

Test Report

Report Number:

F191836E1

Equipment under Test (EUT):

ISGUS Mifare Reader

Applicant:

ISGUS GmbH

Manufacturer:

ISGUS GmbH



Deutsche
Akkreditierungsstelle
D-PL-17186-01-01
D-PL-17186-01-02
D-PL-17186-01-03

References

- [1] **ANSI C63.10: 2013** American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices
- [2] **FCC CFR 47 Part 15** Radio Frequency Devices
- [3] **RSS-210 Issue 9 (August 2016)**
Licence-exempt Radio Apparatus (All Frequency Bands): Category I Equipment
- [4] **RSS-Gen Issue 5 (March 2019) Amendment 1**
General Requirements for Compliance of Radio Apparatus

Test Result

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

Tested and written by:	Michael DINTER		17.01.2020
	_____ Name	_____ Signature	_____ Date
Reviewed and approved by:	Bernd STEINER		17.01.2020
	_____ Name	_____ Signature	_____ Date

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

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1 Identification

1.1 Applicant

Name:	ISGUS GmbH
Address:	Oberdorfstr. 18-22, 78054 Villingen-Schwenningen
Country:	Germany
Name for contact purposes:	Mr. Wolfgang BARWICH
Phone:	+49 (0)7720-393-0
eMail address:	info@isgus.de
Applicant represented during the test by the following person:	None.

1.2 Manufacturer

Name:	ISGUS GmbH
Address:	Oberdorfstr. 18-22, 78054 Villingen-Schwenningen
Country:	Germany
Name for contact purposes:	Mr. Wolfgang BARWICH
Phone:	+49 (0)7720-393-0
eMail address:	info@isgus.de
Manufacturer represented during the test by the following person:	None.

1.3 Test Laboratory

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

Accredited by Deutsche Akkreditierungsstelle GmbH (DAkkS) in compliance with DIN EN ISO/IEC 17025 under Reg. No. D-PL-17186-01-06 and D-PL-17186-01-05, FCC Test Firm Designation Number DE0004, FCC Test Firm Registration Number 469623, CAB Identifier DE0003 and ISED# 3469A.

1.4 EUT (Equipment under Test)

Type of equipment: *	RFID reader
PMN: *	ISGUS Mifare Reader
HVIN: *	MR527E01
Order number: *	Not provided by the applicant
Serial number:*	MR1-000001
FCC ID: *	2AVK6-MR527E01
IC certification number: *	25797-MR527E01
PCB identifier: *	031 1503 527.E01
Hardware version: *	Refer PCB identifier
Software version (FVIN): *	68075J

* Declared by the applicant

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

1.5 Technical Data of Equipment

EUT data						
Power supply EUT: *	5 VDC					
Supply voltage EUT: *	U _{nom} =	5 VDC	U _{min} =	4.75 V DC	U _{max} =	5.25 V DC
Operating frequency range: *	13.56 MHz					
Type of modulation: *	ASK					
Frequency deviation: *	-					
Number of channels: *	1					
Antenna type: *	Internal loop antenna					
Duty cycle: *	100%					
Rated RF power: *	< 250 mW					
Data rate: *	max. 424kbps					
Temperature range: *	-25 to 70 °C (-13 to 158 °F)					
Lowest / highest internal clock frequency: *	Lowest internal clock: 13.56 MHz, highest internal clock: 20 MHz					

* Declared by the applicant

Ports / Connectors				
Identification			Length during test	Shielding (Yes / No)
	EUT	Ancillary		
5 V DC supply	Customized	Customized	1.5 m	No

Ancillary Equipment	
AC adapter* ¹	Enercell CAT/NO.273-316
TAG* ²	Mifare DESFire Standard-Line (4k)

*¹ Provided by the laboratory

*² Provided by the applicant

1.6 Dates

Date of receipt of test sample:	26.10.2019
Start of test:	31.10.2019
End of test:	27.11.2019

2 Operational States

Description of function of the EUT:

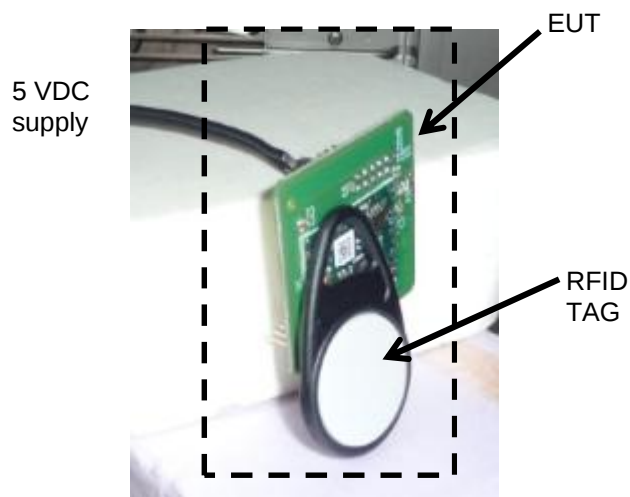
The EUT is RFID reader.

The EUT is supplied by 5 V DC via AC/DC adapter during the tests.

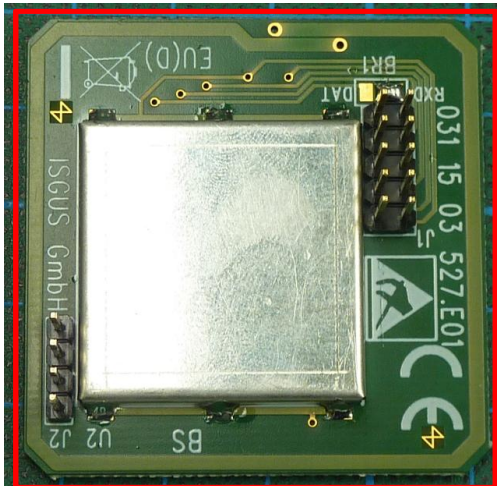
The following states were defined as the operating conditions:

During all tests the EUT was in test mode (continuously reading the TAG).

The system was setup as follows:



The EUT and its physical boundaries



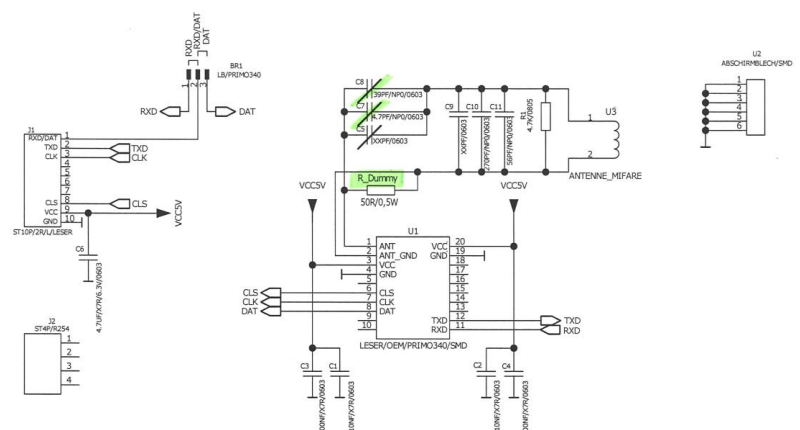
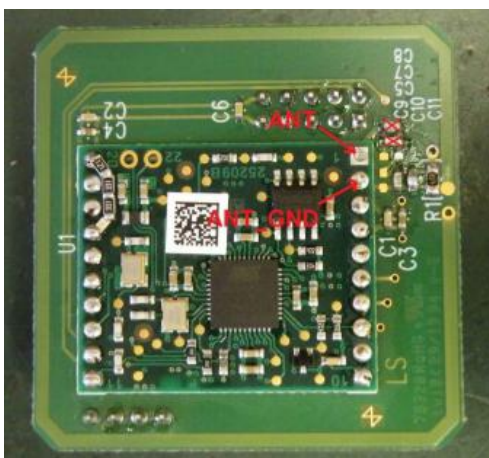
- EUT (radio module ISGUS Mifare Reader)

3 Additional Information

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

To fulfil the conducted emission test a dummy load as described below according to KDB 174176 (06/2015) was used:

The following components were used as suitable dummy load in lieu of the antenna:



4 Overview

Application	Frequency range [MHz]	FCC 47 CFR Part 15 section [2]	RSS-Gen, Issue 5 [4] and RSS-210, Issue 9 [3]	Status	Refer page
Spectrum mask	13.110 to 14.110	15.225 (a) – (d)	B.6 [3]	Passed	10 et seq.
20 dB bandwidth	13.560	15.215 (c)	n.a.	Passed	12 et seq.
99 % bandwidth	13.56	-	6.7 [4]	Passed	14 et seq.
Frequency tolerance	13.560	15.225 (e)	6.11 [4] B.6 [3]	Passed	16 et seq.
Conducted emissions on supply line	0.15 – 30	15.207 (a)	8.8 [4]	Passed	18 et seq.
Radiated emissions	0.009 – 1000***	15.205 (a) 15.209 (a)	8.9 and 8.10 [4] 4.1 and 4.4 [3]	Passed	21 et seq.
Radiated emissions (receiver)	30 – 5.000	15.109 (a)	6.1 [4]	n. a. **	-
Antenna requirement	-	15.203 [2]	6.8 [4]	Passed *	-

*: Integrated antenna only, requirement fulfilled.

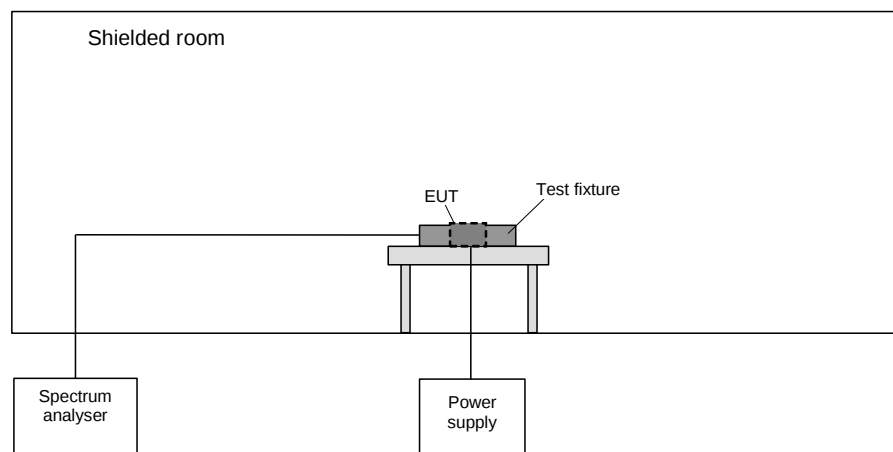
**: No measurement of the receiver spurious emissions was carried out, because of a continuously operating co-located transmitter.

***: As declared by the applicant the highest radio clock frequency is below 108 MHz.
Therefore the radiated emission measurement must be carried out up to 10th of the highest radio clock frequency in this case 1 GHz.

5 Results

5.1 Spectrum mask

5.1.1 Test method



The following procedure will be used for the spectrum mask measurement:

- 1) Place the EUT in the test fixture and switch it on.
- 2) Use the following spectrum analyser settings: $RWB = VBW = 1 \text{ kHz}$, $\text{Span} = \text{wide enough to capture the whole } 13 \text{ MHz band including the frequency ranges where the limit [2; 3] applies}$, $\text{Trace mode} = \text{MaxHold}$, select the limit line. The bandwidth usually has to be 10 kHz for the measurement [1]. Because a measurement with this bandwidth results into an envelope, which is too wide for the 14 kHz spectrum mask, the bandwidth was reduced. The amplitude was determined using the 10 kHz bandwidth.
- 3) After trace stabilisation, set the marker to the signal peak.
- 4) The Reference level will be calculated by the amount of the margin of the wanted signal to its 30 m emission limit plus the marker value.
- 5) The whole signal trace has to be below the limit line.

5.1.2 Test results

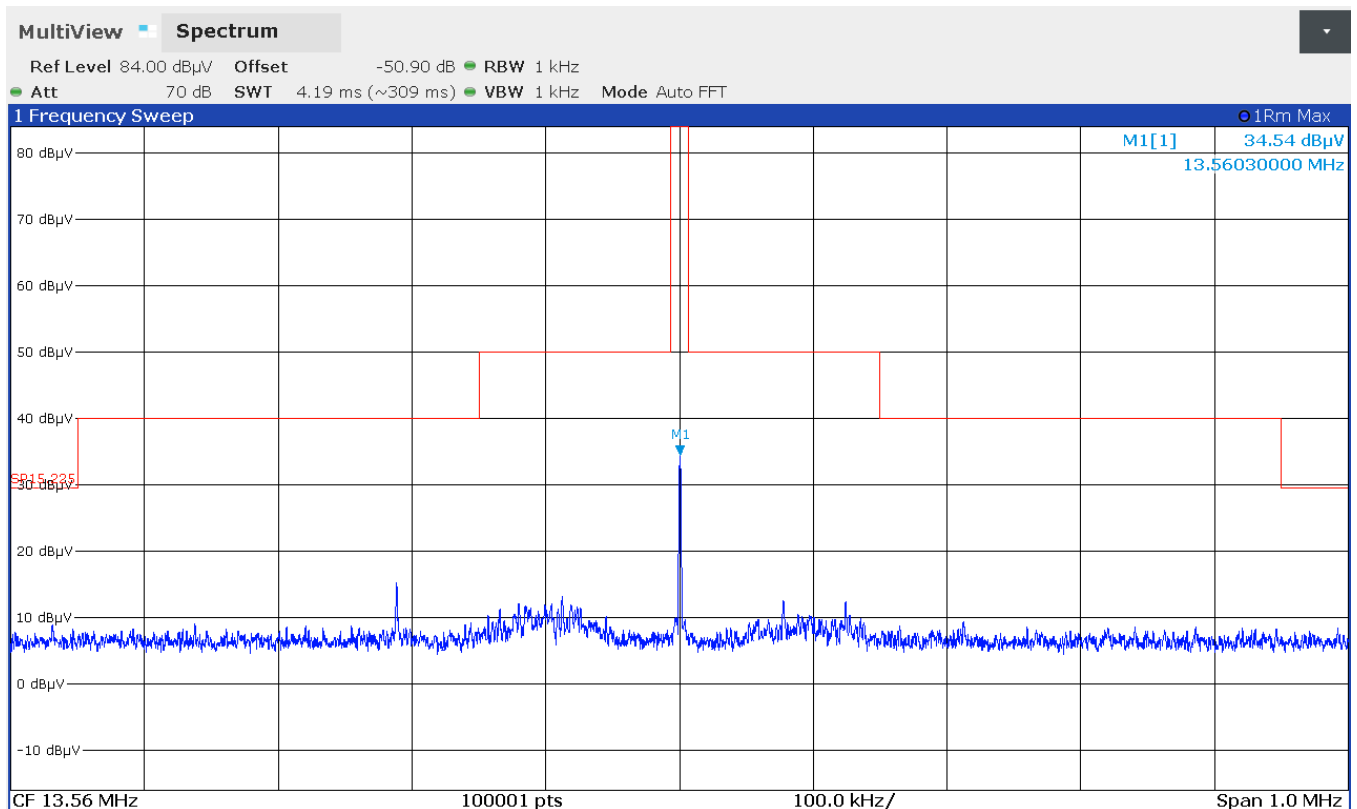
Ambient temperature:	22 °C
Date	27.11.2019

Relative humidity:	40 %
Test engineer:	M. Dinter

Supply voltage: The EUT was supplied with 5 V_{DC}.

Test record: The test was carried out while the EUT was reading a tag.

191836SpecMask225_10k.png: Spectrum mask



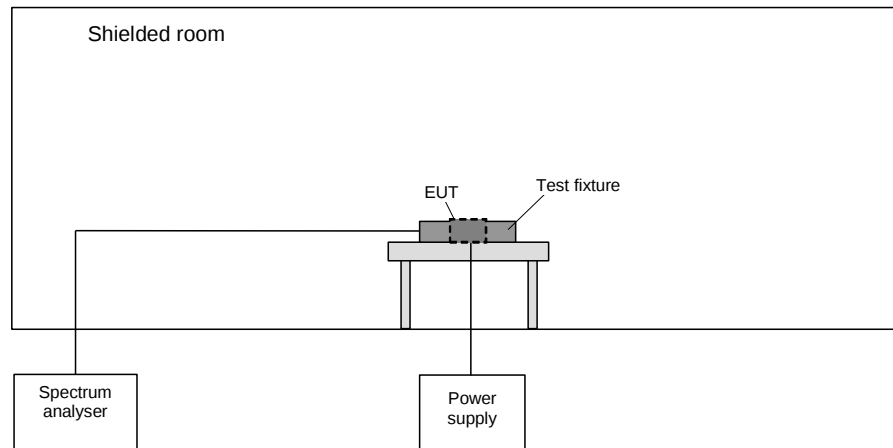
Test result: Passed

Test equipment (please refer to chapter 6 for details)

1 - 3

5.2 20 dB bandwidth

5.2.1 Test method



The following procedure will be used for the occupied bandwidth measurement [1]:

- 1) Place the EUT in the test fixture and switch it on.
- 2) Use the following spectrum analyser settings: RWB = 10 kHz and VBW = 30 kHz, Span = wide enough to capture app. 1.5 times the 20 dB bandwidth, Trace mode = MaxHold.
- 3) After trace stabilisation, set the first marker and the first display line to the signal peak. Set the second display line 20 dB below the first display line. The second marker and its delta marker shall be set to cross points of the spectrum line and the second display line and note these frequencies.
- 4) Alternatively the 20 dB down function of the analyser could be used, if this function will be applicable to the displayed spectrum.

5.2.2 Test results

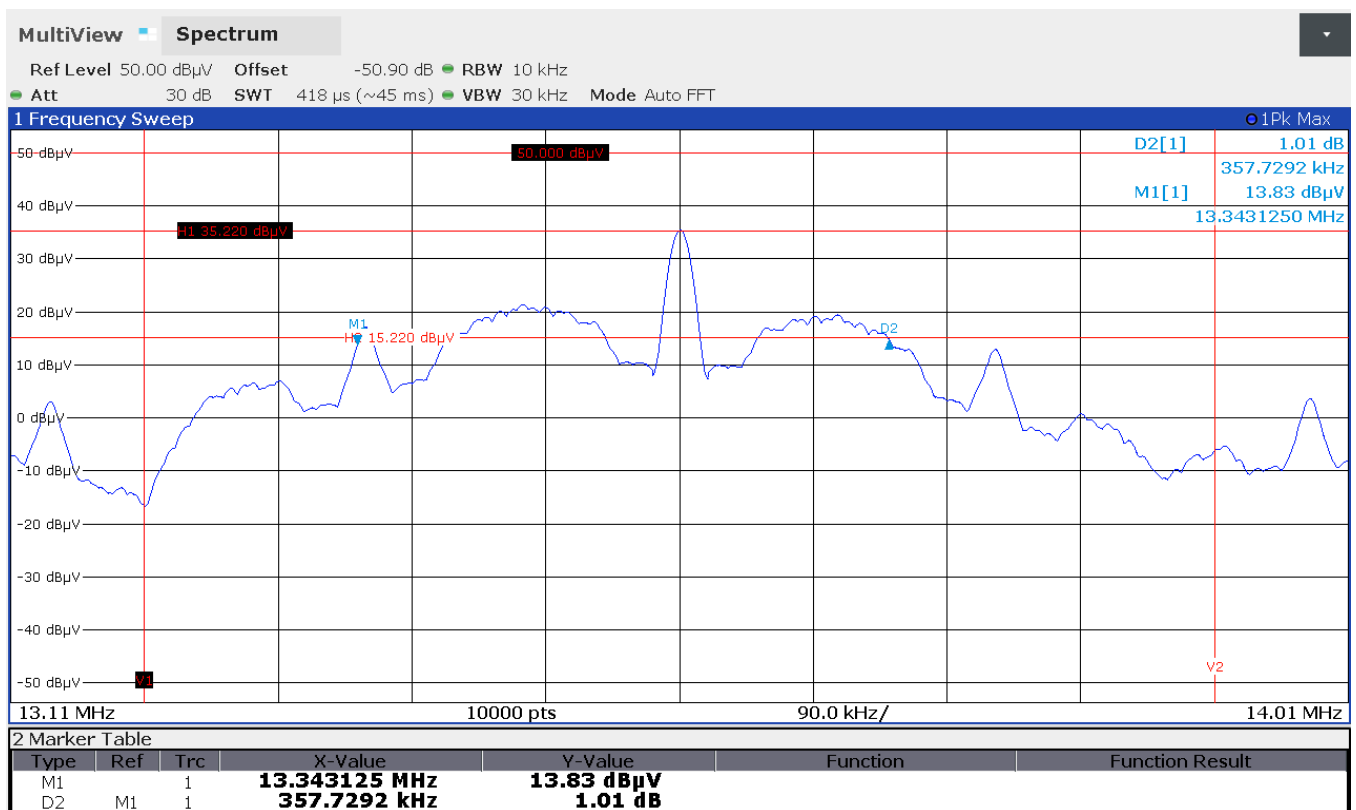
Ambient temperature:	22 °C
Date	27.11.2019

Relative humidity:	40 %
Test engineer:	M. Dinter

Supply voltage: The EUT was supplied with 5 V_{DC}.

Test record: The test was carried out while the EUT was reading a tag.

191836_20dB_10k.png: 20 dB Bandwidth:



F _L	F _U	BW (F _U - F _L)
13.343125 MHz	13.700854 MHz	357.729 kHz
Measurement uncertainty		< 1*10 ⁻⁷

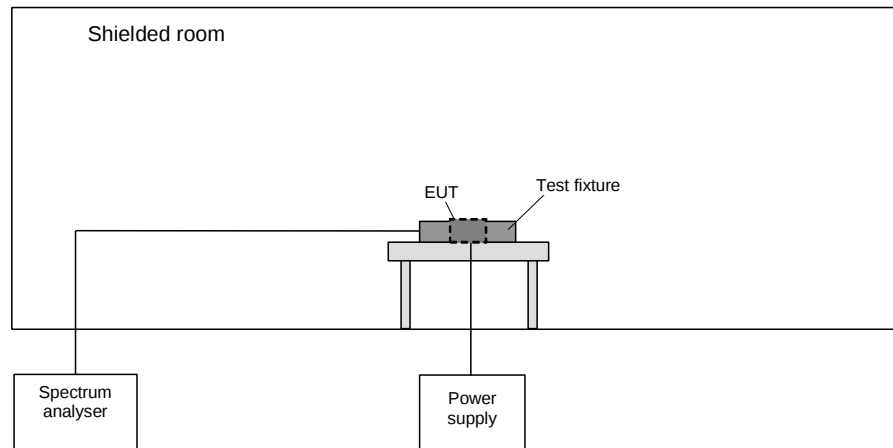
Test: Passed

Test equipment (please refer to chapter 6 for details)

1 - 3

5.3 99 % bandwidth

5.3.1 Test method



The following procedure will be used for the occupied bandwidth measurement according to [1]:

The occupied bandwidth is the frequency bandwidth such that, below its lower and above its upper frequency limits, the mean powers are each equal to 0.5% of the total mean power of the given emission. The following procedure shall be used for measuring 99% power bandwidth:

- The instrument center frequency is set to the nominal EUT channel center frequency. The frequency span for the spectrum analyzer shall be between 1.5 times and 5.0 times the OBW.
- The nominal IF filter bandwidth (3 dB RBW) shall be in the range of 1% to 5% of the OBW, and VBW shall be approximately three times the RBW, unless otherwise specified by the applicable requirement.
- Set the reference level of the instrument as required, keeping the signal from exceeding the maximum input mixer level for linear operation. In general, the peak of the spectral envelope shall be more than $[10 \log (OBW/RBW)]$ below the reference level. Specific guidance is given in 4.1.5.2.
- Step a) through step c) might require iteration to adjust within the specified range.

5.3.2 Test results

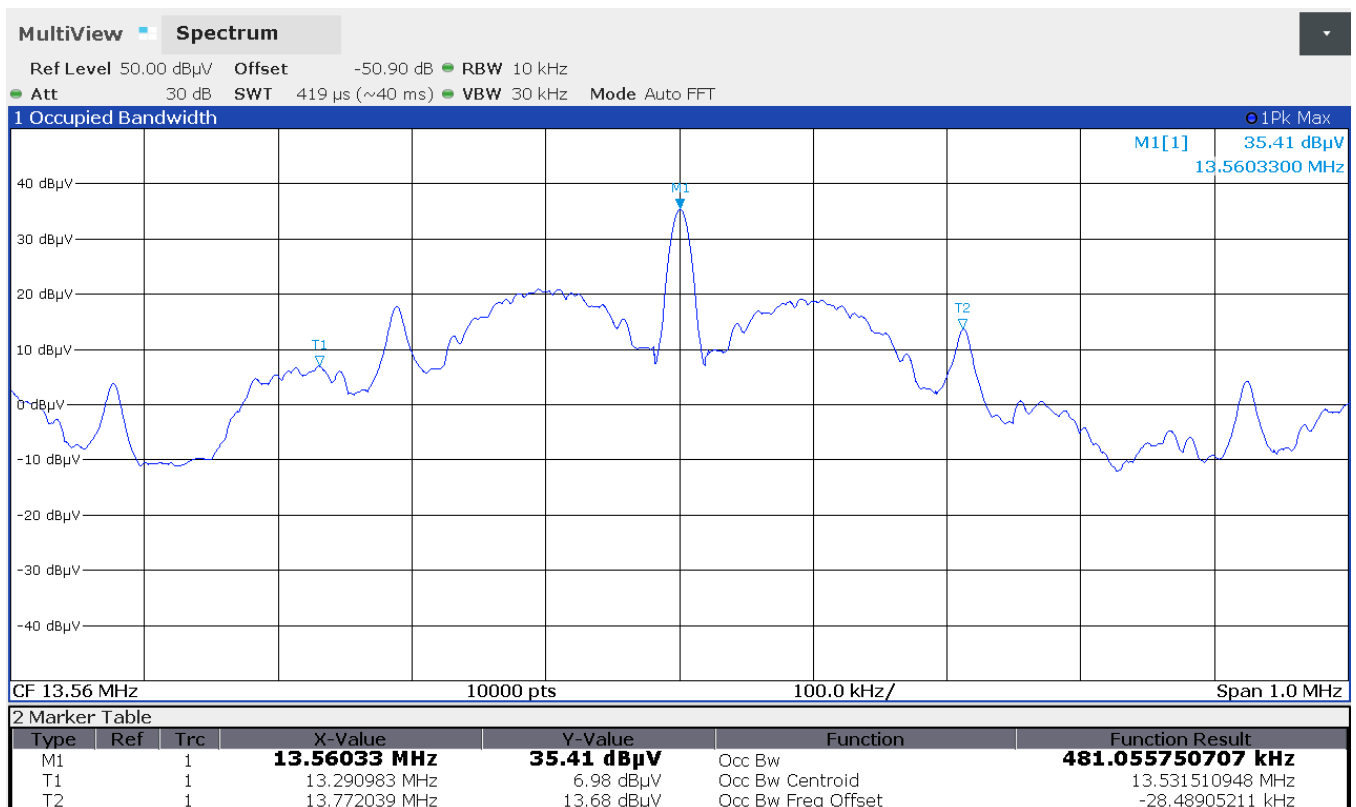
Ambient temperature:	22 °C
Date:	27.11.2019

Relative humidity:	40 %
Test engineer:	M. Dinter

Supply voltage: The EUT was supplied with 5 V_{DC}.

Test record: The test was carried out while the EUT was reading a tag.

191836_99_10k.png: 99% Bandwidth:



F _L	F _U	BW (F _U - F _L)
13.2290983 MHz	13.772039 MHz	481.056 kHz
Measurement uncertainty		< 1*10 ⁻⁷

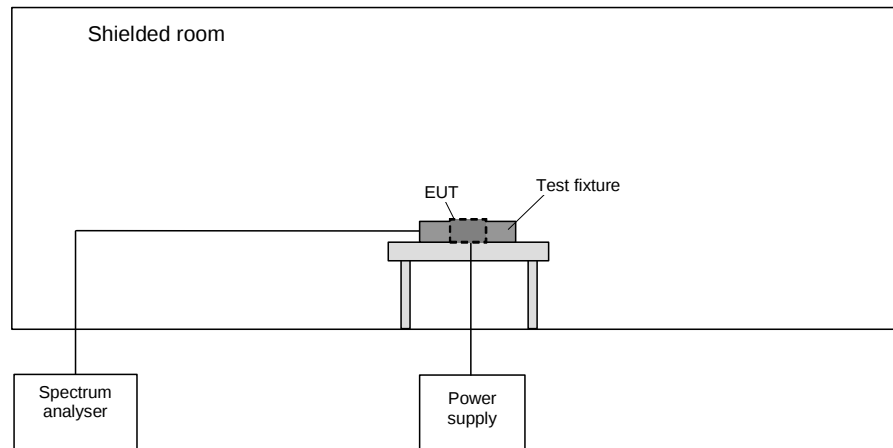
Test: Passed

Test equipment (please refer to chapter 6 for details)

1 - 3

5.4 Frequency tolerance

5.4.1 Test method



The following procedure will be used for the spectrum mask measurement:

- 6) Place the EUT in the test fixture and switch it on.
- 7) Use the following spectrum analyser settings: $RWB = VBW = 1 \text{ kHz}$, $\text{Span} = \text{wide enough to capture the whole } 13 \text{ MHz band including the frequency ranges where the limit [2; 3] applies}$, $\text{Trace mode} = \text{MaxHold}$, select the limit line. The bandwidth usually has to be 10 kHz for the measurement [1]. Because a measurement with this bandwidth results into an envelope, which is too wide for the 14 kHz spectrum mask, the bandwidth was reduced. The amplitude was determined using the 10 kHz bandwidth.
- 8) After trace stabilisation, set the marker to the signal peak.
- 9) The Reference level will be calculated by the amount of the margin of the wanted signal to its 30 m emission limit plus the marker value.
- 10) The whole signal trace has to be below the limit line.

5.4.2 Test results

Ambient temperature:	22 °C
Date:	27.11.2019

Relative humidity:	40 %
Test engineer:	M. Dinter

Test set-up: For this test the EUT was fixed on non-conducted table inside the temperature chamber. For further information of the cable guide refer to the pictures in annex A of this test report.

Temperature	Supply voltage	Minutes after switch on	Frequency In MHz	Allowed tolerance in kHz	Measured tolerance in Hz	Result
70 °C	5 V _{DC}	0	13.560274	±1.356kHz	-56	Passed
		2	13.560293	±1.356kHz	-37	Passed
		5	13.560299	±1.356kHz	-31	Passed
		10	13.560299	±1.356kHz	-31	Passed
60 °C	5 V _{DC}	0	13.560281	±1.356kHz	-49	Passed
		2	13.560271	±1.356kHz	-59	Passed
		5	13.560271	±1.356kHz	-59	Passed
		10	13.56027	±1.356kHz	-60	Passed
50 °C	5 V _{DC}	0	13.560293	±1.356kHz	-37	Passed
		2	13.560299	±1.356kHz	-31	Passed
		5	13.560298	±1.356kHz	-32	Passed
		10	13.560298	±1.356kHz	-32	Passed
40 °C	5 V _{DC}	0	13.560325	±1.356kHz	-5	Passed
		2	13.560311	±1.356kHz	-19	Passed
		5	13.560304	±1.356kHz	-26	Passed
		10	13.560301	±1.356kHz	-29	Passed
30 °C	5 V _{DC}	0	13.560368	±1.356kHz	38	Passed
		2	13.560345	±1.356kHz	15	Passed
		5	13.560341	±1.356kHz	11	Passed
		10	13.560338	±1.356kHz	8	Passed
20 °C	4.75 V _{DC}	0	13.560325	±1.356kHz	-5	Passed
	5 V _{DC}		13.560330	-	0	-
	5.25 V _{DC}		13.560304	±1.356kHz	-26	Passed
10 °C	5 V _{DC}	0	13.560437	±1.356kHz	107	Passed
		2	13.560416	±1.356kHz	86	Passed
		5	13.560413	±1.356kHz	83	Passed
		10	13.560409	±1.356kHz	79	Passed
0 °C	5 V _{DC}	0	13.560446	±1.356kHz	116	Passed
		2	13.56044	±1.356kHz	110	Passed
		5	13.560437	±1.356kHz	107	Passed
		10	13.560437	±1.356kHz	107	Passed
-10 °C	5 V _{DC}	0	13.560434	±1.356kHz	104	Passed
		2	13.560446	±1.356kHz	116	Passed
		5	13.560444	±1.356kHz	114	Passed
		10	13.560444	±1.356kHz	114	Passed
-20 °C	5 V _{DC}	0	13.560382	±1.356kHz	52	Passed
		2	13.560404	±1.356kHz	74	Passed
		5	13.560428	±1.356kHz	98	Passed
		10	13.56043	±1.356kHz	100	Passed
-25 °C	5 V _{DC}	0	13.560344	±1.356kHz	14	Passed
		2	13.560402	±1.356kHz	72	Passed
		5	13.560405	±1.356kHz	75	Passed
		10	13.560406	±1.356kHz	76	Passed
Measurement uncertainty				< ± 1*10 ⁻⁷		

Test result: Passed

Test equipment (please refer to chapter 6 for details)

1 - 5

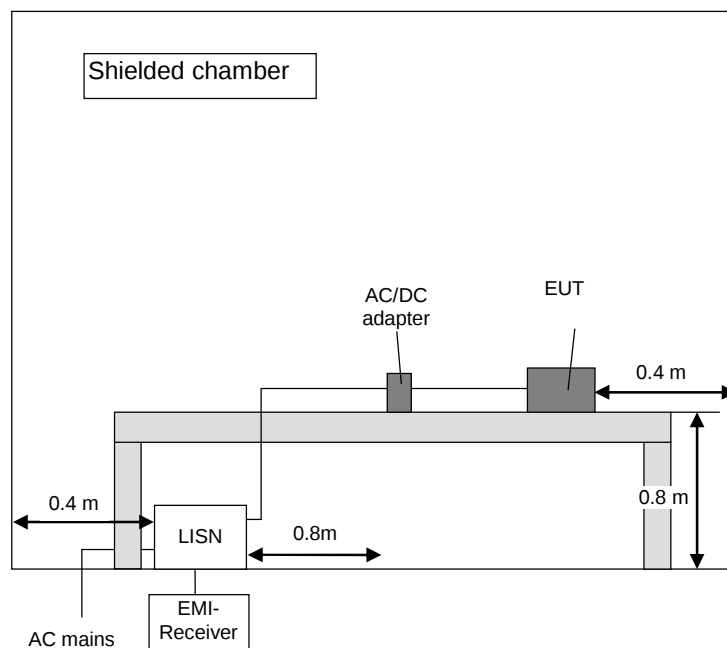
5.5 Conducted emissions on power supply lines

5.5.1 Test method

This test will be carried out in a shielded chamber. Table top devices will set up on a non-conducting support with a size of 1 m by 1.5 m and a height of 80 cm above the ground plane. Floor-standing devices will be placed directly on the ground plane. The setup of the Equipment under test will be in accordance to [1].

The frequency range 150 kHz to 30 MHz will be measured with an EMI Receiver set to MAX Hold mode with peak and average detector and a resolution bandwidth of 9 kHz. A scan will be carried out on the phase (or plus pole in case of DC powered devices) of the AC mains network. If levels detected 10 dB below the appropriate limit, this emission will be measured with the average and quasi-peak detector on all lines.

Frequency range	Resolution bandwidth
150 kHz to 30 MHz	9 kHz



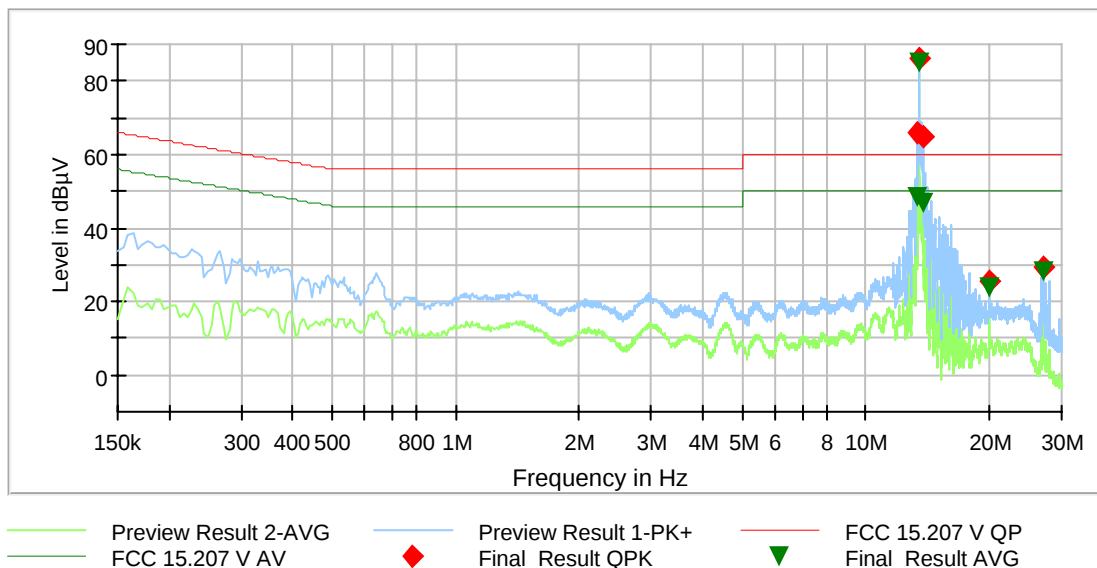
Remark: This test was carried out with dummy load according to KDB 174176 (06/2015).

5.5.2 Results conducted emission measurement on AC mains

Ambient temperature:	21 °C
Date:	14.11.2019

Relative humidity:	26 %
Test engineer:	M. Dinter

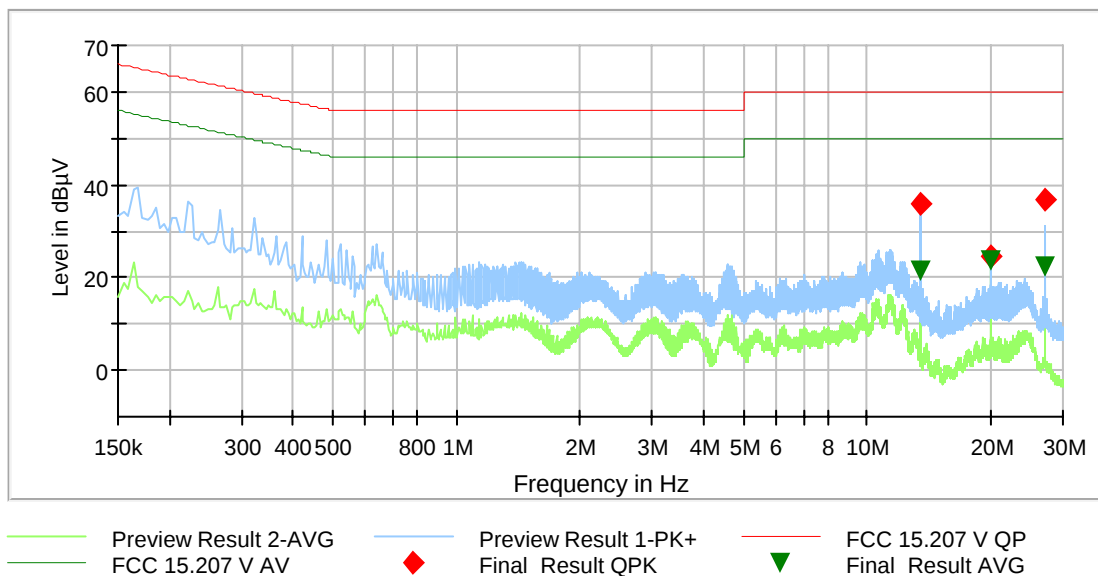
Test description: Conducted emission measurement
 EUT: ISGUS Mifare Reader
 Manufacturer: ISGUS GmbH
 Operating conditions: Reading TAG without dummy load
 Test site: Phoenix TESTLAB GmbH, shielded room M4
 Operator: M.DINTER
 Comment: 5 V DC via AC adapter Enercell CAT/NO.273-316



Remark: The plot with reading TAG was carried out to show the AC power-line conducted tests with the antenna connected to determine compliance with Section 15.207 limits outside the transmitter's fundamental emission band; the following test with a dummy load in lieu of the antenna to determine compliance with Section 15.207 limits within the transmitter's fundamental emission band.

Test description: Conducted emission measurement
 EUT: ISGUS Mifare Reader
 Manufacturer: ISGUS GmbH
 Operating conditions: 50 Ohm dummy load
 Test site: Phoenix TESTLAB GmbH, shielded room M4
 Operator: M.DINTER
 Comment: 5 V DC via AC adapter Enercell CAT/NO.273-316

The curves in the diagrams below only represent for each frequency point the maximum measured value of all preliminary measurements which were made for each power supply line. The top measured curve represents the peak measurement and the bottom measured curve the average measurement. The quasi-peak measured points are marked by ◆ and the average ▼ measured points by ▼.



Final_Result

Frequency (MHz)	QuasiPeak (dBμV)	Average (dBμV)	Limit (dBμV)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Line	PE	Transducer (dB)
13.560000	---	21.31	50.00	28.69	5000.0	9.000	N	FLO	10.8
13.560000	36.08	---	60.00	23.92	5000.0	9.000	N	FLO	10.8
20.000400	---	23.49	50.00	26.51	5000.0	9.000	N	FLO	11.0
20.000400	24.49	---	60.00	35.51	5000.0	9.000	N	GND	11.0
27.120300	---	22.31	50.00	27.69	5000.0	9.000	N	FLO	11.2
27.120300	36.72	---	60.00	23.28	5000.0	9.000	L1	FLO	11.1
Measurement uncertainty				+2.76 dB / -2.76 dB					

Test result Passed

Test equipment (please refer to chapter 6 for details)

6 - 11

5.6 Radiated emissions

5.6.1 Test method

The radiated emission measurement is subdivided into six stages.

- A preliminary measurement carried out in a fully anechoic chamber with a fixed antenna height in the frequency range 9 kHz to 1 GHz.
- A final measurement carried out on an outdoor test site without reflecting ground plane and a fixed antenna height in the frequency range 9 kHz to 30 MHz.
- A preliminary and final measurement carried out in a semi anechoic chamber with a varying antenna height in the frequency range 30 MHz to 1 GHz.
- A preliminary and final measurement carried out in a fully anechoic chamber with a various antenna heights at a distance of 3 m to the EUT position in the frequency range 1 GHz to 13 GHz.

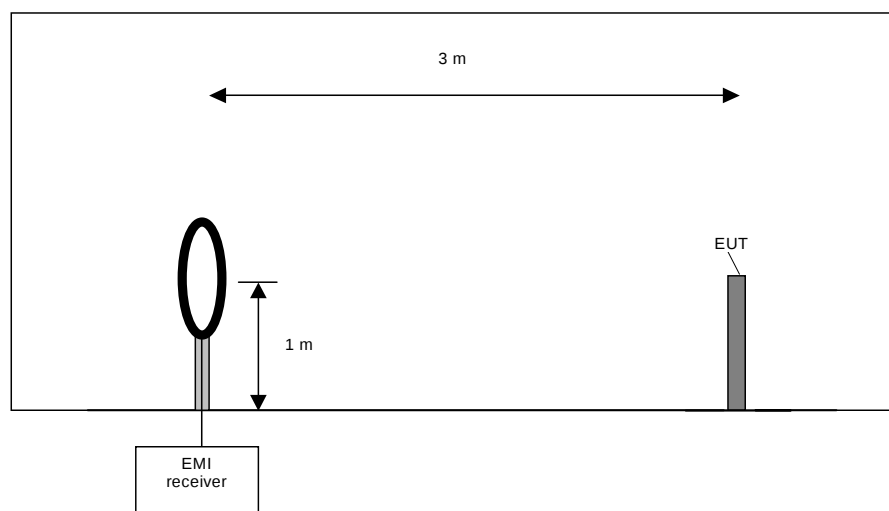
Preliminary measurement (9 kHz to 30 MHz):

In the first stage a preliminary measurement will be performed in a shielded room with a measuring distance of 3 meters. Table-top devices will set up on a non-conducting support with a size of 1 m by 1.5 m and a height of 80 cm. Floor-standing devices will be placed directly on the turntable/ground plane. The setup of the Equipment under test will be in accordance to [1].

The frequency range 9 kHz to 30 MHz will be monitored with a spectrum analyser while the system and its cables will be manipulated to find out the configuration with the maximum emission levels if applicable. The EMI Receiver will be set to MAX Hold mode. The EUT and the measuring antenna will be rotated around their vertical axis to found the maximum emissions.

The resolution bandwidth of the spectrum analyser will be set to the following values:

Frequency range	Resolution bandwidth
9 kHz to 150 kHz	200 Hz
150 kHz to 30 MHz	10 kHz



Preliminary measurement procedure:

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

The following procedure will be used:

- 1) Monitor the frequency range at horizontal polarisation and a EUT azimuth of 0 °.
- 2) Manipulate the system cables within the range to produce the maximum level of emission.
- 3) Rotate the EUT by 360 ° to maximize the detected signals.
- 4) Make a hardcopy of the spectrum.
- 5) Measure the frequencies of highest detected emission with a lower span and resolution bandwidth to increase the accuracy and note the frequency value.
- 6) Repeat steps 1) to 5) with the other orthogonal axes of the EUT (because of EUT is a module and might be used in a handheld equipment application).
- 7) Rotate the measuring antenna and repeat steps 1) to 5).

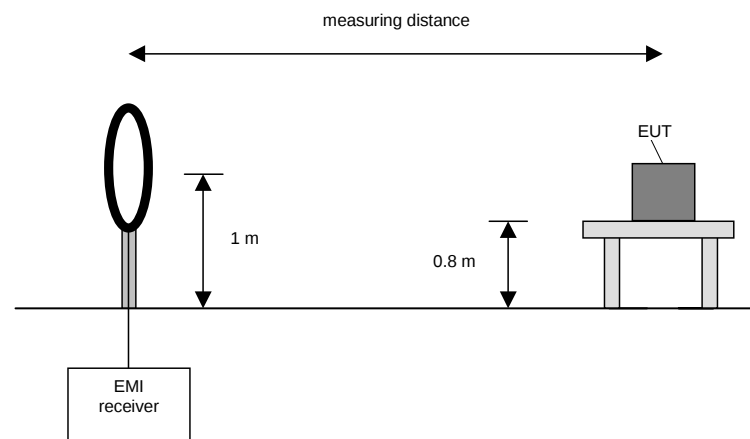
Final measurement (9 kHz to 30 MHz):

In the second stage a final measurement will be performed on an open area test site with no conducting ground plane in a measuring distances of 3 m, 10 m and 30 m. In the case where larger measuring distances are required the results will be extrapolated based on the values measured on the closer distances according to Section 15.31 (f) (2) [2]. The final measurement will be performed with a EMI Receiver set to Quasi Peak detector except for the frequency bands 9 kHz to 90 kHz and 110 kHz to 490 kHz where an average detector will be used according Section 15.209 (d) [2].

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

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

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



Final measurement procedure:

The following procedure will be used:

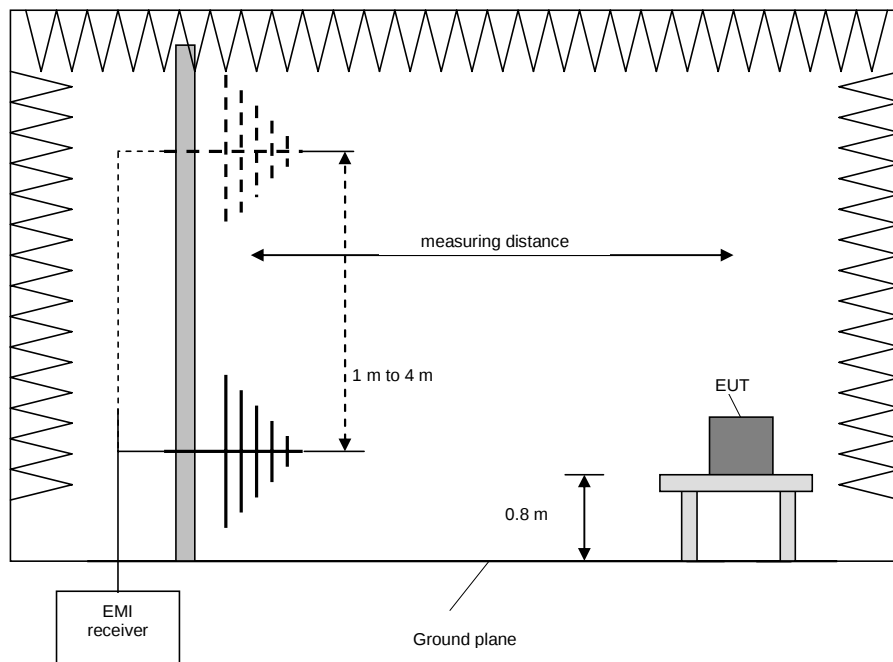
- 1) Monitor the frequency range with the measuring antenna at vertical orientation parallel to the EUT at an azimuth of 0 °.
- 2) Rotate the EUT by 360 ° to maximize the detected signals and note the azimuth and orientation.
- 3) Rotate the measuring antenna to find the maximum and note the value.
- 4) Rotate the measuring antenna and repeat steps 1) to 3) until the maximum value is found.
- 5) Repeat steps 1) to 4) with the other orthogonal axes of the EUT (if the EUT is a module and might be used in a handheld equipment application).

Preliminary and final measurement (30 MHz to 1 GHz)

The preliminary and final measurements were conducted in a semi-anechoic chamber with a metal ground plane. During the test the EUT will be rotated in the range of 0 ° to 360 °, the measuring antenna will be set to horizontal and vertical polarization and raised and lowered in the range from 1 m to 4 m to find the maximum level of emissions.

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

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



Procedure preliminary measurement:

The following procedure is used:

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

Procedure final measurement:

The following procedure is used:

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

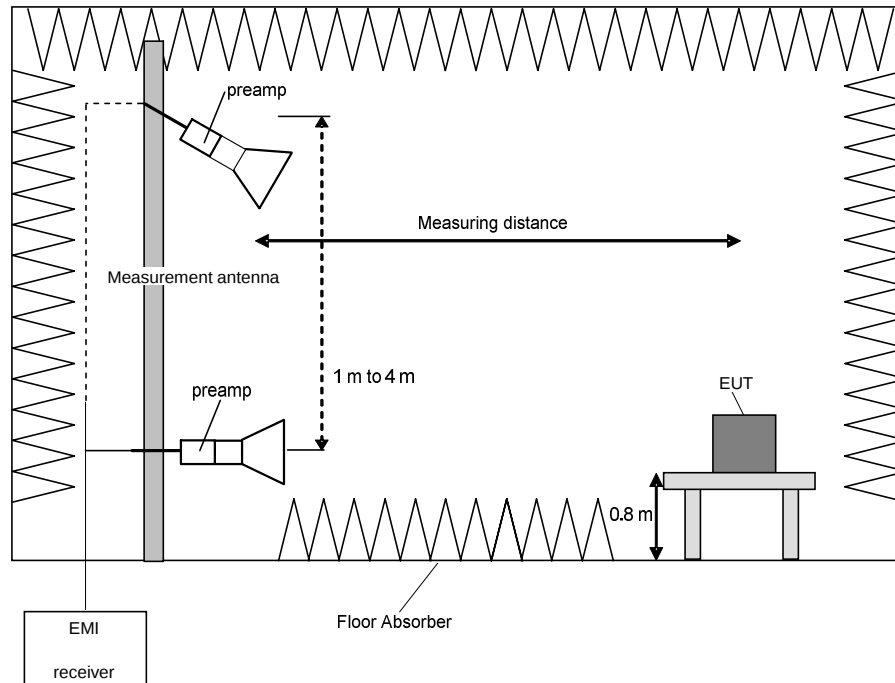
Preliminary and final measurement (1 – 40 GHz)

The preliminary and final measurements were conducted in a semi-anechoic chamber with floor absorbers between EUT and measurement antenna.

During the test the EUT will be rotated in the range of 0 ° to 360 °, the measuring antenna will be set to horizontal and vertical polarization and raised and lowered in the range from 1 m to 4 m to find the maximum level of emissions. For each height the angle of the antenna will be tilted so that the measurement antenna is always aiming at the EUT.

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

Test	Frequency range	Resolution bandwidth
Preliminary measurement	1 - 40 GHz	1 MHz
Frequency peak search	+ / - 10 MHz	100 kHz
Final measurement	1 - 40 GHz	1 MHz



Procedure preliminary measurement:

The following procedure is used:

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

Procedure final measurement:

The following procedure is used:

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

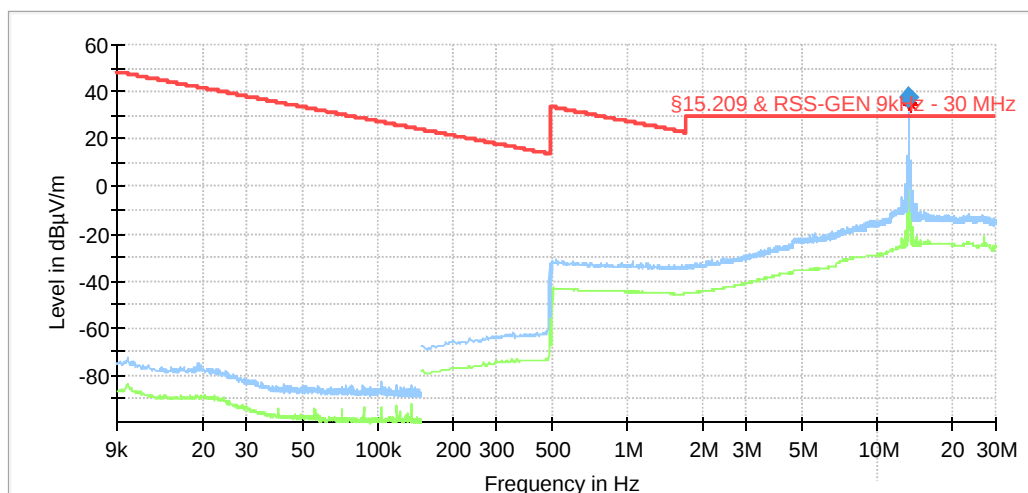
5.6.2 Results preliminary measurement 9 kHz to 30 MHz

Ambient temperature:	20 °C
Date:	06.11.2019

Relative humidity:	56 %
Test engineer:	M. Dinter

Test description: Radiated emission measurement
 EUT: ISGUS Mifare Reader
 Manufacturer: ISGUS GmbH
 Operating conditions: Reading TAG
 Test site: Phoenix TESTLAB GmbH, anechoic chamber M276
 Operator: M. Dinter
 Comment: 120 V AC 60 Hz / 5 V DC via AC adapter Enercell CAT/NO.273-316

Full Spectrum



Except the fundamental of the EUT at no frequency was a value above the noise of the system therefore only a final measurement for the fundamental on the open area test site was carried out. No spurious emissions caused by the equipment under test were found.

The following emission was found according to [2] and [3]. (fundamental of transmitter)

13.56 MHz.

Remark: No further emissions caused by the equipment under were found.

Test equipment (please refer to chapter 6 for details)

12 - 19

5.6.3 Result final measurement from 9 kHz to 30 MHz

Ambient temperature	16 °C
Date:	06.11.2019

Relative humidity	67 %
Test engineer:	M. Dinter

Test description: Radiated emission measurement
 EUT: ISGUS Mifare Reader
 Manufacturer: ISGUS GmbH
 Operating conditions: Reading TAG
 Test site: Phoenix TESTLAB GmbH, outdoor test site
 Operator: M. Dinter
 Comment: 5 V DC supply

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

Results 9kHz - 30 MHz								
Frequency	Reading	Result*	Limit acc. 15.225	Margin	Detector (acc. to §15.209 (d))	Antenna factor	Measuring Distance	Distance correction factor**
[MHz]	[dBµV]	[dBµV/m]	[dBµV/m]	[dB]		[dB/m]	[m]	[dB]
13.560000	55.4	35.3 @ 30m	84.0	48.7	QP	19.9	3	40
Measurement uncertainty			+/- 4.69 dB					

Note: *Result @ norm dist = Reading + Antenna factor - Distance Extrapolation Factor

**40 dB/decade according Part §15.31 (f) (2)

Test: Passed

The test results were calculated with the following formula:

$$\text{Result [dBµV/m]} = \text{reading [dBµV]} + \text{antenna factor [dB/m]} - \text{distance correction (dB)}$$

Test equipment (please refer to chapter 6 for details)
20 - 22

5.6.4 Results measurement 30 MHz to 1 GHz

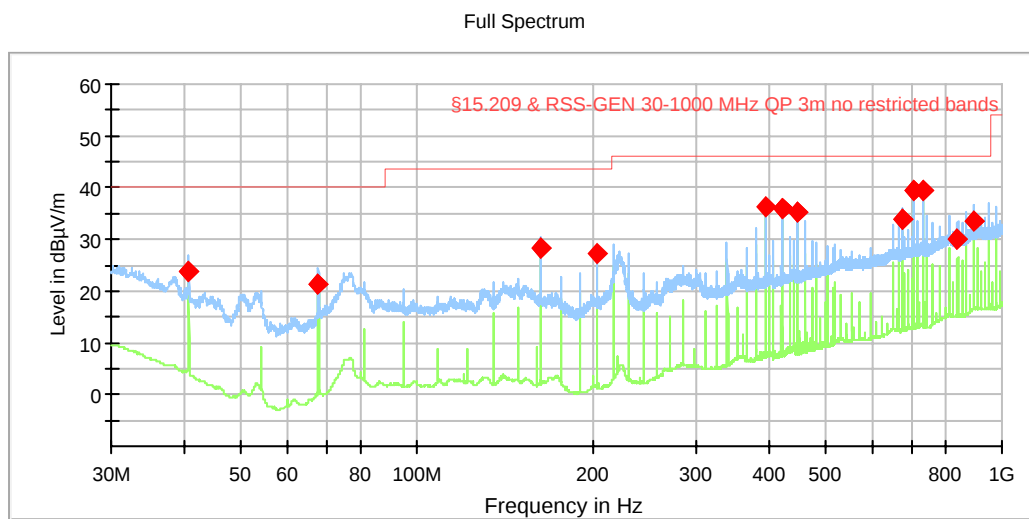
Ambient temperature:	20 °C
Date:	06.11.2019

Relative humidity:	56 %
Test engineer:	M. Dinter

Test description: Radiated emission measurement
 EUT: ISGUS Mifare Reader
 Manufacturer: ISGUS GmbH
 Operating conditions: Reading TAG
 Test site: Phoenix TESTLAB GmbH, anechoic chamber M276
 Operator: M. Dinter
 Comment: 120 V AC 60 Hz / 5 V DC via AC adapter Enercell CAT/NO.273-316

The measured points and the limit line in the following diagram refer to the standard measurement of the emitted interference in compliance with the above-mentioned standard while taking account of the specified requirements for a 3 m measuring distance.

The measured points marked with "◆" are the measured results of the standard subsequent measurement on SAC test site.



Final Result

Frequency (MHz)	QuasiPeak (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
40.660000	23.86	40.00	16.14	1000.0	120.000	118.0	V	125.0	19.4
67.800000	21.49	40.00	18.51	1000.0	120.000	134.0	V	157.0	14.0
162.730000	28.26	43.52	15.26	1000.0	120.000	165.0	H	111.0	16.1
203.430000	27.18	43.52	16.34	1000.0	120.000	115.0	H	113.0	15.8
420.360000	36.13	46.02	9.89	1000.0	120.000	115.0	V	288.0	22.5
420.360000	36.13	46.02	9.89	1000.0	120.000	115.0	V	288.0	22.5
447.490000	35.28	46.02	10.74	1000.0	120.000	115.0	V	87.0	23.3
678.010000	33.96	46.02	12.06	1000.0	120.000	100.0	V	112.0	27.1
705.140000	39.51	46.02	6.51	1000.0	120.000	100.0	V	16.0	27.7
732.260000	39.28	46.02	6.74	1000.0	120.000	106.0	H	95.0	28.4
840.730000	30.02	46.02	16.00	1000.0	120.000	108.0	H	242.0	29.4
895.000000	33.37	46.02	12.65	1000.0	120.000	100.0	H	150.0	30.2
Measurement uncertainty				+/- 5.12 dB					

Test: Passed

The correction factor was calculated as follows.

Corr. (dB) = cable attenuation (dB) + 6 dB attenuator (dB) + antenna factor (dB)

Therefore the reading can be calculated as follows:

Reading (dBμV/m) = result QuasiPeak (dBμV/m) - Corr. (dB)

Test equipment (please refer to chapter 6 for details)

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6 Test Equipment used for Tests

No.	Test equipment	Type	Manufacturer	Serial No.	PM. No.	Cal. Date	Cal Due
1	Signal & Spectrum Analyzer	FSW43	Rohde & Schwarz	100586 & 100926	481720	15.03.2018	03.2020
2	Loop antenna	Loop antenna 11cm	PHOENIX TESTLAB GmbH	-	410084	Calibration not necessary	
3	Power Supply	TOE8852 (DC)	Toellner Electronic Inst.	51712	480233	Calibration not necessary	
4	Multimeter	971A	Hewlett Packard	JP40010640	480724	31.01.2018	01.2020
5	Dynamic temperature chamber	MK 240	WTB Binder Labortechnik GmbH	05-79022	480462	10.07.2019	07.2020
6	Transient Filter Limiter	CFL 9206A	Teseq GmbH	38268	481982	14.03.2018	03.2020
7	LISN	NSLK8128	Schwarzbeck	8128155	480058	14.03.2018	03.2020
8	Software	EMC32	Rohde & Schwarz	100061	481022	Calibration not necessary	
9	Shielded chamber M4	B83117-S1-X158	Siemens	190075	480088	Calibration not necessary	
10	EMI Receiver / Spectrum Analyser	ESIB 26	Rohde & Schwarz	100292	481182	28.02.2018	02.2020
11	AC Supply	AC6803A AC Quelle 2000VA	Keysight	JPVJ002509	482350	Calibration not necessary	
12	Loop antenna	HFH2-Z2	Rohde & Schwarz	832609/014	480059	21.02.2018	02.2020
13	Systemsoftware EMC32 M276	EMC32	Rohde & Schwarz	100970	482972	Calibration not necessary	
14	RF Switch Matrix	OSP220	Rohde & Schwarz		482976	Calibration not necessary	
15	Turntable	TT3.0-3t	Maturo	825/2612/.01	483224	Calibration not necessary	
16	Antenna support	BAM 4.5-P-10kg	Maturo	222/2612.01	483225	Calibration not necessary	
17	Controller	NCD	Maturo	474/2612.01	483226	Calibration not necessary	
18	Semi anechoic chamber M276	SAC5-2	Albatross Projects	C62128-A540-A138-10-0006	483227	Calibration not necessary	
19	EMI test receiver ESW	ESW44	Rohde & Schwarz	101828	482979	12.04.2019	04.2021
20	Outdoor test site	-	PHOENIX TESTLAB GmbH	-	480293	Calibration not necessary	
21	EMI Receiver / Spectrum Analyser	ESI 40	Rohde & Schwarz	100064/040	480355	03.04.2019	04.2020
22	loop antenna	HFH2-Z2	Rohde & Schwarz	100417	481912	10.01.2019	01.2020
23	Ultralog Antenna	HL562E	Rohde & Schwarz		482978	07.08.2019	08.2022

7 Test site Validation

Test equipment	PM. No.	Frequency range	Type of validation	According to	Val. Date	Val Due
OATS Outdoor	480293	9 kHz – 30 MHz	-	ANSI C63.4-2014	-	-
Semi anechoic chamber M276	483227	30 – 1000 MHz	NSA	ANSI C63.4a-2017	19.09.2019	18.09.2021
Shielded chamber M4	480088	9 kHz – 30 MHz	GND-Plane	ANSI C63.4-2014	06.11.2018	05.11.2020

8 Report History

Report Number	Date	Comment
F191836E1	17.01.2020	Initial Test Report

9 List of Annexes

Annex A	Test Setup Photos	3 pages
Annex B	EUT External Photos	3 pages
Annex C	EUT Internal Photos	1 pages