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Information technology — Real-time locating systems (RTLS) —

Part 22: Direct Sequence Spread Spectrum (DSSS) 2,4 GHz air interface protocol: Transmitters operating with multiple spread codes and employing a QPSK data encoding and Walsh offset QPSK (WOQPSK) spreading scheme

Technologies de l'information — Systèmes de localisation en temps réel (RTLS) —

Partie 22: Protocole d'interface d'air à 2,4 GHz d'étalement de spectre à séquence directe (DSSS): Émetteurs fonctionnant avec des codes d'étalement multiples et utilisant un codage de données QPSK et un schéma

Reference number
ISO/IEC 24730-22:2012(E)

Contents

Page

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.

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ISO/IEC 24730-22 was prepared by Joint Technical Committee ISO/IEC JTC 1, *Information technology*, Subcommittee SC 31, *Automatic identification and data capture techniques*.

This first edition of ISO/IEC 24730-22, together with ISO/IEC 24730-2 and ISO/IEC 24730-21, cancels and replaces the first edition of ISO/IEC 24730-2:2006, which has been technically revised.

ISO/IEC 24730 consists of the following parts, under the general title *Information technology — Real-time locating systems (RTLS)*:

— *Part 1: Application program interface (API)*

— *Part 2: Direct Sequence Spread Spectrum (DSSS) 2,4 GHz air interface protocol*

— *Part 5: Chirp spread spectrum (CSS) at 2,4 GHz air interface*

— *Part 21: Direct Sequence Spread Spectrum (DSSS) 2,4 GHz air interface protocol: Transmitters operating with a single spread code and employing a DBPSK data encoding and BPSK spreading scheme*

— *Part 22: Direct Sequence Spread Spectrum (DSSS) 2,4 GHz air interface protocol: Transmitters operating with multiple spread codes and employing a QPSK data encoding and Walsh offset QPSK (WOQPSK) spreading scheme*

The following parts are under preparation:

— *Part 6: Ultra Wide Band Air Interface protocol*

— *Part 61: Low rate pulse repetition frequency Ultra Wide Band (UWB) air interface*

— *Part 62: High rate pulse repetition frequency Ultra Wide Band (UWB) air interface*

Introduction

ISO/IEC 24730 defines a single application program interface (API) for real-time locating systems (RTLs) for use in asset management and is intended to allow for compatibility and to encourage interoperability of products for the growing RTLS market. ISO/IEC 24730 also defines three air interface protocols, as follows: ISO/IEC 24730-2, based on a direct sequence spread spectrum (DSSS), ISO/IEC 24730-5, based on a chirp spread spectrum (CSS) technique, and ISO/IEC 24730-6 Ultra Wide Band Air Interface protocol.

This part of ISO/IEC 24730, the direct sequence spread spectrum (DSSS) 2,4 GHz air interface protocol, establishes a technical standard for real-time locating systems that operate at an internationally available 2,4 GHz frequency band and is intended to provide approximate location with frequent updates (for example, several times a minute). In order to be compliant with this part of ISO/IEC 24730 compliance with ISO/IEC 24730-1 is also required.

Real-time locating systems are wireless systems with the ability to locate the position of an item anywhere in a defined space (local/campus, wide area/regional, global) at a point in time that is, or is close to, present time. Position is derived by measurements of the physical properties of the radio link.

This part of ISO/IEC 24730 specifies the air interface for a system that locates an asset in a controlled area, e.g. warehouse, campus, airport (area of interest is instrumented) with accuracy to 3 m or less.

There are two additional methods of locating an object which are really RFID rather than RTLS:

— locating an asset by virtue of the fact that the asset has passed point A at a certain time and has not passed point B;

— locating an asset by virtue of providing a homing beacon whereby a person with a handheld device can find an asset.

The method of location is through identification and location, generally through multi-lateration. The different types are

— time of Arrival (ToA) / Time of Flight Ranging Systems,

— amplitude / Received Signal Strength Triangulation,

— time Difference of Arrival (TDoA), and

— angle of Arrival (AoA).

This part of ISO/IEC 24730 defines the air interface protocol needed for the creation of an RTLS system.

Although there are many types of location algorithms that could be used, one example of a location algorithm is provided in Annex A of ISO/IEC 24730-21.

This part of ISO/IEC 24730 also defines the physical layer for compliant RTLS transmitters operating with multiple spread codes and employing a QPSK data encoding and Walsh offset QPSK (WOQPSK) spreading scheme, and defines the air interface protocol needed for the reader synchronization essential for the location method based on timing information, such as Time Difference of Arrival (TDOA).

Although there are many types of reader synchronization methods that could be used, an example of RTLS reader synchronization is provided in Annex A.

Information technology — Real-time locating systems (RTLS) —

Part 22:
Direct Sequence Spread Spectrum (DSSS) 2,4 GHz air interface protocol: Transmitters operating with multiple spread codes and employing a QPSK data encoding and Walsh offset QPSK (WOQPSK) spreading scheme

1 Scope

ISO/IEC 24730-2 is comprised of a main document and two additional parts, ISO/IEC 24730-21 and ISO/IEC 24730-22, and defines a networked location system that provides X-Y coordinates and data telemetry. The system utilizes real-time locating systems (RTLS) transmitters that autonomously generate a direct sequence spread spectrum radio frequency beacon. These devices can be field programmable and support an optional exciter mode that allows modification of the rate of location update and location of the RTLS device. ISO/IEC 24730-2 defines these modes, but does not define the means by which they are accomplished.

This part of ISO/IEC 24730 is the mode of ISO/IEC 24730-2 transmitters operating with multiple spread codes and employing a quadrature phase shift keying (QPSK) data encoding and Walsh offset QPSK(WQPSK) spreading scheme.

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 — Real-time locating systems (RTLS) — Part 1: Application program interface (API)*

ISO/IEC 24730-2, *Information technology — Real-time locating systems (RTLS) — Part 2: Direct Sequence Spread Spectrum (DSSS) 2,4 GHz air interface protocol*

ISO/IEC 18000-4:2008, *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*

ISO/IEC 8802-11:2005, *Information technology — Telecommunications and information exchange between systems — Local and metropolitan area networks — Specific requirements — Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) specifications*

IEEE Std 1451.7™-2010, IEEE *Standard for A Smart Transducer Interface for Sensors and Actuators — Transducers to Radio Frequency Identification (RFID) Systems Communication Protocols and Transducer Electronic Data Sheet Formats*

3 Terms and definitions

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

3.1
air interface
wireless communications protocol and signal structure used to communicate data between RTLS transmitters and other RTLS devices

3.2
host applications
customer's management information systems

3.3
RTLS infrastructure
system components existing between the air interface protocol and the RTLS server API

3.4
real-time locating system
set of radio frequency receivers and associated computing equipment used to determine the position of a transmitting device relative to the placement of the aforementioned receivers that is capable of reporting that position within several minutes of the transmission used for determining the position of the transmission

NOTE Refer to Figure 1 for clarity regarding elements of RTLS infrastructure.

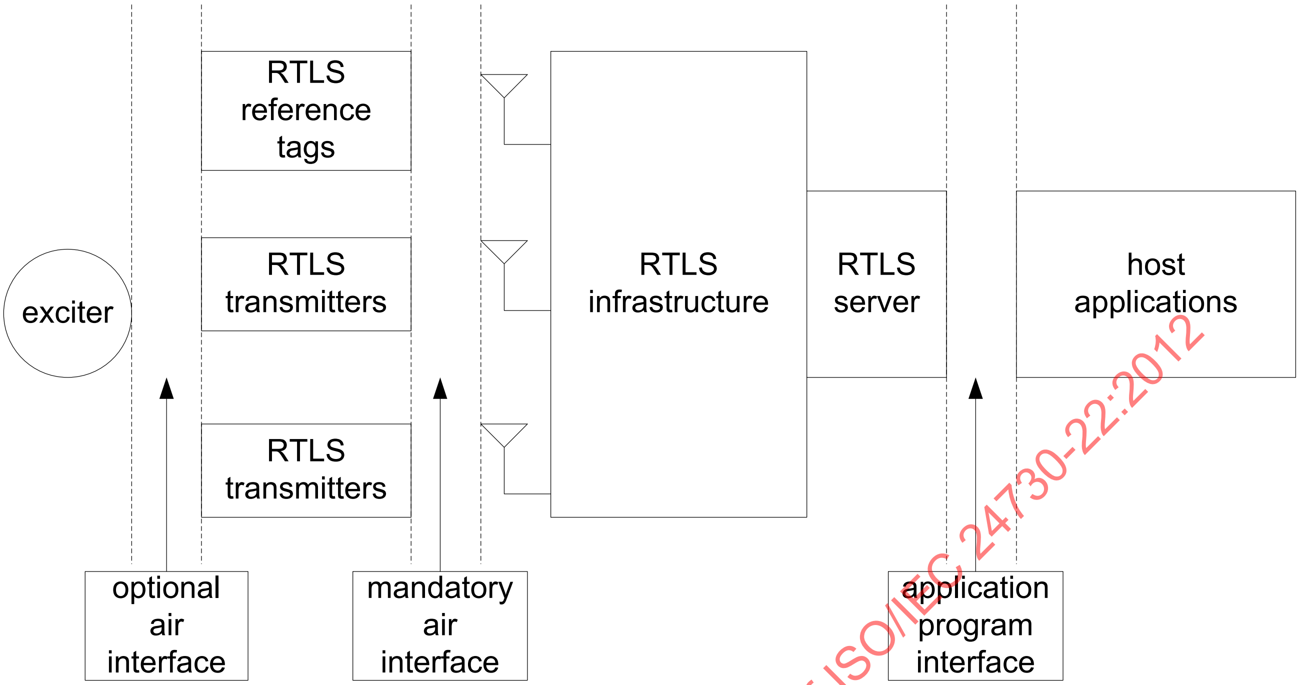


Figure 1 — Elements of RTLS infrastructure

3.5
RTLS server
computing device that aggregates data from the readers and determines location of transmitters

3.6
RTLS transmitter
battery powered radio device that utilizes the protocols specified in ISO/IEC 24730-2

NOTE The term transmitter is used interchangeably with the term tag.

3.7
RTLS reader
device that receives signals from an RTLS transmitter or reference tag

3.8
open field
path from transmitter to receiver is LOS (Line Of Sight)

[ANS T1.523-2001]

3.9
exciter
device that transmits a signal that alters the behaviour of an RTLS transmitter

3.10
upconvert
change a baseband signal to a higher frequency signal

3.11
tag blink
radio frequency transmission(s) from an RTLS transmitter that may consist of one or multiple duplicate messages

3.12
sub-blink
message that is transmitted one or multiple times in a "blink"

3.13
RTLS reference tag
always on powered radio device that utilizes the protocols specified in ISO/IEC 24730-2, mainly for the RTLS reader synchronization

4 Symbols and abbreviated terms

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

AEXB	Exciter Blink
BPSK	Binary Phase Shift Keying
CRC	Cyclic Redundancy Check
DBPSK	Differential Binary Phase Shift Keying
DSSS	Direct Sequence Spread Spectrum
EB	Event Blink
EIRP	Equivalent Isotropically Radiated Power
EXB	EXciter Blink
FSK	Frequency Shift Keying
MSB	Most Significant Bit
OOK	On-Off Keying
PN	Pseudo Noise
QPSK	Quadrature Phase Shift Keying
RSS	Received Signal Strength
RTLS	Real-Time Locating Systems
TIB	Timed Interval Blink
WOQPSK	Walsh Offset Quadrature Phase Shift Keying

5 Requirements

5.1 Frequency range

This part of ISO/IEC 24730 addresses real-time locating systems (RTLS) operating in the 2,400 GHz to 2,4835 GHz frequencies.

5.2 2,4 GHz spread spectrum air interface attributes

The minimum feature set shall include the following:

- RTLS transmitters and reference tags shall autonomously generate a direct sequence spread spectrum radio frequency beacon.
- Transmission shall be at a power level that can facilitate reception at ranges of at least 300 m open-field separation between the transmitter and receiver when operating within the parameters described in Table 1 of ISO/IEC 24730-21 and in from Table 1 to Table 2 of ISO/IEC 24730-22.
- RTLS transmitters and reference tags shall be fully compliant with local regulatory requirements.
- Class 1 RF transmissions are low power and electro-magnetically compatible with and shall not interfere (not cause any measurable difference in throughput) and co-exist with existing standardized ISO/IEC 8802-11:2005 wireless communication networks. They are also systems that co-exist with ISO/IEC 18000-4:2008, and shall not exceed the maximum power of 10 dBm EIRP and the requirements of the local regulatory agencies.
- Class II RF transmissions shall not exceed the maximum power requirements of the local regulatory agencies.

5.3 Compliance requirements

The beacon transmitters specified in this part of ISO/IEC 24730 shall transmit at a power level that can facilitate reception at ranges of at least 300 m LOS separation between the transmitter and receiver. Such RTLS transmitters shall be fully compliant with local radio frequency regulatory requirements. Each receiver shall be capable of receiving and processing data from a minimum of 120 beacon transmissions per second. The nominal location data provided by the RTLS shall be within a 3 m or less radius of the actual location of the RTLS transmitter. The RF transmissions are low power, compatible with, and shall not interfere with existing standardized ISO/IEC 8802-11:2005 wireless communication networks, and systems compliant with ISO/IEC 18000-4:2008.

To be fully compliant with this part of ISO/IEC 24730, RTLS shall also comply with ISO/IEC 24730-1.

5.4 Manufacturer tag ID

The manufacturer's tag identification (ID) number identifies a particular manufacturer and consists of 16 bits. A manufacturer may have more than one ID number. As reported from the RTLS server to the API, the first 16 bits are designated for the manufacturer's identification number. As reported from the Data Link Layer to the API, the remaining 16 bits establish a numbering system made unique by the initial manufacturer ID number. The manufacturer's identification number is a registration in accordance with ISO/IEC 15963. The 16-bit manufacturer's identification number shall be assigned in accordance with ISO/IEC 15963, Allocation Class 16h.

5.5 Physical layer parameters

The parameter definitions in Table 1 to Table 2 apply. These parameters are referenced by parameter name. These operating parameters are to be defined for the temperature range of –30 degrees Celsius to 50 degrees Celsius.

Table 1 — RTLS transmitter DSSS link parameters

Parameter name	Description
Operating frequency range	2400 MHz–2483,50 MHz
Operating frequency accuracy	± 25 ppm maximum
Centre frequency	2441,750 MHz
Occupied channel bandwidth	60 MHz
Transmit power	Class 1: 10 dBm EIRP max. Class 2: Maximum in accordance to local regulations
Spurious emission, out of band	The device shall transmit in conformance with spurious emissions requirements defined by the country's regulatory authority within which the system is operated.
Modulation	WOQPSK DSSS

Parameter name	Description
Data encoding	QPSK encoded
Data bit rate	119,226 kb/s
Packet error rate	0,01%
PN chip rate	30,521875 MHz ± 25 ppm
PN code length	512 (zero padded)
PN polynomial	$f(x) = X^9 + X^8 + X^5 + X^4 + 1$
I/Q orthogonal codes	Walsh codes with a period of 512 chips
Data packet lengths	Option 1: 72 bits Option 2: 88 bits Option 3: 104 bits Option 4: 168 bits
Message CRC polynomial	$G(x) = X^{10} + X^9 + X^5 + X^4 + X + 1$
CRC polynomial initialized value	0x001
Blink interval	Programmable, 5 s minimum
Blink interval randomization	± 638 ms maximum
Number of sub-blinks	Programmable, 1 – 8
Sub-blink interval randomization	150 ms ± 16 ms maximum
Maximum frequency drift	< ± 2 ppm over the duration of the entire message
Phase accuracy	< 0,50 radians within any 33 µs period
Phase noise	< 15 degrees when the noise is integrated from 100 Hz to 100 kHz

Table 2 — RTLS reference tag DSSS link parameters

Parameter name	Description
Operating frequency range	2400 MHz–2483,50 MHz
Operating frequency accuracy	± 0,5 ppm maximum
Centre frequency	2441,750 MHz
Occupied channel bandwidth	60 MHz
Transmit power	Class 1: 10 dBm EIRP max. Class 2: Maximum in accordance to local regulations
Spurious emission, out of band	The device shall transmit in conformance with spurious emissions requirements defined by the country's regulatory authority within which the system is operated.
Modulation	WOQPSK DSSS
Data encoding	QPSK encoded
Data bit rate	119,226 kb/s
Packet error rate	0,01%
PN chip rate	30,521875 MHz ± 0,5 ppm
PN code length (zero padded)	512
PN polynomial	$f(x) = X^9 + X^8 + X^5 + X^4 + 1$
I/Q orthogonal codes	Walsh codes with a period of 512 chips
Data packet lengths	60 bits
Message CRC polynomial	$G(x) = X^{10} + X^9 + X^5 + X^4 + X + 1$

Parameter name	Description
CRC polynomial initialized value	0x001
Blink interval	Programmable, 5 s minimum
Blink interval randomization	± 638 ms maximum
Number of sub-blinks	Programmable, 1 – 8
Sub-blink interval randomization	150 ms ± 16 ms maximum
Maximum frequency drift	< ± 0,2 ppm over the duration of the entire message
Phase noise	< 0,5 degrees when the noise is integrated from 100 Hz to 100 kHz

6 Mandatory air interface protocol specification

ISO/IEC 24730-22 defines the air interface protocols for RTLS DSSS spread-spectrum transmissions and the command/data level air interface communication protocols, operating over the frequency range from 2,400 GHz to 2,4835 GHz. The DSSS air interface shall have the main characteristic that the ISO/IEC 24730-22 transmitters operate with multiple spread codes and employ a QPSK data encoding/WOQPSK spreading scheme. The transmitters spread a QPSK signal for each sub-blink using a randomly selected spread code among pre-defined code pairs. These protocols facilitate communication between a compliant RTLS transmitter and a compliant infrastructure. ISO/IEC 24730-22 follows the optional protocols in clause 7 of ISO/IEC 24730-21 which facilitate communication between the RTLS transmitter and the programming device or exciter device respectively. The timing parameters and signal characteristics for the protocols are defined in the physical link specification in clause 5.

6.1 General

6.1.1 Functional classification

Beacon type RTLS system architecture consists of RTLS transmitters that “blink” a DSSS signal, fixed position reference tags that also “blink” a DSSS signal, and fixed position RTLS readers that receive those signals. The position of the RTLS transmitter (also called the tag) is to be located and tracked, and the reference tag is used to calibrate synchronization errors among readers. The system determines the x, y location of the RTLS transmitters. Location of tagged assets can be determined with better than 3 m accuracy in most environments, indoors and out. Once the location of the RTLS transmitter is determined, the location information and any other information are passed to the host application.

Additionally, an option that provides the ability to transmit telemetry data is defined.

The RTLS transmitter module is typically a compact internally-powered radio frequency device that is a part of the RTLS system. The RTLS system is designed to track and locate items with attached RTLS transmitters. Each locatable transmission is a pulse of direct sequence spread spectrum radio signal. The RTLS infrastructure receives these signals, or blinks. The blink is a short ID-only message or a longer telemetry message also containing the ID of the RTLS transmitter. Each transmission also contains a status data word that provides information on the RTLS transmitter configuration, battery status and other data. The RTLS transmitter’s ID, status data word, and location are provided to the host through the RTLS Infrastructure. Multiple RTLS transmitters may be present in typical installations allowing a large number of items to be tracked and located in real time.

Anti-collision synchronization protocols are not required. Each “blink” is comprised of multiple sub-blinks. The sub-blinks are parts of a multiple level anti-interference system; time diversity, spatial diversity, processing gain, code diversity. The combination of these multiple sub-blinks, multiple receiving antennas and spread spectrum correlation also allow multiple RTLS transmitters to blink simultaneously while still being received.

The format of the DSSS transmission from the RTLS transmitter is shown in Figure 2. Each DSSS transmission from the RTLS transmitter contains a "blink" packet containing *N* sub-blinks. Each set of sub-blinks can be one of four message lengths. All sub-blinks within a "blink" shall be identical to provide time diversity. Each sub-blink includes the 22-bit preamble, RTLS transmitter's 32-bit ID, 5-bit of status data, CRC data, and optional telemetry data depending on the type of message. The "blink" packet occurs at the beginning of the blink interval. Sub-blinks shall be separated by an interval, which is not user configurable. The number of sub-blinks per blink and the blink interval are configurable.

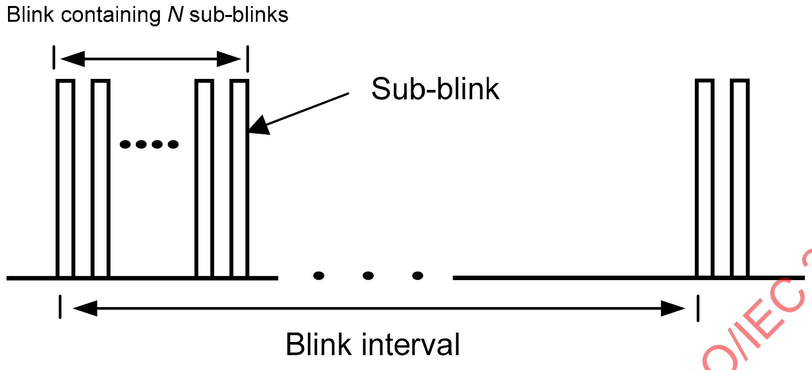


Figure 2 — DSSS air interface

Three classes of DSSS blinks are defined; Timed Interval Blink (TIB), EXciter Blink (EXB), and Event Blink (EB). A TIB shall transmit at a pre-programmed rate. An EB shall be caused by a switch event or external stimulus. A state diagram showing the different operational states of the RTLS transmitter is shown below in Figure 3.

Note: For Figure 3 and all future figures, solid lines denote required features and dotted lines denote optional features.

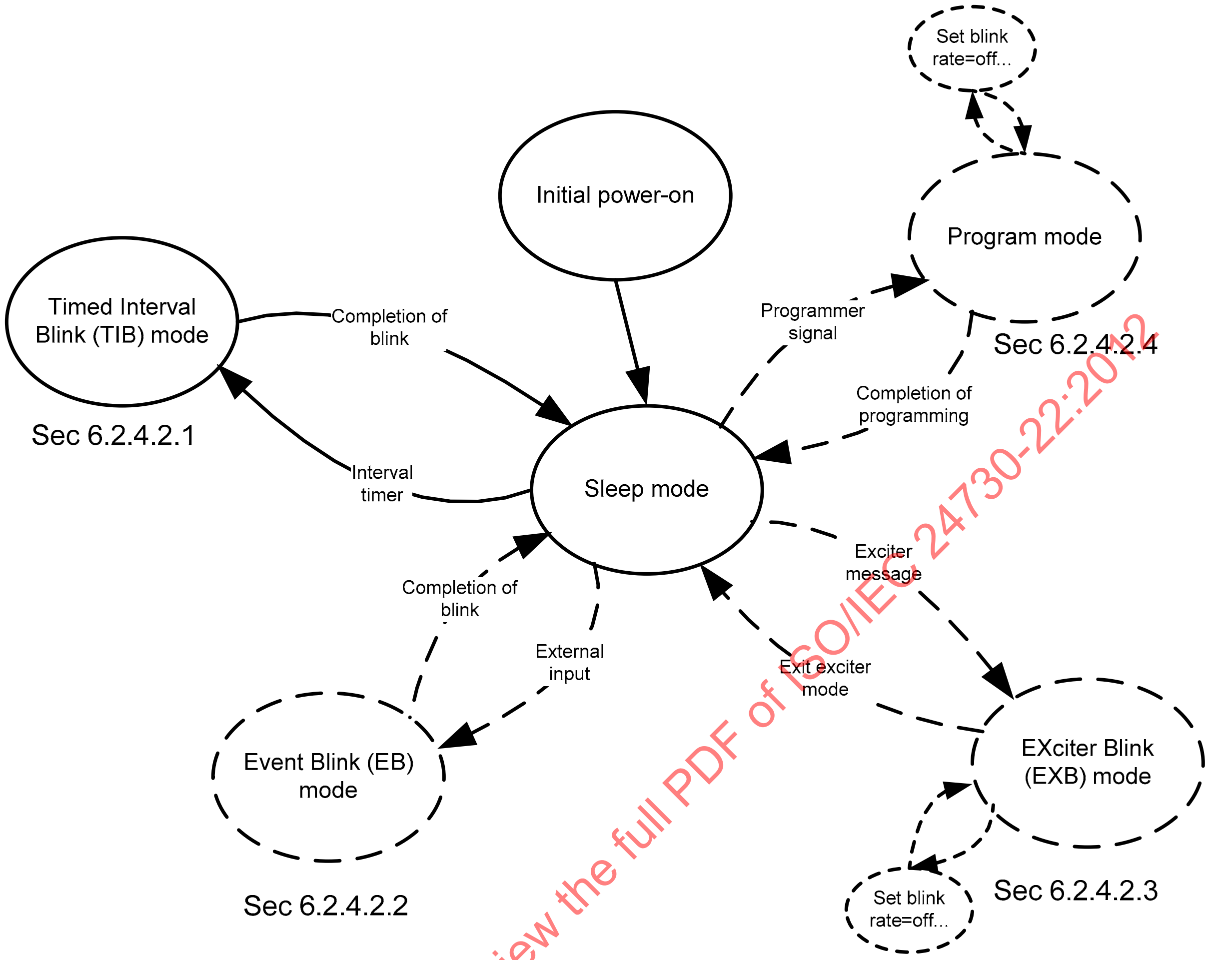


Figure 3 — RTLS transmitter state diagram

The DSSS carrier frequency is fixed at 2441,75 MHz and the chip rate shall be fixed at 30,521875 MHz.

6.1.2 RTLS transmitter radiated power

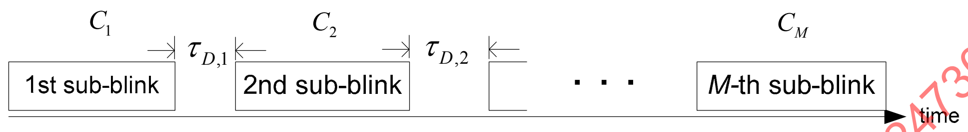
Two classes of RTLS transmitters exist with respect to the output power level they are capable of delivering. The Equivalent Isotropically Radiated Power (EIRP) of a Class 1 RTLS transmitter is less than 10 mW (10 dBm). Class 1 RTLS transmitters are intended for applications with moderate to dense infrastructures and minimal obstructions.

The EIRP of a Class 2 RTLS transmitter is greater than 10 mW (10dBm) and less than the maximum allowed by local radio regulations. Class 2 RTLS transmitters are intended for sparse infrastructures where RTLS readers may be located greater than 300 meters from the RTLS transmitter or environments with major obstructions.

The antenna of the RTLS transmitter should provide a pattern that is as omni-directional as possible within the constraints of the RTLS transmitter packaging requirements. This will ensure near equivalence with regard to orientation performance of individual transmitters within the system. The RF EIRP of a tag shall not vary more than 10 dB peak to peak in a spherical pattern in free space. It shall not vary more than 10 dB in a semi-spherical pattern around a tag mounted directly to a metallic plate of 1 sq. meter in order to achieve the required system performance.

6.2 Physical layer specification

The RTLS system architecture consists of RTLS transmitters that “blink” a DSSS signal, fixed position RTLS reference tags that also “blink” a DSSS signal, and fixed position RTLS readers that receive those signals. QPSK scheme shall be used to encode data for both RTLS transmitters and reference tags. The RTLS transmitters may employ multiple spread code pairs to spread the encoded data. Employing multiple spread code pairs mitigates the packet collision problem so that a small number of sub-blinks be used, thereby significantly reducing tag power consumption. In case of employing multiple spreading code pairs, a spread code pair should be randomly selected for each sub-blink among pre-defined code pairs. The maximum number of code pairs for RTLS transmitters is 4, and the number of code pairs shall be programmable. The spread code pair for reference tags is fixed and has a low cross correlation with those of RTLS transmitters.
Since a reader does not know which code pair was used for a particular sub-blink, parallel demodulators covering all possible code pairs should be implemented. Figure 4 illustrates the basic concept of packet transmissions using multiple spread codes.



C_k : spreading code of the k-th sub-blink, $1 \le k \le M$, $\tau_{D,k-1}$: random delay of the k-th sub-blink

Figure 4 — Basic concept of packet transmission using multiple spread codes

An option that provides the ability to transmit telemetry data and sensing information is also defined.

Each “blink” is comprised of multiple sub-blinks with their own IDs, of which each sub-blink will be spread by randomly selected spread code pair. The sub-blink’s IDs shall be very useful in computing the location of the transmitters at the RTLS server, shown in an example of usefulness of sub-blink ID in Figure 5. The combination of these multiple sub-blinks, multiple receiving antennas and spread spectrum correlation also allow multiple RTLS transmitters to blink simultaneously while still being received.

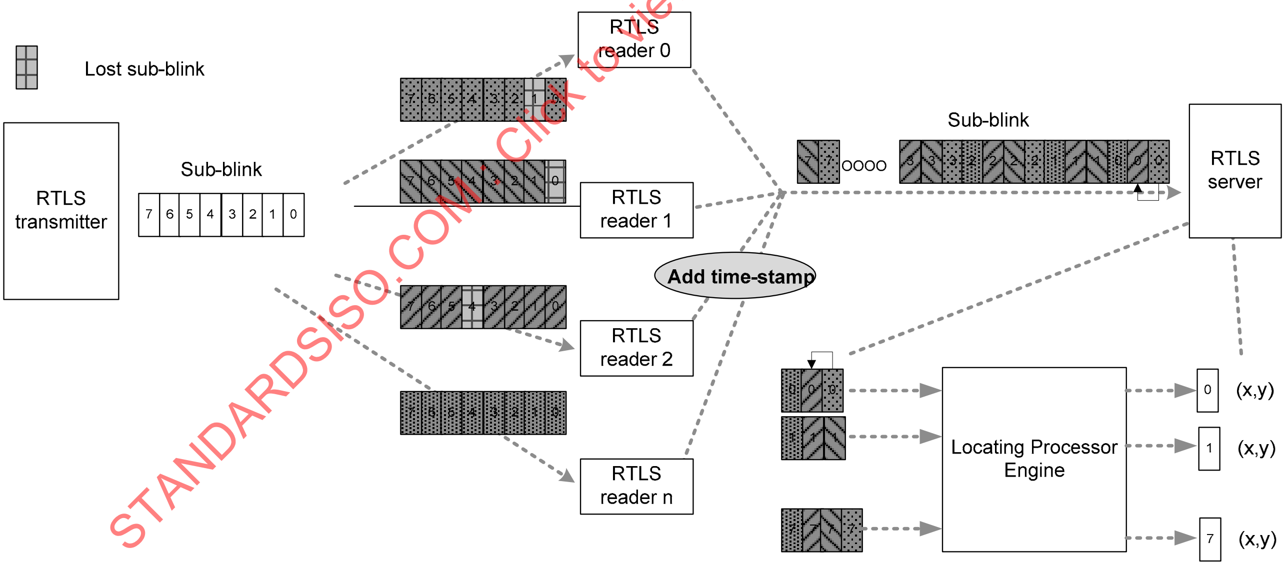


Figure 5 — Example of usefulness of sub-blink ID

6.2.1 Data encoding and spreading

The RTLS transmitters and reference tags both employ a QPSK data encoding and WOQPSK (Walsh offset QPSK) spreading scheme, as shown in Figure 6. The QPSK encoding scheme reduces packet lengths by half compared with the DBPSK scheme and may resolve the unbalance problem between synchronization and demodulation performances. The receivers may demodulate the data by using decision-feedback coherent detection.

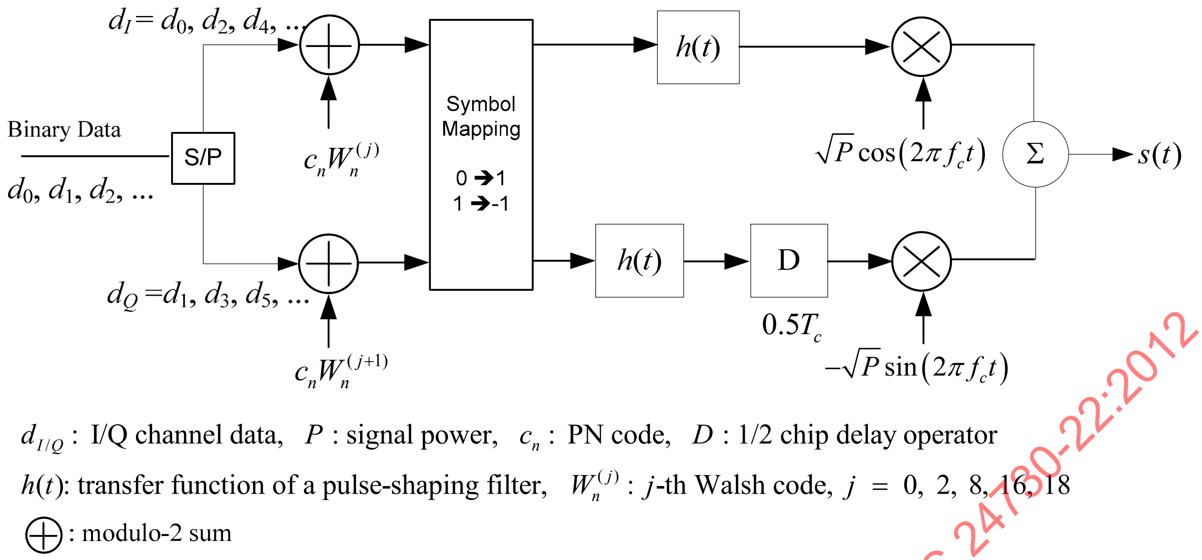


Figure 6 — QPSK encoding and Walsh OQPSK spreading

Binary input data shall be first serial-to-parallel converted and then each of I/Q channel data sequence shall be exclusively OR'd with I/Q channel spread codes, which are obtained by exclusively OR'ing the output of the PN (Pseudo Noise) sequence and Walsh orthogonal code pairs. Symbol mapping is applied to each of I/Q channel sequences followed by pulse-shaping. Binary "0" is mapped to symbol "1", while binary "1" is mapped to symbol "-1". Q-channel sequence is then delayed by 0.5Tc to reduce the PAPR (peak-to-average power ratio). The outputs of pulse-shaping filters are upconverted using a single sideband upconverter. The signal is then amplified and transmitted to the RTLS infrastructure.

The generator polynomial of the PN code shall be $1 + x^4 + x^5 + x^8 + x^9$. Figure 7 illustrates the PN generator.

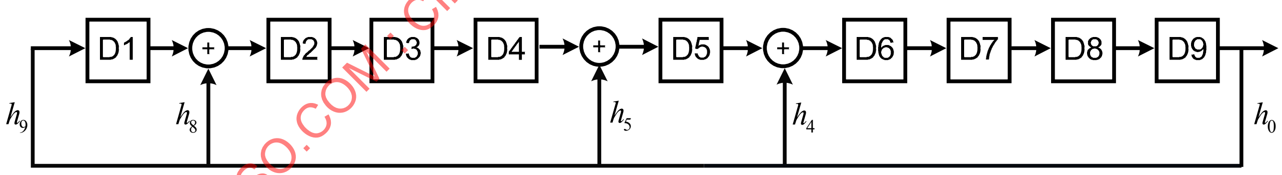


Figure 7 — PN generator

The PN generator is initialized with an "1" in register D9 and "0"s in all other registers and the end of the sequence is padded by a zero bit. Walsh codes have the same period (512 chips) as the zero-padded PN sequence. I/Q channel spread codes are the PN sequence covered by one of pre-defined Walsh code pairs, $\{(j, j+1), j = 0,\ 2,\ 8,\ 16,\ 18\}$. The periods of the PN code and Walsh codes are the same, which correspond to a QPSK symbol duration. The beginning of the PN code and Walsh codes should be aligned exactly with the beginning of data symbol. The Walsh code pairs corresponding to indices $j = 0,\ 2,\ 8,\ 16$ shall be used for RTLS transmitters and the Walsh code pair corresponding to the index $j = 18$ shall be used for reference tags.

The Walsh code pair shall be used not only to isolate I/Q channel signals but also to differentiate the signals from different RTLS transmitters or reference tags. Walsh codes can be generated by following recursive manner:

$$H_0 = [1], \quad H_2 = \begin{bmatrix} 1 & 1 \\ 1 & 0 \end{bmatrix}, \quad H_{2n} = \begin{bmatrix} H_n & H_n \\ H_n & \overline{H}_n \end{bmatrix},$$

where n is a power of 2 and $\overline{H}_n$ denotes the binary complement of H_n. In case of employing a single spread code pair for RTLS transmitters, the Walsh code pair corresponding to the index $j = 0$ shall be used.

6.2.2 Bandwidths and transmit spectral mask

The supported bandwidth shall be 60 MHz. The transmitted spectral products shall be less than the limits specified in Table 3 and Figure 8. For both relative and absolute limits, average spectral power shall be measured using a 100 kHz resolution bandwidth. For the relative limit, the reference level shall be the highest average spectral power measured within ± Bandwidth/2 of the centre frequency, fc. For testing the transmitted spectral power density a pseudo-random binary sequence shall be used as input data.

Table 3 — Spectral mask limits

Frequency	Relative limit	Absolute limit
|f-fc| > Bandwidth/2	-20 dBr	-30 dBm

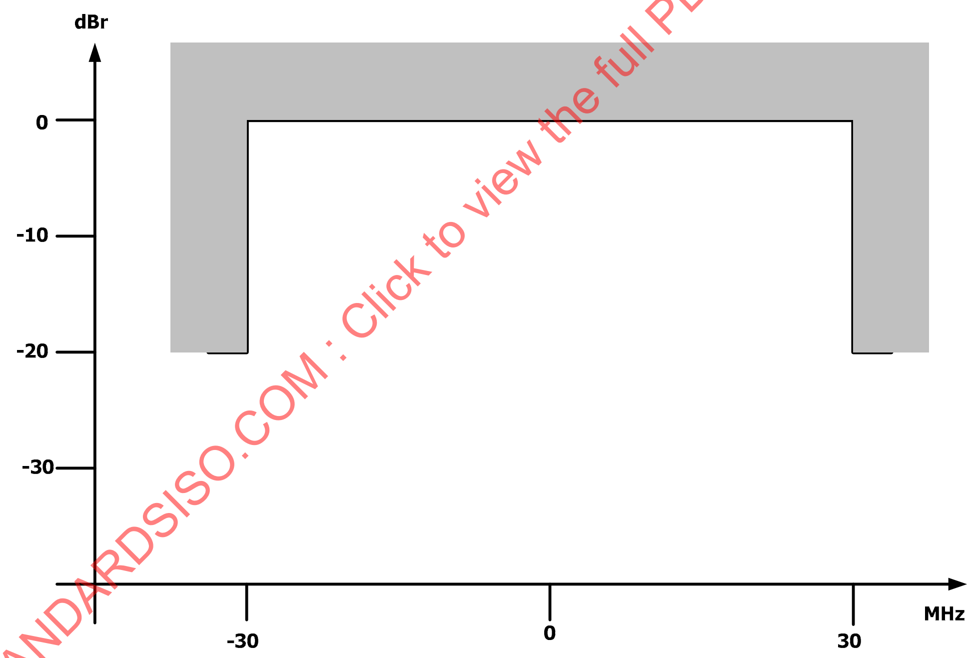


Figure 8 — Spectral mask limits for DSSS at 60 MHz bandwidth

6.2.3 DSSS message specifications

6.2.3.1 DSSS message structures

There are four different message formats for tag determined by the length of the message in bits: the 72-bit message, the 88-bit message, the 104-bit message, and the 168-bit message. An RTLS transmitter shall be capable of transmitting at least one of these message formats. The 72-bit and 88-bit message formats are intended for transmitting the RTLS transmitter ID, the 88 and 104-bit messages are intended for transmitting the RTLS transmitter ID and exciter information, and the 168-bit message format is intended for transmitting limited amounts of telemetry information including sensing data.

Each message type contains

– an 22-bit preamble of 0x00003
– a 5-bit RTLS transmitter status as defined in the message definitions
– a 3-bit sub-blink ID
– a CRC generator polynomial defined by X10 + X9 + X5 + X4 + X + 1. The preamble is not included in this polynomial
– a 32-bit RTLS transmitter ID. These ID's are defined in the range 1 to 4 294 967 296 (0x00000001 to 0xFFFFFFFF)

88- and 104-bit messages may carry an exciter ID. An exciter ID is comprised of 16 bits. The MSB designates whether the RTLS transmitter has entered or left an exciter field.

Figure 9 shows the message structure for RTLS transmitter.

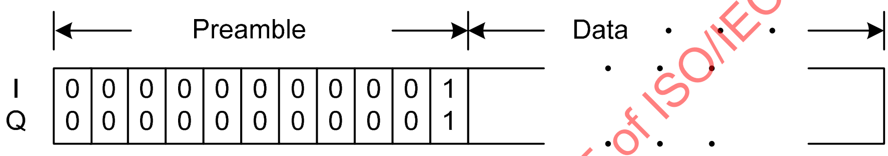


Figure 9 — Message structure of transmitters (tag)

There is one message format for the RTLS reference tag. The length of message for reference tag is 60 bits including 32 bits for preamble. The CRC generator is the same as that used for RTLS transmitter. The structure of each message format is shown in more detail in the following sections.

6.2.3.1.1 DSSS 72-bit message format

The DSSS 72-bit message format for the RTLS transmitter is shown in Table 4. The 72-bit message format consists of the 22-bit preamble, the 5-bit RTLS transmitter status field, a 3-bit sub-blink ID, a 32-bit field containing the RTLS transmitter ID, and the 10-bit CRC field for a total message length of 72 bits. The 72-bit message shall have transmission duration of 0,604 ms.

Table 4 — DSSS 72-bit message format

Preamble	Transmitter status					Sub-blink ID	Transmitter ID	CRC
22	"0"	S2	S1	B	R	3	32	10
22	"1"	Reserved				3	32	10
Bit 71 to bit 50	Bit 49 to bit 45					Bit 44 to bit 42	Bit 41 to bit 10	Bit 9 to bit 0

For S1 and S2 a value of "1" shall equal a set condition. For B, (the battery bit), a value of "1" shall equal a notification of a battery alarm. R indicates a reserved bit.

6.2.3.1.2 DSSS 88-bit message format

The DSSS 88-bit message format for the RTLS transmitter is shown in Table 5. The 88-bit message format consists of the 22-bit preamble, the 5-bit RTLS transmitter status field, a 3-bit sub-blink ID, a 32-bit field containing the RTLS transmitter ID, a 16-bit payload field, and the 10-bit CRC field for a total message length of 88 bits. The 88-bit message can be used for communicating the RTLS transmitter's 32-bit ID and either data or an exciter address or an extended RTLS transmitter ID as payload. The status field determines the content format of the payload field. The 88-bit message shall have transmission duration of 0,739 ms.

Table 5 — DSSS 88-bit message format

Preamble	Transmitter status					Sub-blink ID	Transmitter ID	Payload	CRC
22	"0"	S2	S1	B	R	3	32	Extended ID	10
22	"1"	"0"	"0"	"0"	R	3	32	Exciter ID	10
22	"1"	X	X	X	R	3	32	Indexed Data	10
Bit 87 to bit 66	Bit 65 to bit 61					Bit 60 to bit 58	Bit 57 to bit 26	Bit 25 to bit 10	Bit9 to bit 0

6.2.3.1.3 DSSS 104-bit message format

The DSSS 104-bit message format for the RTLS transmitter is shown in Table 6. The 104-bit message format consists of the 22-bit preamble, a 5-bit RTLS transmitter status field, a 3-bit sub-blink ID, a 32-bit field containing the RTLS transmitter ID, a 16-bit exciter field, an additional 16-bit address field, and a 10-bit CRC field for a total message length of 104 bits. The 104-bit message format can be used for communicating the RTLS transmitter's 32-bit ID and an extended RTLS transmitter ID and either an exciter address or data as the payload. The status field determines the content format of the payload field. The 104-bit message shall have transmission duration of 0,873 ms.

Table 6 — DSSS 104-bit message format

Preamble	Transmitter status					Sub-blink ID	Transmitter ID	Extended address	Payload	CRC
22	"0"	S2	S1	B	R	3	Reserved	Reserved	Extended ID	10
22	"1"	"0"	"0"	"0"	R	3	32	16	Exciter ID	10
22	"1"	X	X	X	R	3	32	16	Indexed data	10
Bit 103 to bit 82	Bit 81 to bit 77					Bit 76 to bit 74	Bit 73 to bit 42	Bit 41 to bit 26	Bit 25 to bit 10	Bit9 to bit 0

6.2.3.1.4 DSSS 168-bit message format

The DSSS 168-bit message format for the RTLS transmitter is shown in Table 7. The 168-bit message format consists of the 22-bit preamble, a 5-bit RTLS transmitter status field, a 3-bit sub-blink ID, a 32-bit field containing the RTLS transmitter ID, a 96-bit data field, and a 10-bit CRC field for a total message length of 168 bits. The 168-bit message shall have transmission duration of 1,410 ms.

