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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

Technologies de l'information — Méthodes d'essai de conformité du dispositif d'identification de radiofréquence —

Partie 6: Méthodes d'essai pour des communications d'une interface d'air à 860 MHz et jusqu'à 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.

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 18047-6 was prepared by Joint Technical Committee ISO/IEC JTC 1, *Information technology*, Subcommittee SC 31, *Automatic identification and data capture techniques*.

This first edition of International Standard ISO/IEC 18047-6 cancels and replaces the previous edition of Technical Report ISO/IEC TR 18047-6:2011.

ISO/IEC 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* [Technical Report]

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

— *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* [Technical Report]

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

Each part of ISO/IEC 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 18047, each interrogator and each tag needs to support at least one of the types A or B or C or D.

NOTE Test methods for interrogator and tag performance are covered by the multiple parts of ISO/IEC 18046.

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 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, are 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 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 is not included in this part of ISO/IEC 18047:

- parameters that are already included in regulatory test requirements;

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 10 describes all necessary conformance tests for ISO/IEC 18000-6 clause 11.5 Manchester mode BAP Type C.

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

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

The interrogators and tags to be tested shall be conditioned to the test environment for a period of 24 hours before testing.

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 for at least 1 minute with the spectrum analyser using the same conditions as for the measurement of the DUT.

The maximum of the measured noise amplitude measured in a 10 kHz bandwidth shall be -60 dB from 0,5 GHz to 2 GHz and -90 dBm around the frequency of the main signal of the tag backscatter signal.

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/IEC Guide 98-3:2008.

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
915 MHz	Recommended for tests under Korean, Australian or US 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 ± 2,9 % of one of the test frequencies. All practically used frequencies in the frequency bands 860-870 MHz, 900 – 930 MHz and 950-960 MHz are within ± 1,7 % of the test frequencies.

NOTE The test frequency of 953 MHz may be skipped in case no region of the world requires frequencies above 930 MHz anymore and the tag will not be used above 930 MHz.

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 2 : 1 over the frequency range of the measurement.

4.1.3 Test apparatus and test circuits for ISO/IEC 18000-6 Type A, Type B and Type C 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 DUT interrogator antenna according Figure 1 at a distance d_S of 0,8 – 1,1 m.

Figure 1 — Interrogator modulation test setup

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 DUT interrogator antenna according Figure 2 at a distance d_{TE} of 0,8 – 1,1 m.

Figure 2 — Interrogator demodulation and turn around test setup

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 measurement equipment that fulfills the requirements in order to act as interrogator and in particular it shall support the minimum tag response to interrogator command turn around time.

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.

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

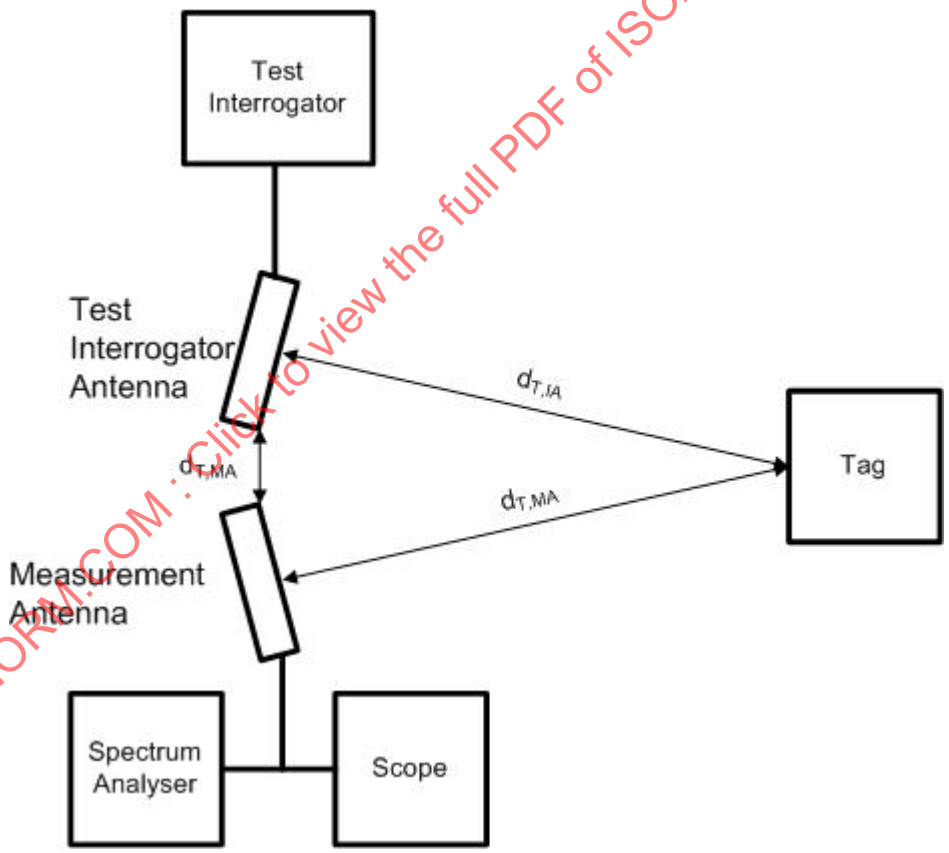

Figure 3 — Tag demodulation test setup

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 signal generator according Annex C, 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 C.

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 3).

The tag backscatter test setup parameters are defined in Table 2.

Table 2 — Tag backscatter setup parameters

Symbol	Name	Description
$d_{T,IA}$	Interrogator antenna to tag distance	0,8 – 1,1 m
$d_{T,MA}$	Measurement antenna to tag distance	0,8 – 1,1 m
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°

4.2.2.3 Tag response time

The setup for this test shall be as described in 5.2.2.1.

4.2.2.4 Tag bit rate accuracy test setup

The setup for this test shall be as described in 5.2.2.1.

4.2.2.5 Tag state storage time test setup

The setup for this test shall be as described in 5.2.2.1.

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.

A digital oscilloscope as specified in Annex C 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 3. 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 3 — 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.

After the command provided by the interrogator has been sent and after the minimum turn around time, a tag emulator as specified in Annex D 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 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 $P_I = 1{,}2\ P_{I,min}$.

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 to Table 4.

Table 4 — 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 3 with the tag positioned in the far field of the transmit antenna.

5.2.2.2 Test procedure

Measurements shall be done with 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 C 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 power versus time, with a sampling rate of at least 5 Msps.

5) With the tag placed in the anechoic chamber, the analyser shall be set to capture the complex IQ power for at least during 10 symbols of tag reply.

6) Calculate the difference of power from the DUT tag backscattering according the following equation: $\Delta P_{tag}(rms) = \frac{1}{2 Z_0} \cdot \left((I_{r,1} - I_{r,0})^2 + (Q_{r,1} - Q_{r,0})^2 \right)$, where Z_0 is the wave resistance of the measurement equipment and usually 50 Ω.

7) Calculate the ΔRCS of the DUT tag using the radar equation given below: $\Delta RCS = \frac{\Delta P_{tag}}{P_e} \frac{4\pi\ d^4}{G_{0t} \cdot G_{0r}} \left(\frac{4\pi}{\lambda} \right)^2$

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

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

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 an oscilloscope as specified in Annex C using the tag backscatter test setup.

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

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 E.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.

A digital oscilloscope as specified in Annex C 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 5. 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 5 — 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 D 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.

Measurements shall be done 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.

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 $P_I = 1{,}2\ P_{I,min}$.

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 6.

Table 6 — 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

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 3 with the tag positioned in the far field of the transmit antenna.

6.2.2.2 Test procedure

Measurements shall be done with 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 C 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 power versus time, with a sampling rate of at least 5 Msps.

5) With the tag placed in the anechoic chamber, the analyser shall be set to capture the complex IQ power for at least during 10 symbols of tag reply.

6) Calculate the difference of power from the DUT tag backscattering according the following equation: $\Delta P_{tag}(rms) = \frac{1}{2 Z_0} \cdot \left((I_{r,1} - I_{r,0})^2 + (Q_{r,1} - Q_{r,0})^2 \right)$, where Z_0 is the wave resistance of the measurement equipment and usually 50 Ω.

7) Calculate the ΔRCS of the DUT tag using the radar equation given below: $\Delta RCS = \frac{\Delta P_{tag}}{P_e} \frac{4\pi \ d^4}{G_{0t} \cdot G_{0r}} \left(\frac{4\pi}{\lambda} \right)^2$

6.2.2.3 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.

6.2.3 Tag response time

6.2.3.1 Test objective

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

6.2.3.2 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.

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 C.

NOTE An example for the measurements is given in Clause E.1.

6.2.3.3 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.

6.2.4 Tag bit rate

6.2.4.1 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.

6.2.4.2 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.

The tag response waveform shall be recorded by a oscilloscope as specified in Annex C using the tag backscatter test setup.

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.

6.2.4.3 Test report

The test report shall give the measured values of bit rate calculated according the following formulas (see Annex E):

$$T_{rlb\_average} = \frac{\sum_1^7 T_{rlb_n}}{7}$$

$$bit\ rate = \frac{1}{T_{rlb\_average}}$$

The pass/fail condition is determined whether the measured values are within the requirements as specified in ISO/IEC 18000-6 Type B.

6.2.5 Tag state storage time

6.2.5.1 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.

6.2.5.2 Test procedure

The interrogator shall transmit a **READ** command 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.

The test shall be executed for a shutoff time of t_{DE_SB} defined in ISO/IEC 18000-6 and the flag DE_SB shall be still be set when verified.

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

6.2.5.3 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 t_{DE_SB}.

7 Conformance tests for ISO/IEC 18000-6 Type C

7.1 Functional tests of interrogator

7.1.1 Interrogator data encoding

7.1.1.1 Purpose

The purpose of this test is to verify that the tolerance on all interrogator data encoding parameters shall be ±1 % as described in ISO/IEC 18000-6 Type C.

7.1.1.2 Procedure

Interrogator data encoding, measurement procedure:

1) The DUT interrogator shall be configured for transmitting at the maximum power, with the first supported frequency and modulation type.

2) The DUT interrogator shall be set with all parameters defined in Table 7 and with the first test case parameters defined in Table 7 for variable parameters.

3) The DUT interrogator shall be set to send a **QUERY** command followed by the continuous wave.

4) The signal analyser shall be set to power versus time mode.

5) Wait until signal analyser is triggered, capture all the demodulated trace power versus time.

6) Measure data-0 and data-1 durations from interrogator preamble trace.

7) The steps 2) to 6) shall be repeated for all the test cases that are supported by the DUT interrogator and compliant with local regulation.

8) The steps 2) to 7) shall be repeated for all DUT interrogator supported frequencies and modulations.

Table 7 — Interrogator data encoding test parameters

TEST : Interrogator data encoding				
RF PARAMETERS				
Power EIRP (dbm) : **max power authorized**			Frequency (MHz) : **Interrogator supported frequencies**	
Modulation type: **Interrogator supported modulations**			Modulation index : **Variable**	
PROTOCOL SETTINGS				
Command : **Query**				
Parameters	DR:**64/3**	M:**1**	Trext:**1**	
Timings	Tari (µs):**Variables**	PW(µs):**0,5* Tari**	RTcal(µs):**A fixed number of times of Tari**	TRcal(µs):**Variable**

Table 8 — Interrogator data encoding test cases

	Tari (µs) = data_0	**RTcal(µs)**	**Modulation index (%)**
1	6,25	2,5*Tari **(data_1= 9,375 µs)**	80
2			100
3		3*Tari **(data_1= 12,5 µs)**	80
4			100
5	12,5	2,5*Tari **(data_1= 18,75 µs)**	80
6			100
7		3*Tari **(data_1= 25 µs)**	80
8			100
9	25	2,5*Tari **(data_1= 37,5 µs)**	80
10			100
11		3*Tari **(data_1= 50 µs)**	80
12			100

7.1.1.3 Test report

The test report shall give for each test case all communication parameters and the test verdict pass or fail, the pass condition for each point is obtained if the tolerance for the duration of data-0 and data-1 are lower than 1 % for all the test conditions.

7.1.2 Interrogator RF envelope parameters

7.1.2.1 Purpose

The purpose of this test is to verify all the parameters pulse modulation depth, rise time, fall time, and PW, and shall be the same for a data-0 and a data-1 as described in ISO/IEC 18000-6 Type C.

7.1.2.2 Procedure

Interrogator RF envelope parameters, measurement procedure:

1) The DUT interrogator shall be configured for transmitting at the maximum power, at the first supported frequency and modulation type.

2) The DUT interrogator shall be set with all parameters defined in Table 9 and with the first test case parameters defined in Table 10 for variable test parameters.

3) The DUT interrogator shall be set to send a **QUERY** command followed by the continuous wave.

4) The signal analyser shall be set to power versus time mode.

5) Wait until signal analyser is triggered, capture all the demodulated trace power versus time.

6) Measure the DUT interrogator PW and envelope rise and fall time as described in ISO/IEC 18000-6 Type C. The parameter pulse modulation depth shall be measured.

7) The steps 2) to 6) shall be repeated for all the test cases that are supported by the DUT interrogator and compliant with local regulation.

8) The steps 2) to 7) shall be repeated for all DUT interrogator supported frequencies and modulations.

Table 9 — Interrogator RF envelope test parameters

TEST : Interrogator RF envelope parameters				
RF PARAMETERS				
Power EIRP (dbm) : **max power authorized**			Frequency (MHz) : **Interrogator supported frequencies**	
Modulation type: **Interrogator supported modulations**			Modulation index : **Variable**	
PROTOCOL SETTINGS				
Command : **Query**				
Parameters	DR:**64/3**	M:**1**	Trext:**1**	
Timings	Tari (µs):**Variables**	PW(µs): **Variable**	RTcal(µs):**A fixed number times of Tari**	TRcal(µs):**Variable**

Table 10 — Interrogator RF envelope test cases

	Tari (µs) = data_0	**PW (µs)**	**Modulation index (%)**
1	6,25	2 **(PW min)**	80
2			100
3		0,525*Tari **(PW max)**	80
4			100
5	12,5	0,256*Tari **(PW min)**	80
6			100
7		0,525*Tari **(PW max)**	80
8			100
9	25	0,256*Tari **(PW min)**	80
10			100
11		0,525*Tari **(PW max)**	80
12			100

7.1.2.3 Test report

The test report shall give for each test case all communication parameters and the test verdict pass or fail, the pass condition for each point is obtained if the value of the parameters shall be in the limit maximum and minimum as specified in ISO/IEC 18000-6 Type C.

7.1.3 Interrogator RF power-up and power-down parameters

7.1.3.1 Purpose

The purpose of this test is to verify that the Interrogator power-up and power down RF envelopes shall comply with RF envelope specified in ISO/IEC 18000-6 Type C.

7.1.3.2 Procedure

Interrogator RF power-up and power-down, measurement procedure:

1) The DUT interrogator shall be configured for transmitting at the maximum power, at the first supported frequency and modulation type.

2) The DUT interrogator under test shall be set to be powered on, to transmit a CW and then powered off.

3) The signal analyser shall capture all the interrogator signal trace.

4) Measure the interrogator rise time, fall time, settling time, signal level when off, undershoot, and overshoot as described in ISO/IEC 18000-6 Type C.

5) In the interrogator power-up trace verify that once the carrier level has risen above the 10 % level, the power-up envelope shall rise monotonically until at least the ripple limit Ml, and that the RF envelope shall not fall below the 90 % point during interval Ts.

6) In the interrogator power-down trace verify that once the carrier level has fallen below the 90 % level, the power-down envelope shall fall monotonically until the power limit Ms.

7) The steps 2) to 7) shall be repeated for all DUT interrogator supported frequencies and modulations.

7.1.3.3 Test report

The test report shall give for each test case all communication parameters and the test verdict pass or fail, the pass condition is obtained if the value of the parameters shall be in the limit maximum and minimum specified in ISO/IEC 18000-6 Type C. Monotonicity shall be as required for the Power-up and Power-down of the RF waveform

7.1.4 Interrogator preamble parameters

7.1.4.1 Purpose

The purpose of this test case is to verify that the preamble shall comprise a fixed-length start delimiter, a data-0 symbol, a R=>T calibration (RTcal) symbol, and a T=>R calibration (TRcal) symbol, as described in ISO/IEC 18000-6 Type C.

7.1.4.2 Procedure

Interrogator preamble parameters, measurement procedure:

1) The DUT interrogator shall be configured for transmitting at the maximum power, at the first supported frequency and modulation type.

2) The DUT interrogator shall be set with all parameters defined in Table 11 and with the first test case parameters defined in Table 12 for variable test parameters.

3) The DUT interrogator shall be set to send a **QUERY** command followed by the continuous wave.

4) The signal analyser shall capture all the interrogator signal trace.

5) Measure the interrogator delimiter duration, Data-0 duration, RTcal and TRcal timings as defined in ISO/IEC 18000-6 Type C.

6) The steps 2) to 5) shall be repeated for all the test cases that are supported by the DUT interrogator and compliant with local regulation.

7) The steps 3) to 7) shall be repeated for all DUT interrogator supported frequencies and modulations.

Table 11 — Interrogator preamble test parameters

TEST : Interrogator preamble parameters				
RF PARAMETERS				
Power EIRP (dbm) : **maximum power authorized**			Frequency (MHz) : **Interrogator supported frequencies**	
Modulation type: **Interrogator supported modulations**			Modulation index : **90 %**	
PROTOCOL SETTINGS				
Command : **Query**				
Parameters	DR:**64/3**	M:**1**	Trext:**1**	
Timings	Tari (µs):**Variable**	PW(µs):**0,5*Tari**	RTcal(µs): **Variable**	TRcal(µs): **Variable**

Table 12 — Interrogator preamble test cases

	Tari (µs)	**RTcal (µs)**	**TRcal (µs)**
1	6,25	2,5*Tari	1,1*RTcal
2			3*RTcal
3		3*Tari	1,1*RTcal
4			3*RTcal
5	12,5	2,5*Tari	1,1*RTcal
6			3*RTcal
7		3*Tari	1,1*RTcal
8			3*RTcal
9	25	2,5*Tari	1,1*RTcal
10			3*RTcal
11		3*Tari	1,1*RTcal
12			3*RTcal

7.1.4.3 Test report

The test report shall give for each test case all communication parameters and the test verdict pass or fail, the pass condition is obtained for each test point if the tolerance for the duration of data-0, RTcal and TRcal shall be lower than 1 % for all the test conditions and the delimiter shall be 12,5 µs ±5 %.

7.1.5 Interrogator link timing T2

7.1.5.1 Purpose

The purpose of this test is to verify that the DUT interrogator meets the timing parameter T2.

7.1.5.2 Procedure

Interrogator link timing T2, measurement procedure:

1) The DUT interrogator shall be configured for transmitting at the maximum power, at the first supported frequency and modulation type.

2) The DUT interrogator shall be set with all parameters defined in Table 13 and with the first test case parameters defined in Table 14 for variable test parameters.

3) The DUT interrogator shall be set to send a **QUERY** command followed by the continuous wave.

4) Set the tag emulator to backscatter an RN16 reply, the RN16 shall be sent after the typical value for T1, the DUT interrogator will send its ACK.

5) The signal analyser shall capture all demodulated trace power versus time (**Query**+**RN16**+**ACK**).

6) Measure the link parameter, finding the end of RN16 frequency variation and the beginning of ACK frequency variation.

7) The steps 3) to 6) shall be repeated for all the test cases that are supported by the DUT interrogator and compliant with local regulation.

8) The steps 3) to 7) shall be repeated for all DUT interrogator supported frequencies and modulations.

Table 13 — Interrogator link timing T2 test parameters

TEST : Tag link timing parameter T2				
RF PARAMETERS				
Power EIRP (dbm) : **maximum power authorized**			Frequency (MHz) : **Variable**	
Modulation type: **DSB-ASK**			Modulation index : **90 %**	
PROTOCOL SETTINGS				
Command : **Query**				
Parameters	DR: **Variable**	M**:1**	Trext:**1**	
Timings	Tari (µs):**Variable**	PW (µs):**0,5*Tari**	Rtcal (µs):**3*Tari**	TRcal (µs): Variable

Table 14 — Tag link timing parameter T2 test cases

	Tari (µs)	D	TRcal (µs)
1	6,25	64/3	33,7 **(BLF=640 KHz)**
2		8	66,7**(BLF=320 KHz)**
3	12,5	64/3	200 **(BLF=40 KHz)**
4		8	33,7 **(BLF=640 KHz)**
5	25	64/3	66,7**(BLF=320 KHz)**
6		8	200 **(BLF=40 KHz)**

7.1.5.3 Test report

The test report shall give for each test case all communication parameters and the test verdict pass or fail, the pass condition is obtained for each test point if the measured time value shall be between T2 min and T2 max. 20 Tpri applies as the test is an interrogator test.

7.1.6 Interrogator link timing T3

7.1.6.1 Purpose

The purpose of this test is to verify that the DUT interrogator meets the timing parameter T3, which define the time an Interrogator waits, after T_1, before it issues another command.

7.1.6.2 Procedure

Interrogator link timing T3, measurement procedure:

1) The DUT interrogator shall be configured for transmitting at the maximum power, at the first supported frequency and modulation type.

2) The signal analyser shall be set to power versus time mode.

3) The DUT interrogator shall be set with all parameters defined in Table 15 and with the first test case parameters defined in Table 16 for variable test parameters.

4) Set DUT interrogator to transmit a **Select** command followed by **Query** command.

5) The signal analyser shall capture all demodulated trace power versus time (**Select** + **Query**).

6) Measure the link timing T3 + T1, finding the end of **Query** frequency variation and the beginning of **QueryRep** frequency variation, the link parameter T3 is calculated by subtracting the T1 maximum value to the measured time (T1+T3).

7) The steps 3) to 6) shall be repeated for all the test cases that are supported by the DUT interrogator and compliant with local regulation.

8) The steps 3) to 7) shall be repeated for all DUT interrogator supported frequencies and modulations.

Table 15 — Tag link timing parameter T3 test parameters

TEST : Tag link timing parameter T3				
RF PARAMETERS				
Power EIRP (dbm) : **maximum power authorized**			Frequency (MHz) : **Variable**	
Modulation type: **DSB-ASK**			Modulation index : **90 %**	
PROTOCOL SETTINGS				
Command : **Query**				
Parameters	DR: **Variable**	M:**1**	Trext:**1**	
Timings	Tari (µs):**Variable**	PW (µs):**0,5*Tari**	Rtcal (µs):**3*Tari**	TRcal (µs): **Variable**

Table 16 — Tag link timing parameter T3 test cases

	Tari (µs)	**D**	**TRcal (µs)**
1	6,25	64/3	33,7 **(BLF=640 KHz)**
2		8	66,7**(BLF=320 KHz)**
3	12,5	64/3	200 **(BLF=40 KHz)**
4		8	33,7 **(BLF=640 KHz)**
5	25	64/3	66,7**(BLF=320 KHz)**
6		8	200 **(BLF=40 KHz)**

7.1.6.3 Test report

The test report shall give for each test case all communication parameters and the test verdict pass or fail, the pass condition is obtained for each test point if the measured time value shall be greater than the minimum value for T3, according to ISO/IEC 18000-6 Type C.

7.1.7 Interrogator link timing T4

7.1.7.1 Purpose

The purpose of this test case is to verify that the DUT interrogator meets the timing parameter T4, which define the minimum time between Interrogator commands.

7.1.7.2 Procedure

Interrogator link timing T4, measurement procedure:

1) The DUT interrogator shall be configured for transmitting at the maximum power, at the first supported frequency and modulation type.

2) The signal analyser shall be set to power versus time mode.

3) The DUT interrogator shall be set with all parameters defined in Table 17 and with the first test case parameters defined in Table 18 for variable test parameters.

4) Set DUT to initiate an inventory round, transmitting a **Query** command followed by **QueryRep** command.

5) The signal analyser shall capture all demodulated trace Power versus time (**Query** + **QueryRep**).

6) Measure the link Timing T4, finding the end of **select** frequency variation and the beginning of Query frequency variation.

7) The steps 3) to 6) shall be repeated for all the test cases that are supported by the DUT interrogator and compliant with local regulation.

8) The steps 3) to 7) shall be repeated for all DUT interrogator supported frequencies and modulations.

Table 17 — Tag link timing parameter T2 test parameters

TEST : Tag link timing parameter T4				
RF PARAMETERS				
Power EIRP (dbm) : **maximum power authorized**			Frequency (MHz) : **Variable**	
Modulation type: **DSB-ASK**			Modulation index : **90 %**	
PROTOCOL SETTINGS				
Command : **Query**				
Parameters	DR: **Variable**	M:**1**	Trext:**1**	
Timings	Tari (µs):**Variable**	PW (µs):**0,5*Tari**	Rtcal (µs):**3*Tari**	TRcal (µs): **Variable**

Table 18 — Tag link timing parameter T2 test cases

	Tari (µs)	**D**	**TRcal (µs)**
1	6,25	64/3	33,7 **(BLF=640 KHz)**
2		8	66,7**(BLF=320 KHz)**
3	12,5	64/3	200 **(BLF=40 KHz)**
4		8	33,7 **(BLF=640 KHz)**
5	25	64/3	66,7**(BLF=320 KHz)**
6		8	200 **(BLF=40 KHz)**

7.1.7.3 Test report

The test report shall give for each test case all communication parameters and the test verdict pass or fail, the pass condition is obtained for each test point if the measured time value shall be greater than the minimum value for T4, according to ISO/IEC 18000-6 Type C.

7.2 Functional tests of tag

7.2.1 Tag Frequency range

7.2.1.1 Purpose

The purpose of this test is to verify that the DUT tag shall be capable of receiving power from and communicating with interrogators within the frequency range from 860 MHz to 960 MHz.

7.2.1.2 Procedure

Tag frequency range, measurement procedure:

1) The test interrogator shall be that its antenna sends the maximum power authorized by the local regulations.

2) A **QUERY** command shall be continuously sent followed by the continuous wave.

3) If the oscilloscope detects a tag response within 100 ms then the test step is PASS. Otherwise it is FAIL.

4) The steps 2) and 3) shall be repeated for all the frequencies defined in Table 1.

Table 19 — Tag frequency range test parameters

TEST : Tag frequency range				
RF PARAMETERS				
Power EIRP (dbm) : **maximum power authorized**			Frequency (MHz) : **Variable**	
Modulation type: **DSB-ASK**			Modulation index : **90 %**	
PROTOCOL SETTINGS				
Command : **Query**				
Parameters	DR:**8**	M:**1**	Trext:**0**	
Timings	Tari (µs):**25**	PW(µs): **12,5**	RTcal(µs): **62,5**	TRcal(µs): **100**

7.2.1.3 Test report

The test report shall give for each test point all communication parameters and the test verdict pass or fail, the pass condition for each point is obtained when the signal analyser is triggered that means that the tag is working at the test frequency.

7.2.2 Tag demodulation capability

7.2.2.1 Purpose

The purpose of this test is to verify that the DUT tag shall be capable of demodulating all three modulation types DSB-ASK, SSB-ASK and PR-ASK.

7.2.2.2 Procedure

Tag demodulation capability, measurement procedure:

1) The waveform generator amplitude shall be set to the maximum value authorized by the local regulations.

2) The Signal analyser Trigger shall be set to frequency mask trigger waiting tag response, the signal analyser trigger will be active if the tag response is present.

3) The signal generator shall be set with all parameters defined in Table 20 and with the first test case parameters defined in Table 21 for variable test parameters.

4) A **QUERY** command shall be continuously sent followed by the continuous wave.

5) Wait until the signal analyser is triggered, if it is not triggered in 1 s, then finish the test case.

6) The steps 3) to 5) shall be repeated for all the test cases defined in Table 21.

Table 20 — Tag demodulation capability test parameters

TEST : Tag demodulation capability				
RF PARAMETERS				
Power EIRP (dbm) : **maximum power authorized**			Frequency (MHz) : **Variable**	
Modulation type: **Variable**			Modulation index : **90 %**	
PROTOCOL SETTINGS				
Command : **Query**				
Parameters	DR:**8**	M:**1**	Trext:**0**	
Timings	Tari (µs):**25**	PW(µs): **12,5**	RTcal(µs): **62,5**	TRcal(µs): **100**

Table 21 — Tag demodulation capability test cases

	Frequency (MHz)	Modulation type
1	866	DSB-ASK
2		SSB-ASK
3		PR-ASK
4	915	DSB-ASK
5		SSB-ASK
6		PR-ASK
7	953	DSB-ASK
8		SSB-ASK
9		PR-ASK

7.2.2.3 Test report

The test report shall give for each test point all communication parameters and the test verdict pass or fail, the pass condition for each point is obtained when the signal analyser is triggered that means that the tag is working at the test frequency and modulation.

7.2.3 Tag duty cycle

7.2.3.1 Purpose

The purpose of this test is to verify that the duty cycle for FM0 and Miller encoding, shall be a minimum of 45 % and a maximum of 55 %, with a nominal value of 50 %.

7.2.3.2 Procedure

Tag duty cycle, measurement procedure:

1) The waveform generator amplitude shall be set to the maximum value authorized by the local regulations.

2) The signal analyser shall be set to power versus time mode.

3) The signal generator shall be set with all parameters defined in Table 22, and with the first test case parameters defined in Table 23 for variable test parameters.

4) A **QUERY** command shall be continuously sent followed by the continuous wave.

5) Wait until signal analyser is triggered, capture the demodulated tag reply trace power versus time.

6) In the demodulated trace data, measure the duty cycle for 00-data and 11-data sequence in case of FM0 tag encoding, and for 0-data and 1-data for Miller tag encoding.

7) The steps 3) to 6) shall be repeated for all the test cases defined in Table 23.

Table 22 — Tag duty cycle test parameters

TEST : Tag duty cycle				
RF PARAMETERS				
Power EIRP (dbm) : **maximum power authorized**			Frequency (MHz) : **Variable**	
Modulation type: **DSB-ASK**			Modulation index : **90 %**	
PROTOCOL SETTINGS				
Command : **Query**				
Parameters	DR: **Variable**	M: **Variable**	Trext:**0**	
Timings	Tari (µs):**Variable**	PW(µs): **0,5*Tari**	RTcal(µs): **3*Tari**	TRcal(µs): **Variable**

Table 23 — Tag duty cycle test cases

	Frequency (MHz)	M	D	Tari (µs)	TRcal (µs)
1	866	1	64/3	6,25	33,3 **(BLF=640 KHz)**
2			64/3	12,5	66,7 **(BLF=320 KHz)**
3			8	25	200 **(BLF=40 KHz)**
4		2	64/3	6,25	33,3 **(BLF=640 KHz)**
5			64/3	12,5	66,7 **(BLF=320 KHz)**
6			8	25	200 **(BLF=40 KHz)**
7		4	64/3	6,25	33,3 **(BLF=640 KHz)**
8			64/3	12,5	66,7 **(BLF=320 KHz)**
9			8	25	200 **(BLF=40 KHz)**
10		8	64/3	6,25	33,3 **(BLF=640 KHz)**
11			64/3	12,5	66,7 **(BLF=320 KHz)**
12			8	25	200 **(BLF=40 KHz)**

	Frequency (MHz)	M	D	Tari (µs)	TRcal (µs)
13	915	1	64/3	6,25	33,3 **(BLF=640 KHz)**
14			64/3	12,5	66,7 **(BLF=320 KHz)**
15			8	25	200 **(BLF=40 KHz)**
16		2	64/3	6,25	33,3 **(BLF=640 KHz)**
17			64/3	12,5	66,7 **(BLF=320 KHz)**
18			8	25	200 **(BLF=40 KHz)**
19		4	64/3	6,25	33,3 **(BLF=640 KHz)**
20			64/3	12,5	66,7 **(BLF=320 KHz)**
21			8	25	200 **(BLF=40 KHz)**
22		8	64/3	6,25	33,3 **(BLF=640 KHz)**
23			64/3	12,5	66,7 **(BLF=320 KHz)**
24			8	25	200 **(BLF=40 KHz)**

	Frequency (MHz)	M	D	Tari (µs)	TRcal (µs)
37	953	1	64/3	6,25	33,3 **(BLF=640 KHz)**
38			64/3	12,5	66,7 **(BLF=320 KHz)**
39			8	25	200 **(BLF=40 KHz)**
40		2	64/3	6,25	33,3 **(BLF=640 KHz)**
41			64/3	12,5	66,7 **(BLF=320 KHz)**
42			8	25	200 **(BLF=40 KHz)**
43		4	64/3	6,25	33,3 **(BLF=640 KHz)**
44			64/3	12,5	66,7 **(BLF=320 KHz)**
45			8	25	200 **(BLF=40 KHz)**
46		8	64/3	6,25	33,3 **(BLF=640 KHz)**
47			64/3	12,5	66,7 **(BLF=320 KHz)**
48			8	25	200 **(BLF=40 KHz)**

7.2.3.3 Test report

The test report shall give for each test point all communication parameters and the test verdict pass or fail, the pass condition for FM0 tag encoding (M=0) is obtained if the measured duty cycle of 00 or 11 sequence is in the range 50 % ± 5 %, for Miller tag encoding (M=1,2,3) the pass condition is obtained if the duty cycle of 0 or 1 symbol is in the range 50 % ± 5 %.

7.2.4 Tag preamble

7.2.4.1 Purpose

The purpose of this test is to verify that the FM0 and Miller preamble signalling shall be as described in ISO/IEC 18000-6 Type C.

7.2.4.2 Procedure

Tag preamble, measurement procedure:

1) The waveform generator amplitude shall be set to the maximum value authorized by the local regulations.

2) The signal analyser shall be set to power versus time mode.

3) The signal generator shall be set with all parameters defined in Table 24 and with the first test case parameters defined in Table 25 for variable test parameters.

4) A **QUERY** command shall be continuously sent followed by the continuous wave.

5) Wait until signal analyser is triggered, capture the demodulated tag reply trace power versus time.

6) In the demodulated trace data, capture and verify the tag preamble.

7) The steps 3) to 6) shall be repeated for all the test cases defined in Table 25.

Table 24 — Tag preamble test parameters

TEST : Tag preamble				
RF PARAMETERS				
Power EIRP (dbm) : **maximum power authorized**			Frequency (MHz) : **Variable**	
Modulation type: **DSB-ASK**			Modulation index : **90 %**	
PROTOCOL SETTINGS				
Command : **Query**				
Parameters	DR: **8**	M: **Variable**	Trext: **Variable**	
Timings	Tari (µs): **25**	PW(µs): **12,5**	RTcal(µs): **62,5**	TRcal(µs): **100**

Table 25 — Tag preamble test cases

	Freq (MHz)	M	TRext
1	866	1	0
2			1
3		2	0
4			1
5		4	0
6			1
7		8	0
8			1

	Freq (MHz)	M	TRext
9	915	1	0
10			1
11		2	0
12			1
13		4	0
14			1
15		8	0
16			1

	Freq (MHz)	M	TRext
25	953	1	0
26			1
27		2	0
28			1
29		4	0
30			1
31		8	0
32			1

7.2.4.3 Test report

The test report shall give for each test point all communication parameters and the test verdict pass or fail, the pass condition is obtained if the DUT tag preamble is as described in ISO/IEC 18000-6 Type C.

7.2.5 Tag link frequency tolerance and variation

7.2.5.1 Purpose

The purpose of this test is to verify that the tag can backscatter its reply with a variable link frequency from 40 to 640 kHz with the tolerance defined in ISO/IEC 18000-6 Type C and to verify that the frequency variation during the tag backscattering is in the range ± 2,5 %.

7.2.5.2 Procedure

Tag link frequency tolerance and variation, measurement procedure:

1) The waveform generator amplitude shall be set to the maximum value authorized by the local regulations.

2) The signal analyser shall be set to power versus time mode.

3) The signal generator shall be set with all parameters defined in Table 26 and with the first test case parameters defined in Table 27 for variable test parameters.

4) A **QUERY** command shall be continuously sent followed by the continuous wave.

5) Wait until signal analyser is triggered, capture the demodulated tag reply trace power versus time.

6) Measure the tag link frequency from the demodulated trace data for each symbol and determine the min and max value.

7) The steps 3) to 5) shall be repeated for all the test cases defined in Table 27.

Table 26 — Tag link frequency tolerance and variation test parameters

TEST : Tag link frequency tolerance and variation				
RF PARAMETERS				
Power EIRP (dbm) : **maximum power authorized**			Frequency (MHz) : **Variable**	
Modulation type: **DSB-ASK**			Modulation index : **90 %**	
PROTOCOL SETTINGS				
Command : **Query**				
Parameters	DR: **Variable**	M: **1**	Trext:**1**	
Timings	Tari (µs): **Variable**	PW(µs):**0,5*Tari**	RTcal(µs):**3*Tari**	TRcal(µs):**Variable**

Table 27 — Tag Link frequency tolerance an variation test cases

	Frequency (MHz)	**Tari (µs)**	**D**	**TRcal (µs)**
1	866	6,25	64/3	33,7 **(BLF=640 KHz)**
2		12,5	64/3	66,7**(BLF=320 KHz)**
3		25	8	200 **(BLF=40 KHz)**
4	915	6,25	64/3	33,7 **(BLF=640 KHz)**
5		12,5	64/3	66,7**(BLF=320 KHz)**
6		25	8	200 **(BLF=40 KHz)**
7	953	6,25	64/3	33,7 **(BLF=640 KHz)**
8		12,5	64/3	66,7**(BLF=320 KHz)**
9		25	8	200 **(BLF=40 KHz)**

7.2.5.3 Test report

The test report shall give for each test point all communication parameters and the test verdict pass or fail, the pass condition for each point is obtained if the tag link frequency respects the tolerances defined in ISO/IEC 18000-6 Type C and the variation of the link frequency during tag backscattering is in the range ± 2,5 %.

7.2.6 Tag link timing T1

7.2.6.1 Purpose

The purpose of this test is to verify that the tag meets the link timing parameter T1 which defined the time from Interrogator transmission to tag response.

7.2.6.2 Procedure

Tag timing parameter T1, measurement procedure:

1) The waveform generator amplitude shall be set to the maximum value authorized by the local regulations.

2) The signal analyser shall be set to power versus time mode.

3) The signal generator shall be set with all parameters defined in Table 28 and with the first test case parameters defined in Table 29 for variable test parameters.

4) A **QUERY** command shall be continuously sent followed by the continuous wave.

5) Wait until signal analyser is triggered, capture the demodulated tag reply trace power versus time.

6) Measure the tag link timing parameter T1, from the last rising edge of the last bit of the Interrogator transmission to the first rising edge of the Tag response.

7) The steps 3) to 5) shall be repeated for all the test cases defined in Table 29.

Table 28 — Tag link timing T1 test parameters

TEST : Tag link timing T1				
RF PARAMETERS				
Power EIRP (dbm) : **maximum power authorized**			Frequency (MHz) : **Variable**	
Modulation type: **DSB-ASK**			Modulation index : **90 %**	
PROTOCOL SETTINGS				
Command : **Query**				
Parameters	DR: **Variable**	M: **1**	Trext:**1**	
Timings	Tari (µs): **Variable**	PW(µs):**0,5*Tari**	RTcal(µs):**3*Tari**	TRcal(µs):**Variable**

Table 29 — Tag Link timing T1 test cases

	Frequency (MHz)	**Tari (µs)**	**D**	**TRcal (µs)**
1	866	6,25	64/3	33,7 **(BLF=640 KHz)**
2		12,5	64/3	66,7**(BLF=320 KHz)**
3		25	8	200 **(BLF=40 KHz)**
4	915	6,25	64/3	33,7 **(BLF=640 KHz)**
5		12,5	64/3	66,7**(BLF=320 KHz)**
6		25	8	200 **(BLF=40 KHz)**
7	953	6,25	64/3	33,7 **(BLF=640 KHz)**
8		12,5	64/3	66,7**(BLF=320 KHz)**
9		25	8	200 **(BLF=40 KHz)**

7.2.6.3 Test report

The test report shall give for each test case all communication parameters and the test verdict pass or fail, the pass condition for each point is obtained if the measured link timing parameter T1 is in the range $MAX(RTcal, 10T_{pri}) \times (1 \pm FT) \pm 2\mu s$ as defined in ISO/IEC 18000-6 Type C.

7.2.7 Tag link timing T2

7.2.7.1 Purpose

The purpose of this test is to verify that the tag meets the link timing parameter T2, the tag under test shall not start backscattering its UII before T2 minimum of 3Tpri and after T2 maximum of 32Tpri.

7.2.7.2 Procedure (reply state)

Tag link timing parameter T2, measurement procedure:

1) The waveform generator amplitude shall be set to the maximum value authorized by the local regulations.

2) The signal analyser shall be set to power versus time mode.

3) The signal generator shall be set with all parameters defined in Table 30 and with the first test case parameters defined in Table 31 for variable test parameters.

4) A **QUERY** command shall be continuously sent followed by the continuous wave.

5) Wait until signal analyser is triggered, capture the demodulated tag reply trace power versus time.

6) The signal analyser shall be set to send an ACK command with the backscattered RN16. The command shall be sent immediately before T_2 minimum.

7) The steps 3) to 5) shall be repeated for the following:

   i) a tag DOES respond to an Interrogator command issued at 3Tpri;

   ii) a tag DOES respond to an Interrogator command issued at 20Tpri;

   iii) a tag DOES NOT respond to an Interrogator command issued at 32Tpri.

8) The steps 3) to 7) shall be repeated for all the test cases defined in Table 31.

Table 30 — Tag link timing T2 test parameters

TEST : Tag link timing T2				
RF PARAMETERS				
Power EIRP (dbm) : **maximum power authorized**			Frequency (MHz) : **Variable**	
Modulation type: **DSB-ASK**			Modulation index : **90 %**	
PROTOCOL SETTINGS				
Command : **Query, Ack**				
Parameters	DR: **Variable**	M: **1**	Trext:**1**	
Timings	Tari (µs): **Variable**	PW(µs):**0,5*Tari**	RTcal(µs):**3*Tari**	TRcal(µs):**Variable**

7.2.7.3 Procedure (acknowledge state)

Tag link timing parameter T2, measurement procedure:

1) The waveform generator amplitude shall be set to the maximum value authorized by the local regulations.

2) The signal analyser shall be set to power versus time mode.

3) The signal generator shall be set with all parameters defined in Table 31 and with the first test case parameters defined in Table 32 for variable test parameters.

4) A QUERY command shall be continuously sent followed by the continuous wave.

5) The signal analyser shall be set to send an ACK command with the backscattered RN16. The command shall be sent after T2 =10Tpri

6) Wait until signal analyser is triggered, capture the demodulated tag reply trace power versus time.

7) The signal analyser shall be set to send an REQ_RN command with the previously backscattered RN16. The command shall be sent immediately before T2 minimum

8) The steps 3) to 7) shall be repeated for the following:

   i) a tag DOES respond to an Interrogator command issued at 3Tpri;

   ii) a tag DOES respond to an Interrogator command issued at 20Tpri;

   iii) a tag DOES NOT respond to an Interrogator command issued at 32Tpri.

9) The steps 3) to 8) shall be repeated for all the test cases defined in Table 32.

Table 31 — Tag link timing T2 test parameters

TEST : Tag link timing T2				
RF PARAMETERS				
Power EIRP (dbm) : **maximum power authorized**			Frequency (MHz) : **Variable**	
Modulation type: **DSB-ASK**			Modulation index : **90 %**	
PROTOCOL SETTINGS				
Command : **Query, Ack, Req_RN**				
Parameters	DR: **Variable**	M: **1**	Trext:**1**	
Timings	Tari (µs): **Variable**	PW(µs):**0,5*Tari**	RTcal(µs):**3*Tari**	TRcal(µs):**Variable**

Table 32 — Tag Link timing T2 test cases

	Frequency (MHz)	**Tari (µs)**	**D**	**TRcal (µs)**
1	866	6,25	64/3	33,7 **(BLF=640 KHz)**
2		12,5	64/3	66,7**(BLF=320 KHz)**
3		25	8	200 **(BLF=40 KHz)**
4	915	6,25	64/3	33,7 **(BLF=640 KHz)**
5		12,5	64/3	66,7**(BLF=320 KHz)**
6		25	8	200 **(BLF=40 KHz)**
7	953	6,25	64/3	33,7 **(BLF=640 KHz)**
8		12,5	64/3	66,7**(BLF=320 KHz)**
9		25	8	200 **(BLF=40 KHz)**

7.2.7.4 Test report

The test report shall give for each test case all communication parameters and the test verdict pass or fail, the pass condition for each point is obtained if the tag does not respond to the ACK command.

7.2.8 Tag state diagram

7.2.8.1 Purpose

The purpose of this test is to verify that the DUT tag implements the correct state machine as described in ISO/IEC 18000-6 Type C.

7.2.8.2 Procedure

Tag state diagram, testing procedure:

1) The waveform generator amplitude shall be set to the maximum value authorized by the local regulations.

2) The tag's AP and KP shall be set to non-zero for an appropriate pre-conditioning of the test

3) The signal analyser shall be set to power versus time mode.

4) The signal generator shall be set with all parameters defined in Table 33.

5) The DUT tag shall be set to the first test initial state "Ready", in order to put the DUT tag into the Test initial state, lookup the corresponding state transition sequence in Table 34, then set the signal generator to apply the state transitions described in the state transition sequence column by looking up the corresponding commands in Table 35.

6) Set the signal generator to send all commands defined in the "Ready states transitions" Table of ISO/IEC 18000-6 Type C Annex F.2.

7) Check if the DUT tag is in the expected target state.

8) The steps 2) to 4) shall be repeated for all tag state, **Arbitrate**, **Acknowledged**, **Open**, **Secured**, **killed**.

Table 33 — Tag state diagram testing

Test: tag state diagram testing					
RF PARAMETERS					
Power EIRP (dbm) : **Maximum authorized**		Frequency (MHz) : **866 or 915 or 953**			
Modulation type: **DSB-ASK**		Modulation index : **90 %**			
PROTOCOL SETTINGS					
Command : **Query**					
Parameters	DR:**8**	M:**1**	Trext:**0**		DR:**8**
Timings	Tari (µs):**25**	PW(µs): **12,5**	RTcal(µs): **62,5**	TRcal(µs): **100**	Tari (µs):**25**

Table 34 — State Transition Sequence Table

Test initial state	State transition Sequence
Power Off	---
Ready	Power Off → Ready
Arbitrate	Power Off → Ready→ Arbitrate
Reply	Power Off → Ready→ Arbitrate→ Reply
Acknowledged	Power Off → Ready→ Arbitrate→ Reply→ Acknowledged
Open	Power Off → Ready→ Arbitrate→ Reply→ Acknowledged→ Open
Secured	Power Off → Ready→ Arbitrate→ Reply→ Acknowledged→ Open→ Secured
Killed	Power Off → Ready→ Arbitrate→ Reply→ Acknowledged→ Open→ Secured→ Killed

Table 35 — State Transition Table

State → Next State	Signal generator command		DUT tag reply
Power Off → Ready	**Power On**	→	
		←	**None**
Ready→ Arbitrate	**Query** [slot<> 0]	→	
		←	**None**
Arbitrate→ Reply	**QueryAdjust** [slot = 0]	→	
		←	**New RN16**
Reply→ Acknowledged	**ACK** [valid RN16]	→	
		←	**UII**
Acknowledged→ Open	**Req_RN** [valid RN16 & access password<>0]	→	
		←	**Handle**
Open→ Secured	**Access** [valid handle & valid access password]	→	
		←	**Handle**
Secured→ Killed	**Kill** [valid handle & valid kill password]	→	
		←	**Handle**

7.2.8.3 Test report

The test report shall give for each test case all communication parameters and the test verdict pass or fail, the pass condition for each point is obtained if the tag implement all correct transition from all diagram states.

7.2.9 Tag backscatter (optional)

7.2.9.1 General

As ISO/IEC 18000-6 does not specify a minimum backscatter value for Type C, this test is informative, however, is used for performance measurements. ISO/IEC 18046-3 refers to this test.

7.2.9.2 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 3 with the tag positioned in the far field of the transmit antenna.

7.2.9.3 Test procedure

Measurements shall be done with 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 C 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 power versus time, with a sampling rate of at least 5 Msps.

5) With the tag placed in the anechoic chamber, the analyser shall be set to capture the complex IQ power for at least during 10 symbols of tag reply.

6) Calculate the difference of power from the DUT tag backscattering according the following equation: $\Delta P_{tag}(rms) = \frac{1}{2\,Z_0} \cdot \left((I_{r,1} - I_{r,0})^2 + (Q_{r,1} - Q_{r,0})^2 \right)$, where Z_0 is the wave resistance of the measurement equipment and usually 50 Ω.

7) Calculate the ΔRCS of the DUT tag using the radar equation given below: $\Delta RCS = \frac{\Delta P_{tag}}{P_e} \frac{4\pi\ d^4}{G_{0t} \cdot G_{0r}} \left(\frac{4\pi}{\lambda} \right)^2$

7.2.9.4 Test report

The test report shall give the measured values of ΔRCS. 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.

The pass/fail condition is not determined as ISO/IEC 18000-6 does not specify a minimum ΔRCS value for Type C.

8 Conformance tests for ISO/IEC 18000-6 Type D

8.1 Functional tests of interrogator

8.1.1 Interrogator modulation test

8.1.1.1 Test objective

The objective of this test is to verify that the interrogator does not modulate in any way while singulating tags.

8.1.1.2 Test procedure

The interrogator shall transmit a CW carrier at the maximum power allowed under the regulations of the selected carrier frequency for testing. Ten tags shall be placed in front of the interrogator at 50% of maximum reading range.

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 spectrum analyser as specified in Annex C and the sense antenna shall be used to record the spectrum provided by the interrogator. It shall also be verified that the interrogator was successfully singulating all ten tags.

8.1.1.3 Test report

The test report shall give the measured values of the parameters according Table 36.

Table 36 — Measurements to be made

Parameter	Conditions
BW	30 dB bandwidth < 100 Hz

8.1.2 Interrogator demodulation and data decoding

8.1.2.1 Test objective

The objectives of this test are to verify whether the interrogator is capable of demodulating signals from the tags, including multiple TTO pages and verification of TID-U CRC.

8.1.2.2 Test procedure

The interrogator shall transmit a CW carrier at the maximum power allowed under the regulations of the selected carrier frequency for testing. A tag emulator as specified in Annex D shall transmit a Type D response as per Table 37 using the minimum *maximum_hold-off_time* as specified in ISO/IEC 18000-6 and at a minimum ΔRCS specified in ISO/IEC 18000-6 Tag: 7d. All other parameters shall be set at the nominal values as specified.

Measurements shall be done with a tag emulator positioned at $d_{TE} = 10\ \lambda$..

In case the interrogator is designed 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.

Table 37 — Measurements to be made

Tag Emulator Configuration		Test Outcome	Notes
1	PPE Modulation	Verify parameters for PPE modulation.	Assume verification of preamble and modulation is correct if data is decoded.
1.1	TID-U Only	Verify single page detection	
1.2	TID-U Only with CRC error	Verify TID-U error detection	Assume detection of one CRC error implies all CRC errors shall be detected.
1.3	TID-U with 7 data pages containing a random distribution of an equal amount of 1 and 0 bits.	Verify multi page data decoding	
1.4	TID-U with 1 data pages as in 1.3, page 1 modulation, separation and page 2 modulation tolerances configured as follows: • Test 1: -20%, -20%, -20% • Test 2: -20%, -20%, +20% • Test 3: +20%, -20%, +20% • Test 4: +20%, -20%, -20% • Test 5: +20%, +20%, -20% • Test 6: -20%, +20%, -20% • Test 7: -20%, +20%, +20% • Test 8: +20%, +20%, +20%	Verify demodulation and page separation timing (ISO/IEC 18000-6 10.2.9.5) tolerances.	This test, verifies the compliance the spread of all timing parameter tolerances. Note each pages has a new pre-amble allowing timing synchronisation.
1.5	For TID-S construct 4 random (as in 1.3) data sets according to the examples in ISO/IEC 18000-6 10.3.3 numbered as follows: • Case 1: $E0_h$ format • Case 2: $E0_h$ format with padded UII Segment • Case 3: $E3_h$ format • Case 4: Maximum length $E2_h$ format Perform the following tests for each case: • All data correct • UII CRC error • Data CRC error	Verify structured data decoding and CRC error detection.	Assume a single correct decoding of random data of structured data set is representative. It is recommended that the 4 cases contain different data and data configurations.

Tag Emulator Configuration		Test Outcome	Notes
1.6	Using Case 1 of 1.5 add a simple sensor page according to ISO/IEC 18000-6 10.3.3.5. Perform the following tests: • Simple Sensor data correct • Simple Sensor data with a CRC error	Verify Simple Sensor decoding.	
2	Miller Modulation	Verify parameters for Miller modulation.	
2.1	Perform tests 1.1-16 on Miller modulation with link bits disabled.	Verify data decoding on Miller modulation	

2.2	Use case 4 on Miller modulation with link bits enabled. Perform the following tests:
	• No errors induced
	• Induce a link bit CRC error
	• Induce a link bit down count error:
	  ○ Missing page 1
	  ○ Missing middle page
	  ○ Missing last page
		Verify link bit decoding	

8.1.2.3 Test report

The test report shall contain the tag emulator distance to the interrogator and the ΔRCS value setup in the tag emulator. Furthermore, the used interrogator output power and the used operation frequency shall be recorded.

8.2 Functional tests of tag

8.2.1.1 General

As ISO/IEC 18000-6 does not specify a minimum backscatter value for Type D, this test is informative, however, is used for performance measurements. ISO/IEC 18046-3 refers to this test.

8.2.1.2 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 3 with the tag positioned in the far field of the transmit antenna.

8.2.1.3 Test procedure

Measurements shall be done with 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 C 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 power versus time, with a sampling rate of at least 5 Msps.

5) With the tag placed in the anechoic chamber, the analyser shall be set to capture the complex IQ power for at least during 10 symbols of tag reply.

6) Calculate the difference of power from the DUT tag backscattering according the following equation: $\Delta P_{tag}(rms) = \frac{1}{2\,Z_0} \cdot \left((I_{r,1} - I_{r,0})^2 + (Q_{r,1} - Q_{r,0})^2 \right)$, where Z_0 is the wave resistance of the measurement equipment and usually 50 Ω.

7) Calculate the ΔRCS of the DUT tag using the radar equation given below: $\Delta RCS = \frac{\Delta P_{tag}}{P_e} \frac{4\pi\ d^4}{G_{0t} \cdot G_{0r}} \left(\frac{4\pi}{\lambda} \right)^2$

8.2.1.4 Test report

The test report shall give the measured values of ΔRCS. 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.

The pass/fail condition is not determined as ISO/IEC 18000-6 does not specify a minimum ΔRCS value for Type D.

8.2.2 Data encoding

8.2.2.1 Test objective

The objective of this test is to verify the data encoding of the tag.

8.2.2.2 Test procedure

For each data encoding type supported by the tag; program the tag with representative data and record the TagMsg transmitted by the tag. The encoding types as specified in ISO/IEC 18000-6 clause 10 are as follows:

- TID-U only
- TID-U with zero or more data pages – the test to be performed with zero and 8 data pages
- TID-S with the 4 cases as specified in clause 8.1.2.2 Table 37 above.
- Optional Simple Sensor encoding for each of the above types.

8.2.2.3 Test report

The test report shall provide all data types tested and the result.

8.2.3 Link bits

8.2.3.1 Test objective

The objective of this test is to verify the correctness of the link bits as specified in ISO/IEC 18000-6 clause 10.2.9.3.

8.2.3.2 Test procedure

Record all the symbols of a tag transmission and inspect the link bits for correctness. The tag should be configured for:

- 1 Page
- 4 Pages
- 8 Pages

8.2.3.3 Test report

The test report shall provide the tag configuration and result.

8.2.4 Tag Timing Parameters

8.2.4.1 Test objective

The objective of this test is to verify the tag transmission's statistical distribution referencing the parameters in ISO/IEC 18000-6 10.2.4.

8.2.4.2 Test procedure

A signal generator shall transmit a CW carrier at the maximum power allowed under the regulations of the selected carrier frequency for testing.

An oscilloscope shall record the start and end of each TagMsg transmission as specified in ISO/IEC 18000-6 clause 10.

The measurements shall be done 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 test as specified in Table 38 shall be performed for each modulation type supported.

The test shall be perform for the tag configured for 1 page and should be perform for 8 pages and maximum transmission pages supported if the test equipment can be configure to detect the start and end of multi-page transmissions.

The tag test set shall consist of a 100 randomly selected tags from a large sample of tags (more than 10,000). All tags must be set to the minimum value of *maximum_hold-off_time*.

Table 38 — Measurements to be made

Tag Emulator Configuration		Test Method	Report
1	Verify the value of Rt_1 to be greater or equal than *minimum_listen_time*.	For the full set of tags perform the following steps: 1. Place ten tags in the beam of the signal generator. 2. Toggle the CW a 100 cycles for 5ms on and 5 ms off. 3. Record any tag modulations.	Note the timing of any tag modulations occurred. The test fails if any tag has modulated.
2.	Verify the value of Rt_n to be greater or equal than *symbol_detect_time* for n greater than 1.	For the each tag of the set perform the following steps: 1. Place the tag in the beam of the signal generator. 2. Switch CW on for 20 seconds. 3. Record each TagMsg transmission start and end.	Note and record any gap between end of transmission and start of transmission less than *symbol_detect_time.* The test fails if any gap is less than *symbol_detect_time.*
3.	Verify the randomness of Rt_n.	Using the data recoded in test 2 calculate the gap between each TagMsg transmission and note the transmission count with the 1st transmission being 1. The 1st transmission gap is measured from the time the CW is switched on. Calculate the mean and median of the gaps to determine the randomness of the gaps for all: • 1st transmissions • 1st 2 transmissions • 1st 5 transmissions • 1st 20 transmissions • All transmissions	The mean and median values shall be no less than 15ms.

8.2.4.3 Test report

The test report shall indicate the deviation of the norm values as specified in ISO/IEC 18000-6 clause 10.2.2 and 10.2.4.

8.2.5 Tag bit rate

8.2.5.1 Test objective

The objective of this test is to verify the bit rate accuracy and data rate of the return link

8.2.5.2 Test procedure

The interrogator shall transmit a CW carrier 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 C 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 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.

8.2.5.3 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 over the full temperature range as specified in clause 10.2.2 for Type D in ISO/IEC 18000-6.

8.2.6 Tag multi-page timing

8.2.6.1 Test objective

The objective of this test is to verify tag multi-page timing

8.2.6.2 Test procedure

The interrogator shall transmit a CW carrier at the maximum power allowed under the regulations of the selected carrier frequency for testing. The tag shall be configured to transmit an ID plus the maximum number of data pages supported.

The tag response waveform shall be recorded by a oscilloscope as specified in Annex C 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 spacing between each of the packets shall be measured.

8.2.6.3 Test report

The test report shall give the spacing in terms of number of bits calculated according the following formula:

$$spacing = \frac{T_{measured}}{T_{bit}}$$

The pass/fail condition is determined whether the measured values are as specified in clause 10.2.2 for Type D in ISO/IEC 18000-6.

8.2.7 Tag LBT

8.2.7.1 Test objective

The objective of this test is to verify that the tag will suspend in the presence of interrogator modulation.

8.2.7.2 Test procedure

The interrogator shall transmit a CW carrier at the maximum power allowed under the regulations of the selected carrier frequency for testing for 2 ms, thereafter it will modulate the carrier with five pulses as specified in ISO/IEC 18000-6 10.2.10.

The tag response waveform shall be recorded by a oscilloscope as specified in Annex C 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. It shall be verified that there are no tag responses for a minimum period of *TOTAL_Wakeup_timeout* as specified in ISO/IEC 18000-6 10.2.2 after the five pulses.

8.2.7.3 Test report

The test report shall note any tag responses received within a time *TOTAL_Wakeup_timeout.*

9 Conformance tests for ISO/IEC 18000-6 Battery Assisted Passive (BAP) Type C

9.1 Tag functional tests

The minimum requirements for BAP tags to support ISO/IEC 18000-6 clause 11 (Battery assisted passive Type C) is to support all commands and features of ISO/IEC 18000-6 clause 9, and that flag persistence has the slightly altered definition of meaning that persistence times begin at the point that tag receive signal strength drops below sensitivity instead of the battery-free definition relative to tag being energized.

9.1.1 Battery assisted Passive tag persistence time test

9.1.1.1 Purpose

The purpose of this test is to verify that the DUT battery assisted tag show the persistence time as defined in ISO/IEC 18000-6 clause 11 (Table 239).

The persistence time for battery assisted tag mean the time that the flag maintains its state before resetting to a default after the tag loss of signal relative to the tag sensitivity level.

9.1.1.2 Procedure

Battery assisted passive tag persistence time , measurement procedure:

1) The waveform generator amplitude shall be set to the maximum value authorized by the local regulations.

2) The signal analyser Trigger shall be set to frequency mask trigger waiting tag response, the signal analyser trigger will be active if the tag response is present.

3) The signal generator shall be set with all RF parameters defined in Table 39.

4) A **SELECT** command shall be sent with protocol settings parameters defined in Table 39 and with the first test case parameters defined in Table 40 for variable test parameters (this command set the DUT tag in the test session to inventoried sTate B).

5) The waveform generator amplitude shall be set to a value below the tag sensitivity level (typically zero) during the persistence time $\mathbf{T_{persistence}}$ defined in Table 40 first test case.

6) A **QUERY** command shall be sent with protocol settings parameters defined in Table 39 and with the first test case parameters defined in Table 40 for variable test parameters.

7) Wait until the signal analyser is triggered, if it is not triggered in 1 s, then finish the test case.

8) The steps 3) to 7) shall be repeated for all the test cases defined in Table 40.

Table 39 — BAP tag persistence time test parameters

TEST : BAP tag persistence time				
RF PARAMETERS				
Power EIRP (dbm) : **maximum power authorized**			Frequency (MHz) : **866 or 915 or 953**	
Modulation type: **DSB-ASK**			Modulation index : **90 %**	
PROTOCOL SETTINGS				
Commands				
Query Parameters	DR:**8**	M:**1**	Sel / Session :**Variable**	Target : **Variable**
Select parameters	Target : Variable	Action : 100 (deassert SL or Flag->B)	Lengtn:0	
Timings	Tari (µs):**25**	PW(µs): **12,5**	RTcal(µs): **62,5**	TRcal(µs): **100**

Table 40 – BAP tag persistence time test cases

	Select [Target]	$T_{Persistence}$	Query [Sel]	Query [Session]	Query [Flag]
1	S0	Min: 50 µs	Sel : All	S0	B
2		Max: 500 µs			A
3	S1	500 ms	Sel : All	S1	B
4		5 s			A
5	S2	2 s	Sel : All	S2	B
6		20 s			A
7	S3	2 s	Sel : All	S3	B
8		20 s			A
9	SL	2 s	Sel : ~ SL	Any	Any
10		20 s	Sel : SL		Any

9.1.1.3 Test report

The test report shall give for each test point all communication parameters and the test verdict pass or fail, the pass condition for each point is obtained when the signal analyser is triggered that means that the tag is reply to the QUREY command.

10 Conformance tests for ISO/IEC 18000-6 Manchester Mode Battery Assisted Passive (BAP) Type C

The Manchester mode BAP is based on the requirements for passive Type C in ISO/IEC 18000-6:2010 clause 9. A device conforming to ISO/IEC 18000-6:2010 clause 11.5 (Manchester mode battery assisted passive Type C) must also support all mandatory requirements in clause 9. The requirements in clause 11.5 include only the additional requirements that the conformant device must support. The conformance tests for ISO/IEC 18000-6:2010 clause 11.5 are specified below.

10.1 Functional tests of interrogator

10.1.1 Interrogator RF envelope parameters

10.1.1.1 Purpose

The purpose of this test is to verify all the RF modulation parameters pulse for a data-0 and a data-1 as described in ISO/IEC 18000-6 clause 11.5.

10.1.1.2 Procedure

Interrogator RF envelope parameters, measurement procedure:

1) The DUT interrogator shall be configured for transmitting at the maximum power, at the first supported frequency and modulation type.

2) The DUT interrogator shall be set with all parameters defined in Table 41 and with the first test case parameters defined in Table 42 for variable test parameters.

3) The DUT interrogator shall be set to send a Short Manchester **ACTIVATION** followed by **QUERY** command followed by the continuous wave.

4) The signal analyser shall be set to power versus time mode.

5) Wait until signal analyser is triggered, capture all the demodulated trace power versus time.

6) Measure the DUT interrogator envelope parameters as described in ISO/IEC 18000-6 clause 11.5.

7) The steps 2) to 6) shall be repeated for all the test cases that are supported by the DUT interrogator and compliant with local regulation.

Table 41 — Interrogator RF envelope test parameters

TEST : Interrogator RF envelope parameters				
RF PARAMETERS				
Power EIRP (dbm) : **max power authorized**			Frequency (MHz) : **Interrogator supported frequencies**	
Modulation type: **Interrogator supported modulations**			Modulation index : **Variable**	
PROTOCOL SETTINGS				
Command : **Activation + Query**				
Parameters	M:**8**	Trext:**1**	T2ext: 0	
Timings	Forward data rate (Kbps):**Variables**	BLF: 160 KHz		

Table 42 — Interrogator RF envelope test cases

	Forward data rate (Kbps)
1	128
2	64
3	32
4	16
5	8

10.1.1.3 Test report

The test report shall give for each test case all communication parameters and the test verdict pass or fail, the pass condition for each point is obtained if the value of the parameters shall be in the limit maximum and minimum as specified in ISO/IEC 18000-6 clause 11.5.2.1.5.

10.1.2 Interrogator activation minimum dwell time T_A

10.1.2.1 Purpose

The purpose of this test is to verify that the DUT interrogator meets the Manchester mode timing parameter T_A.

10.1.2.2 Procedure

Interrogator link timing T_A, measurement procedure:

1) The DUT interrogator shall be configured for transmitting at the maximum power, at the first supported frequency and modulation type.

The DUT interrogator shall be set with all parameters defined in Table 43 and with the first test case parameters defined in

2) Table 44 for variable test parameters.

3) The DUT interrogator shall be set to send a Short Manchester **ACTIVATION** followed by **QUERY** command followed by the continuous wave.

4) The signal analyser shall capture all demodulated trace power versus time (**Activation**+**Query**).

5) Measure the link parameter, finding the end of **Activation** and the beginning of **Query**.

6) The steps 3) to 5) shall be repeated for all the test cases that are supported by the DUT interrogator and compliant with local regulation.

Table 43 — Interrogator link timing TA test parameters

TEST : Tag link timing parameter T_A				
RF PARAMETERS				
Power EIRP (dbm) : **maximum power authorized**			Frequency (MHz) : **Variable**	
Modulation type: **DSB-ASK**			Modulation index : **90 %**	
PROTOCOL SETTINGS				
Command : **Activation + Query**				
Parameters	M:**8**	Trext:**1**	T2ext:0	
Timings	Forward data rate: **Variable**			

Table 44 — Interrogator link timing parameter TA test cases

	Forward data rate (Kbps)
1	8
2	16
3	32
4	64
5	128

10.1.2.3 Test report

The test report shall give for each test case all communication parameters and the test verdict pass or fail, the pass condition is obtained for each test point if the measured time value shall be greater than the maximum tag activation time T_A.

10.1.3 Interrogator link timing T2

10.1.3.1 Purpose

The purpose of this test is to verify that the DUT interrogator meets the Manchester mode timing parameter T2.

10.1.3.2 Procedure

Interrogator link timing T2, measurement procedure:

1) The DUT interrogator shall be configured for transmitting at the maximum power, at the first supported frequency and modulation type.

2) The DUT interrogator shall be set with all parameters defined in Table 45 and with the first test case parameters defined in Table 46 for variable test parameters.

3) The DUT interrogator shall be set to send a Short Manchester **ACTIVATION** followed by **QUERY** command followed by the continuous wave.

4) Set the tag emulator to backscatter an RN16 reply, the RN16 shall be sent after the typical value for T1, the DUT interrogator will send its ACK.

5) The signal analyser shall capture all demodulated trace power versus time (**Activation**+**Query**+**RN16**+**ACK**).

6) Measure the link parameter, finding the end of RN16 frequency variation and the beginning of ACK frequency variation.

7) The steps 3) to 6) shall be repeated for all the test cases that are supported by the DUT interrogator and compliant with local regulation.

Table 45 — Interrogator link timing T2 test parameters

TEST : Tag link timing parameter T2				
RF PARAMETERS				
Power EIRP (dbm) : **maximum power authorized**			Frequency (MHz) : **Variable**	
Modulation type: **DSB-ASK**			Modulation index : **90 %**	
PROTOCOL SETTINGS				
Command : **Activation + Query**				
Parameters	M:**8**	Trext:**1**	T2ext:0	
Timings	Forward data rate: **Variable**	BLF (KHz):**Variable**		

Table 46 — Interrogator link timing parameter T2 test cases

	Forward data rate (Kbps)	BLF (KHz)
1	8	**120 KHz**
2	16	**160 KHz**
3	32	**192 KHz**
4	64	**240 KHz**
5	128	**320 KHz**

10.1.3.3 Test report

The test report shall give for each test case all communication parameters and the test verdict pass or fail, the pass condition is obtained for each test point if the measured time value shall be between T2 min and T2 max.

10.1.4 Interrogator link timing T3

10.1.4.1 Purpose

The purpose of this test is to verify that the DUT interrogator meets the timing parameter T3, which define the time an Interrogator waits, after T_1, before it issues another command.

10.1.4.2 Procedure

Interrogator link timing T3, measurement procedure:

1) The DUT interrogator shall be configured for transmitting at the maximum power, at the first supported frequency and modulation type.

2) The signal analyser shall be set to power versus time mode.

3) The DUT interrogator shall be set with all parameters defined in Table 47 and with the first test case parameters defined in Table 48 for variable test parameters.

4) Set DUT interrogator to transmit Short Manchester **Activation** followed by the **Select** command followed by **Query** command.

5) The signal analyser shall capture all demodulated trace power versus time (**Select** + **Query**).

6) Measure the link timing T3 + T1, finding the end of **Query** frequency variation and the beginning of **QueryRep** frequency variation, the link parameter T3 is calculated by subtracting the T1 maximum value to the measured time (T1+T3).

7) The steps 3) to 6) shall be repeated for all the test cases that are supported by the DUT interrogator and compliant with local regulation.

Table 47 — Tag link timing parameter T3 test parameters

TEST : Tag link timing parameter T3				
RF PARAMETERS				
Power EIRP (dbm) : **maximum power authorized**			Frequency (MHz) : **Variable**	
Modulation type: **DSB-ASK**			Modulation index : **90 %**	
PROTOCOL SETTINGS				
Command : **Activation + Select + Query**				
Parameters	M:**1**	Trext:**1**		
Timings	Forward data rate: **Variable**			

Table 48 — Tag link timing parameter T3 test cases

	Forward data rate (Kbps)	**BLF (KHz)**
1	8	**120 KHz**
2	16	**160 KHz**
3	32	**192 KHz**
4	64	**240 KHz**
5	128	**320 KHz**

10.1.4.3 Test report

The test report shall give for each test case all communication parameters and the test verdict pass or fail, the pass condition is obtained for each test point if the measured time value shall be greater than the minimum value for T3, according to ISO/IEC 18000-6 clause 11.5.

10.1.5 Interrogator link timing T4

10.1.5.1 Purpose

The purpose of this test case is to verify that the DUT interrogator meets the timing parameter T4, which define the minimum time between Interrogator commands.

10.1.5.2 Procedure

Interrogator link timing T4, measurement procedure:

1) The DUT interrogator shall be configured for transmitting at the maximum power, at the first supported frequency and modulation type.

2) The signal analyser shall be set to power versus time mode.

3) The DUT interrogator shall be set with all parameters defined in Table 49 and with the first test case parameters defined in Table 50 for variable test parameters.

4) Set DUT to initiate an inventory round, transmitting a Short Manchester **ACTIVATION** followed by the **QUERY** command followed by **QueryRep** command.

5) The signal analyser shall capture all demodulated trace Power versus time (**Query** + **QueryRep**).

6) Measure the link Timing T4, finding the end of **select** frequency variation and the beginning of Query frequency variation.

7) The steps 3) to 6) shall be repeated for all the test cases that are supported by the DUT interrogator and compliant with local regulation.

Table 49 — Tag link timing parameter T4 test parameters

TEST : Tag link timing parameter T4				
RF PARAMETERS				
Power EIRP (dbm) : **maximum power authorized**			Frequency (MHz) : **Variable**	
Modulation type: **DSB-ASK**			Modulation index : **90 %**	
PROTOCOL SETTINGS				
Command : **Activation + Query + QueryRep**				
Parameters	M:**1**	Trext:**1**		
Timings	Forward data rate: **Variable**			

Table 50 — Tag link timing parameter T4 test cases

	Forward data rate (Kbps)	**BLF (KHz)**
1	8	**120 KHz**
2	16	**160 KHz**
3	32	**192 KHz**
4	64	**240 KHz**
5	128	**320 KHz**

10.1.5.3 Test report

The test report shall give for each test case all communication parameters and the test verdict pass or fail, the pass condition is obtained for each test point if the measured time value shall be greater than the minimum value for T4, according to ISO/IEC 18000-6 clause 11.5.

10.2 Functional tests of tag

10.2.1 Tag demodulation capability

10.2.1.1 Purpose

The purpose of this test is to verify that the DUT tag shall be capable of demodulating a DSB-ASK modulated reader command signal with Manchester encoding.

10.2.1.2 Procedure

Tag demodulation capability, measurement procedure:

1) The waveform generator amplitude shall be set to the maximum value authorized by the local regulations.

2) The Signal analyser Trigger shall be set to frequency mask trigger waiting tag response, the signal analyser trigger will be active if the tag response is present.

3) The signal generator shall be set with all parameters defined in Table 51 and with the first test case parameters defined in Table 52 for variable test parameters.

4) A Short Manchester **ACTIVATION** followed by the **QUERY** command shall be continuously sent followed by the continuous wave.

5) Wait until the signal analyser is triggered, if it is not triggered in 1 s, then finish the test case.

6) The steps 3) to 5) shall be repeated for all the test cases defined in Table 52.

Table 51 — Tag demodulation capability test parameters

TEST : Tag demodulation capability				
RF PARAMETERS				
Power EIRP (dbm) : **maximum power authorized**			Frequency (MHz) : **Variable**	
Modulation type: **Variable**			Modulation index : **90 %**	
PROTOCOL SETTINGS				
Command : **Activation + Query**				
Parameters	M:**8**	Trext:**1**	T2ext: 0	
Timings	Forward data rate (Kbps):**8**	BLF: 160 KHz		

Table 52 — Tag demodulation capability test cases

	Frequency (MHz)	Modulation type
1	866	DSB-ASK
2	915	DSB-ASK
3	953	DSB-ASK

NOTE The test frequency of 953 MHz may be skipped in case no region of the world requires frequencies above 930 MHz anymore and the tag will not be used above 930 MHz.

10.2.1.3 Test report

The test report shall give for each test point all communication parameters and the test verdict pass or fail, the pass condition for each point is obtained when the signal analyser is triggered that means that the tag is working at the test frequency and modulation.

10.2.2 Tag link frequency tolerance and variation

10.2.2.1 Purpose

The purpose of this test is to verify that the tag can backscatter its reply with a variable link frequency from 40 to 640 kHz with ± 2,0 % tolerance as defined in ISO/IEC 18000-6 clause 11.5.

10.2.2.2 Procedure

Tag link frequency tolerance and variation, measurement procedure:

1) The waveform generator amplitude shall be set to the maximum value authorized by the local regulations.

2) The signal analyser shall be set to power versus time mode.

3) The signal generator shall be set with all parameters defined in Table 53 and with the first test case parameters defined in Table 54 for variable test parameters.

4) A Short Manchester **ACTIVATION** followed by the **QUERY** command shall be continuously sent followed by the continuous wave.

5) Wait until signal analyser is triggered, capture the demodulated tag reply trace power versus time.

6) Measure the tag link frequency from the demodulated trace data for each symbol and determine the min and max value.

7) The steps 3) to 5) shall be repeated for all the test cases defined in Table 54.

Table 53 — Tag link frequency tolerance test parameters

TEST : Tag link frequency tolerance				
RF PARAMETERS				
Power EIRP (dbm) : **maximum power authorized**			Frequency (MHz) : **Variable**	
Modulation type: **DSB-ASK**			Modulation index : **90 %**	
PROTOCOL SETTINGS				
Command : **Activation + Query**				
Parameters	M:**8**	Trext:**1**	T2ext: 0	
Timings	Forward data rate (Kbps):**Variables**	BLF: Variable		

Table 54 — Tag Link frequency tolerance and variation test cases

	Frequency (MHz)	**Forward data rate (Kbps)**	**BLF (KHz)**
1	866	128	**640 KHz**
2		32	**320 KHz**
3		8	**40 KHz**
4	915	128	**640 KHz**
5		32	**320 KHz**
6		8	**40 KHz**
7	953	128	**640 KHz**
8		32	**320 KHz**
9		8	**40 KHz**

NOTE The test frequency of 953 MHz may be skipped in case no region of the world requires frequencies above 930 MHz anymore and the tag will not be used above 930 MHz.

10.2.2.3 Test report

The test report shall give for each test point all communication parameters and the test verdict pass or fail, the pass condition for each point is obtained if the tag link frequency respects the tolerances defined in ISO/IEC 18000-6 clause 11.5.

10.2.3 Tag link timing T1

10.2.3.1 Purpose

The purpose of this test is to verify that the tag meets the link timing parameter T1 which defined the time from Interrogator transmission to tag response.

10.2.3.2 Procedure

Tag timing parameter T1, measurement procedure:

1) The waveform generator amplitude shall be set to the maximum value authorized by the local regulations.

2) The signal analyser shall be set to power versus time mode.

3) The signal generator shall be set with all parameters defined in Table 55 and with the first test case parameters defined in Table 56 for variable test parameters.

4) A Short Manchester **ACTIVATION** followed by the **QUERY** command shall be continuously sent followed by the continuous wave.

5) Wait until signal analyser is triggered, capture the demodulated tag reply trace power versus time.

6) Measure the tag link timing parameter T1, from the last rising edge of the last bit of the Interrogator transmission to the first rising edge of the tag response.

7) The steps 3) to 5) shall be repeated for all the test cases defined in Table 56.

Table 55 — Tag link timing T1 test parameters

TEST : Tag link timing T1				
RF PARAMETERS				
Power EIRP (dbm) : **maximum power authorized**			Frequency (MHz) : **Variable**	
Modulation type: **DSB-ASK**			Modulation index : **90 %**	
PROTOCOL SETTINGS				
Command : **Activation + Query**				
Parameters	M:**8**	Trext:**1**	T2ext: 0	
Timings	Forward data rate (Kbps):**Variables**	BLF: Variable		

Table 56 — Tag Link timing T1 test cases

	Frequency (MHz)	Forward data rate (Kbps)	BLF (KHz)
1	866	128	**640 KHz**
2		32	**320 KHz**
3		8	**40 KHz**
4	915	128	**640 KHz**
5		32	**320 KHz**
6		8	**40 KHz**
7	953	128	**640 KHz**
8		32	**320 KHz**
9		8	**40 KHz**

NOTE The test frequency of 953 MHz may be skipped in case no region of the world requires frequencies above 930 MHz anymore and the tag will not be used above 930 MHz.

10.2.3.3 Test report

The test report shall give for each test case all communication parameters and the test verdict pass or fail, the pass condition for each point is obtained if the measured link timing parameter T1 is within the range defined in ISO/IEC 18000-6 clause 11.5.

10.2.4 Tag link timing T2

10.2.4.1 Purpose

The purpose of this test is to verify that the tag meets the link timing parameter T2, the tag under test shall not start backscattering its UII before the T2 minimum defined in ISO/IEC 18000-6 clause 11.5.

10.2.4.2 Procedure (reply state)

Tag link timing parameter T2, measurement procedure:

1) The waveform generator amplitude shall be set to the maximum value authorized by the local regulations.

2) The signal analyser shall be set to power versus time mode.

3) The signal generator shall be set with all parameters defined in Table 57 and with the first test case parameters defined in Table 59 for variable test parameters.

4) A Short Manchester **ACTIVATION** followed by the **QUERY** command shall be continuously sent followed by the continuous wave.

5) Wait until signal analyser is triggered, capture the demodulated tag reply trace power versus time.

6) The signal analyser shall be set to send an ACK command with the backscattered RN16. The command shall be sent immediately before T_2 minimum.

7) The steps 3) to 5) shall be repeated for the following:

   i) a tag DOES respond to an Interrogator command issued at 0,25Tbit;

   ii) a tag DOES respond to an Interrogator command issued at 4Tbit;

iii) a tag DOES NOT respond to an Interrogator command issued at 8Tbit.

8) The steps 3) to 7) shall be repeated for all the test cases defined in Table 59.

Table 57 — Tag link timing T2 test parameters

TEST : Tag link timing T2				
RF PARAMETERS				
Power EIRP (dbm) : **maximum power authorized**			Frequency (MHz) : **Variable**	
Modulation type: **DSB-ASK**			Modulation index : **90 %**	
PROTOCOL SETTINGS				
Command : **Activation + Query + ACK**				
Parameters	M:**8**	Trext:**1**	T2ext: 0	
Timings	Forward data rate (Kbps):**Variables**	BLF: Variable		

10.2.4.3 Procedure (acknowledge state)

Tag link timing parameter T2, measurement procedure:

1) The waveform generator amplitude shall be set to the maximum value authorized by the local regulations.

2) The signal analyser shall be set to power versus time mode.

3) The signal generator shall be set with all parameters defined inTable 58 and with the first test case parameters defined in Table 59 for variable test parameters.

4) A QUERY command shall be continuously sent followed by the continuous wave.

5) The signal analyser shall be set to send an ACK command with the backscattered RN16. The command shall be sent after T2 =10Tpri.

6) Wait until signal analyser is triggered, capture the demodulated tag reply trace power versus time.

7) The signal analyser shall be set to send an REQ_RN command with the previously backscattered RN16. The command shall be sent immediately before T2 minimum

8) The steps 3) to 7) shall be repeated for the following:

   i) a tag DOES respond to an Interrogator command issued at 0,25Tbit;

   ii) a tag DOES respond to an Interrogator command issued at 4Tbit;

   iii) a tag DOES NOT respond to an Interrogator command issued at 8Tbit.

9) The steps 3) to 8) shall be repeated for all the test cases defined in Table 59.

Table 58 — Tag link timing T2 test parameters

TEST : Tag link timing T2				
RF PARAMETERS				
Power EIRP (dbm) : **maximum power authorized**			Frequency (MHz) : **Variable**	
Modulation type: **DSB-ASK**			Modulation index : **90 %**	
PROTOCOL SETTINGS				
Command : **Query, Ack, Req_RN**				
Parameters	M:**8**	Trext:**1**	T2ext: 0	
Timings	Forward data rate (Kbps):**Variables**	BLF: Variable		

Table 59 — Tag Link timing T2 test cases

	Frequency (MHz)	**Forward data rate (Kbps)**	**BLF (KHz)**
1	866	128	**640 KHz**
2		32	**320 KHz**
3		8	**40 KHz**
4	915	128	**640 KHz**
5		32	**320 KHz**
6		8	**40 KHz**
7	953	128	**640 KHz**
8		32	**320 KHz**
9		8	**40 KHz**

NOTE The test frequency of 953 MHz may be skipped in case no region of the world requires frequencies above 930 MHz anymore and the tag will not be used above 930 MHz.

10.2.4.4 Test report

The test report shall give for each test case all communication parameters and the test verdict pass or fail, the pass condition for each point is obtained if the tag does not respond to the ACK command.

10.2.5 Tag activation time maximum T_A

10.2.5.1 Purpose

The purpose of this test is to verify that the tag meets the maximum activation timing parameter T_A which defined the time from the last bit of the activation command to ready to receive the first bit of the preamble of a normal command.

10.2.5.2 Procedure

Tag timing parameter T_A, measurement procedure:

1) The waveform generator amplitude shall be set to the maximum value authorized by the local regulations.

2) The signal analyser shall be set to power versus time mode.

3) The signal generator shall be set with all parameters defined in Table 60 and with the first test case parameters defined in Table 61 for variable test parameters.

4) A Short Manchester **ACTIVATION** followed by the **QUERY** command shall be continuously sent followed by the continuous wave.

5) Wait until signal analyser is triggered, capture the demodulated tag reply trace power versus time.

6) Measure the tag link timing parameter T_A, from the last edge of the last bit of the Interrogator activation command to the first edge of the first preamble bit of a normal command. The measured value is the shortest T_A time which the tag successfully responds.

7) The steps 3) to 5) shall be repeated for all the test cases defined in Table 61.

Table 60 — Tag link timing TA test parameters

TEST : Tag link timing T_A				
RF PARAMETERS				
Power EIRP (dbm) : **maximum power authorized**			Frequency (MHz) : **Variable**	
Modulation type: **DSB-ASK**			Modulation index : **90 %**	
PROTOCOL SETTINGS				
Command : **Activation + Query**				
Parameters	M:**8**	Trext:**1**	T2ext: 0	
Timings	Forward data rate (Kbps):**Variables**	BLF: Variable		

Table 61 — Tag Link timing T_A test cases

	Forward data rate (Kbps)	**BLF (KHz)**
1	128	**640 KHz**
2	64	**320 KHz**
3	32	**240 KHz**
4	16	**160 KHz**
5	8	**120 KHz**

10.2.5.3 Test report

The test report shall give for each test case all communication parameters and the test verdict pass or fail, the pass condition for each point is obtained if the measured link timing parameter T_A is within the range defined in ISO/IEC 18000-6 clause 11.5.

10.2.6 Tag stateful hibernate timer

10.2.6.1 Purpose

The purpose of this test is to verify that the tag meets the stateful hibernate timer accuracy requirements which defined the time from the last bit of the tag response to the Next command to the expiration of the hibernate timer.

10.2.6.2 Procedure

Tag timing hibernate timer measurement procedure:

1) The waveform generator amplitude shall be set to the maximum value authorized by the local regulations.

2) The signal analyser shall be set to power versus time mode.

3) The signal generator shall be set with all parameters defined in Table 62 and with the first test case parameters defined in Table 63 for variable test parameters.

4) A Long Manchester **ACTIVATION** with session locking selected and hibernate timer set to 1 sec followed by the **QUERY** command shall be continuously sent followed by the continuous wave.

5) Wait until signal analyser is triggered, capture the demodulated tag reply trace power versus time.

6) Measure the tag hibernate timer from the last edge of the last bit of the tag response to the Next command to the first edge of the first subsequent Query response from the tag.

7) The steps 3) to 5) shall be repeated for all the test cases defined in Table 63.

Table 62 — Tag stateful hibernate timer test parameters

TEST : Tag link timing T_A				
RF PARAMETERS				
Power EIRP (dbm) : **maximum power authorized**			Frequency (MHz) : **Variable**	
Modulation type: **DSB-ASK**			Modulation index : **90 %**	
PROTOCOL SETTINGS				
Command : **Activation + Query + ACK + Next**				
Parameters	M:**8**	Trext:**1**	T2ext: 0	
Timings	Forward data rate (Kbps):**32 Kbps**	BLF: 160 KHz		

Table 63 — Tag stateful hibernate timer test cases

	Session	**Hibernate timeout (sec)**
1	S0	**1**
2		**8**
3	S1	**1**
4		**8**
5	S2	**1**
6		**8**
7	S3	**1**
8		**8**

10.2.6.3 Test report

The test report shall give for each test case all communication parameters and the test verdict pass or fail, the pass condition for each point is obtained if the measured stateful hibernate timer accuracy is within the range defined in ISO/IEC 18000-6 clause 11.5.

11 Conformance tests for ISO/IEC 18000-6 Sensor support

11.1 Tag functional tests

Two classes of sensors are supported by this ISO/IEC 18000-6 standard, Simple Sensor (SS) and Full-function Sensor (FS).

11.1.1 Simple sensor test

11.1.1.1 Purpose

The purpose of this test is to verify that the DUT tag support the simple sensor (SS) functionality as defined in ISO/IEC 18000-6 clause 12.

11.1.1.2 Procedure

Simple sensor test , measurement procedure:

1) The waveform generator amplitude shall be set to the maximum value authorized by the local regulations.

2) The signal analyser shall be set to power versus time mode.

3) The signal generator shall be set with all parameters defined in Table 64.

4) A **QUERY** + **ACK [RN16]** commands shall be continuously sent followed by the continuous wave.

5) Wait until signal analyser is triggered, capture the demodulated tag reply (**UII+SSD**) trace power versus time.

Table 64 — Simple sensor test parameters

TEST : BAP tag persistence time				
RF PARAMETERS				
Power EIRP (dbm) : **maximum power authorized**			Frequency (MHz) : **866 or 915 or 953**	
Modulation type: **DSB-ASK**			Modulation index : **90 %**	
PROTOCOL SETTINGS				
Commands				
Query Parameters	DR:**8**	M:**1**		
Timings	Tari (µs):**25**	PW(µs): **12,5**	RTcal(µs): **62,5**	TRcal(µs): **100**

11.1.1.3 Test report

The test report shall give all communication parameters and the test verdict pass or fail, the pass condition is obtained when the DUT tag reply to ACK command fulfils to all requirements of Table 65 as defined in ISO/IEC 18000-6 clause 11 (Sensor support).

Table 65 — Simple sensor test pass conditions

1	XPC_W1 bit 215h shall be set to 1 to indicate the presence of a Simple Sensor
2	The 32bits simple sensor data (SSD) shall be appended to the tag UII according to ISO/IEC 18000-6 clause 11 Table 267
3	The 32bits simple sensor data (SSD) shall be as defined in 24753 and ISO/IEC 18000-6 ANNEX U
4	The 5 most significant bits of the PacketPC shall indicate the length of the UII + SSD

11.1.2 Full-function sensor test

11.1.2.1 Purpose

The purpose of this test is to verify that the DUT tag support the Full-function sensor (FS) functionality as defined in ISO/IEC 18000-6 clause 12.

11.1.2.2 Procedure

Full-function sensor test , measurement procedure:

1) The waveform generator amplitude shall be set to the maximum value authorized by the local regulations.

2) The signal analyser shall be set to power versus time mode.

3) The signal generator shall be set with all parameters defined in Table 66.

4) A **READ (Memory Bank : 10_2)** command shall be continuously sent followed by the continuous wave.

5) Wait until signal analyser is triggered, capture the demodulated tag reply (**TID**) trace power versus time.

Table 66 — Full-function sensor test parameters

TEST : Full-function sensor				
RF PARAMETERS				
Power EIRP (dbm) : **maximum power authorized**			Frequency (MHz) : **866 or 915 or 953**	
Modulation type: **DSB-ASK**			Modulation index : **90 %**	
PROTOCOL SETTINGS				
Commands				
READ Parameters	MenBank:**10_2(TID)**	WordPtr:**20h**		
Timings	Tari (µs):**25**	PW(µs): **12,5**	RTcal(µs): **62,5**	TRcal(µs): **100**

11.1.2.3 Test report

The test report shall give all communication parameters and the test verdict pass or fail, the pass condition is obtained when the DUT tag reply to READ command fulfils to all requirements of Table 67 as defined in ISO/IEC 18000-6 clause 12 (Sensor support).

Table 67 — Full-function sensor test pass conditions

1	XPC_W1 bit 216h shall be set to 1 to indicate the presence of a Full-function Sensor
2	The SAM Address shall be stored in the TID memory according to ISO/IEC 18000-6 clause 11 Table 268
3	Tag shall provide a 32-bit SAM Address pointing to the starting word address of a Sensor Address Map.
4	Tag shall have a SAM Address ≠ 0

Annex A
(informative)

Test measurement site

A.1 Test sites and general arrangements for measurements involving the use of radiated fields

This annex describes the three most commonly available test sites, an anechoic chamber, an anechoic chamber with a ground plane and an Open Area Test Site (OATS), which may be used for radiated tests. These test sites are generally referred to as free field test sites. Both absolute and relative measurements can be performed in these sites. Where absolute measurements are to be carried out, the chamber should be verified.

NOTE To ensure reproducibility and tractability of radiated measurements only these test sites should be used in measurements in accordance with the present document.

A.1.1 Anechoic chamber

An anechoic chamber is an enclosure, usually shielded, whose internal walls, floor and ceiling are covered with radio absorbing material, normally of the pyramidal urethane foam type. The chamber usually contains an antenna support at one end and a turntable at the other. A typical anechoic chamber is shown in Figure A.1.

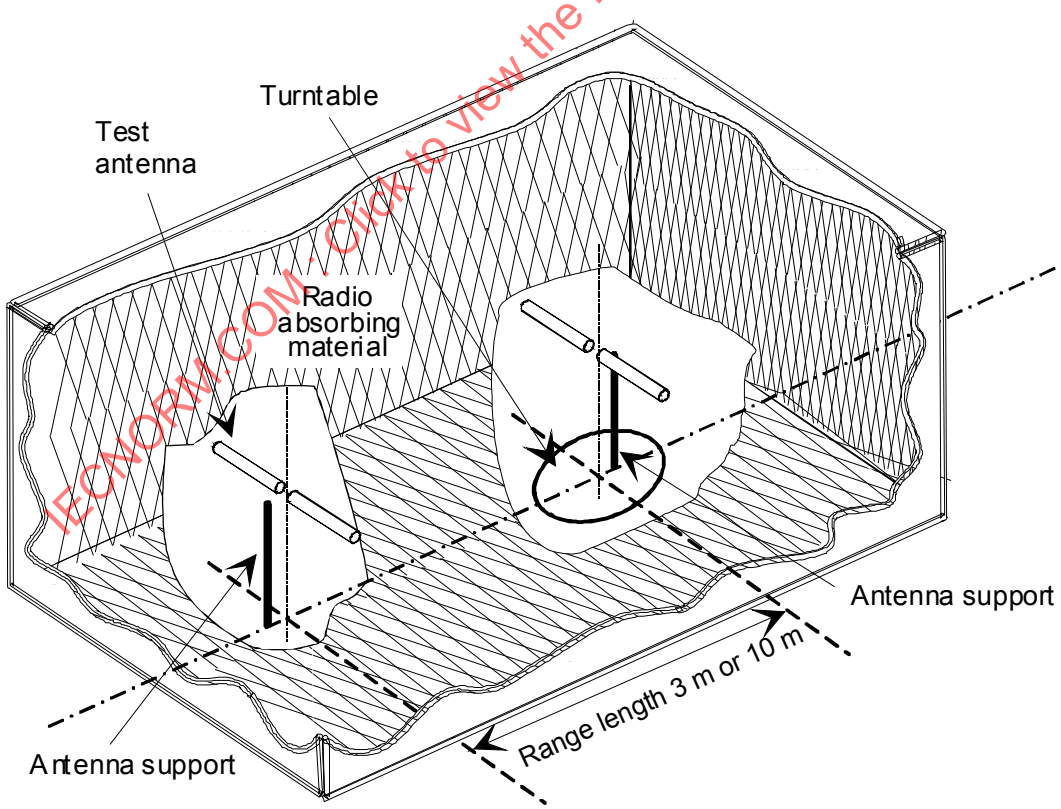

Figure A.1 — A typical anechoic chamber