PHOENIX TESTLAB
Königswinkel 10
32825 Blomberg, Germany
Phone: +49 (0) 52 35 / 95 00-0
Fax: +49 (0) 52 35 / 95 00-10
office@phoenix-testlab.de
www.phoenix-testlab.de

Test Report

Report Number:

F181708E1

Equipment under Test (EUT):

K-MC1_LP

Applicant:

RFbeam Microwave GmbH

Manufacturer:

RFbeam Microwave 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.

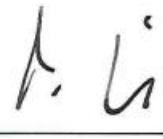
[2] **FCC CFR 47 Part 15** Radio Frequency Devices

[3] **RSS-210 Issue 9 (August 2016)** 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		04.06.2019
	Name	Signature	Date
Authorized reviewer:	Michael DINTER		04.06.2019
	Name	Signature	Date

RESERVATION

This test report is only valid in its original form.

Contents: Page

1 Identification

1.1 Applicant

Name:	RFbeam Microwave GmbH
Address:	Schuppisstrasse 7, 9016 St.Gallen
Country:	Schweiz
Name for contact purposes:	Léon AUDERGON
Phone:	+41 71 245 3380
Fax:	+41 71 245 3381
eMail Address:	audergon@rfbeam.ch
Applicant represented during the test by the following person:	Léon AUDERGON

1.2 Manufacturer

Name:	RFbeam Microwave GmbH
Address:	Schuppisstrasse 7, 9016 St.Gallen
Country:	Schweiz
Name for contact purposes:	Léon AUDERGON
Phone:	+41 71 245 3380
Fax:	+41 71 245 3381
eMail Address:	audergon@rfbeam.ch
Manufacturer represented during the test by the following person:	Léon AUDERGON

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: *	Doppler radar module
Model name / HVIN: *	K-MC1_LP
FCC ID: *	2ASYV-K-MC1LP
IC: *	24358-KMC1LP
PCB identifier: *	RFB_261D
PMN: *	K-MC1_LP
Serial number: *	L1813n00358
Hardware version: *	D
Software version: *	N/A
Lowest / highest internal frequency: *	100 kHz / wanted signal

1.5 Technical data of equipment

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: *	+18 dBm (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: *	Pulsed CW					
Bit rate of transmitter: *	-					
Supply Voltage (EUT): *	U_{Nom} =	3.3 V_{DC}	U_{Min}=	3.15 V_{DC}	U_{Max}=	6.0 V_{DC}
Power Supply: *	External					
Temperature range: *	-20°C to +80°C					
Ancillaries to be tested with:	Control board (provided by the applicant) and AC/DC adapter CAT. NO. 273-316 for conducted emissions on power supply line					

*: Declared by the applicant.

The following external I/O cables were used:

Identification	Connector		Length
	EUT	Ancillary	
DC and IF output	8-pole terminal block	8-pole terminal block (on control board)	0.2 m
-	-	-	-
-	-	-	-
-	-	-	-

1.6 Dates

Date of receipt of test sample:	04.02.2019
Start of test:	04.02.2019
End of test:	21.02.2019

2 Operational states

All tests were carried out with an unmodified sample with integral antenna, which was supplied with 3.3 V_{DC} either by the control board or an external power supply.

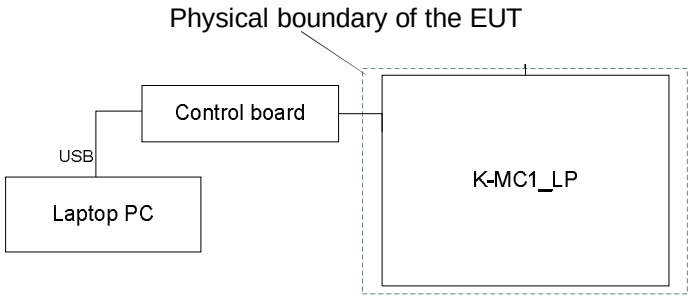
The EUT is a radar transceiver sensor module for distance measurements intended to be used in several applications.

During all measurements except the emission measurement on the AC line, the EUT was connected to a laptop PC via the control board and USB. On the Laptop PC the test software was running (RFbeam SignalViewer Version 3.2.1, supplied by the applicant). During the emission measurement on the AC line the EUT was supplied with 3.3 V_{DC} by an external power supply directly.

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.

For the whole frequency range a preliminary measurement in a fully 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 on an outdoor test site without ground plane (for the frequency range 9 kHz to 30 MHz), on an open area test site with ground plane (for the frequency range 30 MHz to 1 GHz) or the fully anechoic chamber (for the frequency range 1 GHz to 100 GHz).

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



3 Additional Information

The EUT used for the tests was not labeled.

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	11 et seq.
Band edge compliance	24.075 GHz to 24.175 GHz	15.215 (c)	6.10 [1]	Passed	14 et seq.
Field strength of fundamental	24.075 GHz to 24.175 GHz	15.245 (b)	F.1 (a) [3]	Passed	17 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	17 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	17 et seq.
Conducted emissions	150 kHz to 30 MHz	15.207	8.8 [4]	Passed	34 et seq.
Antenna requirement	-	15.203 [2]	6.8 [4]	Passed *	-

*: Integrated antenna only, requirement fulfilled.

5 Test results

5.1 Transmitter timing

5.1.1 Method of measurement

The following measurement technique was used:

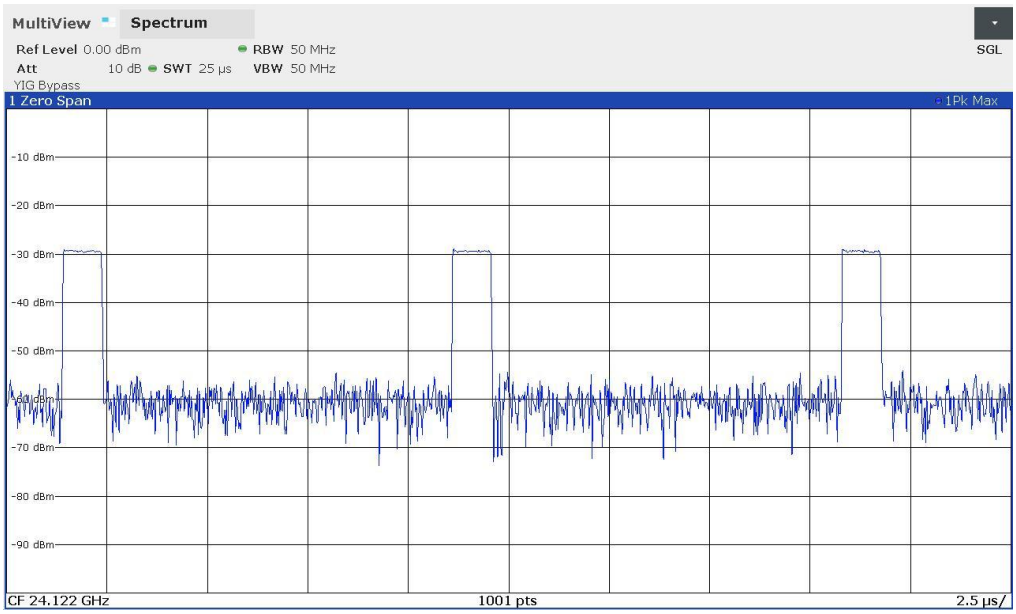
- Set the center frequency of the instrument to the center frequency of the transmission.
- Set RBW ≥ OBW if possible; otherwise, set RBW to the largest available value.
- Set VBW ≥ RBW.
- Set detector = peak or average.
- Set the span to zero-span.
- Set the sweep mode to single sweep.
- The zero-span measurement method shall not be used unless both RBW and VBW are > 50/T and the number of sweep points across duration T exceeds 100. (For example, if VBW and/or RBW are limited to 3 MHz, then the zero-span method of measuring duty cycle shall not be used if T ≤ 16.7 microseconds.)

5.1.2 Test result (transmitter timing)

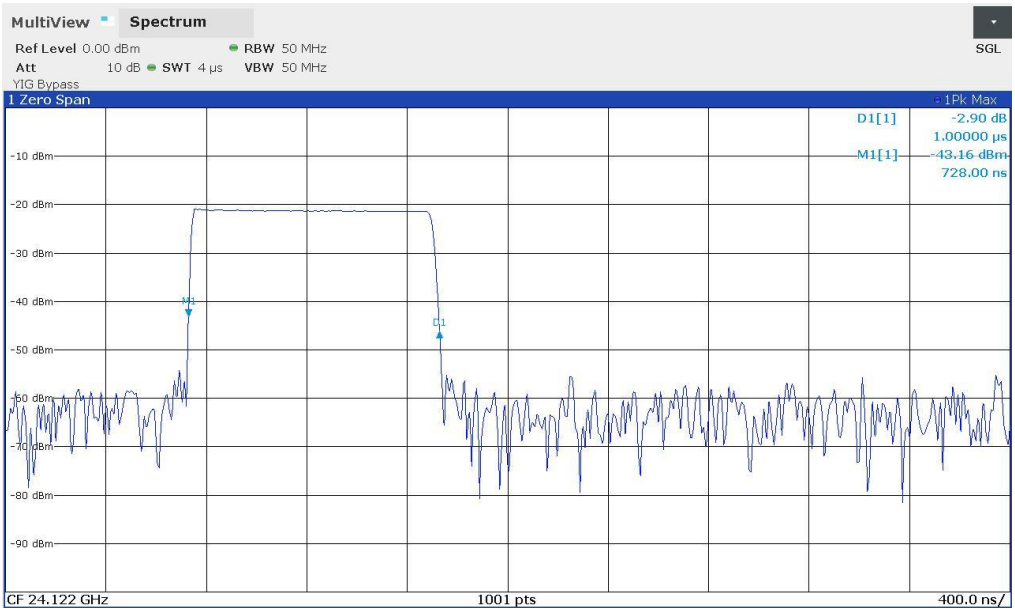
Ambient temperature	22 °C	Relative humidity	37 %

The measurement was performed radiated inside the fully anechoic chamber.

181708_26.wmf: Pulse period:



181708_25.wmf: Transmitter on time:



TX_on [µs]	TX_ges [µs]	RBW [MHz]	Sweep points	Sweep time [µs]	Duty cycle %
1	25	50	1001	25	12

The EUT transmits three 1 ms pulses within 25 ms. This is equal to a duty cycle of 12 %, which could be measured with an average detector according to 15.35 [1].

Test equipment used (refer clause 6):

13, 19, 26

5.2 Bandwidth

5.2.1 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:

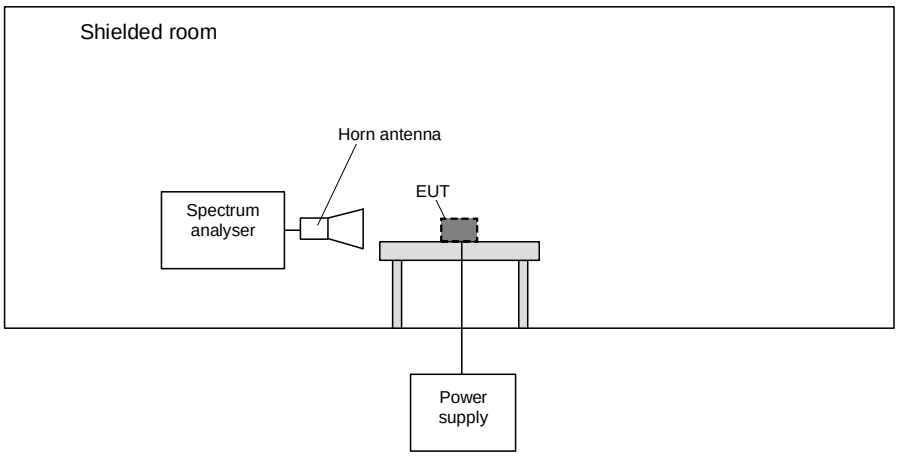
- Span: App. 2 to 3 times the 20 dB bandwidth, centred on the actual channel.
- Resolution bandwidth: App. 1 % of the emission bandwidth.
- Video bandwidth: equal or greater than the RBW.
- Sweep: Auto.
- Detector function: peak.
- Trace mode: Max hold.

<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.



5.3 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 all measurements the EUT was supplied with 3.3 V_{DC} by the control board.

181708_27.jpeg: 20 dB bandwidth:

F_L	F_U	BW (F_U - F_L)
24.102400 GHz	24.109293 GHz	6.893 MHz
Measurement uncertainty		$< \pm 1*10^{-7}$

Test: Passed

Test equipment used (refer clause 6):

13, 19, 26

5.3.1 Test results (99 % bandwidth)

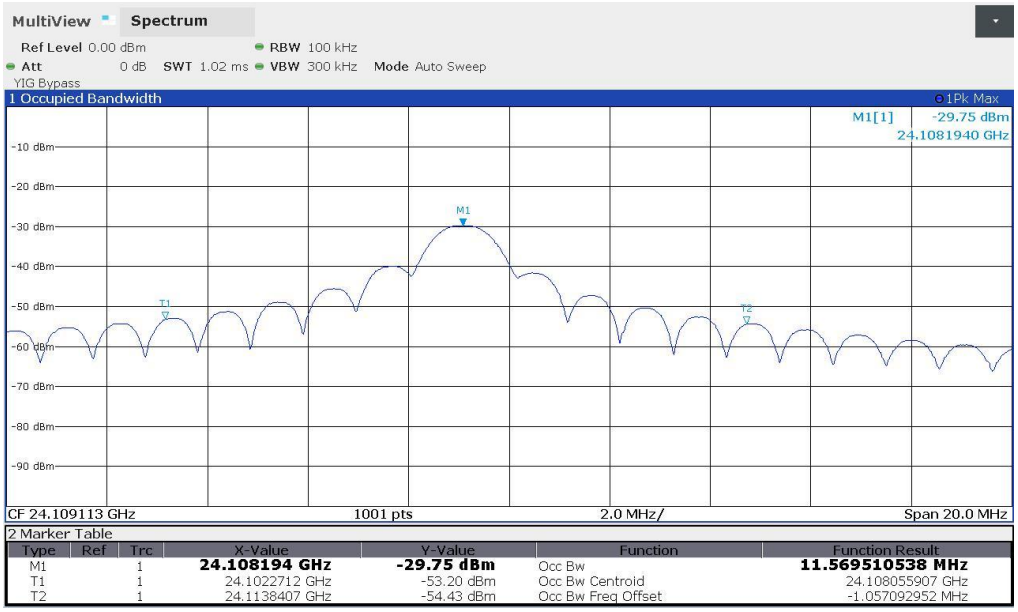
Ambient temperature	22 °C

Relative humidity	37 %

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

Supply voltage: During all measurements the EUT was supplied with 3.3 V_{DC} by the control board.

181708_28.jpeg: 99 % bandwidth:



F_L	F_U	BW (F_U - F_L)
24.102271 GHz	24.113841 GHz	11.570 MHz
Measurement uncertainty		$< \pm 1*10^{-7}$

Test: Passed

Test equipment used (refer clause 6):

13, 19, 26

5.4 Band-edge compliance

5.4.1 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 with 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: ³ 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 5.5.1 of this test report, but 100 kHz resolution bandwidth shall be used.

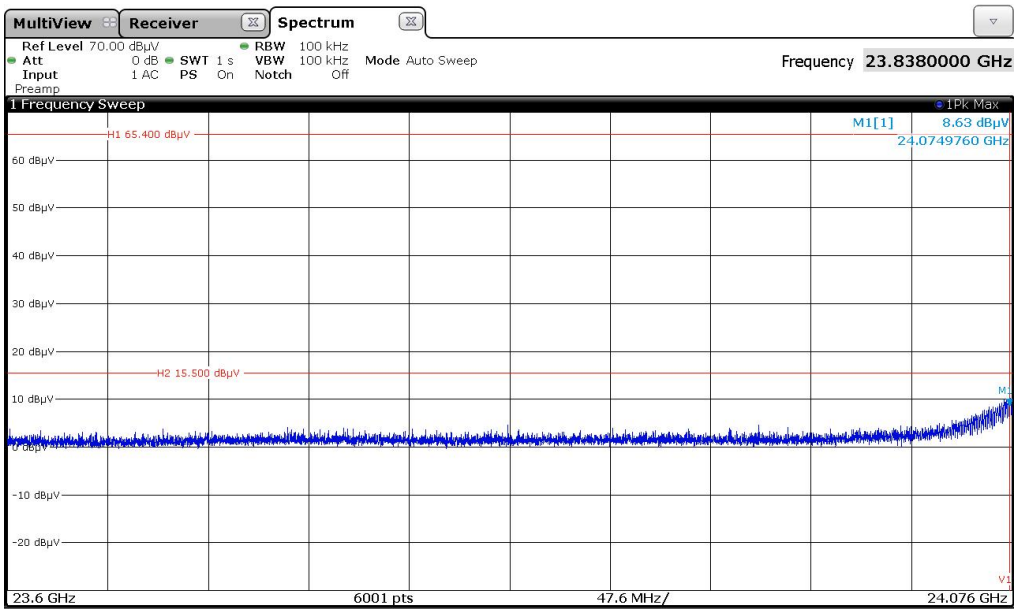
The measurement will be performed at the lower and upper end of the assigned frequency band.

5.4.2 Test results (band-edge compliance)

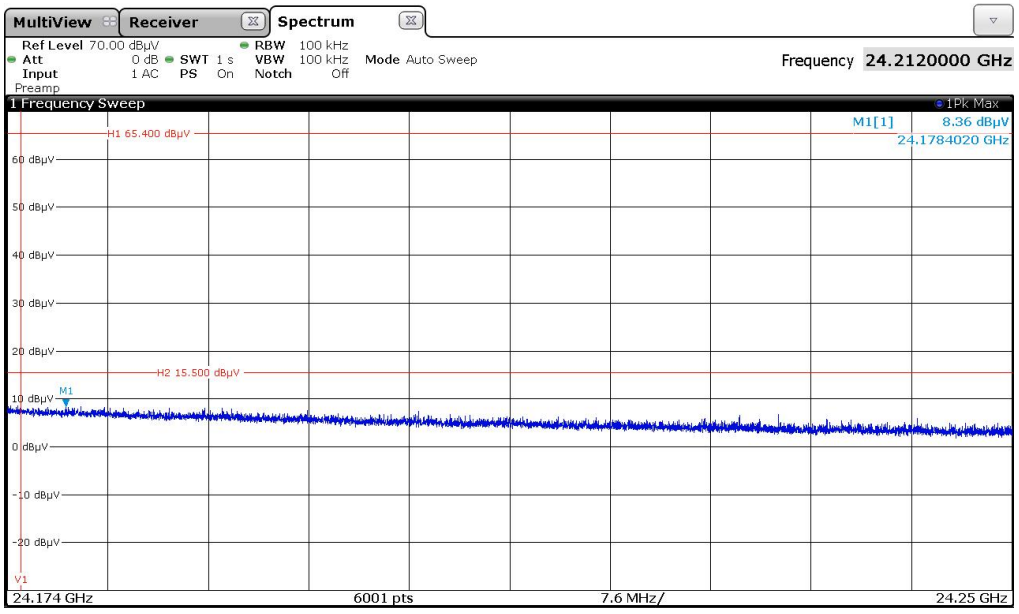
Ambient temperature	22 °C	Relative humidity	65 %

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

181708_15a.wmf: Band-edge compliance, lower band edge:



181708_14a.wmf: 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 (D1) in these plots represents the highest level within the assigned frequency band. The display line 2 (D2) 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 (F1) 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
24.074976	40.6	74.0	33.4	8.6	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
24.074976	34.2	54.0	19.8	2.2	37.2	0.0	4.8	-10.0 / 100 cm	No
Measurement uncertainty							-3.6 dB / +2.2 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
24.178402	40.4	74.0	33.6	8.4	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
24.178402	28.4	54.0	25.6	-3.6	37.2	0.0	4.8	-10.0 / 100 cm	No
Measurement uncertainty							-3.6 dB / +2.2 dB		

Test: Passed

Test equipment used (refer clause 6):

1, 2, 13, 19

5.5 Radiated emissions

5.5.1 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 110 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.

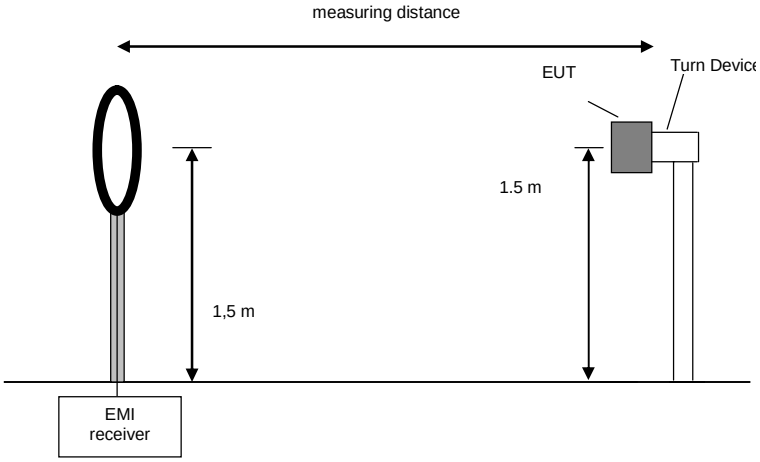
Preliminary measurement (9 kHz to 30 MHz):

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 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 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 (only if the EUT is a module or is used in a handheld application).
7) Rotate the measuring antenna and repeat steps 1) to 5).

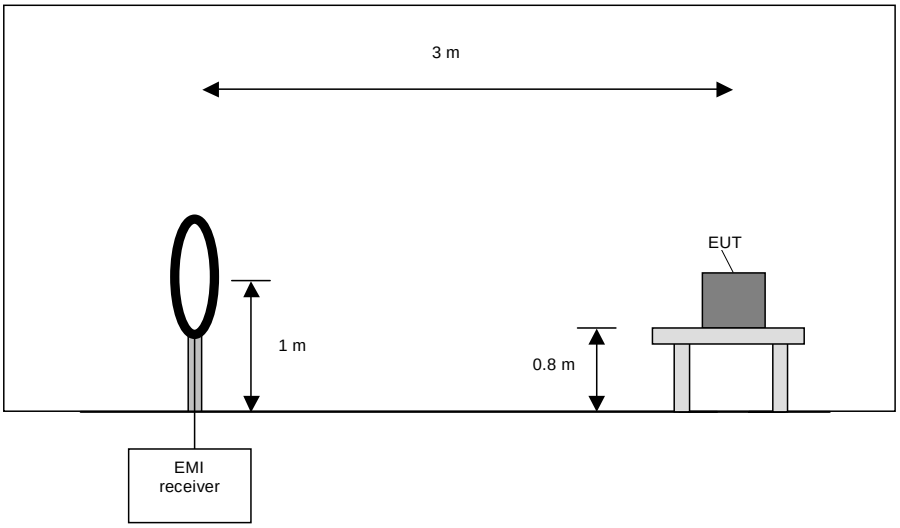
Final measurement (9 kHz to 30 MHz):

In the second stage a final measurement will be performed on an open area test site with no conducting ground plane 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).

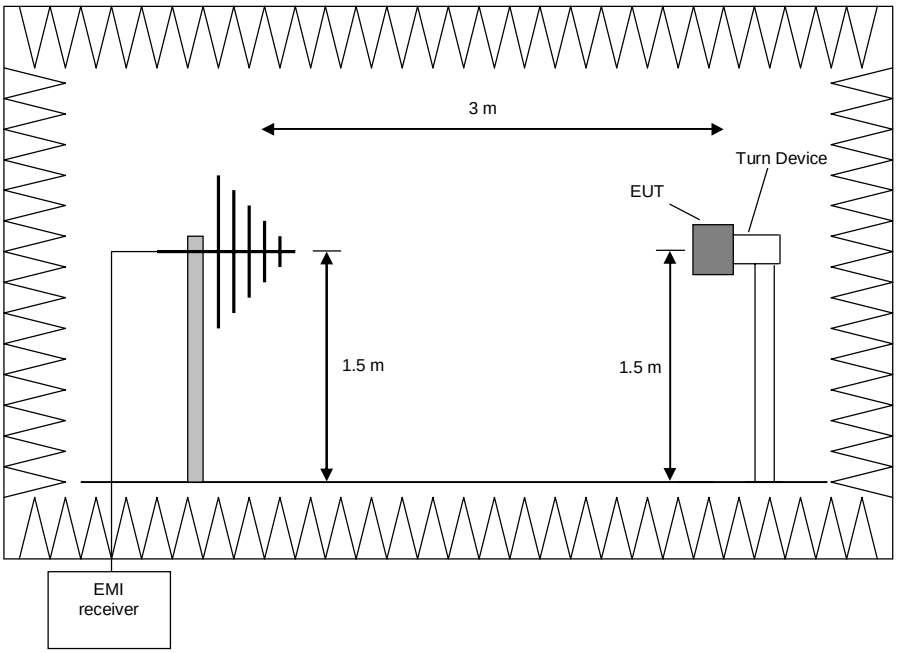
Preliminary measurement (30 MHz to 1 GHz)

In the first stage a preliminary measurement will be performed in a fully anechoic chamber with a measuring distance of 3 meter. Table top 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 1 GHz	120 kHz



Procedure preliminary measurement:

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

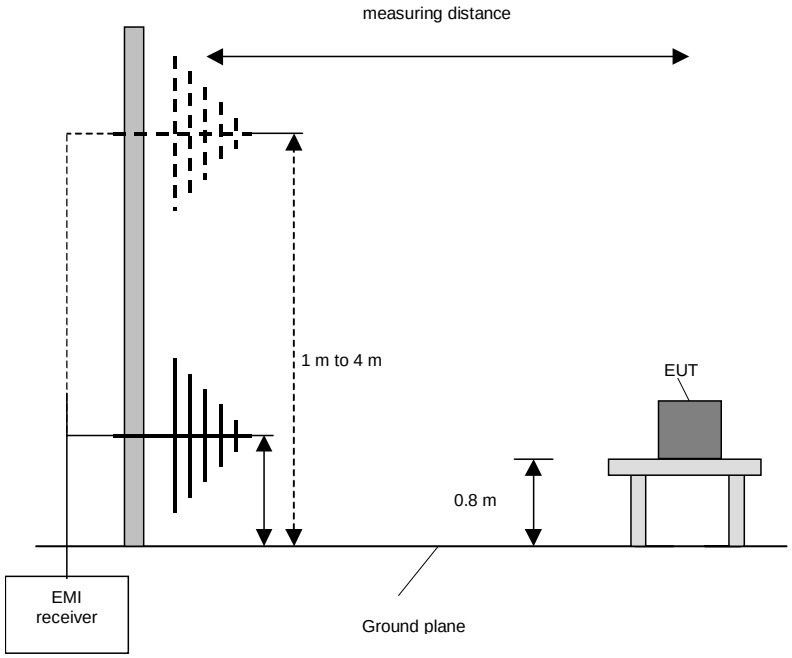
1. Monitor the frequency range at horizontal polarisation and a EUT azimuth of 0 °.
2. Manipulate the system cables within the range to produce the maximum level of emission.
3. Rotate the EUT by 360 ° to maximize the detected signals.
4. Make a hardcopy of the spectrum.
5. Measure the frequency of the 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 (only if the EUT is a module or is used in a handheld 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:

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

Preliminary and final measurement (1 GHz to 40 GHz)

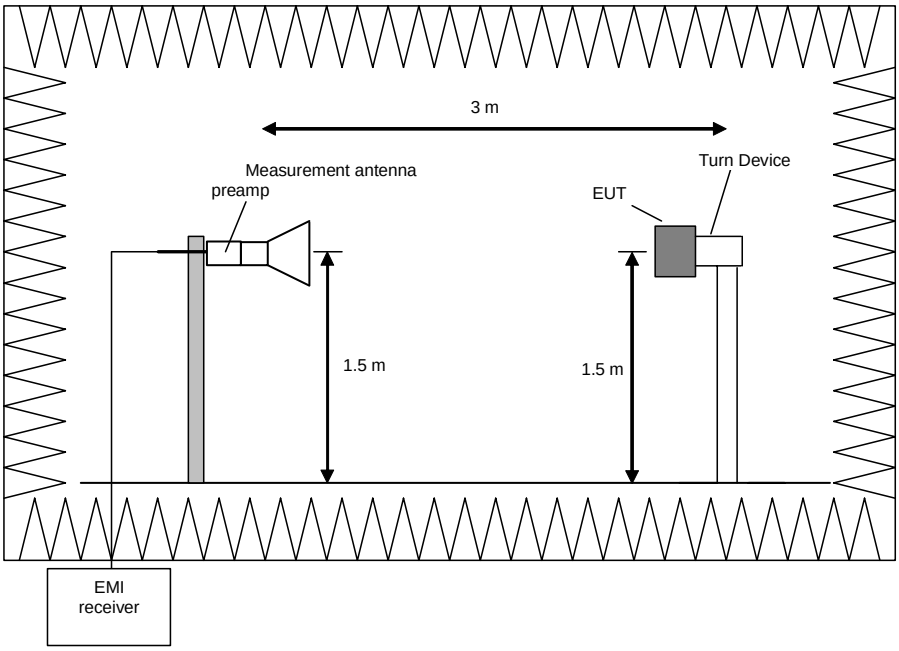
This measurement will be performed in a fully anechoic chamber. Table top devices will set up on a non-conducting turn device on the height of 1.5 m. The set-up of the Equipment under test will be in accordance to [1].

Preliminary measurement (1 GHz to 40 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 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 °. This measurement is repeated after raising the EUT in 30 ° steps according 6.6.5.4 in [1].

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



Procedure preliminary measurement:

Prescans were performed in the frequency range 1 to 40 GHz.
The following procedure will be used:

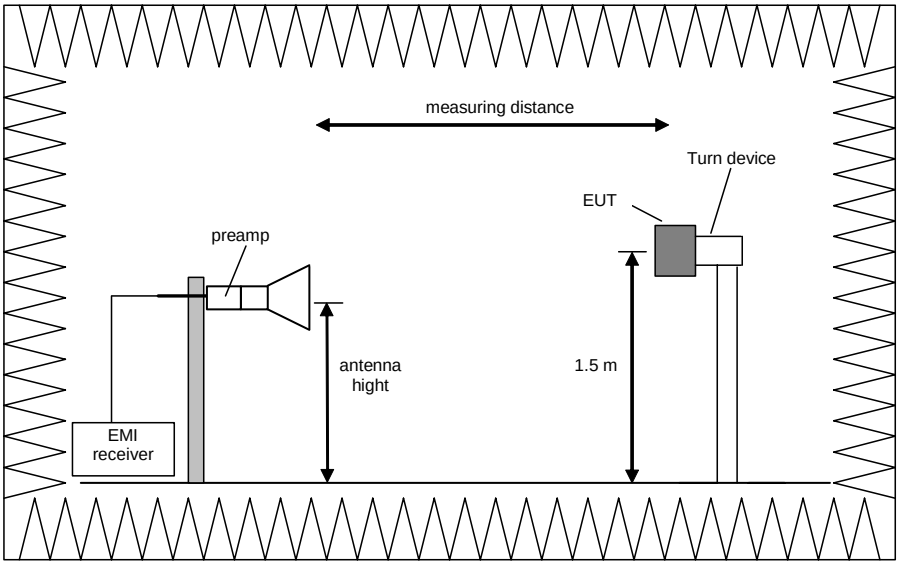
1. Monitor the frequency range at horizontal polarisation and a EUT azimuth of 0 °.
2. Rotate the EUT by 360° to maximize the detected signals.
3. Repeat 1) to 2) with the vertical polarisation of the measuring antenna.
4. Make a hardcopy of the spectrum.
5. Repeat 1) to 4) with the EUT raised by an angle of 30° (60°, 90°, 120° and 150°) according to 6.6.5.4 in [1].
6. Measure the frequency of the detected emissions with a lower span and resolution bandwidth to increase the accuracy and note the frequency value.
7. The measurement antenna polarisation, with the according EUT position (Turntable and Turn device) which produces the highest emission for each frequency will be used for the final measurement. The six closest values to the applicable limit will be used for the final measurement.

Final measurement (1 GHz to 40 GHz)

The frequency range will be divided into different sub ranges depending of the frequency range of the used antenna. The EMI Receiver set to peak and average mode and a resolution bandwidth of 1 MHz. The measurement will be performed by rotating the turntable through 0 to 360° in the worst-case EUT orientation which was obtained during the preliminary measurements.

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



Procedure of measurement:

The measurements were performed in the frequency range 1 GHz to 110 GHz.
The following procedure will be used:

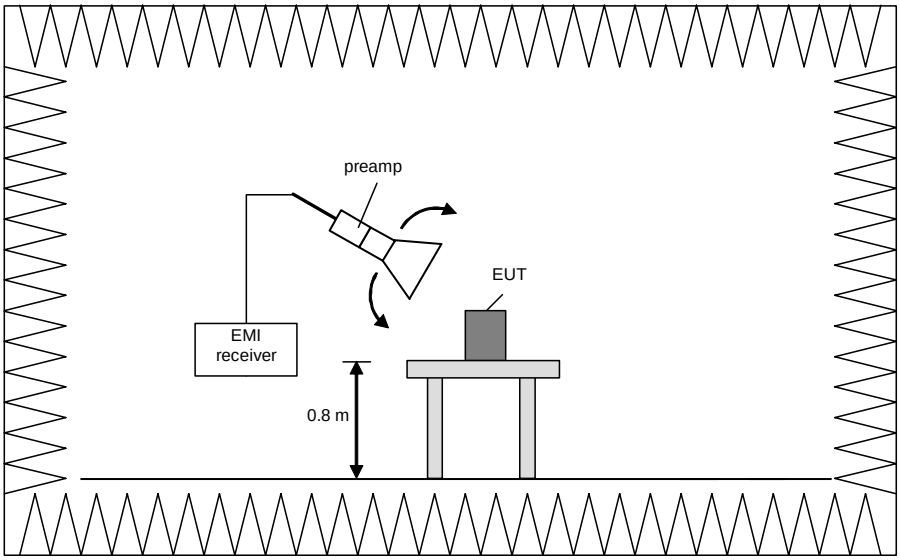
1) Set the turntable and the turn device to obtain the worst-case emission for the first frequency identified in the preliminary measurements.
2) Set the measurement antenna polarisation to the orientation with the highest emission for the first frequency identified in the preliminary measurements.
3) Set the spectrum analyser to EMI mode with peak and average detector activated.
4) Rotate the turntable from 0° to 360° to find the EUT angle that produces the highest emissions.
5) Note the highest displayed peak and average values
6) Repeat the steps 1) to 5) for each frequency detected during the preliminary measurements.

Preliminary 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 spectrum analyser 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, 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

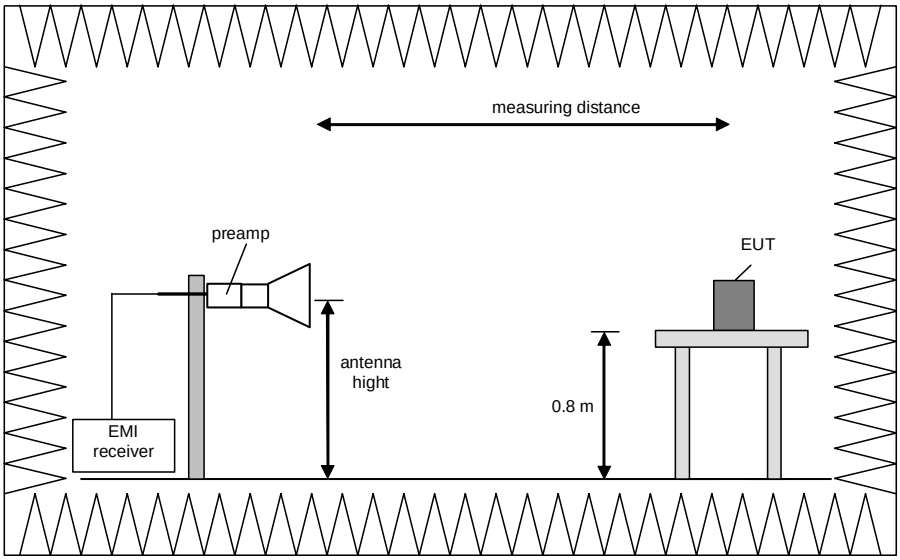


Final measurement (1 GHz to 110 GHz)

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
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 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.

5.5.3 Test results (radiated emissions)

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

Ambient temperature	22 °C	Relative humidity	60 %

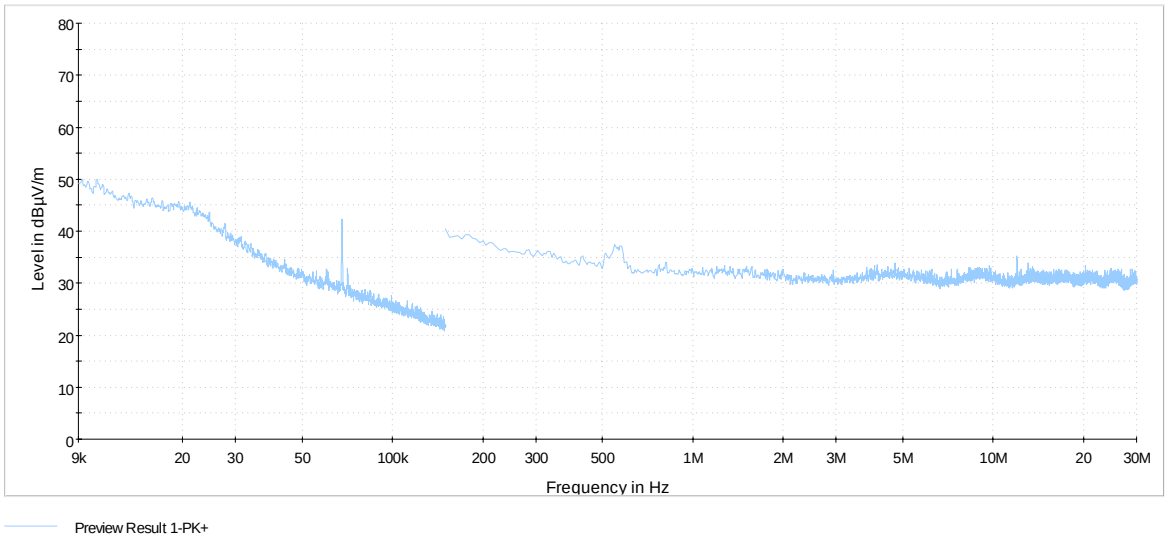
Position of EUT: The EUT was set-up on a non-conducting position device of a height of 1.5 m (9 kHz to 40 GHz) and 80 cm (40 GHz to 100 GHz). The distance between EUT and the antenna was 3 m (9 kHz to 26.5 GHz) and 1 m (26.5 GHz to 100 GHz).

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 3.3 V_{DC} by the control board.

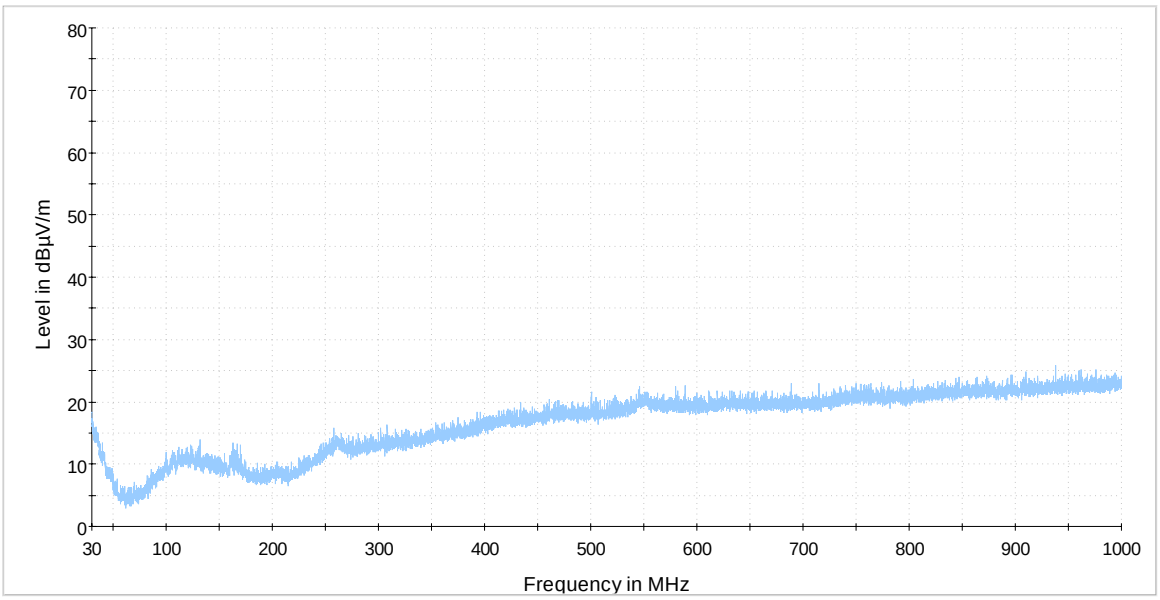
Radiated emissions from 9 kHz to 30 MHz:



The emissions around 71 MHz caused by the measurements system and not by the EUT.

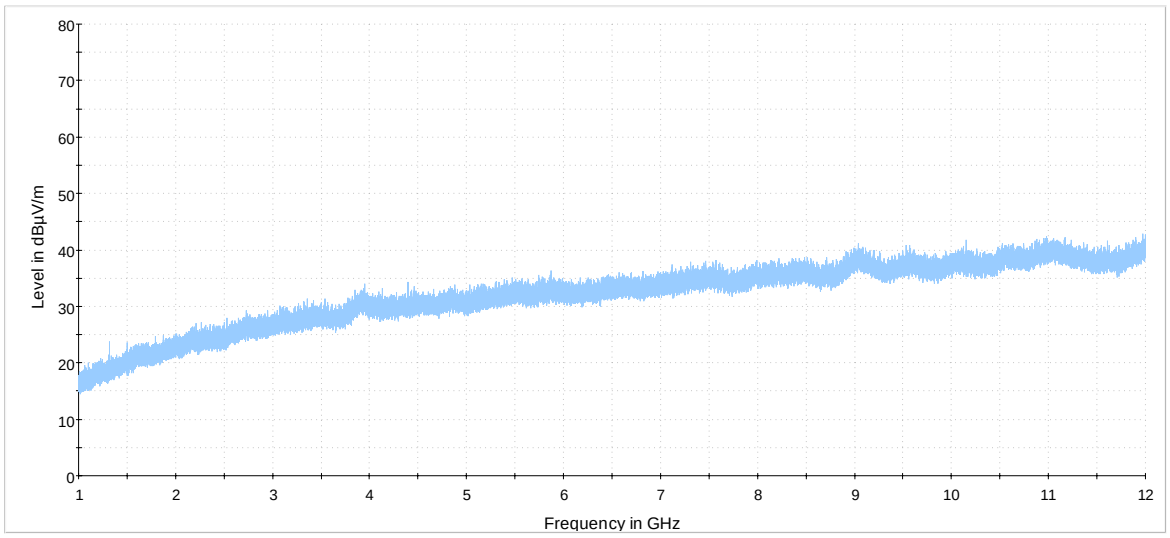
No emissions above the noise floor of the measurement system (max. 48 dBµV/m (measured with peak detector at 3 m distance)) found during the preliminary measurement. So no final measurements on the outdoor test site were carried out.

Radiated emissions from 30 MHz to 1000 MHz:

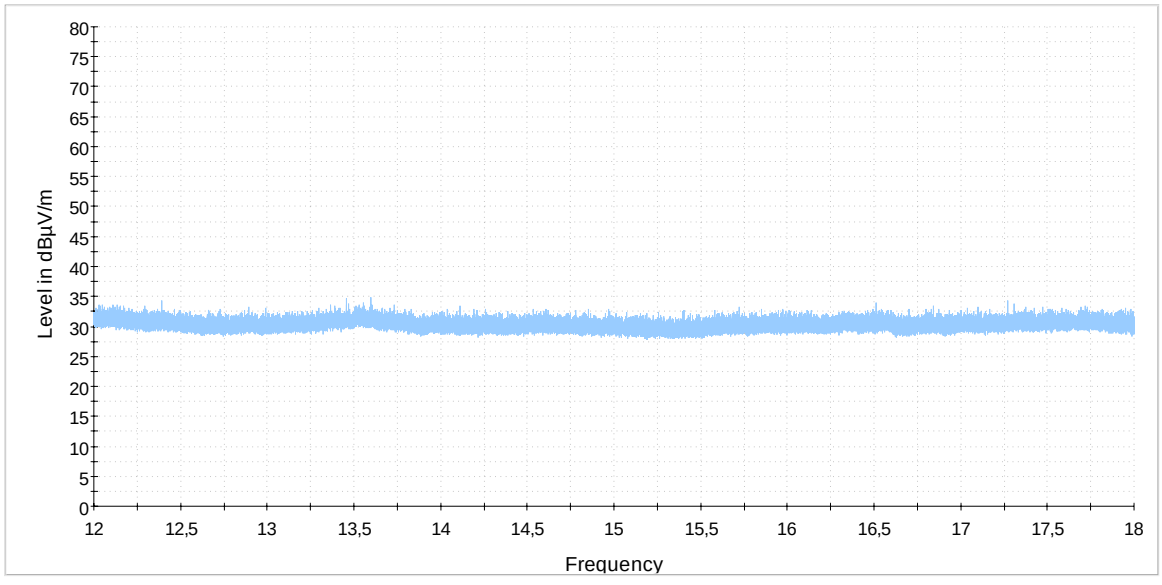


No emissions above the noise floor of the measurement system (max. 25 dBµV/m (measured with peak detector at 3 m distance)) found during the preliminary measurement. So no final measurements on the open area test site were carried out.

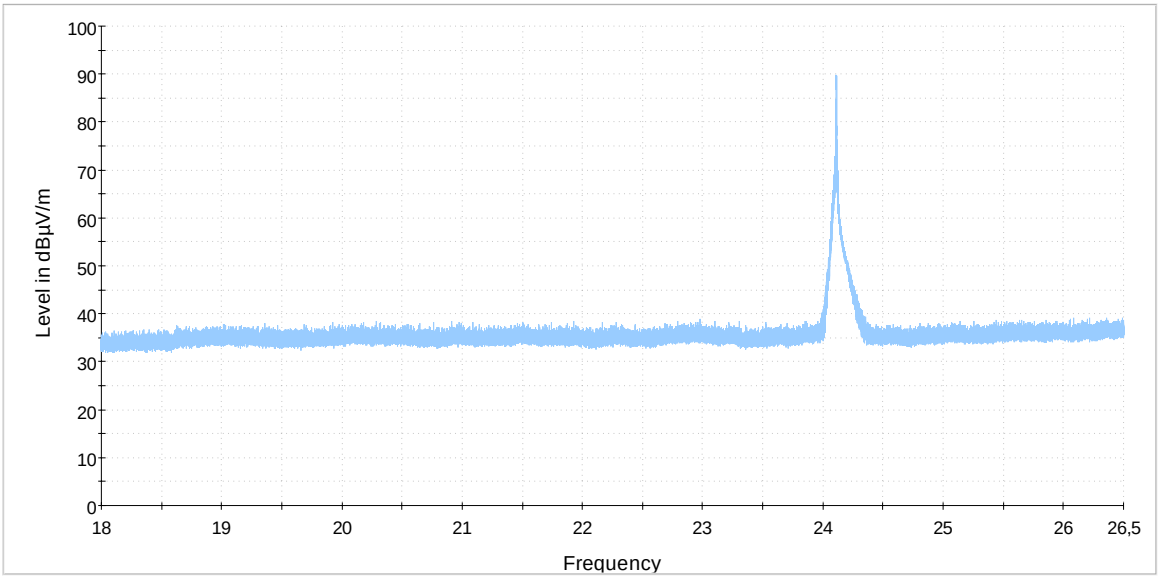
Radiated emissions from 1 GHz to 12 GHz:



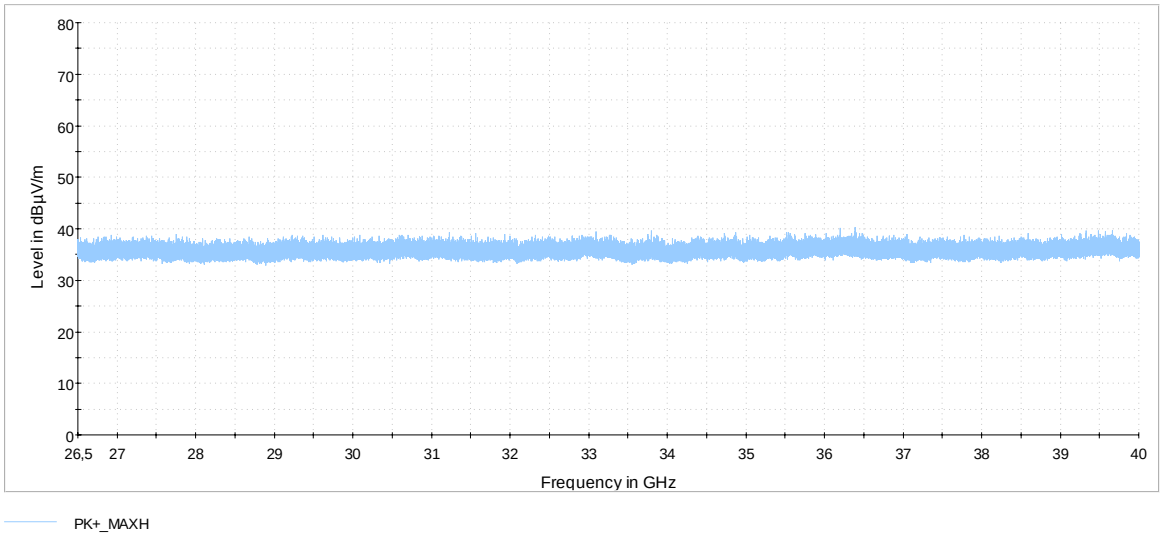
Radiated emissions from 12 GHz to 18 GHz:



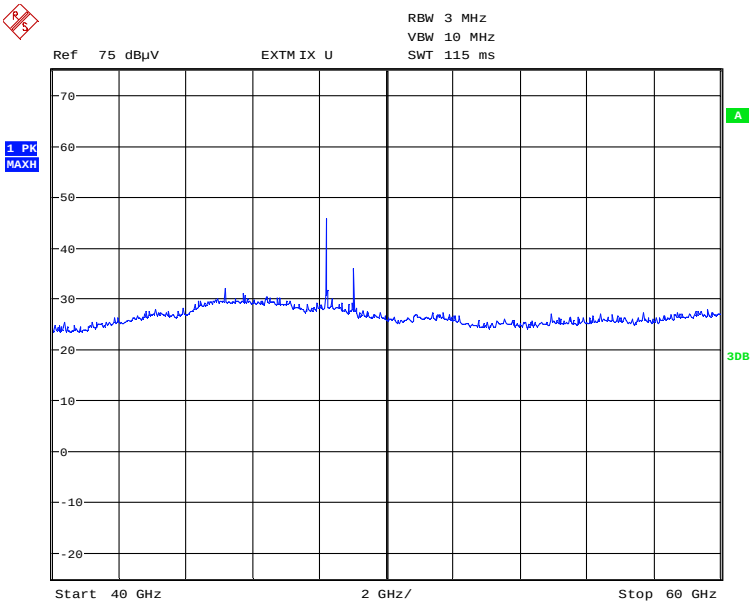
Radiated emissions from 18 GHz to 26.5 GHz:



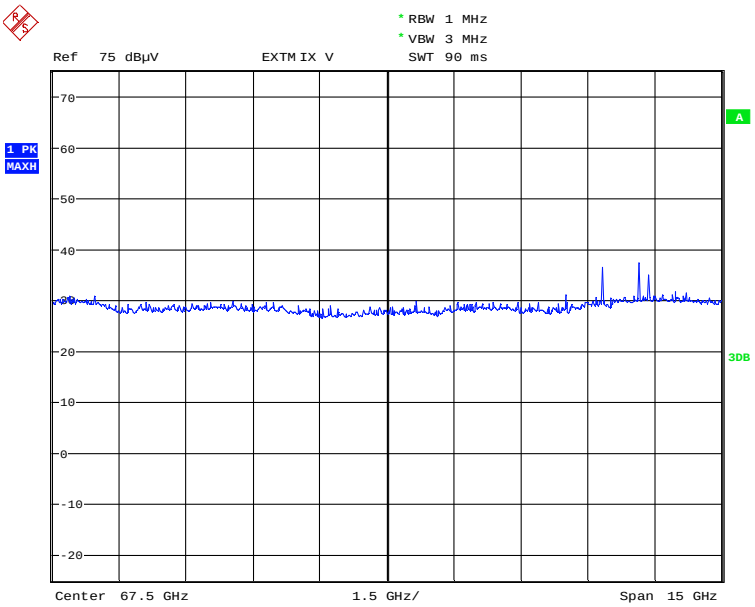
Radiated emissions from 26.5 GHz to 40 GHz:



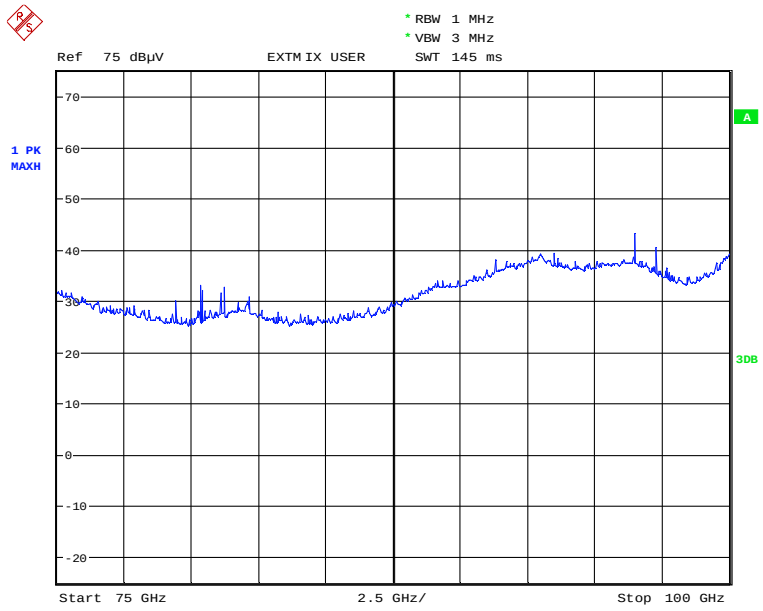
181708_9.wmf: Radiated emissions from 40 GHz to 60 GHz:



181708_10.wmf: Radiated emissions from 60 GHz to 75 GHz:



181708_11.wmf: Radiated emissions from 75 GHz to 100 GHz:



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

- 24.109 GHz.

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

- 48.218 GHz.

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

- 72.327 GHz.

These frequencies have to be measured in a final measurement. The results were presented in the following.

The emissions at 73.149 GHz, 73.365 GHz, 80.370 GHz, 81.170 GHz, 97.276 GHz and 99.474 GHz are mirror frequencies caused by the harmonic mixer.

Test equipment used (refer clause 6):

1 – 21

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

No emissions above the noise floor of the measurement system (max. 48 dBµV/m (measured with peak detector at 3 m distance)) found during the preliminary measurement. So no final measurements on the outdoor test site were carried out.

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

No emissions above the noise floor of the measurement system (max. 25 dBµV/m (measured with peak detector at 3 m distance)) found during the preliminary measurement. So no final measurements on the open area test site were carried out.

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

Ambient temperature	22 °C	Relative humidity	60 %

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 26.5 GHz) and 1 m (26.5 GHz to 110 GHz).

Test record: All results are shown in the following.

Supply voltage: During all measurements the EUT was supplied with 3.3 V_{DC} by the control board.

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

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

Result [dBµV/m] = reading [dBµV] + cable loss [dB] + antenna factor [dB/m] – Preamp [dB] + measuring distance correction factor [dB]

Result measured with the peak detector:

Frequency GHz	Result dBµV/m	Limit dBµV/m	Margin dB	Readings dBµV	Antenna factor 1/m	Preamp dB	Cable loss dB	Corr. Factor * dB	Height cm	Pol.
24.109	107.4	148.0	40.6	65.4	37.2	0.0	4.8	0	150	Vert.
48.218	77.8	108.0	30.2	43.7	44.1	0.0	-	-10.0	80	Hor.
72.327	73.9	108.0	34.1	37.6	46.3	0.0	-	-10.0	80	Hor.
Measurement uncertainty							+2.2 dB / -3.6 dB			

*: Measuring distance correction factor from 1 m to 3 m

Result measured with the average detector:

Frequency GHz	Result dBµV/m	Limit dBµV/m	Margin dB	Readings dBµV	Antenna factor 1/m	Preamp dB	Cable loss dB	Corr. Factor* dB	Height cm	Pol.
24.109	87.8	128.0	40.2	45.8	37.2	0.0	4.8	0	150	Vert.
48.218	57.1	88.0	30.9	23.0	44.1	0.0	-	-10.0	80	Hor.
72.327	58.5	88.0	29.5	22.2	46.3	0.0	-	-10.0	80	Hor.
Measurement uncertainty							+2.2 dB / -3.6 dB			

*: Measuring distance correction factor from 1 m to 3 m

Test: Passed

Test equipment used (refer clause 6):

1, 2, 13, 15, 17, 19

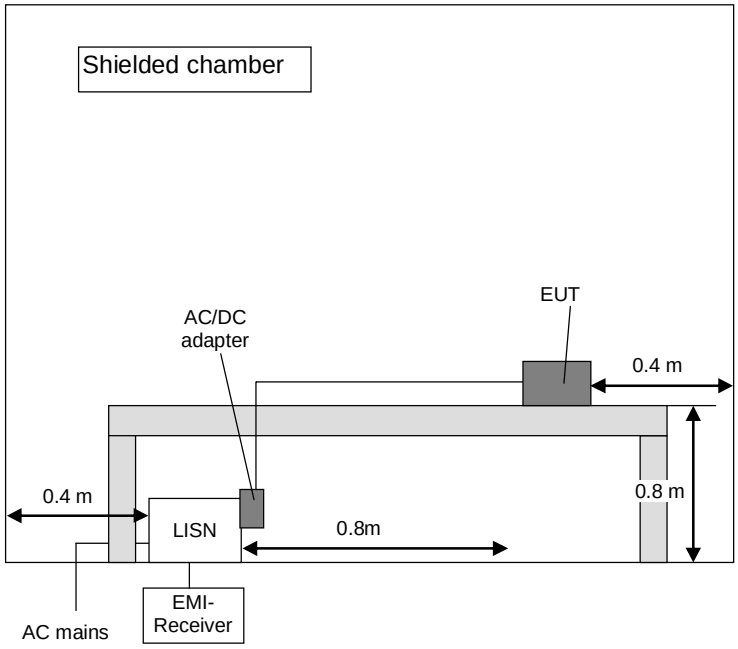
5.6 Conducted emissions on power supply lines (150 kHz to 30 MHz)

5.6.1 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



5.6.2 Test results (conducted emissions on power supply lines)

Ambient temperature	20 °C	Relative humidity	33 %

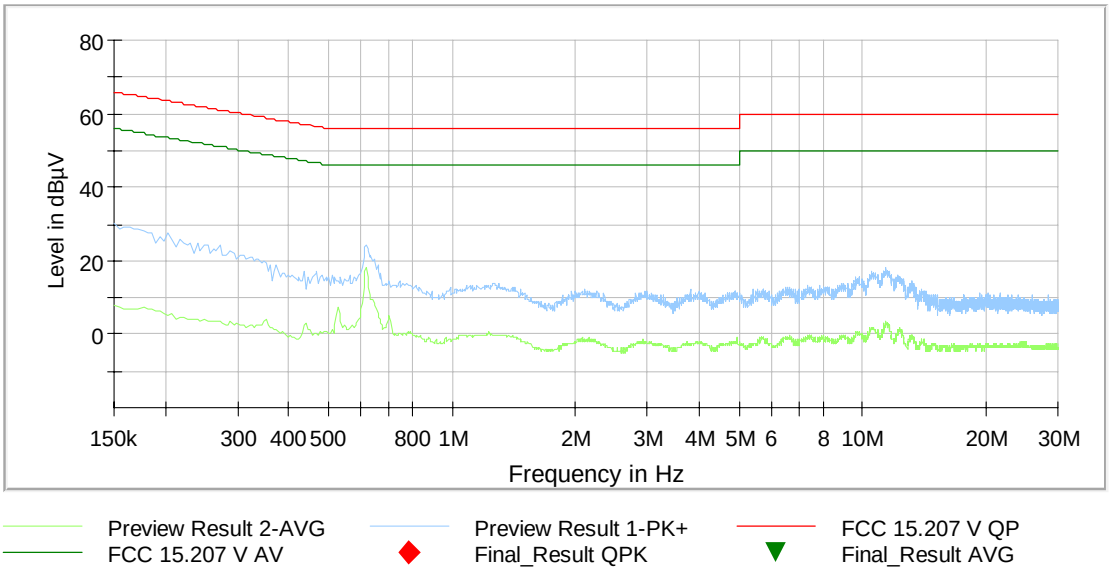
Position of EUT: The EUT was set-up on a non-conducting table of a height of 0.8 m.

Cable guide: The cable of the EUT 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 3.3 V_{DC} by an AC/DC adaptor type enercell CAT.NO. 273-316, 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.



No emissions at least 30 dB below the limit found.

Test: Passed

Test equipment used (refer clause 6):

22 – 25

6 Test equipment and ancillaries used for tests

No.	Test equipment	Type	Manufacturer	Serial No.	PM. No.	Cal. Date	Cal. due
1	Fully anechoic chamber M20	-	Albatross Projects	B83107-E2439-T232	480303	Calibration not necessary	
2	EMI Receiver / Spectrum Analyser	ESW44	Rohde & Schwarz	101635	482467	29.03.2018	03.2019
3	Spectrum analyser	FSU46	Rohde & Schwarz	200125	480956	31.10.2018	10.2019
4	Loop antenna	HFH2-Z2	Rohde & Schwarz	100417	481912	10.01.2019	01.2020
5	Antenna	CBL6112 B	Chase	2688	480328	19.06.2017	06.2020
6	Antenna	HL050	Rohde & Schwarz	100438	481170	09.10.2017	10.2020
7	EMI Software	ES-K1	Rohde & Schwarz	-	480111	Calibration not necessary	
8	RF-cable No. 36	Sucoflex 106B	Suhner	0587/6B	480865	Calibration not necessary	
9	RF-cable No. 3	Sucoflex 106B	Suhner	0563/6B	480670	Calibration not necessary	
10	RF-cable No. 40	Sucoflex 106B	Suhner	0708/6B	481330	Calibration not necessary	
11	Preamplifier 100 MHz – 16 GHz	AFS6-00101600-23-10P-6-R	MITEQ	2011215	482333	10.07.2018	07.2020
12	Standard Gain Horn 11.9 GHz – 18 GHz	18240-20	Flann Microwave	483	480294	Calibration not necessary	
13	Standard Gain Horn 17.9 GHz – 26.7 GHz	20240-20	Flann Microwave	410	480296	Calibration not necessary	
14	Standard Gain Horn 26.4 GHz – 40.1 GHz	22240-20	Flann Microwave	469	480299	Calibration not necessary	
15	Harmonic mixer with Standard Gain Horn 40 GHz – 60 GHz	FZ-Z60 / 24240-20	Rohde & Schwarz / Flann Microwave	100071 / 133313	480481	Calibration not necessary	
16	Harmonic mixer with Standard Gain Horn 50 GHz – 75 GHz	FS-Z75 / 25240-20	Rohde & Schwarz / Flann Microwave	100045 / 135181	480480	Calibration not necessary	
17	Harmonic mixer with Standard Gain Horn 75 GHz – 110 GHz	FS-Z110 / 27240-20	Rohde & Schwarz / Flann Microwave	100049 / 138294	480482	Calibration not necessary	
18	RF-cable 1m	KPS-1533-400-KPS	Insulated Wire	-	480300	Calibration not necessary	
19	RF-cable 2m	Insulated Wire Inc.	Insulated Wire	KPS-1533-800-KPS	480302	Calibration not necessary	
20	Preamplifier	JS3-12001800-16-5A	Miteq	571667	480343	10.07.2018	07.2020
21	Preamplifier	JS4-26004000-25-5A	MITEQ	563593	480344	10.07.2018	07.2020
22	Shielded chamber M4	-	Siemens AG	B83117-S1-X158	480088	Calibration not necessary	
23	EMI Receiver	ESIB 26	Rohde & Schwarz	1088.7490	481182	28.02.2018	02.2020
24	LISN	NSLK8128	Schwarzbeck	8128161	480138	13.03.2018	03.2020
25	Transient Limiter	CFL 9206A	Teseq GmbH	38268	481982	Calibration not necessary	
26	Signal & Spectrum Analyzer	FSW43	Rohde & Schwarz	100586 & 100926	481720	15.03.2018	03.2020

7 Report history

Report Number	Date	Comment
F181708E1	04.06.2019	Document created
-	-	-
-	-	-

8 List of annexes

Annex A	Test setup photographs	6 pages
Annex B	External photographs	2 pages
Annex C	Internal photographs	2 pages