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INTERNATIONAL STANDARD

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Information technology — Radio frequency identification for item management —

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

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

Partie 3: Paramètres pour les communications d'une interface d'air de 13,56 MHz

Reference number
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Contents

Page

Foreword

ISO (the International Organization for Standardization) and IEC (the International Electrotechnical Commission) form the specialized system for worldwide standardization. National bodies that are members of ISO or IEC participate in the development of International Standards through technical committees established by the respective organization to deal with particular fields of technical activity. ISO and IEC technical committees collaborate in fields of mutual interest. Other international organizations, governmental and non-governmental, in liaison with ISO and IEC, also take part in the work. In the field of information technology, ISO and IEC have established a joint technical committee, ISO/IEC JTC 1.

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

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

ISO/IEC 18000-3 was prepared by Joint Technical Committee ISO/IEC JTC 1, *Information technology*, Subcommittee SC 31, *Automatic identification and data capture techniques*.

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*

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

Introduction

ISO/IEC 18000 has been developed by ISO/IEC JTC 1, SC 31, WG 4, *Radio frequency identification for item management*, in order to provide a framework to define common communications protocols for Internationally useable frequencies for Radio Frequency Identification (RFID), and, where possible, to determine the use of the same protocols for ALL frequencies such that the problems of migrating from one to another are diminished; to minimise software and implementation costs; and to enable system management and control and information exchange to be common as far as is possible.

This part of ISO/IEC 18000 has been prepared in accordance with the requirements determined in ISO/IEC 18000-1.

ISO/IEC 18000-1 provides explanation of the concepts behind this part of ISO/IEC 18000.

This part of ISO/IEC 18000 has 2 MODES of operation, intended to address different applications. Clause 8 of this part of ISO/IEC 18000 summarises the differences between MODE characteristics. The detailed technical differences between the modes are shown in the parameter tables.

This part of ISO/IEC 18000 relates solely to systems operating at 13,56 MHz.

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 may involve the use of patents.

The 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 the ISO and IEC. Information may be obtained from the following companies.

NOTE Abstracts of these patents may be found in ISO 18000-1, Annex E.

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	US6177858 B1, EP 96402554.8, CN 21911788	6.1.7.4.2
	US 5426423, EP 90909459.1, CN 2058947	Annex B
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Texas Instruments 34 Forest Street Attleboro MA USA Tel: +1 508 236 3314 Fax: + 1 508 236 1960	EP1 038257, US 09/315708, JP 00-560700, EP 1 034644, US 6442215, CN 1273730A, WO00/04686, EP 0669591B, AT-PS 401127	6.1

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Information technology — Radio frequency identification for item management —

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

1 Scope

1.1 This part of ISO/IEC 18000 provides physical layer, collision management system and protocol values for RFID systems for Item Identification operating at 13,56 MHz in accordance with the requirements of ISO/IEC 18000-1

1.2 This part of ISO/IEC 18000 provides definitions for systems for each MODE determined in Clause 6 below.

1.3 This part of ISO/IEC 18000 defines 2 non interfering MODES.

The MODES are NOT interoperable.

The MODES, whilst not interoperable, are non interfering.

2 Conformance

2.1 Claiming conformance

In order to claim conformance with this part of ISO/IEC 18000 it is necessary to comply to 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 are defined in ISO/IEC TR 18047-3.

3 Normative references

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

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

ISO/IEC 15693 (all parts), *Identification cards — Contactless integrated circuit(s) cards — Vicinity cards*

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

ISO/IEC 18000-1, *Information technology — Radio frequency identification for item management — Reference architecture and definition of parameters to be standardized*

ISO/IEC TR 18047-3, *Information technology — Radio frequency identification device conformance test methods — Part 3: Test methods for air interface communications at 13,56 MHz*

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

EN 300 330, *Electromagnetic compatibility and Radio spectrum Matters (ERM); Short Range Devices (SRD); Technical Characteristics and test methods for Radio equipment in the frequency range 9 kHz to 30 MHz*

4 Terms and definitions

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

4.1
Phase Jitter Modulation
Modulation technique that transmits data as very small phase changes in the powering field

5 Symbols and abbreviated terms

For the purposes of this document, the symbols and abbreviated terms given in ISO/IEC 18000-1, ISO/IEC 19762 and the following apply.

≈ MODE 1 -the value is a rounded value (e.g. ≈ 75.52 µs)

PJM Phase Jitter Modulation

6 Requirements: Physical layer, collision management system and protocol values for 13,56 MHz systems

6.0 General and applicable to both Modes of this part of ISO/IEC 18000

6.0.1 Presentation as determined in ISO/IEC 18000-1

The context, form and presentation of this part, which provides physical layer, collision management system and protocol value definitions for RFID systems for item identification operating at 13,56 MHz are in accordance with the requirements of ISO/IEC 18000-1.

6.0.2 ISO/IEC 18000-3 Interoperability

This part of ISO/IEC 18000 specifies two MODES of operation at 13,56 MHz

These MODES are not interoperable, but they are expected to operate without causing any significant interference with each other. Any known causes of interference are listed in Annex B.

NOTE It is recommended that users select one MODE for any specific application.

NOTE Local national regulations may further limit either power, frequency or bandwidth allocations and such limitations may reduce the capability of a system within that country. Users shall have the responsibility to ensure that they use only systems that comply with these regulations. This implies a user responsibility to obtain proofs from manufacturers, and where appropriate have adequate tests carried out to assure that systems are in compliance.

Informative Comment: At the time of preparation of this part of ISO/IEC 18000, the interrogator to tag link and tag to interrogator link physical layer emissions may be subject to type approval or certification. It is therefore necessary to make reference to local or regional radio regulations and radio standards in addition to this part of ISO/IEC 18000. All systems are required to comply to local radio regulations, which may affect performance.

1) To be published.

6.0.3 ISO/IEC 18000-3 reader conformance/compliance

To claim compliance with this part of ISO/IEC 18000, an interrogator/ reader shall support either MODE 1 or MODE 2. The reader may support both modes as an option (the modes are not interoperable).

6.0.4 ISO/IEC 18000-3 tag compliance.

To claim compliance with this part of ISO/IEC 18000, a tag shall support either MODE 1 or MODE 2. The tag may support both modes as an option (the modes are not interoperable).

6.0.5 Command structure and extensibility

Clauses 6.1 and 6.2, include definition of the structure of command codes between an interrogator and a tag and indicate how many positions are available for future extensions.

Command specification clauses provide a full definition of the command and its presentation.

Each command is labelled as being ‘mandatory’ or ‘optional’.

In accordance with ISO/IEC 18000-1, the clauses of this part of ISO/IEC 18000 make provision for ‘custom’ and ‘proprietary’ commands.

The types of permitted command options are defined in subclauses 6.0.6 to 6.0.9.

6.0.6 Mandatory commands

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

6.0.7 Optional commands

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.

6.0.8 Custom commands

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.

6.0.9 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.

6.1 Physical layer, collision management system and protocols for MODE 1 of this part of ISO/IEC 18000

MODE 1 is not interoperable with any other MODES defined within this International Standard.

6.1.1 Read/Write system

MODE 1 describes a read/write system using a "reader talk first" technique.

6.1.2 Normative Aspects

The physical, collision management and transmission protocols determined in this MODE are consistent with the approach taken in ISO/IEC 15693. See annex G. Clauses 6.1.3 – 6.1.8 provide normative parts of MODE 1 by reference.

Clause 6.1.9 determines an optional protocol extension compliant with, but an extension to, ISO/IEC 15693.

6.1.3 Conformance and performance measurement aspects

The performance and conformance measurement aspects for MODE 1 will be given in the relevant clauses of future Technical Reports (ISO/IEC TR 18046 and ISO/IEC TR 18047-3, respectively).

6.1.4 Physical Layer

The Physical layer for the MODE 1 air interface at 13,56 MHz shall be compliant with ISO/IEC 15693-2, 2000.

6.1.5 Protocol and collision management operating method

The collision management operating method for the MODE 1 air interface at 13,56 MHz shall be compliant with ISO/IEC 15693-3.

6.1.6 Commands

The commands for the MODE 1 air interface at 13,56 MHz shall be compliant with ISO/IEC 15693-3.

6.1.7 Parameter tables for interrogator to tag link

The parameter tables for interrogator to tag link for the MODE 1 air interface at 13,56 MHz shall be compliant with ISO/IEC 15693-2.

6.1.8 Parameter tables for tag to interrogator link

The parameter tables for tag to interrogator link for the MODE 1 air interface at 13,56 MHz shall be compliant with ISO/IEC 15693-2.

6.1.9 Protocol extension

6.1.9.1 Protocol extension optional

The protocol extension is optional, tags may support it. If supported request and response shall comply with the definition given in Clauses 6.1.9 - 6.1.11.

If the tag does not support the protocol extension it shall not return an error code and shall remain silent.

The request consists of the following fields:

- Flags (see Table 1: Bit 4 set to 1 for protocol extension, Bit 5 - Bit 8 shall be set to 0: RFU)
- Protocol extension byte (Bit 1 and Bit 2 of the Protocol extension byte are reserved for future protocol extensions and have to be set to 0).
- CRC

6.1.9.2 Request flags

The request flags are shown in Table 1.

Table 1 — Request flags 1 to 4 definition

Bit Nb	Flag name	State	Description/limits
Bit 1	Sub-carrier_flag	0	A single sub-carrier frequency shall be used by the RF tag
		1	Two sub-carriers shall be used by the RF tag
Bit 2	Data_rate_flag	0	Low data rate shall be used
		1	High data rate shall be used
Bit 3	Response_flag	0	Optional protocol response as specified in 6.1.10.18 & 6.1.10.19, if the tag does not support this response, it shall remain silent.
		1	Optional protocol response as specified in G.8.4.1 Read single block command, and the response format in Figure G33, using coding dependant upon bits 1 and 2 above. If the tag does not support this response, it shall remain silent.
Bit 4	Protocol_Extension_ Flag	1	Protocol format is extended
Bit 5	RFU	0	RFU
Bit 6	RFU	0	RFU
Bit 7	RFU	0	RFU
Bit 8	RFU	0	RFU

6.1.9.3 Request format

Figure 1 only refers to Protocol extension commands if Bit 1 and Bit 2 of the Protocol extension byte are 0.

SOF	Flags	Protocol extension byte	CRC	EOF
	8 bits	8 bits	16 bits	

Figure 1 — Protocol extension request format

6.1.10 Protocol extension- description of collision management method

6.1.10.1 Collision management in protocol extension

This protocol extension contains two major branches: the non-slotted non-terminating multiple tag reading branch, described in 6.1.10.2 and the slotted terminating adaptive round multiple tag reading branch described in 6.1.10.3.

6.1.10.2 Non-slotted non-terminating multiple tag reading protocol

In the non-slotted non-terminating aloha protocol, a Wake-up command shall cause the RF tags to reply at random, with self-determined intervals, as long as they continue to be in the energising field. In this protocol, interrogators will receive, detect and report all replies which arrive without collisions, but will not try to influence the interrogation process other than through the issuing of additional wake-up signals to introduce newly arriving tags into the reply process. Programming is performed with 1 RF tag in the field.

This implementation:

- only requires a Wake-up command
- uses a default reply length (length may be programmed by user)
- performs well when one or only a small number of tags are in the interrogation field at one time.

After a Wake-up command the interrogator listens for RF tags. The type of tag forms part of the preamble of the main reply and is thus signalled to the interrogator which will not try to signal any other commands to a non-slotted non-terminating tag. It is recommended that the default-reply-time to non-reply-time approximately forms the ratio 1 to 10.

Figure 2 shows 3 tags working in the non-slotted non-terminating tag protocol.

- The interrogator issued a Wake-up command and all 3 tags responded resulting in a collision.
- Next RF tag 1 and RF tag 3 responded after a varying hold off time resulting in a collision.
- Next RF tag 2 responded alone and was decoded.
- Next RF tag 1 responded alone and was decoded.
- Next RF tag 2 and RF tag 3 responded resulting in a collision.
- Next RF tag 1 and RF tag 2 responded resulting in a collision.
- Finally RF tag 3 responded and was decoded.

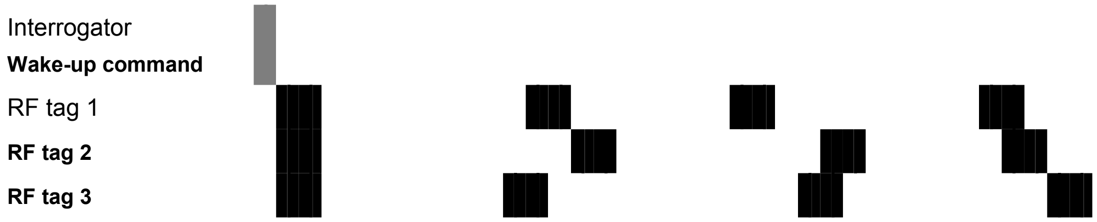


Figure 2 — Example of RF tag response in non-slotted non-terminating multiple tag reading protocol

6.1.10.3 RF tag states in non-slotted, non-terminating adaptive round protocol

The Power-off and Ready states are the same as in the normal protocol.

The transition from the Ready state to the active state occurs as the result of a protocol extension non-terminating/non-slotted Wake-up command (Protocol Extension_flag is set).

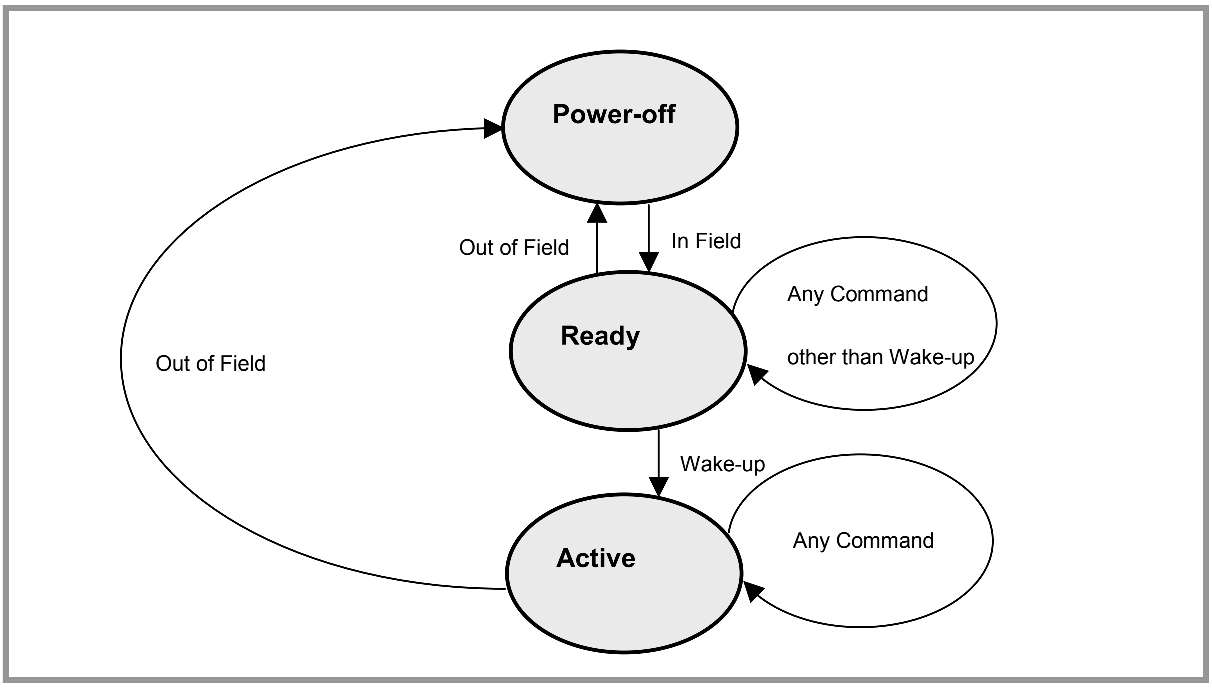


Figure 3 — Tag states in non-slotted non-terminating multiple tag reading protocol

6.1.10.4 Slotted terminating adaptive round multiple tag reading protocol

In the slotted terminating adaptive round protocol, after Wake-up and during the interrogation cycle, there is a continuing dialogue between tags and the interrogator/reader, and a tag shall not continue to reply indefinitely.

The Reader Talks First (RTF) Wake-up can be given frequently for highly dynamic populations. Within a large population of tags, there will be a diminishing number of tags replying, until all have been read.

In this protocol tags will select a random slot number, from a maximum slot number, in which to offer a reply. The maximum slot number is set in the tag as a default value, which may be temporarily over-ridden by an interrogator command. The interrogator signals the start of each slot. The tag keeps track of the number of the current slot timed from the Wake-up command responsible for it waking and subsequent transition to the active state. After responding the RF tag will automatically transition from the active state to the quiet state. If the tag is in the active state when the current slot number equals the maximum slot number, an increment in the current slot number shall cause the tag to reset its current slot value back to one and recalculate the random slot number in which to re-offer its reply. This case arises if the response of a tag collided with another in its chosen reply slot, or the response contained an error. This cycling of current slot numbers continues until the tag response is decoded without error and it remains in the quiet state, or the tag leaves the energising field.

The maximum slot number is referred to as the number of slots in a round. The number of slots in a round may be expanded and contracted as the tag populations grow and shrink.

6.1.10.5 Example of interrogator to tag dialogue

Upon receiving a Wake-up command, tags do not necessarily reply immediately, but begin self-selecting within a default round length a randomly chosen reply slot within this first round. The time duration of a tag reply slot is dependent upon the chosen response format and the number of pages in the default reply. The number of slots which a tag expects within a reply round is dependent upon initial tag programming, but can be modified by interrogator commands. The start of each reply slot is signalled by the interrogator.

An example dialogue is shown in Figure 4.

- The interrogator issued a Wake-up command, which moved RF tags in the ready state to the active state.

- RF tags read their default round size from memory and randomly select a slot in which to respond.

- Slot 0 contained a response from RF tag 1 which after the reply transitions to the quiet state.

- The interrogator issued a Next-slot command, which contained the TEL of RF tag 1 which remains quiet.

- Slot 1 contained no response, and the interrogator issued a Close-slot (EOF) command.

- Slot 2 contained two responses, the precursors of which vary in their contents, so a collision is detected and the slot is closed before the main reply. The two RF tags will offer a response again next round (after the maximum number of slots in the current round have elapsed).

- Slot 3 contained two responses, the collision was not detected during the precursor but was detected in the CRC check of the main reply, so a collision was detected and the interrogator issued an Ultimate-error command. The two RF tags will offer a response again next round.

- Slot 4 contained two responses, but one is significantly stronger than the other so it appeared to the interrogator that only 1 RF tag was in the slot. The interrogator issued a Next-slot command which contained the TEL of RF tag 6. RF tag 7 will offer a response again after the maximum number of slots in the current round.

- Slot 5 contained a response of a particular RF tag which, for one of a variety of reasons, needed to be isolated. The interrogator issued a Selective-stand-by command, which moved RF tag 8 to the active state. RF tags 1 and 6 stay in the quiet state, while all other tags in the active state moved to the Stand-by state.

- At this time there is only one RF tag in the active state and there is an opportunity to request more data or program that tag. The interrogator issued a reply-with-range command, which causes RF tag 8 to respond with an addressed range (Slot 6).

- The interrogator then issued a Next-slot command, which left RF tag 8 in the quiet state.

- The interrogator then issued a Re-enter-round command, which moved the RF tags in the Stand-by state back to the active state.

- Slot 7 contained a response from RF tag 9.

Table 2 — Timing for the slotted terminating adaptive round

	Minimum	Typical	Maximum
t1	$4064/f_c$ (300µs)	$4096/f_c$ (302µs)	$4128/f_c$ (304µs)
t2		44 bits	
t3	$992/f_c$ (73µs)	$1024/f_c$ (76µs)	$1056/f_c$ (78µs)

Where:
t1 = interrogator/reader to tag & tag to interrogator/reader turn around time
t2 = gap between optional precursor and main reply
t3 = period before close slot command is issued

Note: The time t2 is 44 bits where the duration of 1 bit is 4 pulses of 32/fc. The RF tag only listens for the close slot command after the nominal 302µs turn around time has elapsed from the end of the precursor modulation.

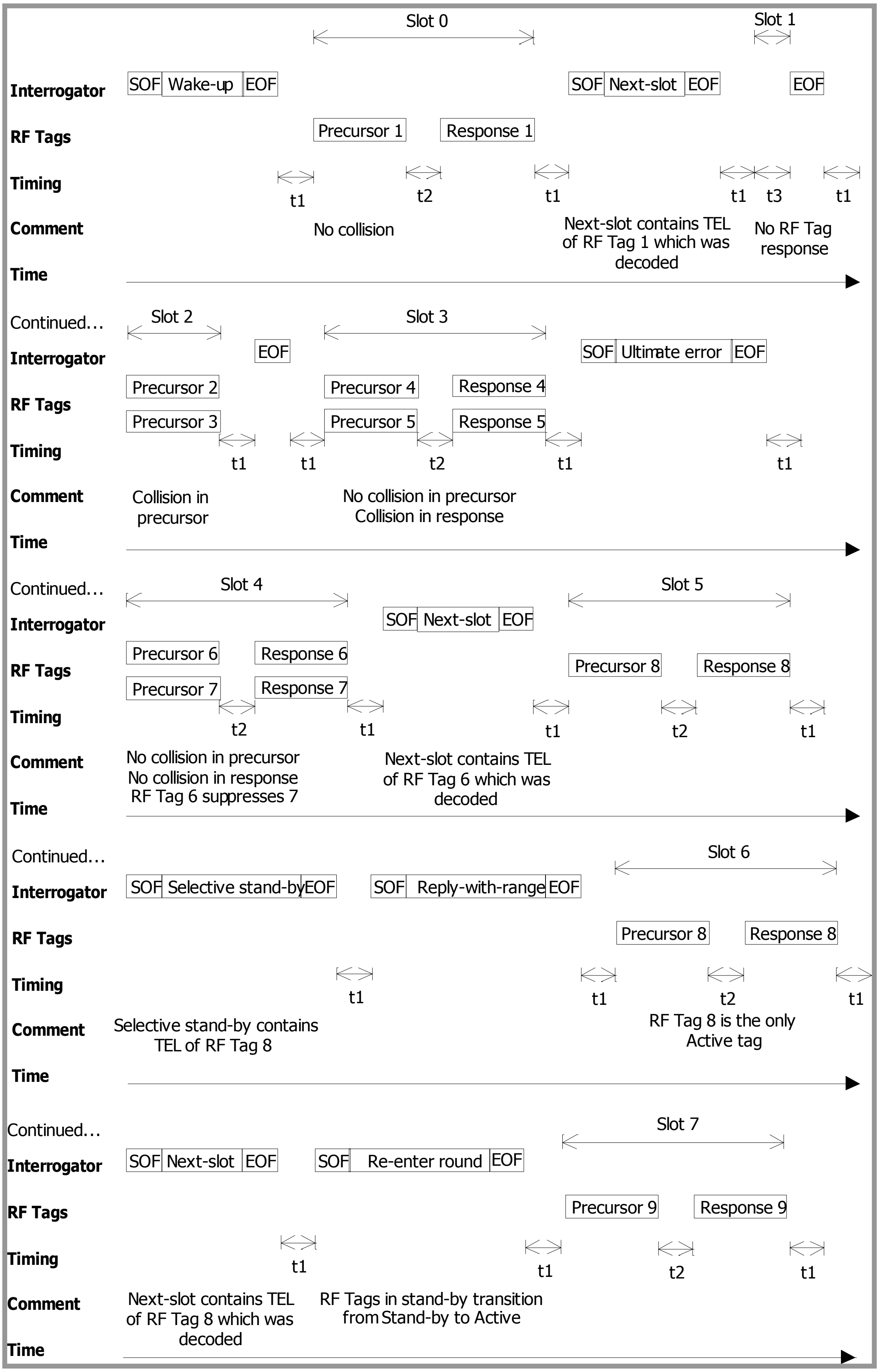
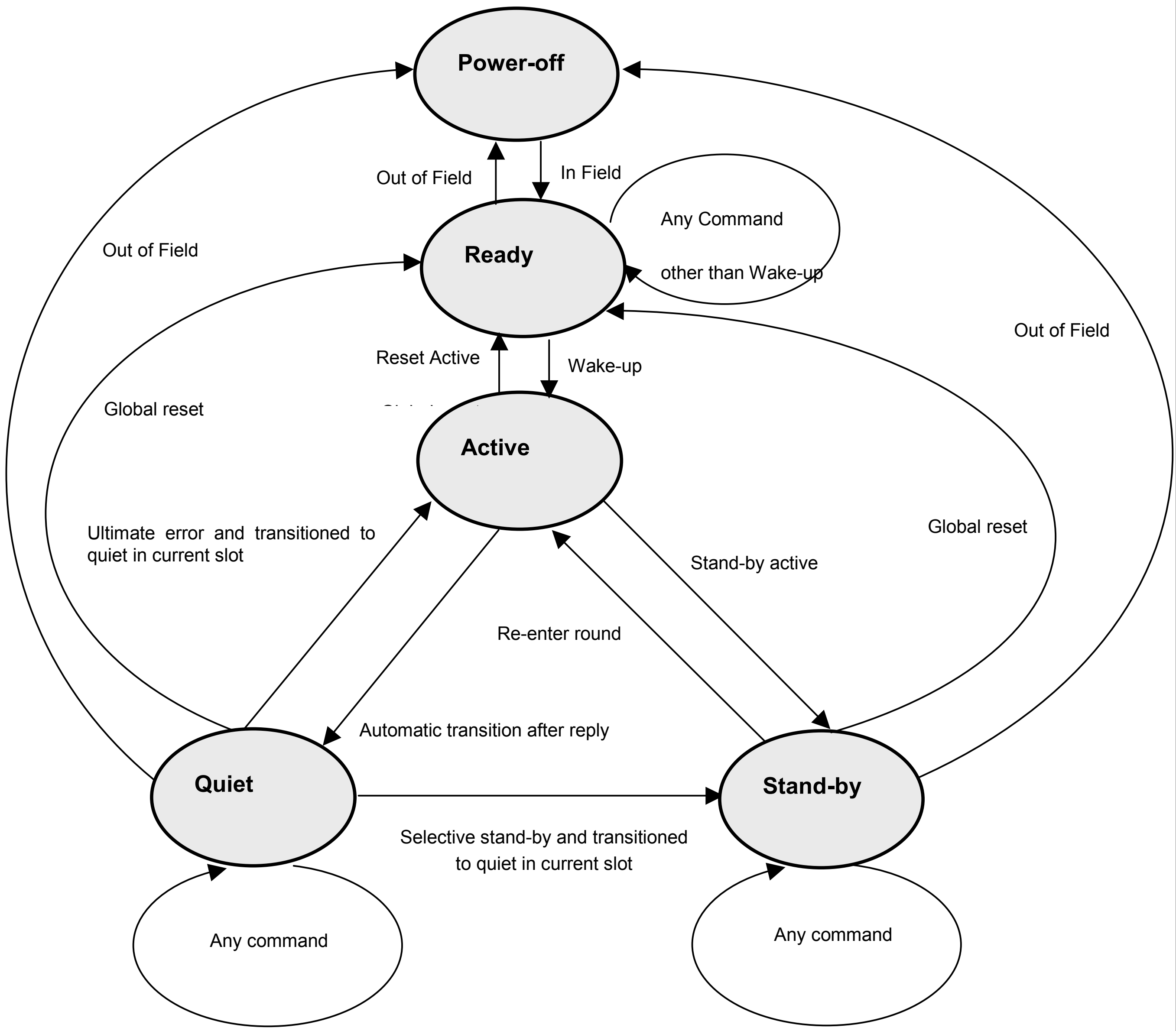


Figure 4 — Slotted terminating adaptive round

6.1.10.6 RF tag states in slotted terminating adaptive round protocol

The Power-off, ready, and quiet states are the same as in the normal protocol. The Selected state of the base protocol can be accessed via the base protocol commands.

The transition from the ready state to the active state occurs as the result of a protocol extension Wake-up command (Protocol Extension_flag is set).



NOTE 1 The transition to the Power-off state from another state occurs after 300ms when state storage bit is set. If power is removed for >10s the tag does not remember any previous state. If power is removed between 300ms and 10s the storage action is uncertain.

NOTE 2 The RF tag state transition diagram shows only valid transitions. In all other cases the current RF tag state remains unchanged. When the RF tag cannot process an interrogator request (e.g. CRC error etc.), it shall stay in its current state except if it has just transitioned to the quiet state where the tag will return to the active state.

Figure 5 — RF tag state transition diagram

6.1.10.7 The active state

An RF tag in the active state will respond with its default reply when the current slot number equals a randomly selected reply number (chosen from the maximum number of slots within the current round of slots). If the current slot number increments past the current maximum number of slots within the round, the current slot number is set back to 1 and a new random reply number is chosen.

The RF tag continues the above process until:

- after having replied, is left in the automatically transitioned to quiet state;
- it receives a command to transition to another state; or
- it leaves the energising field

6.1.10.8 The stand-by state

An RF tag in the Stand-by state shall respond to only a Global reset or a Re-enter round command. The tag holds the value of the current slot number, to be incremented further only after having returned to the active state by the receipt of a Re-enter round command.

In the case of a Global reset command, the RF tag transitions to the ready state and all counters are reset to initial values as would happen if the RF tag had just entered the energising field.

6.1.10.9 MODE 1: Protocol extension - tag response formats

Two response formats are allowed: a main reply with a precursor; and a main reply without a precursor.

The bit ordering for the main reply RF tag response is LSB first and LSByte first.

The bit ordering for the 12 bit precursor, if present, is LSB first.

The precursor allows the early detection of a collision within a slot which may be closed by the interrogator by a close slot (EOF) in the gap between the precursor and the main reply. If the precursor is implemented it shall have a fixed duration of $3456/f_c$, followed by a gap of t2 (see Table 2) before the main reply.

The hardware implementation of the RF tag, together with the wake up command, determines whether or not a precursor is present. The RF tag may be configured, in hardware, to issue the precursor when the time to transmit the default reply data, or the requested reply data, without a precursor would be large with respect to the duration of the precursor and associated gap. Not issuing a precursor only means that the protocol will not be able to perform the early closure of colliding slot, (the collision would be dealt with after the main replies have been transmitted).

By examining the start of the tag response the interrogator determines whether or not a precursor is present. In the case of mixed RF tags, the interrogator would not observe a period of no tag modulation after a period of time equal to the fixed precursor duration, and thus the interrogator would not attempt to close the slot.

6.1.10.10 Response format with precursor

The response with precursor consists of the following fields:

- Precursor
- Gap (t2 as defined in Table 2).
- Main reply

Precursor	Gap	Main reply

Figure 6 — Protocol extension response format with precursor

6.1.10.11 Response format without precursor

The response without precursor consists of the following fields:

Main reply

Main reply

Figure 7 — Protocol extension response format without precursor

6.1.10.12 Precursor format

The precursor consists of the following fields:

Leader as defined in Figure 12.

Collision detection (12 bits using coding in Figure 13 and Figure 14).

Leader	Collision detection

Figure 8 — Precursor format

6.1.10.13 Tag excitation level (optional)

If TEL is unsupported by the tag TEL bits shall be transmitted as 0000.

If TEL is supported by the tag, the tag is able to provide a 4 bit measure of its excitation level. The level 0000 is unused as this value means that TEL is unsupported. This results in 15 valid TEL levels. If less levels are desired then the levels are reduced by resetting TEL bits to 0 starting from the LSB (e.g. 4 levels would have the 2 LSBs fixed at 00). TEL can be turned off by wakeup command parameters, and if implemented will be set to 0000, when turned off.

The TEL level is used in both the precursor as part of the collision detection bits and in the preamble of the tag reply. The TEL value is later echoed by the interrogator/reader and its use protects against the small signal suppression effect.

Variation in coupling between the tag and the interrogator, which occurs over the desired range of operating distances, is such that the power dissipated on chip approximately covers a 30 dB dynamic range of induced current.

The first level starts at the POR (Power on Reset) level of the RF Chip and increments approximately every 2 dB from that level. The final level covers excitation above 28 dB from POR.

Note : RF tags using chips implemented on different processes and using different antenna coils may exhibit different levels when they are exposed to the same magnetic field strength.

6.1.10.14 Collision detection format - TEL implemented, and requested.

Tag excitation level implemented (valid TEL values 0x01-0x0F)

The collision detection consists of the following fields:

4 TEL bits (less resolution can be obtained by fixing LSB(s) to 0)

8 Random bits (less resolution can be obtained by fixing LSB(s) to 0).

TEL bits	Random bits
4 bits	8 bits

Figure 9 — Collision detection field format with TEL implemented

6.1.10.15 Collision detection format - TEL not implemented

Tag excitation level not implemented (main reply will have fixed TEL = 0000)

The collision detection consists of the following fields:

12 Random bits (less resolution can be obtained by fixing LSB(s) to 0)

Random bits
12 bits

Figure 10 — Collision detection field format with TEL not implemented

6.1.10.16 Main reply format

The main reply consists of the following fields:

Preamble (32 bits using coding as defined in 6.1.10.17).

reply data (multiples of 32 bits using coding as defined in 6.1.10.19).

CRC (16 bits using coding as defined in 6.1.10.19)

End of signalling terminator (as defined in Figure 18).

Preamble	Reply data	CRC	End of Signalling Terminator
32 bits	n*32 bits	16 bits	2 bits

Figure 11 — Main reply format

6.1.10.17 Main reply preamble format

The preamble consists of the fields described in Table 3.

Table 3 — Preamble format

Bit Nb	Preamble name	Description/limits
1-4	Start of signalling	1110 (Bit1-4) - Start of main reply. Mandatory.
5	Protocol	0 – non-slotted non-terminating 1 – Tag slotted terminating adaptive round Set by chip manufacturer.
6	UID	0 – main reply does not include UID 1 – first 64 bits of main reply is UID Programmable.
7	Selection	0 - Selection function is not implemented 1 - Selection function is implemented Set by chip manufacturer.
8	State storage	0 - State does not survive an energising field gap. State survives a 300ms energising field gap. Set by chip manufacturer.
9-12	Tag excitation level	0000 (Bit9-12) - If TEL is not implemented. TTTT (Bit9-12) - Dynamic level (excluding 0000) if TEL is implemented.
13	Special bit	0 - Special bit function is off. 1 – Special bit function is on. Programmable.
14-16	Round size	(Bit14-16) 000 – RFU 001 – 8 010 – 16 011 – 32 100 – 64 101 – 128 110 – 256 111 - RFU Programmable. Can be over-ridden by interrogator command.
17-32	Page range	8 Bit Start (Bit17-24) and 8 Bit Finish page (Bit25-32) numbers of reply. Programmable. Can be over-ridden by interrogator command.

6.1.10.18 Bit representation and coding

6.1.10.18.1 Precursor coding

The sub clauses below define the Precursor coding.

6.1.10.18.2 Precursor leader coding

A leader starts with 8 pulses of $f_c/32$ (≈ 423,75 kHz) followed by 4 pulses of $f_c/32$ (≈ 423,75 kHz) of the opposite phase, see Figure 12.

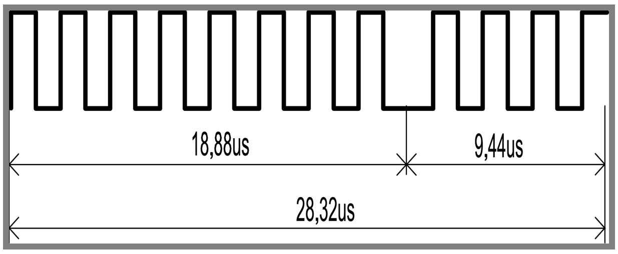


Figure 12 — Leader coding

6.1.10.18.3 Precursor collision detection binary 0 coding

A logic 0 starts with 4 pulses of $f_c/32$ (≈ 423,75 kHz) followed by an unmodulated time of $128/f_c$ (≈ 9,44 μs), see Figure 13.

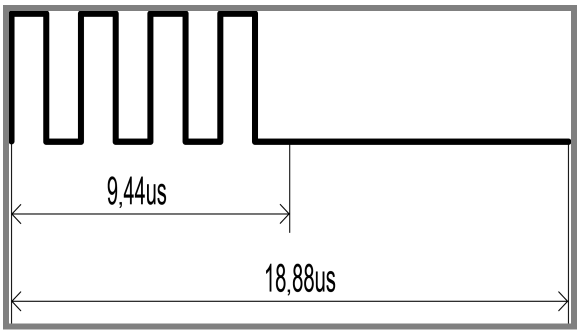


Figure 13 — Collision detection coding - binary 0

6.1.10.18.4 Precursor collision detection binary 1 coding

A logic 1 starts with an unmodulated time of $128/f_c$ (≈ 9,44 μs) followed by 4 pulses of $f_c/32$ (≈ 423,75 kHz), see Figure 14.

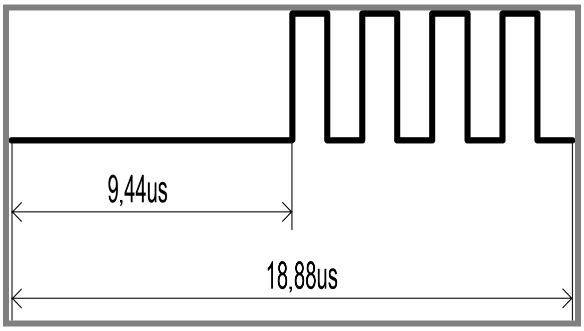


Figure 14 — Collision detection coding - Binary 1

6.1.10.19 Main reply coding

Main reply (including the preamble and CRC) coding uses DBPSK with 4 pulses of $f_c/32$ (≈ 423,75 kHz) for each bit.

6.1.10.19.1 Binary 0 coding

4 pulses of $f_c/32$ (≈ 423,75 kHz) which have the opposite phase from the previous 4 pulses represents a binary 0, see Figure 15.

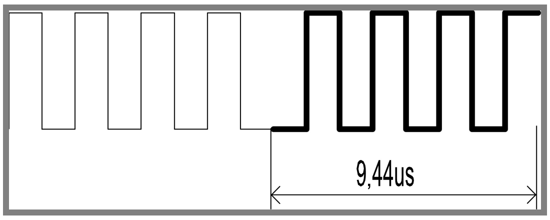


Figure 15 — Reply Coding - Binary 0

6.1.10.19.2 Binary 1 coding

4 pulses of $f_c/32$ (≈ 423,75 kHz) which have the same phase from the previous 4 pulses represents a binary 1, see Figure 16.

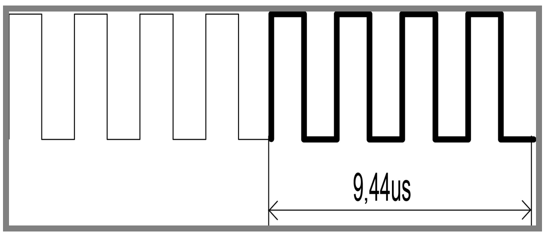


Figure 16 — Reply coding - binary 1

6.1.10.19.3 Example of binary coding.

See Figure 17 for an example of a “10”.

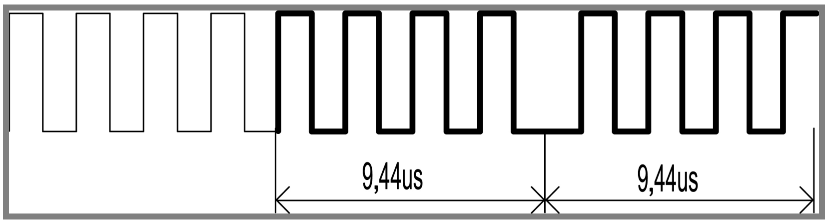


Figure 17 — Reply coding - "10"

6.1.10.19.4 End of signalling terminator coding.

The end of signalling terminator (see Figure 18) comprises:

6 pulses of $f_c/32$ (≈ 423,75 kHz) which have the opposite phase from the previous 4 pulses;

6 pulses of $f_c/32$ (≈ 423,75 kHz) which have the opposite phase from the previous 6 pulses.

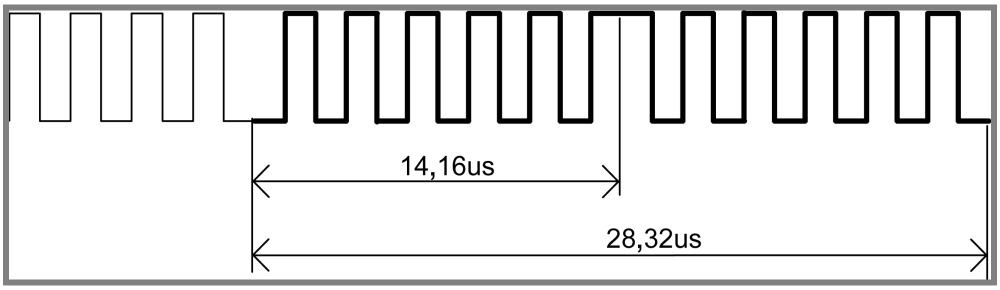


Figure 18 — End of signalling terminator coding

6.1.11 Protocol extension commands

6.1.11.1 Protocol extension command codes

If the Protocol Extension_flag is set the protocol extension byte has Bit 1 and Bit 2 set to 0 and Bits 3-8 are used for protocol extension commands described in Table 4.

For non-slotted/non-terminating tags there is only one mandatory command (0xC4) and two optional commands (0x64 and 0x74). The other commands, together with (0x64 and 0x74) are used by slotted/terminating tags.

Table 4 — Protocol extension command codes

Command code	Command name	Description/limits
0x(0-F)0 TTTT0000	Next slot	Signals the end of the current slot to all tags participating in a round. Contains TEL value TTTT in Most Significant Nibble (MSN).
0x02 00000010	Stay quiet	The Stay quiet command of the normal protocol (command code 02) may be used to signal next slot to RF tags which contain the UID in the default reply (UID Bit set to 1 in preamble), and the protocol extension bit set
0x04 00000100	Reply now	Signals to all tags in the active state to respond with their default reply in the current slot.

0x14 00010100	Reply with full data	Signals to all tags in the active state to update their reply start and stop page addresses with the first and last page addresses of tag memory respectively.
0x24 00100100	Reply with range	Signals to all tags in the active state to update their reply start and stop page addresses with the first and last page addresses contained in the command respectively. The stop address shall be greater than the start address for the default values to be updated.
0x34 00110100	Ultimate error	Signals to tags that have just replied in the current slot to reply again next round.
0x44 01000100	Re-enter round	Signals to tags in the Stand-by state to move to the active state.
0x54 01010100	Reset active tags	Signals to tags in the Active state to move to the ready state.
0X64 01100100	Clear special bit	Clears the special bit to 0.
0X74 01110100	Set special bit	Sets the special bit to 1.
0x(8-B)4 10WW0100	Wake up terminating/slotted tags only	This transfers a tag from the ready state to the active state. WW selects between wake up parameters (see Table 5).
0xC4 11000100	Wake up non-terminating/non-slotted tags only	Wake up non-slotted, non-terminating tags only
0xD4 11010100	Global reset	Signals to all tags to move to the ready state.
0xE4 11100100	Set Protocol Default Parameters	All tags to store in non-volatile memory new protocol default parameters, for round size, start and stop reply pages.
0x(0-F)8 TTTT1000	Selective stand-by	Signals to all tags in the active state to move to the Stand-by state. Signals to tags in the quiet state which have just replied in the current slot and which have TEL bits matching (TTTT in MSN) with those in the command to move to the active state - those tags with non-matching TEL bits move to the Stand-by state.
0x25 00100101	Select	The Select command of the normal protocol (command code 25) may be used to signal next slot to RF tags which contain the UID in the default reply (UID Bit set to 1 in preamble), and the protocol extension bit set. Signals to all tags in the active state to move to the Stand-by state. Signals to tags in the quiet state which have just replied in the current slot and which have a matching UID with the UID specified in the command to move to the active state and those tags with non-matching UID bits move to the Stand-by state.
0x(0-7)C 0RRR1100	New round size	Signals to tags in the active state to reset their slot count registers, set their slot count register to the value represented by RRR and begin a new round (see Table 6).
0x(8-F)C 1CCC1100	Comparison	A comparison command enables tags in the active state to remain in that state by matching any combination of bytes in a particular tag page with bytes sent as further data in the command. tags which do not fit the comparison criteria are sent to the Stand by state.

6.1.11.2 Protocol extension commands

6.1.11.2.1 Next-slot (mandatory)

The Next-slot command is mandatory by implementing one or both of the forms in 6.1.11.2.2 or 6.1.11.2.3.

6.1.11.2.2 Next-slot with TEL

Command code (Protocol extension byte) = 0x(0-F)0

The command carries a 4 bit TEL level TTTT (0-F) in the MSN of the command.

When receiving the Next-slot command:

- \- a tag in the active state shall increment its slot counter;
- \- a tag which has transitioned to the quiet state in the current slot which does not have matching TEL bits shall transition to the active state and increment its slot counter;
- \- a tag which has transitioned to the quiet state in the current slot which has matching TEL bits shall remain in the quiet state.

If TEL is not implemented it is recommended that the UID be present in the tag response (Bit6 of the reply preamble as defined in Table 3 be set to 1), and the Next slot without TEL command be used.

SOF	Flags	Protocol extension byte	CRC16	EOF
	8 bits	8 bits	16 bits	

Figure 19 — Next-Slot With TEL Format

RF tag response

An RF tag in the active state shall respond with its default reply when the current slot number equals its random slot number.

6.1.11.2.3 Next slot without TEL

Command code = 0x02

The stay quiet command of the normal protocol may be used to signal next slot to RF tags which contain the UID in the default reply (UID Bit set to 1 in preamble).

- \- when receiving this form of Next-slot (Stay quiet):
- \- a tag in the active state shall increment its slot counter;

a tag which has transitioned to the quiet state in the current slot which does not have matching UID bits shall transition to the active state and increment its slot counter;

a tag which has transitioned to the quiet state in the current slot which has matching UID bits shall remain in the quiet state.

SOF	Flags	**Stay quiet**	UID	CRC16	EOF
	8 bits	8 bits	64 bits	16 bits	

Figure 20 — Next-slot without TEL format (stay quiet)

RF tag response

An RF tag in the active state shall respond with its default reply when the current slot number equals its random slot number.

An RF tag in the quiet state shall offer no response.

6.1.11.2.4 Reply now (optional)

Command code (Protocol extension byte) = 0x04

When receiving the reply now command all tags in the active state shall reply in the current slot with their default reply.

SOF	Flags	**Protocol extension byte**	CRC16	EOF
	8 bits	8 bits	16 bits	

Figure 21 — Reply-now format

RF tag response

An RF tag in the active state shall respond with its default reply in the current slot (over-rides the requirement for random slot number to equal current slot number).

6.1.11.2.5 Reply with full data (optional)

Command code (Protocol extension byte) = 0x14

When receiving the reply with full data command all tags in the active state shall update their default reply start and stop addresses with the first and last page addresses of their memory.

SOF	Flags	Protocol extension byte	CRC16	EOF
	8 bits	8 bits	16 bits	

Figure 22 — Reply-with-full-data format

RF tag response

An RF tag in the active state will respond with its default reply (which has been updated to cover the full memory) when the current slot number equals its random slot number.

6.1.11.2.6 Reply with range (optional)

Command code (Protocol extension byte) = 0x24

When receiving the reply with range command all tags in the active state shall update their default reply start and stop addresses with the start and stop addresses contained in the command. The stop address shall be greater than the start address for the default values to be updated.

SOF	Flags	Protocol extension byte	Start address	Stop address	CRC16	EOF
	8 bits	8 bits	8 bits	8 bits	16 bits	

Figure 23 — Reply-with-range Format

RF tag response

An RF tag in the active state will respond with its default reply (which has been updated with new start and stop pages) when the current slot number equals its random slot number.

6.1.11.2.7 Ultimate error (mandatory)

Command code (Protocol extension byte) = 0x34

When receiving the Ultimate error command:

a tag in the active state shall increment its slot counter;

a tag which has transitioned to the quiet state in the current slot shall transit to the active state and increment its slot counter.

SOF	Flags	Protocol extension byte	CRC16	EOF
	8 bits	8 bits	16 bits	

Figure 24 — Ultimate-error format

RF tag response

An RF tag in the active state will respond with its default reply when the current slot number equals its random slot number.

6.1.11.2.8 Re-enter round (mandatory if selective-standby is implemented)

Command code (Protocol extension byte) = 0x44

When receiving the Re-enter round command tags in the stand by state shall transit to the active state.

SOF	Flags	Protocol extension byte	CRC16	EOF
	8 bits	8 bits	16 bits	

Figure 25 — Re-Enter-round format

RF tag response

An RF tag in the active state will respond with its default reply when the current slot number equals its random slot number.

6.1.11.2.9 Reset active (mandatory if comparison is implemented)

Command code (Protocol extension byte) = 0x54

When receiving the reset active command tags in the active state shall transition to the ready state.

SOF	Flags	Protocol extension byte	CRC16	EOF
	8 bits	8 bits	16 bits	

Figure 26 — Reset-active format

RF tag response

There is no tag response.

6.1.11.2.10 Clear special bit (optional)

Command code (Protocol extension byte) = 0x64

When receiving the Clear special bit command all tags in the active state shall clear their special bit to 0.

SOF	Flags	Protocol extension byte	CRC16	EOF
	8 bits	8 bits	16 bits	

Figure 27 — Clear special bit format

RF tag response

There is no tag response.

6.1.11.2.11 Set special bit (optional)

Command code (Protocol extension byte) = 0x74

When receiving the Set special bit command all tags in the active state shall set their special bit to 1.

SOF	Flags	Protocol extension byte	CRC16	EOF
	8 bits	8 bits	16 bits	

Figure 28 — Set special bit format

RF tag response

There is no tag response.

6.1.11.2.12 Wake-up (mandatory, for terminating/slotted tags)

Command code (Protocol extension byte) = 0x(8-B)4

The command carries a 2 bit wake up parameter, 10WW (8-B) - see Table 5

When receiving any one of the 4 wake-up commands only terminating/slotted tags in the ready state shall transition to the active state. The use of the 4 wake up commands allows the interrogator/reader to disable TEL and/or the precursor in tag replies. If the interrogator/reader requests TEL and/or the precursor and the tag does not implement TEL and/or the precursor, then TEL and/or the precursor are not provided in the tag reply.

Table 5 — Wake up parameters

Command code 10WW0100	Wake Up request
10000100	TEL and precursor
10010100	TEL, no precursor
10100100	Precursor, no TEL
10110100	No precursor, no TEL

SOF	Flags	Protocol extension byte	CRC16	EOF
	8 bits	8 bits	16 bits	

Figure 29 — Wake-up format

RF tag response

An RF tag in the active state shall respond with its default reply when the current slot number equals its random slot number.

6.1.11.2.13 Wake-up (mandatory, for non-terminating/non-slotted tags)

Command code (Protocol extension byte) = 0xC4

When receiving this wake-up command only non-terminating/non-slotted tags shall begin their reply sequence.

SOF	Flags	Protocol extension byte	CRC16	EOF
	8 bits	8 bits	16 bits	

Figure 30 — Wake-up format

RF tag response

A non-terminating/non-slotted RF tag, shall respond with its reply.

6.1.11.2.14 Global reset (optional)

Command code (Protocol extension byte) = 0xD4

When receiving the Global reset command all tags shall transit to the ready state.

SOF	Flags	**Protocol extension byte**	CRC16	EOF
	8 bits	8 bits	16 bits	

Figure 31 — Global-reset format

RF tag response

There is no tag response.

6.1.11.2.15 Selective stand-by (optional)

6.1.11.2.15.1 Selective stand-by with TEL

Command code (Protocol extension byte) = 0x(0-F)8

The command carries a 4 bit TEL level TTTT (0-F).

When receiving the Selective stand-by command:

all tags in the active state shall transition to the stand-by state;

Tags which have just replied in the current slot and which have TEL bits matching (TTTT in MSN) with those in the command shall move to the active state;

Tags which have just replied in the current slot and which have non-matching TEL bits move to the Stand-by state.

SOF	Flags	Protocol extension byte	CRC16	EOF
	8 bits	8 bits	16 bits	

Figure 32 — Selective-stand-by with TEL format

RF tag response

An RF tag in the active state shall respond with its default reply when the current slot number equals its random slot number.

6.1.11.2.15.2 Selective stand-by without TEL

Command code = 0x25

The Select command of the normal protocol may be used to signal selective stand-by to RF tags which contain the UID in the default reply (UID Bit set to 1 in preamble).

When receiving this form of Selective stand-by (Select):

all tags in the active state shall transition to the stand-by state;

Tags which have just replied in the current slot and which have UID bits matching with those in the command shall move to the active state;

Tags which have just replied in the current slot and which have non-matching UID bits move to the stand-by state.

SOF	Flags	Select	MFG tag ID	CRC16	EOF
	8 bits	8 bits	64 bits	16 bits	

Figure 33 — Selective-stand-by without TEL format (select)

RF tag response

An RF tag in the active state shall respond with its default reply when the current slot number equals its random slot number.

6.1.11.2.16 New round size (mandatory)

Command code (Protocol extension byte) = 0x(0-7)C

The command carries a 3 bit round size RRR (0-7) - see Table 6.

When receiving the New round size command, tags in the active state shall update their round size to the value contained in the command and recalculate their random reply slot number from the new maximum value (0RRR). These tags will then assume the current slot number is one.

Table 6 — New-round-size values

Command code **0**RRR**1100**	**Round size**
0**000**1100	RFU
0**001**1100	8
0**010**1100	16
0**011**1100	32
0**100**1100	64
0**101**1100	128
0**110**1100	256
0**111**1100	RFU

SOF	Flags	Protocol extension byte	CRC16	EOF
	8 bits	8 bits	16 bits	

Figure 34 — New-round-size format

RF tag response

An RF tag in the active state shall respond with its default reply when the current slot number equals its random slot number.

6.1.11.2.17 Comparison (optional)

Command code (Protocol extension byte) = 0x(8-F)C

The comparison command enables tags in the active state to remain in that state by matching any combination of bytes in a particular tag page with bytes sent as further data in the command. Tags which do not fit the selection criteria are sent to the stand by state.

To compare tags using inverse logic, tags in the active state are first compared with normal logic and then moved to the ready state by a Reset active tags command. Then tags in the stand-by state are moved to the active state by a Re-enter round command.

Refinement of comparison is performed by progressively comparing (and at the same time eliminating) tags with comparison criteria.

The comparison is performed on the Comparison_page of memory. The comparison bits (CCC) in the command represent comparison functions and are listed in Table 7.

B0, B1, B2, B3 each represent 8 bits in the Comparison_page or Comparison_data with B0 representing the least significant byte.

Table 7 — Comparison functions

Command code 1CCC1100	**Comparison function**
10001100	contents of the Comparison_page in tag memory = Comparison_data in the command
1**001**1100	B0-B1 of the Comparison_page in tag memory with B0-B1 of the Comparison_data in the command using B2-B3 of the Comparison_data in the command as a mask
1**010**1100	B2-B3 of the Comparison_page in tag memory with B0-B1 of the Comparison_data in the command using B2-B3 of the Comparison_data in the command as a mask
1**011**1100	B0 of the Comparison_page in tag memory ≤ B0 of the Comparison_data in the command
1**100**1100	B0-B1 of the Comparison_page in tag memory ≤ B0-B1 of the Comparison_data in the command
1**101**1100	contents of Comparison_page in tag memory ≤ Comparison_data in the command
1**110**1100	RFU
1**111**1100	RFU

Comparison with a mask is carried out on a bit-wise comparison between 16 bits of data in the Comparison_page in memory and the Comparison_data_B2_B3 (the most significant 16 bits) contained in the comparison command (see Figure 35). When using a 16 bit mask for the comparison, the mask bit shall be 1 to indicate that the corresponding bit position in memory is to be considered, and the mask bit shall be 0 to indicate that the corresponding bit position in memory is to be ignored.

In the “less than or equal to” comparisons, 32 bits are sent as part of the Comparison_data but only the relevant bytes are compared.

A “greater than” function can be performed by eliminating tags which are less than or equal to”. A “less than” *number* function can be performed by choosing *number* to be one smaller than the number required to be less than.

SOF	Flags	**Protocol extension byte**	**Comparison_page**	**Comparison_data**	CRC16	EOF
	8 bits	8 bits	8 bits	32 bits	16 bits	

Figure 35 — Comparison format

Mask	**Data**
Comparison_data_B2_B3	Comparison_data_B0_B1
16 bits	16 bits

Figure 36 — Comparison_data with comparison mask

RF tag response

An RF tag in the active state will respond with its default reply when the current slot number equals its random slot number.

6.1.11.2.18 Set protocol default parameters (optional)

Command code (Protocol extension byte) = 0xE4

When receiving the Set protocol default parameters command all tags in the active state shall program new values for the default round size, start and stop addresses, in the non-volatile memory, with the values contained in the command. The stop address shall be greater than the start address for the default values to be stored. The RFU bits shall be set to 0, and the round size to be defined according to table 6. If this command is not implemented, the default round size will be 8, and the default start and stop page will be page 1.

SOF	Flags	Protocol extension byte	RFU	Default Round Size	Default Start address	Default Stop address	CRC16	EOF
	8 bits	8 bits	5 bits	3 bits	8 bits	8 bits	16 bits	

Figure 37 — Set protocol default parameters - format

RF tag response

There is no tag response.

6.1.12 Air interface application layer

6.1.12.1 Structure

The application layer shall be determined and controlled solely within the interrogator and shall not be carried across the air interface.

6.2 MODE 2: Physical layer, collision management system and protocols for MODE 2 of this part of ISO/IEC 18000

MODE 2 is not interoperable with any other MODE defined in this part of ISO/IEC 18000.

MODE 2 is non interfering with any other MODE defined in this part of ISO/IEC 18000.

The performance and conformance measurement aspects for MODE 2 shall be conformant with the relevant clauses of future Technical Reports (ISO/IEC TR 18046 and ISO/IEC TR 18047-3, respectively).

6.2.1 Normative aspects: physical and media access control (MAC) parameters: interrogator to tag link

Table 8 — Physical and media access control (MAC) parameters : interrogator to tag link

Ref.	Parameter Name	Description
M2-Int: 1	**Operating frequency range**	13,56 MHz ± 7 kHz
M2-Int: 1a	Default operating frequency	13,56 MHz
M2-Int: 1b	Operating channels (for Spread spectrum systems)	N/A
M2-Int: 1c	Operating frequency accuracy	± 100 parts per million Japan: ± 50 parts per million
M2-Int: 1d	Frequency hop rate (for Frequency Hopping [FHSS] systems)	N/A
M2-Int: 1e	Frequency hop sequence (for Frequency Hopping [FHSS] systems)	N/A
M2-Int: 2	**Occupied channel bandwidth**	The modulation sidebands are very low in amplitude but spread wide. They satisfy the ETSI, and FCC regulations. (Occupied channel bandwidth is not regulated in the Japan Radio Law).
M2-Int: 2a	Minimum receiver bandwidth	Suitable to receive tag channel or channels of interest.
M2-Int: 3	Interrogator transmit maximum EIRP	Not relevant parameter in 13,56 MHz systems Maximum EIRP depends on installation Compliant with ETSI and FCC maximum in Band allowed field strength. (Interrogator Transmit Maximum EIRP is not regulated in the Japan Radio Law).
M2-Int: 4	**Interrogator transmit spurious Emissions**	
M2-Int: 4a	Interrogator transmit spurious emissions, in-band (for Spread spectrum systems)	N/A
M2-Int: 4b	Interrogator transmit spurious emissions, out-of-band	Compliant with ETSI, ARIB STD-T82 and FCC maximum out of Band allowed field strength.
M2-Int: 5	**Interrogator transmitter spectrum mask**	Compliant with ETSI, ARIB STD-T82 and FCC maximum out of Band allowed field strength
M2-Int: 6	**Timing**	
M2-Int: 6a	Transmit to receive turn around time	0 - 50 μs
M2-Int: 6b	Receive to transmit turn around time	Class 1 : 0 - 100 μs Class 2 : Dependent on application
M2-Int: 6c	Dwell time or Interrogator transmit power on ramp	0 - 10 μs

Ref.	Parameter Name	Description
M2-Int: 6d	Decay time or Interrogator transmit power down ramp	0 - 10 μs
M2-Int: 7	**Modulation**	PJM (Phase Jitter Modulation) min. level +/- 1,0 ° max. level +/- 2,0 °
M2-Int: 7a	Spreading sequence (for frequency hopping [FHSS] systems)	N/A
M2-Int: 7b	Chip rate (for Spread spectrum systems)	N/A
M2-Int: 7c	Chip rate accuracy (for Spread spectrum systems)	N/A
M2-Int: 7d	Modulation index	N/A - (System is not amplitude modulation)
M2-Int: 7e	Duty cycle	N/A
M2-Int: 7f	FM Deviation	N/A
M2-Int: 8	**Data coding**	Modified Frequency Modulation (MFM) (see Figure 41)
M2-Int: 9	**Bit rate**	423,75 kbit/s
M2-Int: 9a	Bit rate accuracy	Synchronous to the carrier frequency.
M2-Int: 10	**Interrogator transmit modulation accuracy**	N/A
M2-Int: 11	**Preamble**	Includes an MFM encoding violation
M2-Int: 11a	Preamble length	16 bits
M2-Int: 11b	Preamble waveform	The command flag defines the start of a command and the bit interval timings. The flag comprises three parts: • A synchronising string of 9 bits of valid MFM data. • A MFM encoding violation not present in normal data. The violation consists of a sequence of 4 state changes separated by a 2 bit interval, a 1,5 bit interval and 2 bit interval. The edge of the fourth transition defines the beginning of a bit interval. • A trailing zero defining the end of a flag. (See Figure 38 below)
M2-Int: 11c	Bit sync sequence	See M2 Int: 11b
M2-Int: 11d	Frame sync sequence	See M2 Int: 11b
M2-Int: 12	**Scrambling (for Spread spectrum systems)**	N/A
M2-Int: 13	**Bit transmission order**	LSB first
M2-Int: 14	**Wake-up process**	Reader Talks First (RTF) System. Tag cannot respond unless it receives valid command from interrogator.
M2-Int: 15	**Polarization**	N/A

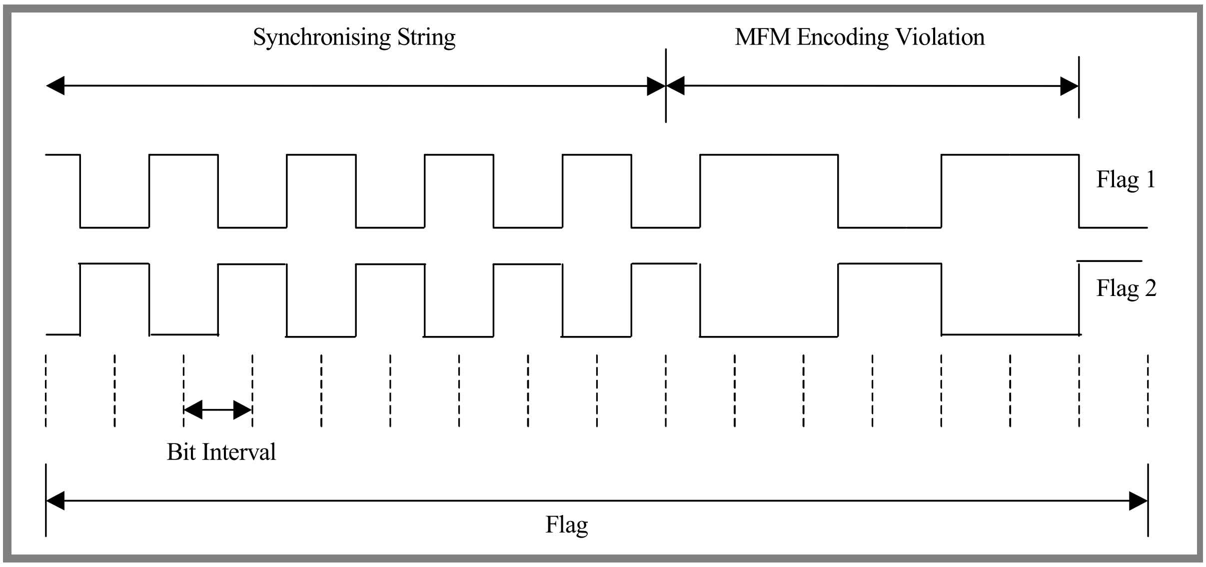


Figure 38 — Two possible command flags

6.2.2 Tag to interrogator link

Table 9 — Tag to interrogator link

Ref.	**Parameter Name**	**Description**
M2-Tag:1	**Operating frequency range**	13,56 MHz ± 3,013 MHz
M2-Tag: 1a	Default operating frequency	N/A – System does not rely on a Default Operating Frequency
M2-Tag: 1b	Operating channels (for Spread spectrum systems)	Multi-frequency operating system where tags can select from 8 reply channels. Tags transmit the whole of their reply using a selected channel. The tag may use one of eight subcarriers. The subcarriers are derived by division of the powering field's frequency. **Channel** / **Frequency kHz** / **Division Ratio** A / 969 / 14 B / 1233 / 11 C / 1507 / 9 D / 1808 / 7,5 E / 2086 / 6,5 F / 2465 / 5,5 G / 2712 / 5 H / 3013 / 4,5
M2-Tag: 1c	Operating frequency accuracy	Synchronous to the carrier frequency.
M2-Tag: 1d	Frequency hop rate (for Frequency hopping [FHSS] systems)	Tags transmit the whole of a reply on a selected channel
M2-Tag: 1e	Frequency hop sequence (for Frequency hopping [FHSS] systems)	Reply channel is randomly selected by the tag.
M2-Tag: 2	**Occupied channel bandwidth**	106 kHz for each of 8 reply channels
M2-Tag: 3	**Transmit maximum EIRP**	N/A

<table>
<tr><th>Ref.</th><th>Parameter Name</th><th>Description</th></tr>
<tr><td>M2-Tag: 4</td><td>Transmit spurious emissions</td><td>N/A</td></tr>
<tr><td>M2-Tag: 4a</td><td>Transmit spurious emissions, In-band (for Spread spectrum systems)</td><td>N/A</td></tr>
<tr><td>M2-Tag: 4b</td><td>Transmit spurious emissions, Out-of-band</td><td>N/A</td></tr>
<tr><td>M2-Tag: 5</td><td>Transmit spectrum mask</td><td>N/A</td></tr>
<tr><td>M2-Tag: 6</td><td></td><td></td></tr>
<tr><td>M2-Tag: 6a</td><td>Transmit to receive turn around time</td><td>0 - 200μs</td></tr>
<tr><td>M2-Tag: 6b</td><td>Receive to transmit turn around time</td><td>50 to 100μs.</td></tr>
<tr><td>M2-Tag: 6c</td><td>Dwell time or transmit power on ramp</td><td>N/A</td></tr>
<tr><td>M2-Tag: 6d</td><td>Decay time or Transmit power down ramp</td><td>N/A</td></tr>
<tr><td>M2-Tag: 7</td><td>Modulation</td><td>Load Modulation</td></tr>
<tr><td>M2-Tag: 7a</td><td>Spreading sequence
(for Frequency hopping [FHSS] systems)</td><td>Tags transmit the whole of a reply in a randomly selected or an interrogator selected channel.</td></tr>
<tr><td>M2-Tag: 7b</td><td>Chip rate
(for Spread spectrum systems)</td><td>N/A</td></tr>
<tr><td>M2-Tag: 7c</td><td>Chip rate accuracy
(for Spread spectrum systems)</td><td>N/A</td></tr>
<tr><td>M2-Tag: 7d</td><td>On-off ratio</td><td>N/A</td></tr>
<tr><td>M2-Tag: 7e</td><td>Sub-carrier frequency</td><td>8 sub-carrier frequencies available:
<table>
<tr><th>Channel</th><th>Frequency kHz</th><th>Division Ratio</th></tr>
<tr><td>A</td><td>969</td><td>14</td></tr>
<tr><td>B</td><td>1233</td><td>11</td></tr>
<tr><td>C</td><td>1507</td><td>9</td></tr>
<tr><td>D</td><td>1808</td><td>7,5</td></tr>
<tr><td>E</td><td>2086</td><td>6,5</td></tr>
<tr><td>F</td><td>2465</td><td>5,5</td></tr>
<tr><td>G</td><td>2712</td><td>5</td></tr>
<tr><td>H</td><td>3013</td><td>4,5</td></tr>
</table></td></tr>
<tr><td>M2-Tag: 7f</td><td>Sub-carrier frequency accuracy</td><td>Synchronous to the carrier frequency.</td></tr>
<tr><td>M2-Tag: 7g</td><td>Sub-carrier modulation</td><td>BPSK (Binary phase shift keying)</td></tr>
<tr><td>M2-Tag: 7h</td><td>Duty cycle</td><td>N/A</td></tr>
<tr><td>M2-Tag: 7I</td><td>FM Deviation</td><td>N/A</td></tr>
<tr><td>M2-Tag: 8</td><td>Data coding</td><td>MFM (Modified frequency modulation)(see Figure 44)</td></tr>
<tr><td>M2-Tag: 9</td><td>Bit rate</td><td>105,9375 kbit/s</td></tr>
<tr><td>M2-Tag: 9a</td><td>Bit rate accuracy</td><td>Synchronous to the carrier frequency.</td></tr>
<tr><td>M2-Tag: 10</td><td>Tag transmit modulation accuracy (for Frequency hopping [FHSS] systems)</td><td>N/A</td></tr>
<tr><td>M2-Tag: 11</td><td>Preamble</td><td>Includes an MFM encoding violation</td></tr>
<tr><td>M2-Tag: 11a</td><td>Preamble length</td><td>16 bits</td></tr>
</table>

Ref.	Parameter Name	Description
M2-Tag: 11b	Preamble waveform	The reply flag defines the start of a reply and the bit interval timings. The flag comprises three parts: • A synchronising string of 9 bits of valid MFM data. • A MFM encoding violation not present in normal data. The violation consists of a sequence of 4 state changes separated by a 2 bit interval, a 1,5 bit interval and 2 bit interval. The edge of the fourth transition defines the beginning of a bit interval. • A trailing zero defining the end of a flag. (See Figure 39 below)
M2-Tag: 11c	Bit sync sequence	See M2-Tag:11b
M2-Tag: 11d	Frame sync sequence	See M2-Tag:11b
M2-Tag: 12	**Scrambling (for Spread spectrum systems)**	N/A
M2-Tag: 13	**Bit transmission order**	LSB first
M2-Tag: 14	**Reserved**	
M2-Tag: 15	**Polarization**	N/A
M2-Tag: 16	**Minimum tag receiver bandwidth**	See Figure 40

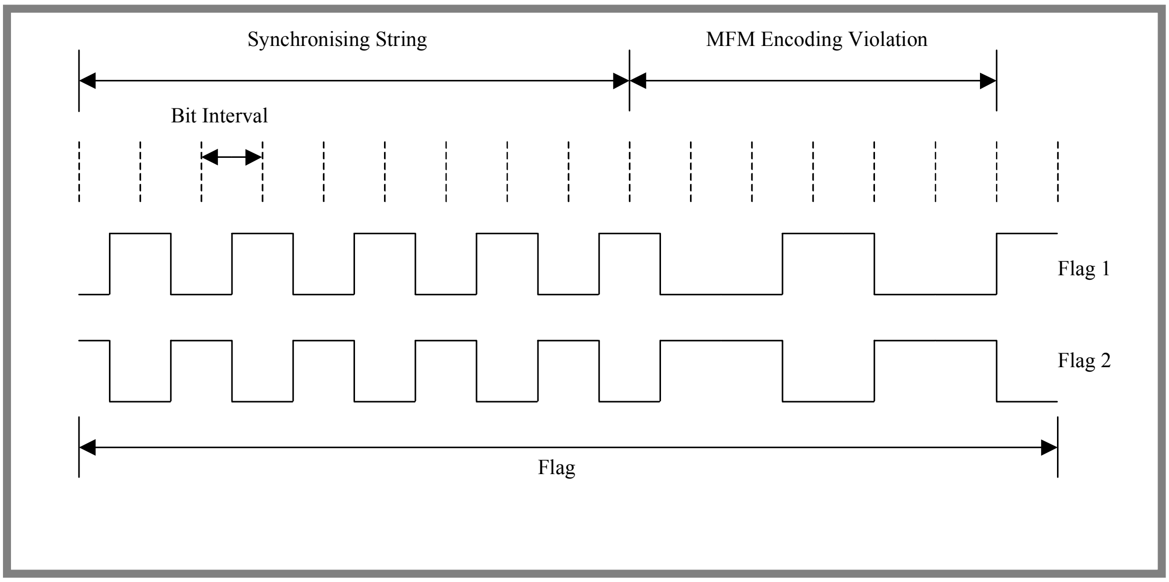


Figure 39 — Two possible reply flags

6.2.3 Description of operating method

6.2.3.1 General

This Clause defines the characteristics of the air interface between the interrogator and the tag. It details the transfer of power and the bi-directional communications between the interrogator and the tag.

Tags are passive. Power is transferred from the interrogator to the tag by a high frequency magnetic field using coupled antennae in the interrogator and the tag. The powering field frequency f_c is 13,56 MHz ± 7 kHz. The interrogator shall be capable of powering a tag at all positions inside the interrogator operating volume.

Commands are transmitted from the interrogator to the tag by Phase Jitter Modulation (PJM) of the powering field. PJM transmits data as very small phase changes in the powering field. These phase changes are between +/- 1,0 ° and +/- 2,0 ° There is no reduction in the transfer of power to the tag during PJM. The bandwidth of PJM is no wider than the original double-sided spectrum of the data. The sideband levels and data rates are decoupled. This allows the sideband levels be set at any arbitrary level without affecting the data rate. Phase Jitter Modulation is described in Annex A.

The command data rate is 423,75 kbit/s encoded using Modified Frequency Modulation (MFM).

The air interface operates as a full duplex communication link. The interrogator operates with full duplex transmissions being able to transmit PJM commands whilst simultaneously receiving multiple tag replies. Tags operate with half duplex transmissions.

Tags reply to the interrogator by inductive coupling whereby the voltage across the tag antenna coil is modulated by a subcarrier. The subcarrier is derived from division of the powering field’s frequency.

Tags can select from one of eight subcarrier frequencies between 969 kHz and 3013 kHz. The reply data rate is 105,9375 kbit/s encoded using Modified Frequency Modulation (MFM) and modulated onto the subcarrier as Binary Phase Shift Keying (BPSK).

To ensure that tags replying on different channels are simultaneously received tag replies are band limited to reduce data and subcarrier harmonic levels.

The interrogator ‘Receive to Transmit Turn Around Time’ defines two Classes. Performance dependant implementations will normally select Class 1 Receive to transmit turn around time. Low cost implementations where high speed performance is not critical may select Class 2 Receive to transmit turn around time where the needs of the application determine the Receive to transmit turn around time. Either option is compliant.

6.2.3.2 Communications signal interface interrogator to tag

Commands are transmitted from the interrogator to the tag by PJM of the powering field. The command data rate is 423,75 kbit/s and all commands are MFM encoded prior to the PJM modulator.

6.2.3.2.1 Modulation

Commands are transmitted from the interrogator to the tag by PJM of the powering field. In PJM data is transmitted as very small phase changes in the powering field. This allows the sideband levels be set at any arbitrary level without affecting the data rate.

The tags operate as intended with a minimum PJM sideband levels that comply with the appropriate FCC and ETSI regulations.

The PJM phase shift waveform of the interrogator magnetic field is described in Figure 40.

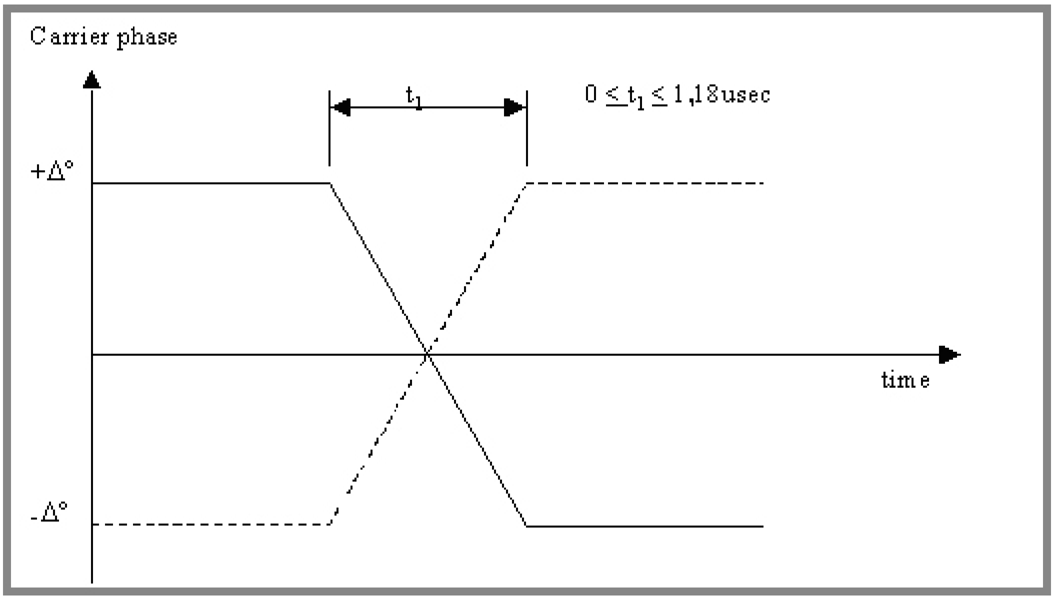


Figure 40 — Command modulation scheme

6.2.3.2.2 Data rate and data coding

The encoded command data rate is 423,75 kbit/s (f_c / 32). The period of a bit interval used for encoding command data is 2,3599 µs.

All commands are MFM encoded prior to the PJM modulator. Bits are encoded using MFM encoding rules. MFM has the lowest bandwidth occupancy of the binary encoding methods. The bit value is defined by a change in state. These encoding rules are defined as follows:

- A bit 1 is defined by a state change at the middle of a bit interval.
- A bit 0 is defined by a state change at the beginning of a bit interval.
- Where a bit 0 immediately follows a bit 1 there is no state change.

An example of command MFM encoding of the binary string 000100 is shown in Figure 41.

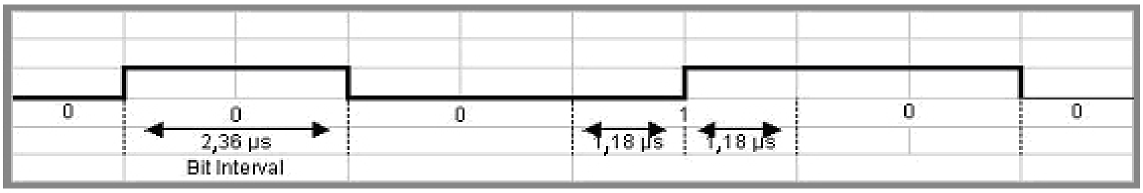


Figure 41 — Command MFM encoding and timing of binary 000100

6.2.3.2.3 Interrogator to tag frames

The command flag defines the start of a command and the bit interval timings. The flag comprises three parts:

- A synchronising string of 9 bits of valid MFM data.
- A MFM encoding violation not present in normal data. The violation consists of a sequence of 4 state changes separated by a 2 bit interval, a 1,5 bit interval and 2 bit interval. The edge of the fourth transition defines the beginning of a bit interval.
- A trailing 0 defining the end of a flag.

The synchronising string, encoding violation and a trailing zero for two possible command flags are illustrated in Figure 42.

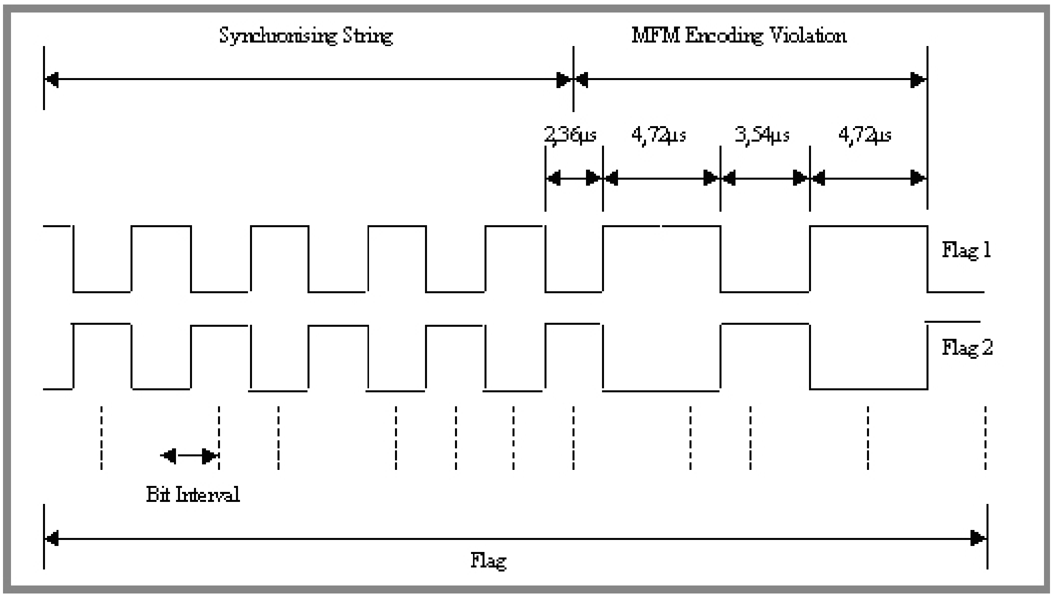


Figure 42 — MFM Encoding and timing for two possible command flags

6.2.3.3 Communications signal interface tag to interrogator

Replies are MFM encoded prior to the BPSK modulator. Tags reply using one of eight selectable modulated subcarriers.

6.2.3.3.1 Subcarriers

The tag may use one of eight subcarriers. The subcarriers are derived by division of the powering field's frequency. The channel frequencies and division ratios are tabulated in Table 10.

Table 10 — Channel frequencies and division ratios

Channel	Frequency kHz	Division Ratio
A	969	14
B	1233	11
C	1507	9
D	1808	7,5
E	2086	6,5
F	2465	5,5
G	2712	5
H	3013	4.5

6.2.3.3.2 Modulation

The tag replies to the interrogator by inductive coupling whereby the voltage across the tag antenna coil is modulated by a subcarrier. Modulation is based on impedance modulation. Encoded data is modulated on to the subcarrier as BPSK modulation.

Systems shall respect local regulations. In order to ensure that tags replying on different channels are simultaneously received, all tag replies shall be band limited to reduce data and subcarrier harmonic levels.

NOTE: For example, the tag reply spectrum for 105,9375 kbit/s MFM encoded all zeros data stream, may be defined to be within the tag reply mask provided in Figure 43 below. Such mask limitation would be appropriate for ITU region 1, 2 and meets Japanese regulations.

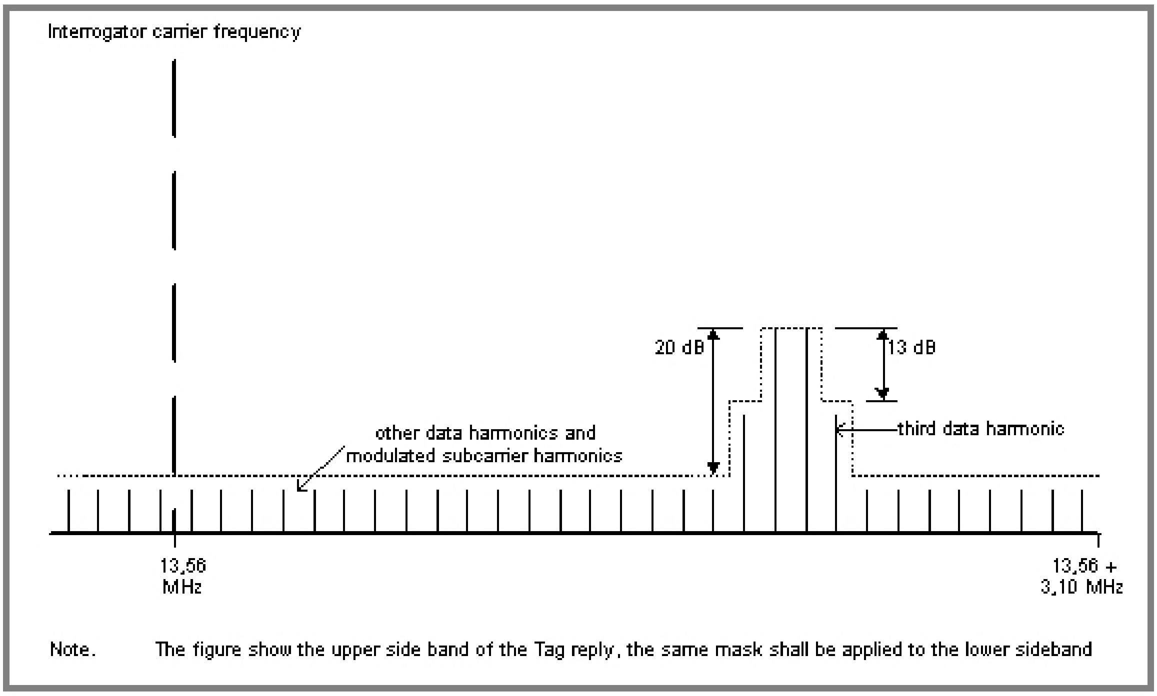


Figure 43 — Tag reply mask

6.2.3.3.3 Data rate and data encoding

The encoded reply data rate is 105,9375 kbit/s (fc / 128). The period of a bit interval used for encoding command data is 9,4395 µs. The modulation used is BPSK.

Tags reply using one of eight selectable modulated subcarriers. The subcarriers are derived by division of the powering field's frequency. Replies are encoded using MFM and modulated onto the subcarrier as Binary Phase Shift Keying (BPSK).

MFM encoding rules are shown in Clause 6.2.3.2.2. An example of reply MFM encoding of the binary string 000100 is shown in Figure 44.

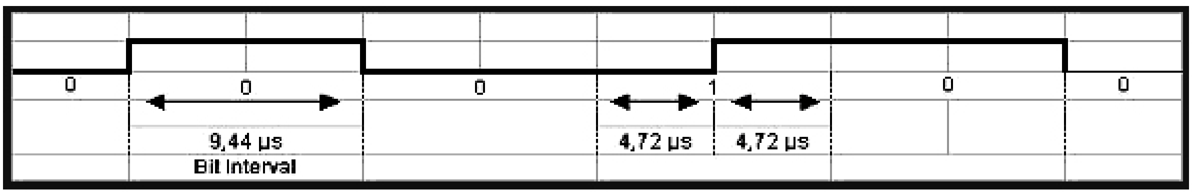


Figure 44 — Reply MFM encoding and timing of binary 000100

6.2.3.3.4 Tag to interrogator frames

The reply flag defines the start of a reply and the bit interval timings. The reply flag comprises three parts:

- A synchronising string of 9 bits of valid MFM data.
- A MFM encoding violation not present in normal data. The violation consists of a sequence of 4 state changes separated by a 2 bit interval, a 1,5 bit interval and 2 bit interval. The edge of the fourth transition defines the beginning of a bit interval.
- A trailing 0.

A synchronising string, encoding violation and a trailing zero for two possible reply flags are illustrated in Figure 45.

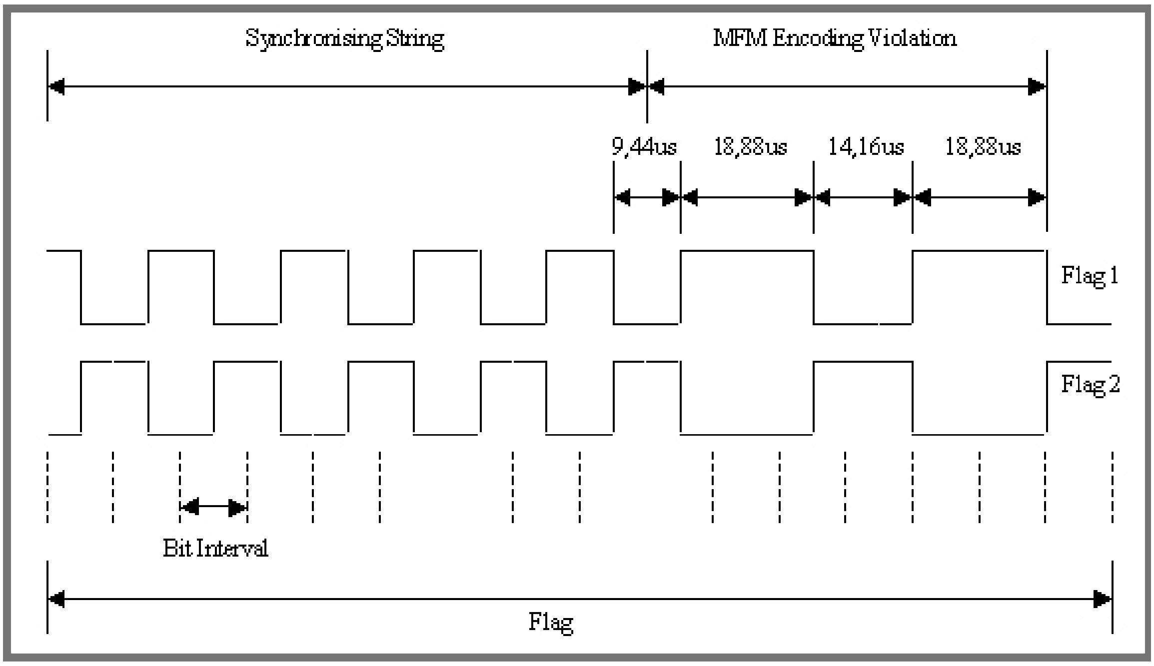


Figure 45 — MFM Encoding and timing for two possible reply flags

6.2.4 Protocol parameters

Table 11 — Protocol parameters

Ref.	Parameter Name	Description
M2-P: 1	Who talks first	Interrogator Talks First (RTF) System. Tag cannot respond unless it receives valid command from interrogator.
M2-P: 2	Tag addressing capability	Yes, tags can be addressed individually or as groups.
M2-P: 3	Tag UID	
M2-P: 3a	UID length	64 bits (32 bit specific identifier, 16 bit application group identifier and 16 bit manufacturing identifier).
M2-P: 3b	UID format	See clauses 6.2.5.6 to 6.2.5.9
M2-P: 4	Read size	Two bytes (16 bits) to maximum memory size.
M2-P: 5	Write size	Minimum and Maximum Write size is dependent upon memory technology, according to instruction defined in Clause 6.2.5.14.
M2-P: 6	Read transaction time	1,282ms + 150 μs per 16 bits (2 bytes).
M2-P: 7	Write transaction time	1,282ms + 75,5 μs per 16 bits (2 bytes), not including memory erase and write time.
M2-P: 8	Error detection	16 bit CRC interrogator to tag, 32 bit tag to interrogator.
M2-P: 9	Error correction	None.
M2-P: 10	Memory size	Product Dependant. No technical limitation.
M2-P: 11	Command structure and extensibility	Command field is 16 bits long, extendable without limit in 16 bit blocks. 8 command types, each with 16 extension types presently available.

6.2.5 Description of protocol operating method

6.2.5.1 Overview

Tags are passive, power is transferred from the interrogator to the tag by a High Frequency (HF) magnetic field using coupled antennas in the interrogator and the tag.

Dialogue between the interrogator and the tag is conducted on a Reader-Talks-First (RTF) basis. Following activation of the tag by a powering field the tag waits silently for a valid command. After receiving a valid command the tag transmits a reply to the command.

Phase Jitter Modulation (PJM) is used (described in 6.2.3 above).

The tag memory is expandable beyond 1 Megabit so that the system is inherently upgradeable, subject to product definition/design.

Multiple tag identification is performed using a combination of Frequency and Time Division Multiple Access (FTDMA). There are eight reply channels available for tags to use. In response to a valid command each tag randomly selects a channel on which to transmit its reply. The reply is transmitted once using the selected channel. Upon receiving the next valid command each tag randomly selects a new channel and transmits the reply using the new selected channel. This method of reply frequency hopping using random channel selection is repeated for each subsequent valid command. In addition to random channel selection the tag can randomly mute individual replies. When a reply is muted the tag will not transmit that reply. Random muting is necessary when identifying very large populations of tags. All FTDMA frequency and time parameters are defined by the command.

All commands are time stamped and tags store the first time stamp received after entering a interrogator. The stored time stamp defines precisely when the tag first entered the interrogator and provides a high resolution method of determining tag order which is decoupled from the speed of identification.

Tag temporary settings shall be stored in tag memory (for example using a technique such as Temporary Random Access Memory TRAM) that retains data contents during power outages caused by switching of the powering field in orientation insensitive interrogators.

6.2.5.2 Definition of data elements

Read data is the data read from chip memory by a valid command.

Write data is the data written to chip memory by a valid command.

Stored data is the data stored in chip memory.

Hardcode data is the data in virtual chip ROM.

6.2.5.3 RF tag memory organization

This part of ISO/IEC 18000 describes the tag memory in virtual terms only and does not intend to restrict the physical implementation of any tag's memory.

The tag memory is split into the three areas shown in Table 12.

Table 12 — Tag memory areas

Memory Area	Comment
Manufacturing system memory area	contains all fields that are set and locked during chip/tag manufacture and manufacturing test
user system memory area	set and locked as required by the user
user memory area	set and locked as required by the user

Tags with 4 kbit or less of virtual memory will use 8 bit address and 8 bit length fields. Tags with greater than 4 kbit of virtual memory shall allow for both 8 and 16 bit address and length fields.

The tag memory includes tag identifiers, configuration and user defined fields. The virtual memory map, see Table 13, includes the defined fields. The bit order of any defined fields is such that the least significant field bit is stored at the lower virtual memory bit address.

The virtual memory is organised and addressed as 16 bit words. MODE 2 makes provision for tag types with varying memory block sizes, where a block is one or more 16 bit words. Read commands read zero or more words. Write commands write whole words, where the number of words that can be written is determined by the memory construction.

The virtual memory block size for words 0 to 9 shall be equal to the rest of the memory for up to a maximum of 2 words.

Memory may be locked. Once locked memory cannot be overwritten.

6.2.5.4 Virtual tag memory

Table 13 shows the virtual memory layout of the tag.

Table 13 — Virtual memory map

word no.	memory type	Comment	register	bit number 15 14 13 12 11 10 9 8 7 6 5 4 3 2 1 0
0	manufacturing system memory	defined fields	RFM	reserved for manufacturer
1			MC	manufacturing code
2			SID0	specific identifier 0
3			SID1	specific identifier 1
4	user system memory	defined fields	GID	application group identifier
5			CID	conditional identifier
6			CW	configuration word
7	user memory	undefined if password is not required	PW0	password 0
8			PW1	password 1
9			PW2	password 2
10 and above		undefined fields		

Specific identifier 0 and password 0 are the least significant words of these multi word fields.

6.2.5.5 Lock pointer

The lock pointer is a 16 bit virtual field, used to prevent tag memory from being over written. The field points to a word in memory. All complete blocks of memory at addresses less than the number stored in the lock pointer cannot be over written. Interrogator commands cannot decrement the lock pointer.

The lock pointer is located at an unaddressable virtual memory location.

6.2.5.6 Unique identification (UID)

The unique identification for MODE 2 may be set permanently at manufacturing.

It shall comprise a logical 64 bit block, consistent with ISO/IEC 15963.

The physical implementation on the tag is left to the manufacturer.

The 64 logical bits are organized into three parts. See Figure 46.

	MODE 2 TAG UID MASK	
MASK 1	***MASK 2***	***Mask 3***
Manufacturing code	**Application Group Identifier**	**Specific Identifer**
16 Bits	16 Bits	32 Bits
	Afi/Asf Not Determined	Serially issued binary value

Figure 46 — Logical organization of UID

6.2.5.7 Manufacturing code

The manufacturing code is a mask of 16 bits.

The physical operation of the system requires only that this mask is populated with a binary value.

However, in order to uniquely identify manufacturers, registration shall be in accordance with ISO/IEC 15963.

Transmission from the tag for this Mode shall be LSB first, and the data available shall conform to the disposition in Table 14.

Example implementation according to ISO/IEC 15963.

The manufacturing code is a 16 bit field set at manufacturing test. The encoding for the manufacturing code is shown in Table 14

Table 14 — Manufacturing code field

MSB	LSB
16 9	8 1
'E0'	manufacturer code according to ISO 7816-6

6.2.5.8 Application group identifier (Afi/Asf)

The second mask is of 16 bits.

The physical operation of the system requires only that this mask is populated with a binary value.

The purpose of this mask is to identify applications or families of tags.

It is recommended that the first octet of this mask is used for an Afi/Asf group identification as defined in ISO/IEC 15962.

The first 4 logical bits shall be used for the Afi (Application Family Identifier), and the second 4 bits shall be used for the Asf (Application Sub Family) in accordance with ISO/IEC 15962.

The second octet of this mask is not specified and provides opportunity to provide further sub classification to enable population groups to be segregated.

6.2.5.9 Specific identifier

The third mask is of 32 bits.

It shall be allocated at manufacture, and shall provide a unique binary value which shall be sequentially issued by the manufacturer and shall not be reused by that manufacturer. It shall provide a unique tag ID for that manufacturer.

The combination of this Specific Identifier value, Application Group Identifier and the Manufacturing code, shall provide a permanent and unambiguous unique tag identification.

This identifier allows a tag to be specifically identified and specifically communicated to. The manufacturing test software shall ensure that the specific identifier is incremented once each time a tag is loaded with this identifier.

6.2.5.10 Conditional identifier

In addition to the tag UID the tag memory shall carry an additional mask, known as the Conditional Identifier (CID). The mask shall be 2 octets (16 bits).

The physical operation of the system requires only that this mask is populated with a binary value.

The CID may be provided at manufacture (as for example a date of manufacture) or may be provided later.

This part of ISO/IEC 18000 is not prescriptive as to whether the CID is programmed at manufacture or later, but manufacturers shall decide which of these options and shall use the CID consistently thereafter.

Example: The CID may provide a date-code to enable conditional access/disbarment according to the datal condition, thus, for example tags manufactured before the CID, or after the CID could be eliminated or selected.

6.2.5.11 Configuration word

The configuration word is a 16 bit field set by the user. The tag configuration is usually set to suit the application. The encoding for the configuration word is shown in Table 15.

Table 15 — Configuration word field

Configuration Word Field			
Bit number	Field	State	Description
Bit 0 to 14	RFU		shall be set to ‘0’
Bit 15	Password	0	password not required
		1	password required

6.2.5.12 Password

The password field is a 48 bit identifier set by the user. It is used to provide a level of security for memory access. If the tag is configured to ‘password not required’ the password memory space is free for user memory. If the tag is configured to ‘password required’ the password cannot be read.

6.2.5.13 User memory

The user sets the user memory.

6.2.5.14 Hardcode

Hardcode is formatted as 16 bit words and is included in some tag types. This part of ISO/IEC 18000 describes the hardcode in virtual terms only and does not intend to restrict the physical implementation of hardcode. The hardcode defines the tag parameters, including memory size and memory block size.

In a normal reply all hardcode words are transmitted first, followed by the time stamp and then the rest of the reply. The MSB of all hardcode words shall be set to ‘1’. The encoding for the hardcode is shown in Table 16.

Table 16 — Hardcode field

Bit number	**Field**	**State**	**Description**
Bit 0 to 6	parameter/ function	00h	memory size in 4 word units (LSB)
		01h	memory size in 4 word units (MSB)
		02h	memory block size in words
		03h	memory sub-block size in words
		04h	memory erase + write time in 100 μs units
		05h to 7Fh	RFU
Bit 7 to 14	code/value	00h to FFh	hexvalue or code associated with parameter or function
Bit 15	MSB		shall be set to ‘1’

For example a tag with:

- 8192 bits of memory (512 words, 128 * 4 word units)
- 4 word memory block size
- 1 word memory sub-block size
- 4 ms memory erase + write time (40 * 100 μs units)

would have the following hardcode:

- memory size C000h
- block size 8202h
- sub-block size 8083h
- erase + write time 9404h

In the above example:

- The memory size MSB is not used, as all the value bits are '0'.
- A sub-block size of 1 word and a block size of 4 words indicates that 1, 2, 3, and 4 memory word writes are allowed where all writes shall be within a block, (no writes across block boundaries).

Note. If in the above example no sub-block size is specified then only 4 word memory writes are allowed where all write shall be within a block.

The block size origin is word 0.

Memory can be locked at sub-block intervals, if the sub-block interval is not given then the memory can only be locked at block intervals.

6.2.5.14.1 Default tag parameters

If a hardcode is not included in the normal reply the default tag parameters are:

block size in words	2
memory erase + write time in ms	10
memory size in words	64

6.2.5.15 Block security status

Refer to Clauses 6.2.5.5 Lock Pointer and 6.2.5.12 Password.

6.2.5.16 Description of operating methodology

Tag and interrogator communications is based on the Reader-Talks-First system. The tag will only respond to a command if the command received is valid. Commands are generally used to identify tags and to read, write and lock memory. Commands also determine the reply type (short or normal) and the reply mode (fixed channel or random channel etc.). A short reply is used to speed up communications, whereas a normal reply includes all hardcode and system memory.

All tags, irrespective of their types can be identified using a universal group command. The universal group command can set the tags to transmit a normal reply. The hardcode and system memory included in a normal reply provides sufficient information so that a user can send other valid commands to the tags.

The various reply modes are selected to suit the interrogator types (single or multi channel) and to speed up communication depending upon tag population within the interrogator operating volume.

6.2.5.16.1 Methods

See Clause 6.2.5.1 and 6.2.5.2

6.2.5.16.2 Command format

The format of command fields is shown in Table 17. All fields are transmitted least significant bit first. For multi word fields the least significant bit of the least significant word defines the least significant bit of the field. All commands are Mandatory as classified in Clause 2 above.

Table 17 — Command fields

Code	Field	Bits	Comment
F	flag	16	MFM violation sequence
Cd	command	16	command field
Cn	command number	16	command number field
SS	specific identifier	32	identifier field
G	application group identifier	16	identifier field
Ci	conditional identifier	16	identifier field
PPP	password	48	identifier field
R	read address and length	16	8 bit address and 8 bit length fields for memory read
W	write address and length	16	8 bit address and 8 bit length fields for memory write
Ra	read address	16	16 bit address field for memory read
Rl	read length	16	16 bit length field for memory read
Wa	write address	16	16 bit address field for memory write
Wl	write length	16	16 bit length field for memory write
D	write data	16	data to be written
C	CRC	16	validation CRC

Table 18 shows the format for valid commands where:

The password field shall only be provided if required by the tag.

The read/write commands shown include a single word write.

Table 18 — Valid command format

Command type	Start fields	Identifier fields	Address and length fields	Data	CRC
group read	F [Cd] Cn	G Ci	[R] or [Ra Rl]		C
Specific read	F [Cd] Cn	SS	[R] or [Ra Rl]		C
group read/write	F [Cd]Cn	G Ci |PPP|	[R W] or [Ra Rl Wa Wl]	D	C
specific read/write	F [Cd]Cn	SS |PPP|	[R W] or [Ra Rl Wa Wl]	D	C

The minimum length command is 7 words (112 bits).

For a zero length write no data will be provided. For a multi-word length writes each word to be written is followed by a CRC. The command format for a two word write is shown in Table 19.

Table 19 — Valid multi-word read/write command format

Command Type	Start Fields	Identifier Fields	Address and Length Fields	Data	CRC	Data	CRC
group read/write	F [Cd] Cn	G Ci |PPP|	[R W] or [Ra Rl Wa Wl]	D	C	D	C
specific read/write	F [Cd] Cn	SS |PPP|	[R W] or [Ra Rl Wa Wl]	D	C	D	C

For all write commands if the start, identifier or address and length fields are invalid no data will be written to tag memory.

If any CRC is invalid the tag will not reply.

6.2.5.16.3 Command fields

6.2.5.16.3.1 Flag field

The flag field contains a MFM violation that is not present during normal data. The field indicates the beginning of a command.

6.2.5.16.3.2 Command field

The encoding of the command field is shown in Table 20.

Table 20 — Command field bit encoding

Command fields			
Bit number	Field	State	Description
bit 0	command type	0	read command
		1	read/write command
bit 1	identifier type	0	specific command
		1	application group conditional (group) command
bit 2	reply type	0	short reply
		1	normal reply
bit 3	fixed/random	0	fixed channel reply
		1	random channel reply
bits 4 to 6	channel/mute ratio	000	[fixed channel A] or [random channel unmuted]
		001	[fixed channel B] or [random channel ½ muted]
		010	[fixed channel C] or [random channel ¾ muted]
		011	[fixed channel D] or [random channel $^{7}/_{8}$ muted]
		100	[fixed channel E] or [random channel $^{31}/_{32}$ muted]
		101	[fixed channel F] or [random channel $^{127}/_{128}$ muted]
		110	[fixed channel G] or [random channel $^{511}/_{512}$ muted]
		111	[fixed channel H] or [random channel fully muted]
bit 7	address and length	0	8 bit address and 8 bit length fields
		1	16 bit address and 16 bit length fields
bits 8 to 14	RFU		shall be set to '0'
bit 15	command extension	0	indicates to the tag that this word is the last command field
		1	indicates to the tag that the following word is a command field extension

For a command to be valid the command field shall be set equal to one of the combinations shown in Table 20. In addition the address and length field (bit 7) shall be set to '0' for tags with 4 kbit or less of virtual memory.

The following describes the fields within the command field.

6.2.5.16.3.3 Command type

The command type field determines if the command is a read or a read/write.

A read command is used to read tag memory. For fast tag identification the read length field can be set to zero.

A read/write command is used to read and write to tag memory. For write only operation the read length is set to zero. To lock tag memory the write length is set to zero and the write address is set to the lowest unlocked memory address.

6.2.5.16.3.4 Identifier type

The identifier type field determines if the command is a specific or an application group conditional command.

Specific commands are used to identify and communicate to individual tags.

Application group conditional (group) commands are used to identify and communicate to a group of tags that meet a conditional test or all groups of tags that meet a conditional test.

6.2.5.16.3.5 Reply type

The reply type field determines if the tag reply is short or normal.

A short reply is used to minimise communication time.

A normal reply is used to when the interrogator requires the hardcode and system memory data to be included in a reply.

6.2.5.16.3.6 Fixed/random

The fixed/random field determines if the tag reply is on a fixed selected channel or a random selected channel.

6.2.5.16.3.7 Channel/mute period

The channel/mute period field determines either the channel selected or the mute period selected.

This field is linked to the fixed/random field described above. If fixed channel is selected then the channel/mute ratio field determines the actual channel to be used in the reply. If random channel is selected then the channel/mute ratio field determines the mute period.

For valid random channel commands:

- If unmuted is selected the tag will transmit replies repetitively on randomly selected channels.

- If ½ to $^{511}/_{512}$ muted is selected the tag will randomly choose to transmit (unmuted) or not transmit (muted) individual replies. The muted ratio supplied in the command (½ muted, ¾ muted etc.) determines the probability of the reply being muted.

- If fully muted is selected the tag will not reply and the tag will be set to the temporary mute state. While the tag is in the temporary mute it will only respond to interrogator command with a new interrogator identifier, see Clause 6.2.5.16.3.9.

6.2.5.16.3.8 Address and length

The address and length field defines whether a command includes 8 bit address and 8 bit length fields

or 16 bit address and 16 bit length fields.

6.2.5.16.3.9 Command number

The command number is used to set a local time stamp and identify interrogators.

The encoding for the command number is shown in Table 21.

Table 21 — Command number fields

Bit number	Field	State	Description
Bit 0 to 7	local time stamp		set as required by the interrogator
bits 8 to 14	Interrogator identifier		set as required by the interrogator
Bit 15	MSB		shall be set to '0'

When a tag enters a new interrogator the tag will store the command number from the first valid command received. The tag shall store this number during brief powered down periods. All tag replies include this stored number, which is called the time stamp. The least significant byte of the command number is periodically incremented by the interrogator and used in subsequent commands. The tag does not update the time stamp. The time stamp therefore indicates when a tag first received a valid command.

A tag determines that it has entered a new interrogator when the most significant byte of the command number (included in all valid commands) and the time stamp are different, or if the tag detects that it has been powered down for longer than a defined period.

In a multi tag scenario if two or more tags reply at the same time on the same channel no reply will be received. If the population is large it is possible that a tag may have to transmit a few times before it selects a unique channel and is therefore received. There is also a chance that the tag will select a unique channel for its first transmission. Thus the order in which tags are received cannot be used to determine the order in which they entered the interrogator. However the time stamp included in the reply will give the correct tag order.

6.2.5.16.3.10 Tag identifiers

6.2.5.16.3.11 Specific identifier field

The specific identifier is used to communicate to an individual tag. For a command to be valid the specific identifier in the command shall be set equal to the specific identifier stored in tag to be communicated to.

6.2.5.16.3.12 Application group identifier field

The application group identifier is used to communicate with tags from the same application group or from all application groups. For a command to be valid the application group identifier in the command shall be set equal to either FFFFh or to the application group identifier stored in the tags to be communicated to.

If the command identifier is set FFFFh and the rest of the command is valid then all application groups will be communicated to.

6.2.5.16.3.13 Conditional identifier field

The conditional identifier is used to communicate to tags that meet a conditional test. For a command to be valid the conditional identifier in the command shall be less than or equal to the conditional identifier stored in the tag.

6.2.5.16.3.14 Password field

The password is used to restrict writes to tag memory. For a command to be valid the password shall only be provided if the tag is configured to password required, and then only for read/write commands. For a read/write command to a password protected tag to be valid the password in the command shall be set equal to the password stored in the tag.

6.2.5.16.3.15 Address and length fields

The command field determines if the command includes 8 bit address and 8 bit length fields or 16 bit address and 16 bit length fields.

The address and length fields define the start address and length in words for memory reads and writes. For a command to be valid, the address and length field shall only select from valid memory addresses. Valid memory addresses are as follows:

— Word 0 to the maximum user memory word available for a memory read of tags configured to password not required.

— Word 10 to the maximum user memory word available for a memory read of tags configured to password required.

The address stored in the lock pointer to the maximum user memory word available for a memory write.

The address stored in the lock pointer and above when locking tag memory.

- To lock tag memory the write length is set to zero and the write address is set to the lowest unlocked memory address, if the command is valid the tag will set the lock pointer equal to the write address.

- In addition, for a command to be valid the address and length fields shall be set as required by different tag types to allow for any block addressing restrictions.

6.2.5.16.3.16 8 bit address and 8 bit length fields

Where the command field selects 8 bit address and 8 bit length fields the address and length field shall be encoded as shown in Table 22 and Table 23.

Table 22 — 8 bit address and 8 bit length fields memory reads

Bit number	Field	State	Description
Bits 0 to 7	8 bit address field		set as required by the user
Bits 7 to 15	8 bit length field		set as required by the user

Table 23 — 8 bit address and 8 bit length fields for memory writes

Bit number	Field	State	Description
Bits 0 to 7	8 bit address field		set as required by the user
Bits 7 to 15	8 bit length field		set as required by the user

6.2.5.16.3.17 16 Bit address and 16 bit length fields

Where the command field selects 16 bit address and 16 bit length fields the address and length field shall be 16 bits each.

6.2.5.17 Write data

The write data is the data to be written to the tag.

6.2.5.18 CRC

All command CRCs are calculated from the end of the flag field.

The 16 bit command CRC algorithm used is the IBM “Synchronous Data-Link Control” (SDLC) polynomial, standardised by CCITT for use in the X.25 packet-switching protocol, and is implemented in most serial communications tags and is embodied in ISO/IEC 13239. The CRC shall be calculated as per the definition in ISO/IEC 13239.

The algorithm used is as follows:

$$g(X) = X^{16} + X^{12} + X^{5} + 1$$

The generation algorithm departs slightly from the basic CRC16 technique, in that the generator is pre-loaded with ‘1’ bits rather than ‘0’ bits. Additionally the check-bits are inverted before transmission. Consequently, a valid message is not recognised by a remainder of zero (as is the case with CRC16), but by a specific constant.

The resulting code vector from the CRC verification is:

$$[00011101\ 00001111]\{X^{15}:X^{00}\}$$

An example interrogator command and CRC is given below.

flag field	
command field	0000
command number	1234
specific identifier 0	1234
specific identifier 1	5678
read address and length	1001
CRC	8C16

The method and an example of this 16 bit CRC is given in Annex E.

6.2.5.19 Reply format

Reply fields are shown in Table 24. All fields are transmitted least significant bit first. For multi byte fields the least significant bit of the least significant byte defines the least significant bit of the field.

Table 24 — Reply fields

Code	Field	Bits	Comment
F	flag	16	MFM violation sequence
H	hardcode	16	hardcode field
T	time stamp	16	identifier field
L	lock pointer	16	identifier field
M	manufacturing code	16	identifier field
SS	specific identifier	32	identifier field
G	application group identifier	16	identifier field
Ci	conditional identifier	16	identifier field
Co	configuration word	16	identifier field
D	read data	16	read data
CC	CRC	32	validation CRC

Table 25 shows the format for valid replies.

Table 25 — Valid reply format

Reply Type	Start Fields	System Memory Fields	Data	CRC
Normal	F [H] T	L M SS G Ci Co	[D]	CC
Short	F T	SS	[D]	CC

The minimum length reply is 96 bits.

The reply type is determined by the interrogator command.

6.2.5.20 Reply fields

6.2.5.20.1 Flag field

The flag field contains a MFM violation that is not present during normal data. The field indicates the beginning of a reply.

6.2.5.20.2 Hardcode fields identifier fields

If the tag design includes hardcode then all hardcode data is sent in normal replies. The MSB of the hardcode is set to ‘1’ and the MSB of the following timestamp is set to ‘0’. The interrogator can detect the end of hardcode data by examining the MSB of received words.

6.2.5.20.3 Time stamp field

The time stamp is used to provide superior tag order identification. The time stamp is set equal to the command number included in the first valid command received after the tag entered a new interrogator.

6.2.5.20.4 System memory fields

The reply system memory fields are as per the system memory stored in tag virtual memory.

6.2.5.21 Read data

The read data is the data requested by a valid command.

6.2.5.22 CRC field

The reply CRC is calculated from the end of the start flag field.

The reply CRC is the 32 bit Ethernet CRC. Its properties are similar to the 16 bit IBM CRC used in the command path, in that the register is loaded with ones, the output word is inverted and the final computation results in a specific constant rather than zero.

The algorithm used is as follows:

$$g(X) = X^{32} + X^{26} + X^{23} + X^{22} + X^{16} + X^{12} + X^{11} + X^{10} + X^{8} + X^{7} + X^{5} + X^{4} + X^{2} + X^{1} + 1$$

The resulting code vector from the CRC verification is:

$$[11000111\ 00000100\ 11011101\ 01111011]\{X^{31}:X^{00}\}$$

An example tag reply and CRC is given below.

flag field	
time stamp	1234
specific identifier 0	1234
specific identifier 1	5678
read data	ABCD
CRC	E8C5 8742

The method and an example of this 32 bit CRC is given in Annex F.

6.2.5.23 RF tag states

6.2.5.23.1 State diagram

A tag can be in one of four following states:

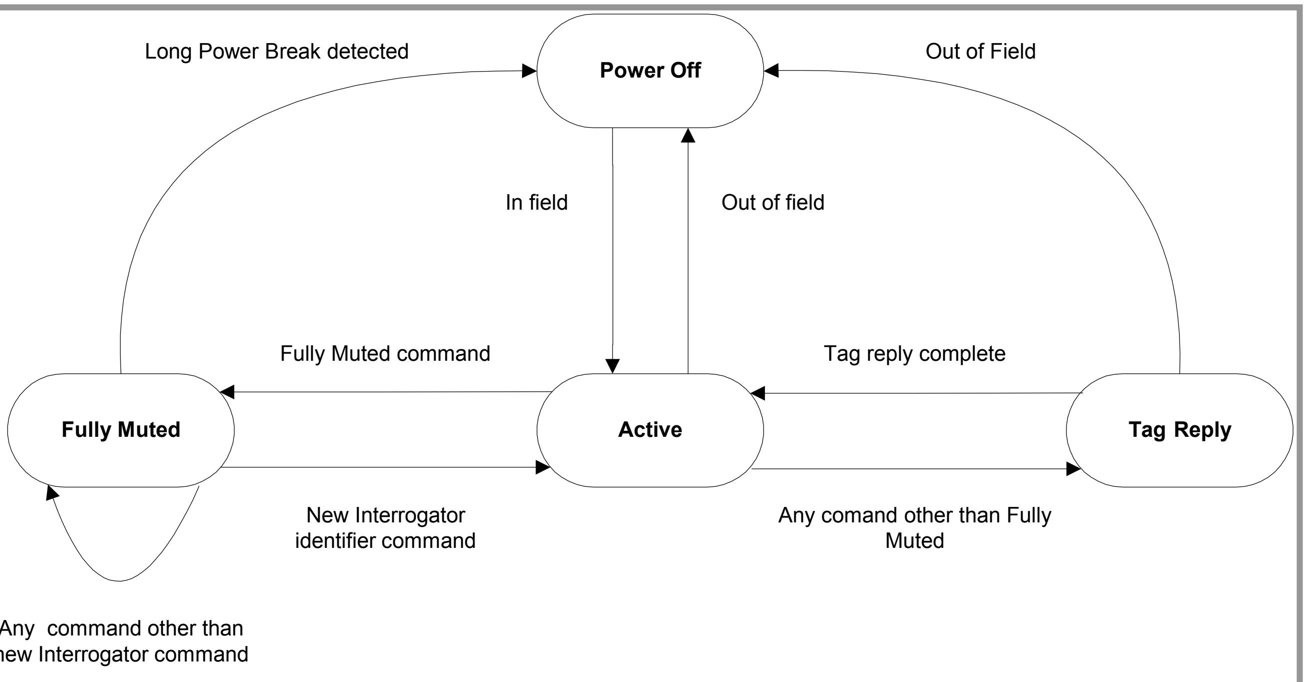
- Power Off
  The tag is in the Power Off state when it cannot be activated by the interrogator. Power off is also achieved as a result of an LPB detection.

- Active
  The tag is in the active state when it is activated by the interrogator. In this state it shall process any interrogator command.

- Tag Reply
  The tag is in the tag Reply state when it has received a valid command. If the tag remains powered then it will stay in this state until it has complete the reply, after which it will return to the active state.

- Fully Muted
  The tag is in the fully muted state when it has received a valid fully muted command. If the tag remains powered then it will stay in this state until it receives a valid new interrogator command.

The transition between these states is specified in Figure 47.



Note For invalid commands the Tag will remain in its current state

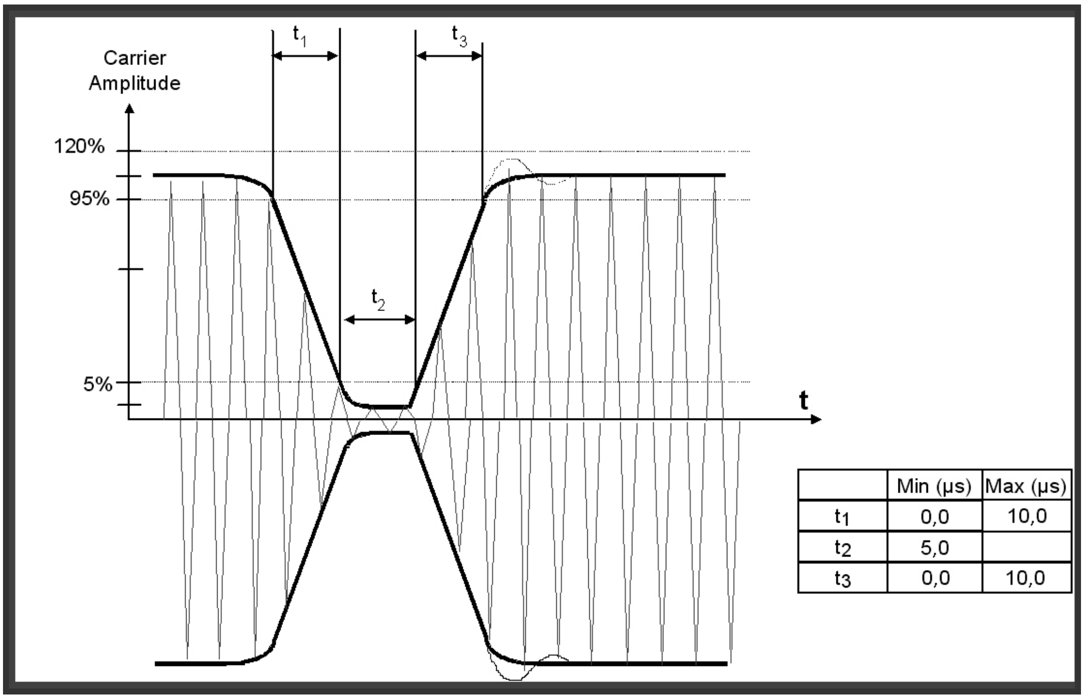
Figure 47 — Tag state transition diagram

6.2.5.23.2 Short power breaks

The tag shall detect a 5 µs or greater break in the interrogator carrier. If the tag detects a power break it initialises and then waits for a valid command.

The tag includes a long power break detector. Any break in power too short to be detected by the long power break detector, which is greater than 5 µs is considered a short power break.

Figure 48 describes interrogator carrier breaks.



	Min (µs)	Max (µs)
t_1	0,0	10,0
t_2	5,0	
t_3	0,0	10,0

Figure 48 — Interrogator powering field breaks

6.2.5.23.3 Long power breaks

The Long Power Break (LPB) detector does not detect a power break less than 50 ms. If an LPB occurs the tag exits the fully muted state. (This function may be realised, for example, using a technique such as TRAM).

6.2.5.23.4 TRAM

This part of ISO/IEC 18000 requires temporary storage of data. A technique called TRAM is referred to in several clauses as a means of achieving this requirement. Other techniques that achieve the same function may be used. This clause describes TRAM and its functionality for those who choose to use this technique. TRAM, as referred to in this Mode, is volatile memory, such as SRAM or DRAM, which has been designed to maximise the storage time after power has been removed from the memory. If power is applied before the TRAM has discharged the memory will be automatically refreshed.

TRAM provides instant write times and short term memory storage. Fast write times are required for setting the fully mute state and writing the time stamp and other temporary settings. Temporary settings shall be stored for a time period longer than the LPB detector time.

NOTE: The following describes how TRAM may be used for the LPB detector.

When the tag is powered the LPB detector is set to ‘1’ and stored in TRAM. When the tag is powered down this TRAM bit discharges. If an LPB occurs the TRAM bit will clear to ‘0’.

At power up the tag inspects the state of the LPB detector, if a long power break has occurred the tag will clear all TRAM.

6.2.5.23.5 Fully muted state

When tagged items are moving on a conveyor the position and orientation of the attached tags are uncontrolled. In order for the conveyor interrogator to power and communicate with tags independent of tag position and orientation it shall generate a interrogator field that is switched cyclically between the X, Y and Z direction orthogonal axes. A consequence of cycling the field is that tags periodically lose power. During these power outages any information held in volatile memory in the tag shall not be lost.

Special regard shall been given to management of power outages arising from the operation of orientation insensitive interrogators. For example where multiple tags are being identified there is a requirement for identified tags to be temporarily muted or silenced so as not to interfere with the identification of any remaining tags.

A technique, such as Temporary Random Access Memory (TRAM), shall be used to retain the temporary mute state during these power outages.

6.2.6 Collision management parameters

Table 26 — Table of collision management parameters

Ref.	Parameter Name	Description
M2-A: 1	Type (probabilistic or deterministic)	Probabilistic.
M2-A: 2	Linearity	Linear for populations less than 10 000 tags, polynomial for populations larger than 10 000 tags.
M2-A: 3	Tag inventory capacity	Greater than 32 000 per application group/conditional identifier.
M2-A: 4	Multiple tag identification rate	100 tags per 150 ms

6.2.7 Description of collision management parameters operating method (informative)

6.2.7.1 General description

In this Mode multiple tag identification is performed using a combination of Frequency and Time Division Multiple Access (FTDMA).

There are eight reply channels available for tags to use. In response to a valid command each tag randomly selects a channel on which to transmit its reply. The reply is transmitted once using the selected channel. Upon receiving the next valid command each tag randomly selects a new channel and transmits the reply using the new selected channel. This method of reply frequency hopping using random channel selection is repeated for each subsequent valid command.

In addition to random channel selection the tag can randomly mute individual replies. When a reply is muted the tag will not transmit that reply. Random muting is necessary when identifying very large populations of tags. Once a tag has been identified it is temporarily muted by command and will then only respond as described in 6.2.5.16.3.7.

All FTDMA frequency and time parameters are defined by command. FTDMA provides superior performance over single frequency TDMA solutions, because multiple tag replies can be simultaneously received on different channels.

In addition to the multiple tags that can be expected in an interrogator there may also be a large population of old or expired tags. For an application that uses disposable tags the population of old and expired tags can be much greater that the population of current tags. A high speed identification RFID system shall be able to identify current tags whilst excluding or ignoring old and expired tags.

In this system tags include a conditional identifier. Each tag's conditional identifier field is programmed when issued. The field can be programmed with a date-time stamp, which will be tested against a conditional identifier transmitted in each command. Tags will only respond to commands if the conditional identifier test is met. In this way old and expired tags are excluded from the identification process.

As it operates with full duplex transmissions the interrogator can command tags while simultaneously receiving replies from other tags. Up to eight tags can simultaneously be replying on the eight channels whilst the interrogator is commanding other different tags.

6.2.7.2 Reply channels

The system uses eight reply channels between 969 kHz and 3 013 kHz. Different reply modes are used to maximise the tag identification rates for different interrogator types and tag populations. The reply mode used by a tag is selected by interrogator command.

6.2.7.3 Reply modes

6.2.7.3.1 Fixed channel reply mode

If an interrogator selects fixed channel reply mode the tag will transmit its complete reply once on the channel selected by the interrogator. This mode can be used for single channel interrogators where the tag population is one.

It can also be used in multi channel interrogators to command identified tags to reply on different fixed channels. Using this mode up to eight tags can be received simultaneously.

6.2.7.3.2 Random channel reply mode

6.2.7.3.2.1 Unmuted

If the interrogator selects unmuted random channel reply mode, tags will transmit the complete reply once on a channel randomly selected by the tag. This mode can be used by multiple channel interrogators for medium tag populations.

This mode can also be used by single channel interrogators for small tag populations. In a single channel interrogator all tag transmissions will clash if fixed channel reply mode is selected with a multiple tag population. Using unmuted random channel reply mode for a single channel interrogator is similar to a TDMA system. Eventually each tag will transmit on the interrogator's channel while all other tags are transmitting on other channels.

6.2.7.3.2.2 Random muted

In the random muted/channel reply mode tags randomly choose to either mute or unmute individual replies. For an unmuted reply the tag randomly selects the reply channel. This mode can be used by multiple channel interrogators for large tag populations.

The ratio of muted replies to possible replies can be varied by interrogator command between ½ and $^{511}/_{512}$. The ratio is ideally increased as the tag population increases. The muted ratio controls the average number of tags replying during a reply period. This method allows for the identification of many thousands of tags simultaneously presented to the interrogator. The muted ratio reduces the average number of tags transmitting to manageable levels.

6.2.7.3.2.3 Fully muted reply mode

The interrogator can set the tag to fully muted reply mode. In this mode the tag will not reply to commands from the same interrogator and therefore will not clash with other tag replies. This mode can be used for multiple tag populations to improve tag identification rates. The tag will exit the fully muted mode when it enters a new interrogator.

A tag determines that it has entered a new interrogator based on data included in the command, or if the tag detects that it has been powered down for longer than a defined period.

6.2.7.4 Random number generator (RNG)

To generate random numbers for reply channels and muted replies the tag uses a RNG equivalent to or better than a 32 bit maximal length linear shift register.

To stop excessively long mute sequences that occur with such a PRBS generator the tag shall include means to force an unmuted reply after a defined number of muted replies.

- When ½ muted is selected the maximum consecutive muted replies shall be 3.
- When ¾ muted is selected the maximum consecutive muted replies shall be 7.
- When $^{7}/_{8}$ muted is selected the maximum consecutive muted replies shall be 15.
- When $^{31}/_{32}$ muted is selected the maximum consecutive muted replies shall be 63.

Channel G is preferred for simple single channel interrogators. To identify multiple tags with such an interrogator, tags are commanded to random channel reply mode or random channel and random muted reply mode. To prevent excessively long sequences without a transmission on channel G the tag shall include means to force a reply on channel G after a sequence of 15 un-muted replies that occur on channels other than G.

The counter value or equivalent used to force the above replies shall use a storage technique, such as TRAM or equivalent, in-order to retain values during short power breaks, see Clause 6.2.5.23.4.

6.2.7.5 Command parameters

Refer Clause 6.2.5.16.2.

6.2.7.6 Request processing by the RF tag

Tags will only respond to valid commands. Tag function is fully defined by the command, see Clause 6.2.5.16.2. The command defines the muting and channel selection behaviour of the tag. Tags will randomly select reply muting and a reply channel when directed by the command. Random selection is done using a PRBS generator resident in the chip. Once a tag has been fully muted it will not respond to any further normal commands.

6.2.7.7 Explanation of an collision management sequence

In this system multiple tag identification is performed using a combination of Frequency and Time Division Multiple Access (FTDMA).

In response to a valid command each tag randomly selects a channel on which to transmit its reply. The reply is transmitted once using the selected channel. Upon receiving the next valid command each tag randomly selects a new channel and transmits the reply using the new selected channel.

This method of reply frequency hopping using random channel selection is repeated for each subsequent valid command.

In addition to random channel selection the tag can randomly mute individual replies. When a reply is muted the tag will not transmit that reply. Random muting is necessary when identifying very large populations of tags. Once a tag has been identified it is temporarily muted by command.

All FTDMA frequency and time parameters are defined by command. FTDMA provides superior performance over single frequency TDMA solutions, because multiple tag replies can be simultaneously received on different channels.

Reading data when multiple tags are present takes advantage of the full duplex operation of the interrogator. Data from up to 8 tags can be received simultaneously on the 8 channels when the interrogator specifically commands tags to reply on different channels.

Probability calculations are required to evaluate the average number of tags that will be identified after each valid read command. For a group of *n* tags with *r* channels available and a muting ratio of ***m*,** where *m* is the probability that a tag will transmit a reply then the average number of tags *N* identified after each valid read command is:

$$N = n.m.\left(\frac{r-1}{r}\right)^{(n.m-1)}$$

The highest identification rate is achieved when the number of tags replying at any time is equal to the number of available channels. The interrogator maximises the identification rate by adjusting the muting ratio so that the product:

$$n.m \approx r$$

The identification rate *N* is plotted against tag numbers *n* from 1 to 10 000 tags for the different muting ratios available to the tag in Figure 49. By suitable selection of muting ratio the identification rate can be maintained between 2 and 3 for up to 8 000 tags.

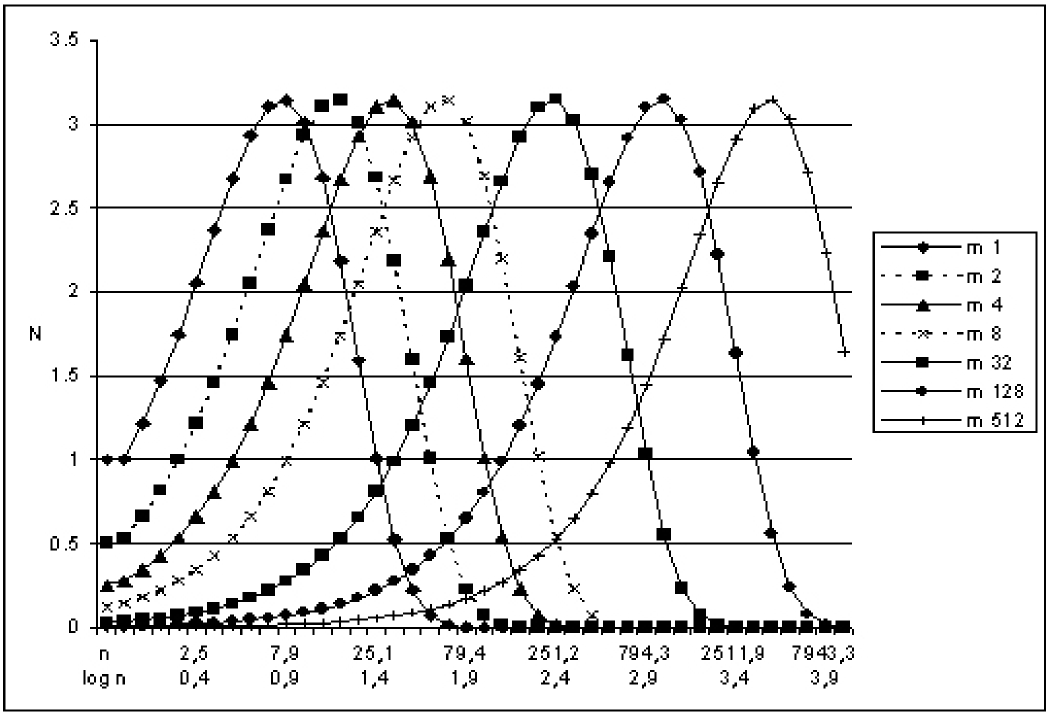


Figure 49 — Identification rate

6.2.7.8 Collision management sequence for small numbers of tags

When identifying and reading data from a small number of tags the muting ratio is set to 1. The average number of tags received is between 1 and 3 tags per read command. The sequence of operation for identifying and reading 8 tags is as follows:

a) Tags placed in the read zone of the interrogator.

b) A zero length read is issued.

c) As tags are identified they are temporarily muted.

d) The sequence is repeated until all tags are identified.

e) Data is read using a specific read command as a single operation following the identification process.

f) Commands are concatenated so that data from 8 tags is read simultaneously.

The sequence of operation for the identification of 8 tags is shown in Table 27 below.

Table 27 — Identification of 8 tags

Action	Result	Number of Tags identified
Start		
Interrogator sends a zero length read (random channel) command	All tags reply on randomly selected channels	0
Interrogator receives 3 tag replies		3
Interrogator sends specific mute commands to each of the identified tags	The muted tags will temporarily not respond to further normal commands	
Interrogator sends a zero length read (random channel) command	The 5 unmuted tags reply on randomly selected channels	3
Interrogator receives 3 tag replies		6
Interrogator sends specific mute commands to each of the identified tags	The muted tags will temporarily not respond to further normal commands	
Interrogator sends a zero length read (random channel) command	The 2 unmuted tags reply on randomly selected channels	
Interrogator receives 2 tag replies		8
Interrogator sends specific mute commands to each of the identified tags	The muted tags will temporarily not respond to further normal commands	
End	Total time identify 8 tags is 5,772 ms. (including minimum turn around times)	8 tags identified

Data can be read as a single operation following the identification process. Reading data as a single operation is the most time efficient method and is well suited to a static tag population.

For each read command the interrogator selects a specific tag and an unused channel for the tag to reply on (Tag I on channel A etc.). The sequence of operation in detail for reading data from 8 tags is shown below in Figure 50

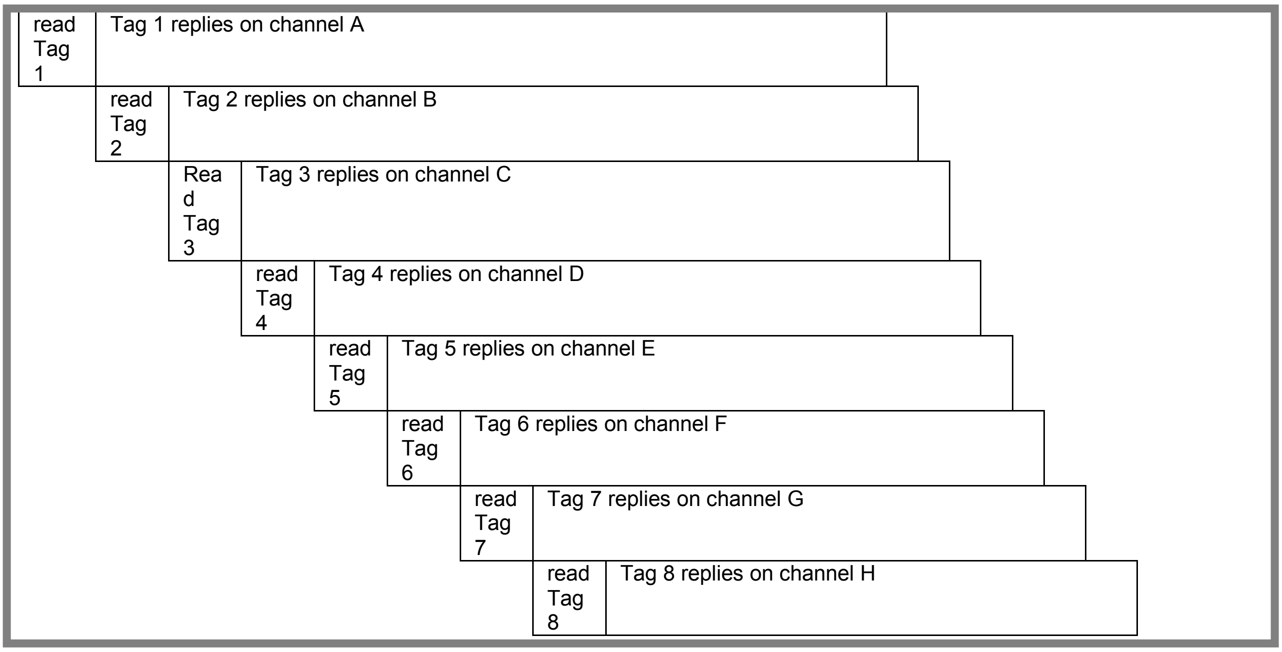


Figure 50 — Reading data from 8 tags

Full duplex transmissions between the interrogator and the tags allow the interrogator to concatenate sequential commands to the tags. This allows up to 8 tags to reply simultaneously.

The total time to read 8 tags is the time for 8 read commands and a single reply from the last tag.

6.2.7.9 Collision management sequence for large numbers of tags

When identifying and reading data from a large number of tags the muting ratio is set to reduce the number of tags replying at any one time to be approximately equal to the number of channels. When correctly set the average number of tags received is between 2 and 3 tags per read command.

The sequence of operation for identifying 500 tags and reading 50 words of data from each tag is as follows:

a. 500 tags placed in the interrogator.
b. A zero length read is issued and the number of tags received is monitored.
c. The muting ratio is increased till the average number of tags received is between 2 and 3 tags per read.
d. As tags are identified they are temporarily muted.
e. The sequence is repeated till all tags are identified. The muting ratio is adjusted as tag numbers decrease so that at least 2 tags are received per read.
f. Data is read using a specific read command either as a single operation following the identification process or as a continuous process during the identification process.
g. Commands are concatenated so that data from 8 tags is read simultaneously.

The sequence of operation in detail for the identification process is shown in Table 28 below.

Table 28 — Identification of 500 tags

Action	Result	Number of commands and replies	Number of tags identified
Start			
Interrogator sends a zero length read (random channel)	All 500 tags reply on randomly selected channels		0
Mute ratio on successive commands is increased till m = 1/128	3,9 (average) tags reply on randomly selected channels.	6 reads 6 short replies	
Interrogator sends zero length reads with muting set to 1/128	175 tags identified	70 reads 70 short replies 175 mutes	175
Interrogator sends zero length reads with muting set to 1/32	245 tags identified	98 reads 98 short replies 245 mutes	420
Interrogator sends zero length reads with muting set to 1/8	60 tags identified	24 reads 24 short replies 60 mutes	480
Interrogator sends zero length reads with muting set to 1/4	15 tags identified	6 reads 6 short replies 15 mutes	495
Interrogator sends zero length read with muting set to ½	2 tags identified	1 read 1 short reply 2 mutes	497
Interrogator sends zero length read with muting set to 1	2 tags identified	1 read 1 short reply 2 mutes	499
Interrogator sends zero length read with muting set to 1	1 tag identified	1 read 1 short reply 1 mutes	500
End and Totals	Total time to identify 500 tags is less than 0,390 s (including minimum turn around times).		500 tags identified

Data can be read as a single operation following the identification process or as a continuous process during the identification process. Reading data as a single operation is the most time efficient method and is well suited to a static tag population. Reading tag data continuously during the identification process is less efficient but is well suited to a dynamic tag population.

The sequence of operation in detail for the single data reading process is shown in Table 29 below:

Table 29 — Reading data from 500 static tags

Action	Result	Number of commands and replies	Tags read
Start			
Specific read command (50 words) on channels A to H	Reads data from tag 1 on channel A, tag 2 on channel B,…., tag 8 on channel H	8 reads 1 read reply	8
Wait till last 264 μs of tag reply on channel A	Tag 9 ready to receive read command and will commence reply on channel A after tag 1 finishes reply		
Specific read command (50 words) on channels A to H	Reads data from tag 9 on channel A, tag 10 on channel B,…., tag 16 on channel H	1 read reply	16
Sequence of operation continues until all tags are read	Sequence repeated a total of 63 times	61 read replies	500
End and totals	Total time to read 500 static tags is 0,540 s		500 static tags read

The total time to identify and read 50 words of data from 500 tags as a single operation is less than 0,390 s + 0,540 s = 0,930 s.

The sequence of operation in detail for the continuous data reading process is shown in Table 30 below. For the continuous read process the mutes tabulated in the identification sequence are not required and are instead required as part of the read sequence.

Table 30 — Reading data from 500 dynamic tags

Action	Result	Number of commands and replies	Tags read
Start			
interrogator identifies 8 tags	8 tags ready to have data read		
Specific read command (50 words) on channels A to H	Reads data from tag 1 on channel A, tag 2 on channel B,…., tag 8 on channel H	8 reads 1 read reply	8
Mute tags after data received		1 mute	
Repeat sequence for every 8 identified tags	Sequence repeated a total of 63 times	492 reads 62 read reply 62 mutes	500
End and Totals	Total time to read 500 dynamic tags is 0,686 s		500 dynamic tags read

The total time to identify and read 50 words of data from 500 tags as a continuous operation is less than 0,258 s + 0,686 s = 0,944 s.

6.2.7.10 Timing definition

The multiple tag identification and reading process requires zero length read commands & replies, mute commands, and read commands & replies. These commands and replies require the following times set out in Table 31 below:

Table 31 — Command and reply timings for multiple identification

Command/Reply Type	Details	Time
Zero length read command	Short zero length read command used for identification	264 μs
Zero length read reply	Short length reply with zero length data	906 μs
Mute command	Temporarily mute specific tag identified by read	264 μs
Read command (W words)	Read command for ***W*** words of data	264 μs
Read reply (W words)	Read reply with ***W*** words of data	906 + 151 ***W*** μs

6.2.8 Tag order sequencing

For applications requiring item order for sortation purposes, the RFID system shall unambiguously correlate each tag to each item regardless of the presence of multiple tags or tag separation. Such resolution is resolvable with MODE 2.

Example, on a processing conveyor moving at 3,6 m/s, with tag to tag separation of 15 cm, with the effect of interrogator axis switching included, the determination of tag order needs take place in under 13,9 ms. In systems, which rely upon tag identification to provide tag order there is not enough time to perform this process.

In this situation tag order is resolved by determining the time that tags enter the interrogator. All commands are time stamped and tags store the first time stamp received after entering an interrogator. The stored time stamp is transmitted in all tag replies. Timing resolution in the millisecond level is achieved. The determination of the tag order is decoupled from the speed of identification.

A technique such as Temporary Random Access Memory (TRAM) shall be used to retain the timestamp value during short power breaks, see Clause 6.2.5.23.4.

6.2.9 Commands

All commands are described in the Clauses above.

6.2.10 Air interface application layer

The Application layer shall be determined and controlled solely within the interrogator and shall not be carried across the air interface.

7 Marking of equipment

All interrogators/readers shall be clearly and permanently marked stating with which National Regulations they comply.

All interrogators/readers shall be clearly permanently marked to show which Modes of ISO/IEC 18000 they support.

8 Table of characteristic differences between the MODES specified in this part of ISO/IEC 18000

Table 32 — Characteristic differences between the MODES specified in this part of ISO/IEC 18000

Feature	MODE 1	MODE 2
Target Markets	General purpose tagging system for manufacturing, logistics, retail, transport and airline baggage.	Tagging system for manufacturing, logistics, retail, transport and airline baggage. Especially suitable for conveyor belt systems.
Characteristics	The principal operating method is consistent and compliant with ISO 15693 (non contact vicinity cards).	
	An extension Protocol provides additional features and an alternative collision management method.	
		Variant set up enables tags in very close proximity (2mm)
Data rate	1,65 kbit/s - 26,48 kbit/s , 105,94 kbit/s	423,75 kbit/s
Memory	To commercial demand	To commercial demand
Collision management	YES	YES High Speed
Global Operation Note: Local Regulations may affect operational capabilities	YES	YES

Annex A
(normative)

Phase jitter modulation (PJM)

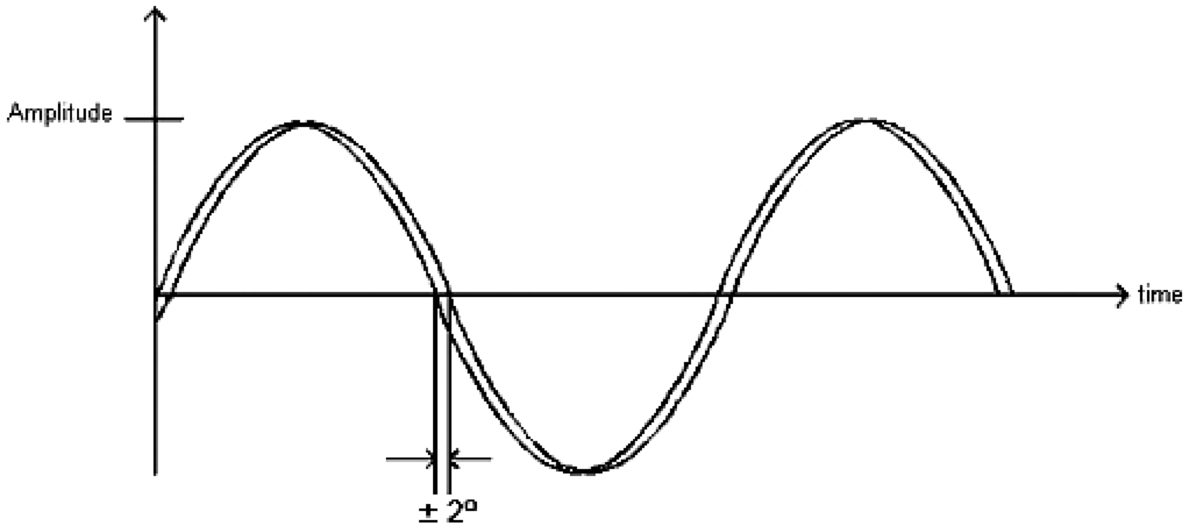


Figure A.1 — Phase jitter modulation

PJM consists of two components:

1. An in-phase (0°) powering signal I.

2. A low level quadrature (90°) data signal ±Q.

The PJM waveform is the sum of these two signals. In phasor notation, these can be represented as shown.

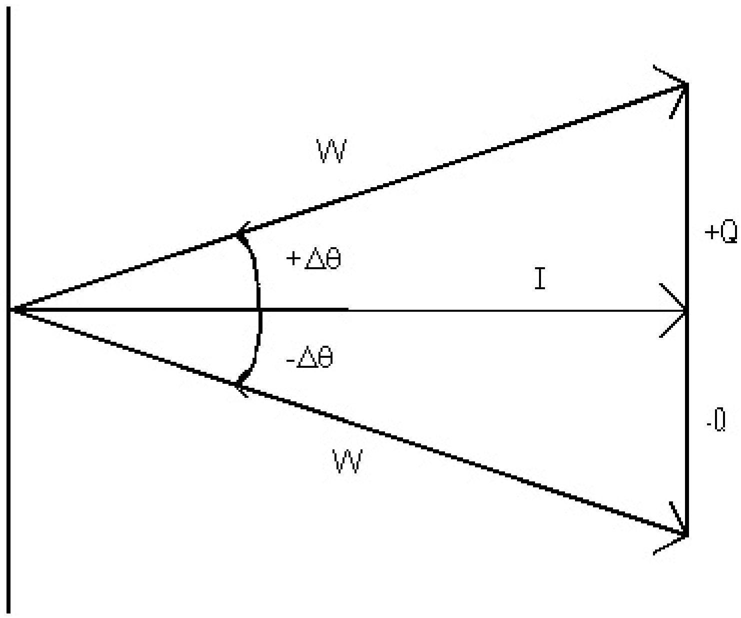


Figure A.2 — Frequency spectrum

The frequency spectrum of the phasor components are shown in Figure A.3:

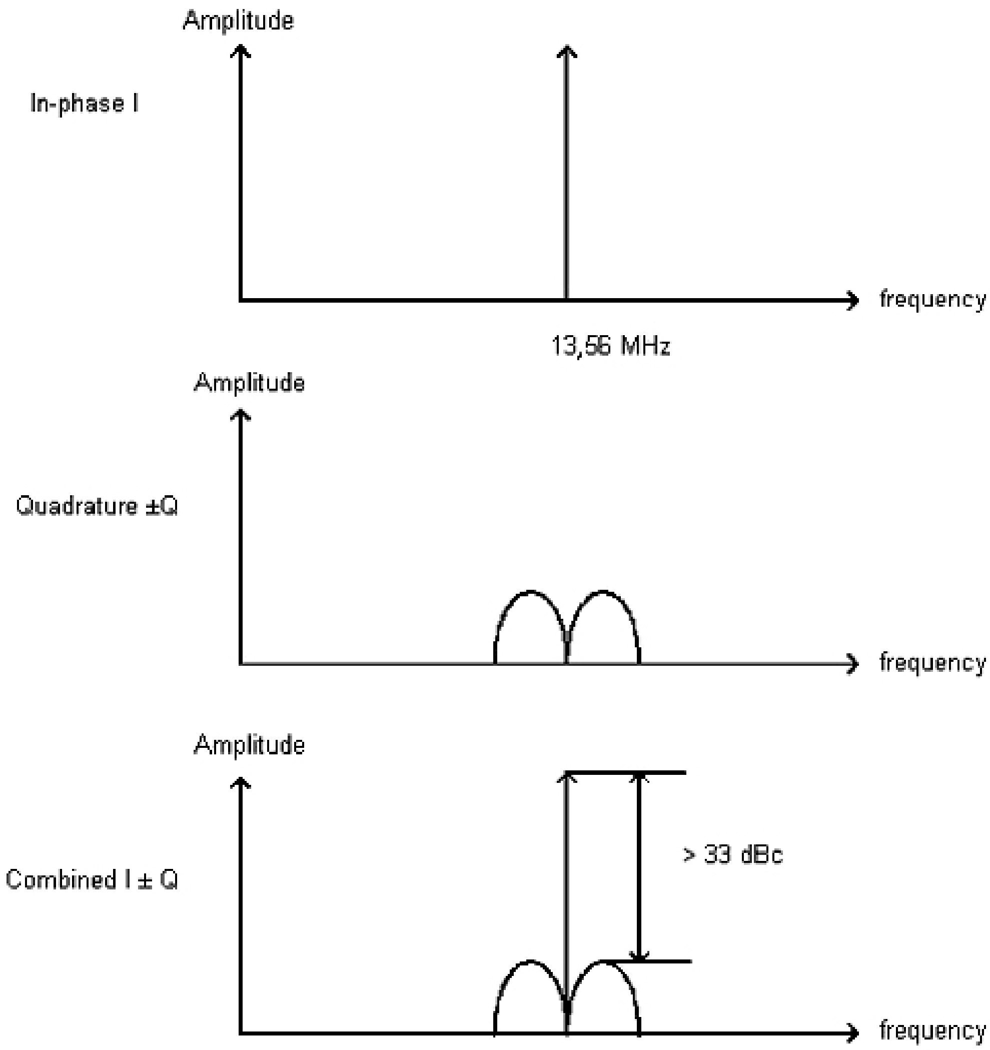


Figure A.3 — Generation of PJM

In MODE 2 of this part of ISO/IEC 18000 :

- the interrogator command bit rate is 423,75 kbit/s , see M2-Int: 9
- The time to complete an interrogator command phase transition is less than or equal to 1,18 µsec, see Figure 40.
- There are two parameters that have to be specified for PJM. The magnitude of the phase change and the time to complete an interrogator command phase transition.

magnitude of the phase change :	min. +/- 1,0 degrees max. +/- 2,0 degrees, see M2-Int: 7
time to complete an interrogator command phase transition	less than or equal to 1,18 µsec, see Figure 40

Features of PJM are:

- Constant amplitude signal with constant power transfer
- Sideband levels independent of data rate and can be adjusted to suit regulations
- Very high speed data can be transmitted because PJM bandwidth is no wider than the original doublesided data bandwidth
- Narrow bandwidth antennas do not limit high speed PJM signals. PJM can be pre-compensated to cancel for the effect of antenna bandwidth.

Example implementations of PJM are given in Figs A4 and A.5:

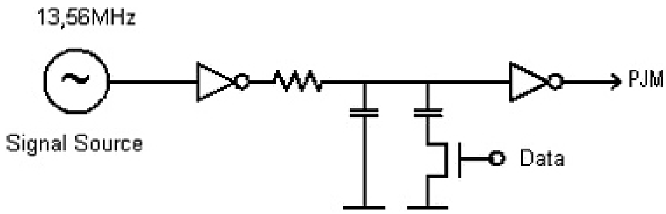


Figure A.4 — Example implementation - A simple circuit for providing a data controlled variable phase delay for generating PJM

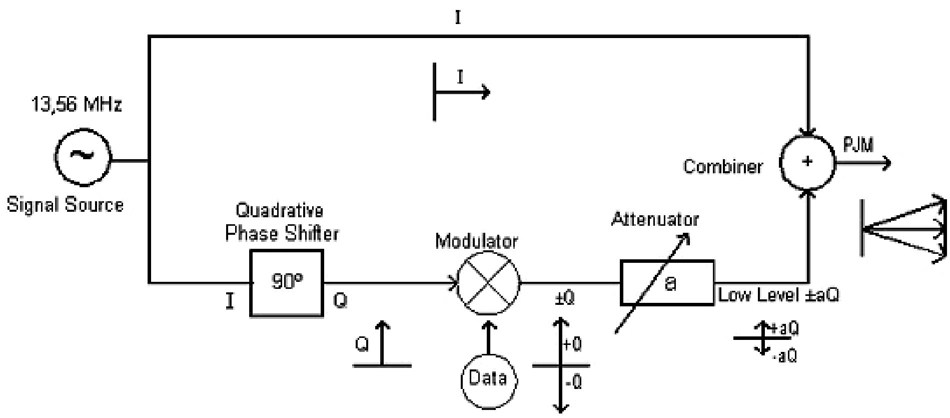


Figure A.5 — Example implementation - circuit for the generation of PJM showing the various elements of a PJM signal

Annex B
(informative)

Known possible interferences between the MODES determined in this part of ISO/IEC 18000

No interference known (they are unlikely because the two modes are completely different and both have a high level of data integrity (RTF, framing, CRC.).

Annex C
(informative)

Interrogator pseudo-code for collision management (Mode 1)

The following pseudo-code describes how the Collision Management could be implemented on the interrogator, using recursivity.

It does not describe the collision detection mechanism.

Algorithm for 16 slot

```
function push (mask, address)    ; pushes on private stack
function pop (mask, address)          ; pops from private stack
function pulse_next_pause        ; generates a power pulse
function store(RF Tag_MFG Tag ID)        ; stores RF Tag_MFG Tag ID

function poll_loop (sub_address_size as integer)
; address length shall be four (4) bits.
pop (mask, address)
mask = address & mask              ; generates new mask
; send the request
mode = Collision Management
send_request(request_cmd, mode, mask length, mask value)
for address = 0 to (2^sub_address_size - 1)

if no_collision_is_detected then     ; RF tag is inventoried
        store (RF Tag_MFG Tag ID)
   else                    ; remember a collision was detected
        push(mask,address)
   endif
pulse_next_pause
next sub_address
; if some collisions have been detected and not yet processed,
; the function calls itself recursively to process the last
; stored collision
if stack_not_empty then poll_loop (sub_address_size)

end poll_loop
main_cycle:
mask = null
address = null
push (mask, address)
poll_loop(sub_address_size)
end_main_cycle
```


Annex D
(informative)

Cyclic Redundancy Check (CRC) (16 bit)

D.1 The CRC error detection method

The Cyclic Redundancy Check (CRC) is calculated on all data contained in a message, from the start of the flags through to the end of data. This CRC is used from interrogator to RF tag and from RF tag to interrogator, as appropriate.

Table D.1 — CRC definition

CRC type	Length	Polynomial	Direction	Preset	Residue
ISO/IEC 13239	16 bits	$X^{16} + X^{12} + X^5 + 1$ = Ox8408	Backward	0xFFFF	0xF0B8

To add extra protection against shifting errors, a further transformation on the calculated CRC is made. The One's complement of the calculated CRC is the value attached to the message for transmission. This transformation is included in the example below.

For checking of received messages the 2 CRC bytes are often also included in the re-calculation, for ease of use.

In this case, given the expected value for the generated CRC is the residue of 0xF0B8.

D.2 CRC calculation example

This example in C language illustrates one method of calculating the CRC on a given set of bytes comprising a message.

```
#define  POLYNOMIAL     0x8408        //  x^16 + x^12 + x^5 + 1
#define  PRESET_VALUE   0xFFFF
#define  CHECK_VALUE    0xF0B8
#define  NUMBER_OF_BYTES    4         // Example: 4 data bytes
#define  CALC_CRC           1
#define  CHECK_CRC          0
void main()
{
  unsigned int  current_crc_value;
  unsigned char array_of_databytes[NUMBER_OF_BYTES + 2] = {1, 2, 3, 4, 0x91, 0x39};
  int         number_of_databytes = NUMBER_OF_BYTES;
  int         calculate_or_check_crc;
  int         i, j;
  calculate_or_check_crc = CALC_CRC;
  //  calculate_or_check_crc = CHECK_CRC;  // This could be an other example
  if (calculate_or_check_crc == CALC_CRC)
  {
    number_of_databytes = NUMBER_OF_BYTES;
  }
  else    // check CRC
  {
    number_of_databytes = NUMBER_OF_BYTES + 2;
  }
  current_crc_value = PRESET_VALUE;
  for (i = 0; i < number_of_databytes; i++)
```

```
 {
    current_crc_value = current_crc_value ^ ((unsigned int)array_of_databytes[i]);
    for (j = 0; j < 8; j++)
    {
       if (current_crc_value & 0x0001)
       {
          current_crc_value = (current_crc_value >> 1) ^ POLYNOMIAL;
       }
       else
       {
          current_crc_value = (current_crc_value >> 1);
       }
    }
 }
 if (calculate_or_check_crc == CALC_CRC)
 {
    current_crc_value = ≈ current_crc_value;


    if (current_crc_value == CHECK_VALUE)
    {
       printf ("Checked CRC is ok (0x%04X)\n", current_crc_value);
    }
    else
    {
       printf ("Checked CRC is NOT ok (0x%04X)\n", current_crc_value);
    }
 }
}
```

Annex E
(informative)

Cyclic redundancy check (CRC) mode 2 (32 bit)

E.1 The CRC 32 error detection method

The Cyclic Redundancy Check (CRC 32) is calculated on all data contained in a reply, from the end of the flag through to the end of data. This CRC is used for replies from tag to interrogator.

Table E.1 — CRC 32 Definition

CRC Definition				
Length	**Polynomial**	**Direction**	**Preset**	**Residue**
32 bits	x32 + x26 + x23 + x22 + x16 + x12 + x11 + x10 + x8 + x7 + x5 + x4 + x2 + x1 + 1 = 0xEDB88320	Backward	0xFFFFFFFF	0x2144DF1C

To add extra protection against shifting errors, a further transformation on the calculated CRC is made. The ones complement of the calculated CRC is the value attached to the message for transmission. This transformation is included in the example below.

For checking of received messages the 2 CRC words may be also included in the re-calculation, for ease of use. In this case, the expected value for the generated CRC is the residue ‘0x2144DF1C’.

E.2 CRC 32 calculation example

This example in C language illustrates one method of calculating the CRC on a given set of words comprising a reply.

```
#define POLYNOMIAL      0xEDB88320

#define PRESET_VALUE  0xFFFFFFFF

#define CHECK_VALUE   0x2144DF1C

#include <stdio.h>
#include <stddef.h>

unsigned long calculate_CRC32(unsigned long current_crc_value, unsigned int new_word)
{
 int  i;

 current_crc_value = current_crc_value ^ ((unsigned int)new_word);

 for (i = 0; i < 16; i++)
 {
  if (current_crc_value & 0x0001)
  {
     current_crc_value = (current_crc_value >> 1) ^ POLYNOMIAL;
  }
  else
```



```
    {
        current_crc_value = (current_crc_value >> 1);
    }
  }
  return(current_crc_value);
}

void main()
{

  unsigned long crc32;
  unsigned long crc_send;

  crc32 = PRESET_VALUE;                        // preset crc to 0xFFFFFFFF
  crc32 = calculate_CRC32(crc32, 0x1234);      // typical tag reply
  crc32 = calculate_CRC32(crc32, 0x0002);
  crc32 = calculate_CRC32(crc32, 0x0003);
  crc32 = calculate_CRC32(crc32, 0x0010);
  crc32 = calculate_CRC32(crc32, 0x0011);

  printf("CRC Results :\n");
  printf("-------------\n");

  crc_send = ≈ crc32;              // inverse of calculated crc is sent
  printf("Send    = 0x%08X\n",crc_send);

  // if transmitted crc is included in calculation by interrogator,
  // CHECK_VALUE should result

  crc32 = calculate_CRC32(crc32, (unsigned int)(crc_send) & 0x0000FFFF);
  crc32 = calculate_CRC32(crc32, (unsigned int)((crc_send >> 16) &  0x0000FFFF));

  crc32 = ≈ crc32;                // invert output to recover residue
  printf("Residue = 0x%08X\n",crc32);

  if (crc32 == CHECK_VALUE)       // should equal CHECK_VALUE
      printf("CRC OK  \n");
  else printf("CRC BAD \n");

}
```

This program, when run should produce the following output :

```
CRC Results :

-------------

Send    = 0xC7D5219F

Residue = 0x2144DF1C

CRC OK
```

E.3 Practical example of CRC 32 calculation

This example refers to a Short Reply command for a two word read starting from tag memory address 0x10.

The Specific Identifier of the tag in this example is 0x00030002 and the command number has been set to 0x1234. The tag memory locations could contain any value, in this example they are assumed to be :

Address	Contents
0x10	0x0010
0x11	0x0011

The reply in this example consists of the following fields :

- The ‘Time Stamp’ whose value is the transmitted command number ‘1234’
- The tag’s Specific Identifier ‘00030002’ which is transmitted as two words, least significant word first.
- The contents of the requested two memory locations, lowest address first : ‘0010’ ‘0011’
- The CRC: ‘C7D5219F’ where ‘219F’ is the least significant word, which is transmitted first.

The reply is then transmitted as follows :

1234 0002 0003 0010 0011 219F C7D5

Step	Input	Calculated CRC in Interrogator
1	Initialised	FFFFFFFF
2	1234	094A9040
3	0002	7399A576
4	0003	B52DBBB2
5	0010	815B13BD
6	0011	C7D5219F
7	219F	41D9D52A
8	C7D5	2144DF1C

NOTE : The CRC which is finally transmitted, C7D5219F is present as the ‘Calculated CRC in interrogator’ at step 6, after each of the data words in the reply has been included in the calculation.

Continuing the calculation with the next two words (the transmitted CRC) produces the final result whose value should be the residue ‘0x2144DF1C’.

NOTE : The CRC is transmitted as two words, with the least significant word transmitted first.

NOTE : Each word is transmitted least significant bit first.

Annex F
(informative)

Mode 1 IC reference

The IC reference*(see "Get System Information")* may be a part of the serial number (bit41 to 48, after the manufacturer code)

MSB LSB

64 57	56 49	48 41	40 1
"E0"	manufacturer code	IC reference	IC manufacturer serial number

NOTE The manufacturer code is already part of the UID and by receiving this information the interrogator already knows if the "IC reference" is supported or not from the manufacturer.

Annex G
(informative)

A description of ISO/IEC 15693 Protocol as used in MODE 1

G.1 Parameter tables for interrogator to tag link

Table G.1 — Parameter Tables for interrogator to tag link

Ref.	Parameter	Description/limits	Options/Comments
M1-Int: 1	Operating frequency range	1 interrogator to tag link channel at (centre frequency) 13,56MHz ± 7 kHz	
M1-Int: 1a	Default operating frequency	13,56 MHz	
M1-Int: 1b	Operating channels (for spread spectrum systems)	Not appropriate for this MODE	
M1-Int: 1c	Operating frequency accuracy	+/- 100 parts per million +/- 50 parts per million in Japan	
M1-Int: 1d	Frequency hop rate (for Frequency hopping [FHSS] systems)	Not appropriate for this MODE	
M1-Int: 1e	Frequency hop sequence (for Frequency hopping [FHSS] systems)	Not appropriate for this MODE	
M1-Int: 2	Occupied channel bandwidth	13,56 MHz ± 7 kHz with modulation as per Figures G.1 and G.2,	See Figures G.1and G.2 Below.
M1-Int: 2a	Minimum receiver bandwidth	13,56 MHz ± (423,75± 40 kHz) 13,56 MHz ± (484,28 ± 40 kHz) Protocol extension 13,56 MHz ± (423,75± 80 kHz)	Centred at the sub carrier frequency.

Ref.	Parameter	Description/limits	Options/Comments
M1-Int: 3	Interrogator transmit maximum EIRP Power limits within communication zone	The interrogator shall not generate a field higher than 12 A/m in any part of the volume where the tag may be present Maximum operating field strength : 5 A/m for ISO card sized tags- As defined in ISO/IEC 7810. Test methods defined in ISO/IEC TR 18047-3. For other label form factors, the label manufacturer shall specify the maximum operating field strength.	No intentional emission (Inductive coupling) Where Local regulations restrict the Power Limits below those determined in this Clause, a degradation of local performance may be expected. Test methods for determining the interrogator operating field are defined in relative clauses of the future Technical Report ISO/IEC TR 18047-3.
M1-Int: 3a	Minimum operating field strength	Minimum Operating Field Strength : 150 mA/m for ISO card sized tags. For other label form factors, the label manufacturer shall specify the minimum operating field strength.	
M1-Int: 4	Interrogator transmit spurious emissions	compliant with regulations US Jurisdictions : FCC 47 Part 15 EU : EN 300 – 330 Japan : ARIB STD – T82	
M1-Int: 4a	Interrogator transmit spurious emissions, in-band (for Spread spectrum systems)	Not appropriate for this MODE	
M1-Int: 4b	Interrogator transmit spurious emissions, out-of-band	Not appropriate for this MODE	
M1-Int: 5	Interrogator transmitter spectrum mask	The modulation technique and bit coding enable maximum tag powering within the following regulations: US Jurisdictions : FCC 47 Part 15 EU : EN 300 – 330 Japan : ARIB STD – T82	
M1-Int:6	Timing		
M1-Int: 6a	Transmit to receive turn around time	Within 0 - 300 µs	
M1-Int: 6b	Receive to transmit Turn around time	Within 0 - 300 µs	
M1-Int: 6c	Dwell time or Interrogator transmit power on ramp	See figures G.1 & G.2	

Ref.	Parameter	Description/limits	Options/Comments
M1-Int: 6d	Decay time or Interrogator transmit power down ramp	See figures G.1 & G.2	
M1-Int: 7	Modulation	Carrier amplitude modulation (ASK 100%,ASK 10%….)	
M1-Int: 7a	Spreading sequence (for Frequency hopping [FHSS] systems)	N/A	
M1-Int: 7b	Chip rate (for Spread Spectrum systems)	N/A	
M1-Int: 7c	Chip Rate Accuracy (for Spread spectrum systems)	Not appropriate for this MODE	
M1-Int: 7d	Modulation index	Two level amplitude modulation. 100% and 10% Modulation Index: **(a – b) / (a + b)** (NOTE: Modulation Depth **(a – b)/ a)**	Either option at determination of the interrogator (See Figures G.1 & G.2) Two modulation indexes are permitted and are determined by the interrogator. The RF tag shall decode both. Modulation shall use the principle of ASK. Depending on the choice made by the interrogator, modulation shall be as described in Figures G.1 & G.2
M1-Int: 7e	Duty cycle	See Figures 1, 2, 3, 4, and 5	
M1-Int: 7f	FM deviation	Not appropriate for this MODE	
M1-Int: 8	Data coding	Data coding shall be implemented using pulse position modulation. Two data coding modes shall be supported by the RF tag. The selection shall be made by the interrogator and indicated to the RF tag within the Start of frame (SOF).	**Data coding mode:** **1 out of 256** The value of one single byte shall be represented by the position of one pulse. The position of the pulse on one of 256 successive time periods of 18,88 µs (256/fc), determines the value of the byte. The figures 3 and 4 illustrates this pulse position modulation technique **Data coding mode:** **1 out of 4** Pulse position modulation shall be used where the position determines two bits at a time. Four successive pairs of bits form a byte. The resulting data rate is 26,48 kbit/s (fc/512). Coding is achieved according to the diagrams in Figures 5 and 6.

Ref.	Parameter	Description/limits	Options/Comments
M1-Int: 9	Bit rate	1 out of 256 Data coding mode : 1,65 kbit/s (fc/8192) 1 out of 4 Data coding mode 26,48 kbit/s (fc/512)	Either mode at the determination of the interrogator
M1-Int: 9a	Bit rate accuracy	Synchronous to the carrier frequency	
M1-Int: 10	Interrogator transmit modulation accuracy	Not appropriate for this MODE	

Ref.	Parameter	Description/limits	Options/Comments
M1-Int: 11	Preamble	Preamble is mandatory Framing has been chosen for ease of synchronization and independence of protocol. Frames are delimited by a Start of frame (SOF) and an End of frame (EOF) and are implemented using code violation. Two types of SOF are defined, either of which determines data coding used (1 out of 4 or 1 out of 256).	
M1-Int:11a	Preamble length	≈ 75,52 µs	
M1-Int:11b	Preamble waveform	See Figures G.7 and G. 8	
M1-Int: 11c	Bit sync sequence	Not appropriate for this MODE	
M1-Int:11d	Frame sync sequence	**SOF to select 1 out of 256 code** The SOF sequence described in the figure below selects the 1 out of 256 data coding mode. See fig G.7 **SOF to select 1 out of 4 code** The SOF sequence described in the figure below selects the 1 out of 4 data coding mode. See Figure G.4	
M1-Int:11e	Postamble	The same EOF sequence shall be used for either data coding mode and shall be as described in Figure G.9.	
M1-Int: 12	Scrambling (for Spread spectrum systems)	Not appropriate for this MODE	
M1-Int: 13	Bit transmission order	Least significant bit first.	
M1-Int: 14	Wake-up process	The dialogue between the interrogator and the RF tag (one or more RF tags may be present at the same time) is conducted through the following consecutive operations: - activation of the RF tag by the RF operating field of the interrogator, - RFID tag waits silently for a command from the interrogator, - transmission of a command by the interrogator, - transmission of a response by the RFID tag.	

Ref.	Parameter	Description/limits	Options/Comments
M1-Int: 15	Polarization	Not applicable (near field)	

G.2 Parameter tables for tag to interrogator link

Table G.2 — Parameter Tables for tag to interrogator link

Ref.	Parameter Name	Description/limits	Options/Comments
M1-Tag: 1	Operating frequency range Sub-carrier frequencies	One or two sub-carriers may be used. The selection between either shall be made by the interrogator using the first bit in the protocol header as defined in ISO / IEC 15693-3. The RF tag shall support both modes. When one sub-carrier is used, the frequency f_{s1} of the sub-carrier load modulation shall be $f_c/32$ (423,75 kHz). When two sub-carriers are used, the frequency f_{s1} shall be $f_c/32$ (423,75 kHz), and the frequency f_{s2} shall be $f_c/28$ (484,28 kHz). When two sub-carriers are used, continuous phase shall be used, as shown in supporting diagrams	
M1-Tag: 1a	Default operating frequency	13,56MHz ± 7 kHz	
M1-Tag: 1b	Operating channels (for Spread spectrum systems)	Not appropriate for this MODE	
M1-Tag: 1c	Operating frequency accuracy	13,56 MHz synchronous to the carrier	
M1-Tag: 1d	Frequency hop Rate (for Frequency hopping [FHSS] systems)	Not appropriate for this MODE	
M1-Tag: 1e	Frequency hop sequence (for Frequency hopping [FHSS] systems)	Not appropriate for this MODE	
M1-Tag: 2	Occupied channel bandwidth	13,56 MHz 4 subcarriers 1 sub carrier: 13,56 MHz ± (423,75 kHz ± 40 kHz) 2 sub carriers: 2 channel: 13,56 MHz ±(484,28 kHz ± 40 kHz) Protocol extension 13,56 MHz ± (423,75+/- 80 kHz)	
M1-Tag: 3	Transmit maximum EIRP	No intentional emission.	No intentional emission (Inductive coupling).
M1-Tag: 4	Transmit spurious emissions		

Ref.	Parameter Name	Description/limits	Options/Comments
M1-Tag: 4a	Transmit spurious emissions, in-band (for Spread spectrum systems)	Not appropriate for this MODE	
M1-Tag: 4b	Transmit spurious emissions, Out-of-band	Not appropriate for this MODE	
M1-Tag: 5	Transmit spectrum mask	In compliance with US: FCC 47 Part 15 EU and other EN:300-330 (Transmit spectrum mask is not regulated in the Japan Radio Law)	
M1-Tag: 6a	Transmit to receive turn around time	0 - 300 µs	
M1-Tag: 6b	Receive to transmit turn around time	0 -300 µs	
M1-Tag: 6c	Dwell time or Transmit power on ramp	Not appropriate for this MODE	
M1-Tag: 6d	Decay time or Transmit power down ramp	Not appropriate for this MODE	
M1-Tag: 7	Modulation (on the carrier)	The RF tag shall be capable of communication to the interrogator via an inductive coupling area whereby the carrier frequency is modulated to generate a sub-carrier with frequency f_s. The sub-carrier shall be generated by switching a load in the RF tag. Test methods for RF tag load modulation are defined in ISO/IEC TR 18047-3. The load modulation amplitude shall be at least 10mV for ISO card sized tags when measured as described in the test methods. For other label form factors, the label manufacturer shall specify the load modulation.	
M1-Tag: 7a	Spreading sequence (for Frequency hopping [FHSS] systems)	Not appropriate for this MODE	
M1-Tag: 7b	Chip rate (for Spread spectrum systems)	Not appropriate for this MODE	

Ref.	Parameter Name	Description/limits	Options/Comments
M1-Tag: 7c	Chip rate accuracy (for Spread spectrum systems)	Not appropriate for this MODE	
M1-Tag: 7d	On-off ratio	Not appropriate for this MODE	
M1-Tag: 7e	Sub-carrier frequency	if one sub carrier is used : 423,75 kHz if two sub carriers are used : 423,75 kHz and 484,28 kHz	
M1-Tag: 7f	Sub-carrier frequency accuracy Tolerance of direct generated tag to Interrogator link carrier	Derived from the carrier.	
M1-Tag: 7g	Sub-carrier modulation	One Subcarrier: A logic ***0*** starts with 8 pulses of 423,75 kHz (fc/32) followed by an unmodulated time of 18,88 µs. (256/fc). See Figure G.10 A logic ***1*** starts with an unmodulated time of 18,88 µs (256/fc) followed by 8 pulses of 423,75 kHz (fc/32). See Figure G.11. Two subcarriers: A logic ***0*** starts with 8 pulses of 423,75 kHz (fc/32) followed by 9 pulses of 484,28 kHz (fc/28). See Figure G.12 A logic ***1*** starts with 9 pulses of 484,28 kHz (fc/28) followed by 8 pulses of 423,75 kHz (fc/32). See Figure G.13. Protocol Extension: A Precursor Logic 0 starts with 4 pulses of 423,75 kHz (fc/32) followed by an unmodulated time of 9,44 µs (128/fc) See Figure 13. A Precursor Logic 1 starts with an unmodulated time of 9,44 µs (128/fc) followed by 4 pulses of 423,75 kHz (fc/32). See Figure 14. A main reply logic 0 consists of 4 pulses of 423,75 kHz (fc/32) which have an opposite phase to the previous 4 pulses. See Figure 15. A main reply logic 1 consists of 4 pulses of 423,75 kHz (fc/32) which have the same phase as the previous 4 pulses. See Figure 16.	Determined by the interrogator. RF tag shall support both.
M1-Tag: 7h	Duty ycle	Not appropriate for this MODE	
M1-Tag: 7 I	FM Deviation	Not appropriate for this MODE	

Ref.	Parameter Name	Description/limits	Options/Comments
M1-Tag: 8	Data coding	Data shall be encoded using Manchester coding, See Figures 10, 11, 12, 13. All timings shown below refer to the high data rate from the RF tag to the interrogator. For the low data rate the same subcarrier frequenci(es) are used, in this case the number of pulses shall be multiplied by 4 and all times will increase by this factor. The protocol extension encoding is defined in Figures 13,14,15 and 16.	
M1-Tag: 9	Bit rate	Refer to Table G.3 (See 6.1.1.3.2.3 below) The protocol extension has a precursor data rate ≈ 52,97 kbit/s (fc/256) and a main reply data rate ≈ 105,94 kbit/s (fc/128)	
M1-Tag: 9a	Bit rate accuracy	Derived from the carrier	
M1-Tag: 10	Tag transmit modulation accuracy (for Frequency hopping [FHSS] systems)	Not applicable for this MODE	
M1-Tag: 11	Preamble	Framing has been chosen for ease of synchronization and independence of protocol. Frames are delimited by a Start of frame (SOF) and an End of frame (EOF) and are implemented using code violation. See figures G.14 and G.15. Protocol extension See Figures 12 and Table 3	
M1-Tag: 11a	Preamble length	See figures G.14 and G.15 Protocol extension See Figures 12 and Table 3	

Ref.	Parameter Name	Description/limits	Options/Comments
M1-Tag: 11b	Preamble waveform	**:SOF when using one subcarrier** The SOF comprises 3 parts: an unmodulated time of 56,64 µs (768/fc), 24 pulses of 423,75 kHz (fc/32), followed by a logic ***1*** which starts with an unmodulated time of 18,88 µs. (256/fc) followed by 8 pulses of 423,75 kHz (fc/32). See Table G.9 **:SOF when using two subcarriers** The SOF comprises 3 parts: 27 pulses of 484,28 kHz (fc/28), 24 pulses of 423,75 kHz (fc/32), a logic ***1*** which starts with 9 pulses of 484,28 kHz (fc/28) followed by 8 pulses of 423,75 kHz (fc/32). See Figure G.15 Protocol extension precursor Start of frame (SOF) starts with 8 pulses of 423,75 kHz (fc/32) followed by a further 4 pulses with the opposite phase of the previous 8. See 12 Protocol extension main reply SOF starts with 12 pulses of 423,75 kHz (fc/32) followed by a further 4 pulses with the opposite phase to the previous 12. See Table 3 (bits 1-4) 3 logical ones followed by a zero **:EOF when using one subcarrier** The EOF comprises 3 parts: a logic ***0*** which starts with 8 pulses of 423,75 kHz (fc/32), an unmodulated time of 18,88µs (256/fc) 24 pulses of 423,75 kHz (fc/32) an unmodulated time of 56,64 µs (768/fc) **:EOF when using two subcarriers** The EOF comprises 3 parts: a logic ***0*** which starts with 8 pulses of 423,75 kHz (fc/32) followed by 9 pulses of 484,28 kHz (fc/28), 24 pulses of 423,75 kHz (fc/32) 27 pulses of 484,28 kHz (fc/28). Protocol extension precursor – No End of frame (EOF), the precursor only contains the leader (Precursor SOF) and 12 collision detection bits. Protocol extension main reply EOF starts with 6 pulses of 423,75 kHz (fc/32) which have the opposite phase of the previous 4 pulses, followed by a further 6 pulses with the opposite phase to the previous 6. See Figure 18.	
M1-Tag: 11c	Bit sync sequence	Not appropriate for this MODE	

Ref.	Parameter Name	Description/limits	Options/Comments
M1-Tag: 12	Scrambling (for Spread spectrum systems)	Not appropriate for this MODE	
M1-Tag: 13	Bit transmission order	Least significant bit first	
M1-Tag: 14	Reserved		
M1-Tag: 15	Polarization	Not applicable (Near Field)	
M1-Tag: 16	Minimum tag receiver bandwidth	see transmitted / received signals :figures 1& 2	

G.3 Description of operating method

G.3.1 Communications signal interface interrogator to tag

For some parameters several options have been defined in order to meet different international radio regulations as well as application requirements.

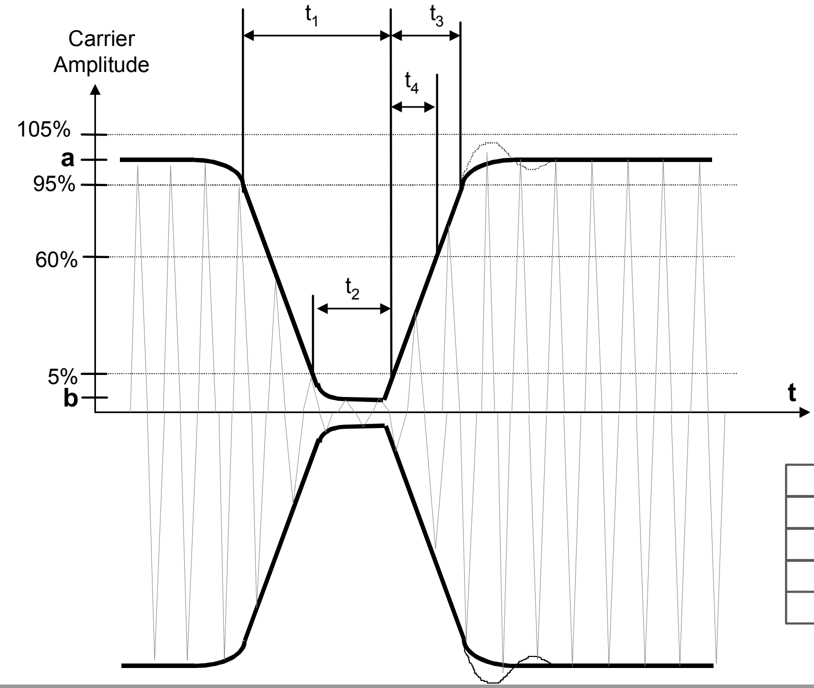
From the modes specified any data coding can be combined with any modulation.

G.3.2 Modulation

Communications between the interrogator and the tag takes place using the modulation principle of ASK. Two modulation indexes are used, 10% and 100%. The tag shall decode both. The interrogator determines which index is used.

Depending on the choice made by the interrogator, a "pause" will be created as described in Figure G.1 and Figure G.2.

NOTE: Figures 1 and 2 are provided to show pulse shapes in the air interface. The tolerance of these shapes are defined in these graphs. Using the measurement methods defined in ISO/IEC 10373-7 or ISO/IEC TR 18047-3, the adequacy of the receiver-bandwidth can be tested to ensure that it is sufficient operation between the minimum and the maximum operating field strength.

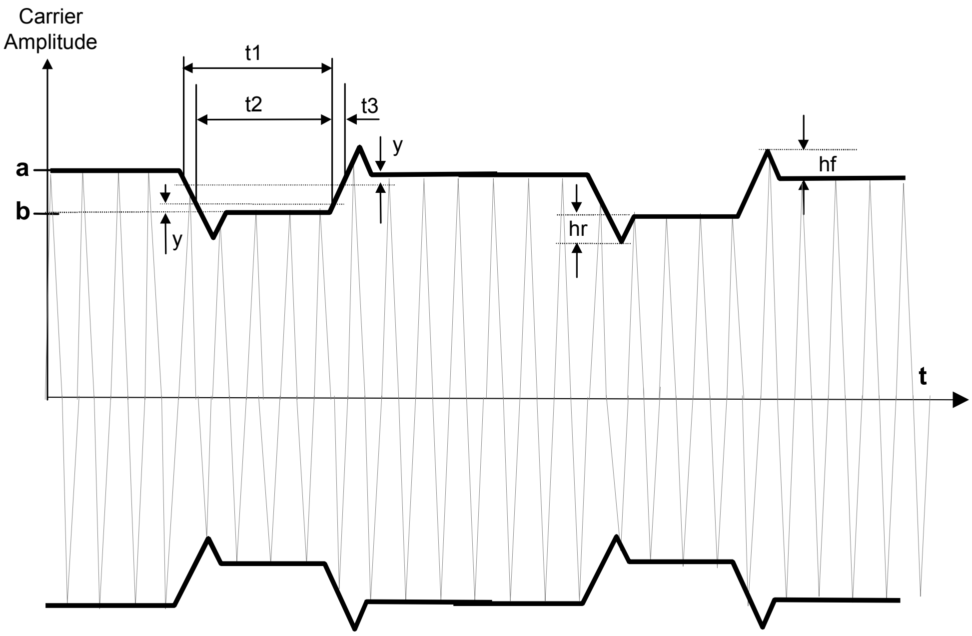


	Min (µs)	Max (µs)
t_1	6,0	9,44
t_2	2,1	t_1
t_3	0	4,5
t_4	0	0,8

Figure G.1 — Modulation of the Carrier for 100% ASK

Time values in Figure G.1, expressed as number of carrier periods « n/Fc are :

9,44µs : 128/fc
18,88µs: 256/fc
37,76µs: 512/fc
75,52µs: 1024/fc



	Min	Max
t1	6,0 µs	9,44 µs
t2	3,0 µs	t1
t3	0	4,5 µs
Modulation Index	10%	30%

y	0,05 (a-b)
hf, hr	0,1 (a-b) max

The tag shall be operational for any value of modulation index between10% and 30%.

Figure G.2 — Modulation of the carrier for 10% ASK

G.3.3 Data rate and data coding

Data coding shall be implemented using pulse position modulation.

Two data coding options shall be supported by the interrogator. The selection shall be made by the interrogator and indicated to the interrogator within the Start of frame (SOF). (described below)

G.3.3.1 Data coding mode: 1 out of 256

The value of one single byte shall be represented by the position of one pause. The position of the pause on 1 of 256 successive time periods of $256/f_c$ (≈ 18,88 µs), determines the value of the byte. In this case the transmission of one byte takes ≈ 4,833 ms and the resulting data rate is 1,65 kbit/s (f_c/8192). The last byte of the frame shall be completely transmitted before the EOF is sent by the interrogator.

Figure G.3 illustrates this pulse position modulation technique.

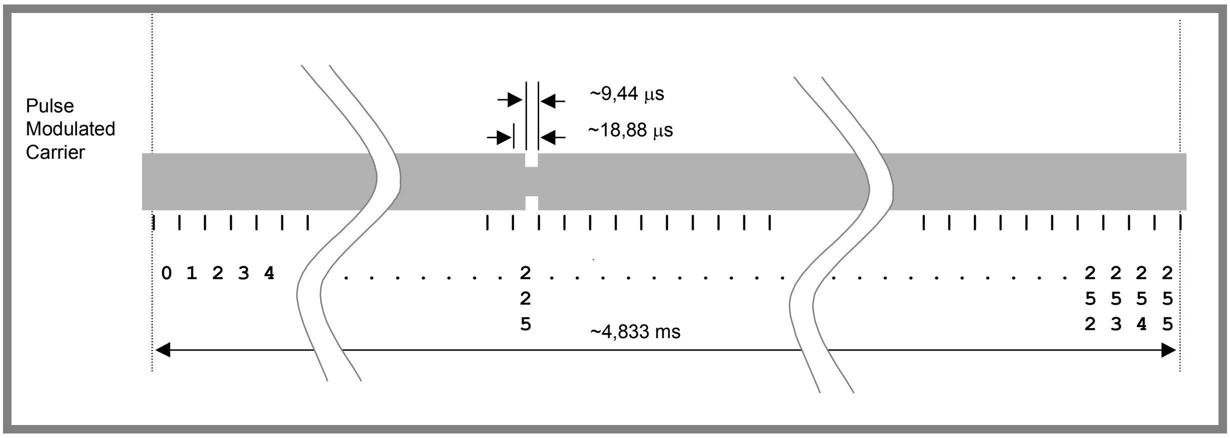


Figure G.3 — 1 out of 256 coding mode

In Figure G.3 data 'E1' = (11100001)b = (225) is sent by the interrogator to the tag.

The pause shall occur during the second half of the position of the time period that determines the value, as shown in Figure G.4.

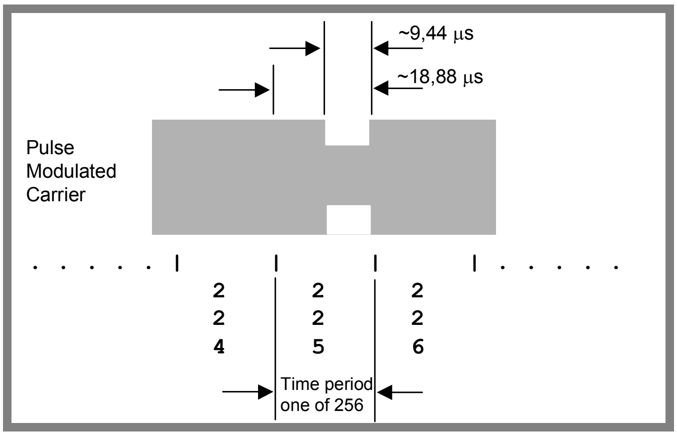


Figure G.4 — Detail of one time period

G.3.3.2 Data coding mode: 1 out of 4

Pulse position modulation for 1 out of 4 mode shall be used, in this case the position determines two bits at a time. Four successive pairs of bits form a byte, where the least significant pair of bits is transmitted first.

The resulting data rate is 26,48 kbit/s (f_c/512).

Coding is effected according to the diagrams in Figure G.5.

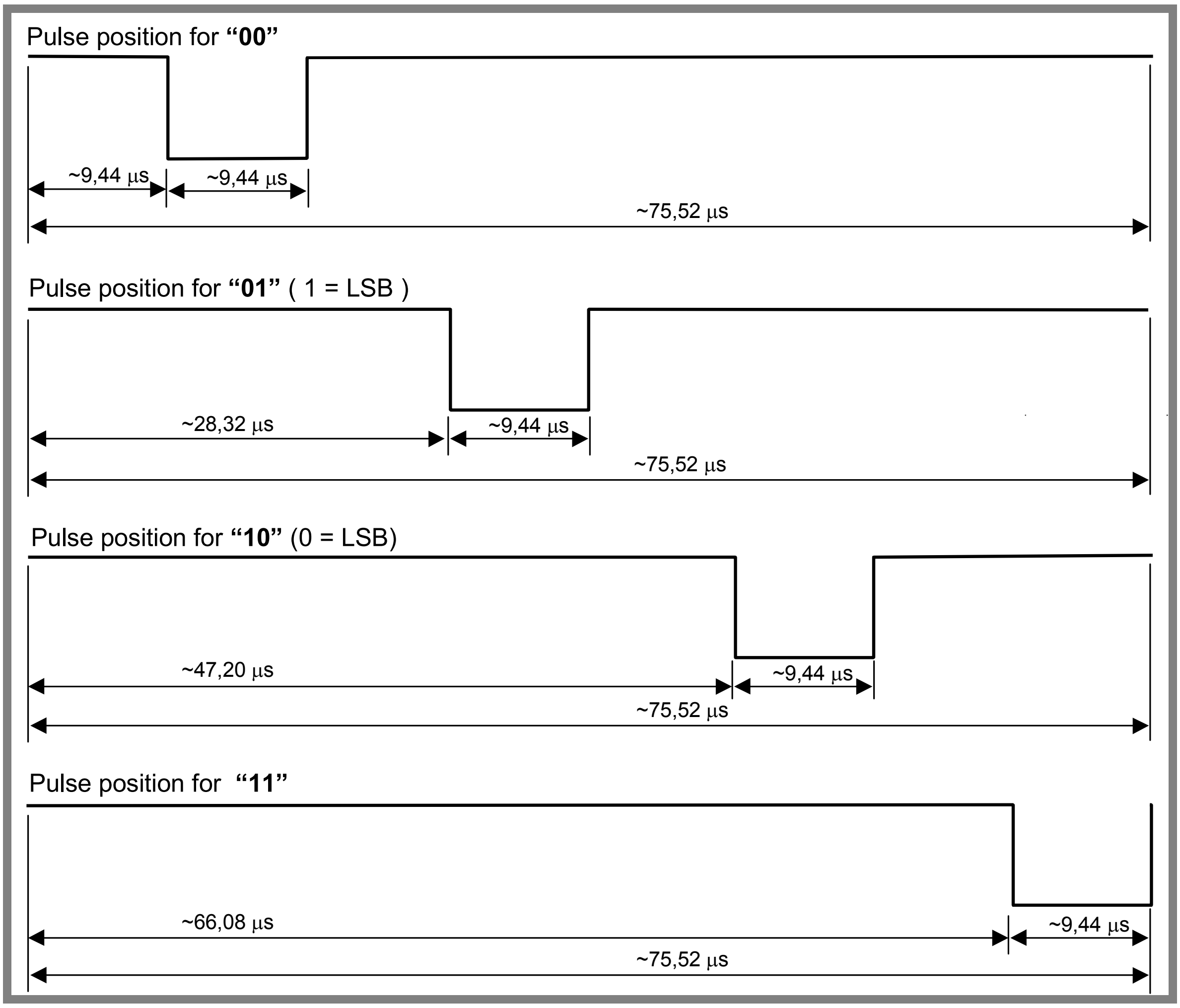


Figure G.5 — 1 out of 4 coding mode

In Figure G.1, the timing is defined by internal clock counts expressed as number of carrier periods « n/Fc are :

9,44µs : 128/fc
18,88µs: 256/fc
37,76µs: 512/fc
75,52µs: 1024/fc

For example Figure G.6 shows the transmission of 'E1' = (11100001)b = 225 by the interrogator.

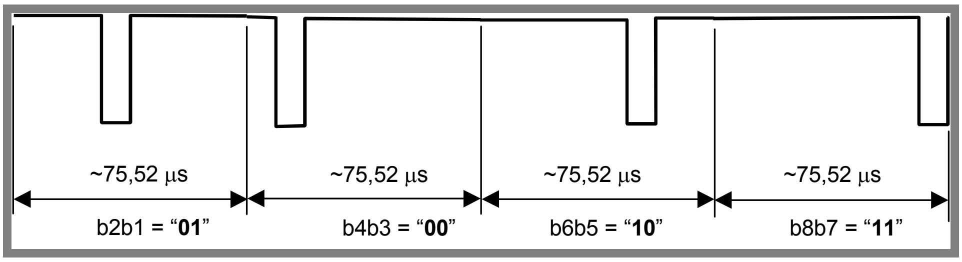


Figure G.6 — 1 out of 4 coding example

G.3.4 Interrogator to tag frames

Framing has been chosen for ease of synchronization and independence of protocol.

Frames shall be delimited by a start of frame (SOF) and an end of frame (EOF) and are implemented using code violation. Unused options are reserved for future use by ISO/IEC.

The tag shall be ready to receive a frame from the interrogator within 30 µs after having sent a frame to the interrogator.

The tag shall be ready to receive a frame within 1 ms of activation by the powering field.

G.3.4.1 SOF to select 1 out of 256 code

The SOF sequence described in Figure G.7 selects the 1 out of 256 data coding mode.

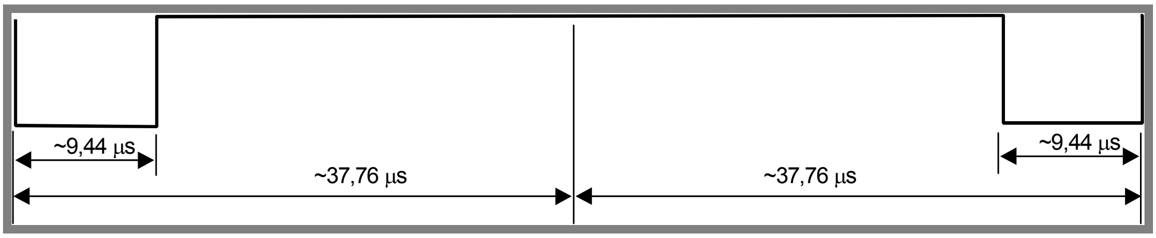


Figure G.7 — Start of frame of the 1 out of 256 mode

G.3.4.2 SOF to select 1 out of 4 code

The SOF sequence described in Figure G.8 selects the 1 out of 4 data coding mode.

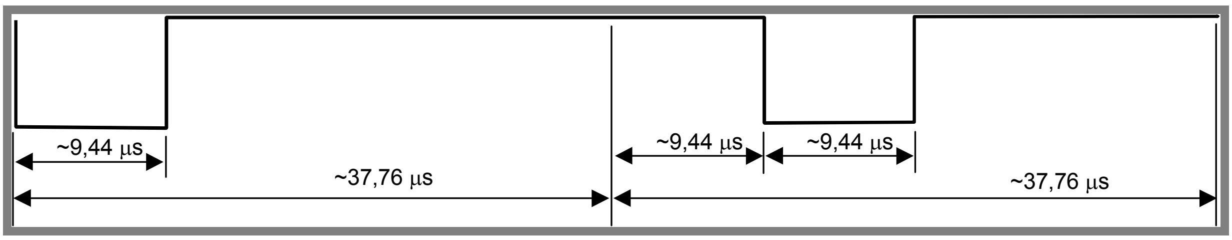


Figure G.8 — Start of frame of the 1 out of 4 mode

G.3.4.3 EOF for either data coding mode

The EOF sequence for either coding mode is described in Figure G.9.

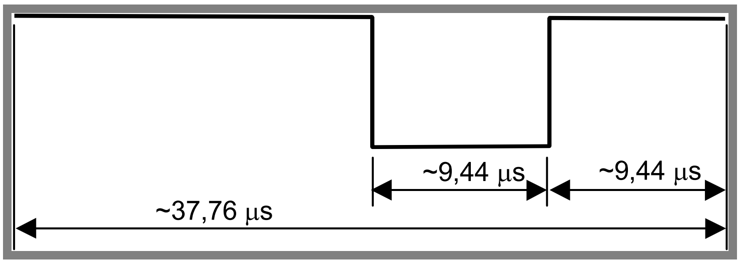


Figure G.9 — End of frame for either mode

G.3.5 Communications signal interface tag to interrogator

For some parameters several modes have been defined in order to allow for use in different noise environments and application requirements.

G.3.5.1 Load modulation

The tag shall be capable of communication to the interrogator via an inductive coupling area whereby the carrier is loaded to generate a subcarrier with frequency fs. The subcarrier shall be generated by switching a load in the tag.

The load modulation amplitude shall be at least 10 mV for ISO card sized tags (e.g. ID1) when measured as described in the test methods.

Test methods for tag load modulation are defined in the relevant clauses of ISO/IEC TR 18047-3.

G.3.5.2 Subcarrier

One or two subcarriers may be used as selected by the interrogator using the first bit in the protocol header as defined in clause G.5.6.1. The tag shall support both modes.

When one subcarrier is used, the frequency f_{s1} of the subcarrier load modulation shall be $f_c/32$ (423,75 kHz).

When two subcarriers are used, the frequency f_{s1} shall be $f_c/32$ (423,75 kHz), and the frequency f_{s2} shall be $f_c/28$ (484,28 kHz).

If two subcarriers are present there shall be a continuous phase relationship between them.

G.3.5.3 Data rates

A low or high data rate may be used. The selection of the data rate shall be made by the interrogator using the second bit in the protocol header as defined in clause G.5.6.1. The tag shall support the data rates shown in Table G.3.

Table G.3 — Data Rates

Data Rate	Single Subcarrier	Dual Subcarrier
Low	6,62 kbit/s ($f_c/2048$)	6,67 kbit/s ($f_c/2032$)
High	26,48 kbit/s ($f_c/512$)	26,69 kbit/s ($f_c/508$)

G.3.5.4 Bit representation and coding

Data shall be encoded using Manchester coding, according to the following schemes.

All timings shown refer to the high data rate from the tag to the interrogator. For the low data rate the same subcarrier frequency or frequencies are used, in this case the number of pulses and the timing shall be multiplied by 4.

G.3.5.5 Bit coding when using one subcarrier

A logic 0 starts with 8 pulses of $f_c/32$ (≈ 423,75 kHz) followed by an unmodulated time of $256/f_c$ (≈ 18,88 μs), see Figure G.10.

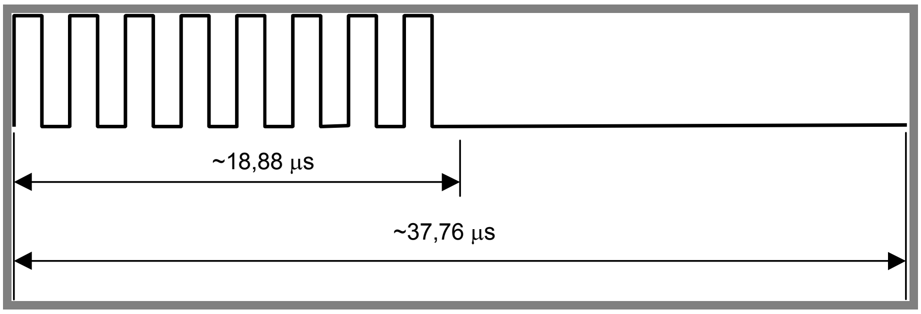


Figure G.10 — Logic 0

A logic 1 starts with an unmodulated time of $256/f_c$ (≈ 18,88 μs) followed by 8 pulses of $f_c/32$ (≈ 423,75 kHz), see Figure G.11.

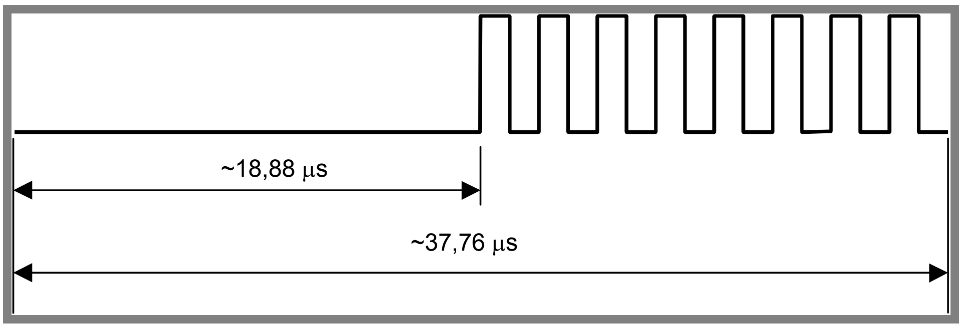


Figure G.11 — Logic 1

G.3.5.6 Bit coding when using two subcarriers

If two subcarriers are present there shall be a continuous phase relationship between them.

A logic 0 starts with 8 pulses of $f_c/32$ (≈ 423,75 kHz) followed by 9 pulses of $f_c/28$ (≈ 484,28 kHz), see Figure G.12.

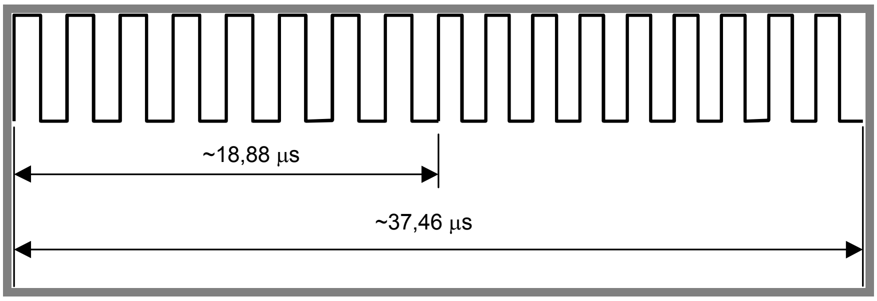


Figure G.12 — Logic 0

A logic 1 starts with 9 pulses of f_c/28 (≈ 484,28 kHz) followed by 8 pulses of f_c/32 (≈ 423,75 kHz), see Figure G.13.

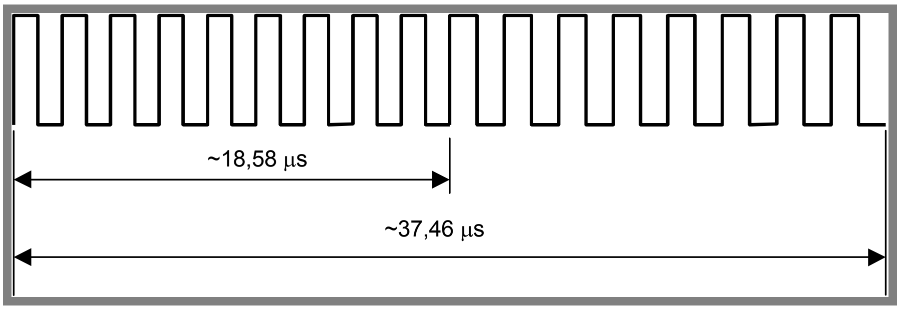


Figure G.13 — logic 1

G.3.5.7 Tag to interrogator frames

Framing has been chosen for ease of synchronization and independence of protocol.

Frames are delimited by a start of frame (SOF) and an end of frame (EOF) and are implemented using code violation. Unused options are reserved for future use by ISO/IEC JTC1.

All timings shown below refer to the high data rate from the tag to the interrogator.

For the low data rate the same subcarrier frequency or frequencies are used, in this case the number of pulses and the timing shall be multiplied by 4.

The interrogator shall be ready to receive a frame from the tag within 300 µs after having sent a frame to the tag.

G.3.5.8 SOF when using one subcarrier

SOF comprises 3 parts:

— an unmodulated time of 768/fc (≈ 56,64 µs).

— 24 pulses of fc/32 (≈ 423,75 kHz).

— a logic 1 which starts with an unmodulated time of 256/fc (≈ 18,88 µs), followed by 8 pulses of fc/32 (≈ 423,75 kHz).

The SOF for one subcarrier is illustrated in Figure G.14.

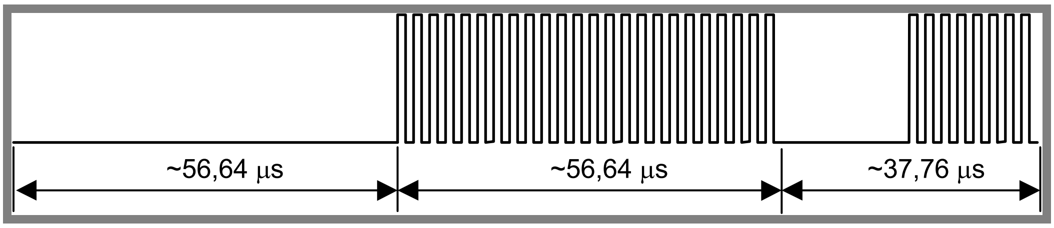


Figure G.14 — Start of frame when using one subcarrier

G.3.5.9 SOF When using two subcarriers

SOF comprises 3 parts:

— 27 pulses of fc/28 (≈ 484,28 kHz).

— 24 pulses of fc/32 (≈ 423,75 kHz).

— a logic 1 which starts with 9 pulses of fc/28 (≈ 484,28 kHz) followed by 8 pulses of fc/32 (≈ 423,75 kHz).

The SOF for 2 subcarriers is illustrated in Figure G.15.

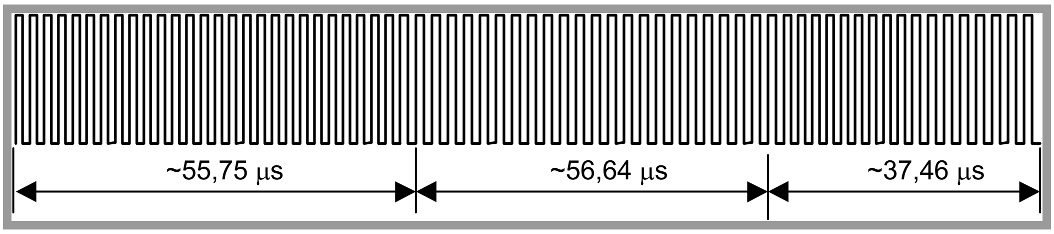


Figure G.15 — Start of frame when using two subcarriers

If two subcarriers are present there shall be a continuous phase relationship between them.

G.3.5.10 EOF when using one subcarrier

EOF comprises 3 parts:

— a logic 0 which starts with 8 pulses of fc/32 (≈ 423,75 kHz), followed by an unmodulated time of 256/fc (≈ 18,88 µs).

— 24 pulses of fc/32 (≈ 423,75 kHz).

— an unmodulated time of 768/fc (≈ 56,64 µs).

The EOF for 1 subcarrier is illustrated in Figure G.16.

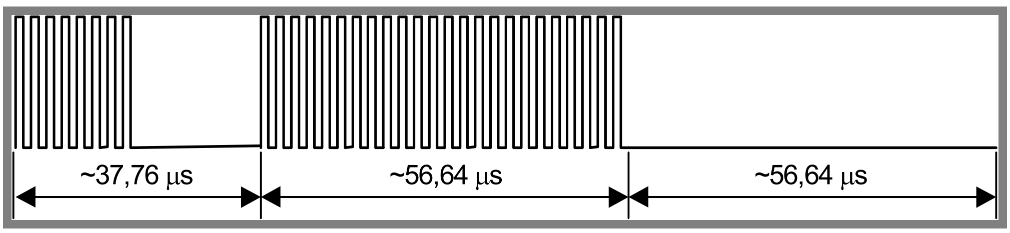


Figure G.16 — End of frame when using one subcarrier

G.3.5.11 EOF when using two subcarriers

EOF comprises 3 parts:

— a logic 0 which starts with 8 pulses of fc/32 (≈ 423,75 kHz) followed by 9 pulses of fc/28 (≈ 484,28 kHz).

— 24 pulses of fc/32 (≈ 423,75 kHz).

— 27 pulses of fc/28 (≈ 484,28 kHz).

The EOF for 2 subcarriers is illustrated in Figure G.17.

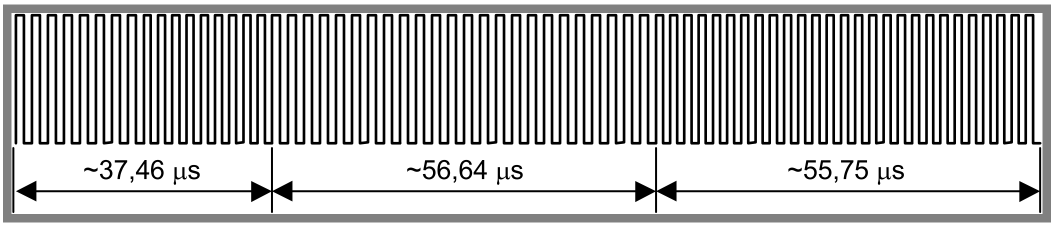


Figure G.17 — End of frame when using 2 subcarriers

G.4 Protocol parameters

G.4.1 Table of protocol parameters

Table G.4 — Table of protocol parameters

Ref.	Parameter	Description/limits	Comment/ Option
M1-P: 1	Who talks first	Interrogator talks first	
M1-P: 2	Tag addressing capability	Yes.	
M1-P: 3	MFG Tag ID	The RF tags are uniquely identified by a 64 bits MFG tag ID. It is used for addressing each RF tag uniquely and individually, during the collision management loop and for one-to-one exchange between an interrogator and an RF Tag. The protocol is based on an exchange of • a request from the interrogator to the tag • a response from the tag(s) to the interrogator Each request and each response are contained in a frame. Each request and each response consist of • Flags • Command code(only in request) • Mandatory and optional parameters fields, depending on the command • Application data fields • CRC The protocol is bit-oriented. The number of bits transmitted in a frame is a multiple of eight (8).	
M1-P: 3a	MFG Tag ID Length	64 bits	

Ref.	Parameter	Description/limits	Comment/ Option
M1-P: 3b	MFG Tag ID Format	The MFG Tag ID comprises: • A fixed part ('E0'), • the IC manufacturer code, • a unique serial number assigned by the IC manufacturer The MFG Tag ID is programmed at the point of manufacture of the IC, and is thereafter unchangeable.	
M1-P: 3c	Application family identifier (Afi)	Afi (Application Family Identifier) represents the type of application targeted by the interrogator and is used to extract from all the tags present only the tags meeting the required application criteria. It may be programmed by the tag issuer (the purchaser of the tag). Once locked, it can not be modified. The most significant nibble of Afi is used to code one specific or all application families. The least significant nibble of Afi is used to code one specific or all application sub-families. Sub-family codes different from 0 are proprietary.	Optional
M1-P: 3d	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 may be locked by the tag issuer (the purchaser of the tag). Once locked, it can not be modified. The code requires one byte. It allows for instant knowledge on the logical organization of the data memory. Its coding is not specified in this part of ISO/IEC 18000. Note: it is intended to conform to ISO/IEC 15961 and 15962 (under development)	Optional
M1-P: 3e	Order of fields	Request : Flags, Command code, Parameter and Data Field, CRC response : Flags, one or more parameter Fields, Data, CRC	
M1-P: 4	Read size	Specified in number of blocks. Up to 256 blocks.	
M1-P: 5	Write size	Specified in number of blocks. Up to 256 blocks.	
M1-P: 6	Read transaction time	Depends upon the interrogator-to-tag data rate, tag-to-interrogator data rate, block size and number of blocks. Example: Time required to read two blocks of 128 bits, using highest data rates in both directions and using the Read Multiple Blocks command: 10,7 ms	
M1-P: 7	Write transaction time	Depends upon the interrogator-to-tag data rate, tag-to-interrogator data rate, block size, number of blocks and memory programming time. Example: Time required to write two blocks of 128 bits, using highest data rates in both directions, in a EEPROM with a write time of 4 ms and using the Write Multiple Blocks command: 14,7 ms	

Ref.	Parameter	Description/limits	Comment/ Option
M1-P: 8	Error detection	Error detection is achieved by a CRC mechanism compliant with ISO/IEC 13239.	
M1-P: 9	Error correction	No.	
M1-P: 10	Memory size	The physical memory is assumed to be organized in blocks (or pages) of fixed size. Up to 256 blocks can be addressed. Block size can be up to 256 bits. This leads to a maximum memory capacity of up to 8 kbytes (64 kbits) without extension flag.	
M1-P: 11	Command structure and extensibility	In a request, the byte "flags" specifies the actions to be performed by the tag. In a response, it indicates how actions have been performed by the tag.	

Ref.	Parameter	Description/limits	Comment/ Option
M1-P: 11a	Request flags	**a) Request flags 1 to 4 definition** **Bit 1 Sub-carrier_flag** **0** A single sub-carrier frequency shall be used by the tag **1** Two sub-carriers shall be used by the tag **Bit 2 Data_rate_flag** **0** Low data rate shall be used **1** High data rate shall be used **Bit 3 Inventory_flag** **0** Flags 5 to 8 meaning is according to a) below **1** Flags 5 to 8 meaning is according to b) below **Bit 4 Protocol extension_flag** **0** No protocol format extension **1** Protocol format is extended according to Table 1. **b) Request flags 5 to 8 definition when inventory_ flag is NOT set** **Bit 5 Select_flag** **0** Request shall be executed by any tag according to the setting of Address_flag **1** Request shall be executed only by tag in selected state. The Address_flag shall be set to 0 and the UID field shall not be included in the request. **Bit 6 Address_flag** **0** Request is not addressed. UID field is not included. It shall be executed by any tag. **1** Request is addressed. UID field is included. It shall be executed only by the tag whose UID matches the UID specified in the request. **Bit 7 Option_flag** **0** Meaning is defined by the command description. It shall be set to 0 if not otherwise defined by the command. **1** Meaning is defined by the command description. **Bit 8 RFU** **0** Reserved for future use. Shall be set to 0.	

Ref.	Parameter	Description/limits	Comment/ Option
M1-P: 11a	Request flags	**Request flags 5 to 8 definition when inventory_ flag is set with** **Bit 5 Afi_flag** **0** Afi field is not present **1** Afi field is present **Bit 6 Nb_slots_flag** **0** 16 slots **1** 1 slot **Bit 7 Option_flag** **0** Meaning is defined by the command description. It shall be set to 0 if not otherwise defined by the command. **1** Meaning is defined by the command description. Bit 8 RFU **0** Reserved for future use. Shall be set to 0.	
M1-P: 11b	Response flags	**Bit 1 Error_flag** **0** No error **1** Error detected. Error code is in the "Error" field. **Bit 2 RFU** **0** Reserved for Future Use. Shall be set to 0 **Bit 3 RFU** **0** Reserved for Future Use. Shall be set to 0 **Bit 4 Extension_flag** **0** No protocol format extension **1** Protocol format is extended. Reserved for future use. **Bit 5 RFU** **0** Reserved for Future Use. Shall be set to 0 **Bit 6 RFU** **0** Reserved for Future Use. Shall be set to 0 **Bit 7 RFU** **0** Reserved for Future Use. Shall be set to 0 **Bit 8 RFU** **0** Reserved for Future Use. Shall be set to 0	
M1-P: 12	Addressing	Each Request (except the inventory command or otherwise specified) can be sent to a specific tag designated by its MFG Tag ID. This is achieved by setting the Address_flag and inserting the MFG Tag ID in the request.	

Ref.	Parameter	Description/limits	Comment/ Option
M1-P: 12a	Addressed mode	When Address_flag is set to 1 (addressed mode), the request shall contain the Unique ID (MFR Tag ID) of the addressed tag. Any tag receiving a request with the Address_flag set to 1 shall compare the received unique ID (address) to its own ID. If it matches, it shall execute it (if possible) and return a response to the interrogator as specified by the command description.. If it does not match, it shall remain silent	
M1-P: 12b	Non addressed mode	When Address_flag is set to 0 (non-addressed mode), the request shall not contain a tag Unique ID. Any tag receiving a request with the Address_flag set to 0 shall execute it (if possible) and shall return a response to the interrogator as specified by the command description.	

G.5 Description of protocol operating method

G.5.1 Definition of data elements

G.5.1.1 MFG tag unique identifier (UID)

The RF tags are uniquely identified by a 64 bits unique identifier (UID). This is used for addressing each RF tag uniquely and individually, during the Collision Management loop and for one-to-one exchange between a interrogator and a RF tag.

The UID shall be set permanently by the IC manufacturer in accordance with Figure G.18.

MSB		LSB
64 57	56 49	48 1
‘E0'	IC Mfg code	IC manufacturer serial number

Figure G.18 — UID format

The UID comprises

- The 8 MSB bits shall be 'E0',
- The IC manufacturer code, on 8 bits according to ISO/IEC 7816-6.
- A unique serial number on 48 bits assigned by the IC manufacturer.

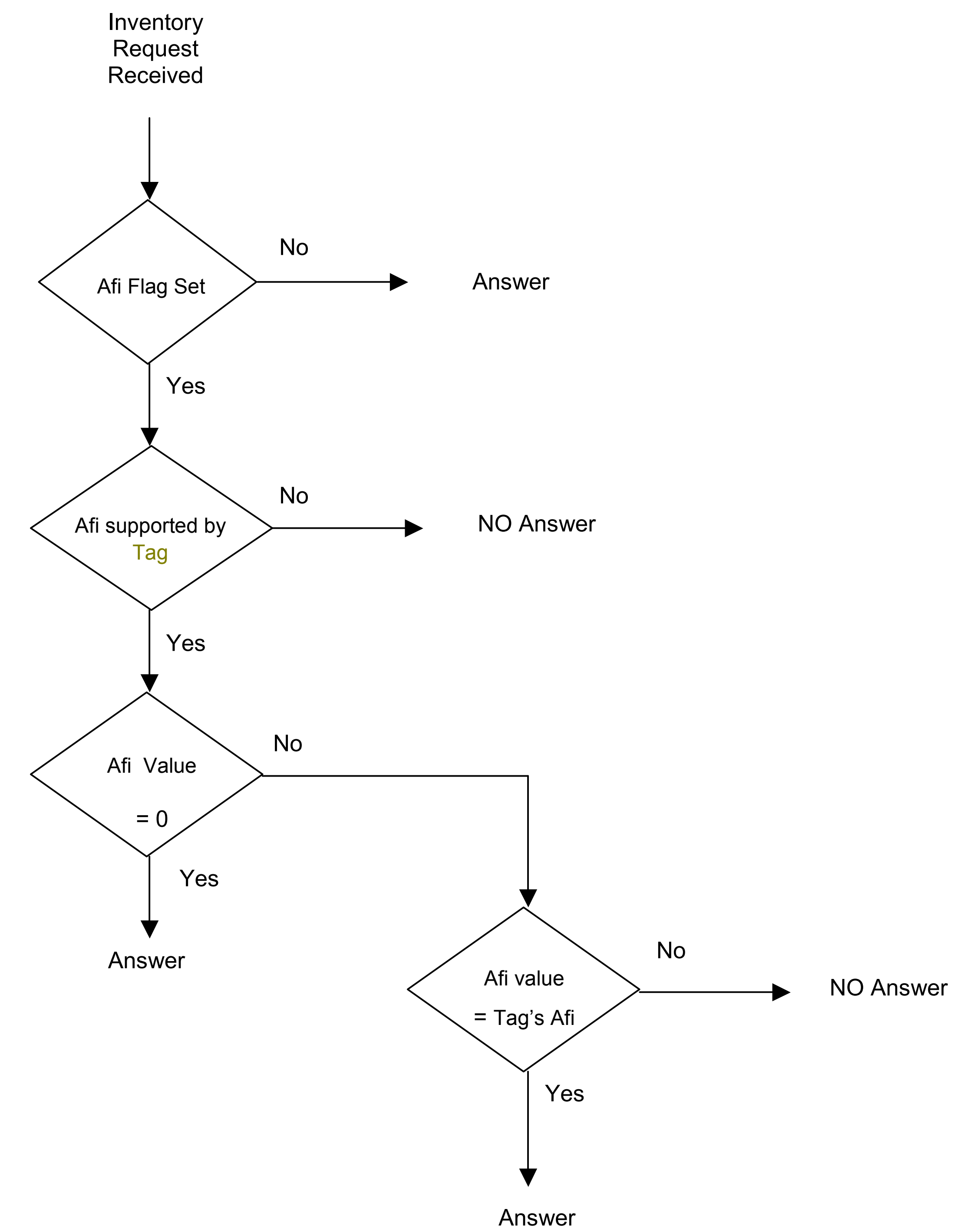
G.5.1.2 Application family identifier (Afi)

Afi (Application family identifier) represents the type of application targeted by the interrogator and is used to extract from all the RF tags present only the RF tags meeting the required application criteria.

It may be programmed and locked by the respective commands.

Afi is coded on one byte, which constitutes 2 nibbles of 4 bits each.

The most significant nibble of Afi is used to code one specific or all application families, as defined in ISO/IEC 15961 and ISO/IEC 15962. The least significant nibble of Afi is used to code one specific or all application sub-families. Sub-family codes different from 0 are proprietary.



NOTE "Answer" means that the RF tag shall answer to the inventory request.

Figure G.19 — RF tag decision tree for Afi

G.5.2 Data storage format identifier (DSFID)

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

It may be programmed and locked by the respective commands. It is coded on one byte. It allows for instant knowledge on the logical organisation of the data.

If its programming is not supported by the RF tag, the RF tag shall respond with the value zero ('00').

G.5.3 CRC

The CRC shall be calculated as per the definition in ISO/IEC 13239.

The initial register content shall be all ones: 'FFFF'.

The two bytes CRC are appended to each request and each response, within each frame, before the EOF. The CRC is calculated on all the bytes after the SOF up to but not including the CRC field.

Upon reception of a request from the interrogator, the RF tag shall verify that the CRC value is valid. If it is invalid, it shall discard the frame and shall not answer (modulate).

Upon reception of a response from the RF tag, it is recommended that the interrogator verify that the CRC value is valid. If it is invalid, actions to be performed are left to the responsibility of the interrogator designer.

The CRC is transmitted least significant byte first.

Each byte is transmitted least significant bit first.

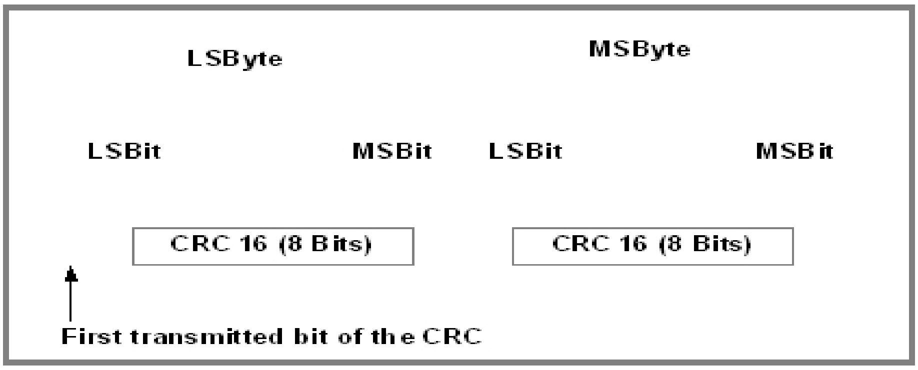


Figure G.20 — CRC bits and bytes transmission rules

The method and an example of this 16 bit CRC is given in Annex E.

G.5.3.1 RF tag memory organization

The commands specified in this part of ISO/IEC 18000 assume that the physical memory is organized in blocks (or pages) of fixed size.

- Up to 256 blocks can be addressed.
- Block size can be of up to 256 bits.
- This leads to a maximum memory capacity of up to 8 kBytes (64 kbit).

Note: The structure allows for future extension of the maximum memory capacity.

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

G.5.3.2 Block security status

The block security status is sent back by the RF tag as a parameter in the response to an interrogator request as specified in clause G.8 (e.g. read single block). It is coded on one byte.

It is an element of the protocol. There is no implicit or explicit assumption that the 8 bits are actually implemented in the physical memory structure of the RF tag.

Table G.5 — Block security status

Bit	Flag name	Value	Description
b1	Lock_flag	0	Not locked
		1	Locked
b2 to b8	RFU	0	

G.5.4 Overall protocol description

Protocol concept

The transmission protocol defines the mechanism to exchange instructions and data between the interrogator and the RF tag, in both directions.

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

This means that any RF tag shall not start transmitting (i.e. modulating according to clause G.3.5) unless it has received and properly decoded an instruction sent by the interrogator.

a) the protocol is based on an exchange of

- a request from the interrogator to the RF tag
- a response from the RF tag(s) to the interrogator

The conditions under which the RF tag sends a response are defined in clause G.8.3.

b) each request and each response are contained in a frame. The frame delimiters (SOF, EOF) are specified in clause G.3.1.3 and clause G.3.2.3

c) each request consists of the following fields:

- Flags
- Command code
- Mandatory and optional parameters fields, depending on the command
- Application data fields
- CRC

d) each response consists of the following fields:

- Flags

- Mandatory and optional parameters fields, depending on the command
- Application data fields
- CRC

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.

e) a single-byte field is transmitted least significant bit (LSBit) first.

f) a multiple-byte field is transmitted least significant byte (LSByte) first, each byte is transmitted least significant bit (LSBit) first.

g) 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.

h) RFU flags shall be set to zero (0).

G.5.5 Modes

NOTE: The use of the term mode is a direct continuance of its use in ISO/IEC 15693, and as this MODE of ISO/IEC 18000-3 is compatible with ISO?IEC 15693, the word mode has been retained in Clause G.2.2.5. The interrogator/reader should note therefore that the terms MODE and mode have different meaning.

In this Clause (G.5.5) the term *mode* (lower case italics) refers to the mechanism to specify in a request the set of RF tag's that shall answer to the request.

G.5.5.1 Addressed *mode*

When the Address_flag is set to 1 (addressed mode), the request shall contain the unique ID (UID) of the addressed RF tag.

Any RF tag receiving a request with the Address_flag set to 1 shall compare the received unique ID (address) to its own ID.

If it matches, it shall execute it (if possible) and return a response to the interrogator as specified by the command description.

If it does not match, it shall remain silent.

G.5.5.2 Non-addressed *mode*

When the Address_flag is set to 0 (non-addressed mode), the request shall not contain a unique ID.

Any RF tag receiving a request with the Address_flag set to 0 shall execute it (if possible) and shall return a response to the interrogator as specified by the command description.

G.5.5.3 Select *mode*

When the Select_flag is set to 1 (select mode), the request shall not contain a RF tag unique ID.

The RF tag in the selected state receiving a request with the Select_flag set to 1 shall execute it (if possible) and shall return a response to the interrogator as specified by the command description.

Only the RF tag in the selected state shall answer to a request having the select flag set to 1.

G.5.5.3.1 Request format

The request consists of the following fields:

- Flags
- Command code (see clause G.8)
- Parameters and data fields
- CRC (see clause G.5.1.4)

SOF	Flags	Command code	Parameters	Data	CRC	EOF

Figure G.21 — General request format

G.5.5.3.2 Request flags

In a request, the field "flags" specifies the actions to be performed by the RF tag and whether corresponding fields are present or not.

It consists of eight bits.

Table G.6 — Request flags 1 to 4 definition

Bit	Flag name	Value	Description
b1	Sub-carrier_flag	0	A single sub-carrier frequency shall be used by the RF tag
		1	Two sub-carriers shall be used by the RF tag
b2	Data_rate_flag	0	Low data rate shall be used
		1	High data rate shall be used
b3	Inventory_flag	0	Flags 5 to 8 meaning is according to Table G.7
		1	Flags 5 to 8 meaning is according to Table G.8
b4	Protocol Extension_flag	0	No protocol format extension
		1	Protocol format is extended. Protocol is extended as described in 6.1.9.

Note: 1. Sub-carrier_flag refers to the RF tag-to-interrogator communication as specified in clause G.7

2. Data_rate_flag refers to the RF tag-to-interrogator communication as specified clause G.7.2

Table G.7 — Request flags 5 to 8 definition when inventory flag is NOT set

Bit	Flag name	Value	Description
b5	Select_flag	0	Request shall be executed by any RF tag according to the setting of Address_flag
		1	Request shall be executed only by RF tag in selected state. The Address_flag shall be set to 0 and the UID field shall not be included in the request.
b6	Address_flag	0	Request is not addressed. UID field is not included. It shall be executed by any RF tag.
		1	Request is addressed. UID field is included. It shall be executed only by the RF tag whose UID matches the UID specified in the request.
b7	Option_flag	0	Meaning is defined by the command description. It shall be set to 0 if not otherwise defined by the command.
		1	Meaning is defined by the command description.
b8	RFU	0	

Table G.8 — Request flags 5 to 8 definition when inventory flag is set

Bit	Flag name	Value	Description
b5	Afi_flag	0	Afi field is not present
		1	Afi field is present
b6	Nb_slots_flag	0	16 slots
		1	1 slot
b7	Option_flag	0	Meaning is defined by the command description. It shall be set to 0 if not otherwise defined by the command.
		1	Meaning is defined by the command description.
b8	RFU	0	

G.5.6 Response format

The response consists of the following fields:

- Flags
- one or more parameter fields
- Data
- CRC (see clause G.5.1.4)

SOF	Flags	Parameters	Data	CRC	EOF

Figure G.22 — General response format

G.5.6.1 Response flags

In a response, it indicates how actions have been performed by the RF tag and whether corresponding fields are present or not.

It consists of eight bits.

Table G.9 — Response flags 1 to 8 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	
b3	RFU	0	
b4	Extension_flag	0	No protocol format extension.
		1	Protocol format is extended.
b5	RFU	0	Reserved for future use.
b6	RFU	0	Reserved for future use.
b7	RFU	0	Reserved for future use.
b8	RFU	0	Reserved for future use.

G.5.6.2 Response error code

When the Error_flag is set by the RF tag, the error code field shall be included and provides information about the error that occurred. Error codes are defined in Table G.10

If the RF tag does not support specific error code(s) listed in Table G.10, it shall answer with the error code '0F' ("Error with no information given").

Table G.10 — Response error code definition

Error code	Meaning
'01'	The command is not supported, i.e. the request code is not recognised.
'02'	The command is not recognised, for example: a format error occurred.
'03'	The command option is not supported.
'0F'	Error with no information given or a specific error code is not supported.
'10'	The specified block is not available (doesn't exist).
'11'	The specified block is already -locked and thus cannot be locked again
'12'	The specified block is locked and its content cannot be changed.
'13'	The specified block was not successfully programmed.
'14'	The specified block was not successfully locked.
'A0' – 'DF'	Custom command error codes
all others	RFU

G.5.7 RF tag states

An RF tag can be in one of the 4 following states:

- Power-off
- Ready
- Quiet
- Selected

The transition between these states is specified in Figure G.17.

The support of power-off, ready and quiet states is mandatory.

The support of selected state is optional.

G.5.7.1 Power-off state

The RF tag is in the power-off state when it cannot be activated by the interrogator.

G.5.7.2 Ready state

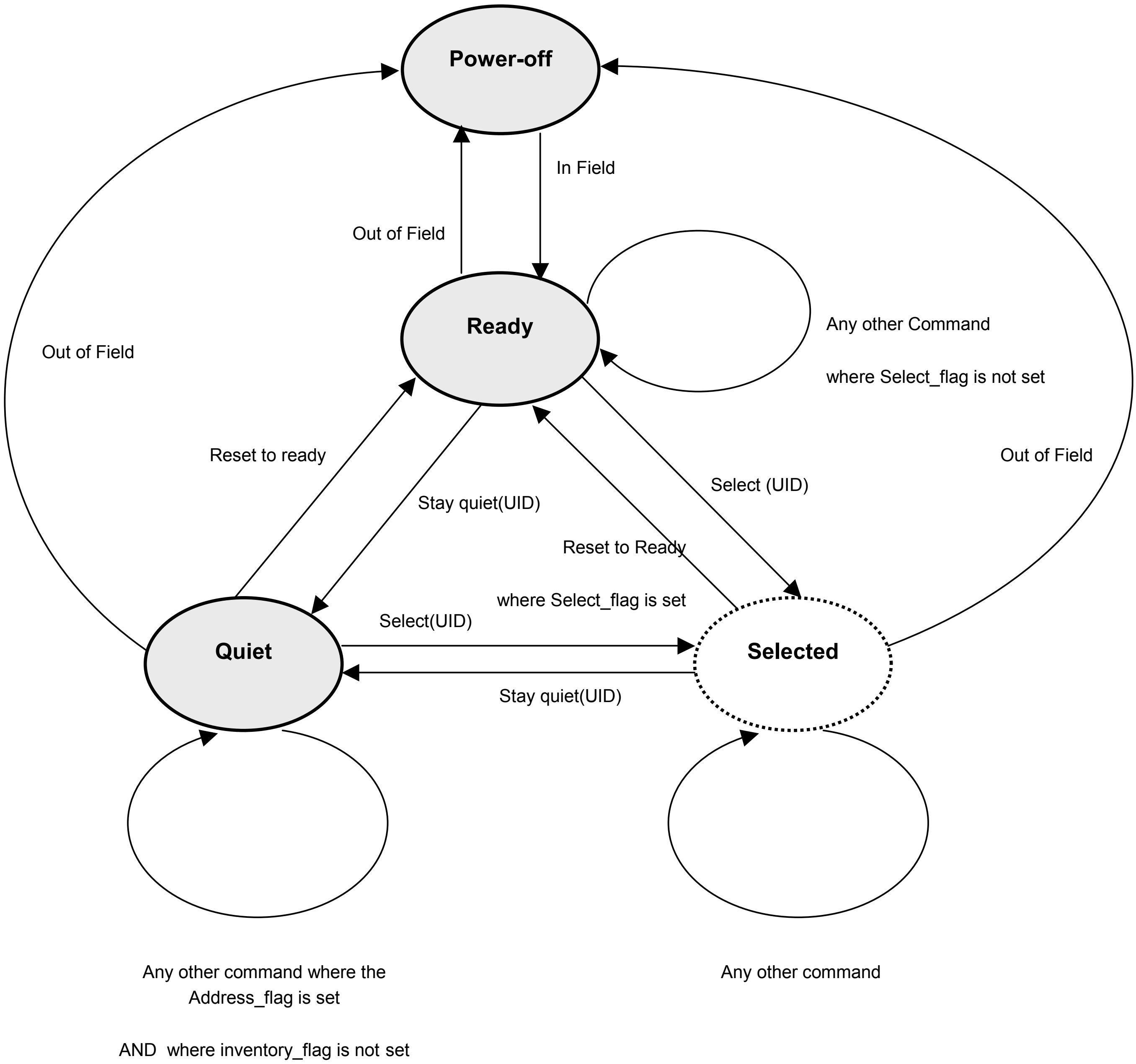
The RF tag is in the ready state when it is activated by the interrogator. It shall process any request where the select flag is not set.

G.5.7.3 Quiet state

When in the quiet state, the RF tag shall process any request where the inventory_flag is not set and where the Address_flag is set.

G.5.7.4 Selected state

Only an RF tag in the selected state shall process requests having the Select_flag set.



NOTE 1 The intention of the state transition method is that only one RF tag should be in the Selected state at a time.

NOTE 2 The RF tag state transition diagram shows only valid transitions. In all other cases the current RF tag state remains unchanged. When the RF tag cannot process a interrogator request (e.g. CRC error etc...), it shall stay in its current state.

NOTE 3 The Selected state is represented with a dotted line to show its support by the RF tag is optional.

Figure G.23 — RF tag state transition diagram

G.6 Collision management

Table G.11 — MODE 1: Table of Collision management Parameters

Ref.	Parameter	Description/limits	Comment/Options
M1-A: 1	**Type (probabilistic or deterministic)**	Deterministic Protocol Extension: Probabilistic	
M1-A: 2	**Linearity**	Yes Protocol Extension : Yes to 500 tags. Not linear above 500 tags in interrogation zone.	
M1-A: 3	**Tag inventory capacity**	2 exp. 64 Protocol Extension : 2 exp. 64	
M1-A: 4	**Request parameters**	When issuing the inventory command, the interrogator shall: • Set the Nb_slots_flag to the desired setting, • Add after the command Field the Mask Length and the Mask Value, • See Figure G.18	
M1-A: 5	**Timing**	See clause G.7.4.	
M1-A: 6	**Mask value**	• Mask Value is contained in an integer number of bytes. However, the number of significant bits is indicated by the Mask Length. LSB shall be transmitted first. It shall be padded with nulls till the next byte boundary. • The next field starts on the next byte boundary	
M1-A: 7	**Afi field**	The Afi field may also be present in the request directly following the command code (if the Afi_flag is set). •	
M1-A: 8	**Rules and restrictions**	• If no tag answer is detected the interrogator may switch to the next slot by sending an EOF • If one or more TAG answers are received, the interrogator shall wait until the tag frames are completely received before sending an EOF for switching to the next slot • The timing is described in clause G.7.4.	

Ref.	Parameter	Description/limits	Comment/Options

M1-A: 9	**Request processing by the tag**	Upon reception of a valid request, the tag shall perform the following algorithm NbS is the total number of slots (1 or 16)
		SN is the current slot number (0 to 15)
		LSB (value, n) function returns the n less significant bits of value
		MSB (value, n) function returns the n most significant bits of value
		"&" is the concatenation operator
		Slot_Frame is either a SOF or an EOF
		
		SN= 0
		if Nb_slots_flag then NbS =1
		SN_length=0
		else NbS = 16 SN_length=4
		endif
		label1:if LSB(MFR Tag ID, SN_length + Mask_Length) = LSB(SN,SN_length) & MSB(Mask, Mask_Length then
		transmit response to inventory request
		endif
		wait (Slot_Frame)
		if Slot_Frame=SOF then
		Stop Collision Management and decode/process request
		exit
		endif
		if SN < NbS-1 then
		SN = SN +1
		goto label1
		exit
		endif
		exit	

Ref.	Parameter	Description/limits	Comment/Options
M1-A: 10	**Commands**	Four sets of commands are defined: • **Mandatory** 01 to 1F all tags shall support them **Optional** 20 to 9F Tags may support them, at their option. If supported, request and response formats shall comply with the definition given in this part of ISO/IEC 18000. If the RF tag does not support an optional command and if the Address_flag or the Select_flag is set, it may return an error code ("Not supported") or remain silent. If neither the Address_flag nor the Select_flag is set, the RF tag shall remain silent. If a command has different options they may be supported by the RF tag otherwise an error code shall be returned. **Custom** A0 to DF tags support them, 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 customized are the Physical 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 RF tag does not support a custom command and if the Address_flag or the Select_flag is set, it may return an error code ("Not supported") or remain silent. If neither the Address_flag nor the Select_flag is set, the RF tag shall remain silent. If a command has different options they may be supported by the RF tag otherwise an error code shall be returned. • **Proprietary** E0 to FF these commands are used by IC and tag manufacturers for different 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. It is likely that these commands will be disabled after IC and/or tag manufacturing. All tags with the same IC Manufacturer code and same IC Version number shall behave the same.	**Comment** the timing issues (write/programming time) are not covered in this part of ISO/IEC 18000 and need to be completed either by an extension to this part of ISO/IEC 18000 or in the subsequent Application Standards. ***Comment*** *It is highly desirable that Custom commands are kept to a minimum.* ***Comment*** *The attention of interrogator designers is drawn on the possibility that tag manufacturers may implement custom commands in quite different ways for the same command code, which may lead to errors whose consequences cannot be predicted. It is therefore recommended that custom commands are performed only after having requested from the tag the IC Manufacturer code and the IC version. These two items of information, linked with the IC manufacturer information, will inform the interrogator on the supported commands and their syntax* ***End comment***

Ref.	Parameter	Description/limits	Comment/Options
M1-A: 11	**Response error code**	If the Error Flag is set by the tag in the response, the Error code field is present and provides information about the error that occurred. The following error codes are specified. Other codes are reserved for future use. 0x01 The command is not supported, i.e. the request code is not recognized. 0x02 The command is not recognized, for example: a format error occurred 0x03 The command option is not supported 0x0F Error with no information given or a specific error code is not supported 0x10 The specified block is not available (doesn't exist). 0x11 The specified block is already -locked and thus cannot be locked again. 0x12 The specified block is locked and its content cannot be changed. 0x13 The specified block was not successfully programmed. 0x14 The specified block was not successfully locked. . "A0"-"DF" Custom command error codes all others RFU	
M1- A: 12	Mandatory commands	**Mandatory commands are :** **:Inventory** **:Stay quiet** **:**	
M1- A: 12a	Inventory	When receiving the inventory request, the tag shall perform the collision management sequence. The response contains: • the Data Storage Format ID • the Unique ID, containing ➢ "E0" ➢ the IC manufacturer code ➢ the IC serial number If the tag detects an error, it shall remain silent.	***NOTE :*** *The MFR Tag ID is programmed by the IC manufacturer.*

Ref.	Parameter	Description/limits	Comment/Options
M1- A: 12b	Stay quiet	Upon execution of this command, the tag shall enter the quiet state and shall not send back a response. There is no response to the Stay quiet command When in quiet state: • the tag shall not process any request where inventory_flag is set • the tag shall process any addressed request. The tag shall exit the quiet state when: • reset (power off) when receiving a Select request It shall then go to the selected state if supported or return an error if not supported • receiving a Reset to ready request. It shall then go to the ready state.	
M1- A: 14	**Use of Manufacturers identity in collision management loop**	The MFR Tag ID is used for addressing each interrogator uniquely and individually, during the collision management loop and for one-to-one exchange between an interrogator and a tag. • The protocol is based on an exchange of • a request from the interrogator to the tag • a response from the tag(s) to the interrogator • Each request and each response are contained in a "Frame". The Frame delimiters (SOF, EOF) are specified above • each request consists of the following fields: Flags Command code Mandatory and optional parameters fields, depending on the command Application data fields CRC each response consists of the following fields: Flags Mandatory and optional parameters fields, depending on the command Application data fields CRC The protocol is bit-oriented. The number of bits transmitted in a frame is a multiple of eight (8).	

G.7 Description of collision management operating method (Informative)

G.7.1 Request parameters

When issuing the iinventory command, the interrogator shall set the Nb_slots_flag to the desired setting and add after the command field the mask length and the mask value.

The mask length indicates the number of significant bits of the mask value. It can have any value between 0 and 60 when 16 slots are used and any value between 0 and 64 when 1 slot is used. LSB shall be transmitted first.

The mask value is contained in an integer number of bytes. LSB shall be transmitted first.

If the mask length is not a multiple of 8 (bits), the mask value MSB shall be padded with the required number of null (set to 0) bits so that the mask value is contained in an integer number of bytes.

The next field starts on the next byte boundary.

SOF	Flags	Command	Mask length	Mask value	CRC16	EOF
	8 bits	8 bits	8 bits	0 to 8 bytes	16 bits	

Figure G.24 — Inventory request format

MSB	LSB
0000	0100 1100 1111
Pad	Mask value

Figure G.25 — Example of the padding of the mask

In the example of the Figure G.25, the mask length is 12 bits. The mask value MSB is padded with four bits set to 0.

The Afi field shall be present if the Afi_flag is set.

The pulse shall be generated according to the definition of the EOF in Mode 1 of this part of ISO/IEC 18000-3.

The first slot starts immediately after the reception of the request EOF.

To switch to the next slot, the interrogator sends an EOF.

Rules and restrictions

The following rules and restrictions apply :

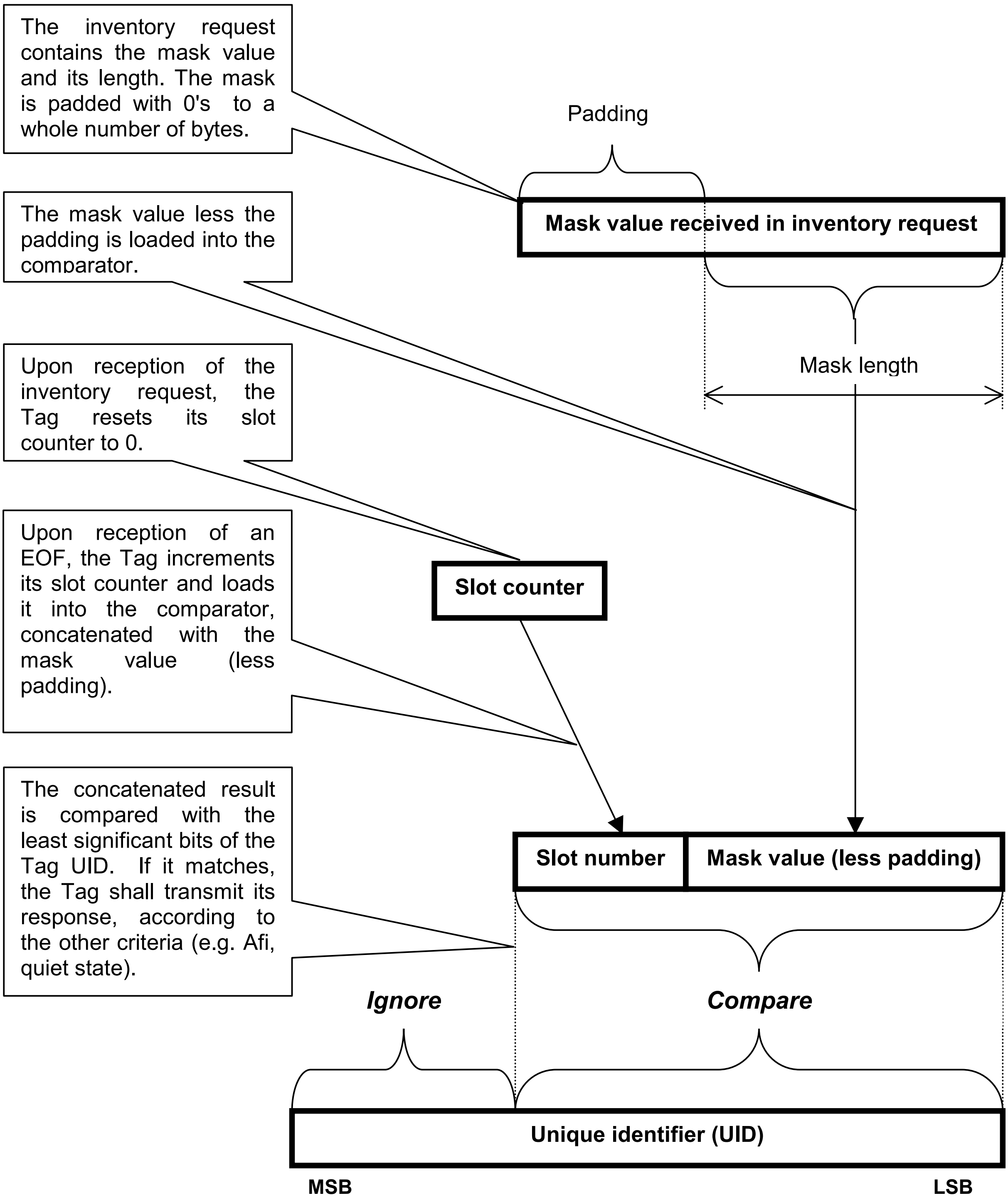
- If no tag answer is detected the interrogator may switch to the next slot by sending an EOF
- If one or more TAG answers are received, the interrogator shall wait until the tag frames are completely received before sending an EOF for switching to the next slot

The timing is specified in clause G.7.4.

G.7.2 Request processing by the RF tag

Upon reception of a valid request, the RF tag shall process it by executing the operation sequence specified in the following text in italics. The step sequence is also graphically represented in Figure G.26.

```
NbS is the total number of slots (1 or 16)
SN is the current slot number (0 to 15)
SN_length is set to 0 when 1 slot is used and set to 4 when 16 slots are used
LSB (value, n) function returns the n less significant bits of value
"&" is the concatenation operator
Slot_Frame is either a SOF or an EOF
     SN= 0
     if Nb_slots_flag    then
          NbS =1  SN_length=0
          else       NbS = 16      SN_length=4
     endif
label1:  if LSB(UID, SN_length + Mask_length) = LSB(SN, SN_length)&LSB(Mask, Mask_length) then
          transmit response to inventory request
     endif
     wait (Slot_Frame)
     if Slot_Frame= SOF then
          Stop Collision Management and decode/process request
          exit
     endif
     if SN<NbS-1 then
          SN = SN +1
          goto label1
          exit
     endif
     exit
```



NOTE When the slot number is 1 (Nb_slots_flag is set to 1), the comparison is made only on the mask (without padding).

Figure G.26 — Principle of comparison between the mask value, slot number and UID

G.7.3 Explanation of a collision management sequence

Figure G.27 summarises the main cases that can occur during a typical Collision Management sequence where the number of slots is 16.

The different steps are:

a) the interrogator sends an inventory request, in a frame, terminated by a EOF. The number of slots is 16.

b) RF tag 1 transmits its response in slot 0. It is the only one to do so, therefore no collision occurs and its UID is received and registered by the interrogator;

c) the interrogator sends an EOF, meaning to switch to the next slot.

d) in slot 1, two RF tags 2 and 3 transmits their response, this generates a collision. The interrogator detects it and remembers that a collision was detected in slot 1.

e) the interrogator sends an EOF, meaning to switch to the next slot.

f) in slot 2, no RF tag transmits a response. Therefore the interrogator does not detect a RF tag SOF and decides to switch to the next slot by sending a EOF.

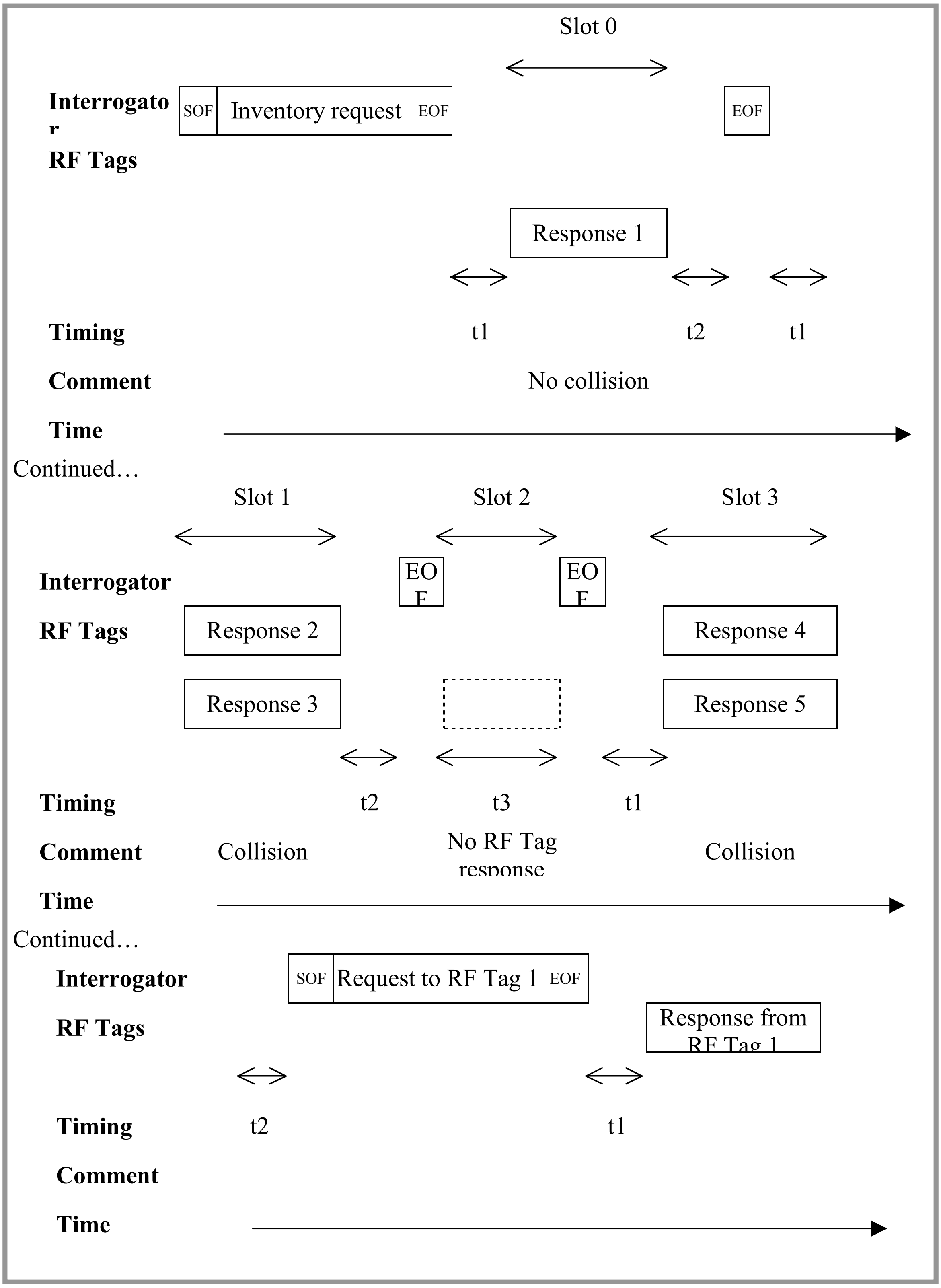
g) in slot 3, there is another collision caused by responses from RF tag 4 and 5

h) the interrogator then decides to send an addressed request (for instance a Read Block) to RF tag 1, which UID was already correctly received.

i) all RF tags detect a SOF and exit the Collision Management sequence. They process this request and since the request is addressed to RF tag 1, only RF tag1 transmit its response.

j) all RF tags are ready to receive another request. If it is an inventory command, the slot numbering sequence restarts from 0.

NOTE The decision to interrupt the Collision Management sequence is up to the interrogator. It could have continued to send EOF’s till slot 15 and then send the request to RF tag 1.



NOTE t1, t2 and t3 are specified in clause G.7.4.

Figure G.27 — Description of a possible collision management sequence

G.7.4 Timing specifications

The interrogator and the RF tag shall comply with the following timing specifications.

G.7.4.1 RF tag waiting time before transmitting its response after reception of an EOF from the interrogator

When the RF tag has detected an EOF of a valid interrogator request or when this EOF is in the normal sequence of a valid interrogator request, it shall wait for a time t1 before starting to transmit its response to a interrogator request or before switching to the next slot when in an inventory process (see clause G.7.2 and G.7.3)

t1 starts from the detection of the rising edge of the EOF received from the interrogator, (clause G.7.3).

NOTE The synchronisation on the rising edge of the interrogator-to-RF tag EOF is needed for ensuring the required synchronisation of the RF tag responses.

The minimum value of t1 is t1min= 4320/f_c (318,6µs)

The nominal value of t1 is t1nom= 4352/f_c (320,9µs)

The maximum value of t1 is t1max= 4384/f_c (323,3µs)

t1max does not apply for Write alike requests. Timing conditions for Write alike requests are defined in the command descriptions.

If the RF tag detects a carrier modulation during this time t1, it shall reset its t1 timer and wait for a further time t1 before starting to transmit its response to a interrogator request or to switch to the next slot when in an inventory process.

G.7.4.2 RF tag modulation ignore time after reception of an EOF from the interrogator

When the RF tag has detected an EOF of a valid interrogator request or when this EOF is in the normal sequence of a valid interrogator request, it shall ignore any received 10% modulation during a time $t_{mit.}$

t_{mit} starts from the detection of the rising edge EOF received from the interrogator (clause G.3.4.3).

The minimum value of t_{mit} is

$$t_{mit}\text{min} = 4384/f_c\,(323{,}3\mu s) + t_{nrt}$$

where

t_{nrt} is the nominal response time of a RF tag.

t_{nrt} is dependant on the RF tag-to-interrogator data rate and subcarrier modulation mode (see clauses G.7.2 and G.7.3).

NOTE The synchronisation on the rising edge of the interrogator-to-RF tag EOF is needed for ensuring the required synchronisation of the RF tag responses.

G.7.4.3 Interrogator waiting time before sending a subsequent request

a) When the interrogator has received a RF tag response to a previous request other than inventory and quiet, it shall wait a time t2 before sending a subsequent request. t2 starts from the time the EOF has been received from the RF tag.

b) When the interrogator has sent a quiet request (which causes no RF tag response), it shall wait a time t2 before sending a subsequent request. t2 starts from the end of the quiet request EOF (rising edge of the EOF plus 9,44µs, , clause G.3.3.3).

The minimum value of t2 is t2min = 4192/f_c (309,2µs).

NOTE 1 This ensures that the RF tags are ready to receive this subsequent request (see clause G.3.3).

NOTE 2 The interrogator should wait at least 1ms after it activated the powering field before sending the first request, to ensure that the RF tags are ready to receive it (see clause G.3.3).

c) When the interrogator has sent an inventory request, it is in an inventory process. See clause G.7.

G.7.4.4 Interrogator waiting time before switching to the next slot during an inventory process

An inventory process is started when the interrogator sends an inventory request. (see clauses G.7.2, G.7.3, G.7.3.1).

To switch to the next slot, the interrogator may send either a 10% or a 100% modulated EOF independent of the modulation index it used for transmitting its request to the RF tag, after waiting a time specified in clauses G.7.4.4.1 and G.7.4.4.2.

G.7.4.4.1 When the interrogator has started to receive one or more RF tag responses

During an inventory process, when the interrogator has started to receive one or more RF tag responses (i.e. it has detected a RF tag SOF and/or a collision), it shall

- wait for the complete reception of the RF tag responses (i.e. when a RF tag EOF has been received or when the RF tag nominal response time t_{nrt} has elapsed),
- wait an additional time t2
- and then send a 10% or 100% modulated EOF to switch to the next slot.

t2 starts from the time the EOF has been received from the RF tag (see, clauses G.7.3).

The minimum value of t2 is t2min = 4192/f_c (309,2µs).

t_{nrt} is dependant on the RF tag-to-interrogator data rate and subcarrier modulation mode, (clauses G.7.2 and G.7.3).

G.7.4.5 When the interrogator has received no RF tag response

During an inventory process, when the interrogator has received no RF tag response, it shall wait a time t3 before sending a subsequent EOF to switch to the next slot.

t3 starts from the time the interrogator has generated the rising edge of the last sent EOF.

a) If the interrogator sends a 100% modulated EOF, the minimum value of t3 is t3min = 4384/f_c (323,3µs) + t_{sof}

If the interrogator sends a 10% modulated EOF, the minimum value of t3 is t3min = 4384/f_c (323,3µs) + t_{nrt}

where

- t_{sof} is the time duration for a RF tag to transmit an SOF to the interrogator.
- t_{nrt} is the nominal response time of a RF tag.

t_{nrt} and t_{sof} are dependant on the RF tag-to-interrogator data rate and subcarrier modulation mode (see clauses G.7.2 and G.7.3).

G.8 Commands

G.8.1 Command types

Four sets of commands are defined: mandatory, optional, custom, proprietary.

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

G.8.1.1 Mandatory

The command codes range from '01' to '1F'.

All RF tags shall support them.

G.8.1.2 Optional

The command codes range from '20' to '9F'.

RF tags may support them, at their option. If supported, request and response formats shall comply with the definition given in this part of ISO/IEC 18000.

If the RF tag does not support an optional command and if the Address_flag or the Select_flag is set, it may return an error code ("Not supported") or remain silent. If neither the Address_flag nor the Select_flag is set, the RF tag shall remain silent.

If a command has different options they may be supported by the RF tag otherwise an error code shall be returned.

G.8.1.3 Custom

The command codes range from 'A0' to 'DF'.

RF tags support them, at their option, to implement manufacturer specific functions. The function of flags (including reserved bits) shall not be modified except the Option_flag. The only fields that can be customized 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 RF tag does not support a custom command and if the Address_flag or the Select_flag is set, it may return an error code ("Not supported") or remain silent. If neither the Address_flag nor the Select_flag is set, the RF tag shall remain silent.

If a command has different options they may be supported by the RF tag otherwise an error code shall be returned.

G.8.1.4 Proprietary

The command codes range from 'E0' to 'FF'.

These commands are used by IC and RF 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. It is allowed that these commands are disabled after IC and/or RF tag manufacturing.

G.8.2 Command codes

Table G.12 — Command codes

Command code	Type	Function
'01'	Mandatory	Inventory
'02'	Mandatory	Stay quiet
'03' – '1F'	Mandatory	RFU
'20'	Optional	Read single block
'21'	Optional	Write single block
'22'	Optional	Lock block
'23'	Optional	Read multiple blocks
'24'	Optional	Write multiple blocks
'25'	Optional	Select
'26'	Optional	Reset to ready
'27'	Optional	Write Afi
'28'	Optional	Lock Afi
'29'	Optional	Write DSFID
'2A'	Optional	Lock DSFID
'2B'	Optional	Get system information
'2C'	Optional	Get multiple block security status
'2D' – '9F'	Optional	RFU
'A0' – 'DF'	Custom	IC Mfg dependent
'E0' – 'FF'	Proprietary	IC Mfg dependent

G.8.3 Mandatory commands

G.8.3.1 Inventory

Command code = '01'

When receiving the inventory request, the RF tag shall perform the Collision Management sequence.

The request contains:

- The flags,
- The inventory command code
- The Afi if the Afi flag is set
- The mask length
- The mask value
- The CRC

The inventory_flag shall be set to 1.

The meaning of flags 5 to 8 is according to Table G.8

SOF	Flags	Inventory	Optional Afi	Mask length	Mask value	CRC16	EOF
	8 bits	8 bits	8 bits	8 bits	0 – 64 bits	16 bits	

Figure G.28 — Inventory request format

The response shall contain:

- The DSFID
- The unique ID

If the RF tag detects an error, it shall remain silent.

SOF	Flags	DSFID	UID	CRC16	EOF
	8 bits	8 bits	64 bits	16 bits	

Figure G.29 — Inventory response format

G.8.3.2 Stay quiet

Command code = '02'

When receiving the Stay quiet command, the RF tag shall enter the quiet state and shall NOT send back a response. There is NO response to the Stay quiet command.

When in quiet state:

- the RF tag shall not process any request where inventory_flag is set,

- the RF tag shall process any addressed request

The RF tag shall exit the quiet state when:

- reset (power off),

- receiving a Select request. It shall then go to the selected state if supported or return an error if not supported,

- receiving a Reset to ready request. It shall then go to the Ready state.

SOF	Flags	Stay quiet	UID	CRC16	EOF
	8 bits	8 bits	64 bits	16 bits	

Figure G.30 — Stay quiet request format

Request parameter:

UID (mandatory)

The Stay quiet command shall always be executed in Addressed mode (Select_flag is set to 0 and Address_flag is set to 1).

G.8.4 Optional commands

G.8.4.1 Read single block

Command code = '20'

When receiving the read single block command, the RF tag shall read the requested block and send back its value in the response.

If the Option_flag is set in the request, the RF tag shall return the block security status, followed by the block value.

If it is not set, the RF tag shall return only the block value.

SOF	Flags	Read single block	UID	Block number	CRC16	EOF
	8 bits	8 bits	64 bits	8 bits	16 bits	

Figure G.31 — Read single block request format

Request parameter:

(Optional) UID

Block number

SOF	Flags	Error code	CRC16	EOF
	8 bits	8 bits	16 bits	

Figure G.32 — Read single block response format when Error_flag is set

SOF	Flags	Block security status	Data	CRC16	EOF
	8 bits	8 bits	Block length	16 bits	

Figure G.33 — Read single block response format when Error_flag is NOT set

Response parameter:

Error_flag (and Error code if Error_flag is set)if Error_flag is not set

Block security status (if Option_flag is set in the request)

Block data

G.8.4.2 Write single block

Command code = '21'

When receiving the Write single block command, the RF tag shall write the requested block with the data contained in the request and report the success of the operation in the response.

If the Option_flag is not set, the RF tag shall return its response when it has completed the write operation starting after:

t1nom (4352/f_c (320,9µs), see clause G.7.4.1) + a multiple of 4096/f_c (302µs) with a total tolerance of +-32/f_c and latest after 20ms upon detection of the rising edge of the EOF of the interrogator request.

If it is set, the RF tag shall wait for the reception of an EOF from the interrogator and upon such reception shall return its response.

SOF	Flags	Write single block	UID	Block number	Data	CRC16	EOF
	8 bits	8 bits	64 bits	8 bits	Block length	16bits	

Figure G.34 — Write single block request format

Request parameter:

(Optional) UID

Block number

Data

SOF	Flags	Error code	CRC16	EOF
	8 bits	8 bits	16 bits	

Figure G.35 — Write single block response format when Error_flag is set

SOF	Flags	CRC16	EOF
	8 bits	16 bits	

Figure G.36 — Write Single block response format when Error_flag is NOT set

Response parameter:

Error_flag (and Error code if Error_flag is set)

G.8.4.3 Lock block

Command code = '22'

When receiving the Lock block command, the RF tag shall lock permanently the requested block.

If the Option_flag is not set, the RF tag shall return its response when it has completed the lock operation starting after:

t1nom ($4352/f_c$ (320,9µs), see clause G.7.4.1) + a multiple of $4096/f_c$ (302µs) with a total tolerance of $+-32/f_c$ and latest after 20ms upon detection of the rising edge of the EOF of the interrogator request.

If it is set, the RF tag shall wait for the reception of an EOF from the interrogator and upon such reception shall return its response.

SOF	Flags	Lock block	UID	Block number	CRC16	EOF
	8 bits	8 bits	64 bits	8 bits	16 bits	

Figure G.37 — Lock single block request format

Request parameter:

(Optional) UID

Block number

SOF	Flags	Error code	CRC16	EOF
	8 bits	8 bits	16 bits	

Figure G.38 — Lock block response format when Error_flag is set

SOF	Flags	CRC16	EOF
	8 bits	16 bits	

Figure G.39 — Lock block response format when Error_flag is NOT set

Response parameter:

Error_flag (and Error code if Error_flag is set)

G.8.4.4 Read multiple blocks

Command code = '23'

When receiving the read multiple block command, the RF tag shall read the requested block(s) and send back their value in the response.

If the Option_flag is set in the request, the RF tag shall return the block security status, followed by the block value sequentially block by block.

If the Option_flag is not set in the request, the RF tag shall return only the block value.

The blocks are numbered from '00' to 'FF' (0 to 255).

The number of blocks in the request is one less than the number of blocks that the RF tag shall return in its response.

E.g. a value of '06' in the "Number of blocks" field requests to read 7 blocks. A value of '00' requests to read a single block.

SOF	Flags	Read multiple block	UID	First block number	Number of blocks	CRC16	EOF
	8 bits	8 bits	64 bits	8 bits	8 bits	16 bits	

Figure G.40 — Read multiple blocks request format

Request parameter:

(Optional) UID

First block number

Number of blocks

SOF	Flags	Error code	CRC16	EOF
	8 bits	8 bits	16 bits	

Figure G.41 — Read multiple blocks response format when Error_flag is set

SOF	Flags	Block security status	Data	CRC16	EOF
	8 bits	8 bits	Block length	16 bits	
			Repeated as needed		

Figure G.42 — Read multiple block response format when Error_flag is NOT set

Response parameter:

Error_flag (and Error code if Error_flag is set)

if Error_flag is not set (the following order shall be respected in the RF tag response)

Block security status N (if Option_flag is set in the request)

Block value N

Block security status N+1 (if Option_flag is set in the request)

Block value N+1

etc…

where N is the first requested (and returned) block.

G.8.4.5 Write multiple blocks

Command code = '24'

When receiving the Write multiple block command, the RF tag shall write the requested block(s) with the data contained in the request and report the success of the operation in the response.

If the Option_flag is not set, the RF tag shall return its response when it has completed the write operation starting after:

t1nom ($4352/f_c$ (320,9µs), see clause G.7.4.1) + a multiple of $4096/f_c$ (302µs) with a total tolerance of $+-32/f_c$ and latest after 20ms upon detection of the rising edge of the EOF of the interrogator request.

If it is set, the RF tag shall wait for the reception of an EOF from the interrogator and upon such reception shall return its response.

The blocks are numbered from '00' to 'FF' (0 to 255).

The number of blocks in the request is one less than the number of blocks that the RF tag shall write.

Example: a value of '06' in the "Number of blocks" field requests to write 7 blocks. The "Data" field shall contain 7 blocks. A value of '00' in the "Number of blocks" field requests to write 1 block. The "Data" field shall contain 1 block.

SOF	Flags	Write multiple block	UID	First block number	Number of blocks	Data	CRC16	EOF
	8 bits	8 bits	64 bits	8 bits	8 bits	Block length	16 bits	
						Repeated as needed		

Figure G.43 — Write multiple blocks request format

Request parameter:

(Optional) UID

First block number

Number of blocks

Block data (repeated as defined in Figure G.44

SOF	Flags	Error code	CRC16	EOF
	8 bits	8 bits	16 bits	

Figure G.44 — Write multiple blocks response format when Error_flag is set

SOF	Flags	CRC16	EOF
	8 bits	16 bits	

Figure G.45 — Write multiple block response format when Error_flag is NOT set

Response parameter:

Error_flag (and Error code if Error_flag is set)

G.8.4.6 Select

Command code = '25'

When receiving the Select command:

- if the UID is equal to its own UID, the RF tag shall enter the selected state and shall send a response.
- if it is different, the RF tag shall return to the Ready state and shall not send a response. The Select command shall always be executed in Addressed mode. (The Select_flag is set to 0. The Address_flag is set to 1.)

SOF	Flags	Select	UID	CRC16	EOF
	8 bits	8 bits	64 bits	16 bits	

Figure G.46 — Select request format

Request parameter:

UID (mandatory)

SOF	Flags	Error code	CRC16	EOF
	8 bits	8 bits	16 bits	

Figure G.47 — Select response format when Error_flag is set

SOF	Flags	CRC16	EOF
	8 bits	16 bits	

Figure G.48 — Select block response format when Error_flag is NOT set

Response parameter:

Error_flag (and Error code if Error_flag is set)

G.8.4.7 Reset to ready

Command code = '26'

When receiving a Reset to ready command, the RF tag shall return to the Ready state.

SOF	Flags	Reset to ready	UID	CRC16	EOF
	8 bits	8 bits	64 bits	16 bits	

Figure G.49 — Reset to ready request format

Request parameter:

(Optional) UID

SOF	Flags	Error code	CRC16	EOF
	8 bits	8 bits	16 bits	

Figure G.50 — Reset to ready response format when Error_flag is set

SOF	Flags	CRC16	EOF
	8 bits	16 bits	

Figure G.51 — Reset to ready response format when Error_flag is NOT set

Response parameter:

Error_flag (and Error code if Error_flag is set)

G.8.4.8 Write Afi

Command code = '27'

When receiving the Write Afi request, the RF tag shall write the Afi value into its memory. If the Option_flag is not set, the RF tag shall return its response when it has completed the write operation starting after:

t1nom (4352/f_c (320,9µs), see clause G.7.4.1) + a multiple of 4096/f_c (302µs) with a total tolerance of +-32/f_c and latest after 20ms upon detection of the rising edge of the EOF of the interrogator request.

If it is set, the RF tag shall wait for the reception of an EOF from the interrogator and upon such reception shall return its response.

SOF	Flags	Write Afi	UID	Afi	CRC16	EOF
	8 bits	8 bits	64 bits	8 bits	16 bits	

Figure G.52 — Write Afi request format

Request parameter:

(Optional) UID

Afi

SOF	Flags	Error code	CRC16	EOF
	8 bits	8 bits	16 bits	

Figure G.53 — Write Afi response format when Error_flag is set

SOF	Flags	CRC16	EOF
	8 bits	16 bits	

Figure G.54 — Write Afi response format when Error_flag is NOT set

Response parameter:

Error_flag (and Error code if Error_flag is set)

G.8.4.9 Lock Afi

Command code = '28'

When receiving the Lock Afi request, the RF tag shall lock the Afi value permanently into its memory.

If the Option_flag is not set, the RF tag shall return its response when it has completed the lock operation starting after:

t1nom ($4352/f_c$ (320,9µs), see clause G.7.4.1) + a multiple of $4096/f_c$ (302µs) with a total tolerance of $+-32/f_c$ and latest after 20ms upon detection of the rising edge of the EOF of the interrogator request.

If it is set, the RF tag shall wait for the reception of an EOF from the interrogator and upon such reception shall return its response.

SOF	Flags	Lock Afi	UID	CRC16	EOF
	8 bits	8 bits	64 bits	16 bits	

Figure G.55 — Lock Afi request format

Request parameter:

(Optional) UID

SOF	Flags	Error code	CRC16	EOF
	8 bits	8 bits	16 bits	

Figure G.56 — Lock Afi response format when Error_flag is set

SOF	Flags	CRC16	EOF
	8 bits	16 bits	

Figure G.57 — Lock Afi response format when Error_flag is NOT set

Response parameter:

Error_flag (and Error code if Error_flag is set)

G.8.4.10 Write DSFID command

Command code = '29'

When receiving the Write DSFID request, the RF tag shall write the DSFID value into its memory.

If the Option_flag is not set, the RF tag shall return its response when it has completed the write operation starting after:

t1nom (4352/f_c (320,9µs), see clause G.7.4.1) + a multiple of 4096/f_c (302µs) with a total tolerance of +-32/f_c and latest after 20ms upon detection of the rising edge of the EOF of the interrogator request.

If it is set, the RF tag shall wait for the reception of an EOF from the interrogator and upon such reception shall return its response.

SOF	Flags	Write DSFID	UID	DSFID	CRC16	EOF
	8 bits	8 bits	64 bits	8 bits	16 bits	

Figure G.58 — Write DSFID request format

Request parameter:

(Optional) UID

DSFID

SOF	Flags	Error code	CRC16	EOF
	8 bits	8 bits	16 bits	

Figure G.59 — Write DSFID response format when Error_flag is set

SOF	Flags	CRC16	EOF
	8 bits	16 bits	

Figure G.60 — Write DSFID response format when Error_flag is NOT set

Response parameter:

Error_flag (and Error code if Error_flag is set)

G.8.4.11 Lock DSFID

Command code = '2A'

When receiving the Lock DSFID request, the RF tag shall lock the DSFID value permanently into its memory.

If the Option_flag is not set, the RF tag shall return its response when it has completed the lock operation starting after:

t1nom ($4352/f_c$ (320,9µs), see clause G.7.4.1) + a multiple of $4096/f_c$ (302µs) with a total tolerance of $+-32/f_c$ and latest after 20ms upon detection of the rising edge of the EOF of the interrogator request.

If it is set, the RF tag shall wait for the reception of an EOF from the interrogator and upon such reception shall return its response.

SOF	Flags	Lock DSFID	UID	CRC16	EOF
	8 bits	8 bits	64 bits	16 bits	

Figure G.61 — Lock DSFID request format

Request parameter:

(Optional) UID

SOF	Flags	Error code	CRC16	EOF
	8 bits	8 bits	16 bits	

Figure G.62 — Lock DSFID response format when Error_flag is set

SOF	Flags	CRC16	EOF
	8 bits	16 bits	

Figure G.63 — Lock DSFID response format when Error_flag is NOT set

Response parameter:

Error_flag (and Error code if Error_flag is set)

G.8.4.12 Get system information

Command code = '2B'

This command allows for retrieving the system information value from the RF tag.

SOF	Flags	Get system info	UID	CRC16	EOF
	8 bits	8 bits	64 bits	16 bits	

Figure G.64 — Get system information request format

Request parameter:

(Optional) UID

SOF	Flags	Error code	CRC16	EOF
	8 bits	8 bits	16 bits	

Figure G.65 — Get system information response when Error_flag is set

SOF	Flags	Info flags	UID	DSFID	Afi	Other fields	CRC16	EOF
	8 bits	8 bits	64 bits	8 bits	8 bits	See below	16 bits	

Figure G.66 — Get system information response format when Error_flag is NOT set

Response parameter:

Error_flag (and Error code if Error_flag is set)

if Error_flag is not set

Information flag

UID (mandatory)

Information fields, in the order of their corresponding flag, as defined in Figure G.51 and Table G.3, if their corresponding flag is set.

Table G.13 — Information flags definition

Bit	Flag name	Value	Description
b1	DSFID	0	DSFID is not supported. DSFID field is not present
		1	DSFID is supported. DSFID field is present
b2	Afi	0	Afi is not supported. Afi field is not present
		1	Afi is supported. Afi field is present
b3	RF tag memory size	0	Information on RF tag memory size is not supported. Memory size field is not present.
		1	Information on RF tag memory size is supported. Memory size field is present.
b4	IC reference	0	Information on IC reference is not supported. IC reference field is not present.
		1	Information on IC reference is supported. IC reference field is present.
b5	RFU	0	
b6	RFU	0	
b7	RFU	0	
b8	RFU	0	

Table G.14 — RF tag memory size Information

MSB		LSB
16 14	13 9	8 1
RFU	Block size in bytes	Number of blocks

Block size is expressed in number of bytes on 5 bits, allowing to specify up to 32 bytes i.e. 256 bits. It is one less than the actual number of bytes. E.G. a value of '1F' indicates 32 bytes, a value of '00' indicates 1 byte.

Number of blocks is on 8 bits, allowing to specify up to 256 blocks. It is one less than the actual number of blocks. E.g. a value of 'FF' indicates 256 blocks, a value of '00' indicates 1 block.

The three most significant bits are reserved for future use and shall be set to zero.

The IC reference is on 8 bits and its meaning is defined by the IC manufacturer.

G.8.4.13 Get multiple block security status

Command code = '2C'

When receiving the Get multiple block security status command, the RF tag shall send back the block security status.

The blocks are numbered from '00 to 'FF' (0 to 255).

The number of blocks in the request is one less than the number of block security status that the RF tag shall return in its response.

E.g. a value of '06' in the "Number of blocks" field requests to return 7 Block security status. A value of '00' in the "Number of blocks" field requests to return a single Block security status.

SOF	Flags	Get multiple block security status	UID	First block number	Number of blocks	CRC16	EOF
	8 bits	8 bits	64 bits	8 bits	8 bits	16 bits	

Figure G.67 — Get multiple block security status request format

Request parameter:

(Optional) UID

First block number

Number of blocks

SOF	Flags	Error code	CRC16	EOF
	8 bits	8 bits	16 bits	

Figure G.68 — Get multiple block security status response format when Error_flag is set

SOF	Flags	Block security status	CRC16	EOF
	8 bits	8 bits	16 bits	
		Repeated as needed		

Figure G.69 — Get multiple block security status response format when Error_flag is NOT set

Response parameter:

Error_flag (and Error code if Error_flag is set)

if Error_flag is not set

Block security status (repeated as per Figure G.69)

G.8.5 Custom commands

The format of custom command is generic and allows unambiguous attribution of custom command codes to each RF tag manufacturer.

The custom command code is the combination of a custom command code and of the RF tag manufacturer code.

The custom request parameters definition is the responsibility of the RF tag manufacturer.

SOF	Flags	Custom	IC Mfg code	Custom request parameters	CRC16	EOF
	8 bits	8 bits	8 bits	Custom defined	16 bits	

Figure G.70 — Custom request format

Request parameter:

IC manufacturer code according to ISO/IEC 7816-6.

SOF	Flags	Error code	CRC16	EOF
	8 bits	8 bits	16 bits	

Figure G.71 — Custom response format when Error_flag is set

SOF	Flags	Custom response parameters	CRC16	EOF
	8 bits	Custom defined	16 bits	

Figure G.72 — Custom response format when Error_flag is NOT set

Response parameter:

Error_flag (and code if Error_flag is set)

if Error_flag is not set

Custom parameters

G.8.6 Proprietary commands

The format of these commands is not defined in this part of ISO/IEC 18000.

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