EMI – TEST REPORT

- FCC Part 15.225 -

Type / Model Name : FFZ-radio module;eP 2.0 Master

Product Description : Truck anchor for distance measurements to a person tag

Applicant : Jungheinrich AG

Address : Friedrich-Ebert-Damm 129

22047 HAMBURG, GERMANY

Manufacturer : ACD Elektronik GmbH

Address : Engelberg 2

88480 ACHSTETTEN, GERMANY

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

Test Report No. : T43580-01-00WP	24. September 2019 Date of issue

Deutsche Akkreditierungsstelle D-PL-12030-01-00

FCC ID: 2AK6M-EP20FMMASTER

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1 TEST STANDARDS

The tests were performed according to following standards:

FCC Rules and Regulations Part 15, Subpart A - General (July, 2019)

FCC Rules and Regulations Part 15, Subpart C - Intentional Radiators (July, 2019)

Part 15, Subpart C, Section 15.209	Radiated emission limits, general requirements
Part 15, Subpart C, Section 15.225	Operation within the band 13.110 - 14.010 MHz
ANSI C63.10: 2013	Testing Unlicensed Wireless Devices

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2 SUMMARY

GENERAL REMARKS:

For testing, the NFC Reader was set in TX-continuous mode. The test software is available for testing only.

All radiated measurements were made with the device positioned in table top orientation.
Such as orientations X, Y and Z (Lying flat, lying on its end and lying on its side).
The values in the test report shows only the maximum measured value.

For detailed information about the device please refer to the user manual.

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 : 02 July 2019

Testing concluded on : 18 July 2019

Checked by:

Klaus Gegenfurtner
I confirm the correctness and integrity of this document.
2019.09.24 09:59:01 +02'00'

Klaus Gegenfurtner
Teamleader Radio

Tested by:

Willibald Probst
I am the author of this document
2019.09.24 09:57:45 +02'00'

Willibald Probst
Radio Team

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3 EQUIPMENT UNDER TEST

3.1 Photo documentation of the EUT

See attachment A to this report for external piuctures of the EuT and attachment B to this report for internal pictures of the EuT.

3.2 Power supply system utilised

Power supply voltage : 24.0 V / DC (Vehicle power supply)

3.3 Short description of the equipment under test (EUT)

The EUT is one of 4 anchors, mounted on a truck. These anchors are communicating with the truck via CAN-bus and with one person tag via UWB. The operator wears the person tag on the body. After an initial pairing process between the EUT and the person tag (by NFC or Bluetooth), the 4 anchors can localize the position of the person tag related to a truck fixed coordinate system. If there are no obstacles, the truck follows the EUT (in driving direction).

Number of tested samples: 1
Serial number: 187100000748
Firmware version (UWB driver): 2.5.9

EUT operation mode:

The equipment under test was operated during the measurement under the following conditions:

- Cont. tag reading mode at 13.56 MHz modulated

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EUT configuration:

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

- Laptop Model : Fujitsu, E751
- CAN Dongle Model : PEAK System
- TAG Model : Supplied by applicant

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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 / 11.2003 „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%	± 3.29 dB
20 dB Bandwidth	Center frequency of EuT	95%	± 2.5 x 10^{-7}
99% Occupied Bandwidth	Center frequency of EuT	95%	± 2.5 x 10^{-7}
Radiated Spurious Emissions	9 kHz to 30 MHz	95%	± 3.53 dB
Radiated Spurious Emissions	30 MHz to 1000 MHz	95%	± 3.71 dB
Radiated Spurious Emissions	1000 MHz to 10000 MHz	95%	± 2.34 dB
Peak conducted output power	902 MHz to 928 MHz	95%	± 0.35 dB
Conducted Spurious Emissions	9 kHz to 10000 MHz	95%	± 2.15 dB

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4.4 Measurement Protocol for FCC

4.4.1 GENERAL INFORMATION

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

FCC: DE 0011 ISED: DE0009

4.4.1.1 Test methodology

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

4.4.1.2 Justification

The equipment under test (EUT) is configured in a typical user arrangement in accordance with the manufacturer's instructions.

4.4.2 Conducted emission

Conducted emissions on the 50 Hz and/or 60 Hz power interface of the EUT are measured in the frequency range of 150 kHz to 30 MHz. The measurements are performed using a receiver, which has CISPR characteristic bandwidth and quasi-peak detection and a Line Impedance Stabilization Network (LISN) with 50 Ω / 50 µH (CISPR 16) characteristics. The receiver is protected by means of an impedance matched pulse limiter connected directly to the RF input. Table top equipment is placed on a non-conducting table 80 centimetres above the floor and is positioned 40 centimetres from the vertical ground plane (wall) of the screen room. If the minimum limit margin appears to be less than 20 dB with a peak mode measurement, the emission are remeasured using a tuned receiver with quasi-peak and average detection and recorded on the data sheets.

4.4.3 Radiated emission

Spurious emission from the EUT is measured in the frequency range of 30 MHz to 1000 MHz using a tuned receiver and appropriate broadband linearly polarized 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 metre 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 C63.4. The interface cables that are closer than 40 centimetres to the ground plane are bundled in the centre 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 centre 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. To locate maximum emissions from the test sample the antenna is varied in height from 1 to 4 metres, measurement scans are made with both horizontal and vertical antenna polarization planes and the EUT is rotated 360 degrees.

4.4.4 Calculation Example

Frequency	Reading level	+	Correction Factor*	=	Level	-	CISPR Limit	=	Delta
(MHz)	(dBµV)		(dB/m)		(dBµV/m)		(dBµV/m)		(dB)
719.0	75.0	+	32.6	=	107.6	-	110.0	=	-2.4

*Correction Factor = Antenna Factor + Cable Attenuation = 30 dB/m + 2.6 dB = 32.6 dB/m

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5 TEST CONDITIONS AND RESULTS

5.1 Conducted emissions

For test instruments and accessories used see section 6 Part **A 4**.

5.1.1 Description of the test location

Test location: NONE

5.1.2 Applicable standard

According to FCC Part 15, Section 15.107(a):
Except for Class A devices, for equipment 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 given limits.

Remarks: The measurement is not applicable.

The EUT will be supplied via vehicle battery, 24.0 V DC.

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5.2 Field strength of the fundamental wave

For test instruments and accessories used see section 6 Part **CPR 1**.

5.2.1 Description of the test location

Test location: OATS1

Test distance: 3 metres

5.2.2 Photo documentation of the test set-up

See attachment C to this report

5.2.3 Applicable standard

According to FCC Part 15, Section 15.225(a):
The field strength of any emission within the band 13.553 – 13.567 MHz shall not exceed 15848 µV/m at 30 m.

5.2.4 Test result

a) Result at a measurement distance of 3m

Frequency (MHz)	Level PK (dBµV)	Level AV (dBµV)	Level QP (dBµV)	Band-width (kHz)	Correct. factor (dB)	Corrected Level PK dB(µV/m)	Corrected Level AV dB(µV/m)	Corrected Level QP dB(µV/m)
13.56	51.4	49.2	50.9	9.0	20	71.4	69.2	70.9

b) Result extrapolated to a distance of 30 m

Frequency (MHz)	Level PK (dBµV)	Level AV (dBµV)	Level QP (dBµV)	Correct. factor (dB)	Corrected Level PK dB(µV/m)	Corrected Level AV dB(µV/m)	Corrected Level QP dB(µV/m)	Limit dB(µV/m)	Delta (dB)
13.56	11.4	9.2	10.9	20	31.4	29.2	30.9	84.0	-53.1

Limit according to FCC Part 15, Section 15.225(a):

Frequency	Field strength of fundamental wave		Measurement distance
(MHz)	(µV/m)	dB(µV/m)	(metres)
13.553 - 13.567	15848	84.0	30

The requirements are **FULFILLED.**

Remarks: _____

_____

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5.3 Spurious emissions

For test instruments and accessories used see section 6 Part **SER 1, SER 2.**

5.3.1 Description of the test location

Test location: OATS1

Test distance: 3 metres

5.3.2 Photo documentation of the test set-up

See attachment C to this report

5.3.3 Applicable standard

According to FCC Part 15C, Section 15.209:
The emissions from an intentional radiator shall not exceed the field strength levels specified in the table below.

5.3.4 Test result

Results at a measurement distance of 3m

9 kHz – 30 MHz:

Frequency [kHz]	L: QP [dBµV]	L: AV [dBµV]	Bandwidth [kHz]	Correct. [dB]	L: QP [dBµV/m]	L: AV [dBµV/m]	Limit [dBµV/m]	Delta [dB]
501.2	24.7	20.4	9.0	20	44.7	40.4	73.6	-28.9
2200.4	9.5	9.1	9.0	20	29.5	29.1	69.5	-40
6300.5	6.7	6.4	9.0	20	26.7	26.4	69.5	-42.8
11650.3	7.8	7.1	9.0	20	27.8	27.1	69.5	-41.7
19850.6	5.9	5.5	9.0	20	25.9	25.5	69.5	-43.6
27120.0	4.0	3.5	9.0	20	24.0	23.5	69.5	-45.5

Note: No unwanted emissions from the EuT could be measured in the frequency range 9 kHz to 30 MHz. Only ambient nosies could be detected!

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30 MHz – 1 GHz:

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)
40.20	10.9	5.4	13.7	12.5	24.6	17.9	40.0	-15.4
40.68	12.0	-2.5	13.7	12.5	25.7	10.0	40.0	-14.3
50.54	9.1	1.1	14.2	13.2	23.3	14.3	40.0	-16.7
53.20	13.7	0.4	14.1	13.1	27.8	13.5	40.0	-12.2
59.40	20.7	15.4	13.9	12.9	34.6	28.3	40.0	-5.4
67.80	8.2	1.2	13.3	12.6	21.5	13.8	40.0	-18.5
80.14	20.6	6.8	10.4	10.1	31.0	16.9	40.0	-9.0
163.00	11.0	1.9	13.5	14.3	24.5	16.2	43.5	-19.0
216.00	2.5	5.2	11.2	11.7	13.7	16.9	43.5	-26.6
253.80	13.9	11.8	13.1	13.3	27.0	25.1	46.0	-19.0

Limit according to FCC Part 15 Subpart 15.209(a):

Frequency	Field strength of spurious emissions		Measurement distance
(MHz)	(µV/m)	dB(µV/m)	(metres)
0.009 - 0.490	2400/F(kHz)	--	300
0.490 - 1.705	24000/F (kHz)	--	30
1.705 - 30.0	30	29.5	30
30 - 88	100	40	3
88 - 216	150	43.5	3
216 - 960	200	46	3
Above 960	500	54	3

The requirements are **FULFILLED.**

Remarks: Measurement has been performed up to 1 GHz.

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5.4 Frequency tolerance

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

5.4.1 Description of the test location

Test location: AREA4 (Climatic Chamber)

5.4.2 Photo documentation of the test set-up

See attachment C to this report

5.4.3 Applicable standard

According to FCC Part 15, Section 15.225(e):
The frequency tolerance of t he carrier signal shall be maintained within ±0.01 % of the operating frequency over a temperature range of -20 °C to +50 °C at normal supply voltage and for a variation in the primary supply voltage from 85 % to 115 % of the rated supply voltage at a temperature of 20 °C. For battery operated equipment, the equipment shall be performed using a new battery.

5.4.4 Test result

Test conditions		Test result	Tolerance	Limit
		Frequency (MHz)	(kHz)	(kHz)
T_{min} (-20)°C	V_{nom} (24 V DC)	13.5611905	+ 1.1905	± 1.356
T (-10)°C	V_{nom} (24 V DC)	13.5611671	+ 1.1671	± 1.356
T (0)°C	V_{nom} (24 V DC)	13.5611379	+ 1.1379	± 1.356
T (10)°C	V_{nom} (24 V DC)	13.5610970	+ 1.0970	± 1.356
T_{nom} (20)°C	V_{min} (20.4 V DC)	13.5610560	+ 1.0560	± 1.356
	V_{nom} (24 V DC)	13.5610560	+ 1.0560	± 1.356
	V_{max} (27.6 V DC)	13.5610560	+ 1.0560	± 1.356
T (30)°C	V_{nom} (24 V DC)	13.5610268	+ 1.0268	± 1.356
T (40)°C	V_{nom} (24 V DC)	13.5610121	+ 1.0121	± 1.356
T_{max} (50)°C	V_{nom} (24 V DC)	13.5610151	+ 1.0151	± 1.356
Measurement uncertainty		± 10 Hz		

Limit Calculation:
Carrier frequency: f_c = 13.56 MHz
Max. tolerance: ± 0.01 % of 13.56 MHz = ± 1.356 kHz

Limit according to FCC Part 15, Section 15.225(e):
The frequency tolerance of the carrier signal shall be maintained within ±0.01 % of the operating frequency.

The requirements are **FULFILLED.**

Remarks: None.

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5.5 20 dB Bandwidth

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

5.5.1 Description of the test location

Test location: AREA4 (Climatic Chamber)

5.5.2 Photo documentation of the test set-up

See attachment C to this report

5.5.3 Applicable standard

According to FCC Part 15C, Section 15.215(c):
Intentional radiators operating under the alternative provisions to the general emission limits, as contained in section 15.217 to 15.257, must be designed to ensure that the 20 dB bandwidth of the emission is contained within the frequency band designated in the rule section under which the equipment is operated. 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.

5.5.4 Test result

Carrier Frequency (MHz)	(F_L) (MHz)	(F_H) (MHz)	Bandwidth (kHz)	Limit (kHz)
13.56	13.558485	13.563530	5.045	14.0

Limit according to FCC Part 15C, Section 15.215(c):

Frequency band (MHz)	Limit 20 dB bandwidth (kHz)
13.553 - 13.567	14.0

The requirements are **FULFILLED.**

Remarks: For detailed test result please refer to following test protocol.

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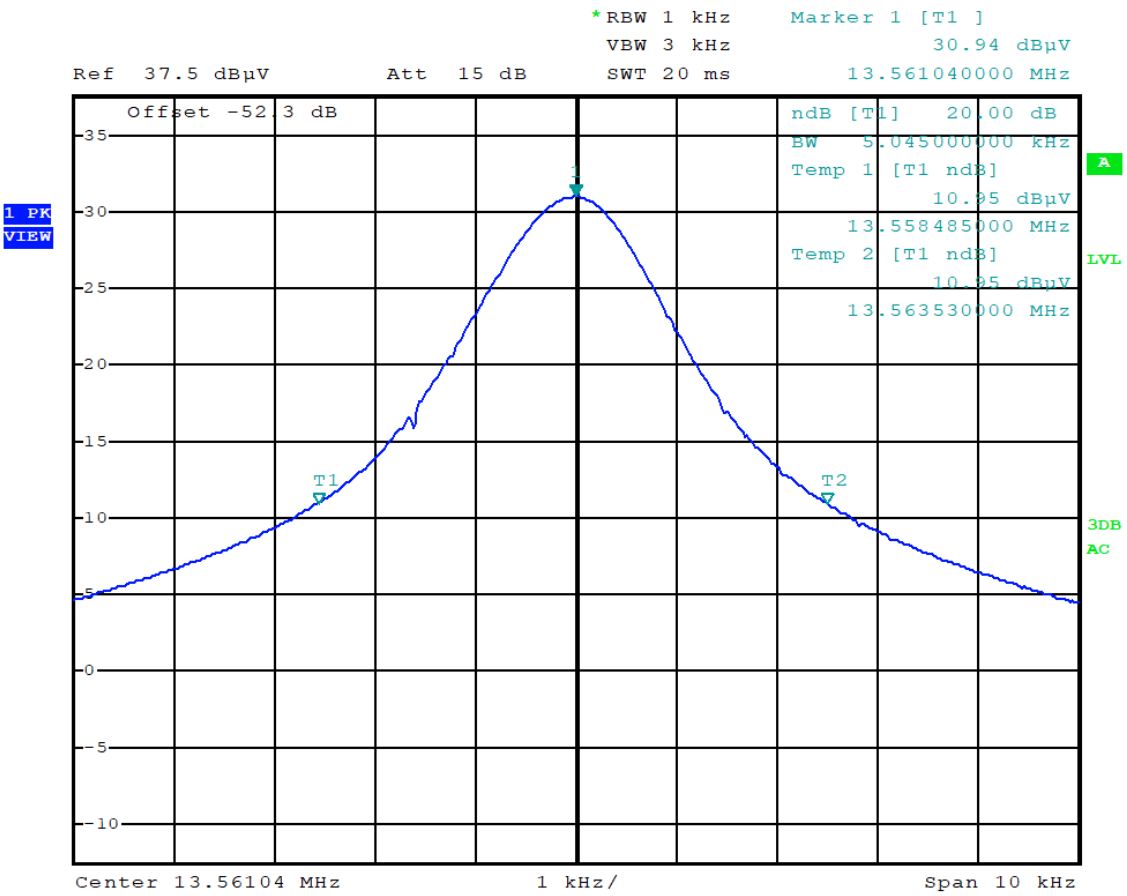
5.5.5 Test protocol



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5.6 Transmitter spectrum mask

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

5.6.1 Description of the test location

Test location: AREA4 (Climatic Chamber)

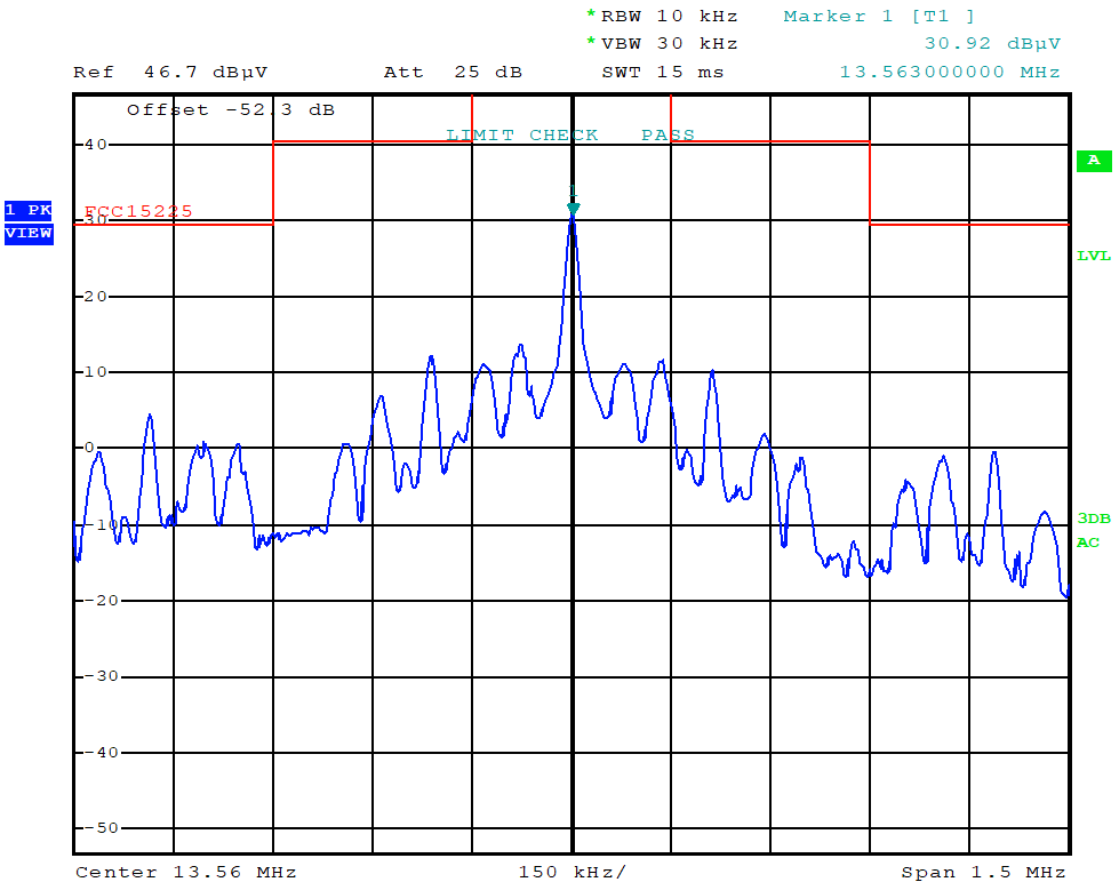
5.6.2 Photo documentation of the test set-up

See attachment C to this report

5.6.3 Applicable standard

According to FCC Part 15C, Section 15.225 (a-d):
The field strength of any emission shall not exceed the limits given in FCC Part 15C, Section 15.225 (a-d)

5.6.4 Test result



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Limits according to FCC Part 15, Section 15.225(a-d):

Frequency band (MHz)	Emission level limit at 30 m (µV/m)	Emission level limit at 30 m (dBµV/m)
13.110 – 13.410	106	40.5
13.410 - 13.553	334	50.5
13.553 - 13.567	15.848	84.0
13.567 – 13.710	334	50.5
13.710 – 14.010	106	40.5
outside of 13.110 – 14.010	30	29.5

The requirements are **FULFILLED.**

Remarks: None.

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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 1	ESCI	02-02/03-05-005	11/12/2019	11/12/2018		
	HFH 2 - Z 2	02-02/24-15-001	28/03/2020	28/03/2019		
	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				
FE	ESCI	02-02/03-05-004	17/09/2019	17/09/2018		
	HFRAE 5161 _ 50 kHz-120	02-02/24-11-004				
	METRAHIT WORLD	02-02/32-15-001	13/12/2019	13/12/2018		
	WK-340/40	02-02/45-05-001	18/04/2020	18/04/2019		
MB	ESCI	02-02/03-05-004	17/09/2019	17/09/2018		
	HFRAE 5161 _ 50 kHz-120	02-02/24-11-004				
SER 1	ESCI	02-02/03-05-005	11/12/2019	11/12/2018		
	HFH 2 - Z 2	02-02/24-15-001	28/03/2020	28/03/2019		
	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 2	VULB 9163	01-02/24-01-006	06/09/2019	06/09/2018		
	ESCI	02-02/03-05-005	11/12/2019	11/12/2018		
	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				