Test Report
23-1-0144201T001a

Number of pages:	36	**Date of Report:**	2024-Jun-13
Testing company:	cetecom advanced GmbH Untertuerkheimer Str. 6-10 66117 Saarbruecken GERMANY	**Applicant:**	RTB GmbH & Co. KG
Product Name: **Kind of Product:**	**Radar unit (IVS-179/ Radarboard)** **Radarbased vehicle classification**		
FCC ID:	2BDLJ-RU-IVS179		--
Testing has been carried out in accordance with:	**FCC Regulations** **Title 47 CFR, Chapter I, Subchapter A, Part 15** **Subpart C Intentional Radiators** § 15.245 operating within the Band 24.075G to 24.175GHz § 15.215(c), § 15.245(b), § 15.207(a) § 15.205 Restricted bands of operation. § 15.209 Radiated emission limits; general requirements		
Tested Technology:	RADAR (24.075G – 24.175GHz)		
Test Results:	☒ **The EUT complies with the requirements in respect of all parameters subject to the test.** The test results relate only to devices specified in this document		
Signatures:			

Dipl.-Ing. Christian Lorenz	B.Sc. Al-Amin Hossain
Lab Manager, Radio Labs	Test Manager
Authorization of test report	Responsible of test report

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The listed attachments are separate documents.			

1 General information

1.1 Disclaimer and Notes

The test results of this test report relate exclusively to the test item specified in this test report as specified in chapter 2.7. cetecom advanced does not assume responsibility for any conclusions and generalizations drawn from the test results with regard to other specimens or samples of the type of the equipment represented by the test item.
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Also we refer on special conditions which the applicant should fulfill according §2.927 to §2.948, special focus regarding modification of the equipment and availability of sample equipment for market surveillance tests.

1.2 Summary of Test Results

Test specification clause	Test case	Temperature conditions	Power supply	Pass	Fail	NA	NP	Remark
§15.215(c) /	Bandwidth and frequency stability of the wanted signal	Nominal Extreme	Nominal Extreme	☒	☐	☐	☐	complies
§15.245(b) /	Field strength of fundamental emission	Nominal	Nominal	☒	☐	☐	☐	complies
§15.209(a) / §15.245(b) /	Field strength of emissions (radiated spurious)	Nominal	Nominal	☒	☐	☐	☐	complies
§15.207(a) / §15.207(c) /	Conducted emissions < 30 MHz	Nominal	Nominal	☒	☐	☐	☐	complies
§15.245(b)(1)(iii) /	Prevention of continuous operation	Nominal	Nominal	☐	☐	☐	☒	see note 2

Note:

1) NA = Not Applicable; NP = Not Performed
2) Only required for field disturbance sensors to be used in motor vehicles or aircraft

Additional comments:

Reference documents: None

Special test descriptions: None

Configuration descriptions: None

Kind of device:
- ☒ Field disturbance sensor (not for use in motor vehicles or aircraft)
- ☐ Field disturbance sensors designed to be used in motor vehicles or aircraft
- ☐ Speed radar meter

Note:

- §15.245(a): Operation under the provisions of this section is limited to intentional radiators used as field disturbance sensors, excluding perimeter protection systems.

Test mode:
- ☒ No test mode available/Normal mode.
- ☐ Special test mode/software is used.

Test device (EUT):

- EUT 1: The normal operation mode (intended use) is used.

Decision Rule: cetecom advanced GmbH follows ILAC G8:2019 chapter 4.2.1 (Simple Acceptance Rule).

1.3 Summary of Test Methods

Test case	Test method
Occupied bandwidth	ANSI C63.10-2020
Radiated Power (EIRP)	
Field strength of emissions (radiated spurious)	
Frequency stability	

2 Administrative Data

2.1 Identification of the Testing Laboratory

Company name:	cetecom advanced GmbH
Address:	Untertuerkheimer Str. 6-10 66117 Saarbruecken Germany
Responsible for testing laboratory:	Dipl.-Ing. (FH) Andreas Luckenbill M.Sc.
Accreditation scope:	**DAkkS Webpage: FCC ISED**
IC Lab company No. / CAB ID:	3462D / DE0001
Test location 1:	Im Teelbruch 116; 45219 Essen
Test location 2:	--

2.2 General limits for environmental conditions

Temperature:	20±2 °C
Relative. humidity:	45±15% rH

2.3 Test Laboratories sub-contracted

Company name:	--

2.4 Organizational Items

Responsible test manager:	B.Sc. Al-Amin Hossain
Receipt of EUT:	2023-Nov-22
Date(s) of test:	2023-Nov-20 to 2023-Nov-27
Version of template:	23.1003

2.5 Applicant's details

Applicant's name:	RTB GmbH & Co. KG
Address:	Schulze-Delitzsch-Weg 10 33175, Bad Lippspringe Germany
Contact Person:	Alexander Schmidt
Contact Person's Email:	Alexander.schmidt@rtb-bl.de

2.6 Manufacturer's details

Manufacturer's name:	RTB GmbH & Co. KG
Address:	Schulze-Delitzsch-Weg 10 33175, Bad Lippspringe Germany

2.7 Equipment under Test (EUT)

EUT No.*)	Sample No.	Product Name	Kind of Product	Type	SN	HW	SW
EUT 1	23-1-01442S03_C01	Radar unit (IVS-179/ Radarboard)	Radarbased vehicle classification	-	10124498	Radar-unit	V2.xx

*) EUT short description is used to simplify the identification of the EUT in this test report.

2.8 Untested Variant (VAR)

VAR No.*)	Sample No.	Product	Model	Type	SN	HW	SW

*) The listed additional untested model variant(s) (VAR) is/are not object of evaluation of compliance. For further information please see Annex 5: Declaration of applicant of model differences.
If the table above does not show any other line than the headline, no untested variants are available.

2.9 Auxiliary Equipment (AE)

AE No.*)	Sample No.	Auxiliary Equipment	Model	SN	HW	SW
AE 1	23-1-01442S04_C01	Battery	WP14-12SE	10025689	N/A	N/A

*) AE short description is used to simplify the identification of the auxiliary equipment in this test report. If the table above does not show any other line than the headline, no AE was used during testing nor was taken into account for evaluation

2.10 Connected cables (CAB)

CAB No.*)	Sample No.	Cable Type	Connectors / Details	Length
CAB 1	23-1-01442S10_C01	Cable	Check Annex-3	N/A
CAB 2	23-1-01442S11_C01	Cable	Check Annex-3	N/A
CAB 3	23-1-01442S08_C01	Cable	Check Annex-3	N/A

*) CAB short description is used to simplify the identification of the connected cables in this test report. If the table above does not show any other line than the headline, no cable was used during testing nor was taken into account for evaluation

2.11 Software (SW)

SW No.*)	Sample No.	SW Name	Description	SW Status

*) SW short description is used to simplify the identification of the used software in this test report. If the table above does not show any other line than the headline, no SW was used during testing nor was taken into account for evaluation.

2.12 EUT set-ups

set-up no.*)	Combination of EUT and AE	Description
1	EUT 1 + AE 1 + CAB 1 + CAB2	➢ Used for radiated measurements ➢ Used for Nominal/Normal Condition
2	EUT 1 + CAB 3	➢ Used for radiated measurements ➢ Used for Extreme Condition with external laboratory power supply

*) EUT set-up no. is used to simplify the identification of the EUT set-up in this test report.

2.13 EUT operation modes

EUT operating mode no.*)	Operating modes	Additional information
op. 1	TX-Mode 1 RADAR active	Once the EUT power on, it starts its intended function, as well as activate the RADAR signal.

*) EUT operating mode no. is used to simplify the test report.

3 Equipment under test (EUT)

3.1 General Data of Main EUT as Declared by Applicant

Firmware	☒ for normal use	☐ Special version for test execution	
Power supply	☐ AC Mains	--	
	☐ DC Mains	--	
	☒ Battery 12V DC	--	
Operational conditions	T_{nom} =20 °C	T_{min} =-20 °C	T_{max} =60 °C
EUT sample type	**Pre-Production**		
Weight	0.370 kg		
Size [LxWxH]	10.5 cm x 9.0 cm x 9.0 cm		
Interfaces/Ports	Check Annex-3 EUT picture for more details		
For further details refer Applicants Declaration & following technical documents			

3.2 Detailed Technical data of Main EUT as Declared by Applicant

Main function	Traffic monitoring, Industrial Application		
Frequency range [GHz]	24.075 – 24.175		
Type of modulation used	2-FSK		
Number of channels	1		
Emission designator	F1X		
Equipment type	☐ Imaging Short-Range comunication device ☐ a) Indoor ☐ b) Outdoor ☐ Field disturbance sensor (within building) ☒ Other Field disturbance sensor		
	☐ Short-Range automotive radar		
Antenna Type	☒ Integrated ☐ External, no RF- connector ☐ External, separate RF-connector		
FCC label attached	No		
For further details refer Applicants Declaration & following technical documents			
Description of Reference Document (supplied by applicant)		**Version**	**Total Pages**
200720_Datasheet_IVS-179_V4.5		**V4.5**	**5**
RTB_Customer_Questionnaire		**--**	**3**

3.3 Modifications on Test sample

Additions/deviations or exclusions	--

4 Measurements

4.1 20 dB Bandwidth and frequency stability of the wanted signal

Description:

Measurement of the bandwidth and the frequency stability of the wanted signal (fundamental emission) under temperature and supply voltage variations.

Limits and provisions:

§15.215(c):
Intentional radiators operating under the alternative provisions to the general emission limits, as contained in §§15.217 through 15.257 and in subpart E of this part, must be designed to ensure that the 20 dB bandwidth of the emission, or whatever bandwidth may otherwise be specified in the specific rule section under which the equipment operates, is contained within the frequency band designated in the rule section under which the equipment is operated. In the case of intentional radiators operating under the provisions of subpart E, the emission bandwidth may span across multiple contiguous frequency bands identified in that subpart. The requirement to contain the designated bandwidth of the emission within the specified frequency band includes the effects from frequency sweeping, frequency hopping and other modulation techniques that may be employed as well as the frequency stability of the transmitter over expected variations in temperature and supply voltage. If a frequency stability is not specified in the regulations, it is recommended that the fundamental emission be kept within at least the central 80% of the permitted band in order to minimize the possibility of out-of-band operation.

Designated frequency bands of §15.245			
Fundamental frequency [GHz]	f_L [GHz]	f_H [GHz]	Bandwidth [MHz]
24.075 – 24.175	> 24.075	< 24.175	<100 MHz

Measurement:

Measurement parameter	
Detector:	Pos-Peak
Resolution bandwidth:	100 kHz
Video bandwidth:	300 kHz
Trace-Mode:	Max Hold

Measurement procedures:

- Bandwidth: ANSI C63.10-2020 6.9
- Frequency stability: ANSI C63.10-2020 6.8

Measurement results:

20 dB bandwidth at normal conditions:

EUT	Mode	Diagram Number	Test condition	f_L [GHz]	f_H [GHz]	Bandwidth [MHz]
S03_C01	Normal mode	D506	T_{nom} / V_{nom}	24.1236149	24.1269132	3.30

Frequency stability:

Mode for frequency stability tests: Normal Mode (Mode with the widest bandwidth, ANSI C63.10-2020 5.6.2.2)

Bandwidth measurement for frequency stability tests: 20 dB bandwidth

Test condition	Diagram Number	Frequency		Bandwidth [MHz]
		f_L [GHz]	f_H [GHz]	
-20 °C / V_{nom}	D500	24.1364044	24.1398677	3.46
-10 °C / V_{nom}	D503	24.1628462	24.1662944	3.45
0 °C / V_{nom}	D504	24.1330150	24.1363533	3.34
10 °C / V_{nom}	D505	24.1295068	24.1327951	3.29
20 °C / V_{nom}	D506	24.1236149	24.1269132	3.30
20 °C / V_{max}	D507	24.1234550	24.1267283	3.27
20 °C / V_{min}	D508	24.1241046	24.1273930	3.29
30 °C / V_{nom}	D509	24.1171731	24.1204214	3.25
40 °C / V_{nom}	D510	24.1107663	24.1140096	3.24
50 °C / V_{nom}	D511	24.1063884	24.1095318	3.14
T_{max} / V_{nom}	D512	24.1035523	24.1067457	3.19

Remark: for more information and graphical plot see annex A1 **TR23-1-0144201T002a-A1**

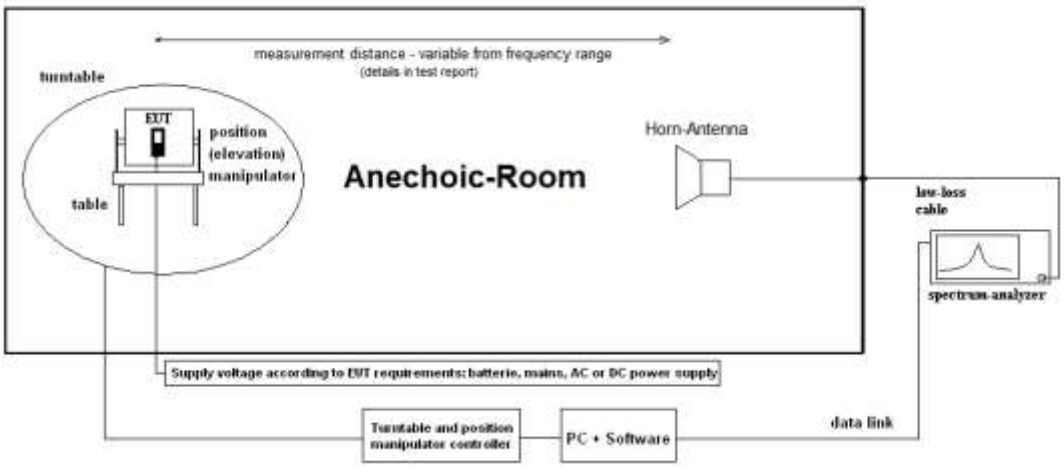
Verdict: Compliant

4.2 Field Strength of Fundamental emission

4.2.1 Description of the general test setup and methodology, see below example:

Evaluating the emissions have to be done first by an exploratory emissions measurement and a final measurement for most critical frequencies. The tests are performed in a CISPR 18-1-4:2010 compliant fully anechoic room (FAR) recognized by the regulatory commission. The measurement distance was set to 3 meter for frequencies up to 18 GHz and 2 meter above 18 GHz. A logarithmic periodic antenna is used for the frequency range 30 MHz to 1 GHz. Horn antennas are used for frequency range 1 GHz to 40 GHz. The EUT is aligned within 3 dB beam width of the measurement antenna with three orthogonal axis measurements on the EUT.

Schematic:



Testing method:

The measurement is made according to relevant reference clauses:
(See Tables *Summary of Test Results* and *Summary of Test Methods* on page 5)

Exploratory, preliminary measurements
The EUT and its associated accessories are placed on a non-conductive position manipulator (tipping device) of 1.55 m height which is placed on the turntable. By rotating the turntable (range 0° to 360°, step 15°) and the EUT itself either on 3-orthogonal axis (portable equipment) or 2-orthogonal axis (defined operational position of EUT) the emission spectrum and it's characteristics was recorded with an EMI-receiver, broadband antenna and software.
The measurements are performed in horizontal and vertical polarization of the measurement antennas. The results are documented in a diagram. If various operating modes are supported, further investigations are made to find the worst-case of them. Also the interconnection cables and equipment position were varied in order to maximize the emissions.

Final measurement on critical frequencies
Based on the exploratory measurements, the most critical frequencies are re-measured by maintaining the EUT's worst-case operation mode, cable position, etc.

First a frequency zoom around the critical frequency is done to locate the frequency more precisely. After this step, for all identified critical frequencies, the maximum peak was determined.

Following parameters were varied: the turntable angle continuously in the range 0 to 360 degree, the EUT itself over 3-orthogonal axis and the height for EUT with large dimensions or three axis scan for portable/small equipment.

On the determined worst-case position, a final measurement with necessary bandwidth and detector according standard has been carried out.

Formula:

$P_{EIRP} = P_{MEAS} + C_L + FSL - G_A$ (1)

P_{MEAS} = measured power at instrument
M = Margin
L_T = Limit

FSL = Free Space loss = Function(frequency, measurement distance)

$M = L_T - P_{EIRP}$

C_L= cable loss
G_A = Gain of pre-amplifier (if used)

All units are dB-units, positive margin means value is below limit.

4.2.2 Measurement Location

Test site	FAC2

Description:

Measurement of the maximum radiated field strength of the wanted signal (fundamental emission).

Limits and provisions:

§15.245 (b):
The field strength of emissions from intentional radiators operated within these frequency bands shall comply with the following:

Fundamental frequency (MHz)	Field strength of fundamental (mV/m)
24075-24175	2500

§15.245 (b)(2):
Field strength limits are specified at a distance of 3 meters.
20*log10(2500000) = 128dBµV/m
Test performed at 2 meter, Therefore correction factor has been used, see below,
Distance correction factor = 20*log10($D_{meas}/D_{speclimit}$) = 20*log10(2/3) = -3.52 dB (Offset)

§15.245 (b)(4):
The emission limits shown above are based on measurement instrumentation employing an average detector. The provisions in §15.35 for limiting peak emissions apply.

§15.35(b):
Unless otherwise specified, on any frequency or frequencies above 1000 MHz, the radiated emission limits are based on the use of measurement instrumentation employing an average detector function. Unless otherwise specified, measurements above 1000 MHz shall be performed using a minimum resolution bandwidth of 1 MHz. When average radiated emission measurements are specified in this part, including average emission measurements below 1000 MHz, there also is a limit on the peak level of the radio frequency emissions. Unless otherwise specified, e.g., see §§ 15.250, 15.252, 15.253(d), 15.255, 15.256, and 15.509 through 15.519, the limit on peak radio frequency emissions is 20 dB above the maximum permitted average emission limit applicable to the equipment under test. This peak limit applies to the total peak emission level radiated by the device, e.g., the total peak power level. Note that the use of a pulse desensitization correction factor may be needed to determine the total peak emission level. The instruction manual or application note for the measurement instrument should be consulted for determining pulse desensitization factors, as necessary.

Applicable limits according to §15.245 (b)

Fundamental frequency (MHz)	Field strength of fundamental		Measurement distance
	average value	peak value	
24075-24175	2500 mV/m (128 dBµV/m)	25000 mV/m (148 dBµV/m)	3 m

Measurement:

Measurement parameter	
Detector:	Peak / Linear average
Resolution bandwidth:	1 MHz
Video bandwidth:	3 MHz
Trace-Mode:	Max Hold

Measurement results:

EUT	Frequency [GHz]	Field strength of fundamental @ 3m [dBµV/m]	Applicable limit	Margin [dB]	Diagram
		Average value			
S03_01	24.075-24.175	112.62	2500 mV/m (128 dBµV/m)	15.11	D100_01

EUT	Frequency [GHz]	Field strength of fundamental @ 3m [dBµV/m]	Applicable limit	Margin [dB]	Diagram
		Peak value			
S03_01	24.075-24.175	119.21	25000 mV/m (148 dBµV/m)	28.79	D101

Remark: for more information and graphical plot see annex A1 **TR23-1-0144201T002a-A1**

Verdict: Compliant

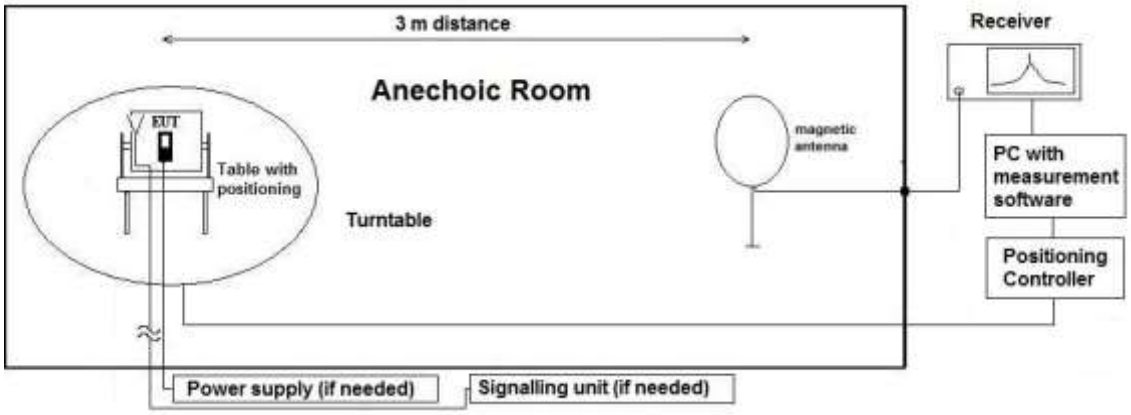
4.3 Radiated field strength emissions below 30 MHz

4.3.1 Description of the general test setup and methodology, see below example:

Evaluating the radiated field emissions are done first by an exploratory emission measurement and a final measurement for most critical frequencies determined.

The loop antenna was placed at 1 m height above ground plane and 3 m measurement distance from set-up for investigations. Because of reduced measurement distance, correction data were applied, as stated in chapter "General Limit - Radiated field strength emissions below 30 MHz". The tests are performed in the semi anechoic room recognized by the regulatory commission.

Schematic:



Testing method:

The measurement is made according to relevant reference clauses:
(See Tables *Summary of Test Results* and *Summary of Test Methods* on page 5)

Exploratory, preliminary measurements
The EUT and it's associated accessories are placed on a non-conductive position manipulator (tipping device) of 0.8 m height which is placed on the turntable. By rotating the turntable (step 90°, range 0°to 360°) and the EUT itself either on 3-orthogonal axis (portable equipment) or 2-orthogonal axis (defined operational position of EUT), the emission spectrum was recorded.

The loop antenna was moved at least to 2-perpendicular axes (antenna vector in direction of EUT and parallel to EUT) in order to maximize the emissions. The results are documented in a diagram. Critical frequencies (low margin to limit) are saved within a data reduction table for further investigations. If various operating modes are supported, further investigations are made to find the worst-case. Also the interconnection cables and equipment position were varied in order to maximize the emissions.

Final measurement on critical frequencies
Based on the exploratory measurements, the most critical frequencies are re-measured by maintaining the EUT's worst-case operation mode, cable position, etc.

First a frequency zoom around the critical frequency is done to locate the frequency more precisely. After this step, for all identified critical frequencies, the maximum peak was determined.

Following parameters were varied: the turntable angle continuously in the range 0 to 360 degree, the EUT itself either over 3-orthogonal axis (not defined usage position) or 2-orthogonal axis (defined usage position).

On the determined worst-case position, a final measurement with necessary bandwidth and detector according standard has been carried out.

Formula:

$E_C = E_R + AF + C_L + D_F - G_A$

$M = L_T - E_C$

AF = Antenna factor
C_L = Cable loss
D_F = Distance correction factor (if used)
E_C = Electrical field – corrected value
E_R = Receiver reading
G_A = Gain of pre-amplifier (if used)
L_T = Limit
M = Margin

All units are dB-units, positive margin means value is below limit.

4.3.2 Sample calculation

Raw-Value [dBuV/m]	Antenna factor	Distance Correction [dB]	Cable Loss	Preamplifier	Resulting correction value [dB]	Final result [dBuV/m]	Remarks
19.83	18.9	-70.75	0.18	--	-51.67	-31.83	30 to 3 m correction used according ANSI C63.10-2020

Remark: This calculation is based on an example value at 458 kHz

4.3.3 Correction factors due to reduced meas. distance (f < 30 MHz):

The used correction factors when the measurement distance is reduced compared to regulatory measurement distance, are calculated according Extrapolation formulas valid for EUT's with maximum dimension of 0.625xLambda. Formula 2+3+4 as presented in ANSI C63.10, Chapter 6.4.4 are used for the calculations of proper extrapolation factors

Frequency Range	f [kHz/MHz]	Lambda [m]	Far-Field Point [m]	Distance Limit accord. 15.209 [m]	1st Condition (dmeas < Dnear-field)	2nd Condition (Limit distance bigger dnear-field)	Distance Correction accord. Formula
kHz	9	33333.33	5305.17	300	fullfilled	not fullfilled	-80.00
	10	30000.00	4774.65		fullfilled	not fullfilled	-80.00
	20	15000.00	2387.33		fullfilled	not fullfilled	-80.00
	30	10000.00	1591.55		fullfilled	not fullfilled	-80.00
	40	7500.00	1193.66		fullfilled	not fullfilled	-80.00
	50	6000.00	954.93		fullfilled	not fullfilled	-80.00
	60	5000.00	795.78		fullfilled	not fullfilled	-80.00
	70	4285.71	682.09		fullfilled	not fullfilled	-80.00
	80	3750.00	596.83		fullfilled	not fullfilled	-80.00
	90	3333.33	530.52		fullfilled	not fullfilled	-80.00
	100	3000.00	477.47		fullfilled	not fullfilled	-80.00
	125	2400.00	381.97		fullfilled	not fullfilled	-80.00
	200	1500.00	238.73		fullfilled	fullfilled	-78.02
	300	1000.00	159.16		fullfilled	fullfilled	-74.49
	400	750.00	119.37		fullfilled	fullfilled	-72.00
	490	612.24	97.44		fullfilled	fullfilled	-70.23
	500	600.00	95.49	30	fullfilled	not fullfilled	-40.00
	600	500.00	79.58		fullfilled	not fullfilled	-40.00
	700	428.57	68.21		fullfilled	not fullfilled	-40.00
	800	375.00	59.68		fullfilled	not fullfilled	-40.00
	900	333.33	53.05		fullfilled	not fullfilled	-40.00
MHz	1.00	300.00	47.75		fullfilled	not fullfilled	-40.00
	1.59	188.50	**30.00**		fullfilled	not fullfilled	-40.00
	2.00	150.00	23.87		fullfilled	fullfilled	-38.02
	3.00	100.00	15.92		fullfilled	fullfilled	-34.49
	4.00	75.00	11.94		fullfilled	fullfilled	-32.00
	5.00	60.00	9.55		fullfilled	fullfilled	-30.06
	6.00	50.00	7.96		fullfilled	fullfilled	-28.47
	7.00	42.86	6.82		fullfilled	fullfilled	-27.13
	8.00	37.50	5.97		fullfilled	fullfilled	-25.97
	9.00	33.33	5.31		fullfilled	fullfilled	-24.95
	10.00	30.00	4.77		fullfilled	fullfilled	-24.04
	10.60	28.30	4.50		fullfilled	fullfilled	-23.53
	11.00	27.27	4.34		fullfilled	fullfilled	-23.21
	12.00	25.00	3.98		fullfilled	fullfilled	-22.45
	13.56	22.12	3.52		fullfilled	fullfilled	-21.39
	15.00	20.00	3.18		fullfilled	fullfilled	-20.51
	15.92	18.85	**3.00**		fullfilled	fullfilled	-20.00
	17.00	17.65	2.81		not fullfilled	fullfilled	-20.00
	18.00	16.67	2.65		not fullfilled	fullfilled	-20.00
	20.00	15.00	2.39		not fullfilled	fullfilled	-20.00
	21.00	14.29	2.27		not fullfilled	fullfilled	-20.00
	23.00	13.04	2.08		not fullfilled	fullfilled	-20.00
	25.00	12.00	1.91		not fullfilled	fullfilled	-20.00
	27.00	11.11	1.77		not fullfilled	fullfilled	-20.00
	29.00	10.34	1.65		not fullfilled	fullfilled	-20.00
	30.00	10.00	1.59		not fullfilled	fullfilled	-20.00

4.3.4 Measurement Location

Test site	SAC

4.3.5 Limit

Radiated emissions limits (3 meters)					
Frequency Range [MHz]	Limit [µV/m]	Limit [dBµV/m]	Distance [m]	Detector	RBW [kHz]
0.009 – 0.09	2400 / f [kHz]	67.6 – 20Log(f) (kHz)	300	Pk & Avg	0.2
0.09 – 0.11	2400 / f [kHz]	67.6 – 20Log(f) (kHz)	300	Quasi peak	0.2
0.11 – 0.15	2400 / f [kHz]	67.6 – 20Log(f) (kHz)	300	Pk & Avg	0.2
0.15 – 0.49	2400 / f [kHz]	67.6 – 20Log(f) (kHz)	300	Pk & Avg	9
0.49 – 1.705	24000 / f [kHz]	87.6 – 20Log(f) (kHz)	30	Quasi peak	9
1.705 - 30	30	29.5	30	Quasi peak	9

*Remark: In Canada same limits apply, just unit reference is different

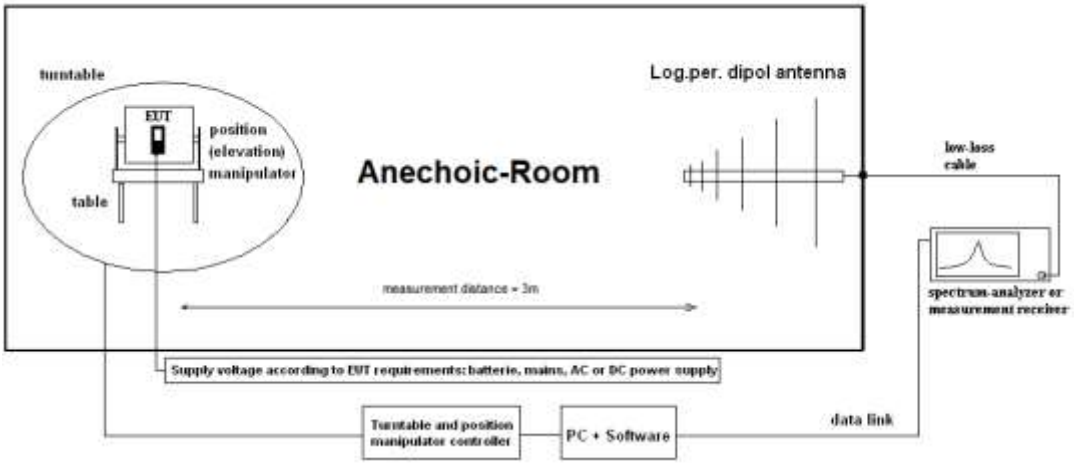
Note: Check Summery Result Table 4.6.1

4.4 Radiated field strength emissions 30 MHz – 960 MHz

4.4.1 Description of the general test setup and methodology, see below example:

Evaluating the emissions have to be done first by an exploratory emissions measurement and a final measurement for most critical frequencies. The tests are performed in a CISPR 16-1-4:2010 compliant Semi anechoic room (SAR) recognized by the regulatory commission. The measurement distance was set to 3 meter for frequencies up to 1 GHz
A logarithmic periodic antenna is used for the frequency range 30 MHz to 1 GHz.
The EUT is aligned within 3 dB beam width of the measurement antenna with three orthogonal axis measurements on the EUT.

Schematic:



Testing method:

The measurement is made according to relevant reference clauses:
(See Tables *Summary of Test Results* and *Summary of Test Methods* on page 5)

Exploratory, preliminary measurements
The EUT and its associated accessories are placed on a non-conductive position manipulator (tipping device) of 0.8 m height which is placed on the turntable. By rotating the turntable (range 0° to 360°, step 90°) and the EUT itself either on 3-orthogonal axis (portable equipment) or 2-orthogonal axis (defined operational position of EUT) the emission spectrum and it's characteristics was recorded with an EMI-receiver, broadband antenna and software.

Measurement antenna: horizontal and vertical, heights: 1,0 m and 1,82 m as worst-case determined by an exploratory emission measurements. The results are documented in a diagram. Critical frequencies (low margin to limit) are saved within a table for further investigations. If various operating modes are supported, further investigations are made to find the worst-case of them. Also the interconnection cables and equipment position were varied in order to maximize the emissions.

Final measurement on critical frequencies
Based on the exploratory measurements, the most critical frequencies are re-measured by maintaining the EUT's worst-case operation mode, cable position, etc. either on 10m OATS or 3m semi-anechoic room.
First a frequency zoom around the critical frequency is done to locate the frequency more precisely. After this step, for all identified critical frequencies, the maximum peak was determined.

Following parameters were varied: the turntable angle continuously in the range 0 to 360 degree, the EUT itself either over 3-orthogonal axis (not defined usage position) or 2-orthogonal axis (defined usage position). The measurement antenna height between 1 m and 4 m.
On the determined worst-case position, a final measurement with necessary bandwidth and detector according standard has been carried out

Formula:

$E_C = E_R + AF + C_L + D_F - G_A$ (1)

$M = L_T - E_C$ (2)

AF = Antenna factor
C_L = Cable loss
D_F = Distance correction factor (if used)
E_C = Electrical field – corrected value
E_R = Receiver reading
G_A = Gain of pre-amplifier (if used)
L_T = Limit
M = Margin

All units are dB-units, positive margin means value is below limit.

4.4.2 Sample calculation

Raw-Value [dBuV/m]	Antenna factor	Distance Correction [dB]	Cable Loss	Preamplifier	Resulting correction value [dB]	Final result [dBuV/m]	Remarks
32.7	22.25	--	3.1	--	25.35	58.05	--

Remark: This calculation is based on an example value at 800.4 MHz

4.4.3 Measurement Location

Test site	225902 - SAC2 (3m) - Radiated Emission <1GHz

4.4.4 Limit

Radiated emissions limits (3 meters)				
Frequency Range [MHz]	Limit [µV/m]	Limit [dBµV/m]	Detector	RBW / VBW [kHz]
30 - 88	100	40.0	Quasi peak	100 / 300
88 - 216	150	43.5	Quasi peak	100 / 300
216 - 960	200	46.0	Quasi peak	100 / 300
960 - 1000	500	54.0	Quasi peak	100 / 300

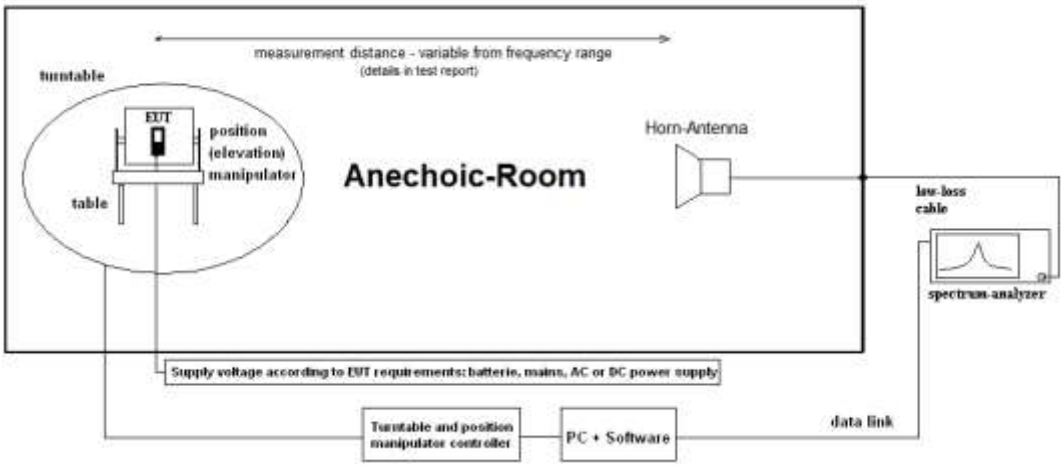
Note: Check Summery Result Table 4.6.1

4.5 Radiated field strength emissions above 1 GHz

4.5.1 Description of the general test setup and methodology, see below example:

Evaluating the emissions have to be done first by an exploratory emissions measurement and a final measurement for most critical frequencies. The tests are performed in a CISPR 18-1-4:2010 compliant fully anechoic Chamber (FAC-2) recognized by the regulatory commission. The measurement distance was set to 3 meter for frequencies up to 18 GHz and 2 meter above 18 GHz. Horn antennas are used for frequency range 1 GHz to 40 GHz. The EUT is aligned within 3 dB beam width of the measurement antenna with three orthogonal axis measurements on the EUT.

Schematic:



Testing method:

The measurement is made according to relevant reference clauses:
(See Tables *Summary of Test Results* and *Summary of Test Methods* on page 5)

Exploratory, preliminary measurements
The EUT and its associated accessories are placed on a non-conductive position manipulator (tipping device) of 1.55 m height which is placed on the turntable. By rotating the turntable (range 0° to 360°, step 15°) and the EUT itself either on 3-orthogonal axis (portable equipment) or 2-orthogonal axis (defined operational position of EUT) the emission spectrum and it's characteristics was recorded with an EMI-receiver, broadband antenna and software.
The measurements are performed in horizontal and vertical polarization of the measurement antennas. The results are documented in a diagram. Critical frequencies (low margin to limit) are saved within a table for further investigations. If various operating modes are supported, further investigations are made to find the worst-case of them. Also the interconnection cables and equipment position were varied in order to maximize the emissions.

Final measurement on critical frequencies
Based on the exploratory measurements, the most critical frequencies are re-measured by maintaining the EUT's worst-case operation mode, cable position, etc.

First a frequency zoom around the critical frequency is done to locate the frequency more precisely. After this step, for all identified critical frequencies, the maximum peak was determined.

Following parameters were varied: the turntable angle continuously in the range 0 to 360 degree, the EUT itself over 3-orthogonal axis and the height for EUT with large dimensions or three axis scan for portable/small equipment.

On the determined worst-case position, a final measurement with necessary bandwidth and detector according standard has been carried out.

Formula:

$P_{EIRP} = P_{MEAS} + C_L + FSL - G_{PreA} – G_{ANT}$ (1)

P_{MEAS} = measured power at instrument
M = Margin
L_T = Limit

FSL = Free Space loss = Function(frequency, measurement distance)

$M = L_T - P_{EIRP}$

C_L= cable loss
G_{PreA} = Gain of pre-amplifier (if used)
G_{ANT} = Gain of antenna in [dBi]

All units are dB-units, positive margin means value is below limit.

4.5.2 Sample calculation

Raw-Value [dBuV/m]	Antenna factor	Distance Correction [dB]	Cable Loss + Preamplifier	Resulting correction value [dB]	Final result [dBuV/m]	Remarks
29.37	41.20	--	24.28	16.92	46.3	CableLoss and PreAmp data in one data correction file

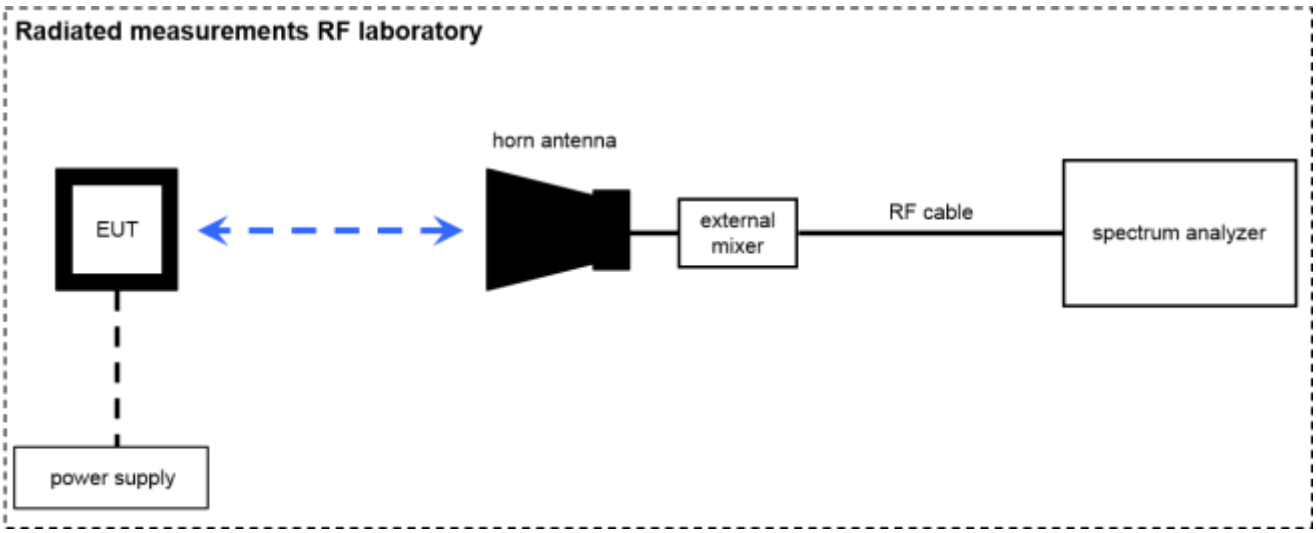
Remark: This calculation is based on an example value at 10 GHz

4.5.3 Measurement Location

Test site	FAC-2

Note: Check Summery Result Table 4.6.1

4.6 Radiated measurements above 60 GHz



Measurement distance: horn antenna e.g. 75 cm

FS = UR + CA + AF
(FS-field strength; UR-voltage at the receiver; CA-loss signal path & distance correction; AF-antenna factor)

Example calculation:
FS [dBµV/m] = 40.0 [dBµV/m] + (-60.1) [dB] + 36.74 [dB/m] = 16.64 [dBµV/m] (6.79 µV/m)

OP = AV + D - G + CA
(OP-radiated output power; AV-analyzer value; D-free field attenuation of measurement distance;
G-antenna gain+amplifier gain; CA-loss signal path)

Example calculation:
OP [dBm] = -59.0 [dBm] + 44.0 [dB] - 20.0 [dBi] + 5.0 [dB] = -30 [dBm] (1 µW)

Note: conversion loss of mixer is already included in analyzer value.

Description:

Measurement of the field strength of emissions radiated outside of the specified frequency bands (in transmit mode).

Limits and provisions:

§15.245 (b):
The field strength of emissions from intentional radiators operated within these frequency bands shall comply with the following:

Fundamental frequency (MHz)	Field strength of fundamental (mV/m)	Field strength of harmonics (mV/m)
902-928	500	1.6
2435-2465	500	1.6
5785-5815	500	1.6
10500-10550	2500	25.0
24075-24175	2500	25.0

(1) Regardless of the limits shown in the table of §15.245 (b), harmonic emissions in the restricted bands below 17.7 GHz, as specified in §15.205, shall not exceed the field strength limits shown in §15.209. Harmonic emissions in the restricted bands at and above 17.7 GHz shall not exceed the following field strength limits:

(i) For the second and third harmonics of field disturbance sensors operating in the 24075-24175 MHz band and for other field disturbance sensors designed for use only within a building or to open building doors, 25.0 mV/m.

(ii) For all other field disturbance sensors, 7.5 mV/m. (here applicable)

(iii) Field disturbance sensors designed to be used in motor vehicles or aircraft must include features to prevent continuous operation unless their emissions in the restricted bands, other than the second and third harmonics from devices operating in the 24075-24175 MHz band, fully comply with the limits given in § 15.209. Continuous operation of field disturbance sensors designed to be used in farm equipment, vehicles such as fork lifts that are intended primarily for use indoors or for very specialized operations, or railroad locomotives, railroad cars and other equipment which travels on fixed tracks is permitted. A field disturbance sensor will be considered not to be operating in a continuous mode if its operation is limited to specific activities of limited duration (e.g., putting a vehicle into reverse gear, activating a turn signal, etc.).

(2) Field strength limits are specified at a distance of 3 meters.

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

(4) The emission limits shown in §15.245 (b) are based on measurement instrumentation employing an average detector. The provisions in §15.35 for limiting peak emissions apply.

§15.205(d)(8):
Devices operated in the 24.075–24.175 GHz band under § 15.245 are exempt from complying with the requirements of this section for the 48.15–48.35 GHz and 72.225–72.525 GHz bands only, and shall not exceed the limits specified in § 15.245(b).

§15.205(e):
Harmonic emissions appearing in the restricted bands above 17.7 GHz from field disturbance sensors operating under the provisions of § 15.245 shall not exceed the limits specified in § 15.245(b).

§15.209 (a):
Except as provided elsewhere in this subpart, the emissions from an intentional radiator shall not exceed the field strength levels specified in the following table

Frequency (MHz)	Field Strength (µV/m)	Measurement distance (m)
0.009 – 0.490	2400/F(kHz)	300
0.490 – 1.705	24000/F(kHz)	30
1.705 – 30.0	30	30
30 88	100**	3
88 – 216	150**	3
216 – 960	200**	3
Above 960	500	3

** Except as provided in paragraph (g), fundamental emissions from intentional radiators operating under this section shall not be located in the frequency bands 54–72 MHz, 76–88 MHz, 174–216 MHz or 470–806 MHz. However, operation within these frequency bands is permitted under other sections of this part, e.g., §§ 15.231 and 15.241

§15.209(b):
In the emission table above, the tighter limit applies at the band edges.

§15.209(c):
The level of any unwanted emissions from an intentional radiator operating under these general provisions shall not exceed the level of the fundamental emission. For intentional radiators which operate under the provisions of other sections within this part and which are required to reduce their unwanted emissions to the limits specified in this table, the limits in this table are based on the frequency of the unwanted emission and not the fundamental frequency. However, the level of any unwanted emissions shall not exceed the level of the fundamental frequency.

§15.209(d):
The emission limits shown in the above table are based on measurements employing a CISPR quasi-peak detector except for the frequency bands 9–90 kHz, 110–490 kHz and above 1000 MHz. Radiated emission limits in these three bands are based on measurements employing an average detector.

§15.33(a):
For an intentional radiator, the spectrum shall be investigated from the lowest radio frequency signal generated in the device, without going below 9 kHz, up to at least the frequency shown in this paragraph:
(2) If the intentional radiator operates at or above 10 GHz and below 30 GHz: to the fifth harmonic of the highest fundamental frequency or to 100 GHz, whichever is lower.

Calculation of limits according to §15.245 (b)(3)

$$E_{pot} = E_{fund} - 50\ dB$$

- E_{pot}: Potential limit according to §15.245 (b)(3)
- E_{fund}: Measured field strength of fundamental emission @ 3m.

EUT	Measured field strength of fundamental emission @ 3m [dBµV/m]	Potential limit according to §15.245 (b)(3) [dBµV/m]	Limit according to §15.209 [dBµV/m]
	average value	average value	average value
S03_C01	112.62	62.62	54 (f > 1GHz)

Note:

- The limit value with the lesser attenuation compared to the fundamental field strength applies.
- The level of any unwanted emissions shall not exceed the level of the fundamental frequency.

Applicable limits according to §15.245 (b), for Harmonic limit §15.245 (b (1)(ii))

EUT	Harmonics [dBµV/m]		Emissions radiated outside of the specified frequency bands (except for harmonics) [dBµV/m]	
	average value	peak value	average value	peak value
S03_C01	77.50	97.50	62.62	82.62

Measurement:

Measurement parameter	
Detector:	Quasi Peak / Peak / Linear average
Resolution bandwidth:	F < 1 GHz: 100 kHz F > 1 GHz: 1 MHz
Video bandwidth:	F < 1 GHz: 300 kHz F > 1 GHz: 3 MHz
Trace-Mode:	Max Hold

Calculation of the boundary near/far field:

The aperture dimensions of the antenna shall be small enough so that the measurement distance in m is equal to or greater than the Rayleigh (far-field) distance (i.e., Rm = 2D2 / λ), where D is the largest dimension of the antenna aperture in m and λ is the free-space wavelength in m at the frequency of measurement.

Antenna range, [GHz]	D* [m]	Highest frequency in the measurement, [GHz]	shortest wavelength λ in the measurement, [m]	Boundary for near/far field, [m]
40-50	0.045	50	0.00599585	0.68
50-75	0.03	75	0.00399723	0.45
75-110	0.02	110	0.00272539	0.29
110-140	0.016	140	0.00214137	0.24
140-162	0.01	162	0.00185057	0.11
140-170	0.01	170	0.00176349	0.11

*) The antenna aperture is estimated according internal photo provided by applicant.

Measurement frequency range:	Measurement distance, [m]	Boundary for near/far field, [m]
40 GHz – 50 GHz	1	0.68
50 GHz – 60 GHz	1	0.45
60 GHz – 75 GHz	1	0.45
75 GHz – 100 GHz	1	0.29

4.6.1 Summery Result Table (9kHz – 100GHz)

Diagram	Frequency f [MHz]	Detector	Measured level [dBµV/m]	Limit [dBµV/m]	Margin [dB]	Result
	Please refer to the following diagrams for more information on the level of spurious emissions					
D290	0.009 - 30	--	No critical level found	--	--	Pass
D291	0.009 - 30	--	No critical level found	--	--	Pass
D292_01	30 - 1000	QPK	38.27 at 41.03MHz	40	**1.73**	Pass
D293	30 - 1000	QPK	38.39 at 39.95MHz, 38.33 at 40.47MHz,	40	**1.61, 1.67**	Pass
D294	1000 - 12400	Peak + Average	No critical level found	Peak: 82.62, Avg: 62.62	--	
D295	12400 - 18000	Peak + Average	No critical level found	Peak: 82.62, Avg: 62.62	--	Pass
D297	18000 - 24075	Peak + Average	No critical level found	Peak: 82.62, Avg: 62.62	--	Pass
D299	18000 - 24075	Peak + Average	No critical level found	Peak: 82.62, Avg: 62.62	--	Pass
D301	24175 - 26500	Peak + Average	No critical level found	Peak: 82.62, Avg: 62.62	--	Pass
D303	24175 - 26500	Peak + Average	No critical level found	Peak: 82.62, Avg: 62.62	--	Pass
D305	26500 - 40000	Peak + Average	No critical level found	Peak: 82.62, Avg: 62.62	--	Pass
D307	26500 - 40000	Peak + Average	No critical level found	Peak: 82.62, Avg: 62.62	--	Pass
D308	40000 - 50000	Peak + Average	Max peak 67.70 at 48.258GHz, Max Avg 58.37 at 48.258GHz	Peak: 82.62, Avg: 62.62	--	Check Diagram D308_02 for Final Test
D308_02	48257 with 1GHz span	Peak + Average	Max peak 71.82 at 48.258GHz, Max Avg 62.34 at 48.258GHz	Peak: 97.50, Avg: 77.50 Harmonics limit line	**Peak: 25.68 AVG: 15.16**	Pass
D309	40000 - 50000	Peak + Average	Max peak 69.83 at 48.263GHz, Max Avg 60.25 at 48.263GHz	Peak: 82.62, Avg: 62.62	--	Check Diagram D309_02 for Final Test
D309_02	48257 with 1GHz span	Peak + Average	Max peak 69.81 at 48.263GHz, Max Avg 60.45 at 48.263GHz	Peak: 82.62, Avg: 62.62	**Peak: 27.69 AVG: 17.05**	Pass
D310	50000 - 60000	Peak + Average	No critical level found	Peak: 82.62, Avg: 62.62	--	Pass
D312	50000 - 60000	Peak + Average	No critical level found	Peak: 82.62, Avg: 62.62	--	Pass
D314_01	60000 - 75000	Peak + Average	No critical level found	Check above table for limit line	--	Pass

D315_01	60000 - 75000	Peak + Average	No critical level found	Check above table for limit line	--	Pass
D316_01	75000 - 100000	Peak + Average	No critical level found	Check above table for limit line	--	Pass
D317_01	75000 - 100000	Peak + Average	No critical level found	Check above table for limit line	--	Pass

Remark: for more information and graphical plot see annex A1 **TR23-1-0144201T002a-A1**

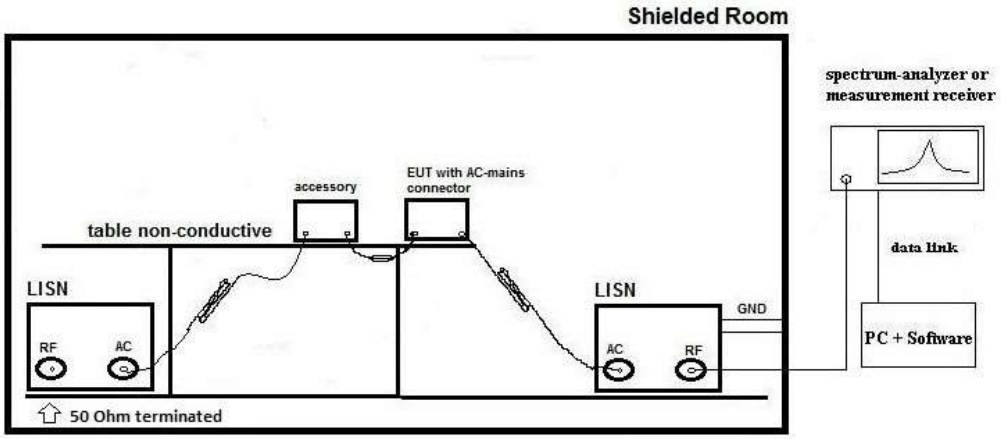
Verdict: Compliant

4.7 Conducted interference voltage (AC mains)

4.7.1 Description of the general test setup and methodology

The measurement is performed as follows:
The entire frequency range is swept with Peak and Average detectors on all lines. The test result curves are based on this Preview Test. If there are peaks with margin less than 10 dB to the limits for emissions, the Final Test is started. All frequencies at which margin to the limits is less than 10 dB are scanned with Quasi peak or Average detectors on corresponding lines around those frequencies. These final values are entered to the test results curve and tables.
Diagrams show the peak values as a sum of measured lines in maxhold mode.

Schematic:



Formula:

$V_C = V_R + C_L$ (1)
$M = L_T - V_C$ (2)

V_C = measured Voltage –corrected value
V_R = Receiver reading
C_L = Cable loss
M = Margin
L_T = Limit

All units are dB-units, positive margin means value is below limit.

4.7.2 Test receiver settings

Measurement:

Parameter		
Detector:	Peak - Quasi Peak / Average	
Sweep time:	Auto	
Video bandwidth:	F < 150 kHz: F > 150 kHz:	200 Hz 9 kHz
Resolution bandwidth:	F < 150 kHz: F > 150 kHz:	1 kHz 100 kHz
Span:	9 kHz to 30 MHz	
Trace-Mode:	Max Hold	

Description:

Measurement of the conducted spurious emissions in transmit mode below 30 MHz. Both power lines, phase and neutral line, are measured. Found peaks are re-measured with average and quasi peak detection to show compliance to the limits.

Limits and provisions:

§15.207(a):
Except as shown in paragraphs (b) and (c) of this section, for an intentional radiator that is designed to be connected to the public utility (AC) power line, the radio frequency voltage that is conducted back onto the AC power line on any frequency or frequencies, within the band 150 kHz to 30 MHz, shall not exceed the limits in the following table, as measured using a 50 µH/50 ohms line impedance stabilization network (LISN). Compliance with the provisions of this paragraph shall be based on the measurement of the radio frequency voltage between each power line and ground at the power terminal. The lower limit applies at the boundary between the frequency ranges.

Frequency of emission (MHz)	Conducted limit (dBµV)	
	Quasi-peak	Average
0.15 – 0.5	66 to 56*	56 to 46*
0.5 – 5	56	46
5 – 30	60	50

* Decreases with the logarithm of the frequency

§15.207(c):
Measurements to demonstrate compliance with the conducted limits are not required for devices which only employ battery power for operation and which do not operate from the AC power lines or contain provisions for operation while connected to the AC power lines. Devices that include, or make provisions for, the use of battery chargers which permit operating while charging, AC adapters or battery eliminators or that connect to the AC power lines indirectly, obtainig their power through another device which is connected to the AC power lines, shall be tested to demonstrate compliance with the conducted limits.

For an EUT that connects to the AC power lines indirectly, through another device, the requirement for compliance with the limits in the table below shall apply at the terminals of the AC power-line mains cable of a representative support device, while it provides power to the EUT. The lower limit applies at the boundary between the frequency ranges. The device used to power the EUT shall be representative of typical applications.

AC power-line conducted emissions limits		
Frequency (MHz)	Conducted limit (dBµV)	
	Quasi-peak	Average
0.15 – 0.5	66 to 56[Note1]	56 to 46[Note1]
0.5 – 5	56	46
5 – 30	60	50

Note 1: The level decreases linearly with the logarithm of the frequency.
[…]

Diagram	Frequency f [MHz]	Detector	Measured level [dBµV/m]	Limit [dBµV/m]	Margin [dB]	Result
	Please refer to the following diagrams for more information on the level of spurious emissions					
D252	0.15 - 30	QPK, Avg	Check diagram	Check above	Check diagram	Pass

Remark: for more information and graphical plot see annex A1 **TR23-1-0144201T002a-A1**

Verdict: Compliant

4.8 Prevention of continuous operation

Description:

Field disturbance sensors must include features to prevent continuous operation under certain conditions.

Limits and provisions:

§15.245(b)(1)(iii):
Field disturbance sensors designed to be used in motor vehicles or aircraft must include features to prevent continuous operation unless their emissions in the restricted bands, other than the second and third harmonics from devices operating in the 24075–24175 MHz band, fully comply with the limits given in § 15.209.
Continuous operation of field disturbance sensors designed to be used in farm equipment, vehicles such as fork lifts that are intended primarily for use indoors or for very specialized operations, or railroad locomotives, railroad cars and other equipment which travels on fixed tracks is permitted.
A field disturbance sensor will be considered not to be operating in a continuous mode if its operation is limited to specific activities of limited duration (e.g., putting a vehicle into reverse gear, activating a turn signal, etc.).

Results:

The provisions depend on the use case and the operation during specific activities. Ensuring compliance with these provisions is the responsibility of the manufacturer and cannot be verified in the laboratory environment.

Verdict: Not performed

4.9 Equipment lists

ID	Description	Manufacturer	SerNo	CheckType	Last Check	Interval	Next Check
	120901 - SAC3 - Radiated Emission <1GHz			calchk	cal: 2015-Jul-21 chk: 2021-Jul-27	cal: 10Y chk: 12M	cal: 2025-Jul-21 chk: 2022-Jul-27
20341	Digital Multimeter Fluke 112	Fluke Deutschland GmbH / Glottertal	81650455	cal	cal: 2024-May-13	cal: 24M	cal: 2026-May-13
20442	Semi Anechoic Chamber	ETS-Lindgren Gmbh / Taufkirchen	without	cnn	cal: - chk: -	cal: - chk: -	cal: - chk: -
20482	filter matrix Filter matrix SAR 1	cetecom advanced GmbH / Essen	without	cnn	cal: - chk: -	cal: - chk: -	cal: - chk: -
20574	Biconilog Hybrid Antenna BTA-L	Frankonia GmbH / Heideck	980026L	cal	cal: 2022-Jun-15	cal: 36M	cal: 2025-Jun-15
20620	Test Receiver ESU26	Rohde & Schwarz Messgerätebau GmbH / Memmingen	100362	cal	cal: 2024-May-15	cal: 12M	cal: 2025-May-15
20885	Power Supply EA3632A	Agilent Technologies Deutschland GmbH	75305850	cnn	cal: - chk: -	cal: - chk: -	cal: - chk: -
25038	Loop Antenna HFH2-Z2	Rohde & Schwarz Messgerätebau GmbH / Memmingen	879824/13	cal	cal: 2022-Jul-04	cal: 24M	cal: 2024-Jul-04
	120907 - FAC2 - Radiated Emissions			chk	chk: 2024-Mar-15	chk: 12M	chk: 2025-Mar-15
20005	AC - LISN 50 Ohm/50µH ESH2-Z5	Rohde & Schwarz Messgerätebau GmbH / Memmingen	861741/005	cal	cal: 2024-May-16	cal: 12M	cal: 2025-May-16
20133	Horn Antenna 3115 (Meas 1)	EMCO Elektronik GmbH / Gilching	9012-3629	cal	cal: 2023-May-22	cal: 36M	cal: 2026-May-22
120907	Fully Anechoic Chamber 2	ETS-Lindgren Gmbh / Taufkirchen	without	cal	Cal: 2024-May-14	cal: 12M	Cal: 2025-May-13
20729	FS-Z140	Rohde & Schwarz Messgerätebau GmbH / Memmingen	101004	cal	cal: 2023-Jun-16	cal: 36M	cal: 2026-Jun-16
20730	FS-Z110	Rohde & Schwarz Messgerätebau GmbH / Memmingen	101468	cal	cal: 2023-Jun-02	cal: 36M	cal: 2026-Jun-02
20731	FS-Z75	Rohde & Schwarz Messgerätebau GmbH / Memmingen	101022	cal	cal: 2022-May-18	cal: 36M	cal: 2025-May-18
20733	Harmonic Mixer FS-Z220	RPG-Radiometer Physics GmbH / Meckenheim	101009	cal	cal: 2024-May-24	cal: 36M	cal: 2027-May-24
20734	Harmonic Mixer FS-Z325	RPG-Radiometer Physics GmbH / Meckenheim	101005	cal	cal: 2024-May-24	cal: 36M	cal: 2027-May-24
20765	Pickett-Potter Horn Antenna FH-PP 40-60	RPG-Radiometer Physics GmbH / Meckenheim	010001	chk	chk: 2023-Oct-20	chk: 12M	chk: 2024-Oct-20
20767	Pickett-Potter Horn Antenna FH-PP 140-220	RPG-Radiometer Physics GmbH / Meckenheim	010011	chk	chk: 2023-Oct-20	chk: 12M	chk: 2024-Oct-20
20811	Horn Antenna ASY-SGH-124-SMA	Antenna Systems Solutions S.L	29F14182337	cal	cal: 2021-Oct-20	cal: 36M	cal: 2024-Oct-20
20812	Pickett-Potter Horn Antenna FH-PP-325	RPG-Radiometer Physics GmbH / Meckenheim	10024	chk	chk: 2023-Oct-20	chk: 12M	chk: 2024-Oct-20
20813	Pickett-Potter Horn Antenna FH-PP 075	RPG-Radiometer Physics GmbH / Meckenheim	10006	chk	chk: 2023-Oct-20	chk: 12M	chk: 2024-Oct-20
20814	Pickett-Potter Horn Antenna FH-PP 140	RPG-Radiometer Physics GmbH / Meckenheim	10008	chk	chk: 2023-Oct-20	chk: 12M	chk: 2024-Oct-20
20815	Pickett-Potter Horn Antenna FH-PP 110	RPG-Radiometer Physics GmbH / Meckenheim	10014	chk	chk: 2023-Oct-20	chk: 12M	chk: 2024-Oct-20
20816	SGH Antenna SGH-26-WR10	Anteral S.L.	1144	cnn	cal: - chk: -	cal: - chk: -	cal: - chk: -
20817	Waveguide Rectangular Horn Antenna SAR-2309-22-S2	ERAVANT / Torrance	13254-01	chk	chk: 2023-Oct-20	chk: 12M	chk: 2024-Oct-20
20836	1-18 GHz Amplifier	Wright Technologies, Inc., Inc. / Roseville	0001	chk		chk: 36M	
20877	JS42-08001800-16-8P Verstärker	Miteq Inc.	2079991 / 2079992	chk	chk: 2024-March-26	chk: 6M	chk: 2024-Sep--25
20907	Waveguide WR-15 attenuator STA-30-15-M2	SAGE Millimeter Inc.	13256-01	cnn	cal: - chk: -	cal: - chk: -	cal: - chk: -
20908	Waveguide WR 10 attenuator STA-30-10-M2	SAGE Millimeter Inc.	13256-01	cnn	cal: - chk: -	cal: - chk: -	cal: - chk: -
20909	Waveguide Horn Antenna PE9881-24	Pasternack Enterprises, Inc.	37/2016	cnn	cal: - chk: -	cal: - chk: -	cal: - chk: -
20910	Frequency Multiplier 936VF-10/385	MI-Wave, Millimeter Wave Products Inc.	142	cnn	cal: - chk: -	cal: - chk: -	cal: - chk: -
20911	Frequency Multiplier 938WF-10/387	MI-Wave, Millimeter Wave Products Inc.	141	cnn	cal: - chk: -	cal: - chk: -	cal: - chk: -
20912	Low noise Amplifier Module 0.5-4GHz	RF-Lambda Europe GmbH / Rüsselsheim	19041200083	cpu	chk: 2020-Dec-01	chk: 6M	chk: 2021-Jun-01
20913	Phase Amplitude Stable Cable Assembly DC-40GHz	RF-Lambda Europe GmbH	AC19040001	cnn	cal: - chk: -	cal: - chk: -	cal: - chk: -
25457	DRG Horn Antenna SAS-574	A.H. Systems, Inc. / Chatsworth	383	cal	cal: 2022-Mar-28	cal: 36M	cal: 2025-Mar-28
20007	Single-Line V-Network (50 Ohm/5µH) ESH3-Z6	Rohde & Schwarz Messgerätebau GmbH / Memmingen	892563/002	cal	cal: 2024-May-14	cal: 12M	cal: 2025-May-14
20033	RF-current probe (100kHz-30MHz) ESH2-Z1	Rohde & Schwarz Messgerätebau GmbH / Memmingen	879581/18	cal	cal: 2023-May-25	cal: 24M	cal: 2025-May-25
20051	VHF-Current Probe ESV-Z1	Rohde & Schwarz Messgerätebau GmbH	872421	cpu			
20099	Passive Voltage Probe ESH2-Z3	Rohde & Schwarz Messgerätebau GmbH	299.7810.52	cpu			
20100	Passive Voltage Probe TK 9416	Schwarzbeck Mess-Elektronik OHG / Schönau	without	cpu			
20300	AC - LISN (50 Ohm/50µH, 1-phase) ESH3-Z5	Rohde & Schwarz Messgerätebau GmbH / Memmingen	892 239/020	cal	cal: 2024-May-14	cal: 12M	cal: 2025-May-14
20373	Single-Line V-Network (50 Ohm/5µH) ESH3-Z6	Rohde & Schwarz Messgerätebau GmbH / Memmingen	100535	cal	cal: 2024-May-14	cal: 12M	cal: 2025-May-14
20377	Test Receiver ESCS30	Rohde & Schwarz Messgerätebau GmbH / Memmingen	100160	cal	cal: 2024-May-16	cal: 12M	cal: 2025-May-16
20468	Digital Multimeter Fluke 112	Fluke Deutschland GmbH / Glottertal	90090455	cal	cal: 2024-May-14	cal: 36M	cal: 2027-May-14
20556	Thermo-/Hygrometer WS-9400	Conrad Electronic GmbH / Hirschau	without	chk	chk: 2023-Jul-14	chk: 24M	chk: 2025-Jul-14

4.9.1 Legend

Note / remarks	Interval of calibration & Verification
12M	12 months
24M	24 months
36M	36 months
10Y	10 Years

Abbreviation Check Type	Description
cnn	Calibration and verification not necessary
cal	Calibration
calchk	Calibration plus intermediate Verification
chk	Verification
cpu	Verification before usage

5 Results from external laboratory

None	-

6 Opinions and interpretations

None	-

7 List of abbreviations

None	-

8 Measurement Uncertainty valid for conducted/radiated measurements

The reported uncertainties are calculated based on the standard uncertainty multiplied with the appropriate coverage factor **k**, such that a confidence level of approximately 95% is achieved. For uncertainty determination, each component used in the concrete measurement set-up was taken in account and it contribution to the overall uncertainty according its statistical distribution calculated.

Issue No.	Measurement type	Reference	Frequency range of measurement		Calculated Uncertainty based on confidence level of 95.54%	Remarks
			Start [MHz]	Stop [MHz]		
1	Magnetic field strength	FCC15/18/22/ 24/27/90, ISED	0.009	30	4.86	Magnetic loop antenna, Pre-Amp on
2	RF-Output power (eirp) Unwanted emissions (eirp) [dB]	FCC15/18 / ISED	30	100	4.57	without Pre-Amp
			30	100	4.91	with Pre-Amp
			100	1000	4.02	without Pre-Amp
			100	1000	4.26	with Pre-Amp
			1000	18000	4.36	without Pre-Amp
			1000	18000	5.23	with Pre-Amp
			18000	33000	4.92	Schwarzbeck BBHA9170 (#20302) Antenna set-up non-waveguide antenna
			33000	50000	4.17	Set-up for Q-Band (WR-22), non-wave guide antenna
			40000	60000	4.69	Set-up U-Band (WR-19), non-waveguide antenna
			50000	75000	4.06	External Mixer set-up V-Band (WR-15)
			75000	110000	4.17	External Mixer set-up W-Band (WR-6)
			90000	140000	5.49	External Mixer set-up F-Band (WR-8)
			140000	225000	6.22	External Mixer set-up G-Band (WR-5)
			225000	325000	7.04	External Mixer set-up (WR-3)
			325000	500000	8.84	External Mixer set-up (WR-2.2)
3	Radiated Blocking [dB]	EN 303 883	1000	18000	2.85	Typical set-up with microwave generator and antenna, value for 7 GHz calculated
			18000	33000	4.66	Typical set-up with microwave generator and antenna
			33000	50000	3.48	WR-22 set-up
			50000	75000	3.73	WR-15 set-up
			75000	110000	4.26	WR-6 set-up
4	Frequency Error / UWB+FMCW [kHz]	EN 303 883 FCC 15	40000	77000	276.19	calculated for 77 GHz (FMCW) carrier
			6000	7000	33.92	calculated for 6.5 GHz UWB Ch.5
	Frequency Error / NFC [Hz]	FCC 15	11.00	14.00	20.76	calculated for 13.56 MHz NFC carrier
5	TS 8997 conducted Parameters	FCC15/18 / ISED	30	6000	1.11	1. Power measurement with Fast-sampling-detector
			30	6000	1.20	2. Power measurement with Spectrum-Analyzer
			30	6000	1.20	3. Power Spectrum-Density measurement
			30	7500	1.20	4. Conducted Spurious emissions:
			0.009	30	2.56	5. Conducted Spurious emissions:
			2.4	2.48	1.95 ppm	6a. Bandwidth / 2-Marker Method for 2.4 GHz ISM
			5.18	5.825	7.180 ppm	6b. Bandwidth / 2-Marker Method for 5 GHz WLAN
			5.18	5.825	1.099 ppm	7. Frequency (Marker method) for 5 GHz WLAN
			30	6000	0.11561µs	8. Medium-Utilization factor / Timing
			30	6000	1.85	9a. Blocking-Level of companion device
			30	6000	1.62	9b. Blocking Generator level
6	Conducted emissions	EN 303 883 FCC 15	0.009	30	3.57	--
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9 Versions of test reports (change history)

Version	Applied changes	Date of release
--	Initial release	2024-Jun-13
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End Of Test Report