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Technical Report

Electromagnetic compatibility and Radio spectrum Matters (ERM); RFID Plugtests to investigate the interoperability of tags manufactured by different vendors; Part 2: Test plan and preliminary tests

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Foreword

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

The present document is part 2 of a multipart deliverable covering RFID Plugtest that was performed at the MGI centre in Neuss and at the VanDerLande premises in Veghel during the period 11th - 15th June 2008.

Part 1: "RFID Plugtests report";

Part 2: "Test plan and preliminary tests".

Introduction

Different applications, like conveyor belts or dock door portals, are characterized by different properties such as field characteristics, tag population, speed and tag/reader density. These properties impose different requirements such as read or write sensitivity and resistance to mutual coupling. When exposing tags of various types from different vendors to application specific conditions, some tags might influence the operability of others, thereby being mutually incompatible.

The goal of tag interoperability tests is to investigate issues of potential incompatibility that arise due to the use of tags of various types from different vendors in application specific conditions.

The result is the test report made publicly available via the ETSI web-page. Prior to the RFID Plugtests, preliminary tests were conducted using a well documented, dedicated test reader with one antenna port and special measurement equipment for extended evaluation options (referred to as the control reader). In order to gain the best understanding of possible anomalies these preliminary tests were conducted using two different set-ups. The ASIC specific test set-up focused on the inventory of multiple tags hard wired to the control reader, (i.e. eliminating the influences of the RF field). The tag specific test set-up focused on the inventory of multiple tags under application specific conditions (using an antenna to generate a RF field instead of hard wiring the tags to the control reader).

In the second step the ETSI RFID Plugtests were executed in application scenarios using commercially available equipment. As the results of the preliminary tests merely provide a basis for understanding potential issues, only the results of the ETSI RFID Plugtests are included in Part 1 of TR 102 644 [i.6].

1 Scope

The present document defines a test plan for tag interoperability tests. The main objective of such tests is to confirm that mixed populations of tags (tags of different types and/or from different vendors) can be identified correctly. The tests are defined in a two-step approach.

The present document identifies the main factors influencing tag interoperability including application scenarios, protocol parameters and individual tag characteristics. Each of these aspects is addressed in detail with the aim of providing a test plan and evaluation matrices for tag interoperability tests. Protocol specific issues in the present document are focused on the EPCglobal Class 1 Generation 2 (C1G2) air interface specification [i.2] and the air interface specification ISO/IEC 18000-6 Type C [i.3].

The present document served as basis for carrying out ETSI Plugtests (RFID Interoperability Event) in June 2008.

2 References

References are either specific (identified by date of publication and/or edition number or version number) or non-specific.

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2.1 Normative references

The following referenced documents are indispensable for the application of the present document. For dated references, only the edition cited applies. For non-specific references, the latest edition of the referenced document (including any amendments) applies.

Not applicable.

2.2 Informative references

The following referenced documents are not essential to the use of the present document but they assist the user with regard to a particular subject area**.** For non-specific references, the latest version of the referenced document (including any amendments) applies.

[i.1] ETSI TS 102 237-1: "Telecommunications and Internet Protocol Harmonization Over Networks (TIPHON) Release 4; Interoperability test methods and approaches; Part 1: Generic approach to interoperability testing".

[i.2] EPCglobal: "EPC™ Radio-Frequency Identity Protocols; Class-1 Generation-2 UHF RFID; Protocol for Communications at 860 MHz - 960 MHz", Version 1.1.0.

NOTE: Available at http://www.epcglobalinc.org/standards/uhfc1g2/uhfc1g2_1_1_0-standard-20071017.pdf.

[i.3] ISO/IEC 18000-6: "Information technology - Radio frequency identification for item management - Part 6: Parameters for air interface communications at 860 MHz to 960 MHz".

[i.4] Void.

[i.5] ETSI EN 302 208-1 (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; Part 1: Technical requirements and methods of measurement".

[i.6] ETSI TR 102 644-1: "Electromagnetic compatibility and Radio spectrum Matters (ERM); RFID Plugtests to investigate the interoperability of tags manufactured by different vendors; Part 1: RFID Plugtests report".

[i.7] CEPT/ERC REC 70-03: Relating to the use of Short Range Devices (SRD).

3 Abbreviations

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

ASIC	Application Specific Integrated Circuit
EUT	Equipment Under Test
RFID	Radio Frequency IDentification
QE	Qualified Equipment

4 Influences On Tag Interoperability

4.1 Preface

The main factors influencing tag interoperability are the application scenario, protocol parameters, and individual tag characteristics. Each of these factors is addressed in detail in the following clauses. However due to the large number of variables associated with application scenarios and protocol parameters, it is only possible to cover the main factors influencing tag behaviour. Since there could be issues in assigning interrogator related characteristics either to the application scenario or to the protocol parameters, the following convention is adopted: **software definable characteristics are assigned to the protocol parameters while all others are assigned to the application scenario.**

4.2 Application Scenario

The application scenario describes the set-up in which an RFID interrogator and tags are used. The main characteristics of an application scenario include:

- Environment:
  - All aspects that have a certain influence on an application but are not part of the application itself (like surrounding material, noise sources of any kind e.g. mobile phones).
- Reader antenna arrangement:
  - Position and orientation of the reader antennas in a set-up.
  - Number of reader antennas.
  - Type of reader antennas.
- Tag arrangement:
  - Position and orientation of the tags in a set-up.
  - Number of tags.

  - Type of tags (different vendors/models).
- Relative movement between reader antennas and tags:
  - Speed.
  - Path:
    - E.g. pallet moving through portal (tags moving).
    - E.g. handheld reader (reader antenna moving).
- Pallet / Case / Item characteristics:
  - Materials.
  - Arrangement.

4.3 Protocol Parameters

The protocol parameters describe the protocol settings, as well as other software options associated with a particular application set-up. The main protocol parameters are (C1G2 specific where applicable):

- Link rates:
  - Forward link.
  - Return link.
- Modulation/Encoding:
  - Modulation type (forward link).
  - Modulation depth (forward link).
  - Duty cycle (forward link).
  - Encoding (return link).
- CW:
  - Power.
  - Frequency.
- Link timing:
  - In most cases not selectable!
- Protocol flow:
  - Command sequence.
  - Collision-arbitration concept (Q protocol).
  - Function:
    - Selection/inventory only.
    - Access - write.
- Session usage:
  - Session flag.
  - Selected flag.

  - A → B, B → A inventory.

- TRext usage:
  - Pilot tone.
  - No pilot tone.
- Reader antenna switching:
  - Sequence.
  - Timing.
  - Interrelation with protocol concepts (e.g. inventory round).

4.4 Individual Tag Characteristics

The individual tag characteristics describe attributes that, due to variations between different tags, may influence tag interoperability. Some of these attributes are defined for the RFID Plugtests and assume tags operating under ISO/IEC 18000-6 [i.3].

- Read range:
  - The sensitivity of a tag typically expressed as forward link range for a given transmit level.
- Orientation tolerance:
  - The sensitivity of a tag in terms of its read range if it is rotated away from its preferred orientation.
- Frequency tolerance:
  - The sensitivity of a tag in terms of its read range at various carrier frequencies from 860 MHz to 960 MHz.
  - Tags with high frequency tolerance typically show less variation in sensitivity if attached to different materials.
- Interference tolerance:
  - Describes the degradation in read range of tags from interference generated by other nearby interrogators (e.g. dense interrogator environment).
- Backscatter range:
  - The strength of a backscatter response from a tag for a given downlink field level in terms of return link range.
  - The range of the return link for passive tags typically is greater than the range of the forward link.
  - The efficiency of the hardware design for generating the backscatter signal.
- Backscatter timing:
  - The interval between the instant that the interrogator ceases transmitting its modulated signal and the instant that the tag starts to transmit its backscatter response.
- Write range:
  - The write sensitivity of the tag, i.e. the maximum forward link range at which it is possible to write data into a tag.
- Write time:
  - The time taken to write x bits into a tag.

- Tag proximity:
  - Describes the degradation in read range of a tag when positioned in proximity to another tag / other tags.
  - Detuning immunity.
  - Mutual coupling.
- Tag flags persistence time:
  - Persistence time of the S1, S2, S3 and SL flags.
- Tag RNG probability:
  - Probability of a tag's RNG to roll a 1 in a specific time slot.

5 Definition of Tag Interoperability Tests

Tag Interoperability Test: ETSI defines interoperability as the "ability of two systems to interoperate using the same communication protocol" ([i.1], p.8). Furthermore, the purpose of interoperability testing is identified as to "prove that end-to-end functionality between (at least) two communicating systems is as required by the standard(s) on which those systems are based" ([i.1], p.9). ETSI clearly highlights that each interoperability test configuration includes one, and only one, subject of test called the Equipment Under Test (EUT) ([i.1], p.13).

For the purposes of the RFID Plugtests tag interoperability is defined as the ability of an RFID interrogator (Qualified Equipment - QE) to interoperate with a population of RFID tags (Equipment Under Test EUT) using the same communication protocol, wheras.

Figure 1 shows the architecture for a tag interoperability test based on this approach (this is modified from figure 7 of [i.1]) where the QE is an RFID interrogator. The EUT comprises a number of tags (two or more) typically of mixed types and/or from different vendors. Thus individual tags can be treated as components of the EUT and interoperability issues will be seen as the inability of the QE to communicate with one or more of these components.

Figure 1: Tag Interoperability Test Setup

This clause introduces the structure of tests for tag interoperability. The tests have in common that they are performed for homogenous tag populations (all tags of the same type) and mixed tag populations (different types of tags are used). The outcome of the tests is assessed mainly by comparing the results for the homogenous and mixed tag populations.

The tests are sub-divided into two steps:

1) Tag interoperability tests that are interrogator independent (preliminary tests) focus solely on issues that influence tag-to-tag interoperability. In particular these tests are executed using a control reader (as described in clause 6). The aim of these tests is to gain knowledge about potential tag-to-tag interoperability issues.

2) The ETSI RFID Plugtests are tag interoperability tests that are performed under various application scenarios. The tests are performed with a range of commercially available interrogators and tags. Further details are defined in clauses 6 and 7.

6 Tag interoperability tests executed in application scenarios (RFID Plugtests)

6.1 Introduction

This clause defines tag interoperability tests that are performed in a series of real life scenarios, which are representative of applications in the logistics and retail industries. The tests include the movement of tagged cartons on pallets moving through dock doors and the movement of tagged objects on conveyors. In addition tests use both shelf readers and hand held readers. For the tests commercially available interrogators and tags are used.

The tests were carried out at an ETSI Plugtests event (RFID Interoperability Event), which took place from 11^{th} to 15^{th} June 2008 at the Metro Group - RFID Innovation Center in Neuss (Germany) and at VanDerLande Industries in Veghel (The Netherlands).

Details are discussed below.

6.2 Purpose

The purpose of the Plugtests described herein is to investigate if there is a satisfactory level of interoperability between RFID equipment (interrogators and tags) supplied by different vendors. The main objective of the tag interoperability tests is to confirm that mixed populations of tags (tags of different types and/or from different vendors) can be identified correctly by interrogators provided by different manufacturers. This information is of major strategic importance to those end-users who wish to use RFID on a global basis.

The results from the Plugtests is published in TR 102 644-1[i.6], which is documented in a way that avoids disclosure of the performance of individual manufacturer's equipment (tags and interrogators).

6.3 Arrangements

The Plugtests took place from 11-15 June 2008. The deadline for registration was 22 May 2008. In order to ease logistics it was recommended that participants ship equipment in advance with a shipment deadline of 27 May 2008.

To allow adequate time for preparation of the test set-ups, tags were provided well in advance with a shipment deadline of 20 May 2008. Details about the preparations for individual tests are covered further below in this clause.

The following days were allocated for carrying out tests:

- Wednesday, 11 June 2008:
  - Application Set-up 3: Rack of DVDs - Shelf Reader.
  - Application Set-up 4: Retail Store - Handheld Reader.
- Thursday, 12 June 2008:
  - Application Set-up 1: Portal - Moving Pallet.
- Friday, 13 June 2008:
  - Application Set-up 2: Conveyor - Moving Case.

The other days were left open in order to allow for investigation of unresolved issues, repetition of individual tests, review of results, and any other business.

Tests commenced at 9 a.m. at each of the test days.

Participating tag and ASIC manufacturers were each requested to provide at least 1 000 tags for the Plugtests. The tags were programmed by Metro during test preparation.