

Electromagnetic compatibility and Radio spectrum Matters (ERM); Report for CESI-ETSI RFID Plugtests™ event to investigate the interoperability of interrogators and tags manufactured by different vendors in a postal environment



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Foreword

This Special Report (SR) has been produced by CESI-ETSI RFID Plugtests™ event cooperation with support from ETSI Technical Committee ERM TG34 and CPST; and with sponsorship from Tektronix.

This and other Plugtests™ events are sponsored by the European Commission.

Executive Summary

The CESI-ETSI RFID Plugtests™ event, to investigate the interoperability of interrogators and tags manufactured by different vendors in a postal environment, was conducted at CPST's premises in Beijing between the 20th to 24th April 2009.

A total of 13 interrogators from 7 manufacturers and 18 different tag types from 9 manufacturers were tested. Among the tags 6 different types of metal tags were used in one of the tests.

The test results revealed that reliable high performance UHF RFID systems can meet the needs of certain operations in the Postal sector using combinations of equipment from different vendors. Further that systems with different UHF air interface protocols (ISO/IEC 18000-6C [i.1], TOTAL [i.1] and IPICO IP-X [i.2]) showed no evidence of interfering with each other. This widens choice for the use of different RFID systems at the same location. Further the test demonstrated the possibility for China to consider a UHF channel plan similar to that deployed in Europe, which would improve the performance and reliability of UHF RFID systems operating in close proximity to each other. Additional late scheduled tests indicated that Chinese tagged goods with tags optimized for Chinese UHF regulations were capable of being read equally well in Europe with interrogators working in compliance with European UHF radio regulations.

The test results showed that there is a need for China to remain vigilant in order to prevent the introduction of non-Chinese compliant UHF RFID devices. There was evidence of partial and complete failure of some equipment to meet Chinese radio regulations with consequential interference to other radio devices and services. Three interrogators were shown not to comply with Chinese radio regulations. These devices participated in the RFID Plugtests™ event where they had no influence on other compliant interrogators and tags. Additionally the results recorded during tests of non Chinese compliant devices have been excluded from the post Plugtest analysis to ensure that the results from these devices did not unfairly reflect upon the general conclusions.

In conclusion the China RFID Plugtests™ event was very successful for all participants. Vendors had the opportunity to gather valuable information on the interoperability of their devices in Postal scenarios. China Post advanced their level of comprehension of the UHF RFID market and their confidence that the performance of passive RFID would meet a number of their favored applications. CESI and ETSI shared a new heightened level of understanding and cooperation with respect to UHF RFID, regional RFID radio spectrum matters, compliance and Plugtests™ event.

Recommended follow-on actions include the repeat testing of some poorly performing metal optimized tags to determine if the results were due to systematic or non systematic failure of the devices under test. All other tests TD_MAIL_2 to 4 should be repeated with representative material in order to establish a higher level of confidence in the appropriate selection of devices. It is recommended to carry out further tests with a view to the introduction of a UHF RFID spectrum channel plan. These spectrum related tests should simulate a dense reader environment in a representative application scenario in order to highlight the possible advantages to Chinese UHF RFID applications. Vendors with devices which were unable to meet Chinese radio regulations are recommended to revise their products and carry out further compliance tests. CESI and ETSI are able to assist vendors with such repeat testing.

Interestingly the series of interference tests highlighted no evidence of any interference between ISO/IEC 18000-6C [i.1] and TOTAL [i.1] or IPICO I-PX [i.2] air interface protocols operating at the same frequency. The only interference demonstrated whether operating at Chinese or European UHF frequencies was between two out of six of the interrogators compliant with ISO/IEC 18000-6C [i.1].

Introduction

This document describes a RFID Plugtests™ event that was performed at CPST in Beijing, China during the period 20th to 24th April 2009, which was co-organized by European Telecommunication Standards (ETSI) and China Electronic Standardization Institute (CESI). The purpose of the RFID Plugtests™ event was to investigate interoperability when tags and interrogators manufactured by different vendors and complying with different standards were used under different postal scenarios defined by China Post Science & Technology Company (CPST). The RFID Plugtests™ event also explored the capability for any combination of simultaneously operating interrogators (supplied by the participating vendors) when located in the vicinity of each other (referred to 'dense reader mode') to maintain their performance. These interference tests were completed with different combinations of UHF interrogators under both Chinese and also European UHF radio regulations. Other tests investigated if there was any evidence of a reduction in performance when China UHF tags were read by European UHF interrogators.

Since RFID postal applications would be a national or global business, interoperability is crucial. It was therefore considered necessary to carry out a series of tests at the earliest opportunity to determine whether there any problem existed. The tests simulated a number of real life scenarios in which tags and interrogators manufactured by different vendors might be present simultaneously in the same interrogation zone. The tests are described in a test plan which was reviewed and approved by ETSI, CESI and CPST and is available at annex A of the present document.

All of three pre-tests and eight scenario-tests were performed at CPST and comprised the following:

- Determining compliance with the Chinese radio regulation.
- Reading RFID tags in a multi-interrogator environment using just 2 channels at Chinese UHF frequencies.
- Reading RFID tags in a multi-interrogator environment using just 2 channels at European UHF frequencies.
- Reading an RFID tag which is mounted on the top of a metal mail container.
- Reading RFID tags which are attached to 60 mail boxes.
- Reading RFID tags which are attached to mail cases on a conveyor.
- Reading RFID tags which are attached to mail bags on a conveyor.

Tests were carried out with interrogators set to the designated European UHF frequency (865 MHz to 868 MHz). Tests were also carried out with ISO/IEC 18000-6C [i.1] tags mixed with TOTAL [i.1] tags, and ISO/IEC 18000-6C [i.1] tags mixed with IPICO IP-X [i.2] tags. These tests showed that equipment in the EU and China were compatible.

Nine RFID manufacturers (interrogators and tags) took part in the RFID Plugtests™ event. They all participated on the basis that the results of the tests on their equipment would remain confidential. The present document therefore only provides an overall summary of the results recorded for each of the tests. In addition all of the participants in the tests had completed the ETSI Non-disclosure Agreement.

1 Scope

The present document provides a description of the event, the test results, and some technical proposals for Postal applications.

2 References

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

- For a specific reference, subsequent revisions do not apply.
- Non-specific reference may be made only to a complete document or a part thereof and only in the following cases:
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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] 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.2] IPICO's IP-X™ RFID Air-interface Protocol

3 Definitions and abbreviations

3.1 Definitions

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

inventory mode: mode in which interrogator is configured to re-read the tags in its reading zone continuously

NOTE: Identification of individual tags may be reported multiple times.

3.2 Abbreviations

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

CESI	China Electronics Standardization Institution
CPST	China Post Science & Technology Company
CW	Continuous Wave
dBch	Decibels referenced to the integrated power in the reference channel
ERP	Effective Radiated Power
f_c	Frequency of operating field (carrier frequency)
f_o	Offset frequency used in pre-test 1

NOTE: See clause 4.

ID	Identifier
R_{BW}	Term used to denote $2.5/T_{ari}$ bandwidth centred at f_c
RFID	Radio Frequency IDentification
RSSI	Received signal strength indicator
S_{BW}	Term used to denote $2.5/T_{ari}$ bandwidth centred at $(n \times f_o) + f_c$
SMA	Subminiature A
Tari	Reference time interval for a data-0 in interrogator-to-tag signalling
TNC	Threaded Neill-Concelman
TOTAL	Tag only talks after listening
UHF	Ultra High Frequency

4 General

Nine manufactures participated in the RFID Plugtests™ event. They were ZTE, Motorola, Sense, WPG, IPICO, INVENGO, Silion, NXP and Impinj. Seven of them provided the UHF interrogators. They were ZTE, Motorola, Sense, IPICO, INVENGO, Silion and Impinj. All of the nine manufactures provided UHF RFID tags. Also Alien RFID tags that were provided by CPST were tested.

For all of the test scenarios pre-programmed tags were attached to each of the objects under test. Each interrogator was also assigned a reference number as were the tests. The objects were divided into groups with tags assigned by tag type to each group. An electronic record was made of the pre-programmed number in the tag, the object and the test group. In addition there were additional groups comprising items that included tags compliant with different standards. This made it possible to compare the performance of tags by type against the performance of a mixed population of tags.

There were four test scenarios in the original test plan specification (see below) but in fact with the agreement of all parties another four test scenarios were added at the end of the test. These additional tests were selected in order to explore the potential for tags optimized for use under Chinese UHF regulations to operate satisfactorily at European UHF frequencies. These tests included both the fixed frequency mode and FHSS mode. Tests were carried out at both Chinese and European UHF frequencies using FHSS even though this is not permitted under existing European UHF regulations.

Three pre-tests were carried out. Pre-test 1 tested the output power, frequency and spectrum mask of each interrogator to make sure that they are conform to the Chinese 920 MHz to 925 MHz regulations. Pre-test 2 tested a dense interrogator environment under Chinese UHF regulations. Pre-test 3 tested the European 4-channel plan.

4.1 Test schedule

The event was held during 20th to 24th April 2009.

Date	Time	Test	Location	Place
Monday 20 April	09:00 - 18:00	Pre-test 1: DRM spectrum mask TD_MAIL_1: Tests with Mail Container TD_MAIL_2: Tests with Mail Cases on Cart	Testing Hall	CPST
Tuesday 21 April	08:30 - 19:00	TD_MAIL_2: Tests with Mail Cases on Cart TD_MAIL_3: Conveyor Tests with Mail Cases TD_MAIL_4: Conveyor Tests with Mail Bags	Testing Hall	CPST
Wednesday 22 April	08:30 - 19:00	Pre-test 2: Multi-interrogator environment Pre-test 3: Four channel plan	Basketball Court	CPST
Thursday 23 April	08:30 - 19:30	TD_MAIL_1: Tests with Mail Container TD_MAIL_2: Tests with Mail Cases on Cart TD_MAIL_3: Conveyor Tests with Mail Cases TD_MAIL_4: Conveyor Tests with Mail Bags TD_MAIL_5: Tests with Mail Cases on Cart TD_MAIL_6: Tests with Mail Cases on Cart TD_MAIL_7: Tests with Mail Cases on Cart TD_MAIL_8: Tests with Mail Cases on Cart	Testing Hall	CPST
Friday 24 April	08:30 - 15:00	TD_MAIL_8: Tests with Mail Cases on Cart Wrap-up meeting	Testing Hall meeting room	CPST

4.2 Interoperability Test Sessions

The objective of each interoperability test session was to execute for each test pair (1 interrogator vendor and 1 tag group) tests according to "Test Descriptions for CESI-ETSI RFID Plugtests™ event" (see annex A). This meant that one interoperability test session constituted of 5 test-runs of a given test pair, e.g. "interrogator vendor A - tag group C" (1 test session = 5 test-runs = 5 log files).

Prior to each interoperability test session one person from the participating teams was selected to be the test session secretary. For each test-run a log file was captured, and the interoperability result was agreed amongst both vendors. At the end of each interoperability test session, the complete batch of 5 log files was submitted by the test secretary to ETSI and CESI.

The log files were analyzed according to the appropriate evaluation formulas (as defined in the respective "Results" sections of clause 5 "Result Summaries"). The results were then entered in the ETSI Test Reporting Tool (<https://services.plugtests.net/reporting/index.php>) and made available for consultation.

Table 1: Example - Overall Results TD_MAIL_1

Interoperability		Not Executed		Totals	
OK	NO	NA	OT	Run	Results
423 (95,7 %)	19 (4,3 %)	0 (0,0%)	38 (7,9%)	442 (92,1 %)	480

The example above shows how the Overall Results per test (Pre-test 2 to TD_MAIL_8) were reported. The "Interoperability" table provided the number of executed test-runs which were recorded as OK and NO (Not OK). The "Not Executed" column indicated why the rest of the test-runs were not executed. This was either because of non applicability (NA) or because of timing constraints (OT). The "Totals" columns showed the total number of test-runs that were executed; and in the "Results" entry it showed the total of all test-runs (sum of executed and not-executed test-runs).

5 Result Summaries

The Test descriptions for CESI-ETSI Plugtests™ event, defining the three pre-tests and the four scenario tests, is attached in annex A. Where time permitted some additional test were carried out. Details of these additional tests are also included in the present document.

5.1 Pre-test 1: DRM spectrum mask

5.1.1 Summary

The purpose of Pre-test 1 is to verify whether spectrum emissions from the supplied RFID interrogators complied with the requirements critical for successful DRM operation under China RFID UHF regulations.

In the test for the intentional emissions interrogators were set to the maximum value permitted by Chinese RFID UHF regulations, and were measured using a spectrum analyser.

The test was carried out in a normal laboratory. The output port of the interrogator was connected directly to the input of the spectrum analyser through a 10 dB attenuator and an interconnecting cable. The cables had to accommodate the following connector types: TNC, SMA and N. The cables were calibrated before the test. The loss of each cable was recorded and taken into account in the measurements.

In order to determine conformance with the Chinese UHF regulations the interrogators were set to an output power of 27 dBm (assuming a typical 6 dB antenna that would deliver 33 dBm ERP) with the centre frequency set to 921,125 MHz. Inventory mode was activated during the measurements in order to force continuous modulation of the carrier. The interrogator manufacturers were asked to set Tari to the maximum value used in any of the other tests. The tests included measurement of the output power and centre frequency, measurement of the channel bandwidth and measurement of the power in the adjacent channels (i.e. channels -3, -2, -1, 1, 2, 3).

Interrogators did not always transmit at their maximum power since for some application test scenarios the output power had to be reduced. The output power will be adjusted according to the gain required for the application scenario.

5.1.2 Exceptions

All interrogator types participating the RFID Plugtests™ event were tested in Pre-test 1. If multiple devices of the same interrogator type were available only one device was tested.

Tolerances in the actual output power when setting the output power in software to 27 dBm were observed for multiple interrogators. Whenever a deviation of more than 1 dB (< 26 dBm or > 28 dBm) of the measured output power was observed, the software settings of an interrogator were altered in order to fit within the 1 dB tolerance range. Along with the measurement results the actual software settings for the output power were noted. These settings were used for those other tests that also required maximum output power.

One of the interrogators under test did not offer possibilities to select the output power in software. Furthermore this interrogator had a built in antenna with a gain lower than 6 dB. Output power calibration to 29 dBm (allowing for lower antenna gain) had to be done manually.

Two of the interrogators under test were optimized for operation in the European frequency band. These interrogators were tested at frequencies of 865,7 MHz and 866,9 MHz respectively.

One of the interrogators under test was optimized for operation in the US frequency band. This interrogator was tested at a frequency of 902 MHz.

One of the interrogators under test initially did not fulfil the requirements for occupied channel bandwidth and spectrum mask. The reason was found to be a Tari setting of 6,25 μ s. As this Tari setting is not permitted under Chinese RFID UHF regulations the setting was changed to a higher value and the test was repeated.