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Information technology — Real time locating systems (RTLS) —

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

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

Partie 21: Protocole d'interface d'air à 2,4 GHz d'étalement de spectre à séquence directe (DSSS): Émetteurs fonctionnant avec un code d'étalement unique et utilisant un codage de données DBPSK et un schéma d'étalement BPSK

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Foreword

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

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

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 24730-2 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 24730-21, together with ISO/IEC 24730-2 and ISO/IEC 24730-22, 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 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 5: Chirp spread spectrum (CSS) at 2,4 GHz air interface*

— *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 24730-21 defines the physical layer for compliant RTLS transmitters operating with a single spread code and employing a DBPSK data encoding and BPSK spreading scheme.

Information technology — Real time locating systems (RTLS) —

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

1 Scope

ISO/IEC 24730-2 is comprised of a main document and two additional parts and defines a networked location system that provides X-Y coordinates and data telemetry. The system utilizes 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 specifies transmitters operating with a single spread code and employing a differential binary phase shift keying (DBPSK) data encoding and binary phase shift keying (BPSK) 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 24730-2:2011, *Information technology — Real time locating systems (RTLS) — Part 2: Direct Sequence Spread Spectrum (DSSS) 2,4 GHz air interface protocol*

ISO/IEC 24730-22:2011, *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*

3 Terms and definitions

For the purposes of this document, the terms and definitions provided in ISO/IEC 24730-2 apply.

4 Symbols and abbreviated terms

For the purposes of this document, the symbols and abbreviated terms provided in ISO/IEC 24730-2 apply.

5 Requirements

5.1 Frequency range

For the purposes of this document, the frequency range provided in ISO/IEC 24730-2 applies.

5.2 2,4 GHz spread spectrum air interface attributes

For the purposes of this document, the 2,4 GHz spread spectrum air interface attributes provided in ISO/IEC 24730-2 apply.

5.3 Compliance requirements

For the purposes of this document, the compliance requirements provided in ISO/IEC 24730-2 apply.

5.4 Manufacturer tag ID

For the purposes of this document, the manufacturer tag ID provided in ISO/IEC 24730-2 applies.

5.5 Physical layer parameters

The parameter definitions in Table 1 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.

An optional mode is defined for utilization in Japan. This allows the operation in conformance with local radio regulations in Japan. This mode shall be used for systems that will be operated in Japan. Link parameters for this mode are defined in Table 2a.

Table 3 and Table 4 specify the parameters for the optional air interfaces that may be implemented.

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	BPSK DSSS
Data encoding	Differentially encoded
Data bit rate	59,7 kb/s
Bit error rate	0,001%
PN chip rate	30,521875 MHz ± 25 ppm
PN code length	511
PN spread code	0x1CB

Parameter name	Description
Data packet lengths	Option 1: 56 bits Option 2: 72 bits Option 3: 88 bits Option 4: 152 bits
Message CRC polynomial	$G(x) = X^{12} + X^{11} + X^3 + X^2 + X + 1$
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	125 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 2a — RTLS transmitter DSSS link parameters for Japan Mode

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	26 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	BPSK DSSS
Data encoding	Differentially encoded
Data bit rate	59,7 kb/s
Bit error rate	0,001%
PN chip rate	15,260938 MHz ± 25 ppm
PN code length	511
PN spread code	0x8D
Data packet lengths	Option 1: 56 bits Option 2: 72 bits Option 3: 88 bits Option 4: 152 bits
Message CRC polynomial	$G(x) = X^{12} + X^{11} + X^3 + X^2 + X + 1$
CRC polynomial initialized value	0x001
Blink interval	Programmable, 5 s minimum
Blink interval randomization	± 638 ms maximum

Parameter name	Description
Number of sub-blinks	Programmable, 1 - 8
Sub-blink interval randomization	125 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 3 — RTLS transmitter OOK link parameters

Parameter Number	Parameter Name	Description
O 1a	Carrier frequency	2400 MHz - 2483,5 MHz
O 1b	Operating frequency accuracy	± 25 ppm maximum
O 1c	Centre frequency	2441,750 MHz
O 2a	Data encoding	Differentially encoded
O 2b	Data packet lengths	Option 1: 88 bits Option 2: 184 bits
O 2c	Message CRC polynomial	$G(x) = X^{16} + X^{12} + X^{5} + 1$
O 2d	CRC polynomial initialized value	0x0001
O 3	Transmit power	Class 1: 10 dBm EIRP max. Class 2: Max. per local radio regulations
O 4	Transmit spurious emissions, out of band	Within local radio regulations
O 5	Modulation	OOK/FSK, using 2 tones @ 376,8 kHz /535,5 kHz
O 5a	Logic “0”	19 cycles at a 377 kHz rate of 2,44652 GHz on/off
O 5b	Logic “1”	27 cycles at a 535 kHz rate of 2,44652 GHz on/off
O 6	Data rate	19,83 kb/s
O 7	Duty cycle	50%
O 8	Data error rate	0,001% max.

Table 4 — RTLS transmitter magnetic link parameters

Parameter Number	Parameter Name	Description
M 1	Signalling frequencies	114,688 kHz and 126,976 kHz
M 2	Field strength	Regulatory/application dependent
M 3	Bit data rate	2,048 kb/s
M 4	Symbol period	244,14 ms
M 5	Data error rate	0,001%
M 6	Start sync.	3 symbol periods @ 114,688 kHz followed by 3 symbol periods @ 126,976 kHz
M 7	End sync.	3 symbol periods @ 126,976 kHz followed by 3 symbol periods @ 114,688 kHz
M 8	Data bit 0	1 symbol period @ 126,976 kHz followed by 1 symbol period @ 114,688 kHz
M 9	Data bit 1	1 symbol period @ 114,688 kHz followed by 1 symbol period @ 126,976 kHz
M 10a	Programmer packet lengths	Option 1: 10 bits Option 2: 48 bits Option 3: 64 bits Option 4: 68 bits Option 5: 144 bits Option 6: 160 bits
M 10b	Exciter packet lengths	Option 1: 10 bits Option 2: 28 bits Option 3: 44 bits Option 4: 144 bits
M 11	Data encoding	Manchester encoding
M 12a	Programmer message CRC polynomial	$G(X) = X^{12} + X^{11} + X^3 + X^2 + X^1 + 1$
M 12b	28-bit exciter CRC polynomial	$G(X) = X^8 + X^4 + X^3 + X^2 + 1$
M 12c	44-bit exciter CRC polynomial	$G(X) = X^{12} + X^{11} + X^3 + X^2 + X^1 + 1$
M 12d	10-bit programmer / exciter CRC polynomial	$G(X) = X^4 + X^1 + 1$

6 Mandatory air interface protocol specification

6.1 General

ISO/IEC 24730-21 defines the 2,400 GHz to 2,4835 GHz RTLS spread-spectrum transmissions and the command/data level air interface communication protocols. These protocols facilitate communication between a compliant RTLS transmitter and a compliant infrastructure. The optional protocols in clause 7 facilitate communication between an RTLS transmitter and a programming device and also an exciter device respectively. The timing parameters and signal characteristics for the protocols are defined in the physical link specification in clause 5.

6.2 Introduction

Beacon type RTLS system architecture consists of RTLS transmitters that “blink” a Direct Sequence Spread Spectrum (DSSS) signal, and fixed position RTLS readers that receive those signals. The system then 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.

6.3 Functional Description and Specification

The RTLS transmitter module is typically a compact internally powered radio frequency device that is a component 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 RTLS transmitters ID. 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 by 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 part of a multiple level anti-interference system; time diversity, spatial diversity, processing gain. The combination of these multiple sub-blinks, multiple receiving antennas and spread spectrum correlation also allow multiple RTLS transmitters to blink simultaneously and still be received.

The RTLS transmitter data shall be binary encoded with the MSB (Most Significant Bit) transmitted first in all messages. It is differentially encoded using the example circuit of Figure 1. The output of the encoder shall be initialized to "1". It shall be exclusively OR’d with the output of the PN (Pseudo Noise) generator, modulated using a BPSK (Bi-Phase Shift Keyed) format and upconverted using a single sideband upconverter. The signal is then amplified and transmitted to the RTLS infrastructure.

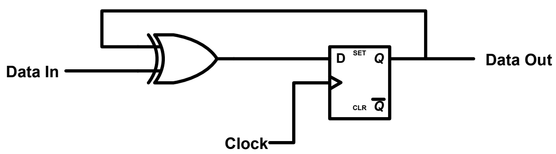

Figure 1 — Example of differential encoding circuit

An example of the RTLS transmitter PN Generator is shown in Figure 2.

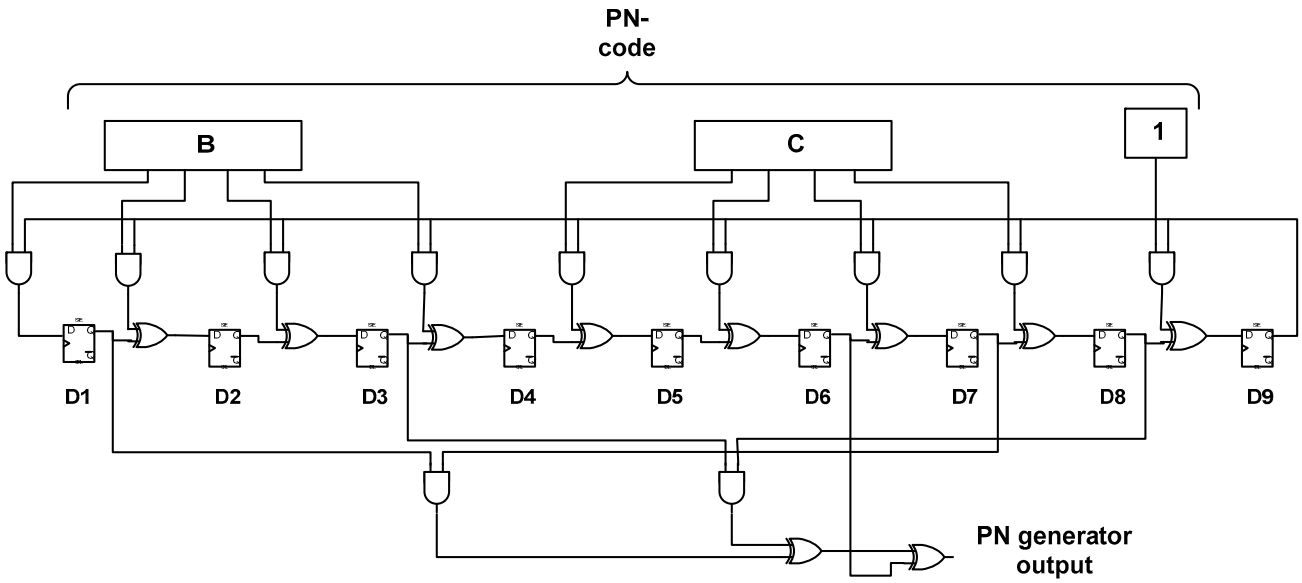

Figure 2 — RTLS transmitter PN generator

An example of the RTLS transmitter PN Generator for Japan mode is shown in Figure 3a.

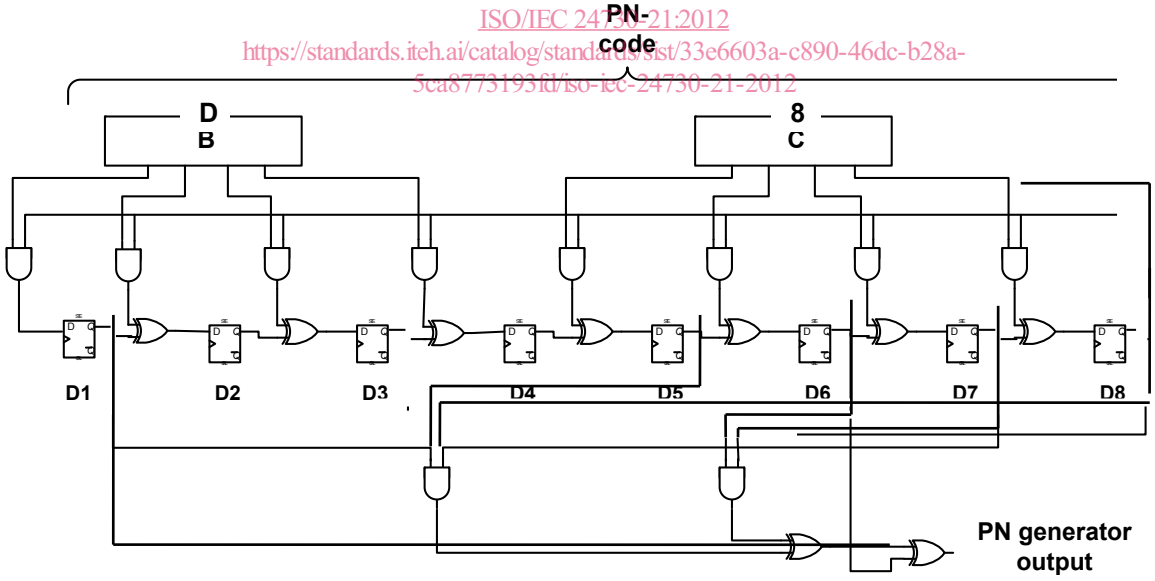

Figure 3a — RTLS transmitter PN generator for Japan Mode

Data encoding and transmission process is shown below in Figure 4.

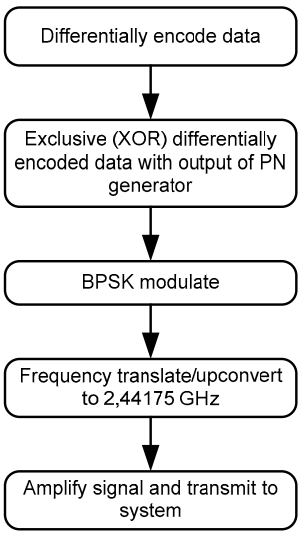

Figure 4 — RTLS transmitter data encoding and transmission process

The format of the DSSS transmission from the RTLS transmitter is shown in Figure 5. 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 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.

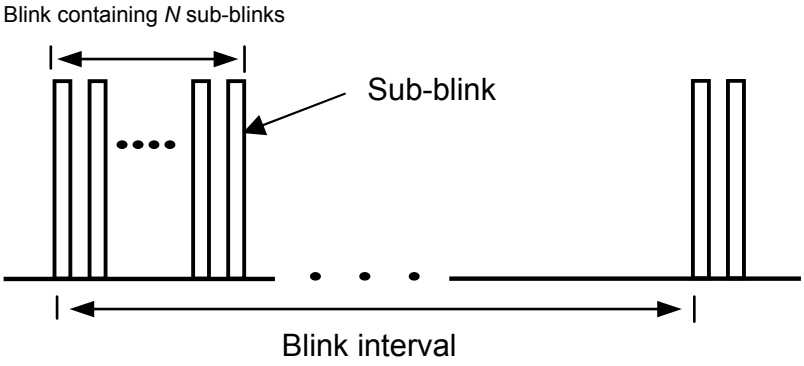

Figure 5 — DSSS air interface

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 6.

Note: For Figure 6 and all future figures, solid lines denote required features and dotted lines denote optional features.