Test Report

22-1-0057101T021-TR1-R02

Number of pages:	33	**Date of Report:**	2024-Jul-18
Testing company:	cetecom advanced GmbH Im Teelbruch 116 45219 Essen Germany Tel. + 49 (0) 20 54 / 95 19-0 Fax: + 49 (0) 20 54 / 95 19-150	**Applicant:**	Zigpos GmbH
Product:	**RTLS anchor**		
Model:	**CorivaSat**		
FCC ID:	2AHHJ-ZP-OXSAT1	**IC:**	32087-ZPOXSAT1
Contains FCC-ID:	Z64-CC3135MOD	**Contains IC:**	451I-CC3135MOD

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
The current version of Test Report 22-1-0057101T021-TR1-R02 replaces the test report 22-1-0057101T021-TR1-R01 dated 2024-07-15. The replaced test report is herewith invalid.

Signatures:

Martin Nunier	Christian Lorenz
Supervisor Radio Services	Lab 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 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)	--	12	--	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)	--	22	--	Passed
Fundamental emission peak power	§15.517(e)	--	25	--	Passed
Timing of transmissions	§15.517(a)(5)	--	28	--	Passed
Antenna requirement	§15.203	--	--	--	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 test ADVANCEDLaboratory.

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

Remarks:
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1.4 Summary of Test Methods

Test case	Test method
10 dB bandwidth	ANSI C63.10-2013, §10.1
Radiated field strength emissions below 30 MHz	ANSI C63.10-2013 §6.3, §6.4
Radiated field strength emissions 30 MHz- 1 GHz	ANSI C63.10-2013 §6.3, §6.5
Radiated field strength 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 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:	Im Teelbruch 116, 45219 Essen

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:	Christian Lorenz
Receipt of EUT:	2023-Jun-05
Date(s) of test:	2023-Jun-26 to 2024-Juli-09
Version of template:	22.0901

2.5 Applicant's details

Applicant's name:	Zigpos GmbH
Address:	Räcknitzhöhe 35a 01217 Dresden Saxony Germany
Contact Person:	Erik Mademann
Contact Person's Email:	mademann@zigpos.com

2.6 Manufacturer's details

Manufacturer's name:	Kathrein Sachsen GmbH
Address:	Lindenstraße 3 09241 Mühlau Germany

2.7 Equipment under Test (EUT)

EUT No.*)	Sample No.	Product	Model	Type	SN	HW	SW
EUT 1	22-1-00571S41_C01	RTLS anchor	CorivaSat	S2AWF-IX	N/A	NIL1.0.3_1.2.0	2023.2
EUT 2	22-1-00571S38_C01	RTLS anchor	CorivaSat	S2AWF-IX	N/A	NIL1.0.3_1.2.0	2023.2
EUT 3	22-1-00571S03_C01	RTLS anchor	CorivaSat	S2AWF-IX	N/A	NIL1.0.3_1.2.0	2023.4

*) EUT short description is used to simplify the identification of the EUT in this test report.
**.) modificated, see chapter 3.3

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	22-1-00571S09_C01	Notebook Dell	XPS13	--	--	*Putty*
2	22-1-00571S35_C01	RS232 to USB converter	--	#1	--	--
3	22-1-00571S11_C01	ZP Gateway B142212	Intel NUC	#320	N/A	2023.4
4	22-1-00571S05_C01	RTLS anchor	CorivaSat	N/A	NIL1.0.3_1.2.0	2023.4
5	22-1-00571S13_C01	PoE Switch	GS308EPP	6V72265H0056A	--	--
6	22-1-00571S16_C01	LAN to USB adapter	CableCreation	--	--	--

*) 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
CAB1	22-1-00571S17_C01	LAN Ethernet CAT5 cable	Ethernet	1.5m
CAB2	22-1-00571S26_C01	LAN Ethernet CAT5 cable	Ethernet	3.0m
CAB3	22-1-00571S27_C01	LAN Ethernet CAT5 cable	Ethernet	3.0m
CAB4	#1	DC-2wired	Un-shielded	1.0m

*) 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	22-1-00571S11_C01	ZP Gateway B142212	Software version timing	2023.4
2	22-1-00571S41_C01	RTLS anchor	UWB Special SW for continuous mode	RF MCU: *"Sat_uwb_simultanuous.hex"*
3	22-1-00571S38_C01	RTLS anchor		
4	22-1-00571S03_C01	RTLS anchor		

*) 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 + AE 2+ CAB1+CAB4	Used for Radiated measurements
2	EUT 2 + AE1 + AE 2+ CAB1+CAB4	Used for Radiated measurements
3	EUT 3 + AE 3 + AE 4 + AE 5 + AE 6 + CAB2 + CAB3 + CAB4	Used for timing tests

*) 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. RF-Path A was activated Power Level settings: 0x86868686 regarding power BW setting 0x2E regarding bandwidth 1 Transmission frame within 1ms period
Op. 2	TX-Mode 2	With help of special test firmware TX-mode was set-up. We refer to applicants information/papers for details about necessary commands. RF-Path B was activated Power Level settings: 0x86868686 regarding power BW setting 0x2E regarding bandwidth 1 Transmission frame within 1ms period
Op. 3	Normal Op. Mode	Used for timing tests
Op. 4	Powered-on	Device powered on DC power connector 24V DC, only Micro-Controller and switched-power supply active. UWB controller not active (Sleep-Mode)

*) 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: Op.Mode2	☒ Special version for test execution Op.Mode1	
Power supply	☐ AC Mains	-	
	☒ DC Mains	24V DC	
	☐ Battery	-	
Operational conditions	T_{nom} =21 °C	T_{min} =-- °C	T_{max} =-- °C
EUT sample type	Pre-Production		
Weight	0.260 kg		
Size [LxWxH]	18.0 cm x 10.0 cm x 5.0 cm		
Interfaces/Ports	Ethernet, DC-Power, Custom 4 lines		
For further details refer Applicants Declaration & following technical documents			

3.2 Detailed Technical data of Main EUT as Declared by Applicant

Main function	UWB device for geo-location		
Frequency range [MHz]	6-9GHz, Channel 9 nominal		
Type of modulation used	PPM		
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: Path A / Path B ☐ External, no RF- connector ☐ External, separate RF-connector		
Max Field strength (radiated)	--		
Max EIRP (radiated)	-41.48 dBm/MHz		
FCC label attached	No		
For further details refer Applicants Declaration & following technical documents			
Description of Reference Document (supplied by applicant)		**Version**	**Total Pages**
--		--	--

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 ☐ Conducted
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	120911

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	1s/1001 bins (1ms/bin)
Detector	Peak detector
Sweep mode	MAX-HOLD

4.1.4 Result, RF-Path A

Diagram no.	Op. Mode:	Set-up No.	Frequency with the maximum power f_M	Power at the frequency f_M	Lowest frequency bound f_L	Highest frequency bound f_H	-10 dB bandwidth	Center Frequency [MHz]	Result
			[MHz]	[dBm]	[MHz]	[MHz]	[MHz]	$fc=(f_L+f_H)/2$	
TID514a	1	2	7985.86	-20.25	7643.96	8181.46	537.5	7912.71	Passed
TID514b	1	2	7986.859	-23.96	7674.559	8236.559	562.0	7955.559	Passed

Remark:
1.) for more information and graphical plot TID514a/b, see corresponding annex A201

4.1.5 Result, RF-Path B

Diagram no.	Op. Mode	Set-up No.	Frequency with the maximum power f_M	Power at the frequency f_M	Lowest frequency bound f_L	Highest frequency bound f_H	-10 dB bandwidth	Center Frequency [MHz]	Result
			[MHz]	[dBm]	[MHz]	[MHz]	[MHz]	$fc=(f_L+f_H)/2$	
TID521a	2	2	7986.859	-21.39	7677.759	8181.359	503.6	7929.559	Passed
TID521b	2	2	7987.858	-22.68	7675.758	8181.658	505.9	7928.708	Passed

1.) for more information and graphical plots, see corresponding annex A202

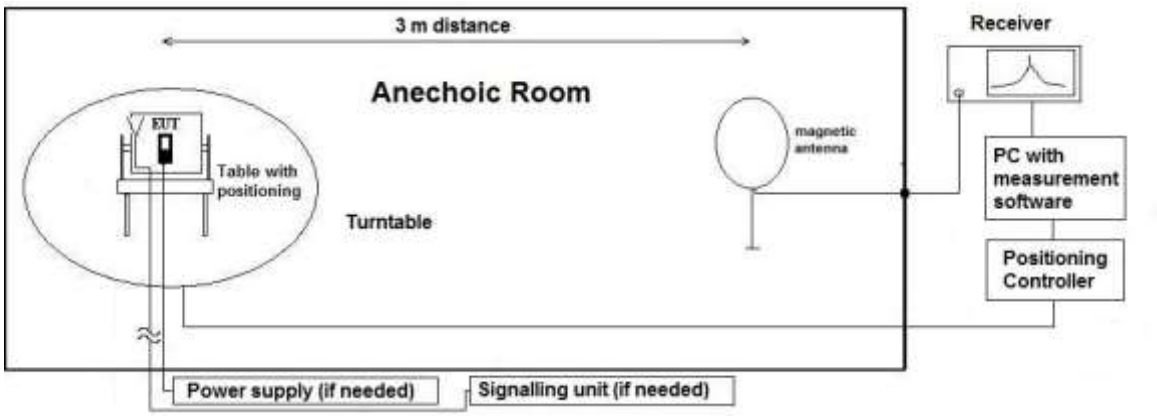
4.2 Radiated field strength emissions below 30 MHz

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

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, Path A

Diagram	Channel	Mode	Maximum Level [dBµV/m] Frequency Range 0.009 – 30 MHz	Result
2.01	Nominal Ch9	1	20.02 (Noise level)	Passed
2.02	Nominal Ch9	1	20.02 (Noise level)	Passed

Remark: for more information and graphical plots, see annex A201

4.2.7 Result, Path B

Diagram	Channel	Mode	Maximum Level [dBµV/m] Frequency Range 0.009 – 30 MHz	Result
TID507	Nominal Ch9	2	20.74@26.78MHz	Passed

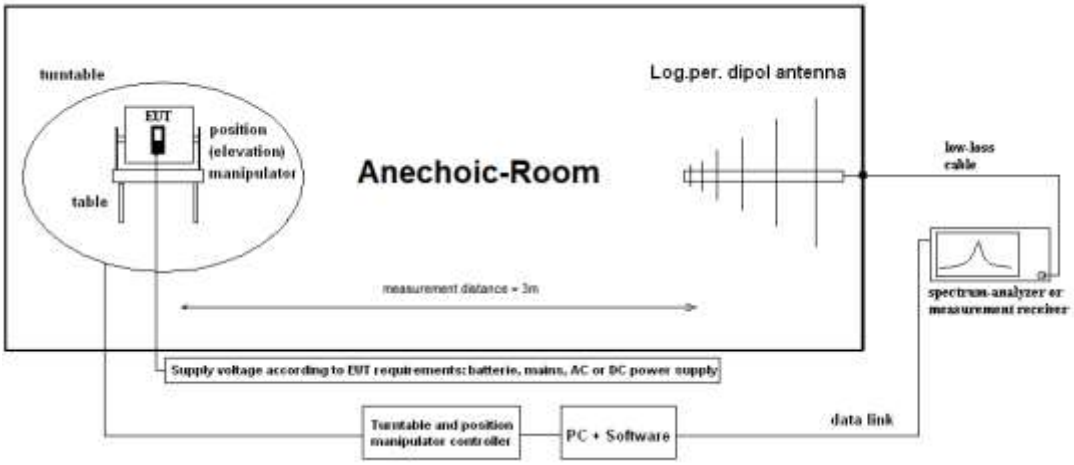
Remark: for more information and graphical plots, see annex A202

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

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, RF-Path A

Diagram	Channel	Mode	Maximum Level [dBµV/m] Frequency Range 30 – 960 MHz	Result
3.01	Nominal Ch9	1	34.94	Passed
3.02	Nominal Ch9	1	8.99	Passed

Remark: for more information and graphical plots, see annex A201

4.3.6 Result, RF-Path B

Diagram	Channel	Mode	Maximum Level [dBµV/m] Frequency Range 30 – 960 MHz	Result
TID506a	Nominal Ch9	2, EUT standing	31.68@148.91MHz	Passed
TID506b	Nominal Ch9	2, EUT laying	34.84@193.17MHz	Passed

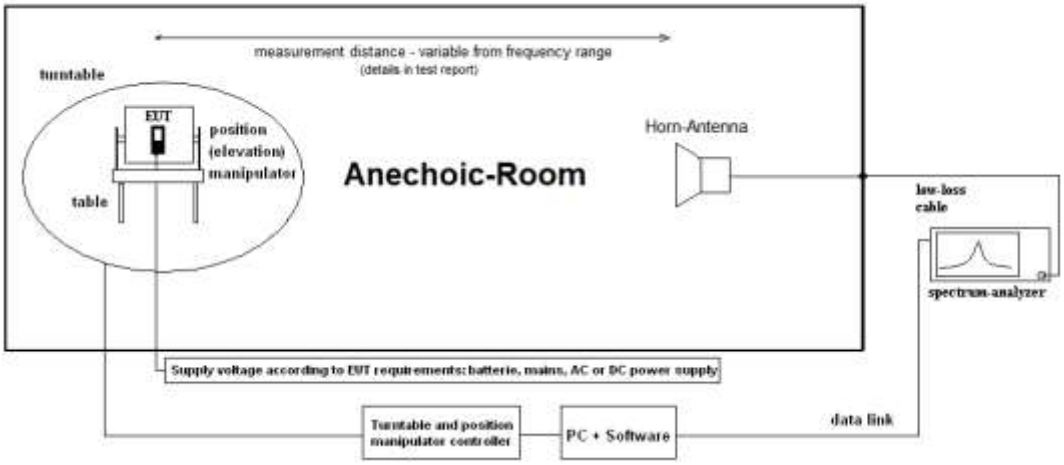
Remark: for more information and graphical plots, see annex A202

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 according §4.4.5. 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 site	120902

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 (FCC&IC)	2.0
1610-1990 (FCC&IC)	2.0
1990-3100 (FCC&IC)	2.0
3100 – 4750 (IC)	1.15m
3100-10600 (FCC&IC)	3.0
10600- 12400 (FCC&IC)	2.0
12400-18000 (FCC&IC)	2.0
18000-40000 (FCC&IC)	1.0

4.4.6 Results, RF Path A

Diagram no.	Frequency range [MHz]	Op.Mode	Value of emission: [dBm]	Result
T021_D007a T021_D007b	960 – 3100	1	≤-80.31 ≤-79.12 (Max. value)	Passed Passed
T021_D008a T021_D008b	3100 - 4750	1	≤-74.55 (Max. value) ≤-75.81	Passed Passed
TID502a TID502b	3100 - 10600	1	≤-41.48 (Max. value) ≤-42.23	Passed Passed
TID509a TID509b	10600 - 12400	1	≤ -60.62 (Noise level) ≤ -60.63 (Noise level)	Passed Passed
TID508a TID508a_01	12400 - 18000	1	-58.39@15.9743GHz	Passed
TID508b TID508b_01			-58.70@15.974GHz	Passed
TID510a TID510a_01	18000 - 40000	1	-66.33@31.948GHz	Passed
TID510b			≤ -64.04 (Noise level)	Passed

Remark: for more information and graphical plot see annex A1

4.4.7 Results, RF Path B

Diagram no.	Frequency range [MHz]	Op.Mode	Value of emission: [dBm]	Result
TID518a TID518b TID518c TID518d	960 – 3100	2	≤-76.35 ≤-79.93 ≤-76.43 ≤-81.56	Passed Passed Passed Passed
TID519a TID519b TID519c TID519d	3100 - 4750	2	≤-76.57 ≤-75.45 ≤-75.98 ≤-76.01	Passed Passed
T021-D001a T021-D001b	3100 - 10600	2	≤-41.61 (Max. value) ≤-42.75	Passed Passed
T021-D004a T021-D004b	10600 - 12400	2	≤ -61.05 ≤ -60.79	Passed Passed
T021-D005a T021-D005b	12400 - 18000	2	-54.03 -55.85	Passed Passed
T021-D0007a T021-D0007b	18000 - 40000	2	-54.07 -54.12	Passed Passed

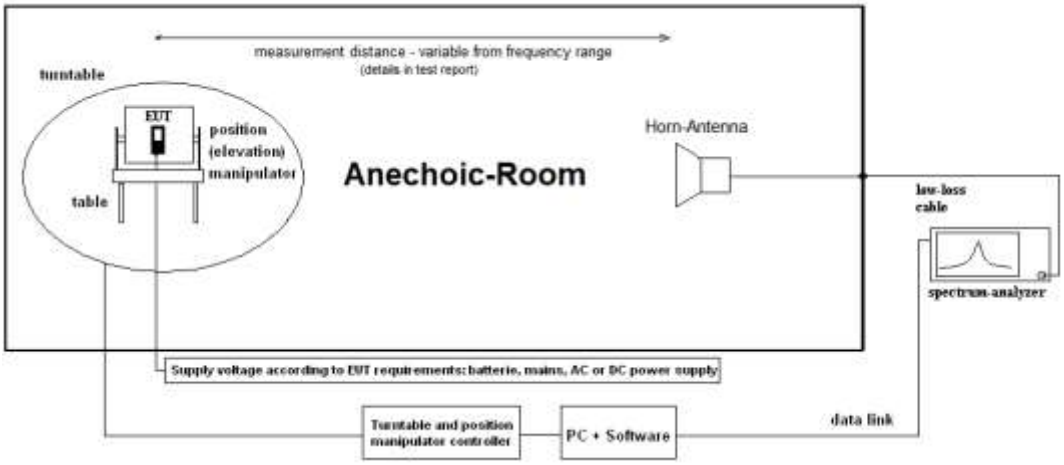
Remark: for more information and graphical plot see annex A1

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. 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

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, RF-Path A

Diagram	Frequency range [MHz]	Mode	Value of emission: [dBm]	Result
TID504a TID504b	1164-1240	1	≤-85.94 ≤-85.93	Passed Passed
TID505a TID505a_01 TID505a_02	1559-1610	1	-82.72@1574.39MHz -81.16 -80.67	Further investigation about origin of emission necessary
TID505a_03 TID505a_04	1559-1610	4	-82.60@1574.399 -81.09	Passed [2.)]
TID505b	1559-1610	1	≤-86.71	Passed

Remark:
1. for more information and graphical plots, see annex A201
2. Emission at 1574.399MHz still present in Op. Mode 4 (EUT powered on, but UWB chip off). Conclusion: not generated by UWB components -> Pass

4.5.5 Result, RF-Path B

Diagram	Frequency range [MHz]	Mode	Value of emission: [dBm]	Result
T021_D003a T021_D003b	1164-1240	2	-86.84 -86.64	Passed Passed
T021_D002a T021_D002b	1559-1610	2	-86.51 -87.36	Passed Passed

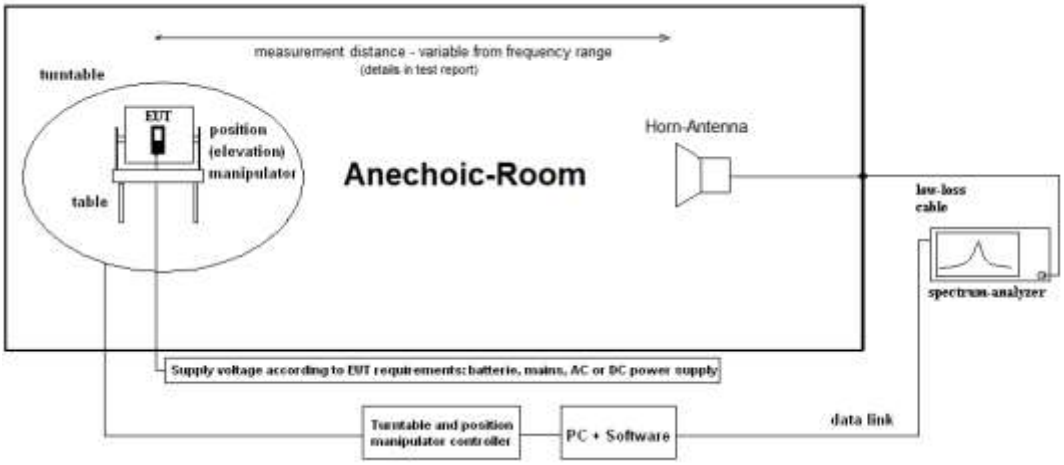
Remark: for more information and graphical plots, see annex A202

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. 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

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 RF-Path A

Diagram	fc [GHz] nominal	fmax [MHz]	Pmax [dBm]	Mode	Remark	Result
TID501a **TID501a_01**	7987.2	7988	-1.5 **-0.53**	1	EUT laying **Max. Search**	Passed Passed
TID501a		7996.8	-2.06	1	EUT standing	Passed
TID501b TID501b_01		7985 7984	-1.68 -1.17	1	EUT standing Max. Search	Passed Passed
TID501b		7985	-8.19	1	EUT laying	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 plots, see annex A201

4.6.5 Result RF-Path B

Diagram	fc [GHz] nominal	fmax [MHz]	Pmax [dBm]	Mode	Remark	Result
T007_D011a	7987.2	7986.8	-3.61	2	--	Passed
T007_D011b		7996.8	-4.12	2	--	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 plots, see annex A202

4.7 Antenna requirement

The antenna is build inside the device. (integral antenna)

4.8 Transmission time measurement

Testing method:

The measurement is made radiated, EUT is place inside an anechoic chamber on a positioning table.
The measurement is made in time domain by the central frequency of the channel with different time span to fully record the EUT time behaviour.
Measurement duration 50ms seconds and 60 s for a long time view of the transmission behaviour.

Normal working op.mode.
1. The UWB intentional radiator (EUT 3) receives an acknowledgement from the associated receiver (AE 4) during all the test time. After disconnecting AE4 from the power. EUT 3 shall cease all data transmissions after last acknowledge in order to pass the test.

EUT settings
Normal SW for operation is set up.

4.8.1 Measurement Location

Test site	120907

4.8.2 Result

The EUT stops to transmissions after the associated receiver is switched off	Result
Yes, compare diagrams: TID009_04, TID009_05 and TID009_06	Passed

Remarks:
1. for more information and graphical plots, see annex A201
2. Set-up 3 used

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: 2024-May-13	cal: 24M	cal: 2026-May-13
20442	Semi Anechoic Chamber SAC3	ETS-Lindgren Gmbh / Taufkirchen	without	cnn	cal: - chk: -	cal: - chk: -	cal: - chk: -
20482	filter matrix Filter matrix SAR 1	cetecom advanced GmbH / Essen	without	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	EMI Test Receiver ESU26	Rohde & Schwarz Messgerätebau GmbH / Memmingen	100362	cal	cal: 2024-May-15	cal: 12M	cal: 2025-May-15
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-Okt-04
	120902 - SAC3 - Radiated Emission >1GHz			calchk	cal: 2017-Jul-15 chk: 2021-Dec-02	cal: 10Y chk:36M	cal: 2027-Jul-15 chk: 2024-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: 2024-Mar-15	chk: 12M	chk: 2025-Mar-15
20133	Horn Antenna 3115 (Meas 1)	EMCO Elektronik GmbH / Gilching	9012-3629	cal	cal: 2023-May-22	cal: 36M	cal: 2026-May-22
20354	DC - Power Supply 40A NGPE 40/40		448	cpu			
20972	Signal- and Spectrum Analyzer FSW50	Rohde & Schwarz Messgerätebau GmbH / Memmingen	101929	cal	cal: 2024-Jan-05	cal: 12M	cal: 2025-Jan-05
20811	Horn Antenna ASY-SGH-124-SMA	Antenna Systems Solutions S.L	29F14182337	cal	cal: 2021-Oct-20	cal: 36M	cal: 2024-Oct-20
20817	Waveguide Rectangular Horn Antenna SAR-2309-22-S2	ERAVANT / Torrance	13254-01	chk	chk: 2023-Oct-20	chk: 12M	chk: 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: 12M	--
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 'P1M3'

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.

Measurement type	Frequency range of measurement		Calculated Uncertainty based on confidence level of 95.54%	Remarks
	Start [MHz]	Stop [MHz]		
Magnetic field strength	0.009	30	4.86	Magnetic loop antenna, Pre-amp on
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)
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
Frequency Error [kHz]	40000	77000	276.19	calculated for 77 GHz (FMCW) carrier
	6000	7000	33.92	calculated for 6.5GHz UWB Ch.5
TS 8997 conducted Parameters	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 2.4GHz ISM
	5.18	5.825	7.180 ppm	6b. Bandwidth / 2-Marker Method for 5GHz WLAN
	5.18	5.825	1.099 ppm	7 Frequency (Marker method) for 5GHz WLAN
	30	6000	0.11561µs	8 Medium-Utilization factor / Timing
	30	6000	1.85	9 Blocking-Level of companion device
	30	6000	1.62	9 Blocking Generator level
Conducted emissions	0.009	30	3.57	

9 Versions of test reports (change history)

Version	Applied changes	Date of release
R01	Initial release containing results for RF-Path A and RF-Path B	2024-Jul-15
R02	Operating bandwidth typo on Path B	2024-Jul-18
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End Of Test Report