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Test report

326494-2TRFFCC

Date of issue: March 28, 2017

Applicant:

Paradox Engineering SA

Via Passeggiata, 7 – CH-6883 Novazzano – Switzerland

Product:

Gateway

Model:

PE.AMI-GW920

FCC ID:

2AKPQ0701142823044

Specifications:

- FCC 47 CFR Part 15 Subpart C, §15.247

  Operation in the 902–928 MHz, 2400–2483.5 MHz, and 5725–5850 MHz

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Review date	March 28, 2017		

Limits of responsibility

Note that the results contained in this report relate only to the items tested and were obtained in the period between the date of initial receipt of samples and the date of issue of the report. This test report has been completed in accordance with the requirements of ISO/IEC 17025. All results contain in this report are within Nemko Spa ISO/IEC 17025 accreditation.

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Section 1. Report summary

1.1 Applicant and manufacturer

Company name	Paradox Engineering SA
Address	Via Passeggiata, 7
City	Novazzano
Postal/Zip code	CH-6883
Country	Switzerland

1.2 Test specifications

FCC 47 CFR Part 15, Subpart C, Clause 15.247	Operation in the 902–928 MHz, 2400–2483.5 MHz, and 5725–585 MHz

1.3 Test methods

558074 D01 DTS Meas Guidance v03r05 (April 8, 2016)	Guidance for Performing Compliance Measurements on Digital Transmission Systems (DTS) Operating Under §15.247
662911 D01 Multiple Transmitter Output v02r01 (October 31, 2013)	Emissions Testing of Transmitters with Multiple Outputs in the Same Band
DA 00-705, Released March 30, 2000	Filing and Measurement Guidelines for Frequency Hopping Spread Spectrum Systems
ANSI C63.10 v2013	American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices

1.4 Statement of compliance

In the configuration tested, the EUT was found compliant.

Testing was completed against all relevant requirements of the test standard. Results obtained indicate that the product under test complies in full with the requirements tested. The test results relate only to the items tested.

See “Summary of test results” for full details.

1.5 Exclusions

None

1.6 Test report revision history

Revision #	Details of changes made to test report
326494-2TRFFCC	Original report issued

Section 2. Summary of test results

2.1 FCC Part 15 Subpart C, general requirements test results

Part	Test description	Verdict
§15.207(a)	Conducted limits	Not tested
§15.31(e)	Variation of power source	Pass[1]
§15.203	Antenna requirement	Not applicable[2]

Notes: [1] Measurements of the variation of the input power or the radiated signal level of the fundamental frequency component of the emission, as appropriate, was performed with the supply voltage varied between 85 % and 115 % of the nominal rated supply voltage. No noticeable output power variation was observed

[2] This requirement does not apply to intentional radiators that must be professionally installed.

2.2 FCC Part 15 Subpart C, intentional radiators test results

Part	Test description	Verdict
§15.247(a)(1)(i)	Frequency hopping systems operating in the 902–928 MHz band	Pass
§15.247(a)(1)(ii)	Frequency hopping systems operating in the 5725–5850 MHz band	Not applicable
§15.247(a)(1)(iii)	Frequency hopping systems operating in the 2400–2483.5 MHz band	Not applicable
§15.247(a)(2)	Minimum 6 dB bandwidth for systems using digital modulation techniques	Not applicable
§15.247(b)(1)	Maximum peak output power of frequency hopping systems operating in the 2400–2483.5 MHz band and 5725–5850 MHz band	Not applicable
§15.247(b)(2)	Maximum peak output power of Frequency hopping systems operating in the 902–928 MHz band	Pass
§15.247(b)(3)	Maximum peak output power of systems using digital modulation in the 902–928 MHz, 2400–2483.5 MHz, and 5725–5850 MHz bands	Not applicable
§15.247(c)(1)	Fixed point-to-point operation with directional antenna gains greater than 6 dBi	Not applicable
§15.247(c)(2)	Transmitters operating in the 2400–2483.5 MHz band that emit multiple directional beams	Not applicable
§15.247(d)	Spurious emissions	Pass
§15.247(e)	Power spectral density for digitally modulated devices	Not applicable
§15.247(f)	Time of occupancy for hybrid systems	Not applicable

For clause 15.247 (d), only band edge emissions have been evaluated (partial application of the standards)

Section 3. Equipment under test (EUT) details

3.1 Sample information

Receipt date	March 17, 2017
Nemko sample ID number	1/4

3.2 EUT information

Product name	Gateway
Model	PE.AMI-GW920
Model variant	--
Serial number	1704PE00030

3.3 Technical information

Frequency band	902–928 MHz
Frequency Min (MHz)	909
Frequency Max (MHz)	921
RF power Min (W), Conducted	67.3 mW
RF power Max (W), Conducted	118.0 mW
Field strength, Units @ distance	N/A
Measured BW (kHz) (20 dB)	80
Calculated BW (kHz), as per TRC-43	N/A
Type of modulation	GFSK
Emission classification (F1D, G1D, D1D)	80KF7D
Antenna information	The EUT is professionally installed.

3.4 Product description and theory of operation

The EUT is a gateway equipped with following radio modules:

1) ELB-PED-0077 (radio narrowband 902-928 MHz)
2) WLE600VX (Wi-Fi cards 2412-2472 MHz and 5745-5825 MHz)

The EUT is also provided with the following antennas:

1) MEGWX-1551SAAX-920 (902-928 MHz)
2) OM24580703 (2412-2472 MHz)
3) MT-485001 (5745-5825 MHz)

3.5 EUT exercise details

The following software has been used to exercise the EUT and it has been set as in the figure, according to applicant's request.

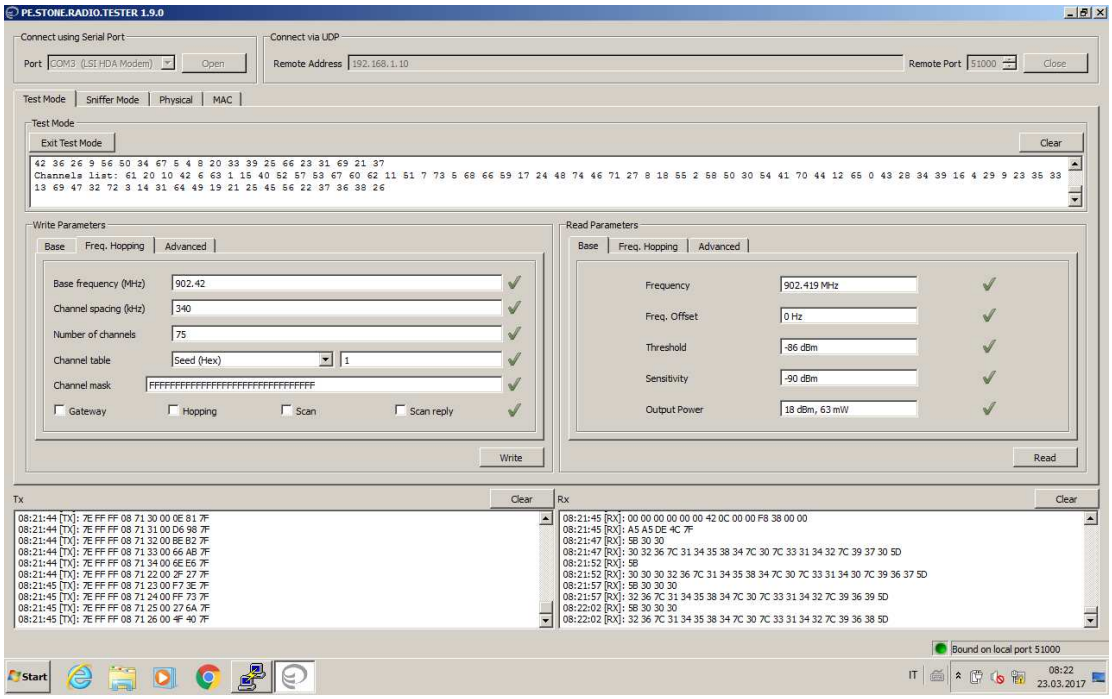


Figure 3.5-1: *Software for radio tests*

3.6 EUT setup diagram

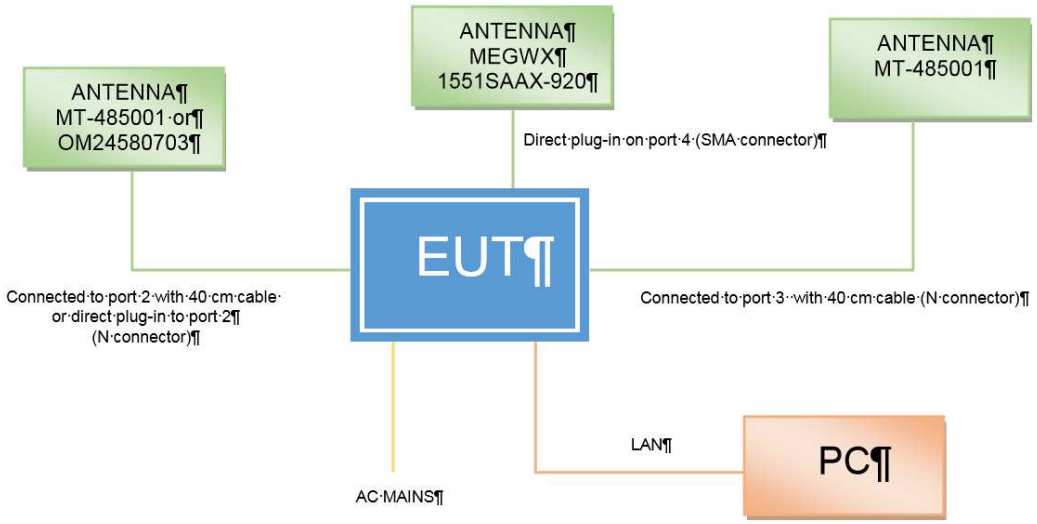


Figure 3.6-1: *Setup diagram*

Section 4. Engineering considerations

4.1 Modifications incorporated in the EUT

There were no modifications performed to the EUT during this assessment.

4.2 Technical judgment

None

4.3 Deviations from laboratory tests procedures

No deviations were made from laboratory procedures.

Section 5. Test conditions

5.1 Atmospheric conditions

Temperature	15–30 °C
Relative humidity	20–75 %
Air pressure	860–1060 mbar

When it is impracticable to carry out tests under these conditions, a note to this effect stating the ambient temperature and relative humidity during the tests shall be recorded and stated.

5.2 Power supply range

The normal test voltage for equipment to be connected to the mains shall be the nominal mains voltage. For the purpose of the present document, the nominal voltage shall be the declared voltage, or any of the declared voltages ±5 %, for which the equipment was designed.

Section 6. Measurement uncertainty

6.1 Uncertainty of measurement

EUT	Type	Test	Range and Setup features	Measurement Uncertainty	Notes
Transmitter	Conducted	Frequency error	0.001MHz ÷ 18 GHz	0.08 ppm	(1)
Transmitter	Conducted	Carrier power RF Output Power	1MHz ÷ 18 GHz With power meter	1.6 dB	(1)
Transmitter	Conducted	Carrier power RF Output Power	1MHz ÷ 18 GHz With spectrum/receiver	3.0 dB	(1)
Transmitter	Conducted	Adjacent channel power	1MHz ÷ 18 GHz	1.6 dB	(1)
Transmitter	Conducted	Conducted spurious emissions	1MHz ÷ 18 GHz	4.2 dB	(1)
Transmitter	Conducted	Intermodulation attenuation	1MHz ÷ 18 GHz	2.2 dB	(1)
Transmitter	Conducted	Attack time – frequency behaviour	1MHz ÷ 18 GHz	2.0 ms	(1)
Transmitter	Conducted	Attack time – power behaviour	1MHz ÷ 18 GHz	2.5 ms	(1)
Transmitter	Conducted	Release time – frequency behaviour	1MHz ÷ 18 GHz	2.0 ms	(1)
Transmitter	Conducted	Release time – power behaviour	1MHz ÷ 18 GHz	2.5 ms	(1)
Transmitter	Conducted	Transient behaviour of the transmitter– Transient frequency behaviour	1MHz ÷ 18 GHz	0.2 kHz	(1)
Transmitter	Conducted	Transient behaviour of the transmitter – Power level slope	1MHz ÷ 18 GHz	9%	(1)
Transmitter	Conducted	Frequency deviation - Maximum permissible frequency deviation	0.001MHz ÷ 18 GHz	1.3%	(1)
Transmitter	Conducted	Frequency deviation - Response of the transmitter to modulation frequencies above 3 kHz	0.001MHz ÷ 18 GHz	0.5 dB	(1)
Transmitter	Conducted	Dwell time	-	3%	(1)
Transmitter	Conducted	Hopping Frequency Separation	0.01MHz ÷ 18 GHz	1%	(1)
Transmitter	Conducted	Occupied Channel Bandwidth	0.01MHz ÷ 18 GHz	2%	(1)
Transmitter	Conducted	Modulation Bandwidth	0.01MHz ÷ 18 GHz	2%	(1)
Transmitter	Radiated	Radiated spurious emissions	30MHz ÷ 18 GHz	6.0 dB	(1)
Transmitter	Radiated	Effective radiated power transmitter	30MHz ÷ 18 GHz	6.0 dB	(1)

NOTES:
(1) The reported expanded uncertainty of measurement is stated as the standard uncertainty of measurement multiplied by the coverage factor k = 2 which has been derived from the assumed normal probability distribution with infinite degrees of freedom and for a coverage probability of 95 %.

Section 7. Test equipment

7.1 Test equipment list

Table 7.1-1: *Equipment list*

Equipment	Manufacturer	Model no.	Asset no.	Next cal.
EMI receiver (20 Hz ÷ 8 GHz)	R&S	ESU8	100202	2017-09
Spectrum Analyzer (9kHz ÷ 40GHz)	R&S	FSEK	848255/005	2018-01
Trilog Broadband Antenna (20MHz ÷ 6GHz)	Schwarzbeck	VULB 9162	9162-025	2018-07
Bilog antenna (1 ÷ 18 GHz)	Schwarzbeck	STLP 9148-123	123	2018-06
Broadband preamplifier (1 ÷ 18 GHz)	Schwarzbeck	BBV 9718	9718-137	2017-12
LISN (9 kHz ÷ 30 MHz)	R&S	ESH2-Z5	872 460/041	2017-11
Antenna mast	R&S	HCM	836 529/05	NCR
Controller	R&S	HCC	836 620/7	NCR
Hydraulic revolving platform	Nemko	RTPL 01	4.233	NCR
Semi-anechoic chamber	Nemko	10m semi-anechoic chamber	530	2018-10
Shielded room	Siemens	10m control room	1947	NCR
Shielded room	Siemens	Conducted emission test room	1862	NCR

Note: NCR - no calibration required, VOU - verify on use

Section 8. Testing data

8.1 FCC 15.247(a)(1) Frequency Hopping Systems requirements

8.1.1 Definitions and limits

(1) Frequency hopping systems shall have hopping channel carrier frequencies separated by a minimum of 25 kHz or the 20 dB bandwidth of the hopping channel, whichever is greater. Alternatively, frequency hopping systems operating in the 2400–2483.5 MHz band may have hopping channel carrier frequencies that are separated by 25 kHz or two-thirds of the 20 dB bandwidth of the hopping channel, whichever is greater, provided the systems operate with an output power no greater than 125 mW. The system shall hop to channel frequencies that are selected at the system hopping rate from a pseudo randomly ordered list of hopping frequencies. Each frequency must be used equally on the average by each transmitter. The system receivers shall have input bandwidths that match the hopping channel bandwidths of their corresponding transmitters and shall shift frequencies in synchronization with the transmitted signals.

(i) For frequency hopping systems operating in the 902-928 MHz band: if the 20 dB bandwidth of the hopping channel is less than 250 kHz, the system shall use at least 50 hopping frequencies and the average time of occupancy on any frequency shall not be greater than 0.4 seconds within a 20 second period; if the 20 dB bandwidth of the hopping channel is 250 kHz or greater, the system shall use at least 25 hopping frequencies and the average time of occupancy on any frequency shall not be greater than 0.4 seconds within a 10 second period. The maximum allowed 20 dB bandwidth of the hopping channel is 500 kHz

8.1.2 Test summary

Test date	March 20, 2017	Temperature	23 °C
Test engineer	Paolo Barbieri	Air pressure	1020 mbar
Verdict	Pass	Relative humidity	45 %

8.1.3 Observations, settings and special notes

Spectrum analyser settings for carrier frequency separation:

Resolution bandwidth	≥ 1 % of the span
Video bandwidth	≥ RBW
Frequency span	wide enough to capture the peaks of two adjacent channels
Detector mode	Peak
Trace mode	Max Hold

Spectrum analyser settings for number of hopping frequencies:

Resolution bandwidth	≥ 1 % of the span
Video bandwidth	≥ RBW
Frequency span	the frequency band of operation
Detector mode	Peak
Trace mode	Max Hold

Spectrum analyser settings for time of occupancy (dwell time):

Resolution bandwidth	1 MHz
Video bandwidth	≥ RBW
Frequency span	Zero span
Detector mode	Peak
Trace mode	Max Hold

Spectrum analyser settings for 20 dB bandwidth:

Resolution bandwidth	≥ 1% of the 20 dB bandwidth
Video bandwidth	≥ RBW
Frequency span	approximately 2 to 3 times the 20 dB bandwidth, centered on a hopping channel
Detector mode	Peak
Trace mode	Max Hold

8.1.4 Test data

Table 8.1-1: *20 dB bandwidth results*

Frequency, MHz	20 dB bandwidth, kHz
909	80.0
915	80.5
921	79.3

Table 8.1-2: *Carrier frequency separation results*

Carrier frequency separation, kHz	Minimum limit, kHz	Margin, kHz
160	80	80

Table 8.1-3: *Number of hopping frequencies results*

Number of hopping frequencies	Minimum limit	Margin
75	15	60

Table 8.1-4: *Average time of occupancy results*

Dwell time of each pulse, ms	Number of pulses within period	Total dwell time within period, ms	Limit, ms	Margin, ms
349.3	1	349.3	400	50.7

Measurement Period is 20 s

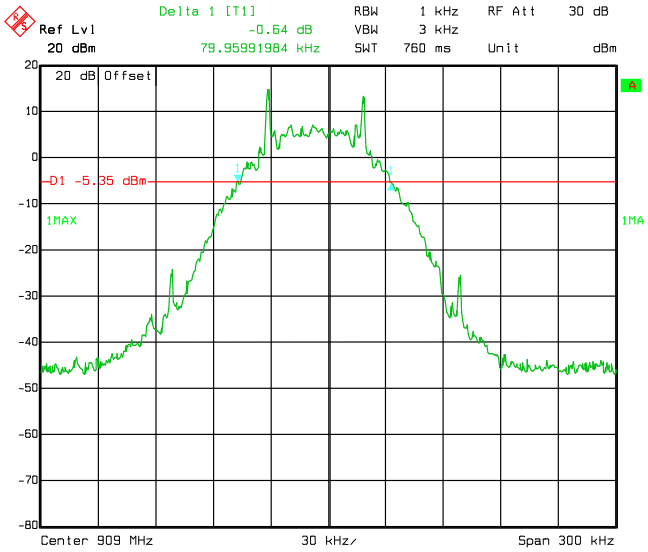


Figure 8.1-1: *20 dB bandwidth on low channel*

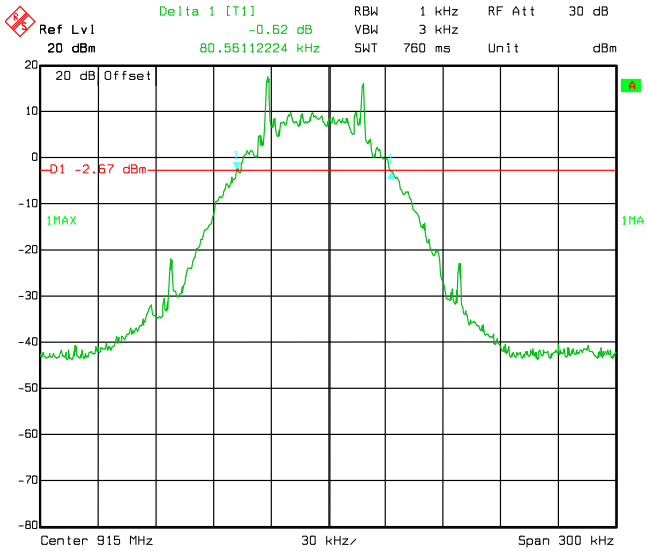


Figure 8.1-2: *20 dB bandwidth on mid channel*

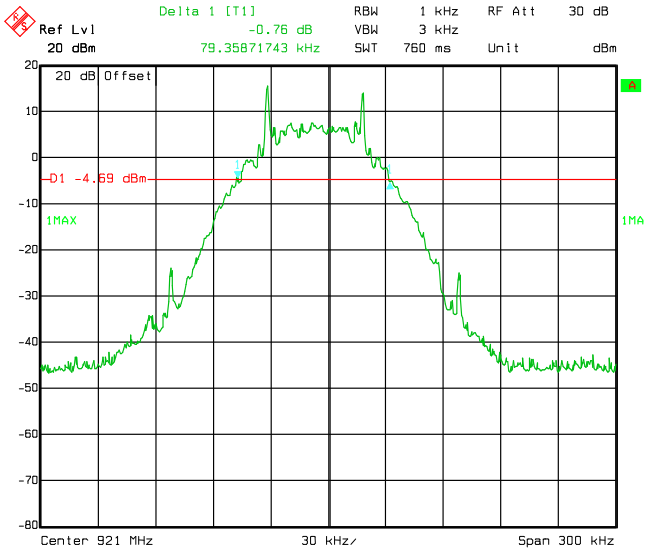


Figure 8.1-3: *20 dB bandwidth on high channel*

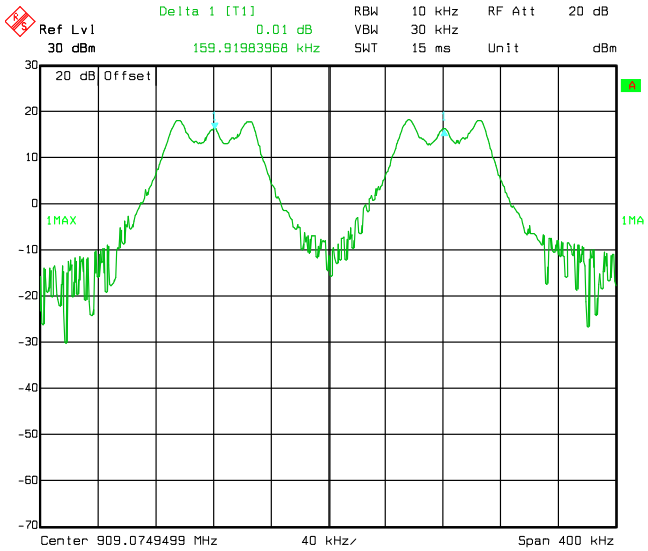


Figure 8.1-4: *Carrier frequency separation*

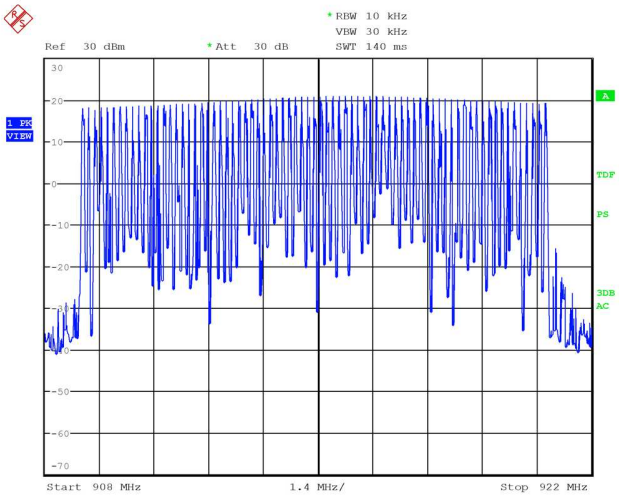


Figure 8.1-5: *Number of hopping channels*

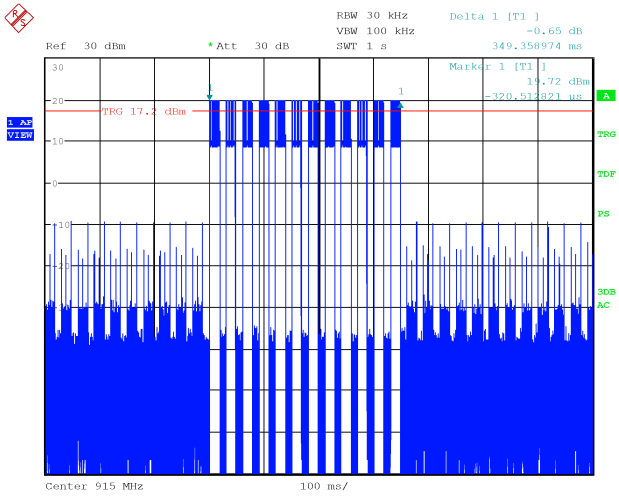


Figure 8.1-6: *Dwell time*

8.2 FCC 15.247(b) Transmitter output power and e.i.r.p. requirements

8.2.1 Definitions and limits

(b) The maximum peak conducted output power of the intentional radiator shall not exceed the following:

(2) For frequency hopping systems operating in the 902-928 MHz band: 1 watt for systems employing at least 50 hopping channels; and, 0.25 watts for systems employing less than 50 hopping channels, but at least 25 hopping channels, as permitted under paragraph (a)(1)(i) of this section.

(4) The conducted output power limit specified in paragraph (b) of this section is based on the use of antennas with directional gains that do not exceed 6 dBi. Except as shown in paragraph (c) of this section, if transmitting antennas of directional gain greater than 6 dBi are used, the conducted output power from the intentional radiator shall be reduced below the stated values in paragraphs (b)(1), (b)(2), and (b)(3) of this section, as appropriate, by the amount in dB that the directional gain of the antenna exceeds 6 dBi.

8.2.2 Test summary

Test date	March 20, 2017	Temperature	23 °C
Test engineer	Paolo Barbieri	Air pressure	1020 mbar
Verdict	Pass	Relative humidity	45 %

8.2.3 Observations, settings and special notes

Spectrum analyser settings for output power:

Resolution bandwidth	> the 20 dB bandwidth of the emission being measured
Video bandwidth	≥ RBW
Frequency span	approximately 5 times the 20 dB bandwidth, centered on a hopping channel
Detector mode	Peak
Trace mode	Max Hold

8.2.4 Test data

Table 8.2-1: *Output power and EIRP results*

Frequency, MHz	Output power, dBm	Output power limit, dBm	Margin, dB	Antenna gain, dBi	EIRP, dBm	EIRP limit, dBm	EIRP margin, dB
909	18.3	30.00	11.7	2	20.3	36.00	15.7
915	20.7	30.00	9.3	2	22.7	36.00	13.3
921	18.7	30.00	11.3	2	20.7	36.00	15.3

EIRP = Output power + Antenna gain

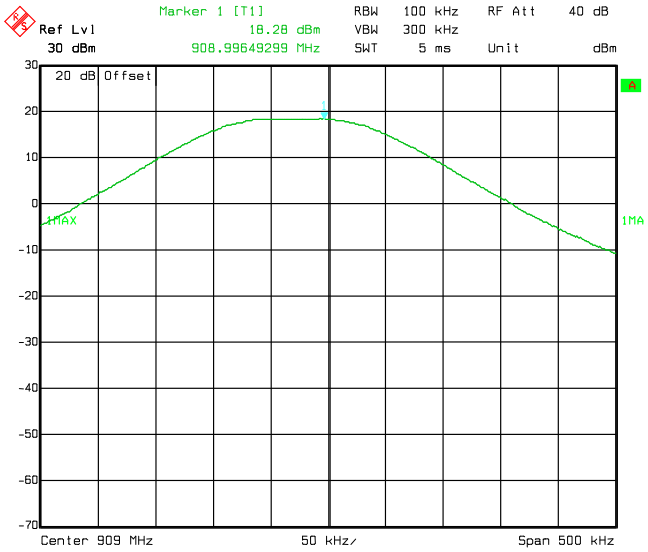


Figure 8.2-1: *Output power on low channel*

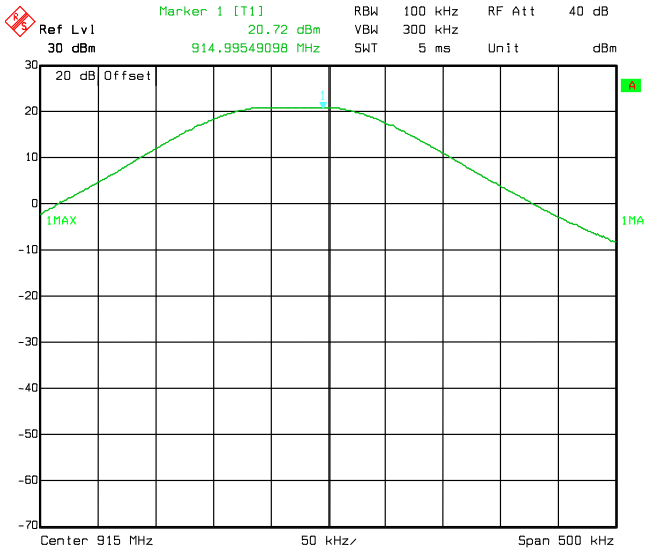


Figure 8.2-2: *Output power on mid channel*

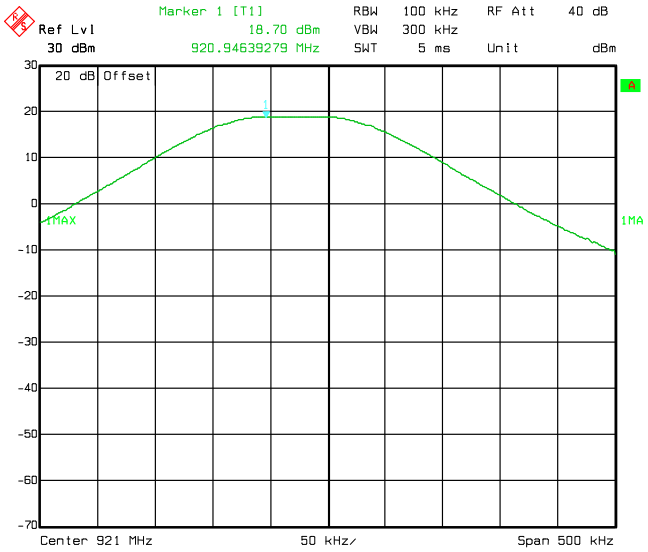


Figure 8.2-3: *Output power on high channel*

8.3 FCC 15.247(d) Spurious (out-of-band) unwanted emissions

8.3.1 Definitions and limits

In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, 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. Attenuation below the general limits specified in §15.209(a) is not required. In addition, radiated emissions which fall in the restricted bands, as defined in §15.205(a), must also comply with the radiated emission limits specified in §15.209(a) (see §15.205(c)).

Table 8.3-1: *FCC §15.209 and RSS-Gen – Radiated emission limits*

Frequency, MHz	Field strength of emissions		Measurement distance, m
	µV/m	dBµV/m	
0.009–0.490	2400/F	$67.6 – 20 \times \log_{10}(F)$	300
0.490–1.705	24000/F	$87.6 – 20 \times \log_{10}(F)$	30
1.705–30.0	30	29.5	30
30–88	100	40.0	3
88–216	150	43.5	3
216–960	200	46.0	3
above 960	500	54.0	3

Notes: In the emission table above, the tighter limit applies at the band edges.
For frequencies above 1 GHz the limit on peak RF emissions is 20 dB above the maximum permitted average emission limit applicable to the equipment under test

Table 8.3-2: *ISED restricted frequency bands*

MHz	MHz	MHz	GHz
0.090–0.110	12.51975–12.52025	399.9–410	5.35–5.46
2.1735–2.1905	12.57675–12.57725	608–614	7.25–7.75
3.020–3.026	13.36–13.41	960–1427	8.025–8.5
4.125–4.128	16.42–16.423	1435–1626.5	9.0–9.2
4.17725–4.17775	16.69475–16.69525	1645.5–1646.5	9.3–9.5
4.20725–4.20775	16.80425–16.80475	1660–1710	10.6–12.7
5.677-5.683	25.5–25.67	1718.8–1722.2	13.25–13.4
6.215–6.218	37.5–38.25	2200–2300	14.47–14.5
6.26775–6.26825	73–74.6	2310–2390	15.35–16.2
6.31175–6.31225	74.8–75.2	2655–2900	17.7–21.4
8.291–8.294	108–138	3260–3267	22.01–23.12
8.362–8.366	156.52475–156.52525	3332–3339	23.6–24.0
8.37625–8.38675	156.7–156.9	3345.8–3358	31.2–31.8
8.41425–8.41475	240–285	3500–4400	36.43–36.5
12.29–12.293	322–335.4	4500–5150	Above 38.6

Note: Certain frequency bands listed in Table 8.3-2 and above 38.6 GHz are designated for low-power licence-exempt applications. These frequency bands and the requirements that apply to the devices are set out in this Standard

Table 8.3-3: *FCC restricted frequency bands*

MHz	MHz	MHz	GHz
0.090–0.110	16.42–16.423	399.9–410	4.5–5.15
0.495–0.505	16.69475–16.69525	608–614	5.35–5.46
2.1735–2.1905	16.80425–16.80475	960–1240	7.25–7.75
4.125–4.128	25.5–25.67	1300–1427	8.025–8.5
4.17725–4.17775	37.5–38.25	1435–1626.5	9.0–9.2
4.20725–4.20775	73–74.6	1645.5–1646.5	9.3–9.5
6.215–6.218	74.8–75.2	1660–1710	10.6–12.7
6.26775–6.26825	108–121.94	1718.8–1722.2	13.25–13.4
6.31175–6.31225	123–138	2200–2300	14.47–14.5
8.291–8.294	149.9–150.05	2310–2390	15.35–16.2
8.362–8.366	156.52475–156.52525	2483.5–2500	17.7–21.4
8.37625–8.38675	156.7–156.9	2690–2900	22.01–23.12
8.41425–8.41475	162.0125–167.17	3260–3267	23.6–24.0
12.29–12.293	167.72–173.2	3332–3339	31.2–31.8
12.51975–12.52025	240–285	3345.8–3358	36.43–36.5
12.57675–12.57725	322–335.4	3600–4400	Above 38.6
13.36–13.41			

8.3.2 Test summary

Test date	March 21, 2017	Temperature	24 °C
Test engineer	Paolo Barbieri	Air pressure	1015 mbar
Verdict	Pass	Relative humidity	40 %

8.3.3 Observations, settings and special notes

The spectrum was searched from 30 MHz to the 10th harmonic.
EUT was set to transmit with 100 % duty cycle.
Radiated measurements were performed at a distance of 3 m.

Spectrum analyser settings for peak radiated measurements within restricted bands above 1 GHz:

Resolution bandwidth:	1 MHz
Video bandwidth:	3 MHz
Detector mode:	Peak
Trace mode:	Max Hold

Spectrum analyser settings for average radiated measurements within restricted bands above 1 GHz:

Resolution bandwidth:	1 MHz
Video bandwidth:	10 Hz
Detector mode:	Peak
Trace mode:	Max Hold

Spectrum analyser settings for conducted spurious emissions measurements:

Resolution bandwidth:	100 kHz
Video bandwidth:	300 kHz
Detector mode:	Peak
Trace mode:	Max Hold

8.3.4 Test data

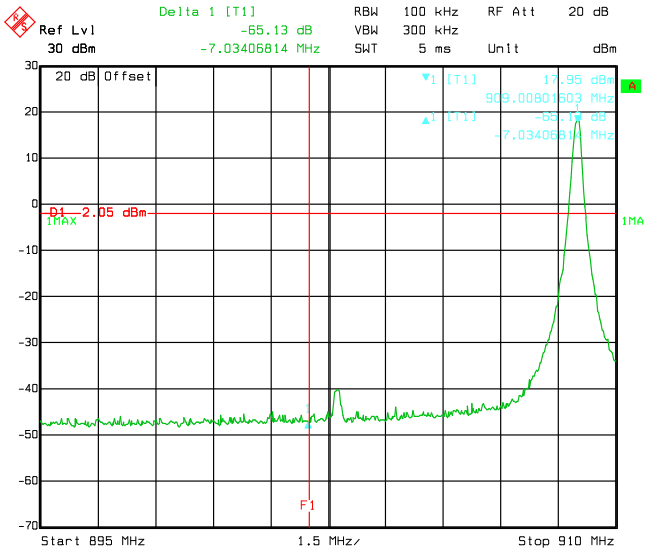


Figure 8.3-1: *Band edge, conducted emission, low channel*

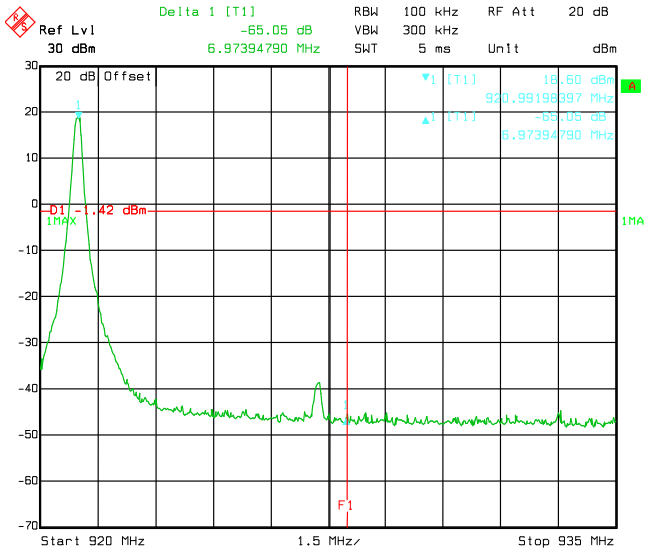


Figure 8.3-2: *Band edge, conducted emission, mid channel*

Edge	Measured, dB	Limit, dB
LOW	-65.1	-20
HIGH	-65.0	-20

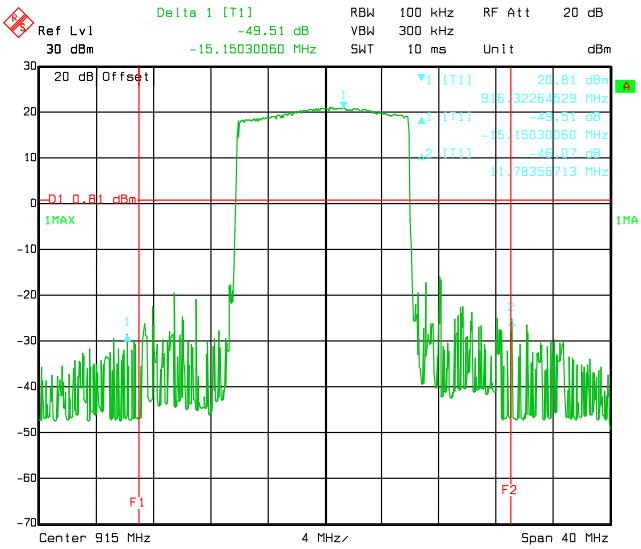


Figure 8.3-3: *Band edge, conducted emission, hopping*

Edge	Measured, dB	Limit, dB
LOW	-49.5	-20
HIGH	-46.1	-20

Section 9. Photos

9.1 Photo documentation of the test set-up

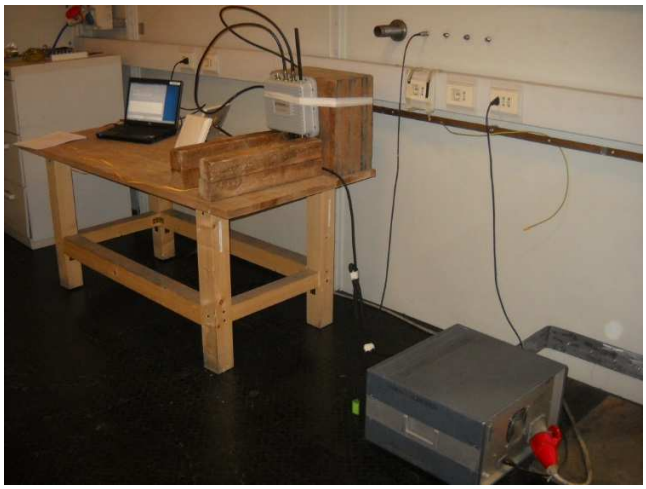


Figure 9.1-1: *AC power line conducted emissions*

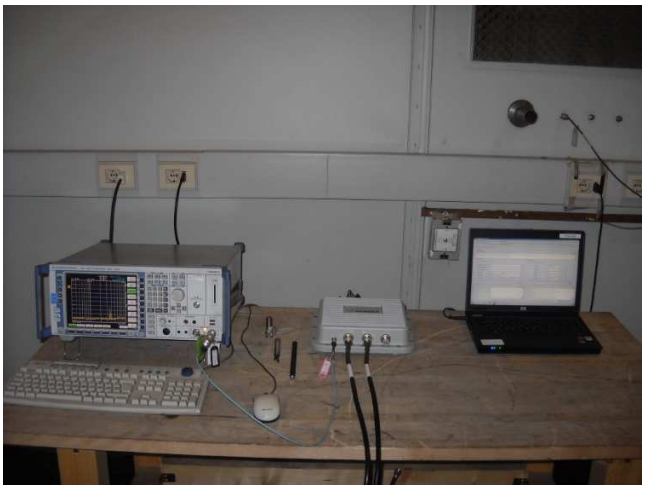


Figure 9.1-2: *Conducted emissions*

Figure 9.1-3: *Radiated emissions below 1 GHz*

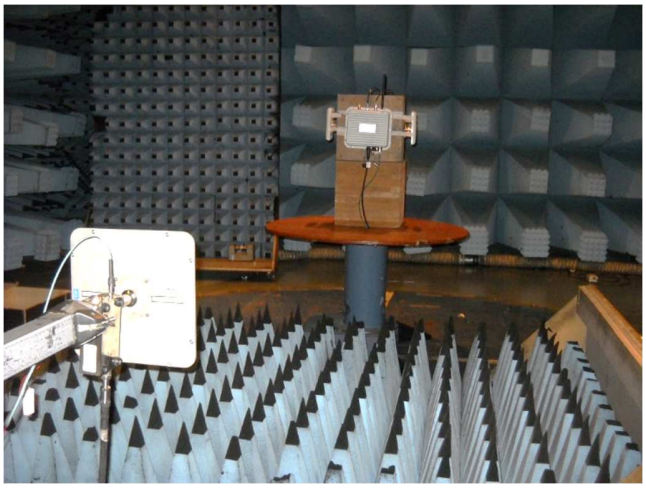


Figure 9.1-4: *Radiated emissions above 1 GHz*

9.2 EUT Photos

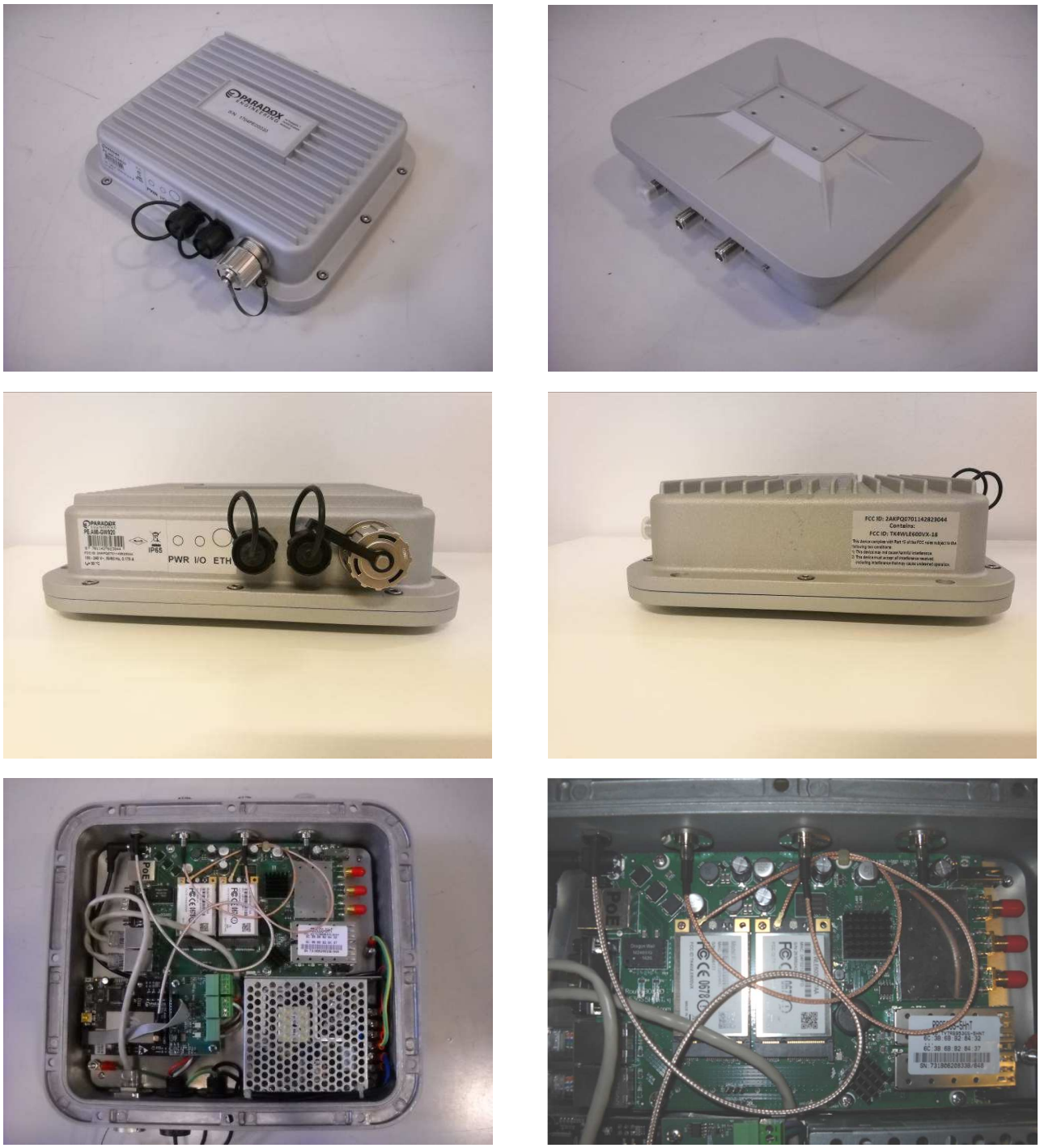
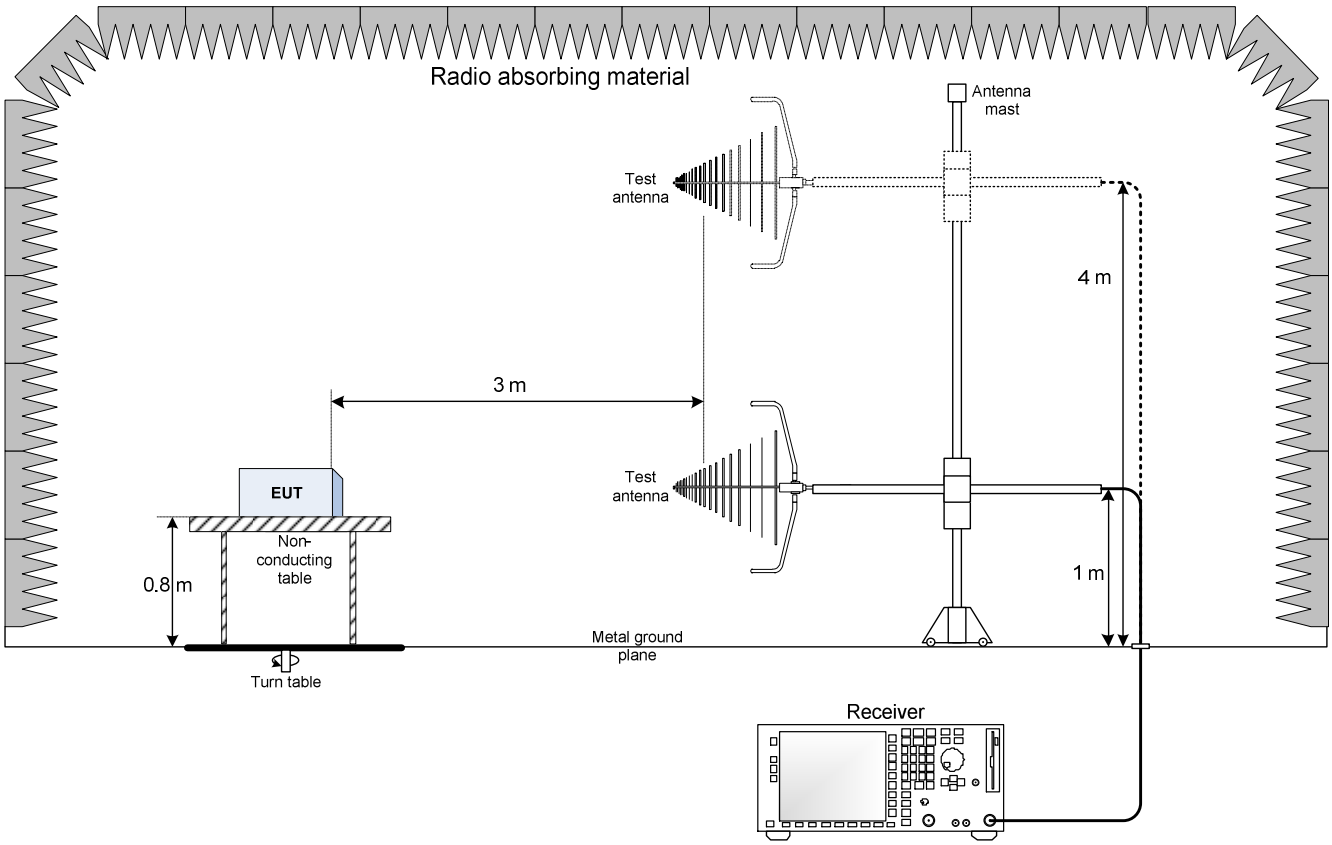


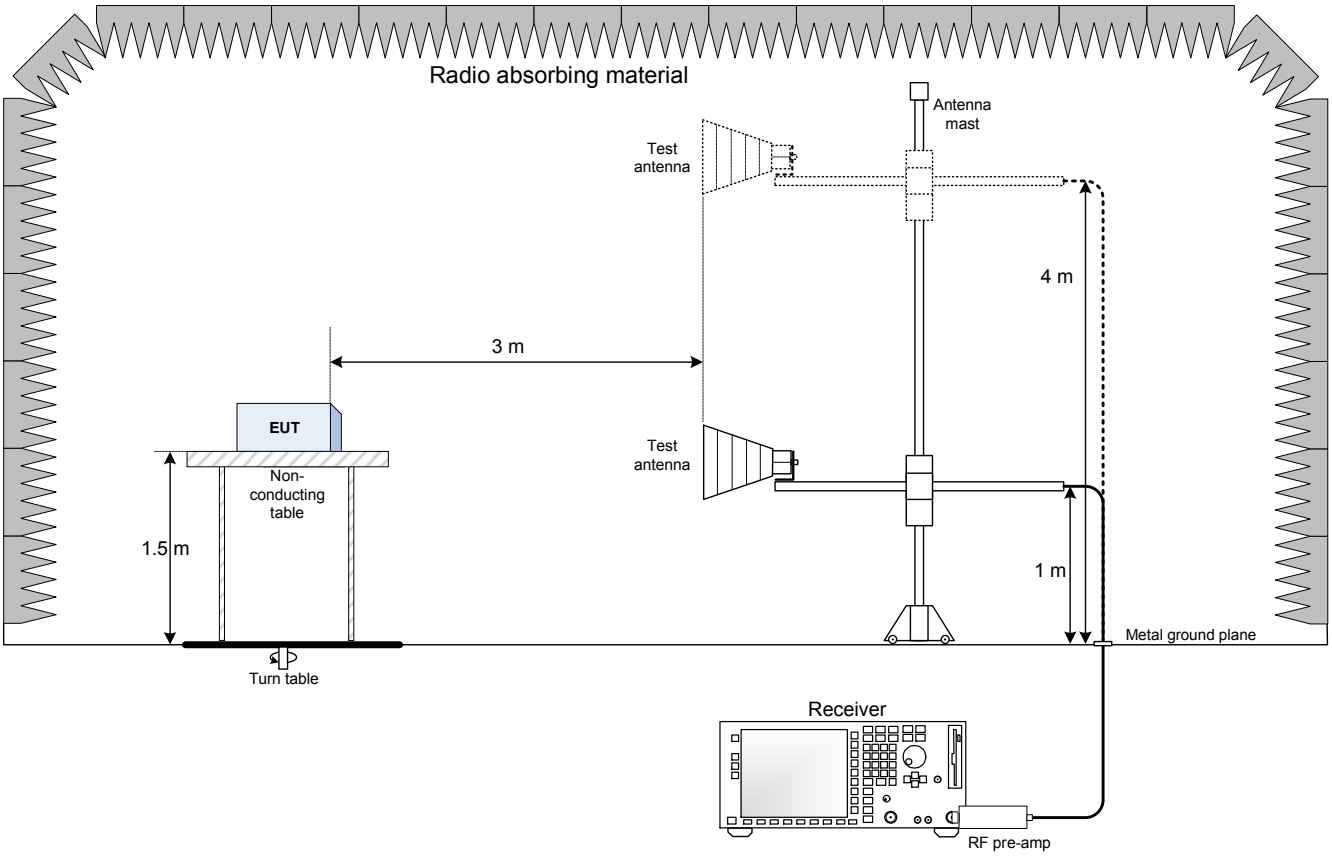
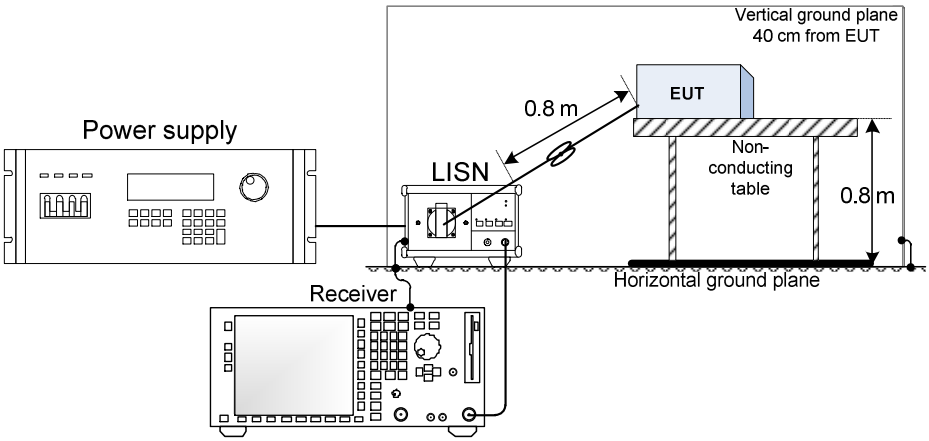
Figure 9.2-1: *EUT photos*

Section 10. Block diagrams of test set-ups

10.1 Radiated emissions set-up for frequencies below 1 GHz



10.2 Radiated emissions set-up for frequencies above 1 GHz



10.3 Conducted emissions set-up