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BSI Standards Publication

# Information technology — Radio frequency identification for item management

## Part 4: Parameters for air interface communications at 2,45 GHz

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## National foreword

This British Standard is the UK implementation of ISO/IEC 18000-4::2015. It supersedes BS ISO/IEC 18000-4:2008 which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee IST/34, Automatic identification and data capture techniques.

A list of organizations represented on this committee can be obtained on request to its secretary.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

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**Compliance with a British Standard cannot confer immunity from legal obligations.**

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INTERNATIONAL STANDARD

# ISO/IEC 18000-4

Third edition
2015-02-01

# Information technology — Radio frequency identification for item management —

## Part 4: Parameters for air interface communications at 2,45 GHz

*Technologies de l'information — Identification par radiofréquence (RFID) pour la gestion d'objets —*

*Partie 4: Paramètres de communications d'une interface d'air à 2,45 GHz*

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# 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.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of document should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT) see the following URL: Foreword - Supplementary information

The committee responsible for this document is ISO/IEC JTC 1, *Information technology*, SC 31, *Automatic identification and data capture techniques*.

This third edition cancels and replaces the second edition (ISO/IEC 18000-4:2008), of which it constitutes a minor revision with the following changes:

— 5.1 has become Clause 5;

— 5.2 has become Clause 6;

— 5.3 has been Clause 7;

— Clause 8 has been introduced;

— Clause 6 has become Clause 9;

— Clause 1, Clause 2, Clause 3, Clause 4, Clause 5, and Clause 9 have been revised as necessary to also cover Clause 8.

ISO/IEC 18000 consists of the following parts, under the general title *Information technology — Radio frequency identification for item management*:

— *Part 1: Reference architecture and definition of parameters to be standardized*

— *Part 2: Parameters for air interface communications below 135 kHz*

— *Part 3: Parameters for air interface communications at 13,56 MHz*

— *Part 4: Parameters for air interface communications at 2,45 GHz*

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

— *Part 61: Parameters for air interface communications at 860 MHz to 960 MHz Type A*

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— *Part 62: Parameters for air interface communications at 860 MHz to 960 MHz Type B*

— *Part 63: Parameters for air interface communications at 860 MHz to 960 MHz Type C*

— *Part 64: Parameters for air interface communications at 860 MHz to 960 MHz Type D*

— *Part 7: Parameters for active air interface communications at 433 MHz*


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# Introduction

This part of ISO/IEC 18000 is one of a series of International Standards and Technical Reports developed by ISO/IEC JTC 1/SC 31, WG 4 for the identification of items (item management) using radio frequency identification (RFID) technology.

This part of ISO/IEC 18000 defines three 2,45 GHz protocols. Each of the specific physical/data link configurations is defined in a separate sub-clause. The configuration descriptions include a physical layer and a data link layer.

The International Organization for Standardization (ISO) and International Electrotechnical Commission (IEC) draw attention to the fact that it is claimed that compliance with this document can involve the use of patents concerning radio-frequency identification technology given in all parts of the document.

ISO and IEC take no position concerning the evidence, validity, and scope of these patent rights.

The holders of these patent rights have assured the ISO and IEC that they are willing to negotiate licences under reasonable and non-discriminatory terms and conditions with applicants throughout the world. In this respect, the statements of the holders of these patent rights are registered with ISO and IEC. Information can be obtained from the following companies.

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# Information technology — Radio frequency identification for item management —

# Part 4: Parameters for air interface communications at 2,45 GHz

## 1 Scope

This part of ISO/IEC 18000 defines the air interface for radio frequency identification (RFID) devices operating in the 2,45 GHz Industrial, Scientific, and Medical (ISM) band used in item management applications. This part of ISO/IEC 18000 provides a common technical specification for RFID devices that can 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 equivalent isotropically radiated power (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. This part of ISO/IEC 18000 further defines the communications protocol used in the air interface.

This part of ISO/IEC 18000 contains the following three modes:

— Mode 1 is an interrogator talks first with passive tag;

— Mode 2 is a tag talks first with battery-assisted passive tag;

— Mode 3 is a globally available, ubiquitous network supporting, among others, the logistics and transportation industry; agnostic to any device, commercial or otherwise, requiring global availability.

The detailed technical differences between the modes are shown in the parameter tables.

## 2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO/IEC 7816-6:—[1], *Identification cards — Integrated circuit cards — Part 6: Interindustry data elements for interchange*

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

ISO/IEC/TR 18047-4, *Information technology — Radio frequency identification device conformance test methods — Part 4: Test methods for air interface communications at 2,45 GHz*

ISO/IEC 19762 (all parts):—[1], *Information technology — Automatic identification and data capture (AIDC) techniques — Harmonized vocabulary*

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ISO/IEC/IEEE 8802-15-4:2010, *Information technology — Telecommunications and information exchange between systems — Local and metropolitan area networks — Specific requirements — Part 15-4: Wireless medium access control (MAC) and physical layer (PHY) specifications for low-rate wireless personal area networks (WPANs)*

## 3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO/IEC 19762 (all parts):—[2)] and the following apply.

**3.1**
**associated**
has successfully negotiated a di-directional wireless link with a coordinator

Note 1 to entry: Associated networks require communication be maintained and monitored for a period of time.

**3.2**
**association**
service used to establish membership for a device communicating within the wireless network described in this International Standard

**3.3**
**block cipher**
cryptographic function that operates on strings of fixed size

**3.4**
**coordinator**
full-function device (FFD) capable of relaying messages

Note 1 to entry: If a coordinator is the principal controller of a personal area network (PAN), it is called the PAN coordinator.

**3.5**
**data server**
device data termination point

**3.6**
**device**
any entity that meets the ISO/IEC/IEEE 8802-15-4 medium access control (MAC), physical interface to the wireless medium, and this protocol specification.

Note 1 to entry: A device can be a reduced-function device (RFD) or a full function device (FFD).

**3.7**
**encryption**
transformation of a message into a new representation so that privileged information is required to recover the original representation

**3.8**
**full-function device**
FFD
device capable of operating as a coordinator

**3.9**
**group key**
key that is known only to a set of devices

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**3.10**
**hailing channel**
ISO/IEC/IEEE 8802-15-4 radio channel used to broadcast the NDB

**3.11**
**key**
privileged information that can be used, for example, to protect information from disclosure to, and/or undetectable modification by, parties that do not have access to this privileged information

**3.12**
**link key**
secret key that is shared between precisely two devices

**3.13**
**mesh networking**
type of network where an FFD serves as a relay for other devices

**3.14**
**message integrity code**
MIC
data whereby an entity receiving a message corroborates evidence about the true source of the information in the message and, thereby, evidence that the message has not been modified in transit

**3.15**
**network channel**
primary ISO/IEC/IEEE 8802-15-4 radio channel between a coordinator and remote devices

**3.16**
**packet**
formatted, aggregated bits that are transmitted together in time across the physical medium

**3.17**
**payload data**
contents of a data message that is being transmitted

**3.18**
**reduced-function device**
RFD
device that is not capable of operating as a coordinator

**3.19**
**server connected coordinator**
**SCC**
network coordinator that terminates the wireless protocol described in this International Standard and is connected to control servers

**3.20**
**tag**
any device type associated with the device and capable of joining the network

## 4 Symbols and abbreviated terms

ACK acknowledgement

CCITT Comité Consultatif International Téléphonique et Télégraphique

Cht Carrier high level tolerance

Clt Carrier low level tolerance

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| | |
|---|---|
| CRC | cyclical redundancy check |
| CSMA | carrier sense multiple access |
| $f_{bitrate}$ | base frequency of the bit rate of Manchester code without bit changes |
| $f_c$ | frequency of operating field (carrier frequency) |
| FCF | frame control field |
| FCS | frame check sequence |
| FHSS | Frequency Hopping Spread Spectrum |
| M | Modulation |
| Ma | Modulation overshoot |
| MAC | medium access control |
| Mb | Modulation undershoot |
| MIC | message integrity code |
| MIN | Manufacturing Identification Number |
| Mlt | Modulation lower tolerance |
| Mut | Modulation upper tolerance |
| NAK | no-acknowledgement |
| NDB | Network Discovery Beacon |
| NSM | Network Status Message |
| QPSK | quad-phased shift keying |
| RTLS | real time locating system |
| Tbmf | Manchester fall time |
| Tbmr | Manchester rise time |
| Tcf | carrier fall time |
| Tcr | carrier rise time |
| Tcs | carrier steady time |
| TDMA | time division multiple access |
| Tf | fall time |
| Tfhf | carrier FHSS fall time |
| Tfhr | carrier FHSS rise time |
| Tfhs | carrier FHSS steady time |
| Tflb | forward link bit time |
| Tr | rise time |


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Trlb return link bit time

TTL tag talk last

# 5 General items on 2,45 GHz RFID protocols that support this part of ISO/IEC 18000

## 5.1 Protocols

Clause 5 describes the general items of the ISO/IEC 18000-4, 2,45 GHz RFID command/data level communication protocols. These protocols facilitate communication between compliant tag and compliant interrogator. The timing parameters and signal characteristics for the protocols are defined in the physical link specifications in each mode. Details of the Modes of various protocols are described in Clauses 6, 7 and 8.

## 5.2 Frequency

This part of ISO/IEC 18000 is intended to address RFID devices operating in the 2 450 MHz Industrial, Scientific and Medical (ISM) frequency band.

### 5.2.1 Interface definitions

This part of ISO/IEC 18000 supports standard parameters and standard air interface implementations for wireless, non-contact information system equipment for Item Management applications. Typical applications operate at ranges greater than one meter.

#### 5.2.1.1 RFID system definition

The radio-frequency identification (RFID) system shall include a host system and RFID equipment (interrogator and tags). The host system runs an application program, which controls interfaces with the RFID. The RFID equipment shall be composed of two principal components: tags and interrogators. The tag is intended for attachment to an item, which a user wishes to manage. It is capable of storing a tag ID number and other data regarding the tag or item and of communicating this information to the interrogator. The interrogator is a device, which communicates to tags in its field of view. Additionally, the interrogator can use its transmitted RF carrier to power the tag. Systems, which rely on the transmitted interrogator carrier for powering the tag, are typically referred to as passive tag systems. The interrogator controls the protocol, reads information from the tag, directs the tag to store data in some cases, and ensures message delivery and validity.

#### 5.2.1.2 Minimum features

RFID systems defined by this part of ISO/IEC 18000 provide the following minimum features:

— identify tag in range,

— read data,

— write data or handle read only systems gracefully,

— selection by group or address,

— graceful handling of multiple tags in the field of view,

— error detection.

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#### 5.2.1.3 Conformance

To claim conformance with this part of ISO/IEC 18000, an RFID system shall comply with one of the physical/data link implementations described in Clause 6, 7 and 8.

The rules for RFID device conformity evaluation are given in ISO/IEC 18047-4.

### 5.3 Tag identification number

A tag identification number shall be included in commands directed to a specific tag unless the protocol provides other means like TTF (Tag Talks First) protocols. This part of ISO/IEC 18000 mandates that each tag shall include a manufacturer's tag identification number as defined in Annex A for mode 1, in Annex C for mode 2 and in sub-clause 8.5.1 for mode 3.

A separate User Tag Identification is not mandatory, but is an option. When a UserTagID is used, it shall consist of the number of bytes required by the user application. This number and other application data shall be accessed as user data fields on the tag. These fields can be accessed via the API using the driver's field name resolution mechanism. The UserTagID is a user-defined tag identifier and is not necessarily unique.

### 5.4 Potential interference

Standards developers have a duty to ensure that no "significant interference" exists between Standardized modes. "Significant Interference" exists if a system of one Standardized mode (working within the most widespread regulated power emissions) is likely to impede the successful operation of a system of another Standardized mode (working within the most widespread regulated power emissions), *in likely expected operating situations.*

Marginal measurable interference that does not impede operation *in likely expected operating situations*, or that could be avoided by simple and inexpensive design improvement, shall not be considered cause to reject a mode.

— Therefore, TTF modes are clearly identified as such in this part of ISO/IEC 18000.

— Therefore, installers of RFID systems are advised that they should make best efforts to be a good neighbour in installing any systems, bearing in mind that there may be other systems sharing the same bandwidth and are advised to take precautions to minimise interference to other systems. Installers are equally advised to be prepared to handle interference within the bandwidth from other users up to transmission powers permitted by local regulations.

## 6 MODE 1: Passive backscatter RFID system

### 6.1 MODE 1: General

The FHSS backscatter option or the narrow band operation RFID system shall include an interrogator that runs the FHSS backscatter option 1 RFID protocol or in narrow band operation, as well as one or more tags within the interrogation zone.

When placed in the RF field of an interrogator, the tag shall begin to power up. If the field is adequate, the tag shall execute a power-on reset and shall be ready to receive commands. Each command shall begin with a preamble and start delimiters that, taken together, enable the tag to perform clock and data recovery on the incoming signal. Data to and from the tag is checked for errors using a Cyclic Redundancy Code (CRC). Therefore, CRC fields are present in all interrogator interrogations and in all tag responses. Additional data protection is provided by Manchester encoding on the forward (interrogator to tag link) and FM0 encoding on the return (tag to interrogator) link.

By using the FHSS backscatter option 1 RFID command set or in narrow band operation, the interrogator can execute a number of functions on tags in its field. For example, the interrogator can send a command sequence, which allows it to identify multiple tags simultaneously in its RF field. Alternately, it can select


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a subset of the tags in the field based on tag memory contents. It can also read data stored on a tag in its field, as well as write or lock data to such a tag.

The description of the RFID tag command set in the following clause shall provide detail regarding the command field and return data/acknowledgement fields, if any. In addition, it shall cover additional high-level elements of the FHSS backscatter option RFID protocol, including how the multiple item identification algorithm works and byte ordering requirements. The more general aspects of the protocol (preambles, CRC-16, etc.) are covered in detail in 6.2.7.

This portion of the International Standard describes a passive backscatter RFID system that supports the following system capabilities:

System protocol

— Identify and communicate with multiple tags in the field

— Select a subgroup of tags to identify or communicate with based on information that the user has stored in the tag

— Read from and write or rewrite data many times to individual tags

— User controlled permanent lock memory

Data integrity protection

— Manchester bit-wise encoding and CRC-16 packet-level protection is applied to the forward link (interrogator-to-tag) data.

— FM0 bit-wise encoding and CRC-16 packet-level protection is applied to the return link (tag-to-interrogator) data.

In this RFID system, interrogators both power and communicate with the tags that are within their range. Tags receive data as on-off key amplitude modulation of the power/data signal from the interrogator. During the time that the tag communicates back to the interrogator, the interrogator broadcasts a steady radio frequency power level, and 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 reflection of its transmitted power.

## 6.2 Physical layer and data coding

### 6.2.1 Interrogator power-up waveform

The interrogator power-up waveform shall comply with the mask specified in Figure 1 and Table 1.

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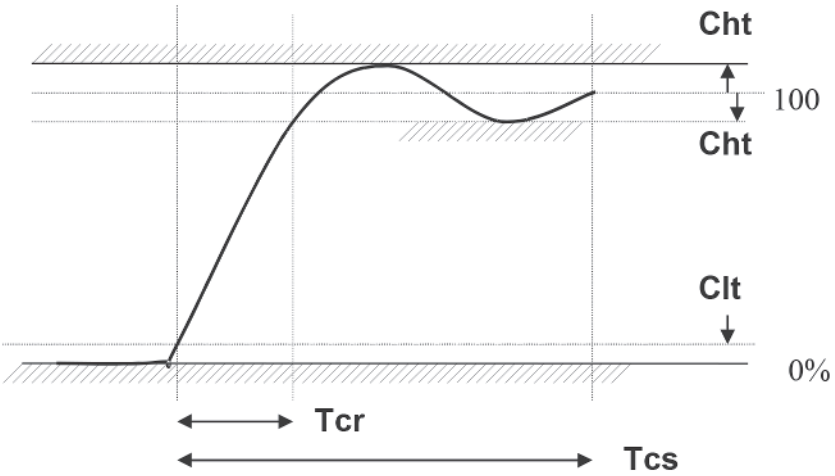


**Figure 1 — Interrogator power-up waveform**

**Table 1 — Interrogator power-up waveform parameter values**

| Parameter | Min | Max |
|---|---|---|
| Tcs | | 400 µs |
| Tcr | 0 µs | 30 µs |
| Cht | | 3 % |
| Clt | | 1 % |

### 6.2.2 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 2 and Table 2.

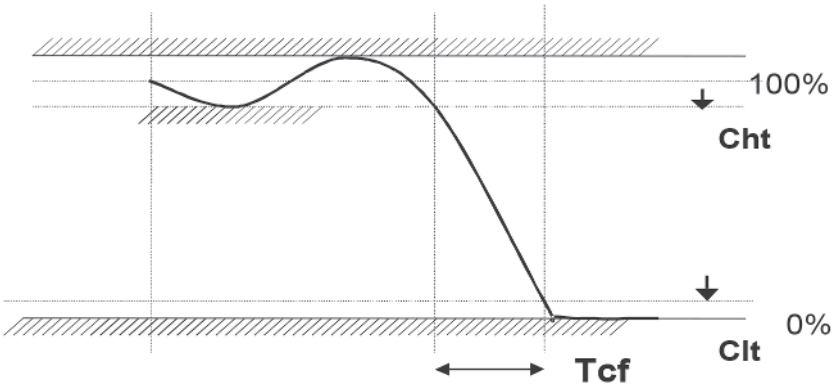


**Figure 2 — Interrogator power-down waveform**

**Table 2 — Interrogator power-down timings**

| Parameter | Min | Max |
|---|---|---|
| Tcf | 1 µs | 500 µs |
| Cht | | 3% |
| Clt | | 1% |


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### 6.2.3 Frequency hopping carrier rise and fall times

When the interrogator operates in the frequency hopping spread spectrum mode (FHSS), the carrier rise and fall times shall conform to the characteristics specified in Figure 3 and Table 3.

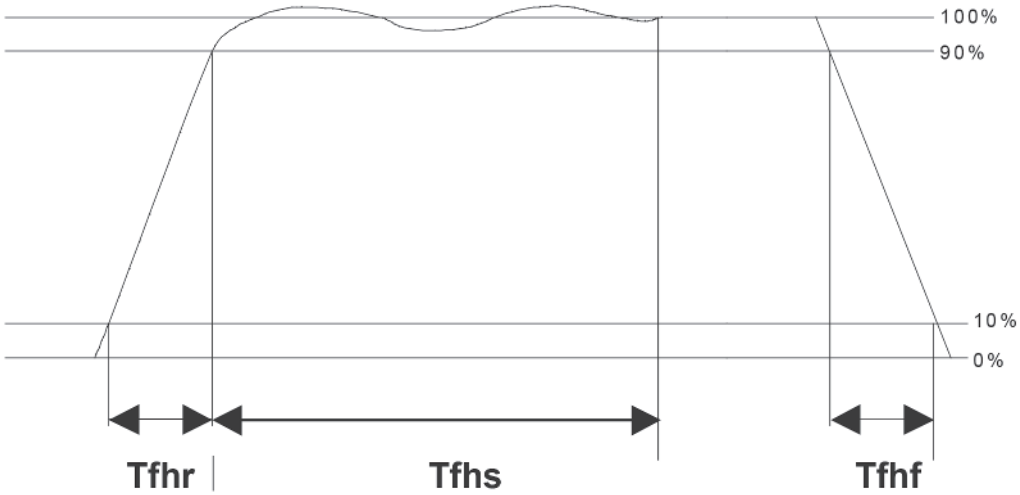


**Figure 3 — FHSS carrier rise and fall characteristics**

**Table 3 — FHSS carrier rise and fall parameters**

| Parameter | Min | Max |
|---|---|---|
| Tfhr | | 15 µs |
| Tfhs | 400 µs | |
| Tfhf | | 15 µs |

NOTE The numbers in Table 3 are an example for current FCC regulations only.

### 6.2.4 Forward link

#### 6.2.4.1 Carrier modulation

The data transmission from the interrogator to the tag is achieved by modulation of the carrier (ASK). The data coding is performed by generating pulses that create a Manchester coding.

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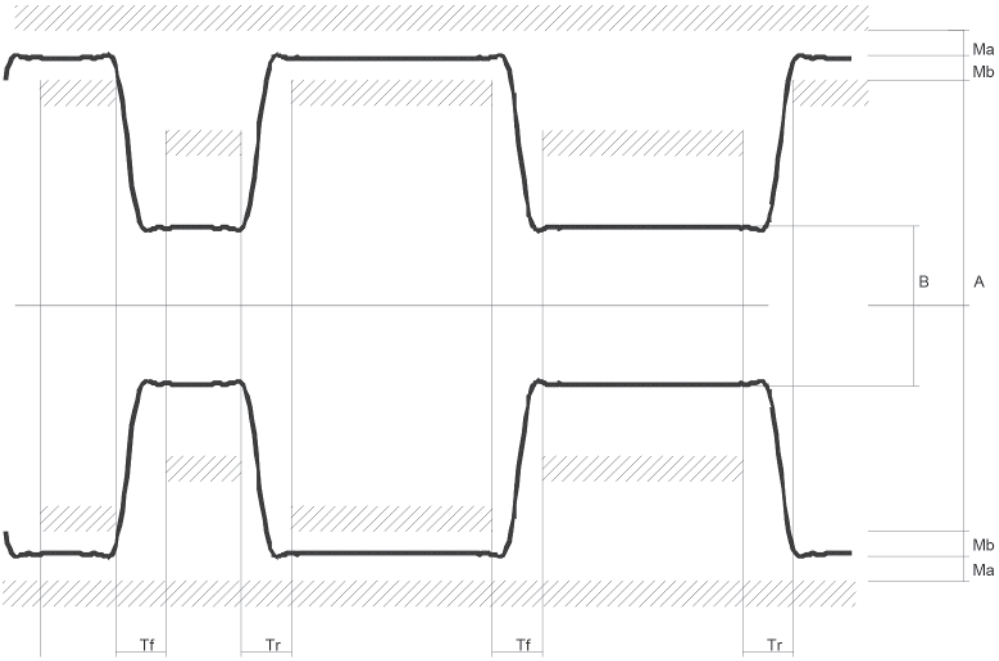


**Figure 4 — Example of 40 kbit/s signal**

**Table 4 — Parameter for 99 % Modulation**

| Parameter | Minimum | Nominal | Maximum |
|---|---|---|---|
| M = (A-B)/(A + B) | 90 | 99 | 100 |
| Ma | 0 | | 0,03 (A-B) |
| Mb | 0 | | 0,03 (A-B) |
| Tr | 0 µs | 1,8 µs | 0,1 / $f_{bitrate}$ |
| Tf | 0 µs | 1,8 µs | 0,1 / $f_{bitrate}$ |

### 6.2.4.2 Bit coding of forward link fields

Data is Manchester encoded as per Figure 5.

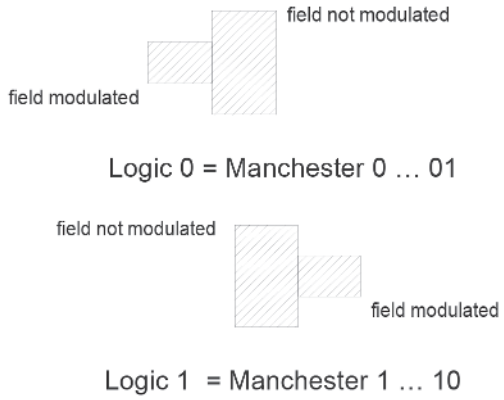


**Figure 5 — Forward link bit coding**


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### 6.2.5 FM0 return link

#### 6.2.5.1 General

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

#### 6.2.5.2 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.

#### 6.2.5.3 Data rate

The return link data rate is derived from the forward link data rate and is typically 40 kbit/s. For details see Table 5.

#### 6.2.5.4 Data coding

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

One symbol period Trlb 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 5 — Return link parameters**

| Data rate | Trlb | Tolerance |
|---|---|---|
| 30 - 40 kbit/s | 25 µs - 33 µs | ± 15 % |

Coding of data is MSB first. Figure 6 illustrates the coding for the 8 bits of ‘B1’.

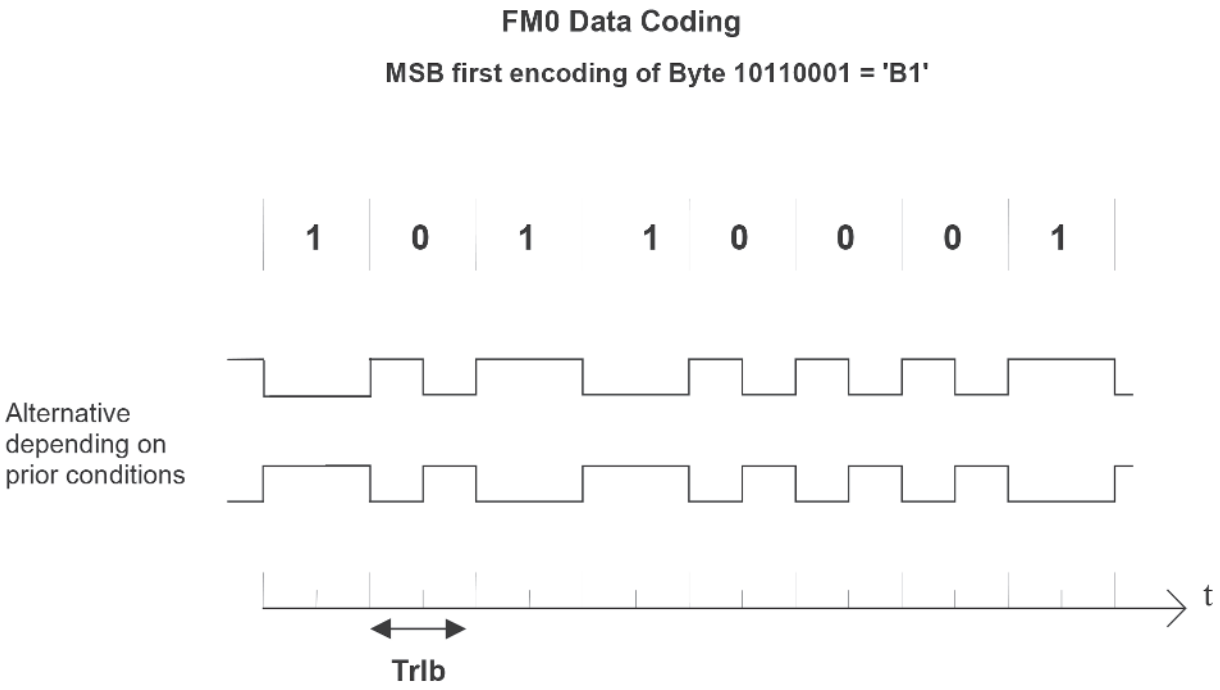


**Figure 6 — Tag to interrogator data coding**

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#### 6.2.5.5 Message format

A Return Link Message consists of n data bits preceded by the Preamble and followed by the tag data. 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 Table 6. There are multiple code violations (sequence not conforming to FM0 rules) that act as a frame marker for the transition from Preamble to Data.

#### 6.2.5.6 Return preamble

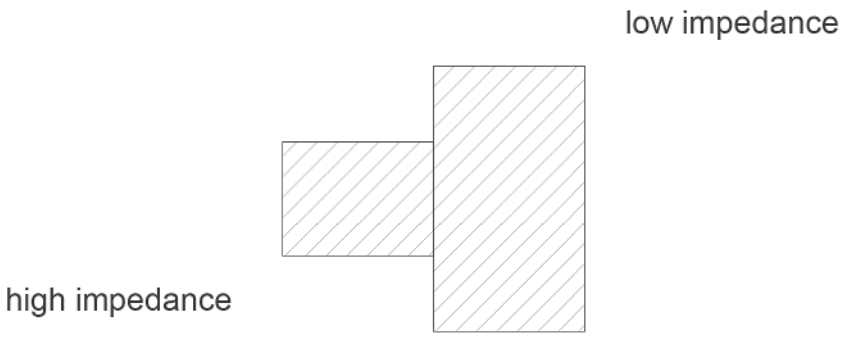
The return preamble is a sequence of backscatter modulation specified in Table 6.

**Table 6 — Return preamble**

| |
|---|
| 00 00 01 01 01 01 01 01 01 01 00 01 10 11 00 01 |

Data '0' is represented by the tag's modulator being in the high impedance state, Data '1' is represented by the tag's modulator switching to the low impedance state, thereby causing a change in the incident energy to be back-scattered.

The tag shall execute backscatter, a half-bit 1 and half-bit 0 sent by the tag defined as follows in Figure 7.




NOTE 1 = low impedance (backscatter), 0 = high impedance (no backscatter).

**Figure 7 — Return link preamble**

### 6.2.6 Cyclic redundancy check (CRC)

When sending a command to the tag, the interrogator shall attach an inverted CRC to the message packet. 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.

The 16 bits CRC applies for both communication directions: From interrogator to tag and from tag to interrogator.

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.

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

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

**Table 7 — 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 | |

### 6.2.7 Protocol concept

Data is encoded and presented in slightly different ways in the constituent fields. For interrogator-to-tag communication (forward link), data is sent using an on-off key format. The radio frequency field being on corresponds to 1, while the radio frequency field being off corresponds to 0. The on-off ratio specification is defined in 6.2.4. In the case of Manchester coding a Manchester 1 is a 1 to 0 transition, while a Manchester 0 is a 0 to 1 transition.

For tag-to-interrogator communication (return link), data is sent using backscatter techniques. This requires that the interrogator provide steady power to the tag during the return link. While the interrogator powers the tag, the tag shall change alternately the effective impedance of the tag front end and thus changing the overall radio frequency reflectivity of the tag as seen by the interrogator. During this time, the interrogator shall not modulate the carrier. During the WAIT field (when tags write data into their memory), the interrogator shall also provide steady power to the tag, and shall not modulate the carrier. The transmission protocol defines the mechanism to exchange instructions and data between the interrogator and the tag, in both directions.

It is based on the concept of “interrogator talks first”.

This means that any tag shall not start transmitting (modulating) unless it has received and properly decoded an instruction sent by the interrogator.

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 6.3.6.

Each command and each response are contained in a frame. The frame is specified in 6.2.7.

Each command consists of the following fields:

— Preamble

— Delimiter

— Command code

— Parameter fields, depending on the command

— Application data fields, depending on the command

— CRC

Each response consists of the following fields:

— Return Preamble

— Application data fields

— CRC

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The protocol is bit-oriented. The number of bits transmitted in a frame is a multiple of eight (8), i.e. an integer number of bytes. However, the frame itself is not based on an integer number of bytes.

In all byte fields, the MSB shall be transmitted first, proceeding to the LSB. In all word (8-byte) data fields, the MSB shall be transmitted first.

The MSB shall be the byte at the specified address. The LSB shall be the byte at the specified address plus 7 (i.e., bytes are transmitted in incrementing address order).

The byte significance is relevant to data transmission and to the GROUP_SELECT and GROUP_UNSELECT greater than and less than comparisons.

The MSB of the byte mask shall correspond to the most significant data byte, the byte at the specified address.

Word (8-byte) addresses are not required to be on an 8-word boundary and may be on any byte boundary.

RFU bits and bytes shall be set to zero (0).

### 6.2.8 Command format

#### 6.2.8.1 General

The command consist of the following fields:

— Preamble

— Delimiter

— Command

— Parameter and data files

— CRC

**Table 8 — General command format**

| | | | | | | |
|---|---|---|---|---|---|---|
| Preamble Detect | Preamble | Delimiter | Command | Parameter | Data | CRC |

#### 6.2.8.2 Preamble detect field

The preamble detect field consist of a steady carrier (no modulation) during a time of at least 400 µs. This corresponds to 16 bits for a communication rate of 40 kbit/s.

#### 6.2.8.3 Preamble

The preamble is equivalent to 9 bits of Manchester 0.

010101010101010101

#### 6.2.8.4 Delimiter

##### 6.2.8.4.1 Start delimiter 1

In NRZ format; includes Manchester errors; spaces ignored

11 00 11 10 10 Delimiter 1

#### 6.2.8.5 CRC

See clauses 6.2.6 and Annex B.


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### 6.2.9 Response format

#### 6.2.9.1 General

The response consists of the following fields:

— Quiet

— Return Preamble

— Data fields

— CRC

**Table 9 — General response format**

| | | | |
|---|---|---|---|
| Quiet | Return Preamble | Data | CRC |

The tag shall use a backscatter technique to communicate data to the interrogator. The interrogator shall be steadily powering the tag as well as listening to the tag response throughout the tag-to-interrogator (backscatter) communication. This applies to all fields in the return link.

#### 6.2.9.2 QUIET

The tag shall not backscatter for 16 * $T_{rlb}$ - 0,75 * $T_{flb}$. The duration of the quiet time is determined by the communication speed of the forward and return link.

#### 6.2.9.3 CRC

See clauses 6.2.6 and Annex B.

### 6.2.10 WAIT

During the WAIT field, the interrogator provides steady power to the tag for duration of at least 15 ms. No on-off key data may be sent during the write operation.

When a tag receives a write command, it shall execute a write operation. (The details of the conditions under which a write will occur are described in 6.3.6.2.5.4.) If a write operation is executed, the final field in the overall field sequence shall always be WAIT.

During the WAIT field, when the tag is writing data into the EEPROM, the interrogator must steadily power the tag. On-off key data shall not be sent during this time.

Details are shown in Figure 8 and in Figure 9.

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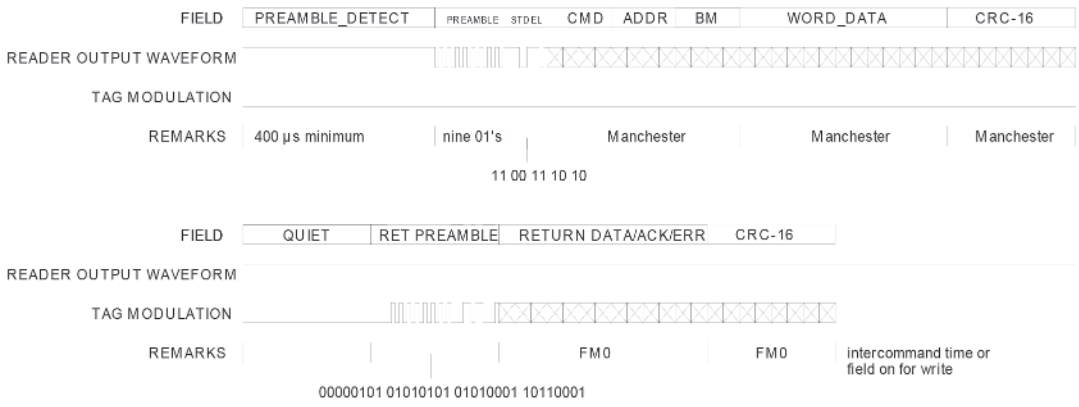


**Figure 8 — Sample Command/Response Packets for (GROUP_SELECT) (40 kbit/s on forward and return link)**

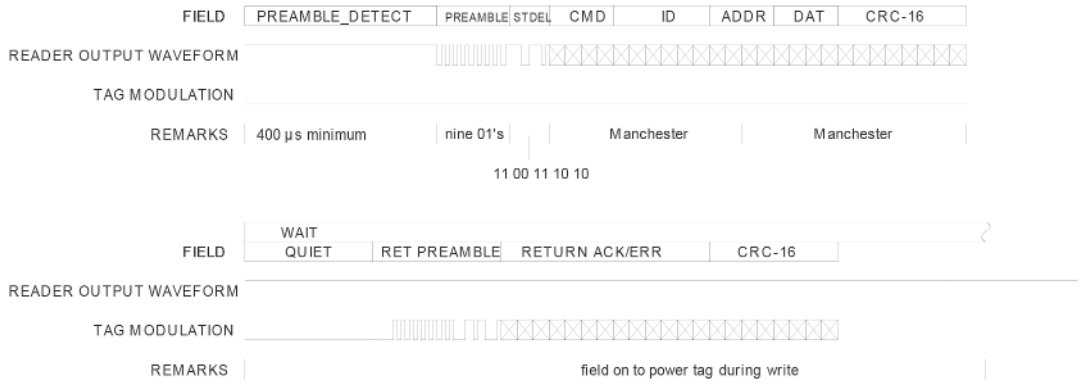


**Figure 9 — Sample Command/Response Packets for WRITE (40 kbit/s on forward and return link)**

### 6.2.11 Communication sequences at packet level

Figure 10 and Figure 11 show several examples of communication sequences at the packet level. Figure 10 depicts a packet sequence that includes a write command. The sequence includes a wait for write time, which provides the necessary time for the chip to complete its write operation. In addition, following the wait for write time, the interrogator issues a tag resync signal. This signal is composed of 10 consecutive 01 signals. The purpose of the tag resync signal is to initialise the tag data recovery circuitry. It is required after a write because the interrogator may output spurious edges during the wait for write time. Without the tag resync, tags may miscalibrate as a result of the spurious signals that may be generated.

Figure 11 depicts a packet sequence in which a frequency hop between commands is included. The tag resync signal is again required after the hop because spurious signals may be generated during the hop time.

In order to ensure that tags do not get confused, frequency hops between command and response should be avoided.


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| Action | COMMAND | RESPONSE | WAIT FOR WRITE | TAG RESYNC | COMMAND | RESPONSE |
|---|---|---|---|---|---|---|
| Component execution action | Interrogator | Tag | Interrogator | Interrogator | Interrogator | Tag |
| Notes | --- | --- | 15 ms minimum | ten 01's | --- | --- |

**Figure 10 — Command sequence (including a write) with no hopping**

| Action | COMMAND | RESPONSE | HOP | TAG RESYNC | COMMAND | RESPONSE |
|---|---|---|---|---|---|---|
| Component execution action | Interrogator | Tag | Interrogator | Interrogator | Interrogator | Tag |
| Notes | --- | --- | < 26 µs | ten 01's | --- | --- |

**Figure 11 — Command sequence with a hop between response and next command**

## 6.3 Protocol and collision arbitration

### 6.3.1 Definition of data elements, bit and byte ordering

#### 6.3.1.1 Unique ID

See Annex A, Clause A.2.

#### 6.3.1.2 CRC

See clause 6.2.6 and Annex B.

#### 6.3.1.3 FLAGS

The tag shall support a field of 8 flags. This field is called flags.

**Table 10 — FLAGS**

| Bit | Name |
|---|---|
| FLAG1 (LSB) | DE_SB (Data_Exchange Status Bit) |
| FLAG2 | WRITE_OK |
| FLAG3 | BATTERY_POWERED |
| FLAG4 | BATTERY_OK |
| FLAG5 | 0 (RFU) |

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**Table 10** *(continued)*

| Bit | Name |
|---|---|
| FLAG6 | 0 (RFU) |
| FLAG7 | 0 (RFU) |
| FLAG8 (MSB) | 0 (RFU) |

#### 6.3.1.3.1 Data Exchange Status Bit (DE_SB)

The tag shall set this bit when the tag goes into the DATA_EXCHANGE state and keep it set unless it moves into the POWER-OFF state.

When the DE_SB is set and the tag comes into the POWER-OFF state, then the tag shall trigger a timer that will reset the DE_SB bit after $t_{DE_SB}$.

$t_{DE_SB}$ shall be at least 2 seconds in the temperature range 30 °C to 60 °C.

$t_{DE_SB}$ shall be at least 4 seconds in the temperature range 0 °C to 50 °C.

When the tag receives the INITIALIZE command, then it shall reset the DE_SB immediately.

#### 6.3.1.3.2 WRITE_OK

The WRITE_OK bit shall be set after a successful write access to the memory. (E.g. WRITE, LOCK)

The WRITE_OK bit is cleared after execution of the command following the write command.

#### 6.3.1.3.3 BATTERY_POWERED

The BATTERY_POWERED bit shall be set when the tag should have a battery. It shall be cleared for passive tags.

#### 6.3.1.3.4 BATTERY_OK

The BATTERY_OK bit shall be set when the battery has enough power to support the tag. It shall be cleared for passive tags.

### 6.3.2 Tag memory organisation

The functional memory shall be organised in blocks of one byte.

Up to 256 blocks of one byte can be addressed.

This leads to a maximum memory capacity of up to 2 kbit.

NOTE This structure allows future extensions of the maximum memory capacity.

### 6.3.3 Block security status

Each byte shall have a corresponding lock bit. The lock bits may be locked by use of the LOCK command. The status of the lock bit may be read by the QUERY_LOCK command. The tag shall not be allowed to reset any lock bit after leaving the final production site. In most cases this is the production site that defines the unique ID.


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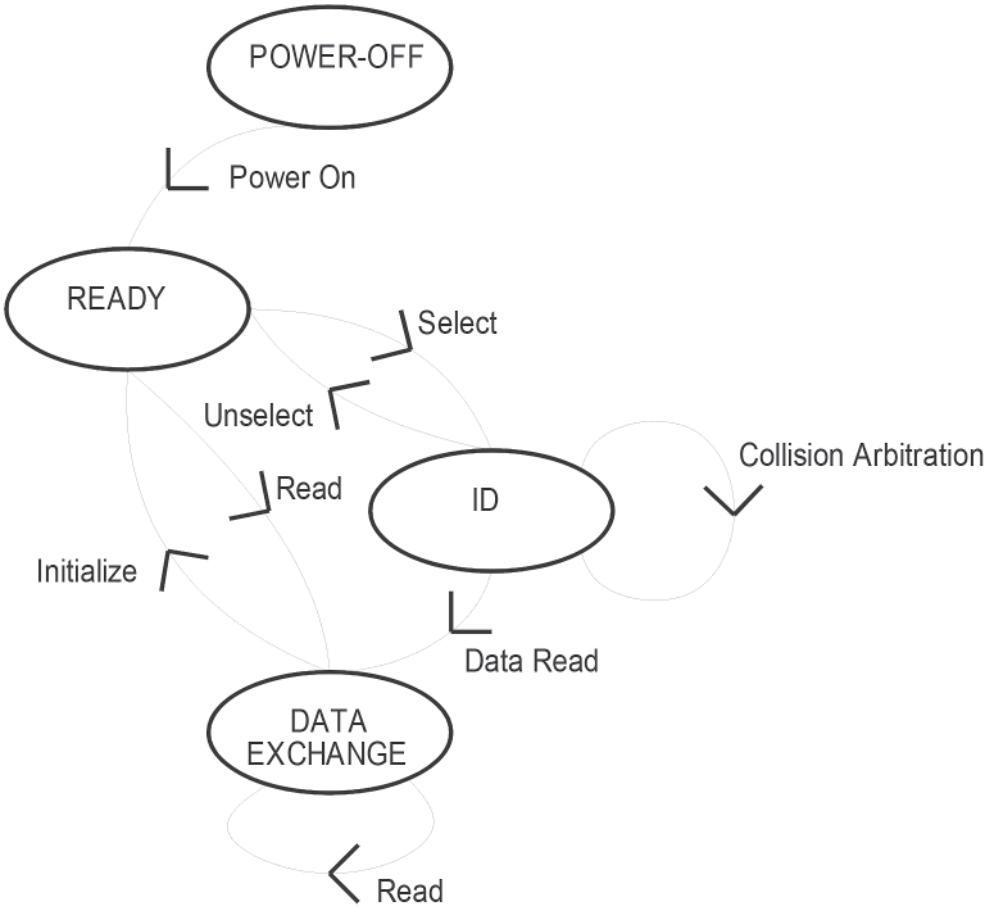
### 6.3.4 Overall protocol description

#### 6.3.4.1 Tag states

The tag has four major states:




**POWER-OFF** The tag is in the POWER-OFF state when the interrogator cannot activate it. (For battery-assisted tags, it means that the level of RF excitation is insufficient to turn on the tag circuits.)

**READY** The tag is in the READY state when the interrogator first powers it up.

**ID** The tag is in the ID state when it is trying to identify itself to the interrogator.

**DATA_EXCHANGE** The tag is in the DATA_EXCHANGE state, when it is known to the interrogator and was selected.

NOTE This diagram does not show that the tag goes into POWER-OFF from all states in the case that the interrogator field is permanently turned-off.

**Figure 12 — State diagram**

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The state diagram only shows an overview of the possible transition. Details are specified in Table 12.

**Power-On** State change when interrogator field is turned on.

**Select** State change due to selection of tag by GROUP_SELECT or READ commands

**Unselect** State change due to deselection of tag by GROUP_UNSELECT commands or INITIALIZE command

**Collision Arbitration** No state change during collision arbitration until single tag is identified.

**Data_Read** State change due to first read access in collision arbitration process

**Read** State change due to read access independent of collision arbitration process.

**Initialize** State change due to deselection of tag by INITIALIZE command

The transition between these states is specified in Table 12.

#### 6.3.4.2 Detailed command processing

Commands shall be active in states marked with "X" and neither causes a state change, nor cause a response in the other states.

**Table 11 — Detailed command processing**

| COMMAND | States | | |
|---|---|---|---|
| | READY | ID | DATA EXCHANGE |
| GROUP_SELECT_EQ | X | X | |
| GROUP_SELECT_NE | X | X | |
| GROUP_SELECT_GT | X | X | |
| GROUP_SELECT_LT | X | X | |
| GROUP_SELECT_EQ_FLAGS | X | X | |
| GROUP_SELECT_NE_FLAGS | X | X | |
| GROUP_UNSELECT_EQ | | X | |
| GROUP_UNSELECT_NE | | X | |
| GROUP_UNSELECT_GT | | X | |
| GROUP_UNSELECT_LT | | X | |
| GROUP_UNSELECT_EQ_FLAGS | | X | |
| GROUP_UNSELECT_NE_FLAGS | | X | |
| MULTIPLE_UNSELECT | | X | |
| FAIL | | X | |
| SUCCESS | | X | |
| RESEND | | X | |
| INITIALIZE | X | X | X |
| READ | X | X | X |
| DATA_READ | | X | X |
| READ_VERIFY | X | X | X |
| READ_VERIFY4BYTE | X | X | X |
| WRITE | X | X | X |


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**Table 11** *(continued)*

| COMMAND | States | | |
|---|---|---|---|
| | READY | ID | DATA EXCHANGE |
| WRITE4BYTE | X | X | X |
| WRITE4BYTE_MULTIPLE | | X | X |
| WRITE_MULTIPLE | | X | X |
| LOCK | | | X |
| QUERY_LOCK | X | X | X |

**Table 12 — State Transition Table**

| Current State | Command | Condition | New state |
|---|---|---|---|
| POWER-OFF | ANY COMMAND | | POWER OFF |
| POWER-OFF | "Power up" | | READY |
| READY | GROUP_SELECT_EQ | ≠ | READY |
| READY | GROUP_SELECT_NE | = | READY |
| READY | GROUP_SELECT_GT | ≤ | READY |
| READY | GROUP_SELECT_EQ_FLAGS | flag not set | READY |
| READY | GROUP_SELECT_NE_FLAGS | flag set | READY |
| READY | GROUP_SELECT_LT | ≥ | READY |
| READY | GROUP_SELECT_EQ | = | ID |
| READY | GROUP_SELECT_NE | ≠ | ID |
| READY | GROUP_SELECT_GT | > | ID |
| READY | GROUP_SELECT_LT | < | ID |
| READY | GROUP_SELECT_EQ_FLAGS | flag set | ID |
| READY | GROUP_SELECT_NE_FLAGS | flag not set | ID |
| READY | INITIALIZE | | READY |
| READY | READ | ID no match | READY |
| READY | READ | ID match | DATA_EXCHANGE |
| READY | READ_VERIFY | ID no match or not WRITE_OK | READY |
| READY | READ_VERIFY | ID match and WRITE_OK | DATA_EXCHANGE |
| READY | READ_VERIFY4BYTE | ID no match or not WRITE_OK | READY |
| READY | READ_VERIFY4BYTE | ID match and WRITE_OK | DATA_EXCHANGE |
| READY | WRITE | ID no match | READY |
| READY | WRITE | ID match | DATA_EXCHANGE |
| READY | WRITE4BYTE | ID no match | READY |
| READY | WRITE4BYTE | ID match | DATA_EXCHANGE |
| READY | QUERY_LOCK | ID no match | READY |
| READY | QUERY_LOCK | ID match | DATA_EXCHANGE |
| ID | GROUP_UNSELECT_EQ | ≠ | ID |
| ID | GROUP_UNSELECT_NE | = | ID |

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**Table 12** *(continued)*

| Current State | Command | Condition | New state |
|---|---|---|---|
| ID | GROUP_UNSELECT_GT | ≤ | ID |
| ID | GROUP_UNSELECT_LT | ≥ | ID |
| ID | GROUP_UNSELECT_EQ_FLAGS | flag not set | ID |
| ID | GROUP_UNSELECT_NE_FLAGS | flag set | ID |
| ID | GROUP_UNSELECT_EQ | = | READY |
| ID | GROUP_UNSELECT_NE | ≠ | READY |
| ID | GROUP_UNSELECT_GT | > | READY |
| ID | GROUP_UNSELECT_LT | < | READY |
| ID | GROUP_UNSELECT_EQ_FLAGS | flag set | READY |
| ID | GROUP_UNSELECT_NE_FLAGS | flag not set | READY |
| ID | MULTIPLE_UNSELECT | ≠ or notWRITE_OK | ID |
| ID | MULTIPLE_UNSELECT | = and WRITE_OK | READY |
| ID | GROUP_SELECT_EQ | | ID |
| ID | GROUP_SELECT_NE | | ID |
| ID | GROUP_SELECT_GT | | ID |
| ID | GROUP_SELECT_LT | | ID |
| ID | GROUP_SELECT_EQ_FLAGS | | ID |
| ID | GROUP_SELECT_NE_FLAGS | | ID |
| ID | FAIL | | ID |
| ID | SUCCESS | | ID |
| ID | RESEND | | ID |
| ID | INITIALIZE | | READY |
| ID | READ | ID no match | ID |
| ID | READ | ID match | DATA_EXCHANGE |
| ID | DATA_READ | ID no match | ID |
| ID | DATA_READ | ID match | DATA_EXCHANGE |
| ID | READ_VERIFY | ID no match or not WRITE_OK | ID |
| ID | READ_VERIFY | ID match and WRITE_OK | DATA_EXCHANGE |
| ID | READ_VERIFY4BYTE | ID no match or not WRITE_OK | ID |
| ID | READ_VERIFY4BYTE | ID match and WRITE_OK | DATA_EXCHANGE |
| ID | WRITE | ID no match | ID |
| ID | WRITE | ID match | DATA_EXCHANGE |
| ID | WRITE4BYTE | ID no match | ID |
| ID | WRITE4BYTE | ID match | DATA_EXCHANGE |
| ID | WRITE_MULTIPLE | | ID |
| ID | WRITE4BYTE_MULTIPLE | | ID |
| ID | QUERY_LOCK | ID no match | ID |
| ID | QUERY_LOCK | ID match | DATA_EXCHANGE |
| DATA_EXCHANGE | INITIALIZE | | READY |


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**Table 12** *(continued)*

| Current State | Command | Condition | New state |
|---|---|---|---|
| DATA_EXCHANGE | READ | | DATA_EXCHANGE |
| DATA_EXCHANGE | DATA_READ | | DATA_EXCHANGE |
| DATA_EXCHANGE | READ_VERIFY | | DATA_EXCHANGE |
| DATA_EXCHANGE | READ_VERIFY4B YTE | | DATA_EXCHANGE |
| DATA_EXCHANGE | WRITE | | DATA_EXCHANGE |
| DATA_EXCHANGE | WRITE4BYTE | | DATA_EXCHANGE |
| DATA_EXCHANGE | WRITE4BYTE_MULTIPLE | | DATA_EXCHANGE |
| DATA_EXCHANGE | WRITE_MULTIPLE | | DATA_EXCHANGE |
| DATA_EXCHANGE | LOCK | | DATA_EXCHANGE |
| DATA_EXCHANGE | QUERY_LOCK | | DATA_EXCHANGE |

### 6.3.5 Collision arbitration

The interrogator may use the GROUP_SELECT and GROUP_UNSELECT commands to define all or a subset of tags in the field to participate in the collision arbitration. It then may use the identification commands to run the collision arbitration algorithm.

For the collision arbitration the tag shall support two pieces of hardware on the tag:

— An 8-bit counter COUNT

— A random 1 or 0 generator.

In the beginning, a group of tags are moved to the ID state by GROUP_SELECT commands and shall set their internal counters to 0. Subsets of the group may be unselected by GROUP_UNSELECT commands back to the READY state. Other groups can be selected before the identification process begins. Simulation results show no advantage in identifying one large group or a few smaller groups.

After above described selection, the following loop should be performed:

a) All tags in the ID state with the counter COUNT at 0 shall transmit their ID. This set initially includes all the selected tags.

b) If more than one tag transmitted, the interrogator receives an erroneous response. The FAIL command shall be sent.

c) All tags receiving a FAIL command with COUNT not equal to 0 shall to increment COUNT. That is, they move further away from being able to transmit.

All tags receiving FAIL a count of 0 (those that just transmitted) shall generate a random number. Those that roll a 1 shall increment COUNT and shall not transmit. Those that roll a zero shall keep COUNT at zero and shall send their UID again.

One of four possibilities now occurs:

d) If more than one tag transmits, the FAIL step 2 repeats. (Possibility 1)

e) If all tags roll a 1, none transmits. The interrogator receives nothing. It sends the SUCCESS command. All the counters decrement, and the tags with a count of 0 transmit. Typically, this returns to step 2. (Possibility 2)

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f) If only one tag transmits and the ID is received correctly, the interrogator shall send the DATA_READ command with the ID. If the DATA_READ command is received correctly, that tag shall move to the DATA_EXCHANGE state and shall transmit its data.

The interrogator shall send SUCCESS. All tags in the ID state shall decrement COUNT.

g) If only one tag has a count of 1 and transmits, step 5 or 6 repeats. If more than one tag transmits, step 2 repeats. (Possibility 3)

h) If only one tag transmits and the ID is received with an error, the interrogator shall send the RESEND command. If the ID is received correctly, step 5 repeats. If the ID is received again some variable number of times (this number can be set based on the level of error handling desired for the system), it is assumed that more than one tag is transmitting, and step 2 repeats. (Possibility 4)

### 6.3.6 Commands

Commands are divided into four functional groups:

— Selection commands

— Identification commands

— Data transfer commands

— Multiple commands

Further, commands have one of the following types:

— Mandatory

— Optional

— Custom

— Proprietary

#### 6.3.6.1 Command types

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

##### 6.3.6.1.1 Mandatory

The command codes range from ‘00’ to ‘0A’, ‘0C’, ‘15’,and ‘1E’, ‘1F’ and ‘20’ to ‘3F’.

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

##### 6.3.6.1.2 Optional

The command codes range from ‘0B’, ‘0D’ to ‘0F’, ‘11’ to ‘13’, ’17 to ‘1C’, ‘1D’ and from ‘40’ to ‘9F’.

Optional commands are commands that are specified within the International Standard. Interrogators shall be technically capable of performing all optional commands that are specified in the International Standard (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 the International Standard.

If the tag does not support an optional command, it shall remain silent.

NOTE The command whose code ranges from ‘17’ to ‘1C’ are optional and not essential to operate the tag. However, their support by the tag is recommended for appropriate performance. To reflect this, they are reported as “recommended” in Table 13.


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#### 6.3.6.1.3 Custom

The command codes range from ‘A0’ to ‘DF’.

Custom commands may be enabled by an International Standard, but they shall not be specified in that International Standard. A custom command shall not solely duplicate the functionality of any mandatory or optional command defined in the International Standard by a different method.

The only fields that can be customised are the parameters 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.

If the tag does not support a custom command it shall remain silent.

#### 6.3.6.1.4 Proprietary

The command codes are ‘10’, ’14’, ‘16’ and the range from ‘E0’ to ‘FF’.

Proprietary Commands Proprietary commands may be enabled by an International Standard, but they shall not be specified in that International Standard. A proprietary command shall not solely duplicate the functionality of any mandatory or optional command defined in the International Standard by a different method.

These commands are used by IC and tag manufacturers for various purposes such as tests, programming of system information, etc.. The IC manufacturer may at its option document them or not. It is allowed that these commands are disabled after IC and/or tag manufacturing.

### 6.3.6.2 Command codes and format

**Table 13 — Command codes and format**

| Command code | Type | Command name | Parameters | | |
|---|---|---|---|---|---|
| ‘00’ | Mandatory | GROUP_SELECT_EQ | ADDRESS | BYTE_MASK | WORD_DATA |
| ‘01’ | Mandatory | GROUP_SELECT_NE | ADDRESS | BYTE_MASK | WORD_DATA |
| ‘02’ | Mandatory | GROUP_SELECT_GT | ADDRESS | BYTE_MASK | WORD_DATA |
| ‘03’ | Mandatory | GROUP_SELECT_LT | ADDRESS | BYTE_MASK | WORD_DATA |
| ‘04’ | Mandatory | GROUP_UNSELECT_EQ | ADDRESS | BYTE_MASK | WORD_DATA |
| ‘05’ | Mandatory | GROUP_UNSELECT_NE | ADDRESS | BYTE_MASK | WORD_DATA |
| ‘06’ | Mandatory | GROUP_UNSELECT_GT | ADDRESS | BYTE_MASK | WORD_DATA |
| ‘07’ | Mandatory | GROUP_UNSELECT_LT | ADDRESS | BYTE_MASK | WORD_DATA |
| ‘08’ | Mandatory | FAIL | none | none | none |
| ‘09’ | Mandatory | SUCCESS | none | none | none |
| ‘0A’ | Mandatory | INITIALIZE | none | none | none |
| ‘0B’ | Optional | DATA_READ | ID | ADDRESS | none |
| ‘0C’ | Mandatory | READ | ID | ADDRESS | none |
| ‘0D’ | Recom-mended | WRITE | ID | ADDRESS | BYTE_DATA |
| ‘0E’ | Recom-mended | WRITE_MULTIPLE | none | ADDRESS | BYTE_DATA |
| ‘0F’ | Recom-mended | LOCK | ID | ADDRESS | none |

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**Table 13** *(continued)*

| Command code | Type | Command name | Parameters | | |
|---|---|---|---|---|---|
| ‘10’ | Proprietary | IC manufacturer dependant | | | |
| ‘11’ | Recom-mended | QUERY_LOCK | ID | ADDRESS | none |
| ‘12’ | Recom-mended | READ_VERIFY | ID | ADDRESS | none |
| ‘13’ | Recom-mended | MULTIPLE_UNSELECT | ADDRESS | BYTE_DATA | none |
| ‘14’ | Proprietary | IC manufacturer dependant | | | |
| ‘15’ | Mandatory | RESEND | none | none | none |
| ‘16’ | Proprietary | IC manufacturer dependant | | | |
| ‘17’ | Recom-mended | GROUP_SELECT_EQ_ FLAGS | none | BYTE_MASK | BYTE_DATA |
| ‘18’ | Recom-mended | GROUP_SELECT_NE_ FLAGS | none | BYTE_MASK | BYTE_DATA |
| ‘19’ | Recom-mended | GROUP_UNSELECT_EQ_ FLAGS | none | BYTE_MASK | BYTE_DATA |
| ‘1A’ | Recom-mended | GROUP_UNSELECT_NE_ FLAGS | none | BYTE_MASK | BYTE_DATA |
| ‘1B’ | Recom-mended | WRITE4BYTE | ID | ADDRESS | BYTE_MASK |
| ‘1C’ | Recom-mended | WRITE4BYTE_MULTIPLE | BYTE_ MASK | ADDRESS | 4BYTE_DATA |
| ‘1D’ | Recom-mended | READ_VERIFY4BYTE | ID | ADDRESS | |
| ‘1E’-‘1F’ | Mandatory | RFU | | | |
| ‘20’-‘3F’ | Mandatory | RFU | | | |
| ‘40’ ‘9F’ | Optional | RFU | | | |
| ‘A0’ ‘DF’ | Custom | IC Manufacturer dependent | | | |
| ‘E0’ ‘FF’ | Proprietary | IC Manufacturer dependent | | | |

#### 6.3.6.2.1 Command fields

**Table 14 — Command fields**

| Field name | Field size |
|---|---|
| COMMAND | 1 byte |
| ADDRESS | 1 byte |
| BYTE_MASK | 1 byte |
| ID | 8 bytes |
| WORD_DATA | 8 bytes |
| BYTE_DATA | 1 byte |
| 4BYTE_DATA | 4 bytes |


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#### 6.3.6.2.2 Tag responses

**Table 15 — Tag responses**

| Response code | Response name | Response size |
|---|---|---|
| '00' | ACKNOWLEDGE | 1 byte |
| | ACKNOWLEDGE_NOK | 1byte |
| '01' | ACKNOWLEDGE_OK | 1byte |
| 'FE' | ERROR_NOK | 1byte |
| 'FF' | ERROR | 1byte |
| | ERROR_OK | 1byte |
| Not applicable | WORD_DATA | 8 bytes |
| Not applicable | BYTE_DATA | 1byte |
| '02' 'FD' | RFU | |

#### 6.3.6.2.3 Selection commands

Selection commands define a subset of tags in the field to be identified or written to and may be used as part of the collision arbitration.

##### 6.3.6.2.3.1 Data comparison for selection command on memory

Each select command of the commands GROUP_SELECT_EQ, GROUP_SELECT_NE, GROUP_SELECT_GT, GROUP_SELECT_LT, GROUP_UNSELECT_EQ, GROUP_UNSELECT_NE, GROUP_UNSELECT_GT, GROUP_UNSELECT_LT has 3 arguments (parameter and data):

ADDRESS

BYTE_MASK

WORD_DATA

and the tag shall make one of 4 possible comparisons:

EQ M EQUAL D

NE M NOT EQUAL D

GT M GREATER THAN D

LT M LOWER THAN D

The arguments of the comparison are

| M7 MSB | M6 | M5 | M4 | M3 | M2 | M1 | M0 LSB |
|---|---|---|---|---|---|---|---|
| Tag memory content at ADDRESS+0 | Tag memory content at ADDRESS+1 | Tag memory content at ADDRESS+2 | Tag memory content at ADDRESS+3 | Tag memory content at ADDRESS+4 | Tag memory content at ADDRESS+5 | Tag memory content at ADDRESS+6 | Tag memory content at ADDRESS+7 |

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$$M = M0 + M1 * 2^{8} + M2 * 2^{16} + M3 * 2^{24} + M4 * 2^{32} + M5 * 2^{40} + M6 * 2^{48} + M7 * 2^{56}$$

and the argument of the command

| D7 MSB | D6 | D5 | D4 | D3 | D2 | D1 | D0 LSB |
|---|---|---|---|---|---|---|---|
| First byte after command | | | | | | | Last byte after command |

$$D = D0 + D1 * 2^{8} + D2 * 2^{16} + D3 * 2^{24} + D4 * 2^{32} + D5 * 2^{40} + D6 * 2^{48} + D7 * 2^{56}$$

The argument BYTE_MASK defines what bytes to be considered for comparison.

**Table 16 — Data masking for Group_Select and Group_Unselect commands**

| BYTE_MASK | WORD_DATA |
|---|---|
| Bit 7 (MSB) is set | Consider D7 and M7 for comparison |
| Bit 6 is set | Consider D6 and M6 for comparison |
| Bit 5 is set | Consider D5 and M5 for comparison |
| Bit 4 is set | Consider D4 and M4 for comparison |
| Bit 3 is set | Consider D3 and M3 for comparison |
| Bit 2 is set | Consider D2 and M2 for comparison |
| Bit 1 is set | Consider D1 and M1 for comparison |
| Bit 0 (LSB) is set | Consider D0 and M0 for comparison |
| Bit 7 (MSB) is cleared | Ignore D7 and M7 for comparison |
| Bit 6 is cleared | Ignore D6 and M6 for comparison |
| Bit 5 is cleared | Ignore D5 and M5 for comparison |
| Bit 4 is cleared | Ignore D4 and M4 for comparison |
| Bit 3 is cleared | Ignore D3 and M3 for comparison |
| Bit 2 is cleared | Ignore D2 and M2 for comparison |
| Bit 1 is cleared | Ignore D1 and M1 for comparison |
| Bit 0 (LSB) is cleared | Ignore D0 and M0 for comparison |

#### 6.3.6.2.3.2 Data comparison for selection command on flags

Each select command of the commands GROUP_SELECT_EQ_FLAGS GROUP_SELECT_NE_FLAGS, GROUP_UNSELECT_EQ_FLAGS, GROUP_UNSELECT_NE_FLAGS, has 2 arguments (parameter and data):

BYTE_MASK

BYTE_DATA

and the tag shall make of 2 possible comparisons:

EQ FLAGS EQUAL D

NE FLAGS NOT EQUAL D


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The arguments of the comparison are FLAGS, as defined in 6.3.1.3 and the argument of the command D, consisting of the bits D7 (MSB) to D0 (LSB).

The argument BYTE_MASK defines what bits to be considered for comparison.

**Table 17 — Data masking for Group_Select_Flags and Group_Unselect_Flags**

| BYTE_MASK | BYTE_DATA |
|---|---|
| Bit 7 (MSB) is set | Consider D7 and FLAG7 for comparison |
| Bit 6 is set | Consider D6 and FLAG6 for comparison |
| Bit 5 is set | Consider D5 and FLAG5 for comparison |
| Bit 4 is set | Consider D4 and FLAG4 for comparison |
| Bit 3 is set | Consider D3 and FLAG3 for comparison |
| Bit 2 is set | Consider D2 and FLAG2 for comparison |
| Bit 1 is set | Consider D1 and FLAG1 for comparison |
| Bit 0 (LSB) is set | Consider D0 and FLAG0 for comparison |
| Bit 7 (MSB) is cleared | Ignore D7 and FLAG7 for comparison |
| Bit 6 is cleared | Ignore D6 and FLAG6 for comparison |
| Bit 5 is cleared | Ignore D5 and FLAG5 for comparison |
| Bit 4 is cleared | Ignore D4 and FLAG4 for comparison |
| Bit 3 is cleared | Ignore D3 and FLAG3 for comparison |
| Bit 2 is cleared | Ignore D2 and FLAG2 for comparison |
| Bit 1 is cleared | Ignore D1 and FLAG1 for comparison |
| Bit 0 (LSB) is cleared | Ignore D0 and FLAG0 for comparison |

Formula describing the EQUAL function:

The EQUAL comparison passes, if (!B7+(D7=FLAG7)) * (!B6+(D6=FLAG6)) * (!B5+(D5=FLAG5)) * * (!B4+(D4=FLAG4)) * (!B3+(D3=FLAG3)) * (!B2+(D2=FLAG2)) * (!B1+(D1=FLAG1)) * (!B0+(D0=FLAG0)) is true.

Formula describing the UNEQUAL function:

The UNEQUAL comparison passes, if B7*(D7!=FLAG7) + B6*(D6!=FLAG6) + B5*(D5!=FLAG5) + B4*(D4!=FLAG4) + B3*(D3!=FLAG3) + B2*(D2!=FLAG2) + B1*(D1!=FLAG1) + B0*(D0!=FLAG0) is true.

#### 6.3.6.2.3.3 GROUP_SELECT_EQ

Command code = ‘00’

On receiving a GROUP_SELECT_EQ command, a tag which is READY state shall read the 8-byte memory content beginning at the specified address and compare it with the WORD_DATA sent by the interrogator. In the case that the memory content is equal to WORD_DATA the tag shall set its internal counter COUNT to 0, read its UID and send back the UID and go into the state ID.

On receiving a GROUP_SELECT_EQ command, a tag which is ID state shall set its internal counter COUNT to 0, read its UID and send back the UID and stay in the ID state.

In all other cases the tag shall not send a reply.

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