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Information technology — Radio frequency identification device performance test methods —

Part 2: Test methods for interrogator performance

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

Partie 2: Méthodes d'essai des performances de l'interrogateur

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Foreword

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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).

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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 second edition cancels and replaces the first edition (ISO/IEC 18046-2:2011), which has been technically revised.

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

— addition of test methods for UHF RFID in the 860-930 MHz in Clause 7.

A list of all parts in the ISO 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 2:
Test methods for interrogator performance

1 Scope

This document defines test methods for performance characteristics of RFID interrogators and specifies the general requirements and test requirements for interrogators which are applicable to the selection of the devices for an application. The summary of the test reports forms a unified interrogator 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 18000-7, *Information technology — Radio frequency identification for item management — Part 7: Parameters for active air interface communications at 433 MHz*

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 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

E_{THR}	electromagnetic field threshold
$E_{\text{THR Identification}}$	identification electromagnetic field threshold
$E_{\text{THR Read}}$	reading electromagnetic field threshold
$E_{\text{THR Write}}$	writing electromagnetic field threshold
E_{Max}	maximum electromagnetic field exposure
$E_{\text{Max Operating}}$	maximum operating electromagnetic field
E_{Survival}	survival electromagnetic field
$I_{\text{Rejection}}$	interference rejection
D	distance between the tag and the antenna
P_{rcv}	interrogator receiver sensitivity power level
P_{back}	tag backscatter power
P_{TX}	interrogator transmit power
P_{r}	power received on the spectrum analyser
f_{a}	antenna factor of the reference antenna
$\lvert\Delta C\rvert$	loss of cable
F_{f}	field strength
$S_{\text{Directivity}}$	sensitivity directivity
G	antenna gain
f_{tsbl}	frequency tag side band left
f_{tsbr}	frequency tag side band right

4.2 Abbreviated terms

LM	load modulation
EMF	electromagnetic field
DUT	device under test
MPE	maximum permissible human exposure
SAR	specific absorption rate
TE	test equipment
RF	radio frequency

RFID	radio frequency identification
RTI	returnable transport items
UHF	ultra high frequency
AIDC	automatic identification and data capture
BLF	backscatter link frequency
UII	unique item identifier

5 Conditions applicable to the test methods

5.1 Number of interrogators to be tested

All measurements defined in this document shall be performed at least on a single interrogator, but higher sampling numbers can be required for statistical purposes.

5.2 Test environment

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

5.3 RF environment

The tests shall be performed in a known RF environment.

For measurements of propagative UHF interrogators (see ISO/IEC 18000-63 and ISO/IEC 18000-7), an anechoic chamber is the recommended test environment. The size of the anechoic chamber shall be justified based on the dimensions of the test setup.

For measurement of inductive interrogators, a typical laboratory environment is sufficient, where consideration is given to minimize the impact of electromagnetic sources that can influence the results.

5.4 Pre-conditioning

Where pre-conditioning is required by the test method, the identification interrogators 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 TE (e.g. linear dimensions) and the test method procedures (e.g. TE 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.

5.7 Test result reporting

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

5.8 Test communication parameters

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

5.9 TE limits

TE for survival field maximum level shall be able to handle the maximum level declared by the product vendor. It shall be ensured that the TE is not limiting the performance measurement.

5.10 Human exposure to EMF

High magnetic or electromagnetic field strength may exceed the limits of maximum permissible human exposure to EMF, which should be considered accordingly. FCC guidelines for MPE and SAR or EC 1999/519/CE are examples for relevant documents.

6 Setup of TE for interrogator test

6.1 Test apparatus and test circuits for ISO/IEC 18000-3 interrogators

The specification for ISO/IEC 18000-3 tags and interrogators specifies an operating frequency of 13,56 MHz ± 7 kHz. Since both the interrogator and the tag may be shifted by 516 ppm and potentially in opposite directions, it is necessary for the interrogator to function with a tag simulator that may be ±1032 ppm (±14 kHz) relative to the nominal centre frequency of the interrogator under test.

This frequency adjustment is made using only the tag simulator's signal source since there might be no convenient way to adjust the frequency of the interrogator being evaluated. The relative interrogator to tag frequency shift is still achieved using this method.

For convenience in setting up the signal source in the tag simulator, use a low carrier frequency at 13,546 MHz, a nominal centre frequency at 13,560 MHz, and a high carrier frequency at 13,574 MHz for all frequency offset tests.

Unless defined differently in the test description, the set up of all TE shall be in an anechoic chamber or some other fully characterized and controlled location that is free from interference sources and propagation influences, such as significant signal reflections, absorptions, or blockages.

Unless otherwise specified, all the tests should be run using a known reference antenna attached to the tag simulator.

The tag simulator used for these tests shall be able to receive interrogator commands and transmit tag replies in conformance with ISO/IEC 18000-3. The command decoder needs to provide a signal to trigger a properly timed response from the code generator so that the entire assembly acts as a tag simulator.

The output of the decoder in the tag simulator is also connected to a computer and appropriate monitoring software so that it can display the tag commands as received from the interrogator being tested in order to confirm that it is sending correct commands.

The timing of the interrogator's transmitted signal and modulation can be monitored using the output of the tag simulator's receiver attached to a storage scope that has sufficient memory depth to allow the capture of complete interrogator/tag transactions.

The interrogator is connected to a control and monitoring computer that allows issuing of wakeup and command transmissions. This software should also provide a display of decoded data received by the interrogator to confirm that it is able to properly decode and output received tag responses.

Unless otherwise specified, the recommended test distance between the interrogator's location and the reference antenna attached to the tag simulator should be 75 % of the maximum working distance which can be obtained with the interrogator under test and the tag simulator.

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

The test apparatus and test circuits for ISO/IEC 18000-61, ISO/IEC 18000-62, ISO/IEC 18000-63, ISO/IEC 18000-64 interrogator tests are defined in 8.1.

6.3 Test apparatus and test circuits for ISO/IEC 18000-7 interrogators

The specification for ISO/IEC 18000-7 tags and interrogators specifies an operating frequency of 433,920 MHz (±20 ppm), which is approximately ±8,7 kHz. Since both the interrogator and the tag may be shifted by 20 ppm and potentially in opposite directions, the interrogator needs to function with a tag simulator that may be ±40 ppm (approximately 17,4 kHz) relative to the nominal centre frequency of the interrogator under test.

This frequency adjustment is made using only the tag simulator's signal source since there may be no convenient way to adjust the frequency of the interrogator being evaluated. The relative interrogator to tag frequency shift is still achieved using this method.

For convenience in setting up the signal source in the tag simulator, use a low carrier frequency at 433,900 MHz, a nominal centre frequency at 433,920 MHz, and a high carrier frequency at 433,940 MHz for all frequency offset tests.

The setup of all TE shall be in an anechoic chamber or some other fully characterized and controlled location that is free from interference sources and propagation influences, such as significant signal reflections, absorptions, or blockages.

Unless otherwise specified, all the tests should be run using a known reference antenna attached to the tag simulator through a splitter/combiner of a known loss as shown in Figure 1.

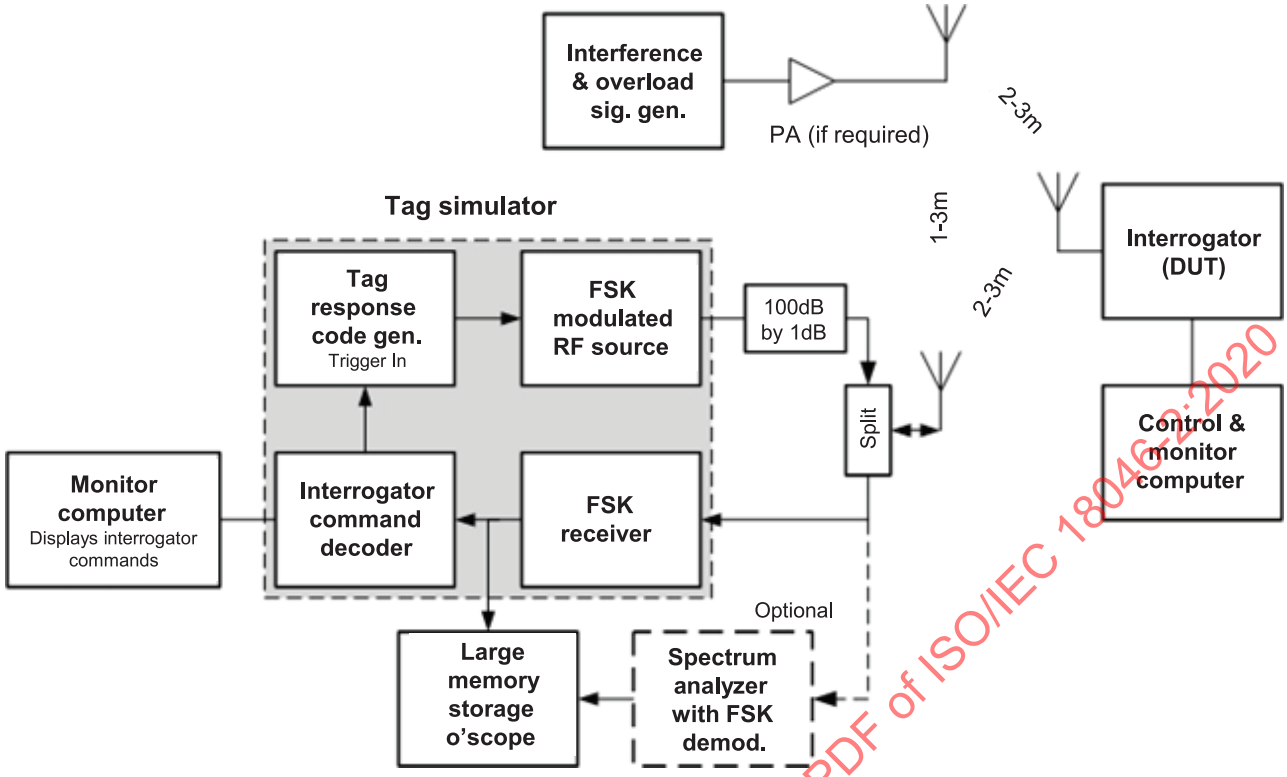

Figure 1 — Test setup for ISO/IEC 18000-7 interrogator measurements

A second reference antenna is located in the place of the interrogator at its test location and shall be connected to a spectrum analyser at the beginning of testing with the tag simulator's signal source set to 0 dBm output to establish the field strength, F_f, at the test site where the interrogator will be placed.

Calculation of field strength is as follows:

$$F_f = 107 + (P_r + f_a + |\Delta C|)$$

where

107 is dB above 1 uV at 0 dBm,

P_r is the power received on the spectrum analyser,

f_a is the antenna factor of the reference antenna, and

$|\Delta C|$ is the loss of cable in dB (absolute value).

EXAMPLE $P_r = -35$ dBm, $f_a = 22$ dB, $\Delta C = |-1,2$ dB|

$$F_f = 107 + (-35 + 22 + 1,2) = 107 + (-11,8) = 95,2\text{dBuV/m}$$

The field strength at 0 dBm reference level shall be used during interrogator sensitivity testing.

The tag simulator used for these tests consists of a code generator conforming to ISO/IEC 18000-7, an FSK modulated 433,920 MHz signal source, an FSK 433,920 MHz receiver, and a decoder conforming to ISO/IEC 18000-7. The decoder needs to provide a signal to trigger a properly timed response from the code generator so that the entire assembly acts as a tag simulator.

The step attenuator shown in the diagram allows adjustment over a 100 dB range in 1 dB steps. The 100 dB of output level change can be adjusted solely using the step attenuator or, as a practical matter, using the level setting capabilities of both the attenuator and the FSK signal source.

The output of the decoder in the tag simulator is also connected to a computer and appropriate monitoring software so that it can display the tag commands as received from the interrogator being tested in order to confirm that it is sending correct commands.

The timing of the interrogator's transmitted signal and modulation can be monitored using the output of the tag simulator's FSK receiver attached to a storage scope that has sufficient memory depth to allow the capture of complete interrogator/tag transactions.

The interrogator is connected to a control and monitoring computer that allows the issuing of wakeup and command transmissions. This software should also provide a display of decoded data received by the interrogator to confirm that it is able to properly decode and output received tag responses.

Unless otherwise specified, the recommended test distance between the interrogator's location and the reference antenna attached to the tag simulator should be 2 m, minimum, with 3 m preferred. This will provide sufficient distance to ensure far field conditions at the interrogator's location yet not require use of a test site exceeding practical dimensions. A 3 m test distance is recommended since this is a common regulatory test distance and is also a distance at which many reference antennae have been calibrated for antenna factor. This distance also meets the far field criteria at a frequency of 433,920 MHz.

7 Functional tests for inductive interrogators as defined in ISO/IEC 18000-2 and ISO/IEC 18000-3

7.1 Interrogator sensitivity in Listen mode (Receiving mode)

7.1.1 Purpose

This test determines the minimum level of modulated carrier at the antenna of the interrogator that can be detected by its receiver.

7.1.2 Test procedure

The LM of the tag simulator is set to the nominal level: 0.

The tag simulator is positioned on the axis of the interrogator's antenna. The distance between the tag simulator and the interrogator's antenna (D) is equal to 75 % of the $E_{\text{THR Identification}}$ distance.

The LM is then increased from 0 to the level where the interrogator starts to recognize the identification data from the tag simulator.

7.1.3 Test report

The test report shall give the measured minimum LM. All parameters shall be recorded according to Table 1.

Table 1 — Parameters recorded for sensitivity measurement

Test: Interrogator sensitivity in Listen mode (Receiving mode)	
Temperature:	Humidity:
Interrogator type:	Interrogator ID:
Air interface protocol between interrogator and tag:	
Test results	
LM minimum	**xx,xx**

7.2 Interference rejection ($I_{Rejection}$)

7.2.1 Purpose

This test determines the interference rejection ability of the interrogator.

This test determines the minimum distances between two identical interrogators (same devices) at which the DUT can read the tag without disturbances.

7.2.2 Test procedure

The waveform generator shall be set to the required operating frequency of 125 kHz or 134,2 kHz or 13,56 MHz respectively for ISO/IEC 18000-2 or ISO/IEC 18000-3 and the waveform generator amplitude shall be set to a value below the identification magnetic field threshold. This amplitude is typically zero.

The tag simulator is positioned on the axis of the interrogator's antenna. The distance between the tag simulator and the interrogator's antenna (D) is equal to 75 % of the $E_{\text{THR Identification}}$ distance.

A second interrogator (identical to the DUT) is positioned near the DUT. The test covers two positions: face to face and side by side.

The test configurations are shown in Figure 2.

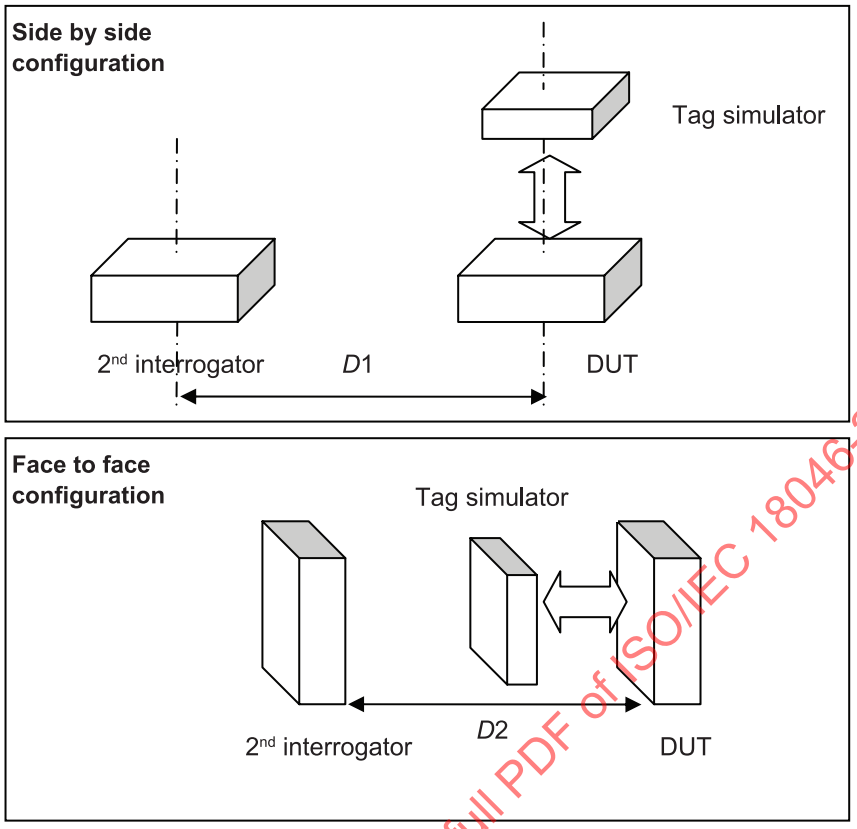

Figure 2 — Test configurations

The dialogue between the DUT and the tag simulator is monitored.

The 2nd interrogator is moved to the DUT until errors are detected in the dialogue between the DUT and the tag simulator.

The dialogue shall alternate between read commands and write commands from the DUT to the tag simulator.

7.2.3 Test report

The test report shall give the measured minimum distance between the two identical interrogators. All parameters shall be recorded according to Table 2.

Table 2 — Parameters recorded for interference rejection distance

Test: Interrogator sensitivity in Listen mode (Receiving mode)	
Temperature:	Humidity:
Interrogator Type:	Interrogator ID:
Air interface protocol between interrogator and tag:	
Test results	
Distance D1 (side by side)	**xx,xx**
Distance D2 (face to face)	**xx,xx**

7.3 Maximum EMF exposure (E_{max})

7.3.1 Purpose

This test determines the maximum value of the EMF generated by another interrogator at which the DUT ceases to operate.

7.3.2 Test procedure

The EMF generated for the test is similar to the field generated by the DUT (same frequency/modulation/protocol). The strength of the EMF should be limited to the maximum allowed value (ETSI EN 300 330-1/2 or 47CFR15[30]).

Exposure time for this test is 1 min for each step of the test. The DUT shall be able to read a tag after each exposure period.

7.3.3 Test report

The test report shall give the measured maximum electomagnetic field exposure, E_{max}. All parameters shall be recorded according to Table 3.

Table 3 — Parameters recorded for maximum electomagnetic field exposure

Test: Maximum electromagnetic field exposure (E_{max})	
Temperature:	Humidity:
Interrogator Type:	Interrogator ID:
Air interface protocol between interrogator and tag:	
Test results	
E_{max}	**xx,xx A/m**

7.4 Ratio between field radiated and power consumption

7.4.1 Purpose

This test determines a ratio between the field radiated and the power consumed by the interrogator.

7.4.2 Test procedure

The LM of the tag simulator is set to the level obtained as a result of test 7.1, interrogator sensitivity in Listen mode (Receiving mode).

The tag simulator is positioned on the axis of the interrogator's antenna. The distance between the tag simulator and the interrogator's antenna (D) is equal to 1 cm, 5 cm, 10 cm, 50 cm and finally 100 cm.

Measurements are expressed as follows:

— Measurement of the average power consumption of the interrogator when transmitting during 1 second: *P1* in W (Watt).

— Measurement of the field strength: F_f in A/m.

The ratio between the field radiated and the power consumed is equal to $F_f/P1$.

7.4.3 Test report

The test report shall give the ratio between the field radiated and the power consumed by the interrogator. All parameters shall be recorded according to Table 4.

Table 4 — Parameters recorded for power injected into the antenna

Test: Power injected into the antenna of the interrogator	
Temperature:	Humidity:
Interrogator type:	Interrogator ID:
Air interface protocol between interrogator and tag:	
Test results	
Ratio (1 cm)	**xx,xx**
Ratio (5 cm)	**xx,xx**
Ratio (10 cm)	**xx,xx**
Ratio (50 cm)	**xx,xx**
Ratio (100 cm)	**xx,xx**

7.5 Field strength distribution

7.5.1 Purpose

This test determines the 3D map of the EMF generated by the interrogator.

Interrogators should be grouped (as defined below) according to ETSI EN 300 330-1/2 and 47CFR15[30]. In order to ease user comparison, 5 groups are defined:

— Class A interrogator with radiated H-field level between 80 % and 100 % of the maximum radiated H-field allowed by local regulations;

— Class B interrogator with radiated H-field level between 60 % and 80 % of the maximum radiated H-field allowed by local regulations;

— Class C interrogator with radiated H-field level between 40 % and 60 % of the maximum radiated H-field allowed by local regulations;

— Class D interrogator with radiated H-field level between 20 % and 40 % of the maximum radiated H-field allowed by local regulations;

— Class E interrogator with radiated H-field level between 0 % and 20 % of the maximum radiated H-field allowed by local regulations.

7.5.2 Test procedure

Measurement should be performed using test procedures as outlined in ETSI EN 300 330-1/2 and 47CFR15[30]. This test gives a table of field strength measurements.

Measurements are performed every 1 cm in the normal direction if the value measured is higher than 0,15 A/m. Measurements in other directions are performed every 1 cm for positions in the normal direction with a measured value higher than 0,15 A/m. Measurements in other directions shall be performed if the value measured is higher than 0,15 A/m.

7.5.3 Test report

The test report shall give a table of EMF measurements. This allows the user to estimate the read range in all directions in front of the interrogator antenna. All parameters shall be recorded according to the example in Table 5.

Table 5 — Parameters recorded for power injected into the antenna

Test: Power injected into the antenna of the interrogator						
Temperature:	Humidity:					
Interrogator type:	Interrogator ID:		Interrogator group:			
Air interface protocol between interrogator and tag:						
Test results						
Normal direction – *Z*: 1	**Other directions X and Y**	**Y = xx**	**Y = –1**	**Y = 0**	**Y = 1**	**Y = xx**
	X = xx	**xx,xx**	**xx,xx**	**xx,xx**	**xx,xx**	**xx,xx**
	X = –1	**xx,xx**	**xx,xx**	**xx,xx**	**xx,xx**	**xx,xx**
	X = 0	**xx,xx**	**xx,xx**	**xx,xx**	**xx,xx**	**xx,xx**
	X = 1	**xx,xx**	**xx,xx**	**xx,xx**	**xx,xx**	**xx,xx**
	X = xx	**xx,xx**	**xx,xx**	**xx,xx**	**xx,xx**	**xx,xx**
Normal direction – *Z*: xx	**Other directions X and Y**	**Y = xx**	**Y = –1**	**Y = 0**	**Y = 1**	**Y = xx**
	X = xx	**xx,xx**	**xx,xx**	**xx,xx**	**xx,xx**	**xx,xx**
	X = –1	**xx,xx**	**xx,xx**	**xx,xx**	**xx,xx**	**xx,xx**
	X = 0	**xx,xx**	**xx,xx**	**xx,xx**	**xx,xx**	**xx,xx**
	X = 1	**xx,xx**	**xx,xx**	**xx,xx**	**xx,xx**	**xx,xx**
	X = xx					

8 Functional tests for interrogators as defined in ISO/IEC 18000-6 and in particular ISO/IEC 18000-63

8.1 Receiver sensitivity for UHF interrogators using wave propagation

8.1.1 Purpose

This test determines the interrogator receiver sensitivity power level, P_{rcv}, which is typically reported in dBm. The test procedure is described for the most commonly used document, ISO/IEC 18000-63, but the principle may be used for ISO/IEC 18000-61, ISO/IEC 18000-62 and ISO/IEC 18000-64 as well.

8.1.2 Test procedure

ISO/IEC 18000-63 provides several parameters that may result in variations of the interrogator receiver sensitivity. For that reason, the parameters as shown in Table 6 and Table 7 shall be specified for the test and recorded. For parameter guidance, the recommended values in Table 6 and Table 7 may be used.

Table 6 — Interrogator settings of ISO/IEC 18000-63 protocol parameters

Parameter	Recommended value	Description
Tari	12,5 µs	As in ISO/IEC 18000-63
M	4	As in ISO/IEC 18000-63
RTcal	31,25 µs (2,5 × Tari)	As in ISO/IEC 18000-63
TRcal	EU: 66,66 µs (= 2,133 × RTcal) FCC: 83,34 µs (= 2,667 RTcal)	As in ISO/IEC 18000-63
DR	64/3	As in ISO/IEC 18000-63
BLF	320 kHz (FCC: 256 kHz)	Value calculated from TRCal and DR as defined in ISO/IEC 18000-63

Table 6 *(continued)*

Parameter	Recommended value	Description
TRext	1 (use Pilot Tone)	As in ISO/IEC 18000-63
P_{TX}	EU: 33 dBm erp FCC: 36 dBm eirp	Interrogator transmit power including *G*, if applicable. All tests shall be performed at the highest power level of DUT. Users shall be aware that maximum threshold values can vary according to local radio regulations. Test with lower power values are recommended in particular, if there is an application need.
f	EU: 866,3 MHz FCC: 915 MHz	Interrogator operating frequency
Others		Other parameters that are of relevance for the interrogator

For all other regions, the setting of TRcal, *D*, P_{TX} and f shall be aligned as much as possible to the above examples.

Table 7 — Test conditions

Parameter	Recommended value	Description
SR	90 %	Pass success rate - Relative number of successful reads by the interrogator
N	100	Number of test round repetitions for a particular setting
BLF_{var}	±20 %	Allowed variation of BLF
BLF_{varN}	9	Number of steps for BLF variation
PS_{var}	±90°	Allowed variation of phase shift
PS_{varN}	9	Number of steps for phase shift variation

The test setup shall be as in Figure 3 or Figure 4 and shall use TE such as a tag emulator or similar equipment that conforms to ISO/IEC 18000-63 in respect to all parameters that have an impact on performance tests and that further allows a controlled variation of the BLF. Optionally, a phase shifter may be used as well. For the contactless test setup, the distance, *D*, shall be selected to ensure that the test is performed in the far field, unless a near field test is intended. If a near field test is performed, then this shall be noted in the test report.

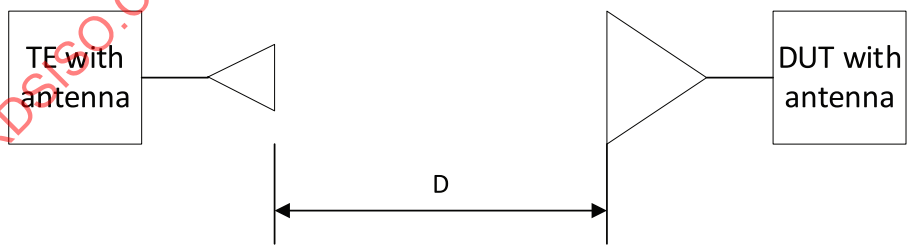

Figure 3 — Contactless test setup

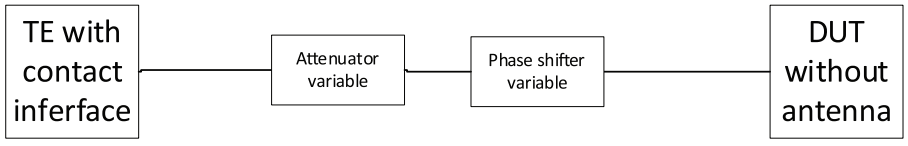

Figure 4 — Contact test setup

For the test, an interrogator shall start to inventory tags. The use of a select command is optional and the command shall be ignored for the test.

The interrogator shall use one of the following sequences:

a) Query – Various Commands – ACK – ReqRN

b) Query – Various Commands – ACK

Various Commands may consist of one or more of the following commands: QueryRep and QueryAdjust.

A reception of a tag response by the reader shall be evaluated as successful as follows:

— Reader sends Req_RN with correct Handle

— Reader sends ACK with the correct RN16

NOTE This test method can lead to incorrect results, as the tag (TE) cannot verify whether the reader understood the response to the ACK command (i.e., the UII.)

In order to facilitate interrogator testing, a tag emulator may choose to always use the first slot but is not required to do so.

The test device shall generate an RN16 that varies and is chosen randomly.

The 96-bit UII shall take the form 0x00FF33CC55AA77889966BB44. However, if the DUT only accepts a certain UII range, then the content of the UII may be amended accordingly.

The received power, P_{rcv}, is specified as the power of the two (left and right) side bands of the tag response according to Annex A, which would be detected by a receiver with carrier filtered.

For a contact test, the emitted power and measurements of the received power are specified at the input/output of the reader.

For a contactless test, the emitted power is specified as the linear component of an EIRP value at the plane of the antenna's maximum gain. The received power is measured at the same plane as power equivalent to using a unity-gain receiving antenna (0 dB).

Tests may be performed for various combinations of the parameters in Table 6.

It shall be confirmed that the interrogator always checks for the correctness of the CRC received as part of the response to the ACK command on receipt of the correct UII, and the correct parsing and verifying of the accompanying CRC of the tag response. This confirmation may be provided by an interrogator manufacturer statement or by detecting a different reader reaction when an UII with correct CRC and an UII with incorrect CRC are presented to the interrogator.

If, during the test, the interrogator reports a received UII that has not been issued by the TE then that test shall be interpreted as a complete failure, as the reader obviously did not correctly verify the CRC.

The test procedure contains the following steps:

1) Setup test configuration with DUT and TE.

2) Select interrogator parameters.

3) Setup interrogator transmit power value.

4) Evaluate tag response for N Query commands.

5) If the success rate of step 4) is higher than SR, then decrease the TE backscatter power and continue with step 4).

6) Report the P_{rcv} value as the lowest received P_{back} according to Annex A, where the measured success rate was higher than or equal to SR.

7) Optionally vary BLF according to Table 6 and continue with step 4).

8) Optionally vary the phase shift according to Table 6 and continue with step 4).

8.1.3 Test report

The test report shall show the minimum received power of the tag that is detectable by the interrogator as P_{rcv}, the actual used values from Table 6 and Table 7 and the applied phase shift and BLF variation. If there is no statement of phase shift or BLF variation, then this shall imply that these parameters have not been verified.

Table 8, Table 9 and Figure 5 show an example test report and and corresponding example test graph.

Table 8 — Test report example — Protocol parameters and conditions

Test: receiver sensitivity for UHF interrogators	
Parameter	**Value**
Tari	22,52 µs
M	4
RTcal	71,15 µs
TRcal	83,25 µs
DR	64/3
BLF	256,25 kHz
TRext	0
P_{TX}	26,55 dBm
f	915 MHz
SR	90 %
N	100
BLF_{var}	±0 %
BLF_{varN}	n.a.
PS_{var}	0 – 345°
PS_{varN}	24

Table 9 — Test report example — Transmit power and receiver sensitifity

BLF /kHz	Phase / °	P_{TX} / dBm	P_{rcv} / dBm
256252	0	26,55	–52,44
256252	15	26,45	–58,99
256252	30	26,45	–59,15
256252	45	26,45	–57,99
256252	60	26,45	–55,28
256252	75	26,45	–56,72
256250	90	26,50	–58,31
256252	105	26,55	–58,21
256252	120	26,65	–58,95
256252	135	26,65	–57,79
256252	150	26,66	–53,28
256252	165	26,75	–49,36
256252	180	26,41	–54,63

Table 9 *(continued)*

BLF /kHz	Phase / °	P_{TX} / dBm	P_{rcv} / dBm
256252	195	26,35	−57,40
256252	210	26,35	−58,56
256252	225	26,44	−56,14
256252	240	26,54	−54,16
256245	255	26,55	−56,68
256252	270	26,55	−58,04
256252	285	26,64	−54,66
256252	300	26,65	−58,25
256252	315	26,65	−57,45
256252	330	26,65	−52,58
256252	345	26,65	−51,03

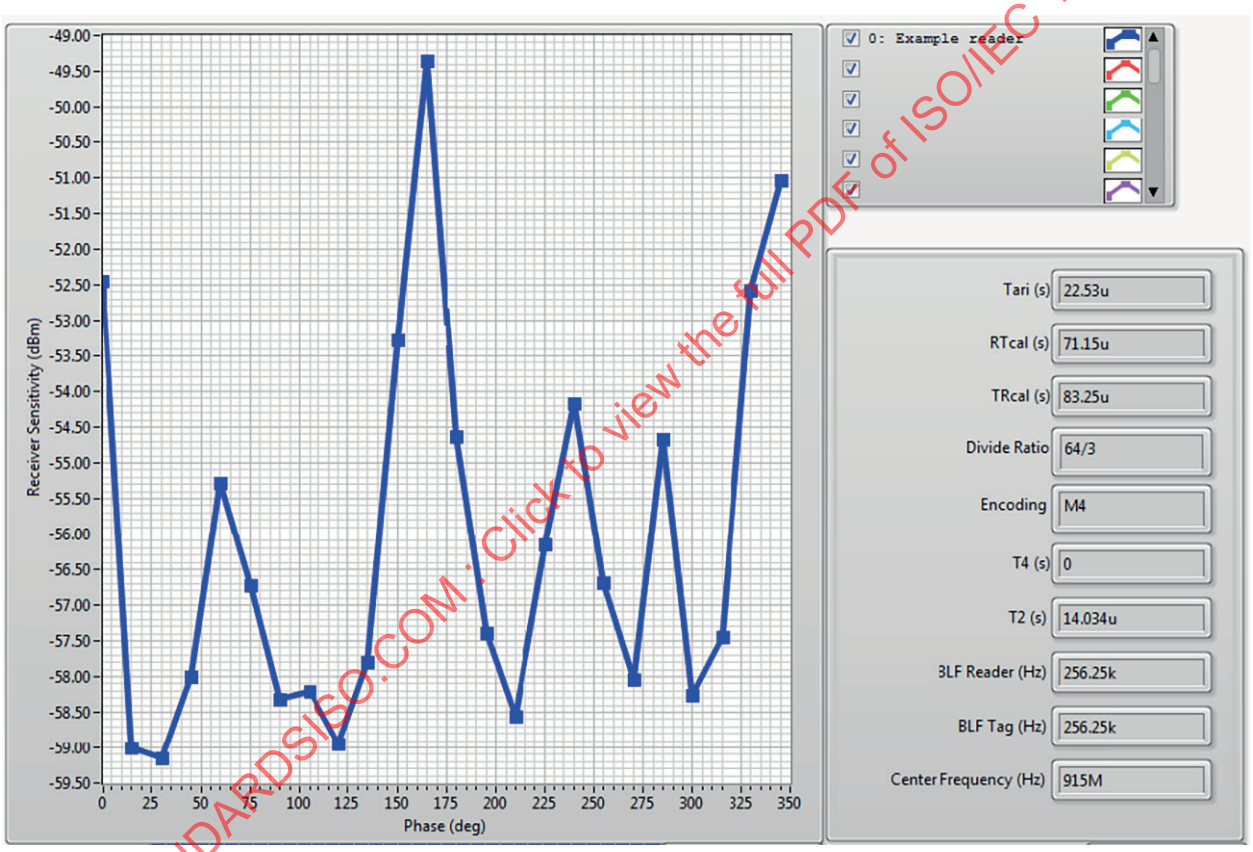

Figure 5 — Test graph example

8.2 Inductive UHF interrogators

The special case of functional tests for inductive interrogators as defined in ISO/IEC 18000-63 shall follow 8.1, whereas the antennae for the TE and DUT shall be changed to antennae that utilize inductive coupling.

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

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

9.1.1 Purpose

This test determines the electromagnetic field threshold level required at the interrogator for tag identification when using an ISO/IEC 18000-7 interrogator functioning in Master-Slave mode (Interrogator Talks First or ITF).

The identification electromagnetic field threshold, $E_{\text{THR Identification}}$, is the minimum electromagnetic field arriving at the interrogator that allows the interrogator to identify a tag reliably. For the purpose of this test, "reliably" means 10 reads out of 10 sequential read attempts.

9.1.2 Test procedure

To determine interrogator sensitivity, the following procedures shall be performed:

1) Test shall be run based on the test apparatus and test setups outlined in 6.2. Set the tag simulator's frequency to 433,920 MHz. Begin by placing the tag simulator's antenna to vertical polarization.

2) Set the tag simulator's attenuator to 30 dB to provide the interrogator with a moderate signal level. Confirm that the interrogator reads the tag simulator response at this level.

3) Increase the tag simulator's attenuator by 1 dB step until the interrogator does not read the tag simulator response.

4) Decrease the attenuator setting until the interrogator reads the tag simulator response 10 times out of 10 attempts.

5) Record this attenuator level in the box provided for attenuator setting for vertical polarization.

6) Convert the attenuator setting into dBµV/m by subtracting this setting from the field strength level at 0 dBm measured in 6.2. Place this into the $E_{\text{THR Identification}}$ (dBµV/m) box in the vertical polarization column.

7) Repeat steps 2 through 4 with the tag simulator's antenna horizontally polarized.

8) Record this attenuator level (unsigned) in the box provided for attenuator setting under the column for horizontal polarization.

9) Convert the unsigned attenuator setting into dBµV/m by subtracting the setting from the field strength level at 0 dBm measured in 6.2. Place this into the $E_{\text{THR Identification}}$ (dBµV/m) box in the horizontal polarization column.

10) Repeat steps 2 through 9 after increasing the centre frequency to 433,940 MHz. In this case, place the data into the boxes provided for 433,940 MHz instead of 433,920 MHz.

11) Repeat steps 2 through 9 after decreasing the centre frequency to 433,900 MHz. In this case, place the data into the boxes provided for 433,900 MHz instead of 433,920 MHz.

12) The measurements in steps 1 through 11 shall be performed on all interrogators. The $E_{\text{THR Identification}}$ value shall be the greatest EMF strength noted out of all measurements.

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

9.1.3 Test report

The test report provides data recorded for the system's lower, nominal, and upper tolerance limits. The environmental conditions and communication parameters shall be recorded according to the example in Table 10.

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

Test: Identification electromagnetic field threshold ($E_{\text{THR Identification}}$) at centre frequency and ±40 ppm		
Temperature: °C	Humidity: %	
Interrogator protocol:	Interrogator UII:	
Forward link		
Deviation (kHz): 50 kHz, nominal	Data rate: 27 kbps	Data coding: Manchester coding
Command: Collect with UDB		
Return link		
Data rate: 27 kbps	Data coding: Manchester coding	
Test results		
Centre frequency	fc + 40 ppm	fc – 40 ppm
433,920 MHz	433,940 MHz	433,900 MHz
Attenuator setting: dB	Attenuator setting: dB	Attenuator setting: dB
$E_{\text{THR Identification}}$: dBuV/m	$E_{\text{THR Identification}}$: dBuV/m	$E_{\text{THR Identification}}$: dBuV/m
ID:	ID:	ID:

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

9.2.1 Purpose

This test determines the electromagnetic field threshold level at the interrogator that allows a tag reading or writing. To successfully read/write tag data, the command shall be transmitted correctly by the interrogator with maximum antenna output power. Maximum limitations can be found in applicable regulations. The reading/writing electromagnetic field threshold, $E_{\text{THR Read/Write}}$, is the minimum electromagnetic field at the interrogator that allows tag reading/writing.

9.2.2 Test procedure

Tests shall be run at signal source set as specified in 6.2. The electromagnetic field of the signal source shall be set below the level that allows an interrogator to read the tag simulator's response to a read or write interrogator command, then it shall be increased to a level where it is possible to read the tag simulator's ID and to read or write the memory contents. For this test, the tag simulator's memory shall be any available memory that permits both reading and writing.

To determine the electromagnetic field threshold ($E_{\text{THR Read/Write}}$), the following measurement procedures shall be performed:

1) Test shall be run based on the test apparatus and test setups outlined in 6.2. Set the tag simulator's frequency to 433,920 MHz. Begin by placing the tag simulator's antenna to vertical polarization.

2) Set the tag simulator's attenuator to 30 dB to provide the interrogator with a moderate signal level. Confirm that the interrogator reads the tag simulator's response at this level.

3) Increase the tag simulator's attenuator by 1 dB step until the interrogator does not read the tag simulator's response.

4) Decrease the attenuator setting until the interrogator reads the tag simulator's response 10 times out of 10 attempts.

5) Record this attenuator level (unsigned) in the box provided for attenuation setting for vertical polarization.

6) Convert the unsigned attenuator setting into dBµV/m by subtracting this setting from the field strength level at 0 dBm measured in 6.2. Place this into the $E_{\text{THR Read/Write}}$ (dBµV/m) box in the vertical polarization column.

7) Repeat steps 2 through 4 with the tag simulator's antenna horizontally polarized.

8) Record this attenuator level (unsigned) in the box provided for attenuation setting under the column for horizontal polarization.

9) Convert the unsigned attenuator setting into dBµV/m by subtracting the setting from the field strength level at 0 dBm measured in 6.2. Place this into the $E_{\text{THR Read/Write}}$ (dBuV/m) box in the horizontal polarization column.

10) Repeat steps 2 through 9 after increasing the centre frequency to 433,940 MHz. In this case, place the data into the boxes provided for 433,940 MHz instead of 433,920 MHz.

11) Repeat steps 2 through 9 after decreasing the centre frequency to 433,900 MHz. In this case, place the data into the boxes provided for 433,900 MHz instead of 433,920 MHz.

12) The measurements in steps 1 and 11 shall be performed on all interrogators. The $E_{\text{THR Read}}$ value shall be the greatest electromagnetic field strength noted out of all measurements.

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

9.2.3 Test report

The test report provides data recorded for the system's lower, nominal, and upper tolerance limits. The environmental conditions and communication parameters shall be recorded according to Table 11.

Table 11 – Parameters recorded for $E_{\text{THR Read}}$ measurement

Test: Identification electromagnetic field threshold ($E_{\text{THR Read}}$) at centre frequency and ±40 ppm		
Temperature: °C	Humidity: %	
Interrogator protocol:	Interrogator UII:	
Forward link		
Deviation (kHz): 50 kHz, nominal	Data rate: 27 kbps	Data coding: Manchester coding
Command: Collect with UDB		
Return link		
Data rate: 27 kbps	Data coding: Manchester coding	
Test results		
Centre frequency	fc + 40 ppm	fc – 40 ppm
433,920 MHz	433,940 MHz	433,900 MHz
Attenuator setting: dB	Attenuator setting: dB	Attenuator setting: dB
$E_{\text{THR Read/Write}}$: dBuV/m	$E_{\text{THR Read/Write}}$: dBuV/m	$E_{\text{THR Read/Write}}$: dBuV/m
ID:	*ID:*	*ID:*

9.3 Sensitivity directivity ($S_{\text{Directivity}}$)

9.3.1 Purpose

This test determines the interrogator's sensitivity to various orientations, such as azimuth and elevation (see Figure 6). This, of course, is a determination of the directivity of the interrogator. It shall be determined under all conditions for which the interrogator is designed. This may include the interrogator being mounted on a metal surface such as the wall of a metal building. A sheet metal reflector of 50 cm × 50 icm can be used to simulate this situation so that the assembly can be rotated conveniently. An interrogator may also be used on a metal or wooden pole where a more omnidirectional pattern can be expected.

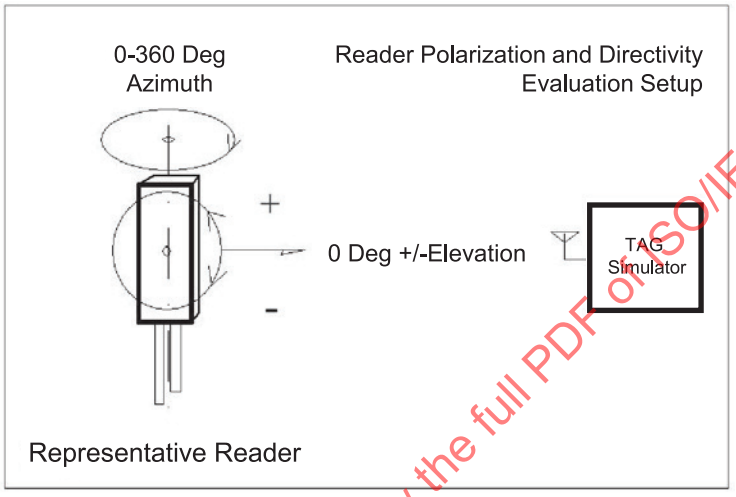

Figure 6 — Measurement setup for sensitivity directivity, $S_{\text{Directivity}}$

9.3.2 Test procedure

To determine the sensitivity directivity of an interrogator, $S_{\text{Directivity}}$, the following measurement procedures shall be performed:

1) Test shall be run based on the test apparatus and test setups outlined in 6.2. Set the tag simulator's frequency to 433,920 MHz. Begin by placing the tag simulator's antenna to vertical polarization. Adjust the interrogator to the azimuth or elevation angle being evaluated.

2) Set the tag simulator's attenuator to 0 dB to provide the interrogator with a full signal level. Confirm that the interrogator reads the tag simulator response at this level.

3) Adjust the tag simulator's attenuator until the interrogator does not read the tag simulator response properly.

4) Decrease the attenuator setting until the interrogator reads the tag simulator response 10 times out of 10 attempts.

5) Record this attenuator level (unsigned) in the box provided for attenuation setting for vertical polarization.

6) Convert the unsigned attenuator setting into dBµV/m by subtracting this setting from the field strength level measured in step 4. Place this into the E_{THR} xx° (dBµV/m) box in the vertical polarization column.

7) Repeat steps 2 – 4 with the tag simulator's antenna horizontally polarized.

8) Record this attenuator level (unsigned) in the box provided for attenuation setting under the column for horizontal polarization.

9) Convert the unsigned attenuator setting into dBμV/m by subtracting the setting from the field strength level measured in step 4. Place this into the E_{THR} xx° (dBμV/m) box in the horizontal polarization column.

10) Repeat steps 2 through 9 after at every 15° increment from 0° to 345° in azimuth, while the elevation is fixed at 0°. Record the appropriate E_{THR} xx° (dBμV/m) values in the box for azimuth angle in the test report.

11) Repeat steps 2 through 9 after at every 15° increment from 0° to ±90° in elevation, while the azimuth is fixed at 0°. Record the appropriate E_{THR} xx° (dBμV/m) values in the box for elevation angle in the test report.

12) The measurements in steps 1 and 11 shall be performed on all interrogators. $S_{Directivity}$ shall be graphed for azimuth and elevation for each interrogator on a common graph.

If one interrogator is clearly lower in sensitivity or shows extreme directivity or nulling pattern problems compared to others, then it should be removed from the tests and replaced with another interrogator.

9.3.3 Test report

The test report provides data recorded for the unit's normal operating situation. Record results according to Table 12.

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

Test: Sensitivity directivity ($S_{Directivity}$)		
Mounting material:		
Temperature:	Humidity:	
Interrogator protocol:	Interrogator UII:	
Forward link		
Deviation: 50 KHz nominal	Data rate: 27 kbps	Data coding: Manchester coding
Command: Collect with UDB		
Return link		
Data rate: kbps	Data coding:	
Test results: Azimuth at 0° elevation		
Azimuth (°)	**Attenuator setting (dB)**	**Sensitivity (dBμV/m)**
0		$E_{Survival}$
15		
:		
345		
Test results: Elevation at 0° azimuth		
Elevation (°)	**Attenuator setting (dB)**	**Sensitivity (dBμV/m)**
0		
15		
:		
90		

9.4 Interference rejection ($I_{\text{Rejection}}$)

9.4.1 Purpose

This test determines the interference rejection ability of the interrogator.

9.4.2 Test procedure

An interrogator is placed in the test setup, and the tag simulator's level is set to 3 dB above the $E_{\text{THR Read}}$ level as determined in measurements reported in 9.2. This provides the interrogator with receive levels that have a 3 dB margin.

A second signal source acts as an interference signal and is attached to an antenna equivalent to that used for the tag simulator. The recommended test distance between the interrogator's location and the two source antennae should be the same and at minimum 2 m, with 3 m preferred. The two source antennae should also be equal in gain and separated from each other by at least one wavelength to reduce interactions between them.

First an unmodulated/modulated signal from the interference source is set to 433,920 MHz and 20 dB below the $E_{\text{THR Read}}$ level. This should still allow the tag simulator responses to be read by the interrogator.

The interference level is then increased until the interrogator is no longer able to decode the tag simulator's signal. This is considered the interrogator's on channel $I_{\text{Rejection}}$ level. This test is repeated for the 1st adjacent channels (±250 kHz) and 2nd adjacent channels (±500 kHz).

To determine the interference rejection of the interrogator in the presence of the unmodulated and modulated interference signal, the following measurement procedures shall be performed:

1) Test shall be run based on the test apparatus and setup outlined in 9.2 using two identical vertical polarized reference antennae. One antenna connects to the tag simulator. The other connects to the interference signal source as shown in Figure 6.

2) Set the tag simulator's attenuator level to the $E_{\text{THR Read}}$ setting for the interrogator being evaluated. Confirm that the interrogator reads the tag simulator response 10 out of 10 times.

3) Readjust the attenuator level to 3 dB below that of the $E_{\text{THR Read}}$ level. This increases the level into the interrogator by 3 dB.

4) Adjust the level of the unmodulated interfering source to 20 dB or more below the $E_{\text{THR Read}}$ level. Confirm that the interrogator still reads the tag simulator's signal 10 out of 10 times.

5) Increase the level of the unmodulated interfering source by 1 dB steps until the interrogator can no longer read 10 out of 10 read attempts from the tag simulator.

6) Record the value 1 dB lower than this level as the co-channel rejection (unmodulated) level.

7) Repeat steps 2 through 5 with the interference source 250 kHz higher in frequency (433,170 MHz). Record the value 1 dB lower than this level as the upper 1st adjacent channel rejection (unmodulated).

8) Repeat steps 2 through 5 with the interference source 500 kHz higher in frequency (433,420 MHz). Record the value 1 dB lower than this level as the upper 2nd adjacent channel rejection (unmodulated).

9) Repeat steps 2 through 5 with the interference source 250 kHz lower in frequency (433,670 MHz). Record the value 1 dB lower than this level as the lower 1st adjacent channel rejection (unmodulated).