Report on RFID Brazil Plugtests

20th – 24th May 2013

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Foreword

This Technical Report (TR) has been produced jointly by the RFID Department of CPqD and ETSI Plugtests team.

1 Scope

The present document is a technical report of the RFID Brazil Interoperability event also called Plugtests event that was 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 testing was performed jointly by CPqD and ETSI experts at Campinas in the RFID lab of CPqD. 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.

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.

In Brazil the frequency band used in RFID technology, (~ 902-907.5 MHz and 915-928 MHz), is very close to the band used by cellular mobile communication technologies, particularly, the GSM 900 reinforcing the need to carry out an interference evaluation test between these systems.

The results of the study are expected to assist in future technical developments in Brazil and contribute towards improvements in their national standards. In addition the Plugtests should lead to greater technological cooperation between the two regions.

2 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 referenced 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.

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2.1 Normative references.

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

Not applicable.

2.2 Informative references

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] EPCGlobal: “Tag Performance Parameters and Test Methods, Version 1.1.3”

[i.2] ISO/IEC 1800-6 “Information technology – Radio frequency identification for item management – Part 6: Parameters for air interface communications at 860 to 960 MHz. Amendment 1: Extension with type C and update Types A and B – 15/06/2006.”

[i.3] 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.”

[i.4] 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".

[i.5] ETSI TS 100 911 V8.23.0 (2005-11): Digital cellular telecommunications system (Phase 2+); Radio subsystem link control; (3GPP TS 05.08 version 8.23.0 Release 1999)

3 Definitions, symbols and abbreviations

3.1 Definitions

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 [given in ... and the following] apply:

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

3.3 Abbreviations

BLF	Backscatter link frequency
DAA	Detect and avoid
dB	decibel
dBm	power level relative to 1 mW
EIRP	Effective Isotropic Radiated Power
kHz	kilo Hertz
FDM	Frequency-division multiplexing
FHSS	Frequency Hopping Spread Spectrum
GSM	Global System for Mobile Communications
RFID	Radio Frequency Identification
TDM	Time-division multiplexing
us	micro second

4 Executive summary

The interoperability event organised in Brazil is part of a series of world wide events co-organised by ETSI and the FP7 Probe-IT project which is looking at identifying world wide Internet of things (IoT) interoperability issues. One efficient tool to identify interoperability issues is to organise interoperability event with stake holders in order to provide real interoperability feedback for a particular technology. After having organised interoperability events for IoT protocols such as 6LoWPAN and CoAP, RFID was identified as important one within the IoT family. As Brazil is very active in using RFID and IoT, the Probe-IT and ETSI decided to organize an interoperability event there, with the support of ERM TG 34, the technical committee in charge of RFID Technology in ETSI.

With support of the IoT Brazilian association and the Brazilian RFID community, CPqD was identified as a Brazilian reference in RFID technology to perform the interoperability test in co-operation with ETSI and FP7 Probe-IT.

The main idea was to compare RFID practices and environment between EU and Brazil which could lead to some interoperability issues.

To do so ,an important part of the tests was 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.

The representatives from ETSI worked jointly with the experts from the RFID laboratory at CPqD to carry out the tests. A total of four tests were performed. The first three were carried out in the semi anechoic chamber at CPqD and the fourth test was performed in a portal constructed outside the chamber. The tests comprised the following scenarios:

- Comparison in performance between FHSS and ETSI 4 channel plan
- Comparison of mitigation techniques
- Analysis of interference between RFID and GSM
- Investigation of reading performance with “unfriendly” items

Analysis of the results showed that the ability of both the FHSS and 4 channel modes to identify a sample of 50 tags correctly was very similar. Also the results for the tests on the mitigation techniques showed that there was very little difference in the performance between them. The one material difference between the two modes was the data rates that were achievable. In dense reader environments the channel spacing specified for the FHSS mode imposes an upper limit that is possible on the both data rates from the interrogator to the tag and from the tag to the interrogator. By contrast the existing European 4 channel plan operates at least one and a half times the data rate used by FHSS. The proposed new European channel plan for the band 915 – 921 MHz will permit data rates of least three times those possible using the FHSS mode.

The present channel plan for FHSS in Brazil produced significant interference from RFID to GSM. However if the channel on either side of the GSM band 907.5 – 915.0 MHz was excluded from the FHSS routine, the results showed that interference could be avoided. If this approach was adopted it would involve a very small reduction in the maximum permitted power to meet national limits on power spectral density. However it is considered that this would have only minimal impact on the reading range.

The tests for interference from RFID to GSM using the 4 channel plan at the frequencies proposed in the new European band 915 – 921 MHz showed no indication of interference.

During the tests involving GSM an operational mobile phone was placed at a distance of about 4 cm from the tags while they were being read by the interrogator. Under these conditions the signal from the mobile phone interfered with the tag response and degraded the reading performance. However it is considered unlikely that operational phones will be placed so close to tags in normal use.

In conclusion the tests showed that RFID could operate satisfactorily in Brazil either with a small change to the FHSS channel plan or by the use of the European 4 channel plan. The principal benefit of the 4 channel plan is that it would permit the use of higher data rates. This would be helpful when reading fast moving objects or when reading a large number of tags. The RFID community in Brazil should consider whether this benefit is sufficient to justify a request to the Brazilian administration for a change to their radio regulations.

5 General

5.1 The test plan for the Plugtest had previously been agreed during a preliminary visit by ETSI representatives to CPqD during the period 5th – 7th March 2013. A copy of the test specification is provided at Annex A of this report. The tests, which were divided into four scenarios, were:

- Comparison in performance between FHSS and 4 channel plan
- Comparison of mitigation techniques
- Analysis of interference between RFID and GSM
- Investigation of reading performance with “unfriendly” items

5.2 The representatives from ETSI worked jointly with the experts from the RFID department at CPqD to carry out the tests. All of the tests were completed satisfactorily within the scheduled period.

5.3 Prior to the tests CPqD had configured a simulation of three adjacent portals as might be found in a distribution centre. This included providing three cardboard sheets each with 50 tags mounted on one side. The simulation was constructed in their semi-anechoic chamber. A picture of the test setup is shown at Fig C.1

5.4 Interrogators supplied by three different manufacturers were used for the tests. One manufacturer supplied three interrogators using the FHSS mode, which were used for scenarios 1 to 3. A second manufacturer supplied the three interrogators for scenarios 1 to 3 operating under the 4 channel plan. A third manufacturer provided the interrogator for the fourth scenario. All of the interrogators were set up to operate in the Miller 4 mode for tag to interrogator communications. Those interrogators using FHSS had an offset frequency (BLF) of approximately 250 kHz while the interrogators using the 4 channel plan had an offset frequency of 320 kHz. The Tari values were set to 25 us for the interrogators using FHSS in scenarios 1 to 3 and approximately 20 us for scenario 4. The interrogators using the 4 channel plan had their Tari.values set to 12.5 us.

5.5 Prior to the tests the cable loss associated with each antenna was measured and the interrogators adjusted to give a transmit level of 33 dBm e.i.r.p. from each antenna.

5.6 An initial check was first made to ensure that there was an acceptable level of isolation between Portal A and Portal B. This was performed as follows. The mid-point of each of the antennas was adjusted to a height of 1.2 m above the ground. With the interrogator at portal A set to transmit continuously, the maximum field level recorded at the tags in portal A was measured. The interrogator in portal A was switched off and the interrogator in portal B was set to transmit continuously. The maximum field at the tags in portal A were again measured. This gave a difference between the two measurements of 26 dB, which comfortably exceeded the minimum acceptable figure of 20 dB. A check was also made to ensure that there was adequate isolation between portals B and C.

5.7 Before starting the tests a measurement was made of the ambient noise level close to portal A inside the semi anechoic chamber. The measurement was made using a measurement antenna connected to a spectrum analyser using the settings shown in clause 7 of the test specification. The mean noise level recorded across the band over a period of two minutes was -97 dBm. During this period an isolated transmission was recorded of –95 dBm. A plot of the recorded noise is shown in Figure 1.

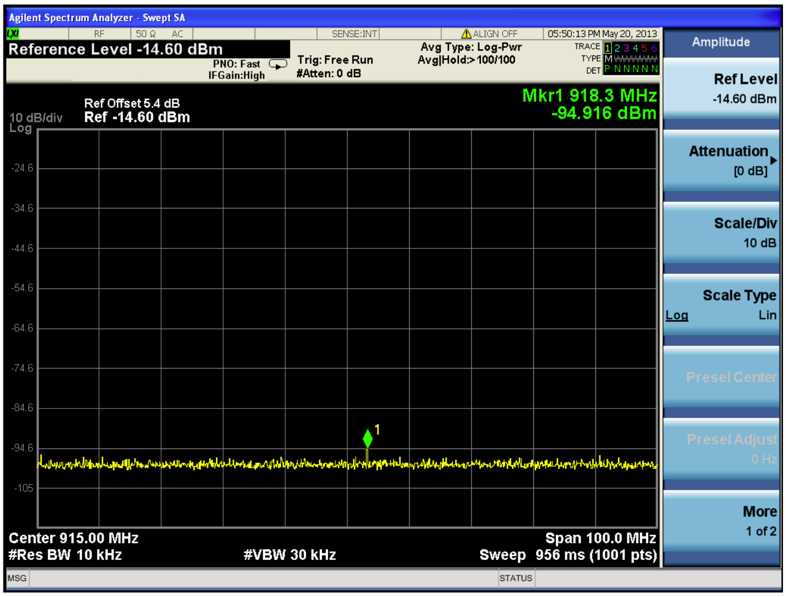


Fig 1 Ambient noise in semi-anechoic chamber

5.8 Using the same settings a second noise measurement was made close to the portal located outside the semi-anechoic chamber. A significant presence of GSM transmissions was detected. However in the two bands designated for use by RFID, the mean noise level did not exceed -85 dBm. During this measurement period an isolated transmission was recorded of –75dBm. A plot of the recorded noise is shown in Figure 2.

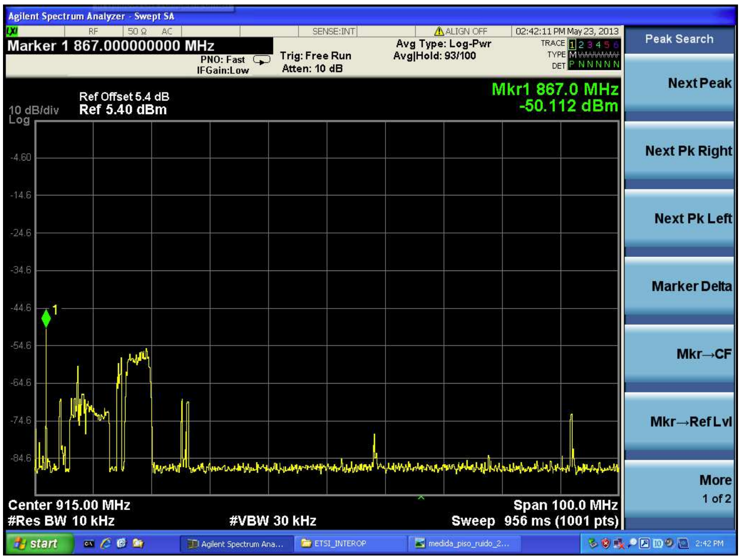


Fig 2 Ambient noise at portal

5.9 All of the tests at the outside portal were performed with an interrogator operating in the FHSS mode. Since this was a test on the relative performance of the tags, it was considered unnecessary to repeat the tests using the 4 channel plan. The pallet used for the baseline measurements carried empty cardboard boxes with standard tags fixed in their optimum orientation on the outside surfaces. The other three pallets carried cartons of drinks in aluminium cans. Tags were attached to these cartons in accordance with the guidelines in Clause 8.5 of the test specification. See Fig 3

Fig 3 Pallet of drinks in aluminium cans

All of tags used in the tests were pre-programmed with known identification numbers as defined in clause 6.1.3 of the test specification so that, if required, their position could be tracked during the tests.

6 Description of tests

The tests were performed in accordance with the previously agreed Test Specification, which for convenience is shown at Annex A. A brief description of each of the tests together with the results is given below.

6.1 Comparison in performance between FHSS and 4 channel plan

6.1.1 With the interrogator in portal A configured to operate in the FHSS mode, the time taken to read all 50 tags was recorded. This was repeated a further four times and the average time was calculated. This gave a baseline figure for the reading performance in portal A with no other interrogators in operation.

6.1.2 All three interrogators were then set to transmit continuously and the reading performance in each portal was measured five times. The average of the five measurements in each portal provided gave the mean level of its performance.

6.1.3 The same procedure was then repeated with interrogators set to the four channel plan. The results from both sets of measurements are shown in Table 1 below.

Table 1 Comparison between performance of FHSS and 4 channel plan

Mitigation	Interrogators	Reading times in seconds					
		#1	#2	#3	#4	#5	Average
FHSS	A only	0.405	0.312	0.327	0.436	0.312	0.3584
	A	0.343	0.327	0.328	0.405	0.312	0.343
	B	0.406	0.405	0.469	0.485	0.469	0.4468
	C	0.469	0.422	0.406	0.422	0.437	0.4312
4 Channel	A only	0.160	0.166	0.158	0.163	0.166	0.1626
	A	0.178	0.160	0.164	0.159	0.174	0.167
	B	0.236	0.231	0.227	0.230	0.226	0.230

	C	0.161	0.175	0.158	0.152	0.175	0.1642

6.1.4 The results for reading times were satisfactory and very much in line with what were expected. It will be seen that the reading times in portal B were greater than in portals A and C. Since portals A and C used only one antenna and portal B had two, this difference was attributed to the additional time taken to switch between the two antennas.

6.1.5 The only noticeable difference between the two modes was in the times to read the tags. This was due to the different link frequencies used for the tag response. In the case of the FHSS mode the link frequency is restricted to around 250 kHz and is a function of the fixed channel width. By contrast the existing 4 channel plan uses a link frequency of 320 kHz. As a consequence the 4 channel plan was able to read the tags in almost half the time required by the FHSS mode. With the introduction of a link frequency of 640 kHz in the proposed new band of 915 – 921 MHz and with the use of a lower value for Tari, the 4 channel plan should be capable of reading tags at least three times faster than is possible with the FHSS mode of operation. This could lead to significant benefits when reading large numbers of tags or when reading fast moving tagged items.

6.2 Comparison of mitigation techniques

6.2.1 The interrogators in portals A and B were configured according to the 4 channel plan as specified in clause 8.2.2.1 of the Test Specification. The time taken to identify all 50 tags in portals A and B was measured five times and the average time in each portal was calculated.

6.2.2 The same process was repeated with the interrogators operating in the FHSS mode as specified in clause 8.2.2.2 of the Test Specification.

6.2.3 The results from both sets of measurements are shown in Table 2 below

Table 2 Comparison of mitigation techniques

Mitigation	Interrogators	Reading times in seconds					
		#1	#2	#3	#4	#5	Average
FHSS	A only	0.327	0.312	0.328	0.343	0.344	0.331
	A	0.312	0.359	0.328	0.312	0.312	0.325
	B only	0.597	0.406	0.469	0.406	0.453	0.466
	B	0.422	0.407	0.422	0.453	0.406	0.422
4 Channel	A only	0.173	0.167	0.161	0.176	0.170	0.169
	A	0.182	0.171	0.165	0.163	0.159	0.168
	B only	0.220	0.240	0.227	0.226	0.227	0.228
	B	0.252	0.248	0.244	0.241	0.237	0.244

6.2.4 Comparing the results between Table 1 and Table 2, the results from scenarios 1 and 2 arre very similar. This showed that under the test configuration there was little impact on reading performance when operating under worst case mitigation conditions.

6.3 Analysis of interference between RFID and GSM

6.3.1 These tests followed the procedure described in clause 8.3 of the Test Specification. The equipment was arranged as shown in Figure 3 below

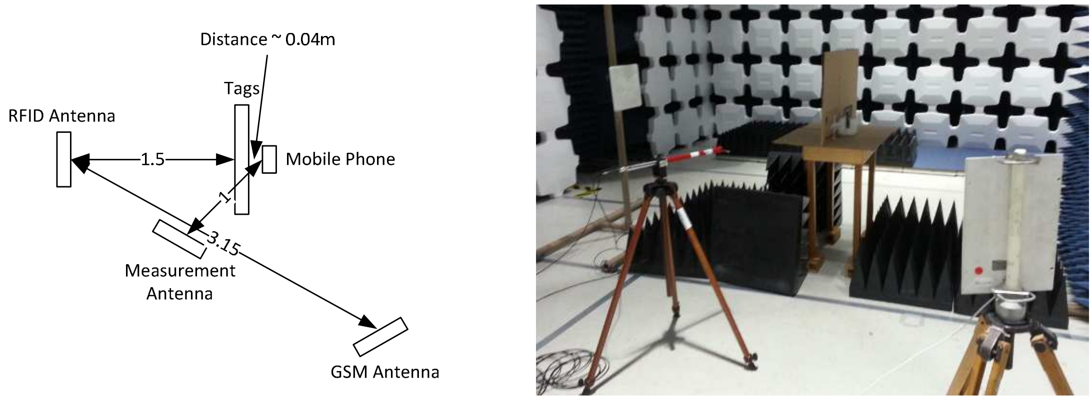


Fig 3 Configuration for measurement of interference GSM and RFID

6.3.2 A mobile phone was positioned at a distance of approximately 4 cm immediately behind the tags as shown in Fig C. Simulation of the GSM base station was achieved using a Rhode and Schwartz Universal Radio Communication Tester CMU 200. In order to establish satisfactory communication it was necessary to restrict the distance between the mobile phone and the antenna of the CMU 200 to approximately 2.0 m. Since the RFID transmissions were at 33 dBm eirp, there was a risk that they would cause blocking to the receiver section of the CMU 200. This was overcome by the insertion of a 20 dB attenuator, which reduced the level of the signal received at the CMU 200 from the interrogator to -29 dBm.

6.3.3 During the tests two different mobile phones were used. Calls were established first on channel 88 and then on channel 124. These were measured as generating transmitted powers of 11 dBm and 16 dBm respectively. This meant that the signal received at the antenna of the simulated base station from the interrogator was typically 17 dBm greater than that from the mobile phone.

6.3.4 Measurements of interference to the CMU 200 were made using RxQual rather than BER. This was in accordance with GSM technical specification 05.08 section 8.2.4 [i.5]. Generally levels 0 to 5 are considered to be acceptable while for levels 6 and 7 there is a possibility of call drops.

6.3.5 The results from the tests are shown in Table 3 below

Table 4 Interference measurements between RFID and GSM

Mitigation	Frequency MHz	Interrogator	Results						Comments
			#1	#2	#3	#4	#5	Average	
FHSS	902,0 - 928,0	A base	0.406	0.343	0.390	0.359	0.343	0.368	Baseline: GSM off, time to read 50 tags in secs
FHSS	902.0 - 928,0	A	0.500	0.515	0.421	0.421	0.530	0.477	Time to read number of tags in line below
FHSS	902.0 - 928,0	A	35	32	30	26	30	30.6	Tags read within 2 seconds of interrogation
GSM	907.6	RxQual	6						Max RxQual value observed over 1 minute
FHSS	902.0 - 928.0	A	0.390	0.343	0.250	0.437		0.355	Time to read tags in line below. Phone died
FHSS	902.0 - 928.0	A	49	50	42	49		47.5	Tags read within 2 second limit
GSM	914.8	RxQual	6						Max RxQual value observed over 1 minute
FHSS	902.0 - 928.0	A	0.359	0.296	0.406	0.515	0.296	0.374	Same measurements as in block above with different mobile phone
FHSS	902.0 - 928.0	A	33	18	24	35	34	28.8	Note effect of stronger signal from phone
GSM	914.8	RxQual	6						Max RxQual value observed over 1 minute
	915.0 - 928.0	A base	0.312	0.406	0.344			0.354	Baseline: GSM off, time to read 50 tags in secs
FHSS	915.0 - 928.0	A	0.406	0.421	0.359			0.395	GSM on. FHSS in the upper RFID band only
FHSS	915.0 - 928.0	A	23	21	30			24.67	Tags read within 2 sec limit
GSM	914.8	RxQual	6						Max RxQual measurement over 1 minute
Fixed	907.25	A	Not possible - call dropped					0	

GSM	907.6	RxQual	Not possible - call dropped					0	
Fixed	915.25	A	Not possible - call dropped					0	
GSM	914.8	RxQual	Not possible - call dropped					0	
Fixed	915.75	A	38	34	44			38.7	Time to read 50 tags in secs
GSM	914.8	RxQual	0						RxQual measurement over 1 minute
Fixed	916.25	A	15	26	23			21.3	Time to read 50 tags in secs
GSM	914.8	RxQual	0						RxQual measurement over 1 minute
4 Channel	916.3	A base	0.154	0.161	0.161	0.168	0.165	0.162	Baseline: GSM off. Time to read 50 tags in secs
4 Channel	916.3	A	1.919	1.922	1.632	1.721	1.713	1.781	Time to read tags in line below within limit of 2 ses
4 Channel	916.3	A	43	34	50	44	40	42.2	Tags read within 2 seconds of interrogation
4 Channel	916.3	A	4.908	3.346	2.927			3.727	Time to read 50 tags without time limit
GSM	914.8	RxQual	0						Max RxQual value observed over 1 minute

6.3.6 The results showed that using the existing channel plan for FHSS in Brazil, RFID can cause a noticeable degradation in the performance of GSM. However if interrogators are prevented from operating on the two RFID channels adjacent to the GSM band, it should be possible to operate without causing interference to GSM. The loss of these two channels would mean that the transmitted power from the interrogator would have to be reduced by a factor of 35/37 in order to maintain the same spectral density required by the Brazilian regulations. This would mean a reduction to 97.3% of the present maximum reading range that is currently achievable, which is probably acceptable.

6.3.7 The results showed that it should be possible to operate the 4 channel plan using the proposed European channel allocations without causing interference to GSM and with no loss in performance.

6.3.8 With the mobile phone operating on either channel 88 or 124 and positioned 4 cm from the tags, the reading performance of the tags was degraded. However it was considered that such a situation would be unlikely to occur in practical use.

6.4 Investigation of reading performance with “unfriendly” items

6.4.1 The system was set up as described in clause 8.4 of the Test Specification. A fork lift truck was used to move the pallets through the portal. Since the objective of the tests was to compare the reading performance between tags on the different pallets, measurements were made using an interrogator configured only in the FHSS mode.

6.4.2 The results from the tests are shown in Table 4 and Table 5 below

Table 4 Reading performance of tags attached to “unfriendly” items

Run	Tags Read	Pallet 1	Pallet 2	Pallet 3	Pallet 4	Comment
#1	Wanted	30	7	5	28	Pallet 1 Cardboard with
	Unwanted	2	2	2	4	standard tags
#2	Wanted	30	14	9	27	Pallet 2 Cans with standard tags
	Unwanted	3	7	6	4	
#3	Wanted	30	13	7	28	Pallet 3 Cans with high dielectric tags in random orientation
	Unwanted	1	4	9	5	
#4	Wanted	30	9	6	29	Pallet 4 Cans with high

						dielectric tags in optimum orientation
	Unwanted	0	4	7	5	
#5	Wanted	30	9	7	30	
	Unwanted	1	4	6	4	
	Average	30	10.4	6.8	28.4	

Table 5 Total number of Tag reads for each pallet

Run	Total Reads	Pallet 1	Pallet 2	Pallet 3	Pallet 4	Comment
#1	Wanted	490	11	36	112	Pallet 1 Cardboard with
	Unwanted	5	15	18	14	standard tags
#2	Wanted	397	55	35	131	Pallet 2 Cans with standard
	Unwanted	9	28	21	8	tags
#3	Wanted	417	49	27	160	Pallet 3 Cans with high dielectric tags in random
	Unwanted	1	6	26	25	orientation
#4	Wanted	387	37	25	111	Pallet 4 Cans with high dielectric tags in optimum
	Unwanted	0	27	32	23	orientation
#5	Wanted	384	22	29	157	
	Unwanted	2	22	19	14	
	Average	415	34,8	30,4	134,2	

6.4.3 From the results it can be seen that there were a number of “unwanted” tags in the area. These are recorded in separate rows in Table 4. It is believed that these tags were likely to have originated from the floor immediately above the portal. However it was not considered that their presence had any significant effect on the overall conclusions to be drawn from the results.

6.4.4 The results were very similar to what was expected. The initial test with the tags mounted on cardboard boxes verified that the set-up was satisfactory. Testing with standard tags attached to aluminium cans carrying drinks showed a significant reduction in reading performance. Similarly poor reading performance was recorded for the scenario where tags, intended for use on “unfriendly” items, were attached to aluminium cans in sub-optimal orientations. However the reading performance was greatly improved in scenario 4 where the high dielectric tags were attached to the aluminium cans in optimal orientations.

6.4.5 The results clearly demonstrated the importance of using “high dielectric” tags for attachment to “unfriendly” items and ensuring that they were aligned in their optimal orientations.

7 Conclusions

7.1 Analysis of the results for reading performance and mitigation techniques showed that the ability of both the FHSS and 4 channel modes to identify samples of 50 tags correctly was very similar. Also the results for the mitigation techniques gave very similar results. The one important difference between the two modes was in the data rates that were achievable. In dense reader environments the channel spacing specified for the FHSS mode imposes an upper limit on the data rate both from the tag to the interrogator and tag to the interrogaator. By contrast the existing European 4 channel plan enables the tag response to operate at least 1.5 times the data rate possible in the FHSS mode. Use of the proposed new European channel plan for the band 915 – 921 MHz will permit data rates of at least three times those possible with the FHSS mode.

7.2 The present channel plan for FHSS in Brazil showed significant interference from RFID to GSM. However if the RFID channel on either side of the GSM band was excluded from the FHSS routine, the results showed that interference could be avoided. If this approach was adopted it would involve a very small reduction in the maximum permitted power transmitted by interrogators due to national limits on power spectral density . However it is not considered that this would have any material effect on the reading range.

7.3 The tests for interference from RFID to GSM at the frequencies in the proposed new European band 915 – 921 MHz showed no evidence of interference.

7.4 During the tests involving GSM an operational mobile phone was placed at a distance of about 4 cm from the tags while they were being read by the interrogator. Under these conditions the signal from the mobile phone interfered with the tag response and degraded the reading performance of the interrogator. However it is considered unlikely that operational phones will be placed so close to tags in normal use.

7.5 The tests showed that RFID could be compatible with GSM in Brazil either with a small change to the FHSS channel plan or by the use of the European 4 channel plan. The principal benefit of the 4 channel plan is that it would permit a higher data rate. This would be beneficial when reading fast moving objects or when reading a large number of tags. It will be important for the RFID community in Brazil to consider whether this benefit is sufficient to justify a request to the Brazilian administration for a change to their radio regulations.

7.6 The results of the reading tests with objects on pallets carrying “unfriendly” items were very much as expected. They demonstrated the importance of selecting the correct design of tag for the object to be tagged and ensuring that it was attached in the optimum orientation.

Annex A: Test specification

Specification for the RFID Interoperability Test Event in Brazil

May-2013

Nº of Pages: 16

Contents

Contents

A.1 Introduction

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 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.

The results of the study will greatly assist in future technical developments in Brazil and contribute towards improvements in their national standards. In addition the Plugtests should lead to greater technological cooperation between the two regions.

A.2 Arrangements

A.2.1 Dates for the event

The Plugtest will take place at CPqD (Telecommunications Research Center) near Sao Paulo. The event is jointly organized by ETSI, CpQD, Probe-IT project. The provisional programme for the Plugtest will be as follows:

- Monday 20th May — Check and prepare equipment for the tests
- Tuesday 21st May — Comparison between FHSS and 4-channel plan
- Wednesday 22nd May — a.m. Complete comparison of mitigation techniques
  p.m. GSM interference tests.
  Preparation for tag performance tests
- Thursday 23rd May — Perform tag performance tests
- Friday 24th May — Assess results and tear down

A.2.2 Mains power

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

110 ~ 127V/ 60 Hz - Fase/Neutro and 220V / 60 Hz - Fase / Fase

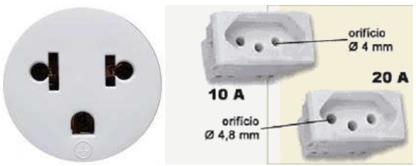


Fig 1 Picture of mains plugs

A.2.3 Supervision of Trial

The Parts 1 and 2 of the Plugtest will be supervised by Representatives from ETSI. They shall be 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 shall jointly prepare a report, which will include an analysis of the test results.

A.3 Equipment

ETSI shall provide the following equipment for the Plugtests

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

2. All interrogators shall be fitted with SMA female connectors.

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

To ensure that equipment sent from Europe reaches the test-site well in advance of the Plugtest, shipment will be made by no later than 29 March. This should allow adequate time for the shipment to reach Brazil, clear customs and be transported to the test area.

CPqD shall provide

1. 3 x interrogators using FHSS mode and modified for operation at Brazilian frequencies.
2. 4 x circularly polarised 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 Fig 4.
6. An additional 120 tags applied as described in clause 6.1.3.
7. Three simulated portals as illustrated in Fig 3
8. One GSM emulator.
9. One portal for use in scenario 4.
10. One optical light beam for use in scenario 4.

A.4 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 section 8.

A.5 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%

Fig. 2 - Semi-Anechoic Chamber

Three adjacent portals shall be installed inside the chamber in accordance with the dimensions in Fig 3 below. In order to minimize interference, shielding (at least 1m wide by 1.5m high) shall be placed between the portals.

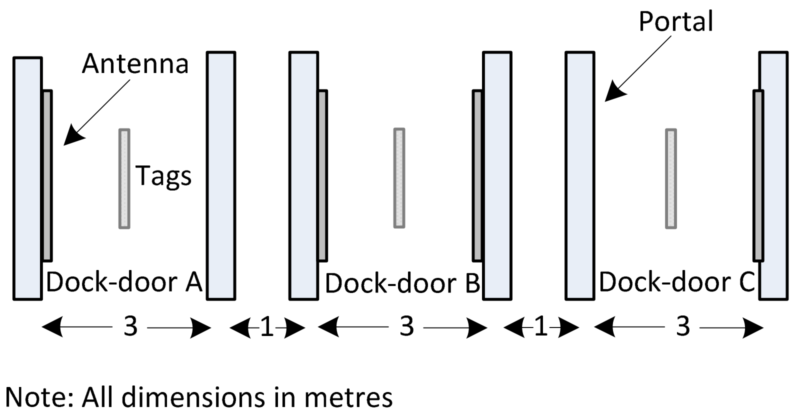


Fig 3 Layout of dock-doors

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

CPqD will make their portal available for use by the team to evaluate the performance of different tags as specified in scenario 4

A.6 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 8.3.2

The tags selected for scenario 4 shall follow the same procedure described above.

A.6.1 Tag Selection Method

The tags should 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.

A.6.1.1 Test Setup

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.

A.6.1.2 Measuring Procedure

Using the equipment described in section 6.1.1 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 1.15.1 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 +30dBm;
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.

A.6.1.3 Tag Selection

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 Fig 4

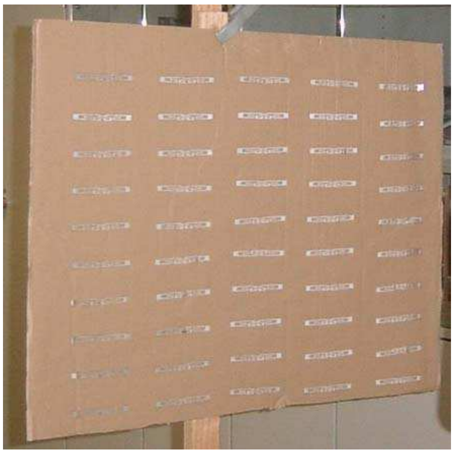


Fig 4 Photo of 50 tags mounted on cardboard sheet

Note: The tags shall 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 shall be the same for all tags. The values of SS, RR and CC shall 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. (eg 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)

A.7. 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.

A.8 Test Procedure Proposal

A.8.1 Scenario 1 - Comparative Performance of FHSS and 4 Channel Plan

A.8.1.1 Objective

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 will be a baseline test with just one interrogator enabled. In a second step all three interrogators will be enabled at the same time in order to evaluate the impact of simultaneous operation.

A.8.1.2 Test Setup

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 should be installed in the semi-anechoic chamber illustrated in Fig 2. Each interrogator is 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).

A.8.1.3 Test procedure

Tests shall be carried out as described in sections 0 and 0. The average times to read the tags in each portal for both of the modes shall be compared.

A.8.1.3.1 FHSS System used in Brazil

Using the test setup described in section 8.1.2, 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.

A.8.1.3.2 4 Channel Plan at proposed new European frequency

For this test the FHSS interrogators described in section 8.1.2 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 steps described in section 8.1.3.1 shall be repeated.

A.8.2 Scenario 2 - Comparison of Mitigation Techniques

A.8.2.1 Objective

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

A.8.2.2 Test Setup

For this test, the setup described in section 8.1.2 shall be used.

Tests shall be carried out as described below in sections 0 and 0. An assessment of the results will allow a comparison to be made between the two mitigation techniques.

A.8.2.2.1 4 Channel Plan at proposed new European frequency

Using the same test setup described in section 8.1.2, 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.

A.8.2.2.2 FHSS System used in Brazil

Using the test setup described in section 8.1.2 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.

A.8.3 Scenario 3: Analysis of Interference between RFID and GSM

A.8.3.1 Objective

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.

A.8.3.2 Test Setup

For this test, the setup described in section 8.1.2 shall be used. In addition the equipment to simulate GSM communication shall be placed within a 2 m radius of portal A.

A.8.3.3 Test procedure

Tests shall be carried out as described in sections 0 and 0. 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.

A.8.3.3.1 Compatibility of FHSS System with GSM

Using the test setup described in section 8.1.2, 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 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.

A.8.3.3.2 Compatibility of 4 Channel Plan with GSM

Using the test setup described in section 8.1.2 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.

A.8.4 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.

A.8.4.1 Set-up for tests

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 Fig 5. An interrogator operating in the FHSS mode at Brazilian 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 connecetd to the interrogator so that reading is initiated when the beam is broken.

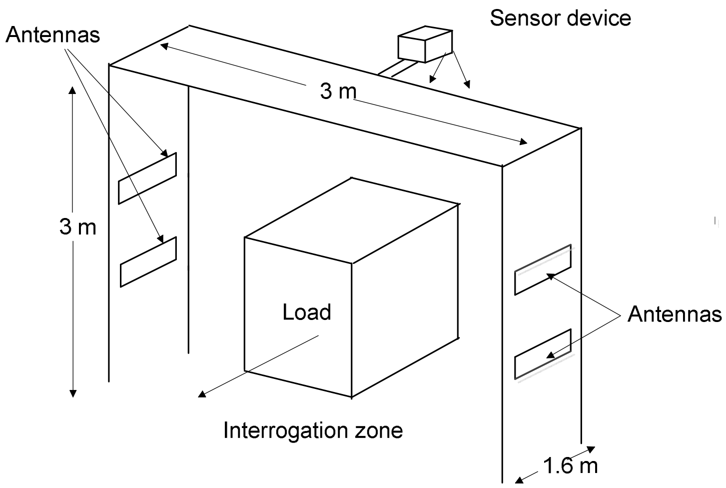


Fig 5 Diagram of portal for use in scenario 4

A.8.4.2 Test procedure

Before starting the test the spurious noise in the test area shall be measured using the procedure described in section 6.2

The following steps shall be performed:

1. The interrogator shall be set-up to transmit in the FHSS mode at the Brazilian 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.

A.9 Measurement Uncertainties

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

Table 1 ETSI limits for measurement uncertainty

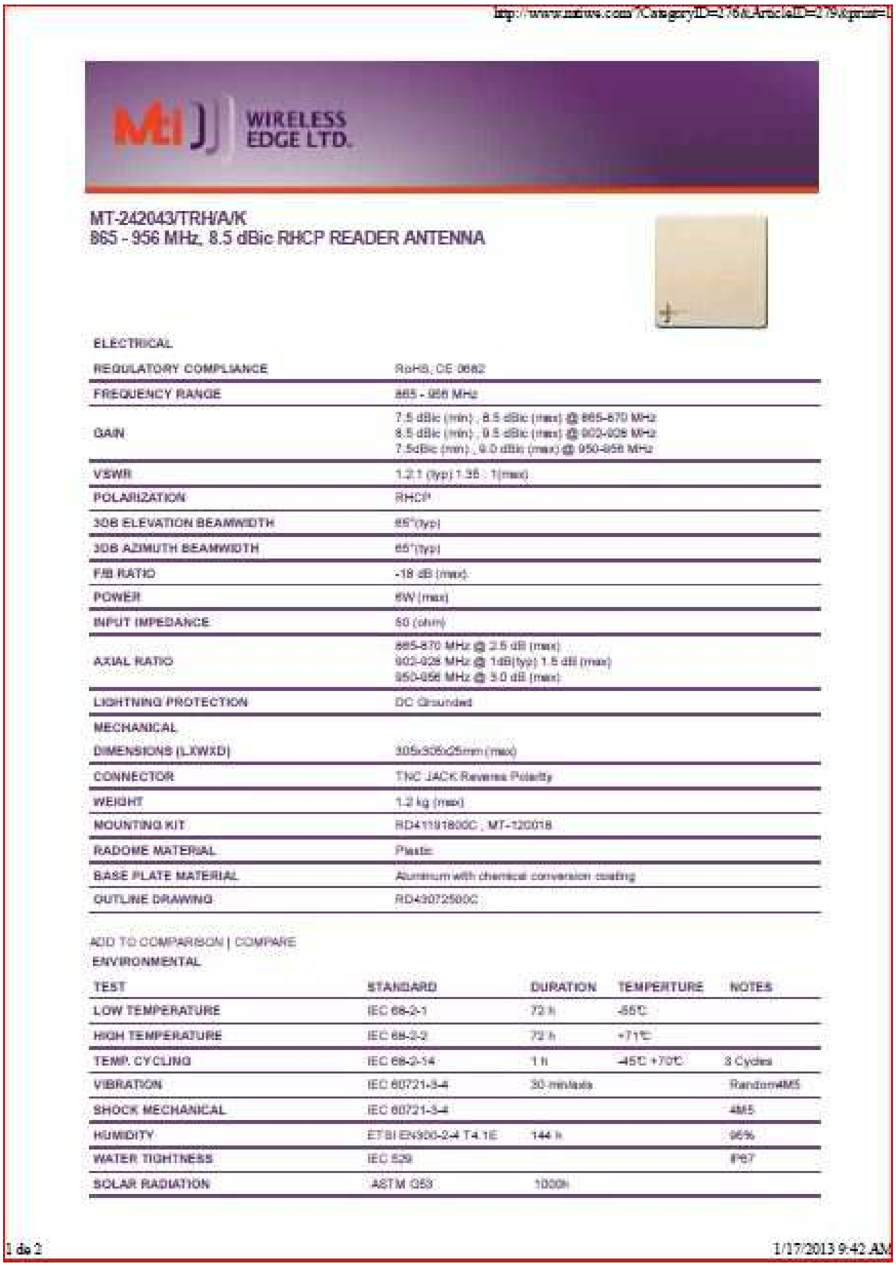
Parameter	Uncertainty
RF frequency	$\pm 1 \times 10^{-7}$
RF power, conducted	±0,75 dB
RF power, radiated, valid up to 12,75 GHz	±6 dB
Maximum frequency deviation for FM	±5 %
Two-signal measurements	±4 dB
Time	±5 %
Temperature	±1 K
Humidity	±5 %

Test Specification Revision History

Date	Version	Description
4 January 2013	A	Initial version
8 March 2013	1.0	Test plan agreed at Campinas
23 May 2013	2.0	Minor improvements to specification

Annex B: Equipment

B.1 Antennas for scenarios 1, 2 and 3



http://www.mtiwe.com/?CategoryID=276&ArticleID=279&print=1

MTI WIRELESS EDGE LTD.

MT-242043/TRH/A/K
865 - 956 MHz, 8.5 dBic RHCP READER ANTENNA

ELECTRICAL	
REGULATORY COMPLIANCE	RoHS, CE 0682
FREQUENCY RANGE	865 - 956 MHz
GAIN	7.5 dBic (min) , 8.5 dBic (max) @ 865-870 MHz 8.5 dBic (min) , 9.5 dBic (max) @ 902-928 MHz 7.5dBic (min) , 9.0 dBic (max) @ 950-956 MHz
VSWR	1.2:1 (typ) 1.35 : 1(max)
POLARIZATION	RHCP
3DB ELEVATION BEAMWIDTH	65°(typ)
3DB AZIMUTH BEAMWIDTH	65°(typ)
F/B RATIO	-18 dB (max)
POWER	6W (max)
INPUT IMPEDANCE	50 (ohm)
AXIAL RATIO	865-870 MHz @ 2.5 dB (max) 902-928 MHz @ 1dB(typ) 1.5 dB (max) 950-956 MHz @ 3.0 dB (max)
LIGHTNING PROTECTION	DC Grounded
MECHANICAL	
DIMENSIONS (LXWXD)	305x305x25mm (max)
CONNECTOR	TNC JACK Reverse Polarity
WEIGHT	1.2 kg (max)
MOUNTING KIT	RD41191800C , MT-120018
RADOME MATERIAL	Plastic
BASE PLATE MATERIAL	Aluminum with chemical conversion coating
OUTLINE DRAWING	RD43072580C

ADD TO COMPARISON | COMPARE

ENVIRONMENTAL

TEST	STANDARD	DURATION	TEMPERTURE	NOTES
LOW TEMPERATURE	IEC 68-2-1	72 h	-55℃	
HIGH TEMPERATURE	IEC 68-2-2	72 h	+71℃	
TEMP. CYCLING	IEC 68-2-14	1 h	-45℃ +70℃	3 Cycles
VIBRATION	IEC 60721-3-4	30 min/axis		Random4M5
SHOCK MECHANICAL	IEC 60721-3-4			4M5
HUMIDITY	ETSI EN300-2-4 T4.1E	144 h		95%
WATER TIGHTNESS	IEC 529			IP67
SOLAR RADIATION	ASTM G53	1000h		

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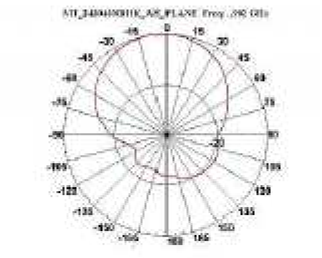
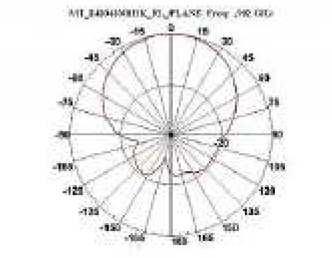
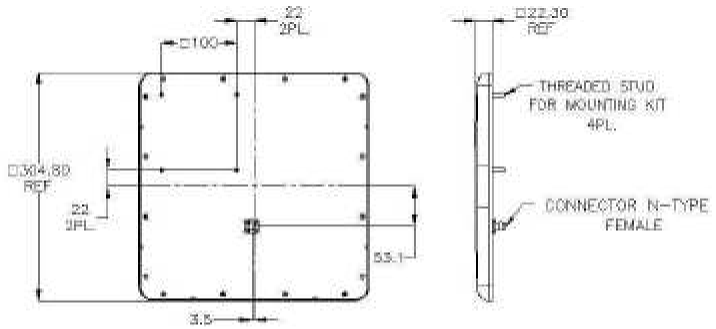
FLAMMABILITY	UL 94		Class HB
SALT SPRAY	IEC 68-2-11 Ka	168 h	
ICE AND SNOW			25mm Radial
WIND SPEED SURVIVAL OPERATION			220 Km/h 180 Km/h
WIND LOAD (SURVIVAL) FRONT THRUST SIDE THRUST			26.8 kg 2.2 kg

AZIMUTH RADIATION PATTERN MIDBAND
FREQ. 0.902 GHZ



ELEVATION RADIATION PATTERN MIDBAND
FREQ. 0.902 GHZ





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B.2 Antennas for portal

Product Overview

FAVITE

FS-GA203/204/205

– FAVITE UHF RFID Antenna for Fix Readers

Favite's general purpose antennas are optimized for UHF RFID system and complement the outstanding performance and range offered by Favite's readers and tags. The all-purpose antennas can be used for both indoor or outdoor applications requiring large area coverage.

Able to withstand extreme heat and cold as well as moisture and vibration, the Favite's Reader Antennas are ideal for nearly any applications, including manufacturing, warehouse or indoor asset tracking environments and more. A mounting kit is included for easy deployment.

FS-GA203

High-Performance
Linear Polarization
Indoor-Outdoor
Mono-Static Antenna

Electrical Characteristics	
Frequency Range	902-928 MHz (US) / 865-868 MHz (ETSI)
Gain	10 dbi
Polarization	Linear
VSWR	≦1.5
Front to Back Ratio	>16 db
Vertical 3db Beamwidth	48° @ E-Plane
Horizontal 3db Beamwidth	56° @ H-Plane
Impedance	50Ω
Input Power	6 watts (max)

Physical Characteristics	
Dimensions(L x W x D)	360 x 220 x 40 mm
Weight	0.938 kg
Connector	Type "N" Female
Connector Position	Bottom
Environmental Sealing	IP65

User Environment	
Operating Temperature	-40° to +158°F / -40° to +70°C
Cold Test	IEC-68-2-1 (-40° F/-40° C for 24 hours)
Heat Test	IEC-68-2-2 (158° F/70° C for 24 hours)
Temperature Shock Test	IEC-68-2-14 (-40° F rising to 158°F -40°C rising to 70° C in 10 cycles of 60 minutes each)
Humidity Test	IEC-68-2-30 (77° to 104°F/-25° to 40°C 24 hour cycles of 90% relative humidity)
Rain Test	IEC-68-2-18 (3 hr min in rain chamber at 43 psi)
Salt Fog Test	IEC-68-2-11 (96 hours, repetitive cycling)
Random Vibration Test	IEC-68-2-6 (10 to 150 Hz, 05 g, 1 hour in each of 2 axes)

FS-GA203/204/205

FS-GA204

High-Performance
Circular Polarization
Indoor-Outdoor
Mono-Static Antenna

Electrical Characteristics

Frequency Range	902-928 MHz (US); 865-868 MHz (ETSI)
Gain	8 dbi
Polarization	Circular, LHCP and RHCP
Return Loss	25db (VSWR = 1.18)
Front to Back Ratio	>15 db
Vertical 3db Beamwidth	60° @ E-Plane
Horizontal 3db Beamwidth	50° @ H-Plane
Impedance	50Ω
Input Power	6 watts (max)

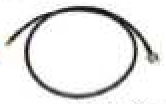
Physical Characteristics

Dimensions(L x W x D)	260 x 260 x 42 mm
Weight	0.823 kg
Connector	Type "N" Female
Connector Position	Bottom
Environmental Sealing	IP65

User Environment

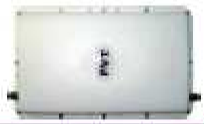
Operating Temperature	-40° to +158°F/-40° to +70°C
Cold Test	IEC-68-2-1 (-40° F/-40° C for 24 hours)
Heat Test	IEC-68-2-2 (158° F/70° C for 24 hours)
Temperature Shock Test	IEC-68-2-14 (-40° F rising to 158°F/-40°C rising to 70° C in 10 cycles of 60 minutes each)
Humidity Test	IEC-68-2-30 (77° to 104°F/-25° to 40°C 24 hour cycles of 90% relative humidity
Rain Test	IEC-68-2-18 (8 hr min in rain chamber at 43 psi)
Salt Fog Test	IEC-68-2-11 (96 hours, repetitive cycling)
Random Vibration Test	IEC-68-2-6 (10 to 150 Hz, 05 g, 1 hour in each of 2 axes)

Accessory:
RF Cable SMA to N Jack



FS-GA205

High-Performance
Circular Polarization
Indoor-Outdoor
Bi-Static Antenna



Electrical Characteristics

Frequency Range	902-928 MHz (US); 865-868 MHz (ETSI)
Gain	10 dbi
Polarization	Two circular polarized patch array
VSWR	≦1.5
Front to Back Ratio	>15 db
Vertical 3db Beamwidth	50° @ E-Plane
Horizontal 3db Beamwidth	56° @ H-Plane
Impedance	50Ω
Input Power	6 watts (max)

Physical Characteristics

Dimensions(L x W x D)	380 x 220 x 40 mm
Weight	1.117 kg
Connector	Type "N" Female x 2
Connector Position	Bottom
Environmental Sealing	IP65

User Environment

Operating Temperature	-40° to +158°F/-40° to +70°C
Cold Test	IEC-68-2-1 (-40° F/-40° C for 24 hours)
Heat Test	IEC-68-2-2 (158° F/70° C for 24 hours)
Temperature Shock Test	IEC-68-2-14 (-40° F rising to 158°F/-40°C rising to 70° C in 10 cycles of 60 minutes each)
Humidity Test	IEC-68-2-30 (77° to 104°F/-25° to 40°C 24 hour cycles of 90% relative humidity
Rain Test	IEC-68-2-18 (8 hr min in rain chamber at 43 psi)
Salt Fog Test	IEC-68-2-11 (96 hours, repetitive cycling)
Random Vibration Test	IEC-68-2-6 (10 to 150 Hz, 05 g, 1 hour in each of 2 axes)

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B.3 Rhode and Schwartz Universal Radio Communication Tester CMU 200

Data sheet for CMU 200 available at:

http://cdn.rohde-schwarz.com/dl_downloads/dl_common_library/dl_brochures_and_datasheets/pdf_1/CMU200_dat-sw_en.pdf

B.4 Spectrum Analyser

Agilent N9020A MXA Signal Analyzer

Data sheet available from:

http://www.home.agilent.com/en/pd-784671-pn-N9020A/mxa-signal-analyzer?cc=US&lc=eng

Annex C: Photographs

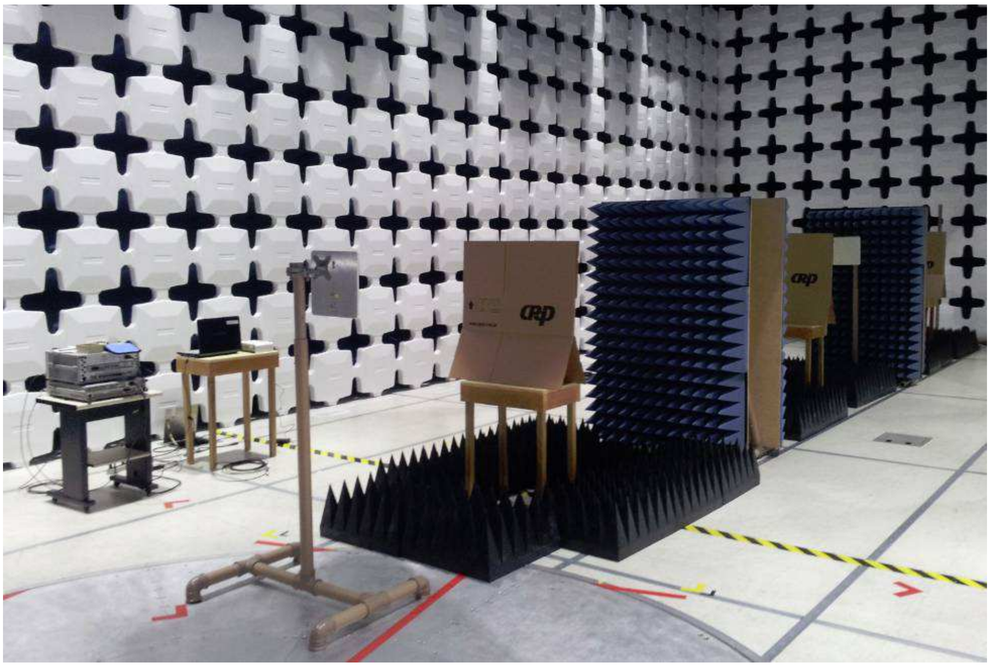

Fig C.1 View of Portal B in aneochic chamber

Fig C.2 Mobile phone positioned next to tags

Fig C.3 Moving pallet through portal

History

Document history		
V001	7 June 2013	Initial draft
V002	10 June 2013	Editorial changes
V100	14 June 2013	Final version
V110	17 June 2013	Minor editorial changes