T E S T R E P O R T
No.: 18-1-0130902T05a-C1

According to:
FCC Regulations
Part 15.205
Part 15.209
Part 15.247

ISED-Regulations
RSS-Gen, Issue 5
RSS-247, Issue 2

for

Vorwerk Elektrowerke GmbH & Co. KG

Thermomix TM6-5
Household equipment with WLAN

FCC ID: 2AGELTM65
ISED: 20889-TM65

Laboratory Accreditation
ilac-MRA DAkkS Deutsche Akkreditierungsstelle D-PL-12047-01-01 D-PL-12047-01-03 D-PL-12047-01-04
accredited according to DIN EN ISO/IEC 17025
CETECOM GmbH Laboratory Radio Communications & Electromagnetic Compatibility Im Teelbruch 116 • 45219 Essen • Germany Registered in Essen, Germany, Reg. No.: HRB Essen 8984 Tel.: + 49 (0) 20 54 / 95 19-954 • Fax: + 49 (0) 20 54 / 95 19-964 E-mail: info@cetecom.com • Internet: www.cetecom.com
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Table of contents

Table of Annex			
Annex No.	**Contents**	**Reference Description**	**Total Pages**
Annex 1	Test results	**CETECOM_TR18_1_0130902T05a_A1**	75
Annex 2	External photographs of EUT	**CETECOM_TR18_1_0130902T02a_A2**	10
Annex 3	Internal photographs of EUT	For Internal photographs of EUT, see applicant's documentation	--
Annex 4	Test set-up photographs	**CETECOM_TR18_1_0130902T02a_A4**	7
The listed attachments are an integral part of this report.			

1. Summary of test results

The test results apply exclusively to the test samples as presented in this Report. The CETECOM GmbH does not assume responsibility for any conclusions and generalizations taken in conjunction with other specimens or samples of the type of the item presented to tests. 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.

The presented Equipment Under Test (in this report, hereinafter referred as EUT) integrates a Bluetooth©EDR transmitter Other implemented wireless technologies are not considered within this test report.

Following test cases have been performed to show compliance with valid Part 15.209/15.247 of the FCC CFR Title 47 Rules, Edition 2017 and ISED RSS-247 Issue 2/RSS-Gen Issue 5 standards.

1.1. Tests overview of US CFR (FCC) and Canada ISED (RSS) Standards

Test cases	Port	References and Limits			EUT set-up	EUT op. mode	Result
		FCC Standard	RSS Section	Test limit			
TX-Mode							
20 dB bandwidth	Antenna terminal (conducted)	§15.247 (a)(1)	RSS-247, Issue 2: 5.1 (a)	At least 25 kHz or 2/3 of 20 dB bandwith	2	1	Passed
Channel carrier frequency separation			RSS-247, Issue 2: 5.1 (b)		2	2	
99% occupied bandwidth	Antenna terminal (conducted)	--	RSS-Gen, Issue 5: Chapter 6.6	99% Power bandwidth	2	1	Passed
Channel use, average channel use, input band-width and synchronization between signals	--	§15.247 (a)(1)	RSS-247, Issue 2: 5.1 (d)	See specification	2	2	Passed
Channel average Occupancy time and number of channels	Antenna terminal (conducted)	§15.247 (a)(1) (iii)	RSS-247, Issue 2: 5.1 (d)	0.4 seconds	2	2	Passed
Transmitter Peak output power	Antenna terminal (conducted)	§15.247 (b)(1)	RSS-247, Issue 2: 5.1 (b)	< 125 mW	2	1	Passed
Transmitter frequency stability	Antenna terminal (conducted)	--	RSS-Gen Issue 5, Chapter 8.11	Operation within designated operational band	2	1	Passed
Transmitter Peak output power radiated	Enclosure (radiated)	§15.247 (b)(4)	RSS-247, Issue 2: 5.1 (b)	< 125 mW (EIRP) for antenna with directional gain less 6 dBi	--	--	Passed (calculated)
Out-Of-Band RF- emissions Band-Edge emissions	Antenna terminal (conducted)	§15.247 (d)	RSS-247, Issue 2, Chapter 5.5	20 dBc and Emissions in restricted bands must meet the general field strength radiated limits	1	1 + 2	Passed
General field strength emissions + restricted bands	Enclosure + Interconnecting cables (radiated)	§15.247 (d) §15.205 §15.209	RSS-247, Issue 2, Chapter 5.5 RSS-Gen: Issue 5: §8.9 Table 4+5+6	Emissions in restricted bands must meet the general field-strength radiated limits	1+3	1+3	Passed

AC-Power Lines Conducted Emissions	AC-Power lines	§15.207	RSS-Gen, Issue 5: Chapter 8.8 Table 3	FCC §15.107 class B limits §15.207 limits ISED: Table 3, Chapter 8.8	--	--	Passed

1.2. Attestation:

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

The current version of the Test Report CETECOM_TR18-1-0130902T05a-C1 replaces the Test Report CETECOM_TR18-1-0130902T05a dated 2019-03-06. The replaced test report is herewith invalid.

.....	.....
Dipl.-Ing. Niels Jeß	M.Sc. Patrick Marzotko
Responsible for test section	Responsible for test report

Digital signiert von: M.Sc. Patrick Marzotko
Name: CN = M.Sc. Patrick Marzotko email = patrick.marzotko@cetecom.com C = DE O = Cetecom GmbH OU = RC/EMC
Datum: 2019.07.16 14:14:44 + 02'00'

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. Niels Jeß

2.2. Test location

2.2.1. Test laboratory "CTC"

Company name:	see chapter 2.1. Identification of the testing laboratory

2.3. Organizational items

Responsible for test report: project leader:	M.Sc. P. Marzotko
Receipt of EUT:	2019-01-31
Date(s) of test:	2019-02-01 - 2019-07-09
Date of report:	2019-07-16

2.4. Applicant's details

Applicant's name:	Vorwerk Elektrowerke GmbH & Co. KG
Address:	Mühlenweg 17-37 42270 Wuppertal Germany
Contact person:	Mr. Michael Sickert

2.5. Manufacturer's details

Manufacturer's name:	see applicant's details
Address:	see applicant's details

3. Equipment under test (EUT)

3.1. Technical data of main EUT declared by applicant

Model Nr.	TM6-5		
Type	Household equipment with WLAN		
FCC ID	2AGELTM65		
ISED	20889-TM65		
Frequency range (US/Canada -bands)	☒ 2402 MHz (Channel 1 or 37) to 2480 MHz (Channel 39)		
Type of modulation	GFSK		
Number of channels (USA/Canada -bands)	1 - 79		
Antenna Type	☒ Integrated ☐ External, no RF- connector ☐ External, separate RF-connector		
Antenna Model	PCB Antenna		
Antenna Gain	-2.4dBi		
Peak Power (measured CH 1 conducted Ch39 conducted Ch79 conducted	 -1.7dBm -1.6dBm -2.3dBm		
EIRP Power (calculated) CH 1 radiated Ch39 radiated Ch79 radiated	 -1.7dBm – 2.4dBi = -4.1dBm -1.6dBm – 2.4dBi = -4.0dBm -2.3dBm – 2.4dBi = -4.7dBm		
Installed options	☒ 802.11 a/n/ac (not tested within this report) ☒ 802.11 b/g/n (not tested within this report) ☒ Bluetooth EDR (not tested within this report) ☒ Bluetooth LE		
Power supply	☒ 120 V AC / 60 Hz		
Special EMI components	--		
Does EUT contain devices susceptible to magnetic fields, e.g. Hall elements, electrodynamics microphones, etc.?	☐ yes ☒ no		
EUT sample type	☐ Production	☒ Pre-Production	☐ Engineering
FCC label attached	☐ yes	☒ no	

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

Short description*)	EUT	Type	S/N serial number	HW hardware status	SW software status
EUT A S02	Thermomix TM6-5 (radiated sample)	--	18434212024100415	13	0.18.109-201808300615
EUT B S03	Thermomix TM6-5 (conducted sample)	--	18434212024100545	13	0.18.109-201808300615
EUT C S23	Thermomix TM6-5 (radiated sample)	--	19094204681605368	13	0.18.109-201808300615

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

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

AE short description *)	Auxiliary Equipment	Type	S/N serial number	HW hardware status	SW software status
AE 4	USB Cable	--	--	--	--
AE 5	USB Converter	Delock	120900043	--	--
AE 6	LAN cable	--	--	--	--
AE 7	Laptop	Lenovo	Pf-OHYVAF 16/04	--	--
AE 8	Bluetooth speaker	MF8090	YFMF8090314R03013U	--	--
AE 9	WLAN router	Nighthawk(R) X4S R7800	5K5188590067B		V1.0.2.46
AE 10	Test Laptop	Dell (CTC462012)	--	--	--
AE 11	Test Laptop	Terra Mobile 1515	NKN750BU0008L02745	--	--

*) Auxiliary Equipment (AE): Type, S/N etc. and short descriptions
*) AE short description is used to simplify the identification of the auxiliary equipment in this test report.

3.4. EUT set-ups

EUT set-up no.*)	Combination of EUT and AE	Remarks
set. 1	EUT A + AE 4-7	Radiated measurement set-up
set. 2	EUT B + AE 4-7	Conducted measurement set-up
set. 3	EUT C + AE 4-6 + AE 8-11	Radiated measurement set-up for simultaneous transmissions tests

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

3.5. EUT operating modes

EUT operating mode no.*1)	Description of operating modes	Additional information
op. 1	Bluetooth BDR/EDR Modes* TX-Fixed Channel (Modulated)	With help of test tool "QSPR" the EUT was put to **Fixed Channel (Modulated) Continuous transmissions mode** with help of QDART RF test tool *Other supported wireless technologies were put in idle mode using special test software *2)
op. 2	Bluetooth BDR/EDR Modes* Normal operating mode	With help of test tool "QSPR" the EUT was put into **normal hopping mode**. *Other supported wireless technologies were put in idle mode using special test software *2)
op. 3	WLAN and Bluetooth normal operating mode	With help of software "Iperf" and a bluetooth connection to a Bluetooth device EUT was put into **normal Wifi and Bluetooth operation mode** simultaneously.

Remarks:
*1) EUT operating mode no. is used to simplify the test report.
*2) Please refer to document "Vorwerk-UGCZ1-RF Test Tool Manual_Ver2.0_20180625"

3.6.1 Test tool information

Software name: QSPR (part of QDART tools)
Software version: 5.0-00071
Software date: Jun 13 2016 (16:26)

The following settings have been done under QSPR for Bluetooth tests:
- The power level is always 7 dBm

4. Description of test system set-up's

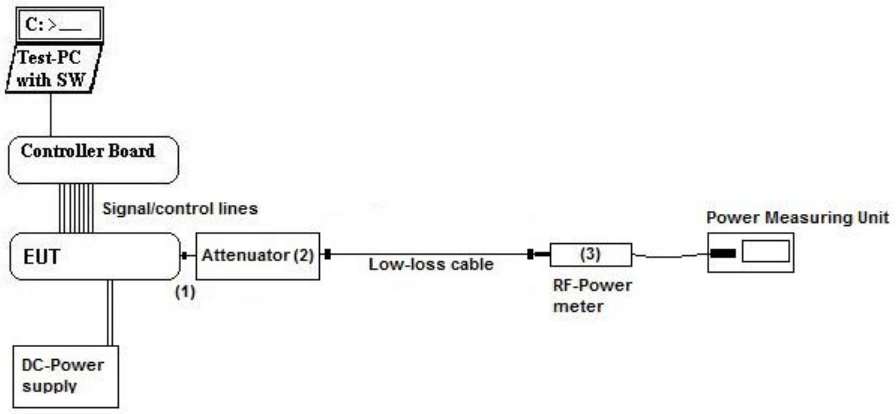
4.1. Test system set-up for conducted measurements on antenna port

Conducted RF-Setup 1 (BT1 Set-up)

General description:

The EUT's RF-signal is coupled out by a suitable antenna coupling connector (1). The signal is first attenuated (2) then connected to the power meter (3) for conducted power 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: ANSI C63.10:2013, KDB 558074 D01 DTS Meas.Guidance v05r02

Used Equipment

Passive Elements	Test Equipment	Remark:
☒ 20 dB Attenuator	☒ Power Meter	See List of equipment under each test case and chapter 8 for calibration info
☒ Low loss RF-cables	☒ DC-Power Supply	
☒	☒ Spectrum-Analyser	

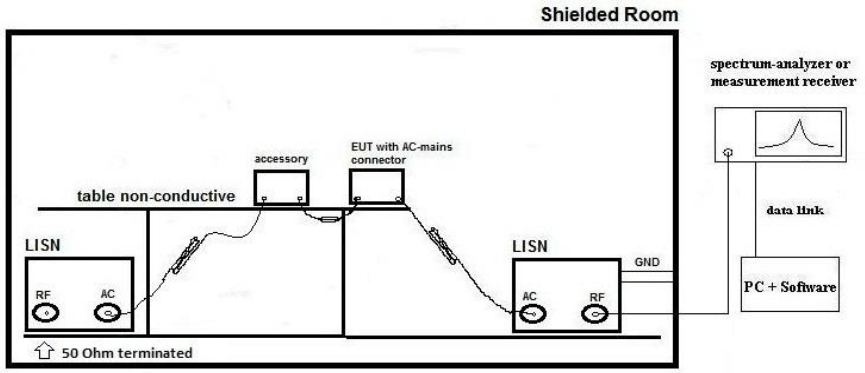
Measurement uncertainty See chapter 8

4.2. Test system set-up for AC power-line conducted emission measurements

Specification: ANSI C63.4-2009 chapter 7, ANSI C63.10-2013 chapter 6.2

General Description: 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 a 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:



Only schematic view, we refer to figure 6, 7 and 8 of ANSI C63.4-2009 for more details.

Testing method: **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 testing 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

Values are in dB, positive margin means value is below limit.

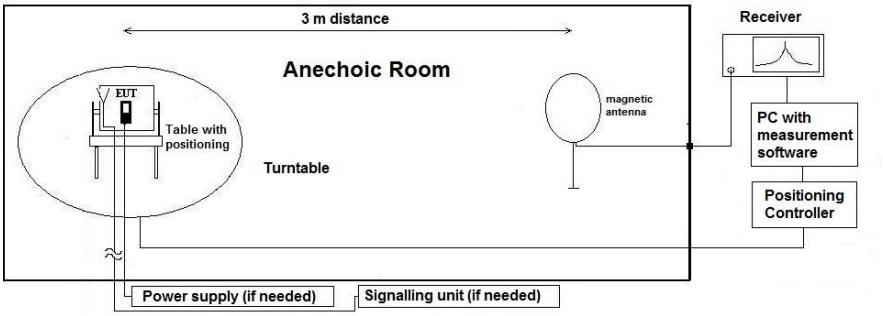
4.3. Test system set-up for radiated magnetic field measurements below 30 MHz

Specification: ANSI C63.10-2013 chapter 6.4 (§6.4.4.2)

General Description: 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:

Exploratory, preliminary measurement
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
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.

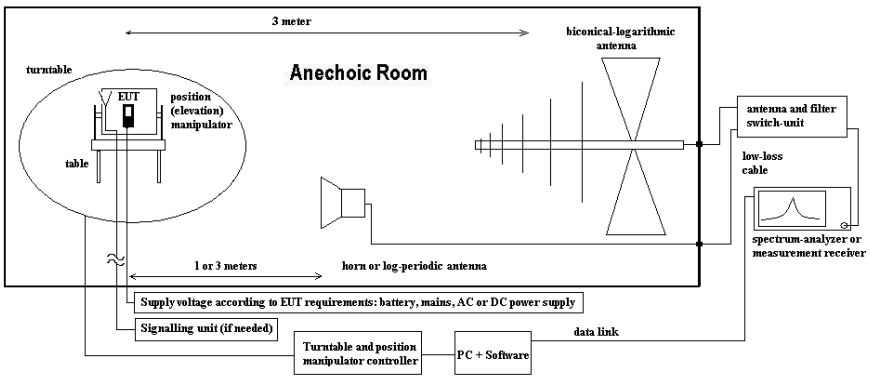
Distance correction: Reference for applied correction (extrapolating) factors due to reduced measurement distance:
ANSI C63.10:2013, §6.4.4.2 - Equations (2) + (3) + (4)

4.4. Test system set-up for radiated electric field measurement 30 MHz to 1 GHz

Specification: ANSI C63.4-2014 chapter 8.2.3, ANSI C63.10-2013 chapter 6.5

General Description: Evaluating the field 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 NSA-compliant semi anechoic room (SAR) recognized by the regulatory commissions.

Schematic:



Testing method:

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

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

Final measurement on critical frequencies
Based on the exploratory measurements, the most critical frequencies are re-measured by maintaining the EUT's worst-case operation mode, cable position, etc. either on 10m OATS or 3m semi-anechoic room.

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

Following parameters were varied: the turntable angle continuously in the range 0 to 360 degree, the EUT itself either over 3-orthogonal axis (not defined usage position) or 2-orthogonal axis (defined usage position). The measurement antenna height between 1 m and 4 m.

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

Formula:

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

$M = L_T - E_C$ (2)

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

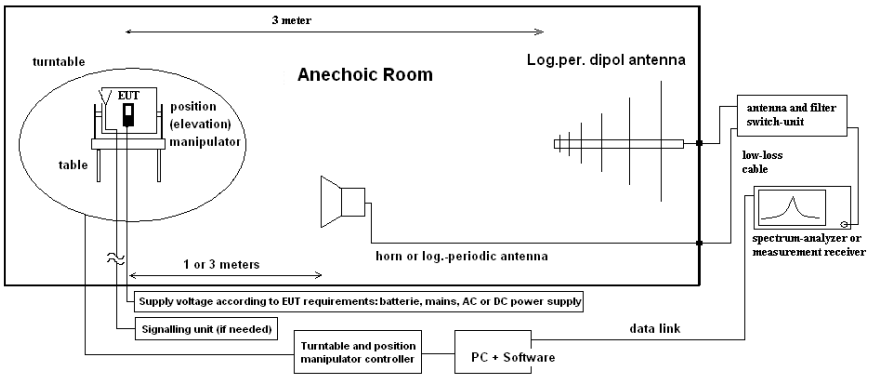
All units are dB-units, positive margin means value is below limit.

4.5. Test system set-up for radiated electric field measurement above 1 GHz

Specification: ANSI C63.4-2014 chapter 8.3, ANSI C63.10-2013 chapter 6.6.3.3 & 6.6.4

General Description: 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:

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.

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

E_C = Electrical field – corrected value
E_R = Receiver reading
M = Margin
L_T = Limit
AF = 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.

5. Measurement results

5.1. General Limit - Conducted emissions on AC-Power lines

5.1.1. Test location and equipment

test location	☒ CETECOM Essen (Chapter 2.2.1)		☐ Please see Chapter 2.2.2		☐ Please see Chapter 2.2.3	
test site	☐ 333 EMI field	☒ 348 EMI cond.				
receiver	☐ 001 ESS	☒ 377 ESCS 30	☐ 489 ESU 40	☐ 620 ESU 26		
LISN	☒ 005 ESH2-Z5	☐ 007 ESH3-Z6	☐ 300 ESH3-Z5 & 50Ω used for AE		☐ no LISN for AE	
signaling	☐ 392 MT8820A	☐ 436 CMU	☐ 547 CMU	☐ 594 CMW		
line voltage	☒ 120 V/AC			☒ 060 120 V 60 Hz via PAS 5000 (for AE 4)		

5.1.2. Requirements

FCC		☒ Part 15 Subpart B, §15.107 (a) Class B ☐ Part 15 Subpart C, §15.207	
ISED		☒ RSS-Gen, Issue 5 Chapter 8.8, Table 4 ☒ ICES-003, Issue 6 Section 6.1 Class B Table 2	
ANSI		☒ C63.4-2014 ☐ C63.10-2009	
Limit	Frequency [MHz]	☒ Conducted limit Class B	
		QUASI-Peak [dBµV]	AVERAGE [dBµV]
	0.15 – 0.5	66 to 56*	56 to 46*
	0.5 – 5	56	46
	5 – 30	60	50
Remark: * decreases with the logarithm of the frequency			

5.1.3. Test condition and test set-up

Signal link to test system (if used):		☒ air link	☐ cable connection	☐ none
EUT-grounding		☐ none	☒ with power supply	☐ additional connection
Equipment set up		☒ table top (40 cm distance to reference ground plane (wall)		☐ floor standing EUT stands isolated on reference ground plane (floor)
Climatic conditions		Temperature: (22±3°C)		Rel. humidity: (40±20)%
EMI-Receiver or Analyzer settings	Scan data	☐ 9 – 150 kHz, RBW = 200 Hz, Step = 61 Hz ☒ 150 kHz – 30 MHz RBW = 9 kHz, Step = 4 kHz ☐ other:		
	Scan-Mode Pre-measurement Final measurement	6 dB EMI-Receiver Mode Peak detector, Repetitive-Scan, max-hold, sweep-time 50 µs per frequency point Average & Quasi-peak detector at critical frequencies		
General measurement procedures		Please see chapter "Test system set-up for AC power line conducted emissions measurements"		

5.1.4. AC-Power Lines Conducted Emissions Results

Set-up no.: 2			**EUT OP-mode no.: 1**	
Diagram-No.	Used Detector	Power line	Mode Details	Result
1.01	☒ Peak (pre-scan) ☐ CAV (final) ☒ QP (final)	L1/ N	BT TX Ch0	**Pass**
Remark 1: For further details please refer → Annex 1: Test results **CETECOM_TR18-1-0130902T05a-A1**				

5.2. RF-Parameter Duty-Cycle

5.2.1. Test location and equipment

(for reference numbers please see chapter 'List of test equipment')

Ambient Climatic conditions			Temperature: (22±2)°C	Rel. humidity: (45±15)%		
test site	☐ 441 EMI SAR	☐ 348 EMI cond.	☐ 443 EMI FAR	☐ 347 Radio.lab.	☐ 337 OATS	☒ TS 8997
equipment	☐ 331 HC 4055	☐	☐	☐	☐	☐
spectr. analys.	☐ 683 FSU26	☐ 120 FSEM	☐ 264 FSEK	☐	☐	☐
power meter	☐ 262 NRV-S	☐ 266 NRV-Z31	☐ 265 NRV-Z33	☐ 261 NRV-Z55	☐ 356 NRV-Z1	☐
multimeter	☐ 341 Fluke 112	☐	☐	☐	☐	☐
DC power	☐ 086 LNG50-10	☐ 087 EA3013	☐ 354 NGPE 40	☐ 349 car battery	☐ 350 Car battery	☐ 463 HP3245A
Supply Voltage	☒ 016 Line Impedance Simulating Network: 120V AC 60Hz				☐ 13.5V DC	
otherwise	☐ 530 Attenuator 10dB		☒ K4 Cable		☐	☐

5.2.2. Reference

ANSI	☒ ANSI 63.10:2013

5.2.3. 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.

5.2.4. Measurement method:

Method of measurement: ☒ conducted
☐ radiated

Calculated with following formulas:

Duty cycle:	$x = \frac{Tx_{on}}{Tx_{on} + Tx_{off}}$	Duty cycle factor [dB]:	$10\log\left(\frac{1}{x}\right)$

☒ 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%

5.2.5. RESULTS

Modulation	DUT Frequency (MHz)	DutyCycle (%)	DutyCycle (dB)
DH5	2402	77,191	1,124
	2440	77,195	1,124
	2480	77,209	1,123
2DH3	2402	65,930	1,809
	2440	65,936	1,809
	2480	65,947	1,808
3DH3	2402	65,870	1,813
	2440	65,876	1,183
	2480	65,885	1,182

5.3. RF-Parameter Maximum peak conducted output power

5.3.1. Test location and equipment (for reference numbers please see chapter 'List of test equipment')

test location	☒ CETECOM Essen (Chapter. 2.2.1)		☐ 443 System CTC-FAR-EMI-		☐ Please see Chapter. 2.2.3	
test site	☐ 441 EMI SAR	☐ 487 SAR NSA	☐ 347 Radio.lab.	☒ TS 8997	☐	☐
receiver	☐ 377 ESCS30	☐ 001 ESS	☐ 489 ESU 40	☐	☐	☐
spectr. analys.	☐ 584 FSU	☐ 120 FSEM	☐ 264 FSEK	☐ 489 ESU 40	☐	☐
antenna	☐ 574 BTA-L	☐ 133 EMCO3115	☐ 302 BBHA9170	☐ 289 CBL 6141	☐ 030 HFH-Z2	☐ 477 GPS
signaling	☐ 392 MT8820A	☐ 436 CMU	☐ 547 CMU			
otherwise	☐ 266 NRV-Z31	☐ 600 NRVD	☐ 110 USB LWL	☐ 482 Filter Matrix	☐ 378 RadiSense	☒ 693 TS8997
DC power	☐ 671 EA-3013S	☐ 463 HP3245A	☐ 459 EA 2032-50	☐ 268 EA- 3050	☐ 494 AG6632A	☐ 498 NGPE 40
otherwise	☐ 331 HC 4055	☐ 248 6 dB Attenuator	☐ 529 Power divider	☐ - cable OTA20		
	☒ 530 10dB Attenuator		☐ K 4 Cable kit			
Supply Voltage	☒ 016 Line Impedance Simulating Network: 120V AC 60Hz			☐ 13.5V DC		

5.3.2. Reference

FCC	☒ §15.247(b) (3) + KDB 558074 D01 DTS Meas Guidance v05r01
ISED	☒ RSS-247, Chapter 5.4(4)
ANSI	☒ ANSI 63.10:2013
Specification	*For systems using digital modulation in the 902-928 MHz, 2400-2483.5 MHz, and 5725-5850 MHz bands: 1 Watt. As an alternative to a peak power measurement, compliance with the one Watt limit can be based on a measurement of the maximum conducted output power. Maximum Conducted Output Power is defined as the total transmit power delivered to all antennas and antenna elements averaged across all symbols in the signaling alphabet when the transmitter is operating at its maximum power control level. Power must be summed across all antennas and antenna elements. The average must not include any time intervals during which the transmitter is off or is transmitting at a reduced power level. If multiple modes of operation are possible (e.g., alternative modulation methods), the maximum conducted output power is the highest total transmit power occurring in any mode.*

5.3.3. 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.

5.3.4. Test condition and measurement test set-up

Signal ink to test system (if used):	☐ air link	☐ cable connection	☒ none
EUT-grounding	☒ none	☐ with power supply	☐ additional connection
Equipment set up	☒ table top 1.5m height		☐ floor standing
Climatic conditions	Temperature: (22±3°C)		Rel. humidity: (40±20)%
General measurement procedures	Please see chapter “Test system set-up for conducted RF-measurement at antenna Port” (W1 Set-up)		

5.3.5. Measurement method and analyzer settings:

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

MEASUREMENT METHOD/ SPECTRUM-ANALYZER SETTINGS:

Measurement Method 1.)	§15.247(b) (3) Maximum Peak	1.) ☒ 7.8.5 ANSI63:10:2013, Maximum peak conducted output power (RBW > 20dB-bandwidth of the signal) 2.) ☐ 9.1.3. PKPM1 Peak reading power meter (broadband PK meter)
	§15.247(b) (3) Maximum Average	3.) ☐ AVGSA-1 / AVGSA-1 alternative (duty-cycle > 98%) 4.) ☐ AVGSA-2 / AVGSA-2 alternative (duty-cycle < 98%, constant) 5.) ☐ AVGSA-3 / AVGSA-3 alternative (duty-cycle < 98%, not constant) 6.) ☐ AVPM(duty-cycle < 98% (constant) 7.) ☐ AVPM-G (duty-cycle < 98% (constant)
	MIMO	8.) ☐ Summarization of values from two antenna ports
Center Frequency		Nominal channel frequency
Span		30% higher than the EBW measured before
Resolution Bandwidth (RBW)		2MHz
Video Bandwidth (VBW)		10MHz
Sweep time		coupled
Detector		Peak, Max hold mode for method PK1/PK2 or RMS and trace average for method AVG1/AVG2
Sweep Mode		Repetitive mode, allow trace to stabilize
Analyzer-Mode		☒ normal ☐ activated channel integration method with limits set to the EBW of the signal

Remark 1: guidance 558074 D01 measurement DTS guidance v05r01 or ANSI 63.10:2013

5.3.6. RESULTS

APLICANT'S DECLARED ANTENNA CHARACTERISTICS:

☒ Directional Gain < 6 dBi (measured: difference between measured conducted and radiated eirp. power)
☐ Directional Gain > 6 dBi (measured / applicant's declaration) -> conducted power reduction necessary

The antenna gain was measured at 3 different frequencies.
-2.41dBi

Different modulation types and data rates were tested in order to find the maximum conducted output power. **Enclosed are only the maximum values for each modulation format**, pls. compare separate document A1 for all results.

Modulation	DUT Frequency (MHz)	Peak Power (dbm)	Antenna Gain (dBi)	EIRP (dBm)
DH5	2402	**-1,30**	-2,41	-3,71
	2441	**-1,10**	-2,41	-3,51
	2480	**-1,80**	-2,41	-4,21
2DH3	2402	**0,03**	-2,41	-2,36
	2441	**-0,05**	-2,41	-2,46
	2480	**-0,98**	-2,41	-3,39
3DH3	2402	**0,45**	-2,41	-1,94
	2441	**0,30**	-2,41	-2,09
	2480	**-0,56**	-2,41	-2,97

Remark: External Path Loss -> set as correction factor in spectrum-analyzer.

5.3.7. Conducted Peak Output Power Verdict: Pass

5.4. RF-Parameter – Frequency Stability

5.4.1.Test location and equipment (for reference numbers please see chapter 'List of test equipment')

test location	☒ CETECOM Essen (Chapter. 2.2.1)		☐ 443 System CTC-FAR-EMI-		☐ Please see Chapter. 2.2.3	
test site	☐ 441 EMI SAR	☐ 487 SAR NSA	☐ 337 OATS	☒ 347 Radio.lab.	☐	☐
receiver	☐ 377 ESCS30	☐ 001 ESS	☒ 489 ESU 40	☐ 620 ESU 26	☐	☐
otherwise	☐ 600 NRVD	☐ 357 NRV-Z1	☐ 693 TS8997			
spectr. analys.	☐ 683 FSU	☐ 120 FSEM	☐ 264 FSEK	☐ 714 FSW 67	☐	☐
power supply	☐ 456 EA 3013A	☐ 457 EA 3013A	☐ 459 EA 2032-50	☐ 268 EA- 3050	☐ 494 AG6632A	☐ 354 NGPE 40
otherwise	☒ 613 20 dB Attenuator	☐ 248 6 dB Attenuator	☐ 529 Power divider	☐ - cable OTA20	☐ 530 10dB Atten	☐ K5 Cable
Supply Voltage	☒ 016 Line Impedance Simulating Network: 120V AC 60Hz			☐ 13.5V DC		

5.4.2. Requirements:

ISED	☒ RSS-Gen, Issue5 , Chapter 6.11
Remark	Frequency stability is a measure of frequency drift due to temperature and supply voltage variations, with reference to the frequency measured at an appropriate reference temperature and the rated supply voltage.

5.4.3. EUT settings

For FHSS-systems hopping mode was switched-off so fixed two different channels could be measured.
The EUT was instructed to send with maximum power (if adjustable) according applicants instructions.

5.4.4. Measurement method

1. The First Measurement was done at Normal Temperature +20°C and ±15% of the supply voltage.
2. The Second Measurement was done at 3 different Temperatures -20°C (-4°F), +20°C (+68°F) and +50°C (+122°F), and the nominal supply Voltage

3. Also the 99% emission bandwidth was measured. Two markers are placed on frequency points such that left to lower f-marker and right to higher f-marker only 1% of the TX-power is contained. Between the markers, 99% of the power is laying.

5.4.5. Spectrum-Analyzer Settings

Span	Set as to fully display the emissions and approximate 20dB below the PEAK level
Resolution Bandwidth (RBW)	Set to approx. 1% …3% of the emission width
Video Bandwidth (VBW)	3 times the resolution bandwidth
Sweep time	Coupled and low enough to have no gaps within power envelope
Detector	Sample (if bin width: Span/no. of frequency points SA < 0.5*RBW SA otherwise Peak detector)
Sweep mode	Repetitive Mode, Max hold

5.4.6. Tmin – Vnom

Modulation	Channel	99% OBW	Tnom - Vnom		Vnom -Tnom	
			left Bandedge	right Bandedge	left Bandedge	right Bandedge
	MHZ	in MHZ	in HZ	in HZ	in HZ	in HZ
DH5	2402	1,012987	2401545455	2402493506	2401532468	2402532468
	2440	1,000000	2439545455	2440493506	2439532468	2440584416
	2480	1,065000	2479545455	2480493506	2479532468	2480558442
verdict					Pass	
2-DH3	2402	1,234000	2401376623	2402610390	2401415584	2402649351
	2440	1,207793	2439402597	2440610390	2439402597	2440649351
	2480	1,233767	2479389610	2480623377	2479428571	2480649351
verdict					Pass	
3-DH3	2402	1,233767	2401389610	2402623377	2401415584	2402649351
	2440	1,233767	2439389610	2440623377	2439428571	2440662338
	2480	1,246754	2479389610	2480636364	2479428571	2480662338
verdict					Pass	

5.4.7. Tmax – Vnom

Modulation	Channel	99% OBW	Tnom - Vnom		Tmax - Vnom	
			left Bandedge	right Bandedge	left Bandedge	right Bandedge
		in MHZ	in HZ	in HZ	in HZ	in HZ
DH5	2402	1,012987	2401545455	2402493506	2401493506	2402571429
	2440	1,000000	2439545455	2440493506	2439480519	2440493506
	2480	1,065000	2479545455	2480493506	2479454545	2480545455
verdict					Pass	
2-DH3	2402	1,234000	2401376623	2402610390	2401376623	2402636364
	2440	1,207793	2439402597	2440610390	2439376623	2440597403
	2480	1,233767	2479389610	2480623377	2479363636	2480597403
verdict					Pass	
3-DH3	2402	1,233767	2401389610	2402623377	2401376623	2402649351
	2440	1,233767	2439389610	2440623377	2439376623	2440610390
	2480	1,246754	2479389610	2480636364	2479376623	2480623377
verdict					Pass	

5.4.8. Tnom – Vmin

Modulation	Channel	99% OBW	Tnom - Vnom		Tnom - Vmin	
			left Bandedge	right Bandedge	left Bandedge	right Bandedge
		in MHZ	in HZ	in HZ		
DH5	2402	1,012987	2401504950	2402475248	2401519481	2402519481
	2440	1,000000	2440504950	2441455446	2439519481	2440532468
	2480	1,065000	2479504950	2480475280	2479519481	2480571429
verdict					Pass	
2-DH3	2402	1,234000	2401326733	2402534653	2401389610	2402623377
	2440	1,207793	2440326733	2441534653	2439402597	2440623377
	2480	1,233767	2479326733	2480534653	2479324675	2480649351
verdict					Pass	
3-DH3	2402	1,233767	2401326733	2402554455	2401350649	2402649351
	2440	1,233767	2440326733	2441554455	2439363636	2440636364
	2480	1,246754	2479326733	2480554455	2479376623	2480636364
verdict					Pass	

5.4.9. Tnom – Vmax

Modulation	Channel	99% OBW	Tnom - Vnom		Tnom - Vmax	
			left Bandedge	right Bandedge	left Bandedge	right Bandedge
		in MHZ	in HZ	in HZ		
DH5	2402	1,012987	2401504950	2402475248	2401506494	2402519481
	2440	1,000000	2440504950	2441455446	2439506494	2440558442
	2480	1,065000	2479504950	2480475280	2479519481	2480519481
verdict					Pass	
2-DH5	2402	1,234000	2401326733	2402534653	2401402597	2402623377
	2440	1,207793	2440326733	2441534653	2439402597	2440623377
	2480	1,233767	2479326733	2480534653	2479389610	2480636364
verdict					Pass	
3-DH5	2402	1,233767	2401326733	2402554455	2401389610	2402623377
	2440	1,233767	2440326733	2441554455	2439402597	2440623377
	2480	1,246754	2479326733	2480554455	2479389610	2480636364
verdict					Pass	

5.4.10. Frequency Stability Verdict: pass

5.5. RF-Parameter – 99% Occupied Bandwidth

5.5.1.Test location and equipment (for reference numbers please see chapter 'List of test equipment')

test location	☒ CETECOM Essen (Chapter. 2.2.1)		☐ 443 System CTC-FAR-EMI-		☐ Please see Chapter. 2.2.3	
test site	☐ 441 EMI SAR	☐ 487 SAR NSA	☐ 337 OATS	☒ 347 Radio.lab.	☐	☐
receiver	☐ 377 ESCS30	☐ 001 ESS	☐ 489 ESU 40	☐ 620 ESU 26	☐	☐
otherwise	☐ 600 NRVD	☐ 357 NRV-Z1	☒ 693 TS8997			
spectr. analys.	☒ 683 FSU	☐ 120 FSEM	☐ 264 FSEK	☐ 714 FSW 67	☐	☐
power supply	☐ 456 EA 3013A	☐ 457 EA 3013A	☐ 459 EA 2032-50	☐ 268 EA- 3050	☐ 494 AG6632A	☐ 354 NGPE 40
otherwise	☒ 613 20 dB Attenuator	☐ 248 6 dB Attenuator	☐ 529 Power divider	☐ - cable OTA20	☐ 530 10dB Atten	☐ K5 Cable
Supply Voltage	☒ 016 Line Impedance Simulating Network: 120V AC 60Hz		☐ 13.5V DC			

5.5.2. Requirements:

FCC	☒ 2.1049(h) ☒ FCC 2.202 for information
ISED	☒ RSS-Gen, Issue5 , Chapter 6.7
Remark	The occupied bandwidth, that is the frequency bandwidth such that, below its lower and above its upper frequency limits, the mean powers radiated are each equal to 0.5 percent of the total mean power radiated by a given emission When the occupied bandwidth limit is not stated in the applicable RSS or reference measurement method, the transmitted signal bandwidth shall be reported as the 99% emission bandwidth, as calculated or measured.

5.5.3. EUT settings

For FHSS-systems hopping mode was switched-off so fixed three different channels could be measured.
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.

5.5.4. Measurement method

The measurement was performed with the RBW set to 30kHz. The span was set to cover the complete carrier. Three carrier frequencies (low/middle/high) were used for showing the compliance with this requirement. A 99% OBW measurement function was used to measure the bandwidth compared 99% of the highest In-Band power. The operating modes have been varied (e.g. data rate, modulation scheme, etc.). The hopping-mode is switched off.

5.5.5. Spectrum-Analyzer Settings

Span	Set as to fully display the emissions and approximate 20dB below the PEAK level
Resolution Bandwidth (RBW)	Set to approx. 1% …3% of the emission width
Video Bandwidth (VBW)	3 times the resolution bandwidth
Sweep time	Coupled and low enough to have no gaps within power envelope
Detector	Sample (if bin width: Span/no. of frequency points SA < 0.5*RBW SA otherwise Peak detector)
Sweep mode	Repetitive Mode, Max hold

5.5.6. 99% Occupied Bandwidth Results:

99% Occupied Bandwidth Measurements			
Temperature: +21 °C	**Voltage Supply 120 V AC / 60 Hz**	**Setup: 2**	**Op. Mode: 1**
Frequency Hopping OFF			

Data Rate	Frequency [MHz]	99% Occupied Bandwidth Measurements [MHz]	Plot No.
DH5	2402	**1.012987**	Remark 1
	2440	1.000000	
	2480	1.064935	
2DH3	2402	**1.233767**	
	2440	1.207793	
	2480	1.233767	
3DH3	2402	1.233767	
	2440	1.233767	
	2480	**1.246754**	

Remark 1: For further details please refer → Annex 1: Test results - **CETECOM_TR18-1-0130902T05a_A1**

5.5.7. 99% Occupied Bandwidth Verdict: For Information only

5.6. RF-Parameter - 20 dB Bandwidth

5.6.1.Test location and equipment (for reference numbers please see chapter 'List of test equipment')

test location	☒ CETECOM Essen (Chapter. 2.2.1)		☐ 443 System CTC-FAR-EMI-		☐ Please see Chapter. 2.2.3	
test site	☐ 441 EMI SAR	☐ 487 SAR NSA	☐ 337 OATS	☒ 347 Radio.lab.	☐	☐
receiver	☐ 377 ESCS30	☐ 001 ESS	☐ 489 ESU 40	☐ 620 ESU 26	☐	☐
otherwise	☐ 600 NRVD	☐ 357 NRV-Z1	☐ 693 TS8997			
spectr. analys.	☒ 683 FSU	☐ 120 FSEM	☐ 264 FSEK	☐ 714 FSW 67	☐	☐
power supply	☐ 456 EA 3013A	☐ 457 EA 3013A	☐ 459 EA 2032-50	☐ 268 EA- 3050	☐ 494 AG6632A	☐ 354 NGPE 40
otherwise	☒ 613 20 dB Attenuator	☐ 248 6 dB Attenuator	☐ 529 Power divider	☐ - cable OTA20	☐ 530 10dB Atten	☐ K5 Cable
Supply Voltage	☒ 016 Line Impedance Simulating Network: 120V AC 60Hz			☐ 13.5V DC		

5.6.2. Requirements:

FCC	☒ §15.247 (a) (1)
ISED	☒ RSS-247, Issue 2, Chapter 5.1,a
Remark	The bandwidth of a frequency hopping channel is the 20 dB emission bandwidth, measured with the hopping stopped.

5.6.3. EUT settings

For FHSS-systems hopping mode was switched-off so fixed three different channels could be measured.
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.

5.6.4. Measurement method

The measurement was performed with the RBW set to 3kHz. The span was set to cover the complete carrier. Three carrier frequencies (low/middle/high) were used for showing the compliance with this requirement. A DELTA Marker method was set to measure the bandwidth compared to the highest In-Band power. The operating modes have been varied (e.g. data rate, modulation scheme, etc.). The hopping-mode is switched off.

5.6.5. Spectrum-Analyzer Settings

Span	Set as to fully display the emissions and approximate 20dB below the PEAK level
Resolution Bandwidth (RBW)	Set to approx. 1% …3% of the emission width
Video Bandwidth (VBW)	3 times the resolution bandwidth
Sweep time	Coupled and low enough to have no gaps within power envelope
Detector	Sample (if bin width: Span/no. of frequency points SA < 0.5*RBW SA otherwise Peak detector)
Sweep mode	Repetitive Mode, Max hold

5.6.6. 20 dB Bandwidth Results:

20 dB Emission Bandwidth Measurements			
Temperature :+21 °C	**Voltage Supply 120 V AC / 60 Hz**	**Setup: 2**	**Op. Mode: 1**
Frequency Hopping OFF			

Channel	Frequency	20 dB Emission Bandwidth Measurements	Plot No.
[Number]	[MHz]	[MHz]	
DH5	2402	1.155845	Remark 1
DH5	2441	1.402598	
DH5	2480	1.363637	
2DH3	2402	1.415585	
2DH3	2441	1.402598	
2DH3	2480	1.493507	
3DH3	2402	1.370000	
3DH3	2441	1.415585	
3DH3	2480	1.467533	

Remark 1: For further details please refer → Annex 1: Test results - **CETECOM_TR18-1-0130902T05a_A1**

5.6.7. 20 dB Bandwidth Verdict: Pass

5.7. RF-Parameter - Channel Carrier Frequency Separation for FHSS-systems

5.7.1.Test location and equipment (for reference numbers please see chapter 'List of test equipment')

test location	☒ CETECOM Essen (Chapter. 2.2.1)		☐ 443 System CTC-FAR-EMI-		☐ Please see Chapter. 2.2.3	
test site	☐ 441 EMI SAR	☐ 487 SAR NSA	☐ 337 OATS	☒ 347 Radio.lab.	☐	☐
receiver	☐ 377 ESCS30	☐ 001 ESS	☐ 489 ESU 40	☐ 620 ESU 26	☐	☐
otherwise	☐ 600 NRVD	☐ 357 NRV-Z1	☒ 693 TS8997			
spectr. analys.	☒ 683 FSU	☐ 120 FSEM	☐ 264 FSEK	☒ 714 FSW 67	☐	☐
power supply	☐ 456 EA 3013A	☐ 457 EA 3013A	☐ 459 EA 2032-50	☐ 268 EA- 3050	☐ 494 AG6632A	☐ 354 NGPE 40
otherwise	☐ 613 20 dB Attenuator	☐ 248 6 dB Attenuator	☐ 529 Power divider	☐ - cable OTA20	☐ 530 10dB Atten	☐ K5 Cable
Supply Voltage	☒ 016 Line Impedance Simulating Network: 120V AC 60Hz			☐ 13.5V DC		

5.7.2. Requirements:

FCC	☒ §15.247 (a) (1)
ISED	☒ RSS-247, Issue 2, Chapter 5.1,b
Remark	Frequency hopping systems shall have hopping channel carrier frequencies separated by a minimum of 25 kHz or the 20 dB bandwidth of the hopping channel, whichever is greater. Alternatively, frequency hopping systems operating in the 2400-2483.5 MHz band may have hopping channel carrier frequencies that are separated by 25 kHz or two-thirds of the 20 dB bandwidth of the hopping channel, whichever is greater, provided the systems operate with an output power no greater than 125 mW. The system shall hop to channel frequencies that are selected at the system hopping rate from a pseudo randomly ordered list of hopping frequencies. Each frequency must be used equally on the average by each transmitter. The system receivers shall have input bandwidths that match the hopping channel bandwidths of their corresponding transmitters and shall shift frequencies in synchronization with the transmitted signals..

5.7.3. EUT settings

For FHSS-systems hopping mode was switched-on so that adjacent Frequency Hopping channels could be measured. 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.

5.7.4. Measurement method

The measurement to prove this requirement was performed with a low RBW of 100kHz, peak detector and trace Hold-Max function in order to resolve each frequency carrier separately.

The span of the frequency analyzer was set to cover the carrier investigated as well as its neighbour channels. A frequency DELTA Marker method was set to measure the frequency separation between the channels.

5.7.5. Channel Carrier Frequency Separation Results:

Channel Carrier Frequency Separation Measurements			
Temperature :+21 °C	**Voltage Supply 120 V AC / 60 Hz**	**Setup: 2**	**Op. Mode: 2**
Frequency Hopping ON			

Neighboring Channels	**Carrier Frequency Separation**	**Minimum CFS**	**Plot No.**
[Number]	**[MHz]**	**[kHz]**	Remark 1
Low channel	0.993	**25**	
Mid Channel	1.013	**25**	
High Channel	0.993	**25**	
Hopping Channel Carrier Frequencies Separation Limits- FCC 15.247		**25 kHz**	
Hopping Channel Carrier Frequencies Separation Limits - RSS-247, Issue 2			
Remark 1: For further details please refer → Annex 1: Test results - **CETECOM_TR18-1-0130902T05a_A1**			

5.7.6. Hopping Channel Carrier Frequencies Separation Verdict: Pass

5.8. RF-Parameter – Number of Hopping Channels for FHSS-systems

5.8.1.Test location and equipment (for reference numbers please see chapter 'List of test equipment')

test location	☒ CETECOM Essen (Chapter. 2.2.1)		☐ 443 System CTC-FAR-EMI-		☐ Please see Chapter. 2.2.3	
test site	☐ 441 EMI SAR	☐ 487 SAR NSA	☐ 337 OATS	☒ 347 Radio.lab.	☐	☐
receiver	☐ 377 ESCS30	☐ 001 ESS	☐ 489 ESU 40	☐ 620 ESU 26	☐	☐
otherwise	☐ 600 NRVD	☐ 357 NRV-Z1	☒ 693 TS8997			
spectr. analys.	☒ 683 FSU	☐ 120 FSEM	☐ 264 FSEK	☒ 714 FSW 67	☐	☐
power supply	☐ 456 EA 3013A	☐ 457 EA 3013A	☐ 459 EA 2032-50	☐ 268 EA- 3050	☐ 494 AG6632A	☐ 354 NGPE 40
otherwise	☐ 613 20 dB Attenuator	☐ 248 6 dB Attenuator	☐ 529 Power divider	☐ - cable OTA20	☐ 530 10dB Atten	☐ K5 Cable
Supply Voltage	☒ 016 Line Impedance Simulating Network: 120V AC 60Hz			☐ 13.5V DC		

5.8.2. Requirements:

FCC	☒ §15.247 (a) (1) (iii)
ISED	☒ RSS-247, Issue 2, Chapter 5.1,d
Remark	Frequency hopping systems in the 2400-2483.5 MHz band shall use at least 15 channels. Transmissions on particular hopping frequencies may be avoided or suppressed provided that at least 15 hopping channels are used.

5.8.3. EUT settings

For FHSS-systems hopping mode was switched-on so that adjacent Frequency Hopping channels could be measured. 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.

5.8.4. Measurement method

The measurement to prove this requirement was performed with a low RBW of 100kHz, peak detector and trace Hold-Max function in order to resolve each frequency carrier separately.

The span of the frequency analyzer was set to cover the Hopping channels in two parts namely 2.4 GHz Lower spectrum and 2.4 GHz Upper spectrum. On extreme right & left channels Markers were set to indicate the corresponding channel frequency.

5.8.5. Number of Hopping Channels Results:

Number of Hopping Channels Measurements			
Temperature :+21 °C	**13.5 VDC**	**Setup: 2**	**Op. Mode: 2**
Frequency Hopping ON		**Total Channels** **2.4 GHz Spectrum**	**Plot No.**
		[Number]	Remark 1
		79	
Minimum Number of Hopping Channels Limits- FCC 15.247		**15**	
Minimum Number of Hopping Channels Limits - RSS-247, Issue 2			
Remark 1: For further details please refer → Annex 1: Test results - **CETECOM_TR18-1-0130902T05a_A1**			

5.8.6. Minimum Number of Hopping Channels Verdict: Pass

5.9. RF-Parameter – Average Time of Occupancy for FHSS systems

5.9.1.Test location and equipment (for reference numbers please see chapter 'List of test equipment')

test location	☒ CETECOM Essen (Chapter. 2.2.1)		☐ 443 System CTC-FAR-EMI-		☐ Please see Chapter. 2.2.3	
test site	☐ 441 EMI SAR	☐ 487 SAR NSA	☐ 337 OATS	☒ 347 Radio.lab.	☐	☐
receiver	☐ 377 ESCS30	☐ 001 ESS	☐ 489 ESU 40	☐ 620 ESU 26	☐	☐
otherwise	☐ 600 NRVD	☐ 357 NRV-Z1	☐ 693 TS8997			
spectr. analys.	☒ 683 FSU	☐ 120 FSEM	☐ 264 FSEK	☐ 714 FSW 67	☐	☐
power supply	☐ 456 EA 3013A	☐ 457 EA 3013A	☐ 459 EA 2032-50	☐ 268 EA- 3050	☐ 494 AG6632A	☐ 354 NGPE 40
otherwise	☐ 613 20 dB Attenuator	☐ 248 6 dB Attenuator	☐ 529 Power divider	☐ - cable OTA20	☒ 530 10dB Atten	☐ K5 Cable
Supply Voltage	☒ 016 Line Impedance Simulating Network: 120V AC 60Hz			☐ 13.5V DC		

5.9.2. Requirements:

FCC	☒ §15.247 (a) (1) (iii)
ISED	☒ RSS-247, Issue 2, Chapter 5.1,d
Remark	The average time of occupancy on any channel shall not be greater than 0.4 seconds within a period of 0.4 seconds multiplied by the number of hopping channels employed.

5.9.3. EUT settings

For FHSS-systems hopping mode was switched-on so that occupancy time of Frequency Hopping channels could be measured. 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.

5.9.4. Measurement method:

The measurement was performed with a spectrum analyzer set to ZERO span. The device was set to work within the defined specification with frequency Hopping Mode ON. The spectrum-analyzer was set the MAX-Hold positive peak detector mode. 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.

5.9.5. Average occupancy time calculations:

Formula for calculating the dwell time (pseudo-hopping sequence over all channels assumed):

$$\text{Average Dwell Time} = Timeslot\ length \cdot \frac{Hop\ rate}{number of\ hopping\ channels} \cdot time\ period$$

The EUT employs Proprietary 2.4 GHz RF Transceiver Frequency Hopping system with total 79 channels. The maximum staying time of 0.4 seconds within a period of 0.4 seconds multiplied by the number of hopping channels employed. = 0.4 seconds X 79 = 31,6 Seconds.

That means the average time of occupancy on any channel shall not be greater than 0.4 seconds within 240 seconds.

5.9.6. Average occupancy time Results:

Average Occupancy Time Measurements				
Temperature: +21 °C		**Voltage Supply 120 V AC / 60 Hz**	**Setup: 2**	**Op. Mode: 2**
Frequency Hopping ON				
Data Rate	**Channel**	**Single Transmission Time**	**Number of Transmissions in 31.6 Seconds**	**Average Occupancy Time in 31.6 Seconds**
[Kbps]	**[Number]**	**[milliseconds]**	**[Number]**	**[milliseconds]**
DH1	39	0.368	640	235.52
DH3		1.624	213	345.91
DH5		2.876	128	368.13
Average Occupancy Time Limits- FCC 15.247				**≤ 400 milliseconds**
Remark 1: For further details please refer → Annex 1: Test results - **CETECOM_TR18-1-0130902T05a_A1**				

5.9.7. Average Occupancy Time Verdict: Pass

5.10. RF-Parameter – Out-of-Band 20 dBc Conducted Emissions for FHSS systems

5.10.1.Test location and equipment (for reference numbers please see chapter 'List of test equipment')

test location	☒ CETECOM Essen (Chapter. 2.2.1)		☐ 443 System CTC-FAR-EMI-		☐ Please see Chapter. 2.2.3	
test site	☐ 441 EMI SAR	☐ 487 SAR NSA	☐ 337 OATS	☒ 347 Radio.lab.	☐	☐
receiver	☐ 377 ESCS30	☐ 001 ESS	☒ 683 FSU 26	☐ 714 FSW67	☐	☐
spectr. analys.	☐ 489 ESU	☐ 120 FSEM	☐ 264 FSEK	☐	☐	☐
power supply	☐ 456 EA 3013A	☐ 457 EA 3013A	☐ 459 EA 2032-50	☐ 268 EA- 3050	☐ 494 AG6632A	☒ 354 NGPE 40
otherwise	☒ 530 10dB Attenuator	☒ RTK161	☐ Directional Coupler 1539R-10			
Supply Voltage	☒ 016 Line Impedance Simulating Network: 120V AC 60Hz		☐ 13.5V DC			

5.10.2. Requirements:

FCC	☒ §15.247 (d)
Remark	In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated device is operating. the RF power that is produced shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power. based on either an RF conducted or a radiated measurement. provided that the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of root-mean-square averaging over a time interval. as permitted under FCC15.247 paragraph (b)(3) / RSS-247section 5.4(d). the attenuation required shall be 30 dB instead of 20 dB

5.10.3. EUT settings

Fixed Channel Mode:
For FHSS-systems Hopping mode was switched-off so fixed three different channels could be measured.
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.

Hopping Mode:
For FHSS-systems Hopping mode was switched- ON so emissions from hopping channels could be measured.
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.

5.10.4. Measurement Method:

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

5.10.5. Results: Hopping mode off

Set-up no.: 2 Op-Mode: 1	**RF-Conducted test: 20 dBc spurious emissions**					
Frequency Range	**Modulation 8-DPSK** Low channel =0 (2402 MHz) Level Reference (In-Band)= 8.62 dBm – 10 dB (Offset) Limit= -11.38 dBm – 10 dB (Offset)		**Modulation GFSK** Middle channel = 39 (2440 MHz) Level Reference (In-Band) = -1.48 dBm – 10 dB (Offset) Limit = -21.48 dBm – 10 dB (Offset)		**Modulation Pi/4-QPSK** High channel = 78 (2480 MHz) Level Reference (In-Band) = -2.20 dBm – 10 dB (Offset) Limit= -22.20 dBm – 10 dB (Offset)	
	Frequency [MHz]	Value [dBc]	Frequency [MHz]	Value [dBc]	Frequency [MHz]	Value [dBc]
150kHz to 30 MHz	--	> 35	--	> 35	--	> 35
30MHz to 2.8 GHz	--	> 35	--	> 35	--	> 35
2.8 to 25 GHz	--	> 35	--	> 35	--	> 35
Band-Edge (no hopping)	--					

Remark 1: For further details please refer → Annex 1: Test results - **CETECOM_TR18-1-0130902T05a_A1**
The limit on the diagrams is 20dB under the reference level measured In-Band for each channel.
Only worst case from non-hopping Modulation was measured.
Remark 2: Plots are 10dB less, 10dB offset was used.

5.10.6. Results: Hopping mode on

Set-up no.: 2 Op-Mode: 2	**RF-Conducted test: 20 dBc spurious emissions**					
Frequency Range	**Modulation GFSK** Level Reference (In-Band)= 8.62 dBm – 10 dB (Offset) Limit= -11.38 dBm – 10 dB (Offset)		**Modulation Pi/4-QPSK** Level Reference (In-Band)= 8.62 dBm – 10 dB (Offset) Limit= -11.38 dBm – 10 dB (Offset)		**Modulation 8-DPSK** Level Reference (In-Band)= 8.62 dBm – 10 dB (Offset) Limit= -11.38 dBm – 10 dB (Offset)	
	Frequency [MHz]	Value [dBc]	Frequency [MHz]	Value [dBc]	Frequency [MHz]	Value [dBc]
150kHz to 30 MHz	--	> 35	--	> 40	--	> 40
30MHz to 2.8 GHz	--	> 35	--	> 40	--	> 40
2.8 to 25 GHz	--	> 35	--	> 40	--	> 40
Band-Edge (hopping)	--	> 40	--	> 40	--	> 40

Remark 1: For further details please refer → Annex 1: Test results - **CETECOM_TR18-1-0130902T05a_A1**
The limit on the diagrams is 20dB under the reference level measured In-Band for each channel.
Only worst case from non-hopping Modulation was measured.
Remark 2: Plots are 10dB less, 10dB offset was used.

5.10.7. Out-of-Band 20 dBc Conducted Emissions Verdict: Pass

5.11. General Limit - Radiated field strength emissions below 30 MHz

5.11.1. Test location and equipment

test location	☒ CETECOM Essen (Chapter. 2.2.1)		☐ Please see Chapter. 2.2.2		☐ Please see Chapter. 2.2.3	
test site	☒ 441 EMI SAR	☐ 487 SAR NSA	☐ 347 Radio.lab.		☐	☐
receiver	☐ 377 ESCS30	☒ 001 ESS	☐	☐	☐	☐
spectr. analys.	☐ 584 FSU	☐ 120 FSEM	☐ 264 FSEK	☐	☐	☐
antenna	☐ 574 BTA-L	☐ 133 EMCO3115	☐ 302 BBHA9170	☐ 289 CBL 6141	☒ 030 HFH-Z2	☐ 477 GPS
signaling	☐ 392 MT8820A	☐ 371 CBT32	☐ 547 CMU	☐ 594 CMW		
otherwise	☐ 400 FTC40x15E	☐ 401 FTC40x15E	☐ 110 USB LWL	☐ 482 Filter Matrix	☐ 378 RadiSense	
DC power	☐ 671 EA-3013S	☐ 457 EA 3013A	☒ 459 EA 2032-50	☐ 268 EA- 3050	☐ 494 AG6632A	☐ 498 NGPE 40
Supply Voltage	☒ 016 Line Impedance Simulating Network: 120V AC 60Hz		☐ 13.5V DC			

5.11.2. Requirements

FCC	Part 15, Subpart C, §15.205 & §15.209			
ISED	RSS-Gen: Issue 5: §8.9 Table 5 RSS-247, Issue 2,			
ANSI	C63.10-2013			
Frequency [MHz]	Field strength limit [µV/m]	[dBµV/m]	Distance [m]	Remarks
0.009 – 0.490	2400/f (kHz)	67.6 – 20Log(f) (kHz)	300	Correction factor used due to measurement distance of 3 m
0.490 – 1.705	24000/f (kHz)	87.6 – 20Log(f) (kHz)	30	Correction factor used due to measurement distance of 3 m
1.705 – 30	30	29.5	30	Correction factor used due to measurement distance of 3 m

5.11.3. Test condition and test set-up

Signal link to test system (if used):		☐ air link	☐ cable connection	☒ none
EUT-grounding		☒ none	☐ with power supply	☐ additional connection
Equipment set up		☒ table top		☐ floor standing
Climatic conditions		Temperature: (22±3°C)		Rel. humidity: (40±20)%
EMI-Receiver or Analyzer Settings	Scan data	☒ 9 – 150 kHz RBW/VBW = 200 Hz Scan step = 80 Hz ☒ 150 kHz – 30 MHz RBW/VBW = 9 kHz Scan step = 4 kHz ☐ other:		
	Scan-Mode Detector Mode: Sweep-Time	☒ 6 dB EMI-Receiver Mode ☐ 3dB Spectrum analyser Mode Peak (pre-measurement) and Quasi-PK/Average (final if applicable) Repetitive-Scan, max-hold Coupled – calibrated display if continuous signal otherwise adapted to EUT's individual transmission duty-cycle		
General measurement procedures		Please see chapter "Test system set-up radiated magnetic field measurements below 30 MHz"		

5.11.4. Measurement Results

The results are presented below in summary form only. For more information please consult the diagrams included in annex 1.

The EUT is put on operation on middle channel in test mode only. If critical peaks are found (Margin <10 dB) the lowest and highest channels will be performed too.
Table of measurement results:

Diagram No.	Carrier Channel		Frequency range	Set-up no.	OP-mode no.	Remark	Used detector			Result
	Range	No.					PK	AV	QP	
2.02a	Low	0	9 kHz - 30 MHz	1	1	BT-BDR-GFSK-1Mbps EUT standing	☒	☐	☐	Pass
2.04a	Low-High	0-78	9 kHz - 30 MHz	3	3	WLAN2.4+BT	☒	☐	☐	Pass
2.05a	Low-High	0-78	9 kHz - 30 MHz	3	3	WLAN5+BT	☒	☐	☐	Pass

5.11.5. 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< $D_{near-field}$)	2'te Condition (Limit distance bigger $d_{near-field}$)	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

5.12. General Limit - Radiated field strength emissions, 30 MHz - 1 GHz

5.12.1. Test location and equipment

test location	☒ CETECOM Essen (Chapter. 2.2.1)		☐ Please see Chapter. 2.2.2		☐ Please see Chapter. 2.2.3	
test site	☒ 441 EMI SAR	☒ 487 SAR NSA				
receiver	☐ 377 ESCS30	☒ 001 ESS	☐ 489 ESU 40	☐ 620 ESU 26		
spectr. analys.	☐ 584 FSU	☐ 120 FSEM	☐ 264 FSEK			
antenna	☒ 574 BTA-L	☐ 133 EMCO3115	☐ 302 BBHA9170	☐ 289 CBL 6141	☐ 030 HFH-Z2	☐ 477 GPS
signaling	☐ 392 MT8820A	☐ 371 CBT32	☐ 547 CMU	☐ 594 CMW		
otherwise	☐ 400 FTC40x15E	☐ 401 FTC40x15E	☐ 110 USB LWL	☒ 482 Filter Matrix		
DC power	☐ 456 EA 3013A	☒ 457 EA 3013A	☐ 459 EA 2032-50	☐ 268 EA- 3050	☐ 494 AG6632A	☐ 498 NGPE
Supply Voltage	☒ 016 Line Impedance Simulating Network: 120V AC 60Hz		☐ 13.5V DC			

5.12.2. Requirements/Limits

FCC	☐ Part 15 Subpart B. §15.109. class B ☒ Part 15 Subpart C. §15.209 @ frequencies defined in §15.205 ☒ Part 15.247 (d)		
ISED	☒ RSS-Gen.. Issue 5. Chapter 8.9. Table 5+7 (licence-exempt radio apparatus) ☐ RSS-Gen.. Issue 5. Chapter 7.1.2. Table 3 (receiver) ☐ ICES-003. Issue 6. Table 5 (Class B) ☒ RSS-247. Issue 2. Chapter 5		
ANSI	☐ C63.4-2014 ☒ C63.10-2013		
Limit	Frequency [MHz]	Radiated emissions limits. 3 meters	
		QUASI Peak [µV/m]	QUASI-Peak [dBµV/m]
	30 - 88	100	40.0
	88 - 216	150	43.5
	216 - 960	200	46.0
	above 960	500	54.0

5.12.3. Restricted bands of operation (FCC §15.205)

MHz	MHz	MHz	GHz
0.090-0.110	16.42-16.423	399.9-410	4.5-5.15
0.495-0.505	16.69475-16.69525	608-614	5.35-5.46
2.1735-2.1905	16.80425-16.80475	960-1240	7.25-7.75
4.125-4.128	25.5-25.67	1300-1427	8.025-8.5
4.20725-4.20775	37.5-38.25	1645.5-1646.5	9.3-9.5
6.215-6.218	73-74.6	1660-1710	10.6-12.7
6.26775-6.26825	74.8-75.2	1718.8-1722.2	13.25-13.4
6.31175-6.31225	108-121.94	2200-2300	14.47-14.5
8.291-8.294	123-138	2310-2390	15.35-16.2
8.362-8.366	149.9-150.05	2483.5-2500	17.7-21.4
8.37625-8.38675	156.52475-156.52525	2690-2900	22.01-23.12
8.41425-8.41475	156.7-156.9	3260-3267	23.6-24.0
12.29-12.293	162.0125-167.17	3332-3339	31.2-31.8
12.51975-12.52025	167.72-173.2	3345.8-3358	36.43-36.5
12.57675-12.57725	240-285	3600-4400	--
13.36-13.41	322-335.4	--	--
Remark: only spurious emissions are allowed within these frequency bands not exceeding the limits per §15.209			

5.12.4. Test condition and measurement test set-up

Signal link to test system (if used):		☐ air link	☐ cable connection	☒ none
EUT-grounding		☒ none	☐ with power supply	☐ additional connection
Equipment set up		☒ table top 0.8m height		☐ floor standing
Climatic conditions		Temperature: (22±3°C)		Rel. humidity: (40±20)%
EMI-Receiver (Analyzer) Settings	Scan frequency range:	☒ 30 – 1000 MHz ☐ other:		
	Scan-Mode	☒ 6 dB EMI-Receiver Mode ☐ 3 dB spectrum analyser mode		
	Detector	Peak / Quasi-peak		
	RBW/VBW	100 kHz/300 kHz		
	Mode:	Repetitive-Scan, max-hold		
	Scan step	80 kHz		
	Sweep-Time	Coupled – calibrated display if continuous tx-signal otherwise adapted to EUT's individual duty-cycle		
General measurement procedures		Please see chapter "Test system set-up for electric field measurement in the range 30 MHz to 1 GHz"		

5.12.5. MEASUREMENT RESULTS

5.12.5.1. Measurement Results 30MGHz to 1GHz

The results are presented below in summary form only. For more information please consult the diagrams included in annex 1.

Table of measurement results:

Dia-gram no.	Carrier Channel		Frequency range	Set-up no.	OP-mode no.	Remark	Used detector			Result
	Range	No.					PK	AV	QP	
3.01a	High	78	30 MHz – 1 GHz	1	1	BT-EDR-2Mbps EUT standing	☒	☐	☐	Pass
3.02a	Low	0	30 MHz – 1 GHz	1	1	BT-EDR-3Mbps EUT standing	☒	☐	☐	Pass
3.03a	Mid	39	30 MHz – 1 GHz	1	1	BT-BDR-1Mbps EUT standing	☒	☐	☐	Pass
3.04a	Low-High	0-78	30 MHz – 1 GHz	3	3	WLAN2.4+BT	☒	☐	☐	Pass
3.05a	Low-High	0-78	30 MHz – 1 GHz	3	3	WLAN5+BT	☒	☐	☐	Pass

5.13. General Limit - Radiated emissions, above 1 GHz

5.13.1. Test location and equipment FAR

test site	☐441 EMI SAR	☐348 EMI cond.	☒443 EMI FAR	☐347 Radio.lab.	☐337 OATS	☐
spectr. analys.	☐584 FSU	☐120 FSEM	☐264 FSEK	☒489 ESU 40	☐	☐
antenna meas	☐574 BTA-L	☐289 CBL 6141	☒608 HL 562	☒549 HL025	☒302 BBHA9170	☐477 GPS
antenna meas	☐123 HUF-Z2	☐132 HUF-Z3	☐030 HFH-Z2	☐376 BBHA9120E		☐
antenna subst	☐071 HUF-Z2	☐020 EMCO3115	☐063 LP 3146	☐303 BBHA9170	☐	☐
multimeter	☐341 Fluke 112	☐	☐	☐	☐	☐
signaling	☐392 MT8820A	☐371 CBT32	☐547 CMU	☐594 CMW		
DC power	☐086 LNG50-10	☒087 EA3013	☐354 NGPE 40	☐349 car battery	☐350 Car battery	☐
Supply Voltage	☒ 016 Line Impedance Simulating Network: 120V AC 60Hz			☐ 13.5V DC		

5.13.2. Requirements/Limits (CLASS B equipment)

FCC	☐ Part 15 Subpart B. §15.109 class B ☒ Part 15 Subpart C. §15.209 for frequencies defined in §15.205 ☒ Part 15.247 (d)			
ISED	☒ RSS-Gen.. Issue 5. Chapter 8.9. Table 5+7 (transmitter licence excempt) ☐ RSS-Gen.. Issue 5. Chapter 8.9. Table 3 (receiver) ☐ ICES-003. Issue 6. Chapter 6.2.2. Table 7 (class B) ☒ RSS-247. Issue 2. Chapter 5			
ANSI	☐ C63.4-2014 ☒ C63.10-2013			
Frequency [MHz]	Limits			
	AV [µV/m]	AV [dBµV/m]	Peak [µV/m]	Peak [dBµV/m] or [dBm/MHz]
above 1 GHz for frequencies as defined in §15.205 or RSS-Gen.. Issue 5. §8.10 - Table 5	500	54.0	5000	74.0 dBµV/m

5.13.3. Test condition and measurement test set-up

Signal link to test system (if used):		☐ air link	☐ cable connection	☒ none
EUT-grounding		☒ none	☐ with power supply	☐ additional connection
Equipment set up		☒ table top 1.5m height		☐ floor standing
Climatic conditions		Temperature: (22±3°C)		Rel. humidity: (40±20)%
Spectrum-Analyzer settings	Scan frequency range:	☒ 1 – 18 GHz ☒18 – 25 GHz ☐ 18 – 40 GHz ☐ other:		
	Scan-Mode	☒ 6 dB EMI-Receiver Mode ☐ 3 dB Spectrum analyser Mode		
	Detector	Peak and Average		
	RBW/VBW	1 MHz / 3 MHz		
	Mode:	Repetitive-Scan, max-hold		
	Scan step	400 kHz		
	Sweep-Time	Coupled – calibrated display if CW signal otherwise adapted to EUT's individual duty-cycle		
General measurement procedures		Please see chapter "Test system set-up for radiated electric field measurements above 1 GHz"		

5.13.4. Measurement Results

The results are presented below in summary form only. For more information please consult the diagrams included in annex 1.

5.13.4.1. Measurement Results for frequency range 1 GHz to 18 GHz

Dia-gram no.	Carrier Channel		Frequency range	Set-up no.	OP-mode no.	Remark	Used detector			Result
	Range	No.					PK	AV	QP	
4.01a	High	78	1 GHz – 18 GHz	1	1	BT-EDR-2Mbps	☒	☒	☐	Pass
4.02a	Low	0	1 GHz – 18 GHz	1	1	BT-EDR-3Mbps	☒	☒	☐	Pass
4.03a	Mid	39	1 GHz – 18 GHz	1	1	BT-BDR-1Mbps	☒	☒	☐	Pass
4.04a	Low-High	0-78	1 GHz – 18 GHz	3	3	WLAN2.4+BT	☒	☒	☐	Pass
4.05a	Low-High	0-78	1 GHz – 18 GHz	3	3	WLAN5+BT	☒	☒	☐	Pass

5.13.4.2. Measurement Results for frequency range 18 GHz to 26.5 GHz

Dia-gram no.	Carrier Channel		Frequency range	Set-up no.	OP-mode no.	Remark	Used detector			Result
	Range	No.					PK	AV	QP	
4.01b	High	78	18 GHz – 26.5 GHz	1	1	BT-EDR-2Mbps	☒	☒	☐	Pass
4.02b	Low	0	18 GHz – 26.5 GHz	1	1	BT-EDR-3Mbps	☒	☒	☐	Pass
4.03b	Mid	39	18 GHz – 26.5 GHz	1	1	BT-BDR-1Mbps	☒	☒	☐	Pass
4.04b	Low-High	0-78	18 GHz – 26.5 GHz	3	3	WLAN2.4+BT	☒	☒	☐	Pass
4.05b	Low-High	0-78	18 GHz – 26.5 GHz	3	3	WLAN5+BT	☒	☒	☐	Pass

5.14. RF-Parameter - Radiated Band Edge compliance measurements

5.14.1. Test location and equipment FAR

test site	☐441 EMI SAR	☐348 EMI cond.	☒443 EMI FAR	☐347 Radio.lab.	☐337 OATS	☐
spectr. analys.	☐584 FSU	☐120 FSEM	☒264 FSEK	☐489 ESU 40	☐	☐
antenna meas	☐574 BTA-L	☐289 CBL 6141	☐608 HL 562	☒549 HL025	☐302 BBHA9170	☐477 GPS
antenna meas	☐123 HUF-Z2	☐132 HUF-Z3	☐030 HFH-Z2	☐	☐	☐
antenna subst	☐071 HUF-Z2	☐020 EMCO3115	☐063 LP 3146	☐303 BBHA9170	☐	☐
multimeter	☐341 Fluke 112	☐	☐	☐	☐	☐
signaling	☐392 MT8820A	☐371 CBT32	☐547 CMU	☐594 CMW		
DC power	☐086 LNG50-10	☒087 EA3013	☐354 NGPE 40	☐349 car battery	☐350 Car battery	☐
Supply Voltage	☒ 016 Line Impedance Simulating Network: 120V AC 60Hz			☐ 13.5V DC		

5.14.2. Requirements/Limits

FCC	☐ Part 15 Subpart B. §15.109 class B ☒ Part 15 subpart C. §15.209 @ frequencies defined in §15.205 ☒ Part 15.247 (d)
ISED	☒ RSS-247. Issue 2. Chapter 5 ☒ RSS-Gen: Issue 5. Chapter 8.9. Table 5+7
ANSI	☐ C63.4-2009 ☐ C63.4-2014 ☐ C63.10-2009 ☒ C63.10-2013. Chapter 6.10.6

5.14.3. Test condition and measurement test set-up

Signal ink to test system (if used):		☐ air link	☐ cable connection	☒ none
EUT-grounding		☒ none	☐ with power supply	☐ additional connection
Equipment set up		☒ table top 1.5m height		☐ floor standing
Climatic conditions		Temperature: (22±3°C)		Rel. humidity: (40±20)%
Spectrum-Analyzer settings	Scan frequency range: Scan-Mode Detector RBW/VBW Mode: Scan step Sweep-Time	☐ 1 – 18 GHz ☐ 18 – 25 GHz ☐ 18 – 40 GHz ☒ other: see diagrams ☐ 6 dB EMI-Receiver Mode ☒ 3 dB Spectrum analyser Mode Peak and Average Left band-edge: 100kHz/300kHz Right band-edge: 1 MHz / 3 MHz Repetitive-Scan, max-hold 40kHz or 400 kHz Coupled – calibrated display if CW signal otherwise adapted to EUT's individual duty-cycle		
General measurement procedures		Please see chapter "Test system set-up for radiated electric field measurements above 1 GHz" for general measurements procedures in anechoic chamber.		

5.14.4. Measurement Method

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 is according ANSI C63.10:2013, Chapter 6.10.6 "Marker-Delta method",. 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 or RSS-Gen. Issue 5. Chapter 8.10. Table 7 with the general limits of FCC §15.209 or RSS-Gen. Issue 5 Chapter 8.9. Table 5.

5.14.5. EUT settings

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

5.14.6. Results: for non-restricted bands near-by

5.14.6.1. Non-restricted bands near-by - limits according FCC §15.247

Diagramm no.	Channel no.	Restricted band ?	Fundamental Value		Peak-Value at Band-	Difference [dB]	Limit [dBc]	Margin [dB]	Verdict	Remark:
			Peak-Value	Average-Value						
9.01a	0	no	91,087	79,924	50,7	40,387	20	20,387	PASS	PWR-VALUE=7dBm 2-DH3
9.02a	0	no	90,515	80,305	50,7	39,815	20	19,815	PASS	PWR-VALUE=7dBm 3-DH3
9.03a	0	no	92,327	87,017	52,152	40,175	20	20,175	PASS	PWR-VALUE=7dBm DH5
9.04a	0	no	88,163	77,581	50,246	37,917	20	17,917	PASS	PWR-VALUE=7dBm Hopping ON

5.14.6.2. Restricted bands near-by §15.205 with limits accord. FCC §15.209/RSS-Gen.

Diagramm no.	Channel no.	Restricted band ?	Fundamental Value		Value at Band-Edge		Limits		Duty-Cycle	Margin		Verdict	Remark:
			Peak-Value	Average-Value	Peak -Value	Average -Value	Peak -Value	Average -Value	[dB]	Peak	Average		
9.01b	78	yes	92,841	88,825	57,764	45,582	74	54	1,809	16,236	6,609	PASS	PWR-VALUE=7dBm 2-DH3
9.02b	78	yes	90,757	86,796	57,244	45,559	74	54	1,182	16,756	7,259	PASS	PWR-VALUE=7dBm 3-DH3
9.03b	78	yes	92,118	91,581	57,244	45,5	74	54	1,124	16,756	7,376	PASS	PWR-VALUE=7dBm DH5
9.04b	78	yes	92,64	91,09	57,2	46,8	74	54	1,124	16,8	6,076	PASS	PWR-VALUE=7dBm Hopping ON

5.15. Measurement uncertainties

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's contribution to the overall uncertainty according it's statistical distribution calculated.

Following table shows expectable uncertainties for each measurement type performed.

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						-
Radiated emissions Enclosure	CISPR 16-2-3	30 MHz - 1 GHz 1 GHz - 18 GHz	4.2 dB 5.1 dB						E-Field
Disturbance power	CISPR 16-2-2	30 MHz - 300 MHz	-						-
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 - 26.5GHz	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 - 12.75GHz	1.48	N/A	1.51	N/A	1.43	--	
		12.75 GHz - 18GHz	1.81	N/A	1.83	N/A	1.77	--	
		18 GHz - 26.5GHz	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 30 MHz - 1 GHz 1 GHz - 20 GHz	5.0 dB 4.2 dB 3.17 dB						Magnetic field E-field Substitution

Table: measurement uncertainties, valid for conducted/radiated measurements

6. Abbreviations used in this report

The abbreviations	
ANSI	American National Standards Institute
AV , AVG, CAV	Average detector
EIRP	Equivalent isotropically radiated power, determined within a separate measurement
EGPRS	Enhanced General Packet Radio Service
EUT	Equipment Under Test
FCC	Federal Communications Commission, USA
IC	Industry Canada
n.a.	not applicable
Op-Mode	Operating mode of the equipment
PK	Peak
RBW	resolution bandwidth
RF	Radio frequency
RSS	Radio Standards Specification, Dokuments from Industry Canada
Rx	Receiver
TCH	Traffic channel
Tx	Transmitter
QP	Quasi peak detector
VBW	Video bandwidth
ERP	Effective radiated power

7. Accreditation details of CETECOM's laboratories and test sites

Ref.-No.	Accreditation Certificate	Valid for laboratory area or test site	Accreditation Body
-	D-PL-12047-01-01	All laboratories and test sites of CETECOM GmbH, Essen	DAkkS, Deutsche Akkreditierungsstelle GmbH
337 487 558 348 348	736496	Radiated Measurements 30 MHz to 1 GHz, 3 m / 10 m (OATS) Radiated Measurements 30 MHz to 1 GHz, 3 m (SAR) Radiated Measurements above 1 GHz, 3 m (FAR) Mains Ports Conducted Interference Measurements Telecommunication Ports Conducted Interference Measurem.	FCC, Federal Communications Commission Laboratory Division, USA (MRA US-EU 0003)
337 487 550 558	3462D-1 3462D-2 3462D-2 3462D-3	Radiated Measurements 30 MHz to 1 GHz, 3 m / 10 m (OATS) Radiated Measurements 30 MHz to 1 GHz, 3 m (SAR) Radiated Measurements 1 GHz to 6 GHz, 3 m (SAR) Radiated Measurements above 1 GHz, 3 m (FAR)	ISED, Industry Canada Certification and Engineering Bureau
487 550 348 348	R-2666 G-301 C-2914 T-1967	Radiated Measurements 30 MHz to 1 GHz, 3 m (SAR) Radiated Measurements 1 GHz to 6 GHz, 3 m (SAR) Mains Ports Conducted Interference Measurements Telecommunication Ports Conducted Interference Measurem.	VCCI, Voluntary Control Council for Interference by Information Technology Equipment, Japan
OATS = Open Area Test Site, SAR = Semi Anechoic Room, FAR = Fully Anechoic Room			

8. Instruments and Ancillary

The “Ref.-No” in the left column of the following tables allows the clear identification of the laboratory equipment.

8.0.1. Test software and firmware of equipment

Ref.-No.	Equipment	Type	Serial-No.	Version of Firmware or Software during the test
012	Signal Generator (EMS-cond.)	SMY 01	839069/027	Firm.= V 2.02
013	Power Meter (EMS cond.)	NRVD	839111/003	Firm.= V 1.51
017	Digital Radiocommunication Tester	CMD 60 M	844365/014	Firmware = V 3.52 .22.01.99, DECT = D2.87 13.01.99
119	RT Harmonics Analyzer dig. Flickermeter	B10	G60547	Firm.= V 3.1DHG
261	Thermal Power Sensor	NRV-Z55	825083/0008	EPROM-Datum 02.12.04, SE EE 1 B
262	Power Meter	NRV-S	825770/0010	Firm.= 2.6
295	Racal Digital Radio Test Set	6103	1572	UNIT Firmware= 4.04, SW-Main=4.04, SW-BBP=1.04, SW-DSP=1.02, Hardboot=1.02, Softboot=2.02
298	Univ. Radio Communication Tester	CMU 200	832221/091	R&S Test Firmware =3.53 /3.54 (current Testsoftw. f. all band used
323	Digital Radiocommunication Tester	CMD 55	825878/0034	Firm.= 3.52 .22.01.99
335	CTC-EMS-Conducted	System EMS Conducted	-	EMC 32 V 8.52
340	Digital Radiocommunication Tester	CMD 55	849709/037	Firm.= 3.52 .22.01.99
366	Ultra Compact Simulator	UCS 500 M4	V0531100594	Firm. UCS 500=001925/3.06a02, rc=ISMIEC 4.10
371	Bluetooth Tester	CBT32	100153	CBT V5,30+ SW-Option K55, K57
377	EMI Test Receiver	ESCS 30	100160	Firm.= 2.30, OTP= 02.01, GRA= 02.36
378	Broadband RF Field Monitor	RadiSense III	03D00013SNO-08	Firm.= V.03D13
389	Digital Multimeter	Keithley 2000	0583926	Firm. = A13 (Mainboard) A02 (Display)
392	Radio Communication Tester	MT8820A	6K00000788	Firm.= 4.50 #005, IPL=4.01#001,OS=4.02#001, GSM=4.41#013, W-CDMA= 4.54#004, scenario=
436	Univ. Radio Communication Tester	CMU 200	103083	R&S Test Firmware Base=5.14, Mess-Software= GSM:5.14 WCDMA:5.14 (current Testsoftw. F. all band
441	CTC-SAR-EMI Cable Loss	System EMI field (SAR)	-	EMC 32 Version 8.52
442	CTC-SAR-EMS	System EMS field (SAR)	-	EMC 32 Version 8.40
443	CTC-FAR-EMI-RSE	System CTC-FAR-EMI-RSE	-	Spuri 7.2.5 or EMC 32 Ver. 9.15.00
444	CTC-FAR-EMS field	System-EMS-Field (FAR)	-	EMC 32 Version 9.15.00
460	Univ. Radio Communication Tester	CMU 200	108901	R&S Test Firmware Base=5.14, GSM=5.14 WCDMA=5.14 (current Testsoftw.,f. all band to be used,
489	EMI Test Receiver	ESU40	1000-30	Firmware=4.43 SP3, Bios=V5.1-16-3, Spec. =01.00
491	ESD Simulator dito	ESD dito	dito307022	V 2.30
524	Voltage Drop Simulator	VDS 200	0196-16	Software Nr: 000037 Version V4.20a01
526	Burst Generator	EFT 200 A	0496-06	Software Nr. 000034 Version V2.32
527	Micro Pulse Generator	MPG 200 B	0496-05	Software-Nr. 000030 Version V2.43
528	Load Dump Simulator	LD 200B	0496-06	Software-Nr. 000031 Version V2.35a01
546	Univ. Radio Communication Tester	CMU 200	106436	R&S Test Firmware Base=5.14, GSM=5.14 WCDMA=5.14 (current Testsoftw.,f. all band to be used
547	Univ. Radio Communication Tester	CMU 200	835390/014	R&S Test Firmware Base=V5.1403 (current Testsoftw., f. all band used, GSM = 5.14 WCDMA: = 5.14
584	Spectrum Analyzer	FSU 8	100248	2.82_SP3
597	Univ. Radio Communication Tester	CMU 200	100347	R&S Test Firmware Base=5.01, GSM=5.02 WCDMA= not installed, Mainboard= µP1=V.850
607	Signal Generator	SMR 20	832033/011	V1.25
620	EMI Test Receiver	ESU 26	100362	4.43_SP3
642	Wideband Radio Communication Tester	CMW 500	126089	Setup V03.26, Test programm component V03.02.20
670	Univ. Radio Communication Tester	CMU 200	106833	µP1 =V8.50, Firmware = V.20
689	Vector Signal Generator	SMU200	100970	02.20.360.142
692	Bluetooth Tester	CBT 32	100236	CBT V 5.40, FW: V.2.41 (FPGA Digital, V. 3.09 FPGA RF)
699	Audio Analyzer	UPL16	833494/005	3.06

8.0.2. Single instruments and test systems

Ref.-No.	Equipment	Type	Serial-No.	Manufacturer	Interval of calibration	Remark	Cal due
005	AC - LISN (50 Ohm/50µH, test site 1)	ESH2-Z5	861741/005	Rohde & Schwarz	12 M	-	23.05.2020
007	Single-Line V-Network (50 Ohm/5µH)	ESH3-Z6	892563/002	Rohde & Schwarz	12 M	-	23.05.2020
009	Power Meter (EMS-radiated)	NRV	863056/017	Rohde & Schwarz	24 M	-	23.05.2021
016	Line Impedance Simulating Network	Op. 24-D	B6366	Spitzenberger+Spies	36 M	-	22.05.2022
020	Horn Antenna 18 GHz (Subst 1)	3115	9107-3699	EMCO	36/12 M	-	31.07.2021
021	Loop Antenna (H-Field)	6502	9206-2770	EMCO	36 M	-	30.05.2021
030	Loop Antenna (H-field)	HFH-Z2	879604/026	Rohde & Schwarz	36 M	-	30.04.2018
033	RF-current probe (100kHz-30MHz)	ESH2-Z1	879581/18	Rohde & Schwarz	24 M	-	23.05.2021
057	relay-switch-unit (EMS system)	RSU	494440/002	Rohde & Schwarz	pre-m	1a	
060	power amplifier (DC-2kHz)	PAS 5000	B6363	Spitzenberger+Spies	-	3	
066	notch filter (WCDMA; FDD1)	WRCT 1900/2200-5/40-10EEK	5	Wainwright GmbH	12 M	1g	16.11.2019
086	DC - power supply, 0 -10 A	LNG 50-10	-	Heinzinger Electronic	pre-m	2	
087	DC - power supply, 0 -5 A	EA-3013 S	-	Elektro Automatik	pre-m	2	
091	USB-LWL-Converter	OLS-1	007/2006	Ing. Büro Scheiba	-	4	
099	passive voltage probe	ESH2-Z3	299.7810.52	Rohde & Schwarz	36 M	-	30.05.2021
100	passive voltage probe	Probe TK 9416	without	Schwarzbeck	36 M	-	30.05.2021
110	USB-LWL-Converter	OLS-1	-	Ing. Büro Scheiba	-	4	
119	RT Harmonics Analyzer dig. Flickermeter	B10	G60547	BOCONSULT	36 M	-	22.05.2022
133	horn antenna 18 GHz (Meas 1)	3115	9012-3629	EMCO	36 M	1c	10.03.2020
134	horn antenna 18 GHz (Subst 2)	3115	9005-3414	EMCO	36 M	-	10.03.2020
136	adjustable dipole antenna (Dipole 1)	3121C-DB4	9105-0697	EMCO	36 M	-	30.04.2018
248	attenuator	SMA 6dB 2W	-	Radiall	pre-m	2	
249	attenuator	SMA 10dB 10W	-	Radiall	pre-m	2	
252	attenuator	N 6dB 12W	-	Radiall	pre-m	2	
256	attenuator	SMA 3dB 2W	-	Radiall	pre-m	2	
257	hybrid	4031C	04491	Narda	pre-m	2	
260	hybrid coupler	4032C	11342	Narda	pre-m	2	
261	Thermal Power Sensor	NRV-Z55	825083/0008	Rohde & Schwarz	24 M	-	30.05.2020
262	Power Meter	NRV-S	825770/0010	Rohde & Schwarz	24 M	-	30.05.2020
265	peak power sensor	NRV-Z33, Model 04	840414/009	Rohde & Schwarz	24 M	-	30.05.2020
266	Peak Power Sensor	NRV-Z31, Model 04	843383/016	Rohde & Schwarz	24 M	-	30.05.2020
267	notch filter GSM 850	WRCA 800/960-6EEK	9	Wainwright GmbH	pre-m	2	
270	termination	1418 N	BB6935	Weinschel	pre-m	2	
271	termination	1418 N	BE6384	Weinschel	pre-m	2	
272	attenuator (20 dB) 50 W	Model 47	BF6239	Weinschel	pre-m	2	
273	attenuator (10 dB) 100 W	Model 48	BF9229	Weinschel	pre-m	2	
274	attenuator (10 dB) 50 W	Model 47 (10 dB) 50 W	BG0321	Weinschel	pre-m	2	
275	DC-Block	Model 7003 (N)	C5129	Weinschel	pre-m	2	
276	DC-Block	Model 7006 (SMA)	C7061	Weinschel	pre-m	2	
279	power divider	1515 (SMA)	LH855	Weinschel	pre-m	2	
287	pre-amplifier 25MHz - 4GHz	AMF-2D-100M4G-35-10P	379418	Miteq	12 M	1c	16.11.2019
291	high pass filter GSM 850/900	WHJ 2200-4EE	14	Wainwright GmbH	12 M	1c	16.11.2019
298	Univ. Radio Communication Tester	CMU 200	832221/091	Rohde & Schwarz	pre-m	3	
300	AC LISN (50 Ohm/50µH, 1-phase)	ESH3-Z5	892 239/020	Rohde & Schwarz	12 M	-	22.05.2020
301	attenuator (20 dB) 50W, 18GHz	47-20-33	AW0272	Lucas Weinschel	pre-m	2	
302	horn antenna 40 GHz (Meas 1)	BBHA9170	155	Schwarzbeck	36 M	-	14.03.2020
303	horn antenna 40 GHz (Subst 1)	BBHA9170	156	Schwarzbeck	36 M	-	20.03.2020
331	Climatic Test Chamber -40/+180 Grad	HC 4055	43146	Heraeus Vötsch	24 M	-	10.01.2021
341	Digital Multimeter	Fluke 112	81650455	Fluke	24 M	-	30.05.2020
342	Digital Multimeter	Voltcraft M-4660A	IB 255466	Voltcraft	24 M	-	23.05.2021
347	laboratory site	radio lab.	-	-	-	5	
348	laboratory site	EMI conducted	-	-	-	5	
354	DC - Power Supply 40A	NGPE 40/40	448	Rohde & Schwarz	pre-m	2	
357	power sensor	NRV-Z1	861761/002	Rohde & Schwarz	24 M	-	21.05.2021
371	Bluetooth Tester	CBT32	100153	R&S	36 M	-	30.05.2019
373	Single-Line V-Network (50 Ohm/5µH)	ESH3-Z6	100535	Rohde & Schwarz	12 M	-	22.05.2020
377	EMI Test Receiver	ESCS 30	100160	Rohde & Schwarz	12 M	-	22.05.2020
389	Digital Multimeter	Keithley 2000	0583926	Keithley	pre-m	-	
392	Radio Communication Tester	MT8820A	6K00000788	Anritsu	12 M	-	01.07.2020
396	Thermo/Hygrometer	Thermo/Hygrometer	-	Conrad	24 M	-	09.01.2021
405	Thermo-/Hygrometer	OPUS 10 THI	126.0604.0003.3.3.3.22	LUFFT Mess u. Regeltechnik GmbH	24 M	-	30.03.2019
431	Model 7405	Near-Field Probe Set	9305-2457	EMCO	-	4	
436	Univ. Radio Communication Tester	CMU 200	103083	Rohde & Schwarz	12 M	-	25.05.2020
439	UltraLog-Antenna	HL 562	100248	Rohde & Schwarz	36 M	-	10.03.2020

Ref.-No.	Equipment	Type	Serial-No.	Manufacturer	Interval of calibration	Remark	Cal due
441	CTC-SAR-EMI Cable Loss	System EMI field (SAR) Cable	-	CETECOM	12 M	5	05.06.2017
443	CTC-FAR-EMI-RSE	System CTC-FAR-EMI-RSE	-	ETS-Lindgren / CETECOM	12 M	5	16.11.2019
448	notch filter WCDMA_FDD II	WRCT 1850.0/2170.0-5/40-10SSK	5	Wainwright Instruments GmbH	12 M	1c	16.11.2019
449	notch filter WCDMA FDD V	WRCT 824.0/894.0-5/40-8SSK	1	Wainwright	12 M	1c	16.11.2019
454	Oscilloscope	HM 205-3	9210 P 29661	Hameg	-	4	
456	DC-Power supply 0-5 A	EA 3013 S	207810	Elektro Automatik	pre-m	2	
459	DC -Power supply 0-5 A , 0-32 V	EA-PS 2032-50	910722	Elektro Automatik	pre-m	2	
460	Univ. Radio Communication Tester	CMU 200	108901	Rohde & Schwarz	12 M	-	30.05.2020
463	Universal source	HP3245A	2831A03472	Agilent	-	4	
466	Digital Multimeter	Fluke 112	89210157	Fluke USA	24 M	-	30.05.2020
467	Digital Multimeter	Fluke 112	89680306	Fluke USA	36 M	-	30.05.2021
468	Digital Multimeter	Fluke 112	90090455	Fluke USA	36 M	-	30.04.2021
477	ReRadiating GPS-System	AS-47	-	Automotive Cons. Fink	-	3	
480	power meter (Fula)	NRVS	838392/031	Rohde & Schwarz	24 M	-	30.05.2021
482	filter matrix	Filter matrix SAR 1	-	CETECOM (Brl)	-	1d	
484	pre-amplifier 2,5 - 18 GHz	AMF-5D-02501800-25-10P	1244554	Miteq	12 M	-	16.11.2019
487	System CTC NSA-Verification SAR-EMI	System EMI field (SAR) NSA	-	ETS Lindgren / CETECOM	24 M	-	16.04.2021
489	EMI Test Receiver	ESU40	1000-30	Rohde & Schwarz	12 M	-	30.06.2020
502	band reject filter	WRCG 1709/1786-1699/1796-	SN 9	Wainwright	pre-m	2	
503	band reject filter	WRCG 824/849-814/859-60/10SS	SN 5	Wainwright	pre-m	2	
512	notch filter GSM 850	WRCA 800/960-02/40-6EEK	SN 24	Wainwrght	12 M	1c	16.11.2019
517	relais switch matrix	HF Relais Box Keithley System	SE 04	Keithley	pre-m	2	
523	Digital Multimeter	L4411A	MY46000154	Agilent	24 M	-	23.05.2021
529	6 dB Broadband resistive power divider	Model 1515	LH 855	Weinschel	pre-m	2	
530	10 dB Broadband resistive power divider	R 416110000	LOT 9828	-	pre-m	2	
546	Univ. Radio Communication Tester	CMU 200	106436	R&S	12 M	-	30.07.2019
547	Univ. Radio Communication Tester	CMU 200	835390/014	Rohde & Schwarz	12 M	-	30.07.2019
549	Log.Per-Antenna	HL025	1000060	Rohde & Schwarz	36/12 M	-	31.07.2021
550	System CTC S-VSWR Verification SAR-EMI	System EMI Field SAR S-VSWR	-	ETS Lindgren/CETECOM	24 M	-	30.08.2019
552	high pass filter 2,8-18GHz	WHKX 2.8/18G-10SS	4	Wainwright	12 M	1c	16.11.2019
557	System CTC-OTA-2	R&S TS8991	-	Rohde & Schwarz	12 M	5	24.01.2020
558	System CTC FAR S-VSWR	System CTC FAR S-VSWR	-	CTC	24 M	-	08.08.2019
574	Biconilog Hybrid Antenna	BTA-L	980026L	Frankonia	36/12 M	-	03.05.2022
584	Spectrum Analyzer	FSU 8	100248	Rohde & Schwarz	pre-m	-	
594	Wideband Radio Communication Tester	CMW 500	101757	Rohde & Schwarz	12 M	-	26.06.2020
597	Univ. Radio Communication Tester	CMU 200	100347	Rohde & Schwarz	pre-m	-	
600	power meter	NRVD (Reserve)	834501/018	Rohde & Schwarz	24 M	-	30.05.2021
602	peak power sensor	NRV-Z32 (Reserve)	835080	Rohde & Schwarz	24 M	-	
611	DC power supply	E3632A	KR 75305854	Agilent	pre-m	2	
612	DC power supply	E3632A	MY 40001321	Agilent	pre-m	2	
613	Attenuator	R416120000 20dB 10W	Lot. 9828	Radiall	pre-m	2	
616	Digitalmultimeter	Fluke 177	88900339	Fluke	24 M	-	30.05.2020
617	Power Splitter/Combiner	ZFSC-2-2-S+	S F987001108	Mini Circuits	-	2	
618	Power Splitter/Combiner	50PD-634	600994	JFW Industries USA	-	2	
619	Power Splitter/Combiner	50PD-634	600995	JFW Industries, USA	-	3	
620	EMI Test Receiver	ESU 26	100362	Rohde-Schwarz	12 M	-	30.05.2020
621	Step Attenuator 0-139 dB	RSP	100017	Rohde & Schwarz	pre-m	2	
625	Generic Test Load USB	Generic Test Load USB	-	CETECOM	-	2	
634	Spectrum Analyzer	FSM (HF-Unit)	826188/010	Rohde & Schwarz	pre-m	2	
637	High Speed HDMI with Ethernet 1m	HDMI cable with Ethernet 1m	-	KogiLink	-	2	
638	HDMI Kabel with Ethernet 1,5 m flach	HDMI cable with Ethernet 1,5m	-	Reichelt	-	2	
640	HDMI cable 2m rund	HDMI cable 2m rund	-	Reichelt	-	2	
641	HDMI cable with Ethernet	Certified HDMI cable with	-	PureLink	-	2	
644	Amplifierer	ZX60-2534M+	SN865701299	Mini-Circuits	-	-	
670	Univ. Radio Communication Tester	CMU 200	106833	Rohde & Schwarz	24 M	-	30.05.2020
671	DC-power supply 0-5 A	EA-3013S	-	Elektro Automatik	pre-m	2	

Ref.-No.	Equipment	Type	Serial-No.	Manufacturer	Interval of calibration	Remark	Cal due
678	Power Meter	NRP	101638	Rohde&Schwarz	pre-m	-	
683	Spectrum Analyzer	FSU 26	200571	Rohde & Schwarz	12 M	-	30.05.2020
686	Field Analyzer	EHP-200A	160WX30702	Narda Safety Test Solutions	24 M	-	29.09.2019
687	Signal Generator	SMF 100A	102073	Rohde&Schwarz	12 M	-	30.05.2020
688	Pre Amp	JS-18004000-40-8P	1750117	Miteq	pre-m	-	
690	Spectrum Analyzer	FSU	100302/026	Rohde&Schwarz	24 M	-	30.05.2021
691	OSP120 Base Unit	OSP120	106833	Rohde & Schwarz	12 M	-	30.05.2020
692	Bluetooth Tester	CBT 32	100236	Rohde & Schwarz	36 M	-	29.05.2020
693	TS8997	CTC-Radio Lab 1_TS8997	-	Rohde&Schwarz	12 M	5	07.01.2020
697	Power Splitter	ZN4PD-642W-S+	165001445	Mini-Circuits	-	2	
701	CMW500 wide. Radio Comm.	CMW500	158150	Rohde & Schwarz	24 M	-	30.07.2020
703	INNCO Antennen Mast	MA 4010-KT080-XPET-ZSS3	MA4170-KT100-XPET-ZSS3	INNCO	pre-m	-	
704	INNCON Controller	CO 3000-4port	CO3000/933/384105 16/L	INNCO Systems GmBh	pre-m	-	
711	Harmonic Mixer 90 GHz - 140GHz	RPG FS-Z140	101004	RPG	36 M	-	22.02.2020
712	Harmonic Mixer 75 GHz - 110GHz	FS-Z110	101468	Rohde & Schwarz	36 M	-	22.02.2020
713	Harmonic Mixer, 50 GHz - 75GHz	FS-Z75	101022	Rohde & Schwarz	24 M	-	05.07.2021
714	Signal Analyzer 67GHz	FSW67	104023	Rohde & Schwarz	24 M	-	04.07.2021
715	Harmonic Mixer, 140 GHz - 220GHz	FS-Z220	101009	RPG Radiometer Physics	36 M	-	03.08.2020
716	Harmonic Mixer 220 GHz to 325 GHZ	FS-Z325	101005	RPG Radiometer Physics	36 M	-	13.02.2020
747	Spectrum Analyzer	FSU 26	200152	Rohde & Schwarz	12 M	-	30.05.2019
748	Pickett-Potter Horn Antenna	FH-PP 4060	010001	Radiometer Physiscs	36 M	-	
750	Pickett-Potter Horn Antenna	FH-PP 220	010011	Radiometer Physics	36 M	-	
751	Digital Optical System	optoCAN-FD Transceiver	17-010416	mk-messtechnik GmbH	-	-	
752	Digital Optical System	optoCAN-FD Transceiver	17-010083	mk-messtechnik GmbH	-	-	
753	Digital Optical System	optoCAN-FD Transceiver	17-010084	mk-messtechnik GmbH	-	-	
754	Digital Optical System	optoCAN-FD Transceiver	17-010415	mk-messtechnik GmbH	-	-	
755	Digital Optical System	optoLAN-100-MAX Transceiver	17-010795	mk-messtechnik GmbH	-	-	
757	WIDEBAND RADIO COMMUNICATION	CMW500	163673	Rohde&Schwarz	12 M	-	30.05.2020
758	Signal Generator	SMU 200A	100754	Rohde & Schwarz	24 M	-	11.10.2019
781	Power Supply	PS 2042-10 B	2815450369	Elektro-Automatik GmbH &Co.KG	-	-	
782	Power Supply	PS 2042-10 B	2815450348	lektro-Automatik GmbH &Co.KG	-	-	
783	Spectrum Analyzer	FSU 26	100414	Rohde & Schwarz	12 M	-	30.05.2020
784	Power Supply	NGSM 32/10	00196	Rohde & Schwarz	12 M	-	
785	RSP	RF Step Attenuator 0…139.9dB	860712/012	Rohde & Schwarz	12 M	-	
786	SAR Probe	ES3DV3	3340	Speag	36 M	-	14.02.2021
787	OSP	OSP B157WX	101264	Rohde & Schwarz	24 M	-	30.05.2020
788	Precision Omnidirectional Dipole	POD 618	6182558/Q	Seibersdorf Labaratories	36 M	-	30.06.2021
789	Precision Omnidirectional Dipole	POD 16	162496/Q	Seibersdorf Laboratories	36 M	-	30.06.2021
790	Horn Antenna	ASY-SGH-124-SMA	29F14182337	Antenna System Solutions	36 M	-	08.10.2021
791	Pickett-Potter Horn Antenna	FH-PP-325	10024	Radiometer Physics	36 M	-	
792	Pickett-Potter Horn Antenna	FH-PP 075	10006	Radiometer Physics	36 M	-	
793	Pickett-Potter Horn Antenna	FH-PP 140	10008	Radiometer Physics	36 M	-	
794	Pickett-Potter Horn Antenna	FH-PP 110	10014	Radiometer Physics	36 M	-	
795	SGH Antenna	SGH-26-WR10	1144	Anteral S.L.	36 M	-	
798	WR-22 Rectangular Gain Horn	SAR-2309-22-S2	13254-01	SAGE Millimeter, Inc.	36 M	-	
799	Transceiver	optoLAN-Gb	18-014746	mk messtechnik	pre-m	-	
801	Spectrum Analyzer	FSP 13	100960	Rohde & Schwarz	24 M	-	14.01.2021
802	Exposure Level Tester	ELT-400	O-0026	NARDA Safety Solutions	24 M	-	30.01.2021
803	Probe	ELT probe 3cm²	O-0026	Narda Safety Test Solution	24 M	-	30.01.2021
805	Thermo-Hygrometer	Web-Thermo-Hygrometer	02749814	W&T	24 M	-	
806	AC2600 Smart Wifi Router	Netgear Nighthawk x4S	5K5188590067B	Netgear	-	-	
807	Direct Coupler	Direct Coupler C-05020-10	511	ET Industries	-	-	
808	Diode Power Sensor	NRV-Z1	829894/001	Rohde & Schwarz	24 M	-	24.05.2021
809	Standard gain Horn Antenna	WR-159 Horn Antenna	-	Pasternack Enterprises Inc.	-	-	

8.1. Legend

Note / remarks		Calibrated during system calibration:
	1a	System CTC-SAR-EMS (Ref.-No. 442)
	1b	System-CTC-EMS-Conducted (Ref.-No. 335)
	1c	System CTC-FAR-EMI-RSE (Ref.-No . 443)
	1d	System CTC-SAR-EMI (Ref.-No . 441)
	1e	System CTC-OATS (EMI radiated) (Ref.-No. 337)
	1 f	System CTC-CTIA-OTA (Ref.-No . 420)
	1 g	System CTC-FAR-EMS (Ref.-No . 444)
	2	Calibration or equipment check immediately before measurement
	3	Regulatory maintained equipment for functional check or support purpose
	4	Ancillary equipment without calibration e.g. mechanical equipment or monitoring equipment
	5	Test System

Interval of calibration	12 M	12 month
	24 M	24 month
	36 M	36 month
	24/12 M	Calibration every 24 months, between this every 12 months internal validation
	36/12 M	Calibration every 36 months, between this every 12 months internal validation
	Pre-m	Check before starting the measurement
	-	Without calibration

9. Versions of test reports (change history)

Version	Applied changes	Date of release
--	Initial release	2019-03-06
C1	- Updated RSS-Gen and KDB references - Added Chapter AC-Power lines - Added measurements for test case simultaneous transmissions	2019-07-16

END OF TEST REPORT