Test Report
20-1-0167901T02a-C1

Number of pages:	28	**Date of Report:**	2021-Oct-08
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:**	Geolux d.o.o.
Product: **Model:**	**Water Level Sensor** **LX80**		
FCC ID:	2AN9XLX801	**IC:**	26475-LX801
Testing has been carried out in accordance with:	**Title 47 CFR, Chapter I** **FCC Regulations, Subchapter A** Part 15, Subpart C: §15.256 **ISED Regulations** RSS-Gen, Issue 5 + Amendment 2 RSS-211, Issue 1 Deviations, modifications or clarifications (if any) to above mentioned documents are written in each section under "Test method and limit".		
Tested Technology:	Radar		
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 This test report CETECOM_TR20-1-0167901T02a_C1 dated on 2021-Oct-08 substitutes the CETECOM_TR20-1-0167901T02a dated on 2021-Sep-21, which herewith gets invalid.		
Signatures:	Ninovic Perez 2021.10.08 17:00:26 + 02'00'		Guangcheng Huang 2021.10.08 13:00:38 + 02'00'
	Dipl.-Ing. Ninovic Perez Test Lab Manager Authorization of test report		Guangcheng Huang Test manager Responsible of test report

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1 General information

1.1 Disclaimer and Notes

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

1.2 Attestation

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

1.3 Summary of Test Results

The EUT integrates a Radar transmitter. Other implemented wireless technologies were not considered within this test report.

Test case	Reference Clause FCC ☒	Reference Clause ISED ☒	Page	Remark	Result
fundamental bandwidth	FCC §15.265 (f)	RSS-211, sec.5.1(a)(b)(c)	10	-	PASSED
Fundamental emissions	FCC §15.265 (g)	RSS-211, sec.5.2(b)	11	-	PASSED
Unwanted emissions	FCC §15.209	RSS-211, sec.5.1(d) / RSS-Gen, 8.9	13	-	PASSED
Antenna beamwidth and side lobe gain	FCC §15.256 (i)(B)&(j)	RSS-211, sec.5.2(a)(c)	24	-	PASSED
Emissions from digital circuitry	FCC §15.256 (k)	-	-	1)	NT

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.
NT	Not tested
N/A	Not applicable
Remark 1)	refer test report CETECOM_TR20-1-0167901T03a

* 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
Fundamental bandwidth	ANSI C63.10-2013 §9.3, §9.5
Fundamental emissions	ANSI C63.10-2013 §9.8
Unwanted emissions (radiated spurious)	ANSI C63.10-2013 §9.6, § 9.7, §9.10, §9.11
Frequency stability	ANSI C63.10-2013 §9.5

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:	Ninovic Perez
Accreditation scope:	**DAkkS Webpage: FCC ISED**
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:	Guangcheng Huang
Receipt of EUT:	2021-Jan-28
Date(s) of test:	2021-Mar-17 – 2021-Sep-06
Version of template:	14.7

2.5 Applicant's details

Applicant's name:	Geolux d.o.o.
Address:	Ljudevita Gaja 62 10430 Samobor Croatia
Contact Person:	Tomislav Grubesa
Contact Person's Email:	tomislav.grubesa@geolux.hr

2.6 Manufacturer's details

Manufacturer's name:	Geolux d.o.o.
Address:	Ljudevita Gaja 62 10430 Samobor Kroatien

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	20-1-01679S07_C01	Water Level Sensor	LX80	LX80-15	LX-00102-054	RevB	2.2.9

*) 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 1	-	Test laptop	Dell Latitude 7480	G0CSMH2	-	Win10

*) 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	20-1-01679S10_C01	DC power supply	Banana plug + RS-232	8 m

*) 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 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 + AE 1 + CAB 1	Used for Radiated measurements

*) 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.*)	Operating modes	Additional information
op. 1	TX-Mode 1	EUT operates under FMCW mode continuously. We refer to applicants information/papers for details about necessary commands.
op. 2	TX-Mode 2	EUT operates under CW mode at fixed frequencies f_high/midlle/low 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

Product name	LX80		
Kind of product	Water Level Sensor		
Firmware	☒ for normal use	☒ Special version for test execution	
Power supply	☐ AC Mains	Wählen Sie ein Element aus.	
	☒ DC Mains	**12** V DC via **banana** Connector	
	☐ Battery	Wählen Sie ein Element aus.	
Operational conditions	T_{nom} =20 °C	T_{min} =-40 °C	T_{max} =+85 °C
EUT sample type	**Pre-Production**		
Weight	0.5 kg		
Size [LxWxH]	Diameter 65 mm x Height 78 mm		
Interfaces/Ports	Serial / CAN / Analog / SDI-12		
For further details refer Applicants Declaration & following technical documents Report_Questionnaire_v2.xlsx LX-80 Datasheet.pdf User Manual - LX-80 – RevB.pdf			

3.2 Detailed Technical data of Main EUT as Declared by Applicant

TX Frequency range [MHz]	77 GHz to 81 GHz		
Type of modulation used	FMCW		
Antenna polarization	Not reported		
Bandwidth	4 GHz		
Interfaces	See sec.3.1		
Emission classification	F0N		
Coaxial antenna connector available	☒ No connector	☐ Only for testing purpose	☐ Regular use
Antenna Type	☒ Integrated – monopole ☐ External, no RF- connector ☐ External, separate RF-connector		
Antenna Gain	- dBi (not reported)	☐ Declared by applicant	☐ Measured
For further details refer Applicants Declaration & following technical documents			
Description of Reference Document (supplied by applicant)		**Version**	**Total Pages**
See section 3.1		-	-

3.3 Modifications on Test sample

Additions/deviations or exclusions	

4 Measurements

4.1 Fundamental bandwidth

Testing method:

The measurement is made in the radiated way. 10 dB bandwidth is measured under nominal and extreme conditions. At first the EUT is tested under nominal condition. Then it is tested under extreme conditions (extreme temperatures and voltages) with the help of a climate cabinet and a variable power supply.

EUT settings

The EUT is set to FMCW mode and 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

4.1.2 Limit

Test limit [GHz]
75 - 85

4.1.3 Spectrum-Analyzer Settings

Span	5 GHz
Resolution Bandwidth (RBW)	FCC: 1 MHz IC: 1 MHz
Video Bandwidth (VBW)	FCC: 3 MHz IC: 3 MHz
Sweep time	Auto
Detector	Peak detector
Sweep mode	Continuous sweep, MAX-HOLD

4.1.4 Result

Mode	Low edge [GHz]	High edge [GHz]	Voltage [V]	Temperature [°C]	10 dB bandwidth [GHz]	Result
Op.1	77.02134	81.00238	12	20	3.98104	PASSED
Op.1	77.02184	81.00188	9	20	3.98004	PASSED
Op.1	77.02134	81.00238	27	20	3.98104	PASSED
Op.1	77.67324	80.46381	12	-40	2.79057	PASSED
Op.1	77.02184	81.00238	12	85	3.98054	PASSED

Remark: for more information and graphical plot see annex A1 **CETECOM_TR20-1-0167901T02a_A1_C1**

4.2 Fundamental emissions EIRP

Testing method:

The measurement is made in the radiated way. The fundamental emission level is measured under nominal condition. The measured power is EIRP*.

For the maximum peak power EIRP / peak EIRP spectral density test function Signal-ID is activated to exclude ghost signals (product of the mixer).
*EIRP: Equivalent Isotropic Radiated Power

4.2.1 Measurement Location

Test site	120907 - FAC2

4.2.2 Limit

Average [dBm]	Peak [dBm]
-3	34

4.2.3 Spectrum-Analyzer Settings

Span	5 GHz
Resolution Bandwidth (RBW)	1 MHz (Average) / 50 MHz (Peak)
Video Bandwidth (VBW)	Auto
Sweep time	Auto
Detector	Peak detector with max peak search. RMS peak search.
Sweep mode	Continuous sweep, MAX-HOLD

4.2.4 Result

Average emission in any 1 MHz bandwidth

Mode	Voltage [V]	Tempera-ture [°C]	Peak detector, RBW = 1 MHz [dBm]	Peak power correction [dB]	Average factor [dB]	Average emission level [dBm]	Limit [dBm]	Result
Op.1	12	20	-2.93	20.4 [2)]	-45.63 [3)]	-28.16	-3	PASSED

Remark 1) for more information and graphical plot see annex A1 **CETECOM_TR20-1-0167901T02a_A1_C1**
Remark 2) The peak power correction is calculated according to the application note 1EF107_1E_FMCW_Radar_p.pdf from the spectrum analyzer manufacturer.
Remark 3) The average factor calculation see section 4.3 Duty cycle (for information only).

Peak emission in any 50 MHz bandwidth

Mode	Voltage [V]	Temperature [°C]	Peak detector, RBW = 50 MHz [dBm]	Limit [dBm]	Result
Op.1	12	20	10.69	34	PASSED

Remark: for more information and graphical plot see annex A1 **CETECOM_TR20-1-0167901T02a_A1_C1**

4.3 Duty cycle (for information only)

Testing method:

The measurement is made in the radiated way. The fundamental emission level is measured under nominal condition.

4.3.1 Measurement Location

Test site	120907 - FAC2

4.3.2 Spectrum-Analyzer Settings

Span	0
Resolution Bandwidth (RBW)	80 MHz
Video Bandwidth (VBW)	Auto
Sweep time	> cycle time
Detector	Peak detector
Sweep mode	Single sweep

4.3.3 Result

Mode	Voltage [V]	Temperature [°C]	Frequency sweep time [µs]	Sweep span [MHz]	Retrace time [µs]	Cycle time [µs]	Average factor [dB]
Op.1	12	20	16	3981	131	147	-45.63

Remark: for more information and graphical plot see annex A1 **CETECOM_TR20-1-0167901T02a_A1_C1**

According to KDB TR 14-1007 under FCC15.256, average factor = (sweep freq. time in s/sweep span in MHz)/cycle time in s.

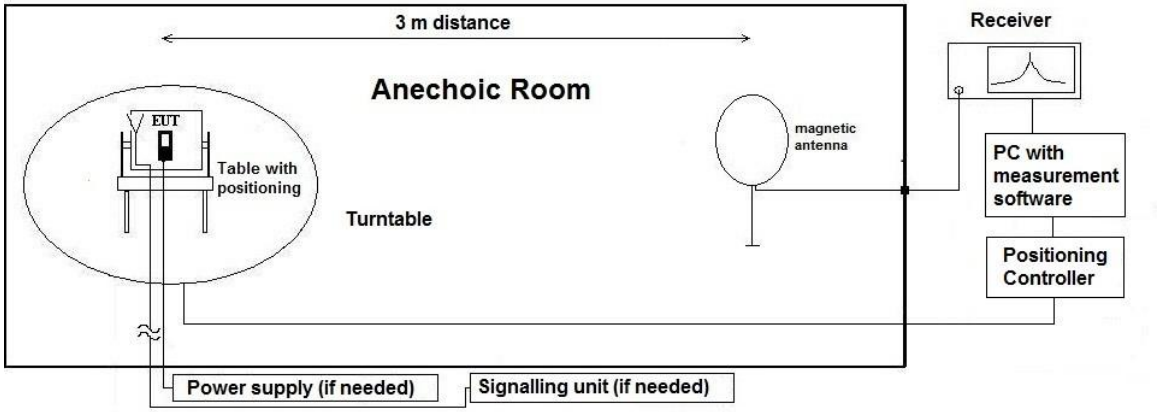
4.4 wanted emissions below 30 MHz

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

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

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

Schematic:



Testing method:

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

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

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

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

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

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

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

Formula:

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

$M = L_T - E_C$

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

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

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 [Hz/MHz]	Lambda [m]	Far-Field Point [m]	Distance Limit accord. 15.209 [m]		1st Condition (dmeas< Dnear-field)	2'te Condition (Limit distance bigger dnear-field)	Distance Correction accord. Formula
Hz	9.00E+03	33333.33	5305.17	300		fullfilled	not fullfilled	-80.00
	1.00E+04	30000.00	4774.65			fullfilled	not fullfilled	-80.00
	2.00E+04	15000.00	2387.33			fullfilled	not fullfilled	-80.00
	3.00E+04	10000.00	1591.55			fullfilled	not fullfilled	-80.00
	4.00E+04	7500.00	1193.66			fullfilled	not fullfilled	-80.00
	5.00E+04	6000.00	954.93			fullfilled	not fullfilled	-80.00
	6.00E+04	5000.00	795.78			fullfilled	not fullfilled	-80.00
	7.00E+04	4285.71	682.09			fullfilled	not fullfilled	-80.00
	8.00E+04	3750.00	596.83			fullfilled	not fullfilled	-80.00
	9.00E+04	3333.33	530.52			fullfilled	not fullfilled	-80.00
	1.00E+05	3000.00	477.47			fullfilled	not fullfilled	-80.00
	1.25E+05	2400.00	381.97			fullfilled	not fullfilled	-80.00
	2.00E+05	1500.00	238.73			fullfilled	fullfilled	-78.02
	3.00E+05	1000.00	159.16			fullfilled	fullfilled	-74.49
	4.00E+05	750.00	119.37			fullfilled	fullfilled	-72.00
	4.90E+05	612.24	97.44			fullfilled	fullfilled	-70.23
	5.00E+05	600.00	95.49	30		fullfilled	not fullfilled	-40.00
	6.00E+05	500.00	79.58			fullfilled	not fullfilled	-40.00
	7.00E+05	428.57	68.21			fullfilled	not fullfilled	-40.00
	8.00E+05	375.00	59.68			fullfilled	not fullfilled	-40.00
	9.00E+05	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

4.4.2 Measurement Location

Test site	120901 - SAC - Radiated Emission <1GHz

4.4.3 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

4.4.4 Result

Diagram	Channel	Op. Mode / EUT position	Maximum Level [dBµV/m] Frequency Range 0.009 – 30 MHz	Result
8	1	1 / EUT standing	19.19	PASSED
9	1	1 / EUT lying	19.88	PASSED

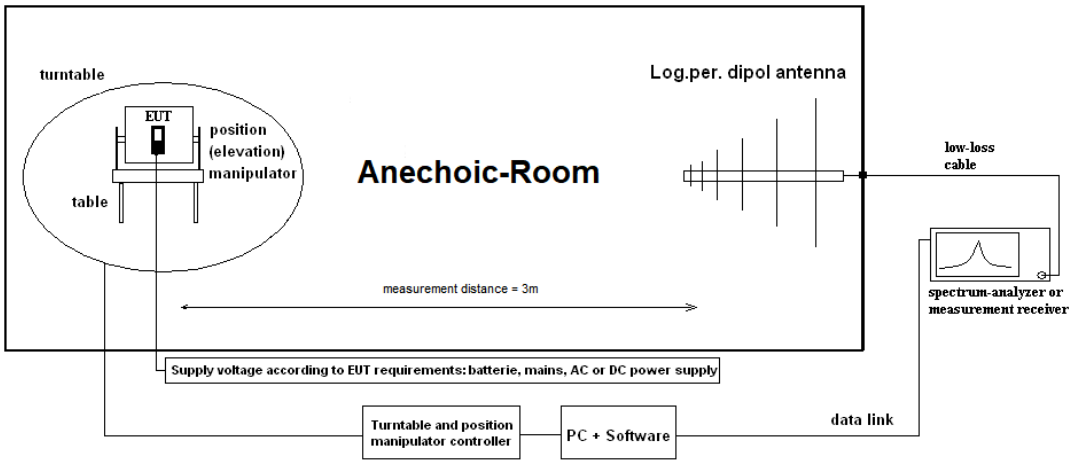
Remark: for more information and graphical plot see annex A1 **CETECOM_TR20-1-0167901T02a_A1_C1**

4.5 Unwanted emissions 30 MHz – 960 MHz

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 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 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.

4.5.2 Measurement Location

Test site	120901 - SAC - Radiated Emission <1GHz

4.5.3 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

4.5.4 Result

Diagram	Channel	Op. Mode / EUT position	Maximum Level [dBµV/m] Frequency Range 30 – 960 MHz	Result
10	1	1 / EUT standing	36.05	PASSED
11	1	1 / EUT lying	36.06	PASSED

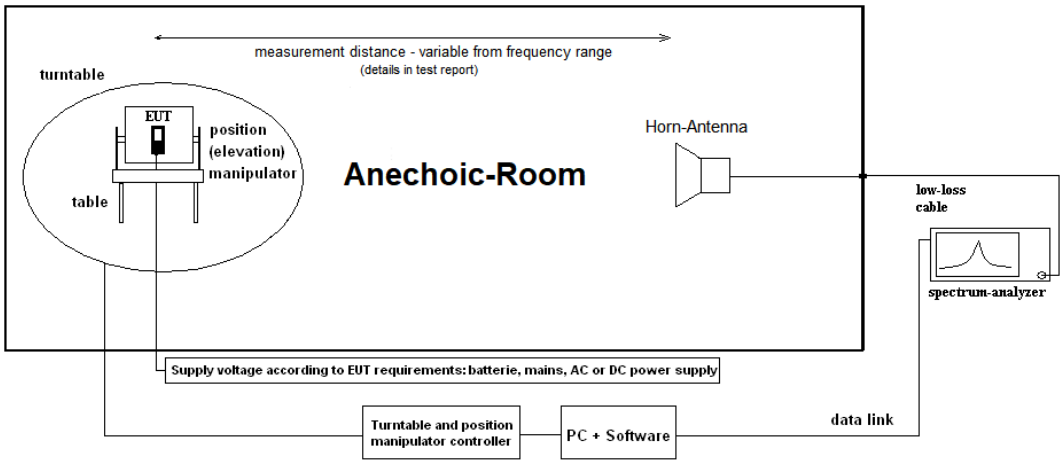
Remark: for more information and graphical plot see annex A1 **CETECOM_TR20-1-0167901T02a_A1_C1**

4.6 Unwanted emissions 960 MHz – 40 GHz

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 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 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

4.6.3 Limit

Frequency Range [MHz]	EIRP [dBm]	Field strength [dBµV/m] at 3 m	RBW / VBW [kHz]
960 - 40000	−41.23	54	1000 / 3000

EIRP limit was calculated according to the equation (38) in ANSI C63.10-2013:
EIRP [dBm] = E[dBµV/m]+ 20log(d [m])−104.77
EIRP limit = [54 + 20log(3)−104.77] dBm
= [54 + 9.54−104.77] dBm
= -41.23 dBm

4.6.4 Measurement distance

Frequency Range [GHz]	Measurement distance [m]
1 - 8	3
8 - 17	3
17 - 40	1

4.6.5 Result

Diagram	Mode	Frequency range [GHz]	Max level [dBm]	Result
10-11	1	0.96 - 1	-36.06	PASSED
12	1	1-17	-45.76	PASSED
13	1	17-33	-47.84	PASSED
14	1	33-50	-43.31	PASSED

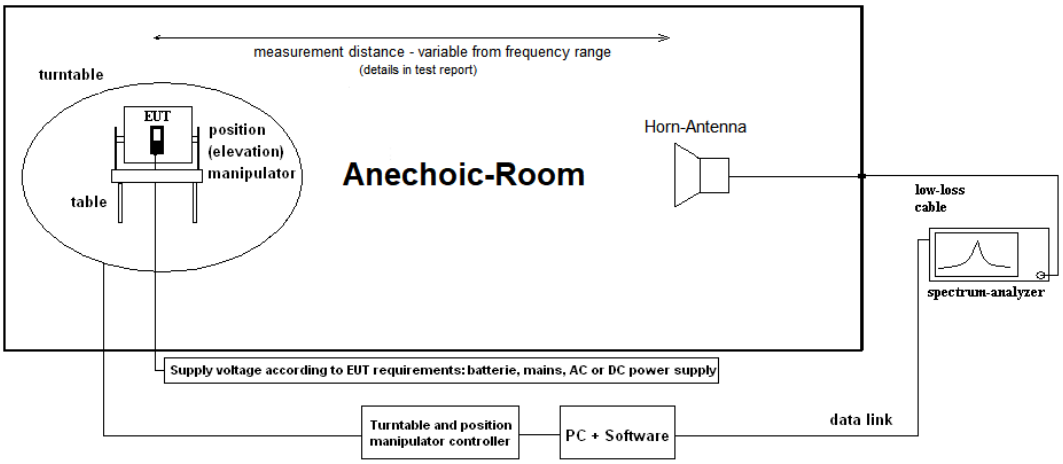
Remark: for more information and graphical plot see annex A1 **CETECOM_TR20-1-0167901T02a_A1_C1**

4.7 Unwanted emissions above 40 GHz

4.7.1 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:

Measurement is done for op. mode 1. The measuring sweeps are repeated with Maxhold function activated. Thus the measuring diagrams in annex 1 covers emissions of the EUT in all 3D directions. The alignment where the EUT transmits the maximum power is also determined.

The measurements are made with the mixer. There is a ref level line in all measurements. This line is not to be mistaken for limit line.

There are many image signals and mixer products to see on the measurement graphs. Signal ID function is used for the most measurement above 55 GHz for the purpose to distinguish these image signals and mixer products from the real signals. Here is the description of Signal ID function from user manual for R&S FSW Signal and Spectrum Analyzer (1173.9411.02 – 31):

Two sweeps are performed alternately. Trace 1 shows the trace measured on the upper side band (USB) of the LO (the test sweep), trace 2 shows the trace measured on the lower side band (LSB), i.e. the reference sweep.

*The reference sweep is performed using an LO setting shifted downwards by 2*IF/<Harmonic order>. Input signals in the desired sideband that are converted using the specified harmonic are displayed in both traces at the same position on the frequency axis. Image signals and mixer products caused by other harmonics are displayed at different positions in both traces. The user identifies the signals visually by comparing the two traces.*

Since the LO frequency is displaced downwards in the reference sweep, the conversion loss of the mixer may differ from the test sweep. Therefore the signal level should only be measured in the test sweep (trace 1).

According to the description of the Signal ID function above the following measurement procedure was developed: the measurement was done with Signal ID function ON, when there are any emissions on the measurement graph or with Signal ID function OFF, when there are no emissions at all. On the measurement graph with Signal ID function ON there

are two traces at first, LSB and USB. These traces can cover each other. For this reason two more graphs are made and included in the test report for each measurement. One graph with only USB trace and one graph with only LSB trace. These two already saved graphs are opened and compared on the wide enough screen. The scaling of the both graphs is the same. So the graphs can be easily compared by the switching between them (at first one graph is showed on the screen and then the second one). Each area of both traces is compared manually in this way. When there is an emission at the same frequency at LSB as well as at USB trace then it is a real signal. Such signal will be flagged with a marker and later re-measured.

Calculation of the boundary near/far field:

The aperture dimensions of the antenna shall be small enough so that the measurement distance in m is equal to or greater than the Rayleigh (far-field) distance (i.e., Rm = 2D2 / λ), where D is the largest dimension of the antenna aperture in m and λ is the free-space wavelength in m at the frequency of measurement.

Antenna range, [GHz]	D, [m]	Highest frequency in the measurement, [GHz]	Smallest wavelength λ in the measurement, [m]	Boundary for near/far field, [m]
33-50	0.04	50	0.006	0.35
40-60	0.0307	60	0.004	0.36
50-75	0.025	75	0.004	0.31
75-110	0.02	110	0.0027	0.29
90-140	0.0165	140	0.0021	0.25
140-220	0.0107	200	0.0015	0.15

Measurement distance: see results table below

4.7.2 Measurement Location

Test site	120907 - FAC2

4.7.3 Limit

FCC Frequency range [GHz]	FCC field strength [µV/m at 3 m]	FCC EIRP [dBm]
40 - 200	500	-41.23
ISED Frequency range [GHz]	**ISED field strength [µV/m at 3 m]**	**ISED EIRP [dBm]**
40 - 200	500	-41.23
Limit conversion (µV/m to dBm)	EIRP limit is calculated according to the equation (38) in ANSI C63.10-2013: EIRP [dBm] = 20log(E [µV/m]) + 20log(d [m]) − 104.77 EIRP limit = [54 + 20log(3) − 104.77] dBm = [54 + 9.54 − 104.77] dBm = -41.23 dBm	

4.7.4 Spectrum-Analyzer Settings

Resolution Bandwidth (RBW)	1 MHz
Video Bandwidth (VBW)	Minimum 3 times the resolution bandwidth
Sweep time	auto
Detector	RMS detector.
Sweep mode	continuous sweep, MAX-HOLD

4.7.5 Result

Diagram	Mode	Frequency range [GHz]	Measuring distance, [m]	Boundary for far field, [m]	Max level [dBm]	Result
14	1	33-50	1	0.54	-43.31 *)	PASSED
15	1	50-60	0.5	0.36	-49.95 *)	PASSED
16-20	2 / f_high	60-75	0.5	0.31	-47 *)	PASSED
21-24	2 / f_middle	60-75	0.5	0.31	-47 *)	PASSED
25	2 / f_low	60-75	0.5	0.31	-47 *)	PASSED
26-27	2 / f_high	75-90	0.32	0.24	-47 *)	PASSED
28-29	2 / f_middle	75-90	0.32	0.24	-47 *)	PASSED
30	2 / f_low	75-90	0.32	0.24	-47 *)	PASSED
31-38	2 / f_high	90-110	0.32	0.29	-44 *)	PASSED
39-47	2 / f_middle	90-110	0.32	0.29	-44 *)	PASSED
48-52	2 / f_low	90-110	0.32	0.29	-44 *)	PASSED
53-67	2 / f_high	110-140	0.32	0.27	-43 *)	PASSED
68-70	2 / f_middle	110-140	0.32	0.27	-43 *)	PASSED
71-73	2 / f_low	110-140	0.32	0.27	-43 *)	PASSED
74-75	2 / f_high	140-200	0.17	0.16	-28 *)	1)
76-82	2 / f_high	140-200	0.17	0.16	-42 *)	PASSED
83-84	2 / f_middle	140-200	0.17	0.16	-28 *)	1)
85-86	2 / f_low	140-200	0.17	0.16	-28 *)	1)

Remark: for more information and graphical plot see annex A1 **CETECOM_TR20-1-0167901T02a_A1_C1**
Remark 1): for information only.
Remark *): noise level.

4.8 Antenna beamwidth and side lobe gain

Testing method:

The EUT is set to CW mode at fixed frequency. The measuring antenna is setup aiming the EUT at distance and capture the emission level with both horizontal and vertical polarization. The antenna pattern is captured while turning the EUT in azimuth and tilting in elevation.

4.8.1 Measurement Location

Test site	120907 - FAC2

4.8.2 Limit

FCC & ISED
For the band 75-85 GHz: ➢ In the antenna main lobe, the -3 dB beamwidth is no greater than 8° ➢ The antenna side lobe gain relative to the main beam gain for off-axis angles from the main beam of greater than 60° is no greater than -38 dB

4.8.3 Spectrum-Analyzer Settings

Span	1 GHz
Resolution Bandwidth (RBW)	200 kHz
Video Bandwidth (VBW)	Auto
Sweep time	1 s
Detector	PK
Sweep mode	Single sweep

4.8.4 Result

Diagram	Mode	Main lobe beamwidth	Beamwidth limit	Rel. side lobe gain for off-axis angle > 60°	Rel. side lobe gain limit	Result
87	2 / f_middle	-	8°	-	-38 dB	For info only
88	2 / f_middle	<8°	8°	<38 dB	-38 dB	PASSED
89	2 / f_middle	<8°	8°	<38 dB	-38 dB	PASSED

Remark: for more information and graphical plot see annex A1 **CETECOM_TR20-1-0167901T02a_A1_C1**

4.9 Results from external laboratory

None	-

4.10 Opinions and interpretations

None	-

4.11 List of abbreviations

None	-

5 Equipment lists

ID	Description	Manufacturer	SerNo	Cal due date
	120901 - SAC - Radiated Emission <1GHz			**2025-Jul-21**
20574	Biconilog Hybrid Antenna BTA-L	Frankonia GmbH	980026L	2022-May-03
20487	CETECOM Semi Anechoic Chamber < 1GHz	ETS-Lindgren Gmbh	-	2025-Jul-15
20341	Digital Multimeter Fluke 112	Fluke Deutschland GmbH	81650455	2022-May-25
20620	EMI Test Receiver ESU26	Rohde & Schwarz Messgerätebau GmbH	100362	2022-May-20
20482	filter matrix Filter matrix SAR 1	CETECOM GmbH	-	Pre-m
25038	Loop Antenna HFH2-Z2	Rohde & Schwarz Messgerätebau GmbH	879824/13	2022-Apr-07
20885	Power Supply EA3632A	Agilent Technologies Deutschland GmbH	75305850	Pre-m
	120902 - SAC - Radiated Emission >1GHz			**2027-Jul-15**
20550	CETECOM Semi anechoic Chamber > 1Ghz	ETS-Lindgren Gmbh	-	2025-Jul-15
20376	Horn Antenna BBHA9120 E	Schwarzbeck Mess-Elektronik OHG	BBHA 9120 E 179	2023-Apr-08
	120907 - FAC2			
20836	1-18 GHz Amplifier	Wright Technologies, Inc., Inc.	0001	1
20730	FS-Z110	Rohde & Schwarz Messgerätebau GmbH	101468	2023-Jun-19
20729	FS-Z140	Rohde & Schwarz Messgerätebau GmbH	101004	2023-May-26
20731	FS-Z75	Rohde & Schwarz Messgerätebau GmbH	101022	2022-Jun-16
20733	Harmonic Mixer FS-Z220	RPG-Radiometer Physics GmbH	101009	2024-Mai-26

ID	Description	Manufacturer	SerNo	Cal due date
20811	Horn Antenna ASY-SGH-124-SMA	Antenna Systems Solutions S.L	29F14182337	2021-Oct-08
20302	Horn Antenna BBHA9170 (Meas 1)	Schwarzbeck Mess-Elektronik OHG	155	2023-Apr-15
20814	Pickett-Potter Horn Antenna FH-PP 140	RPG-Radiometer Physics GmbH	10008	1
20767	Pickett-Potter Horn Antenna FH-PP 140-220	RPG-Radiometer Physics GmbH	010011	1
20816	SGH Antenna SGH-26-WR10		1144	1
20732	Signal- and Spectrum Analyzer FSW67	Rohde & Schwarz Messgerätebau GmbH	104023	2022-May-26
20817	WR-22 Horn / SAR-2309-22-S2	SAGE Millimeter Inc.	13254-01	2023-Jul-29

5.1 Legend

Note / remarks		
	1	Annual internal validation
	Pre-m	Check before starting the measurement
	-	Without calibration

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.

RF-Measurement	Reference	Frequency range	Calculated uncertainty based on a confidence level of 95%						Remarks
Conducted emissions (U_{CISPR})	CISPR 16-2-1	9 kHz - 150 kHz 150 kHz - 30	4.0 dB 3.6 dB						-
Radiated emissions Enclosure	CISPR 16-2-3	30 - 1 GHz 1 GHz - 18 GHz	4.2 dB 5.1 dB						E-Field
Disturbance power	CISPR 16-2-2	30 - 300	-						-
Power Output radiated	-	30 - 4 GHz	3.17 dB						Substitution method
Power Output conducted	-	Set-up No.	Cel-C1	Cel-C2	BT1	W1	W2	--	
		9 kHz - 12.75 GHz	N/A	0.60	0.7	0.25	N/A	--	-
		12.75 GHz - 26.5 GHz	N/A	0.82	--	N/A	N/A	--	
Conducted emissions on RF-port	-	9 kHz - 2.8 GHz	0.70	N/A	0.70	N/A	0.69	--	N/A - not applicable
		2.8 GHz - 12.75 GHz	1.48	N/A	1.51	N/A	1.43	--	
		12.75 GHz – 18 GHz	1.81	N/A	1.83	N/A	1.77	--	
		18 GHz - 26.5 GHz	1.83	N/A	1.85	N/A	1.79	--	
Occupied bandwidth	-	9 kHz - 4 GHz	0.1272 ppm (Delta Marker)						Frequency error
			1.0 dB						Power
Emission bandwidth	-	9 kHz - 4 GHz	0.1272 ppm (Delta Marker)						Frequency error
	-		See above: 0.70 dB						Power
Frequency stability	-	9 kHz - 20 GHz	0.0636 ppm						-
Radiated emissions Enclosure	-	150 kHz - 30 MHz	5.0 dB						Magnetic field
		30 MHz - 1 GHz	4.2 dB						E-field
		1 GHz - 18 GHz	3.17 dB						Substitution Method
		18-33 GHz	3.60 dB						
		33-50 GHz	3.99 dB						
		40-60 GHz	3.95 dB						
		50-75 GHz	3.24 dB						External Mixer
		75-90 GHz	3.32 dB						
		90-140 GHz	4.94 dB						
		140-225 GHz	5.42 dB						

7 Versions of test reports (change history)

Version	Applied changes	Date of release
--	Initial release	2021-Sep-21
C1	Update measurement EIRP, duty cycle, antenna beamwidth and side lobe gain, etc.	2021-Oct-08
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End of Test Report