

Test Report

Report Number:

F161791E2

Equipment under Test (EUT):

**13.56 MHz Reader Module
THVAC002
inside representative host device Excellence Titrator T9**

Applicant:

Mettler-Toledo GmbH

Manufacturer:

Mettler-Toledo GmbH



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

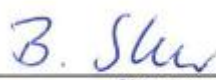
References

- [1] **ANSI C63.10: 2013** American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices
- [2] **FCC CFR 47 Part 15 (October 2015)** Radio Frequency Devices
- [3] **RSS-210 Issue 9 (August 2016)** Licence-Exempt Radio Apparatus: Category I Equipment
- [4] **RSS-Gen Issue 4 (November 2014)** General Requirements for Compliance of Radio Apparatus

Test result

The requirements of the tests performed as shown in the overview (chapter 4 of this test report) were fulfilled by the equipment under test.

The complete test results are presented in the following.

Test engineer:	Thomas KÜHN		10/05/2017
	Name	Signature	Date
Authorized reviewer:	Bernd STEINER		10/05/2017
	Name	Signature	Date

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This test report is valid in hardcopy form as well as in electronic form.

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1 Identification

1.1 Applicant

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Country:	Switzerland
Name for contact purposes:	Mr. René RISSI
Phone:	+41 44 806 73 82
eMail Address:	rene.rissi@mt.com
Applicant represented during the test by the following person:	None

1.2 Manufacturer

Name:	Mettler-Toledo GmbH
Address:	Sonnenbergstrasse 74 CH-8603 Schwerzenbach
Country:	Switzerland
Name for contact purposes:	Mr. René RISSI
Phone:	+41 44 806 73 82
eMail Address:	rene.rissi@mt.com
Manufacturer represented during the test by the following person:	-

1.3 Test Laboratory

The tests were carried out at:

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-17186-01-02, FCC Test Firm Accreditation with the registration number 469623, designation number DE0004 and Industry Canada Test site registration SITE# IC3469A-1.

1.4 EUT (Equipment Under Test)

Type object: *	13.56 MHz Reader Module
Model name / HVIN: *	THVAC002
PMN: *	THVAC002
Serial No.:	51109030
FCC ID: *	THVAC002
IC: *	22032-AC002
PCB identifier:	30090089
Hardware version: *	N.a.
Software version / FVIN: *	V 1.2
Lowest internal frequency: *	Not provided by the applicant
Highest internal frequency: *	13.56 MHz

*: declared by the applicant.

1.5 Technical data of equipment

Channel 1	RX:	13.56 MHz	TX:	13.56 MHz
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Rated RF output power: *	<1 μ W				
Antenna type: *	PCB coil antenna with 0.008 m ²				
Number of channels: *	1				
Antenna connector: *	None				
Modulation: *	ASK, ISO15693				
Data rate: *	Max. 24.48 kBit				
Supply voltage: *	U Nom =	230 VAC	U Min=	90 VAC	U Max= 264 VAC
Power supply: *	External by FSP120-AAAN2 (dedicated AC/DC adaptor)				
Temperature range: *	0 °C to 40 °C				
Ancillary used for test:	FSP120-AAAN2 (dedicated AC/DC adaptor), Excellence Titrator T9 (host) with Terminal (support device)				

*: declared by the applicant.

Ports / Connectors (EUT)			
Identification	Connector		Length during test
	EUT	Ancillary	
Power supply input	C14 Connector	Fixed	2.0 m
Terminal	HDMI	HDMI	1.0.m
CAN OUT	RJ-11	RJ-11	3.0.m
All other Ports were left open during the tests			



1.6 Dates

Date of receipt of test sample:	10/26/2016
Start of test:	10/26/2016
End of test:	02/13/2017

2 Operational states and test setup

The EUT is 13.56 MHz RFID reader module, which could not be tested on a standalone basis. Therefore it was tested mounted inside a host device. The host device is classified as class A digital device. Because the emissions of the host are much higher than the emissions caused by the RFID reader, the host was measured with and without the RFID module in order to identify the source of the emissions found.

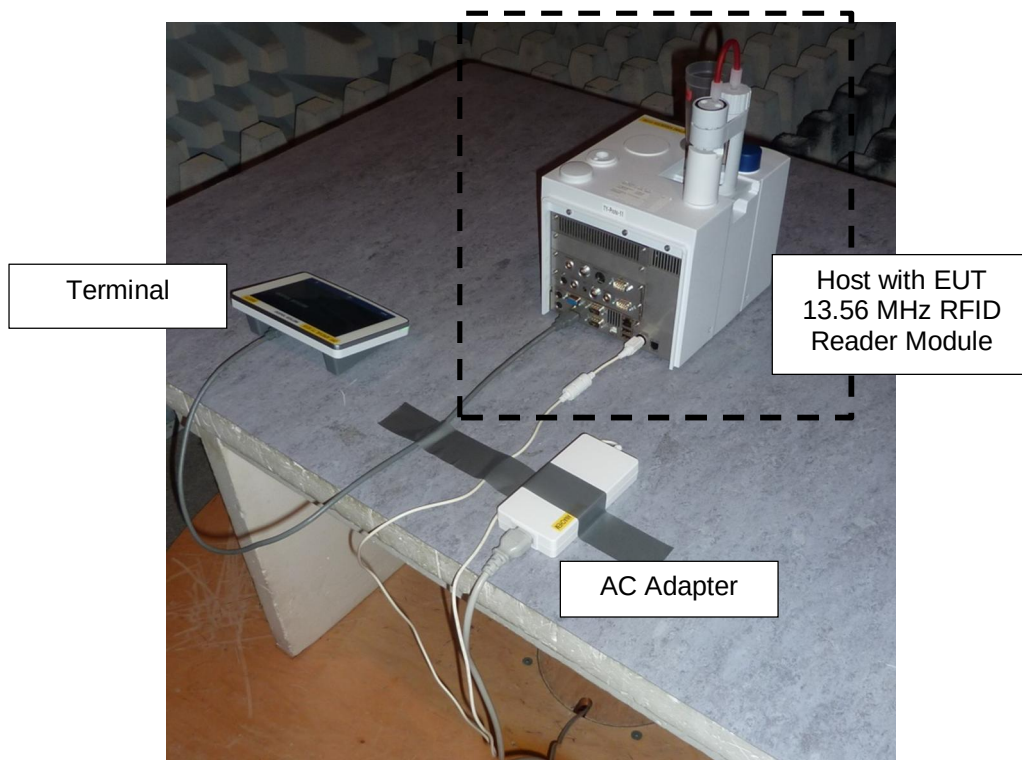
The 13.56 MHz RFID chip is: TRF7970A (Texas Instruments)

As declared by the applicant, the host (Excellence Titrator T9) will always be used with a dedicated AC/DC adaptor type FSP120-AAAN2.

During all measurements a measuring cup and burette with integrated TAGs were mounted on the host devices.

All measurements were carried out with an unmodified sample operating in a test mode. The test mode was entered by the control panel. With this test mode the TAG data were cyclically read and the TAG was written.

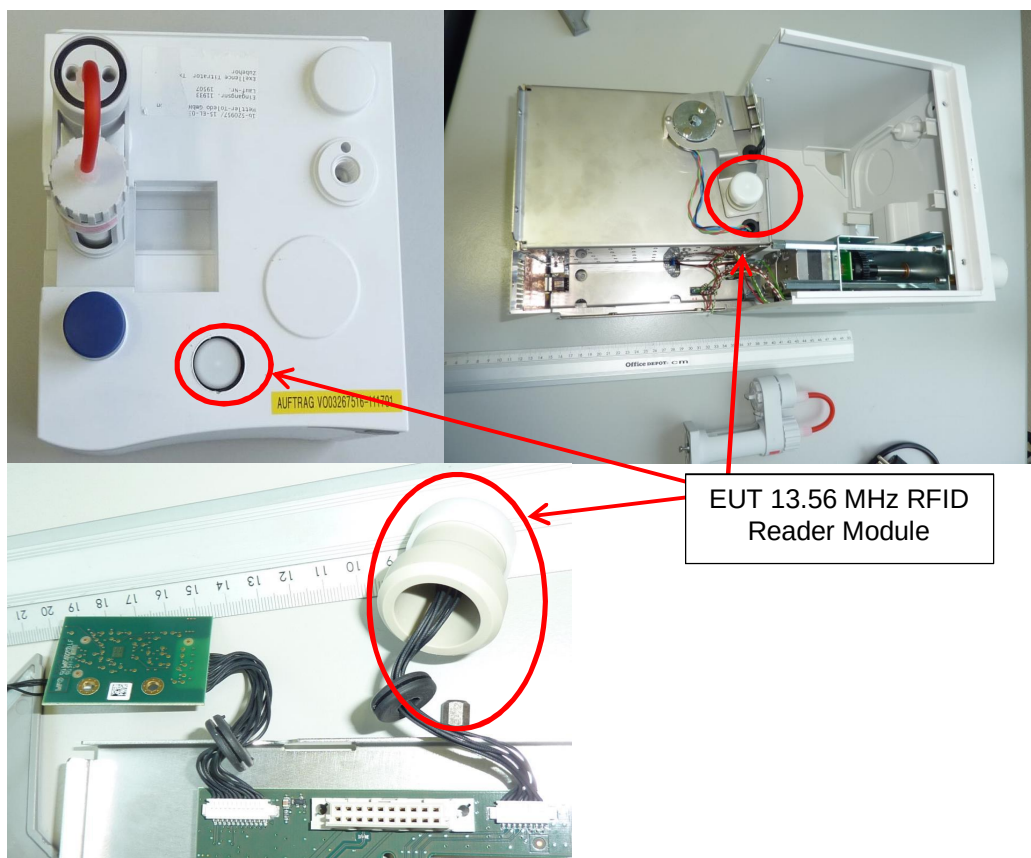
Physical boundaries of the host equipment



3 Additional information

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

Host: 13.56 MHz RFID Reader Module mounted inside host Excellence Titrator T9, which also includes a separate 125 kHz RFID reader, which is fully documented under PHOENIX TESTLAB GmbH test report reference F161791E1.



For more details refer photographs in annex C of this test report.

4 Overview

Application	Frequency range [MHz]	FCC 47 CFR Part 15 section [2]	RSS-Gen, Issue 4 [4] and RSS-210, Issue 9 [3]	Status	Refer page
Conducted emissions on supply line	0.15 – 30	15.207 (a)	8.8 [4]	Passed	9 et seq.
Radiated emissions	0.009 – 1.000	15.205 (a) 15.209 (a)	8.9, 8.10 [4] 4.4 [3]	Passed	13 et seq.
99 % bandwidth	13.56	-	6.6 [4]	-	29 et seq.
Antenna requirement	-	15.203 [2]	-	Passed *	-

*: Integrated antenna only, requirement fulfilled.

5 Results

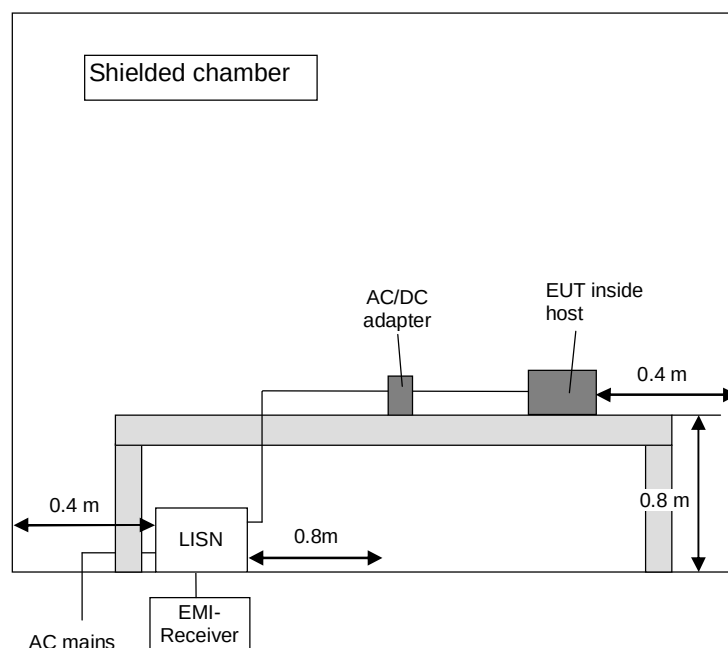
5.1 Conducted emissions on power supply lines (150 kHz to 30 MHz)

5.1.1 Method of measurement

This test will be carried out in a shielded chamber. Tabletop 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 appropriable 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



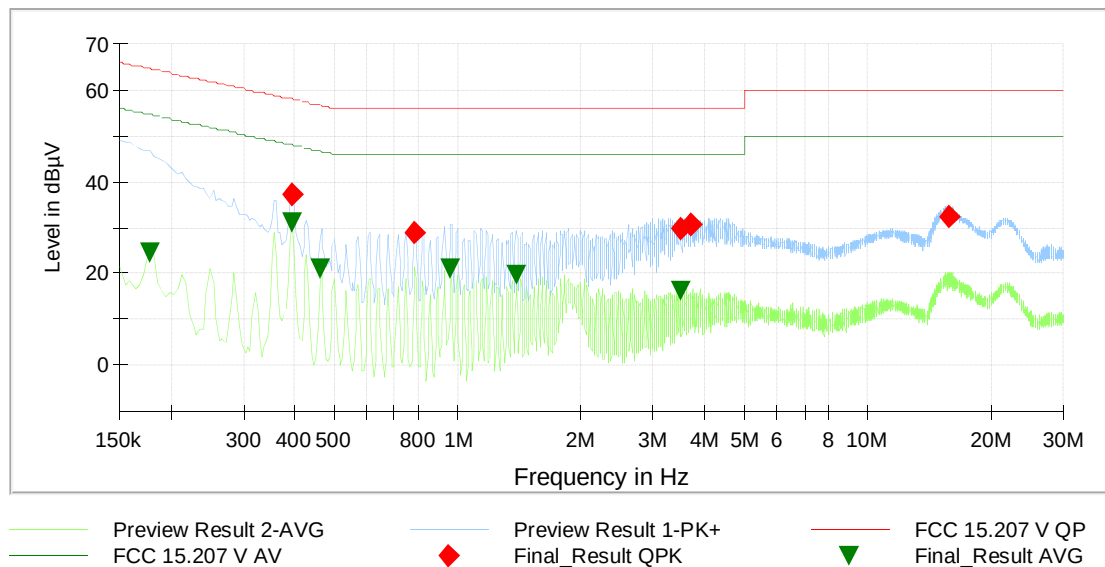
5.1.2 Test results (conducted emissions on power supply lines)

Ambient temperature	21 °C	Relative humidity	59 %
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- Position of EUT: The EUT was set-up on a non-conducting table of a height of 0.8 m.
- Cable guide: The cables of the host were fixed on the non-conducting table. For further information of the cable guide refer to the pictures in annex A of this test report.
- Test record: The test was carried out in TAG reading and writing mode of the EUT (refer also clause 2 of this test report). All results are shown in the following.
- Supply voltage: During this test the host was powered with 24 V_{DC} by the FSP120-AAAN2, which was itself supplied with 120 V_{AC} / 60 Hz.

The curves in the diagram 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 ▼.

Host RFIDs in TAG reading and writing mode

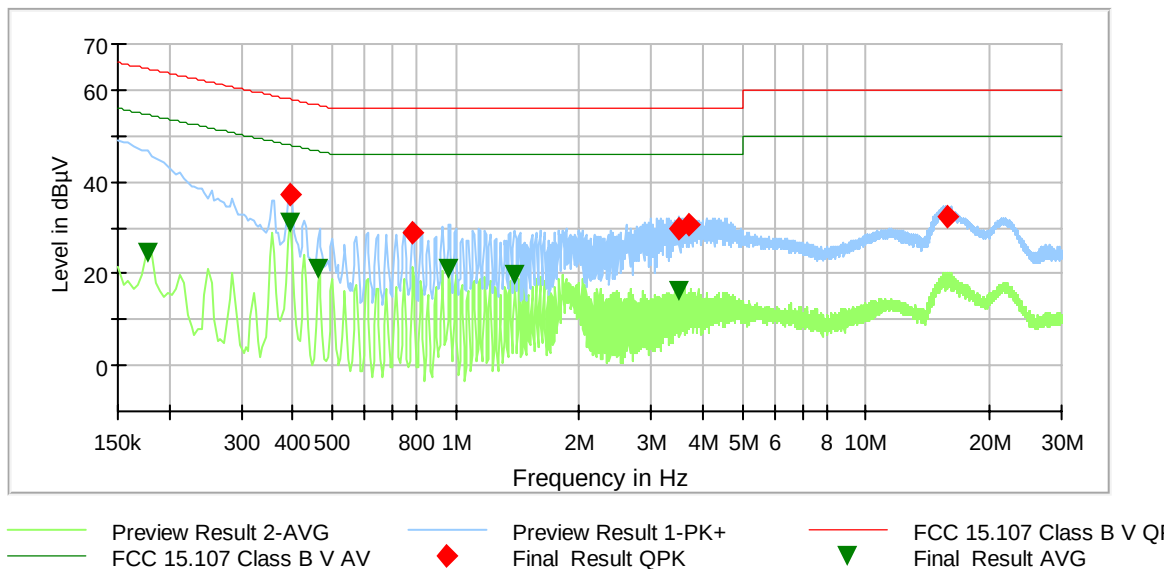


Data record name: 161791_AC_MainUnitActiveRFID

Remark: The limits of FCC 15.207 are identical to [3]

Frequency (MHz)	QuasiPeak (dBµV)	Average (dBµV)	Limit (dBµV)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Line	PE	Transducer (dB)
0.150000	42.9	---	66.0	23.1	5000.0	9.000	N	FLO	9.8
0.392100	---	32.0	48.0	16.0	5000.0	9.000	N	FLO	9.9
0.393000	37.8	---	58.0	20.2	5000.0	9.000	L1	GND	9.9
0.463200	---	22.1	46.6	24.5	5000.0	9.000	L1	FLO	9.9
0.784500	---	21.7	46.0	24.3	5000.0	9.000	L1	GND	9.9
0.964500	29.1	---	56.0	26.9	5000.0	9.000	L1	FLO	9.9
1.391100	---	19.5	46.0	26.5	5000.0	9.000	L1	FLO	9.9
1.826700	26.4	---	56.0	29.6	5000.0	9.000	L1	FLO	10.0
3.498000	---	16.3	46.0	29.7	5000.0	9.000	L1	GND	10.3
3.502500	29.3	---	56.0	26.7	5000.0	9.000	L1	GND	10.3
3.712200	30.4	---	56.0	25.6	5000.0	9.000	L1	GND	10.3
16.747800	---	16.7	50.0	33.3	5000.0	9.000	L1	FLO	10.8
Measurement uncertainty				+2.78 dB / -2.78 dB					

Host without RFID antennas (antennas plugged out)



Data record name: 161791_AC_MainUnit_digPart

Frequency (MHz)	QuasiPeak (dBµV)	Average (dBµV)	Limit (dBµV)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Line	PE	Transducer (dB)
0.177900	---	24.7	54.6	29.9	5000.0	9.000	N	FLO	9.8
0.393000	---	31.2	48.0	16.8	5000.0	9.000	L1	FLO	9.9
0.393900	37.4	---	58.0	20.6	5000.0	9.000	L1	FLO	9.9
0.464100	---	21.1	46.6	25.5	5000.0	9.000	L1	FLO	9.9
0.788100	29.1	---	56.0	26.9	5000.0	9.000	L1	FLO	9.9
0.962700	---	21.1	46.0	24.9	5000.0	9.000	L1	FLO	9.9
1.392000	---	19.6	46.0	26.4	5000.0	9.000	L1	FLO	9.9
3.502500	---	16.3	46.0	29.7	5000.0	9.000	L1	GND	10.3
3.506100	29.8	---	56.0	26.2	5000.0	9.000	L1	GND	10.3
3.716700	30.7	---	56.0	25.3	5000.0	9.000	L1	GND	10.3
15.739800	32.5	---	60.0	27.5	5000.0	9.000	L1	FLO	10.8
Measurement uncertainty				+2.78 dB / -2.78 dB					

Test: Passed

Test equipment used (see chapter 6)

1 - 4, 6

5.2 Radiated emissions

5.2.1 Method of measurement (radiated emissions)

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 measurement carried out in a fully anechoic chamber with a fixed antenna height in the frequency range 30 MHz to 1 GHz.
- A final measurement carried out on an open area test site with reflecting ground plane and various antenna heights in the frequency range 30 MHz to 1 GHz.
- A preliminary measurement carried out in a fully anechoic chamber with a fixed antenna height in the frequency range 1 GHz to 5 GHz.
- A final measurement carried out in a fully anechoic chamber with a fixed antenna height in the frequency range 1 GHz to 5 GHz.

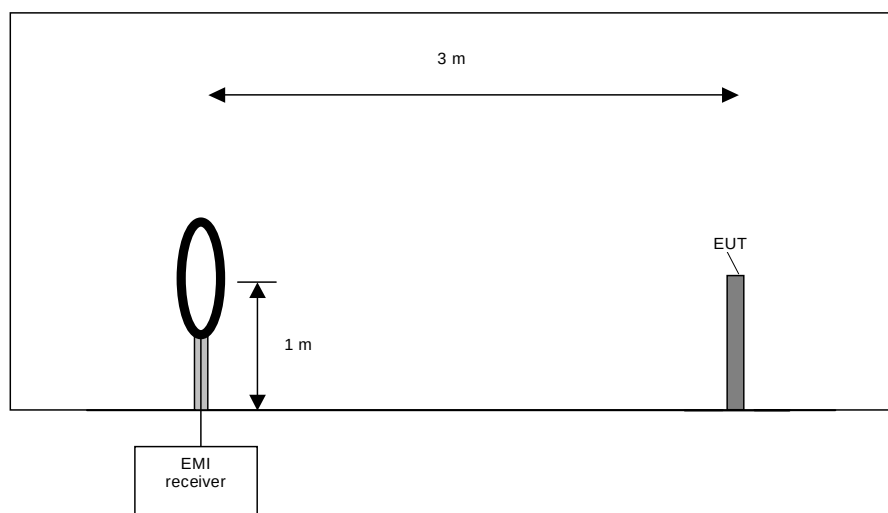
Preliminary measurement (9 kHz to 30 MHz):

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 set up 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:

Prescans 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).

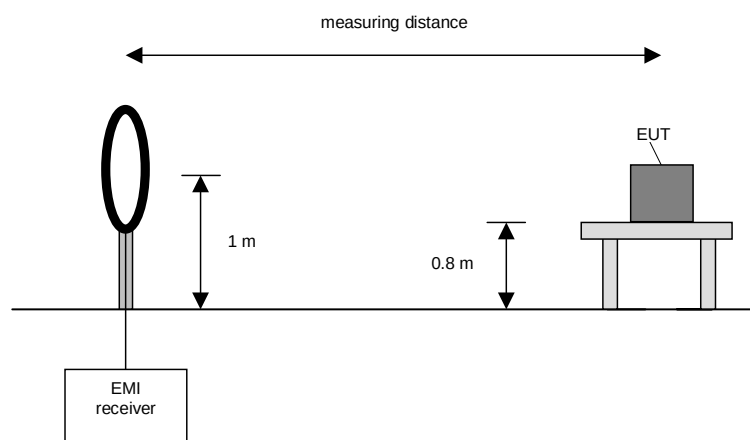
Final measurement (9 kHz to 30 MHz):

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).

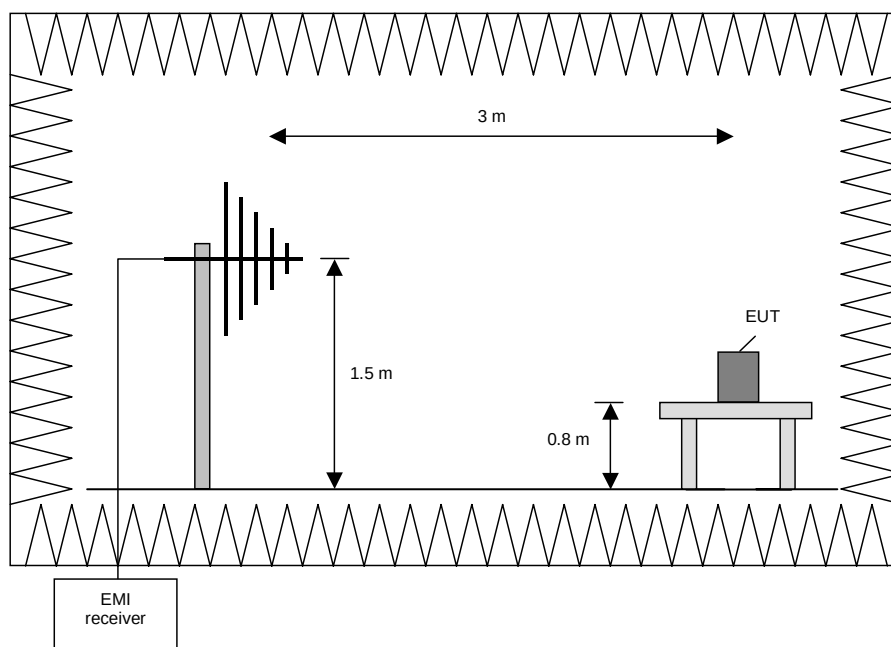
Preliminary measurement (30 MHz to 1 GHz)

In the first stage a preliminary measurement will be performed in a fully anechoic chamber with a measuring distance of 3 meter. Tabletop 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 set up of the Equipment under test will be in accordance to [1].

The frequency range 30 MHz to 1 GHz will be measured with an EMI Receiver set to MAX Hold mode and a resolution bandwidth of 120 kHz. The measurement will be performed in horizontal and vertical polarisation of the measuring antenna and while rotating the EUT in its vertical axis in the range of 0 ° to 360 °.

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

Frequency range	Resolution bandwidth
30 MHz to 1 GHz	120 kHz



Procedure preliminary measurement:

Prescans were performed in the frequency range 30 MHz to 1 GHz.

The following procedure will be used:

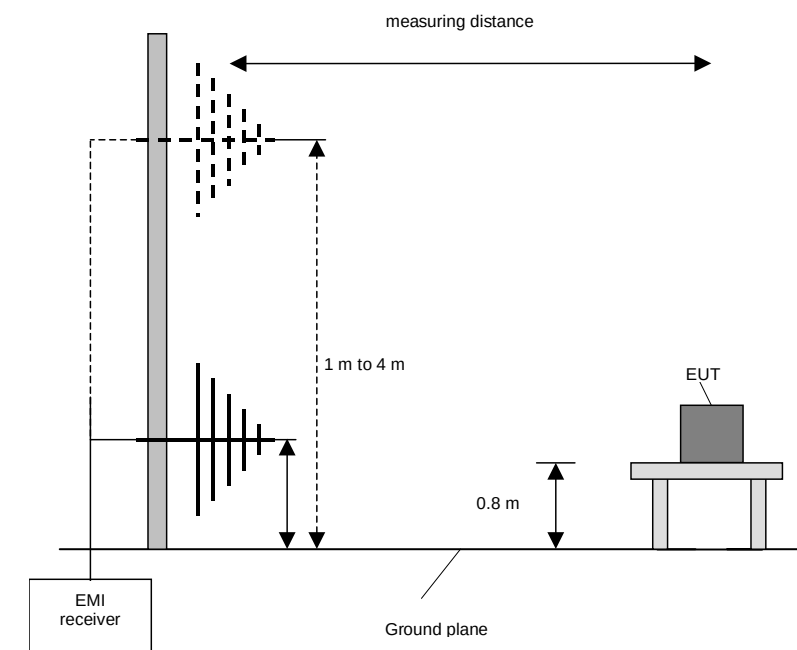
1. Monitor the frequency range at horizontal polarisation and a EUT azimuth of 0 °.
2. Manipulate the system cables within the range to produce the maximum level of emission.
3. Rotate the EUT by 360 ° to maximize the detected signals.
4. Make a hardcopy of the spectrum.
5. Measure the frequency of the detected emissions with a lower span and resolution bandwidth to increase the accuracy and note the frequency value.
6. Repeat 1) to 4) with the other orthogonal axes of the EUT if handheld equipment.
7. Repeat 1) to 5) with the vertical polarisation of the measuring antenna.

Final measurement (30 MHz to 1 GHz)

A final measurement on an open area test site will be performed on selected frequencies found in the preliminary measurement. During this test the EUT will be rotated in the range of 0 ° to 360 °, the measuring antenna will be set to horizontal and vertical polarisation 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:

Frequency range	Resolution bandwidth
30 MHz to 1 GHz	120 kHz



Procedure final measurement:

The following procedure will be used:

- 1) Measure on the selected frequencies at an antenna height of 1 m and a EUT azimuth of 23 °.
- 2) Move the antenna from 1 m to 4 m and note the maximum value at each frequency.
- 3) Rotate the EUT by 45 ° and repeat 2) until an azimuth of 337 ° is reached.
- 4) Repeat 1) to 3) for the other orthogonal antenna polarization.
- 5) Move the antenna and the turntable to the position where the maximum value is detected.
- 6) Measure while moving the antenna slowly +/- 1 m.
- 7) Set the antenna to the position where the maximum value is found.
- 8) Measure while moving the turntable +/- 45 °.
- 9) Set the turntable to the azimuth where the maximum value is found.
- 10) Measure with Final detector (QP and AV) and note the value.
- 11) Repeat 5) to 10) for each frequency.
- 12) Repeat 1) to 11) for each orthogonal axes of the EUT if handheld equipment.

Preliminary and final measurement (1 GHz to 110 GHz)

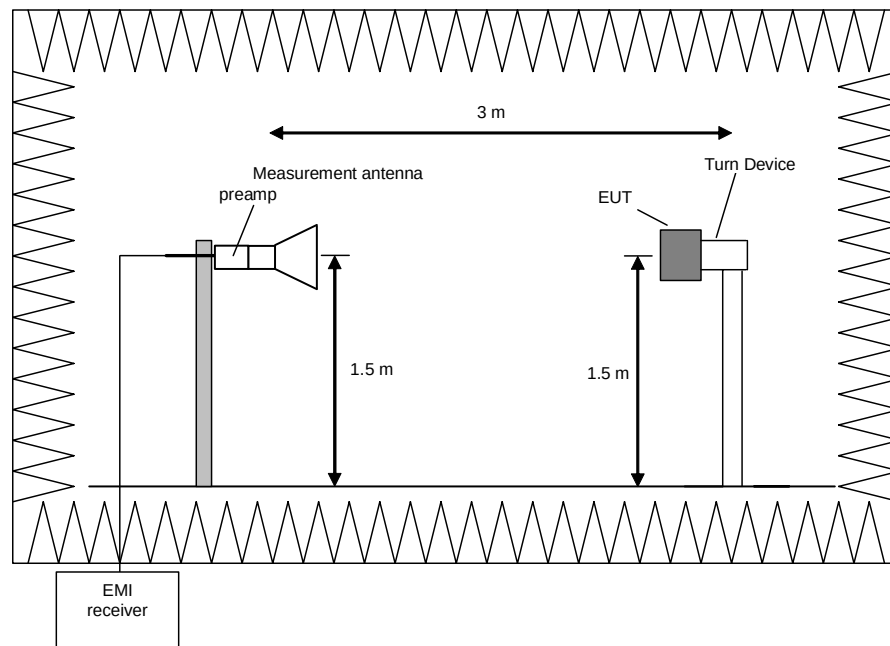
This measurement will be performed in a fully anechoic chamber. Table top devices will set up on a non-conducting turn device on the height of 1.5 m. The set-up of the Equipment under test will be in accordance to [1].

Preliminary measurement (1 GHz to 40 GHz)

The frequency range will be divided into different sub ranges depending of the frequency range of the used horn antenna. The spectrum analyser set to MAX Hold mode and a resolution bandwidth of 100 kHz. The measurement will be performed in horizontal and vertical polarisation of the measuring antenna and while rotating the EUT in its vertical axis in the range of 0 ° to 360 °. This measurement is repeated after raising the EUT in 30 ° steps according 6.6.5.4 in [1].

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

Frequency range	Resolution bandwidth
1 GHz to 4 GHz	1 MHz
4 GHz to 12 GHz	1 MHz
12 GHz to 18 GHz	1 MHz
18 GHz to 26.5 GHz	1 MHz
26.5 GHz to 40 GHz	1 MHz
40 GHz to 60 GHz	1 MHz
50 GHz to 75 GHz	1 MHz
75 GHz to 110 GHz	1 MHz



Procedure preliminary measurement:

Prescans were performed in the frequency range 1 to 40 GHz.

The following procedure will be used:

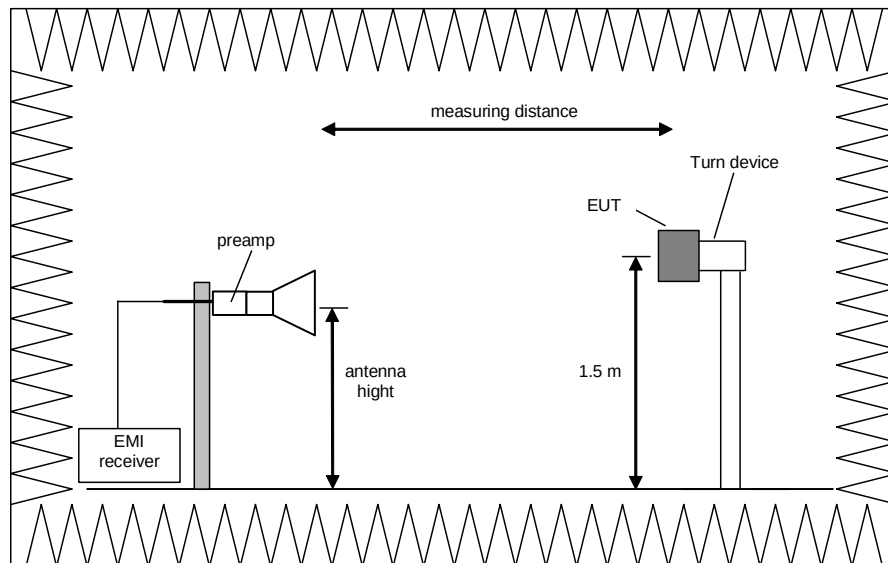
1. Monitor the frequency range at horizontal polarisation and a EUT azimuth of 0°.
2. Rotate the EUT by 360° to maximize the detected signals.
3. Repeat 1) to 2) with the vertical polarisation of the measuring antenna.
4. Make a hardcopy of the spectrum.
5. Repeat 1) to 4) with the EUT raised by an angle of 30° (60°, 90°, 120° and 150°) according to 6.6.5.4 in [1].
6. Measure the frequency of the detected emissions with a lower span and resolution bandwidth to increase the accuracy and note the frequency value.
7. The measurement antenna polarisation, with the according EUT position (Turntable and Turn device) which produces the highest emission for each frequency will be used for the final measurement. The six closest values to the applicable limit will be used for the final measurement.

Final measurement (1 GHz to 110 GHz)

The frequency range will be divided into different sub ranges depending of the frequency range of the used antenna. The EMI Receiver set to peak and average mode and a resolution bandwidth of 1 MHz. The measurement will be performed by rotating the turntable through 0 to 360° in the worst-case EUT orientation which was obtained during the preliminary measurements.

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

Frequency range	Resolution bandwidth
1 GHz to 4 GHz	1 MHz
4 GHz to 12 GHz	1 MHz
12 GHz to 18 GHz	1 MHz
18 GHz to 26.5 GHz	1 MHz
26.5 GHz to 40 GHz	1 MHz
40 GHz to 60 GHz	1 MHz
50 GHz to 75 GHz	1 MHz
75 GHz to 110 GHz	1 MHz



Procedure of measurement:

The measurements were performed in the frequency range 1 GHz to 110 GHz.

The following procedure will be used:

- 1) Set the turntable and the turn device to obtain the worst-case emission for the first frequency identified in the preliminary measurements.
- 2) Set the measurement antenna polarisation to the orientation with the highest emission for the first frequency identified in the preliminary measurements.
- 3) Set the spectrum analyser to EMI mode with peak and average detector activated.
- 4) Rotate the turntable from 0° to 360° to find the EUT angle that produces the highest emissions.
- 5) Note the highest displayed peak and average values
- 6) Repeat the steps 1) to 5) for each frequency detected during the preliminary measurements.

5.2.2 Results preliminary measurement 9 kHz to 1 GHz

Ambient temperature	22 °C	Relative humidity	62 %
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Position of EUT: The host was set-up on a non-conducting table.

Cable guide: The cables of the host were fixed on the non-conducting table. For further information of the cable guide refer to the pictures in annex A of this test report.

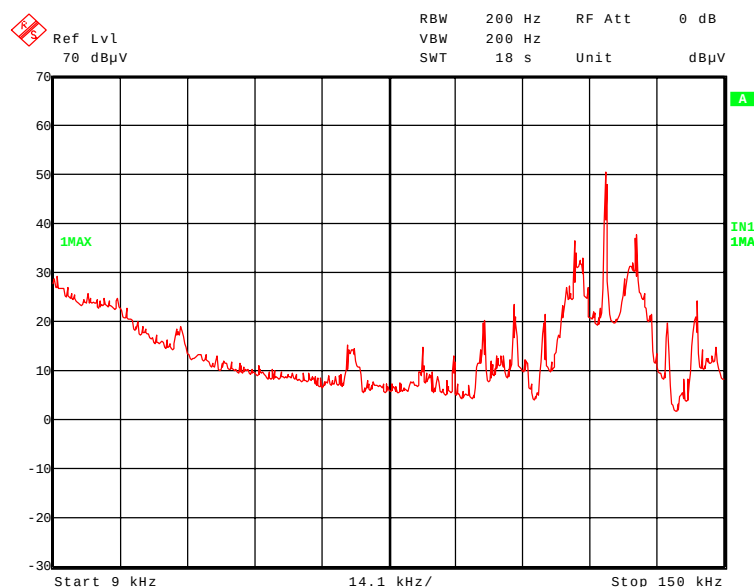
Test record: The test was carried out in TAG reading and writing mode of the EUT (refer also clause 2 of this test report). The tests were carried out in two positions; Position 1 host is standing and Position 2 host is lying. The results of the worst case positions are shown in the following. Additionally tests without RFID antennas were carried out to show that the emissions above the limit are from the digital part of the host and not from the tested radio module.

Power supply: During this test the host was powered with 24 V_{DC} by the FSP120-AAAN2, which was itself supplied with 120 V_{AC} / 60 Hz.

Frequency range: According to [2] from 9 kHz to 1 GHz.

Host RFIDs in TAG reading and writing mode

161791_202.wmf: Spurious emissions from 9 kHz to 150 kHz:

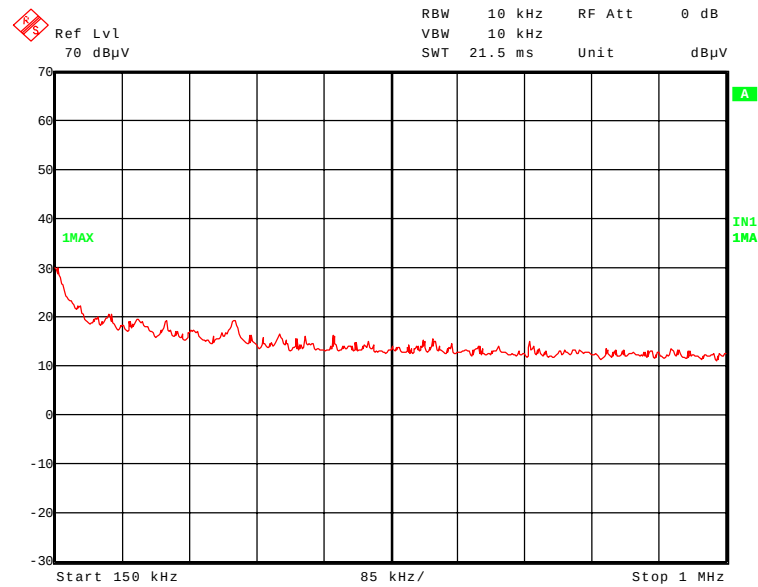


Remark: The emissions incl. the peak at 125 kHz caused by the RFID of the host and are fully documented PHOENIX TESTLAB GmbH test report reference F161791E1.

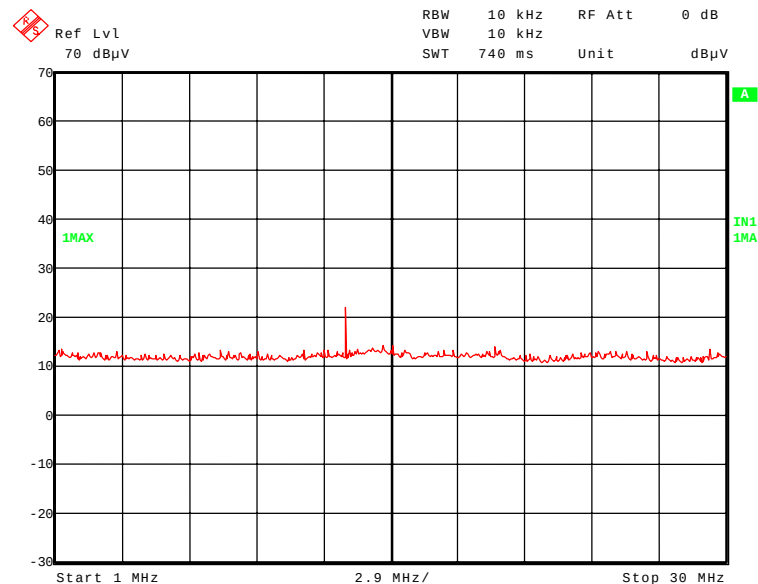
Test equipment used (see chapter 6)

30 – 35, 44, 51

161791_203.wmf: Spurious emissions from 150 kHz to 1 MHz:



161791_204.wmf: Spurious emissions from 1 MHz to 30 MHz:

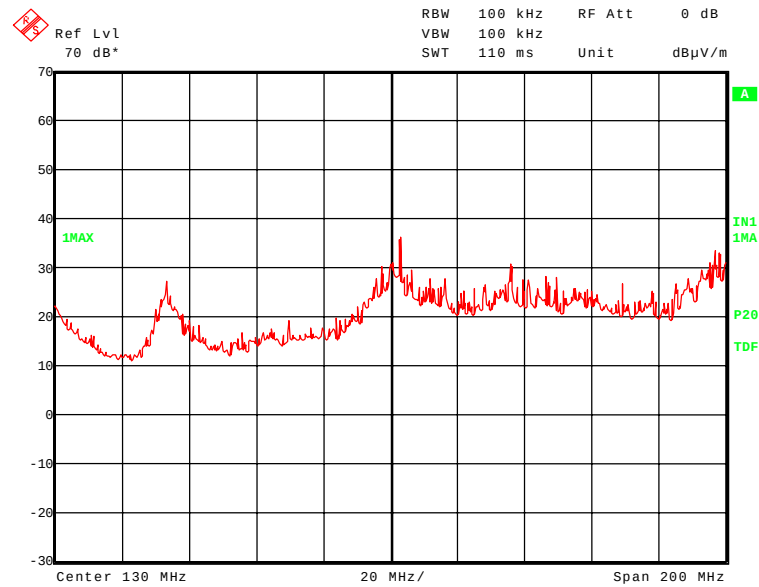


The following emissions were found according to [2] and [3].

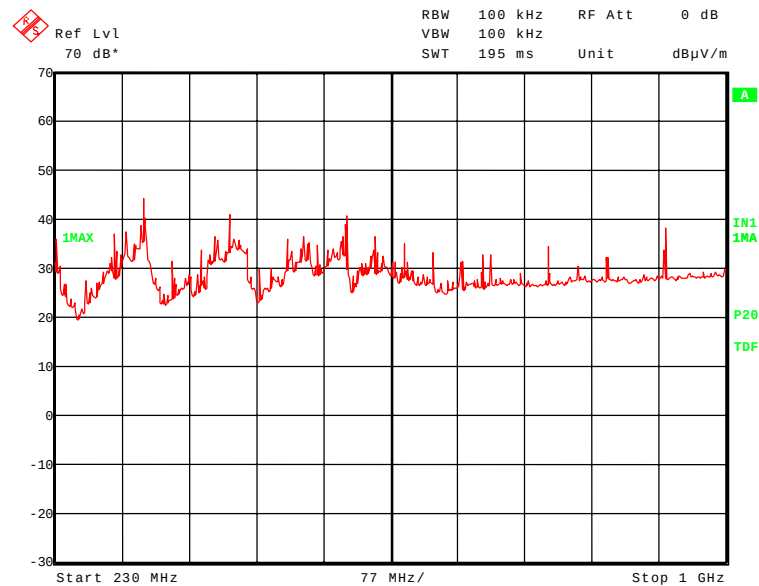
- 71.833 kHz, 105.788 kHz, 119.363 kHz, 125.013 kHz, 130.467 kHz, 144.198 kHz, 375.039 kHz and 13.560 MHz

These frequencies have to be measured on the outdoor test site. The result is presented in the following.

161791_200.wmf: Spurious emissions from 30 MHz to 230 MHz:

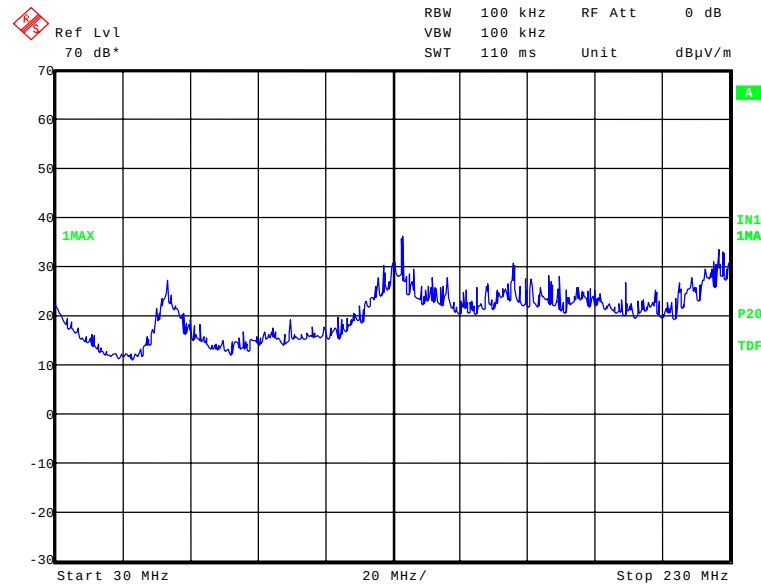


161791_201.wmf: Spurious emissions from 230 MHz to 1 GHz:

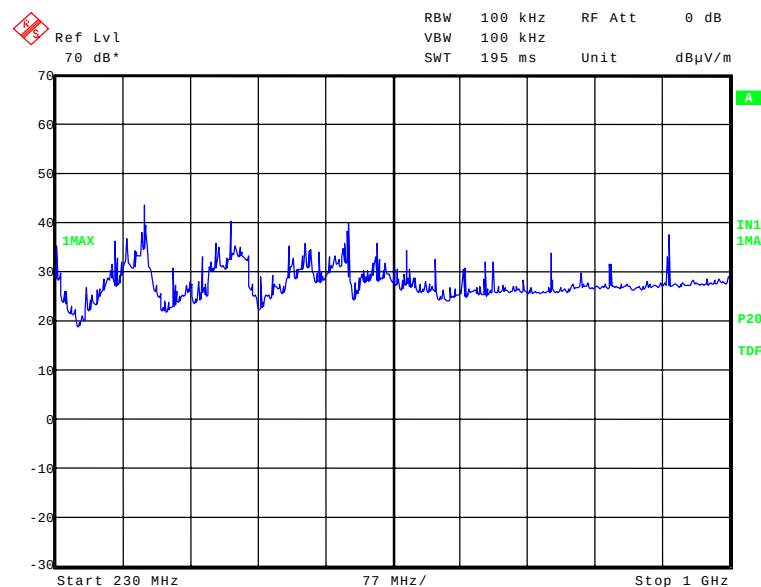


Host without RFID antennas (antennas plugged out):

161791_205.wmf: Spurious emissions from 30 MHz to 230 MHz:



161791_206.wmf: Spurious emissions from 230 MHz to 1 GHz:



The following frequencies were found emission test outside and inside restricted bands during the preliminary radiated:

- 63.312 MHz, 132.751 MHz, 165.939 MHz, 199.127 MHz, 226.443 MHz, 231.552 MHz, 331.881 MHz, 430.678 MHz, 564.194 MHz, 796.513 MHz, 929.259 MHz

These frequencies have to be measured on the open area test site. The results were presented in the following.

5.2.3 Result final measurement from 9 kHz to 30 MHz

Ambient temperature	10 °C	Relative humidity	72 %
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Position of EUT: The host was set-up on a non-conducting table of a height of 0.8 m. The distance between EUT and antenna was 3 m and 10 m.

Cable guide: The cables of the host were fixed on the non-conducting support. For further information of the cable guide refer to the pictures in annex A of this test report.

Test record: The test was carried out in TAG reading and writing mode of the EUT (refer also clause 2 of this test report). The tests were carried out in two positions; Position 1 host is standing and Position 2 host is lying. The results of the worst case positions are shown in the following. Additionally tests without RFID antennas were carried out to show that the emissions above the limit are from the digital part of the host and not from the tested radio module.

Power supply: During this test the EUT was powered with 24 V_{DC} by the FSP120-AAAN2, which was itself supplied with 120 V_{AC} / 60 Hz.

Test results: The test results were calculated with the following formula:

$$\text{Result [dB}\mu\text{V/m]} = \text{reading [dB}\mu\text{V]} + \text{antenna factor [dB/m]}$$

Host RFIDs in TAG reading and writing mode

Results with measuring distance of 3 m						
Frequency (kHz)	Result (dBμV/m)	Limit ²⁾ (dBμV/m)	Margin (dB)	Detector	Readings (dBμV)	Antenna factor ¹⁾ (dB/m)
71.833	35.6	110.5	74.9	AV	15.6	20.0
105.788	42.6	107.1	64.5	QP	22.6	20.0
119.363	41.7	106.1	64.4	AV	21.7	20.0
130.467	42.4	105.3	62.9	AV	22.4	20.0
144.198	36.7	104.4	67.7	AV	16.7	20.0
375.039	34.9	96.1	61.2	AV	14.9	20.0
13560.0 ⁴⁾	34.8	69.5	34.7	QP	14.8	20.0
Results with measuring distance of 10 m						
Frequency (kHz)	Result (dBμV/m)	Limit ²⁾ (dBμV/m)	Margin (dB)	Detector	Readings (dBμV)	Antenna factor ¹⁾ (dB/m)
125.013 ³⁾	43.9	85.7	41.8	AV	53.3	20.0
-	All signals were below the noise floor of the measuring system at 10 m distance					
Measurement uncertainty: +4.69 dB / -4.69 dB						

- 1): Cable loss included
 2): Limits according to [2] and [3] extrapolated with a factor of 40 dB/decade according to [2]
 3): Wanted signal 125 kHz RFID system (not part of this test report)
 4): Wanted signal 13.56 MHz RFID system

Test: Passed

Test equipment used (see chapter 6)

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5.2.4 Result final measurement from 30 MHz to 1 GHz

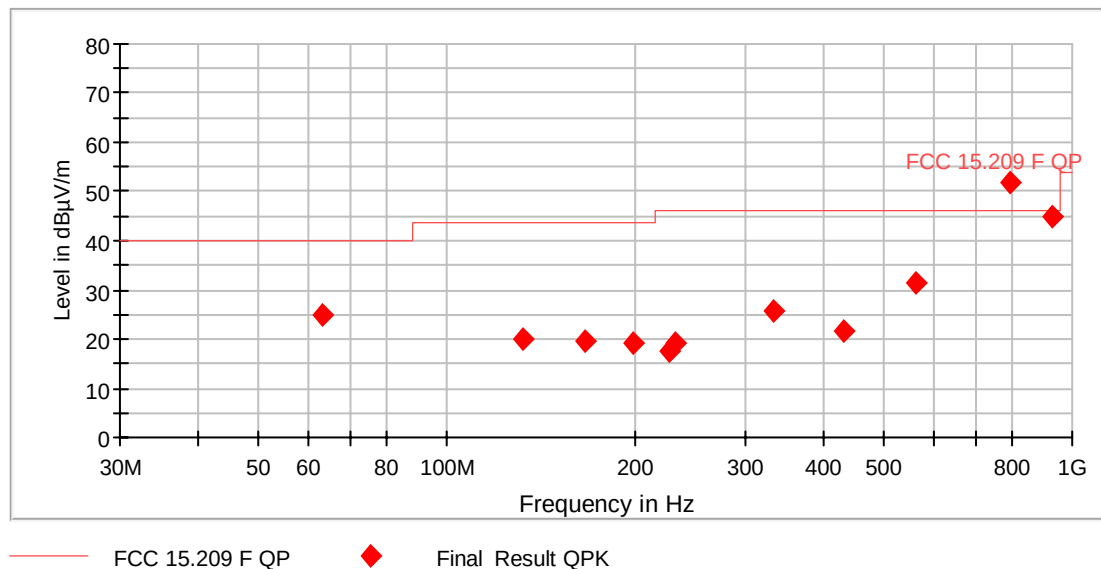
Ambient temperature	22 °C	Relative humidity	60 %
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- Position of EUT:** The host was setup on a non-conducting table of a height of 0.8 m. The distance between host and antenna was 3 m.
- Test record:** The test was carried out in TAG reading and writing mode of the EUT (refer also clause 2 of this test report). The tests were carried out in two positions; Position 1 host is standing and Position 2 host is lying. The results of the worst case positions are shown in the following. Additionally tests without RFID antennas were carried out to show that the emissions above the limit are from the digital part of the host and not from the tested radio module.
- Power supply:** During this test the host was powered with 24 V_{DC} by the FSP120-AAAN2, which was itself supplied with 120 V_{AC} / 60 Hz.
- Test results:** The test results were calculated with the following formula:
- $$\text{Result [dB}\mu\text{V/m]} = \text{reading [dB}\mu\text{V]} + \text{cable loss [dB]} + \text{antenna factor [dB/m]} + 6 \text{ dB}$$

The measured points and the limit line in the following diagrams refer to the standard measurement of the emitted interference in compliance with the above-mentioned standard. The measured points marked with an ◆ are the measured results of the standard final measurement on the open area test site.

The results of the standard subsequent measurement on the open area 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 3 m measuring distance. The measurement time with the quasi-peak measuring detector is 1 seconds.

Host RFIDs in TAG reading and writing mode, position 1

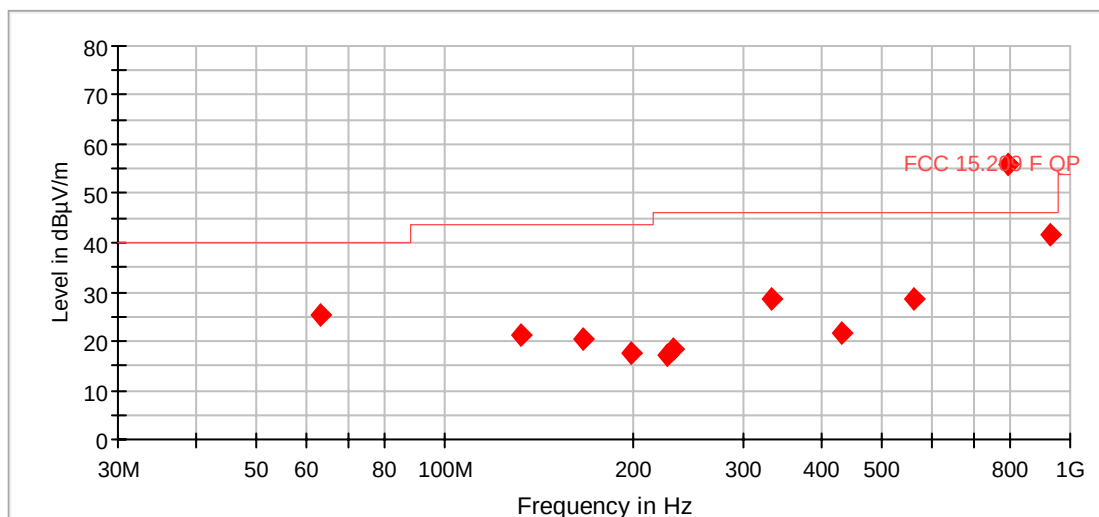


Data record name: 161971FF01 Position 1

Frequency (MHz)	QuasiPeak (dB μ V/m)	Limit (dB μ V/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)	Rest. Band
63.312000	24.8	40.0	15.2	1000.0	120.000	206.0	V	136.0	13.6	No
132.751000	20.2	43.5	23.3	1000.0	120.000	394.0	V	280.0	20.1	Yes
165.939000	19.5	43.5	24.0	1000.0	120.000	152.0	H	108.0	18.4	Yes
199.127000	19.0	43.5	24.5	1000.0	120.000	145.0	H	95.0	17.6	No
226.443000	17.5	46.0	28.5	1000.0	120.000	114.0	H	262.0	18.3	No
231.552000	19.2	46.0	26.8	1000.0	120.000	134.0	H	271.0	18.7	No
331.881000	25.9	46.0	20.1	1000.0	120.000	102.0	H	289.0	22.3	Yes
430.678000	21.6	46.0	24.4	1000.0	120.000	172.0	V	192.0	25.3	No
564.194000	31.5	46.0	14.5	1000.0	120.000	214.0	H	258.0	27.9	No
796.513000	52.0	46.0	-6.0	1000.0	120.000	400.0	H	175.0	29.5	No
929.259000	44.9	46.0	1.1	1000.0	120.000	209.0	V	162.0	30.6	No
Measurement uncertainty: +4.78 dB / -4.78 dB										

Remark: The radiated emissions above the FCC 15.209 limit line 796.513 MHz were caused host device which was classified as class A digital devices. Therefore the test can be seen as passed.

Host RFIDs in TAG reading and writing mode, position 2



— FCC 15.209 F QP ◆ Final_Result QPK

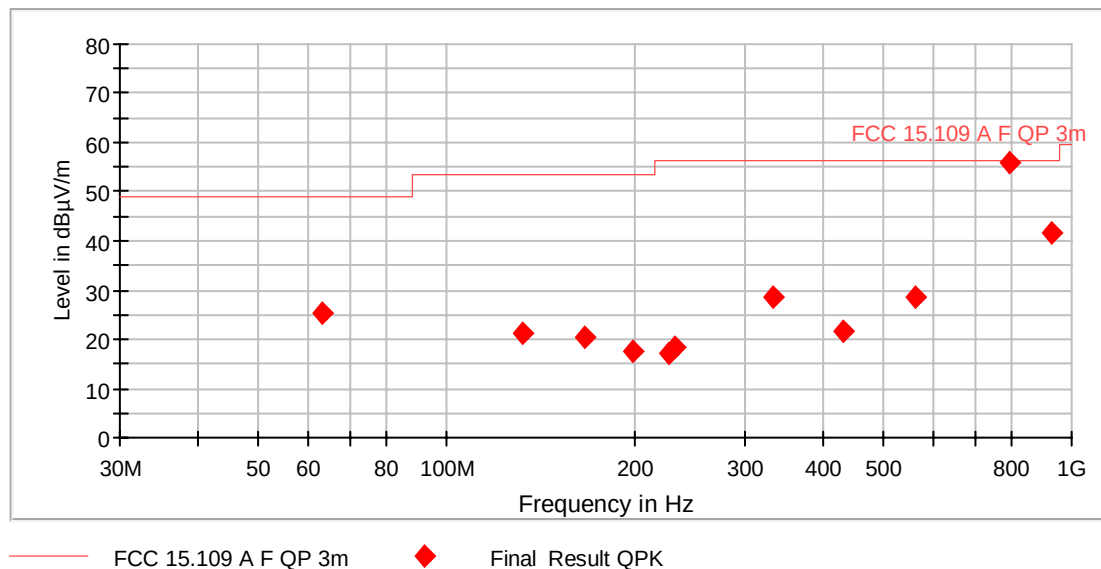
Data record name: 161971FF02 Position 2

Frequency (MHz)	QuasiPeak (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)	Rest. Band
63.312000	25.4	40.0	14.6	1000.0	120.000	207.0	V	136.0	13.6	No
132.751000	21.3	43.5	22.2	1000.0	120.000	374.0	V	226.0	20.1	Yes
165.939000	20.3	43.5	23.2	1000.0	120.000	201.0	H	85.0	18.4	Yes
199.127000	17.5	43.5	26.0	1000.0	120.000	139.0	H	72.0	17.6	No
226.443000	17.2	46.0	28.8	1000.0	120.000	140.0	H	27.0	18.3	No
231.552000	18.6	46.0	27.4	1000.0	120.000	118.0	H	192.0	18.7	No
331.881000	28.6	46.0	17.4	1000.0	120.000	100.0	H	96.0	22.3	Yes
430.678000	21.8	46.0	24.2	1000.0	120.000	177.0	H	162.0	25.3	No
564.194000	28.7	46.0	17.3	1000.0	120.000	115.0	H	268.0	27.9	No
796.513000	56.1	46.0	-10.1	1000.0	120.000	305.0	V	33.0	29.5	No
929.259000	41.7	46.0	4.3	1000.0	120.000	395.0	V	55.0	30.6	No
Measurement uncertainty: +4.78 dB / -4.78 dB										

Remark: The radiated emissions above the FCC 15.209 limit line 796.513 MHz were caused host device which was classified as class A digital devices. Therefore the test can be seen as passed.

Host without RFID antennas (position 1 only was measured as worst case)

Remark: The host devices are classified as class A digital devices. Because the emissions of the hosts are much higher than the emissions caused by the RFID reader, the hosts were measured with and without RFID module in order to identify the source of the emissions found.



Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)	Rest. Band
63.312000	25.4	49.0	23.6	1000.0	120.000	207.0	V	136.0	13.6	
132.751000	21.3	53.5	32.2	1000.0	120.000	374.0	V	226.0	20.1	
165.939000	20.3	53.5	33.2	1000.0	120.000	201.0	H	85.0	18.4	
199.127000	17.5	53.5	36.0	1000.0	120.000	139.0	H	72.0	17.6	
226.443000	17.2	56.4	39.3	1000.0	120.000	140.0	H	27.0	18.3	
231.552000	18.6	56.4	37.8	1000.0	120.000	118.0	H	192.0	18.7	
331.881000	28.6	56.4	27.8	1000.0	120.000	100.0	H	96.0	22.3	
430.678000	21.8	56.4	34.6	1000.0	120.000	177.0	H	162.0	25.3	
564.194000	28.7	56.4	27.7	1000.0	120.000	115.0	H	268.0	27.9	
796.513000	56.1	56.4	0.3	1000.0	120.000	305.0	V	33.0	29.5	
929.259000	41.7	56.4	14.7	1000.0	120.000	395.0	V	55.0	30.6	

Measurement uncertainty: +4.78 dB / -4.78 dB

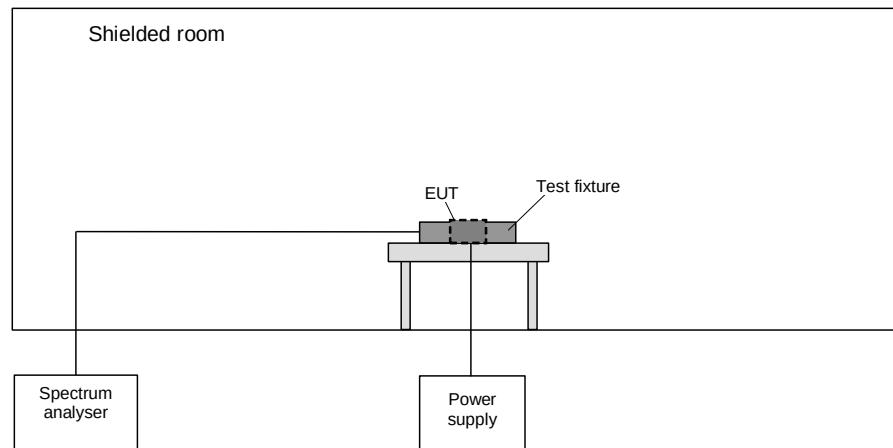
Test: Passed

Test equipment used (see chapter 6)

14 - 21

5.3 99 % bandwidth

5.3.1 Method of measurement



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

The span of the analyzer shall be set to capture all products of the modulation process, including the emission skirts. The resolution bandwidth shall be set to as close to 1% of the selected span as is possible without being below 1%. The video bandwidth shall be set to 3 times the resolution bandwidth. Video averaging is not permitted. Where practical, a sampling detector shall be used since a peak or, peak hold, may produce a wider bandwidth than actual.

The trace data points are recovered and are directly summed in linear terms. The recovered amplitude data points, beginning at the lowest frequency, are placed in a running sum until 0.5% of the total is reached and that frequency recorded. The process is repeated for the highest frequency data points. This frequency is recorded.

The span between the two recorded frequencies is the occupied bandwidth.

5.3.2 Test results

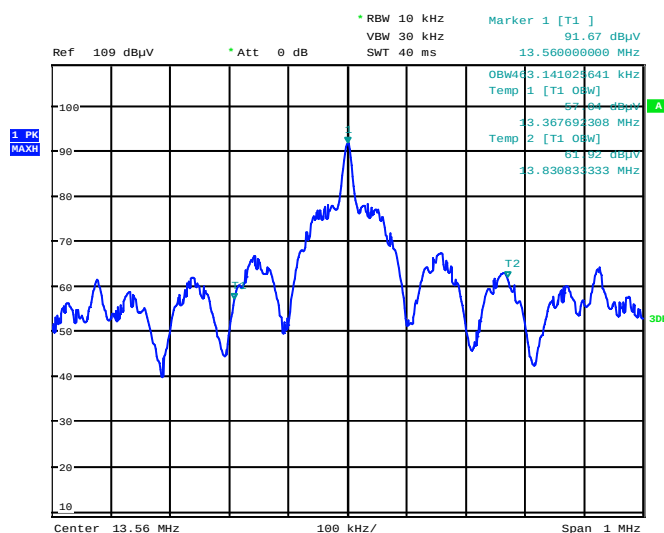
Ambient temperature:	21 °C	Relative humidity:	45 %
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Test record: The test was carried out in TAG reading and writing mode of the EUT (refer also clause 2 of this test report). All results are shown in the following.

Power supply: During this test the host was powered with 24 V_{DC} by the FSP120-AAAN2, which was itself supplied with 120 V_{AC} / 60 Hz.

Host RFIDs in TAG reading and writing mode

MT99A_004.wmf: 99 % bandwidth:



F_L	F_U	BW ($F_U - F_L$)
13.367692 MHz	13.830833 MHz	463.141 kHz
Measurement uncertainty		$< 1 \cdot 10^{-7}$

Test equipment used (see chapter 6)

43, 52

6 Test equipment

No.	Test equipment	Type	Manufacturer	Serial No.	PM. No.	Cal. Date	Cal. due
1	Shielded chamber M4	-	Siemens	B83117-S1-X158-	480088	Weekly verification (system cal.)	
2	EMI Receiver	ESIB 26	Rohde & Schwarz	1088.7490	481182	02/15/2016	02/2018
3	LISN	NSLK8128	Schwarzbeck	8128161	480138	02/16/2016	02/2018
4	Transient Filter Limiter	CFL 9206A	Teseq GmbH	38268	481982	Weekly verification (system cal.)	
6	EMI Software	EMC 32	Rohde & Schwarz	100061	481022	-	-
7	Outdoor test site	-	Phoenix Test-Lab	-	480293	Weekly verification (system cal.)	
14	Open area test site	-	Phoenix Test-Lab	-	480085	Weekly verification (system cal.)	
15	Measuring receiver	ESIB7	Rohde & Schwarz	100304	480521	02/18/2016	02/2018
16	Controller	HD100	Deisel	100/670	480139	-	-
17	Turntable	DS420HE	Deisel	420/620/80	480087	-	-
18	Antenna support	AS615P	Deisel	615/310	480086	-	-
19	Antenna	CBL6111 D	Chase	25761	480894	09/18/2014	09/2017
20	EMI-Software	EMC 32	Rohde & Schwarz	-	481022	-	-
21	6 dB attenuator	R412706000	Radiall	9833	410082	Annual verification	
30	Fully anechoic chamber M20	-	Albatross Projects	B83107-E2439-T232	480303	Weekly verification (system cal.)	
31	Measuring receiver	ESI 40	Rohde & Schwarz	100064	480355	02/16/2016	02/2017
32	Controller	MCU	Maturo	MCU/043/971107	480832	-	-
33	Turntable	DS420HE	Deisel	420/620/80	480315	-	-
34	Antenna support	AS615P	Deisel	615/310	480187	-	-
35	Antenna	CBL6112 B	Chase	2688	480328	04/14/2014	04/2017
43	Spectrum analyser	FSU46	Rohde & Schwarz	200125	480956	02/17/2016	02/2017
44	RF-cable No. 36	Sucoflex 106B	Suhner	0522/6B	480571	Weekly verification (system cal.)	
51	Loop antenna	HFH2-Z2	Rohde & Schwarz	832609/014	480059	02/29/2016	02/2018
52	Loop Antenna $\lambda = 110$ mm	-	Phoenix Testlab	-	410084	-	-
53	Outdoor test site	-	Phoenix Testlab	-	480293	-	-

7 Report history

Report Number	Date	Comment
F161791E2	10/05/2017	Document created
-	-	-

8 List of annexes

Annex A Test setup photos

7 pages

161791emiB1.jpg: Host (Excellence Titrator T9), test setup fully anechoic chamber
 161791emiB2.jpg: Host (Excellence Titrator T9), test setup fully anechoic chamber
 161791emiB3.jpg: Host (Excellence Titrator T9), test setup fully anechoic chamber
 161791emiB4.jpg: Host (Excellence Titrator T9), test setup outdoor test site
 161791emiB5.jpg: Host (Excellence Titrator T9), test setup open area test site
 161791emiB6.jpg: Host (Excellence Titrator T9), test setup open area test site
 161791emicB1.jpg: Host (Excellence Titrator T9), test setup shielded chamber

Annex B External photos

15 pages

161791eut1.jpg: Host (Excellence Titrator T9), 3D-view 1
 161791eut2.jpg: Host (Excellence Titrator T9), rear view
 161791eut3.jpg: Host (Excellence Titrator T9), top view
 161791eut4.jpg: Host (Excellence Titrator T9), side view
 161791eut5.jpg: Host (Excellence Titrator T9), bottom view
 161791eut6.jpg: Host (Excellence Titrator T9), type plate view
 161791eut7.jpg: Host (Excellence Titrator T9), top view, burette removed
 161791eut8.jpg: Burette (with TAG), 3D-view 1
 161791eut9.jpg: Burette (with TAG), 3D-view 2
 161791eut10.jpg: Type plate of dedicated AC/DC adaptor
 161791eut11.jpg: Terminal, 3D-view 1
 161791eut12.jpg: Terminal, 3D-view 2
 161791eut20.jpg: Burette (with TAG), 3D-view 1
 161791eut21.jpg: Burette (with TAG), 3D-view 2
 161791eut22.jpg: Measuring cup with 13.56 MHz TAG

Annex C Internal photos

25 pages

161791eut15.jpg: Host (Excellence Titrator T9), internal view 1
 161791eut19.jpg: Host (Excellence Titrator T9), internal view 3
 161791pcbA1.jpg: Host (Excellence Titrator T9), PCB 1, top view 1
 161791pcbG22: EUT (13.56 MHz RFID reader module) inside plastic housing
 161791pcbG1; EUT (13.56 MHz RFID reader module), PCB, top view
 161791pcbG; EUT (13.56 MHz RFID reader module), PCB, bottom view
 161791pcbA2.jpg: Host (Excellence Titrator T9), PCB 1, top view 2
 161791pcbA3.jpg: Host (Excellence Titrator T9), PCB 1, bottom view
 161791pcbB1.jpg: Host (Excellence Titrator T9), PCB 2, top view
 161791pcbB3.jpg: Host (Excellence Titrator T9), PCB 2, bottom view
 161791pcbC1.jpg: Host (Excellence Titrator T9), PCB 3, top view
 161791pcbC2.jpg: Host (Excellence Titrator T9), PCB 3, bottom view
 161791pcbC3.jpg: Host (Excellence Titrator T9), PCB 3, front view
 161791pcbD1.jpg: Host (Excellence Titrator T9), PCB 4, top view
 161791pcbD2.jpg: Host (Excellence Titrator T9), PCB 4, bottom view
 161791pcbD3.jpg: Host (Excellence Titrator T9), PCB 4, front view
 161791pcbE1.jpg: Host (Excellence Titrator T9), PCB 5, top view 1
 161791pcbE2.jpg: Host (Excellence Titrator T9), PCB 5, top view 2, PCB 6 removed
 161791pcbE3.jpg: Host (Excellence Titrator T9), PCB 5, bottom view
 161791pcbE4.jpg: Host (Excellence Titrator T9), PCB 5, front view
 161791pcbE6.jpg: Host (Excellence Titrator T9), PCB 5, top view 2
 161791eut18.jpg: Host (Excellence Titrator T9), 125 kHz RFID antenna
 161791eut17.jpg: Host (Excellence Titrator T9), 125 kHz RFID antenna installation
 161791pcbF1.jpg: Host (Excellence Titrator T9), PCB 6, top view
 161791pcbF2.jpg: Host (Excellence Titrator T9), PCB 6, bottom view