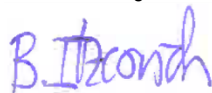


Report:	Electromagnetic compatibility and Radio spectrum Matters		Report no:	18-EL-0290.R02
Product name:	13.56 MHz RFID System		Mandate no:	18-EL-0290
Applicant:	Ivoclar Vivadent AG Bendererstrasse 2 9494 Schaan Principality of LIECHTENSTEIN	Model number:	TS-ModIV	
		Serial no:	1804 54610	
Manufacturer:	GiS mbH Höllochstraße 1 73252 Lenningen GERMANY	Date of test:	February 7 – 8, 2019	

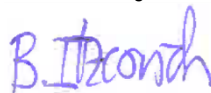
Standards		Result
47 CFR, Part 15	(Subpart C, Intentional radiators: §§ 15.207/209/225)	Pass
	(Subpart B, Class B digital devices: § 15.109)	Pass
Industry Canada	RSS-210, Licence-exempt Radio Apparatus: Category I Equipment	Pass
	RSS-Gen, General Requirements and Information for the Certification of Radio Apparatus	

These results were achieved without modification of EUT

Test performed by
Mr B. Itzcovich
EMC Test Engineer



Report prepared by
Mr B. Itzcovich
EMC Test Engineer



Report controlled and approved by
Mr J. Ding
EMC Test Engineer



Rossens, April 12, 2019

(Issue Date)

Main language : English

The present document results from tests on one specimen and does not prejudice to the conformity of all the manufactured products. This report must not be used to claim product certification, approval, or endorsement by NVLAP, NIST, or any agency of the U.S. Government.

t:\dossiers\el\2018\02xx\18-el-0290 ivoclar ag beratung red-anforderungen\4 prüfberichte\18-el-0290.r02_ivoclar_rfid_fcc.docx

Contents

	<i>Page</i>
1. SUMMARY OF TEST RESULTS.....	3
2. APPLIED STANDARDS	3
3. CLIENT.....	4
4. EQUIPMENT UNDER TEST	4
4.1 Identification	4
4.2 Pictures of the EUT	5
4.3 Classification.....	6
4.4 Transmitter characteristics (according to Ivoclar Vivadent AG)	7
4.5 Ports.....	7
5. TEST CONDITIONS.....	8
5.1 Climatic conditions, location and date	8
5.2 Test facility and methodology	8
5.3 Attendant persons.....	8
5.4 Test configuration	8
5.5 Operating conditions.....	9
5.6 Auxiliary equipment.....	9
6. TEST RESULTS	10
6.1 Field strength within and outside the band 13.110-14.010 MHz (Carrier and Band Edge)	11
6.2 Spurious emissions, transmit mode – radiated.....	15
6.2.1 9 kHz to 30 MHz.....	15
6.2.2 30 MHz to 1 GHz.....	19
6.3 Spurious emissions, standby mode – radiated.....	22
6.3.1 30 MHz to 1 GHz.....	22
6.4 Conducted emission – Interference voltage	25
6.5 Frequency stability	28
6.6 Designation of emission.....	30
7. APPENDIX	31
7.1 Test equipment	32

1. Summary of test results

- ✓ Pass
- ✗ Fail
- Ø Not applicable to this product
- Not tested
- # No requirements / not required

§	Test Type	Result
6	Emission	CFR 47 Part 15 Industry Canada
6.1	Field strength within the band 13.110-14.010 MHz (Carrier)	CFR 47 § 15.225 (a) (b) (c) RSS-210 § B.6 ✓
6.1	Band-edge emission (radiated)	CFR 47 § 15.225 (d) CFR 47 § 15.205 RSS-Gen Table 7 ✓
6.2	Spurious emissions – radiated (transmitter)	CFR 47 § 15.225 (d) CFR 47 § 15.209 (a) CFR 47 § 15.205 RSS-210 § B.6 RSS-Gen Tables 5 and 6 ✓
6.3	Radiated emission – unintentional radiator	CFR 47 § 15.109 RSS-Gen Table 3 ✓
6.4	Conducted emission	CFR 47 § 15.207 RSS-Gen Table 4 ✓
6.5	Frequency stability	CFR 47 § 15.225 (e) RSS-210 § B.6 ✓
6	Emission	CFR 47 Part 2
6.6	Designation of emission	FCC 47 §2.201 FCC 47 §2.202 15H9A1D

2. Applied standards

47 CFR Part 15 Subpart C	Code of Federal Regulations - Title 47 - Telecommunication, Part 15, Subpart C: "Intentional Radiators"
47 CFR Part 15 Subpart B	Code of Federal Regulations - Title 47 - Telecommunication, Part 15, Subpart B: "Unintentional Radiators"
RSS-Gen issue 5, April 2018	Spectrum Management and Telecommunications - Radio Standards Specification General Requirements and Information for the Certification of Radio Apparatus
RSS-210 issue 9, August 2016	Spectrum Management and Telecommunications - Radio Standards Specification Licence-exempt Radio Apparatus (All Frequency Bands): Category I Equipment

3. Client

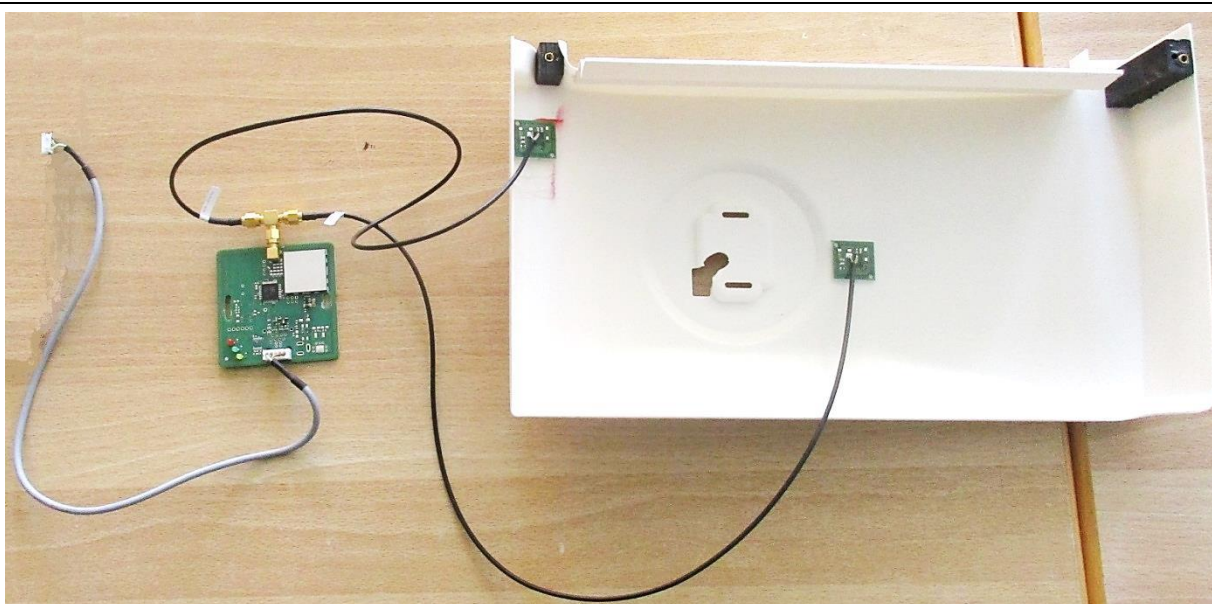
Client name and address	Ivoclar Vivadent AG Bendererstrasse 2 9494 Schaan Principality of LIECHTENSTEIN
Contact Person	Mr Alexander Bucher
Telephone	+423 235 33 02
E-mail	alexander.bucher@ivoclarvivadent.com
Mandate no	18-EL-0290

4. Equipment under test

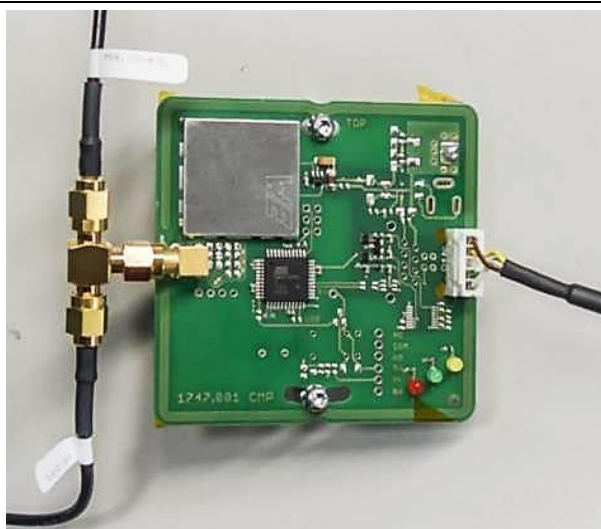
4.1 Identification

Applicant name and address	Ivoclar Vivadent AG Bendererstrasse 2 9494 Schaan Principality of LIECHTENSTEIN
Manufacturer name and address	GiS mbH Höllochstraße 1 73252 Lenningen GERMANY
Production country	Germany
Trade mark	Ivoclar Vivadent AG
Product name	13.56 MHz RFID System
Product description	13.56 MHz RFID System
Model number	TS-ModIV
Serial no	1804 54610
Software/Firmware version	1.01
FCC ID IC ID	FCC: 2ASXH-TSMODIV100 IC: 24922-TSMODIV100
Lowest Frequency	13.56 MHz (main crystal)
Highest frequency	32 MHz (internal μ Controller clock)
Supply	$U = 5 V_{DC} / I_{max} = 100 \text{ mA}$
Dimension	~70 x 70 x 10 mm (main PCB)
Technical	None. The equipment is completely identified by the above-mentioned information. Ivoclar Vivadent AG assures the traceability of the documentation and is responsible for the product identification.

4.2 Pictures of the EUT



General view



Electronic board (top)



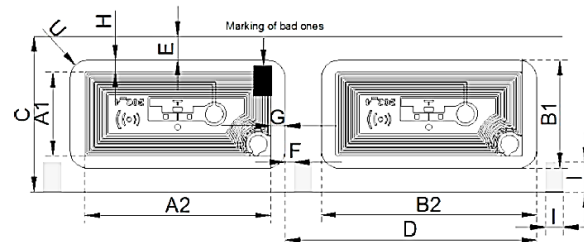
Electronic board (bottom)



Antennas

Mechanical dimensions

A1 x A2	Antenna size	14 x 31 mm	± 0,5 mm	0,551 x 1,220 in
B1 x B2	Die-cut size	18 x 36 mm	± 0,2 mm	0,709 x 1,417 in
C	Web width	26 mm	± 0,5 mm	1,024 in
D	Pitch, length per piece MD	42 mm	± 1,5 mm	1,654 in
E	Die-cut to web edge	4 mm	± 1,5 mm	0,157 in
F	Die-cut to register mark	1,5 mm	± 1,0 mm	0,059 in
G	Antenna to die-cut (MD)	2,5 mm	± 1,5 mm	0,098 in
H	Antenna to die-cut (CD)	2 mm	± 1,5 mm	0,079 in
	Minimum size of register mark (width x length)	5x3 mm		0,197 x 0,118 in
U	Die-cut corner radius	3 mm		0,118 in
	Thickness of the IC	127 µm	± 15 %	
	Overall thickness of transponder package (excluding IC and siliconized paper)	201 µm	± 10 %	
	Thickness of the siliconized paper	56 µm	± 5 %	



Tag (drawing)

4.3 Classification

CFR 47 Part 15	☒ Unintentional radiator (Subpart B), Standby mode ☐ Class A digital device ☒ Class B digital device ☒ The highest frequency of the internal sources of the EUT is less than 108 MHz (measurement shall be made up to 1 GHz). ☐ The highest frequency of the internal sources of the EUT is between 108 MHz and 500 MHz (measurement shall be made up to 2 GHz). ☐ The highest frequency of the internal sources of the EUT is between 500 MHz and 1 GHz (measurement shall be made up to 5 GHz). ☐ The highest frequency of the internal sources of the EUT is above 1 GHz (measurement shall be made up to 5 times the highest frequency or 40 GHz, whichever is lower). ☒ Intentional radiator (Subpart C), Read / Write mode ☒ The highest fundamental frequency of the EUT is less than 10 GHz (measurement shall be made up to the tenth harmonic or 40 GHz, whichever is lower). ☐ The highest fundamental frequency of the EUT is between 10 GHz and 30 GHz (measurement shall be made up to the fifth harmonic or 100 GHz, whichever is lower). ☐ The highest fundamental frequency of the EUT is above 30 GHz (measurement shall be made up to the fifth harmonic or 200 GHz, whichever is lower).
----------------	--

4.4 Transmitter characteristics (according to Ivoclar Vivadent AG)

Radio technology	<i>Near magnetic field communication 13.56 MHz</i>
Type of equipment	<i>3D Printer with RFID Reader</i>
Supply voltage	<i>5 VDC (module)</i>
Data rate	<i>26 kBd ISO 15693</i>
Temperature range	<i>-10 °C to +55 °C</i>
TX operating frequency range	<i>13.56 MHz</i>
Number of channels	<i>1</i>
Channel separation (if applicable)	<i>N/A</i>
Maximum rated output power	<i>200 mW Transmitter ASIC</i>
Type of modulation	<i>ASK (no FHSS)</i>
RF Electronic Board	<i>TS-HRW390-1437</i>
Antenna / Coil used	<i>2x TS-AH20-1854</i>
Tag used	<i>TS-HICX2-36x18</i>

4.5 Ports

Port	Cable			Remark
	Max. length	Type	Screen	
<i>J1503</i>	<i>46 cm</i>	<i>JST XHP-4 (4 wires)</i>	<i>None</i>	<i>5 VDC power input and RS232 signals</i>
<i>Antenna</i>	<i>60 cm</i>	<i>SMA</i>	<i>Coaxial</i>	<i>Permanently attached to dedicated antennas</i>

5. Test conditions

5.1 Climatic conditions, location and date

Location	Date	Temp.	Pressure	Rel. humidity
<i>Eurofins Electrosuisse Product Testing AG 1728 Rossens SWITZERLAND</i>	<i>February 7 – 8, 2019</i>	<i>See § 6</i>		

5.2 Test facility and methodology

The test site is accepted by FCC:

- Test Firm Registration Number: 683197
- Designation Number: CH5001

The test site is accepted by Industry Canada:

- ISED Assigned Code: 3625A
- Ferrite chamber (06-01): 3625A-2
- Foam chamber (06-00): 3625A-3

Conducted and radiated measurements are performed according to the ANSI C63.4-2014 and C63.10-2013 procedures.

5.3 Attendant persons

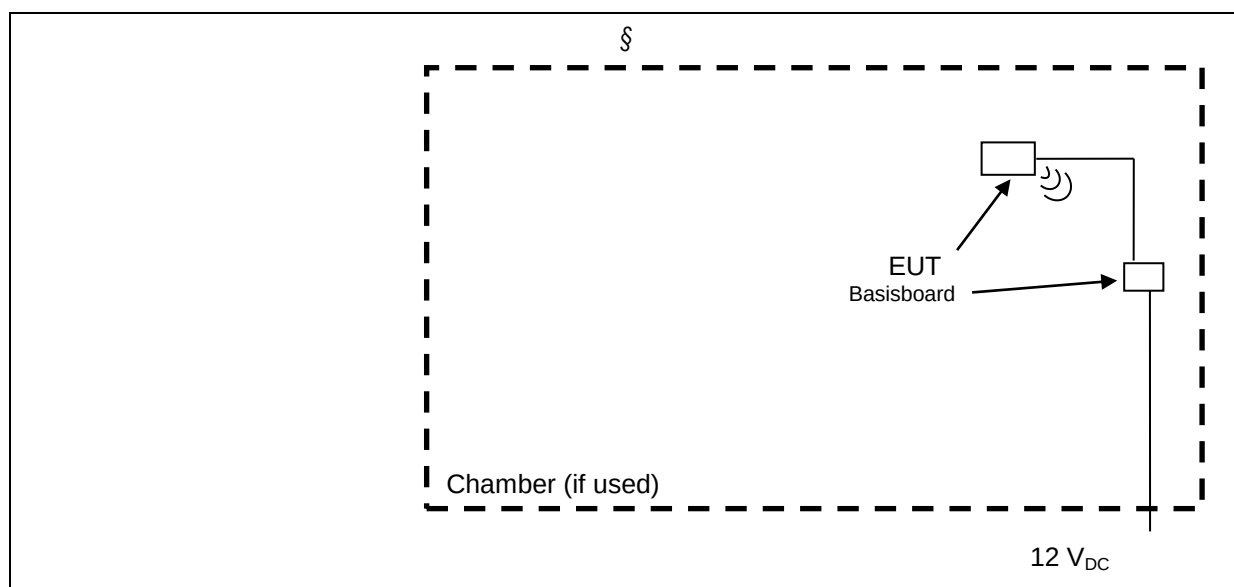
Test Engineer(s):

*Mr B. Itzcovich
EMC Test Engineer*

Other(s):

Name	Company
<i>Mr Alexander Bucher</i>	<i>Ivoclar Vivadent AG</i>

5.4 Test configuration



5.5 Operating conditions

Power supply during tests if not stated otherwise in § 6 : 5 V_{DC}

- Alternatively reading and writing at maximum power, with modulation, $T = 0.5$ s
- Standby

5.6 Auxiliary equipment

The following pieces of equipment are used for the monitoring of the EUT or are necessary for the EUT but they are not part of the EUT

Product	Brand	Model No.	ID	Remark
Basisboard	Ivoclar Vivadent	SL-G2	18256-6202 V3.1	To power EUT and set it into operation
Printer	Ivoclar Vivadent	PrograPrint PR5	9200000007	To power EUT from the AC mains



Printer

PrograPrint PR5

ivoclar
digital:

2018

Ivoclar Vivadent AG
FL-9494 Schaan
Liechtenstein
Made in Austria

V ~ 100 - 240
Hz 50 - 60
A 2.5 max

Ser. No. 9200000003



+9200000003W/

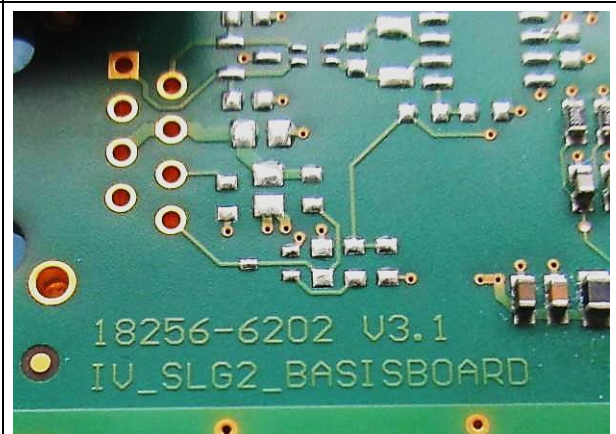


+DIVO6987031W

Marking on Printer



Basisboard



18256-6202 V3.1
IV_SLG2_BASISBOARD

Marking on Basisboard

6. Test results

6.1 Field strength within and outside the band 13.110-14.010 MHz (Carrier and Band Edge)Test site: ☒ semi-anechoic chamber (ferrites) ☐ semi-anechoic chamber (foam)Distance: ☐ 1 m ☒ 3 m ☐ 10 m ☐ 30 m

Position of EUT: 0.8 m (height of the equipment under test above floor)

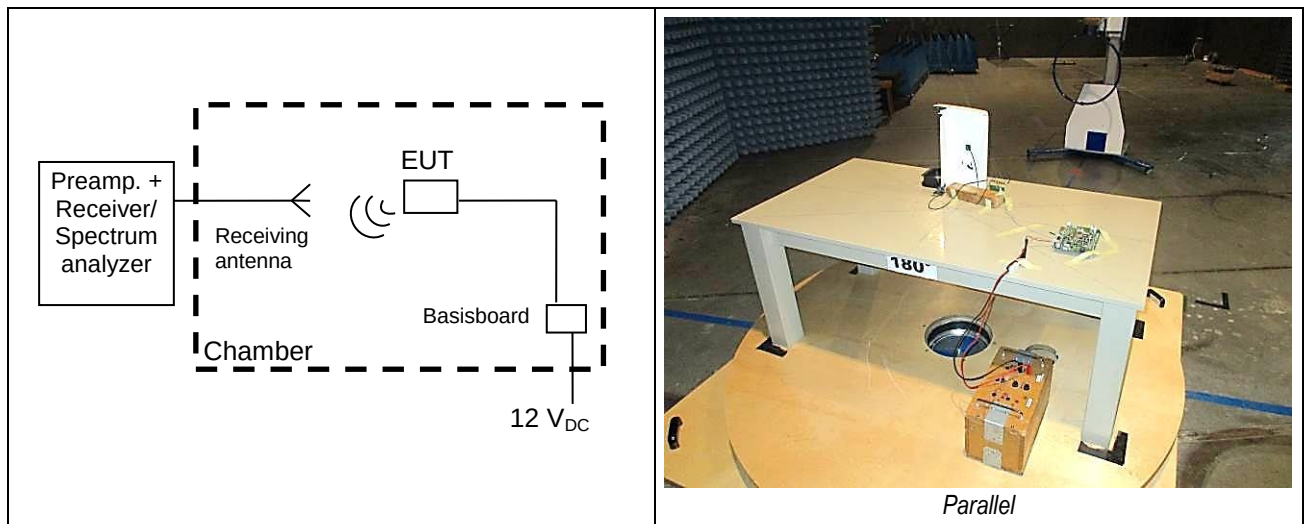
Meas. uncertainty: ± 2.8 dB (10 m)

Test method: The magnetic disturbance radiated by the equipment under test is measured using a spectrum analyzer and a wide band magnetic antenna. The center of the antenna is placed at 1 m of height, first in the direction of the apparatus under test, then at 90° to the apparatus and if required also horizontally. If possible the turning table is operated through 360° during the measurement. The recording is carried out taking into account the maximum value of the disturbance appearing during the functioning of the apparatus under test. The peak values are recorded continuously on a graph. The values exceeding the limits are re-measured using a measuring receiver.

Modifications: ☒ None ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

Climatic conditions: Temperature: 22 °C Humidity: 45 % Pressure QFE: 932 hPa

Test set-up:



Remarks: Measurement performed at 3 m distance because carrier level is very low.
Limit values expressed in dB μ V/m and transformed to the measuring distance, if different from the distance of the limit (factor used = 40 dB/decade). e.g.: for $f = 13.56$ MHz the limit is 15'848 μ V/m at 30 m;

$$20 \log \left(\frac{15'848 \frac{\mu V}{m}}{1 \frac{\mu V}{m}} \right) + 40 \log \left(\frac{30 m}{3 m} \right) = 124.0 \frac{dB \mu V}{m} \text{ at } 3 m$$

Test equipment:

Spectrum analyzer	☐ 88-14	☐ 94-24	☐ 02-06	☐ 03-45	☐ 05-39	☒ 10-70
Receiver	☐ 85-04	☐ 90-43	☐ 94-35	☐ 04-29	☒ 10-70	
Preamplifier	☐ 90-01	☐ 95-86	☐ 05-56	☐ 05-59	☐ 05-62	
Antenna (type: magnetic)	☒ 90-25	☐ 90-28	☐ 99-32	☐ 04-79		
Cables	☒ 18-10	☐ 06-236				

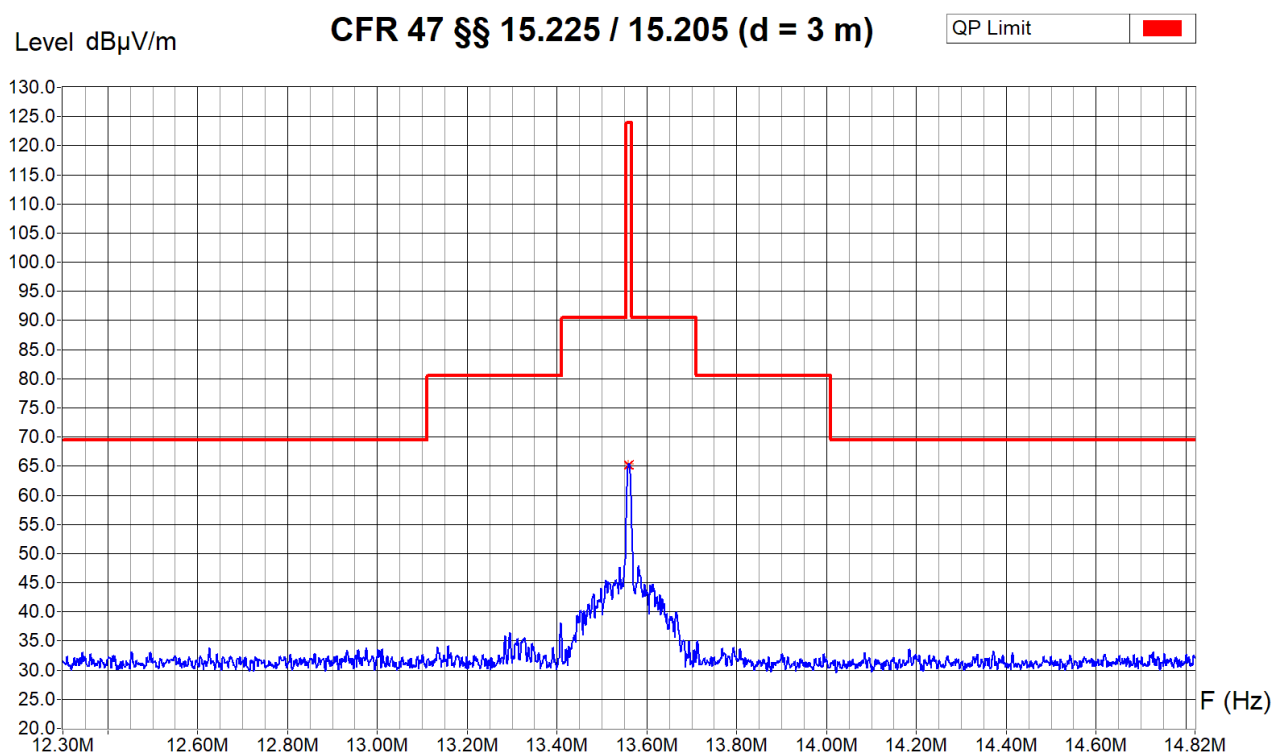
Result: ☒ pass ☐ fail ☐ not applicable ☐ not tested

Measurement Type : Radiated Field
 Polarisation : Parallel
 Table Angle : 0 - 360°
 Antenna Height : 1 m



Electrosuisse
Product Testing

Equipment Under Test : TS-ModIV RFID System (incl. TS-HRW390-1437 & 2x TS-AH20-1854 antennas)
 Set-Up : With auxiliary SL-G2 Baseboard and Tag TS-HICX2-36x18 on table. See photos
 Operating Conditions : TX (Reading and Writing), f = 13.56 MHz, Max. power (200 mW), modulated
 Remarks : Chamber 06-01. "Parallel" means "Loop antenna axis towards EUT"



Zone	12.30 MHz - 14.82
Video Bandwidth	30 KHz
Resol Bandwidth	9 KHz

Receiver Measures

Frequency	Peak	QuasiPeak (x)	Average (+)	QP Margin
13.56 MHz	65.5 dB μ V/m	65.2 dB μ V/m	65.4 dB μ V/m	58.8 dB

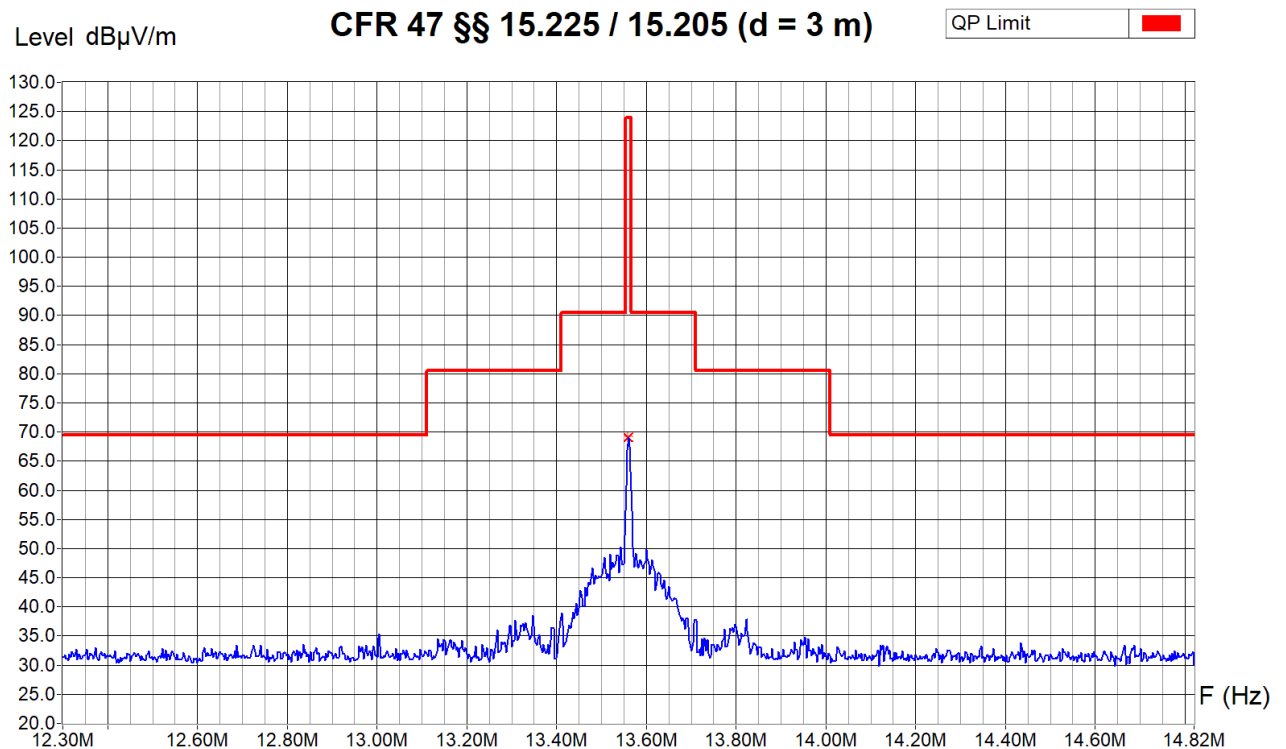
Sample calculation with all conversion and correction factors used				
Frequency [MHz]	Receiver QP value [dB μ V]	Cable att. corr. [dB]	Antenna factor corr. [dB]	QP field [dB μ V/m]
13.56	44.3	+0.3	+20.6	= 65.2

Operator: B. Itzcovich
 Date/Time: 07.02.2019 13:35
 Filename:
 05_RE_13M56_TX_FCC_Par.png/
 .txt

Measurement Type : Radiated Field
Polarisation : Perpendicular
Table Angle : 0 - 360°
Antenna Height : 1 m



Equipment Under Test : TS-ModIV RFID System (incl. TS-HRW390-1437 & 2x TS-AH20-1854 antennas)
Set-Up : With auxiliary SL-G2 Baseboard and Tag TS-HICX2-36x18 on table. See photos
Operating Conditions : TX (Reading and Writing), f = 13.56 MHz, Max. power (200 mW), modulated
Remarks : Chamber 06-01. "Parallel" means "Loop antenna axis towards EUT"



Zone	12.30 MHz - 14.82
Video Bandwidth	30 KHz
Resol Bandwidth	9 KHz

Receiver Measures

Frequency	Peak	QuasiPeak (x)	Average (+)	QP Margin
13.56 MHz	69.2 dB μ V/m	69.1 dB μ V/m	69.2 dB μ V/m	54.9 dB

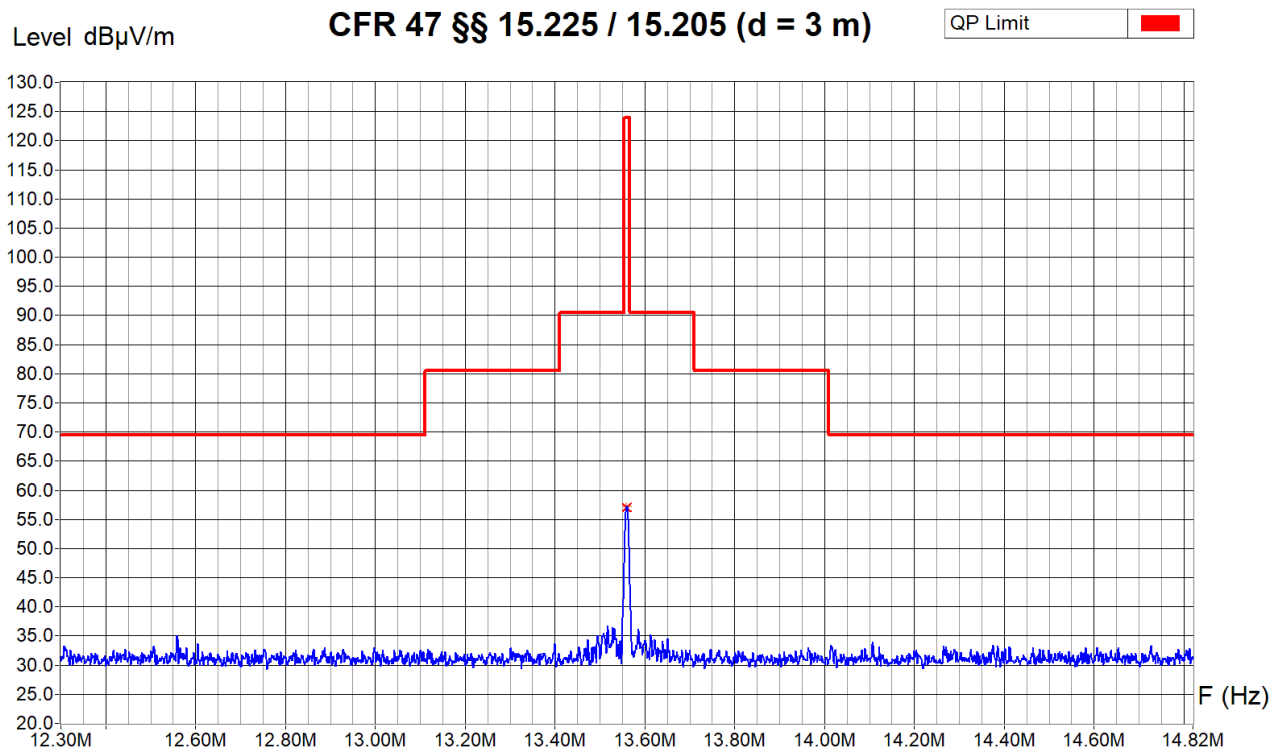
Operator: B. Itzcovich
Date/Time: 07.02.2019 14:13
Filename:
06_RE_13M56_TX_FCC_Per.png/
.txt

Measurement Type : Radiated Field
Polarisation : Horizontal
Table Angle : 0 - 360°
Antenna Height : 1 m



Electrosuisse
Product Testing

Equipment Under Test : TS-ModIV RFID System (incl. TS-HRW390-1437 & 2x TS-AH20-1854 antennas)
Set-Up : With auxiliary SL-G2 Baseboard and Tag TS-HICX2-36x18 on table. See photos
Operating Conditions : TX (Reading and Writing), $f = 13.56$ MHz, Max. power (200 mW), modulated
Remarks : Chamber 06-01. "Parallel" means "Loop antenna axis towards EUT"



Zone	12.30 MHz - 14.82
Video Bandwidth	30 KHz
Resol Bandwidth	9 KHz

Receiver Measures

Frequency	Peak	QuasiPeak (x)	Average (+)	QP Margin
13.56 MHz	57.5 dB μ V/m	57.1 dB μ V/m	57.2 dB μ V/m	66.9 dB

Operator: B. Itzcovich
Date/Time: 07.02.2019 14:28
Filename:
07_RE_13M56_TX_FCC_Hor.png/
.txt

6.2 Spurious emissions, transmit mode – radiated

6.2.1 9 kHz to 30 MHz

Test site: ☐ semi-anechoic chamber (foam) ☐ open test site
☒ semi-anechoic chamber (ferrites) ☐

Distance: ☒ 3 m ☐ 10 m ☐ 30 m

Position of EUT: 0.8 m (height of the equipment under test above floor)

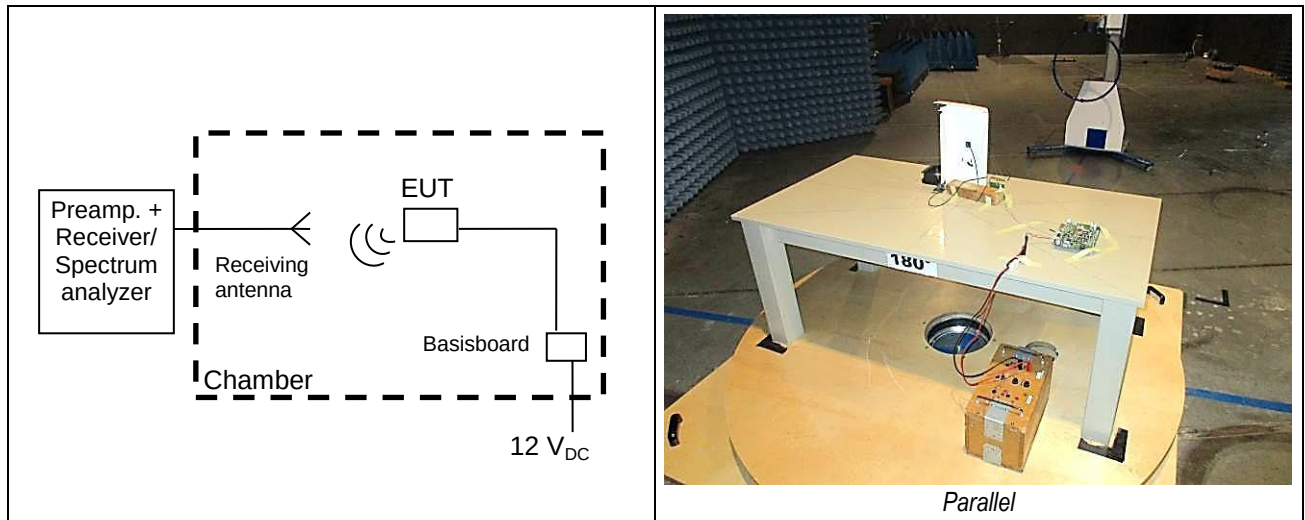
Meas. Uncertainty: ± 2.8 dB

Test method: The magnetic disturbance radiated by the equipment under test is measured using a spectrum analyzer and a wide band magnetic antenna. The antenna is placed at 1 m height, first in the direction of the apparatus under test, then at 90° to the apparatus and if required also horizontally. If possible the turning table is operated through 360° during the measurement. The recording is carried out taking into account the maximum value of the disturbance appearing during the functioning of the apparatus under test. The peak values are recorded continuously on a graph. The values exceeding the limits are re-measured using a measuring receiver.

Modifications: ☒ None ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

Climatic conditions: Temperature: 22 °C Humidity: 45 % Pressure QFE: 932 hPa

Test set-up:



Remarks: Limit values expressed in dB μ V/m and transformed to a measuring distance of 3 m
 (factor used = 40 dB/decade) if necessary
 e.g.: for $f = 10$ MHz the limit is 30 μ V/m at 30 m;

$$20 \log \left(\frac{30 \frac{\mu V}{m}}{1 \frac{\mu V}{m}} \right) + 40 \log \left(\frac{30 m}{10 m} \right) = 69.5 \frac{dB\mu V}{m} \text{ at } 3m$$

Test equipment:

Spectrum analyzer	☐ 88-14	☐ 94-24	☐ 02-06	☐ 03-45	☐ 05-39	☒ 10-70
Receiver	☐ 85-04	☐ 90-43	☐ 94-35	☐ 04-29	☒ 10-70	
Preamplifier	☐ 90-01	☐ 95-86	☐ 05-56	☐ 05-59	☐ 05-62	
Antenna (type: magnetic)	☒ 90-25	☐ 90-28	☐ 99-32	☐ 04-79		
Cables	☒ 18-10	☐ 06-236				

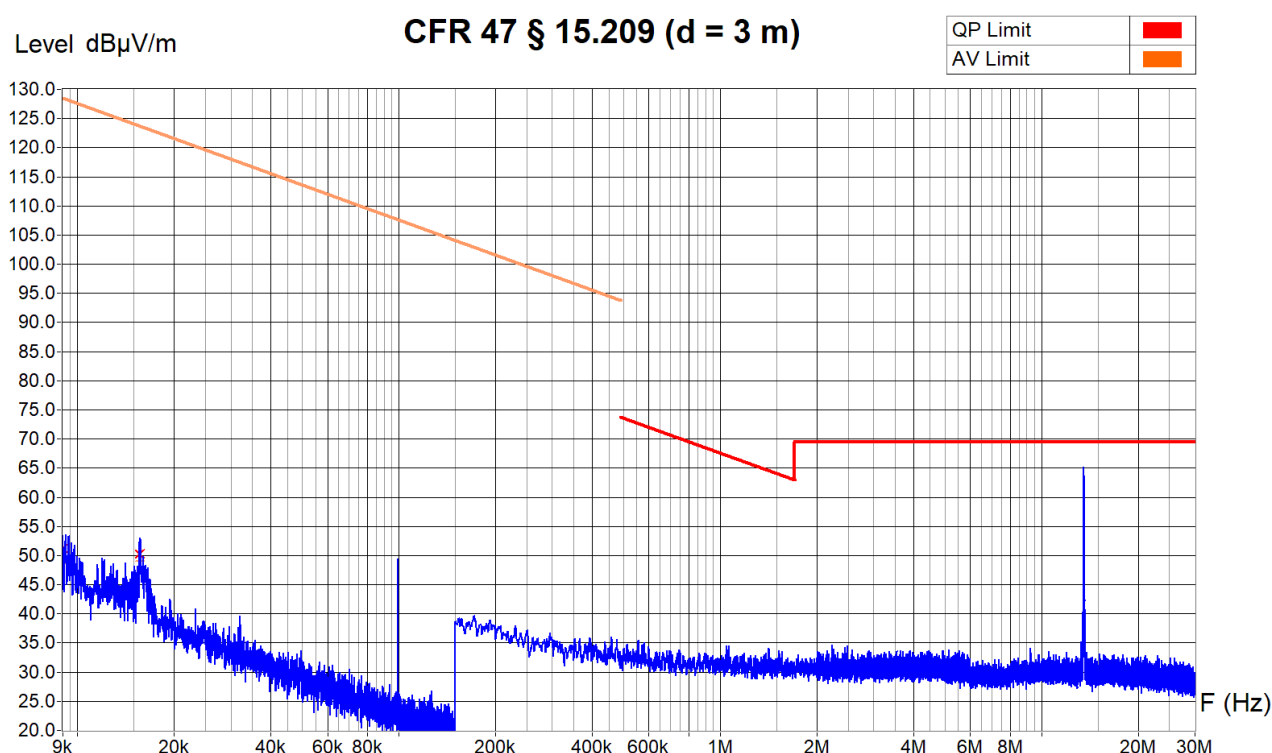
Result: ☒ pass ☐ fail ☐ not applicable ☐ not tested

Measurement Type : Radiated Field
Polarisation : Parallel
Table Angle : 0 - 360°
Antenna Height : 1 m



Electrosuisse
Product Testing

Equipment Under Test : TS-ModIV RFID System (incl. TS-HRW390-1437 & 2x TS-AH20-1854 antennas)
Set-Up : With auxiliary SL-G2 Baseboard and Tag TS-HICX2-36x18 on table. See photos
Operating Conditions : TX (Reading and Writing), f = 13.56 MHz, Max. power (200 mW), modulated
Remarks : Chamber 06-01. "Parallel" means "Loop antenna axis towards EUT"



Zone	9 KHz - 150 KHz	150 KHz - 6 MHz	6 MHz - 30 MHz
Video Bandwidth	2 KHz	100 KHz	100 KHz
Resol Bandwidth	200 Hz	9 KHz	9 KHz

Receiver Measures

Frequency	Peak	QuasiPeak (x)	Average (+)
9.01 KHz	57.4 dBμV/m	51.3 dBμV/m	48.6 dBμV/m
15.62 KHz	55.8 dBμV/m	50.2 dBμV/m	49.0 dBμV/m

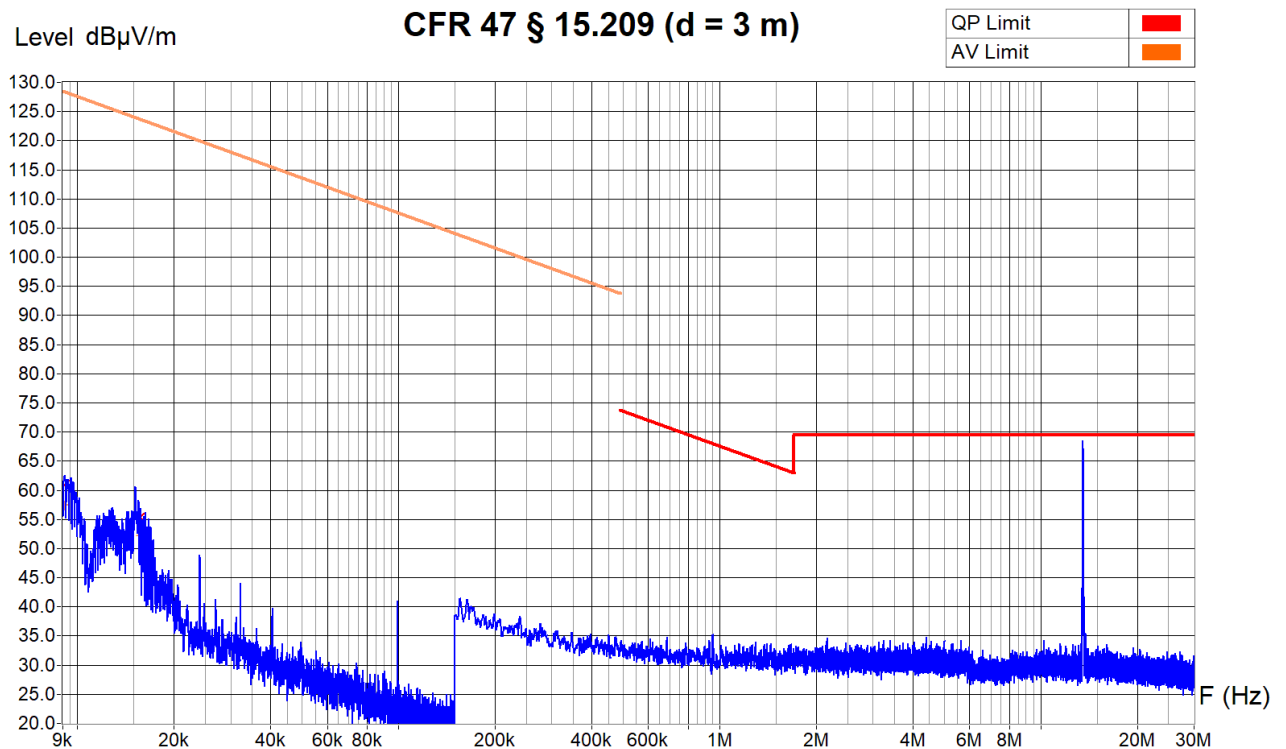
Sample calculation with all conversion and correction factors used				
Frequency [kHz]	Receiver AV value [dBμV]	Cable att. corr. [dB]	Antenna factor corr. [dB]	AV field [dBμV/m]
15.62	28.1	+0.2	+20.7	= 49.0

Operator: B. Itzcovich
Date/Time: 07.02.2019 15:32
Filename:
08_RE_9k-
30M_TX_FCC_Par.png/.txt

Measurement Type : Radiated Field
 Polarisation : Perpendicular
 Table Angle : 0 - 360°
 Antenna Height : 1 m



Equipment Under Test : TS-ModIV RFID System (incl. TS-HRW390-1437 & 2x TS-AH20-1854 antennas)
 Set-Up : With auxiliary SL-G2 Baseboard and Tag TS-HICX2-36x18 on table. See photos
 Operating Conditions : TX (Reading and Writing), f = 13.56 MHz, Max. power (200 mW), modulated
 Remarks : Chamber 06-01. "Parallel" means "Loop antenna axis towards EUT"



Zone	9 KHz - 150 KHz	150 KHz - 6 MHz	6 MHz - 30 MHz
Video Bandwidth	2 KHz	100 KHz	100 KHz
Resol Bandwidth	200 Hz	9 KHz	9 KHz

Receiver Measures

Frequency	Peak	QuasiPeak (x)	Average (+)
9.13 KHz	72.7 dB μ V/m	61.0 dB μ V/m	57.4 dB μ V/m
15.63 KHz	62.2 dB μ V/m	55.4 dB μ V/m	52.2 dB μ V/m

Frequency	Average RMS detector meas. @ 3 m
9.13 kHz	57.4 dB μ V/m

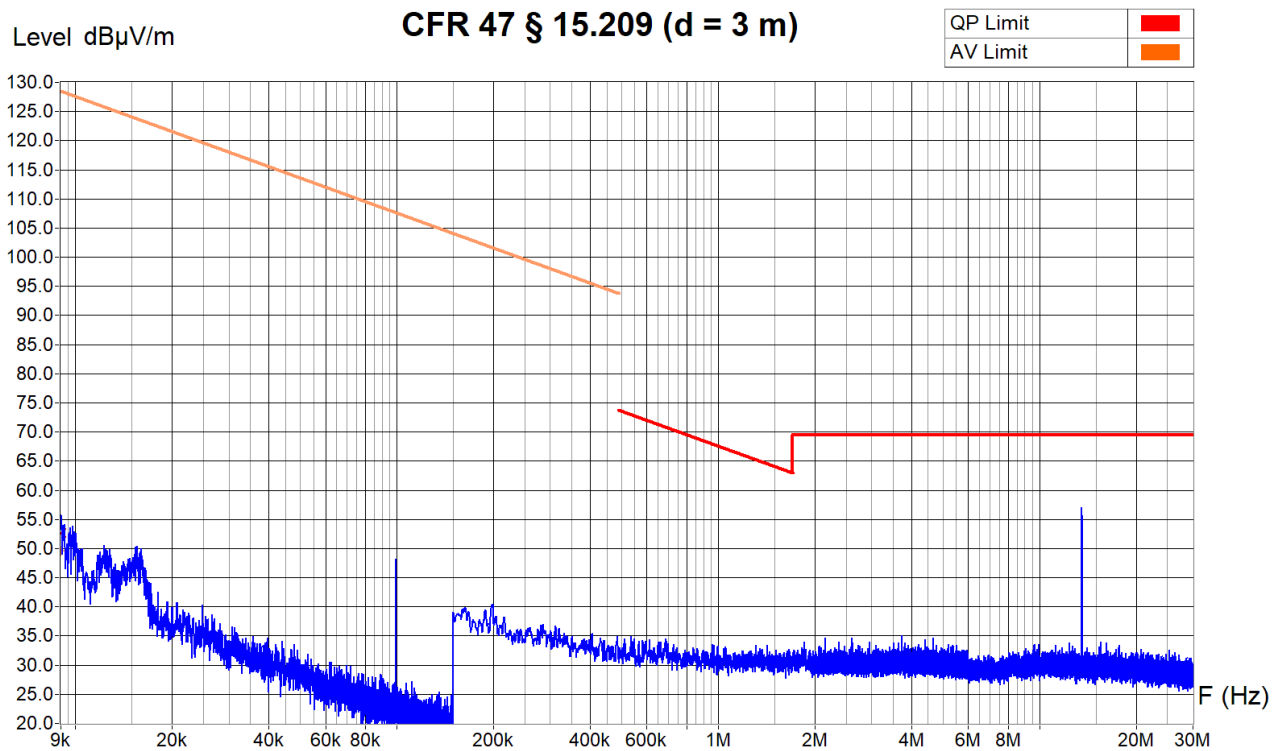
Operator: B. Itzcovich
 Date/Time: 07.02.2019 15:13
 Filename:
 09_RE_9k-
 30M_TX_FCC_Per.png/.txt

Measurement Type : Radiated Field
 Polarisation : Horizontal
 Table Angle : 0 - 360°
 Antenna Height : 1 m



Electrosuisse
Product Testing

Equipment Under Test : TS-ModIV RFID System (incl. TS-HRW390-1437 & 2x TS-AH20-1854 antennas)
 Set-Up : With auxiliary SL-G2 Baseboard and Tag TS-HICX2-36x18 on table. See photos
 Operating Conditions : TX (Reading and Writing), f = 13.56 MHz, Max. power (200 mW), modulated
 Remarks : Chamber 06-01. "Parallel" means "Loop antenna axis towards EUT"



Zone	9 KHz - 150 KHz	150 KHz - 6 MHz	6 MHz - 30 MHz
Video Bandwidth	2 KHz	100 KHz	100 KHz
Resol Bandwidth	200 Hz	9 KHz	9 KHz

Receiver Measures

Frequency	Peak	QuasiPeak (x)	Average (+)
9.01 KHz	58.4 dB μ V/m	52.6 dB μ V/m	49.6 dB μ V/m

Operator: B. Itzcovich
 Date/Time: 07.02.2019 14:55
 Filename:
 10_RE_9k-
 30M_TX_FCC_Hor.png/.txt

6.2.2 30 MHz to 1 GHz

Test site: ☐ semi-anechoic chamber (foam) ☐ open test site
☒ semi-anechoic chamber (ferrites) ☐

Distance: ☐ 3 m ☒ 10 m ☐ 30 m

Position of EUT: 0.8 m (height of the equipment under test above floor)

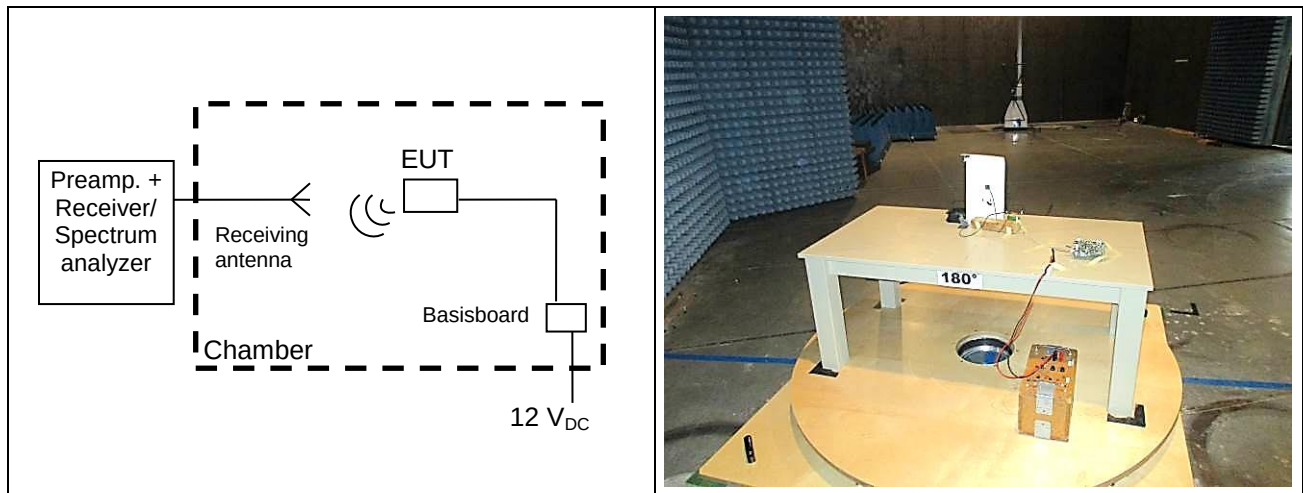
Meas. Uncertainty: ± 4.6 dB (30 – 300 MHz) / ± 3.7 dB (300 – 1000 MHz)

Test method: The electromagnetic disturbance radiated by the equipment is measured using a spectrum analyzer and a wide band antenna. The antenna is moved from 1 to 4 m in height successively with horizontal and vertical polarizations. The turning table is operated through 360° during the measurements. The recordings are carried out taking into account the maximum value of all the disturbances appearing while the apparatus is under test. The peak values are recorded continuously on the graph. The values exceeding a limit are re-measured manually using a receiver.

Modifications: ☒ None ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

Climatic conditions: Temperature: 22 °C Humidity: 45 % Pressure QFE: 933 hPa

Test set-up:



Remarks: - Limit values expressed in dB μ V/m and transformed to a measuring distance of 10 m (factor used = 20 dB/decade) if necessary
 e.g.: for f = 40 MHz the limit is 100 μ V/m at 3 m;

$$20 \log \left(\frac{100 \frac{\mu V}{m}}{1 \frac{\mu V}{m}} \right) + 20 \log \left(\frac{3m}{10m} \right) = 29.54 \frac{dB\mu V}{m} \text{ at } 10m$$

Test equipment:

Spectrum analyzer	☐ 88-14	☐ 94-24	☐ 02-06	☐ 03-45	☐ 05-39	☒ 10-70
Receiver	☐ 85-04	☐ 90-43	☐ 94-35	☐ 04-29	☒ 10-70	
Preamplifier	☐ 90-01	☐ 95-86	☐ 05-56	☒ 05-59	☐ 05-62	☐ 05-87
Antenna (bilog)	☒ 94-03	☐ 05-38				
Cables	☒ 18-10					

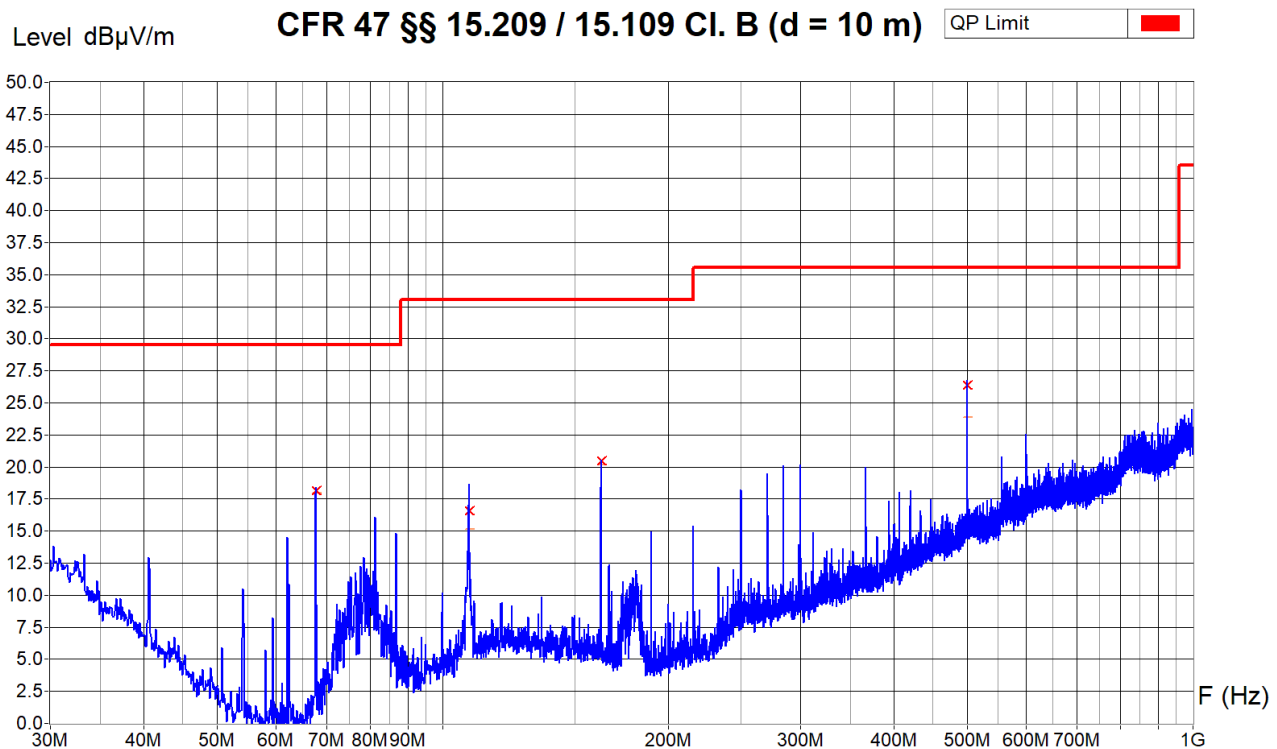
Result: ☒ pass ☐ fail ☐ not applicable ☐ not tested

Measurement Type : Radiated Field
 Polarisation : Vertical
 Table Angle : 0 - 360°
 Antenna Height : 1 - 4m



Electrosuisse
Product Testing

Equipment Under Test : TS-ModIV RFID System (incl. TS-HRW390-1437 & 2x TS-AH20-1854 antennas)
 Set-Up : With auxiliary SL-G2 Baseboard and Tag TS-HICX2-36x18 on table. See photos
 Operating Conditions : TX (Reading and Writing), f = 13.56 MHz, Max. power (200 mW), modulated
 Remarks : Chamber 06-01



Zone	30 MHz - 1 GHz
Video Bandwidth	500 KHz
Resol Bandwidth	120 KHz

Receiver Measures

Frequency	Peak	QuasiPeak (x)	Average (+)	QP Margin
67.80 MHz	19.4 dBμV/m	18.1 dBμV/m	18.0 dBμV/m	11.4 dB
108.48 MHz	20.9 dBμV/m	16.6 dBμV/m	15.2 dBμV/m	16.5 dB
162.72 MHz	21.8 dBμV/m	20.4 dBμV/m	20.2 dBμV/m	12.6 dB
500.05 MHz	29.0 dBμV/m	26.4 dBμV/m	23.9 dBμV/m	9.2 dB

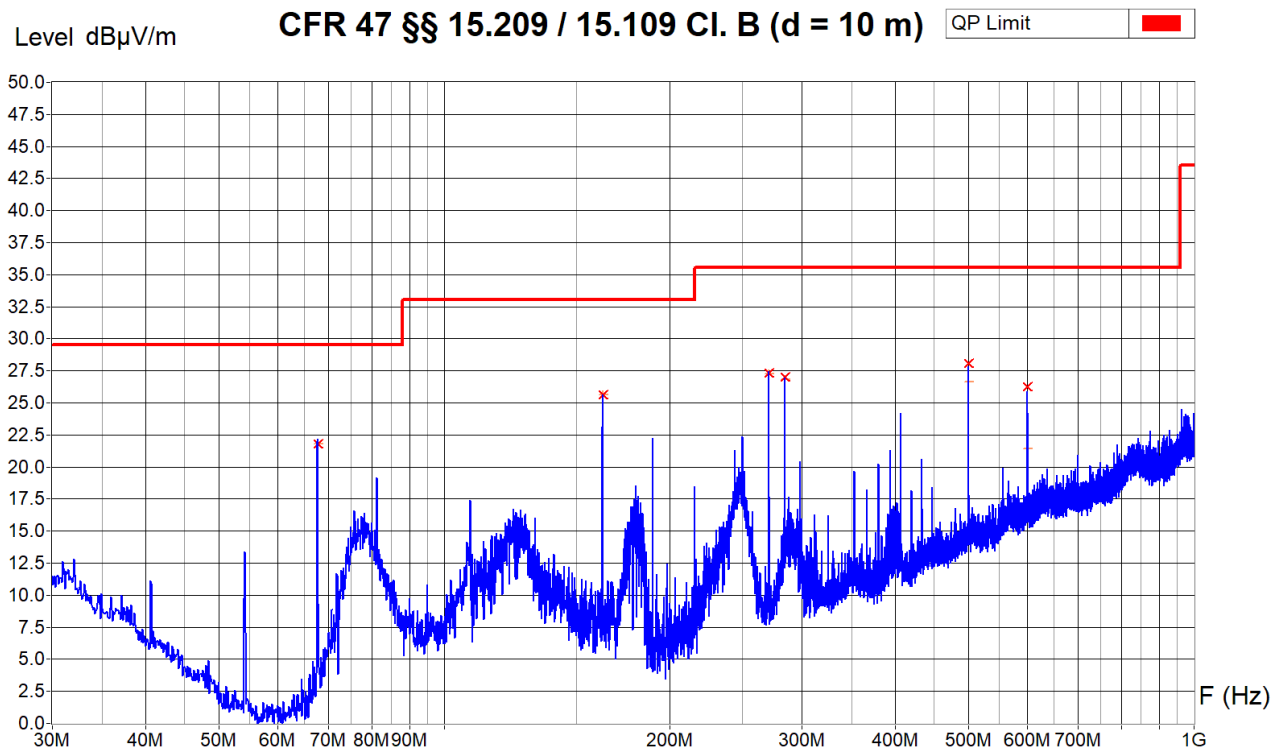
Sample calculation with all conversion and correction factors used					
Frequency [MHz]	Receiver QP value [dBμV]	Cable att. corr. [dB]	Preamp. gain corr. [dB]	Antenna factor corr. [dB]	QP field [dBμV/m]
500.05	34.2	+2	-28.8	+19.0	= 26.4

Operator: B. Itzcovich
 Date/Time: 07.02.2019 09:47
 Filename:
 01_RE_30M-1G_TX_FCC_V.png/
 .txt

Measurement Type : Radiated Field
 Polarisation : Horizontal
 Table Angle : 0 - 360°
 Antenna Height : 1 - 4m



Equipment Under Test : TS-ModIV RFID System (incl. TS-HRW390-1437 & 2x TS-AH20-1854 antennas)
 Set-Up : With auxiliary SL-G2 Baseboard and Tag TS-HICX2-36x18 on table. See photos
 Operating Conditions : TX (Reading and Writing), f = 13.56 MHz, Max. power (200 mW), modulated
 Remarks : Chamber 06-01



Zone	30 MHz - 1 GHz
Video Bandwidth	500 KHz
Resol Bandwidth	120 KHz

Receiver Measures

Frequency	Peak	QuasiPeak (x)	Average (+)	QP Margin
67.80 MHz	22.9 dB μ V/m	21.8 dB μ V/m	21.8 dB μ V/m	7.8 dB
162.72 MHz	26.8 dB μ V/m	25.7 dB μ V/m	25.6 dB μ V/m	7.4 dB
271.20 MHz	28.3 dB μ V/m	27.3 dB μ V/m	27.2 dB μ V/m	8.2 dB
284.76 MHz	29.3 dB μ V/m	27.0 dB μ V/m	26.8 dB μ V/m	8.5 dB
500.05 MHz	30.5 dB μ V/m	28.1 dB μ V/m	26.6 dB μ V/m	7.5 dB
599.99 MHz	30.1 dB μ V/m	26.2 dB μ V/m	21.4 dB μ V/m	9.3 dB

Operator: B. Itzcovich
 Date/Time: 07.02.2019 10:24
 Filename:
 02_RE_30M-1G_TX_FCC_H.png/
 .txt

6.3 Spurious emissions, standby mode – radiated

6.3.1 30 MHz to 1 GHz

Test site: ☐ semi-anechoic chamber (foam) ☐ open test site
☒ semi-anechoic chamber (ferrites) ☐

Distance: ☐ 3 m ☒ 10 m ☐ 30 m

Position of EUT: 0.8 m (height of the equipment under test above floor)

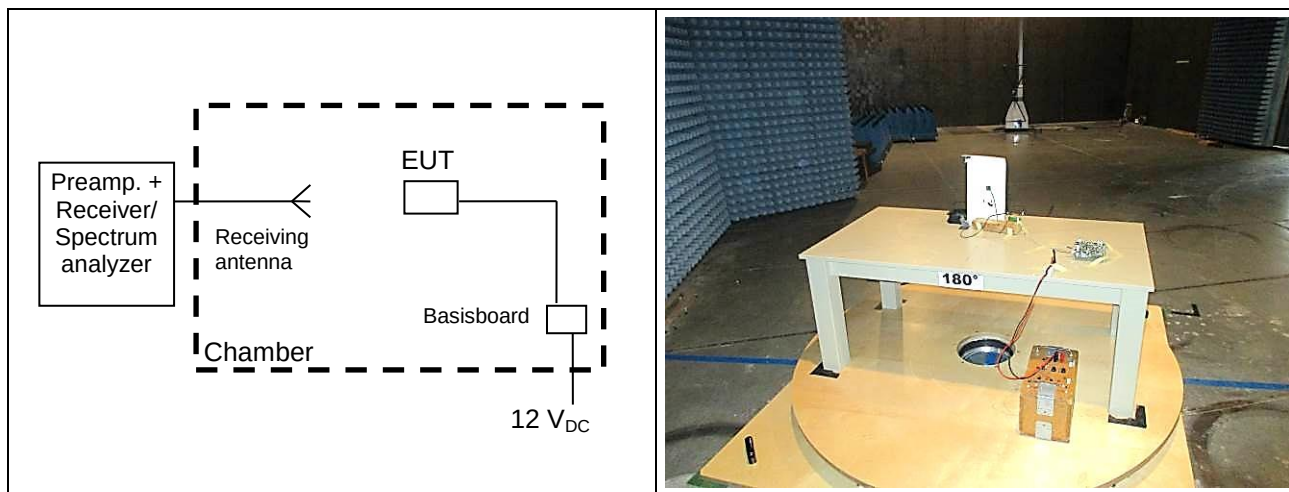
Meas. Uncertainty: ± 4.6 dB (30 – 300 MHz) / ± 3.7 dB (300 – 1000 MHz)

Test method: The electromagnetic disturbance radiated by the equipment is measured using a spectrum analyzer and a wide band antenna. The antenna is moved from 1 to 4 m in height successively with horizontal and vertical polarizations. The turning table is operated through 360° during the measurements. The recordings are carried out taking into account the maximum value of all the disturbances appearing while the apparatus is under test. The peak values are recorded continuously on the graph. The values exceeding a limit are re-measured manually using a receiver.

Modifications: ☒ None ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

Climatic conditions: Temperature: 22 °C Humidity: 45 % Pressure QFE: 933 hPa

Test set-up:



Remarks: - Limit values expressed in dB μ V/m and transformed to a measuring distance of 10 m (factor used = 20 dB/decade) if necessary
 e.g.: for f = 40 MHz the limit is 100 μ V/m at 3 m;

$$20 \log \left(\frac{100 \frac{\mu V}{m}}{1 \frac{\mu V}{m}} \right) + 20 \log \left(\frac{3m}{10m} \right) = 29.54 \frac{dB\mu V}{m} \text{ at } 10m$$

Test equipment:

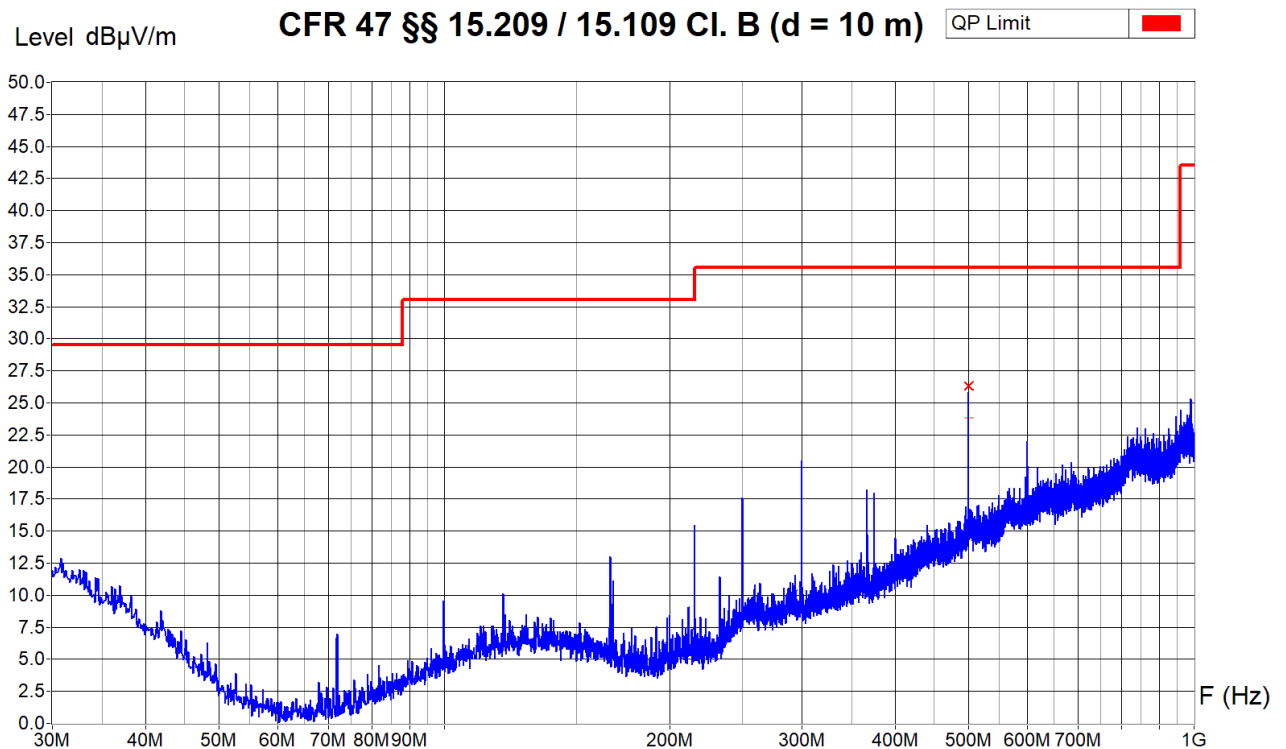
Spectrum analyzer	☐ 88-14	☐ 94-24	☐ 02-06	☐ 03-45	☐ 05-39	☒ 10-70
Receiver	☐ 85-04	☐ 90-43	☐ 94-35	☐ 04-29	☒ 10-70	
Preamplifier	☐ 90-01	☐ 95-86	☐ 05-56	☒ 05-59	☐ 05-62	☐ 05-87
Antenna (bilog)	☒ 94-03	☐ 05-38				
Cables	☒ 18-10					

Result: ☒ pass ☐ fail ☐ not applicable ☐ not tested

Measurement Type : Radiated Field
 Polarisation : Vertical
 Table Angle : 0 - 360°
 Antenna Height : 1 - 4m



Equipment Under Test : TS-ModIV RFID System (incl. TS-HRW390-1437 & 2x TS-AH20-1854 antennas)
 Set-Up : With auxiliary SL-G2 Baseboard and Tag TS-HICX2-36x18 on table. See photos
 Operating Conditions : Standby
 Remarks : Chamber 06-01



Zone	30 MHz - 1 GHz
Video Bandwidth	500 KHz
Resol Bandwidth	120 KHz

Receiver Measures

Frequency	Peak	QuasiPeak (x)	Average (+)	QP Margin
500.05 MHz	28.9 dBμV/m	26.3 dBμV/m	23.8 dBμV/m	9.3 dB

Sample calculation with all conversion and correction factors used					
Frequency [MHz]	Receiver QP value [dBμV]	Cable att. corr. [dB]	Preamp. gain corr. [dB]	Antenna factor corr. [dB]	QP field [dBμV/m]
500.05	34.1	+2	-28.8	+19.0	= 26.3

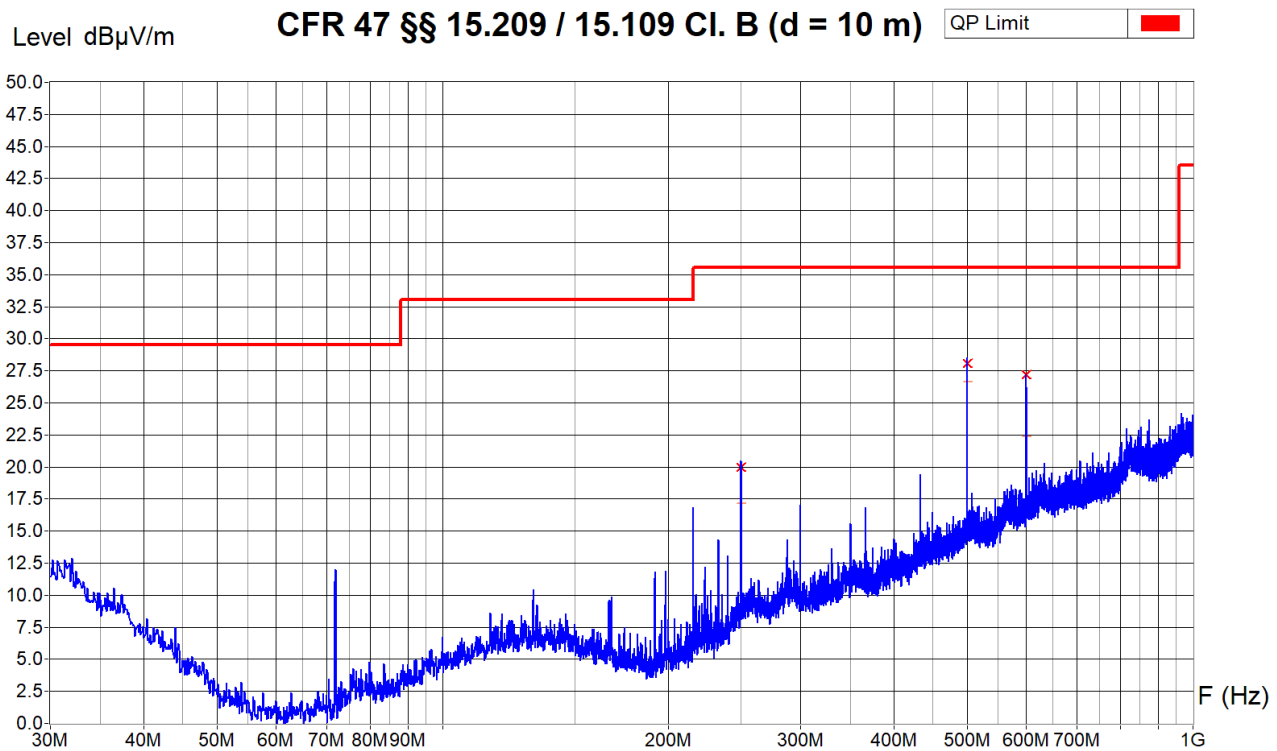
Operator: B. Itzcovich
 Date/Time: 07.02.2019 11:19
 Filename:
 03_RE_30M-
 1G_Stby_FCC_V.png/.txt

Measurement Type : Radiated Field
Polarisation : Horizontal
Table Angle : 0 - 360°
Antenna Height : 1 - 4m



Electrosuisse
Product Testing

Equipment Under Test : TS-ModIV RFID System (incl. TS-HRW390-1437 & 2x TS-AH20-1854 antennas)
Set-Up : With auxiliary SL-G2 Baseboard and Tag TS-HICX2-36x18 on table. See photos
Operating Conditions : Standby
Remarks : Chamber 06-01



Zone	30 MHz - 1 GHz
Video Bandwidth	500 KHz
Resol Bandwidth	120 KHz

Receiver Measures

Frequency	Peak	QuasiPeak (x)	Average (+)	QP Margin
250.02 MHz	22.1 dB μ V/m	20.0 dB μ V/m	17.1 dB μ V/m	15.6 dB
500.05 MHz	30.5 dB μ V/m	28.1 dB μ V/m	26.6 dB μ V/m	7.5 dB
600 MHz	32.0 dB μ V/m	27.2 dB μ V/m	22.4 dB μ V/m	8.3 dB

Operator: B. Itzcovich
Date/Time: 07.02.2019 10:56
Filename:
04_RE_30M-
1G_Stby_FCC_H.png/.txt

6.4 Conducted emission – Interference voltage

Test site: ☐ semi-anechoic chamber (foam) ☐ shielded room
☒ Semi-anechoic chamber (ferrites) ☐ laboratory

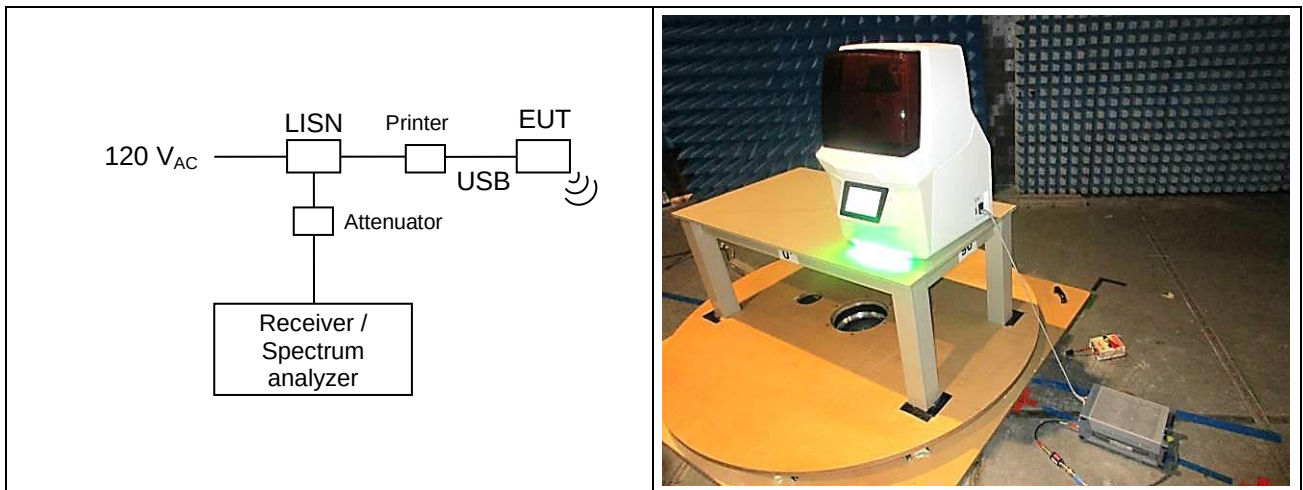
Meas. Uncertainty: ± 3.6 dB

Measuring method: The conducted disturbance is measured using a spectrum analyzer and a line impedance substitution network (LISN). The measurement of the voltage against the earth is carried out successively. The peak values are recorded continuously on the graph. The values that exceed the limit are re-measured with a measuring receiver.

Modifications: ☒ None ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

Climatic conditions: Temperature: 22 °C Humidity: 45 % Pressure QFE: 932 hPa

Test set-up:



Remarks: *EUT is powered the 120 VAC power line through an auxiliary printer because it's the intended use*

Test equipment:

Spectrum analyzer	☐ 88-14	☐ 94-24	☐ 02-06	☐ 03-45	☐ 05-39	☒ 10-70
Receiver	☐ 85-12	☐ 90-11	☒ 10-70	☐ 04-28	☐ 06-29	
LISN	☐ 85-13	☐ 90-08	☐ 94-36	☐ 94-40	☐ 95-12	☒ 00-43
Protection 10 dB	☐ 95-33	☐ 95-35	☒ 91-45	☐ 96-38	☐ included in LISN	
Protection 20 dB	☐ 91-46	☐ 95-33	☐ 95-38	☐ included in LISN		
Power source	☒ 18-02					
Cables	☒ 18-10	☐ 10-41				

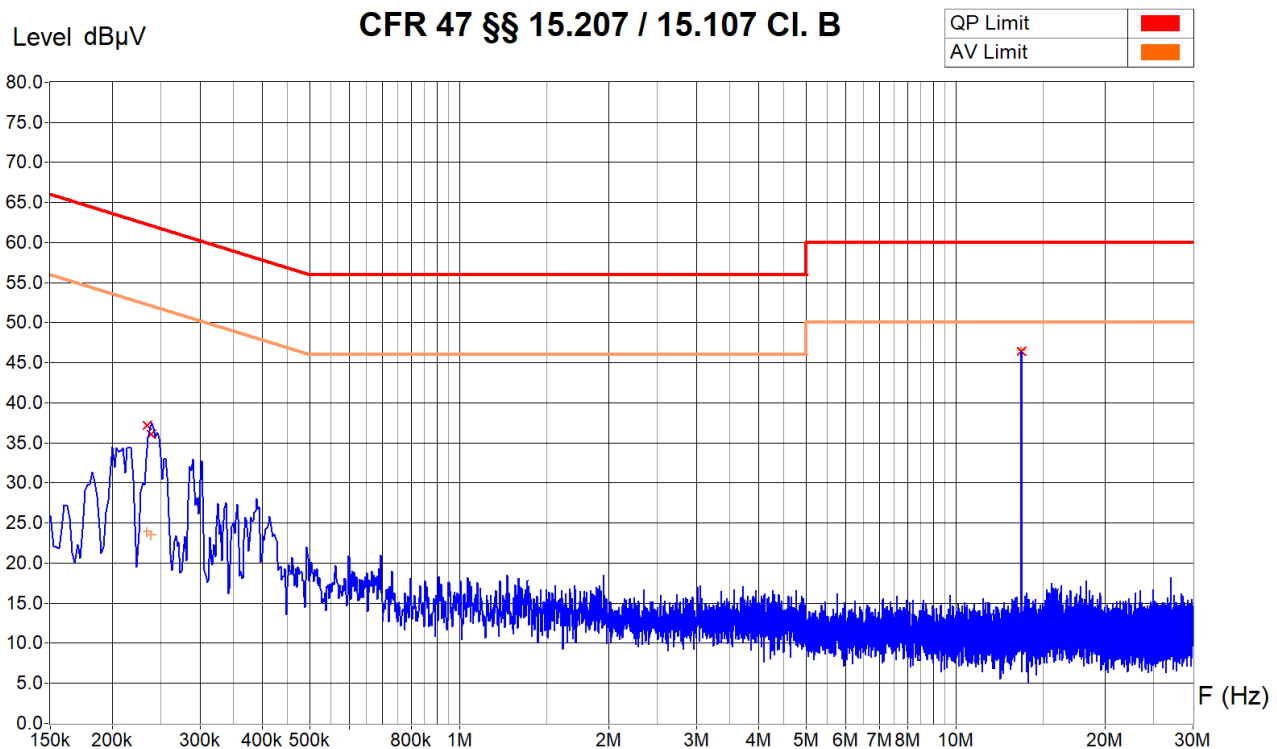
Result: ☒ pass ☐ fail ☐ not applicable ☐ not tested

Measurement Type : Voltage Interference
 Supply : Line 1
 Other : 120 V / 60 Hz



Electrosuisse
Product Testing

Equipment Under Test : TS-ModIV RFID System (incl. TS-HRW390-1437 & 2x TS-AH20-1854 antennas)
 Set-Up : Installed inside and powered from auxiliary Printer Ivoclar Vivadent PR5. See photos
 Operating Conditions : TX (Reading and Writing), f = 13.56 MHz, Max. power (200 mW), modulated
 Remarks : Chamber 06-01



Zone	150 KHz - 30 MHz
Video Bandwidth	100 KHz
Resol Bandwidth	9 KHz

Receiver Measures

Frequency	Peak	QuasiPeak (x)	Average (+)	QP Margin
235 KHz	41.0 dB μ V	37.2 dB μ V	24.0 dB μ V	25.1 dB
239 KHz	39.3 dB μ V	36.0 dB μ V	23.5 dB μ V	26.1 dB
13.56 MHz	46.7 dB μ V	46.4 dB μ V	46.5 dB μ V	13.6 dB

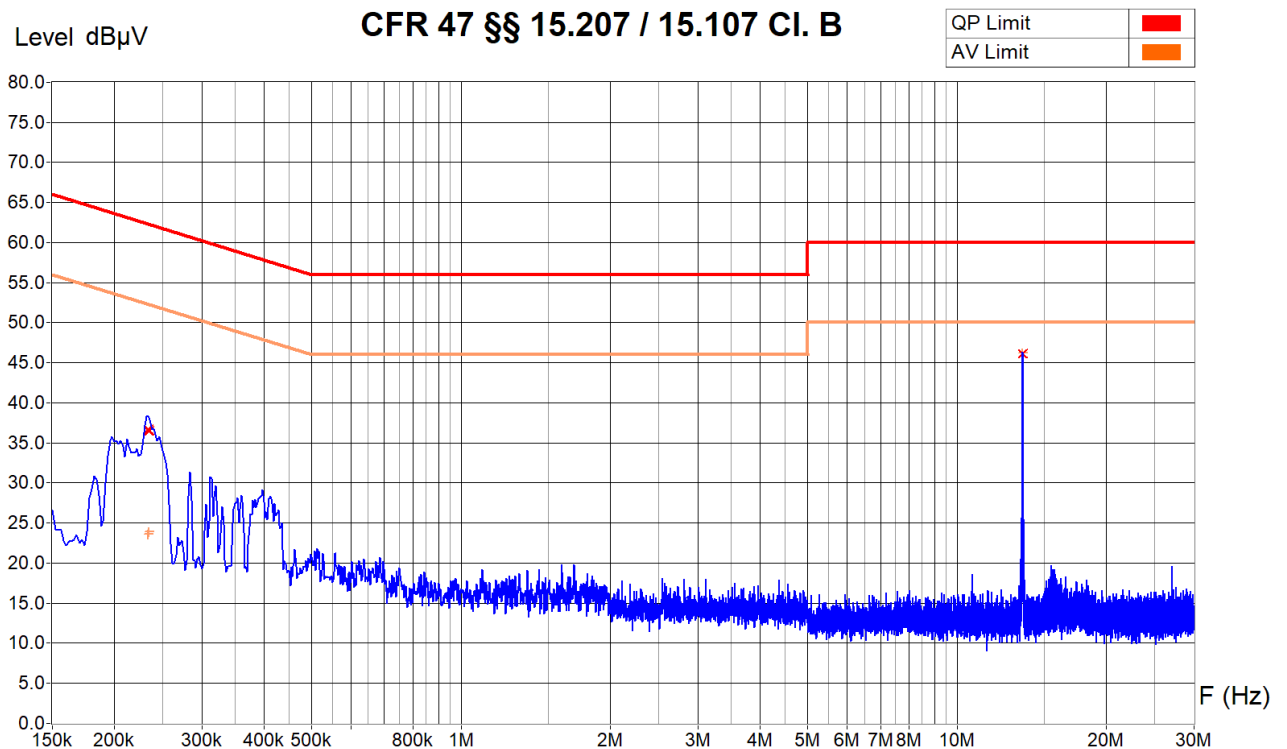
Sample calculation with all conversion and correction factors used				
Frequency [MHz]	Receiver QP value [dB μ V]	Cable att. corr. [dB]	Attenuator corr. [dB]	QP voltage [dB μ V]
13.56	36.2	+0.3	+ 10.0	= 46.5

Operator: B. Itzcovich
 Date/Time: 07.02.2019 16:27
 Filename:
 11_CV_150k-
 30M_TX_FCC_L.png/.txt

Measurement Type : Voltage Interference
 Supply : Neutral
 Other : 120 V / 60 Hz



Equipment Under Test : TS-ModIV RFID System (incl. TS-HRW390-1437 & 2x TS-AH20-1854 antennas)
 Set-Up : Installed inside and powered from auxiliary Printer Ivoclar Vivadent PR5. See photos
 Operating Conditions : TX (Reading and Writing), f = 13.56 MHz, Max. power (200 mW), modulated
 Remarks : Chamber 06-01



Zone	150 KHz - 30 MHz
Video Bandwidth	100 KHz
Resol Bandwidth	9 KHz

Receiver Measures

Frequency	Peak	QuasiPeak (x)	Average (+)	QP Margin
234 KHz	38.8 dBμV	36.7 dBμV	23.6 dBμV	25.7 dB
235 KHz	38.7 dBμV	36.5 dBμV	23.9 dBμV	25.8 dB
13.56 MHz	46.5 dBμV	46.1 dBμV	46.3 dBμV	13.9 dB

Operator: B. Itzcovich
 Date/Time: 07.02.2019 16:39
 Filename:
 12_CV_150k-
 30M_TX_FCC_N.png/.txt

6.5 Frequency stability

Introduction: The frequency error, known as frequency drift, is the difference between the frequency of the EUT measured under normal test conditions and the frequency measured under extreme conditions.

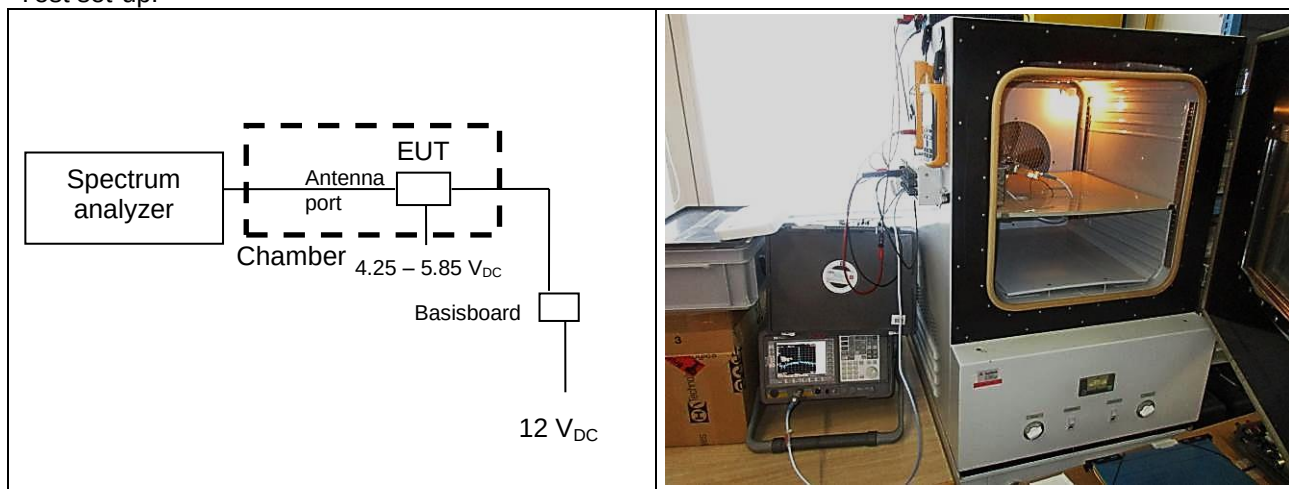
Limit: CFR 47 §15.225 (e) The frequency tolerance of the carrier signal shall be maintained within $\pm 0.01\%$ of the operating frequency over a temperature variation of -20°C to $+50^{\circ}\text{C}$ at normal supply voltage, and for a variation in the primary supply voltage from 85% to 115% of the rated supply voltage at a temperature of 20°C . For battery operated equipment, the equipment tests shall be performed using a new battery.

Test site: ☐ anechoic chamber (foam) ☐ shielded room
☐ anechoic chamber (ferrites) ☒ laboratory

Meas. uncertainty: $\pm 2.6 \mu\text{Hz/Hz}$

Test method: Measurement of the frequency and the power level at the antenna connector or at the test fixture.

Test set-up:



Remarks: ---

Test equipment:

Spectrum analyzer	☐ 88-14	☐ 94-24	☒ 02-06	☐ 03-45	☐ 05-39	☐ 10-70
Attenuator 10dB	☒ 11-36					
Temperature chamber	☒ 06-66					
Temperature probe	☐ 08-03	☐ 03-05	☐ 05-34	☒ 08-32		
Power supply	☒ 99-07	☐ 04-31				
Variable transformer	☐ 75-04					
Multimeter	☒ 14-15					
Cables	☒ 11-13					

Result: ☒ pass ☐ fail ☐ not applicable ☐ partly tested

Results of the test

Client: Ivoclar Vivadent AG
 Equipment: 13.56 MHz RFID System
 Operating mode: TX (f = 13.56 MHz), max. power
 Remarks: Measured on temporary antenna connector
 RBW = VBW = 10 Hz; Span = 1 kHz; ST = 478 ms; RefLev = 30 dBm; RefLev Offset = 10 dB;
 Detector = Peak; Trace mode = Clear Write; Nb points = 1001

Modifications: ☒ None ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5
 Climatic conditions: Temperature: 22 °C Humidity: 30 % Pressure QFE: 935 hPa

Variation of the temperature (measured at nominal supply voltage)

Reference value:

Temp [C]	Frequency [MHz]	Error [ppm]	Limit [ppm]	P [dBm]	P ERP [dbm]	Limit [dBm]	Remarks
20	13.559919	---	---	22.2	-28.3	26.6	See §6.1

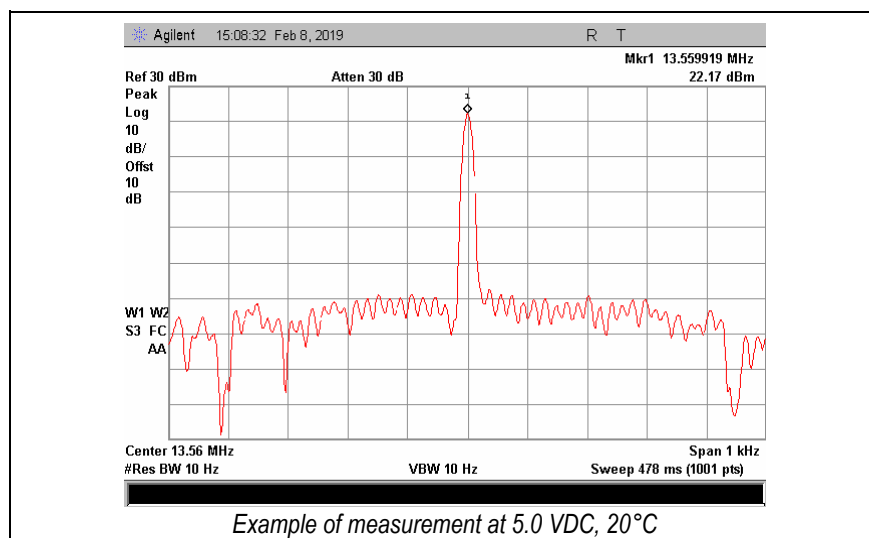
Temp [C]	Frequency [MHz]	Error [ppm]	Limit [ppm]	P [dBm]	P ERP [dbm]	Limit [dBm]	Remarks	Pass	
								Yes	No
-20	13.559881	2.8	100	22.3	-28.2	26.6	---	☒	☐
-10	13.559927	-0.6	100	22.1	-28.4	26.6	---	☒	☐
0	13.559943	-1.8	100	22.1	-28.3	26.6	---	☒	☐
10	13.559937	-1.3	100	22.2	-28.3	26.6	---	☒	☐
30	13.559902	1.3	100	22.1	-28.4	26.6	---	☒	☐
40	13.559859	4.4	100	22.2	-28.2	26.6	---	☒	☐
50	13.559834	6.3	100	22.0	-28.5	26.6	---	☒	☐

Variation of the voltage (measured at nominal temperature)

Reference value:

Voltage [V]	Frequency [MHz]	Error [ppm]	Limit [ppm]	P [dBm]	P ERP [dbm]	Limit [dBm]	Remarks
5	13.559919	---	---	22.2	-28.3	26.6	See §6.1

Voltage [V]	Frequency [MHz]	Error [ppm]	Limit [ppm]	P [dBm]	P ERP [dbm]	Limit [dBm]	Remarks	Pass	
								Yes	No
4.25	13.559920	-0.1	100	20.7	-29.8	26.6	---	☒	☐
5.75	13.559920	-0.1	100	23.4	-27.1	26.6	---	☒	☐



Place and date of test:
 Operator:

Rossens, February 8, 2019
 B. Itzcovich

6.6 Designation of emission

Standard: United States: 47 CFR "Code of Federal Regulations" – Telecommunication
☒ FCC Part 2, Subpart C: Emission: §2.201 and §2.202

Introduction: A system of designating emission, modulation and transmission characteristics shall be employed.

(a) Emissions are designated according to their classification and their necessary bandwidth.

(b) A minimum of three symbols are used to describe the basic characteristics of radio waves.

(c) Four symbols are used to describe the necessary bandwidth.

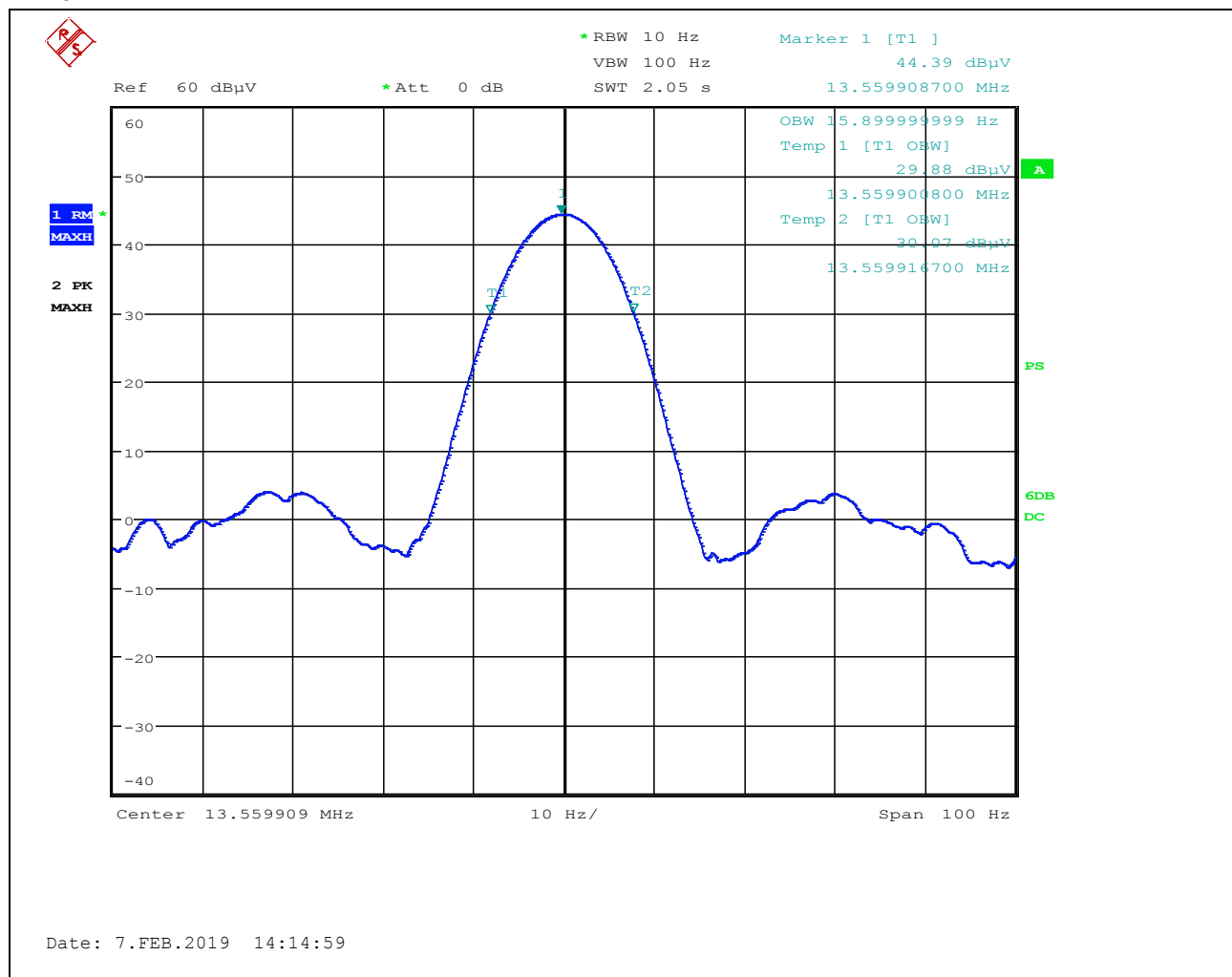
Modifications: ☒ None ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

Necessary bandwidth: For a given class of emission, the minimum value of the occupied bandwidth sufficient to ensure the transmission of information at the rate and with the quality required for the system employed, under specified conditions.

$B_n = 15.9$ Hz (occupied bandwidth)

Basic characteristics: A1D A : Double-sideband
 1 : A single channel containing quantized or digital information without the use of a modulating sub-carrier, excluding time-division multiplex
 D : data transmission

Designation of emission: 15H9A1D



Place and date of test: Rossens, February 7, 2019
 Operator: B. Itzcovich

7. Appendix

7.1 Test equipment

Inventory No.	Designation	Manufacturer	Type	Serial No.	Cal. Date	Next calibr.	Cal. Period [year]
90-25	Loop antenna	Chase	HLA6120	002	02 Jun 2017	02 Jun 2019	2
94-03	Bi-Log antenna	Chase	CBL6111	1056	24 Oct 2018	24 Oct 2020	2
91-45	Attenuator	Montena EMC	10 dB	1	05 Jun 2018	05 Jun 2020	2
11-36	Attenuator	Agilent	8491B 10 dB	MY39266234	25 Apr 2016	25 Apr 2019	3
05-59	Preamplifier	Montena EMC	AM-1300	432972	03 May 2018	03 May 2020	2
18-10	Cable	Huber&Suhner	SF118B/11N/11N/ 15000mm	500000/118	30 Nov 2018	30 Nov 2020	2
11-13	Cable	Huber&Suhner	SF104	332033/4	10 May 2017	10 May 2019	2
00-43	LISN	Rohde&Schwarz	ESH3-Z5	890 604/026	06 Jun 2018	06 Jun 2020	2
02-06	Spectr. Analyzer	Hewlett Packard	E4407B	US39010188	22 Jan 2019	22 Jan 2021	2
10-70	Receiver + Spectr. Analyzer	Rohde&Schwarz	ESU8 1302.6005K08	100231	03 Dec 2018	03 Dec 2020	2
14-15	Multimeter	Fluke	179	26250434	28 Oct 2016	28 Oct 2019	3
08-32	Temperature probe	Yokogawa	MV2000	S5H102176	03 Dec 2018	03 Dec 2020	2
18-02	Power Supply	Regatron	TC.ACS.50.528.4WR .S.LC	174125099	08 May 2018	08 May 2020	2
99-07	Power supply	Coutant	LA200.2	8A.259.	NO CAL	NO CAL	-
06-66	Temperature chamber	Ernst Vötsch	VTK 04 / 125	11 303	30 Mar 2010	NO CAL	-

Remark: The test equipment, for which no calibration date is defined, is controlled during the test by calibrated equipment. E.g. the output of a power supply is verified by a calibrated multimeter.