

Test Report

Report Number:

F230859E5, 2nd version

Equipment under Test (EUT):

COM2016 CEM2

Applicant:

KOSTAL Engineering CR, spol. s r.o.

Manufacturer:

KOSTAL Bulgaria Automotive EOOD



Deutsche
Akkreditierungsstelle
D-PL-17186-01-00

References

- [1] **ANSI C63.10: 2013** American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices
- [2] **FCC CFR 47 Part 15** Radio Frequency Devices
- [3] **RSS-210 Issue 11 (June 2024)**
Licence-Exempt Radio Apparatus: Category I Equipment
- [4] **RSS-Gen, Issue 5 Amendment 2 (2021-02)**
General Requirements for Compliance of Radio Apparatus

Test Result

The requirements of the tests performed as shown in the overview (clause 4) were fulfilled by the equipment under test. The complete test results are presented in the following.

“Passed” indicates that the equipment under test conforms with the relevant limits of the testing standard without taking any measurement uncertainty into account as stated in clause 1.3 of ANSI C63.10 (2013). However, the measurement uncertainty is calculated and shown in this test report.

Tested and written
by:

Signature

Reviewed and
approved by:

Signature

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1 Identification

1.1 Applicant

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Applicant represented during the test by the following person:	None

1.2 Manufacturer

Name:	KOSTAL Bulgaria Automotive EOOD
Address:	Sinitevska Str.4, 4400 Pazardzhik
Country:	Bulgaria
Name for contact purposes:	Atanas Kostov Apostolov
Phone:	+359 344 99 621
eMail address:	a.apostolov@kostal.com
Manufacturer 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 Deutsche Akkreditierungsstelle GmbH (DAkKS) in compliance with DIN EN ISO/IEC 17025 under Reg. No. D-PL-17186-01-05 and 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)

Test object: *	Steering column module (SCM)
Model name: *	COM2016 CEM2
Model number: *	12190182-01
Order number: *	98639722YX
FCC ID: *	2BCB9-COM2016
IC certification number: *	31740-COM2016
PMN: *	COM2016
HVIN: *	COM2016

	EUT number		
	1	2	3
Serial number: *	92910WHS0007M	-	-
PCB identifier: *	12095526-04	-	-
Hardware version: *	9.8	-	-
Software version: *	15	-	-

* Declared by the applicant

One EUT was used for all tests.

The EUT was labeled as follows:



As declared by the applicant, this is not the label of the final product. The final product will be labeled as follows:



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

General			
Power supply EUT: *	DC		
Supply voltage EUT: *	$U_{nom} = 13.5 \text{ V}$	$U_{min} = 8 \text{ V}$	$U_{max} = 16 \text{ V}$
Temperature range: *	-40 °C to +85 °C		
Lowest / highest internal frequency: *	125 kHz / 16 MHz		
Receiver frequency: *	433 MHz		

* Declared by the applicant

Technical data of the 433 MHz receiver	
Operating Frequency: *	433.920 MHz
Receiver bandwidth: *	300 kHz
Duty cycle class: *	N/A (EUT is a receiver only)
Data rate: *	4400 kBit/s
Antenna: *	Integrated PCB antenna
Number of channels: *	1

* Declared by the applicant

Technical data of the 125 kHz transceiver	
Type of modulation: *	ASK
Operating frequency: *	125 kHz
Antenna area: *	12.5 cm ²
Antenna type: *	Loop-Antenna
Number of channels: *	1

* Declared by the applicant

Equipment used for testing	
CAN box*	Sets the EUT's 125 kHz part into operation mode

* Provided by the applicant

Ancillary equipment	
Ignition lock *	Equipped with a coil antenna for 125 kHz communication
Key *	

* Provided by the applicant

1.6 Dates

Date of receipt of test sample:	15.12.2023
Start of test:	15.01.2024
End of test:	16.01.2024

2 Operational States

Description of function of the EUT:

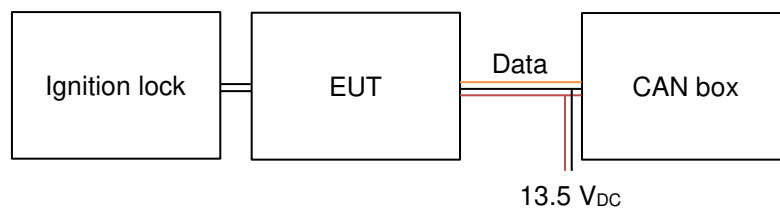
The EUT is a Steering Column Module for vehicular use only with a 125 kHz key transponder and a 433 MHz immobilizer.

The following states were defined as the operating conditions:

These tests were carried out to address the spurious emissions of the 125 kHz transceiver.

During all tests the EUT was supplied by 13.5 V_{DC} via a laboratory power supply.
An ignition lock with key and a CAN box were connected to the EUT. The 125 kHz RFID part of the EUT was operating with a 100 ms cycle.

The system was setup as follows:



3 Additional Information

The EUT was not labeled as required by FCC / IC.

4 Overview

Application	Frequency range [MHz]	FCC 47 CFR Part 15 section [2]	RSS-Gen, Issue 5 [4] and RSS-210, Issue 11 [3]	Tested EUT	Status
Radiated emissions	0.009 – 1000 **	15.205 (a) 15.209 (a)	8.9 and 8.10 [4] 8.1 and 8.3 [3]	1	Passed
99 % bandwidth	0.125	-	6.7 [4]	1	Passed
Antenna requirement	-	15.203 [2]	6.8 [4]	-	Passed *

*: Integrated antenna only, requirement fulfilled.

**: As declared by the applicant the highest radio clock frequency is 125 kHz.
Therefore the radiated emission measurement must be carried out up to 10th of the highest radio clock frequency in this case 1.25 MHz.

Remark: Because the EUT is for vehicular use, no conducted emissions on supply line were carried out.

5 Results

5.1.1 Radiated: 9 kHz to 30 MHz

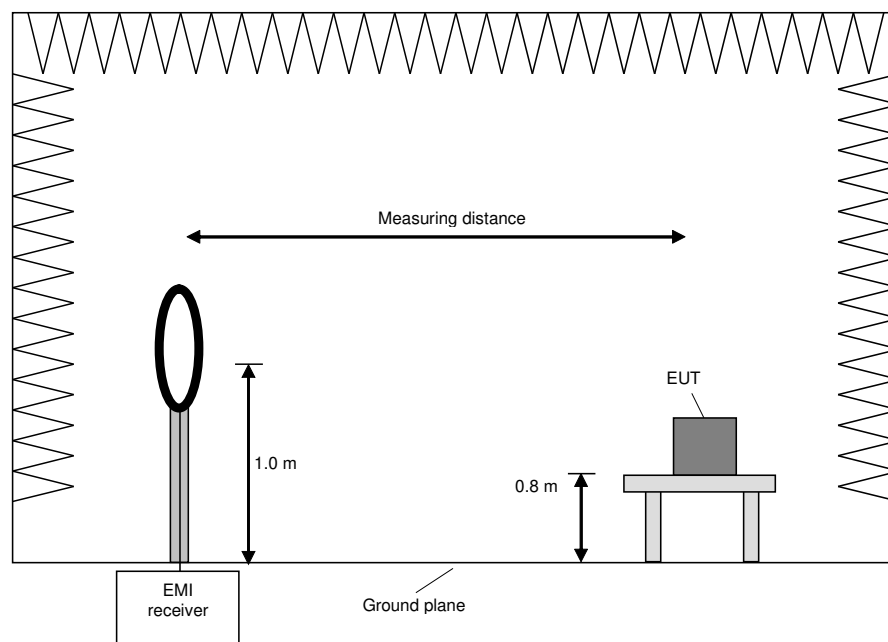
5.1.1.1 Preliminary measurement 9 kHz to 30 MHz

In the first stage a preliminary measurement is performed in a semi-anechoic chamber at a measuring distance of 3 meters. Table-top devices are set up on a non-conducting support with a size of 1 m by 1.5 m and a height of 80 cm. Floor-standing devices are placed directly on the turntable / ground plane. The setup of the equipment under test is in accordance with [1].

The frequency range 9 kHz to 30 MHz is monitored with an EMI receiver while the system and its cables are manipulated to find out the configuration with the maximum emission levels if applicable. The EMI receiver is set to MAX hold mode. The EUT and the measuring antenna are rotated around their vertical axis to find the maximum emission levels.

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

Frequency range	Resolution bandwidth
9 kHz to 150 kHz	200 Hz
150 kHz to 30 MHz	9 kHz



Procedure preliminary measurement:

Pre-scans are performed in the frequency range 9 kHz to 150 kHz and 150 kHz to 30 MHz.

The following procedure is used:

- 1) Monitor the frequency range with the measuring antenna facing the EUT and an EUT / turntable azimuth of 0 °.
- 2) Manipulate the system cables to produce the maximum levels of emissions.
- 3) Rotate the EUT by 360 ° to maximize the detected signals.
- 4) Measure the frequencies of the highest detected emissions with a lower span and resolution bandwidth to increase the accuracy and note the frequency values.
- 5) If the EUT is portable or ceiling mounted, repeat steps 1 to 4 with other orientations (x,y,z) of the EUT.
- 6) Rotate the measuring antenna and repeat steps 1 to 5.

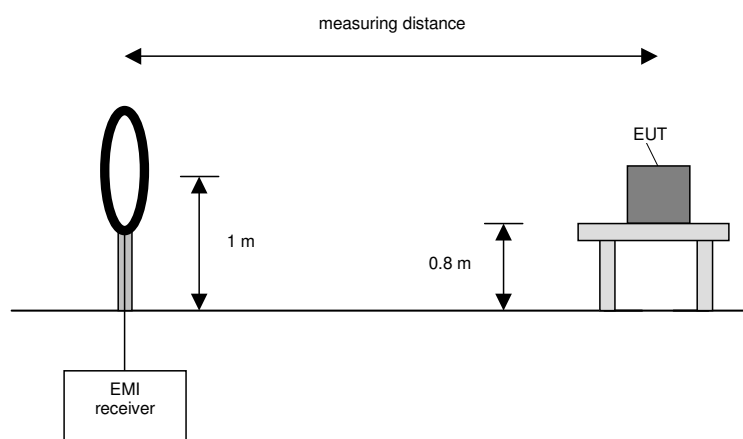
5.1.1.2 Final measurement 9 kHz to 30 MHz

In the second stage a final measurement is performed on an open area test site with no conducting ground plane at a measuring distance of 3 m, 10 m, or 30 m. If the standard requires larger measuring distances for a given frequency, the results are extrapolated according to section 15.31 (f) (2) [2]. The final measurement is performed with an EMI receiver set to Quasi-Peak detector, except for the frequency bands 9 kHz to 90 kHz and 110 kHz to 490 kHz where an Average detector is used according section 15.209 (d) [2].

At the frequencies, which were detected during the preliminary measurements, the final measurement is performed while rotating the EUT and the measuring antenna in the range of 0 ° to 360 ° around their vertical axis until the maximum level value is found.

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

Frequency range	Resolution bandwidth	Measuring time
9 kHz to 150 kHz	200 Hz	1 s
150 kHz to 30 MHz	9 kHz	1 s



Procedure final measurement:

The following procedure is used:

- 1) Monitor the selected frequencies from the preliminary measurement with the measuring antenna facing the EUT and an EUT azimuth of 0 °.
- 2) Rotate the EUT by 360 ° to maximize the detected signals.
- 3) Rotate the measuring antenna and repeat steps 1 to 2 until the maximum value is found and note it.
- 4) If the EUT is portable or ceiling mounted, repeat steps 1 to 3 with other orientations (x,y,z) of the EUT.

5.1.2 Radiated: 30 MHz to 1 GHz

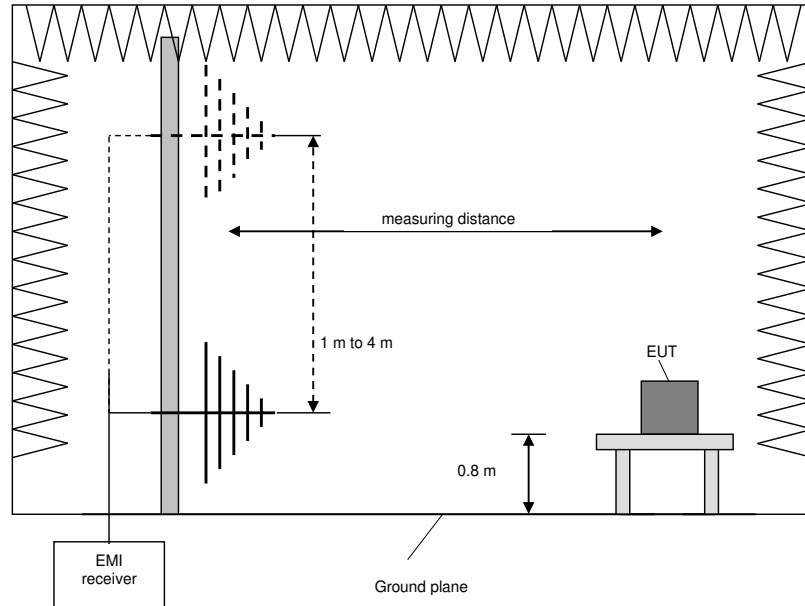
5.1.2.1 Preliminary and final measurement 30 MHz to 1 GHz

The preliminary and final measurements are performed in a semi-anechoic chamber with a metal ground plane at a measuring distance of 3 meters. Table-top devices are set up on a non-conducting support with a size of 1 m by 1.5 m and a height of 80 cm. Floor-standing devices are placed directly on the turntable / ground plane. The setup of the equipment under test is in accordance with [1].

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	Step-size	Resolution bandwidth	Measuring time	Detector
Preliminary measurement	30 MHz to 1 GHz	30 kHz	120 kHz	-	Peak Average
Frequency peak search	± 120 kHz	10 kHz	120 kHz	1 s	Peak
Final measurement	30 MHz to 1 GHz	-	120 kHz	1 s	QuasiPeak



Procedure preliminary measurement:

The following procedure is used:

- 1) Set the measuring antenna to 1 m height.
- 2) Monitor the frequency range at horizontal polarization 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 polarization 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 step size 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 99 % bandwidth

5.2.1 Test setup (99 % bandwidth)

Test setup (99 % bandwidth)			
Used	Setup	See sub-clause	Comment
<input checked="" type="checkbox"/>	Radiated: 9 kHz to 30 MHz	5.1.1	-
<input type="checkbox"/>	Test setup (antenna port conducted)	-	-

5.2.2 Test method (99 % bandwidth)

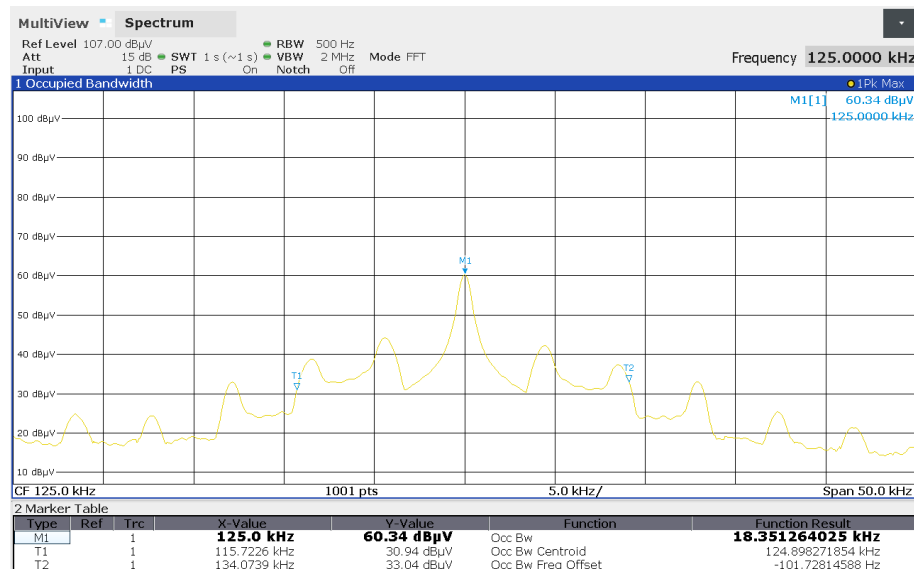
Test method (99 % bandwidth)				
Used	Sub-Clause [1]	Name of method	Applicability	Comment
<input checked="" type="checkbox"/>	6.9.3	Occupied bandwidth – power bandwidth (99%) measurement procedure	*1	-

*1 See RSS-GEN Issue 5 (2018-05) sub-clause 6.7 for details.

5.2.3 Test results (99 % bandwidth)

Ambient temperature:	21 °C
Relative humidity:	24 %

Date:	15.01.2024
Tested by:	S. KREHS



F_L	F_U	$BW (F_U - F_L)$
115.723 kHz	134.074 kHz	18.351 kHz

Test result: Passed

Test equipment (please refer to chapter 7 for details)
3 – 10

5.3 Radiated emissions

5.3.1 Test setup (Maximum unwanted emissions)

Test setup (Maximum unwanted emissions)			
Used	Setup	See sub-clause	Comment
<input checked="" type="checkbox"/>	Radiated: 9 kHz to 30 MHz / 30 MHz to 1 GHz	5.1.1 / 5.1.2	-

5.3.2 Test method (Maximum unwanted emissions)

☒ Test method (radiated) see sub-clause 5.1.1 / 5.1.2 as described herein

5.3.3 Test results (Maximum unwanted emissions)

5.3.3.1 Test results preliminary measurement 9 kHz to 30 MHz

Ambient temperature:	21 °C	Date:	15.01.2024
Relative humidity:	24 %	Tested by:	S. KREHS

Position of EUT: For tests for f between 9 kHz to 30 MHz, the EUT was set-up on a table with a height of 80 cm. The distance between EUT and antenna was 3 m.

Cable guide: For detail information of test set-up and the cable guide refer to the pictures in the annex A in the test report.

Test record: -

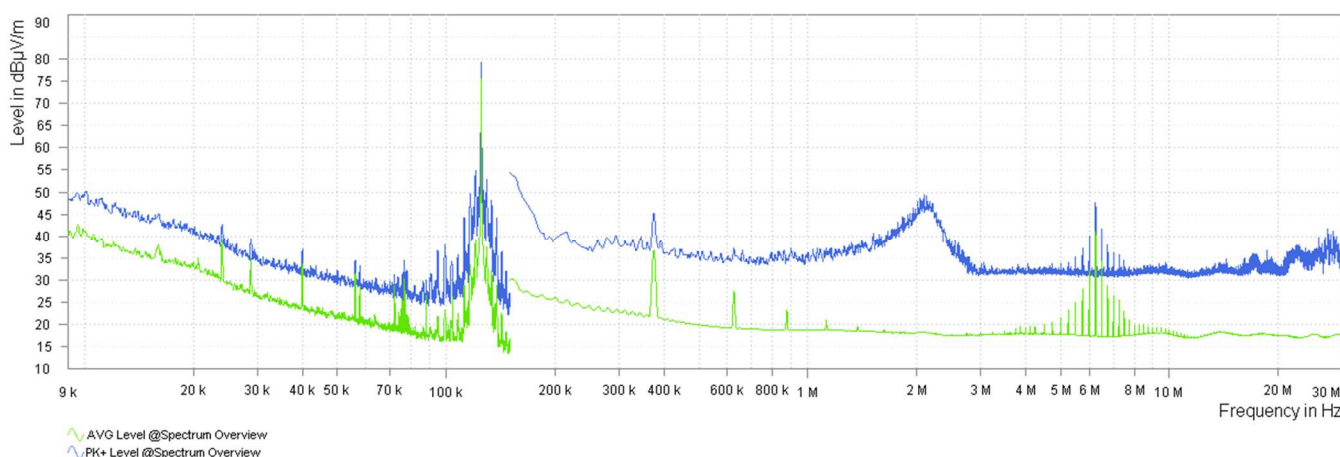
Remark: The EUT was measured in its normal position / orientation.

Calculations:

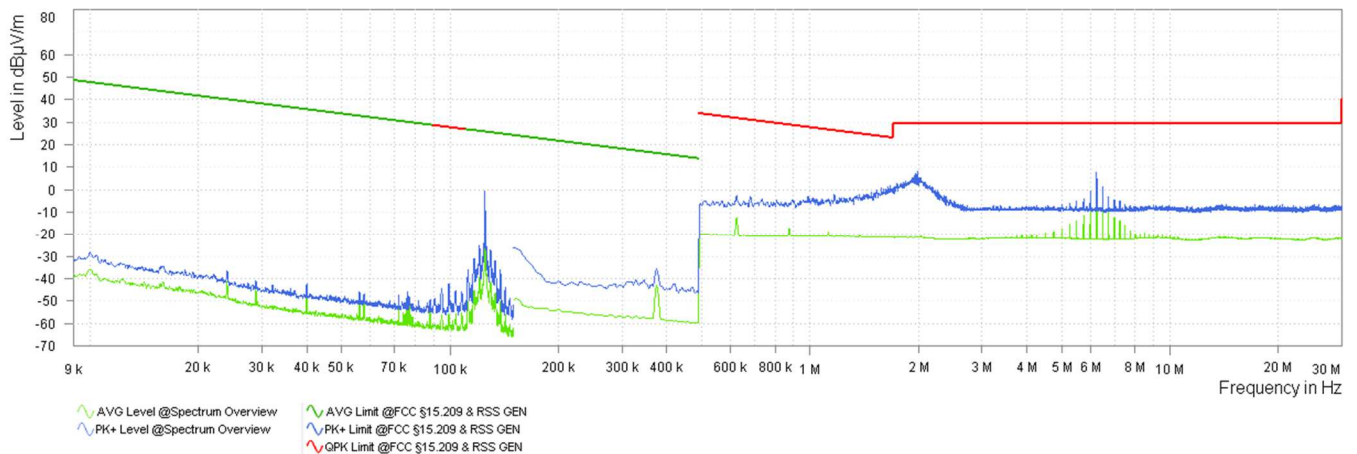
Result @ norm. dist. [dB μ V/m] = Reading [dB μ V] + AF [dB/m] + Distance corr. fact. [dB μ V/m]

Result @ norm. dist. [dB μ A/m] = Result @ norm. dist. [dB μ V/m] – 20 x log₁₀ (377 Ω)

Margin [dB] = Limit [dB(μ V| μ A)/m] - Result [dB(μ V| μ A)/m]



In the following plot, the measurement value was already corrected by 40 dB/decade as described in 47 CFR 15.31(f)(2) regarding to the measurement distance as requested in 47 CFR 15.209(a).



Remark: No unwanted emissions close than 20 dB to the limit, so only a final measurement of the wanted signal at 125 kHz will be carried out.

Test equipment (please refer to chapter 7 for details)
3 – 10

5.3.3.2 Test results final measurement 9 kHz to 30 MHz

Ambient temperature:	0 °C
Relative humidity:	80 %

Date:	09.01.2024
Tested by:	S. KREHS

The results of the standard subsequent measurement on the outdoor test site are indicated in the table below. The limits as well as the measured results (levels) refer to the above-mentioned standard while taking account of the specified requirements for a 30 | 300 m measuring distance.

Results 9 kHz - 30 MHz											
Frequency [MHz]	Reading @ measuring distance [dB(μV)]	Result @ norm. distance [dB(μV/m)]	Result @ norm. distance [dB(μA/m)]	Limit acc. 15.209 [dB(μV/m)]	Limit acc. RSS-Gen Table 6 [dB(μA/m)]	Margin [dB]	Detector	Antenna factor [dB/m]	Measuring distance [m]	Normative distance [m]	Distance correction factor [dB]
0.125	29.1	-9.5	-61.0	25.7	-25.9	35.2	AV	20.3	10	300	59.1

Remark:

The limits in CFR 47, Part 15, Subpart C, paragraph 15.209 (a), are identical to those in RSS-GEN Section 8.9, Table 6, since the measurements are performed in terms of magnetic field strength and converted to electric field strength levels (as reported in the table) using the free space impedance of 377 Ω. For example, the measurement frequency X kHz resulted in the level of Y dBμV/m, which is equivalent to Y - 51.5 = Z dBμA/m, which was the same margin, W dB, to the corresponding RSS-GEN Table 6 as it has to the 15.209(a) limit.

Test result: Passed

Test equipment (please refer to chapter 7 for details)
2, 12, 13

5.3.3.3 Test results (30 MHz – 1 GHz)

Ambient temperature:	21 °C
Relative humidity:	21 %

Date:	16.01.2024
Tested by:	S. KREHS

Position of EUT: For tests for f between 30 MHz to 1 GHz, the EUT was set-up on a table with a height of 80 cm. The distance between EUT and antenna was 3 m.

Cable guide: For detail information of test set-up and the cable guide refer to the pictures in the annex A in the test report.

Test record: Plots for each frequency range are submitted below.

Remark: All 3 orthogonal planes were tested separately

Calculations:

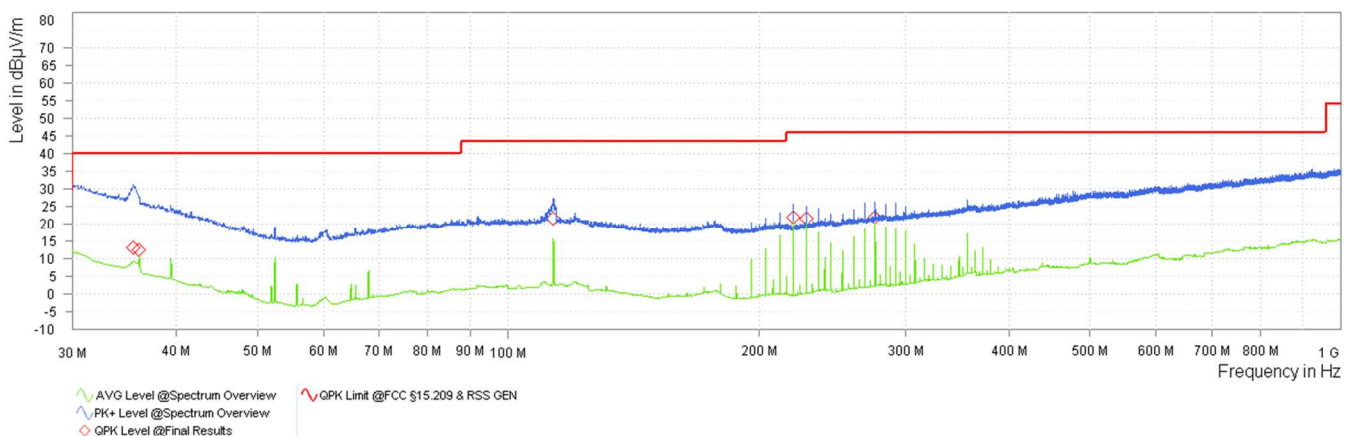
Result [dBμV/m] = Reading [dBμV] + Correction [dBμV/m]

Correction [dBμV/m] = AF [dB/m] + Cable attenuation [dB] + optional preamp gain [dB]

Margin [dB] = Limit [dBμV/m] - Result [dBμV/m]

The measured points and the limit line in the following diagram refer to the standard measurement of the emitted interference in compliance with the above-mentioned standard. The measured points marked with “◆” are the measured results of the standard subsequent measurement in a semi-anechoic chamber.

Spurious emissions from 30 MHz to 1 GHz:



Result table:

Frequency [MHz]	Result (QP) [dBμV/m]	Limit [dBμV/m]	Margin [dB]	Readings [dBμV]	Correction [dB/m]	Height [cm]	Azimuth [deg]	Pol. (H/V)
35.470	13.19	40.00	26.81	-9.48	22.67	162	14	V
36.040	12.58	40.00	27.42	-9.76	22.34	156	340	H
113.350	21.53	43.50	21.97	3.92	17.61	189	139	V
220.000	22.02	46.00	23.98	6.26	15.76	109	182	H
228.010	21.66	46.00	24.34	5.30	16.36	120	182	H
276.010	21.82	46.00	24.18	3.73	18.09	100	172	H

Test result: Passed

Test equipment (please refer to chapter 7 for details)
1, 4 – 11

6 Measurement Uncertainties

Conducted measurements		
Measurement method	Standard used for calculating measurement uncertainty	Expanded measurement uncertainty (95 %) U_{lab}
Frequency error	ETSI TR 100 028	4.5×10^{-8}
Bandwidth measurements	-	9.0×10^{-8}
Conducted emissions from 150 kHz to 30 MHz with LISN	CISPR 16-4-2	2.8 dB

Radiated measurements		
Frequency error		
(Semi-) Anechoic chamber	ETSI TR 100 028	4.5×10^{-8}
OATS	ETSI TR 100 028	4.5×10^{-8}
Test fixture	ETSI TR 100 028	4.5×10^{-8}
Bandwidth measurements		
(Semi-) Anechoic chamber	-	9.0×10^{-8}
OATS	-	9.0×10^{-8}
Test fixture	-	9.1×10^{-8}
Radiated field strength M20		
CBL6112B @ 3 m 30 MHz – 1 GHz	CISPR 16-4-2	5.3 dB
R&S HL050 @ 3 m		
1 – 6 GHz	CISPR 16-4-2	5.1 dB
6 – 18 GHz	CISPR 16-4-2	5.4 dB
Flann Standard Gain Horns 18 – 40 GHz	-	5.9 dB
Radiated field strength M276		
R&S HL562E @ 3 m 30 MHz – 1 GHz	CISPR 16-4-2	4.8 dB
R&S HL050 @ 3 m	-	
1 – 6 GHz	CISPR 16-4-2	5.1 dB
6 – 18 GHz	CISPR 16-4-2	5.4 dB
Flann Standard Gain Horns 18 – 40 GHz	-	5.9 dB
OATS		
Field strength measurements below 30 MHz on OATS without ground plane	-	4.4 dB

7 Test Equipment used for Tests

No.	Test equipment	Type	Manufacturer	Serial No.	PM. No.	Cal. Date	Cal Due
1	Ultralog Antenna	HL562E	Rohde & Schwarz	101079	482978	18.03.2021	03.2024
2	Loop antenna	HFH2-Z2	Rohde & Schwarz	832609/014	480059	22.02.2022	02.2024
3	Loop antenna	HFH2-Z2	Rohde & Schwarz	100417	481912	22.02.2022	02.2024
4	RF Switch Matrix	OSP220	Rohde & Schwarz	--	482976	Calibration not necessary	
5	Turntable	TT3.0-3t	Maturo	825/2612/.01	483224	Calibration not necessary	
6	Antennasupport	BAM 4.5-P-10kg	Maturo	222/2612.01	483225	Calibration not necessary	
7	Controller	NCD	Maturo	474/2612.01	483226	Calibration not necessary	
8	Semi Anechoic Chamber M276	SAC5-2	Albatross Projects	C62128-A540-A138-10-0006	483227	Calibration not necessary	
9	Testsoftware M276	Elektra V5.01	Rohde & Schwarz	101381	483755	Calibration not necessary	
10	EMI Testreceiver	ESW44	Rohde & Schwarz	101828	482979	08.12.2021	02.2024
11	Attenuator 6 dB	WA2-6	Weinschel	--	482793	Calibration not necessary	
12	Open area testsite	-	Phoenix Testlab GmbH	-	480293	Calibration not necessary	
13	EMI Receiver	ESI 40	Rohde & Schwarz	100064/040	480355	18.02.2022	02.2024

8 Test site Verification

Test equipment	PM. No.	Frequency range	Type of validation	According to	Val. Date	Val Due
OATS Outdoor	480293	9 kHz – 30 MHz	-	ANSI C63.4-2014	-	-
Semi anechoic chamber M276	483227	30 MHz – 1 GHz	NSA/RSM	CISPR 16-1-4 + Cor1:2010 + A1:2012 +A2:2017	01.03.2023	28.02.2026

9 Report History

Report Number	Date	Comment
F230859E5	25.04.2024	Initial Test Report
F230859E5, 2 nd version	20.01.2025	Updated reference [3]
-	-	-

10 List of Annexes

Annex A	Test Setup Photos	4 pages
	EUT External Photos	5 pages
	EUT Internal Photos	7 pages