Test Report

23-1-0035501T001a-C02

Number of pages:	39	**Date of Report:**	2024-Sep-03
Testing company:	cetecom advanced GmbH Untertuerkheimer Str. 6-10 66117 Saarbruecken GERMANY	**Applicant:**	Schmitz Cargobull AG
Product:	**Telematic Device**		
Model:	**CTU-Pro**		
FCC ID:	2BBVQ-CTUPRO	**IC:**	N/A
Testing has been carried out in accordance with:	**FCC Regulations** **Title 47 CFR, Chapter I, Subchapter A, Part 15** **Subpart C Intentional Radiators** § 15.247 Operation within the bands 902-928 MHz, 2400-2483.5 MHz, and 5725-5850 MHz		
Tested Technology:	2.4 GHz W-LAN (IEEE 802.11)		
Test Results:	**☒ The EUT complies with the requirements in respect of selected parameters subject to the test.** The test results relate only to devices specified in this document		

The current version of Test Report 23-1-0035501T001a-C02 replaces the test report 23-1-0035501T001a-C01 dated 2023-Mar-21. The replaced test report is herewith invalid.

Signatures:

B.Eng. Martin Nunier	Salih Öztan
Supervisor Radio Services	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.

1.3 Summary of Test Results

The EUT integrates a 2.4 GHz W-LAN transmitter. Other implemented wireless technologies were not considered within this test report.

Test case	Reference Clause FCC ☒	Page	Remark	Result
Duty-Cycle	§15.35(c)	12	--	PASSED
Minimum Emission Bandwidth 6 dB	§15.247 5.2(a)	18	--	PASSED
Occupied Channel Bandwidth 99%	2.1049(h)	20	--	PASSED
RF output power	§15.247(b)(3)	13	--	PASSED
Transmitter Peak output power radiated	§15.247(b)(4)(c)(i)	--	--	NP
Emissions in non-restricted frequency bands	§15.247(d)	22	--	PASSED
Radiated Band-Edge emissions	§15.205(b) §15.247(d)	33	--	PASSED
Power spectral density	§15.247(e)	16	--	PASSED
Radiated field strength emissions below 30 MHz	§15.205(a) §15.209(a)	24	--	PASSED
Radiated field strength emissions 30 MHz – 1GHz	§15.209 §15.247(d)	28	--	PASSED
Radiated field strength emissions above 1 GHz	§15.209(a) §15.247(d)	30	--	PASSED
AC-Power Lines Conducted Emissions	§15.207	--	--	NP

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
Duty-Cycle	ANSI C63.10:2013, §11.6(b)
Minimum Emission Bandwidth 6 dB	ANSI C63.10:2013, §6.9.2, §11.8
Occupied Channel Bandwidth 99%	ANSI C63.10:2013, §6.9.3
RF output power	ANSI C63.10:2013, §11.9
Power spectral density	ANSI C63.10:2013, §11.10
Emissions in non-restricted frequency bands	ANSI C63.10:2013, §11.11, §6.10.5
Radiated Band-Edge emissions	ANSI C63.10-2013; “Marker-Delta method”, §6.10.5, §11.13
Transmitter Peak output power radiated	Result calculated with measured conducted RF-power value and stated/measured antenna gain for band of interest
Radiated field strength emissions below 30 MHz	ANSI C63.10-2013 §6.3, §6.4
Radiated field strength emissions 30 MHz- 1 GHz	ANSI C63.4-2014 §8.2.3, ANSI C63.10-2013 §6.3, §6.5
Radiated field strength emissions above 1 GHz	ANSI C63.4-2014 §8.3, ANSI C63.10-2013 §6.3, §6.6
AC-Power Lines Conducted Emissions	ANSI C63.4-2014 §7, ANSI C63.10-2013 §6.2

And reference also to Test methods in KDB558074

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:	22±2 °C
Relative. humidity:	45±15% rH

2.3 Test Laboratories sub-contracted

Company name:	--

2.4 Organizational Items

Responsible test manager:	Salih Öztan
Receipt of EUT:	2023-Jun-14
Date(s) of test:	2023-Jun-30 to 2023-Jul-12
Version of template:	23.0401

2.5 Applicant's details

Applicant's name:	Schmitz Cargobull AG
Address:	Bahnhofstrasse 22 48612 Horstmar Germany
Contact Person:	Dieter Honkomp
Contact Person's Email:	dieter.honkomp@cargobull.com

2.6 Manufacturer's details

Manufacturer's name:	Bosch Car Multimédia Portugal, S.A.
Address:	Rua Max Grundig, 35 4705-820 Lomar Braga Norte Portugal

2.7 Equipment under Test (EUT)

EUT No.*)	Sample No.	Product	Model	Type	SN	HW	SW
EUT 1	23-1-00355S04_C01	Telematic Device	CTU-Pro	7620000458	99003313	H01	CBT.TCU3_EVO.21.01.D.064
EUT 2	23-1-00355S05_C01	Telematic Device	CTU-Pro	7620000458	99003219	H01	CBT.TCU3_EVO.21.01.D.064

*) 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
VAR 1	23-1-00355S15_C01	Telematic Device	CTU-Pro	7620000456	99003222	H01	CBT.TCU3_EVO.21.01.D.064

*) 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	23-1-00355S11_C01	Laptop	HP EliteBook 840	N/A	N/A	N/A
AE 2	23-1-00355S14_C01	CAN/LIN Interface	VN1630A	18804	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	23-1-00355S07_C01	Cable harness	--	< 300 cm
CAB 2	23-1-00355S08_C01	Cable harness	--	< 300 cm
CAB 3	23-1-00355S10_C01	USB cable	--	< 100 cm

*) 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 2 + AE 1 + AE 2 + CAB 1 + CAB 2 + CAB 3	Used for conducted measurements AE 1 + AE 2 + CAB 3 used only for configuration.
2	EUT 1 + AE 1 + AE 2 + CAB 1 +CAB 2 + CAB 3	Used for radiated measurements AE 1 + AE 2 + CAB 3 used only for configuration.

*) 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	WLAN_TX-Mode	With help of special test firmware TX-mode was set-up. We refer to applicants information/papers for details about necessary commands.
op. 2	WLAN_RX-Mode	With help of special test firmware RX-mode was set-up. We refer to applicants information/papers for details about necessary commands.

*) 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	**12** V DC	
	☐ Battery	-	
Operational conditions	T_{nom} = +21 °C	T_{min} = -40 °C	T_{max} = +65 °C
EUT sample type	**Pre-Production**		
Weight	1.350 kg		
Size [LxWxH]	24.5 cm x 16.0 cm x 6.0 cm		
Interfaces/Ports	--		
For further details refer Applicants Declaration & following technical documents			
For further details regarding radio parameters, please refer to IEEE802.11 Specification			

3.2 Detailed Technical data of Main EUT as Declared by Applicant

Frequency Band	2.4 GHz ISM Band (2400 MHz - 2483.5 MHz)		
MIMO	☐		
Frequency | Channel | B.W. (USA bands only)	☒ WLAN 2.4 GHz 802.11b g n (SISO)	Ch 1 | 2 | 3| 4 | 5 | 6 | 7 Ch. 8| 9| 10 | 11	Bandwidth 20 MHz
	☐ WLAN 2.4 GHz 802.11n (SISO)	Ch 3| 4 | 5 | 6 | 7| 8| 9 | 10 | 11	Bandwidth 40 MHz
802.11b – Mode OFDM Modulation | Data Rates	☒ DBPSK | 1 Mbps ☒ DQPSK | 2 Mbps ☒ CCK-PBCC | 5.5 Mbps / 11 Mbps ☐ ERP-PBCC | 22 Mbps		
802.11g – Mode OFDM Modulation | Data Rates	☒ BPSK | 6 Mbps / 9 Mbps ☒ QPSK | 12 Mbps / 18 Mbps ☒ 16-QAM | 24 Mbps / 36 Mbps ☒ 64-QAM | 48 Mbps / 54 Mbps		
802.11n – Mode OFDM Modulation | Data Rates	☒ HT20(MCS0 to MCS7)| 7.2 / 14.4 / 21.7 / 28.9 / 43.3 / 57.8 / 65 / 72.2 Mbps ☐ HT40(MCS0 to MCS15)| 15/30/45/60/90/120/135/150/180/240/270/300 Mbps		
Other wireless options	☐ WLAN 5 GHz 802.11 a/n/ac mode ((not tested within this report) ☐ Bluetooth LE (not tested within this report) ☐ Bluetooth EDR (not tested within this report) ☒ Cellular transceiver (2G/3G/4G/5G/GPS, not tested in this report)		
Max. Conducted Output Power	b-mode: **15.7** dBm g-mode: **23.7** dBm n-mode(20 MHz): **23.9** dBm		
EIRP WLAN (Calculated EIRP)	b-mode: **15.7** dBm + **2** dBi = **17.7** dBm g-mode: **23.7** dBm+ **2** dBi = **25.7** dBm n-mode(20 MHz): **23.9** dBm + **2** dBi = **25.9** dBm		
Antenna Type	Internal antenna		
Antenna Gain	2 dBi		
FCC label attached	No		
Test firmware / software and storage location	EUT 1 and EUT 2		
For further details refer Applicants Declaration & following technical documents			
Description of Reference Document (supplied by applicant)		**Version**	**Total Pages**
TECHNICAL_PASSPORT_CTU-PRO_7620000456_458_V3-1		**3.1**	**32**

3.3 Worst case identification

WLAN mode	Data rate
802.11b	2Mbps
802.11g	6Mbps
802.11n, 20 MHz bandwidth	MCS7

3.4 Modifications on Test sample

Additions/deviations or exclusions	--

4 Measurements

4.1 Duty-Cycle

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)

The necessary duty-cycle correction factor is determined on nominal conditions on middle channel only. It is assumed that no noticeable changes occur when tested on other channels or climatic conditions.

EUT settings
The EUT was instructed to send with maximum power (if adjustable) according applicants instructions.
Different modulation characteristics have been checked, e.g. data rates which EUT can operate.

A special firmware program is used for test purposes. In opposite to normal operating mode a higher duty-cycle is set in order to facilitate the measurements. This is maximized at the extent possible.

The necessary duty-cycle correction factor is determined on nominal conditions on one channel in each operable frequency-band. It is assumed that no noticeable changes occur when tested on other channels or climatic conditions. The Duty-Cycle was constant, means without variations.

Formula to calculate Duty-Cycle:

Duty cycle calculations:	Duty cycle factor: DC=	Regarding power: $10 * log(1/x)$ dB
$x = TX_{ON}/(TX_{ON} + TX_{OFF})$		Regarding field strength: $20 * log(1/x)$ dB

☒ The results were corrected in order to evaluate for worst-case result each time when average values are necessary for example average radiated emissions or similar
☐ No correction necessary: Duty-Cycle > 98%

4.1.1 Measurement Location

Test site	120910 - Radio Laboratory 1 (TS 8997)

4.1.2 Result

Mode	Duty-Cycle [%]	Duty-Cycle correction Power [dB]	Duty-Cycle correction Field Strength [dB]
b-mode	46.162	3.354	6.708
g-mode	41.310	3.840	7.680
n20-mode	4.551	13.468	26.936

Remark: only worst case listed for more information and graphical plot see annex A1 **TR23-1-0035501T001a-C02-A1**

4.2 RF output power

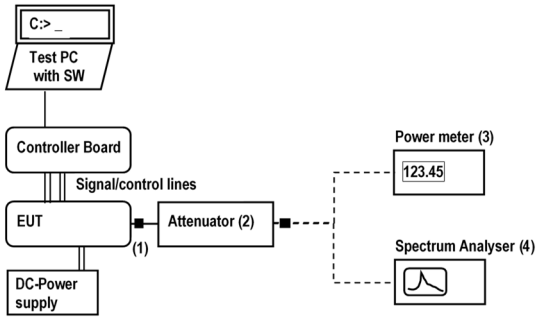
4.2.1 Description of the general test setup and methodology, see below example:

The EUT's RF-signal is coupled out by a suitable antenna coupling connector (1). The signal is first attenuated (2) then connected to power meter (3) or spectrum-analyzer (4) for RF-conducted measurements. The specific attenuation loss is determined prior to the measurement within a set-up attenuation measurement. These are then taken into account by correcting the measurement readings.

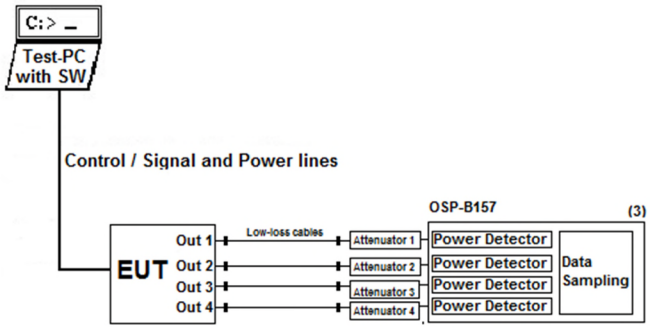
MIMO

The EUT use MIMO technology as it use multiple antennas for receive and transmit. The measurements are performed by using R&S TS8997 (Ref.No. 693) test system which is able to perform measurements simultanuously and time-synchronized on maximum 8 antenna conducted RF-ports. A common trigger ensures the sampling time is minimized so the total power represents a sampling value calculated for all 8-ports simultanuously for each time bin/frame. A high data sampling rate together with a wide band power measurement capability ensures that latest modulation schemes are correctly measured. Therefore testing method Subchapter E1 of KDB662911 is fulfilled. (measure-and-sum technique).

Schematic:



Schematic MIMO:



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)

Measurement is made using Rohde & Schwarz TS8997 test system.

Test method	PKPM1 Peak reading power meter (broadband PK RF-power meter)
SISO	☒
MIMO	☐ Summation of values from two antenna ports
Remarks	--

The measurement was performed in non-hopping transmission mode with the carrier set to lowest/middle and highest channel.

EUT settings
The EUT was instructed to send with maximum power (if adjustable) according applicants instructions.
Different modulation characteristics have been checked, e.g. data rates which EUT can operate

4.2.2 Measurement Location

Test site	120910 - Radio Laboratory 1 (TS 8997)

4.2.3 Limit

Frequency Range [MHz]	Limit [W]	Limit [dBm]	Detector	RBW / VBW [MHz]
2400 - 2483.5	1	30	Max Peak	50 / 10

4.2.4 Result

Mode	Channel	DUT Frequency (MHz)	Peak Power (dBm)	Limit Max (dBm)	Result
b-mode [11MBps]; 2412MHz	1	2412.000000	15.6	30.0	Passed
b-mode [11MBps]; 2437MHz	6	2437.000000	15.6	30.0	Passed
b-mode [11MBps]; 2462MHz	11	2462.000000	15.2	30.0	Passed
b-mode [1MBps]; 2412MHz	1	2412.000000	15.5	30.0	Passed
b-mode [1MBps]; 2437MHz	6	2437.000000	15.6	30.0	Passed
b-mode [1MBps]; 2462MHz	11	2462.000000	15.2	30.0	Passed
b-mode [2MBps]; 2412MHz	1	2412.000000	15.6	30.0	Passed
b-mode [2MBps]; 2437MHz	6	2437.000000	15.7	30.0	Passed
b-mode [2MBps]; 2462MHz	11	2462.000000	15.3	30.0	Passed
b-mode [5.5MBps]; 2412MHz	1	2412.000000	14.7	30.0	Passed
b-mode [5.5MBps]; 2437MHz	6	2437.000000	14.8	30.0	Passed
b-mode [5.5MBps]; 2462MHz	11	2462.000000	14.4	30.0	Passed
g-mode [12MBps]; 2412MHz	1	2412.000000	19.6	30.0	Passed
g-mode [12MBps]; 2437MHz	6	2437.000000	19.6	30.0	Passed
g-mode [12MBps]; 2462MHz	11	2462.000000	19.4	30.0	Passed
g-mode [18MBps]; 2412MHz	1	2412.000000	20.0	30.0	Passed
g-mode [18MBps]; 2437MHz	6	2437.000000	20.1	30.0	Passed
g-mode [18MBps]; 2462MHz	11	2462.000000	19.8	30.0	Passed
g-mode [24MBps]; 2412MHz	1	2412.000000	19.5	30.0	Passed
g-mode [24MBps]; 2437MHz	6	2437.000000	19.4	30.0	Passed
g-mode [24MBps]; 2462MHz	11	2462.000000	19.2	30.0	Passed
g-mode [36MBps]; 2412MHz	1	2412.000000	18.4	30.0	Passed
g-mode [36MBps]; 2437MHz	6	2437.000000	18.4	30.0	Passed
g-mode [36MBps]; 2462MHz	11	2462.000000	18.1	30.0	Passed

g-mode [48MBps]; 2412MHz	1	2412.000000	18.0	30.0	Passed
g-mode [48MBps]; 2437MHz	6	2437.000000	17.9	30.0	Passed
g-mode [48MBps]; 2462MHz	11	2462.000000	17.7	30.0	Passed
g-mode [54MBps]; 2412MHz	1	2412.000000	19.1	30.0	Passed
g-mode [54MBps]; 2437MHz	6	2437.000000	19.0	30.0	Passed
g-mode [54MBps]; 2462MHz	11	2462.000000	18.8	30.0	Passed
g-mode [6MBps]; 2412MHz	1	2412.000000	20.9	30.0	Passed
g-mode [6MBps]; 2437MHz	6	2437.000000	19.9	30.0	Passed
g-mode [6MBps]; 2462MHz	11	2462.000000	23.7	30.0	Passed
g-mode [9MBps]; 2412MHz	1	2412.000000	21.3	30.0	Passed
g-mode [9MBps]; 2437MHz	6	2437.000000	19.8	30.0	Passed
g-mode [9MBps]; 2462MHz	11	2462.000000	21.3	30.0	Passed
n20-mode [MCS0]; 2412MHz	1	2412.000000	19.6	30.0	Passed
n20-mode [MCS0]; 2437MHz	6	2437.000000	18.5	30.0	Passed
n20-mode [MCS0]; 2462MHz	11	2462.000000	23.4	30.0	Passed
n20-mode [MCS1]; 2412MHz	1	2412.000000	20.7	30.0	Passed
n20-mode [MCS1]; 2437MHz	6	2437.000000	19.6	30.0	Passed
n20-mode [MCS1]; 2462MHz	11	2462.000000	19.4	30.0	Passed
n20-mode [MCS2]; 2412MHz	1	2412.000000	19.3	30.0	Passed
n20-mode [MCS2]; 2437MHz	6	2437.000000	19.8	30.0	Passed
n20-mode [MCS2]; 2462MHz	11	2462.000000	16.5	30.0	Passed
n20-mode [MCS3]; 2412MHz	1	2412.000000	19.5	30.0	Passed
n20-mode [MCS3]; 2437MHz	6	2437.000000	23.1	30.0	Passed
n20-mode [MCS3]; 2462MHz	11	2462.000000	17.9	30.0	Passed
n20-mode [MCS4]; 2412MHz	1	2412.000000	20.0	30.0	Passed
n20-mode [MCS4]; 2437MHz	6	2437.000000	19.5	30.0	Passed
n20-mode [MCS4]; 2462MHz	11	2462.000000	18.8	30.0	Passed
n20-mode [MCS5]; 2412MHz	1	2412.000000	16.4	30.0	Passed
n20-mode [MCS5]; 2437MHz	6	2437.000000	23.6	30.0	Passed
n20-mode [MCS5]; 2462MHz	11	2462.000000	16.3	30.0	Passed
n20-mode [MCS6]; 2412MHz	1	2412.000000	17.2	30.0	Passed
n20-mode [MCS6]; 2437MHz	6	2437.000000	18.9	30.0	Passed
n20-mode [MCS6]; 2462MHz	11	2462.000000	19.1	30.0	Passed
n20-mode [MCS7]; 2412MHz	1	2412.000000	17.3	30.0	Passed
n20-mode [MCS7]; 2437MHz	6	2437.000000	23.8	30.0	Passed
n20-mode [MCS7]; 2462MHz	11	2462.000000	23.9	30.0	Passed

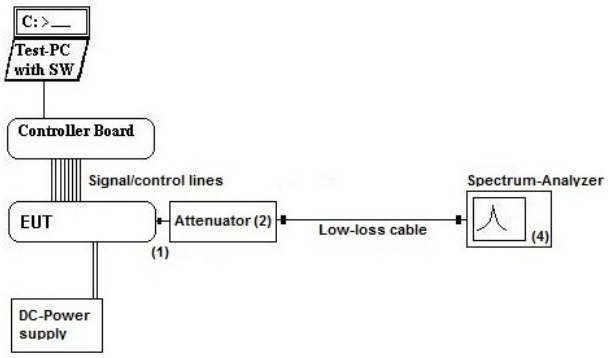
Remark: for more information and graphical plot see annex A1 **TR23-1-0035501T001a-C02-A1**

4.3 Power spectral density

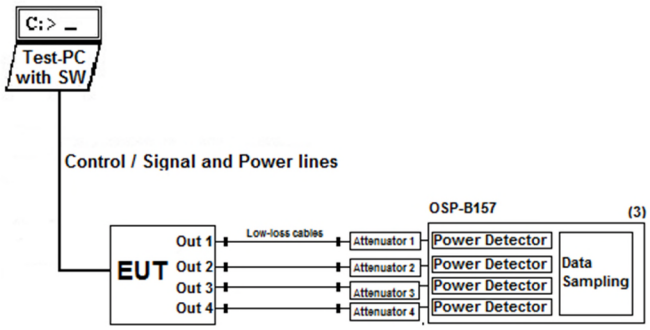
4.3.1 Description of the general test setup and methodology, see below example:

The EUT's RF-signal is coupled out by a suitable antenna coupling connector (1). The signal is first attenuated (2) then connected to spectrum-analyzer (4) for RF-conducted measurements. The specific attenuation loss is determined prior to the measurement within a set-up attenuation measurement. These are then taken into account by correcting the measurement readings of the spectrum-analyzer.

Schematic:



Schematic MIMO:



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)

Measurement is made using Rohde & Schwarz TS8997 test system.

Test method	PKPSD-Method
SISO	☒
MIMO	☐ Summation of values from two antenna ports
Remarks	

EUT settings
The EUT was instructed to send with maximum power (if adjustable) according applicants instructions.

4.3.2 Measurement Location

Test site	120910 - Radio Laboratory 1 (TS 8997)

4.3.3 Limit

Limit [dBm] @ 3 kHz	Detector [MaxHold]	RBW / VBW [kHz]
≤ 8	Peak	3 / 10

4.3.4 Result

Mode	Channel	Frequency [MHz]	PSD [dBm]	Result
2412 MHz; b-mode [2MBps] (20 dBm); 20 MHz	1	2412.725000	3.067	Passed
2437 MHz; b-mode [2MBps] (20 dBm); 20 MHz	6	2437.575000	2.811	Passed
2462 MHz; b-mode [2MBps] (20 dBm); 20 MHz	11	2462.675000	2.425	Passed
2412 MHz; g-mode [6MBps] (20 dBm); 20 MHz	1	2413.825000	-6.680	Passed
2437 MHz; g-mode [6MBps] (20 dBm); 20 MHz	6	2434.425000	-6.630	Passed
2462 MHz; g-mode [6MBps] (20 dBm); 20 MHz	11	2459.425000	-7.036	Passed
2412 MHz; n20-mode [MCS7] (20 dBm); 20 MHz	1	2414.425000	-1.662	Passed
2437 MHz; n20-mode [MCS7] (20 dBm); 20 MHz	6	2439.425000	-1.624	Passed
2462 MHz; n20-mode [MCS7] (20 dBm); 20 MHz	11	2464.425000	-2.134	Passed

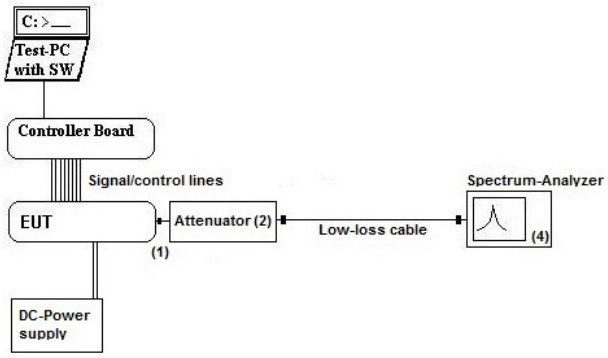
Remark: for more information and graphical plot see annex A1 **TR23-1-0035501T001a-C02-A1**

4.4 Minimum Emission Bandwidth 6 dB

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

The EUT's RF-signal is coupled out by a suitable antenna coupling connector (1). The signal is first attenuated (2) then connected to spectrum-analyzer (4) for RF-conducted measurements. The specific attenuation loss is determined prior to the measurement within a set-up attenuation measurement. These are then taken into account by correcting the measurement readings of the spectrum-analyzer.

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)

Measurement is made using Rohde & Schwarz TS8997 test system.

4.4.2 Measurement Location

Test site	120910 - Radio Laboratory 1 (TS 8997)

4.4.3 Limit

Limit [kHz]	Detector [MaxHold]	RBW / VBW [kHz]
≥ 500	**MaxPeak**	**100 / 300**

4.4.4 Result

Mode	Channel	Frequency [MHz]	6 dB bandwidth [MHz]	Result
2412 MHz; b-mode [2MBps] (20 dBm); 20 MHz	1	2412.000000	10.150000	Passed
2437 MHz; b-mode [2MBps] (20 dBm); 20 MHz	6	2437.000000	10.150000	Passed
2462 MHz; b-mode [2MBps] (20 dBm); 20 MHz	11	2462.000000	10.150000	Passed
2412 MHz; g-mode [6MBps] (20 dBm); 20 MHz	1	2412.000000	16.400000	Passed
2437 MHz; g-mode [6MBps] (20 dBm); 20 MHz	6	2437.000000	16.400000	Passed
2462 MHz; g-mode [6MBps] (20 dBm); 20 MHz	11	2462.000000	16.400000	Passed
2412 MHz; n20-mode [MCS7] (20 dBm); 20 MHz	1	2412.000000	17.750000	Passed
2437 MHz; n20-mode [MCS7] (20 dBm); 20 MHz	6	2437.000000	17.750000	Passed
2462 MHz; n20-mode [MCS7] (20 dBm); 20 MHz	11	2462.000000	17.750000	Passed

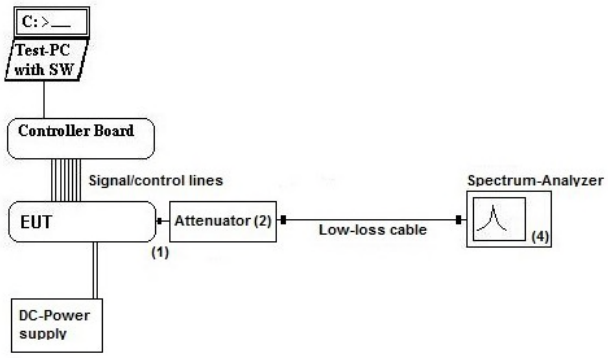
Remark: for more information and graphical plot see annex A1 **TR23-1-0035501T001a-C02-A1**

4.5 Occupied Channel Bandwidth 99%

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

The EUT's RF-signal is coupled out by a suitable antenna coupling connector (1). The signal is first attenuated (2) then connected to spectrum-analyzer (4) for RF-conducted measurements. The specific attenuation loss is determined prior to the measurement within a set-up attenuation measurement. These are then taken into account by correcting the measurement readings of the spectrum-analyzer.

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)

Measurement is made using Rohde & Schwarz TS8997 test system.

4.5.2 Measurement Location

Test site	120910 - Radio Laboratory 1 (TS 8997)

4.5.3 Limit

When the occupied bandwidth limit is not stated in the applicable reference measurement method, the transmitted signal bandwidth shall be reported as the 99% emission bandwidth, as calculated or measured.

4.5.4 Result

Mode	Channel	Frequency [MHz]	99% Occupied bandwidth [MHz]	Result
2412 MHz; b-mode [2MBps] (20 dBm); 20 MHz	1	2412.000000	13.200000	Passed
2437 MHz; b-mode [2MBps] (20 dBm); 20 MHz	6	2437.000000	13.300000	Passed
2462 MHz; b-mode [2MBps] (20 dBm); 20 MHz	11	2462.000000	13.200000	Passed
2412 MHz; g-mode [6MBps] (20 dBm); 20 MHz	1	2412.000000	16.600000	Passed
2437 MHz; g-mode [6MBps] (20 dBm); 20 MHz	6	2437.000000	16.600000	Passed
2462 MHz; g-mode [6MBps] (20 dBm); 20 MHz	11	2462.000000	16.600000	Passed
2412 MHz; n20-mode [MCS7] (20 dBm); 20 MHz	1	2412.000000	17.700000	Passed
2437 MHz; n20-mode [MCS7] (20 dBm); 20 MHz	6	2437.000000	17.600000	Passed
2462 MHz; n20-mode [MCS7] (20 dBm); 20 MHz	11	2462.000000	17.600000	Passed

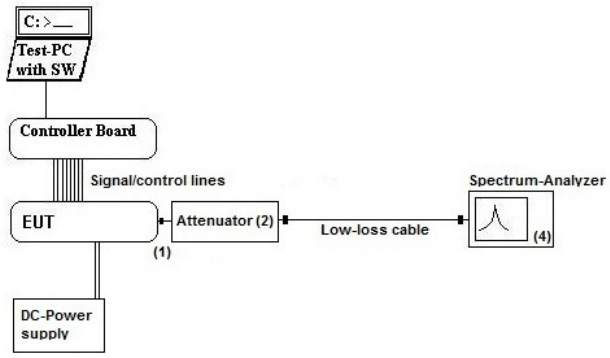
Remark: for more information and graphical plot see annex A1 **TR23-1-0035501T001a-C02-A1**

4.6 Emissions in non-restricted frequency bands

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

The EUT's RF-signal is coupled out by a suitable antenna coupling connector (1). The signal is first attenuated (2) then connected to spectrum-analyzer (4) for RF-conducted measurements. The specific attenuation loss is determined prior to the measurement within a set-up attenuation measurement. These are then taken into account by correcting the measurement readings of the spectrum-analyzer.

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)

The measurements were performed with the RBW set to 100 kHz & maximum carrier level was indicated with MAX-Hold positive peak detector using markers. Then a frequency line was set 20 or 30 dB below this measured maximum carrier level.

Then using RBW 100 kHz & spectrum analyzer span from 150 kHz to 25 GHz in three steps spurious emissions were measured with MAX-Hold positive peak detector.

The sweep time set as long as necessary to capture the full signal burst per hopping channel. The burst on-period is captured by setting appropriate markers in the rising and falling edges.

EUT settings
The EUT was instructed to send with maximum power (if adjustable) according applicants instructions.
Different modulation characteristics have been checked. e.g. data rates which EUT can operate.

4.6.2 Measurement Location

Test site	120910 - Radio Laboratory 1 (TS 8997)

4.6.3 Limit

Frequency Range [MHz]	Limit [dBc]
0.15 – 25000	-20 / -30

4.6.4 Result

Maximum Level Peak [dBc]

Mode	Channel	Frequency [MHz]	Result
b-mode [2MBps]	1	2412	Passed
b-mode [2MBps]	6	2437	Passed
b-mode [2MBps]	11	2462	Passed
g-mode [6MBps]	1	2412	Passed
g-mode [6MBps]	6	2437	Passed
g-mode [6MBps]	11	2462	Passed
n20-mode [MCS7]	1	2412	Passed
n20-mode [MCS7]	6	2437	Passed
n20-mode [MCS7]	11	2462	Passed

Remark1: every RF-Port tested separatelly in case on MIMO device
Remark2: for more information and graphical plot see annex A1 **TR23-1-0035501T001a-C02-A1**

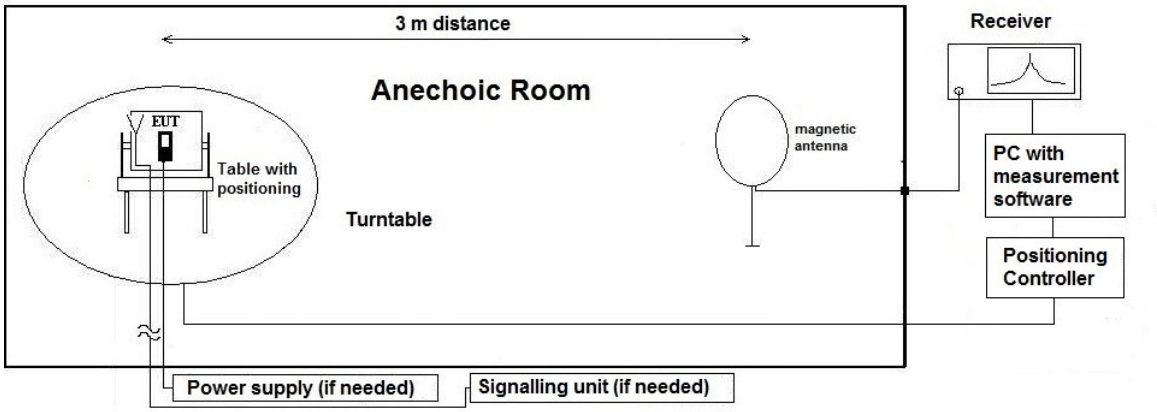
4.7 Radiated field strength emissions below 30 MHz

4.7.1 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 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 (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.

4.7.2 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

4.7.3 Measurement Location

Test site	225911 - SAC1 (5m) - Radiated Emission < 1GHz

4.7.4 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

4.7.5 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: none

4.7.6 Result

Diagram	Channel	Mode	Maximum Level [dBµV/m] Frequency Range 0.009 – 30 MHz	Result
2.01a	11	b-mode | 2Mbit| ch11	No peaks found	Passed
2.01b	11	b-mode | 2Mbit| ch11	No peaks found	Passed
2.02a	6	g-mode | 6Mbit| ch06	@24.254 MHz, 19.616	Passed
2.02b	6	g-mode | 6Mbit| ch06	@21.970 MHz, 18.349	Passed
2.03a	1	n-mode | HT20 | MCS7| ch01	@25.146 MHz, 19.680	Passed
2.03b	1	n-mode | HT20 | MCS7| ch01	@27.886 MHz, 20.404	Passed

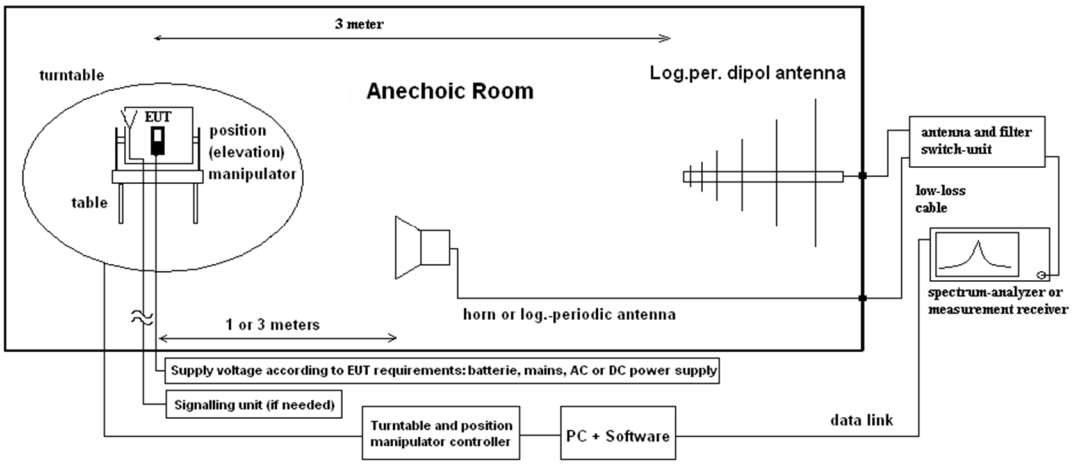
Remark: for more information and graphical plot see annex A1 **TR23-1-0035501T001a-C02-A1**

4.8 Radiated field strength emissions 30 MHz – 1 GHz

4.8.1 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) and 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 its 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.

4.8.2 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

4.8.3 Measurement Location

Test site	120904 - FAC1 - Radiated Emissions

4.8.4 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

4.8.5 Result

Diagram	Channel	Mode	Maximum Level [dBµV/m] Frequency Range 30 – 1000 MHz	Result
3.01a	11	b-mode | 2Mbit| ch11	@624.99MHz, 39.88	Passed
3.01b	11	b-mode | 2Mbit| ch11	@249.99MHz, 37.80	Passed
3.02a	6	g-mode | 6Mbit| ch06	@624.99MHz, 41.22	Passed
3.02b	6	g-mode | 6Mbit| ch06	@249.99MHZ, 38.00	Passed
3.03a	1	n-mode | HT20 | MCS7| ch01	@624.99MHz, 40.65	Passed
3.03b	1	n-mode | HT20 | MCS7| ch01	@479.95MHz, 24.18	Passed

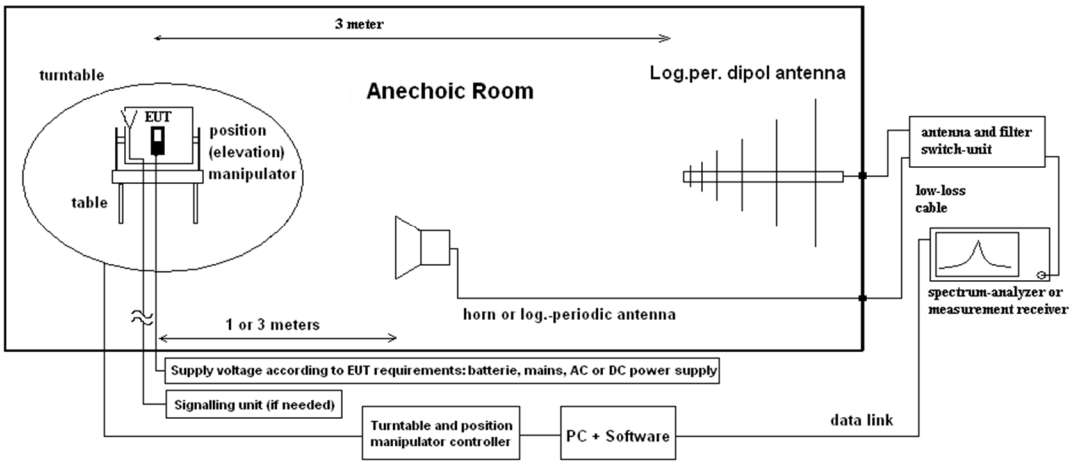
Remark: for more information and graphical plot see annex A1 **TR23-1-0035501T001a-C02-A1**

4.9 Radiated field strength emissions above 1 GHz

4.9.1 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 its 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:

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

$M = L_T - E_C$ (2)

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

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

4.9.2 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

4.9.3 Measurement Location

Test site	120907 - FAC2 - Radiated Emissions

4.9.4 Limit

Radiated emissions limits (3 meters)				
Frequency Range [MHz]	Limit [µV/m]	Limit [dBµV/m]	Detector	RBW / VBW [kHz]
Above 1000	500	54	Average	1000 / 3000
Above 1000	5000	74	Peak	1000 / 3000

4.9.5 Result

Diagram	Channel	Mode	Maximum Level [dBµV/m] Frequency Range 1 – 15 GHz	Maximum Level [dBµV/m] Frequency Range 15 – 18 GHz	Maximum Level [dBµV/m] Frequency Range 18 – 26.5 GHz	Result
4.01a	11	b-mode|2Mbit	47.93	--	--	Passed
4.01b	11	b-mode|2Mbit	--	43.833	--	Passed
4.01c	11	b-mode|2Mbit	--	43.851	--	Passed
4.01d	11	b-mode|2Mbit	--	--	47.047	Passed
4.01e	11	b-mode|2Mbit	--	--	47.043	Passed

Remark: for more information and graphical plot see annex A1 **TR23-1-0035501T001a-C02-A1**

Diagram	Channel	Mode	Maximum Level [dBµV/m] Frequency Range 1 – 18 GHz	Maximum Level [dBµV/m] Frequency Range 18 – 26.5 GHz	Result
4.02a	6	g-mode|6Mbit	No peaks found	--	Passed
4.02b	6	g-mode|6Mbit	--	47.536	Passed
4.02c	6	g-mode|6Mbit	--	46.911	Passed

Remark: for more information and graphical plot see annex A1 **TR23-1-0035501T001a-C02-A1**

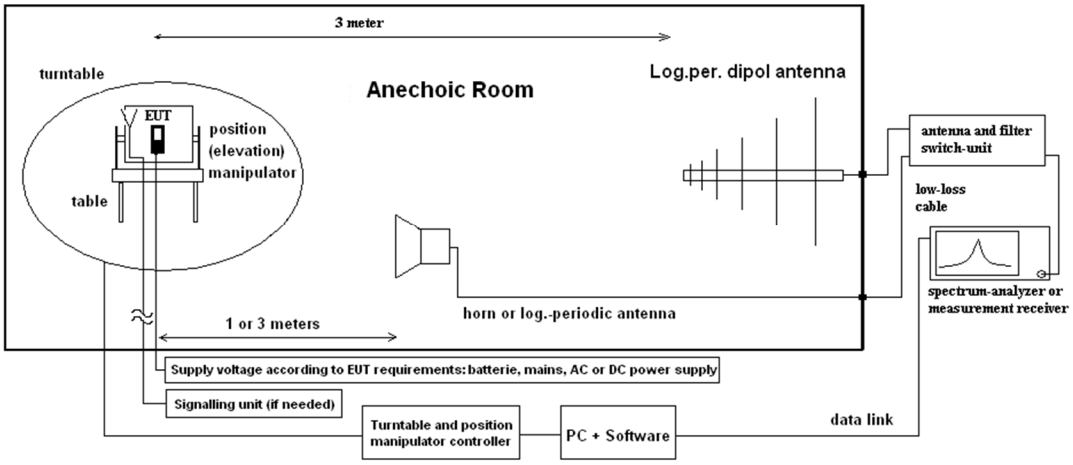
Diagram	Channel	Mode	Maximum Level [dBµV/m] Frequency Range 1 – 15 GHz	Maximum Level [dBµV/m] Frequency Range 15 – 18 GHz	Maximum Level [dBµV/m] Frequency Range 18 – 26.5 GHz	Result
4.03a	1	n-mode|HT20|MCS7	40.33	--	--	Passed
4.03b	1	n-mode|HT20|MCS7	--	--	47.104	Passed
4.03c	1	n-mode|HT20|MCS7	--	--	47.088	Passed
4.04d	1	n-mode|HT20|MCS7	--	43.953	--	Passed
4.04e	1	n-mode|HT20|MCS7	--	43.980	--	Passed

Remark: for more information and graphical plot see annex A1 **TR23-1-0035501T001a-C02-A1**

4.10 Radiated Band-Edge emissions

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

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)

For uncritical results where a measurement resolution bandwidth of 1MHz can clearly show the compliance without influencing the results, a field strength measurement was performed to show compliance.

For critical results a Marker-Delta marker method was used for showing compliance to restricted bands.
The method consists of three independent steps:

1. Step: Prior to the measurement the fundamental radiated In-Band field strength was performed. The determined value is used as reference value.

2. Step: Second step consist of finding the relative attenuation between the fundamental emission and the maximum local out-of-band emission (within 2 MHz range around the band edge either on the band-edge directly or some modulation product if the level is greater than that on the band-edge) when measured with lower resolution bandwidth.

3. .Step: The delta value recorded in step 2 will be subtracted from value recorded in step 1, thus giving the required field strength at the band-edge. This value must fulfil the requirements for radiated spurious emissions in restricted bands in FCC §15.205 with the general limits of FCC §15.209

The EUT was instructed to send with maximum power (if adjustable) according to applicants instructions.

4.10.2 Measurement Location

Test site	120904 - FAC1 - Radiated Emissions

4.10.3 Limit

Frequency Range [MHz]	Pk Limit [dBc]	Avg Limit [dBc]	Avg Limit [dBµV/m]	Pk Limit [dBµV/m]	Detector	RBW / VBW [kHz]
Below 2390	-	-	54	74	Average / Peak	1000 / 3000
Above 2483.5	-	-	54	74	Average / Peak	1000 / 3000
2390 - 2400	-20	-	-	-	Peak	100 / 300
2390 - 2400	-	-30	-	-	Average	100 / 300

4.10.4 Result

Non-restricted bands near-by

Diagram	Channel	Mode	Peak [dBc]	Average [dBc]	Result
9.01a	1	b-mode | 2Mbit	46.716	46.681	Passed
9.02a	1	g-mode | 6Mbit	35.39	38.089	Passed
9.03a	1	n-mode | HT20 | MCS7	32.431	36.24	Passed

Remark: for more information and graphical plot see annex A1 **TR23-1-0035501T001a-C02-A1**

Restricted bands near-by

Diagram	Channel	Mode	Peak [dBµV/m]	Average [dBµV/m]	Result
9.01b	11	b-mode | 2Mbit	59.8	47.395	Passed
9.02b	11	g-mode | 6Mbit	59.581	48.284	Passed
9.03b	11	n-mode | HT20 | MCS7	59.8	48.1	Passed

Remark: for more information and graphical plot see annex A1 **TR23-1-0035501T001a-C02-A1**

4.11 Equipment lists

ID	Description	Manufacturer	SerNo	CheckType	Last Check	Interval	Next Check
	120904 - FAC1 - Radiated Emissions			chk	chk: 2022-Jun-30	chk: 12M	chk: 2023-Jun-30
20020	Horn Antenna 3115 (Subst 1)	EMCO Elektronik GmbH	9107-3699	calchk	cal: 2021-Aug-17 chk: 2013-Apr-20	cal: 36M chk: 12M	cal: 2024-Aug-17
20066	Notch Filter WRCT 1900/2200-5/40-10EEK	Wainwright Instruments GmbH	5	chk	chk: 2022-Jun-30	chk: 12M	chk: 2023-Jun-30
20121	Notch Filter WRCB 1879,5/1880,5EE	Wainwright Instruments GmbH	15	chk	chk: 2022-Jun-30	chk: 12M	chk: 2023-Jun-30
20122	Notch Filter WRCB 1747/1748	Wainwright Instruments GmbH	12	chk	chk: 2022-Jun-30	chk: 12M	chk: 2023-Jun-30
20254	High Pass Filter 5HC 2600/12750-1.5KK	Trilithic	23042	chk	chk: 2022-Jun-30	chk: 12M	chk: 2023-Jun-30
20287	Pre-Amplifier 25MHz - 4GHz AMF-2D-100M4G-35-10P	Miteq Inc.	379418	chk	chk: 2022-Jun-30	chk: 12M	chk: 2023-Jun-30
20290	Notch Filter WRCA 901,9/903,1SS	Wainwright Instruments GmbH	3RR	chk	chk: 2022-Jun-30	chk: 12M	chk: 2023-Jun-30
20291	High Pass Filter WHJ 2200-4EE	Wainwright Instruments GmbH	14	chk	chk: 2022-Jun-30	chk: 12M	chk: 2023-Jun-30
20338	Pre-Amplifier 100MHz - 26GHz JS4-00102600-38-5P	Miteq Inc.	838697	chk	chk: 2022-Jun-30	chk: 12M	chk: 2023-Jun-30
20341	Digital Multimeter Fluke 112	Fluke Deutschland GmbH / Glottertal	81650455	cal	cal: 2022-May-18	cal: 24M	cal: 2024-May-18
20448	Notch Filter WRCT 1850.0/2170.0-5/40-10SSK	Wainwright Instruments GmbH	5	chk	chk: 2022-Jun-30	chk: 12M	chk: 2023-Jun-30
20449	Notch Filter WRCT 824.0/894.0-5/40-8SSK	Wainwright Instruments GmbH	1	chk	chk: 2022-Jun-30	chk: 12M	chk: 2023-Jun-30
20484	Pre-Amplifier 2,5GHz - 18GHz AMF-5D-02501800-25-10P	Miteq Inc.	1244554	chk	chk: 2022-Jun-30	chk: 12M	chk: 2023-Jun-30
20489	Test Receiver ESU40	Rohde & Schwarz Messgerätebau GmbH / Memmingen	100030	cal	cal: 2023-May-24	cal: 12M	cal: 2024-May-24
20512	Notch Filter WRCA 800/960-02/40-6EEK (GSM 850)	Wainwright Instruments GmbH	24	chk	chk: 2022-Jun-30	chk: 12M	chk: 2023-Jun-30
20549	Log. Per. Antenna HL025	Rohde & Schwarz Messgerätebau GmbH	1000060	calchk	cal: 2021-Aug-18	cal: 36M chk: 12M	cal: 2024-Aug-18
20558	Fully Anechoic Chamber 1	ETS-Lindgren Gmbh / Taufkirchen	-	cnn	cal: - chk: -	cal: - chk: -	cal: - chk: -
20611	Power Supply E3632A	Agilent Technologies Deutschland GmbH	KR 75305854	cpu			
20670	Radio Communication Tester CMU200	Rohde & Schwarz Messgerätebau GmbH / Memmingen	106833	cal	cal: 2022-May-10	cal: 24M	cal: 2024-May-10
20690	Spectrum Analyzer FSU	Rohde & Schwarz Messgerätebau GmbH / Memmingen	100302/026	cal	cal: 2023-May-25	cal: 24M	cal: 2025-May-25
20720	Measurement Software EMC32 [FAC]	Rohde & Schwarz Messgerätebau GmbH	V10.xx	cnn	cal: - chk: -	cal: - chk: -	cal: - chk: -
20868	High Pass Filter AFH-07000	AtlanTecRF	16071300004	chk	chk: 2022-Jun-30	chk: 12M	chk: 2023-Jun-30
20883	Open Switch and control Platform OSP-B200S2 Satellite	Rohde & Schwarz Messgerätebau GmbH / Memmingen	101432	chk	chk: 2022-Jun-30	chk: 12M	chk: 2023-Jun-30
20884	Open Switch and control Platform OSP320	Rohde & Schwarz Messgerätebau GmbH / Memmingen	101391	chk	chk: 2022-Jun-30	chk: 12M	chk: 2023-Jun-30
	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: 2023-May-25	cal: 12M	cal: 2024-May-25
20302	Horn Antenna BBHA9170 (Meas 1)	Schwarzbeck Mess-Elektronik OHG / Schönau	155	cpu	chk: 2020-Apr-15	chk: 12M	
20412	Fully Anechoic Chamber 2	ETS-Lindgren Gmbh / Taufkirchen	without	chk	chk: 2023-Apr-14	chk: 6M	chk: 2023-Oct-14
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: 2023-May-25	cal: 12M	cal: 2024-May-25
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. / Roseville	0001	chk		chk: 36M	
20877	JS42-08001800-16-8P Verstärker	Miteq Inc.	2079991 / 2079992	chk	chk: 2023-Feb-27	chk: 6M	chk: 2023-Aug-27
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: -	cal: -	cal: -

ID	Description	Manufacturer	SerNo	CheckType	Last Check	Interval	Next Check
					chk: -	chk: -	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
	120910 - Radio Laboratory 1 (TS 8997)			chk	chk: 2022-Mar-16	chk: 12M	chk: 2023-Mar-16
20559	Vector Signal Generator SMU200A	Rohde & Schwarz Messgerätebau GmbH / Memmingen	103736	cal	cal: 2023-May-25	cal: 24M	cal: 2025-May-25
20691	Open Switch and control Platform OSP120	Rohde & Schwarz Messgerätebau GmbH	101056	cal	cal: 2020-May-13	cal: 36M	cal: 2023-May-13
20805	Open Switch and control Platform OSP B157WX 40GHz 8Port Switch	Rohde & Schwarz Messgerätebau GmbH / Memmingen	101264	cal	cal: 2023-May-26	cal: 36M	cal: 2026-May-26
20866	Signal Analyzer FSV3030	Rohde & Schwarz Messgerätebau GmbH / Memmingen	101247	cal	cal: 2022-Jun-20	cal: 12M	cal: 2023-Jun-20
20871	NRP-Z81	Rohde & Schwarz Messgerätebau GmbH / Memmingen	104631	cal	cal: 2023-May-23	cal: 12M	cal: 2024-May-23
20872	NRX Power Meter	Rohde & Schwarz Messgerätebau GmbH / Memmingen	101831	cal	cal: 2022-May-17	cal: 24M	cal: 2024-May-17
20904	Climatic Chamber ClimeEvent C/1000/70a/5	Weiss Umwelttechnik GmbH / Reiskirchen-Lindenstruth	58226223240010	cal	cal: 2022-Nov-29	cal: 24M	cal: 2024-Nov-29
	225911 - SAC1 (5m) - Radiated Emission <1GHz			calchk	cal: 2016-Apr-05 chk: 2021-Jan-20	cal: 120M chk: 12M	cal: 2026-Apr-05 chk: 2022-Jan-20
25316	Multifunction AC/DC Power Source Netwave 20	EM TEST GmbH / Kamen	V1227113059	cal	cal: 2021-May-20	cal: 36M	cal: 2024-May-20
25348	Test Receiver ESR7	Rohde & Schwarz Messgerätebau GmbH / Memmingen	101600	cal	cal: 2023-May-25	cal: 24M	cal: 2025-May-25
25352	Open Switch and control Platform OSP120	Rohde & Schwarz Messgerätebau GmbH	101542-rV	cpu			
25357	Ultrabroadband Antenna HL562E	Rohde & Schwarz Messgerätebau GmbH	100824	cal	cal: 2020-Oct-09	cal: 36M	cal: 2023-Oct-09
25358	Semi Anechoic Chamber SAC5	Albatross Projects GmbH / Nattheim	P27281-016	cal	cal: 2022-Aug-12	cal: 10Y	cal: 2032-Aug-12
25360	Antenna Mast BAM 4.5-P	maturo GmbH / Pfreimd	BAM 4.5-P/091/17791115	cnn	cal: - chk: -	cal: - chk: -	cal: - chk: -
25361	Controller NCD	maturo GmbH	NCD/202/17791115	cnn	cal: - chk: -	cal: - chk: -	cal: - chk: -
25376	Measurement Software EMC32 [SAC5]	Rohde & Schwarz Messgerätebau GmbH	v10.60.10	cnn	cal: - chk: -	cal: - chk: -	cal: - chk: -

Tools used in 'P1M1'

4.11.1 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-waveguide 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	--
			--	--	--	--

9 Versions of test reports (change history)

Version	Applied changes	Date of release
--	Initial release	2023-Oct-27
C01	Updated applicant and manufacturer.	2024-Mar-21
C02	AC-Power Lines Conducted Emissions, removed not needed 4.1.2 Remark added Antenna Gain correction	2024-Sep-03
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End Of Test Report