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Test Report

Report Number:

F172171E1

Equipment under Test (EUT):

RLS

Applicant:

OTT Hydromet GmbH

Manufacturer:

OTT Hydromet GmbH

References

[1] **ANSI C63.10-2013**, American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices

[2] **FCC CFR 47 Part 15**, Radio Frequency Devices

[3] **KDB publication 890966 D01** Measurement procedure for Level Probing Radars v01 (April 2014)

Test Result

The requirements of the tests performed as shown in the overview (clause 4) were fulfilled by the equipment under test.
The complete test results are presented in the following.

Test engineer	Thomas KÜHN		02/12/2018
	Name	Signature	Date
Authorized reviewer:	Michael DINTER		02/12/2018
	Name	Signature	Date

This test report is only valid in its original form.

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1 Identification

1.1 Applicant

Name:	OTT Hydromet GmbH
Address:	Ludwigstraße 16 87437 Kempten
Country:	Germany
Name for contact purposes:	Mr. Martin KENNERKNECHT
Phone:	+49 831 56 17 - 310
eMail Address:	m.kennerknecht@ott.com
Applicant represented during the test by the following person:	Mr. Martin KENNERKNECHT

1.2 Manufacturer

Name:	OTT Hydromet GmbH
Address:	Ludwigstraße 16 87437 Kempten
Country:	Germany
Name for contact purposes:	Mr. Martin KENNERKNECHT
Phone:	+49 831 56 17 - 310
eMail Address:	m.kennerknecht@ott.com
Manufacturer represented during the test by the following person:	Mr. Martin KENNERKNECHT

1.3 Test Laboratory

The tests were carried out by: **PHOENIX TESTLAB GmbH**
Königswinkel 10
32825 Blomberg
Germany

Accredited by *Deutsche Akkreditierungsstelle GmbH* in compliance with DIN EN ISO/IEC 17025 under Reg. No. ***D-PL-17186-01-02***.

1.4 EUT (Equipment Under Test)

Test object: *	Radar level sensor
Type designation / model name: *	RLS
FCC ID: *	OA6RLS253
PCB identifier: *	63.109.800.3.2 A
Serial No.: *	000006
Hardware version: *	A0
Software version: *	None
Lowest / highest internal frequency: *	32.768 kHz / transmit frequency

*: Declared by the applicant.

1.5 Technical Data Of Equipment

Antenna type: *	Internal patch antenna (for details refer antenna specification)					
Antenna connector: *	None (not possible)					
Type of modulation: *	None					
Data rate:*	Not applicable					
Operating frequency:*	25.3 GHz					
Number of channels: *	Not applicable (one channel operation)					
Power supply – EUT: *	Unom=	12.0 V DC	Umin=	5.4 V DC	Umax=	28.0 V DC
Temperature range: *	-40 °C to 85 °C					
Ancillaries used for testing:	None					

* Declared by the applicant

Ports / Connectors:

Identification	Connector		Length
	EUT	Ancillary	
DC in	Fixed (terminal block)	-	2.0 m
SDI12	Fixed (terminal block)	-	2.0 m **
RS485	Fixed (terminal block)	-	2.0 m **
4 to 20 mA output	Fixed (terminal block)	-	2.0 m **

*: Length during the test if no other specified.
**: connected but not used during test
All lines were unshielded.

1.6 Dates

Date of receipt of test sample:	01/16/2018
Start of test:	01/16/2018
End of test:	01/30/2018

2 Operational States

All tests were carried out with an unmodified sample.

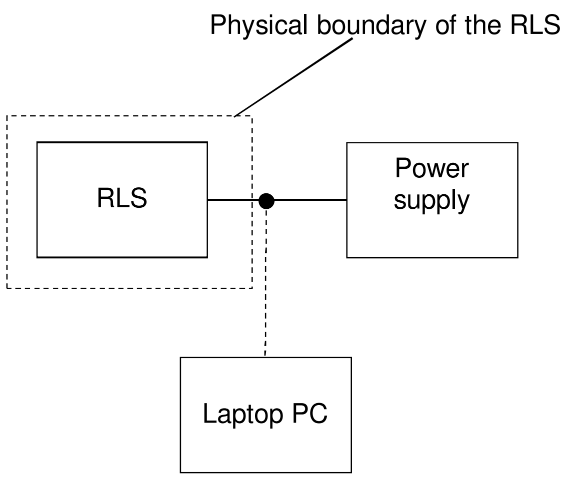
During all tests the EUT was supplied with a DC supply voltage, which was provided by an external power supply or an AC / DC adaptor type enercell (used only for the conducted emissions on AC-mains). For the conducted emission measurement on AC-mains the AC / DC adaptor was supplied with 120 V AC / 60 Hz.

If a variation of the supply voltage was necessary, it was done in the range 5.4 V DC to 28 V DC. This range was declared by the applicant as extreme supply voltage range.

A variation of the environmental temperature was done in a wider range (85° C to -40 °C) as it is requested in the measurement procedure [3] because the applicant declares this range as the operational temperature range.

All emission tests were carried out in two positions of the EUT: Position 1 is the normal installation position (antenna shows downwards), for position 2 measurement the antenna shows sidewards (antenna boresight). For details of the positions refer also the photographs in annex A of this test report. The plots in the following showing the maximum results of both measurements. The measurements of the fundamental emission were carried out in position 2 in order to measure the maximum emission.

The physical boundaries of the Equipment Under Test are shown below.



3 Additional Information

None

4 Overview

Application	Frequency range	FCC 47 CFR Part 15 section [2]	Status	Refer page
Fundamental emission bandwidth	24.05 to 29.00 GHz	15.256 (f) (1)	Passed	8 et seq.
Fundamental emission	24.05 to 29.00 GHz	15.256 (g)	Passed	10 et seq.
Unwanted emissions	9 kHz to 100 GHz	15.256 (h) + (k), 15.209	Passed	13 et seq.
Frequency stability	24.05 to 29.00 GHz	15.256 (f) (2)	Passed	30 et seq.
Conducted emissions on power supply line	150 kHz to 30 MHz	15.207	Passed	32 et seq.
Antenna requirement	-	15.256 (b)	Passed	Integrated, refer photographs in annex B of this test report
Antenna beamwidth	Wanted frequency range	15.256 (i)	Passed	Refer Measurement and Simulation Report provided by the applicant
Antenna side lobe gain	Wanted frequency range	15.256 (j)	Passed	Refer Measurement and Simulation Report provided by the applicant

5 Results

5.1 10 dB bandwidth

5.1.1 Method of measurement (10 dB bandwidth)

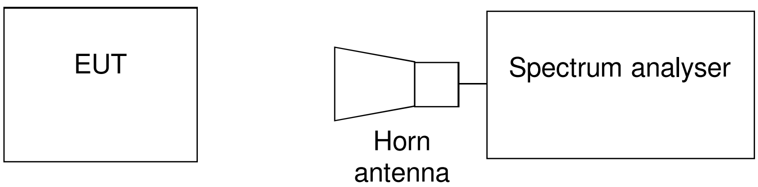
The calibration of the spectrum analyser has to be checked with the help of a known signal from a signal generator. The EUT has to be connected to the spectrum analyser via a low loss cable. If the EUT is not equipped with an antenna connector, a temporary antenna connector has to be installed or a suitable antenna has to be used to couple the EUTs signal to the spectrum analyser. The EUT has to be switched on.

The following spectrum analyser settings shall be used:
- Span: Wide enough to capture emission bandwidth.
- Resolution bandwidth: 1 MHz.
- Video bandwidth: 3 MHz.
- Sweep: Auto.
- Detector function: Peak.
- Trace mode: Max hold.

After trace stabilisation the marker shall be set on the signal peak. The display line has to be set 10 dB below the peak marker. The second and third marker shall be set on the intersection points between the display line and the measured curve.

The measurement will be performed at the upper, the lower end and the middle of the assigned frequency band (if applicable).

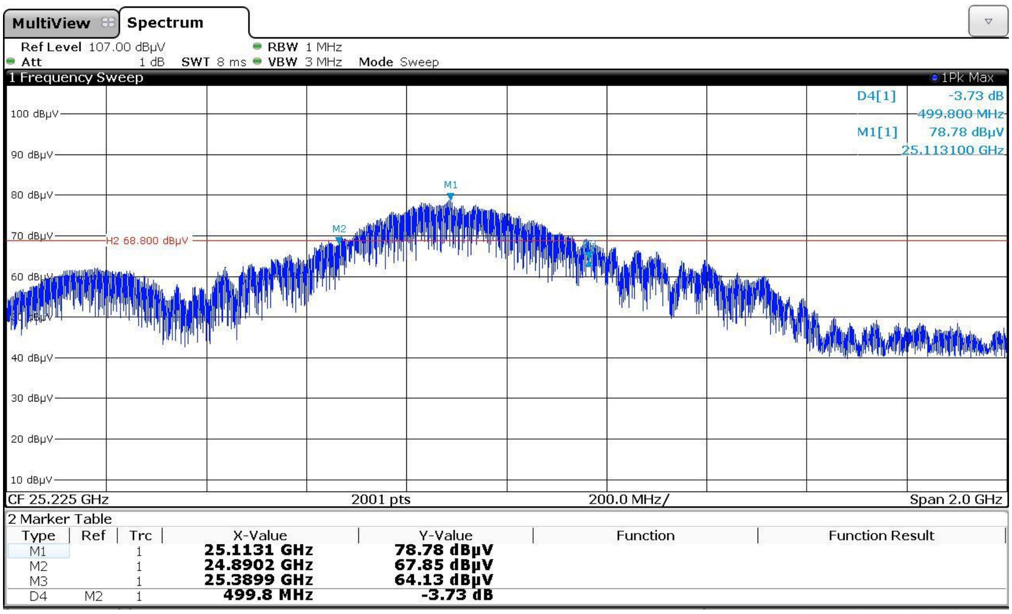
Test set-up:



5.1.2 Test results (10 dB bandwidth)

Ambient temperature	22 °C		Relative humidity	26 %

172171_201.wmf: 10 dB bandwidth:



Lower 10 dB frequency	Upper 10 dB frequency	10 dB bandwidth	Limit
24.8902 GHz	25.3899 GHz	499.8 MHz	50 MHz (required minimum), furthermore the 10 dB bandwidth has to stay within the assigned frequency band (24.05 to 29.00 GHz)
Measurement uncertainty		+0.66 dB / -0.72 dB	

Test result Passed

Test equipment used (refer clause 6):

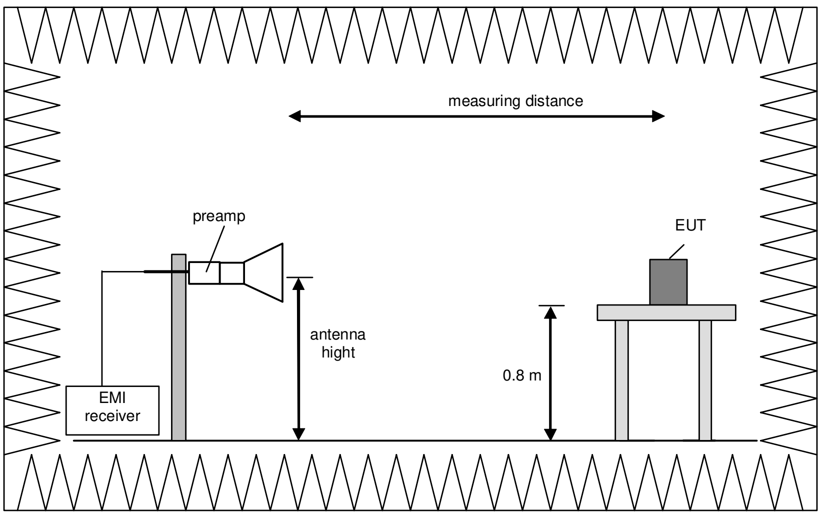
6, 7, 27, 35, 41, 43

5.2 Fundamental emission

5.2.1 Method of measurement (fundamental emission)

1) Locate the receive test antenna at a far field distance boresighted on the LPR transmit antenna. Adjust the LPR and the test antenna for maximum main beam coupling.
2) Set the spectrum analyzer for power averaging (RMS) detector and 1 MHz RBW.
3) Record the maximum level and frequency of the signal within the fundamental emission bandwidth, which must be contained entirely within the authorized frequency band.
4) Centered on the frequency of the maximum signal recorded in step 3, select peak detector, 50 MHz RBW and at least 50 MHz VBW.
   a. If 50 MHz RBW is not available on the spectrum analyzer, determine the maximum of the spectrum trace in a narrower RBW which is greater than or less than the PRF by a factor of 3, but not less than 1 MHz, and calculate the maximum signal level in 50 MHz by adding the appropriate correction factor shown below to the maximum measured signal level.
      i. For pulsed LPRs
         20 Log (50/RBW) dB, if PRF < RBW/3
         20 Log (50/PRF) dB, if PRF > 3*RBW
      ii. For FMCW, step or hopping LPRs
         20 Log (50/RBW) dB
   b. It may be necessary to offset the measurement frequency in order to ensure that the measurement is made within the fundamental emission bandwidth because the 3 dB bandwidth of the RBW is not entirely within the fundamental emission bandwidth. The measurement shall be made at the nearest frequency to the frequency identified in step 4 when the 3 dB point of the RBW closest to the fundamental emission band edge is at the frequency of the band edge.
   c. If the measurement must be performed with a RBW greater than 3 MHz because the PRF is between 1 MHz and 3 MHz or for any other reason, the test report must contain a detailed description of the test procedure, calibration of the test setup, and the instrumentation used.
5) Determine the conducted power output of the EUT or the field strength produced by the EUT at a given distance from the measurements in steps 1 to 4 by calculation taking into account all attenuators, amplifier gains, antenna factor, measurement distance extrapolation, conversion loss, cable losses, etc. as applicable or the signal substitution method.
6) The EIRP is then calculated by applying the appropriate equation as follows:
   EIRP (dBm) = E (dBµV/m) – 104.8 + 20 Log D
   where E is the field strength at the far field distance D.

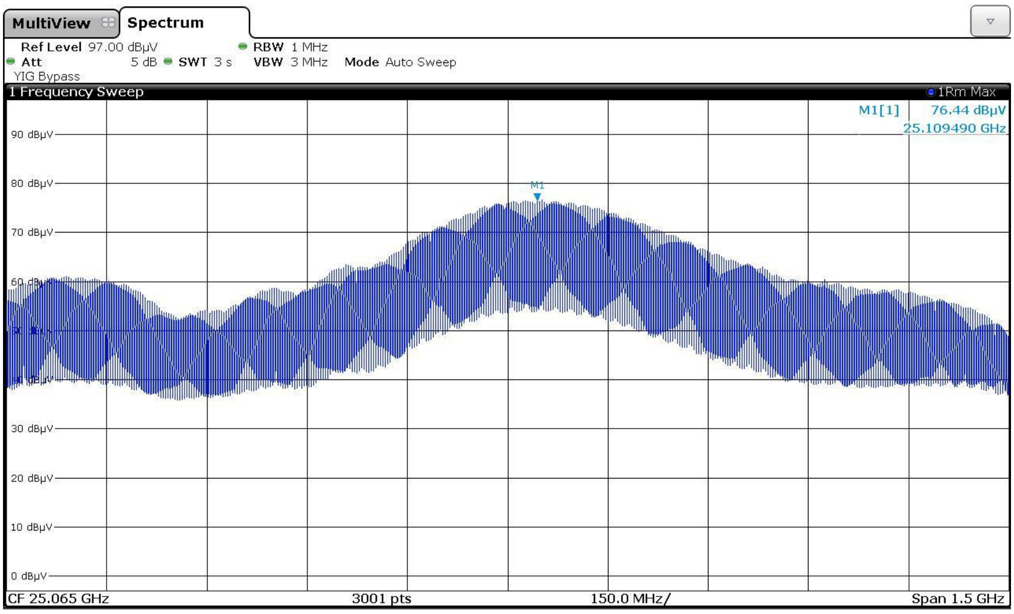
Test set-up:



5.2.2 Test results (fundamental emission)

Ambient temperature	22 °C		Relative humidity	28 %

172171_5.jpeg: Fundamental emission (average):



172171_6.jpeg: Fundamental emission(peak):

PHOENIX TESTLAB

Fundamental emission (average):

Readings dBµV	Antenna factor 1/m	Preamp dB	Cable loss dB	Measured field strength dBµV/m	Height cm	Pol.	Measuring distance m	Level fundamental (EIRP) dBm	Limit dBm	Margin dB
76.4	37.3	38.6	4.8	79.9	100	Hor.	1.0	-24.9	-14.0	10.9
Measurement uncertainty							+2.2 dB / -3.6 dB			

Fundamental emission (peak):

Readings dBµV	Antenna factor 1/m	Preamp dB	Cable loss dB	Measured field strength dBµV/m	Height cm	Pol.	Measuring distance m	Level fundamental (EIRP) dBm	Limit dBm	Margin dB
103.7	37.3	38.7	4.8	107.1	100	Hor.	1.0	2.3	26.0	23.7
Measurement uncertainty							+2.2 dB / -3.6 dB			

Test result: Passed

Test equipment used (refer clause 6):

6, 7, 19, 21, 22, 28, 35, 41, 43

5.3 Radiated emissions

5.3.1 Method of measurement (radiated emissions)

The radiated emission measurement is subdivided into four stages.

- A preliminary measurement carried out in a fully anechoic chamber with a fixed antenna height in the frequency range 9 kHz to 110 GHz.
- A final measurement carried out on an outdoor test side without reflecting ground plane and a fixed antenna height in the frequency range 9 kHz to 30 MHz.
- A final measurement carried out on an open area test side with reflecting ground plane and various antenna heights in the frequency range 30 MHz to 1 GHz.
- A final measurement carried out in a fully anechoic chamber with a fixed antenna height in the frequency range 1 GHz to 110 GHz.

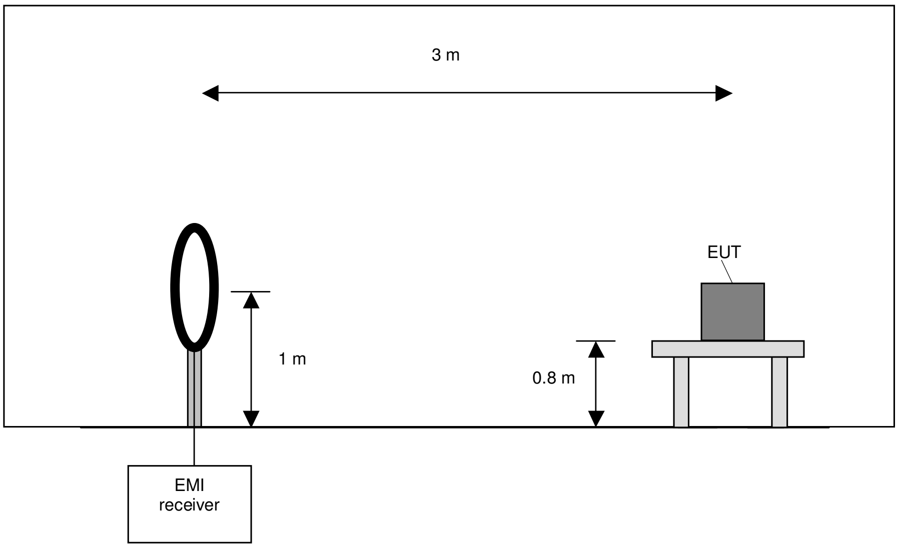
Preliminary measurement (9 kHz to 30 MHz):

In the first stage a preliminary measurement will be performed in a shielded room with a measuring distance of 3 meters. Tabletop devices will set up on a non-conducting support with a size of 1 m by 1.5 m and a height of 80 cm. Floor-standing devices will be placed directly on the turntable/ground plane. The set-up of the Equipment under test will be in accordance to [1].

The frequency range 9 kHz to 30 MHz will be monitored with a spectrum analyser while the system and its cables will be manipulated to find out the configuration with the maximum emission levels if applicable. The EMI Receiver will be set to MAX Hold mode. The EUT and the measuring antenna will be rotated around their vertical axis to found the maximum emissions.

The resolution bandwidth of the spectrum analyser will be set to the following values:

Frequency range	Resolution bandwidth
9 kHz to 150 kHz	200 Hz
150 kHz to 30 MHz	10 kHz



Preliminary measurement procedure:

Prescans were performed in the frequency range 9 kHz to 150 kHz, 150 kHz to 1 MHz and 1 MHz to 30 MHz.

The following procedure will be used:

1) Monitor the frequency range at horizontal polarisation and a EUT azimuth of 0 °.
2) Manipulate the system cables within the range to produce the maximum level of emission.
3) Rotate the EUT by 360 ° to maximize the detected signals.
4) Make a hardcopy of the spectrum.
5) Measure the frequencies of highest detected emission with a lower span and resolution bandwidth to increase the accuracy and note the frequency value.
6) Repeat steps 1) to 5) with the other orthogonal axes of the EUT (because of EUT is a module and might be used in a handheld equipment application).
7) Rotate the measuring antenna and repeat steps 1) to 5).

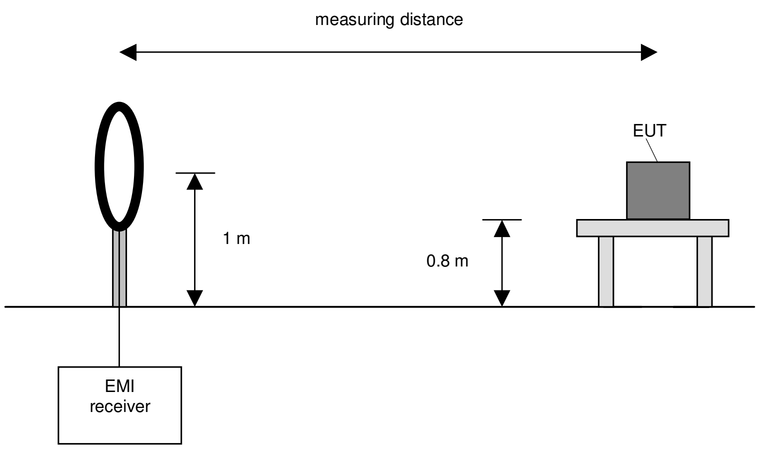
Final measurement (9 kHz to 30 MHz):

In the second stage a final measurement will be performed on an open area test site with no conducting ground plane with measuring distances of 3 m, 10 m and 30 m. In the case where larger measuring distances are required the results will be extrapolated based on the values measured on the closer distances according to Section 15.31 (f) (2) [2]. The final measurement will be performed with a EMI Receiver set to Quasi Peak detector except for the frequency bands 9 kHz to 90 kHz and 110 kHz to 490 kHz where an average detector will be used according Section 15.209 (d) [2].

On the during the preliminary measurement detected frequencies the final measurement will be performed while rotating the EUT and the measuring antenna in the range of 0 ° to 360 ° around their vertical axis until the maximum value is found.

The resolution bandwidth of the EMI Receiver will be set to the following values:

Frequency range	Resolution bandwidth
9 kHz to 150 kHz	200 Hz
150 kHz to 30 MHz	10 kHz



Final measurement procedure:

The following procedure will be used:

1) Monitor the frequency range with the measuring antenna at vertical orientation parallel to the EUT at an azimuth of 0 °.
2) Rotate the EUT by 360 ° to maximize the detected signals and note the azimuth and orientation.
3) Rotate the measuring antenna to find the maximum and note the value.
4) Rotate the measuring antenna and repeat steps 1) to 3) until the maximum value is found.
5) Repeat steps 1) to 4) with the other orthogonal axes of the EUT (because of EUT is a module and might be used in a handheld equipment application).

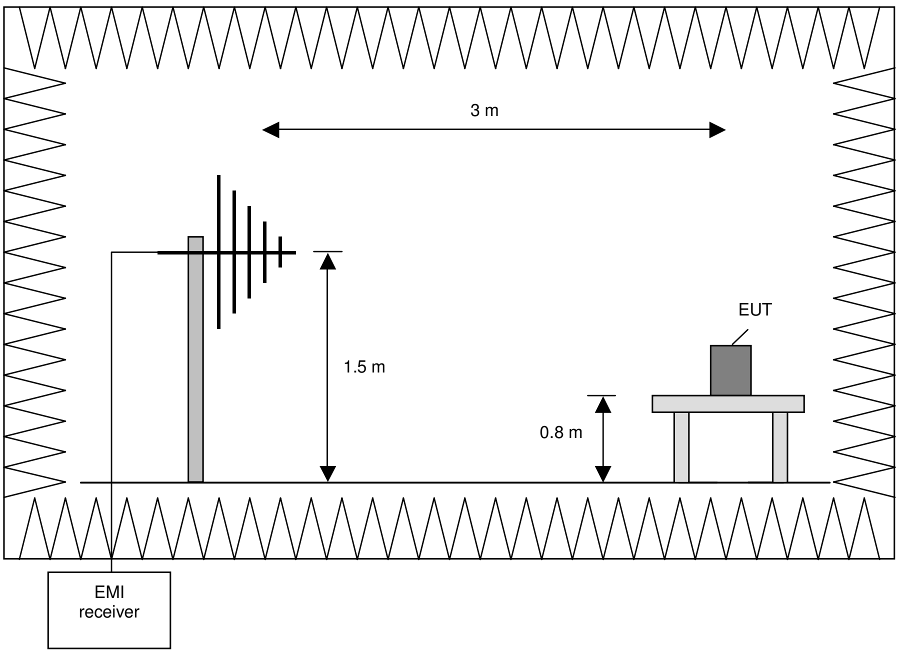
Preliminary measurement (30 MHz to 1 GHz)

In the first stage a preliminary measurement will be performed in a fully anechoic chamber with a measuring distance of 3 meter. Tabletop devices will set up on a non-conducting support with a size of 1 m by 1.5 m and a height of 80 cm. Floor-standing devices will be placed directly on the turntable/ground plane. The setup of the Equipment under test will be in accordance to [1].

The frequency range 30 MHz to 1 GHz will be measured with an EMI Receiver set to MAX Hold mode and a resolution bandwidth of 100 kHz. The measurement will be performed in horizontal and vertical polarisation of the measuring antenna and while rotating the EUT in its vertical axis in the range of 0 ° to 360 °.

The resolution bandwidth of the EMI Receiver will be set to the following values:

Frequency range	Resolution bandwidth
30 MHz to 230 MHz	100 kHz
230 MHz to 1 GHz	100 kHz



Procedure preliminary measurement:

Prescans were performed in the frequency range 30 MHz to 200 MHz and 200 MHz to 1 GHz.
The following procedure will be used:

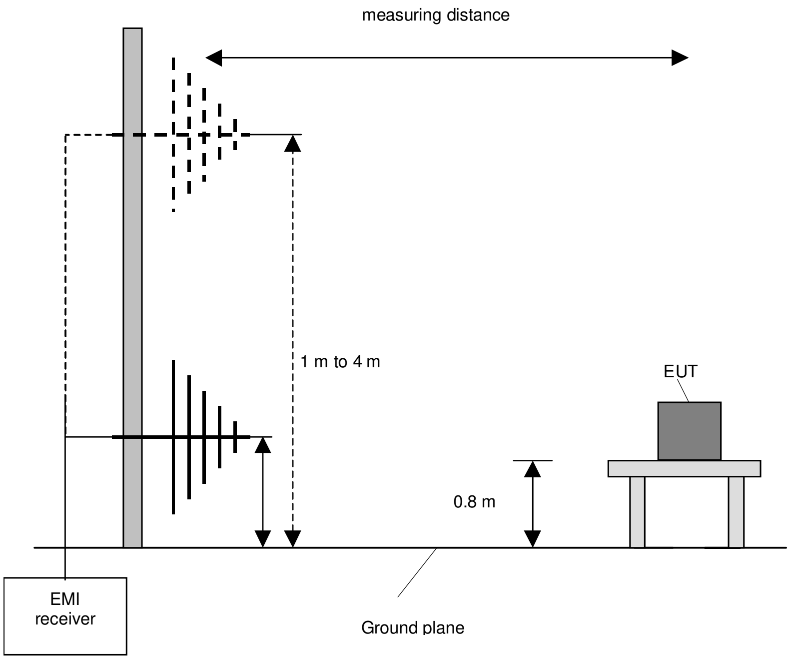
1) Monitor the frequency range at horizontal polarisation and a EUT azimuth of 0 °.
2) Manipulate the system cables within the range to produce the maximum level of emission.
3) Rotate the EUT by 360 ° to maximize the detected signals.
4) Make a hardcopy of the spectrum.
5) Measure the frequency of the detected emissions with a lower span and resolution bandwidth to increase the accuracy and note the frequency value.
6) Repeat 1) to 4) with the other orthogonal axes of the EUT (because of EUT is a module and might be used in a handheld equipment application).
7) Repeat 1) to 5) with the vertical polarisation of the measuring antenna.

Final measurement (30 MHz to 1 GHz)

A final measurement on an open area test site will be performed on selected frequencies found in the preliminary measurement. During this test the EUT will be rotated in the range of 0 ° to 360 °, the measuring antenna will be set to horizontal and vertical polarisation and raised and lowered in the range from 1 m to 4 m to find the maximum level of emissions.

The resolution bandwidth of the EMI Receiver will be set to the following values:

Frequency range	Resolution bandwidth
30 MHz to 1 GHz	120 kHz



Procedure final measurement:

The following procedure will be used:

7) Measure on the selected frequencies at an antenna height of 1 m and a EUT azimuth of 23 °.
8) Move the antenna from 1 m to 4 m and note the maximum value at each frequency.
9) Rotate the EUT by 45 ° and repeat 2) until an azimuth of 337 ° is reached.
10) Repeat 1) to 3) for the other orthogonal antenna polarization.
11) Move the antenna and the turntable to the position where the maximum value is detected.
12) Measure while moving the antenna slowly +/- 1 m.
13) Set the antenna to the position where the maximum value is found.
14) Measure while moving the turntable +/- 45 °.
15) Set the turntable to the azimuth where the maximum value is found.
16) Measure with Final detector (QP and AV) and note the value.
17) Repeat 5) to 10) for each frequency.
18) Repeat 1) to 11) for each orthogonal axes of the EUT (because of EUT is a module and might be used in a handheld equipment application).

Preliminary and final measurement (1 GHz to 110 GHz)

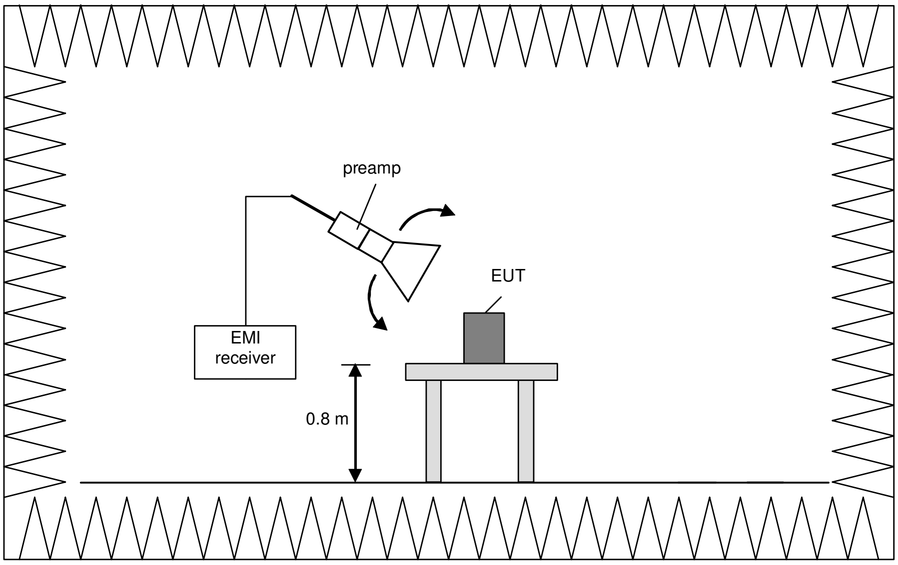
This measurement will be performed in a fully anechoic chamber. Tabletop devices will set up on a non-conducting support with a size of 1 m by 1.5 m and a height of 80 cm. Floor-standing devices will be placed directly on the turntable/ground plane. The setup of the Equipment under test will be in accordance to [1].

Preliminary measurement (1 GHz to 110 GHz)

The frequency range will be divided into different sub ranges depending of the frequency range of the used horn antenna. The spectrum analyser set to MAX Hold mode and a resolution bandwidth of 1 MHz. The measurement will be performed in horizontal and vertical polarisation of the measuring antenna, the antenna close to the EUT and while moving the antenna over all sides of the EUT. With the spectrum analyser in CLEAR / WRITE mode the cone of the emission should be found and than the measuring distance will be set to 3 m with the receiving antenna moving in this cone of emission. At this position the final measurement will be carried out.

The resolution bandwidth of the EMI Receiver will be set to the following values:

Frequency range	Resolution bandwidth
1 GHz to 4 GHz	1 MHz
4 GHz to 12 GHz	1 MHz
12 GHz to 18 GHz	1 MHz
18 GHz to 26.5 GHz	1 MHz
26.5 GHz to 40 GHz	1 MHz
40 GHz to 60 GHz	1 MHz
50 GHz to 75 GHz	1 MHz
75 GHz to 110 GHz	1 MHz

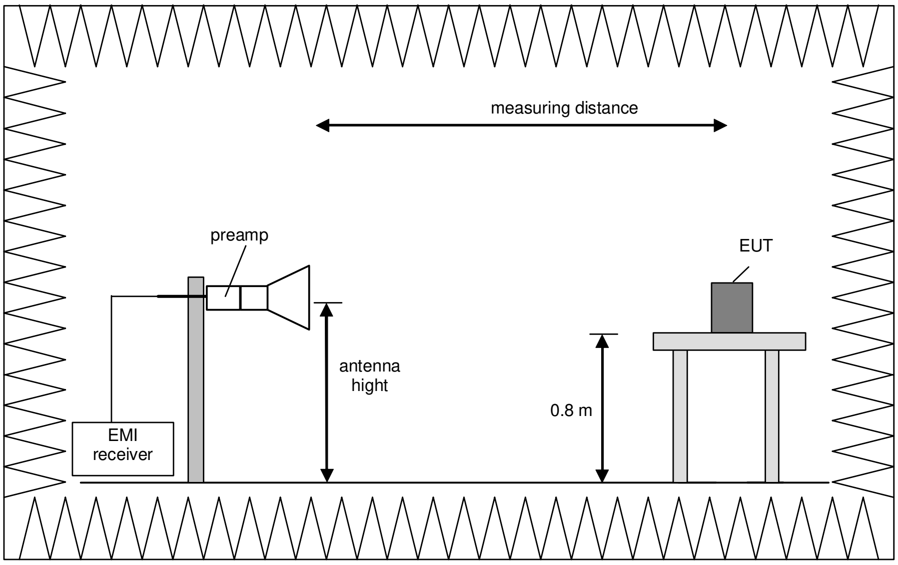


Final measurement (1 GHz to 110 GHz)

The frequency range will be divided into different sub ranges depending of the frequency range of the used horn antenna. The EMI Receiver set to peak and average mode and a resolution bandwidth of 1 MHz. The measurement will be performed in horizontal and vertical polarisation of the measuring antenna and while rotating the EUT in its vertical axis in the range of 0 ° to 360 ° in order to have the antenna inside the cone of radiation.

The resolution bandwidth of the EMI Receiver will be set to the following values:

Frequency range	Resolution bandwidth
1 GHz to 4 GHz	1 MHz
4 GHz to 12 GHz	1 MHz
12 GHz to 18 GHz	1 MHz
18 GHz to 26.5 GHz	1 MHz
26.5 GHz to 40 GHz	1 MHz
40 GHz to 60 GHz	1 MHz
50 GHz to 75 GHz	1 MHz
75 GHz to 110 GHz	1 MHz



Procedure of measurement:

The measurements were performed in the frequency range 1 GHz to 4 GHz, 4 GHz to 12 GHz, 12 GHz to 18 GHz, 18 GHz to 26.5 GHz, 26.5 GHz to 40 GHz, 40 GHz to 60 GHz, 60 GHz to 75 GHz and 75 GHz to 110 GHz.
The following procedure will be used:

1) Monitor the frequency range at horizontal polarisation and move the antenna over all sides of the EUT (if necessary move the EUT to another orthogonal axis).
2) Change the antenna polarisation and repeat 1) with vertical polarisation.
3) Make a hardcopy of the spectrum.
4) Measure the frequency of the detected emissions with a lower span and resolution bandwidth to increase the accuracy and note the frequency value.
5) Change the analyser mode to Clear / Write and found the cone of emission.
6) Rotate and move the EUT, so that the measuring distance can be enlarged to 3 m and the antenna will be still inside the cone of emission.
7) Measure the level of the detected frequency with the correct resolution bandwidth, with the antenna polarisation and azimuth and the peak and average detector, which causes the maximum emission.
8) Repeat steps 1) to 7) for the next antenna spot if the EUT is larger than the antenna beamwidth.

Step 1) to 6) are defined as preliminary measurement.

5.3.2 Test results (radiated emissions)

5.3.2.1 Preliminary radiated emission measurement

Ambient temperature	22 °C		Relative humidity	28 %

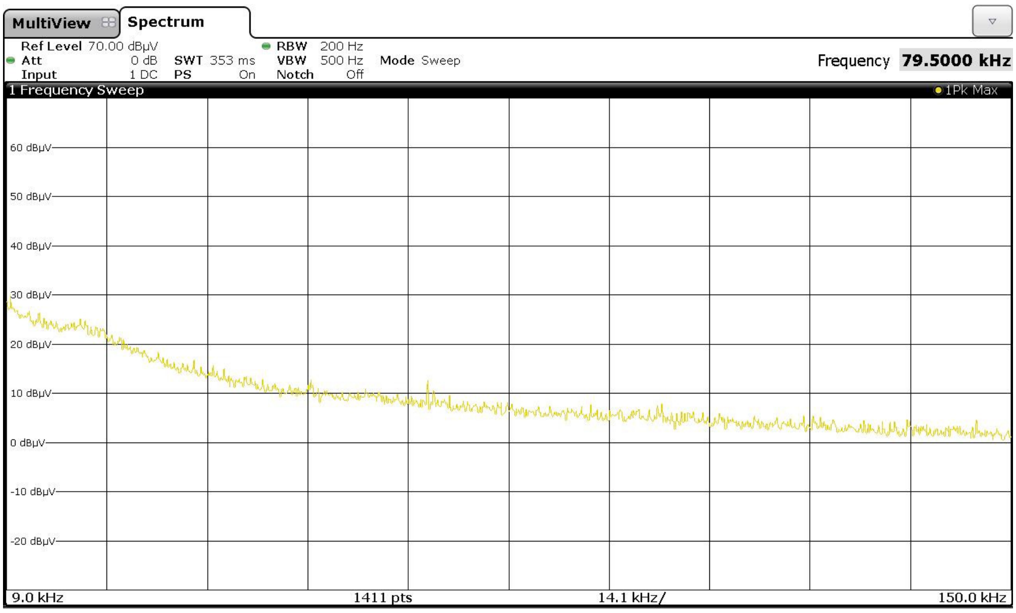
Position of EUT: The EUT was set-up on a non-conducting table of a height of 0.8 m. The distance between EUT and antenna was 3 m.

Test record: All results are shown in the following.

Supply voltage: During all measurements the EUT was supplied with 12 V DC by an external power supply.

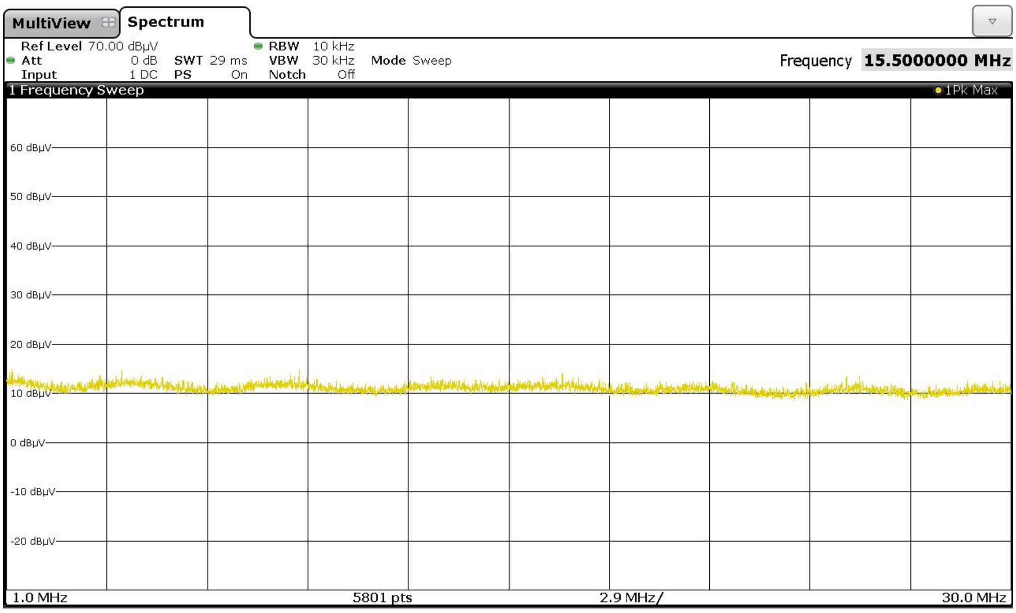
Remark: All emission tests were carried out in two positions of the EUT: Position 1 is the normal installation position (antenna shows downwards), for position 2 measurement the antenna shows sideward (boresight view). For details of the positions refer also the photographs in annex A of this test report. The plots in the following showing the maximum results from both measurements.

172171_17.jpeg: Spurious emissions from 9 kHz to 150 kHz:

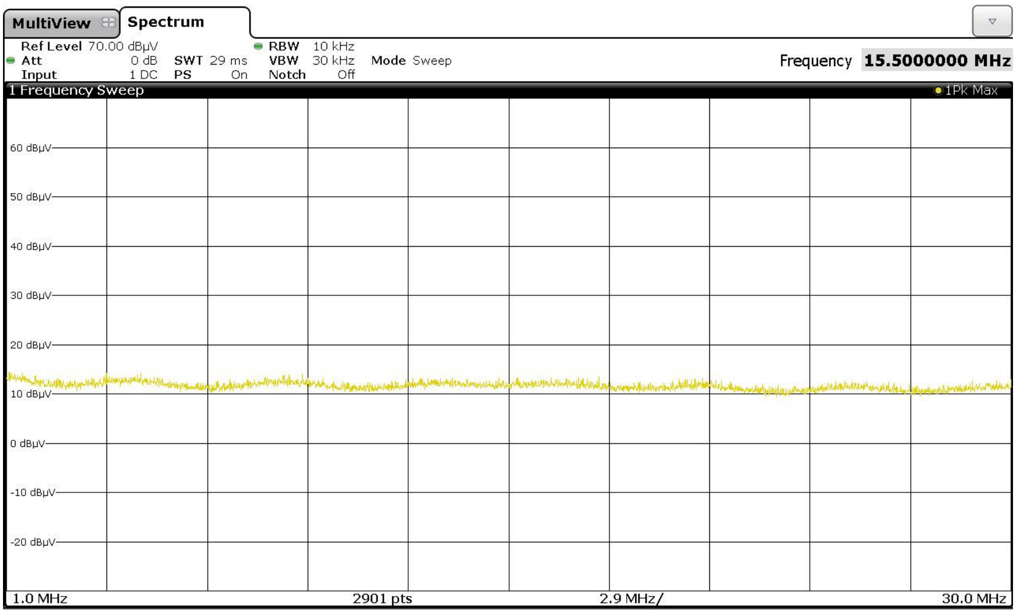


No significant frequencies above the noise floor of the system (49.5 dBµV/m (peak) measured at 3 m) were found during the preliminary radiated emission test in this frequency range, so no measurements were carried out on the outdoor test site.

172171_18.jpeg: Spurious emissions from 150 kHz to 1 MHz:

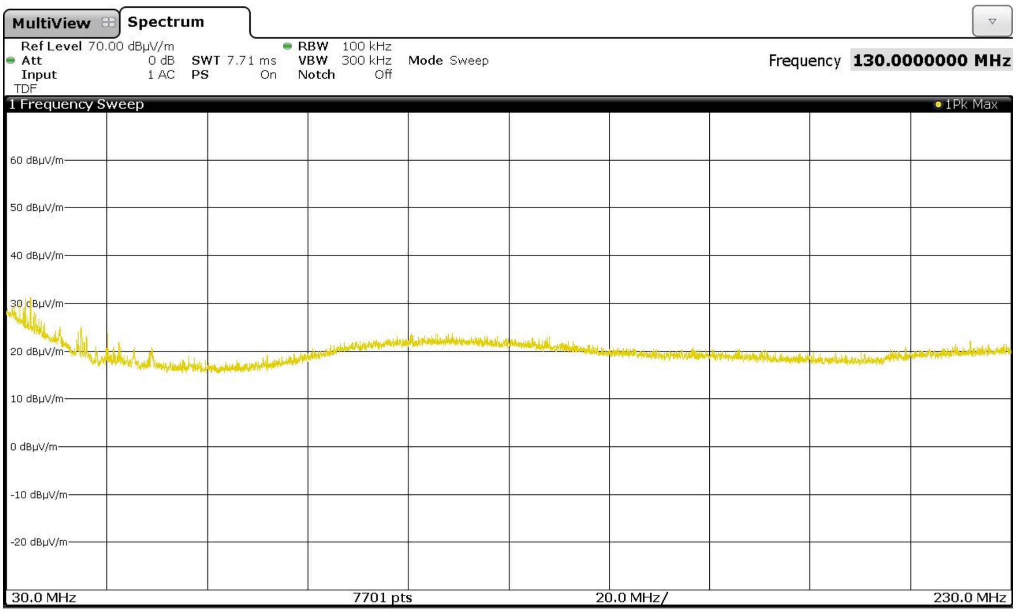


172171_16.jpeg: Spurious emissions from 1 MHz to 30 MHz:

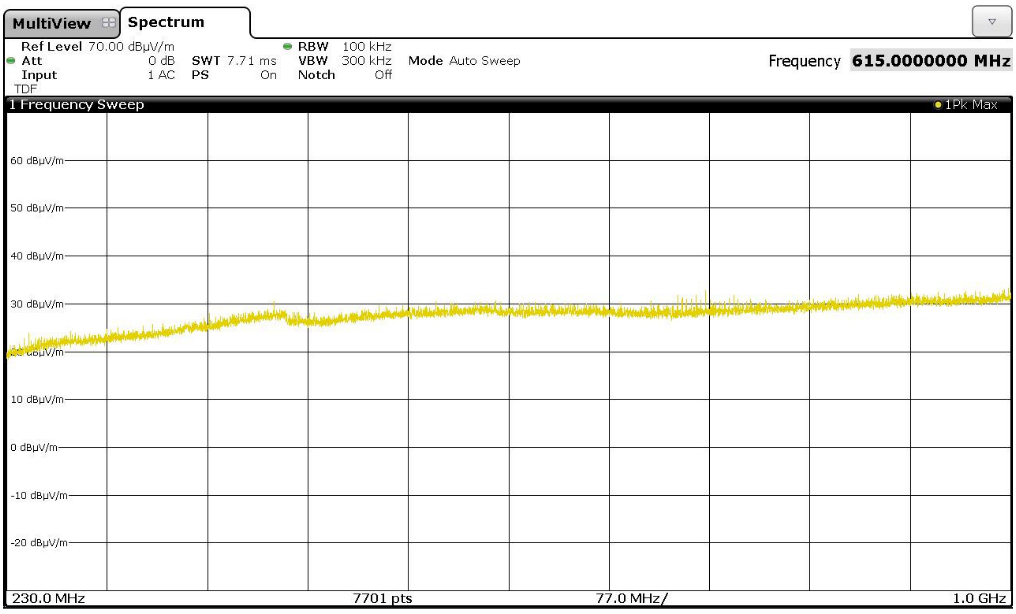


No significant frequencies above the noise floor of the system (34.6 dBµV/m (peak) measured at 3 m) were found during the preliminary radiated emission test, so no measurements were carried out on the outdoor test site.

172171_15.jpeg: Spurious emissions from 30 MHz to 230 MHz:



172171_14.jpeg: Spurious emissions from 230 MHz to 1 GHz:



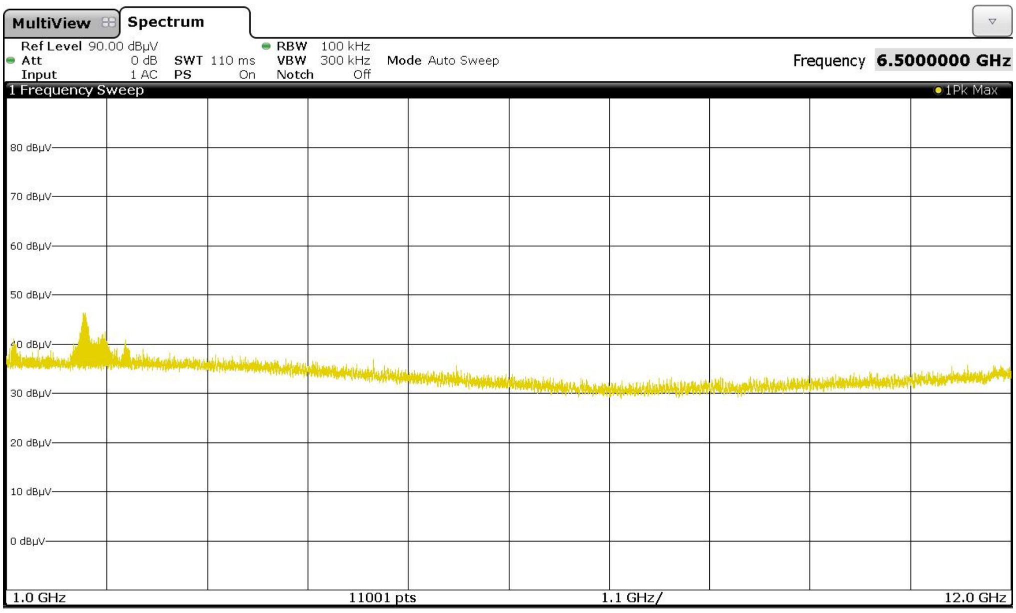
The following frequencies were found outside the restricted bands during the preliminary radiated emission test:

- 30.601 MHz, 44.931 MHz, 52.307 MHz, 214.716 MHz, 436.685 MHz and 769.565 MHz.

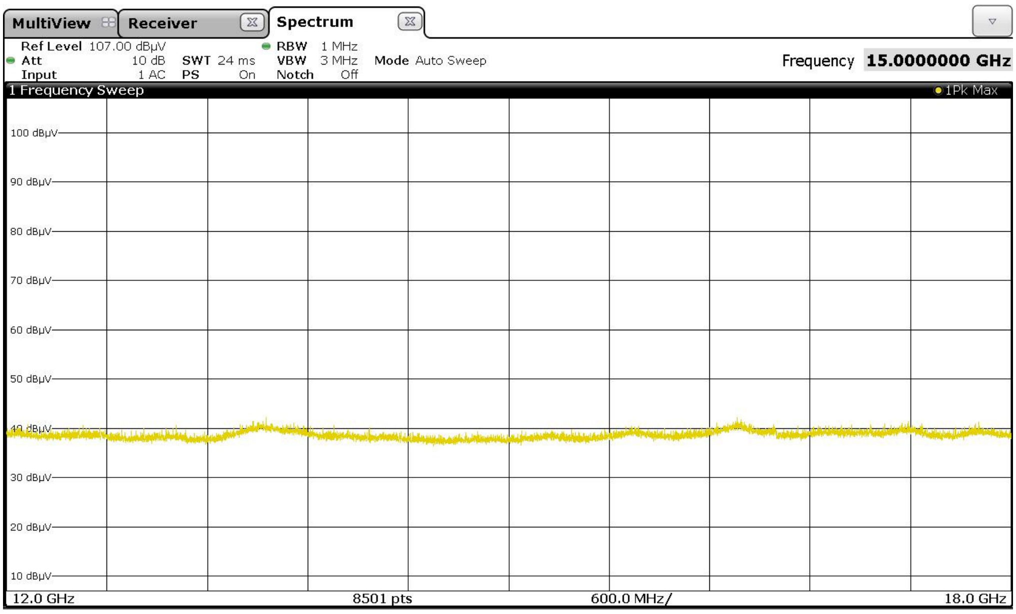
No frequencies were found inside the restricted bands during the preliminary radiated emission test.

These frequencies have to be measured on the open area test site. The result is presented in the following.

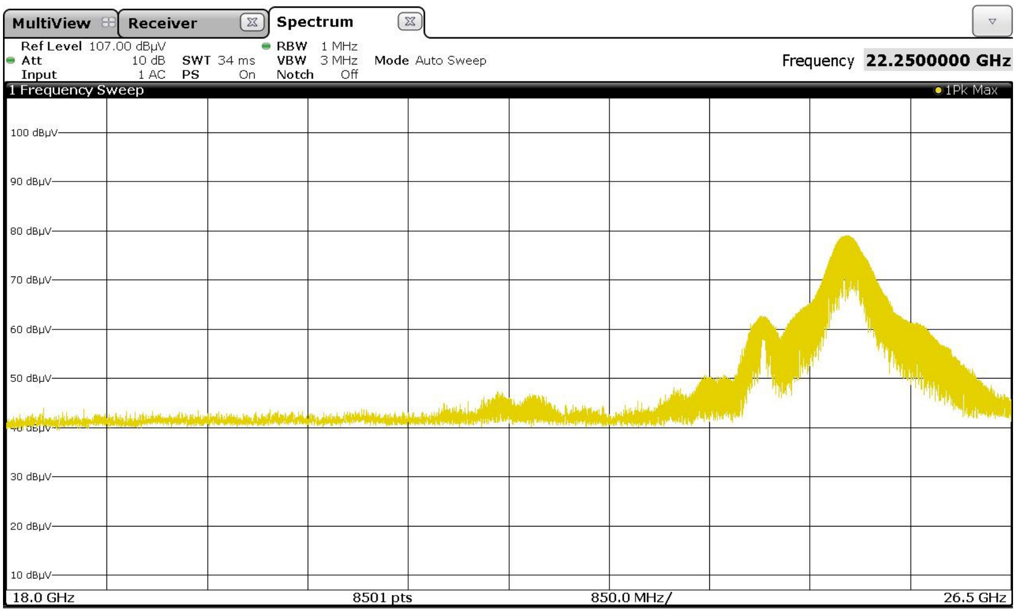
172171_13.jpeg: Spurious emissions from 1 GHz to 12 GHz:



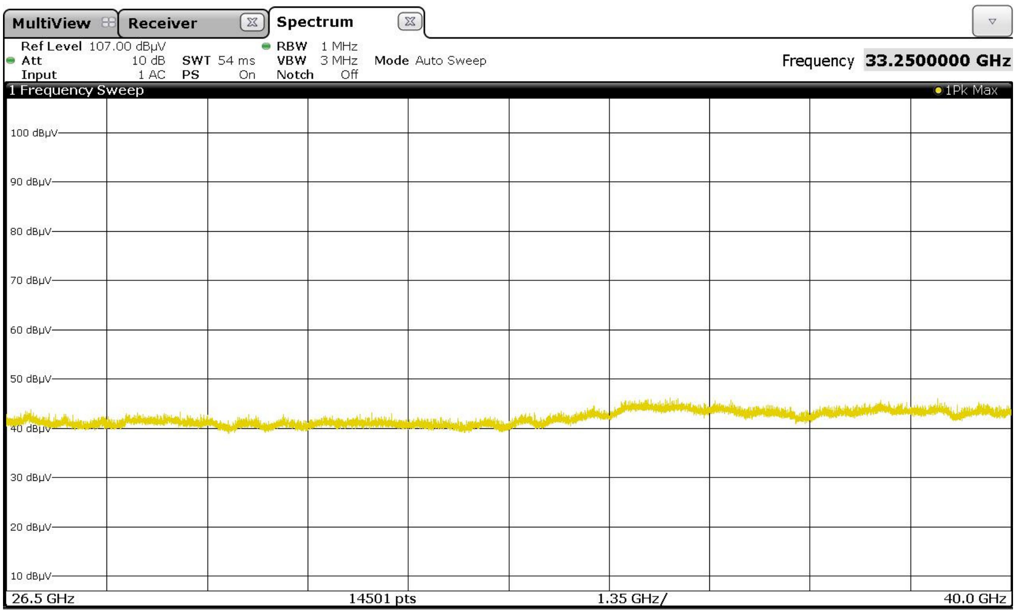
172171_8.jpeg: Spurious emissions from 12 GHz to 18 GHz:



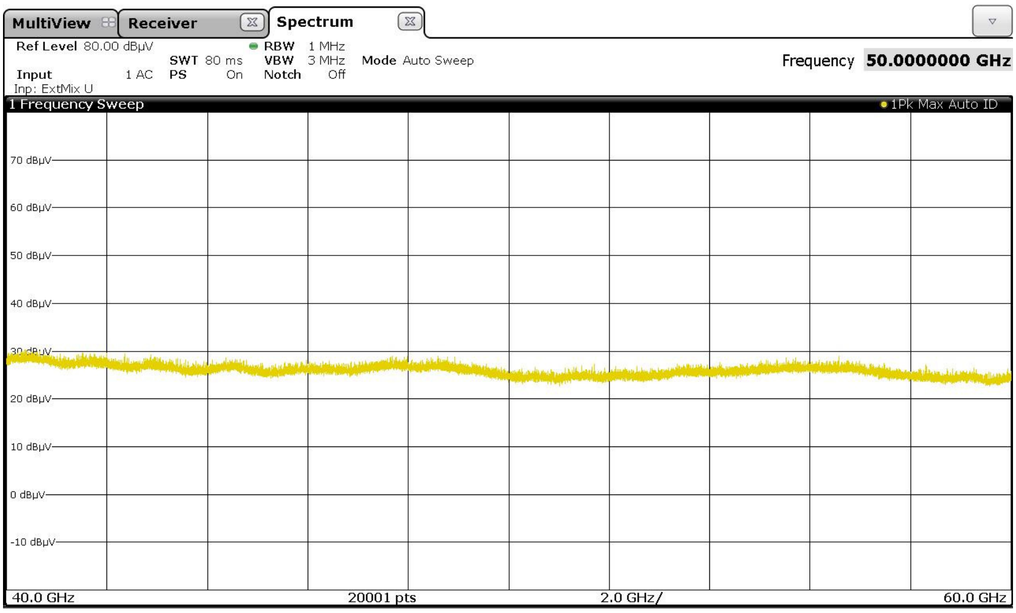
172171_7.jpeg: Spurious emissions from 18 GHz to 26.5 GHz:



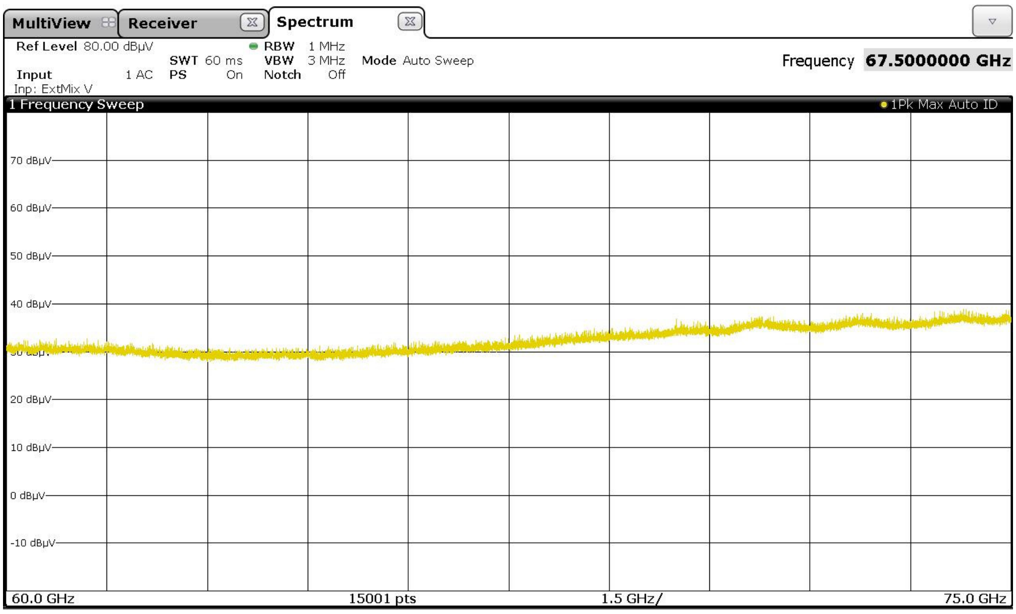
172171_9.jpeg: Spurious emissions from 26.5 GHz to 40 GHz:



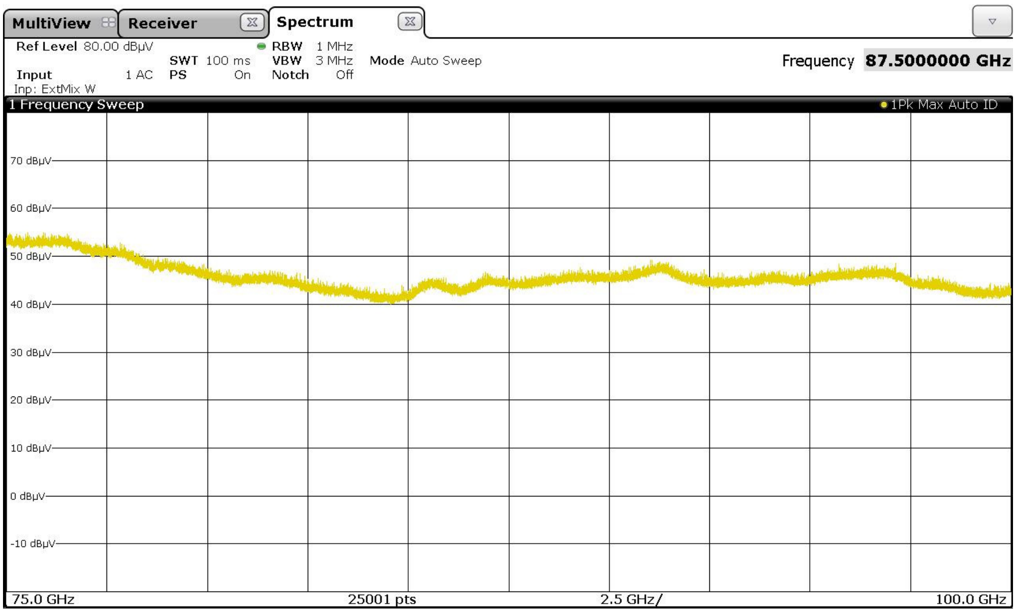
172171_10.jpeg: Spurious emissions from 40 GHz to 60 GHz:



172171_11.jpeg: Spurious emissions from 60 GHz to 75 GHz:



172171_12.jpeg: Spurious emissions from 75 GHz to 100 GHz:



The following frequencies were found inside the restricted bands during the preliminary radiated emission test:

- 1080.977 MHz and 22428.060 MHz.

The following frequency was found outside the restricted bands during the preliminary radiated emission test:

- 1850.542 MHz, 2305.120 MHz and 24389.780 MHz.

This frequency has to be measured in a final measurement. The results were presented in the following.

Test equipment used (refer clause 6):

7, 19 - 41, 43

5.3.2.2 Final radiated emission measurement (1 MHz to 30 MHz)

No significant frequencies above the noise floor of the system (max. 34.6 dBµV/m (measured with peak detector) at 3 m distance) were found during the preliminary radiated emission test, so no measurements were carried out on the outdoor test site.

5.3.2.3 Final radiated emission measurement (30 MHz to 1 GHz)

Ambient temperature	22 °C		Relative humidity	29 %

Position of EUT: The EUT was set-up on a non-conducting table of a height of 0.8 m. The distance between EUT and antenna was 3 m.

Test record: All results are shown in the following.

Supply voltage: During all measurements the EUT was supplied with 12 V DC by an external power supply.

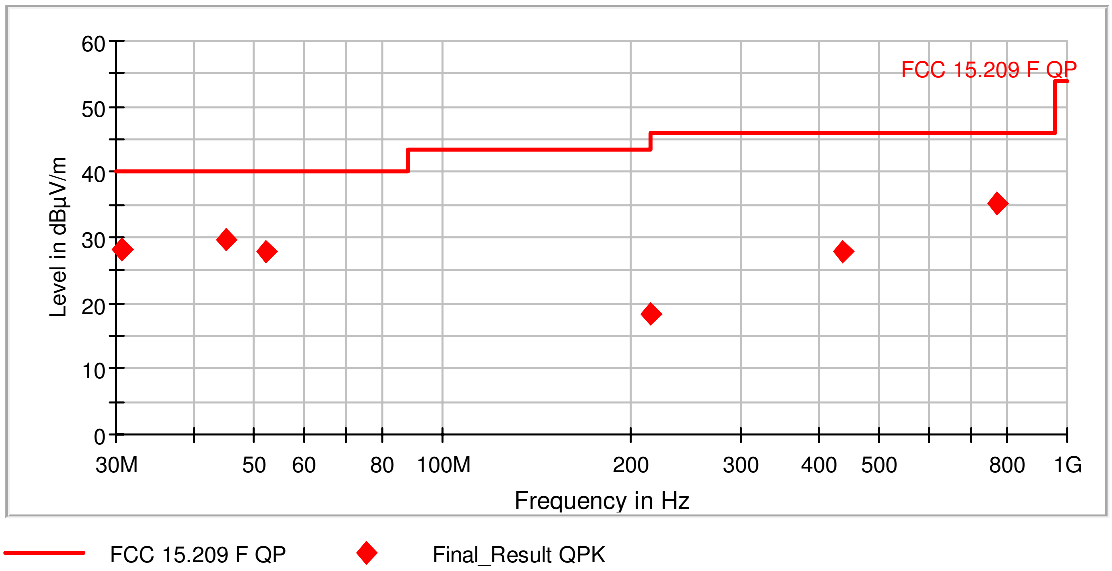
Test results: The test results were calculated with the following formula:

Result [dBµV/m] = reading [dBµV] + cable loss [dB] + antenna factor [dB/m]

The measured points and the limit line in the following diagrams refer to the standard measurement of the emitted interference in compliance with the above-mentioned standard. The measured points marked with an x are the measured results of the standard final measurement on the open area test site.

The results of the standard subsequent measurement on the open area test site are indicated in the table below. The limits as well as the measured results (levels) refer to the above mentioned standard while taking account of the specified requirements for a 3 m measuring distance.

The measurement time with the quasi-peak measuring detector is 1 second.



Data record name: 172171ff_2

Spurious emissions outside restricted bands										
Frequency MHz	Result dBµV/m	Limit dBµV/m	Margin dB	Readings dBµV	Antenna factor dB/m	Cable loss dB	Height cm	Azimuth deg	Pol.	Pos.
30.601	31.8	40.0	8.2	11.8	19.4	0.6	104.0	226.0	Vert.	1
44.931	29.8	40.0	10.2	16.9	12.2	0.7	100.0	46.0	Vert.	2
52.307	28.0	40.0	12.0	19.2	8.0	0.8	100.0	329.0	Vert.	2
214.716	18.3	43.5	25.2	7.3	9.4	1.6	150.0	108.0	Hor.	2
436.685	27.8	46.0	18.2	9.1	16.4	2.4	196.0	241.0	Hor.	2
769.565	37.2	46.0	8.8	12.6	21.5	3.2	137.0	241.0	Hor.	1
Measurement uncertainty				+2.2 dB / -3.6 dB						

Test: Passed

Test equipment used (refer clause 6):

2, 7 – 18, 43

5.3.2.4 Final radiated emission measurement (1 GHz to 100 GHz)

Ambient temperature	22 °C		Relative humidity	25 %

Position of EUT: The EUT was set-up on a non-conducting table of a height of 0.8 m. The distance between EUT and antenna was 3 m.

Test record: All results are shown in the following.

Supply voltage: During all measurements the EUT was supplied with 12 V DC by an external power supply.

Resolution bandwidth: For all measurements a resolution bandwidth of 1 MHz was used.

The test results were calculated with the following formula:

Result [dBµV/m] = reading [dBµV] + cable loss [dB] + antenna factor [dB/m] – Preamp [dB] + Distance correction factor (dB)

Result measured with the peak detector:

Frequency MHz	Result dBµV/m	Limit dBµV/m	Margin dB	Reading dBµV	Antenna factor 1/m	Preamp dB	Cable loss dB	Dist. m	Dist. corr. factor dB	Height cm	Pol.	Restr. Band	Pos.
1080.977	52.2	74.0	21.8	52.0	24.3	26.0	1.9	3	0.0	100	V	Yes	2
1850.542	60.1	74.0	13.9	56.3	26.9	25.7	2.6	3	0.0	100	V	No	2
2305.120	59.4	74.0	14.6	54.6	27.8	25.9	3.0	3	0.0	100	H	No	2
22428.060	40.9	74.0	33.1	46.9	37.2	37.7	4.5	1	-10.0	100	H	Yes	1
24389.780	56.6	74.0	17.4	63.3	37.2	38.6	4.7	1	-10.0	100	H	No	1
Measurement uncertainty									+2.2 dB / -3.6 dB				

Result measured with the average detector:

Frequency MHz	Result dBµV/m	Limit dBµV/m	Margin dB	Reading dBµV	Antenna factor 1/m	Preamp dB	Cable loss dB	Dist. m	Dist. corr. factor dB	Height cm	Pol.	Restr. Band	Pos.
1080.977	38.8	54.0	15.2	38.6	24.3	26.0	1.9	3	0.0	100	V	Yes	2
1850.542	46.4	54.0	7.6	42.6	26.9	25.7	2.6	3	0.0	100	V	No	2
2305.120	40.6	54.0	13.4	35.8	27.8	25.9	3.0	3	0.0	100	H	No	2
22428.060	31.6	54.0	22.4	37.6	37.2	37.7	4.5	1	-10.0	100	H	Yes	1
24389.780	53.9	54.0	0.1	60.6	37.2	38.6	4.7	1	-10.0	100	H	No	1
Measurement uncertainty									+2.2 dB / -3.6 dB				

Test: Passed

Test equipment used (refer clause 6):

7, 19 - 23, 24, 27, 31 - 33, 35, 41, 43

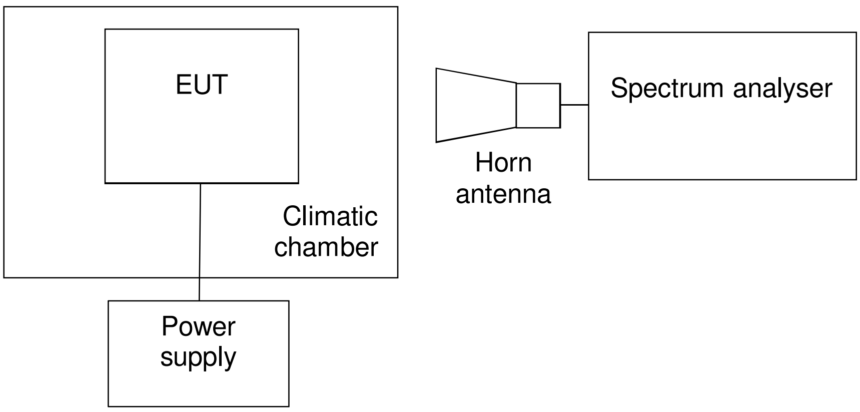
5.4 Frequency stability

5.4.1 Method of measurement (frequency stability)

The following procedure will be used:

1) Place the EUT in the climatic chamber.
2) Switch on the EUT and check the correct function and the settings of the spectrum analyser.
3) Switch off the EUT and tune the climatic chamber to a temperature of 50 °C or the highest temperature specified for the EUT. Wait until the thermal balance is obtained.
4) Switch the EUT on with nominal supply voltage and record the frequencies according to the procedure described under clause 4.1 of this test report within 1 minute after start-up. Switch the EUT off and wait for ten minutes.
5) Switch the EUT on with minimum supply voltage (85 %) and record the frequencies according to the procedure described under clause 4.1 of this test report within 1 minute after start-up. Switch the EUT off and wait for ten minutes.
6) Switch the EUT on with maximum supply voltage (115 %) and record the frequencies according to the procedure described under clause 4.1 of this test report within 1 minute after start-up.
7) Switch off the EUT and tune the climatic chamber to a temperature range of 50 °C (or the highest temperature specified for the EUT) to –20 °C (or the lowest temperature specified for the EUT) in ten-degree steps. Wait until the thermal balance is obtained for every step and repeat step 4) to 7) with the next temperature step until –20 °C or the lowest temperature specified for the EUT were reached.

Test set-up:



5.4.2 Test result (frequency stability)

Ambient temperature	22 °C

Relative humidity	26 %

Test set-up: For this test the EUT was fixed on a wooden table inside the climatic chamber.For further information of the cable guide refer to the pictures in annex A of this test report.

Temperature	Supply voltage	Lower frequency	Upper frequency	10 dB bandwidth	Peak frequency	Result
85 °C	5.4 V DC (U_{min})	24.8292 GHz	25.3289 GHz	498.8 MHz	25.0561 GHz	Passed
	12 V DC (U_{nom})	24.8252 GHz	25.3609 GHz	534.7 MHz	25.0561 GHz	Passed
	28 V DC (U_{max})	24.8322 GHz	25.3349 GHz	501.7 MHz	25.0521 GHz	Passed
80 °C	5.4 V DC (U_{min})	24.8292 GHz	25.3289 GHz	499.8 MHz	25.0561 GHz	Passed
	12 V DC (U_{nom})	24.8292 GHz	25.3359 GHz	505.7 MHz	25.0521 GHz	Passed
	28 V DC (U_{max})	24.8432 GHz	25.3250 GHz	480.8 MHz	25.0561 GHz	Passed
70 °C	5.4 V DC (U_{min})	24.8432 GHz	25.3359 GHz	492.8 MHz	25.0521 GHz	Passed
	12 V DC (U_{nom})	24.8432 GHz	25.3359 GHz	492.8 MHz	25.0521 GHz	Passed
	28 V DC (U_{max})	24.8362 GHz	25.3359 GHz	499.8 MHz	25.0521 GHz	Passed
60 °C	5.4 V DC (U_{min})	24.8472 GHz	25.3389 GHz	491.8 MHz	25.0591 GHz	Passed
	12 V DC (U_{nom})	24.8472 GHz	25.3469 GHz	499.8 MHz	25.0561 GHz	Passed
	28 V DC (U_{max})	24.8822 GHz	25.3289 GHz	446.8 MHz	25.0521 GHz	Passed
50 °C	5.4 V DC (U_{min})	24.8472 GHz	25.3859 GHz	538.7 MHz	25.0591 GHz	Passed
	12 V DC (U_{nom})	24.8862 GHz	25.3859 GHz	499.8 MHz	25.0551 GHz	Passed
	28 V DC (U_{max})	24.8862 GHz	25.3859 GHz	499.8 MHz	25.0551 GHz	Passed
40 °C	5.4 V DC (U_{min})	24.5812 GHz	25.3899 GHz	538.7 MHz	25.1091 GHz	Passed
	12 V DC (U_{nom})	24.8892 GHz	25.3859 GHz	496.8 MHz	25.1091 GHz	Passed
	28 V DC (U_{max})	24.8502 GHz	25.3899 GHz	539.7 MHz	25.1091 GHz	Passed
30 °C	5.4 V DC (U_{min})	24.8682 GHz	25.3859 GHz	517.7 MHz	25.1091 GHz	Passed
	12 V DC (U_{nom})	24.8682 GHz	25.3899 GHz	521.7 MHz	25.1091 GHz	Passed
	28 V DC (U_{max})	24.8502 GHz	25.3899 GHz	539.7 MHz	25.1091 GHz	Passed
20 °C	5.4 V DC (U_{min})	24.8902 GHz	25.3899 GHz	499.8 MHz	25.1131 GHz	Passed
	12 V DC (U_{nom})	24.8902 GHz	25.3899 GHz	499.8 MHz	25.1131 GHz	Passed
	28 V DC (U_{max})	24.8902 GHz	25.3859 GHz	495.8 MHz	25.1131 GHz	Passed
10 °C	9.6 V DC (U_{min})	24.8932 GHz	25.3899 GHz	496.8 MHz	25.1131 GHz	Passed
	12 V DC (U_{nom})	24.8932 GHz	25.3579 GHz	468.8 MHz	25.1131 GHz	Passed
	28 V DC (U_{max})	24.8932 GHz	25.3899 GHz	496.8 MHz	25.1131 GHz	Passed
0 °C	5.4 V DC (U_{min})	24.8932 GHz	25.3829 GHz	489.8 MHz	25.1131 GHz	Passed
	12 V DC (U_{nom})	24.8932 GHz	25.3899 GHz	496.8 MHz	25.1131 GHz	Passed
	28 V DC (U_{max})	24.8972 GHz	25.3899 GHz	492.8 MHz	25.1131 GHz	Passed
-10 °C	5.4 V DC (U_{min})	24.8722 GHz	25.3969 GHz	524.7 MHz	25.1131 GHz	Passed
	12 V DC (U_{nom})	24.8972 GHz	25.3929 GHz	495.8 MHz	25.1161 GHz	Passed
	28 V DC (U_{max})	24.9222 GHz	25.3889 GHz	465.8 MHz	25.1161 GHz	Passed
- 20 °C	9.6 V DC (U_{min})	24.9182 GHz	25.3929 GHz	474.8 MHz	25.1161 GHz	Passed
	12 V DC (U_{nom})	24.9251 GHz	25.3929 GHz	467.8 MHz	25.1131 GHz	Passed
	28 V DC (U_{max})	24.9222 GHz	25.3959 GHz	473.8 MHz	25.1161 GHz	Passed
-30 °C	5.4 V DC (U_{min})	24.9222 GHz	25.3929 GHz	470.8 MHz	25.1161 GHz	Passed
	12 V DC (U_{nom})	24.9182 GHz	25.3959 GHz	477.8 MHz	25.1161 GHz	Passed
	28 V DC (U_{max})	24.9152 GHz	25.3929 GHz	477.8 MHz	25.1161 GHz	Passed
-40 °C	5.4 V DC (U_{min})	24.8712 GHz	25.3999 GHz	528.7 MHz	25.1161 GHz	Passed
	12 V DC (U_{nom})	24.8712 GHz	25.3999 GHz	528.7 MHz	25.1161 GHz	Passed
	28 V DC (U_{max})	24.8962 GHz	25.4029 GHz	506.7 MHz	25.1121 GHz	Passed
Measurement uncertainty				$< \pm 1 \cdot 10^{-7}$		

Test equipment used (refer clause 6):

6, 7, 28, 35, 41 - 43

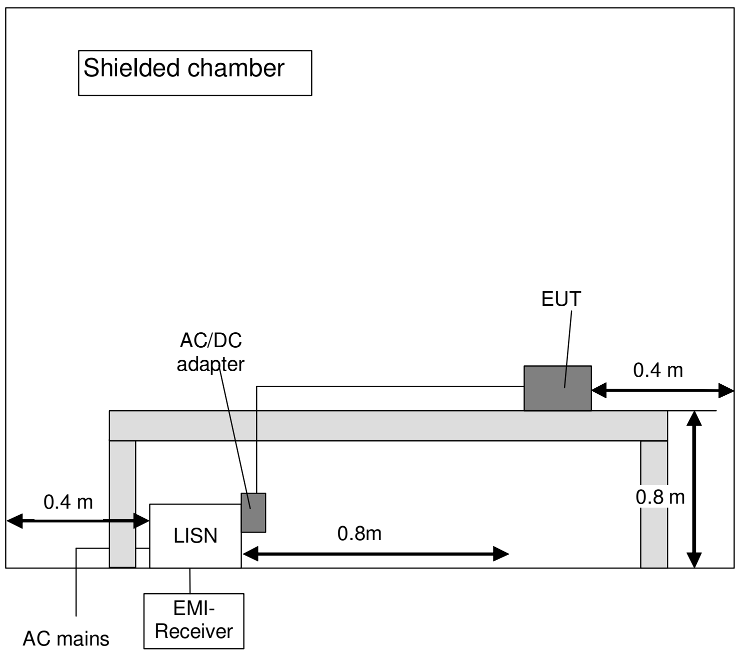
5.5 Conducted emissions on power supply lines (150 kHz to 30 MHz)

5.5.1 Method of measurement (conducted emissions on power supply lines)

This test will be carried out in a shielded chamber. Tabletop devices will set up on a non-conducting support with a size of 1 m by 1.5 m and a height of 80 cm above the ground plane. Floor-standing devices will be placed directly on the ground plane. The set-up of the Equipment under test will be in accordance to [1].

The frequency range 150 kHz to 30 MHz will be measured with an EMI Receiver set to MAX Hold mode with peak and average detector and a resolution bandwidth of 9 kHz. A scan will be carried out on the phase (or plus pole in case of DC powered devices) of the AC mains network. If levels detected 10 dB below the appropriable limit. This emission will be measured with the average and quasi-peak detector on all lines.

Frequency range	Resolution bandwidth
150 kHz to 30 MHz	9 kHz



5.5.2 Test results (conducted emissions on power supply lines)

Ambient temperature	21 °C		Relative humidity	36 %

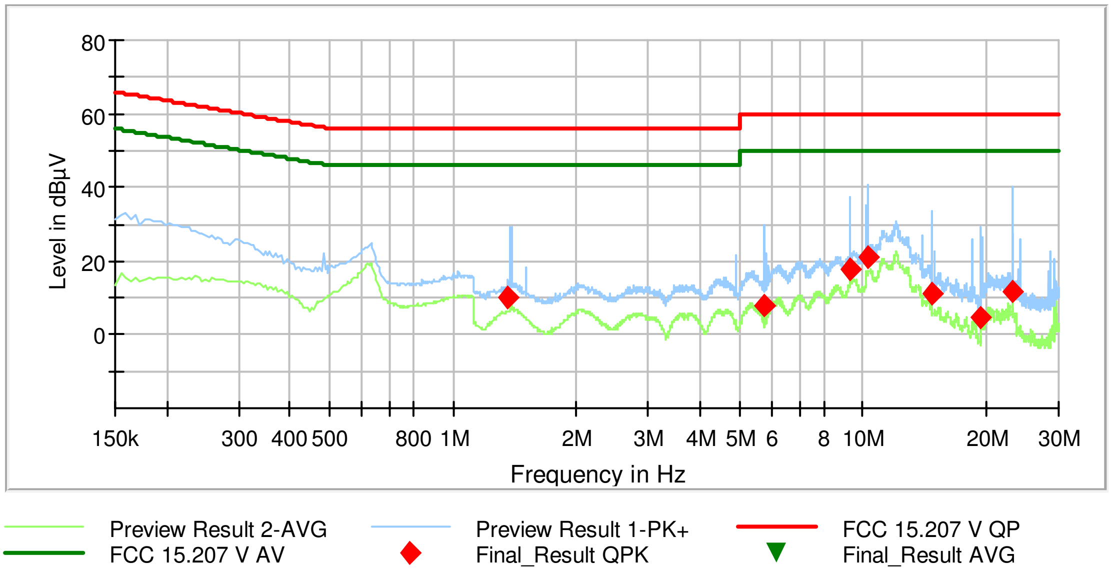
Position of EUT: The EUT was set-up on a non-conducting table of a height of 0.8 m.

Cable guide: The cables of the EUT were fixed on the non-conducting table. For further information of the cable guide refer to the pictures in annex A of this test report.

Test record: All results are shown in the following. This test was carried out in

Supply voltage: During all measurements the EUT was supplied with 12.0 V DC by an AC / DC adaptor type enercell, which was supplied by 120 V AC / 60 Hz.

The curves in the diagram only represent for each frequency point the maximum measured value of all preliminary measurements, which were made for each power supply line. The top measured curve represents the peak measurement and the bottom measured curve the average measurement.



Data record name: 172171_AC

Frequency (MHz)	QuasiPeak (dBµV)	Average (dBµV)	Limit (dBµV)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Line	PE	Corr. (dB)
1.358700	10.0	---	56.0	46.0	5000.0	9.000	L1	FLO	9.9
5.748000	8.1	---	60.0	51.9	5000.0	9.000	L1	GN	10.4
9.317400	17.5	---	60.0	42.5	5000.0	9.000	L1	GN	10.5
10.326300	21.1	---	60.0	38.9	5000.0	9.000	L1	FLO	10.6
14.794800	11.1	---	60.0	48.9	5000.0	9.000	N	FLO	10.8
19.423500	4.6	---	60.0	55.4	5000.0	9.000	N	GN	10.9
23.115300	11.5	---	60.0	48.5	5000.0	9.000	L1	GN	10.9
Measurement uncertainty					±2.8 dB				

Test: Passed

Test equipment used (refer clause 6):

1 – 4, 18

6 Test equipment and ancillaries used for tests

No.	Test equipment	Type	Manufacturer	Serial No.	PM. No.	Cal. Date	Cal. due
1	Shielded chamber M4	-	Siemens	B83117-S1-X158	480088	Calibration not necessary	
2	EMI Receiver	ESIB 26	Rohde & Schwarz	1088.7490	481182	02/15/2016	02/2018
3	LISN	NSLK8128	Schwarzbeck	8128161	480138	Calibration not necessary	
4	Transient filter limiter	CFL 9206A	Teseq	38268	481982	Calibration not necessary	
6	Spectrum Analyzer	FSW	Rohde & Schwarz	100586	481720	02/24/2016	02/2018
7	Power supply	TOE8752-32	Toellner	31566	480010	Calibration not necessary	
8	Open area test site	-	Phoenix Test-Lab	-	480085	Calibration not necessary	
14	Controller	HD100	Deisel	100/670	480139	Calibration not necessary	
15	Turntable	DS420HE	Deisel	420/620/80	480087	Calibration not necessary	
16	Antenna support	AS615P	Deisel	615/310	480086	Calibration not necessary	
17	Antenna	CBL6111 D	Chase	25761	480894	10/19/2017	10/2020
18	EMI Software	ES-K1	Rohde & Schwarz	-	480111	Calibration not necessary	
19	Fully anechoic chamber M20	-	Albatross Projects	B83107-E2439-T232	480303	Calibration not necessary	
20	Measuring receiver	ESW44	Rohde & Schwarz	101635	482467	06/22/2017	06/2019
21	Controller	MCU	Maturo	MCU/043/971107	480832	Calibration not necessary	
22	Turntable	DS420HE	Deisel	420/620/80	480315	Calibration not necessary	
23	Antenna support	AS615P	Deisel	615/310	480187	Calibration not necessary	
24	Antenna	CBL6112 B	Chase	2688	480328	06/19/2017	06/2020
25	Antenna	HL050	Rohde & Schwarz	100438	481170	10/09/2017	10/2020
26	Standard Gain Horn 11.9 GHz – 18 GHz	18240-20	Flann Microwave	483	480294	Calibration not necessary	
27	Standard Gain Horn 17.9 GHz – 26.7 GHz	20240-20	Flann Microwave	411	480297	Calibration not necessary	
28	Standard Gain Horn 17.9 GHz – 26.7 GHz	20240-20	Flann Microwave	410	480296	Calibration not necessary	
29	Standard Gain Horn 26.4 GHz – 40.1 GHz	22240-20	Flann Microwave	468	480298	Calibration not necessary	
30	RF-cable No. 36	Sucoflex 106B	Suhner	0522/6B	480571	Calibration not necessary	
31	RF-cable No. 3	Sucoflex 106B	Suhner	0563/6B	480670	Calibration not necessary	
32	RF-cable No. 40	Sucoflex 106B	Suhner	0708/6B	481330	Calibration not necessary	
33	Preamplifier	AFS6-00101600-23-10P-6-R	Miteq	2011215	482333	11/23/2016	11/2018
34	Preamplifier	JS3-12001800-16-5A	Miteq	571667	480343	02/18/2016	02/2018
35	Preamplifier	JS3-18002600-20-5A	Miteq	658697	480342	02/17/2016	02/2018
36	Preamplifier	JS3-26004000-25-5A	Miteq	563593	480344	02/18/2016	02/2018

No.	Test equipment	Type	Manufacturer	Serial No.	PM. No.	Cal. Date	Cal. due
37	Loop antenna	HFH2-Z2	Rohde & Schwarz	100417	481912	12/19/2017	12/2019
38	Standard Gain Horn 40 GHz – 60 GHz	24240-20	Flann Microwave	133313	480481	Calibration not necessary	
	Harmonic Mixer 40…60 GHz	FS-Z60	Rohde & Schwarz	100071			
39	Standard Gain Horn 50 GHz – 75 GHz	25240-20	Flann Microwave	135181	480480	Calibration not necessary	
	Harmonic Mixer 50…75 GHz	FS-Z75	Rohde & Schwarz	100045			
40	Standard Gain Horn 75 GHz – 110 GHz	27240-20	Flann Microwave	132148	480482	Calibration not necessary	
	Harmonic Mixer 75…110 GHz	FS-Z110	Rohde & Schwarz	100049			
41	RF cable	KPS-1533-800-KPS	Insulated Wire		480302	Calibration not necessary	
42	Temperature chamber	MK 240	Binder	05-79022	480462	02/08/2017	08/2018
43	Multimeter	971A	Hewlett Packard	JP3900936 5	480722	03/15/2016	03/2018

7 Report History

Report Number	Date	Comment
F172171E1	02/12/2018	Initial test report
-	-	-
-	-	-

8 List Of Annexes