INTERNATIONAL STANDARD

ISO/IEC 24730-61

First edition
2013-08-01

Information technology — Real time locating systems (RTLS) —

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

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

Partie 61: Interface d'air ultra large à bas taux de bande de fréquence de répétition d'impulsion (UWB)

Reference number
ISO/IEC 24730-61:2013(E)

ISO copyright office
Case postale 56 • CH-1211 Geneva 20
Tel. + 41 22 749 01 11
Fax + 41 22 749 09 47
E-mail copyright@iso.org
Web www.iso.org

Published in Switzerland

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.

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 24730-61 was prepared by Joint Technical Committee ISO/IEC JTC 1, *Information technology*, Subcommittee SC 31, *Automatic identification and data capture techniques*.

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*

— *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

This series of standards defines an air interface protocol 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.

This document establishes an air interface technical standard for Real Time Locating Systems that operates within the 6 – 10.6 GHz unlicensed band. RTLSs 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, real time. Position is derived by measurements of the physical properties of the radio link.

Conceptually there are four classifications of RTLS:

- Locating an asset via satellite - requires line-of-sight - accuracy to 10 meters
- Locating an asset in a controlled area, e.g., warehouse, campus, airport - area of interest is instrumented - accuracy to 3 meters
- Locating an asset in a more confined area - area of interest is instrumented - accuracy to tens of centimetres
- Locating an asset over a terrestrial area using a terrestrial mounted readers over a wide area, cell phone towers for example – accuracy 200 meters

With a further two methods of locating an object which are really Radio Frequency Identification (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 signal whereby a person with a handheld can find an asset

Method of location is through identification and location, generally through multilateration types

- Time of Flight Ranging Systems
- Amplitude Triangulation
- Time Difference of Arrival (TDOA)
- Cellular Triangulation
- Satellite Multilateration
- Angle of Arrival

This standard defines the air interface protocol needed for the creation of an RTLS system. There are many types of location algorithms that could be used. Examples of location algorithms are given in Annex A.

Significant portions of this standard were excerpted from IEEE 802.15.4a-2007, *IEEE Standard for Information Technology — Telecommunications and information exchange between systems — Local and metropolitan area networks — Specific Requirements Part 15.4: Wireless Medium Access Control (MAC) and Physical Layer (PHY) Specifications for Low-Rate Wireless Personal Area Networks (WPANs) Amendment 1: Add Alternate PHYs* and from IEEE 802.15.4f-2012, *IEEE Standard for Local and metropolitan area networks — Part 15.4: Low-Rate Wireless Personal Area Networks (LR-WPANs) Amendment 2: Active Radio Frequency Identification (RFID) System Physical Layer*, copyright IEEE, and reproduced with permission by limited license from IEEE. Permission for further use of this material must be obtained from IEEE. Requests may be sent to stds-ipr@ieee.org

Information technology — Real time locating systems (RTLS) —

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

1 Scope

This part of ISO/IEC 24730 defines the physical layer (PHY) and tag management layer (TML) of an ultra wide band (UWB) air interface protocol that supports one directional simplex communication readers and tags of a real time locating system (RTLS). This protocol is best utilized for low-data-rate wireless connectivity with fixed, portable, and moving devices with very limited battery consumption requirements.

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/IEEE 8802-15-4, *Information technology — Telecommunications and information exchange between systems — Local and metropolitan area networks — Specific requirements Part 15-4: Wireless Medium Access Control (MAC) and Physical Layer (PHY) Specifications for Low-Rate Wireless Personal Area Networks (WPANs)*

ISO/IEC 15963, *Information technology — Radio frequency identification for item management – Unique identification for RF tags*

ISO/IEC 19762, *Information technology AIDC techniques — Harmonized vocabulary — (all parts)*

3 Terms, definitions, and abbreviated terms

3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO/IEC/IEEE 8802-15-4, ISO/IEC 19762 (all parts), and the following apply.

3.1.1
burst
group of ultra wide band (UWB) pulses occurring at consecutive chip periods

3.1.2
frame
format of aggregated bits from a tag management layer (TML) sublayer and/or physical layer (PHY) entity that are transmitted together in time

3.1.3
hybrid modulation
transmission methodology used in the ultra wide band (UWB) physical layer (PHY) that combines both binary phase-shift keying (BPSK) and pulse position modulation (PPM) so that both coherent and non-coherent readers can be used to demodulate the signal

3.1.4
location enhancing information postamble
LEIP
optional set of bits added after the completion of a frame that is used to enhance the ability to locate the transmitter

3.1.5
packet
formatted, aggregated bits that are transmitted together in time across the physical medium

3.1.6
real time locating system
set of radio frequency readers and associated computing equipment used to determine the position of a transmitting device relative to the placement of the reader.

3.1.7
reader
device that receives signals from radio frequency identification (RFID) or real time locating system (RTLS) transmitters.

3.1.8
tag management layer
TML
layer above the physical layer that is utilized for control and encoding of message

3.2 Symbols (and abbreviated terms)

AOA	angle-of-arrival
API	application program interface
BPM	burst position modulation
BPSK	binary phase-shift keying
CRC	cyclic redundancy check
DSN	data sequence number
ETSI	European telecommunications standards institute
FC	frame control for PHY
FCC	federal communications commission
FCS	frame check sequence
IC	Industry Canada
ITU-T	international telecommunication union – telecommunication standardization sector
LEIP	location enhancing information postamble
LRP	low rate PRF
LSbit	least significant bit
MSbit	most significant bit
OOK	on-off keying

PHR	PHY header
PHY	physical layer
PPDU	PHY protocol data unit
PPM	pulse position modulation
PRF	pulse repetition frequency
PSD	power spectral density
PSDU	PHY service data unit
RF	radio frequency
RFID	radio frequency identification
RSSI	received signal strength indicator
RTLS	real time locating system
SECDED	single error correct, double error detect
SFD	start-of-frame delimiter
SHR	synchronization header
TDOA	time difference of arrival
TFR	TML footer
THR	TML header
TML	tag management layer
TOA	time-of-arrival
TPDU	TML protocol data unit
TSD	temperature sensor data bit
UWB	ultra wide band

4 General description

4.1 Introduction

A low rate PRF (LRP) UWB RTLS network is a simple, low-cost locating network. The main objectives of an LRP UWB RTLS network are ease of installation, precision locating, medium range, and RFID auto-identification.

Some of the characteristics of an LRP UWB RTLS network are as follows:

- Over-the-air data rates of 1 Mbit/s, 250 kbit/s, 31.25 kbit/s
- ALOHA media access
- Low rate pulse repetition frequency UWB (1 or 2 MHz)
- Star wireless topology
- Low power consumption
- 3 LRP UWB frequency bands

There are many types of algorithms that could be used to determine the location of objects in the network. Examples of location algorithms are given in Annex A.

4.2 Components of the ISO/IEC 24730-61 RTLS network

The major components of an RTLS and the relationship of those components are shown in Figure 1 — RTLS components. As shown in this figure, the tags communicate with an infrastructure over an air interface. This standard defines this interface from the tag to the infrastructure. There is an optional interface from the infrastructure to the tag, whose definition is outside the scope of this standard. The infrastructure is manufacturer specific and is not within the scope of this document. The infrastructure provides an application program interface (API) through which an application can control the RTLS and retrieve information about location and state of tags. This API is defined by ISO/IEC 24730-1.

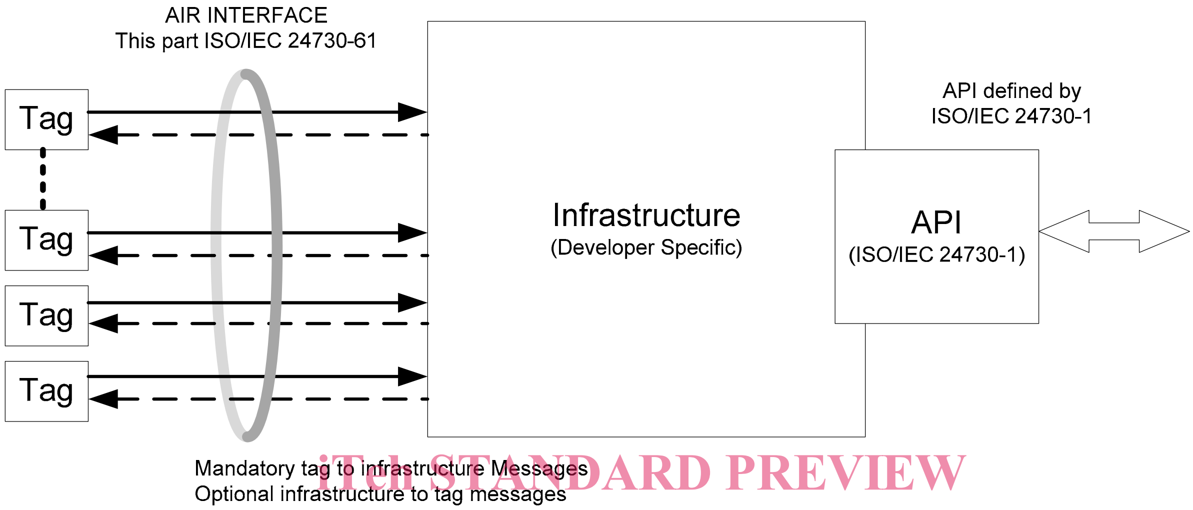

Figure 1 — RTLS components

The design of the infrastructure (e.g., the density of RTLS reader nodes, how the RTLS readers are controlled and communicate with each other, how the infrastructure is set up, etc.) is left completely to the developer. Due to variations in the design of the infrastructure, there may be large variations in vendor design as well as specific implementation scenarios.

4.3 Architecture

The ISO/IEC 24730-61 architecture is defined in terms of a number of blocks in order to simplify the standard. These blocks are called layers. Each layer is responsible for one part of the standard and offers services to the higher layers. An LRP UWB device comprises at least one PHY, which contains the radio frequency (RF) transceiver along with its low-level control mechanism, and a TML sublayer that provides access to the physical channel for all types of transfer. This layered approach is shown in Figure 2.

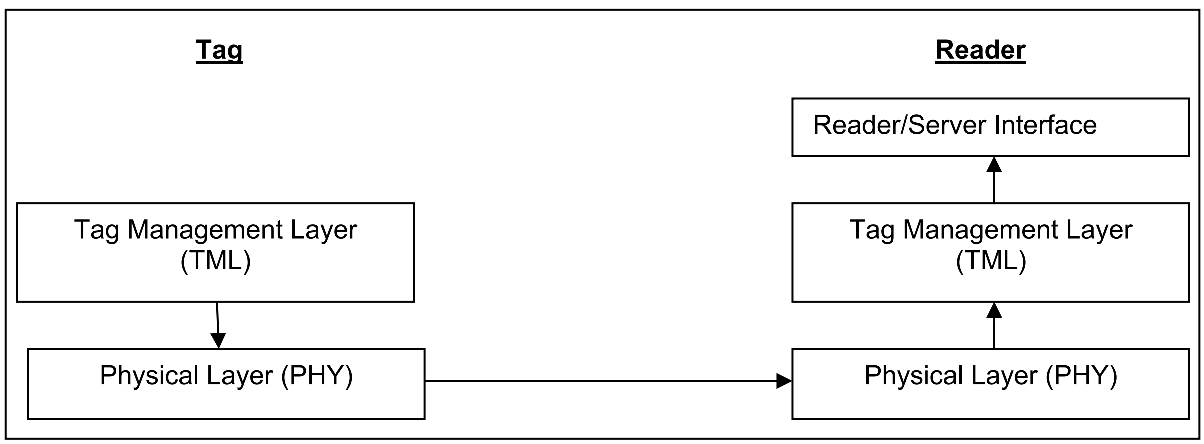

Figure 2 — LRP UWB device architecture

The upper layers, shown in Figure 2, consist of a network layer, which provides network configuration, manipulation, and message routing, and an application layer, which provides the intended function of the device. The definition of these upper layers is outside the scope of this standard.

4.4 Functional overview

A brief overview of the general functions of an LRP UWB system is given in this subclause.

4.4.1 Data transfer from tag to infrastructure reader

When a tag wishes to transfer data to an infrastructure reader, it uses an ALOHA protocol.

In the ALOHA protocol, a device transmits when it desires to transmit without sensing the medium or waiting for a specific time slot. The ALOHA mechanism is appropriate for LRP UWB networks since the probability of collision is reasonably small if the probability of clear channel is sufficiently large. In addition, the energy required for a UWB transmission is so small, it allows for rapid blink rates, thereby allowing an occasional transmission to be sacrificed for the benefits of simplifying the tag transmit protocol.

Due to the inherent broadcast nature of the ALOHA protocol, care should be taken to ensure that groups of tags that are blinking at the same rate do not overlap for long periods of time. Depending on the precision of the clock used to time the blink rate, design considerations should be considered to prevent sustained collisions between tags.

4.4.2 Frame structure

The frame structures have been designed to keep the complexity to a minimum while at the same time making them sufficiently robust for transmission on a noisy channel. Each successive protocol layer adds to the structure with the layer-specific headers and footers. The TML frames are passed to the PHY as the PHY service data unit (PSDU), which becomes the PHY payload. The PHY protocol data unit (PPDU) or PHY layer is shown in Figure 3.

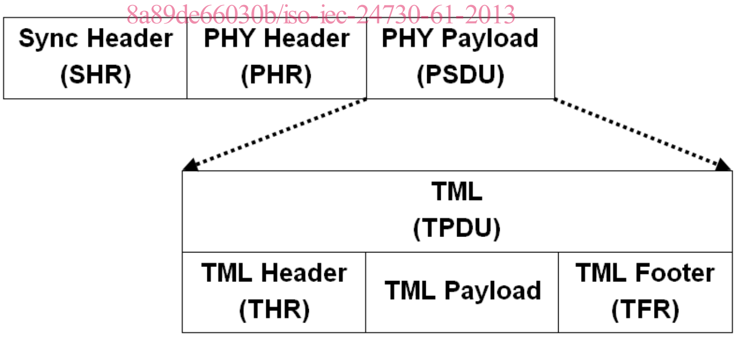

Figure 3 — PHY layer frame Structure (PPDU)

The format of the synchronization header (SHR) and PHY header (PHR) is defined in clause 5 in their respective clause.

The format of the TML header (THR) and TML footer (TFR) is defined in clause 6 in their respective clause.

4.4.3 Data verification

In order to detect bit errors, a frame check sequence (FCS) mechanism employing a 16-bit International Telecommunication Union—Telecommunication Standardization Sector (ITU-T) cyclic redundancy check (CRC) is used to detect errors in every PSDU, as defined in clause 6.10.

4.4.4 Overview of UWB options

The UWB PHY allows for operation using possibilities selected from lists of the following variables:

- Center frequencies
- Bandwidths occupied
- Pulse repetition frequencies (PRFs)
- Data rates
- Pulses per bit

5 PHY specification

5.1 General requirements and definitions

Unless otherwise specified in the PHY clause, all reserved fields shall be set to zero on transmission and may be ignored upon reception.

The LRP UWB PHY waveform is based upon an impulse radio signalling scheme using band-limited data pulses. It consists of three frequency channels and occupies the spectrum from 6.2896 to 9.1856 GHz.

A combination of on-off keying (OOK) modulation or pulse position modulation (PPM) is used to support both coherent and non-coherent readers using a common signaling scheme. The choice of OOK or PPM is used to modulate the symbols, with each symbol being composed of one or more active bursts of UWB pulses. The various data rates are supported through the use of variable-length bursts.

The LRP UWB PHY supports three transmission modes as shown in Table 1.

Table 1 — LRP UWB signalling modes and data rates

Mode	PRF (MHz)	Data Rate	Comment
Long Range Mode	2.0	31.25 kbit/s	Best Sensitivity
Extended Mode	1.0	250 kbit/s	Moderate data rate, but improved sensitivity
Base Mode	1.0	1 Mbit/s	Highest data rate

All transmit modes are optional, but all shall be implemented in the reader and operate concurrently. Active RFID systems are often simplex systems so mandatory modes are not defined for the PHY but separately for the transmitter and reader.

Where the PHY has different characteristics depending on the transmission mode, those characteristics are defined for each mode separately. Otherwise, the characteristics of the PHY are independent of transmission mode.

5.2 Modulation and data rates

A compliant device shall operate in one or more frequency bands using the modulation and spreading formats summarized in Table 2.

Table 2 — Modulations and data rates

PHY (MHz)	Chip Rate (kchip/s)	Modulation	Bit Rate (kbit/s)	Symbol Rate (ksymbol/s)	Symbols
LRP UWB (optional)	2000	Manchester PPM	31.25	31.25	Binary
LRP UWB (optional)	1000	OOK	250	250	Binary
LRP UWB (optional)	1000	OOK	1000	1000	Binary

This standard is intended to conform to established regulations in Europe, Japan, Republic of Korea, Canada, China, and the United States. The regulatory documents listed below are for information only and are subject to change and revisions at any time. Devices conforming to this standard shall also comply with specific regional legislation.

Europe:

- Approval standards: European Telecommunications Standards Institute (ETSI)
- Documents: ETSI EN 302 500-1, ETSI EN 302 500-2]
- Approval authority: National type approval authorities

United States:

- Approval standards: Federal Communications Commission (FCC), United States
- Documents: FCC CFR47, Clauses 15.247 and 15.519

Canada:

- Approval standards: Industry Canada (IC), Canada
- Document: GL36 Document: IC RSS210

5.3 LRP UWB PHY channel numbering

The LRP UWB PHY uses three possible frequencies, and the channel numbers are defined in Table 3. A total of 3 channels, numbered 0 to 2, are available in the 6289.6-9185.6 MHz frequency band.

Table 3 — LRP UWB PHY channel frequencies

Channel Number	Center Frequency (MHz)
0	6489.6
1	6988.8
2	7987.2

5.4 LRP UWB PHY symbol structure

In base mode, a LRP UWB PHY symbol consists of presence/absence of pulses in 1 MHz PRF train.

In extended mode, LRP UWB PHY symbol consists of presence/absence of pulses in 1 MHz PRF train generated by convolution code with octal generators (5, 7, 7, 7).

In long range mode, LRP UWB PHY symbol consists of Manchester-encoded groups of 64 pulses (32 on, 32 off) in 2 MHz PRF train.