PARTIAL
Test Report 19-1-0097801T01a-C1

Number of pages:	28	**Date of Report:**	2020-May-14
Testing company:	CETECOM GmbH Im Teelbruch 116 45219 Essen Germany Tel. + 49 (0) 20 54 / 95 19-0 Fax: + 49 (0) 20 54 / 95 19-150	**Applicant:**	Robert Bosch GmbH
Test Object / Tested Device(s):	BUI350		
Listing FCC ID:	2AUXS-NYON350	**ISED:**	25847-NYON350
Testing has been carried out in accordance with:	**Title 47 CFR, Chapter I** **FCC Regulations, Subchapter A** Subpart C: §15.247 (DTS) **RSS-247, Issue 2 (DTS)** **RSS-Gen., Issue 5** Deviations, modifications or clarifications (if any) to above mentioned documents are written in each section under "Test method and limit".		
Tested Technology:	2.4 GHz W-LAN (IEEE 802.11)		
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		

The current version of the Test Report CETECOM_TR19-1-0097801T01a_C1 replaces the the test report CETECOM_TR19-1-0097801T01a dated 2020-05-11. The replaced test report is herewith invalid.

Signatures:

Digital signiert von: Christian Lorenz
Name: CN = Christian Lorenz email = christian.lorenz@cetecom.com C = DE O = CETECOM GmbH OU = RC&EMC
Datum: 2020.05.14 21:07:51 + 02'00'

Digital unterschrieben von B.Sc. Mohamed Ahmed
DN: cn=B.Sc. Mohamed Ahmed, o=Cetecom GmbH, ou=RC/EMC, email=mohamed.ahmed@cetecom.com, c=DE
Datum: 2020.05.14 16:47:02 +02'00'

Dipl.-Ing. Ch. Lorenz	B.Sc. M. Ahmed
Authorization of test report	Test manager

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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 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.

1.1. Summary of Test Results

The EUT integrates a 2.4GHz WLAN transmitter. Other implemented wireless technologies were not considered in this report.

Test case	Reference Clause FCC	Reference Clause ISED	Page	Remark	Result
Duty-Cycle	§15.35(c)	RSS-Gen Issue 5, §8.2	10	--	PASSED
Minimum Emission Bandwidth 6 dB	§15.247 5.2(a)	RSS-247, § 5.2(a) RSS-Gen Issue 5,: §6.7	--	*1)	NP
Occupied Channel Bandwidth 99%	2.1049(h)	RSS-Gen Issue 5, § 6.7	--	*1)	NP
RF output power	§15.247(b)(3)	RSS-247, § 5.4(d)	11	--	PASSED
Transmitter Peak output power radiated	§15.247(b)(4)(c)(i)	RSS-247, § 5.4(d)	--	--	NP
Emissions in non-restricted frequency bands	§15.247(d)	RSS-247, § 5.5	--	*1)	NP
Radiated Band-Edge emissions	§15.205(b) §15.247(d)	RSS-Gen: Issue 5 §8.9, §8.10 RSS-247, § 5.5	21	--	PASSED
Power spectral density	§15.247(e)	RSS-247, § 5.2(b)	--	*1)	NP
Radiated field strength emissions below 30MHz	§15.205(a) §15.209(a)	RSS-Gen: Issue 5 §8.9 Table 6	13	--	PASSED
Radiated field strength emissions 30MHz – 1GHz	§15.209 §15.247(d)	RSS-Gen: Issue 5 §8.9 Table 5 RSS-247, § 5.5	17	--	PASSED
Radiated field strength emissions above 1GHz	§15.209(a) §15.247(d)	RSS-Gen: Issue 5: §8.9 Table 5+7 RSS-247, § 5.5	19	--	PASSED
AC-Power Lines Conducted Emissions	§15.207	RSS-Gen Issue 5: § 8.8, Table 4	--	--	PASSED

Remarks:
*1) Please refer to Module report "RF151228C18-2" issued on Dec. 28, 2015 **FCC ID VPYLB1DX** and **ISED ID: 772C-LB1DX**
Grant:
https://apps.fcc.gov/oetcf/tcb/reports/Tcb731GrantForm.cfm?mode=COPY&RequestTimeout=500&tcb_code=&application_id=GkZkTjQX9pm6q8FKf9kFjg%3D%3D&fcc_id=VPYLB1DX

PASSED	The EUT complies with the essential requirements in the standard.
FAILED	The EUT does not comply with the essential requirements in the standard.
NP	The test was not performed by the CETECOM Laboratory.

1.2. Summary of Test Methods

Test case	Test method
Duty-Cycle	ANSI 63.10:2013, §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 strenght emissions below 30MHz	ANSI C63.10-2013 §6.3, §6.4
Radiated field strenght emissions 30MHz- 1GHz	ANSI C63.4-2014 §8.2.3, ANSI C63.10-2013 §6.3, § 6.5
Radiated field strenght emissions above 1GHz	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 KDB558074v05r02

2 Administrative Data

2.1 Identification of the Testing Laboratory

Company name:	CETECOM GmbH
Address:	Im Teelbruch 116 45219 Essen - Kettwig Germany
Responsible for testing laboratory:	Mr. Volker Wittmann
Accreditation scope:	DAkkS Webpage
Test location:	CETECOM GmbH; Im Teelbruch 116 ;45219 Essen - Kettwig

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

Order No.:	19-1-00978
Responsible for test report	Mr. M. Ahmed
Project leader:	Mr. N. Perez
Receipt of EUT:	16.09.2019
Date(s) of test:	2019-Okt-10 – 2019-Nov-27
Version of template:	13.02

2.5 Applicant’s details

Applicant’s name:	Robert Bosch GmbH
Address:	Robert-Bosch-Platz 1 70839 Gerlingen-Schillerhöhe Baden-Württemberg Germany
Contact Person:	Mr. Uwe Feuchter (CM-CI2/EEB)

2.6 Manufacturer’s details

Manufacturer’s name:	see Applicant’s details
Address:	see Applicant’s details

2.7 EUT: Type, S/N etc. and short descriptions used in this test report

Short descrip-tion*)	PMT Sample No.	EUT	Type	S/N	HW status	SW status
EUT A	Sample 09	BUI350	E-Bike computer with Navigation (Radiated)	4	0.8.2.0	0.197.5.0
EUT B	Sample 05	BUI350	E-Bike computer with Navigation (Conducted)	1	0.8.2.0	0.197.5.0

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

2.8 Auxiliary Equipment (AE): Type, S/N etc. and short descriptions

AE short descrip tion *)	Auxiliary Equipment	Type	S/N serial number	HW hardware status	SW software status
AE 1	Micro USB cable	Type B cable	--	--	--
AE 2	DELL Laptop	Latitude E6420	DPN:VVF52 A01	Intel core i5	Windows 7
AE 3	19-1-00978S14	E-Bike Holder with Power supply connection	BUI135	--	--
AE 4	19-1-02039S03	Bicycle Handlebar	V7161	--	--
AE 5	ANKER 24W 2-Port USB Charger	A2021	--	Input: 100-240V AC - 0.7A 50-60Hz 5V DC – 2.4 A per Port max.	--

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

2.9 Connected cables

Cable short descrip tion *)	Cable type	Connectors	Length
CAB 1	USB Cable	--	1 m

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

2.10 EUT set-ups

set-up no.*)	Combination of EUT and AE	Description
set. 1	EUT A + AE 1 + (AE 2) + AE 3 + AE4	Used for Radiated measurements. AE2 only used to set required operating mode and was removed during the measurement.
set. 2	EUT B + AE 1 + (AE2)	Used for Conducted measurements.
set. 3	EUT A + AE 1 + AE 5	AC-Power Lines Conducted Emissions

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

2.11 EUT operation modes

EUT operating mode no.*)	Operating modes	Additional information
op. 1	WLAN_TX-Mode	With help of certain commands WLAN was set in continuous traffic mode using Putty. 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

Product name	BUI350		
Kind of product	E-Bike computer with Navigation		
Firmware	☐ for normal use	☒ Special version for test execution	
Power supply13,5 V DC	☐ AC Mains	-	
	☐ DC Mains	--	
	☒ Battery	Lithium Ion battery	
Operational conditions	T_{nom} = 22 °C	T_{min} = -10 °C	T_{max} = 50 °C
EUT sample type	**Pre-Production**		
Weight			
Size			
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)		
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 | 12| 13	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		
Other wireless options	☐ a/n/ac mode ☒ 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: **18.9** dBm g-mode: **20.3** dBm n-mode(20MHz): **21.1** dBm		
EIRP WLAN (Calculated EIRP)	b-mode: **18.9** dBm **- 1.3** dBi = **17.6** dBm g-mode: **20.3** dBm **- 1.3** dBi = **19** dBm n-mode(20MHz): **21.1** dBm - **1.3** dBi = **19.8** dBm		
Antenna Type(s)	PCB		
Antenna Gain(s)	-1.3 dBi		
FCC label attached	No		
Test firmware / software and storage location	EUTA, EUTB / Putty stored in AE2		
For further details refer Applicants Declaration & following technical documents			
Description of Reference Document (supplied by applicant)		**Version**	**Total Pages**
LBEE5KL1DX-977_JEBMM0-1454A_2018-05-15		**15. May 2018**	**42**

3.3 Worst case identification

The following WLAN modes were selected for testing after performing the maximum conducted transmitted power tests.

WLAN mode	Data rate
802.11b	2 Mbps
802.11g	6 Mbps
802.11n, 20MHz bandwidth	MCS0

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

Measurement Location and Equipment

Test location	Cetecom Essen
Test site	120910 - Radio Lab
Test receiver	20805 – FSV3030 Signal Analyzer

Result:

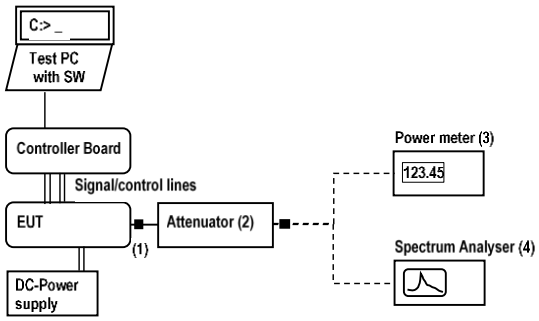
☐ The results were corrected in order to evaluate for worst-case result each time when average values are necessary for example average radiated emissions or similar
☒ No correction necessary: Duty-Cycle > 98%

4.2 Peak output power (Sweep)

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.

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.

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

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 Limit

Frequency Range [MHz]	Limit [W]	Limit [dBm]	Detector	RBW / VBW [MHz]
2400 - 2483.5	**1**	**30**	**Peak**	**20 / 30**

4.2.3 Measurement Location and Equipment

Test location	Cetecom Essen
Test site	120910 - Radio Lab
Test receiver	20871 – NRP-Z81

4.2.4 Result

Manufacturer declared Antenna Gain: -1.3 dBi.

Mode	Channel	Frequency [MHz]	Max Peak Power Conducted [dBm]	Result
b-mode (2 Mbps)	01	2412	**18.9**	Passed
	06	2437	18.8	Passed
	11	2462	18.4	Passed
g-mode (6 Mbps)	01	2412	19.7	Passed
	06	2437	**20.3**	Passed
	11	2462	19.7	Passed
n-mode (MCS0)	01	2412	20.5	Passed
	06	2437	**21.1**	Passed
	11	2462	20.6	Passed

Remark: for more informations and graphical plot see report **CETECOM_TR19_1_0097801T01a_A1**

⇨ **All radiated tests were performed in n–mode, MCS0**

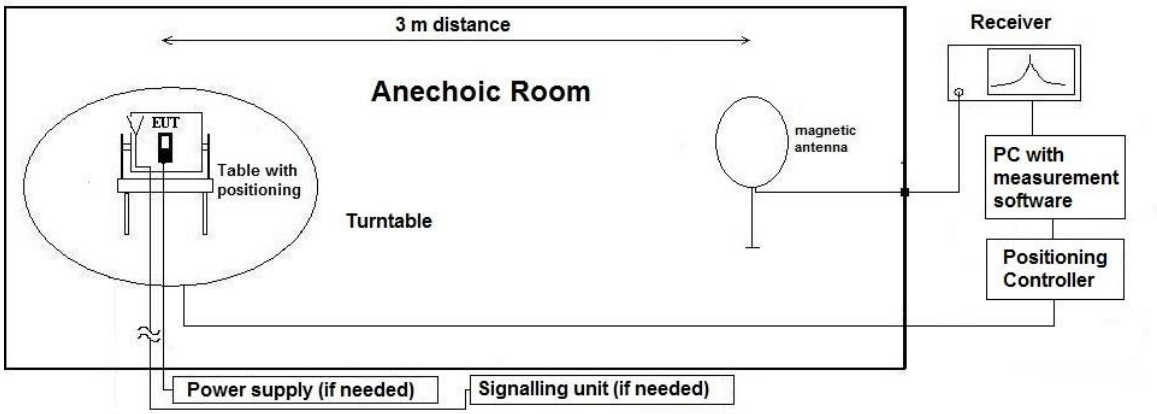
4.3 Radiated field strength emissions below 30MHz

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

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

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

Schematic:



Testing method:

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

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

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

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

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

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

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

Formula:

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

$M = L_T - E_C$

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

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

Distance correction:

Reference for applied correction (extrapolating) factors due to reduced measurement distance:
ANSI C63.10:2013, §6.4.4.2 - Equations (2) + (3) + (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 to 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)	2'te Condition (Limit distance bigger dnear-field)	Distance Correction accord. Formula
kHz	9.00E+03	33333.33	5305.17	300		fullfilled	not fullfilled	-80.00
	1.00E+04	30000.00	4774.65			fullfilled	not fullfilled	-80.00
	2.00E+04	15000.00	2387.33			fullfilled	not fullfilled	-80.00
	3.00E+04	10000.00	1591.55			fullfilled	not fullfilled	-80.00
	4.00E+04	7500.00	1193.66			fullfilled	not fullfilled	-80.00
	5.00E+04	6000.00	954.93			fullfilled	not fullfilled	-80.00
	6.00E+04	5000.00	795.78			fullfilled	not fullfilled	-80.00
	7.00E+04	4285.71	682.09			fullfilled	not fullfilled	-80.00
	8.00E+04	3750.00	596.83			fullfilled	not fullfilled	-80.00
	9.00E+04	3333.33	530.52			fullfilled	not fullfilled	-80.00
	1.00E+05	3000.00	477.47			fullfilled	not fullfilled	-80.00
	1.25E+05	2400.00	381.97			fullfilled	not fullfilled	-80.00
	2.00E+05	1500.00	238.73			fullfilled	fullfilled	-78.02
	3.00E+05	1000.00	159.16			fullfilled	fullfilled	-74.49
	4.00E+05	750.00	119.37			fullfilled	fullfilled	-72.00
	4.90E+05	612.24	97.44			fullfilled	fullfilled	-70.23
	5.00E+05	600.00	95.49	30		fullfilled	not fullfilled	-40.00
	6.00E+05	500.00	79.58			fullfilled	not fullfilled	-40.00
	7.00E+05	428.57	68.21			fullfilled	not fullfilled	-40.00
	8.00E+05	375.00	59.68			fullfilled	not fullfilled	-40.00
	9.00E+05	333.33	53.05			fullfilled	not fullfilled	-40.00
MHz	1.00	300.00	47.75			fullfilled	not fullfilled	-40.00
	1.59	188.50	**30.00**			fullfilled	not fullfilled	-40.00
	2.00	150.00	23.87			fullfilled	fullfilled	-38.02
	3.00	100.00	15.92			fullfilled	fullfilled	-34.49
	4.00	75.00	11.94			fullfilled	fullfilled	-32.00
	5.00	60.00	9.55			fullfilled	fullfilled	-30.06
	6.00	50.00	7.96			fullfilled	fullfilled	-28.47
	7.00	42.86	6.82			fullfilled	fullfilled	-27.13
	8.00	37.50	5.97			fullfilled	fullfilled	-25.97
	9.00	33.33	5.31			fullfilled	fullfilled	-24.95
	10.00	30.00	4.77			fullfilled	fullfilled	-24.04
	10.60	28.30	4.50			fullfilled	fullfilled	-23.53
	11.00	27.27	4.34			fullfilled	fullfilled	-23.21
	12.00	25.00	3.98			fullfilled	fullfilled	-22.45
	13.56	22.12	3.52			fullfilled	fullfilled	-21.39
	15.00	20.00	3.18			fullfilled	fullfilled	-20.51
	15.92	18.85	**3.00**			fullfilled	fullfilled	-20.00
	17.00	17.65	2.81			not fullfilled	fullfilled	-20.00
	18.00	16.67	2.65			not fullfilled	fullfilled	-20.00
	20.00	15.00	2.39			not fullfilled	fullfilled	-20.00
	21.00	14.29	2.27			not fullfilled	fullfilled	-20.00
	23.00	13.04	2.08			not fullfilled	fullfilled	-20.00
	25.00	12.00	1.91			not fullfilled	fullfilled	-20.00
	27.00	11.11	1.77			not fullfilled	fullfilled	-20.00
	29.00	10.34	1.65			not fullfilled	fullfilled	-20.00
	30.00	10.00	1.59			not fullfilled	fullfilled	-20.00

4.3.2 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

4.3.3 Measurement Location and Equipment

Test location	**Cetecom Essen**
Test site	**120901 – SAC – Radiated Emission <1GHz**

4.3.4 Result

Diagram	Channel	Mode	Maximum Level [dBµV/m] / Frequency Range 0.009 – 30MHz	Result
2.01a	06	n-Mode-MCS0-Laying	20 dBµV/m @ 23.7 MHz	Passed
2.01b	06	n-Mode-MCS0-Standing	19 dBµV/m @ 18.9 MHz	Passed

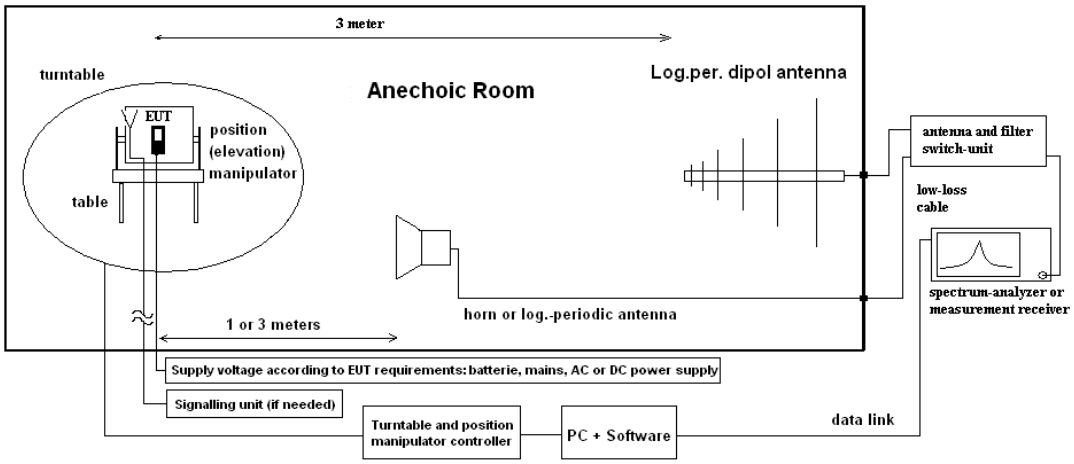
Remark: for more information and graphical plot see report **CETECOM_TR19_1_0097801T01a_A1**

4.4 Radiated field strength emissions 30MHz – 1GHz

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

Evaluating the emissions have to be done first by an exploratory emissions measurement and a final measurement for most critical frequencies. The tests are performed in a CISPR 16-1-4:2010 compliant 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.

4.4.2 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

4.4.3 Measurement Location and Equipment

Test location	**Cetecom Essen**
Test site	**120901 – SAC – Radiated Emission <1GHz**

4.4.4 Result

Diagram	Channel	Mode	Maximum Level [dBµV/m] Frequency Range 30 – 1000MHz	Result
3.01a	6	n20-mode-MCS0- Laying	35.29 dBµV/m @ 36.84 MHz	Passed
3.01b	6	n20-mode-MCS0-Standing	36.90 dBµV/m @ 36.33 MHz	Passed

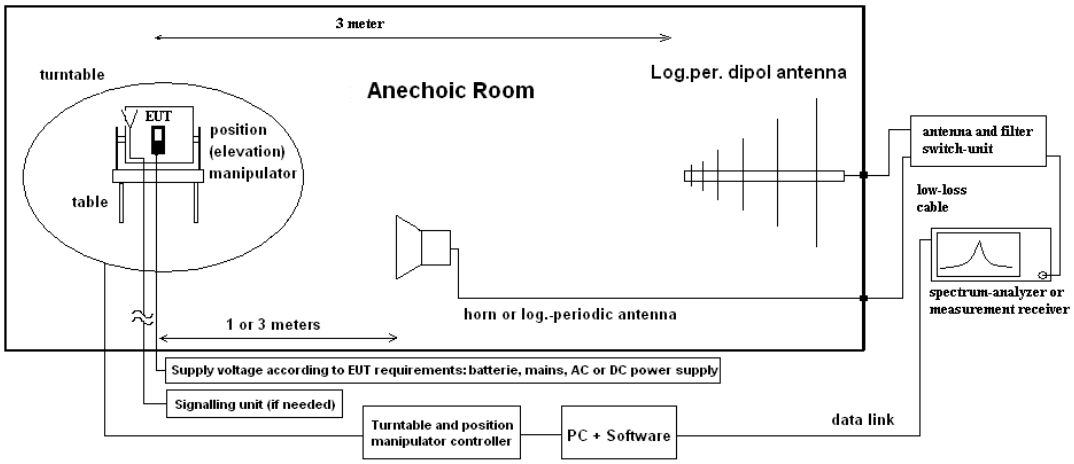
Remark: for more information and graphical plot see report **CETECOM_TR19_1_0097801T01a_A1**

4.5 Radiated field strength emissions above 1GHz

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

Evaluating the emissions have to be done first by an exploratory emissions measurement and a final measurement for most critical frequencies. The tests are performed in a CISPR 18-1-4:2010 compliant fully anechoic 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:

$E_C = E_R + A_F + C_L + D_F - G_A$ (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.

4.5.2 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

4.5.3 Measurement Location and Equipment

Test location	**Cetecom Essen**
Test site	**120904 – FAC – Radiated Emission**

4.5.4 Result

Diagram	Channel	Mode	Maximum Level [dBµV/m] Frequency Range 1 – 15GHz	Result
4.03a	6	n20-mode-MCS0	49.11 dBµV/m @ 14.212 GHz (AV) 61.577 dBµV/m @ 14.351 GHz (PK)	Passed

Remark: for more information and graphical plot see report **CETECOM_TR19_1_0097801T01a_A1**

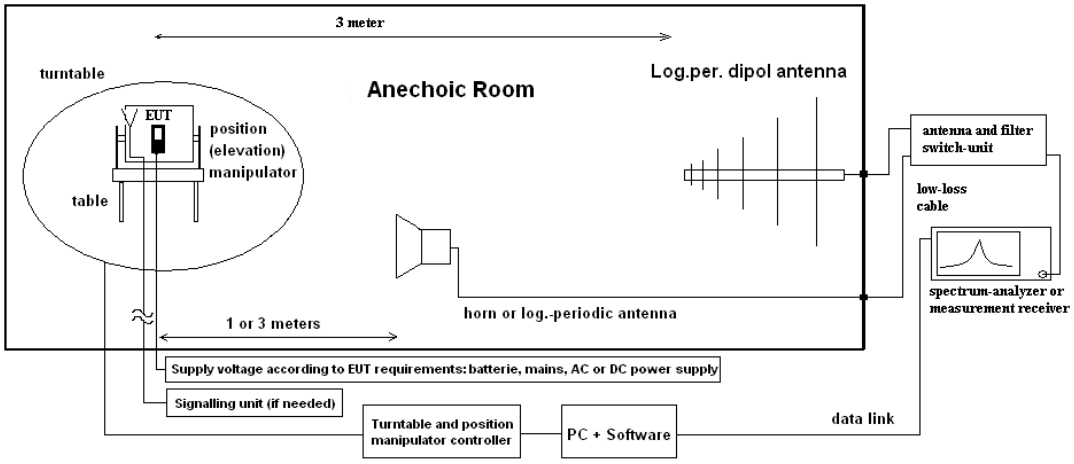
Diagram	Channel	Mode	Maximum Level [dBµV/m] Frequency Range 15 – 25 GHz	Result
4.03c	6	n20-mode-MCS0	49.51 dBµV/m @ 24.496 GHz (AV) 59.59 dBµV/m @ 24.685.31 (PK)	Passed

Remark: for more information and graphical plot see report **CETECOM_TR19_1_0097801T01a_A1**

4.6 Radiated Band-Edge emissions

4.6.1 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.

4.6.2 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	100 / 300
Above 2483.5	-	-	54	74	Average / Peak	1000 / 3000
2390 - 2400	-20	-	-	-	Peak	100 / 300
2390 - 2400	-	-30	-	-	Average	100 / 300

4.6.3 Measurement Location and Equipment

Test location	**Cetecom Essen**
Test site	**120904 – FAC – Radiated Emission**

4.6.4 Result

Non-restricted bands near-by

Diagram	Channel	Mode	Peak [dBc]	Average [dBc]	Result
9.01a	01	b-mode	48.80	49.05	Passed
9.02a	01	g-mode	34.78	35.20	Passed
9.03a	01	n-mode HT20	34.29	33.77	Passed

Remark: for more informations and graphical plot see report **CETECOM_TR19_1_0097801T01a_A1**.

Restricted bands near-by

Diagram	Channel	Mode	Peak [dBµV/m]	Average [dBµV/m]	Result
9.01b	11	b-mode	58.50	47.70	Passed
9.02b	11	g-mode	59.71	48.63	Passed
9.03b	11	n-mode HT20	59.96	48.77	Passed

Remark: for more informations and graphical plot see report **CETECOM_TR19_1_0097801T01a_A1**.

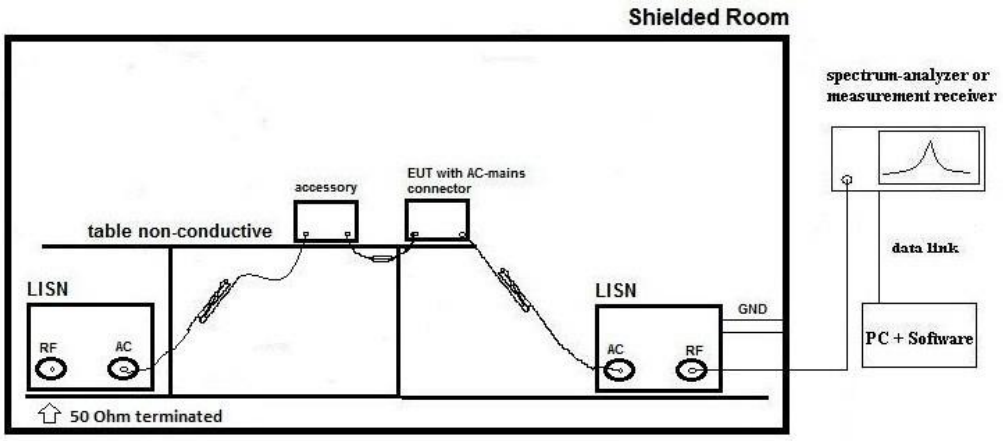
4.7 AC-Power Lines Conducted Emissions

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

The radio frequency voltage conducted back into the AC power line in the frequency range 150 kHz to 30 MHz has to be investigated.
Compliance should be tested by measuring the radio frequency voltage between each power line and ground at the power terminals in the stated frequency range.
A 50 Ohm / 50 µH line impedance stabilization network (LISN) is used coupling the interface to the measurement equipment.
The EUT power input leads are connected through the LISN to the AC-power source. The LISN enclosure is electrically connected to the ground plane. The measuring instrument is connected to the coaxial output of the LISN.

Tabletop devices were set-up on an 80 cm height above reference ground plane, floor standing equipment 10 cm raised above ground plane.
Measurements have been performed on each phase line and neutral line of the devices AC-power lines.
The EUT was power supplied with 120 V/60 Hz. The EUT was tested in the defined operating mode
and installed (connected) to accessory equipment according the general description of use given by the applicant.

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
As a first step, determines the worst-case phase line (neutral or phase) as well as the most critical operating mode of the equipment. A complete frequency-sweep with PK-Detector is performed on each current-carrying conductor.

Final measurement on critical frequencies
For power phases and critical frequencies (Margin to AV- or QP limit lower than 3 dB) as a second step includes measurements with receivers detector set to Quasi-Peak and Average.

Formula:

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

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

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

4.7.2 Limit

Frequency Range [MHz]	QUASI-Peak [dBµV]	AVERAGE [dBµV]
0.15 – 0.5	66 to 56*	56 to 46*
0.5 – 5	56	46
5 – 30	60	50

4.7.3 Measurement Location and Equipment

Test location	**Cetecom Essen**
Test site	**120919 – Conducted Emissions**

4.7.4 Result

Diagram	Mode	Power Line	Max [dBµV]	Detector	Result
1.01	n-mode MCS0	L1	53.93 @150kHz	QPK	Passed
1.01	n-mode MCS0	L1	38.30 @ 594kHz	AVG	Passed

Remark: see more in diagrams in separate document **CETECOM_TR19_1_0097801T01a_A1**

4.8 Results from external laboratory

None	-

4.9 Opinions and interpretations

None	-

5 Equipment lists

ID	Description	Manufacturer	SerNo	Cal Date
120904	FAC1 - Radiated Emissions			
20720	EMC32 [FAC]	Rohde & Schwarz Messgerätebau GmbH	V10.50	
20020	Horn Antenna 3115 (Subst 1)	EMCO Elektronik GmbH	9107-3699	19.07.2021
20549	Log.Per-Antenna HL025	Rohde & Schwarz Messgerätebau GmbH	1000060	31.07.2021
20700	PC ctc662012 [FAC]	Dell Inc.		
20262	Power Meter NRV-S	Rohde & Schwarz Messgerätebau GmbH	825770/0010	15.05.2020
20357	power sensor NRV-Z1	Rohde & Schwarz Messgerätebau GmbH	861761/002	21.05.2021
20338	Pre-Amplifier 100MHz - 26GHz JS4-00102600-38-5P	Miteq Inc.	838697	
20484	Pre-Amplifier 2,5GHz - 18GHz AMF-5D-02501800-25-10P	Miteq Inc.	1244554	
20287	Pre-Amplifier 25MHz - 4GHz AMF-2D-100M4G-35-10P	Miteq Inc.	379418	
20690	Spectrum Analyzer FSU	Rohde & Schwarz Messgerätebau GmbH	100302/026	23.05.2021
120901	SAC - Radiated Emission <1GHz			
25038	Loop Antenna (H-Field) HFH2-Z2	Rohde & Schwarz	879824/13	31.03.2022
20574	Biconilog Hybrid Antenna BTA-L	Frankonia	980026L	03.05.2022

ID	Description	Manufacturer	SerNo	Cal Date
20302	Horn Antenna BBHA9170	Schwarzbeck Mess-Elektronik OHG	155	30.03.2022
20620	ESU 26	Rohde & Schwarz	100362	30.05.2020
120910	CTC-Radio Laboratory 1			
20866	FSV3030 Signal Analyzer 30GHz	Rohde & Schwarz Messgerätebau GmbH	101247	02.10.2020
20805	Open Switch and control Platform OSP B157WX 40GHz 8Port Switch	Rohde & Schwarz Messgerätebau GmbH	101264	03.05.2020
20693	TSS8997	Rohde & Schwarz Messgerätebau GmbH	--	--
20871	NRP-Z81	Rohde & Schwarz Messgerätebau GmbH	104631	08.04.2021
	120919 - Conducted Emission			
20300	AC - LISN (50 Ohm/50µH, 1-phase) ESH3-Z5	Rohde & Schwarz Messgerätebau GmbH	892 239/020	22.05.2020
20005	AC - LISN 50 Ohm/50µH ESH2-Z5	Rohde & Schwarz Messgerätebau GmbH	861741/005	23.05.2020
20468	Digital Multimeter Fluke 112	Fluke Deutschland GmbH	90090455	16.05.2021
20377	EMI Test Receiver ESCS30	Rohde & Schwarz Messgerätebau GmbH	100160	22.05.2020
20536	Impedance Stabilization Network ISN ST08	Teseq GmbH	25867	18.05.2020
20533	Impedance Stabilization Network ISN T200A	Teseq GmbH	25706	18.05.2020
20534	Impedance Stabilization Network ISN T400A	Teseq GmbH	24881	18.05.2020
20541	Impedance Stabilization Network ISN T8-Cat6	Teseq GmbH	26373	18.05.2020
20535	Impedance Stabilization Network ISN T800	Teseq GmbH	26321	18.05.2020
20099	Passive Voltage Probe ESH2-Z3	Rohde & Schwarz Messgerätebau GmbH	299.7810.52	16.05.2021
20100	passive voltage probe TK 9416	Schwarzbeck Mess-Elektronik OHG	without	16.05.2021

ID	Description	Manufacturer	SerNo	Cal Date
20033	RF-current probe (100kHz-30MHz) ESH2-Z1	Rohde & Schwarz Messgerätebau GmbH	879581/18	23.05.2021
20373	Single-Line V-Network (50 Ohm/5µH) ESH3-Z6	Rohde & Schwarz Messgerätebau GmbH	100535	22.05.2020
20007	Single-Line V-Network (50 Ohm/5µH) ESH3-Z6	Rohde & Schwarz Messgerätebau GmbH	892563/002	23.05.2020
20556	Thermo-/Hygrometer WS-9400	Conrad Electronic GmbH	-	
20051	VHF-Current Probe 20-300 MHz ESV-Z1	Rohde & Schwarz Messgerätebau GmbH	872421	16.05.2021

6 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.

RF-Measurement	Reference	Frequency range	Calculated uncertainty based on a confidence level of 95%						Remarks
Conducted emissions (U_{CISPR})	-	9 kHz - 150 kHz 150 kHz - 30 MHz	4.0 dB 3.6 dB						-
Power Output radiated	-	30 MHz - 4 GHz	3.17 dB						Substitution method
Power Output conducted	-	Set-up No.	Cel-C1	Cel-C2	BT1	W1	W2	--	
		9 kHz - 12.75 GHz	N/A	0.60	0.7	0.25	N/A	--	-
		12.75 - 26.5 GHz	N/A	0.82	--	N/A	N/A	--	
Conducted emissions on RF-port	-	9 kHz - 2.8 GHz	0.70	N/A	0.70	N/A	0.69	--	N/A - not applicable
		2.8 GHz - 12.75 GHz	1.48	N/A	1.51	N/A	1.43	--	
		12.75 GHz – 18 GHz	1.81	N/A	1.83	N/A	1.77	--	
		18 GHz - 26.5 GHz	1.83	N/A	1.85	N/A	1.79	--	
Occupied bandwidth	-	9 kHz - 4 GHz	0.1272 ppm (Delta Marker)						Frequency error
			1.0 dB						Power
Emission bandwidth	- -	9 kHz - 4 GHz	0.1272 ppm (Delta Marker)						Frequency error
			See above: 0.70 dB						Power
Frequency stability	-	9 kHz - 20 GHz	0.0636 ppm						-
Radiated emissions Enclosure	-	150 kHz - 30 MHz	5.01dB						Magnetic field strength
		30 MHz - 1 GHz 1 GHz - 18 GHz 18-26.5 GHz	5.83 dB 4.91 dB 5.06 dB						Electrical Field strength

7 Versions of test reports (change history)

Version	Applied changes	Date of release
--	Initial release	2020-May-11
C1	Chapter 1.1: module reference updated Chapter 4.5: Result Table updated see also Annex 1	2020-May-14
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End of Test Report