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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

Reference number
ISO/IEC 24730-21:2012(E)

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 24730-2 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.

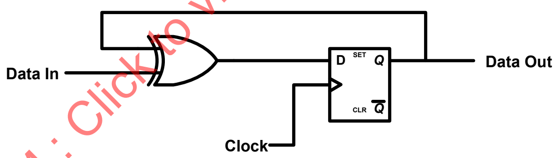

Figure 1 — Example of differential encoding circuit

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

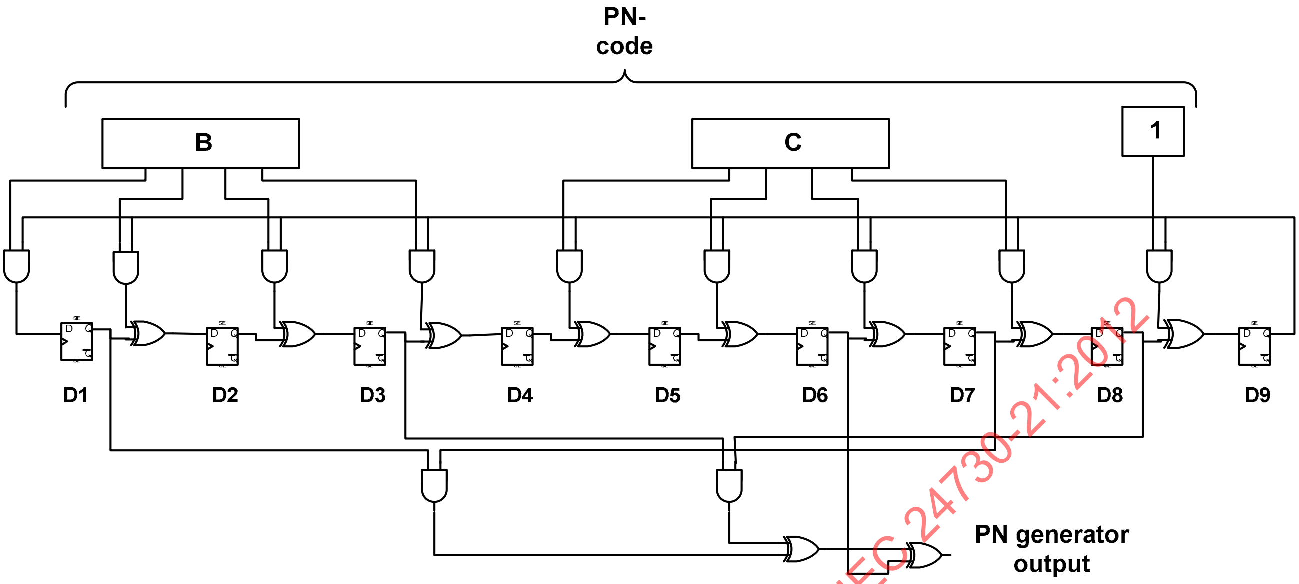

Figure 2 — RTLS transmitter PN generator

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

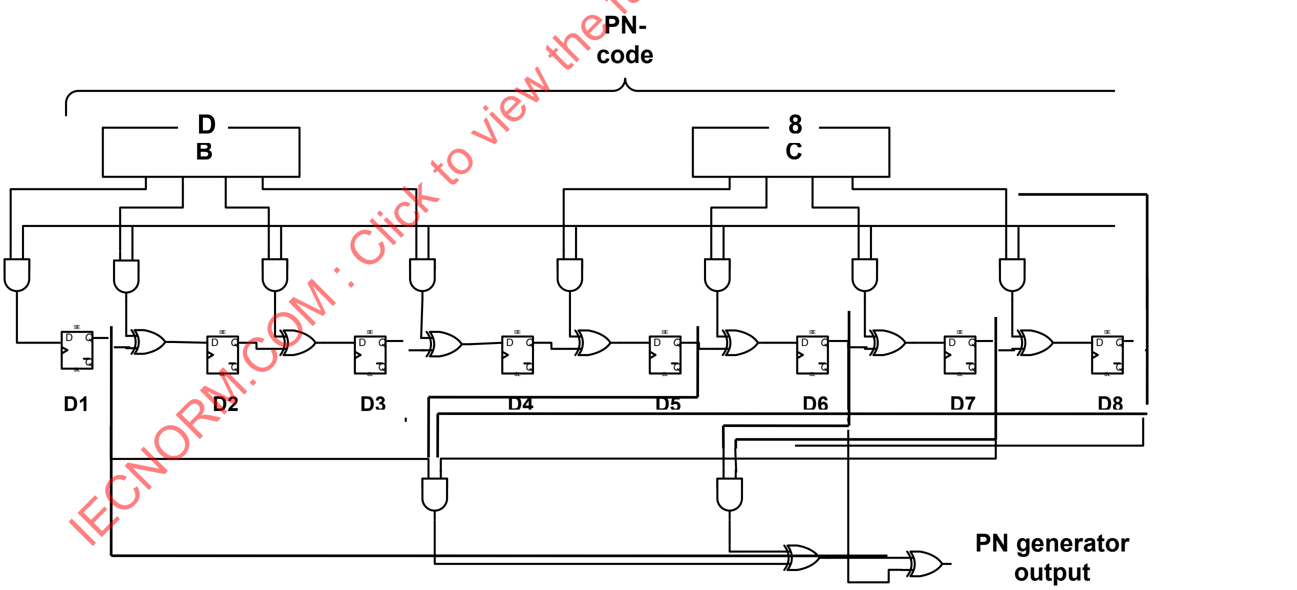

Figure 3a — RTLS transmitter PN generator for Japan Mode

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

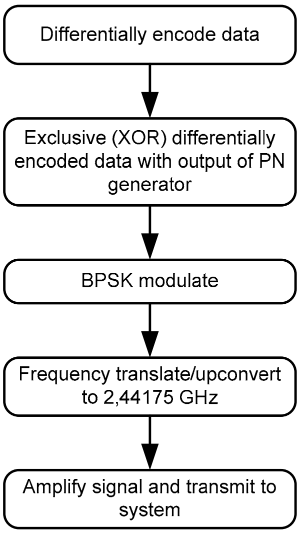

Figure 4 — RTLS transmitter data encoding and transmission process

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.

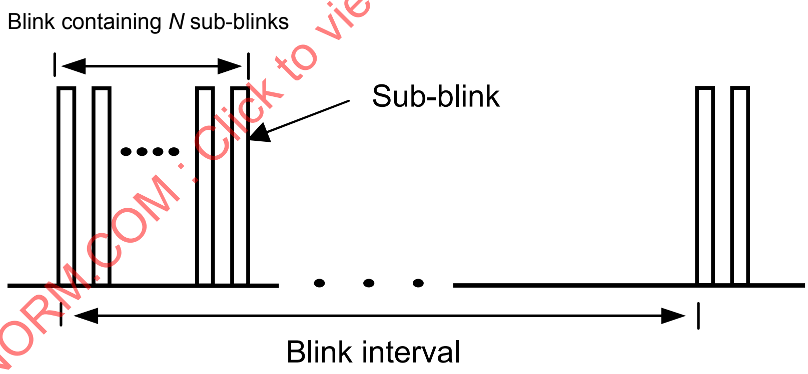

Figure 5 — DSSS air interface

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.

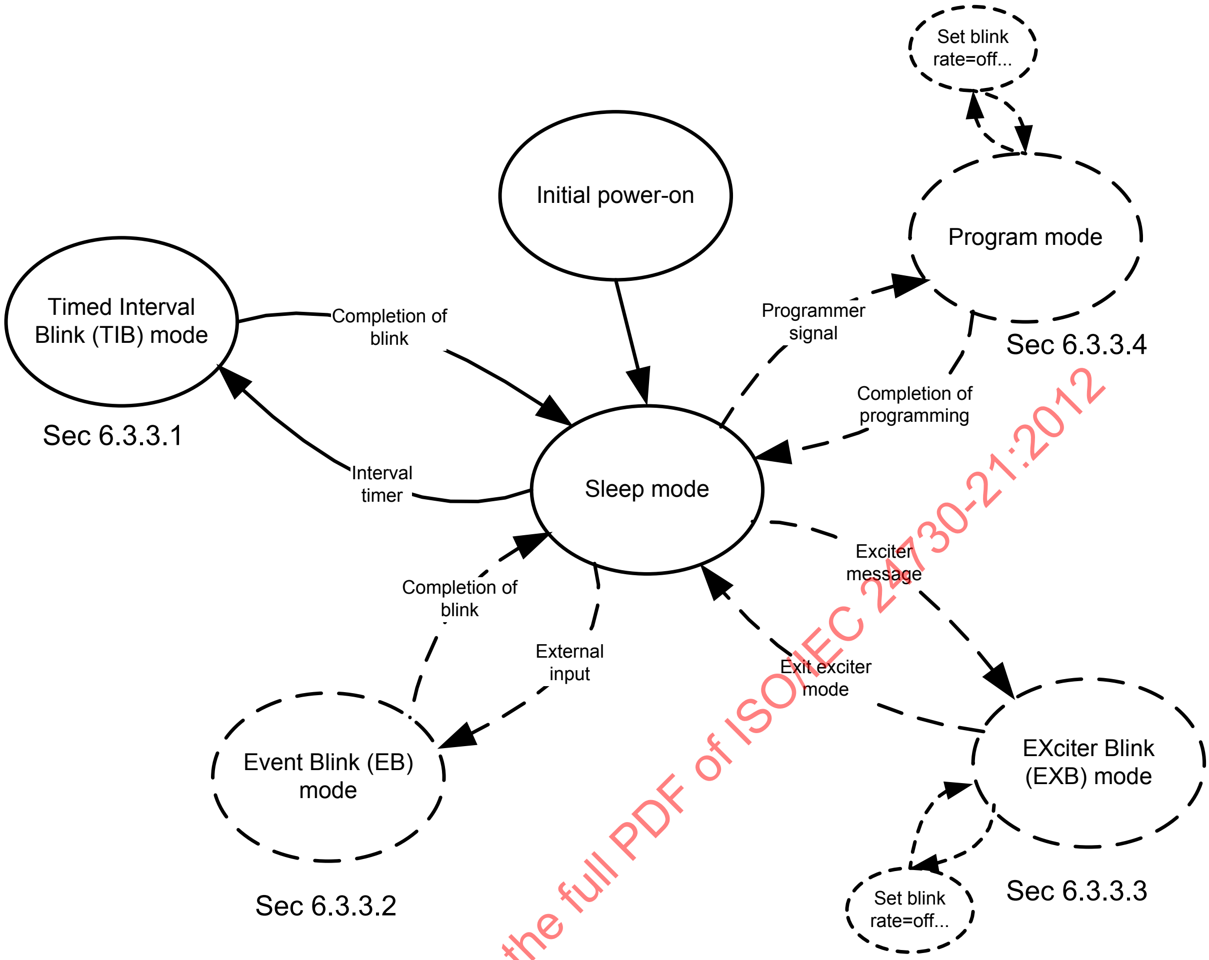

Figure 6 — RTLS transmitter state diagram

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

6.4 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.

6.5 DSSS message specifications

The message specifications are provided below.

6.5.1 DSSS message encoding

The PN Spreading Code shall be 0x1CB. The PN Generator is initialized with a “1” in register D9 and “0”’s in all other registers.

The beginning of the blink interval shall be randomized by a maximum of ±638 ms to avoid repeatedly colliding with blinks from other RTLS transmitters. The beginning of each successive sub-blink shall also be randomized. The interval between each sub-blink shall be 125 ms randomized by a maximum of ±16 ms from the beginning of the previous sub-blink.

6.5.2 DSSS message structures

There are four different message formats determined by the length of the message in bits: the 56-bit message, the 72-bit message, the 88-bit message, and the 152-bit message. An RTLS transmitter shall be capable of transmitting at least one of these message formats. The 56-bit and 72-bit message format is intended for transmitting the RTLS transmitter ID, the 72 and 88-bit messages are intended for transmitting the RTLS transmitter ID and exciter information, and the 152-bit message format is intended for transmitting limited amounts of telemetry information. The structure of each of these message formats is shown in more detail in the following sections.

Each message type contains an 8-bit preamble of 0x01.

Each message type contains a 4-bit RTLS transmitter status as defined in the message definitions.

72- and 88-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.

Each message type contains a CRC generator polynomial defined by X12 + X11 + X3 + X2 + X + 1. The preamble is not included in this polynomial.

Each message contains a 32-bit RTLS transmitter ID. These ID’s are defined in the range 1 to 4 294 967 296 (0x00000001 to 0xFFFFFFFF).

Unique data to the each message type is shown.

6.5.2.1 DSSS 56-bit message format

The DSSS 56-bit message format for the RTLS transmitter is shown in Table 5. The 56-bit message format consists of the 8-bit preamble, the 4-bit RTLS transmitter status field, a 32-bit field containing the RTLS transmitter ID, and the 12-bit CRC field for a total message length of 56 bits. The 56-bit message shall have transmission duration of 937.5 µs.

Table 5 — DSSS 56-bit message format

Preamble	RTLS transmitter status				RTLS transmitter ID	CRC
8	"0"	S2	S1	B	32	12
8	"1"	Reserved			32	12
Bit 55 to bit 48	Bit 47 to bit 44				Bit 43 to bit 12	Bit 11 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.

6.5.2.2 DSSS 72-bit message format

The DSSS 72-bit message format for the RTLS transmitter is shown in Table 6. The 72-bit message format consists of the 8-bit preamble, the 4-bit RTLS transmitter status field, a 32-bit field containing the RTLS transmitter ID, a 16-bit payload field, and the 12-bit CRC field for a total message length of 72 bits. The 72-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 72-bit message shall have transmission duration of 1.205 ms.

Table 6 — DSSS 72-bit message format

Preamble	RTLS transmitter status				RTLS transmitter ID	Payload	CRC
8	"0"	S2	S1	B	32	Extended ID	12
8	"1"	"0"	"0"	"0"	32	Exciter ID	12
8	"1"	X	X	X	32	Indexed Data	12
Bit 71 to bit 64	Bit 63 to bit 60				Bit 59 to bit 28	Bit 27 to bit 12	Bit11 to bit 0

6.5.2.3 DSSS 88-bit message format

The DSSS 88-bit message format for the RTLS transmitter is shown in Table 7. The 88-bit message format consists of an 8-bit preamble, a 4-bit RTLS transmitter status field, a 32-bit field containing the RTLS transmitter ID, a 16-bit exciter field, an additional 16-bit address field, and a 12-bit CRC field for a total message length of 88 bits. The 88-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 88-bit message shall have transmission duration of 1,473 ms.

Table 7 — DSSS 88-bit message format

Preamble	RTLS transmitter status				RTLS transmitter ID	Extended address	Payload	CRC
Reserved	"0"	S2	S1	B	Reserved	Reserved	Reserved	Reserved
8	"1"	"0"	"0"	"0"	32	16	Exciter ID(16)	12
8	"1"	X	X	X	32	16	Indexed data(16)	12
Bit 87 to bit 80	Bit 79 to bit 76				Bit 75 to bit 44	Bit 43 to bit 28	Bit 27 to bit 12	Bit11 to bit 0

6.5.2.4 DSSS 152-bit message format

The DSSS 152-bit message format for the RTLS transmitter is shown in Table 8. The 152-bit message format consists of an 8-bit preamble, a 4-bit RTLS transmitter status field, a 32-bit field containing the RTLS transmitter ID, a 96-bit data field, and a 12-bit CRC field for a total message length of 152 bits. The 152-bit message shall have transmission duration of 2,544 ms.

Table 8 — DSSS 152-bit message format

Preamble	RTLS transmitter status				RTLS transmitter ID	Payload			CRC
8	X	S2	S1	B	32	96			12
8	X	S2	S1	B	32	60-DF	16 ext ID	72	12
Bit 151 to bit 144	Bit 143 to bit 140				Bit 139 to bit 108	Bit 107 to bit 100	Bit 99 to bit 84	Bit 83 to bit 12	Bit 11 to bit 0

6.5.3 DSSS message modes

There are multiple message modes. These modes allow the system to be matched to the application requirements, by providing the ability to: minimize airtime, transmit exciter ID's, transmit event notifications, or transmit telemetry data.

6.5.3.1 Timed Interval Blink (TIB) mode

Timed Interval Blink mode transmits one of four message types transmitted over the DSSS link. The following parameters may be configurable in conformance with the specifications provided.

6.5.3.1.1 Number of sub-blinks

The number of sub-blinks transmitted by the RTLS transmitter during a TIB may be configurable. If the number of sub-blinks is configurable, they shall be configurable from 1 to 8 sub-blinks per blink.

6.5.3.1.2 Blink interval

The blink interval of TIB transmissions may be configurable. The minimum blink interval shall be 5 s. A command to set the blink interval to 0 shall disable an RTLS transmitter.

6.5.3.1.3 152-bit blink repetition rate

The 152-bit blink repetition rate shall define the TIB repetition rate for 152-bit messages. Available intervals shall be every 8^{th} blink, every 64^{th} blink, always or never.

6.5.3.2 Event Blink (EB) mode

Events are defined as pushbutton activation, slide switch toggles, or other external inputs. Event blinks shall occur only after an event is detected. After an event is detected, the RTLS transmitter shall blink from 1 to 15 times as programmed. The minimum blink interval shall be 5 s. An EB shall be 56, 72, or 152 bits in length.

If the transmitter is disabled an event shall not cause a blink.

6.5.3.2.1 Number of event blinks

The number of EBs for the RTLS transmitter should be configurable from 0 to 15 blinks per event.

6.5.3.2.2 Event blink interval

The event blink Interval shall be 5 s or greater.

6.5.3.2.3 Event blink re-trigger time

The event blink re-trigger interval is defined as the time to ignore the same event input after the last blink. The event blink re-trigger interval period shall be 5 s or greater.

6.5.3.3 EXciter Blink (EXB) mode

If supported, EXciter Blink Mode allow the system to modify the RTLS transmitter blink rate to provide a different blink rate or a finer level of location by providing a locate function with regard to the exciter.

6.5.3.4 Program mode

If supported, Program mode allows an RTLS transmitter to have operational parameters programmed. The RTLS transmitter may also be turned on and off in this mode.

7 Optional air interfaces

7.1 General

The RTLS transmitter may support the use of a programmer and an exciter. If the RTLS transmitter does support the use of these devices, then it shall comply with the following clauses.

7.2 RTLS transmitter OOK/FSK message specifications

If the RTLS transmitter does support the use of a programmer, then it shall respond to the programmer with OOK/FSK messages as defined below.

7.2.1 OOK/FSK blink message description

The RTLS transmitter may include a method to respond to a programming device.

If the RTLS transmitter includes this capability, the transmitter shall receive commands transmitted using magnetic FSK and use OOK/FSK transmissions to respond to the programming device. The programming device may be used to write and read configuration information, load data registers, and/or read the identity from the RTLS transmitter.

If external programming and/or data load is supported, there shall be two different message lengths, 88-bit and 184-bit. The structure of the 88-bit message shall include a 24-bit preamble, an 8-bit status field, a 32-bit tag ID, an 8-bit ACK, a 16-bit CRC. The structure of the 184-bit message shall add 96 bits of data between the ACK and the CRC.

The data transmitted shall be differentially encoded and start with logic “0”. The FSK rate shall correspond to the differential data with 376.8 kHz representing logic “0”, and 535.5 kHz representing logic “1”. Each bit period shall be 50.423 ms.

7.2.2 OOK/FSK message encodation

A logical “0” shall be represented by 19 cycles at a 377 kHz rate of 2.44652 GHz RF signal. A logical “1” shall be represented by 27 cycles at a 535 kHz rate of 2,44652 GHz RF signal. The OOK/FSK message encodation is shown in Figure 7 below.

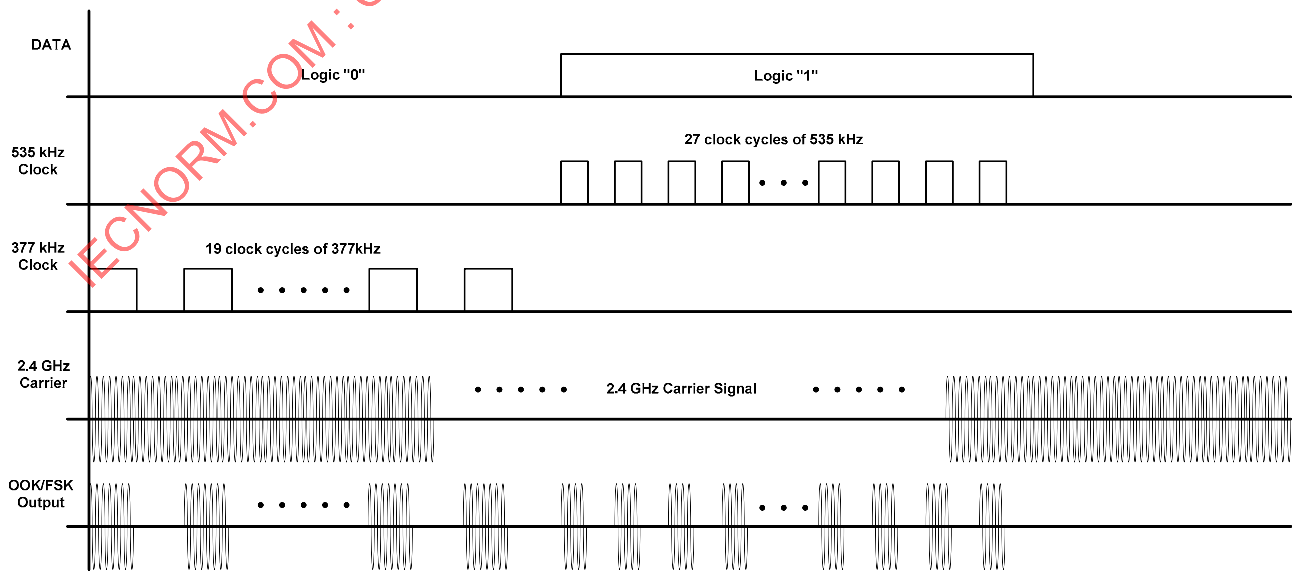

Figure 7 — OOK/FSK message encodation

7.2.3 OOK/FSK message formats

Table 9 shows the message structure that shall be used for an 88-bit OOK/FSK message.

Table 9 — OOK/FSK 88-bit message structure

Bits	Field length	Description
87 to 64	24-bit	Preamble = “0x00F7BC”
63 to 56	8-bit	Tag Status (= 0000 + the RTLS transmitter’s last status sent via a DSSS message)
55 to 24	32-bit	Tag ID
23 to 16	8-bit	ACK, $G(x) = x^8 + x^4 + x^3 + x^2 + 1$ in response to magnetic messages of 28 bits or more ACK shall be 0x00 in response to magnetic messages of less than 28 bits
15 to 0	16-bit	Message CRC: $G(x) = x^{16} + x^{12} + x^5 + 1$

Table 10 shows the message structure that shall be used for a 184-bit OOK/FSK message.

Table 10 — OOK/FSK 184-bit message structure

Bits	Field Length	Description
183 to 160	24-bit	Preamble = “0x00F7BC”
159 to 152	8-bit	Tag status (= 0000 + the RTLS transmitter’s last status sent via a DSSS message)
151 to 120	32-bit	Tag ID
119 to 112	8-bit	ACK = 0x00
111 to 16	96-bit	Data payload
15 to 0	16-bit	Message CRC: $G(x) = x^{16} + x^{12} + x^5 + 1$

7.2.4 OOK/FSK message modes

OOK/FSK messages may be supported. If OOK/FSK messages are supported they shall comply with the all OOK/FSK specifications. OOK/FSK messages shall be response to valid queries received by the RTLS transmitter through the magnetic link.

7.2.4.1 OOK 88-bit message mode

The RTLS transmitter may support a Who-Are-You function. In order to use this function a programmer shall be required to receive the OOK response.

When the RTLS transmitter’s receiver acquires a magnetic link message with an exciter ID of 0010, it shall not transmit a DSSS message, but shall transmit an 88-bit OOK message containing its 32-bit ID. The OOK message contains a 24-bit preamble, an 8-bit status, a 32-bit ID, an 8-bit op-code (always 0), and a 16-bit CRC.

7.2.4.2 OOK 184-bit message mode

The RTLS transmitter may support OOK 184-bit messages. In order to use this function a programmer would be required to receive the OOK response.

When the RTLS transmitter's receiver acquires a valid programmer or exciter message with an ID of 0100, it shall not transmit a DSSS message, but shall transmit an OOK message containing its 32-bit ID and the last programmed 96-bit data payload. The 184 bit OOK message shall contain a 24-bit preamble, an 8-bit status, a 32-bit ID, an 8-bit op-code (always 0), a 96-bit data payload, and a 16-bit CRC.

7.2.5 RTLS transmitter OOK/FSK link

Table 3 lists the physical link specifications for the RTLS transmitter.

7.3 Programmer magnetic FSK message specifications

If the RTLS transmitter does support the use of a programmer, then the programmer shall transmit messages to the RTLS transmitter with magnetic FSK messages as defined below. Additional messages may also be used as determined by the manufacturer.

7.3.1 Programmer command interface description

An RTLS programmer may be capable of transmitting the RTLS transmitter configuration and/or data payload magnetically to the RTLS transmitter. The programmer may also be capable of transmitting direct sequence spread spectrum (DSSS) data to the RTLS infrastructure (emulating an RTLS transmitter).

If used, the interface from the programmer to the RTLS transmitter shall be via an FSK magnetic signal using Manchester encoding. The response from the RTLS transmitter to the programmer for acknowledgements shall be via the previously defined OOK/FSK RF signal as defined in 7.1.2.

7.3.2 Programmer configuration message protocol

The programmer configuration message is used to set the transmitters configurable parameters and operating modes.

The message exchange between the programmer and the RTLS transmitter shall be as shown in Figure 8.

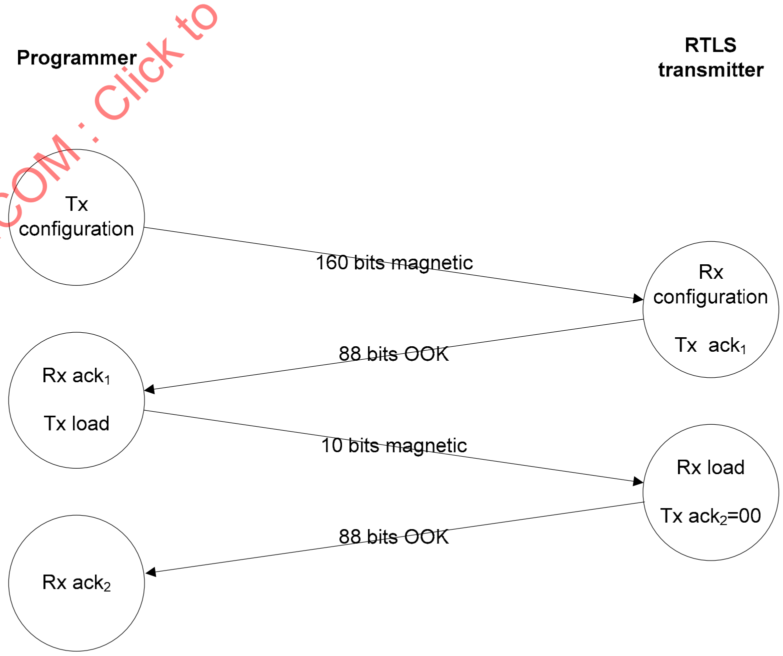

Figure 8 — Write configuration message exchange

The programmer configuration message shall consist of a 160-bit magnetic message containing

- 4-bit op-code = “1010”,
- 32-bit RTLS transmitter ID,
- 112-bit RTLS transmitter configuration,
- 12-bit message CRC.

The 160-bit configuration message is preceded by 200 ms of an alternating “1” and “0” signal at the symbol rate defined in 7.1.1. This signal shall cause the magnetic receiver to stay active until the message is received. The configuration message from the programmer to the RTLS transmitter shall be Manchester coded. The format of the 160-bit configuration message is shown in Table 11.

Table 11 — Programmer configuration message format (160 bits)

Bits	Description
159 to 156	Op-code = "1010"
155 to 124	Message ID = RTLS transmitter ID
123 to 92	RTLS transmitter ID, RTLS transmitter ID will assume after configuration
91 to 88	TIB interval
87 to 85	Number of sub-blinks per TIB
84 to 75	DSSS PN code
74 to 72	Reserved = “000”
71	Reserved = “0”
70 to 67	Number of exciter blinks
66 to 64	Exciter blink interval
63 to 61	Exciter re-trigger mode
60 to 55	Event configuration
54 to 52	Reserved = "000"
51 to 48	Number of event blinks
47 to 45	Event blink interval
44 to 42	Event blink re-trigger time
41 to 40	Reserved = "00"
39	Reserved = "0"
38 to 36	Reserved = "100"
35 to 32	Alternate exciter blink mode interval
31 to 29	Alternate exciter blink mode duration
28	Sib field-dependent re-trigger
27 to 25	Reserved = "011"
24 to 21	Reserved = "0000"
20	Reserved = "0"
19	Rx on interval, 200 ms or 500 ms
18	Reserved = "0"
17 to 16	DSSS long message interval
15	Reserved = "0"
14	Reserved = "0"
13 to 12	Reserved = "00"
11 to 0	Message CRC $G(x) = x^{12} + x^{11} + x^{3} + x^{2} + x^{1} + 1$

The RTLS transmitter shall respond within 1.5 s via OOK/FSK if the programmer's message meets the following requirements:

- the message is 160 bits,
- the message ID matches the RTLS transmitter's ID,
- the op-code field is "1010",
- the 12-bit CRC check passes.

The OOK/FSK message contains

- 24-bit preamble,
- the RTLS transmitter's 8-bit status,
- 32-bit ID,
- 8-bit CRC ACK calculated on the magnetic message,
- 16-bit OOK message CRC.

The format of the acknowledgement (ACK) message is shown in Table 12.

Table 12 — Acknowledgement message format

Bits	Description
87 to 64	Preamble = "0x00F7BC"
63 to 56	RTLS transmitter status
55 to 24	RTLS transmitter ID
23 to 16	ACK CRC: $G(x) = x^8 + x^4 + x^3 + x^2 + 1$
15 to 0	Message CRC: $G(x) = x^{16} + x^{12} + x^5 + 1$

If the programmer receives the OOK/FSK acknowledgement and verifies the message content, the programmer shall send a 10-bit message, 11 0000 0110, preceded by 200 ms of an alternating "1" and "0" signal at the symbol rate defined in 7.1.1. This signal shall cause the magnetic receiver to stay active until the message is received.

Once validated, the RTLS transmitter shall load the new configuration into the RTLS transmitter's internal registers. The RTLS transmitter shall respond via OOK/FSK. This OOK/FSK message shall contain

- 24-bit preamble,
- 8-bit status,
- 32-bit ID,
- 8-bit ACK = "00",
- 16-bit OOK message CRC.

The format of the acknowledge message to the load command is shown in Table 13.

Table 13 — Load acknowledgement message format

Bits	Description
87 to 64	Preamble = "0x00F7BC"
63 to 56	RTLS transmitter status
55 to 24	RTLS transmitter ID
23 to 16	ACK CRC = "0x00"
15 to 0	Message CRC: $G(x) = x^{16} + x^{12} + x^5 + 1$

7.3.3 Programmer data message protocol

The programmer can send 96 bits of data payload to the RTLS transmitter that can be transmitted either via DSSS to the infrastructure or OOK/FSK to a programmer.

The message exchange between the programmer and the RTLS transmitter shall be as shown in Figure 9.

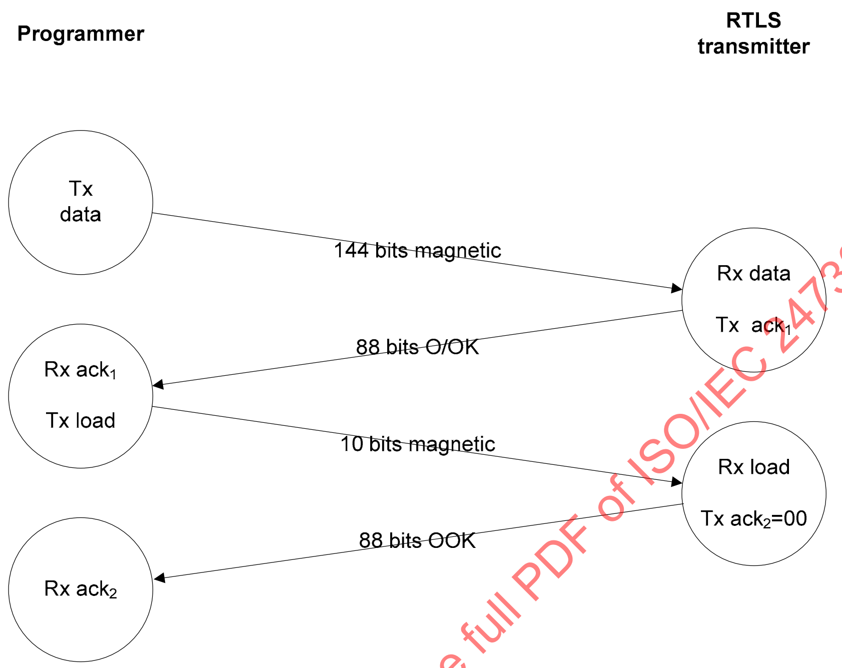

Figure 9 — write data message protocol

The programmer shall send a 144-bit magnetic message containing

- 4-bit op-code = "1000",
- 32-bit RTLS transmitter ID,
- 96-bit user data,
- 12-bit message CRC.

The 144-bit data message is preceded by 200 ms of an alternating “1” and “0” signal at the symbol rate defined in 7.1.1. This signal shall cause the magnetic receiver to stay active until the message is received. The format of the 144-bit programmer data message is shown in Table 14.

Table 14 — Programmer data message format

Bits	Description
143 to 140	Op-code = "1000"
139 to 108	Message ID = RTLS transmitter ID or wild card 0x00000000
107 to 12	User data
11 to 0	Message CRC: $G(x) = x^{12} + x^{11} + x^3 + x^2 + x^1 + 1$

The RTLS transmitter shall acknowledge and load the programmer data message using the same procedure as is used for the programmer configuration message discussed in 7.2.2. The acknowledgement messages between the RTLS transmitter and the programmer are shown in Table 12 and Table 13.

7.3.4 Write indexed data command (68-bit)

The following commands all cause the RTLS transmitter to respond with DSSS transmission as defined by the EXB portion of 6.3.3.3.

The message exchange between the programmer and the RTLS transmitter shall be as shown in Figure 10.

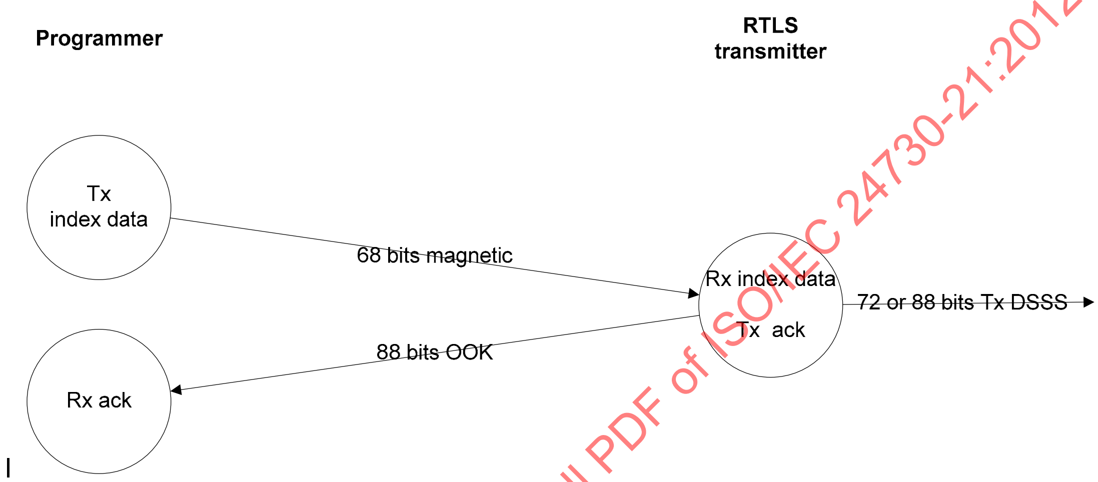

Figure 10 — Write indexed data message protocol

The 88-bit data message is preceded by 200 ms of an alternating “1” and “0” signal at the symbol rate defined in 7.1.1. This signal shall cause the magnetic receiver to stay active until the message is received.

The type of transmission and the data included shall depend on the op-code of the command. See Table 15 for bit definitions of the magnetic commands. The RTLS transmitter shall respond with an OOK/FSK ACK and DSSS blinks if the message is validated for length, op-code, and CRC. The OOK/FSK ACK response shall be as defined below:

- 24-bit preamble,
- 8-bit status,
- 32-bit RTLS transmitter ID,
- 8-bit CRC ACK calculated on the magnetic message,
- 16-bit OOK message CRC.

When the validated message op-code is "1111", the RTLS transmitter shall respond with 152-bit DSSS message blinks following the OOK acknowledge message. The message is defined as follows:

- 8-bit preamble,
- 4-bit RTLS transmitter status = Defined in command,
- 32-bit RTLS transmitter ID,
- 8-bit = “0xFE”,
- 16-bit data payload,
- last 72-bits of RTLS transmitter 96-bit data register,
- 12-bit CRC.

When the validated message op-code is “1101”, the RTLS transmitter shall respond with 72/88-bit DSSS message blinks following the OOK acknowledge message. The message is defined as follows:

- 8-bit preamble,
- 4-bit RTLS transmitter status = Defined in command,
- 32-bit RTLS transmitter ID,
- *ext ID (only if 88 bit message),
- 16-bit data payload,
- 12-bit CRC.

Table 15 — 68-bit data payload commands

Bits	152-bit Response	72/88-bit Response
67 to 64	Op-code = “1111”	Op-code = “1101”
63 to 60	RTLS transmitter status	RTLS transmitter status
59 to 28	RTLS transmitter ID	RTLS transmitter ID
27 to 12	Data payload	Data payload
11 to 0	Message CRC	Message CRC

7.3.5 Write RTLS transmitter extended ID command (64-bit)

The following command shall cause the RTLS transmitter to respond with an OOK/FSK transmission.

The message exchange between the programmer and the RTLS transmitter shall be as shown in Figure 11.

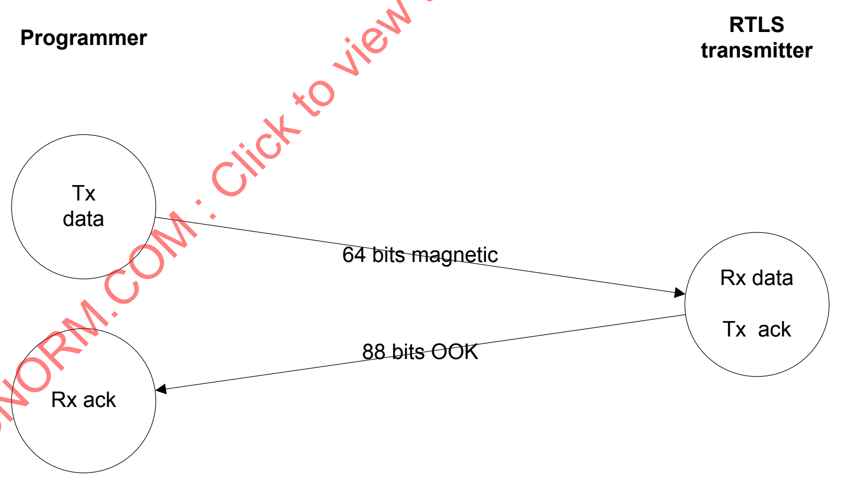

Figure 11 — Write extended ID

The 64-bit data message is preceded by 200 ms of an alternating “1” and “0” signal at the symbol rate defined in 7.1.1. This signal shall cause the magnetic receiver to stay active until the message is received.

The RTLS transmitter will receive this 64-bit command and validate message length, op-code, CRC, and ID. Bit definitions are shown in Table 16. If all is good, the RTLS transmitter will respond with an OOK/FSK short message transmission as described below:

- 24-bit preamble,
- 8-bit RTLS transmitter status,
- 32-bit RTLS transmitter ID,
- 8-bit CRC ACK calculated on the magnetic message,
- 16-bit CRC.

The RTLS transmitter DSSS message length shall be defined by the 16-bit extended ID value.

If the extended ID is set to 0x0000, the TIB/AEXB shall be 56 bits.

If the extended ID is non-zero, the TIB/AEXB shall be 72 bits.

Table 16 — 64-bit RTLS transmitter extended ID command

Bits	Description
63 to 60	Op-code = "1000"
59 to 28	Message ID = RTLS transmitter ID (no wild card allowed)
27 to 12	RTLS transmitter extended ID bits [47 to 32]
11 to 0	Message CRC

7.3.6 Sleep on / off commands

If supported, all of the following commands shall cause the RTLS transmitter to respond with OOK/FSK transmissions as specified as follows.

The message exchange between the programmer and the RTLS transmitter shall be as shown in Figure 12.

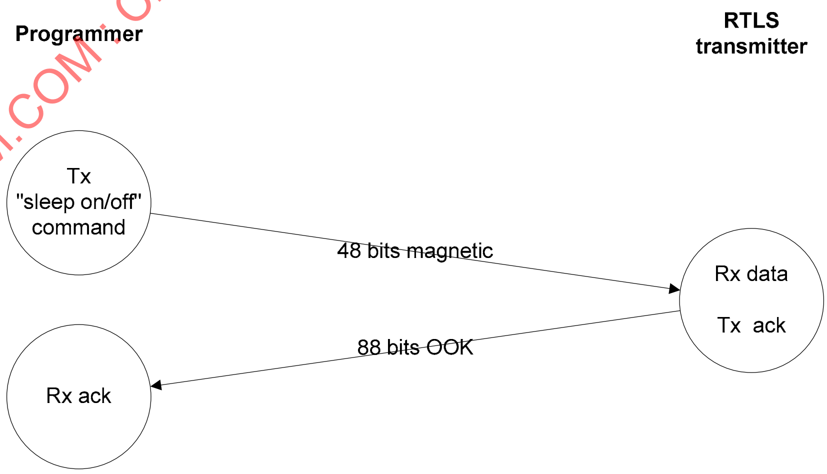

Figure 12 — Sleep on / off command message protocol

The 48-bit read message is preceded by 200 ms of an alternating “1” and “0” signal at the symbol rate defined in 7.1.1. This signal shall cause the magnetic receiver to stay active until the message is received. The transmission bit-length and the data shall depend on the op-code of the command. See Table 17 for bit definitions.

Table 17 — 48-bit RTLS transmitter read commands

Bits	Sleep On	Sleep Off	Read RTLS transmitter configuration	Read data	Read RTLS transmitter diagnostics	Read last exciter
47 to 44	Op-code = "1010"	Op-code = "1011"	Op-code = "1100"	Op-code = "1101"	Op-code = "1110"	Op-code = "1111"
43 to 12	RTLS transmitter ID	RTLS transmitter ID	RTLS transmitter ID	RTLS transmitter ID	RTLS transmitter ID	RTLS transmitter ID
11 to 0	Message CRC	Message CRC	Message CRC	Message CRC	Message CRC	Message CRC

7.3.6.1 Sleep mode on command

When the op-code is “1010” and the message is validated, the RTLS transmitter shall respond with an 88-bit OOK/FSK message. The RTLS transmitter shall then force its receiver interval to 500 ms. It shall disable all RF transmissions after it sends the OOK/FSK acknowledge. The RTLS transmitter shall remain in sleep mode for 5 min or until it receives and validates the sleep mode off command, whichever is first. This command is intended for use during battery replacement.

7.3.6.2 Sleep mode off command

When the op-code is “1011” and the message is validated, the RTLS transmitter shall respond with an 88-bit OOK/FSK message. The RTLS transmitter shall restore the receiver interval and re-enable all RF transmissions.

7.3.7 Read RTLS transmitter commands

If supported, all of the following commands shall cause the RTLS transmitter to respond with OOK/FSK transmissions as specified as follows.

The 48-bit read message is preceded by 200 ms of an alternating “1” and “0” signal at the symbol rate defined in 7.1.1. This signal shall cause the magnetic receiver to stay active until the message is received. The transmission bit-length and the data shall depend on the op-code of the command. See Table 17 for bit definitions.

The message exchange between the programmer and the RTLS transmitter shall be as shown in Figure 13.

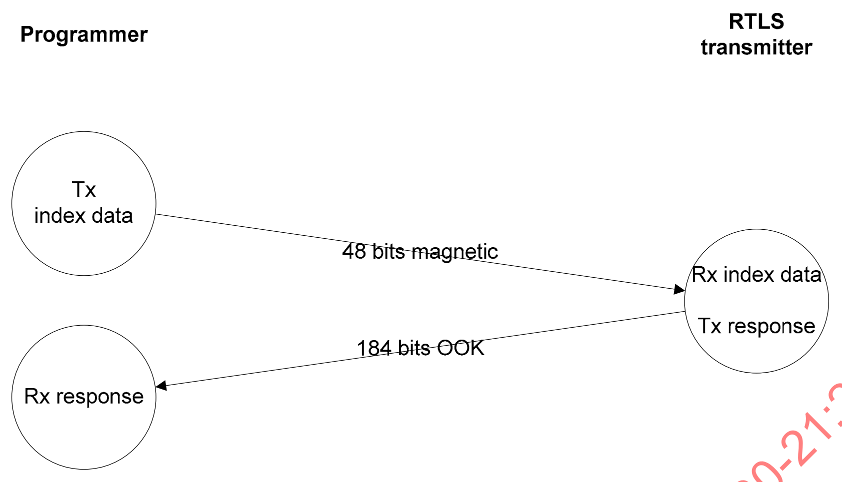

Figure 13 — Read command message protocol

7.3.7.1 Read RTLS transmitter 96-bit data payload command

When the op-code is "1100" and the message is validated, the RTLS transmitter shall respond with a 184-bit OOK/FSK message:

- 24-bit preamble,
- 8-bit RTLS transmitter status,
- 32-bit RTLS transmitter ID,
- 24-bit = “0x00FFFF”,
- 80-bit configuration data (see note),
- 16-bit CRC.

The 80-bit configuration data is a mirror of magnetic configuration command bits 91 to 12.

7.3.7.2 Read RTLS transmitter configuration command

When the op-code is "1101" and the message is validated, the RTLS transmitter will respond with a 184-bit OOK/FSK message:

- 24-bit preamble,
- 8-bit RTLS transmitter status,
- 32-bit RTLS transmitter ID,
- 8-bit = "000000000",
- 96-bit data payload,
- 16-bit CRC.

7.3.7.3 Read RTLS transmitter diagnostics command

When the op-code is "1110" and the message is validated, the RTLS transmitter shall respond with a 184-bit OOK/FSK message:

- 24-bit preamble,
- 8-bit RTLS transmitter status,
- 32-bit RTLS transmitter ID,
- 8-bit = “0x00”,
- 6-bit = “111111”,
- 6-bit watchdog alarms,

- 28-bit DSSS counter,
- 24-bit exciter blink counter,
- 24-bit OOK counter,
- 8-bit battery alarm counter,
- 16-bit CRC.

7.3.7.4 Read last exciter command

When the op-code is "1111" and the message is validated, the RTLS transmitter shall respond with a 184-bit OOK/FSK message:

- 24-bit preamble,
- 8-bit RTLS transmitter status,
- 32-bit RTLS transmitter ID,
- 16-bit RTLS transmitter ID extension,
- 16-bit exciter ID,
- 16-bit data payload,
- 4-bit exciter status,
- 44-bit = “0x00”,
- 16-bit CRC.

7.3.8 RTLS transmitter who-are-you commands

The programmer may send a magnetic command to the RTLS transmitter to cause the RTLS transmitter to respond with an OOK/FSK message containing the RTLS transmitter’s ID. Two commands shall be supported.

The message exchange between the programmer and the RTLS transmitter shall be as shown in Figure 14.

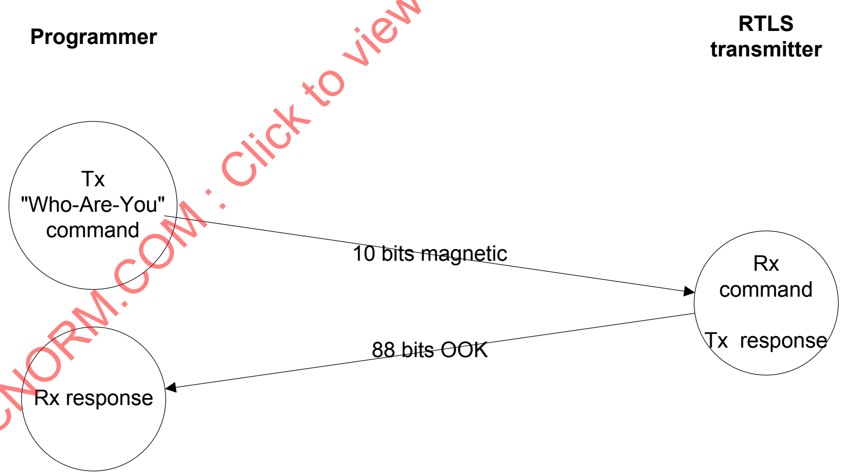

Figure 14 — Who-Are-You command protocol

7.3.8.1 RTLS transmitter 88-bit Who-Are-You command

The programmer may send a magnetic command to the RTLS transmitter to cause the RTLS transmitter to respond with an OOK/FSK message containing the RTLS transmitter’s 32-bit ID.

The 10-bit Who-Are-You command (11 0010 0000) is preceded by 200 ms of an alternating “1” and “0” signal at the symbol rate defined in 7.1.1. This signal shall cause the magnetic receiver to stay active until the message is received. See Table 18 for bit definitions.

