REPORT

issued by an Accredited Testing Laboratory

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Equipment Authorization measurements on 2405-2480 MHz Transceiver Unit

Rev.1, 2018-06-26: Page 1, clarified the test objects. Page 49: Corrected the upper band edge frequency, 2483.5 MHz. Page 55: Added references to RSS-102 in the procedure section.

Test objects

Ink machine consisting of two transmitters,TPS-500 and POWERP2

EUT 1: Main unit with Scorpion charger attached
Product name: TPS-500
Serial number: 05-0618
Firmware revision: r1565
Software: r1565
FCC id: 2AA7B-TPS-500
IC: 11500A-TPS500

EUT 2: Power pack attached on an ink machine Scorpion tattoo machine
Product name: POWERP2
Serial number: 04-0618
Firmware revision: r1565
Software: r1565
FCC id: 2AA7B-SCPOWER
IC: 11500A-SCPOWER

RISE Research Institutes of Sweden AB
Electronics - EMC

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ISO/IEC 17025

Table of Content

Summary

Standard	Compliant	Remarks
FCC 47 CFR Part 15 C 15.249 Operation within the band 2400-2483.5 MHz	**Yes**	
IC RSS-210 Issue 9, August 2016	**Yes**	
Duty cycle measurements	N/A	
15.249 (a) / RSS-210 B.10(a) Field strength of fundamental	Yes	Note 1
15.249 (d) (e) / RSS-210 B.10(b) Radiated emission	Yes	
15.215 (c) 20 dB bandwidth	Ye	
15.207 / RSS-Gen 8.8 Conducted emission limits	Yes	
2.1049 / RSS-Gen 6.6 Occupied bandwidth	Yes	
2.1049 / RSS-210 B.10(b) Band Edge	Yes	
RF Exposure	Yes	

Note 1: To reduce the radiated emission below limits for the EUT 1, Main unit, a modification was performed, the output power was reduced .

Commission

The tests were performed to verify that the electromagnetic emission from the test object meets the requirements of FCC Part 15C and RSS-210.

Manufacturer representative

Christian Johansson
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Test object

The TPS-500 is designed and developed solely for tattooing of humans for the use by professional tattoo artists only. The TPS-500 can be used wirelessly with the products Scorpion, Stingray and Dragonfly and with other tattoo machines by wire.
Standard software in the test objects were used, except for the possibility the adjust the output power, which is not available in the standard software.

Main unit
The Main unit is equipped with an LCD display that makes it possible to view status and make settings to connected Powerpacks. Communications between the units are by radio for optimal reliability and performance. The TPS-500 can handle up to 6 active Powerpacks and charge 2. The Main unit is also equipped with regular ¼" Phono plugs and can handle other tattoo machines and foot switches by wire for full compatibility. There is also a USB connection for future software upgrades and for connection of the Neorail.
The USB cable should ONLY be used for software upgrades to the Main unit.

Charger
The charger is used together with the Main unit. It is connected to the Main unit and can charge two Powerpacks at a time.

Powerpack
The battery packs or Powerpacks are made with leading edge battery technology weighing only 70 grams each. The normal RCA or clip cord from the machine to the floor weighs about 50 grams, so the actual weight difference from a normal corded setup is about 20 grams.

Neorail
The Neorail should be used together with the supplied stand and USB cable.
It is made to handle tattoo needles of type Neo-Cartridges. Neorail can handle up to six Neo-Cartridges. When used, it takes over the setting of voltage from the Powerpack(s) and each Neo-Cartridge have their own setting of voltage. Only one Neo-Cartridge can be used at a time and the rest should remain on the Neorail when working.
At every needle position on the Neorail there is a LED light. This light will change colour depending on if the Neo-Cartridge is in place or not. White is working light, blue indicates that a Neo-Cartridge is in place and red indicates position for the Neo-Cartridge which is currently active.

EUT 1: Transceiver:	Main unit
EUT 2: Transceiver	Power pack
Antenna:	Integral, PCB
Antenna gain, vertical, typical:	2.2 dBi
Antenna gain, vertical, average:	1.0 dBi
Antenna gain, horizontal, typical:	1.3-1.5 dBi
Antenna gain, horizontal, average:	0.0 dBi
Frequency range:	2405-2480 MHz
Frequencies used during test:	2405, 2440 and 2480 MHz
Output power, max, setting	RF ATTENUA = 0 (0 dB)
Tune-up tolerance	±3 dB
Modulation:	O-QPSK
Data rate:	250 kbit/s
Supply voltage, EUT 1: Main unit	120 V AC
Supply voltage, EUT 2: Power pack	7.4 V DC (2x3.7 V DC), internal batteries Lithium Polymer, 2x3.7 VDC

The EUT 1, Main unit, was powered by 120 V AC/60 Hz.

Cabling during tests: Main unit TPS-500:

EUT port	Cable type	Termination / use
AC mains port	2 wire unshielded 1.7 m	Connected to AC mains
Phono (to wired pen)	Coaxial 1.9 m	Unterminated
Foot pedal	Coaxial 1.8 m	Terminated in an foot pedal, GEM-V2
USB	USB 1.0 m	Neorail

The test items were delivered to RISE 2017-10-13.

Testing was carried by Fredrik Isaksson and Markel Bertilsson at 2017-12-18—2018-12-21.

Operational test mode

Justification measurements for the Power pack attached on an ink machine Scorpion tattoo machine were performed with rotation of the EUT through three orthogonal axes to determine in which orientation the radio module had the highest emission levels, see photos in page 64.

Two power packs were attached in the Main unit/charger during the test on the Main unit. The test was performed with max output power, continuous transmission (100% duty cycle), if not otherwise stated, and with normal modulation. The test mode was set via the Main unit. The both EUT were tested as table top equipment. All tests were performed individually on each EUT, even as the system will only work together and in a way as a composite system. Additional test with the motor in the motor in the ink machine Scorpion tattoo machine activated were performed.

For normal duty cycle measurements see page 8 (additional test).
EUT 1: In normal mode the duty cycle was varied between 0.0007-0.003 %
EUT 2: In normal mode the duty cycle was varied between 0.005-0.021 %

All then tests were performed with 100 % duty cycle (except for the duty cycle measurements), thus the PRF and pulse desensitization were not to be considered.

Connected equipment during the test

Ink machine Scorpion tattoo machine attached on the Power pack	Client equipment
Foot pedal, GEM Switch GEM-V2	Client equipment
Neorail. Ink machines	Client equipment

Measurement equipment

Measurement equipment	RISE number	Calibration Due
Semi anechoic chamber, Edison	504114	2018-09
Computer Lenovo ThinkCentre	-	-
Software R&S EMC32, ver.9.15.00	503889	-
EMI test receiver R&S ESU 26	902210	2018-07
Signal Analyser R&S FSIQ40	503738	2018-07
Antenna Schaffner CBL 6143	504079	2019-04
Antenna ETS-Lindgren 3115	902212	2019-04
Standard gain horn Flann 16240-20	503673	2018-01
Standard gain horn Flann 18240-20	503673	2018-01
Standard gain horn Flann 20240-20	503674	2018-01
Low Noise Amplifier Miteq	503277	2018-12
Low Noise Amplifier Miteq	504160	2019-01
3 GHz High pass filter Wainwright WHKY	504200	2018-06
Coaxial cable	BX32218	2018-03
Coaxial cable	504102	2018-03
Coaxial cable	504103	2018-03
Coaxial cable	504104	2018-03
Multimeter Fluke 83	501522	2018-06
Temperature and humidity meter Testo 625	504117	2018-06

Test facility

The used semi-anechoic chamber is compliant with ANSI C63.4. The site complies with RSS Gen and is accepted by Industry Canada for the performance of radiated measurements, IC-file number 3482A-2.

References

Measurements were done according to relevant parts of the following standards:

ANSI 63.4-2014
ANSI 63.10-2013
eCFR 47, part 15 C, December 2017
RSS-210, Issue 9
RSS-Gen Issue 4
RSS-102 Issue 5
KDB 447498 D01 General RF Exposure Guidance v06

Uncertainties

Measurement and test instrument uncertainties are described in the quality assurance documentation ”SP-QD 10885”. 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**
Duty cycle	1.3 %
Radiated emission, 30 – 1000 MHz	6.3 dB
Radiated emission, 1 – 6 GHz	5.2 dB
Radiated emission, 6-40 GHz	5.6 dB
Conducted emission AC	3.5 dB
20 dB bandwidth	2.6 %
Occupied bandwidth	2.6 %

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

The test results apply to the tested items only
The test results in this report apply only to the particular Equipment Under Test (EUT) as declared in the report.

To reduce the radiated emission at 3xf0 below limits for the EUT 1, Main unit, a modification was performed. The output power was reduced in the software, RF ATTENUA was decreased from setting 0 (0 dB) to setting 11 (8 dB).
Investigation has been made for which radio parameters that could have impact on the results.
The following tests of EUT 1 were re tested after the modification:

- Field strength of fundamental, including RF safety
- Radiated emission (partly)
- Band edge

Test results

Duty cycle measurements

Date	Temperature	Humidity
2017-12-20	22 °C ± 3 °C	26 % ± 5 %

Test setup and procedure

The measurements were performed according to ANSI C63.10-2013 clause 11.6.

The radiated measurements were performed in a semi anechoic chamber.
The antenna distance was 3.0 m.
The test was performed with normal duty cycle and with normal modulation.

Test set-up photos during the tests can be found in the photo section in the end of the report.

Measurement equipment	RISE number
Semi anechoic chamber, Edison	504114
Computer Lenovo ThinkCentre	-
Software R&S EMC32, ver.9.15.00	503889
EMI test receiver R&S ESU 26	902210
Antenna ETS-Lindgren 3115	902212
Coaxial cable	BX32218
Coaxial cable	504102
Coaxial cable	504103
Coaxial cable	504104
Multimeter Fluke 83	501522
Temperature and humidity meter Testo 625	504117

Results

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

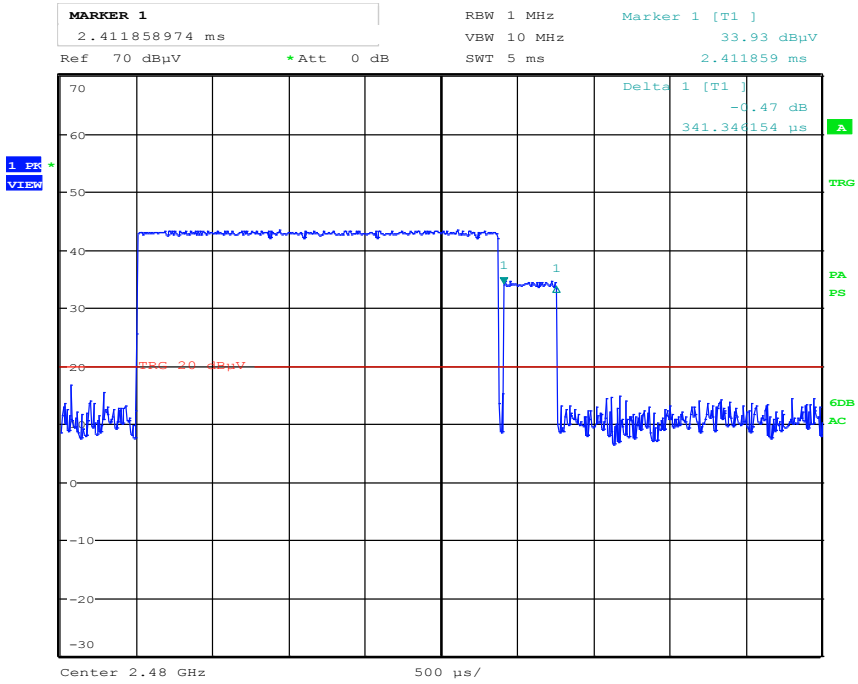
Diagram 1	EUT 1	2480 MHz	Tx on with normal duty cycle
Diagram 2	EUT 2	2480 MHz	Tx on with normal duty cycle
Diagram 3	EUT 1+2	2480 MHz	Period time with normal duty cycle, measurement 1
Diagram 4	EUT 1+2	2480 MHz	Period time with normal duty cycle, measurement 2
Diagram 5	EUT 1+2	2480 MHz	Period time with normal duty cycle, measurement 3
Diagram 6	EUT 1+2	2480 MHz	Period time with normal duty cycle, measurement 4

EUT 1: In normal mode the duty cycle was varied between 0.0007-0.003 %
EUT 2: In normal mode the duty cycle was varied between 0.005-0.021 %

Test engineers: Fredrik Isaksson and Markel Bertilsson

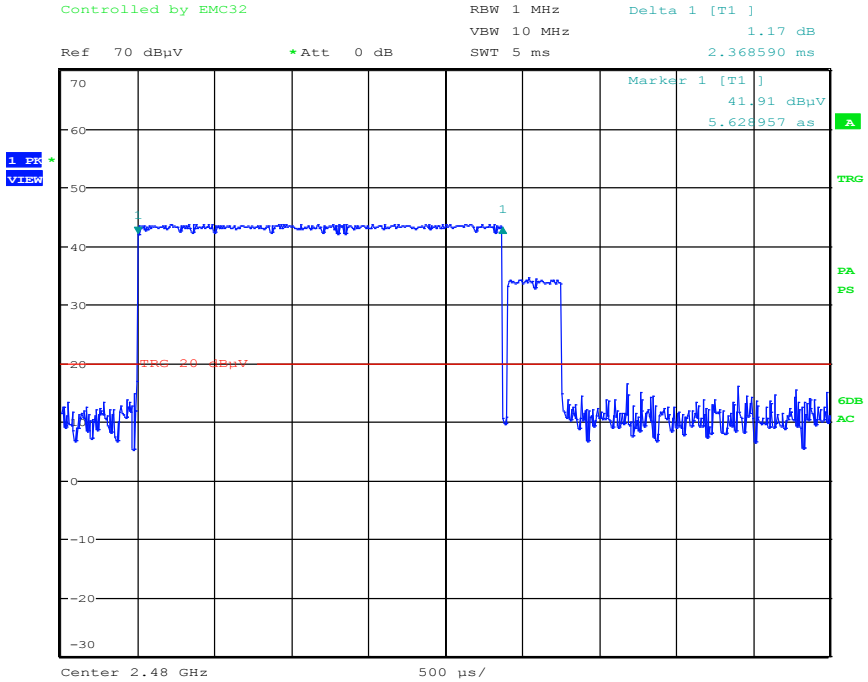
Complies?	N/A

Diagram 1



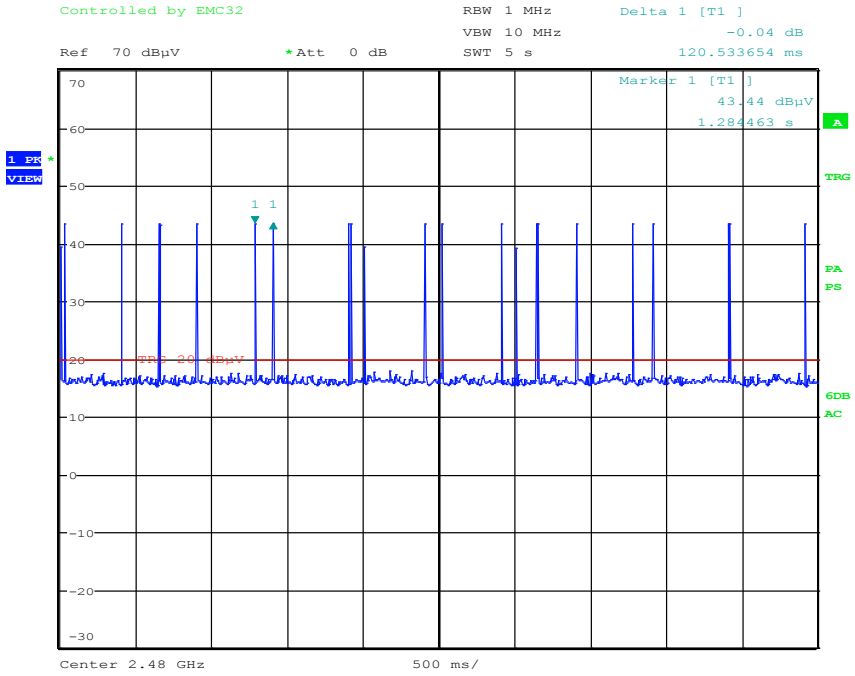
Date: 20.DEC.2017 14:25:41

Diagram 2



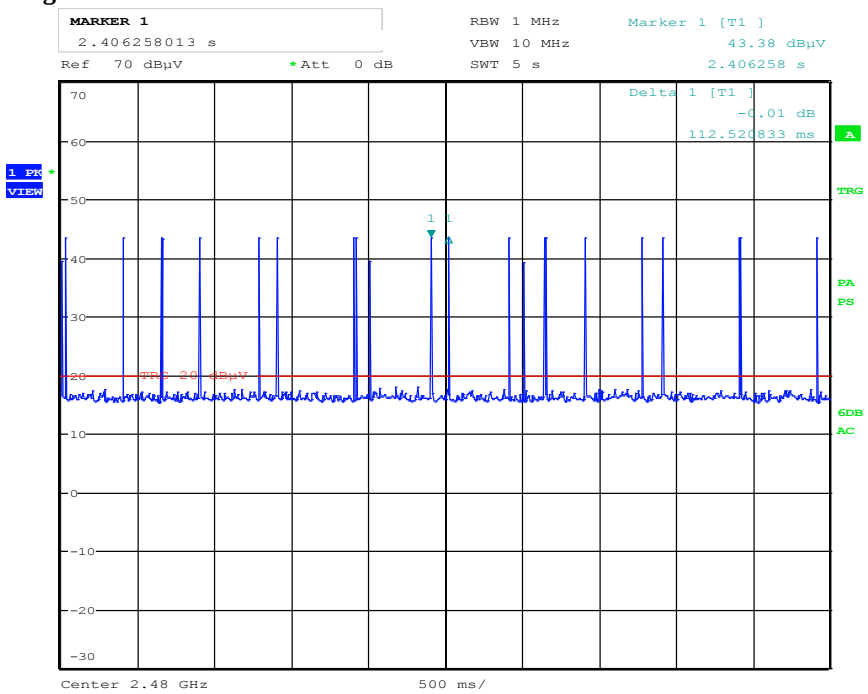
Date: 20.DEC.2017 14:22:47

Diagram 3



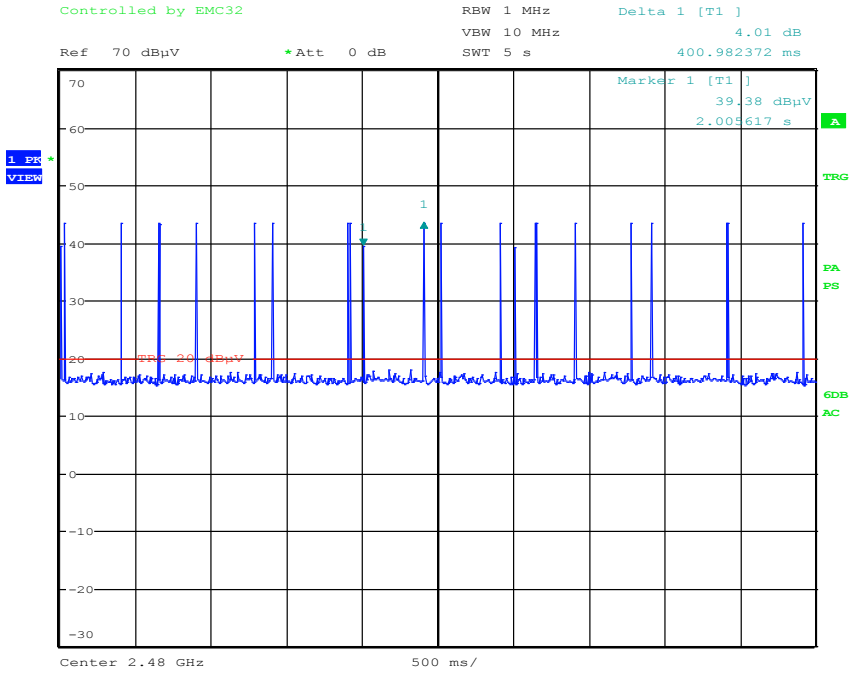
Date: 20.DEC.2017 14:29:58

Diagram 4



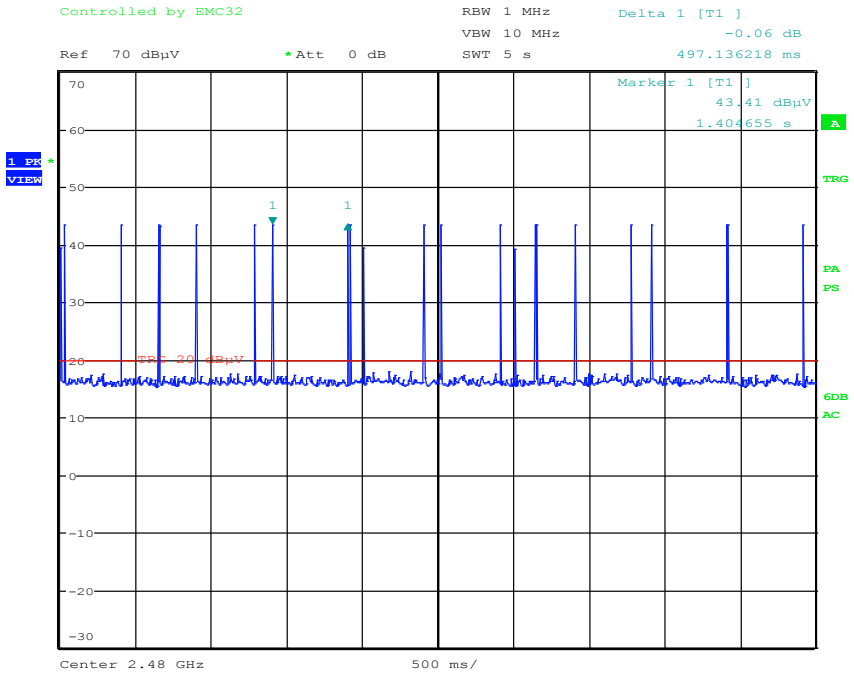
Date: 20.DEC.2017 14:30:38

Diagram 5



Date: 20.DEC.2017 14:31:34

Diagram 6



Date: 20.DEC.2017 14:32:27

Field strength of fundamental measurements according to FCC 47 CFR part 15.249 (a) / RSS-210 B.10(a)

Date	Temperature	Humidity
2017-12-18	22 °C ± 3 °C	25 % ± 5 %
2017-12-21	22 °C ± 3 °C	31 % ± 5 %

Test setup and procedure

The measurements were performed according to ANSI C63.10, clause 6.6 and 5.13.

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

The maximum peak radiated output power measurements were performed radiated in the semi-anechoic chamber.
The fundamental was scanned with peak-detector and the antenna height 1-4 m and the turntable was varied between 0-360 degrees for maximum response. The antenna distance during the measurements was 3.0 m.
Final measurement was performed with detector according to the FCC rules.

Test set-up photos during the tests can be found in the photo section in the end of the report.

Measurement equipment	RISE number
Semi anechoic chamber, Edison	504114
Computer Lenovo ThinkCentre	-
Software R&S EMC32, ver.9.15.00	503889
EMI test receiver R&S ESU 26	902210
Antenna ETS-Lindgren 3115	902212
Coaxial cable	BX32218
Coaxial cable	504102
Coaxial cable	504103
Coaxial cable	504104
Multimeter Fluke 83	501522
Temperature and humidity meter Testo 625	504117

Results

RBW=1 MHz

EUT 1, Main unit:

		Max peak Field strength of fundamental CISPR average detector (Peak detector)		
		2405 MHz	2440 MHz	2480 MHz
	EUT axis	N/A	N/A	N/A
	Antenna height	1.51 m	1.39 m	1.34 m
	Azimuth	0°	0°	2°
	Polarization	Horizontal	Horizontal	Horizontal
T_{nom} 22°C	V_{nom} 120 V AC	78.6 dBµV/m (84.5 dBµV/m) Note 1	77.9 dBµV/m (83.7 dBµV/m) Note 1	76.7 dBµV/m (82.0 dBµV/m) Note 1
T_{nom} 22°C	V_{min} 102 V AC	78.4 dBµV/m (84.3 dBµV/m)	77.9 dBµV/m (83.7 dBµV/m)	76.7 dBµV/m (82.0 dBµV/m)
T_{nom} 22°C	V_{max} 138 V DC	78.4 dBµV/m (84.3 dBµV/m)	77.9 dBµV/m (83.7 dBµV/m)	76.7 dBµV/m (82.0 dBµV/m)

Note 1: For RF Exposure evaluation also the RMS level was measured.
RMS levels: 2405 MHz=80.8 dBµV/m, 2440 MHz=77.9 dBµV/m,
2480 MHz=78.2 dBµV/m,

EUT 2, Power pack:

		Max peak Field strength of fundamental CISPR average detector (Peak detector)		
		2405 MHz	2440 MHz	2480 MHz
	EUT axis	Y	Y	Y
	Antenna height	1.00	1.12	1.39
	Azimuth	320°	320°	309°
	Polarization	Horizontal	Horizontal	Vertical
T_{nom} 22°C	V_{nom} 7.4 V DC	85.7 dBµV/m (89.1 dBµV/m) Note 2	81.8 dBµV/m (85.1 dBµV/m) Note 2	78.9 dBµV/m (82.4 dBµV/m) Note 2

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.

Note 2: For RF Exposure evaluation also the RMS level was measured.
RMS levels: 2405 MHz=82.3 dBµV/m, 2440 MHz=81.6 dBµV/m,
2480 MHz=78.9 dBµV/m,

Remark

The test on the EUT 1 was performed with the reduced power, RF ATTENUA was decreased from setting 0 (0 dB) to setting 11 (8 dB).

Limits

According to 47CFR 15.249(a), the field strength of emissions from intentional radiators operated within these frequency bands shall comply with the following:

According to RSS-210 B.10(a), the field strength measured at 3 meter shall not exceed the following:

Fundamental Frequency	Field strength of fundamental	Field strength of harmonics
2400-2483.5 MHz	50 mV/m = 94 dBµV/m	500 µV/m = 54 dBµV/m

Test engineers: Fredrik Isaksson and Markel Bertilsson

Complies?	Yes

Radiated emission measurements according to FCC 47 CFR part 15.249 (d) (e) / RSS-210 B.10 (b)

Date	Temperature	Humidity
2017-12-18	22 °C ± 3 °C	25 % ± 5 %
2017-12-19	21 °C ± 3 °C	27 % ± 5 %
2017-12-20	22 °C ± 3 °C	26 % ± 5 %
2017-12-21	22 °C ± 3 °C	31 % ± 5 %

Test setup and procedure

The measurements were performed according to ANSI C63.10, clause 6.3 and 6.6.

The test was performed 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 was 3.0 m in the frequency range 30MHz-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. For measurement < 1 GHz the test object is measured in eight directions with the antenna at three heights, 1.0 m, 1.5 m and 2.0. For measurement between 1 GHz – 18 GHz the test object is measured in seventeen directions with the antenna at three heights, 1.0 m, 1.5 m and 2.0. For measurements > 18 GHz the test object is measured in seventeen directions with the antenna height at 1.0 m.
2. For measurements in the frequency range 1 – 18 GHz, RF absorbers were covering an floor area to comply with site validation requirements according to CISPR 16-1-4:2010.
3. 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 measurement was first performed with peak detector.
The following RBW were used:
30 MHz-1 GHz: RBW=120 kHz
1-25 GHz: RBW=1 MHz

Test set-up photos during the tests can be found in the photo section in the end of the report.

Measurement equipment	RISE number
Semi anechoic chamber, Edison	504114
Computer Lenovo ThinkCentre	-
Software R&S EMC32, ver.9.15.00	503889
EMI test receiver R&S ESU 26	902210
Signal Analyser R&S FSIQ40	503738
Antenna Schaffner CBL 6143	504079
Antenna ETS-Lindgren 3115	902212
Standard gain horn Flann 16240-20	503673
Standard gain horn Flann 18240-20	503673
Standard gain horn Flann 20240-20	503674
Coaxial cable	BX32218
Coaxial cable	504102
Coaxial cable	504103
Coaxial cable	504104
Low Noise Amplifier Miteq	503277
Low Noise Amplifier Miteq	504160
3 GHz High pass filter Wainwright WHKY	504200
Multimeter Fluke 83	501522
Temperature and humidity meter Testo 625	504117

Results

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

Diagram 1:	30-1000 MHz, Ambient, vertical and horizontal polarization
Diagram 2:	30-1000 MHz, EUT 1, ch 2480M, vertical and horizontal polarization
Diagram 3:	30-1000 MHz, EUT 2, ch. 2440M, Y-axis, vertical and horizontal polarization
Diagram 4:	30-1000 MHz, EUT 2, ch. 2480M, motor activated, Y-axis, vertical and horizontal polarization (additional test)
Diagram 5:	1-3 GHz, EUT 1, ch, 2405M, vertical and horizontal polarization
Diagram 6:	1-3 GHz, EUT 2, ch, 2440M, Y-axis, vertical and horizontal polarization
Diagram 7:	1-3 GHz; EUT 2,ch. 2480M, motor activated, Y-axis, vertical and horizontal polarization (additional test)
Diagram 8:	3-8.2 GHz, EUT 1, ch 2440M, vertical and horizontal polarization
Diagram 9:	3-8.2 GHz, EUT 2, ch 2440M, Y-axis, vertical and horizontal polarization
Diagram 10:	8.2-12 GHz, EUT 1, 2440M, vertical and horizontal polarization
Diagram 11:	8.2-12 GHz, EUT 2, 2440M, Y-axis, vertical and horizontal polarization
Diagram 12:	12-18 GHz, EUT 1, ch 2440M, vertical and horizontal polarization
Diagram 13:	12-18 GHz, EUT 2, ch 2440M, Y-axis, vertical and horizontal polarization
Diagram 14:	18-25 GHz, EUT 1, ch. 2440M, vertical polarization
Diagram 15:	18-25 GHz, EUT 1, ch. 2440M, horizontal polarization
Diagram 16:	18-25 GHz, EUT 2, ch. 2440M, Y-axis, vertical polarization
Diagram 17:	18-25 GHz, EUT 2, ch. 2440M, Y-axis, horizontal polarization

Note: Only 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.

EUT 1, 2405 MHz

Frequency (MHz)	QP level (dBµV/m)	CISPRAV level (dBµV/m)	Peak level (dBµV/m)	Corr (dB)	Limit (dBµV/m)	Height (cm)	Azimuth (deg)	Pol.
39.196	**33.7**	N/A	36.8	2.0	40.0 (QP)	167	6	Vertical
80.327	**25.6**	N/A	37.3	13.8	40.0 (QP)	100	287	Vertical
72.731	**20.1**	N/A	34.8	14.7	40.0 QP)	124	91	Vertical
214.987	**36.3**	N/A	41.3	18.9	43.5 (QP)	100	307	Vertical
287.129	**36.7**	N/A	39.8	19.9	46.0 (QP)	226	357	Horizontal
330.147	**40.4**	N/A	43.1	20.9	46.0 (QP)	117	219	Horizontal
4808.998	N/A	**51.2**	**59.3**	-10.3	53.9 (AV)	165	139	Vertical
7216.522	N/A	**47.9** Note 1	**56.1** Note 1	-1.8	53.9 (AV)	102	260	Horizontal
9622.003	N/A	**42.7** Note 1	**50.5** Note 1	-8.6	53.9 (AV)	155	0	Horizontal

EUT 1, 2440 MHz

Frequency (MHz)	QP level (dBµV/m)	CISPRAV level (dBµV/m)	Peak level (dBµV/m)	Corr (dB)	Limit (dBµV/m)	Height (cm)	Azimuth (deg)	Pol.
40.356	**33.9**	N/A	37.1	2.0	40.0 (QP)	159	2	Vertical
71.650	**22.2**	N/A	35.0	14.8	40.0 QP)	164	196	Vertical
72.242	**23.1**	N/A	37.3	14.7	40.0 (QP)	110	238	Vertical
80.194	**25.0**	N/A	36.8	13.8	40.0 (QP)	100	294	Vertical
289.315	**36.2**	N/A	39.5	19.9	46.0 (QP)	222	6	Horizontal
329.126	**39.4**	N/A	41.9	20.9	46.0 (QP)	109	225	Horizontal
4881.160	N/A	**49.3**	**58.3**	-10.3	53.9 (AV)	181	137	Vertical
7321.560	N/A	**51.5** Note 1	**58.9** Note 1	-1.8	53.9 (AV)	100	259	Horizontal
9762.282	N/A	**37.9** Note 1	**46.7** Note 1	-8.6	53.9 (AV)	152	347	Horizontal

EUT 1, 2480 MHz

Frequency (MHz)	QP level (dBµV/m)	CISPRAV level (dBµV/m)	Peak level (dBµV/m)	Corr (dB)	Limit (dBµV/m)	Height (cm)	Azimuth (deg)	Pol.
39.664	**31.9**	N/A	36.1	24.2	40.0 (QP)	121	17	Vertical
72.436	**20.5**	N/A	35.4	14.7	40.0 QP)	127	95	Vertical
215.654	**36.8**	N/A	41.7	18.9	43.5 (QP)	100	311	Vertical
286.772	**37.0**	N/A	40.0	19.9	46.0 (QP)	231	0	Horizontal
331.985	**40.6**	N/A	43.5	20.9	46.0 (QP)	119	216	Horizontal
472.426	**34.5**	N/A	38.8	24.3	46.0 (QP)	206	216	Horizontal
4880.998	N/A	**48.6**	**51.3**	-10.3	53.9 (AV)	100	263	Vertical
7441.513	N/A	**47.2** Note 1	**55.2** Note 1	-1.8	53.9 (AV)	119	136	Horizontal
9762.282	N/A	**32.9** Note 1	**42.9** Note 1	-8.6	53.9 (AV)	156	0	Horizontal

Note: The levels in the table above on the EUT 1 is with maximum output power, if not either stated.

Note 1: The noted levels are with the output power reduced in the software, RF ATTENUA, was decreased from setting 0 (0 dB) to setting 11 (8 dB).

EUT 2, Y-axis, 2405 MHz

Frequency (MHz)	QP level (dBµV/m)	CISPRAV level (dBµV/m)	Peak level (dBµV/m)	Corr (dB)	Limit (dBµV/m)	Height (cm)	Azimuth (deg)	Pol.
4810.993	N/A	**41.9**	**50.0**	-10.3	53.9 (AV)	128	42	Horizontal
9621.923	N/A	**32.2**	**43.1**	-8.6	53.9 (AV)	152	281	Vertical

EUT 2, Y-axis, 2440 MHz

Frequency (MHz)	QP level (dBµV/m)	CISPRAV level (dBµV/m)	Peak level (dBµV/m)	Corr (dB)	Limit (dBµV/m)	Height (cm)	Azimuth (deg)	Pol.
4881.160	N/A	**41.9**	**50.1**	-10.3	53.9 (AV)	133	42	Horizontal
7318.317	N/A	**34.4**	**47.2**	-1.8	53.9 (AV)	100	81	Horizontal
9762.197	N/A	**32.8**	**43.9**	-8.6	53.9 (AV)	149	283	Vertical
12197.273	N/A	**32.8**	**45.7**	-1.9	53.9 (AV)	105	164	Vertical

EUT 2, Y-axis, 2480 MHz

Frequency (MHz)	QP level (dBµV/m)	CISPRAV level (dBµV/m)	Peak level (dBµV/m)	Corr (dB)	Limit (dBµV/m)	Height (cm)	Azimuth (deg)	Pol.
4958.998	N/A	**43.8**	**51.3**	-10.3	53.9 (AV)	126	30	Horizontal
9921.878	N/A	**36.3**	**45.3**	-8.6	53.9 (AV)	153	282	Vertical

EUT 2, Y-axis, 2480 MHz
(Additional test with motor in ink machine Scorpion activated)

Frequency (MHz)	QP level (dBµV/m)	CISPRAV level (dBµV/m)	Peak level (dBµV/m)	Corr (dB)	Limit (dBµV/m)	Height (cm)	Azimuth (deg)	Pol.
340.263	**21.4**	N/A	26.8	21.0	46.0 (QP)	107	273	Vertical
486.894	**22.4**	N/A	28.9	24.6	46.0 (QP)	348	10	Vertical
866.310	**28.3**	N/A	34.3	28.5	46.0 (QP)	292	193	Horizontal

Remark

To reduce the radiated emission at 3xf0 below limits for the EUT 1, Main unit, a modification was performed. The output power was reduced in the software, RF ATTENUA was decreased from setting 0 (0 dB) to setting 11 (8 dB).
The levels of 3xf0 and 4xf0 were verified of EUT 1 with the reduced output power level described above (noted in the final result tables).
The other levels of EUT 1 noted in the result tables and diagrams are with maximum output power with no power reduction.

Limits

According to 47CFR 15.249(a), the field strength of emissions from intentional radiators operated within these frequency bands shall comply with the following:

Fundamental Frequency	Field strength of harmonics
2400-2483.5 MHz	500 μV/m = 54 dBμV/m

According to 47CFR 15.249(d), emission radiated outside of the specified frequency bands, except for harmonics, shall be attenuated by at least 50 dB below the level of the fundamental or to the general radiated emission limits in section 15.209, whichever is the lesser attenuation.

According to 47CFR 15.249(e), the peak field strength of any emission shall not exceed the maximum permitted average limits specified above by more than 20 dB under any condition of modulation.

According to RSS-210 B.10 (b), emissions radiated outside of the specified frequency bands, except for harmonics, shall be attenuated by at least 50 dB below the level of the fundamental emissions or to the general field strength limits listed in RSS-Gen, whichever is the less stringent.

Test engineers: Fredrik Isaksson and Markel Bertilsson

Complies?	Yes

Measuring distance: 3 m

Diagram 1

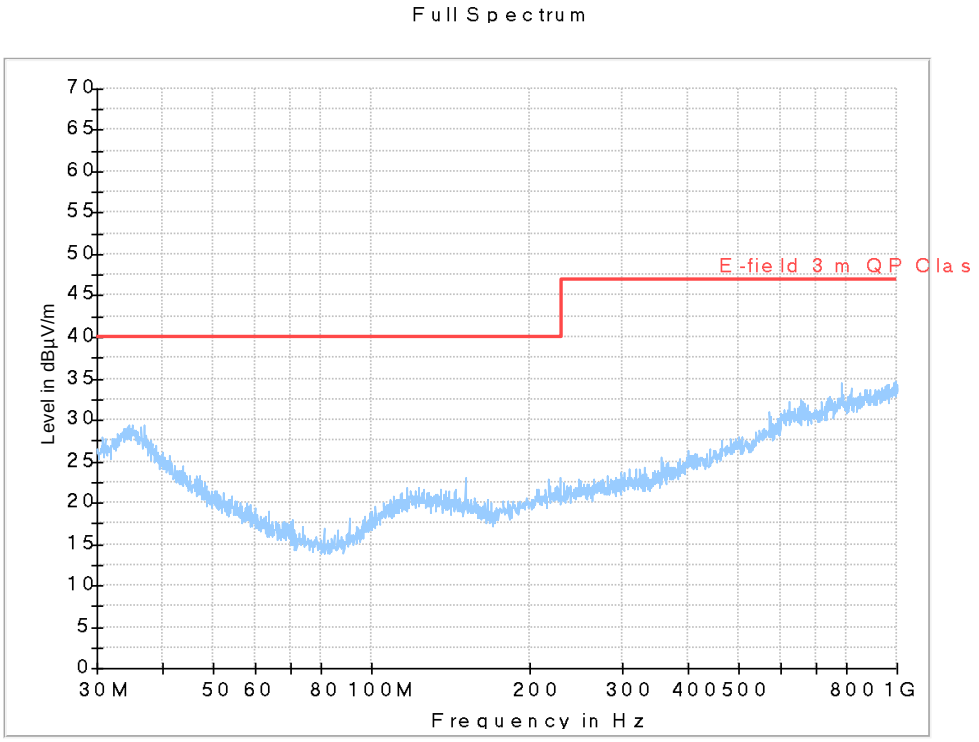
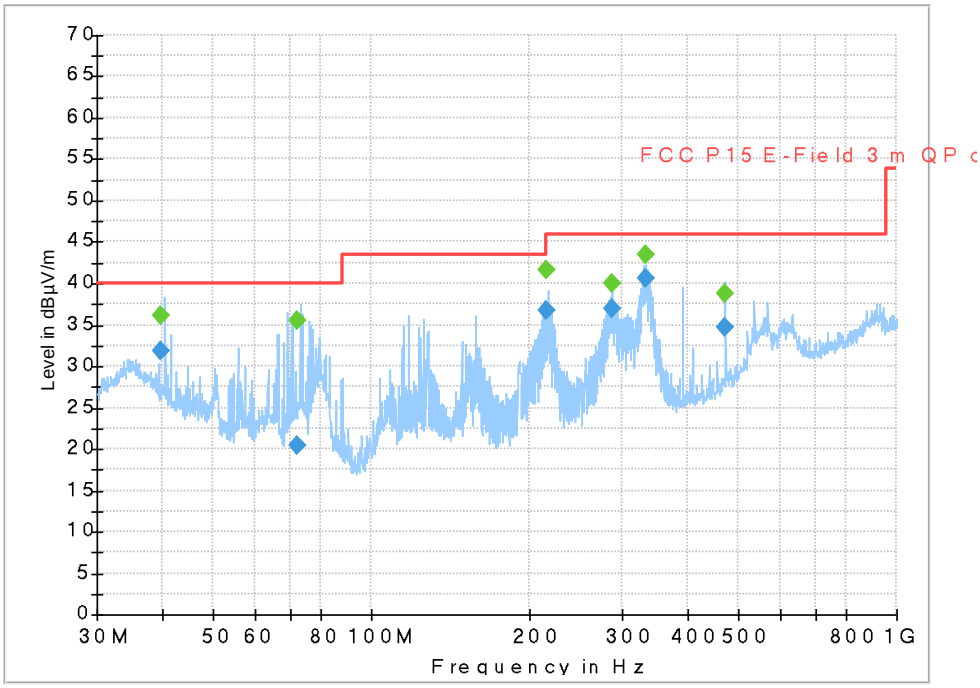


Diagram 2



Measuring distance: 3 m

Diagram 3

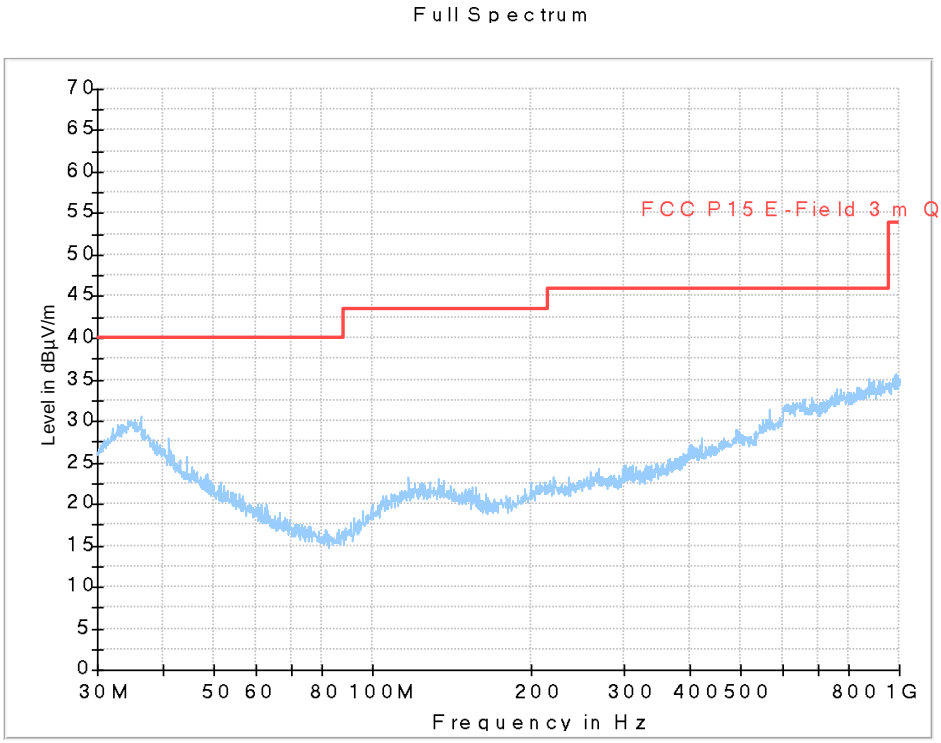
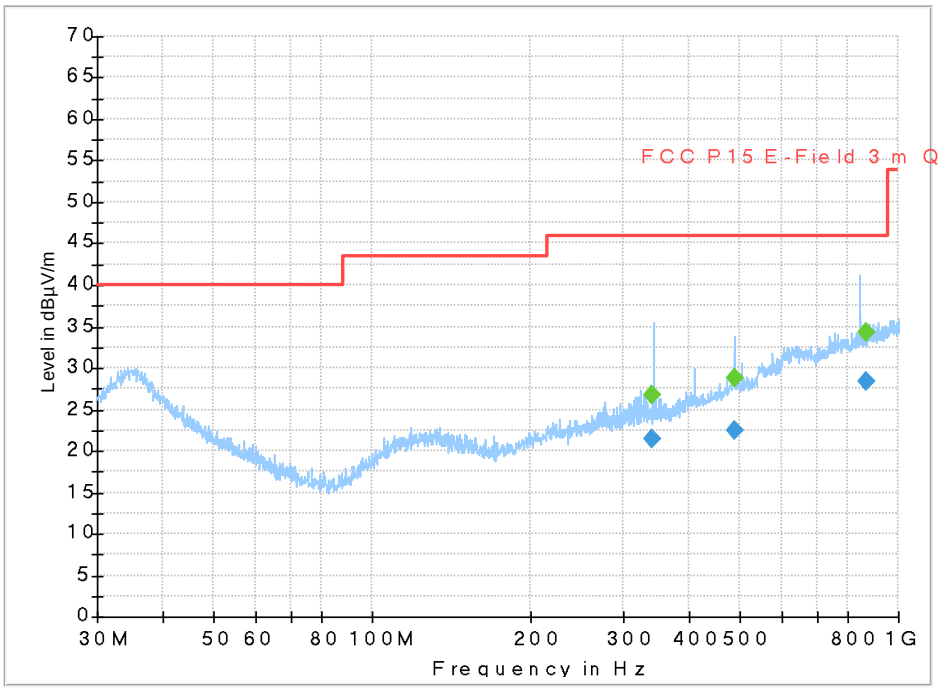


Diagram 4



Measuring distance: 3 m

Diagram 5

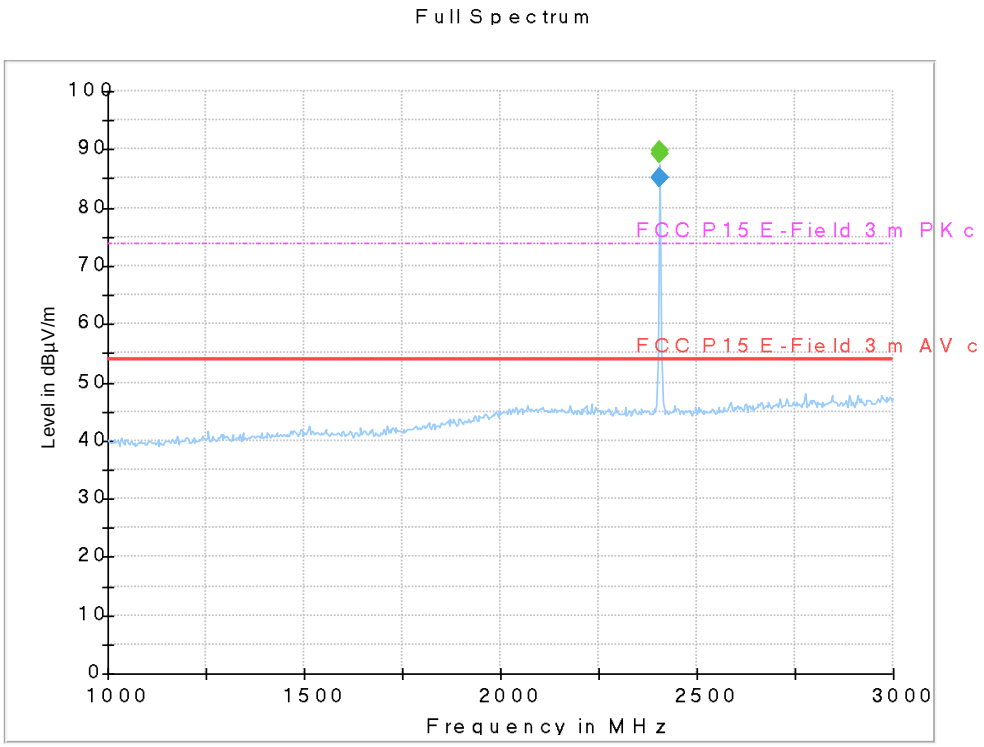
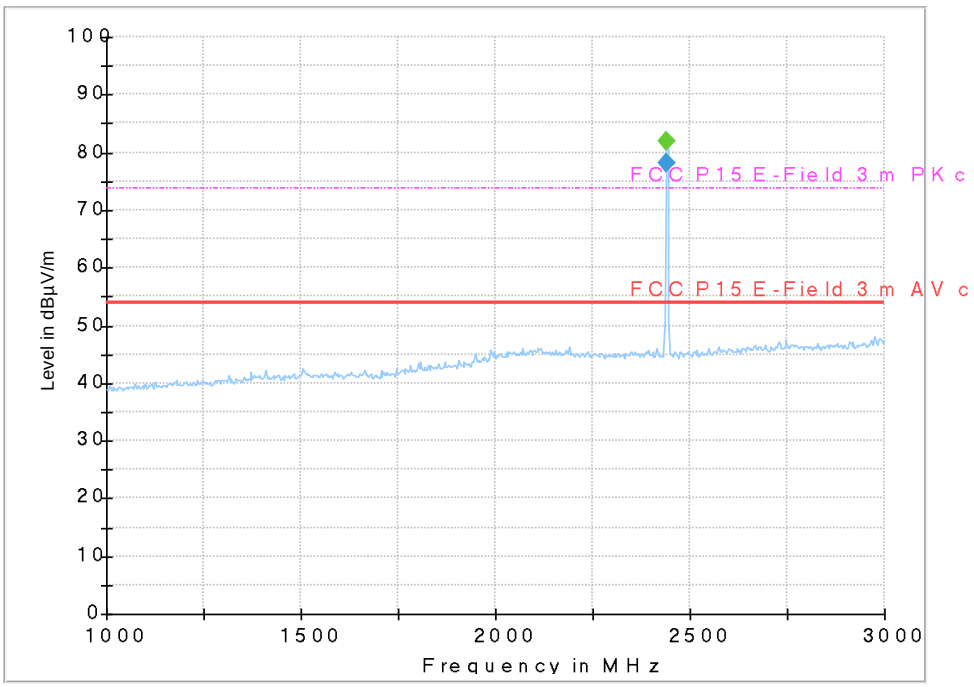


Diagram 6



Measuring distance: 3 m

Diagram 7

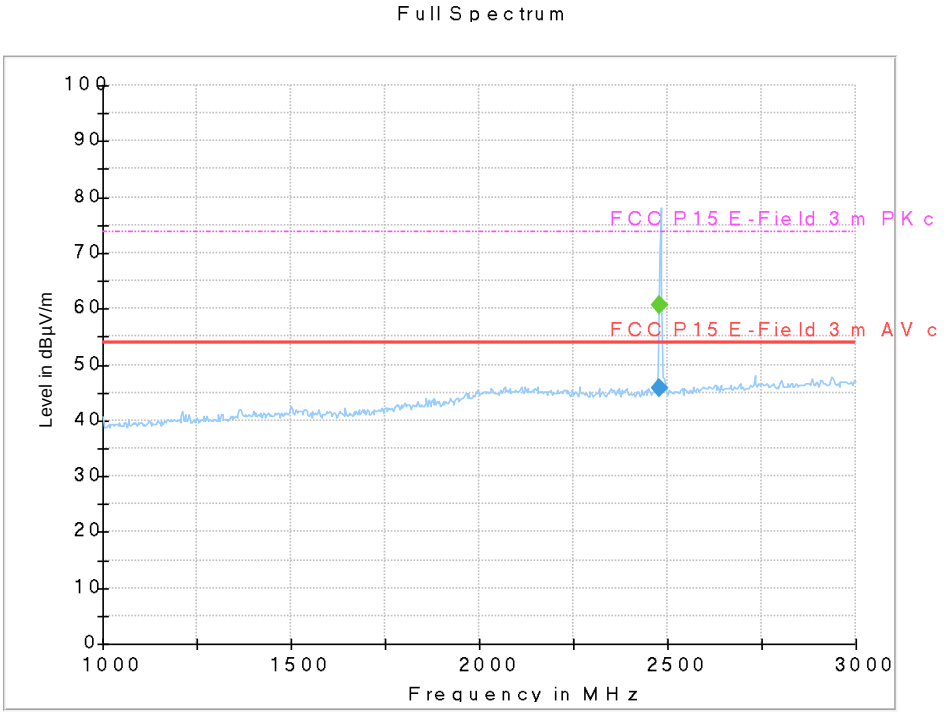
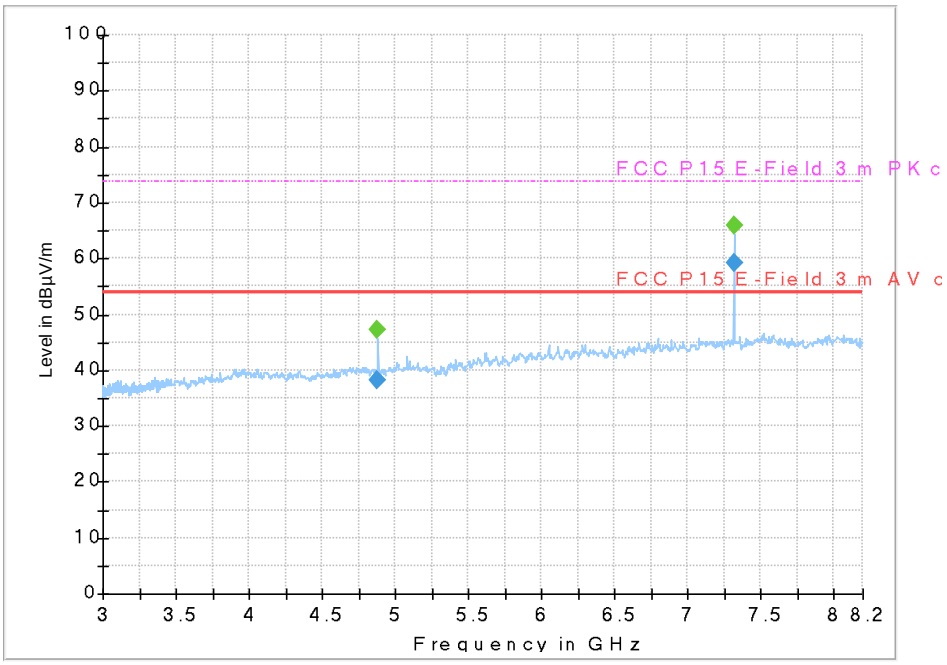


Diagram 8



The levels of 3xf0 in the diagram is with maximum output power with no power reduction. Manual measurement was performed with the reduced output power level (noted level in the final result tables), which was compliant.

Measuring distance: 3 m

Diagram 9

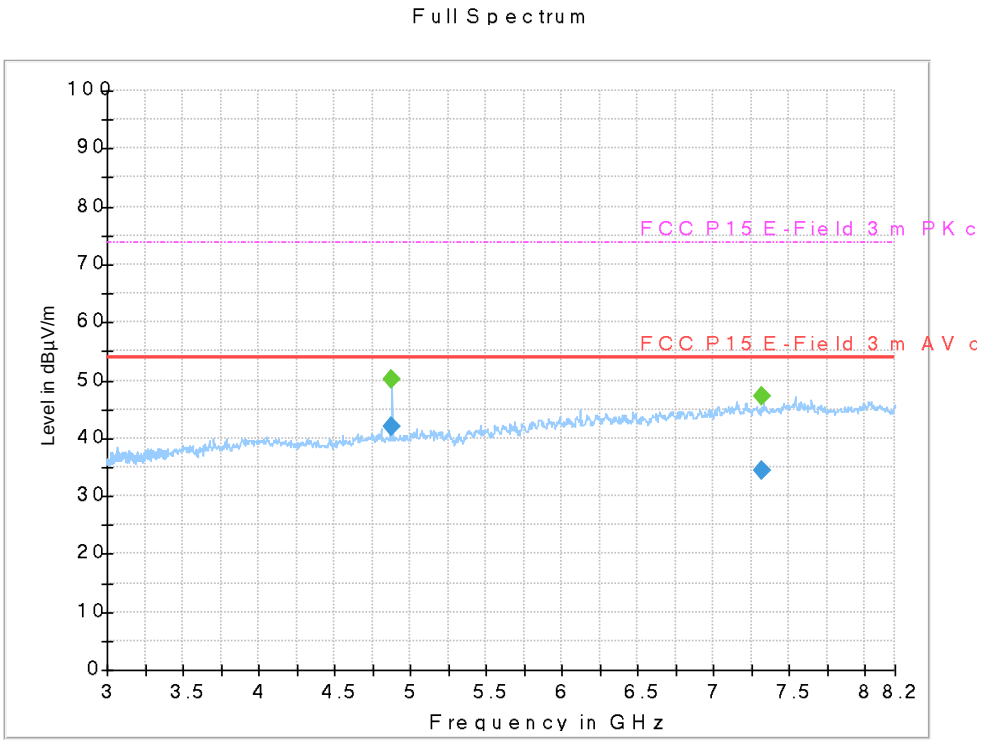
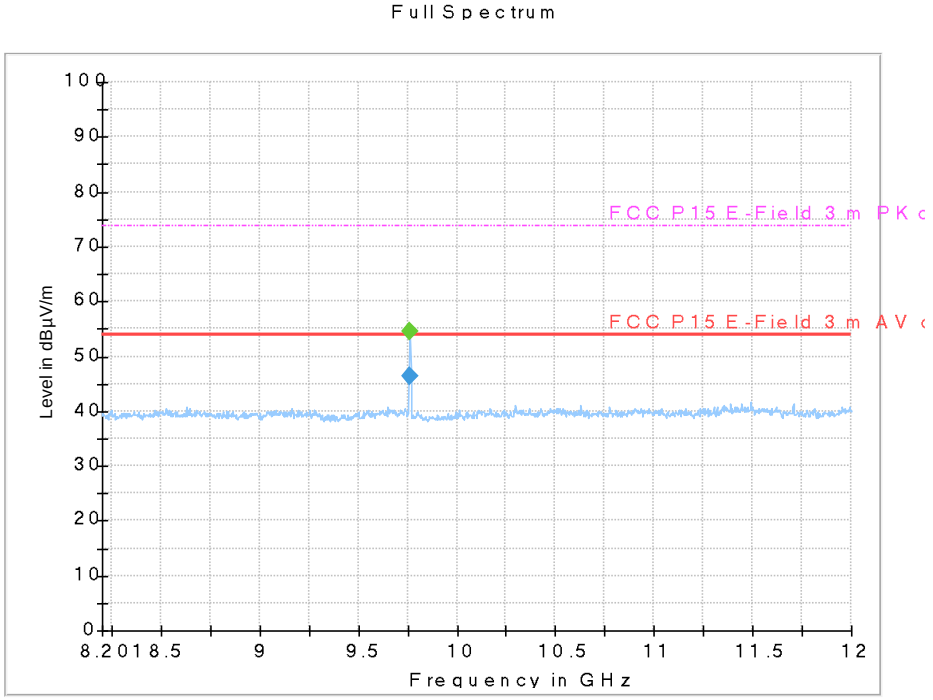


Diagram 10



Measuring distance: 3 m

Diagram 11

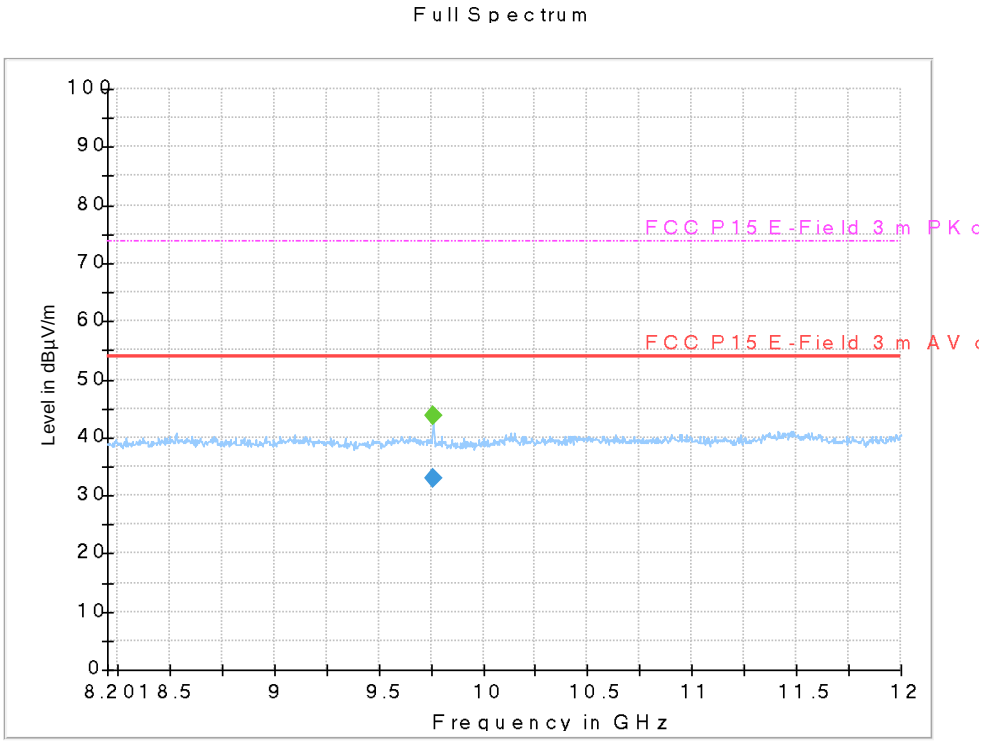
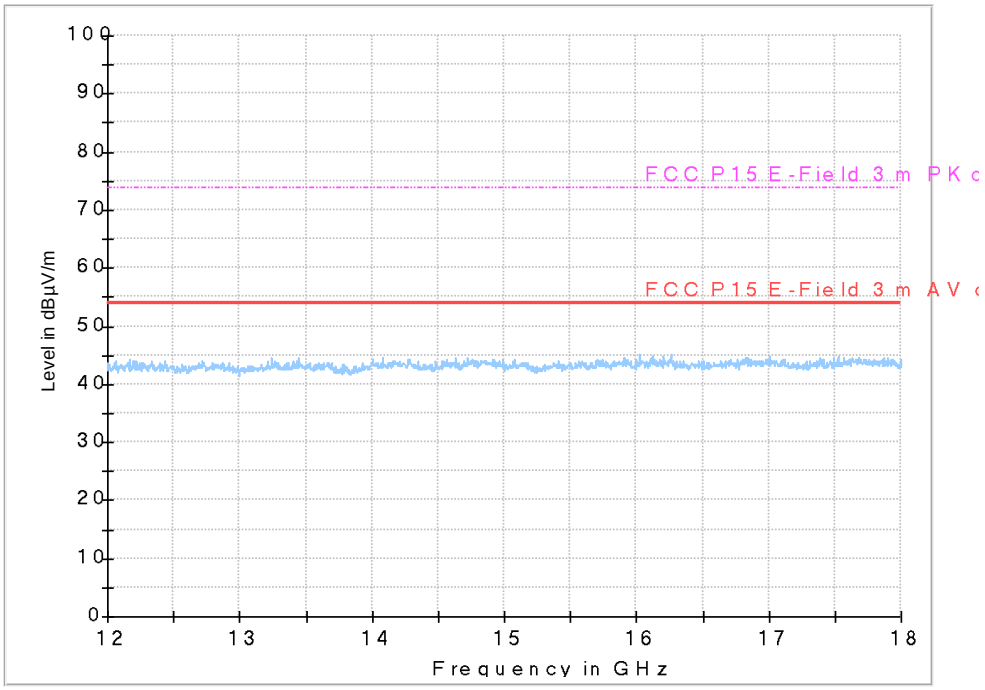
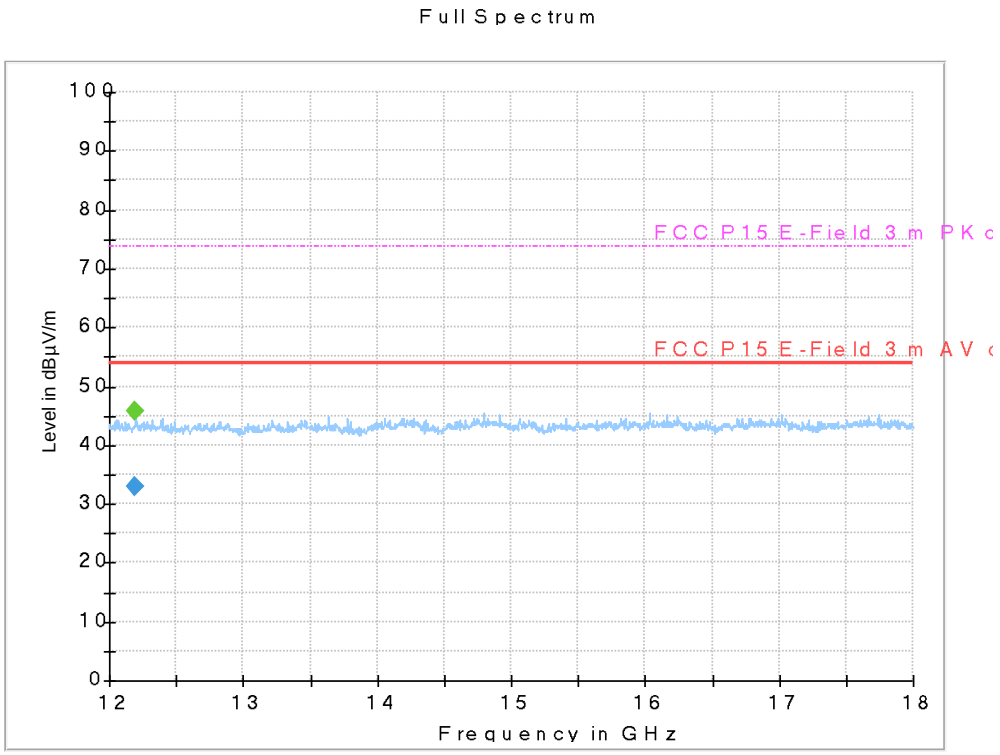


Diagram 12



Measuring distance: 3 m

Diagram 13



Measuring distance: 1 m

Diagram 14

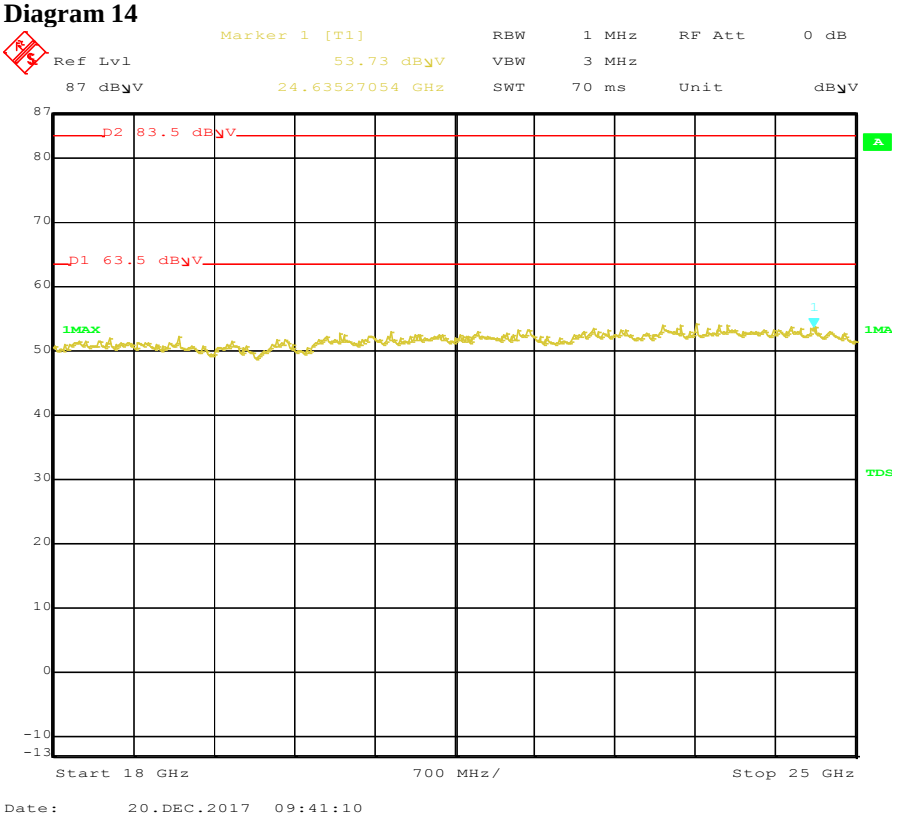
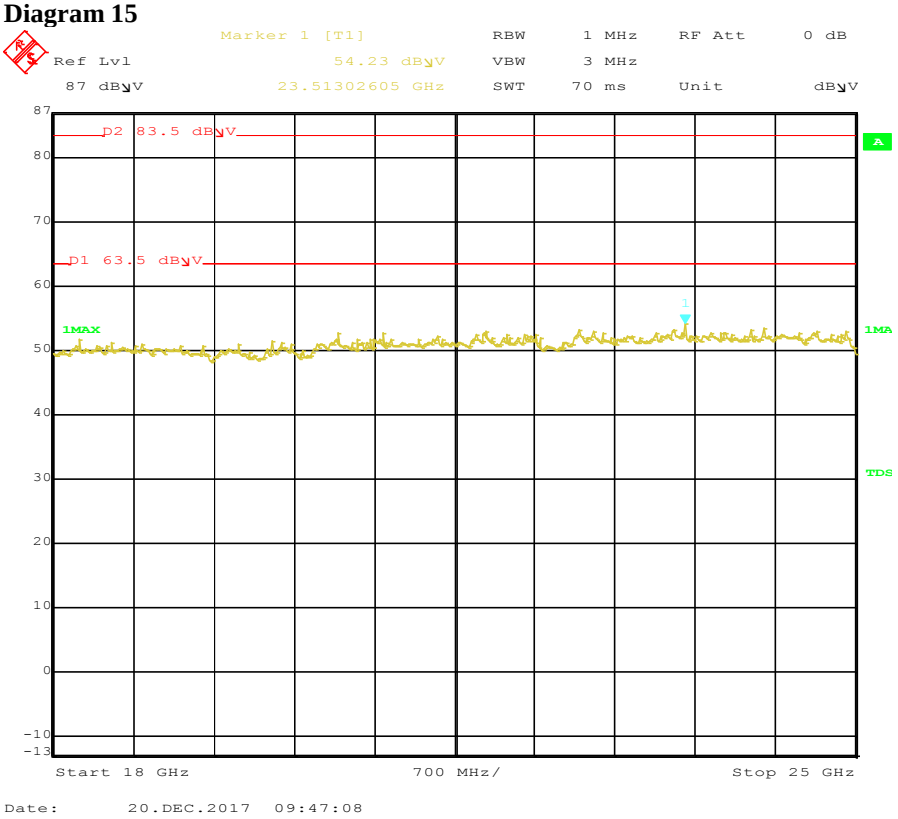


Diagram 15



Measuring distance: 1 m

Diagram 14

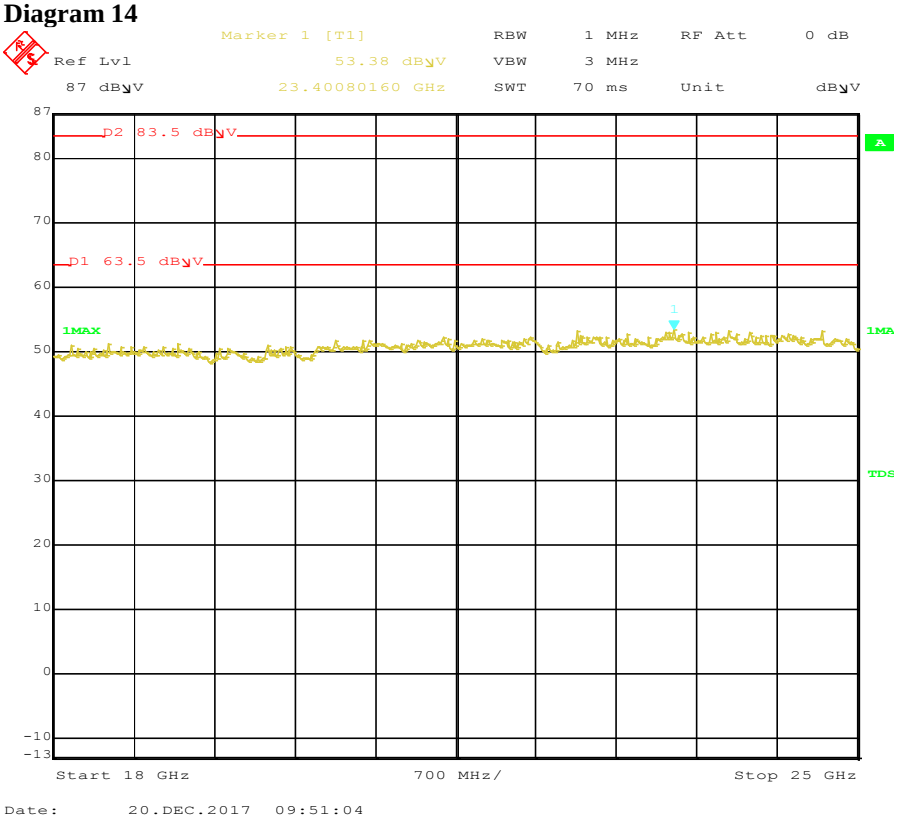
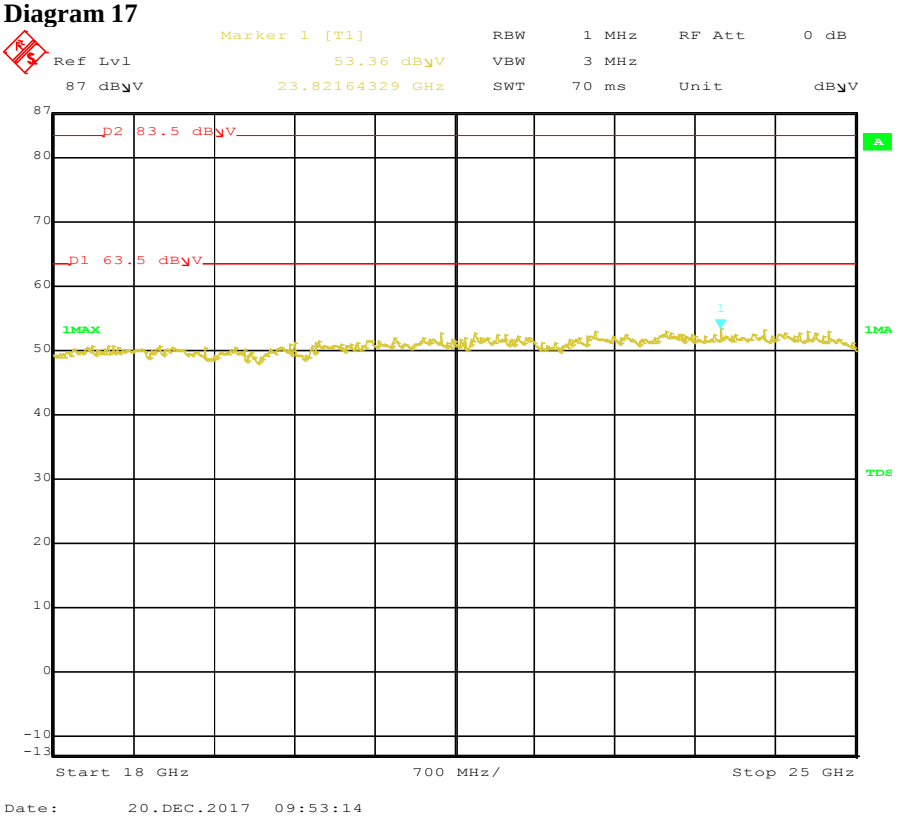


Diagram 17



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

Date	Temperature	Humidity
2017-12-18	22 °C ± 3 °C	25 % ± 5 %

Test setup and procedure

The measurements were performed according to ANSI C63.10 cl. 6.9.2.

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

The radiated measurements were performed in a semi anechoic chamber. The measurements were performed with the EUT-axis (if applicable), antenna position, polarization and the turntable in the position giving the highest level at the fundamental, see page 64. The antenna distance was 3.0 m.
The test was performed with peak detector.

Test set-up photos during the tests can be found in the photo section in the end of the report.

Measurement equipment	RISE number
Semi anechoic chamber, Edison	504114
Computer Lenovo ThinkCentre	-
Software R&S EMC32, ver.9.15.00	503889
EMI test receiver R&S ESU 26	902210
Antenna ETS-Lindgren 3115	902212
Coaxial cable	BX32218
Coaxial cable	504102
Coaxial cable	504103
Coaxial cable	504104
Multimeter Fluke 83	501522
Temperature and humidity meter Testo 625	504117

Results

The 20 dB BW measurements can be found in the diagrams below:

Diagram 1	EUT 1	2405 MHz	20 dB BW = **2.05 MHz**
Diagram 2	EUT 1	2440 MHz	20 dB BW = **2.30 MHz**
Diagram 3	EUT 1	2480 MHz	20 dB BW = **2.30 MHz**
Diagram 4	EUT 2, Y-axis	2405 MHz	20 dB BW = **2.07 MHz**
Diagram 5	EUT 2, Y-axis	2440 MHz	20 dB BW = **2.32 MHz**
Diagram 6	EUT 2, Y-axis	2480 MHz	20 dB BW = **2.32 MHz**

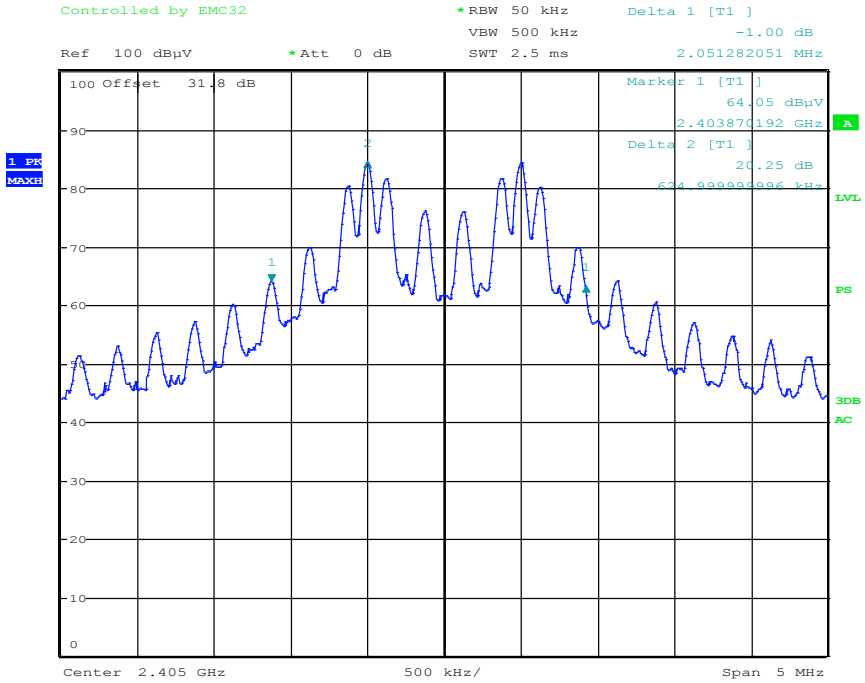
Limits

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 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.

Test engineers: Fredrik Isaksson and Markel Bertilsson

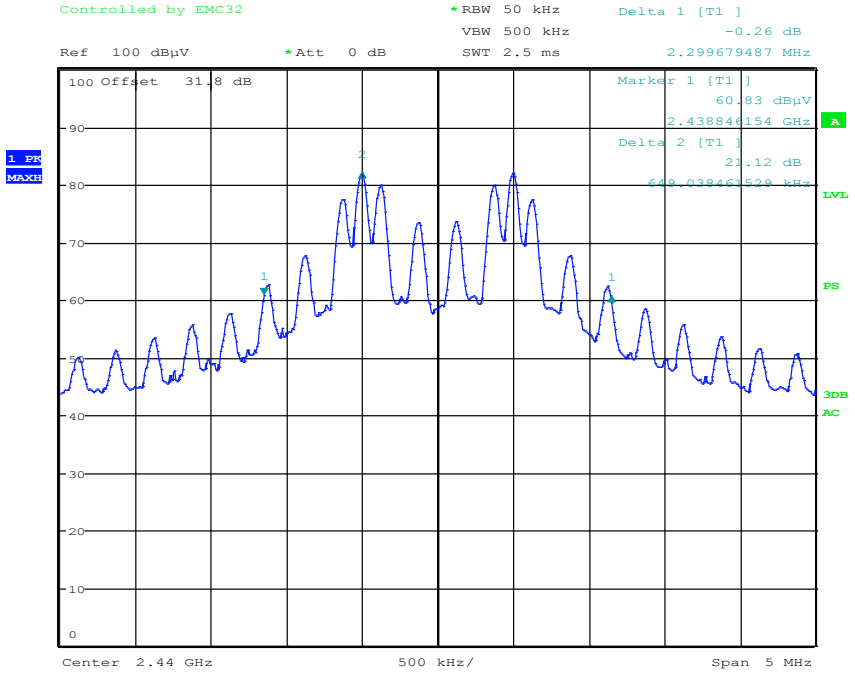
Complies?	Yes

Diagram 1:



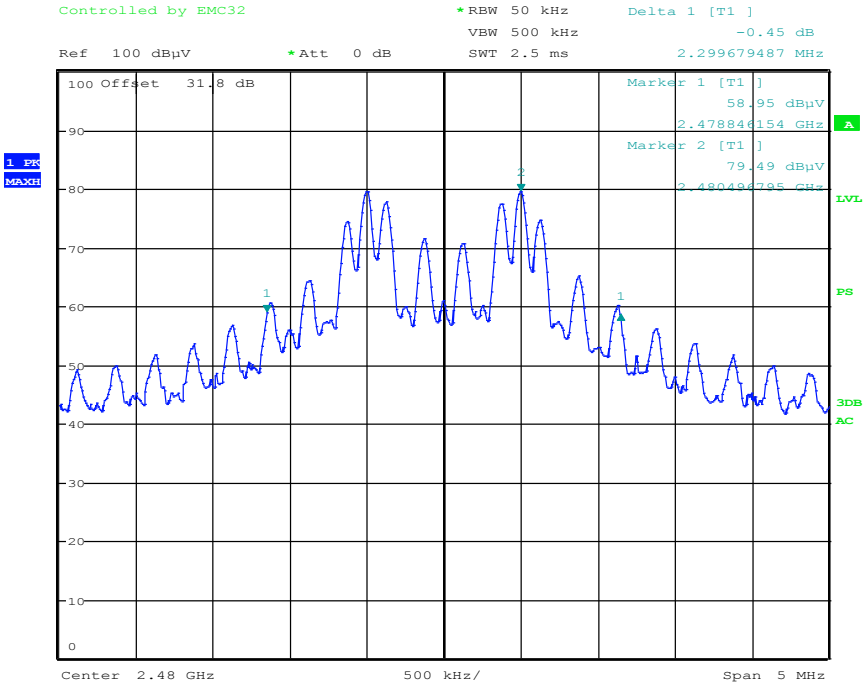
Date: 18.DEC.2017 16:05:53

Diagram 2:



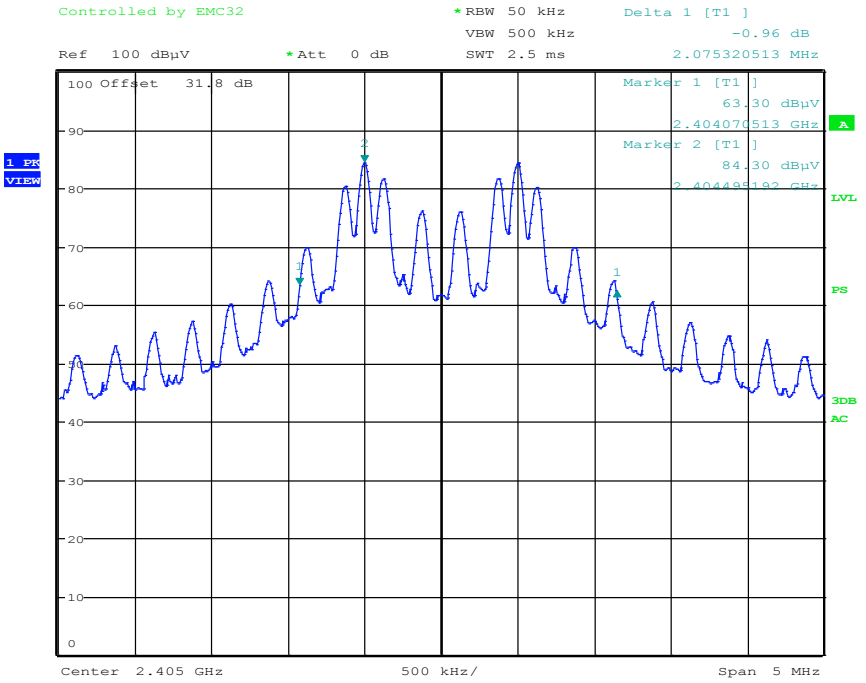
Date: 18.DEC.2017 16:17:28

Diagram 3:



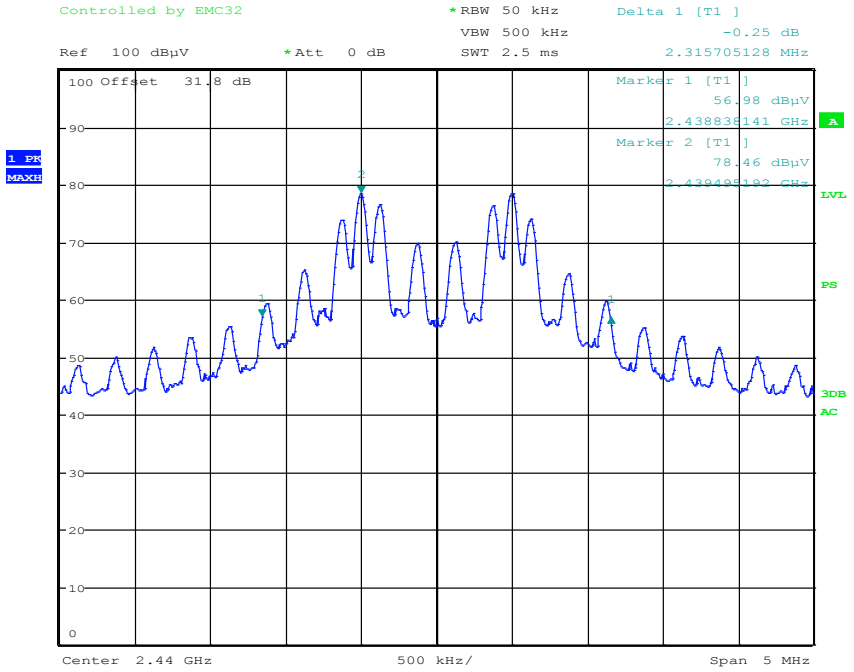
Date: 18.DEC.2017 15:46:32

Diagram 4:



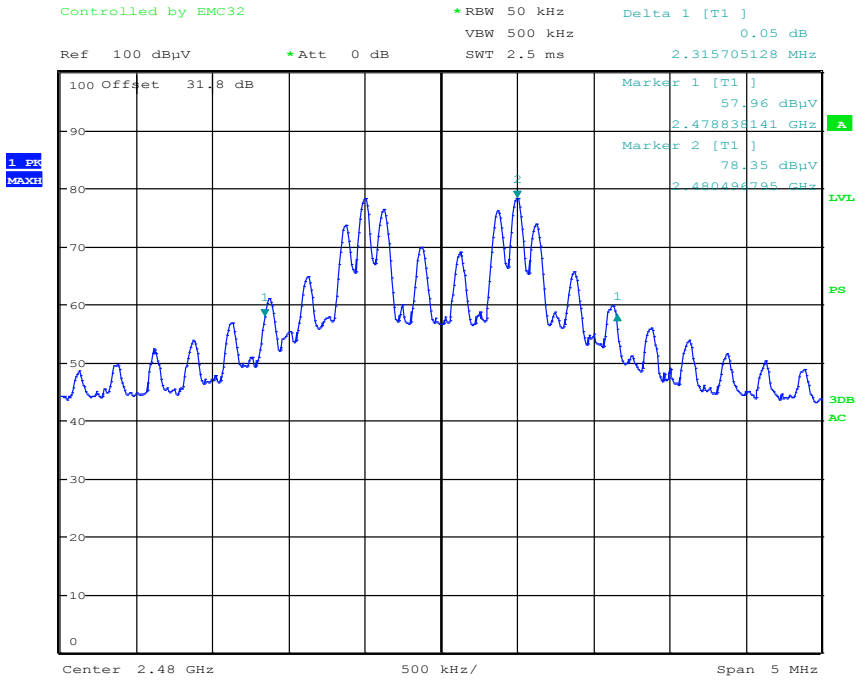
Date: 19.DEC.2017 11:01:31

Diagram 5:



Date: 19.DEC.2017 11:14:48

Diagram 6:



Date: 19.DEC.2017 10:39:51

AC Conducted emission measurements according to FCC 47 CFR part 15.207 / RSS-Gen 8.8

Date	Temperature	Humidity
2017-12-20	22 °C ± 3 °C	26 % ± 5 %

Test setup and procedure

The measurements were performed according to ANSI C63.4.

The test was only relevant on EUT 1, EUT 2was only battery powered.
The test was performed with continuous transmission (100% duty cycle) and with normal modulation.
Measurements were performed on the Main unit on the 120 V AC/60 Hz, phase and neutral terminals.
Two power packs were attached in the Main unit/charger and were charged during the test.

Test set-up photos during the tests can be found in the photo section in the end of the report.

Measurement equipment	RISE number
Semi anechoic chamber, Edison	504114
Computer Lenovo ThinkCentre	-
Software R&S EMC32, ver.9.15.00	503889
EMI test receiver R&S ESU 26	902210
LISN Schwarzbeck NNLA 8120	BX70761
Limiter, EM-7600	BX42883
Coaxial cable	BX32218
Coaxial cable	504102
Coaxial cable	504103
Coaxial cable	504104
Multimeter Fluke 83	501522
Temperature and humidity meter Testo 625	504117

Results

The conducted emission spectra can be found in the diagrams below:

Diagram 1:	120 V AC, Ambient, phase terminal
Diagram 2:	120 V AC, EUT 1, ch. 2405M, neutral terminal
Diagram 3:	120 V AC, EUT 1, ch. 2405M, phase terminal
Diagram 4:	120 V AC, EUT 1, ch. 2440M, neutral terminal
Diagram 5:	120 V AC, EUT 1, ch. 2440M, phase terminal
Diagram 6:	120 V AC, EUT 1, ch. 2480M, neutral terminal
Diagram 7:	120 V AC, EUT 1, ch. 2480M, phase terminal

Limits

According to 47CFR 15.207 and according to RSS-Gen 8.8,

Frequency (MHz)	Quasi-peak value (dBµV)	Average value (dBµV/m)
0.15-0.5	66-56*	56-46*
0.5-5	56	46
5-30	60	50

*=Decreases with the logarithm of the frequency

Test engineers: Fredrik Isaksson and Markel Bertilsson

Complies?	Yes

Diagram 1:

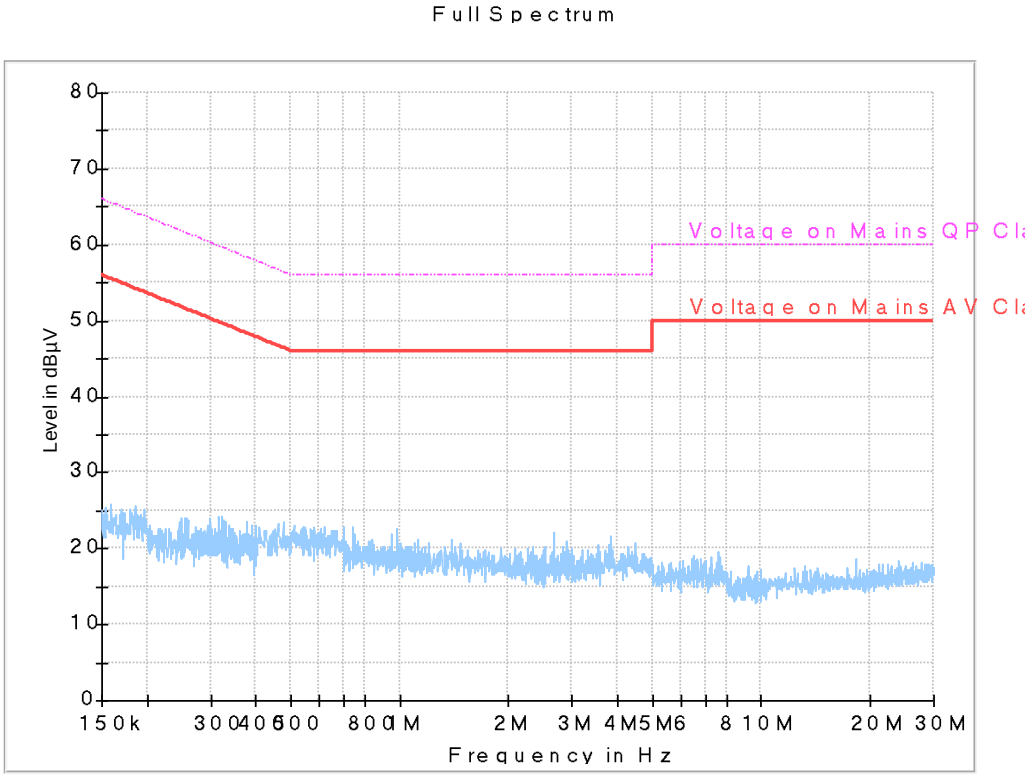
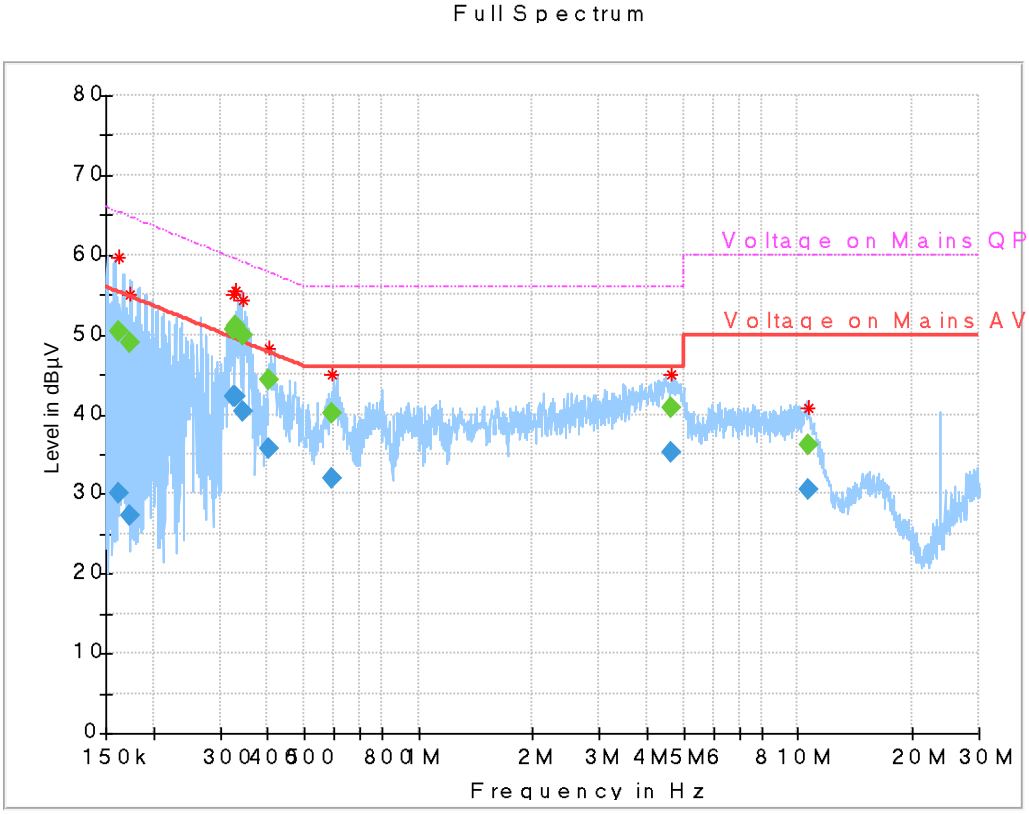

Full Spectrum
Voltage on Mains QP Cl
Voltage on Mains AV Cl
Level in dBµV
80
70
60
50
40
30
20
10
0
150k
300
400
600
800
1M
2M
3M
4M
5M
6M
8
10M
20M
30M
Frequency in Hz

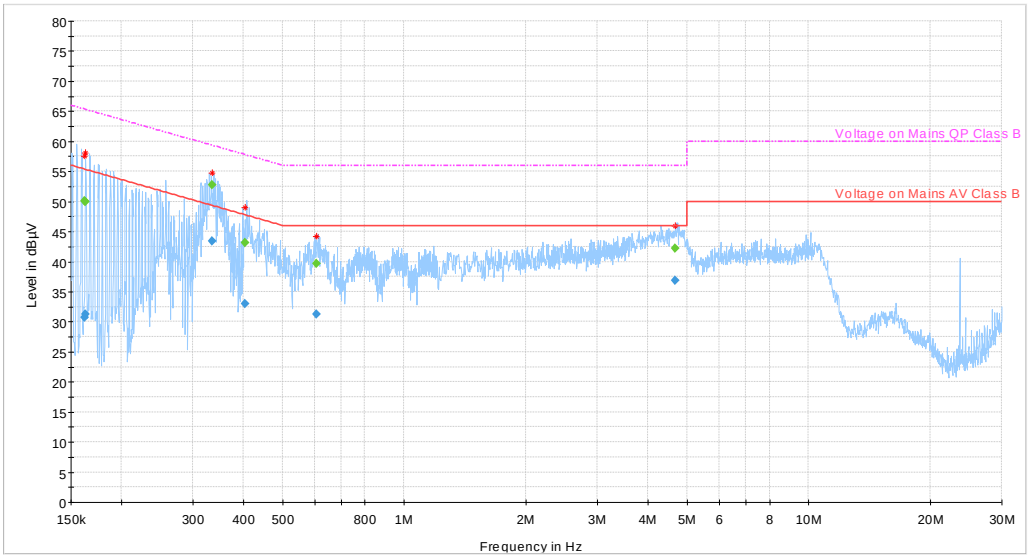
Diagram 2:



Final_Result

Frequency (MHz)	CAverage (dBµV)	QuasiPeak (dBµV)	Limit (dBµV)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Line	Corr. (dB)
0.162605	---	50.31	65.33	15.02	5000.0	9.000	N	9.9
0.162605	30.18	---	55.33	25.15	5000.0	9.000	N	9.9
0.173726	---	49.03	64.78	15.75	5000.0	9.000	N	9.9
0.173726	27.27	---	54.78	27.51	5000.0	9.000	N	9.9
0.326659	42.23	---	49.54	7.31	5000.0	9.000	N	9.9
0.326659	---	50.55	59.54	8.99	5000.0	9.000	N	9.9
0.331291	---	50.99	59.42	8.42	5000.0	9.000	N	9.9
0.331291	42.25	---	49.42	7.17	5000.0	9.000	N	9.9
0.346354	40.46	---	49.05	8.59	5000.0	9.000	N	9.9
0.346354	---	49.89	59.05	9.16	5000.0	9.000	N	9.9
0.404247	---	44.36	57.77	13.40	5000.0	9.000	N	9.9
0.404247	35.67	---	47.77	12.10	5000.0	9.000	N	9.9
0.592820	---	40.08	56.00	15.92	5000.0	9.000	N	9.9
0.592820	32.05	---	46.00	13.95	5000.0	9.000	N	9.9
4.658726	---	40.72	56.00	15.28	5000.0	9.000	N	10.0
4.658726	35.25	---	46.00	10.75	5000.0	9.000	N	10.0
10.629407	---	36.12	60.00	23.88	5000.0	9.000	N	10.3
10.629407	30.53	---	50.00	19.47	5000.0	9.000	N	10.3

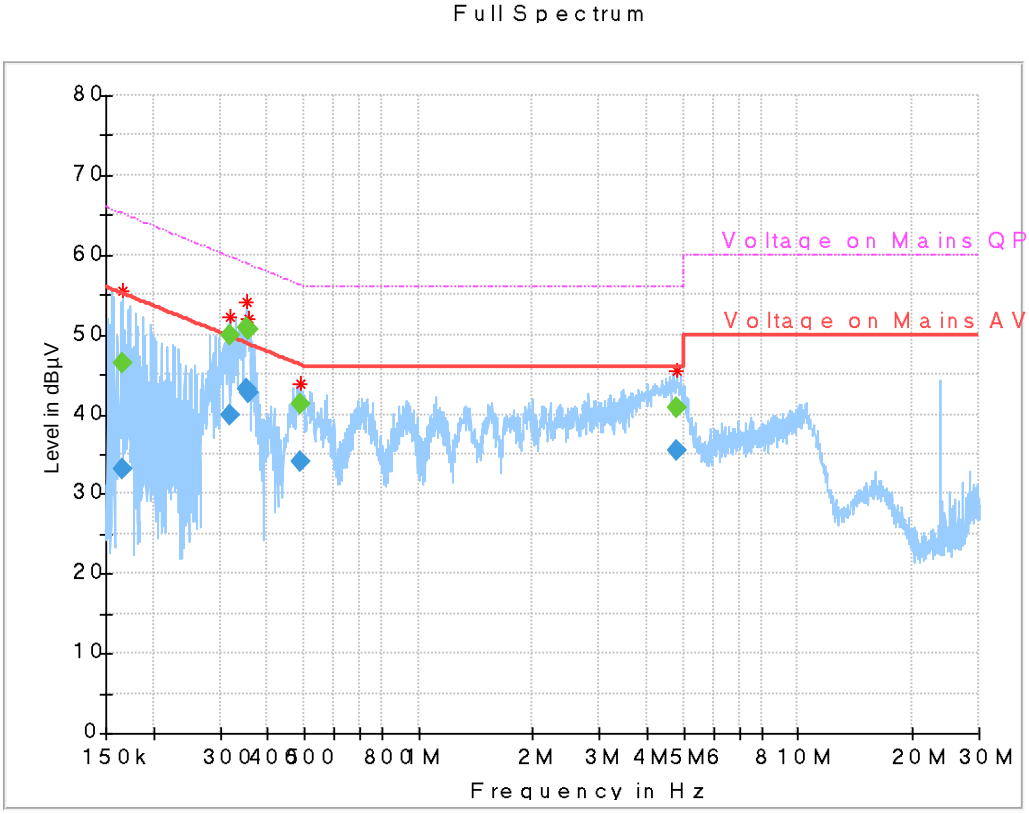
Diagram 3:



Final_Result

Frequency (MHz)	CAverage (dBµV)	QuasiPeak (dBµV)	Limit (dBµV)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Line	Corr. (dB)
0.162133	30.69	---	55.35	24.66	5000.0	9.000	L1	9.9
0.162133	---	50.06	65.35	15.29	5000.0	9.000	L1	9.9
0.162949	31.29	---	55.31	24.02	5000.0	9.000	L1	9.9
0.162949	---	50.00	65.31	15.31	5000.0	9.000	L1	9.9
0.334864	---	52.80	59.33	6.53	5000.0	9.000	L1	9.9
0.334864	43.42	---	49.33	5.91	5000.0	9.000	L1	9.9
0.404757	---	43.16	57.76	14.60	5000.0	9.000	L1	9.9
0.404757	32.99	---	47.76	14.77	5000.0	9.000	L1	9.9
0.607859	---	39.71	56.00	16.29	5000.0	9.000	L1	9.9
0.607859	31.28	---	46.00	14.72	5000.0	9.000	L1	9.9
4.683157	---	42.26	56.00	13.74	5000.0	9.000	L1	10.0
4.683157	36.83	---	46.00	9.17	5000.0	9.000	L1	10.0

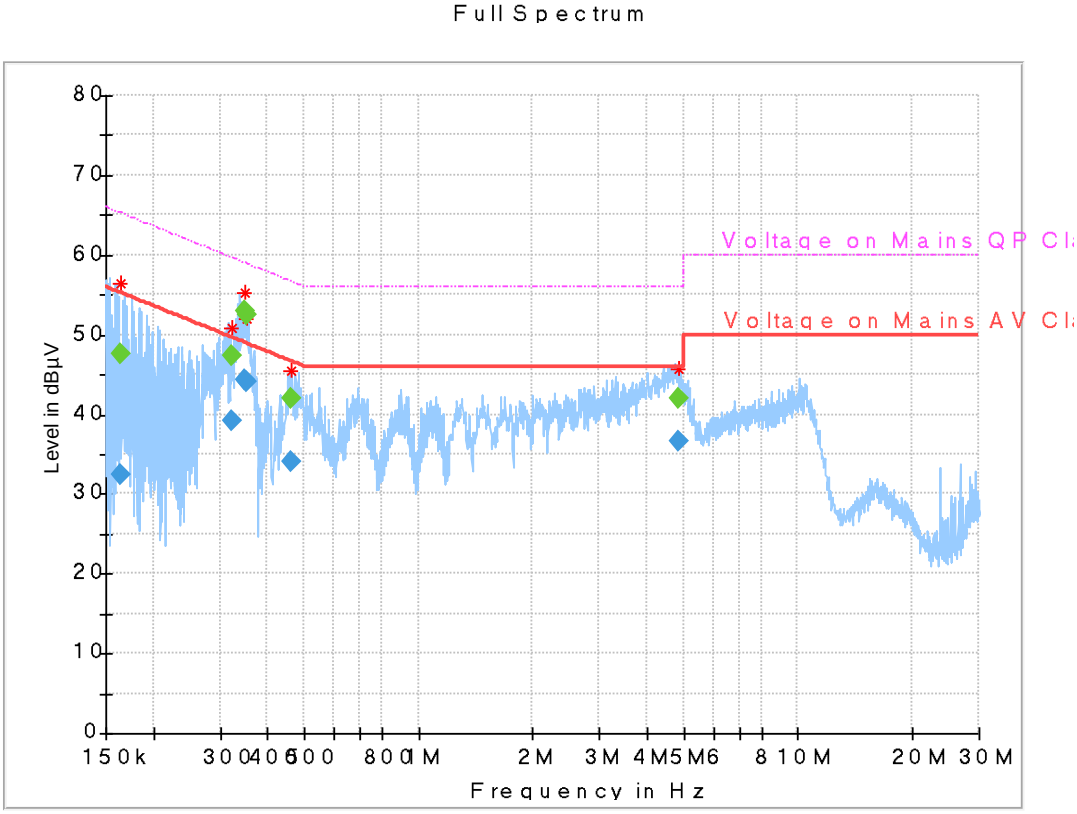
Diagram 4:



Final_Result

Frequency (MHz)	CAverage (dBµV)	QuasiPeak (dBµV)	Limit (dBµV)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Line	Corr. (dB)
0.165766	---	46.31	65.17	18.86	5000.0	9.000	N	9.9
0.165766	33.19	---	55.17	21.98	5000.0	9.000	N	9.9
0.319944	---	49.91	59.71	9.80	5000.0	9.000	N	9.9
0.319944	39.93	---	49.71	9.78	5000.0	9.000	N	9.9
0.353934	43.13	---	48.87	5.74	5000.0	9.000	N	9.9
0.353934	---	50.87	58.87	8.00	5000.0	9.000	N	9.9
0.355513	42.75	---	48.83	6.08	5000.0	9.000	N	9.9
0.355513	---	50.69	58.83	8.14	5000.0	9.000	N	9.9
0.488365	---	41.25	56.20	14.95	5000.0	9.000	N	9.9
0.488365	34.08	---	46.20	12.11	5000.0	9.000	N	9.9
4.798309	---	40.80	56.00	15.20	5000.0	9.000	N	10.0
4.798309	35.37	---	46.00	10.63	5000.0	9.000	N	10.0

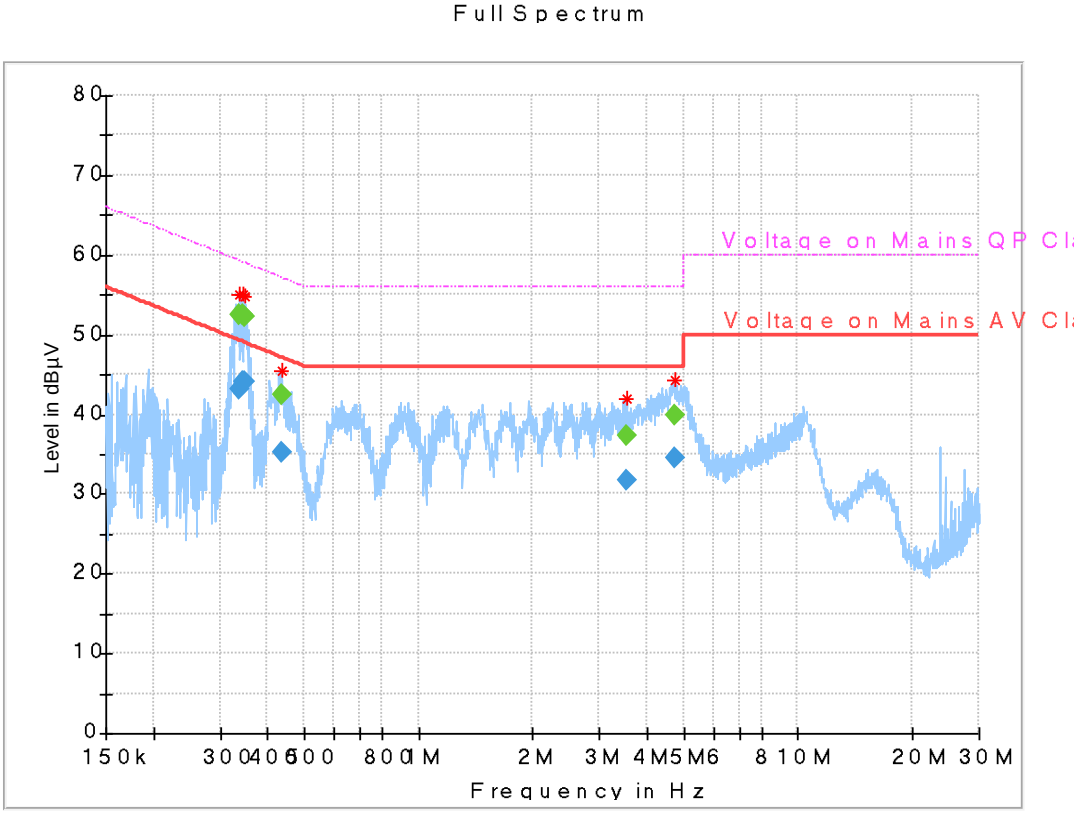
Diagram 5:



Final_Result

Frequency (MHz)	CAverage (dBµV)	QuasiPeak (dBµV)	Limit (dBµV)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Line	Corr. (dB)
0.163267	---	47.70	65.30	17.60	5000.0	9.000	L1	9.9
0.163267	32.44	---	55.30	22.85	5000.0	9.000	L1	9.9
0.322426	---	47.35	59.64	12.30	5000.0	9.000	L1	9.9
0.322426	39.27	---	49.64	10.38	5000.0	9.000	L1	9.9
0.348242	---	52.88	59.00	6.13	5000.0	9.000	L1	9.9
0.348242	44.32	---	49.00	4.68	5000.0	9.000	L1	9.9
0.351963	---	52.45	58.92	6.46	5000.0	9.000	L1	9.9
0.351963	44.19	---	48.92	4.72	5000.0	9.000	L1	9.9
0.464454	---	41.89	56.61	14.73	5000.0	9.000	L1	9.9
0.464454	34.10	---	46.61	12.51	5000.0	9.000	L1	9.9
4.829145	---	41.98	56.00	14.02	5000.0	9.000	L1	10.0
4.829145	36.58	---	46.00	9.42	5000.0	9.000	L1	10.0

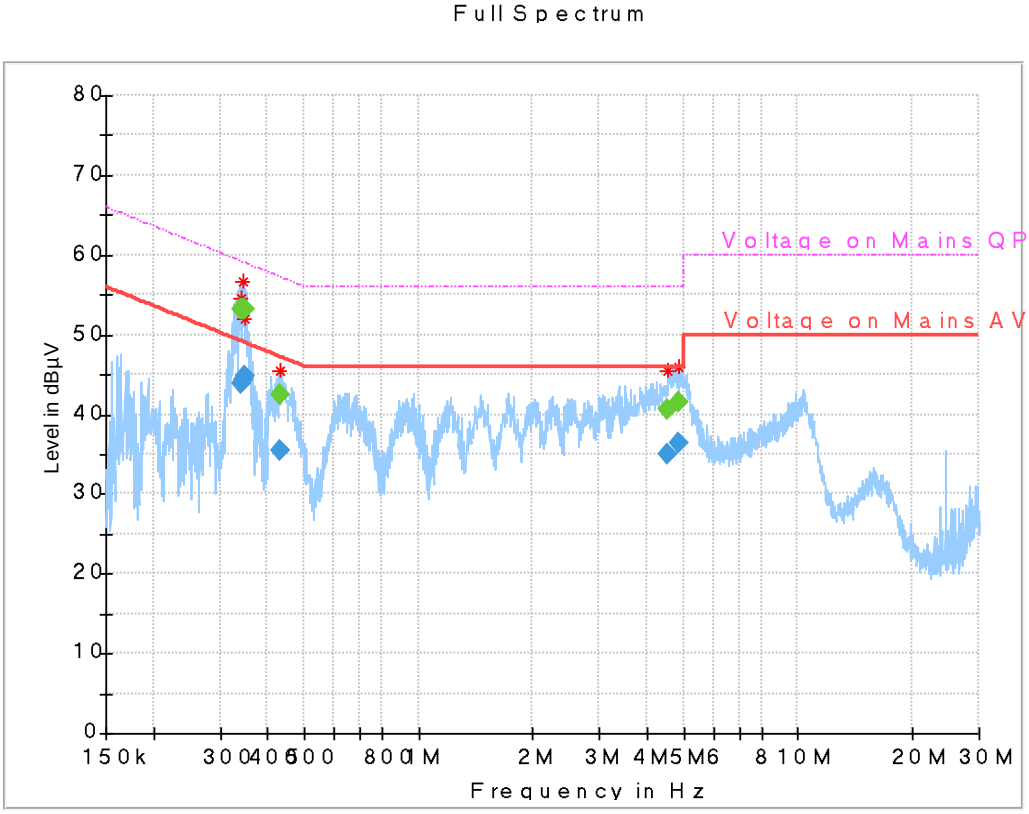
Diagram 6:



Final_Result

Frequency (MHz)	CAverage (dBµV)	QuasiPeak (dBµV)	Limit (dBµV)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Line	Corr. (dB)
0.337075	43.25	---	49.28	6.03	5000.0	9.000	N	9.9
0.337075	---	52.38	59.28	6.89	5000.0	9.000	N	9.9
0.345929	---	52.36	59.06	6.70	5000.0	9.000	N	9.9
0.345929	43.97	---	49.06	5.09	5000.0	9.000	N	9.9
0.347940	44.19	---	49.01	4.82	5000.0	9.000	N	9.9
0.347940	---	52.35	59.01	6.66	5000.0	9.000	N	9.9
0.437660	---	42.35	57.11	14.76	5000.0	9.000	N	9.9
0.437660	35.25	---	47.11	11.86	5000.0	9.000	N	9.9
3.529399	---	37.31	56.00	18.69	5000.0	9.000	N	10.0
3.529399	31.74	---	46.00	14.26	5000.0	9.000	N	10.0
4.738638	---	39.92	56.00	16.08	5000.0	9.000	N	10.0
4.738638	34.47	---	46.00	11.53	5000.0	9.000	N	10.0

Diagram 7:



Final_Result

Frequency (MHz)	CAverage (dBµV)	QuasiPeak (dBµV)	Limit (dBµV)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Line	Corr. (dB)
0.339129	---	53.16	59.23	6.07	5000.0	9.000	L1	9.9
0.339129	43.74	---	49.23	5.49	5000.0	9.000	L1	9.9
0.345771	---	53.07	59.06	6.00	5000.0	9.000	L1	9.9
0.345771	44.39	---	49.06	4.67	5000.0	9.000	L1	9.9
0.347401	---	53.14	59.02	5.89	5000.0	9.000	L1	9.9
0.347401	44.67	---	49.02	4.36	5000.0	9.000	L1	9.9
0.432511	---	42.45	57.20	14.76	5000.0	9.000	L1	9.9
0.432511	35.49	---	47.20	11.71	5000.0	9.000	L1	9.9
4.553662	---	40.49	56.00	15.51	5000.0	9.000	L1	10.0
4.553662	35.06	---	46.00	10.94	5000.0	9.000	L1	10.0
4.834084	---	41.58	56.00	14.42	5000.0	9.000	L1	10.0
4.834084	36.30	---	46.00	9.70	5000.0	9.000	L1	10.0

Occupied bandwidth measurements according to 47CFR 2.1049 207 / RSS-Gen 6.6

Date	Temperature	Humidity
2017-12-18	22 °C ± 3 °C	25 % ± 5 %

Test setup and procedure

The measurements were performed according to ANSI C63.10 cl. 6.9.3.

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

The radiated measurements were performed in a semi anechoic chamber. The measurements were performed with the EUT-axis (if applicable), antenna position, polarization and the turntable in the position giving the highest level at the fundamental, see page 64. The antenna distance was 3.0 m.
The test was performed with RMS detector.

Test set-up photos during the tests can be found in the photo section in the end of the report.

Measurement equipment	RISE number
Semi anechoic chamber, Edison	504114
Computer Lenovo ThinkCentre	-
Software R&S EMC32, ver.9.15.00	503889
EMI test receiver R&S ESU 26	902210
Antenna ETS-Lindgren 3115	902212
Coaxial cable	BX32218
Coaxial cable	504102
Coaxial cable	504103
Coaxial cable	504104
Multimeter Fluke 83	501522
Temperature and humidity meter Testo 625	504117

Results

The OBW measurements can be found in the diagrams below:

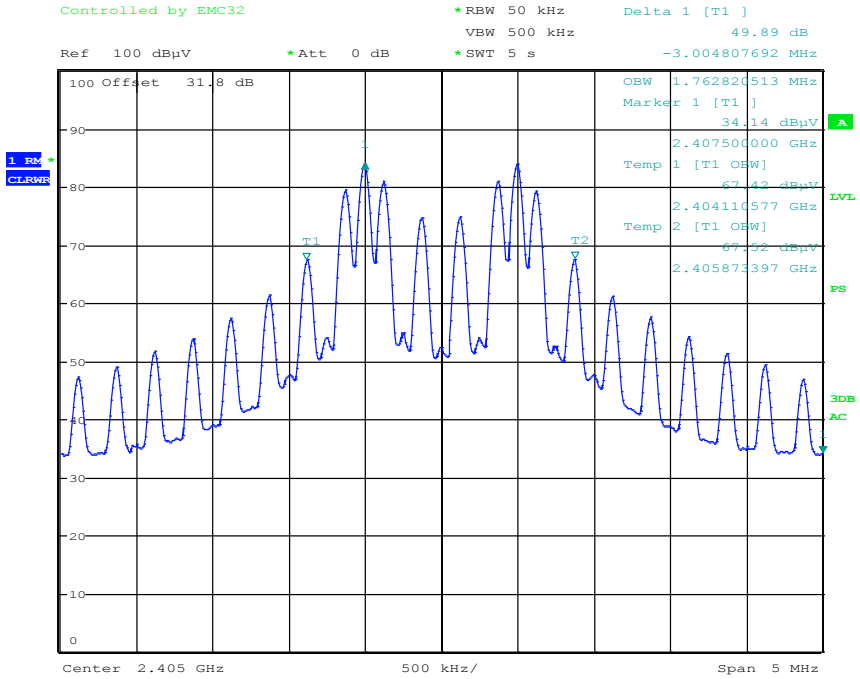
Diagram 1	EUT 1	2405 MHz	OBW = **1.76 MHz** (99%)
Diagram 2	EUT 1	2440 MHz	OBW = **1.77 MHz** (99%)
Diagram 3	EUT 1	2480 MHz	OBW = **1.79 MHz** (99%)
Diagram 4	EUT 2, Y-axis	2405 MHz	OBW = **1.78 MHz** (99%)
Diagram 5	EUT 2, Y-axis	2440 MHz	OBW = **1.79 MHz** (99%)
Diagram 6	EUT 2, Y-axis	2480 MHz	OBW = **1.92 MHz** (99%)

Limits

Test engineers: Fredrik Isaksson and Markel Bertilsson

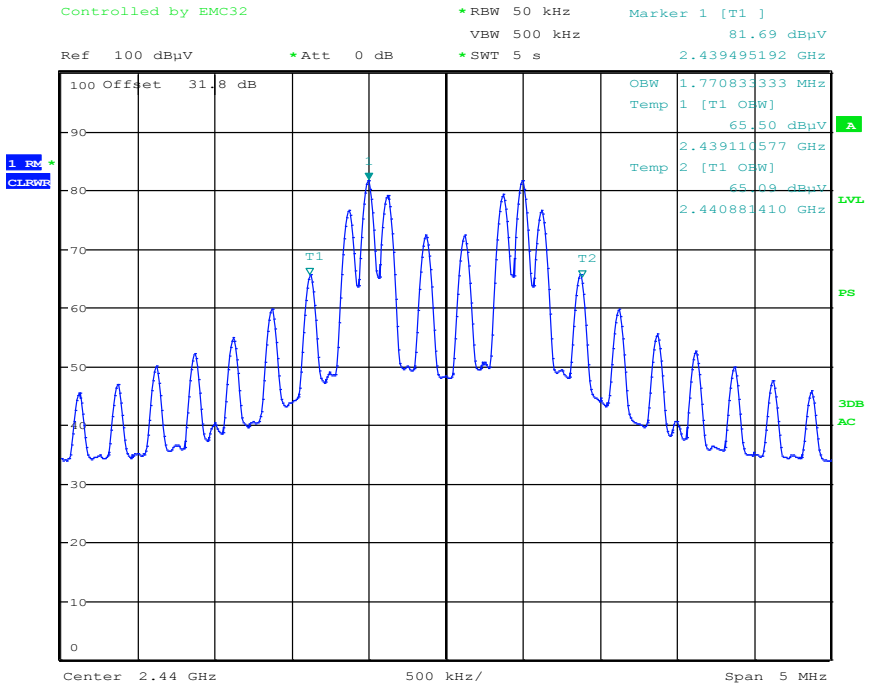
Complies?	Yes

Diagram 1:



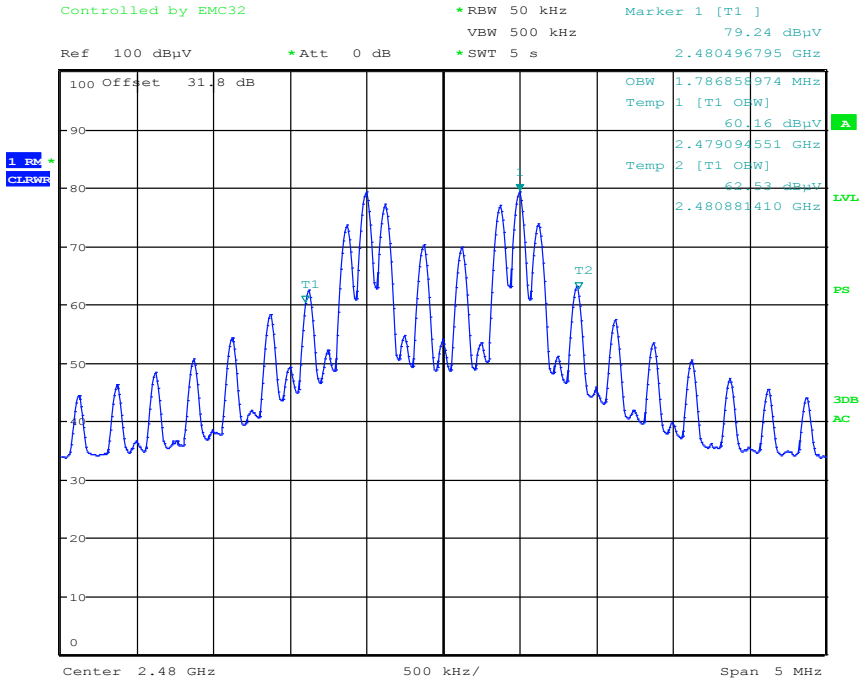
Date: 18.DEC.2017 16:08:08

Diagram 2:



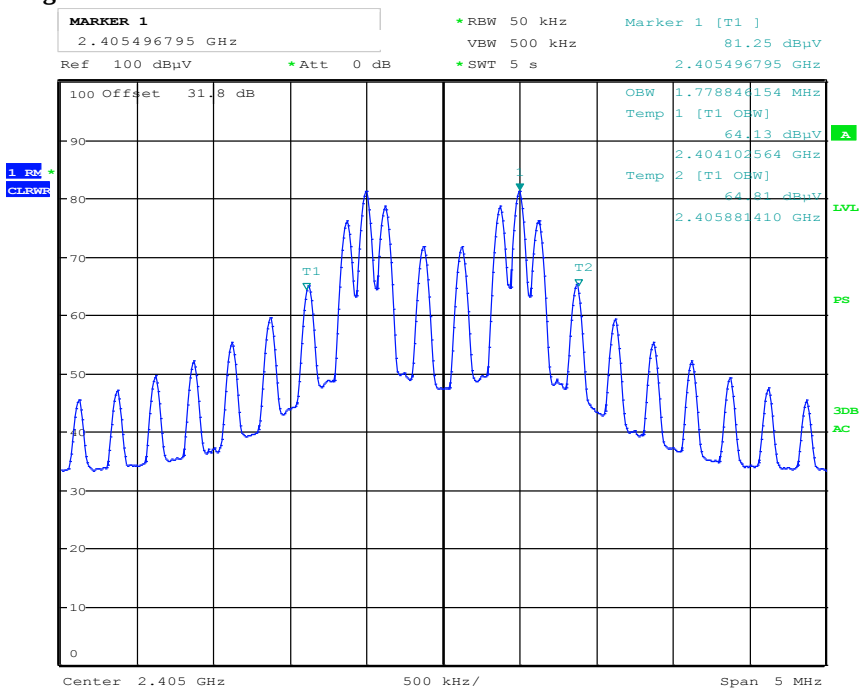
Date: 18.DEC.2017 16:11:03

Diagram 3:



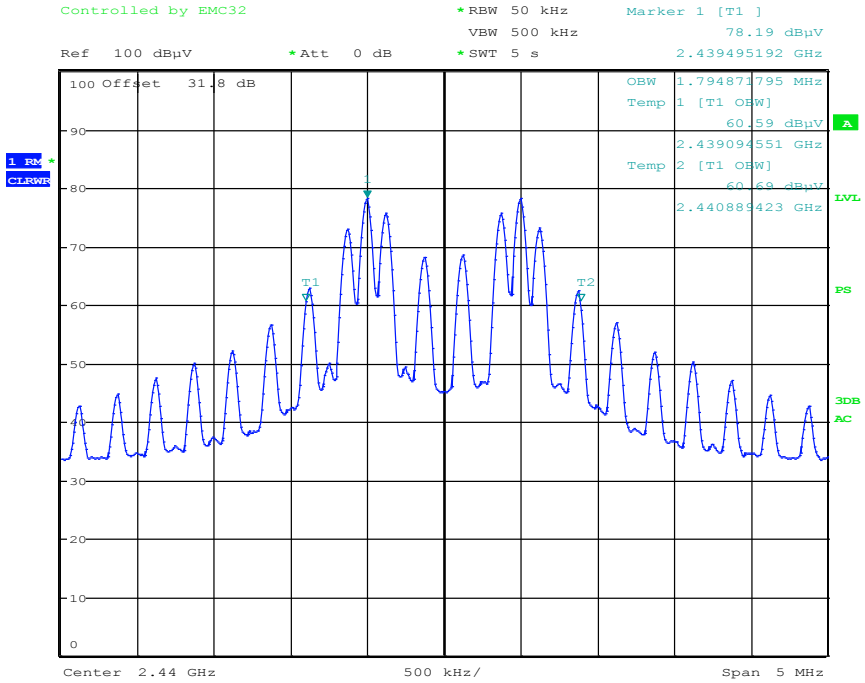
Date: 18.DEC.2017 15:45:39

Diagram 4:



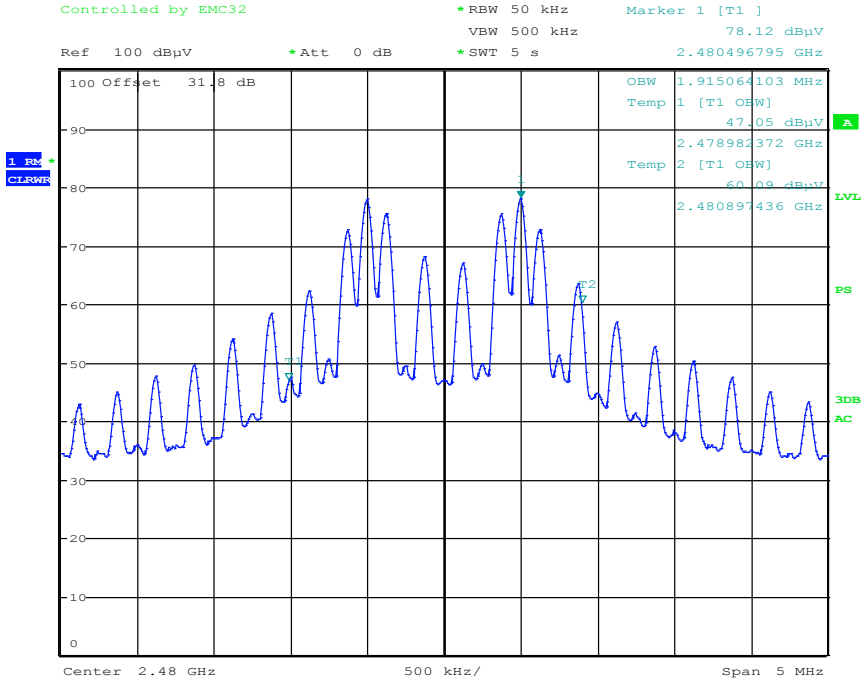
Date: 19.DEC.2017 11:04:14

Diagram 5:



Date: 19.DEC.2017 11:18:01

Diagram 6:



Date: 19.DEC.2017 10:42:25

Band edge measurements according to 47CFR 2.1049 / RSS-210 B.10(b)

Date	Temperature	Humidity
2017-12-18	22 °C ± 3 °C	25 % ± 5 %
2017-12-21	22 °C ± 3 °C	31 % ± 5 %

Test setup and procedure

The measurements were performed according to ANSI C63.10 cl. 6.10.5.

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

The radiated measurements were performed in a semi anechoic chamber. The measurements were performed with the EUT-axis (if applicable), antenna position, polarization and the turntable in the position giving the highest level at the fundamental, see page 64. The antenna distance was 3.0 m.
The test was performed with both peak and average detector.

Test set-up photos during the tests can be found in the photo section in the end of the report.

Measurement equipment	RISE number
Semi anechoic chamber, Edison	504114
Computer Lenovo ThinkCentre	-
Software R&S EMC32, ver.9.15.00	503889
EMI test receiver R&S ESU 26	902210
Antenna ETS-Lindgren 3115	902212
Coaxial cable	BX32218
Coaxial cable	504102
Coaxial cable	504103
Coaxial cable	504104
Multimeter Fluke 83	501522
Temperature and humidity meter Testo 625	504117

Results

Operation band 2400-2483.5 MHz

The measurement diagrams with peak and average detector can be found in the diagrams below.

EUT 1

Diagram 1: 2405 MHz Peak level at 2400 MHz = 50.9 dBµV/m (limit=74.0 dBµV/m)
Diagram 2: Average level at 2400 MHz = 40.3 dBµV/m (limit=54.0 dBµV/m)
Diagram 3: 2480 MHz Peak level at 2483.5 MHz = 54.9 dBµV/m (limit=74.0 dBµV/m)
Diagram 4: Average level at 2483.5 MHz = 44.9 dBµV/m (limit=54.0 dBµV/m)

EUT 2, Y-axis

Diagram 5: 2405 MHz Peak level at 2400 MHz = 52.5 dBµV/m (limit=74.0 dBµV/m)
Diagram 6: Average level at 2400 MHz = 41.7 dBµV/m (limit=54.0 dBµV/m)
Diagram 7: 2480 MHz Peak level at 2483.5 MHz = 58.5 dBµV/m (limit=74.0 dBµV/m)
Diagram 8: Average level at 2483.5 MHz = 47.7 dBµV/m (limit=54.0 dBµV/m)

Remark

The test on the EUT 1 was performed with the reduced power, RF ATTENUA was decreased from setting 0 (0 dB) to setting 11 (8 dB).

Limits

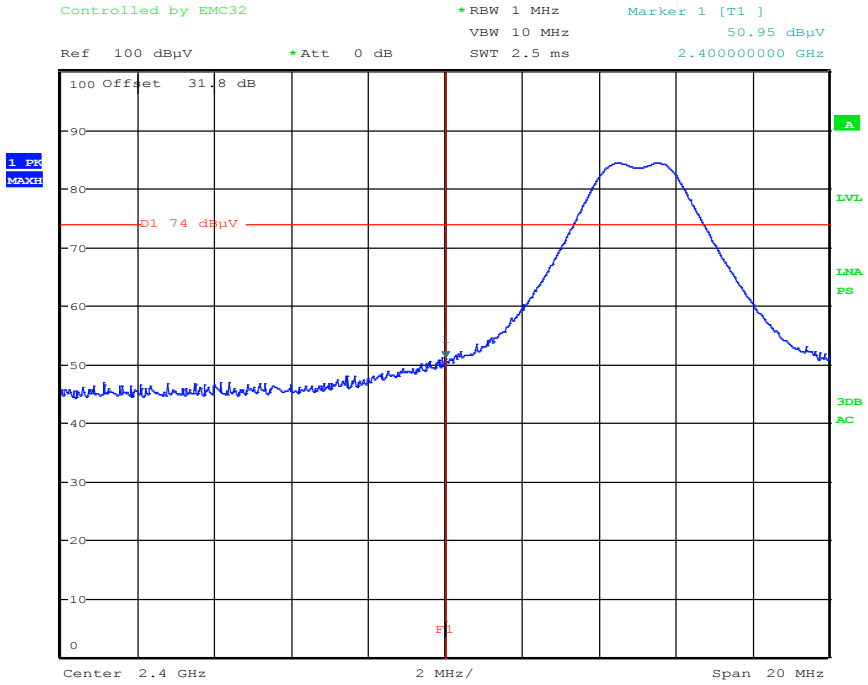
According to 47CFR 15.249(d), emission radiated outside of the specified frequency bands, except for harmonics, shall be attenuated by at least 50 dB below the level of the fundamental or to the general radiated emission limits in section 15.209, whichever is the lesser attenuation.

According to RSS-210 B.10(b), emissions radiated outside of the specified frequency bands, except for harmonics, shall be attenuated by at least 50 dB below the level of the fundamental or to the general field strength limits listed in RSS-Gen, whichever is the less stringent.

Test engineers: Fredrik Isaksson and Markel Bertilsson

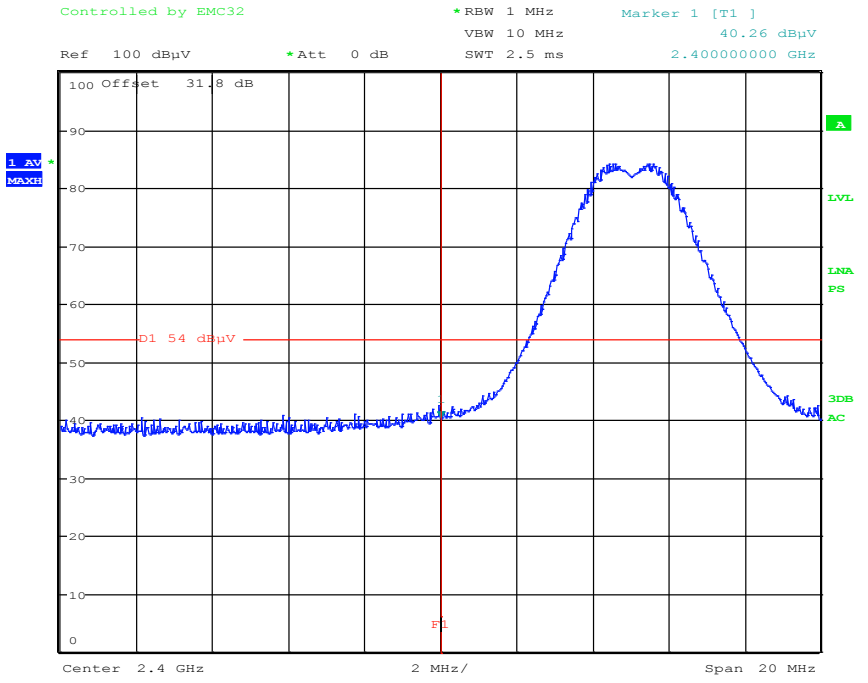
Complies?	Yes

Diagram 1:



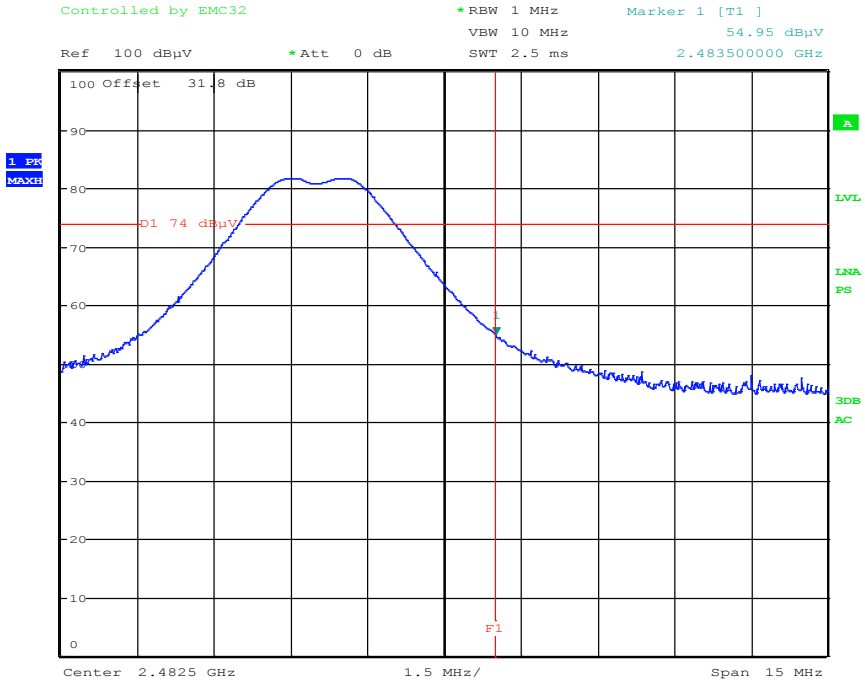
Date: 21.DEC.2017 15:51:38

Diagram 2:



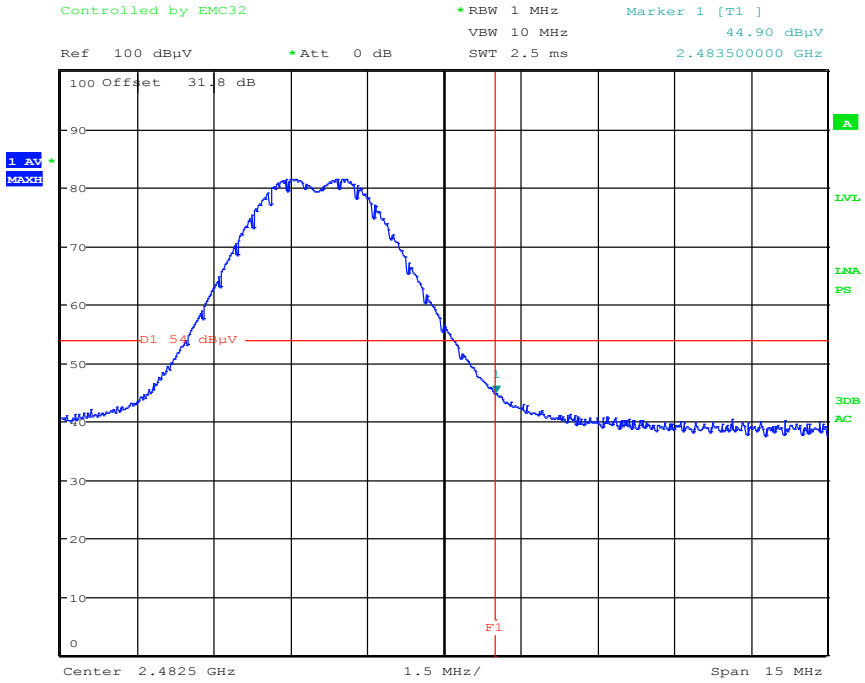
Date: 21.DEC.2017 15:52:50

Diagram 3:



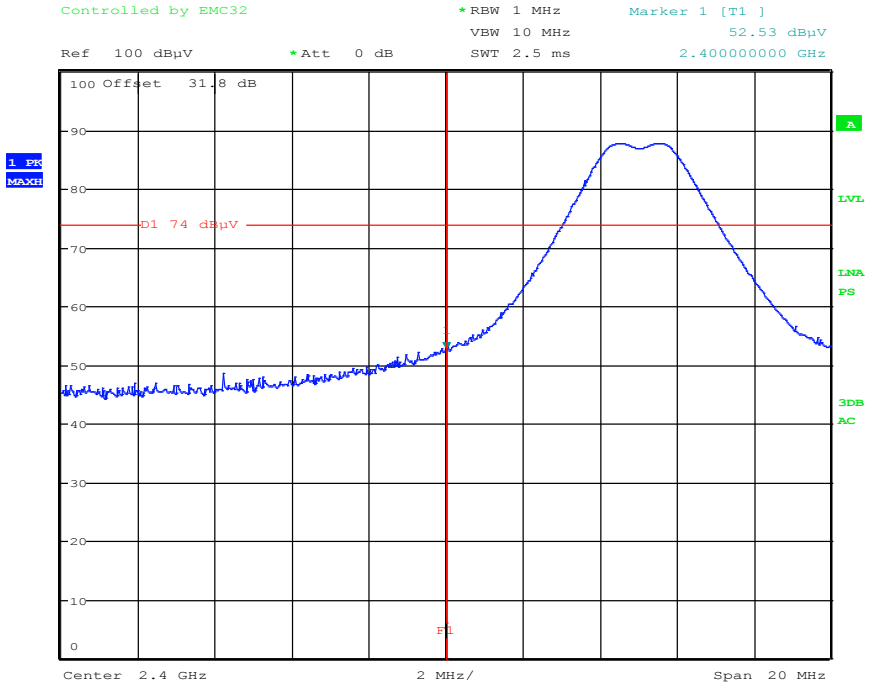
Date: 21.DEC.2017 15:59:16

Diagram 4:



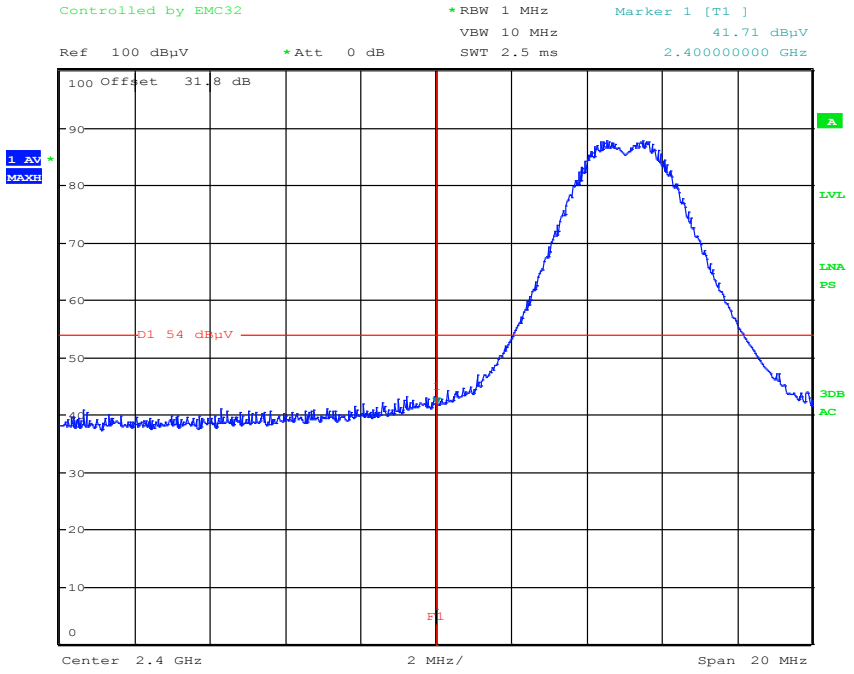
Date: 21.DEC.2017 15:58:06

Diagram 5:



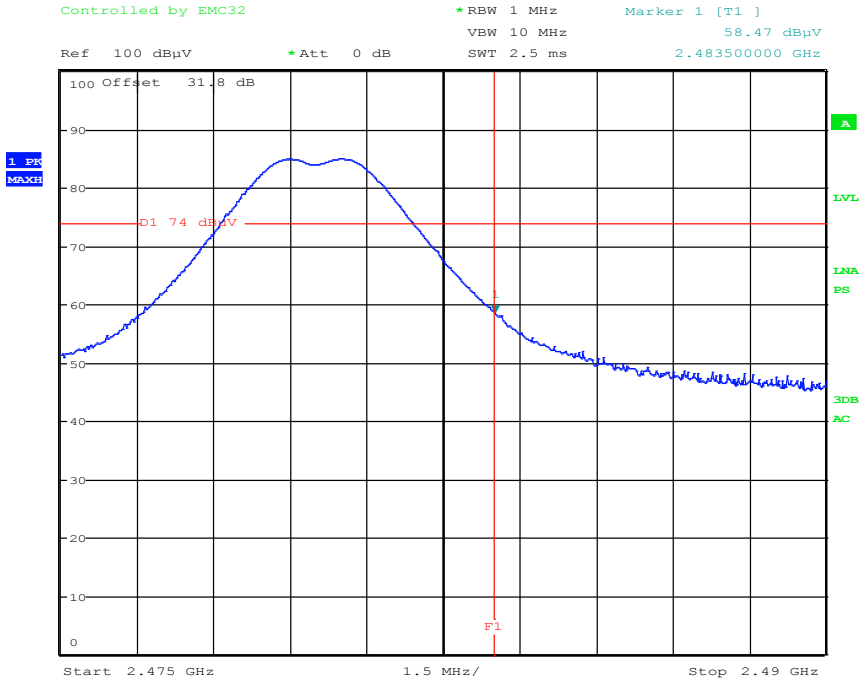
Date: 19.DEC.2017 11:05:44

Diagram 6:



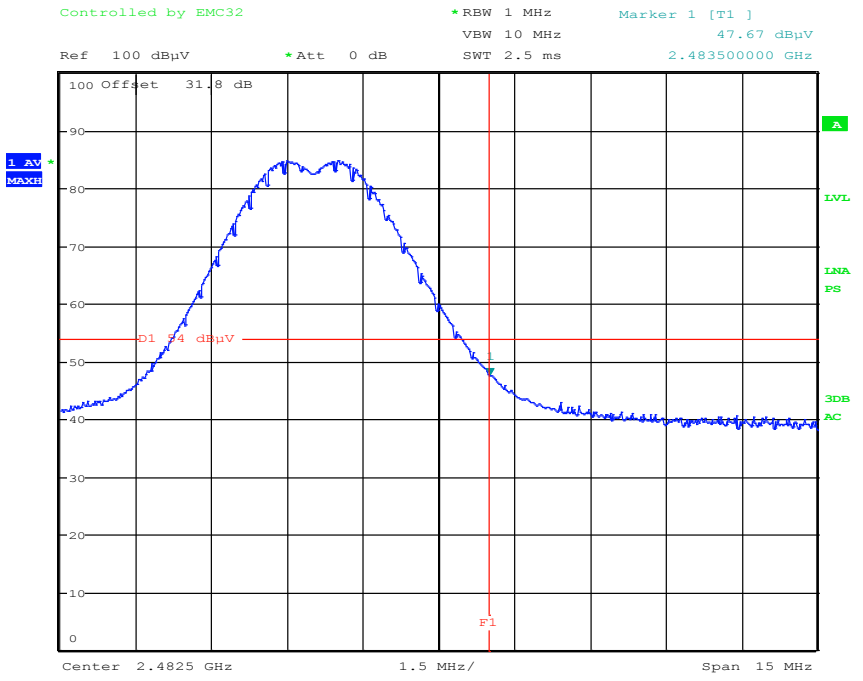
Date: 19.DEC.2017 11:06:18

Diagram 7:



Date: 19.DEC.2017 10:47:12

Diagram 8:



Date: 19.DEC.2017 10:44:06

RF exposure evaluation: 2.1091 Mobile devices / KDB 447498/ RSS-102 2.5.2 and 2.1093 Portable devices / KDB 447498/ RSS-102 2.5.1

Date	Temperature	Humidity
2017-12-18	22 °C ± 3 °C	25 % ± 5 %
2017-12-21	22 °C ± 3 °C	31 % ± 5 %

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 2.1091 and RSS-102 2.5.2 this device has been defined as a mobile device (EUT 1) whereby a distance of 20 cm can be maintained between the user and the device.
In accordance with 47 CFR FCC Part 2 Subpart J, section 2.1093 and RSS-102 2.5.1 this devices (EUT 2) have been defined as a portable device to be used within 20 centimetres of the body of the user.

According to KDB 447498 D01 General RF Exposure Guidance v06.

Results

Mobile devices: EUT 1:

The following formula was used to calculate the RF exposure,
$Pd = Pout \times G/(4 \times \pi \times r^2_{cm})$

where,
Pd = power density in mW/cm^2
Pout = Maximum output power measured with RMS detector, in mW
G = gain of antenna in linear scale
$\pi = 3.1416$
r = distance between observation and center of the radiator in cm

From the peak EUT RF output power, the minimum mobile separation distance, r=20 cm, as well as the gain of the used antenna, the RF power density can be obtained.

The maximum radiated RMS output power from page 64 was used for calculation of Maximum Permissible Exposure, MPE.

EUT 1:

Frequency f, (MHz)	Antenna Gain (dBi)	Antenna Gain (numeric)	EIRP RMS output power (dBm)	Pout (dBm) acc. to soured -based time averag ing	Pout (mW)	Power density, Pd [S] (mW/cm^2)	Limit of power density (mW/cm^2)
2405 Note 1	Note 2	Note 2	-14.4 Note 3	-64.9 Note 4	$6.45x10^{-7}$ Note 5	**$1.28x10^{-10}$** Note 2, 6	1.0

Note 1: Only the frequency with the highest RMS value, 80.8 dBµV/m, is noted.

Note 2: The antenna gain is not used in the MPE calculation as the EIRP value (including the antenna) is used.

Note 3: The measurements were performed in field strength in dBµV/m. The EIRP level was then calculated by the formula $P = (Exd)^2/30xG$, with G as unity gain of 1.

Note 4: The highest measured duty cycle (worst case) in normal operating according duty cycle section was 0.003%, thus the duty cycle correction was calculated (dB=20 log duty cycle) to -50.5 dB).

Note 5: According to RSS-102 cl. 2.5.1 the RMS value shall be adjusted for tune-up tolerance. According to the client the tune-up tolerance was declared to ±3 dB, thus the values at Note 4 were increased with 3 dB to -61.9 dBm.

Note 6: As the Power density value was very low, a complementary calculation as a Portable/SAR exclusion was presented, see below.

Portable devices: EUT 1:

Standalone SAR exclusion:

The maximum radiated RMS output power from page 64 was used for calculation.

Frequency f, (GHz) Note 1	EIRP RMS output power (dBm) Note 2	Pout (dBm) acc. to soured-based time averaging Note 3	Peak output power (mW) Note 4
2.405	-14.4	-64.9	$6.45x10^{-7}$

Note 1: Only the frequency with the highest RMS value, 80.8 dBµV/m, is noted.

Note 2: The measurements were performed in field strength in dBµV/m. The EIRP level was then calculated by the formula $P = (Exd)^2/30xG$, with G as unity gain of 1.

Note 3: The highest measured duty cycle (worst case) in normal operating according duty cycle section was 0.003%, thus the duty cycle correction was calculated (dB=20 log duty cycle) to -50.5 dB).

Note 4: According to RSS-102 cl. 2.5.1 the RMS value shall be adjusted for tune-up tolerance. According to the client the tune-up tolerance was declared to ±3 dB, thus the value at Note 3 were increased with 3 dB to -61.9 dBm.

Step a):
The following formula was used to calculate the RF exposure SAR exclusion threshold,
Thld=[Pout /r] x [√f]

where,
Thld= SAR exclusion threshold
Pout = Maximum output power measured with RMS detector, in mW
r = minimum test separation distance, in mm
f=frequency, in GHz

Frequency f, (GHz)	Pout, (mW)	Distance r, (mm)	Exclusion threshold Thld	Limit Threshold 1-g SAR	Limit Threshold 10-g SAR
2.405	$6.45x10^{-7}$	5	$2.00x10^{-7}$	< 3	< 7.5

Portable devices: EUT 2:

Standalone SAR exclusion:

The maximum radiated RMS output power from page 64 was used for calculation.

Frequency f, (GHz) Note 1	EIRP RMS output power (dBm) Note 2	Pout (dBm) acc. to soured-based time averaging Note 3	Peak output power (mW) Note 4
2.405	-12.9	-46.4	$4.57x10^{-5}$

Note 1: Only the frequency with the highest RMS value, 82.3 dBµV/m, is noted.

Note 2: The measurements were performed in field strength in dBµV/m. The EIRP level was then calculated by the formula $P = (Exd)^2/30xG$, with G as unity gain of 1.

Note 3: The highest measured duty cycle (worst case) in normal operating according duty cycle section was 0.021%, thus the duty cycle correction was calculated (dB=20 log duty cycle) to -33.5 dB).

Note 4: According to RSS-102 cl. 2.5.1 the RMS value shall be adjusted for tune-up tolerance. According to the client the tune-up tolerance was declared to ±3 dB, thus the value at Note 3 were increased with 3 dB to -43.4 dBm.

Step a):
The following formula was used to calculate the RF exposure SAR exclusion threshold,
Thld=[Pout /r] x [√f]

where,
Thld= SAR exclusion threshold
Pout = Maximum output power measured with RMS detector, in mW
r = minimum test separation distance, in mm
f=frequency, in GHz

Frequency f, (GHz)	Pout, (mW)	Distance r, (mm)	Exclusion threshold Thld	Limit Threshold 1-g SAR	Limit Threshold 10-g SAR
2.405	4.57×10^{-5}	5	1.42×10^{-4}	< 3	< 7.5

Limits

Mobile devices: EUT 1:

Limits for Maximum Permissible Exposure (MPE)

(A) Limits for Occupational/Controlled Exposure

Frequency range (MHz)	Electric field strength [E] (V/m)	Magnetic filed strength [H] (A/m)	Power density [S] (mW/cm^2)	Averaging time $\|E\|^2$, $\|H\|^2$ or S (minutes)
0.3-3.0	614	1.63	(100)*	6
3.0-30	1842/f	4.89/f	(900/f)*	6
30-300	61.4	0.163	1.0	6
300-1500			F/300	6
1500-100,000			5	6

(B) Limits for General Population/Uncontrolled Exposure

Frequency range (MHz)	Electric field strength [E] (V/m)	Magnetic filed strength [H] (A/m)	Power density [S] (mW/cm^2)	Averaging time $\|E\|^2$, $\|H\|^2$ or S (minutes)
0.3-1.34	614	1.63	(100)*	30
1.34-30	824/f	2.19/f	(180/f)*	30
30-300	27.5	0.073	0.2	30
300-1500			F/1500	30
1500-100,000			**1.0**	**30**

Note: f=frequency in MHz, *Plane-wave equivalent power density

IC RSS-102 Issue 5 cl. 2.5.2 Exemption from Routine Evaluation – RF Exposure Evaluation

RF exposure evaluation is required if the separation distance between the user and/or bystander and the device's radiating element is greater than 20 cm, except when the device operates as follows:

- below 20 MHz and the source-based, time-averaged maximum e.i.r.p. of the device is equal to or less than 1 W (adjusted for tune-up tolerance);
- at or above 20 MHz and below 48 MHz and the source-based, time-averaged maximum e.i.r.p. of the device is equal to or less than $4.49/f^{0.5}$W (adjusted for tune-up tolerance), where f is in MHz;
- at or above 48 MHz and below 300 MHz and the source-based, time-averaged maximum e.i.r.p. of the device is equal to or less than 0.6 W (adjusted for tune-up tolerance);
- **at or above 300 MHz and below 6 GHz and the source-based, time-averaged maximum e.i.r.p. of the device is equal to or less than $1.31 \times 10^{-2} f^{0.6834}$ W (adjusted for tune-up tolerance), where f is in MHz (2.73 W)**;
- at or above 6 GHz and the source-based, time-averaged maximum e.i.r.p. of the device is equal to or less than 5 W (adjusted for tune-up tolerance).

In these cases, the information contained in the RF exposure technical brief may be limited to information that demonstrates how the e.i.r.p. was derived.

Portable devices: EUT 1 and EUT 2:

FCC 2.1093 / KDB 447498 D01 General RF Exposure Guidance v06

4.3.1 Standalone SAR exclusion:

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

b) At 100 MHz to 6 GHz and for test separation distances > 50 mm, the SAR test exclusion threshold is determined according to the following, and as illustrated in Appendix B.
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 ≤ 6 GHz

c) At frequencies below 100 MHz, the following may be considered for SAR test exclusion, and as illustrated in Appendix C:
a) The power threshold at the corresponding test separation distance at 100 MHz in step 2) is multiplied by [1 + log(100/$f_{(MHz)}$)] for *test separation distances* > 50 mm and < 200 mm
b) The power threshold determined by the equation in a) for 50 mm and 100 MHz is multiplied by ½ for *test separation distances* ≤ 50 mm
c) SAR measurement procedures are not established below 100 MHz. When SAR test exclusion cannot be applied, a KDB inquiry is required to determine SAR evaluation requirements for any test results to be acceptable.

IC RSS-102 Issue 5 cl. 2.5.1 Exemption from Routine Evaluation Limits – SAR Evaluation

SAR evaluation is required if the separation distance between the user and/or bystander and the antenna and/or radiating element of the device is less than or equal to 20 cm, except when the device operates at or below the applicable output power level (adjusted for tune-up tolerance) for the specified separation distance defined in Table 1.

Table 1: SAR evaluation – Exemption limits for routine evaluation based on frequency and separation distance

Frequency (MHz)	Exemption Limits (mW)				
	At separation distance of ≤5 mm	At separation distance of 10 mm	At separation distance of 15 mm	At separation distance of 20 mm	At separation distance of 25 mm
≤300	71 mW	101 mW	132 mW	162 mW	193 mW
450	52 mW	70 mW	88 mW	106 mW	123 mW
835	17 mW	30 mW	42 mW	55 mW	67 mW
1900	7 mW	10 mW	18 mW	34 mW	60 mW
2450	**4 mW**	7 mW	15 mW	30 mW	52 mW
3500	2 mW	6 mW	16 mW	32 mW	55 mW
5800	1 mW	6 mW	15 mW	27 mW	41 mW

Frequency (MHz)	Exemption Limits (mW)				
	At separation distance of 30 mm	At separation distance of 35 mm	At separation distance of 40 mm	At separation distance of 45 mm	At separation distance of ≥50 mm
≤300	223 mW	254 mW	284 mW	315 mW	193 mW
450	141 mW	159 mW	177 mW	195 mW	123 mW
835	80 mW	92 mW	105 mW	117 mW	67 mW
1900	99 mW	153 mW	225 mW	316 mW	60 mW
2450	83 mW	123 mW	173 mW	235 mW	52 mW
3500	86 mW	124 mW	170 mW	225 mW	55 mW
5800	56 mW	71 mW	85 mW	27 mW	41 mW

Output power level shall be the higher of the maximum conducted or equivalent isotropically radiated power (e.i.r.p.) source-based, time-averaged output power. For controlled use devices where the 8 W/kg for 1 gram of tissue applies, the exemption limits for routine evaluation in Table 1 are multiplied by a factor of 5. For limb-worn devices where the 10 gram value applies, the exemption limits for routine evaluation in Table 1 are multiplied by a factor of 2.5. If the operating frequency of the device is between two frequencies located in Table 1, linear interpolation shall be applied for the applicable separation distance. For test separation distance less than 5 mm, the exemption limits for a separation distance of 5 mm can be applied to determine if a routine evaluation is required.
For medical implants devices, the exemption limit for routine evaluation is set at 1 mW. The output power of a medical implants device is defined as the higher of the conducted or e.i.r.p to determine whether the device is exempt from the SAR evaluation.

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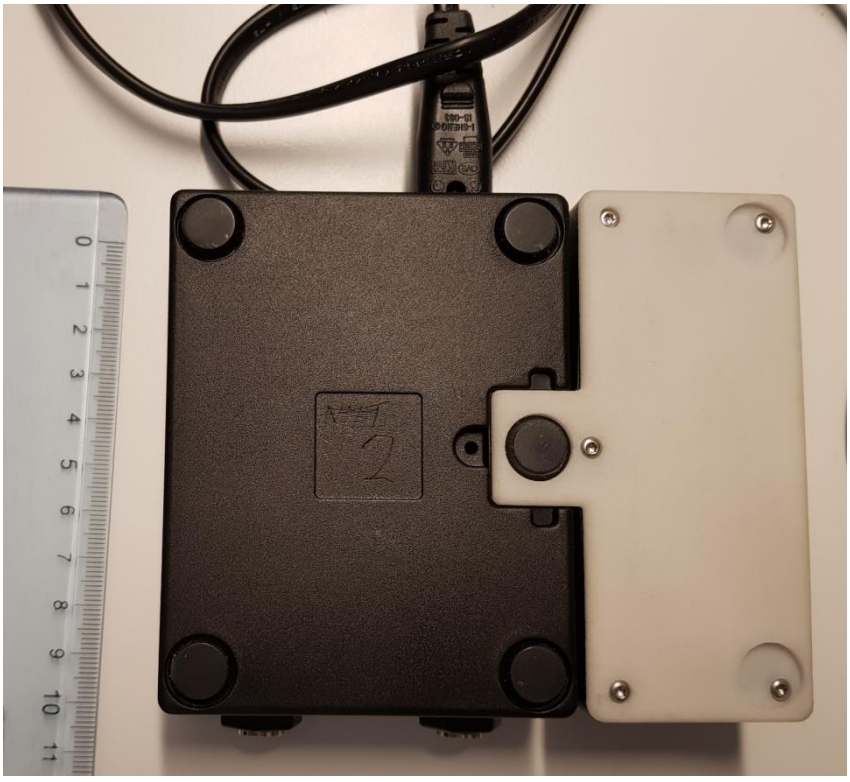
Test engineers: Fredrik Isaksson and Markel Bertilsson

Complies?	Yes

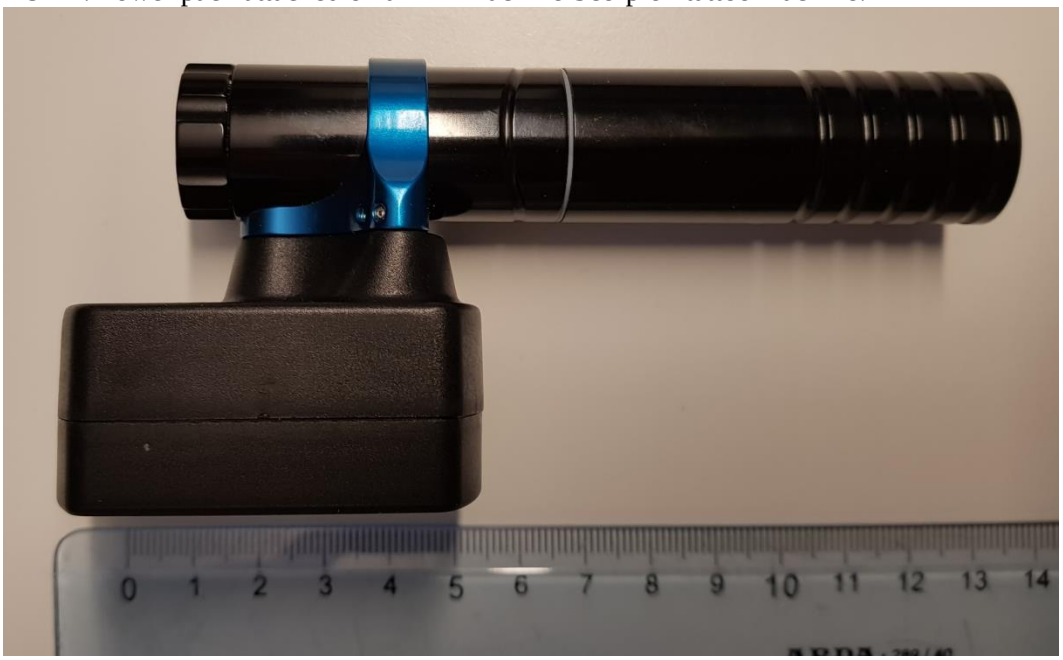
Photos

EUT 1: Main unit with Scorpion charger attached:



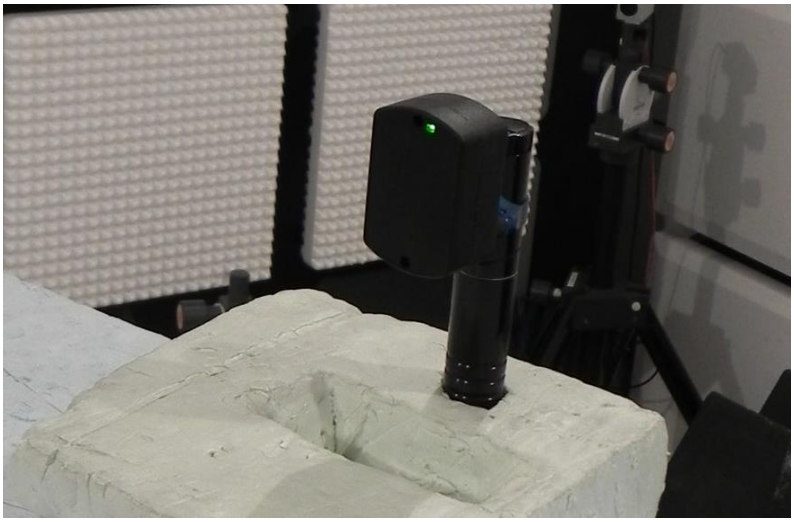
EUT 2: Power pack:

EUT 2: Power pack attached on an ink machine Scorpion tattoo machine:

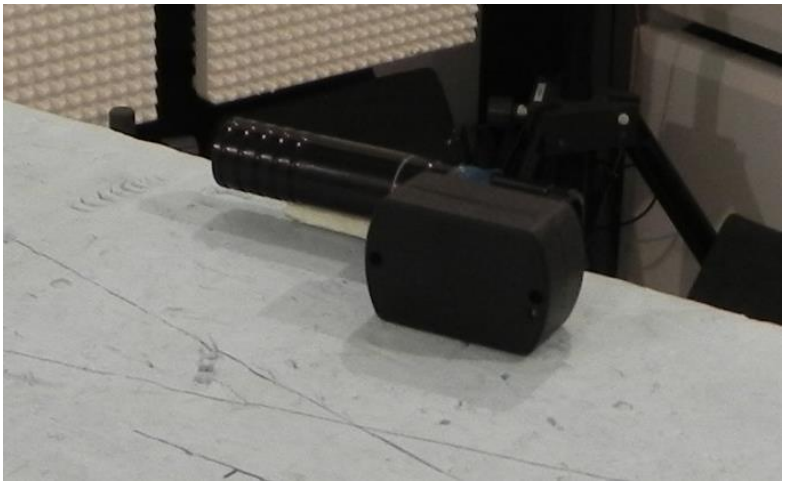


The test set-up during the radiated tests can be seen in the pictures below.

EUT 2 in X-axis:

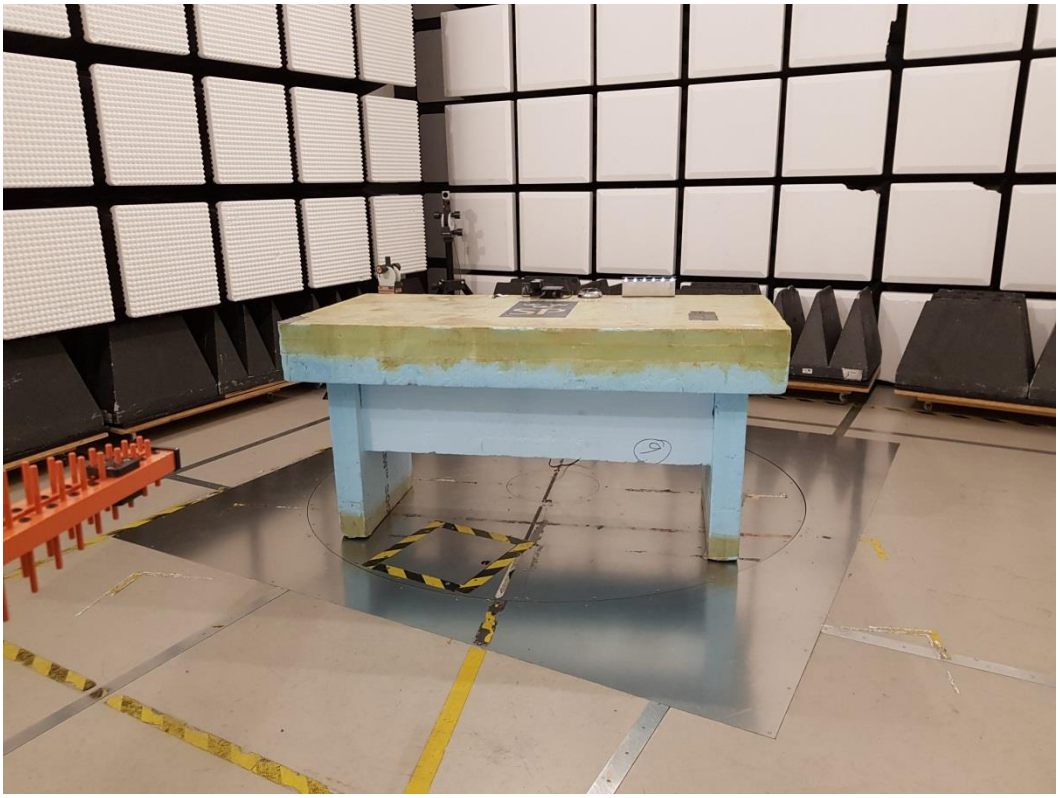


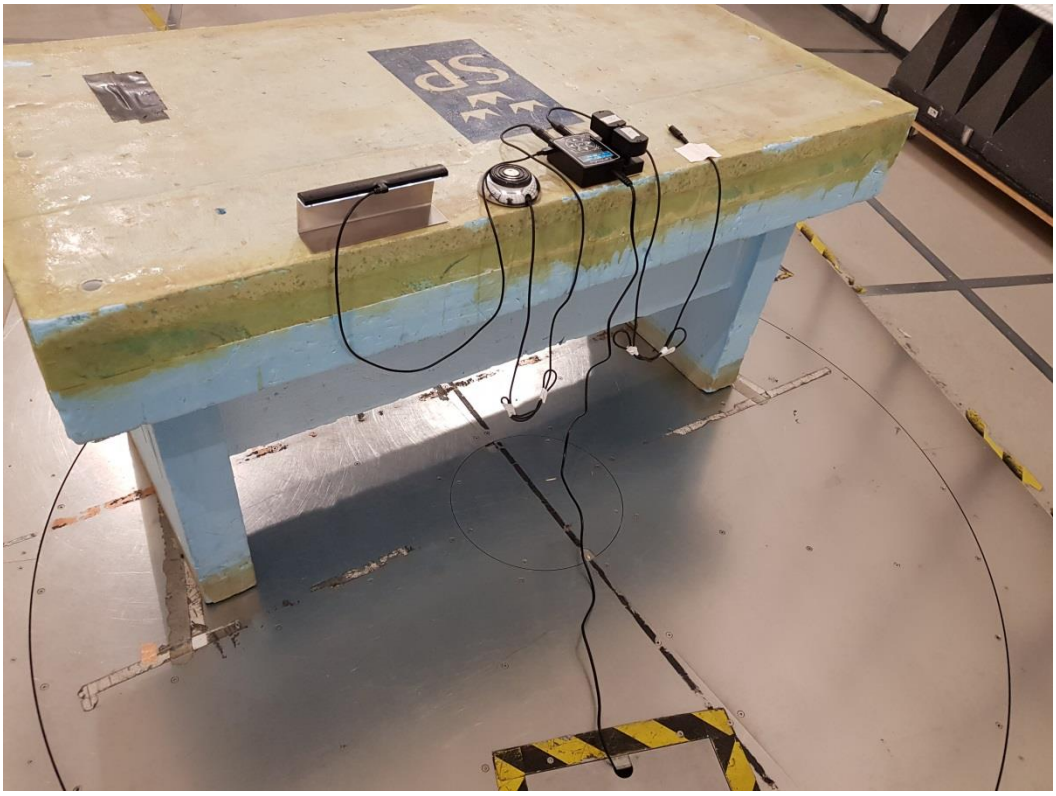
EUT 2 in Y-axis:



EUT 2 in Z-axis:

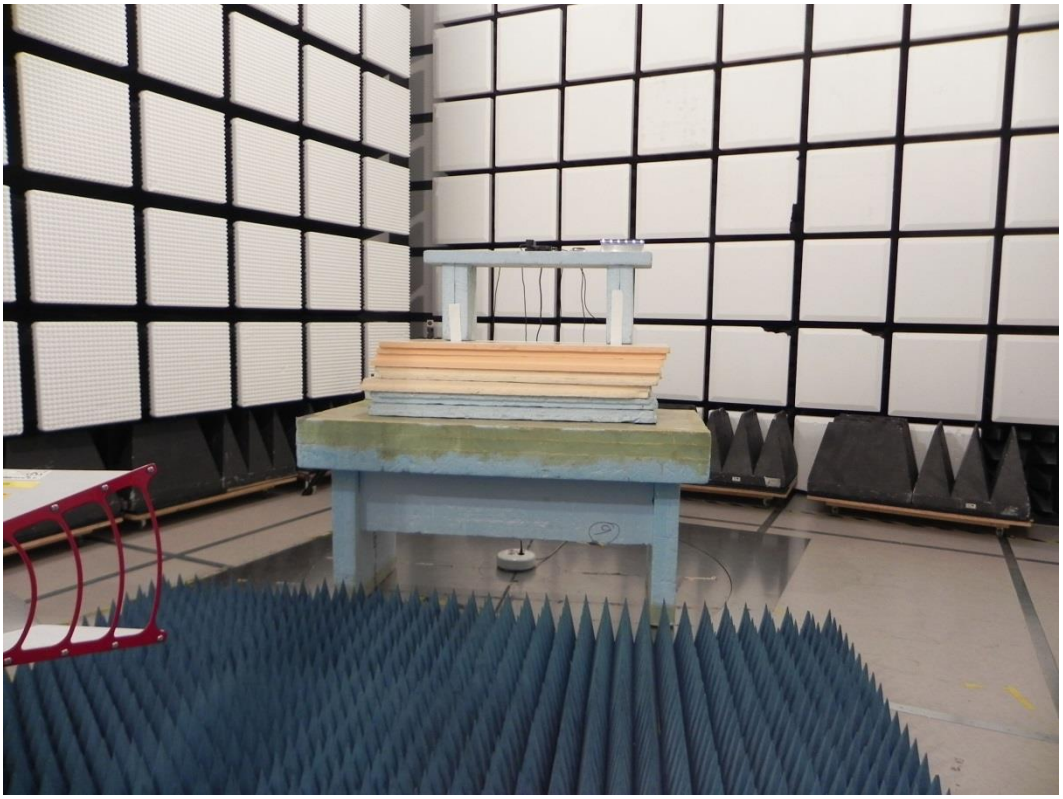
EUT 1: 30-1000 MHz:

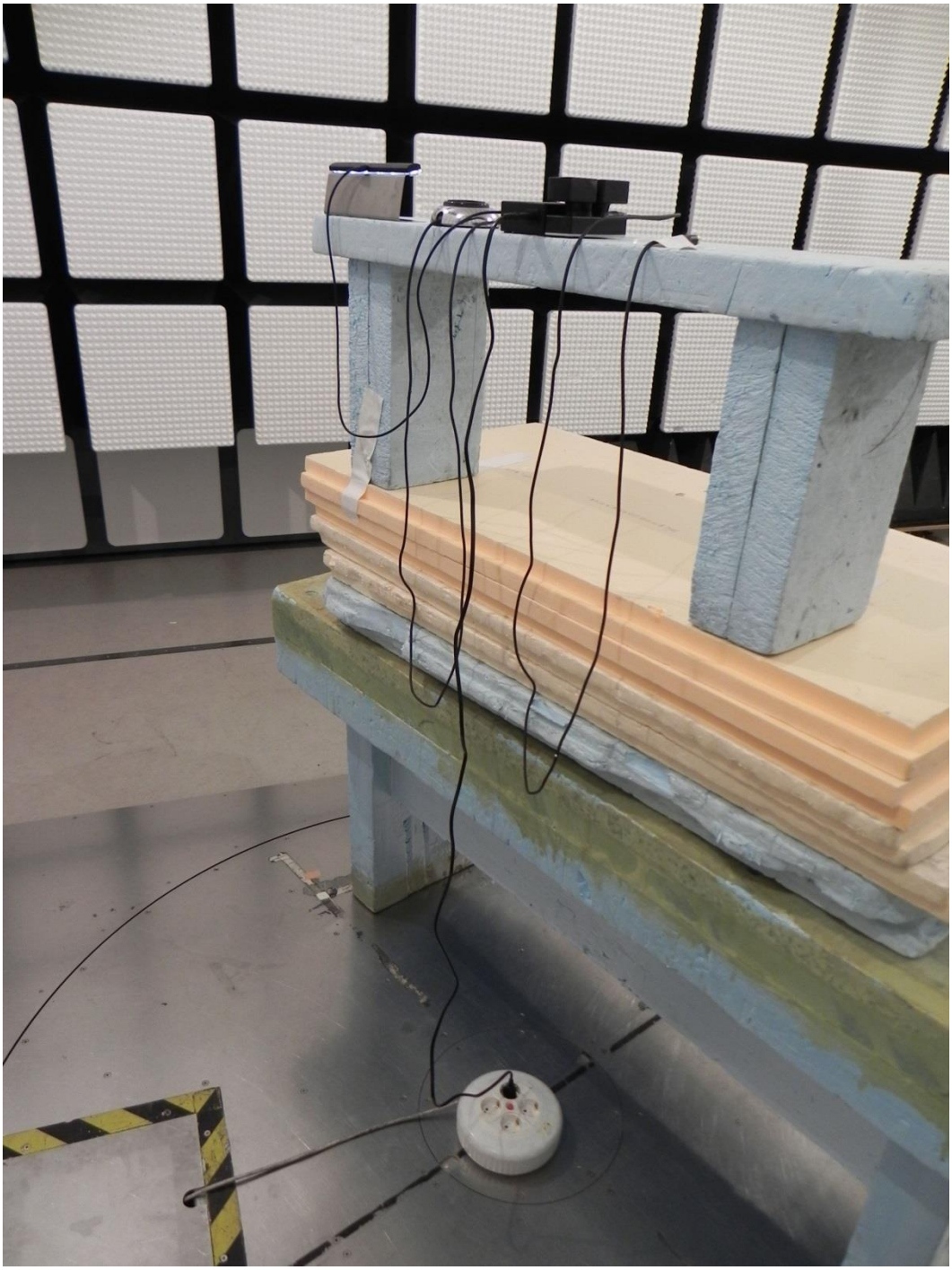




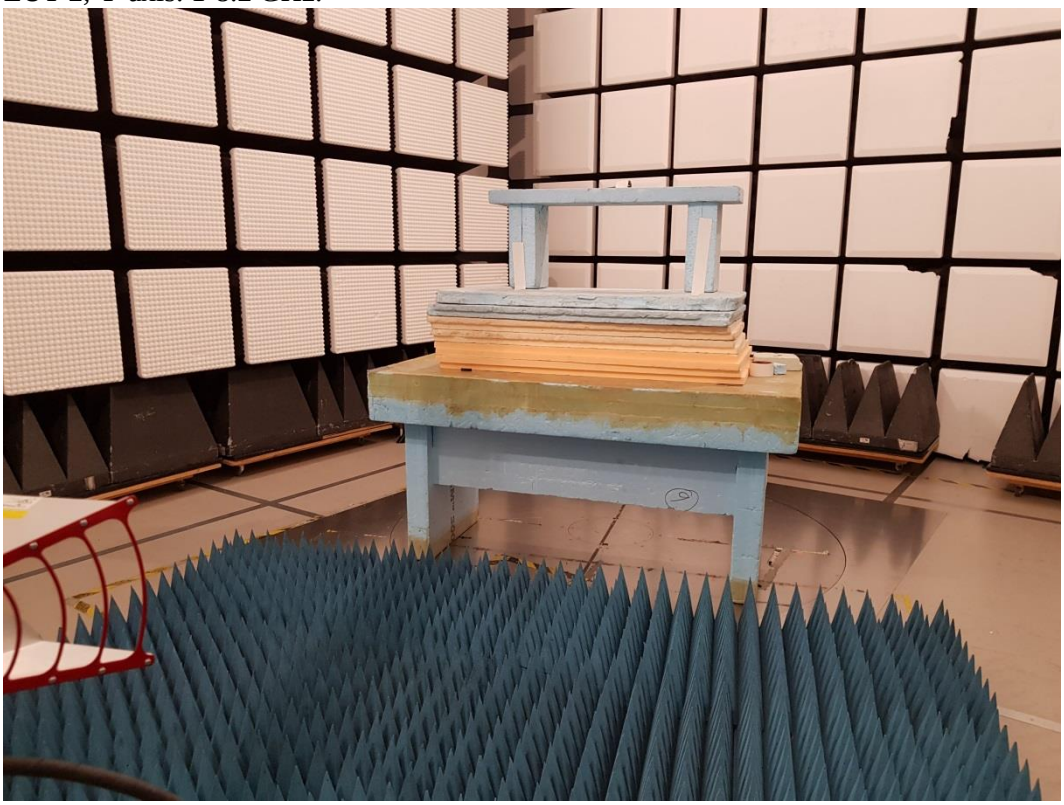
EUT 2. Y-axis: 30-1000 MHz:

EUT 1: 1-8.2 GHz:

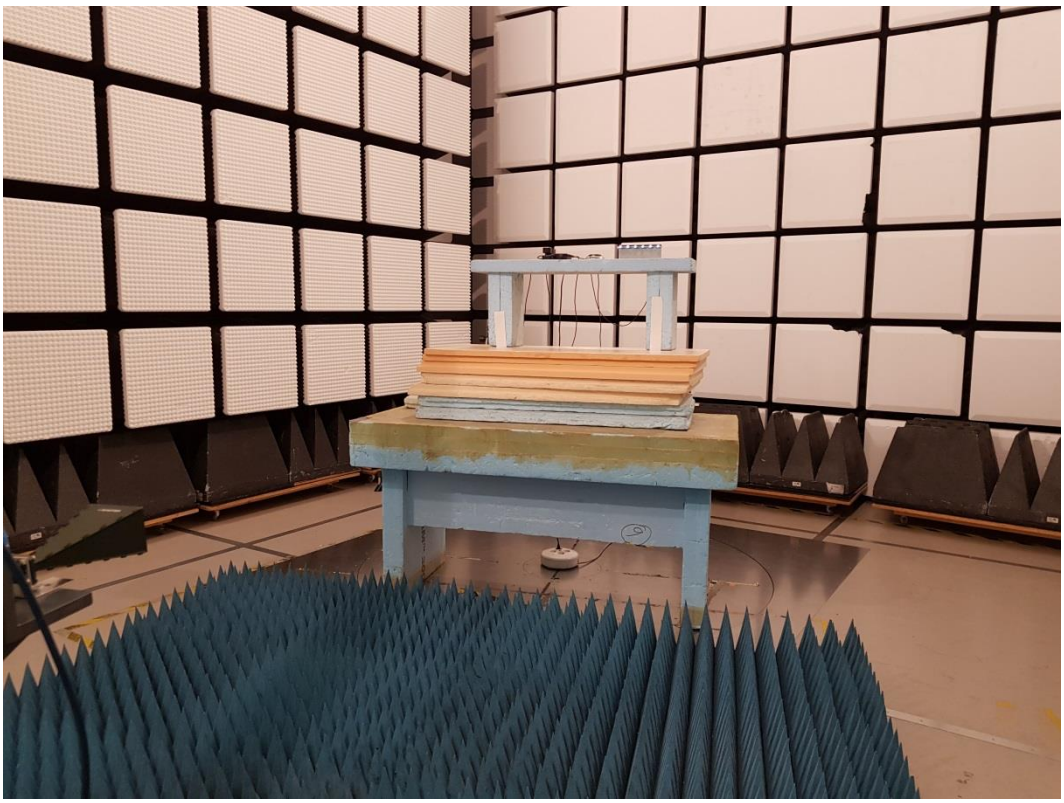




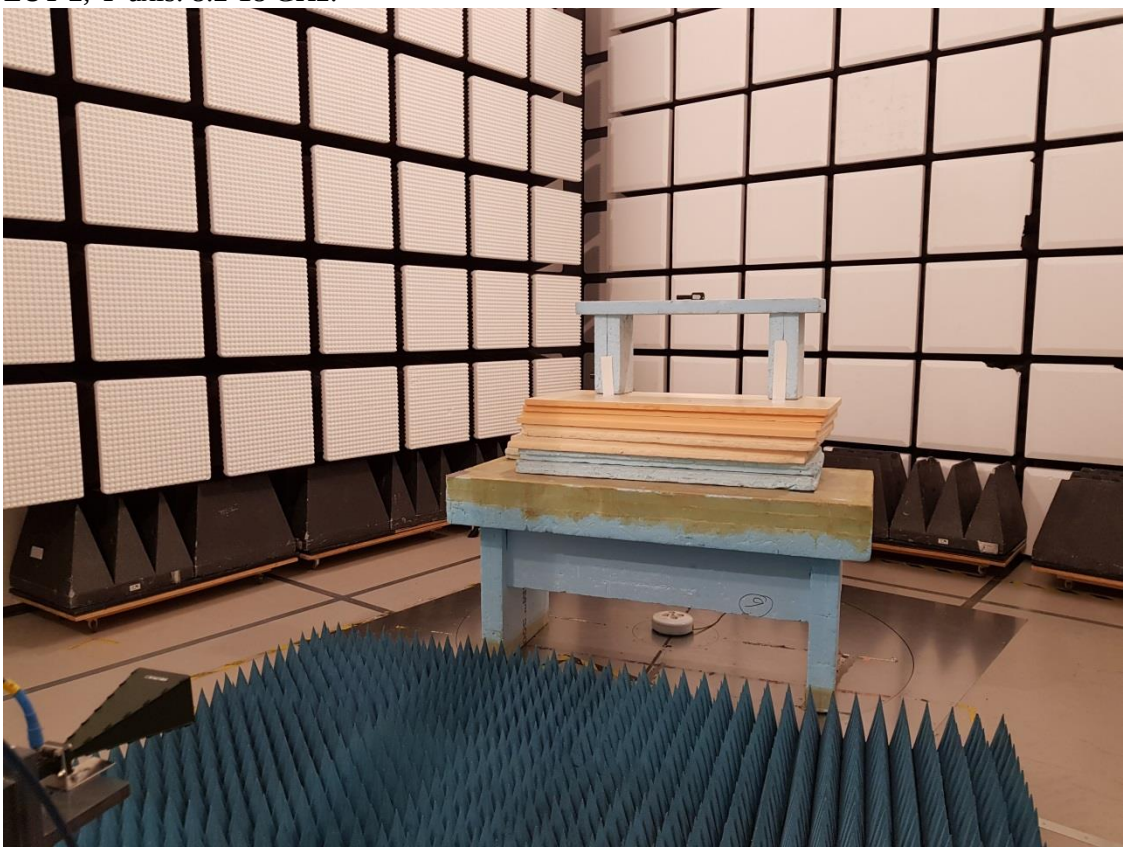
EUT 2, Y-axis: 1-8.2 GHz:



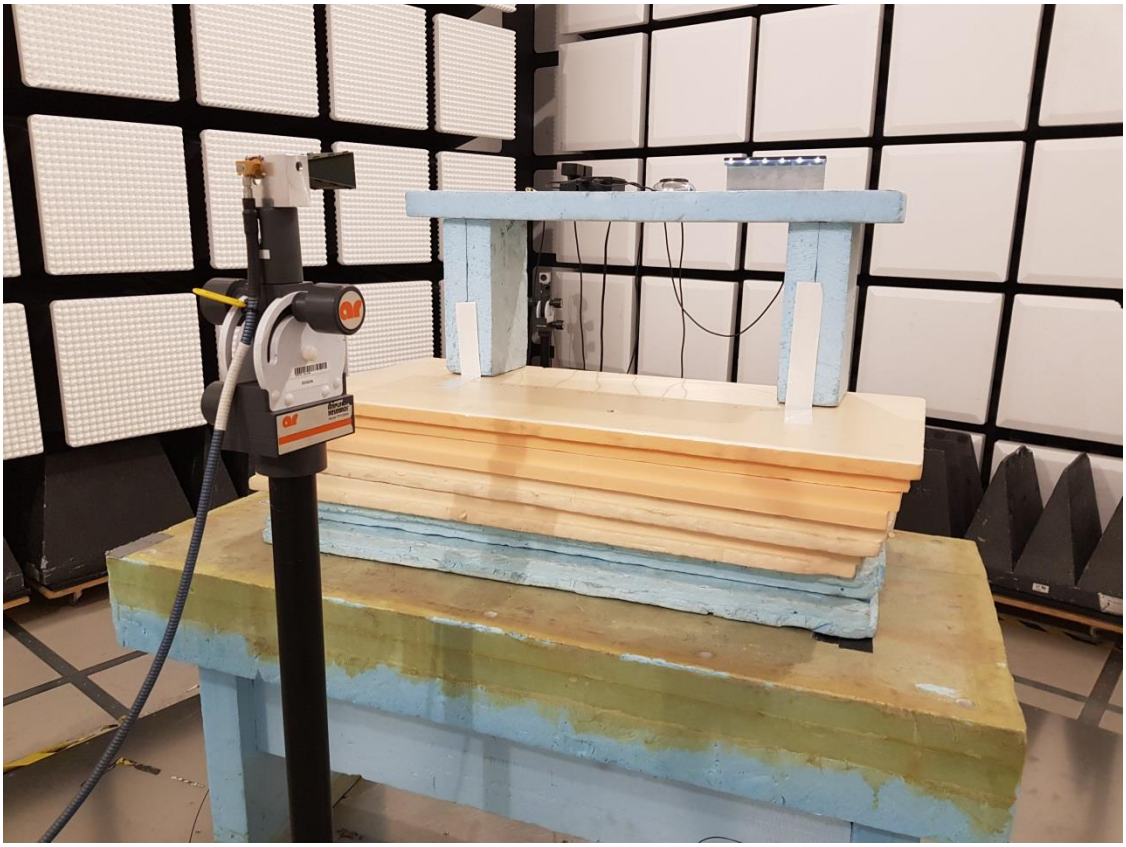
EUT 1: 8.2-18 GHz:



EUT 2, Y-axis: 8.2-18 GHz:



EUT 1: 18-25 GHz:



EUT 2, Y-axis: 18-25 GHz:

The test set-up during the conducted AC tests of EUT 1 can be seen in the pictures below.