

Certification Radio test report

According to the standard:
CFR 47 FCC PART 15

Equipment under test:
MICRO TRACKER 2

FCC ID: 2AOSP-U002

Company:
ABEEWAY

Distribution: Mrs DENIS

(Company: ABEEWAY)

Number of pages: 29 with 4 annexes

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			Name and Function	Visa
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DESIGNATION OF PRODUCT: Micro Tracker 2

Serial number (S/N): 20635F01010001F1

Reference / model (P/N): ABWH-AZ190-00235

Software version: 2017-05-05-1431_sak-HW2.0-EU868_bootloader-file-BLEonly
Asset Tracker v1.x (for production)

MANUFACTURER: ABEeway

COMPANY SUBMITTING THE PRODUCT:

Company: ABEeway

Address: 635, ROUTE DES LUCIOLES
06560 VALBONNE
FRANCE

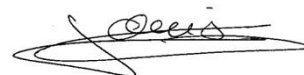
Responsible: Mrs DENIS

DATES OF TEST: From 17-Oct-17 to 20-Oct-17

TESTING LOCATION: EMITECH ANGERS laboratory at JUIGNE SUR LOIRE (49) FRANCE
FCC Accredited under US-EU MRA Designation Number: FR0009
Test Firm Registration Number: 873677

TESTED BY: S. LOUIS

VISA:



WRITTEN BY: S. LOUIS

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1. INTRODUCTION

This report presents the results of radio test carried out on the following radio equipment: **Micro Tracker 2**, in accordance with normative reference.

The product integrates:

- BLE radio transceiver
- a multifrequencies wireless transceiver LoRa
- WiFi radio transceiver
- GPS receiver.

This radio test report concern only the results for certification procedure on the BLE part, for test under subpart B see radio test report RR051-17-103200-7-A.

The transceivers (LoRa, BLE and WiFi) can't emit simultaneously as declared by the manufacturer.

The applicant declares that radio functions are not operational during the charge of the battery.

2. PRODUCT DESCRIPTION

Class:	B
Utilization:	Residential
Antenna type and gain:	integral antenna (unknown gain); (considered 0 dBi)
Operating frequency range:	From 2402 MHz to 2480 MHz
Number of channels:	40
Channel spacing:	2MHz
Modulation:	Bluetooth Low Energy
Power source:	3.7Vdc Lithium Battery

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.

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 (2018) Radio Frequency Devices

ANSI C63.10 2013
Procedures for Compliance Testing of Unlicensed Wireless Devices.

558074 D01 DTS v05 Guidance for compliance measurements on digital transmission system,
frequency hopping spread spectrum system, and hybrid system devices
operating under section 15.247 of the FCC rules.

447498 D01 General RF RF Exposure procedures and equipment authorization policies for mobile and
Exposure Guidance v06 portable equipment

4. **TEST METHODOLOGY**

Radio performance tests procedures given in CFR 47 part 15:

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 calibration	Calibration interval (years)	Next calibration due
0000	BAT-EMC V3.6.0.32	Software	/	/	/
1406	EMCO 6502	Loop antenna	13/04/2017	2	13/04/2019
4087	Filtek LP03/1000-7GH	Low Pass Filter	11/04/2016	2	11/04/2018
4088	R&S FSP40	Spectrum Analyzer	02/11/2015	2	02/11/2017
5625	BL Microwave BP2442-84-7CS	Band pass filter	29/03/2016	2	29/03/2018
7124	A.H. Systems SAS-572	Antenna	21/03/2015	3	21/03/2018
7190	R&S HL223	Antenna	15/03/2016	3	15/03/2019
7240	Emco 3110	Biconical antenna	15/03/2016	3	15/03/2019
7299	Microtronics BRM50702	Reject band filter	06/11/2015	2	06/11/2017
7566	Testo 608-Hi	Meteo station	15/02/2016	2	15/02/2018
8535	EMCO 3115	Antenna	10/02/2016	4	10/02/2020
8704	LUCIX Corp S180265L3201 LNA	Low-noise amplifier	02/05/2017	1	02/05/2018
8896	ACQUISYS GPS8	Satellite synchronized frequency standard	/	/	/
8974	STORM MICROWAE k-20cm	cable	13/11/2015	2	13/11/2017
10730	Mini-circuit ZFL-1000LN	Low-noise amplifier	05/04/2017	1	05/04/2018
10739	LUCIX Corp S005180M3201	Low-noise amplifier	29/03/2017	1	29/03/2018
10759	SIDT Cage 3	Anechoic chamber	/	/	/
10771	EMCO 3117	Antenna	23/11/2016	3	23/11/2019
12917	SUCOFLEX K-2m	cable	28/04/2016	2	28/04/2018
14303	SUCOFLEX N-2m	cable	28/11/2016	2	28/11/2018
14304	SUCOFLEX N-2.5m	cable	28/11/2016	2	28/11/2018
14305	SUCOFLEX N-4m	cable	28/11/2016	2	28/11/2018
14476	Fluke 177	Multimeter	20/03/2017	1	20/03/2018
-	GPIB SHOT V2.4	Software	/	/	/

6. TESTS RESULTS SUMMARY

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		Note 2
FCC Part 15.209	RADIATED EMISSION LIMITS; general requirements	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		
	(a) (2) Digital modulation techniques	X				Note 5
	(b) Maximum peak output power	X				Note 6
	(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				

NAP: Not Applicable

NAs: Not Asked

Note 1: Integral antenna without standard connector.

Note 2: Supplied by batteries. The radio part of the equipment is no operational during charging mode.

Note 3: See FCC part 15.247 (d).

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

Note 5: The minimum 6 dB bandwidth of the equipment is 629 kHz (see appendix 2).

Note 6: Conducted measurement is not possible (integral antenna), so we used the radiated method in open field.

7. MEASUREMENT UNCERTAINTY

To declare, or not, the compliance with the specifications, it was not explicitly taken into account of uncertainty associated with the result(s)

The reported expanded uncertainty of measurement is stated as the standard uncertainty of measurement multiplied by the coverage factor $k=2$, which for normal distribution corresponds to a coverage probability of approximately 95%.

Parameter	Emitech Uncertainty
RF power, conducted	$\pm 0.75\text{dB}$
Radiated emission valid to 26 GHz	
F < 62.5 MHz:	$\pm 5.14\text{ dB}$
62.5 MHz < F < 1 GHz:	$\pm 5.13\text{ dB}$
1 GHz < F < 26 GHz:	$\pm 5.16\text{ dB}$
AC Power Lines conducted emissions	$\pm 3.38\text{ dB}$
Temperature	$\pm 1\text{ }^{\circ}\text{C}$
Humidity	$\pm 5\text{ \%}$

8. ADDITIONAL PROVISIONS TO THE GENERAL RADIATED EMISSION LIMITATIONS**Temperature (°C) :** 24.2**Humidity (%HR):** 54**Date :** October 18, 2017**Technician :** S. LOUIS**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 modulated transmission mode, at the highest output power level at which the transmitter is intended to operate.

We used for power source the internal battery of the equipment and we noted:

Voltage at the beginning of test (Vdc): 4.27

Voltage at the end of test (Vdc): 4.12

Percentage of voltage drop during the test (%): 3.51

Results:

Lower Band Edge: From 2400 MHz to 2402 MHz

Upper Band Edge: From 2483.5 MHz to 2485.5 MHz

Sample N° 1

Fundamental frequency (MHz)	Field Strength Level of fundamental (dBμV/m)	Detector (Peak or Average)	Frequency of maximum Band-edges Emission (MHz)	Delta Marker (dB) (1)	Calculated Max Out-of-Band Emission Level (dBμV/m)	Limit (dBμV/m)	Margin (dB)
2402	86.8	Peak	2399.92	-40.99	-45.81	66.8	20.99
2480	80.9	Peak	2485.45	-32.80	-48.10 (2)	74	25.90

(1) Marker-Delta method

(2) The peak level is lower than the average limit (54 dBμV/m)

Band-edge curves are given in appendix 4.

Test conclusion:

RESPECTED STANDARD

9. MAXIMUM PEAK CONDUCTED OUTPUT POWER**Temperature (°C) :** 23.8**Humidity (%HR):** 53**Date :** October 18, 2017**Technician :** S. LOUIS**Standard:** FCC Part 15**Test procedure:** paragraph 15.247 (b)

RBW≥DTS bandwidth method of paragraph 11.9.1.1 of ANSI C63.10

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 system is tested in anechoic chamber, the EUT is placed on a rotating table, 1.50 m from a ground plane.

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

See photos in appendix 2.

Distance of antenna: 3 meters (in anechoic room)**Antenna height:** 1.50 meter (in anechoic room)**Antenna polarization:** vertical and horizontal (only the highest level is recorded)

The measurement of the radiated electro-magnetic field is realized with an analyser and peak detector. The resolution bandwidth is adjusted at 10 MHz and video bandwidth at 10 MHz. (9.1.1 of KDB 558074)

Finally the radiated electro-magnetic field is converted in dBm with the following formula:

$$EIRP(dBm) = E (dB\mu V/m) + 20\log(D) - 104.8; \text{ where } D \text{ is the measurement distance in meters and antenna Gain} = 0 \text{ dBi.}$$
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.

We used for power source the internal battery of the equipment and we noted:

Voltage at the beginning of test (Vdc): 4.28

Voltage at the end of test (Vdc): 4.16

Percentage of voltage drop during the test (%): 2.80

Results:

Sample N° 1 : Low Channel (F = 2402 MHz)

	Electro-magnetic field (dBμV/m):	Maximum Peak conducted output power (1)		Limit (W)
		(dBm)	(W)	
Nominal supply voltage:	87.5	-7.75	0.00017	1

Polarization of test antenna: Vertical (height: 150 cm)

Position of equipment: Upright position (azimuth: 205 degrees)

Sample N° 1 : Central Channel (F = 2426 MHz)

	Electro-magnetic field (dBμV/m):	Maximum Peak conducted output power (1)		Limit (W)
		(dBm)	(W)	
Nominal supply voltage:	86.5	-8.75	0.00013	1

Polarization of test antenna: Vertical (height: 150 cm)

Position of equipment: Upright position (azimuth: 225 degrees)

Sample N° 1 : High Channel (F = 2480 MHz)

	Electro-magnetic field (dBμV/m):	Maximum Peak conducted output power (1)		Limit (W)
		(dBm)	(W)	
Nominal supply voltage:	82	-13.25	0.00005	1

Polarization of test antenna: Vertical (height: 150 cm)

Position of equipment: Upright position (azimuth: 180 degrees)

(1) Maximum Peak conducted output power:

$EIRP(dBm) = E (dB\mu V/m) + 20\log(D) - 104.8$; where D is the measurement distance in meters and antenna Gain = 0 dBi.

Test conclusion:

RESPECTED STANDARD

10. INTENTIONAL RADIATOR**Temperature (°C) :** 24.2**Humidity (%HR):** 54**Date :** October 18, 2017**Technician :** S. LOUIS**Standard:** FCC Part 15**Test procedure:** paragraph 15.205, paragraph 15.209, paragraph 15.247 (d)

Emissions in non-restricted frequency bands method of paragraph 11.11 of ANSI C63.10

Emissions in restricted frequency bands method of paragraph 11.12 of ANSI C63.10

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, 1.50 m 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 25GHz - 10th harmonic of the highest fundamental frequency (2480MHz).**Detection mode:** Quasi-peak ($F < 1$ GHz)Peak / Average ($F > 1$ GHz)**Bandwidth:** 200Hz ($9 \text{ kHz} < F < 150\text{kHz}$)
9 kHz ($150 \text{ kHz} < F < 30\text{MHz}$)
120 kHz ($30 \text{ MHz} < F < 1 \text{ GHz}$)
100 kHz / 1 MHz ($F > 1 \text{ GHz}$)**Distance of antenna:** 3 meters (in anechoic room)**Antenna height:** 1.50 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.

We used for power source the internal battery of the equipment and we noted:

Voltage at the beginning of test (Vdc): 4.28

Voltage at the end of test (Vdc): 4.16

Percentage of voltage drop during the test (%): 2.80

Results:

Sample N° 1 : Low Channel (F = 2402 MHz)

Frequencies (MHz)	Detector P QP Av	Position	Antenna height (cm)	RBW (kHz)	Polarization H: Horizontal V: Vertical	Field strength Measured at 3 m (dB μ V/m)	Limits (dB μ V/m) or (dBm)	Margin (dB)
4804 (1)	P	2	150	1000	H	54.5	74	19.5
4804 (1)	Av	2	150	1000	H	50	54	4
7206	P	2	150	100	H	50.9	66.8	15.9

P= Peak, QP=Quasi-peak, Av=Average

(1) Restricted bands of operation in 15.205

Sample N° 1 : Central Channel (F = 2426 MHz)

Frequencies (MHz)	Detector P QP Av	Position	Antenna height (cm)	RBW (kHz)	Polarization H: Horizontal V: Vertical	Field strength Measured at 3 m (dB μ V/m)	Limits (dB μ V/m) or (dBm)	Margin (dB)
4852 (1)	P	2	150	1000	H	53.3	74	20.7
4852 (1)	Av	2	150	1000	H	51.8	54	2.2
7278 (1)	P	2	150	1000	H	56.3	74	17.7
7278 (1)	Av	2	150	1000	H	50.5	54	3.5

P= Peak, QP=Quasi-peak, Av=Average

(1) Restricted bands of operation in 15.205

Sample N° 1 : High Channel (F = 2480 MHz)

Frequencies (MHz)	Detector P QP Av	Position	Antenna height (cm)	RBW (kHz)	Polarization H: Horizontal V: Vertical	Field strength Measured at 3 m (dB μ V/m)	Limits (dB μ V/m) or (dBm)	Margin (dB)
4960 (1)	P	2	150	1000	H	55.6	74	18.4
4960 (1)	Av	2	150	1000	H	52	54	2
7440 (1)	P	2	150	1000	H	55.7	74	18.3
7440 (1)	Av	2	150	1000	H	50.1	54	3.9

P= Peak, QP=Quasi-peak, Av=Average

(1) 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 86.8 dB μ V/m on Low channel.

So the applicable limit is 66.8 dB μ V/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)).

Test conclusion:

RESPECTED STANDARD

11. MAXIMUM PEAK CONDUCTED POWER DENSITY**Temperature (°C) :** 23.8**Humidity (%HR):** 53**Date :** October 18, 2017**Technician :** S. LOUIS**Standard:** FCC Part 15**Test procedure:** paragraph 15.247 (e)

PKPSD (Peak PSD) method of paragraph 11.10.2 of ANSI C63.10

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

The system is tested in anechoic chamber, the EUT is placed on a rotating table, 1.50 m from a ground plane.

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

See photos in appendix 2.

Distance of antenna: 3 meters (in anechoic room)**Antenna height:** 1.50 meter (in anechoic room)**Antenna polarization:** vertical and horizontal (only the highest level is recorded)

The measurement of the radiated electro-magnetic field is realized with an analyser.

Span:	1MHz
Resolution bandwidth:	3kHz
Video bandwidth:	10kHz
Detector:	Peak
Sweep time:	Autocouple
Trace mode:	MaxHold

Then the peak marker function is used.

Finally the radiated electro-magnetic field is converted in dBm with the following formula:

$$EIRP(dBm) = E (dB\mu V/m) + 20\log(D) - 104.8; \text{ where } D \text{ is the measurement distance in meters and antenna Gain} = 0 \text{ dBi.}$$

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.

We used for power source the internal battery of the equipment and we noted:

Voltage at the beginning of test (Vdc): 4.28

Voltage at the end of test (Vdc): 4.16

Percentage of voltage drop during the test (%): 2.80

Results:

Sample N° 1 : Low Channel (F = 2402 MHz)

	Electro-magnetic field (dBμV/m):	Maximum Peak conducted power density(1) (dBm / 3 kHz)	Limit (dBm / 3 kHz)
Nominal supply voltage:	74.4	-20.85	8

Polarization of test antenna: Vertical (height: 150 cm)

Position of equipment: Upright position (azimuth: 205 degrees)

Sample N° 1 : Central Channel (F = 2426 MHz)

	Electro-magnetic field (dBμV/m):	Maximum Peak conducted power density(1) (dBm / 3 kHz)	Limit (dBm / 3 kHz)
Nominal supply voltage:	74.3	-20.95	8

Polarization of test antenna: Vertical (height: 150 cm)

Position of equipment: Upright position (azimuth: 225 degrees)

Sample N° 1 : High Channel (F = 2480 MHz)

	Electro-magnetic field (dBμV/m):	Maximum Peak conducted power density(1) (dBm / 3 kHz)	Limit (dBm / 3 kHz)
Nominal supply voltage:	68.7	-26.55	8

Polarization of test antenna: Vertical (height: 150 cm)

Position of equipment: Upright position (azimuth: 225 degrees)

Maximum Peak conducted power density:

$EIRP(dBm / 3 kHz) = E (dBμV/m / 3 kHz) + 20\log(D) - 104.8$; where D is the measurement distance in meters and antenna Gain = 0 dBi.

Test conclusion:

RESPECTED STANDARD

□□□ End of report, 4 appendixes to be forwarded □□□

APPENDIX 1: Test equipment list

Additional provisions to the general radiated emission limitations

TYPE	MANUFACTURER	EMITECH NUMBER
Full anechoic chamber	EMITECH	10759
Satellite synchronized frequency standard GPS8	ACQUISYS	8896
Spectrum Analyzer FSP40	Rohde & Schwarz	4088
Antenna 3117	ETS-Lindgren	10771
Low-noise amplifier S005180M3201	LUCIX Corp.	10739
Cable N-2m	SUCOFLEX	14303
Cable N-2.5m	SUCOFLEX	14304
Cable N-4m	SUCOFLEX	14305
Multimeter 177	Fluke	14476
Meteo station 608-H1	Testo	7566
Software	GPIBSHOT V2.4	-

Maximum Peak Conducted (Average) Output Power

TYPE	MANUFACTURER	EMITECH NUMBER
Full anechoic chamber	EMITECH	10759
Satellite synchronized frequency standard GPS8	ACQUISYS	8896
Spectrum Analyzer FSP40	Rohde & Schwarz	4088
Band pass filter BP2442-84-7CS	BL Microwave	5625
Antenna 3115	EMCO	8535
Low-noise amplifier S005180M3201	LUCIX Corp.	10739
Cable N-2m	SUCOFLEX	14303
Cable N-2.5m	SUCOFLEX	14304
Cable N-4m	SUCOFLEX	14305
Multimeter 177	Fluke	14476
Meteo station 608-H1	Testo	7566
Software	BAT-EMC V3.6.0.32	0000

Intentional Radiator

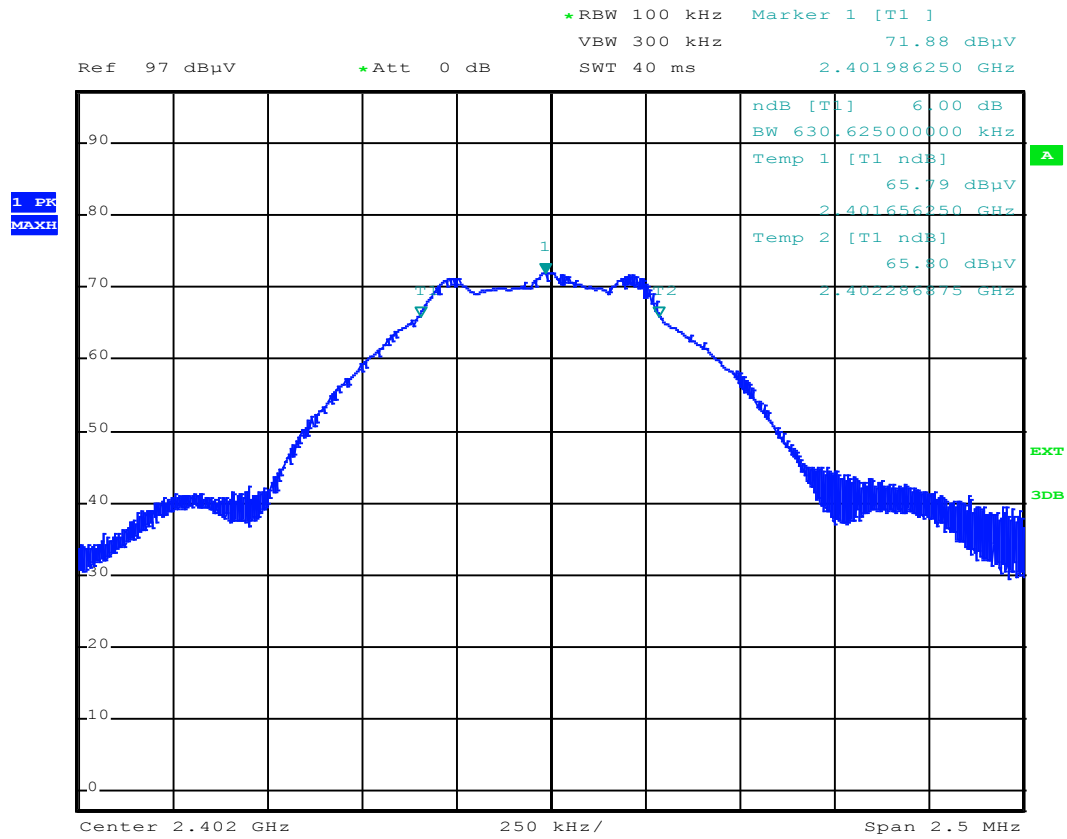
TYPE	MANUFACTURER	EMITECH NUMBER
Full anechoic chamber	EMITECH	10759
Satellite synchronized frequency standard GPS8	ACQUISYS	8896
Spectrum Analyzer FSP40	Rohde & Schwarz	4088
Loop antenna 6502	EMCO	1406
Biconical antenna 3110	Emco	7240
Log periodic antenna HL223	Rohde & Schwarz	7190
Antenna 3117	ETS-Lindgren	10771
Antenna SAS-572	AH Systems	7124
Low-noise amplifier ZFL-1000LN	Mini-circuit	10730
Low-noise amplifier S005180M3201	LUCIX Corp.	10739
Low-noise amplifier S180265L3201 LNA	LUCIX Corp.	8704
Low pass filter LP03/1000-7GH	Filtek	4087
Reject band filter BRM50702	Microtronics	7299
Cable N-2m	SUCOFLEX	14303
Cable N-2.5m	SUCOFLEX	14304
Cable N-4m	SUCOFLEX	14305
Cable k-20cm	STORM MICROWAE	8974
Cable K-2m	SUCOFLEX	12917
Multimeter 177	Fluke	14476
Meteo station 608-H1	Testo	7566
Software	BAT-EMC V3.6.0.32	0000

Maximum Conducted Power Density

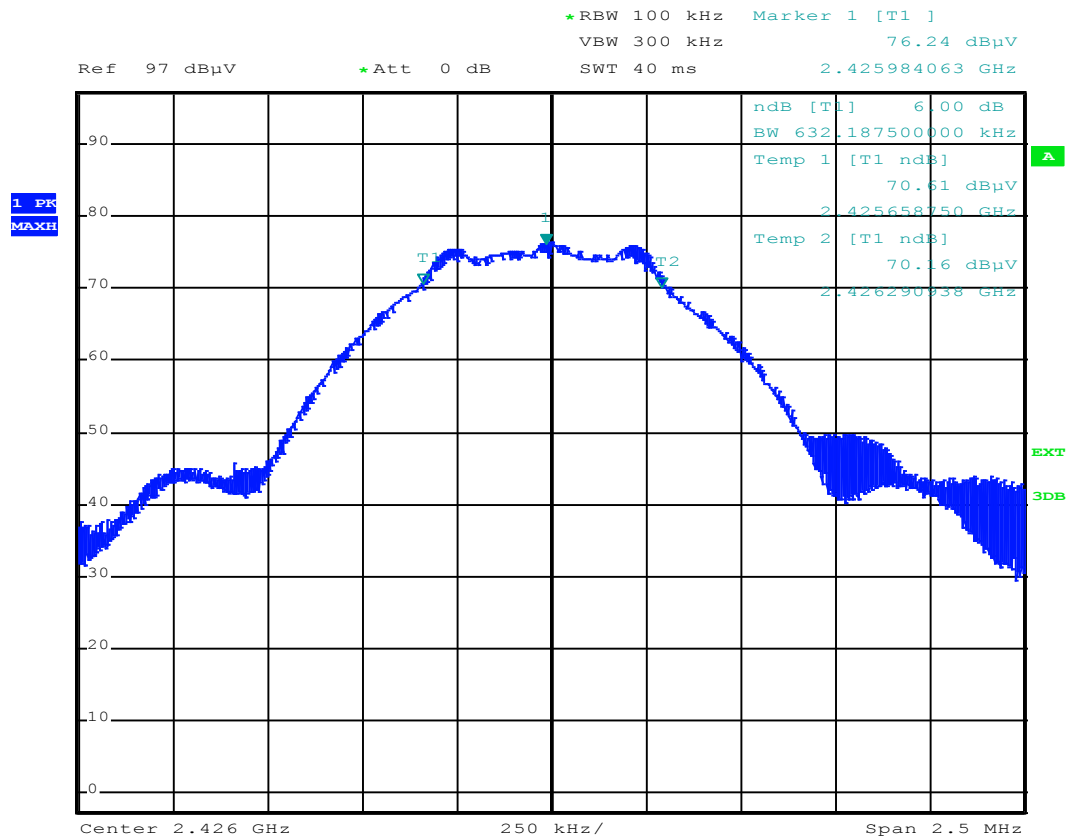
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Band pass filter BP2442-84-7CS	BL Microwave	5625
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Low-noise amplifier S005180M3201	LUCIX Corp.	10739
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Cable N-2.5m	SUCOFLEX	14304
Cable N-4m	SUCOFLEX	14305
Multimeter 177	Fluke	14476
Meteo station 608-H1	Testo	7566
Software	BAT-EMC V3.6.0.32	0000

APPENDIX 2: 6 dB bandwidth

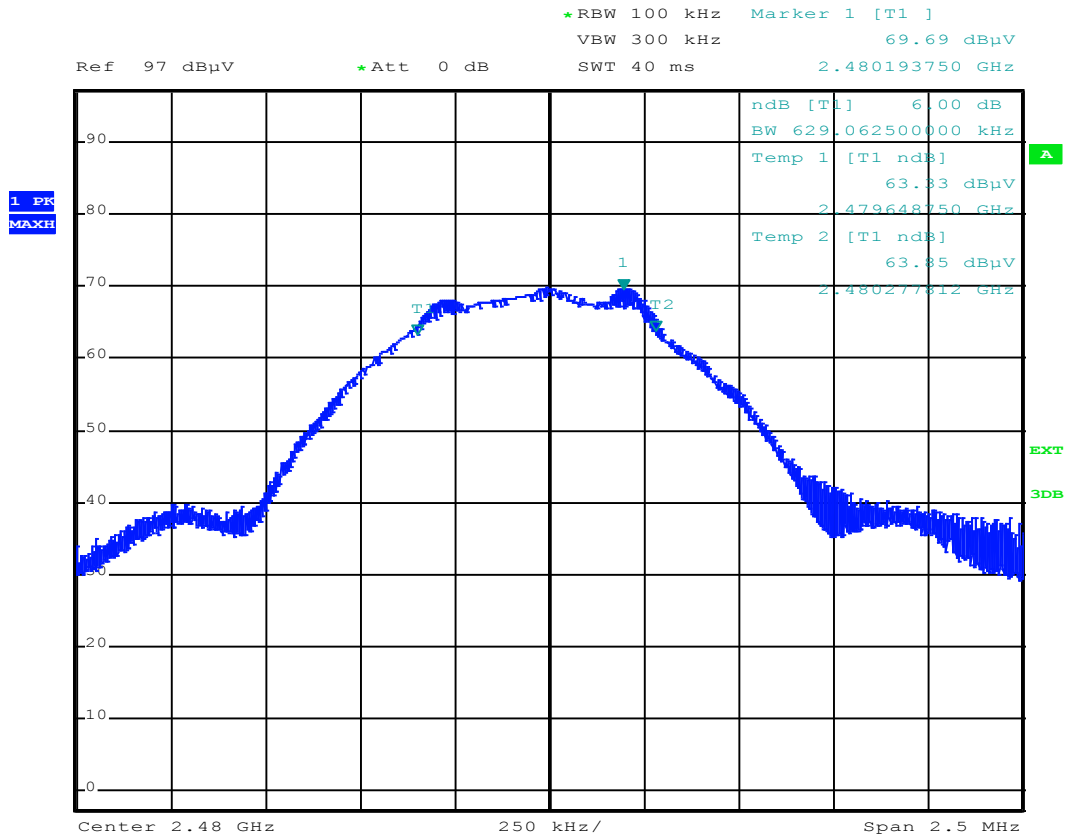
Low Channel



Central Channel

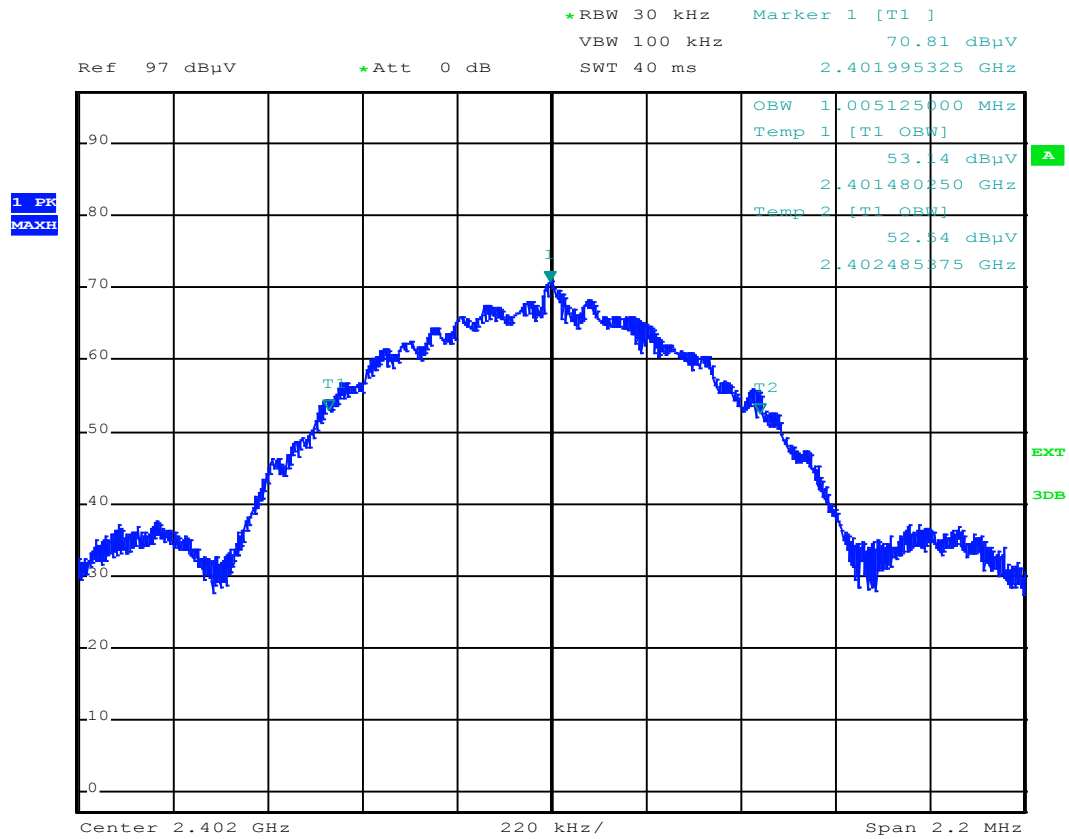


High Channel

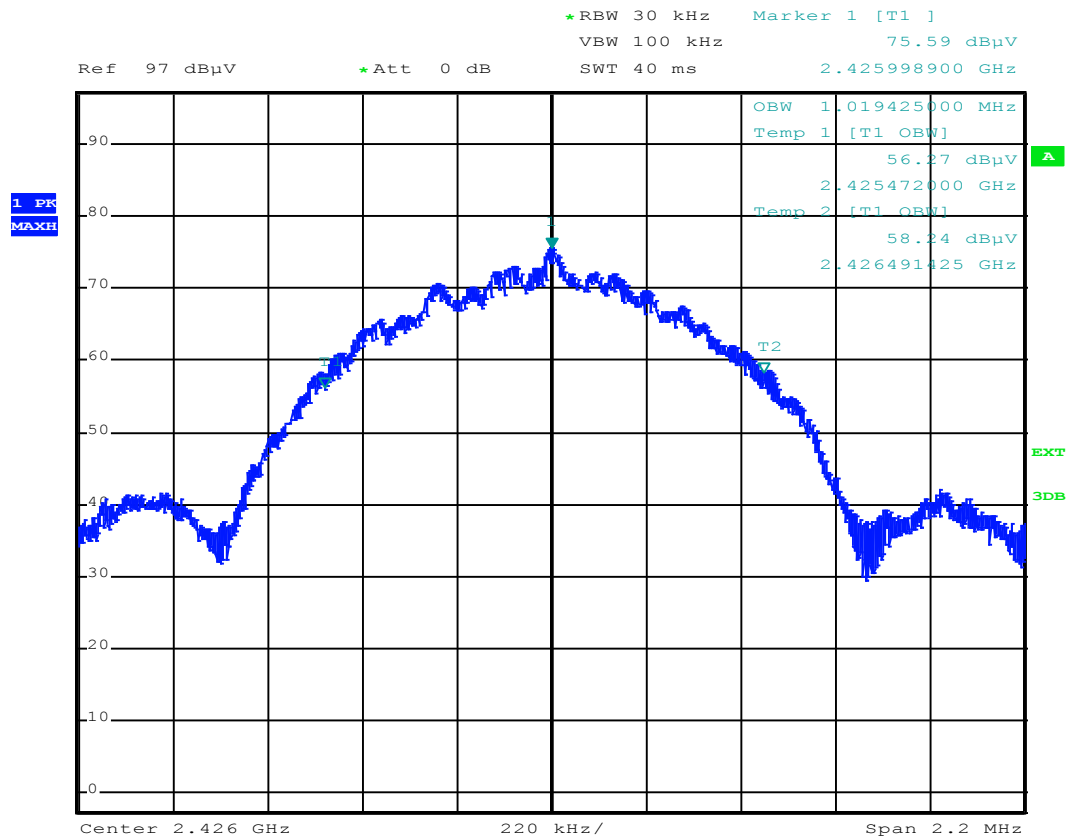


APPENDIX 3: 99% bandwidth

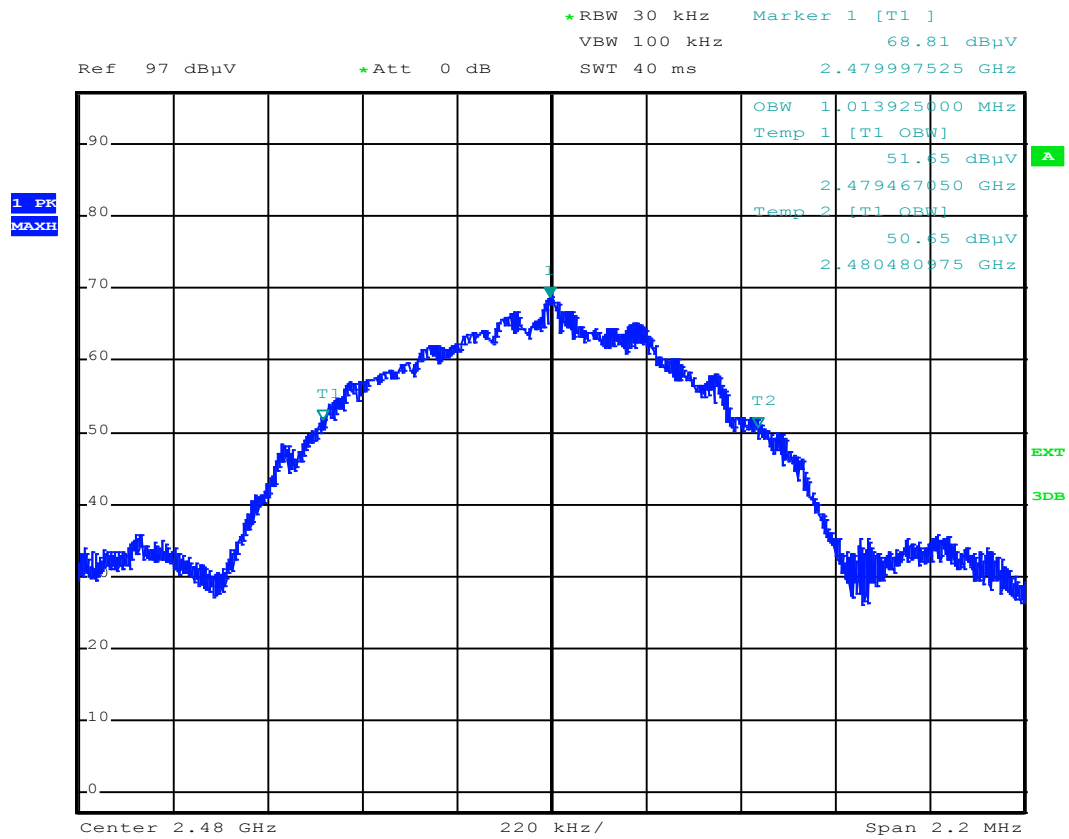
Low Channel



Central Channel

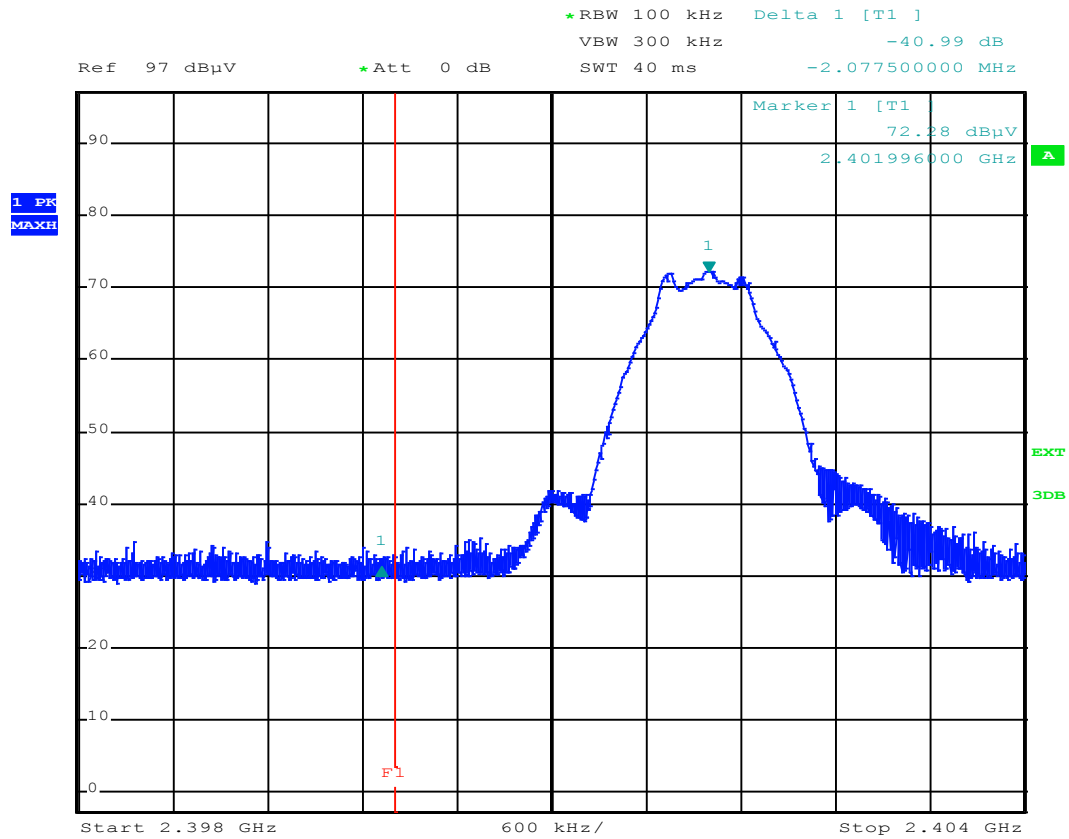


High Channel



APPENDIX 4: Band edge

Low Channel



High Channel

