FCC Measurement/Technical Report on

Door Control System
Scania DCS

FCC ID: 2AHV8-C31859
IC: -

Report Reference: MDE_BROSE_2004_FCC_01

Test Laboratory:
7layers GmbH
Borsigstrasse 11
40880 Ratingen
Germany

Deutsche Akkreditierungsstelle D-PL-12140-01-00

TABLE OF CONTENTS

1 APPLIED STANDARDS AND TEST SUMMARY

1.1 APPLIED STANDARDS

Type of Authorization
Certification for an Intentional Radiator (Periodic operation in the band above 70 MHz)

Applicable FCC Rules

Edition of FCC Rules: October 1, 2019

Prepared in accordance with the requirements of FCC Rules and Regulations as listed in 47 CFR Ch.1 Parts 2 and 15. The following subparts are applicable to the results in this test report.

Part 2, Subpart J - Equipment Authorization Procedures, Certification

Part 15, Subpart C – Intentional Radiators

§ 15.201 Equipment authorization requirement

§ 15.207 Conducted limits

§ 15.209 Radiated emission limits; general requirements

§ 15.231 Periodic operation in the band 40.66-40.70 MHz, above 70 MHz

Note: § 15.207 is not applicable because the EUT is DC powered and only used in vehicles. It will not be connected to the public AC mains network.

Summary Test Results:

The EUT complied with all performed tests as listed in chapter 1.3 Measurement Summary / Signatures.

1.2 FCC-IC CORRELATION TABLE

Correlation of measurement requirements for Momentarily (incl. Periodically) Operated Devices and Remote Control from FCC and IC

Radio equipment

Measurement	FCC reference	IC reference
Transmitter spurious radiated emissions	§ 15.231 (b) / (e)	RSS Gen Issue 5 & AMD1 & AMD2: 6.10/6.13/8.9/8.10; RSS-210 Issue 10 & AMD1: A1.2 Table 2
Duty cycle measurement (based on dwell time measurement)	§ 15.231 (a)	RSS-210 Issue 10 & AMD1: A1.1
Maximum radiated field strength at fundamental frequency	§ 15.231 (b) / (e)	RSS-210 Issue 10 & AMD1: A1.2 Table 2; RSS Gen Issue 5 & AMD1 & AMD2: 6.12
Occupied bandwidth	§ 15.231 (c)	RSS-210 Issue 10 & AMD1: A1.3
Antenna requirement	§ 15.203 / 15.204	RSS Gen Issue 5 & AMD1 & AMD2: 8.3
Receiver spurious emissions	–	RSS-210 Issue 10 & AMD1: 2.3 RSS Gen Issue 5 & AMD1 & AMD2: 5/7 *)

*) Receivers are exempted from certification besides if operating in stand-alone mode in the frequency range 30–960 MHz or if these are scanner receivers.

1.3 MEASUREMENT SUMMARY /SIGNATURES

FCC Part 15, Subpart C		**§ 15.207**	
Conducted emissions (AC power line)			
The measurement was performed according to ANSI C63.10			2013
OP-Mode	**Setup**	**Port**	**Final Result**
		AC Port (power line)	N/A

FCC Part 15, Subpart C		**§ 15.231**	
Duty cycle measurement (based on dwell time measurement)			
The measurement was performed according to ANSI C63.10			2013
OP-Mode	**Setup**	**Port**	**Final Result**
op-mode 2	Setup_01	Enclosure	passed

FCC Part 15, Subpart C	**§ 15.231**		
Spurious Radiated Emissions			
The measurement was performed according to ANSI C63.10			2013
OP-Mode	**Setup**	**Port**	**Final Result**
op-mode 1	Setup_01	Enclosure	passed

FCC Part 15, Subpart C	**§ 15.231**		
Maximum radiated field strength at fundamental frequency			
The measurement was performed according to ANSI C63.10			2013
OP-Mode	**Setup**	**Port**	**Final Result**
op-mode 1	Setup_01	Enclosure	passed

FCC Part 15, Subpart C	**§ 15.231**		
Occupied Bandwidth			
The measurement was performed according to ANSI C63.10			2013
OP-Mode	**Setup**	**Port**	**Final Result**
op-mode 1	Setup_01	Enclosure	passed

N/A not applicable (the EUT is powered by vehicle lead-acid battery)

1.4 REPORT VERSION CONTROL

Report version control			
Version	**Release date**	**Change Description**	**Version validity**
initial	2021-11-03	---	valid

(responsible for accreditation scope)
Dipl.-Ing. Marco Kullik

(responsible for testing and report)
Dipl.-Ing. Dobrin Dobrinov

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2 ADMINISTRATIVE DATA

2.1 TESTING LABORATORY

Company Name:	7layers GmbH
Address:	Borsigstr. 11 40880 Ratingen Germany

The test facility is accredited by the following accreditation organisation:

Laboratory accreditation no:	DAkkS D-PL-12140-01-00
FCC Designation Number:	DE0015
FCC Test Firm Registration:	929146
ISED CAB Identifier:	DE0007; ISED#: 3699A
Responsible for accreditation scope:	Dipl.-Ing. Marco Kullik
Report Template Version:	2020-02-12

2.2 PROJECT DATA

Responsible for testing and report:	Dipl.-Ing. Dobrin Dobrinov
Date of Report:	2021-11-03
Testing Period:	2021-03-22 to 2021-03-30

2.3 APPLICANT DATA

Company Name:	Brose Fahrzeugteile SE & Co. Kommanditgesellschaft, Bamberg
Address:	Berliner Ring 1 96052 Bamberg Germany
Contact Person:	Mr. Maximilian Lengel

2.4 MANUFACTURER DATA

Company Name:	Please see applicant
Address:	

3 TEST OBJECT DATA

3.1 GENERAL EUT DESCRIPTION

Kind of Device product description	The EUT is a is a transceiver for non-periodic operation in the band above 70 MHz. The operating frequency is in the 433 MHz band.
Product name	Door Control System
Type	Scania DSC
Declared EUT data by the supplier	
Voltage Type	DC, vehicle lead-acid battery
Normal Voltage	24.0 V
Low Voltage	20.4 V
High Voltage	27.6 V
Normal Temperature	25 °C
Low Temperature	-40 °C
High Temperature	+85 °C
Specific product description for the EUT	The EUT is a combined Identification and operational device from a Remote Keyless System of a vehicle, installed in a car door
Operating frequency	433.92 MHz
The EUT provides the following ports:	Enclosure DC-Power
Special software used for testing	Provided by the manufacturer

The main components of the EUT are listed and described in Chapter 3.2.

3.2 EUT MAIN COMPONENTS

Sample Name	Sample Code	Description
EUT A	DE1170001aa01	radiated sample
Sample Parameter	**Value**	
Serial No.	C31859-0009	
HW Version	2306116	
SW Version	Special test software	
Comment	Used for radiated measurements, continuously sending non-modulated carrier for Output Power measurement (CW) and continuously modulated carrier for Spurious emissions, and Occupied BW measurements.	

Sample Name	Sample Code	Description
EUT B	DE1170001ab01	radiated sample
Sample Parameter	**Value**	
Serial No.	C31859-0002	
HW Version	2306116	
SW Version	Regular software version	
Comment	Used for the Duty cycle measurements	

3.3 GENERAL DESCRIPTION OF ANCILLARY EQUIPMENT

Device	Details (Manufacturer, Type Model, OUT Code)	Reason for using
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3.4 GENERAL DESCRIPTION OF AUXILIARY EQUIPMENT

Device	Details (Manufacturer, HW, SW, S/N)	Description
AUX 1	Test Box -114055801, A000427576-005	Used for switching different test modes of operation
AUX 2	Remote Keyless entry Transceiver (Key fob), S/N: 16230FBB 5F 20 02 CC 8A 8E DB DC FE 52 D0 60 D4 6F 0F BB	SCANIA

3.5 EUT SETUPS

This chapter describes the combination of EUTs and ancillary equipment used for testing.

Setup No.	Combination of EUTs	Description
Setup_01	EUT A + AUX 1	Setup for radiated measurements: Output power and Spurious emissions bellow 30 MHz, 30 MHz to 1 GHz and 1 to 5 GHz.
Setup_02	EUT B + AUX 2	Setup for Duty Cycle measurements

3.6 OPERATING MODES

This chapter describes the operating modes of the EUTs used for testing.

Op. Mode	Description of Operating Modes	Remarks
op-mode 1	Continuous transmission	Transmitter sends continuously unmodulated or modulated signal
op-mode 2	Single burst	Receiver receives a single burst Transmitter sends a single burst

3.7 PRODUCT LABELLING

3.7.1 FCC ID label

2AHV8-C31859

3.7.2 IC Label

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3.7.3 LOCATION OF THE LABEL ON THE EUT

Please refer to the documentation of the applicant.

4 TEST RESULTS

4.1 DUTY CYCLE MEASUREMENT (BASED ON DWELL TIME MEASUREMENT)

Standard **FCC Part 15 Subpart C**

The test was performed according to:
ANSI C63.10

4.1.1 TEST DESCRIPTION

The Equipment Under Test (EUT) was setup in a shielded room to perform the dwell time measurements. For analyzer settings please see measurement plots.

4.1.2 TEST REQUIREMENTS / LIMITS

Depending on the function of the EUT different paragraphs of FCC §15.231 apply:

Either
(a)(1): A manually operated transmitter shall employ a switch that will automatically deactivate the transmitter within not more than 5 seconds of being released.

Or
(a)(2) A transmitter activated automatically shall cease transmission within 5 seconds after activation.

And
(a)(3) Periodic transmissions at regular predetermined intervals are not permitted. However, polling or supervision transmissions, including data, to determine system integrity of transmitters used in security or safety applications are allowed if the total duration of transmissions does not exceed more than two seconds per hour for each transmitter. There is no limit on the number of individual transmissions, provided the total transmission time does not exceed two seconds per hour.

Otherwise
(e) Intentional radiators may operate at a periodic rate exceeding that specified in paragraph (a) of this section and may be employed for any type of operation [...].
In addition, [...] the duration of each transmission shall not be greater than one second and the silent period between transmissions shall be at least 30 times the duration of the transmission but in no case less than 10 seconds.

This test is also performed to determine the pulse train of the transmitter and calculate the correction factor for pulse modulated transmitters according to FCC §15.35. This factor is used as a correction factor for the field strength measurements, both for Spurious radiated emissions and Maximum radiated field strength at fundamental frequency.

4.1.3 TEST PROTOCOL

Temperature: 23 °C
Air Pressure: 1009 hPa
Humidity: 32 %

Op. Mode	Setup	Port
op-mode 2	Setup_02	Enclosure

a) Determine the total duration of a transmission within 100 ms:

Duty cycle = ((L1*N1) + (L2*N2) + ... + (Ln*Nn)) / 100 ms or T, whichever is less
Correction factor = 20 * LOG (Duty cycle) [dB]

Step 1	Holdover time	Less than 5s
Step 2	Cycle to determine the on/off ratio within a cycle (period T)	100 ms
Step 3	Sweep of a data word to determine the on time within a data word (L1-LN)	L1 = 24.52 ms

PKE mode - Calculation of Duty Cycle / Correction Factor:
If T > 100 ms => T = 100 ms; L1 = 24.52 ms; N1 = 1;

In 100 ms T_{on} = 24.52 ms

Duty cycle = 24.52 / 100 = 0.2452

CORRECTION FACTOR = 20*log (0.2452) ≈ **-12.21 dB**

b) Determine the period of periodic re-transmission, if any, or cease (deactivation) time:

The period of retransmission depends on how much LF interrogations are sent. Normally, after the answer (0.02452 s), there are no more transmissions from the EUT.

Deactivation after **T_C = 0.0 s**, **Limit: ≤ 5 s**

c) Determine the total duration of periodic transmissions within 1 hour, if any:

Duration t_d of all pulses/bursts during T_R ("on-time"):

d) If the result of c) exceeds 2 seconds/hour then paragraph (e) applies:

Determine the duration of each transmission (one complete pulse train) and silent time:
Duration t_{PT}, Limit: ≤ 1 s (Remark: t_{PT} is identical to t_d if T ≤ 100 ms).

The duration of each transmission shall not be greater than one second and the silent period between transmissions shall be at least 30 times the duration of the transmission but in no case less than 10 seconds.

t_{PT} = **0.02452 s** (≤ 1 s)

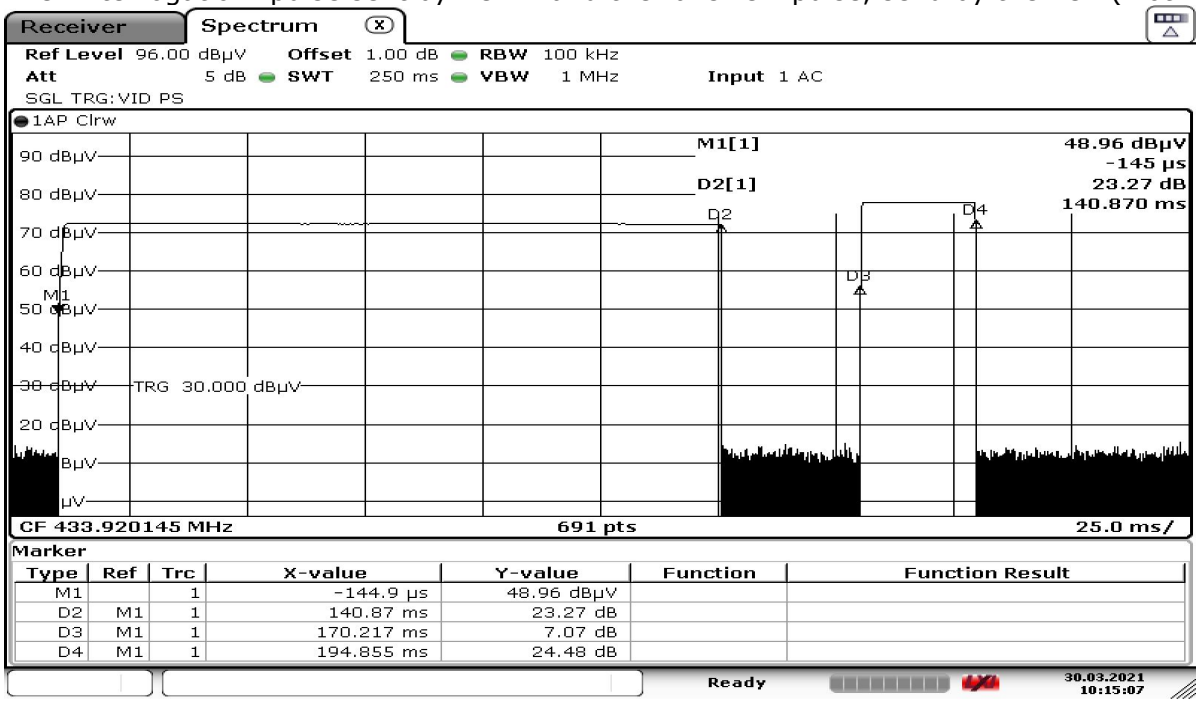
Silent time between transmissions**:** After the answer, there are no more transmissions.
Limit: ≤ Maximum (>10 s and >30*t_{PT}).

Note: "Interrogation" pulse sent by AUX 2 from M1 to D2 and the EUT "answer" pulse from D2 to D3 markers are shown on Plot 1.

On Plot 2 is the EUT "answer" pulse, used for the calculation of the Duty Cycle correction factor.

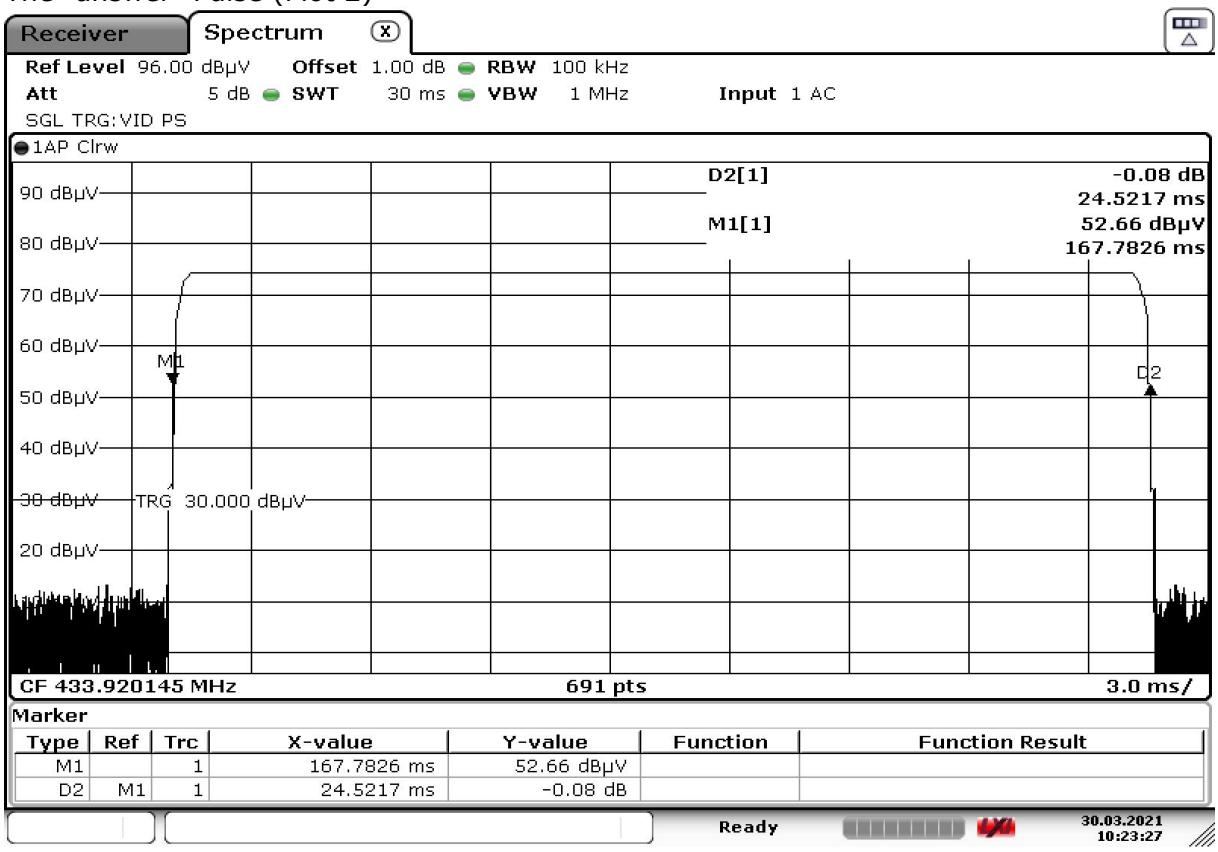
MEASUREMENT PLOTS DUTY CYCLE

The "interrogation" pulse sent by AUX 2 and the "answer" pulse, send by the EUT (Plot 1)



Date: 30.MAR.2021 10:15:07

The "answer" Pulse (Plot 2)



Date: 30.MAR.2021 10:23:27

4.2 SPURIOUS RADIATED EMISSIONS

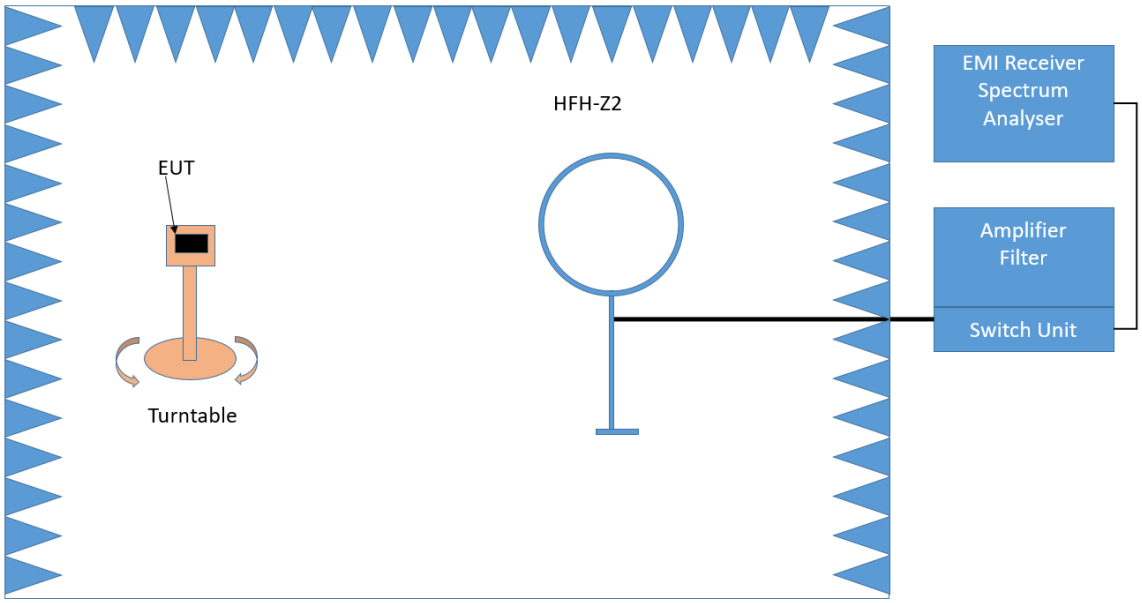
Standard **FCC Part 15 Subpart C**

The test was performed according to:
ANSI C63.10–2013

4.2.1 Test Description

The test set-up was made in accordance to the general provisions of ANSI C63.10 in a typical installation configuration. The Equipment Under Test (EUT) was set up on a non-conductive table 1.0 x 2.0 m² in the semi-anechoic chamber. The influence of the EUT support table that is used between 30–1000 MHz was evaluated.
The measurement procedure is implemented into the EMI test software EMC32 from R&S. (Exploratory) Tests are performed at 3 orthogonal axes to determine the worst-case orientation of a body-worn or handheld EUT. The final test on all kind of EUTs is performed at 2 axes. A pre-check is also performed while the EUT is powered from DC (battery) power in order to find the worst-case operating condition.

1. Measurement up to 30 MHz



Test Setup; Spurious Emission Radiated (SAC), 9 kHz – 30 MHz

The Loop antenna HFH2-Z2 is used.

Step 1: premeasurement
- Anechoic chamber
- Antenna distance: 3 m
- Antenna height: 1 m (lowest part to ground)
- Antenna polarisation: 3 axis
- Detector: Peak-Maxhold
- Frequency range: 0.009 - 0.15 MHz and 0.15 – 30 MHz
- Frequency steps: 0.05 kHz and 2.25 kHz

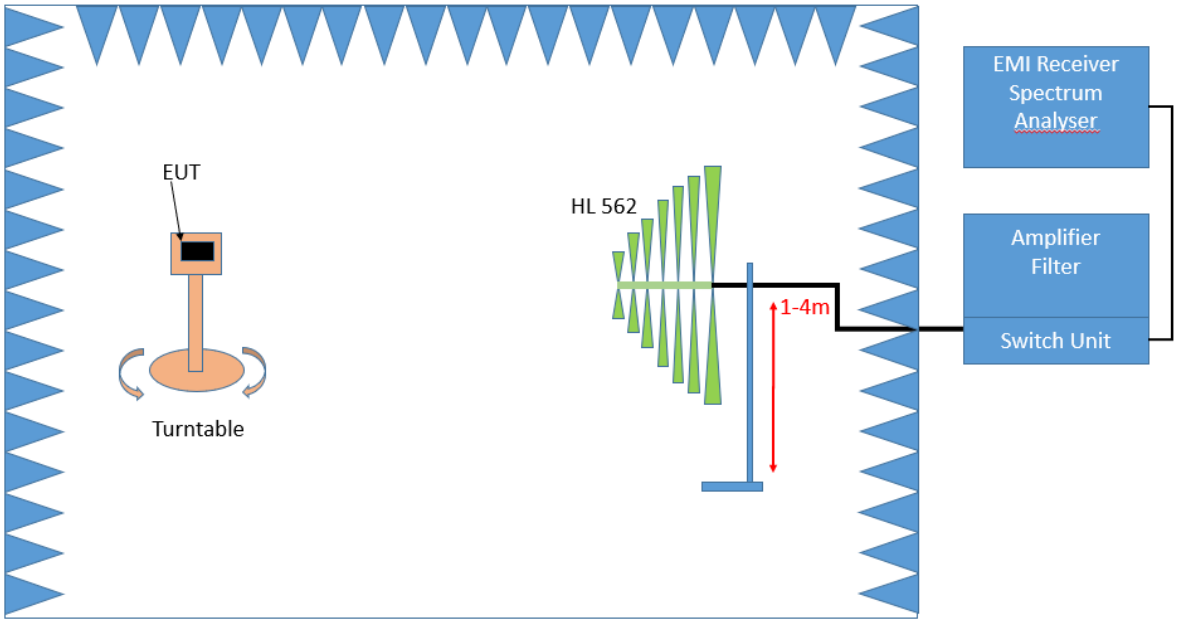
- IF–Bandwidth: 0.2 kHz and 9 kHz
- Measuring time / Frequency step: 100 ms (FFT-based)

Intention of this step is, to determine the radiated EMI-profile of the EUT. Afterwards the relevant emissions for the final measurement are identified.

Step 2: final measurement
For the relevant emissions determined in step 1, an additional measurement will be performed with the following changed settings. Intention of this step is to find the maximum emission level.

- Detector: Quasi-Peak besides 9–90 kHz and 110–490 kHz: Average and Peak
- Measuring time / Frequency step: 1 s

2. Measurement above 30 MHz and up to 1 GHz



Test Setup; Spurious Emission Radiated (SAC), 30 MHz- 1GHz

Step 1: Preliminary scan
This is a preliminary test to identify the highest amplitudes relative to the limit.
Settings for step 1:

- Antenna distance: 3 m
- Detector: Peak-Maxhold / Quasipeak (FFT-based)
- Frequency range: 30 – 1000 MHz
- Frequency steps: 30 kHz
- IF–Bandwidth: 120 kHz
- Measuring time / Frequency step: 100 ms
- Turntable angle range: –180° to 90°
- Turntable step size: 90°
- Height variation range: 1 – 4 m
- Height variation step size: 1.5 m
- Polarisation: Horizontal + Vertical

Intention of this step is, to determine the radiated EMI-profile of the EUT. Afterwards the relevant emissions for the final measurement are identified.

Step 2: Adjustment measurement
In this step the accuracy of the turntable azimuth and antenna height will be improved. This is necessary to find out the maximum value of every frequency.
For each frequency, which was determined the turntable azimuth and antenna height will be adjusted. The turntable azimuth will slowly vary. During this action, the value of emission is continuously measured. The turntable azimuth at the highest emission will be recorded and adjusted. In this position, the antenna height will also slowly vary. During this action, the value of emission is also continuously measured. The antenna height of the highest emission will also be recorded and adjusted.

- Detector: Peak – Maxhold
- Measured frequencies: in step 1 determined frequencies
- IF – Bandwidth: 120 kHz
- Measuring time: 100 ms
- Turntable angle range: 360°
- Height variation range: 1 – 4 m
- Antenna Polarisation: max. value determined in step 1

Step 3: Final measurement with QP detector
With the settings determined in step 2, the final measurement will be performed:
EMI receiver settings for step 3:

- Detector: Quasi-Peak (< 1 GHz)
- Measured frequencies: in step 1 determined frequencies
- IF – Bandwidth: 120 kHz
- Measuring time: 1 s

After the measurement, a plot will be generated. It contains a diagram with the results of the preliminary scan and a chart with the frequencies and values of the results of the final measurement.

Above 1 GHz:

The following changes apply to the measurement procedure for the frequency range > 1 GHz:

Step 1:
- Turntable step size: 45°
- Detector: Peak, Average (Maxhold)
- IF – Bandwidth: 1 MHz
- Frequency steps: 250 kHz
- Measuring time: 500 ms / GHz

Step 2:
- IF – Bandwidth: 1 MHz

Step 3:
- Detector: Peak / CISPR Average
- IF – Bandwidth: 1 MHz

After every measurement a plot will be generated which contains a diagram with the results of the preliminary scan and a chart with the frequencies and values of the results of the final measurement.

Floor absorbers are placed between test volume and measurement antenna.

4.2.2 Test Requirements / Limits

1) FCC Part 15, Subpart C, §15.209, Radiated Emission Limits

Frequency in MHz	Limit (µV/m)	Measurement distance (m)	Limit (dBµV/m)
0.009 – 0.49	2400/F(kHz)@300m	3	(48.5 – 13.8)@300m
0.49 – 1.705	24000/F(kHz)@30m	3	(33.8 – 23.0)@30m
1.705 – 30	30@30m	3	29.5@30m

The measured values are corrected with an inverse linear distance extrapolation factor (40 dB/decade) according to FCC §15.31 (2).

Frequency in MHz	Limit (µV/m)	Measurement distance (m)	Limit (dBµV/m)
30 – 88	100@3m	3	40.0@3m
88 – 216	150@3m	3	43.5@3m
216 – 960	200@3m	3	46.0@3m
960 - 26000	500@3m	3	54.0@3m
26000 - 40000	500@3m	1	54.0@3m

§15.35(b)
..., there is also a limit on the radio frequency emissions, as measured using instrumentation with a peak detector function, corresponding to 20 dB above the maximum permitted average limit....

Used conversion factor: Limit (dBµV/m) = 20 log (Limit (µV/m)/1µV/m)

2) RSS-216, 6.2.2.2, Radiated Emission Limits

The raw values obtained at the measurement distance are extrapolated to the FCC's definition distance. The limits defined in RSS-216 are calculated for these FCC's distances in order to include the limits directly in one measurement plot and to demonstrate if compliance is achieved. The verdict related to RSS-216 is basing on the margin which is constant for different distances and i.e. is not altered by these linear transformations.

Limits ICES-001, 3.3.4.1, table 2 (quasi-peak limits) of magnetic field strength:

Frequency in MHz	Limit (RSS-216) (dBµA/m) @3m	Measurement distance (m)	Limit (dBµV/m) @ FCC distance	Comment
0.009 – 0.070	69	3	(40.5)@300m	–
0.07 – 0.15	69 – 39 *)	3	(40.5 – 10.5)@300m	–
0.15 – 0.49	39 – 31.9 *'***)	3	(10.5 – 3.4)@300m	intermediate step
0.49 – 30.0	31.9 – 7 ***)	3	(43.4 – 18.5)@30m	intermediate step

*) Decreasing linearly with logarithm of frequency between 0.07 and 0.15 MHz
***) Decreasing linearly with logarithm of frequency between 0.15 and 30.0 MHz

The alternate 60 cm loop test method and corresponding limits for small residential WPT devices is used for the tests in the frequency range 9 kHz – 30 MHz.

The measured field strength is extrapolated to the distance specified using the formula indicating that the field strength varies as the inverse distance square (40 dB per decade of distance), according to RSS-Gen, 6.5.
For fractal values of definition and reference distance the factor of $40*LOG_{10}(d_{ref}/d_{def})$ applies.
Relation between electrical and magnetic field strength: dBµV = dBµA + 51.5 dB.

Limits ICES-001, 3.3.4.2, table 4 (quasi-peak limits) of electric field strength:

Frequency in MHz	Limit (dBµV/m) OATS or SAC @10m	Limit (dBµV/m) OATS or SAC @3m	Limit (dBµV/m) FAR @3m	SAC Limit (dBµV/m) @ FCC distance
30 – 230	30	40	42 – 35 **)	(40)@3m
230 – 1000	37	47	42	(47)@3m

**) The limit level in dBµV/m decreases linearly with the logarithm of frequency.

Note: OATS = open-area test site, SAC = semi-anechoic chamber, FAR = fully anechoic room

4.2.3 TEST REQUIREMENTS / LIMITS

FCC Part 15, Subpart C, §15.231 (b)
... In addition, radiated emissions which fall in the restricted bands, as defined in Section 15.205(a), must also comply with the radiated emission limits specified in Section 15.209(a) (see Section 15.205(c)).

FCC Part 15, Subpart C, §15.209, Radiated Emission Limits

Frequency in MHz	Limit (µV/m)	Measurement distance (m)	Calculate Limit (dBµV/m @10m)	Limit (dBµV/m) @10m
0.009 – 0.49	2400/F (kHz)	300	(48.5 – 13.8) + 59.1 dB	107.6 – 72.9
0.49 – 1.705	24000/F (kHz)	30	(33.8 – 23.0) + 19.1 dB	52.9 – 42.1
1.705 – 30	30	30	29.5 + 19.1 dB	39.5

Frequency in MHz	Limit (µV/m)	Measurement distance (m)	Limit (dBµV/m)
30 – 88	100	3	40.0
88 – 216	150	3	43.5
216 – 960	200	3	46.0
above 960	500	3	54.0

§15.35(b)
..., there is also a limit on the radio frequency emissions, as measured using instrumentation with a peak detector function, corresponding to 20 dB above the maximum permitted average limit....

Used conversion factor: Limit (dBµV/m) = 20 log (Limit (µV/m)/1µV/m)

§15.35(b) ..., there is also a limit on the radio frequency emissions, as measured using instrumentation with a peak detector function, corresponding to 20 dB above the maximum permitted average limit ...

Used conversion factor: Limit (dBµV/m) = 20 log (Limit (µV/m)/1µV/m)

§15.35(c):
[...] when the radiated emission limits are expressed in terms of the average value of the emission, and pulsed operation is employed, the measurement field strength shall be determined by averaging over one complete pulse train, including blanking intervals, as long as the pulse train does not exceed 0.1 seconds.

As an alternative (provided the transmitter operates for longer than 0.1 seconds) or in cases where the pulse train exceeds 0.1 seconds, the measured field strength shall be determined from the average absolute voltage during a 0.1 second interval during which the field strength is at its maximum value. The exact method of calculating the average field strength shall be submitted [...].

§15.231 (b) emissions table

Fundamental frequency (MHz)	Field strength of fundamental (microvolts/meter)	Field strength of spurious emissions (microvolts/meter)
40.66-40.70	2,250	225
70-130	1,250	125
130-174	[1]1,250 to 3,750	[1]125 to 375
174-260	3,750	375
260-470	[1]3,750 to 12,500	[1]375 to 1,250
Above 470	12,500	1,250

[1]Linear interpolations.

§15.231(b)(3)
The limits on the field strength of the spurious emissions in the above table are based on the fundamental frequency of the intentional radiator.
Spurious emissions shall be attenuated to the average (or, alternatively, CISPR quasi-peak) limits shown in this table or to the general limits shown in §15.209, whichever limit permits a higher field strength.

Interpretation of the test laboratory:
The last subordinate clause of §15.231(b)(3) is overruled by §15.205/209, therefore within the restricted bands the limits defined at §15.205/209 and outside the restricted bands the limits defined at §15.231(b) resp. §15.231(e) are applied.

§15.231 (e) emissions table

Fundamental frequency (MHz)	Field strength of fundamental (microvolts/meter)	Field strength of spurious emission (microvolts/meter)
40.66-40.70	1,000	100
70-130	500	50
130-174	500 to 1,500[1]	50 to 150[1]
174-260	1,500	150
260-470	1,500 to 5,000[1]	150 to 500[1]
Above 470	5,000	500

[1]Linear interpolations.

4.2.4 TEST PROTOCOL

4.2.4.1 MEASUREMENT UP TO 30 MHz

Temperature: 24 °C
Air Pressure: 1009 hPa
Humidity: 35 %

Op. Mode	Setup	Port
op-mode 1	Setup_01	Enclosure

Measuring Antenna Polarisation	Spurious Emission Frequency [MHz]	Corrected value [dBµV/m]			Limit [dBµV/m]	Limit [dBµV/m]	Limit [dBµV/m]	Margin to limit [dB]	Margin to limit [dB]
		QP	Peak	AV	QP	Peak	AV	QP/Peak	AV
0°	---	---	---	---	---	---	---	---	---
90°	---	---	---	---	---	---	---	---	---

Remark: In step 1 no spurious emissions in the range 20 below the limit were found, using a peak detector, therefore step 2 (using a QP-detector) was not performed. For this test, the EUT was sending a continuously modulated signal. Please see the measurement plot.

4.2.4.2 MEASUREMENT ABOVE 30 MHz TO 6 GHz

Temperature: 24 °C
Air Pressure: 1009 hPa
Humidity: 35 %

Op. Mode	Setup	Port
op-mode 1	Setup_01	Enclosure

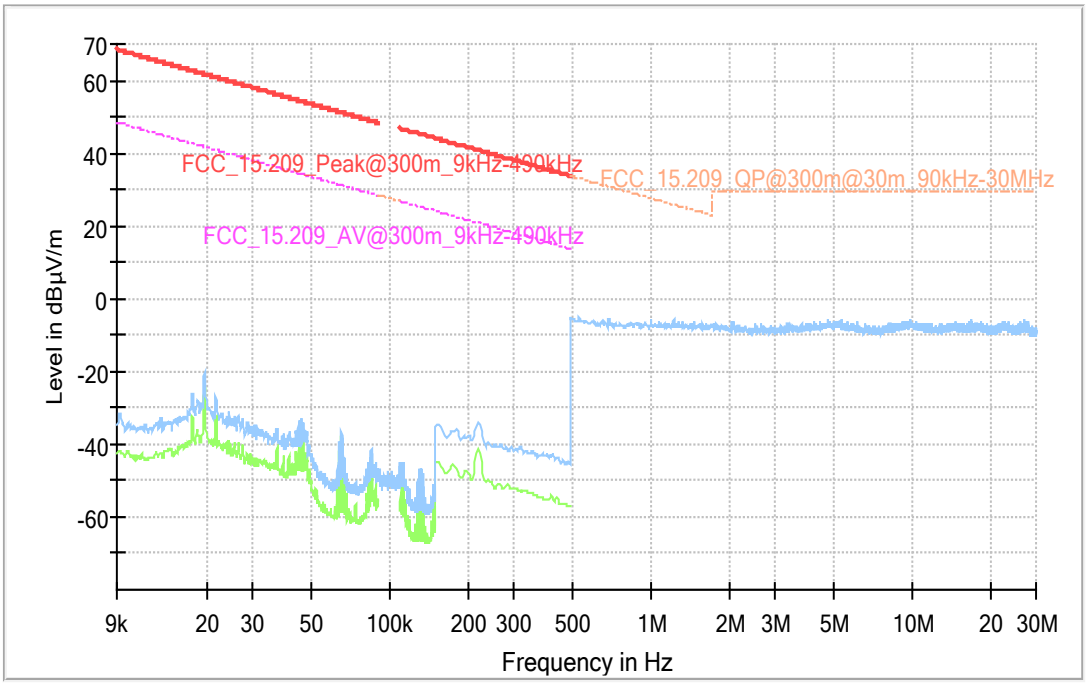
Polarisation of the antenna and the EUT	Spurious Emission Frequency [MHz]	Corrected value [dBµV/m]			Limit [dBµV/m]	Limit [dBµV/m]	Limit [dBµV/m]	Margin to limit [dB]	Margin to limit [dB]
		QP	Peak	AV	QP	Peak	AV	QP/Peak	AV
0°	---	---	---	---	---	---	---	---	---
90°	---	---	---	---	---	---	---	---	---

Remarks: No other spurious emissions in the range 15 dB below the limit were found.

4.2.5 MEASUREMENT PLOTS

4.2.5.1 RADIATED EMISSIONS (f < 30 MHz)

Test Description:	Radiated Emissions, Test Site: Semi Anechoic Chamber @ 3 m
Test Standard:	FCC 15c.209
EUT / Setup Code:	DE1170001aa01
Operating Conditions:	Modulated TX on 433.92MHz
Operator Name:	DOB
Comment:	24V_DC
x-Orientation (indicate h=100)	loop plane vertical, vector in measurement axis directed to EUT
y-Orientation (indicate h=200)	loop plane vertical, vector perpendicular to measurement axis
z-Orientation (indicate h=300)	loop plane horizontal, normal vector directed to ground
Legend:	Trace: blue = Peak; green = AV, Star: = critical frequency; Rhombus: blue = final QP

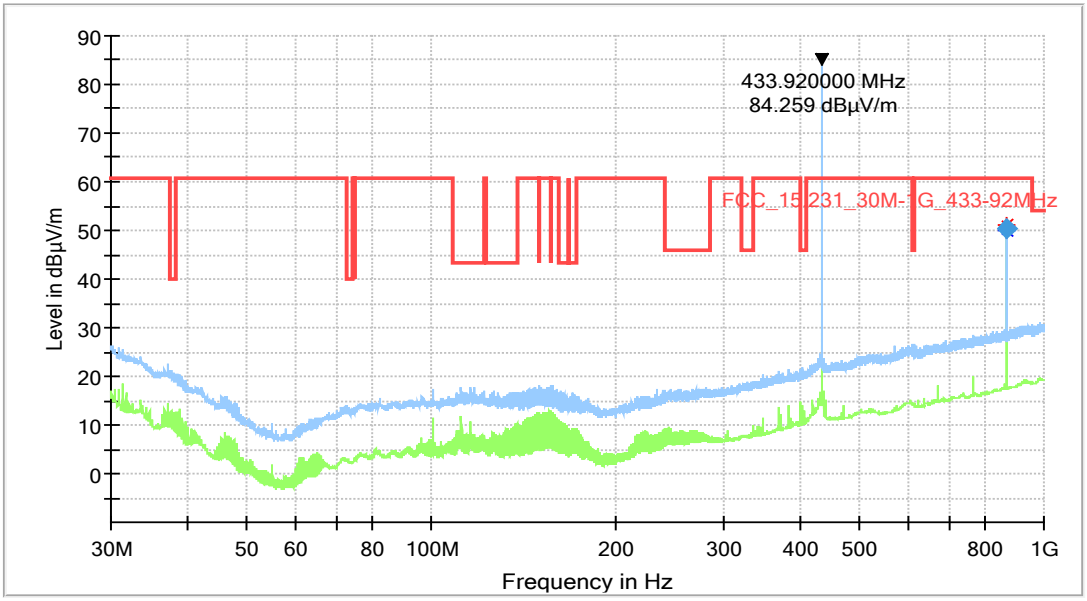


Final_Result

Frequency (MHz)	QuasiPeak (dBµV/m)	DET 2 (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
---	---	---	---	---	---	---	---	---	---	---

4.2.5.2 RADIATED EMISSIONS (30 MHz < f < 1 GHz)

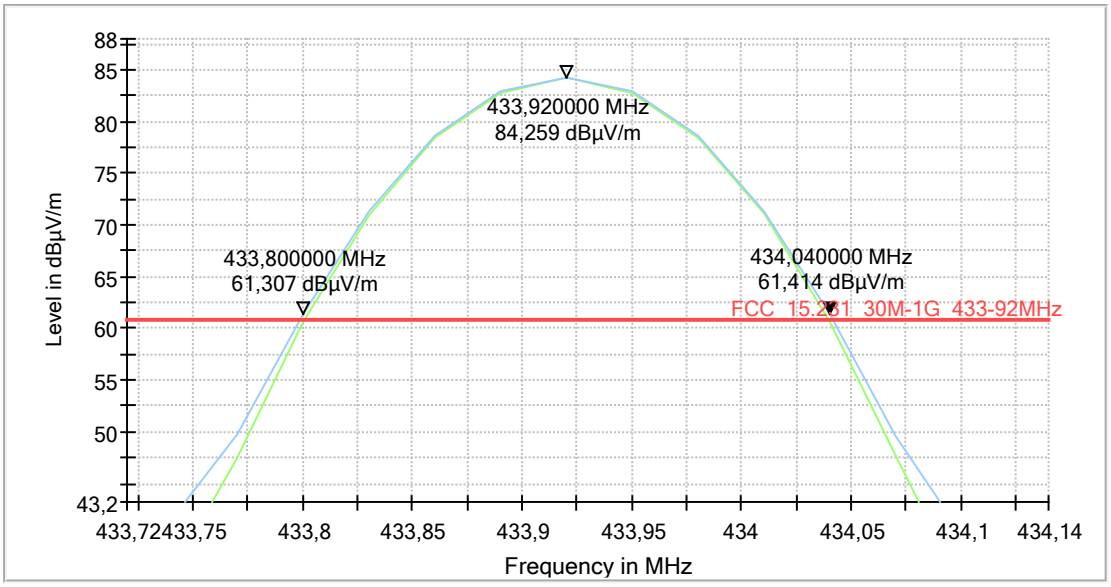
Test Standard:	FCC 15c.231
EUT / Setup Code:	DE1170001aa01
Operating Conditions:	Modulated TX on 433.92MHz
Operator Name:	URO
Comment:	24 V DC
Legend:	Trace (preview): blue = PK, green = QP; Star: red or blue = critical frequency; Rhombus: blue = final QP



Final_Result

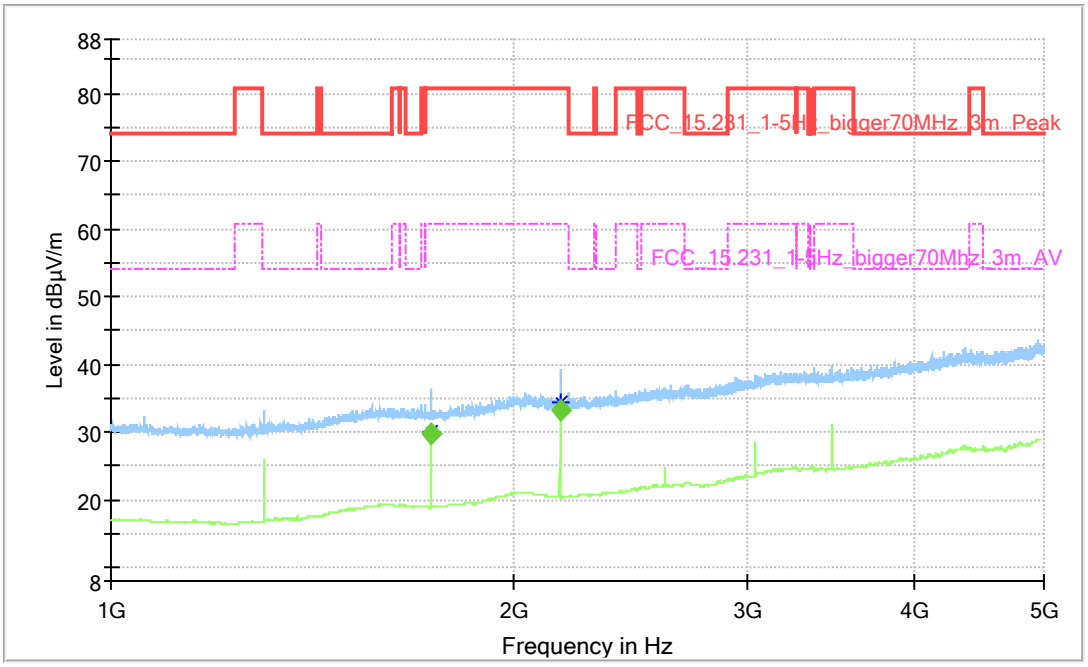
Frequency (MHz)	QuasiPeak (dBµV/m)	DET 2 (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
867.840000	50.45	---	60.80	10.35	1000.0	120.000	100.0	H	101.0	23.8

Note: The peak value over the limit line is the modulated carrier in the exclusion band. Below is a detailed plot.



4.2.5.3 RADIATED EMISSIONS (1 GHz < f < 5 GHz)

Test Description:	Radiated Emissions @ 3 m, SAC + mobile floor absorber
Test Standard:	FCC 15c.231
EUT / Setup Code:	DE1170001aa01
Operating Conditions:	Modulated TX on 433.92MHz
Operator Name:	DOB
Comment:	Test script FCC_15c.231_Radiated_Emissions-1GHz to 5 GHz
Legend:	loop plane vertical, vector in measurement axis directed to EUT



Final_Result

Frequency (MHz)	MaxPeak (dBµV/m)	CAverage (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
1735.750000	---	29.81	60.79	30.98	200.0	1000.000	360.0	V	-225.0	2.8
2169.500000	---	33.35	60.79	27.44	200.0	1000.000	190.0	H	-225.0	5.0

4.3 MAXIMUM RADIATED FIELD STRENGTH AT FUNDAMENTAL FREQUENCY

Standard FCC Part 15, Subpart C

The test was performed according to:
ANSI C63.10–2013

4.3.1 TEST DESCRIPTION

Please refer to sub-clause 4.1.1

4.3.2 TEST LIMITS

Please refer to sub-clause 4.1.2 FCC 15.231 b) applies.

4.3.3 TEST PROTOCOL

Temperature: 24 °C
Air Pressure: 1009 hPa
Humidity: 38 %

Op. Mode	Setup	Port
op-mode 1	Setup_01	Enclosure

Frequency [MHz]	Output power [dBµV/m]	Limit [dBµV/m]	Margin to Limit [dB]	Remarks
433.92	74.85	80.81	5.98	Maximum radiated field strength

Notes: The values shown in the table above are corrected by using the corresponding the Duty Cycle Correction Factors, calculated in 4.1.3
The EUT transmitted continuously modulated carrier.

4.3.4 TEST RESULT:

MAXIMUM RADIATED FIELD STRENGTH AT FUNDAMENTAL FREQUENCY

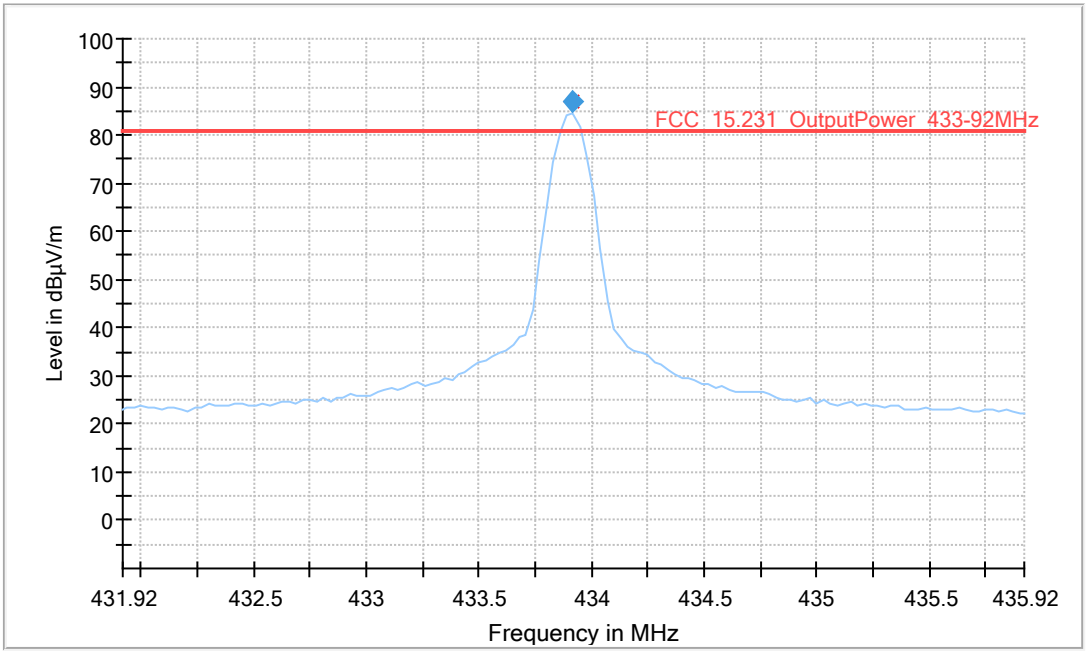
FCC Part 15, Subpart C	Op. Mode	Result
	op-mode 1	passed

4.3.5 MEASUREMENT PLOTS

4.3.5.1 MAXIMUM RADIATED FIELD STRENGTH AT FUNDAMENTAL FREQUENCY

Common Information

Test Description:	Output Power
Test Standard:	FCC 15c.231
EUT / Setup Code:	DE1170001aa01
Operating Conditions:	CW_TX on 433.92MHz F_low
Operator Name:	DOB
Comment:	24V_DC
Legend:	Trace (preview): blue = PK, green = QP; Star: red or blue = critical frequency; Rhombus: blue = final QP



Final Result – without Duty Cycle correction

Frequency (MHz)	QuasiPeak (dBµV/m)	-	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
433.92	87.06	---	80.83	-6.23	1000.0	120.000	102.0	H	-45.0	16.6

Final Result – with Duty Cycle correction

Frequency (MHz)	QuasiPeak (dBµV/m)	DC Corr. (dB)	QuasiPeak (dBµV/m) corrected	Limit (dBµV/m)	Margin (dB)
433.92	87.06	-12.21	74.85	80.83	5.98

Note: Duty Cycle correction factor, calculated in 4.1.3 is **-12.21** dB.

4.4 OCCUPIED BANDWIDTH

Standard **FCC Part 15 Subpart C**

The test was performed according to:
ANSI C63.10–2013

4.4.1 TEST DESCRIPTION

The Equipment Under Test (EUT) was setup in a shielded room to perform the occupied bandwidth measurements.
For analyzer settings please see the measurement plots.

4.4.2 TEST LIMITS

FCC Part 15, Subpart C, §15.231(c)
The maximum 20 dB bandwidth of a transmitter operating at a frequency range:
70 to 900 MHz is 0.25% of the centre frequency
above 900 MHz is 0.5% of the centre frequency

4.4.3 TEST PROTOCOL

Temperature: 23 °C
Air Pressure: 1009 hPa
Humidity: 42 %

Op. Mode	Setup	Port
op-mode 1	Setup_01	Enclosure

Cannel Frequency [MHz]	20 dB bandwidth [kHz]	99% bandwidth [kHz]	Limit [kHz]	Remarks
433.92	9.899	9.638	1084.8	Limit calculated as: 433.93 MHz (declared by applicant) * 0.25% = 1084.8 kHz.

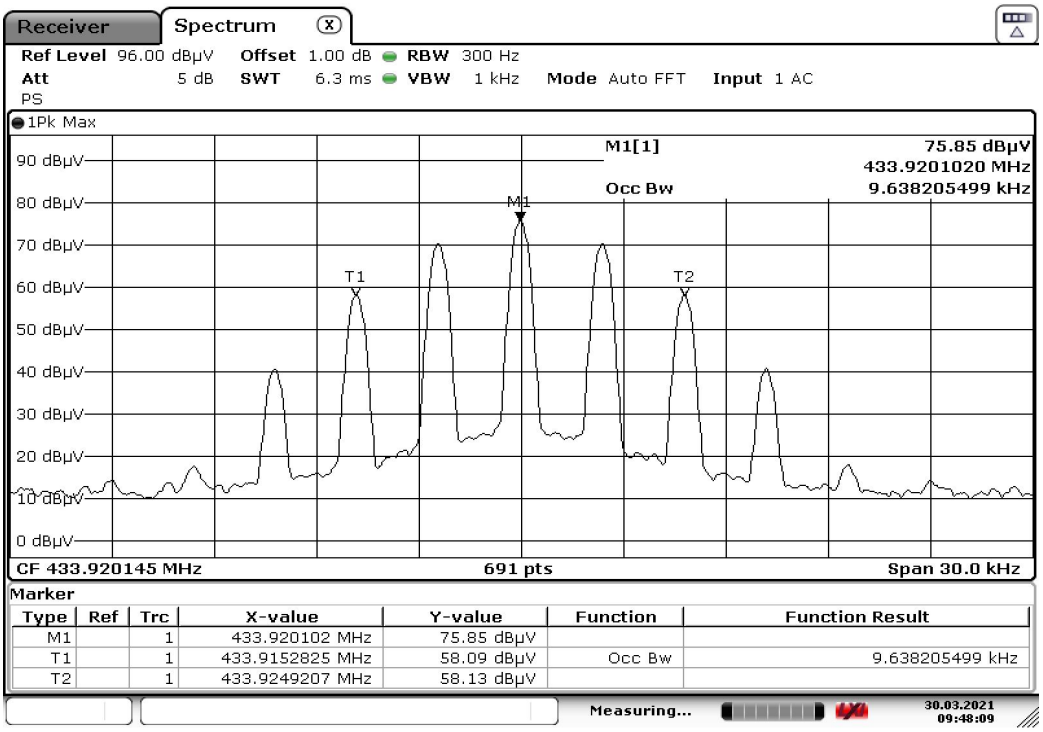
Remark: Please see the measurement plots.

4.4.4 TEST RESULT: OCCUPIED BANDWIDTH

FCC Part 15, Subpart C	Op. Mode	Result
	op-mode 1	passed

4.4.5 MEASUREMENT PLOTS OCCUPIED BANDWIDTH

99% bandwidth



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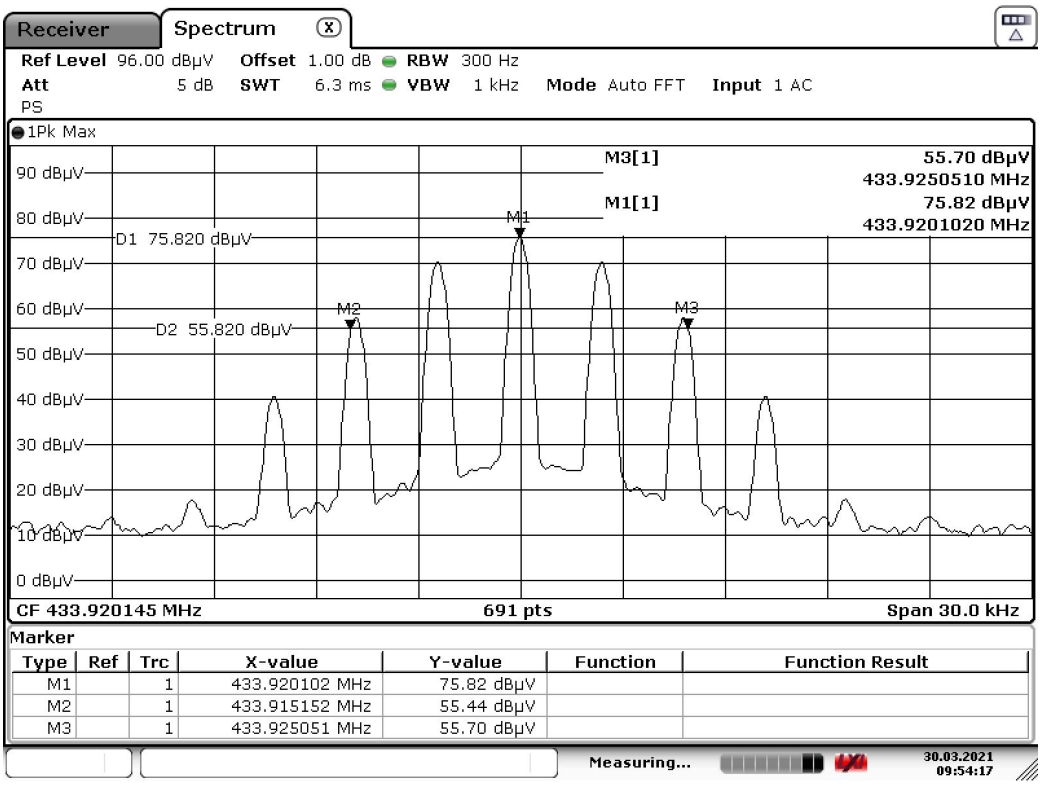
20 dB bandwidth



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Test Equipment

1 Radiated Emissions

Lab to perform radiated emission tests

Ref.No.	Device Name	Description	Manufacturer	Serial Number	Last Calibration	Calibration Due
1.1	NRV-Z1	Sensor Head A	Rohde & Schwarz GmbH & Co. KG	827753/005		
1.2	MFS	Rubidium Frequency Normal MFS	Datum GmbH	002	2020-11	2021-11
1.3	Opus10 TPR (8253.00)	ThermoAirpressure Datalogger 13 (Environ)	Lufft Mess- und Regeltechnik GmbH	13936	2019-05	2021-05
1.4	ESW44	EMI Test Receiver	Rohde & Schwarz GmbH & Co. KG	101603	2019-12	2021-12
1.5	Anechoic Chamber	10.58 x 6.38 x 6.00 m³	Frankonia	none	2018-06	2021-06
1.6	HL 562	Ultralog new biconicals	Rohde & Schwarz	830547/003	2018-07	2021-07
1.7	5HC2700/12750-1.5-KK	High Pass Filter	Trilithic	9942012		
1.8	ASP 1.2/1.8-10 kg	Antenna Mast	Maturo GmbH	-		
1.9	Fluke 177	Digital Multimeter 03 (Multimeter)	Fluke Europe B.V.	86670383	2020-04	2022-04
1.10	JS4-18002600-32-5P	Broadband Amplifier 18 GHz - 26 GHz	Miteq	849785		
1.11	WHKX 7.0/18G-8SS	High Pass Filter	Wainwright	09		
1.12	4HC1600/12750-1.5-KK	High Pass Filter	Trilithic	9942011		
1.13	Chroma 6404	AC Power Source	Chroma ATE INC.	64040001304		
1.14	TT 1.5 WI	Turn Table	Maturo GmbH	-		
1.15	5HC3500/18000-1.2-KK	High Pass Filter	Trilithic	200035008		
1.16	HFH2-Z2	Loop Antenna	Rohde & Schwarz	829324/006	2021-01	2024-01
1.17	Opus10 THI (8152.00)	ThermoHygro Datalogger 12 (Environ)	Lufft Mess- und Regeltechnik GmbH	12482	2019-06	2021-06
1.18	ESR 7	EMI Receiver / Spectrum Analyzer	Rohde & Schwarz	101424	2021-01	2023-01
1.19	JS4-00101800-35-5P	Broadband Amplifier 30 MHz - 18 GHz	Miteq	896037		
1.20	AS 620 P	Antenna mast	HD GmbH	620/37		
1.21	Tilt device Maturo (Rohacell)	Antrieb TD1.5-10kg	Maturo GmbH	TD1.5-10kg/024/3790709		
1.22	PAS 2.5 - 10 kg	Antenna Mast	Maturo GmbH	-		
1.23	AFS42-00101800-25-S-42	Broadband Amplifier 25 MHz - 18 GHz	Miteq	2035324		
1.24	AM 4.0	Antenna mast	Maturo GmbH	AM4.0/180/11920513		
1.25	HF 907	Double-ridged horn	Rohde & Schwarz	102444	2018-07	2021-07

6 ANTENNA FACTORS, CABLE LOSS AND SAMPLE CALCULATIONS

This chapter contains the antenna factors with their corresponding path loss of the used measurement path for all antennas as well as the insertion loss of the LISN.

6.1 ANTENNA R&S HFH2-Z2 (9 KHZ – 30 MHZ)

Frequency	AF HFH-Z2)	Corr.	cable loss 1 (inside chamber)	cable loss 2 (outside chamber)	cable loss 3 (switch unit)	cable loss 4 (to receiver)	distance corr. (-40 dB/ decade)	d_{Limit} (meas. distance (limit)	d_{used} (meas. distance (used)
MHz	dB (1/m)	dB	dB	dB	dB	dB	dB	m	m
0.009	20.50	-79.6	0.1	0.1	0.1	0.1	-80	300	3
0.01	20.45	-79.6	0.1	0.1	0.1	0.1	-80	300	3
0.015	20.37	-79.6	0.1	0.1	0.1	0.1	-80	300	3
0.02	20.36	-79.6	0.1	0.1	0.1	0.1	-80	300	3
0.025	20.38	-79.6	0.1	0.1	0.1	0.1	-80	300	3
0.03	20.32	-79.6	0.1	0.1	0.1	0.1	-80	300	3
0.05	20.35	-79.6	0.1	0.1	0.1	0.1	-80	300	3
0.08	20.30	-79.6	0.1	0.1	0.1	0.1	-80	300	3
0.1	20.20	-79.6	0.1	0.1	0.1	0.1	-80	300	3
0.2	20.17	-79.6	0.1	0.1	0.1	0.1	-80	300	3
0.3	20.14	-79.6	0.1	0.1	0.1	0.1	-80	300	3
0.49	20.12	-79.6	0.1	0.1	0.1	0.1	-80	300	3
0.490001	20.12	-39.6	0.1	0.1	0.1	0.1	-40	30	3
0.5	20.11	-39.6	0.1	0.1	0.1	0.1	-40	30	3
0.8	20.10	-39.6	0.1	0.1	0.1	0.1	-40	30	3
1	20.09	-39.6	0.1	0.1	0.1	0.1	-40	30	3
2	20.08	-39.6	0.1	0.1	0.1	0.1	-40	30	3
3	20.06	-39.6	0.1	0.1	0.1	0.1	-40	30	3
4	20.05	-39.5	0.2	0.1	0.1	0.1	-40	30	3
5	20.05	-39.5	0.2	0.1	0.1	0.1	-40	30	3
6	20.02	-39.5	0.2	0.1	0.1	0.1	-40	30	3
8	19.95	-39.5	0.2	0.1	0.1	0.1	-40	30	3
10	19.83	-39.4	0.2	0.1	0.2	0.1	-40	30	3
12	19.71	-39.4	0.2	0.1	0.2	0.1	-40	30	3
14	19.54	-39.4	0.2	0.1	0.2	0.1	-40	30	3
16	19.53	-39.3	0.3	0.1	0.2	0.1	-40	30	3
18	19.50	-39.3	0.3	0.1	0.2	0.1	-40	30	3
20	19.57	-39.3	0.3	0.1	0.2	0.1	-40	30	3
22	19.61	-39.3	0.3	0.1	0.2	0.1	-40	30	3
24	19.61	-39.3	0.3	0.1	0.2	0.1	-40	30	3
26	19.54	-39.3	0.3	0.1	0.2	0.1	-40	30	3
28	19.46	-39.2	0.3	0.1	0.3	0.1	-40	30	3
30	19.73	-39.1	0.4	0.1	0.3	0.1	-40	30	3

Sample calculation

E (dB µV/m) = U (dB µV) + AF (dB 1/m) + Corr. (dB)
U = Receiver reading
AF = Antenna factor
Corr. = sum of single correction factors of used cables, switch unit, distance correction, amplifier (if applicable)
distance correction = -40 * LOG (d_{Limit}/ d_{used})
Linear interpolation will be used for frequencies in between the values in the table.
Table shows an extract of values

6.2 ANTENNA R&S HL562 (30 MHZ – 1 GHZ)

(d_{Limit} = 3 m)

Frequency	AF R&S HL562	Corr.	cable loss 1 (inside chamber)	cable loss 2 (outside chamber)	cable loss 3 (switch unit)	cable loss 4 (to receiver)	distance corr. (-20 dB/ decade)	d_{Limit} (meas. distance (limit)	d_{used} (meas. distance (used)
MHz	dB (1/m)	dB	dB	dB	dB	dB	dB	m	m
30	18.6	0.6	0.29	0.04	0.23	0.02	0.0	3	3
50	6.0	0.9	0.39	0.09	0.32	0.08	0.0	3	3
100	9.7	1.2	0.56	0.14	0.47	0.08	0.0	3	3
150	7.9	1.6	0.73	0.20	0.59	0.12	0.0	3	3
200	7.6	1.9	0.84	0.21	0.70	0.11	0.0	3	3
250	9.5	2.1	0.98	0.24	0.80	0.13	0.0	3	3
300	11.0	2.3	1.04	0.26	0.89	0.15	0.0	3	3
350	12.4	2.6	1.18	0.31	0.96	0.13	0.0	3	3
400	13.6	2.9	1.28	0.35	1.03	0.19	0.0	3	3
450	14.7	3.1	1.39	0.38	1.11	0.22	0.0	3	3
500	15.6	3.2	1.44	0.39	1.20	0.19	0.0	3	3
550	16.3	3.5	1.55	0.46	1.24	0.23	0.0	3	3
600	17.2	3.5	1.59	0.43	1.29	0.23	0.0	3	3
650	18.1	3.6	1.67	0.34	1.35	0.22	0.0	3	3
700	18.5	3.6	1.67	0.42	1.41	0.15	0.0	3	3
750	19.1	4.1	1.87	0.54	1.46	0.25	0.0	3	3
800	19.6	4.1	1.90	0.46	1.51	0.25	0.0	3	3
850	20.1	4.4	1.99	0.60	1.56	0.27	0.0	3	3
900	20.8	4.7	2.14	0.60	1.63	0.29	0.0	3	3
950	21.1	4.8	2.22	0.60	1.66	0.33	0.0	3	3
1000	21.6	4.9	2.23	0.61	1.71	0.30	0.0	3	3

(d_{Limit} = 10 m)

30	18.6	-9.9	0.29	0.04	0.23	0.02	-10.5	10	3
50	6.0	-9.6	0.39	0.09	0.32	0.08	-10.5	10	3
100	9.7	-9.2	0.56	0.14	0.47	0.08	-10.5	10	3
150	7.9	-8.8	0.73	0.20	0.59	0.12	-10.5	10	3
200	7.6	-8.6	0.84	0.21	0.70	0.11	-10.5	10	3
250	9.5	-8.3	0.98	0.24	0.80	0.13	-10.5	10	3
300	11.0	-8.1	1.04	0.26	0.89	0.15	-10.5	10	3
350	12.4	-7.9	1.18	0.31	0.96	0.13	-10.5	10	3
400	13.6	-7.6	1.28	0.35	1.03	0.19	-10.5	10	3
450	14.7	-7.4	1.39	0.38	1.11	0.22	-10.5	10	3
500	15.6	-7.2	1.44	0.39	1.20	0.19	-10.5	10	3
550	16.3	-7.0	1.55	0.46	1.24	0.23	-10.5	10	3
600	17.2	-6.9	1.59	0.43	1.29	0.23	-10.5	10	3
650	18.1	-6.9	1.67	0.34	1.35	0.22	-10.5	10	3
700	18.5	-6.8	1.67	0.42	1.41	0.15	-10.5	10	3
750	19.1	-6.3	1.87	0.54	1.46	0.25	-10.5	10	3
800	19.6	-6.3	1.90	0.46	1.51	0.25	-10.5	10	3
850	20.1	-6.0	1.99	0.60	1.56	0.27	-10.5	10	3
900	20.8	-5.8	2.14	0.60	1.63	0.29	-10.5	10	3
950	21.1	-5.6	2.22	0.60	1.66	0.33	-10.5	10	3
1000	21.6	-5.6	2.23	0.61	1.71	0.30	-10.5	10	3

Sample calculation

E (dB µV/m) = U (dB µV) + AF (dB 1/m) + Corr. (dB)
U = Receiver reading
AF = Antenna factor
Corr. = sum of single correction factors of used cables, switch unit, distance correction, amplifier (if applicable)
distance correction = -20 * LOG (d_{Limit}/ d_{used})
Linear interpolation will be used for frequencies in between the values in the table.
Tables show an extract of values.

6.3 ANTENNA R&S HF907 (1 GHZ – 18 GHZ)

Frequency	AF R&S HF907	Corr.	cable loss 1 (relay + cable inside chamber)	cable loss 2 (outside chamber)	cable loss 3 (switch unit, atten-uator & pre-amp)	cable loss 4 (to receiver)		
MHz	dB (1/m)	dB	dB	dB	dB	dB		
1000	24.4	-19.4	0.99	0.31	-21.51	0.79		
2000	28.5	-17.4	1.44	0.44	-20.63	1.38		
3000	31.0	-16.1	1.87	0.53	-19.85	1.33		
4000	33.1	-14.7	2.41	0.67	-19.13	1.31		
5000	34.4	-13.7	2.78	0.86	-18.71	1.40		
6000	34.7	-12.7	2.74	0.90	-17.83	1.47		
7000	35.6	-11.0	2.82	0.86	-16.19	1.46		

Frequency	AF R&S HF907	Corr.	cable loss 1 (relay inside chamber)	cable loss 2 (inside chamber)	cable loss 3 (outside chamber)	cable loss 4 (switch unit, atten-uator & pre-amp)	cable loss 5 (to receiver)	used for FCC 15.247
MHz	dB (1/m)	dB	dB	dB	dB	dB	dB	
3000	31.0	-23.4	0.47	1.87	0.53	-27.58	1.33	
4000	33.1	-23.3	0.56	2.41	0.67	-28.23	1.31	
5000	34.4	-21.7	0.61	2.78	0.86	-27.35	1.40	
6000	34.7	-21.2	0.58	2.74	0.90	-26.89	1.47	
7000	35.6	-19.8	0.66	2.82	0.86	-25.58	1.46	

Frequency	AF R&S HF907	Corr.	cable loss 1 (relay inside chamber)	cable loss 2 (High Pass)	cable loss 3 (pre-amp)	cable loss 4 (inside chamber)	cable loss 5 (outside chamber)	cable loss 6 (to receiver)
MHz	dB (1/m)	dB	dB	dB	dB	dB	dB	dB
7000	35.6	-57.3	0.56	1.28	-62.72	2.66	0.94	1.46
8000	36.3	-56.3	0.69	0.71	-61.49	2.84	1.00	1.53
9000	37.1	-55.3	0.68	0.65	-60.80	3.06	1.09	1.60
10000	37.5	-56.2	0.70	0.54	-61.91	3.28	1.20	1.67
11000	37.5	-55.3	0.80	0.61	-61.40	3.43	1.27	1.70
12000	37.6	-53.7	0.84	0.42	-59.70	3.53	1.26	1.73
13000	38.2	-53.5	0.83	0.44	-59.81	3.75	1.32	1.83
14000	39.9	-56.3	0.91	0.53	-63.03	3.91	1.40	1.77
15000	40.9	-54.1	0.98	0.54	-61.05	4.02	1.44	1.83
16000	41.3	-54.1	1.23	0.49	-61.51	4.17	1.51	1.85
17000	42.8	-54.4	1.36	0.76	-62.36	4.34	1.53	2.00
18000	44.2	-54.7	1.70	0.53	-62.88	4.41	1.55	1.91

Sample calculation

E (dB µV/m) = U (dB µV) + AF (dB 1/m) + Corr. (dB)
U = Receiver reading
AF = Antenna factor
Corr. = sum of single correction factors of used cables, switch unit, distance correction, amplifier (if applicable)
Linear interpolation will be used for frequencies in between the values in the table.
Tables show an extract of values.

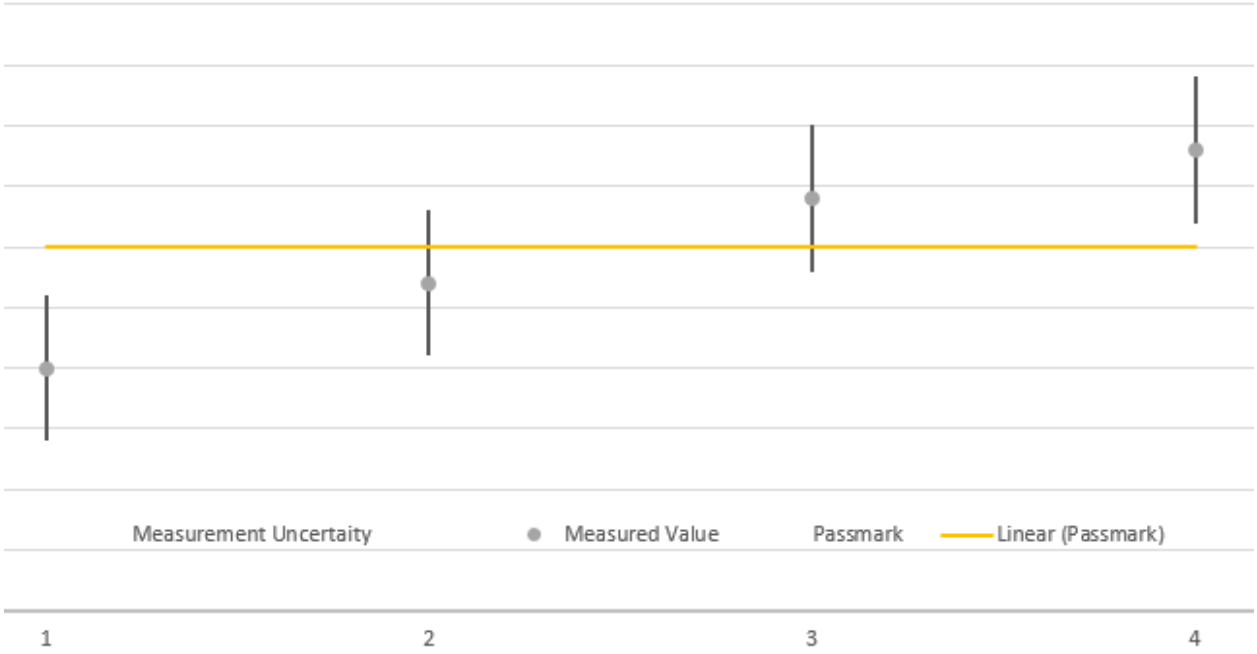
7 PHOTO REPORT

Photos are included in an external report.

MEASUREMENT UNCERTAINTIES

Parameter	Uncertainty
Radio frequency	± 0.5 ppm
RF Power, conducted	± 1.5 dB
Unwanted Emissions, conducted	± 3.0 dB
All emissions, radiated	± 4.5 dB
Temperature	± 0.3 °C
Humidity	± 3%
DC and low frequency voltages	± 1.5% + 2 digits
Time	± 5%
Duty Cycle	± 5%
RF level uncertainty for a given BER	± 1.5 dB

The measurement uncertainties for all parameters are calculated with an expansion factor (coverage factor) k = 1.96. This means, that the true value is in the corresponding interval with a probability of 95 %.



The verdicts in this test report are given according to the above diagram:

Case	Measured Value	Uncertainty Range	Verdict
1	below pass mark	below pass mark	Passed
2	below pass mark	within pass mark	Passed
3	above pass mark	within pass mark	Failed
4	above pass mark	above pass mark	Failed

That means, the laboratory applies, as decision rule (see ISO/IEC 17025:2017), the so-called shared risk principle.