TECHNICAL REPORT

ISO/IEC TR 18047-7

Second edition
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Information technology — Radio frequency identification device conformance test methods —

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

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

Partie 7: Méthodes d'essai pour des communications d'interface d'air active à 433 MHz

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Foreword

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

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

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

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

— type 1, when the required support cannot be obtained for the publication of an International Standard, despite repeated efforts;

— type 2, when the subject is still under technical development or where for any other reason there is the future but not immediate possibility of an agreement on an International Standard;

— type 3, when the joint technical committee has collected data of a different kind from that which is normally published as an International Standard ("state of the art", for example).

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

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

ISO/IEC TR 18047-7, which is a Technical Report of type 3, was prepared by Joint Technical Committee ISO/IEC JTC 1, *Information technology*, Subcommittee SC 31, *Automatic identification and data capture techniques*.

This second edition cancels and replaces the first edition (ISO/IEC TR 18047-7:2005), which has been technically revised.

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

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

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

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

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

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

Introduction

ISO/IEC 18000 defines the air interfaces for radio frequency identification (RFID) devices used in item management applications. ISO/IEC 18000-7:2009 defines the active air interface for these devices operating in the 433,92 MHz Industrial, Scientific, and Medical (ISM) band.

ISO/IEC TR 18047 provides test methods for conformance with the various parts of ISO/IEC 18000. This part of ISO/IEC TR 18047 contains the compliance measurements required to be fulfilled by a product in order to be compliant to ISO/IEC 18000-7:2009.

Information technology — Radio frequency identification device conformance test methods —

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

1 Scope

This part of ISO/IEC TR 18047 defines test methods for determining the conformance of radio frequency identification (RFID) devices (tags and interrogators) for item management with the specifications given in ISO/IEC 18000-7, but does not apply to the testing of conformity with regulatory or similar requirements.

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

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

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

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

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

Unless otherwise specified, the tests in this part of ISO/IEC TR 18047 are to be applied exclusively to RFID tags and interrogators defined in ISO/IEC 18000-7.

2 Normative references

The following referenced documents are indispensable for the application of this part of ISO/IEC TR 18047. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO/IEC 18000-7:2009, *Information technology — Radio frequency identification for item management — Part 7: Parameters for active air interface communications at 433 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 (all parts) and the following apply.

3.1.1
Reference Interrogator
RFID interrogator, or device that emulates an RFID interrogator, that has been tested as compliant to both ISO/IEC 18000-7:2009 and ISO/IEC TR 18047-7:2010, and is used as a reference for testing tags

3.1.2
Reference Tag
RFID tag, or device that emulates an RFID tag, that has been tested as compliant to both ISO/IEC 18000-7:2009 and ISO/IEC TR 18047-7:2010, and is used as a known reference for testing interrogators

3.2 Symbols and abbreviated terms

RSSI Receiver Signal Strength Indicator

4 Physical Conformance Tests

4.1 General

This clause specifies the tests to determine whether interrogators and tags conform to ISO/IEC 18000-7:2009 at the physical level. The Physical Conformance Tests include measurements relating to signal quality (frequency, modulation, bandwidth, timing, etc.) of the transmitter and receiver, and the proper interaction of interrogators and tags to the signals.

4.2 Default items applicable to the test methods

4.2.1 Test environment

Unless otherwise specified, testing shall take place in an environment of temperature 23 °C ± 3 °C (73 °F ± 5 °F) and relative humidity of 40% to 60%. Tested equipment is to maintain performance limits stated herein in this environment. In addition to this minimum requirement, manufacturers may specify for their products an operational temperature range over which they intend to maintain performance limits stated in their specifications.

4.2.2 Pre-conditioning

Where pre-conditioning is required by the test method, the tags and interrogators to be tested shall be conditioned to the test environment by a method specified by the manufacturer before testing.

4.2.3 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).

4.2.4 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.

4.2.5 Test Report Format

Test reports shall be prepared individually for each tag or interrogator tested. Values measured for parameters in each subclause of clause 4.5 for interrogators and clause 4.6 for tags shall be recorded.

4.3 Test set-up and measurement equipment

4.3.1 General

The RFID system specified in ISO/IEC 18000-7:2009 is designed for long-range operation. Therefore a good receiver characteristic on both interrogator and tag is useful. The range of an RFID system also depends on the output power of the interrogator, which is set according to regulatory limits and application needs.

This clause defines the test set-up and measurement equipment for verifying the operation of a tag or an interrogator according to ISO/IEC 18000-7:2009.

Test results shall not be influenced by the set-up method of the test.

Test set-ups include:

- Test set-up for interrogator testing (see 4.3.2)
- Test set-up for tag testing (see 4.3.3)
- Test equipment (see 4.3.4)

4.3.2 Test set-up for interrogator testing

The conformance tests are designed to verify compliance with the basic radio-frequency parameters of the interrogator and tag while undergoing bi-directional communication.

Measurements are to be conducted with equipment configured to provide a high signal to noise ratio over the air interface. To achieve this, an interrogator with integral antenna(s) may be equipped with temporary antenna connector(s). Alternatively, a coupling device such as a sense antenna may be used to connect to the test equipment. Such an antenna should be selected with consideration for polarization and range to reduce measurement variations. Engineering judgment may be applied to select test equipment to support the variety of specific design features offered by different manufacturers. The antenna type, polarization, height and distance shall be recorded in the test report.

A control computer with appropriate software and user documentation provided by the vendor is expected to perform the control of all tests. All interrogator commands defined for this conformance testing are defined in ISO/IEC 18000-7:2009 Command codes.

To set up an interrogator with the appropriate test pattern and operational modes, one of the two methods shall be used (combinations shall also be possible):

- A pre-programmed, semi-automatic test mode implemented at the manufacturer's option through test code internal to the product. The operation of such code may require special purpose commands or connections beyond the scope of this Standard.
- A reference tag with which the interrogator may execute Link Layer operations.

The air interface parameter in a test mode shall behave the same as the air interface parameter during normal usage.

Unless otherwise stated the frequency of the reference carrier shall be set to 433,92 MHz.

The implementation of the test mode shall be in accordance with the air interface parameters and timing specified herein. If not stated herein, consult ISO/IEC 18000-7:2009.

The frequency of the interrogator transmitter shall be within the tolerance specified herein. The output power shall be set according to the manufacturer's instructions, not to exceed the maximum allowed by local regulatory rules taking into consideration the antenna gain. A control computer is required to set up and trigger all interrogator activity, as shown in Figure 1. The RF test equipments in the figure include RF receiver (including a sense antenna with or without an FM demodulator), spectrum analyser and logic analyser.

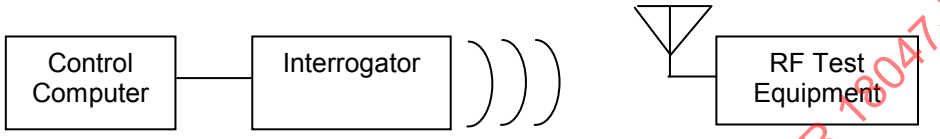

Figure 1 — Interrogator test system

4.3.3 Test set-up for tag testing

The conformance tests are designed to verify compliance with the basic radio-frequency parameters of the tag.

Measurements are to be conducted with equipment configured to provide a high signal to noise ratio over the air interface. To achieve this, an interrogator with integral antenna(s) may be equipped with temporary antenna connector(s). Alternatively, a coupling device such as a sense antenna may be used to connect to the test equipment. Such an antenna should be selected with consideration for polarization and range to reduce measurement variations. The antenna type, polarization, height and distance shall be recorded in the test report.

To set-up a tag with the test pattern and operational modes, one of the two methods shall be used (combinations shall also be possible):

- A pre-programmed, internal self-test mode in the tag. Note that design of this optional self-test mode is specific to each manufacturer. Special purpose over-the-air commands outside of ISO/IEC 18000-7:2009 or external connections may be required to operate in this mode.

- A reference interrogator for which the tag may execute Link Layer operations.

If no internal self-test mode is implemented in the tag, the conformance tests shall be performed during RF traffic between the tag and reference interrogator. For R/W tags without a test mode, a reference interrogator for initializing the appropriate operational mode shall be used. In this RFID system the interrogator is a master which initiates air interface activity and the tag only transmits in response to interrogator commands.

If a built-in test mode is incorporated in the tag, all air interface parameters shall behave the same as the air interface parameter during normal usage.

A control computer and reference interrogator are required to set up and trigger all tag activities as shown in Figure 2.

The RF test equipments in Figure 2 may include an RF receiver (including a sense antenna with or without an FM demodulator), a spectrum analyser, a logic analyser, or other similar instruments.

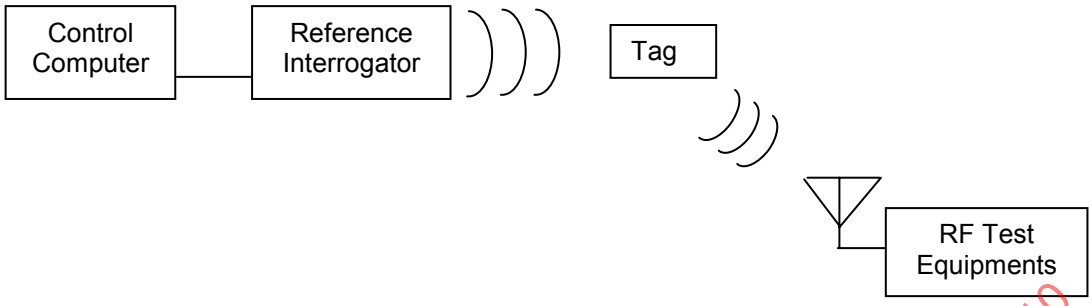

Figure 2 — Tag test system setup

4.3.4 Test equipment

All tests shall be done with commercial test equipment. Numerous types of RF measurement instruments are available with extended features for spectrum analysis, modulation analysis and data recording. The instruments listed below are examples of suitable equipment. Other variants may be used which are capable of making the measurements to the necessary degree of accuracy. All test equipment shall be calibrated by a nationally certified calibration laboratory within 12 months preceding the date of test.

Additional equipment such as power supplies, splitters, combiners and cables may be used as required.

The RF signal reference port for all measurements shall be either an antenna connector, or an appropriate coupling device such as a probe antenna. The reference port location shall be identified in the test report.

4.3.4.1 Spectrum analyser

A spectrum analyser or other instrument with equivalent features is required. The instrument requires internal triggering with the capability of capturing the RF signal leading edges, or an external triggering device.

4.3.4.2 Modulation analyser

A means of detecting and analyzing the data bit stream encoded on the RF signal is required. An example of a suitable instrument is a modulation analyser with the capability of analysing the signal's central frequency and frequency deviation. Instruments with other combinations of features may be employed.

4.3.4.3 Signal generator

It is necessary to emulate the interrogator Wake Up Signal over the frequency range required for the tag to detect it and respond. For this purpose, a modulated signal generator for the 433 MHz band may be used. The signal level for the tests shall be within the operational range of the receiver input of the tag. The input level shall be specified by the tag manufacturer and shall be documented in the test report.

4.3.4.4 Logic analyser

Instrumentation is required to capture and verify data transmission timing and correctness. An example of such equipment is a logic analyser with memory. The analyser should be capable of sampling at a rate of at least 100 mega-samples per second with a resolution of at least 8 bits at optimum scaling.

4.4 Physical Layer Parameter Values and Limits

Table 1 and Table 2 below list the critical parameters to be measured and verified in the subclauses listed in the first column. These tables refer to values in ISO/IEC 18000-7:2009 Table 117 and Table 118, or to clause numbers in that standard. The first column identifies the corresponding ISO/IEC 18000-7:2009 entry in parentheses as "(Ref.)".

Table 1 — Interrogator Parameter Values and Limits

Subclause (Ref.)	Parameter	Min	Nominal	Max
4.5.1 (Int. 1)	Interrogator Tx Centre Frequency @ 23° C +/- 3° C	433,906983 MHz (-30 ppm)	433,920 MHz	433,933018 MHz (+30 ppm)
4.5.2 (Int. 7f)	Interrogator Tx FSK Frequency Deviation (RMS)	40 kHz (-20%)	50 kHz	60 kHz (+20%)
	Interrogator Tx FSK Frequency Deviation (Peak)	30 kHz (-40%)	50 kHz	70 kHz (+40%)
4.5.3 (Int. 2)	Interrogator Tx Modulation Bandwidth containing 99% of RF Power			200 kHz
4.5.4 (6.1)	Interrogator Wakeup Header Duration	2,35 s		4,80 s
4.5.4 (6.1)	Interrogator Wakeup Header Square Wave Period	2x15,68 µs (-2%)	2x16 µs	2x16,32 µs (+2%)
4.5.4 (6.1)	Interrogator Wakeup Header Square Wave Frequency	30,625 kHz (-2%)	31,25 kHz	31,875 kHz (+2%)
4.5.5 (6.1)	Interrogator 100ms Co-Header Square Wave Period	2 x 49 µs (-2%)	2 x 50 µs	2 x 51 µs (+2%)
4.5.5 (6.1)	Interrogator Co-header Tx Duration	98 ms	100 ms	102 ms
4.5.6 (6.2)	Preamble Start (Low Period)	15 µs		
4.5.6 (Int.11; 6.2)	Interrogator Tx Preamble Square Wave Period, 20 cycles duration.	2 x 29,4 µs (-2%)	2 x 30 µs	2 x 30,6 µs (+2%)
4.5.6 (Int.11; 6.2)	Preamble Terminator Cycle Timing	53 µs (-2%) 53 µs (-2%)	54 µs high 54 µs low	55 µs (+2%) 55 µs (+2%)
4.5.7 (Int.8; 6.2)	Interrogator Data Tx Bit Interval	2x17,64 µs(-2%)	2x18 µs	2x18,36 µs (+2%)
4.5.7 (Int.8; 6.2)	Interrogator Data Bit Rate	27,222 kbps (-2%)	27,778 kbps	28,334 kbps (+2%)
Not Specified	FSK rise time or fall time.			6 µs between +/- 30 kHz, Fig 3
4.5.7 (6.2)	Packet Terminator (Low Period)	35.28 µs	36.00 µs	36.72 µs
4.5.7 (6.2)	Packet Terminator (High Period)	15 µs		
4.5.8 (Int.2a)	Interrogator Rx Bandwidth @ -3dB	300 kHz		

Table 2 — Tag Parameter Values and Limits

Subclause (Ref.)	Parameter	Min	Nominal	Max
4.6.1 (Tag:1)	Tag Tx Centre Frequency @ 23 °C +/- 3 °C	433,906983 MHz (-30 ppm)	433,920 MHz	433,933018 MHz (+30 ppm)
4.6.2 (Tag:7i)	Tag Tx FSK Frequency Deviation (RMS)	40 kHz (-20%)	50 kHz	60 kHz (+20%)
	Tag Tx FSK Frequency Deviation (Peak)	30 kHz (-20%)	50 kHz	70 kHz (+20%)
4.6.3 (Tag:2)	Tag Tx Modulation Bandwidth containing 99% of RF power			200 kHz
4.6.4 (6.2)	Preamble Start (Low Period)	15 µs		
4.6.4 (Tag:11c)	Tag Tx Preamble Square Wave Period, 20 cycles duration	2 x 28,5 µs(-5%)	2 x 30 µs	2 x 31,5 µs (+5%)
4.6.4 (Tag:11c)	Preamble Terminator Cycle Timing	40 µs (-5%) 51 µs (-5%)	42 µs high 54 µs low	44 µs (+5%) 57 µs (+5%)
4.6.5 (Tag:8)	Tag Data Tx Bit Interval	2x17,1 µs (-5%)	2x18 µs	2x18,9 µs (+5%)
4.6.5 (Tag:8)	Tag Data Bit Rate	26,389 kbps (-5%)	27,778 kbps	29,167 kbps (+5%)
Not specified	FSK rise time or fall time			6 µs between +/- 30 kHz, Fig 3
Not Specified	Tag Wakeup Time			End of Wakeup Period
4.6.5 (6.2)	Packet Terminator (Low Period)	34.20 µs	36.00 µs	37.80 µs
4.6.5 (6.2)	Packet Terminator (High Period)	15 µs		
4.6.7 (Tag:2a)	Tag Rx Bandwidth @ -3 dB	300 kHz		
4.6.8 (6.1)	Tag Awake Timeout	30 s		

4.5 Functional Test - Interrogator

4.5.1 Transmitter frequency accuracy

4.5.1.1 Test objective

The objective of this test is to verify that the interrogator transmitter frequency complies with the requirements of Table 1.

4.5.1.2 Test procedure

The interrogator shall transmit a broadcast or point-to-point tag collection command, which includes a tag Wake Up Signal. The centre frequency of the transmitted signal shall be measured by means of a spectrum analyzer or modulation analyzer. It is to be noted that the FSK spectrum suppresses energy at the nominal centre frequency, so that the measurement must be made by taking the midpoint between modulation peaks.

4.5.1.3 Measurement values and limits

The interrogator centre frequency shall be within the frequency range specified in Table 1.

4.5.1.4 Test report data

The test report shall state the measured frequency.

4.5.2 FSK modulation

4.5.2.1 Test objective

The objective of this test is to ensure that the interrogator average frequency deviation is within acceptable operating limits. Note that the FSK modulation waveform rise time and over-shoot produce power spectra affecting the Transmitter Modulation Bandwidth measurement in subclause 4.5.3.

4.5.2.2 Test procedure

The interrogator shall transmit a collection command, including a tag Wake Up Signal comprising a Wakeup Header and Co-Header. The Wake Up Signal is a regular waveform of sufficient duration to facilitate test equipment synchronization over the air. The positive and negative FSK frequency deviations of the transmitter shall be measured separately, evaluated as the RMS deviation over any individual Symbol-High or Symbol-Low period in the Wake Up Signal or collection command waveform. Alternatively, if test equipment does not permit RMS deviation measurements then the peak measurement may be taken instead.

A modulation analyzer or spectrum analyzer with suitable features shall be used for this measurement.

4.5.2.3 Measurement values and limits

A waveform mask representing the base-band frequency deviation appears in Figure 3 showing the limits for maximum rise and fall times, maximum over-shoot and under-shoot, and limits for the time-averaged frequency deviation for any pulse. All of these parameters are to be satisfied simultaneously.

4.5.2.4 Test report data

The test report shall evaluate the waveform compliance with the Mask of Figure 3 and record a Pass or list the failing parameters. The report shall also record separately the measured Positive Frequency Deviation and Negative Frequency Deviation.

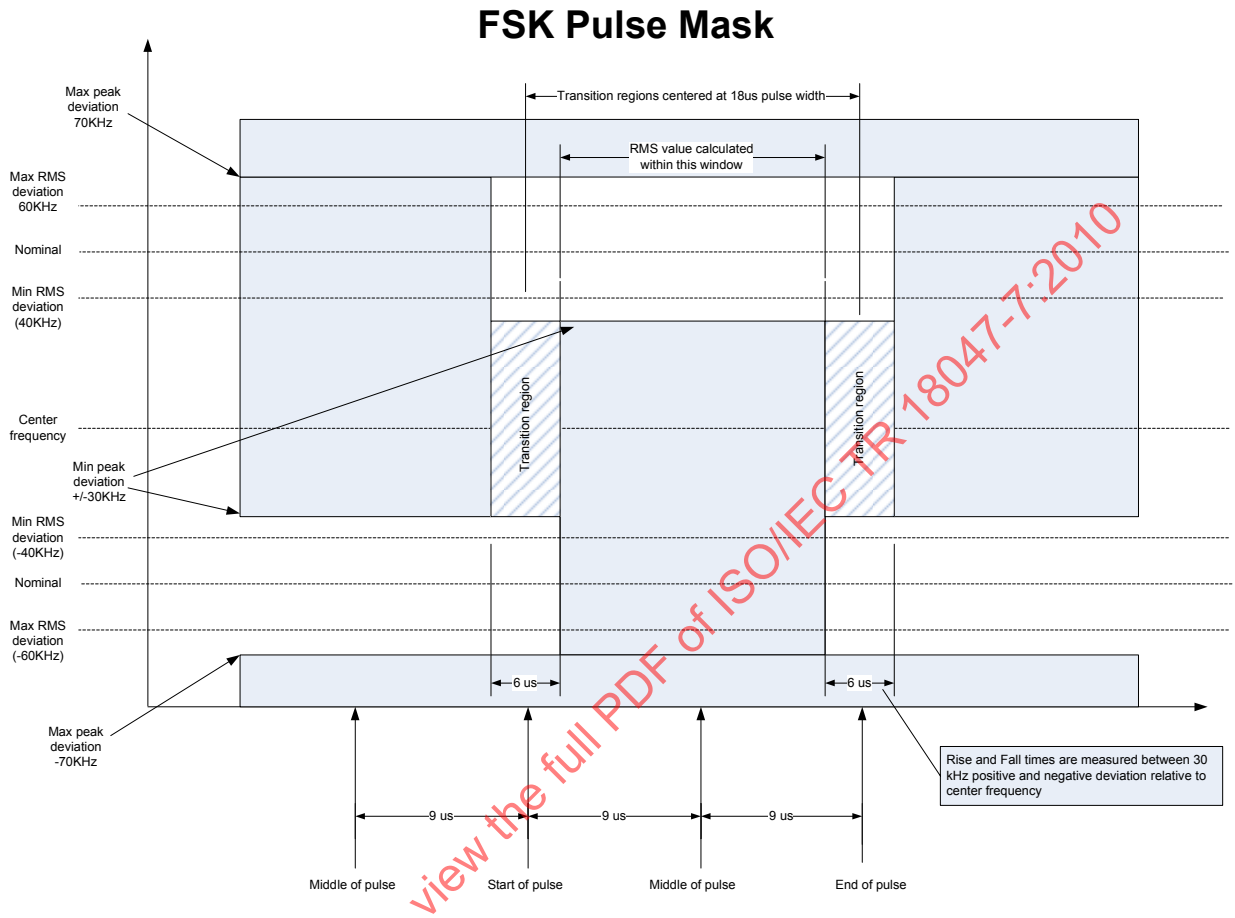

Figure 3 — FSK Pulse Mask

4.5.3 Transmitter Modulation Bandwidth

4.5.3.1 Test objective

This measurement ensures that the transmitter signal modulation does not result in excessive bandwidth spreading and does not interfere with adjacent channels, if present.

4.5.3.2 Test procedure

A spectrum analyzer or similar instrument with the capability of measuring the bandwidth occupied by 99% of the total RF power is to be used. The instrument should have a Resolution Bandwidth of 10 kHz and a Video Bandwidth of 10 kHz to capture the modulated spectrum over the Wakeup Signal interval. The full span of the display shall be between 500 kHz and 1 MHz. Utilize the automatic measurement features of the instrument to measure the 99% bandwidth.

4.5.3.3 Measurement values and limits

The value measured shall not exceed the maximum bandwidth specified in Table 1.

4.5.3.4 Test report data

The test report shall record the measured bandwidth.

4.5.4 Wake Up Header Signal

4.5.4.1 Test objective

The objective of this test is to verify that the Wakeup Header square wave frequency and duration are within specified values.

4.5.4.2 Test procedure

The interrogator shall transmit a tag collection command that initially transmits the tag Wake Up Signal to wake up all tags in the range of the interrogator.

An example of a suitable measurement system appears in Figure 4. It consists of an RF receiver with FM demodulator tuned to 433,92 MHz. The Wakeup Header square wave period and modulation frequency are to be measured with a logic analyzer or other suitable instruments. The wakeup coding shall be measured and verified for correctness.

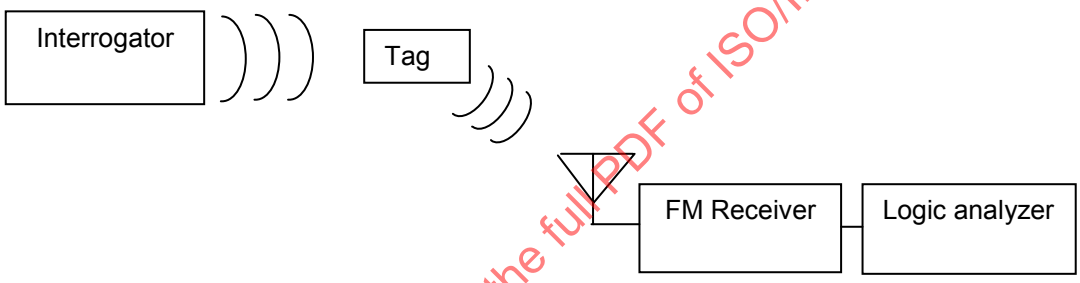

Figure 4 — Wakeup Header testing setup

4.5.4.3 Measurement values and timing

Verify that the Wakeup Header for a single antenna consists of:

- Wakeup Header square wave with period and frequency as specified in Table 1.
- Wakeup Header duration is between the minimum and maximum values specified in Table 1.

All timing measurements shall be made from edge to edge at the 50% levels of each signal transition.

4.5.4.4 Test report data

The test report shall record the waveform period, the Wakeup Header square wave frequency, and the Wakeup Header duration.

4.5.5 Co-Header Signal

4.5.5.1 Test objective

The objective of this test is to verify that the Co-Header square wave modulation frequency and duration are within specified values. This test is designed to ensure that the interrogator transmits a Co-Header square wave that can be recognized by tags for use in power management.

4.5.5.2 Test Procedure

The interrogator shall transmit a tag collection command that includes the Wake Up Signal.

An example of a suitable measurement system appears in Figure 5. It consists of an RF receiver with FM demodulator tuned to 433,92 MHz. The Co-Header square wave period and modulation frequency are to be measured with a logic analyzer or other suitable instruments. The wakeup coding shall be measured and verified for correctness.

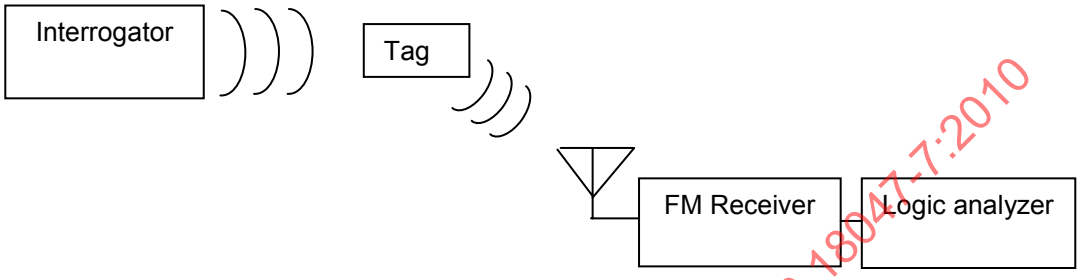

Figure 5 — Co-Header signal testing setup

4.5.5.3 Measurement values and timing

Verify that the Co-Header consists of:

- Square wave periods and frequency stated in Table 1.
- Co-Header duration stated in Table 1.

All timing measurements shall be made from edge to edge at the 50% levels of each signal transition.

4.5.5.4 Test report data

The test report shall record the waveform period, the square wave frequency, and the Co-Header signal duration.

4.5.6 Interrogator Message preamble format and timing

4.5.6.1 Test objective

The objective of this test is to verify the interrogator preamble structure and timing conforms to the specification.

Each interrogator command includes a preamble of 20 square wave cycles, preceded by a 15us logic low and followed by the preamble terminator cycle. The preamble is shown in Figure 6, with the first byte of a sample data packet. Data bytes are transmitted Least Significant Bit first. The example byte shown is 0x64.

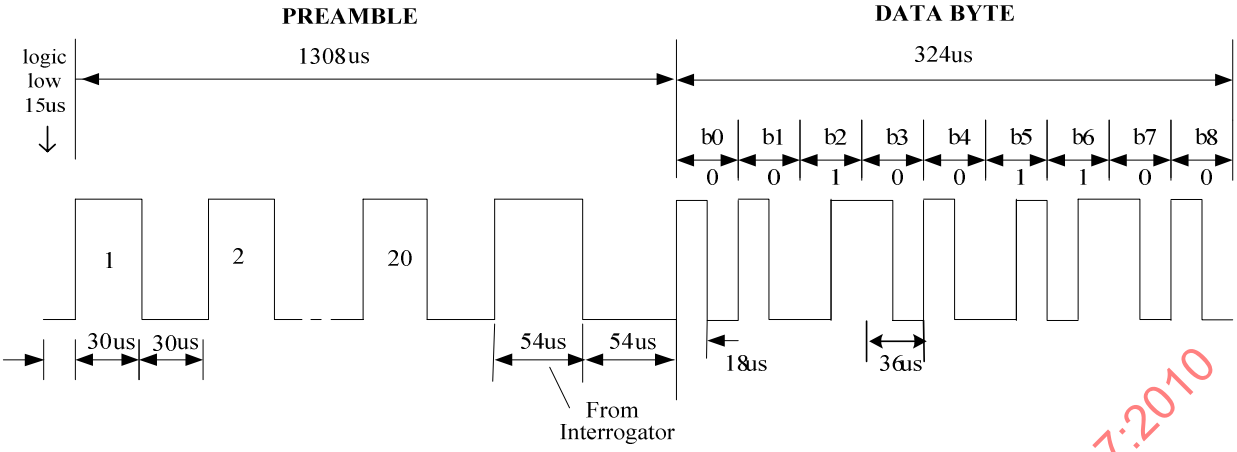

Figure 6 — Interrogator data communication and timing

4.5.6.2 Test procedure

The interrogator shall transmit a broadcast or point-to-point command. Each command sends a preamble including the preamble terminator cycle that identifies the interrogator-to-tag communication direction.

An example of a suitable measurement system is the same as appearing in Figure 4. It consists of an RF receiver with FM demodulator tuned to 433,92 MHz. The preamble square wave period and modulation frequency are to be measured with a logic analyzer or other suitable instruments. The preamble coding shall be measured and verified for correctness.

4.5.6.3 Measurement values and timing

Verify that the command preamble complies with the requirements of Table 1:

- There is a minimum of 15 µs low period preceding the first preamble pulse
- The nominal duration of the preamble is 1308 µs duration, +/- 2%.
- 20 square wave cycles in sequence
- The preamble terminator cycle low and high periods are as specified.

All timing measurements shall be made from edge to edge at the midpoint (50%) levels of each signal transition as shown in Figure 7.

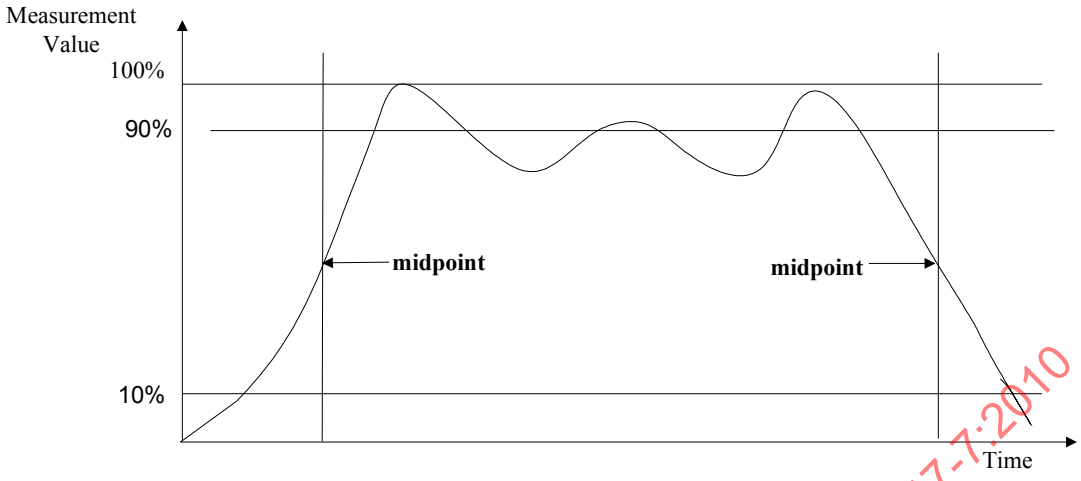

Figure 7 — Signal example with reference levels

4.5.6.4 Test report data

The test report shall record the following values:

- The total duration of the preamble
- The cycle timing of the preamble
- The timing of the preamble terminator cycle

4.5.7 Transmitter Data coding and reference timing

4.5.7.1 Test objective

The objective of this test is to verify the interrogator transmission employs Manchester coding and the data timing is within defined limits as shown in Figure 8. This test is designed to ensure that the interrogator transmits data at the specified rate so that:

- The transmission will be correctly interpreted as data by tags
- The transmission will not be incorrectly interpreted as a Wakeup Header at 31,25 kHz.

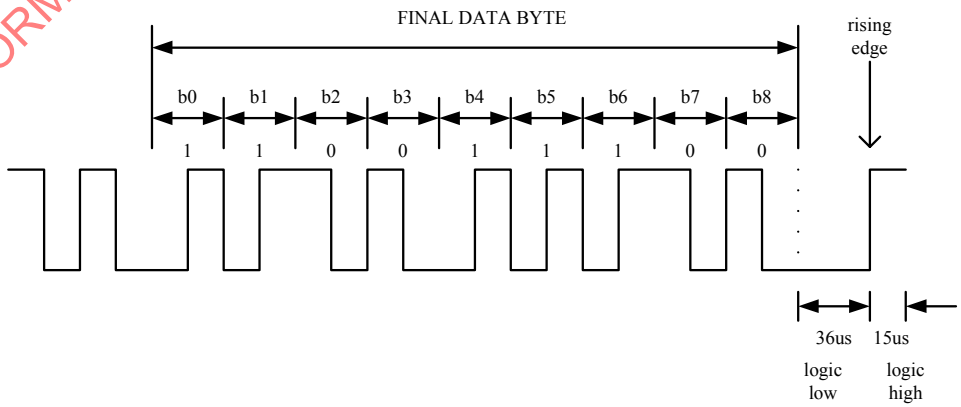

Figure 8 — Final Data Byte Timing

4.5.7.2 Test procedure

The interrogator shall be set up to transmit a Collection with Universal Data Block (UDB) command. This transmitted command data shall be analyzed for proper Manchester coding.

An example of a suitable measurement system is the same as appearing in Figure 4. It consists of an RF receiver with FM demodulator tuned to 433,92 MHz.

4.5.7.3 Measurement values and limits

Observe that Manchester coding is employed with a high-to-low or low-to-high transition in the centre of each data bit position.

The edge timing of the demodulated “high” and “low” transitions shall be measured to determine the Manchester symbol periods. The symbol period shall be measured at the beginning, the middle and the end of the transmitted message. The timing measurements shall be made from edge to edge at the midpoint (50%) levels of each signal transition.

Verify the interrogator inserts a “stop bit” (0) after every eight data bits, and after the last Manchester encoded bit within the packet it then transmits a final period of 36 µs of logic low followed by a rising edge and held high for at least 15 µs.

4.5.7.4 Test report data

The test report shall give the measured coding format and timing parameters. The pass/fail condition is determined by the values in Table 1.

4.5.8 Interrogator Receiver bandwidth

4.5.8.1 Test objective

The objective of this test is to verify that the interrogator has a minimum -3 dB receiver bandwidth of 300 kHz. The following test requires the interrogator to be able to measure and communicate the RSSI value.

Alternative means may be used to verify the receiver bandwidth if the interrogator does not provide the RSSI readout.

4.5.8.2 Test procedure

With a programmable signal generator and RF modulator, generate and transmit an ISO/IEC 18000-7:2009 compliant RF message at 433,92 MHz, the nominal band centre. Other transmissions will be made above and below channel centre to determine relative attenuation by reading the RSSI value.

At each frequency, read the RSSI value provided by the interrogator.

a) The RSSI shall be verified to be linearly proportional to the power, otherwise a calibration of the test setup needs to be done.

b) Next, develop an average RSSI value from five (5) RSSI measurements made at 433,92 MHz ±10 kHz in 5 kHz steps (433,91 MHz to 433,93 MHz).

c) Repeat the RSSI measurements at two adjacent points: 433,92 MHz ±150 kHz (433,770 MHz and 434,070 MHz).

4.5.8.3 Measurement values and limits

Verify that both adjacent RSSI values measured in Step c) are no more than 3 dB below the average RSSI developed in step b) of the test procedure. Values greater than 3 dB are not compliant.

4.5.8.4 Test report data

The test report shall give the measured RSSI values and their relationship to the average RSSI in dB.

4.6 Functional Test - Tag

4.6.1 Transmitter frequency accuracy

4.6.1.1 Test objective

The objective of this test is to verify that the tag transmitter frequency complies with the requirements of Table 2.

4.6.1.2 Test procedure

Initialize for the test:

- The tag shall have a suitable n-byte data pattern pre-stored in user memory.
- The tag shall be in a sleep state, waiting for the Wake Up Signal.

The interrogator shall issue a “Collection with Universal Data Block” command as described in ISO/IEC 18000-7:2009. The maximum packet size may be specified up to 255 bytes to enable the tag to transmit a long record and facilitate over-the-air synchronization of the test instrumentation. The tag shall respond with the Broadcast response message format of ISO/IEC 18000-7:2009 with transmission of the selected, pre-stored data. A spectrum analyzer or modulation analyzer may be used to measure the centre frequency. It is to be noted that the FSK spectrum suppresses energy at the nominal centre frequency, so that the measurement must be made by taking the midpoint between modulation peaks.

4.6.1.3 Measurement values and limits

The tag centre frequency shall lie within the frequency range specified in Table 2.

4.6.1.4 Test report data

The test report shall record the measured centre frequency.

4.6.2 FSK modulation

4.6.2.1 Test objective

The objective of this test is to ensure that the tag average frequency deviation is within acceptable operating limits. Note that the FSK modulation waveform rise time and over-shoot produce power spectra affecting the Transmitter Modulation Bandwidth measurement subclause below.

4.6.2.2 Test procedure

In the manner of subclause 4.6.1, the interrogator shall transmit a collection command. The tag response is to be measured. The positive and negative FSK frequency deviations of the tag transmitter shall be measured separately, evaluated as the RMS deviation over any individual Symbol-High or Symbol-Low period in the signal waveform. Alternatively, if test equipment does not permit RMS deviation measurements then the peak measurement may be taken instead.

A modulation analyzer or spectrum analyzer with suitable features shall be used for this measurement.

4.6.2.3 Measurement values and limits

A waveform mask representing the base-band frequency deviation appears in Figure 3 showing the limits for maximum rise and fall times, maximum over-shoot and under-shoot, and limits for the time-averaged frequency deviation for any pulse. All of these parameters are to be satisfied simultaneously.

4.6.2.4 Test report data

The test report shall evaluate the waveform compliance with the Mask of Figure 3 and record a Pass or list the failing parameters. The report shall also record separately the measured Positive Frequency Deviation and Negative Frequency Deviation.

4.6.3 Transmitter Modulation Bandwidth

4.6.3.1 Test objective

This measurement ensures that the transmitter signal modulation does not result in excessive bandwidth spreading and does not interfere with adjacent channels, if present.

4.6.3.2 Test procedure

A spectrum analyzer or similar instrument with the capability of measuring the bandwidth occupied by 99% of the total RF power is to be used. The instrument should have a Resolution Bandwidth of 10 kHz and a Video Bandwidth of 10 kHz to capture the modulated spectrum over the entire modulated data interval. The full span of the display shall be between 500 kHz and 1 MHz. Utilize the automatic measurement features of the instrument to measure the 99% bandwidth.

4.6.3.3 Measurement values and limits

The value measured shall not exceed the maximum bandwidth specified in Table 2.

4.6.3.4 Test report data

The test report shall record the measured bandwidth.

4.6.4 Transmitted message preamble format and timing

4.6.4.1 Test objective

The objective of this test is to verify that the tag transmitted message preamble structure and timing complies with requirements specified in Table 2.

Each tag response includes a preamble of 20 square wave cycles, preceded by a 15us logic low and followed by the preamble terminator cycle, as shown in Figure 9 below, with the first byte (example) of a data packet. Pulse width in μs. Data byte transmitted significant bit first. Byte shown is code 0x64.

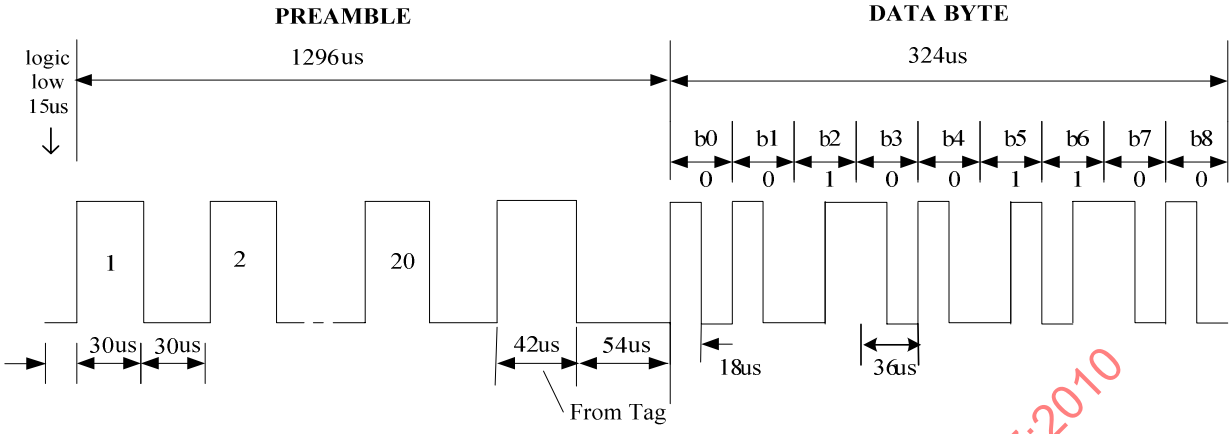

Figure 9 — Tag data communication and timing

4.6.4.2 Test procedure

Initialize for the test:

- The tag must have an easily recognizable n-byte data pattern (e.g. all “1’s” or all “0’s”, alternating “1’s” and “0’s”, etc.) pre-stored in user memory.

The interrogator shall transmit a point-to-point “Collection with Universal Data Block (UDB)” command with the test tag ID. The tag shall respond with transmission of the selected, pre-stored data. The tag response shall be analyzed to determine the message preamble and timing.

An example of a suitable measurement system appears in Figure 4. It consists of an RF receiver with FM demodulator tuned to 433,92 MHz. The preamble square wave cycle period, preamble terminator cycle timing and modulation frequency are to be measured with a logic analyzer or other suitable instruments. The coding shall be measured and verified for correctness.

4.6.4.3 Measurement values and timing

Verify that the tag response preamble complies with the requirements of Table 2:

- There is a minimum of 15 µs low period preceding the first preamble pulse
- The nominal duration of the preamble is 1296 µs duration, +/- 5%.
- 20 square wave cycles in sequence
- The preamble terminator cycle low and high periods are as specified.

All timing measurements shall be made from edge to edge at the 50% levels of each signal transition..

4.6.4.4 Test report data

The test report shall give the measured modulation parameters. The pass/fail condition is determined by the values in Table 2 and the values defined in ISO/IEC 18000-7:2009 tag to interrogator Link Parameters for the reverse link Tag:11c and Tag:11d.

4.6.5 Transmitter Data coding and reference timing

4.6.5.1 Test objective

The objective of this test is to verify the tag transmission employs Manchester coding and the data timing is within the specified limits as shown in Figure 10.

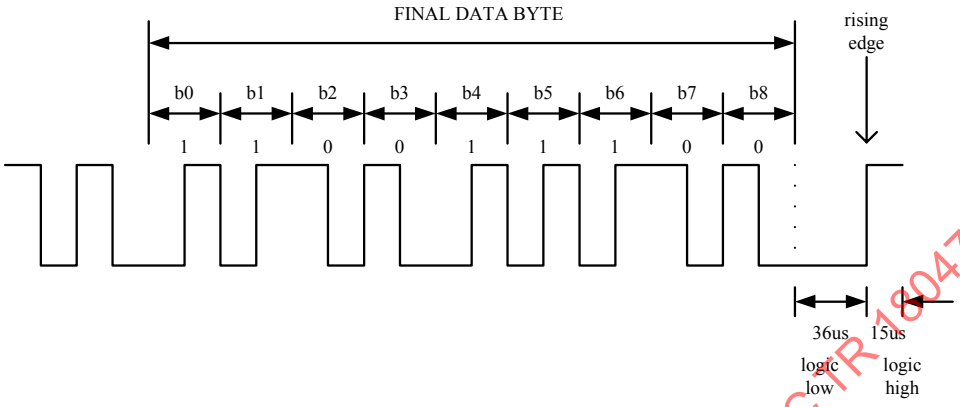

Figure 10 — Final Data Byte Timing

4.6.5.2 Test procedure

Initialize for the test:

- The tag must have an easily recognizable n-byte data pattern (e.g. all “1’s” or all “0’s”, alternating “1’s” and “0’s”, etc.) pre-stored in user memory.

In the manner described in Subclause 4.6.1, the interrogator shall issue the broadcast command: “Collect with Universal Data Block”. The tag shall respond with transmission of the selected, pre-stored data. The tag response shall be analyzed to determine the data coding and data order.

An example of a suitable measurement system appears in Figure 4. It consists of an RF receiver with FM demodulator tuned to 433,92 MHz. The tag to interrogator link parameters and logic analyzer shall be used for observing the correct Manchester coding and measuring the bit/symbol timing.

4.6.5.3 Measurement values and limits

Observe that Manchester coding is employed with a high-to-low or low-to-high transition in the centre of each data bit position.

The demodulated “high” and “low” signal shall each be measured for bit times in three separate and distinct portions of the transmitted message. Limits are as specified in Table 2 All measurements are made from edge to edge at the 50% levels of each signal transition.

Verify that the tag inserts a “stop bit” (0) after every eight data bits, and after the last Manchester encoded bit within the packet it then transmits a final period of 36 µs of logic low followed by a rising edge and held high for at least 15 µs.

4.6.5.4 Test report data

The test report shall give the measured coding and timing parameters. The pass/fail condition is determined by the value in Table 2.

4.6.6 Wake Up Signal response

4.6.6.1 Test objective

The objective of this test is to verify that the tag will wake up in response to a correct interrogator Wake Up Signal, consisting of the Wake Up Header and Co-Header. The tag must be capable of recognizing the Wakeup square wave signal at its high and low limits, and with the modulated UHF frequency deviation at the high and low limits. The tag Wakeup Time must be no longer than the value specified in Table 2.

4.6.6.2 Test procedure

Initialize for the test:

- The tag shall be in a sleep state, waiting for the Wake Up Signal.

The interrogator shall transmit a Wakeup Signal followed by a “Collection with Universal Data Block” command with the test tag ID. The tag shall respond with transmission of its Identification Code and contents of the UDB, if any.

An example of a suitable measurement system is the same as appearing in Figure 4. It consists of an RF receiver with FM demodulator tuned to 433,92 MHz. The Identification Code of the tag under test can be recognized as an indication that the tag was successfully awakened. Transmit the Wakeup Signal and observe - the tag awoke and responded to the Collection with Universal Data Block command. After the Collection Period completes issue a Sleep command to the tag [or wait 30 seconds for the tag to go to sleep]. Repeat for the total number of wakeups specified below, with the tag returning to sleep each time.

Note that a tag with a Wakeup Sample Interval longer than that specified in Table 2 may still be successfully awakened a large percentage of the time, depending on timing statistics. Perform 50 sample measurements on one tag for each of the following two cases.

Case 1: High Modulation Frequency Deviation and High wakeup square wave Frequency according to limits of Table 1.

Case 2: Low Modulation Frequency Deviation and Low wakeup square wave Frequency according to limits of Table 1.

4.6.6.3 Measurement values and limits

Only one failure in 50 successive Wakeups is permitted.

4.6.6.4 Test report data

The test report shall record the number of successful and failed wakeup events for each of Case 1 and Case 2.

4.6.7 Tag Receiver bandwidth

4.6.7.1 Test objective

The objective of this test is to verify that the tag has a minimum -3 dB receiver bandwidth of 300 kHz. The following test requires the tag to be able to measure and communicate the RSSI value.

Alternative means may be used to verify the receiver bandwidth if the tag does not provide the RSSI readout.

4.6.7.2 Test procedure

With a programmable signal generator and RF modulator, generate and transmit an ISO/IEC18000-7:2009 compliant RF message at 433,92 MHz, the nominal band centre. Other transmissions will be made above and below channel centre to determine relative attenuation by reading the RSSI value.

At each frequency, read the RSSI value provided by the tag.

a) The RSSI shall be verified to be linearly proportional to the power, otherwise a calibration of the test setup needs to be done.

b) Next, develop an average RSSI value from five (5) RSSI measurements made at 433,92 MHz ±10 kHz in 5 kHz steps (433,91 MHz to 433,93 MHz).

c) Repeat the RSSI measurements at two adjacent points: 433,92 MHz ±125 kHz (433,795 MHz and 434,045 MHz).

4.6.7.3 Measurement values and limits

Verify that both adjacent RSSI values measured in Step c) are no more than 3 dB below the average RSSI developed in step b) of the test procedure.

4.6.7.4 Test report data

The test report shall give the measured RSSI values and their relationship to the average RSSI in dB.

4.6.8 Tag Awake Timeout

4.6.8.1 Test Objective

Verify that the tag remains awake for the minimum specified time after detecting the Wake Up Signal or receipt of the last valid command. Note that this is the maximum time allowed for the application software to perform other transactions before returning to this tag for another point-to-point transaction before another Wake Up Signal is needed. However, the tag will measure the time from the earliest point at which it detects the Wake Up Signal. Therefore, the time the tag is accessible by the interrogator may be reduced by the duration of the Wake Up Signal. The Collection command re-initializes the tag timer, which improves the accuracy of this measurement.

4.6.8.2 Test Procedure

Transmit a wakeup square wave signal to the tag followed by a Collection command, which initiates the tag timer. After an elapsed time equal to the minimum required, issue a point-to-point tag read command to determine if the tag is still awake. Repeat the operation a total of 10 times.

4.6.8.3 Measurement Values and Limits

Verify that the tag responds for all ten samples performed at the minimum time specified in Table 2.

4.6.8.4 Test Report

Record the number of successful responses and the number of failures.

5 Command Protocol Conformance Tests

5.1 General

This clause specifies the tests to determine whether interrogators and tags conform to ISO/IEC 18000-7:2009 at the Command Protocol level (specified as Link Level in ISO/IEC 18000-7:2009). The Command Protocol Conformance Tests evaluate the communication protocol and behaviour between interrogators and tags. These tests do not evaluate those communication layers above this level, including the Application Layer (communications between the Application and the interrogator), the interrogator User Interface, and the Application software.

5.2 Default items applicable to the test methods

Unless specified below, the default items applicable to the test methods for Physical Conformance Tests in clause 4 also apply to the Command Protocol Conformance Tests defined herein.

5.2.1 Prerequisites to Testing

Because communications integrity depends upon reliable signal quality the interrogator and tag under test shall have been tested and passed the Physical Conformance Tests described in this part of ISO/IEC TR 18047.

All reference interrogators and reference tags used must have been previously tested and verified to conform to the tests defined by this part of ISO/IEC TR 18047 no more than one year prior to the date of testing.

5.2.2 Test Report Format

A comprehensive ISO/IEC 18000-7 Command Protocol Conformance Test Report shall be prepared individually for each tag or interrogator tested showing each test, the number of iterations of the test that was performed and the total failures seen, and whether the unit passed or failed. If a test fails then comments are required to indicate the reason for failure with supporting data as necessary.

5.3 Test Setup

In general, the Test Setup and equipment specified in clause 4 for the Physical Conformance Tests may also be used for the Command Protocol Conformance Tests defined herein. However, the reference interrogator and reference tag (or multiples of each used in combination) must support all mandatory and optional ISO/IEC 18000-7:2009 commands in order to completely evaluate the interrogator and tag under test. Additionally, the interrogator application software and/or interrogator User Interface must provide a means to execute each command and to report tag responses to the tester. It also may be desirable for the reference tag to be able to output the data received from the interrogator to aid in evaluation.

5.4 Interrogator Commands - Mandatory

This clause is used to test an interrogator for ISO/IEC 18000-7:2009 compliance with the individual mandatory Broadcast and Point-to-Point commands. These tests require a known compliant ISO/IEC 18000-7:2009 reference tag to be used with the interrogator being tested. The reference tag must be previously tested and verified to conform to the tests defined by this part of ISO/IEC TR 18047 no more than one year prior to the date of testing.

5.4.1 Collection With Universal Data Block (Broadcast - Command Code 0x1F)

5.4.1.1 Test Case 1 – Interrogator Tag Collection

Verify the interrogator performs the Tag Collection Process specified in 6.4 of ISO/IEC 18000-7:2009 using the following sequence:

1. Interrogator begins Collection Process by transmitting the Wakeup Period which may include one or more Wake Up Signals. Verify the Wakeup Period is transmitted only once during the Collection Process.
2. Interrogator initiates the Collection Period by broadcasting the first Collection With Universal Data Block command to all tags. Verify the interrogator transmits the correct parameter structure and values.
3. For each tag responding with a valid response, the interrogator collects all UDB data within the response, and may optionally issue additional Read Universal Data Block commands to retrieve additional UDB data (see subclause 5.4.7), or any other set of commands to perform other operations.
4. Prior to ending the Collection Period the interrogator shall issue a Sleep command to each tag identified within the Collection Period.
5. Interrogator continues the Collection Process by transmitting additional Collection Periods (steps 2-4 above) until no tag replies or collisions are detected in a Collection Period.
6. When a Collection Period with no replies or collisions is detected the interrogator continues to process at least one additional, and no more than four total, consecutive Collection Periods where no tag reply or tag collisions were detected (steps 2-5 above).
7. Interrogator reports all tags identified during the Collection Process.

5.4.1.2 Test Case 2 – Verify Interrogator Detects Tag Replies for all Slots

5.4.2 Sleep All But (Broadcast - Command Code 0x16)

5.4.2.1 Test Case 1 – Correct Parameters

Verify the interrogator transmits the correct parameter structure and values (e.g. Command Code, Tag Manufacturer ID, Tag Serial Number, etc.) and receives a no response from the tag.

5.4.3 Write User ID (Point-to-Point - Command Code 0x93)

5.4.3.1 Test Case 1 – New User ID

NOTE Execution of this test requires the reference tag to have Password Protection disabled to avoid an Authorization Failure Error (0x08).

Verify the interrogator transmits the correct parameter structure and values (e.g. Command Code, User ID Length, User ID, etc.) to write a new 60 byte User ID and receives a successful response from the tag.

5.4.4 Read User ID (Point-to-Point - Command Code 0x13)

5.4.4.1 Test Case 1 – Verify New User ID

Verify the interrogator transmits the correct parameter structure and values (e.g. Command Code, User ID Length, User ID, etc.) to successfully retrieve the User ID from the tag.

5.4.5 Write Routing Code (Point-to-Point - Command Code 0x89)

5.4.5.1 Test Case 1 – Verify Write Routing Code

NOTE Execution of this test requires the reference tag to have Password Protection disabled to avoid an Authorization Failure Error (0x08).

Verify the interrogator transmits the correct parameter structure and values (e.g. Command Code, Routing Code Length, Routing Code, etc.) to write a new 50 byte Routing Code and receives a successful response from the tag.