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Equipment Authorization measurements on 2402-2480 MHz Transceiver Unit, Bluetooth Low Energy FCC ID: 2AB46-11515 (12 appendices)

Test object

Product name: Droples
Rev: 11515-B
Two different samples were used during the test:
Prototype #1 radiated sample
Prototype #2 conducted sample, temporary antenna connector

Summary

See Appendix 1 for general information and Appendix 12 for photos.
Emission measurements as specified below have been performed.

Standard	Compliant	Appendix	Remarks
FCC 47 CFR Part 15 C (07-10-08)			
15.247 Operation within the band 2400-2483.5 MHz	Yes		
IC RSS-210 Issue 8, December 2010	Yes		
Duty cycle measurements	N/A	2	
15.247 (a) (2) / RSS-210 A8.2(a) 6 dB bandwidth	Yes	3	
15.247 (b) (3) / RSS-210 A8.4(4) Maximum peak conducted power	Yes	4	
15.247 (d) / RSS-210 A8.5 20 dBc below fundamental	Yes	5	
15.247 (d) / RSS-210 A8.5 Restricted bands of operation	Yes	6	
15.247 (e) / RSS-210 A8.2(b) Power spectral density	Yes	7	
15.247 (i) / RSS-102 2.5.1 RF Safety	Yes	8	
15.215 (c) 20 dB bandwidth	Yes	9	
15.207 / RSS-Gen 7.2.4 Conducted emission limits	N/A		Note 1
2.1049 / RSS-Gen 4.6.1 Occupied bandwidth	Yes	10	
2.1049 / RSS-210 A8.5 Band Edge	Yes	11	

Note: Above RSS items are given as cross-reference only. Measurements were performed according to ANSI procedures referenced by FCC and covered by SP's accreditation.

Note 1: Test not applicable, only battery powered.

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FCC ID: 2AB46-11515

**SP Technical Research Institute of Sweden
Electronics - EMC**

Performed by



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Fredrik Isaksson

Examined by



Signed by: Anders Nordlöf
Reason: I have reviewed this document
Date & Time: 2014-05-19 12:39:14 +02:00

Anders Nordlöf

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Appendix 1

Performance test and requirements

The tests were performed to verify that Droplets meets the electromagnetic compatibility requirements of FCC 47 CFR part 15 C.

Test facility

The used anechoic chamber is compliant with the requirements of section 2.948 of the FCC rules and listed, registration number 96866, as a facility accepted for certification under parts 15 and 18. The site complies with RSS Gen, Issue 2 and is accepted by Industry Canada for the performance of radiated measurements, IC-file number 3482A-2.

Test object

The EUT is a Bluetooth Low Energy device, operating as a Digital Transmission System (DTS) with the following test relevant specification:

Transceiver:	Droplets
Antenna connector	Not applicable
Antenna:	Integral, PCB
Antenna gain, max:	2 dB
Frequency range:	2402-2480 MHz
Number of channels	40 (channel 0-39)
Frequencies used during test:	2402 MHz 2426 MHz 2440 MHz 2480 MHz
Modulation:	GFSK
Max power setting (used during the test):	0 dBm
Data rate:	1 Mbit/s
Supply voltage:	Nominal: 3.0 V DC, Battery
Battery type	Litium. CR2032

The radiated tests were performed with the internal battery. The conducted tests were performed with the external DC Power supply, HP E3632A SP503170, 3.0 V DC.

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Appendix 1

Measurement equipment

Measurement equipment	Calibration Due	SP number
Test site Edison	2016-12	504 114
R&S ESIB26 EMI Test Receiver	2014-07	503 885
R&S FSIQ Signal Analyser	2014-07	503 738
R&S ESU EMI Test Receiver	2014-07	901 385
Antenna Schaffner CBL 6143	2016-10	504 079
Horn antenna ETS Lindgren 3115	2016-03	902 212
Standard gain horn Flann 16240-25	-	503 939
Standard gain horn Flann 18240-25	-	503 900
Standard gain horn Flann 20240-20	-	503 674
Low Noise Amplifier Miteq	2015-01	503 277
Low Noise Amplifier Miteq	2015-02	504 160
High pass filter Wainwright	2014-07	504 200
Multimeter Fluke 85 III	2014-08	503 418
Multimeter Fluke 83	2014-08	501 522
Temperature and humidity meter Testo 625	2014-06	504 117
Temperature and humidity meter Testo 615	2014-06	503 498

Operational test mode

Justification measurements were performed with rotation of the EUT through three orthogonal axes to determine which orientation the EUT had the highest emission levels, see photos in Appendix 12.

The EUT was tested stand alone.

The following modes of the EUT were used during the tests:

- Advertising – Normal mode, not connected, transmitting at three channels, 2402, 2426 and 2480 MHz.
- Connected – Normal mode, connected to an external mobile phone, transmitting at all channels.
- Single channels with continuous transmission (100% duty cycle) and normal modulation at 2402, 2440 and 2480 MHz, separately.

For duty cycle measurements see appendix 2.

The duty cycle of the EUT was measured to:

Advertising mode, during 100 ms: $0.331 / 100 \text{ ms} = 0.0033 = 0.33\%$.

Connected mode, during 100 ms: $0.099 / 100 \text{ ms} = 0.0010 = 0.10\%$.

The lowest duty cycle correction factor (Advertising mode) was calculated to, $20 \log(0.331/100 \text{ ms}) = -49.6 \text{ dB}$.

The duty cycle correction factor was not used in this report.

The PRF was calculated to $\text{PRF} = 1/T = 1/106 \text{ ms} = 9 \text{ Hz}$, thus QP-detector was used without any correction for pulse desensitization.

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Appendix 1

Uncertainties

Measurement and test instrument uncertainties are described in the quality assurance documentation "SP QD 10885". The measurement uncertainties can be found in the table below. The uncertainties are calculated with a coverage factor $k=2$ (95% level of confidence). The measurement uncertainties can be found in the table below:

Method	Uncertainty
Radiated emission, 30 – 1000 MHz	4.8/5.6 dB (V/H-pol)
Radiated emission, 1 – 40 GHz	2.6 dB
Conducted emission	3.5 dB

Compliance evaluation is based on a shared risk principle with respect to the measurement uncertainty.

Reservation

The test results in this report apply only to the particular test object as declared in the report.

Delivery of test object

The test object was delivered: 2014-02-27

Test participant

Thomas Malm, Volantic AB (partly present)

Test engineers

Fredrik Isaksson and Ermin Pasalic, SP

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Appendix 2

Duty cycle measurements

Date 2014-02-28	Temperature 22 °C ± 3 °C	Humidity 30 % ± 5 %
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Test set-up and procedure

The measurements were performed according to ANSI C63.10-2009.

Conducted measurements were performed at the antenna connector and the test was performed with normal duty cycle, normal modulation and both in Advertising and Connected mode.

Measurement equipment	SP number
Test site, Edison	504 114
Signal analyzer R&S FSIQ	503 738
Multimeter Fluke 83	501 522
Temperature and humidity meter Testo 625	504 117

Results

The duty cycle measurements can be found in the diagrams below:

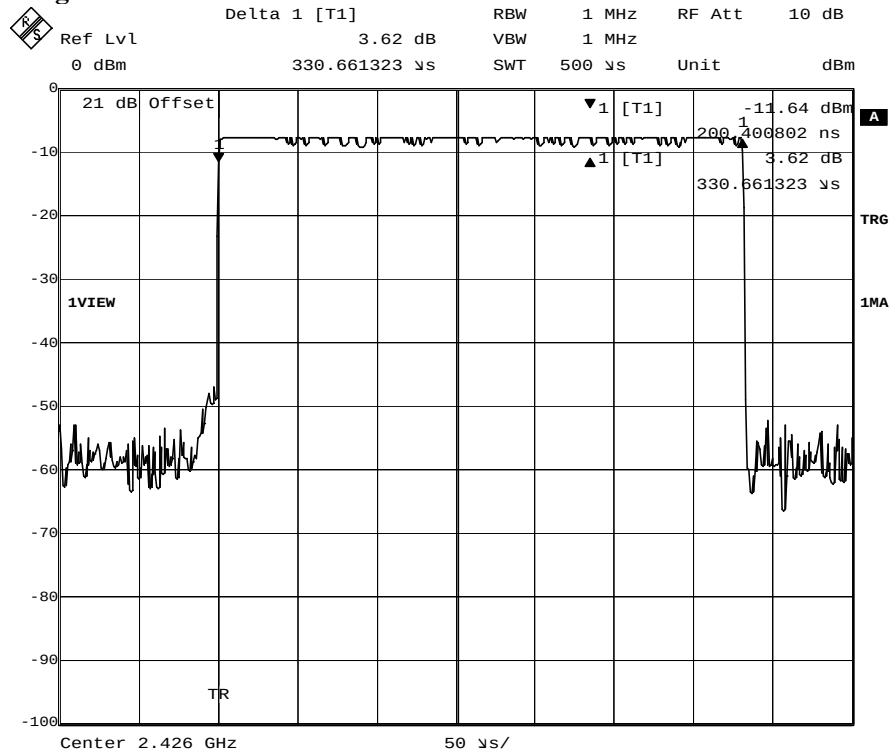
Diagram 1	Advertising mode	Tx on at 2426 MHz
Diagram 2	Advertising mode	Period time at 2426 MHz
Diagram 3	Connected mode	Tx on at 2408 MHz
Diagram 4	Connected mode	Period time at 2408 MHz

Complies?	N/A
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Appendix 2

Diagram 1

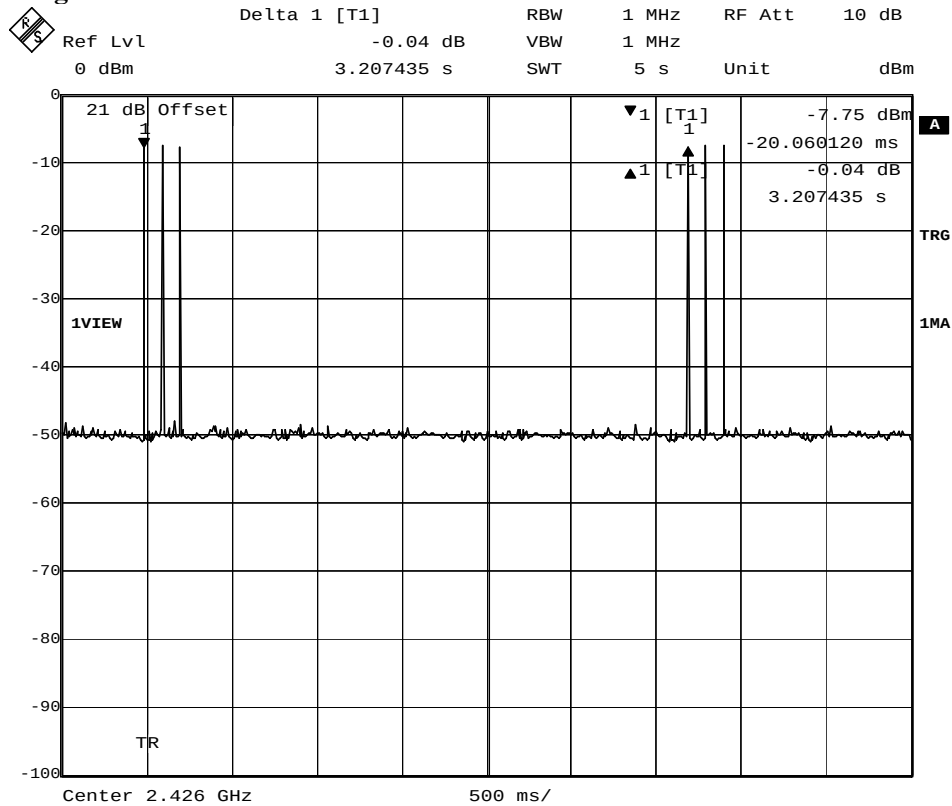


Date: 28.FEB.2014 10:49:01

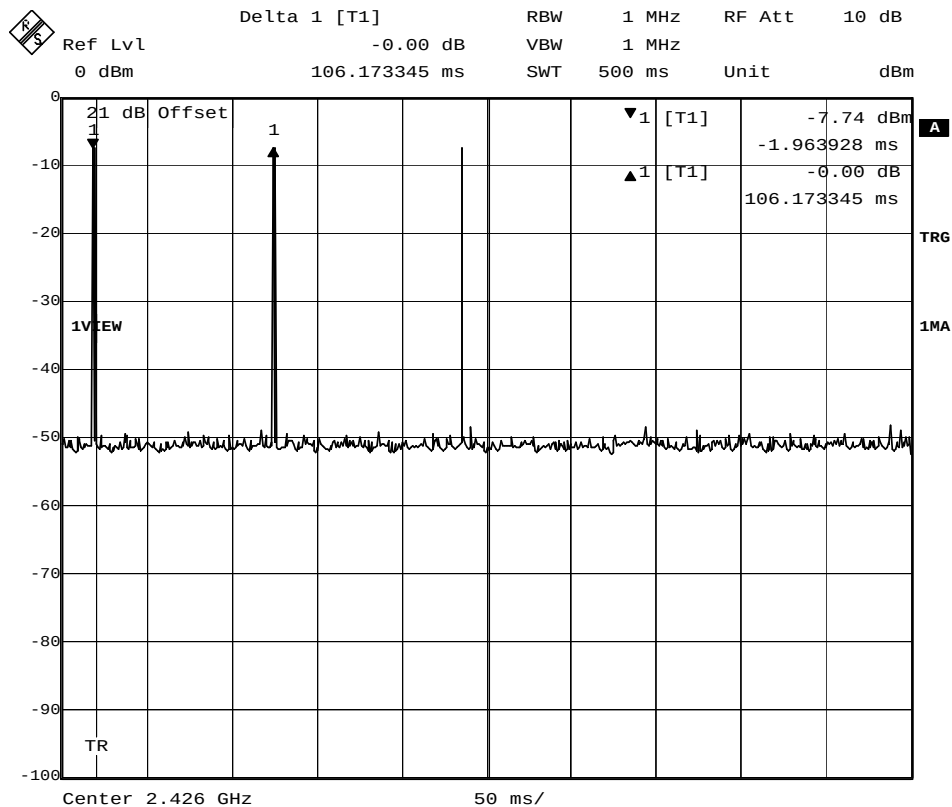
FCC ID: 2AB46-11515

Appendix 2

Diagram 2



Date: 28.FEB.2014 10:44:25

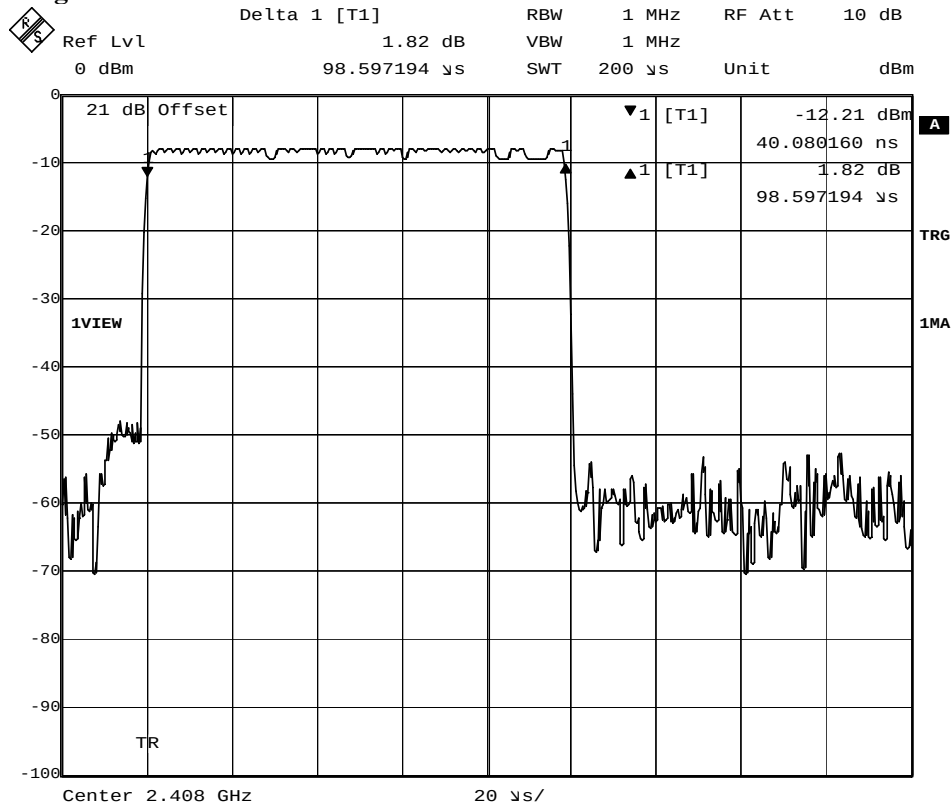


Date: 28.FEB.2014 10:46:22

FCC ID: 2AB46-11515

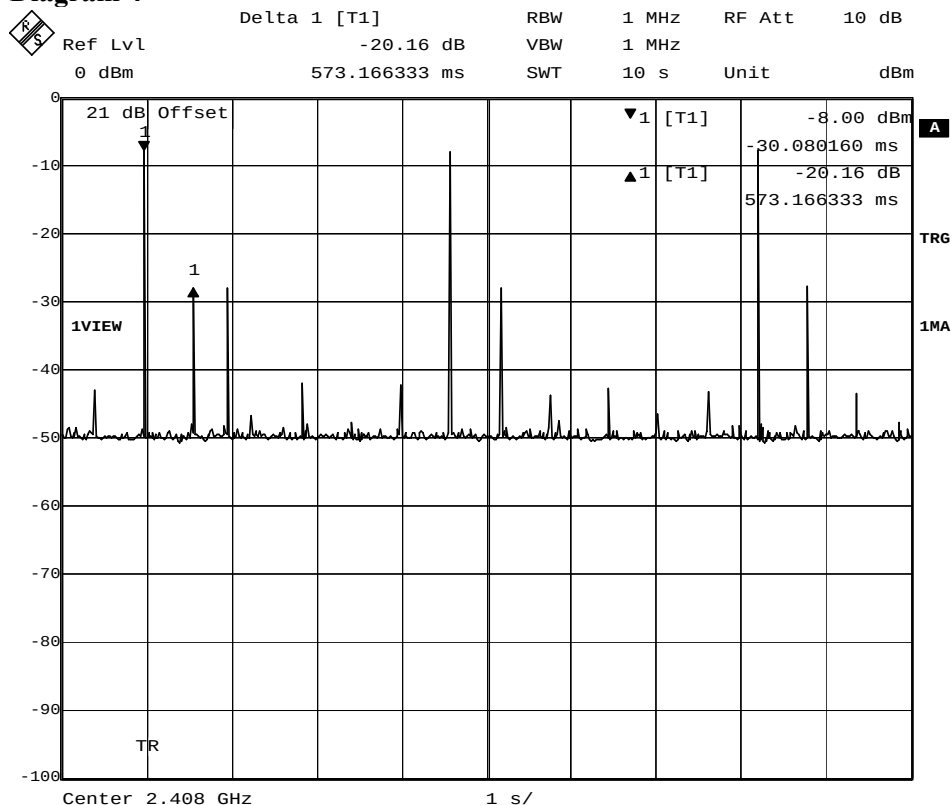
Appendix 2

Diagram 3



Date: 28.FEB.2014 11:34:22

Diagram 4



Date: 28.FEB.2014 11:27:16

FCC ID: 2AB46-11515

Appendix 3

6 dB bandwidth measurements according to FCC 47 CFR part 15.247 (a) (2) / RSS-210 A8.2(a)

Date 2014-03-18	Temperature 22 °C ± 3 °C	Humidity 30 % ± 5 %
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Test set-up and procedure

The measurements were performed according to ANSI C63.10-2009 and the guideline 558074 D01 DTS Meas Guidance, April 9, 2013.

Conducted measurements were performed at the temporary antenna connector with continuous transmission (100% duty cycle) and with normal modulation.

Measurement equipment	SP number
Test site, Edison	504 114
Signal analyzer R&S FSIQ	503 738
Multimeter Fluke 83	501 522
Temperature and humidity meter Testo 625	504 117

Measurement uncertainty: 2.6 %**Results**

6 dB measurements can be found in the diagrams below:

Diagram 1 2402 MHz 6 dBW = **726.45 kHz**
Diagram 2 2440 MHz 6 dBW = **716.43 kHz**
Diagram 3 2480 MHz 6 dBW = **736.47 kHz**

Limits

According to 47CFR 15.247(a)(2), the minimum 6 dB bandwidth shall be at least 500 kHz.

According to RSS-210 A8.2(a), the minimum -6 dB bandwidth shall be at least 500 kHz.

Complies?	Yes
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Appendix 3

Diagram 1

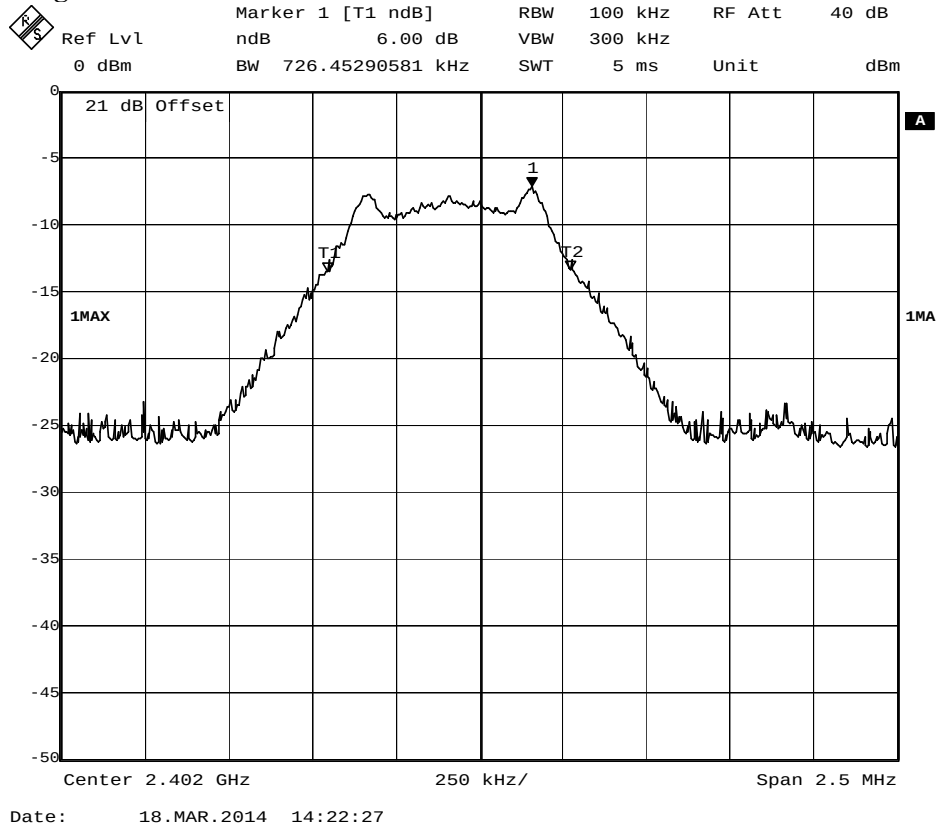
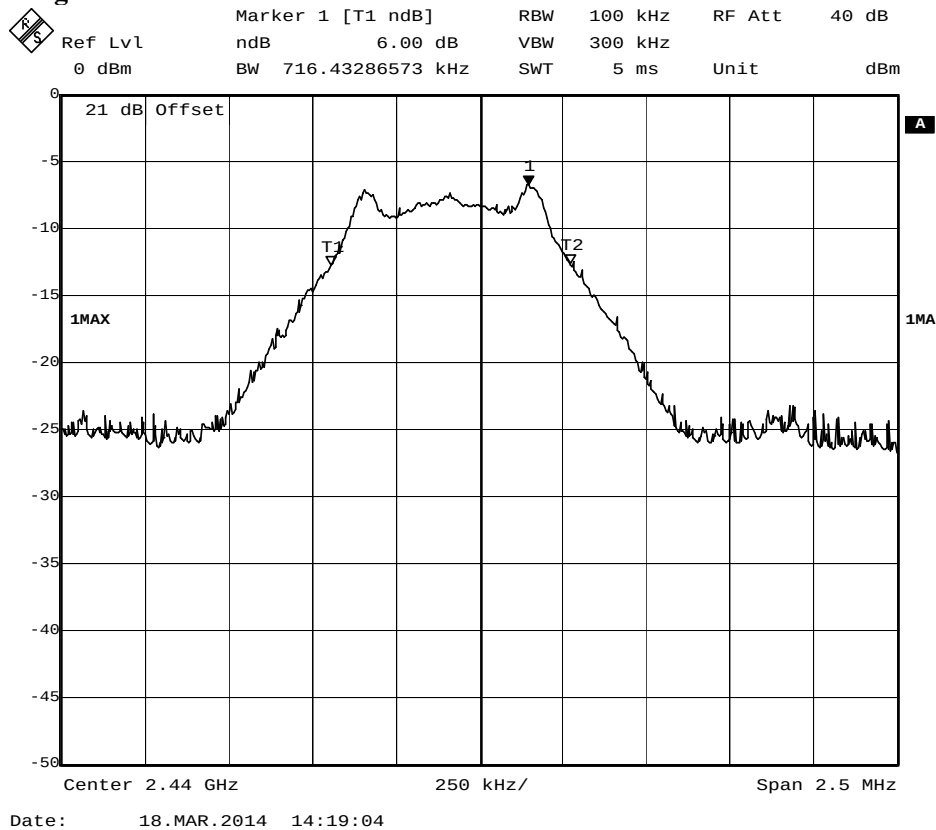


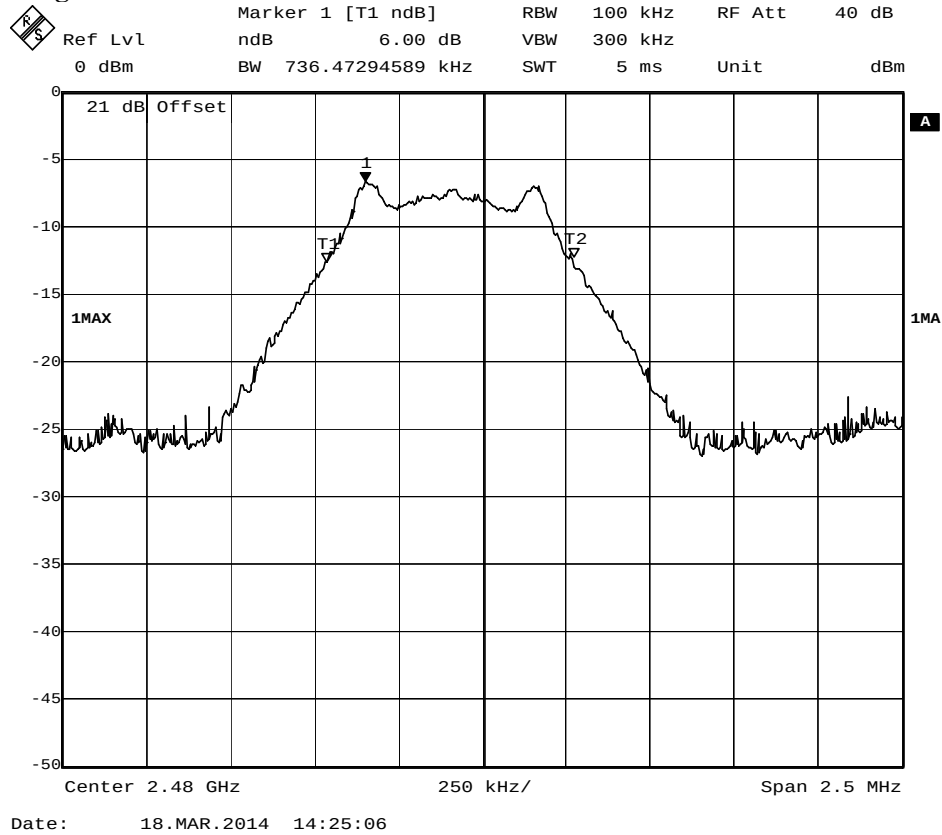
Diagram 2



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Appendix 3

Diagram 3



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Appendix 4

**Maximum peak output power measurements according to
FCC 47 CFR part 15.247 (b) (3) / RSS 210-210 A8.4(4)**

Date	Temperature	Humidity
2014-02-27	22 °C ± 3 °C	33 % ± 5 %
2014-03-19	22 °C ± 3 °C	27 % ± 5 %

Test set-up and procedure

The measurements were performed according to ANSI C63.10-2009 and the guideline 558074 D01 DTS Meas Guidance, April 9, 2013.

The test was performed with continuous transmission (100% duty cycle) and with normal modulation.

The test was performed both radiated and conducted, conducted tests were performed at the temporary antenna connector.

The test of radiated emission was performed in a semi anechoic chamber. The measurements were performed with both horizontal and vertical polarizations of the antenna. The antenna distance was 3.0 m.

The fundamental was scanned with PEAK-detector with the antenna height was varied between 1-4 m and the turntable was rotated between 0-360 degrees for maximum response. The antenna distance during the measurements was 3.0 m

The maximum peak conducted output power was measured with a spectrum analyser with a RBW ≥ DTS (6 dB) bandwidth.

Test set-up photos during the tests can be found in Appendix 12.

Radiated test:

Measurement equipment	SP number
Semi anechoic chamber, Edison	504 114
Spectrum analyzer R&S ESI 26	503 885
EMI measurement computer	-
Software: R&S EMC32, ver. 8.53.0	902 212
Horn antenna ETS Lindgren 3115	501 548
Multimeter Fluke 83	501 522
Temperature and humidity meter Testo 625	504 117

Conducted test:

Measurement equipment	SP number
Test site, Galvani	15:117
Signal analyzer R&S FSIQ	503 738
Multimeter Fluke 85 III	503 418
Temperature and humidity meter Testo 615	503 498

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Appendix 4

Results

RBW=1 MHz (greater than 6 dB BW)

		Max peak radiated output power Peak detector		
		2402 MHz	2440 MHz	2480 MHz
	EUT pos	2	2	2
	Antenna height	2.00	2.00	1.88
	Azimuth	102	91	91
	Polarization	Horizontal	Horizontal	Horizontal
T_{nom} 22°C	V_{nom} 3.0 V DC	93.9 dB μ V/m	93.2 dB μ V/m	90.8 dB μ V/m
		Max peak conducted output power Peak detector		
		2402 MHz	2440 MHz	2480 MHz
T_{nom} 22°C	V_{nom} 3.0 V DC	0.19 mW	0.22 mW	0.22 mW

Note: According 47CFR 15.31(e), for intentional radiators, measurements of the variation of the input power or the radiated signal level of the fundamental frequency component of the emission, as appropriate, shall be performed with the supply voltage varied between 85% and 115% of the nominal rated supply voltage. For battery operated equipment, the equipment tests shall be performed using a new battery.

Limits

According to 47CFR 15.247(b)(3), for systems using digital modulation in the 2400-2483.5 MHz band: 1 Watt (30 dBm).

According to RSS-210 A8.4(4), for systems employing digital modulation techniques in the 2400-2483.5 MHz, the maximum peak conducted output power shall not exceed 1 Watt (30 dBm).

Complies?	Yes
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Appendix 5

20 dBc below fundamental measurements according to FCC 47 CFR part 15.247 (d) / RSS-210 A8.5

Date 2014-03-19	Temperature 22 °C ± 3 °C	Humidity 27 % ± 5 %
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Test set-up and procedure

The measurements were performed according to ANSI C63.10-2009 and the guideline 558074 D01 DTS Meas Guidance, April 9, 2013.

Conducted measurements were performed at the temporary antenna connector with continuous transmission (100% duty cycle) and with normal modulation.

The test was performed with peak detector and with RBW=100 kHz. The EMI Test Receiver was set to 30001 sweep points/measurements points during the test.

Measurement equipment	SP number
Test site, Galvani	15:117
EMI Test Receiver R&S ESU	901 385
Multimeter Fluke 85 III	503 418
Temperature and humidity meter Testo 615	503 498

Measurement uncertainty: 2.6 dB**Results**

The measurements can be found in the diagrams below:

Diagram 1:	2402 MHz	Fundamental
Diagram 2:	2402 MHz	9 kHz–3 GHz
Diagram 3:	2402 MHz	3-6 GHz
Diagram 4:	2402 MHz	6-9 GHz
Diagram 5:	2402 MHz	9-12 GHz
Diagram 6:	2402 MHz	12-15 GHz
Diagram 7:	2402 MHz	15-18 GHz
Diagram 8:	2402 MHz	18-21 GHz
Diagram 9:	2402 MHz	21-24 GHz
Diagram 10:	2402 MHz	24-27 GHz

Diagram 11:	2440 MHz	Fundamental
Diagram 12:	2440 MHz	9 kHz–3 GHz
Diagram 13:	2440 MHz	3-6 GHz
Diagram 14:	2440 MHz	6-9 GHz
Diagram 15:	2440 MHz	9-12 GHz
Diagram 16:	2440 MHz	12-15 GHz
Diagram 17:	2440 MHz	15-18 GHz
Diagram 18:	2440 MHz	18-21 GHz
Diagram 19:	2440 MHz	21-24 GHz
Diagram 20:	2440 MHz	24-27 GHz

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Appendix 5

Diagram 21:	2480 MHz	Fundamental
Diagram 22:	2480 MHz	9 kHz–3 GHz
Diagram 23:	2480 MHz	3-6 GHz
Diagram 24:	2480 MHz	6-9 GHz
Diagram 25:	2480 MHz	9-12 GHz
Diagram 26:	2480 MHz	12-15 GHz
Diagram 27:	2480 MHz	15-18 GHz
Diagram 28:	2480 MHz	18-21 GHz
Diagram 29:	2480 MHz	21-24 GHz
Diagram 30:	2480 MHz	24-27 GHz

Limits

According to 47CFR 15.247(d), 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, based on either an RF conducted or a radiated measurement, provided the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, as permitted under paragraph (b)(3) of this section, the attenuation required under this paragraph shall be 30 dB instead of 20 dB.

Radiated emissions which fall in the restricted bands, as defined in Section 15.205(a), must also comply with the radiated emission limits specified in Section 15.209(a).

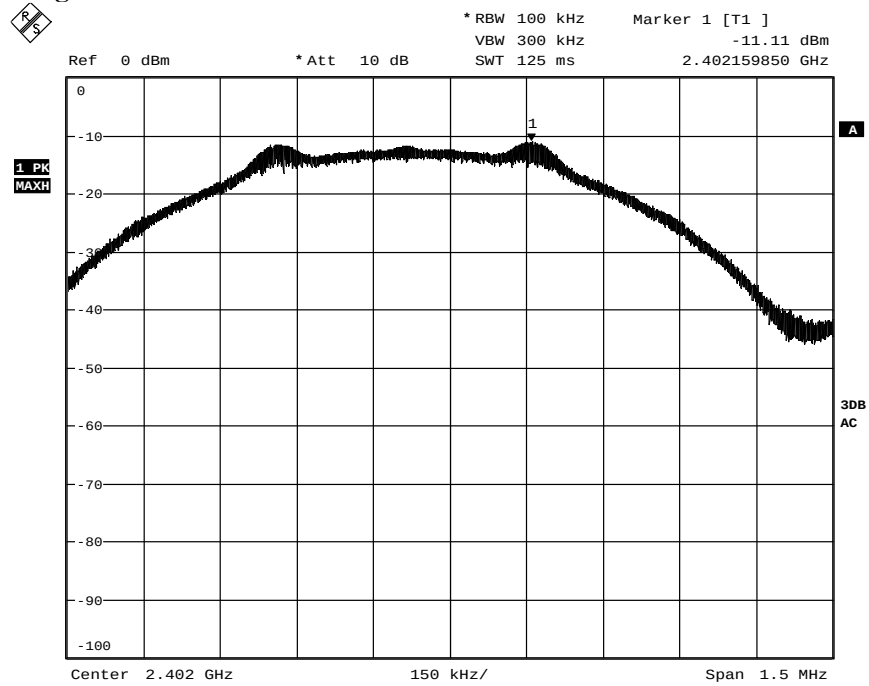
According to RSS-210 A8.5, in any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the RF power that is produced shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided that the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of root-mean square averaging over a time interval, as permitted under Section A8.4(4), the attenuation required shall be 30 dB instead of 20 dB. Attenuation below the general field strength limits specified in RSS-Gen is not required.

Complies?	Yes
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FCC ID: 2AB46-11515

Appendix 5

Diagram 1

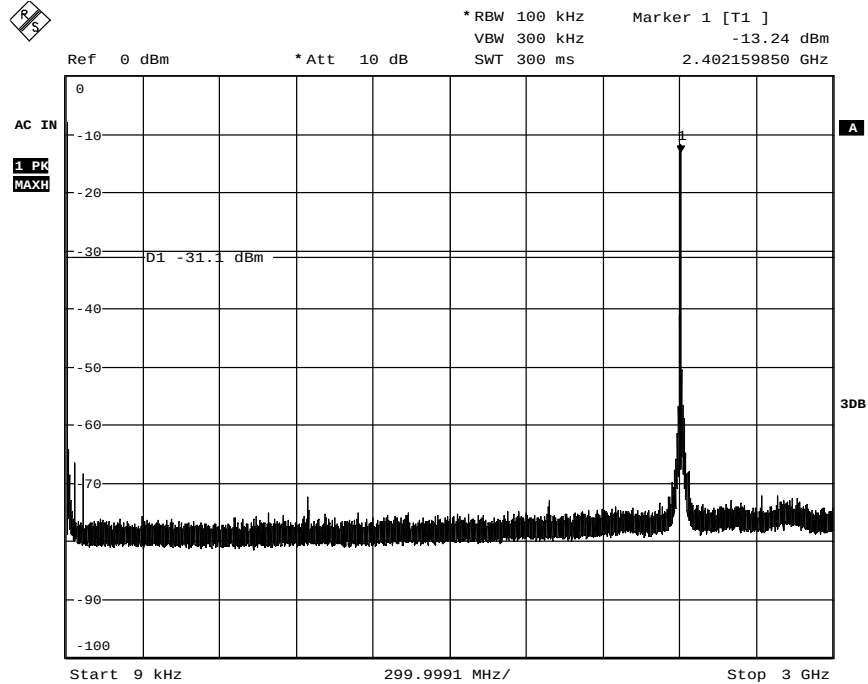


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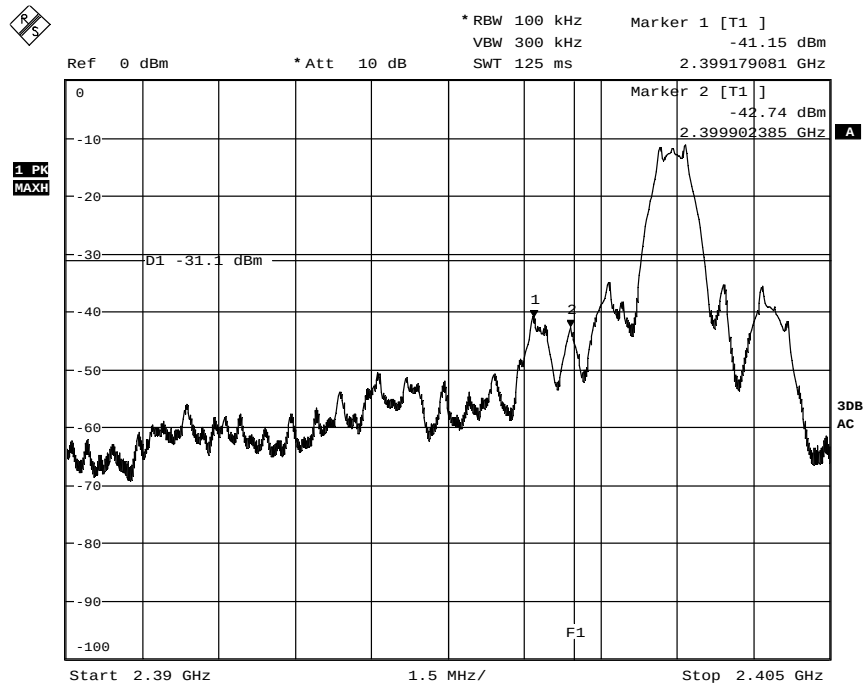
FCC ID: 2AB46-11515

Appendix 5

Diagram 2



Date: 19.MAR.2014 10:06:16

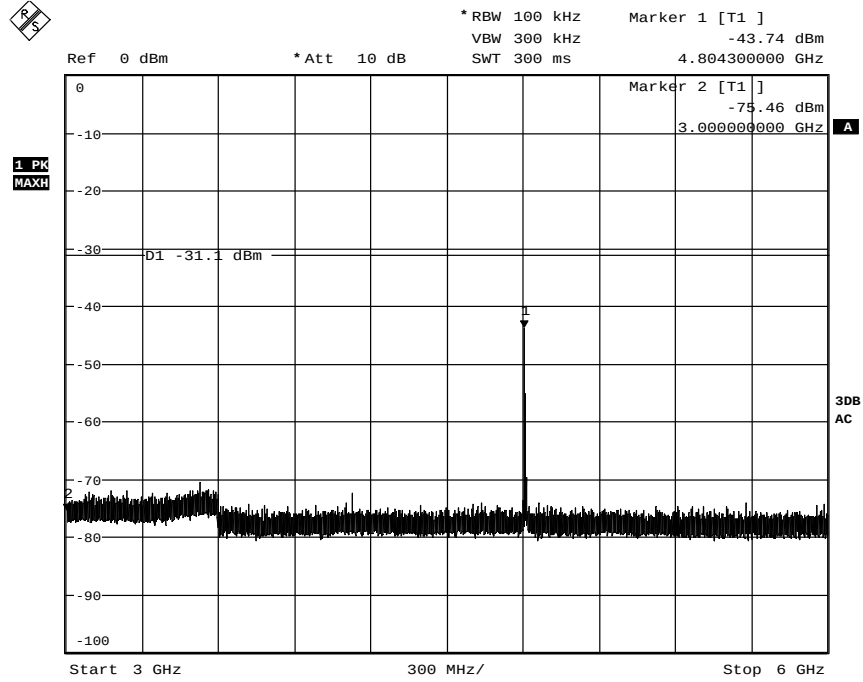


Date: 19.MAR.2014 10:31:53

FCC ID: 2AB46-11515

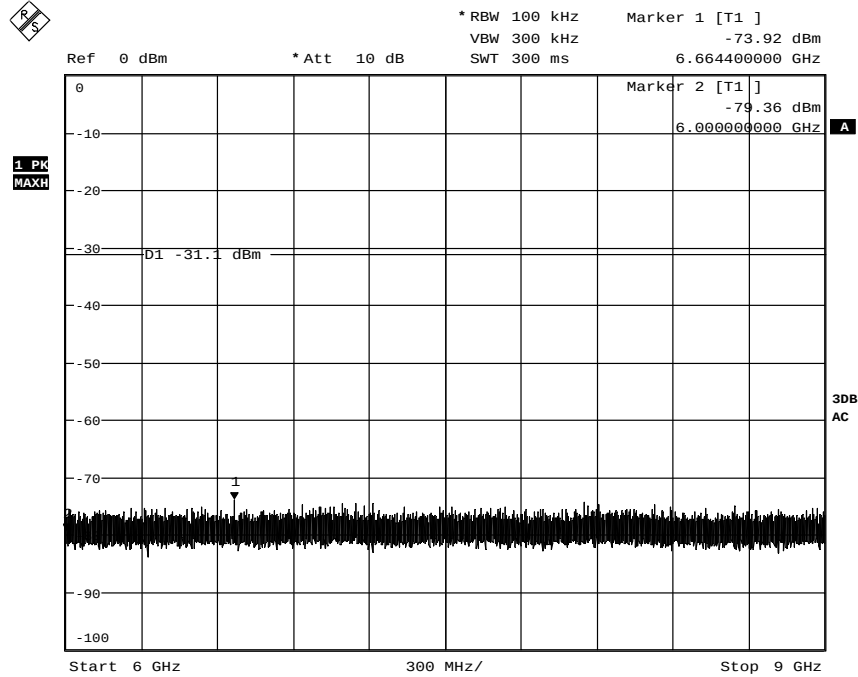
Appendix 5

Diagram 3



Date: 19.MAR.2014 10:34:24

Diagram 4

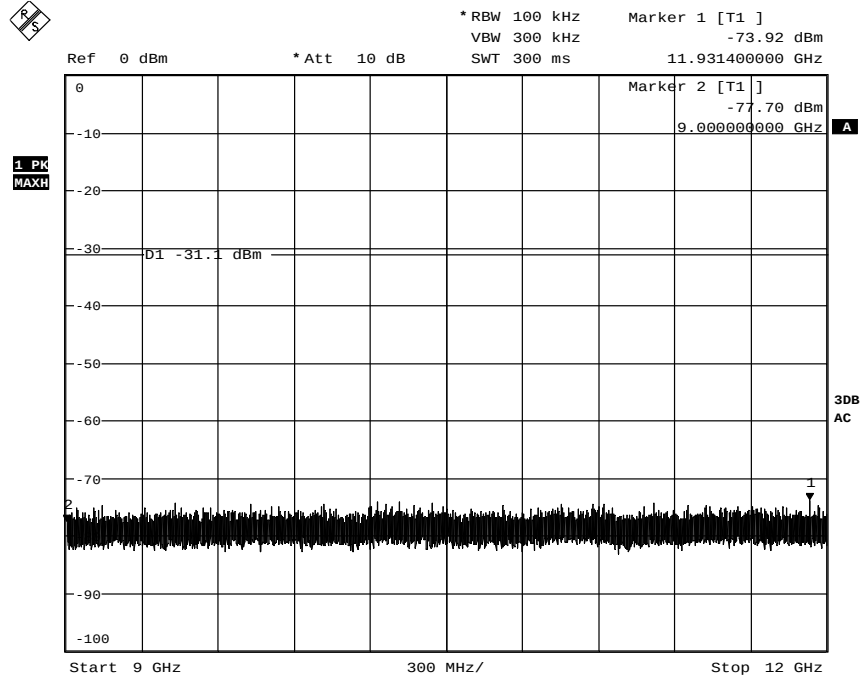


Date: 19.MAR.2014 10:35:08

FCC ID: 2AB46-11515

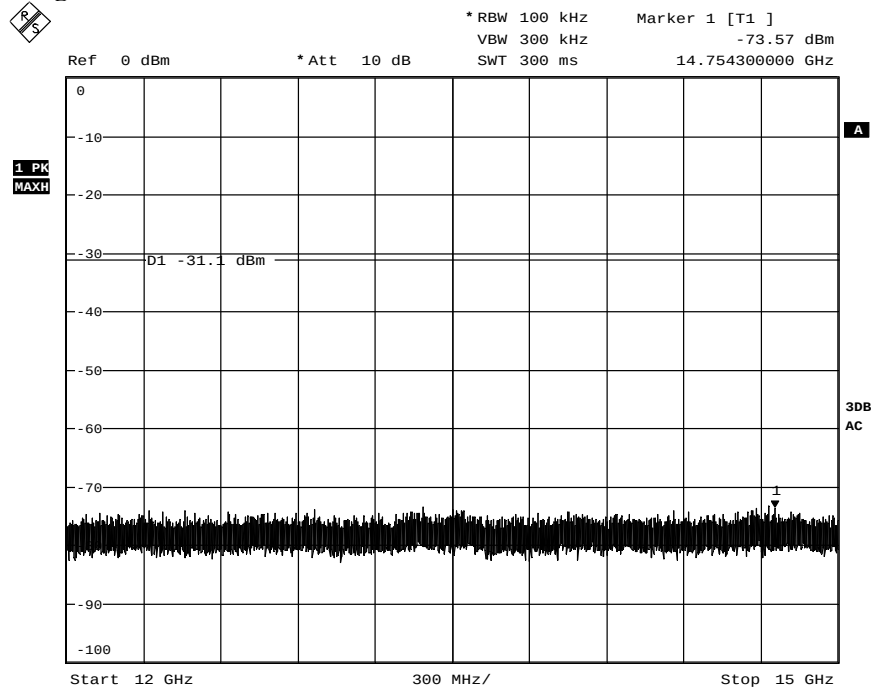
Appendix 5

Diagram 5



Date: 19.MAR.2014 10:36:40

Diagram 6

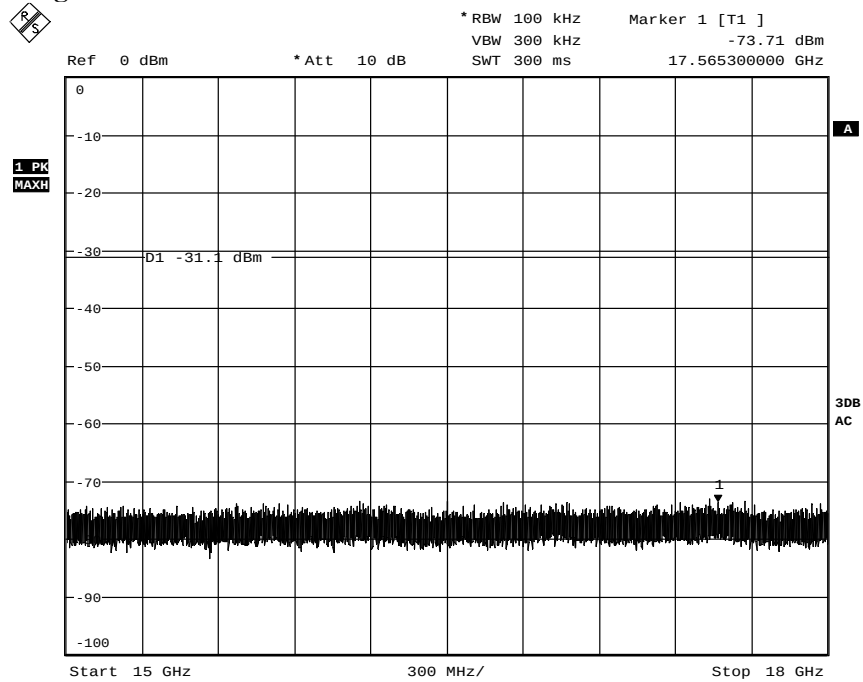


Date: 19.MAR.2014 10:37:16

FCC ID: 2AB46-11515

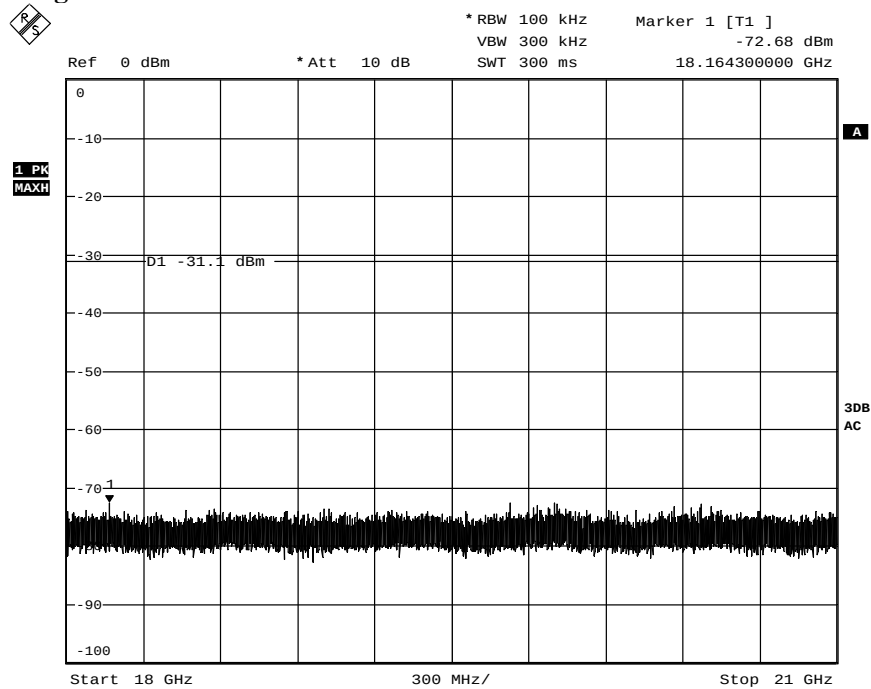
Appendix 5

Diagram 7



Date: 19.MAR.2014 10:38:04

Diagram 8

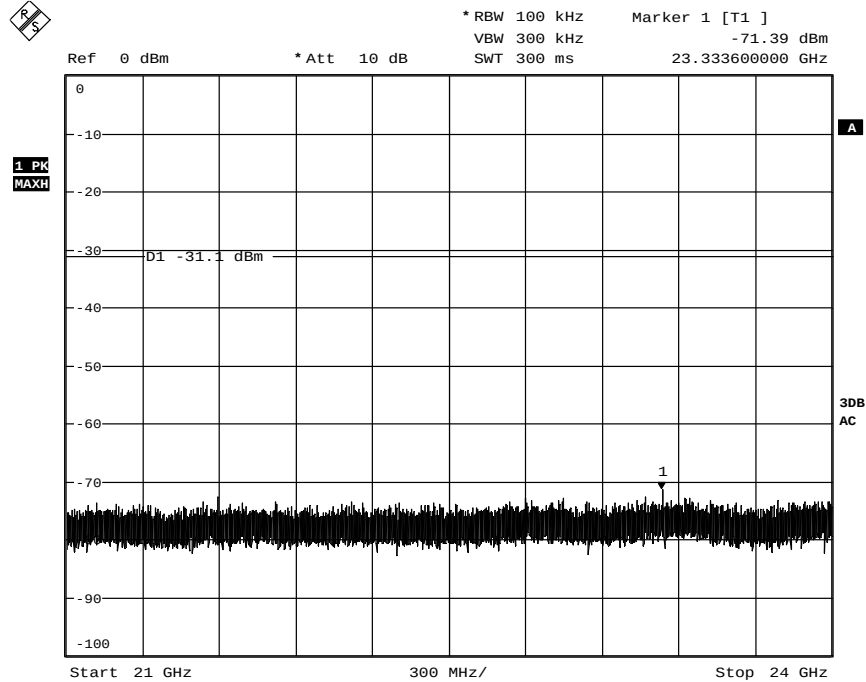


Date: 19.MAR.2014 10:38:41

FCC ID: 2AB46-11515

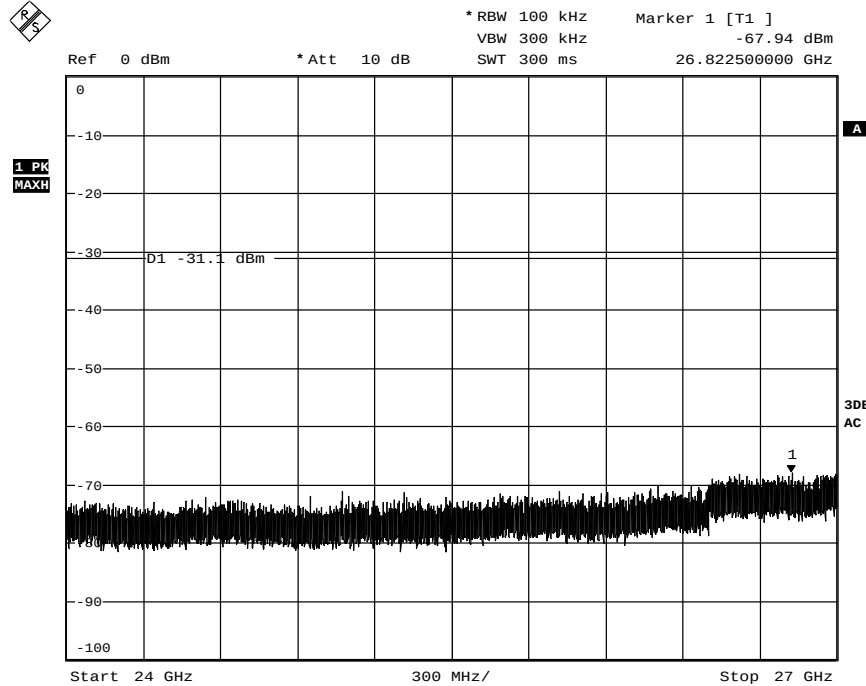
Appendix 5

Diagram 9



Date: 19.MAR.2014 10:39:19

Diagram 10

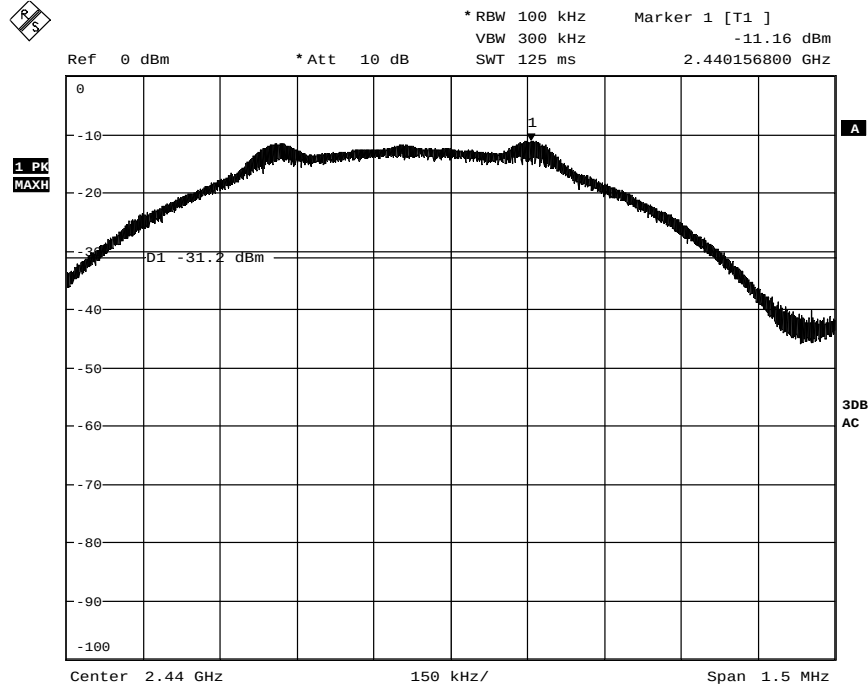


Date: 19.MAR.2014 10:39:52

FCC ID: 2AB46-11515

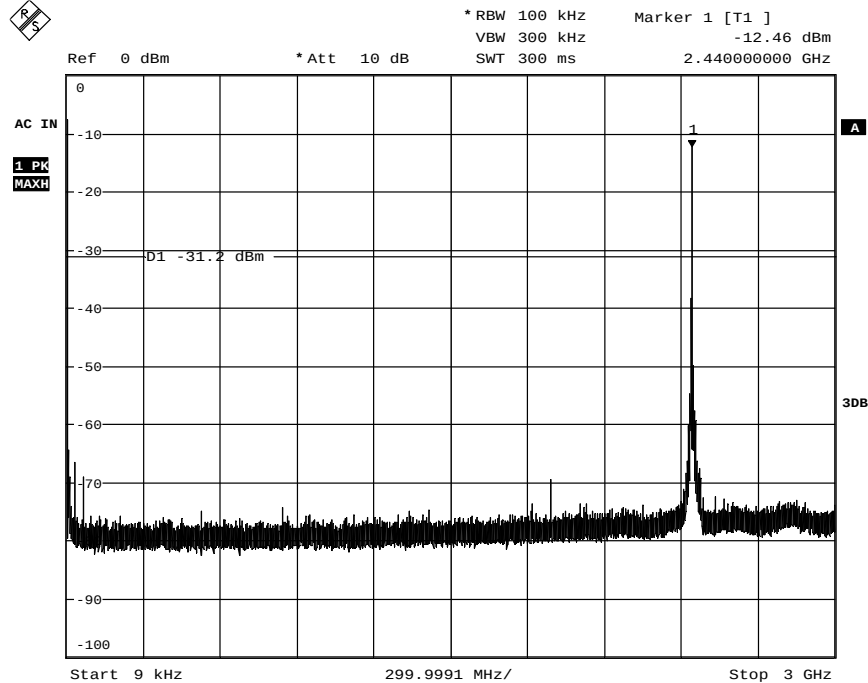
Appendix 5

Diagram 11



Date: 19.MAR.2014 09:28:56

Diagram 12

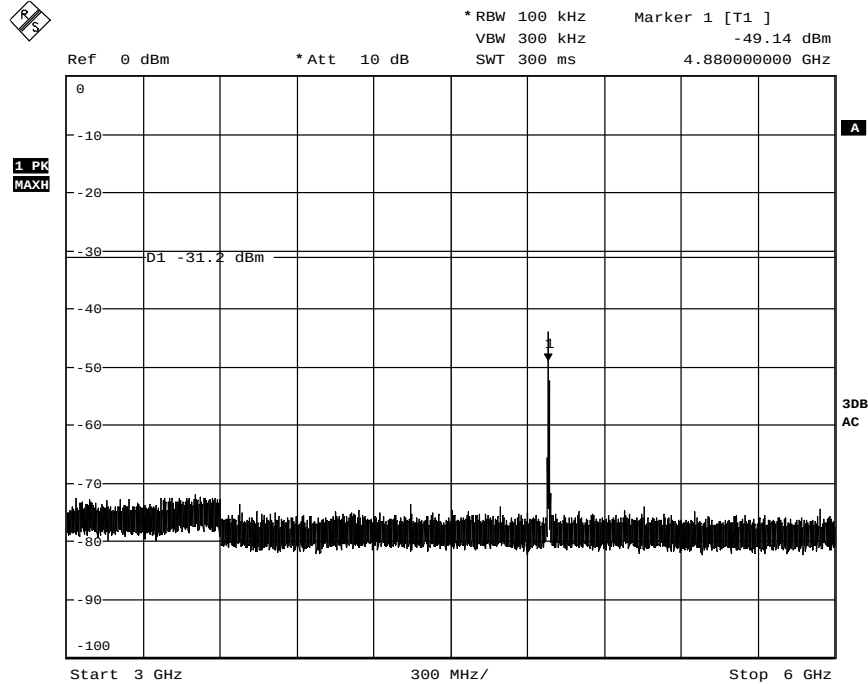


Date: 19.MAR.2014 09:31:51

FCC ID: 2AB46-11515

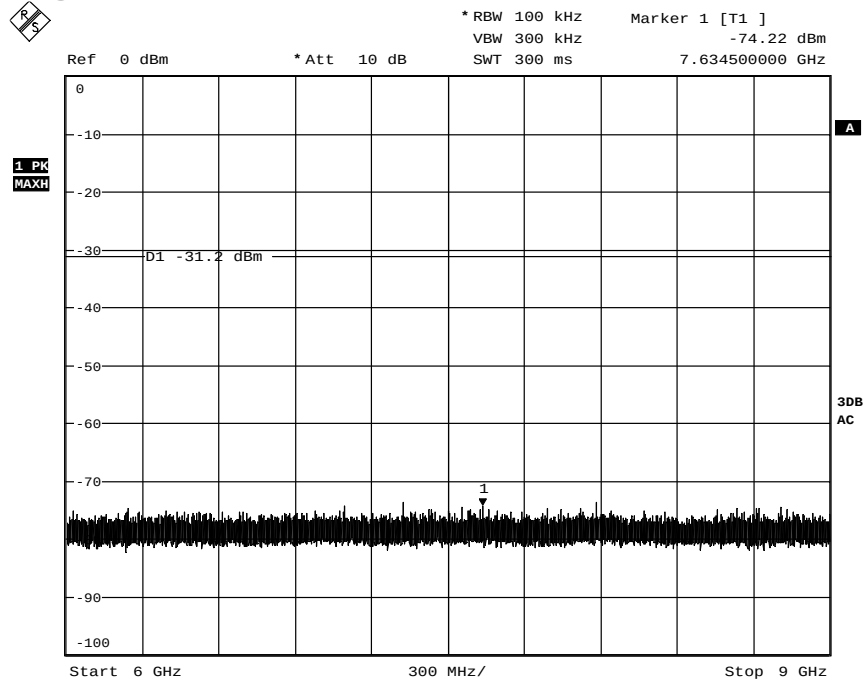
Appendix 5

Diagram 13



Date: 19.MAR.2014 09:36:40

Diagram 14

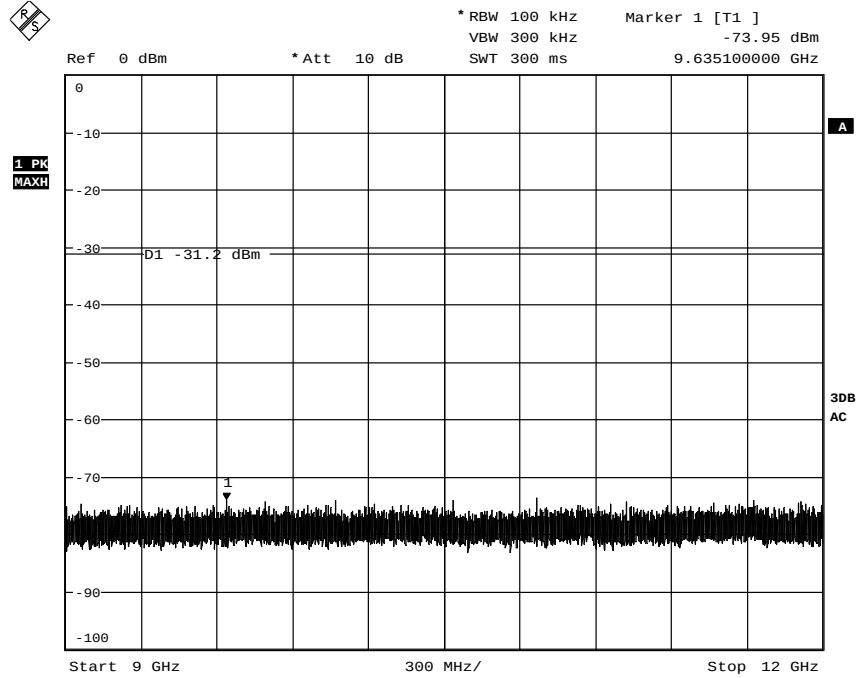


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FCC ID: 2AB46-11515

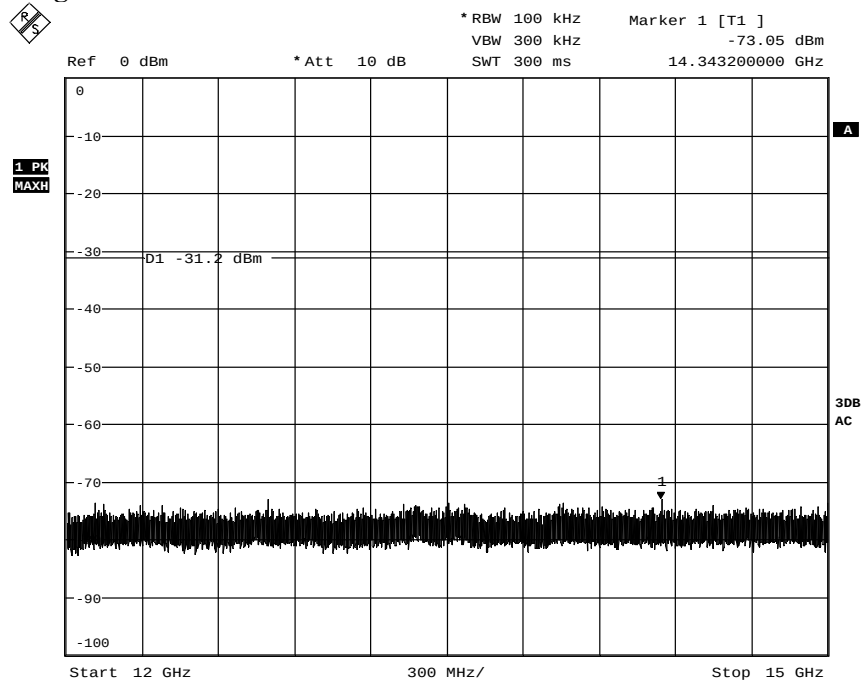
Appendix 5

Diagram 15



Date: 19.MAR.2014 09:38:42

Diagram 16

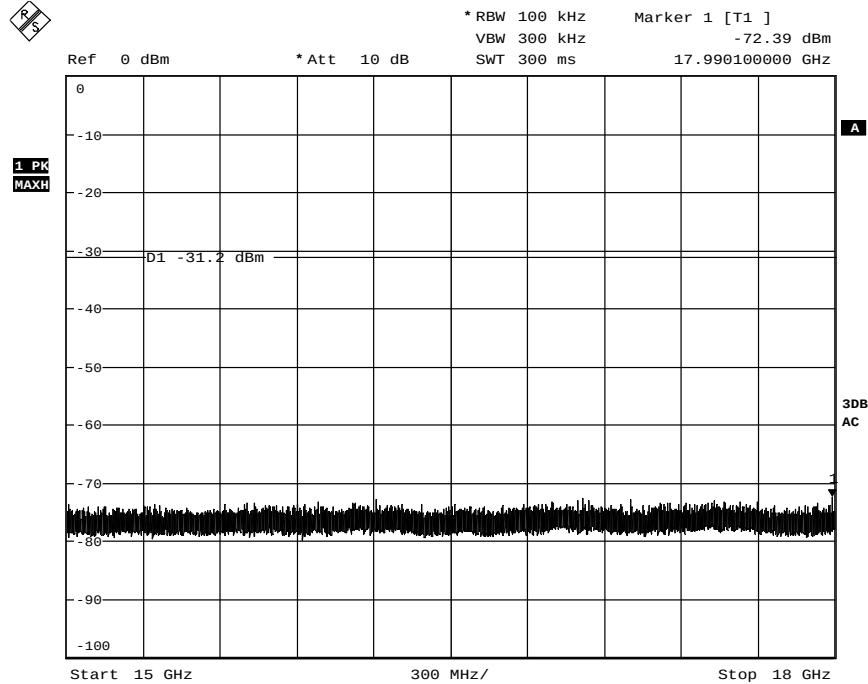


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FCC ID: 2AB46-11515

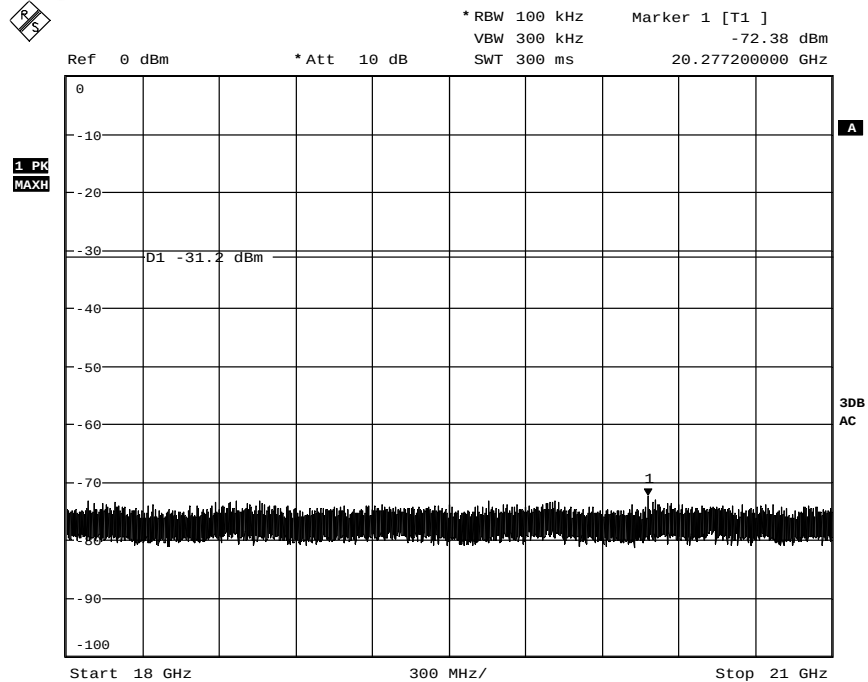
Appendix 5

Diagram 17



Date: 19.MAR.2014 09:41:15

Diagram 18

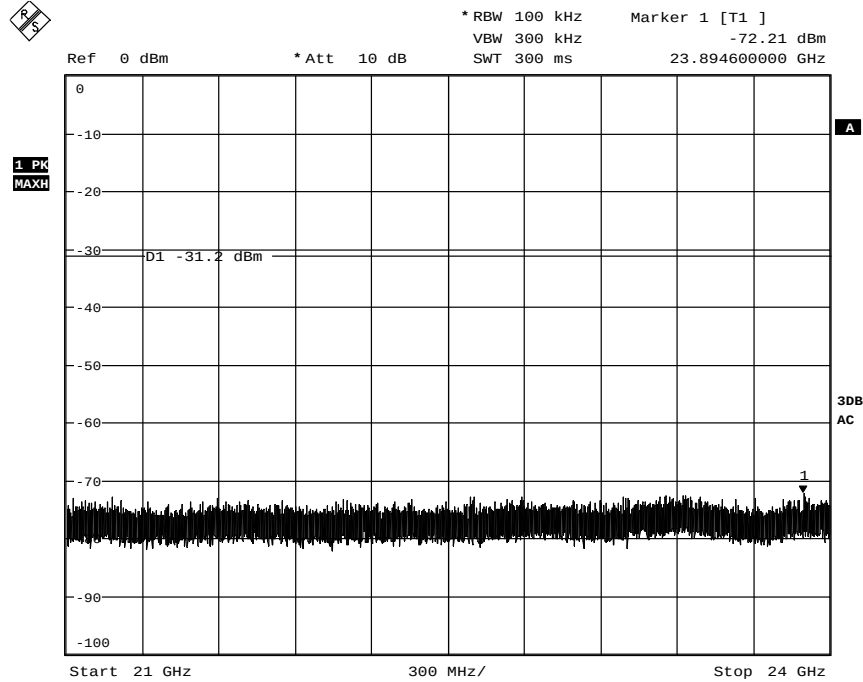


Date: 19.MAR.2014 09:42:47

FCC ID: 2AB46-11515

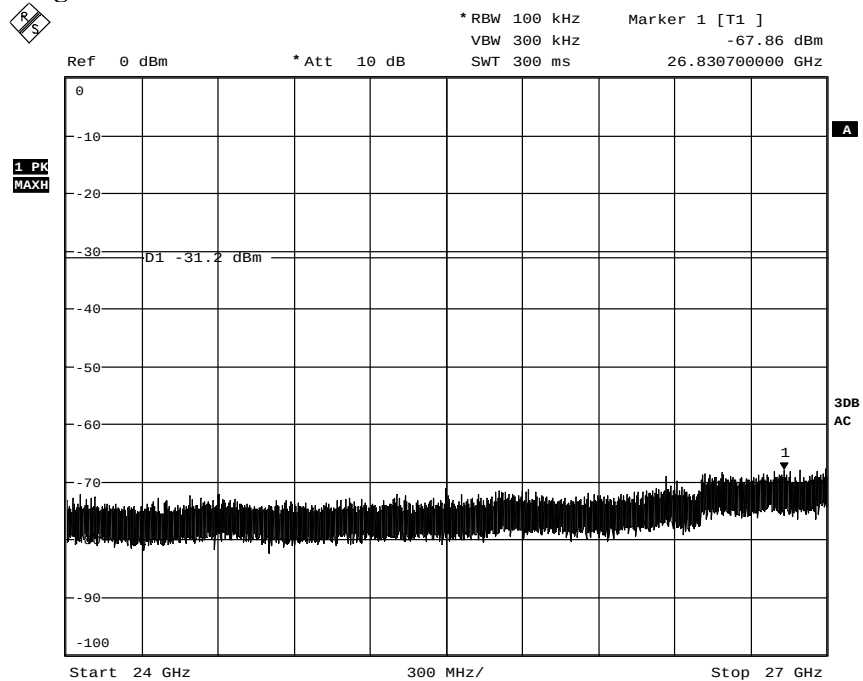
Appendix 5

Diagram 19



Date: 19.MAR.2014 09:43:23

Diagram 20

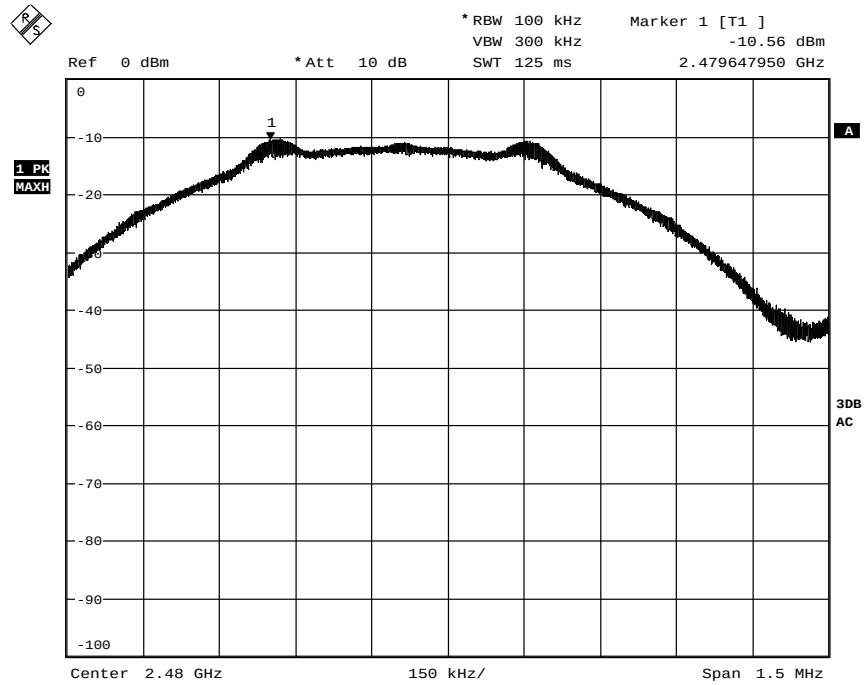


Date: 19.MAR.2014 09:44:18

FCC ID: 2AB46-11515

Appendix 5

Diagram 21

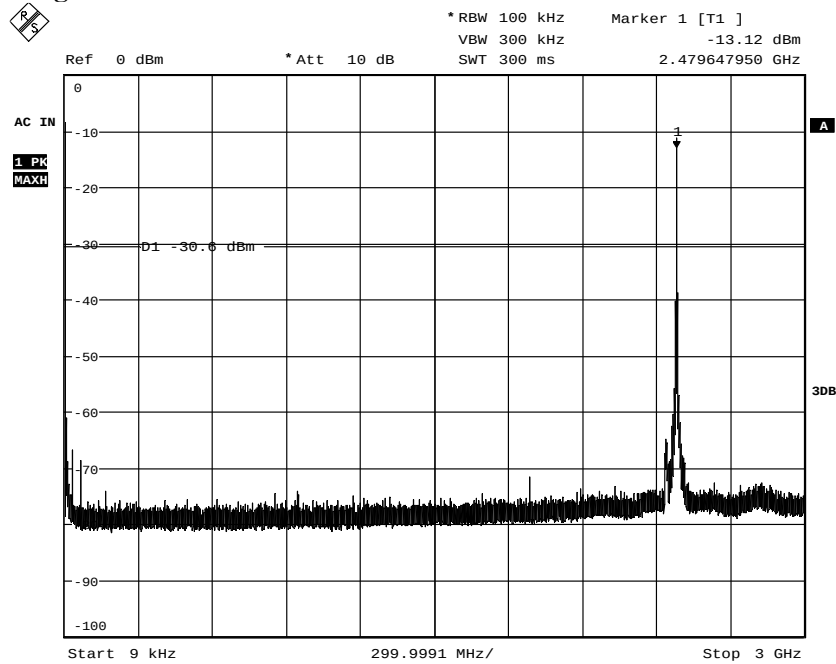


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FCC ID: 2AB46-11515

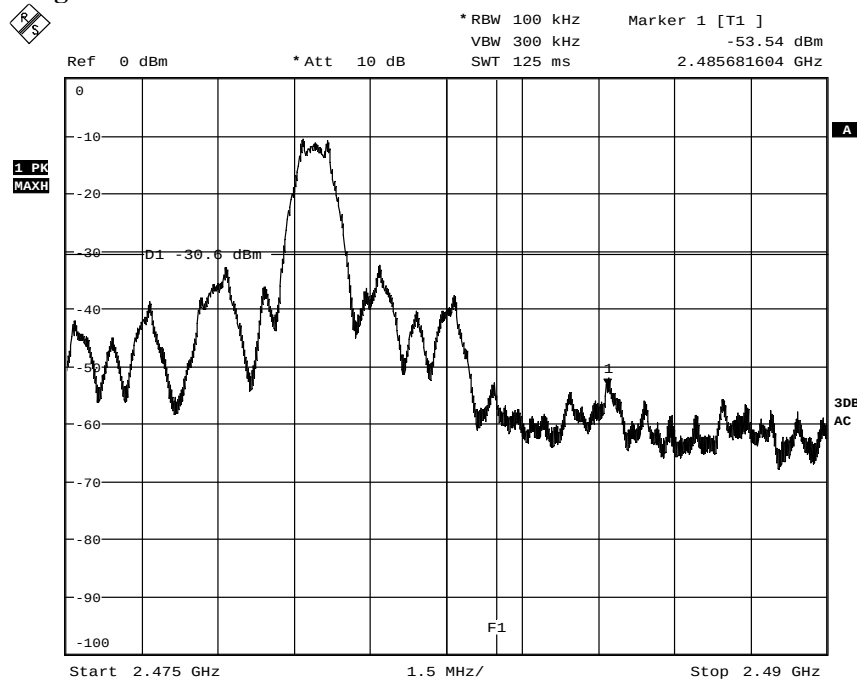
Appendix 5

Diagram 22



Date: 19.MAR.2014 10:50:27

Diagram 23

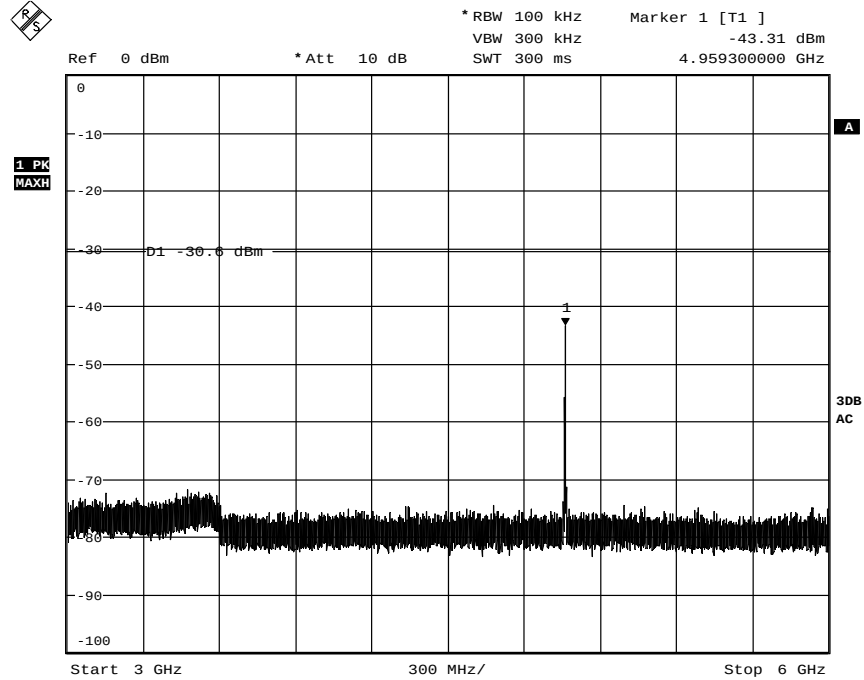


Date: 19.MAR.2014 10:53:11

FCC ID: 2AB46-11515

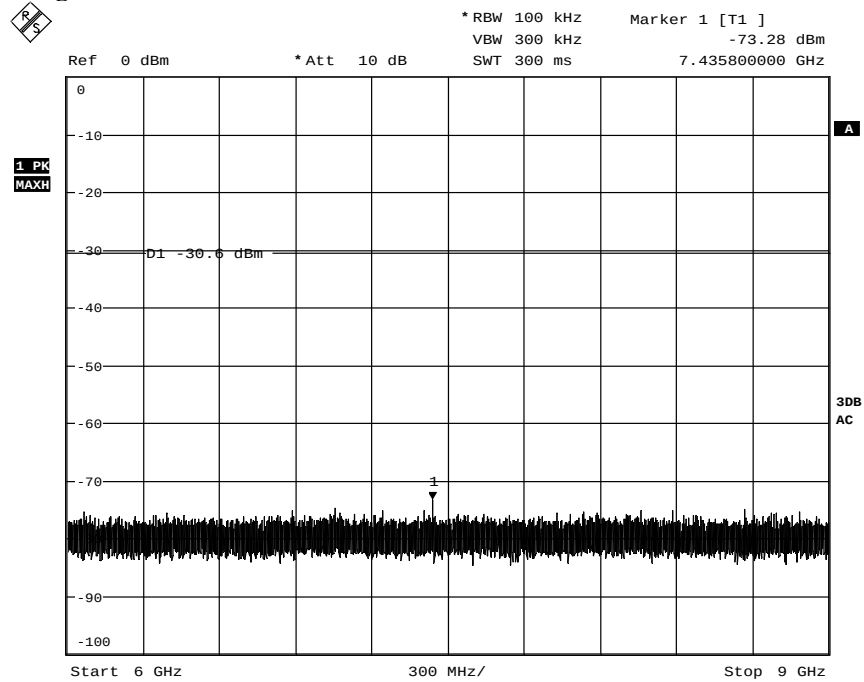
Appendix 5

Diagram 24



Date: 19.MAR.2014 10:55:41

Diagram 25

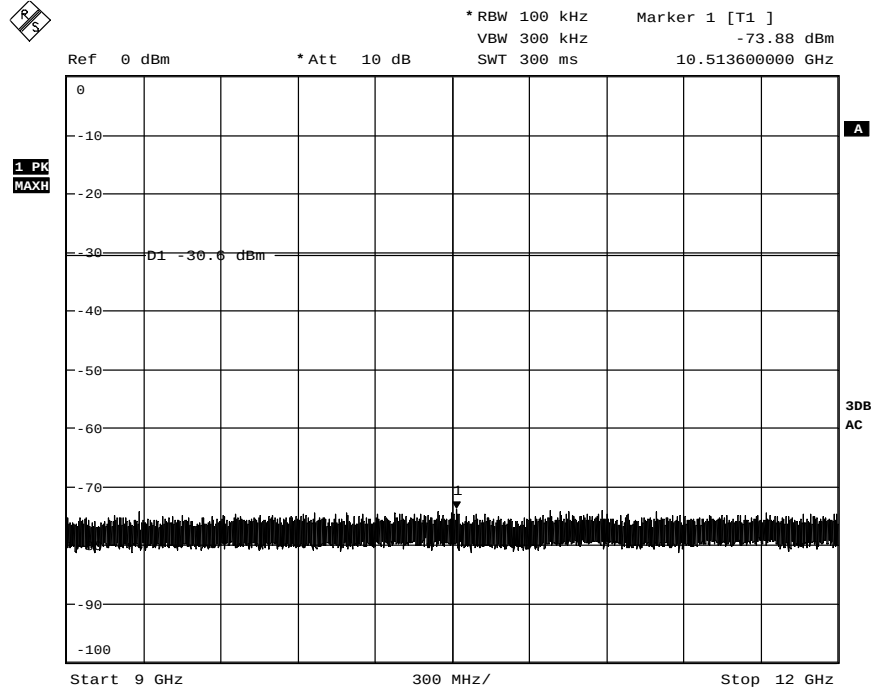


Date: 19.MAR.2014 10:56:12

FCC ID: 2AB46-11515

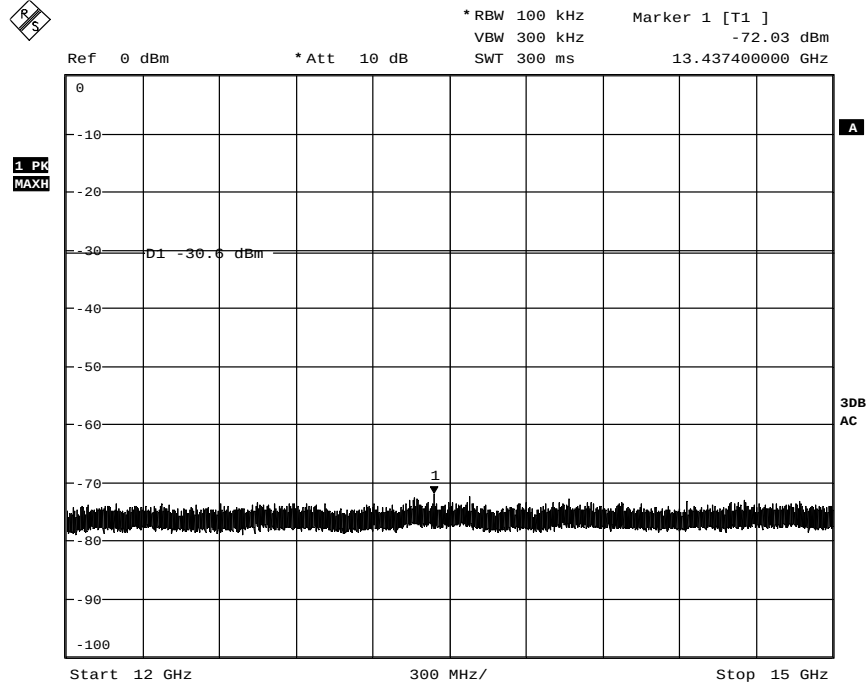
Appendix 5

Diagram 26



Date: 19.MAR.2014 10:57:28

Diagram 27

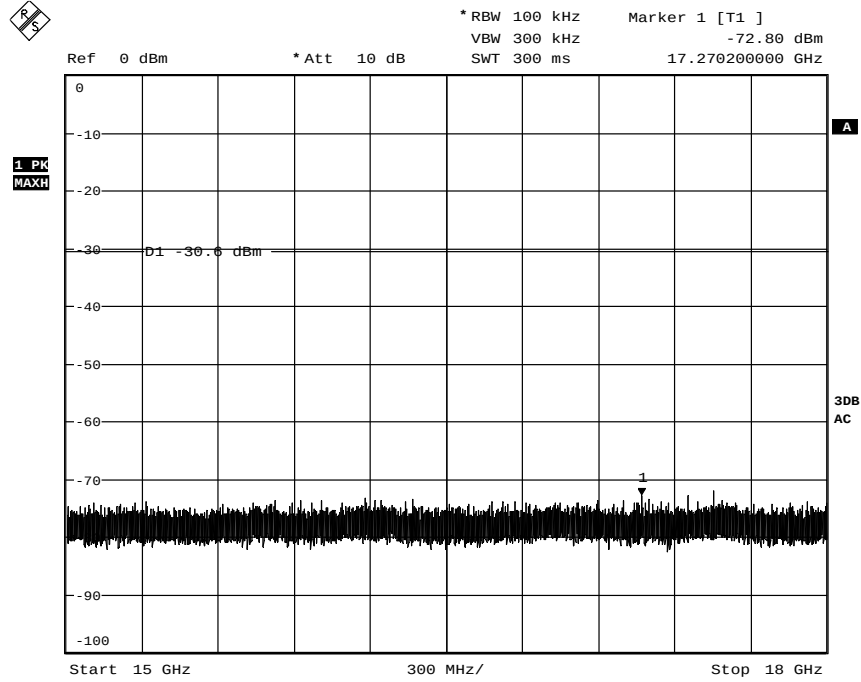


Date: 19.MAR.2014 11:02:31

FCC ID: 2AB46-11515

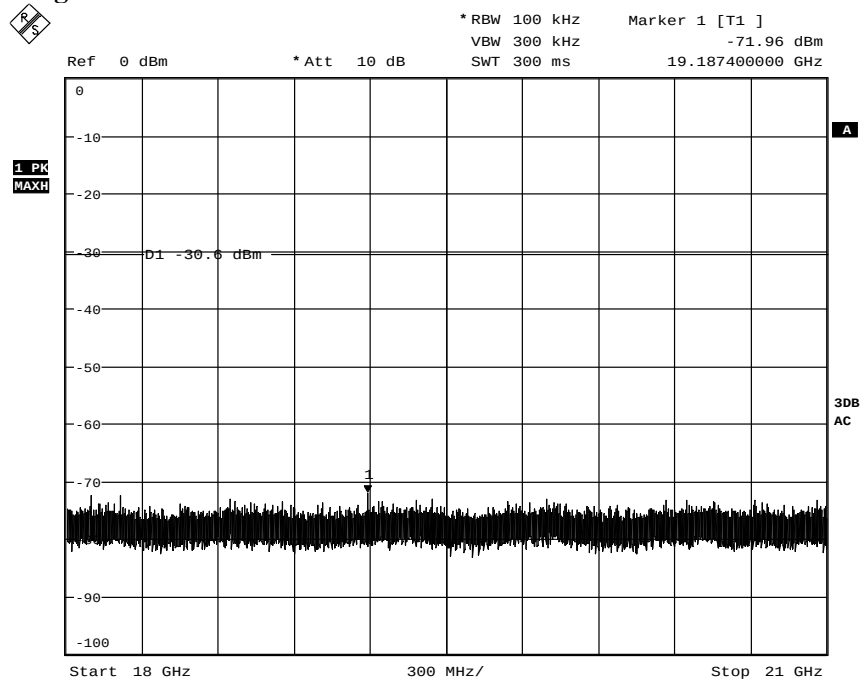
Appendix 5

Diagram 28



Date: 19.MAR.2014 11:03:09

Diagram 29

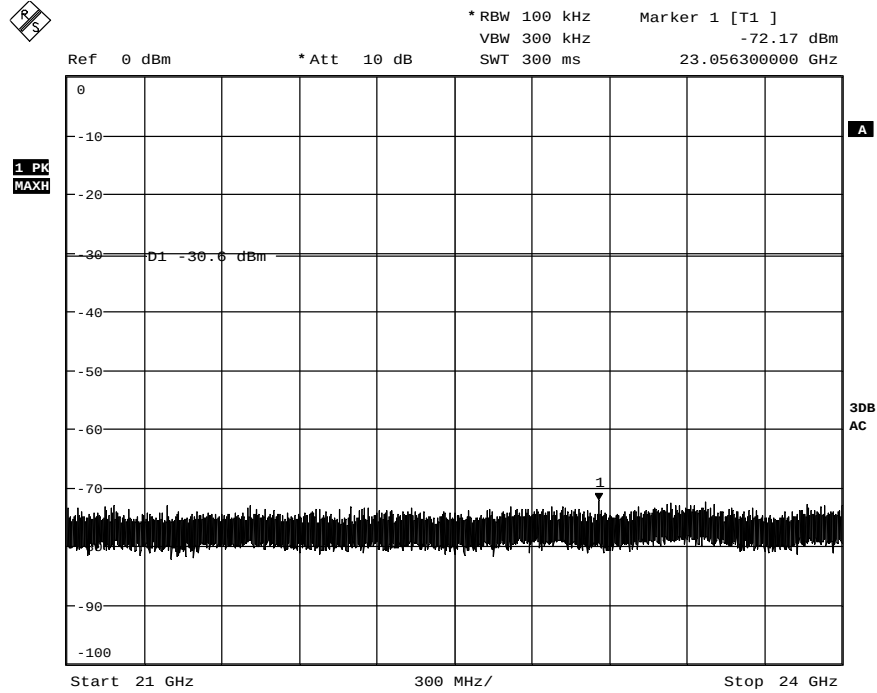


Date: 19.MAR.2014 11:03:41

FCC ID: 2AB46-11515

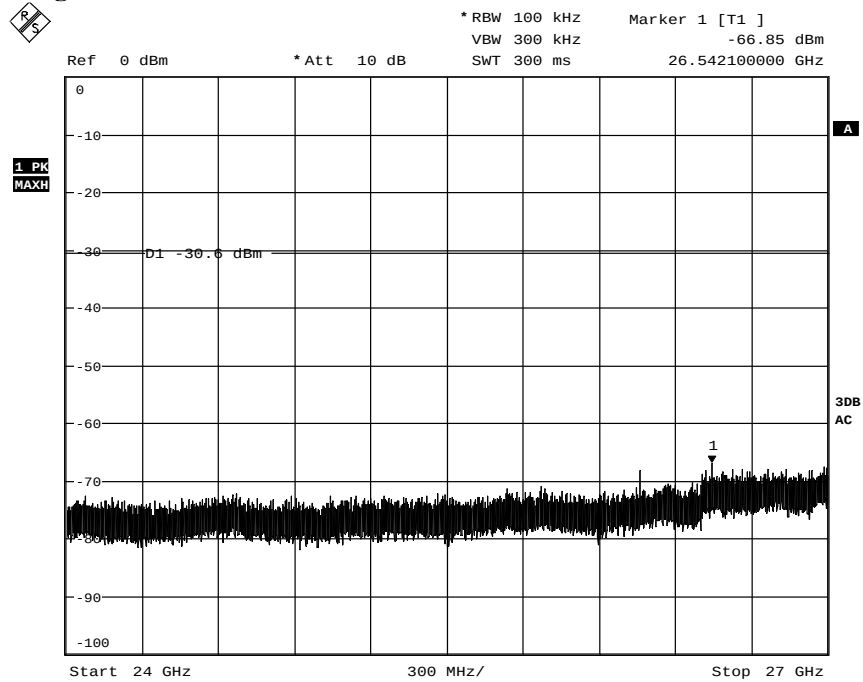
Appendix 5

Diagram 30



Date: 19.MAR.2014 11:04:15

Diagram 31



Date: 19.MAR.2014 11:04:45

Restricted bands of operation measurements according to FCC 47 CFR part 15.247 (d) / RSS-210 A8.5

Date	Temperature	Humidity
2014-02-27	22 °C ± 3 °C	33 % ± 5 %
2014-02-28	23 °C ± 3 °C	29 % ± 5 %
2014-03-18	22 °C ± 3 °C	30 % ± 5 %

Test set-up and procedure

The measurements were performed according to ANSI C63.10-2009 and the guideline 558074 D01 DTS Meas Guidance, April 9, 2013.

The test was performed at single channel with continuous transmission (100% duty cycle) and with normal modulation.

The test of radiated emission was performed in a semi anechoic chamber. The measurements were performed with both horizontal and vertical polarizations of the antenna. The antenna distance during the measurements was 3.0 m in the frequency range 30 MHz-18 GHz and 1.0 m in the frequency range 18-25 GHz.

The measurement procedure is as follows:

1. A pre-measurement is performed with peak detector. The test object is measured in eight directions with the antenna at three heights, 1.0 m, 1.5 m and 2.0 m.
2. If the emission is close or above the limit during the pre-measurement, the test object is scanned 360 degrees and the antenna height scanned from 1 to 4 m for maximum response. Then the emission is measured with the quasi-peak detector on frequencies below 1 GHz and with the average detector above 1 GHz.

The following RBW were used:

30 MHz-1 GHz: RBW=100 kHz

1-25 GHz: RBW=1 MHz

Test set-up photos during the tests can be found in Appendix 12.

Measurement equipment	SP number
Semi anechoic chamber, Edison	504 114
Spectrum analyzer R&S ESI 26	503 885
EMI measurement computer	-
Software: R&S EMC32, ver. 8.53.0	503 745
Antenna Schaffner Bilog CBL6143	504 079
Horn antenna ETS Lindgren 3115	902 212
Low Noise Amplifier Miteq	504 160
Low Noise Amplifier Miteq	503 277
Standard gain horn Flann 16240-25	503 939
Standard gain horn Flann 18240-25	503 900
Standard gain horn Flann 20240-20	503 674
High pass filter Wainwright WHKX	504 200
Multimeter Fluke 83	501 522
Temperature and humidity meter Testo 625	504 117

FCC ID: 2AB46-11515

Appendix 6

Results

The pre-measurement emission spectra can be found in the diagrams below:

Diagram 1:	30-1000 MHz, 2440 MHz, vertical and horizontal polarization, EUT pos 2
Diagram 2:	1-3 GHz, 2440 MHz, vertical and horizontal polarization, EUT pos 2
Diagram 3:	3-8.2 GHz, 2440 MHz, vertical and horizontal polarization, EUT pos 2
Diagram 4:	8.2-12 GHz, 2440 MHz, vertical and horizontal polarization, EUT pos 2
Diagram 5:	12-18 GHz, 2440 MHz, vertical and horizontal polarization, EUT pos 2
Diagram 6:	18-25 GHz, 2440 MHz, vertical polarization, EUT pos 2
Diagram 7:	18-25 GHz, 2440 MHz, horizontal polarization, EUT pos 2

Note: Worst-case plots are attached.

The highest detected levels during the final measurement in the frequency range 30 MHz-25 GHz are listed in the tables below.

2402 MHz

Frequency (MHz)	QP level (dB μ V/m)	CISPR AV level (dB μ V/m)	Peak level (dB μ V/m)	Corr (dB)	Limit (dB μ V/m)	Height (m)	Azimuth (deg)	Polarization
2402.210	N/A	90.3	93.9	32.0	Carrier	2.00	102	Horizontal
4804.311	N/A	38.8	47.9	-9.6	53.9 (CAV)	1.48	232	Horizontal

2440 MHz

Frequency (MHz)	QP level (dB μ V/m)	CISPR AV level (dB μ V/m)	Peak level (dB μ V/m)	Corr (dB)	Limit (dB μ V/m)	Height (m)	Azimuth (deg)	Polarization
2440.210	N/A	89.8	93.2	32.0	Carrier	2.00	91	Horizontal
4880.230	N/A	40.7	49.0	-9.6	53.9 (CAV)	1.49	278	Horizontal

2480 MHz

Frequency (MHz)	QP level (dB μ V/m)	CISPR AV level (dB μ V/m)	Peak level (dB μ V/m)	Corr (dB)	Limit (dB μ V/m)	Height (m)	Azimuth (deg)	Polarization
2479.664	N/A	88.0	90.8	32.0	Carrier	1.88	91	Horizontal
4959.429	N/A	38.5	47.3	-9.6	53.9 (CAV)	1.51	280	Horizontal

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Appendix 6

Limits

According to 47CFR 15.247(d), 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, based on either an RF conducted or a radiated measurement, provided the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, as permitted under paragraph (b)(3) of this section, the attenuation required under this paragraph shall be 30 dB instead of 20 dB.

Radiated emissions which fall in the restricted bands, as defined in Section 15.205(a), must also comply with the radiated emission limits specified in Section 15.209(a).

According to RSS-210 A8.5, in any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the RF power that is produced 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, based on either an RF conducted or a radiated measurement, provided that the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of root-mean square averaging over a time interval, as permitted under Section A8.4(4), the attenuation required shall be 30 dB instead of 20 dB. Attenuation below the general field strength limits specified in RSS-Gen is not required.

Complies?	Yes
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FCC ID: 2AB46-11515

Appendix 6

Diagram 1

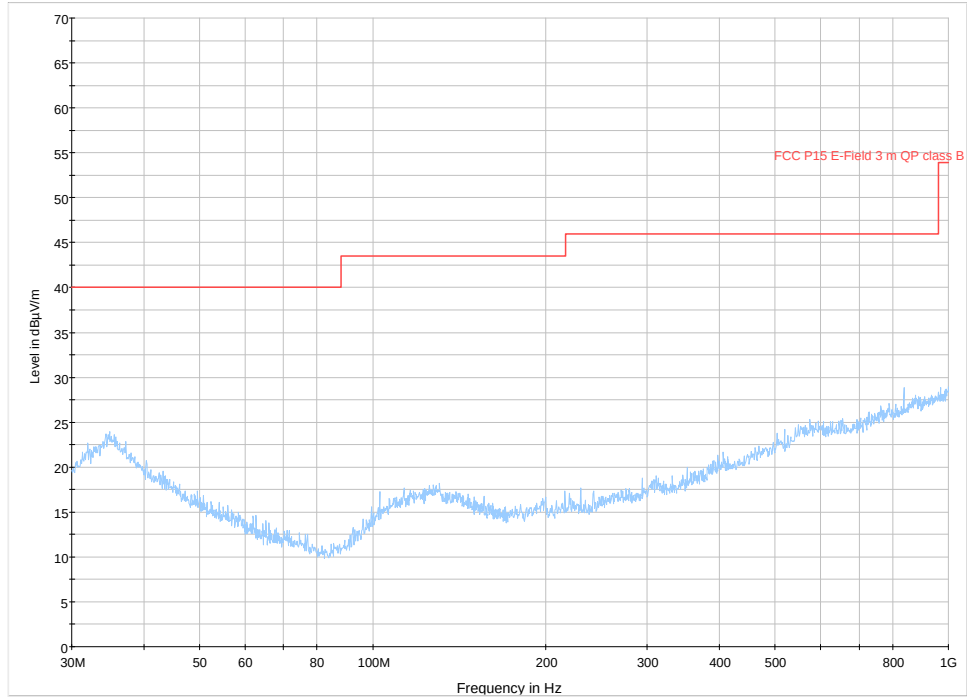
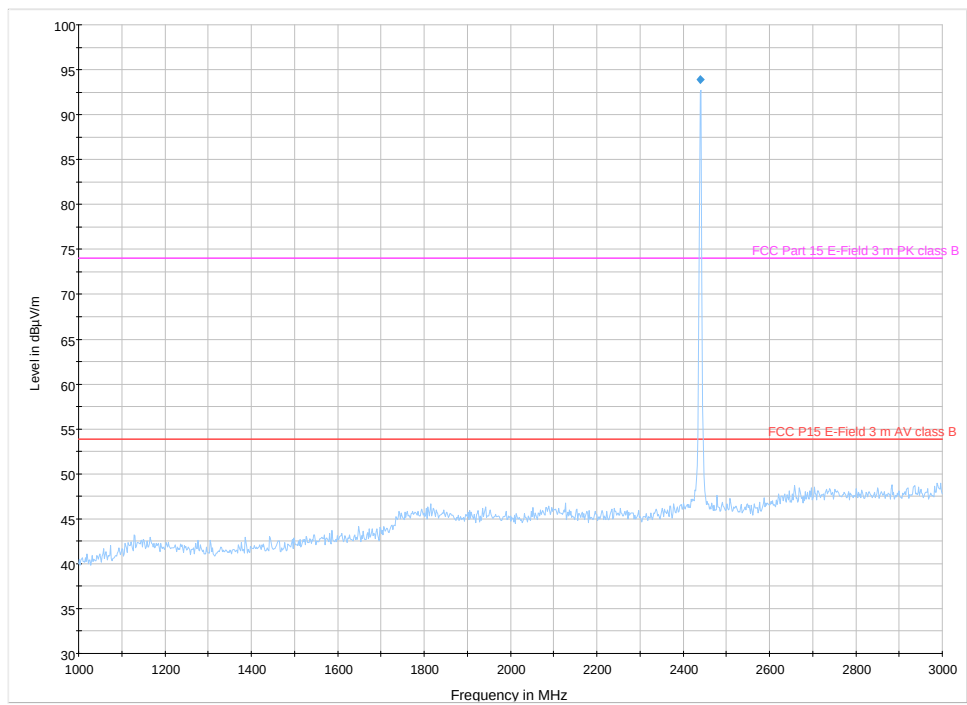


Diagram 2



FCC ID: 2AB46-11515

Appendix 6

Diagram 3

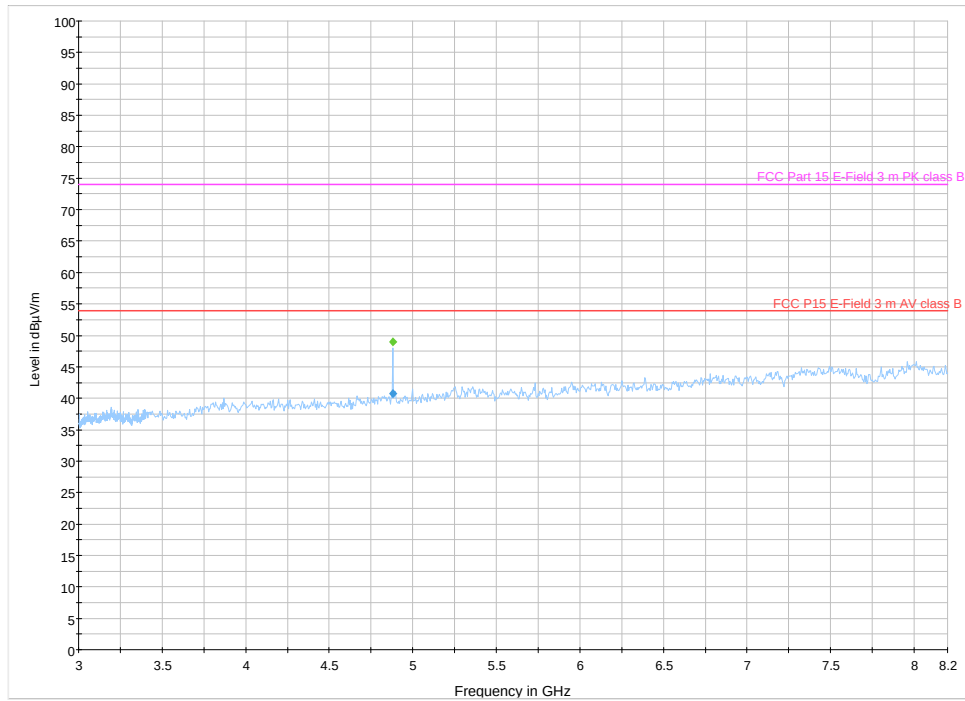
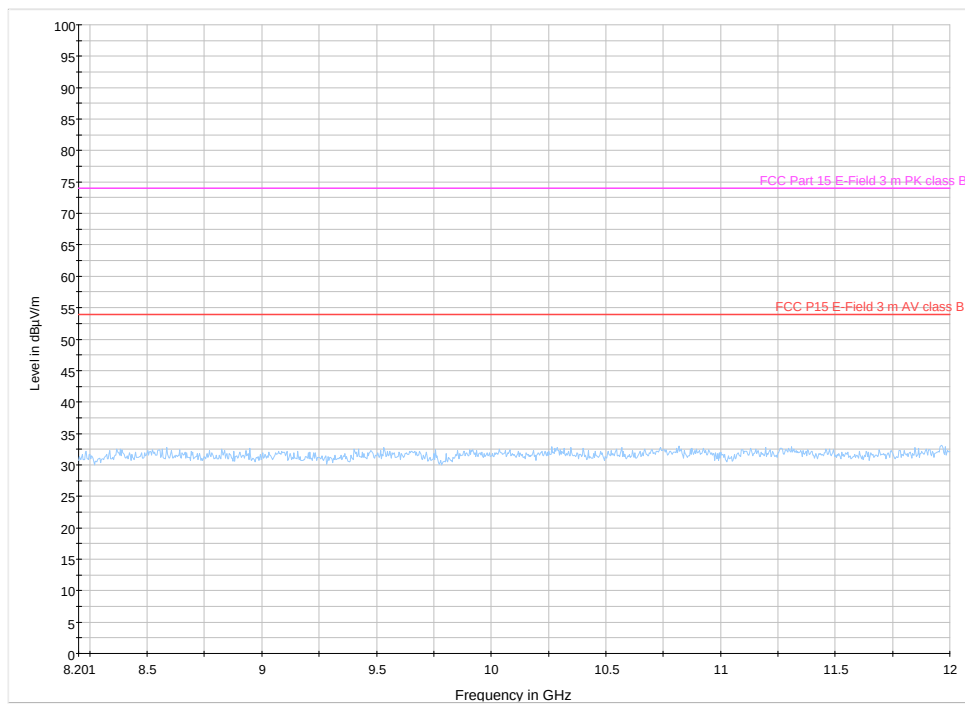


Diagram 4



FCC ID: 2AB46-11515

Appendix 6

Diagram 5

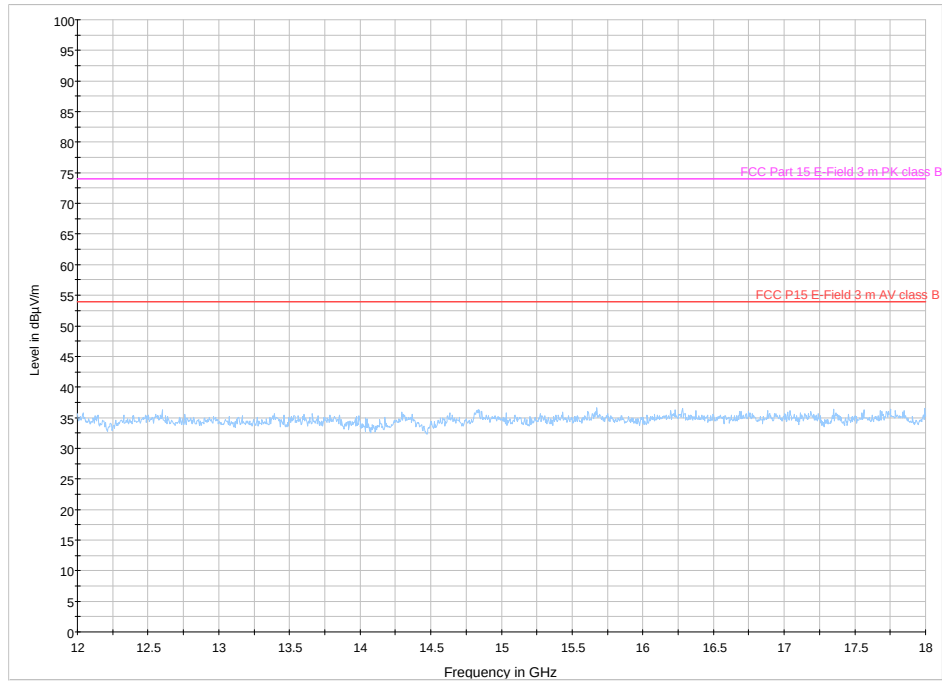
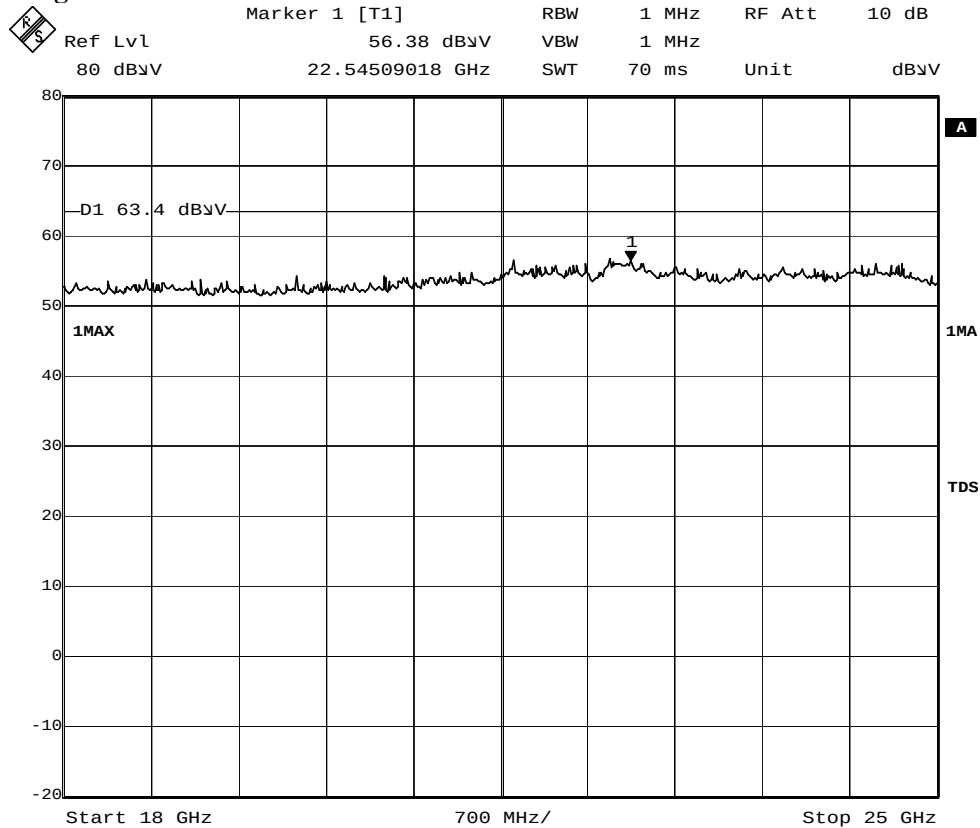


Diagram 6

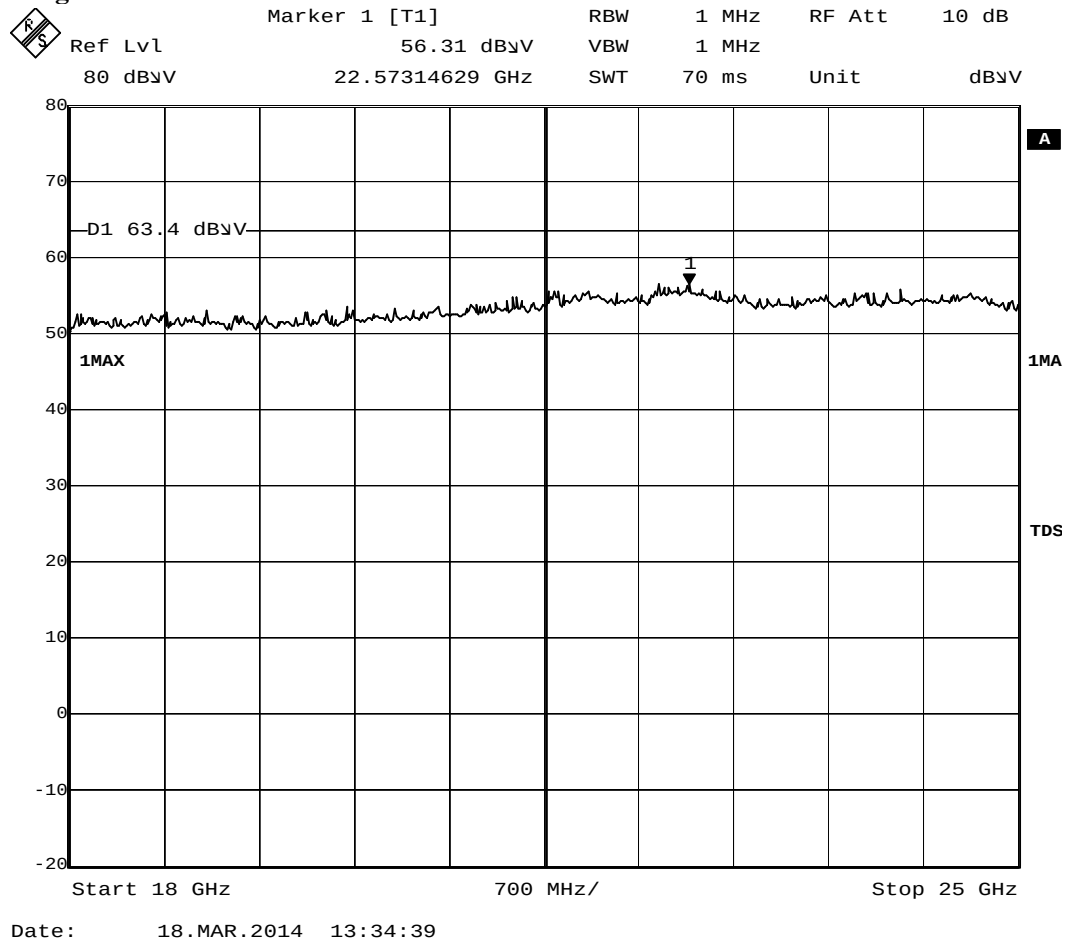


Date: 18.MAR.2014 13:32:59

FCC ID: 2AB46-11515

Appendix 6

Diagram 7



FCC ID: 2AB46-11515

Appendix 7

**Power spectral density according to FCC 47 CFR part 15.247 (e)
/ RSS-210 A8.2 (b)**

Date 2014-03-19	Temperature 22 °C ± 3 °C	Humidity 27 % ± 5 %
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Test set-up and procedure

The measurements were performed according to ANSI C63.10-2009 and the guideline 558074 D01 DTS Meas Guidance, April 9, 2013.

Conducted measurements were performed at the temporary antenna connector with continuous transmission (100% duty cycle) and with normal modulation.

Measurement equipment	SP number
Test site, Galvani	15:117
Signal analyzer R&S FSIQ	503 738
Multimeter Fluke 85 III	503 418
Temperature and humidity meter Testo 615	503 498

Results

The measurements can be found in the diagrams below:

Diagram 1	2402 MHz	Power spectral density = -19.5 dBm
Diagram 2	2440 MHz	Power spectral density = -18.7 dBm
Diagram 3	2480 MHz	Power spectral density = -18.8 dBm

Limits

According to 47CFR 15.247(e), for digitally modulated systems, the power spectral density conducted from the intentional radiator to the antenna shall not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission.

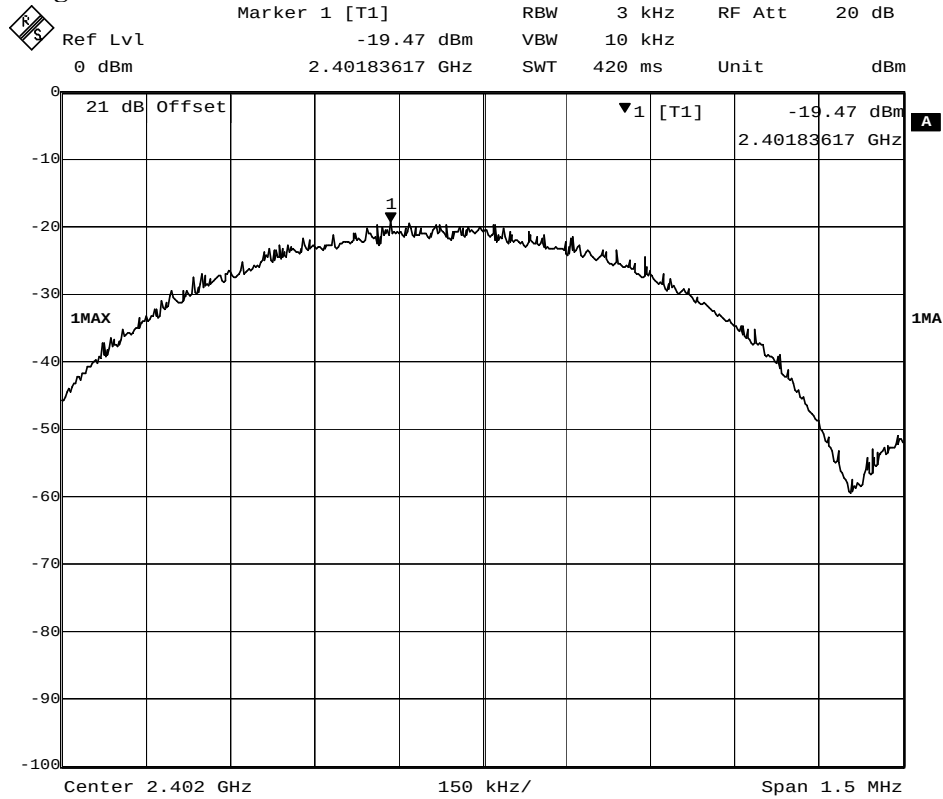
According to RSS-210 A8.2(b), the transmitter power spectral density conducted from the transmitter to the antenna shall not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission. This power spectral density shall be determined in accordance with the provisions of Section A8.4 (4),
(i.e. the power spectral density shall be determined using the same method as is used to determine the conducted output power).

Complies?	Yes
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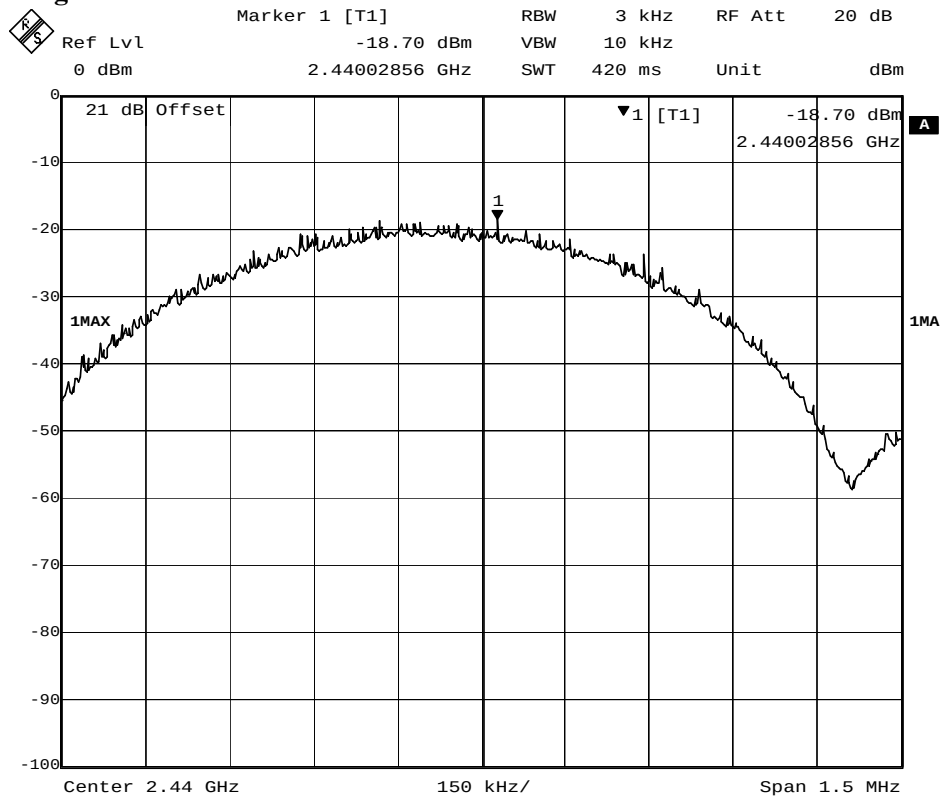
Appendix 7

Diagram 1



Date: 19.MAR.2014 06:59:25

Diagram 2

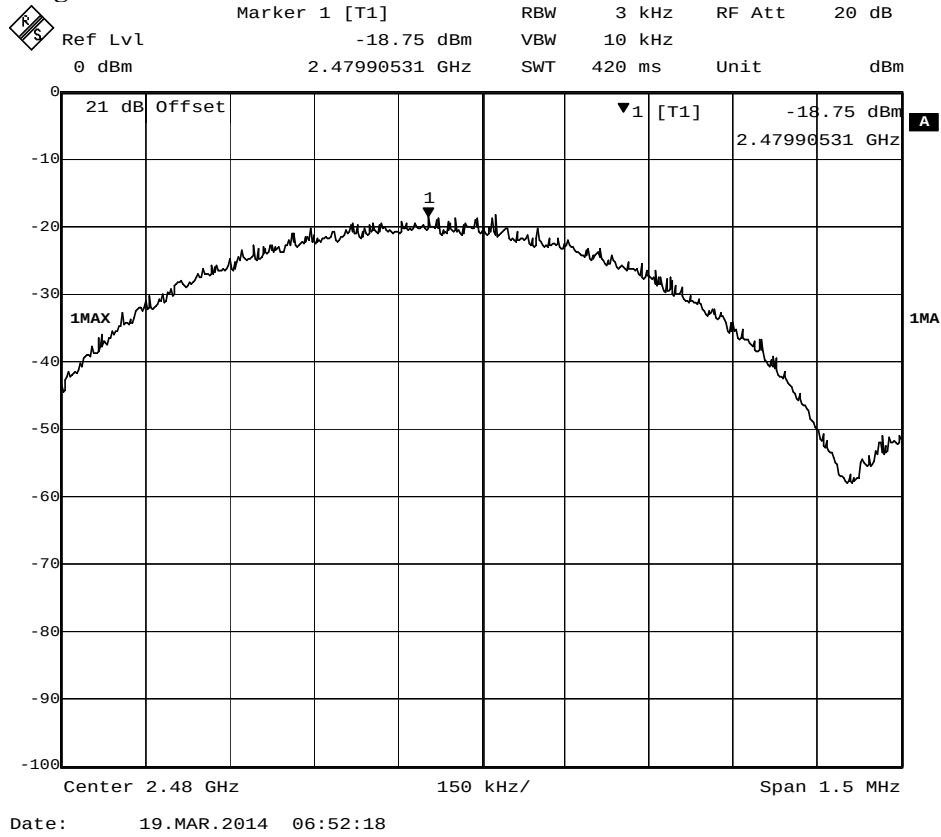


Date: 19.MAR.2014 06:54:37

FCC ID: 2AB46-11515

Appendix 7

Diagram 3



RF exposure evaluation: 2.1093 Portable devices / KDB 447498/ RSS-102 2.5.1

Date 2014-02-27	Temperature 22 °C ± 3 °C	Humidity 33 % ± 5 %
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Procedure

Systems operating under the provisions of this section shall be operated in a manner that ensures that the public is not exposed to radio frequency energy levels in excess limit for maximum permissible exposure. In accordance with 47 CFR FCC Part 2 Subpart J, section 2.1093 this device has been defined as a portable device to be used within 20 centimetres of the body of the user.

Results

The following formula was used to calculate the RF exposure SAR exclusion threshold,
 $Thld = [P_{out} / r] \times [\sqrt{f}]$

where,

Thld= SAR exclusion threshold

P_{out} = Peak output power, in mW

r = minimum test separation distance, in mm

f=frequency, in GHz

Frequency f, (GHz)	Peak output power P _{out} , (mW)	Distance r, (mm)	Exclusion threshold Thld	Limit Threshold 1-g SAR	Limit Threshold 10-g SAR
2.440	0.22	5	0.068	< 3	< 7.5

The maximum conducted peak output power from Appendix 4 was used for calculation.

Limits**FCC- 2.1093 / KDB 447498 (ver 5 rev 2) 4.3.1:**

1) The 1-g and 10-g SAR test exclusion thresholds for 100 MHz to 6 GHz at test separation distances ≤ 50 mm are determined by:

$[(\text{max. power of channel, including tune-up tolerance, mW}) / (\text{min. test separation distance, mm})] \times [\sqrt{f(\text{GHz})}] \leq 3.0$ for 1-g SAR and ≤ 7.5 for 10-g extremity SAR, where

- f(GHz) is the RF channel transmit frequency in GHz
- Power and distance are rounded to the nearest mW and mm before calculation
- The result is rounded to one decimal place for comparison

The test exclusions are applicable only when the minimum test separation distance is ≤ 50 mm and for transmission frequencies between 100 MHz and 6 GHz. When the minimum test separation distance is < 5 mm, a distance of 5 mm is applied to determine SAR test exclusion.

2) At 100 MHz to 6 GHz and for test separation distances > 50 mm, the SAR test exclusion threshold is determined according to the following,

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Appendix 8

- a) [Power allowed at numeric threshold for 50 mm in step 1) + (test separation distance - 50 mm) x (f(MHz)/150)] mW, at 100 MHz to 1500 MHz
- b) [Power allowed at numeric threshold for 50 mm in step 1) + (test separation distance - 50 mm) x 10] mW at > 1500 MHz and $\leq$ 6 GHz

RSS-102 2.5.1 Exemption from Routine Evaluation Limits – SAR Evaluation

SAR evaluation is required if the separation distance between the user and the radiating element of the device is less than or equal to 20 cm, except when the device operates as follows:

above 2.2 GHz and up to 3 GHz inclusively, and with output power (i.e. the higher of the conducted or radiated (e.i.r.p.) source-based, time-averaged output power) that is less than or equal to 20 mW for general public use and 100 mW for controlled use;

Complies?	Yes
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Appendix 9

20 dB bandwidth measurements according to FCC 47 CFR part 15.215 (c)

Date 2014-03-18	Temperature 22 °C ± 3 °C	Humidity 30 % ± 5 %
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Test set-up and procedure

The measurements were performed according to ANSI C63.10-2009.

Conducted measurements were performed at the temporary antenna connector with continuous transmission (100% duty cycle) and with normal modulation.

Measurement equipment	SP number
Test site, Edison	504 114
Signal analyzer R&S FSIQ	503 738
Multimeter Fluke 83	501 522
Temperature and humidity meter Testo 625	504 117

Measurement uncertainty: 2.6 %

Results

The measurements can be found in the diagrams below:

Diagram 1: 2402 MHz 20 dB BW = **1.22 MHz**
Diagram 2: 2440 MHz 20 dB BW = **1.22 MHz**
Diagram 3: 2480 MHz 20 dB BW = **1.21 MHz**

Limits

According to 47CFR 15.215(c), intentional radiators operating under the alternative provisions to the general emission limits, as contained in §§ 15.217 through 15.257 and in Subpart E of this part, must be designed to ensure that the 20 dB bandwidth of the emission, or whatever bandwidth may otherwise be specified in the specific rule section under which the equipment operates, is contained within the frequency band designated in the rule section under which the equipment is operated. The requirement to contain the designated bandwidth of the emission within the specified frequency band includes the effects from frequency sweeping, frequency hopping and other modulation techniques that may be employed as well as the frequency stability of the transmitter over expected variations in temperature and supply voltage. If a frequency stability is not specified in the regulations, it is recommended that the fundamental emission be kept within at least the central 80% of the permitted band in order to minimize the possibility of out-of-band operation.

Complies?	Yes
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FCC ID: 2AB46-11515

Appendix 9

Diagram 1

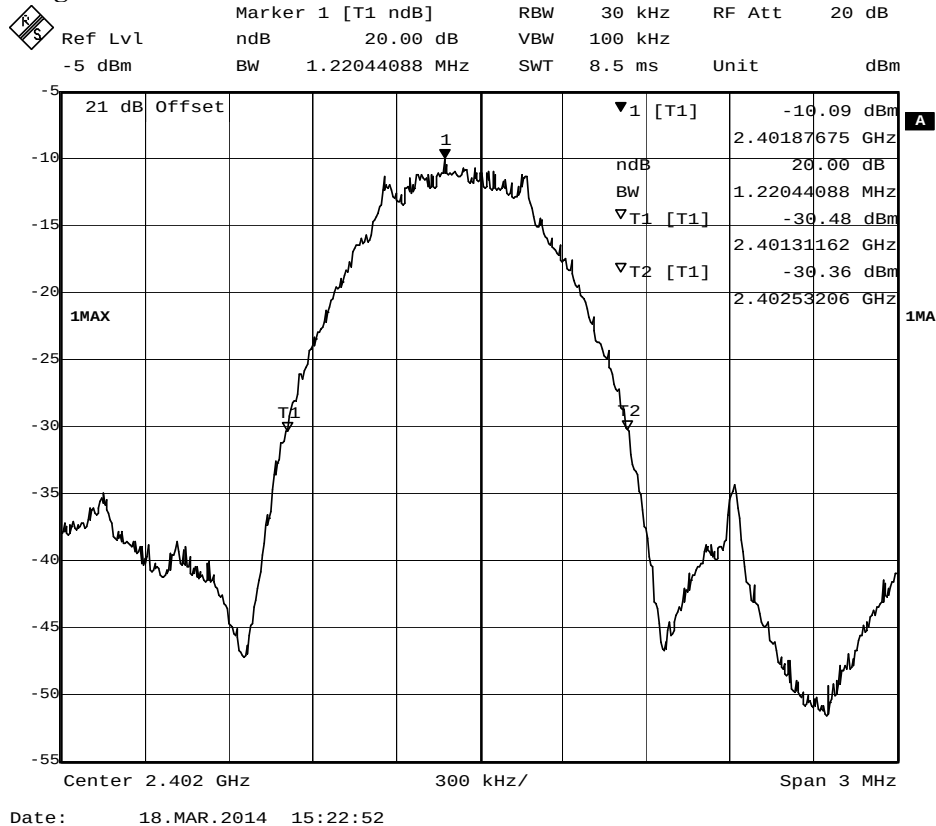
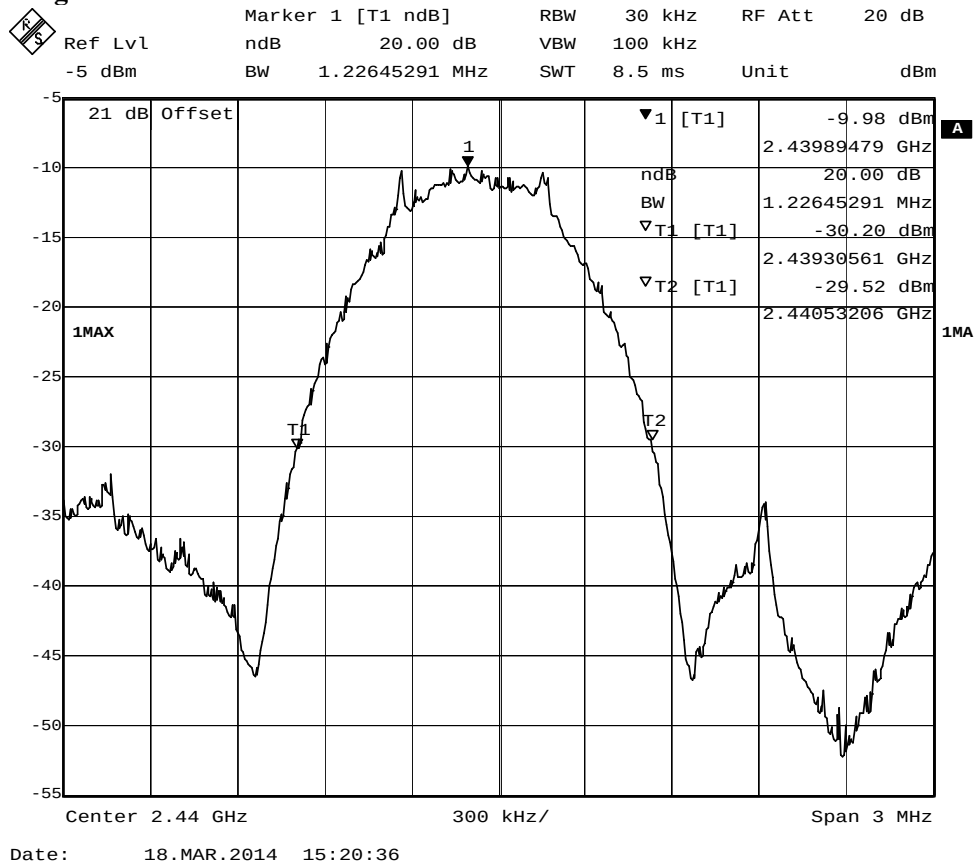


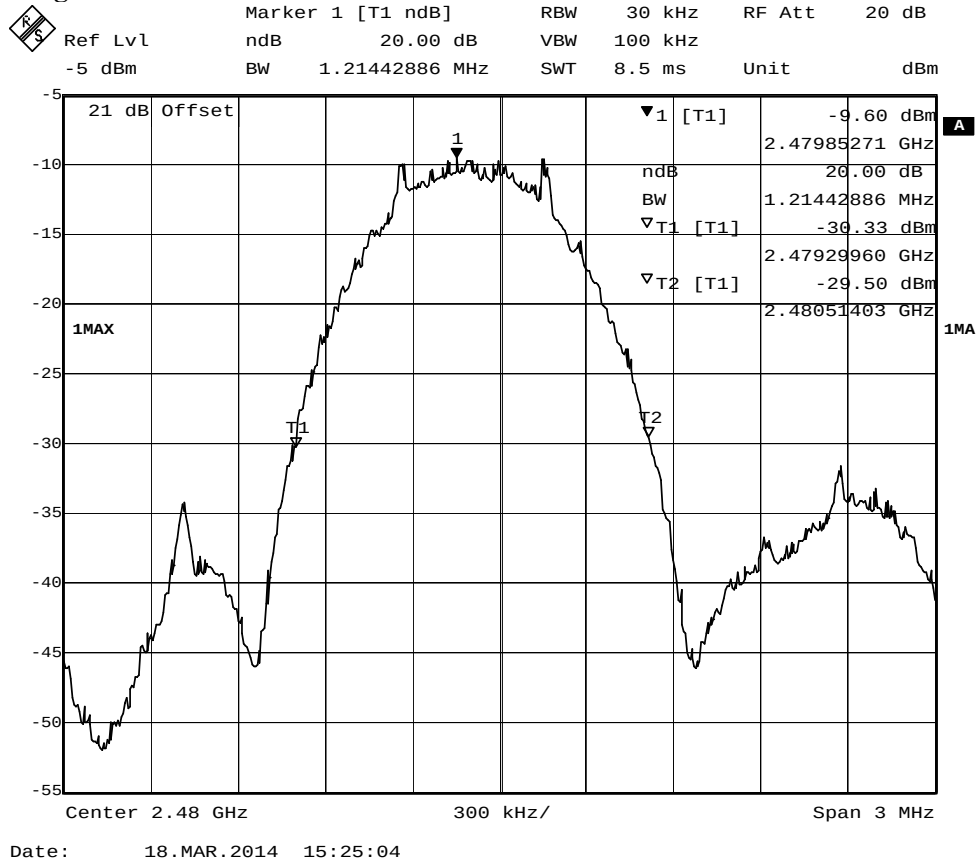
Diagram 2



FCC ID: 2AB46-11515

Appendix 9

Diagram 3



FCC ID: 2AB46-11515

Appendix 10

Occupied bandwidth measurements according to 47CFR 2.1049 / RSS-Gen 4.6.1

Date 2014-03-19	Temperature 22 °C ± 3 °C	Humidity 27 % ± 5 %
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Test set-up and procedure

The measurements were performed according to ANSI C63.10-2009.

Conducted measurements were performed at the temporary antenna connector with continuous transmission (100% duty cycle) and with normal modulation.

Measurement equipment	SP number
Test site, Galvani	15:117
Signal analyzer R&S FSIQ	503 738
Multimeter Fluke 85 III	503 418
Temperature and humidity meter Testo 615	503 498

Measurement uncertainty: 2.6 %

Results

The measurements can be found in the diagrams below:

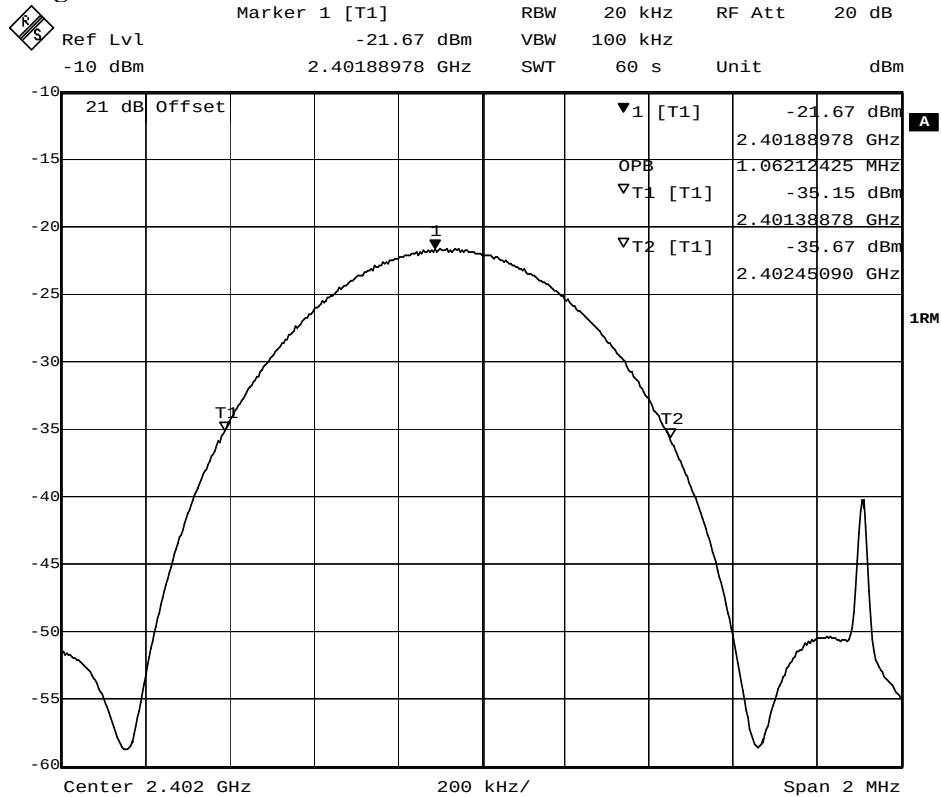
Diagram 1 2402 MHz OBW = **1.06 MHz (99%)**
Diagram 2 2440 MHz OBW = **1.07 MHz (99%)**
Diagram 3 2480 MHz OBW = **1.06 MHz (99%)**

Complies?	Yes
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FCC ID: 2AB46-11515

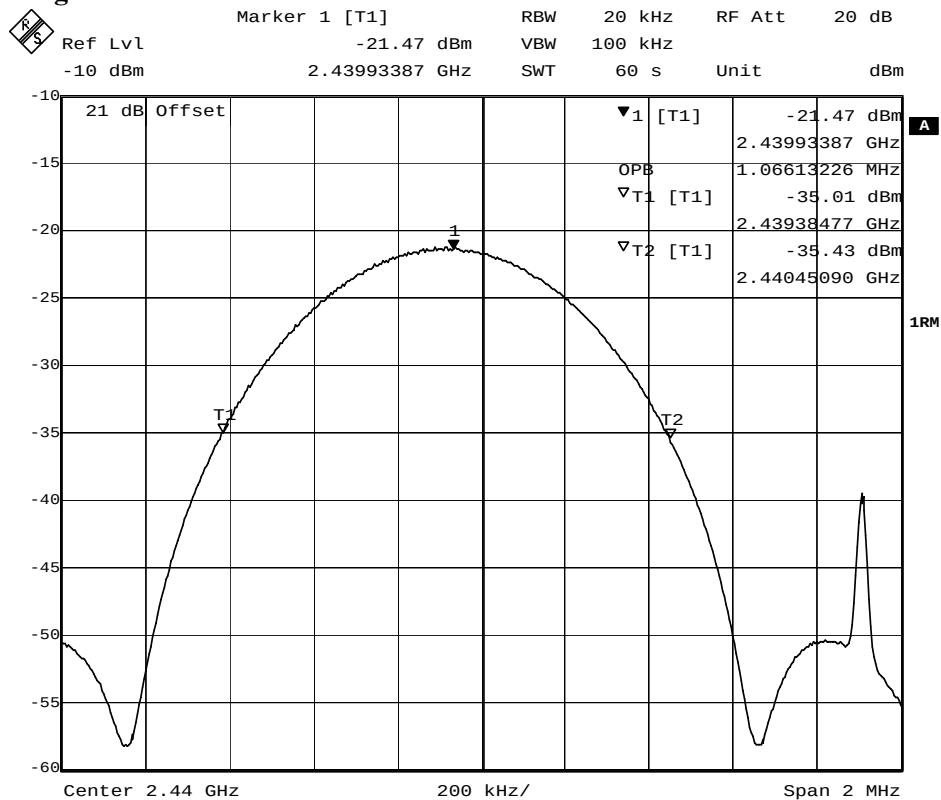
Appendix 10

Diagram 1



Date: 19.MAR.2014 10:55:02

Diagram 2

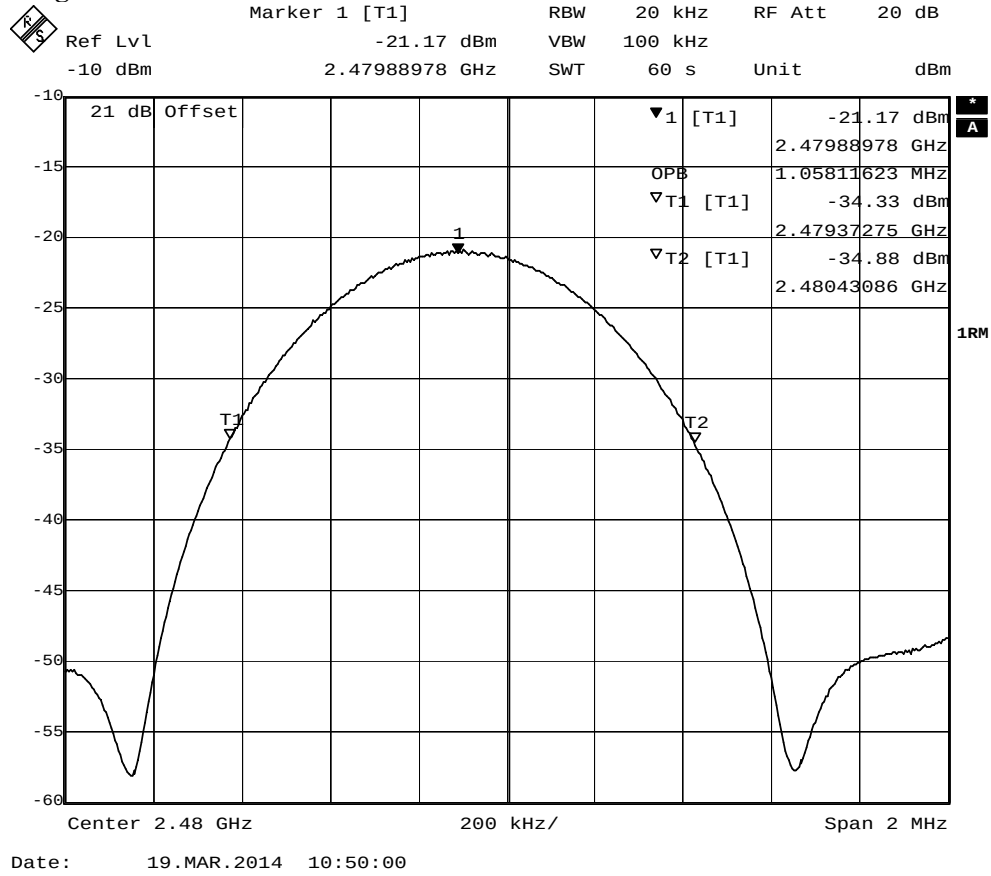


Date: 19.MAR.2014 10:53:25

FCC ID: 2AB46-11515

Appendix 10

Diagram 3



Band edge measurements according to 47CFR 2.1049 / RSS-210 A8.5

Date 2014-02-27	Temperature 22 °C ± 3 °C	Humidity 33 % ± 5 %
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Test set-up and procedure

The measurements were performed according to ANSI C63.10-2009 and the guideline 558074 D01 DTS Meas Guidance, April 9, 2013.

The test was performed with continuous transmission (100% duty cycle) and with normal modulation.

The radiated band edge measurements were performed in a semi anechoic chamber. The measurements were performed with the EUT-axis, antenna at the position, polarization and the turntable in the position giving the highest level at the fundamental, see Appendix 4. The antenna distance was 3.0 m.

Test set-up photos during the tests can be found in Appendix 12.

Measurement equipment	SP number
Semi anechoic chamber, Edison	504 114
Spectrum analyzer R&S ESI 26	503 885
EMI measurement computer	-
Horn antenna ETS Lindgren 3115	902 212
Multimeter Fluke 83	501 522
Temperature and humidity meter Testo 625	504 117

Results

Operation band 2400-2483.5 MHz

The pre-measurements band edge emission can be found in the diagrams below.
The absolute values below are the levels from the final measurement in receiver mode

Diagram 1 2402 MHz Band edge at 2390 MHz (limit=54.0 dBμV/m (CAverage))
(Restricted band)
CAverage level at 2390 MHz =**35.3 dBμV/m** (noise floor)
Peak level at 2390 MHz =**48.2 dBμV/m**

Diagram 2 2402 MHz Band edge at 2400 MHz (20 dBc limit)
RBW=100 kHz
dBc at 2400 MHz = **31.5 dBc**

Diagram 3 2480 MHz Band edge at 2483.5 MHz (limit=54.0 dBμV/m (CAverage))
(Restricted band)
CAverage level at 2483.5 MHz =**45.4 dBμV/m** (noise floor)
Peak level at 2483.5 MHz =**54.5 dBμV/m**

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Appendix 11

Limits

Band edge at 2400 MHz:

According to 47CFR 15.247(d), 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, based on either an RF conducted or a radiated measurement, provided the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, as permitted under paragraph (b)(3) of this section, the attenuation required under this paragraph shall be 30 dB instead of 20 dB.

According to RSS-210 A8.5, in any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the RF power that is produced 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, based on either an RF conducted or a radiated measurement, provided that the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of root-mean square averaging over a time interval, as permitted under Section A8.4(4), the attenuation required shall be 30 dB instead of 20 dB. Attenuation below the general field strength limits specified in RSS-Gen is not required.

Band edge at 2483.5 MHz:

In addition, radiated emissions which fall in the restricted bands, as defined in Section 15.205(a), must also comply with the radiated emission limits specified in Section 15.209(a).

According to RSS-210 A8.5, in any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the RF power that is produced 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, based on either an RF conducted or a radiated measurement, provided that the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of root-mean square averaging over a time interval, as permitted under Section A8.4(4), the attenuation required shall be 30 dB instead of 20 dB. Attenuation below the general field strength limits specified in RSS-Gen is not required.

Complies?	Yes
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FCC ID: 2AB46-11515

Appendix 11

Diagram 1

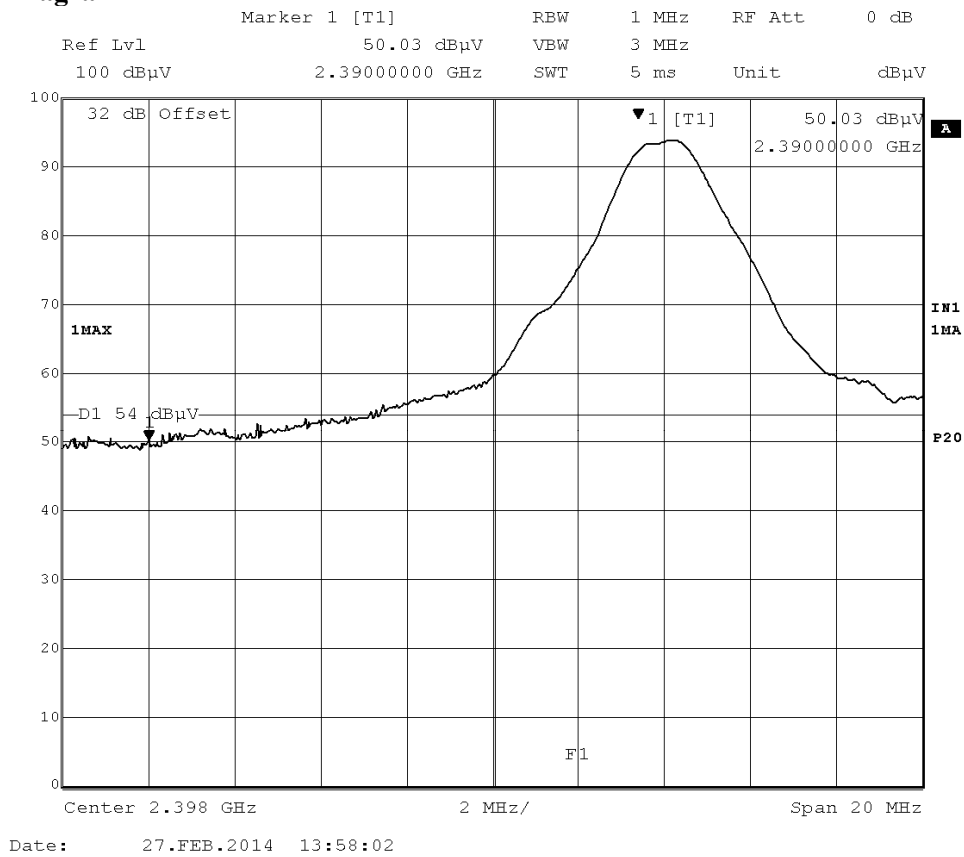
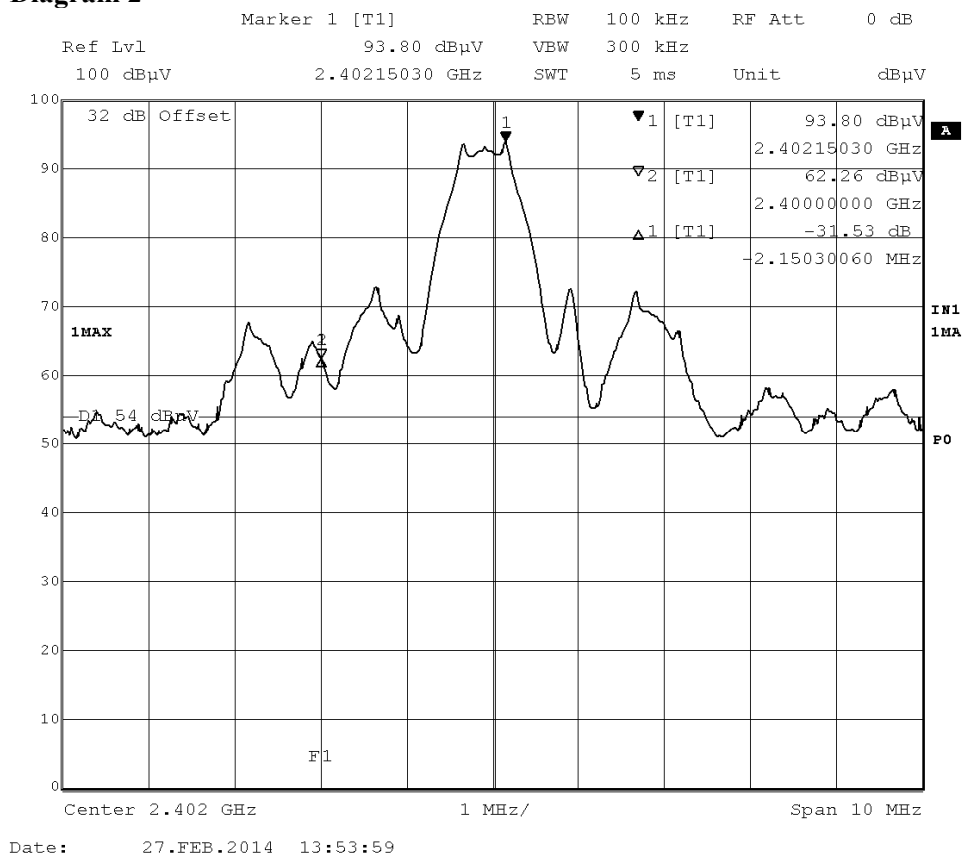


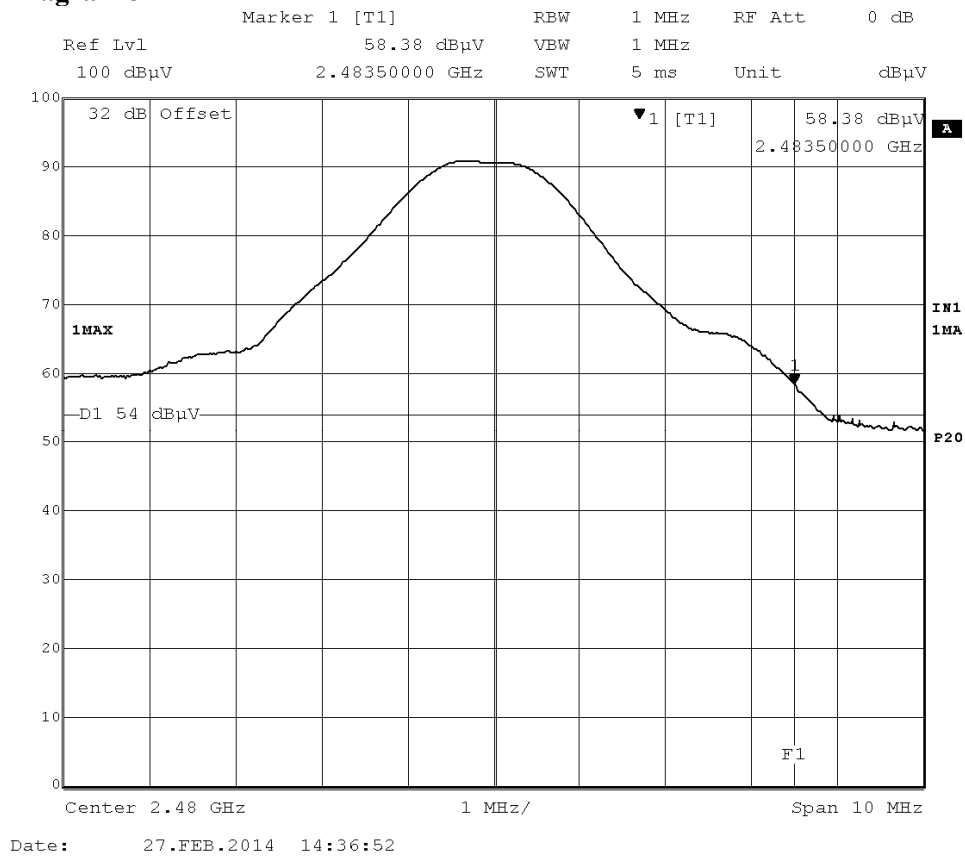
Diagram 2



FCC ID: 2AB46-11515

Appendix 11

Diagram 3



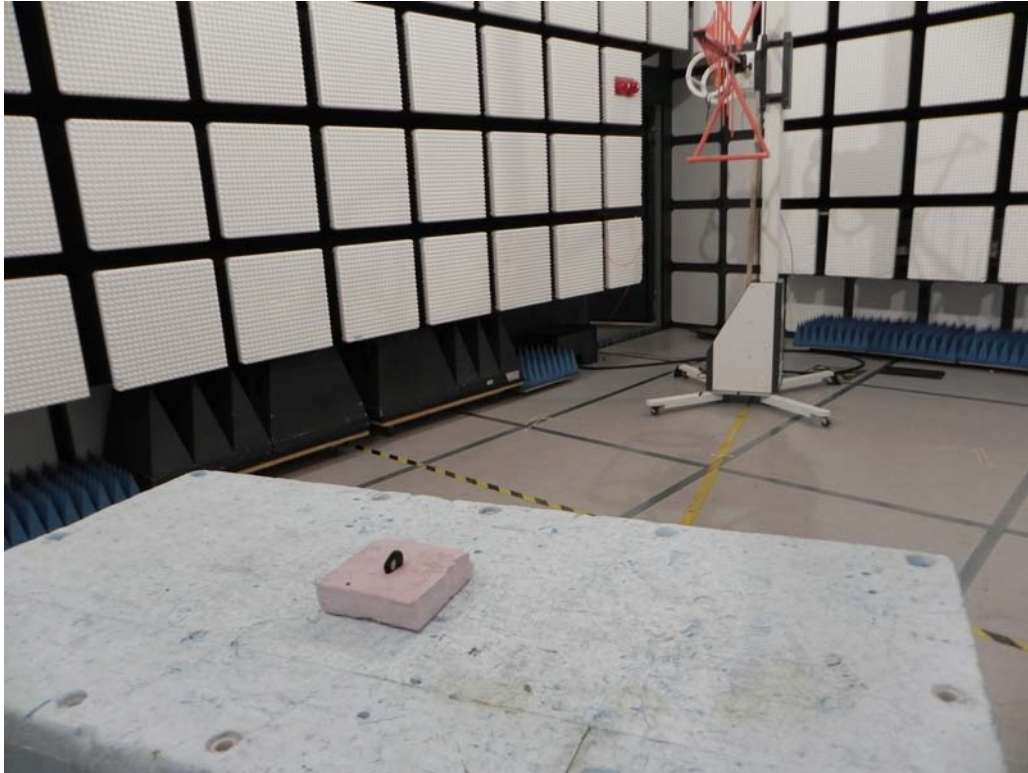
FCC ID: 2AB46-11515

Appendix 12

Photos

The test set-up during all the radiated tests can be seen in the pictures below.

30-1000 MHz:



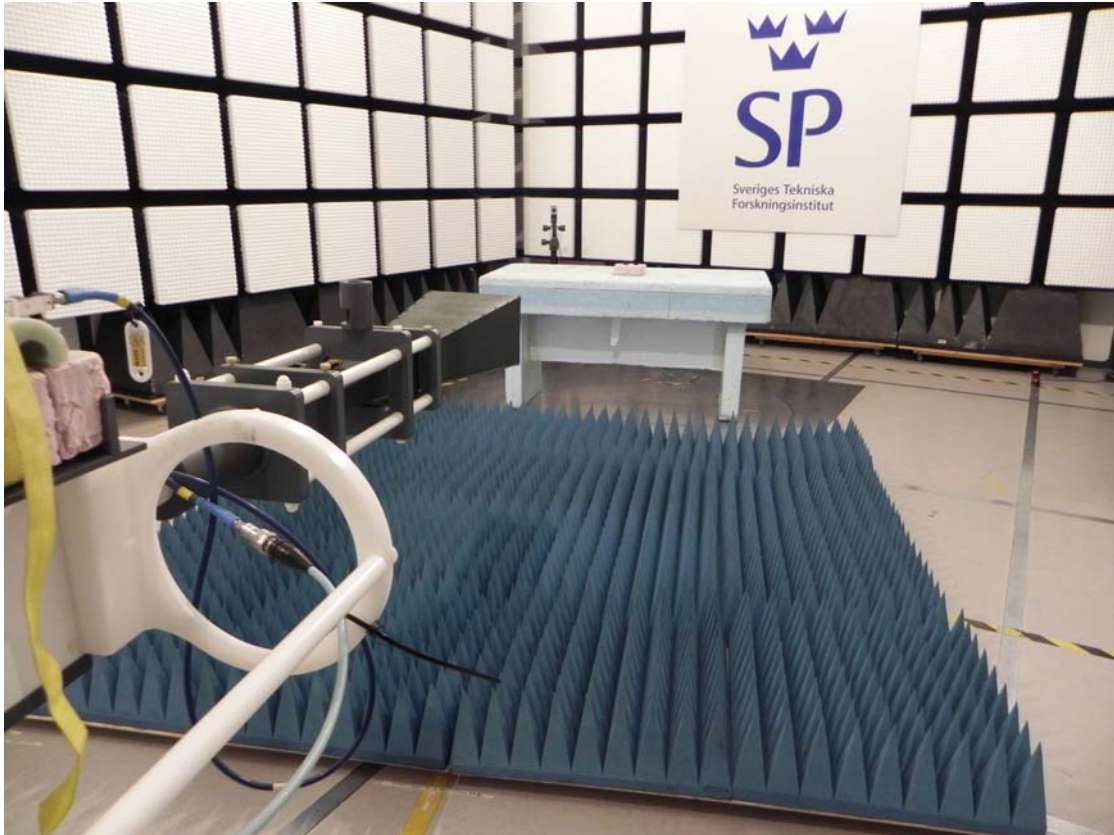
1-8.2 GHz:



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Appendix 12

8.2-12 GHz



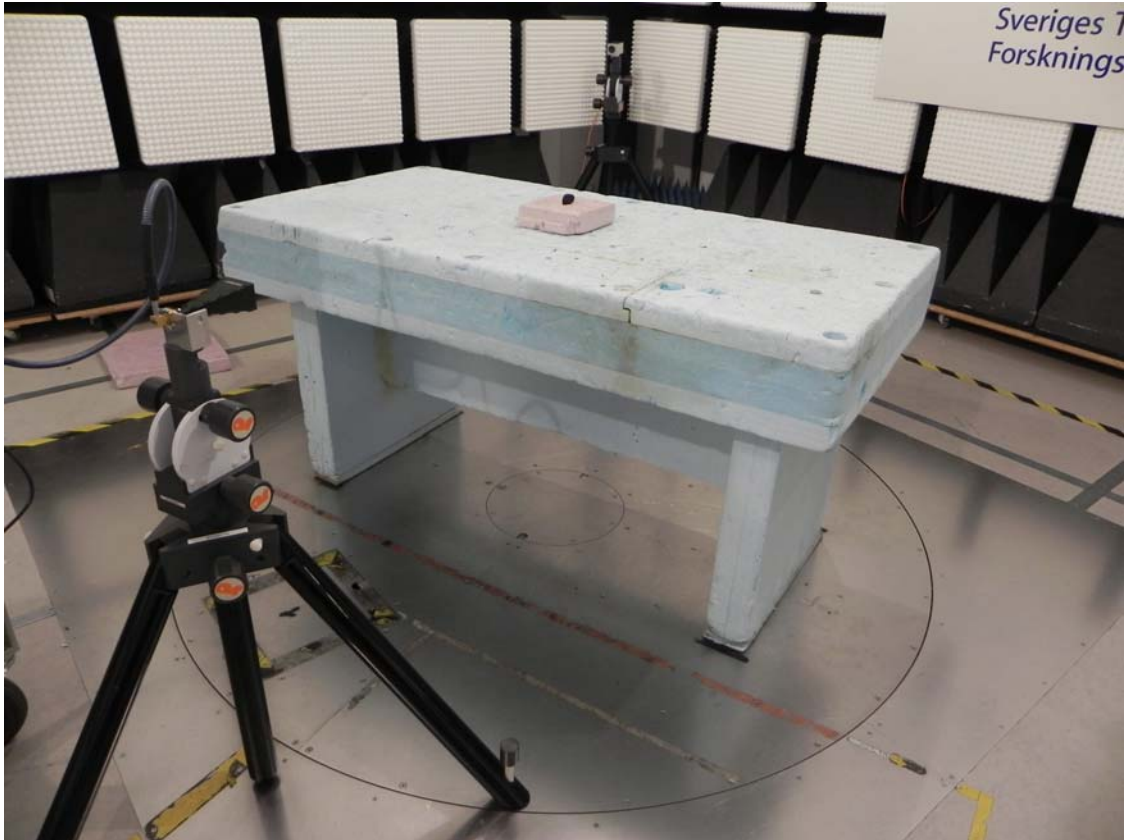
12-18 GHz



FCC ID: 2AB46-11515

Appendix 12

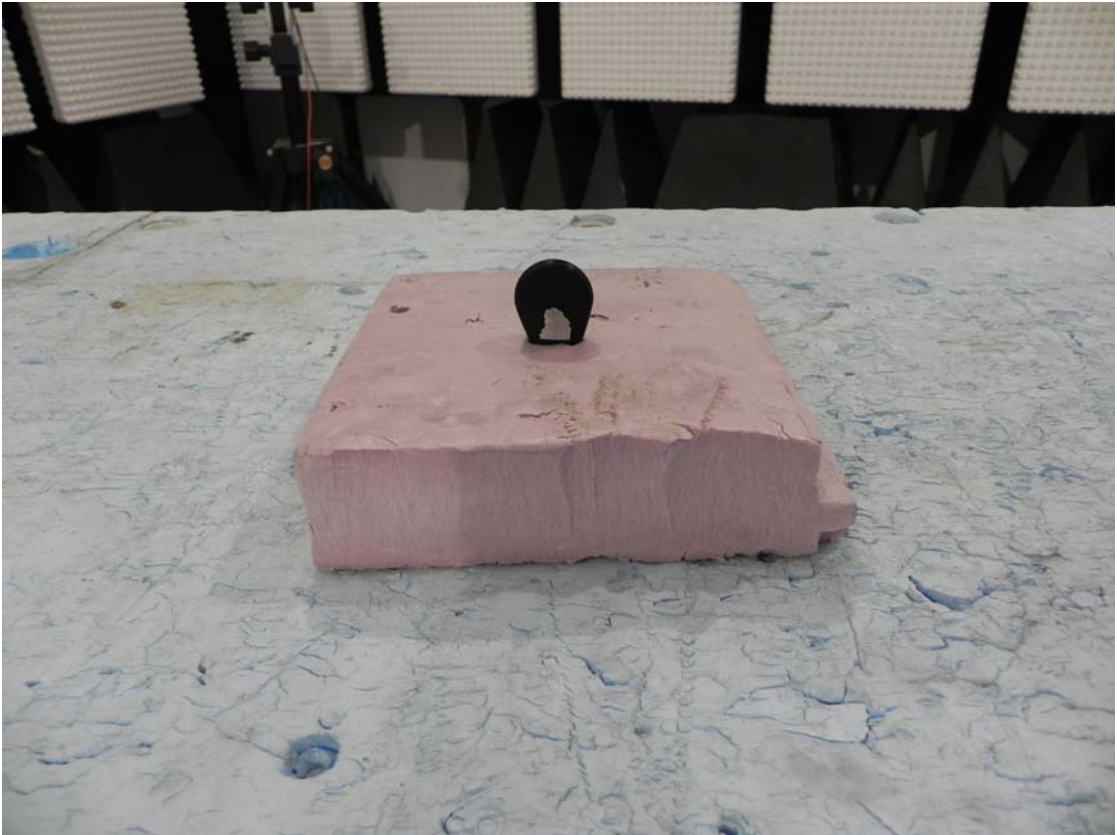
18-25 GHz:



FCC ID: 2AB46-11515

Appendix 12

Pos 1



Pos 2



FCC ID: 2AB46-11515

Appendix 12

Pos 3



FCC ID: 2AB46-11515

Appendix 12

EUT, radiated sample

Front



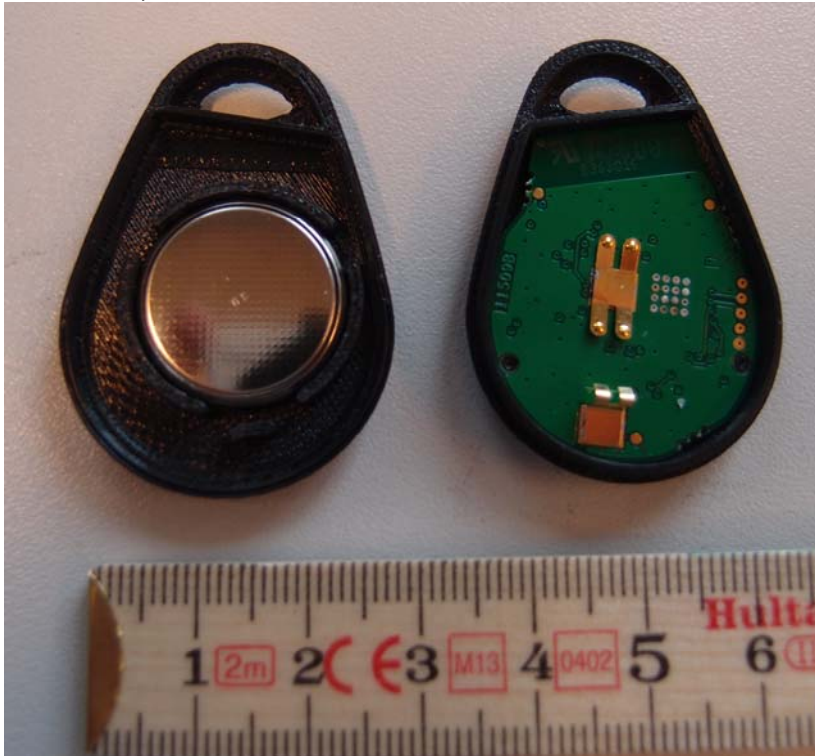
Rear



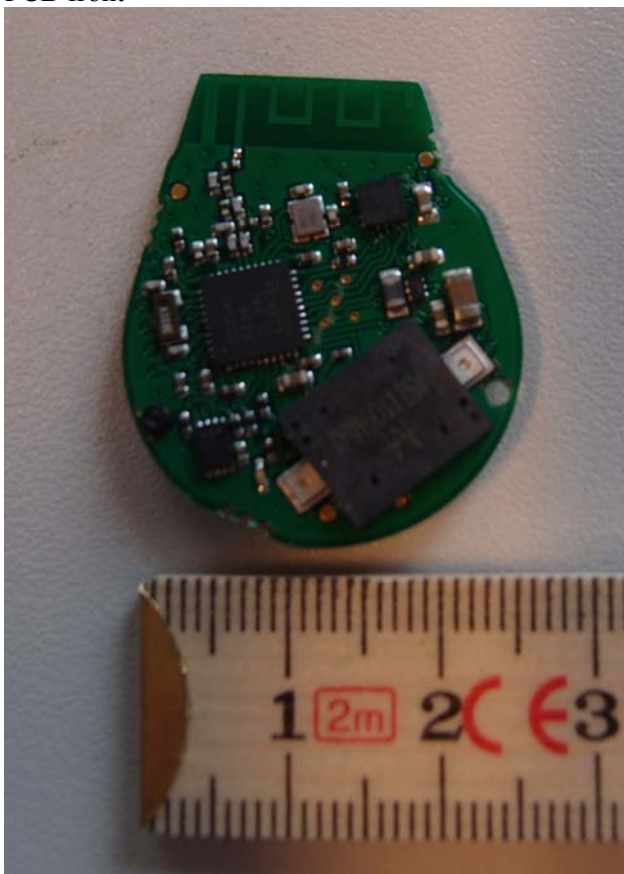
FCC ID: 2AB46-11515

Appendix 12

Inside view, PCB rear



PCB front

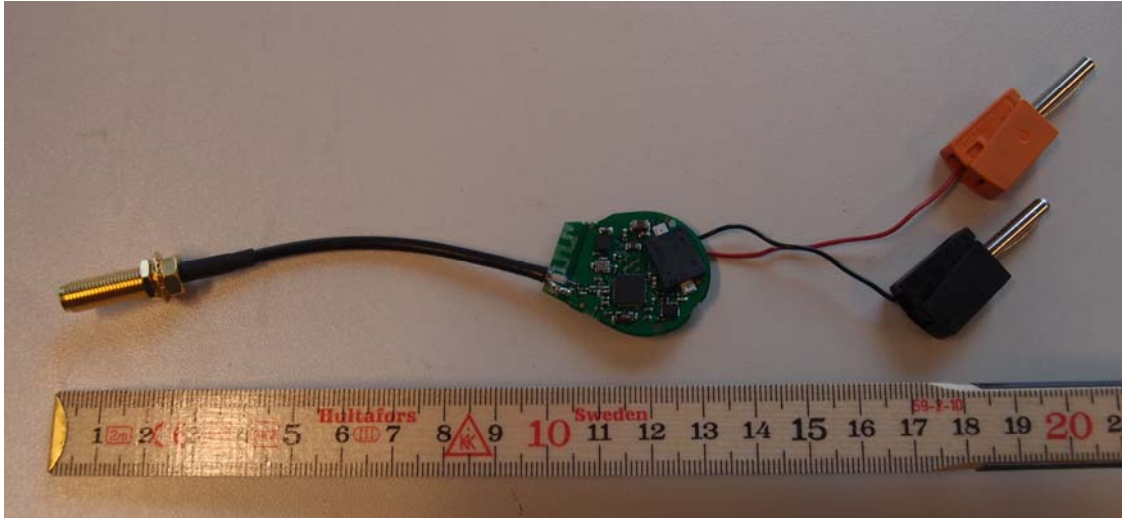


FCC ID: 2AB46-11515

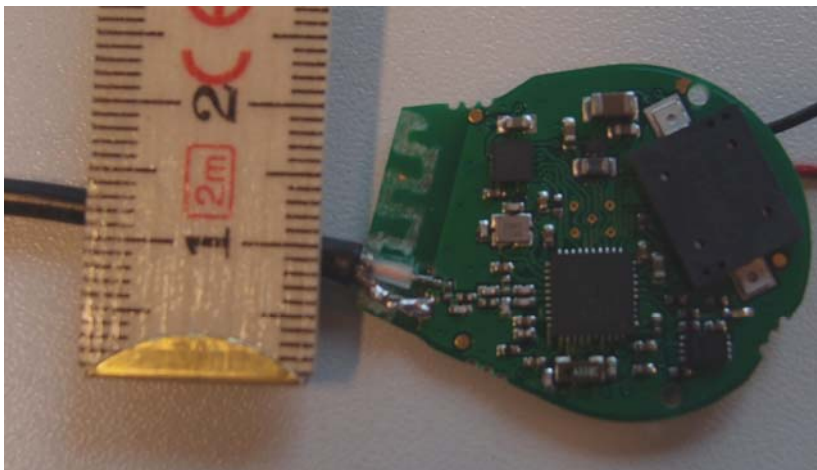
Appendix 12

EUT, conducted sample

Overview



PCB Front



PCB Rear

