Specification for RFID Air Interface

EPC™ Radio-Frequency Identity Protocols
Class-1 Generation-2 UHF RFID
Conformance Requirements
Version 1.0.2

Contents

Foreword

This document specifies the requirements for a Class-1 radio-frequency identification (RFID) Tag or Interrogator to be certified as conformant to the *EPCglobal™ Class-1 Generation-2 UHF RFID Protocol for Communications at 860 MHz – 960 MHz* (**the Protocol**), where compliance, conformance, and certification shall have the following meanings:

Compliance

Suitability of products, processes, or services, for use together, under specified conditions, without causing unacceptable interactions, in fulfillment of the requirements of a protocol.

Conformance

Fulfillment by a product, process, or service of the specified compliance requirements.

Certification

Measurement of a product, process, or service to ensure conformance.

Introduction

This document specifies the compliance requirements for a passive-backscatter, Interrogator-talks-first (ITF), radio-frequency identification (RFID) system operating in the 860 MHz – 960 MHz frequency range. The system comprises Interrogators, also known as Readers, and Tags, also known as Labels.

An Interrogator transmits information to a Tag by modulating an RF signal in the 860 MHz – 960 MHz frequency range. The Tag receives both information and operating energy from this RF signal. Tags are passive, meaning that they receive all of their operating energy from the Interrogator's RF waveform.

An Interrogator receives information from a Tag by transmitting a continuous-wave (CW) RF signal to the Tag; the Tag responds by modulating the reflection coefficient of its antenna, thereby backscattering an information signal to the Interrogator. The system is ITF, meaning that a Tag modulates its antenna reflection coefficient with an information signal only after being directed to do so by an Interrogator.

Interrogators and Tags are not required to talk simultaneously; rather, communications are half-duplex, meaning that Interrogators talk and Tags listen, or vice versa.

1. Scope

This document specifies:

- Compliance requirements for physical interactions (the signaling layer of the communications) between Interrogators and Tags, and
- Compliance requirements for Interrogator and Tag operating procedures and commands.

2. Conformance

2.1 Claiming conformance

A device shall not claim conformance with this document unless certified, in writing, by EPCglobal, Inc., or one of its designated representatives. To conform, a device shall comply with all clauses in this document (except those marked as optional) and all local radio regulations. Conformance may also require a license from the owner of any intellectual property utilized by said device.

2.2 General conformance requirements

2.2.1 Interrogators

To conform to the Protocol, an Interrogator shall:

- Meet the requirements of the Protocol,
- Implement the mandatory commands defined in the Protocol,
- Modulate/transmit and receive/demodulate a sufficient set of the electrical signals defined in the signaling layer of the Protocol to communicate with conformant Tags, and
- Conform to all local radio regulations.

To conform to the Protocol, an Interrogator may:

- Implement any subset of the optional commands defined in the Protocol, and
- Implement any proprietary and/or custom commands in conformance with the Protocol.

To conform to the Protocol, an Interrogator shall not:

- Implement any command that conflicts with the Protocol, or
- Require using an optional, proprietary, or custom command to meet the requirements of the Protocol.

2.2.2 Tags

To conform to the Protocol, a Tag shall:

- Meet the requirements of the Protocol,
- Implement the mandatory commands defined in the Protocol,
- Modulate a backscatter signal only after receiving the requisite command from an Interrogator, and
- Conform to all local radio regulations.

To conform to the Protocol, a Tag may:

- Implement any subset of the optional commands defined in the Protocol, and
- Implement any proprietary and/or custom commands as defined in 2.3.3 and 2.3.4, respectively.

To conform to the Protocol, a Tag shall not:

- Implement any command that conflicts with the Protocol,
- Require using an optional, proprietary, or custom command to meet the requirements of the Protocol, or
- Modulate a backscatter signal unless commanded to do so by an Interrogator using the signaling layer defined in the Protocol.

2.3 Command structure and extensibility

Subclause 6.3.2.10 of the Protocol defines the structure of the command codes used by Interrogators and Tags, as well as the availability of future extensions. Each command is defined and labeled as mandatory or optional.

2.3.1 Mandatory commands

Conforming Tags and Interrogators shall support all mandatory commands.

2.3.2 Optional commands

Conforming Interrogators may or may not support optional commands. Conforming Tags may or may not support optional commands. If an Interrogator or a Tag implements an optional command, it shall implement it in the manner specified.

2.3.3 Proprietary commands

Proprietary commands may be enabled in conformance with the Protocol, but are not specified in the Protocol. All proprietary commands shall be capable of being permanently disabled. Proprietary commands are intended for manufacturing purposes and shall not be used in field-deployed RFID systems.

2.3.4 Custom commands

Custom commands may be enabled in conformance with the Protocol, but are not specified in the Protocol. An Interrogator shall issue a custom command only after singulating a Tag and reading (or having prior knowledge of) the Tag manufacturer's identification in the Tag's TID memory. An Interrogator shall use a custom command only in accordance with the specifications of the Tag manufacturer identified in the TID.

3. Normative references

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

EPCglobal™: *EPC™ Radio-Frequency Identity Protocols, Class-1 Generation-2 UHF RFID, Protocol for Communications at 860 MHz – 960 MHz, Version 1.0.9*

EPCglobal™: *EPC™ Tag Data Standards*

EPCglobal™ (2004): *FMCG RFID Physical Requirements Document (draft)*

EPCglobal™ (2004): *Class-1 Generation-2 UHF RFID Implementation Reference (draft)*

European Telecommunications Standards Institute (ETSI), EN 302 208: *Electromagnetic compatibility and radio spectrum matters (ERM) – Radio-frequency identification equipment operating in the band 865 MHz to 868 MHz with power levels up to 2 W, Part 1 – Technical characteristics and test methods*

European Telecommunications Standards Institute (ETSI), EN 302 208: *Electromagnetic compatibility and radio spectrum matters (ERM) – Radio-frequency identification equipment operating in the band 865 MHz to 868 MHz with power levels up to 2 W, Part 2 – Harmonized EN under article 3.2 of the R&TTE directive*

ISO/IEC Directives, Part 2: *Rules for the structure and drafting of International Standards*

ISO/IEC 3309: *Information technology – Telecommunications and information exchange between systems – High-level data link control (HDLC) procedures – Frame structure*

ISO/IEC 15961: *Information technology, Automatic identification and data capture – Radio frequency identification (RFID) for item management – Data protocol: application interface*

ISO/IEC 15962: *Information technology, Automatic identification and data capture techniques – Radio frequency identification (RFID) for item management – Data protocol: data encoding rules and logical memory functions*

ISO/IEC 15963: *Information technology — Radiofrequency identification for item management — Unique identification for RF tags.*

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

ISO/IEC 18000-6: *Information technology automatic identification and data capture techniques — Radio frequency identification for item management air interface — Part 6: Parameters for air interface communications at 860–960 MHz*

ISO/IEC 19762: *Information technology AIDC techniques – Harmonized vocabulary – Part 3: radio-frequency identification (RFID)*

U.S. Code of Federal Regulations (CFR), Title 47, Chapter I, Part 15: *Radio-frequency devices, U.S. Federal Communications Commission*

4. Terms and definitions

The principal terms and definitions used in this document are described in the Protocol and in ISO/IEC 19762.

4.1 Additional terms and definitions

Terms and definitions specific to this document that supersede any normative references are as follows:

- **By design**

  Design parameters and/or theoretical analysis that ensure compliance. A vendor submitting a component or system for compliance testing shall provide the necessary technical information, in the form of a technical memorandum or similar. A test laboratory approved by EPCglobal™ shall certify the technical analysis as being sufficient to ensure conformance of the component or system.

  For Protocol requirements that are verified **by design**, the method of technical analysis is at the discretion of the submitting vendor and, except in special cases, is not specified by this document. In general, the technical analysis shall have sufficient rigor and technical depth to convince a test engineer knowledgeable of the Protocol that the particular requirement has been met.

- **By demonstration**

  Laboratory testing of one, or if required for statistical reasons multiple, products, processes, or services to ensure compliance. A test laboratory certified by EPCglobal™ shall perform the indicated testing to ensure conformance of the component or system.

  For Protocol requirements that are verified **by demonstration**, the test conditions are specified by this document. The detailed test plan is at the discretion of the certifying test laboratory.

  Interrogators submitted for testing purposes shall include physical connections and test modes suitable for the certifying laboratory to evaluate Interrogator performance under the test conditions specified in this document.

  Tags submitted for testing purposes shall include all documentation required by 6.3.1.3.5 of the Protocol. The minimum sample size shall be 100 Tags. The certifying laboratory's test plan will specify the submitted Tags' memory contents (i.e. the contents of Reserved, EPC, TID, and User memory as well as the lock status of these memory banks).

- **As implemented**

  If a Tag or Interrogator implements a subset of the Protocol, compliance shall be verified over the subset actually implemented. For example, although Interrogators may implement DSB-ASK, SSB-ASK, or PR-ASK modulation, a manufacturer may choose to only implement DSB-ASK modulation, in which case compliance testing shall only use DSB-ASK modulation. For parameters that are continuously variable, compliance shall be verified at the minimum and maximum values of the implemented range, unless the test conditions specifically state otherwise.

5. Symbols, abbreviated terms, and notation

The principal symbols and abbreviated terms used in this document are detailed in

- ISO/IEC 19762: *Information technology AIDC techniques – vocabulary*.
- *EPCglobal™: EPC™ Radio-Frequency Identity Protocols, Class-1 Generation-2 UHF RFID, Protocol for Communications at 860 MHz – 960 MHz, Version 1.0.9.*

Symbols, abbreviated terms, and notation specific to this document are as follows:

5.1 Symbols

None

5.2 Abbreviated terms

None

5.3 Notation

This document uses the following notational conventions:

- States and flags are denoted in bold. Example: **ready**.
- Commands are denoted in italics. Variables are also denoted in italics. Where there might be confusion between commands and variables, this specification will make an explicit statement. Example: *Query*.
- Command parameters are underlined. Example: pointer.
- For logical negation, labels are preceded by '~'. Example: If **flag** is true, then **~flag** is false.
- The symbol, R=>T, refers to commands or signaling from an Interrogator to a Tag (Reader-to-Tag).
- The symbol, T=>R, refers to commands or signaling from a Tag to an Interrogator (Tag-to-Reader).

6. Protocol requirements

Protocol Subclause	Requirement	Applies To	How Verified
6.1.1	Tags shall not be required to demodulate Interrogator commands while backscattering.	Tag	**By design**
6.1.1	A Tag shall not respond using full-duplex communications to a mandatory or optional command.	Tag	**By design**
6.3.1.1	Tags shall be capable of receiving power from and communicating with Interrogators within the frequency range from 860 MHz to 960 MHz, inclusive.	Tag	**By demonstration.** Test conditions: Temp: 23 +/– 5 ºC Freq: 860, 910, & 960 MHz Power: 0 dBm at Tag antenna Modulation: DSB-ASK Tari: 25 µs RTcal: 62.5 µs PW: 0.5 Tari Modulation depth: 90% Rise/fall time: ≤ 0.33 Tari TRcal: 100 µs DR: 8 M: 1 TRext: 0
6.3.1.1	Interrogators certified for operation in dense-Interrogator environments shall be capable of communications as described in Annex G of the Protocol.	Interrogator	**By design**
6.3.1.2	Interrogators shall use a fixed modulation format and data rate for the duration of an inventory round.	Interrogator	**By design**
6.3.1.2.1	Interrogators certified for operation in single- or multiple-Interrogator environments shall have a frequency accuracy that meets local regulations.	Interrogator	**By design**
6.3.1.2.1	Interrogators certified for operation in dense-Interrogator environments shall have a frequency accuracy of +/– 10 ppm over the nominal temperature range (–25 °C to +40 °C) and +/– 20 ppm over the extended temperature range (–40°C to +65 °C), unless local regulations specify tighter accuracy, in which case the Interrogator frequency accuracy shall meet the local regulations	Interrogator	**By demonstration**, for dense-Interrogator certification, unless local regulations specify tighter frequency accuracy than the Protocol, in which case the Interrogator manufacturer shall provide evidence of certification by the local regulatory body in lieu of laboratory demonstration. Test conditions: Temp: –40, –25, 40, 65 ºC (all +/– 5 ºC) Freq: 5 test points linearly spanning the supported frequency range
6.3.1.2.2	Interrogators shall communicate using DSB-ASK, SSB-ASK, or PR-ASK modulation, detailed in Annex H of the Protocol.	Interrogator	**By design**

Protocol Subclause	Requirement	Applies To	How Verified
6.3.1.2.2	Tags shall be capable of demodulating all three modulation types.	Tag	**By demonstration** Test conditions: Temp: 23 +/– 5 ºC Freq: 866.5 & 915.25 MHz Power: 0 dBm at Tag antenna Modulation: DSB-ASK, SSB-ASK, & PR-ASK Tari: 6.25, 12.5, & 25 µs RTcal: 2.5×Tari PW: min and max Modulation depth: 90% ASK, 200% PR-ASK DSB-ASK rise/fall time: ≤ 0.33 Tari SSB-ASK rise/fall time: ≤ 0.33 Tari PR-ASK rise/fall time: ≤ 0.62×PW TRcal: 2×RTcal DR: 8 M: 1 TRext: 0
6.3.1.2.3	The R=>T link shall use PIE, shown in Figure 6.1 of the Protocol.	Interrogator	**By design**
6.3.1.2.3	The tolerance on all parameters shall be +/–1%.	Interrogator	**By demonstration** Test conditions: Temp: –25, 25, 40 ºC (all +/– 5 ºC) Freq: 866.5 MHz (if certified for operation in Europe); 915.25 MHz (if certified for operation in North America) Power: Maximum Interrogator transmit power, as implemented. Modulation: As implemented Tari: 6.25, 12.5, & 25 µs x: 0.5×Tari, 1.0×Tari (see Figure 6.1 of the Protocol) PW: As implemented Modulation depth: As implemented Rise/fall time: As implemented
6.3.1.2.3	Pulse modulation depth, rise time, fall time, and PW shall be as specified in Table 6.6 of the Protocol, and shall be the same for a data-0 and a data-1.	Interrogator	**By demonstration** Test conditions: Temp: 23 +/– 5 ºC Freq: 866.5 MHz (if certified for operation in Europe); 915.25 MHz (if certified for operation in North America) Power: Maximum Interrogator transmit power, as implemented. Modulation: As implemented Tari: 6.25, 12.5, & 25 µs x: 0.5×Tari, 1.0×Tari (see Figure 6.1 of the Protocol) PW: As implemented Modulation depth: As implemented Rise/fall time: As implemented
6.3.1.2.3	Interrogators shall use a fixed modulation depth, rise time, fall time, PW, and Tari for the duration of an inventory round.	Interrogator	**By design**

Protocol Subclause	Requirement	Applies To	How Verified
6.3.1.2.3	The RF envelope shall be as specified in Figure 6.2 [and Table 6.6] of the Protocol.	Interrogator	**By demonstration** Test conditions: Temp: 23 +/– 5 ºC Freq: 866.5 MHz (if certified for operation in Europe); 915.25 MHz (if certified for operation in North America) Power: Maximum Interrogator transmit power, as implemented. Modulation: As implemented Tari: 6.25, 12.5, & 25 µs x: 0.5×Tari, 1.0×Tari (see Figure 6.1 of the Protocol) PW: As implemented Modulation depth: As implemented Rise/fall time: As implemented
6.3.1.2.4	Interrogators shall communicate using Tari values between 6.25µs and 25µs, inclusive.	Interrogator	**By design**
6.3.1.2.4	Interrogator compliance shall be evaluated using the preferred Tari values specified in Table 6.2 of the Protocol and the encoding shown in Figure 6.1 of the Protocol with *x* = 0.5 Tari and *x* = 1.0 Tari.	Interrogator	This document uses the preferred Tari and x values as required by the Protocol.
6.3.1.2.4	An Interrogator shall use fixed data-0 and data-1 symbol lengths for the duration of an inventory round.	Interrogator	**By design**
6.3.1.2.4	The choice of Tari value shall be in accordance with local radio regulations.	Interrogator	**By design**
6.3.1.2.5	The R=>T RF envelope shall comply with Figure 6.2 and Table 6.6 of the Protocol.	Interrogator	Tested in compliance with 6.3.1.2.3
6.3.1.2.5	An Interrogator shall not change the R=>T modulation type (i.e. shall not switch between DSB-ASK, SSB-ASK, or PR-ASK) without first powering down its RF waveform.	Interrogator	**By design**
6.3.1.2.6	The Interrogator power-up RF envelope shall comply with Figure 6.3 and Table 6.7 of the Protocol.	Interrogator	**By demonstration** Test conditions: Temp: 23 +/– 5 ºC Freq: 866.5 MHz (if certified for operation in Europe); 915.25 MHz (if certified for operation in North America) Power: Maximum Interrogator transmit power, as implemented.
6.3.1.2.6	Once the carrier level has risen above the 10% level, the power-up envelope shall rise monotonically until at least the ripple limit M_l. The RF envelope shall not fall below the 90% point in Figure 6.3 of the Protocol during interval T_s.	Interrogator	**By demonstration** Test conditions: Temp: 23 +/– 5 ºC Freq: 866.5 MHz (if certified for operation in Europe); 915.25 MHz (if certified for operation in North America) Power: Maximum Interrogator transmit power, as implemented.
6.3.1.2.6	Interrogators shall not issue commands before the end of the maximum settling-time interval in Table 6.7 of the Protocol (i.e. before T_s).	Interrogator	**By design**

Protocol Subclause	Requirement	Applies To	How Verified
6.3.1.2.7	The Interrogator power-down RF envelope shall comply with Figure 6.3 and Table 6.8 of the Protocol.	Interrogator	**By demonstration** Test conditions: Temp: 23 +/– 5 ºC Freq: 866.5 MHz (if certified for operation in Europe); 915.25 MHz (if certified for operation in North America) Power: Maximum Interrogator transmit power, as implemented.
6.3.1.2.7	Once the carrier level has fallen below the 90% level, the power-down envelope shall fall monotonically until the power-off limit M_s.	Interrogator	**By demonstration** Test conditions: Temp: 23 +/– 5 ºC Freq: 866.5 MHz (if certified for operation in Europe); 915.25 MHz (if certified for operation in North America) Power: Maximum Interrogator transmit power, as implemented.
6.3.1.2.7	Once powered off, an Interrogator shall remain powered off for a least 1ms before powering up again.	Interrogator	**By design**
6.3.1.2.8	An Interrogator shall begin all R=>T signaling with either a preamble or a frame-sync, both of which are shown in Figure 6.4 of the Protocol.	Interrogator	**By design**
6.3.1.2.8	A preamble shall precede a *Query* command and denotes the start of an inventory round.	Interrogator	**By design**
6.3.1.2.8	All other signaling shall begin with a frame-sync.	Interrogator	**By design**
6.3.1.2.8	The tolerance on all parameters specified in units of Tari shall be +/–1%. PW shall be as specified in Table 6.6 of the Protocol.	Interrogator	Tested in compliance with 6.3.1.2.3
6.3.1.2.8	The RF envelope shall be as specified in Figure 6.2 of the Protocol.	Interrogator	Tested in compliance with 6.3.1.2.3
6.3.1.2.8, Figure 6.4	A preamble shall comprise a fixed-length start delimiter, a data-0 symbol, an R=>T calibration (RTcal) symbol, and a T=>R calibration (TRcal) symbol.	Interrogator	**By demonstration** Test conditions: Temp: 23 +/– 5 ºC Freq: 866.5 MHz (if certified for operation in Europe); 915.25 MHz (if certified for operation in North America) Power: Maximum Interrogator transmit power, as implemented. Modulation: As implemented Tari: 6.25, 12.5, & 25 µs RTcal: 2.5×Tari, 3.0×Tari TRcal: 1.1×RTcal, 3.0×RTcal PW: As implemented Modulation depth: As implemented Rise/fall time: As implemented
6.3.1.2.8	RTcal: An Interrogator shall set RTcal equal to the length of a data-0 symbol plus the length of a data-1 symbol (RTcal = $0_{length} + 1_{length}$).	Interrogator	**By design**
6.3.1.2.8	RTcal: A Tag shall measure the length of RTcal and compute *pivot* = RTcal / 2.	Tag	**By design**
6.3.1.2.8	RTcal: The Tag shall interpret subsequent Interrogator symbols shorter than *pivot* to be data-0s, and subsequent Interrogator symbols longer than *pivot* to be data-1s.	Tag	**By design**

Protocol Subclause	Requirement	Applies To	How Verified
6.3.1.2.8	RTcal: The Tag shall interpret symbols longer than 4 RTcal to be bad data.	Tag	**By design**
6.3.1.2.8	RTcal: Prior to changing RTcal, an Interrogator shall transmit CW for a minimum of 8 RTcal.	Interro-gator	**By design**
6.3.1.2.8	**TRcal:** An Interrogator shall specify a Tag's backscatter link frequency (its FM0 datarate or the frequency of its Miller sub-carrier) using the TRcal and divide ratio (DR) in the preamble and payload, respectively, of a *Query* command that initiates an inventory round.	Interro-gator	**By design**
6.3.1.2.8	**TRcal:** A Tag shall measure the length of TRcal, compute LF, and adjust its T=>R link rate to be equal to LF.	Tag	Tested in compliance with 6.3.1.3.3
6.3.1.2.8	**TRcal:** The TRcal and RTcal that an Interrogator uses in any inventory round shall meet the constraints in Equation (2) of the Protocol.	Interro-gator	Tested in compliance with 6.3.1.2.8, Figure 6.2
6.3.1.2.8	An Interrogator, for the duration of an inventory round, shall use the same length RTcal in a frame-sync as it used in the preamble that initiated the round.	Interro-gator	**By design**
6.3.1.2.9	When an Interrogator uses frequency-hopping spread spectrum (FHSS) signaling, the Interrogator's RF envelope shall comply with Figure 6.5 and Table 6.9 of the Protocol. The RF envelope shall not fall below the 90% point in Figure 6.5 of the Protocol during interval T_{hs}.	Interro-gator	**By demonstration**, for Interrogators that use FHSS: Test conditions: Temp: 23 +/– 5 ºC Freq: 866.5 MHz (if certified for operation in Europe); 915.25 MHz (if certified for operation in North America) Power: Maximum Interrogator transmit power, as implemented.
6.3.1.2.9	Interrogators shall not issue commands before the end of the maximum settling-time interval in Table 6.9 of the Protocol (i.e. before T_{hs}).	Interro-gator	**By design**
6.3.1.2.9	The maximum time between frequency hops and the minimum RF-off time during a hop shall meet local regulatory requirements.	Interro-gator	**By design**
6.3.1.2.10	Interrogators certified for operation in single-Interrogator environments shall meet local regulations for spread-spectrum channelization.	Interro-gator	**By design**
6.3.1.2.10	Interrogators certified for operation in multiple- or dense-Interrogator environments, when operating under FCC Title 47, Part 15 regulations, shall be additionally capable of centering their R=>T signaling in channels whose width and center frequencies are shown in Table 6.10 of the Protocol.	Interro-gator	**By demonstration**, for multiple- or dense-Interrogator certification. Test conditions: Freq: 50 discrete center frequencies, as specified in Table 6.10 of the Protocol Power: Maximum Interrogator transmit power, as implemented
6.3.1.2.11	Interrogators certified for operation according to this protocol shall meet local regulations for out-of-channel and out-of-band spurious radio-frequency emissions.	Interro-gator	**By design**

Protocol Subclause	Requirement	Applies To	How Verified
6.3.1.2.11, Figure 6.6	Interrogators certified for operation in multiple-Interrogator environments, in addition to meeting local regulations, shall also meet the specified Multiple-Interrogator Transmit Mask.	Interrogator	**By demonstration**, for multiple-Interrogator certification. Test conditions: Temp: 23 +/– 5 ºC Freq: f_c = 866.5 MHz for Interrogators certified for operation in Europe; f_c = 915.25 MHz for Interrogators certified for operation in North America. Power: Maximum Interrogator transmit power, as implemented. Channel width: 200 kHz for Interrogators certified for operation in Europe; 500 kHz for Interrogators certified for operation in North America. Modulation: As implemented Tari: 25 µs for Interrogators certified for operation in Europe; 6.25µs for Interrogators certified for operation in North America. RTcal: 2.5×Tari, 3.0×Tari TRcal: 1.1×RTcal, 3.0×RTcal PW: As implemented Modulation depth: As implemented Rise/fall time: As implemented
6.3.1.2.11	Multiple-Interrogator Transmit Mask: For an Interrogator transmitting in channel *R*, and any other channel *S*≠*R*, the ratio of the integrated power *P*() in channel *S* to that in channel *R* shall not exceed the specified values:	Interrogator	Tested in compliance with 6.3.1.2.11, Figure 6.6
6.3.1.2.11	Each channel that exceeds the mask shall be counted as a separate exception.	Interrogator	Tested in compliance with 6.3.1.2.11, Figure 6.6
6.3.1.2.11, Figure 6.7	Interrogators certified for operation in dense-Interrogator environments shall meet both local regulations and the Transmit Mask shown in Figure 6.7 of the Protocol.	Interrogator	**By demonstration**, for dense-Interrogator certification. Test conditions: Temp: 23 +/– 5 ºC Freq: f_c = 866.5 MHz for Interrogators certified for operation in Europe; f_c = 915.25 MHz for Interrogators certified for operation in North America. Power: Maximum Interrogator transmit power, as implemented. Reference bandwidth: 2.5/Tari Modulation: As implemented Tari: 25 µs RTcal: 2.5×Tari, 3.0×Tari TRcal: 1.1×RTcal, 3.0×RTcal PW: As implemented Modulation depth: As implemented Rise/fall time: As implemented
6.3.1.2.11	In addition, they shall be capable of meeting the following Dense-Interrogator Transmit Mask when using dense-Interrogator channelized signaling as outlined in Annex G of the Protocol.	Interrogator	Tested in compliance with 6.3.1.2.11, Figure 6.7
6.3.1.2.11	Finally, unlike Interrogators certified for operation in multiple-Interrogator environments, those certified for operation in dense-Interrogator environments shall not be permitted any exceptions to a transmit mask.	Interrogator	Tested in compliance with 6.3.1.2.11, Figure 6.7

Protocol Subclause	Requirement	Applies To	How Verified
6.3.1.2.11	**Dense-Interrogator Transmit Mask:** For Interrogator transmissions centered at a frequency f_c, a 2.5/Tari bandwidth R_{BW} also centered at f_c, an offset frequency f_o = 2.5/Tari, and a 2.5/Tari bandwidth S_{BW} centered at ($n \times f_o$) + f_c (integer n), the ratio of the integrated power P() in S_{BW} to that in R_{BW} shall not exceed the specified values:	Interrogator	Tested in compliance with 6.3.1.2.11, Figure 6.7
6.3.1.3	A Tag shall backscatter using a fixed modulation format, data encoding, and data rate for the duration of an inventory round.	Tag	**By design**
6.3.1.3.1	Tag backscatter shall use ASK and/or PSK modulation.	Tag	**By design**
6.3.1.3.1	Interrogators shall be capable of demodulating either modulation type.	Interrogator	**By design**
6.3.1.3.2	Tags shall encode the backscattered data as either FM0 baseband or Miller modulation of a subcarrier at the data rate.	Tag	Tested in compliance with 6.3.1.3.2.1 and 6.3.1.3.2.3
6.3.1.3.2.1	The duty cycle of a 00 or 11 sequence, measured at the modulator output, shall be a minimum of 45% and a maximum of 55%, with a nominal value of 50%.	Tag	**By demonstration** Test conditions: Temp: 23 +/– 5 ºC Freq: 866.5 & 915.25 MHz Power: 0 dBm at Tag antenna Modulation: DSB-ASK PW: 0.5 Tari Modulation depth: 90% Rise/fall time: ≤ 0.33 Tari TRext: 0 Test # 1 Tari: 6.25 µs RTcal: 18.75 µs TRcal: 33.3 & 50 µs DR: 64/3 M: 1 Test # 2 Tari: 12.5 µs RTcal: 31.25 µs TRcal: 66.7, 83.3 µs DR: 64/3 M: 1
6.3.1.3.2.1	FM0 signaling shall always end with a “dummy” data-1 bit at the end of a transmission, as shown in Figure 6.8 of the Protocol.	Tag	**By design**
6.3.1.3.2.2	T=>R FM0 signaling shall begin with one of the two preambles shown in Figure 6.11 of the Protocol.	Tag	**By demonstration** Test conditions: Temp: 23 +/– 5 ºC Freq: 866.5 & 915.25 MHz Power: 0 dBm at Tag antenna Modulation: DSB-ASK PW: 0.5 Tari Modulation depth: 90% Rise/fall time: ≤ 0.33 Tari Tari: 25 µs RTcal: 75 µs TRcal: 100 µs DR: 8 M: 1 TRext: 0 & 1
6.3.1.3.2.3	Figure 6.13 of the Protocol shows Miller-modulated subcarrier sequences; the Miller sequence shall contain exactly two, four, or eight subcarrier cycles per bit, depending on the M value specified in the *Query* command that initiated the inventory round.	Tag	**By design**

Protocol Subclause	Requirement	Applies To	How Verified
6.3.1.3.2.3	The duty cycle of a 0 or 1 symbol, measured at the modulator output, shall be a minimum of 45% and a maximum of 55%, with a nominal value of 50%.	Tag	**By demonstration** Test conditions: Temp: 23 +/– 5 ºC Freq: 866.5 & 915.25 MHz Power: 0 dBm at Tag antenna Modulation: DSB-ASK PW: 0.5 Tari Modulation depth: 90% Rise/fall time: ≤ 0.33 Tari TRext: 0 Test # 1 Tari: 6.25 µs RTcal: 18.75 µs TRcal: 33.3 & 50 µs DR: 64/3 M: 2, 4, 8 Test # 2 Tari: 12.5 µs RTcal: 31.25 µs TRcal: 66.7, 83.3 µs DR: 64/3 M: 2, 4, 8
6.3.1.3.2.3	Miller signaling shall always end with a “dummy” data-1 bit at the end of a transmission, as shown in Figure 6.14 of the Protocol.	Tag	**By design**
6.3.1.3.2.4	T=>R subcarrier signaling shall begin with one of the two preambles shown in Figure 6.15 of the Protocol.	Tag	**By demonstration** Test conditions: Temp: 23 +/– 5 ºC Freq: 866.5 & 915.25 MHz Power: 0 dBm at Tag antenna Modulation: DSB-ASK PW: 0.5 Tari Modulation depth: 90% Rise/fall time: ≤ 0.33 Tari Tari: 25 µs RTcal: 75 µs TRcal: 100 µs DR: 8 M: 2, 4, 8 TRext: 0 & 1

Protocol Subclause	Requirement	Applies To	How Verified
6.3.1.3.3	Tags shall support the R=>T Tari values specified in 6.3.1.2.4 of the Protocol, the T=>R link frequencies and tolerances specified in Table 6.11 of the Protocol, and the T=>R data rates specified in Table 6.12 of the Protocol.	Tag	The FT requirements in Table 6.11 of the Protocol shall be verified **by design**. Tag manufacturers shall provide plots of worst-case FT error versus TRcal. Tag manufacturers shall also provide measured data used to generate the FT plots, including: 1. Tag oscillator frequency tolerance 2. Tag oscillator frequency drift 3. TRcal measurement error budget 4. Other contributors to FT error The frequency-variation during backscatter requirements in Table 6.11 of the Protocol shall be verified **by demonstration**. The testing laboratory shall measure the minimum, median, and maximum symbol length (M=1) or subcarrier period (M=2, 4, 8) during backscatter of a 128-bit sequence (16-bit PC, 96-bit EPC, and a CRC-16). The minimum and maximum values shall not deviate by more than 2.5% from the median. The test conditions are: Temp: 23 +/– 5 ºC Freq: 866.5 & 915.25 MHz Power: 0 dBm at Tag antenna Modulation: DSB-ASK PW: 0.5 Tari Modulation depth: 90% Rise/fall time: ≤ 0.33 Tari TRext: 0 Test # 1 Tari: 6.25 µs RTcal: 18.75 µs TRcal: 33.3 & 50 µs DR: 64/3 M: 1, 2, 4, 8 Test # 2 Tari: 25 µs RTcal: 75 µs TRcal: 200 µs DR: 8 M: 1, 2, 4, 8
6.3.1.3.4	Tags energized by an Interrogator shall be capable of receiving and acting on Interrogator commands within a period not exceeding the maximum settling-time interval specified in Table 6.7 or Table 6.9 of the Protocol, as appropriate (i.e. within T_s or T_{hs}, respectively).	Tag	**By design**
6.3.1.3.5	For Tags certified to this protocol, operating under manufacturer's specified conditions in accordance with local regulations, and mounted on one or more manufacturer-selected materials, the Tag manufacturer shall specify (1) free-space, interference-free sensitivity, and (2) minimum relative backscattered modulated power (ASK modulation) or change in radar cross-section or equivalent (phase modulation).	Tag	**By design**

Protocol Subclause	Requirement	Applies To	How Verified
6.3.1.4	The transmission order for all R=>T and T=>R communications shall respect the following convention: • Within each message, the most-significant word shall be transmitted first. • Within each word, the most-significant bit (MSB) shall be transmitted first.	Tag and Interrogator	**By design**
6.3.1.5, Table 6.13	Tags and Interrogators shall meet all timing requirements shown in Table 6.13 of the Protocol.	Tag and Interrogator	**By demonstration** Interrogator test conditions: Verify Interrogator meets T_2, T_3, & T_4 Temp: 23 +/– 5 ºC Freq: 866.5 MHz (if certified for operation in Europe); 915.25 MHz (if certified for operation in North America) Power: Maximum Interrogator transmit power, as implemented. Modulation: As implemented Tari: 6.25, 12.5, & 25 µs RTcal: 2.5×Tari, 3.0×Tari TRcal: 1.1×RTcal, 3.0×RTcal PW: As implemented Modulation depth: As implemented Rise/fall time: As implemented Tag test conditions: Verify Tag meets T_1 & T_2 Temp: 23 +/– 5 ºC Freq: 866.5 & 915.25 MHz Power: 0 dBm at Tag antenna Modulation: DSB-ASK PW: 0.5 Tari Modulation depth: 90% Rise/fall time: $\leq$ 0.33 Tari TRext: 0 Tari: 6.25 µs RTcal: 18.75 µs TRcal: 33.3 & 50 µs DR: 64/3 M: 1, 2, 4, 8
6.3.1.5	… an Interrogator shall use a fixed R=>T link rate for the duration of an inventory round.	Interrogator	**By design**
6.3.1.5	Prior to changing the R=>T link rate, an Interrogator shall transmit CW for a minimum of 8 RTcal.	Interrogator	**By design**
6.3.1.5	The maximum value for T_2 shall apply only to Tags in the **reply** or **acknowledged** states.	Tag	**By design**
6.3.1.5	For a Tag in the **reply** or **acknowledged** states, if T_2 expires (i.e. reaches its maximum value) without the Tag receiving a valid command, the Tag shall transition to the **arbitrate** state.	Tag	**By design**
6.3.1.5	For a Tag in the **reply** or **acknowledged** states, if T_2 expires (i.e. reaches its maximum value) during the reception of a valid command, the Tag shall execute the command.	Tag	**By design**
6.3.1.5	For a Tag in the **reply** or **acknowledged** states, if T_2 expires (i.e. reaches its maximum value) during the reception of an invalid command, the Tag shall transition to **arbitrate** upon determining that the command is invalid.	Tag	**By design**
6.3.1.5	In all states other than the **reply** or **acknowledged** states, the maximum value for T_2 shall be unrestricted.	Tag	**By design**
6.3.1.5	T_1+T_3 shall not be less than T_4.	Tag	**By design**

Protocol Subclause	Requirement	Applies To	How Verified
6.3.2.1	Tag memory shall be logically separated into four distinct banks, each of which may comprise zero or more memory words.	Tag	**By design**
6.3.2.1	**Reserved memory** shall contain the kill and access passwords.	Tag	**By design**
6.3.2.1	The kill password shall be stored at memory addresses 00_h to $1F_h$.	Tag	**By design**
6.3.2.1	The access password shall be stored at memory addresses 20_h to $3F_h$.	Tag	**By design**
6.3.2.1	If a Tag does not implement the kill and/or access password(s), the Tag shall act as though it had zero-valued password(s) that are permanently read/write locked, and the corresponding memory locations in Reserved memory need not exist.	Tag	**By design**
6.3.2.1	**EPC memory** shall contain a CRC-16 at memory addresses 00_h to $0F_h$, Protocol-Control (PC) bits at memory addresses 10_h to $1F_h$, and a code (such as an EPC, and hereafter referred to as an EPC) that identifies the object to which the tag is or will be attached beginning at address 20_h.	Tag	**By design**
6.3.2.1	The CRC-16, PC, and EPC shall be stored MSB first (the EPC's MSB is stored in location 20_h).	Tag	**By design**
6.3.2.1	**TID memory** shall contain an 8-bit ISO/IEC 15963 allocation-class identifier (11100010_2 for EPCglobal) at memory locations 00_h to 07_h. TID memory shall contain sufficient identifying information above 07_h for an Interrogator to uniquely identify the custom commands and/or optional features that a Tag supports. For Tags whose ISO/IEC 15963 allocation class identifier is 11100010_2, this identifying information shall comprise a 12-bit Tag mask-designer identifier (free to members of EPCglobal) at memory locations 08_h to 13_h, and a 12-bit Tag model number at memory locations 14_h to $1F_h$.	Tag	**By demonstration** Singulate the Tag, read its TID memory, and verify the contents. Tag test conditions: Temp: 23 +/– 5 ºC Freq: 866.5 & 915.25 MHz Power: 0 dBm at Tag antenna Modulation: DSB-ASK PW: 0.5 Tari Modulation depth: 90% Rise/fall time: ≤ 0.33 Tari Tari: 25 µs RTcal: 75 µs TRcal: 100 µs DR: 8 M: 1 TRext: 0
6.3.2.1	The logical addressing of all memory banks shall begin at zero (00_h).	Tag	**By design**
6.3.2.1	When Tags backscatter memory contents, this backscatter shall fall on word boundaries (except in the case of a truncated reply).	Tag	**By design**
6.3.2.1	Operations in one logical memory bank shall not access memory locations in another bank.	Tag	**By design**
6.3.2.1	A *Write*, *BlockWrite*, or *BlockErase* shall not alter a Tag's killed status regardless of the memory address (whether valid or invalid) specified in the command.	Tag	**By design**
6.3.2.1.1	The kill password is a 32-bit value stored in Reserved memory 00_h to $1F_h$, MSB first. The default (unprogrammed) value shall be zero.	Tag	**By design**
6.3.2.1.1	An Interrogator shall use a Tag's kill password once, to kill the Tag and render it silent thereafter.	Interrogator	**By design**

Protocol Subclause	Requirement	Applies To	How Verified
6.3.2.1.1	A Tag shall not execute a kill operation if its kill password is zero.	Tag	**By demonstration** Issue a *Kill* command to a Tag with a zero-valued kill password. Verify that the Tag backscatters an error code and does not execute the kill. Tag test conditions: Temp: 23 +/– 5 ºC Freq: 866.5 & 915.25 MHz Power: 0 dBm at Tag antenna Modulation: DSB-ASK PW: 0.5 Tari Modulation depth: 90% Rise/fall time: ≤ 0.33 Tari Tari: 25 µs RTcal: 75 µs TRcal: 100 µs DR: 8 M: 1 TRext: 0
6.3.2.1.2	The access password is a 32-bit value stored in Reserved memory 20_h to $3F_h$, MSB first. The default (unprogrammed) value shall be zero.	Tag	**By design**
6.3.2.1.2	Tags with a nonzero access password shall require an Interrogator to issue this password before transitioning to the **secured** state.	Tag	**By design**
6.3.2.1.3	To generate a CRC-16 an Interrogator or Tag shall first generate the CRC-16 precursor shown in Table 6.14 of the Protocol, then take the ones-complement of the generated precursor to form the CRC-16.	Tag and Interrogator	**By design**
6.3.2.1.3	At power-up a Tag shall compute this CRC-16 over EPC memory location 10_h to the end of the EPC (not necessarily to the end of EPC memory, but to the end of the EPC specified by the length field in the PC) and map the computed CRC-16 into EPC memory 00_h to $0F_h$, MSB first.	Tag	**By demonstration** Test for rewriteable Tags: Sequentially write a Tag's EPC, one 16-bit word at a time. Following each write, update the length field specified in the PC bits, power down the Tag, then power it up again and singulate it. Verify that the backscattered CRC-16 matches the backscattered EPC after each write operation. Test for prewritten Tags: Power up the Tag and singulate it. Verify that the backscattered CRC-16 matches the backscattered EPC. Tag test conditions for either case: Temp: 23 +/– 5 ºC Freq: 866.5 & 915.25 MHz Power: 0 dBm at Tag antenna Modulation: DSB-ASK PW: 0.5 Tari Modulation depth: 90% Rise/fall time: ≤ 0.33 Tari Tari: 25 µs RTcal: 75 µs TRcal: 100 µs DR: 8 M: 1 TRext: 0

Protocol Subclause	Requirement	Applies To	How Verified
6.3.2.1.3	Because the {PC+EPC} is stored in EPC memory on word boundaries, this CRC-16 shall be computed on word boundaries.	Tag	**By design**
6.3.2.1.3	Tags shall finish this CRC-16 computation and memory mapping by the end of interval T_s or T_{hs} (as appropriate) in Figure 6.3 or Figure 6.5 of the Protocol, respectively.	Tag	**By design**
6.3.2.1.3	Tags shall not recalculate this CRC-16 for a truncated reply.	Tag	**By design**
6.3.2.1.4	Bits 15_h – 16_h: RFU (shall be set to 00_2 for Class-1 Tags). Bit 17_h: Shall be set to 0.	Tag	**By demonstration**
6.3.2.1.4	The default (unprogrammed) PC value shall be 0000_h.	Tag	**By demonstration** Tag test (unwritten Tags only): Power up the Tag and singulate it. Verify that the backscattered PC bits are 0000_h. Tag test conditions: Temp: 23 +/– 5 ºC Freq: 866.5 & 915.25 MHz Power: 0 dBm at Tag antenna Modulation: DSB-ASK PW: 0.5 Tari Modulation depth: 90% Rise/fall time: ≤ 0.33 Tari Tari: 25 µs RTcal: 75 µs TRcal: 100 µs DR: 8 M: 1 TRext: 0
6.3.2.1.4	A Tag shall backscatter an error code if an Interrogator attempts to write a (PC + EPC) length that is not supported by the Tag to the first 5 bits of the Tag's PC.	Tag	**By design**
6.3.2.1.4	At power-up a Tag shall compute its CRC-16 over the number of (PC + EPC) words designated by the first 5 bits of the PC rather than over the length of the entire EPC memory.	Tag	Tested in compliance with 6.3.2.1.3
6.3.2.2	Interrogators shall support and Tags shall provide 4 sessions (denoted S0, S1, S2, and S3).	Tag and Interrogator	**By design**
6.3.2.2	Tags shall participate in one and only one session during an inventory round.	Tag	**By design**
6.3.2.2	Tags shall maintain an independent **inventoried** flag for each session.	Tag	**By design**
6.3.2.2	Tags participating in an inventory round in one session shall neither use nor modify the **inventoried** flag for a different session.	Tag	**By design**
6.3.2.2	A Tag's **inventoried** flags shall have the persistence times shown in Table 6.15 of the Protocol.	Tag	**By design**
6.3.2.2	A Tag shall power-up with its **inventoried** flags set as follows: The S0 **inventoried** flag shall be set to *A*.	Tag	**By design**: Tested in compliance with 6.3.2.3, Table 6.15
6.3.2.2	A Tag shall power-up with its **inventoried** flags set as follows: The S1 **inventoried** flag shall be set to either *A* or *B*, depending on its stored value, unless the flag was set longer in the past than its persistence time, in which case the Tag shall power-up with its S1 **inventoried** flag set to *A*. Because the S1 **inventoried** flag is not automatically refreshed, it may revert from *B* to *A* even when the Tag is powered.	Tag	**By design**

Protocol Subclause	Requirement	Applies To	How Verified
6.3.2.2	A Tag shall power-up with its **inventoried** flags set as follows: The S2 **inventoried** flag shall be set to either *A* or *B*, depending on its stored value, unless the Tag has lost power for a time greater than its persistence time, in which case the Tag shall power-up with the S2 **inventoried** flag set to *A*.	Tag	**By design**
6.3.2.2	A Tag shall power-up with its **inventoried** flags set as follows: The S3 **inventoried** flag shall be set to either *A* or *B*, depending on its stored value, unless the Tag has lost power for a time greater than its persistence time, in which case the Tag shall power-up with its S3 **inventoried** flag set to *A*.	Tag	**By design**
6.3.2.2	A Tag shall be capable of setting any of its inventoried flags to either *A* or *B* in 2 ms or less, regardless of the initial flag value.	Tag	**By design**
6.3.2.2	A Tag shall refresh its S2 and S3 flags while powered, meaning that every time a Tag loses power its S2 and S3 **inventoried** flags shall have the persistence times shown in Table 6.15 of the Protocol.	Tag	**By design**
6.3.2.2	A Tag shall not let its S1 **inventoried** flag lose persistence while the Tag is participating in an inventory round. Instead, the Tag shall retain the flag value until the next *Query* command, at which point the flag may lose its persistence (unless the flag was refreshed during the round, in which case the flag shall assume its new value and new persistence).	Tag	**By design**
6.3.2.3	Tags shall implement a selected flag, **SL**, which an Interrogator may assert or deassert using a *Select* command.	Tag	**By design**
6.3.2.3	A Tag's **SL** flag shall have the persistence times shown in Table 6.15 of the Protocol.	Tag	**By design**: Tested in compliance with 6.3.2.3, Table 6.15
6.3.2.3	A Tag shall power-up with its **SL** flag either asserted or deasserted, depending on the stored value, unless the Tag has lost power for a time greater than the **SL** persistence time, in which case the Tag shall power-up with its **SL** flag deasserted (set to **~SL**).	Tag	**By design**
6.3.2.3	A Tag shall be capable of asserting or deasserting its **SL** flag in 2 ms or less, regardless of the initial flag value.	Tag	**By design**
6.3.2.3	A Tag shall refresh its **SL** flag when powered, meaning that every time a Tag loses power its **SL** flag shall have the persistence times shown in Table 6.15 of the Protocol.	Tag	**By design**
6.3.2.3, Table 6.15	For a randomly chosen and sufficiently large Tag population, 95% of the Tag persistence times shall meet the persistence requirement, with a 90% confidence interval.	Tag	**By design** Tag manufacturers shall provide data and analysis demonstrating that Tags meet the persistence requirements of Table 6.15.

Protocol Subclause	Requirement	Applies To	How Verified
6.3.2.4, Figure 6.19	Tags shall implement the states and the slot counter shown in Figure 6.19 of the Protocol.	Tag	**By demonstration** Tag test: Tag manufacturers shall supply a population of Tags for testing. The testing laboratory shall exercise all of the states and state transitions shown in Figure 6.19 by selecting, singulating, inventorying, reading, writing, accessing, and (for Tags that implement kill) killing the Tags. Tag test conditions: Temp: 23 +/– 5 ºC Freq: 866.5 & 915.25 MHz Power: 0 dBm at Tag antenna Modulation: DSB-ASK PW: 0.5 Tari Modulation depth: 90% Rise/fall time: ≤ 0.33 Tari Tari: 25 µs RTcal: 75 µs TRcal: 100 µs DR: 8 M: 1 TRext: 0
6.3.2.4.1	Tags shall implement a **ready** state.	Tag	**By design** Also tested in compliance with 6.3.2.4, Figure 6.19
6.3.2.4.1	Upon entering an energizing RF field a Tag that is not killed shall enter **ready**.	Tag	**By design**
6.3.2.4.1	The Tag shall remain in **ready** until it receives a *Query* command whose inventoried parameter (for the session specified in the *Query*) and sel parameter match its current flag values.	Tag	**By design**
6.3.2.4.1	Matching Tags shall draw a *Q*-bit number from their RNG, load this number into their slot counter, and transition to the **arbitrate** state if the number is nonzero, or to the **reply** state if the number is zero.	Tag	**By design**
6.3.2.4.1	If a Tag in any state except **killed** loses power it shall return to **ready** upon regaining power.	Tag	**By design**
6.3.2.4.2	Tags shall implement an **arbitrate** state.	Tag	**By design** Also tested in compliance with 6.3.2.4, Figure 6.19
6.3.2.4.2	A Tag in **arbitrate** shall decrement its slot counter every time it receives a *QueryRep* command whose session parameter matches the session for the inventory round currently in progress, and it shall transition to the **reply** state when its slot counter reaches 0000_h.	Tag	**By design**
6.3.2.4.2	Tags that return to **arbitrate** (for example, from the **reply** state) with a slot value of 0000_h shall decrement their slot counter from 0000_h to $7FFF_h$ at the next *QueryRep* (with matching session) and, because their slot value is now nonzero, shall remain in **arbitrate**.	Tag	**By design**
6.3.2.4.3	Tags shall implement a **reply** state.	Tag	**By design** Also tested in compliance with 6.3.2.4, Figure 6.19
6.3.2.4.3	Upon entering **reply** a Tag shall backscatter an RN16.	Tag	**By design**

Protocol Subclause	Requirement	Applies To	How Verified
6.3.2.4.3	If the Tag receives a valid acknowledgement (*ACK*) it shall transition to the **acknowledged** state, backscattering its PC, EPC and CRC-16.	Tag	**By design**
6.3.2.4.3	If the Tag fails to receive an *ACK*, or receives an invalid *ACK*, it shall return to **arbitrate**.	Tag	**By design**
6.3.2.4.3	In the **reply** state, Tag and Interrogator shall meet all timing requirements specified in Table 6.13 of the Protocol.	Tag	Tested in compliance with 6.3.1.5, Table 6.13
6.3.2.4.4	Tags shall implement an **acknowledged** state.	Tag	**By design** Also tested in compliance with 6.3.2.4, Figure 6.19
6.3.2.4.4	In the **acknowledged** state, Tag and Interrogator shall meet all timing requirements specified in Table 6.13 of the Protocol.	Tag	Tested in compliance with 6.3.1.5, Table 6.13
6.3.2.4.5	Tags shall implement an **open** state.	Tag	**By design** Also tested in compliance with 6.3.2.4, Figure 6.19
6.3.2.4.5	A Tag in the **acknowledged** state whose access password is nonzero shall transition to **open** upon receiving a *Req_RN* command, backscattering a new RN16 (denoted handle) that the Interrogator shall use in subsequent commands and the Tag shall use in subsequent replies.	Tag and Interrogator	**By design**
6.3.2.4.5	In the **open** state, Tag and Interrogator shall meet all timing requirements specified in Table 6.13 of the Protocol except $T_{2(max)}$.	Tag	Tested in compliance with 6.3.1.5, Table 6.13
6.3.2.4.6	Tags shall implement a **secured** state.	Tag	**By design** Also tested in compliance with 6.3.2.4, Figure 6.19
6.3.2.4.6	A Tag in the **acknowledged** state whose access password is zero shall transition to **secured** upon receiving a *Req_RN* command, backscattering a new RN16 (denoted handle) that the Interrogator shall use in subsequent commands and the Tag shall use in subsequent replies.	Tag and Interrogator	**By design**
6.3.2.4.6	A Tag in the **open** state whose access password is nonzero shall transition to **secured** upon receiving a valid *Access* command, maintaining the same handle that it previously backscattered when it transitioned from the **acknowledged** to the **open** state.	Tag	**By design**
6.3.2.4.6	In the **secured** state, Tag and Interrogator shall meet all timing requirements specified in Table 6.13 of the Protocol except $T_{2(max)}$.	Tag	**By design** Also tested in compliance with 6.3.2.4, Figure 6.19
6.3.2.4.7	Tags shall implement a **killed** state.	Tag	**By design**
6.3.2.4.7	A Tag in either the **open** or **secured** states shall enter the **killed** state upon receiving a *Kill* command with a valid nonzero kill password and valid handle.	Tag	**By design**
6.3.2.4.7	Upon entering the **killed** state a Tag shall notify the Interrogator that the kill operation was successful, and shall not respond to an Interrogator thereafter.	Tag	**By design** Also tested in compliance with 6.3.2.4, Figure 6.19
6.3.2.4.7	Killed Tags shall remain in the **killed** state under all circumstances, and shall immediately enter killed upon subsequent power-ups.	Tag	**By design** Also tested in compliance with 6.3.2.4, Figure 6.19
6.3.2.4.8	Tags shall implement a 15-bit slot counter.	Tag	**By design**
6.3.2.4.8	Upon receiving a *Query* or *QueryAdjust* command a Tag shall preload a value between 0 and 2^Q–1, drawn from the Tag's RNG, into its slot counter.	Tag	**By design**

Protocol Subclause	Requirement	Applies To	How Verified
6.3.2.4.8	Upon receiving a *QueryRep* command a Tag shall decrement its slot counter.	Tag	**By design**
6.3.2.4.8	The slot counter shall be capable of continuous counting, meaning that, after the slot counter decrements to 0000_h it shall roll over and begin counting down from $7FFF_h$.	Tag	**By design**
6.3.2.5	Tags shall implement a random or pseudo-random number generator (RNG).	Tag	**By design**
6.3.2.5	The RNG shall meet the following randomness criteria independent of the strength of the energizing field, the R=>T link rate, and the data stored in the Tag (including the PC, EPC, and CRC-16).	Tag	**By design**
6.3.2.5	Tags shall generate 16-bit random or pseudo-random numbers (RN16) using the RNG.	Tag	**By design**
6.3.2.5	Tags shall have the ability to extract *Q*-bit subsets from an RN16 to preload the Tag's slot counter.	Tag	**By design**
6.3.2.5	Tags shall have the ability to temporarily store at least two RN16s while powered, to use, for example, as a handle and a 16-bit cover-code during password transactions (see Figures 6.22 and 6.24 of the Protocol.	Tag	**By design**
6.3.2.5	The probability that any RN16 drawn from the RNG has value RN16 = *j*, for any *j*, shall be bounded by $0.8/2^{16} < P(RN16 = j) < 1.25/2^{16}$.	Tag	**By design** Tag manufacturers shall provide data and analysis demonstrating that Tags meet the requirements of 6.3.2.5
6.3.2.5	For a Tag population of up to 10,000 Tags, the probability that any two or more Tags simultaneously generate the same sequence of RN16s shall be less than 0.1%, regardless of when the Tags are energized.	Tag	**By design** Tag manufacturers shall provide data and analysis demonstrating that Tags meet the requirements of 6.3.2.5
6.3.2.5	An RN16 drawn from a Tag's RNG 10ms after the end of T_r in Figure 6.3 of the Protocol shall not be predictable with a probability greater than 0.025% if the outcomes of prior draws from the RNG, performed under identical conditions, are known.	Tag	**By design** Tag manufacturers shall provide data and analysis demonstrating that Tags meet the requirements of 6.3.2.5.
6.3.2.7	A *Select* that modifies **SL** shall not modify **inventoried**, and vice versa.	Tag	**By design**
6.3.2.8	Upon receiving a *Query* participating Tags shall pick a random value in the range $(0, 2^Q - 1)$, inclusive, and shall load this value into their slot counter. Tags that pick a zero shall transition to the **reply** state and reply immediately. Tags that pick a nonzero value shall transition to the **arbitrate** state and await a *QueryAdjust* or a *QueryRep* command.	Tag	**By design**
6.3.2.8	If the Tag fails to receive the *ACK* in step (b) within time T_2 (see Figure 6.16 of the Protocol), or receives the *ACK* with an erroneous RN16, it shall return to **arbitrate**.	Tag	**By design**
6.3.2.8	If the Interrogator sends a valid *ACK* (i.e. an *ACK* containing the correct RN16) to the Tag in the **acknowledged** state the Tag shall re-backscatter its PC, EPC, and CRC-16.	Tag	**By design** Also tested in compliance with 6.3.2.4, Figure 6.19
6.3.2.8	At any point the Interrogator may issue a *NAK*, in response to which all Tags in the inventory round shall return to **arbitrate** without changing their **inventoried** flag.	Tag	**By design**
6.3.2.8	Tags in the **arbitrate** or **reply** states that receive a *QueryAdjust* … [and] pick zero shall transition to the **reply** state and reply immediately.	Tag	**By design**

Protocol Subclause	Requirement	Applies To	How Verified
6.3.2.8	Tags in the **arbitrate** or **reply** states that receive a *QueryAdjust* … [and] pick a nonzero value shall transition to the **arbitrate** state and await a *QueryAdjust* or a *QueryRep* command.	Tag	**By design**
6.3.2.8	Tags whose slot counter reached 0000_h, who replied, and who were not acknowledged (including Tags that responded to the original *Query* and were not acknowledged) shall return to **arbitrate** with a slot value of 0000_h and shall decrement this slot value from 0000_h to $7FFF_h$ at the next *QueryRep*, thereby effectively preventing subsequent replies until the Tag loads a new random value into its slot counter.	Tag	**By design**
6.3.2.8	Tags shall reply at least once in $2^Q - 1$ *QueryRep* commands.	Tag	**By design** Also tested in compliance with 6.3.2.4, Figure 6.19
6.3.2.8	Tags in any state except **killed** shall execute a *Query*, starting a new round in the specified session and transitioning to **ready**, **arbitrate**, or **reply**, as appropriate (see Figure 6.19 of the Protocol).	Tag	**By design**
6.3.2.8	If a Tag in the **acknowledged**, **open**, or **secured** states receives a *Query* whose session parameter matches the prior session it shall invert its **inventoried** flag (i.e. $A \rightarrow B$ or $B \rightarrow A$) for the session before it evaluates whether to transition to **ready**, **arbitrate**, or **reply**.	Tag	**By design**
6.3.2.8	If a Tag in the **acknowledged**, **open**, or **secured** states receives a *Query* whose session parameter does not match the prior session it shall leave its **inventoried** flag for the prior session unchanged as it evaluates whether to transition to **ready**, **arbitrate**, or **reply**.	Tag	**By design**
6.3.2.8	Tags in any state except **ready** or **killed** shall execute a *QueryAdjust* or *QueryRep* command if, and only if, the session parameter in the command matches the session parameter in the *Query* that started the round.	Tag	**By design**
6.3.2.8	Tags shall ignore a *QueryAdjust* or *QueryRep* with mismatched session.	Tag	**By design**
6.3.2.8	If a Tag in the **acknowledged**, **open**, or **secured** states receives a *QueryAdjust* or *QueryRep* whose session parameter matches the session parameter in the prior *Query*, it shall invert its **inventoried** flag (i.e. $A \rightarrow B$ or $B \rightarrow A$) for the current session then transition to **ready**.	Tag	**By design**
6.3.2.8	In the latter case the collided Tags, not observing a valid reply within T_2 (see Figure 6.16 of the Protocol), shall return to **arbitrate** and await the next *Query* or *QueryAdjust* command.	Tag	**By design**
6.3.2.9	When in either [the **open** or **secured** states] …, Tags shall verify that the handle is correct prior to executing an access command, and shall ignore access commands with an incorrect handle.	Tag	**By design**
6.3.2.9	An Interrogator shall not use handle for cover-coding purposes.	Interrogator	**By design**
6.3.2.9	An Interrogator shall not re-use an RN16 for cover-coding.	Interrogator	**By design**
6.3.2.9	If an Interrogator reissues a command that contained cover-coded data, then the Interrogator shall reissue the command unchanged.	Interrogator	**By design**
6.3.2.9	If the Interrogator changes the data, then it shall first issue a *Req_RN* to obtain a new RN16 and shall use this new RN16 for cover-coding.	Interrogator	**By design**

Protocol Subclause	Requirement	Applies To	How Verified
6.3.2.9	Interrogator and Tag shall transmit all strings MSB first.	Tag and Interro-gator	**By design**
6.3.2.10	Interrogator-to-Tag commands shall have the format shown in Table 6.16 of the Protocol.	Interro-gator	**By design**
6.3.2.10	No other commands shall have these lengths.	Interro-gator	**By design**
6.3.2.10	If a Tag receives one of these commands with an incorrect length it shall ignore the command.	Tag	**By design**
6.3.2.10	Tags shall ignore invalid commands.	Tag	**By design**
6.3.2.10.1.1	Interrogators and Tags shall implement the *Select* command shown in Table 6.18 of the Protocol.	Tag and Interro-gator	**By design** Also tested in compliance with 6.3.2.4, Figure 6.19
6.3.2.10.1.1	Target shall indicate whether the *Select* modifies a Tag's **SL** or **inventoried** flag, and in the case of the **inventoried** flag, for which session.	Tag	**By design**
6.3.2.10.1.1	Action shall elicit the Tag response shown in Table 6.19 of the Protocol.	Tag	**By design**
6.3.2.10.1.1	Truncate indicates whether a Tag's backscattered reply shall be truncated to include only those EPC and CRC-16 bits following Mask.	Tag	**By design**
6.3.2.10.1.1	Class-1 Tags shall ignore *Select* commands whose Target is 101_2, 110_2, or 111_2.	Tag	**By design**
6.3.2.10.1.1	*Select* commands shall apply to a single memory bank.	Tag	**By design**
6.3.2.10.1.1	MemBank shall not specify Reserved memory.	Tag	**By design**
6.3.2.10.1.1	If a Tag receives a *Select* specifying MemBank = 00_2 it shall ignore the *Select*.	Tag	**By design**
6.3.2.10.1.1	If Pointer and Length reference a memory location that does not exist on the Tag then the Tag shall consider the *Select* to be non-matching.	Tag	**By design**
6.3.2.10.1.1	If Length is zero then all Tags shall be considered matching, unless Pointer references a memory location that does not exist on the Tag, in which case the Tag shall consider the *Select* to be non-matching.	Tag	**By design**
6.3.2.10.1.1	If an Interrogator asserts Truncate, and if a subsequent *Query* specifies Sel=10 or Sel=11, then matching Tags shall truncate their reply to an *ACK* to that portion of the EPC immediately following Mask, followed by the CRC-16 stored in EPC memory 00_h to $0F_h$.	Tag	**By design**
6.3.2.10.1.1	Interrogators shall assert Truncate: in the last (and only in the last) *Select* that the Interrogator issues prior to sending a *Query*; if and only if the *Select* has Target = 100_2, and; if and only if Mask ends in the EPC.	Interro-gator	**By design**
6.3.2.10.1.1	Tags shall power-up with Truncate deasserted.	Tag	**By design**
6.3.2.10.1.1	Tags shall decide whether to truncate their backscattered EPC on the basis of the most recently received *Select*.	Tag	**By design**
6.3.2.10.1.1	If a Tag receives a *Select* with Truncate=1 but Target<>100_2 the Tag shall ignore the *Select*.	Tag	**By design**
6.3.2.10.1.1	If a Tag receives a *Select* in which Truncate=1 but MemBank<>01, the Tag shall consider the *Select* to be invalid.	Tag	**By design**

Protocol Subclause	Requirement	Applies To	How Verified
6.3.2.10.1.1	If a Tag receives a *Select* in which Truncate=1, MemBank=01, but Mask ends outside the EPC specified in the PC bits, the Tag shall consider the *Select* to be not matching.	Tag	**By design**
6.3.2.10.1.1	Mask may end at the last bit of the EPC, in which case a selected Tag shall backscatter its CRC-16.	Tag	**By design**
6.3.2.10.1.1	A Tag shall preface its truncated reply with five leading zeros (00000_2) inserted between the preamble and the truncated reply.	Tag	**By design**
6.3.2.10.1.1	Interrogators shall prepend a *Select* with a frame-sync.	Interrogator	**By design**
6.3.2.10.1.1	Tags shall not reply to a *Select*.	Tag	**By design** Also tested in compliance with 6.3.2.4, Figure 6.19
6.3.2.10.2.1	Interrogators and Tags shall implement the *Query* command shown in Table 6.20 of the Protocol.	Tag and Interrogator	**By design** Also tested in compliance with 6.3.2.4, Figure 6.19
6.3.2.10.2.1	Interrogators shall prepend a *Query* with a preamble.	Interrogator	**By design** Also tested in compliance with 6.3.2.4, Figure 6.19
6.3.2.10.2.1	If a Tag receives a *Query* with a CRC-5 error it shall ignore the command.	Tag	**By design**
6.3.2.10.2.1	If a Tag, in response to the *Query*, loads its slot counter with zero, then its reply to a *Query* shall be as shown in Table 6.21 of the Protocol; otherwise the Tag shall remain silent.	Tag	**By design**
6.3.2.10.2.1	If a Tag in the **acknowledged**, **open**, or **secured** states receives a *Query* whose session parameter matches the prior session it shall invert its **inventoried** flag (i.e. $A \rightarrow B$ or $B \rightarrow A$) for the session.	Tag	**By design**
6.3.2.10.2.1	If a Tag in the **acknowledged**, **open**, or **secured** states receives a *Query* whose session parameter does not match the prior session it shall leave its **inventoried** flag for the prior session unchanged when beginning the new round.	Tag	**By design**
6.3.2.10.2.1	Tags shall support all DR and M values specified in Tables 6.11 and 6.12 of the Protocol, respectively.	Tag	**By design**
6.3.2.10.2.1	Tags in any state other than **killed** shall execute a *Query* command;	Tag	**By design**
6.3.2.10.2.1	Tags in the **killed** state shall ignore a *Query*.	Tag	**By design**
6.3.2.10.2.2	Interrogators and Tags shall implement the *QueryAdjust* command shown in Table 6.22 of the Protocol.	Tag and Interrogator	**By design** Also tested in compliance with 6.3.2.4, Figure 6.19
6.3.2.10.2.2	If a Tag receives a *QueryAdjust* whose session number is different from the session number in the *Query* that initiated the round it shall ignore the command.	Tag	**By design**
6.3.2.10.2.2	If a Tag receives a *QueryAdjust* with an UpDn value different from those specified above it shall ignore the command.	Tag	**By design**
6.3.2.10.2.2	If a Tag whose *Q* value is 15 receives a *QueryAdjust* with UpDn = 110 it shall change UpDn to 000 prior to executing the command…	Tag	**By design**
6.3.2.10.2.2	…likewise, if a Tag whose *Q* value is 0 receives a *QueryAdjust* with UpDn = 011 it shall change UpDn to 000 prior to executing the command.	Tag	**By design**
6.3.2.10.2.2	Tags shall maintain a running count of the current *Q* value.	Tag	**By design**

Protocol Subclause	Requirement	Applies To	How Verified
6.3.2.10.2.2	A *QueryAdjust* shall be prepended with a frame-sync.	Interrogator	**By design**
6.3.2.10.2.2	If a Tag, in response to the *QueryAdjust*, loads its slot counter with zero, then its reply to a *QueryAdjust* shall be shown in Table 6.23 of the Protocol; otherwise, the Tag shall remain silent.	Tag	**By design**
6.3.2.10.2.2	Tags shall respond to a *QueryAdjust* only if they received a prior *Query*.	Tag	**By design**
6.3.2.10.2.3	Interrogators and Tags shall implement the *QueryRep* command shown in Table 6.24 of the Protocol.	Tag and Interrogator	**By design** Also tested in compliance with 6.3.2.4, Figure 6.19
6.3.2.10.2.3	If a Tag receives a *QueryRep* whose session number is different from the session number in the *Query* that initiated the round it shall ignore the command.	Tag	**By design**
6.3.2.10.2.3	A *QueryRep* shall be prepended with a frame-sync.	Interrogator	**By design**
6.3.2.10.2.3	If a Tag, in response to the *QueryRep*, decrements its slot counter and the decremented slot value is zero, then its reply to a *QueryRep* shall be as shown in Table 6.25 of the Protocol; otherwise the Tag shall remain silent.	Tag	**By design**
6.3.2.10.2.3	Tags shall respond to a *QueryRep* only if they received a prior *Query*.	Tag	**By design**
6.3.2.10.2.4	Interrogators and Tags shall implement the *ACK* command shown in Table 6.26 of the Protocol.	Tag and Interrogator	**By design** Also tested in compliance with 6.3.2.4, Figure 6.19
6.3.2.10.2.4	If an Interrogator issues an *ACK* to a Tag in the **reply** or **acknowledged** states, then the echoed RN16 shall be the RN16 that the Tag previously backscattered as it transitioned from the **arbitrate** state to the **reply** state.	Interrogator	**By design**
6.3.2.10.2.4	If an Interrogator issues an *ACK* to a Tag in the **open** or **secured** states, then the echoed RN16 shall be the Tag's handle.	Interrogator	**By design**
6.3.2.10.2.4	An *ACK* shall be prepended with a frame-sync.	Interrogator	**By design**
6.3.2.10.2.4	The Tag reply to a successful *ACK* shall be as shown in Table 6.27 of the Protocol.	Tag	**By design** Also tested in compliance with 6.3.2.4, Figure 6.19
6.3.2.10.2.4	A Tag that receives an *ACK* with an incorrect RN16 or an incorrect handle (as appropriate) shall return to **arbitrate** without responding, unless the Tag is in **ready** or **killed**, in which case it shall ignore the *ACK* and remain in its present state.	Tag	**By design**
6.3.2.10.2.5	Interrogators and Tags shall implement the *NAK* command shown in Table 6.28 of the Protocol.	Tag and Interrogator	**By design** Also tested in compliance with 6.3.2.4, Figure 6.19
6.3.2.10.2.5	*NAK* shall return all Tags to the **arbitrate** state unless they are in **ready** or **killed**, in which case they shall ignore the *NAK* and remain in their current state.	Tag	**By design**
6.3.2.10.2.5	A *NAK* shall be prepended with a frame-sync.	Interrogator	**By design**
6.3.2.10.2.5	Tags shall not reply to a *NAK*.	Tag	**By design** Also tested in compliance with 6.3.2.4, Figure 6.19

Protocol Subclause	Requirement	Applies To	How Verified
6.3.2.10.3	A Tag's reply to all access commands that write memory (i.e. *Write*, *Kill*, *Lock*, *BlockWrite*, and *BlockErase*) shall use the extended preamble shown in Figures 6.11 or 6.15 of the Protocol, as appropriate (i.e. the Tag shall reply as if TRext=1 regardless of the TRext value specified in the *Query* command that initiated the inventory round).	Tag	**By design** Also tested in compliance with 6.3.2.4, Figure 6.19
6.3.2.10.3	Tags that receive an optional access command that they do not support shall ignore the command.	Tag	**By design**
6.3.2.10.3.1	Interrogators and Tags shall implement the *Req_RN* command shown in Table 6.29 of the Protocol.	Tag and Interrogator	**By design** Also tested in compliance with 6.3.2.4, Figure 6.19
6.3.2.10.3.1	When issuing a *Req_RN* command to a Tag in the **acknowledged** state, an Interrogator shall include the Tag's last backscattered RN16 as a parameter in the *Req_RN*.	Interrogator	**By design**
6.3.2.10.3.1	If the Tag receives the *Req_RN* with a valid CRC-16 and a valid RN16 it shall generate and store a new RN16 (denoted handle), backscatter this handle, and transition to the **open** or **secured** state.	Tag	**By design**
6.3.2.10.3.1	If the Tag receives the *Req_RN* command with a valid CRC-16 but an invalid RN16 it shall ignore the *Req_RN* and remain in the **acknowledged** state.	Tag	**By design**
6.3.2.10.3.1	When issuing a *Req_RN* command to a Tag in the **open** or **secured** states, an Interrogator shall include the Tag's handle as a parameter in the *Req_RN*.	Interrogator	**By design**
6.3.2.10.3.1	If the Tag receives the *Req_RN* with a valid CRC-16 and a valid handle it shall generate and backscatter a new RN16.	Tag	**By design**
6.3.2.10.3.1	If the Tag receives the *Req_RN* with a valid CRC-16 but an invalid handle it shall ignore the *Req_RN*.	Tag	**By design**
6.3.2.10.3.1	In either case the Tag shall remain in its current state (**open** or **secured**, as appropriate).	Tag	**By design**
6.3.2.10.3.1	Tags that receive an *ACK* with an invalid handle shall return to **arbitrate** (Note: If a Tag receives an *ACK* with an invalid handle it returns to **arbitrate**, whereas if it receives an access command with an invalid handle it ignores the command).	Tag	**By design**
6.3.2.10.3.1	The first bit of the backscattered RN16 shall be denoted the MSB; the last bit shall be denoted the LSB.	Tag	**By design**
6.3.2.10.3.1	A *Req_RN* shall be prepended with a frame-sync.	Interrogator	**By design**
6.3.2.10.3.1	The Tag reply to a *Req_RN* shall be as shown in Table 6.30 of the Protocol.	Tag	**By design** Also tested in compliance with 6.3.2.4, Figure 6.19
6.3.2.10.3.2	Interrogators and Tags shall implement the *Read* command shown in Table 6.31 of the Protocol.	Tag and Interrogator	**By design** Also tested in compliance with 6.3.2.4, Figure 6.19
6.3.2.10.3.2	*Read* commands shall apply to a single memory bank.	Tag	**By design**
6.3.2.10.3.2	If WordCount = 00_h the Tag shall backscatter the contents of the chosen memory bank starting at WordPtr and ending at the end of the bank, unless MemBank = 01, in which case the Tag shall backscatter the EPC memory contents starting at WordPtr and ending at the length of the EPC specified by the first 5 bits of the PC if WordPtr lies within the EPC, and shall backscatter the EPC memory contents starting at WordPtr and ending at the end of EPC memory if WordPtr lies outside the EPC.	Tag	**By design**

Protocol Subclause	Requirement	Applies To	How Verified
6.3.2.10.3.2	If a Tag receives a *Read* with a valid CRC-16 but an invalid handle it shall ignore the *Read* and remain in its current state (**open** or **secured**, as appropriate).	Tag	**By design**
6.3.2.10.3.2	A *Read* shall be prepended with a frame-sync.	Interro-gator	**By design**
6.3.2.10.3.2	If all of the memory words specified in a *Read* exist and none are read-locked, the Tag reply to the *Read* shall be as shown in Table 6.32 of the Protocol.	Tag	**By design**
6.3.2.10.3.2	If a one or more of the memory words specified in the *Read* command either do not exist or are read-locked, the Tag shall backscatter an error code, within time T_1 in Table 6.13 of the Protocol, rather than the reply shown in Table 6.32 of the Protocol.	Tag	**By design**
6.3.2.10.3.3	Interrogators and Tags shall implement the *Write* command shown in Table 6.33 of the Protocol.	Tag and Interro-gator	**By design** Also tested in compliance with 6.3.2.4, Figure 6.19
6.3.2.10.3.3	Before each and every *Write* the Interrogator shall first issue a *Req_RN* command;	Interro-gator	**By design**
6.3.2.10.3.3	The Interrogator shall cover-code the data by EXORing it with this new RN16 prior to transmission.	Interro-gator	**By design**
6.3.2.10.3.3	If a Tag in the **open** or **secured** states receives a *Write* with a valid CRC-16 but an invalid handle, or it receives a *Write* before which the immediately preceding command was not a *Req_RN*, it shall ignore the *Write* and remain in its current state.	Tag	**By design**
6.3.2.10.3.3	A *Write* shall be prepended with a frame-sync.	Interro-gator	**By design**
6.3.2.10.3.3	After issuing a *Write* an Interrogator shall transmit CW for the lesser of T_{REPLY} or 20ms, where T_{REPLY} is the time between the Interrogator's *Write* command and the Tag's backscattered reply.	Interro-gator	**By design** Also tested in compliance with 6.3.2.4, Figure 6.19
6.3.2.10.3.3	After completing the *Write* a Tag shall backscatter the reply shown in Table 6.34 and Figure 6.22 of the Protocol comprising a header (a 0-bit), the Tag's handle, and a CRC-16 calculated over the 0-bit and handle.	Tag	**By design** Also tested in compliance with 6.3.2.4, Figure 6.19
6.3.2.10.3.3	The Tag shall backscatter an error code during the CW period rather than the reply shown in Table 6.34 of the Protocol.	Tag	**By design**
6.3.2.10.3.3	Upon receiving a valid *Write* command a Tag shall write the commanded Data into memory.	Tag	**By design**
6.3.2.10.3.3	The Tag's reply to a successful *Write* shall use the extended preamble shown in Figures 6.11 or 6.15 of the Protocol, as appropriate (i.e. a Tag shall reply as if TRext=1 regardless of the TRext value in the *Query* that initiated the round).	Tag	**By design** Also tested in compliance with 6.3.2.4, Figure 6.19
6.3.2.10.3.4	Interrogators and Tags shall implement the *Kill* command shown in Table 6.35 of the Protocol.	Tag and Interro-gator	**By design** Also tested in compliance with 6.3.2.4, Figure 6.19
6.3.2.10.3.4	When communicating with Class-1 Tags, Interrogators shall set these bits to 000_2.	Interro-gator	**By design**
6.3.2.10.3.4	Class-1 Tags shall ignore these bits.	Tag	**By design**
6.3.2.10.3.4	To kill a Tag, an Interrogator shall follow the multi-step kill procedure outlined in Figure 6.23 of the Protocol.	Interro-gator	**By design**
6.3.2.10.3.4	Each EXOR operation shall be performed MSB first (i.e. the MSB of each half-password shall be EXORed with the MSB of its respective RN16).	Interro-gator	**By design**

Protocol Subclause	Requirement	Applies To	How Verified
6.3.2.10.3.4	Tags shall incorporate the necessary logic to successively accept two 16-bit subportions of a 32-bit kill password.	Tag	**By design**
6.3.2.10.3.4	Interrogators shall not intersperse commands other than *Req_RN* between the two successive *Kill* commands.	Interrogator	**By design**
6.3.2.10.3.4	If a Tag, after receiving a first *Kill*, receives any command other than *Req_RN* before the second *Kill*, it shall return to **arbitrate**, unless the intervening command is a *Query*, in which case the Tag shall execute the *Query* (inverting its **inventoried** flag if the session parameter in the *Query* matches the prior session).	Tag	**By design**
6.3.2.10.3.4	The Tag reply to the first *Kill* shall be as shown in Table 6.36 of the Protocol.	Tag	**By design**
6.3.2.10.3.4	The reply shall use the TRext value specified in the *Query* command that initiated the round.	Tag	**By design**
6.3.2.10.3.4	After issuing the second *Kill* an Interrogator shall transmit CW for the lesser of T_{REPLY} or 20ms, where T_{REPLY} is the time between the Interrogator's second *Kill* command and the Tag's backscattered reply.	Interrogator	**By design** Also tested in compliance with 6.3.2.4, Figure 6.19
6.3.2.10.3.4	After completing the *Kill* the Tag shall backscatter the reply shown in Table 6.36 and Figure 6.22 of the Protocol comprising a header (a 0-bit), the Tag's handle, and a CRC-16 calculated over the 0-bit and handle.	Tag	**By design** Also tested in compliance with 6.3.2.4, Figure 6.19
6.3.2.10.3.4	Immediately after this reply the Tag shall render itself silent and shall not respond to an Interrogator thereafter.	Tag	**By design**
6.3.2.10.3.4	The Tag shall backscatter an error code during the CW period rather than the reply shown in Table 6.36 of the Protocol.	Tag	**By design**
6.3.2.10.3.4	A *Kill* shall be prepended with a frame-sync.	Interrogator	**By design**
6.3.2.10.3.4	Upon receiving a valid *Kill* command sequence a Tag shall render itself killed.	Tag	**By design**
6.3.2.10.3.4	The Tag's reply to the second *Kill* command shall use the extended preamble shown in Figures 6.11 or 6.15 of the Protocol, as appropriate (i.e. a Tag shall reply as if TRext=1 regardless of the TRext value in the *Query* that initiated the round).	Tag	**By design** Also tested in compliance with 6.3.2.4, Figure 6.19
6.3.2.10.3.5	Interrogators and Tags shall implement the *Lock* command shown in Table 6.37 and Figures 6.24 of the Protocol.	Tag and Interrogator	**By design** Also tested in compliance with 6.3.2.4, Figure 6.19
6.3.2.10.3.5	Only Tags in the **secured** state shall execute a *Lock* command.	Tag	**By design**
6.3.2.10.3.5	A Tag shall interpret these bit values as follows: Mask = 0: Ignore the associated Action field and retain the current lock setting; Mask = 1: Implement the associated Action field and overwrite the current lock setting.	Tag	**By design**
6.3.2.10.3.5	A Tag shall interpret these bit values as follows: Action = 0: Deassert lock for the associated memory location; Action = 1: Assert lock or permalock for the associated memory location.	Tag	**By design**
6.3.2.10.3.5	The payload of a *Lock* command shall always be 20 bits in length.	Tag	**By design**
6.3.2.10.3.5	If an Interrogator issues a *Lock* command whose Mask and Action fields attempt to change the lock status of a nonexistent memory bank or nonexistent password, the Tag shall ignore the entire *Lock* command and instead backscatter an error code (see Annex I).	Tag	**By design**

Protocol Subclause	Requirement	Applies To	How Verified
6.3.2.10.3.5	If a Tag receives a *Lock* whose payload attempts to deassert a previously asserted permalock bit, the Tag shall ignore the *Lock* and backscatter an error code.	Tag	**By design**
6.3.2.10.3.5	If a Tag receives a *Lock* whose payload attempts to reassert a previously asserted permalock bit, the Tag shall simply ignore this particular Action field and implement the remainder of the *Lock* payload.	Tag	**By design**
6.3.2.10.3.5	All Tags shall implement memory locking.	Tag	**By design** Also tested in compliance with 6.3.2.4, Figure 6.19
6.3.2.10.3.5	All Tags shall implement the *Lock* command.	Tag	**By design** Also tested in compliance with 6.3.2.4, Figure 6.19
6.3.2.10.3.5	If a Tag receives a *Lock* it cannot execute because one or more of the passwords or memory banks do not exist, or one or more of the Action fields attempt to change a previously permalocked value, or one or more of the passwords or memory banks are either not lockable or not unlockable, the Tag shall ignore the entire *Lock* and instead backscatter an error code.	Tag	**By design**
6.3.2.10.3.5	The only exception to this general rule relates to Tags whose only lock functionality is to permanently lock **all** memory (i.e. all memory banks and all passwords) at once; these Tags shall execute a *Lock* whose payload is $FFFFF_h$, and shall backscatter an error code for any payload other than $FFFFF_h$.	Tag	**By design**
6.3.2.10.3.5	A *Lock* shall be prepended with a frame-sync.	Interrogator	**By design**
6.3.2.10.3.5	After issuing a *Lock* an Interrogator shall transmit CW for the lesser of T_{REPLY} or 20ms, where T_{REPLY} is the time between the Interrogator's *Lock* command and the Tag's backscattered reply.	Interrogator	**By design** Also tested in compliance with 6.3.2.4, Figure 6.19
6.3.2.10.3.5	After completing the *Lock* the Tag shall backscatter the reply shown in Table 6.38 and Figure 6.22 of the Protocol comprising a header (a 0-bit), the Tag's handle, and a CRC-16 calculated over the 0-bit and handle.	Tag	**By design** Also tested in compliance with 6.3.2.4, Figure 6.19
6.3.2.10.3.5	The Tag shall backscatter an error code during the CW period rather than the reply shown in Table 6.38 of the Protocol.	Tag	**By design**
6.3.2.10.3.5	Upon receiving a valid *Lock* command a Tag shall perform the commanded lock operation.	Tag	**By design**
6.3.2.10.3.5	The Tag's reply to a *Lock* shall use the extended preamble shown in Figures 6.11 or 6.15 of the Protocol, as appropriate (i.e. a Tag shall reply as if TRext=1 regardless of the TRext value in the *Query* that initiated the round).	Tag	**By design** Also tested in compliance with 6.3.2.4, Figure 6.19
6.3.2.10.3.6	Interrogators and Tags may implement an *Access* command; if they do, the command shall be as shown in Table 6.40 of the Protocol.	Tag and Interrogator	**By design** If implemented, then tested in compliance with 6.3.2.4, Figure 6.19
6.3.2.10.3.6	To access a Tag, an Interrogator shall follow the multi-step procedure outlined in Figure 6.25 of the Protocol.	Interrogator	**By design**
6.3.2.10.3.6	Each EXOR operation shall be performed MSB first (i.e. the MSB of each half-password shall be EXORed with the MSB of its respective RN16).	Interrogator	**By design**
6.3.2.10.3.6	Tags shall incorporate the necessary logic to successively accept two 16-bit subportions of a 32-bit access password.	Tag	**By design**
6.3.2.10.3.6	Interrogators shall not intersperse commands other than *Req_RN* between the two successive *Access* commands.	Interrogator	**By design**

Protocol Subclause	Requirement	Applies To	How Verified
6.3.2.10.3.6	If a Tag, after receiving a first *Access*, receives any command other than *Req_RN* before the second *Access*, it shall return to **arbitrate**, unless the intervening command is a *Query*, in which case the Tag shall execute the *Query* (inverting its **inventoried** flag if the session parameter in the *Query* matches the prior session).	Tag	**By design**
6.3.2.10.3.6	An *Access* shall be prepended with a frame-sync.	Interrogator	**By design**
6.3.2.10.3.6	The Tag reply to an *Access* command shall be as shown in Table 6.41 of the Protocol.	Tag	**By design** If implemented, then tested in compliance with 6.3.2.4, Figure 6.19
6.3.2.10.3.7	Interrogators and Tags may implement a *BlockWrite* command; if they do, they shall implement it as shown in Table 6.42 of the Protocol.	Tag and Interrogator	**By design** If implemented, then tested in compliance with 6.3.2.4, Figure 6.19
6.3.2.10.3.7	*BlockWrite* commands shall apply to a single memory bank.	Tag	**By design**
6.3.2.10.3.7	If WordCount = 00_h the Tag shall ignore the *BlockWrite*.	Tag	**By design**
6.3.2.10.3.7	If WordCount = 01_h the Tag shall write a single data word.	Tag	**By design**
6.3.2.10.3.7	Data contains the 16-bit words to be written, and shall be 16 × WordCount bits in length.	Interrogator	**By design**
6.3.2.10.3.7	If a Tag receives a *BlockWrite* with a valid CRC-16 but an invalid handle it shall ignore the *BlockWrite* and remain in its current state (**open** or **secured**, as appropriate).	Tag	**By design**
6.3.2.10.3.7	A *BlockWrite* shall be prepended with a frame-sync.	Interrogator	**By design**
6.3.2.10.3.7	After issuing a *BlockWrite* an Interrogator shall transmit CW for the lesser of T_{REPLY} or 20ms, where T_{REPLY} is the time between the Interrogator's *BlockWrite* command and the Tag's backscattered reply.	Interrogator	**By design** If implemented, then tested in compliance with 6.3.2.4, Figure 6.19
6.3.2.10.3.7	**The *BlockWrite* succeeds:** After completing the *BlockWrite* a Tag shall backscatter the reply shown in Table 6.43 and Figure 6.22 of the Protocol, comprising a header (a 0-bit), the Tag's handle, and a CRC-16 calculated over the 0-bit and handle.	Tag	**By design** If implemented, then tested in compliance with 6.3.2.4, Figure 6.19
6.3.2.10.3.7	**The Tag encounters an error:** The Tag shall backscatter an error code during the CW period rather than the reply shown in Table 6.43 of the Protocol.	Tag	**By design**
6.3.2.10.3.7	Upon receiving a valid *BlockWrite* command a Tag shall write the commanded Data into memory.	Tag	**By design**
6.3.2.10.3.7	The Tag's reply to a *BlockWrite* shall use the extended preamble shown in figures 6.11 or 6.15 of the Protocol, as appropriate (i.e. a Tag shall reply as if TRext=1 regardless of the TRext value in the *Query* that initiated the round).	Tag	**By design** If implemented, then tested in compliance with 6.3.2.4, Figure 6.19
6.3.2.10.3.8	Interrogators and Tags may implement a *BlockErase* command; if they do, they shall implement it as shown in Table 6.44 of the Protocol.	Tag and Interrogator	**By design** If implemented, then tested in compliance with 6.3.2.4, Figure 6.19
6.3.2.10.3.8	*BlockErase* commands shall apply to a single memory bank.	Tag	**By design**
6.3.2.10.3.8	If WordCount = 00_h the Tag shall ignore the *BlockErase*.	Tag	**By design**
6.3.2.10.3.8	If WordCount = 01_h the Tag shall erase a single data word.	Tag	**By design**
6.3.2.10.3.8	If a Tag receives a *BlockErase* with a valid CRC-16 but an invalid handle it shall ignore the *BlockErase* and remain in its current state (**open** or **secured**, as appropriate).	Tag	**By design**

Protocol Subclause	Requirement	Applies To	How Verified
6.3.2.10.3.8	A *BlockErase* shall be prepended with a frame-sync.	Interrogator	**By design**
6.3.2.10.3.8	After issuing a *BlockErase* an Interrogator shall transmit CW for the lesser of T_{REPLY} or 20ms, where T_{REPLY} is the time between the Interrogator's *BlockErase* command and the Tag's backscattered reply.	Interrogator	**By design** If implemented, then tested in compliance with 6.3.2.4, Figure 6.19
6.3.2.10.3.8	After completing the *BlockErase* a Tag shall backscatter the reply shown in Table 6.45 and Figure 6.22 of the Protocol, comprising a header (a 0-bit), the Tag's handle, and a CRC-16 calculated over the 0-bit and handle.	Tag	**By design** If implemented, then tested in compliance with 6.3.2.4, Figure 6.19
6.3.2.10.3.8	**The Tag encounters an error:** The Tag shall backscatter an error code during the CW period rather than the reply shown in Table 6.45 of the Protocol.	Tag	**By design**
6.3.2.10.3.8	Upon receiving a valid *BlockErase* command a Tag shall erase the commanded memory words.	Tag	**By design**
6.3.2.10.3.8	The Tag's reply to a *BlockErase* shall use the extended preamble shown in Figures 6.11 or 6.15 of the Protocol, as appropriate (i.e. a Tag shall reply as if TRext=1 regardless of the TRext value in the *Query* that initiated the round).	Tag	**By design** If implemented, then tested in compliance with 6.3.2.4, Figure 6.19
Annex A	Although a general EBV may contain blocks of varying lengths, Tags and Interrogators manufactured according to this specification shall use blocks of length 8 bits (EBV-8).	Tag and Interrogator	**By design**
Annex A	Tags and Interrogators shall use the EBV-8 word format specified in Table A.1 of the Protocol.	Tag and Interrogator	**By design**
Annex B	State-transition tables B1 to B.7 of the Protocol shall define a Tag's response to Interrogator commands.	Tag	**By design** Also tested in compliance with 6.3.2.4, Figure 6.19
Table B.1	"Invalid" shall mean an erroneous command, an unsupported command, a command with invalid parameters, a command with a CRC error, or any other command either not recognized or not executable by the Tag.	–	Definition. Not verified.
Table B.2	"Invalid" shall mean an erroneous command, an unsupported command, a command with invalid parameters, a command with a CRC error, a command (other than a *Query*) with a session parameter not matching that of the inventory round currently in progress, or any other command either not recognized or not executable by the Tag.	–	Definition. Not verified.
Table B.3	"Invalid" shall mean an erroneous command, an unsupported command, a command with invalid parameters, a command with a CRC error, a command (other than a *Query*) with a session parameter not matching that of the inventory round currently in progress, or any other command either not recognized or not executable by the Tag.	–	Definition. Not verified.
Table B.4	"Invalid" shall mean an erroneous command, an unsupported command, a command with invalid parameters, a command with a CRC error, a command (other than a *Query*) with a session parameter not matching that of the inventory round currently in progress, or any other command either not recognized or not executable by the Tag.	–	Definition. Not verified.
Table B.5	"Invalid" shall mean an erroneous command, an unsupported command, a command with invalid parameters, a command with a CRC error, a command (other than a *Query*) with a session parameter not matching that of the inventory round currently in progress, or any other command either not recognized or not executable by the Tag.	–	Definition. Not verified.

Protocol Subclause	Requirement	Applies To	How Verified
Table B.6	"Invalid" shall mean an erroneous command, an unsupported command, a command with invalid parameters, a command with a CRC error, a command (other than a *Query*) with a session parameter not matching that of the inventory round currently in progress, or any other command either not recognized or not executable by the Tag.	–	Definition. Not verified.
Table B.7	"Invalid" shall mean an erroneous command, an unsupported command, a command with invalid parameters, a command with a CRC error, or any other command either not recognized or not executable by the Tag.	–	Definition. Not verified.
Annex C	Command-response tables C.1 to C.17 of the Protocol shall define a Tag's response to Interrogator commands.	Tag	**By design** Also tested in compliance with 6.3.2.4, Figure 6.19
Table C.17	"Invalid" shall mean an erroneous command, an unsupported command, a command with invalid parameters, a command with a CRC error, or any other command either not recognized or not executable by the Tag.	–	Definition. Not verified.
Table C.17	"Invalid" shall mean an erroneous command, an unsupported command, a command with invalid parameters, a command with a CRC error, a command (other than a *Query*) with a session parameter not matching that of the inventory round currently in progress, or any other command either not recognized or not executable by the Tag.	–	Definition. Not verified.
Annex G.1	Interrogators certified for operation in dense-Interrogator environments shall be capable of supporting one or more of the frequency plans or TDM approaches described below.	Interrogator	**By design**
Annex G.1	**Single-channel regulatory environment:** Interrogator transmissions and Tag responses shall be separated temporally, with synchronized Interrogators first commanding Tags, then all Interrogators transmitting CW and listening for Tag responses.	Interrogator	**By design**
Annex G.1	**Single-channel regulatory environment:** Interrogator signaling (both modulated and CW) shall be centered in the channel with a frequency accuracy as specified in 6.3.1.2.1 of the Protocol.	Interrogator	**By design** Also tested in compliance with 6.3.1.2.1
Annex G.1	**Single-channel regulatory environment:** If an Interrogator uses SSB modulation, the transmit spectrum shall be centered in the channel during R=>T signaling, and the CW shall be centered in the channel during Tag backscatter.	Interrogator	Tested in compliance with Annex G.1 for multi-channel regulatory environments
Annex G.1	**Multi-channel regulatory environment:** Interrogator transmissions and Tag responses shall be separated spectrally, with Interrogator transmissions located in even-numbered channels and Tag backscatter located in odd-numbered channels.	Interrogator	**By design**
Annex G.1	**Multi-channel regulatory environment:** Interrogator signaling (both modulated and CW) shall be centered in a channel with a frequency accuracy as specified in 6.3.1.2.1 of the Protocol.	Interrogator	**By design** Also tested in compliance with 6.3.1.2.1

Protocol Subclause	Requirement	Applies To	How Verified
Annex G.1	**Multi-channel regulatory environment:** If an Interrogator uses SSB-ASK modulation, the transmit spectrum shall be centered in the channel during R=>T signaling, and the CW shall be centered in the channel during Tag backscatter.	Interrogator	**By demonstration** (only for Interrogators that implement SSB modulation in dense-Interrogator environments) Test conditions: Temp: 23 +/– 5 ºC Freq: 866.5 MHz (if certified for operation in Europe); 915.25 MHz (if certified for operation in North America) Power: Maximum Interrogator transmit power, as implemented. Modulation: SSB Tari: 25 µs RTcal: 75 µs TRcal: 200 µs PW: As implemented Modulation depth: As implemented Rise/fall time: As implemented
Annex G.1	**Multi-channel regulatory environment:** Interrogator transmissions shall satisfy the dense-Interrogator transmit mask in Figure 6.7 of the Protocol with Tari=25µs.	Interrogator	Tested in compliance with 6.3.1.2.11, Figure 6.7
Annex G.1	**Multi-channel regulatory environment:** Tag backscatter shall be 53.3 or 26.7 kbps data on a 213.3 kHz subcarrier (M=4 or M=8).	Interrogator	**By design**
Annex G.1	Interrogator transmissions and Tag responses shall be separated spectrally, with Interrogator transmissions centered in channels and Tag responses situated at channel boundaries.	Interrogator	**By design**
Annex G.1	The frequency band shall be channelized as in Table 6.10 of the Protocol.	Interrogator	Tested in compliance with 6.3.1.2.10
Annex G.1	Interrogator signaling (both modulated and CW) shall be centered in a channel with frequency accuracy as specified in 6.3.1.2.1 of the Protocol.	Interrogator	**By design** Also tested in compliance with 6.3.1.2.1
Annex G.1	If an Interrogator uses SSB modulation, the transmit spectrum shall be centered in the channel during R=>T signaling, and the CW shall be centered in the channel during Tag backscatter.	Interrogator	Tested in compliance with Annex G.1 for multi-channel regulatory environments
Annex G.1	Interrogator transmissions shall satisfy the dense-Interrogator transmit mask in Figure 6.7 of the Protocol, with Tari=25µs.	Interrogator	Tested in compliance with 6.3.1.2.11, Figure 6.7
Annex G.1	Tag backscatter shall be 64 or 32 kbps data on a 256 kHz subcarrier (M=4 or M=8).	Interrogator	**By design**
Annex I.1	If a Tag encounters an error when executing an access command that reads from or writes to memory, and if the command is a handle-based command (i.e. *Read*, *Write*, *Kill*, *Lock*, *BlockWrite*, or *BlockErase*), then the Tag shall backscatter an error code as shown in Table I.1 of the Protocol instead of its normal reply.	Tag	**By design**
Annex I.1	If the Tag supports error-specific codes, it shall use the error-specific codes shown in Table I.2 of the Protocol.	Tag	**By design**
Annex I.1	If the Tag does not support error-specific codes, it shall backscatter error code 00001111_2 (indicating a non-specific error) as shown in Table I.2 of the Protocol.	Tag	**By design**
Annex I.1	Tags shall backscatter error codes only from the **open** or **secured** states.	Tag	**By design**

Protocol Subclause	Requirement	Applies To	How Verified
Annex I.1	A Tag shall not backscatter an error code if it receives an invalid access command; instead, it shall ignore the command.	Tag	**By design**
Annex I.1	If an error is described by more than one error code, the more specific error code shall take precedence and shall be the code that the Tag backscatters.	Tag	**By design**

7. Revision History

Date & Version Number	Section(s)	Change	Approved by
Nov 14, 2004 Version 1.0.0	All	Original document	
Dec 11, 2004 Version 1.0.1	Multiple	Modified per the Gen2 conformance V1.0.0 comment resolution.	
Jan 26, 2005 Version 1.0.2	Multiple	Modified per the Gen2 V1.0.8 errata and AFI enhancement requests.	