ETSI TS 103 302 V1.1.1 (2015-04)

Electromagnetic compatibility and Radio spectrum Matters (ERM); Test Specification for the RFID Interoperability Test Event in Brazil May 2013

Reference
DTS/ERM-TG34-263

Keywords
ID, radio, RFID

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Foreword

This Technical Specification (TS) has been produced by ETSI Technical Committee Electromagnetic compatibility and Radio spectrum Matters (ERM).

Modal verbs terminology

In the present document "**shall**", "**shall not**", "**should**", "**should not**", "**may**", "**need not**", "**will**", "**will not**", "**can**" and "**cannot**" are to be interpreted as described in clause 3.2 of the ETSI Drafting Rules (Verbal forms for the expression of provisions).

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Introduction

Currently the Brazilian regulations concerning RFID are based on the FHSS mode of operation, as commonly used in the Americas, rather than the four channel plan that has been adopted in Europe. However with the increasing number of RFID technologies and applications available at UHF, the Brazilian RFID community has recently expressed a strong interest in participating in an ETSI Plugtests event. They believed that this would provide them with a better understanding of the role of ETSI within Europe and of the standardization activities that had taken place on RFID at UHF within the ETSI Technical Body TC ERM TG34.

CPqD is aware of the increasing number of RFID technologies and applications presently available at UHF. Furthermore in Brazil GSM operates in the frequency bands 907,5 - 915 MHz, which is adjacent to the band occupied by RFID. These factors have led CPqD to identify the need to perform an interoperability test in co-operation with an independent international standardization body. Subsequently arrangements were made to perform Plugtests with the European Telecommunications Standards Institute (ETSI).

The present document describes a test plan to evaluate the comparative performance of the FHSS mode of operation as commonly used in the Americas and the four channel plan that has been adopted in Europe.

1 Scope

The present document describes the test scenarios performed at the RFID Interoperability event in Brazil. The interoperability event, also called Plugtests event is being organized by ETSI, CPqD and FP7 Probe-IT Project. The event took place from 20 - 24 May 2013 at the CPqD Head Quarters, in Campinas, Brazil.

The primary purpose of the tests was to compare the performance between interrogators when configured in the FHSS mode and interrogators configured to operate in accordance with the 4 channel plan, defined by ETSI and adopted in Europe. In addition further tests were carried out to assess the reading performance of tags when attached to "unfriendly" items and the effect of tag orientation.

2 References

2.1 Normative references

References are either specific (identified by date of publication and/or edition number or version number) or non-specific. For specific references, only the cited version applies. For non-specific references, the latest version of the reference document (including any amendments) applies.

Referenced documents which are not found to be publicly available in the expected location might be found at http://docbox.etsi.org/Reference.

NOTE: While any hyperlinks included in this clause were valid at the time of publication, ETSI cannot guarantee their long term validity.

The following referenced documents are necessary for the application of the present document.

Not applicable.

2.2 Informative references

References are either specific (identified by date of publication and/or edition number or version number) or non-specific. For specific references, only the cited version applies. For non-specific references, the latest version of the reference document (including any amendments) applies.

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The following referenced documents are not necessary for the application of the present document but they assist the user with regard to a particular subject area.

[i.1] ETSI TR 103 271: "Electromagnetic compatibility and Radio spectrum Matters (ERM); Report on RFID Brazil Plugtests 20th - 24th May 2013".

3 Definitions, symbols and abbreviations

3.1 Definitions

For the purposes of the present document, the following terms and definitions apply:

interrogator: device that can read and write to RFID tags

tag: transponder that holds data and responds to an interrogation signal

Tari: reference time interval for a data-0 in interrogator-to-tag signalling

3.2 Symbols

For the purposes of the present document, the following symbols apply:

dB	decibel
dBm	power level relative to 1 mW
kHz	kilo Hertz
m	metres
MHz	Mega Hertz
us	micro second

3.3 Abbreviations

For the purposes of the present document, the following abbreviations apply:

BER	Bit Error Rate
DAA	Detect And Avoid
EIRP	Effective Isotropic Radiated Power
EPC	Electronic Product Code
FDM	Frequency-Division Multiplexing
FHSS	Frequency Hopping Spread Spectrum
FM	Frequency Modulation
GSM	Global System for Mobile communications
RBW	Resolution BandWidth
RF	Radio Frequency
RFID	Radio Frequency IDentification
SMA	SubMiniature version A (connector)
TDM	Time-Division Multiplexing
UHF	Ultra High Frequency
VBW	Video BandWidth

4 Test preparation

4.1 Arrangements

The test schedule for the Plugtests, has been split as follows:

- 1st Day Check and prepare equipment for the tests;
- 2nd DayComparison between FHSS and 4-channel plan;
- 3rd Day a.m. Complete comparison of mitigation techniques;

  p.m. GSM interference tests;

  preparation for tag performance tests;
- 4th Day Perform tag performance tests;
- 5th Day Assess results and tear down;

Sufficient mains power points were provided. The mains supplies are both 110 V and 220 V at 60 Hz using the types of plugs illustrated in Figure 1.

110 ~ 127V/ 60 Hz - Phase/Neutral and 220V / 60 Hz - Phase / Phase

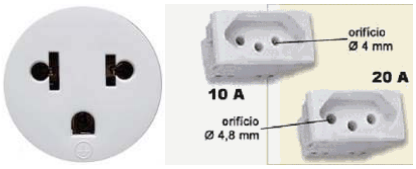


Figure 1: Picture of mains plugs

The Parts 1 and 2 of the Plugtest were supervised by Representatives from ETSI. They were assisted by representatives of CPqD. Following completion of Parts 1 and 2 representatives from CPqD shall supervise Part 3 and Part 4 assisted by the representatives from ETSI. On completion of the Plugtest CPqD and ETSI jointly prepare a Technical Report (ETSI TR 103 271 [i.1]), which includes an analysis of the test results.

4.2 Equipment

ETSI provided the following equipment for the Plugtests:

1) 3 x demonstrators capable of operating in the band 915 - 921 MHz and incorporating DAA. Additionally they had the ability to operate under the four channel plan. Each interrogator was capable of driving at least two antennas with an output of 4 W eirp.

2) All interrogators were fitted with SMA female connectors.

3) The software application for operating the demonstrators and controlling operation of the DAA. This software included the ability to log the successful reading of tags together with recording the total time taken to complete the operation.

CPqD provided:

1) 3 x interrogators using FHSS mode and modified for operation at Brazilian frequencies.

2) 4 x circularly polarized antennas for operation in the band 902 - 928 MHz for use in scenarios 1, 2 and 3.

3) An additional four antennas for scenario 4.

4) 3 x laptops for interfacing with the interrogators under test.

5) 3 x cardboard sheets each with 50 tags mounted on one side as shown in Figure 4.

6) An additional 120 tags applied as described in clause 5.4.

7) Three simulated portals as illustrated in Figure 3.

8) One GSM emulator.

9) One portal for use in scenario 4.

10) One optical light beam for use in scenario 4.

4.3 Application Scenarios

The test plan defines four different application scenarios. Each scenario describes the set-up in which RFID interrogators and tags are used. The four test scenarios are:

- Scenario 1: Comparative performance of FHSS and 4 channel Plan.
- Scenario 2: Comparison of mitigation techniques.
- Scenario 3: Analysis of interference between RFID and GSM.
- Scenario 4: Analysis of tag performance.

The detailed specifications for these scenarios are described in clause 5.

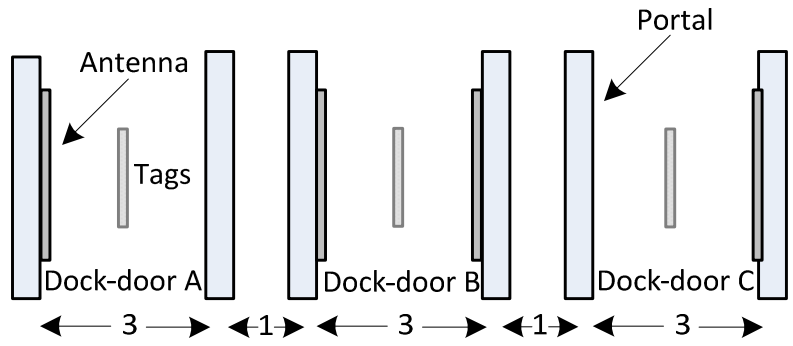
4.4 Test arrangements

Scenarios 1, 2 and 3 shall be performed in a semi-anechoic chamber. A picture of the chamber, which is at least 19 m in length, is shown in Figure 2. The environmental conditions inside the chamber are:

- Ambient temperature: 20 to 26 °C;
- Relative Humidity: 40 to 60 %.

Figure 2: Semi-Anechoic Chamber

Three adjacent portals shall be installed inside the chamber in accordance with the dimensions in Figure 3. In order to minimize interference, shielding (at least 1 m wide by 1,5 m high) shall be placed between the portals.



Note: All dimensions in metres

Figure 3: Layout of dock-doors

The tags, which shall be mounted on cardboard sheets, shall be placed midway between the dock-doors.

CPqD shall make an additional portal available in order to evaluate the performance of different tags as specified in scenario 4.

4.5 Selection of Tags

For scenarios 1, 2 and 3, 150 tags shall be fixed in equal numbers to three cardboard sheets. For scenario 4, tags shall be attached to cartons as specified in clause 5.4.

The tags shall be selected from 500 samples using the selection and verification method described below.

This process seeks to select the tags with the most consistent performance.

In order to perform the selection, the following equipment is required:

- RFID interrogator with control software;
- RFID antenna with circular polarization;
- Measurement antenna;
- Spectrum analyser.

Using the above equipment, the following steps shall be performed in order to select the tags:

1) Connect the RFID interrogator to a computer which has the RFID application installed;
2) Connect the RFID antenna (with circular polarization) to the RFID interrogator using a cable with a known cable loss;
3) Install the RFID antenna on a non-metallic support (recommended wood or plastic);
4) Adjust the RFID antenna to a height of 1,15 m above the ground;
5) Mount the measurement antenna on a non-metallic support (recommended wood or plastic)
6) Adjust the measurement antenna to a height of 1,2 m above the ground;
7) Align the measurement antenna parallel to the face of the RFID antenna;
8) Position the measurement antenna at a distance of 1 m from the RFID antenna;
9) Using an RF cable (with known cable loss), connect the measurement antenna to the spectrum analyzer;
10) Disable the frequency hop mode in the interrogator;
11) Configure the interrogator to operate at 915 MHz;
12) Adjust the output power of the interrogator to +30 dBm;
13) Configure the spectrum analyser to the following parameters:
    - Central Frequency: 915 MHz;
    - Span: 100 MHz;
    - RBW and VBW: automatic;
    - Max Hold;
14) Verify that the measured maximum peak power is in the range +10 and +20 dBm;
15) Record the measured value;
16) Record the EPC number of the tag under test
17) Mount the tag on a non-metallic support (recommended wood or plastic);
18) Adjust the tags to an average height of to 1,2 m above the ground;
19) Position the tag at a distance of 10 m from the circular polarized antenna;

20) Move the tag towards the interrogator recording the distance at which it is first identified;

21) Record the measured value as **Dmax** corresponding to EPC number of the tag;

22) Repeat the steps 19 until 22 for all the tags to be tested.

In order to select the tags for use in the scenarios the following the steps shall be taken:

1) Find the minimum and the maximum values recorded in Dmax;

2) Calculate the arithmetic average between the minimum and maximum values found for Dmax;

3) Record the Dmax arithmetic average value as Dav;

4) Select the tags whose Dmax values are closest to Dav.

5) Mount 150 tags on 3 x cardboard back-planes (50 tags on each) as shown in Figure 4.

Figure 4: Photo of 50 tags mounted on cardboard sheet

NOTE: The tags should be pre-programmed with sequential EPC numbers and arranged in a way that permits rapid identification. The EPC should be:

0x mm mm CB 00 00 SS RR CC,

where mm may be any 32 bit number, which should be the same for all tags. The values of SS, RR and CC should denote the cardboard sheet number, the row and column where the tag is mounted. Record the coordinates of each tag on the cardboard back-plane.

For scenario 4 a further 120 loose tags shall be programmed in accordance with a numbering scheme similar to the one defined above. (e.g. 0x mm mm CB 00 PP LL aa bb where PP is pallet number, LL is level and aa, bb are coordinates of the carton on each level).

4.6 Noise Level Measurement

Before starting the Plugtests, the spurious noise level should be measured using the procedure described below.

- Readings should be taken using the measurement antenna inside the semi-anechoic chamber close to the three portals, and outside the chamber close to the portal for scenario 4.
- The spectrum analyzer should be set to the following parameters:
  - Center Frequency: 915 MHz;
  - Span: 100 MHz;
  - RBW: 10 kHz and VBW 30 kHz;

- Max hold.

The ambient RF noise level should be measured over 2 minutes and the max. peak value recorded. A screen shot of one of the measurements should be made for inclusion in the test report.

For all measurements inside the semi-anechoic chamber (scenarios 1, 2 and 3), the peak power of the spurious noise level within the band 902 - 928 MHz should be less than -90 dBm. For scenario 4 the level shall be recorded.

5 Test Procedure

5.1 Scenario 1 - Comparative Performance of FHSS and 4 Channel Plan

The objective of this test scenario is to compare the performance of the FHSS system used in Brazil against the new 4 channel plan proposed for Europe but at existing data rates.

Each system is evaluated in two steps. First, there shall be a baseline test with just one interrogator enabled. In a second step all three interrogators shall be enabled at the same time in order to evaluate the impact of simultaneous operation.

This setup simulates the environmental conditions found at the dock doors of logistics distribution centers where RFID is in use. In this application RFID interrogators are commonly installed in portals, which are positioned close to the dock doors. Since the portals are physically very close, there is a risk of interference between them.

In such applications, the standard technique called Dense Interrogator Mode is used. This separates the frequency of operation of the signal transmitted by the interrogator from the response from the tag. The technique includes the use of FDM (Frequency-division multiplexing) and TDM (Time-division multiplexing).

The setup consists of simulations of three dock-door portals, circular polarized antennas mounted on tripods and shielding between the individual portals. The setup shall be installed in the semi-anechoic chamber illustrated in Figure 2. Each interrogator shall be connected to its own computer complete with its control software. Initially tests shall be performed using three interrogators operating in the FHSS mode at the Brazilian frequency bands. Subsequently the tests shall be repeated with interrogators operating in accordance with the 4 channel plan in the proposed new European frequency band.

Interrogators should be configured to transmit at a power of 4 W (EIRP).

Tests shall be carried out as described below. The average times to read the tags in each portal for both of the modes shall be compared.

Using the test setup described below, the Brazilian interrogators shall be connected to their respective antennas mounted in the portals.

The following steps shall be performed:

1) With just the interrogator in portal A in operation, the time taken to identify all 50 tags in its inventory zone shall be measured. The results shall be recorded.

2) The test shall be repeated a further four times and the average time to identify the tags shall be computed.

3) With all interrogators simultaneously in operation, the time taken to identify all 50 tags in each portal shall be measured. The results shall be recorded.

4) The test shall be repeated a further four times and the average time to identify the tags in each portal shall be computed.

For this test the FHSS interrogators described below shall be replaced by interrogators using the 4 channel plan. The following steps shall be performed:

1) The interrogators in portal A and C shall be configured to operate on 918,7 MHz while the interrogator in portal B shall operate on 919,9 MHz.

2) The "four" steps described above shall be repeated.

5.2 Scenario 2 - Comparison of Mitigation Techniques

The purpose of this test is to compare the mitigation techniques for a simulated installation using firstly DAA and secondly FHSS.

For this test, the setup described below shall be used.

Tests shall be carried out as described below. An assessment of the results will allow a comparison to be made between the two mitigation techniques.

Using the same test setup described in clause 5.1, the three interrogators shall be connected to their antennas at the dock-door portals and configured to work with the 4 channel plan. The following steps shall be performed:

1) The interrogators in portals A and B shall be configured to operate at 919,9 MHz. This simulates the situation where one high power channel has been blocked by a primary user and both interrogators have to share the same channel.

2) With just the interrogator in portal A in operation, the time taken to identify all 50 tags in its inventory zone shall be measured. The results shall be recorded.

3) The test shall be repeated a further four times and the average time to identify the tags in each portal shall be computed.

4) With just the interrogator in portal B in operation, the time taken to identify all 50 tags in its inventory zone shall be measured. The results shall be recorded.

5) The test shall be repeated a further four times and the average time to identify the tags in each portal shall be computed.

6) With the interrogators in portal A and B simultaneously in operation (and the interrogator in portal C switched off), the time taken to identify all 50 tags in portals A and B shall be measured. The results shall be recorded.

7) The test shall be repeated a further four times and the average time to identify the tags in each portal shall be computed.

Using the test setup described in clause 5.1 the three interrogators shall be replaced with interrogators operating in FHSS mode at the Brazilian frequency bands. The following steps shall be performed:

1) The interrogator in portal A shall be set to operate at a frequency of 916,25 MHz and the interrogator in portal B shall be set to operate at 916,75 MHz. This simulates the scenario where at least five operational interrogators are in close proximity and investigates if there would be any degradation in their performance.

2) With just the interrogator in portal A in operation, the time taken to identify all 50 tags in its inventory zone shall be measured. The results shall be recorded.

3) The test shall be repeated a further four times and the average time to identify the tags in each portal shall be computed.

4) With just the interrogator in portal B in operation, the time taken to identify all 50 tags in its inventory zone shall be measured. The results shall be recorded.

5) The test shall be repeated a further four times and the average time to identify the tags in each portal shall be computed.

6) With the interrogators in portal A and B simultaneously in operation (and the interrogator in portal C switched off), the time taken to identify all 50 tags in portals A and B shall be measured. The results shall be recorded.

7) The test shall be repeated a further four times and the average time to identify the tags in each portal shall be computed.

5.3 Scenario 3: Analysis of Interference between RFID and GSM

The objective of this test is to analyze possible degradation in performance of both RFID and GSM systems when operating in adjacent frequency bands. Evaluations will be performed for the FHSS system used in Brazil and the existing 4 channel plan at the proposed new European frequency.

For the test a base station simulator and a GSM mobile terminal reference device will be used to replicate GSM communication.

For this test, the setup described in clause 5.1 shall be used. In addition the equipment to simulate GSM communication shall be placed within a 2 m radius of portal A.

Tests shall be carried out as described below. The average times to read the tags in portal A shall be compared. In addition the average BER recorded by the base station simulator shall be analysed.

Using the test setup described in clause 5.1, one of the interrogators shall be configured to operate in FHSS mode in the Brazilian frequency bands and connected to the antenna in portal A (portals B and C will be unused). The following steps shall be performed:

1) With the interrogator switched off, the BER recorded by the base station simulator shall be noted after 1 minute of operation.

2) The interrogator in portal A shall be set to operate in FHSS using all available RFID channels in the Brazilian frequency bands.

3) The time taken to identify all 50 tags in portal A shall be measured. The results shall be recorded.

4) A call shall be established between the base station simulator and the GSM mobile terminal reference device using the Uplink and Downlink channels closest to the two Brazilian frequency ranges designated to RFID. (902 - 907,5 MHz and 915 - 928 MHz);

5) The interrogator in portal A shall be set to read the tags continuously in its interrogation zone.

6) The time taken to identify all 50 tags in portal A shall be measured. The results shall be recorded.

7) The BER recorded by the base station simulator shall be noted after 1 minute of simultaneous operation of the RFID and GSM systems.

8) The test shall be repeated a further four times and the average time to identify the tags in portal A and the average BER of the GSM system shall be computed.

9) Steps 1 to 7 shall be repeated with the interrogator in portal A set to operate at a centre frequency of 907,25 MHz.

10) Steps 1 to 7 shall be repeated with the interrogator in portal A set to operate at a centre frequency of 915,25 MHz.

Using the test setup described in clause 5.1 the interrogator in portal A shall be connected to its antenna and configured to work with the 4 channel plan (Portals B and C will be unused). The following steps shall be performed:

1) Adjust the interrogator in portal A to operate at a centre frequency of 916,3 MHz (This is closest to Brazilian GSM).

2) The time taken to identify all 50 tags in portal A shall be measured. The results shall be recorded.

3) Establish a call between the base station simulator and the GSM mobile terminal reference device using the Uplink and Downlink channels to be closest to the RFID frequency range.

4) The interrogator in portal A shall be set to continuously read the tags in its interrogation zone.

5) The time taken to identify all 50 tags in portal A shall be measured. The results shall be recorded.

6) The BER recorded by the base station simulator shall be recorded after 1 minute of simultaneous operation of the RFID and GSM systems.

7) The test shall be repeated a further four times and the average time to identify the tags in each portal and average BER of the GSM system shall be computed.

5.4 Scenario 4: Door Portal Application

The purpose of this test is to compare the reading performance of different types of tags when attached to cartons containing different materials loaded on a pallet. The tests will also compare the reading performance of the tags when placed at different positions on the carton in different orientations.

Four pallets will be prepared each carrying 30 cartons. The cartons in the first pallet will contain items that do not adversely affect the reading performance of the tags. The cartons in the remaining pallets will contain "unfriendly" items that are known to affect adversely the reading performance.

Tags will be provided for the test that are both suitable and unsuitable for use with "unfriendly" items. The cartons on the first pallet will be fitted with tags of both types. The cartons on the second pallet will be fitted with tags known to be adversely affected by the contents of the cartons. The cartons on the remaining two pallets will be fitted with tags designed for use with "unfriendly" items. For the third pallet the tags will be fixed in positions and orientations that are sub-optimal. For the fourth pallet the tags will be attached to cartons in their optimal position and orientation. The position of each tag and its corresponding ID shall be recorded.

The tests will be performed using a portal that will be located in the test area outside the anechoic chamber. Details of the portal are shown in Figure 5. An interrogator operating in the FHSS mode at Brazilian RFID frequencies will be connected to the four antennas on the portal. A laptop loaded with a suitable test application will be connected to the interrogator. An optical beam shall be positioned in front of the portal to detect the presence of the pallet as it enters the portal. The output from the optical beam shall be connected to the interrogator so that reading is initiated when the beam is broken.

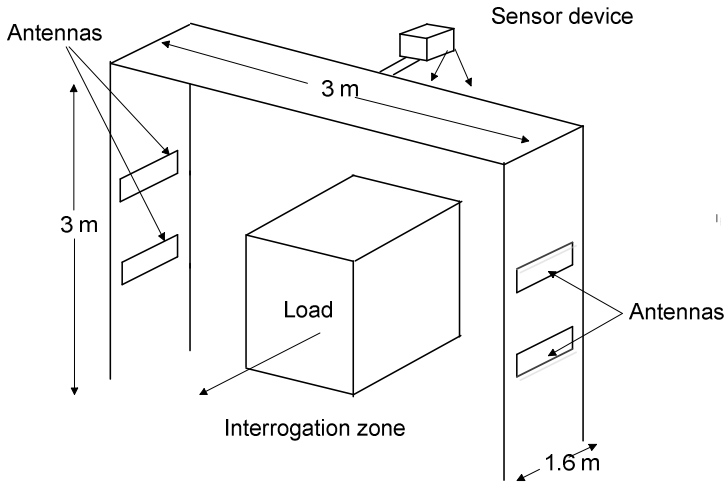


Figure 5: Diagram of portal for use in scenario 4

Before starting the test the spurious noise in the test area shall be measured using the procedure described in clause 4.6:

The following steps shall be performed:

1) The interrogator shall be set-up to transmit in the FHSS mode at the Brazilian RFID frequencies. It shall be switched on and configured to operate for a period of 3 s from the moment when it is triggered by the optical beam.

2) The first pallet will be loaded onto a forklift trolley.

3) The forklift trolley shall be moved through the portal at a speed of approximately 1 m/s.

4) A record will be made of the number of tags that were identified and the number of times each tag was correctly read.

5) Steps 3 and 4 will be repeated a further four times.

6) The first pallet will be off-loaded from the forklift trolley and replaced by the second pallet.

7) Steps 3, 4 and 5 will be repeated using the second pallet.

8) The second pallet will be off-loaded from the forklift trolley and replaced by the third pallet.

9) Steps 3, 4 and 5 will be repeated a further four times.

10) The third pallet will be off-loaded from the forklift trolley and replaced by the fourth pallet.

11) Steps 3, 4 and 5 will be repeated a further four times.

12) An analysis will be made of the results obtained for each of the four pallets.

5.5 Measurement Uncertainties

In the event that it is necessary to consider measurement uncertainty, reference will be made to the values in table 1.

Table 1: ETSI limits for measurement uncertainty

Parameter	Uncertainty
RF frequency	$\pm 1 \times 10^{-7}$
RF power, conducted	±0,75 dB
RF power, radiated, valid up to 12,75 GHz	±6 dB
Maximum frequency deviation for FM	±5 %
Two-signal measurements	±4 dB
Time	±5 %
Temperature	±1 K
Humidity	±5 %

Annex A (informative): Bibliography

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ISO/IEC TR 18047-6: "Information technology - Radio frequency identification device conformance test methods - Part 6: Test methods for air interface communications at 860 MHz to 960 MHz".

ETSI EN 302 208 (V1.2.1): "Electromagnetic compatibility and Radio spectrum Matters (ERM); Radio Frequency Identification Equipment operating in the band 865 MHz to 868 MHz with power levels up to 2 W".

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History

Document history		
V1.1.1	April 2015	Publication