



EMI - TEST REPORT

- FCC Part 15.250, RSS-210 -

Type / Model Name : KNX-T5.1-5 / ePaper Tag

Product Description : UWB Tracking Tag with ePaper Display

Applicant : Kinexon Inc.

Address : 200 S Wacker Drive, Suite 3100

CHICAGO, IL 60606, USA

Manufacturer : Kinexon GmbH

Address : Schellingstraße 35

80799 MÜNCHEN, GERMANY

Test Result according to the standards
listed in clause 1 test standards:

POSITIVE

Test Report No. : **80081673-04 Rev2**

09. September 2021

Date of issue



Deutsche
Akkreditierungsstelle
D-PL-12030-01-03
D-PL-12030-01-04

FCC ID: 2ALC5-KNX-ETAG1 IC: 25557-KNXETAG1

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ATTACHMENT A separate supplement

The test report merely corresponds to the test sample. It is not permitted to copy extracts of these test results without the written permission of the test laboratory.

1 TEST STANDARDS

The tests were performed according to following standards:

FCC Rules and Regulations Part 15, Subpart A - General (September 2020)

Part 15, Subpart A, Section 15.31	Measurement standards
Part 15, Subpart A, Section 15.33	Frequency range of radiated measurements

FCC Rules and Regulations Part 15, Subpart C - Intentional Radiators (September 2020)

Part 15, Subpart C, Section 15.203	Antenna requirement
Part 15, Subpart C, Section 15.204	External radio frequency power amplifiers and antenna modifications
Part 15, Subpart C, Section 15.205	Restricted bands of operation
Part 15, Subpart C, Section 15.207	Conducted limits
Part 15, Subpart C, Section 15.209	Radiated emission limits, general requirements
Part 15, Subpart C, Section 15.250	Operation of wideband systems within the band 5925-7250 MHz
ANSI C63.10: 2013	Testing Unlicensed Wireless Devices
ETSI TR 100 028 V1.3.1: 2001-03	Electromagnetic Compatibility and Radio Spectrum Matters (ERM); Uncertainties in the Measurement of Mobile Radio Equipment Characteristics—Part 1 and Part 2

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2 EQUIPMENT UNDER TEST

2.1 General remarks

This test report replaces the test report 80081673-01 Rev1. The changes are as follows:

- using WBT instead of UWB
- additional remarks on page 30

Rev1 changes:

- redefining type / model name on page 1
- expansion and redefining of variants of the EUT on page 5
- redefining power supply list on page 5

Rev0: Initial report

2.2 Information provided by the Client

Please note, we do not take any responsibility for information provided by the client or his representative which may have an influence on the validity of the test results.

2.3 Sampling

The customer is responsible for the choice of sample. Sample configuration, start-up and operation is carried out by the customer or according his/her instructions.

2.4 Photo documentation of the EUT – Detailed photos see ATTACHMENT A

2.5 Equipment type

Portable WBT Device

2.6 Short description of the equipment under test (EUT)

The ePaper solution combines high-precision WBT localization technology with smart process visualization. The KINEXON ePaper Tag can be placed on workpieces and load carriers to track their entire value-added process. In addition, an integrated display automatically informs about production steps.

Number of tested samples:	1
Serial number:	233247 (cont. transmission on channel 5)
WBT driver version:	5.1

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2.7 Variants of the EUT

There are eight variants of the EUT.

Model	Description	Comment
KNX-T5.1-1.1-2	Model with primary battery, b/w/r display	not tested
KNX-T5.1-1.4-2	Model with primary battery, b/w display	not tested
KNX-T5.1-4.1-1	Model with primary battery, b/w/r display, BLE module	not tested
KNX-T5.1-4.4-1	Model with primary battery, b/w display, BLE module	not tested
KNX-T5.1-2.2-2	Model with Qi charging, b/w/r display	not tested
KNX-T5.1-2.5-2	Model with Qi charging, b/w display	not tested
KNX-T5.1-5.2-1	Model with Qi charging, b/w/r display, BLE module	tested
KNX-T5.1-5.5-1	Model with Qi charging, b/w display, BLE module	not tested

All tests presented in the report were performed with the variant KNX-T5.1-5.2-1. All other variants were not tested and we do not take any responsibility for or make statements about the conformity.

2.8 Operation frequency and channel plan

The operating frequency band is 5925 MHz to 7250 MHz.

Channel plan:

Channel number	f_c (MHz)
Channel 5	6489.6

2.9 Transmit operating modes

Modulation: variable pulse position modulation (PPM) in combination with binary phase shift keying (BPSK).

Data rate: 6.8 Mbit/s

2.10 Antenna

The following antennas shall be used with the EUT:

Number	Characteristic	Model number	Plug	f-range (GHz)	Peak Gain (dBi)	Average Gain (dBi)
1	Omni	3100AT51A7200	None, PCB	3.1 – 10.3	1.5	-3.5

2.11 Power supply system utilised

Power supply voltage : 3.0 V DC (variants with primary battery)
3.7 V DC (variants with Qi charging)

2.12 Peripheral devices and interface cables

The following peripheral devices and interface cables are connected during the measurements:

- --- Model : ---

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2.13 Determination of worst case conditions for final measurement

Measurements are made in all three orthogonal axes with horizontal and vertical antenna positions to determine the worst case condition.

2.13.1 Test jig

No test jig is used.

2.13.2 Test software

No test software was used. The EUT is in a continuous transmission mode.

The test report merely corresponds to the test sample. It is not permitted to copy extracts of these test results without the written permission of the test laboratory.

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3 TEST RESULT SUMMARY

WBT device using digital modulation:

Operating in the 5925 MHz - 7250 MHz band:

FCC Rule Part	RSS Rule Part	Description	Result
15.207(a)	RSS-Gen, 8.8	AC power line conducted emissions	not applicable
15.250(b)	RSS-210, Annex K, K2	WBT Bandwidth	passed
15.209(a) 15.250(c)	RSS-Gen, 8.9 RSS-210, Annex K, K3(a)	Radiated Emissions 9 kHz to 40 GHz	passed
15.250(d)	RSS-210, Annex K, K3(b)	Radiated Emissions at 1164-1240 MHz and 1559-1610 MHz	passed
15.250(d)	RSS-210, Annex K, K3(c)	Peak Power radiated	passed
15.203	RSS-Gen, 6.6	Antenna requirement	passed

Note: AC power line conducted emissions not applicable because EUT has no AC mains connection.

The mentioned RSS Rule Parts in the above table are related to:

RSS-Gen, Issue 5, March 2019

RSS-210, Issue 10, December 2019

RSS-220, Issue 1, July 2018

3.1 Final assessment

The equipment under test fulfills the EMI requirements cited in clause 1 test standards.

Date of receipt of test sample : acc. to storage records

Testing commenced on : 14 June 2021

Testing concluded on : 28 June 2021

Checked by:

Tested by:

Jürgen Pessinger
Radio Team

Franz-Xaver Schrettenbrunner
Radio Team

4 TEST ENVIRONMENT

4.1 Address of the test laboratory

**CSA Group Bayern GmbH
Ohmstrasse 1-4
94342 STRASSKIRCHEN
GERMANY**

4.2 Environmental conditions

During the measurement the environmental conditions were within the listed ranges:

Temperature: 15 - 35 °C

Humidity: 30 - 60 %

Atmospheric pressure: 86 - 106 kPa

4.3 Statement of the measurement uncertainty

The data and results referenced in this document are true and accurate. It is noted that the expanded measurement uncertainty corresponds to the measurement results from the standard measurement uncertainty multiplied by the coverage factor $k = 2$. The true value is located in the corresponding interval with a probability of 95 %. The measurement uncertainty was calculated for all measurements listed in this test report acc. to CISPR 16-4-2 / 2011 + A1 / 2014 „Uncertainties, statistics and limit modelling – Uncertainty in EMC measurements“ and is documented in the quality system acc. to DIN EN ISO/IEC 17025. For all measurements shown in this report, the measurement uncertainty of the test laboratory, CSA Group Bayern GmbH, is below the measurement uncertainty as defined by CISPR. Therefore, no special measures must be taken into consideration with regard to the limits according to CISPR. Furthermore, component and process variability of devices similar to that tested may result in additional deviation. The manufacturer has the sole responsibility of continued compliance of the device.

Measurement Type	Range	Confidence Level (%)	Calculated Uncertainty
AC Conducted Spurious Emissions	0.15 MHz to 30 MHz	95%	$\pm 3.29 \text{ dB}$
20 dB Bandwidth	Center frequency of EUT	95%	$\pm 2.5 \times 10^{-7}$
99% Occupied Bandwidth	Center frequency of EUT	95%	$\pm 2.5 \times 10^{-7}$
Radiated Spurious Emissions	9 kHz to 30 MHz	95%	$\pm 3.53 \text{ dB}$
Radiated Spurious Emissions	30 MHz to 1000 MHz	95%	$\pm 3.71 \text{ dB}$
Radiated Spurious Emissions	1000 MHz to 10000 MHz	95%	$\pm 2.34 \text{ dB}$
Peak conducted output power	902 MHz to 928 MHz	95%	$\pm 0.35 \text{ dB}$
Conducted Spurious Emissions	9 kHz to 10000 MHz	95%	$\pm 2.15 \text{ dB}$

4.4 Conformity Decision Rule

The conformity decision rule is based on the ILAC G8 published at the time of reporting.

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4.5 Measurement protocol for FCC and ISED

4.5.1 General information

CSA Group Bayern GmbH is recognized as wireless testing laboratory under the CAB identifier:

FCC: DE 0011
ISED: DE0009

4.5.2 General Standard information

The test methods used comply with ANSI C63.10 - "Testing Unlicensed Wireless Devices".

4.5.2.1 Justification

The equipment under test (EUT) is configured in a typical user arrangement in accordance with the manufacturer's instructions. A cable is connected to each available port and either terminated with a peripheral using the appropriate impedance characteristic or left unterminated. Where appropriate, cables are manually manipulated with respect to each other thus obtaining maximum disturbances from the unit.

4.5.2.2 Radiated emission (electrical field 30 MHz - 1 GHz)

Spurious emissions from the EUT are measured in the frequency range of 30 MHz to 1000 MHz using a tuned receiver and appropriate broadband linearly polarised antennas. Measurements between 30 MHz and 1000 MHz are made with 120 kHz/6 dB bandwidth and quasi-peak detection. Table top equipment is placed on a 1.0 X 1.5 m non-conducting table 80 centimetres above the ground plane. Floor standing equipment is placed directly on the turntable/ground plane. The setup of the equipment under test is established in accordance with ANSI C63.10. The interface cables that are closer than 40 centimetres to the ground plane are bundled in the center in a serpentine fashion so that they are at least 40 centimetres from the ground plane. Cables to simulators/testers (if used in this test) are routed through the center of the table and to a screened room located outside the test area. The antenna is positioned 3, 10 or 30 metres horizontally from the EUT and is repeated vertically. To locate maximum emissions from the test sample the antenna is varied in height from 1 to 4 metres and the EUT is rotated 360 degrees.

The final level in dB μ V/m is calculated by taking the reading from the EMI receiver (Level dB μ V) and adding the correction factors and cable loss factor (dB). The FCC or CISPR limit is subtracted from this result in order to provide the limit margin listed in the measurement protocol.

The resolution bandwidth setting:

30 MHz – 1000 MHz: RBW: 120 kHz

Example:

Frequency Delta (MHz)	Level (dB μ V)	+	Factor (dB)	=	Level (dB μ V/m)	-	CISPR Limit (dB μ V/m)	=	(dB)
719.0	75.0	+	32.6	=	107.6	-	110.0	=	-2.4

FCC ID: 2ALC5-KNX-ETAG1 IC: 25557-KNXETAG1**4.5.2.3 Radiated emission (electrical field 1 GHz - 40 GHz)**

Radiated emissions from the EUT are measured in the frequency range 1 GHz up to the maximum frequency as specified in 47 CFR Part 15, Subpart A, Section 15.33, using a spectrum analyser and appropriate linearly polarized antennas. Table top equipment is placed on a 1.0 X 1.5 metre non-conducting table, 1.5 metre above the ground plane. Floor standing equipment is placed directly on the turntable/ground plane. The setup of the equipment under test is following set out in ANSI C63.10. The interface cables that are closer than 40 centimetres to the ground plane are bundled in the center in a serpentine fashion so they are at least 40 centimetres from the ground plane. Cables to simulators/testers (if used in this test) are routed through the center of the table and to a screened room located outside the test area. Measurements are made in both the horizontal and vertical polarization planes in a fully anechoic room using a spectrum analyzer set to max peak detector function and a resolution 1 MHz and video bandwidth 3 MHz for peak measurement. The conditions determined as worst case will then be used for the final measurements. When the EUT is larger than the beam width of the measuring antenna it will be moved over the surface for the four sides of the equipment. Where appropriate, the test distance may be reduced in order to detect emissions under better uncertainty and are calculated at the specified test distance.

The test report merely corresponds to the test sample. It is not permitted to copy extracts of these test results without the written permission of the test laboratory.

5 TEST CONDITIONS AND RESULTS

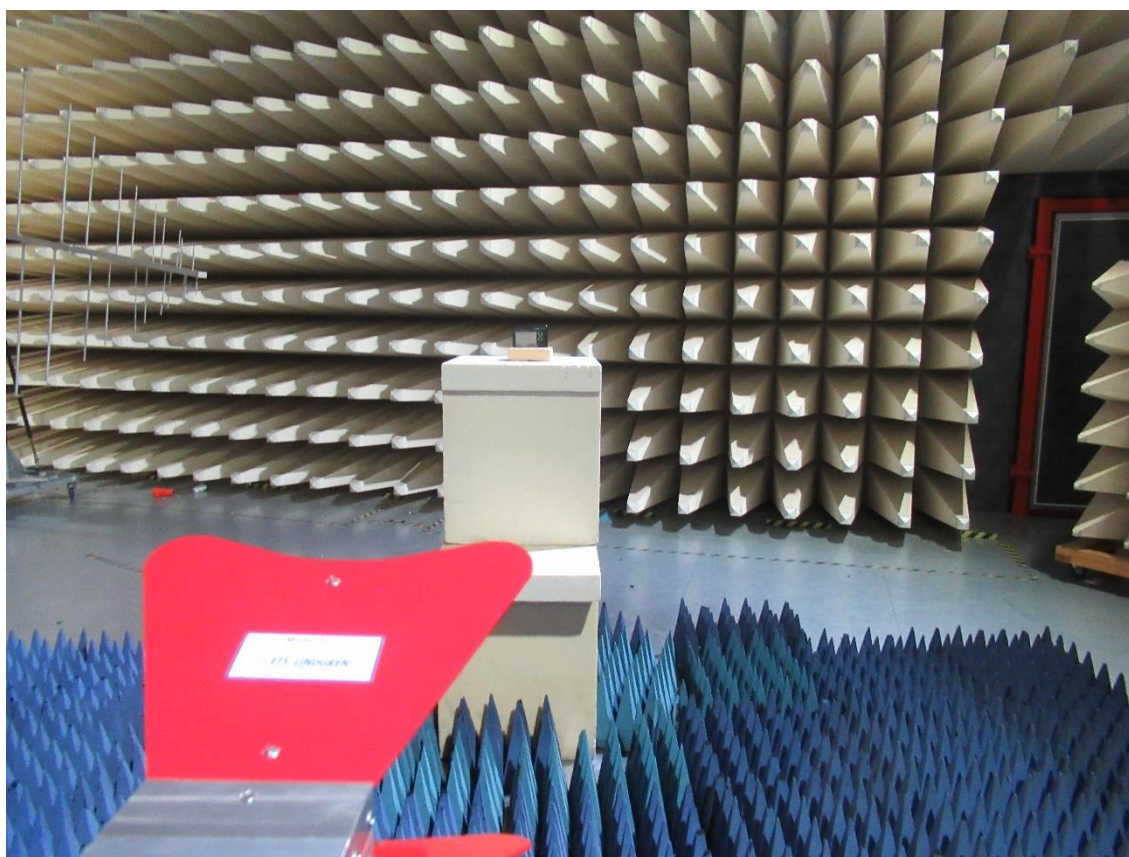
5.1 WBT Bandwidth

For test instruments and accessories used see section 6 Part CPR 3.

5.1.1 Description of the test location

Test location: Anechoic chamber 1

5.1.2 Photo documentation of the test set-up



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5.1.3 Applicable standard

According to FCC Part 15, Section 15.250(a):

The -10 dB bandwidth of a device operating under the provisions of this section must be contained within the 5925-7250 MHz band under all conditions of operation including the effects from stepped frequency, frequency hopping or other modulation techniques that may be employed as well as the frequency stability of the transmitter over expected variations in temperature and supply voltage.

According to FCC Part 15, Section 15.250(b):

The -10 dB bandwidth of the fundamental emission shall be at least 50 MHz. For transmitters that employ frequency hopping, stepped frequency or similar modulation types, measurement of the -10 dB minimum bandwidth specified in this paragraph shall be made with the frequency hop or step function disabled and with the transmitter operating continuously at a fundamental frequency following the provisions of §15.31(m)

5.1.4 Description of Measurement

The measurement was performed radiated at a distance of 1 m. The bandwidth was measured at an amplitude level reduced from the reference level of a modulated channel by a ratio of -10 dB.

Spectrum analyser settings:

RBW: 1 MHz, VBW: 3 MHz, Detector: Peak

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5.1.5 Test result

channel	lowest frequency f_L (MHz)	highest frequency f_H (MHz)	permitted frequency range (MHz)	WBT bandwidth (MHz)	required WBT bandwidth (MHz)	result
5	6248.26	6746.92	5925-7250	498.66	> 50	passed

Limit according to FCC Part 15, Section 15.250(b):

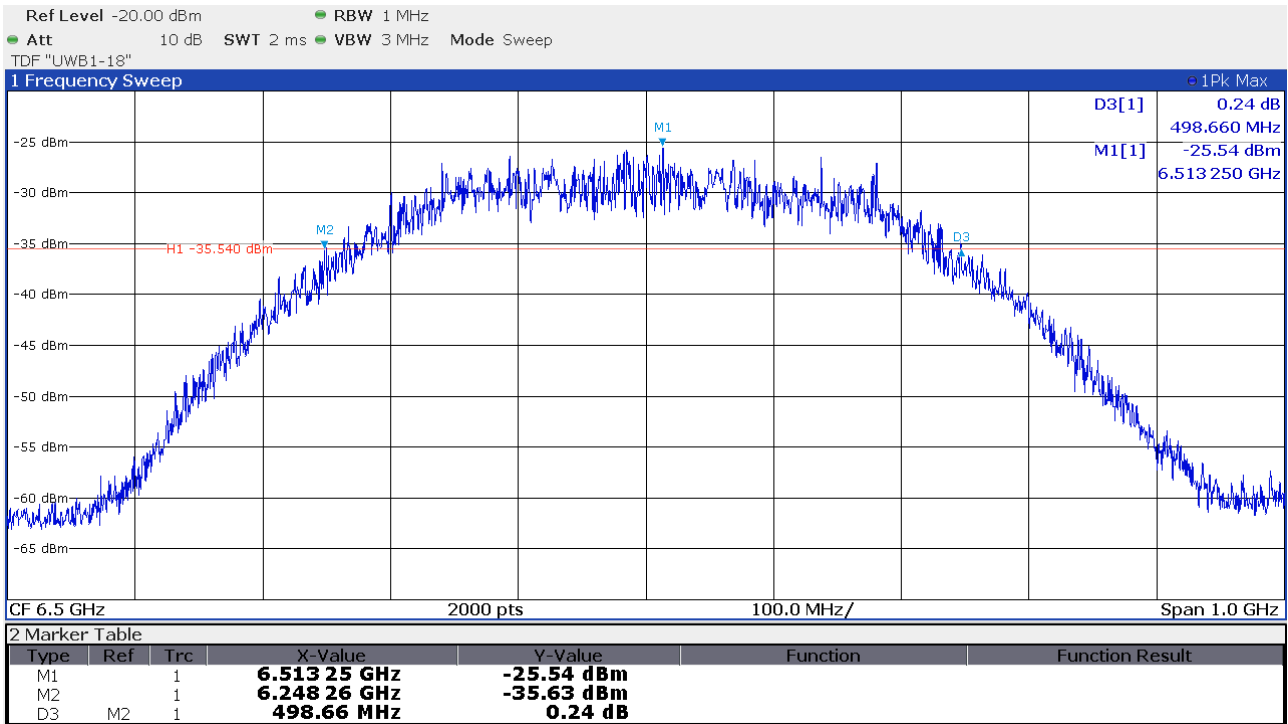
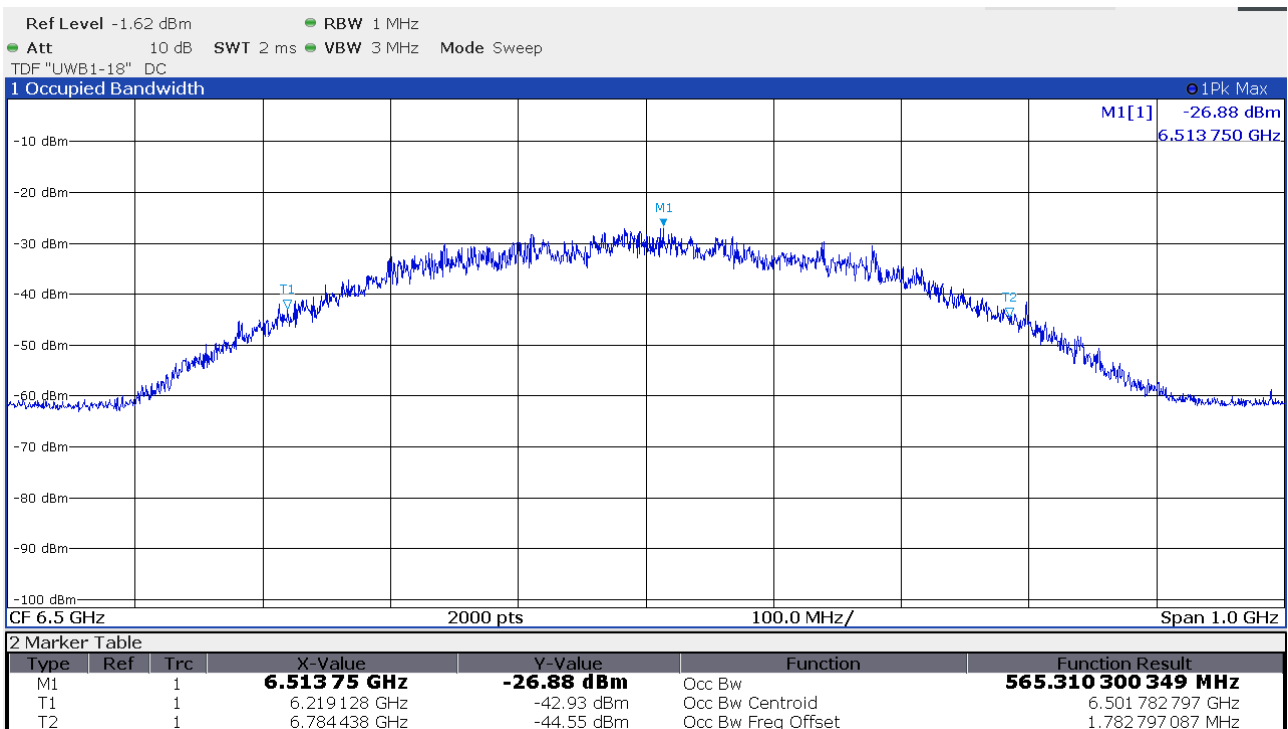
The -10 dB bandwidth of the fundamental emission shall be at least 50 MHz.

Limit according to RSS-210 Annex K, K.2(b):

The 10 dB bandwidth of the device shall be at least 50 MHz and less than 500 MHz.

The requirements are **FULFILLED**.

Remarks: For detailed test results please refer to following test protocols.

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5.1.6 Test protocols EBW
Channel 5

5.1.7 Test protocols OBW 99%
Channel 5


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5.2 Radiated Emissions 9 kHz to 40 GHz

For test instruments and accessories used see section 6 Part **SER 2** and **SER 3**.

5.2.1 Description of the test location

Test location: OATS 1
Test location: Anechoic chamber 1

5.2.2 Photo documentation of the test set-up

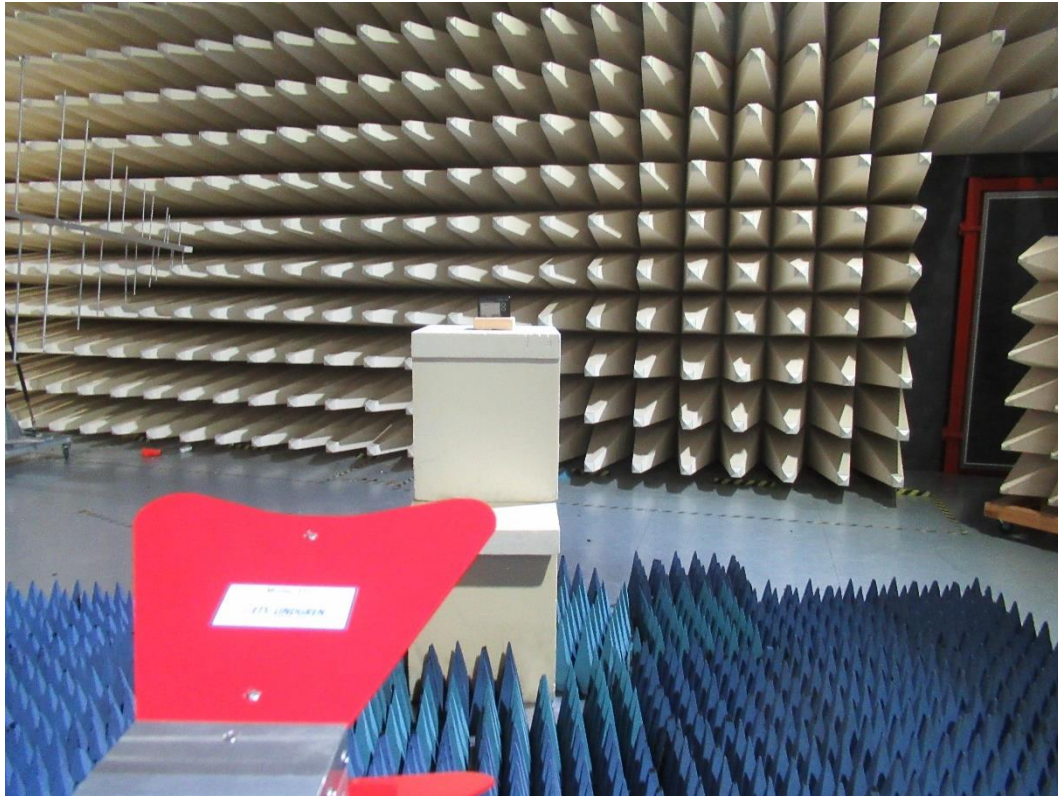
30 MHz – 960 MHz



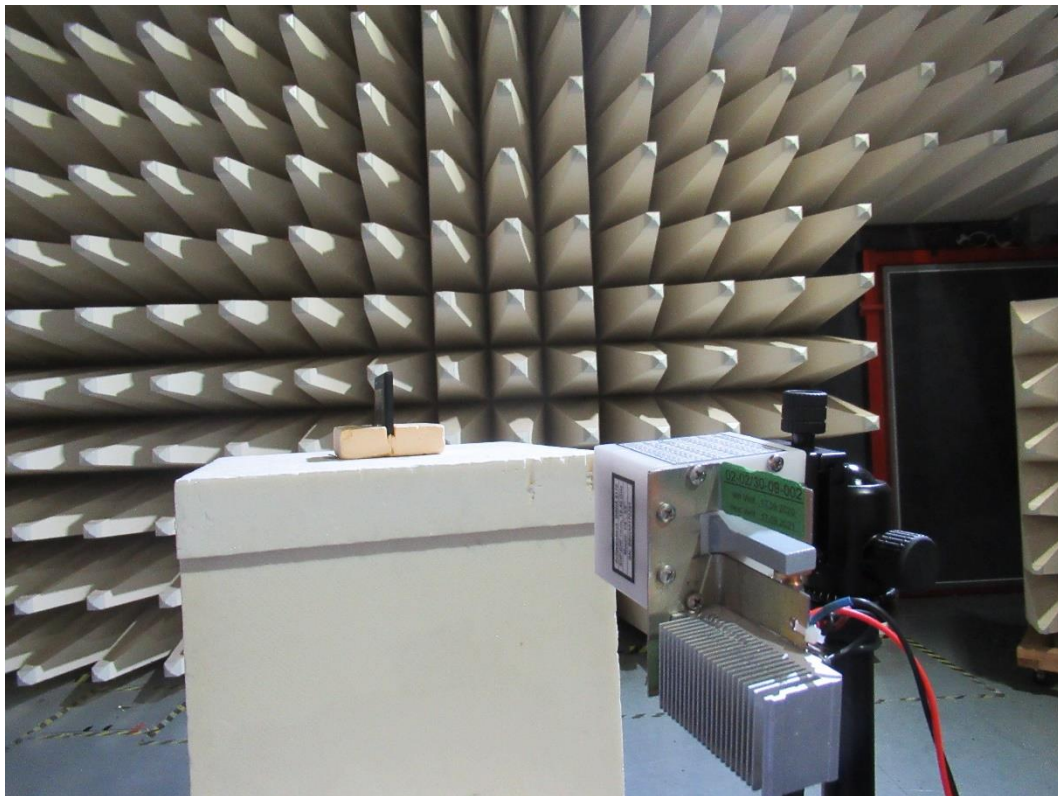
The test report merely corresponds to the test sample. It is not permitted to copy extracts of these test results without the written permission of the test laboratory.

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960 MHz - 18000 MHz



18000 MHz – 40000 MHz



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5.2.3 Applicable standard

According to FCC Part 15, Section 15.250(d):

Radiated emissions at or below 960 MHz shall not exceed the emission levels in §15.209. The radiated emissions above 960 MHz from a device operating under the provisions of this section shall not exceed the following RMS average limits based on measurements using a 1 MHz resolution bandwidth.

5.2.4 Analyser settings

9 kHz – 150 kHz	RBW: 200 Hz				
150 kHz - 30 MHz	RBW: 9 kHz				
30 MHz – 960 MHz	RBW: 120 kHz	Detector: QP			
960 MHz – 40 GHz	RBW: 1 MHz	VBW: 3 MHz	Detector: RMS	Sweep time: 1ms per MHz	

5.2.5 Test result
5.2.5.1 Measurement 9 kHz to 30 MHz

Note: Pre-measurements have shown, there are no detectable emissions in this frequency range.

5.2.5.2 Measurement 30 MHz to 960 MHz

Frequency (MHz)	Reading Vert. (dBµV)	Reading Hor. (dBµV)	Correct. Vert. (dB)	Correct. Hor. (dB)	Level Vert. (dBµV/m)	Level Hor. (dBµV/m)	Limit (dBµV/m)	Dlimit (dB)
80.00	4.8	4.6	11.1	10.8	15.9	15.4	40.0	-24.1
150.00	-0.1	1.1	13.9	14.8	13.8	15.9	43.5	-27.6
300.00	0.4	6.9	16.9	16.5	17.3	23.4	46.0	-22.6
450.00	-2.3	-0.6	21.2	20.9	18.9	20.3	46.0	-25.7
600.00	-3.1	-1.6	25.5	25.3	22.4	23.7	46.0	-22.3
700.00	-2.8	-2.7	27.0	26.5	24.2	23.8	46.0	-21.8

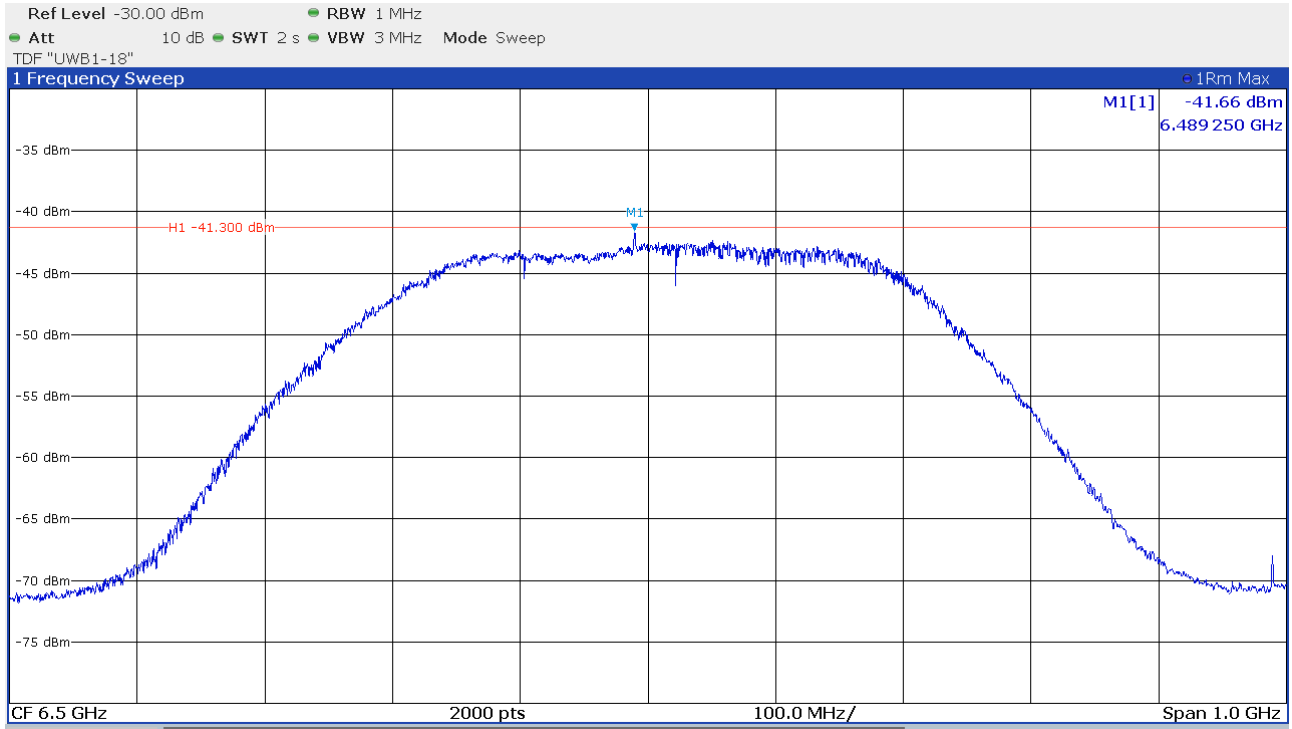
Note: No emissions from the EUT detectable between 30 MHz and 960 MHz, all measured values represent the noise level of the test site.

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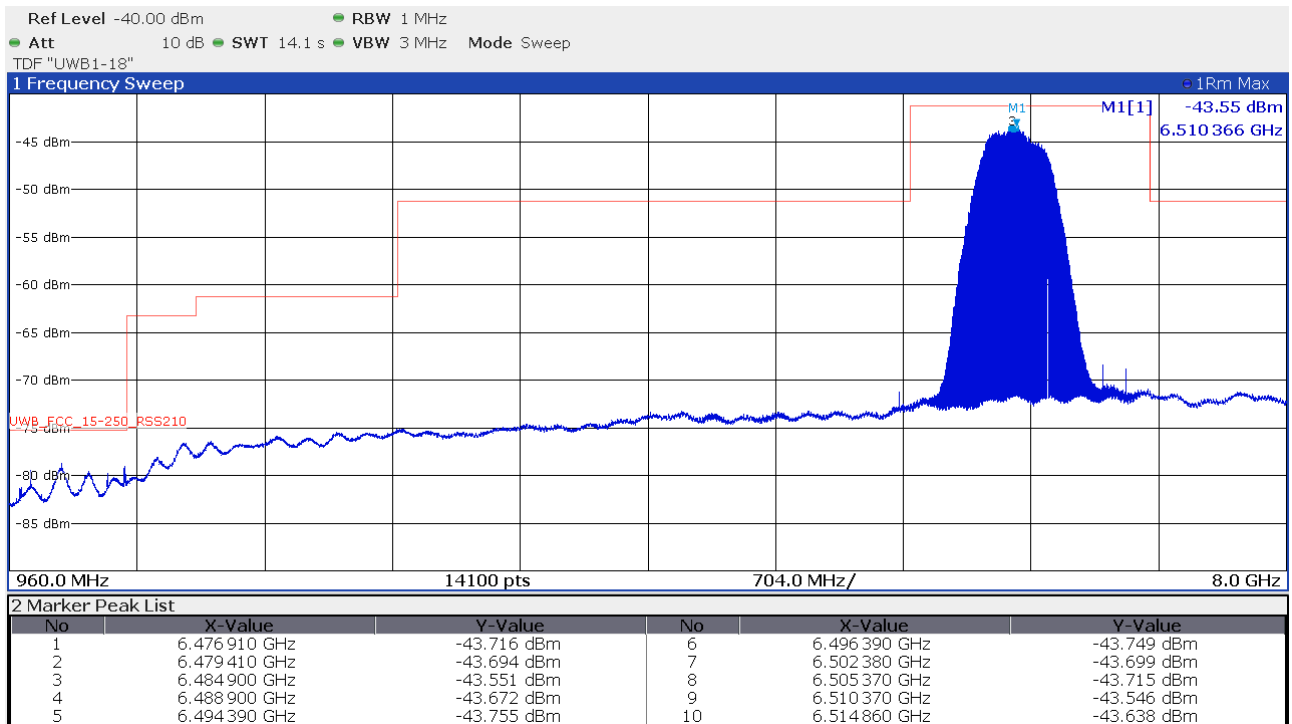
5.2.5.3 Measurement 960 MHz to 40 GHz

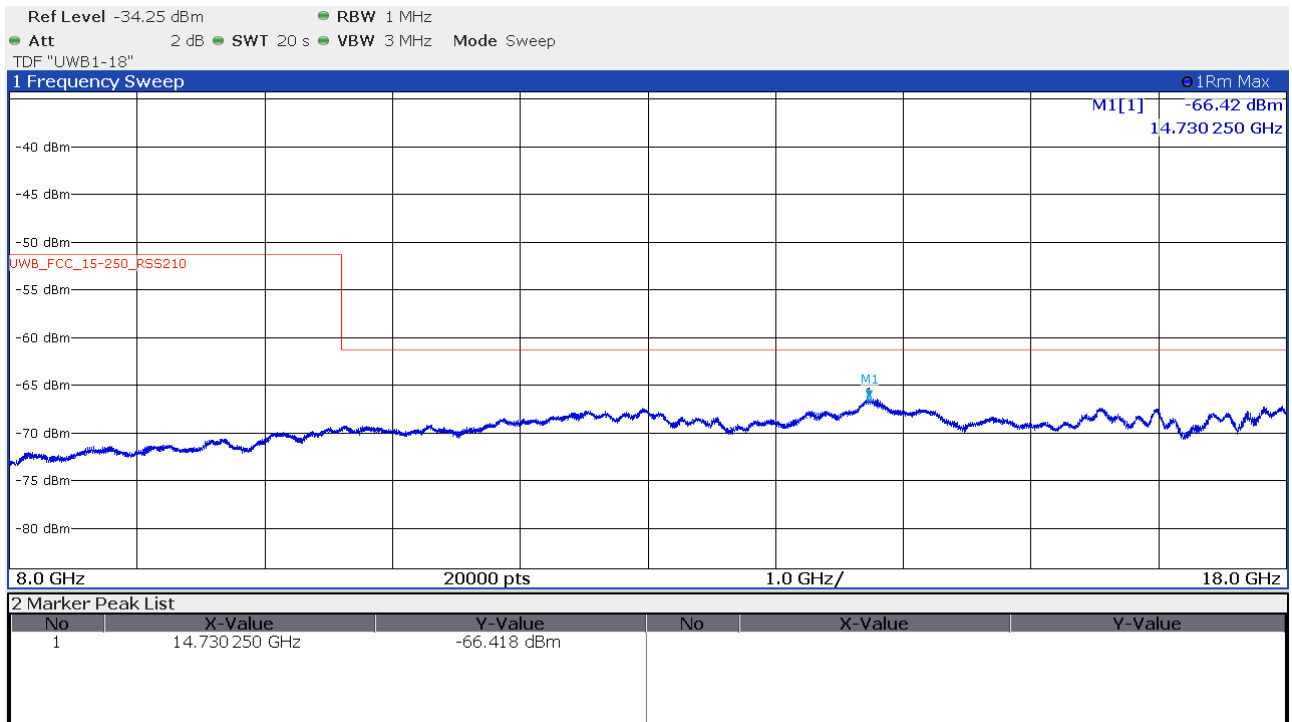
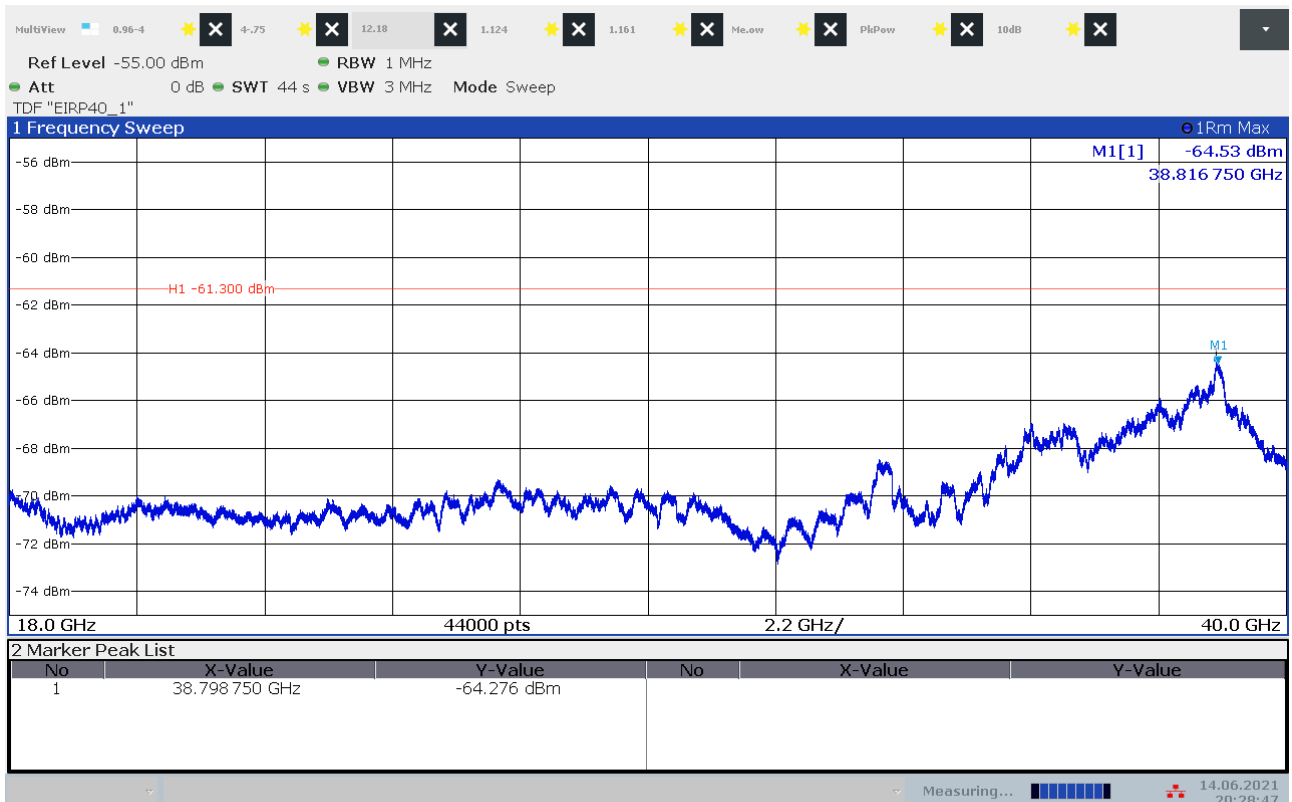
Channel 5

Mean Power



960 MHz to 18 GHz



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18 GHz to 40 GHz


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Limit according §15.209(a) in the frequency range 9 kHz 960 MHz:

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

Limit according §15.250(d)(1) in the frequency range 960 MHz to 40 GHz:

Frequency in MHz	EIRP in dBm
960-1610	-75.3
1610-1990	-63.3
1990-3100	-61.3
3100-5925	-51.3
5925-7250	-41.3
7250-10600	-51.3
Above 10600	-61.3

Limit according RSS-210 K.3(a) in the frequency range 960 MHz to 40 GHz:

Frequency in MHz	EIRP in dBm
960-1610	-75.3
1610-1990	-63.3
1990-3100	-61.3
3100-5925	-51.3
5925-7250	-41.3
7250-10600	-51.3
Above 10600	-61.3

The requirements are **FULFILLED**.

Remarks: None.

FCC ID: 2ALC5-KNX-ETAG1 IC: 25557-KNXETAG1

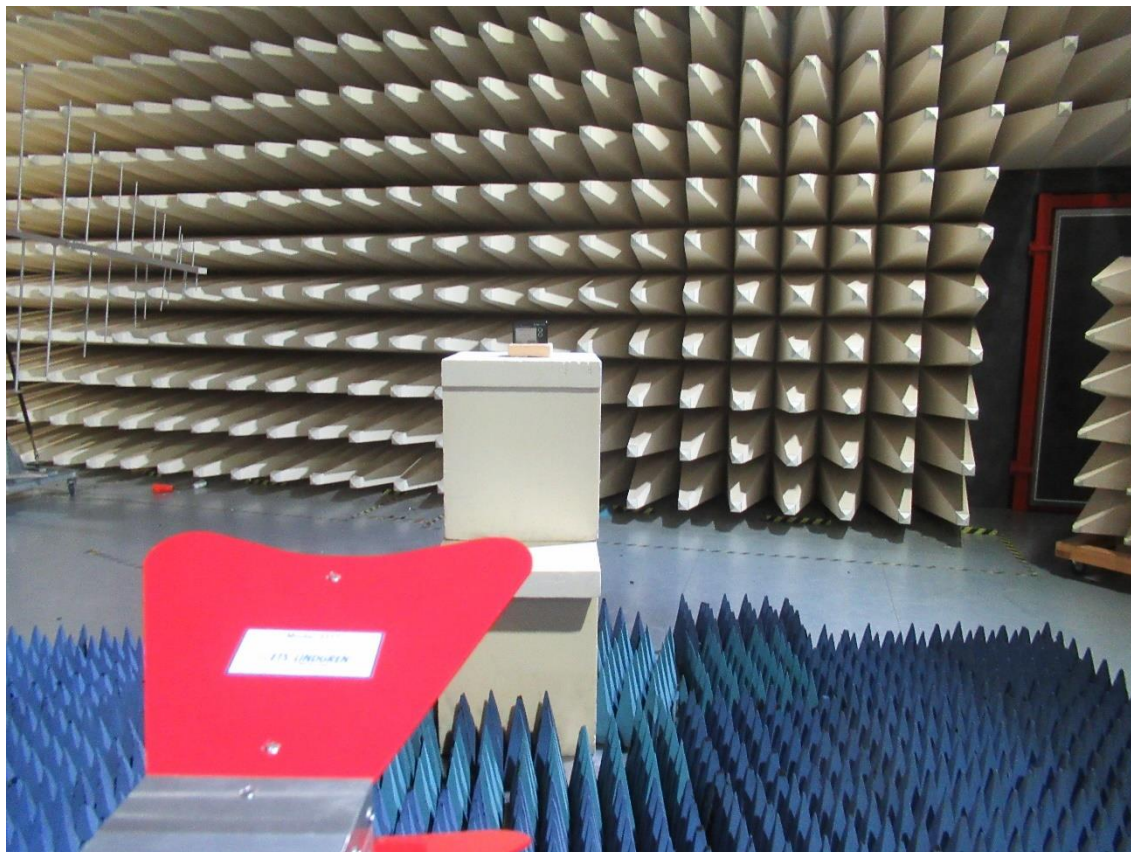
5.3 Radiated Emissions at 1164-1240 MHz and 1559-1610 MHz

For test instruments and accessories used see section 6 Part **SER 3**.

5.3.1 Description of the test location

Test location: Anechoic chamber 1

5.3.2 Photo documentation of the test set-up



The test report merely corresponds to the test sample. It is not permitted to copy extracts of these test results without the written permission of the test laboratory.

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5.3.3 Applicable standard

According to FCC Part 15, Section 15.250(d):

In addition to the radiated emission limits specified in the table in paragraph (d)(1) of this section, transmitters operating under the provisions of this section shall not exceed the following RMS average limits when measured using a resolution bandwidth of no less than 1 kHz

5.3.4 Analyser settings

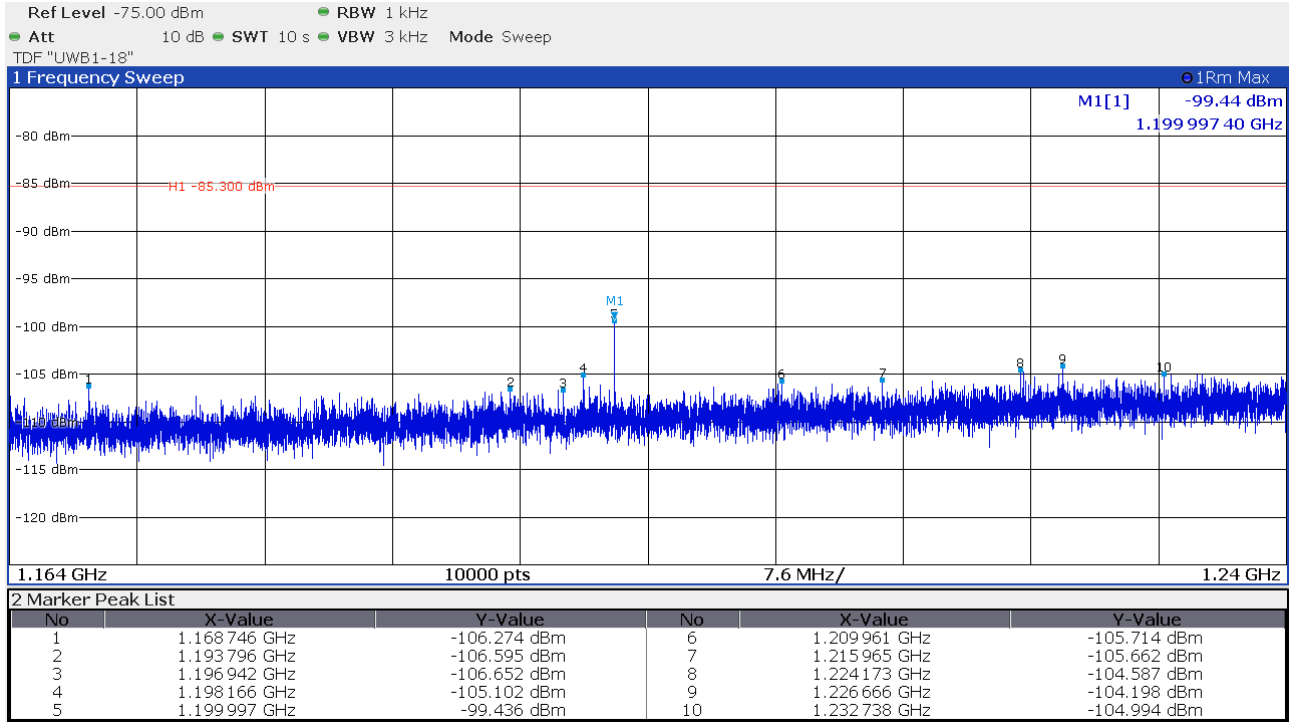
RBW: 1 kHz, VBW: 3 kHz, Detector: RMS, Sweep time: 1 ms/1kHz,

FCC ID: 2ALC5-KNX-ETAG1 IC: 25557-KNXETAG1

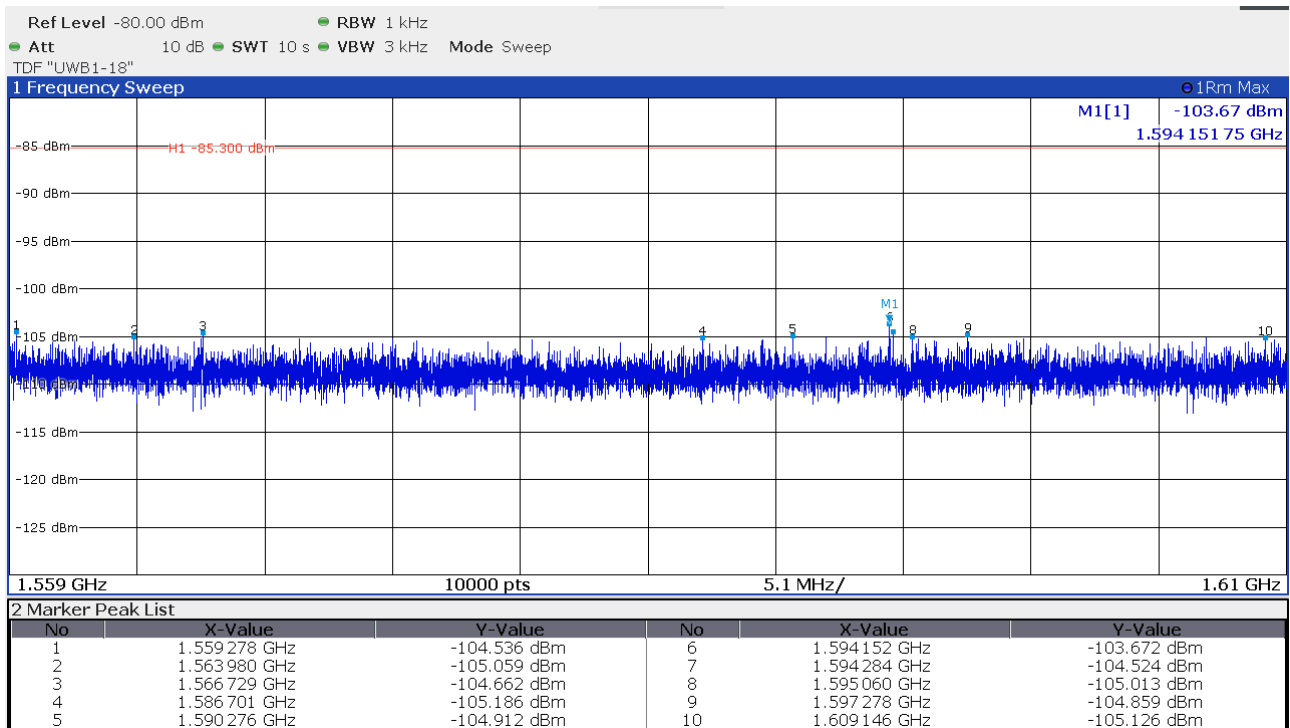
5.3.5 Test result

Channel 5 horizontal

1164 MHz to 1240 MHz

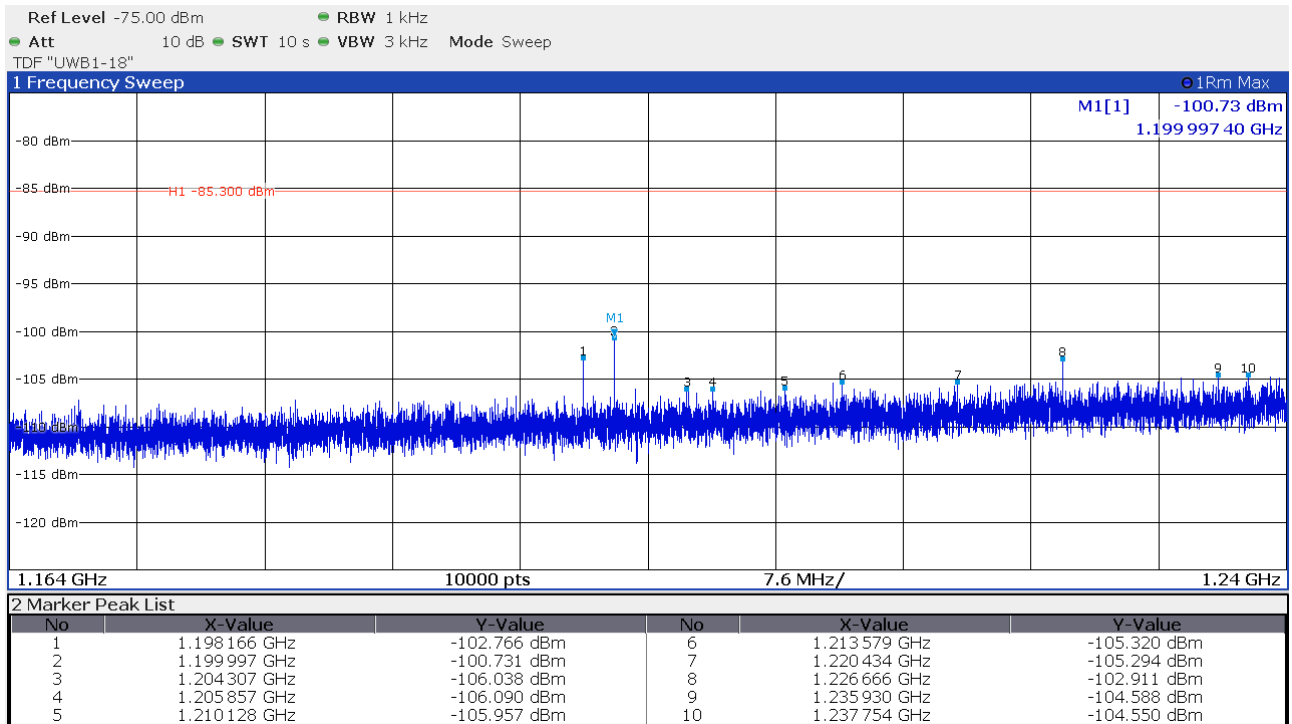


1559 MHz to 1610 MHz

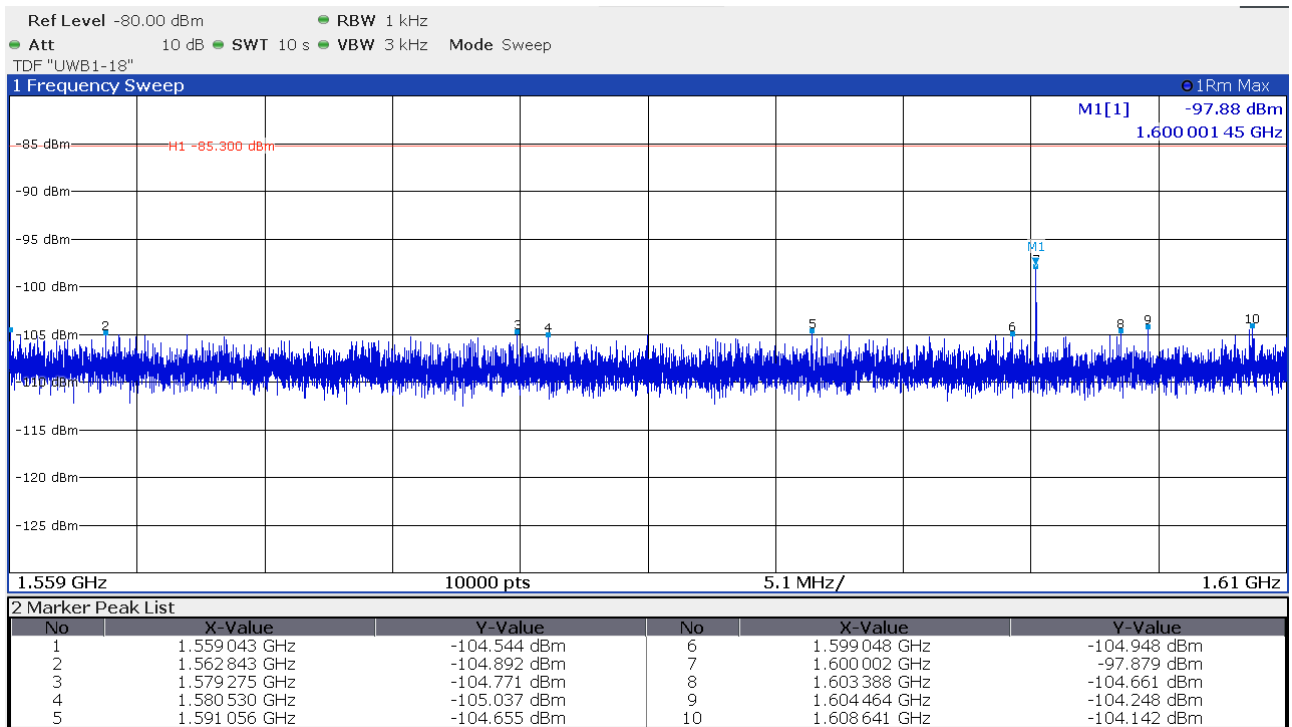


FCC ID: 2ALC5-KNX-ETAG1 IC: 25557-KNXETAG1
Channel 5 vertical

1164 MHz to 1240 MHz



1559 MHz to 1610 MHz



FCC ID: 2ALC5-KNX-ETAG1 IC: 25557-KNXETAG1

Limit according §15.250(d) in the frequency

Frequency in MHz	EIRP in dBm
1164-1240	-85.3
1559-1610	-85.3

The requirements are **FULFILLED**.

Remarks: None.

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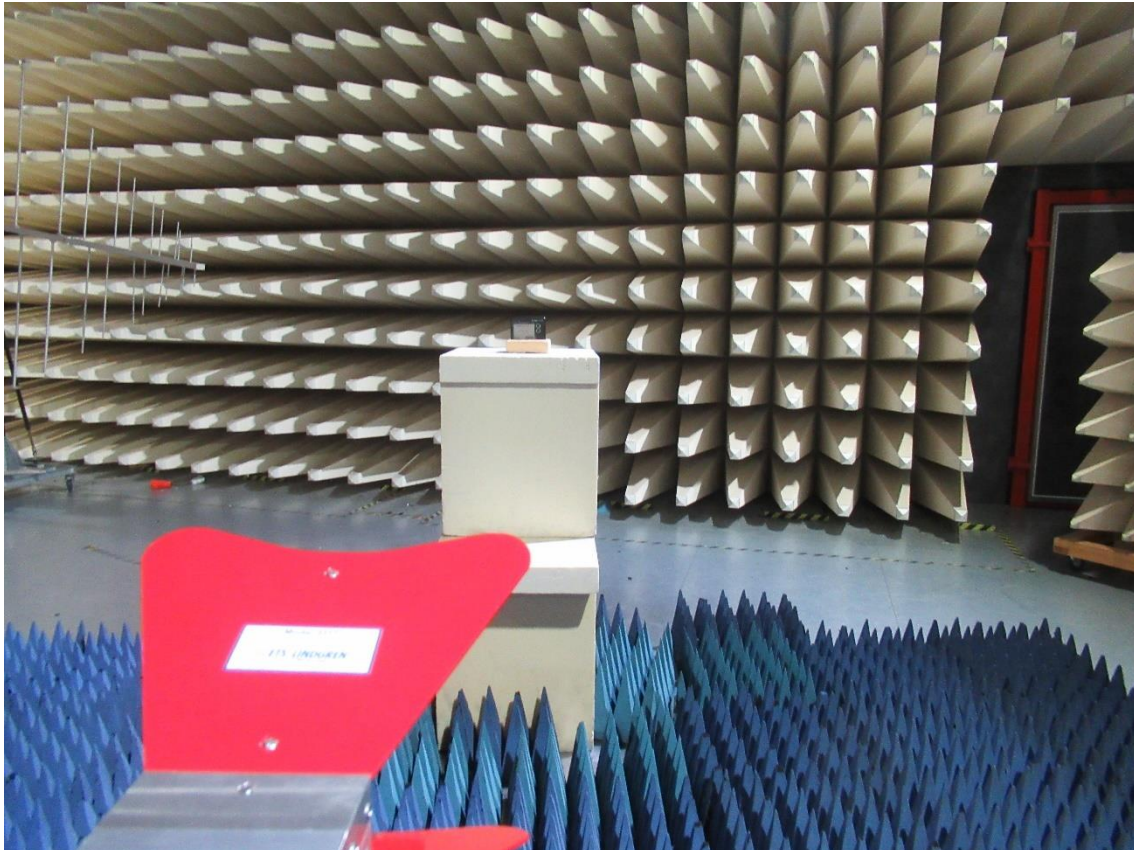
5.4 Peak Power radiated

For test instruments and accessories used see section 6 Part **CPR 3**.

5.4.1 Description of the test location

Test location: Anechoic chamber 1

5.4.2 Photo documentation of the test set-up – see ATTACHMENT B



The test report merely corresponds to the test sample. It is not permitted to copy extracts of these test results without the written permission of the test laboratory.

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5.4.3 Applicable standard

According to FCC Part 15, Section 15.250(d)(3):

There is a limit on the peak level of the emissions contained within a 50 MHz bandwidth centered on the frequency at which the highest radiated emission occurs, f_m . That limit is 0 dBm EIRP. It is acceptable to employ a different resolution bandwidth, and a correspondingly different peak emission limit, following the procedures described in §15.521.

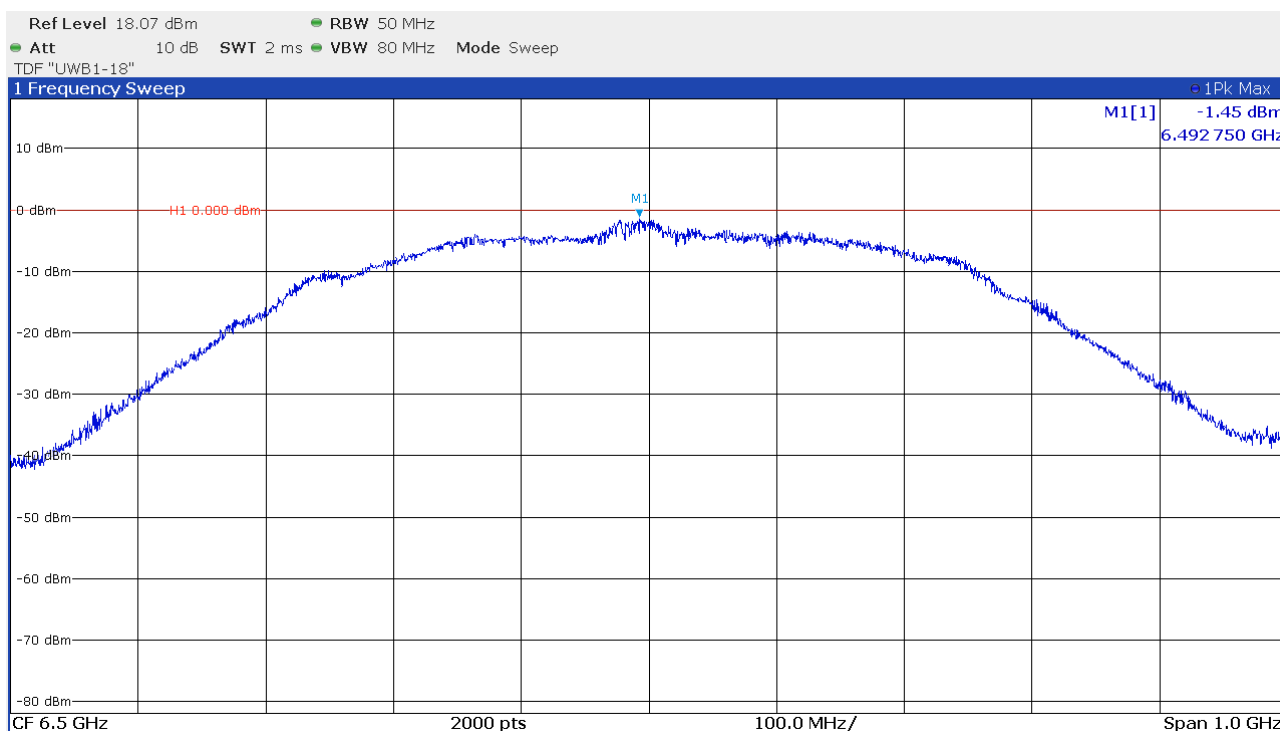
5.4.4 Analyser settings

RBW: 50 MHz, VBW: 80 MHz, Detector: Peak, Trace Mode: Max hold

FCC ID: 2ALC5-KNX-ETAG1 IC: 25557-KNXETAG1

5.4.5 Test result

Channel 5



Min. limit margin: -1.45 dB at 6.49275 GHz

The requirements are **FULFILLED**.

Remarks: None.

FCC ID: 2ALC5-KNX-ETAG1 IC: 25557-KNXETAG1

5.5 Antenna application

5.5.1 Applicable standard

According to FCC Part 15C, Section 15.203:

An intentional radiator shall be designed to ensure that no antenna other than that furnished by the responsible party shall be used with the device. The use of a permanently attached antenna or of an antenna that uses a unique coupling to the intentional radiator shall be considered sufficient to comply with the provisions of this section. The manufacturer may design the unit that broken antennas can be replaced by the user, but the use of a standard antenna jack is prohibited.

The EUT has an integrated antenna. No other antenna can be used with the device.

All supplied antennas meet the requirements of part 15.203 and 15.204.

Remarks: None.

The test report merely corresponds to the test sample. It is not permitted to copy extracts of these test results without the written permission of the test laboratory.

FCC ID: 2ALC5-KNX-ETAG1 IC: 25557-KNXETAG1

6 USED TEST EQUIPMENT AND ACCESSORIES

All test instruments used are calibrated and verified regularly. The calibration history is available on request.

Test ID	Model Type	Equipment No.	Next Calib.	Last Calib.	Next Verif.	Last Verif.
CPR 3	FSW43	02-02/11-15-001	06/04/2022	06/04/2021		
	AMF-6D-01002000-22-10P	02-02/17-15-004				
	3117	02-02/24-05-009	18/06/2021	18/06/2020		
	BAM 4.5-P	02-02/50-17-024				
	NCD	02-02/50-17-025				
	KK-SF106-2X11N-6,5M	02-02/50-18-016				
	BAT-EMC 3.20.0.23	02-02/68-13-001				
SER 2	ESVS 30	02-02/03-05-006	15/07/2021	15/07/2020		
	VULB 9168	02-02/24-05-005	18/12/2021	18/12/2020		
	NW-2000-NB	02-02/50-05-113				
	KK-EF393/U-16N-21N20 m	02-02/50-12-018				
	KK-SD_7/8-2X21N-33,0M	02-02/50-15-028				
SER 3	FSW43	02-02/11-15-001	06/04/2022	06/04/2021		
	AFS5-12001800-18-10P-6	02-02/17-06-002				
	AFS4-01000400-10-10P-4	02-02/17-13-002				
	AMF-4F-04001200-15-10P	02-02/17-13-003				
	LNA-40-18004000-33-5P	02-02/17-20-002				
	3117	02-02/24-05-009	18/06/2021	18/06/2020		
	BBHA 9170	02-02/24-05-013	19/05/2023	19/05/2020	04/02/2022	04/02/2021
	Sucoflex N-2000-SMA	02-02/50-05-075				
	WHKX 7.5/18G-8SS	02-02/50-07-010				
	KMS116-GL140SE-KMS116-	02-02/50-20-026				

Remarks: All CPR3 and SER3 measurements using 3117 antenna were performed in the period before 18/06/2021.

The test report merely corresponds to the test sample. It is not permitted to copy extracts of these test results without the written permission of the test laboratory.