PD ISO/IEC TR 18047-6:2011

BSI Standards Publication

Information technology — Radio frequency identification device conformance test methods

Part 6: Test methods for air interface communications at 860 MHz to 960 MHz

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National foreword

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Part 6: Test methods for air interface communications at 860 MHz to 960 MHz

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Foreword

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

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

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

In exceptional circumstances, when the joint technical committee has collected data of a different kind from that which is normally published as an International Standard ("state of the art", for example), it may decide to publish a Technical Report. A Technical Report is entirely informative in nature and shall be subject to review every five years in the same manner as an International Standard.

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

ISO/IEC TR 18047-6 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 edition (ISO/IEC TR 18047-6:2008), which has been technically revised.

ISO/IEC TR 18047 consists of the following parts, under the general title *Information technology — Radio frequency identification device conformance test methods*:

— *Part 2: Test methods for air interface communications below 135 kHz*

— *Part 3: Test methods for air interface communications at 13,56 MHz*

— *Part 4: Test methods for air interface communications at 2,45 GHz*

— *Part 6: Test methods for air interface communications at 860 MHz to 960 MHz*

— *Part 7: Test methods for active air interface communications at 433 MHz*

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Introduction

ISO/IEC 18000 defines the air interfaces for radio frequency identification (RFID) devices used in item management applications. ISO/IEC 18000-6 defines the air interface for these devices operating at frequencies from 860 MHz to 960 MHz.

ISO/IEC TR 18047 provides test methods for conformance with the various parts of ISO/IEC 18000.

Each part of ISO/IEC TR 18047 contains all measurements required to be made on a product in order to establish whether it conforms to the corresponding part of ISO/IEC 18000. For this part of ISO/IEC TR 18047, each interrogator and each tag needs to support at least one of the types A or B or C or D.

NOTE Measurement of tag and interrogator performance is covered by the multiple parts of ISO/IEC 18046.

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Information technology — Radio frequency identification device conformance test methods —

Part 6:
Test methods for air interface communications at 860 MHz to 960 MHz

1 Scope

This part of ISO/IEC TR 18047 defines test methods for determining the conformance of radio frequency identification (RFID) devices (tags and interrogators) for item management with the specifications given in ISO/IEC 18000-6, but does not apply to the testing of conformity with regulatory or similar requirements.

The test methods require only that the mandatory functions, and any optional functions which are implemented, be verified. This can, in appropriate circumstances, be supplemented by further, application-specific functionality criteria that are not available in the general case.

The interrogator and tag conformance parameters in this part of ISO/IEC TR 18047 are the following:

- type-specific conformance parameters including nominal values and tolerances;
- parameters that apply directly affecting system functionality and inter-operability.

The following are not included in this part of ISO/IEC TR 18047:

- parameters that are already included in regulatory test requirements;
- high-level data encoding conformance test parameters (these are specified in ISO/IEC 15962).

Unless otherwise specified, the tests in this part of ISO/IEC TR 18047 are to be applied exclusively to RFID tags and interrogators defined in ISO/IEC 18000-6.

Clause 5 describes all necessary conformance tests for ISO/IEC 18000-6 Type A.

Clause 6 describes all necessary conformance tests for ISO/IEC 18000-6 Type B.

Clause 7 describes all necessary conformance tests for ISO/IEC 18000-6 Type C.

Clause 8 describes all necessary conformance tests for ISO/IEC 18000-6 Type D.

Clause 9 describes all necessary conformance tests for ISO/IEC 18000-6 Type C Battery Assisted Passive (BAP), whereas optional features will only be tested when supported.

Clause 10 describes all necessary conformance tests for ISO/IEC 18000-6 Type C Sensor support, whereas optional features will only be tested when supported.

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2 Normative references

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

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*

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

3 Terms, definitions, symbols and abbreviated terms

3.1 Terms and definitions

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

3.2 Symbols

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

D Modulation depth of data coding pulse

d1 Distance between the interrogator and test antenna

d2 Distance between test antenna and DUT tag

ds Distance between the interrogator antenna and sense antenna

dT,IA Interrogator antenna to tag distance

dT,MA Measurement antenna to tag distance

dTE Distance between the interrogator antenna and tag emulator

GI Interrogator antenna gain

GIA Gain of interrogator antenna

GMA Gain of measurement antenna

K Calibration factor

L Maximum interrogator antenna dimension

M Modulation index

PI Delivered power at the carrier frequency

PM Measured power at the carrier frequency

Tf Fall time

Tr Rise time

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3.3 Abbreviated terms

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

DUT Device under test

RCS Radar cross-section

ΔRCS Change in radar cross-section

RBW Resolution bandwidth

VBW Video bandwidth

3.4 Default conditions applicable to the test methods

3.4.1 Test environment

Unless otherwise specified, testing shall take place in an environment of temperature 23 °C ± 3 °C and of non-condensing humidity from 40 % to 60 %.

3.4.2 Pre-conditioning

Where pre-conditioning is required by the test method, the interrogators and tags to be tested shall be conditioned to the test environment for an appropriate time period, which shall be recorded.

3.4.3 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).

3.4.4 Noise floor at test location

Noise floor at test location shall be measured with the spectrum analyser using the same conditions as for the measurement of the DUT.

The spectrum analyser shall measure the noise for at least 1 minute.

The maximum of the measured amplitude shall be 20 dB below the value of the amplitude of the measured tag backscatter operating at minimum power ($P_{I,min}$, see clause 5.2.2.2), and the tag placed at 10 λ from the measurement antenna.

Special attention has to be given to spurious emissions, e.g., insufficiently shielded computer monitors. The electromagnetic test conditions of the measurements shall be checked by performing the measurements with and without a tag in the field.

3.4.5 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 Guide 98-3:2008.

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4 Setup of test equipment

4.1 Setup of test equipment for interrogator tests

4.1.1 General

The DUT shall be an interrogator including an antenna.

All conformance measurements and setups shall be done in an anechoic chamber as defined in Annex A.

Dependent of the regulatory requirements all measurements shall be done at one of the test frequencies in Table 1.

Table 1 — Test frequencies

Test carrier frequency	Comment
866 MHz	Recommended for tests under European regulations
910 MHz	Recommended for tests under Korean or US regulations
922 MHz	Recommended for tests under Australian regulations
953 MHz	Recommended for tests under Japan regulations

NOTE With the test frequencies specified in Table 1 all frequencies of the entire band from 860 MHz to 960 MHz are within ± 2,5 % of one of the test frequencies.

4.1.2 Sense antenna

Where applicable, tests shall be carried out using a sense antenna, which shall be a substantially non-reactive non-radiating load of 50 Ω equipped with an antenna connector. The Voltage Standing Wave Ratio (VSWR) at the 50 Ω connector shall not be greater than 1,2 : 1 over the frequency range of the measurement.

4.1.3 Test apparatus and test circuits for ISO/IEC 18000-6 Type A and B interrogator

4.1.3.1 Interrogator modulation test setup

For this test the sense antenna shall always be placed and orientated for optimum field strength reception in the direction of the major power radiation of the interrogator antenna according Figure 1 at a distance d_S which is defined in clause 5.1.1.2.

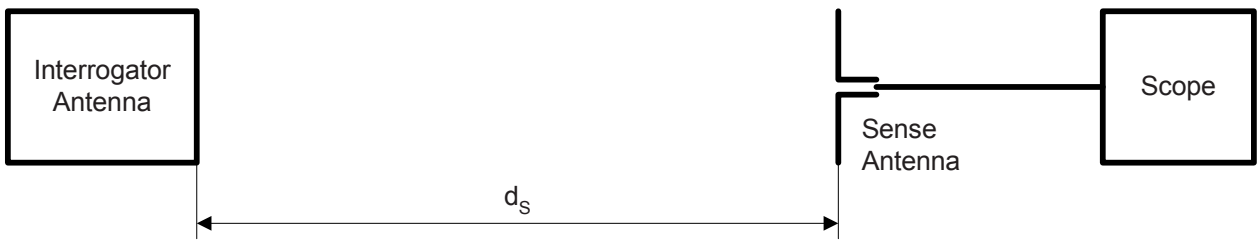

Figure 1 — Interrogator modulation test setup

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4.1.3.2 Interrogator demodulation and turn around time test setup

For this test the tag emulator as defined in Annex F shall be placed and orientated for optimum field strength reception in the direction of the major power radiation of the interrogator according Figure 2 at a distance d_{TE}, which is defined in clause 5.1.2.2.

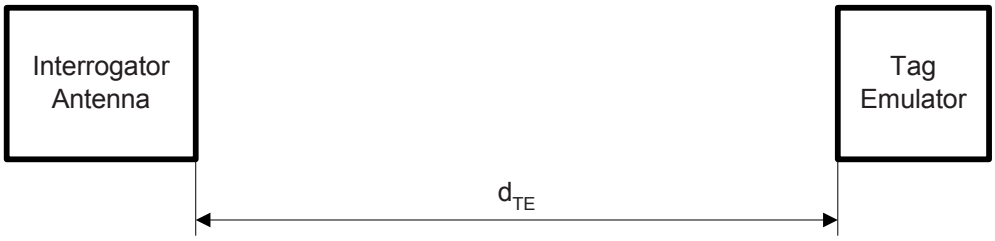

Figure 2 — Interrogator demodulation and turn around test setup

4.1.4 Test apparatus and test circuits for ISO/IEC 18000-6 Type C interrogator

The DUT shall be an interrogator including an antenna.

For this test, the sense antenna shall always be placed according to Figure 3. The distance between an interrogator antenna and a sense antenna shall be $\mathbf{d_1}$. The sense antenna shall be placed in the optimum orientation so as to receive the highest possible power level radiated by the interrogator antenna.

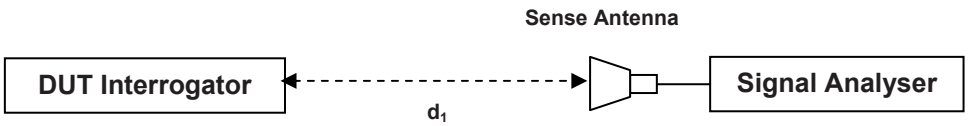

Figure 3 — Interrogator test setup

For some interrogator tests a tag emulator as defined in Annex F shall be used, the tag emulator shall be placed and orientated for optimum field strength reception in the direction of the major power radiation of the interrogator.

4.2 Setup of test equipment for tag tests

4.2.1 General

The DUT shall be a tag including all means in order to be capable to communicate with an interrogator.

When tests require use of an interrogator this shall be an interrogator including antenna that conforms to ISO/IEC 18000-6 according to the methods defined in this Type of ISO/IEC TR 18047, or it shall be a signal generator including antenna. Furthermore, the interrogator shall support the minimum tag response to interrogator command turn around time.

The interrogator antenna shall fulfil the specification of Table 2.

Table 2 — Interrogator antenna requirements for tag tests

Symbol	Parameter	Minimum Value	Maximum Value
L	Maximum Interrogator antenna dimension	0,1 m	$\sqrt{\frac{\lambda\, d_{T,IA}}{2}}$
G_I	Interrogator antenna gain	2 dBi	8 dBi

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All conformance measurements and setups shall be done in an anechoic chamber as defined in Annex A.

Dependent of the regulatory requirements all measurements shall be done at either of the test frequencies in Table 1.

4.2.2 Test apparatus and test circuits for ISO/IEC 18000-6 Type A, B and D tags

4.2.2.1 Tag demodulation and turn around time test setup

For this test the tag shall be placed and oriented for optimum field strength reception in the direction of the major power radiation of the interrogator in a distance

$$d_{T,IA} > \frac{2L^2}{\lambda}, \; d_{T,MA} > \frac{2L^2}{\lambda}$$

with L being the maximum dimension of the interrogator antenna according Figure 4.

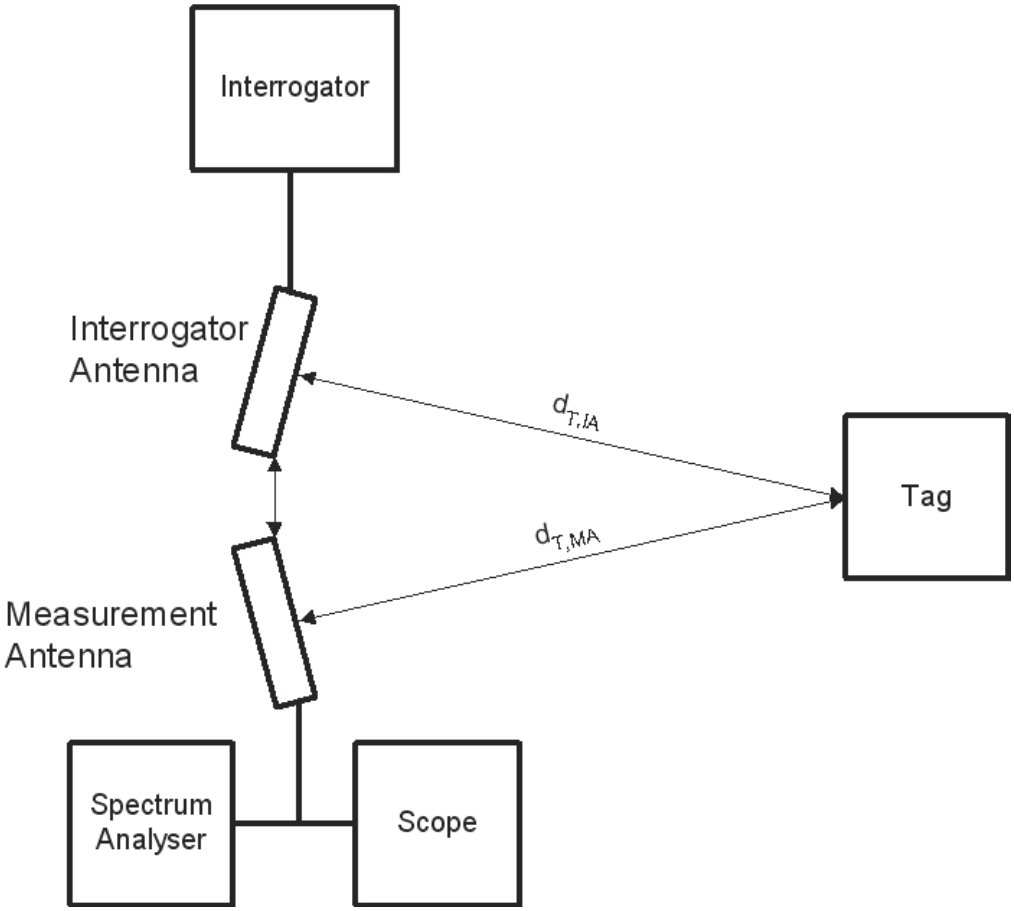

Figure 4 — Tag demodulation test setup

4.2.2.2 Tag backscatter test setup

For this test the test interrogator antenna setup, where the interrogator may alternately also be realized with a vector signal generator according Annex H, shall consist of a set of two mechanically assembled antennas specifically designed to reduce the signal coupling between each other. One shall be used as interrogator antenna while the second, shall be used as measurement antenna and shall be connected either to a spectrum analyser or to an oscilloscope as specified according to Annex D.

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The main lobe axis of these two antennas cross each other with an angle value that shall be lower than 15°. The tag under test shall be placed at this focal point and oriented for optimum field strength reception.

The distances between the tag and the antennas are $d_{T,IA}$ and $d_{T,MA}$ respectively (see Figure 4).

The tag backscatter test setup parameters are defined in Table 3.

Table 3 — Tag backscatter setup parameters

Symbol	Name	Description
$d_{T,IA}$	Interrogator antenna to tag distance	
$d_{T,MA}$	Measurement antenna to tag distance	
G_{IA}	Gain of interrogator antenna	The maximum 3 dB beam width shall be ± 35°
G_{MA}	Gain of measurement antenna	The maximum 3 dB beam width shall be ± 35°

The residual signal coupling between the two antennas shall be measured in free space, and anechoic or similar RF absorbing material shall be used between two antennas to increase isolation up to 45 dB when the value in free space is not better than 45 dB.

L shall be the greater value of the maximum electrical dimension of the Interrogator and Measurement Antenna.

The spectrum analyser shall be to a RBW of 30 kHz, a VBW of 100 kHz. The minimum span should be at least 1 MHz or 8 times the data rate, whichever is greater. The frequency analyser shall use max peak detection.

For this test the tag shall be setup to provide only one modulation frequency. Therefore the tag shall except for the preamble, only reply with a bit stream of zero data bits.

4.2.2.3 Tag response time

The setup for this test shall be as described in chapter 4.2.2.1.

4.2.2.4 Tag bit rate accuracy test setup

The setup for this test shall be as described in chapter 4.2.2.1.

4.2.2.5 Tag state storage time test setup

The setup for this test shall be as described in chapter 4.2.2.1.

4.2.3 Test apparatus and test circuits for ISO/IEC 18000-6 Type C tags

The DUT shall be a tag including all means in order to be capable to communicate with an interrogator.

For this test the tag shall be placed and oriented for optimum field strength reception in the direction of the major power radiation of the interrogator in a distance

$$d_{T,IA} > \frac{2L^2}{\lambda}, \; d_{T,MA} > \frac{2L^2}{\lambda}$$

with L being the maximum dimension of the interrogator antenna according to Figure 4.

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5 Conformance tests for ISO/IEC 18000-6 Type A

5.1 Functional tests of interrogator

5.1.1 Interrogator modulation test

5.1.1.1 Test objective

The objective of this test is to verify that the interrogator provides the appropriate modulation waveform required for operation of tags.

5.1.1.2 Test procedure

The interrogator shall transmit an **Init_round_all** command at the maximum power allowed under the regulations of the selected carrier frequency for testing.

In case the interrogator is intended for operation of non-overlapping RF bands, then this test shall be done for each RF band.

Measurements shall be done with a sense antenna positioned at a distance $d_S = 3\,\lambda$ and $d_S = 10\,\lambda$ and for each operation mode.

A digital oscilloscope as specified in Annex D and the sense antenna shall be used to record the waveform provided by the interrogator.

5.1.1.3 Test report

The test report shall give the measured values of the parameters according Table 4. The pass/fail condition is determined whether the measured values are within the requirements as specified in ISO/IEC 18000-6. Furthermore, the DUT and the sense antenna orientation and position, as well as the used interrogator output power and the used operation frequency shall be recorded.

Table 4 — Measurements to be made

Parameter	Conditions
D	Default modulation operation mode
Tapr	Default modulation operation mode
Tapf	Default modulation operation mode

5.1.2 Interrogator demodulation and turn around time

5.1.2.1 Test objective

The objectives of this test are to verify whether the interrogator is capable of

— demodulating signals from the tags,

— receiving the data transmitted by the tag emulator after the minimum specified turn-around time.

5.1.2.2 Test procedure

The interrogator shall transmit an **Init_round_all** command (see clause B.1.1) at the maximum power allowed under the regulations of the selected carrier frequency for testing.

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After the command provided by the interrogator has been sent and after the minimum turn around time, a tag emulator as specified in Annex F shall transmit a typical response to the **Init_round_all** command at a minimum ΔRCS specified in ISO/IEC 18000-6 Tag: 7d. The tag emulator does not need to demodulate the command, but shall only detect its end to respond after the minimum turn-around time.

When the interrogator is intended for operation of non-overlapping RF bands this test shall be done for each RF band.

Measurements shall be done with a tag emulator positioned at $d_{TE} = 10\ \lambda$ for both the minimum and maximum tag response data rate, i.e. the turn around time from interrogator command to tag response.

In case the interrogator is design for shorter communication distances, then the distance d_{TE} may be decreased and the actual used value shall be mentioned in test report.

The interrogator (digital) demodulator shall accept the tag response including verification of the CRC.

5.1.2.3 Test report

The test report shall contain the tag emulator distance to the interrogator and the ΔRCS value setup in the tag emulator. Furthermore, also the set up turnaround time from the tag emulator, the DUT and the tag emulator orientation and position, as well as the used interrogator output power and the used operation frequency shall be recorded.

5.2 Functional tests of tag

5.2.1 Tag demodulation and turn around time

5.2.1.1 Test objective

The objectives of this test are to verify whether the tag is capable of

— demodulating signals from the interrogator,

— receiving the data transmitted by the interrogator after the minimum specified response to command turn-around time.

5.2.1.2 Test procedure

The test interrogator shall transmit an **Init_round_all** (see clause B.1.1) command.

The tag (DUT) shall receive the command provided by the interrogator and shall provide an appropriate response. After complete reception of the tag response the interrogator shall generate a **Next_slot** command within the minimum specified turn around time between tag response and interrogator command.

Measurements shall be done by verifying that the tag detected the command appropriately by means of evaluation of its response. Measurements shall be done at $P_I = 1{,}2\ P_{I,min}$ or the minimum tag activation power density $S_{T,min}$ for each operation type of the interrogator command data rate.

The power density $S_{T,min}$ is related to the test interrogator radiated power $P_{I,min}$ as following:

$$P_{I,min} = 4\pi d_{T,IA}^2 S_{T,min} \frac{1}{G_{IA}}$$

In case the interrogator is design for shorter communication distances, then the distance d_{TE} may be decreased and the actual used value shall be mentioned in test report.

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The test shall be seen as successful, when it could be shown that the tag sent the correct response for both commands including verification of the CRC.

The interrogator waveform shall contain the setups of the waveform for the respective types according to Table 5.

Table 5 — Setups of waveforms

Setup number	Setup description	Parameter setting
A-1	Minimum modulation depth	D = Dmin
A-2	Medium modulation depth	D = (Dmax + Dmin)/2
A-3	Maximum modulation depth	D = Dmax

5.2.1.3 Test report

The test result shall be recorded as successful or unsuccessful. The test report shall contain the tag distance to the interrogator. Furthermore, also the set up turn around time from the tag response to interrogator command, the DUT and the interrogator orientation and position, as well as the used interrogator output power and the used operation frequency shall be recorded.

5.2.2 Tag backscatter

5.2.2.1 Test objective

The objective of this test is to verify that the tag provides the appropriate modulation waveform and backscatter strength required to be successfully detected and received by the interrogator.

Measurements are carried out in an anechoic chamber in bistatic antennas configuration as shown in Figure 4, I and Q signals are measured with and without the tag present in the anechoic chamber that allows measurement of the difference of re-radiated power issued only from the tag, and thus find the ΔRCS.

5.2.2.2 Test procedure

Measurements shall be done with a tag positioned $d_{T,IA}$ = 1m and $d_{T,MA}$ = 1m away from the interrogator antenna at a power $P_{I,min}$.

Where $P_{I,min}$ is the minimum power allowing the DUT tag activation.

A vector signal analyser as specified in Annex E shall be used to record the quadrature baseband voltages I and Q versus time.

Test setup shall be calibrated to determine antennas gain and mismatch and also cables loss, to be taking into account for all power measurements.

Delta radar cross-section measurement procedure:

1) The signal generator shall be set to the required test frequency.

2) The signal generator amplitude shall be set to a value that allows the DUT tag activation.

3) Using the power meter determine the power at the entrance of the transmit antenna **Pe**, which is defined as the average power measured over at least 100μs period during the continues waves signal following the signal generator command.

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4) The signal analyser shall be set to measure the quadrature baseband I and Q voltages versus time, with a sampling rate of at least 5Msps.

5) Without the tag placed in the anechoic chamber, the signal analyser shall be set to capture at least 100µs period of I and Q samples at the continues wave just following the signal generator command, determine the Ic and Qc voltages levels.

6) With the tag now placed in the anechoic chamber, the analyser shall be set to capture I and Q voltage samples at least during 10 symbols of tag reply, determine the I and Q voltages corresponding to the two modulation states of tag ($I_{r,0}/Q_{r,0}$) and ($I_{r,1}/Q_{r,1}$).

7) Measure the difference of power issue from the DUT tag backscattering according to the equation below:

$$\Delta P_{tag}(rms) = \frac{1}{100} \cdot \left| \left((I_{r,1} - I_c)^2 + (Q_{r,1} - Q_c)^2 \right) - \left((I_{r,0} - I_c)^2 + (Q_{r,0} - Q_c)^2 \right) \right|$$

8) Define the ΔRCS of the DUT tag using the radar equation given below:

$$\Delta RCS = \frac{\Delta P_{tag}}{P_e} \frac{4\pi}{G_{0t} \cdot G_{0r}} \left(\frac{4\pi}{\lambda} \right)^2$$

NOTE This procedure is based on “UHF RFID Tag Delta Radar Cross Section (ΔRCS) Measurement” document, see bibliography.

5.2.2.3 Test report

The test report shall give the measured values of ΔRCS. The pass/fail condition is determined whether the measured values are within the requirements as specified in figures in ISO/IEC 18000-6 and the evaluated ΔRCS is at least above the value from ISO/IEC 18000-6. Furthermore, the DUT and the interrogator orientation and position, as well as the used interrogator output power and the used operation frequency shall be recorded.

5.2.3 Tag response time

5.2.3.1 Test purpose

The objective of this test is to verify the tag response time Trs referencing the parameters in ISO/IEC 18000-6.

5.2.3.2 Test procedure

The interrogator shall transmit a **Init_round_all** command (See clause B.1.1) at the maximum power allowed under the regulations of the selected carrier frequency for testing.

The measurements shall be done using the tag backscatter test setup, the tag positioned $d_{T,IA}$ = 3 λ and $d_{T,MA}$ = 3 λ away from the test interrogator antennas.

The response time shall be measured by a scope as specified in Annex D.

NOTE An example for the measurements is given in clause G.1.

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5.2.3.3 Test report

The test report shall give the measured values of turn around time. The pass/fail condition is determined whether the measured values are within the requirements for the response time specified to the respective Type.

5.2.4 Tag bit rate

5.2.4.1 Test objective

The objective of this test is to verify the bit rate accuracy and data rate of the return link by verification of the Trlb parameter.

5.2.4.2 Test procedure

The interrogator shall transmit a **Init_round_all** command (See clause B.1.1)at the maximum power allowed under the regulations of the selected carrier frequency for testing.

The tag response waveform shall be recorded by a oscilloscope as specified in Annex D using the tag backscatter test setup, the tag positioned $d_{T,IA} = 3\ \lambda$ and $d_{T,MA} = 3\ \lambda$ away from the test interrogator antennas.

The bit rate accuracy shall be measured on the preamble of the tag response for each type respectively.

The average on the first seven bits of preamble shall be used to measure the bite rate accuracy.

5.2.4.3 Test report

The test report shall give the measured values of bit rate calculated according the following formulas:

$$T_{B7} = 7_{Trlb}$$

$$bit\ rate = \frac{7}{7 \cdot T_{B7}}$$

The pass/fail condition is determined whether the measured values are within the requirements as specified in clause 6.5.4 for type A in ISO/IEC 18000-6.

5.2.5 Tag state storage time

5.2.5.1 Test objective

The objective of this test is to verify the state storage time of the tag if the energising field is absent or insufficient.

5.2.5.2 Test procedure

The interrogator shall transmit a **Init_round_all** command (See clause B.1.1) at the maximum power allowed under the regulations of the selected carrier frequency for testing.

After the end of mandatory command sent by the generator, the field shall be shut down for a specified time during two tag states.

For type A the following shall be done:

a) Quiet state

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The test shall be executed for shutoff time equal to the lower limit value of time defined in ISO/IEC 18000-6 on which the tag has to keep the Quiet state.

b) Other states

The test shall be executed for shutoff time equal to the lower limit value of time defined in ISO/IEC 18000-6 during which the tag has to retain its state.

NOTE An example for the measurements is given in Clause G.2.

5.2.5.3 Test report

The test report shall give the tested values of limit storage state time. The pass/fail condition is determined whether the measured values are within the requirements in the ISO/IEC 18000-6 Timing Specification for Tag state storage for Type A.

6 Conformance tests for ISO/IEC 18000-6 Type B

6.1 Functional tests of interrogator

6.1.1 Interrogator modulation test

6.1.1.1 Test objective

The objective of this test is to verify that the interrogator provides the appropriate modulation waveform required for operation of tags.

6.1.1.2 Test procedure

The interrogator shall transmit a **GROUP_SELECT_EQ** command (see Clause B.2.1) at the maximum power allowed under the regulations of the selected carrier frequency for testing.

In case the interrogator is intended for operation of non-overlapping RF bands, then this test shall be done for each RF band.

Measurements shall be done with a sense antenna positioned at a distance $d_S = 3\ \lambda$ and $d_S = 10\ \lambda$ and for each operation mode.

A digital oscilloscope as specified in Annex D and the sense antenna shall be used to record the waveform provided by the interrogator.

6.1.1.3 Test report

The test report shall give the measured values of the parameters according Table 6. The pass/fail condition is determined whether the measured values are within the requirements as specified in ISO/IEC 18000-6. Furthermore, the DUT and the sense antenna orientation and position, as well as the used interrogator output power and the used operation frequency shall be recorded.

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Table 6 — Measurements to be made

Parameter	Conditions
M	Low index interrogator modulation mode
Tr	Low index interrogator modulation mode
Tf	Low index interrogator modulation mode
M	High index interrogator modulation mode
Tr	High index interrogator modulation mode
Tf	High index interrogator modulation mode

6.1.2 Interrogator demodulation and turn around time

6.1.2.1 Test objective

The objectives of this test are to verify whether the interrogator is capable of

— demodulating signals from the tags,

— receiving the data transmitted by the tag emulator after the minimum specified turn-around time.

6.1.2.2 Test procedure

The interrogator shall transmit a **GROUP_SELECT_EQ** command (see Clause B.2.1) at the maximum power allowed under the regulations of the selected carrier frequency for testing.

After the command provided by the interrogator has been sent and after the minimum turn around time, a tag emulator as specified in Annex F shall transmit a typical response to the **GROUP_SELECT_EQ** command at a minimum ΔRCS specified in ISO/IEC 18000-6 Tag: 7d. The tag emulator does not need to demodulate the command, but shall only detect its end to respond after the minimum turn-around time.

When the interrogator is intended for operation of non-overlapping RF bands this test shall be done for each RF band.

Measurements shall be done with a tag emulator positioned at d_{TE} = 10 λ for both the minimum and maximum tag response data rate, i.e. the turn around time from interrogator command to tag response.

In case the interrogator is design for shorter communication distances, then the distance d_{TE} may be decreased and the actual used value shall be mentioned in test report.

The interrogator (digital) demodulator shall accept the tag response including verification of the CRC.

6.1.2.3 Test report

The test report shall contain the tag emulator distance to the interrogator and the ΔRCS value setup in the tag emulator. Furthermore, also the set up turnaround time from the tag emulator, the DUT and the tag emulator orientation and position, as well as the used interrogator output power and the used operation frequency shall be recorded.

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6.2 Functional tests of tag

6.2.1 Tag demodulation and turn around time

6.2.1.1 Test objective

The objectives of this test are to verify whether the tag is capable of

— demodulating signals from the interrogator,

— receiving the data transmitted by the interrogator after the minimum specified response to command turn-around time.

6.2.1.2 Test procedure

The test interrogator shall transmit a **GROUP_SELECT_EQ** command (see Clause B.2.1).

The tag (DUT) shall receive the command provided by the interrogator and shall provide an appropriate response. After complete reception of the tag response the interrogator shall generate a new **GROUP_SELECT_EQ** command within the minimum specified turn around time between tag response and interrogator command.

Measurements shall be done by verifying that the tag detected the command appropriately by means of evaluation of its response. Measurements shall be done at P_I = 1,2 $P_{I,min}$ or the minimum tag activation power density $S_{T,min}$ for each operation type of the interrogator command data rate.

The power density $S_{T,min}$ is related to the test interrogator radiated power $P_{I,min}$ as following:

$$P_{I,\min} = 4\pi d_{T,IA}^2 S_{T,\min} \frac{1}{G_{IA}}$$

In case the interrogator is design for shorter communication distances, then the distance d_{TE} may be decreased and the actual used value shall be mentioned in test report.

The test shall be seen as successful, when it could be shown that the tag sent the correct response for both commands including verification of the CRC.

The interrogator waveform shall contain the setups of the waveform for the respective types according Table 7.

Table 7 — Setups of waveforms

Setup number	Setup description	Parameter setting
B-1	Minimum modulation index for low modulation index operation mode	M = Mmin
B-2	Maximum modulation index for low modulation index operation mode	M = Mmax
B-3	Minimum modulation index for high modulation index operation mode	M = Mmin
B-4	Maximum modulation index for high modulation index operation mode	M ⩾ 99% * Mmax

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6.2.1.3 Test report

The test result shall be recorded as successful or unsuccessful. The test report shall contain the tag distance to the interrogator. Furthermore, also the set up turn around time from the tag response to interrogator command, the DUT and the interrogator orientation and position, as well as the used interrogator output power and the used operation frequency shall be recorded.

6.2.2 Tag backscatter

6.2.2.1 Test objective

The objective of this test is to verify that the tag provides the appropriate modulation waveform and backscatter strength required to be successfully detected and received by the interrogator.

Measurements are carried out in an anechoic chamber in bistatic antennas configuration as shown in Figure 4, I and Q signals are measured with and without the tag present in the anechoic chamber that allows measurement of the difference of re-radiated power issued only from the tag, and thus find the ΔRCS.

6.2.2.2 Test procedure

Measurements shall be done with a tag positioned $d_{T,IA}$ = 1m and $d_{T,MA}$ = 1m away from the interrogator antenna at a power $P_{I,min}$.

Where $P_{I,min}$ is the minimum power allowing the DUT tag activation.

A vector signal analyser as specified in Annex E shall be used to record the quadrature baseband voltages I and Q versus time.

Test setup shall be calibrated to determine antennas gain and mismatch and also cables loss, to be taking into account for all power measurements.

Delta radar cross-section measurement procedure:

1) The signal generator shall be set to the required test frequency.

2) The signal generator amplitude shall be set to a value that allows the DUT tag activation.

3) Using the power meter determine the power at the entrance of the transmit antenna **Pe**, which is defined as the average power measured over at least 100μs period during the continues waves signal following the signal generator command.

4) The signal analyser shall be set to measure the quadrature baseband I and Q voltages versus time, with a sampling rate of at least 5Msps.

5) Without the tag placed in the anechoic chamber, the signal analyser shall be set to capture at least 100μs period of I and Q samples at the continues wave just following the signal generator command, determine the Ic and Qc voltages levels.

6) With the tag now placed in the anechoic chamber, the analyser shall be set to capture I and Q voltage samples at least during 10 symbols of tag reply, determine the I and Q voltages corresponding to the two modulation states of tag ($I_{r,0}/Q_{r,0}$) and ($I_{r,1}/Q_{r,1}$).

7) Measure the difference of power issue from the DUT tag backscattering according to the equation below:

$$\Delta P_{tag}(rms) = \frac{1}{100} \cdot \left| \left((I_{r,1} - I_c)^2 + (Q_{r,1} - Q_c)^2 \right) - \left((I_{r,0} - I_c)^2 + (Q_{r,0} - Q_c)^2 \right) \right|$$

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