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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 1: RFID Plugtests report

Reference

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Contents

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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 1 of a multi-part deliverable covering RFID Plugtests to investigate the interoperability of tags manufactured by different vendors, as identified below:

Part 1: "RFID Plugtests report";

Part 2: "Test plan and preliminary tests".

Introduction

The present document describes an RFID Plugtest that was performed at the MGI centre in Neuss and at the VanDerLande premises in Veghel during the period 11^{th} - 15^{th} June 2008. The purpose of the tests was to investigate if there were any problems of interoperability when multiple tags manufactured by different vendors were simultaneously present in the same interrogation field. The question had been raised by some members of ERM_TG34 who had observed reduced reading performance when using different tag types on loads containing multiple items. This had led them to suspect that there may be an incompatibility between different designs of tag built with different ASICs.

Since RFID is a global business that is frequently used in open systems, members of ERM_TG34 recognized that any interoperability between tags would be unacceptable. It was therefore considered necessary to carry out a series of tests at the earliest opportunity to determine whether there were any such problems existed. The tests simulated a number of real life scenarios in which tags 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 members of ERM_TG34 and are available at annex A. In addition, prior to the Plugtests, a practical investigation was made to measure certain characteristics of the ASICs. It was considered that these measurements might assist in understanding the reasons for any incompatibility observed during the Plugtests.

Three of the four test scenarios were preformed at the MGI centre in Neuss and comprised of the following:

- Reading tagged items of clothing using a hand-held reader.
- Reading of stacks of individually tagged DVDs using shelf antennas.
- Reading pallets containing multiple tagged items passing through a portal.

In addition tests were carried out on a conveyor system at VanDerLande on which items with multiple tags passed reading stations. These tests simulated, for example, airline baggage fitted with RFID tags or tagged goods moving along a production line.

Seven RFID manufacturers took part in the Plugtests. 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 describes an 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.

The purpose of the tests was to investigate if there were any problems of interoperability when multiple tags manufactured by different vendors were simultaneously present in the same interrogation field.

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:
    - if it is accepted that it will be possible to use all future changes of the referenced document for the purposes of the referring document;
    - for informative references.

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

For online referenced documents, information sufficient to identify and locate the source shall be provided. Preferably, the primary source of the referenced document should be cited, in order to ensure traceability. Furthermore, the reference should, as far as possible, remain valid for the expected life of the document. The reference shall include the method of access to the referenced document and the full network address, with the same punctuation and use of upper case and lower case letters.

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

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 EN 302 208 (all parts): "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.2] ISO 18000-6C: "Information technology - Radio frequency identification for item management - Part 6: Parameters for air interface communications at 860 MHz to 960 MHz".

[i.3] ETSI TR 102 644-2: "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".

3 Definitions, symbols and abbreviations

3.1 Definitions

Void.

3.2 Symbols

Void.

3.3 Abbreviations

Void.

4 Executive summary

These Plugtests were held at the request of members of ERM_TG34 who were concerned at possible problems of interoperability between tags manufactured by different vendors. To determine if this was the case, a series of tests, simulating real life scenarios, were defined. The tests were carried out the Metro Innovation Center in Neuss and at VanDerLande in Veghel.

Seven manufacturers of interrogators and two tag vendors participated in the tests. A total of eleven different tag types were tested, which included some RFID baggage labels provided by Air France.

Prior to the Plugtests an investigation had been carried out under laboratory conditions to determine if there were any obvious differences in the behaviour of ASICs (in the tags) that were manufactured by different foundries. Measurements made during this investigation showed that there was a noticeable difference in the behaviour of the session flags, which appeared to be dependent on the foundry that had produced the ASIC. However it was not clear if the difference would give rise to a reduction in reading performance in normal operation where mixed populations of tags were present.

The results from the Plugtests showed that there was no apparent difference in reading performance, due to any interoperability issues associated with the ASICs, between populations of tags from a single manufacturer and with mixed populations of tags.

It was observed that there was a noticeable difference in the sensitivity of different tag types, which directly affects their reading range. In applications where mixed types of tag might be used, it will be important to specify all tag types correctly to ensure that they are compatible with the system requirements.

Two distinctly different types of tag are available for item level tagging. One type is designed to be operated by a conventional radio wave. The other type is energized by a field that is predominantly magnetic. The antennas designed to read these two tag types are different. In an environment where both tag types are present, care will be necessary during system design to ensure that acceptable reading performance is achieved.

Tests on a conveyor demonstrated that it is possible to operate satisfactorily in situations where the interval between successive reads of the same tag by different interrogators is less than 2 s. Additional tests showed that using the select command it is possible to read only the "wanted tags" from a large population of mixed tags.

During the Plugtests it became apparent that not all manufacturers had a proper understanding of the features in the ASICs. This applied in particular to the use of the "select" command and the session flags. The correct use of these features is essential if optimum performance is to be achieved. Guidance on the behaviour of these functions, and how best they should be configured, is provided in an annex to the present document.

The outcome from the Plugtests was satisfactory and, based on the samples presented for the tests, showed that there was no incompatibility between different tag and ASIC types.

5 General

The names of the seven manufacturers of interrogators who participated in the tests were Hoeft & Wessel, Impinj, Kathrein, Nordic ID, Panmobil, Sirit and ThingMagic. In addition 10 different tag types were provided by three label manufacturers using ASICS from two different foundries. Further details of the tags are included in annex A. Also a number of airline RFID baggage labels were supplied by Air France.

For three of the test scenarios a pre-programmed tag was attached to each of the objects under test. The objects were divided into groups with tags assigned by tag type to each group. In addition there was an additional group which comprised items that included tags manufactured by different tag vendors. This made it possible to compare the performance of tags by type against the performance of a mixed population of tags. For practical reasons, in the case of the conveyor system, each item had three different tag types attached to it, although it was possible at any time to disable any two of the three tags.

The ID number and type of all of the tags were pre-loaded into the IBM server prior to the Plugtests. In addition the server contained an application tool that enabled easy manipulation of the recorded results to provide useful information. Each participant recorded each of their results on log files, which were subsequently transferred to the server following each test sequence. The total number of individual records that were logged during the Plugtests exceeded half a million.

Prior to each test the participant provided the test supervisor with details of the configuration of his interrogator. The configuration selected was the one considered by the participant to be the most suitable for the application that was being tested.

Pictures of each of the test scenarios are provided in annex E.

One of the interrogators presented for the Plugtests differed from the configuration that had been assumed in the Test Plan. Instead of being designed to drive four external antennas, the unit was equipped with an in-built antenna and an option to drive one external antenna. Where relevant, details of the set-up for this equipment are included in the description of each of the test scenarios.

With the exception of one manufacturer all of the interrogators presented at the Plugtests operated in accordance with EN 302 208 [
]. (This describes the four-channel plan). One equipment operated in accordance with the earlier version of the standard which specifies "Listen before Talk" and permits transmission on any channel within the band 865,6 MHz to 867,6 MHz.

All of the tags used in the Plugtests were compliant with the specification in ISO 18000-6 C [i.2].

The tests were managed by three neutral test supervisors, who were John Falck (Chairman ERM_TG34), Josef Preishuber-Pfluegl (Vice Chairman ERM_TG34) and Manfred Jantscher (CISC).

6 Description of tests

The definition of the four test scenarios is contained in the Test Plan at annex A. Where time permitted some additional tests were carried out. Details of these additional tests are also included in the present document. The Appendix to the Test Plan also describes some preliminary tests that were carried out prior to the Plugtests.

6.1 Garment tests

Four racks were prepared, each comprising forty tagged nightdresses, as described in clause 6.10.4.2 of TR 102 644-2 [i.3]. Three tag types, A, B and C, were used for the tests. The garments on three of the four racks were each tagged with tags of a particular type. The fourth rack contained an equal number of tags of all three types. An identical arrangement was configured for four stacks of trousers. Details of all of the individual tag ID numbers were stored in the IBM server.

The output power of the different handheld readers ranged from 200 dBm e.r.p. to 500 dBm e.r.p. All manufacturers with one exception operated in accordance with the four channel plan. All handheld readers were operated using session S0. Subsequently one manufacturer tried setting his reader to session S1 and achieved an improvement in his reading performance.

Each participant was asked to configure their handheld reader for optimum performance for the application. To ensure consistency in the reading process, a representative from Metro scanned the garments on each rack using each of the handheld readers in turn. The results from each scan were transferred to the IBM server. This same process was repeated for the stacks of trousers.

The results, averaged for all handheld readers, is shown below in figure 1.

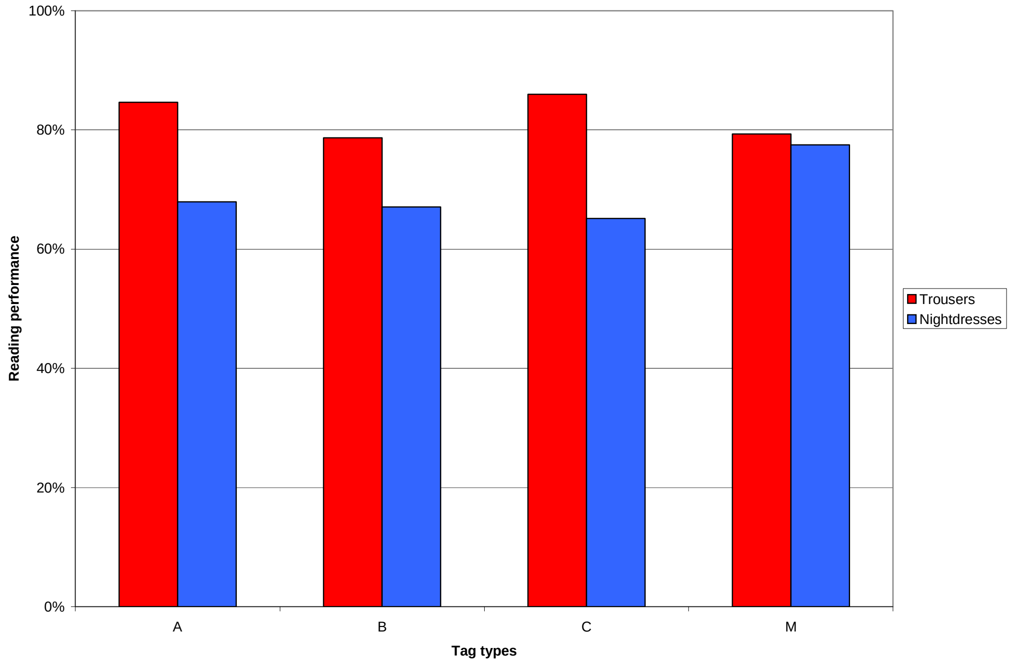


Figure 1: Averaged results for garment tests

The average results for the three tag types are shown in red for the trousers and in blue for the nightdresses. The two right hand columns show the results for the mixed types of tags.

Manufacturers of the handheld readers pointed out that in normal use operators would move garments hanging on racks as they scanned the tags. This would provide significantly better results than those recorded in the tests. However in order to obtain consistency in the testing of the different readers, it was decided scan the tags with only minimal movement of the nightdresses.

As might be expected there was a variation in the reading performance between interrogators. One reader consistently achieved reading rates of 96 % on the nightdresses and 100 % on the trousers.

6.2 DVD tests

The tests were performed using different stacks of DVDs each comprising ten cased DVDs. Each stack was tagged with different combinations of spine tags and inductive tags. A total of four different tags from three tag manufacturers were used in the tests. In every case each tag combination was repeated to give three identical stacks of a particular type. In total 31 different stack combinations were prepared for the tests.

The spine tags were fixed to the DVD cases while the inductive tags were attached directly to the DVDs. A particular feature of the inductive tag is that it is designed to be activated predominantly by a magnetic field. Three different manufacturers supplied tags that included both the spine and inductive varieties.

The test position comprised four shelf antennas arranged in a square and mounted immediately beneath a horizontal wooden surface. The antennas were connected to the interrogator under test and driven in turn sequentially. All participants operated using the "select" command but some interrogators used session S2, while others used either session S0 or session S1.

Initially three stacks of an identical tag type were positioned over three of the shelf antennas and the interrogator was activated for a period of 4 s. The number of tags read in each stack was recorded. This process was repeated with successively more complex combinations of stacks. Details of each of the combinations that were tested are shown in annex C.

The results from each of the combinations were analysed to provide an average figure for the reading performance of all of the interrogators that were measured. During the analysis it was discovered that two tags had been incorrectly programmed and two other tags were defective. These four faulty tags were excluded from the results. The corrected results are shown in figures 2 and 3 below in the form of bar charts. For ease of interpretation the results for the spine tags are shown in blue while the inductive tags are displayed in red. The tag types used in each test can be determined from the table in annex C.

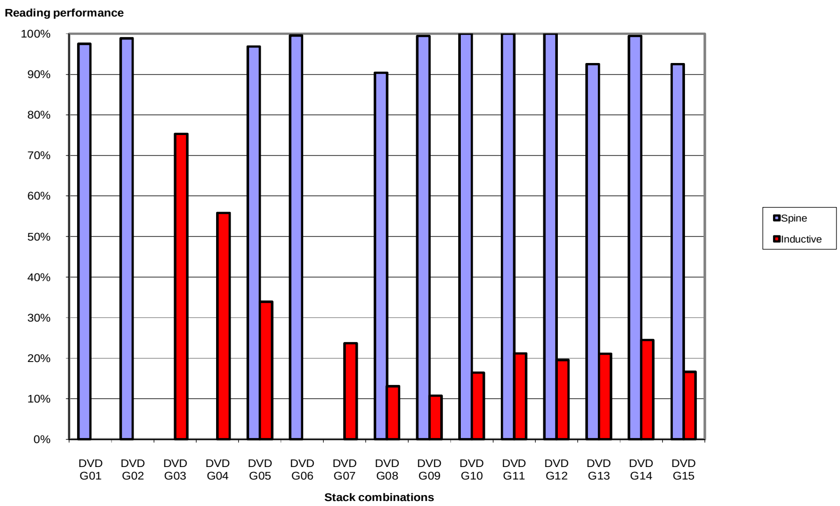


Figure 2: Averaged results for basic DVD tests

For some of the simpler DVD combinations a number of the interrogators achieved a reading performance that came close to 100 %.

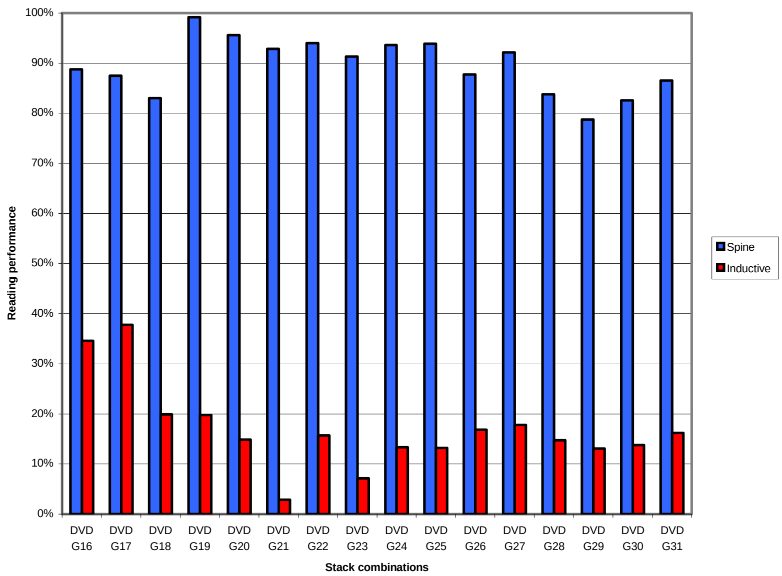


Figure 3: Averaged results for advanced DVD tests

From the results it is clear that the inductive tags performed less favourably than the spine tags. The reason for this was considered due to the use in the tests of shelf antennas that predominantly generated electro-magnetic transmissions. Additional tests were subsequently performed using one of the interrogators connected to a near field antenna. The conducted power level of the interrogator was left unchanged. The use of the near field antenna improved the reading performance of the inductive tags from 56 % to 71 %. It was still possible to read the spine tags although the reading performance dropped from 98 % to 90 %. It should be borne in mind that these tests were concerned solely with interoperability and comparisons between the performance of different systems is inappropriate.

It should be noted that one of the interrogators that participated in the tests was designed to drive just two antennas. To achieve compatibility in the results, two interrogators were used provide the four shelf antennas for the test set-up.

In certain orientations it was possible to read a spine tag at distances of up to 1 m from the near field antenna. It was also observed that type C (inductive) tags appeared to give a more consistent performance than type D (inductive) tags.

6.3 Portal tests

The portal tests were carried out using small pallets comprising 50 tagged cases and large pallets with 200 tagged cases. Details of the arrangement of the positions of tags and the type of tags are provided in annex D. This also includes details of the composition of the cases in each of the two sizes of pallet. Many of the cases contained items that were "r.f. unfriendly".

Four different tag types were used in the tests. For each pallet size there were four pallets each comprising tagged cases of one of the tag types. A fifth pallet comprised cases that were tagged with an equal number of the four different tag types.

Two test stations were used for the tests. One test station consisted of a portal positioned inside a dock door that led to a trailer parked outside. The portal was fitted with a pair of antennas on both sides and with a metal reflector positioned behind both pairs of antennas. A motioned detection device coupled combined with an infra-red curtain was mounted above the portal. This device was capable of determining the direction of motion of a pallet and could trigger an interrogator when a pallet was at a defined position in front of a portal.

The second test station used an identical design of portal but was positioned at the centre of a rail track testing system. This system could move a pallet repeatedly at a specified speed through the portal.

Each of the interrogators was set-up in turn to transmit at a power level of 33 dBm e.r.p. with a transmission period of 3 s for the dock door and 4 s for the rail track system. Manufacturers chose to operate their interrogators in either session S1 or session S2 and to use the select command.

The tests with the small pallets required each one in turn to be removed from the truck positioned outside the dock door and through the portal. Each pallet was carried by a fork lift that moved at an approximate speed of 1.5 m/s. The test was repeated five times for each pallet with each of the four different interrogators. The number of tags read each time that a pallet passed through the portal was recorded.

Due to their size the pallets with 200 cases could not readily be moved using the fork lift truck. To ensure repeatability of the testing procedure, the large pallets were tested on the rail track system. The format of the tests was identical to the procedure for the small pallets.

In order to test the interrogator with only two antennas, the system was configured using two interrogators, each one driving a pair of antennas on one side of the portal.

The combined results showing the average reading performance by tag type for small and large pallets is shown in figure 4. One anomaly in these results is that the reading performance for a mixed tag types improves with a small pallet, while the reverse is true for a large pallet. However this may not be significant.

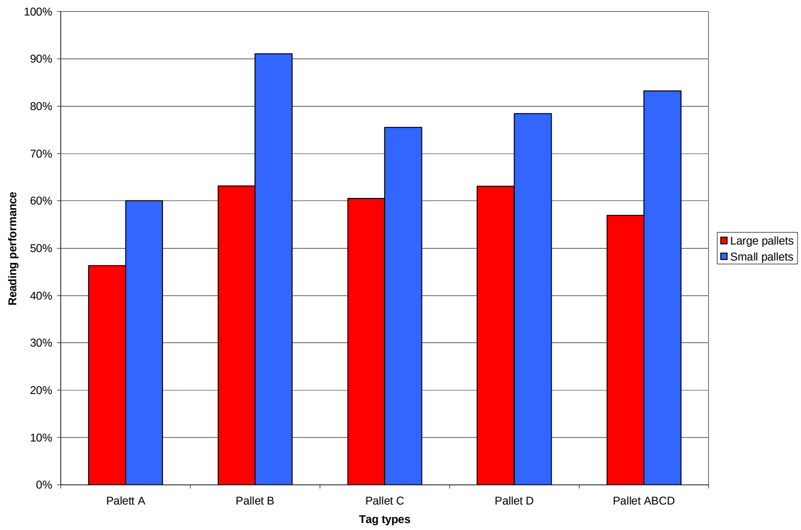


Figure 4: Averaged results for portal tests

Some interrogators achieved a better reading performance than others. The best performing interrogator achieved a figure, averaged over 5 runs, of 96 % with a "type B" 50 tag pallet. For a "type C" 200 tag pallet the equivalent figure was 78 %.

6.4 Conveyor tests

The conveyor tests were performed at the Innovation Centre of VanDerLande in Veghel. The conveyor used for the tests was of the type developed by VanDerLande for baggage handling at airports. The items used for the tests consisted of a variety of suitcases and bags. All twenty two of the suitcases and bags were filled with an assortment of objects, some of which were "r.f. unfriendly".

Three different tag types were used for the tests. One tag of each tag type was attached to the outside of each suitcase and bag. In addition a number of airline baggage labels, each incorporating an RFID tag, were provided for the Plugtests by Air France. These labels were attached to a selection of the suitcases.

The suitcases were placed on the conveyor in a known order with the tags facing upwards so that they could be observed during the tests. If required it was possible to read only a single tag type on a bag by covering the other two with adhesive-backed silver foil. The conveyor was set to run at a constant speed of 1 m/s.

Two types of reading station were used for the tests. One reading station comprised two patch MTI antennas mounted on pedestals on opposite sides of the conveyor. Each antenna was directed downwards towards the conveyor at an angle of approximately 45 degrees. Interrogators were connected in turn to the MTI antennas and adjusted to transmit at a level of 33 dBm e.r.p. The second reading station consisted of an array of two patch antennas arranged side by side within a moulded flexible mat. The mat was positioned beneath the conveyor belt. A metal hood above the belt contained the emissions from the antennas to the wanted reading area. The output from the interrogator driving the antenna array was set to a conducted power level of 22 dBm.

As a result of some initial experiments with the system, it was found that the reading performance was the same irrespective of the number of tags on the suitcases that were covered by silver foil. Similarly there was no apparent difference in the results when either one reading station was operated alone or both reading stations operated simultaneously. Based on these observations it was decided to conduct all of the tests with all silver foil removed and both reading stations in operation at the same time.

An interrogator with its select command enabled was connected to each reading station. Some manufacturers chose to use session S2 while others used session S0 or session S1. The tags were logged for five complete revolutions of the conveyor. The same procedure was repeated for the other remaining interrogators. For practically every interrogator the reading performance was 100 %. The only exceptions were when a tag came away from a suitcase and when one of the airline labels became damaged.

By means of the select command an additional test was carried out in which interrogators were required to singulate the airline labels. All of the airline labels were identified, despite the fact that other tags manufactured by different vendors were simultaneously present on the bags and suitcases.

In a further test a roll of 150 tags were placed inside one of the suitcases. All three of the wanted tags on the case were correctly read and 45 % of the 150 unwanted tags were identified.

In a final additional test two read stations of the type used at station 1 were spaced two metres apart along the conveyor. The antennas at each reading station were connected to a separate interrogator. The reading performance was logged at both stations for five complete revolutions of the conveyor. The results showed that the reading performance remained at 100 % at both reading stations.

7 Discussion

Although the results from the tests showed that there were no problems of interoperability between different tag types, all of the tags tested contained ASICs from only two foundries. As volumes of tags ramp up it is probable that additional foundries will enter the market. Provided that these new foundries comply with the specification in ISO 18000-6C [i.2], issues of incompatibility are unlikely. However tag manufacturers should be alive to the potential risks.

The advanced DVD tests placed many stacks simultaneously over the same shelf antenna. In a real application the numbers of stacks placed over a single antenna will be similar to those used in the basic tests. However the results for the basic tests are probably better than will be obtained in practice. This is because, unlike for the tests, DVDs are wrapped in cellophane and are printed using metallic ink. These have a detrimental effect on reading performance.

The use of a near-field antenna to read spine tags (i.e. e.m. tags) may lead to problems in real applications. In particular the reading performance will be reduced. Furthermore since a near-field antenna may radiate a significant e.m. field in certain directions, it is capable of reading a spine tag at distances of up to 1 metre. To avoid reading unwanted spine tags, it may be necessary in some applications to define a "protection zone" around the near-field antenna. The additional tests on the conveyor system demonstrated satisfactory operation where the interval between successive reads of the same tag by different interrogators is less than two seconds. Further additional tests showed that, by means of the select command, it is possible to read only the "wanted tags" from a large population of mixed tags.

Proper use of the session flags and select command are essential if optimum reading performance is to be achieved. During the Plugtests some manufacturers improved their results by adjusting these parameters during the set-up of their interrogators. Some guidance on the operation and use of session flags and the "select" command is provided in annex D of the present document.

During a detailed analysis of the results it was observed that with interrogators manufactured by one manufacturer, tags of one particular type responded faster than the others. The cause for this behaviour is unclear. It did not appear to effect the overall reading performance.

8 Conclusions

From examination of the results the following conclusions were reached:

- There was no clear evidence of interoperability problems when tags manufactured by different vendors were simultaneously present in an interrogation zone.
- It was apparent that there is a difference in reading performance between different tag types, which appears due principally to variations in their sensitivities.
- Some variation in the reading performance of interrogators provided by different manufacturers was evident.
- Inductive tags can only be read satisfactorily using near field antennas.
- It was possible to read the same tag at successive reading stations at intervals of less than 2 s.

- By means of the "select" command it is possible to interrogate one particular category of tag only within a population of different tag types and categories.
- Some vendors appeared to have a poor understanding of session flags and the select command.

9 Acknowledgements

Particular thanks are due to the following for their contribution towards the tests:

- CISC Semiconductor GmbH.
- IBM (SerCon GmbH).
- Metro Innovation Centre and the EECC.
- Scanology BV.
- VanDerLande Industries.

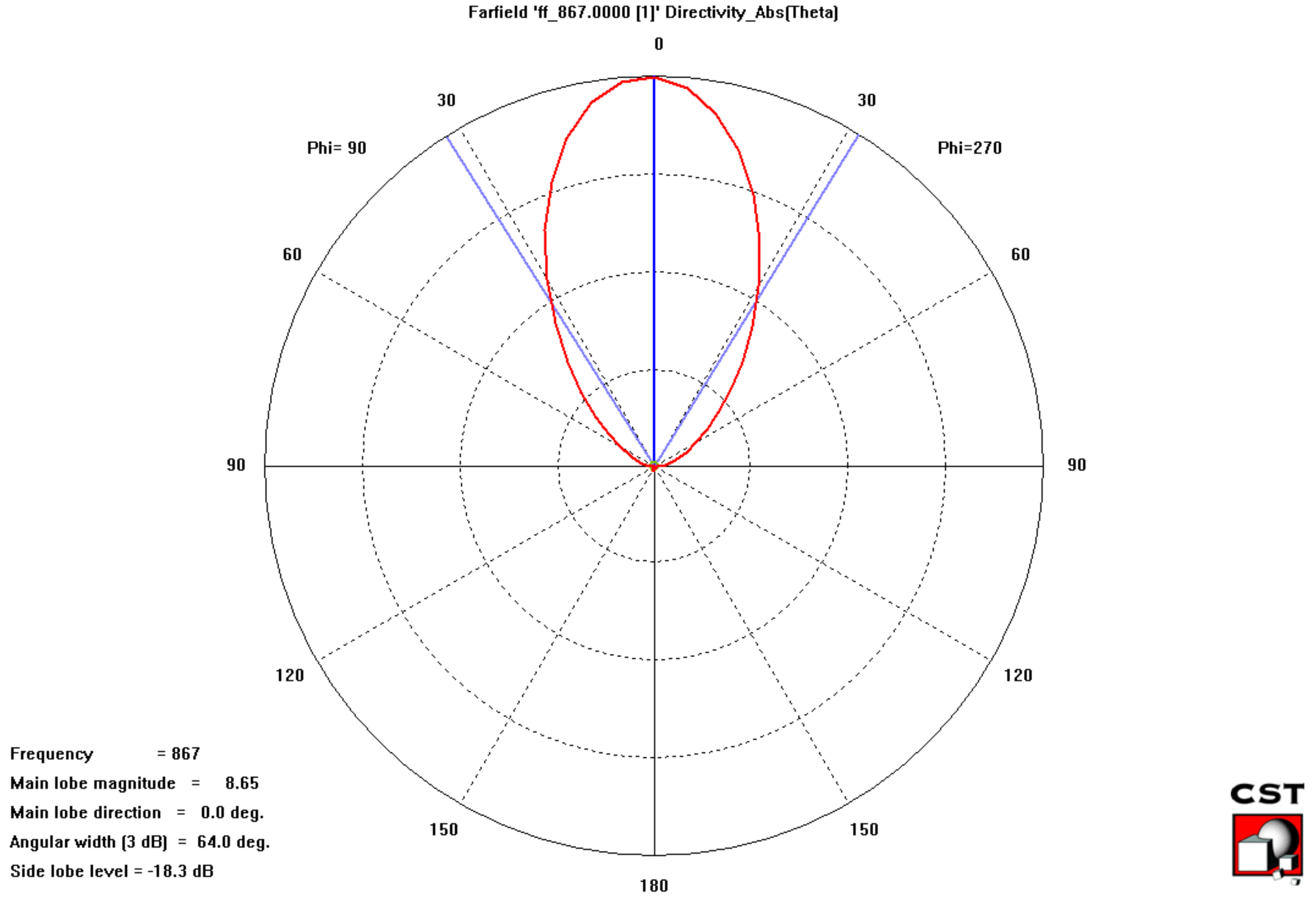
Annex A: Test equipment

A.1 List of tags

- AD 222/Avery Dennison/Impinj Monza 2.
- Air France Tags.
- Short Dipole G2X/UPM Raflatac/NXP G2X.
- RSI Imperial/RSI/NXP G2X.
- RSI Satellite/RSI/Impinj Monza 1a(!).
- RSI Corkscrew/RSI/NXP G2X.
- Short Dipole Monza 2/UPM Raflatac/Impinj Monza 2.
- UPM Spine/UPM Raflatac/NXP G2X.
- UPM Satellite/UPM Raflatac/Impinj Monza 1a(!).
- UPM Rabbit/UPM Raflatac/NXP G2X.
- UPM Web G2X(Crab)/UPM Raflatac/NXP G2X.

A.2 Antennas

A.2.1 Checkpoint



A.2.2 Kathrein Antenna

KATHREIN
SCALA DIVISION

25-180 Series

RFID Directional LHCP Antenna

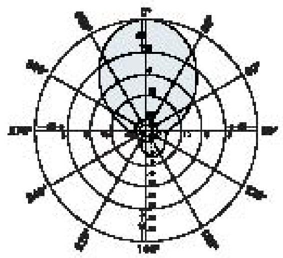
Kathrein-Scala RFID Antennas are designed and manufactured to the same standards as our wireless panel antennas, using the finest materials for strength and reliability. Heavy-duty radomes of high strength pulltruded fiberglass, rigid matching network and element circuit boards, and stainless steel mounting hardware all contribute to antennas that will perform in the toughest outdoor environment.

These directional antennas are available with other polarizations (LHCP, RHCP, Linear), and with other gains. Part 15 and 90 FCC requirements are available. Far-field and Near-field radiation patterns available.

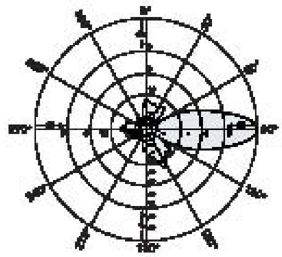
- For Far-field, specify azimuth and/or elevation and orientation.
- For Near-field, specify distance from antenna to tag.
- Gain can be adjusted for ESTI and FCC requirements.

General Specifications:

Frequency range	865–870 MHz
Gain	10.5 dBic
Impedance	50 ohms
Grounding	DC grounding
VSWR	< 1.3:1
Axial ratio	< 3 dB over entire half power beam
Polarization	Circular
Front-to-back ratio	>20 dB
Maximum input power	100 watts (at 50°C)
Far field beamwidths	70 degrees (half-power) 30 degrees (half-power)
Connector	N female, reverse polarity N female
Weight	8 lb (3.63 kg)
Dimensions	21.8 x 10.3 x 2.3 inches (555 x 262 x 59 mm)
Equivalent flat plate area	2.22 ft² (0.205 m²)
Wind survival rating	120 mph (200 kph)
Materials	Radome is gray fiberglass and mounting hardware is stainless steel.
Mounting	Mounting hardware kit required. Fixed mount kits and tilt mount kits available for 1.2 to 5.3 inch (30 to 135 mm) OD masts. Antenna panel may be inverted.



H-plane
Azimuth pattern



E-plane
Elevation pattern

10850-B

Kathrein Inc., Scala Division Post Office Box 4580 Medford, OR 97501 (USA) Phone: (541) 779-6500 Fax: (541) 779-3991
Email: RFID@kathrein.com Internet: www.kathrein-scala.com

A.2.3 MTI Wireless Edge

WIRELESS EDGE LTD.

Antenna Data Sheet
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MT - 242014/NRH

865 - 870 MHz, 8.5 dBic, Reader Antenna

Specifications

MTI PART NUMBER	MT-242014/NRH
ELECTRICAL	
FREQUENCY RANGE	865 - 870 MHz
GAIN	8.5 dBic (min)
VSWR	1.3:1 (max)
3 dB BEAMWIDTH AZIMUTH / ELEVATION	65° (typ)
POLARIZATION	RHCP ** See other Existing Antenna Versions below
SIDELOBES LEVEL @ 90°	-16 dB (max)
AXIAL RATIO AT BORESIGHT	2 dB (max)
F/B RATIO	-18 dB (max), -20 dB (typ)
INPUT IMPEDANCE	50 (Ohm)
INPUT POWER	6 W (max)
LIGHTNING PROTECTION	DC Grounded
MECHANICAL	
DIMENSIONS (LxWxD)	305x305x25 mm
WEIGHT	1.2 kg (max)
CONNECTOR	N - type, Female
RADOME	Plastic UV Resistant per ETSI 300
BASE PLATE	Aluminum with chemical conversion coating
OUTLINE DRAWING	See page 2
MOUNTING KIT	MT-120018

ENVIRONMENTAL

TEST	STANDARD	DURATION	TEMPERTURE	NOTES
TEMPERATURE	IEC 68-2-1/2	72 h	-55°C to +71°C	-
TEMP. CYCLING	IEC 68-2-14	1 h	-45°C +70°C	3 Cycles
THERMAL SHOCK NON-OPER.			-30°C to +70°C	Ramp 30°C/min
HUMIDITY	ETSI EN300-2-4 T4.1E	144 h	-	95%
WATER TIGHTNESS*	IEC 529	-	-	IP54
DUST RESISTANCE*				IP54
SOLAR RADIATION	ASTM G53	1000 h	-	-
OZONE RESISTANCE	ETSI 300			
FLAMMABILITY	UL 94	-	-	Class HB
SALT SPRAY	IEC 68-2-11 Ka	500 h	-	-
ICE AND SNOW	-	-	-	25mm Radial
WIND SPEED SURVIVAL	- -	-	-	220 Km/h
OPERATION		-	-	160 Km/h
WIND LOAD (SURV.): FRONT	-	-	-	26.8 kg
SIDE THRUST	-	-	-	2.2 kg
QUASI RANDOM VIBRATION				20g rms for 4 hours
VEHICLE VIBRATION OPERATING	1g rms, 10-500 Hz, in 3 axis	6 hours total, 2 hr in each axis. Accelerated wear - an additional 50hrs in worst case axis.		
MECHANICAL SHOCK OPERATING	10g, 11 msec, half sine pulse			

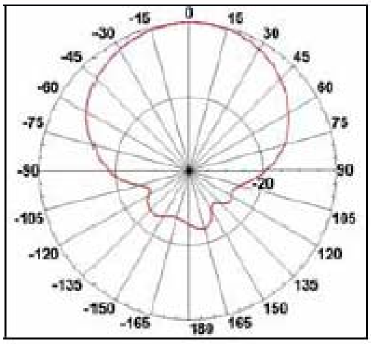
WIRELESS EDGE LTD.

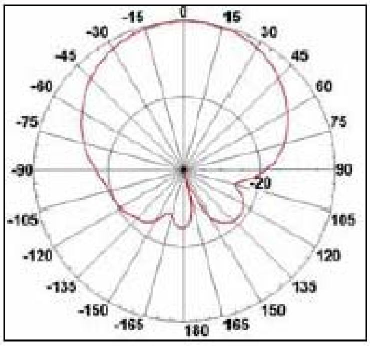
Antenna Data Sheet
MT - 242014/NRH
Page 2 of 2

MT - 242014/NRH

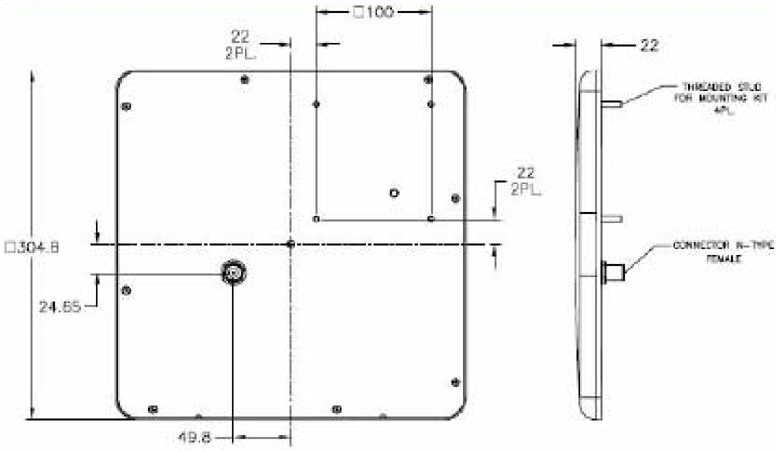
865 – 870 MHz, 8.5 dBic, Reader Antenna

Azimuth Radiation Pattern Midband Freq. 0.867 GHz	Elevation Radiation Pattern Midband Freq. 0.867 GHz





Dimensions [mm]



Existing Antenna Versions

MT-242014/NLH	** Polarization: LHCP
MT-242014/NRH/B	For more information about this model, please contact us
MT-242014/NRH/F	For more information about this model, please contact us
	* IP 67 AVAILABLE UPON REQUEST

MTI Wireless Edge is certified according to ISO 9001 and ISO 14001.

MTI Wireless Edge Ltd.
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Document No: MT-242014/NRH
Issued: 26/11/2006

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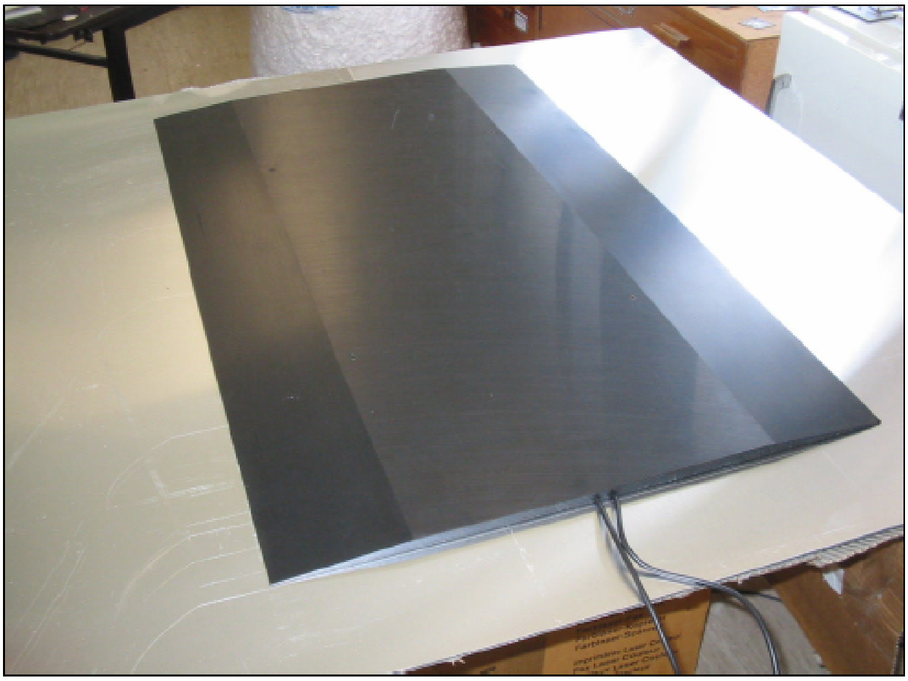
A.2.4 Scanology

SCANOLOGY
BARCODE AND RFID SOLUTIONS

DATASHEET

Part number: TBA Low Profile CP UHF array 1000 x 610 mm SMA fitting



General

The Low Profile CP array has been designed for installation under conveyor belts. It is fitted with a Ultra High Molecular Weight Polyethylene radome, which provides excellent slip and wear characteristics with minimum attenuation of the radiated energy.

The array is fitted with two Low Profile CP antenna 375 x 375 mm SMA fitting (Scanology **Part number:** 20707019)

Dimensions

1000 mm x 610 mm x 10.8 mm

Part number: TBA Low Profile CP array 1000 x 610 mm SMA fitting

Version 1.0 ©Scanology 2008 Page 1 of 2

Issued 7 January 2008

SCANOLOGY
BARCODE AND RFID SOLUTIONS

DATASHEET

Part number: 20707019 Low Profile CP antenna 375 x 375 mm SMA fitting

GENERAL

This Low Profile CP UHF Antenna has been designed for use in tunnel and conveyor belt applications on its own or as part of an array. The antenna delivers a tightly defined field, and is particularly effective operated at low conducted power input, where tags can be read reliably in both near and far field.

Dimensions:	37.5 cm x 37.5 cm x 1.06 cm
Weight:	1.78 Kg
Cable:	4 meter RJ58 with SMA F connector

GAIN

The results shown are for a typical antenna, and in free air conditions.

The results are for far field conditions. In the near field, the gain will be lower and will vary with distance from the antenna.

When two antennae in close proximity are powered simultaneously, the near field radiation patterns may change significantly. The patterns may also be influenced by the loading of the antenna(e) from items in the energy field.

Part number: 20707019 Low Profile CP antenna 375 x 375 mm SMA fitting

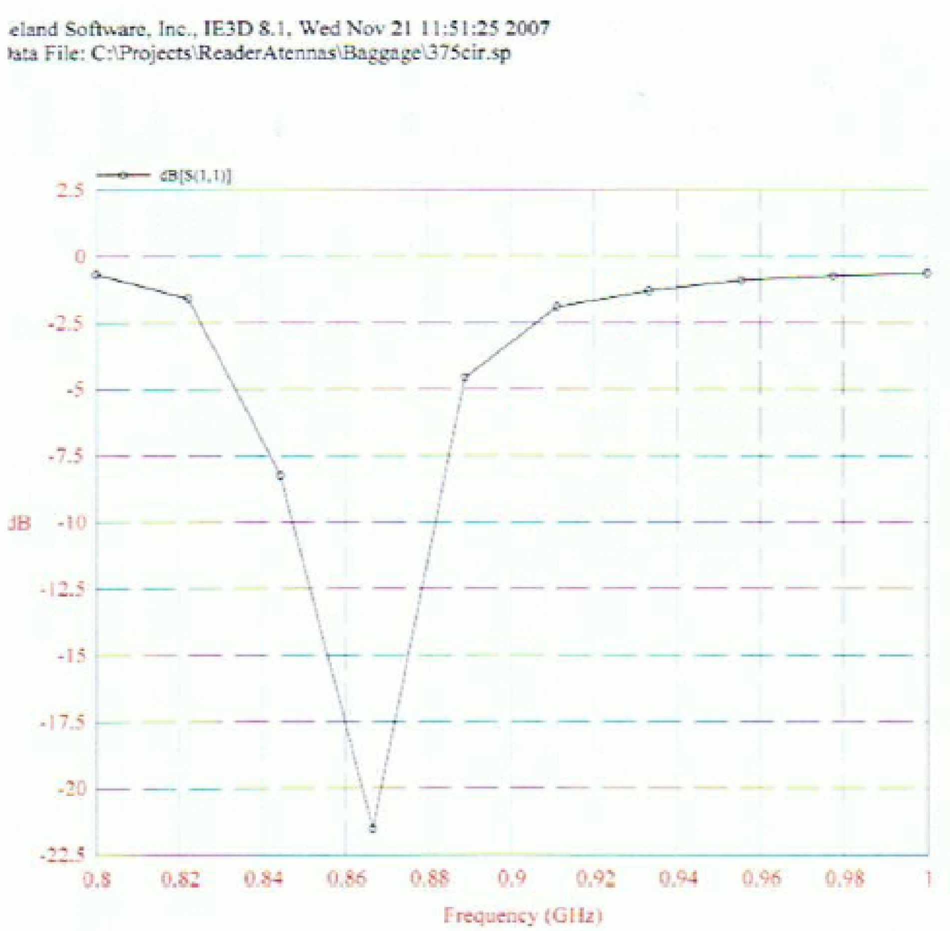
Version 0.1 **Page 1 of 5**

Issued 24 November 2007

SCANOLOGY
BARCODE AND RFID SOLUTIONS

Part number: 20707019 Low Profile CP antenna 375 x 375 mm SMA fitting

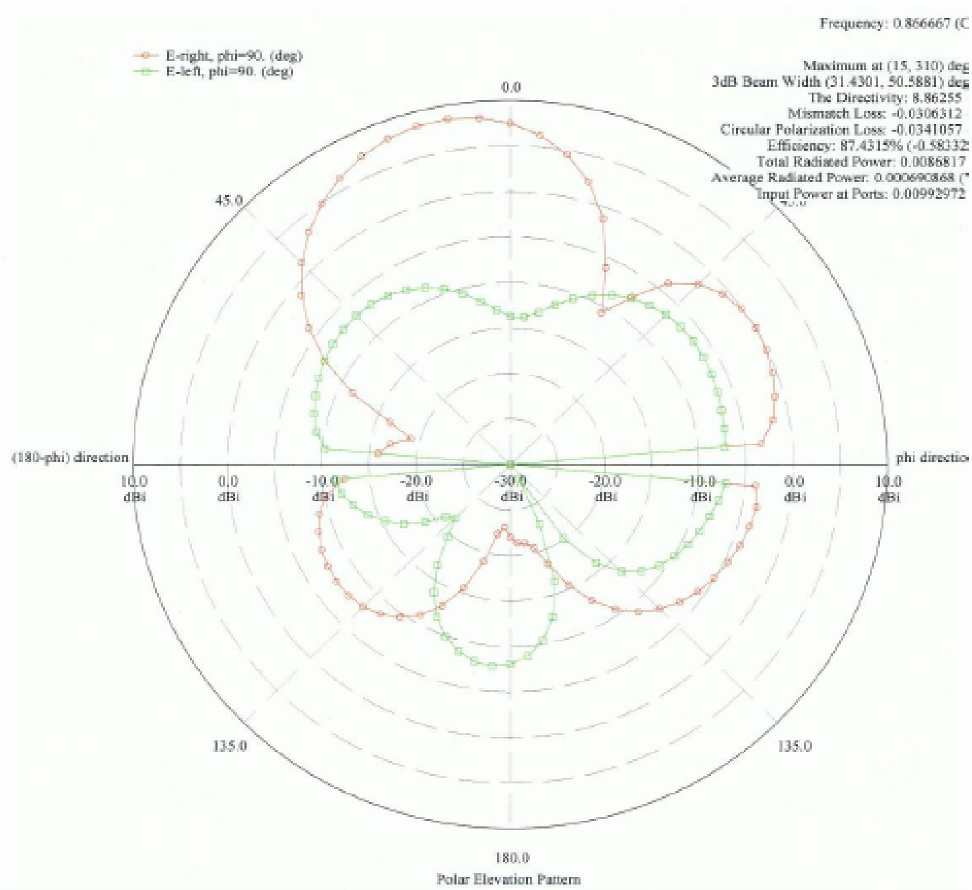
RETURN LOSS



SCANOLOGY
BARCODE AND RFID SOLUTIONS

Part number: 20707019 Low Profile CP antenna 375 x 375 mm SMA fitting

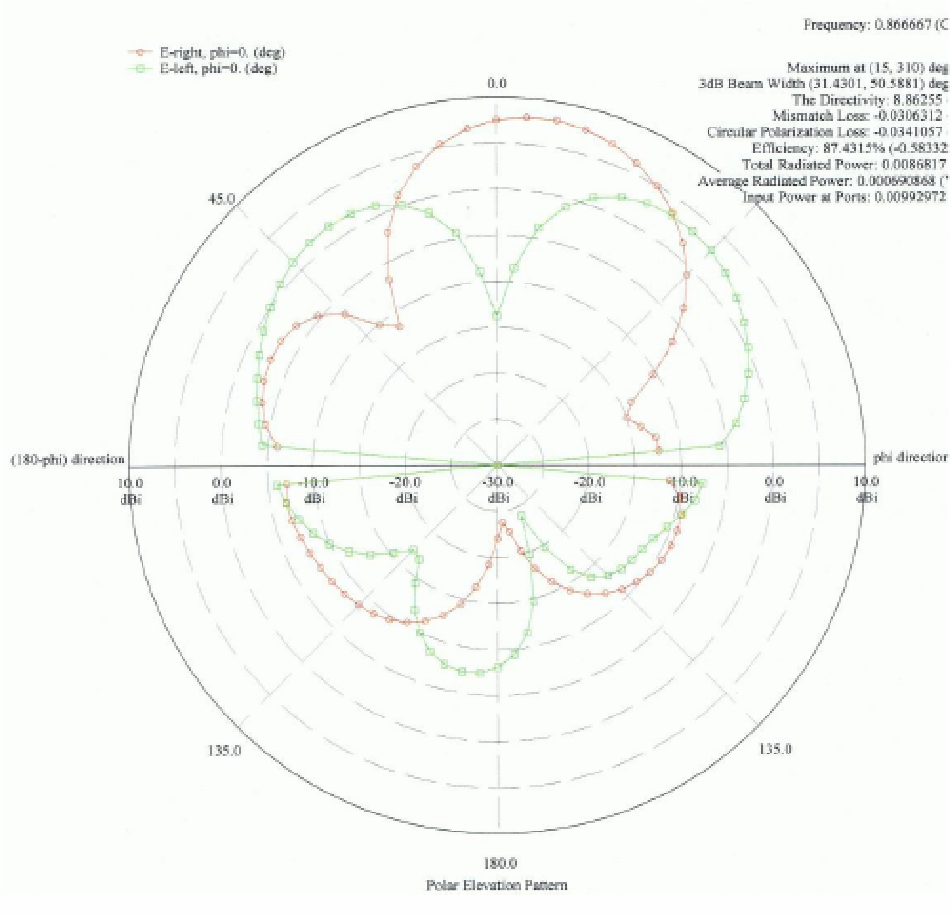
VERTICAL FIELD / CROSS POLARISATION



SCANOLOGY
BARCODE AND RFID SOLUTIONS

Part number: 20707019 Low Profile CP antenna 375 x 375 mm SMA fitting

HORIZONTAL FIELD/ CROSS POLARIZATION.



Part number: 20707019 Low Profile CP antenna 375 x 375 mm SMA fitting

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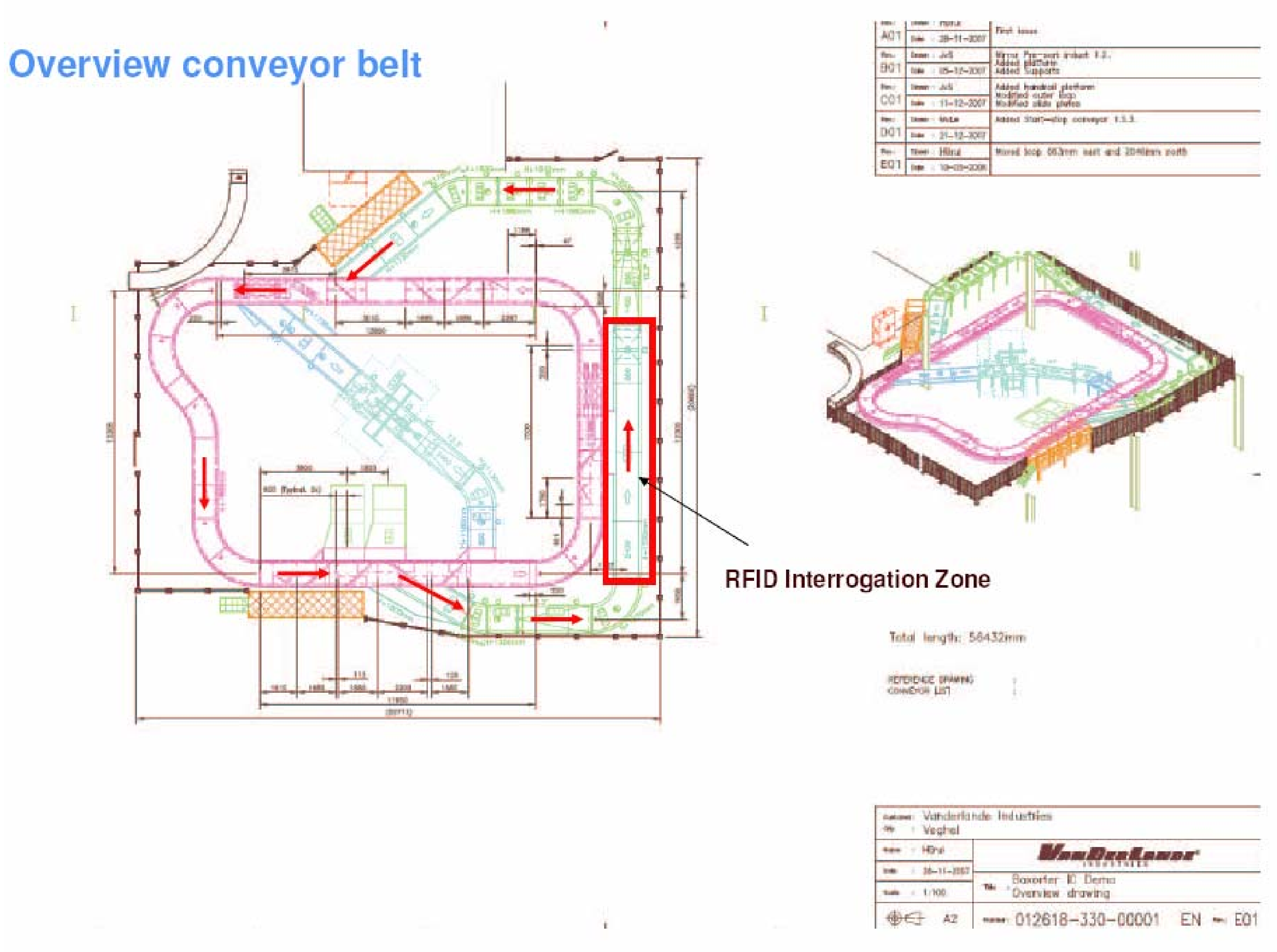
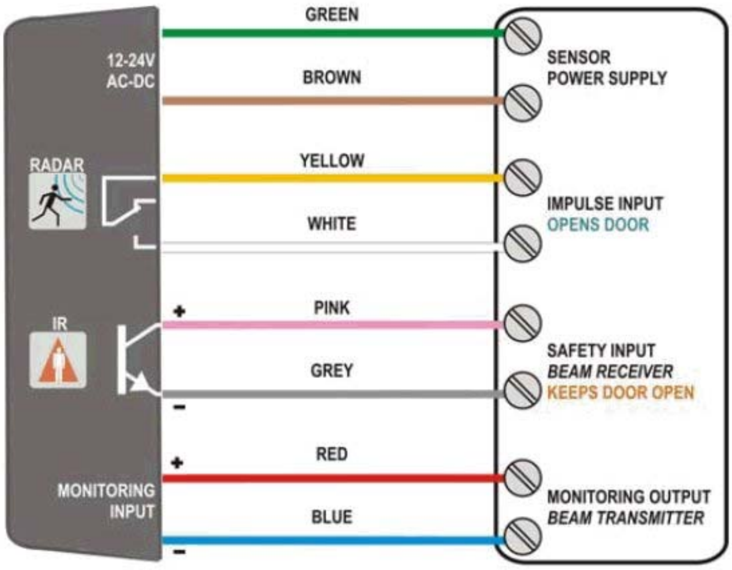
A.3 Conveyor system



A.4 Motion sensor

Details of the motion sensors fitted to the two portals are provided below.



Annex B: DVD test combinations

Stacks				
Case tagged	Case tagged	DVD tagged	DVD tagged	Mixed
Tagtype A	Tagtype B	TagType C	Tagtype D	Mixed
CA1	CB1	DC1	DD1	M1
CA2	CB2	DC2	DD2	M2
CA3	CB3	DC3	DD3	M3

Groups / Testcases

G1		G2		G3		G4		G5		G6		
CA1	CA2	CB1	CB2	DC1	DC2	DD1	DD2	M1	M2	CB1	CB2	CB3
	CA3		CB3		DC3		DD3		M3	CA1	CA2	CA3

G7			G8			G9			G10		
DC1	DC2	DC3	CA1	CA2	CA3	CB1	CB2	CB3	DC1	DC2	DC3
DD1	DD2	DD3	M1	M2	M3	M1	M2	M3	M1	M2	M3

G11			G12			G13			G14			G15	
DD1	DD2	DD3	DC1	DC2	DC3	DD1	DD2	DD3	DD1	DD2	DD3	DC1	DC2
M1	M2	M3	CA1	CA2	CA3	CB1	CB2	CB3	CA1	CA2	CA3	CB1	CB2

G16			G17			G18			G19		
DC1	DC2	DC3	DD1	DD2	DD3	DD1	DD2	DD3	DD1	DD2	DD3
CB1	CB2	CB3	CB1	CB2	CB3	DC1	DC2	DC3	DC1	DC2	DC3
CA1	CA2	CA3	CA1	CA2	CA3	CA1	CA2	CA3	CB1	CB2	CB3

G20			G21			G22			G23		
CA1	DD2	CA3	CA1	M1	CA3	CB1	CA2	DC1	CA1	DD1	CB1
CB1	DC2	DC3	DD1	M2	DC1	M1	M2	M3	DD2	M1	DD3
DC1	CB2	DD3	CB1	M3	CB3	DD2	DC2	DD1	DC3	CB3	CA2

G24			G25			G26			G27		
M1	DC1	CB1	M1	DD1	CB1	M1	CA1	DD1	M1	CB1	DD1
CA2	M2	CB2	CA2	M2	CB2	DC2	M2	DD2	DC2	M2	DD2
CA3	DC3	M3	CA3	DD3	M3	DC3	CA3	M3	DC3	CB3	M3

G28					G29				
CA1	CB1	M1	DC1	DD1	CA1	DD1	CA2	DC1	CB1
CB2	CA2	M2	DD2	DC2	DD2	M1	CB2	M2	DC2
CA3	CB3	M3	DC3	DD3	DC3	CB3	M3	CA3	DD3

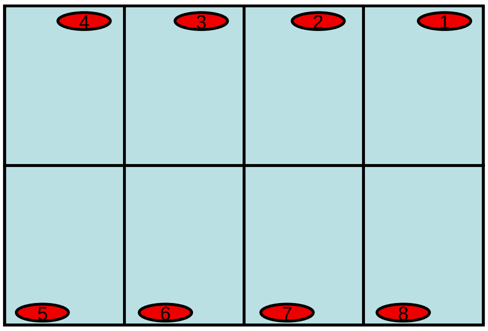
G30					G31				
CA1	M1	DC3	CA3	DD1	CA1	DD1	CA2	DC1	CB1
DC2	CB3	M2	DD2	CB2	CB3	M1	M2	M3	DC2
CB1	DD3	CA2	M3	DC1	DC3	DD2	CB2	CA3	DD3

Annex C: Pallet details

C.1 50 tag pallet

C.1.1 Homogeneous tags

Layer 1



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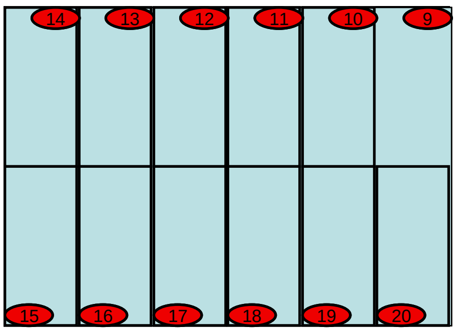

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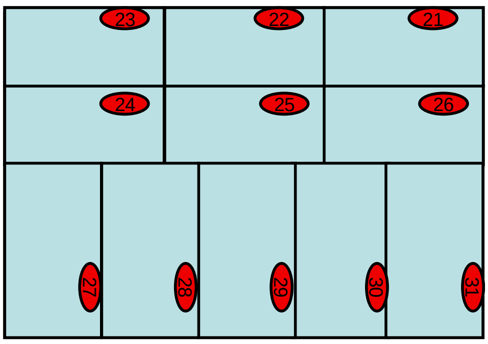

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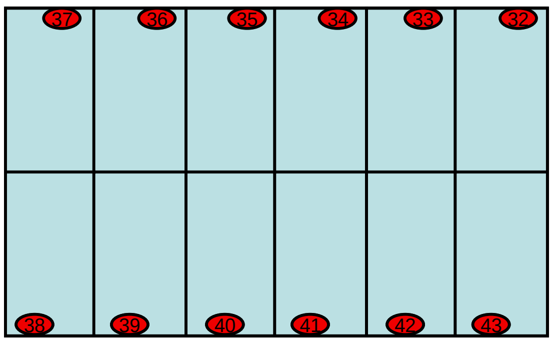

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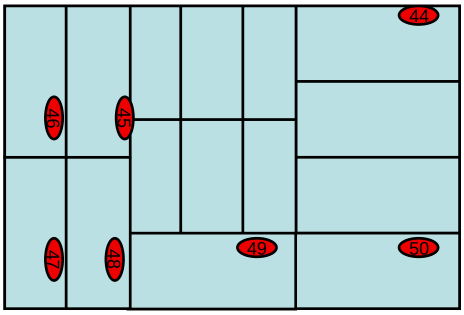

C.1.2 Mixed tags

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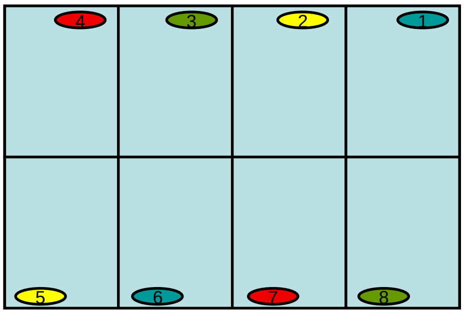

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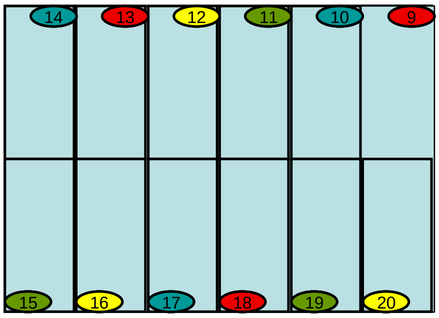

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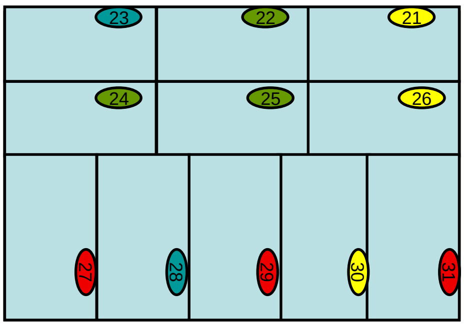

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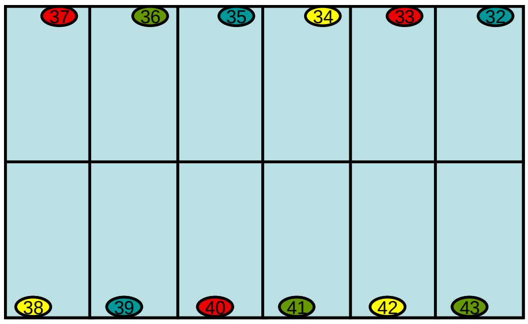
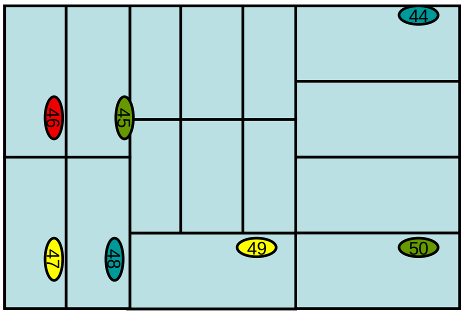


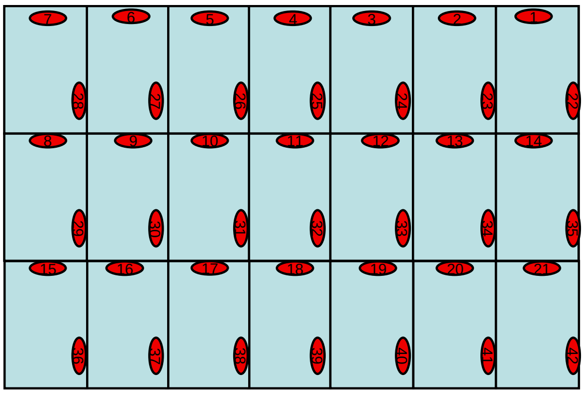
Layer 5



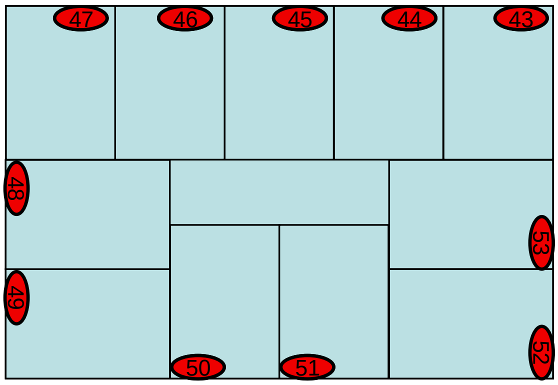
C.2 200 tag pallet

C.2.1 Homogeneous tags

Layer 1



Layer 2



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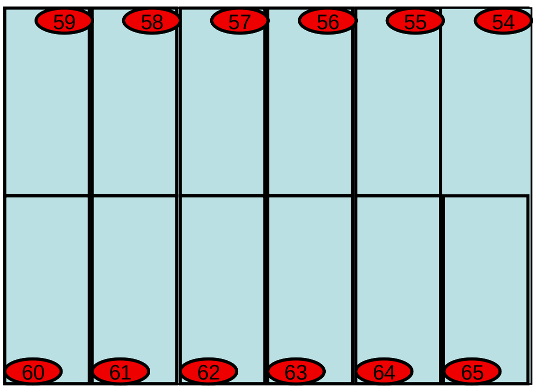

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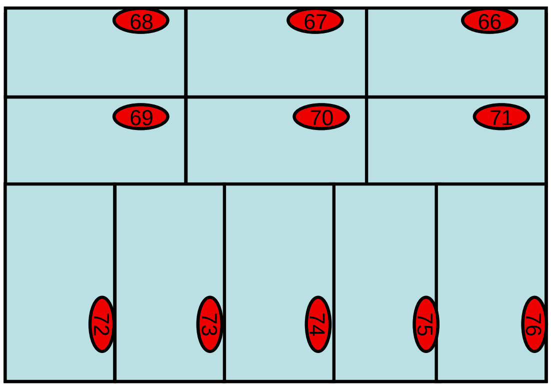

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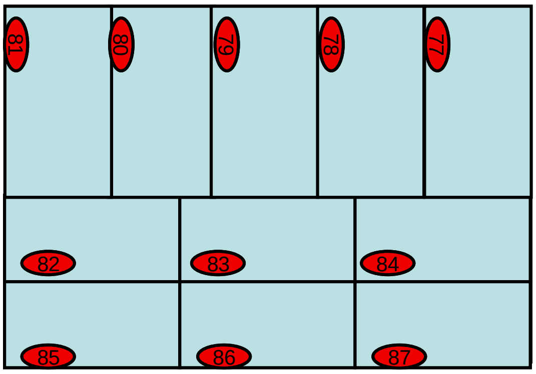

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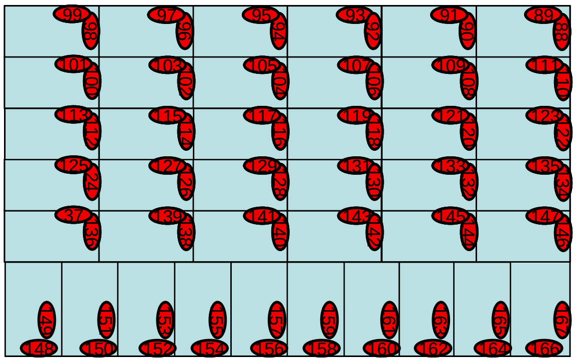

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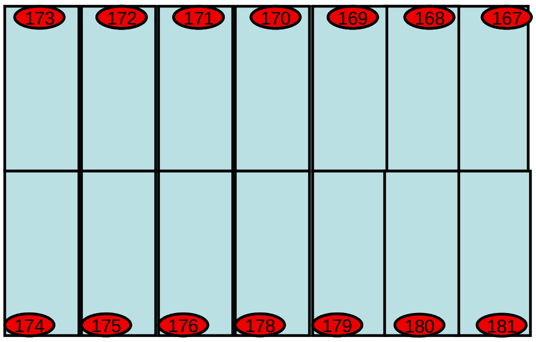

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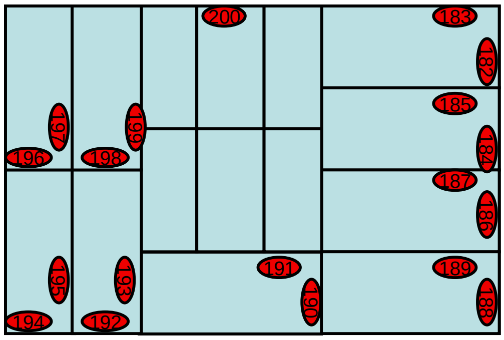

C.2.2 Mixed tags

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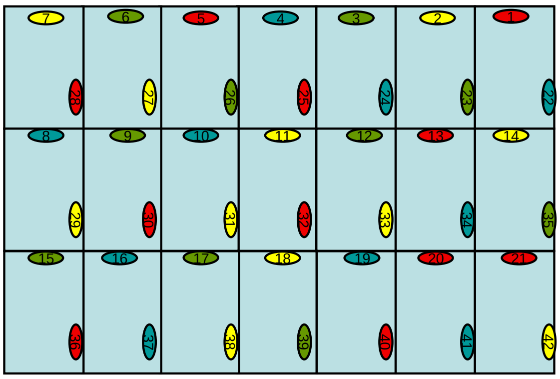

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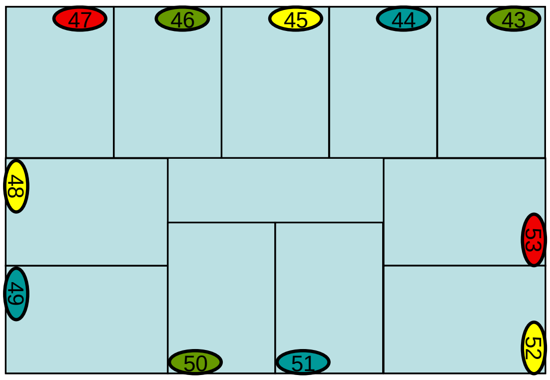

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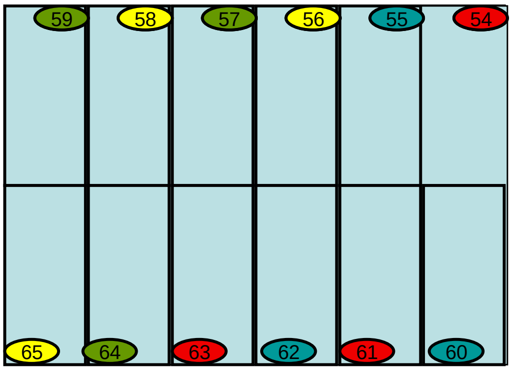

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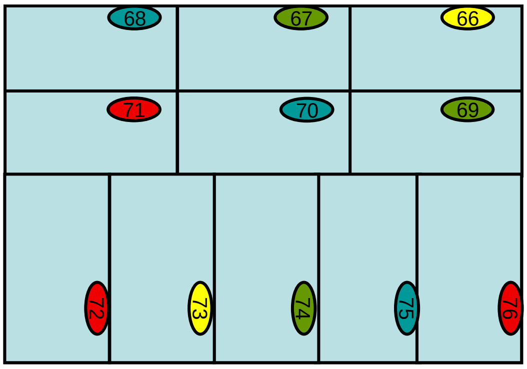

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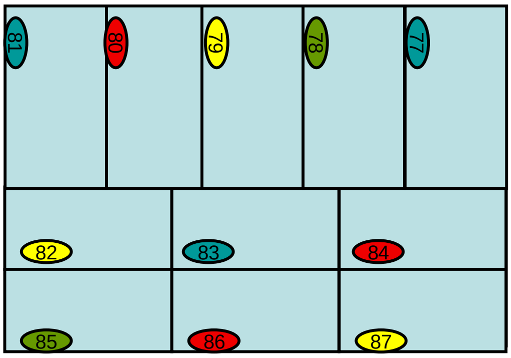

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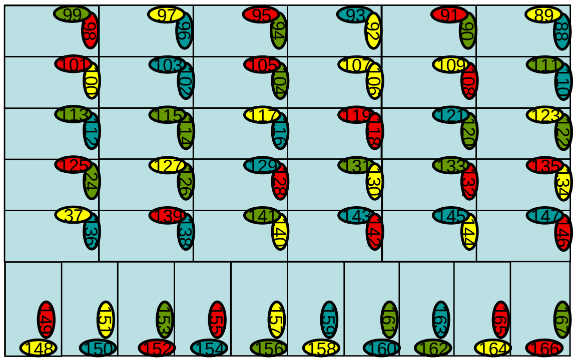
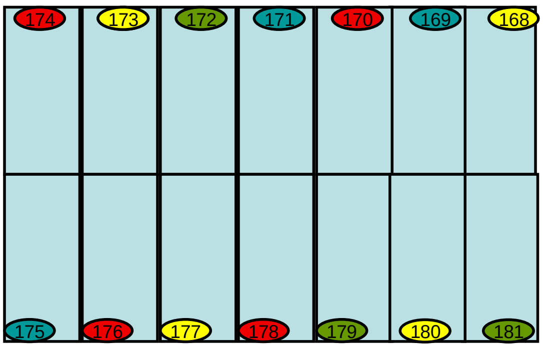


Layer 7



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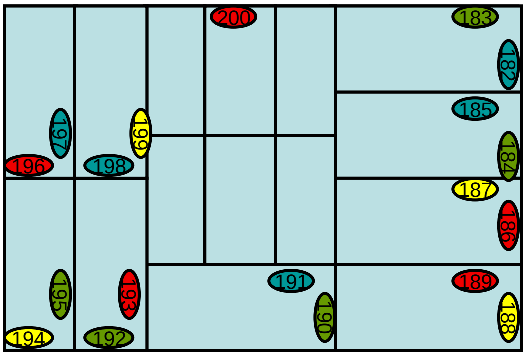

Annex D:
Session flags and "Select" command

D.1 Handling of "select" command and session flags

D.1.1 Introduction

This annex applies to tags that operate in accordance with the standard ISO 18000-6C [i.2]. The specification of the air interface protocol within the present document defines four session flags, a "selected" flag and a "select" command. The choice of the most appropriate flags for an application and correct use of the "select" command is essential if optimum reading performance is to be achieved.

Guidance is provided on selection of the most suitable session flag and handling of the Select command. The annex tries, in simple words, to explain the purpose of the different flags and the "select" command in order to gain maximum benefit from these features.

D.1.2 Session Flags

Session flags (also called inventoried flags) are used to indicate whether a tag has been read during an inventory round. This is useful in order to distinguish between tags that have already been identified and those that have still to be identified. Generally, session flags are single-bit registers within a tag that each have a certain persistence time. The persistence time is the time that a flag remains in a known state once it ceases to receive energy from an interrogator. Each flag may exist in one of two possible states known as A or B (corresponding to 0 or 1).

At the start of an inventory round the interrogator will transmit a Query command, which designates the session flag that will be used by all tags in the interrogation zone. The Query command will also specify the state of this session flag. For example if the interrogator designates session flag S0 in state A, only tags with matching conditions will reply. On being correctly read the tag will switch to state B. Similarly a tag that is correctly read in state B will switch to state A.

The characteristics of each of the four session flags in a tag are different. Session flag S0 does not have a persistence time, which means that it resets to state A on each power-on-reset of a tag. The session flag S1 has a specified persistence time of greater than 500 ms but less than 5 s and is not retriggerable. This means that the flag will always reset to state A within a period of between 500 ms and 5 s regardless of whether the tag is energized.

Session flags S2 and S3 have a minimum specified persistence time of 2 s but no maximum figure is defined. The S2 and S3 flags will not reset while the tag remains powered. When the tag ceases to be energized, flags S2 and S3 will remain in their current state for a period of at least 2 s. The flags will reset to state A some unspecified time after the 2 s persistence period has elapsed.

At the start of an inventory round an interrogator designates a session flag and specifies its state (either A or B). Both parameters are contained within the Query command. A tag compares the information in the Query command with the state of its designated session flag and thus knows whether to participate in the inventory round. For example an interrogator that defines an inventory round using session flag S3 in state B would only interrogate tags with their session flags S3 in state B.

D.1.3 Selected Flag

Tags possess a fifth flag called the "selected" flag. The physical characteristics of the "selected" flag are the same as those for session flags S2 and S3. (i.e. a persistence time of greater than 2 s). The state of the "selected" flag may only be altered by the "select" command. An interrogator may specify three possible conditions for the "selected" flag as part of the Query command. These are either 0 (~SL) or 1 (SL) or "don't care" (All). On decoding a Query command, a tag will determine whether the condition of the "select" command matches the state of its "selected" flag. If the values differ the tag will not participate in the inventory round.

In many situations matching conditions are necessary for both the designated session flag and the "selected" flag in order for a tag to respond. The ways in which both types of flag are used in an application are examined in more detail in clause D.1.4.

D.1.4 Select Command

The "select" command precedes the Query command and prepares a population of tags in an interrogation zone for the subsequent inventory round. It may be used to change the state of the session flags and/or the "selected" flag.

In addition the "select" command allows tags to be selected based on the content of part of the data in their memory. This is done by specifying the location of a mask in the tag's memory, the data content of the mask, and the number of bits to be compared. This feature makes it possible to read only certain categories of tag within a mixed population such as, for example, cartons containing a particular product on a pallet that is carrying a range of different items. Where this function is not required for an inventory round, the value of the data content to be compared should be set to zero.

By means of multiple "select" commands it is possible to toggle the state of the flags in order to perform sophisticated selection procedures. The names of two of these selection procedures are "union" and "intersection". The union procedure allows an interrogator to identify two or more categories of tag in a single inventory round. For the selection of just two categories, the first "select" command would define the conditions to identify the first category, and the second "select" command would repeat the process for the other one.

The intersection procedure allows an interrogator to read only those tags that satisfy a multiple set of conditions. For example it may be necessary to read only airline tags with a defined E.P.C. code length. To set up the necessary conditions, the first "select" command would specify that only airline tags would be read while the second "select" command would define the required number of data bits.

Three examples should clarify how the "select" command might be used:

- A "select" command may ask all tags in the interrogation zone to set their session flag S2 to state A.
- A "select" command may ask all tags in the interrogation zone to set their "selected" flag to 1.
- A "select" command may ask those tags with an EPC length of 96 bits (comparison of the Protocol Control bits) to set their "selected" flag to 1 while the remaining tags should set their "selected" flag to 0.

Since the "select" command only changes the state of a tag flag, it does not by itself determine which subset of tags participates in an inventory round. As explained in clauses C.1.1 and C.1.2, the Query command specifies which tags should participate in an inventory round based on the values of their designated session flag and "selected" flag.

D.1.5 Use of flags and select commands

The choice of the most appropriate session flag and use of the "select" command is very dependent on the nature of each individual application. It is not possible therefore to list a full range of applications and recommend the most suitable session flags for each of them. Instead installers should be prepared to experiment with different settings in order to determine the optimum configuration for the application. A good understanding of the operation of the flags will greatly assist in this process.

Two examples of how flags might be used are provided below:

1) **Selection of a subset of tags:** This is useful in applications where a particular category of tags is of interest. For example for the handling of airline baggage, it may be desirable to read only the airline baggage labels and ignore all other categories. Similarly in logistics applications users may wish to read only tags on cartons and not read tags on individual items. Selection by categories may be particularly beneficial in situations where the number of wanted tags is relatively low, while the population of unwanted tags is large.

2) **Separation between read and unread tags:** In many applications users wish to read all of the tags present in an interrogation zone. To maximize reading efficiency, flags may be used to avoid repeatedly reading tags that have already been identified. This allows the interrogator to focus on tags that have still to be read.

In addition to these two examples the "select" command and flags provide considerable flexibility in setting up systems. However, care must be exercised when using the "select" command and flags otherwise system performance may be degraded. The most important considerations are listed below.

Since there is no acknowledgement of a "select" command, an interrogator cannot know if it was received by all tags in the interrogation zone. To minimize this problem, "select" commands should always be repeated at regular intervals in order to increase their probability of being received by all tags.

NOTE: There are various reasons why a tag may not correctly receive a "select" command. For example some tags may arrive in the interrogation zone later than others. Also some tags may be subject to standing wave nulls, noise, etc.

When interrogating large or fast moving tag populations it may be beneficial to avoid use of the "select" command. This is because the time taken to transmit the "select" command reduces the time available to read the tags. Additionally some tags may not receive the "select" command. In these circumstances it may be advantageous to use the session flag S0.

In certain types of application tags may experience several interruptions in received power, which might be caused, for example, by field nulls or by antenna switching. A likely situation where this may occur is when reading large populations of tags. Depending on the length of the interruptions, a tag may experience a number of power-on-resets, which on each occasion will reset its session flag S0 to state A. Thus if the session flag S0 is used, tags may be identified more often than intended. In the worst case an interrogator may fail completely to identify some tags because it is repeatedly identifying others. In such applications either session flag S1 or S2 or S3 should be used.

Unless a tag has been de-energized for at least 5 s the state of its session flag S1, is generally unknown. Provided sufficient time is available to meet the needs of the application, the use of the "select" command to put the session flag S1 into a defined state is recommended.

Where a limited number of tags move rapidly through an interrogation zone or where multiple interrogation zones are close together, it is preferable to use session flag S0 instead of session flag S1. This is because in such applications not all tags will successfully receive the "select" command.

Some applications require an interrogator to perform multiple inventory rounds in order to achieve best reading performance. The process might begin by an interrogator requesting that tags with their designated session flag in state A should respond. In the subsequent inventory round the interrogator would request that tags with their designated session flag in state B should reply. This process might continue from A to B and B to A until the interrogation is complete. This technique minimizes the number of times that a tag is repeatedly read. It also means that each time the state of the session flag is switched, the same tags will be identified again.

No upper limit is specified for the persistence time of session flags S2 and S3. It is therefore unwise to assume their state has changed to A after a certain period without being energized. Measurements have shown a great variation in these persistence times from around 5 s to 70 s for different tag types. In applications where there is insufficient time to put session flags S2 and S3 into a known state with the "select" command, the use of either session flag S0 or S1 is recommended.

Unless the "selected" flag is used to identify a certain category of tags, the interrogator should always choose the "All" option in the Query command. This ensures that all tags participate in an inventory round regardless of the state of their "selected" flags.

Session flags S2 and S3 are useful in situations where two reading stations are very close together or where two interrogators wish to identify the same population of tags in a common interrogation zone. One of the interrogators will designate session flag S2 for its use, while the other will use S3. This arrangement allows both interrogators to address the same tags without causing confusion. The only requirement is that the two interrogators may not perform their inventory rounds at the same time.

Annex E:
Photographs of tests

E.1 Pictures of RFID Plugtests

Figure E.1: Reading hanging garments on a rack

Figure E.2: Reading stack of garments on a shelf

Figure E.3: Basic DVD tests

Figure E.4: Advanced DVD tests

Figure E.5: Pallet tests at a dock door

Figure E.6: Pallet tests using rail track system

Figure E.7: Airline bags with tags

Figure E.8: Conveyor system with side antennas

Figure E.9: Conveyor system with slimline antenna

History

Document history		
V1.1.1	December 2008	Publication