Test Report
21-1-0116001T01a

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

Number of pages:	26	**Date of Report:**	2022-May-27
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:**	Alois Kober GmbH
Product: **Model:**	**E&P levelsystem** **E&P levelsystem Main unit**		
FCC ID:	2A5AD-4100970	**IC:**	N/A
Testing has been carried out in accordance with:	**Title 47 CFR, Chapter I** **FCC Regulations, Subchapter A** Part 15, Subpart C: §15.249 Deviations, modifications or clarifications (if any) to above mentioned documents are written in each section under "Test method and limit".		
Tested Technology:	SRD		
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:	Digital signiert von: christian.lorenz@cetecom.com Name: CN = christian.lorenz@cetecom.com Datum: 2022.05.27 16:10:25 +02'00'		Digital signiert von: Timo Franke Name: CN = Timo Franke email = timo.franke@cetecom.com C = DE O = Cetecom GmbH OU = Compliance Lab Datum: 2022.05.27 16:09:48 +02'00'
	Dipl.-Ing. Christian Lorenz Senior Test manager Authorization of test report		Timo Franke Test manager Responsible of test report

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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 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 non-specific 902 MHz – 928 Mhz transmitter. Other implemented wireless technologies were not considered within this test report.

Test case	Reference Clause FCC ☒	Reference Clause ISED ☒	Page	Remark	Result
Occupied Channel Bandwidth 99%	2.202(a) 2.1049(h)	RSS-Gen, Issue 5, §6.7	20	--	PASSED
Transmitter Peak output power radiated Band edge radiated	§15.249(a) §15.249(d)	RSS-210, Issue 10: B.10(a)	10	--	PASSED
Radiated field strength emissions below 30 MHz	§15.205(a) §15.209 §15.249(d)	RSS-Gen, Issue 5: §8.9 Table 6 + 7	12	--	PASSED
Radiated field strength emissions 30 MHz – 1 GHz	§15.205(a) §15.209 §15.249(d)	RSS-Gen, Issue 5: §8.9 Table 5 + 7 RSS-210, Issue 10: B.10 (a)	16	--	PASSED
Radiated field strength emissions above 1 GHz	§15.205 §15.209 §15.249(a)(d)(e)	RSS-Gen, Issue 5: §8.9 Table 5+7 RSS-210, Issue 10: B.10 (b)	18	--	PASSED
Frequency stability	§15.249(b)	--	--	Only for fixed point-to-point operation	N/A

PASSED	The EUT complies with the essential requirements in the standard.
FAILED	The EUT does not comply with the essential requirements in the standard.
NP	The test was not performed by the CETECOM Laboratory.
N/A	Not applicable

*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
Transmitter Peak output power radiated	ANSI C63.10-2013 §6.3, §11.9
Band-edge measurements	ANSI C63.10-2013 §6.10.6 “Marker-delta method“
Occupied Channel Bandwidth 99%	ANSI C63.10:2013 §6.9.3
Emissions in non-restricted frequency bands	ANSI C63.10-2013 §11.11, §6.10.5
Radiated field strength emissions below 30 MHz	ANSI C63.10-2013 §6.3, §6.4
Radiated field strength emissions 30 MHz- 1 GHz	ANSI C63.4-2014 §8.2.3, ANSI C63.10-2013 §6.3, §6.5
Radiated field strength emissions above 1 GHz	ANSI C63.4-2014 §8.3, ANSI C63.10-2013 §6.3, §6.6

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:	Timo Franke
Receipt of EUT:	2021-Nov-29
Date(s) of test:	2021-Dec-03 – 2021-Dec-08
Version of template:	21.1101

2.5 Applicant's details

Applicant's name:	Alois Kober GmbH
Address:	Ichenhauser Str. 14 89359 Kötz Bavaria Germany
Contact Person:	Mr. Sebastian Weis
Contact Person's Email:	sebastian.weis@alko-tech.com

2.6 Manufacturer's details

Manufacturer's name:	Q.E.F. electronic innovations
Address:	Marconiweg 2A 3417 XK Montfoort The Netherlands (NL)

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

Short description*)	PMT Sample No.	Product	Model	Type	S/N	HW status	SW status
EUT 1	21-1-01160S03_C01	E&P levelsystem	E&P levelsystem Main unit	Main unit Camper/Caravan	--	Rev. 1.9	V3.14

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

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

Short description*)	PMT Sample No.	Auxiliary Equipment	Type	S/N	HW status	SW status
--	--	--	--	--	--	--

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

2.9 Connected cables

Short description*)	PMT Sample No.	Cable type	Connectors	Length
CAB 1	21-1-01160S11_01	Power cable	n/a	270 cm
CAB 2	21-1-01160S12_C01	USB cable	USB to 4-Pin-connector	180 cm

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

2.10 Software

Short description*)	PMT Sample No.	Software	Type	S/N	HW status	SW status
SW 1	--	Putty	Serial connection interface	--	--	--

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

2.11 EUT set-ups

set-up no.*)	Combination of EUT and AE	Description
Set 1	EUT 1 + CAB 1 (+ CAB 2 + SW 2)	Used for Radiated and conducted measurements. CAB 2 just used to configure EUT in testmode

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

2.12 EUT operation modes

EUT operating mode no.*1)	Operating modes	Additional information
Op. 1	TX-Mode	EUT set to a specific fixed channel, continuosly transmitting a modulated carrier

*1) 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	**12** V DC via **banana** Connector	
	☐ Battery	-	
Operational conditions	T_{nom} =21 °C	T_{min} =-- °C	T_{max} =-- °C
EUT sample type	**Engineering Samples**		
Weight	0.2 kg		
Size [LxWxH]	14 cm x 8.5 cm x 3 cm		
Interfaces/Ports	9-Pin connection		
For further details refer Applicants Declaration & following technical documents 3af39eec97851004cba7123651444dfa.pdf E&P LevelM_system overview_211001.pdf			

3.2 Detailed Technical data of Main EUT as Declared by Applicant

Frequency Band	902 MHz – 915 MHz	
Number of Channels (USA/Canada -bands)	15	
Nominal Channel Bandwidth	58 kHz – 540 kHz (depends on data rate)	
Type of Modulation | Data Rate	19 kbit / s	
Other installed options	☐ WIFI ☐ Bluetooth LE (not tested within this report) ☐ Cellular transceiver (2G/3G/4G/5G/GPS, not tested in this report) ☒ none	
Output Power	**0** dBm	
Antenna Type	Not reported	
Antenna Gain	Not reported	
FCC label attached	No	
Test firmware / software and storage location	EUT 1	
For further details refer Applicants Declaration & following technical documents		
Description of Reference Document (supplied by applicant)	**Version**	**Total Pages**
EPH_0611 - Wireless Communication | 22.10.2021	**1.0**	**11**

3.3 Modifications on Test sample

Additions/deviations or exclusions	--

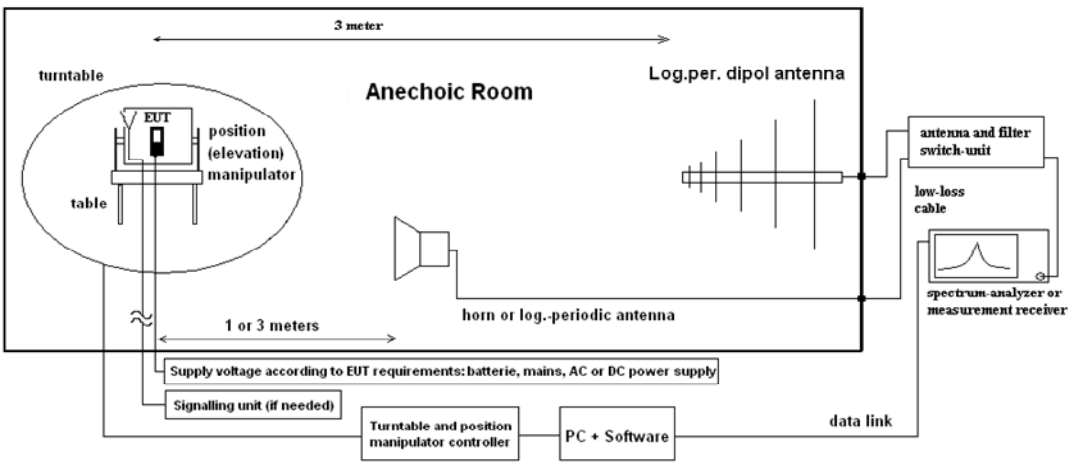
4 Measurements

4.1 Transmitter Peak output power radiated and band edge, §15.249(a)

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

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

Schematic:



Testing method:

The measurement is made according to relevant reference clauses:
(See Tables *Summary of Test Results* and *Summary of Test Methods* on page 6)

4.1.2 Measurement Location

Test site	120901 - SAC - Radiated Emission <1GHz

4.1.3 Limit radiated power

Frequency Range [MHz]	Limit [mV/m]	Limit [dBµV/m]	Limit EIRP [dBm]	Detector
902 – 928	50	94	-1.25	MaxPeak

4.1.4 Result radiated power

Diagram	Mode	Channel	Frequency [MHz]	Max Peak Value [dBµV/m]	Max Peak Power [dBm] 1)	Result
3.04a	Op. 1 | standing	Low	902.48	91.02	-4.18	PASSED
3.04b	Op. 1 | lying	Low	902.48	91.15	-4.05	PASSED
3.05a	Op. 1 | standing	Mid	905.98	90.98	-4.22	PASSED
3.05b	Op. 1 | lying	Mid	905.98	90.86	-4.34	PASSED
3.06a	Op. 1 | standing	High	909.48	91.79	-3.41	PASSED
3.06b	Op. 1 | lying	High	909.48	90.90	-4.30	PASSED

Remark: for more information and graphical plot see annex A1**CETECOM_TR21-1-0116001T01a_A1**
Remark 1: Max Peak Power [dBm] = Max Peak Value [dBµV/m] – 95.2dB (correction factor for 3 m measurement distance)

4.1.5 Limit radiated power

Frequency Range [MHz]	Limit	Detector
902 – 928	50 dBc or general emission limits in § 15.209, whichever is less attenuation	MaxPeak

4.1.6 Result radiated band-edge

Diagram	Mode	Channel	Frequency [MHz]	Max peak value [dBµV/m]	Level at band edge [dBµV/m]	Limit at band edge [dBµV/m] 1)	Result
3.04a	Op. 1 | standing	Low	902.48	91.02	42.70 4)	46 2)	PASSED
3.04b	Op. 1 | lying	Low	902.48	91.15	42.83 4)	46 2)	PASSED
3.06a	Op. 1 | standing	High	909.48	91.79	1) 2)	3)	PASSED
3.06b	Op. 1 | lying	High	909.48	90.90	1) 2)	3)	PASSED

Remark: for more information and graphical plot see annex A1**CETECOM_TR21-1-0116001T01a_A1**
Remark 1): noise level
Remark 2): general § 15.209 emission limit
Remark 3): due the large margin to the upper band edge and the small signal bandwidth measurement is not critical
Remark 4): marker delta method -> measured delta = 48.32 dB | delta is subtracted by the measured radiated Max Peak value

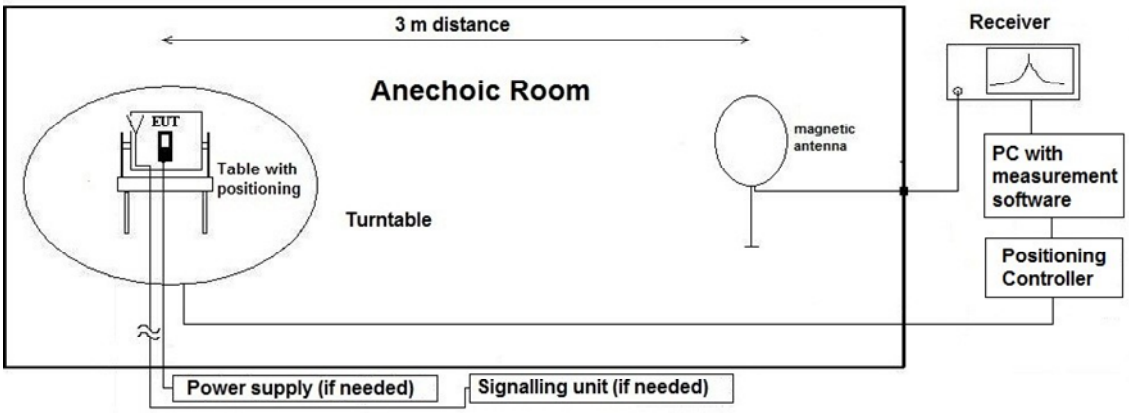
4.2 Radiated field strength emissions below 30 MHz, §15.209

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 6)

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

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

Final measurement on critical frequencies
Based on the exploratory measurements, the most critical frequencies are re-measured by main-taining 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 Measurement Location

Test site	120901 - SAC - Radiated Emission <1GHz

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 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
2.01	Low | 902.5 MHz | lying	1	19.596 (PK) [1)]	PASSED
2.02	Low | 902.5 MHz | standing	1	20.164 (PK) [1)]	PASSED
2.03	Mid | 906 Mhz | lying	1	19.476 (PK) [1)]	PASSED
2.04	Mid | 906 Mhz | standing	1	19.726 (PK) [1)]	PASSED
2.05	High | 909.5 MHz | lying	1	19.737 (PK) [1)]	PASSED
2.06	High | 909.5 MHz | standing	1	20.412 (PK) [1)]	PASSED

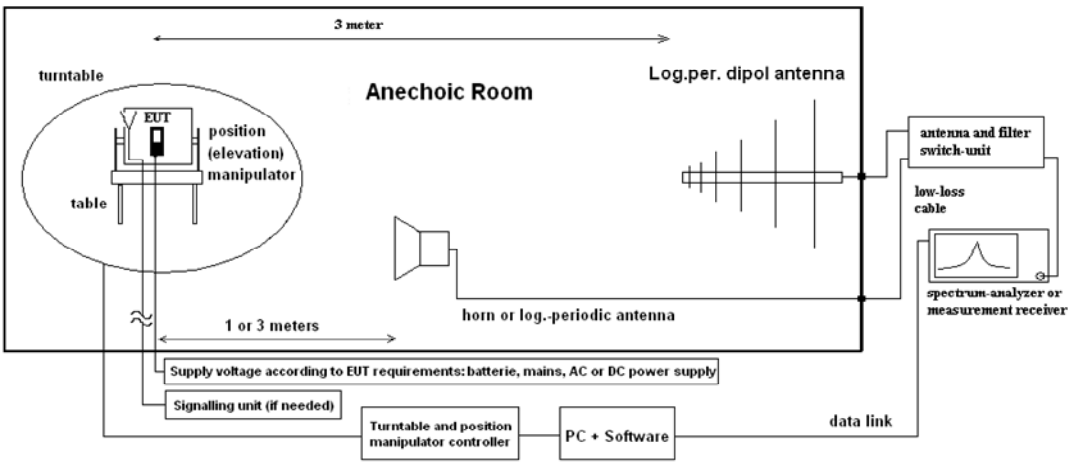
Remark: for more information and graphical plot see annex A1**CETECOM_TR21-1-0116001T01a_A1**
Remark 1: noise level

4.3 Radiated field strength emissions 30 MHz – 1 GHz, §15.209 and §15.249(d)

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

Schematic:



Testing method:

The measurement is made according to relevant reference clauses:
(See Tables *Summary of Test Results* and *Summary of Test Methods* on page 6)

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

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

Final measurement on critical frequencies
Based on the exploratory measurements, the most critical frequencies are re-measured by 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 radiated spurious emissions

Diagram	Channel	Mode	Maximum Level [dBµV/m] Frequency Range 30 – 1000 MHz	Result
3.01a	Low | 902.5 MHz | standing	Op. 1	37.403 (PK)	PASSED
3.01b	Low | 902.5 MHz | lying	Op. 1	35.657 (PK)	PASSED
3.02a	Mid | 906 Mhz | standing	Op. 1	37.001 (PK)	PASSED
3.02b	Mid | 906 Mhz | lying	Op. 1	36.036 (PK)	PASSED
3.03a	High | 909.5 MHz | standing	Op. 1	37.583 (PK)	PASSED
3.03b	High | 909.5 MHz | lying	Op. 1	36.609 (PK)	PASSED

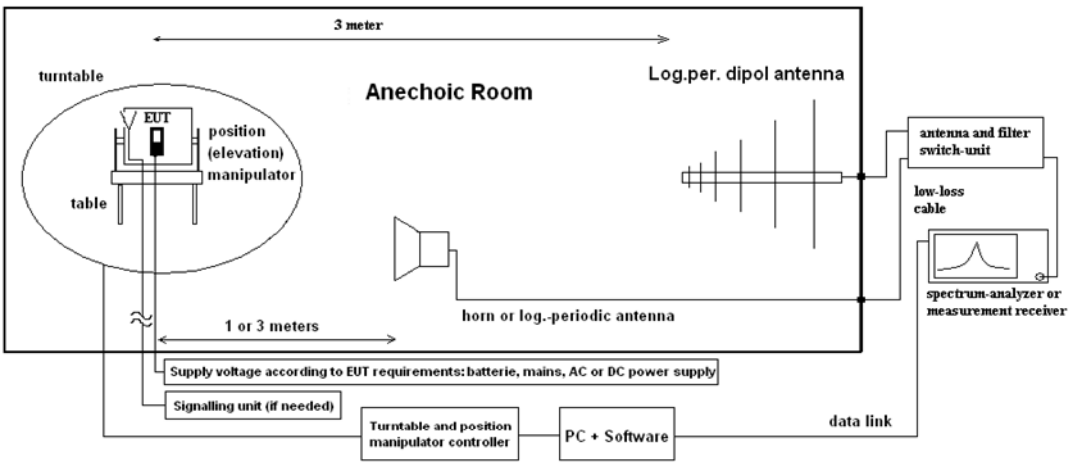
Remark: for more information and graphical plot see annex A1**CETECOM_TR21-1-0116001T01a_A1**

4.4 Radiated field strength emissions above 1 GHz, §15.209 and §15.249(a)(d)(e)

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 6)

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 its 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, the antenna height and tilting 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:

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

$M = L_T - E_C$ (2)

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

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

4.4.2 Measurement Location

Test site 1 – 9.5 GHz	120904 - FAC1 - Radiated Emissions

4.4.3 Limit

Radiated emissions limits, (3 meters)				
Frequency Range [MHz]	Limit [µV/m]	Limit [dBµV/m]	Detector	RBW / VBW [kHz]
Above 1000	500	54	Average	1000 / 3000
Above 1000	5000	74	Peak	1000 / 3000

4.4.4 Result

Diagram	Channel	Mode	Maximum Level [dBµV/m] Frequency Range 1 – 9.5 GHz	Result
4.01a	Low | 902.5 MHz	1	47.91 (AV) 1)	PASSED
4.01b	Low | 902.5 MHz	1	47.81 (AV) 2)	PASSED
4.02	Mid | 906 Mhz	1	48.21 (AV) 2)	PASSED
4.03	High | 909.5 MHz	1	51.25 (AV) 2)	PASSED

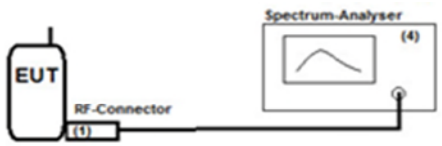
Remark: for more information and graphical plot see annex A1**CETECOM_TR21-1-0116001T01a_A1**
Remark 1: noise level.
Remark 2: level where margin in relation to limit is most critical.

4.5 Occupied Channel Bandwidth 99%, §2.1049(h)

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

The EUT's RF-signal is coupled out by a suitable antenna coupling connector (1). The signal is first attenuated (2) then on the RF-coupler the coupled RF-path is connected to a Bluetooth test unit communication tester (5). The direct RF-path is connected to the spectrum – analyzer (4) for specific RF-measurements. The specific attenuation losses for both signal paths/branches are determined prior to the measurement within a set-up calibration. These are then taken into account by correcting the measurement readings on the spectrum-analyzer.

Schematic:



Testing method:

The measurement is made according to relevant reference clauses:
(See Tables *Summary of Test Results* and *Summary of Test Methods* on page 6)

EUT settings
For FHSS-systems hopping mode was switched-off so fixed three different channels could be measured.
The EUT was instructed to send with maximum power (if adjustable) according applicants instructions.
Different modulation characteristics have been checked, e.g. data rates which EUT can operate.

4.5.2 Measurement Location

Test site	120910 - Radio Laboratory 1 (TS 8997)

4.5.3 Limit

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

4.5.4 Result

Op.Mode	Channel	Frequency [MHz]	99% Occupied bandwidth [kHz]
1	Low	902.5	49.78
1	Mid	906.0	49.78
1	High	909.5	49.80

Remark: for more information and graphical plot see annex A1

4.6 Results from external laboratory

None	-

4.7 Opinions and interpretations

None	-

4.8 List of abbreviations

None	-

5 Equipment lists

ID	Description	Manufacturer	SerNo	Check Type	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
20341	Digital Multimeter Fluke 112	Fluke Deutschland GmbH	81650455	cal	cal: 05-25-2020	cal: 24M	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			
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			
20487	Semi Anechoic Chamber < 1GHz	ETS-Lindgren Gmbh	-	calchk	cal: 07-15-2015 chk: 05-19-2020	cal: 10Y chk: 12M	cal: July 2025 chk: May 2021
	120904 - FAC1 - Radiated Emissions			**chk**	**chk: 06-11-2021**	**chk: 12M**	**chk: June 2022**
20558	CETECOM Fully Anechoic Chamber	CETECOM GmbH	-	chk	cal: 05-08-2019 chk: 06-11-2021	chk: 24M	chk: June 2023
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	cal: 07-14-2014 chk: 06-11-2021	chk: 12M	chk: June 2022
20868	High Pass Filter AFH-07000	AtlanTecRF	16071300004	chk	chk: 06-11-2021	chk: 12M	chk: June 2022
20291	High Pass Filter WHJ 2200-4EE	Wainwright Instruments GmbH	14	chk	cal: 07-14-2014 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
20302	Horn Antenna BBHA9170 (Meas 1)	Schwarzbeck Mess-Elektronik OHG	155	calchk	cal: 04-15-2020 chk: 04-15-2020	cal: 36M chk: 12M	
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			
20512	Notch Filter WRCA 800/960-02/40-6EEK (GSM 850)	Wainwright Instruments GmbH	24	chk	cal: 07-14-2014 chk: 06-11-2021	chk: 12M	chk: June 2022
20290	Notch Filter WRCA 901,9/903,1SS	Wainwright Instruments GmbH	3RR	chk	cal: 07-14-2014 chk: 06-11-2021	chk: 12M	chk: June 2022
20122	Notch Filter WRCB 1747/1748	Wainwright Instruments GmbH	12	chk	cal: 07-14-2014		

ID	Description	Manufacturer	SerNo	Check Type	Last Check	Interval	Next Check
					chk: 06-11-2021	chk: 12M	chk: June 2022
20121	Notch Filter WRCB 1879,5/1880,5EE	Wainwright Instruments GmbH	15	chk	cal: 07-14-2014 chk: 06-11-2021	chk: 12M	chk: June 2022
20448	Notch Filter WRCT 1850.0/2170.0-5/40-10SSK	Wainwright Instruments GmbH	5	chk	cal: 07-14-2014 chk: 06-11-2021	chk: 12M	chk: June 2022
20066	Notch Filter WRCT 1900/2200-5/40-10EEK	Wainwright Instruments GmbH	5	chk	cal: 07-14-2007 chk: 06-11-2021	chk: 12M	chk: June 2022
20449	Notch Filter WRCT 824.0/894.0-5/40-8SSK	Wainwright Instruments GmbH	1	chk	cal: 07-14-2014 chk: 06-11-2021	chk: 12M	chk: June 2022
20611	Power Supply E3632A	Agilent Technologies Deutschland GmbH	KR 75305854	cpu			
20338	Pre-Amplifier 100MHz - 26GHz JS4-00102600-38-5P	Miteq Inc.	838697	chk	cal: 07-14-2014 chk: 06-11-2021	chk: 12M	chk: June 2022
20484	Pre-Amplifier 2,5GHz - 18GHz AMF-5D-02501800-25-10P	Miteq Inc.	1244554	chk	cal: 07-14-2014 chk: 06-11-2021	chk: 12M	chk: June 2022
20287	Pre-Amplifier 25MHz - 4GHz AMF-2D-100M4G-35-10P	Miteq Inc.	379418	chk	cal: 07-14-2014 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
	120911 - Radio Laboratory 2			**cnn**			
20869	Climatic Chamber VT4002	Vötsch Industrietechnik GmbH, a schunk company	521/79152	chk	chk: 10-07-2020	chk: 12M	chk: October 2021
20468	Digital Multimeter Fluke 112	Fluke Deutschland GmbH	90090455	cal	cal: 06-01-2021	cal: 36M	cal: June 2024
20431	Near-Field Probe Set Model 7405	EMCO Elektronik GmbH	9305-2457	cpu			
20457	Power Supply EA-3013 S	EA Elektro-Automatik GmbH & Co. KG	9624680	cpu			
25417	Spectrum Analyser FSU 26	Rohde & Schwarz Messgerätebau GmbH	200413	cal	cal: 07-01-2021	cal: 24M	cal: July 2023

5.1 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

6 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	

7 Versions of test reports (change history)

Version	Applied changes	Date of release
--	Initial release	2022-May-27
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End Of Test Report