Test Report
21-1-0037301T008a

Number of pages:	26	**Date of Report:**	2022-Dec-16
Testing company:	CETECOM GmbH Im Teelbruch 116 45219 Essen Germany Tel. + 49 (0) 20 54 / 95 19-0 Fax: + 49 (0) 20 54 / 95 19-150	**Applicant:**	WITTE-Velbert GmbH & Co.KG
Product: **Model:**	**BTLE enabled secure vehicle access box** **flinkey BLE**		
FCC ID:	FCC ID: V2TFB33 Contains FCC ID: SQGBL652	**IC:**	IC: 7575A-FB33 Contains IC: 3147A-BL652
Testing has been carried out in accordance with:	**FCC Regulations** **Title 47 CFR, Chapter I, Subchapter A, Part 15** **Subpart C**, **Intentional Radiators** § 15.207 Conducted limits § 15.225 Radiated emission limits **ISED-Regulations** **RSS-Gen, Issue 5 + Amendment 2** General Requirements for Compliance of Radio Apparatus **RSS-210, Issue 10, Annex B.6**		
Tested Technology:	NFC 13.56MHz		
Test Results:	**☒ The EUT complies with the requirements in respect of all parameters subject to the test.** The test results relate only to devices specified in this document		
Signatures:			
	Dipl.-Ing. Ninovic Perez Test Lab Manager Authorization of test report		Dipl.-Ing. Christian Lorenz Senior Test Manager Responsible of test report

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1 General information

1.1 Disclaimer and Notes

The test results of this test report relate exclusively to the test item specified in this test report as specified in chapter 2.7. CETECOM does not assume responsibility for any conclusions and generalizations drawn from the test results with regard to other specimens or samples of the type of the equipment represented by the test item.
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Also we refer on special conditions which the applicant should fulfill according §2.927 to §2.948, special focus regarding modification of the equipment and availability of sample equipment for market surveillance tests.

1.2 Attestation

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

1.3 Summary of Test Results

The EUT integrates **RFID** technology. Other implemented wireless technologies were not considered within this test report.

Test case	Reference Clause FCC ☒	Reference Clause ISED ☒	Page	Remark	Result
Radiated field strength emissions and emission mask	§15.225(a)(b)(c)(d)	RSS-210, Issue 10, Annex B.6 (a)	12	--	PASSED
Radiated field strength emissions below 30 MHz	§15.209(a)	RSS-Gen: Issue 5 §8.9 Table 6	12	--	PASSED
Radiated field strength emissions 30 MHz – 1 GHz	§15.209(a)	RSS-Gen: Issue 5 §8.9 Table 5	16	--	PASSED
Occupied Channel Bandwidth 99%	§2.202(a) §2.1049(h)	RSS-Gen, Issue 5, §6.6	18	--	PASSED
Frequency stability	§2.1055 §15.225(e)	RSS-210, Issue 10, Annex B.6 (b)	20	--	PASSED
AC-Power Lines Conducted Emissions	§15.207	RSS-Gen Issue 5: §8.8, Table 4	18	--	PASSED

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

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

1.4 Summary of Test Methods

Test case	Test method
Occupied Channel Bandwidth 99%	ANSI C63.10:2013, §6.9
Radiated field strength emissions below 30 MHz	ANSI C63.10-2013 §6.3, §6.4
Radiated field strength emissions 30 MHz- 1 GHz	ANSI C63.4-2014 §8.2.3, ANSI C63.10-2013 §6.3, § 6.5
Frequency stability tests	ANSI C63.10-2013; §6.8
AC-Power Lines Conducted Emissions	ANSI C63.4-2014 §7, ANSI C63.10-2013 § 6.2

2 Administrative Data

2.1 Identification of the Testing Laboratory

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

2.2 General limits for environmental conditions

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

2.3 Test Laboratories sub-contracted

Company name:	--

2.4 Organizational Items

Responsible test manager:	Dipl.-Ing. Christian Lorenz
Receipt of EUT:	2022-Aug-16
Date(s) of test:	2022-Aug-22 to 2022-Dez-07
Version of template:	22.0901

2.5 Applicant's details

Applicant's name:	WITTE-Velbert GmbH & Co.KG
Address:	Höferstr. 3 - 15 42551 Velbert Germany
Contact Person:	Christian Goldschmidt
Contact Person's Email:	christian.goldschmidt@witte.digital

2.6 Manufacturer's details

Manufacturer's name:	WITTE-Velbert GmbH & Co.KG
Address:	Höferstr. 3 - 15 42551 Velbert Germany

2.7 Equipment under Test (EUT)

EUT No.*)	Sample No.	Product	Model	Type	SN	HW	SW
EUT 1	21-1-00373S20_C01	BTLE enabled secure vehicle access box	flinkey Box	n/a	#DR0080	3.3	EMCTest
EUT 2	21-1-00373S30_C01	BTLE enabled secure vehicle access box	flinkey Box	n/a	#DR0083	3.3	EMCTest
EUT 3	21-1-00373S29_C01	BTLE enabled secure vehicle access box	flinkey Box	n/a	#DR0081	3.3 (no NFC antenna)	EMCTest

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

2.8 Untested Variant (VAR)

VAR No.*)	Sample No.	Product	Model	Type	SN	HW	SW

*) The listed additional untested model variant(s) (VAR) is/are not object of evaluation of compliance. For further information please see Annex 5: Declaration of applicant of model differences.
If the table above does not show any other line than the headline, no untested variants are available.

2.9 Auxiliary Equipment (AE)

AE No.*)	Sample No.	Auxiliary Equipment	Model	SN	HW	SW
AE 1	21-1-00373S18_C01	AC/DC Adapter	Q5004-EU	DR055	N/A	N/A
AE 2	21-1-00373S32_C01	NFC control cards	START NFC PRBS Mode NFC Mode CWF ACTUATOR DEMO DISABLE	#1 #2 #3 #4	--	--

*) AE short description is used to simplify the identification of the auxiliary equipment in this test report. If the table above does not show any other line than the headline, no AE was used during testing nor was taken into account for evaluation

2.10 Connected cables (CAB)

CAB No.*)	Sample No.	Cable Type	Connectors / Details	Length
CAB 1	21-1-00373S17_C01	Cable	USB-C	120 cm

*) CAB short description is used to simplify the identification of the connected cables in this test report. If the table above does not show any other line than the headline, no cable was used during testing nor was taken into account for evaluation

2.11 Software (SW)

SW No.*)	Sample No.	SW Name	Description	SW Status

*) SW short description is used to simplify the identification of the used software in this test report. If the table above does not show any other line than the headline, no SW was used during testing nor was taken into account for evaluation.

2.12 EUT set-ups

set-up no.*)	Combination of EUT and AE	Description
1	EUT 1 + AE1 + CAB1 (+ AE2)	Used for Radiated measurements
2	EUT 2 (+ AE2)	Used for climatic chamber measurements
3	EUT 3 + AE1 + CAB1	Used for conducted EMI-measurements on modified sample without NFC antenna

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

2.13 EUT operation modes

EUT operating mode no.*)	Operating modes	Additional information
1	TX continuous, modulated	PRBS data scheme, 100% duty-cycle
2	TX continuous, un-modulated	100% duty-cycle with AE2-card: NFC Mode CWF

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

3 Equipment under test (EUT)

3.1 General Data of Main EUT as Declared by Applicant

Firmware	☐ for normal use	☒ Special version for test execution	
Power supply	☐ AC Mains	-	
	☐ DC Mains	-- V DC via -- Connector	
	☒ Battery Li-Io	-	
Operational conditions	T_{nom} =21 °C	T_{min} =-40 °C	T_{max} =80 °C
EUT sample type	**Pre-Production**		
Weight	0.700 kg		
Size [LxWxH]	16.5 cm x 14.0 cm x 6.5 cm		
Interfaces/Ports	microUSB power port		
For further details refer Applicants Declaration & following technical documents: D102.0_P.04499_D3.3 Technical Data Sheet			

3.2 Modifications on Test sample

Additions/deviations or exclusions	On EUT 3, replacement of NFC antenna with resistor for EMI-measurements on AC-mains due direct field coupling into AC lines on normal sample and connected accessories.

4 Measurements

4.1 Duty-Cycle

Testing method:

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

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

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

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

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

Formula to calculate Duty-Cycle:

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

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

4.1.1 Result

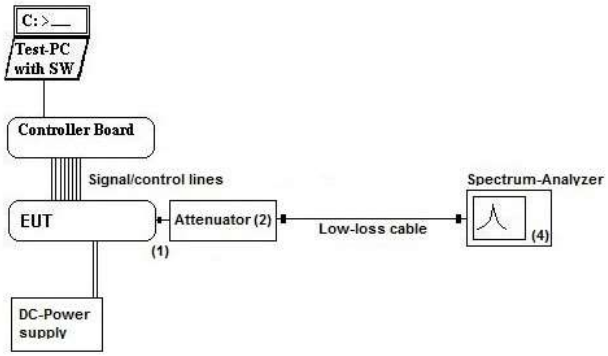
Duty-Cycle [%]	Duty-Cycle correction Power [dB]	Duty-Cycle correction Field Strength [dB]
100	0	0

4.2 Occupied Channel Bandwidth 99%

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

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

Schematic:



Testing method:

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

Measurement is made using Rohde & Schwarz TS8997 test system.

4.2.2 Measurement Location

Test site	120911 - Radio Laboratory 2

4.2.3 Limit

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

4.2.4 Result

Mode	Channel	Frequency [MHz]	99% Occupied bandwidth [MHz]
1 - TX	Nominal	13.5599 (nominal conditions)	1.0677

Remark: for more information and graphical plot see annex A1 **CETECOM_TR21-1-0037301T008a_A1**

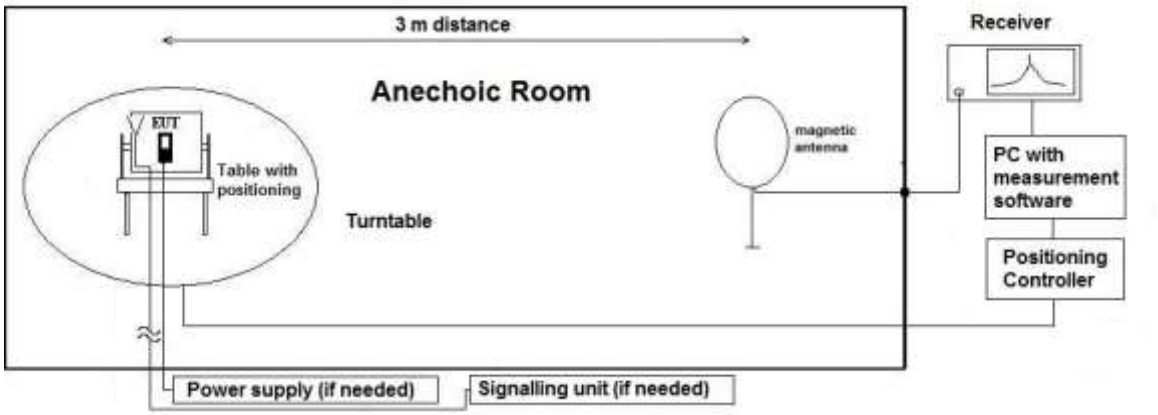
4.3 Radiated field strength emissions below 30 MHz

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

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

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

Schematic:



Testing method:

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

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

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

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

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

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

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

Formula:

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

$M = L_T - E_C$

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

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

4.3.2 Sample calculation

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

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

4.3.3 Measurement Location

Test site	120901 - SAC - Radiated Emission <1GHz

4.3.4 Correction factors due to reduced meas. distance (f < 30 MHz):

The used correction factors when the measurement distance is reduced compared to regulatory measurement distance, are calculated according Extrapolation formulas valid for EUT's with maximum dimension of 0.625xLambda. Formula 2+3+4 as presented in ANSI C63.10, Chapter 6.4.4 are used for the calculations of proper extrapolation factors

Frequency Range	f [kHz/MHz]	Lambda [m]	Far-Field Point [m]	Distance Limit accord. 15.209 [m]	1st Condition (dmeas < Dnear-field)	2nd Condition (Limit distance bigger dnear-field)	Distance Correction accord. Formula
kHz	9	33333.33	5305.17	300	fullfilled	not fullfilled	-80.00
	10	30000.00	4774.65		fullfilled	not fullfilled	-80.00
	20	15000.00	2387.33		fullfilled	not fullfilled	-80.00
	30	10000.00	1591.55		fullfilled	not fullfilled	-80.00
	40	7500.00	1193.66		fullfilled	not fullfilled	-80.00
	50	6000.00	954.93		fullfilled	not fullfilled	-80.00
	60	5000.00	795.78		fullfilled	not fullfilled	-80.00
	70	4285.71	682.09		fullfilled	not fullfilled	-80.00
	80	3750.00	596.83		fullfilled	not fullfilled	-80.00
	90	3333.33	530.52		fullfilled	not fullfilled	-80.00
	100	3000.00	477.47		fullfilled	not fullfilled	-80.00
	125	2400.00	381.97		fullfilled	not fullfilled	-80.00
	200	1500.00	238.73		fullfilled	fullfilled	-78.02
	300	1000.00	159.16		fullfilled	fullfilled	-74.49
	400	750.00	119.37		fullfilled	fullfilled	-72.00
	490	612.24	97.44		fullfilled	fullfilled	-70.23
	500	600.00	95.49	30	fullfilled	not fullfilled	-40.00
	600	500.00	79.58		fullfilled	not fullfilled	-40.00
	700	428.57	68.21		fullfilled	not fullfilled	-40.00
	800	375.00	59.68		fullfilled	not fullfilled	-40.00
	900	333.33	53.05		fullfilled	not fullfilled	-40.00
MHz	1.00	300.00	47.75		fullfilled	not fullfilled	-40.00
	1.59	188.50	**30.00**		fullfilled	not fullfilled	-40.00
	2.00	150.00	23.87		fullfilled	fullfilled	-38.02
	3.00	100.00	15.92		fullfilled	fullfilled	-34.49
	4.00	75.00	11.94		fullfilled	fullfilled	-32.00
	5.00	60.00	9.55		fullfilled	fullfilled	-30.06
	6.00	50.00	7.96		fullfilled	fullfilled	-28.47
	7.00	42.86	6.82		fullfilled	fullfilled	-27.13
	8.00	37.50	5.97		fullfilled	fullfilled	-25.97
	9.00	33.33	5.31		fullfilled	fullfilled	-24.95
	10.00	30.00	4.77		fullfilled	fullfilled	-24.04
	10.60	28.30	4.50		fullfilled	fullfilled	-23.53
	11.00	27.27	4.34		fullfilled	fullfilled	-23.21
	12.00	25.00	3.98		fullfilled	fullfilled	-22.45
	13.56	22.12	3.52		fullfilled	fullfilled	-21.39
	15.00	20.00	3.18		fullfilled	fullfilled	-20.51
	15.92	18.85	**3.00**		fullfilled	fullfilled	-20.00
	17.00	17.65	2.81		not fullfilled	fullfilled	-20.00
	18.00	16.67	2.65		not fullfilled	fullfilled	-20.00
	20.00	15.00	2.39		not fullfilled	fullfilled	-20.00
	21.00	14.29	2.27		not fullfilled	fullfilled	-20.00
	23.00	13.04	2.08		not fullfilled	fullfilled	-20.00
	25.00	12.00	1.91		not fullfilled	fullfilled	-20.00
	27.00	11.11	1.77		not fullfilled	fullfilled	-20.00
	29.00	10.34	1.65		not fullfilled	fullfilled	-20.00
	30.00	10.00	1.59		not fullfilled	fullfilled	-20.00

4.3.5 Limit

Radiated emissions limits, (3 meters)					
Frequency Range [MHz]	Limit [µV/m]	Limit [dBµV/m] *	Distance [m]	Detector	RBW [kHz]
0.009 – 0.09	2400 / f [kHz]	67.6 – 20Log(f) (kHz)	300	Pk & Avg	0.2
0.09 – 0.11	2400 / f [kHz]	67.6 – 20Log(f) (kHz)	300	Quasi peak	0.2
0.11 – 0.15	2400 / f [kHz]	67.6 – 20Log(f) (kHz)	300	Pk & Avg	0.2
0.15 – 0.49	2400 / f [kHz]	67.6 – 20Log(f) (kHz)	300	Pk & Avg	9
0.49 – 1.705	24000 / f [kHz]	87.6 – 20Log(f) (kHz)	30	Quasi peak	9
1.705 - 30	30	29.5	30	Quasi peak	9

*Remark: In Canada same limits apply, just unit reference is different

4.3.6 Result spectrum-mask

Diagram	Channel	Mode	Maximum Level [dBµV/m] Frequency Range 0.009 – 30 MHz	Result
2.02a	nominal	1 / EUT laying	24.06	Passed
2.02b	nominal	1 / EUT standing	33.41	Passed

Remark: for more information and graphical plot see annex A1 **CETECOM_TR21-1-0037301T008a_A1**

4.3.7 Result radiated spurious emissions

Diagram	Channel	Mode	Maximum Level [dBµV/m] Frequency Range 0.009 – 30 MHz	Result
2.03	nominal	1 / EUT standing	≤20.0 (Noise level) Carrier visible on diagram, not used for verdict	Passed

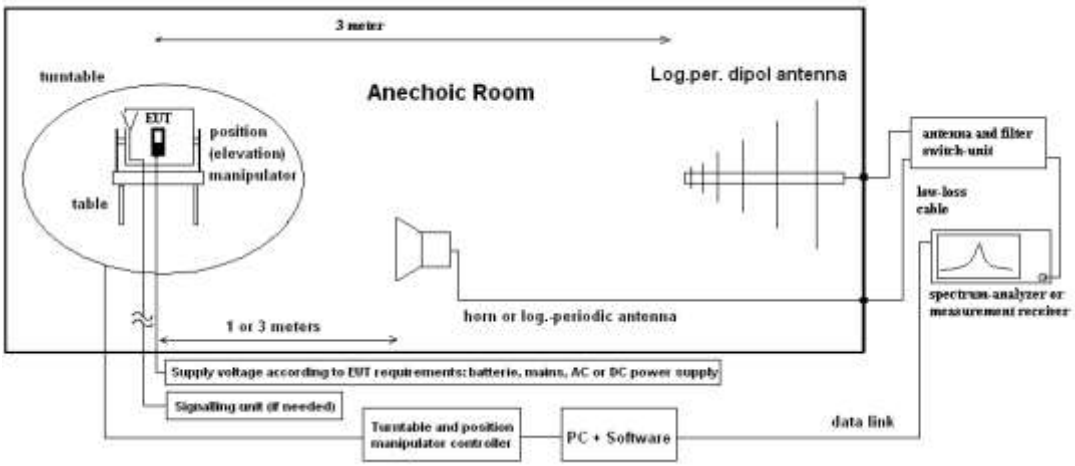
Remark: for more information and graphical plot see annex A1 **CETECOM_TR21-1-0037301T008a_A1**

4.4 Radiated field strength emissions 30 MHz – 1 GHz

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

Evaluating the emissions have to be done first by an exploratory emissions measurement and a final measurement for most critical frequencies. The tests are performed in a CISPR 16-1-4:2010 compliant semi anechoic room (SAR) and fully anechoic room (FAR) recognized by the regulatory commission. The measurement distance was set to 3 meter for frequencies up to 18 GHz and 2 meter above 18 GHz. A logarithmic periodic antenna is used for the frequency range 30 MHz to 1 GHz. Horn antennas are used for frequency range 1 GHz to 40 GHz. The EUT is aligned within 3 dB beam width of the measurement antenna with three orthogonal axis measurements on the EUT.

Schematic:



Testing method:

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

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

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

Final measurement on critical frequencies
Based on the exploratory measurements, the most critical frequencies are re-measured by main-taining the EUT's worst-case operation mode, cable position, etc. either on 10m OATS or 3m semi-anechoic room.
First a frequency zoom around the critical frequency is done to locate the frequency more precisely. After this step, for all identified critical frequencies, the maximum peak was determined.

Following parameters were varied: the turntable angle continuously in the range 0 to 360 degree, the EUT itself either over 3-orthogonal axis (not defined usage position) or 2-orthogonal axis (defined usage position). The measurement antenna height between 1 m and 4 m.
On the determined worst-case position, a final measurement with necessary bandwidth and detector according standard has been carried out

Formula:

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

$M = L_T - E_C$ (2)

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

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

4.4.2 Sample calculation

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

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

4.4.3 Measurement Location

Test site	120901 Radiated emissions 30MHz < f < 1GHz

4.4.4 Limit

Radiated emissions limits, (3 meters)				
Frequency Range [MHz]	Limit [µV/m]	Limit [dBµV/m]	Detector	RBW / VBW [kHz]
30 - 88	100	40.0	Quasi peak	100 / 300
88 - 216	150	43.5	Quasi peak	100 / 300
216 - 960	200	46.0	Quasi peak	100 / 300
960 - 1000	500	54.0	Quasi peak	100 / 300

4.4.5 Result

Diagram	Channel	Mode	Maximum Level [dBµV/m] Frequency Range 30 – 1000 MHz	Result
3.01a	Nominal	1 / EUT standing	42.06	Passed
3.01b	Nominal	1 / EUT laying	35.79	Passed

Remark: for more information and graphical plot see annex A1 **CETECOM_TR21-1-0037301T008a_A1**

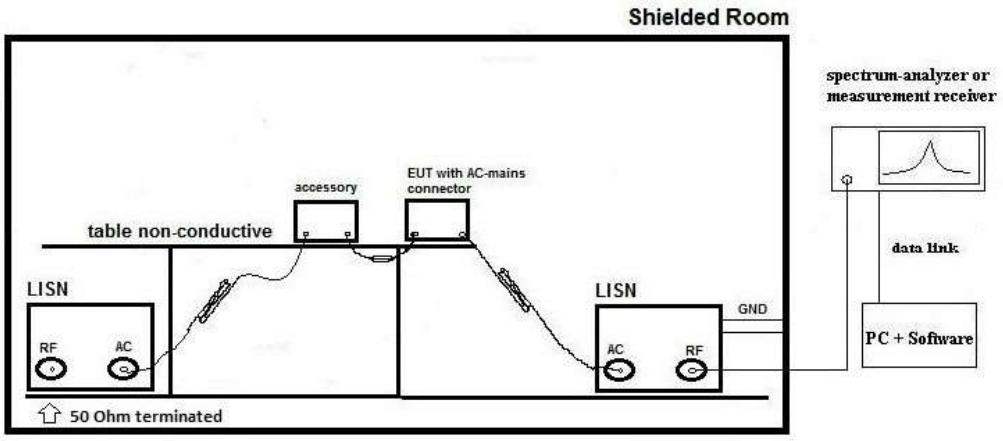
4.5 AC-Power Lines Conducted Emissions

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

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

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

Schematic:



Testing method:

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

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

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

Formula:

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

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

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

4.5.2 Measurement Location

Test site	225924

4.5.3 Limit

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

4.5.4 Result

Diagram	Mode	Power Line	Max [dBµV]	Detector	Result
1.01	1 / TX	L1/N	43.84	AV	Further investigation necessary due NFC carrier on diagram
1.02	1 /TX. Remark2	L1/N	34.50	QP	Passed

Remarks:

1.) see more in diagrams in separate document **CETECOM_TR21-1-0037301T008a_A1**
2.) EUT NFC antenna was substituted by resistor in order to check for coupling of 13.56MHz and first harmonic into AC-main power line. With NFC antenna substituted, the direct RF-coupling into AC-mains cable on 13.56MHz and harmonic could be avoided.

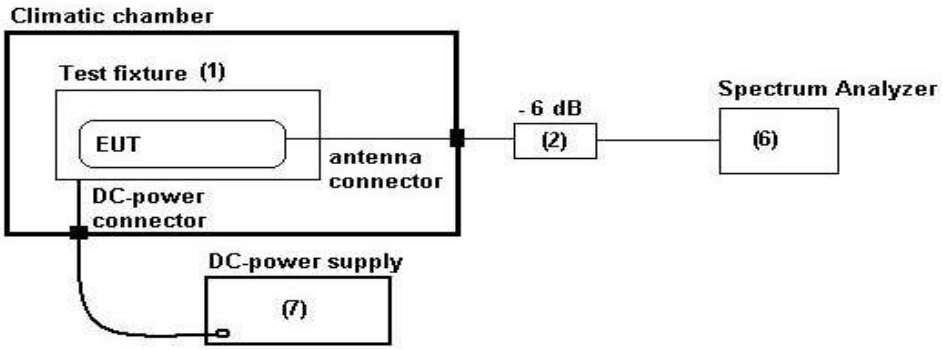
4.6 Frequency stability

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

A sniffer antenna acts like a coupling antenna for measuring the fundamental frequency. This is placed at about 20cm away from the equipment. Also connecting cables at the equipment are avoided on the extent possible in order not to degrade the resonance frequency of the equipment and integral antenna.

If the equipment is capable of producing an un-modulated carrier then a trace with max-hold function was recorded. The maximum peak within the span was found, then the frequency deviation was recorded with the build-in frequency counter within the spectrum-analyze. The maximum resolution was chosen on the settings.
The frequency deviation was recorded at switching on point of the equipment and on 2 minutes, 5 minutes and 10 minutes after at in accordance with ANSI 63.10: 2013, Chapter 6.8
All measurements data are enclosed in annex measurements. Here only maximum frequency error is reported.

Schematic:



Testing method:

The measurement is made according to relevant reference clauses:
(See Tables *Summary of Test Results* and *Summary of Test Methods* on page **Fehler! Textmarke nicht definiert.**)

4.6.2 Measurement Location

Test site	227951

4.6.3 Limit

Frequency Range [MHz]	Frequency tolerance			Remarks
	%	[ppm]	[Hz]	
13.553 – 13.567	±0.01	±100	±1355.99161	For voltage variation
13.553 – 13.567	±0.01	±100	±1355.99161	For temperature variation

Remark: for more information and graphical plot see annex A1 **CETECOM_TR21-1-0037301T008a_A1**

4.6.4 Results

4.6.4.1 Results for voltage variation

Set-up: 2
Op.Mode: 2

FreqError §15.225

DC power supply

Nominal condition

Vnom = 5.0 V (full battery) Tnom = 21°C	13.55991610	MHz	Limit-> 100ppm:	1355.99161	Hz
			f_{MIN}:	13.55856011	MHz
			f_{MAX}:	13.56127209	MHz

Extreme conditions

Voltage		Frequency measured	Values for Frequency Error		
[V]		[MHz]	[Hz]	[%]	[ppm]
V_{MAX}	5.50	13.5599139	-2	0.000016	0.16
	5.40	13.5599142	-2	0.000014	0.14
	5.30	13.5599143	-2	0.000013	0.13
	5.20	13.5599145	-2	0.000012	0.12
	5.10	13.5599147	-1	0.000010	0.10
	5.00	13.5599161			
	4.90	13.5599138	-2	0.000017	0.17
	4.80	13.5599136	-3	0.000018	0.18
	4.70	13.5599135	-3	0.000019	0.19
	4.60	13.5599134	-3	0.000020	0.20
	4.50	13.5599133	-3	0.000021	0.21
	4.40	13.5599132	-3	0.000021	0.21
V_{MIN}	4.30	13.5599131	-3	0.000022	0.22

Remark: for more information and graphical plot see annex A1 **CETECOM_TR21-1-0037301T008a_A1**

Verdict: PASSED

4.6.4.2 Results for temperature variation

Set-up: 2
Op.Mode: 2

FreqError §15.225

Nominal conditions

Vnom = 5.0V (DC Supply) Tnom = 21°C	**Measured Reference frequency [MHz]**	**13.5599161**	Limit-> 100 ppm: 1355.99161 Hz

Extreme conditions

Temperature	Measurement period after power-up the EUT	Frequency measured	Values for Frequency Error [Hz]	[%]	[ppm]	Abs. Maximum Value	Absolute Maximum value	Verdict
Tmax=80°C	on StartUp	13.5598895	-26.6000000	-0.000196	-1.96	1.96	14.34	Passed
	2 Minutes	13.5598949	-21.2000000	-0.000156	-1.56			
	5 Minutes	13.5598997	-16.4000000	-0.000121	-1.21			
	10 Minutes	13.5599067	-9.4000000	-0.000069	-0.69			
Tmax=70°C	on StartUp	13.5598467	-69.4000000	-0.000512	-5.12	5.12		
	2 Minutes	13.5598494	-66.7000000	-0.000492	-4.92			
	5 Minutes	13.5598515	-64.6000000	-0.000476	-4.76			
	10 Minutes	13.5598545	-61.6000000	-0.000454	-4.54			
Tmax=60°C	on StartUp	13.5598332	-82.9000000	-0.000611	-6.11	6.13		
	2 Minutes	13.5598330	-83.1000000	-0.000613	-6.13			
	5 Minutes	13.5598330	-83.1000000	-0.000613	-6.13			
	10 Minutes	13.5598332	-82.9000000	-0.000611	-6.11			
Tmax=50°C	on StartUp	13.5598441	-72.0000000	-0.000531	-5.31	5.62		
	2 Minutes	13.5598426	-73.5000000	-0.000542	-5.42			
	5 Minutes	13.5598414	-74.7000000	-0.000551	-5.51			
	10 Minutes	13.5598399	-76.2000000	-0.000562	-5.62			
T=40°C	on StartUp	13.5598673	-48.8000000	-0.000360	-3.60	4.09		
	2 Minutes	13.5598649	-51.2000000	-0.000378	-3.78			
	5 Minutes	13.5598633	-52.8000000	-0.000389	-3.89			
	10 Minutes	13.5598607	-55.4000000	-0.000409	-4.09			
T=30°C	on StartUp	13.5598957	-20.4000000	-0.000150	-1.50	2.46		
	2 Minutes	13.5598828	-33.3000000	-0.000246	-2.46			
	5 Minutes	13.5598909	-25.2000000	-0.000186	-1.86			
	10 Minutes	13.5598883	-27.8000000	-0.000205	-2.05			
T=10°C	on StartUp	13.5598800	-36.1000000	-0.000266	-2.66	2.66		
	2 Minutes	13.5598825	-33.6000000	-0.000248	-2.48			
	5 Minutes	13.5598871	-29.0000000	-0.000214	-2.14			
	10 Minutes	13.5598943	-21.8000000	-0.000161	-1.61			
T=0°C	StartUp	13.5599455	29.4000000	0.000217	2.17	2.17		
	2 Minutes	13.5599453	29.2000000	0.000215	2.15			
	5 Minutes	13.5599453	29.2000000	0.000215	2.15			
	10 Minutes	13.5599452	29.1000000	0.000215	2.15			
T=-10°C	StartUp	13.5599392	23.1000000	0.000170	1.70	1.80		
	2 Minutes	13.5599399	23.8000000	0.000176	1.76			
	5 Minutes	13.5599402	24.1000000	0.000178	1.78			
	10 Minutes	13.5599405	24.4000000	0.000180	1.80			
T=-20°C	StartUp	13.5598895	-26.6000000	-0.000196	-1.96	1.96		
	2 Minutes	13.5598930	-23.1000000	-0.000170	-1.70			
	5 Minutes	13.5598951	-21.0000000	-0.000155	-1.55			
	10 Minutes	13.5598976	-18.5000000	-0.000136	-1.36			
T=-30°C	StartUp	13.5598263	-89.8000000	-0.000662	-6.62	6.62		
	2 Minutes	13.5598308	-85.3000000	-0.000629	-6.29			
	5 Minutes	13.5598332	-82.9000000	-0.000611	-6.11			
	10 Minutes	13.5598359	-80.2000000	-0.000591	-5.91			
T=-40°C	StartUp	13.5597217	-194.4000000	-0.001434	-14.34	14.34		
	2 Minutes	13.5597278	-188.3000000	-0.001389	-13.89			
	5 Minutes	13.5597313	-184.8000000	-0.001363	-13.63			
	10 Minutes	13.5597357	-180.4000000	-0.001330	-13.30			

Remark: for more information and graphical plot see annex A1**CETECOM_TR21-1-0037301T008a_A1**

Verdict: PASSED

4.7 Equipment lists

ID	Description	Manufacturer	SerNo	CheckType	Last Check	Interval	Next Check
	120901 - SAC - Radiated Emission <1GHz			calchk	cal: 2015-Jul-21 chk: 2021-Jul-27	cal: 10Y chk: 12M	cal: 2025-Jul-21 chk: 2022-Jul-27
20341	Digital Multimeter Fluke 112	Fluke Deutschland GmbH / Glottertal	81650455	cal	cal: 2022-May-18	cal: 24M	cal: 2024-May-18
20442	Semi Anechoic Chamber	ETS-Lindgren Gmbh / Taufkirchen	-	cnn	cal: - chk: -	cal: - chk: -	cal: - chk: -
20482	filter matrix Filter matrix SAR 1	CETECOM GmbH	-	cnn	cal: - chk: -	cal: - chk: -	cal: - chk: -
20574	Biconilog Hybrid Antenna BTA-L	Frankonia GmbH / Heideck	980026L	cal	cal: 2022-Jun-15	cal: 36M	cal: 2025-Jun-15
20620	Test Receiver ESU26	Rohde & Schwarz Messgerätebau GmbH / Memmingen	100362	cal	cal: 2022-Jun-08	cal: 12M	cal: 2023-Jun-08
20885	Power Supply EA3632A	Agilent Technologies Deutschland GmbH	75305850	cnn	cal: - chk: -	cal: - chk: -	cal: - chk: -
25038	Loop Antenna HFH2-Z2	Rohde & Schwarz Messgerätebau GmbH / Memmingen	879824/13	cal	cal: 2022-Jul-04	cal: 24M	cal: 2024-Jul-04
				cnn	cal: - chk: -	cal: - chk: -	cal: - chk: -
	227951 - Environmental Climatic Change			cnn	cal: - chk: -	cal: - chk: -	cal: - chk: -
20904	Climatic Chamber ClimeEvent C/1000/70a/5	Weiss Umwelttechnik GmbH / Reiskirchen-Lindenstruth	58226223240010	cal	cal: 2022-Nov-29	cal: 24M	cal: 2024-Nov-29
27292	Climatic Chamber WK3-600/70	Weiss Umwelttechnik GmbH / Reiskirchen-Lindenstruth	59226080110010	cal	cal: 2022-Nov-25	cal: 24M	cal: 2024-Nov-25
20431	Near-field probe set Model 7405 EMCO	ETS Lindgreen	9305-2457	cpu	--	--	--
20690	Spectrum Analyzer FSU	Rohde & Schwarz Messgerätebau GmbH	100302/026	cal	Cal: 2021-Mai-20	Cal12	Cal: 2023-Mai-19
20611	Power Supply E3632A	Agilent Technologies Deutschland GmbH	KR 75305854	cpu	--	--	--

Tools used in 'P1M2'

4.7.1 Legend

Note / remarks	Interval of calibration & Verification
12M	12 months
24M	24 months
36M	36 months
10Y	10 Years

Abbreviation Check Type	Description
cnn	Calibration and verification not necessary
cal	Calibration
calchk	Calibration plus intermediate Verification
chk	Verification
cpu	Verification before usage

5 Results from external laboratory

None	--

6 Opinions and interpretations

None	--

7 List of abbreviations

None	--

8 Measurement Uncertainty valid for conducted/radiated measurements

The reported uncertainties are calculated based on the standard uncertainty multiplied with the appropriate coverage factor **k**, such that a confidence level of approximately 95% is achieved. For uncertainty determination, each component used in the concrete measurement set-up was taken in account and it contribution to the overall uncertainty according its statistical distribution calculated.

Issue No.	Measurement type	Reference	Frequency range of measurement		Calculated Uncertainty based on confidence level of 95.54%	Remarks
			Start [MHz]	Stop [MHz]		
1.	RF-Output power (eirp) Unwanted emissions (eirp) [dB]		30	100	4.57	without Pre-Amp
			30	100	4.91	with PreAmp
			100	1000	4.02	without Pre-Amp
			100	1000	4.26	with PreAmp
			1000	18000	4.36	without Pre-Amp
			1000	18000	5.23	with PreAmp
			18000	33000	4.92	Schwarzbeck BBHA9170 (#20302) Antenna set-up non-waveguide antenna)
			33000	50000	4.17	Set-up for Q-Band (WR-22), non-wave guide antenna
			40000	60000	4.69	Set-up U-Band (WR-19), non-waveguide antenna
			50000	75000	4.06	External Mixer set-up V-Band (WR-15)
			75000	110000	4.17	External Mixer set-up W-Band (WR-6)
			90000	140000	5.49	External Mixer set-up F-Band (WR-8)
			140000	225000	6.22	External Mixer set-up G-Band (WR-5)
			225000	325000	7.04	External Mixer set-up (WR-3)
			325000	500000	8.84	External Mixer set-up (WR-2.2)
2.	Radiated Blocking [dB]		1000	18000	2.85	Typical set-up with microwave generator and antenna, value for 7GHz calculated
			18000	33000	4.66	Typical set-up with microwave generator and antenna
			33000	50000	3.48	WR-22 set-up
			50000	75000	3.73	WR-15 set-up
			75000	110000	4.26	WR-6 set-up
3	Frequency Error [kHz]		40000	77000	276.19	calculated for 77 GHz (FMCW) carrier
			6000	7000	33.92	calculated for 6.5GHz UWB Ch.5
	Frequency error [Hz]		11	14	20.76	calculated for 13.56MHz carrier
4	Magnetic field strength		0.009	30	4.86	Magnetic loop antenna, Pre-amp on

9 Versions of test reports (change history)

Version	Applied changes	Date of release
--	Initial release	2022-Dec-16
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End Of Test Report