

Australian Standard[®]

**Information technology—Radio
frequency identification for item
management**

**Part 6: Parameters for air interface
communications at 860 MHz to 960 MHz**



This Australian Standard® was prepared by Committee IT-034, Automatic Identification and Data Capture Techniques. It was approved on behalf of the Council of Standards Australia on 15 November 2006.

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 - Australian Data Capture Association
 - Australian Electrical and Electronic Manufacturers Association
 - Australian Retailers Association
 - Australian Veterinary Association
 - Department of Communications, Information Technology and the Arts
 - Department of Defence
 - Department of Primary Industries, Vic
 - GS1 Australia
 - RFID Association of Australia
 - The University of Adelaide
-

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**Information technology—Radio
frequency identification for item
management**

**Part 6: Parameters for air interface
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PREFACE

This Standard was prepared by the Standards Australia Committee IT-034, Automatic Identification and Data Capture Techniques.

The objective of this Standard is to provide a common technical specification for RFID devices to operating in the 860 MHz to 960 MHz Industrial, Scientific, and Medical (ISM) band used in item management applications.

This Standard is identical with, and has been reproduced from ISO/IEC 18000-6:2004, *Information technology—Radio frequency identification for item management—Part 6: Parameters for air interface communications at 860 MHz to 960 MHz*.

As this Standard is reproduced from an international standard, the following applies:

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<i>Reference to International Standard</i>	<i>Australian Standard</i>
ISO/IEC	AS ISO/IEC
19762-3 Information technology— Automatic identification and data capture (AIDC) techniques— Harmonized vocabulary—Part 3: Radio frequency identification (RFID)	19762.3 Information technology— Automatic identification and data capture (AIDC) techniques—Harmonized vocabulary—Part 3: Radio frequency identification (RFID)

Only international references that have been adopted as Australian or Australian/New Zealand Standards have been listed.

The terms ‘normative’ and ‘informative’ are used to define the application of the annex to which they apply. A normative annex is an integral part of a standard, whereas an informative annex is only for information and guidance.

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INTRODUCTION

This part of ISO/IEC 18000 describes a passive backscatter RFID system that supports the following system capabilities:

- Identification and communication with multiple tags in the field
- Selection of a subgroup of tags for identification or with which to communicate
- Reading from and writing to or rewriting data many times to individual tags
- User-controlled permanently lockable memory
- Data integrity protection
- Interrogator-to-tag communications link with error detection
- Tag-to-interrogator communications link with error detection.
- Support for both passive back-scatter tags with or without batteries.

In this RFID system, the interrogator powers and communicates with the tags that are within range. Tags receive data as amplitude modulation of the power/data signal from the interrogator. During the time that the tag responds to the interrogator, the interrogator transmits at a constant radio frequency power level, while the tag modulates the impedance of its radio frequency load attached to the tag antenna terminals. The interrogator then receives the data back from the tag as a variation in a reflection of its transmitted power.

AUSTRALIAN STANDARD

Information technology — Radio frequency identification for item management —**Part 6:
Parameters for air interface communications at 860 MHz to 960 MHz****1 Scope**

This part of ISO/IEC 18000 defines the air interface for radio frequency identification (RFID) devices operating in the 860 MHz to 960 MHz Industrial, Scientific, and Medical (ISM) band used in item management applications. Its purpose is to provide a common technical specification for RFID devices that may be used by ISO committees developing RFID application standards. This part of ISO/IEC 18000 is intended to allow for compatibility and to encourage inter-operability of products for the growing RFID market in the international marketplace. This part of ISO/IEC 18000 defines the forward and return link parameters for technical attributes including, but not limited to, operating frequency, operating channel accuracy, occupied channel bandwidth, maximum EIRP, spurious emissions, modulation, duty cycle, data coding, bit rate, bit rate accuracy, bit transmission order, and where appropriate operating channels, frequency hop rate, hop sequence, spreading sequence, and chip rate. It further defines the communications protocol used in the air interface.

This part of ISO/IEC 18000 contains one mode with two types. Both types use a common return link and are reader talks first. Type A uses Pulse Interval Encoding (PIE) in the forward link, and an adaptive ALOHA collision arbitration algorithm. Type B uses Manchester in the forward link and an adaptive binary tree collision arbitration algorithm. The detailed technical differences between the two types are shown in the parameter tables.

2 Conformance**2.1 Interrogator conformance and obligations**

To conform to this part of ISO/IEC 18000, the interrogator shall support both communication types. It shall be able to switch from one type to the other.

The interrogator shall be locally programmable by the user to switch from one type to the other and to control the sequence and allocation of the ratio of time between the two types.

The proportion of the total time spent by the interrogator in addressing each type of tag shall be field-programmable from 0% to 100%.

Interrogators shall be set up to operate within local regulations.

2.2 Tag conformance and obligations

To conform to this part of ISO/IEC 18000, the tag shall support at least one type. It may optionally support both.

The tag shall operate over the frequency range of 860 MHz to 960 MHz.

NOTE Depending on the tag antenna characteristics, the operating performance (i.e. operating range) may vary depending on the actual frequency used in the 860-960 MHz band.

When the tag receives a modulated signal from the interrogator that it does not support or recognise, it shall remain silent.

2.3 Claiming conformance

In order to claim conformance with this part of ISO/IEC 18000 it is necessary to comply with all of the relevant clauses of this part of ISO/IEC 18000 except those marked 'optional' and it is also necessary to operate within the local national radio regulations (which may require further restrictions).

Relevant conformance test methods will be given in a future Technical Report (ISO/IEC TR 18047-6).

3 Normative references

ISO/IEC 19762-3, *Information technology — Automatic identification and data capture (AIDC) techniques — Harmonized vocabulary — Part 3: Radio frequency identification (RFID)*¹⁾

ISO/IEC 7816-6, *Identification cards — Integrated circuit cards — Interindustry data elements for interchange*

4 Terms, definitions, symbols and abbreviated terms

4.1 Terms and definitions

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

4.1.1

collision arbitration loop

algorithm used to prepare for and handle a dialogue between an interrogator and a tag. This is also known as collision arbitration.

4.1.2

byte

8 bits of data designated b1 to b8, from the most significant bit (MSB, b8) to the least significant bit (LSB, b1).

4.2 Symbols

Cht	Carrier high-level tolerance
Clt	Carrier low-level tolerance
D	Modulation depth of data coding pulse
f_c	Frequency of operating field (carrier frequency)
M	Modulation Index
Ma	Modulation upper tolerance type B
Mb	Modulation lower tolerance type B

1) To be published.

Taq	Quiet time - type A
Tapf	Pulse fall time - type A
Tapr	Pulse rise time - type A
Tapw	Pulse width - type A
Tari	Reference interval time - type A
Tbmf	Manchester fall time – type B
Tbmr	Manchester rise time – type B
Tcf	Carrier fall time
Tcr	Carrier rise time
Tcs	Carrier steady state time
Tf	Fall time
Tfhf	Carrier FHSS fall time
Tfhr	Carrier FHSS rise time
Tfhs	Carrier FHSS steady time
Tr	Rise Time
Trlb	Return link bit time

4.3 Abbreviated terms

AFI	Application family identifier
CRC	Cyclic redundancy check
CRC-5	Five bit CRC used in type a Interrogator to tag commands, used in Type A
CRC-16	Sixteen bit CRC used in both Type A and Type B commands and responses
DSFID	Data storage format identifier
DSSS	Direct Sequence Spread Spectrum
EOF	End of frame
FHSS	Frequency Hopping Spread Spectrum
LSB	Least significant bit
MSB	Most significant bit
NRZ	Non Return to Zero
PIE	Pulse interval encoding, used in Type A
RFU	Reserved for future use

SOF	Start of frame
SUID	Sub unique identifier
TEL	Tag excitation level
UID	Unique identifier

5 Overview

5.1 General

This part of ISO/IEC 18000 specifies two communication types: Type A and Type B.

Figure 1, Figure 2, and Figure 3 show their architecture; Table 1 provides a comparison.

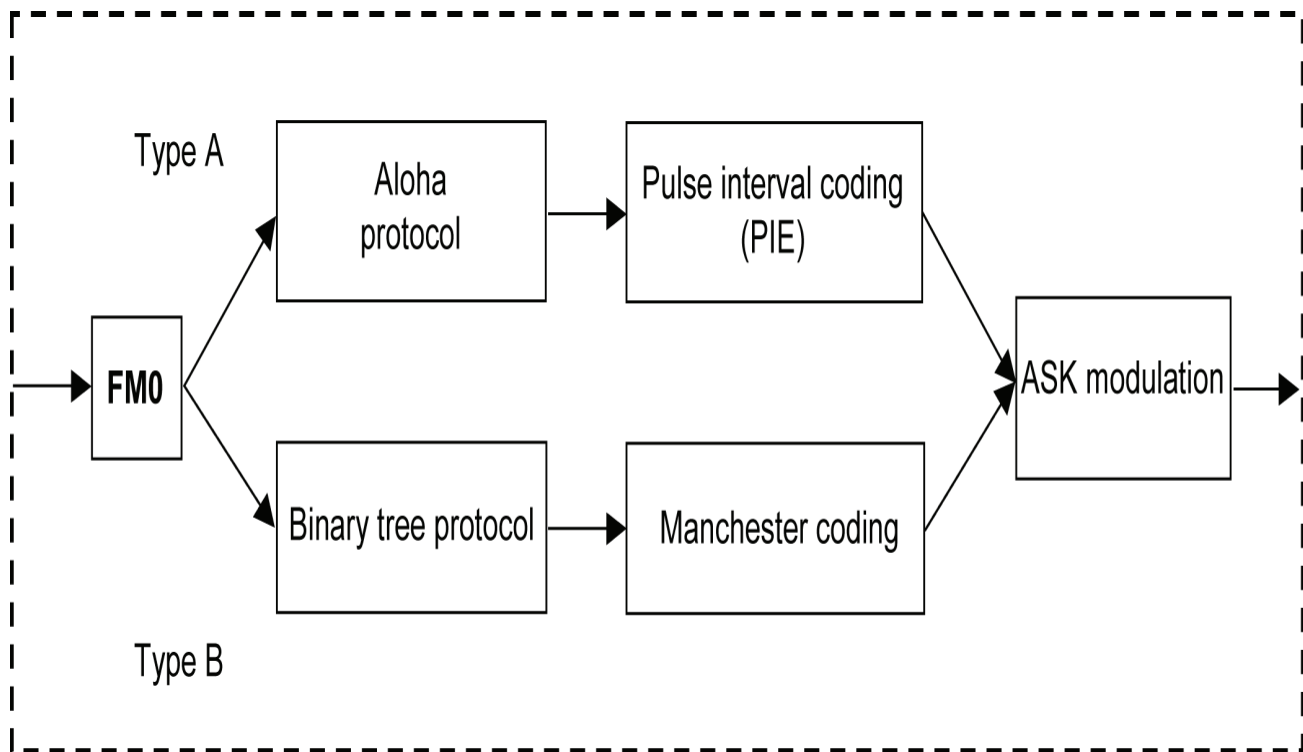


Figure 1 — Interrogator architecture

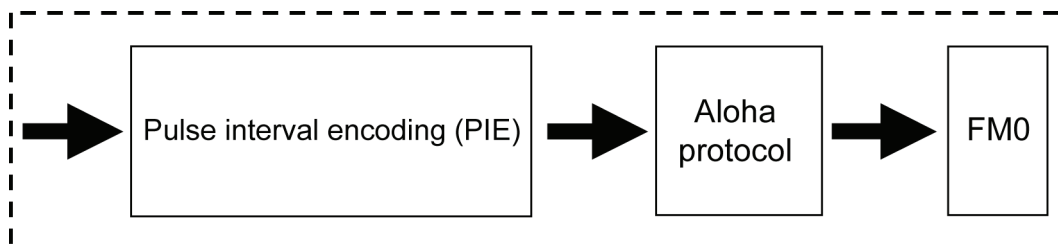


Figure 2 — Type A tag architecture

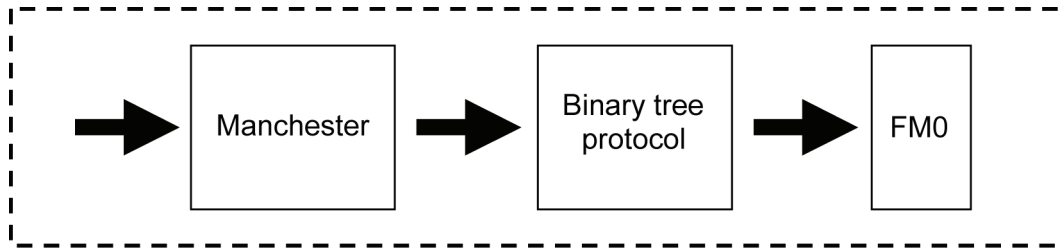


Figure 3— Type B tag architecture

Table 1 — Comparison of Type A and Type B

Parameter	Type A	Type B
Forward link encoding	PIE	Manchester
Modulation index	27% to 100%	18% or 100%
Data rate	33 kbit/s (mean)	10 or 40 kbit/s (according to local regulations)
Return link encoding	FM0	FM0
Collision arbitration	ALOHA	Binary Tree
Tag unique identifier	64 bits (40 bit SUID)	64 bits
Memory addressing	Blocks up to 256 bits	Byte blocks, 1,2,3 or 4 byte writes.
Error detection forward link	5 bit CRC for all commands (with an additional 16 bit CRC appended for all long commands)	16 bit CRC
Error detection return link	16 bit CRC	16 bit CRC
Collision arbitration linearity	Up to 250 tags	Up to 2^{256}

5.2 Parameter tables

Table 2, Table 3, Table 4 and Table 5 contain the parameters for both types A and B in accordance with ISO/IEC 18000-1. Detailed description of the operating modes and parameters are specified in the subsequent clauses.

Table 2 — Interrogator to tag link parameters

Interrogator to tag	Parameter name	Description
Int: 1	Operating frequency range	860 – 960 MHz The interrogator operating frequency range shall be determined by the radio regulations in force in a particular regulatory jurisdiction and by the type approval requirements of the particular jurisdiction. Before an interrogator may be used, it shall meet the local radio regulations of the country in which it is to be used. It is envisaged that there will be more than one version of interrogator having different frequency and power characteristics in order to comply with local regulations. NOTE Performance will vary according to bandwidth and power output permitted by local regulations.
Int: 1a	Default operating frequency	In accordance with the local radio regulations. See Int: 1
Int: 1b	Operating channels	In accordance with the local radio regulations. See Int: 1
Int: 1c	Operating frequency accuracy	In accordance with the local radio regulations See Int: 1
Int: 1d	Frequency hop rate (for frequency hopping [FHSS] systems)	Not applicable for single fixed frequency or channelized Adaptive Frequency Agile systems. Where FHSS is permitted, the hop rate shall be in accordance with the local radio regulations.
Int: 1e	Frequency hop sequence (for frequency hopping [FHSS] systems)	In accordance with the local radio regulations. Where not specified by such regulations a pseudo-random hopping sequence shall be used that ensures an even distribution of transmissions over the available channels.
Int: 2	Occupied channel bandwidth	In accordance with the local radio regulations.
Int:2a	Minimum receiver bandwidth	In accordance with the local radio regulations.
Int: 3	Interrogator transmitter maximum EIRP	In accordance with the local radio regulations
Int: 4	Interrogator transmitter spurious emissions	In accordance with the local radio regulations.
Int: 4a	Interrogator transmitter spurious emissions, in-band (for spread spectrum systems)	In accordance with the local radio regulations.
Int: 4b	Interrogator transmitter spurious emissions, out-of-band	In accordance with the local radio regulations.
Int: 5	Interrogator transmitter spectrum mask	As per Int: 2 and Int: 4a.
Int:6	Timing	See below Int: 6x.
Int: 6a	Transmit to receive turn around time	The interrogator transmit/receive settling time shall not exceed 85µs.
Int: 6b	Receive to transmit turn around time	As determined by the communication protocol – refer Tag: 6a.
Int: 6c	Dwell time or interrogator transmit power on ramp	Maximum 1.5ms.
Int: 6d	Decay time of interrogator transmitter power down ramp	Maximum 1ms.

Table 2 (continued)

Interrogator to tag	Parameter name	Description
Int: 7	Modulation	Amplitude Modulation.
Int: 7a	Spreading sequence (for direct sequence [DSSS] systems)	Not applicable.
Int: 7b	Chip rate (for spread spectrum systems)	Not applicable.
Int: 7c	Chip rate accuracy (for spread spectrum systems)	Not applicable.
Int: 7d	Modulation index	Type A: Nominal 30 % to 100 %. See Table 11 and clause 7.1.1. Type B: Nominal 18% or 100% .
Int: 7e	Duty cycle	In accordance with local regulations.
Int: 7f	FM deviation	Not applicable.
Int: 7g	Transmitter modulation pulse shape (falling and rising slopes)	The modulation pulse fall and rise times shall conform to the detailed specifications in subsequent clauses. Type A see Figure 11 and Table 11, and Type B see Figure 20, Figure 21, Table 93 and Table 94.
Int: 8	Data coding	Type A: Pulse Interval Encoding Type B: Manchester bi-phase
Int: 9	Bit rate	Type A: 33 kbit/s as constrained by the local radio regulations Type B: 10 kbit/s or 40 kbit/s as constrained by the local radio regulations.
Int: 9a	Bit rate accuracy	100 ppm
Int: 10	Interrogator transmit modulation accuracy	Not applicable.
Int: 11	Preamble	Type A : has no preamble Type B: See clause 8.1.4.3
Int:11a	Preamble length	Type A: not applicable. Type B: 9 bits. See clause 8.1.4.3.
Int:11b	Preamble waveform	Type A: not applicable . Type B: See clause 8.1.4.3.
Int: 11c	Bit sync sequence	Type A: not applicable. Type B: see clause 8.1.4.3
Int: 11d	Frame sync sequence	Not applicable.
Int: 12	Scrambling (for spread spectrum systems)	Not Applicable
Int: 13	Bit transmission order	MSB first
Int: 14	Wake-up process	Presence of an appropriate RF signal at the tag followed by a wake-up command as required by the tag type. See relevant clauses.
Int: 15	Polarization	Interrogator dependent. Not defined in this part of ISO/IEC 18000.

Table 3 — Tag to interrogator link parameters

Tag to interrogator	Parameter name	Description
Tag:1	Operating frequency range	860 MHz – 960 MHz
Tag:1a	Default operating frequency	The tag shall respond to an interrogator signal within the frequency range specified in Tag: 1.
Tag:1b	Operating channels (for spread spectrum systems)	The tag shall respond to an interrogator signal within the frequency range specified in Tag: 1.
Tag:1c	Operating frequency accuracy	The tag shall respond to an interrogator signal within the frequency range specified in Tag: 1.
Tag:1d	Frequency hop rate (for frequency hopping [FHSS] systems)	Not applicable
Tag:1e	Frequency hop sequence (for frequency hopping [FHSS] systems)	Not applicable
Tag:2	Occupied channel bandwidth	As permitted by the local radio regulations.
Tag:3	Transmit maximum EIRP	As permitted by the local radio regulations.
Tag:4	Transmit spurious emissions	As permitted by the local radio regulations.
Tag:4a	Transmit spurious emissions, in-band (for spread spectrum systems)	As permitted by the local radio regulations.
Tag:4b	Transmit spurious emissions, out-of-band	As permitted by the local radio regulations.
Tag:5	Transmit spectrum mask	As permitted by the local radio regulations.
Tag:6a	Transmit to receive turn around time	Type A: The tag shall open its receive command window within 2 bit periods of the end of its response. Type B: 400 µs
Tag:6b	Receive to transmit turn around time	Type A: Range from 150 to 1150 µs (see clause 7.5.3 and Table 28) Type B: Range 85 to 460 µs (see clause 8.1.5.2)
Tag:6c	Dwell time or transmit power on ramp	Not applicable.
Tag:6d	Decay time or transmit power down ramp	Not applicable.
Tag:7	Modulation	Bi-state amplitude modulated backscatter.
Tag:7a	Spreading sequence (for direct sequence [DSSS] systems)	Not applicable.
Tag:7b	Chip rate (for spread spectrum systems)	Not applicable.
Tag:7c	Chip rate accuracy (for spread spectrum systems)	Not applicable.
Tag:7d	On-off ratio	The tag Delta RCS (Varying Radar Cross Sectional area) affects system performance. A typical value is greater than 0.005m ² .
Tag:7e	Sub-carrier frequency	Not applicable.
Tag:7f	Sub-carrier frequency accuracy	Not applicable.
Tag:7g	Sub-carrier modulation	Not applicable.

Table 3 (continued)

Tag to interrogator	Parameter name	Description
Tag:7h	Duty cycle	The tag shall transmit its response when commanded to do so by the interrogator.
Tag:7i	FM deviation	Not applicable
Tag:8	Data coding	Bi-phase space (FM0)
Tag:9	Bit rate	Typical 40 kbit/s or 160 kbit/s (subject to tag clock tolerance see Table 9), The return bit rate selection for 160 kbit/s for Type B is defined in clause 8.1.4.4.5.
Tag:9a	Bit rate accuracy	+/- 15% (refer to Table 9)
Tag:10	Tag transmit modulation accuracy (for frequency hopping [fhss] systems)	Not applicable.
Tag:11	Preamble	The preamble is defined in clause 6.5.6
Tag:11a	Preamble length	16 bits made up of a quiet period, followed by sync, followed by a code violation followed by an orthogonal code.
Tag:11b	Preamble waveform	Bi-phase encoded data '1'.
Tag:11c	Bit sync sequence	Included in the preamble.
Tag:11d	Frame sync sequence	Included in the preamble.
Tag:12	Scrambling (for spread spectrum systems)	Not applicable.
Tag:13	Bit transmission order	MSB first.
Tag:14	Reserved	Deliberately left blank.
Tag:15	Polarization	Product design feature. Not defined in this part of ISO/IEC 18000.
Tag:16	Minimum tag receiver bandwidth	860 – 960 MHz

Table 4 — Protocol parameters

Ref.	Parameter name	Description
P:1	Who talks first	Interrogator talks first.
P:2	Tag addressing capability	Type A see clause 7.3.1 Type B see clause 8.2.2
P:3	Tag unique identifier (UID)	Contained in tag memory and accessible by means of a command.
P:3a	UID length	Type A: 64 bits. An SUID of 40 bits is used during census or collision arbitration transactions. Type B: 64 bits
P:3b	UID format	The UID format is different for types A and B. See clause 7.2.1 for type A. See clause B.2 for type B.

Table 4 (continued)

Ref.	Parameter name	Description
P:4	Read size	Type A: Addressable in blocks of up to 256 bits, but always an integer multiple of bytes. Type B: Addressable in byte blocks.
P:5	Write size	Type A: Addressable in blocks of up to 256 bits, but always an integer multiple of bytes. Type B: Addressable in byte blocks. Writing in blocks of 1, 2, 3 or 4 bytes. See details in relevant clauses.
P:6	Read transaction time	A single tag can typically be identified and have its first 128 bits of user memory read in less than 10 ms. This time may vary depending on the data rate used as constrained by the local radio regulations.
P:7	Write transaction time	Once a tag has been identified and selected, a 32-bit data block can typically be written in less than 20 ms. This time may vary depending on the data rate used as constrained by the local radio regulations.
P:8	Error detection	Interrogator to tag Type A: 16-bit commands: CRC-5. Commands of more than 16 bits have an additional CRC-16, bit protection. Type B: CRC-16 Tag to interrogator: CRC-16 for both types.
P:9	Error correction	No forward error correction code used. Errors are handled by signalling an error to the interrogator that then repeats its last transmission.
P:10	Memory size	No minimum user memory size is specified, but if user memory is provided it shall be an integer multiples of 4 bytes.
P:11	Command structure and extensibility	Type A: Several command codes are reserved for future use. In addition, a Protocol extension flag allows for further extensions. Type B: Several command codes are reserved for future use.

Table 5 — Anti-collision parameters

Ref.	Parameter name	Description
A:1	Type (Probabilistic or Deterministic)	Type A: Probabilistic. Type B: Probabilistic.
A:2	Linearity	Type A: Essentially linear using adaptive slot allocation up to 256 slots for 250 tags in an interrogator zone. Type B: Essentially linear up to 2^{256} tags depending on size of data content.
A:3	Tag inventory capacity	The algorithm permits the reading of not less than 250 tags in the reading zone of the interrogator.

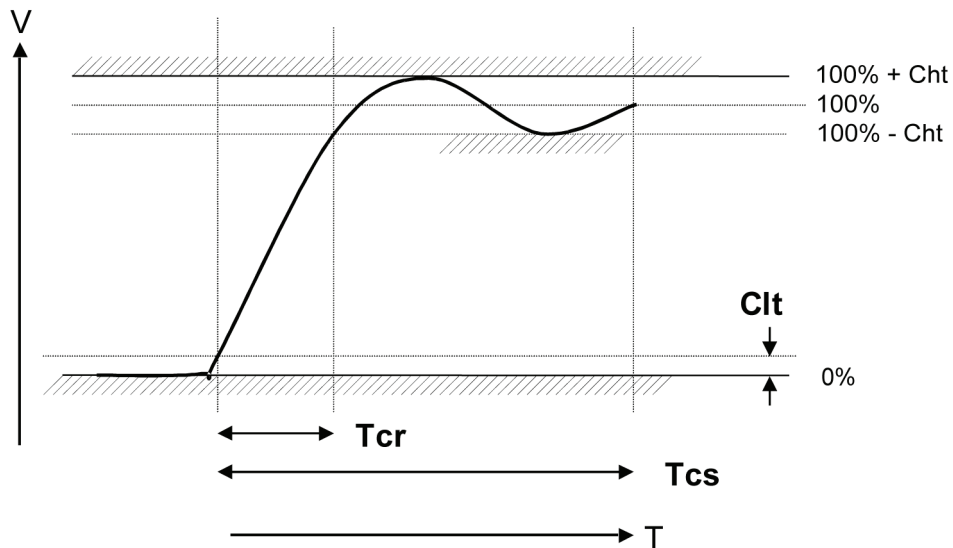


Figure 4 — Interrogator power-up waveform

Table 6 — Interrogator power-up waveform parameter values

Parameter	Min	Max
Tcs		1500µs
Tcr	1 µs	500 µs
Cht		10%
Clf		1%

6 Common elements of the physical layer for types A and B

6.1 General

Types A and B have several common elements for the physical layers. They are specified in the following sub-clauses.

6.2 Interrogator power-up waveform

The interrogator power-up waveform shall comply with the mask specified in Figure 4 and Table 6.

6.3 Interrogator power-down

Once the carrier level has dropped below the ripple limit Cht, power down shall be monotonic and of duration Tcf, as specified in Figure 5 and Table 7.

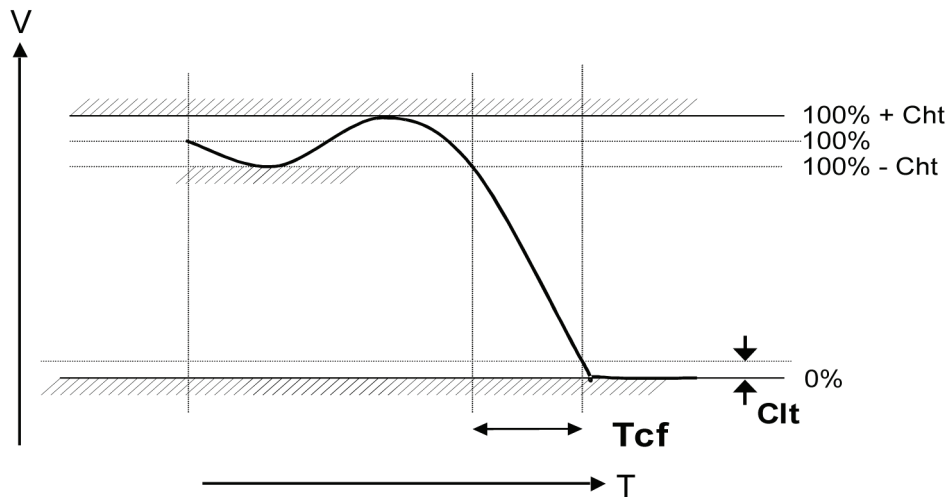


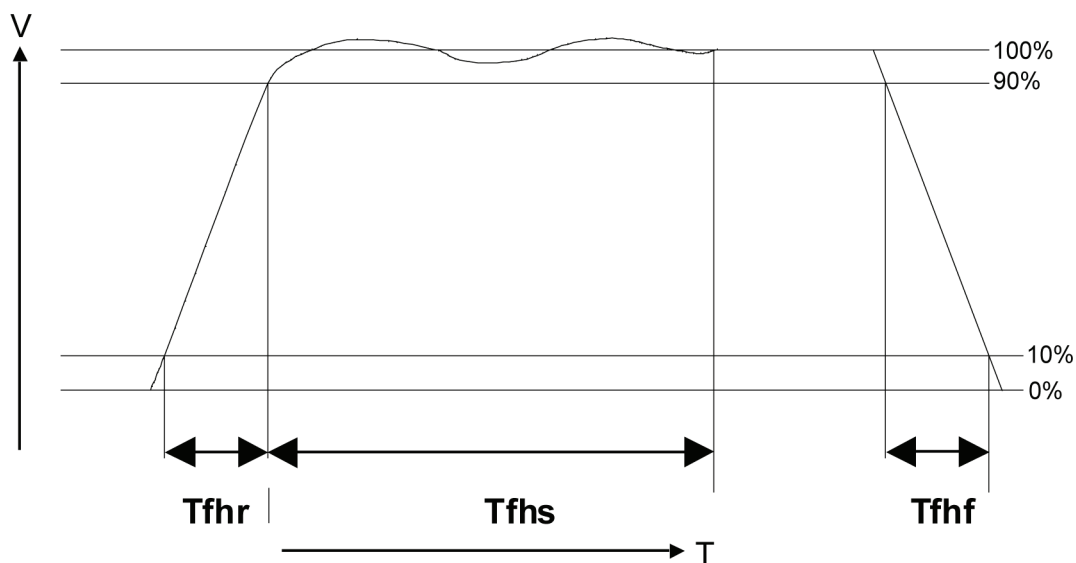
Figure 5 — Interrogator power-down waveform

Table 7 — Interrogator power-down timings

Parameter	Min	Max
Tcf	1 μ s	500 μ s
Cht		$\pm 5\%$ of steady state (100 %) level
Clc		1 %

6.4 Frequency hopping carrier rise and fall times

When the interrogator operates in the frequency operating hopping spread spectrum mode (FHSS), the carrier rise and fall times shall conform to the characteristics specified in Figure 6 and Table 8. The interrogator shall complete a frequency hop in a time not exceeding 30 μ s (to ensure that the tag is not reset by the frequency hop). The frequency hop is measured from the beginning of Tfhf to the end of Tfhr.



NOTE Ripple is $\pm 5\%$ of 100 % of steady state level

Figure 6 — FHSS carrier rise and fall characteristics

Table 8 — FHSS carrier rise and fall parameters

Parameter	Min	Max
Tfhr		30 μ s
Tfhs	400 μ s	
Tfhf		30 μ s

6.5 FM0 return link

6.5.1 FM0 return link general

The tag transmits information to the interrogator by modulating the incident energy and reflecting it back to the interrogator (backscatter).

6.5.2 Modulation

The tag switches its reflectivity between two states. The “space” state is the normal condition in which the tag is powered by the interrogator and able to receive and decode the forward link. The “mark” state” is the alternative condition created by changing the antenna configuration or termination.

6.5.3 Data rate

The data rate is 40kbit/s.

6.5.4 Data coding

Data is coded using the FM0 technique, also known as Bi-Phase Space.

One symbol period $Trlb$, as specified in Table 9, is allocated to each bit to be sent. In FM0 encoding, data transitions occur at all bit boundaries. In addition, data transitions occur at the mid-bit of logic 0 being sent.

Table 9 — Return link parameters

Data rate	$Trlb$	Tolerance
40kbit/s	25 μ s	+/-15%

Coding of data is MSB first. Figure 7 illustrates the coding for the 8 bits of 'B1'.

FM0 Data Coding
MSB first encoding of Byte 10110001 = 'B1'

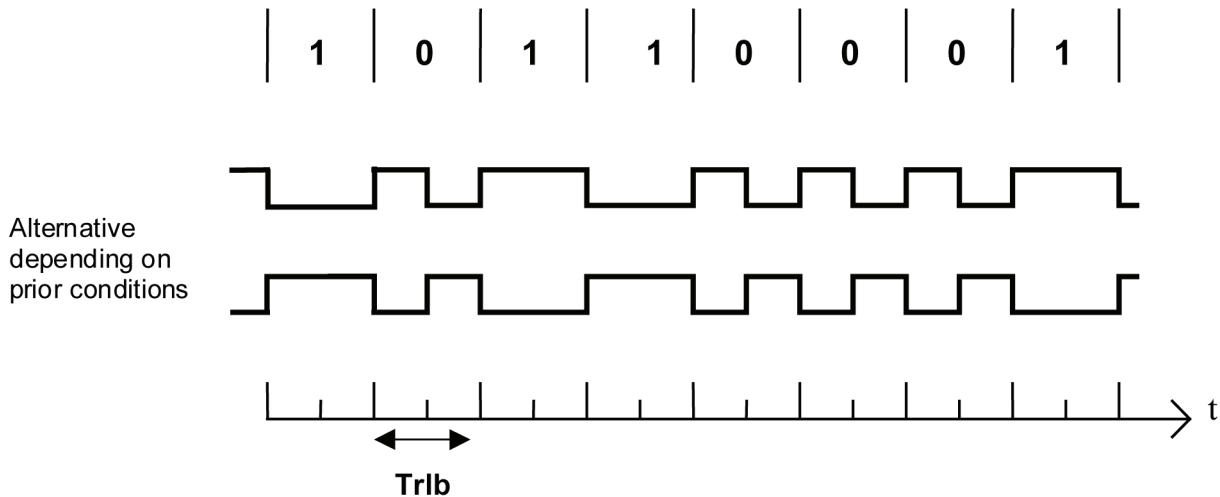


Figure 7 — Tag to interrogator data coding

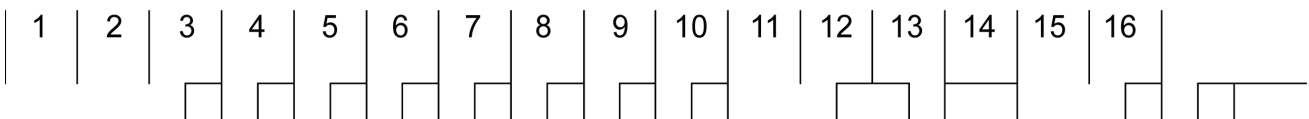
6.5.5 Message format

A return Link Message consists of n data bits preceded by the Preamble. The data bits are sent MSB first.

The Preamble enables the interrogator to lock to the tag data clock and begin decoding of the message. It consists of 16 bits as shown in Figure 8. There are multiple code violations (sequences not conforming to FM0 rules) that act as a frame marker for the transition from Preamble to Data.

6.5.6 Return preamble

The return preamble is a sequence of backscatter modulation specified in Figure 8.



NOTE The high state represents high reflectivity and the low state represents low reflectivity.

Figure 8 — Preamble waveform

Changing the Tag's modulator switch from the high impedance state to the low impedance state causes a change in the incident energy to be back-scattered, see Figure 9.

The tag shall execute backscatter, a half-low and half-high sent by the tag defined as follows:

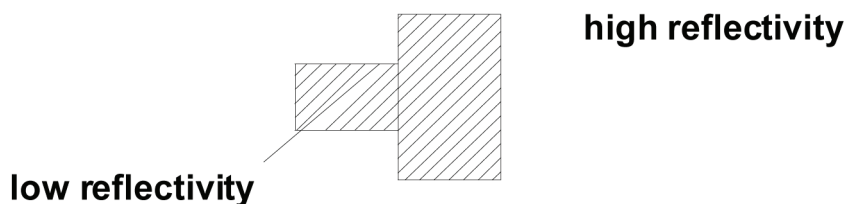


Figure 9 — Return link bit coding

6.5.7 Cyclic redundancy check (CRC)

6.5.7.1 CRC General

Types A and B use the same CRC-16 for the forward and the return links. In addition, Type A uses CRC-5 for short commands when it satisfies the required level of protection against errors.

On receiving a command from the interrogator, the tag shall verify that the checksum or the CRC value is valid. If it is invalid, it shall discard the frame, shall not respond and shall not take any other action.

6.5.7.2 Interrogator to tag 5 bit CRC-5

The 5 bit CRC shall be calculated on all the command bits after the SOF up to but not including the first CRC bit.

The polynomial used to calculate the CRC is $x^5 + x^3 + 1$.

A possible implementation is using a 5-bit shift register as defined in Clause A.1. The 5 bit CRC register is named Q4 to Q0, with Q4 being the MSB and Q0 being the LSB. The 5-bit register must be preloaded with '01001' (MSB to LSB) or in hexadecimal notation 0x09 (HEX), as shown in Table A.1

The 11 bits of data must be clocked through the CRC register, using the MSB first. The 5 CRC bits are then sent, MSB first. After the LSB of the CRC-5 bit is clocked through, the 5-bit CRC register should contain all zero's.

NOTE A schematic of a possible implementation is provided in Annex A.

6.5.7.3 Interrogator to tag 16 bit CRC-16

6.5.7.3.1 Interrogator to tag CRC-16 general

The 16 bit CRC shall be calculated on all the command bits after the SOF up to but not including the first CRC bit.

The polynomial used to calculate the CRC is $x^{16} + x^{12} + x^5 + 1$. The 16-bit register shall be preloaded with 'FFFF'. The resulting CRC value shall be inverted, attached to the end of the packet and transmitted.

The most significant byte shall be transmitted first. The most significant bit of each byte shall be transmitted first.

NOTE A schematic of a possible implementation is provided in Annex A.

The CRC may be implemented in one of two ways:

6.5.7.3.2 Inversion of incoming CRC bits by the tag

At the tag, the incoming CRC bits are inverted and then clocked into the register. After the LSB CRC bit is clocked into the register the 16 bit CRC register should contain all zero's.

6.5.7.3.3 Non-inversion of incoming CRC bits by the tag

If the received CRC bits are not inverted before clocking into the register, then after the LSB CRC bit is clocked into the register the 16 bit CRC register will have the value 0x1D0F (HEX)

6.5.7.4 Tag to interrogator 16 bit CRC-16

6.5.7.4.1 Tag to interrogator to tag CRC-16 general

The 16 bit CRC shall be calculated on all data bits up to, but not including, the first CRC bit.

The polynomial used to calculate the CRC is $x^{16} + x^{12} + x^5 + 1$. The 16-bit register shall be preloaded with 0xFFFF (HEX). The resulting CRC value shall be inverted, attached to the end of the packet and transmitted.

The most significant byte shall be transmitted first, see Table 10. The most significant bit of each byte shall be transmitted first.

On receiving of a response from the tag, it is recommended that the interrogator verifies that the CRC value is valid. If it is invalid, appropriate remedial action is the responsibility of the interrogator designer.

NOTE A schematic of a possible implementation is provided in Annex A.

Table 10 — CRC-16 bits and bytes transmission rules

MSByte	LSByte
MSB LSB	MSB LSB
CRC-16 (8 bits)	CRC-16 (8 bits)
↑ first transmitted bit of the inverted CRC	

The CRC may be implemented in one of two ways.

6.5.7.4.2 Inversion of incoming CRC bits by the interrogator

At the reader receiver, the incoming CRC bits are inverted and then clocked into the register. After the LSB CRC bit is clocked into the register the 16 bit CRC register should contain all zero's.

6.5.7.4.3 Non-inversion of incoming CRC bits by the interrogator

If the received CRC bits are not inverted before clocking, the CRC register will have the value 0x1D0F (HEX).

7 Type A

7.1 Physical layer and data coding

7.1.1 PIE (Pulse interval encoding) forward link

7.1.1.1 Carrier modulation pulses

The data transmission from the interrogator to the tag is achieved by modulating the carrier amplitude (ASK). The data coding is performed by generating pulses at variable time intervals. The duration of the interval between two successive pulses carries the data coding information.

The tag shall measure the inter-pulse time on the high to low transitions (falling) edges of the pulse as shown in Figure 10.

The carrier modulation pulses are negative-going raised cosine shaped, their characteristics are specified in Figure 11 and Table 11.

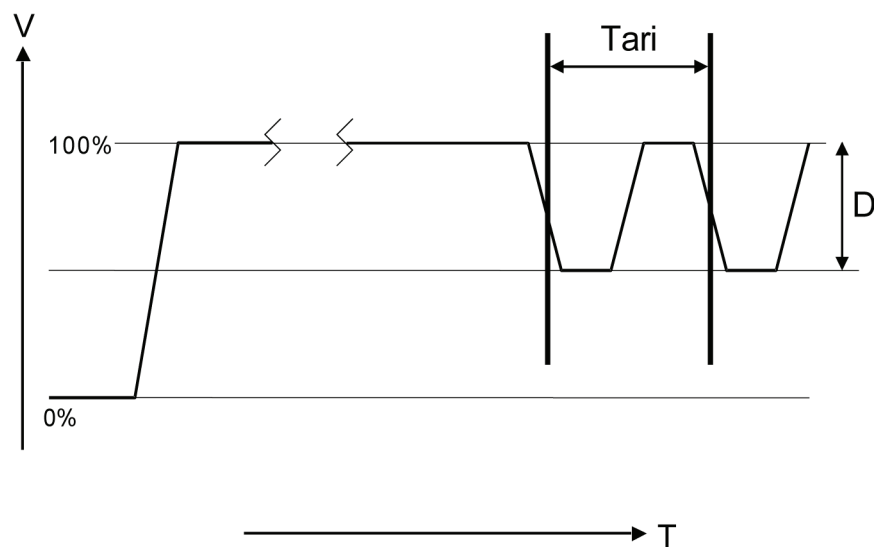
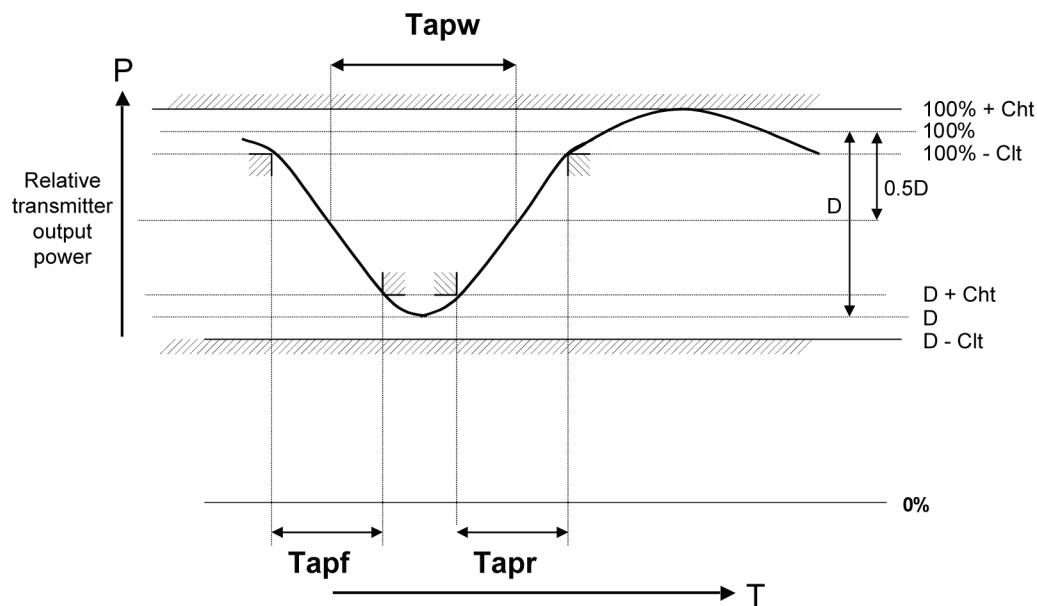


Figure 10 — Inter-pulse mechanism



NOTE The vertical lines occur at the half power (3dB) point on the modulation carrier dip.

Figure 11 — Modulation shaping

Table 11 — Modulation parameters

Parameter	Min	Nominal	Max
Tapw		10µs	
D	27% See NOTE 1		See NOTE 2
Tapf		4µs	
Tapr		4µs	
Cht			0.1 D
Clf			0.1 D
NOTE 1 The minimum modulation depth value is the absolute limit over the interrogator's operating temperature range.			
NOTE 2 The maximum modulation depth is may be in the range of 0.73 to 0 times the steady state value and will depend on the radio regulatory environment.			

The interrogator shall maintain a constant modulation depth during the transmission of a command, within the Cht and Clf tolerances.

7.1.1.2 Data coding and framing

The time Tari specifies the reference interval between the falling edges of two successive pulses representing the symbol '0' as transmitted by the interrogator; its value is specified in Table 12

Table 12 — Reference interval timing

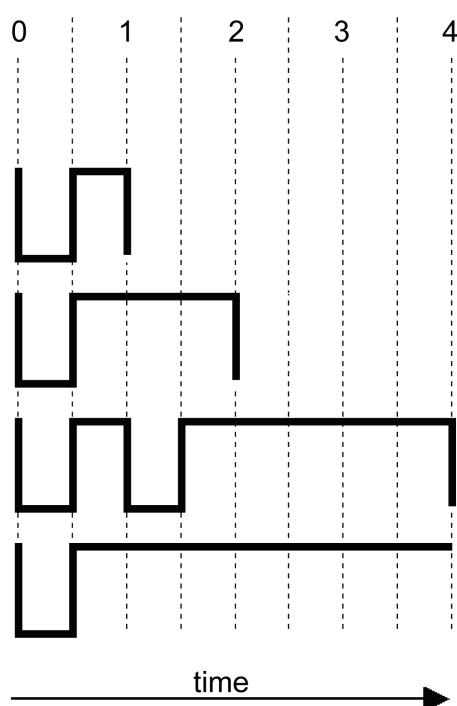
Tari	Tolerance
20 μ s	$\pm$ 100 ppm

Four symbols are defined as shown as shown in Table 13 and Figure 12. The symbols are referenced to the interval Tari and have a duration of 1 Tari, 2 Tari, and 4 Tari being integer multiples of Tari and shall have a tolerance with respect to Tari as defined in Table 13. The Start of Frame, SOF symbol is a combinational symbol made up by concatenating a '0' symbol with a symbol having a duration of 3 Tari, for an overall length of 4 Tari.

Table 13 — PIE symbols, coding

Symbol	Duration	Tolerance with respect to 1 Tari
0	1 Tari	
1	2 Tari	$\pm$ 100 ppm
SOF	1 Tari followed by 3 Tari	$\pm$ 100 ppm
EOF	4 Tari	$\pm$ 100 ppm

Symbol	Number of Tari
'0'	1
'1'	2
SOF	4
EOF	4

**Figure 12 — PIE symbols**

7.1.1.3 Decoding of PIE symbols by the tag

The tag shall be able to decode a PIE encoded transmission having symbols of duration as specified in Table 14:

Table 14 — Pie symbols, decoding

Symbol	Mean duration	Limits
0	1 Tari	$1/2 \text{ Tari} < '0' \leq 3/2 \text{ Tari}$
1	2 Tari	$3/2 \text{ Tari} < '1' \leq 5/2 \text{ Tari}$
SOF	1 Tari followed by 3 Tari	Calibration sequence
EOF	4 Tari	$\geq 4 \text{ Tari}$

The reference for the decoder is derived from the SOF and is $= 3/2 \text{ Tari}$

The tag shall interpret an interval between received symbols of $>4 \text{ Tari}$ as an EOF and shall discard the preceding data.

If the tag does not receive data for a period greater than EOF, the tag shall wait for a SOF.

7.1.1.4 Frame format

The bits transmitted by the interrogator to the tag are embedded in a frame as specified in Figure 13.

Before sending the frame, the interrogator shall ensure that it has established an unmodulated carrier for a duration of at least T_{aq} (Quiet time) of $300\mu\text{s}$.

The frame consists of a Start Of Frame (SOF), immediately followed by the data bits and terminated by an End Of Frame (EOF). After having sent the EOF the interrogator shall maintain a steady carrier for the time specified by the protocol so that the tags are powered for transmitting their response.

If the tag does not receive data for a period greater than EOF, then the command decoder shall revert to the ready state and await another SOF.

The tag shall interpret an interval between received symbols of $>4 \text{ Tari}$ as an error and shall discard the preceding data.

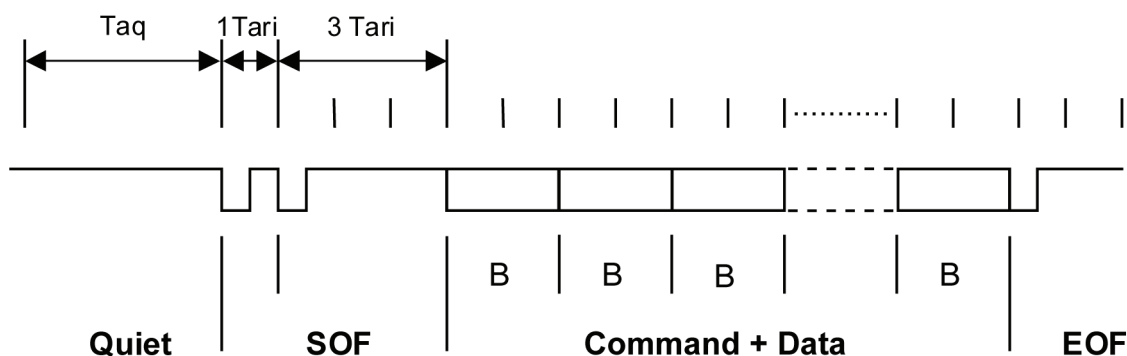


Figure 13 — Forward link frame format

7.1.1.5 Data decoding

The tag shall decode the symbols specified in Table 13.

The tag shall be able to decode an incoming signal having a modulation depth (as specified in clause 7.1.1.1, Figure 11 and Table 11) with respect to the reader steady state carrier of 27 % or greater (ie 27 % to 100 %). In other words the modulation depth may be anywhere in the range of 0.73 to 0 times the steady state carrier amplitude.

If the tag detects an invalid code, it shall discard the frame and wait for an unmodulated carrier of 4Tari duration.

7.1.1.6 Bits and byte ordering

Coding of data into symbols shall be MSB first. The coding for the 8 bits of hex byte 'B1' is shown in Figure 14.

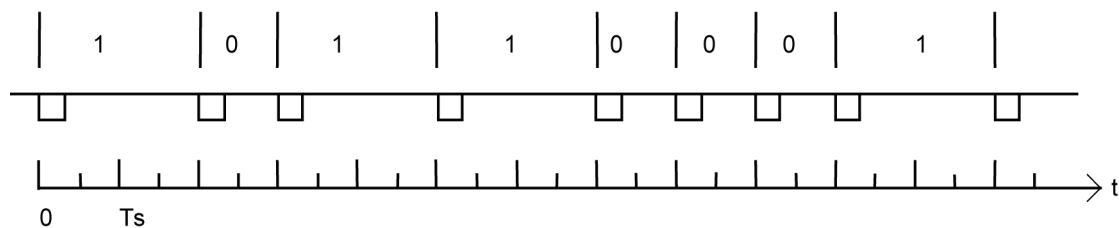


Figure 14 — Example of PIE byte encoding for 'B1'

7.2 Data elements

7.2.1 Unique identifier (UID)

Tags may be uniquely identified in order to provide a one-to-one transaction between the tag and the interrogator and to provide traceability information relating to the transponder chip. When thus used, the tag Unique Identification number (UID) shall be in this form as specified in Table 15 and ISO/IEC 15963.

If used, the UID shall be set permanently by the IC manufacturer in accordance with Table 15.

Table 15 — UID format

MSB			LSB
b64 .. b57	b56 .. b49	b48 .. b33	b32 .. b1
'E0'	IC Mfg code	RFU set to '0'	IC manufacturer serial number

The tag UID shall comprise

- The 8 MSB bits defined as 'E0',
- The IC manufacturer code of 8 bits according to ISO/IEC 7816-6, and
- A unique serial number of 48 bits assigned by the IC manufacturer.

7.2.2 Sub-UID

When the Aloha protocol is used, only a part of the UID, called Sub-UID (SUID) is transmitted in most commands and in the tag response during a collision arbitration process. The only exception is the `Get_system_information` command that returns the complete UID of 64 bits. See clause 7.8.7.

The SUID consists of 40 bits: the 8 bits manufacturer code followed by the 32 LSBs of the serial number.

The 16 MSBs (bits 33 to 48) of the serial number shall be set to 0, as bits 33 to 48 are ignored in the SUID.

The mapping of the 64 bit UID to the transmitted 40 bits and back is described in Figure 15.

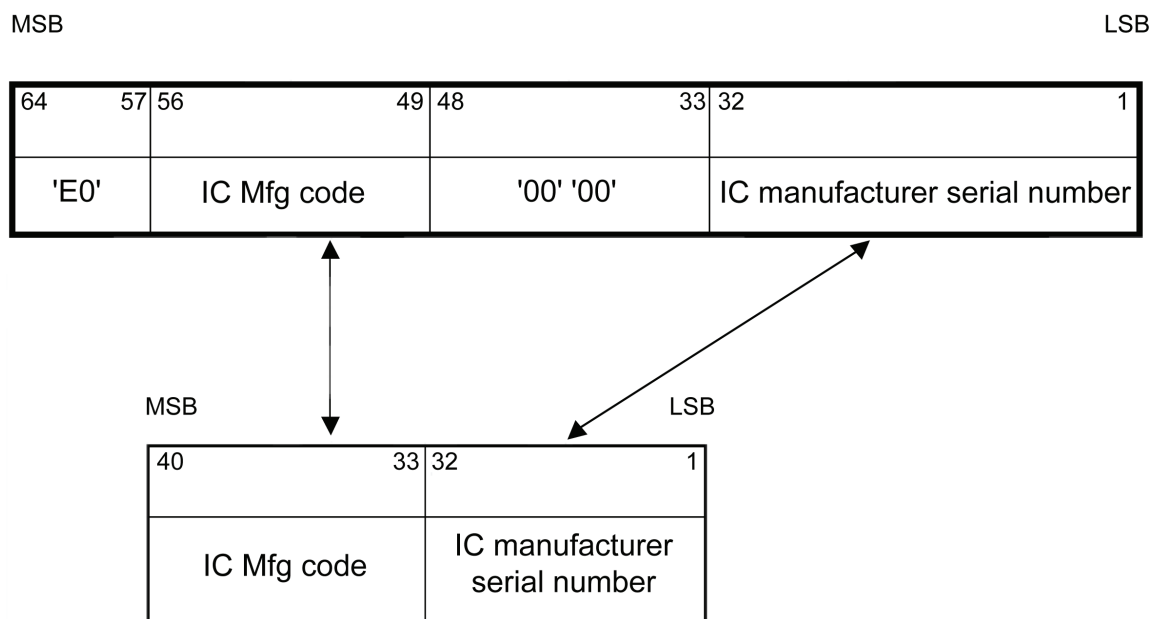


Figure 15 — UID/SUID mapping from 64 to 40

The interrogator shall use the 64-bit format specified in clause 7.2.1 when exchanging the UID with the application. It shall perform the required mapping described in Figure 15.

7.2.3 Application family identifier

An Application Family Identifier (AFI) may optionally be used to group select tags. The AFI shall comprise a byte (8 bits). The AFI is a parameter in the `Init_round` command, or the first 8 bits in the selection mask of the `Begin_round` command.

When the AFI is used in the Init_round or the Begin_round command it shall conform to the format specified in ISO/IEC 15961 and ISO/IEC 15962 and shown in Table 16.

When an arbitration sequence is initiated using the Init_round or Begin_round command, the AFI parameter shall contain the value of either 0x00 in which case all tags shall respond or; a specific 8 bit value, in which case only those tags which have a matching value shall respond.

Table 16 — AFI/ASF coding

AFI	Meaning tags respond from	Examples / note
'00'	All families respond	No applicative preselection
'XY'	Tags match 'XY' respond	

NOTE Table 16 is taken from ISO/IEC 15961 and ISO/IEC 15962. Users should refer to the latest version of ISO/IEC 15961 and ISO/IEC 15962, for their reference.

7.2.4 Data storage format identifier (DSFID)

The Data storage format identifier indicates how the data is structured in the tag memory.

It may be programmed and locked by the respective commands. It is coded using one byte. It provides knowledge of the logical organisation of the data.

Its coding shall conform to ISO/IEC 15962.

Where the tag does not support programming of DSFID, it shall respond with the value of DSFID being set to zero ('00').

7.3 Protocol elements

7.3.1 Tag memory organisation

The commands specified in this part of ISO/IEC 18000 assume that the physical memory is organised in blocks of a fixed size.

Up to 256 blocks can be addressed, block sizes can be up to 256 bits, which leads to a maximum memory capacity of up to 8 kBytes (64 kBits).

NOTE The command structure allows for extension of the maximum memory capacity, if required, in revisions of this part of ISO/IEC 18000.

The commands described in this part of ISO/IEC 18000 allow access (read and write) by block(s). There is no implicit or explicit restriction regarding other access methods (e.g., by byte or by logical object in revisions of this part of ISO/IEC 18000, or in custom commands).

7.3.2 Support of battery-assisted tags

This part of ISO/IEC 18000 makes provision for the support of battery-assisted tags.

In normal operation, there is no functional difference between passive and battery-assisted tags.

The mechanisms provided to handle the differences in performance and maintenance of tags that are battery-assisted and those that are not battery-assisted are as follows:

- a) The type of tag and its sensitivity level are returned in the answer to the Get_system_information command. See clause 7.8.7.
- b) The type of tag (battery/no battery) and the battery status is returned in the tag answer during the collision arbitration sequence. See clause 7.7.5.

7.3.3 Block lock status

The block lock status is returned by the tag as a parameter in the response to an interrogator command as specified in clause 7.8.16. The block lock status is coded using two bits. Table 17 shows the 2 bits used for each block diagrammatically, with the actual implementation left to the IC designer.

The block lock status is an element of the protocol. There is no implicit or explicit assumption that the 2 bits are actually implemented in the physical memory structure of the tag.

User locking is performed by the Lock_blocks command.

Factory locking may be performed by a proprietary command.

Table 17 — Block lock status

Bit	Flag name	Value	Description
b1	User_lock_flag	0	Not user locked
		1	User locked
b2	Factory_lock_flag	0	Not factory locked
		1	Factory locked

7.3.4 Tag signature

The tag signature comprises 4 bits. It is used in the Aloha collision arbitration mechanism.

The purpose of the tag signature is to provide a transient session identity that gives differentiation between tags that have answered in the same slot.

The signature is designed to avoid inadvertent isolation, selection or acknowledgement of a tag masked by another tag due to weak signal masking. The tag may generate its signature by a number of mechanisms. For example, by means of a 4 bit pseudo-random number generator, or; by using a part of the tag's UID, or; tag's CRC or; by having a circuit that measures the tag's excitation level [TEL]. The means by which the signature is generated is left to the manufacturer and is not specified in this part of ISO/IEC 18000.

During the collision arbitration process, the tag transmits its signature along with its data or SUID. The interrogator then uses the signature in its communication with the tag by including it in transmitted commands so that only the tag with a matching signature will be responsive to those commands.

On receiving a command requiring a signature, the tag shall test the received signature against the one it has generated and sent. The tag shall behave in accordance with the state diagram, see Figure 16, and the respective state transition tables. For the Next_slot command see Table 31 and for the Standby_round command see Table 33.

7.4 Protocol description

7.4.1 Protocol concept

The transmission protocol defines the mechanism for exchanging commands and data between the interrogator and the tag, in both directions.

It is based on the concept of "interrogator talks first".

This means that the tag shall wait to receive a correctly decoded command from the interrogator before transmitting.

a) The protocol is based on an exchange of

- A command from the interrogator to the tag, and
- A response from the tag(s) to the interrogator.

The conditions under which the tag sends a response are defined in clause 7.7 and 7.8.

b) Each command and each response are contained in a frame. Each command consists of the following fields:

- SOF,
- RFU field (reserved for protocol extension),
- A command code,
- Parameters (or RFU) ,
- CRC-5,
- Optional parameter fields, depending on the command ,
- Application data fields,
- CRC-16, and
- EOF.

c) Each response consists of the following fields:

- SOF,
- Flags,
- Mandatory and optional parameter fields, depending on the command ,
- Application data fields,
- CRC-16, and
- EOF.

d) The protocol is bit-oriented. A single field is transmitted most significant bit (MSB) first.

- e) A multiple-byte field is transmitted most significant byte (MSByte) first, each byte is transmitted most significant bit (MSB) first.
- f) The setting of the flags indicates the presence of the optional fields. When the flag is set (to one), the field is present. When the flag is reset (to zero), the field is absent.
- g) RFU flags shall be set to zero (0).

7.4.2 Command format

7.4.2.1 Type A command format general

There are two forms of commands, short commands of 16 bits, and longer.

7.4.2.2 Short command format

A short command consists of the fields defined in Table 18.

Table 18 — Short command format

SOF	RFU	Command code	Parameters/Flags	CRC-5	EOF
	1 bit	6 bits	4 bits	5 bits	

7.4.2.3 Long command format

A long command consists of the fields defined in Table 19.

Table 19 — Long command format

SOF	RFU	Command code	Parameters or flags	CRC-5	SUID (optional)	Data	Data (optional)	CRC-16	EOF
	1 bit	6 bits	4 bits	5 bits	40 bits	8 bits	8 to n	16 bits	

The upper value of the optional data field length is specified as n, where $n = m + 8$, and where m = the number of bits to program in the tag's memory. Currently, the value of m = 32 is used, but the protocol allows m to be up to 256.

7.4.3 Command flags

7.4.3.1 Command flags

There is only one command flag, and if present is the SUID flag.

7.4.3.2 SUID flag

7.4.3.2.1 SUID flag general

The SUID flag is contained in the most significant bit position of the command parameter field. Its function is modified by the particular command. Refer to Table 22.

7.4.3.2.2 SUID flag and inventory commands

Inventory commands are:

- Init_round,
- Init_round_all,
- Begin_Round,
- New_Round,
- Close_Slot, and
- Next_Slot.

The first four of the six inventory commands are used for round Initialisation. These four commands can select between receiving the first page of user memory or the tag's SUID as the data message received as part of the inventory process.

If the SUID flag is not set ('0'), the tag shall return the first page of user memory. It shall not include the SUID in its response. (A page of user memory may be as little as 0 bits, but if user memory is present it must be a multiple of 4 bytes (32 bits) depending on the specific implementation.)

If the SUID flag is set ('1'), the tag shall return the SUID. See clauses 7.8.2 and 7.7.5

7.4.3.2.3 SUID flag and non-inventory commands

If the SUID flag is present in the Select, Read_blocks, Get_system_information, Write_block, Write_multiple_blocks, Lock_blocks, Write_AFI, Lock_AFI, Write_DSFD, Lock_DSFD or Get_block_lock_status, then only that tag addressed by the SUID will process the command.

When the SUID flag is set ('1'), the command shall contain the SUID of the addressed tag. On receiving a command with the SUID flag set, the tag shall compare the SUID contained in the command with its SUID. If the SUID matches, the tag shall execute the command. If the SUID does not match, the tag shall ignore the command.

When the SUID flag is not set ('0'), the command shall not contain the SUID. On receiving a command the tag shall respond to the command if it is in the select state. (ie. it was previously selected by means of a Standby_round command with valid signature, or by means of the select command.) If the tag is not in the select state it shall ignore the command.

7.4.4 Round size

The round size is coded using 3 bits according to Table 20.

Table 20 — Round size coding

Value	Bit coding		Round size
	MSB	LSB	
'0'	0	0 0	1
'1'	0	0 1	8
'2'	0	1 0	16
'3'	0	1 1	32
'4'	1	0 0	64
'5'	1	0 1	128
'6'	1	1 0	256
'7'	1	1 1	RFU

7.4.5 Command code definition and structure

The size of the command code is 6 bits.

7.4.6 Command classes

7.4.6.1 Command classes general

Four sets of commands, as shown in Table 21, are defined: mandatory, optional, custom and proprietary.

Table 21 — Command classes

Code	Class	Number of possible codes
'00', '02', '04', '06', '0A', and '0C' – '0F'	Mandatory	10
'01', '03', '05', '07', '08', '09', '0B' and '10' – '27'	Optional	30
'28' – '37'	Custom	16
'38' – '3F'	Proprietary	8

All tags with the same IC manufacturer code and same IC version number shall behave the same.

7.4.6.2 Mandatory

The mandatory command codes are '02', '04', '06' and '0A'. Command codes '00' and '0C' to '0F', are RFU.

Mandatory commands shall be supported by all tags that claim to be compliant. Interrogators which claim compliance shall support all mandatory commands.

7.4.6.3 Optional

The optional command codes are '01', '03', '05', '07', '08', '09', '0B' and '10' to '27'.

Optional commands are commands that are specified within this part of ISO/IEC 18000. Interrogators shall be technically capable of performing all optional commands that are specified in this part of ISO/IEC 18000 (although need not be set up to do so). Tags may or may not support optional commands.

If an optional command is used, it shall be implemented in the manner specified in this part of ISO/IEC 18000.

If a tag in the selected state does not support the optional command it shall return the error code "command is not supported", see clause 7.4.8.2.

If the command specifies an SUID and the tag with the matching SUID does not support the optional command it shall return the error code "command is not supported", see clause 7.4.8.2.

All other tags shall remain silent.

7.4.6.4 Custom

The custom command codes range from '28' to '37'. Custom commands may be enabled by this part of ISO/IEC 18000, but they shall not be specified in this part of ISO/IEC 18000. A custom command shall not solely duplicate the functionality of any mandatory or optional command defined in this part of ISO/IEC 18000 by a different method.

Tags may support custom commands, at their option, to implement manufacturer specific functions. The function of flags (including reserved bits) shall not be modified. The only fields that can be customised are the parameter and the data fields.

Any custom command contains as its first parameter the IC manufacturer code. This allows IC manufacturers to implement custom commands without risking duplication of command codes and thus misinterpretation.

A tag in the selected state that does not support the Custom command shall return the error code "command is not supported", see clause 7.4.8.2.

If the command specifies an SUID and the tag with the matching SUID, does not support the Custom command, it shall return the error code "command is not supported", see clause 7.4.8.2.

All other tags shall remain silent.

7.4.6.5 Proprietary

The proprietary command codes range from '38' to '3F'. Proprietary commands may be enabled this part of ISO/IEC 18000, but they shall not be specified in this part of ISO/IEC 18000. A proprietary command shall not solely duplicate the functionality of any mandatory or optional command defined in this part of ISO/IEC 18000 by a different method.

These commands are used by IC and tag manufacturers for various purposes such as tests, programming of system information, etc. They are not specified in this part of ISO/IEC 18000. The IC manufacturer may at its option document them or not. This part of ISO/IEC 18000 allows these commands to be disabled after IC and/or tag manufacturing.

7.4.7 Command codes and CRC

All mandatory and optional commands are mandatory for a reader implementation, although the reader may not be set-up to provide them all.

This part of ISO/IEC 18000 currently defines 4 mandatory tag commands, **Next_slot**, **Standby_round**, **Reset_to_ready** and **Init_round_all**, and 6 RFU mandatory commands. All commands are summarised in Table 22, with the 4 mandatory tag commands being highlighted in bold.

Table 22 — Command codes

Command 6 bits	Op code	Parameter / flags 4 bits		CRC-5	Extended parameters				CRC-16	Comments
RFU	00									
Init_round	01	SUID 1 bit	Round size 3 bits	5 bits	AFI 8 bits				16 bits	SUID = 0 tag responds with first page of user data SUID = 1 tag responds with SUID If AFI field = 0x00 (HEX), all tags respond, else if AFI is other value, only tags with matching AFI respond
Next_slot	02	Signature 4 bits		5 bits	none					The signature may be one of 15 values between 0x01 (HEX) and 0x0F (HEX) as transmitted by the tag in its last transmission. A signature value of 0x00 (HEX) will only advance the slot counter (equivalent to close-slot command.)
Close_slot	03	Null		5 bits	none					
Standby_round	04	Signature 4 bits		5 bits	none					The signature may be one of 15 values between 0x01 (HEX) and 0x0F (HEX) as transmitted by the tag in its last transmission.
New_round	05	SUID 1 bit	Round size 3 bits	5 bits	none					
Reset_to_read y	06	Null		5 bits	none					
Select	07	SUID=1 1 bit	Null 3 bits	5 bits	SUID 40 bits				16 bits	
Read_blocks	08	SUID=0 1 bit	Null 3 bits	5 bits	First Block 8 bits	Number of blocks 8 bits			16 bits	
Read_blocks	08	SUID=1 1 bit	Null 3 bits	5 bits	SUID 40 bits	First Block 8 bits	Number of blocks 8 bits		16 bits	
Get_system _information	09	SUID=0 1 bit	Null 3 bits	5 bits						

Table 22 (continued)

Command 6 bits	Op code	Parameter / flags 4 bits		CRC-5	Extended parameters			CRC-16	Comments
Get_system_information	09	SUID=1 1 bit	Null 3 bits	5 bits	SUID 40 bits			16 bits	
Init_round_all	0A	SUID 1 bit	Round size 3 bits	5 bits					SUID = 0 tag responds with first page of user data SUID = 1 tag responds with SUID
Begin_round	0B	SUID=0	Round size 3 bits	5 bits	Mask Length 8 bits	Mask n bits			n=0 to 255
RFU	0C to 0F								
Write_block	10	SUID=0 1 bit	Null 3 bits	5 bits	Block number 8 bits	Data n bits		16 bits	n is currently 32 bits, but can be defined up to 256 bits
Write_block	10	SUID=1 1 bit	Null 3 bits	5 bits	SUID 40 bits	Block number 8 bits	Data n bits	16 bits	n is currently 32 bits, but can be defined up to 256 bits
Write_multiple_blocks	11	SUID=0 1 bit	Null 3 bits	5 bits	First Block 8 bits	Number of blocks 8 bits	Data n bits	16 bits	n is currently 32 bits, but can be defined up to 256 bits B is the number of blocks, with valid numbers being 1 to 256.
Write_multiple_blocks	11	SUID=1 1 bit	Null 3 bits	5 bits	SUID 40 bits	First Block 8 bits	Number of blocks 8 bits	D a t a n b i t s 16 bits	B is the number of blocks, with valid numbers being 1 to 256
Lock_blocks	12	SUID=0 1 bit	Lock Block number 3 bits	5 bits	Lock block data 32 bits			16 bits	
Lock_blocks	12	SUID=1 1 bit	Lock Block number 3 bits	5 bits	SUID 40 bits	Lock block data 32 bits		16 bits	
Write_AFI	13	SUID=0 1 bit	Null 3 bits	5 bits	AFI 8 bits			16 bits	
Write_AFI	13	SUID=1 1 bit	Null 3 bits	5 bits	SUID 40 bits	AFI 8 bits		16 bits	

Table 22 (continued)

Command 6 bits	Op code	Parameter / flags 4 bits		CRC-5	Extended parameters			CRC-16	Comments
Lock_AFI	14	SUID=0 1 bit	Null 3 bits	5 bits					
Lock_AFI	14	SUID=1 1 bit	Null 3 bits	5 bits	SUID 40 bits			16 bits	
Write_DSFID	15	SUID=0 1 bit	Null 3 bits	5 bits	DSFID 8 bits			16 bits	
Write_DSFID	15	SUID=1 1 bit	Null 3 bits	5 bits	SUID 40 bits	DSFID 8 bits		16 bits	
Lock_DSFID	16	SUID=0 1 bit	Null 3 bits	5 bits					
Lock_DSFID	16	SUID 1 bit	Null 3 bits	5 bits	SUID 40 bits			16 bits	
Get_block_lock_status	17	SUID=0 1 bit	Lock Block number 3 bits	5 bits					
Get_block_lock_status	17	SUID=1 1 bit	Lock Block number 3 bits	5 bits	SUID 40 bits			16 bits	
RFU	18-27								
Custom	28 - 37								
Proprietary	38-3F								

7.4.8 Response format

7.4.8.1 Response format general

The response from the tag, as shown in Table 23, consists of the following fields:

- Preamble (See clause 6.5.6),
- Flags (See clause 7.4.8.2),
- One or more parameter fields (Defined in each command),
- Data (Defined in each command), and
- CRC-16 (See clause 6.5.7.4).

Table 23 — General response format

Preamble	Flags	Parameters	Data	CRC-16
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7.4.8.2 Response error flags

In a response, two flags, as shown in Table 24, Table 25 and Table 26, indicate how the tag has performed actions and whether corresponding fields are present or not.

Table 24 — Response format when Error_flag is set

Preamble	Flags	Error code	Terminator
	2 bits	Optional 4 bits See Table 27	'0' 1 bit

Table 25 — Response format when Error_flag is NOT set, and there is NO appended data.

Preamble	Flags	Terminator
	2 bits	'0' 1 bit

Response parameter:

Error_flag (and Error code if Error_flag is set)

Table 26 — Response flags b1 to b2 definition

Bit	Flag name	Value	Description
b1	Error_flag	0	No error
		1	Error detected. Error code is in the "Error" field.
b2	RFU	0	Shall be set to 0.

7.4.8.3 Response error code

The error code comprises four bits.

When the tag sets the Error_flag, the error code field shall be included and provides information about the error that occurred. Error codes are specified in Table 27.

If the tag does not support specific error code(s) listed in Table 27, it shall answer with the error code 'F' ("Error with no information given").

Table 27 — Response error codes

Code	Description
'0'	RFU
'1'	The command is not supported, i.e. the command code is not recognised
'2'	The command is not recognised, for example: a format error occurred
'3'	The specified block is not available (does not exist)
'4'	The specified block is locked and its content cannot be changed
'5'	The specified block was not successfully programmed and/or locked
'6' – 'A'	RFU
'B'-'E'	Custom command error codes
'F'	Error with no information given or a specific error code is not supported.

7.4.9 Tag states

7.4.9.1 Tag states general

A tag can be in one of the following states:

- RF field off,
- Ready,
- Quiet,
- Selected,
- Round_active, and
- Round_standby.

The transitions between states are shown in Figure 16 and are specified in tables in each command description.

7.4.9.2 RF field off state

The tag is in the RF field off state when it does not receive the required RF field from the interrogator.

For passive tags, it means that the tag is not powered.

For battery-assisted tags, it means that the level of RF excitation is insufficient to turn on the tag circuits.

7.4.9.3 Ready state

The tag is in the Ready state when it is receiving sufficient energy from the interrogator to function correctly. It shall process any command where the Select flag is not set.

7.4.9.4 Quiet state

When in the Quiet state, the tag shall process any command where the SUID flag is set and the SUID matches.

NOTE A tag will move to the Quiet state after it has been correctly identified within its slot by the interrogator and takes no further part within the current or subsequent rounds.

7.4.9.5 Selected state

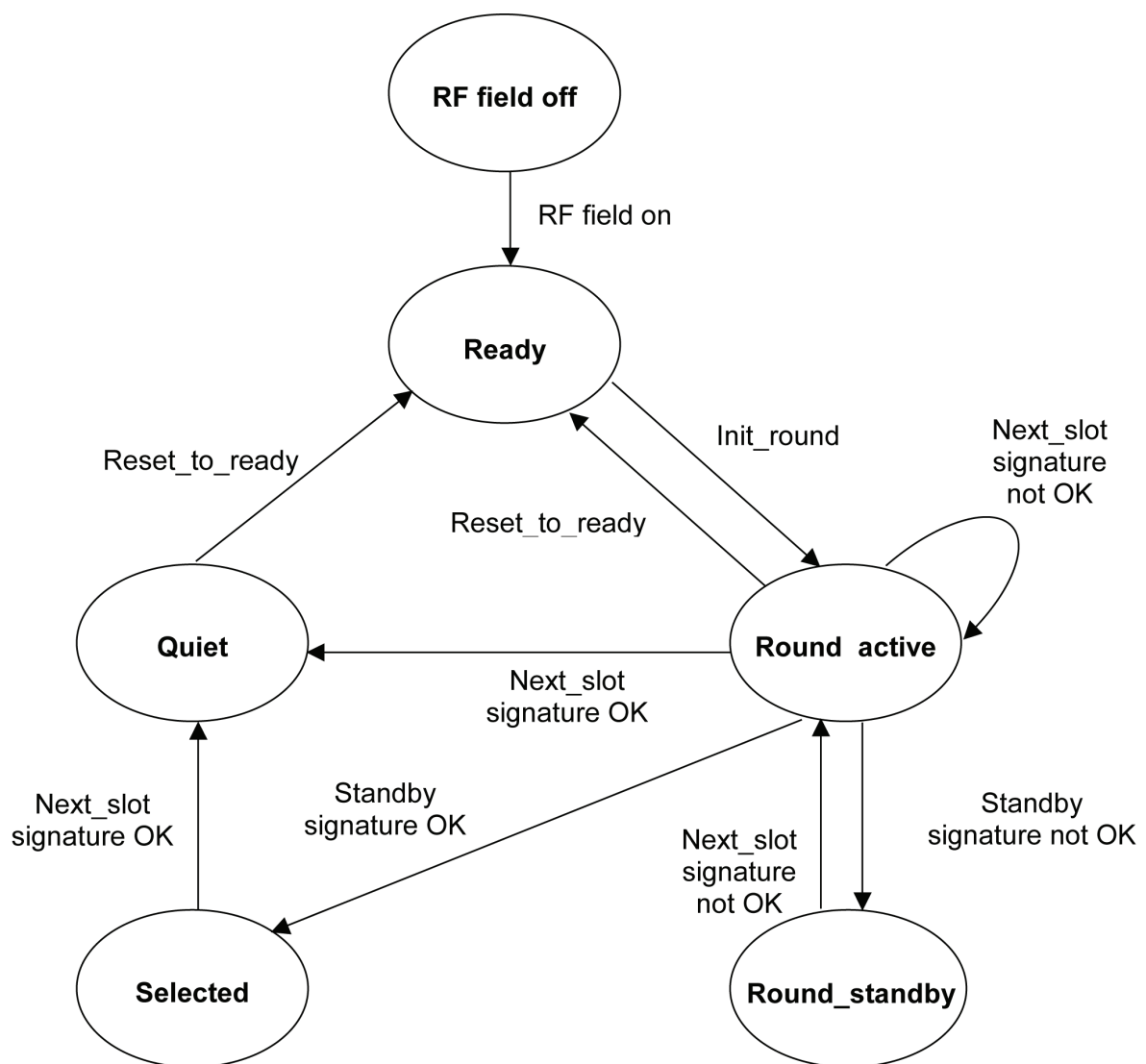
Only a tag in the Selected state shall process commands with the SUID flag set to 0, with the exception of Init_round, Init_round_all, Begin_round and New_round commands, which will be processed even if the SUID flag is set to 1.

7.4.9.6 Round_active state

When in the Round_active state, the tag shall participate in the collision arbitration described in clauses 7.4.10 and 7.4.11.

7.4.9.7 Round_standby state

When in the Round_standby state, the tag shall suspend its participation in the collision arbitration as described in clauses 7.4.10 and 7.4.11.



NOTE This state diagram shows some of the main transitions. State transitions are specified in detail in each command description.

Figure 16 — Tag state transition diagram

7.4.10 Collision arbitration

The purpose of the collision arbitration sequence is to perform a census of the tags present in the interrogator field and to receive information on the tag capabilities and data contents, all in a single sequence. The information that the tag shall return, is specified by the SUID flag, set in the command from the interrogator.

The interrogator is the master of the communication with one or multiple tags.

NOTE This mechanism is also some times referred to as the "wake-up" sequence.

7.4.11 General explanation of the collision arbitration mechanism

The collision arbitration uses a mechanism that allocates tag transmissions into rounds and slots. A round consists of a number of slots. Each slot has a duration, long enough for the interrogator to receive a tag response. The interrogator determines the actual duration of a slot.

In the absence of an RF field, the tags are in the RF_field off state. When the tags enter the energising field of an interrogator, they go through a power on reset sequence and move into the Ready state.

The interrogator initiates a tag census or collision arbitration process by sending an Init_round command, or the Init_round_all command.

Tags receiving an Init_round command randomly select a slot in which to respond but do not immediately start transmitting. The number of slots in a round referred to as round size, is determined by the interrogator and signalled to the tag in the Init_round command. The initial round size is predetermined by the user. During the subsequent collision arbitration process the interrogator dynamically chooses an optimum round size for the next round based on the number of collisions in the round. The number of collisions is a function of the number of tags in the active state present in the interrogator field and the round size.

On receiving an Init_round command, tags select a slot in which to respond. The selection is determined by a pseudo-random number generator. If the tag has selected the first slot it will wait a pseudo-random time delay equal to a time of between 0 and 7 periods and then transmit its response.

The tag includes its four bit tag signature in its response.

If the tag has selected a slot number greater than one, it will retain its slot number and wait for a further command.

After the interrogator has sent the Init_round command there are three possible outcomes:

- 1) The interrogator does not receive a response because either no tag has selected slot one or the interrogator has not detected a tag response. It then issues a Close_slot command because it has not received a response.
- 2) The interrogator detects a collision between two or more tag responses. Collisions may be detected either as contention from the multiple transmissions or by detecting an invalid CRC. Having verified that there are no tags transmitting, the interrogator sends a Close_slot command.
- 3) The interrogator receives a tag response without error, i.e. with a valid CRC. The interrogator sends a Next_slot command containing the signature of the tag just received.

When tags that have not transmitted in the current slot receive a Close_slot or Next_slot command, they increment their slot counters by one. When the slot counter equals the slot number previously selected by the tag, the tag transmits according to the rules above, otherwise the tag waits for another command.

When a tag in the active state receives a Close_slot command, it increments its slot counter.