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Test Report

Report Number:

F200299E1

Equipment under Test (EUT):

Weather sensor family with / without ultra-sonic sensor
PMN:
WS400-UMB
WS600-UMB
WS700-UMB
WS800-UMB

Applicant:

G. Lufft Mess- und Regeltechnik GmbH

Manufacturer:

G. Lufft Mess- und Regeltechnik GmbH

ilac-MRA

DAkkS
Deutsche
Akkreditierungsstelle
D-PL-17186-01-01
D-PL-17186-01-02
D-PL-17186-01-03

REFERENCES

[1] **ANSI C63.10-2013** American National Standard for Methods of Measuring of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz.

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

[3] **RSS-210 Issue 10 (December 2019)** Licence-exempt Radio Apparatus: Category I Equipment

[4] **RSS-Gen Issue 5 (March 2019) Amendment 1** General Requirements for Compliance of Radio Apparatus

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	T. Li	20.04.2020
	Name	Signature	Date
Authorized reviewer:	Bernd SELCK	B. Selck	20.04.2020
	Name	Signature	Date

RESERVATION

This test report is only valid in its original form.

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1 Identification

1.1 Applicant

Name:	G. Lufft Mess- und Regeltechnik GmbH
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Country:	Germany
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Applicant represented during the test by the following person:	Mr. Martin KIEPFER

1.2 Manufacturer

Name:	G. Lufft Mess- und Regeltechnik GmbH
Address:	Gutenbergstr. 20 70736 Fellbach
Country:	Germany
Name for contact purposes:	Mr. Martin KIEPFER
Phone:	(0711) 518 22-891
Fax:	(0711) 518 22-41
eMail Address:	martin.kiepfer@otthydromet.com
Manufacturer represented during the test by the following person:	Mr. Martin KIEPFER

1.3 Test laboratory

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

Accredited by Deutsche Akkreditierungsstelle GmbH (DAkkS) in compliance with DIN EN ISO/IEC 17025 under Reg. No. D-PL-17186-01-02 and D-PL-17186-01-05, FCC Test Firm Designation Number DE0004, FCC Test Firm Registration Number 469623, CAB Identifier DE0003 and ISED# 3469A.

1.4 EUT (Equipment Under Test)

Test object: *	Weather sensor family with doppler radar module
Model name: *	WS400-UMB, WS600-UMB, WS700-UMB and WS800-UMB
FCC ID: *	UF9-WSX00
IC: *	6650A-WSX00
HVIN: *	WW20
Software version / FVIN: *	61
Lowest / highest internal frequency: *	20 kHz / 24.175 GHz

*: Declared by the applicant.

Note: PHOENIX TESTLAB GmbH does not choose samples. The samples used for tests are provided exclusively by the applicant.

1.5 Technical data of equipment (all)

Channel 1	RX:	24.075 GHz to 24.175 GHz	TX:	24.075 GHz to 24.175 GHz
Channel 2	RX:	-	TX:	-
Channel 3	RX:	-	TX:	-

Duty cycle:*	100 %					
Rated RF output power: *	+20dBm (e.i.r.p.)					
Antenna type:	Integral patch antenna					
Alignment range: *	24.075 GHz to 24.175 GHz					
Switching range: *	24.075 GHz to 24.175 GHz					
Modulation: *	CW					
Bit rate of transmitter: *	-					
Supply Voltage (EUT): *	U_{Nom} =	24.0 V_{DC}	U_{Min}=	11.0 V_{DC}	U_{Max}=	32.0 V_{DC}
Power Supply: *	External DC					
Temperature range: *	-50°C to +60°C					
Ancillaries to be tested with:	USB to serial converter **, PHOENIX Contact RS232 to RS485 converter type PSM-ME-RS232/RS485-P **, PHOENIX Contact AC/DC adapter type Quint-PS-100-240AC / 24DC / 5 for conducted emissions on power supply line ***, Fujitsu Laptop PC type LIVEBOOK E-Series *** with test-software ConfigTool_NET Version 1.4 **					

*: Declared by the applicant.
**: Provided by the applicant.
***: Provided by the laboratory.

The following external I/O cables were used:

Identification	Connector		Length
	EUT	Ancillary	
DC and data	8 pole M12 connector	8 pole M12 connector	4.0 m
-	-	-	-
-	-	-	-

1.5.1 Technical data of equipment (WS400-UMB)

Measurement capabilities: *	Temperature, relative humidity, precipitation intensity, precipitation type, precipitation quantity and air pressure
PCB identifiers: *	SPLAN.0613.BB.26, SPLAN.0613.Rain.21
PMN: *	WS400-UMB
Article No.: *	8369.U01-NA
Serial number: *	158-0320.0613.932
Hardware version: *	22

*: Declared by the applicant.

1.5.2 Technical data of equipment (WS600-UMB)

Measurement capabilities: *	Temperature, relative humidity, precipitation intensity, precipitation type, precipitation quantity, air pressure, wind direction, wind speed
PCB identifiers: *	SPLAN.0613.BB.26, SPLAN.0613.Rain.21, SPLAN.1002.SB.15
PMN: *	WS600-UMB
Article No.: *	8370.U01-NA
Serial number: *	152.0320.0701.932
Hardware version / HVIN: *	22
Frequency range of the ultra-sonic module: *	295 kHz to 310 kHz
Rated output power of the ultra-sonic module: *	1.2 mW

*: Declared by the applicant.

1.5.3 Technical data of equipment (WS700-UMB)

Measurement capabilities: *	Temperature, relative humidity, precipitation intensity, precipitation type, precipitation quantity, air pressure, wind direction, wind speed, radiation
PCB identifiers: *	SPLAN.0613.BB.26, SPLAN.0613.Rain.21, SPLAN.1002.SB.15, SPLAN.0613.Rad&Lightning.03
PMN: *	WS700-UMB
Article No.: *	8380.U01-NA
Serial number: *	150.0320.1305.932
Hardware version / HVIN: *	22
Frequency range of ultra-sonic module: *	295 kHz to 310 kHz
Rated output power of the ultra-sonic module: *	1.2 mW

*: Declared by the applicant.

1.5.4 Technical data of equipment (WS800-UMB)

Measurement capabilities: *	Temperature, relative humidity, air pressure, wind direction, wind speed, precipitation intensity, precipitation quantity, radiation, lightning strikes
PCB identifiers: *	SPLAN.0613.BB.26, SPLAN.0613.Rain.21, SPLAN.1002.SB.15, SPLAN.0613.Rad&Lightning.03
PMN: *	WS800-UMB
Article No.: *	8381.U01-NA
Serial number: *	091.0319.1309.932
Hardware version / HVIN: *	22
Frequency range of ultra-sonic module: *	295 kHz to 310 kHz
Rated output power of the ultra-sonic module: *	1.2 mW

*: Declared by the applicant.

1.6 Dates

Date of receipt of test sample:	16.03.2020
Start of test:	16.03.2020
End of test:	23.03.2020

2 Operational states

All tests were carried out with unmodified samples with integral antenna, which were supplied with 24.0 V_{DC} by an external power supply.
During the emission measurement on the AC line the EUT was supplied with 24.0 V_{DC} by an external power supply, which was connected to an AC mains network with 120 V_{AC} / 60 Hz.

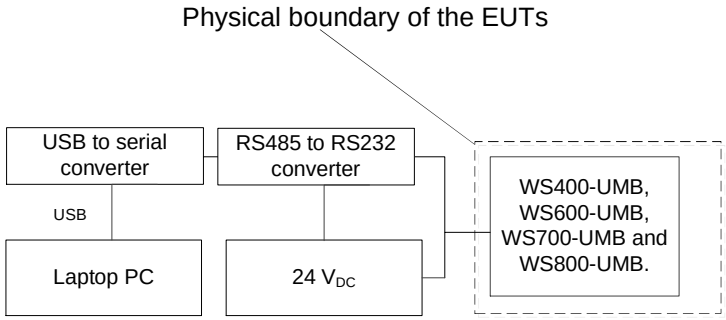
The EUTs are part of a weather station family with a radar transceiver sensor for rain measurements and with or without ultra-sonic sensor for wind measurements.

For the radiated measurements pretests with all devices were carried out, to find that one that causes the highest emissions. With this device preliminary and final measurements were carried out. Because of the different power consumption, conducted measurements on the power supply were carried out with all four devices.
For the whole frequency range a preliminary measurement in a semi anechoic chamber was carried out to determine the frequencies, which were radiated by the EUT. The final measurements on the detected frequencies were carried out at an outdoor test site without ground plane for the frequency range 9 kHz to 30 MHz and inside a semi anechoic chamber with ground plane for the frequency range 30 MHz to 100 GHz.

During all measurements the EUT was connected to a laptop PC via a USB to serial converter and RS232 to RS485 converter. On the Laptop PC the test software was running (ConfigTool_NET Version 1.4, supplied by the applicant), which displayed the actual measured weather data with a refreshing rate of 1 s (the shortest rate that was selectable).

No tests in stand-by mode of the transmitter / receive mode were carried out, because the transmitter is operating continuously and has no stand-by mode.

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



3 Additional Information

The EUTs used for the tests were not labelled with the final version of the label.

The EUTs WS600-UMB, WS700-UMB and WS800-UMB containing an ultra-sonic sensor, which is not part of this test report. The results of the ultra-sonic sensor are documented in a separate report.

4 Overview

Application	Frequency range	FCC 47 CFR Part 15 section [2]	RSS-Gen [4] and RSS 210 [3]	Status	Refer page
Bandwidth	24.075 GHz to 24.175 GHz	15.215 (c)	6.7 [4]	Passed	9 et seq.
Band edge compliance	24.075 GHz to 24.175 GHz	15.215 (c)	6.10 [1]	Passed	12 et seq.
Field strength of fundamental	24.075 GHz to 24.175 GHz	15.245 (b)	F.1 (a) [3]	Passed	15 et seq.
Field strength of harmonics	Restricted bands	15.245 (b) (1) (i), 15.245 (b) (1) (ii)	F.1 (a) [3] F.1 (c) (i) [3]	Passed	15 et seq.
Emissions outside the specified bands	9 kHz to 110 GHz	15.205 (a), 15.209 (a), 15.245 (b) (3)	8.9 [4] 8.10 [4] F.1 (e) [3]	Passed	15 et seq.
Conducted emissions	150 kHz to 30 MHz	15.207 (a)	8.8 [4]	Passed	31 et seq.
Antenna requirement	-	15.203	6.8 [4]	Passed *	-

*: Integrated antenna only, requirement fulfilled.

5 Test results

5.1 Bandwidth

5.1.1 Method of measurement (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 test fixture shall be used. The EUT has to be switched on, the transmitter shall work with its maximum data rate.

The following spectrum analyser settings shall be used:

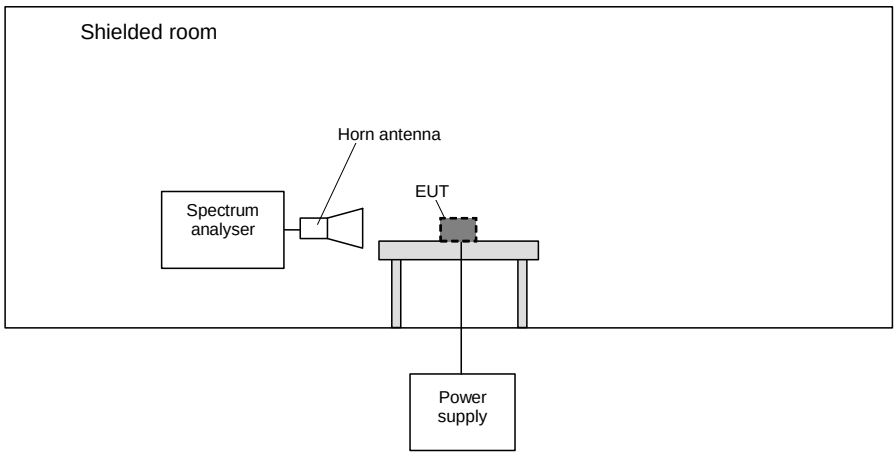
- Span: Approx. 2 to 3 times the 20 dB bandwidth, centred on the actual channel.
- Resolution bandwidth: Approx. 1 % of the emission bandwidth.
- Video bandwidth: equal or greater than the RBW.
- Sweep: Auto.
- Detector function: peak.
- Trace mode: Max hold.

<u>20 dB bandwidth:</u>

After trace stabilisation the marker shall be set on the signal peak. The first display line has to be set on this value. The second display line has to be set 20 dB below the first line (or the peak marker). The frequency lines shall be set on the intersection points between the second display line and the measured curve.

<u>99 % bandwidth:</u>

After trace stabilisation the marker shall be set on the signal peak. Use the 99 % bandwidth functionality of the spectrum analyser to integrate the requested bandwidth.



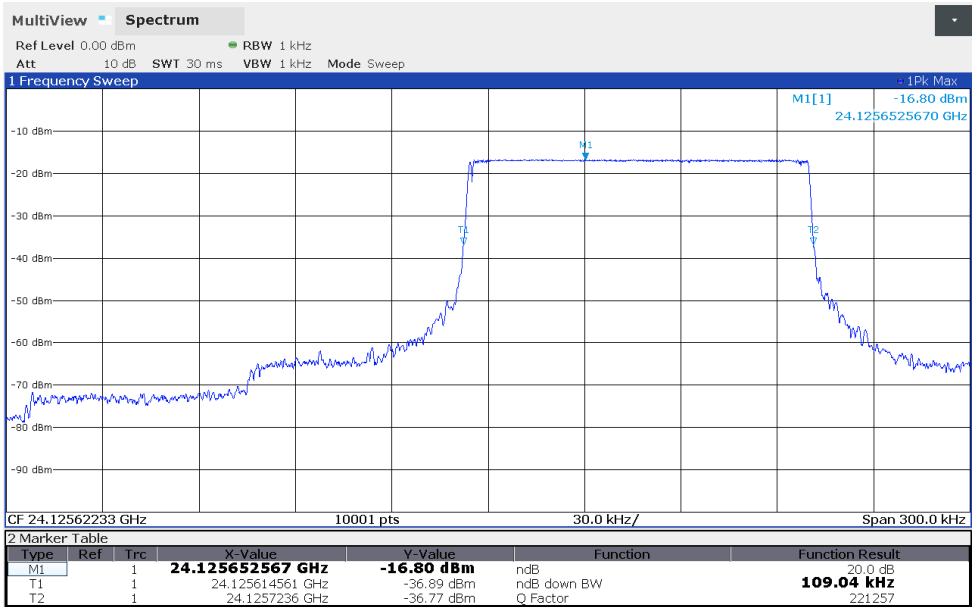
5.2 Test results (20 dB bandwidth)

Ambient temperature	22 °C	Relative humidity	37 %

Position of EUT: The EUT was set-up 30 cm in front of the measuring antenna.

Supply voltage: During the measurement the EUT was supplied with 24.0 V_{DC} by an external power supply.

200299_5.png: 20 dB bandwidth:



F_L	F_U	BW (F_U - F_L)
24.1256146 GHz	24.1257236 GHz	109.04 kHz
Measurement uncertainty		< ± 1*10^{-7}

Test: Passed

Test equipment used (refer clause 6):

1, 8, 13, 35, 37

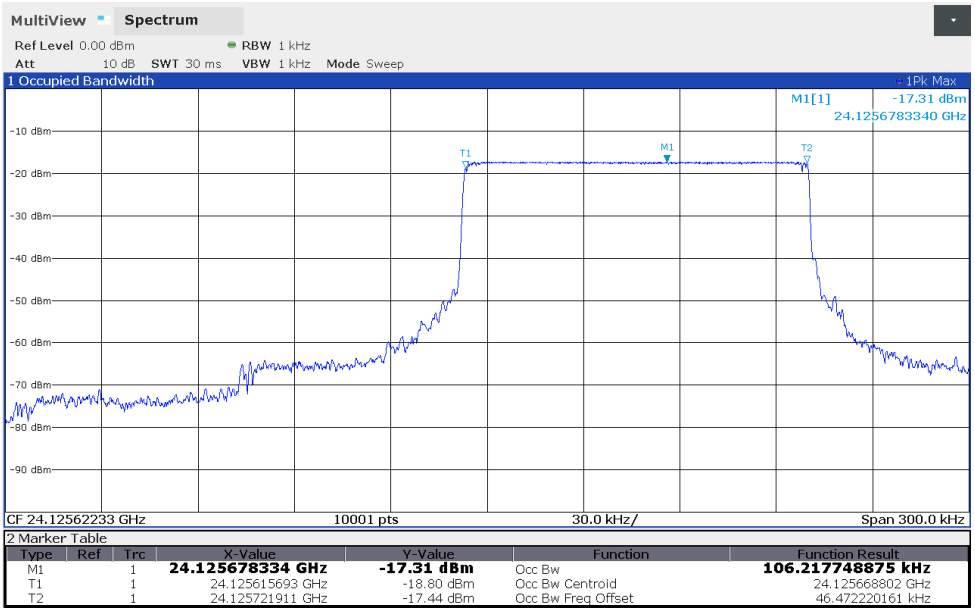
5.2.1 Test results (99 % bandwidth)

Ambient temperature	22 °C	Relative humidity	37 %

Position of EUT: The EUT was set-up 30 cm in front of the measuring antenna.

Supply voltage: During the measurement the EUT was supplied with 24.0 V_{DC} by an external power supply.

200299_4.png: 99 % bandwidth:



F_L	F_U	BW (F_U - F_L)
24.1256157 GHz	24.1257219 GHz	106.218 kHz
Measurement uncertainty		< ± 1*10^{-7}

Test: Passed

Test equipment used (refer clause 6):

1, 8, 13, 35, 37

5.3 Band-edge compliance

5.3.1 Method of measurement (band-edge compliance)

The same test set-up as used for the final radiated emission measurement shall be used.
The measurements shall be carried out using a resolution bandwidth of 100 kHz.

The following spectrum analyser settings shall be used:

- Span: Wide enough to capture the peak level of the emission on the channel closest to the band-edge, as well as any modulation products, which fall outside the assigned frequency band.
- Resolution bandwidth: 100 kHz.
- Video bandwidth: ≥ the resolution bandwidth.
- Sweep: Auto.
- Detector function: Peak.
- Trace mode: Max hold.

After trace stabilisation the marker shall be set on the signal peak. The first display line has to be set on this value. The second display line has to be set 50 dB below the first line (or the peak marker). The frequency line shall be set on the edge of the assigned frequency band. Set the second marker on the emission at the band-edge, or on the highest modulation product outside of the band, if this level is higher than that at the band-edge. This frequency shall be measured with the EMI receiver as described in subclause 5.4.1 of this test report, but 100 kHz resolution bandwidth shall be used.

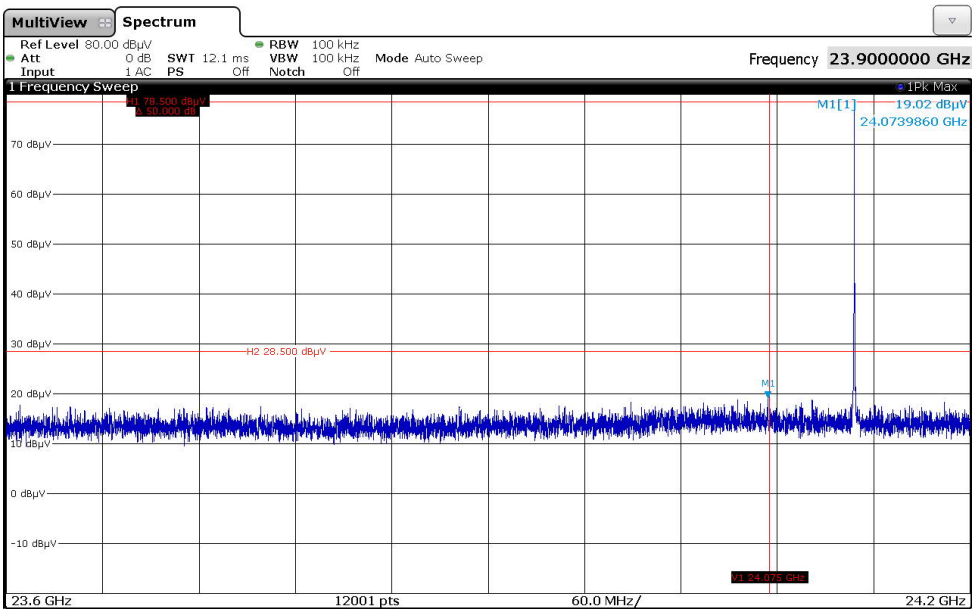
The measurement will be performed at the lower and upper edge of the assigned frequency band.

5.3.2 Test results (band-edge compliance)

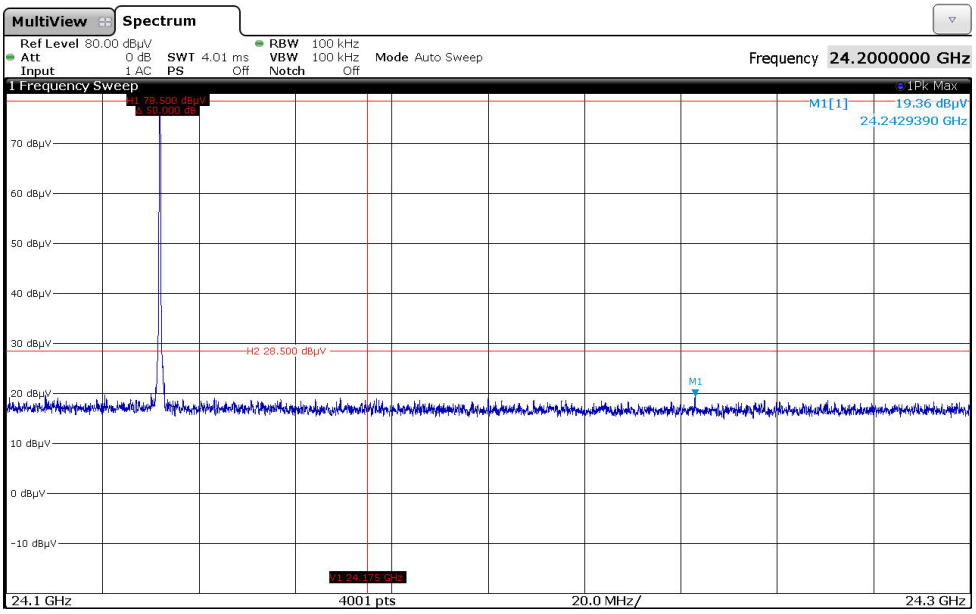
Ambient temperature	22 °C		Relative humidity	37 %

Position of EUT: The EUT was set-up 100 cm in front of the measuring antenna.

200299_lbec.png: Band-edge compliance, lower band edge:



200299_ubec.png: Band-edge compliance, upper band edge:



The plots on the page before are showing the band-edge compliance for the lower and upper band-edge. The display line 1 (H1) in these plots represents the highest level within the assigned frequency band. The display line 2 (H2) represents the -50 dB offset to this highest level and shows the compliance with FCC 47 CFR Part 15.245 (b) (3). The frequency line 1 (V1) shows the edge of the assigned frequency.

Band-edge compliance (lower band edge)									
Result measured with the peak detector:									
Frequency GHz	Result dBµV/m	Limit (3 m) dBµV/m	Margin dB	Readings dBµV	Antenna factor 1/m	Preamp dB	Cable loss dB	Corr. [dB] / measuring distance [cm]	Restr. Band
24.073986	51.0	74.0	23.0	19.0	37.2	0.0	4.8	-10.0 / 100 cm	No
Result measured with the average detector:									
Frequency GHz	Result dBµV/m	Limit (3 m) dBµV/m	Margin dB	Readings dBµV	Antenna factor 1/m	Preamp dB	Cable loss dB	Corr. [dB] / measuring distance [cm]	Restr. Band
24.073986	37.6	60.7	23.1	5.6	37.2	0.0	4.8	-10.0 / 100 cm	No
Measurement uncertainty							±4.6 dB		

Band-edge compliance (upper band edge)									
Result measured with the peak detector:									
Frequency GHz	Result dBµV/m	Limit (3 m) dBµV/m	Margin dB	Readings dBµV	Antenna factor 1/m	Preamp dB	Cable loss dB	Corr. [dB] / measuring distance [cm]	Restr. Band
24.242939	51.5	74.0	22.5	19.4	37.2	0.0	4.8	-10.0 / 100 cm	No
Result measured with the average detector:									
Frequency GHz	Result dBµV/m	Limit (3 m) dBµV/m	Margin dB	Readings dBµV	Antenna factor 1/m	Preamp dB	Cable loss dB	Corr. [dB] / measuring distance [cm]	Restr. Band
24.242939	36.8	60.7	23.9	4.8	37.2	0.0	4.8	-10.0 / 100 cm	No
Measurement uncertainty							±4.6 dB		

Test: Passed

Test equipment used (refer clause 6):

1, 8, 13, 35, 37

5.4 Radiated emissions

5.4.1 Method of measurement (radiated emissions)

The radiated emission measurement is subdivided into 7 stages.

- A preliminary measurement carried out in a fully anechoic chamber with a fixed antenna height in the frequency range 9 kHz to 1 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 preliminary measurement carried out in a fully anechoic chamber with a variable antenna distance and height in the frequency range 1 GHz to 40 GHz.
- A final measurement carried out in a fully anechoic chamber with a fixed antenna height in the frequency range 1 GHz to 40 GHz.
- A preliminary measurement carried out in a fully anechoic chamber with a variable antenna distance and height in the frequency range 40 GHz to 100 GHz.
- A final measurement carried out in a fully anechoic chamber with a fixed antenna height in the frequency range 40 GHz to 110 GHz.

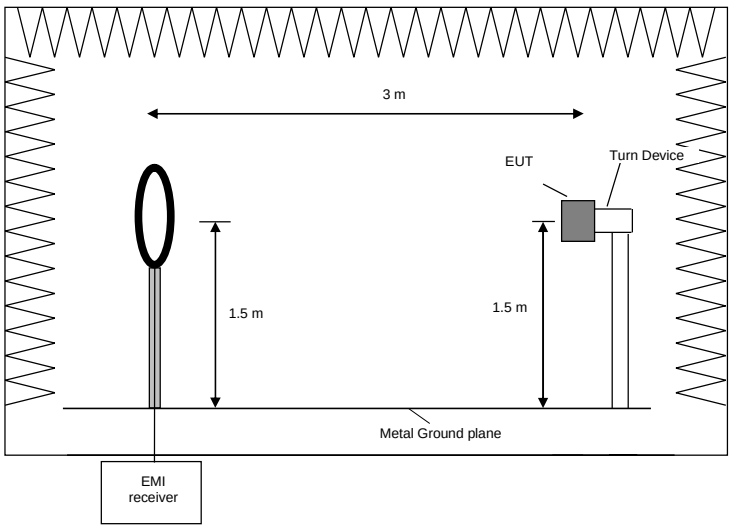
Preliminary measurement (9 kHz to 30 MHz):

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 setup 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 find 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 and 150 kHz 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.
7) Rotate the measuring antenna and repeat steps 1) to 5).

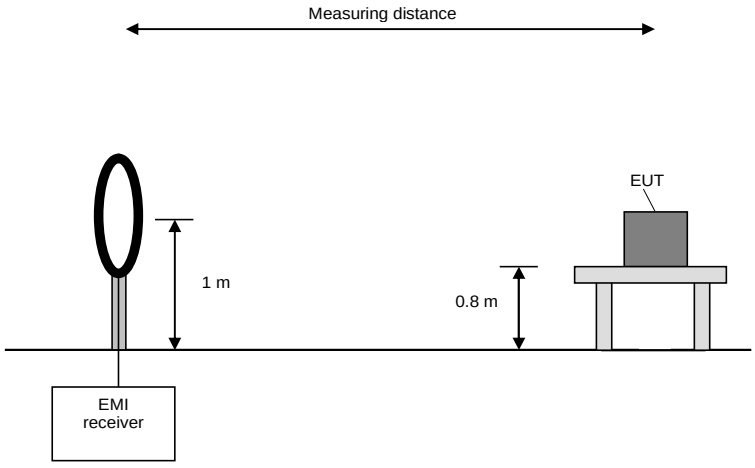
Final measurement (9 kHz to 30 MHz):

In the second stage a final measurement will be performed on an open area test site with no conducting ground plane in a measuring distances of 3 m, 10 m and 30 m whichever is appropiate. In the case where larger measuring distances were required the results will be extrapolated based on the values measured on the closer distances according to [2]. The final measurement will be performed with a EMI Receiver set to Quasi Peak detector except for the frequency bands 30 kHz to 90 kHz and 110 kHz to 490 kHz where an average detector will be used according to [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	9 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 (only if the EUT is a module or is used in a handheld application).

Preliminary and final measurement (30 MHz to 1 GHz)

The EUT is measured in the frequency range from 30 MHz to 1 GHz in a semi anechoic chamber with a metal ground plane, which has been validated to the requirements of [1]. It is placed on a 3D-positioner to allow different positions at a distance of 3 meters from the receiving antenna. Both polarizations (vertical and horizontal) have been evaluated and the turn table has been turned to 360° to maximize the emissions. The receiving antenna is raised from 1 to 4 m.

Procedure preliminary measurement:

The following procedure is used:

1. Set the measurement antenna to 1 m height.
2. Monitor the frequency range at vertical polarisation and a EUT azimuth of 0 °.
3. Rotate the EUT by 360° to maximize the detected signals.
4. Repeat 1) to 2) with the horizontal polarisation of the measuring antenna.
5. Increase the height of the antenna for 0.5 m and repeat steps 2 – 4 until the final height of 4 m is reached.
6. The highest values for each frequency will be saved by the software, including the antenna height, measurement antenna polarization and turntable azimuth for that value.

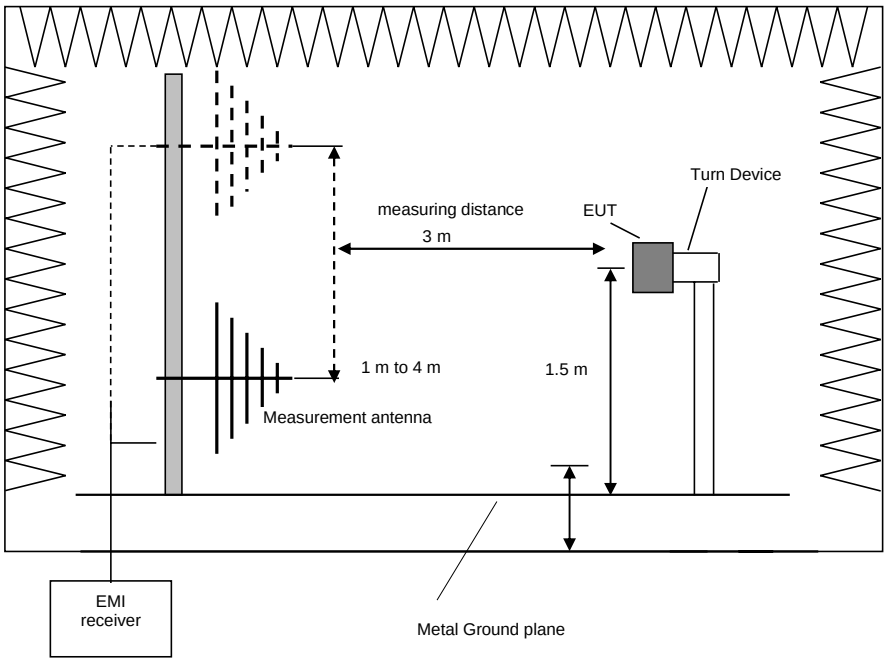
Procedure final measurement:

The following procedure is used:

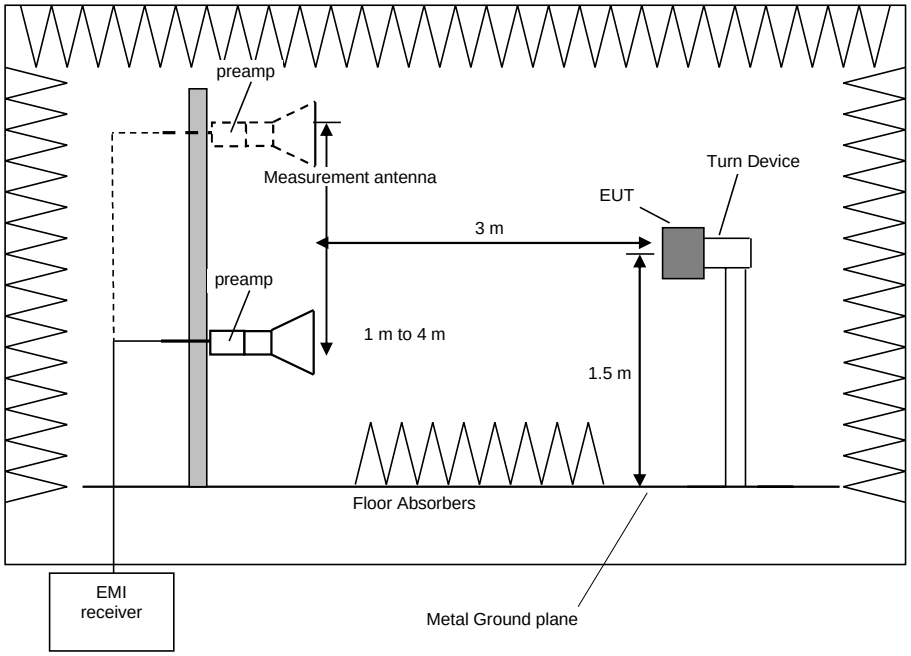
1. Select the highest frequency peaks to the limit for the final measurement.
2. The software will determine the exact peak frequencies by doing a partial scan with reduced RBW with +/- 10 times the RBW of the pre-scan of the selected peaks.
3. If the EUT is portable or ceiling mounted, find the worst case EUT position (x,y,z) for the final test.
4. The worst measurement antenna height is found by the measurement software by varying the measurement antenna height by +/- 0.5 m from the value obtained in the preliminary measurement, and to monitor the emission level.
5. The worst azimuth turntable position is found by varying the turntable azimuth by +/- 25° from the value obtained in the preliminary measurement, and to monitor the emission level.
6. The final measurement is performed at the worst-case antenna height and the worst case turntable azimuth
7. Steps 2 – 6 will be repeated for each frequency peak selected in step 1.

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

Frequency range	Resolution bandwidth
30 MHz to 1 GHz	100 kHz
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



Test setup for measurements below 1 GHz



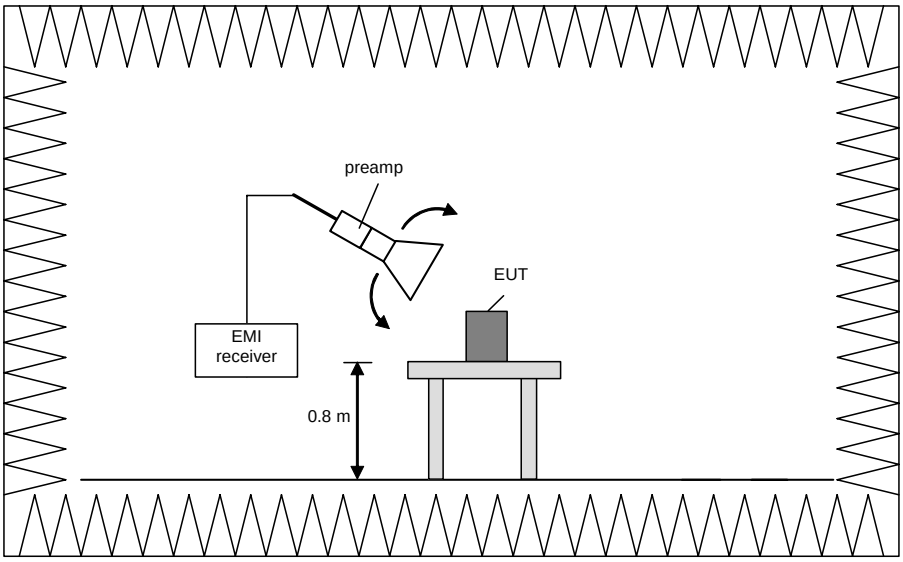
Test setup for measurements above 1 GHz

Preliminary measurement (40 GHz to 110 GHz)

The frequency range will be divided into different sub ranges depending on the frequency range of the used horn antenna. The spectrum analyser set to MAX Hold mode and a resolution bandwidth of 1 MHz kHz. 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 then 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
40 GHz to 60 GHz	1 MHz
50 GHz to 75 GHz	1 MHz
75 GHz to 110 GHz	1 MHz

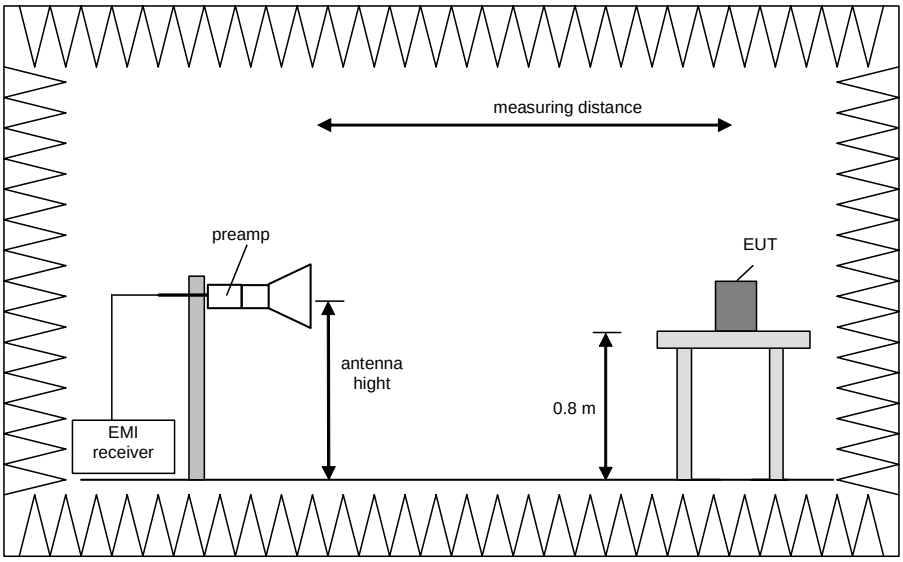


Final measurement (40 GHz to 110 GHz)

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
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 are performed in the frequency range 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 find 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.

5.4.3 Test results (radiated emissions)

5.4.3.1 Preliminary radiated emission measurement (9 kHz to 100 GHz)

Ambient temperature	21 °C	Relative humidity	29 %

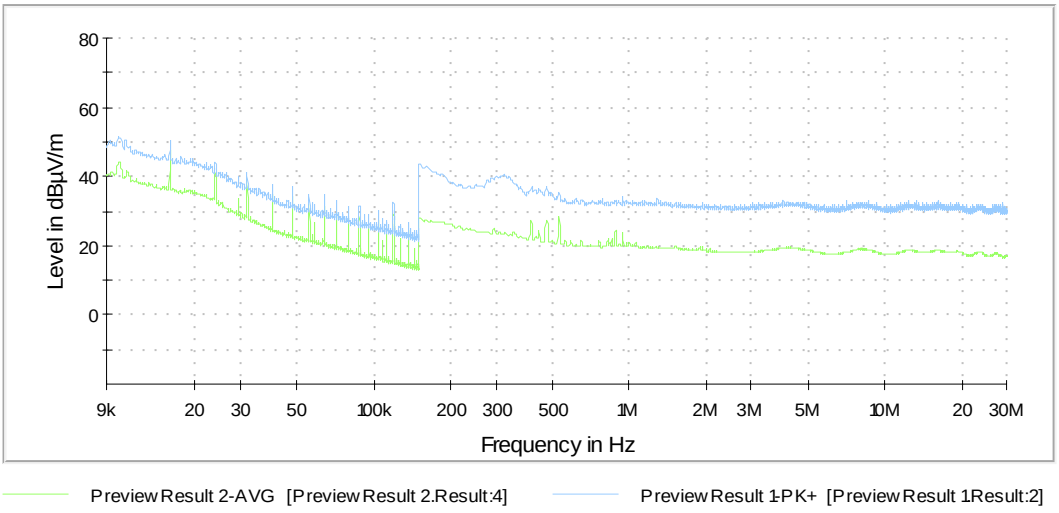
Position of EUT: The EUT was set-up on a non-conducting position device of a height of 1.5 m (9 kHz to 40 GHz) and 80 cm (40 GHz to 100 GHz). The distance between EUT and the antenna was 3 m (9 kHz to 26.5 GHz), 30 cm and 1 m (26.5 GHz to 100 GHz).

Cable guide: For further information refer to the pictures in annex A of this test report.

Test record: The test was carried out in normal operation mode of the EUT.

Supply voltage: During all measurements the EUT was supplied with 24.0 V_{DC} by an external power supply.

<u>Radiated emissions from 9 kHz to 30 MHz:</u>

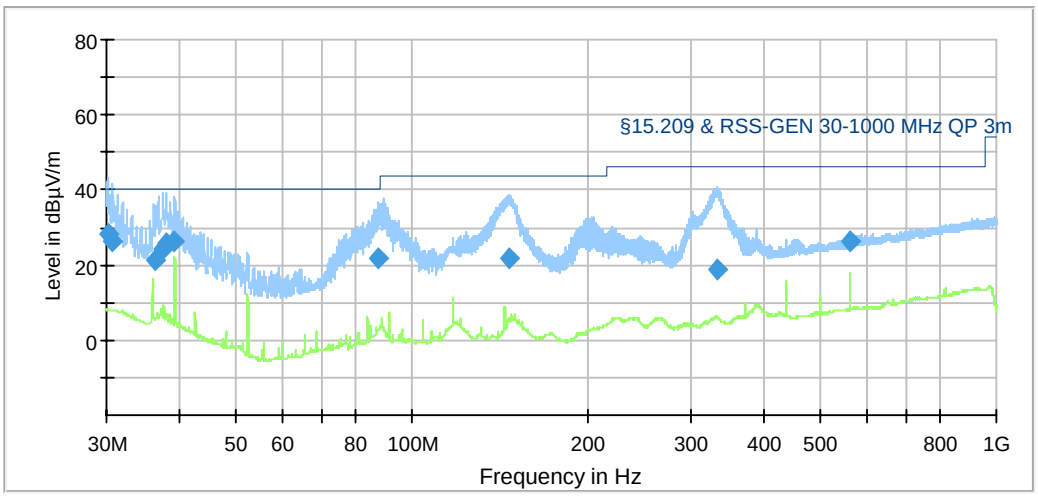


The following emission was found according to [2] and [3].

- 16.000 kHz, 64.000 kHz, 119.550 kHz, 309.250 kHz, 413.250 kHz, 476.250 kHz, 478.500 kHz, 530.250 kHz, 885.750 kHz and 944.250 kHz.

These frequencies have to be measured at the outdoor test site. The result is presented in the following.

Radiated emissions from 30 MHz to 1000 MHz:



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

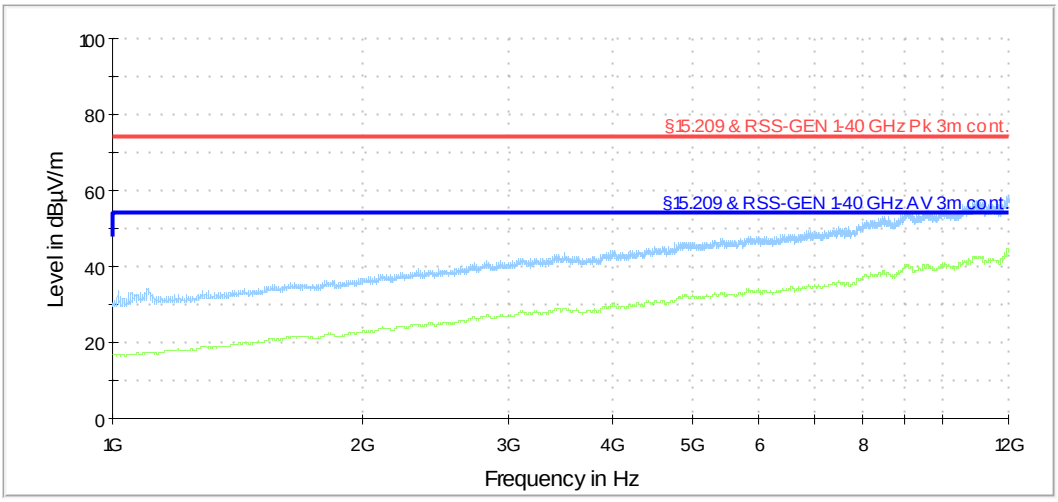
- 30.130 MHz, 30.740 MHz, 36.230 MHz, 37.450 MHz, 39.270 MHz, 87.360 MHz, 146.790 MHz and 562.500 MHz.

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

- 38.050 MHz and 333.960 MHz.

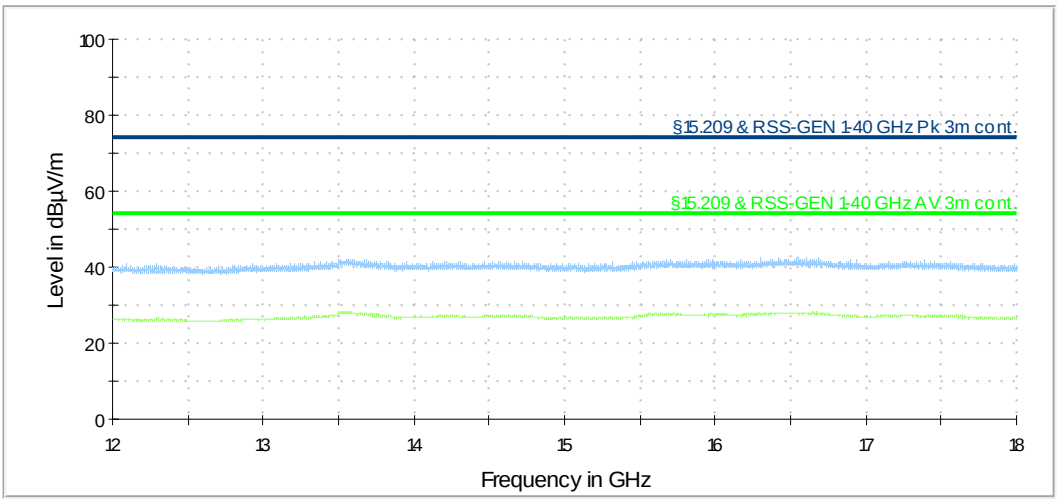
On these frequencies a final measurement has to be carried out. The result is presented in the following.

Radiated emissions from 1 GHz to 12 GHz:



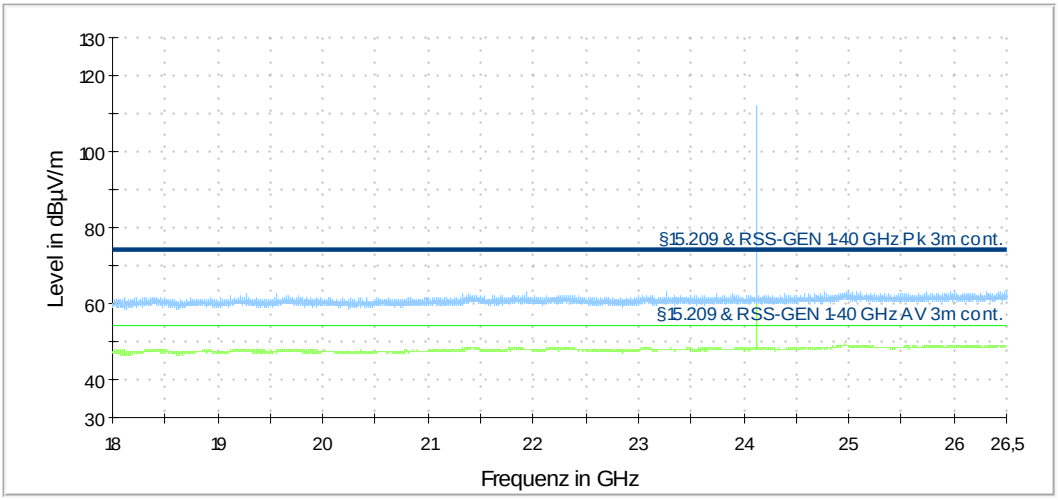
No significant frequencies above the noise floor of the system were found during the preliminary radiated emission test, so no final measurements were carried out.

Radiated emissions from 12 GHz to 18 GHz:

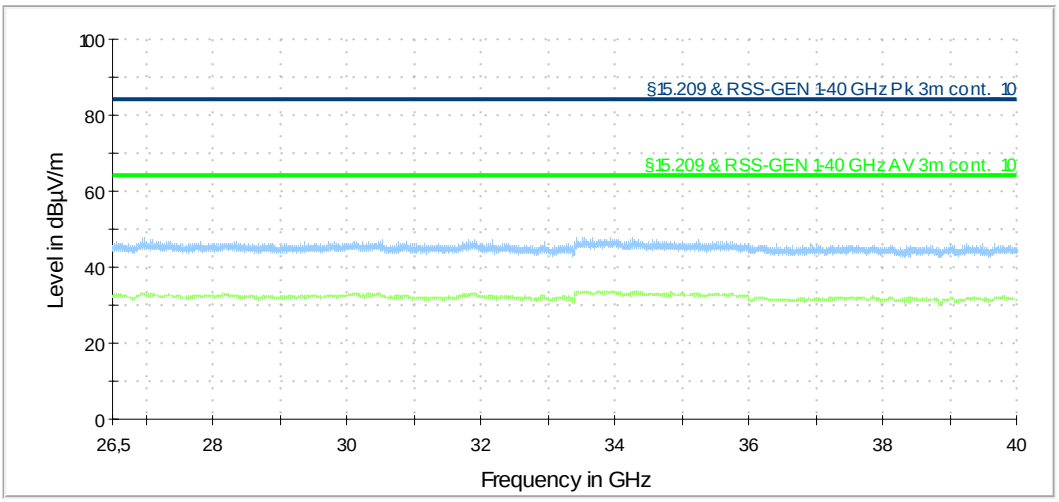


No significant frequencies above the noise floor of the system were found during the preliminary radiated emission test, so no final measurements were carried out.

Radiated emissions from 18 GHz to 26.5 GHz:

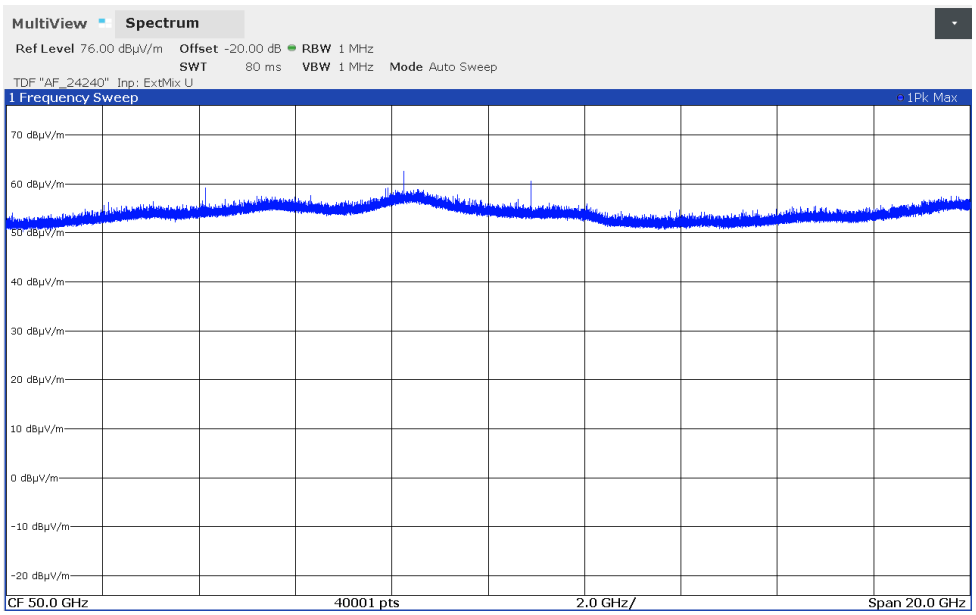


Radiated emissions from 26.5 GHz to 40 GHz:

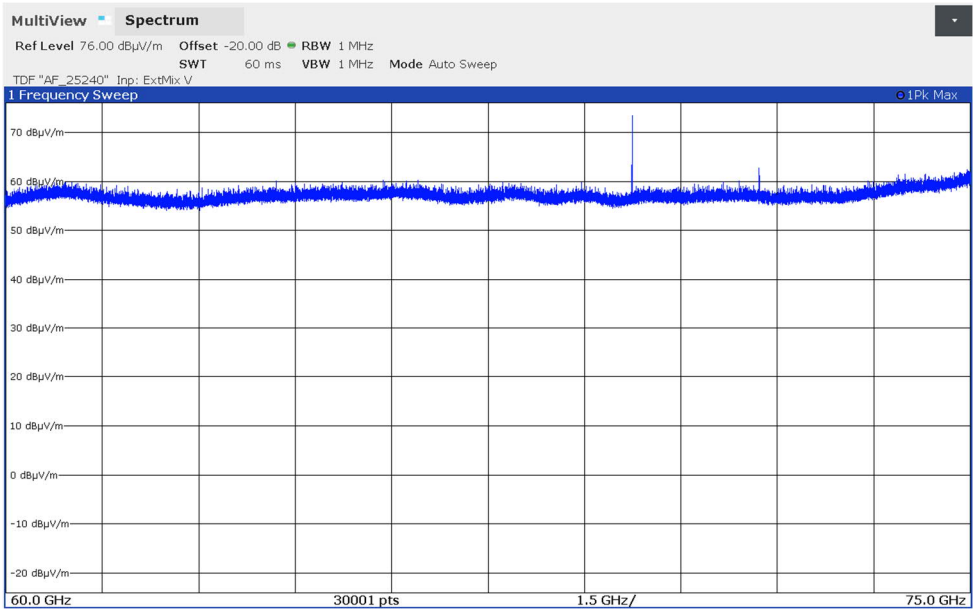


No significant frequencies above the noise floor of the system were found during the preliminary radiated emission test, so no final measurements were carried out.

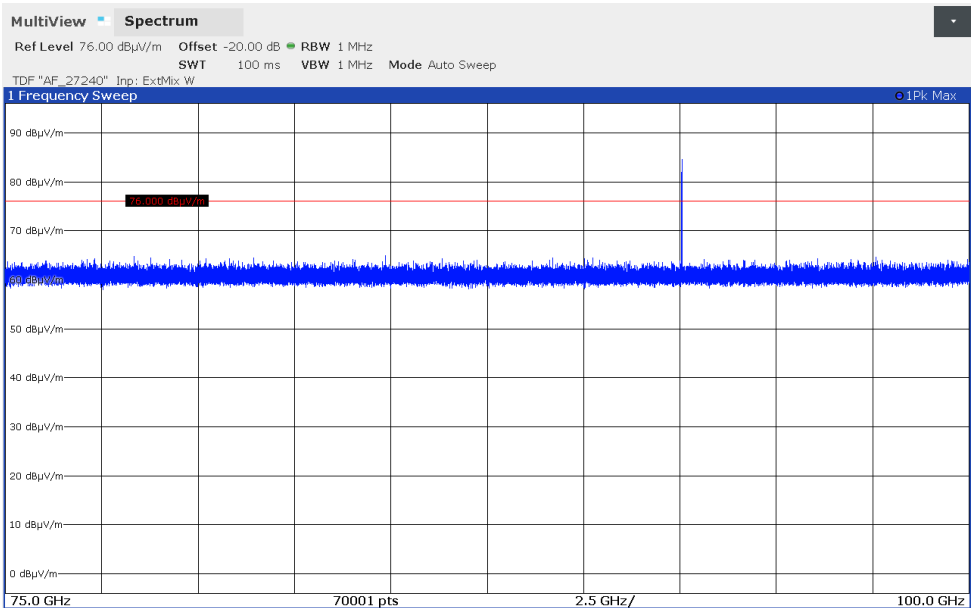
200299_1.png: Radiated emissions from 40 GHz to 60 GHz:



200299_2.png: Radiated emissions from 60 GHz to 75 GHz:



200299_3.png: Radiated emissions from 75 GHz to 100 GHz:



The following fundamental frequency was found during the preliminary radiated emission measurement:

- 24.125 GHz.

The following second harmonic emission frequency was found during the preliminary radiated emission measurement:

- 48.250 GHz.

The following third harmonic emission frequency was found during the preliminary radiated emission measurement:

- 72.375 GHz.

On these frequencies a final measurement has to be carried out. The results were presented in the following.

The emissions arround 51 GHz, 71 GHz and 92 GHz are mirror frequencies caused by the harmonic mixer, not by the EUT.

Test equipment used (refer clause 6):

1 - 27, 35, 37

5.4.3.2 Final radiated emission measurement (9 kHz to 30 MHz)

Ambient temperature	18 °C	Relative humidity	37 %

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.

Cable guide: For detail information of test set-up and the cable guide refer to the pictures in annex A of this test report.

Test record: All results are shown in the following.

Supply voltage: During the measurement the EUT was supplied with 24 V DC by an external power supply.

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

Result [dBµV/m] = reading [dBµV] + antenna factor [dB/m] + Distance correction dB]

Result [dBµA/m] = Result [dBµV/m] – 51.5

Results with measuring distance of 3 m

Frequency [kHz]	Result [dBµV/m]	Result [dBµA/m]	Limit [dBµV/m]	Limit [dBµA/m]	Margin [dB]	Distance correction [2] [dB]	Readings [dBµV]	Detector	Antenna factor [1] [dB/m]
16.000	-46.2 @ 300 m	-97.7 @ 300 m	43.5	-8.0	89.7	-80.0	13.6	AV	20.2
64.000	-65.5 @ 300 m	-117.0 @ 300 m	31.5	-20.0	97.0	-80.0	-5.6	AV	20.1
119.550	-58.5 @ 300 m	-110.0 @ 300 m	26.1	-25.4	84.6	-80.0	1.4	AV	20.1
309.250	-44.3 @ 300 m	-95.8 @ 300 m	17.8	-33.7	62.1	-80.0	15.6	AV	20.1
413.250	-64.8 @ 300 m	-116.3 @ 300 m	15.3	-36.2	80.1	-80.0	-4.9	AV	20.1
476.250	-63.7 @ 300 m	-115.2 @ 300 m	14.0	-37.5	77.7	-80.0	-3.7	AV	20.0
478.500	-62.0 @ 300 m	-113.5 @ 300 m	14.0	-37.5	76.0	-80.0	-2	AV	20.0
530.250	-16.0 @ 30 m	-67.5 @ 30 m	33.1	-18.4	49.1	-40.0	3.9	QP	20.1
885.750	-16.3 @ 30 m	-67.8 @ 30 m	28.7	-22.8	45.0	-40.0	3.6	QP	20.1
944.250	-22.1 @ 30 m	-73.6 @ 30 m	28.1	-23.4	50.2	-40.0	-2.2	QP	20.1
Measurement uncertainty:			±4.4 dB						

[1]: Cable loss included
[2]: Correction Factor according to [2] and [3] extrapolated with a factor of 40 dB/decade according to [2]

Test: Passed

Test equipment used (refer clause 6):

27 - 29, 35, 37

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

Ambient temperature	20 °C	Relative humidity	32 %

Position of EUT: The EUT was set-up on a non-conducting non-conducting position device of a height of 1.5 m. The distance between EUT and antenna was 3 m.

Cable guide: For detail information of test set-up and the cable guide refer to the pictures in annex A of this test report.

Test record: All results are shown in the following.

Supply voltage: During the measurement the EUT was supplied with 24 V DC by an external power supply.

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

Result measured with the quasi-peak detector:

Frequency [MHz]	Result [dBµV/m]	Limit [dBµV/m]	Margin [dB]	Correction * [dB]	Height [cm]	Azimuth [deg]	Elevation [deg]	Pol.	Restr. Band
30.130	28.3	60.7	32.4	25.3	102	108	0	Vert.	No
30.740	26.1	60.7	34.6	25.0	112	123	0	Vert.	No
36.230	21.1	60.7	39.6	22.0	102	219	90	Vert.	No
37.450	24.3	60.7	36.4	21.3	102	344	0	Vert.	No
38.050	25.6	40.0	14.4	21.0	100	311	0	Vert.	Yes
39.270	26.5	60.7	34.2	20.3	104	277	0	Vert.	No
87.360	21.7	60.7	39.0	16.5	206	249	0	Hor.	No
146.790	21.9	60.7	38.8	15.9	137	102	90	Hor.	No
333.960	18.9	46.0	27.1	20.3	102	169	0	Vert.	Yes
562.500	26.1	60.7	34.6	25.4	120	338	0	Vert.	No
Measurement uncertainty				±5.5 dB					

*: Antenna factor and cable attenuation

Test: Passed

Test equipment used (refer clause 6):

1 - 9, 35, 37

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

Ambient temperature	22 °C	Relative humidity	31 %

Position of EUT: The EUT was set-up on a non-conducting table of a height of 1.5 m (1 GHz to 40 GHz) and 80 cm (40 GHz to 110 GHz). The distance between EUT and the antenna was 3 m (1 GHz to 40 GHz) and 10 cm /30 cm (40 GHz to 110 GHz).

Test record: All results are shown in the following.

Supply voltage: During the measurement the EUT was supplied with 24 V DC by an external power supply.

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

Result measured with the peak detector:

Frequency [GHz]	Result [dBµV/m]	Limit [dBµV/m]	Margin [dB]	Antenna factor [1/m]	Preamp [dB]	Cable loss [dB]	Corr. Factor [dB]	Azimuth [deg]	Elevation [deg]	Height [cm]	Pol.
24.125	110.8	148.0	37.2	37.2	0.0	4.8	0	346	30	150	Hor.
48.250	63.7	108.0	44.3	44.1	0.0	-	-20.0 *	-	-	150	Hor.
72.375	61.0	108.0	47.0	46.3	0.0	-	-30.0 **	-	-	150	Hor.
Measurement uncertainty							±4.7 dB				

*: Measuring distance correction factor from 30 cm to 3 m
**: Measuring distance correction factor from 10 cm to 3 m

Result measured with the average detector:

Frequency [GHz]	Result [dBµV/m]	Limit [dBµV/m]	Margin [dB]	Antenna factor [1/m]	Preamp [dB]	Cable loss [dB]	Corr. Factor [dB]	Azimuth [deg]	Elevation [deg]	Height [cm]	Pol.
24.125	110.7	128.0	17.3	68.7	37.2	4.8	0	346	30	150	Hor.
48.250	63.7	88.0	44.3	39.6	44.1	0.0	-20.0 *	-	-	150	Hor.
72.375	61.0	88.0	47.0	44.7	46.3	0.0	-30.0 **	-	-	150	Hor.
Measurement uncertainty							±4.7 dB				

*: Measuring distance correction factor from 30 cm to 3 m
**: Measuring distance correction factor from 10 cm to 3 m

Test: Passed

Test equipment used (refer clause 6):

1 - 6, 8, 9, 13, 17, 18, 24 - 26, 35, 37

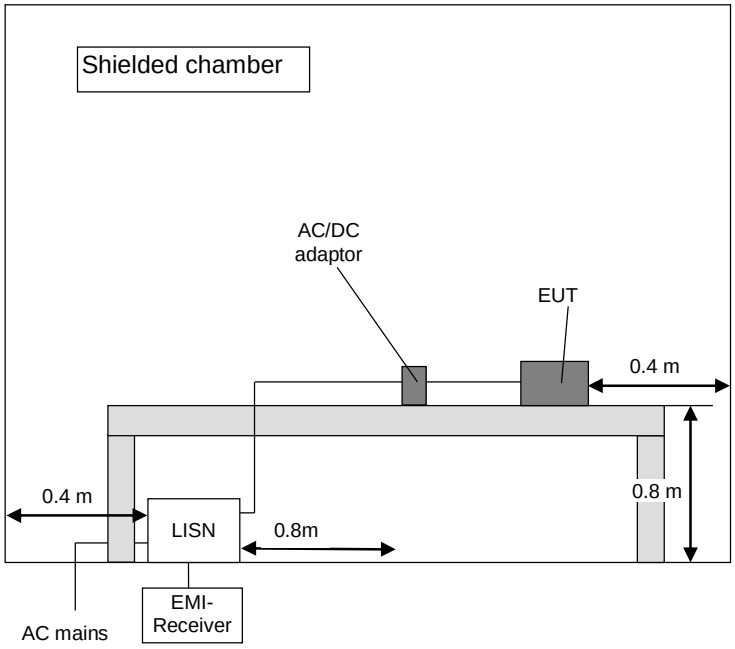
5.5 Conducted emissions on power supply lines (150 kHz to 30 MHz)

5.5.1 Method of measurement

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 setup 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) for WS400-UMB

Ambient temperature	20 °C	Relative humidity	12 %

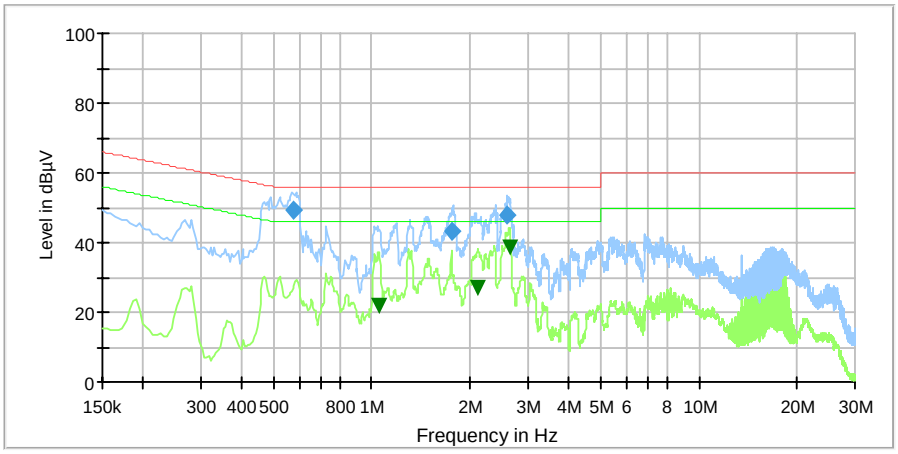
Position of EUT: The EUTs were set-up on a non-conducting table of a height of 0.8 m.

Cable guide: The cable of the EUTs was 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.

Supply voltage: The EUT was supplied with 24.0 V_{DC} by a PHOENIX Contact AC/DC adapter type Quint-PS-100-240AC / 24DC / 5, which was connected to an AC mains network with 120 VAC / 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. The quasi-peak measured points are marked by◆the average measured points are marked with ▼.



Remark: The limits of FCC 15.207 are identical to [3]

Frequency (MHz)	QuasiPeak (dBµV)	Average (dBµV)	Limit (dBµV)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Line	PE	Transducer (dB)
0.5766	49.3	---	56.0	6.7	5000	9	L1	FLO	9.9
1.0572	---	22.0	46.0	24.0	5000	9	N	FLO	9.9
1.7574	43.1	---	56.0	12.9	5000	9	L1	FLO	10.0
2.1048	---	26.9	46.0	19.1	5000	9	N	FLO	10.1
2.5998	47.9	---	56.0	8.1	5000	9	N	FLO	10.2
2.6592	---	38.8	46.0	7.2	5000	9	N	FLO	10.2
Measurement uncertainty			±2.8 dB						

Test: Passed

Test equipment used (refer clause 6):

29 - 34, 36, 37

5.5.3 Test results (conducted emissions on power supply lines) for WS600-UMB

Ambient temperature	20 °C	Relative humidity	12 %

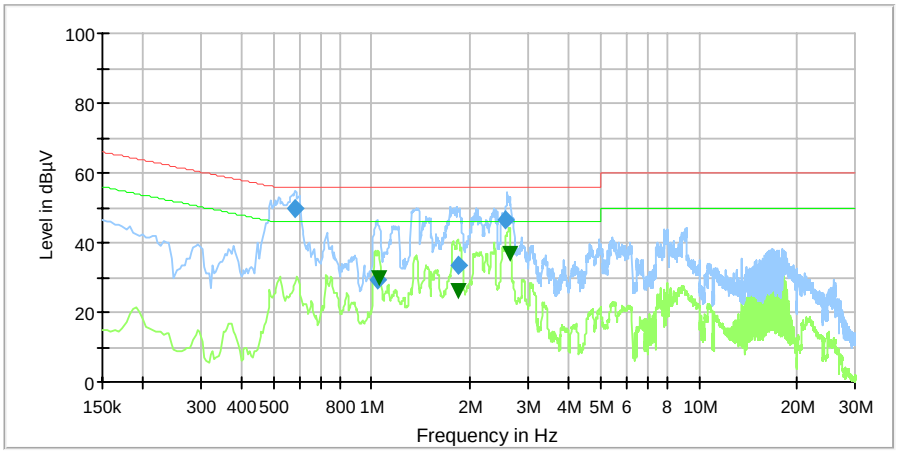
Position of EUT: The EUTs were set-up on a non-conducting table of a height of 0.8 m.

Cable guide: The cable of the EUTs was 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.

Supply voltage: The EUT was supplied with 24.0 V_{DC} by a PHOENIX Contact AC/DC adapter type Quint-PS-100-240AC / 24DC / 5, which was connected to an AC mains network with 120 VAC / 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. The quasi-peak measured points are marked by◆the average measured points are marked with ▼.



Remark: The limits of FCC 15.207 are identical to [3]

Frequency (MHz)	QuasiPeak (dBµV)	Average (dBµV)	Limit (dBµV)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Line	PE	Transducer (dB)
0.5820	49.8	---	56.0	6.2	5000	9	L1	FLO	9.9
1.0383	29.3	---	56.0	26.7	5000	9	L1	FLO	9.9
1.0554	---	29.7	46.0	16.3	5000	9	L1	FLO	9.9
1.8375	33.5	---	56.0	22.5	5000	9	N	FLO	10.0
1.8438	---	26.3	46.0	19.7	5000	9	N	FLO	10.0
2.5737	46.6	---	56.0	9.4	5000	9	N	FLO	10.2
2.6502	---	36.8	46.0	9.2	5000	9	N	FLO	10.2
Measurement uncertainty			±2.8 dB						

Test: Passed

Test equipment used (refer clause 6):

29 - 34, 36, 37

5.5.4 Test results (conducted emissions on power supply lines) for WS700-UMB

Ambient temperature	20 °C	Relative humidity	12 %

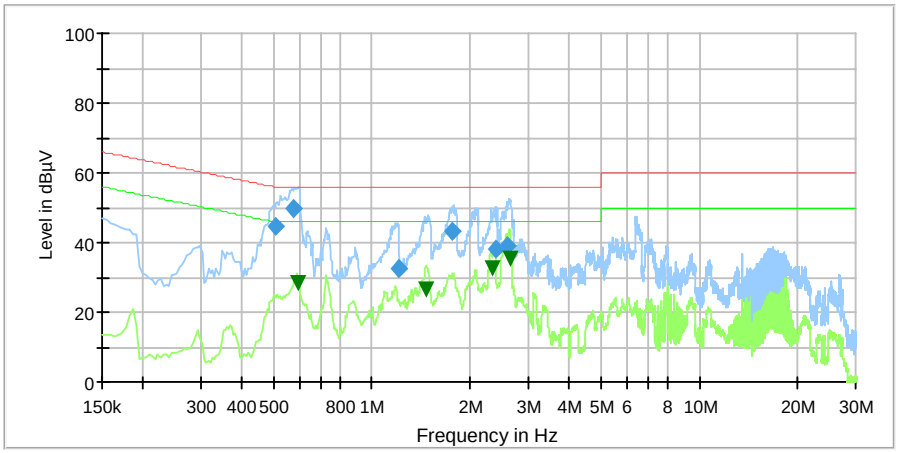
Position of EUT: The EUTs were set-up on a non-conducting table of a height of 0.8 m.

Cable guide: The cable of the EUTs was 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.

Supply voltage: The EUT was supplied with 24.0 V_{DC} by a PHOENIX Contact AC/DC adapter type Quint-PS-100-240AC / 24DC / 5, which was connected to an AC mains network with 120 VAC / 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. The quasi-peak measured points are marked by◆the average measured points are marked with ▼.



Frequency (MHz)	QuasiPeak (dBµV)	Average (dBµV)	Limit (dBµV)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Line	PE	Transducer (dB)
0.5091	44.7	---	56.0	11.3	5000	9	L1	GND	9.9
0.5766	49.8	---	56.0	6.2	5000	9	L1	FLO	9.9
0.5928	---	28.3	46.0	17.7	5000	9	L1	FLO	9.9
1.2066	32.6	---	56.0	23.4	5000	9	L1	FLO	9.9
1.4595	---	26.4	46.0	19.6	5000	9	N	FLO	9.9
1.7511	43.1	---	56.0	12.9	5000	9	N	FLO	10.0
2.3442	---	32.7	46.0	13.3	5000	9	N	FLO	10.2
2.3973	37.9	---	56.0	18.1	5000	9	L1	FLO	10.2
2.6016	39.0	---	56.0	17.0	5000	9	L1	FLO	10.2
2.6448	35.4	---	46.0	10.6	5000	9	N	FLO	10.2
Measurement uncertainty			±2.8 dB						

Test: Passed

Test equipment used (refer clause 6):

29 - 34, 36, 37

5.5.5 Test results (conducted emissions on power supply lines) for WS800-UMB

Ambient temperature	20 °C	Relative humidity	12 %

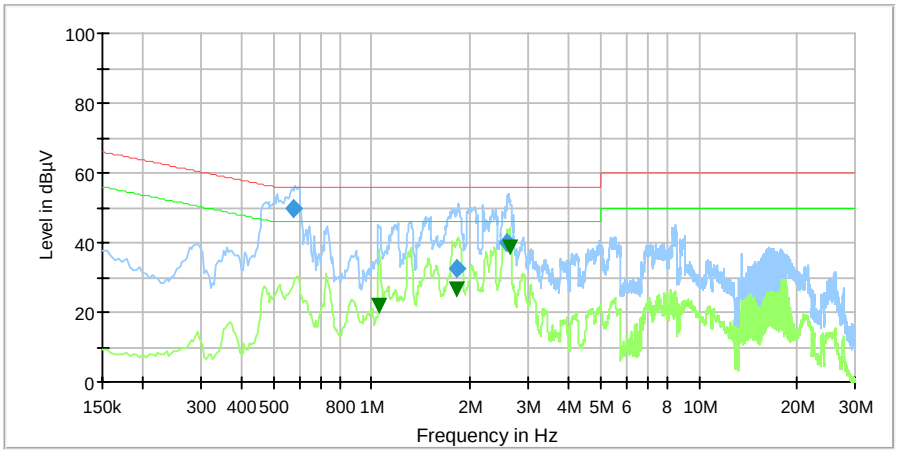
Position of EUT: The EUTs were set-up on a non-conducting table of a height of 0.8 m.

Cable guide: The cable of the EUTs was 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.

Supply voltage: The EUT was supplied with 24.0 V_{DC} by a PHOENIX Contact AC/DC adapter type Quint-PS-100-240AC / 24DC / 5, which was connected to an AC mains network with 120 VAC / 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. The quasi-peak measured points are marked by◆the average measured points are marked with ▼.



Frequency (MHz)	QuasiPeak (dBµV)	Average (dBµV)	Limit (dBµV)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Line	PE	Transducer (dB)
0.5766	49.7	---	56.0	6.3	5000	9	L1	FLO	9.9
1.0572	---	22.0	46.0	24.0	5000	5000	L1	FLO	9.9
1.8150	32.7	---	56.0	23.3	5000	5000	L1	GND	10.0
1.8276	---	26.4	46.0	19.6	5000	5000	N	FLO	10.0
2.5998	39.9	---	56.0	16.1	5000	5000	N	FLO	10.2
2.6601	---	38.6	46.0	7.4	5000	5000	N	FLO	10.2
Measurement uncertainty			±2.8 dB						

Test: Passed

Test equipment used (refer clause 6):

29 - 34, 36, 37

6 Test equipment and ancillaries used for tests

No.	Test equipment	Type	Manufacturer	Serial No.	PM. No.	Cal. Date	Cal. due
1	Semi anechoic chamber M276	SAC5-2	Albatross Projects	C62128-A540-A138-10-0006	483227	Calibration not necessary	
2	RF Switch Matrix	OSP220	Rohde & Schwarz		482976	Calibration not necessary	
3	Turntable	TT3.0-3t	Maturo	825/2612/.01	483224	Calibration not necessary	
4	Controller	NCD	Maturo	474/2612.01	483226	Calibration not necessary	
5	Positioner	TG1.5-10kg	Maturo	110/2648.01	483042	Calibration not necessary	
6	System software EMC32 M276	EMC32	Rohde & Schwarz	100970	482972	Calibration not necessary	
7	Ultralog Antenna	HL562E	Rohde & Schwarz	101079	482978	07.08.2019	08.2022
8	EMI Test receiver ESW	ESW44	Rohde & Schwarz	101828	482979	12.04.2019	04.2021
9	Antenna support	BAM 4.5-P-10kg	Maturo	222/2612.01	483225	Calibration not necessary	
10	Log Per Antenna	HL050	Rohde & Schwarz	4062.4063.02-100908	482977	13.08.2019	08.2022
11	Preamplifier	LNA-30-00101800-25-10P	Narda-Miteq	2110917	482967	18.02.2020	02.2022
12	Standard gain horn 12 GHz – 18 GHz	18240-20	Flann	267220	483025	Calibration not necessary	
13	Standard gain horn 18 GHz – 26.5 GHz	20240-20	Flann	266399	483026	Calibration not necessary	
14	Standard gain horn 26.5 GHz – 40 GHz	22240-20	Flann	266405	483027	Calibration not necessary	
15	Preamplifier	LNA-30-12001800-13-10P	Narda-Miteq	2089798	482968	17.02.2020	02.2022
16	Preamplifier	LNA-30-26004000-27-10P	Narda-Miteq	2110293	482970	17.02.2020	02.2022
17	Harmonic mixer with	FS-Z60	Rohde & Schwarz	100980	482708	11.03.2020	03.2021
	Standard gain horn 40 GHz – 60 GHz	24240-20	Flann Microwave	263442	482858	Calibration not necessary	
18	Harmonic mixer with	FS-Z75	Rohde & Schwarz	101067	482705	11.03.2020	03.2021
	Standard gain horn 50 GHz – 75 GHz	25240-20	Flann Microwave	263443	482859	Calibration not necessary	
19	Harmonic mixer with	FS-Z110	Rohde & Schwarz	101528	482707	11.03.2020	03.2021
	Standard gain horn 75 GHz – 110 GHz	27240-20	Flann Microwave	263447	482861	Calibration not necessary	
20	Cable C417	Sucoflex 118	Huber+Suhner	500654/118	-	Calibration not necessary	
21	Cable C416	Sucoflex 118	Huber+Suhner	500651/118	-	Calibration not necessary	
22	Cable C416.1	Sucoflex 118	Huber+Suhner	500653/118	-	Calibration not necessary	
23	Cable C419	Sucoflex 102	Huber+Suhner	510842/2	-	Calibration not necessary	
24	RF-cable 0.5 m	SF102	Huber+Suhner	510210/2	483030	Calibration not necessary	
25	RF-cable 0.5 m	SF102	Huber+Suhner	510213/2	483031	Calibration not necessary	
26	Signal & Spectrum Analyzer	FSW43	Rohde & Schwarz	100586 & 100926	481720	04.03.2020	03.2022

No.	Test equipment	Type	Manufacturer	Serial No.	PM. No.	Cal. Date	Cal. due
27	Loop antenna	HFH2-Z2	Rohde & Schwarz	100417	481912	05.02.2020	02.2021
28	Outdoor test site	-	PHOENIX TESTLAB	-	480293	Calibration not necessary	
29	EMI Receiver / Spectrum Analyser	ESI 40	Rohde & Schwarz	100064/040	480355	11.02.2020	02.2021
30	Shielded chamber M4	-	Siemens	B83117-S1-X158	480088	Calibration not necessary	
31	EMI Receiver	ESIB 26	Rohde & Schwarz	1088.7490	481182	12.02.2020	02.2022
32	LISN	NSLK8128	Schwarzbeck	8128161	480138	11.02.2020	02.2022
33	Transient Limiter	CFL 9206A	Teseq	38268	481982	Calibration not necessary	
34	Software	EMC32	Rohde & Schwarz	100061	481022	Calibration not necessary	
35	DC power supply	HM8142	Hameg	142981P 03955	480719	Calibration not necessary	
36	AC source	AC6803A	Keysight	JPVJ002509	482350	Calibration not necessary	
37	Digital multimeter	971A	Hewlett Packard	JP39009358	480721	16.01.2020	01.2021

7 Test site validation

Test equipment	PM. No.	Frequency range	Type of validation	According to	Val. Date	Val Due
Semi anechoic chamber M276	483227	30 – 1000 MHz	NSA	ANSI C63.4-2014	28.10.2019	27.10.2020
Semi anechoic chamber M276	483227	1 -18 GHz	SVSWR	CISPR 16-1-4 Amd. 1	28.10.2019	27.10.2020
Shielded chamber M4	480088	9 kHz – 30 MHz	GND-Plane	ANSI C63.4-2014	06.11.2018	05.11.2020

8 Report history

Report Number	Date	Comment
F200299E1	20.04.2020	Document created
-	-	-
-	-	-

9 List of annexes

Annex A Test setup photographs 10 pages