Test Report
20-1-0018201T008a

Deutsche Akkreditierungsstelle
D-PL-12047-01-01
D-PL-12047-01-03
D-PL-12047-01-04

Number of pages:	36	**Date of Report:**	2023-Mar-03
Testing company:	cetecom advanced GmbH Im Teelbruch 116 45219 Essen Germany Tel. + 49 (0) 20 54 / 95 19-0 Fax: + 49 (0) 20 54 / 95 19-150	**Applicant:**	Brose Fahrzeugteile SE & Co. Kommanditgesellschaft, Bamberg
Product:	**Kick Sensor (HfA)**		
Model:	**R-HFA GEN1**		
FCC ID:	2AHV8-G45476	**IC:**	29958-G45476

Testing has been carried out in accordance with:

FCC Regulations
Title 47 CFR, Chapter I, Subchapter D, Part 95
Subpart M
The 76-81 GHz Band Radar Service
§ 95.3367 76-81 GHz Band Radar Service radiated power limits
§ 95.3379 76-81 GHz Band Radar Service unwanted emissions limits

ISED-Regulations
Radio Standards Specification
RSS-251, Issue 2
Vehicular Radar and Airport Fixed or Mobile Radar in the 76-81 GHz Frequency Band

Tested Technology:	Radar, 77G – 79GHz
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. Ninovic Perez	B.Sc. Al-Amin Hossain
Test Lab Manager	Test Manager
Authorization of test report	Responsible of test report

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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 Attestation

I declare that all measurements were performed by me or under my supervision and that all measurements have been performed and are correct to my best knowledge and belief to Industry Canada standards. All of the above requirements are met in accordance with enumerated standards.

1.3 Summary of Test Results

The EUT integrates a Radar transmitter. Other implemented wireless technologies were not considered within this test report.

Test case	Reference Clause FCC ☒	Reference Clause ISED ☒	Page	Remark	Result
Power density	FCC §95.3367 (a) (b)	RSS-251 (Section 8 and 9)	12	--	Passed
Modulation characteristics	FCC §2.1047 (d)	RSS-251 (Section 6b)	13	--	Passed
Occupied bandwidth	FCC §95.3379 (b)	RSS-251 (Section 7)	15	--	Passed
Field strength of emissions (band edge)	FCC §95.3379 (a)(2)(i)	RSS-251 (Section 10)	--	--	N/A
Field strength of emissions (radiated spurious)	FCC §95.3379 (a)	RSS-251 (Section 10)	19	--	Passed
Frequency stability	FCC §95.3379 (b)	RSS-251 (Section 11)	31	--	Passed

PASSED	The EUT complies with the essential requirements in the standard.
FAILED	The EUT does not comply with the essential requirements in the standard.
N/A	Test case does not apply to the test object.
NP	The test was not performed by the cetecom advanced laboratory.

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

1.4 Summary of Test Methods

Test case	Test method
Power density	ANSI C63.26-2015, ANSI C63.10-2013
Modulation characteristics	--
Occupied bandwidth	ANSI C63.26-2015, ANSI C63.10-2013 §6.3, §6.4
Field strength of emissions (band edge)	ANSI C63.26-2015, ANSI C63.10-2013 §6.3, §6.5
Field strength of emissions (radiated spurious)	ANSI C63.26-2015 , ANSI C63.10-2013 §6.3, §6.6
Frequency stability	ANSI C63.26-2015 , ANSI C63.10-2019 §6.8

2 Administrative Data

2.1 Identification of the Testing Laboratory

Company name:	cetecom advanced GmbH
Address:	Im Teelbruch 116 45219 Essen - Kettwig Germany
Responsible for testing laboratory:	Dipl.-Ing. Ninovic Perez
Accreditation scope:	**DAkkS Webpage: FCC ISED**
IC Lab company No. / CAB ID:	3462D / DE0005
Test location:	Im Teelbruch 116; 45219 Essen

2.2 General limits for environmental conditions

Temperature:	22±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:	2022-Sep-30
Date(s) of test:	2023-Jan-03 to 2023-Jan-17
Version of template:	22.1101

2.5 Applicant's details

Applicant's name:	Brose Fahrzeugteile SE & Co. Kommanditgesellschaft, Bamberg
Address:	Berliner Ring 1 96052 Bamberg Bavaria Germany
Contact Person:	Bertram Bopp
Contact Person's Email:	Bertram.Bopp@brose.com

2.6 Manufacturer's details

Manufacturer's name:	Brose Fahrzeugteile SE & Co. Kommanditgesellschaft, Bamberg
Address:	Berliner Ring 1 96052 Bamberg Germany

2.7 Equipment under Test (EUT)

EUT No.*)	Sample No.	Product	Model	Type	SN	HW	SW
EUT 1	20-1-00182S40_C01	Kick Sensor (HfA)	R-HFA GEN1	AWR1843	--	G45476-080	C0_SWR5_2
EUT 2	20-1-00182S48_C01	Kick Sensor (HfA)	R-HFA GEN1	AWR1843	--	G45476-080	C0_SWR5_2

*) 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	**20-1-00182S35_C01**	**VectorBox**	**VN1630A**	--	--	--
AE 2	**20-1-00182S32_C01**	**Laptop**	**HP Elitebook 840 G7**	--	--	--
AE 3	**20-1-00182S30_C01**	**Power supply**	**TPN-CA14**	--	--	--

*) 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	**20-1-00182S24_C01**	**Cable harness**	--	--
CAB 2	**20-1-00182S25_C01**	**USB Cable**	**USB-A / USB-B**	--

*) 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 + AE 2 + AE 3 + CAB 1 + CAB 2	➢ Used for Radiated measurements ➢ Fundamental Measurements ➢ Radiated Spurious Emission below 40 GHz
2	EUT 2 + CAB 1	➢ Used for Radiated measurements ➢ Radiated Spurious Emission above 40 GHz

*) 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 Gesture Detect	With help of special test firmware TX-mode was set-up. We refer to applicants information/papers for details about necessary commands.
op. 2	TX-Mode 2 High Temperature	With help of special test firmware TX-mode was set-up. We refer to applicants information/papers for details about necessary commands.
op. 3	TX-Mode 3 CW mode at low, mid and high channel	CW mode has been configured by the Customer, Plug and Play, no additional instructions are necessary. Once the EUT plug in, it starts to trnasmit

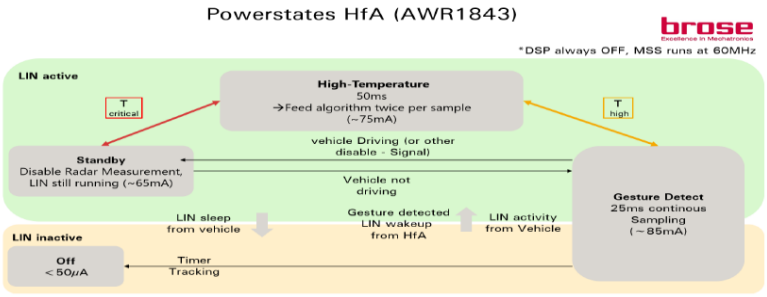
*) EUT operating mode no. is used to simplify the test report.

For more information regarding operation modes, please check below document,

- CANape_mode_settings_Radar-HfA – updated
- Anleitung LIN Tracing Via CANape

2. Mode-Overview

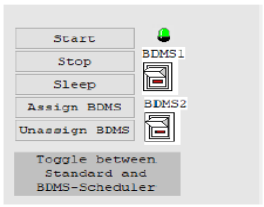
Mode	Current (@12V)	LIN	Radar
Sleep/Off	<50µA	OFF	OFF
Standby	~65mA	ON	OFF
Gesture Detect	~85mA	ON	ON (25ms Sampling)
High-Temperature	~75mA	ON	ON (50ms Sampling)



b. Gesture Detect Mode (with active LIN)

Press Start again to restart LIN

ECU should be active now an consume ~85mA



d. High temperature Mode

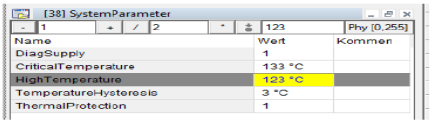
To get into this mode, you have also to change the Temperature values.

Set "CriticalTemperature" to 133°C and "HighTemperature" to 5°C (It is expected that the measurements are done at room temperature)

Then push the "Write"-Button (indicator then should be green):

After some seconds, the ECU should now consume around 75mA

To get into normal measurement mode, set the values back to default values and write them in the ECU:



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	**12** V DC	
	☐ Battery	--	
Operational conditions	T_{nom} =20 °C	T_{min} =-40 °C	T_{max} =+105 °C
	Vnom=12 V DC	Vmin=9 V DC	Vmax=16 V DC
EUT sample type	**Pre-Production**		
Weight	0.100 kg		
Size [LxWxH]	7.5 cm x 6.0 cm x 2.0 cm		
Interfaces/Ports	 Only one port for cable/harness		
For further details refer Applicants Declaration & following technical documents ➢ **BROSE R-HfA-Datasheet-221006**			

Remark:
Customer has been declared below Operational conditions,

R-HFA GEN1

Datasheet

Voltage	
Min	9,0V
Mean	12,0V
Max	16,0V
Temperature	
Min	-40°C
Max	+105°C

3.2 Detailed Technical data of Main EUT as Declared by Applicant

TX Frequency range [MHz]	77.050 GHz to 78.950 GHz		
Type of modulation used	FMCW		
Antenna polarization	--		
Modulation method	32 Chirps per radar cycle		
Bandwidth	1.9 GHz		
Interfaces	--		
Emission classification	F3N		
Coaxial antenna connector available	☒ No connector	☐ Only for testing purpose	☐ Regular use
Antenna Type	☒ Integrated – monopole ☐ External, no RF- connector ☐ External, separate RF-connector		
Antenna Gain	9.40 dBi	☐ Declared by applicant	☒ Measured
	--	--	9.40 dBi
For further details refer Applicants Declaration & following technical documents			

Description of Reference Document (supplied by applicant)	**Version**	**Total Pages**
Antenna 2022_11_23	28/10/2022	1
BROSE R-HfA-Datasheet-221006	10/10/2022	1

Remark: for more information regarding Antenna gain, please check document "**TR20-1-0018210T001a**".

3.3 Modifications on Test sample

Additions/deviations or exclusions	--

4 Measurements

4.1 The maximum peak power EIRP / peak EIRP spectral density. The maximum power EIRP/ average EIRP.

Testing method:

All the measurements are done according to standards and rules listed in subsection 5.1.2. The measured power is EIRP*.
The EUT is ON and set to default mode: FMCW modulation. At first the EUT is tested under nominal condition. Then it is tested under extreme conditions (extreme temperatures and voltages) with the help of a climate cabinet and a variable power supply.
For the maximum peak power EIRP / peak EIRP spectral density test function Signal-ID is activated to exclude ghost signals (product of the mixer).
*EIRP: Equivalent Isotropic Radiated Power

4.1.1 Measurement Location

Test site	120907 - FAC2 - Radiated Emissions

4.1.2 Limit

Average [dBm]	Peak [dBm]
50	55

4.1.3 Spectrum-Analyzer Settings

Span	> 2 GHz
Resolution Bandwidth (RBW)	1 MHz, 10 MHz
Video Bandwidth (VBW)	3 times the resolution bandwidth
Sweep time	≥ Span/RBW*EUT Cycle Time
Detector	Peak detector with max peak search. RMS with channel power measurement.
	Used FMCW Peak Desensitization correction factor for Peak Power measurements
Sweep mode	Single Sweep, MAX-HOLD

4.1.4 Result

Diagram	Mode	Peak detector, max peak search (marker) [dBm]	Peak detector, max peak search (marker frequency) [GHz]	RMS detector, channel power measurement [dBm]	Voltage [V]	Temperature [°C]	Result
D118_02a	1@vertical	16.60	78.88	--	Vnom=12	Tnom=20	Passed
D119_02a	1@horizontal	5.65	78.08	--	Vnom=12	Tnom=20	Passed
D118_05a	1@vertical	16.41	77.64	--	Vnom=12	Tmin=-40	Passed
D118_07a	1@vertical	15.85	78.89	--	Vnom=12	Tmax=105	Passed
D118_09a	1@vertical	15.90	78.64	--	Vmax=16	Tnom=20	Passed
D118_11a	1@vertical	16.30	78.64	--	Vmin=9	Tnom=20	Passed
D118_02b	2@vertical	16.09	78.89	--	Vnom=12	Tnom=20	Passed
D119_02b	2@horizontal	6.97	78.09	--	Vnom=12	Tnom=20	Passed
D118_05b	2@vertical	16.46	77.64	--	Vnom=12	Tmin=-40	Passed
D118_07b	2@vertical	16.32	78.89	--	Vnom=12	Tmax=105	Passed
D118_09b	2@vertical	16.29	78.64	--	Vmax=16	Tnom=20	Passed
D118_11b	2@vertical	16.54	78.64	--	Vmin=9	Tnom=20	Passed
D113_01a	1@vertical	--	--	1.15	Vnom=12	Tnom=20	Passed
D114_01a	1@horizontal	--	--	-4.47	Vnom=12	Tnom=20	Passed
D113_02a	1@vertical	--	--	-3.45	Vnom=12	Tmin=-40	Passed
D113_03a	1@vertical	--	--	-5.39	Vnom=12	Tmax=105	Passed
D113_04a	1@vertical	--	--	-0.05	Vmin=9	Tnom=20	Passed
D113_05a	1@vertical	--	--	-0.06	Vmax=16	Tnom=20	Passed
D113_01b	2@vertical	--	--	-1.66	Vnom=12	Tnom=20	Passed
D114_01b	2@horizontal	--	--	-4.87	Vnom=12	Tnom=20	Passed
D113_02b	2@horizontal	--	--	-2.45	Vnom=12	Tmin=-40	Passed
D113_03b	2@horizontal	--	--	-7.27	Vnom=12	Tmax=105	Passed
D113_04b	2@horizontal	--	--	-2.11	Vmax=16	Tnom=20	Passed
D113_05b	2@horizontal	--	--	-2.13	Vmax=16	Tnom=20	Passed

Remark: for more information and graphical plot see annex A1 **TR20-1-0018201T008a-A1**

All measurements have been performed with Antenna vertical Polarization and found as worst case scenario in respect to Output Peak Power (EIRP), at Horizontal Polarization, Peak power is very low.
Therefore all Power (EIRP) Measurements have been carried out with Antenna Vertical Polarization.

For more information, check below Diagrams,
D118_02a and D119_02a for GD mode (1),
D118_02b and D119_02b for HT mode (2),

D113_01a and D114_01a for GD mode (1),
D113_01b and D114_01b for HT mode (2),

4.2 Modulation characteristics

Testing method:

Start and stop frequency was measured for all operating modes and all frequency bands with nominal conditions.
Wave form and sweep characteristics were supplied by applicant

4.2.1 Measurement Location

Test site	120907 - FAC2 - Radiated Emissions

4.2.2 Limit

Limit
--

4.2.3 Spectrum-Analyzer Settings

Span	> 2 GHz
Resolution Bandwidth (RBW)	1 MHz, 10 MHz
Video Bandwidth (VBW)	3 times the resolution bandwidth
Sweep time	≥ Span/RBW*EUT Cycle Time
Detector	Peak detector with max peak search.
	Used FMCW Peak Desensitization correction factor for Peak Power measurements
Sweep mode	Single Sweep, MAX-HOLD

4.2.4 Result

Remark: for more information and graphical plot see annex A1 **TR20-1-0018201T008a-A1**

4.3 Occupied bandwidth

Testing method:

Occupied bandwidth was measured for operating mode 1 and 2 under nominal and extreme conditions. Occupied bandwidth (99 %) function is activated in spectrum analyzer for this measurement.

EUT settings

The measurement is made radiated. The EUT was instructed to transmit continuously with maximum power (if adjustable) according applicants declared and applicable settings.
Different characteristics have been checked, e.g. data rates which EUT can operate if applicable.

4.3.1 Measurement Location

Test site	120907 - FAC2 - Radiated Emissions

4.3.2 Limit

Test limit [GHz]
76 - 81

4.3.3 Spectrum-Analyzer Settings

Span	3 GHz
Resolution Bandwidth (RBW)	FCC: 30 MHz (1% to 5% of the actual occupied / x dB bandwidth) IC: 30 MHz (1% to 5% of the actual occupied / x dB bandwidth) RSS-Gen Issue 5 March 2019 Amendment 1 Section 6.7.: “The resolution bandwidth (RBW) shall be in the range of 1% to 5% of the actual occupied / x dB bandwidth and the video bandwidth (VBW) shall not be smaller than three times the RBW value.” **Actual occupied bandwidth (99% emission bandwidth) of the EUT is app. 1900 MHz.** So RBW = 30 MHz was chosen.
Video Bandwidth (VBW)	FCC: 80 MHz IC: 80 MHz
Sweep time	≥ Span/RBW*EUT Cycle Time EUT Cycle time, GD mode (1) = approx. 25 ms, EUT Cycle time, HT mode (2)= approx. 50 ms,
Detector	Peak detector
Sweep mode	Single Sweep, MAX-HOLD

4.3.4 Result

Diagram	Mode	Low edge [GHz]	High edge [GHz]	Voltage [V]	Temperature [°C]	Occ. bandwidth [GHz]	Result
D108_02a	1@vertical	76.9972	78.9191	Vnom=12	Tnom=20	1.9219	Passed
D109_02a	1@horizontal	76.9997	78.9191	Vnom=12	Tnom=20	1.9195	Passed
D108_11a	1@vertical	76.9951	78.9215	Vmin=9	Tnom=20	1.9264	Passed
D109_10a	1@horizontal	77.0051	78.9011	Vmin=9	Tnom=20	1.8971	Passed
D108_13a	1@vertical	76.9953	78.9214	Vmax=16	Tnom=20	1.9261	Passed
D109_12a	1@horizontal	77.0141	78.9011	Vmax=16	Tnom=20	1.8882	Passed
D108_09a	1@vertical	76.9944	78.9246	Vnom=12	Tmax=105	1.9302	Passed
D109_08a	1@horizontal	76.9979	78.9093	Vnom=12	Tmax=105	1.9114	Passed
D108_07a	1@vertical	76.9938	78.9241	Vnom=12	Tmin=-40	1.9303	Passed
D109_06a	1@horizontal	77.0125	78.9116	Vnom=12	Tmin=-40	1.8991	Passed
D108_02b	2@vertical	76.9956	78.9215	Vnom=12	Tnom=20	1.9266	Passed
D109_02b	2@horizontal	77.0060	78.9090	Vnom=12	Tnom=20	1.9008	Passed
D108_11b	2@vertical	76.9958	78.9195	Vmin=9	Tnom=20	1.9237	Passed
D109_10b	2@horizontal	77.0047	78.8994	Vmin=9	Tnom=20	1.8947	Passed
D108_13b	2@vertical	76.9971	78.9202	Vmax=16	Tnom=20	1.9231	Passed
D109_12b	2@horizontal	77.0047	78.8994	Vmax=16	Tnom=20	1.8947	Passed
D108_09b	2@vertical	76.9951	78.9253	Vnom=12	Tmax=105	1.9302	Passed
D109_08b	2@horizontal	76.9979	78.9093	Vnom=12	Tmax=105	1.9114	Passed
D108_05b	2@vertical	76.9955	78.9244	Vnom=12	Tmin=-40	1.9290	Passed
D109_05b	2@horizontal	77.1065	78.9094	Vnom=12	Tmin=-40	1.8029	Passed

Remark: for more information and graphical plot see annex A1 **TR20-1-0018201T008a-A1**

Occupied Bandwidth measured = ~ 1.9 GHz

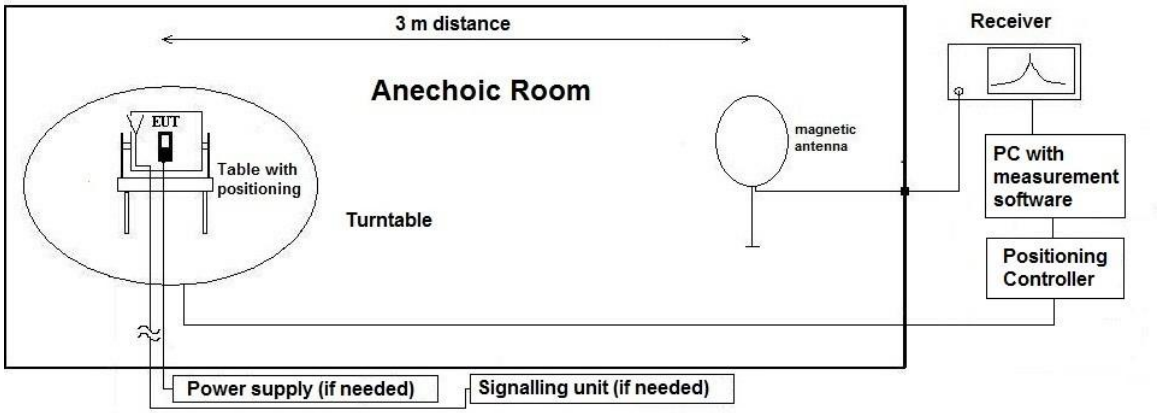
4.4 Radiated field strength emissions below 30 MHz

4.4.1 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.

4.4.2 Sample calculation

Raw-Value [dBuV/m]	Antenna factor	Distance Correction [dB]	Cable Loss	Preamplifier	Resulting correction value [dB]	Final result [dBuV/m]	Remarks
19.83	18.9	-70.75	0.18	--	-51.67	-31.83	30 to 3 m correction used according ANSI C63.10-2013

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

4.4.3 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

4.4.4 Measurement Location

Test site	120901 - SAC - Radiated Emission <1GHz

4.4.5 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

4.4.6 Result

Diagram	Mode	Maximum Level [dBµV/m] Frequency Range 0.009 – 30 MHz	Result
2.01	1 (GD mode) @EUT Standing	No critical level found	Passed
2.02	1 (GD mode) @EUT Laying	No critical level found	Passed
2.03	2 (HT mode) @EUT Standing	No critical level found	Passed
2.04	2 (HT mode) @EUT Laying	No critical level found	Passed

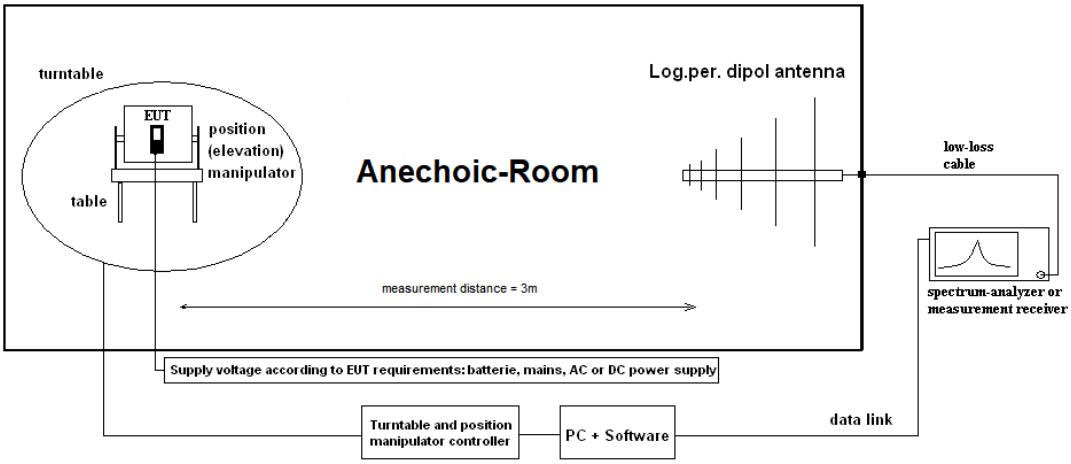
Remark: for more information and graphical plot see annex A1 **TR20-1-0018201T008a-A1**

4.5 Radiated field strength emissions 30 MHz – 960 MHz

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 16-1-4:2010 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 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.

4.5.2 Sample calculation

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

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

4.5.3 Measurement Location

Test site	120907 - FAC2 - Radiated Emissions

4.5.4 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

4.5.5 Result

Diagram	Mode	Maximum Level [dBµV/m] Frequency Range 30 – 960 MHz	Result
3.01	1 (GD mode)@EUT Standing	34.98@85.750000	Passed
3.02	1 (GD mode) @EUT Laying	34.43@87.830000	Passed
3.03	2 (HT mode) @EUT Standing Only worst case position has been performed	33.44@84.350000	Passed

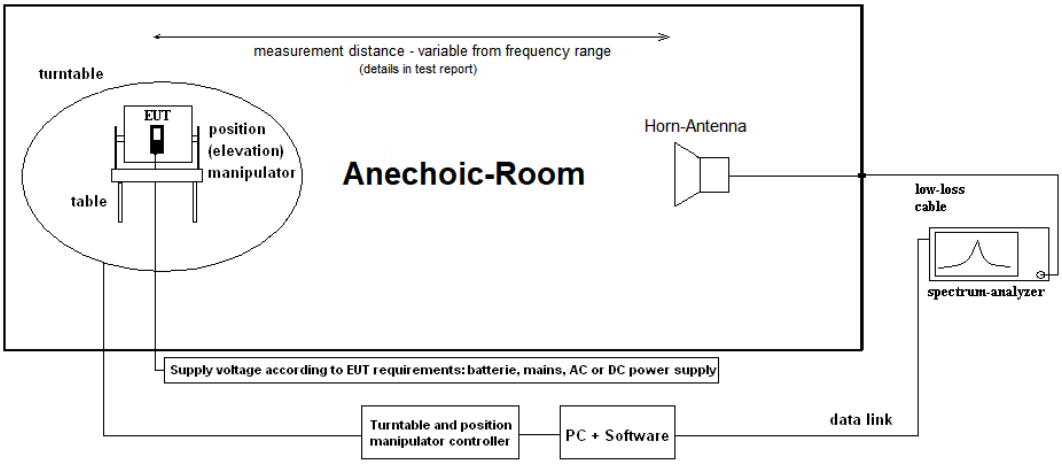
Remark: for more information and graphical plot see annex A1 **TR20-1-0018201T008a-A1**

4.6 Radiated field strength emissions 960 MHz – 40 GHz

4.6.1 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. 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:

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

4.6.2 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

4.6.3 Measurement Location

Test site	120907 - FAC2 - Radiated Emissions

4.6.4 Limit

Frequency Range [MHz]	Measurement distance [m]	EIRP [dBm] Peak Detector	EIRP [dBm] Average Detector	Field strength [dBµV/m] Peak Detector	Field strength [dBµV/m] Average Detector	RBW / VBW [kHz]
960-40000	3	−21.23	−41.23	74	54	1000 / 3000
960-40000	1	-11.65	-31.65	--	--	1000 / 3000

EIRP limit was calculated according to the equation (38) in ANSI C63.10-2013:

EIRP[dBm] = E[dBµV/m]+ 20log(d [m])−104.77

EIRP limit = [54 + 20log(3)−104.77] dBm
= [54 + 9.54−104.77] dBm
= -41.23 dBm

4.6.5 Measurement distance

Frequency Range [GHz]	Measurement distance [m]	EIRP limit [dBm]
1 - 8	3	-41.23
8 – 12.4	3	-41.23
12.4 - 18	1	-31.65
18 - 40	1	-31.65

4.6.6 Result

Diagram	Mode	Frequency [GHz]	Max level [dBm]	Result
D127_01	1@ver+hor	1G to 12.4GHz	No critical level found	Passed
D128_01	2@ver+hor	1G to 12.4GHz	No critical level found	Passed
D127_05a	1@vertical	12.4G to 18GHz	No critical level found	Passed
D127_02a	1@horizontal	12.4G to 18GHz	No critical level found	Passed
D127_05b	2@vertical	12.4G to 18GHz	No critical level found	Passed
D127_02b	2@horizontal	12.4G to 18GHz	No critical level found	Passed
D130_pretest	1@vertical	18G to 40GHz	No critical level found	Passed
D130_01_final test	1@vertical	18G to 40GHz	No critical level found	Passed
D130_02	1@vertical	38G to 40GHz, RBW 1MHz	No critical level found	Passed
D130_03	1@vertical	38G to 40GHz, RBW 10MHz	No critical level found	Passed
D129_pretest	1@horizontal	18G to 40GHz	No critical level found	Passed
D129_01	1@horizontal	18G to 40GHz	Check D129_02 to D129_07	Passed
D129_02	1@horizontal	38G to 40GHz, RBW 1MHz	Peak power, -20.98 dBm@39.5GHz Avg power, -39.75 dBm@38.5GHz	Passed
D129_04	1@horizontal	@38.5GHz, RBW 1MHz, Span: 200 MHz	Peak power, -23.44 dBm@38.5GHz Avg power, -39.09 dBm@38.5GHz	Passed
D129_05	1@horizontal	@39.5GHz, RBW 1MHz, Span: 200 MHz	Peak power, -21.31 dBm@39.5GHz Avg power, -42.90 dBm@39.5GHz	Passed
D129_03	1@horizontal	38G to 40GHz, RBW 10MHz	Peak power, -18.28 dBm@39.5GHz Avg detector is not considered for desensitization factor	Passed
D129_06	1@horizontal	@38.5GHz, RBW 10MHz, Span: 200 MHz	Peak power, -19.09 dBm@38.5GHz Avg detector is not considered for desensitization factor	Passed
D129_07	1@horizontal	@39.5GHz, RBW 10MHz, Span: 200 MHz	Peak power, -18.41 dBm@39.5GHz Avg detector is not considered for desensitization factor	Passed
D150_pretest	2@vertical	18G to 40GHz	No critical level found	Passed
D150_01_final test	2@vertical	18G to 40GHz	No critical level found	Passed
D151_pretest	2@ horizontal	18G to 40GHz	No critical level found	Passed
D151_01_final test	2@horizontal	18G to 40GHz	No critical level found	Passed
D151_02	2@horizontal	38G to 40GHz	Peak power, -23.22 dBm@39.5GHz Avg power, -45.59 dBm@38.5GHz	Passed

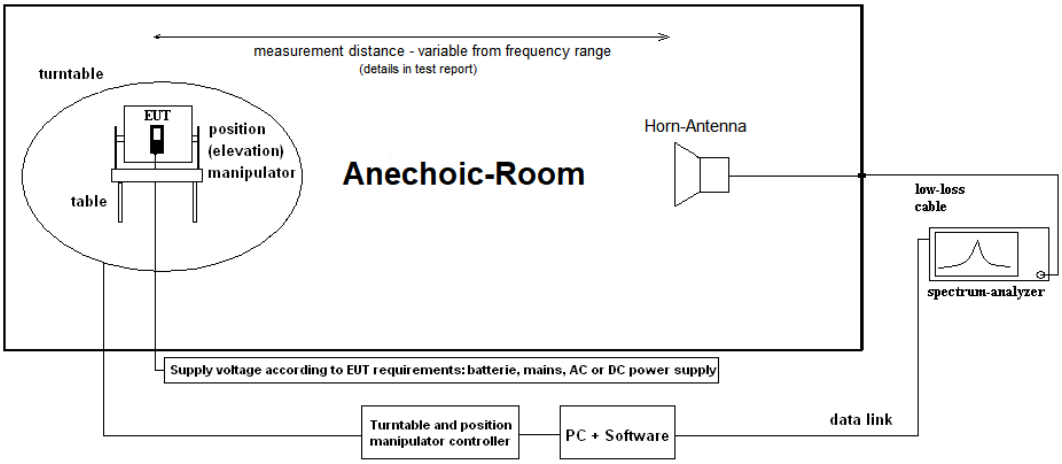
Remark: for more information and graphical plot see annex A1 **TR20-1-0018201T008a-A1**

4.7 Radiated field strength emissions, above 40 GHz

4.7.1 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:

Measurement is done for op. mode 1. The measuring sweeps are repeated with Maxhold function activated. Thus the measuring diagrams in annex 1 covers emissions of the EUT in all 3D directions. The alignment where the EUT transmits the maximum power is also determined.
The measurements are made with the mixer. There is a ref level line in all measurements. This line is not to be mistaken for limit line.
There are many image signals and mixer products to see on the measurement graphs. Signal ID function is used for the most measurement above 55 GHz for the purpose to distinguish these image signals and mixer products from the real signals. Here is the description of Signal ID function from user manual for R&S FSW Signal and Spectrum Analyzer (1173.9411.02 – 31):
two sweeps are performed alternately. Trace 1 shows the trace measured on the upper side band (USB) of the LO (the test sweep), trace 2 shows the trace measured on the lower side band (LSB), i.e. the reference sweep.
*The reference sweep is performed using an LO setting shifted downwards by 2*IF/<Harmonic order>. Input signals in the desired sideband that are converted using the specified harmonic are displayed in both traces at the same position on the frequency axis. Image signals and mixer products caused by other harmonics are displayed at different positions in both traces. The user identifies the signals visually by comparing the two traces.*
Since the LO frequency is displaced downwards in the reference sweep, the conversion loss of the mixer may differ from the test sweep. Therefore the signal level should only be measured in the test sweep (trace 1).
According to the description of the Signal ID function above the following measurement procedure was developed: the measurement was done with Signal ID function ON, when there are any emissions on the measurement graph or with Signal ID function OFF, when there are no emissions at all. On the measurement graph with Signal ID function ON there are two traces at first, LSB and USB. These traces can cover each other. For this reason two more graphs are made and

included in the test report for each measurement. One graph with only USB trace and one graph with only LSB trace. These two already saved graphs are opened and compared on the wide enough screen. The scaling of the both graphs is the same. So the graphs can be easily compared by the switching between them (at first one graph is showed on the screen and then the second one). Each area of both traces is compared manually in this way. When there is an emission at the same frequency at LSB as well as at USB trace then it is a real signal. Such signal will be flagged with a marker and later re-measured.

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]	Lowest wavelength λ in the measurement [m]	Boundary for near/far field [m]
40-60	0.0384	50	0.491520000	0.49
55-75	0.0307	60	0.003997233	0.38
55-75	0.0307	75	0.471245000	0.47
75-110	0.0208	78	0.224972800	0.22
75-110	0.0208	96	0.276889600	0.28
90-140	0.0165	115	0.208725000	0.21
90-140	0.0165	125	0.226875000	0.23
90-140	0.0165	135	0.245025000	0.25
90-140	0.0165	140	0.254100000	0.25
140-220	0.0107	150	0.167918667	0.17
140-220	0.0107	160	0.122122667	0.12
140-220	0.0107	170	0.129755333	0.13
140-220	0.0107	180	0.137388000	0.14
140-220	0.0107	190	0.145020667	0.15
140-220	0.0107	200	0.152653333	0.15
140-220	0.0107	210	0.160286000	0.16
140-220	0.0107	220	0.167918667	0.17
220-243	0.00705	243	0.080518050	0.08

Measurement distance:

Measurement frequency range:	Measurement distance [m]	Boundary for near/far field [m]
40 GHz – 55 GHz	0.5	0.49
55 GHz – 65 GHz	1	0.38
65 GHz – 75 GHz	1	0.47
75 GHz – 81 GHz	1	0.22
81 GHz – 93 GHz	1	0.28
93 GHz – 110 GHz	1	0.28
110 GHz – 120 GHz	0.5	0.21
120 GHz – 130 GHz	0.5	0.23
130 GHz – 140 GHz	0.5	0.25
140 GHz – 150 GHz	0.32	0.12
150 GHz – 162 GHz	0.32	0.12
162 GHz – 200 GHz	0.17	0.15
200 GHz – 220 GHz	0.17	0.17
220 GHz – 243 GHz	0.25	0.08

4.7.2 Measurement Location

Test site	120907 - FAC2 - Radiated Emissions

4.7.3 Limit

FCC Frequency [GHz]	FCC EIRP [dBm]	ISED Frequency [GHz]	ISED EIRP [dBm]
40 - 200	600 pW/cm2 ~ -1.7	40 - 162	-30
200 - 231	1000 pW/cm2 ~ 0.5	--	--
Limit conversion (pW/cm2 to dBm):	P[dBm]=10*log(4*pi*d2*P[W/m2]) d- distance of the limit defined in W/m2. Here: 3 m. --- 600 pW/cm2: P[dBW]= 10*log(4*pi*(3m)2*6*10-6W/m2) 600 pW/cm2: P[dBW]= -31.7 dBW P[dBm] = P[dBW] + 30 600 pW/cm2: P[dBm]= -31.7 dBW + 30 600 pW/cm2: P[dBm]= -1.7 dBm --- 1000 pW/cm2: P[dBW]= 10*log(4*pi*(3m)2*1*10-5W/m2) 1000 pW/cm2: P[dBW]= -29.5 dBW P[dBm] = P[dBW] + 30 1000 pW/cm2: P[dBm]= -29.5 dBW + 30 1000 pW/cm2: P[dBm]= +0.5 dBm		

4.7.4 Spectrum-Analyzer Settings

Resolution Bandwidth (RBW)	1 MHz, 500 kHz, 100 kHz etc.
Video Bandwidth (VBW)	Minimum 3 times the resolution bandwidth
Sweep time	Auto
Detector	Peak detector – Premeasurements, RMS detector – Final measurements (if necessary)
Sweep mode	continuance sweep, MAX-HOLD
EUT Signal Type	CW mode

Remarks:

- Spurious Emission above 40 GHz has been performed with CW mode sample,
- Three Samples on CW_Low, CW_Mid, CW_High channels are configured from Customer on three different Frequencies,
- Maximum Peak Power measurements have performed on Three different sample on three different Frequencies,
- Maximum Power has been found at CW_mid, check Diagrams in Annex-1,
- Therefore all Spurious Emission above 40 GHz have been performed with CW_mode_mid_channel.

4.7.5 Result

Diagram	Mode	Frequency [GHz]	Max level [dBm]	Limit [dBm] FCC	Limit [dBm] ISED	Result
D131_01	3 mid channel @vertical	40 – 49.5	No critical level found	-1.7	-30	Passed
D131_02	3 mid channel @vertical	49.5 – 55	No critical level found	-1.7	-30	Passed
D132_01	3 mid channel @horizontal	40 – 49.5	No critical level found	-1.7	-30	Passed
D132_02	3 mid channel @horizontal	49.5 – 55	No critical level found	-1.7	-30	Passed
D133_01	3 mid channel @vertical	55 – 65	No critical level found	-1.7	-30	Passed
D134_01	3 mid channel @horizontal	55 – 65	No critical level found	-1.7	-30	Passed
D133_02	3 mid channel @vertical	65 – 75	No critical level found	-1.7	-30	Passed
D133_03	3 mid channel @vertical	@67	No critical level found Only ghost signal	-1.7	-30	Passed
D134_02	3 mid channel @horizontal	65 – 75	No critical level found	-1.7	-30	Passed
D134_03	3 mid channel @horizontal	@67	No critical level found Only ghost signal	-1.7	-30	Passed
D002	3 mid channel @vertical	75 – 76 for assessment, 76 -81 only for information	No critical level found Only ghost signal	-1.7	-30	Passed
D004	3 mid channel @horizontal	75 – 76 for assessment, 76 -81 only for information	No critical level found Only ghost signal	-1.7	-30	Passed
D006	1@vertical	75 - 85	No critical level found Only ghost signal	Only for information		
D007	1@ horizontal	75 - 85	No critical level found Only ghost signal			
D008	2@vertical	75 - 85	No critical level found Only ghost signal			
D009	2@ horizontal	75 - 85	No critical level found Only ghost signal			
D135	3 mid channel @vertical	81 – 93	No critical level found	-1.7	-30	Passed
D136a	3 mid channel @horizontal	81 – 93	No critical level found	-1.7	--	Passed
D136b	3 mid channel @horizontal	81 – 93	No critical level found	--	-30	Passed
D137a	3 mid channel @vertical	93 – 110	No critical level found	-1.7	--	Passed
D137b	3 mid channel @vertical+ horizontal	93 – 110	No critical level found	--	-30	Passed
D138	3 mid channel @horizontal	93 – 110	No critical level found	-1.7	--	Passed
D139_01a	3 mid channel @vertical	110 – 120	No critical level found	-1.7	--	Passed
D139_01b	3 mid channel @vertical	110 – 120	No critical level found	--	-30	Passed
D140_01a	3 mid channel @horizontal	110 – 120	No critical level found	-1.7	--	Passed
D140_01b	3 mid channel @horizontal	110 – 120	No critical level found	--	-30	Passed
D139_02a	3 mid channel @vertical	120 – 130	No critical level found	-1.7	--	Passed
D139_02b	3 mid channel @vertical	120 – 130	No critical level found	--	-30	Passed
D140_02a	3 mid channel @horizontal	120 – 130	No critical level found	-1.7	--	Passed
D140_02b	3 mid channel @horizontal	120 – 130	No critical level found	--	-30	Passed
D139_03a	3 mid channel @vertical	130 – 140	No critical level found	-1.7	--	Passed
D139_03b	3 mid channel @vertical	130 – 140	No critical level found	--	-30	Passed
D140_03a	3 mid channel @horizontal	130 – 140	No critical level found	-1.7	--	Passed
D140_03b	3 mid channel @horizontal	130 – 140	No critical level found	--	-30	Passed
D141_01	3 mid channel @vertical	140 – 150	No critical level found	-1.7	--	Passed
D142_01	3 mid channel @horizontal	140 – 150	No critical level found	-1.7	--	Passed

D141_02	3 mid channel @vertical	150 – 162	No critical level found	-1.7	--	Passed
D142_02	3 mid channel @horizontal	150 – 162	No critical level found	-1.7	--	Passed
D141_03	3 mid channel @vertical	140 – 162	No critical level found	--	-30	Passed
D142_03	3 mid channel @horizontal	140 – 162	No critical level found	--	-30	Passed
D143	3 mid channel @vertical	162 – 200	No critical level found	-1.7	--	Passed
D145	3 mid channel @horizontal	162 – 200	No critical level found	-1.7	--	Passed
D145_01	3 mid channel @horizontal	@181.7	No critical level found, Only ghost signal	-1.7	--	Passed
D145_02	3 mid channel @horizontal	@184.8	No critical level found Only ghost signal	-1.7	--	Passed
D144	3 mid channel @vertical	200 – 220	No critical level found	0.5	--	Passed
D146	3 mid channel @horizontal	200 – 220	No critical level found	0.5	--	Passed
D146_01	3 mid channel @horizontal	@217.9	No critical level found Only ghost signal	0.5	--	Passed
D147	3 mid channel @vertical	220 – 243	No critical level found	0.5	--	Passed
D148	3 mid channel @horizontal	220 – 243	No critical level found	0.5	--	Passed

Remark: for more information and graphical plot see annex A1 **TR20-1-0018201T008a-A1**

4.8 Frequency stability

Testing method:

Frequency stability was measured for operating mode 2 under nominal and extreme conditions. One marker was set on the low and high edge of the signal in each measurement. The frequency of the markers was compared for all measurements.

4.8.1 Measurement Location

Test site	120907 - FAC2 - Radiated Emissions

4.8.2 Limit

Test limit
The radar device's occupied bandwidth (i.e. 99% emission bandwidth) shall be maintained within the 76-81 GHz frequency band while subjected to all conditions of operation specified in RSS-Gen.

4.8.3 Spectrum-Analyzer Settings

Span	3 GHz
Resolution Bandwidth (RBW)	FCC: 30 MHz (1% to 5% of the actual occupied / x dB bandwidth) IC: 30 MHz (1% to 5% of the actual occupied / x dB bandwidth) RSS-Gen Issue 5 March 2019 Amendment 1 Section 6.7.: "The resolution bandwidth (RBW) shall be in the range of 1% to 5% of the actual occupied / x dB bandwidth and the video bandwidth (VBW) shall not be smaller than three times the RBW value." **Actual occupied bandwidth (99% emission bandwidth) of the EUT is approx. 1900 MHz.** So RBW = 30 MHz was chosen.
Video Bandwidth (VBW)	FCC: 80 MHz IC: 80 MHz
Sweep time	≥ Span/RBW*EUT Cycle Time EUT Cycle time, GD mode (1) = approx. 25 ms, EUT Cycle time, HT mode (2)= approx. 50 ms,
Detector	Peak detector
Sweep mode	Single Sweep, MAX-HOLD

4.8.4 Result

Diagram	Mode	Low edge [GHz]	High edge [GHz]	Voltage [V]	Temperature [°C]	Occ. bandwidth [GHz]	Result
D108_02a	1@vertical	76.9972	78.9191	Vnom=12	Tnom=20	1.9219	Passed
D109_02a	1@horizontal	76.9997	78.9191	Vnom=12	Tnom=20	1.9195	Passed
D108_11a	1@vertical	76.9951	78.9215	Vmin=9	Tnom=20	1.9264	Passed
D109_10a	1@horizontal	77.0051	78.9011	Vmin=9	Tnom=20	1.8971	Passed
D108_13a	1@vertical	76.9953	78.9214	Vmax=16	Tnom=20	1.9261	Passed
D109_12a	1@horizontal	77.0141	78.9011	Vmax=16	Tnom=20	1.8882	Passed
D108_09a	1@vertical	76.9944	78.9246	Vnom=12	Tmax=105	1.9302	Passed
D109_08a	1@horizontal	76.9979	78.9093	Vnom=12	Tmax=105	1.9114	Passed
D108_07a	1@vertical	76.9938	78.9241	Vnom=12	Tmin=-40	1.9303	Passed
D109_06a	1@horizontal	77.0125	78.9116	Vnom=12	Tmin=-40	1.8991	Passed
D108_02b	2@vertical	76.9956	78.9215	Vnom=12	Tnom=20	1.9266	Passed
D109_02b	2@horizontal	77.0060	78.9090	Vnom=12	Tnom=20	1.9008	Passed
D108_11b	2@vertical	76.9958	78.9195	Vmin=9	Tnom=20	1.9237	Passed
D109_10b	2@horizontal	77.0047	78.8994	Vmin=9	Tnom=20	1.8947	Passed
D108_13b	2@vertical	76.9971	78.9202	Vmax=16	Tnom=20	1.9231	Passed
D109_12b	2@horizontal	77.0047	78.8994	Vmax=16	Tnom=20	1.8947	Passed
D108_09b	2@vertical	76.9951	78.9253	Vnom=12	Tmax=105	1.9302	Passed
D109_08b	2@horizontal	76.9979	78.9093	Vnom=12	Tmax=105	1.9114	Passed
D108_05b	2@vertical	76.9955	78.9244	Vnom=12	Tmin=-40	1.9290	Passed
D109_05b	2@horizontal	77.1065	78.9094	Vnom=12	Tmin=-40	1.8029	Passed

Remark: for more information and graphical plot see annex A1 **TR20-1-0018201T008a-A1**

4.9 Equipment lists

ID	Description	Manufacturer	SerNo	CheckType	Last Check	Interval	Next Check
	120901 - SAC - Radiated Emission <1GHz			calchk	cal: 2015-Jul-21 chk: 2021-Jul-27	cal: 10Y chk: 12M	cal: 2025-Jul-21 chk: 2022-Jul-27
20442	Semi Anechoic Chamber	ETS-Lindgren Gmbh / Taufkirchen	-	cnn	cal: - chk: -	cal: - chk: -	cal: - chk: -
20482	filter matrix Filter matrix SAR 1	CETECOM GmbH	-	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: 2022-Jun-08	cal: 12M	cal: 2023-Jun-08
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: 2023-Feb-21	chk: 12M	chk: 2024-Feb-21
20005	AC - LISN 50 Ohm/50µH ESH2-Z5	Rohde & Schwarz Messgerätebau GmbH / Memmingen	861741/005	cal	cal: 2022-May-19	cal: 12M	cal: 2023-May-19
20133	Horn Antenna 3115 (Meas 1)	EMCO Elektronik GmbH	9012-3629	cal	cal: 2020-Apr-08	cal: 36M	cal: 2023-Apr-08
20412	Fully Anechoic Chamber 2	ETS-Lindgren Gmbh / Taufkirchen	without	cnn	cal: - chk: -	cal: - chk: -	cal: - chk: -
20729	FS-Z140	Rohde & Schwarz Messgerätebau GmbH	101004	cal	cal: 2020-May-26	cal: 36M	cal: 2023-May-26
20730	FS-Z110	Rohde & Schwarz Messgerätebau GmbH	101468	cal	cal: 2020-Jun-19	cal: 36M	cal: 2023-Jun-19
20731	FS-Z75	Rohde & Schwarz Messgerätebau GmbH / Memmingen	101022	cal	cal: 2022-May-18	cal: 36M	cal: 2025-May-18
20732	Signal- and Spectrum Analyzer FSW67	Rohde & Schwarz Messgerätebau GmbH / Memmingen	104023	cal	cal: 2022-Jun-08	cal: 12M	cal: 2023-Jun-08
20733	Harmonic Mixer FS-Z220	RPG-Radiometer Physics GmbH	101009	cal	cal: 2021-May-27	cal: 36M	cal: 2024-May-27
20734	Harmonic Mixer FS-Z325	RPG-Radiometer Physics GmbH	101005	cal	cal: 2021-May-27	cal: 36M	cal: 2024-May-27
20765	Pickett-Potter Horn Antenna FH-PP 40-60	RPG-Radiometer Physics GmbH / Meckenheim	010001	cal	cal: 2020-Sep-15	cal: 36M	cal: 2023-Sep-15
20767	Pickett-Potter Horn Antenna FH-PP 140-220	RPG-Radiometer Physics GmbH / Meckenheim	010011	cnn	cal: - chk: -	cal: - chk: -	cal: - chk: -
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	10024	cnn	cal: - chk: -	cal: - chk: -	cal: - chk: -
20813	Pickett-Potter Horn Antenna FH-PP 075	RPG-Radiometer Physics GmbH / Meckenheim	10006	cal	cal: 2020-Sep-09	cal: 36M	cal: 2023-Sep-09
20814	Pickett-Potter Horn Antenna FH-PP 140	RPG-Radiometer Physics GmbH	10008	cnn	cal: - chk: -	cal: - chk: -	cal: - chk: -
20815	Pickett-Potter Horn Antenna FH-PP 110	RPG-Radiometer Physics GmbH	10014	cal	cal: 2020-Sep-04	cal: 36M	cal: 2023-Sep-04
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	ERAVAN	13254-01	cal	cal: 2020-Jul-29	cal: 36M	cal: 2023-Jul-29
20836	1-18 GHz Amplifier	Wright Technologies, Inc., Inc.	0001	chk		chk: 36M	
20877	JS42-08001800-16-8P Verstärker	Miteq Inc.	2079991 / 2079992	chk	chk: 2020-Feb-27	chk: 36M	chk: 2023-Feb-26
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	19041200083	cnn	cal: - chk: -	cal: - chk: -	cal: - chk: -
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

Tools used in 'P2M1'

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.

Measurement type	Frequency range of measurement		Calculated Uncertainty based on confidence level of 95.54%	Remarks
	Start [MHz]	Stop [MHz]		
Magnetic field strength	0.009	30	4.86	Magnetic loop antenna, Pre-amp on
RF-Output power (eirp) Unwanted emissions (eirp) [dB]	30	100	4.57	without Pre-Amp
	30	100	4.91	with PreAmp
	100	1000	4.02	without Pre-Amp
	100	1000	4.26	with PreAmp
	1000	18000	4.36	without Pre-Amp
	1000	18000	5.23	with PreAmp
	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)
Radiated Blocking [dB]	1000	18000	2.85	Typical set-up with microwave generator and antenna, value for 7GHz 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
Frequency Error [kHz]	40000	77000	276.19	calculated for 77 GHz (FMCW) carrier
	6000	7000	33.92	calculated for 6.5GHz UWB Ch.5
TS 8997 conducted Parameters	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 2.4GHz ISM
	5.18	5.825	7.180 ppm	6b. Bandwidth / 2-Marker Method for 5GHz WLAN
	5.18	5.825	1.099 ppm	7 Frequency (Marker method) for 5GHz WLAN
	30	6000	0.11561µs	8 Medium-Utilization factor / Timing
	30	6000	1.85	9 Blocking-Level of companion device
	30	6000	1.62	9 Blocking Generator level
Conducted emissions	0.009	30	3.57	

9 Versions of test reports (change history)

Version	Applied changes	Date of release
--	Initial release	2023-Mar-03
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End Of Test Report