INTERNATIONAL STANDARD

ISO/IEC 18046-3

Third edition
2020-10

Information technology — Radio frequency identification device performance test methods —

Part 3:
Test methods for tag performance

Technologies de l'information — Méthodes d'essai des performances du dispositif d'identification par radiofréquence —

Partie 3: Méthodes d'essai des perfomances du tag

Reference number
ISO/IEC 18046-3:2020(E)

ISO copyright office
CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva
Phone: +41 22 749 01 11
Email: copyright@iso.org
Website: www.iso.org

Published in Switzerland

Contents

Page

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.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of document should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents) or the IEC list of patent declarations received (see https://patents.iec.c).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see www.iso.org/iso/foreword.html.

This document was prepared by Joint Technical Committee ISO/IEC JTC 1, *Information technology*, Subcommittee SC 31, *Automatic identification and data capture techniques*.

This third edition cancels and replaces the second (ISO/IEC 18046-3:2012), which has been technically revised.

The main changes compared to the previous edition are as follows:

— Change of the frequency range to 860 MHz to 930 MHz, as no countries, including Japan, support a frequency in the 930 MHz to 960 MHz range anymore;

— Adaptation of the test method for 860 MHz to 930 MHz band based on 10 years experience of the use of this document.

A list of all parts in the ISO/IEC 18046 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user’s national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

Radio frequency identification (RFID) technology has broad applicability to the automatic identification and data capture (AIDC) industry in item management. As a wireless communication technique based on radio frequency technology, the applications cover multiple levels of the industrial, commercial and retail supply chains. These can include:

— freight containers,

— returnable transport items (RTI),

— transport units,

— product packaging, and

— product tagging.

Performance tests define test methods which deliver results that allow the comparison of different RFID systems, interrogators and tags in order to select among them for use in a particular application.

The performance characteristics of devices (tags and interrogation equipment) can vary drastically due to application factors as well as the particular RFID air interface (frequency, modulation, protocol, etc.) being supported. Of key concern is the matching of the various performance characteristics to the user application. Additionally, in an open environment, users of such technology demand multiple sources for these devices from technology providers. A key challenge is a method of evaluating the differences between various technology providers' products in a consistent and equitable manner.

This document provides a framework for meeting the above noted concerns and challenges. To this end, clear definitions of performance as related to user application of RFID technology in the supply chain are provided. Based on such application-based definitions, test methods are defined with attention to the test parameters required for a consistent evaluation of RFID devices.

Of particular significance, these tests are defined for RFID devices with one antenna. It is common practice to have products with both single and multiple antennae to define an RFID transaction zone sufficient for the application. The defined test methods used are for a single antenna but can equivalently be extended to equipment with multiple antennae, in order to evaluate performance under conditions more closely matching those of a particular application. However, it is important to exercise care in multiple-antenna measurement since multiple antennae can cause antenna-to-antenna interactions, physical packaging limitations, mutual coupling issues, shadowing issues, directivity issues and other impacts, even with respect to interrogators since these can be limited in size, shape and mounting method for many RFID applications.

Information technology — Radio frequency identification device performance test methods —

Part 3: Test methods for tag performance

1 Scope

This document defines test methods for performance characteristics of RFID tags for item management and specifies the general requirements and test requirements for tags which are applicable to the selection of devices for an application. The summary of the test reports forms a unified tag datasheet.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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 18000-2, *Information technology — Radio frequency identification for item management — Part 2: Parameters for air interface communications below 135 kHz*

ISO/IEC 18000-3, *Information technology — Radio frequency identification for item management — Part 3: Parameters for air interface communications at 13,56 MHz*

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 General*

ISO/IEC 18000-61, *Information technology — Radio frequency identification for item management — Part 61: Parameters for air interface communications at 860 MHz to 960 MHz Type A*

ISO/IEC 18000-62, *Information technology — Radio frequency identification for item management — Part 62: Parameters for air interface communications at 860 MHz to 960 MHz Type B*

ISO/IEC 18000-63, *Information technology — Radio frequency identification for item management — Part 63: Parameters for air interface communications at 860 MHz to 960 MHz Type C*

ISO/IEC 18000-64, *Information technology — Radio frequency identification for item management — Part 64: Parameters for air interface communications at 860 MHz to 960 MHz Type D*

ISO/IEC 18000-7, *Information technology — Radio frequency identification for item management — Part 7: Parameters for active air interface communications at 433 MHz*

ISO/IEC 18047-2, *Information technology — Radio frequency identification device conformance test methods — Part 2: Test methods for air interface communications below 135 kHz*

ISO/IEC 18047-6:2017, *Information technology — Radio frequency identification device conformance test methods — Part 6: Test methods for air interface communications at 860 MHz to 960 MHz*

ISO/IEC 19762, *Information technology — Automatic identification and data capture (AIDC) techniques — Harmonized vocabulary*

3 Terms and definitions

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

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

4 Symbols and abbreviated terms

4.1 Symbols

λ	wavelength
BLF	backscatter link frequency
BW	bandwidth
D	distance between the tag and the antenna
E	electric field
E_{Max}	maximum operating electromagnetic field
E_{Survival}	survival electromagnetic field
$E_{\text{THR Identification}}$	identification electromagnetic field threshold
$E_{\text{THR Read}}$	reading electromagnetic field threshold
$E_{\text{THR Write}}$	writing electromagnetic field threshold
f_{c}	center frequency
F_{Res}	resonant frequency
f_{tsbr}	frequency tag side band right (frequency of the right side band of the tag spectrum)
f_{tsbl}	frequency tag side band left (frequency of the left side band of the tag spectrum)
G	antenna gain
H_{T}	magnetic field strength
$H_{\text{THR Identification}}$	identification magnetic field threshold
$H_{\text{THR Read}}$	reading magnetic field threshold
$H_{\text{THR Write}}$	writing magnetic field threshold
H_{Max}	maximum operating magnetic field
H_{Survival}	survival magnetic field
$I_{\text{Rejection}}$	interference rejection
M	number of subcarrier cycles per symbol
P_{Max}	maximum operating power of tag
P_{Survival}	survival electromagnetic power of tag

$P_{Rejection}$	interference power
P_{Min}	minimum power operation threshold
$P_{Min,Fade}$	maximum fade rate
P_{Rcv}	interrogator sensitivity
P_{Back}	backscatter power at tag position
Q	quality factor
$RTcal$	interrogator to tag calibration symbol
$S_{Degradation}$	sensitivity degradation
$S_{Directivity}$	sensitivity directivity
$TRcal$	tag to interrogator calibration symbol
U_{RHTA}	peak-peak value of the voltage drop at external serial measurement resistor

NOTE Minimum power operation threshold, P_{Min}, is defined as the minimum power received by the isotropic antenna from the E-field required for the tag to turn-on.

4.2 Abbreviated terms

C	directional coupler
CW	continuous wave
DUT	device under test
EMF	electro magnetic field
FCC	federal communications commission
FR	fade rate
FSK	frequency shift keying
ITF	interrogator talk first
L	length
LM	load modulation
MPE	maximum permissible human exposure
NP0	negative-positive 0 ppm/°C
PCB	printed circuit board
PIE	pulse interval encoding
PR-ASK	phase reversal amplitude shift keying
UHF	ultra high frequency
RF	radio frequency

RX	receive antenna
SAR	specific absorption rate
TE	test equipment
TX	transmit antenna
UII	unique item identifier
V	voltage
VSWR	voltage standing wave ratio

5 Conditions applicable to the test methods

5.1 Number of tags to be tested

All measurements defined in this document may be performed on a single tag, but higher sampling numbers may be required for measurement campaigns for statistical purpose.

5.2 Test environment

Unless otherwise specified, testing shall take place in air environment of temperature (23 ± 3) °C [(73 ± 5) °F)] and of relative humidity 40 % to 60 %.

5.3 RF environment

The tests shall be performed in a known RF environment.

For measurements of propagative UHF tags an anechoic chamber is the recommended test environment (see ISO/IEC 18000-61, ISO/IEC 18000-62, ISO/IEC 18000-63 or ISO/IEC 18000-64).

For measurements of inductive tags at frequencies below 30 MHz, a typical laboratory environment is sufficient, where consideration is given to minimize the impact of electromagnetic sources that may influence the results.

5.4 Pre-conditioning

Where pre-conditioning is required by the test method, the identification tags to be tested shall be conditioned to the test environment for a period of 24 hours before testing.

5.5 Default tolerance

Unless otherwise specified, a default tolerance of ±5 % shall be applied to the quantity values given to specify the characteristics of the test equipment (e.g. linear dimensions) and the test method procedures (e.g. test equipment adjustments).

For power values represented in dB or dBm, the tolerance shall be ± 0,5 dB.

NOTE ± 0,5 dB is approximately ± 12 % of the non-logarithmics value.

5.6 Total measurement uncertainty

The total measurement uncertainty for each quantity determined by these test methods shall be stated in the test report.

NOTE Basic information is given in ISO/IEC Guide 98-3:2008.

5.7 Test result reporting

Each test result shall be reported with the number of samples tested. For statistical evaluation, optionally the minimum value, maximum value, mean value and standard deviation may be reported as well.

5.8 Test mounting material

For UHF tags, the tests may be performed with or without applied mounting material. When the mounting material is defined by the tag manufacturer, the tests shall be performed with the specified mounting material and in the free air.

If the dielectric parameter or other critical parameters of material are known, then they should be specified in the test report.

5.9 Test communication parameters

All of the tests can be performed for various communication parameters (forward and return link). The test conditions shall be recorded in the test report.

5.10 Test equipment limitations

Test equipment for survivability field maximum level shall be able to handle the maximum level declared by the product vendor. It shall be ensured that the test equipment is not limiting the performance measurement.

5.11 Human exposure to EMF

High magnetic or electromagnetic field strength may exceed the limits of MPE to EMF. This should be taken into account as necessary.

NOTE FCC guidelines for MPE and SAR or EC 1999/519/CE are examples of relevant documents.

6 Setup of test equipment for tag test

6.1 Test apparatus and test circuits for ISO/IEC 18000-2 tags

This clause defines the test apparatus and test circuits for verifying the operation of a tag according to the base standard ISO/IEC 18000-2. The test setups used shall be as described in ISO/IEC 18047-2.

6.2 Test apparatus and test circuits for ISO/IEC 18000-3 tags

This clause defines the test apparatus and test circuits for verifying the operation of a tag according to the base standard ISO/IEC 18000-3. The test setups described in ISO/IEC/TR 18047-3 may be used.

As the test apparatus described in ISO/IEC/TR 18047-3 is only designed for a magnetic field strength up to 5 A/m, the test setups as described in Annex B may be used for magnetic field strength exceeding 5 A/m.

6.3 Test apparatus and test circuits for ISO/IEC 18000-61, ISO/IEC 18000-62, ISO/IEC 18000-63 and ISO/IEC 18000-64 tags

6.3.1 Propagative UHF tags measurement

6.3.1.1 General

This clause defines the test apparatus and test circuits for verifying the operation of a tag according to the base standards ISO/IEC 18000-61, ISO/IEC 18000-62, ISO/IEC 18000-63 and ISO/IEC 18000-64. The test setup used for measurements of propagative UHF tags shall be as shown in 6.3.1.2. Alternatively, the test setup described in ISO/IEC 18047-6 may be used.

6.3.1.2 Setup of the devices

The test setup shall use either a bistatic test setup, as in Figure 1, or a monostatic test setup, as in Figure 2. It shall be ensured that the test equipment (TE) receiver is sensitive enough to not limit the measurements.

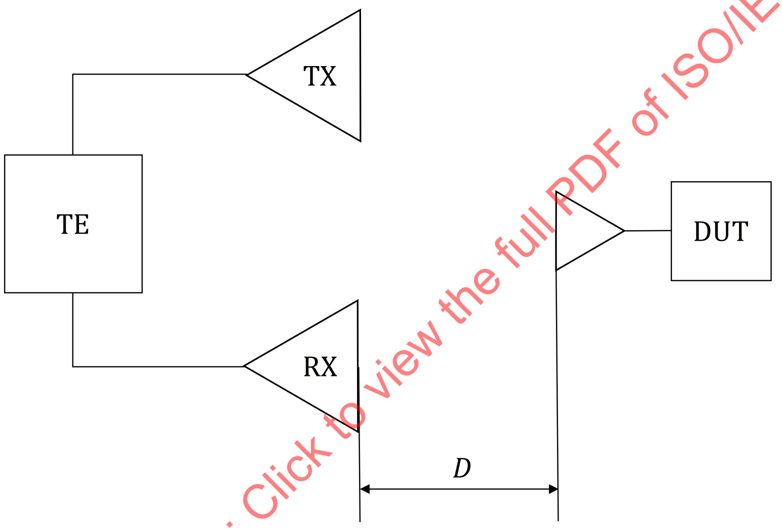


Figure 1 — Bistatic test setup

In Figure 1, RX is the receive antenna, TX is the transmit antenna and TE is the test equipment.

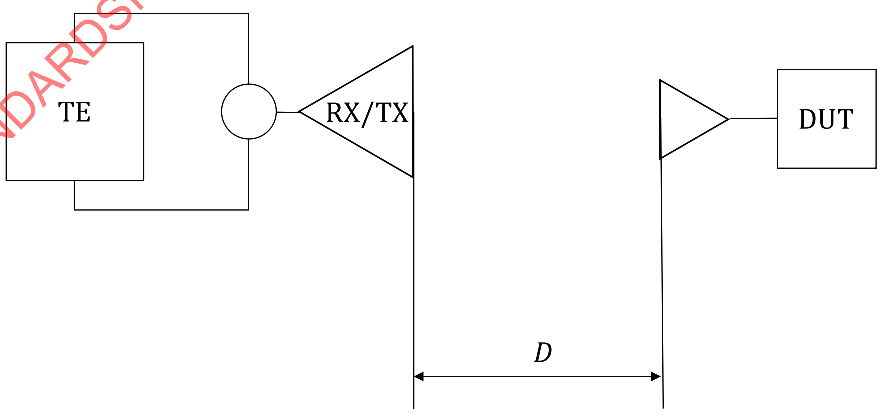


Figure 2 — Monostatic test setup

In Figure 2, the same antenna is used as RX and TX.

6.3.1.3 DUT placement

The DUT shall be placed in the far field according to Figure 1 or Figure 2. The distance, *D*, shall be at least as caluclated using Formula (1):

$$D = \frac{2L^2}{\lambda} \quad (1)$$

where

λ is the wavelength, and

L is the maximum dimension of the test antenna.

6.3.1.4 Antenna polarization and requirements

For propagative UHF tests, a linear or circular polarized antenna shall be used, except when testing tags that have more than one antenna or for sensitivity degradation measurements, in which case a circular polarized antenna shall be used.

The circular polarized antenna shall have an axial ratio that is less than 1 dB over the frequency and orientation ranges of the testing.

Antennae used together in one measurement setup shall have the same gain with a VSWR <1:2.

6.3.1.5 Test setup for interference rejection measurements of propagative UHF tags

Figure 3 and Figure 4 show the test setup arrangements for interference rejection measurements:

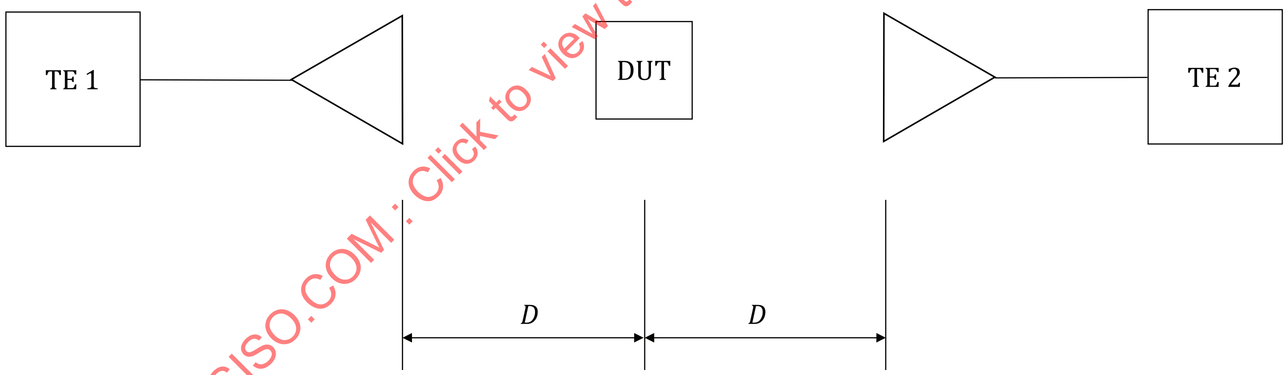


Figure 3 — Test setup for interference rejection measurement

In Figure 3, TE 1 represents the desired RF generator test equipment and TE 2 represents the interferer RF generator test equipment.

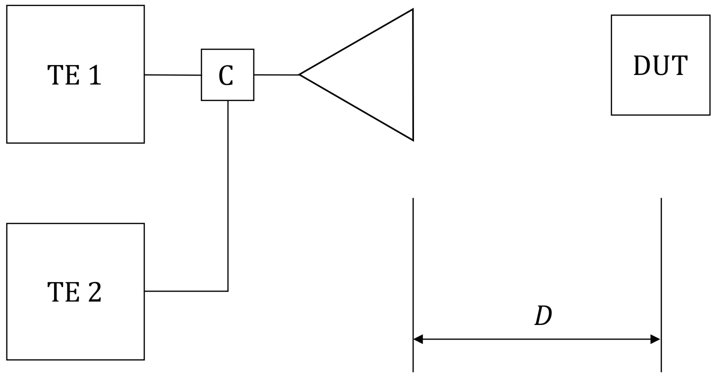


Figure 4 — Test setup for interference rejection measurement

In Figure 4, TE 1 represents the desired RF generator test equipment and TE 2 represents the interferer RF generator test equipment. C is a directional coupler.

For this test, the tag under test shall be placed at the same distance, *D*, from the two RF generators and oriented for optimum field strength reception. The distance, *D*, shall be at least as in defined in Formula (1) for performing the measurements in the far field.

6.3.2 Inductive UHF tags measurement

This clause defines the test apparatus and test circuits for verifying the operation of a tag according to the base standards, ISO/IEC 18000-6, ISO/IEC 18000-61, ISO/IEC 18000-62, ISO/IEC 18000-63 and ISO/IEC 18000-64. The test setup used for measurements of inductive UHF tags is shown in Annex C.

6.4 Test apparatus and test circuits for ISO/IEC 18000-7 tags

This clause defines the test apparatus and test circuits for verifying the operation of a tag according to the base standard, ISO/IEC 18000-7. The test setups used shall be as described in ISO/IEC/TR 18047-7.

7 Functional tests for inductive tags as defined in ISO/IEC 18000-2 and ISO/IEC 18000-3, ISO/IEC 18000-61, ISO/IEC 18000-62, ISOIEC 18000-63 and ISO/IEC 18000-64

7.1 Identification magnetic field threshold ($H_{THR\ Identification}$)

7.1.1 Purpose

The purpose of this test is to determine the threshold level of magnetic field strength required for tag identification. As the tag needs energy to operate, this energy shall be supplied by the magnetic field. The identification magnetic field threshold, $H_{THR\ Identification}$, is the minimum field strength allowing tag identification.

7.1.2 Test procedure

7.1.2.1 General

At a fixed frequency as allowed by the regulation, the magnetic field strength of the generating field shall be varied from zero until modulation of the tag is detected and the tag is identified.

7.1.2.2 ISO/IEC 18000-2 tags

The selection of system parameters shall be made in order to challenge the tag energy supply.

Identification magnetic field threshold, $H_{\text{THR Identification}}$, measurement procedure:

1) The waveform generator shall be set to the required operating frequency of 125 kHz or 134,2 kHz.

2) The waveform generator amplitude shall be set to a value below $H_{\text{THR Identification}}$. This amplitude is typically zero.

3) The tag shall be inserted in the test equipment.

4) An inventory command (see Annex D) shall be continuously sent with the code generator and the amplitude shall be increased after each inventory command until the complete UII can be measured with the Helmholtz coils.

5) The data transfer shall be verified by comparison with ISO/IEC 18000-2. If the tag response is wrong, step 4) shall be repeated with higher amplitude.

6) The tag shall be removed from the test equipment.

7) The magnetic field strength H for the individual tag shall be calculated by use of the measurement of U_{RHTA}.

The measurements shall be performed on all tags. $H_{\text{THR Identification}}$ shall be the highest value of all measured magnetic field strength, *H*, for the individual tags.

7.1.2.3 ISO/IEC 18000-3 tags

The selection of system parameters shall be made in order to challenge the tag energy supply.

Identification magnetic field threshold, $H_{\text{THR Identification}}$, measurement procedure:

1) The waveform generator shall be set to the required operating frequency of 13,56 MHz.

2) The waveform generator amplitude shall be set to a value below the identification magnetic field threshold. This amplitude is typically zero.

3) The tag shall be inserted in the test equipment.

4) An inventory command (see Annex D) shall be continuously sent with the code generator and the amplitude shall be increased after each inventory command until the complete UII can be measured with the sense coils.

5) The data transfer shall be verified by comparison with ISO/IEC 18000-3. If the tag response is wrong, step 4) shall be repeated with higher amplitude.

6) The tag shall be removed from the test equipment and the calibration coil shall be inserted in the test equipment.

7) The magnetic field strength, *H*, for the individual tag shall be calculated by use of the measurement made on the calibration coil.

The measurements shall be performed on all tags. $H_{\text{THR Identification}}$ shall be the highest value of all measured magnetic field strength, *H*, for the individual tags.

7.1.2.4 ISO/IEC 18000-61, ISO/IEC 18000-62, ISOIEC 18000-63 and ISO/IEC 18000-64 tags

For inductive coupled tags according to ISO/IEC 18000-61, ISO/IEC 18000-62, ISO/IEC 18000-63 and ISO/IEC 18000-64, the test methods of 8.1 with test setup as in 6.3.2 shall be applied. Additional to the measurement results of P_{Min} and P_{Back} it shall be described how the H-field is derived.

7.2 Reading magnetic field threshold ($H_{THR\ Read}$)

7.2.1 Purpose

The purpose of this test is to determine the threshold level of magnetic field strength that allows a tag reading. In order to successfully read tag data, the command shall be transmitted correctly and enough energy (flux density) shall be available to read the tag. The reading magnetic field threshold, $H_{THR\ Read}$, is the minimum magnetic field strength allowing tag reading.

7.2.2 Test procedure

7.2.2.1 General

At a fixed frequency the magnetic field strength of the generating field has to be varied from zero until a reading of block user memory is possible. The reading shall be performed on the first and the last block memory address with a read single block command. Beforehand, all blocks of the user memory shall be filled with data with the same number of 1 and 0 uniformly distributed, (i.e. by using the binary digits represented by the byte sequence 5A hex, 3C hex, 0F hex and F0 hex throughout the memory for a four bytes memory block).

7.2.2.2 ISO/IEC 18000-2 tags

The selection of system parameters shall be made in order to challenge the tag energy supply.

Reading magnetic field threshold, $H_{THR\ Read}$, measurement procedure:

1) The waveform generator shall be set to the required operating frequency of 125 kHz or 134,2 kHz.

2) The waveform generator amplitude shall be set to a value below the identification magnetic field threshold. This amplitude is typically zero.

3) The tag shall be inserted in the test equipment.

4) A read single block command shall be continuously sent to the first block address with the code generator and the amplitude shall be increased after each read single block command until the complete tag response can be measured with the Helmholtz coils.

5) The data transfer shall be verified by comparison with ISO/IEC 18000-2. If the tag response is wrong, then step 4) shall be repeated with higher amplitude.

6) The tag shall be removed from the test equipment.

7) The magnetic field strength, H, for the individual tag shall be calculated by use of the measurement U_{RHTA}, as defined in ISO/IEC 18047-2.

8) Repeat steps 3) to 7) with the read single block command sent to the last block address.

The measurements shall be performed on all tags. $H_{THR\ Read}$ shall be the highest value of all measured magnetic field strength, H, for the individual tags.

7.2.2.3 ISO/IEC 18000-3 tags

The selection of system parameters shall be made in order to challenge the tag energy supply.

Reading magnetic field threshold, $H_{THR\ Read}$, measurement procedure:

1) The waveform generator shall be set to the required operating frequency of 13,56 MHz.

2) The waveform generator amplitude shall be set to a value below the identification magnetic field threshold. This amplitude is typically zero.

3) The tag shall be inserted in the test equipment.

4) A read single block command shall be continuously sent to the first block address with the code generator and the amplitude shall be increased after each read single block command until the complete tag response can be measured with the sense coils.

5) The data transfer shall be verified by comparison with ISO/IEC 18000-3. If the tag response is wrong, step 4) shall be repeated with higher amplitude.

6) The tag shall be removed from the test equipment and the calibration coil shall be inserted in the test equipment.

7) The magnetic field strength, H, for the individual tag shall be calculated by use of the measurement made on the calibration coil.

8) Repeat steps 3) to 7) with the read single block command sent to the last block address.

The measurements shall be performed on all tags. $H_{\text{THR Read}}$ shall be the highest value of all measured magnetic field strength, H, for the individual tags.

7.2.3 Test report

The test report shall give the measured reading magnetic field threshold, $H_{\text{THR Read}}$, the environment conditions and communication parameters. All these parameters shall be recorded according to the example in Table 1.

Table 1 — Parameters recorded for reading magnetic field threshold

Test: Reading magnetic field threshold ($H_{\text{THR Read}}$)		
Temperature: °C	Humidity: %	
Tag Protocol:	Tag UII:	
Forward Link		
Modulation index: %	Data rate: kbps	Data coding:
Block number:		
Command: 0x		
Return Link		
Data rate: kbps	Data coding:	
Data block size: bytes	Data read:	
Test Results		
$H_{\text{THR Read}}$	**xx,xx mA/m**	

7.3 Writing magnetic field threshold ($H_{\text{THR Write}}$)

7.3.1 Purpose

The purpose of this test is to determine the threshold level of magnetic field strength, H, that allows tag writing. In order to successfully write data into the tag, the data shall be transmitted correctly and enough energy (flux density) shall be available during the memory access. The writing magnetic field threshold, $H_{\text{THR Write}}$, is the minimum magnetic field strength, H, allowing writing into the tag.

7.3.2 Test procedure

7.3.2.1 General

At a fixed frequency the magnetic field strength, H, of the generating field shall be varied from zero until a writing of block user memory is possible. The writing shall be performed on the first and the last block memory address with a write single block command. The data shall have the same number of 1 and 0 uniformly distributed and its size equal to the block size. (i.e by using the binary digits represented by the byte sequence 5A hex, 3C hex, 0F hex and F0 hex throughout the memory for a four bytes memory block).

7.3.2.2 ISO/IEC 18000-2 tags

The selection of system parameters shall be made in order to challenge the tag energy supply.

Writing magnetic field threshold, $H_{\mathrm{THR\ Write}}$, measurement procedure:

1) The waveform generator shall be set to the required operating frequency of 125 kHz or 134,2 kHz.

2) The waveform generator amplitude shall be set to a value below the identification magnetic field threshold, $H_{\mathrm{THR\ Identification}}$. This amplitude is typically zero.

3) The tag shall be inserted in the test equipment.

4) A write single block command shall be continuously sent to the first block address with the code generator and the amplitude shall be increased after each write single block command until the complete tag response can be measured with the Helmholtz coils.

5) The data transfer shall be verified by comparison with ISO/IEC 18000-2. If the tag response is wrong, then step 4) shall be repeated with higher amplitude.

6) The tag shall be removed from the test equipment.

7) The magnetic field strength, H, for the individual tag shall be calculated by use of the measurement U_{RHTA}.

8) Repeat steps 3) to 7) with the read single block command sent to the last block address.

The measurements shall be performed on all tags. $H_{\mathrm{THR\ Write}}$ shall be the highest value of all measured magnetic field strength values, H, for the individual tags.

7.3.2.3 ISO/IEC 18000-3 tags

The selection of system parameters shall be made in order to challenge the tag energy supply.

Writing magnetic field threshold, $H_{\mathrm{THR\ Write}}$, measurement procedure:

1) The waveform generator shall be set to the required operating frequency of 13,56 MHz.

2) The waveform generator amplitude shall be set to a value below the identification magnetic field threshold, $H_{\mathrm{THR\ Identification}}$. This amplitude is typically zero.

3) The tag shall be inserted in the test equipment.

4) A write single block command shall be continuously sent to the first block address with the code generator and the amplitude shall be increased after each write single block command until the complete tag response can be measured with the sense coils.

5) The data transfer shall be verified by comparison with ISO/IEC 18000-3. In case the tag response is wrong, then step 4) shall be repeated with higher amplitude.

6) The tag shall be removed from the test equipment and the calibration coil shall be inserted in the test equipment.

7) The magnetic field strength, H, for the individual tag shall be calculated by use of the measurement made on the calibration coil.

8) Repeat steps 3) to 7) with the read single block command sent to the last block address.

The measurements shall be performed on all tags. $H_{THR\ Write}$ shall be the highest value of all measured magnetic field strength values, H, for the individual tags.

7.4 Maximum operating magnetic field (H_{Max})

7.4.1 Purpose

The purpose of this test is to determine the maximum operating magnetic field strength, $H_{Max,}$ for allowing tag identification.

7.4.2 Test procedure

At a fixed frequency the magnetic field strength of the generating field shall be increased from the identification magnetic field threshold, $H_{THR\ Identification}$, until identification of the tag is not possible. The maximum operating magnetic field strength, H_{max}, is the maximum magnetic field allowing tag identification.

As this test may be destructive, a different lot of samples shall be used.

7.5 Survival magnetic field ($H_{Survival}$)

7.5.1 Purpose

The purpose of this test is to determine the maximum survival magnetic field value, $H_{Survival}$, at which the tag stops operating when exposed to this high value, even if the operating magnetic field is reduced to a value in the range between $H_{THR\ Identification}$ and H_{Max} afterwards.

7.5.2 Test procedure

At a fixed frequency the magnetic field strength of the generating field shall be increased from the identification magnetic field threshold, $H_{THR\ Identification}$, until tag destruction. The survival magnetic field, $H_{Survival}$, is the maximum magnetic field before tag destruction.

As this test is destructive, a different lot of samples shall be used.

7.6 Load modulation (LM)

7.6.1 Purpose

The purpose of this test is to determine the amplitude of the load modulation signal within the operating magnetic field range.

7.6.2 Test procedure

7.6.2.1 General

At a fixed frequency, the magnetic field strength of the generating field shall be increased from the identification magnetic field threshold, $H_{THR\ Identification}$, to the maximum operating magnetic field, H_{max}, with a step of 1 A/m for ISO/IEC 18000-2 tags, a regular step of 0,5 A/m for ISO/IEC 18000-3 tags and a regular step of 0,1 A/m for ISO/IEC 18000-6 tags. The tag LM shall be calculated according to the LM conformance measurement for the steps of magnetic field strength.

7.6.2.2 ISO/IEC 18000-2 tags

LM signal measurement procedure:

1) The waveform generator shall be set to the required operating frequency of 125 kHz or 134,2 kHz.

2) The waveform generator amplitude shall be set to the value of the identification magnetic field threshold, $H_{\text{THR Identification}}$.

3) The tag shall be inserted in the test equipment.

4) An inventory command (see Annex D) shall be sent with the code generator.

5) The LM for the individual tag shall be calculated by use of the measurement made with the test equipment according the conformance procedure of ISO/IEC 18047-2.

6) The magnetic field strength, *H*, shall be increased to the next value and the LM measurement for the individual tag shall be calculated for each magnetic field strength step until reaching the maximum operating field (H_{Max}).

For each magnetic field strength step, the LM value shall be the lowest of all LM values calculated for the individual tags.

7.6.2.3 ISO/IEC 18000-3 tags

LM signal measurement procedure:

1) The waveform generator shall be set to the required operating frequency of 13,56 MHz.

2) The waveform generator amplitude shall be set to the value of the identification magnetic field threshold, $H_{\text{THR Identification}}$.

3) The tag shall be inserted in the test equipment.

4) An inventory command (see Annex D) shall be sent with the code generator.

5) The LM for the individual tag can be calculated by use of the measurement made with the test equipment according to the conformance procedure of ISO/IEC/TR 18047-3.

6) The magnetic field strength shall be increased to the next value and the LM measurement for the individual tag shall be calculated for each magnetic field strength step until reaching the maximum operating field, H_{Max}.

For each magnetic field strength step, the LM value shall be the lowest of all LM values calculated for the individual tags.

7.7 Optional resonant frequency and Q factor measurement for inductive tag

7.7.1 Purpose

The purpose of this optional test is to determine the resonant frequency and the −3 dB bandwidth to calculate the quality factor of the tag for a magnetic field strength equal to $H_{\text{THR Identification}}$.

7.7.2 Test procedure

A proposed test procedure is described in Annex A for ISO/IEC 18000-2 and ISO/IEC 18000-3 tags.

8 Functional tests for propagative tags as defined in ISO/IEC 18000-61, ISO/IEC 18000-62, ISO/IEC 18000-63 and ISO/IEC 18000-64

8.1 Minimum power operation threshold (P_{Min}) for identification, read and write

8.1.1 Purpose

The purpose of this test is to determine the minimum power operation threshold (P_{Min}) required for tag identification. As the tag needs energy to operate, energy shall be supplied by the electromagnetic field. The identification power is the minimum power threshold allowing tag identification.

8.1.2 Test procedure

For the ISO/IEC 18000-6 frequency band from 860 to 930 MHz, the electromagnetic field strength of the generating field shall be varied from zero until modulation of the tag is detected and the tag responds. This test shall be performed with a frequency step of 5 MHz, covering at least 860 MHz to 930 MHz.

The selection of system parameters shall be made in order to challenge the tag energy supply by use of the following procedure:

1) The waveform generator shall be set to the required operating frequency of 860 MHz.

2) The waveform generator amplitude shall be set to a value below the minimum power threshold. This amplitude is typically zero.

3) The tag shall be inserted in the test equipment.

4) The defined command, which shall be selected according Table 2, shall be sent continuously using a code generator. The amplitude shall be increased after each command until the complete tag response can be measured.

5) The data transfer shall be verified by comparison with the respective command reply according to the selected standard. If the tag response is wrong, step 4) shall be repeated with a higher amplitude. In order to reduce the measurement time, a binary search using values above and below the expected result may also be applied.

6) The minimum power operation threshold, P_{Min} shall be calculated by use of the waveform generator amplitude.

7) The backscatter power, P_{Back}, shall be measured at P_{Min} +2 dB as described in Annex E.

8) Steps 1) to 6) shall be repeated by increasing the frequency by maximum 5 MHz to the next frequency step, including the two test frequencies 865 MHz and 915 MHz.

NOTE Increasing the power by 2 dB provides a sufficient power margin to guarantee stable operation of the tag with stable backscatter power, P_{Back}.

Table 2 — Test commands for minimum power threshold for identification, read and write

TEST	ISO/IEC 18000-61	ISO/IEC 18000-62	ISO/IEC 18000-63	ISO/IEC 18000-64
Identification power	Init_Round_All	Group_Select	Select – Query – ACK[a]	TOTAL
Read power			Select – Query – ACK – ReqRN – Read	TOTAL
Write power			Select – Query – ACK – ReqRN – Write	TOTAL

[a] It is recommended to select the minimal possible time, T4.

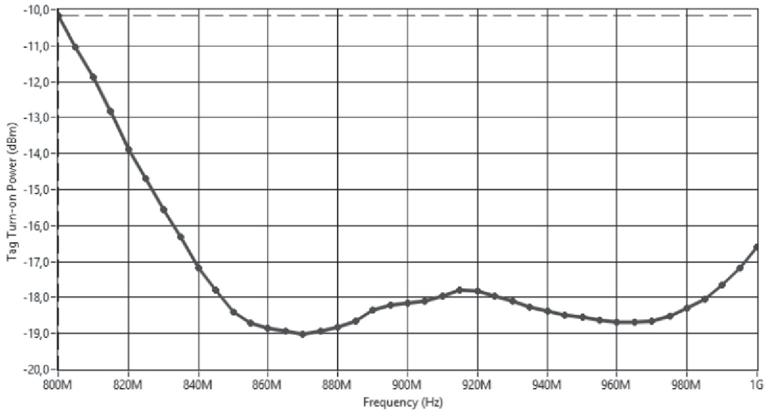
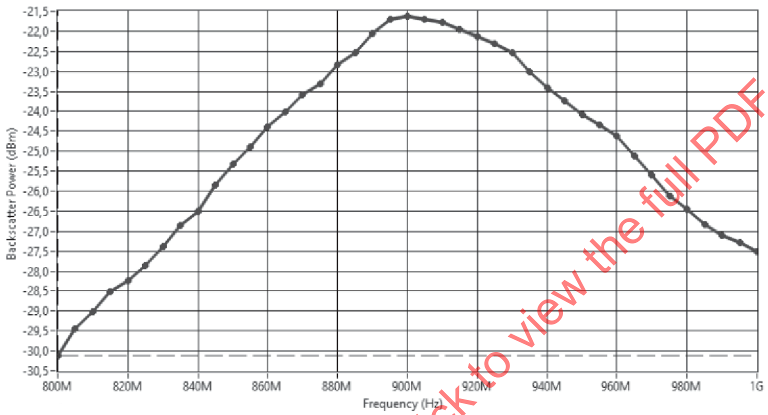
8.1.3 Test report

The test report shall give at least the full band from 860 MHz to 930 MHz with a minimum step width of 5 MHz, including the two test frequencies 865 MHz and 915 MHz, as P_{Min} versus frequency curves. All parameters shall be recorded according to the example in Table 3.

Table 3 — Parameters recorded for minimum power threshold measurement

Test: Minimum power operation threshold (P_{Min})		
Mounting Material: *paper*		
Temperature: *23 °C*	Humidity: *50 %*	
Tag Protocol: ISO/IEC 18000-63	Identifier: *UII: 0x3012 3456 7890 ABCD 0123 4567 89AB CDEF* *TID: 0xE000 0123 4567 89AB*	
Forward Link		
Modulation index: *90 %* Modultion type: *PR-ASK*	Data rate information: *Tari = 12,5 µs* *Tari-1 = 1,5 Tari-*	Data coding: *PIE*
Command(s) including time between commands: *Select (01b1010, Target=000, Action=000, MemBank=10, Pointer=0, Length=0, Mask=empty, Truncate=0)* *T4 = 1 ms* *Query (0b1000, DR=64/3, M=4, TRext=1, Sel=00, Session=00, Target=A, Q=0)*		
Return Link		
Data rate: kbps RTcal = *2.5 Tari* TRcal = *2,133 TRcal*	Data coding: *M=4*	
Test Results		
Frequency / MHz	**P_{Min} / dBm**	**P_{Back} / dBm**
860		
865		
870		
875		
880		
885		
890		
895		
900		
905		
910		
915		
920		
925		
930		

Table 3 *(continued)*

Test: Minimum power operation threshold (P_{Min})
Example of P_{Min} versus frequency curve

Example of P_{Back} versus frequency curve

NOTE Examples for ISO/IEC 18000-63 are shown in italics.

8.2 Sensitivity degradation ($S_{Degradation}$)

8.2.1 Purpose

The purpose of this test is to determine the sensitivity degradation (directivity) of the tag in various orientations (azimuth and elevation).

8.2.2 Test procedure

The test shall be performed at one or multiple test frequencies, where the recommended values are 865 MHz and 915 MHz.

Sensitivity degradation, $S_{Degradation}$, measurement procedure:

1) The waveform generator shall be set to the required operating frequency.

2) The waveform generator amplitude shall be set to a value below the minimum power threshold. This amplitude is typically zero.

3) The tag shall be inserted in the test equipment at the reference point in optimal orientation. Flat tags shall be placed with the flat side facing the measurement antenna. The optimal (reference) orientation shall be the orientation of maximum sensitivity.

4) The defined commands, which shall be selected according to Table 2, shall be sent continuously using a code generator. The amplitude shall be increased after each command until the complete tag response can be measured.

5) Data transfer shall be verified by comparison with the respective command reply according the selected standard. If the tag response is wrong, step 4) shall be repeated with a higher amplitude. In order to reduce the measurement time, a binary search using valuesabove and below the expected result may also be applied.

6) The minimum power threshold shall be calculated by use of the waveform generator amplitude.

7) The backscatter power, P_{Back}, shall be measured at P_{Min} +2 dB as described in Annex E.

8) In addition to the initial position of 0, steps 4) to 7) shall be repeated with horizontal tag rotation of 15° to 345° with 15° step width.

9) The tag shall be vertically rotated by 90° and steps 3) to 8) shall be repeated.

NOTE Increasing the power by 2 dB provides a sufficient power margin to guarantee stable operation of the tag with stable backscatter power, P_{Back}.

Although dipoles may have symmetric $S_{Degradation}$, it is recommended to perform the measurement over all 360° as other tags and in particular metal tags may not have a symmetric $S_{Degradation}$.

8.2.3 Test report

The test report shall give the $S_{Degradation}$ as P_{Min} versus the orientation. All parameters shall be recorded according to the example in Table 4.

Table 4 — Parameters recorded for $S_{Degradation}$ measurement

Test: Sensitivity degradation ($S_{Degradation}$)			
Mounting Material: *paper*			
Temperature: *23 °C*	Humidity: *50 %*		
Tag Protocol: ISO/IEC 18000-63	Identifier: *UII: 0x3012 3456 7890 ABCD 0123 4567 89AB CDEF* *TID: 0xE000 0123 4567 89AB*		
Forward Link			
Modulation index: *90 %* Modultion type: *PR-ASK*	Data rate information: *Tari = 12,5 µs* *Tari-1 = 1,5 Tari-*	Data coding: *PIE*	
Command(s) including time between commands: *Select (01b1010, Target=000, Action=000, MemBank=10, Pointer=0, Length=0, Mask=empty, Truncate=0)* *T4 = 1 ms* *Query (0b1000, DR=64/3, M=4, TRext=1, Sel=00, Session=00, Target=A, Q=0)*			
Return Link			
Data rate: kbps *RTcal = 2,5 Tari* *TRcal = 2,133 TRcal*	Data coding: *M=4*		
Test Results			
Vertical Orientation / °	**Horizontal Orientation / °**	**P_{Min} / dBm**	**P_{Back} / dBm**
0°	0°		
0°	15°		
...	...		

Table 4 *(continued)*

Test: Sensitivity degradation ($S_{Degradation}$)			
0°	345°		
90°	0°		
90°	15°		
90°	...		
90°	345°		
NOTE: Examples for ISO/IEC 18000-63 are shown in italics.			

8.3 Maximum operating power of tag (P_{Max})

8.3.1 Purpose

The purpose of this test is to determine the maximum operating power, P_{Max}, allowing for tag identification.

8.3.2 Test procedure

For the UHF frequencies 865 MHz and 915 MHz, the electromagnetic field strength of the generating field shall be increased from P_{Min} until the identification of the tag is no longer possible.

The selection of system parameters shall be made in order to challenge the tag energy supply by use of the following procedure:

1) The waveform generator shall be set to the required operating frequency.

2) The waveform generator amplitude shall be set to a value below the minimum power threshold. This amplitude is typically zero.

3) The tag shall be inserted in the test equipment.

4) The tag shall be left in the RF field for 5 seconds.

5) The defined commands, which shall be selected according to Table 2, shall be sent continuously.

6) Data transfer shall be verified by comparison with the respective command reply according to the selected standard. If the tag response is correct, step 4) shall be repeated with a higher amplitude. In order to reduce the measurement time, the step width may vary, but the lowest step width shall be applied before the last measurement step.

7) The maximum operating power threshold, P_{Max}, shall be calculated by use of the waveform generator amplitude, where P_{Max} is the highest value with a correct response.

8) The backscatter power, P_{Back}, shall be measured at P_{Min} +2 dB as described in Annex E.

NOTE Increasing the power by 2 dB provides a sufficient power margin to guarantee stable operation of the tag with stable backscatter power, P_{Back}.

8.3.3 Test report

The test report shall give the measured maximum operating power, P_{Max}. All parameters shall be recorded according to the example in Table 5.

Table 5 — Parameters recorded for P_{Max} measurement

<table>
<tr><th colspan="5">Test: Maximum operating power (P_{Max})</th></tr>
<tr><td colspan="5">Mounting Material: paper</td></tr>
<tr><td colspan="2">Temperature: 23 °C</td><td colspan="3">Humidity: 50 %</td></tr>
<tr><td colspan="2">Tag Protocol: ISO/IEC 18000-63</td><td colspan="3">Identifier:
UII: 0x3012 3456 7890 ABCD 0123 4567 89AB CDEF
TID: 0xE000 0123 4567 89AB</td></tr>
<tr><th colspan="5">Forward Link</th></tr>
<tr><td colspan="2">Modulation index: 90 %
Modultion type: PR-ASK</td><td colspan="2">Data rate information:
Tari = 12,5 µs
Tari-1 = 1,5 Tari-</td><td>Data coding: PIE</td></tr>
<tr><td colspan="5">Command(s) including time between commands:
Select (01b1010, Target=000, Action=000, MemBank=10, Pointer=0, Length=0, Mask=empty, Truncate=0)
T4 = 1 ms
Query (0b1000, DR=64/3, M=4, TRext=1, Sel=00, Session=00, Target=A, Q=0)</td></tr>
<tr><th colspan="5">Return Link</th></tr>
<tr><td colspan="2">Data rate: kbps
RTcal = 2,5 Tari
TRcal = 2,133 TRcal</td><td colspan="3">Data coding:
M=4</td></tr>
<tr><th colspan="5">Test Results</th></tr>
<tr><th>Frequency</th><th colspan="2">P_{Max}</th><th colspan="2">P_{Back}</th></tr>
<tr><td>865 MHz</td><td colspan="2">xx,xx dB</td><td colspan="2">xx,xx dB</td></tr>
<tr><td>915 MHz</td><td colspan="2">xx,xx dB</td><td colspan="2">...</td></tr>
<tr><td colspan="5">NOTE: Examples for ISO/IEC 18000-63 are shown in italics.</td></tr>
</table>

8.4 Survival electromagnetic power of tag ($P_{Survial}$)

8.4.1 Purpose

The purpose of this test is to determine the maximum survival power at which the tag stops operating when exposed to this high value, even if the operating electromagnetic field is reduced to a value within the range between P_{Min} and P_{Max}.

8.4.2 Test procedure

For the UHF frequencies 865 MHz and 915 MHz, the electromagnetic field strength of the generating field shall be increased from P_{Min} until the identification of the tag is no longer possible.

The selection of system parameters shall be made in order to challenge the tag energy supply by use of the following procedure:

1) The waveform generator shall be set to the required operating frequency.

2) The waveform generator amplitude shall be set to a value below the minimum power threshold. This amplitude is typically zero.

3) The tag shall be inserted in the test equipment.

4) The tag shall be left in the RF field for 5 seconds.

5) The defined commands, which shall be selected according to Table 2, shall be sent at a power level of around P_{Min} +2 dB using a code generator.

6) Data transfer shall be verified by comparison with the respective command reply according the selected standard. If the tag response is correct, step 4) shall be repeated with higher amplitude. In order to reduce the measurement time, the step width may vary, but the lowest step width shall be applied before the last measurement step.

7) The maximum survival power, $P_{Survival}$, shall be calculated by use of the waveform generator amplitude as the power where the tag still replied after exposure.

NOTE Increasing the power by 2 dB provides a sufficient power margin to guarantee stable operation of the tag with stable backscatter power, P_{Back}.

8.4.3 Test report

The test report shall give the measured maximum operating power (P_{Max}). All parameters shall be recorded according to the example in Table 6.

Table 6 — Parameters that shall be recorded for this measurement

Test: Maximum operating power (P_{Max})		
Mounting Material: *paper*		
Temperature: *23 °C*	Humidity: *50 %*	
Tag Protocol: ISO/IEC 18000-63	Identifier: *UII: 0x3012 3456 7890 ABCD 0123 4567 89AB CDEF* *TID: 0xE000 0123 4567 89AB*	
Forward Link		
Modulation index: *90 %* Modultion type: *PR-ASK*	Data rate information: *Tari = 12,5 µs* *Tari-1 = 1,5 Tari-*	Data coding: *PIE*
Command(s) including time between commands: *Select (01b1010, Target=000, Action=000, MemBank=10, Pointer=0, Length=0, Mask=empty, Truncate=0)* *T4 = 1 ms* *Query (0b1000, DR=64/3, M=4, TRext=1, Sel=00, Session=00, Target=A, Q=0)*		
Return Link		
Data rate: kbps *RTcal = 2,5 Tari* *TRcal = 2,133 TRcal*	Data coding: *M=4*	
Test Results		
Frequency	**P_{Max}**	**P_{Back} (optional)**
865 MHz	**xx,xx dB**	**xx,xx dB**
915 MHz	**xx,xx dB**	**...**
NOTE: Examples for ISO/IEC 18000-63 are shown in italics.		

8.5 Interference rejection ($I_{Rejection}$)

8.5.1 Purpose

The purpose of this test is to determine the interference rejection, $I_{Rejection}$, ability of the tag.

8.5.2 Test procedure

8.5.2.1 General

For the frequencies 865 MHz and 915, the interferer power shall be increased relative to the desired electromagnetic field until the tag can no longer demodulate the desired generator command. For this test, the test setup described in subclause 6.3.1.5 is used.

8.5.2.2 Continuous wave (CW) interference rejection

1) The desired generator shall be set to the required operating frequency.

2) The desired generator waveform amplitude shall be set to the value of P_{Min}.

3) The interferer generator shall be set to the operating frequency +/-0 Hz frequency offset.

4) The interferer generator amplitude shall be set to a value below identification magnetic field threshold, which is typically zero.

5) The tag shall be inserted in the test equipment.

6) The interferer generator amplitude shall emit a CW signal at increasing amplitude until the tag can no longer demodulate the desired generator command.

7) The interferer power shall be calculated by use of the interferer generator amplitude. The interference rejection is the difference between the interference power and the minimum operating power: $I_{Rejection} = P_{Rejection} - P_{Min}$.

8) Steps 3) to 7) shall be repeated for the interferer frequency offsets +/- 200 kHz, +/- 400 kHz, +/- 500 kHz, +/- 600 kHz, +/- 800 kHz, +/- 1000 kHz and +/- 1200 kHz.

8.5.2.3 Modulated interference rejection

1) The desired generator shall be set to the required operating frequency.

2) The desired generator waveform amplitude shall be set to 6 dB above the value of P_{Min}.

3) The interferer generator shall be set to the operating frequency +/-0 Hz frequency offset using the same coding.

4) The interferer generator amplitude shall be set to a value below P_{Min}, which is typically zero.

5) The tag shall be inserted in the test equipment.

6) The interferer generator amplitude shall send an appropriate command at increasing or decreasing amplitude in 0,25 dB steps until the tag replies to 50 % (40 %-60 %) of the desired generator command at the given amplitude level.

7) The interferer power shall be calculated by use of the interferer generator amplitude.

8) Steps 3) to 7) shall be repeated for the interferer frequency offset +/- 200 kHz, +/- 400 kHz, +/- 500 kHz, +/- 600 kHz, +/- 800 kHz, +/- 1000 kHz and +/- 1200 kHz.

8.5.3 Test report

The test report shall give the interferer electromagnetic field strength for each frequency offset for 865 MHz and 915 MHz, plus the environment conditions and communication parameters. All of these parameters shall be recorded according to the example in Table 7.

Table 7 — Parameters recorded $I_{Rejection}$ measurement (Examples for ISO/IEC 18000-63 are shown Italics)

Test: Interference rejection ($I_{Rejection}$)		
Mounting Material: *paper*		
Temperature: *23 °C*	Humidity: *50 %*	
Tag Protocol: ISO/IEC 18000-63	Identifier: *UII: 0x3012 3456 7890 ABCD 0123 4567 89AB CDEF* *TID: 0xE000 0123 4567 89AB*	
Forward Link		
Modulation index: *90 %* Modultion type: *PR-ASK*	Data rate information: *Tari = 12,5 µs* *Tari-1 = 1,5 Tari-*	Data coding: *PIE*
Command(s) including time between commands: *Select (01b1010, Target=000, Action=000, MemBank=10, Pointer=0, Length=0, Mask=empty, Truncate=0)* *T4 = 1 ms* *Query (0b1000, DR=64/3, M=4, TRext=1, Sel=00, Session=00, Target=A, Q=0)*		
Return Link		
Data rate: kbps *RTcal = 2,5 Tari* *TRcal = 2,133 TRcal*	Data coding: *M=4*	
Test Results		
Interferer frequency Offset (kHz)	**CW $I_{Rejection}$**	**Modulated $I_{Rejection}$**
- 1 200		
- 1 000		
- 800		
- 400		
- 200		
0		
+ 200		
+ 400		
+ 500		
+ 600		
+ 800		
+ 1 000		
+ 1 200		
NOTE: Examples for ISO/IEC 18000-63 are shown in italics.		

8.6 Maximum fade rate ($P_{Min,Fade}$)

8.6.1 Purpose

The purpose of this test is to determine the maximum fade rate that a tag can tolerate during identification.

8.6.2 Test procedure

For the test frequencies 865 MHz and 915 MHz the RF field is modulated with an increasing triangle wave modulation rate, until the tag stops responding (see Figure 5).

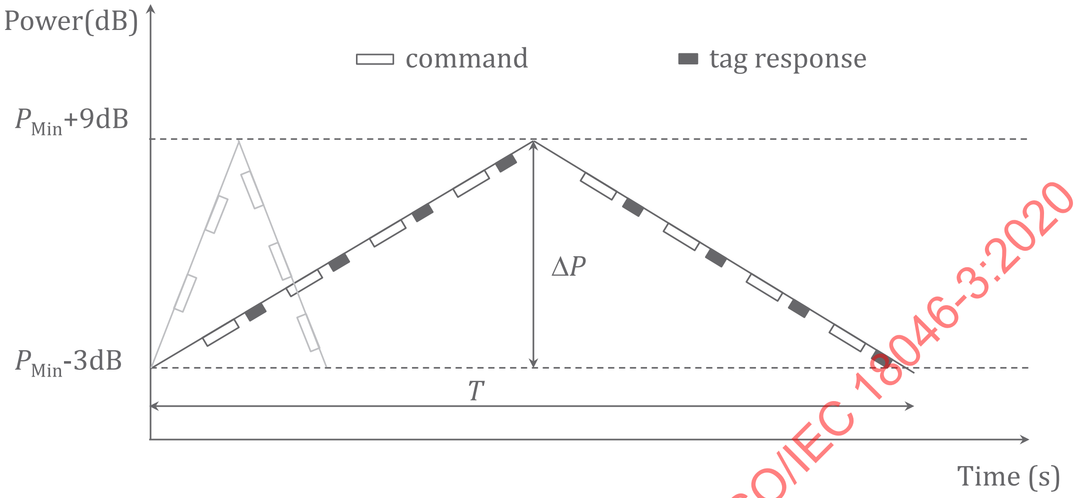


Figure 5 — Fade rate measurement

Fade rate (FR) (in dBm/s) is calculated using Formula (2) as follows:

$$FR = \frac{\Delta P}{T/2} = 2.\Delta P.F \quad (2)$$

where

- ΔP is the field power variation in dBm
- T is the period time in seconds
- F is the frequency in Hz

Identification fade rate measurement procedure:

1) The waveform generator shall be set to the required operating frequency.

2) The waveform generator amplitude shall be set to be 3 dB above the tag's minimum power operation threshold P_{Min} and the maximum waveform generator amplitude shall be set to 9 dB above the tag's minimum power operation threshold P_{Min}.

3) The tag shall be inserted in the test equipment.

4) The defined commands, which shall be selected according to Table 2, shall be sent continuously using a code generator.

5) The data transfer shall be verified by comparison with the respective command reply according to the selected standard. If the tag response is wrong, step 4) shall be repeated with higher amplitude. In order to reduce the measurement time a binary search using values above and below the expected result may also be applied.

6) The amplitude envelope shall be modulated, as described in step 2), using triangle-wave modulation, from 0 Hz to the frequency at which the tag stops responding. The triangle-wave modulation frequency shall be recorded.

7) The maximum fade rate, $P_{Min,Fade}$, shall be calculated by use of the triangle-wave envelope's frequency.

8.6.3 Test report

The test report shall give the measured fade rate for the selected frequencies. Allparameters shall be recorded according to the example in Table 8.

Table 8 — Parameters recorded for maximum fade rate measurement (Examples for ISO/IEC 18000-63 are shown Italics)

Test: Maximum fade rate ($P_{Min,Fade}$)		
Mounting Material: *paper*		
Temperature: *23 °C*	Humidity: *50 %*	
Tag Protocol: ISO/IEC 18000-63	Identifier: *UII: 0x3012 3456 7890 ABCD 0123 4567 89AB CDEF* *TID: 0xE000 0123 4567 89AB*	
Forward Link		
Modulation index: *90 %* Modultion type: *PR-ASK*	Data rate information: *Tari = 12,5 µs* *Tari-1 = 1,5 Tari-*	Data coding: *PIE*
Command(s) including time between commands: *Select (01b1010, Target=000, Action=000, MemBank=10, Pointer=0, Length=0, Mask=empty, Truncate=0)* *T4 = 1 ms* *Query (0b1000, DR=64/3, M=4, TRext=1, Sel=00, Session=00, Target=A, Q=0)*		
Return Link		
Data rate: kbps *RTcal = 2,5 Tari* *TRcal = 2,133 TRcal*	Data coding: *M=4*	
Test Results		
Frequency (MHz)	**Triangle wave modulation frequency**	**Power fade rate**
865	**xx Hz**	**V / ms**
915	**xx,xx dB**	**...**
NOTE: Examples for ISO/IEC 18000-63 are shown in italics.		

9 Functional tests for 433,920 MHz propagative tags as defined in ISO/IEC 18000-7

9.1 Identification electromagnetic field threshold ($E_{THR\ Identification}$) and frequency tolerance

9.1.1 Purpose

This test determines the electromagnetic field threshold, $E_{THR\ Identification}$, level required for tag identification when using an ISO/IEC 18000-7 reader functioning in Master-Slave mode (Interrogator Talks First or ITF).

The identification electromagnetic field threshold, $E_{THR\ Identification}$, is the minimum electromagnetic field that allows a tag to be identified.

9.1.2 Test procedure

The specification for ISO/IEC 18000-7 tags and readers specifies an operating frequency of 433,920 MHz (±20 ppm), which is approximately ±8,7 kHz. Since both the reader and the tag may be shifted by 20 ppm, and potentially in opposite directions, the system must function within ±40 ppm (approximately

17,4 kHz) of the nominal centre frequency. For convenience in setting up the signal generator, use a centre frequency low of 433,900 MHz, nominal of 433,920 MHz, and a high of 433,940 MHz for the following tests.

Identification electromagnetic field threshold, $E_{\text{THR Identification}}$, measurement procedure:

1) Set up all test equipment in an anechoic chamber or another fully characterized and controlled location free from interference sources and propagation influences, such as significant signal reflections, absorptions, or blockages.

   Tests should be run using a known reference antenna attached to the signal source and receiver.

   The recommended test distance between the tag's location and the reference antenna should be 2 metres, minimum, with 3 metres preferred.

2) Set a signal source to transmit FSK with a 433,920 MHz centre frequency, using FSK modulation at ±50 kHz with waveforms and timings as specified in ISO/IEC 18000-7. The signal source's output level must be adjustable over a 100 dB range in 10 dB steps, with at least 10 dBm available as the maximum output.

   As a modulator for this signal source, use a code generator calibrated to properly generate relevant command sequences and timing.

   The generator shall be set up so that the following conditions exist when modulated:

   Symbol LOW = f_c +50 kHz (433,970 when centred at 433,920 MHz)

   Symbol HIGH = f_c -50 kHz (433,870 MHz when centred at 433,920 MHz)

3) Use an FSK receiver and decoder to receive, decode, and send tag responses to appropriate monitoring software so tag responses can be evaluated. Synchronize the decoder with the code generator so all protocol timing can be maintained within correct relationships.

4) Mount the tag being evaluated on a minimum 50 cm x 50 cm metal sheet reflector for this test, attached in the mounting configuration specified for the specific tag model being evaluated. Orient the tag so its main response is facing the source signal.

5) Alternatively, depending on expected tag usage, the tag can be placed on a non-metallic mounting plate or pole, or attached in the mounting configuration specified for the tag model being evaluated.

6) Adjust the signal source for minimum output, then send a Wakeup Header command followed immediately by a Collect command as defined in ISO/IEC 18000-7. Adjust the signal source until the tag under test responds reliably.

7) Record data for the tag when mounted vertically, then when horizontally polarized.

8) Repeat steps 6) and 7) after increasing the centre frequency to 433,940 MHz.

9) Repeat steps 6) and 7) after decreasing the centre frequency to 433,900 MHz.

10) Perform the measurements in steps 6) and 7) on all tags. The $E_{\text{THR Identification}}$ value is the greatest electromagnetic field strength noted out of all measurements.

If one tag is clearly lower in sensitivity than all others—requires more signal before it will respond—it should be removed from the tests and replaced with another tag.

9.1.3 Test report

The test report provides data recorded for the system's low, nominal, and high tolerance limits. Record the environmental conditions and communication parameters according to the example in Table 9.

Table 9 — Parameters recorded for $E_{THR\ Identification}$ measurement

Test: Identification electromagnetic field threshold ($E_{THR\ Identification}$) at centre frequency and +/-40 ppm		
Mounting Material:		
Temperature:	Humidity:	
Tag Protocol:	Tag UII:	
Forward Link		
Deviation (kHz):	Data Rate: kbps	Data Coding:
Command: Wakeup followed by Collect command		
Return Link		
Data Rate: kbps	Data Coding:	
Test Results		
Centre Frequency	**f_c −40 ppm**	**f_c +40 ppm**
xxx MHz	**xxx MHz**	**xxx MHz**
$E_{THR\ Identification}$: xx,xx dBuV/m	**$E_{THR\ Identification}$: xx,xx dBuV/m**	**$E_{THR\ Identification}$: xx,xx dBuV/m**
ID:	**ID:**	**ID:**

9.2 Reading electromagnetic field threshold ($E_{THR\ Read}$) and frequency tolerance

9.2.1 Purpose

This test determines the electromagnetic field threshold level that allows a tag reading. To successfully read tag data, transmit the command correctly, with enough energy available to read the tag. The reading electromagnetic field threshold, $E_{THR\ Read}$, is the minimum electromagnetic field that allows tag reading.

9.2.2 Test procedure

Run the tests at 433,920 MHz, nominal, then at 433,900 MHz (-40 ppm) and 433,940 MHz (+40 ppm). Set the signal source's electromagnetic field below the level that allows a tag to respond to a command, then increase the field to a level where it is possible to read the tag's ID and memory contents.

For this test, use user memory or, if this is not available, any other memory that is not the UII memory.

The specification for ISO/IEC 18000-7 tags and readers specifies an operating frequency of 433,920 MHz (±20 ppm), which is approximately ±8,7 kHz. Since both the reader and the tag may be shifted by 20 ppm and potentially in opposite directions, the system must function within ±40 ppm (approximately 17,4 kHz) of the nominal centre frequency.

For convenience in setting up the signal source, use a low frequency of 433,900 MHz, nominal centre frequency of 433,920 MHz, and a high frequency of 433,940 MHz for the following tests.

Reading electromagnetic field threshold, $E_{THR\ Read}$, measurement procedure:

1) Set up all test equipment in an anechoic chamber or some other fully characterized and controlled location free from interference sources and propagation influences, such as significant signal reflections, absorptions, or blockages.

   Tests should be run using a known reference antenna attached to the signal source and receiver.

   Recommended test distance between the tag's location and the reference antenna should be 2 metres, minimum, with 3 metres preferred.

2) Set a signal source to transmit FSK with a 433,920 MHz centre frequency, using FSK modulation at ±50 kHz with waveforms and timings as specified in ISO/IEC 18000-7. The signal source's output

level must be adjustable over a 100 dB range in 10 dB steps, with at least 10 dBm available as the maximum output.

Use a code generator calibrated to properly generate relevant command sequences and timing as a modulator for this signal source.

The generator shall be set up so the following conditions exist when modulated:

Symbol LOW = f_c +50 kHz (433,970 MHz when centred at 433,920 MHz)

Symbol HIGH = f_c -50 kHz (433,870 MHz when centred at 433,920 MHz)

3) Use an FSK receiver and decoder to receive, decode, and send tag responses to appropriate monitoring software so tag responses can be evaluated. Synchronize the decoder with the code generator so all protocol timing can be maintained within correct relationships.

4) Mount the tag being evaluated on a minimum 50 x 50 cm metal sheet reflector for this test, attached in the mounting configuration specified for the specific tag model being evaluated. Orient the tag so its main response is facing the source signal.

5) Alternatively, depending on expected tag usage, the tag can be placed on a non-metallic mounting plate or pole, or attached in the mounting configuration specified for the tag model being evaluated.

6) Adjust the signal source for minimum output, then send a Wakeup Header command followed immediately by a Collect With Data command as defined in 18000-7. Adjust the signal source until the tag under test responds reliably.

7) Record the data for the tag when mounted vertically, then when horizontally polarized.

8) Repeat steps 6) and 7) after increasing the centre frequency to 433,940 MHz.

9) Repeat steps 6) and 7) after decreasing the centre frequency to 433,900 MHz.

10) Measure all tags. The $E_{\text{THR Read}}$ value is the greatest electromagnetic field strength noted out of all measurements.

If one tag is clearly lower in sensitivity than all others—requires more signal before it will respond—it should be removed from the tests and replaced with another tag.

9.2.3 Test report

The test report provides data recorded for the system's low, nominal, and high tolerance limits. Record the environmental conditions and communication parameters according to the example in Table 10.

Table 10 — Parameters recorded for $E_{\text{THR Read}}$ measurement

Test: Reading electromagnetic field threshold ($E_{\text{THR Read}}$) at centre frequency and ±40 ppm		
Mounting Material:		
Temperature:	Humidity:	
Tag Protocol:	Tag UII:	
Forward Link		
Deviation (kHz):	Data Rate: kbps	Data Coding:
Command: Wakeup followed by Collect With Data command		
Return Link		
Data Rate: kbps	Data Coding:	
Test Results		
Centre Frequency	f_c **−40 ppm**	f_c **+40 ppm**
xxx MHz	**xxx MHz**	**xxx MHz**
$E_{\text{THR Read}}$: **xx,xx dBuV/m**	$E_{\text{THR Read}}$: **xx,xx dBuV/m**	$E_{\text{THR Read}}$: **xx,xx dBuV/m**
ID & Data:	**ID & Data:**	**ID & Data:**

9.3 Writing electromagnetic field threshold ($E_{\text{THR Write}}$)

9.3.1 Purpose

This test determines the electromagnetic field threshold level that allows a tag write operation. To successfully write data into the tag, data is to be transmitted correctly, with enough energy available during the memory access. The writing electromagnetic field threshold ($E_{\text{THR Write}}$) is the minimum electromagnetic field allowing a tag write operation.

9.3.2 Test procedure

Run tests at 433,920 MHz, nominal, and at 433,900 MHz (-40 ppm) and 433,940 MHz (+40 ppm). Set the signal source's electromagnetic field below the level that allows a tag to respond to a command to a level where it is possible to write the tag's memory.

For this test, use user memory or, if this is not available, any other memory that is not the UII memory.

Writing electromagnetic field threshold, $E_{\text{THR Write}}$, measurement procedure:

1) Set up all test equipment in an anechoic chamber or some other fully characterized and controlled location free from interference sources and propagation influences, such as significant signal reflections, absorptions, or blockages.

   Tests should be run using a known reference antenna attached to the signal source and receiver.

   Recommended test distance between the tag's location and the reference antenna should be 2 metres, minimum, with 3 metres preferred.

2) Set a signal source to transmit FSK with a 433,920 MHz centre frequency, using FSK modulation at ±50 kHz with waveforms and timings as specified in ISO/IEC 18000-7. The signal source's output level must be adjustable over a 100 dB range in 10 dB steps, with at least 10 dBm available as the maximum output.

   As a modulator for this signal source, use a code generator calibrated to properly generate relevant command sequences and timing.

   The generator shall be set up so the following conditions exist when modulated:

   Symbol LOW = f_c +50 kHz (433,970 MHz when centred at 433,920 MHz)

Symbol HIGH = f_c -50 kHz (433,870 MHz when centred at 433,920 MHz)

3) Use an FSK receiver and decoder to receive, decode, and send tag responses to appropriate monitoring software so tag responses can be evaluated. Synchronize the decoder with the code generator so all protocol timing can be maintained within correct relationships.

4) Mount the tag being evaluated on a minimum 50 x 50 cm metal sheet reflector for this test, attached in the mounting configuration specified for the specific tag model being evaluated. Orient the tag so its main response is facing the source signal.

5) Alternatively, depending on expected tag usage, the tag can be placed on a non-metallic mounting plate or pole, or attached in the mounting configuration specified for the tag model being evaluated.

6) Adjust the signal source for minimum output, then send a Wakeup Header command followed immediately by a Write command as defined in ISO/IEC 18000-7. Adjust the signal source until the tag under test responds reliably.

7) Record the data for the tag when mounted vertically, then when horizontally polarized.

8) Repeat steps 6) and 7) after increasing the centre frequency to 433,940 MHz.

9) Repeat steps 6) and 7) after decreasing the centre frequency to 433,900 MHz.

10) Measure all tags. The $E_{\text{THR Write}}$ value is the greatest electromagnetic field strength noted out of all measurements.

NOTE If one tag is clearly lower in sensitivity than all others—requires more signal before it will respond—it can be removed from the tests and replaced with another tag.

9.3.3 Test report

The test report provides data recorded for the system's low, nominal, and high tolerance limits. Record the environmental conditions and communication parameters according to the example in Table 11.

Table 11 — Parameters recorded for $E_{\text{THR Write}}$ measurement

Test: Writing electromagnetic field threshold ($E_{\text{THR Write}}$) at centre frequency and ±40 ppm		
Mounting Material:		
Temperature:	Humidity:	
Tag Protocol:	Tag UII:	
Forward Link		
Deviation (kHz):	Data Rate: kbps	Data Coding:
Command: Wakeup followed by Write command		
Return Link		
Data Rate: kbps	Data Coding:	
Test Results		
Centre Frequency	**f_c – 40ppm**	**f_c +40ppm**
xxx MHz	**xxx MHz**	**xxx MHz**
$E_{\text{THR Write}}$ **xx,xx dBuV/m**	$E_{\text{THR Write}}$ **xx,xx dBuV/m**	$E_{\text{THR Write}}$ **xx,xx dBuV/m**

9.4 Sensitivity Directivity ($S_{\text{Directivity}}$)

9.4.1 Purpose

This test determines the tag's sensitivity to various orientations, such as azimuth and elevation (see Figure 6). This is a determination of the directivity of the tag. Determine the directivity under all conditions for which the tag is designed. This may include the tag being mounted on a metal surface (a reflector of 50 x 50 cm being representative) or on a non-metallic object, such as a cardboard box or wooden post.

9.4.2 Test procedure

Run tests at 433,920 MHz, nominal. Set the signal source's electromagnetic field below the level that allows a tag to respond to a Wakeup/Collect command, then raise the field to a level where the tag responds reliably to a Wakeup/Collect command.

Rotate the tag in 15° increments. Record the level that is then required for a reliable Wakeup/Collect command to get reliable responses from the tag at 0°, 15°, 30°, 45°, 60°, 75°, 90°, 105°, 120°, 135°, 150°, 165°, 180°, 195°, 210°, 225°, 240°, 255°, 270°, 285°, 300°, 315°, 330° and 345°. However, if the tag is mounted on a metal plate, only 0°–90° and 315°–345° levels need to be taken.

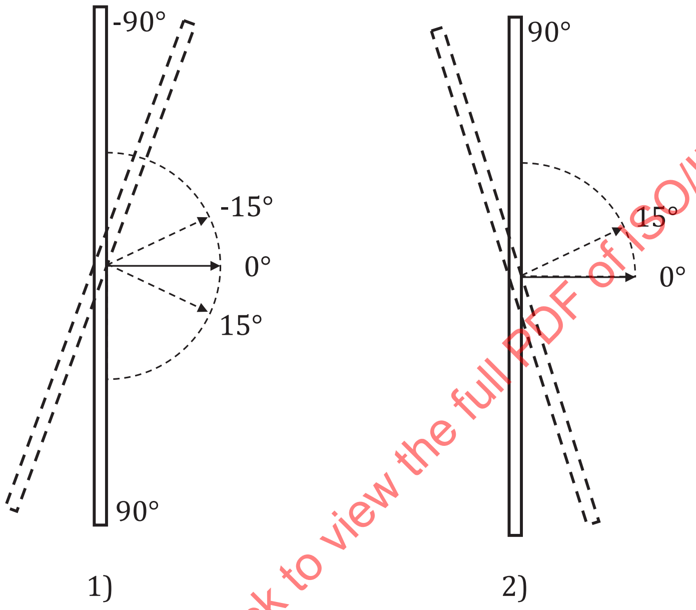


Figure 6 — Azimuth and elevation pattern

In Figure 6, 1) represents the top view (azimuth pattern) and 2) represents the side view (elevation pattern)

Sensitivity Directivity, $S_{Directivity}$, measurement procedure:

1) Set up all test equipment in an anechoic chamber or some other fully characterized and controlled location free from interference sources and propagation influences, such as significant signal reflections, absorptions, or blockages. This is particularly important when measuring tag patterns since any reflections will distort the pattern measurement.

   Tests should be run using a known reference antenna attached to the signal source and receiver.

   Recommended test distance between the tag's location and the reference antenna should be 2 metres, minimum, with 3 metres preferred.

2) Set a signal source to transmit FSK with a 433,920 MHz centre frequency, using FSK modulation at ±50 kHz with waveforms and timings as specified in ISO/IEC 18000-7. The signal source's output level must be adjustable over a 100 dB range in 10 dB steps, with at least 10 dBm available as the maximum output.

   Use a code generator calibrated to properly generate relevant command sequences and timing as a modulator for this signal source.

   The generator shall be set up so the following conditions exist when modulated:

   Symbol LOW = f_c +50 kHz (433,970 MHz when centred at 433,920 MHz)

   Symbol HIGH = f_c -50 kHz (433,870 MHz when centred at 433,920 MHz)

3) Use an FSK receiver and decoder to receive, decode, and send tag responses to appropriate monitoring software so tag responses can be evaluated. Synchronize the decoder with the code generator so all protocol timing can be maintained within correct relationships.

4) Mount the tag being evaluated on a minimum 50 x 50 cm metal sheet reflector for this test, attached in the mounting configuration specified for the specific tag model being evaluated. Orient the tag so its main response is facing the source signal. If mounted on a metal sheet, only ±90° from zero reference between tag and reader needs to be evaluated.

5) Alternatively, depending on expected tag usage, the tag can be placed on a non-metallic mounting plate or pole, or attached in the mounting configuration specified for the tag model being evaluated. If used in this manner, take a full 360° pattern.

6) Adjust the signal source for minimum output, then send a Wakeup Header command followed immediately by a Collect command as defined in ISO/IEC 18000-7. Adjust the signal source until the tag under test responds reliably.

7) Record the data for the tag when mounted vertically, then when horizontally polarized.

8) Repeat steps 6) and 7), rotating the azimuth by 15° until data has been taken for 0°, 15°, 30°, 45°, 60°, 75°, 90°, 105°, 120°, 135°, 150°, 165°, 180°, 195°, 210°, 225°, 240°, 255°, 270°, 285°, 300°, 315°, 330° and 345°, while elevation remains at 0°.

   If a metal mounting plate has been used to mount the tag, measurements can be restricted to 0°–90° then 270°–345°, since radiation between 105°–255° will be blocked by the metal mounting surface.

9) Repeat steps 6) and 7), rotating the elevation by 15° until data has been taken for 0°, 15°, 30°, 45°, 60°, 75° and 90°, while azimuth remains at 0°.

10) Measure all tags. The $S_{\text{Directivity}}$ value is the greatest electromagnetic field strength noted out of all measurements.

9.4.3 Test report

The test report gives for each angle the $S_{\text{Directivity}}$ values and curves (E versus azimuth and E versus elevation), plus all environmental conditions and communication parameters. Record all these parameters according to the example in Table 12.

Table 12 — Parameters recorded for $S_{Directivity}$ measurement

Test: Sensitivity directivity ($S_{Directivity}$)						
Mounting Material:						
Temperature:	Humidity:					
Tag Protocol:	Tag UII:					
Forward Link						
Modulation Index: %	Data Rate: kbps	Data Coding:				
Command: 0x						
Return Link						
Data Rate: kbps	Data Coding:					
Test Results						
$E_{(dBuV/m)}$ **vs. Azimuth**	-15°:	-30°:	-45°:	-60°:	-75°:	-90°:
$E_{(dBuV/m)}$ **vs. Azimuth**	15°:	30°:	45°:	60°:	75°:	90°:
$E_{(dBuV/m)}$ **vs. Elevation**	15°:	30°:	45°:	60°:	75°:	90°:
$S_{Directivity}$ **versus Azimuth curve:**	$S_{Directivity}$ **versus Elevation curve:**					

9.5 Interference rejection ($I_{Rejection}$)

9.5.1 Purpose

This test determines the interference rejection ability of the tag.

9.5.2 Test procedure

9.5.2.1 General

A tag is placed in the test setup, and the signal source's level is set to 3 dB above $E_{THR\ Read}$ so that the tag is responding to all Wakeup plus Collect commands with its ID.

A second, unmodulated signal source at 433,920 MHz is set to a level 20 dB below the $E_{THR\ Read}$ level, then the level is increased until the tag no longer responds to the Wakeup plus Collect commands. This is considered the tag's On Channel $I_{Rejection}$ level. This is repeated for the 1st adjacent channel (±250 kHz) and 2nd adjacent channel (±500 kHz).

9.5.2.2 Unmodulated interference rejection:

1) Set up all test equipment in an anechoic chamber or some other fully characterized and controlled location free from interference sources and propagation influences, such as significant signal reflections, absorptions, or blockages.

   Tests should be run using two identical reference antennae attached to two signal sources, with one antenna also connected to a receiver.

The recommended test distance between the tag's location and the source antennae should be 2 metres, minimum, with 3 metres preferred. The two antennae should be equal in gain and separated from each other by at least one wavelength to reduce interactions between them.

2) Set a signal source to transmit FSK with a 433,920 MHz centre frequency, using FSK modulation at ±50 kHz with waveforms and timings as specified in ISO/IEC 18000-7. The signal source's output level must be adjustable to the $E_{\mathrm{THR\ Read}}$ level +3 dB.

   Use a code generator calibrated to properly generate relevant command sequences and timing as a modulator for this signal source.

   The generator shall be set up so the following conditions exist when modulated:

   Symbol LOW = f_c +50 kHz (433,970 MHz when centred at 433,920 MHz)

   Symbol HIGH = f_c -50 kHz (433,870 MHz when centred at 433,920 MHz)

3) Use an FSK receiver and decoder to receive, decode, and send tag responses to appropriate monitoring software so tag responses can be evaluated. Synchronize the decoder with the code generator so all protocol timing can be maintained within correct relationships.

4) Mount the tag being evaluated on a minimum 50 x 50 cm metal sheet reflector for this test, attached in the mounting configuration specified for the specific tag model being evaluated. Orient the tag so its main response is facing the source signal.

5) Alternatively, depending on expected tag usage, the tag can be placed on a non-metallic mounting plate or pole, or attached in the mounting configuration specified for the tag model being evaluated.

6) Adjust the signal source for minimum output, then send a Wakeup Header command followed immediately by a Collect command as defined in ISO/IEC 18000-7. Adjust the signal source until the tag under test responds reliably ($E_{\mathrm{THR\ Read}}$), then increase the signal by 3 dB.

7) Adjust the second unmodulated signal source to 433,920 MHz. Set the level to 20 dB below the $E_{\mathrm{THR\ Read}}$ level set in step 6).

8) Adjust the second generator to the level at which the tag no longer responds to the Wakeup plus Collect commands from the 1st generator. This is considered the tag's Co-Channel $I_{\mathrm{Rejection}}$ level. Record this value in Table 13.

9) Adjust the second unmodulated signal source to 433,920 MHz + 250 kHz (434,170 MHz). Set the level to 20 dB below the $E_{\mathrm{THR\ Read}}$ level set in step 6).

10) Adjust the second generator to the level at which the tag no longer responds to the Wakeup plus Collect commands from the 1st generator. This is considered the tag's upper 1st Adjacent Channel $I_{\mathrm{Rejection}}$ level. Record this value in Table 13.

11) Adjust the second unmodulated signal source to 433,920 MHz − 250 kHz (433,670 MHz). Set the level to 20 dB below the $E_{\mathrm{THR\ Read}}$ level set in step 6).

12) Adjust the second generator to the level at which the tag no longer responds to the Wakeup plus Collect commands from the 1st generator. This is considered the tag's lower 1st Adjacent Channel $I_{\mathrm{Rejection}}$ level. Record this value in Table 13.

13) Adjust the second unmodulated signal source to 433,920 MHz + 500 kHz (434,420 MHz). Set the level to 20 dB below the $E_{\mathrm{THR\ Read}}$ level set in step 6).

14) Adjust the second generator to the level at which the tag no longer responds to the Wakeup plus Collect commands from the 1st generator. This is considered the tag's upper 2nd Adjacent Channel $I_{\mathrm{Rejection}}$ level. Record this value in Table 13.

15) Adjust the second unmodulated signal source to 433,920 MHz − 500 kHz (433,470 MHz). Set the level to 20 dB below the $E_{\mathrm{THR\ Read}}$ level set in step 6).

16) Adjust the second generator to the level at which the tag no longer responds to the Wakeup plus Collect commands from the 1st generator. This is considered the tag's lower 2nd Adjacent Channel $I_{Rejection}$ level. Record this value in Table 13.

9.5.2.3 Modulated interference rejection

1) Set up all test equipment in an anechoic chamber or some other fully characterized and controlled location free from interference sources and propagation influences, such as significant signal reflections, absorptions, or blockages.

   Tests should be run using two identical reference antennae attached to two signal sources, with one antenna also connected to a receiver.

   Recommended test distance between the tag's location and the source antennae should be 2 metres, minimum, with 3 metres preferred. The two antennae should be equal in gain and separated from each other by at least one wavelength to reduce interactions between them.

2) Set signal source 1 to transmit FSK with a 433,920 MHz centre frequency, using FSK modulation at ±50 kHz with waveforms and timings as specified in ISO/IEC 18000-7. The signal source's output level must be adjustable to the $E_{THR\ Read}$ level +3 dB.

   Use a code generator calibrated to properly generate relevant command sequences and timing as a modulator for this signal source.

   The generator shall be set up so the following conditions exist when modulated:

   Symbol LOW = f_c +50 kHz (433,970 MHz when centred at 433,920 MHz)

   Symbol HIGH = f_c -50 kHz (433,870 MHz when centred at 433,920 MHz)

3) Use an FSK receiver and decoder to receive, decode, and send tag responses to appropriate monitoring software so tag responses can be evaluated. Synchronize the decoder with the code generator so all protocol timing can be maintained within correct relationships.

4) Mount the tag being evaluated on a minimum 50 x 50 cm metal sheet reflector for this test, attached in the mounting configuration specified for the specific tag model being evaluated. Orient the tag so its main response is facing the source signal.

5) Alternatively, depending on expected tag usage, the tag can be placed on a non-metallic mounting plate or pole, or attached in the mounting configuration specified for the tag model being evaluated.

6) Adjust the signal source for minimum output, then send a Wakeup Header command followed immediately by a Collect command as defined in ISO/IEC 18000-7. Adjust the signal source until the tag under test responds reliably ($E_{THR\ Read}$), then increase the signal by 3 dB.

7) Adjust the second modulated signal source to 433,920 MHz. Set the level to 20 dB below the $E_{THR\ Read}$ level set in step 6).

8) Adjust the second generator to the level at which the tag no longer responds to the Wakeup plus Collect commands from the 1st generator This is considered the tag's Co-Channel $I_{Rejection}$ level. Record this value in Table 13.

9) Adjust the second modulated signal source to 433,920 MHz + 250 kHz (434,170 MHz). Set the level to 20 dB below the $E_{THR\ Read}$ level set in step 6).

10) Adjust the second generator to the level at which the tag no longer responds to the Wakeup plus Collect commands from the 1st generator. This is considered the tag's upper 1st Adjacent Channel $I_{Rejection}$ level. Record this value in Table 13.

11) Adjust the second modulated signal source to 433,920 MHz – 250 kHz (433,670 MHz). Set the level to 20 dB below the $E_{THR\ Read}$ level set in step 6).

12) Adjust the second generator to the level at which the tag no longer responds to the Wakeup plus Collect commands from the 1st generator. This is considered the tag's lower 1st Adjacent Channel $I_{Rejection}$ level. Record this value in Table 13.

13) Adjust the second modulated signal source to 433,920 MHz + 500 kHz (434,420 MHz). Set the level to 20 dB below the $E_{THR\ Read}$ level set in step 6).

14) Adjust the second generator to the level at which the tag no longer responds to the Wakeup plus Collect commands from the 1st generator. This is considered the tag's upper 2nd Adjacent Channel $I_{Rejection}$ level. Record this value in Table 13.

15) Adjust the second modulated signal source to 433,920 MHz − 500 kHz (433,470 MHz). Set the level to 20 dB below the $E_{THR\ Read}$ level set in step 6).

16) Adjust the second generator to the level at which the tag no longer responds to the Wakeup plus Collect commands from the 1st generator. This is considered the tag's lower 2nd Adjacent Channel $I_{Rejection}$ level. Record this value in Table 13.

Measure all tags. The interferer electromagnetic field value recorded is the smallest one of all measurements done.

9.5.3 Test report

The test report provides data for On Channel, 1st Adjacent Channel (±250 kHz), and 2nd Adjacent (±500 kHz) channels, plus all environmental conditions and communication parameters. Record all these parameters according to the example in Table 13.

Table 13 — Parameters recorded for $I_{Rejection}$ measurement

Test: Interference rejection ($I_{Rejection}$)					
Mounting Material:					
Temperature:	Humidity:				
Tag Protocol:	Tag UII:				
Forward Link					
Modulation Index: %	Data Rate: kbps		Data Coding:		
Command: 0x					
Return Link					
Data Rate: kbps	Data Coding:				
Test Results					
Interferer Frequency Offset	**0 Hz**	**250 khz**	**-250 kHz**	**500 kHz**	**-500 kHz**
CW Interference Rejection					
Modulated Interference Rejection					

9.6 Maximum operating electromagnetic field (E_{Max})

9.6.1 Purpose

This test determines the maximum electromagnetic field (E_{Max}) that still allows tag identification.

9.6.2 Test procedure

Run the tests at 433,920 MHz, nominal. First, set the signal source's electromagnetic field to a level that allows a tag to respond to a command in order to confirm that it operates correctly. The signal level will then be raised to a level where the tag ceases to respond to commands or to the full signal level available from the test source, whichever comes first.

Maximum operating electromagnetic field, E_{Max}, measurement procedure:

1) Set up all test equipment in an anechoic chamber or some other fully characterized and controlled location free from interference sources and propagation influences, such as significant signal reflections, absorptions, or blockages.

   Tests should be run using a known reference antenna attached to the signal source and receiver.

   Recommended test distance between the tag's location and the source antenna should be 2 metres, maximum, with 1 metre preferred.

   Set a signal source to transmit FSK with a 433,920 MHz centre frequency, using FSK modulation at ±50 kHz with waveforms and timings as specified in ISO/IEC 18000-7. The signal source's output level must be adjustable over a 100 dB range in 10 dB steps, with at least 10 dBm available as the maximum output.

   It may be necessary to add a power amplifier, with up to 10 watts output, between the signal source and the antenna to obtain sufficient signal strength to overload the tag.

   Any relay or duplexer used to isolate the signal source from the receiver used in these tests must have sufficient isolation and power handling capacity to handle this power level.

   Use a code generator calibrated to properly generate relevant command sequences and timing as a modulator for this signal source.

   The signal source should be set up so the following conditions exist when modulated:

   Symbol LOW = f_c +50 kHz (433,970 MHz when centred at 433,920 MHz)

   Symbol HIGH = f_c -50 kHz (433,870 MHz when centred at 433,920 MHz)

2) Use an FSK receiver and decoder to receive, decode, and send tag responses to appropriate monitoring software so tag responses can be evaluated. Synchronize the decoder with the code generator so all protocol timing can be maintained within correct relationships.

3) Mount the tag being evaluated on a minimum 50 x 50 cm metal sheet reflector for this test, attached in the mounting configuration specified for the specific tag model being evaluated. Orient the tag so its main response is facing the source signal.

4) Alternatively, depending on expected tag usage, the tag can be placed on a non-metallic mounting plate or pole, or attached in the mounting configuration specified for the tag model being evaluated.

5) Adjust the signal source for minimum output, then send a Wakeup Header command followed immediately by a Collect command as defined in ISO/IEC 18000-7. Adjust the signal source until the tag under test responds reliably.

6) Adjust the signal source level for maximum output, then send a Wakeup Header command followed immediately by a Collect command as defined in ISO/IEC 18000-7.

7) If the tag responds, record this level as E_{Max} for the tag. If the tag does not respond, lower the source level until the tag begins to respond once again, and record this level as E_{Max}. Test with the tag mounted vertically, then when horizontally polarized.

8) Measure all tags. The E_{Max} value is the lowest electromagnetic field strength noted that causes the tag to cease to respond properly out of all measurements made during these tests.

NOTE If one tag is clearly lower in overload capacity than all others—requires less signal before it ceases to respond—it can be removed from the tests and replaced with another tag.

9.6.3 Test report

The test report provides data recorded for the tags. Record the environmental conditions and communication parameters. Record all parameters according to the example in Table 14.

Table 14 — Parameters recorded for E_{Max} measurement

Test: Maximum operating electromagnetic field (E_{Max}) at centre frequency		
Mounting Material:		
Temperature:	Humidity:	
Tag Protocol:	Tag UII:	
Forward Link		
Deviation (kHz):	Data Rate: kbps	Data Coding:
Command: Wakeup followed by Collect command		
Return Link		
Data Rate: kbps	Data Coding:	
Test Results		
Centre Frequency		
xxx MHz		
EMax: xx,xx dBuV/m		

9.7 Survival electromagnetic field ($E_{Survival}$)

9.7.1 Purpose

This test determines the maximum survival electromagnetic field ($E_{Survival}$) value after which the tag ceases to operate even if signal levels are returned to within the operating range as defined by $E_{THR\ Read}$ and E_{Max}.

9.7.2 Test procedure

Expose each tag to an increasing electromagnetic field strength beyond the normally expected operating conditions, then attempt to read the tag with levels reset to a normal level between $E_{THR\ Read}$ and E_{Max}. When the tag ceases to respond to normal signal levels, it indicates that it has not survived the last used overload signal level. The survival electromagnetic field ($E_{Survival}$) is the level of extreme electromagnetic field above E_{Max} achieved before tag destruction.

Survival electromagnetic field, $E_{Survival}$, measurement procedure:

1) Set up all test equipment in an anechoic chamber or some other fully characterized and controlled location free from interference sources and propagation influences, such as significant signal reflections, absorptions, or blockages.

WARNING — Since this test uses high EMF energy that could exceed appropriate human exposure levels, proper precautions should be taken.

Tests should be run using a known reference antenna or radiating structure attached to the signal source and receiver.

Recommended test distance between the tag's location and the source antenna should be 2 metres, maximum, with 1 metre preferred. Closer spacing may be required, depending on the type of EMF test equipment chosen to generate high-power EMF signals.

2) Set a signal source to transmit FSK with a 433,920 MHz centre frequency, using FSK modulation at ±50 kHz with waveforms and timings as specified in ISO/IEC 18000-7. Adjust the signal source's

output below E_{Max} but well above $E_{THR\ Read}$. It can be the same or a separate signal source from the high-power EMF generator being used to try to overload the tag.

Use a code generator calibrated to properly generate relevant command sequences and timing as a modulator for this signal source.

The generator shall be set up so the following conditions exist when modulated:

Symbol LOW = f_c +50 kHz (433,970 MHz when centred at 433,920 MHz)

Symbol HIGH = f_c -50 kHz (433,870 MHz when centred at 433,920 MHz)

3) Use an FSK receiver and decoder to receive, decode, and send tag responses to appropriate monitoring software so tag responses can be evaluated. Synchronize the decoder with the code generator so all protocol timing can be maintained within correct relationships.

4) Mount the tag being evaluated on a minimum 50 x 50 cm metal sheet reflector for this test, attached in the mounting configuration specified for the specific tag model being evaluated. Orient the tag so its main response is facing the source signal.

5) Alternatively, depending on expected tag usage, the tag can be placed on a non-metallic mounting plate or pole, or attached in the mounting configuration specified for the tag model being evaluated.

6) Adjust the signal source for proper output, then send a Wakeup Header command followed immediately by a Collect command as defined in ISO/IEC 18000-7. Adjust the signal source until the tag under test responds reliably.

7) Adjust the high-power signal source to a level higher than E_{Max}, then remove this level (or if a single generator is being used, reduce the level to a normal reading level).

8) At a level between $E_{THR\ Read}$ and E_{Max}, attempt to read the tag.

9) If the tag responds correctly, readjust the high-power signal source to a level at least 3 dB higher than the previous level used, then repeat step 8).

10) If the tag does not respond, repeat the read attempt several times to confirm that the tag has been damaged.

11) Measure all tags. The $E_{Survival}$ value is the lowest electromagnetic field strength noted out of all measurements just below the level that causes tag failure.

NOTE If one tag is clearly lower in survival capacity than all others—requires less signal before it ceases to function—it can be removed from the tests and replaced with another tag.

9.7.3 Test report

The test report gives the measured minimum electromagnetic field level causing damage to the tag, $E_{Survival}$. Record all parameters according to the example in Table 15.

Table 15 — Parameters recorded for $E_{Survival}$ measurement

Test: Survival electromagnetic field ($E_{Survival}$)	
Mounting Material:	
Temperature:	Humidity:
Tag Type:	Tag ID:
Test Results	
$E_{Survival}$	**xx,xx V/m**

