PARTIAL Test Report

22-1-0043303T008a

Number of pages:	37	**Date of Report:**	2024-Jul-04
Testing company:	cetecom advanced GmbH Untertuerkheimer Str. 6-10 66117 Saarbruecken GERMANY	**Applicant:**	Hans Turck GmbH & Co. KG
Product:	**Radar Sensor**		
Model:	**MR15-Q80-IOLCJ-H1141**		
FCC ID:	YQ7-MR15Q80		--
Testing has been carried out in accordance with:	FCC Regulations Title 47 CFR The 57-71 GHz Band Radar Service § 15.255 Operating within band 57 – 64 GHz 47 CFR 15.255(c)(2)(iii)(A)		
Tested Technology:	Radar		
Test Results:	**☒ The EUT complies with the requirements in respect of selected parameters subject to the test.** The test results relate only to devices specified in this document		
Signatures:			
	Dipl.-Ing. Christian Lorenz Lab Manager Authorization of test report		B.Sc. Al-Amin Hossain Testing 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 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 Summary of Test Results

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

Test specification clause	Test case	Temperature conditions	Power supply	Pass	Fail	NA	NP	Remark
47 CFR 15.215(c) 47 CFR 15.255(f)	**Occupied bandwidth & Frequency stability**	Nominal Extreme	Nominal Extreme	☒	☐	☐	☐	complies
47 CFR 15.255(c) (2)(iii)(A)	**Radiated power (EIRP)**	Nominal	Nominal	☒	☐	☐	☐	complies
47 CFR 15.255(c)(2) 47 CFR 15.255(e)	**Peak transmitter conducted output power**	Nominal	Nominal	☐	☐	☒	☐	--
47 CFR 15.255(c)(2)(iii)(A)	**Time domain requirements**	Nominal	Nominal	☒	☐	☐	☐	complies
47 CFR 15.255(d)	**Spurious emissions radiated**	Nominal	Nominal	☒	☐	☐	☐	complies
47 CFR 15.207	**Conducted emissions < 30 MHz (AC power line)**	Nominal	Nominal	☒	☐	☐	☐	complies

Note: NA = Not applicable; NP = Not performed

PASS	The EUT complies with the essential requirements in the standard.
FAIL	The EUT does not comply with the essential requirements in the standard.
NA	Test case does not apply to the test object.
NP	The test was not performed by the cetecom advanced laboratory.

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

1.3 Summary of Test Methods

Test case	Test method
Occupied bandwidth	ANSI C63.10-2020 §9.4
Radiated Power (EIRP)	ANSI C63.10-2020 §9.8
Field strength of emissions (radiated spurious)	ANSI C63.10-2020 §9.10, §9.11
Frequency stability	ANSI C63.10-2020 §9.5

1.4 Basic information of the DUT & selection of applicable rule parts

Basic information of the DUT:

General: see chapter "2.7 Test item"

Operation condition:

☐ Operation on aircraft (47 CFR 15.255(b))

☐ Unmanned aircraft (47 CFR 15.255(b)(3))

☐ Not unmanned aircraft

☒ No operation on aircraft

Note: Operation under the provisions of this section is not permitted for equipment used on satellites (47 CFR 15.255(a)).

Kind of DUT:

☐ Devices other than field disturbance sensors and other than fixed point-to-point transmitters located outdoors

☐ Fixed point-to-point transmitters located outdoors

☒ Field disturbance sensors/radars

☐ Pulsed field disturbance sensors/radars

☒ Other than pulsed field disturbance sensors/radars

Frequency band:

☐ Operating within band 57 – 71 GHz (47 CFR 15.255 / 47 CFR 15.255(c))

☐ Operating within band 59.3 – 71.0 GHz (47 CFR 15.255(b)(2)(iii))

☐ Operating within band 60 – 64 GHz (47 CFR 15.255(b)(3))

☒ Operating within band 57 – 64 GHz (47 CFR 15.255(c)(2)(iii))

☐ Operating within band 57 – 71 GHz (47 CFR 15.255(c)(2))

☐ Operating within band 57.0 – 59.4 GHz (47 CFR 15.255(c)(2)(i))

☐ Operating within band 57.0 – 61.56 GHz (47 CFR 15.255(c)(2)(ii))

☐ Operating within band 61.0 – 61.5 GHz (47 CFR 15.255(c)(2)(v))

Note: See results in chapter / annex

Selection of applicable rule parts:

Applicable rule parts and limits depend on the basic information of the DUT (see chapter 1.6).
The comparison of the basic information of the DUT with the rule parts lead to the following conclusions:

Rule Part	Applicable? Yes	Applicable? No
47 CFR 15.255:		
(a) **General:** Operation under the provisions of this section is not permitted for equipment used on satellites.	☒	
(b) **Operation on aircraft:** Operation on aircraft is permitted under the following conditions:	☐	☐
(1) When the aircraft is on the ground.	☐	☐
(2) While airborne, only in closed exclusive on-board communication networks within the aircraft, with the following exceptions:	☐	☐
(i) Equipment shall not be used in wireless avionics intra-communication (WAIC) applications where external structural sensors or external cameras are mounted on the outside of the aircraft structure.	☐	☐
(ii) Except as permitted in paragraph (b)(3) of this section, equipment shall not be used on aircraft where there is little attenuation of RF signals by the body/fuselage of the aircraft.	☐	☐
(iii) **Field disturbance sensor/radar** devices may only operate in the frequency band **59.3–71.0 GHz** while installed in passengers' personal portable electronic equipment (e.g., smartphones, tablets) and shall comply with paragraph (b)(2)(i) of this section, and relevant requirements of paragraphs (c)(2) through (c)(4) of this section.	☐	☐
(3) **Field disturbance sensors/radar** devices deployed on **unmanned aircraft** may operate within the frequency band **60–64 GHz**, provided that the transmitter not exceed 20 dBm peak EIRP. The sum of continuous transmitter off-times of at least two milliseconds shall equal at least 16.5 milliseconds within any contiguous interval of 33 milliseconds. Operation shall be limited to a maximum of 121.92 meters (400 feet) above ground level.	☐	☐
(c) **Radiated power limits:** Within the **57–71 GHz band**, emission levels shall not exceed the following equivalent isotropically radiated power (EIRP):	☒	
(1) **Devices other than field disturbance sensors** shall comply with one of the following power limits, as measured during the transmit interval:	☐	☐
(i) The average power of any emission shall not exceed 40 dBm and the peak power of any emission shall not exceed 43 dBm; or	☐	☐
(ii) For **fixed point-to-point transmitters located outdoors**, the average power of any emission shall not exceed 82 dBm, and shall be reduced by 2 dB for every dB that the antenna gain is less than 51 dBi. The peak power of any emission shall not exceed 85 dBm, and shall be reduced by 2 dB for every dB that the antenna gain is less than 51 dBi.	☐	☐
(A) The provisions in this paragraph (c) for reducing transmit power based on antenna gain shall not require that the power levels be reduced below the limits specified in paragraph (c)(1)(i) of this section.	☐	☐
(B) The provisions of § 15.204(c)(2) and (4) that permit the use of different antennas of the same type and of equal or less directional gain do not apply to intentional radiator systems operating under this provision. In lieu thereof, intentional radiator systems shall be certified using the specific antenna(s) with which the system will be marketed and operated. Compliance testing shall be performed using the highest gain and the lowest gain antennas for which certification is sought and with the intentional radiator operated at its maximum available output power level. The responsible party, as defined in § 2.909 of this chapter, shall supply a list of acceptable antennas with the application for certification.	☐	☐
(2) **Field disturbance sensors/radars** shall not exceed −10 dBm peak conducted output power and 10 dBm peak EIRP except that field disturbance sensors/radars that limit their operation to all or part of the specified frequency band may operate without being subject to a transmitter conducted output power limit if they operate in compliance with paragraph (b)(3) of this section or with one or more of the provisions below:	☐	☐
(i) **57.0–59.4 GHz**: the peak EIRP level shall not exceed 20 dBm for **indoor operation** or 30 dBm for **outdoor operation**;	☐	☐

(ii) **57.0–61.56 GHz**: the peak EIRP shall not exceed 3 dBm except that the peak EIRP shall not exceed 20 dBm if the sum of continuous transmitter off-times of at least two milliseconds equals at least 16.5 milliseconds within any contiguous interval of 33 milliseconds;	☐	☐
(iii) **57.0–64.0 GHz:**	☐	☐
(A) The peak EIRP shall not exceed 14 dBm, and the sum of continuous transmitter off-times of at least two milliseconds shall equal at least 25.5 milliseconds within any contiguous interval of 33 milliseconds, except as specific in paragraph (c)(2)(iii)(B) of this section;	☒	☐
(B) The peak EIRP shall not exceed 20 dBm, and the sum of continuous transmitter off-times of at least two milliseconds shall equal at least 16.5 milliseconds within any contiguous interval of 33 milliseconds when operated outdoors:	☐	☐
(1) As part of a **temporary or permanently fixed application**; or	☐	☐
(2) When being used in **vehicular applications to perform specific tasks of moving something or someone, except for in-cabin applications**;	☐	☐
(iv) A **field disturbance sensor** may operate in any of the modes in the above sub-sections so long as the device operates in only one mode at any time and does so for at least 33 milliseconds before switching to another mode.	☐	☐
(v) **61.0–61.5 GHz:** For **field disturbance sensors/radars** that occupy 500 MHz bandwidth or less that are contained wholly **within the frequency band 61.0–61.5 GHz**, the average power of any emission, measured during the transmit interval, shall not exceed 40 dBm, and the peak power of any emission shall not exceed 43 dBm. In addition, the average power of any emission **outside of the 61.0–61.5 GHz band**, measured during the transmit interval, but still within the 57–71 GHz band, shall not exceed 10 dBm, and the peak power of any emission shall not exceed 13 dBm.	☐	☐
(3) For **pulsed field disturbance sensors/radars** operating in the 57–64 GHz band that have a maximum pulse duration of 6 ns, the average EIRP shall not exceed 13 dBm and the transmit duty cycle shall not exceed 10% during any 0.3 µs time window. In addition, the average integrated EIRP within the frequency band **61.5–64.0 GHz** shall not exceed 5 dBm in any 0.3 µs time window. Peak emissions shall not exceed 20 dB above the maximum permitted average emission limit applicable to the equipment under test. The radar bandwidth is the frequency band bounded by the points that are 10 dB below the highest radiated emission, as based on the complete transmission system including the antenna	☐	☐
(4) The provisions in § 15.35(b) and (c) that require emissions to be averaged over a 100 millisecond period and that limits the peak power to 20 dB above the average limit do not apply to devices operating under paragraphs (c)(2) and (3) of this section.	☐	☐
(d) Limits on spurious emissions:	☒	
(1) The power density of any emissions outside the 57–64 GHz band shall consist solely of spurious emissions.	☒	
(2) Radiated emissions below 40 GHz shall not exceed the general limits in § 15.209.	☒	
(3) Between 40 GHz and 200 GHz, the level of these emissions shall not exceed 90 pW/cm^2 at a distance of 3 meters.	☒	
(4) The levels of the spurious emissions shall not exceed the level of the fundamental emission.	☒	
(e) Limits on transmitter conducted output power.	☐	☐
(1) Except as specified in paragraph (e)(2) of this section, the peak transmitter conducted output power of **devices other than field disturbance sensors/radars** shall not exceed 500 mW. Depending on the gain of the antenna, it may be necessary to operate the intentional radiator using a lower peak transmitter output power in order to comply with the EIRP limits specified in paragraph (c) of this section.	☐	☐
(2) **Devices other than field disturbance sensors/radars** with an emission bandwidth of less than 100 megahertz must limit their peak transmitter conducted output power to the product of 500 mW times their emission bandwidth divided by 100 megahertz. For the purposes of this paragraph, emission bandwidth is defined as the instantaneous frequency range occupied by a steady state radiated signal with modulation, outside which the radiated power spectral density never exceeds 6 dB below the maximum radiated power spectral density in the band, as measured with a 100 kilohertz resolution bandwidth spectrum analyzer. The center frequency must be stationary during the measurement interval, even if not stationary during normal operation (e.g., for frequency hopping devices).	☐	☐
(f) Frequency stability: Fundamental emissions must be contained within the frequency bands specified in this section during all conditions of operation. Equipment is presumed to operate over the	☒	

temperature range −20 to + 50 degrees Celsius with an input voltage variation of 85% to 115% of rated input voltage, unless justification is presented to demonstrate otherwise.		
(g) Radio frequency radiation exposure: Radio frequency devices operating under the provisions of this part are subject to the radio frequency radiation exposure requirements specified in §§ 1.1307(b), 1.1310, 2.1091, and 2.1093 of this chapter, as appropriate. Applications for equipment authorization of mobile or portable devices operating under this section must contain a statement confirming compliance with these requirements. Technical information showing the basis for this statement must be submitted to the Commission upon request.	☐	
(h) Group installation: Any transmitter that has received the necessary FCC equipment authorization under the rules of this chapter may be mounted in a group installation for simultaneous operation with one or more other transmitter(s) that have received the necessary FCC equipment authorization, without any additional equipment authorization. However, no transmitter operating under the provisions of this section may be equipped with external phase-locking inputs that permit beam-forming arrays to be realized.	☐	
(i) Compliance measurement. Measurement procedures that have been found to be acceptable to the Commission in accordance with § 2.947 of this chapter may be used to demonstrate compliance.	☒	
(1) For purposes of demonstrating compliance with this section, corrections to the transmitter conducted output power may be made due to the antenna and circuit loss.	☐	
(2) Compliance measurements of **frequency-agile field disturbance sensors/radars** shall be performed with any related frequency sweep, step, or hop function activated.	☐	☐
47 CFR 15.215		
(c) Intentional radiators operating under the alternative provisions to the general emission limits, as contained in §§ 15.217 through 15.257 and in subpart E of this part, must be designed to ensure that the **20 dB bandwidth of the emission**, or whatever bandwidth may otherwise be specified in the specific rule section under which the equipment operates, is contained within the frequency band designated in the rule section under which the equipment is operated. In the case of intentional radiators operating under the provisions of subpart E, the emission bandwidth may span across multiple contiguous frequency bands identified in that subpart. The requirement to contain the designated bandwidth of the emission within the specified frequency band includes the effects from frequency sweeping, frequency hopping and other modulation techniques that may be employed as well as the frequency stability of the transmitter over expected variations in temperature and supply voltage. If a frequency stability is not specified in the regulations, it is recommended that the fundamental emission be kept within at least the central 80% of the permitted band in order to minimize the possibility of out-of-band operation.	☐	☐
47 CFR 15.209	☒	
47 CFR 15.207		
(a) Except as shown in paragraphs (b) and (c) of this section, for an intentional radiator that is designed to be connected to the public utility (AC) power line, the radio frequency voltage that is conducted back onto the AC power line on any frequency or frequencies, within the band 150 kHz to 30 MHz, shall not exceed the limits in the table of this paragraph (see chapter 4.9) as measured using a 50 µH/50 ohms line impedance stabilization network (LISN). Compliance with the provisions of this paragraph shall be based on the measurement of the radio frequency voltage between each power line and ground at the power terminal. The lower limit applies at the boundary between the frequency ranges.	☒	
(c) Measurements to demonstrate compliance with the conducted limits are not required for devices which only employ battery power for operation and which do not operate from the AC power lines or contain provisions for operation while connected to the AC power lines. Devices that include, or make provisions for, the use of battery chargers which permit operating while charging, AC adapters or battery eliminators or that connect to the AC power lines indirectly, obtainig their power through another device which is connected to the AC power lines, shall be tested to demonstrate compliance with the conducted limits.	☐	☐

2 Administrative Data

2.1 Identification of the Testing Laboratory

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

2.2 General limits for environmental conditions

Temperature:	22±2 °C
Relative. humidity:	45±15% rH

2.3 Test Laboratories sub-contracted

Company name:	--

2.4 Organizational Items

Responsible testing manager:	B.Sc. Al-Amin Hossain
Receipt of EUT:	2024-Feb-23
Date(s) of test:	2024-Feb-23 to 2024-May-07
Version of template:	24.0301

2.5 Applicant's details

Applicant's name:	Hans Turck GmbH & Co. KG
Address:	Witzlebenstr. 7 45472 Mülheim an der Ruhr North Rhine-Westphalia Germany
Contact Person:	Alexander Fischer
Contact Person's Email:	Alexander.Fischer@turck.com

2.6 Manufacturer's details

Manufacturer's name:	Werner Turck GmbH & Co. KG
Address:	Goethestraße 7 58553 Halver Deutschland

2.7 Equipment under Test (EUT)

EUT No.*)	Sample No.	Product	Model	HW	SW
1	22-1-00433S18_C01	Radar Sensor	MR15-Q80-IOLCJ-H1141	1.0	3.7.3.1

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

2.8 Untested Variant (VAR)

VAR No.*)	Sample No.	Product	Model	Type	SN	HW	SW

*) The listed additional untested model variant(s) (VAR) is/are not object of evaluation of compliance. For further information please see Annex 5: Declaration of applicant of model differences.
If the table above does not show any other line than the headline, no untested variants are available.

2.9 Auxiliary Equipment (AE)

AE No.*)	Sample No.	Auxiliary Equipment	Model	SN	HW	SW

*) 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
CAB 1	22-1-00433S25_C01	Power Cable	--	N/A
CAB 2	22-1-00433S26_C01	Power Cable	--	N/A

*) CAB short description is used to simplify the identification of the connected cables in this test report. If the table above does not show any other line than the headline, no cable was used during testing nor was taken into account for evaluation

2.11 Software (SW)

SW No.*)	Sample No.	SW Name	Description	SW Status

*) SW 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 + CAB 1	➢ Used for radiated measurements
2	EUT 1 + CAB 1 + CAB 2	➢ CAB 2 has been used as a termination ➢ This setup has been used for Radiated measurement 9k – 1GHz

*) 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	Normal TXRX	Transmitting and Receiving simultaneously.

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

2.14 Test tool information

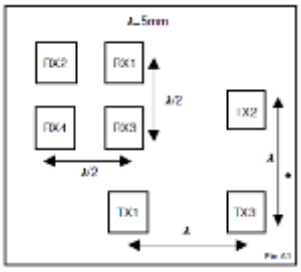
Once the EUT power on, it goes automatically in normal operation. Therefore no adiitional tool is required.

3 Equipment under test (EUT)

3.1 General Data of Main EUT as Declared by Applicant

Firmware	☒ normal use	☐ Special version for test execution	
Power supply	☐ AC Mains	--	
	☒ DC Mains	**24** V DC via **Banana** Connector	
	☐ Battery		
Operational conditions	T_{nom} =22 °C	T_{min} =-40 °C	T_{max} =+85 °C
EUT sample type	**Pre-Production**		
Weight	0.47 kg		
Size [LxWxH]	91mm x 80mm x 35cm		
Interfaces/Ports	Check Annex-3		
For further details refer Applicants Declaration & following technical documents			

3.2 Detailed Technical data of Main EUT as Declared by Applicant

TX Frequency range [GHz]	60 GHz to 64 GHz		
Type of modulation used	FMCW		
Bandwidth	4 GHz		
Coaxial antenna connector available	☒ No connector	☐ Only for testing purpose	☐ Regular use
Antenna Type	☒ Integrated – 3 Tx antennas multiplexed 		
Antenna Gain	5.2 dBi	☒ Declared by applicant	☐ Measured
For further details refer Applicants Declaration & following technical documents			

Description of Reference Document (supplied by applicant)	Version	Total Pages
Displacment MIMO	**--**	**5**
22-1-0043303T004_SYS_ETSI_EN_305_550_(57-64GHz122-123GHz)_Questionnaire (required from customer)_2024-02-07_V1.0	**2024-02-07_V1.0**	**4**

3.3 Modifications on Test sample

Additions/deviations or exclusions	--

4 Measurements

4.1 The maximum peak power EIRP

Testing method:

All the measurements are done according to standards and rules listed in Chapter 1.3. The measured power is EIRP*.
The EUT is ON and set to default mode: FMCW modulation. At first the EUT is tested under nominal condition.

For the maximum peak power EIRP / peak EIRP test function Auto ID is activated to exclude ghost signals (product of the mixer).

*EIRP: Equivalent Isotropic Radiated Power

4.1.1 Measurement Location

Test site	FAC2

Limits and provisions:

Selection of applicable rule parts: see chapter 1.4.3

Applicable limits for radiated power (EIRP)			
Applicable	**Rule part**	**Limit average EIRP**	**Limit peak EIRP**
☐	15.255(c)(1)(i)	40 dBm (see note 1)	43 dBm
☐	15.255(c)(1)(ii)	(see note 1 & 2.1)	(see note 1 & 2.2)
☐	15.255(c)(2)	none	10 dBm
☐	15.255(c)(2)(i)	none	20 dBm (indoor) 30 dBm (outdoor)
☐	15.255(c)(2)(ii)	none	3 dBm (general) 20 dBm (+ off-time requirement)
☒	15.255(c)(2)(iii)(A)	none	14 dBm (+ off-time requirement)
☐	15.255(c)(2)(iii)(B)	none	20 dBm (+ off-time requirement)
☐	15.255(c)(2)(v)	40 dBm (within 61-61.5 GHz) (see note 1)	43 dBm (within 61.0-61.5 GHz)
		10 dBm (outside 61-61.5 GHz) (see note 1)	13 dBm (outside 61-61.5 GHz)
☐	15.255(c)(3)	13 dBm (+ time domain requirement)	applicable average limit + 20 dB
		5 dBm (average integrated EIRP within 61.5–64.0 GHz in any 0.3 µs time window)	

Spectrum analyzer:

Measurement parameter	
Detector:	Peak
Resolution bandwidth:	50 MHz
Video bandwidth:	80 MHz
Trace-Mode:	Max Hold

Measurement results:

TID	EUT	Mode	Test condition	Peak E.I.R.P.	Limit peak E.I.R.P
TID011	S18_C01	1	T_{nom} / V_{nom}	13.54 dBm	14 dBm

Note:

- Detailed measurement results: see measurement report TR22-1-0043303T008a-A1

Verdict: Compliant

4.2 Occupied bandwidth & emission bandwidth & Frequency stability

Testing method:

Occupied bandwidth was measured for operating mode 1 under nominal and extreme conditions. Occupied bandwidth (ndB, n=20dB) function is activated in spectrum analyzer for this measurement and added a Horizontal line in the Y-Axis to verify 20dBc value for T1 and T2. T1 = lower band, T2 = upper Band in the measurement diagram.

4.2.1 Measurement Location

Test site	FAC2

4.2.2 Limit

Test limit [GHz]
57 - 64

Description

Measurement of the bandwidth and the frequency stability of the wanted signal (fundamental emission) under temperature and supply voltage variations.

Limits and provisions:

Selection of applicable rule parts: see 1.4

Designated frequency band of 47 CFR 15.215
57 GHz – 64 GHz

Bandwidth to be measured		
Applicable	**Rule part**	**Bandwidth**
☒	15.215(c)	20 dB bandwidth
☐	15.255(c)(3)	10 dB bandwidth
☐	15.255(e)(2)	6 dB emission bandwidth

Measurement:

Measurement parameter	
Detector:	Pos-Peak
Resolution bandwidth:	1 MHz* **RBW 1MHz has been used based on Reference Number: KDB 364244 Item 5.2**
Video bandwidth:	3 MHz
Trace-Mode:	Max Hold

Measurement procedures:

- Bandwidth: ANSI C63.10-2013 6.9 / 9.3
- Frequency stability: ANSI C63.10-2013 6.8 / 9.4

1MHz*: RBW 1MHz has been used based on Reference Number: KDB 364244 Item 5.2

20 dB bandwidth at normal conditions:

TID	EUT	Mode	Test condition	f_L [GHz]	f_H [GHz]	Bandwidth [GHz]
100	S18_C01	1	T_{nom} / V_{nom}	60.0873	63.9807	3.89

Frequency stability: ANSI C63.10-2020 §6.8, §9.5

Bandwidth measurement for frequency stability tests: 20 dB bandwidth

Test condition	TID	Frequency f_L [GHz]	Frequency f_H [GHz]	Bandwidth [MHz]
T_{nom} / V_{min}	101	60.0883	63.9797	3.89
T_{nom} / V_{max}	102	60.8830	63.9817	3.89
-20 °C / V_{nom}	104	60.0923	63.9837	3.89
-10 °C / V_{nom}	105	60.0923	63.9837	3.89
0 °C / V_{nom}	106	60.0903	63.9837	3.89
10 °C / V_{nom}	107	60.0903	63.9827	3.89
20 °C / V_{nom}	108	60.0883	63.9787	3.89
30 °C / V_{nom}	109	60.0883	63.9817	3.89
40 °C / V_{nom}	110	60.0883	63.9817	3.89
50 °C / V_{nom}	111	60.0873	63.9807	3.89

Note:

- Detailed measurement results: see measurement report TR22-1-0043303T008a-A1

Verdict: Compliant

4.3 Time domain requirements: Continous transmitter off-times & transmit duty cycle

Description:

Measurement of the time domain parameter.

Limits and provisions:

Selection of applicable rule parts: see chapter 1 3

Applicable time domain requirements		
Applicable	**Rule part**	**Time domain requirement**
☐	15.255(b)(3)	sum of continuous transmitter off-times of at least two milliseconds shall equal at least 16.5 milliseconds within any contiguous interval of 33 milliseconds
☐	15.255(c)(2)(i)	Peak EIRP ≤ 3 dBm: none
		Peak EIRP ≤ 20 dBm: sum of continuous transmitter off-times of at least two milliseconds equals at least 16.5 milliseconds within any contiguous interval of 33 milliseconds
☒	15.255(c)(2)(iii)(A)	sum of continuous transmitter off-times of at least two milliseconds shall equal at least 25.5 milliseconds within any contiguous interval of 33 milliseconds
☐	15.255(c)(2)(iii)(B)	sum of continuous transmitter off-times of at least two milliseconds shall equal at least 16.5 milliseconds within any contiguous interval of 33 milliseconds
☐	15.255(c)(3)	maximum pulse duration of 6 ns; transmit duty cycle shall not exceed 10% during any 0.3 µs time window
☐		none

Note:

- Continous transmitter off-times:
  Off-times are only taken into account if they are larger than the specified minimum value (e.g. 2 ms).
  Off-times smaller than the specified minimum value are not considered when checking the specified limit (e.g. "at least 25.5 ms within any contiguous interval of 33 ms").

Measurement:

Measurement parameter	
Detector:	Pos-Peak (RF-Detector)
Video bandwidth:	Video bandwidth:

Measurement results:

EUT	Mode	Test condition	Maximum sum of continuous transmitter off-times of at least two milliseconds within any contiguous interval of 33 milliseconds.	
S18_C01	1	T_{nom} / V_{nom}	Measured value	Limit
			Transmitter on time: 2.11 ms, Transmitter off time: 47.96 ms	Off time ≥2ms (continuous) and ≥25.5ms within 33ms

Note:

- Detailed measurement results: see measurement report TR22-1-0043303T008a-A1

Verdict: Compliant

4.4 Spurious emissions radiated

Description:

Measurement of the radiated spurious emissions.

Limits and provisions:

Selection of applicable rule parts: see chapter 1.3

47CFR Part 15.209(a)		
Frequency (MHz)	Field strength (microvolts/meter)	Measurement distance (meters)
0.009 – 0.490	2400/F(kHz)	300
0.490 – 1.705	24000/F(kHz)	30
1.705 – 30.0	30	30
30 – 88	100	3
88 – 216	150	3
216 – 960	200	3
Above 960	500	3
47 CFR 15.255(d)		
Frequency (GHz)	Power density [pW/cm2]	Equivalent isotropically radiated power: EIRP [dBm]
Below 40	See §15.209	
40 - 200	90 @ distance of 3 m	-10
The power density of any emissions outside the 57-71 GHz band shall consist solely of spurious emissions.		
The levels of the spurious emissions shall not exceed the level of the fundamental emission.		
47 CFR 15.255(i)(2)		
Compliance measurements of frequency-agile field disturbance sensors/radars shall be performed with any related frequency sweep, step, or hop function activated.		
47 CFR 15.33(a)(3)		
If the intentional radiator operates at or above 30 GHz: to the fifth harmonic of the highest fundamental frequency or to 200 GHz, whichever is lower, unless specified otherwise elsewhere in the rules.		

Limit conversion (ANSI C63.10-2013 9.6):

$EIRP[dBm] = 10 \times \log(4 \times \pi \times d^2 \times PD[W/m^2])$

- Power density at the distance specified by the limit: PD [W/m²]
- Equivalent isotropically radiated power: EIRP [dBm]
- Distance at which the power density limit is specified: d [m]

According to this formula, an emission limit of PD = 90 pW/cm² at a distance of d = 3 m corresponds to an equivalent isotropically radiated power of EIRP = -10 dBm.

Measurement:

Measurement parameter	
Detector:	Quasi Peak / Pos-Peak / RMS
Resolution bandwidth:	F < 1 GHz: 100 kHz F > 1 GHz: 1 MHz
Video bandwidth:	F < 1 GHz: 300 kHz F > 1 GHz: 3 MHz
Trace-Mode:	Max Hold

Measurement results:

TID	EUT	Mode	Frequency	Max level	Limit	Result
020	S18_C01	1	9k – 30MHz	No critical level found	Check diagram in Annex A1	Pass
020_01	S18_C01	1	9k – 30MHz	No critical level found	Check diagram in Annex A1	Pass
021	S18_C01	1	30M – 1GHz	37.17 dBµV/m	40 dBµV/m	Pass
021_01	S18_C01	1	30M – 1GHz	36.64 dBµV/m	40 dBµV/m	Pass
022_01	S18_C01	1	1G – 15GHz	Peak: 60.97 dBµV/m, Avg: 49.51 dBµV/m	Peak: 74 dBµV/m Avg: 54 dBµV/m	Pass
022_02_ant_ver	S18_C01	1	15G – 18GHz	No critical level found	Peak: 74 dBµV/m Avg: 54 dBµV/m	Pass
022_03_ant_hor	S18_C01	1	15G – 18GHz	No critical level found	Peak: 74 dBµV/m Avg: 54 dBµV/m	Pass
024	S18_C01	1	18G – 40GHz	Maximum Emission found at 28.7987GHz, checkTID 24_02 for Final test	Peak: 74 dBµV/m Avg: 54 dBµV/m	Pass
024_02_ant_hor	S18_C01	1	@28.7987GHz	Peak: 59.98 dBµV/m Avg: 48.11 dBµV/m	Peak: 74 dBµV/m Avg: 54 dBµV/m	Pass
023_03_ant_ver	S18_C01	1	@28.7987GHz	Peak: 63.96 dBµV/m Avg: 49.91 dBµV/m	Peak: 74 dBµV/m Avg: 54 dBµV/m	Pass
026	S18_C01	1	40G – 50GHz	No critical level found	-10dBm	Pass
027	S18_C01	1	50G – 60GHz 64G – 65GHz	No critical level found	-10dBm	Pass
For In Band Measurements from 60G – 64GHz, please check chapter 4.1 and 4.2						
028_02	S18_C01	1	65G – 75GHz	No critical level found	-10dBm	Pass
029	S18_C01	1	75G – 90GHz	No critical level found	-10dBm	Pass
030	S18_C01	1	90G – 110GHz	No critical level found	-10dBm	Pass
032	S18_C01	1	110G – 140GHz	No critical level found	-10dBm	Pass
033	S18_C01	1	140G – 170GHz	No critical level found	-10dBm	Pass
034	S18_C01	1	170G – 200GHz	No critical level found	-10dBm	Pass
Please refer to the following plots for more information on the level of spurious emissions						

Note: Only Worst case Measurement Antenna Polarization Results stated here, Detailed measurement results: see measurement report TR22-1-0043303T008a-A1

Verdict: Compliant

Measurement have been carried out in the below Chambers.

9 kHz – 30 MHz: Chamber SAC 3
PMT Number: 120901

30 MHz – 1GHz: Chamber SAC 3
PMT Number: 120901

1GHz – 200 GHz: Chamber FAC2
PMT Number: 120907

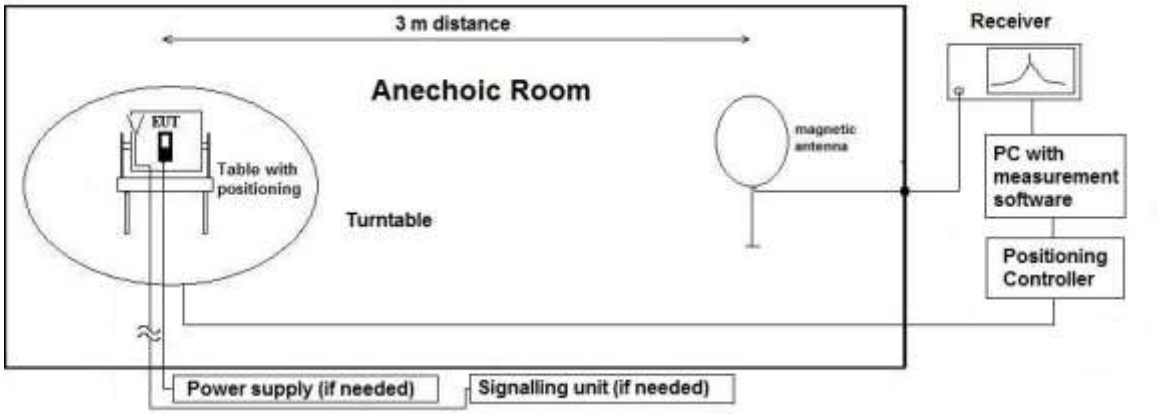
4.5 Radiated field strength emissions below 30 MHz (Chamber: SAC 3)

4.5.1 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.

4.5.2 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

4.5.3 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

4.5.4 Measurement Location

Test site	SAC 3

4.5.5 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

4.5.6 Result

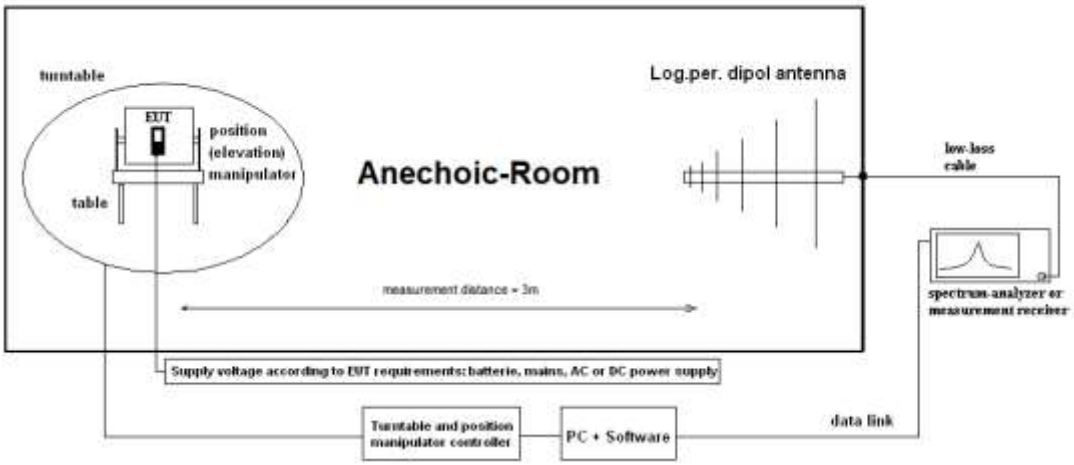
Note: Check chapter 4.4.

4.6 Radiated field strength emissions 30 MHz – 1000 MHz (Chamber: SAC 3)

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 16-1-4:2010 compliant Semi anechoic Chamber (SAC) recognized by the regulatory commission. The measurement distance was set to 3 meter for frequencies up to 1 GHz. A logarithmic periodic antenna is used for the frequency range 30 MHz to 1 GHz.

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.

4.6.2 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

4.6.3 Measurement Location

Test site	SAC 3

4.6.4 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

4.6.5 Result

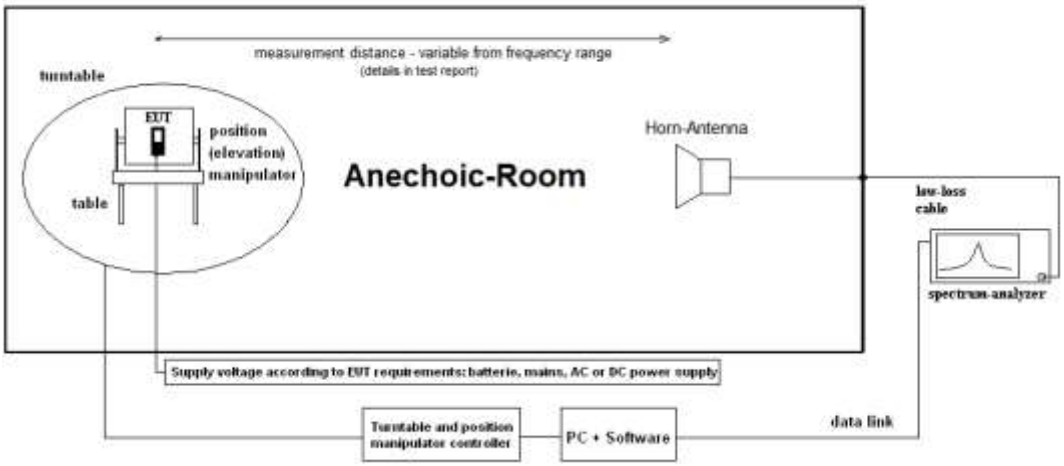
Note: Check Chapter 4.4

4.7 Radiated field strength emissions 1 GHz – 65 GHz (FAC2)

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 15 GHz Regarding measurement distance above 15 GHz check below table (4.7.5), Horn antennas are used for frequency range 1 GHz to 65 GHz.

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.

4.7.2 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

4.7.3 Measurement Location

Test site	120907 - FAC2 - Radiated Emissions

4.7.4 Measurement distance

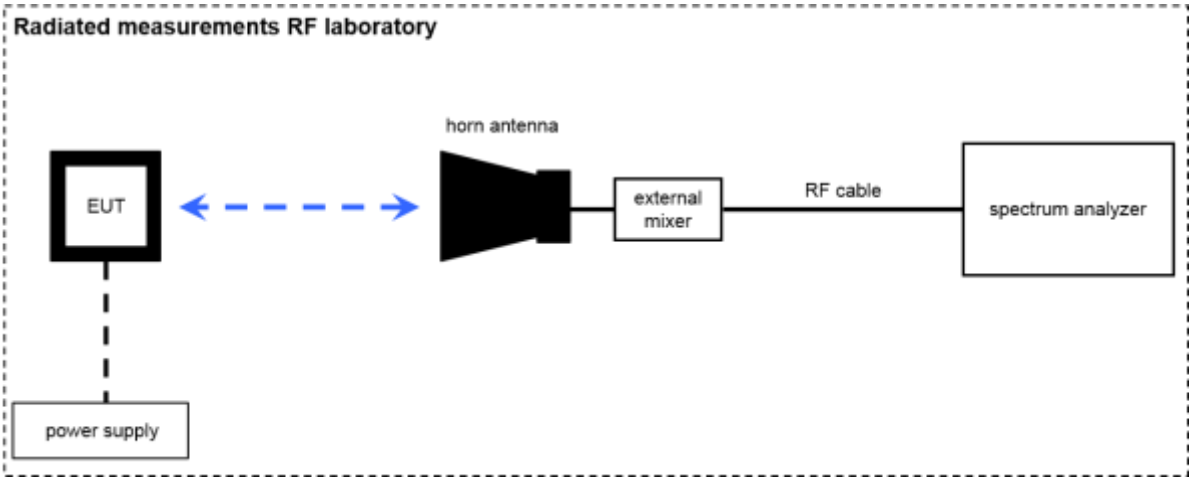
Frequency Range [GHz]	Measurement distance [m]
1 - 15	3
15 - 18	2
18 - 40	1

4.7.5 Result

Note: Check chapter 4.4

4.8 Radiated field strength emissions, above 65 GHz (FAC2)

Schematic:



Testing method:

OP = AV + D - G + CA
(OP-radiated output power; AV-analyzer value; D-free field attenuation of measurement distance; G-antenna gain+amplifier gain; CA-loss signal path)

Example calculation:
OP [dBm] = -65.0 [dBm] + 50.0 [dB] - 20.0 [dBi] + 5.0 [dB] = -30 [dBm] (1 µW)
Note: conversion loss of mixer is already included in analyzer value.

EUT settings
The EUT is ON and set to default mode: FMCW modulation. At first all modes are tested with normal/nominal conditions.

Testing method:

The measurements are done for averaging time × number of sweep points sweep time. 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 determined.
Then the measurement is repeated with averaging time × number of sweep points sweep time. Average time is larger than the EUT cycle time.
The measurements are made with the mixer. There is a ref level line in all measurements. This line is not to be mistaken for the 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 54 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 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. 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. No image signals and mixer products are flagged with the marker. There are too many image signals and mixer products. When all they will be flagged with the marker then it looks not clearly.

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]	shortest wavelength λ in the measurement, [m]	Boundary for near/far field, [m]
40-50	0.045	50	0.00599585	0.68
50-75	0.03	75	0.00399723	0.45
75-110	0.02	110	0.00272539	0.29
110-140	0.016	140	0.00214137	0.24
140-162	0.01	162	0.00185057	0.11
140-170	0.01	170	0.00176349	0.11
140-220	0.01	220	0.00136269	0.15

*) The antenna aperture is estimated according internal photo provided by applicant.

Measurement frequency range:	Measurement distance, [m]	Boundary for near/far field, [m]
40 GHz – 50 GHz	1	0.68
50 GHz – 65 GHz	1	0.45
65 GHz – 75 GHz	1	0.45
75 GHz – 90 GHz	1	0.29
90 GHz – 110 GHz	1	0.29
110 GHz – 140 GHz	0.50	0.24
140 GHz – 170 GHz	0.50	0.11
170 GHz – 200 GHz	0.50	0.15

4.8.1 Measurement Location

Test site	120907 - FAC2 - Radiated Emissions

4.8.2 Result

Note: Check Chapter 4.4.

4.9 Conducted interference voltage DC

4.9.1 Description of the general test setup and methodology

The measurement is performed as follows:
The entire frequency range is swept with Peak and Average detectors on all lines. The test result curves are based on this Preview Test. If there are peaks with margin less than 10 dB to the limits for emissions, the Final Test is started. All frequencies at which margin to the limits is less than 10 dB are scanned with Quasi peak or Average detectors on corresponding lines around those frequencies. These final values are entered to the test results curve and tables.
Diagrams show the peak values as a sum of measured lines in maxhold mode.

Measurement of the conducted spurious emissions in transmit mode below 30 MHz. Both power lines, phase and neutral line, are measured. Found peaks are re-measured with average and quasi peak detection to show compliance to the limits.

4.9.2 Test receiver settings

Detector	Peak	Average	Quasi peak
Min. attenuation	10 dB	10 dB	10 dB
Resolution bandwidth	9 kHz	9 kHz	9 kHz
Dector Meas-time	10 ms	Pre-measurement: 10 ms Final measurement: 1 s	1 s
Step size	3 kHz	Pre-measurement: 3 kHz Final measurement: selected frequencies	Selected frequencies
Preamp	Off	Off	Off

4.9.3 Measurement Protocol(s)

Measurement No.	P3M1
Environmental conditions	Temperature: 21.0 °C Humidity: 42.0 % rH
Test date (mm-dd-yyyy)	2024-Mar-04
Operator	Al-Amin Hossain
EuT power supply:	DC +24.0 V
Operating mode	01
Setup	01
Remarks	AC/DC adapter has been used to perform this test

Diagram	Detector	Tested line(s)	Additional (scan-) information or remarks	Result
TID18	☒ Peak (pre-scan) ☐ CAV (pre-scan) ☒ CAV (final) ☒ QP (final)	(+), (-)	Pre-test Fast scan, Maxhold; CAV + QP- Final Measurement	PASS

Remark: for more information and graphical plot see annex A1 **TR22-1-0043303T008a-A1**

4.9.4 Limits

47 CFR 15.207(a)		
Frequency of emission (MHz)	Conducted limit (dBµV)	
	Quasi-peak	Average
0.15 – 0.5	66 to 56*	56 to 46*
0.5 – 5	56	46
5 – 30	60	50

* Decreases with the logarithm of the frequency

4.9.5 Measurement location and Equipment list

ID	Description	Manufacturer	SerNo
120919	Conducted Emission		
20005	AC - LISN 50 Ohm/50µH ESH2-Z5	Rohde & Schwarz Messgerätebau GmbH / Memmingen	861741/005
20007	Single-Line V-Network (50 Ohm/5µH) ESH3-Z6	Rohde & Schwarz Messgerätebau GmbH / Memmingen	892563/002
20033	RF-current probe (100kHz-30MHz) ESH2-Z1	Rohde & Schwarz Messgerätebau GmbH / Memmingen	879581/18
20051	VHF-Current Probe ESV-Z1	Rohde & Schwarz Messgerätebau GmbH	872421
20099	Passive Voltage Probe ESH2-Z3	Rohde & Schwarz Messgerätebau GmbH	299.7810.52
20100	Passive Voltage Probe TK 9416	Schwarzbeck Mess-Elektronik OHG / Schönau	without
20300	AC - LISN (50 Ohm/50µH, 1-phase) ESH3-Z5	Rohde & Schwarz Messgerätebau GmbH / Memmingen	892 239/020
20348	Shielded Room EMI conducted	Albatross Projects GmbH	without
20373	Single-Line V-Network (50 Ohm/5µH) ESH3-Z6	Rohde & Schwarz Messgerätebau GmbH / Memmingen	100535
20377	Test Receiver ESCS30	Rohde & Schwarz Messgerätebau GmbH / Memmingen	100160
20468	Digital Multimeter Fluke 112	Fluke Deutschland GmbH	90090455
20533	Impedance Stabilization Network ISN T200A	Teseq GmbH / Berlin	25706
20534	Impedance Stabilization Network ISN T400A	Teseq GmbH / Berlin	24881
20535	Impedance Stabilization Network ISN T800	Teseq GmbH / Berlin	26321
20536	Impedance Stabilization Network ISN ST08	Teseq GmbH / Berlin	25867
20541	Impedance Stabilization Network ISN T8-Cat6	Teseq GmbH / Berlin	26373
20556	Thermo-/Hygrometer WS-9400	Conrad Electronic GmbH	-

4.10 Equipment lists

ID	Description	Manufacturer	SerNo	CheckType	Last Check	Interval	Next Check
	120901 - SAC3 - Radiated Emission <1GHz			calchk	cal: 2015-Jul-21 chk: 2021-Jul-27	cal: 10Y chk: 12M	cal: 2025-Jul-21 chk: 2022-Jul-27
20341	Digital Multimeter Fluke 112	Fluke Deutschland GmbH / Glottertal	81650455	cal	cal: 2022-May-18	cal: 24M	cal: 2024-May-18
20442	Semi Anechoic Chamber	ETS-Lindgren Gmbh / Taufkirchen	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	Test Receiver ESU26	Rohde & Schwarz Messgerätebau GmbH / Memmingen	100362	cal	cal: 2024-May-05	cal: 12M	cal: 2025-May-04
20885	Power Supply EA3632A	Agilent Technologies Deutschland GmbH	75305850	cnn	cal: - chk: -	cal: - chk: -	cal: - chk: -
25038	Loop Antenna HFH2-Z2	Rohde & Schwarz Messgerätebau GmbH / Memmingen	879824/13	cal	cal: 2022-Jul-04	cal: 24M	cal: 2024-Jul-04
	120907 - FAC2 - Radiated Emissions			chk	chk: 2024-Mar-15	chk: 12M	chk: 2025-Mar-15
20005	AC - LISN 50 Ohm/50µH ESH2-Z5	Rohde & Schwarz Messgerätebau GmbH / Memmingen	861741/005	cal	cal: 2024-May-14	cal: 12M	cal: 2025-May-13
20133	Horn Antenna 3115 (Meas 1)	EMCO Elektronik GmbH / Gilching	9012-3629	cal	cal: 2023-May-22	cal: 36M	cal: 2026-May-22
20302	Horn Antenna BBHA9170 (Meas 1)	Schwarzbeck Mess-Elektronik OHG / Schönau	155	cpu	chk: 2020-Apr-15	chk: 12M	
20303	Horn Antenna BBHA9170 (Subst 1)	Schwarzbeck Mess-Elektronik OHG	156	cpu		chk: 12M	
20354	DC - Power Supply 40A NGPE 40/40		448	cpu			
20729	FS-Z140	Rohde & Schwarz Messgerätebau GmbH / Memmingen	101004	cal	cal: 2023-Jun-16	cal: 36M	cal: 2026-Jun-16
20730	FS-Z110	Rohde & Schwarz Messgerätebau GmbH / Memmingen	101468	cal	cal: 2023-Jun-02	cal: 36M	cal: 2026-Jun-02
20731	FS-Z75	Rohde & Schwarz Messgerätebau GmbH / Memmingen	101022	cal	cal: 2022-May-18	cal: 36M	cal: 2025-May-18
20732	Signal- and Spectrum Analyzer FSW67	Rohde & Schwarz Messgerätebau GmbH / Memmingen	104023	cal	cal: 2023-May-25	cal: 12M*	cal: 2024-Aug.-24
20733	Harmonic Mixer FS-Z220	RPG-Radiometer Physics GmbH	101009	cal	cal: 2024-May-24	cal: 36M	cal: 2027-May-23
20734	Harmonic Mixer FS-Z325	RPG-Radiometer Physics GmbH / Meckenheim	101005	cal	cal: 2024-May-24	cal: 36M	cal: 2027-May-23
20765	Pickett-Potter Horn Antenna FH-PP 40-60	RPG-Radiometer Physics GmbH / Meckenheim	010001	chk	chk: 2023-Oct-20	chk: 12M	chk: 2024-Oct-20
20767	Pickett-Potter Horn Antenna FH-PP 140-220	RPG-Radiometer Physics GmbH / Meckenheim	010011	chk	chk: 2023-Oct-20	chk: 12M	chk: 2024-Oct-20
20811	Horn Antenna ASY-SGH-124-SMA	Antenna Systems Solutions S.L	29F14182337	cal	cal: 2021-Oct-20	cal: 36M	cal: 2024-Oct-20
20812	Pickett-Potter Horn Antenna FH-PP-325	RPG-Radiometer Physics GmbH / Meckenheim	10024	chk	chk: 2023-Oct-20	chk: 12M	chk: 2024-Oct-20
20813	Pickett-Potter Horn Antenna FH-PP 075	RPG-Radiometer Physics GmbH / Meckenheim	10006	chk	chk: 2023-Oct-20	chk: 12M	chk: 2024-Oct-20
20814	Pickett-Potter Horn Antenna FH-PP 140	RPG-Radiometer Physics GmbH / Meckenheim	10008	chk	chk: 2023-Oct-20	chk: 12M	chk: 2024-Oct-20
20815	Pickett-Potter Horn Antenna FH-PP 110	RPG-Radiometer Physics GmbH / Meckenheim	10014	chk	chk: 2023-Oct-20	chk: 12M	chk: 2024-Oct-20
20816	SGH Antenna SGH-26-WR10	Anteral S.L.	1144	cnn	cal: - chk: -	cal: - chk: -	cal: - chk: -
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	
20907	Waveguide WR-15 attenuator STA-30-15-M2	SAGE Millimeter Inc.	13256-01	cnn	cal: - chk: -	cal: - chk: -	cal: - chk: -
20908	Waveguide WR 10 attenuator STA-30-10-M2	SAGE Millimeter Inc.	13256-01	cnn	cal: - chk: -	cal: - chk: -	cal: - chk: -
20909	Waveguide Horn Antenna PE9881-24	Pasternack Enterprises, Inc.	37/2016	cnn	cal: - chk: -	cal: - chk: -	cal: - chk: -
20910	Frequency Multiplier 936VF-10/385	MI-Wave, Millimeter Wave Products Inc.	142	cnn	cal: - chk: -	cal: - chk: -	cal: - chk: -
20911	Frequency Multiplier 938WF-10/387	MI-Wave, Millimeter Wave Products Inc.	141	cnn	cal: - chk: -	cal: - chk: -	cal: - chk: -
20913	Phase Amplitude Stable Cable Assembly DC-40GHz	RF-Lambda Europe GmbH	AC19040001	cnn	cal: - chk: -	cal: - chk: -	cal: - chk: -
20757	Thermal Power Sensor NRP110T	Rohde & Schwarz Messgerätebau GmbH / Memmingen	1424.6215K02-100984-nm	cal	chk: 2022-May-31	chk: 36M	chk: 2025-May-31
20622	Digital Oscilloscope DPO 3014	Tektronix UK Ltd. / Berkshire	C013619	cal	chk: 2023-May-23 chk: 2024-May-13	chk: 12M	chk: 2025-May-12

4.10.1 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

4.10.2 Legend

Note / remarks	Interval of calibration & Verification
12M	12 months
24M	24 months
36M	36 months
10Y	10 Years

Abbreviation Check Type	Description
cnn	Calibration and verification not necessary
cal	Calibration
calchk	Calibration plus intermediate Verification
chk	Verification
cpu	Verification before usage

5 Results from external laboratory

None	-

6 Opinions and interpretations

None	-

7 List of abbreviations

None	-

8 Measurement Uncertainty valid for conducted/radiated measurements

The reported uncertainties are calculated based on the standard uncertainty multiplied with the appropriate coverage factor **k**, such that a confidence level of approximately 95% is achieved. For uncertainty determination, each component used in the concrete measurement set-up was taken in account and it contribution to the overall uncertainty according its statistical distribution calculated.

Issue No.	Measurement type	Reference	Frequency range of measurement		Calculated Uncertainty based on confidence level of 95.54%	Remarks
			Start [MHz]	Stop [MHz]		
1	Magnetic Field Strength	EN ,FCC, JP, IC	0.009	30	4.86	Magnetic loop antenna, Pre-Amp on
2	RF-Output Power (EIRP) Unwanted emissions (EIRP) [dB]	EN, FCC, JP, IC	30	100	4.57	without Pre-Amp
			30	100	4.91	with Pre-Amp
			100	1000	4.02	without Pre-Amp
			100	1000	4.26	with Pre-Amp
			1000	18000	4.36	without Pre-Amp
			1000	18000	5.23	with Pre-Amp
			18000	33000	4.92	Schwarzbeck BBHA9170 (#20302) Antenna set-up non-waveguide antenna)
			33000	50000	4.17	Set-up for Q-Band (WR-22), non-wave guide antenna
			40000	60000	4.69	Set-up U-Band (WR-19), non-waveguide antenna
			50000	75000	4.06	External Mixer set-up V-Band (WR-15)
			75000	110000	4.17	External Mixer set-up W-Band (WR-6)
			90000	140000	5.49	External Mixer set-up F-Band (WR-8)
			140000	225000	6.22	External Mixer set-up G-Band (WR-5)
			225000	325000	7.04	External Mixer set-up (WR-3)
			325000	500000	8.84	External Mixer set-up (WR-2.2)
3	Radiated Blocking [dB]	EN	1000	18000	2.85	Typical set-up with microwave generator and antenna, value for 7 GHz calculated
			18000	33000	4.66	Typical set-up with microwave generator and antenna
			33000	50000	3.48	WR-22 set-up
			50000	75000	3.73	WR-15 set-up
			75000	110000	4.26	WR-6 set-up
4	Frequency Error / UWB+FMCW [kHz]	EN, FCC, JP, ISED	40000	77000	276.19	calculated for 77 GHz (FMCW) carrier
			6000	7000	33.92	calculated for 6.5 GHz UWB Ch.5
	Frequency Error / NFC [Hz]	EN, FCC, JP, ISED	11.00	14.00	20.76	calculated for 13.56 MHz NFC carrier
5	TS 8997 Conducted Parameters	FCC15/18 / ISED	30	6000	1.11	1. Power measurement with Fast-sampling-detector
			30	6000	1.20	2. Power measurement with Spectrum-Analyzer
			30	6000	1.20	3. Power Spectrum-Density measurement
			30	7500	1.20	4. Conducted Spurious emissions
			0.009	30	2.56	5. Conducted Spurious emissions
			2.4	2.48	1.95 ppm	6a. Bandwidth / 2-Marker Method for 2.4 GHz ISM
			5.18	5.825	7.180 ppm	6b. Bandwidth / 2-Marker Method for 5 GHz WLAN
			5.18	5.825	1.099 ppm	7. Frequency (Marker method) for 5 GHz WLAN
			30	6000	0.11561 µs	8. Medium-Utilization factor / Timing
			30	6000	1.85	9a. Blocking-Level of companion device
			30	6000	1.62	9b. Blocking Generator level
6	Conducted Emissions	EN, FCC	0.009	30	3.57	general EMI-measurements on AC/DC ports

9 Versions of test reports (change history)

Version	Applied changes	Date of release
--	Initial release	2024-Jul-04
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End Of Test Report