Test Report

23-1-0078001T001a

Number of pages:	30	**Date of Report:**	2023-Dez-29
Testing company:	cetecom advanced GmbH Untertuerkheimer Str. 6-10 66117 Saarbruecken GERMANY	**Applicant:**	Eliko Tehnoloogia Arenduskeskus OÜ
Product:	**Positioning device**		
Model:	**ELIKO ANCHOR**		
FCC ID:	2AF2I-ANCHOR	**IC:**	27124-ANCHOR
Contains FCC ID:	2AC7Z-ESPWROOM32D	**Contains IC:**	21098-ESPWROOM32D

Testing has been carried out in accordance with:

FCC Regulations
Title 47 CFR, Chapter I, Subchapter A, Part 15
Subpart C Intentional Radiators
§ 15.203 Antenna requirement
§ 15.205 Restricted bands of operation.
§ 15.209 Radiated emission limits; general requirements
Subpart F Ultra-Wideband Operation
§ 15.517 Technical requirements for indoor UWB systems
§ 15.521 Technical requirements applicable to all UWB devices

ISED-Regulations
Radio Standards Specifications
RSS-Gen, Issue 5
General Requirements for Compliance of Radio Apparatus
RSS-220, Issue 1 + Amendment 1 (July 2018)
Devices Using Ultra-Wideband (UWB) Technology

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:

B.Eng. Martin Nunier	Dipl.-Ing. Christian Lorenz
Supervisor Radio Services	Lab Manager
Authorization of test report	Responsible of test report

Table of Contents

Table of Annex			
Annex No.	**Contents**	**Reference Description**	**Total Pages**
Annex 1	Test result diagrams	**TR23-1-0078001T001a_A1**	39
Annex 2	Internal photographs of EUT	**To be supplied by applicant**	--
Annex 3	External photographs of EUT	**TR23-1-0078001T001a_A3**	5
Annex 4	Test set-up photographs	**TR23-1-0078001T001a_A4**	6
The listed attachments are separate documents.			

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 advanced 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(a)	--	10	--	Passed
Radiated field strength emissions below 30 MHz	§15.205(a) §15.209(a)	--	14	--	Passed
Radiated field strength emissions 30 MHz – 960 MHz	§15.209 §15.517(c)	--	16	--	Passed
Radiated field strength emissions above 960 MHz	§15.521(h) §15.517(c)	--	19	--	Passed
Radiated emissions in the GPS bands	§15.517(d)	--	21	--	Passed
Fundamental emission peak power	§15.517(e)	--	23	--	Passed
Antenna requirement	§15.203	--	24	--	NP
Timing requirements	§15.517(a)(5)	--	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 advanced laboratory.

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

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	--

2 Administrative Data

2.1 Identification of the Testing Laboratory

Company name:	cetecom advanced GmbH
Address:	Untertuerkheimer Str. 6-10 66117 Saarbruecken Germany
Responsible for testing laboratory:	Dipl.-Ing. (FH) Andreas Luckenbill M.Sc.
Accreditation scope:	**DAkkS Webpage: FCC ISED**
IC Lab company No. / CAB ID:	3462D / DE0001
Test location 1:	Im Teelbruch 116; 45219 Essen
Test location 2:	--

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:	2023-Aug-29
Date(s) of test:	2023-Oct-25 to 2023-Nov-17
Version of template:	23.1003

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
EUT 1	23-1-00780S06_C01 ("Testsetup A")	Positioning device	ELIKO ANCHOR	standard	KA4D37UEW_0009C1	KA4D37 UEW	4.1
EUT 2	23-1-00780S08_C01 ("Testsetup B/D")	Positioning device	ELIKO ANCHOR		KA4D37UEW_0009D4	KA4D37 UEW	4.1

*) 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
1	23-1-00780S13_C01	Notebook Samsung	NP900X3C	J9VZ91DCB00064B	--	--
2	23-1-00780S10_C01	Mikro Tik POE injector	Gigabit PoE	#1	--	--
3	23-1-00780S04_C01	Positioning device	ELIKO TAG	KT5d34UB_000A8	KT5D34 UB	4.1
4	23-1-00780S11_C01	Samsung Ethernet Adapter	Ethernet to uUSB	#1	--	--
5	23-1-00780S17_C01	Banana DC to 3.5mm jack	--	#1	--	--

*) 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
	#1	Etherne	CAT5	1.5m

*) 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
1	--	Configuration Tool V1.1	Software for configuration of device	V1.1.

*) 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	EUT1 + AE2 + AE4+AE5 + (AE1)	Used for radiated measurements AE1 used temporary for setting up the connection.
2	EUT2 + AE2 + AE3 + AE4 + AE5 + (AE1)	Used for radiated timing measurements. Regular communication to tag (AE3).

*) 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.Mode 1	TX-Mode 1 (A3)	With help of special test firmware TX-mode was set-up. Compliant max. power setting: 0xC4C4C4C4 We refer to applicants information/papers for details about necessary commands. SW1 to be used. 850kBit/s data rate, PRF:64MHz, 256Symbols, Packet size:73
Op.Mode 2	TX-Mode 2 (A1)	With help of special test firmware TX-mode was set-up. Compliant max. power setting: 0xC4C4C4C4 We refer to applicants information/papers for details about necessary commands. SW1 to be used. 850kBit/s data rate, PRF:64MHz, 256Symbols, Packet size:56
Op.Mode 3	TX-Mode 2 (A2)	With help of special test firmware TX-mode was set-up. Compliant max. power setting: 0xC4C4C4C4 We refer to applicants information/papers for details about necessary commands. SW1 to be used. 6.8MBit/s data rate, PRF:64MHz, 128Symbols, Packet size:56
Op.Mode 4	TX-Mode 2	With help of special test firmware TX-mode was set-up. EUT 2 set as Anchor operational mode. (normal mode) We refer to applicants information/papers for details about necessary commands.

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

3 Equipment under test (EUT)

3.1 General Data of Main EUT as Declared by Applicant

Firmware	☒ for normal use (Set-up 2)	☒ Special version for test execution (Set-up1)	
Power supply	☐ AC Mains	-	
	☒ DC Mains	48 V DC via – Ethernet Connector	
	☐ Battery	-	
Operational conditions	T_{nom} =21 °C	T_{min} =0 °C	T_{max} =50 °C
EUT sample type	Pre-Production		
Weight	kg		
Size [LxWxH]	8cm x 7.5 cm x1.5 cm		
Interfaces/Ports	microUSB, Ethernet line		
For further details refer Applicants Declaration & following technical documents			

3.2 Detailed Technical data of Main EUT as Declared by Applicant

Main function	Tag detection/Positioning device		
Frequency range [MHz]	Channel 5 (6489.6MHz)		
Type of modulation used	BPSK/BPM		
Number of channels	1		
Emission designator	M7D		
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. mean power density per MHz (radiated)	-41.85 dBm@3m distance and 1 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**
"Test plan for ELIKO anchor and Tag UWB CH5 FCC testing"		1.0	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	1.0 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
1	6489.6	-26.57 (PK)	6238.4	6743.6	505.2	Passed
2	6489.6	-25.94 (PK)	6238.5	6741.4	502.9	Passed
3	6487.6	-29.51 (PK)	6221.3	6770.7	549.4	Passed

Remark: for more information and graphical plot see annex A1 **TR23-1-0078001T001a_A1**

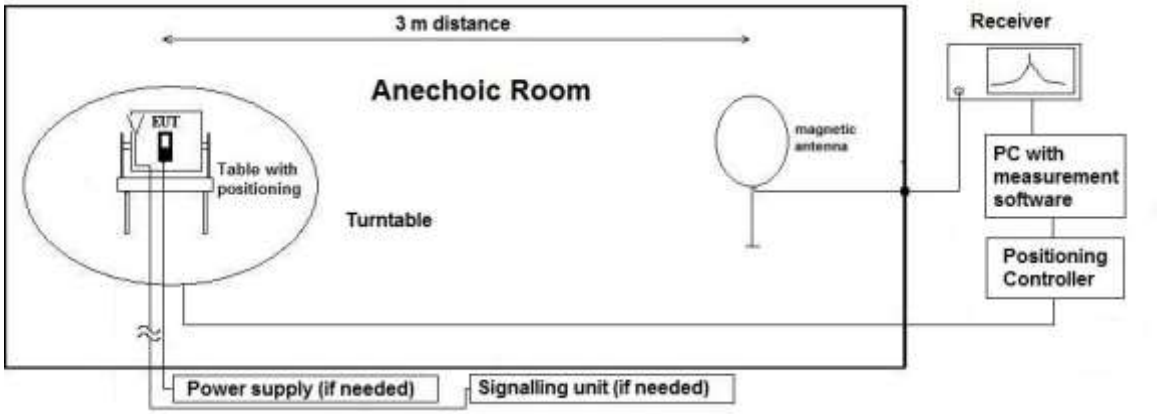
4.2 Radiated field strength emissions below 30 MHz

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 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

4.2.3 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

4.2.4 Measurement Location

Test site	120901 - SAC3 - Radiated Emission <1GHz

4.2.5 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

4.2.6 Result

Diagram	Channel	Mode	Maximum Level [dBµV/m] Frequency Range 0.009 – 30 MHz	Result
2.01	5	1	19.97	Passed
2.02	5	1	19.65	Passed

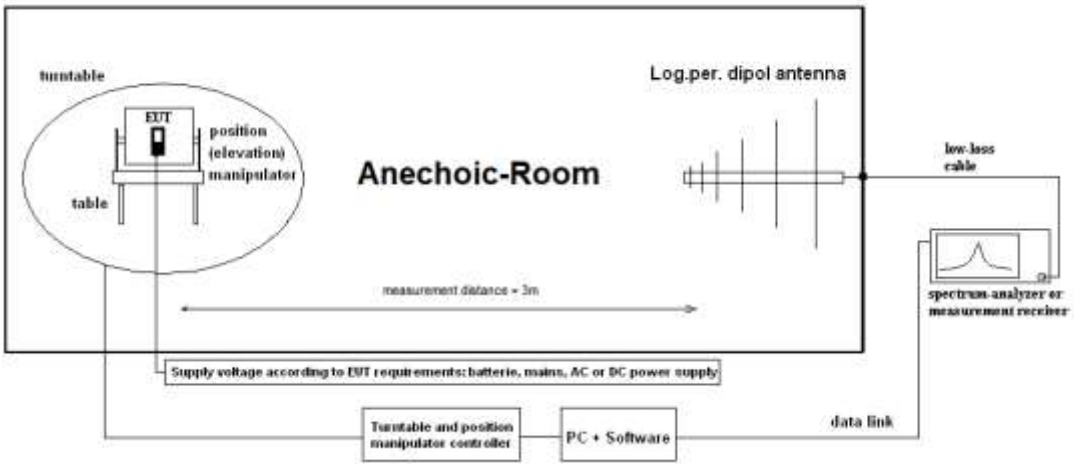
Remark: for more information and graphical plot see annex A1 **TR23-1-0078001T001a_A1**

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 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

4.3.3 Measurement Location

Test site	120901 - SAC3 - Radiated Emission <1GHz

4.3.4 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

4.3.5 Result

Diagram	Channel	Mode	Maximum Level [dBµV/m] Frequency Range 30 – 960 MHz	Result
3.01	5	1	36.37	Passed
3.02	5	1	36.03	Passed

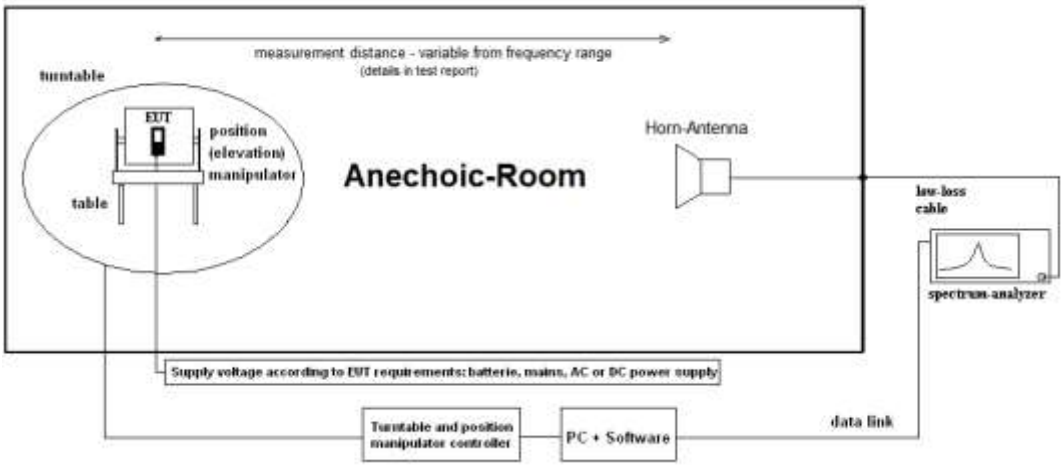
Remark: for more information and graphical plot see annex A1 **TR23-1-0078001T001a_A1**

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 distances in range 1 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 Sample calculation

Raw-Value [dBuV/m]	Antenna factor	Distance Correction [dB]	Cable Loss + Preamplifier	Resulting correction value [dB]	Final result [dBuV/m]	Remarks
29.37	41.20	--	24.28	16.92	46.3	CableLoss and PreAmp data in one data correction file

Remark: This calculation is based on an example value at 10 GHz

4.4.3 Measurement Location

Test site1	120907 - FAC2 - Radiated Emissions
Test site2	120901 - SAC3

4.4.4 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

4.4.5 Measurement distance

Frequency Range [MHz]	Measurement distance [m]
960-1610	2.0 (SAC3)
1610-1990	2.0 (SAC3)
1990-3100	2.0 (SAC3)
3100 - 4750	1.0 (SAC3)
3100-10600	3.0 (FAC2)
18000-33000	1.23 (FAC2)
33000-40000	1.0 (FAC2)

4.4.6 Result

Diagram	Frequency range [MHz]	Mode	Remark	Result
TID020a	960 – 1610	1	AntH, EUT laying	Passed
	1610 - 3100	1	AntH, EUT standing	Passed
TID020b	960 – 1610	1	AntV, EUT laying	Passed
	1610 - 3100	1	AntV, EUT standing	Passed
TID021a_02	3100 - 4750	1	Canada only (more critical limits): AntH, EUT laying	Passed
TID021a_03		1	Canada only (more critical limits): AntH, EUT standing	Passed
TID021a_01	3100 - 4750	1	Canada only (more critical limits): AntV, EUT laying	Passed
TID021a_04		1	Canada only (more critical limits): AntV, EUT standing	Passed
TID007a	6000 - 7000	1	Max. PSD per [MHz]: AntH: -41.85dBm	Passed
TID013a	3100 - 10600	1	Ant H (ax. Value: -41.81dBm)	Passed
TID013b		1	AntV	Passed
TID014a	10600-12400	1	Ant H	Passed
TID014b		1	AntV	Passed
TID015a	12400-18000	1	Ant H	Passed
TID015b		1	AntV	Passed
TID018a	18000-33000	1	Ant H	Passed
TID018b		1	AntV	Passed
TID019a	33000-40000	1	Ant H	Passed
TID019b		1	AntV	Passed

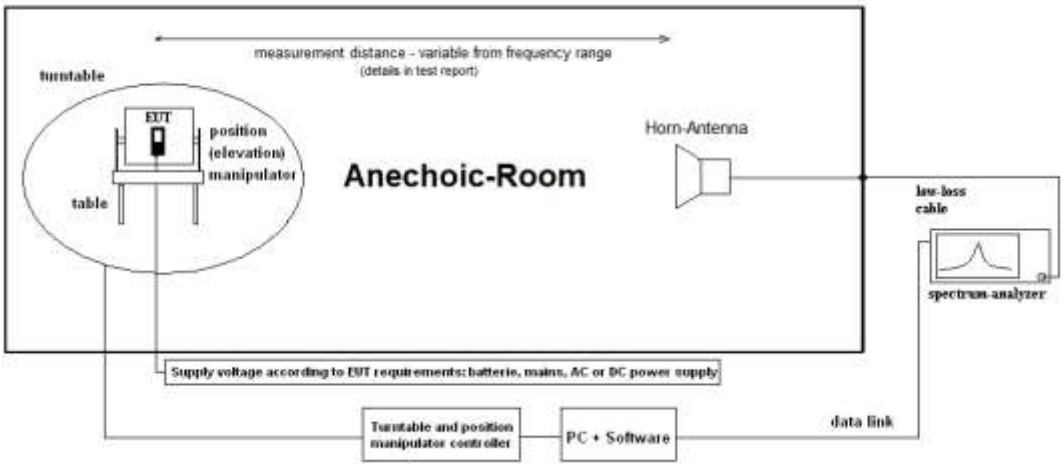
Remark: for more information and graphical plot see annex A1 **TR23-1-0078001T001a_A1**

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	

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
TID016a	1164-1240	1	AntH	Passed
TID016b			AntV	Passed
TID017a	1559-1610	1	AntH	Passed
TID017b			AntV	Passed

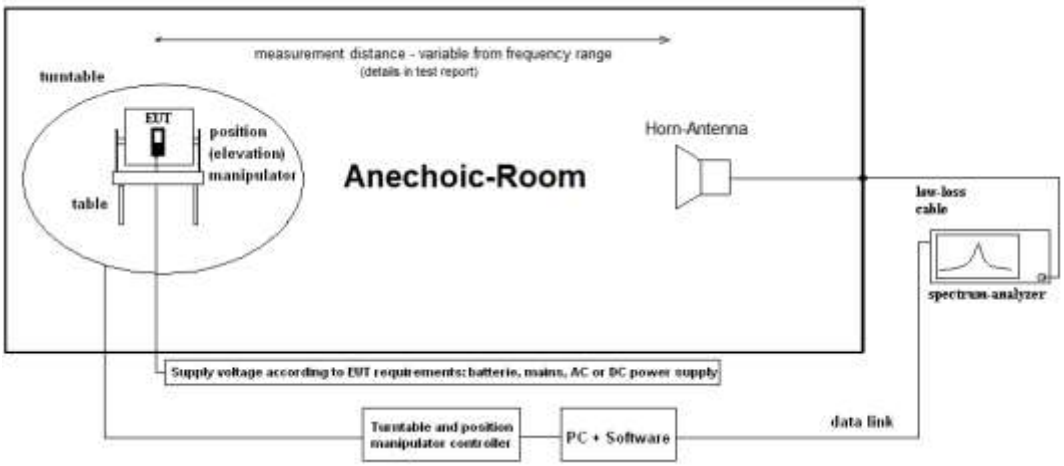
Remark: for more information and graphical plot see annex A1 **TR23-1-0078001T001a_A1**

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
TID009a	6489.6	6489.6	-6.42	1	ANT H	Passed
TID009b	6489.6	6748.5	-17.28	1	ANT V	Passed

Remark1: for more information and graphical plot see annex A1 **TR23-1-0078001T001a_A1**

4.7 Antenna requirement

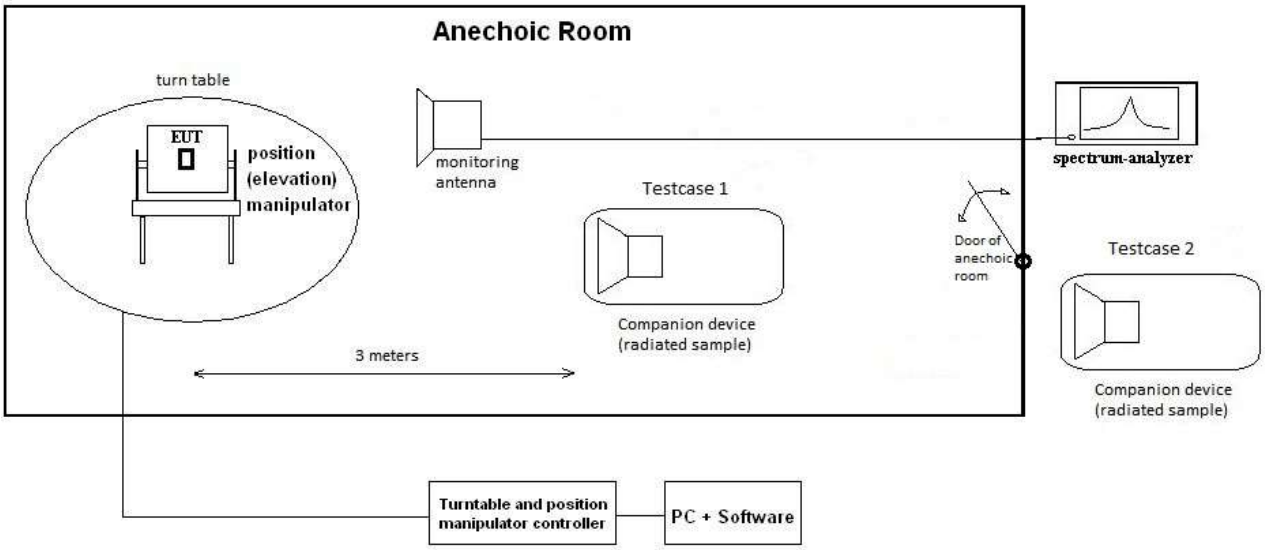
The antenna is integrated inside the EUT, see annex 2 for details

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: Tag companion device placed near-by DUT/EUT and a second test case tag companion device not placed near-by DUT/EUTor switched-off. 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 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

4.8.5 Result

Diagram No.	TX-on	TX-off	Duty-Cycle	Reaction of EUT	Remarks	Verdict
TID022_01	--	--	--	Data transmissions	Companion Tag device present	1.) 5ms period zero span trace shot, showing detailed timing
TID022_02	--	98.84ms	--	Data transmissions	Companion Tag device present	1.) 100ms period zero span trace shot
TID022_03	--	--	--	Data transmissions	Companion Tag device present	1.) 10s period zero span trace shot
TID022_04	--	--	--	Data transmissions	Companion Tag device not present	1.) after 2.7seconds interruption of EUT emissions, silence period can be observed
TID022_05	--	--	--	Data transmissions	Companion Tag device not present	1.) silence period of EUT when no Tag present

4.8.6 Verdict

Passed

4.9 Equipment lists

ID	Description	Manufacturer	SerNo	CheckType	Last Check	Interval	Next Check
	120901 - SAC3 - 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: 2023-May-24	cal: 12M	cal: 2024-May-24
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
	120902 - SAC3 - Radiated Emission >1GHz			calchk	cal: 2017-Jul-15 chk: 2021-Dec-02	cal: 10Y chk: 24M	cal: 2027-Jul-15 chk: 2023-Dec-02
20376	Horn Antenna BBHA9120 E	Schwarzbeck Mess-Elektronik OHG / Schönau	BBHA 9120 E 179	cal	cal: 2023-May-22	cal: 36M	cal: 2026-May-22
	120907 - FAC2 - Radiated Emissions			chk	chk: 2023-Feb-21	chk: 12M	chk: 2024-Feb-21
20133	Horn Antenna 3115 (Meas 1)	EMCO Elektronik GmbH / Gilching	9012-3629	cal	cal: 2023-May-22	cal: 36M	cal: 2026-May-22
20302	Horn Antenna BBHA9170 (Meas 1)	Schwarzbeck Mess-Elektronik OHG / Schönau	155	cpu	chk: 2020-Apr-15	chk: 12M	
20412	Fully Anechoic Chamber 2	ETS-Lindgren Gmbh / Taufkirchen	without	chk	chk: 2023-Apr-14	chk: 6M	chk: 2023-Oct-14
20732	Signal- and Spectrum Analyzer FSW67	Rohde & Schwarz Messgerätebau GmbH / Memmingen	104023	cal	cal: 2023-May-25	cal: 12M	cal: 2024-May-25
20811	Horn Antenna ASY-SGH-124-SMA	Antenna Systems Solutions S.L	29F14182337	cal	cal: 2021-Oct-20	cal: 36M	cal: 2024-Oct-20
20836	1-18 GHz Amplifier	Wright Technologies, Inc., Inc. / Roseville	0001	chk		chk: 36M	
20877	JS42-08001800-16-8P Verstärker	Miteq Inc.	2079991 / 2079992	chk	chk: 2023-Feb-27	chk: 6M	chk: 2023-Aug-27
20909	Waveguide Horn Antenna PE9881-24	Pasternack Enterprises, Inc.	37/2016	cnn	cal: - chk: -	cal: - chk: -	cal: - chk: -
20912	Low noise Amplifier Module 0.5-4GHz	RF-Lambda Europe GmbH / Rüsselsheim	19041200083	cpu	chk: 2020-Dec-01	chk: 6M	chk: 2021-Jun-01
20913	Phase Amplitude Stable Cable Assembly DC-40GHz	RF-Lambda Europe GmbH	AC19040001	cnn	cal: - chk: -	cal: - chk: -	cal: - chk: -
25457	DRG Horn Antenna SAS-574	A.H. Systems, Inc. / Chatsworth	383	cal	cal: 2022-Mar-28	cal: 36M	cal: 2025-Mar-28

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.

Issue No.	Measurement type	Reference	Frequency range of measurement		Calculated Uncertainty based on confidence level of 95.54%	Remarks
			Start [MHz]	Stop [MHz]		
1	Magnetic field strength	FCC15/18/22/ 24/27/90, ISED	0.009	30	4.86	Magnetic loop antenna, Pre-Amp on
2	RF-Output power (eirp) Unwanted emissions (eirp) [dB]	FCC15/18 / ISED	30	100	4.57	without Pre-Amp
			30	100	4.91	with Pre-Amp
			100	1000	4.02	without Pre-Amp
			100	1000	4.26	with Pre-Amp
			1000	18000	4.36	without Pre-Amp
			1000	18000	5.23	with Pre-Amp
			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)
3	Radiated Blocking [dB]	EN 303 883	1000	18000	2.85	Typical set-up with microwave generator and antenna, value for 7 GHz 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
4	Frequency Error / UWB+FMCW [kHz]	EN 303 883 FCC 15	40000	77000	276.19	calculated for 77 GHz (FMCW) carrier
			6000	7000	33.92	calculated for 6.5 GHz UWB Ch.5
	Frequency Error / NFC [Hz]	FCC 15	11.00	14.00	20.76	calculated for 13.56 MHz NFC carrier
5	TS 8997 conducted Parameters	FCC15/18 / ISED	30	6000	1.11	1. Power measurement with Fast-sampling-detector
			30	6000	1.20	2. Power measurement with Spectrum-Analyzer
			30	6000	1.20	3. Power Spectrum-Density measurement
			30	7500	1.20	4. Conducted Spurious emissions:
			0.009	30	2.56	5. Conducted Spurious emissions:
			2.4	2.48	1.95 ppm	6a. Bandwidth / 2-Marker Method for 2.4 GHz ISM
			5.18	5.825	7.180 ppm	6b. Bandwidth / 2-Marker Method for 5 GHz WLAN
			5.18	5.825	1.099 ppm	7. Frequency (Marker method) for 5 GHz WLAN
			30	6000	0.11561µs	8. Medium-Utilization factor / Timing
			30	6000	1.85	9a. Blocking-Level of companion device
			30	6000	1.62	9b. Blocking Generator level
6	Conducted emissions	EN 303 883 FCC 15	0.009	30	3.57	--
			--	--	--	--

9 Versions of test reports (change history)

Version	Applied changes	Date of release
--	Initial release	2023-Dez-29
--	--	--
--	--	--

End Of Test Report