FCC Measurement/Technical Report on

NFC tranceiver – part of
Testo Saveris Multifunction Handle

0560 1020

FCC ID: WAF-05601020
IC: 6127B-05601020

Report Reference: MDE_TESTO_2004_FCC_03

Test Laboratory:
7layers GmbH
Borsigstrasse 11
40880 Ratingen
Germany

Deutsche Akkreditierungsstelle
D-PL-12140-01-01
D-PL-12140-01-02
D-PL-12140-01-03

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1 Summary

1.1 Technical Report Summary

Type of Authorization
Certification for an intentional radiator operating at 13.56 MHz

Applicable FCC Rules

Prepared in accordance with the requirements of FCC Rules and Regulations as listed in 47 CFR Ch.1 Parts 2 and 15 (10-1-19 Edition). 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

§ 15.205 Restricted bands of operation

§ 15.207 Conducted limits

§ 15.209 Radiated emission limits; general requirements

§ 15.215 Additional provisions to the general radiated emission limitations

§ 15.225 Operation within the band 13.110-14.010 MHz

Note:
ANSI C63.10-2013 is applied

Summary Test Results:

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

1.2 FCC-IC Correlation Table

The following tables show the correlation of measurement requirements Radio equipment operating in the Band 13.110-14.010 MHz from FCC and IC.

Radio equipment

Measurement	FCC reference	IC reference
Conducted emissions on AC Mains	§ 15.207	RSS-Gen Issue 5 & Amdt. 1 2019: 8.8
Out-of-band emissions	§ 15.225 (d)	RSS Gen Issue 5 & Amdt. 1 2019: 6.13/8.9/8.10; RSS-210 Issue 10 & Amdt. 2020: B.6
In-band emissions	§ 15.225 (a) / (b) / (c)	RSS-210 Issue 10 & Amdt. 2020: B.6
Frequency Stability	§ 15.225 (e)	RSS-210 Issue 10 & Amdt. 2020: B.6
Antenna requirement	§ 15.203 / 15.204	RSS-Gen Issue 5 & Amdt. 1 2019: 8.3
Receiver spurious emissions	–	RSS-210 Issue 10 & Amdt. 2020: 2.3; RSS Gen Issue 5 & Amdt. 1 2019: 5/7 *)
Handling of active and passive tag devices of RFID application	§ 15.225 (f)	RSS Gen Issue 5 & Amdt. 1 2019: 8.7

*) 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				
OP-Mode	**Setup**	**Port**	**Date**	**Final Result**
–	–	–		N/A

FCC Part 15, Subpart C			§15.209	
Radiated Emissions The measurement was performed according to ANSI C63.10				
OP-Mode	**Setup**	**Port**	**Date**	**Final Result**
NFC reading	Setup_01	Enclosure	2020-11-06/08	passed

FCC Part 15, Subpart C			§ 15.215	
Occupied Bandwidth The measurement was performed according to FCC § 2.1049				
OP-Mode	**Setup**	**Port**	**Date**	**Final Result**
NFC reading	Setup_01	Enclosure	2020-12-08	passed

FCC Part 15, Subpart C			§ 15.225	
Spectrum Mask The measurement was performed according to ANSI C63.10				
OP-Mode	**Setup**	**Port**	**Date**	**Final Result**
NFC reading	Setup_01	Enclosure	2020-11-06	passed

FCC Part 15, Subpart C			§ 15.225	
Frequency Tolerance The measurement was performed according to FCC § 2.1055				
OP-Mode	**Setup**	**Port**	**Date**	**Final Result**
NFC reading	Setup_02	Enclosure	2020-12-09	passed

N/A not applicable (the EUT is battery powered)

1.4 Revision History

Version	Release date	Change Description	Version validity
initial	2020-12-17	--	valid

Responsible for Accreditation Scope: _____ Responsible for Test Report: _____

7 layers GmbH, Borsigstr. 11
40880 Ratingen, Germany
Phone +49 (0)2102 749 0

2 Administrative Data

2.1 Testing Laboratory

Company Name:	7layers GmbH
Address	Borsigstr. 11 40880 Ratingen Germany
Laboratory accreditation no:	DAkkS D-PL-12140-01-01 | -02 | -03
ISED CAB Identifier	DE0007; ISED#: 3699A
FCC Designation Number:	DE0015
FCC Test Firm Registration:	929146
Responsible for Accreditation Scope:	Dipl.-Ing. Marco Kullik
Report Template Version:	2020-11-23

2.2 Project Data

Responsible for testing and report:	M.Sc. Joel Asongwe
Date of Report:	2020-12-17
Testing Period:	2020-11-06 to 2020-12-09

2.3 Applicant Data

Company Name:	Testo SE & Co. KGaA
Address:	Celsiusstr. 2 79822 Titisee-Neustadt Germany
Contact Person:	Mr. Udo Spiwoks

2.4 Manufacturer Data

Company Name:	please see applicant data
Address:	
Contact Person:	

3 Test object Data

3.1 General EUT Description

Kind of Device product description	The EUT is a NFC tranceiver – part of Testo Saveris Multifunction Handle		
Type designation	0560 1020		
Voltage Type	DC (powered by 4 x 1.5 V AA batteries)		
Voltage level (nominal)	6.0 V		
Normal and extreme test conditions	T_{nor} = +25 °C	T_{min} = -20 °C	T_{max} = +50 °C
	V_{nor} = 6.0 V	V_{min} = 3.6 V	V_{max} = 6.0 V
Antenna	Printed on PCB		
Product Class	1 (integral antennas)		
Extreme temperature	Category III – indoor use		
RF power adjustable	No		
EUT is tagging system	Yes		
EUT operating frequency	13.56 MHz		

3.1.1 General product description:

NFC transceiver is operating at 13.56 MHz nominal frequency

3.1.2 Specific product description for the EUT:

For a detailed description please refer to the documentation provided by the applicant.

The EUT provides the following ports:

Ports
Enclosure

3.2 EUT Main components

Type, S/N, Short Descriptions etc. used in this Test Report

Short Description	Equipment under Test	Type Designation	Serial No.	HW Status	SW Status
EUT A (Code: DE1101029ag01)	NFC Transceiver	0560 1020	-	2.2	1.0.0

NOTE: The short description is used to simplify the identification of the EUT in this test report.

3.3 Ancillary Equipment

For the purposes of this test report, ancillary equipment is defined as equipment which is used in conjunction with the EUT to provide operational and control features to the EUT. It is necessary to configure the system in a typical fashion, as a customer would normally use it. But nevertheless Ancillary Equipment can influence the test results.

Short Description	Equipment under Test	Type Designation	Serial No.	HW Status	SW Status
–	–	–	–	–	–

3.4 Auxiliary Equipment

For the purposes of this test report, auxiliary equipment is defined as equipment which is used temporarily to enable operational and control features especially used for the tests of the EUT which is not used during normal operation or equipment that is used during the tests in combination with the EUT but is not subject of this test report. It is necessary to configure the system in a typical fashion, as a customer would normally use it.
But nevertheless Auxiliary Equipment can influence the test results.

Short Description	Device	Type Designation	Serial No.	HW Status	SW Status
AUX 1	NFC Tag	0554 2590	-	1.0	-

3.5 EUT Setups

This chapter describes the combination of EUTs and equipment used for testing. The rationale for selecting the EUTs, ancillary and auxiliary equipment and interconnecting cables, is to test a representative configuration meeting the requirements of the referenced standards.

Setup No.	Combination of EUTs	Description and Rationale
Setup_01	EUT A, AUX 1	EUT is reading a tag (AUX 1)
Setup_02	EUT A	EUT is not reading a tag Setup for Frequency stability measurements: Instead of batteries, two external wires are connected, to power the EUT with variable voltage

3.6 Operating Modes

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

Op. Mode	Description of Operating Modes	Remarks
NFC reading	EUT is transmitting a continuously modulated signal	When reading a tag the Handle vibrate
NFC not reading	EUT is transmitting a continuously modulated signal	When not reading a tag the Handle does not vibrate

3.7 Special software used for testing

Yes, provided by the applicant.

3.8 Product labelling

Please refer to the documentation of the applicant.

4 Test Results

4.1 Spurious radiated emissions

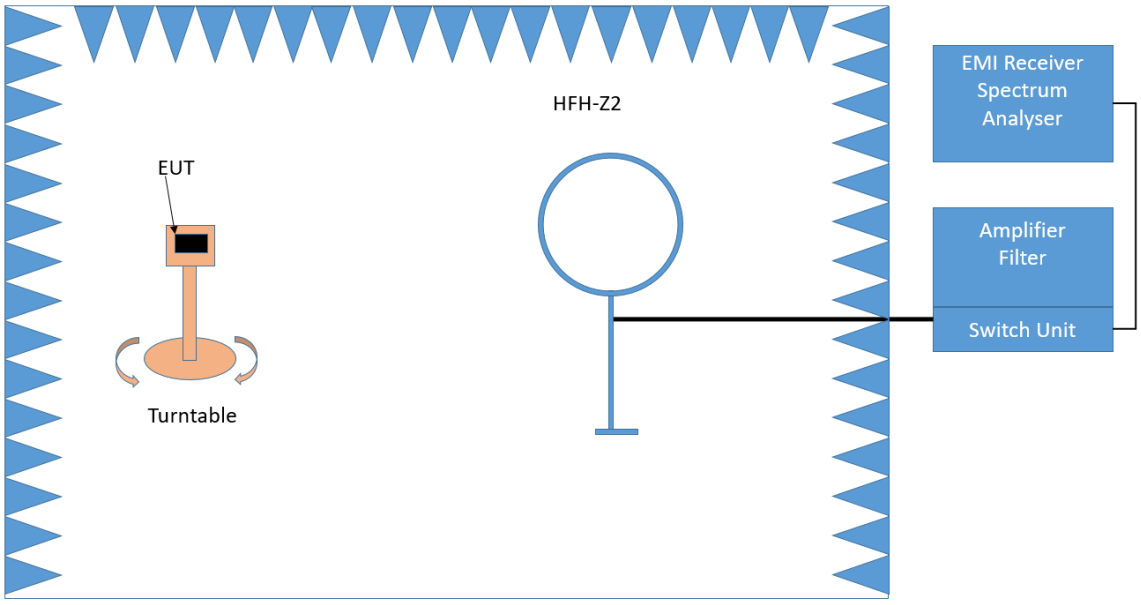
Standard FCC Part 15, Subpart C

The test was performed according to: ANSI C63.10

4.1.1 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 EMC32 test software 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

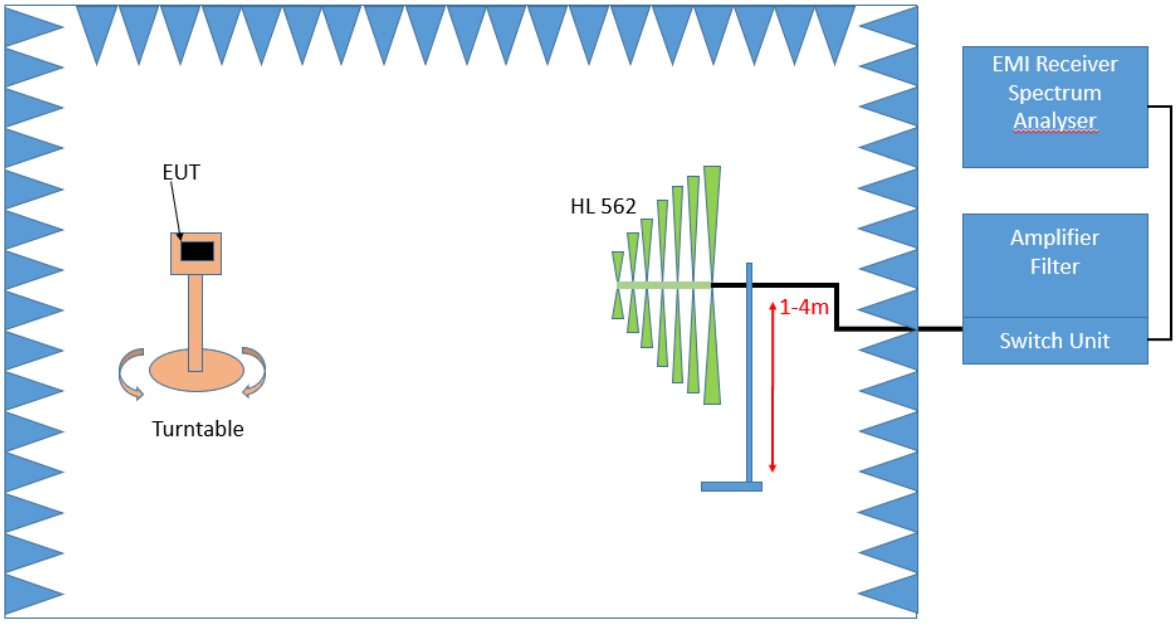
The Loop antenna HFH2-Z2 (shielded magnetic loop antenna) is used.

Step 1: pre measurement
- 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 and 0.15 – 30 MHz
- Frequency steps: 0.1 kHz and 5 kHz
- IF–Bandwidth: 0.2 kHz and 10 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 with the following settings will be performed. 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
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.

4.1.2 Test Requirements / Limits

FCC Part 15, Subpart C, §15.225 (d)
The field strength of any emissions appearing outside of the 13.110–14.010 MHz band shall not exceed the general radiated emission limits in § 15.209.

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

Frequency in MHz	Limit (µV/m)	Measurement distance (m)	Limits (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 FCC §15.31 (2).

Frequency in MHz	Limit (µV/m)	Measurement distance (m)	Limits (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

§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)

4.1.3 Test Protocol

Temperature: 21-24 °C
Air Pressure: 1014-1033 hPa
Humidity: 39-42 %

4.1.3.1 Measurement up to 30 MHz

Op. Mode	Setup	Port
NFC reading	Setup_01	Enclosure

Antenna orientation	EUT orientation	Frequency MHz	Corrected value dBµV/m			Limit dBµV/m	Limit dBµV/m	Limit dBµV/m	Margin dB	Margin dB
			QP	Peak	AV	QP	Peak	AV	QP/Peak	AV
Vert.&Hor.	Vertical	13.56	-	–	–	–	–	–	–	–

Remark: No spurious emissions in the range 20 dB below the limit were found therefore step 2 was not performed.
EUT is tested at horizontal position as in this position it transmittis a maximal power.

4.1.3.2 Measurement above 30 MHz

Op. Mode	Setup	Port
NFC reading	Setup_01	Enclosure

Antenna orientation	EUT orientation	Frequency MHz	Corrected value dBµV/m			Limit dBµV/m	Limit dBµV/m	Limit dBµV/m	Margin dB	Margin dB
			QP	Peak	AV	QP	Peak	AV	QP/Peak	AV
Vertical	Horizontal	693.360000	21.85	–	–	46.00	–	–	24.15	–
Vertical	Horizontal	994.590000	22.70	–	–	54.00	–	–	31.30	–

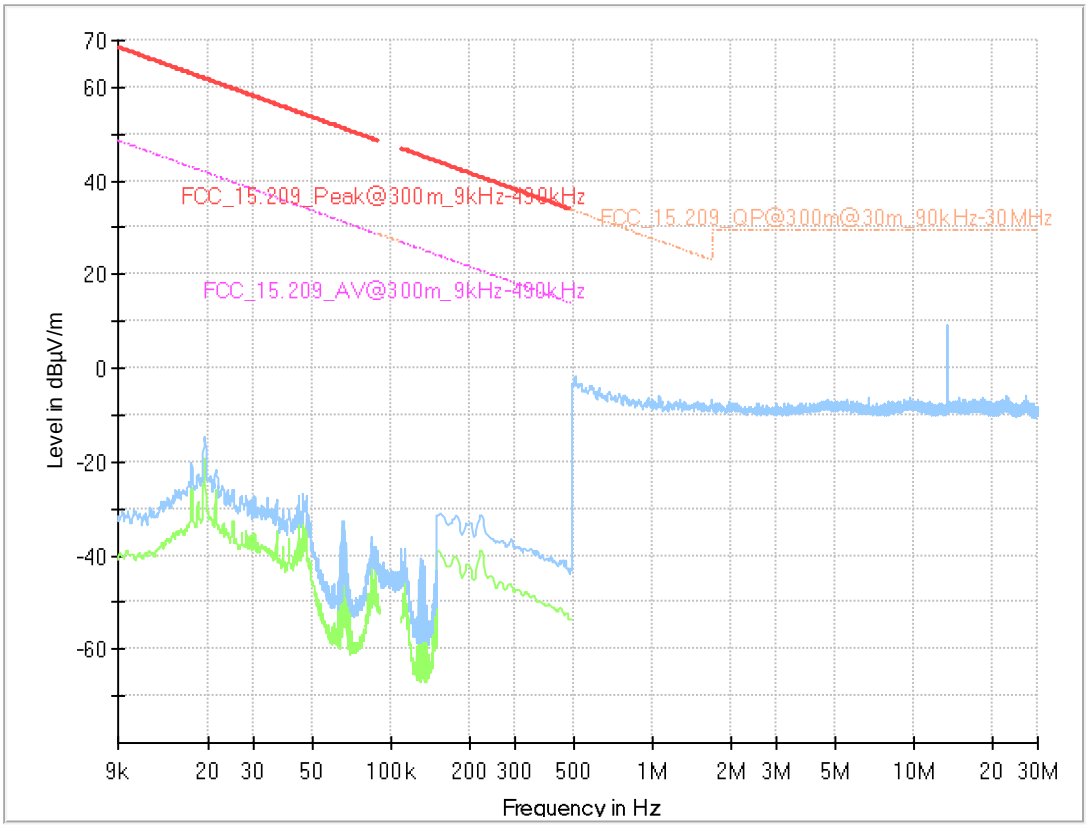
Remark: No further spurious emissions in the range 20 dB below the limit found.

4.1.4 Measurement Plots (worst case)

4.1.4.1 Below 30 MHz

Common information

Test Description:	Radiated Emissions, Test Site: Semi Anechoic Chamber @ 3 m
Test Standard:	FCC 15c209
EUT / Setup Code:	DE1101029ag01
Operating Conditions:	NFC TX on 13.56 MHz, reading tag ; EUT horizontal
Operator Name:	WES/DOB
Comment:	-
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



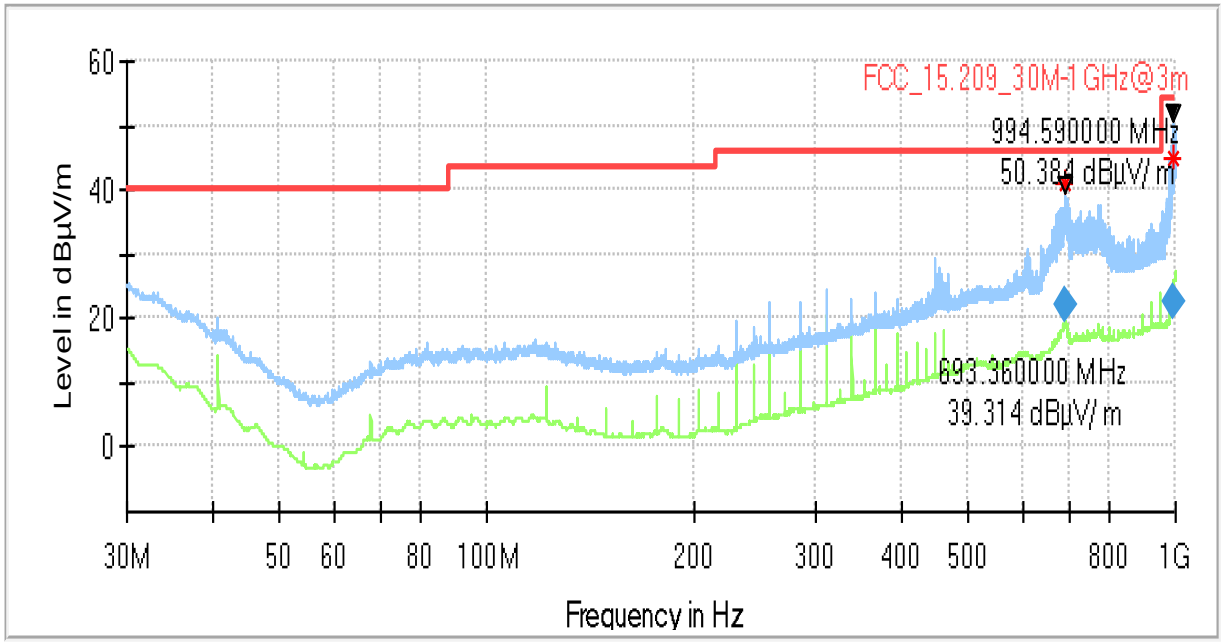
Final_Result

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

4.1.4.2 Above 30 MHz

Common Information

Test Description:	Radiated Emissions, Test Site: Semi Anechoic Chamber @ 3 m
Test Standard	FCC 15c.209
EUT Code:	DER1101029
Operating conditions:	DC powered 4 x AA batteries, reading TAG
Operator Name:	DOB
Comment:	None
Legend:	Trace: blue = Peak; green = AV, Star: = critical frequency; Rhombus: blue = final QP



Final_Result

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
693.360000	21.85	46.00	24.15	1000.0	120.000	124.0	H	-70.0	21.5
994.590000	22.70	54.00	31.30	1000.0	120.000	105.0	H	-108.0	25.3

4.1.5 Test Equipment used

- Radiated Emissions

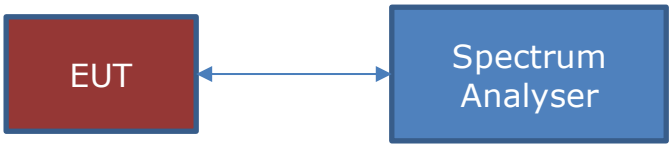
4.2 Occupied bandwidth

Standard FCC Part 15, Subpart C

The test was performed according to: FCC §15.31

4.2.1 Test Description

The Equipment Under Test (EUT) was setup in a shielded room to perform the occupied bandwidth measurements.
The reference level is the level of the highest amplitude signal observed from the transmitter at either the fundamental frequency or first-order modulation products in all typical modes of operation, including the unmodulated carrier, even if atypical.
The results recorded were measured with the modulation which produces the worst-case (widest) occupied bandwidth.



Test Setup for conducted tests

4.2.2 Test Requirements / Limits

FCC Part 15, Subpart C, §15.215 (c)
Intentional radiators operating under the alternative provisions to the general emission limits, as contained in §§ 15.217 through 15.257 and in Subpart E of this part, must be designed to ensure that the 20 dB bandwidth of the emission, or whatever bandwidth may otherwise be specified in the specific rule section under which the equipment operates, is contained within the frequency band designated in the rule section under which the equipment is operated. …

4.2.3 Test Protocol

Temperature: 25 °C
Air Pressure: 1016 hPa
Humidity: 42 %

Op. Mode	Setup	Port
NFC reading	Setup_01	Enclosure

20 dB bandwidth kHz	99% bandwidth kHz	Remarks
0.550	0.451	The 20 dB bandwidth from 13.560331 MHz to 13.560871 MHz is contained within the designated frequency band 13.110 MHz to 14.010 MHz.

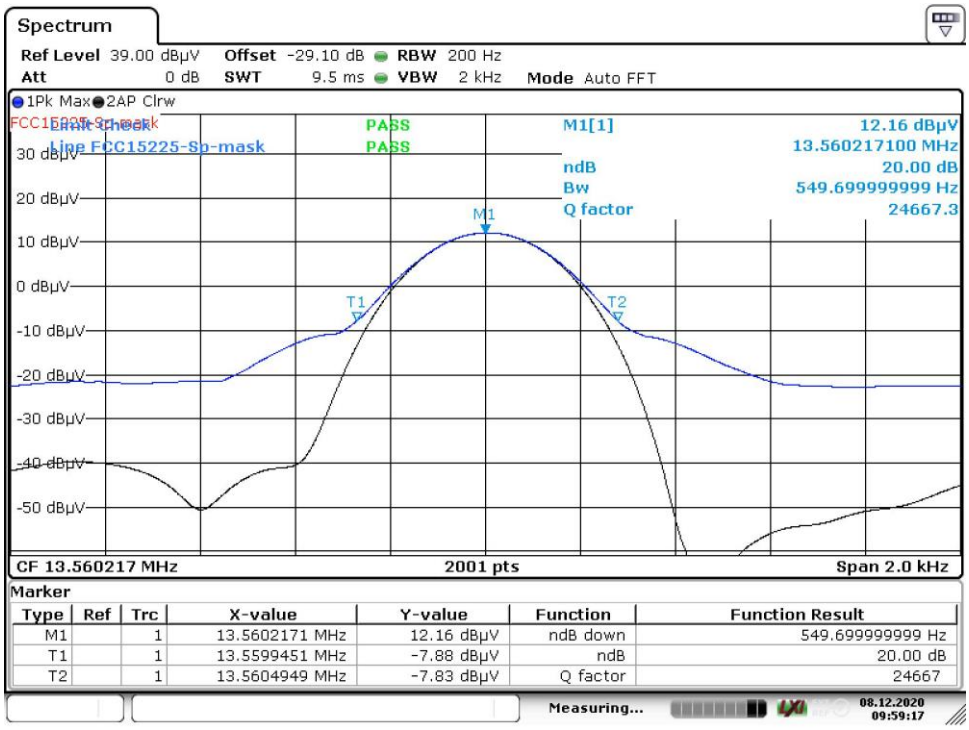
Op. Mode	Setup	Port
NFC not reading	Setup_02	Enclosure

20 dB bandwidth kHz	99% bandwidth kHz	Remarks
0497	0.424	The 20 dB bandwidth from 13.553812 MHz to 13.567343 MHz is contained within the designated frequency band 13.110 MHz to 14.010 MHz.

Remark: None

4.2.4 Measurement Plots (worst case)

4.2.4.1 20 dB bandwidth, NFC reading



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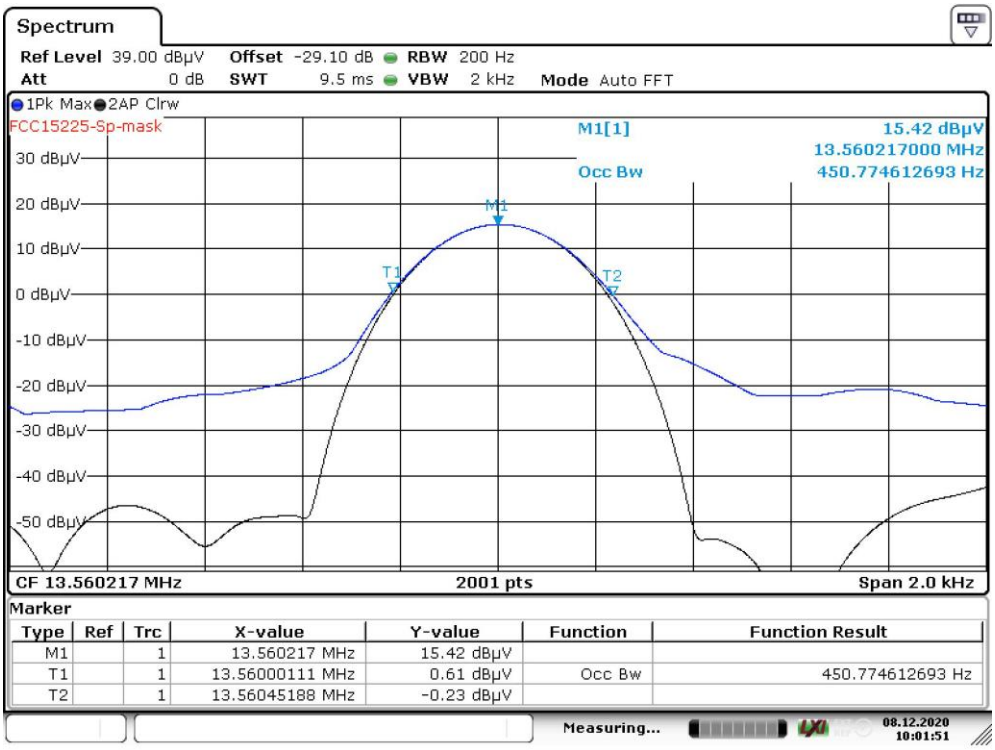
4.2.4.2 99% bandwidth, NFC reading



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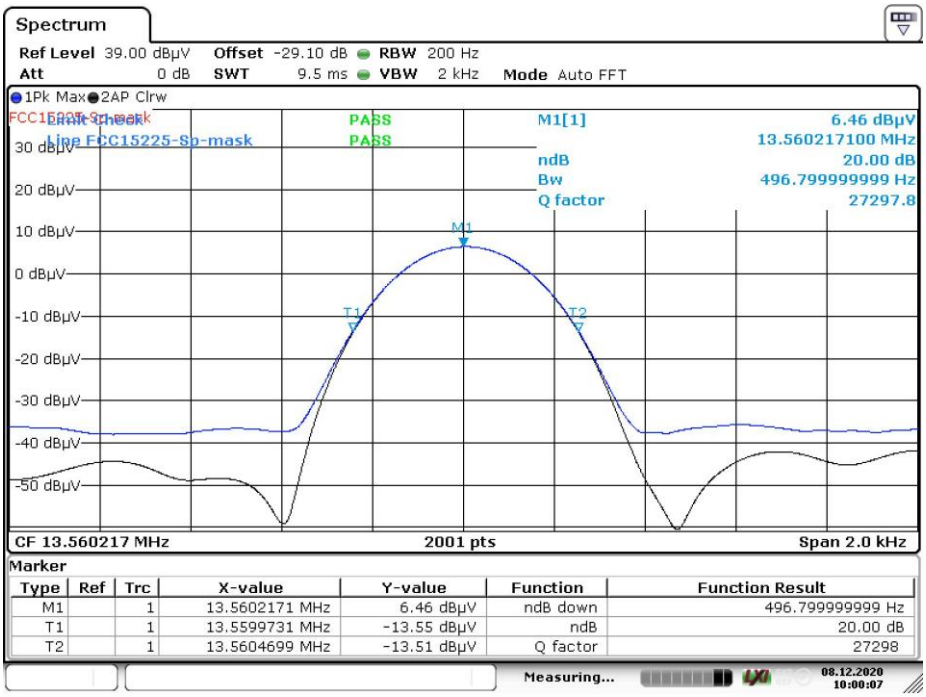
4.2.4.3 20 dB bandwidth, NFC no tag



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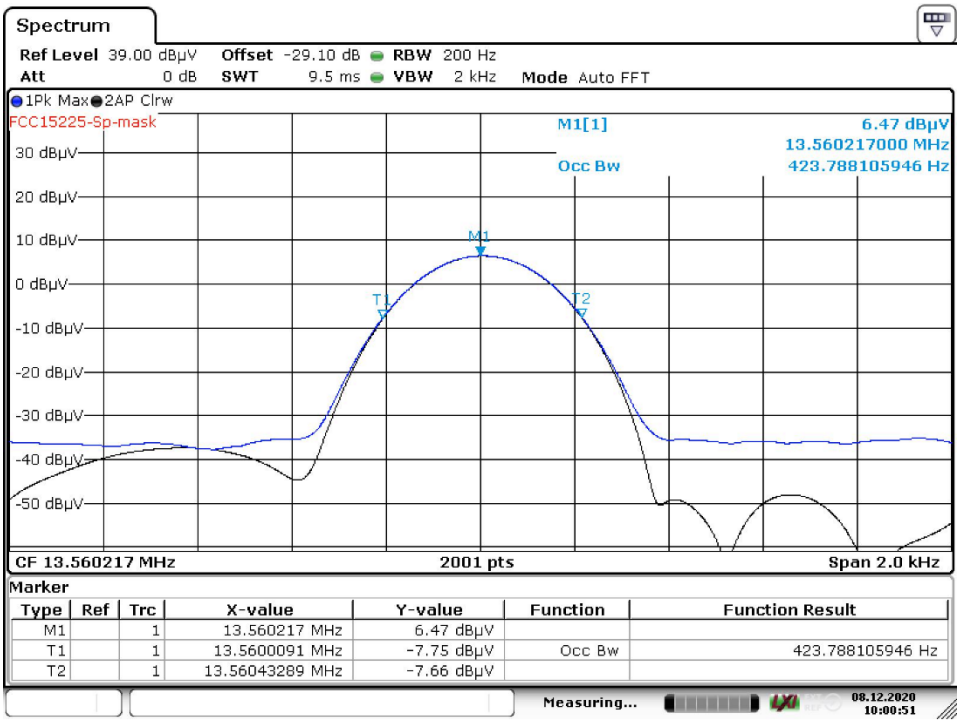
4.2.4.4 99% bandwidth, NFC no tag



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4.2.5 Test Equipment used

- Radio Lab

4.3 Spectrum mask

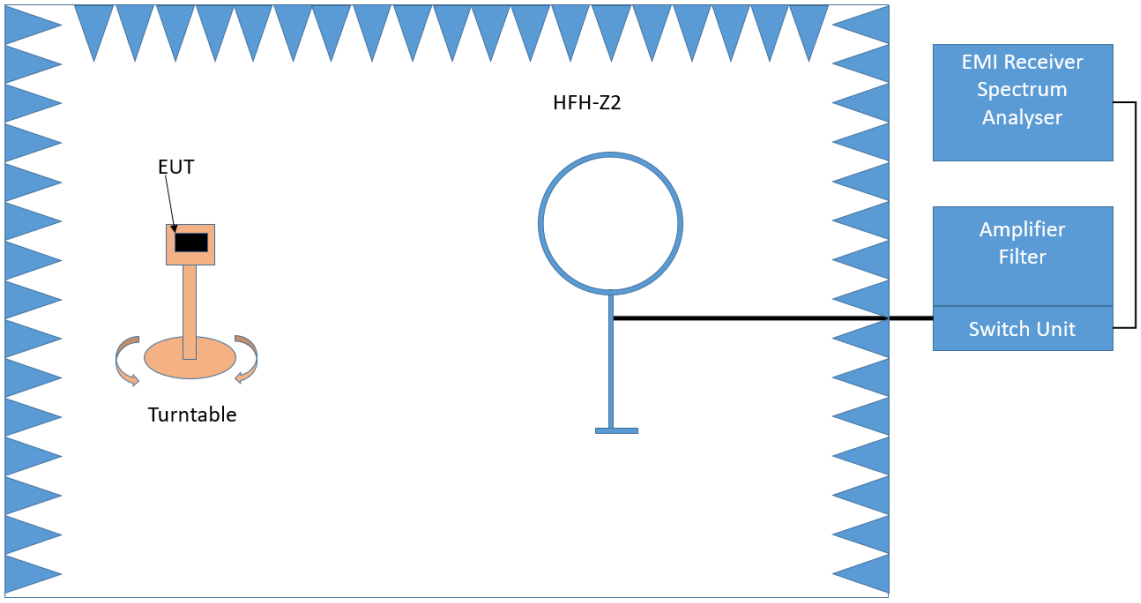
Standard FCC Part 15, Subpart C

The test was performed according to: FCC §15.225

4.3.1 Test Description

The test set-up was made in accordance to the general provisions of ANSI C 63.10.
The Equipment Under Test (EUT) was set up on a non-conductive table in the anechoic chamber.
The radiated emissions measurements were made in a typical installation configuration.
The measurement procedure is implemented into the EMI test software EMC32 from R&S.
The Loop antenna HFH2-Z2 is used.

- Semi-anechoic chamber
- Antenna distance: 3 m
- Detector: Quasi-Peak
- Frequency range: 13.06 – 14.06 MHz
- Frequency steps: 5 kHz
- IF–Bandwidth:10 kHz
- Measuring time / Frequency step: 1 s



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

4.3.2 Test Limits

FCC Part 15, Subpart C, §15.225 (a-d), and §15.209, corrected by the means of the extrapolation of §15.31 due to the reduced measuring distance from 30 m to 3 m.
The merits of the maximum value as well as the limit are referencing to a distance of 30 m.

4.3.3 Test Protocol

Temperature: 23 °C
Air Pressure: 1014 hPa
Humidity: 42 %

Op. Mode	Setup	Port
NFC reading	Setup_01	Enclosure

Maximum value dBµV/m	Limit dBµV/m	Margin dB	Remarks
10.12	84.0	73.9	EUT horizontal

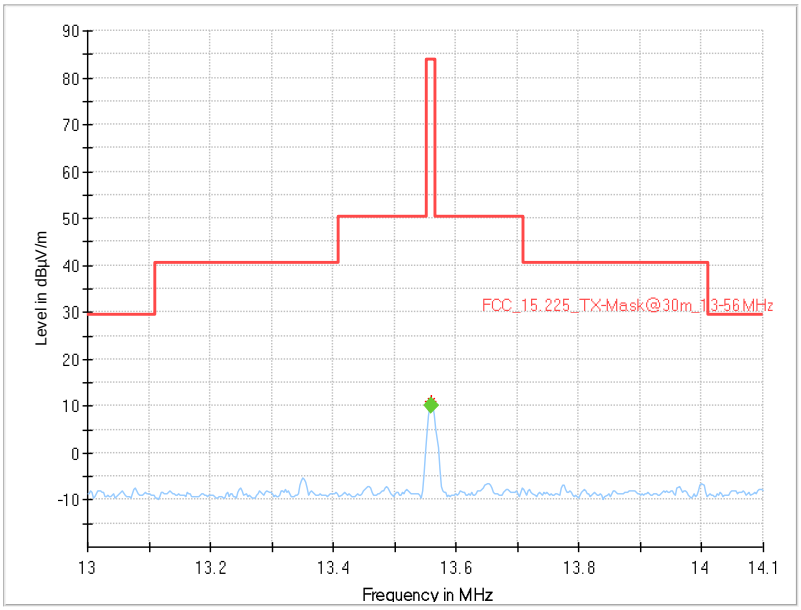
Remark: The EUT is tested in vertical and horizontal position. The result above is a maximal value.

4.3.4 Measurement Plots (worst case)

4.3.4.1 Setup_01, Mode NFC reading

Common Information

Test Description:	Radiated Emissions, Test Site: Semi Anechoic Chamber @ 3 m
Test Standard:	FCC 15.225
EUT / Setup Code:	DE1101029ag01
Operating Conditions:	NFC TX-Mask on 13.56 MHz ; EUT horizontal, reading a tag
Operator Name:	WES/DOB
Legend:	Trace: blue = Peak; green = AV, Star: = critical frequency; Rhombus: blue = final QP



Final_Result

Frequency (MHz)	MaxPeak (dBµV/m)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)
13.560000	---	10.12	84.00	73.88	1000.0	9.000	100.0	H	-104.0

4.3.5 Test Equipment used

- Radiated Emissions

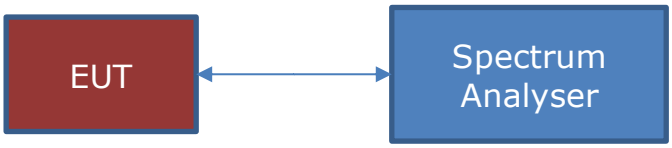
4.4 Frequency tolerance

Standard FCC Part 15, Subpart C

The test was performed according to: FCC §15.225

4.4.1 Test Description

The Equipment Under Test (EUT) is placed in a temperature chamber.
The frequency drift during temperature and voltage variation is measured by the means of a spectrum analyser with frequency counter function.
The temperature was varied from –20 °C to +50 °C. At +20 °C the wider extreme power supply voltages of 8.0 and 16.0 V (instead of 85% and 115%) are applied. After reaching each target temperature and waiting sufficient time allowing the temperature to stabilize, one measurement is performed immediately after powering on the EUT, and two further measurements are performed after 5 and 10 minutes continuous operation of the EUT.



Test Setup for conducted tests

4.4.2 Test Limits

FCC Part 15, Subpart C, §15.225 (e): The frequency tolerance of the carrier signal shall be maintained within ±0.01% of the operating frequency over a temperature variation of -20 degrees to +50 degrees 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 degrees C.

4.4.3 Test Protocol

Temperature: 27 °C
Air Pressure: 1017 hPa
Humidity: 38 %

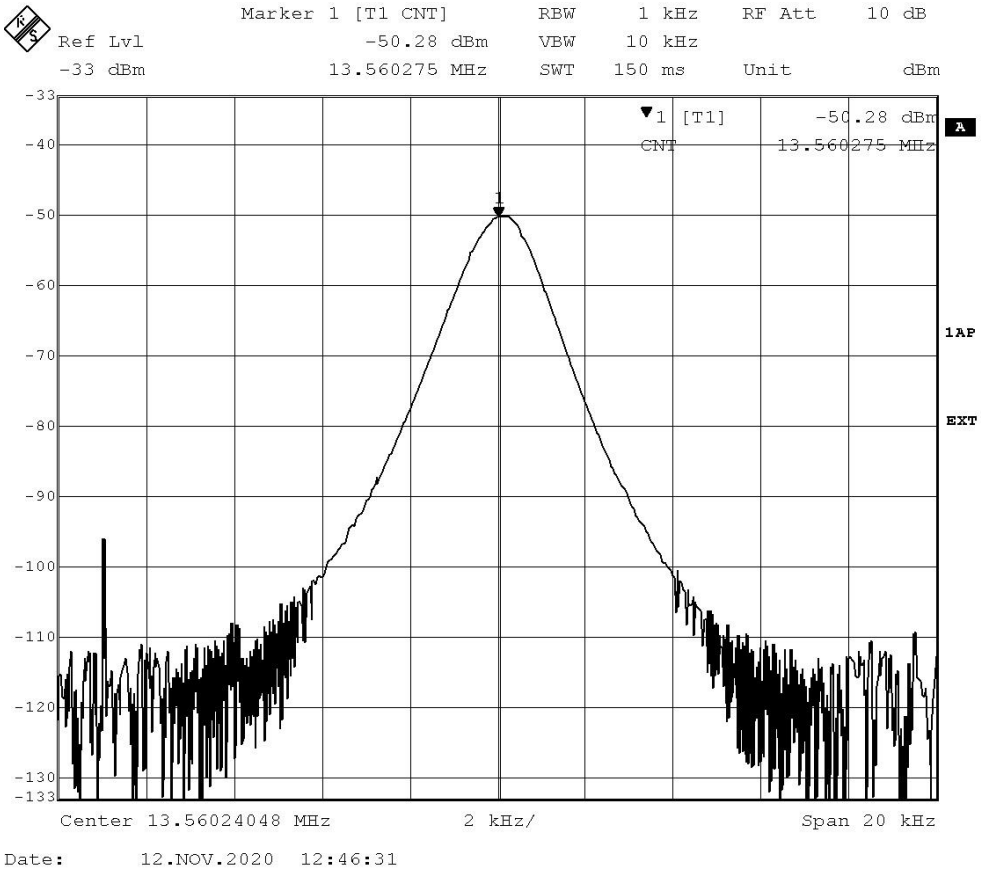
Op. Mode	Setup	Port
NFC not reading	Setup_02	Enclosure

Temperature / °C	Voltage / V	Time / min.	Frequency / MHz	Delta / Hz
50	6.00	0	13.560165	165
50	6.00	2	13.560164	164
50	6.00	5	13.560164	164
50	6.00	10	13.560164	164
40	6.00	0	13.560171	171
40	6.00	2	13.560173	173
40	6.00	5	13.560176	176
40	6.00	10	13.560170	170
30	6.00	0	13.560211	211
30	6.00	2	13.560207	207
30	6.00	5	13.560207	207
30	6.00	10	13.560207	207
20	6.00	0	13.560244	244
20	6.00	2	13.560241	241
20	6.00	5	13.560240	240
20	6.00	10	13.560240	240
20	3.60	0	13.560247	247
20	3.60	2	13.560242	242
20	3.60	5	13.560242	242
20	3.60	10	13.560242	242
10	6.00	0	13.560275	**275**
10	6.00	2	13.560271	271
10	6.00	5	13.560269	269
10	6.00	10	13.560260	260
0	6.00	0	13.560207	207
0	6.00	2	13.560206	206
0	6.00	5	13.560206	206
0	6.00	10	13.560206	206
-10	6.00	0	13.560202	202
-10	6.00	2	13.560203	203

Remark: The limit is a delta of max. ±1356 Hz (0.01 %).

Maximum deviation from nominal frequency: 275 Hz

4.4.4 Measurement Plots (worst case)



4.4.5 Test Equipment used

- Radio Lab

5 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	MFS	Rubidium Frequency Normal MFS	Datum GmbH	002	2020-11	2022-11
1.2	N5000/NP	Filter for EUT, 2 Lines, 250 V, 16 A	ETS-LINDGREN	241515		
1.3	Opus10 TPR (8253.00)	ThermoAirpressure Datalogger 13	Lufft Mess- und Regeltechnik GmbH	ID 13936	2019-05	2021-05
1.4	ESW44	EMI Receiver / Spectrum Analyzer	Rohde & Schwarz GmbH & Co. KG	101603	2019-12	2021-12
1.5	Anechoic Chamber 01	SAC/FAR, 10.58 m x 6.38 m x 6.00 m	Frankonia	none	2018-06	2021-06
1.6	Anechoic Chamber 03	FAR, 8.80m x 4.60m x 4.05m	Albatross Projects	P26971-647-001-PRB	2018-06	2021-06
1.7	HL 562 ULTRALOG	Biconical-log-per antenna (30 MHz - 3 GHz) with HL 562E biconicals	Rohde & Schwarz GmbH & Co. KG	830547/003	2018-07	2021-07
1.8	AMF-7D00101800-30-10P-R	Broadband Amplifier 100 MHz - 18 GHz	Miteq			
1.9	ASP 1.2/1.8-10 kg	Antenna Mast	Maturo GmbH	-		
1.10	Fluke 177	Digital Multimeter 03 (Multimeter)	Fluke Europe B.V.	86670383	2020-04	2021-04
1.11	NRVD	Power Meter	Rohde & Schwarz GmbH & Co. KG	828110/016	2020-08	2021-08
1.12	FSW 43	Spectrum Analyzer	Rohde & Schwarz	103779	2019-02	2021-02
1.13	DS 420S	Turn Table 2 m diameter	HD GmbH	420/573/99		
1.14	JS4-00102600-42-5A	Broadband Amplifier 30 MHz - 26 GHz	Miteq	619368		
1.15	TT 1.5 WI	Turn Table	Maturo GmbH	-		
1.16	HL 562 ULTRALOG	Biconical-log-per Antenna (30 MHz - 3 GHz)	Rohde & Schwarz GmbH & Co. KG	100609	2019-05	2022-05
1.17	Air compressor	Anechoic Chamber; 8.8m x 4.6 m x 4.05 m	JUN-AIR Deutschland GmbH	612582		
1.18	HFH2-Z2	Loop Antenna	Rohde & Schwarz	829324/006	2018-01	2021-01
1.19	Opus10 THI (8152.00)	ThermoHygro Datalogger 12	Lufft Mess- und Regeltechnik GmbH	ID 12482	2019-06	2021-06

Ref. No.	Device Name	Description	Manufacturer	Serial Number	Last Calibration	Calibration Due
1.20	JS4-00101800-35-5P	Broadband Amplifier 30 MHz - 18 GHz	Miteq	896037		
1.21	AS 620 P	Antenna Mast (pneumatic polarisation)	HD GmbH	620/37		
1.22	TD1.5-10kg	EUT Tilt Device (Rohacell)	Maturo GmbH	TD1.5-10kg/024/3790709		
1.23	NRV-Z1	Sensor Head B	Rohde & Schwarz GmbH & Co. KG	827753/006	2020-08	2021-08
1.24	PAS 2.5 - 10 kg	Antenna Mast	Maturo GmbH	-		
1.25	AFS42-00101800-25-S-42	Broadband Amplifier 25 MHz - 18 GHz	Miteq	2035324		
1.26	AM 4.0	Antenna Mast 4 m	Maturo GmbH	AM4.0/180/11920513		

2 Radio Lab
Lab to perform conducted tests

Ref. No.	Device Name	Description	Manufacturer	Serial Number	Last Calibration	Calibration Due
2.1	MFS	Rubidium Frequency Standard	Datum-Beverly	5489/001	2020-09	2021-09
2.2	ESR 7	EMI Receiver / Spectrum Analyzer 10 Hz - 7 GHz	Rohde & Schwarz	101424	2019-01	2021-01
2.3	Fluke 177	Digital Multimeter 03 (Multimeter)	Fluke Europe B.V.	86670383	2020-04	2021-04
2.4	KWP 120/70	Temperature Chamber	Weiss	59226012190010	2020-05	2022-05
2.5	A8455-4	4 Way Power Divider (SMA)		-		
2.6	Opus10 THI (8152.00)	ThermoHygro Datalogger 03 (Environ)	Lufft Mess- und Regeltechnik GmbH	7482	2019-06	2021-06
2.7	FSV30	Signal Analyzer 10 Hz - 30 GHz	Rohde & Schwarz	103005	2020-05	2022-05
2.8	VT 4002	Temperature Chamber	Vötsch	58566002150010	2020-05	2022-05

The calibration interval is the time interval between “Last Calibration” and “Calibration Due”.

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.

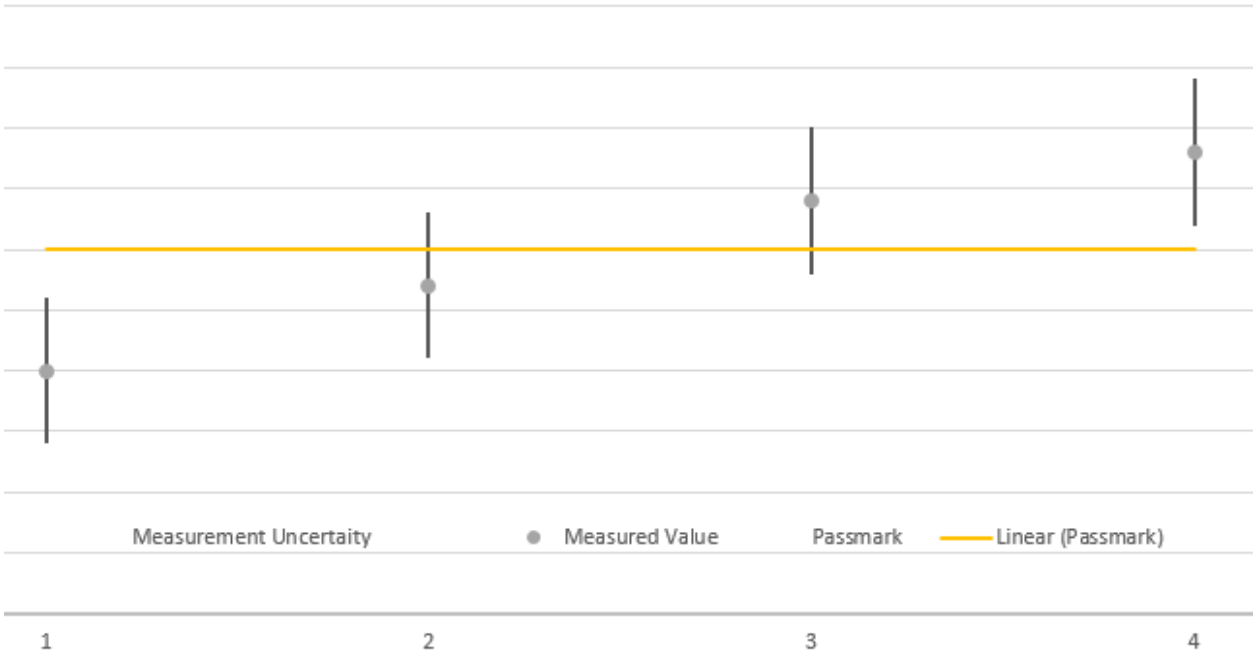
7 Photo Report

Photos are included in an external report.

8 Measurement uncertainty

Test Case	Parameter	Uncertainty
Peak power output	Fieldstrength	± 5.5 dB
Occupied bandwidth	Power Frequency:	± 2.9 dB ± 0.125 kHz
Spurious radiated emissions	Fieldstrength Frequency:	± 5.5 dB ± 11.2 kHz
AC Power Line	Power	± 3.4 dB
Frequency tolerance (frequency counter)	Frequency	± 2 Hz

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 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.