TECHNICAL REPORT

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Information technology — Radio frequency identification device conformance test methods —

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

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

Partie 4: Méthodes d'essai pour les communications d'une interface d'air à 2,45 GHz

Reference number
ISO/IEC TR 18047-4:2004(E)

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Foreword

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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 Technical Reports of type 3 do not necessarily have to be reviewed until the data they provide are considered to be no longer valid or useful.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 18047-4, which is a Technical Report of type 2, was prepared by Joint Technical Committee ISO/IEC JTC 1, *Information technology*, Subcommittee SC 31, *Automatic identification and data capture techniques*.

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

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

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

Test methods for air interface communications below 135 kHz, at 860 MHz to 960 MHz, and at 433 MHz will form the subjects of the future Parts 2, 6 and 7, respectively.

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Introduction

ISO/IEC 18000-4 defines the air interface for radio frequency identification (RFID) devices operating in the 2,45 GHz Industrial, Scientific, and Medical (ISM) band used in item management applications. The purpose of this part of ISO/IEC TR 18047 is to provide a test method for ISO/IEC 18000-4.

This part of ISO/IEC TR 18047 contains all compliance measurements required to be fulfilled by a product in order to be compliant to 18000-4 Mode 2.

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Information technology — Radio frequency identification device conformance test methods —

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

1 Scope

This part of ISO/IEC TR 18047 defines test methods for determining the conformance of radio frequency identification devices (tags and interrogators) for item management with the specifications given in the corresponding part of ISO/IEC 18000, 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:

- 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 apply exclusively to RFID tags and interrogator defined in ISO/IEC 18000-4 Mode 2.

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 amendments) applies.

ISO/IEC 18000-1, *Information technology — Radio frequency identification for item management — Part 1: Reference architecture and definition of parameters to be standardized*

ISO/IEC 18000-4, *Information technology — Radio frequency identification for item management — Part 4: Parameters for air interface communications at 2,45 GHz*

ISO/IEC 19762 (all parts), *Information technology — Automatic identification and data capture techniques — Harmonized vocabulary*[1)]

ISBN 92-67-10188-9, 1993, *ISO Guide to the expression of uncertainty in measurement*

1) To be published.

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3 Terms and definitions

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

4 Symbols and abbreviations

CW	continuous wave
f_{CC}	frequency of the communication carrier
f_{CH}	channel spacing
f_{IF}	frequency of the intermediate frequency
f_{RC}	frequency of the reference carrier
OOK	on-off keying
R/O-tag	read only tag
R/W-tag	read/write tag

5 Conformance tests for ISO/IEC 18000-4 — 2,45 GHz

This part of ISO/IEC TR 18047 specifies a series of tests to determine the conformance of interrogators and tags. The results of these tests shall be compared with the parameters specified in ISO/IEC 18000-4 to determine whether the interrogator or tag under test conforms.

5.1 Default items applicable to the test methods

5.1.1 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 %.

5.1.2 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 for an appropriate period of time before testing.

5.1.3 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).

5.1.4 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 Guide to the Expression of Uncertainty in Measurement”, ISBN 92-67-10188-9, 1993.

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5.2 Conformance tests for ISO/IEC 18000-4 Mode 2

The long-range, high data-rate RFID system specified in ISO/IEC 18000-4 is designed for long-range operation. Therefore a good receiver characteristic on both side's interrogator and tag (if applicable) 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.

Therefore receiver sensitivity and transmitter output power measurements are not part of this part of ISO/IEC TR 18047.

5.2.1 Test set-up and measurement equipment for Mode 2

This clause defines the test set-up and measurement equipment for verifying the operation of a tag or an interrogator according to ISO/IEC 18000-4.

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 5.2.1.1),
- test set-up for tag testing (see 5.2.1.2),
- test equipment (see 5.2.1.3).

These are described in the following subclauses.

5.2.1.1 Test set-up for interrogator testing

An interrogator with integral antenna(s) shall be equipped with temporary antenna connector(s), or coupling device(s) [i.e. sense antenna(s)] shall be used to connect to the test equipment.

A sense antenna shall not affect test results; appropriate distances (e.g. 30 cm), antenna sizes and types (e.g. patch antenna), as well as antenna polarization (i.e. circular polarization) shall be used. The antenna configuration and distance shall be included in the test report.

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

- an implemented test mode,
- a tag for initializing the appropriate operational mode.

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

Unless otherwise stated the following frequencies shall be used for all tests.

The frequency of the reference carrier shall be set to $f_{RC,nom.\ i} = (2931+i)*f_{CH}$, where f_{CH} = 819,2 kHz; the frequency of the communication carrier shall be set to $f_{CC,\ nom.\ i} = (2944+i)*f_{CH}$. All tests shall be performed at channels i = 0, 43, 86. The output power shall be set to maximum (both carriers switched on).

The difference between a pair of channels $f_{IF,i}$ is defined as $f_{CC,i} - f_{RC,i}$. Figure 1 shows all 3 pairs of frequencies used for the tests.

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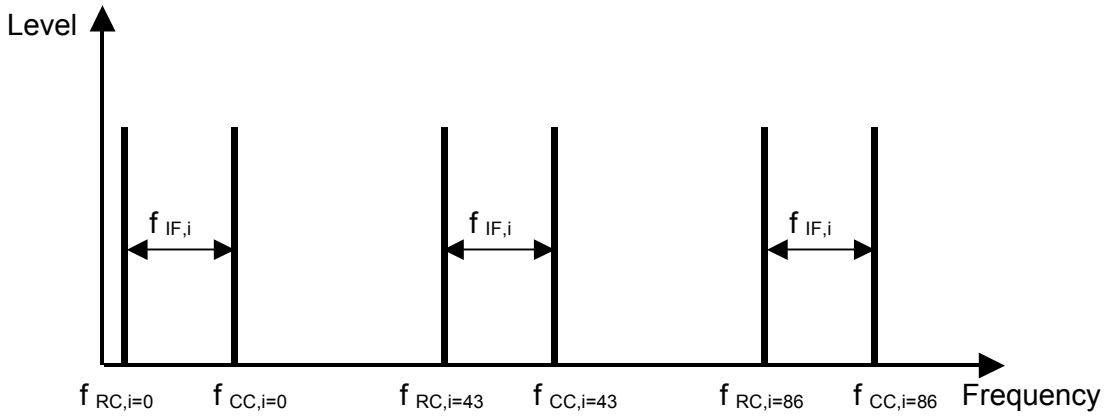

Figure 1 – Reference and communication carrier for 3 channel numbers i (0, 43, 86)

5.2.1.2 Test set-up for tag testing

A tag with integral antenna(s) shall be equipped with temporary antenna connector(s), or suitable coupling device(s) [i.e. antenna(s)] shall be used to connect to the test equipment.

A sense antenna shall not affect test results; appropriate distances (e.g. 30 cm), antenna sizes and types (e.g. patch antenna), as well as antenna polarization (i.e. circular polarization) shall be used. The antenna configuration and distance shall be included in the test report.

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

- an implemented test mode,
- an interrogator for initializing the appropriate operational mode.

Because the air interface of mode 2 uses tag talks first protocol, a tag will backscatter independently of an interrogator. Therefore a tag will backscatter the synchronization information and the Tag-ID continuously (the inactive time is according to the duty cycle). If no test mode is implemented in the tag the conformance tests shall be performed during this operational period. For R/W-tags without a test mode an interrogator for initializing the appropriate operational mode shall be used. The implementation of a test mode shall be in accordance with the specified air interface parameters and timings in ISO/IEC 18000-4 Mode 2. The air interface parameter in the test mode shall behave the same as the air interface parameter during normal usage.

Unless otherwise stated, all tests shall be performed at channels i = 0, 43, 86. For the description of frequency calculation refer to 5.2.1.1.

5.2.1.3 Test equipment

All tests shall be done with commercial test equipment. In addition to the measurement devices described below appropriate devices such as power supplies, splitters, combiners and cables shall be used.

The reference point for all measurements shall be either (temporary) antenna connector(s), or appropriate coupling device(s). The reference point shall be documented in the test report.

5.2.1.3.1 Spectrum analyser

A spectrum analyser with the capability of digital demodulating and vector signal analysis capability shall be used. Appropriate trigger functionality shall be either implemented in the spectrum analyser, or generated externally with additional measurement devices.

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5.2.1.3.2 Signal generator

A signal generator for the 2,45 GHz band shall be used to generate an interrogator output signal for testing tags. 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.

5.2.1.3.3 Logic analyser

A logic analyser shall be used for verification of the correct data. Therefore the analyser shall be capable of sampling at a rate of at least 6,144 Mega samples per second with a resolution of at least 8 bits at optimum scaling.

5.2.2 Functional test – interrogator

5.2.2.1 Modulation

5.2.2.1.1 Purpose

This test measures the modulation of the transmitted signals of the interrogator. This test is used to determine the index of modulation of the interrogator output as well as the rise and fall times of the modulation as defined in ISO/IEC 18000-4 Parameter Table for the Forward Link (Interrogator to Tag Link) (reference M2-Int:7, reference M2-Int:7f). For timings and tolerances refer to Figure 2.

5.2.2.1.2 Test procedure

The communication carrier shall be modulated with a bit sequence including the following pattern:

- 0101 or 1010,
- 1100 or 0011,
- 11110000 or 00001111.

The measurement can also be executed in three steps by using the first pattern, followed by the second pattern and the third pattern.

The symbol rate shall be in accordance with the ISO/IEC 18000-4 Mode 2 specification.

All measurements are relative to the power at the carrier frequency.

A spectrum analyser with digital demodulator and vector signal analysis shall be used for this measurement.

Modulation characteristic of communication carrier:

A verification of a correct modulation index shall be performed. Therefore the demodulation bandwidth of the analyser shall be set to 3 MHz and the centre frequency of the analyser shall be set to the actual carrier frequency.

5.2.2.1.3 Measurement values and limits

The peak frequency deviation from the carrier shall not exceed the specified maximum FM deviation.

The pulse width at a frequency deviation of 50 kHz shall be at least 1 µs.

The modulation characteristic limits are specified in Figure 2. The specified conditions shall be fulfilled at any place in the modulation pattern.

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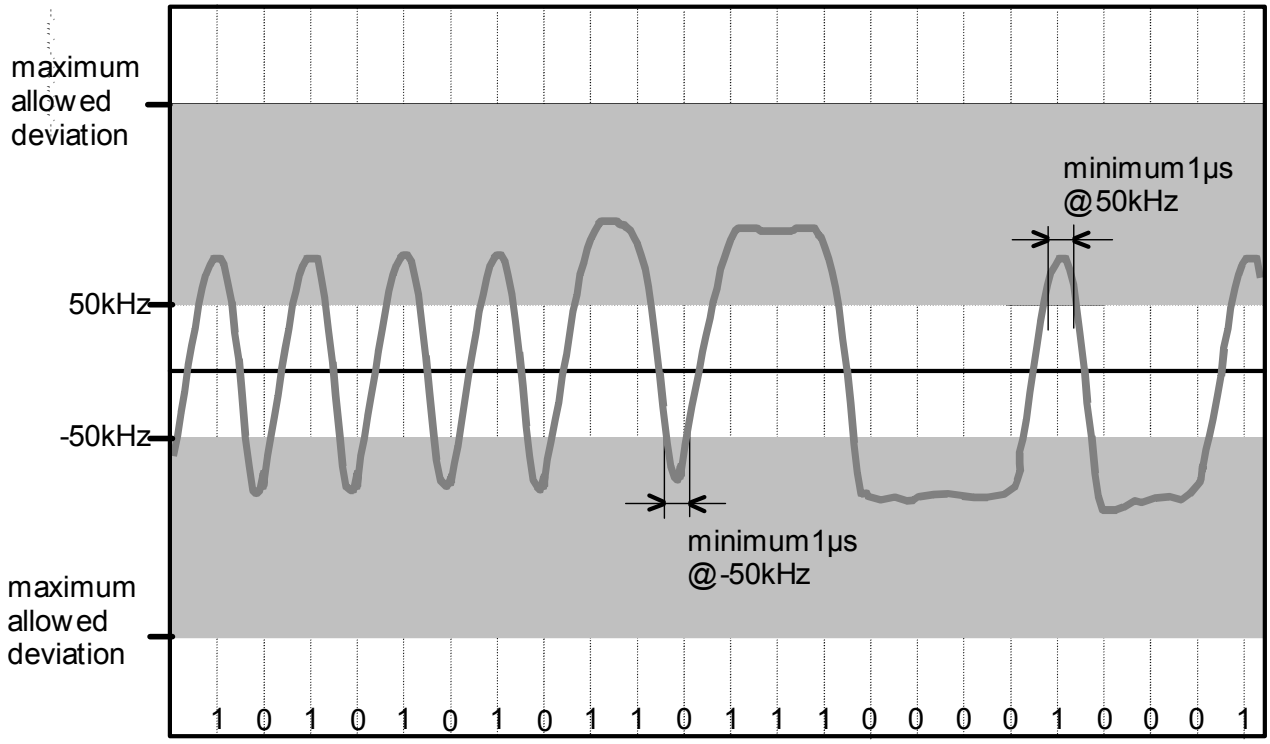

Figure 2 – Mask representation of the limits for modulation characteristic

5.2.2.1.4 Test report

The test report shall give the measured maximum deviation and the pulse width at a frequency deviation of ± 50 kHz for each defined pattern. The pass/fail condition is determined by the values defined in ISO/IEC 18000-4 Parameter Table for the Forward Link (Interrogator to Tag Link) (reference M2-Int:7, reference M2-Int:7f). For timings and tolerances refer to Figure 2.

5.2.2.2 Operating frequency accuracy

5.2.2.2.1 Purpose

This test measures the accuracy of the reference and the communication carrier as defined in ISO/IEC 18000-4 Parameter Table for the Forward Link (Interrogator to Tag Link) (reference M2-Int:1, reference M2-Int:1a, reference M2-Int:1b, reference M2-Int:1c).

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5.2.2.2.2 Test procedure

Reference carrier:

The reference carrier shall be CW.

The actual channel frequency shall be measured with a spectrum analyser.

Communication carrier:

The communication carrier shall be either CW or GMSK modulated.

In case of CW the actual channel frequency shall be measured with a spectrum analyser.

In case of GMSK a spectrum analyser with digital demodulator and vector signal analysis capability shall be used for this test. The centre frequency of the analyser shall be set to the actual channel frequency of the communication carrier $f_{CC,\ nom.\ i}$ and the resolution bandwidth shall be set to 3 MHz. The measurement of the frequency error shall be done by demodulating the RF-signal.

5.2.2.2.3 Measurement values and limits

The following equations shall be fulfilled:

$(f_{RC,\ nom.\ i}$ - maximum tolerance) $\leq f_{RC,i} \leq (f_{RC,\ nom.\ i}$ + maximum tolerance).

$(f_{CC,\ nom.\ i}$ - maximum tolerance) $\leq f_{CC,i} \leq (f_{CC,\ nom.\ i}$ + maximum tolerance).

$(f_{IF,\ nom.\ i}$ - maximum tolerance) $\leq f_{IF,i} \leq (f_{IF,\ nom.\ i}$ + maximum tolerance).

5.2.2.2.4 Test report

The test report shall give the measured frequencies. The pass/fail condition is determined by the equations in 5.2.2.2.3 and the values defined in ISO/IEC 18000-4 Parameter Table for the Forward Link (Interrogator to Tag Link) (reference M2-Int:1, reference M2-Int:1a, reference M2-Int:1b, reference M2-Int:1c).

5.2.3 Functional test – tag

5.2.3.1 Modulation

5.2.3.1.1 Purpose

This test measures the modulation of the backscattered signal according to the values as defined in ISO/IEC 18000-4 Parameter Table for the Return Link (Tag to Interrogator) (reference M2-Tag:7, reference M2-Tag:7d, reference M2-Tag:7g). For timings and tolerances refer to Figure 3, Figure 4 and Figure 5. The manufacturer of the tag shall specify the type of tag and modulation used.

5.2.3.1.2 Test procedure

A signal generator shall generate an unmodulated carrier (CW) with frequency $f_{CC,i=43}$ and within the operating frequency accuracy (refer to 5.2.2.2). This carrier shall be coupled to the tag antenna or conducted into a temporary antenna connector to the tag. The backscattered signal of the tag shall be separated from the CW carrier and shall be fed into the RF-input of a spectrum analyser with digital demodulator and vector signal analysis capability.

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Modulation measurement in case of BPSK and R/W- or R/O-tags:

The modulation shall be measured on a slot with low data rate. A 01-sequence after Manchester coding shall be applied, e.g. Training Sequence Type 1 channel (TS1-CH).

Measurement of the constellation diagram shall be done by digital signal processing in the analyser.

Modulation measurement in case of BPSK and R/W-tags:

The modulation shall be measured on a slot with the high data rate, i.e. a slot in the communication channel. A 01-sequence after Manchester coding shall be applied.

Measurement of the constellation diagram shall be done by digital signal processing in the analyser.

Modulation measurement in case of OOK and R/O-tags:

The modulation shall be measured on a slot with a 01-sequence after Manchester coding, e.g. Training Sequence Type 1 channel (TS1-CH).

Measurement of the on-off ratio shall be done by zero span measurement in the analyser.

5.2.3.1.3 Measurement values and limits

Measurement values in case of BPSK:

Magnitude 100 %, Phase 180 degrees

Limits in case of BPSK:

Magnitude 100 ± 20 %, Phase 180 ± 30 degrees, refer to the constellation diagram in Figure 3.

The timing of the modulation shall be measured as an eye diagram, the rise and fall time in the eye diagram shall be according to Figure 4.

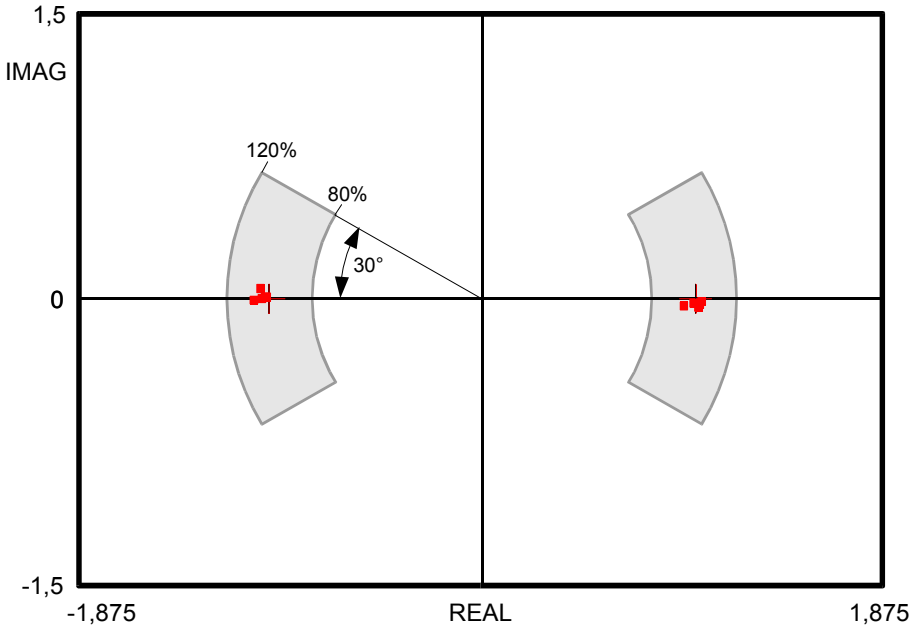

Figure 3 – Constellation diagram and measurement limits for BPSK modulation

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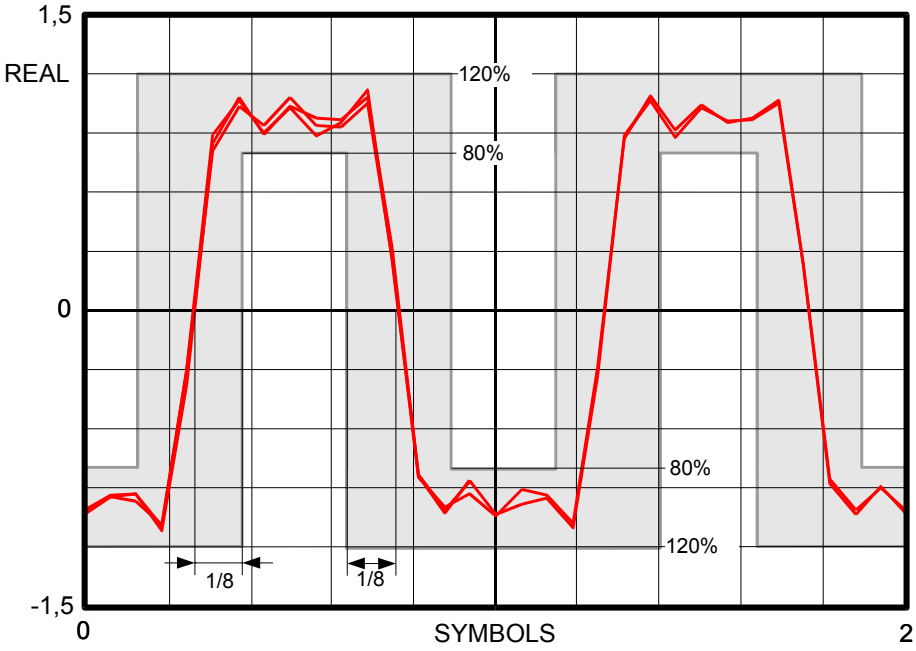

Figure 4 – Eye diagram and measurement limits for BPSK modulation

Limits in case of OOK:

The on-off ratio shall be greater or equal to specified on-off ratio defined in ISO/IEC 18000-4. The on- and off-time of the OOK shall be a minimum of one quarter the duration of one symbol as shown in Figure 5.

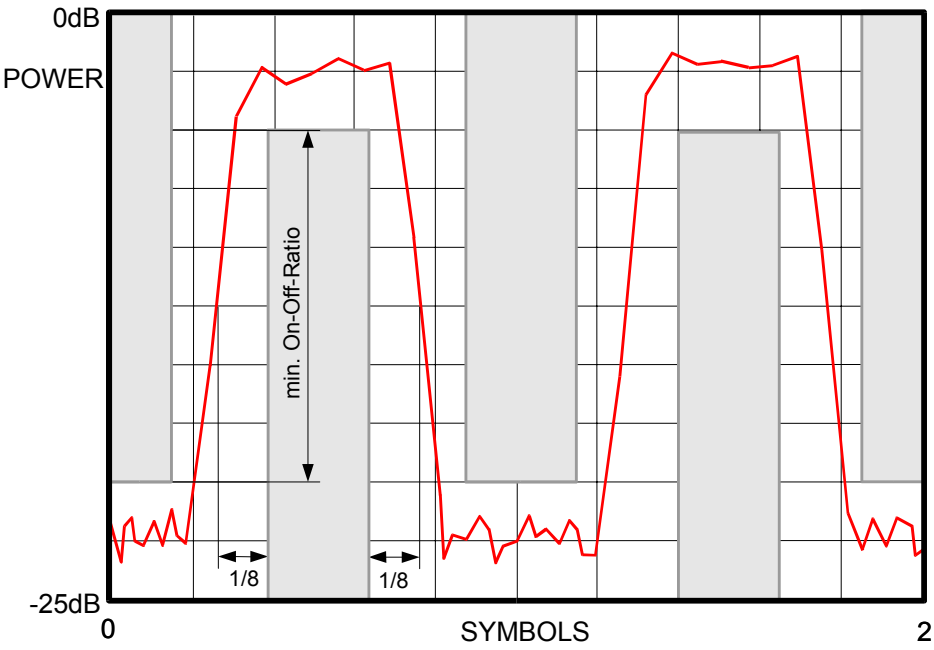

Figure 5 – Power over time diagram with measurement limits for OOK modulation

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5.2.3.1.4 Test report

The test report shall give the measured modulation parameter. The pass/fail condition is determined by the values defined in ISO/IEC 18000-4 Parameter Table for the Return Link (Tag to Interrogator) (reference M2-Tag:7, reference M2-Tag:7d, reference M2-Tag:7g). For timings and tolerances refer to Figure 3, Figure 4 and Figure 5. The type of tag shall be specified in the test report.

5.2.3.2 Coding

5.2.3.2.1 Purpose

This test measures the correct line coding in the tag according to the values as defined in ISO/IEC 18000-4 Parameter Table for the Return Link (Tag to Interrogator) (reference M2-Tag:8).

5.2.3.2.2 Test procedure

No analogue coding is applied. A signal generator shall generate a communication carrier with frequency $f_{CC,i=43}$ and within the operating frequency accuracy (refer to 5.2.2.2). This carrier shall be coupled to the tag antenna or conducted into a temporary antenna connector to the tag. The backscattered signal of the tag shall be separated from the signal generator output signal and shall be fed into the RF-input of a spectrum analyser with digital demodulator and vector signal analysis capability. The demodulator output of the analyser shall be fed into a logic analyser where the original data shall be compared with the defined bits in ISO/IEC 18000-4 Mode 2.

5.2.3.2.3 Measurement values and limits

The specified line coding shall be applied.

5.2.3.2.4 Test report

The test report shall give the measured coding. The pass/fail condition is determined by the values defined in ISO/IEC 18000-4 Parameter Table for the Return Link (Tag to Interrogator) (reference M2-Tag:8).

5.2.3.3 Sub-carrier frequency

5.2.3.3.1 Purpose

This test measures if the tag generates the correct sub-carrier frequencies according to the values as defined in ISO/IEC 18000-4 Parameter Table for the Return Link (Tag to Interrogator) (reference M2-Tag:7e, reference M2-Tag:7f). The manufacturer of the tag shall specify the type of tag. According to the type of tag all applicable sub-carrier frequencies shall be measured.

5.2.3.3.2 Test procedure

A signal generator shall generate an unmodulated carrier (CW), with a frequency of $f_{CC,\ i=43}$, and within the operating frequency accuracy (refer to 5.2.2.2). This carrier shall be coupled to the tag antenna or conducted into a temporary antenna connector to the tag. The backscattered signal of the tag shall be separated from the signal generator output signal and shall be fed into the RF-input of a spectrum analyser.

Sub-carrier frequency measurement in case of R/W- and R/O-tags:

A tag shall transmit a 01-sequence (after Manchester coding) with a rate of 153,6 kHz for a minimum of 1 consecutive slot.

Measurement of the sub-carrier frequency shall be done by analogue signal processing in the analyser.

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Sub-carrier frequency measurement in case of R/W-tags:

For R/W-tags the sub-carrier frequency for communication shall be tested. A tag shall transmit a 01-sequence (after Manchester coding) with a rate of 384 kHz.

5.2.3.3.3 Measurement values and limits

For R/W- and R/O-tags:

Measurement value: sub-carrier frequency for Notification

Tolerance: sub-carrier frequency accuracy for Notification

In addition for R/W-tags:

Measurement value: sub-carrier frequency for Communication

Tolerance: sub-carrier frequency accuracy for Communication

5.2.3.3.4 Test report

The test report shall give the measured sub-carrier frequencies. The pass/fail condition is determined by the values defined in ISO/IEC 18000-4 Parameter Table for the Return Link (Tag to Interrogator) (reference M2-Tag:7e, reference M2-Tag:7f). The type of tag shall be specified in the test report.

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