Test Report
20-1-0194901T11a

DAkkS Deutsche Akkreditierungsstelle
D-PL-12047-01-01
D-PL-12047-01-03
D-PL-12047-01-04

Number of pages:	32	**Date of Report:**	2022-Jan-24
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:**	Eliko Tehnoloogia Arenduskeskus OÜ
Product: **Model:**	**Positioning device** **ELIKO ANCHOR**		
FCC ID:	2AF2I-ANCHOR (Contains FCC ID: 2AC7Z-ESPWROOM32D)	**IC:**	--
Testing has been carried out in accordance with:	**CFR Title 47, Chapter I, Subchapter A** Part15 / Subpart F §15.517 Deviations, modifications or clarifications (if any) to above mentioned documents are written in each section under "Test method and limit".		
Tested Technology:	UWB		
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:

ninovic.perez@cetecom.com 2022.01.25 16:52:21 +01'00'

Digital signiert von: Christian Lorenz
Name: CN = Christian Lorenz email = christian.lorenz@cetecom.com C = DE O = CETECOM GmbH OU = RC&EMC
Datum: 2022.01.25 11:14:31 +01'00'

Dipl.-Ing. Ninovic Perez	Dipl.-Ing. Christian Lorenz
Test Lab Manager	Senior Test Manager
Authorization of test report	Responsible of test report

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1 General information

1.1 Disclaimer and Notes

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

1.2 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 a UWB transmitter. Other implemented wireless technologies were not considered within this test report.

Test case	Reference Clause FCC ☒	Reference Clause ISED ☒	Page	Remark	Result
10 dB bandwidth	§15.517(b)	--	11	--	Passed
Radiated field strength emissions below 30 MHz	§15.205(a) §15.209(a)	--	15	--	Passed
Radiated field strength emissions 30 MHz – 960 MHz	§15.209 §15.517(c)	--	17	--	Passed
Radiated field strength emissions above 960 MHz	§15.521(h) §15.517(c)	--	20	--	Passed
Radiated emissions in the GPS bands	§15.517(d)	--	22	--	Passed
Fundamental emission peak power	§15.517(e)	--	24	--	Passed
Transmission requirements	§15.517(a)(5)	--	--	--	Passed
Operation location	§15.517(f)	--	--	Only indoors	NP
Antenna requirement	§15.203	--	25	--	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.

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

1.4 Summary of Test Methods

Test case	Test method
10 dB bandwidth	ANSI C63.10-2013, §10.1
Radiated field strenght emissions below 30 MHz	ANSI C63.10-2013 §6.3, §6.4
Radiated field strenght emissions 30 MHz- 1 GHz	ANSI C63.10-2013 §6.3, §6.5
Radiated field strenght emissions above 1 GHz	ANSI C63.10-2013 §6.3, §6.6
Radiated emissions in the GPS bands	ANSI C63.10-2013 §6.3, §6.6
Fundamental emission peak power	ANSI C63.10-2013 §6.3, §6.6
Antenna requirement	--

And reference also to Test methods in KDB558074

2 Administrative Data

2.1 Identification of the Testing Laboratory

Company name:	CETECOM GmbH
Address:	Im Teelbruch 116 45219 Essen - Kettwig Germany
Responsible for testing laboratory:	Dipl.-Ing. Ninovic Perez
Accreditation scope:	**DAkkS Webpage: 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:	2021-Apr-08
Date(s) of test:	2021-08-31 to 2021-12-16
Version of template:	22.0101

2.5 Applicant's details

Applicant's name:	Eliko Tehnoloogia Arenduskeskus OÜ
Address:	Aiandi 13/1 12918 Tallinn Estonia
Contact Person:	Inderk Ruiso
Contact Person's Email:	info@eliko.ee

2.6 Manufacturer's details

Manufacturer's name:	Eliko Tehnoloogia Arenduskeskus OÜ
Address:	Aiandi 13/1 12918 Tallinn Estland

2.7 Equipment under Test (EUT)

EUT No.*)	Sample No.	Product	Model	Type	SN	HW	SW
01	20-1-01949S46_C02	Positioning device	ELIKO ANCHOR	-	0009C1	4.9	3.1.0
--	--	--	--	--	--	--	--

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

2.8 Untested Variant (VAR)

2.9 Auxiliary Equipment (AE)

AE No.*)	Sample No.	Auxiliary Equipment	Model	SN	HW	SW
01	20-1-01949S40_C02	Positioning device	ELIKO TAG	000A8E	5D.11	3.1.0
02	20-1-01949S13_C01	Notebook	NP900X3C	J9VZ91DCB00064B	--	Win10+ TeraTerm
03	20-1-01949S31_C01	Ethernet Switch	TEF1109P-8-63W	E6442013938000304	--	--
04	20-1-01949S32_C01	Power supply for AE03	BN031-A65051	--	--	--

*) 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
01	20-1-01949S69_C01	CAT5e PoE	DC power	1.5m
02	20-1-01949S05_C01	Ethernet cable	RJ45	3.0

*) 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 1	--	Commands on Terminal SW	For different Tests: TX, RX, Tag, Anchor	N/A

*) 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 + CAB01	Used for Radiated measurements. AE03 used for some measurements but excluded later from set-up. CAB01 used directly for powering instead. Power setting: 0x23232323.
2	EUT 1 + AE01+AE02+AE03+AE04+CAB02	Used for Timing measurements

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

2.13 EUT operation modes

EUT operating mode no.*)	Operating modes	Additional information
op. 1	TX-Mode 1	With help of special test firmware TX-mode was set-up. We refer to applicants information/papers for details about necessary commands.
op. 2	TX/RX	Communication link to AE01 on channel4

*) 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	**48** V DC via **PoE** connector	
	☐ Battery	Wählen Sie ein Element aus.	
Operational conditions	T_{nom} =21 °C	T_{min} =0 °C	T_{max} =+50 °C
EUT sample type	**Pre-Production**		
Weight	0.1 kg		
Size [LxWxH]	8.0 cm x 7.5 cm x 1.5 cm		
Interfaces/Ports	Ethernet, microUSB		
For further details refer Applicants Declaration & following technical documents			

3.2 Detailed Technical data of Main EUT as Declared by Applicant

Main function	UWB fixed positioning device
Frequency range [MHz]	3100-10GHz
Type of modulation used	Pulsed
Number of channels	1 (channel 4)
Emission designator	--
Equipment type	☐ Imaging Short-Range comunication device ☐ a) Indoor ☐ b) Outdoor ☐ Field disturbance sensor ☐ Short-Range automotive radar
Antenna Type	☒ Integrated ☐ External, no RF- connector ☐ External, separate RF-connector
Max EIRP/1MHz (radiated)	-42.43 dBm / 1 MHz RBW
Max EIRP/50MHz (radiated)	-3.35 dBm / 50 MHz RBW
FCC label attached	No
For further details refer Applicants Declaration & following technical documents	

Description of Reference Document (supplied by applicant)	**Version**	**Total Pages**
Quick set-up guide	1.1	16

3.3 Modifications on Test sample

Additions/deviations or exclusions	--

4 Measurements

4.1 10 dB bandwidth measurement

Testing method:

The frequency at which the maximum power level is measured with the peak detector is designated f_M (RBW=1 MHz, VBW= 3 MHz, peak detection, maxhold). The outermost 1 MHz segments above and below f_M, where the peak power falls by 10 dB relative to the level at f_M, are designated as f_H and f_L. The UWB transmission, and the -10 dB bandwidth (B - 10), is defined as (f_H - f_L). -10 dB bandwidth should be ≥500 MHz and must be contained between 3100 MHz and 10.600 MHz.

Test method	Radiated, 3m distance
Remarks	--

EUT settings

The measurement is made radiated. The EUT was instructed to transmit continuously with maximum power (if adjustable) according applicants declared and applicable settings.
Different characteristics have been checked, e.g. data rates which EUT can operate if applicable.

4.1.1 Measurement Location

Test site	120907 - FAC2 - Radiated Emissions

4.1.2 Limit

Test limit [GHz]
3.1 – 10.6

4.1.3 Spectrum-Analyzer Settings

Span	1.5 GHz
Resolution Bandwidth (RBW)	ANSI 63.10-2013, chapter 10.1
Video Bandwidth (VBW)	Minimum 3 times the resolution bandwidth
Sweep time	Auto-coupled
Detector	Peak detector
Sweep mode	Repetitive Mode, MAX-HOLD, trace stabilization

4.1.4 Result

Mode	Frequency with the maximum power f_M [MHz]	Power at the frequency f_M [dBm]	Lowest frequency bound f_L [MHz]	Highest frequency bound f_H [MHz]	-10 dB bandwidth [MHz]	Result
D11_013a	4029.0	-26.95 (PK)	3650.3	4303.6	653.3	Passed
D11_013b	3994.1	-25.40 (PK)	3684.299	4330.4	646.1	Passed

Remark: for more information and graphical plot see annex A1, **CETECOM_TR20-1-0194901T11a-A1**

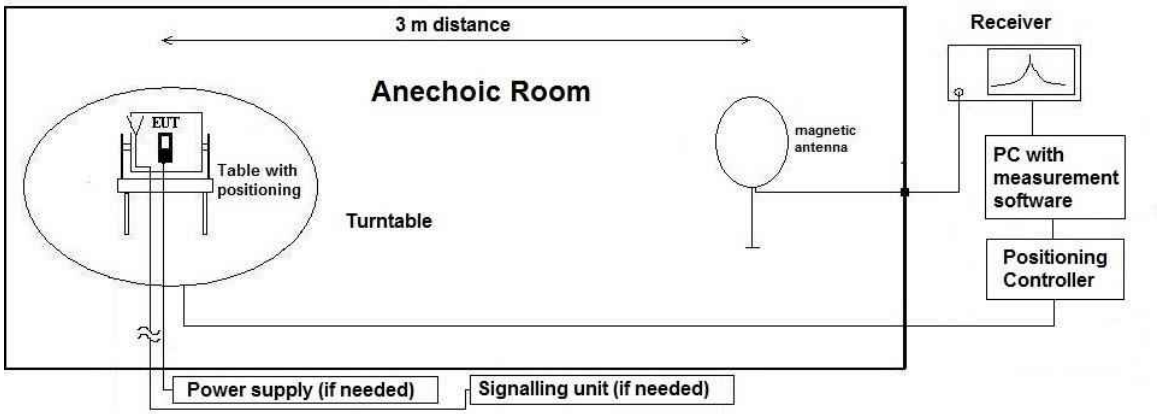
4.2 Radiated field strength emissions below 30 MHz

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

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

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

Schematic:



Testing method:

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

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

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

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

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

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

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

Formula:

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

$M = L_T - E_C$

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

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

4.2.2 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

4.2.3 Measurement Location

Test site	120901 - SAC - Radiated Emission <1GHz

4.2.4 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

4.2.5 Result

Diagram	Channel	Mode	Maximum Level [dBµV/m] Frequency Range 0.009 – 30 MHz	Result
D11_3.03	Ch4	OpMode1	< 20.03	Passed
D11_3.04	Ch4	OpMode1	< 20.79	Passed

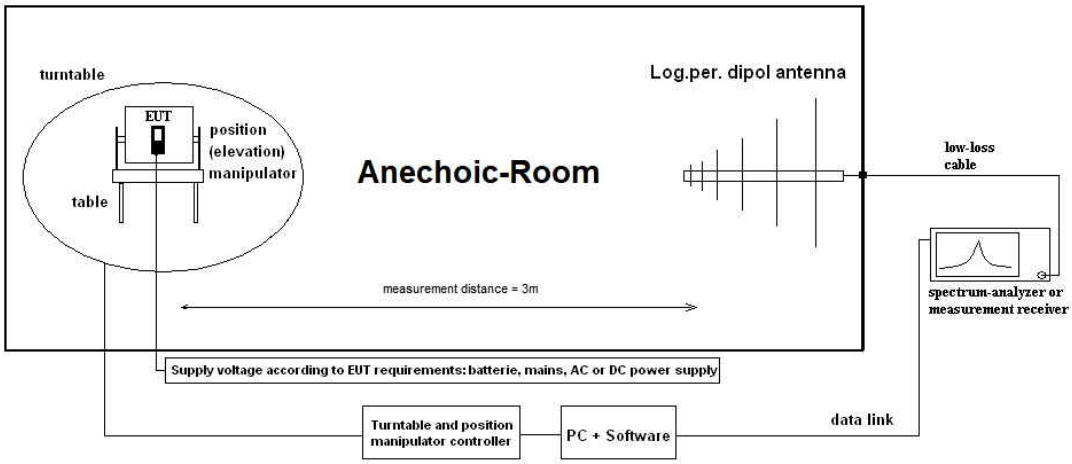
Remark: for more information and graphical plot see annex A1, **CETECOM_TR20-1-0194901T11a-A1**

4.3 Radiated field strength emissions 30 MHz – 960 MHz

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

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

Schematic:



Testing method:

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

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

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

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

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

Formula:

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

$M = L_T - E_C$ (2)

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

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

4.3.2 Measurement Location

Test site	120901 - SAC - Radiated Emission <1GHz

4.3.3 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

4.3.4 Result

Diagram	Channel	Mode	Maximum Level [dBµV/m] Frequency Range 30 – 960 MHz	Result
D11_3.05	Ch4	OpMode 4	32.13	Passed
D11_3.06	Ch4	OpMode4	34.60	Passed

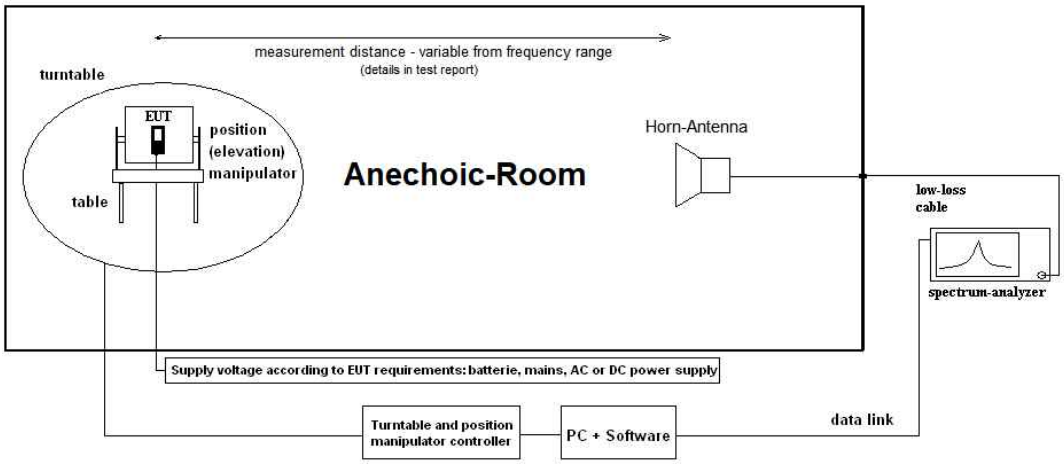
Remark: for more information and graphical plot see annex A1, **CETECOM_TR20-1-0194901T11a-A1**

4.4 Radiated field strength emissions above 960 MHz

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 18-1-4:2010 compliant fully anechoic room (FAR) recognized by the regulatory commission. The measurement distance was set to 3 meter for frequencies up to 18 GHz and 2 meter above 18 GHz. A logarithmic periodic antenna is used for the frequency range 30 MHz to 1 GHz. Horn antennas are used for frequency range 1 GHz to 40 GHz. The EUT is aligned within 3 dB beam width of the measurement antenna with three orthogonal axis measurements on the EUT.

Schematic:



Testing method:

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

Exploratory, preliminary measurements
The EUT and its associated accessories are placed on a non-conductive position manipulator (tipping device) of 1.55 m height which is placed on the turntable. By rotating the turntable (range 0° to 360°, step 15°) and the EUT itself either on 3-orthogonal axis (portable equipment) or 2-orthogonal axis (defined operational position of EUT) the emission spectrum and it's characteristics was recorded with an EMI-receiver, broadband antenna and software.
The measurements are performed in horizontal and vertical polarization of the measurement antennas. The results are documented in a diagram. Critical frequencies (low margin to limit) are saved within a table for further investigations. If various operating modes are supported, further investigations are made to find the worst-case of them. Also the interconnection cables and equipment position were varied in order to maximize the emissions.

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

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

Following parameters were varied: the turntable angle continuously in the range 0 to 360 degree, the EUT itself over 3-orthogonal axis and the height for EUT with large dimensions or three axis scan for portable/small equipment.

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

Formula:

$P_{EIRP} = P_{MEAS} + C_L + FSL - G_A$ (1)

P_{MEAS} = measured power at instrument
M = Margin
L_T = Limit

FSL = Free Space loss = Function(frequency, measurement distance)

$M = L_T - P_{EIRP}$

C_L= cable loss
G_A = Gain of pre-amplifier (if used)

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

4.4.2 Measurement Location

Test site1	120901 - SAC - Radiated Emission <1GHz
Test site2	120907 – FAC2

4.4.3 Limit

Frequency Range [MHz]	EIRP [dBm]	Detector	RBW / VBW [kHz]
960-1610	−75.3	RMS	1000 / 3000
1610-1990	−53.3	RMS	1000 / 3000
1990-3100	−51.3	RMS	1000 / 3000
3100-4750	−41.3	RMS	1000 / 3000
4750-10600	−41.3	RMS	1000 / 3000
10600- 40000	−51.3	RMS	1000 / 3000

4.4.4 Measurement distance

Frequency Range [MHz]	Measurement distance [m]
960-1610	2.0
1610-1990	2.0
1990-4193	2.0
4193-10600	3.0
10600- 15000	2.0
15000-18000	2.0
18000-33000	2.0
33000-40000	1.0

4.4.5 Result

Diagram	Frequency range [MHz]	Mode	Remark	Result
D11_019a	960 – 3100	Op.Mode1	EUT laying, Ant H	Passed, remark1
D11_019a		Op.Mode1	EUT standing, Ant H	Passed, remark1
D11_019a_f1	1136.117	Op.Mode1	EUT laying, Ant H	Passed (digital emission)
D11_019b	960 – 3100	Op.Mode1	EUT laying, Ant V	Passed, remark1
D11_019b		Op.Mode1	EUT standing, Ant V	Passed, remark1
D11_11a	3100 - 10600	Op.Mode1	AntH	Passed
D11_11b		Op.Mode1	AntV	Passed
D11_12a	10600 - 12400	Op.Mode1	AntH	Passed
D11_12b		Op.Mode1	AntV	Passed
D11_09a	12400 - 18000	Op.Mode1	EUT laying, AntH	Passed
D11_09a		Op.Mode1	EUT standing, AntH	Passed
D11_09b		Op.Mode1	AntV	Passed
D11_10a	18000 – 40000	Op.Mode1	AntH	Passed
D11_10b		Op.Mode1	AntV	Passed

Remark:

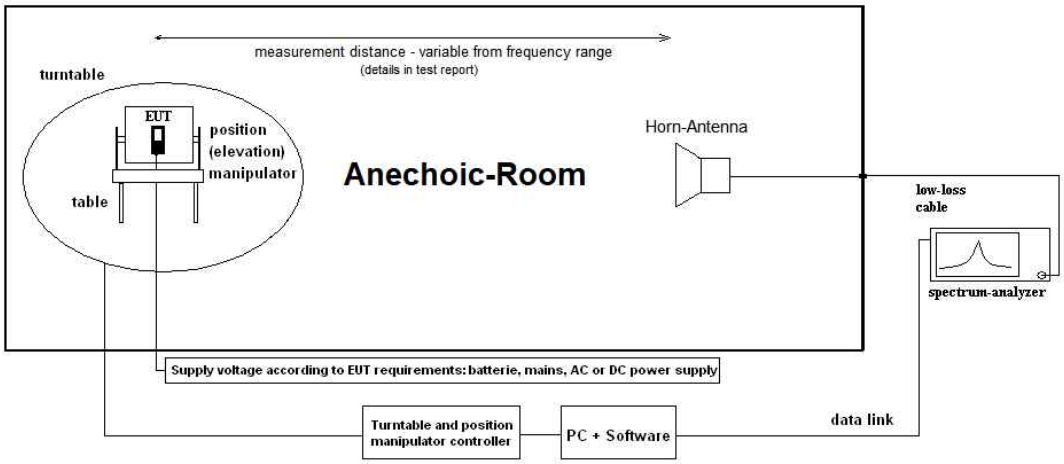
1. Further investigation on nature of emission necessary: UWB emission or digital emission, details in annex A1
2. for more information and graphical plot see annex A1**, CETECOM_TR20-1-0194901T11a-A1**

4.5 Radiated emissions in the GPS bands

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

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

Schematic:



Testing method:

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

Exploratory, preliminary measurements
The EUT and its associated accessories are placed on a non-conductive position manipulator (tipping device) of 1.55 m height which is placed on the turntable. By rotating the turntable (range 0° to 360°, step 15°) and the EUT itself either on 3-orthogonal axis (portable equipment) or 2-orthogonal axis (defined operational position of EUT) the emission spectrum and it's characteristics was recorded with an EMI-receiver, broadband antenna and software.
The measurements are performed in horizontal and vertical polarization of the measurement antennas. The results are documented in a diagram. Critical frequencies (low margin to limit) are saved within a table for further investigations. If various operating modes are supported, further investigations are made to find the worst-case of them. Also the interconnection cables and equipment position were varied in order to maximize the emissions.

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

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

Following parameters were varied: the turntable angle continuously in the range 0 to 360 degree, the EUT itself over 3-orthogonal axis and the height for EUT with large dimensions or three axis scan for portable/small equipment.

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

Formula:

$P_{EIRP} = P_{MEAS} + C_L + FSL - G_A$ (1)

P_{MEAS} = measured power at instrument
M = Margin
L_T = Limit

FSL = Free Space loss = Function(frequency, measurement distance)

$M = L_T - P_{EIRP}$

C_L= cable loss
G_A = Gain of pre-amplifier (if used)

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

4.5.2 Measurement Location

Test site	120907 - FAC2 - Radiated Emissions

4.5.3 Limit

Radiated emissions limits (3 meters)			
Frequency Range [MHz]	EIRP [dBm]	Detector	RBW / VBW [kHz]
1164-1240	−85.3	RMS	1 / 3
1559-1610	−85.3	RMS	1 / 3

4.5.4 Result

Diagram	Frequency range [MHz]	Mode	Remark	Result
D11_020a	1164-1240	OpMode1	AntH	Passed
D11_020b		Op.Mode1	AntV	Passed
D11_021a	1559-1610	Op.Mode1	AntH	Passed
D11_021b		Op.Mode1	AntV	Passed

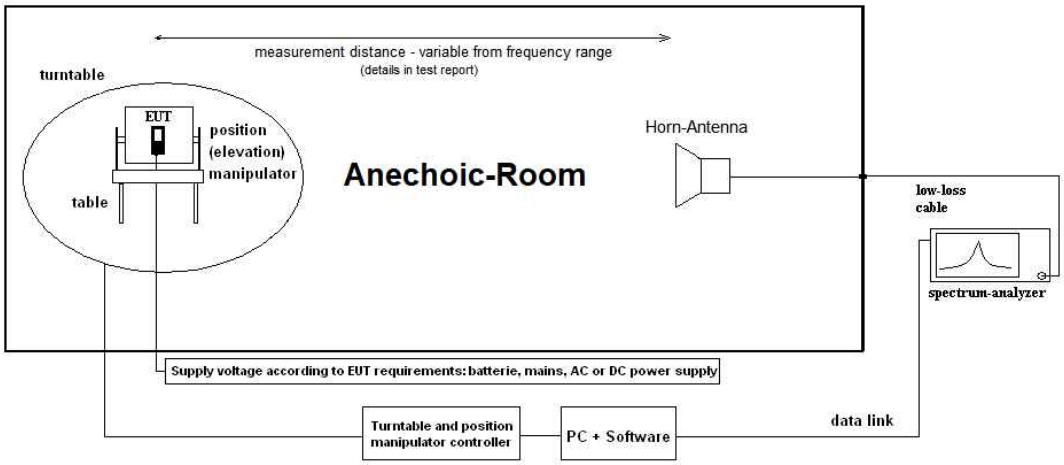
Remark: for more information and graphical plot see annex A1, **CETECOM_TR20-1-0194901T11a-A1**

4.6 Fundamental emission peak power

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

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

Schematic:



Testing method:

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

Exploratory, preliminary measurements
The EUT and its associated accessories are placed on a non-conductive position manipulator (tipping device) of 1.55 m height which is placed on the turntable. By rotating the turntable (range 0° to 360°, step 15°) and the EUT itself either on 3-orthogonal axis (portable equipment) or 2-orthogonal axis (defined operational position of EUT) the emission spectrum and it's characteristics was recorded with an EMI-receiver, broadband antenna and software.
The measurements are performed in horizontal and vertical polarization of the measurement antennas. The results are documented in a diagram. If various operating modes are supported, further investigations are made to find the worst-case of them. Also the interconnection cables and equipment position were varied in order to maximize the emissions.

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

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

Following parameters were varied: the turntable angle continuously in the range 0 to 360 degree, the EUT itself over 3-orthogonal axis and the height for EUT with large dimensions or three axis scan for portable/small equipment.

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

Formula:

$P_{EIRP} = P_{MEAS} + C_L + FSL - G_A$ (1)

P_{MEAS} = measured power at instrument
M = Margin
L_T = Limit

FSL = Free Space loss = Function(frequency, measurement distance)

$M = L_T - P_{EIRP}$

C_L= cable loss
G_A = Gain of pre-amplifier (if used)

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

4.6.2 Measurement Location

Test site	120907 - FAC2 - Radiated Emissions

4.6.3 Limit

Radiated emissions limits (3 meters)			
Frequency Range [MHz]	**EIRP [dBm]**	**Detector**	**RBW / VBW [MHz]**
Frequency with the highest radiated emission contained within a 50 MHz bandwidth	0	MaxPeak	50 / 80

4.6.4 Result

Diagram	fc [MHz]	fmax [MHz]	Pmax [dBm]	Mode	Remark	Result
D03_056a	4007.3	4007.3	-5.70	OpMode1	AntH	Passed
D03_056b	4004.3	4004.3	-3.35	OpMode1	AntV	Passed

Remark1: frequency with the highest radiated emission contained within a 50 MHz bandwidth from the measurement is the frequency inside of the fundamental emission.

Remark2: for more information and graphical plot see annex A1, **CETECOM_TR20-1-0194901T11a-A1**

4.7 Antenna requirement

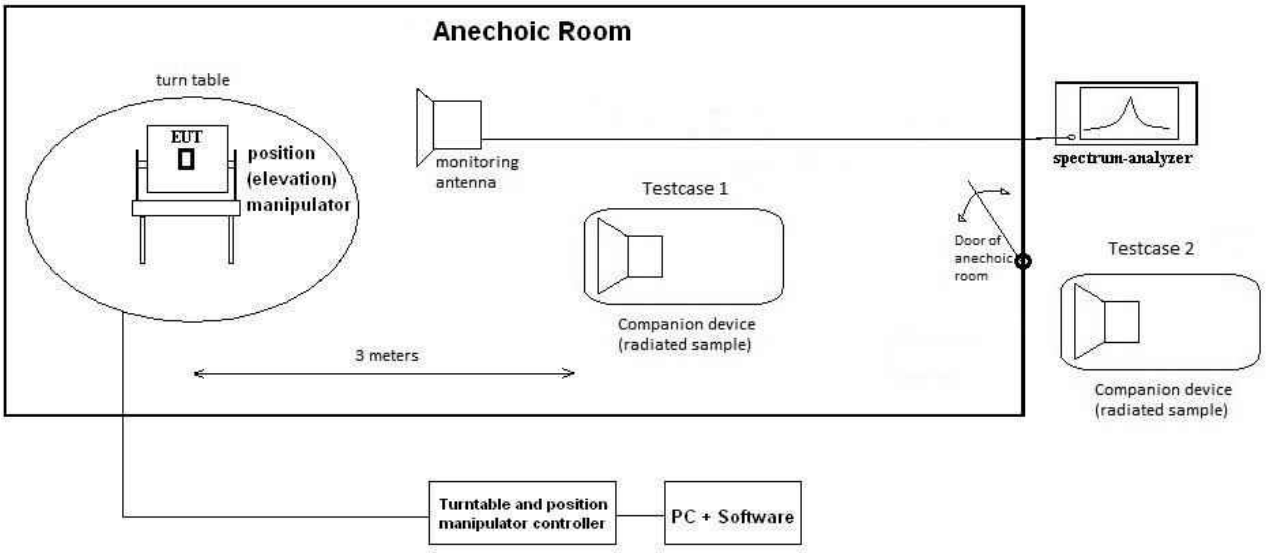
The antenna is integrated, no external connector

4.8 Timing of transmission

4.8.1 Description of the general test setup location and methodology, see below example

The tests are performed in a CISPR 16-1-4:2010 compliant fully anechoic room (FAR). The measurement distance was set to a proper valuable distance for good traffic link communication between the main EUT/DUT and the companion device.

4.8.2 Schematic:



4.8.3 Testing method:

- The tests have been performed in a Fully-Anechoic-Chamber of normative 3m measurement distance or other suitable distance as indicated as typical distance of the system by the applicant. Constraints are the physical distance of the anchoic room.
- Radiated tests at nominal environmental conditions have been performed
- A monitoring horn antenna (1GHz-18GHz) is connected to an spectrum-analyzer (time domain) and is placed near-by the EUT/DUT. Therefore its regular transmission and reaction is captured for two possible test cases: companion device placed near-by DUT/EUT and a second test case companion device not placed near-by DUT/EUT. For both cases a timing diagram is recorded to show the RF-transmissions. In case the communication link system can'not communicate (Anechoic-room door closed) no other transmissions are allowed except for physical detection of the device. In no case data transmissions are allowed.

4.8.4 Measurement Location

Test site	120907 - FAC2 - Radiated Emissions

4.8.5 Limits

Title 47 / Chapter I / Subchapter A/ Part 15	
§15.517(a)(5)	Other then ping/discovery transmissions are not allowed when no associated receiver is present
$15.519(a)(1)	Cease of transmissions within 10seconds

4.8.6 Result

Diagram No.	TX-on	TX-off	Duty-Cycle	Reaction of EUT	Remarks	Verdict
D11_030b	--	97.023ms	--	Data communication with tag	companion device present	-- 1.)
D11_031b	--	--	--	Data communication with tag	companion device present	-- 1.)
D11_032b	--	97.516ms	--	Data transmissions	• Companion device present • D1 Marker on Tag transmissions	-- 1.)
D11_034b	--	--	--	TX cease transmissions after 13.81s	Behavior if no associated companion device present	Passed (Interruption of data transmissions)
D11_036b	--	--	--	TX cease transmissions , no ones following	Long time behavior	Passed (Interruption of data transmissions)

Remarks: D16_051a/052a/053a/056a show regular transmissions to associated receiver for the used case, no verdict necessary

4.9 Equipment lists

ID	Description	Manufacturer	SerNo	CheckType	Last Check	Interval	Next Check
	120901 - SAC - Radiated Emission <1GHz			calchk	cal: 07-21-2015 chk: 05-19-2020	cal: 10Y chk: 12M	cal: July 2025 chk: May 2021
20574	Biconilog Hybrid Antenna BTA-L	Frankonia GmbH	980026L	cal	cal: 05-03-2019	cal: 36M	cal: May 2022
20620	EMI Test Receiver ESU26	Rohde & Schwarz Messgerätebau GmbH	100362	cal	cal: 05-21-2021	cal: 12M	cal: May 2022
20482	filter matrix Filter matrix SAR 1	CETECOM GmbH	-	cnn	cal: - chk: -	cal: - chk: -	cal: - chk: -
25038	Loop Antenna HFH2-Z2	Rohde & Schwarz Messgerätebau GmbH	879824/13	cal	cal: 04-07-2020	cal: 24M	cal: April 2022
20885	Power Supply EA3632A	Agilent Technologies Deutschland GmbH	75305850	cnn	cal: - chk: -	cal: - chk: -	cal: - chk: -
20442	Semi Anechoic Chamber	ETS-Lindgren Gmbh / Taufkirchen	-	cnn	cal: - chk: -	cal: - chk: -	cal: - chk: -
	120902 - SAC - Radiated Emission >1GHz			calchk	cal: 07-15-2017 chk: 12-02-2021	cal: 10Y chk: 24M	cal: July 2027 chk: December 2023
20376	Horn Antenna BBHA9120 E	Schwarzbeck Mess-Elektronik OHG	BBHA 9120 E 179	cal	cal: 04-08-2020	cal: 36M	cal: April 2023
	120904 - FAC1 - Radiated Emissions			chk	chk: 06-11-2021	chk: 12M	chk: June 2022
20341	Digital Multimeter Fluke 112	Fluke Deutschland GmbH	81650455	cal	cal: 05-25-2020	cal: 24M	cal: May 2022
20489	EMI Test Receiver ESU40	Rohde & Schwarz Messgerätebau GmbH	100030	cal	cal: 05-19-2021	cal: 12M	cal: May 2022
20254	High Pass Filter 5HC 2600/12750-1.5KK	Trilithic	23042	chk	chk: 06-11-2021	chk: 12M	chk: June 2022
20291	High Pass Filter WHJ 2200-4EE	Wainwright Instruments GmbH	14	chk	chk: 06-11-2021	chk: 12M	chk: June 2022
20020	Horn Antenna 3115 (Subst 1)	EMCO Elektronik GmbH	9107-3699	calchk	cal: 08-17-2021 chk: 04-20-2013	cal: 36M chk: 12M	cal: August 2024
20549	Log. Per. Antenna HL025	Rohde & Schwarz Messgerätebau GmbH	1000060	calchk	cal: 08-18-2021	cal: 36M chk: 12M	cal: August 2024
20720	Measurement Software EMC32 [FAC]	Rohde & Schwarz Messgerätebau GmbH	V10.xx	cnn	cal: - chk: -	cal: - chk: -	cal: - chk: -
20611	Power Supply E3632A	Agilent Technologies Deutschland GmbH	KR 75305854	cpu			
20338	Pre-Amplifier 100MHz - 26GHz JS4-00102600-38-5P	Miteq Inc.	838697	chk	chk: 06-11-2021	chk: 12M	chk: June 2022
20484	Pre-Amplifier 2,5GHz - 18GHz AMF-5D-02501800-25-10P	Miteq Inc.	1244554	chk	chk: 06-11-2021	chk: 12M	chk: June 2022
20287	Pre-Amplifier 25MHz - 4GHz AMF-2D-100M4G-35-10P	Miteq Inc.	379418	chk	chk: 06-11-2021	chk: 12M	chk: June 2022
20670	Radio Communication Tester CMU200	Rohde & Schwarz Messgerätebau GmbH	106833	cal	cal: 06-16-2020	cal: 24M	cal: June 2022
20690	Spectrum Analyzer FSU	Rohde & Schwarz Messgerätebau GmbH	100302/026	cal	cal: 05-20-2021	cal: 24M	cal: May 2023
20439	Ultrabroadband-Antenna HL562	Rohde & Schwarz Messgerätebau GmbH	100248	calchk	cal: 03-10-2017	cal: 72M chk: 12M	cal: March 2023
	120907 - FAC2 - Radiated Emissions			chk	chk: 08-30-2021	chk: 12M	chk: August 2022
20836	1-18 GHz Amplifier	Wright Technologies, Inc., Inc.	0001	chk		chk: 36M	
20005	AC - LISN 50 Ohm/50µH ESH2-Z5	Rohde & Schwarz Messgerätebau GmbH	861741/005	cal	cal: 05-20-2021	cal: 12M	cal: May 2022
20412	Fully Anechoic Chamber 2	ETS-Lindgren Gmbh / Taufkirchen	without	cnn	cal: - chk: -	cal: - chk: -	cal: - chk: -
20133	Horn Antenna 3115 (Meas 1)	EMCO Elektronik GmbH	9012-3629	cal	cal: 04-08-2020	cal: 36M	cal: April 2023
20811	Horn Antenna ASY-SGH-124-SMA	Antenna Systems Solutions S.L	29F14182337	cal	cal: 10-20-2021	cal: 36M	cal: October 2024
20302	Horn Antenna BBHA9170 (Meas 1)	Schwarzbeck Mess-Elektronik OHG	155	calchk	cal: 04-15-2020 chk: 04-15-2020	cal: 36M chk: 12M	
20877	JS42-08001800-16-8P Verstärker	Miteq Inc.	2079991 / 2079992	chk	chk: 02-27-2020	chk: 3M	chk: May 2020
20912	Low noise Amplifier Module 0.5-4GHz	RF-Lambda Europe GmbH	19041200083	cnn	cal: - chk: -	cal: - chk: -	cal: - chk: -
20913	Phase Amplitude Stable Cable Assembly DC-40GHz	RF-Lambda Europe GmbH	AC19040001	cnn	cal: - chk: -	cal: - chk: -	cal: - chk: -
20816	SGH Antenna SGH-26-WR10	Anteral S.L.	1144	cnn	cal: - chk: -	cal: - chk: -	cal: - chk: -
20732	Signal- and Spectrum Analyzer FSW67	Rohde & Schwarz Messgerätebau GmbH	104023	cal	cal: 05-27-2021	cal: 12M	cal: May 2022
20909	Waveguide Horn Antenna PE9881-24	Pasternack Enterprises, Inc.	37/2016	cnn	cal: - chk: -	cal: - chk: -	cal: - chk: -

Tools used in 'P1M1'

4.9.1 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.

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	4.0 dB 3.6 dB						-
Radiated emissions Enclosure	CISPR 16-2-3	30 - 1 GHz 1 GHz - 18 GHz	4.2 dB 5.1 dB						E-Field
Disturbance power	CISPR 16-2-2	30 MHz - 300	-						-
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 GHz - 26.5 GHz	N/A	0.82	--	N/A	N/A	--	
Conducted emissions on RF-port	-	9 kHz - 2.8 GHz	0.70	N/A	0.70	N/A	0.69	--	N/A - not applicable
		2.8 GHz - 12.75 GHz	1.48	N/A	1.51	N/A	1.43	--	
		12.75 GHz – 18 GHz	1.81	N/A	1.83	N/A	1.77	--	
		18 GHz - 26.5 GHz	1.83	N/A	1.85	N/A	1.79	--	
Occupied bandwidth	-	9 kHz - 4 GHz	0.1272 ppm (Delta Marker)						Frequency error
			1.0 dB						Power
Emission bandwidth	-	9 kHz - 4 GHz	0.1272 ppm (Delta Marker)						Frequency error
	-		See above: 0.70 dB						Power
Frequency stability	-	9 kHz - 20 GHz	0.0636 ppm						-
Radiated emissions Enclosure	-	150 kHz - 30 MHz 30 MHz - 1 GHz 1 GHz - 18 GHz 18 GHz – 26.5 GHz 26.5 GHz – 40 GHz	5.0 dB 4.2 dB 4.91 dB 5.06 dB 5.52 dB						--

9 Versions of test reports (change history)

Version	Applied changes	Date of release
--	Initial release	2022-Jan-24
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End Of Test Report