PARTIAL
Test Report 18-1-0097201T24a-C01

D-PL-12047-01-01
D-PL-12047-01-03
D-PL-12047-01-04

Number of pages:	27	**Date of Report:**	2021-Sep-08
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:**	Actia Nordic AB
Test Object / Tested Device(s):	**103360002, Telematics Device**		
Listing FCC ID:	2AGKK103360002	**ISED:**	20839-103360002
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:	2.4GHz 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 the Test Report TR18-1-0097201T24a-C01 replaces the Test Report TR18-1-0097201T24a dated 2020-07-23.
The replaced Test Report is herewith invalid.

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Dipl.-Ing. Ninovic Perez	M.Sc. Patrick Marzotko
Test Lab Manager	Test Manager
Authorization of test report	Responsible of test report

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1 General information

1.1 Disclaimer and Notes

The test results of this test report relate exclusively to the test item specified in this test report as specified in chapter 2.7. CETECOM 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 2.4 GHz W-LAN transmitter. Other implemented technologies were not considered within this test 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
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 30 MHz	§15.205(a) §15.209(a)	RSS-Gen: Issue 5 §8.9 Table 6	13	--	PASSED
Radiated field strength emissions 30 MHz – 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 1 GHz	§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	--	--	Not applicable

Remarks:
*1) Please refer to Module test report '' MDE_UBLOX_1701_FCCd_SIGNED'' issued on 2018-May-05 with the **FCC ID: XPYJODYW164-07A** and **ISED ID: 8595A-JODYW16407A**

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.

*The calculation of the measurement uncertainty shows compliance with the "maximum measurement uncertainties" of the tested standard and therefore for result evaluation the stated uncertainties will not be additionally added to the measured results.

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 KDB558074

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:	Dipl.-Ing. Ninovic Perez
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.:	18-1-00972
Responsible test manager:	B.Sc. M. Ahmed
Receipt of EUT:	2019-Nov-27
Date(s) of test:	2019-Dez-11 – 2020-Apr-06
Version of template:	13.03

2.5 Applicant's details

Applicant's name:	ACTIA Nordic AB
Address:	Hammarbacken 4A, 3tr 191 49 Sollentuna Sweden
Contact Person:	Mr. Salah Alazawi
Contact Person's Email:	salah.alazawi@actia.se

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 description*)	PMT Sample No.	Model Name	Type	S/N	HW status	SW status
EUT A	Sample 20	103360002	Telematics Device	AN103350102B160	H1	1
EUT B	Sample 17	103360002	Telematics Device	AN103350102B163	H1	1

*) 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

Short description*)	PMT Sample No.	Auxiliary Equipment	Type	S/N	HW status	SW status
AE1	Sample 10	Cable Harness	Power Cable	--	--	--
AE2	Sample 11	Fakra Cable	--	--	--	--
AE3	Sample 12	Fakra Cable	--	--	--	--
AE4	Sample 13	Fakra Cable	--	--	--	--
AE5	Sample 14	Fakra Cable	--	--	--	--
AE6	Sample 58	CALEARO LTE Antenna	7680588	--	16MA800CP	--
AE7	Sample 59	CALEARO LTE Antenna	7680588	--	16MA800CP	--
AE8	Sample 64	CALEARO Wifi Antenna	7750162	--	16MA396CP	--
AE9	Sample 16	Cable	USB Cable	--	--	--
AE10	Sample 78	GNSS Antenna	CALEARO GNSS Antenna	7750161	16MA439CP	--
AE11	--	AN103640101	NI-MH Hybride Battery	BK-12F3G1	REV-A Sep10	
AE12	--	DELL Laptop	Latitude E6420	DPN:VVF52 A01	Intel core i5	Windows 7

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

2.9 Connected cables

Cable short description *)	Cable type	Connectors	Length
CAB 1	AE2 to AE5(Shielded)	FAKRA	2 m
CAB 2	AE9 (Shielded)	USB , RS232	2 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
1	EUT A + AE1 + AE2 + AE3 + AE4 + AE5 + AE6 + AE7 + AE8 + AE9 + AE10 + (AE12)	Used for Radiated measurements. AE11 was used to setup the operating mode and was removed during measurements.
2	EUT B + AE1 + AE9 + AE12	Used for Conducted measurements

*) 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 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

Product name	103360002	
Kind of product	Telematics Device	
Firmware	☐ for normal use	☒ Special version for test execution
	☐ AC Mains	-
	☒ DC Mains	**13.8** V DC
	☒ Battery	NI-MH 3.6V 1200 mAh
Operational conditions	T_{nom} = 23 °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)		
MIMO	☐ yes ☒ no		
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		
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)		
EIRP Calculation	**Max Conducted Output Power+ Antenna Gain – Cable Loss (only external Antenna)**		
Max. Conducted Output Power (External Antenna) (Measured RMS Power)	b-mode: **12.81** dBm g-mode: **13.01** dBm n-mode(20MHz): **12.81** dBm		
EIRP WLAN (External Antenna) (Calculated EIRP)	b-mode: **12.81** dBm + **0** dBi – **1.8** dB= **11.01** dBm g-mode: **13.01** dBm+ **0** dBi - **1.8** dB = **11.21** dBm n-mode(20MHz): **12.81** dBm + **0** dBi - **1.8** dB = **11.01** dBm		
Max. Conducted Output Power (Internal Antenna) (Measured RMS Power)	b-mode: **13.01** dBm g-mode: **12.81** dBm n-mode(20MHz): **12.81** dBm		
EIRP WLAN (Internal Antenna) (Calculated EIRP)	b-mode: **13.01** dBm + **3** dBi = **16.01** dBm g-mode: **12.81** dBm+ **3** dBi = **15.81** dBm n-mode(20MHz): **12.81** dBm + **3** dBi = **15.81** dBm		
Antenna Type	PIFA Antenna (Internal) , PCB Patch Antenna (External)		
Antenna Gain(s)	3 dBi (Internal), 0 dBi (External)		
FCC label attached	☐ yes ☒ no		
FCC label attached	☐ yes ☒ no		
Test firmware / software and storage location	AE11		
For further details refer Applicants Declaration & following technical documents			
Description of Reference Document (supplied by applicant)		**Version**	**Total Pages**
ACU6 Technical Description 103360002 (US_CANADA)_0.2		**17-12-2019**	**14**

3.3 Worst case identification

WLAN mode	Data rate
802.11b	1 Mbit
802.11g	6 Mbit
802.11n, 20MHz bandwidth	MCS0

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

☐ 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 Result

Mode	DUT Frequency	DutyCycle (%)	Duty Cycle Correction dB
b-mode 1M; 2412MHz	2412.0000	99.925	DC > 98% = 0dB
b-mode 1M; 2437MHz	2437.0000	99.925	DC > 98% = 0dB
b-mode 1M; 2462MHz	2462.0000	99.925	DC > 98% = 0dB
g-mode 6M; 2412MHz	2412.0000	99.288	DC > 98% = 0dB
g-mode 6M; 2437MHz	2437.0000	99.286	DC > 98% = 0dB
g-mode 6M; 2462MHz	2462.0000	99.286	DC > 98% = 0dB
n-mode MCS0; 2412MHz	2412.0000	99.234	DC > 98% = 0dB
n-mode MCS0; 2437MHz	2437.0000	99.231	DC > 98% = 0dB
n-mode MCS0; 2462MHz	2462.0000	99.232	DC > 98% = 0dB

4.2 RF output power

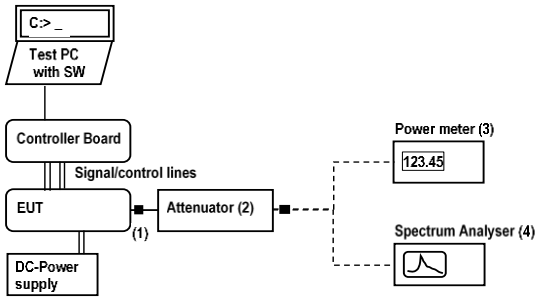
4.2.1 Description of the general test setup and methodology, see below example:

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.

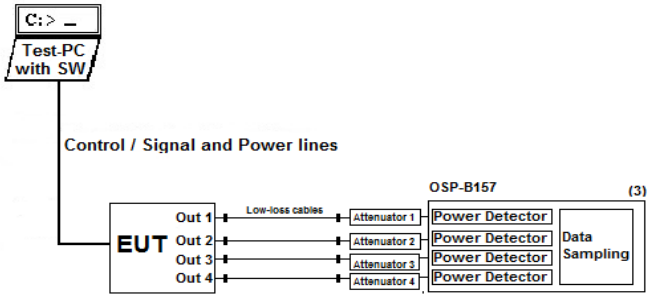
MIMO

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	AVPM-G (duty-cycle < 98% (constant)
SISO	☒
MIMO	☐ Summation of values from two antenna ports
Remarks	In Compliance

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	RMS	1 / 3

4.2.3 Result

4.2.3.1 External Antenna

Mode	Channel	f_C [MHz]	Max conducted Power [dBm]	Internal loss (dBm)	Max RMS Power [dBm]	Temperature [°C]	Result
b-mode [1 Mbps]	1	2412	12.4	0.31	12.71	23	PASS
b-mode [1 Mbps]	6	2437	12.5	0.31	**12.81**	23	PASS
b-mode [1 Mbps]	11	2462	11.4	0.31	11.71	23	PASS
g-mode [6 Mbps]	1	2412	12.6	0.31	12.91	23	PASS
g-mode [6 Mbps]	6	2437	12.7	0.31	**13.01**	23	PASS
g-mode [6 Mbps]	11	2462	11.5	0.31	11.81	23	PASS
n-mode [MCS0]	1	2412	12.3	0.31	12.61	23	PASS
n-mode [MCS0]	6	2437	12.5	0.31	**12.81**	23	PASS
n-mode [MCS0]	11	2462	11.5	0.31	11.81	23	PASS

Remark: for more informations and graphical plot see annex A1 **CETECOM_TR18_1_0097201T24a_C01_A1**

4.2.3.2 Internal Antenna

Mode	Channel	f_C [MHz]	Max conducted Power [dBm]	Internal loss (dBm)	Max RMS Power [dBm]	Temperature [°C]	Result
b-mode [1 Mbps]	1	2412	11.9	0.31	12.21	23	PASS
b-mode [1 Mbps]	6	2437	12.7	0.31	**13.01**	23	PASS
b-mode [1 Mbps]	11	2462	11.4	0.31	11.71	23	PASS
g-mode [6 Mbps]	1	2412	11.9	0.31	12.21	23	PASS
g-mode [6 Mbps]	6	2437	12.5	0.31	**12.81**	23	PASS
g-mode [6 Mbps]	11	2462	11.4	0.31	11.71	23	PASS
n-mode [MCS0]	1	2412	11.9	0.31	12.21	23	PASS
n-mode [MCS0]	6	2437	12.5	0.31	**12.81**	23	PASS
n-mode [MCS0]	11	2462	11.4	0.31	11.71	23	PASS

Remark: for more informations and graphical plot see annex A1 **CETECOM_TR18_1_0097201T24a_C01_A1**

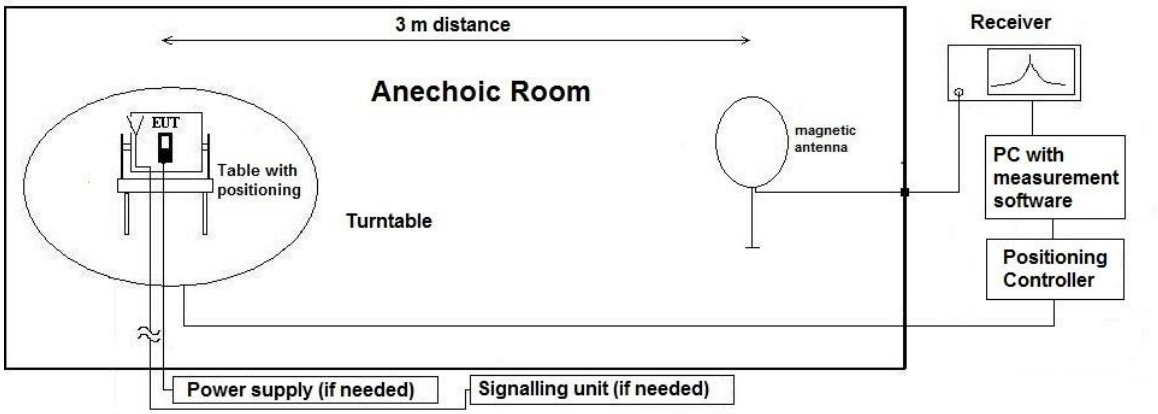
4.3 Radiated field strength emissions below 30 MHz

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

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

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

Schematic:



Testing method:

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

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

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

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

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

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

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

Formula:

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

$M = L_T - E_C$

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

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

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)	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 Result

4.3.3.1 External Antenna

Diagram	Channel	Mode	Maximum Level [dBµV/m] Frequency Range 0.009 – 30MHz	Result
2.01a	6	g-mode | 6Mbit | laying	18.10 @ 19.61 MHz	Passed
2.01b	6	g-mode | 6Mbit| standing	20.72 @ 25.35 MHz	Passed

Remark: for more informations and graphical plot see annex A1 **CETECOM_TR18_1_0097201T24a_C01_A1**

4.3.3.2 Internal Antenna

Diagram	Channel	Mode	Maximum Level [dBµV/m] Frequency Range 0.009 – 30MHz	Result
2.02a	6	b-mode | 1Mbit | laying	17.80 @ 20.62 MHz	Passed
2.02b	6	b-mode | 1Mbit | standing	18.07 @ 16.13 MHz	Passed

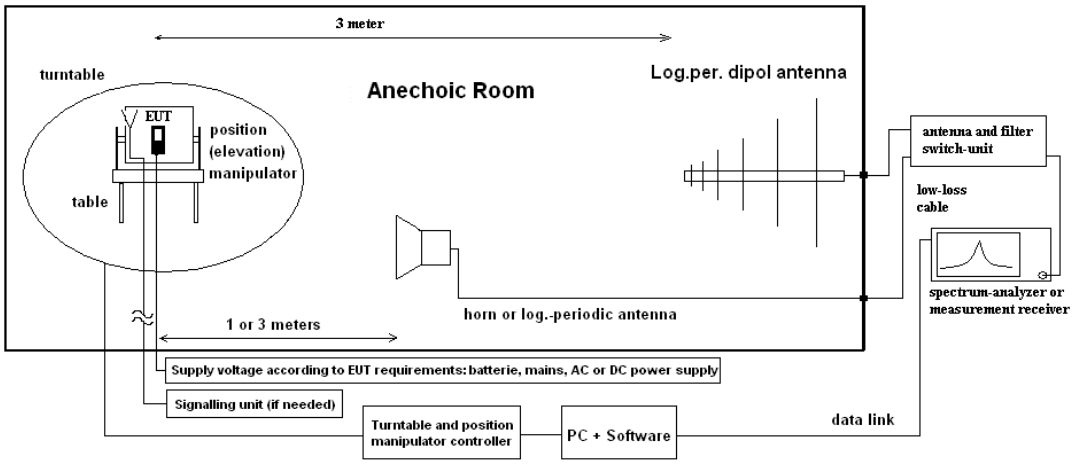
Remark: for more informations and graphical plot see annex A1 **CETECOM_TR18_1_0097201T24a_C01_A1**

4.4 Radiated field strength emissions 30 MHz – 1 GHz

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 Result

4.4.3.1 External Antenna

Diagram	Channel	Mode	Maximum Level [dBµV/m] Frequency Range 30 – 1000MHz	Result
3.01a	6	g-mode | 6Mbit | laying	41.94 @ 934.69 MHz	Passed
3.01b	6	g-mode | 6Mbit| standing	41.99 @ 894.4 MHz	Passed

Remark: for more informations and graphical plot see annex A1 **CETECOM_TR18_1_0097201T24a_C01_A1**

4.4.3.2 Internal Antenna

Diagram	Channel	Mode	Maximum Level [dBµV/m] Frequency Range 30 – 1000MHz	Result
3.02a	6	b-mode | 1Mbit | laying	41.32 @ 839.16 MHz	Passed
3.02b	6	b-mode | 1Mbit | standing	41.62 @ 852.8 MHz	Passed

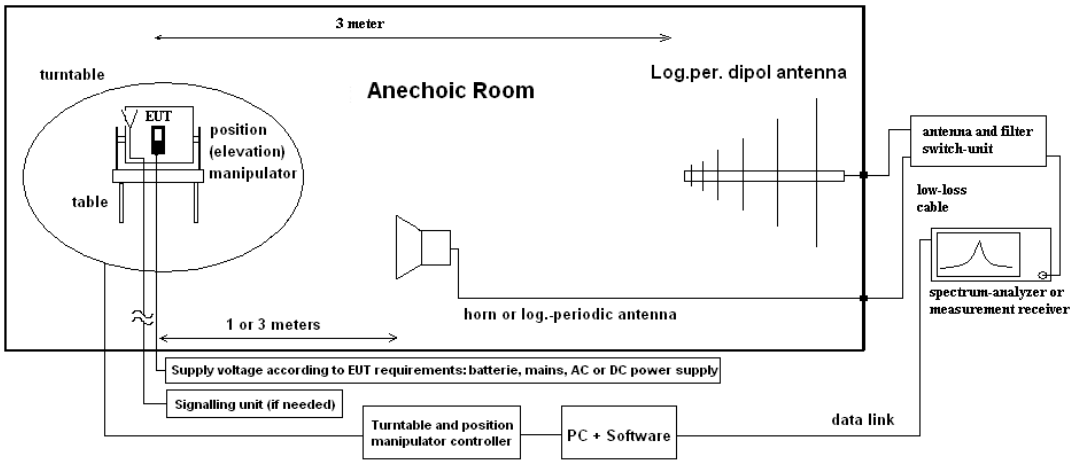
Remark: for more informations and graphical plot see annex A1 **CETECOM_TR18_1_0097201T24a_C01_A1**

4.5 Radiated field strength emissions above 1 GHz

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

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

4.5.3.1 External Antenna

Diagram	Channel	Mode	Maximum Level [dBµV/m] Frequency Range 1 – 18 GHz	Result
4.01a	6	g-mode | 6Mbit | laying	63.51 @ 17.25 GHz (PK) 51.511 @ 17.24 GHz (AV)	Passed
4.01b	6	g-mode | 6Mbit| standing	63.49 @ 17.22 GHz (PK) 51.414 @ 17.211 GHz (AV)	Passed

Remark: for more informations and graphical plot see annex A1 **CETECOM_TR18_1_0097201T24a_C01_A1**

Diagram	Channel	Mode	Maximum Level [dBµV/m] Frequency Range 18 – 26.5 GHz	Result
4.11a	6	g-mode | 6Mbit | laying	57.80 @ 25.96 GHz(PK) 49.71 @ 25.99 GHz(AV)	Passed

Remark: for more informations and graphical plot see annex A1 **CETECOM_TR18_1_0097201T24a_C01_A1**

4.5.3.2 Internal Antenna

Diagram	Channel	Mode	Maximum Level [dBµV/m] Frequency Range 1 – 18 GHz	Result
4.02a	6	b-mode | 1Mbit | laying	60.08 @ 16.24 GHz 57.67 @ 16.24 GHz (AV)	Passed
4.02b	6	b-mode | 1Mbit | standing	60.34 @ 17.70 GHz (PK) 48.04 @ 17.70 GHz (AV)	Passed

Remark: for more informations and graphical plot see annex A1 **CETECOM_TR18_1_0097201T24a_C01_A1**

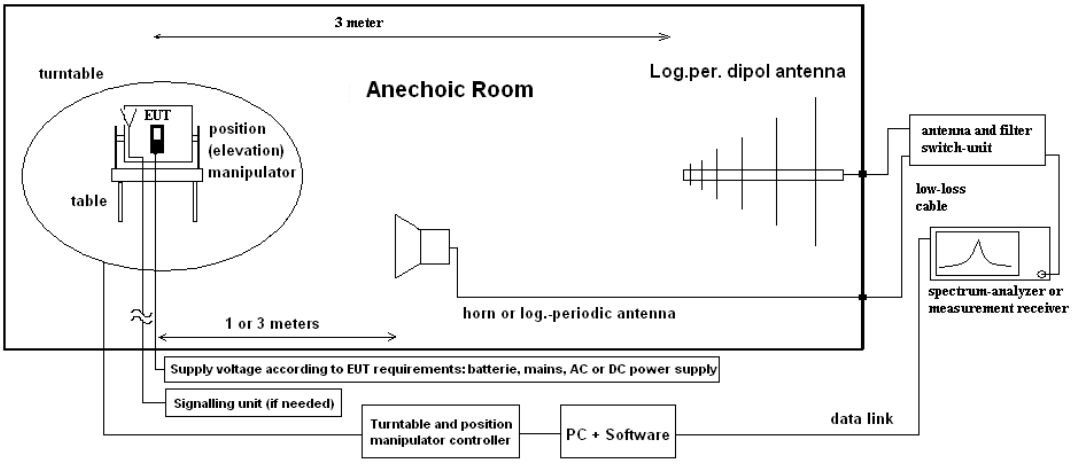
Diagram	Channel	Mode	Maximum Level [dBµV/m] Frequency Range 18 – 26.5 GHz	Result
4.12a	6	b-mode | 1Mbit | laying	56.44 @ 25.47 GHz (PK) 47.98 @ 25.42 GHz (AV)	Passed

Remark: for more informations and graphical plot see annex A1 **CETECOM_TR18_1_0097201T24a_C01_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 Result

4.6.3.1 External Antenna

Non-restricted bands near-by

Diagram	Channel	Mode	Peak [dBc]	Average [dBc]	Result
9.01a	01	b-mode | 1Mbit| laying	44.87	44.87	Passed
9.01b	01	b-mode | 1Mbit| standing	47.57	46.8	Passed
9.03a	01	g-mode | 6Mbit| laying	38.19	39.48	Passed
9.03b	01	g-mode | 6Mbit| standing	36.38	38.87	Passed
9.05a	01	n-mode | HT20 | MCS0| laying	35.56	39.15	Passed
9.05b	01	n-mode | HT20 | MCS0| standing	33.84	38.80	Passed

Restricted bands near-by

Diagram	Channel	Mode	Peak [dBµV/m]	Average [dBµV/m]	Result
9.02a	11	b-mode | 1Mbit| laying	57.80	46.62	Passed
9.02b	11	b-mode | 1Mbit| standing	57.92	47.12	Passed
9.04a	11	g-mode | 6Mbit| laying	61.84	49.13	Passed
9.04b	11	g-mode | 6Mbit| standing	63.7	52.58	Passed
9.06a	11	n-mode | HT20 | MCS0| laying	66.94	51.26	Passed
9.06b	11	n-mode | HT20 | MCS0| standing	62.4	49.77	Passed

Remark: for more informations and graphical plot see annex A1 **CETECOM_TR18_1_0097201T24a_C01_A1**

4.6.3.2 Internal Antenna

Non-restricted bands near-by

Diagram	Channel	Mode	Peak [dBc]	Average [dBc]	Result
9.11a	01	b-mode | 1Mbit| laying	44.34	44.76	Passed
9.11b	01	b-mode | 1Mbit| standing	44.42	46.51	Passed
9.13a	01	g-mode | 6Mbit| laying	35.53	39.41	Passed
9.13b	01	g-mode | 6Mbit| standing	33.60	38.04	Passed
9.15a	01	n-mode | HT20 | MCS0| laying	35.18	38.17	Passed
9.15b	01	n-mode | HT20 | MCS0| standing	36.18	38.82	Passed

Restricted bands near-by

Diagram	Channel	Mode	Peak [dBµV/m]	Average [dBµV/m]	Result
9.12a	11	b-mode | 1Mbit| laying	58.22	46.83	Passed
9.12b	11	b-mode | 1Mbit| standing	58.54	47.25	Passed
9.14a	11	g-mode | 6Mbit| laying	63.33	50.7	Passed
9.14b	11	g-mode | 6Mbit| standing	64.36	50.73	Passed
9.16a	11	n-mode | HT20 | MCS0| laying	64.18	51.09	Passed
9.16b	11	n-mode | HT20 | MCS0| standing	65	51.39	Passed

Remark: for more informations and graphical plot see annex A1 **CETECOM_TR18_1_0097201T24a_C01_A1**

4.7 Results from external laboratory

None	-

4.8 Opinions and interpretations

None	-

5 Equipment lists

ID	Description	Manufacturer	SerNo	Cal due date
	120901 - SAC - Radiated Emission <1GHz			29.09.2015
20574	Biconilog Hybrid Antenna BTA-L	Frankonia GmbH	980026L	03.05.2022
20620	EMI Test Receiver ESU26	Rohde & Schwarz Messgerätebau GmbH	100362	13.05.2021
20482	filter matrix Filter matrix SAR 1	CETECOM GmbH	-	
20885	Power Supply EA3632A	Agilent Technologies Deutschland GmbH	75305850	
20487	System CTC NSA-Verification SAR-EMI System EMI field (SAR) NSA	ETS-Lindgren Gmbh	-	23.03.2021
25038	Loop Antenna HFH2-Z2	Rohde & Schwarz Messgerätebau GmbH	879824/13	07.04.2022
	120904 - FAC1 - Radiated Emissions			
20341	Digital Multimeter Fluke 112	Fluke Deutschland GmbH	81650455	25.05.2022
20720	EMC32 [FAC]	Rohde & Schwarz Messgerätebau GmbH	V10.xx	
20489	EMI Test Receiver ESU40	Rohde & Schwarz Messgerätebau GmbH	1000-30	13.05.2021
20868	High Pass Filter AFH-07000	AtlanTecRF	16071300004	
20291	High Pass Filter WHJ 2200-4EE (GSM 850/900)	Wainwright Instruments GmbH	14	
20020	Horn Antenna 3115 (Subst 1)	EMCO Elektronik GmbH	9107-3699	19.07.2021
20302	Horn Antenna BBHA9170 (Meas 1)	Schwarzbeck Mess-Elektronik OHG	155	15.04.2023
20549	Log.Per-Antenna HL025	Rohde & Schwarz Messgerätebau GmbH	1000060	31.07.2021
20611	Power Supply E3632A	Agilent Technologies Deutschland GmbH	KR 75305854	
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	
20670	Radio Communication Tester CMU200	Rohde & Schwarz Messgerätebau GmbH	106833	16.06.2022
20690	Spectrum Analyzer FSU	Rohde & Schwarz Messgerätebau GmbH	100302/026	23.05.2021

ID	Description	Manufacturer	SerNo	Cal due date
20439	UltraLog-Antenna HL 562	Rohde & Schwarz Messgerätebau GmbH	100248	10.03.2023
20828	Netgear Nighthawk x4S	NETGEAR Ireland International Ltd	5K5188590067B	
20732	Signal- and Spectrum Analyzer FSW67	Rohde & Schwarz Messgerätebau GmbH	104023	27.05.2021
	120910 - Radio Laboratory 1 (TS 8997)			
20904	Climatic Chamber ClimeEvent C/1000/70a/5	Weiss Umwelttechnik GmbH	58226223240010	09.05.2021
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	13.05.2021
20691	Open Switch and control Platform OSP120	Rohde & Schwarz Messgerätebau GmbH	101056	13.05.2021
20687	Signal Generator SMF 100A	Rohde & Schwarz Messgerätebau GmbH	102073	07.02.2021
20559	Vector Signal Generator SMU200A	Rohde & Schwarz Messgerätebau GmbH	103736	22.05.2021
20873	WTS-80 Schirmbox	CETECOM GmbH	P3101	

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})	CISPR 16-2-1	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-Jul-23
C01	- Updated antenna gains of external and internal antenna (p. 10) - Updated conducted power values (p. 10)	2021-Sep-08

End Of Test Report