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Secretariat, ISO/IEC JTC 1, American National Standards Institute, 25 West 43rd Street, New York, NY 10036; Telephone: 1 212 642 4932; Facsimile: 1 212 840 2298; Email: lrajchel@ansi.org

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Telephone: (609) 620-0200; Facsimile: (609) 620-1200; E-Mail: SC31@gs1us.org ;
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Foreword

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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 24769, 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*.

Introduction

ISO/IEC 24730 defines the air interfaces and an application programming interface for Real Time Locating Systems (RTLS) devices used in asset management applications. Part 2 of ISO/IEC 24730 defines the air interface for these devices operating at frequencies from 2.4-2.483 GHz.

The purpose of Technical Report 24769 is to provide test methods for conformance with the various parts of ISO/IEC 24730-2.

TR 24769 contains all measurements required to be made on a product in order to establish whether it conforms ISO/IEC 24730-2.

Information technology, automatic identification and data capture techniques — RTLS device conformance test methods — Test methods for air interface communication at 2.4 GHz

1 Scope

This document defines the test methods for determining the conformance of 2.4 GHz real time location system (RTLS) tags with the specifications given in the corresponding parts of ISO/IEC24730-2, 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 to the general case.

The RTLS tag conformance parameters included in this document include the mandatory direct sequence spread spectrum (DSSS) 2.4 GHz radio frequency beacon. It also includes the optional on-off keyed, frequency shift keyed (OOK/FSK) short range radio frequency link and the optional magnetic air interface

Unless otherwise specified, the tests in the document shall be applied exclusively to RTLS tags defined in ISO/IEC 24730-2.

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 24730-1 *Information technology automatic identification and data capture techniques – Real Time Locating Systems (RTLS) – Part 1: Application Program Interface (API)*
- ISO/IEC 24730-2 *Information technology – Real time location systems (RTSL) – Part 2: 2,4 GHz air interface protocol*
- 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 19762-1 *Information technology -- Automatic identification and data capture (AIDC) techniques -- Harmonized vocabulary -- Part 1: General terms relating to AIDC*
- ISO/IEC 19762-3 *Information technology -- Automatic identification and data capture (AIDC) techniques -- Harmonized vocabulary -- Part 3: Radio frequency identification (RFID)*
- ISO/IEC 15963 *Information technology -- Radio frequency identification for item management -- Unique identification for RF tags*

3 Terms, definitions, symbols and abbreviated terms

The following terms, definitions, symbols, and abbreviated terms are used in this document.

3.1 General

For the purposes of this document, the terms and definitions given in ISO/IEC 19762-1, ISO/IEC 19762-3 and the following apply.

3.2 Terms and definitions

Error vector magnitude	Error vector represents the difference between the measured signal and a reference (a perfectly modulated signal) . EVM is the magnitude of the error vector.

All other terms and definitions used in this document are specified in ISO/IEC 19762-3.

3.3 Symbols

For the purposes of this document the following symbols apply.

3.4 Abbreviated terms

ARB Arbitrary waveform generator

BPSK Binary phase shift keying

DSSS Direct sequence spread spectrum

DUT Device under test

EIRP Effective isotropic radiated power

EVM Error vector magnitude

FSK Frequency shift keying

OOK On-off keying

PPM Parts per million

RBW Resolution bandwidth

RTLS Real time location system

TIB Timed interval blink

VBW Video bandwidth

4 Conformance tests for ISO/IEC 24730-2

The following subsections describe the conformance tests.

4.1 General

This Technical Report specifies a series of tests to determine the conformance of RTLS tags to the ISO/IEC 24730-2 air interfaces. The results of this test shall be compared with the values of the parameters specified in ISO/IEC 24730-2 to determine whether the tag under test conforms.

This Technical Report also specifies a series of tests to determine the conformance of RTLS RF receivers to the ISO/IEC 24730-2 air interfaces. The results of these tests shall be compared with the values of the parameters specified in ISO/IEC 24730 to determine whether the RF receiver under test conforms.

This Technical Report additionally specifies tests to determine the conformance of the magnetic exciter device that is specified as an optional air interface for the 24730-2 standard.

4.2 Default conditions applicable to the test methods

These conditions apply to all tests.

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 of relative humidity 25 % to 75 %.

4.2.2 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 and the test method procedures.

4.2.3 Noise floor at test location

Noise floor at test location shall be measured with the spectrum analyzer in the same conditions as the measurement of the DUT, with a span of 10 MHz: RBW, VBW and antenna.

The spectrum analyzer shall be configured in acquisition mode for at least 1 minute.

The maximum of the measured amplitude shall be at least 60 dB below the expected value of the amplitude of the measured tag DSSS transmission at 0 dBm power with the tag placed at 1 meter from the measurement antenna.

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

4.2.4 Total measurement uncertainty

The test equipment will introduce a level of measurement uncertainty. For example, the frequency accuracy of the local oscillator used in RF down-converter will add uncertainty to the calculated frequency accuracy of the measured RF. The specifications of the test equipment used shall be included in the report.

4.3 Tag DSSS RF Transmission Tests

This portion of the document describes the tests of the DSSS transmissions.

4.3.1 General

The DUT shall be an RTLS tag. The measurement equipment shall consist of an anechoic chamber as described in annex A, and a measuring antenna and a vector signal analyzer for example an Agilent E4443A or equivalent, with 80 MHz bandwidth, as described in annex C. Figure 1 shows the required test equipment setup.

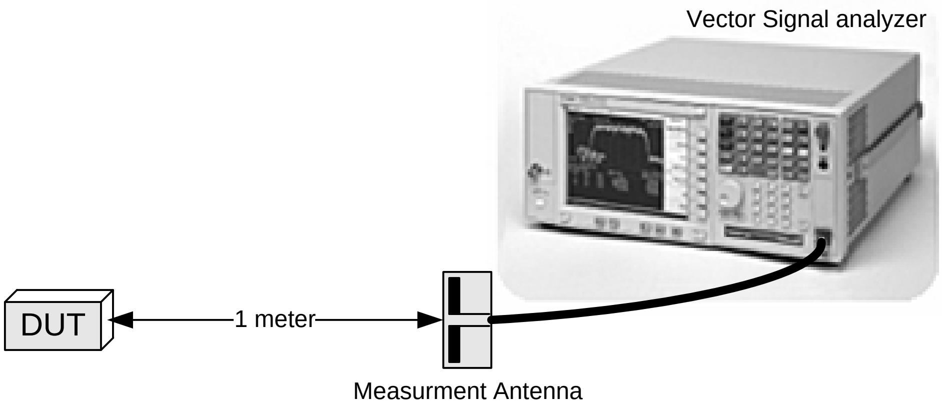

Figure 1 — Setup of equipment for DSSS RF Test

4.3.2 Test Objective

The objective of this test is to verify that the RTLS tag provides the appropriate DSSS modulation waveform required for proper system performance.

4.3.3 Test procedure

The tag shall be configured to transmit a 152-bit DSSS blink (as defined in clause 6.4.2.4 of ISO-24730-2) at an interval of 10 seconds or less. Each blink shall be configured with at least 2 sub-blinks. The tag shall be configured to transmit at a class 1 power between 0 dBm and +10 dBm EIRP. The measurement equipment shall be configured to start capturing for not less than 2,5 milliseconds after the RF energy detected is above the threshold. The post processing software shall calculate the raw samples and produce metrics for the following parameters to verify compliance of the tag.

4.3.4 Test measurements and requirements

This section describes the test measurements and requirements.

4.3.4.1 Carrier frequency

The carrier frequency shall be 2441,750 MHz ± 61 kHz (25 PPM). The carrier frequency drift over the duration of the entire message shall be less than 5 kHz (2 PPM).

4.3.4.2 Transmit power

The transmitted power shall be calculated based on the power received at the measurement antenna. The calculated power shall be within ± 2.0 dB of the DUT specified transmit power.

4.3.4.3 Chip rate

The chip rate of the BPSK shall be 30,521875 MHz ± 763 Hz (25 PPM). No phase transitions shall occur at less than the chip rate, and all phase transitions shall occur at an integral multiple of the chip rate. An example methodology for measuring these transitions is provided in Appendix F.

4.3.4.4 Message content and structure

The post processing software shall verify the 152-bit message format including preamble, status bits, tag ID, data, and message CRC are in compliance with the format specified in ISO/IEC 24730-2, sector 6.4.2.1. The post processing software shall verify differential data encoding within the message.

4.3.4.5 PN code length and polynomial

The polynomial used for driving the BPSK DSSS modulation is defined in figure 3 of section 6.2 of ISO/IEC 24730-2. The entire captured message shall be 511 * 152 = 77672 chips in length. The post processing software shall verify compliance with the defined PN sequence polynomial and second order non-linearity equation specified in ISO/IEC 24730-2.

4.3.4.6 Error vector magnitude

A BPSK signal shall produce a phase/amplitude constellation of two points. The post processing software shall determine the error vector magnitude of the distribution of the captured signal. The EVM must be less than 10%.

4.3.4.7 Sub-blink interval and dither

Connect the measurement antenna to the vector signal analyzer. Set up the analyzer to trigger on the energy of the first sub-blink of a blink, and measure the time between the falling edge of the first sub-blink to the rising edge of the second sub-blink. This interval shall be nominally 125 milliseconds ± 16 milliseconds. Verify that over several successive blinks, the interval changes but does not go below 108 milliseconds or exceed 142 milliseconds.

4.3.5 Test report

The test report shall contain the tag distance to the measurement antenna and all of the measured data. A brief narrative of the post processing software used to evaluate the captured signal shall also be included as an annex to the data. As mentioned before (in 4.2.4), the report shall also contain the uncertainties of the measurement equipment.

4.4 Receiver DSSS RF Tests

This section describes the conformance tests for the base station DSSS receiver (reader).

4.4.1 General

The DUT shall be an RTLS RF receiver. Example measurement equipment could consist of an Agilent E4438C Vector Signal Generator (VSG) with options 5 (6G hard drive) & 602 (Internal Baseband Generator 64Msa memory) Figure 2 shows the required test equipment set-up. An ISO/IEC 24730 format set-up and configuration file for the Agilent E4438C is also included in this document package in Appendix E.

N/A

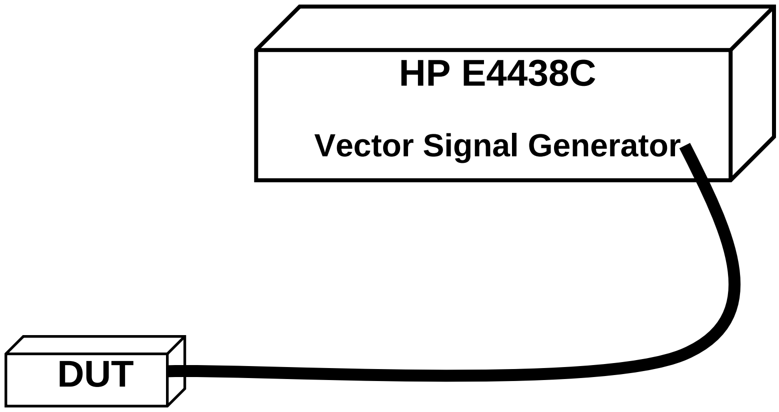

Figure 2 — Setup of equipment for DSSS RF Test

4.4.2 Test Objective

The objective of this test is to verify that the RTLS RF receiver (DUT) provides the appropriate DSSS signal detection required for proper system performance.

4.4.3 Test procedure

The VSG shall be configured to transmit all four blink lengths (56-bit, 72-bit, 88-bit and 152-bit). Each blink type shall be configured with 8 sub-blinks. This should correspond to an average airtime usage of approximately 5% for each of the four types. The post processing software shall calculate the raw samples and produce detection quality (% of total messages sent) metrics for the test parameters described below to verify compliance of the RF receiver.

4.4.3.1 152-bit blinks

A 152-bit DSSS blink (as defined in clause 6.4.2.4 of ISO-24730-2) is to be set at an interval of 0.42 seconds. This corresponds to an approximate air time usage of 5% for 8 sub-blink configuration.

4.4.3.2 88-bit blinks

A 88-bit DSSS blink (as defined in clause 6.4.2.3 of ISO-24730-2) is to be set at an interval of 0.24 seconds. This corresponds to an approximate air time usage of 5% for 8 sub-blink configuration.

4.4.3.3 72-bit blinks

A 72-bit DSSS blink (as defined in clause 6.4.2.2 of ISO-24730-2) is to be set at an interval of 0.20 seconds. This corresponds to an approximate air time usage of 5% for 8 sub-blink configuration.

4.4.3.4 56-bit blinks

A 56-bit DSSS blink (as defined in clause 6.4.2.1 of ISO-24730-2) is to be set at an interval of 0.15 seconds. This corresponds to an approximate air time usage of 5% for 8 sub-blink configuration.

4.4.4 Test measurements and requirements

Stated below are the test measurements and requirements.

4.4.4.1 Carrier frequency tests

The centre carrier frequency test shall be 2441.750 MHz. The edge carrier test frequencies shall be 2441.81104375 MHz (+25 ppm) and 2441.68895625 MHz (-25 ppm). The carrier frequency accuracy for all three tests should be +/- 1ppm. The carrier frequency drift over the duration of the entire message shall be less than 4.88 KHz (2 ppm) for all tests.

4.4.4.2 Receiver input RF power levels

The VSG shall be configured to provide two input signal levels to the DUT: -100 dbm (threshold sensitivity) & -40 dbm (dynamic range).

4.4.4.3 Chip rate

The chip rate of the BPSK shall be 30,521875 MHz ± 30.5 Hz (1 PPM). No phase transitions shall occur at less than the chip rate, and all phase transitions shall occur at an integral multiple of the chip rate. An example methodology for measuring these transitions is provided in Appendix F.

4.4.4.4 Message content and structure

The post processing software shall verify the 152-bit message format including preamble, status bits, tag ID, data, and message CRC are in compliance with the format specified in ISO/IEC 24730-2, sector 6.4.2.1. The post processing software shall verify differential data encoding within the message for reception error detection.

4.4.4.5 PN code length and polynomial

The polynomial used for driving the BPSK DSSS modulation is defined in figure 3 of section 6.2 of ISO/IEC 24730-2. The entire captured message shall be 511 * 152 = 77672 chips in length. The post processing software shall verify compliance with the defined PN sequence polynomial and second order non-linearity equation specified in ISO/IEC 24730-2. As mentioned before (in 4.2.4), the report shall also contain the uncertainties of the measurement equipment.

4.4.4.6 Detection error magnitude

For each set of the 4 message lengths, 3 test frequencies & 2 RF input levels (24 total tests), the reception error shall be better than 98% of all sub-links sent. Each test shall consist of a minimum of 1000 blinks X 8 sub-blinks

4.4.4.7 Sub-blink interval and dither

The sub-blink interval shall be nominally 125 milliseconds ± 16 milliseconds. Verify that over several successive blinks, the interval changes but does not go below 108 milliseconds or exceed 142 milliseconds.

4.4.5 Test report

The test report shall contain a summation detection percentage value for each of the 24 tests and all of the measured data. A brief narrative of the post processing software used to evaluate the detection percentage shall also be included as an annex to the data.

4.5 Tests for Optional Air Interfaces

Below are the tests for the air interfaces which are optional.

4.5.1 Tag optional OOK/FSK RF tests

This subsections describes the tests for the OOK/FSK optional air interface.

4.5.1.1 Setup of equipment for optional tag OOK/FSK RF tests

The DUT shall be an RTLS tag. The test shall require an RTLS programmer, or an arbitrary waveform generator and magnetic transmit coil, to induce the OOK/FSK transmissions. The measurement equipment shall consist of an anechoic chamber and measuring antenna as described in annex A, and a measurement antenna and a vector signal analyzer such as an Agilent E4443A, or equivalent, as described in annex C. Figure 3 shows the required test equipment setup.

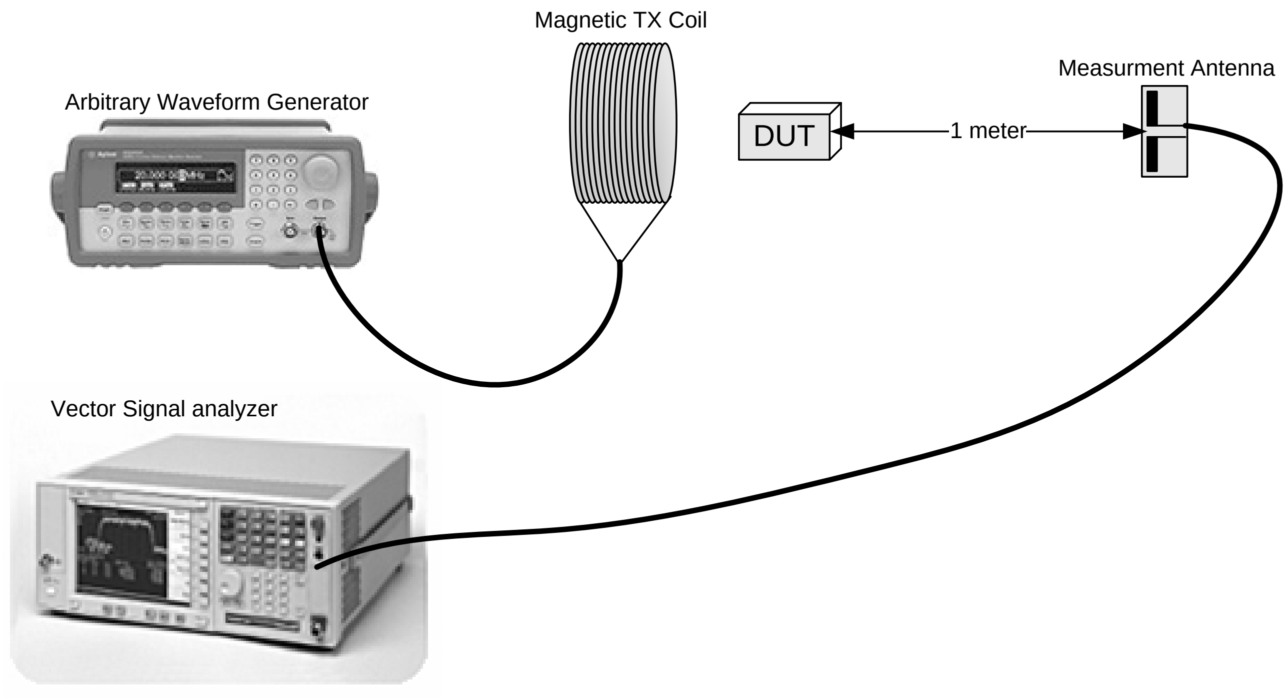

Figure 3 — Setup of equipment for optional OOK/FSK RF test

4.5.1.2 Test objective

The objective of this test is to verify that the RTLS tag provides the appropriate OOK/FSK modulation waveform required for proper performance with RTLS programmer devices.

4.5.1.3 Test procedure

The tag shall be configured to turn on its receiver at least every 200 milliseconds in order to ensure that it receives the RTLS programmer's magnetic message. The RTLS programmer, or arbitrary wave form generator with magnetic transmit coil shall send the magnetic Who-Are-You message to the tag as defined in section 7.2.8.1 of ISO/IEC 24730-2. The measurement equipment shall be configured to start capturing for not less than 4,5 milliseconds after the detected RF energy of the tag ACK is above the threshold. The post processing software shall process the raw samples and produce metrics for the following parameters to verify compliance of the tag.

4.5.1.4 Test measurements

This sections describes the measurements that are to be made in the performing the tests.

4.5.1.4.1 Carrier frequency

The carrier frequency shall be 2446,519 MHz ± 61 kHz (25 PPM). The carrier frequency drift over the duration of the entire message shall be less than 5 kHz (2 PPM).

4.5.1.4.2 Transmit power

The transmitted power shall be calculated based on the power received at the measurement antenna. The calculated power shall be 0 dBm ± 2.0 dB.

4.5.1.4.3 Modulation depth and duty cycle

The modulation depth (on-to-off ratio) of the OOK signal shall be greater than 99.36%, which corresponds to 50 dB.

4.5.1.4.4 FSK frequencies

The logic 0 FSK frequency shall be 376,8 kHz ± 0.1 kHz

The logic 1 FSK frequency shall be 535,5 kHz ± 0.1 kHz.

4.5.1.4.5 OOK/FSK transmission content and format

The post processing software shall verify the content of the 88-bit OOK/FSK message from the tag including preamble, status, tag ID, ACK, and CRC are in compliance with ISO/IEC 24730-2, section 7.1.3.

4.5.1.4.6 Data rate

The bit data rate of the OOK/FSK signal shall be 19,83 kb/s.

4.5.1.5 Test report

The test report shall contain the tag distance to the measurement antenna and all of the measured data. A brief narrative of the post processing software used shall also be included as an annex to the test report data. An description of the functionality of this test software is included in Appendix G of this technical report.

4.5.2 Tag optional magnetic receiver test

This subsections describes the tests for the optional magnetic receiver.

4.5.2.1 Setup of equipment for optional magnetic receiver test

The DUT shall be an RTLS tag. The test shall require an arbitrary waveform generator and a magnetic transmit coil as defined in annex D. The tag's magnetic pickup coil shall be oriented for maximum coupling to the transmit coil of the test equipment. The test equipment shall also include a vector signal analyzer. Figure 4 shows the required test equipment setup.

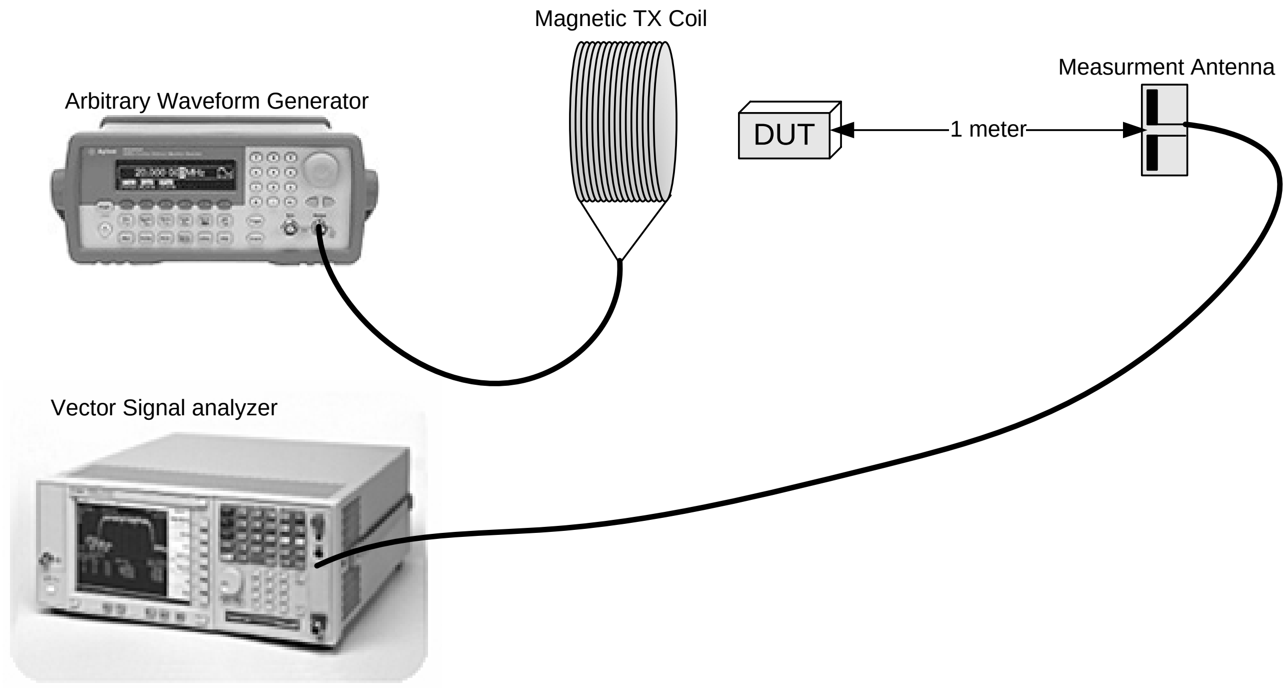

Figure 4 — Setup of equipment for optional magnetic receiver test

The RTLS tag DUT shall be configured with TIB blinks turned off. It shall also be configured to send one EXB which time the tag receives a valid exciter message. The exciter retrigger shall be set to 1 second or less, and the retrigger mode shall be timed based upon the blink transmission, and not upon leaving the exciter field. The DUT tag shall be configured to turn on its receiver every 200 milliseconds.

4.5.2.2 Test objective

The objective of this test is to verify that the tag properly demodulates magnetic messages and has enough sensitivity to ensure proper operation with RTLS programmer and exciter devices with acceptable packet error rates.

4.5.2.3 Test procedure

The ARB output voltage through the coil shall be set such the magnetic field strength at the DUT pickup coil increased from 42 dBuA/m up to 150 dBuA/m for sensitivity and dynamic range testing. The ARB output voltage through the coil shall be set such the field strength at the DUT pickup coil is 42 dBuA/m for packet error rate testing.

For each test, the ARB shall transmit valid 28-bit exciter messages as defined section 7.3.1.1 of ISO/IEC 24730-2 back to back without gap for a period of 250 milliseconds. The ARB shall then turn off the output, or at least stop FSK modulation for a period of 2.75 seconds. This process shall repeat throughout the duration of each test. The vector signal analyzer shall be used to verify that the tag has indeed decoded the message and sent the exciter blink.

4.5.2.4 Test measurements

This subsections describes the measurements that are to be made when performing tests on the magnetic receiver.

4.5.2.4.1 Exciter blink (EXB) format and content

The post processing software shall verify that the DSSS exciter blink content and format including preamble, status, tag ID, exciter ID, and CRC are compliant with ISO/IEC 24730-2, section 6.4.2.2.

4.5.2.4.2 Minimum sensitivity and dynamic range

The tag must respond to the exciter message at all field strengths between a minimum of 42 dBuA/m and a maximum of 150 dBuA/m at the DUT pick up coil.

4.5.2.4.3 Packet error rate

The tag should respond to no less than 99 % of the total messages sent over a 15 minute period (900 seconds / 3 second cycle = 300 blinks).

4.5.2.5 Test Report

The test report shall include all measured data as well a brief narrative describing the magnetic transmit coil and the method used to determine the magnetic field strength at the DUT pickup coil.

4.5.3 Optional Exciter Magnetic Transmitter Test

4.5.3.1 Setup of equipment for exciter magnetic transmitter test

The DUT shall be an RTLS exciter. The test shall require a calibrated magnetic loop antenna for the 125 kHz frequency range with preamplifier, and a digital oscilloscope as shown in Figure 5. The exciter shall be oriented with the plane of its coil parallel to the plane of the loop antenna coil. The two coils shall be aligned such the vector from the centre of the exciter coil to the centre of the loop antenna coil is perpendicular to the plane of both coils.

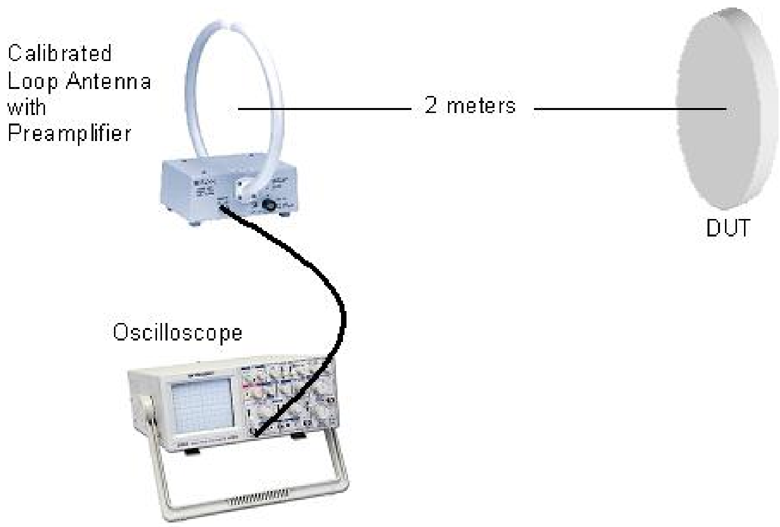

Figure 5 Setup of equipment for exciter magnetic transmitter test

4.5.3.2 Test objective

The objective of this test is to verify that the RTLS exciter properly generates a magnetic FSK signal that will be correctly demodulated by RTLS tag devices.

4.5.3.3 Test procedure

The exciter test shall be conducted for exciter messages lengths of first 28-bit and then 44-bit as described in IS0 24730-2, section 7.3. The 28-bit exciter message shall be 0xD12348F. The 44-bit exciter message shall be 0xD1234386655

The oscilloscope shall be connected to the output of the calibrated loop antenna preamplifier. Use the digital oscilloscope to measure the frequency of the two FSK Tones, the voltage amplitude out of the loop antenna preamplifier, and to decoded the message.

4.5.3.4 Test measurements

This subsection details the measurements to be logged.

4.5.3.4.1 Exciter message continuity

Verify that there are no gaps in the exciter signal and that the messages of repeated back-to-back without gap.

4.5.3.4.2 Exciter FSK frequencies

Verify that the exciter signal consists of two alternating frequencies. The first frequency (logic 1) shall be 114.688 kHz ± 0.2%. The second frequency (logic 0) shall be 126.976 ± 0.2% .

4.5.3.4.3 Exciter Manchester code sync period and data period

With the digital oscilloscope, search for a place there the exciter sends the stop sync of one message immediately followed by the start sync of the next message.

At this point, the exciter shall send a logic 1 (114.688 kHz) for 1.465 milliseconds (± 0.2%).

Immediately after this point, the exciter shall send a logic 0 (126.976 kHz) for 732.4 microseconds (± 0.2%).

Immediately before this point, the exciter shall send a logic 0 (126.976 kHz) for 976.6 microseconds (± 0.2%).

All other parts of the message will have the two FSK tones toggle at either 244.1 microseconds (± 0.2%) or 488.3 microseconds (± 0.2%).

4.5.3.4.4 Exciter Manchester message content

The 28-bit message 0xD12348F shall be constructed as follows with each 1 and each 0 representing one Manchester period of 244.14 microseconds. 1 represents the 114.688 kHz tone and 0 represents the 126.976 kHz tone. The following string shows the end sync of the previous message as well as the start sync of the next message. Spaced have been added between sync periods and data nibbles only for readability.

…000111 111000 10100110 01010110 01011001 01011010 01100101 10010101 10101010 000111 111000…

The 44-bit message 0xD1234386655 shall be constructed as follows with each 1 and each 0 representing on Manchester period of 244.14 microseconds. 1 represents the 114.688 kHz tone and 0 represents the 126.976 kHz tone. The following string shows the end sync of the previous message as well as the start sync of the next message. Spaced have been added between sync periods and data nibbles only for readability.

…000111 10100110 01010110 01011001 01011010 01100101 01011010 10010101 01101001 01101001 01100110 01100110 000111 111000…

4.5.3.4.5 Exciter transmit power

With the exciter set to maximum power and the distance between the exciter and the loop antenna at 2 meters, verify that the RMS voltage measured on the oscilloscope corresponds at a minimum of 80 dBuA/m $\pm$ 5%. This calculation will need to account for preamplifier gain and the loop antenna conversion factor at 121 kHz nominal.

4.5.3.4.6 Test Report

The test report shall log the measured FSK frequencies, and well as the time duration of the sync and data periods.

4.5.4 Tag system response timing

This set of tests will test the timing of the optional air interfaces.

4.5.4.1 Setup of equipment for system response timing test

The DUT is an RTLS tag. The equipment needed for this test include a ARB with magnetic transmit coil, and an RF antenna with an RF crystal detector, and an oscilloscope as shown in Figure 6. The tag's magnetic pickup coil shall be oriented for maximum coupling to the transmit coil of the test equipment.

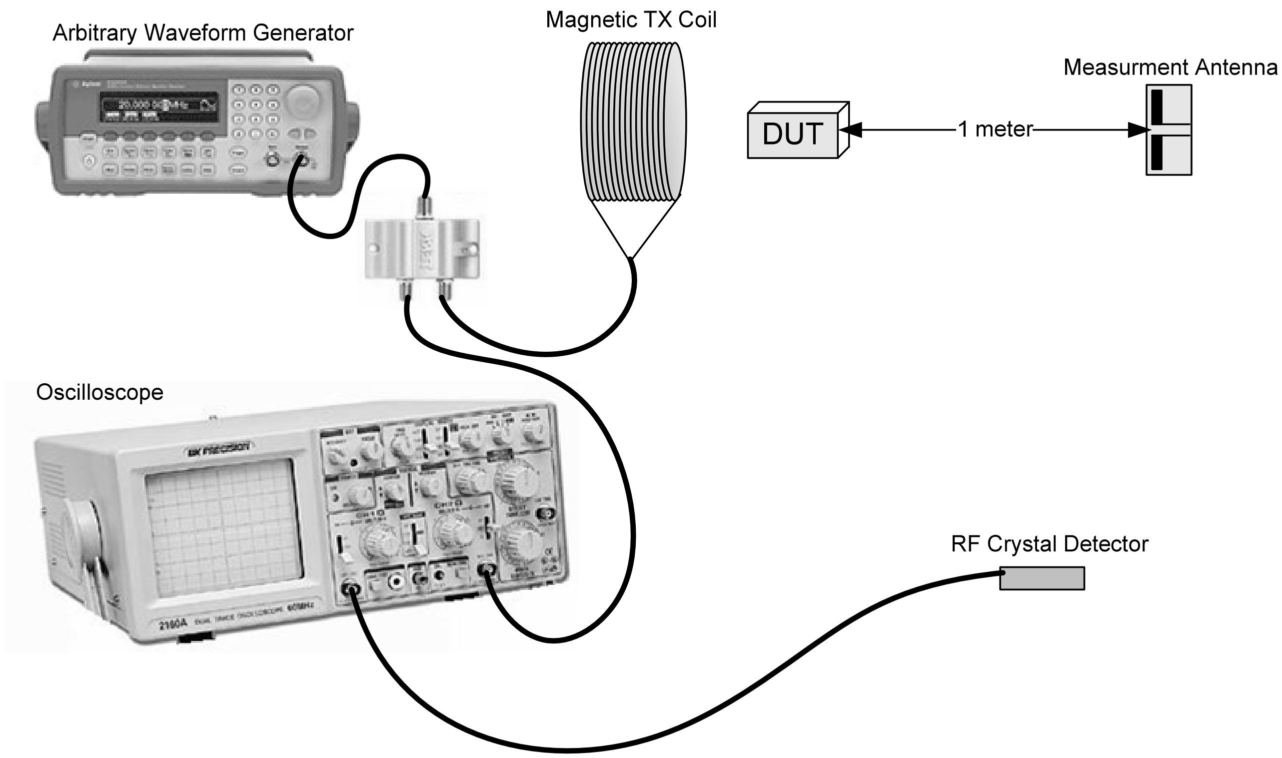

Figure 6 — Setup of equipment for tag system response timing test

The RTLS tag DUT shall be configured with TIB blinks turned off. It shall also be configured to send one EXB which time the tag receives a valid exciter message. The DUT tag shall be configured to turn on its receiver every 200 milliseconds.

4.5.4.2 Test objective

The objective of this test is to verify that the RTLS tag responds to magnetic messages within the required amount of time to work properly with RTLS exciter devices, RTLS programmer devices.

4.5.4.3 Test procedure

Channel 1 of the oscilloscope should be connected to the FSK drive to the ARB.

Channel 2 of the oscilloscope should be connected to the RF detector.

Trigger on channel 1 and measure the time between the end of the FSK modulation on channel 1 and the detected RF on channel 2. This time should be less than 1,25 seconds.

4.5.4.4 Test measurements

4.5.4.4.1 Exciter response time

Configure the ARB to send a single valid 28-bit exciter message, preceded by a wake signal consisting of 200 milliseconds of an alternating “1” and “0” signal at the symbol rate defined in Section 6.5.1.2 of ISO/IEC 24730-2.

Trigger on channel 1 and measure the time between the end of the FSK modulation on channel 1 and the detected DSSS RF on channel 2. This time should be less than 1,25 seconds.

4.5.4.4.2 Programmer response time

Configure the ARB to send a single valid 48-bit programmer read tag message, preceded by a wake signal consisting of 200 milliseconds of an alternating “1” and “0” signal at the symbol rate defined in Section 7.2.7 of ISO/IEC 24730-2.

Trigger on channel 1 and measure the time between the end of the FSK modulation on channel 1 and the detected OOK/FSK RF on channel 2. This time shall be less than 100 milliseconds.

4.5.4.5 Test report

Report the response time for exciter –to- DSSS blink and for programmer –to- OOK ACK.

Annex A
(informative)

RF Test measurement site

A.1 Test site

This annex describes the test site for measuring and characterizing the tag DSSS and OOK/FSK RF transmissions. The tests should be run in an anechoic chamber, but open air testing is acceptable if background noise is low enough to allow measurements such as DSSS EVM or OOK/FSK modulation depth. If open air testing is used, the test chamber discussion of DUT orientation and distance from antenna still apply.

The test chamber shall be large enough to allow (1) a minimum of 1.0 meter between the DUT and the anechoic chamber wall and (2) a minimum of 1.0 meter between the measurement antenna and the anechoic chamber wall and (3) a minimum of 1.0 meter between the DUT and the measurement antenna.

The DUT must be able to be mounted and rotated such that any tag surface (assuming the tag shape to be approximated by a rectangular prism) can be directly facing the measurement antenna as shown in Figure A.1. With any one surface facing the measurement antenna, the tag must be able to be mounted or rotated 360 degrees clockwise or counter-clockwise around the axis between the DUT and the measurement antenna.

Figure A.1 — RF Test Chamber

Annex B
(normative)

Message formats for tests

The magnetic data is sent in FSK format. A high level, or 1, on the FSK data line corresponds to an output frequency of 114.688 kHz. A low level, or 0 on the FSK data line corresponds to an output frequency of 126.976 kHz. Since the data is Manchester encoded, each bit is split into two halves. Each half bit period is 244,14 microseconds.

The wake signal that precedes programmer messages can be created by inverting FSK line every half bit period for a total of 200 ms. Thus, the output shall toggle between the two FSK tones at the half bit rate. If the wake signal is used in sending the message, it is important that the end of the wake signal has no gap before the start sync such that the half bit time does not shift.

The wake signal to pre-amble transition may be as shown in Figure B.1:

```
01010101 … (total 200 ms) … 01010111100010 … (rest of message) … 000111

|-------------wake-----------|sync|-----message-------|sync|
```

Figure B.1

The 10-bit Who-Are-You magnetic message, used in section 4.4.3 of this document, is defined in ISO/IEC 24730-2 section 7.2.8.1. It does utilize the wake signal as shown in Table B.1.

Table B.1

Wake signal	Sync	Message	Sync
200 milliseconds	START	10-bits: 1100100000	STOP

The 28-bit exciter message, used in section 4.5.3 of this document, is defined is ISO/IEC 24730-2 section 7.3.1.1. One possible message is 0xD12348F as shown in Table B.2. This includes (op-code = 0xD), (Exciter ID = 0x1234), (CRC = 0x8F). The message of course still requires the start and stop sync before and after the message. This message is sent continuously, back to back with gap, such the stop sync of one message is followed immediately by the start sync of the next message.

Table B.2

Previous Sync	Sync	Message	Sync	*Next Sync*
STOP < -------	START	28-bits: 0xD12348F	STOP	*START* -------- >

The 144-bit exciter message , used in section 4.5.4.3 of this document, is not completely defined in ISO/IEC 24730-2, but is listed in table 3. The actual message between start and stop sync shall be 0x9000000000123456789ABCDEEF01234567661 as shown in Table B.3. This message is sent continuously, back to back with gap, such the stop sync of one message is followed immediately by the start sync of the next message.

Table B.3

Previous Sync	Sync	Message	Sync	*Next Sync*
STOP < -------	START	144-bits: 0x9000000000123456789ABCDEF01234567661	STOP	*START* -------- >

The 28-bit exciter message, used in section 4.6.4.1 of this document, is defined is ISO/IEC 24730-2 section 7.3.1.1, but is going to be sent only once and preceded by the 200 millisecond wake signal used in programmer messages defined in section 7.2 of ISO/IEC 24730-2. One possible message is 0xD12348F as shown Table B.4. This includes (op-code = 0xD), (Exciter ID = 0x1234), (CRC = 0x8F). The message of course still requires the start and stop sync before and after the message. This message timing shall actually be more related to programmer device timing and shall use the 200 millisecond wake up signal followed by the exciter message only once, then the FSK modulation stops. This is to allow timing from a know time at which the tag received the magnetic message.

Table B.4

Wake signal	Sync	Message	Sync
200 milliseconds	START	28-bits: 0xD12348F	STOP

The 48-bit read tag configuration magnetic message, used in section 4.6.4.2 of this document, is defined in ISO/IEC 24730-2 section 7.2.6 as shown in Table B.5. It does utilize the wake signal.

Table B.5

Wake signal	Sync	Message	Sync
200 milliseconds	START	48-bits: 0xD [32-bit tag ID] [12-bit CRC]	STOP

Annex C
(normative)

Technical requirements of measurement antenna and vector signal analyzer

This annex defines the minimum requirements of the measurement antenna and baseband converting digitizing oscilloscope or its equivalent.

The measurement antenna is used in testing the DUT in which RF transmission is being characterized. The antenna shall be a 2.4 GHz dipole antenna. Unless other wise noted in the test procedure, the measurement antenna shall be placed 1.0 meter from the DUT.

The vector signal analyzer (or its equivalent) must have an analysis bandwidth of at least 80 MHz. The Agilent E4443A vector signal analyzer with 80 MHz bandwidth option is sufficient for this test. Any unit that matches performance characteristics of the E4443A is also acceptable.

Annex D
(normative)

Technical requirements of the arbitrary waveform generator and magnetic coil

The arbitrary waveform generator, or ARB, and the magnetic transmit coil are used to induce tag action and to produce the signals required for testing the DUT magnetic receiver functionality.

The ARB shall have the ability to produce a sinusoidal FSK signal with the two frequencies of 114.688 kHz and 126.976 kHz. The FSK drive can be external or from internal memory, but must be at the proper half symbol time of 244,14 microseconds and integral multiples thereof. It shall be able to reproduce the entire magnetic message including 200 millisecond wake time, start sync, message, and stop sync.

The output of the ARB shall connect via 50 ohm cable to the magnetic transmit coil. The transmit coil shall be located and positioned for favourable coupling to the DUT receive antenna. The coil should have 64 turns and a circular area of 1.0 cm^2.

For interference testing, a second ARB is coupled in using a coupler or a splitter on the 50 ohm lines and then the combined signal is cabled to the magnetic transmit coil.

Annex E
(informative)

Configuration file for the Agilent E4438C

This annex includes a text version of the configuration file required to setup the Agilent E4438C to create RF transmissions that are in conformance with the ISO/IEC 24730-2 DSSS standard.

ASCII Representation of Agilent Binary File

Line 1	58 01 00 00 00 00 00 00 8F 08 00 00 00 00 00 00
Line 2	00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
Line 3	00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
Line 4	00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
Line 5	00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
Line 6	00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
Line 7	00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
Line 8	00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
Line 9	00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
Line 10	00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
Line 11	00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
Line 12	00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
Line 13	00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
Line 14	00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
Line 15	00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
Line 16	00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
Line 17	00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
Line 18	00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
Line 19	00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00

Line 20	00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
Line 21	00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
Line 22	00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
Line 23	00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
Line 24	00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
Line 25	00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
Line 26	00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
Line 27	00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
Line 28	00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
Line 29	00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
Line 30	00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
Line 31	00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
Line 32	00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
Line 33	00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
Line 34	00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
Line 35	00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
Line 36	00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
Line 37	00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
Line 38	00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
Line 39	00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
Line 40	00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
Line 41	00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
Line 42	00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
Line 43	00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
Line 44	00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
Line 45	00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
Line 46	00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
Line 47	00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00

Line 48	00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
Line 49	00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
Line 50	00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
Line 51	00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
Line 52	00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
Line 53	00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
Line 54	00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
Line 55	00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
Line 56	00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
Line 57	00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
Line 58	00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
Line 59	00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
Line 60	00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
Line 61	00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
Line 62	00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
Line 63	00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
Line 64	00 00 80 24 84 7E C3 4A AB 29 39 74 01 9A 16 1A
Line 65	70 BA 08 18 73 57 BA 50 41 E3 F6 D3 CE FD F2 DD
Line 66	4B 32 78 B0 A6 47 53 A9 B3 79 D3 E2 2F 1D 12 9A
Line 67	F9 83 BD 36 44 15 C8 BD 1B 42 EC 32 39 AA F8 D9
Line 68	F5 F7 00 49 08 FD 86 95 56 52 72 E8 03 34 2C 34
Line 69	E1 74 10 30 E6 AF 74 A0 83 C7 ED A7 9D FB E5 BA
Line 70	96 64 F1 61 4C 8E A7 53 66 F3 A7 C4 5E 3A 25 35
Line 71	F3 07 7A 6C 88 2B 91 7A 36 85 D8 64 73 55 F1 B3
Line 72	EB EE 00 92 11 FB 0D 2A AC A4 E5 D0 06 68 58 69
Line 73	C2 E8 20 61 CD 5E E9 41 07 8F DB 4F 3B F7 CB 75
Line 74	2C C9 E2 C2 99 1D 4E A6 CD E7 4F 88 BC 74 4A 6B
Line 75	E6 0E F4 D9 10 57 22 F4 6D 0B B0 C8 E6 AB E3 67

Line 76	D7 DC 01 24 23 F6 1A 55 59 49 CB A0 0C D0 B0 D3
Line 77	85 D0 40 C3 9A BD D2 82 0F 1F B6 9E 77 EF 96 EA
Line 78	59 93 C5 85 32 3A 9D 4D 9B CE 9F 11 78 E8 94 D7
Line 79	CC 1D E9 B2 20 AE 45 E8 DA 17 61 91 CD 57 C6 CF
Line 80	AF B8 02 48 47 EC 34 AA B2 93 97 40 19 A1 61 A7
Line 81	0B A0 81 87 35 7B A5 04 1E 3F 6D 3C EF DF 2D D4
Line 82	B3 27 8B 0A 64 75 3A 9B 37 9D 3E 22 F1 D1 29 AF
Line 83	98 3B D3 64 41 5C 8B D1 B4 2E C3 23 9A AF 8D 9F
Line 84	5F 70 04 90 8F D8 69 55 65 27 2E 80 33 42 C3 4E
Line 85	17 41 03 0E 6A F7 4A 08 3C 7E DA 79 DF BE 5B A9
Line 86	66 4F 16 14 C8 EA 75 36 6F 3A 7C 45 E3 A2 53 5F
Line 87	30 77 A6 C8 82 B9 17 A3 68 5D 86 47 35 5F 1B 3E
Line 88	BE E0 09 21 1F B0 D2 AA CA 4E 5D 00 66 85 86 9C
Line 89	2E 82 06 1C D5 EE 94 10 78 FD B4 F3 BF 7C B7 52
Line 90	CC 9E 2C 29 91 D4 EA 6C DE 74 F8 8B C7 44 A6 BE
Line 91	60 EF 4D 91 05 72 2F 46 D0 BB 0C 8E 6A BE 36 7D
Line 92	7D BF ED BD C0 9E 5A AA 6B 63 45 FF 32 F4 F2 C7
Line 93	A2 FB F3 C6 54 22 D7 DF 0E 04 96 18 81 06 91 5A
Line 94	66 C3 A7 AC DC 56 2B 26 43 16 0E E8 71 76 B2 83
Line 95	3E 21 64 DD F5 1B A1 72 5E 89 E6 E3 2A 83 93 05
Line 96	04 7F DB 7B 81 3C B5 54 D6 C6 8B FE 65 E9 E5 8F
Line 97	45 F7 E7 8C A8 45 AF BE 1C 09 2C 31 02 0D 22 B4
Line 98	CD 87 4F 59 B8 AC 56 4C 86 2C 1D D0 E2 ED 65 06
Line 99	7C 42 C9 BB EA 37 42 E4 BD 13 CD C6 55 07 26 0A
Line 100	08 FF B6 F7 02 79 6A A9 AD 8D 17 FC CB D3 CB 1E
Line 100	8B EF CF 19 50 8B 5F 7C 38 12 58 62 04 1A 45 69
Line 102	9B 0E 9E B3 71 58 AC 99 0C 58 3B A1 C5 DA CA 0C
Line 103	F8 85 93 77 D4 6E 85 C9 7A 27 9B 8C AA 0E 4C 14

Line 104	11 FF 6D EE 04 F2 D5 53 5B 1A 2F F9 97 A7 96 3D
Line 105	17 DF 9E 32 A1 16 BE F8 70 24 B0 C4 08 34 8A D3
Line 106	36 1D 3D 66 E2 B1 59 32 18 B0 77 43 8B B5 94 19
Line 107	F1 0B 26 EF A8 DD 0B 92 F4 4F 37 19 54 1C 98 28
Line 108	23 FE DB DC 09 E5 AA A6 B6 34 5F F3 2F 4F 2C 7A
Line 109	2F BF 3C 65 42 2D 7D F0 E0 49 61 88 10 69 15 A6
Line 110	6C 3A 7A CD C5 62 B2 64 31 60 EE 87 17 6B 28 33
Line 111	E2 16 4D DF 51 BA 17 25 E8 9E 6E 32 A8 39 30 50
Line 112	47 FD B7 B8 13 CB 55 4D 6C 68 BF E6 5E 9E 58 F4
Line 113	5F 7E 78 CA 84 5A FB E1 C0 92 C3 10 20 D2 2B 4C
Line 114	D8 74 F5 9B 8A C5 64 C8 62 C1 DD 0E 2E D6 50 67
Line 115	C4 2C 9B BE A3 74 2E 4B D1 3C DC 65 50 72 60 A0
Line 116	8F FB 6F 70 27 96 AA 9A D8 D1 7F CC BD 3C B1 E8
Line 117	BE FC F1 95 08 B5 F7 C3 81 25 86 20 41 A4 56 99
Line 118	B0 E9 EB 37 15 8A C9 90 C5 83 BA 1C 5D AC A0 CF
Line 119	88 59 37 7D 46 E8 5C 97 A2 79 B8 CA A0 E4 C1 41
Line 120	1F F6 DE E0 4F 2D 55 35 B1 A2 FF 99 7A 79 63 D1
Line 121	7D F9 E3 2A 11 6B EF 87 02 4B 0C 40 83 48 AD 33
Line 122	61 D3 D6 6E 2B 15 93 21 8B 07 74 38 BB 59 41 9F
Line 123	10 B2 6E FA 8D D0 B9 2F 44 F3 71 95 41 C9 82 82
Line 124	3F ED BD C0 9E 5A AA 6B 63 45 FF 32 F4 F2 C7 A2
Line 125	FB F3 C6 54 22 D7 DF 0E 04 96 18 81 06 91 5A 66
Line 126	C3 A7 AC DC 56 2B 26 43 16 0E E8 71 76 B2 83 3E
Line 127	21 64 DD F5 1B A1 72 5E 89 E6 E3 2A 83 93 05 04
Line 128	7F DB 7B 81 3C B5 54 D6 C6 8B FE 65 E9 E5 8F 45
Line 129	F7 E7 8C A8 45 AF BE 1C 09 2C 31 02 0D 22 B4 CD
Line 130	87 4F 59 B8 AC 56 4C 86 2C 1D D0 E2 ED 65 06 7C
Line 131	42 C9 BB EA 37 42 E4 BD 13 CD C6 55 07 26 0A 08

Line 132	FF B6 F7 02 79 6A A9 AD 8D 17 FC CB D3 CB 1E 8B
Line 133	EF CF 19 50 8B 5F 7C 38 12 58 62 04 1A 45 69 9B
Line 134	0E 9E B3 71 58 AC 99 0C 58 3B A1 C5 DA CA 0C F8
Line 135	85 93 77 D4 6E 85 C9 7A 27 9B 8C AA 0E 4C 14 12
Line 136	00 92 11 FB 0D 2A AC A4 E5 D0 06 68 58 69 C2 E8
Line 137	20 61 CD 5E E9 41 07 8F DB 4F 3B F7 CB 75 2C C9
Line 138	E2 C2 99 1D 4E A6 CD E7 4F 88 BC 74 4A 6B E6 0E
Line 139	F4 D9 10 57 22 F4 6D 0B B0 C8 E6 AB E3 67 D7 DC
Line 140	01 24 23 F6 1A 55 59 49 CB A0 0C D0 B0 D3 85 D0
Line 141	40 C3 9A BD D2 82 0F 1F B6 9E 77 EF 96 EA 59 93
Line 142	C5 85 32 3A 9D 4D 9B CE 9F 11 78 E8 94 D7 CC 1D
Line 143	E9 B2 20 AE 45 E8 DA 17 61 91 CD 57 C6 CF AF B8
Line 144	02 48 47 EC 34 AA B2 93 97 40 19 A1 61 A7 0B A0
Line 145	81 87 35 7B A5 04 1E 3F 6D 3C EF DF 2D D4 B3 27
Line 146	8B 0A 64 75 3A 9B 37 9D 3E 22 F1 D1 29 AF 98 3B
Line 147	D3 64 41 5C 8B D1 B4 2E C3 23 9A AF 8D 9F 5F 70
Line 148	04 90 8F D8 69 55 65 27 2E 80 33 42 C3 4E 17 41
Line 149	03 0E 6A F7 4A 08 3C 7E DA 79 DF BE 5B A9 66 4F
Line 150	16 14 C8 EA 75 36 6F 3A 7C 45 E3 A2 53 5F 30 77
Line 151	A6 C8 82 B9 17 A3 68 5D 86 47 35 5F 1B 3E BE E0
Line 152	09 21 1F B0 D2 AA CA 4E 5D 00 66 85 86 9C 2E 82
Line 153	06 1C D5 EE 94 10 78 FD B4 F3 BF 7C B7 52 CC 9E
Line 154	2C 29 91 D4 EA 6C DE 74 F8 8B C7 44 A6 BE 60 EF
Line 155	4D 91 05 72 2F 46 D0 BB 0C 8E 6A BE 36 7D 7D C0
Line 156	12 42 3F 61 A5 55 94 9C BA 00 CD 0B 0D 38 5D 04
Line 157	0C 39 AB DD 28 20 F1 FB 69 E7 7E F9 6E A5 99 3C
Line 158	58 53 23 A9 D4 D9 BC E9 F1 17 8E 89 4D 7C C1 DE
Line 159	9B 22 0A E4 5E 8D A1 76 19 1C D5 7C 6C FA FB 80

Line 160	24 84 7E C3 4A AB 29 39 74 01 9A 16 1A 70 BA 08
Line 161	18 73 57 BA 50 41 E3 F6 D3 CE FD F2 DD 4B 32 78
Line 162	B0 A6 47 53 A9 B3 79 D3 E2 2F 1D 12 9A F9 83 BD
Line 163	36 44 15 C8 BD 1B 42 EC 32 39 AA F8 D9 F5 F7 00
Line 164	49 08 FD 86 95 56 52 72 E8 03 34 2C 34 E1 74 10
Line 165	30 E6 AF 74 A0 83 C7 ED A7 9D FB E5 BA 96 64 F1
Line 166	61 4C 8E A7 53 66 F3 A7 C4 5E 3A 25 35 F3 07 7A
Line 167	6C 88 2B 91 7A 36 85 D8 64 73 55 F1 B3 EB EE 00
Line 168	92 11 FB 0D 2A AC A4 E5 D0 06 68 58 69 C2 E8 20
Line 169	61 CD 5E E9 41 07 8F DB 4F 3B F7 CB 75 2C C9 E2
Line 170	C2 99 1D 4E A6 CD E7 4F 88 BC 74 4A 6B E6 0E F4
Line 171	D9 10 57 22 F4 6D 0B B0 C8 E6 AB E3 67 D7 DC 01
Line 172	24 23 F6 1A 55 59 49 CB A0 0C D0 B0 D3 85 D0 40
Line 173	C3 9A BD D2 82 0F 1F B6 9E 77 EF 96 EA 59 93 C5
Line 174	85 32 3A 9D 4D 9B CE 9F 11 78 E8 94 D7 CC 1D E9
Line 175	B2 20 AE 45 E8 DA 17 61 91 CD 57 C6 CF AF B8 02
Line 176	48 47 EC 34 AA B2 93 97 40 19 A1 61 A7 0B A0 81
Line 177	87 35 7B A5 04 1E 3F 6D 3C EF DF 2D D4 B3 27 8B
Line 178	0A 64 75 3A 9B 37 9D 3E 22 F1 D1 29 AF 98 3B D3
Line 179	64 41 5C 8B D1 B4 2E C3 23 9A AF 8D 9F 5F 70 04
Line 180	90 8F D8 69 55 65 27 2E 80 33 42 C3 4E 17 41 03
Line 181	0E 6A F7 4A 08 3C 7E DA 79 DF BE 5B A9 66 4F 16
Line 182	14 C8 EA 75 36 6F 3A 7C 45 E3 A2 53 5F 30 77 A6
Line 183	C8 82 B9 17 A3 68 5D 86 47 35 5F 1B 3E BE E0 09
Line 184	21 1F B0 D2 AA CA 4E 5D 00 66 85 86 9C 2E 82 06
Line 185	1C D5 EE 94 10 78 FD B4 F3 BF 7C B7 52 CC 9E 2C
Line 186	29 91 D4 EA 6C DE 74 F8 8B C7 44 A6 BE 60 EF 4D
Line 187	91 05 72 2F 46 D0 BB 0C 8E 6A BE 36 7D 7D C0 12

Line 188	42 3F 61 A5 55 94 9C BA 00 CD 0B 0D 38 5D 04 0C
Line 189	39 AB DD 28 20 F1 FB 69 E7 7E F9 6E A5 99 3C 58
Line 190	53 23 A9 D4 D9 BC E9 F1 17 8E 89 4D 7C C1 DE 9B
Line 191	22 0A E4 5E 8D A1 76 19 1C D5 7C 6C FA FB 80 24
Line 192	84 7E C3 4A AB 29 39 74 01 9A 16 1A 70 BA 08 18
Line 193	73 57 BA 50 41 E3 F6 D3 CE FD F2 DD 4B 32 78 B0
Line 194	A6 47 53 A9 B3 79 D3 E2 2F 1D 12 9A F9 83 BD 36
Line 195	44 15 C8 BD 1B 42 EC 32 39 AA F8 D9 F5 F7 00 49
Line 196	08 FD 86 95 56 52 72 E8 03 34 2C 34 E1 74 10 30
Line 197	E6 AF 74 A0 83 C7 ED A7 9D FB E5 BA 96 64 F1 61
Line 198	4C 8E A7 53 66 F3 A7 C4 5E 3A 25 35 F3 07 7A 6C
Line 199	88 2B 91 7A 36 85 D8 64 73 55 F1 B3 EB EE 00 92
Line 200	11 FB 0D 2A AC A4 E5 D0 06 68 58 69 C2 E8 20 61
Line 201	CD 5E E9 41 07 8F DB 4F 3B F7 CB 75 2C C9 E2 C2
Line 202	99 1D 4E A6 CD E7 4F 88 BC 74 4A 6B E6 0E F4 D9
Line 203	10 57 22 F4 6D 0B B0 C8 E6 AB E3 67 D7 DC 01 24
Line 204	23 F6 1A 55 59 49 CB A0 0C D0 B0 D3 85 D0 40 C3
Line 205	9A BD D2 82 0F 1F B6 9E 77 EF 96 EA 59 93 C5 85
Line 206	32 3A 9D 4D 9B CE 9F 11 78 E8 94 D7 CC 1D E9 B2
Line 207	20 AE 45 E8 DA 17 61 91 CD 57 C6 CF AF B8 02 48
Line 208	47 EC 34 AA B2 93 97 40 19 A1 61 A7 0B A0 81 87
Line 209	35 7B A5 04 1E 3F 6D 3C EF DF 2D D4 B3 27 8B 0A
Line 210	64 75 3A 9B 37 9D 3E 22 F1 D1 29 AF 98 3B D3 64
Line 211	41 5C 8B D1 B4 2E C3 23 9A AF 8D 9F 5F 70 04 90
Line 212	8F D8 69 55 65 27 2E 80 33 42 C3 4E 17 41 03 0E
Line 213	6A F7 4A 08 3C 7E DA 79 DF BE 5B A9 66 4F 16 14
Line 214	C8 EA 75 36 6F 3A 7C 45 E3 A2 53 5F 30 77 A6 C8
Line 215	82 B9 17 A3 68 5D 86 47 35 5F 1B 3E BE E0 09 21

Line 216	1F B0 D2 AA CA 4E 5D 00 66 85 86 9C 2E 82 06 1C
Line 217	D5 EE 94 10 78 FD B4 F3 BF 7C B7 52 CC 9E 2C 29
Line 218	91 D4 EA 6C DE 74 F8 8B C7 44 A6 BE 60 EF 4D 91
Line 219	05 72 2F 46 D0 BB 0C 8E 6A BE 36 7D 7D C0 12 42
Line 220	3F 61 A5 55 94 9C BA 00 CD 0B 0D 38 5D 04 0C 39
Line 221	AB DD 28 20 F1 FB 69 E7 7E F9 6E A5 99 3C 58 53
Line 222	23 A9 D4 D9 BC E9 F1 17 8E 89 4D 7C C1 DE 9B 22
Line 223	0A E4 5E 8D A1 76 19 1C D5 7C 6C FA FB 80 24 84
Line 224	7E C3 4A AB 29 39 74 01 9A 16 1A 70 BA 08 18 73
Line 225	57 BA 50 41 E3 F6 D3 CE FD F2 DD 4B 32 78 B0 A6
Line 226	47 53 A9 B3 79 D3 E2 2F 1D 12 9A F9 83 BD 36 44
Line 227	15 C8 BD 1B 42 EC 32 39 AA F8 D9 F5 F7 00 49 08
Line 228	FD 86 95 56 52 72 E8 03 34 2C 34 E1 74 10 30 E6
Line 229	AF 74 A0 83 C7 ED A7 9D FB E5 BA 96 64 F1 61 4C
Line 230	8E A7 53 66 F3 A7 C4 5E 3A 25 35 F3 07 7A 6C 88
Line 231	2B 91 7A 36 85 D8 64 73 55 F1 B3 EB EE 00 92 11
Line 232	FB 0D 2A AC A4 E5 D0 06 68 58 69 C2 E8 20 61 CD
Line 233	5E E9 41 07 8F DB 4F 3B F7 CB 75 2C C9 E2 C2 99
Line 234	1D 4E A6 CD E7 4F 88 BC 74 4A 6B E6 0E F4 D9 10
Line 235	57 22 F4 6D 0B B0 C8 E6 AB E3 67 D7 DC 01 24 23
Line 236	F6 1A 55 59 49 CB A0 0C D0 B0 D3 85 D0 40 C3 9A
Line 237	BD D2 82 0F 1F B6 9E 77 EF 96 EA 59 93 C5 85 32
Line 238	3A 9D 4D 9B CE 9F 11 78 E8 94 D7 CC 1D E9 B2 20
Line 239	AE 45 E8 DA 17 61 91 CD 57 C6 CF AF B7 FD B7 B8
Line 240	13 CB 55 4D 6C 68 BF E6 5E 9E 58 F4 5F 7E 78 CA
Line 241	84 5A FB E1 C0 92 C3 10 20 D2 2B 4C D8 74 F5 9B
Line 242	8A C5 64 C8 62 C1 DD 0E 2E D6 50 67 C4 2C 9B BE
Line 243	A3 74 2E 4B D1 3C DC 65 50 72 60 A0 90 04 90 8F

Line 244	D8 69 55 65 27 2E 80 33 42 C3 4E 17 41 03 0E 6A
Line 245	F7 4A 08 3C 7E DA 79 DF BE 5B A9 66 4F 16 14 C8
Line 246	EA 75 36 6F 3A 7C 45 E3 A2 53 5F 30 77 A6 C8 82
Line 247	B9 17 A3 68 5D 86 47 35 5F 1B 3E BE E0 09 21 1F
Line 248	B0 D2 AA CA 4E 5D 00 66 85 86 9C 2E 82 06 1C D5
Line 249	EE 94 10 78 FD B4 F3 BF 7C B7 52 CC 9E 2C 29 91
Line 250	D4 EA 6C DE 74 F8 8B C7 44 A6 BE 60 EF 4D 91 05
Line 251	72 2F 46 D0 BB 0C 8E 6A BE 36 7D 7D BF ED BD C0
Line 252	9E 5A AA 6B 63 45 FF 32 F4 F2 C7 A2 FB F3 C6 54
Line 253	22 D7 DF 0E 04 96 18 81 06 91 5A 66 C3 A7 AC DC
Line 254	56 2B 26 43 16 0E E8 71 76 B2 83 3E 21 64 DD F5
Line 255	1B A1 72 5E 89 E6 E3 2A 83 93 05 04 7F DB 7B 81
Line 256	3C B5 54 D6 C6 8B FE 65 E9 E5 8F 45 F7 E7 8C A8
Line 257	45 AF BE 1C 09 2C 31 02 0D 22 B4 CD 87 4F 59 B8
Line 258	AC 56 4C 86 2C 1D D0 E2 ED 65 06 7C 42 C9 BB EA
Line 259	37 42 E4 BD 13 CD C6 55 07 26 0A 09 00 49 08 FD
Line 260	86 95 56 52 72 E8 03 34 2C 34 E1 74 10 30 E6 AF
Line 261	74 A0 83 C7 ED A7 9D FB E5 BA 96 64 F1 61 4C 8E
Line 262	A7 53 66 F3 A7 C4 5E 3A 25 35 F3 07 7A 6C 88 2B
Line 263	91 7A 36 85 D8 64 73 55 F1 B3 EB EE 00 92 11 FB
Line 264	0D 2A AC A4 E5 D0 06 68 58 69 C2 E8 20 61 CD 5E
Line 265	E9 41 07 8F DB 4F 3B F7 CB 75 2C C9 E2 C2 99 1D
Line 266	4E A6 CD E7 4F 88 BC 74 4A 6B E6 0E F4 D9 10 57
Line 267	22 F4 6D 0B B0 C8 E6 AB E3 67 D7 DC 01 24 23 F6
Line 268	1A 55 59 49 CB A0 0C D0 B0 D3 85 D0 40 C3 9A BD
Line 269	D2 82 0F 1F B6 9E 77 EF 96 EA 59 93 C5 85 32 3A
Line 270	9D 4D 9B CE 9F 11 78 E8 94 D7 CC 1D E9 B2 20 AE
Line 271	45 E8 DA 17 61 91 CD 57 C6 CF AF B7 FD B7 B8 13

Line 272	CB 55 4D 6C 68 BF E6 5E 9E 58 F4 5F 7E 78 CA 84
Line 273	5A FB E1 C0 92 C3 10 20 D2 2B 4C D8 74 F5 9B 8A
Line 274	C5 64 C8 62 C1 DD 0E 2E D6 50 67 C4 2C 9B BE A3
Line 275	74 2E 4B D1 3C DC 65 50 72 60 A0 90 04 90 8F D8
Line 276	69 55 65 27 2E 80 33 42 C3 4E 17 41 03 0E 6A F7
Line 277	4A 08 3C 7E DA 79 DF BE 5B A9 66 4F 16 14 C8 EA
Line 278	75 36 6F 3A 7C 45 E3 A2 53 5F 30 77 A6 C8 82 B9
Line 279	17 A3 68 5D 86 47 35 5F 1B 3E BE DF F6 DE E0 4F
Line 280	2D 55 35 B1 A2 FF 99 7A 79 63 D1 7D F9 E3 2A 11
Line 281	6B EF 87 02 4B 0C 40 83 48 AD 33 61 D3 D6 6E 2B
Line 282	15 93 21 8B 07 74 38 BB 59 41 9F 10 B2 6E FA 8D
Line 283	D0 B9 2F 44 F3 71 95 41 C9 82 82 40 12 42 3F 61
Line 284	A5 55 94 9C BA 00 CD 0B 0D 38 5D 04 0C 39 AB DD
Line 285	28 20 F1 FB 69 E7 7E F9 6E A5 99 3C 58 53 23 A9
Line 286	D4 D9 BC E9 F1 17 8E 89 4D 7C C1 DE 9B 22 0A E4
Line 287	5E 8D A1 76 19 1C D5 7C 6C FA FB

Annex F
(normative)

High SNR Demodulation of ISO/IEC 24730-2 DSSS BPSK Signals

1. The 2441.75 MHz DSSS signal is gain adjusted and mixed down to -250 kHz IQ complex pseudo-baseband using a 2442.00 MHz precision low phase noise local oscillator. The cosine mixer is low pass filtered at 35 MHz to create the I pseudo-baseband signal. The –sine mixer is low pass filtered at 35 MHz to create the Q pseudo-baseband signal.

2. Upon detection of a -38 dBm envelope signal amplitude, the filtered I and Q signals are then sampled at 80 MHz using a 12 bit A/D converter into a memory buffer for the DSSS burst duration. A 56 bit burst with 511 chips/bit requires about just under1 mS of sampled data to capture the entire packet.

3. The I sample vector constitutes the real and the Q sample vector the imaginary part of a complex signal vector. The instantaneous amplitude is sqrt(I^2+Q^2) and the instantaneous phase is arctan(Q/I).

4. The BPSK carrier frequency is recovered by the following process:

a. Square the complex sample vector term by term to extract the double frequency carrier term of -500 kHz.

b. Compute the instantaneous phase angle, term by term using arctan(Q/I).

c. Unwrap the modulo two pi phase vector.

d. Fit a line for best fit to the unwrapped phase vector and determine its slope. This slope is the actual frequency of the double frequency carrier term. If there were no error, then this frequency equals -500 kHz, or a slope of -2 * pi * 500000 radians/sec.

d. Divide the resulting frequency in half to obtain the actual pseudo-baseband frequency. This is the clockwise rotation rate of the BPSK signal at 250 kHz approximately.

5. Using the determined pseudo-baseband frequency, complex mix the pseudo-baseband vector to true baseband, obtaining a complex signal vector.

6. The chip clock recovery can be obtained either from the amplitude or phase information. For high SNR, the amplitude is used. Bandwidth limited antipodal BPSK always exhibits a deep amplitude null at during phase shifts. This information is used in conjunction with an early/late phase locked loop to identify the chip centers.

7. The baseband signal vector is sampled at the chip centers to create a chip sample vector consisting of 56*511 IQ samples.

8. A complex equalizer using the LMS algorithm is used to derotate and equalize the baseband BPSK signal.

9. The derotated BPSK chip elements are sliced out of the equalized vector to obtain a 56*511 chip vector.

10. A 511 chip correlator is used to identify bit boundaries and extract the 56 data bits.

11. The 56 data bits are differentially decoded to obtain the final received bit pattern.

12. CRC error detection is then applied to complete the decoding process.

Annex G
(normative)

High SNR Demodulation of ISO/IEC 24730-2 OOK Signals

1. The 2446.519 MHz OOK signal is gain adjusted and mixed down to -481 kHz IQ complex pseudo-baseband using a 2447.00 MHz precision low phase noise local oscillator. The cosine mixer is low pass filtered at 35 MHz to create the I pseudo-baseband signal. The –sine mixer is low pass filtered at 35 MHz to create the Q pseudo-baseband signal.

2. Upon detection of a -38 dBm envelope signal amplitude, the filtered I and Q signals are then sampled at 80 MHz using a 12 bit A/D converter into a memory buffer for the OOK burst duration. The duration of OOK responses greatly vary, depending on the packet format type. Sufficient storage is required to capture the entire burst.

3. The I sample vector constitutes the real and the Q sample vector the imaginary part of a complex signal vector. The instantaneous amplitude is sqrt(I^2+Q^2) and the instantaneous phase is arctan(Q/I).

4. The OOK carrier frequency is recovered by the following process:

a. Bandpass filter the -481 kHz large carrier using a 100 ppm bandwidth.

b. Compute the instantaneous phase angle, term by term using arctan(Q/I).

c. Unwrap the modulo two pi phase vector.

d. Fit a line for best fit to the unwrapped phase vector and determine its slope. This slope is the actual frequency OOK carrier term. If there were no error, then this frequency equals -481 kHz, or a slope of -2 * pi * 481000 radians/sec.

This is the clockwise rotation rate of the OOK signal at 481 kHz approximately. This frequency is only necessary for accurate carrier measurement purposes.

5. The instantaneous amplitude is modulated with a FSK signal. This envelope modulation is frequency translated by the mean FSK frequency of (535.5 kHz + 376.8 kHz)/2 to baseband and bandpass filtered with a bandwidth of 1 MHz.

6. The FSK toggles between -79.35 kHz and + 79.35 kHz. The phase is computed, then unwrapped, then differentiated to obtain frequency as a function of time. This signal is then sliced to obtain differentially encoded data.

6. The clock recovery can be obtained from the sliced data samples. This information is used in conjunction with an early/late phase locked loop to identify the bit centers.

7. The data bits are differentially decoded to obtain the final received bit pattern.

8. CRC error detection is then applied to complete the decoding process.

ISO/IEC JTC 1/SC 31/WG 3/SG1 N368

Resolutions from the ISO/IEC PDTR 24769 BRM meeting of Vienna, Austria, 9th of April 2008

Resolution 1:
ISO/IEC 24769 BRM approves the resolution of comments on PDTR 24769 according document N0369 done by the ballot resolution group.
UNANIMOUS

Resolution 2:
ISO/IEC 24769 BRM requests the project editor Tim Harrington of WI 24769 to update PDTR 24769 according to N0369 on or before 30.04.2008 and issue it to the convener of the BRM Josef Preishuber-Pfuegl.
UNANIMOUS

Resolution 3:
ISO/IEC 24769 BRM requests the convener of the BRM Josef Preishuber-Pflügl to forward the reviewed and updated document according to N0369 to SC31 Secretariat for a 3 month DTR ballot.
UNANIMOUS

Template for comments and secretariat observations

Date: Sep 21, 2007	Document: ISO/IEC JTC 1/SC 31 N 2324

1	2	(3)	4	5	(6)	(7)
MB[1]	**Clause No./ Subclause No./ Annex** (e.g. 3.1)	**Paragraph/ Figure/Table/ Note** (e.g. Table 1)	**Type of com-ment**[2]	**Comment (justification for change) by the MB**	**Proposed change by the MB**	**Secretariat observations** on each comment submitted
DE	Introduction		ge	The statement "ISO/IEC 24730 defines the air interfaces for…" Is not correct. E.g. 24730-1 defines an API not an air interface	Change to "ISO/IEC 24730 defines components for…"	Resolved:. Change sentence to add: "and an application programming interface (API)
AT 1	3.4		Ed	Abbreviation should not contain another abbreviation	Change to " BPSK Binary phase shift keying"	Accept
DE	4.1	1	ed	"specified in ISO 24730" is not complete	Change to "specified in ISO 24730-2"	Resolved, Check to see that ISO/IEC is referenced
DE	4.1	2	ed	"specified in ISO 24730" is not complete	Change to "specified in ISO 24730-2"	Resolved, Check to see that ISO/IEC is referenced
AT 2	4.1		Ed	Plural required	The results of these tests …	Accept
AT 3	4.3.1		Ge	The Agilent product has to be clearly highlighted as example	Change to "such as e.g. an Agilent E4443A"	Resolved be changing "such as" to "for example"
AT 4	4.3.4		Ed	Singular	Change sections to section	Accept
AT 5	4.3.4.6		Ge	Definition of " Error vector magnitude" is missing	Add definition in appropriate section of document	Resolved – we will add it to the definitions and terms section.
DE	4.4		te	What exactly is the output of the DSSS receiver? Baseband samples? Chips? Bits?	Please clarify.	Accept by rewording
AT 6	4.4.1		Ge	The listed products have to be clearly highlighted as example	Change to "The measurement equipment could e.g. consist of an Agilent E4438C Vector Signal Generator (VSG) with options 5 (6G hard drive) & 602 (Internal Baseband Generator 64Msa memory). Figure 2 shows the required test equipment set-up	Resolve per comment AT3
AT 7	4.3.5		Ge	Report details incomplete	Add the following sentence at end of paragraph: " As mentioned before (in 4.2.4), the report shall	Resolved with slight rewording: " As mentioned in

1 **MB** = Member body (enter the ISO 3166 two-letter country code, e.g. CN for China; comments from the ISO/CS editing unit are identified by **)
2 **Type of comment:** **ge** = general **te** = technical **ed** = editorial
NOTE Columns 1, 2, 4, 5 are compulsory.

1	2	(3)	4	5	(6)	(7)
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					contain also the uncertainties of the measurement equipment."	4.2.4, the report shall contain the uncertainties of the measurement equipment."
AT 8	4.4.5		Ge	Report details incomplete	Add the following sentence at end of paragraph: " As mentioned before (in 4.2.4), the report shall contain also the uncertainties of the measurement equipment."	Resolved with slight rewording: " As mentioned in 4.2.4, the report shall contain the uncertainties of the measurement equipment."
AT 9	4.5.1.1		Ed	Readability	Change paragraph to: " The DUT shall be an RTLS tag. The measurement equipment shall consist of an anechoic chamber and measuring antenna as described in annex A, and a measurement antenna and a vector signal analyzer for example, an Agilent E4443A, or equivalent, as described in annex C. The test shall require an RTLS programmer, or an arbitrary waveform generator and magnetic transmit coil, to induce the OOK/FSK transmissions. Figure 3 shows the required test equipment setup."	Accept, with rewording
AT 10	4.5.1.1	Figure 3	Te	Figure does not fit to description in this chapter	Correct Figure content	Accept: Corrected Figure
AT 11	4.5.2.1	Figure 4	Te	Figure does not fit to description in this chapter	Correct connections of equipment	Resolved: Corrected figure and change verbiage to add: "or arbitrary wave form generator with magnetic transmit coil
AT 12	4.5.3.4		Ge	Chapter on Test report missing	Add chapter 4.5.3.4.6	Accept: Add Test Report section.
AT 13	All		Ed	Multiple positions of double-spaces and minor editorial issues	Check with spell-checker and grammar checker	Accept: make changes

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DE			ge	Missing spectral mask and bandwidth definition. 24730-2 calls out a bandwidth of 60 MHz without further definition (is this the 3 dB, 6 dB, or 30 dB bandwidth?) and without spectral mask. In order to verify the conformance of a tag with the standard a mask with lower and upper bounds for emitted spectra is necessary.	Add respective masks	Rejected: Comment not relevant to PDTR 24769.

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