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Freight containers — Radio-frequency communication protocol for electronic seals

Conteneurs pour le transport de marchandises — Protocole de communication par fréquence radio, relatif aux scellements électroniques

ICS 55.180.10

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Contents

Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 3.

Draft International Standards adopted by technical committee are circulated to member bodies for voting. Publication as an International Standard requires approval by at least 75% of the member bodies casting a vote.

International Standard ISO 18185 was prepared by Technical Committee 104 Freight Container, Subcommittee SC 4, Identification and communication, WG2 AEI (Automatic Identification Equipment) for containers and container related equipment

Attention is drawn to the possibility that some of the elements of this part of ISO 18185 may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

Annex B (Glossary of terms) is an integral and normative part of the document. Annex C (Semantics and Syntax Used in Electronic Freight Container Seals) provides recommendations on semantics and syntax.

Introduction

This Standard was developed by ISO TC104/SC 4/WG 2.

A Radio Frequency communication protocol for an electronic seal for freight containers has been developed by the committee to provide for the communication requirements related to the unambiguous interrogation and maintenance of the secureness of a Freight Container from point of sealing (closure) to point of unsealing (opening).

This standard accommodates approved Freight Container Identification architecture.

It also provides for a system of building blocks to ensure both compatibility and functionality for a wide range of media.

This standard has been created to ensure global adoption of the standard, providing an open platform and integrity in the security solution developed.

This standard complies with the data structure defined in ISO 6346. Its usage shall provide maximum interoperability and conformance to existing Standards.

There are several air interfaces described in this document.

- Passive 862 –928 MHz, Frequency Hopping Spread Spectrum (FHSS). This air interface is compliant with that of the EAN.UCC GTAG standard, ANSI INCITS 256 (Radio Frequency Identification), and ANSI MH10.8.4 (RFID for Returnable Containers).
- Passive 915 MHz, Narrowband. This air interface is compliant with that of ISO 10374.
- Active 433.92 MHz, Narrowband, This air interface is compliant with ANSI INCITS 256 and the implementation of the U.S. Department of Defense.
- A multi-frequency (915 MHz, 433.92 MHz, and 315 MHz) tag that shares the same Data Link Layer across the three physical interfaces

Freight containers — Radio-frequency communication protocol for electronic seals

1 Scope

This International Standard provides a system for the identification and presentation of information about freight container electronic seals. The identification system provides an unambiguous unique identification of the container seal, its status, and related information.

The presentation of this information is provided through a radio-communications interface providing seal identification and a method to determine whether a freight container's security has been compromised.

This International Standard specifies a freight container seal identification system, with an associated system for verifying the accuracy of use, having:

- a seal status identification system;
- a battery status indicator;
- a unique security seal identifier including the identification of the manufacturer;
- a container number; and
- a method of providing additional information within the seal.

This International Standard specifies an Application Programming Interface (API), defined in Normative Annex A, that is shared by all standard-compliant systems. This API is intended to be implementation independent.

This International Standard applies to all electronic seals used on:

- freight containers covered by International Standards ISO 668, parts 1 to 5 of ISO 1496, ISO 8323 and should, wherever appropriate and practicable, be applied:
- freight containers other than those covered by the International Standards mentioned in clause 2;
- container-related and/or detachable equipment.

This International Standard does not cover the higher-level applications for container seals and freight container identification.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this International Standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on International Standards are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below. Members of ISO maintain registers of current, valid International Standards.

ISO 646:1991	Information processing - ISO 7-bit coded character set for information interchange
ISO 668:1995	Series 1 freight containers - Classification, dimensions and ratings
ISO 830:1999	Freight containers - Vocabulary
ISO 1496-1:1990	Series 1 freight containers - Specification and testing - Part 1: General cargo containers for general purposes
ISO 1496-2:1996	Series 1 freight containers - Specification and testing - Part 2: Thermal containers
ISO 1496-3:1995	Series 1 freight containers - Specification and testing - Part 3: Tank containers for liquids, gases and pressurized dry bulk
ISO 1496-4:1991	Series 1 freight containers ó Specification and testing - Part 4: Non- pressurized containers for dry bulk
ISO 1496-5:1991	Series 1 freight containers ó Specification and testing - Part 5: Platform and platform-based containers
ISO 6346:1995	Freight containers - Coding Identification and Marking
ISO 8323:1985	Freight containers - Air/surface (intermodal) general purpose containers - Specifications and tests
ISO/TS 14816:2000	Road transport and traffic telematics - Automatic vehicle and equipment identification -Numbering and data structure
ISO 18000 (relevant parts only)	Information Technology AIDC Techniques - RFID for Item Management Air Interface
ISO/IEC 19762	Information Technology AIDC Techniques - Harmonized Vocabulary

3 Terms and definitions

For the purposes of this International Standard, the definitions contained in Annex B apply. In addition to the applicable definitions in the aforementioned standards, the following definitions apply:

3.1 electronic seal: a freight container seal that provides an electronic indication of whether the container has been opened since its sealing.

4 General Design Requirements

4.1 The design specification for this International Standard is to support a reading minimum of 3 seals per second.

4.2 The design specification for this International Standard is a target read range of 4 meters.

5 Radio Frequency Seal Data Structure

5.1 **The Electronic Seal data block includes Seal Status, Seal Number, Freight Container Number, and the CRC.**

5.2 **The data block scheme is shown below.**

Table 1 – Seal Data Structure.

Identifier	Battery Failure Status	Seal Status	RF Component Manufac-turer ID	Seal Number (Alpha)	Seal Number (Numeric)	Container Number Prefix (Alpha)	Container Number & Check Digit (Numeric)	Extensibi lity Flag	Spare	CRC
4 bits	1 bit	1 bit	8 bits	20 bits	28 bits	20 bits	24 bits	1 bit	5 bits	16 bits

5.2.1 **The Flag for Extension occupies 1-bit. For Extension Flag; “1” indicates an additional 128 bits. “0” indicates no additional 128 bits.**

5.2.2 **The Identifier occupies 4-bits. The 4-bit Identifier is “0001”.**

5.2.3 **The Seal Status occupies 1-bit. For Seal Status; “1” indicates secure. “0” indicates tampered.**

5.2.4 **The Battery Failure Status occupies 1-bit. For Battery Failure Status; “1” indicates battery state is above threshold. “0” indicates battery state at or below threshold. For battery-less seals this field is fixed to a value of “1”.**

5.2.5 **The Spare occupies 2-bits. Spare is for future applications. Not withstanding these applications this field is fixed to a value of "00".**

5.2.6 **The RF Component Manufacturer ID occupies 8-bits. This is the manufacturer identification of the tag component manufacturer. This identification is assigned in accordance with ISO/TS 14816:2000. The RF Component Manufacturer ID of the seal is programmed by the RF Component Manufacturer.**

5.2.7 **The Seal Number Alpha occupies 15-bits (3 characters of alphabetic data).**

5.2.8 **The Seal Number Numeric occupies 28-bits. The Seal Number is assigned and programmed by manufacturer.**

5.2.9 **The Container Number Prefix occupies 20-bits (4 characters of alphabetic data). The Container Number Prefix is assigned in accordance with ISO 6346.**

5.2.10 **The Container Number and check digit occupies 24-bits. The Container Number and check digit is assigned in accordance with ISO 6346.**

5.2.11 The CRC occupies 16-bits. The format of the CCITT CRC-16 shall be calculated as follows: CRC-16 = $X^{16} + X^{12} + X^5 + 1$

5.2.12 **The total number of bits for the mandatory Electronic Seal data block is 128.**

5.3 **The Electronic Seal's optional second data block includes: Extensibility Flag, Random Value, Spare bits, and the CRC.**

5.3.1 **The second optional data block scheme is shown below.**

Table 2 – Seal Data Structure, optional block.

Extensibility Flag	Random value	Spare	CRC	
1 bit	16 bit	95 bit	16 bit	Number of bits

5.3.2 **The optional random value occupies 16-bits. This value should be generated by the reader/interrogator and programmed together with the Container Number. The random value should be reset to value ZERO by the seal upon modifying the Seal Status flag from "1" to "0" to indicate tampered.**

5.4 **If the Extensibility Flag is set to "1" in the second or subsequent blocks, this signifies that an additional 128 bit block follows without a prescribed format except that the last 16 bits are the CRC of that block.**

6 Physical Link Specifications

6.1 862 - 928 MHz - Frequency Hopping Spread Spectrum

This portion of the standard describes a frequency hopping spread spectrum RFID system that supports the following system capabilities:

6.1.1 Table 3 lists the physical link specifications from the reader to the seal (forward link) for 862 to 928 MHz.

Table 3 - Physical Link Specifications - Forward Link

ITEM	PARAMETER	VALUE
F1	Default Operating Frequencies	862 - 928 MHz as required by National regulations
F 1b	Operating Channels	ITU Region 1. Current Regulations: 5 to 1 channels in 869.4 to 869.65 MHz per REC 70-03 Annex 1. ITU Region 1. Proposed Regulations: awaiting input (RP08 proposed region 1: 2 watts ERP, 865.5 – 867.6 MHz, adaptively agile Fixed Frequency, Spread Spectrum not permitted). Minimum of 10 channels with a maximum channel spacing of 200 kHz. ITU Region 2: Minimum of 50 channels in the 902–928 MHz band with a maximum channel spacing of 400 kHz.
F 1c	Operating Frequency Accuracy	± 25 ppm maximum over operating temperature range
F 1d	Frequency Hop Rate	Compliant to local regulations ITU Region 1: Not applicable (Fixed Frequency) ITU Region 2: A minimum hop rate of 2.5 hops per second. Compliant with FCC Part 15 Section 247 (a)(1)(i)
F 1e	Frequency Hop Sequences	Compliant to local regulations. ITU Region 1: Current regulations: not applicable (Fixed Frequency) ITU Region 1: Proposed Regulations: as presented in ETSI RP08 proposals for 865.6 - 867.6 MHz: not applicable (Fixed Frequency) ITU Region 2: A minimum hop rate of 2.5 hops per second. Compliant with FCC Part 15 Section 247.
F 2	Occupied Channel Bandwidth	In ITU Region 1 the system shall operate compliant to current regulations REC 70-03 Annex 1 and future regulations ITU Region 1 (to be defined once agreed). Currently 869.4 – 869.65 MHz: -36 dBm from fc at ± 25 kHz from f_c In ITU Region 2 the system shall use 902 – 928 MHz: +20 dBc from f_c at ± 200 kHz from f_c

ITEM	PARAMETER	VALUE
F 2a	Minimum Receiver Bandwidth	160 kHz
F 3	Interrogator Transmit Maximum EIRP	ITU Region 1: the system shall operate compliant to current regulations REC 70-03 Annex 1 and future regulations ITU Region 1 (to be defined once agreed) In ITU Region 2 the maximum is 30 dBm output from the interrogator, and 4W (36 dBm) EIRP from the interrogator transmit antenna.
F 4	Interrogator Transmit Spurious Emissions	ITU Region 1:Out of band emission: less than 250 nW EIRP, and 4 nW EIRP for f <= 862 MHz
F 4a	Interrogator Transmit Spurious Emissions, In-Band (for Spread Spectrum systems)	ITU Region 1: Not applicable, as Spread Spectrum systems not allowed under current regulations. ITU Region 2: Within FCC Part 15 Section 247
F 4b	Interrogator Transmit Spurious Emissions, Out of Band	ITU Region 1: Within REC 70-03 Annex 1 ITU Region 2: Within FCC Part 15 Section 247
F 5	Interrogator Transmitter Spectrum Mask	Will operate within the spectrum mask defined in REC 70-03 for ITU Region 1
F 6	Modulation	On-Off Keying (OOK)
F 6a	Transmit to Receive Turn Around Time	2 bytes quiet time at the return link data rate. (= 400 µs for 40 kbps return link)
F 6b	Receive to Transmit Turn Around Time	2 bytes quiet time
F 6c	Dwell Time or Interrogator Transmit Power On Ramp	< 5 % of bit period
F 6d	Decay Time or Interrogator Transmit Power Down Ramp	< 5 % of bit period
F 7	Modulation	On-off Keying (OOK) or ASK
F 7a	Spreading Sequence (for Frequency Hopping [FHSS] systems)	
F 7b	Chip Rate (for Spread Spectrum systems)	
F 7c	Chip Rate Accuracy (for Spread Spectrum systems)	50% ± 5%
F 7d	Modulation Index	99% (40 dBc) or 11% (1.94 dBc)

ITEM	PARAMETER	VALUE
F 7e	Duty Cycle	50% ± 5%
F 7M1	FM Deviation	
F 8	Data Coding	Manchester
F 9	Bit Rate	30 – 40 kbps for 99% modulation index 8 – 40 kbps for 11% modulation index The communication bit rate is determined by the clock frequency of the message preamble.
F 10	Interrogator Transmit Modulation Accuracy	
F 11	Preamble	Yes See section 7.1.2.3
F 11a	Preamble Length	9 bits of Manchester zero

6.1.2 Table 4 lists the physical link specifications from the seal to the reader (backscatter return link).for 862 to 928 MHz.

Table 4 - Physical Link Specifications – Backscatter Return Link

ITEM	PARAMETER	VALUE
R 1	Operating Frequency	862 MHz – 928 MHz
R 2	Occupied Channel Bandwidth	In accordance with the applicable local regulations.
R 4b	Transmit Spurious Emissions, Out of Band	In accordance with the applicable local regulations.
R 6a	Transmit-Receive Turn Around Time	2 bytes quiet time (= 400 µs at 40 kbps)
R 6b	Receive-Transmit Turn Around Time	2 bytes quiet time at the return link data rate. (= 400 µs for 40 kbps return link)
R 7	Modulation	Bi-state amplitude modulated backscatter.
R 7d	On-Off Ratio – Tag modulation depth – backscatter modulation	The tag shall have a Delta RCS (Varying Radar Cross Sectional area) of not less than 0.005m2.
R 7h	Duty Cycle	The tag shall transmit its message when commanded to do so by the reader.
R 8	Data Encoding	Bi-phase space (FM0)
R 9	Bit Rate	40kb/s
R 9a	Bit Rate Accuracy	+/- 15%
R 11	Preamble	Yes, See section 7.1.2.3

ITEM	PARAMETER	VALUE
R 11a	Preamble Length	16 bits made up of a quiet period, followed by sync, followed by a code violation followed by an orthogonal code.
R 11b	Preamble Waveform	Bi-phase encoded data '1'.
R 11c	Bit Sync Sequence	Yes. Included in preamble
R 11d	Frame Sync Sequence	Yes. Included in preamble
R 12	Scrambling (for Spread Spectrum systems)	Not applicable
R 13	Bit Transmission Order	MSB first
R 14	Reserved	Deliberately left blank
R 15	Antenna Polarization	Default- linear polarization with dipole-like characteristics; may be varied by an application specific requirement
R 16	Minimum Tag Receiver Bandwidth	Baseband low-pass filter characteristic, having a 3dB cut-off frequency of 100kHz (2.5 bit rate) and a minimum slope of 6dB/octave

6.2 915 MHz - Passive Narrowband

This portion of the standard describes a narrowband Passive RFID system that supports the described system capabilities.

6.2.1 Table 5 lists the physical link specifications from the reader to the seal (forward link) for narrowband 915 MHz Passive Narrowband RFID.

Table 5 - Physical Link Specifications - Forward Link

ITEM	PARAMETER	VALUE
F1	Default Operating Frequencies	Any single frequency (or frequencies) in the 862 - 928 MHz band (for frequency coordination purposes for readers located near each other, a table of standard frequencies can be prepared)
F 1b	Operating Channels	Channels separated by 0.5 MHz as needed in the 862 - 928 MHz band
F 1c	Operating Frequency Accuracy	± 25 ppm maximum
F 2	Occupied Channel Bandwidth	Less than 250kHz using 20dB bandwidth definition as per FCC Part 15 regulations.
F 3	Interrogator Transmit Maximum EIRP	The maximum is 30 dBm output from the interrogator, and 4W (36 dBm) EIRP from the interrogator transmit antenna or as allowed by National regulations.

ITEM	PARAMETER	VALUE
F 4b	Interrogator Transmit Spurious Emissions, Out of Band	The interrogator shall transmit in conformance with spurious emissions requirements defined in FCC Part 15, sections 15.205 and 15.209. At the time of drafting of this document, this level is 200 μV/m @ 3 m for frequencies from 216 to 960 MHz.
F 5a	Receive to Transmit Turn Around Time	< 1 ms
F 5c	Interrogator Transmit Power-On Ramp	< 5 % of bit period
F 5d	Interrogator Transmit Power-Down Ramp	< 5 % of bit period
F 6	Modulation	On-Off Keying (OOK)
F 6d	On/Off Ratio	> 40 dBc
F 6e	Duty Cycle	50% ± 5%
F 7	Data Coding	Manchester
F 8	Bit Rate	Any fixed rate between 20 kbps and 40 kbps, nominal 31.25 ± 10% kbps.
F 10	Seal Receiver Non-Destructive Input RF Level	≤ +13 dBm, in band
F 11	Preamble	See section 7.1.2.3

6.2.2 Table 6 lists the physical link specifications from the seal to the reader (return link) for 915 MHz passive narrowband.

Table 6 - Physical Link Specifications – Passive Narrowband Return Link

ITEM	PARAMETER	VALUE
R 1b	Operating Channels	Channels separated by 0.5 MHz as needed in the 862 - 928 MHz band
R 1c	Operating Frequency Accuracy	± 25 ppm maximum, for signal transmitted by interrogator
R 2	Occupied Channel Bandwidth	Less than 250kHz using 20dB bandwidth definition as per FCC Part 15 regulations.
R 3	Transmit Maximum EIRP	The combination of an interrogator and a tag shall limit transmitted power to 36 dBm EIRP