PHOENIX TESTLAB

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Test Report

Report Number:

E240086E2 2nd Version

Equipment under Test (EUT):

iEBS Premium

Applicant:

ZF CV Systems Hannover GmbH

Manufacturer:

ZF CV Systems Hannover GmbH

ilac-MRA

DAkkS
Deutsche
Akkreditierungsstelle
D-PL-17186-01-00

References

Family standards / generic standards:

[1] **ANSI C63.4:2014** American National Standard for Methods of Measuring of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz.

[2] **FCC 47 CFR Part 2:** General Rules and Regulations

[3] **FCC 47 CFR Part 15:** Radio Frequency Devices (Subpart B)

[4] **RSS-Gen Issue 5 – December 2019 + Amendment 2 – April 2020**, General Requirements for Compliance of Radio Apparatus

Note on the release status

The officially published CFR version, which is updated annually. may not reflect recent CFR changes.
For this reason, the version of the eCFR valid at the start of the test period is taken into account.
For more information see: eCFR :: Title 47 of the CFR -- Telecommunication

Test Result

The requirements of the standards listed under the section "product (-family) standard(s) / generic standard(s)" on page 2 of this test report were fulfilled by the EUT. Restrictions for the use of the EUT in certain environments and / or under special conditions of use are defined in chapter 3, if applicable. Details are shown in the following pages.

tested, written and approved by:	Tobias BRÄHLER 27.08.2024	Signature
reviewed by:	Lars Witte 27.08.2024	Signature

The measurement uncertainty for all measurement and test procedures of the laboratory have been determined and can be viewed if required. With regard to the emission measurement method according to CISPR 16-4-2 the measurement uncertainty of the test laboratory (U_{Lab}) is less than the CISPR-defined measurement uncertainty (U_{CISPR}). This means that if the measured values for emitted interference fall below the limit value, the requirements of the relevant standard are met. For disturbance immunity, the decision rule of “simple acceptance” is applied with respect to the disturbance level.

If the customer requires an individual decision rule for conformity to the standard or the standard does not specify a decision rule, the measurement uncertainty and the decision rule are explicitly stated in the test report.

This test report is only valid in its original form.

The test results herein refer only to the tested sample. PHOENIX TESTLAB GmbH is not responsible for any generalisations or conclusions drawn from these test results concerning further samples. Any modification of the tested samples is prohibited and leads to the invalidity of this test report. Each page necessarily contains the PHOENIX TESTLAB Logo and the TEST REPORT NUMBER.

Contents:

1 Identification

1.1 Applicant

Name:	ZF CV Systems Hannover GmbH
Address:	Am Lindener Hafen 21 30453 Hannover
Country:	Germany
Applicant represented during the test by the following person:	none

1.2 Manufacturer

Name:	ZF CV Systems Hannover GmbH
Address:	Am Lindener Hafen 21 30453 Hannover
Country:	Germany
Applicant represented during the test by the following person:	none

1.3 Test Laboratory

The tests were carried out by: **PHOENIX TESTLAB GmbH**
Königswinkel 10
32825 Blomberg
Germany

accredited by the German accreditation body - DAkkS - according to DIN EN ISO/IEC 17025:2018.
The accreditation is only valid for the scope of accreditation listed in the annex D-PL-17186-01-06.

FCC Test Firm Designation Number DE0004, FCC Test Firm Registration Number 469623, CAB Identifier DE0003 and ISED# 3469A.

1.4 EUT (Equipment under Test)

Type of equipment: *	**iEBS Premium**
Order number: *	480 102 401 0, 480 102 402 0, 480 102 403 0, 480 102 405 0
Serial number: *	3519001629
PCB identifier: *	446 145 275 4
Hardware version: *	446 145 274 2
Software version: *	tf0022102b
FCC ID: *	2AHGF-IEBS
IC certification number: *	N/A

	EUT number		
	1	2	3
Serial number: *	3519001629	-	-
PCB identifier: *	446 145 275 4	-	-
Hardware version: *	446 145 274 2	-	-
Software version: *	tf0022102b	-	-

* Declared by the applicant

Note: Phoenix Testlab GmbH does not take samples. The samples used for tests are provided exclusively by the applicant.

1.5 Technical Data of Equipment

Power supply:	DC battery
Supply voltage:	U_{min} = 12 V
	U_{max} = 24 V
highest internal frequency[1]:	433.92 MHz

*1 Provided by the applicant

Technical data of the 433 MHz receiver	
Operating frequency: *	433.92 MHz
Receiver category: *	2
Receiver bandwidth: *	300 kHz
Data rate: *	19200 Baud (WIS Sensor)
Antenna type: *	Integrated PCB antenna

*1 Provided by the applicant

1.6 Dates

Date of receipt of test sample:	11.04.2024
Start of test:	17.04.2024
End of test:	18.04.2024

2 Operational States and Test Setup

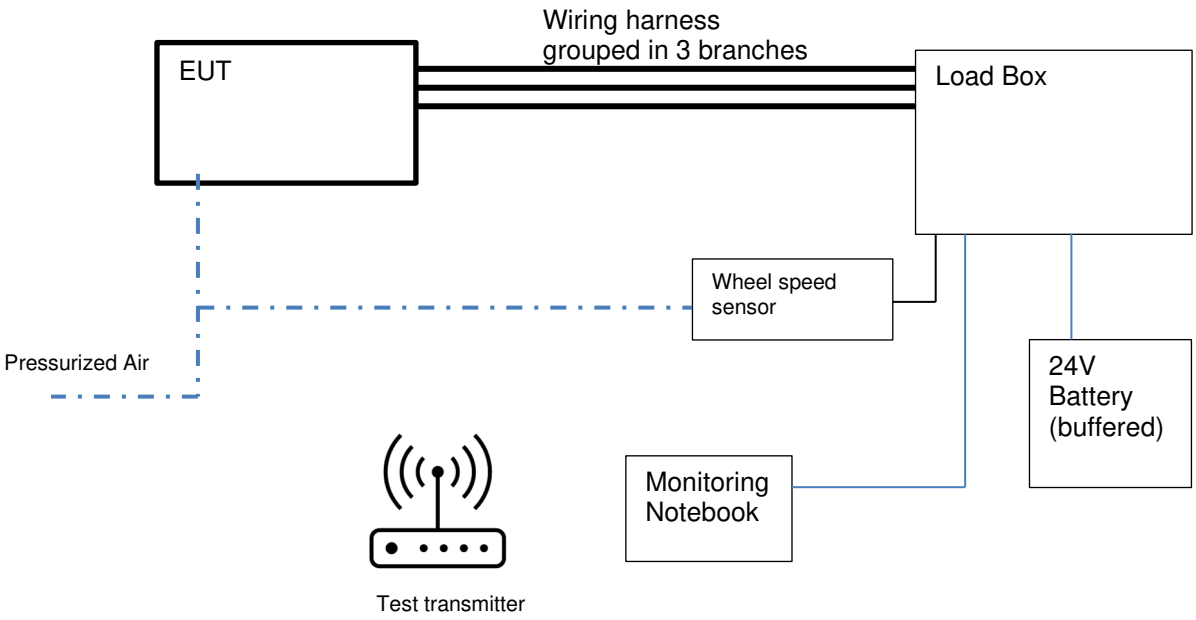
Description of function of the EUT:

- The EUT is a trailer brake control with an integrated 433 MHz receiver, which receives data from tire pressure sensors.

The following states were defined as the operating conditions:

- The EUT was supplied by 24.0 V_{DC} during all tests.
- The 433 MHz receiver was on during all tests.

The system was setup as follows:



Input/output Ports					
Port No.	**Name**	**Type***	**Cable Max. >3m**	**Cable Shielded**	**Comments (Sip/Sop lines must include description of use)**
0	Enclosure	N/E	—	—	None
1	☐ AC Power Ports	AC	--	N/A	---
2	☒ DC Power Ports	DC	2.5 m	No	---
3	☐ Battery powered	Batt	☐ Operation during battery charging allowed?		

Supplementary information:

*Note: AC = AC Power Port DC = DC Power Port N/E = Non-Electrical
Batt=Battery
Sip/Sop= Signal Input/output Port
TP = Telecommunication Ports

Ports / Connectors				
Identification	Connector		Length during test	Shielding (Yes / No)
	EUT	Ancillary		
GIO 1	GIO 1		2.5 m	No
GIO 2	GIO 2		2.5 m	No
SUBSYSTEM II	SUBSYSTEM II	LIN cable (4498390000)	2.5 m	No
SUBSYSTEM I	SUBSYSTEM I	Telematic 4-core cable (4499360000)	2.5 m	No
ABS F	ABS F		2.5 m	No
ABS D	ABS D		2.5 m	No
GIO 6	GIO 6		2.5 m	No
GIO 7	GIO 7		2.5 m	No
IN/OUT	IN/OUT		2.5 m	No
POWER	POWER		2.5 m	No
ABS E	ABS E		2.5 m	No
ABS C	ABS C		2.5 m	No

Equipment used for testing	
Load Adapter *1	TEBS-F RPD (882 200 533 9), Adm. No.: R0157 / R0156 / R0155
Wheel Speed Simulation *1	Speed signal simulation by spinning pole wheel driven by pneumatic motor.
Cable Harness *1	Connection of DUT to the load simulation (LTA) via 2.5 m cable harness

*1 Provided by the applicant
*2 Provided by the laboratory

Ancillary equipment	
Monitoring *1	CAN communication via FOL by CANalyzer 12.0 software
Monitoring *1	LIN communication via FOL
OptiTire ECU *1	As an external 433 MHz RF-transmitter controlled by CANalyzer software
433 MHz pass filter *1	For 433 MHz signal transmitter

*1 Provided by the applicant

3 Additional Information

General information:

- none

Classification of cables:

- none

Maximum length of cables, declared by the manufacturer:

- no maximum length declared

Type of cables, declared by the manufacturer:

- no special type of cable declared

Deviation of the standard or test plan:

- none

Special EMC measures, as a result of the tests:

- none

4 Overview

Radiated emissions	FCC 47 CFR Part 15 section 15.109 (a),(b) [3]. RSS-GEN [4]				
Application	Frequency range	Limits	Reference standard	Tested EUT	Status
Radiated Emission Class B	30 to 88 MHz 88 to 216 MHz 216 to 960 MHz 960 to 1000 MHz above 1000 MHz	40.0 dB(µV/m) QP at 3 m 43.5 dB(µV/m) QP at 3 m 46.0 dB(µV/m) QP at 3 m 54.0 dB(µV/m) QP at 3 m 54.0 dB(µV/m) AV at 3 m and 74.0 dB(µV/m) PK at 3 m	ANSI C63.4	1	Passed

For frequencies above 1000MHz, the field strength limits are based on average detector, however, the peak field strength of any emission shall not exceed the maximum permitted average limits, specified above by more than 20dB under any condition of modulation.

Remark: As declared by the applicant the highest internal clock frequency is < 500 MHz.
Therefore, the radiated emission measurement must be carried out up to 2 GHz.

The EUT was classified by the applicant as CLASS B equipment.

5 Results

5.1 Radiated emissions

5.1.1 Test method

The radiated emission measurement is subdivided into two stages.

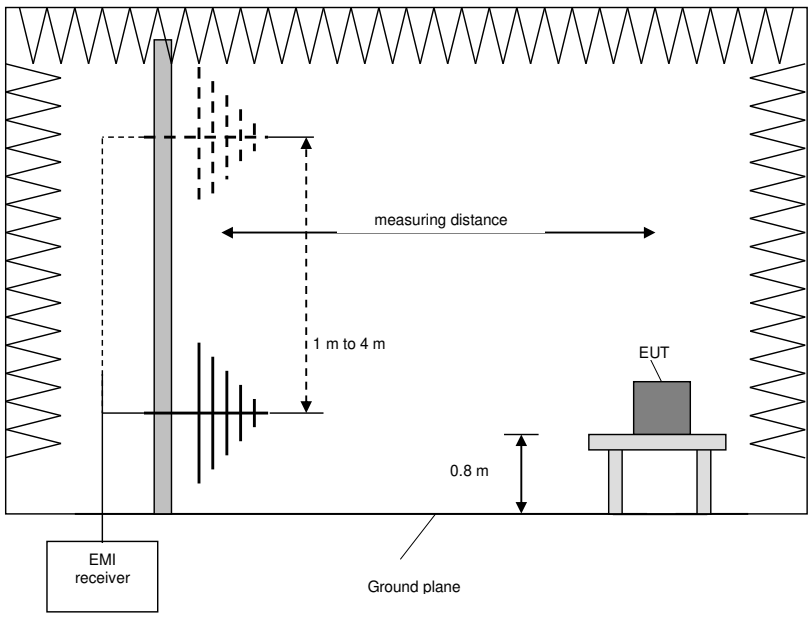
- A measurement carried out in a semi anechoic chamber with reflecting ground plane and various antenna heights in the frequency range 30 MHz to 1 GHz.
- A measurement carried out in a fully anechoic chamber and various antenna heights of 100 to 400 cm at a distance of 3 m to the EUT position in the frequency range 1 GHz to 40 GHz.

Preliminary and final measurement 30 MHz to 1 GHz

The preliminary and final measurements are performed in a semi-anechoic chamber with a metal ground plane in a 3 m distance.
Tabletop devices will set up on a non-conducting support with a height of 80 cm
During the tests the EUT is rotated in the range of 0 ° to 360 °, the measuring antenna is set to horizontal and vertical polarization and raised and lowered in the range from 1 m to 4 m to find the maximum level of emissions.

The resolution bandwidth of the EMI Receiver is set to the following values:

Test	Frequency range	Resolution bandwidth
Preliminary measurement	30 MHz to 1 GHz	100 kHz
Frequency peak search	+ / - 1 MHz	10 kHz
Final measurement	30 MHz to 1 GHz	120 kHz



Procedure preliminary measurement:

The following procedure is used:

1) Set the measuring antenna to 1 m height.
2) Monitor the frequency range at horizontal polarisation of the measuring antenna and an EUT / turntable azimuth of 0 °.
3) Rotate the EUT by 360° to maximize the detected signals.
4) Repeat steps 2 to 3 with the vertical polarisation of the measuring antenna.
5) Increase the height of the measuring antenna for 0.5 m and repeat steps 2 to 4 until the final height of 4 m is reached.
6) The highest values for each frequency are saved by the software, including the measuring antenna height and polarization and the turntable azimuth for that value.

Procedure final measurement:

The following procedure is used:

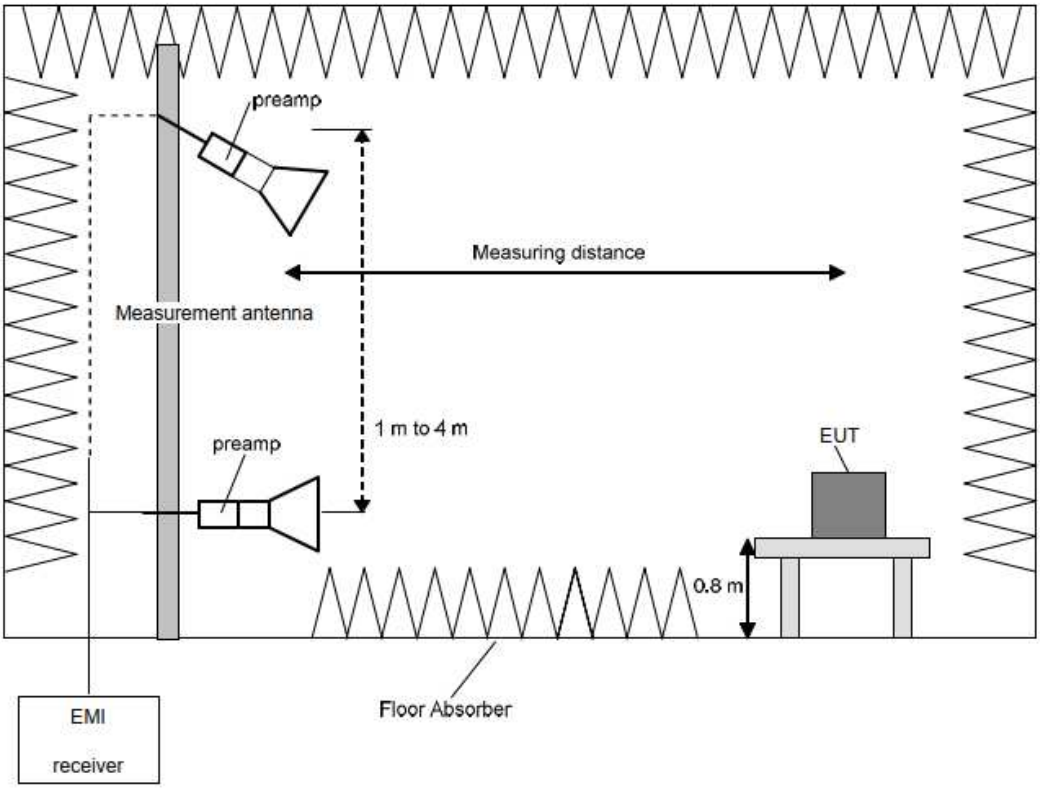
1) Select the highest frequency peaks (lowest margin to the limit) for the final measurement.
2) The software determines the exact peak frequencies by doing a partial scan with reduced RBW with +/- 10 times the RBW of the pre-scan of the selected peaks.
3) If the EUT is portable or ceiling mounted, find the worst-case EUT orientation (x,y,z) for the final test.
4) The worst-case measuring antenna height is found via varying the height by +/- 0.5 m from the value obtained in the preliminary measurement while monitoring the emission level.
5) The worst-case turntable position is found via varying the turntable azimuth by +/- 30° from the value obtained in the preliminary measurement while monitoring the emission level.
6) The final measurement is performed at the worst-case measuring antenna height and the worst-case turntable azimuth.
7) Steps 2 to 6 are repeated for each frequency peak selected in step 1.

Preliminary and final measurement > 1 GHz

The preliminary and final measurements are performed in a semi-anechoic chamber with floor absorbers between EUT and measuring antenna. The measuring distance is 3 m.
During the tests the EUT is rotated in the range of 0 ° to 360 °, the measuring antenna is set to horizontal and vertical polarisation and raised and lowered in the range from 1 m to 4 m to find the maximum level of emissions. While changing the height, the measuring antenna gets tilted so that it is always aiming at the EUT.

The resolution bandwidth of the EMI Receiver is set to the following values:

Test	Frequency range	Resolution bandwidth
Preliminary measurement	1 – 2 GHz	1 MHz
Frequency peak search	+ / - 10 MHz	100 kHz
Final measurement	1 - 2 GHz	1 MHz



Procedure preliminary measurement:

The following procedure is used:

1) Set the measuring antenna to 1 m height.
2) Monitor the frequency range at horizontal polarisation of the measuring antenna and an EUT / turntable azimuth of 0 °.
3) Rotate the EUT by 360° to maximize the detected signals.
4) Repeat steps 2 to 3 with the vertical polarisation of the measuring antenna.
5) Increase the height of the measuring antenna for 0.5 m and repeat steps 2 to 4 until the final height of 4 m is reached.
6) The highest values for each frequency are saved by the software, including the measuring antenna height and polarization and the turntable azimuth for that value.

Procedure final measurement:

The following procedure is used:

1) Select the highest frequency peaks (lowest margin to the limit) for the final measurement.
2) The software determines the exact peak frequencies by doing a partial scan with reduced RBW with +/- 10 times the RBW of the pre-scan of the selected peaks.
3) If the EUT is portable or ceiling mounted, find the worst-case EUT orientation (x,y,z) for the final test.
4) The worst-case measuring antenna height is found via varying the height by +/- 0.5 m from the value obtained in the preliminary measurement while monitoring the emission level.
5) The worst-case turntable position is found via varying the turntable azimuth by +/- 30° from the value obtained in the preliminary measurement while monitoring the emission level.
6) The final measurement is performed at the worst-case measuring antenna height and the worst-case turntable azimuth.
7) Steps 2 to 6 are repeated for each frequency peak selected in step 1.

5.2 Radiated radio disturbance frequency range 30 MHz to 1 GHz according to FCC 47 CFR Part 15 section 15.109 and RSS-Gen Issue 5

Measuring setup: - Table setup
- Photo(s) are shown in annex A

Measuring record: The measuring records are presented on the following pages.

Measuring result: The requirements Class B made in the test documents were fulfilled.

Test description:	Radiated emission measurement
Test site:	Phoenix TESTLAB GmbH, Semi Anechoic Chamber M153
Setup:	Table setup
Operator:	T. Brähler
EUT:	iEBS Premium
Manufacturer:	ZF-Wabco
Operating conditions:	EUT grounded, wheel speed simulation, compressed air supply, Continuous driving condition, voltage supply via terminal 30 + KL15
Comment:	

EMI Auto Test Template: 30 MHz - 1 GHz

Hardware Setup:	30MHz-6GHz_HL562E
Measurement Type:	Open-Area-Test-Site (SAC/FAR)
Frequency Range:	30 MHz - 1 GHz
Graphics Level Range:	0 dBµV/m - 80 dBµV/m

Preview Measurements:
Scan Test Template: 30 MHz - 6 GHz, HL562E, FFT, PRE

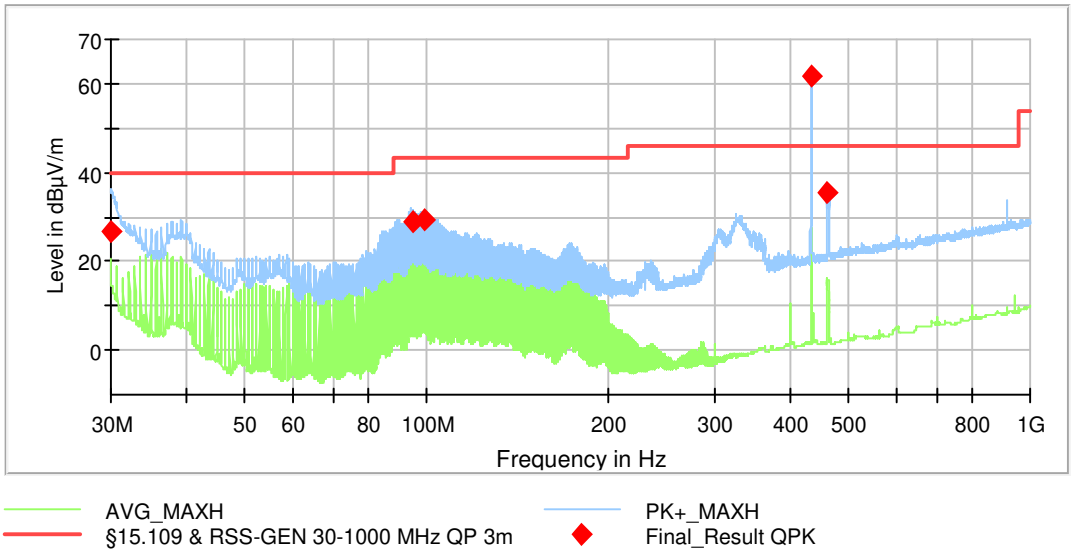
Subrange	Step Size	Detectors	IF BW	Meas. Time	Preamp
Receiver: [ESW 44]					
30 MHz - 1 GHz	25 kHz	PK+ ; AVG	100 kHz	0,5 s	20 dB

Frequency Zoom:
Zoom Scan Template: 30 MHz - 6 GHz, HL562E, ZOOM

Adjustment:
Template for Single Meas.: 30 MHz - 6 GHz, HL562E, PSC

Final Measurements:
Template for Single Meas.: 30 MHz - 1 GHz, HL562E, FIN

Subrange	Step Size	Detectors	IF BW	Meas. Time	Preamp
Receiver: [ESW 44]					
30 MHz - 1 GHz	40 kHz	QPK	120 kHz	1 s	20 dB



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Final_Result

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (s)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
30.06500	26.87	40.00	13.13	1.0	120.0	106.0	V	29.0	19.6
94.99500	28.79	43.50	14.71	1.0	120.0	387.0	H	-8.0	10.8
99.27500	29.29	43.50	14.21	1.0	120.0	273.0	H	211.0	10.9
433.95500	61.62	46.00	-15.62	1.0	120.0	103.0	V	94.0	16.4
461.79500	35.30	46.00	10.70	1.0	120.0	106.0	V	84.0	17.2

The emission at 433.955 MHz is caused by the ancillary equipment, as pretest has shown, to stimulate the EUT receiver during the emission testing.

Measuring equipment:

Test site and Type		Manufacturer	Serial No.	PM. No.	Val. Date	Val Due
M153 Semi Anechoic Chamber		Albatross Projects		482784	-	
Type of validation: NSA according to: ANSI C63.4a-2017 CISPR 16-1-4 + Cor1:2010 + A1:2012 +A2:2017					2024	02.2025
Test equipment	Type	Manufacturer	Serial No.	PM. No.	Cal. Date	Cal Due
Ultralog Antenna	HL562E	Rohde & Schwarz	101061	483152	18.05.2021	05.2024
Attenuator 6 dB	WA2-6	Weinschel		482794	*	*
Systemsoftware EMC32 M153	EMC32	Rohde & Schwarz	100622	483150	*	*
RF Switch Matrix	OSP 220	Rohde & Schwarz	101376	483141	*	*
RF Switch Matrix	OSP 220	Rohde & Schwarz	101367	483142	*	*
RF Switch Matrix	OSP 220	Rohde & Schwarz	101423	483143	*	*
EMI Testreceiver ESW	ESW	Rohde & Schwarz	101819	483149	17.11.2022	11.2024

(*) Calibration not necessary time stamp: 12.05.2023 used: 12.06.2024

5.3 Radiated radio disturbance frequency range 1 GHz up to 2 GHz according to FCC 47 CFR Part 15 section 15.109 and RSS-Gen Issue 5

Measuring setup: - Table setup

Measuring record: The measuring records are presented on the following pages.

EMI Auto Test Template: FCC-1GHz-13GHz-HL050

Hardware Setup: 800MHz-18GHz_HL50
Measurement Type: Open-Area-Test-Site (SAC/FAR)
Frequency Range: 1 GHz - 13 GHz
Graphics Level Range: 0 dBµV/m - 80 dBµV/m

Preview Measurements:
Scan Test Template: 1 GHz - 13 GHz, HL50, FFT, PRE

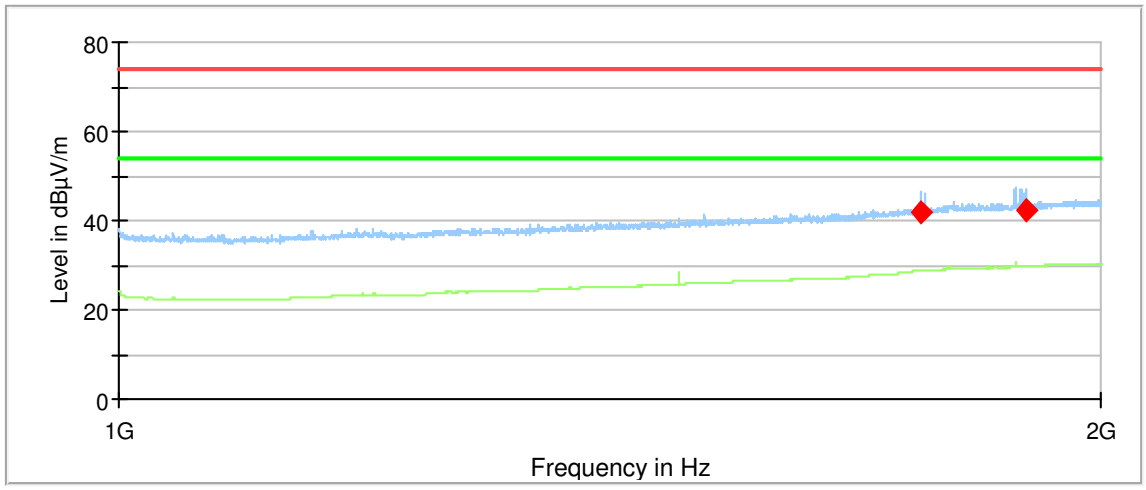
Subrange	Step Size	Detectors	IF BW	Meas. Time	Preamp
Receiver: [ESW 44]					
1 GHz - 13 GHz	250 kHz	PK+ ; AVG	1 MHz	0,05 s	20 dB

Adjustment:
Template for Single Meas.: 1 GHz - 13 GHz, HL50-JS3, FFT, PRE

Subrange	Step Size	Detectors	IF BW	Meas. Time	Preamp
Receiver: [ESW 44]					
1 GHz - 13 GHz	250 kHz	PK+ ; AVG	1 MHz	0,05 s	20 dB

Final Measurements:
Template for Single Meas.: 1 GHz - 13 GHz, HL50-JS3, FIN

Subrange	Step Size	Detectors	IF BW	Meas. Time	Preamp
Receiver: [ESW 44]					
1 GHz - 13 GHz	400 kHz	PK+ ; AVG	1 MHz	1 s	20 dB



240086_FCC_2G 11.04.2024

Final_Result

Frequency (MHz)	MaxPeak (dBµV/m)	Average (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (s)	Bandwidth (MHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
1762.00000	41.70	---	74.00	32.30	1.0	1.0	150.0	V	321.0	29.3
1897.25000	42.17	---	74.00	31.83	1.0	1.0	150.0	V	307.0	29.9
2443.75000	48.51	---	74.00	25.49	1.0	1.0	150.0	H	96.0	32.8

Measuring equipment:

Test site and Type		Manufacturer	Serial No.	PM. No.	Val. Date	Val Due
M153 Semi Anechoic Chamber with floor absorber		Albatross Projects		482784	-	-
Type of validation: SVSWR according to: ANSI C63.4a-2017 CISPR 16-1-4 + Cor1:2010 + A1:2012 +A2:2017					09.04.2024	04.2026
Test equipment	Type	Manufacturer	Serial No.	PM. No.	Cal. Date	Cal Due
Antenna (Log.Per.)	HL050	Rohde & Schwarz	100908	482977	22.09.2022	09.2025
standard gain horn antenna	18240-20	Flann	483	480294	*	*
standard gain horn antenna	20240-20	Flann	411	480297	*	*
standard gain horn antenna	22240-20	Flann	469	480299	*	*
Preamplifier 100 MHz - 13 GHz	JS3-00101200-23-5A	MITEQ Hauppauge N.Y.	681851	480337	*	*
Preamplifier 18 GHz - 26 GHz	JS4-18002600-20-5A	MITEQ Hauppauge N.Y.	658697	480342	19.02.2024	02.2026
Preamplifier 12 GHz - 18 GHz	JS3-12001800-16-5A	MITEQ Hauppauge N.Y.	571667	480343	19.02.2024	02.2026
Preamplifier 26 GHz - 40 GHz	JS4-26004000-25-5A	MITEQ Hauppauge N.Y.	563593	480344	*	*
standard gain horn antenna	18240-20	Flann	269813	483215	*	*
standard gain horn antenna	20240-20	Flann	266399	483026	*	*
standard gain horn antenna	22240-20	Flann	266405	483027	*	*
Preamplifier 1 GHz -18 GHz	LNA-30-00101800-25-10P	Narda-Miteq	2110917	482967	20.02.2024	02.2026
Preamplifier 12 GHz -18 GHz	LNA-30-12001800-13-10P	Narda-Miteq	2089798	482968	*	*
Preamplifier 18 GHz - 26 GHz	LNA-30-18002650-20-10P	Narda-Miteq	2110911	482969	19.02.2024	02.2026
Preamplifier 26 GHz - 40 GHz	LNA-30-26004000-27-10P	Narda-Miteq	2110293	482970	19.02.2024	02.2026
EMI Receiver / Spectrum Analyser	ESW	Rohde & Schwarz	101819	483149	26.02.2024	02.2026
Software	EMC32	Rohde & Schwarz	100622	483150	*	*

(*) Calibration not necessary time stamp: 21.06.2024 used: 15.08.2024

6 Report History

Report Number	Date	Comment
E240086E2	12.06.2024	Initial Test Report
E240086E2 2nd Version	27.08.2024	Test report completely revised Annex A and B added.
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7 List of Annexes

Annex A	Test Setup Photos	1 page
Annex B	EUT Photos	5 pages

– – – End of test report – – –