
**Information technology — Radio
frequency identification for item
management — Implementation
guidelines —**

**Part 3:
Implementation and operation of UHF
RFID Interrogator systems in logistics
applications**

*Technologies de l'information — Identification par radiofréquence pour
la gestion d'objets — Lignes directrices de mise en application —*

*Partie 3: Mise en application et fonctionnement des systèmes
d'interrogation UHF RFID dans les applications logistiques*



PDF disclaimer

This PDF file may contain embedded typefaces. In accordance with Adobe's licensing policy, this file may be printed or viewed but shall not be edited unless the typefaces which are embedded are licensed to and installed on the computer performing the editing. In downloading this file, parties accept therein the responsibility of not infringing Adobe's licensing policy. The ISO Central Secretariat accepts no liability in this area.

Adobe is a trademark of Adobe Systems Incorporated.

Details of the software products used to create this PDF file can be found in the General Info relative to the file; the PDF-creation parameters were optimized for printing. Every care has been taken to ensure that the file is suitable for use by ISO member bodies. In the unlikely event that a problem relating to it is found, please inform the Central Secretariat at the address given below.



COPYRIGHT PROTECTED DOCUMENT

© ISO/IEC 2009

All rights reserved. Unless otherwise specified, no part of this publication may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying and microfilm, without permission in writing from either ISO at the address below or ISO's member body in the country of the requester.

ISO copyright office
Case postale 56 • CH-1211 Geneva 20
Tel. + 41 22 749 01 11
Fax + 41 22 749 09 47
E-mail copyright@iso.org
Web www.iso.org

Published in Switzerland

Contents

Page

Foreword	iv
1 Scope	1
2 Normative references	1
3 Terms and definitions	1
4 Application requirements	2
4.1 General	2
4.2 General RF emissions general population	2
4.3 RF emissions and susceptibility in health care setting	2
5 Basic RFID system principles and operation	2
5.1 Characteristics of RFID at UHF Frequencies (860-960 MHz).....	3
5.2 Regulatory Considerations.....	8
6 Site and operating environment considerations.....	10
6.1 Site survey.....	10
6.2 Radio Frequency Interference.....	11
6.3 Water and Dust	15
6.4 Shock and Vibration	18
6.5 Drop Specification	18
6.6 Temperature	18
6.7 Connectors and Cabling	19
6.8 Grounding	19
7 Fixed RFID Reading Devices	19
7.1 Dock Door Portals	19
7.2 Open conveyor read points	22
8 Mobile RFID Reading Devices	26
8.1 Hand Held RFID Readers	26
8.2 Forklift/Vehicle Mounted RFID Readers	27
8.3 As a source of Interference	29
8.4 As a subject of Interference	29
9 Implementation	29
9.1 Basic System Approach	30
9.2 Antenna selection and configuration	31
9.3 Antenna Positioning.....	32
9.4 Outside Antennas	32
9.5 Shielding.....	32
9.6 Commissioning the System	33
9.7 Site Records	34
10 Tuning and Maintenance	34
10.1 Dust and Contaminates	35
10.2 Antenna Fixtures	35
Bibliography.....	36

Foreword

ISO (the International Organization for Standardization) and IEC (the International Electrotechnical Commission) form the specialized system for worldwide standardization. National bodies that are members of ISO or IEC participate in the development of International Standards through technical committees established by the respective organization to deal with particular fields of technical activity. ISO and IEC technical committees collaborate in fields of mutual interest. Other international organizations, governmental and non-governmental, in liaison with ISO and IEC, also take part in the work. In the field of information technology, ISO and IEC have established a joint technical committee, ISO/IEC JTC 1.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of the joint technical committee is to prepare International Standards. Draft International Standards adopted by the joint technical committee are circulated to national bodies for voting. Publication as an International Standard requires approval by at least 75 % of the national bodies casting a vote.

In exceptional circumstances, the joint technical committee may propose the publication of a Technical Report of one of the following types:

- type 1, when the required support cannot be obtained for the publication of an International Standard, despite repeated efforts;
- type 2, when the subject is still under technical development or where for any other reason there is the future but not immediate possibility of an agreement on an International Standard;
- type 3, when the joint technical committee has collected data of a different kind from that which is normally published as an International Standard ("state of the art", for example).

Technical Reports of types 1 and 2 are subject to review within three years of publication, to decide whether they can be transformed into International Standards. Technical Reports of type 3 do not necessarily have to be reviewed until the data they provide are considered to be no longer valid or useful.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO and IEC shall not be held responsible for identifying any or all such patent rights.

ISO/IEC TR 24729-3, which is a Technical Report of type 3, was prepared by Joint Technical Committee ISO/IEC JTC 1, *Information technology*, Subcommittee SC 31, *Automatic identification and data capture techniques*.

ISO/IEC TR 24729 consists of the following parts, under the general title *Information technology — Radio frequency identification for item management — Implementation guidelines*:

- *Part 1: RFID-enabled labels and packaging supporting ISO/IEC 18000-6C*
- *Part 2: Recycling and RFID tags*
- *Part 3: Implementation and operation of UHF RFID Interrogator systems in logistics applications*
- *Part 4: Tag data security*

Information technology — Radio frequency identification for item management — Implementation guidelines —

Part 3: Implementation and operation of UHF RFID Interrogator systems in logistics applications

1 Scope

This part of ISO/IEC TR 24729 provides reference information and practical knowledge in the selection, installation and application of ISO/IEC 18000-6C RFID Readers. RFID Readers include fixed mounted (such as portal, conveyor, and wrap stations), handheld (tethered and wireless), and mobile mounted (such as those found on forklifts). This part of ISO/IEC TR 24729 presents guidelines to improve the performance of RFID data collection systems for more successful applications and to cover the approaches necessary to ensure that the operational requirements of the end user are met. Many of the techniques recommended are the result of practical tests in working environments. However, each application is different and thus the techniques recommended herein might not be applicable in all situations.

2 Normative references

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

ISO/IEC 19762-1, *Information technology — Automatic identification and data capture (AIDC) techniques — Harmonized vocabulary — Part 1: General terms relating to AIDC*

ISO/IEC 19762-3, *Information technology — Automatic identification and data capture (AIDC) techniques — Harmonized vocabulary — Part 3: Radio frequency identification (RFID)*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO/IEC 19762-1 and ISO/IEC 19762-3 apply.

4 Application requirements

4.1 General

The measure of success for any data collection system will be based on the degree to which it meets or exceeds the particular application requirements. A clear understanding of these is necessary even prior to the planning of the implementation. This can have direct impact on the cost and duration of implementation, the cost of ongoing maintenance and thus the very economic viability of the project. What are the business objectives for the implementation? Will the system be presented with one or multiple tags for data collection at instances for reading? What percentage of reading tags in the interrogation zone is required? Will business process changes be implemented concurrently? Examples such as these should be set out with metrics for measurement and acceptance levels established.

Understanding these metrics will influence the selection and implementation of an RFID interrogator.

At an early stage in the project it is important to establish a set of tests that will demonstrate performance of the installed system in accordance with the agreed requirements.

4.2 General RF emissions general population

Device manufacturers claiming conformance to this standard shall self-certify that RF emissions do not exceed the maximum permitted exposure limits recommended by either IEEE C95.1:2005 or ICNIRP according to IEC 62369-1. If a device manufacturer is unsure as to which recommendation to be cited for compliance the manufacturer shall self-certify to ICNIRP limits.

4.3 RF emissions and susceptibility in health care setting

Device manufacturers claiming conformance to this standard shall self-certify that RF emissions and susceptibility comply with IEC 60601-1-2.

5 Basic RFID system principles and operation

A basic RFID system consists of an interrogator (reader/writer) with its associated antennas and one or more tags. The antennas are arranged to transmit their signal within an interrogation zone. Tags are attached to objects that are to be identified. When a tag enters an interrogation zone, it is activated by the transmitted signal from the interrogator. Typically the tag will respond by sending its identity and possibly some associated data. The identity and data from the tag is validated by the receiver in the interrogator and passed to its host system. A block diagram of a basic RFID system is shown in Figure 1.

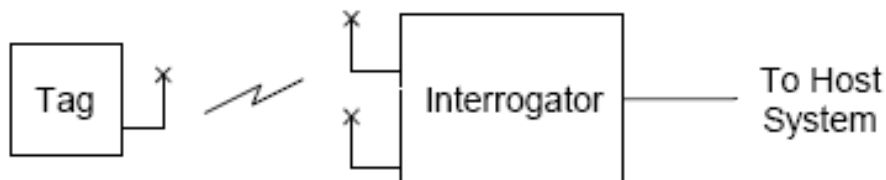


Figure 1 — Basic RFID system

The ISO/IEC 18000-6C protocol is used to handle the transfer of data between the interrogator and tags. This ensures the integrity of data transfer. In addition the protocol handles the process for writing data to the tag and controls the procedure for reading multiple tags that may be present simultaneously within the same interrogation zone.

Tags exist in a range of shapes and sizes to satisfy the particular needs of their intended application. Many tags are passive and derive the power for their operation from the field generated by the interrogator. However some tags may be fitted with batteries, which may enable them to operate at significantly greater ranges.

5.1 Characteristics of RFID at UHF Frequencies (860-960 MHz)

The performance of RFID systems, particularly those operating at UHF frequencies (860-960 MHz), is strongly influenced by their environment and usage. The materials and area surrounding the RFID readers have a great impact on the success of the system. Controlling configurations such as location, read cycle duration, etc. will also impact performance. Likewise, the materials surrounding the RFID tag and its placement are key factors in the success of a robust system implementation. Users are referred to ISO/IEC TR 24729-1 for guidelines on selecting placement of RFID enabled labels and optimising the readability.

UHF transmission, between 300 MHz and 3 GHz, takes place by means of electromagnetic waves. At these frequencies electromagnetic waves have properties that have many similarities to light. Transmissions travel in a straight line and the power of the received signal is a function of the inverse square of the distance from its source. For example if the distance from a transmit antenna is doubled the received power drops to one quarter. This property means that it is possible with UHF systems to achieve significant reading ranges. Operation in the UHF band also makes it possible to transfer information at high data rates. Both of these characteristics make UHF systems well suited for use in applications where tags are moving at speed or in which there are multiple tags present in an interrogation zone.

However UHF can present the installer with a number of challenges. RF energy at UHF is reflected by many metals and absorbed by many liquids. Transmissions at UHF are readily reflected from many surfaces such as floors, walls, ceilings and fixtures. These can cause the unwanted activation of tags and can also give rise to an effect known as standing wave nulls. This can produce points within the interrogation zone where there are very low levels of signal. UHF signals also experience significant levels of attenuation in the presence of water. In applications where water may be present, system integrators must therefore make suitable provision for a reduction in reading range during the design and configuration of the installation. A successful system design will account for many of these factors before installation of any equipment occurs. After installation a thorough analysis and tune up along with proper maintenance is required.

RFID systems typically implement far-field propagative electro-magnetic coupling techniques. Inductive and capacitive near-field coupling techniques are also implemented for item level tagging. This document focuses on far-field electromagnetic coupling considerations of UHF systems.

5.1.1 Antennas and Antenna Radiation Patterns

All antennas radiate RF power in asymmetrical patterns. Understanding the radiation pattern of the antennas to be used in your system is an important consideration for good system design. Patterns are usually represented as polar plots in a horizontal and a vertical plane with the relative power in decibels (dBs) expressed in the rings. In some instances the antenna radiation and gain properties must be expressed in dBi (using an isotropic antenna reference) and dBd (using a $\frac{1}{2}$ -wave dipole antenna reference) for proper evaluation. An example of an antenna radiation pattern is shown in Figure 2.

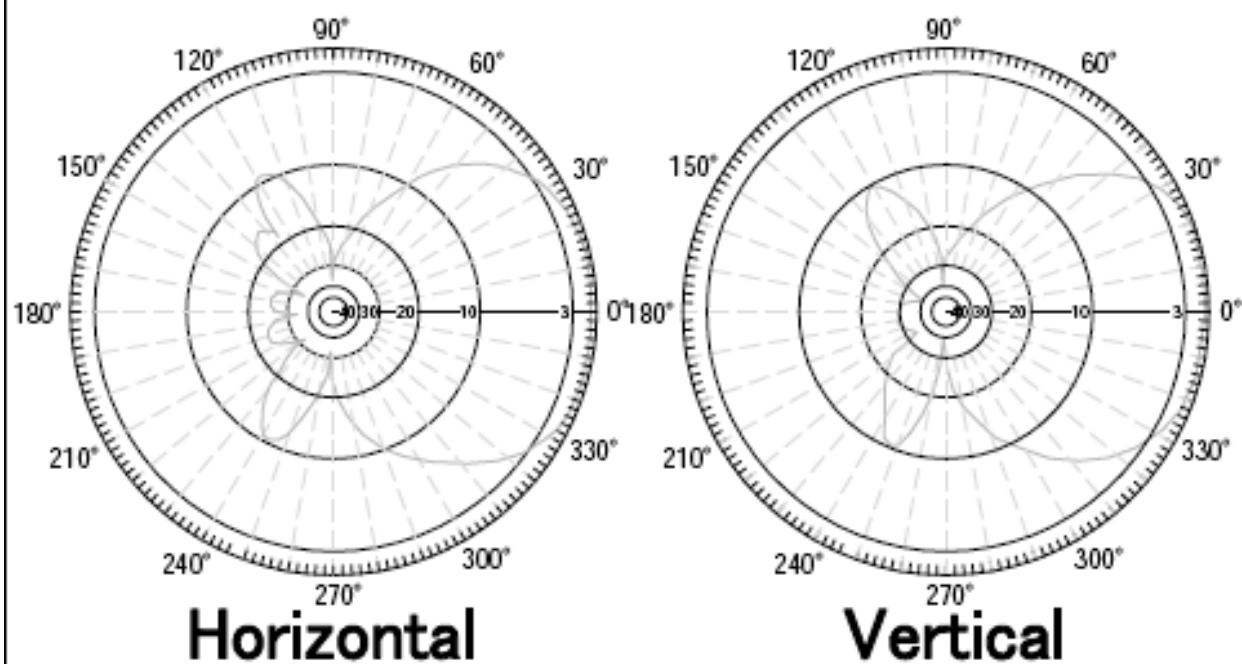


Figure 2 — Sample antenna plots

The antenna shown in these plots has some gain in a main front lobe with two side lobes at 10 dB lower power and a back lobe at 30 dB lower power. Use these antenna plots to understand the “width” of the antenna power and the side lobes direction and relative power level. The angle subtended between the half power (or 3 dB) points of the main front lobe is known as the beam width. Often beam width is expressed as both a horizontal and vertical value, which need not necessarily be the same. In many installations the long reading ranges possible at UHF mean that tags outside the desired interrogation zone are inadvertently activated. The relationship between variable reading ranges and the desired interrogation zone is shown in Figure 3. The desired interrogation zone (best zone) is different depending on the individual application, especially in practical operational space. For example, in wide warehouse spaces, long reading range will be required to read the tags of large pallets. On the other hand, in narrow spaces such as a parts centre, the short reading range is desired for reading tags of small size packages to avoid the inadvertently reading the tags of the adjacent zone.

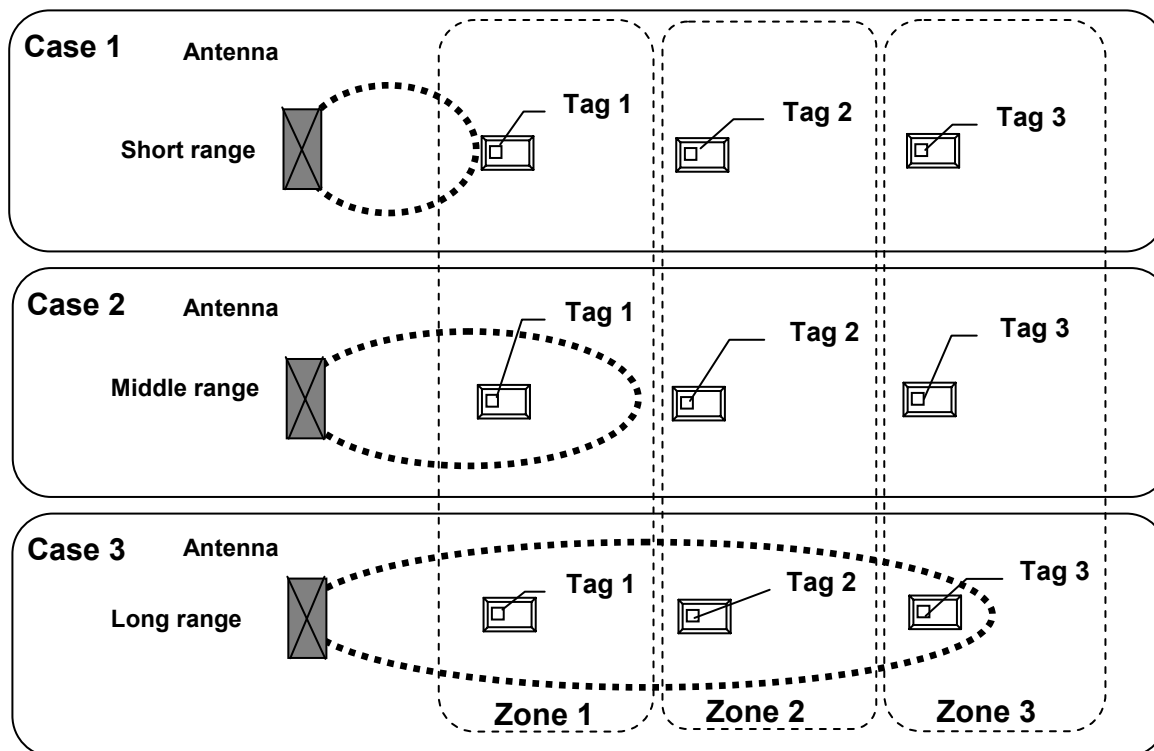
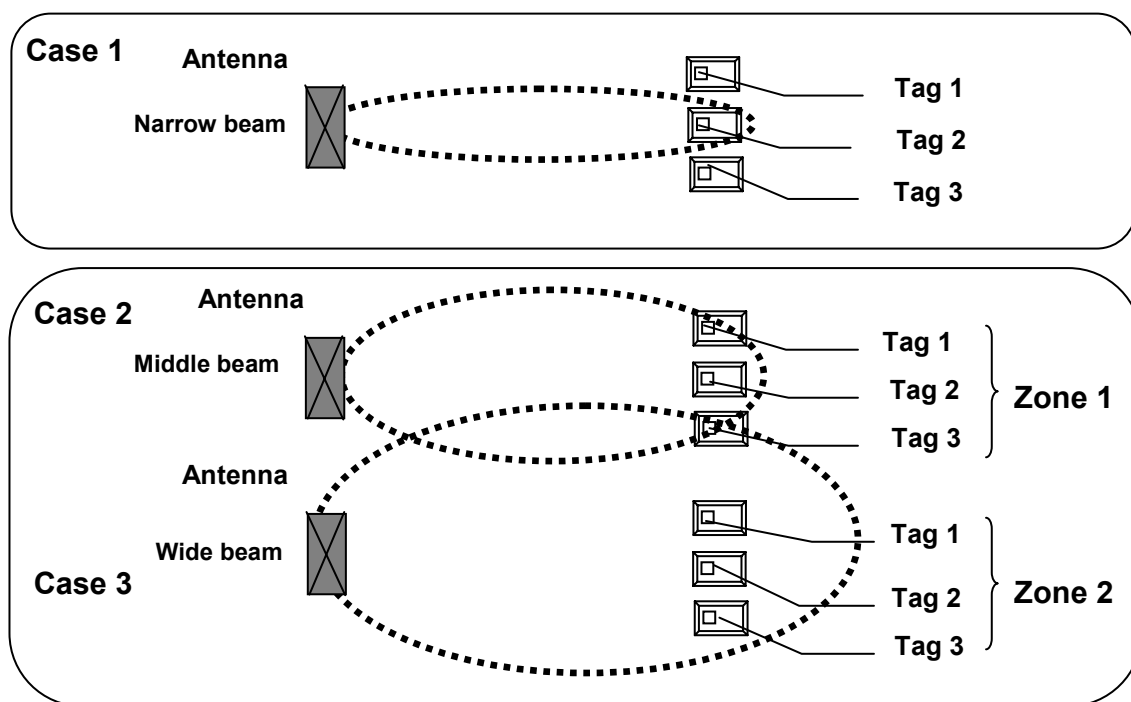


Figure 3 — Relationship between variable reading ranges and the desired interrogation zone

The use of antennas with a narrow beam width provides one means by which it is possible to limit the area of the interrogation zone.

The most common type of antenna used at UHF is the patch antenna. This typically has a beam width of 70 degrees. The patch antenna is fully satisfactory for many short to medium range applications where there are no other interrogators and unwanted tags in the immediate vicinity. In applications where longer reading ranges are required it may be necessary to control the extent of the interrogation zone more precisely. A first order of improvement may be achieved by using a version of the standard patch antenna that is physically larger. This makes it possible to produce antennas with a horizontal beam width down to 30 degrees. Other types of antenna exist with narrower beam widths. One of these is the helical antenna, which can have a beam width of as little as 10 degrees. This narrow beam width makes it possible to generate an interrogation zone that is very directional. The relationship between variable beam width and the wanted interrogation zone is shown in Figure 4.

As the beam width of an antenna is reduced the transmitted power is compressed into a smaller volume, which produces increased field intensity. This effect is quantified by the term "antenna gain". Since the radio regulations limit the maximum field level that is permitted, it is necessary to reduce the level of power generated by the interrogator to compensate for the increased gain of the antenna. Where the use of different antennas is allowed by the product specifications, adjustment methods should be included within the interrogator product manual.



NOTE

In case 1, Tag 2 is read

In case 2, Tags 1, 2 and 3 in Zone 1 are read

In case 3, Tags 1, 2 and 3 in Zone 2 are read plus Tag 3 in Zone 1

Figure 4 — Relationship between variable beam width and the wanted interrogation zone

Generally transmissions from the antenna of the interrogator will be circularly polarized. This eliminates differences in the reading range of tags caused by their orientation in the x and y planes (but not the z plane, which is the direction of travel of the radio wave). Users are again referred to ISO/IEC TR 24729-1 for guidelines on selecting placement of RFID enabled labels and optimising the readability.

Where the orientation of the tag is known it is possible to use a linear antenna, which will provide an increase of about 40% in the maximum achievable reading range. The reason for this is that with a linear antenna, the tag will continuously be in its optimum orientation. For a circularly polarized transmission the tag will experience optimum orientation for only some of the time because the transmit field is rotating. In the later case less power is transferred to the tag, which therefore operates at less range. This reduced range is caused by the fact that when a circularly polarized wave impinges on a linear antenna, only the component of the wave along the antenna axis has any effect. Thus a circularly polarized wave will interact with a linear antenna tilted at any angle with the plane perpendicular to the axis of propagation, but in every case only have the transmitted power can be received.

5.1.2 Protocol Influences

The ISO/IEC 18000-6C RFID air interface protocol enables advanced RFID implementations such as Dense Reader Mode and Session Control that allow multiple readers in close proximity to function with higher reliability. A thorough understanding of these features is required for systems designed with a large number of readers. It is typically recommended to work with an equipment supplier to understand which of these features are supported and how to configure them.

5.1.3 Detuning and Absorption

The proximity of certain materials to UHF tags may cause a significant reduction in their reading range. This effect is due predominantly to de-tuning of the resonant frequency of the tag. Spacing the tag a small distance away from the material can significantly reduce this effect. However, the application may impose a restriction on the extent to which spacing is acceptable. Alternatively, where the material to be tagged is known in advance, it may be possible to adjust the tuning of the tag to compensate. Nevertheless, recovery of the full free space reading range is unlikely to be achievable. This difference is due to power absorption by the material.

In situations where an electromagnetic wave meets a boundary between two dissimilar materials, some of the energy is reflected at the surface and some of the energy passes into the material. The proportion of the energy that passes into the material is a function of its physical properties (known as its dielectric constant). This process is repeated at each boundary between two dissimilar materials.

Where a tag is read through an object, the consequent reduction in the level of signal reaching the tag will reduce its reading range. Some indication of the scale of reduction in reading range caused by different materials is given in Table 1. The figures in the table are based on some informal tests and are illustrative only.

Table 1 — Typical effect of materials on performance

Scenario	Reference	Range – cm	(R/Ref) ²	Loss dB
	Distance - cm			
Air	200	200	1,00	0,00
Tag on front of plastic case	200	180	1,23	0,92
Tag on front of plywood sheet	200	131	2,33	3,69
Tag on front of wood block 2.5 cm deep	200	120	2,78	4,44
Tag on front of paper 3 cm thick	200	108	3,43	5,35
Tag on front of empty plastic jug	200	149	1,80	2,56
Tag on rear of empty plastic jug	200	138	2,10	3,22
Tag on front of plastic jug filled with tap water	200	46	18,90	12,77
Tag on rear of plastic jug filled with tap water	200	31	41,62	16,19
Tag behind metal mesh 10 cm × 10 cm	200	28	51,02	17,08
Tag behind metal mesh 1 mm × 1 mm	200	10	400,00	26,02
NOTE: For the purpose of making these measurements the transmit level from the interrogator was set to a constant value.				

Similar effects are evident in tests conducted with real food products as illustrated in Figure 5.

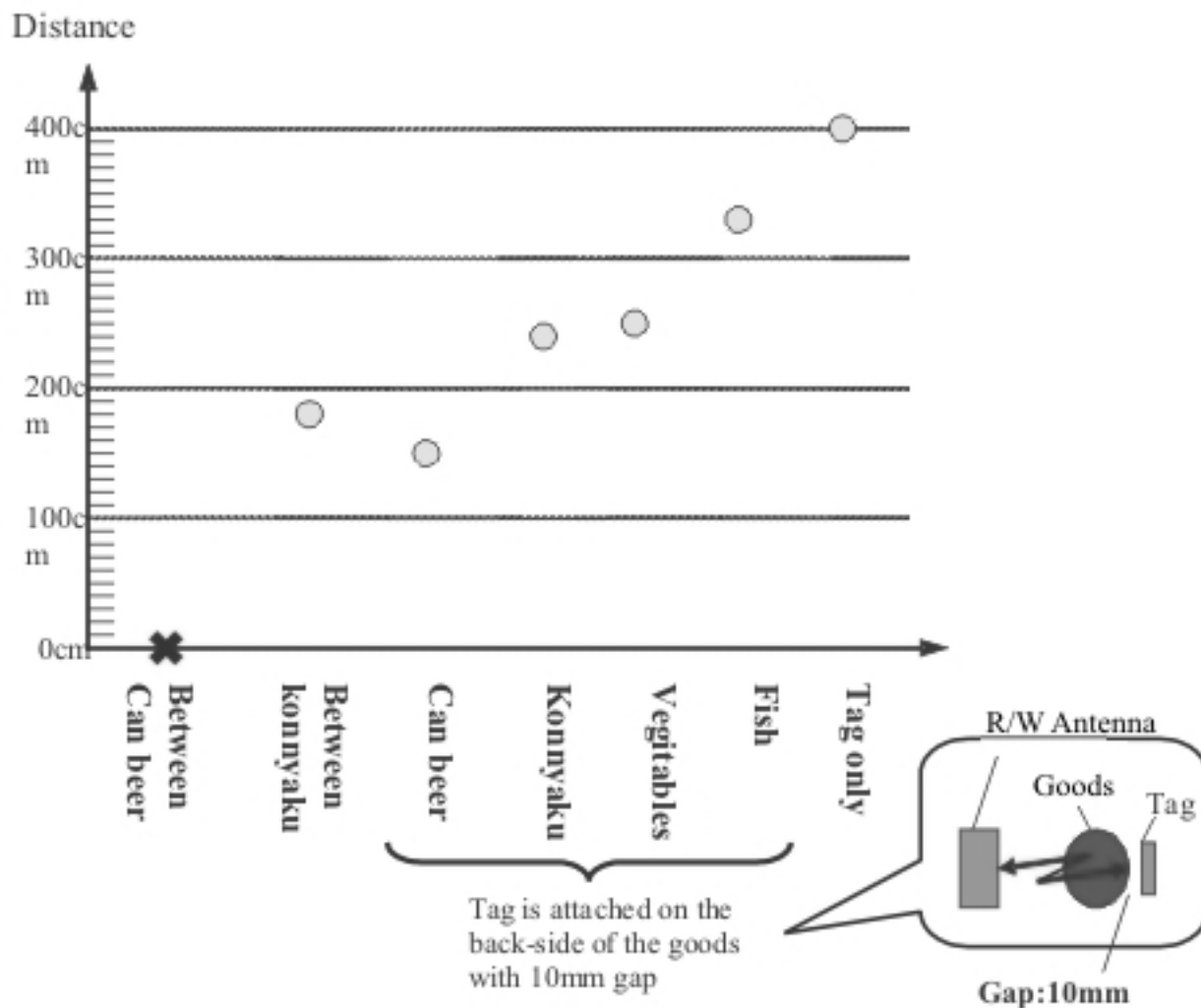


Figure 5 — Typical effect of food products on performance

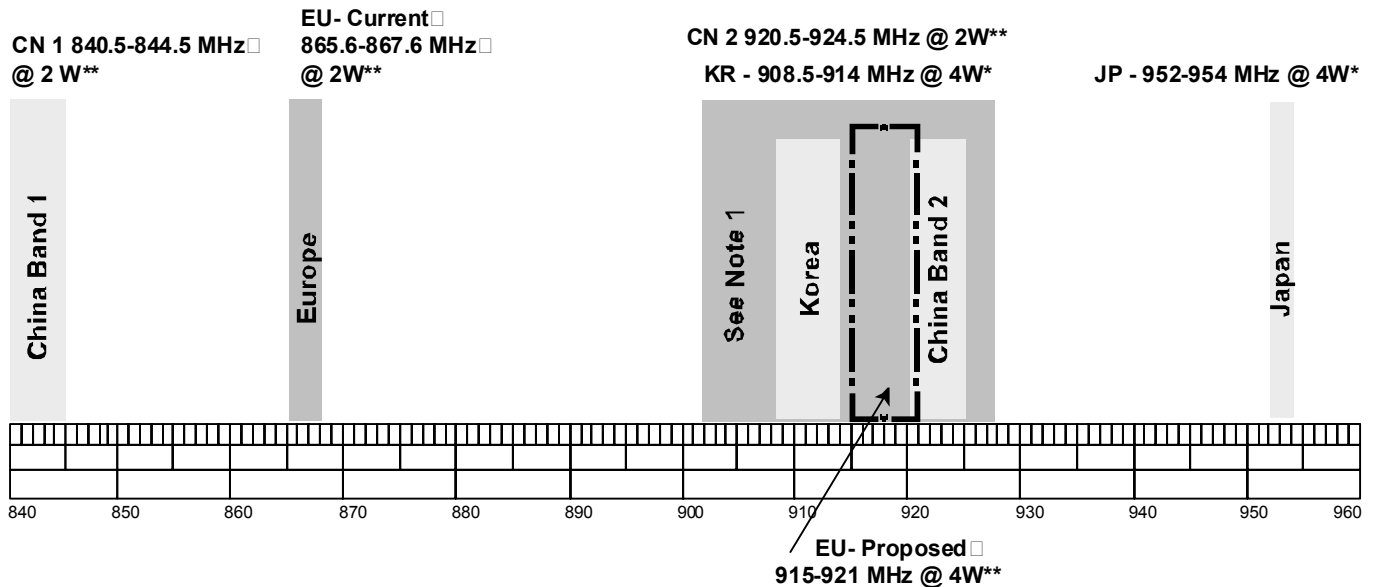
Effective implementations rely then on an understanding of the above coupled with live testing and system design around the constituency of products and tag positions relative to the reader's antennas.

An associated effect, which can also reduce the reading range of a tag, is its proximity and orientation with respect to other adjacent tags. The effect is greatest where tags are parallel with each other since this produces the highest level of mistuning and absorption. A similar situation arises where a second tag is positioned a short distance behind the first one and in line with the transmission path from an interrogator. The tag nearest to the interrogator creates a "shadow", which reduces the field available to power the tag that is further away.

It is important for end-users to understand and assess the impact of all of the above effects on their application.

5.2 Regulatory Considerations

RFID readers are subject to local regulations regarding frequency, RF power, number of channels, modulation techniques, and other parameters.



Note 1:

- US, CA, MX, Chile, Argentina, Peru, Uruguay 902-928 @4W*
- Australia_ 920-926 MHz @4W* and 918-926 @1W*
- Brazil_ 902-907.5 MHz @4W* and 915-928 MHz @4W*
- Israel_ 915-917 @2W*
- Singapore_ 920-925 MHz @2 W** and 866-869 @0.5 W**
- South Africa_ 915.4-919 MHz @4W* and 865.6-867.6 MHz @2W**
- Thailand_ 920-925 @4W*

* - HRP
 ** - ERP
 † - License Required

Figure 6 — Frequency ranges for various regions of the world

For example, in North America, the nominal operating frequencies are 902-928 MHz. Random frequency hopping is required with at least 50 channels. Power is limited to 1 watt with a 6 dBi antenna (4W EIRP). 6 dBi is the maximum allowed LINEAR gain. The difference between the maximum linear gain of the circular polarized antenna strongly depends on its axial ratio: the difference is close to 3 dB if the axial ratio is very low (0 dB) and close to 0 dB if the axial ratio is very high. Readers are allowed to start transmission at any time. No site license is needed. The complete implementation requirements are defined in FCC Part 15.247.

According to the revised ETSI standard EN 302 208-1 v1.2.1 published in April 2008: Interrogators shall operate within the band 865 MHz to 868 MHz on any of the four specified high power channels as illustrated below. The bandwidth of each high power channel shall be 200 kHz and the centre frequency of the lowest channel shall be 865,7 MHz. The remaining three high power channels shall be spaced at equal intervals of 600 kHz. Tags should preferably respond in the dense interrogator mode within the low power channels. A diagram of the channel plan for the band is given below.

This permits RFID use in four of the channels (channels 4, 7, 10, and 13) at higher power transmit at levels, up to 2 Watts E.R.P., only in the following four designated high power channels shown below. Specification of the 4-channel plan included removal of the mandatory requirement for Listen Before Talk (LBT).

- 865.6-865.8 MHz
- 866.2-866.4 MHz
- 866.8-867.0 MHz
- 867.4-867.6 MHz

The maximum continuous transmit on-time on a channel for each interrogator cannot exceed 4 seconds. The minimum transmit off-time on a channel for each interrogator shall be greater than 100 msec. There is no restriction on beam-width below 500 mW; above 500 mW beam width subject to the requirements of EN 302 208. This revision included a revised spectrum mask to minimise inter-modulation products in tags. LBT remains as an option.