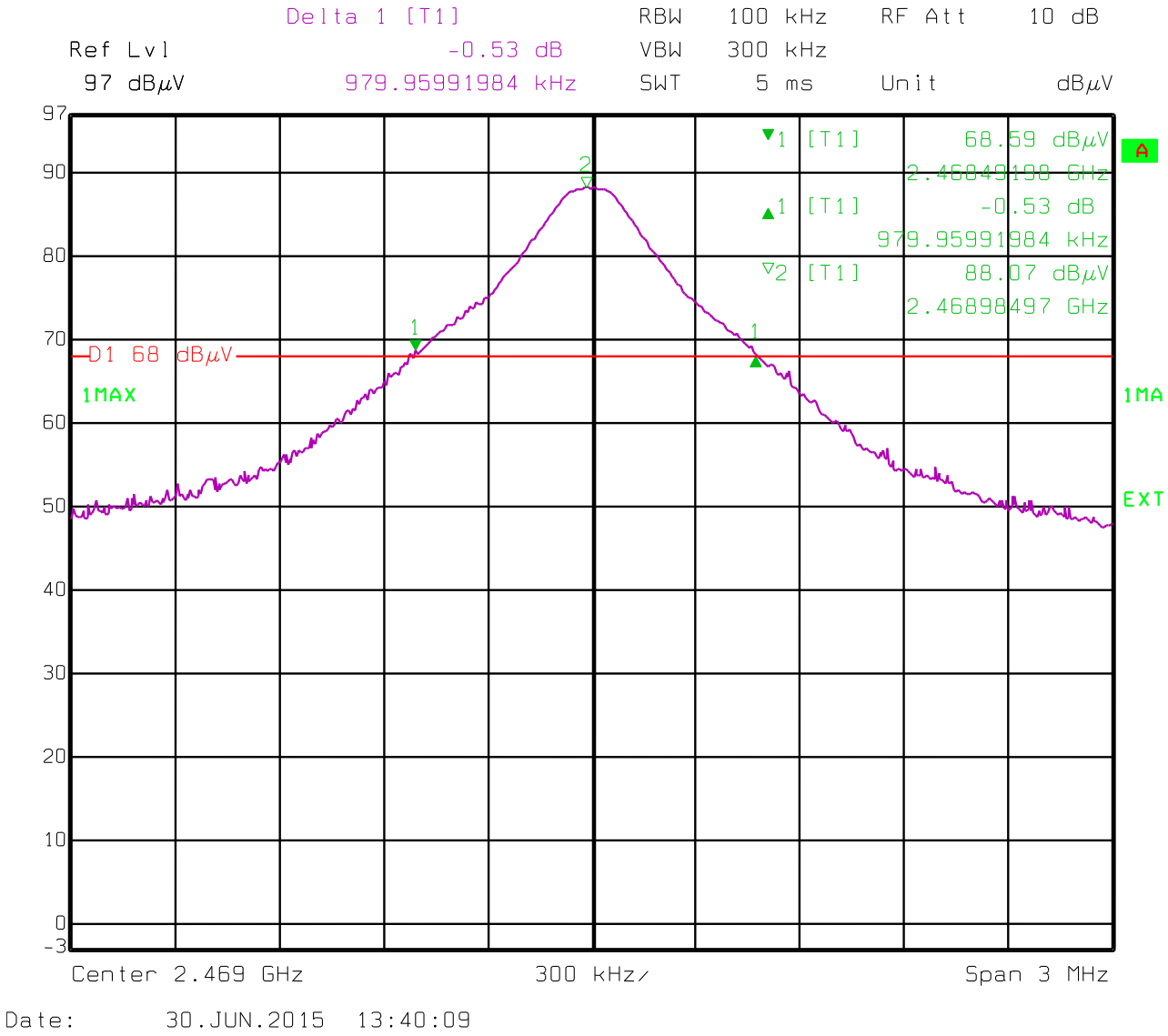
Low Channel – 100Kbit/s



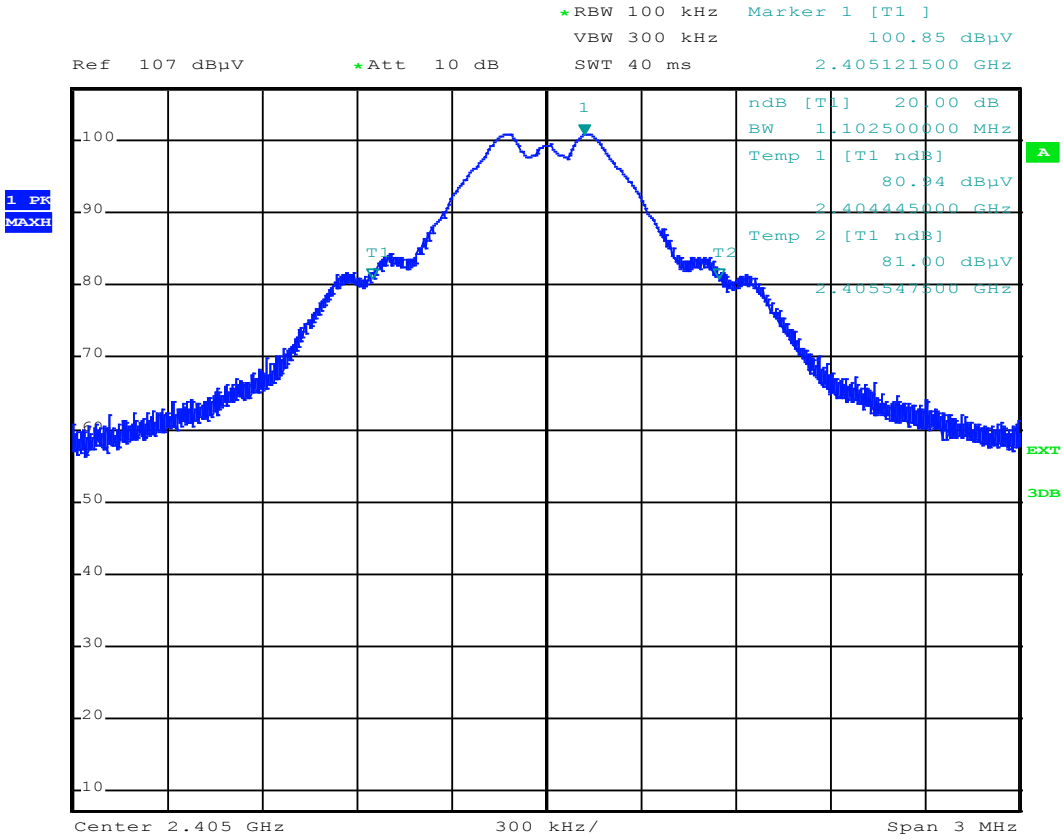
Central Channel – 100Kbit/s



High Channel – 100Kbit/s

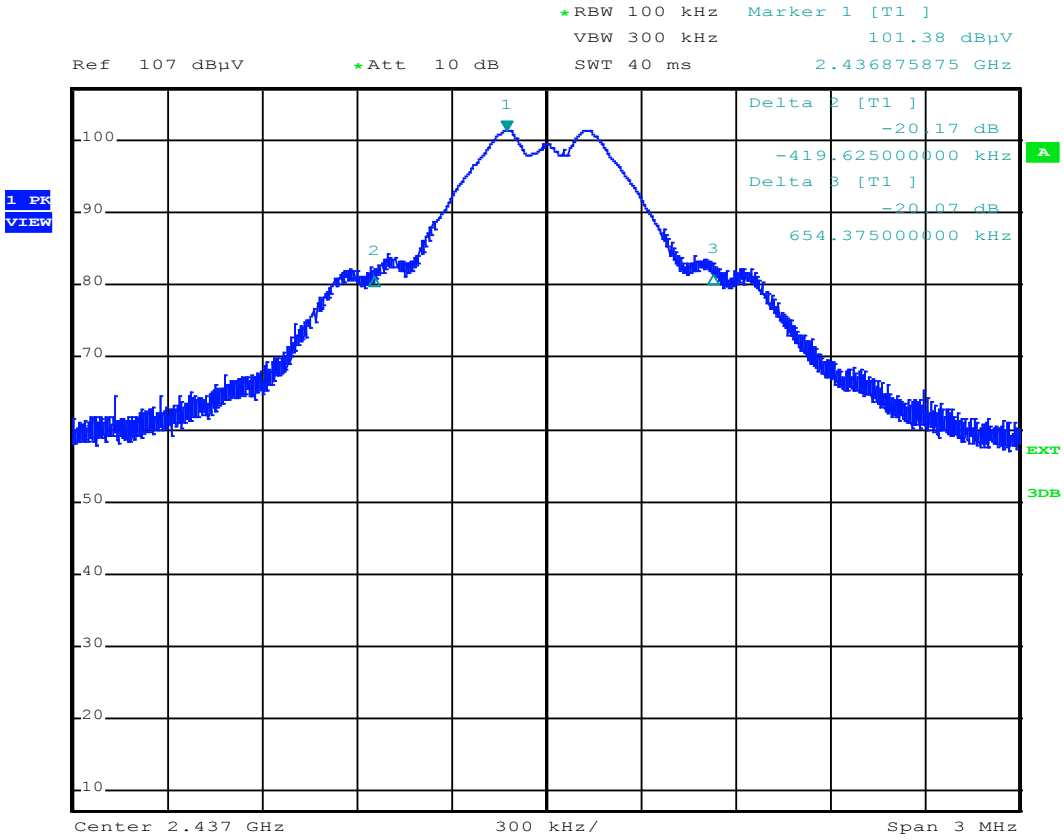


Low Channel – 500Kbit/s



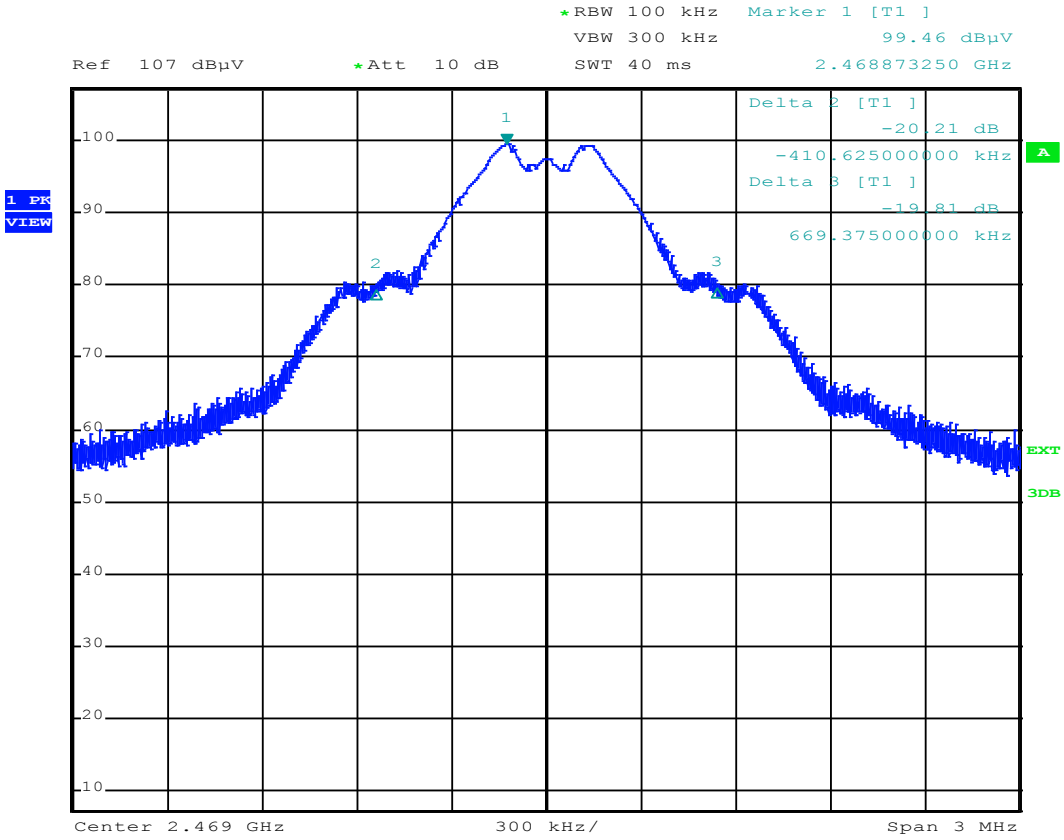
Date: 22.SEP.2014 10:01:26

Central Channel – 500Kbit/s



Date: 22.SEP.2014 10:03:59

High Channel – 500Kbit/s

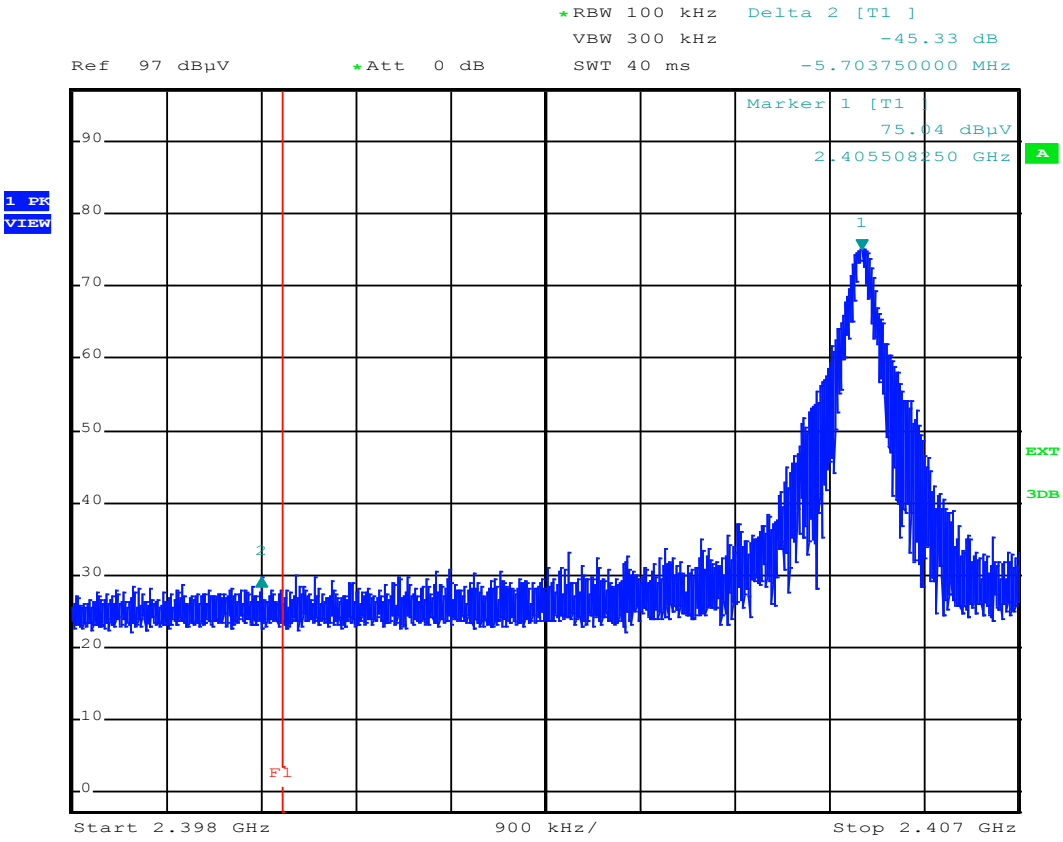


Date: 22.SEP.2014 10:07:27

APPENDIX 6: Band edge

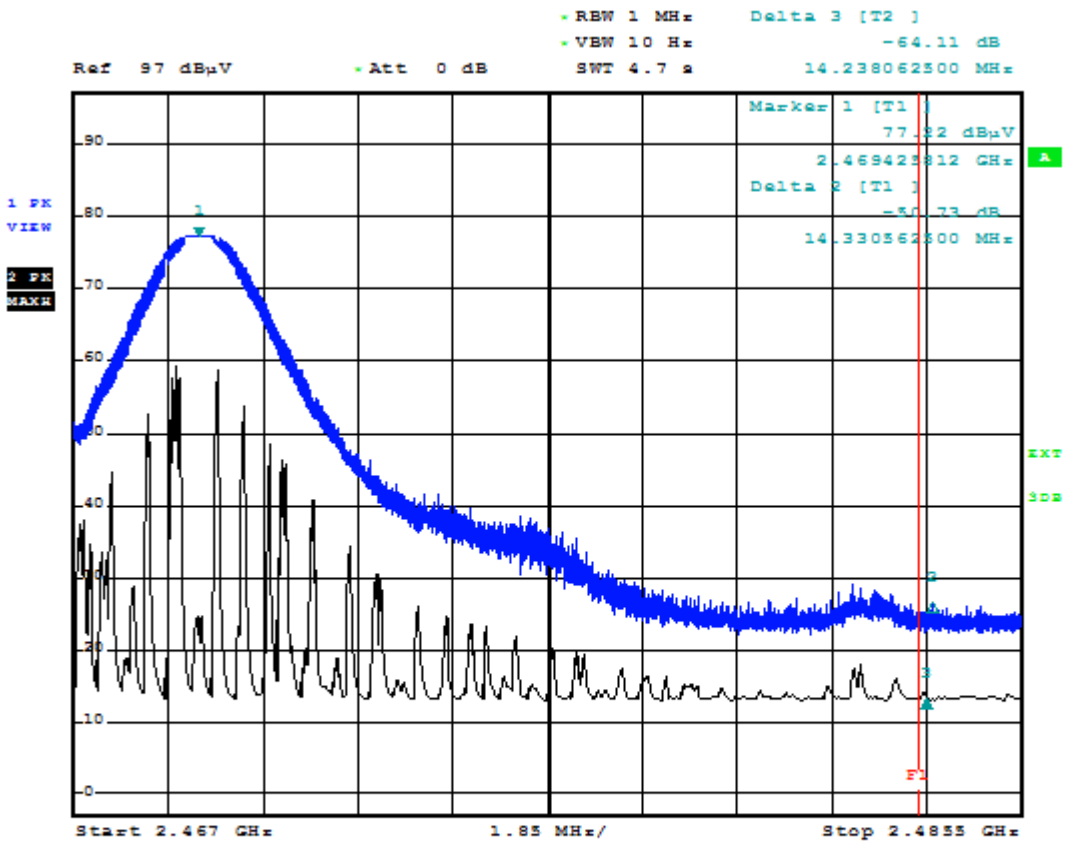
Hopping on mode

Low channel –100Kbit/s



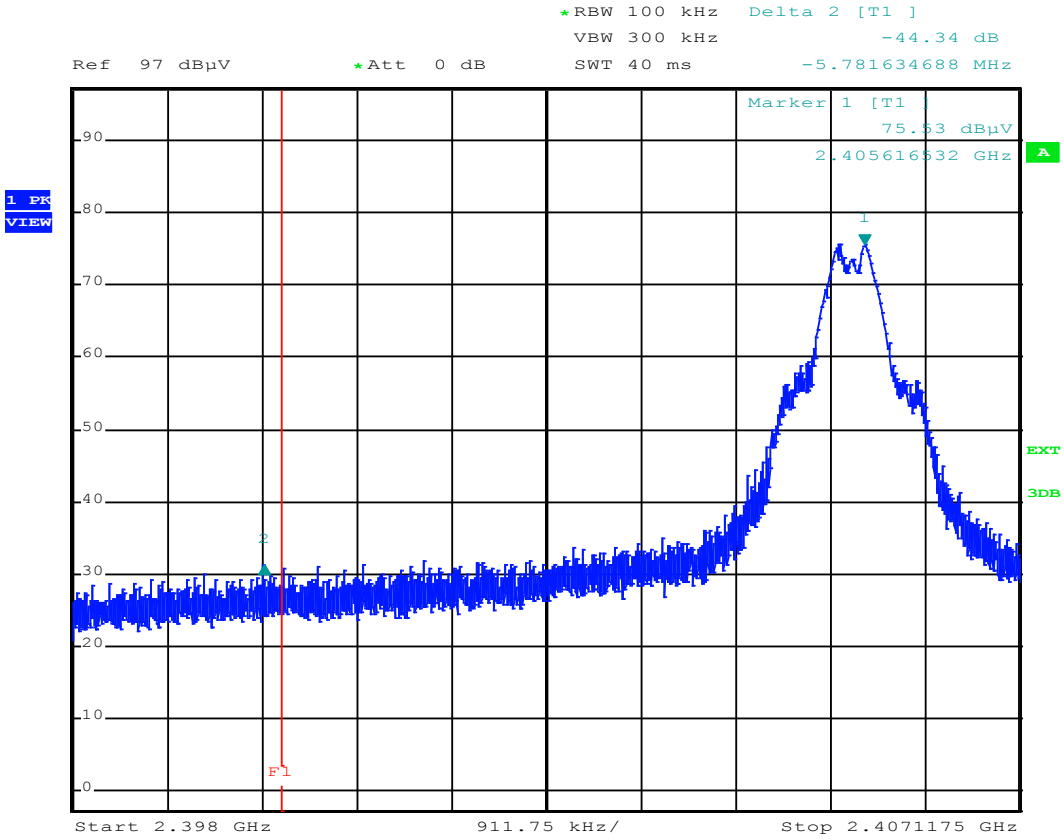
Date: 29.SEP.2014 11:26:54

High channel –100Kbit/s



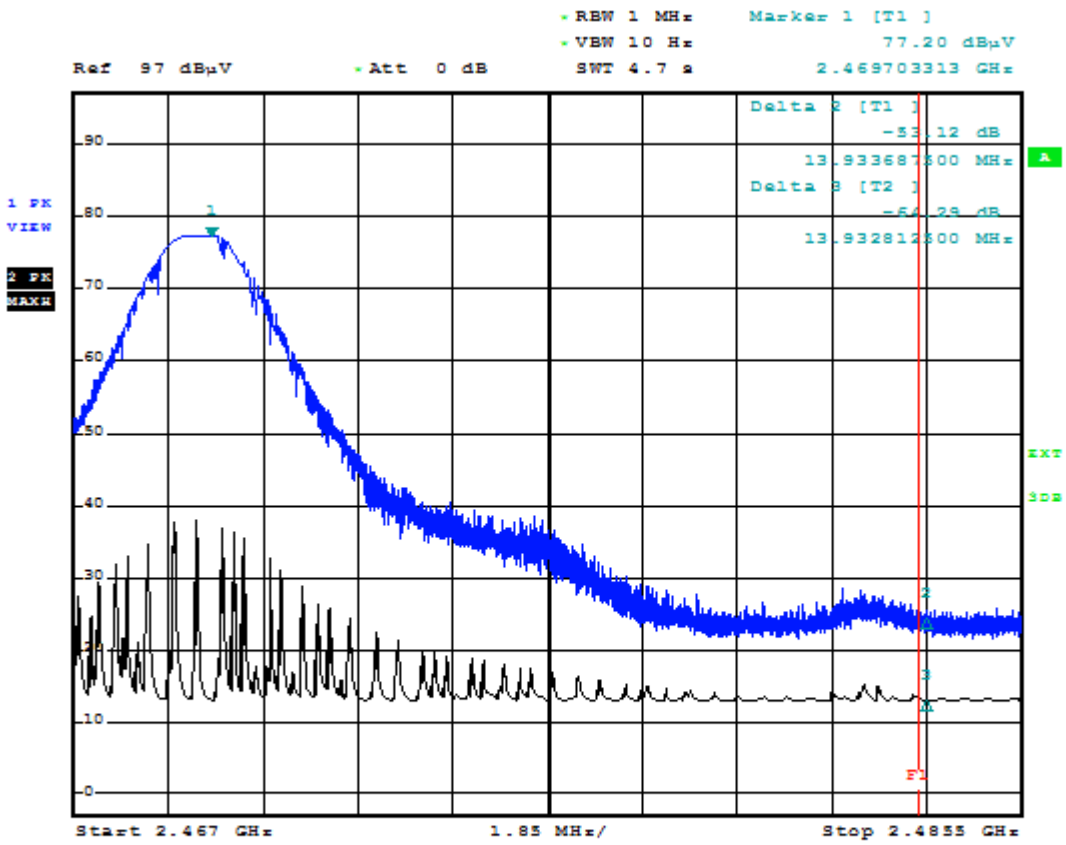
Date: 29.SEP.2014 11:28:24

Low channel –500Kbit/s



Date: 29.SEP.2014 11:01:18

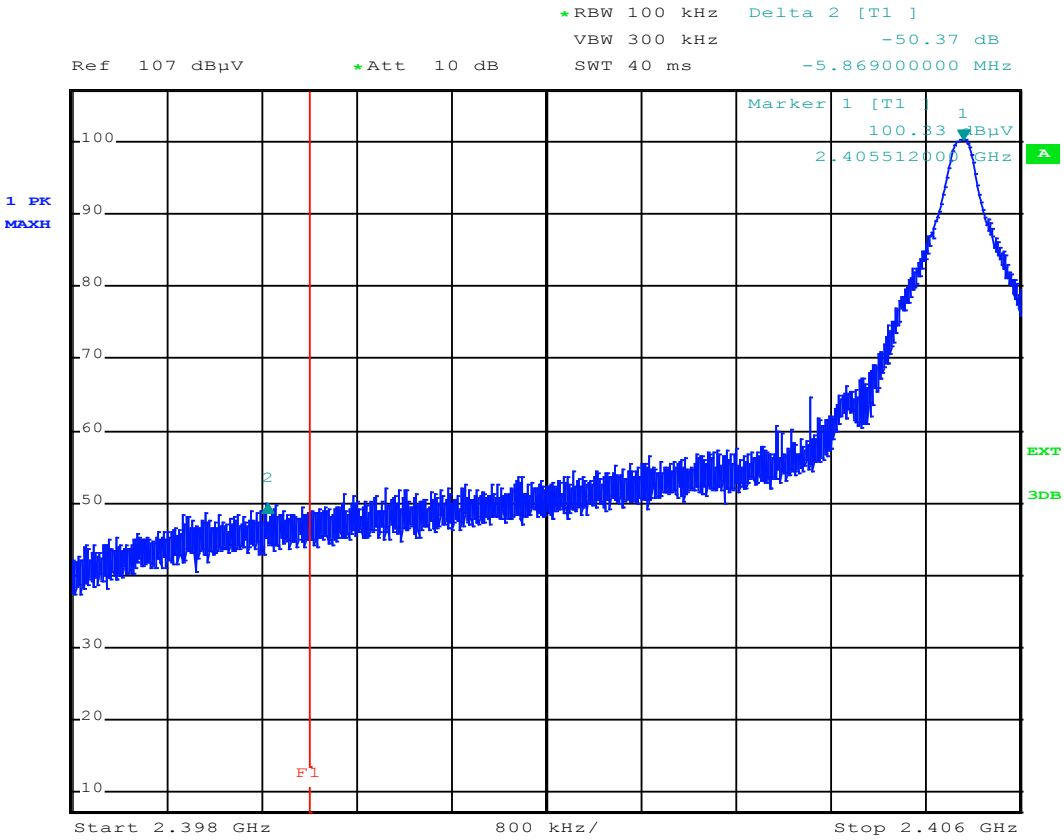
High channel –500Kbit/s



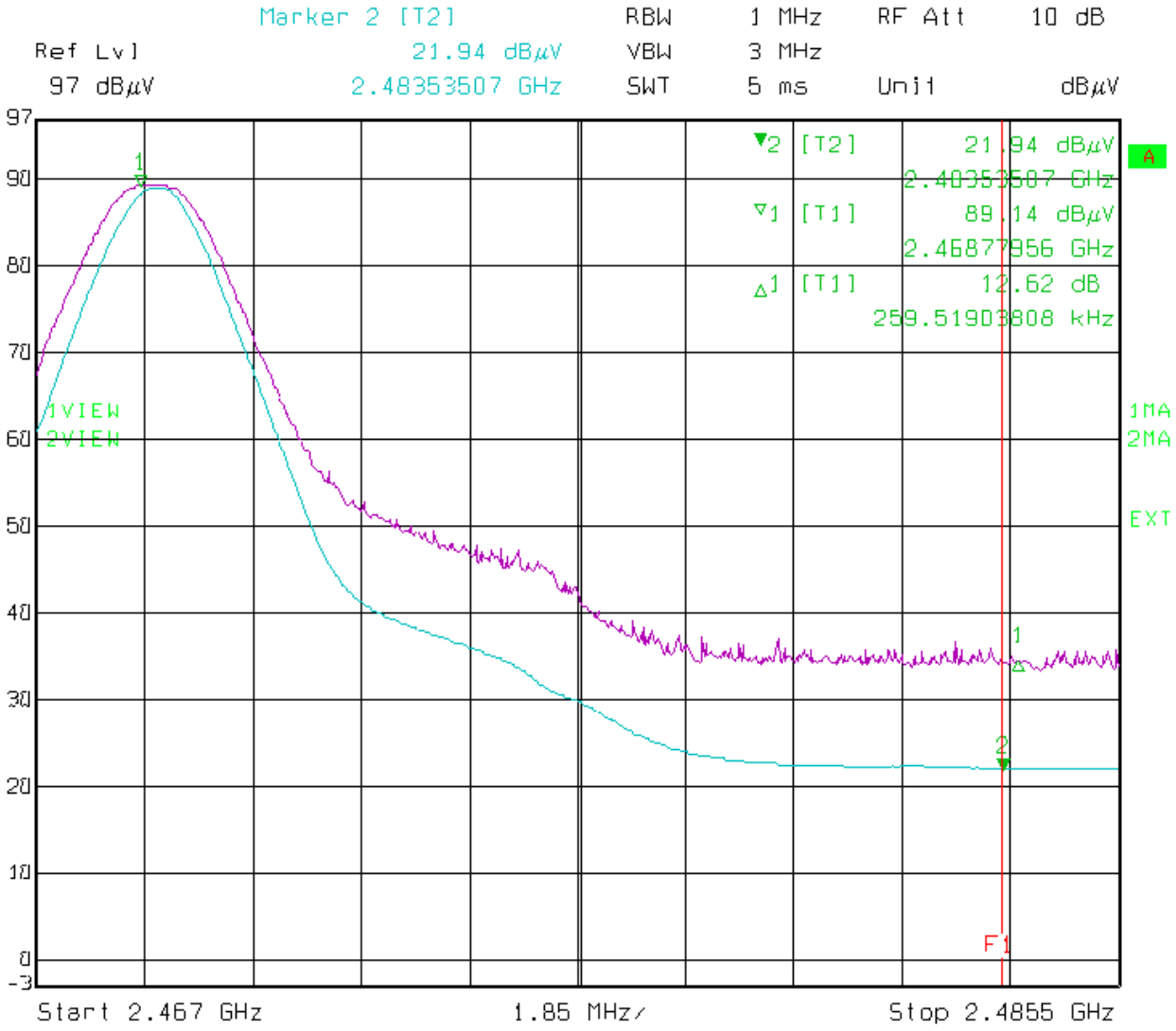
Date: 29.SEP.2014 11:11:56

Hopping off mode

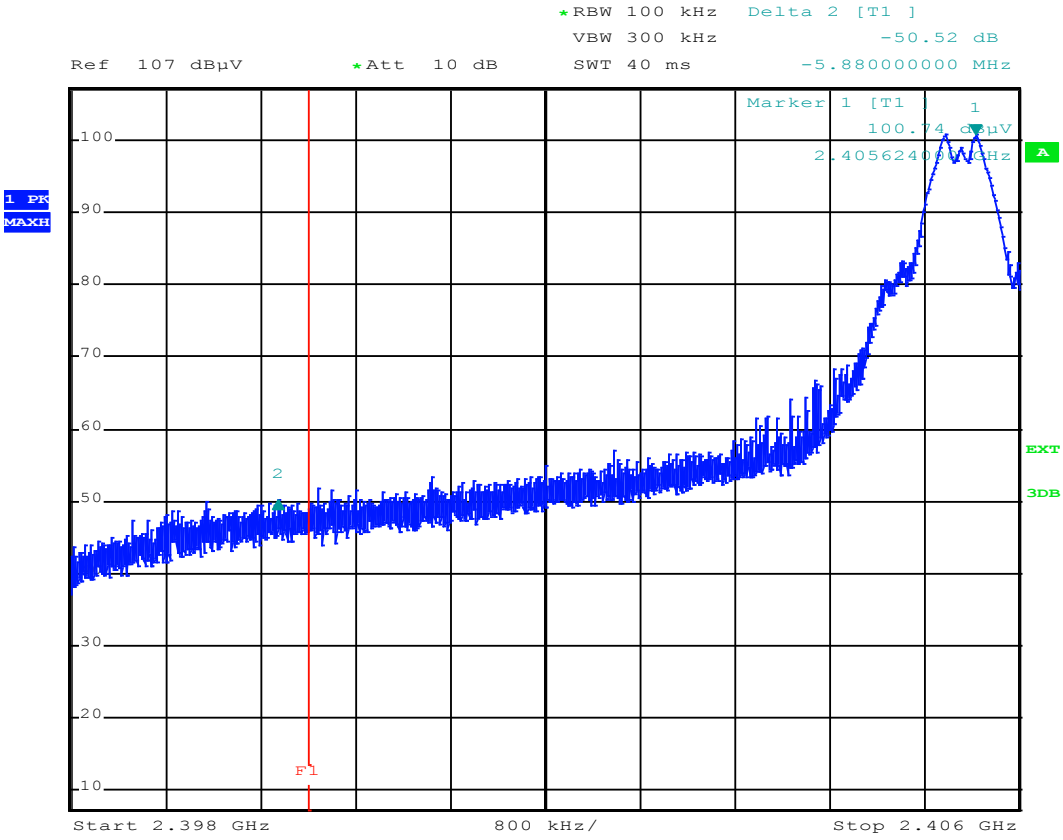
Low channel –100Kbit/s



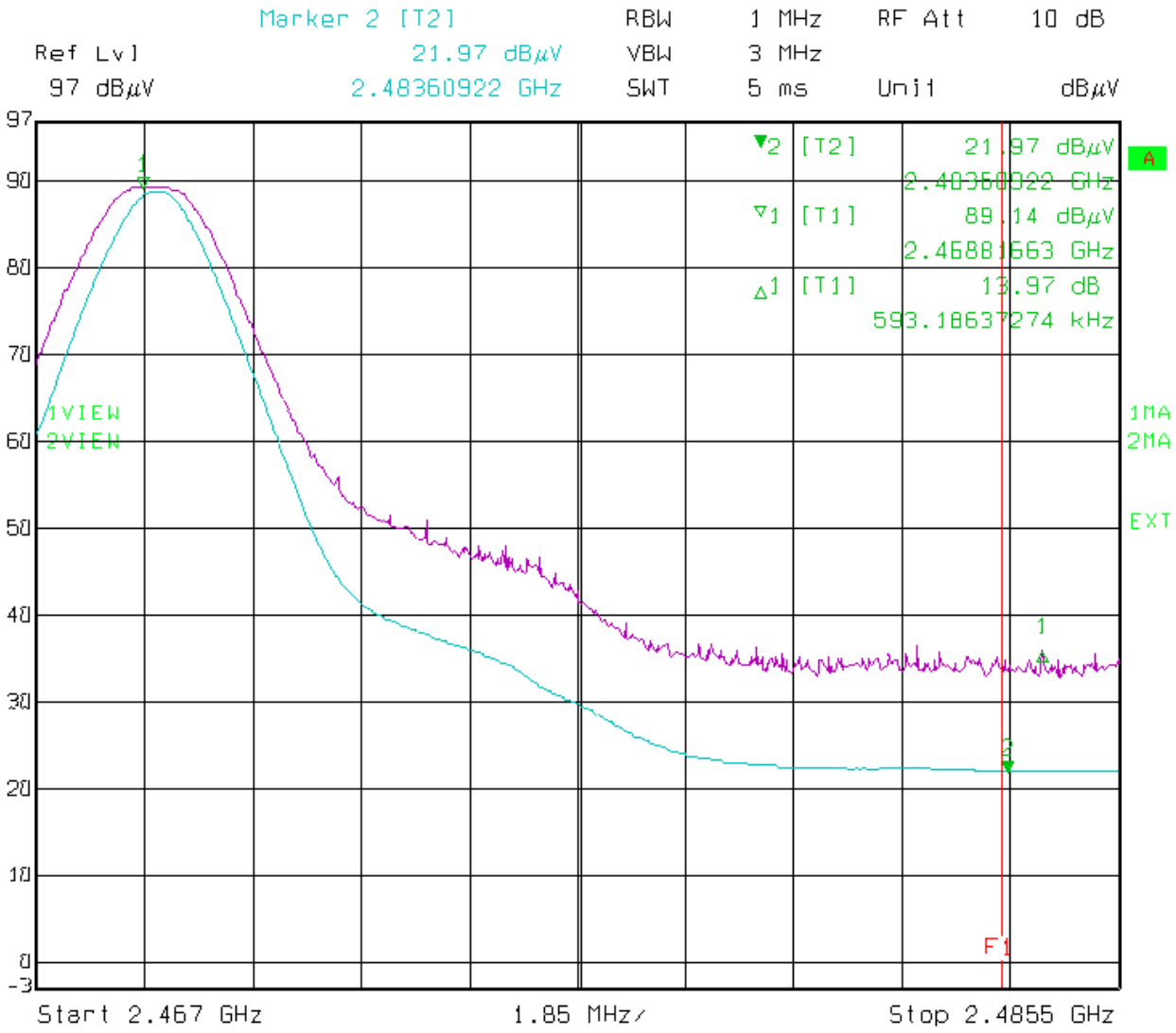
High channel –100Kbit/s



Low channel –500Kbit/s

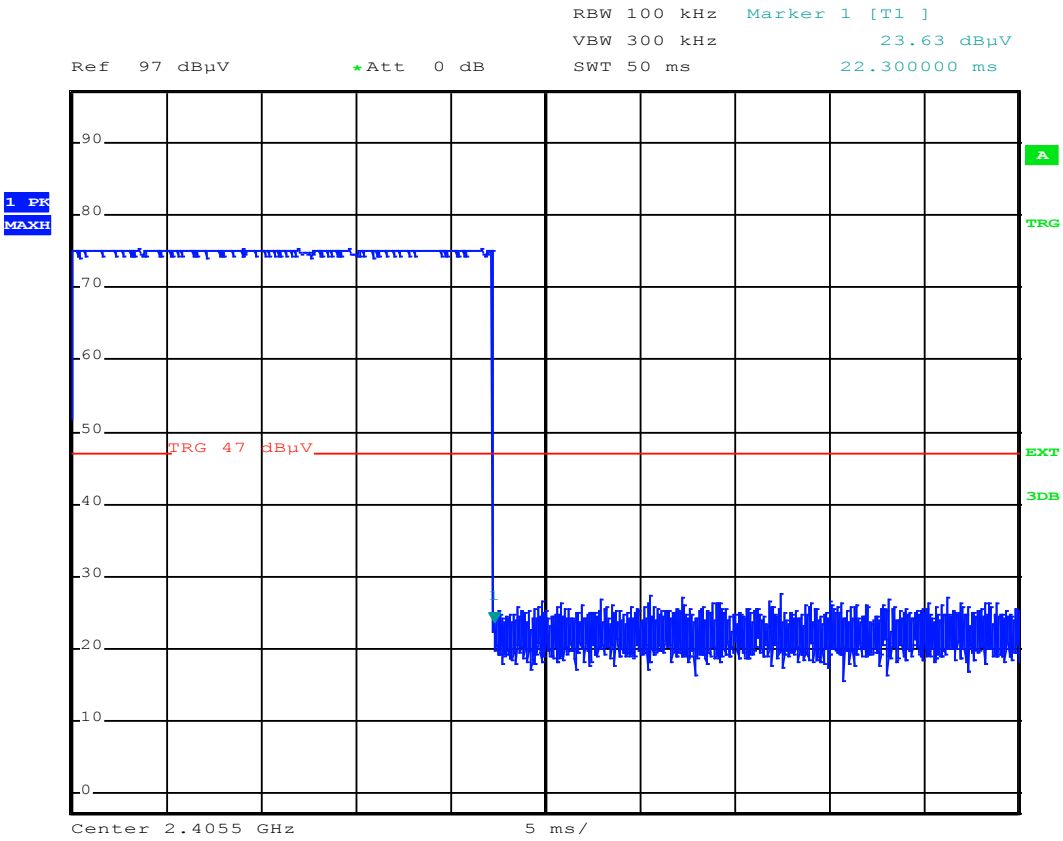


High channel –500Kbit/s



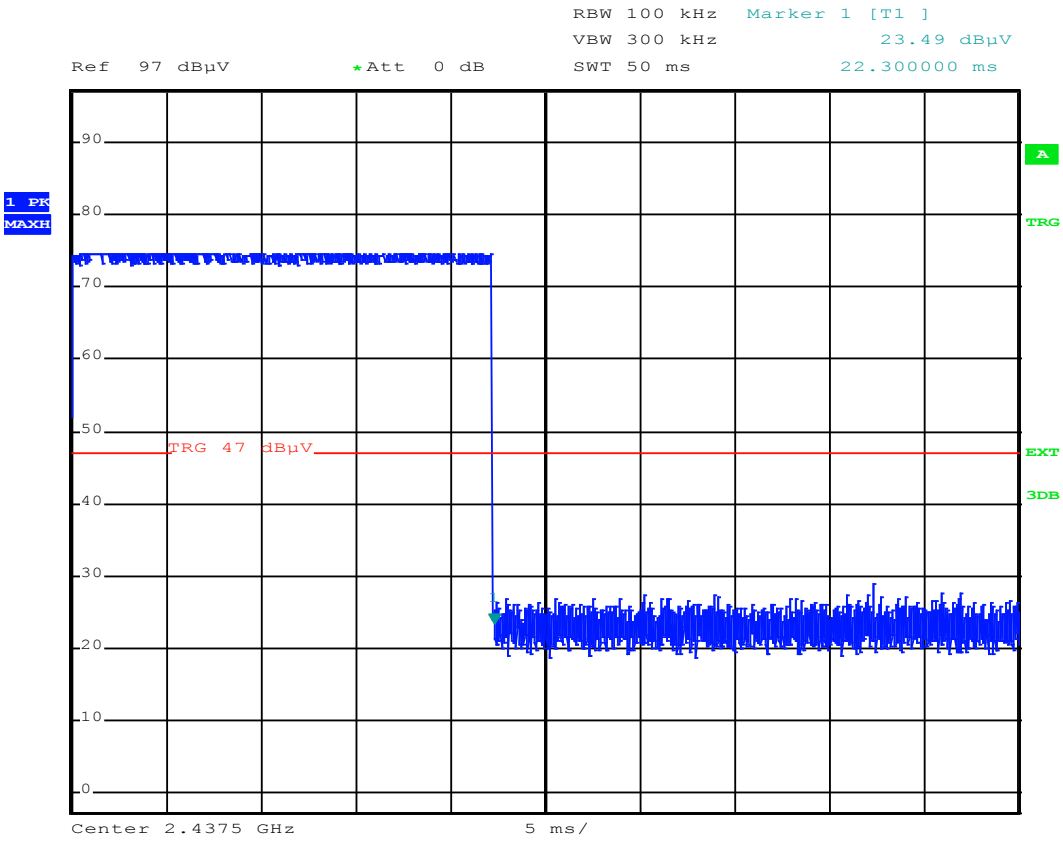
APPENDIX 7: Time of occupancy on any frequency

Low channel – Rate 100Kbit/s



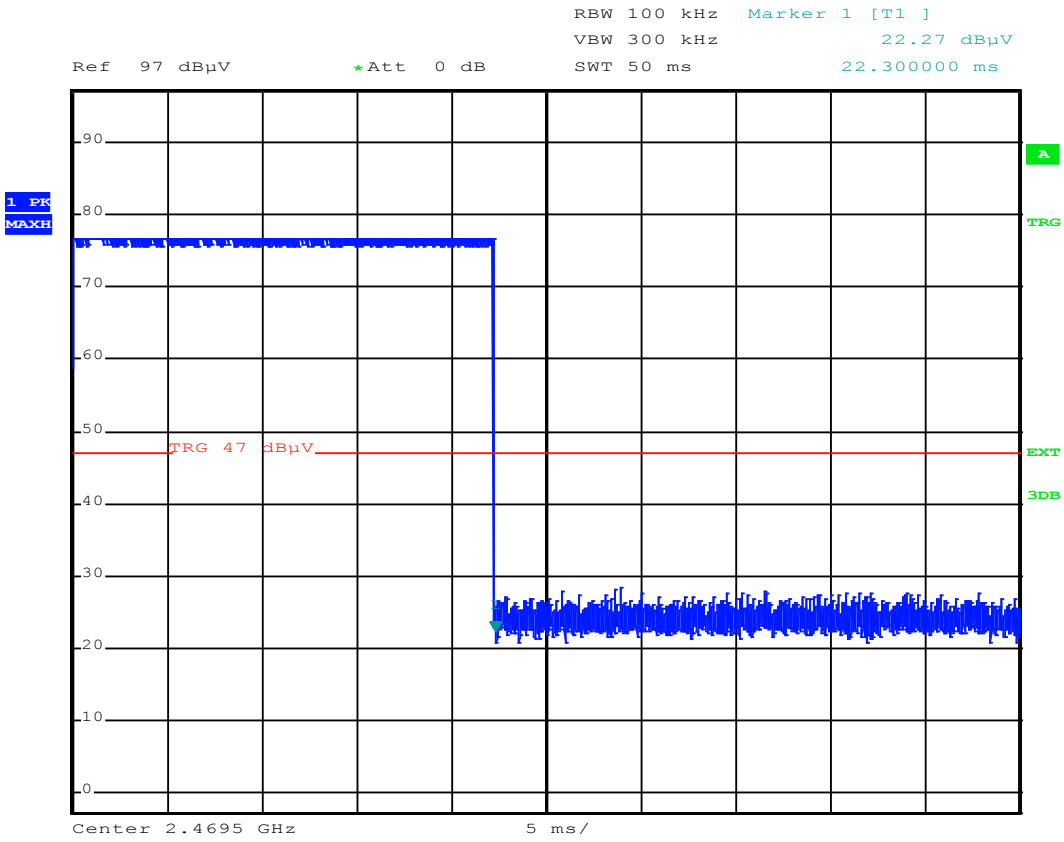
Date: 29.SEP.2014 11:24:11

Central channel – Rate 100Kbit/s



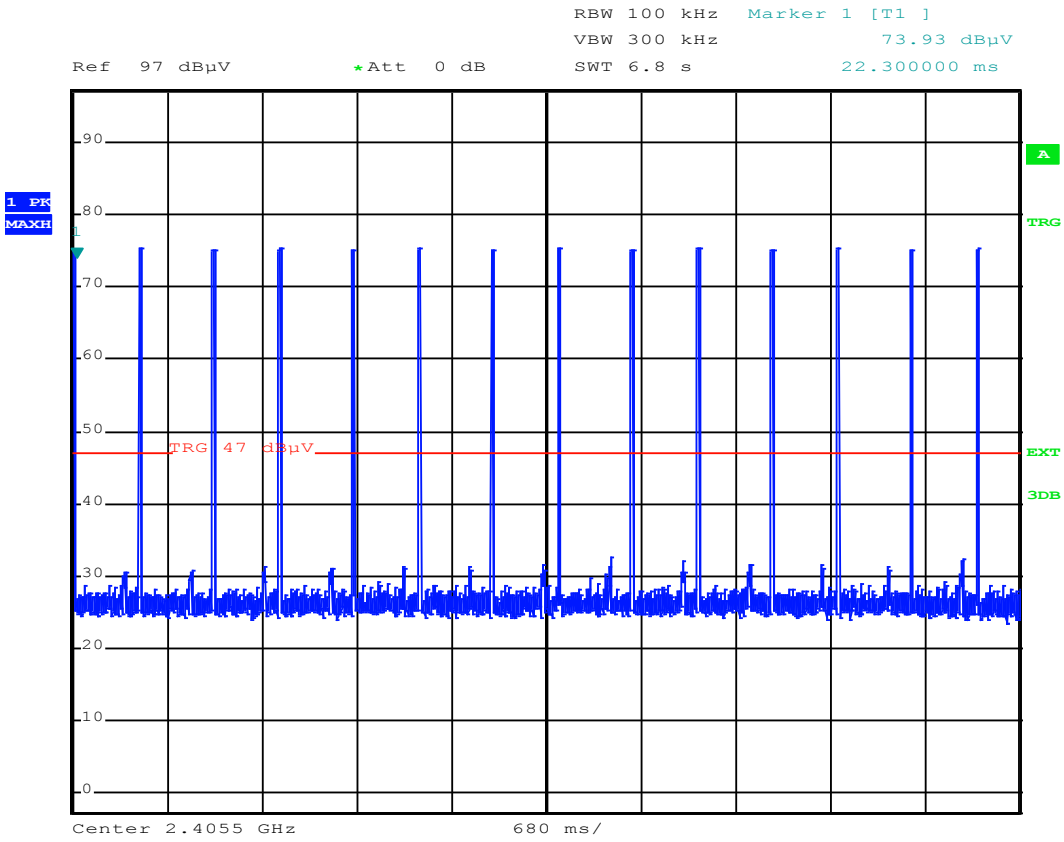
Date: 29.SEP.2014 11:23:56

High channel – Rate 100Kbit/s



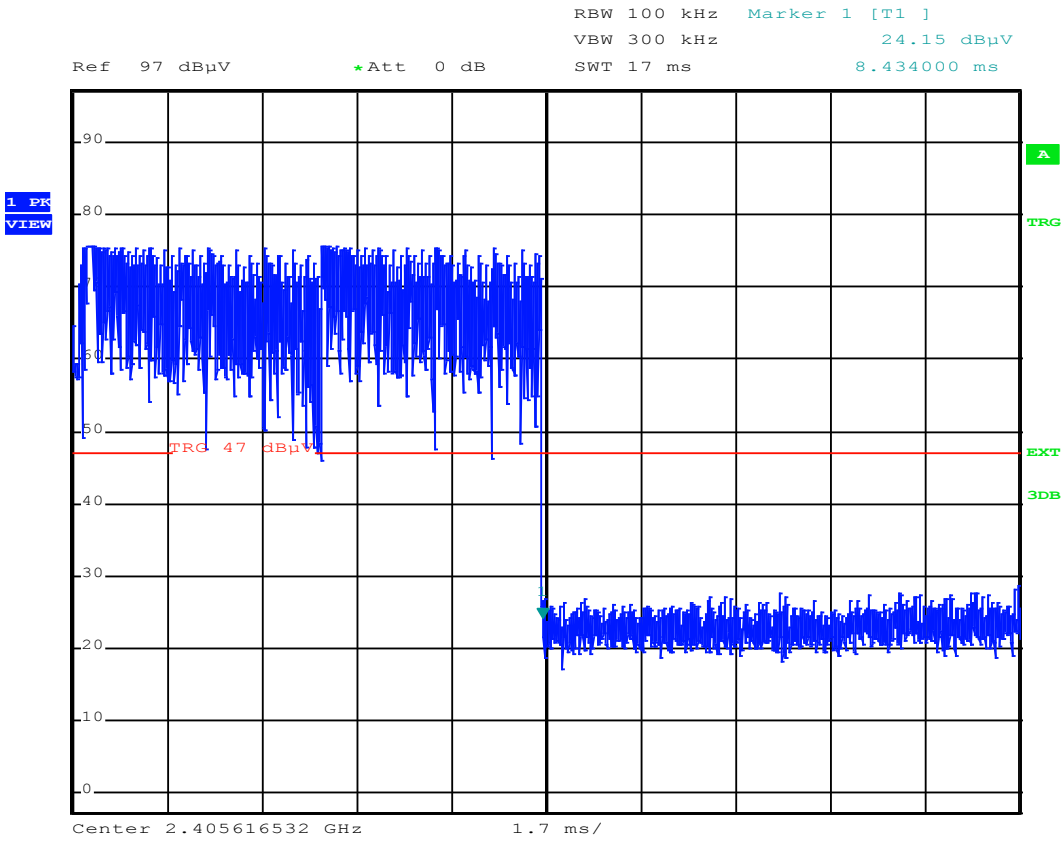
Date: 29.SEP.2014 11:23:18

Burst repetition- Rate 100Kbit/s



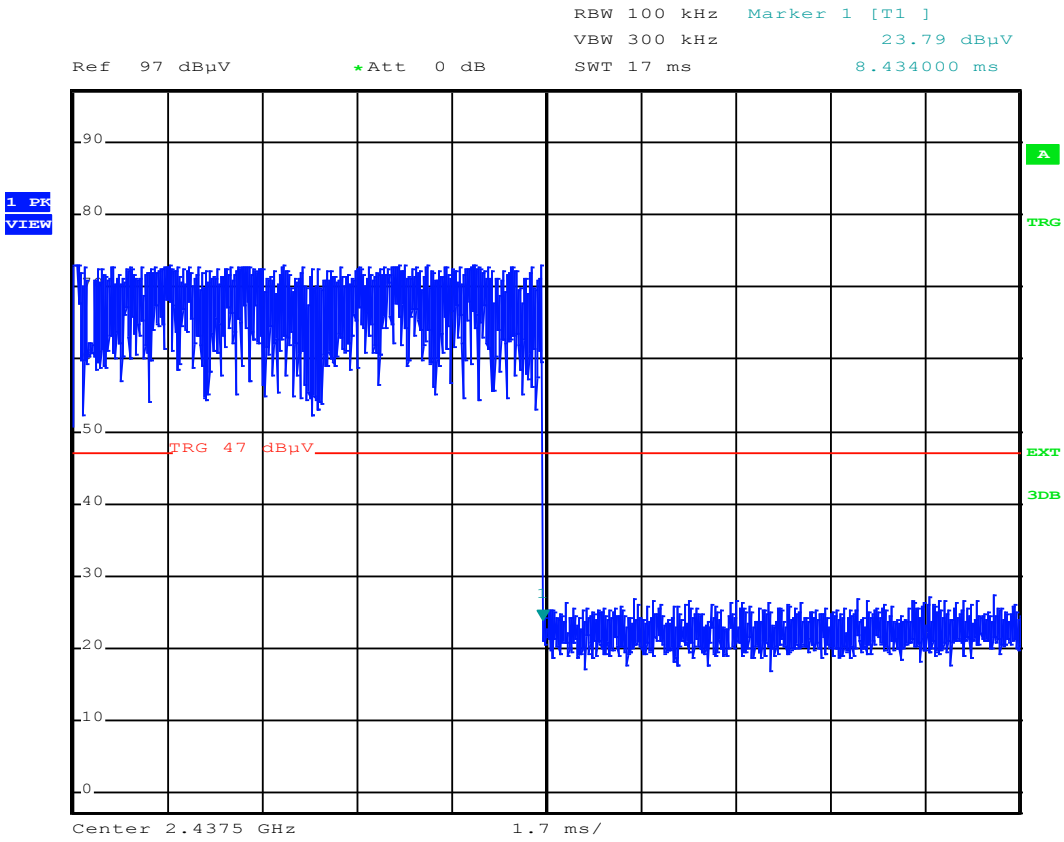
Date: 29.SEP.2014 11:25:17

Low channel – Rate 500Kbit/s



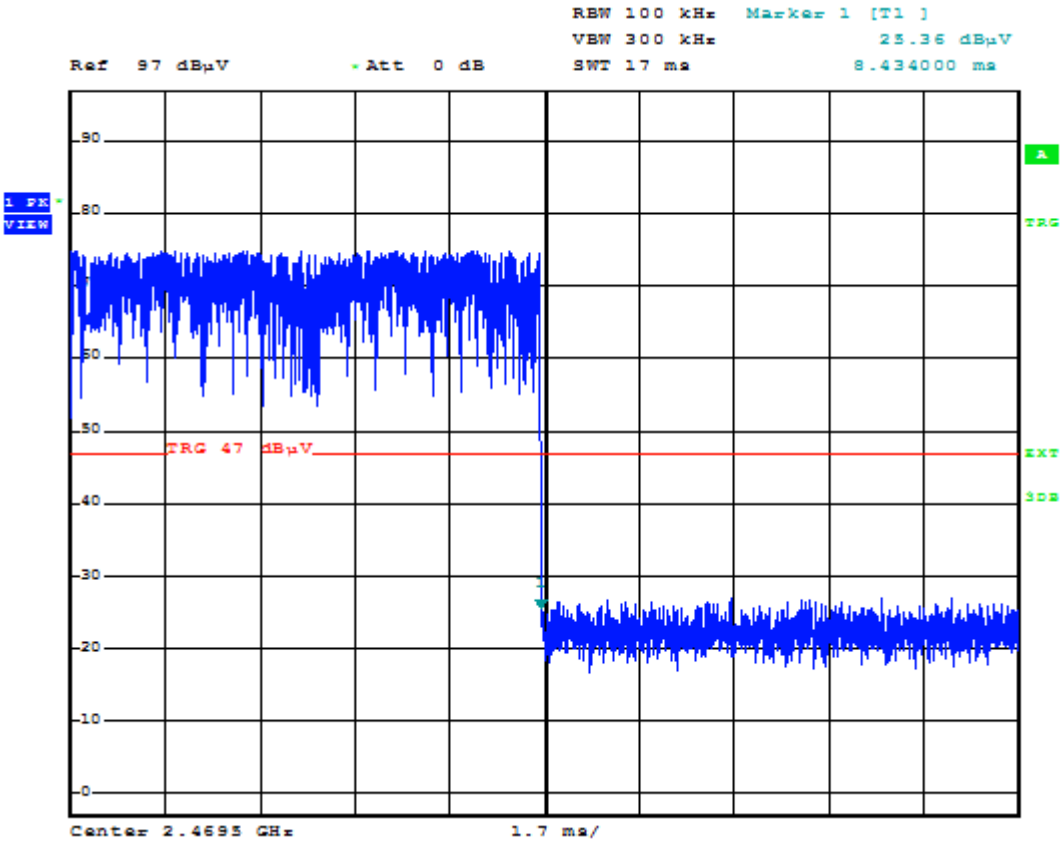
Date: 29.SEP.2014 11:04:13

Central channel – Rate 500Kbit/s

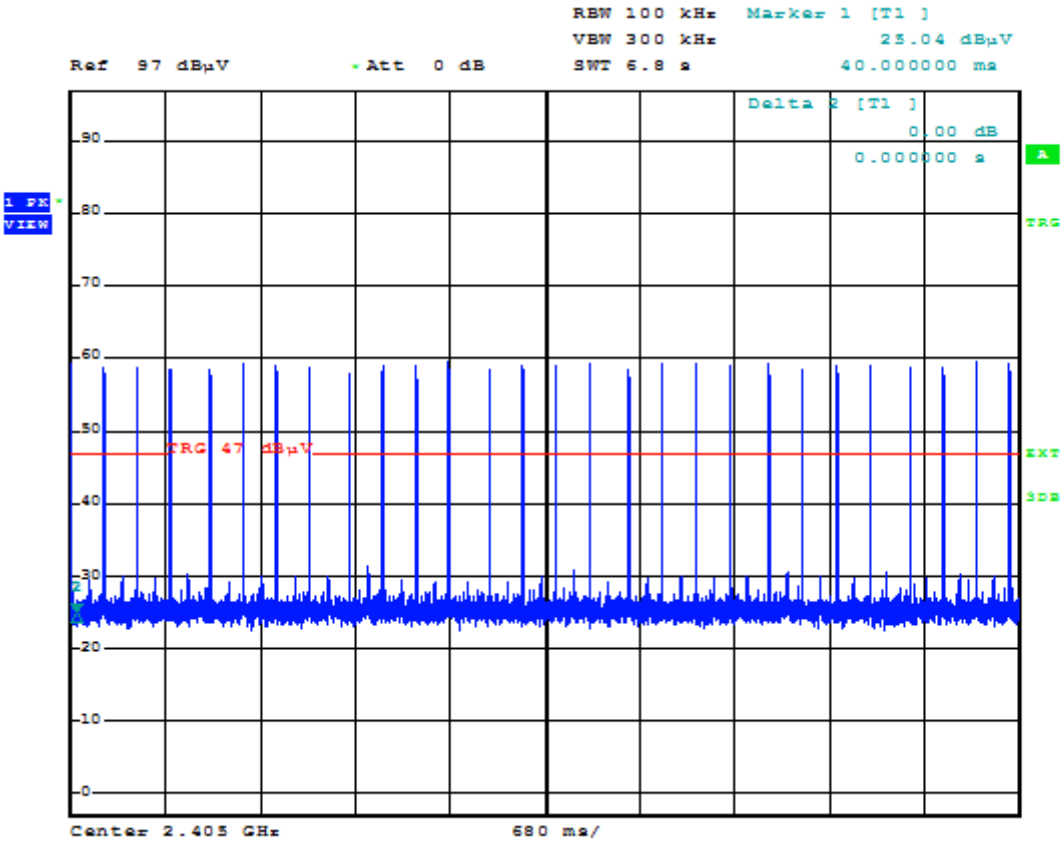


Date: 29.SEP.2014 11:05:02

High channel – Rate 500Kbit/s

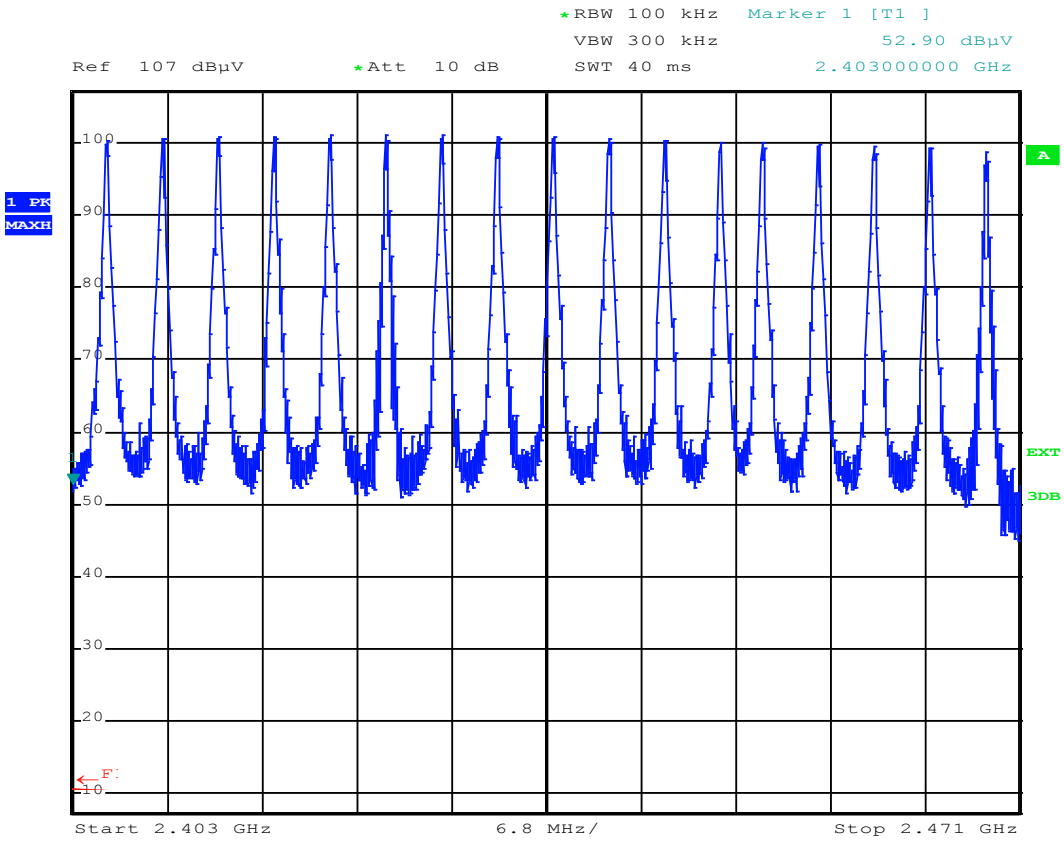


Burst repetition- Rate 500Kbit/s



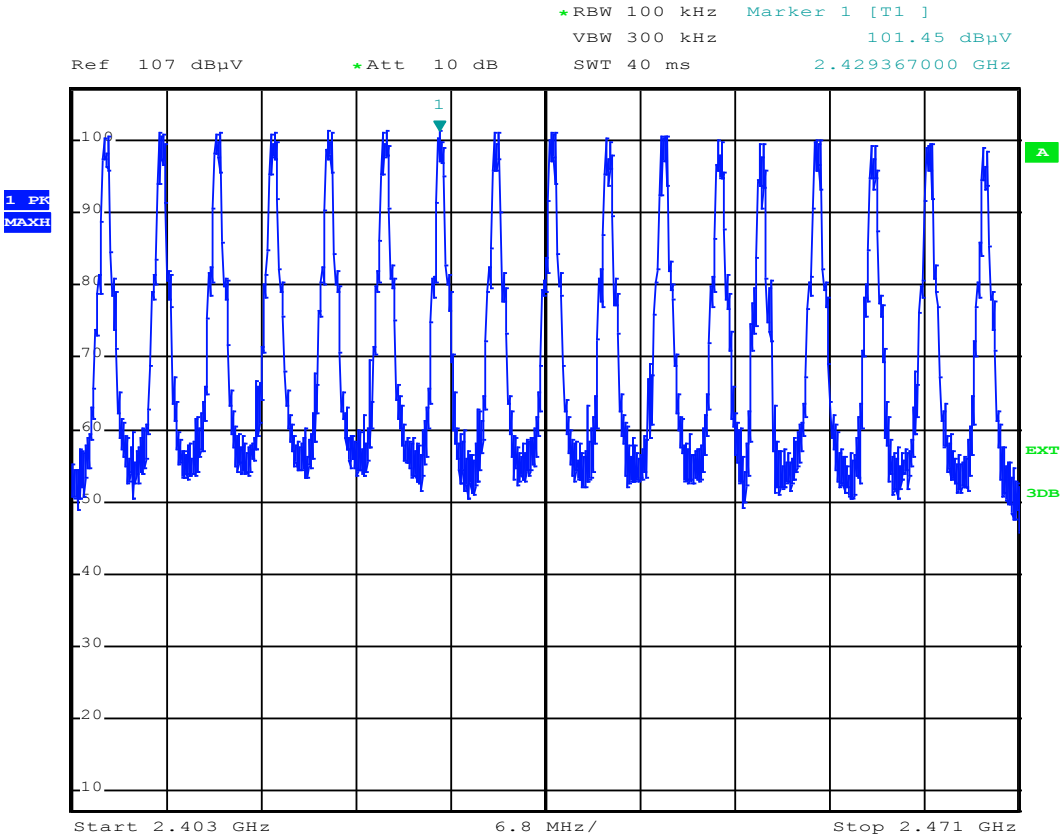
APPENDIX 8: Number of hopping channels

Rate: 100Kbits/s



Date: 22.SEP.2014 11:06:41

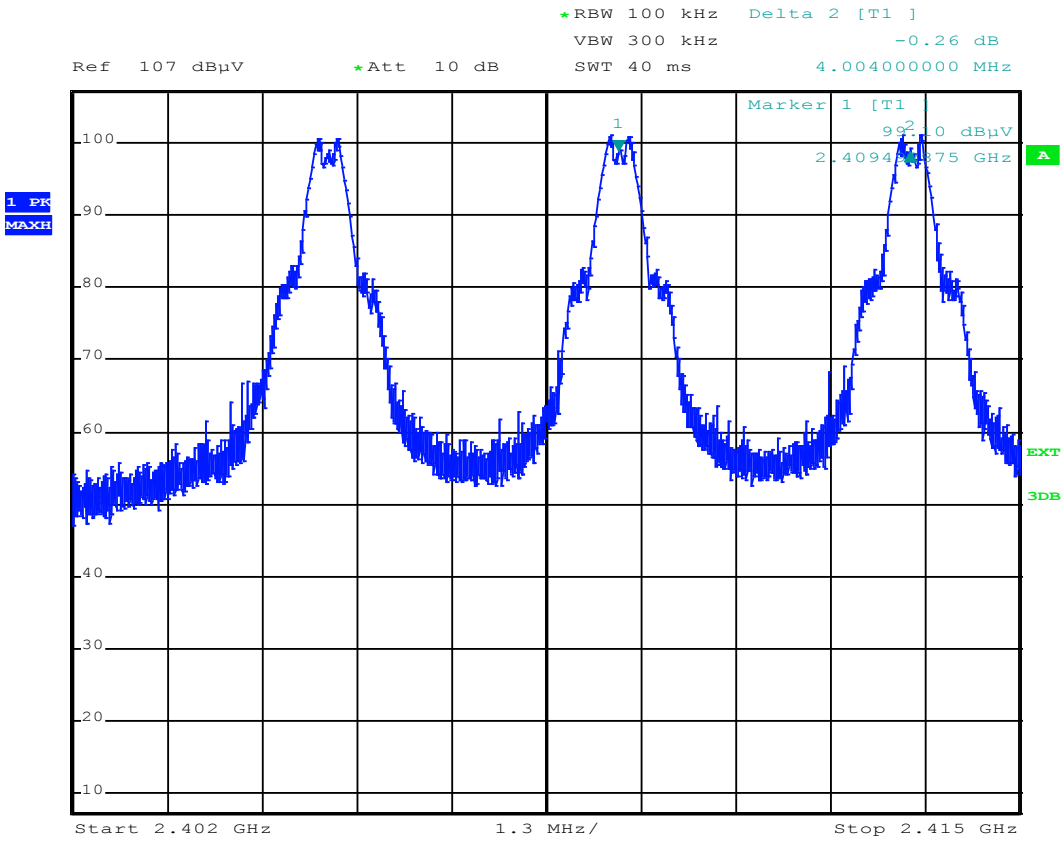
Rate: 500Kbits/s



Date: 22.SEP.2014 10:32:40

APPENDIX 9: Channel spacing

Rate: 500Kbit/s



Date: 22.SEP.2014 10:35:19