Specification for RFID Air Interface

EPC™ Radio-Frequency Identity Protocols
Class-1 Generation-2 UHF RFID
Conformance Requirements
Version 1.0.4

This version was approved by the EPCglobal Technical Steering Committee on July 21, 2006.

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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 conformance 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 the Protocol 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 when appropriately commanded by an Interrogator.

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 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: <u>pointer</u>.
- 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

Item	Protocol Subclause	Requirement	Applies To	How Verified
1	6.1.1	Tags shall not be required to demodulate Interrogator commands while backscattering.	Tag	**By design**
2	6.1.1	A Tag shall not respond using full-duplex communications to a mandatory or optional command.	Tag	**By design**
3	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 +/– 3 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
4	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**
5	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	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**
7	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: max(–40, minimum supported temperature) and min(65, maximum supported temperature). If supported temperature range exceeds –25 or 40 then testing shall also be performed at –25 or 40 respectively. All temperatures are in ºC (all +/– 3 ºC). See Annex A, Q7. Freq: 5 test points situated at the band edges and linearly spanning the supported band at valid channel frequencies.
8	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**

Item	Protocol Subclause	Requirement	Applies To	How Verified
9	6.3.1.2.2	Tags shall be capable of demodulating all three modulation types.	Tag	**By demonstration** Test conditions: Temp: 23 +/– 3 ºC Freq: 860 & 960 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
10	6.3.1.2.3	The R=>T link shall use PIE, shown in Figure 6.1 of the Protocol.	Interrogator	**By design**
11	6.3.1.2.3	The tolerance on all parameters shall be +/–1%.	Interrogator	**By demonstration** Test conditions: Temp: Either (a) or (b) shown below a) Single and Multi-Interrogators: 23 ºC +/– 3 ºC b) Dense-Interrogators tested at modulation, data rate, and encoding parameters specified in Annex G of the Protocol specification: max(–40, minimum supported temperature) and min(65, maximum supported temperature). If supported temperature range exceeds –25 or 40 then testing shall also be performed at –25 or 40 respectively. All temperatures are in ºC (all +/– 3 ºC). See Annex A, Q7. Freq: At channel frequency closest to center of supported band. Power: Maximum Interrogator transmit power, as implemented. Other transmit parameters: As implemented
12	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 +/– 3 ºC Freq: At channel frequency closest to center of supported band. Power: Maximum Interrogator transmit power, as implemented. Other transmit parameters: As implemented See Annex A, Q10.

Item	Protocol Subclause	Requirement	Applies To	How Verified
13	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**
14	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 +/– 3 ºC Freq: At channel frequency closest to center of supported band. Power: Maximum Interrogator transmit power, as implemented. Other transmit parameters: As implemented See Annex A, Q10.
15	6.3.1.2.4	Interrogators shall communicate using Tari values between 6.25µs and 25µs, inclusive.	Interrogator	**By design**
16	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.
17	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**
18	6.3.1.2.4	The choice of Tari value shall be in accordance with local radio regulations.	Interrogator	**By design**
19	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
20	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**
21	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 +/– 3 ºC Freq: At channel frequency closest to center of supported band. Power: Maximum Interrogator transmit power, as implemented. See Annex A, Q8.
22	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_I. 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 +/– 3 ºC Freq: At channel frequency closest to center of supported band. Power: Maximum Interrogator transmit power, as implemented. See Annex A, Q9.
23	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**

Item	Protocol Subclause	Requirement	Applies To	How Verified
24	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 +/– 3 ºC Freq: At channel frequency closest to center of supported band. Power: Maximum Interrogator transmit power, as implemented.
25	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 +/– 3 ºC Freq: At channel frequency closest to center of supported band. Power: Maximum Interrogator transmit power, as implemented. See Annex A, Q9.
26	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**
27	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**
28	6.3.1.2.8	A preamble shall precede a *Query* command and denotes the start of an inventory round.	Interrogator	**By design**
29	6.3.1.2.8	All other signaling shall begin with a frame-sync.	Interrogator	**By design**
30	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
31	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
32	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 +/– 3 ºC Freq: At channel frequency closest to center of supported band. Power: Maximum Interrogator transmit power, as implemented. Other transmit parameters: As implemented
33	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**
34	6.3.1.2.8	RTcal: A Tag shall measure the length of RTcal and compute *pivot* = RTcal / 2.	Tag	**By design**
35	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**
36	6.3.1.2.8	RTcal: The Tag shall interpret symbols longer than 4 RTcal to be bad data.	Tag	**By design**
37	6.3.1.2.8	RTcal: Prior to changing RTcal, an Interrogator shall transmit CW for a minimum of 8 RTcal.	Interrogator	**By design**

Item	Protocol Subclause	Requirement	Applies To	How Verified
38	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 subcarrier) using the TRcal and divide ratio (DR) in the preamble and payload, respectively, of a *Query* command that initiates an inventory round.	Interrogator	**By design**
39	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
40	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.	Interrogator	Tested in compliance with 6.3.1.2.8, Figure 6.2
41	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.	Interrogator	**By design**
42	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}.	Interrogator	**By demonstration**, for Interrogators that use FHSS: <u>Test conditions:</u> Temp: 23 +/– 3 ºC Freq: At channel frequency closest to center of supported band. Power: Maximum Interrogator transmit power, as implemented.
43	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}).	Interrogator	**By design**
44	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.	Interrogator	**By design**
45	6.3.1.2.10	Interrogators certified for operation in single-Interrogator environments shall meet local regulations for spread-spectrum channelization.	Interrogator	**By design**
46	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.	Interrogator	**By demonstration**, for multiple- or dense-Interrogator certification. <u>Test conditions:</u> Temp: 23 +/– 3 ºC Freq: Either (a) or (b) shown below a) Interrogators that are capable of commanding Tags to backscatter using subcarrier signaling: 50 discrete center frequencies as specified in Table 6.10 of the Protocol. b) Interrogators that are not capable of commanding Tags to backscatter using subcarrier signaling: All center frequencies supported by the Interrogator (note: the certification laboratory reserves the right to test a random subset of the Interrogator's supported center frequencies). Power: Maximum Interrogator transmit power, as implemented

Item	Protocol Subclause	Requirement	Applies To	How Verified
47	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.	Interrogator	**By design**
48	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. <u>Test conditions:</u> Temp: 23 +/– 3 ºC Freq: At channel frequency closest to center of supported band. Power: Maximum Interrogator transmit power, as implemented. Channel width: 200 kHz for Interrogators certified for operation in Europe; A maximum of 500 kHz for Interrogators certified for operation in North America. Modulation: As implemented Transmit data: Either (a) or (b), below a) a continuous repeating 9-bit maximum length sequence with polynomial $x^9 + x^4 + 1$, initially seeded with all ones, resulting in a repeating 511-bit sequence of FF83DF1732094ED1E7CD8A91C6D5C4C44021184E5586F4DC8A15A7EC92DF93533018CA34BFA2C759678FBA0D6DD82D7D540A57977039D27AEA243385ED9A1DE0$_h$, or b) a single *Select* command with a 252 bit <u>Mask</u> value set to ACBCD2114DAE1577C6DBF4C91A3CDA2F169B340989C1D32C290465E5C1423CC$_h$ Bit sequences are listed MSB first. Other transmit parameters: As implemented
49	6.3.1.2.11	Multiple-Interrogator Transmit Mask: For an Interrogator transmitting in channel *R*, and any other channel $S \neq R$, 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
50	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

Item	Protocol Subclause	Requirement	Applies To	How Verified
51	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 +/– 3 ºC Freq: At channel frequency closest to center of supported band. Power: Maximum Interrogator transmit power, as implemented. Reference bandwidth: 2.5/Tari Modulation: As implemented Transmit data: Either (a) or (b) below a) a continuous repeating 9-bit maximum length sequence with polynomial $x^9 + x^4 + 1$, initially seeded with all ones, resulting in a repeating 511-bit sequence of FF83DF1732094ED1E7CD8A91C6D5C4C44021184E5586F4DC8A15A7EC92DF93533018CA34BFA2C759678FBA0D6DD82D7D540A57977039D27AEA243385ED9A1DE0$_h$, or b) a single *Select* command with a 252 bit Mask value set to ACBCD2114DAE1577C6DBF4C91A3CDA2F169B340989C1D32C290465E5C1423CC$_h$ Bit sequences are listed MSB first. Tari: 25 µs Backscatter data rate: One or more of the dense-interrogator data rates specified in Annex G of the Protocol specification, as implemented. Other transmit parameters: As implemented
52	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
53	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
54	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
55	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**
56	6.3.1.3.1	Tag backscatter shall use ASK and/or PSK modulation.	Tag	**By design**
57	6.3.1.3.1	Interrogators shall be capable of demodulating either modulation type.	Interrogator	**By design**

Item	Protocol Subclause	Requirement	Applies To	How Verified
58	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
59	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 +/– 3 ºC Freq: 860 & 960 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
60	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**
61	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 +/– 3 ºC Freq: 860 & 960 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
62	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**

Item	Protocol Subclause	Requirement	Ap-plies To	How Verified
63	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 +/– 3 ºC Freq: 860 & 960 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
64	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**
65	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 +/– 3 ºC Freq: 860 & 960 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

Item	Protocol Subclause	Requirement	Applies To	How Verified
66	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 +/– 3 ºC Freq: 860 & 960 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
67	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**

Item	Protocol Subclause	Requirement	Applies To	How Verified
68	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**
69	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**
70	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** <u>Interrogator test conditions:</u> Verify Interrogator meets T_2, T_3, & T_4 Temp: 23 +/– 3 ºC Freq: At channel frequency closest to center of supported band. Power: Maximum Interrogator transmit power, as implemented. Other transmit parameters: As implemented <u>Tag test conditions:</u> Verify Tag meets T_1 over T_2 extremes Temp: 23 +/– 3 ºC Freq: 860 & 960 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 Minimum T_2 condition: Tari: 6.25 µs RTcal: 18.75 µs TRcal: 33.3 & 50 µs DR: 64/3 M: 1 Maximum T_2 condition: Tari: 25 µs RTcal: 75 µs TRcal: 200 µs DR: 8 M: 2, 4, 8
71	6.3.1.5	… an Interrogator shall use a fixed R=>T link rate for the duration of an inventory round.	Interrogator	**By design**
72	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**
73	6.3.1.5	The maximum value for T_2 shall apply only to Tags in the **reply** or **acknowledged** states.	Tag	**By design**

Item	Protocol Subclause	Requirement	Applies To	How Verified
74	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**
75	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**
76	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**
77	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**
78	6.3.1.5	T_1+T_3 shall not be less than T_4.	Tag	**By design**
79	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**
80	6.3.2.1	**Reserved memory** shall contain the kill and access passwords.	Tag	**By design**
81	6.3.2.1	The kill password shall be stored at memory addresses 00_h to $1F_h$.	Tag	**By design**
82	6.3.2.1	The access password shall be stored at memory addresses 20_h to $3F_h$.	Tag	**By design**
83	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**
84	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**
85	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**
86	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. <u>Tag test conditions:</u> Temp: 23 +/– 3 ºC Freq: 860 & 960 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

Item	Protocol Subclause	Requirement	Applies To	How Verified
87	6.3.2.1	The logical addressing of all memory banks shall begin at zero (00_h).	Tag	**By design**
88	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**
89	6.3.2.1	Operations in one logical memory bank shall not access memory locations in another bank.	Tag	**By design**
90	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**
91	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**
92	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**
93	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. <u>Tag test conditions:</u> Temp: 23 +/– 3 ºC Freq: 860 & 960 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
94	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**
95	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**
96	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**

Item	Protocol Subclause	Requirement	Applies To	How Verified
97	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** <u>Test for rewriteable Tags:</u> 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. <u>Test for prewritten Tags:</u> Power up the Tag and singulate it. Verify that the backscattered CRC-16 matches the backscattered EPC. <u>Tag test conditions for either case:</u> Temp: 23 +/– 3 ºC Freq: 860 & 960 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
98	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**
99	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**
100	6.3.2.1.3	Tags shall not recalculate this CRC-16 for a truncated reply.	Tag	**By design**
101	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** <u>Tag test conditions:</u> Temp: 23 +/– 3 ºC Freq: 860 & 960 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

Item	Protocol Subclause	Requirement	Applies To	How Verified
102	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 +/– 3 ºC Freq: 860 & 960 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
103	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**
104	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
105	6.3.2.2	Interrogators shall support and Tags shall provide 4 sessions (denoted S0, S1, S2, and S3).	Tag and Interrogator	**By design**
106	6.3.2.2	Tags shall participate in one and only one session during an inventory round.	Tag	**By design**
107	6.3.2.2	Tags shall maintain an independent **inventoried** flag for each session.	Tag	**By design**
108	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**
109	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**
110	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
111	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**
112	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**

Item	Protocol Subclause	Requirement	Applies To	How Verified
113	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**
114	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**
115	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**
116	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**
117	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**
118	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
119	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**
120	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**
121	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**
122	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.

Item	Protocol Subclause	Requirement	Applies To	How Verified
123	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 +/– 3 ºC Freq: 860 & 960 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
124	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
125	6.3.2.4.1	Upon entering an energizing RF field a Tag that is not killed shall enter **ready**.	Tag	**By design**
126	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**
127	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**
128	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**
129	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
130	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**
131	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**
132	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
133	6.3.2.4.3	Upon entering **reply** a Tag shall backscatter an RN16.	Tag	**By design**

Item	Protocol Subclause	Requirement	Applies To	How Verified
134	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**
135	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**
136	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
137	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
138	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
139	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
140	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**
141	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
142	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
143	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**
144	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**
145	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
146	6.3.2.4.7	Tags shall implement a **killed** state.	Tag	**By design**
147	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**
148	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
149	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

Item	Protocol Subclause	Requirement	Applies To	How Verified
150	6.3.2.4.8	Tags shall implement a 15-bit slot counter.	Tag	**By design**
151	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**
152	6.3.2.4.8	Upon receiving a *QueryRep* command a Tag shall decrement its slot counter.	Tag	**By design**
153	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**
154	6.3.2.5	Tags shall implement a random or pseudo-random number generator (RNG).	Tag	**By design**
155	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**
156	6.3.2.5	Tags shall generate 16-bit random or pseudo-random numbers (RN16) using the RNG.	Tag	**By design**
157	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**
158	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**
159	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
160	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
161	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.
162	6.3.2.7	A *Select* that modifies **SL** shall not modify **inventoried**, and vice versa.	Tag	**By design**
163	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**
164	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**
165	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

Item	Protocol Subclause	Requirement	Applies To	How Verified
166	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**
167	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**
168	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**
169	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**
170	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
171	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**
172	6.3.2.8	If a Tag in the **acknowledged**, **open**, or **secured** states receives a *Query* whose <u>session</u> 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**
173	6.3.2.8	If a Tag in the **acknowledged**, **open**, or **secured** states receives a *Query* whose <u>session</u> 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**
174	6.3.2.8	Tags in any state except **ready** or **killed** shall execute a *QueryAdjust* or *QueryRep* command if, and only if, the <u>session</u> parameter in the command matches the <u>session</u> parameter in the *Query* that started the round.	Tag	**By design**
175	6.3.2.8	Tags shall ignore a *QueryAdjust* or *QueryRep* with mismatched session.	Tag	**By design**
176	6.3.2.8	If a Tag in the **acknowledged**, **open**, or **secured** states receives a *QueryAdjust* or *QueryRep* whose <u>session</u> parameter matches the <u>session</u> 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**
177	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**
178	6.3.2.9	When in either [the **open** or **secured** states] …, Tags shall verify that the <u>handle</u> is correct prior to executing an access command, and shall ignore access commands with an incorrect <u>handle</u>.	Tag	**By design**

Item	Protocol Subclause	Requirement	Applies To	How Verified
179	6.3.2.9	An Interrogator shall not use handle for cover-coding purposes.	Interrogator	**By design**
180	6.3.2.9	An Interrogator shall not re-use an RN16 for cover-coding.	Interrogator	**By design**
181	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**
182	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**
183	6.3.2.9	Interrogator and Tag shall transmit all strings MSB first.	Tag and Interrogator	**By design**
184	6.3.2.10	Interrogator-to-Tag commands shall have the format shown in Table 6.16 of the Protocol.	Interrogator	**By design**
185	6.3.2.10	No other commands shall have these lengths.	Interrogator	**By design**
186	6.3.2.10	If a Tag receives one of these commands with an incorrect length it shall ignore the command.	Tag	**By design**
187	6.3.2.10	Tags shall ignore invalid commands.	Tag	**By design**
188	6.3.2.10.1.1	Interrogators and Tags shall implement the *Select* command shown in Table 6.18 of the Protocol.	Tag and Interrogator	**By design** Also tested in compliance with 6.3.2.4, Figure 6.19
189	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**
190	6.3.2.10.1.1	Action shall elicit the Tag response shown in Table 6.19 of the Protocol.	Tag	**By design**
191	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**
192	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**
193	6.3.2.10.1.1	*Select* commands shall apply to a single memory bank.	Tag	**By design**
194	6.3.2.10.1.1	MemBank shall not specify Reserved memory.	Tag	**By design**
195	6.3.2.10.1.1	If a Tag receives a *Select* specifying MemBank = 00_2 it shall ignore the *Select*.	Tag	**By design**
196	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**
197	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**
198	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**

Item	Protocol Subclause	Requirement	Applies To	How Verified
199	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.	Interrogator	**By design**
200	6.3.2.10.1.1	Tags shall power-up with Truncate deasserted.	Tag	**By design**
201	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**
202	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**
203	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**
204	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**
205	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**
206	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**
207	6.3.2.10.1.1	Interrogators shall prepend a *Select* with a frame-sync.	Interrogator	**By design**
208	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
209	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
210	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
211	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**
212	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**
213	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**
214	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**
215	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**
216	6.3.2.10.2.1	Tags in any state other than **killed** shall execute a *Query* command;	Tag	**By design**

Item	Protocol Subclause	Requirement	Applies To	How Verified
217	6.3.2.10.2.1	Tags in the **killed** state shall ignore a *Query*.	Tag	**By design**
218	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
219	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**
220	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**
221	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**
222	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**
223	6.3.2.10.2.2	Tags shall maintain a running count of the current *Q* value.	Tag	**By design**
224	6.3.2.10.2.2	A *QueryAdjust* shall be prepended with a frame-sync.	Interrogator	**By design**
225	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**
226	6.3.2.10.2.2	Tags shall respond to a *QueryAdjust* only if they received a prior *Query*.	Tag	**By design**
227	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
228	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**
229	6.3.2.10.2.3	A *QueryRep* shall be prepended with a frame-sync.	Interrogator	**By design**
230	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**
231	6.3.2.10.2.3	Tags shall respond to a *QueryRep* only if they received a prior *Query*.	Tag	**By design**
232	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
233	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**
234	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**

Item	Protocol Subclause	Requirement	Applies To	How Verified
235	6.3.2.10.2.4	An *ACK* shall be prepended with a frame-sync.	Interrogator	**By design**
236	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
237	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**
238	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
239	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**
240	6.3.2.10.2.5	A *NAK* shall be prepended with a frame-sync.	Interrogator	**By design**
241	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
242	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
243	6.3.2.10.3	Tags that receive an optional access command that they do not support shall ignore the command.	Tag	**By design**
244	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
245	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**
246	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**
247	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**
248	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**
249	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**
250	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**

Item	Protocol Subclause	Requirement	Applies To	How Verified
251	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**
252	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**
253	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**
254	6.3.2.10.3.1	A *Req_RN* shall be prepended with a frame-sync.	Interrogator	**By design**
255	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
256	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
257	6.3.2.10.3.2	*Read* commands shall apply to a single memory bank.	Tag	**By design**
258	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**
259	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**
260	6.3.2.10.3.2	A *Read* shall be prepended with a frame-sync.	Interrogator	**By design**
261	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**
262	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**
263	6.3.2.10.3.3	Interrogators and Tags shall implement the *Write* command shown in Table 6.33 of the Protocol.	Tag and Interrogator	**By design** Also tested in compliance with 6.3.2.4, Figure 6.19
264	6.3.2.10.3.3	Before each and every *Write* the Interrogator shall first issue a *Req_RN* command;	Interrogator	**By design**
265	6.3.2.10.3.3	The Interrogator shall cover-code the data by EXORing it with this new RN16 prior to transmission.	Interrogator	**By design**
266	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**

Item	Protocol Subclause	Requirement	Applies To	How Verified
267	6.3.2.10.3.3	A *Write* shall be prepended with a frame-sync.	Interrogator	**By design**
268	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.	Interrogator	**By design** Also tested in compliance with 6.3.2.4, Figure 6.19
269	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
270	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**
271	6.3.2.10.3.3	Upon receiving a valid *Write* command a Tag shall write the commanded Data into memory.	Tag	**By design**
272	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
273	6.3.2.10.3.4	Interrogators and Tags shall implement the *Kill* command shown in Table 6.35 of the Protocol.	Tag and Interrogator	**By design** Also tested in compliance with 6.3.2.4, Figure 6.19
274	6.3.2.10.3.4	When communicating with Class-1 Tags, Interrogators shall set these bits to 000_2.	Interrogator	**By design**
275	6.3.2.10.3.4	Class-1 Tags shall ignore these bits.	Tag	**By design**
276	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.	Interrogator	**By design**
277	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).	Interrogator	**By design**
278	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**
279	6.3.2.10.3.4	Interrogators shall not intersperse commands other than *Req_RN* between the two successive *Kill* commands.	Interrogator	**By design**
280	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**
281	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**
282	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**
283	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

Item	Protocol Subclause	Requirement	Applies To	How Verified
284	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
285	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**
286	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**
287	6.3.2.10.3.4	A *Kill* shall be prepended with a frame-sync.	Interrogator	**By design**
288	6.3.2.10.3.4	Upon receiving a valid *Kill* command sequence a Tag shall render itself killed.	Tag	**By design**
289	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
290	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
291	6.3.2.10.3.5	Only Tags in the **secured** state shall execute a *Lock* command.	Tag	**By design**
292	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**
293	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**
294	6.3.2.10.3.5	The payload of a *Lock* command shall always be 20 bits in length.	Tag	**By design**
295	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**
296	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**
297	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**
298	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
299	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

Item	Protocol Subclause	Requirement	Applies To	How Verified
300	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**
301	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**
302	6.3.2.10.3.5	A *Lock* shall be prepended with a frame-sync.	Interrogator	**By design**
303	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
304	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
305	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**
306	6.3.2.10.3.5	Upon receiving a valid *Lock* command a Tag shall perform the commanded lock operation.	Tag	**By design**
307	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
308	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
309	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**
310	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**
311	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**
312	6.3.2.10.3.6	Interrogators shall not intersperse commands other than *Req_RN* between the two successive *Access* commands.	Interrogator	**By design**
313	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**
314	6.3.2.10.3.6	An *Access* shall be prepended with a frame-sync.	Interrogator	**By design**

Item	Protocol Subclause	Requirement	Applies To	How Verified
315	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
316	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
317	6.3.2.10.3.7	*BlockWrite* commands shall apply to a single memory bank.	Tag	**By design**
318	6.3.2.10.3.7	If WordCount = 00_h the Tag shall ignore the *BlockWrite*.	Tag	**By design**
319	6.3.2.10.3.7	If WordCount = 01_h the Tag shall write a single data word.	Tag	**By design**
320	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**
321	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**
322	6.3.2.10.3.7	A *BlockWrite* shall be prepended with a frame-sync.	Interrogator	**By design**
323	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
324	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
325	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**
326	6.3.2.10.3.7	Upon receiving a valid *BlockWrite* command a Tag shall write the commanded Data into memory.	Tag	**By design**
327	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
328	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
329	6.3.2.10.3.8	*BlockErase* commands shall apply to a single memory bank.	Tag	**By design**
330	6.3.2.10.3.8	If WordCount = 00_h the Tag shall ignore the *BlockErase*.	Tag	**By design**
331	6.3.2.10.3.8	If WordCount = 01_h the Tag shall erase a single data word.	Tag	**By design**
332	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**

Item	Protocol Subclause	Requirement	Applies To	How Verified
333	6.3.2.10.3.8	A *BlockErase* shall be prepended with a frame-sync.	Interrogator	**By design**
334	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
335	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
336	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**
337	6.3.2.10.3.8	Upon receiving a valid *BlockErase* command a Tag shall erase the commanded memory words.	Tag	**By design**
338	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
339	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**
340	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**
341	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
342	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.
343	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.
344	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.
345	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.

Item	Protocol Subclause	Requirement	Applies To	How Verified
346	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.
347	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.
348	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.
349	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
350	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.
351	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.
352	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**
353	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**
354	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
355	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
356	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**
357	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

Item	Protocol Subclause	Requirement	Applies To	How Verified
358	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 +/– 3 ºC Freq: At channel frequency closest to center of supported band. Power: Maximum Interrogator transmit power, as implemented. Modulation: SSB Tari: 25 µs Backscatter data rate: One or more of the dense-interrogator data rates specified in Annex G of the Protocol specification, as implemented. Other transmit parameters: As implemented
359	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
360	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**
361	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**
362	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
363	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
364	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
365	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
366	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**
367	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**
368	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**
369	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**

Item	Protocol Subclause	Requirement	Applies To	How Verified
370	Annex I.1	Tags shall backscatter error codes only from the **open** or **secured** states.	Tag	**By design**
371	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**
372	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.	
August 10, 2005 Version 1.0.3	Multiple	Modified per the Test and Certification Working Group recommendations.	
February 15, 2006 Version 1.0.4	Multiple	Modified per the Test and Certification Working Group recommendations. Added Annex A.	

Annex A

A.1 Scope

This annex provides additional explanation of conformance items, testing parameters, and equipment badging. Some of the questions answered here are referenced in the **How Verified** column of in the Protocol Requirements table in section 6, while others relate generally to the conformance process.

The terms Reader and Interrogator are synonymous.

A.2 Q and A

Q1: How does a reader vendor specify R=>T and T=>R parameters to be tested?

A: The reader vendor specifies modulation type, PIE ratio, DR and mask type (dense, multi or single) for each Tari/Backscatter Data Rate (BDR)/encoding combination they wish to have tested in the Mode Table (Table A-1 is a sample completed table). BDR is defined as Link Frequency (LF) divided by M.

Field entry options are:

Modulation types	DSB-ASK, SSB-ASK or PR-ASK
PIE ratio	A value in the range 1.5:1 to 2:1, inclusive
DR	8 or 64/3
Mask type	DI (Dense Interrogator), MI (Multi Interrogator), or SI (Single Interrogator)

The vendor enters up to six Tari's to be tested. If more than one Tari value is to be tested, the vendor must list their minimum and maximum Tari.

The same encoding/BDR values can appear more than once (note M=8, BDR=32 entries in each subcarrier category in Table A-1). This is necessary if a different modulation type, PIE ratio, DR value, or mask type is to be tested for the same Tari/BDR/encoding values.

Table A-1 – Sample of completed Reader Mode Table

Backscatter Encoding	M	Backscatter Data Rate (kbps)	Tari (μs)					
			25	7.14	10			
FM0	1	160			PR/2:1/8			
	1	320		DS/1.5:1/8				
	1	640		DS/1.5:1/64				
Subcarrier	8	64	PR/2:1/64					
	8	32	PR/1.5:1/64					
Subcarrier (DI environment)	8	32	PR/2:1/64					
	4	64						
	4	20						
	8	26.7						
	4	53.3						

Key:

	Dense interrogator mask met (necessary but not sufficient for DI certification)
	Multiple interrogator mask met
	Single interrogator mask met

DS	DSB-ASK
SS	SSB-ASK
PR	PR-ASK
X:1	PIE ratio
8	DR=8
64	DR=64/3

A “mode” is defined as a combination of Tari, modulation type, PIE, DR, BDR, mask type, and encoding (i.e. a particular entry in the Mode Table). For example, Table A-1 indicates six “modes” for testing.

Table A-2 is a Mode Table template where VS indicates Vendor Selection, parameters to be chosen by the vendor.

Table A-2 – Reader Mode Table template

Backscatter Encoding	M	Backscatter Data Rate (kbps)	Tari (μs)					
			VS max	VS min	VS	VS	VS	VS
FM0	1	VS						
	1	VS						
	1	VS						
	1	VS						
	1	VS						
	1	VS						
Subcarrier	VS	VS						
	VS	VS						
	VS	VS						
	VS	VS						
	VS	VS						
	VS	VS						
Subcarrier (DI environment)	8	32						
	4	64						
	4	20						
	8	26.7						
	4	53.3						

Parameters declared in the table are tested. The entries uniquely determine the expected RTcal and TRcal values. The test facility will derive test limits from these values.

Q2: The Mode Table is informative but contains an overwhelming amount of information. Is the HW certified or not?

A: EPCglobal will list a Conformance Badge for Readers and Tags. For Readers, the Conformance Badge will contain a hyperlink that takes the viewer to the mode table for more detailed information. The following are examples of Reader and Tag badges.

Reader Conformance Badge		**Options**
Reader or Module	Reader	*Reader, Module*
Intended Operating Region	US	*Intended region of operation*
Frequency Range	902 – 928 MHz	*Band of operation*
Modulation Types	PR-ASK and DSB-ASK	*PR-ASK, DSB-ASK, SSB-ASK*
Tari's	7.14 μs, 25 μs, 10 μs	*Tested Tari's*
Backscatter Encoding Support	FM0, Miller Subcarrier	*FM0, Miller Subcarrier*
Frequency Scheme	FHSS	*FHSS, Agility, Fixed*
Temperature Range	-40°C to 65°C	*Product temperature range*
Environment	Dense and Multi Interrogator	*Dense, Multi Interrogator*
Optional Command Support	Access, BlockWrite	*Access, BlockWrite, BlockErase*

Tag Conformance Badge		**Options**
Frequency Range	860 – 960 MHz	*Band of operation*
Backscatter Modulation Type	ASK	*ASK, PSK*
Temperature Range	-40°C to 65°C	*Product temperature range*
Optional Command Support	Access, BlockWrite	*Access, BlockWrite, BlockErase*

Q3: What are the criteria for receiving a DI or MI certification? Does DI or MI certified mean the Reader meets the respective mask in all modes tested?

A: Criteria for getting DI certification are as follows:

1) Pass DI mask in at least one of the dense subcarrier modes with Tari of 25 μs

2) Pass channelization test (frequency accuracy)

MI certification is granted in the Conformance Badge if the MI mask is met for any one of the modes in the Mode Table; that is, at least one entry contains a yellow mark.

The vendor may choose to be tested against the DI mask in any mode. If the mask is met, this will be indicated in the Mode Table by a green mark. A mark, in itself, is not sufficient to achieve DI certification in the Conformance Badge. The other DI criteria must also be met.

DI or MI certified does not mean the Reader meets the respective mask for all modes tested. As described above, the mask must be met in at least one mode. For DI certification, the mode must be a DI subcarrier mode with a 25 μs Tari, and the channelization test must be passed.

Q4: Can a Reader get a MI (yellow) and DI (green) mask mark at the same Tari, modulation type, PIE ratio, DR, BDR, and encoding values in the Mode Table?

A: No, either a DI, MI, or SI mask mark is given for a particular set of these parameters. If a DI mask is met, it supercedes MI and SI, so DI credit is given (green mark). Likewise, MI supercedes SI. The vendor chooses DI, MI, or SI testing for a particular set of these parameters. The vendor has the option to move to a less stringent mask if they can not meet the more stringent mask during test.

If at least one of the parameters listed above is unique this will appear as a separate entry in the Mode Table.

Both DI and MI certification can be achieved if at least two modes are specified and DI mask testing is performed for one and MI performed for the other. SI is not listed in the Conformance Badge unless neither the DI nor MI criteria are met.

Q5: If table entries are optional, what is the incentive for a vendor to attempt certification in multiple modes? The more modes elected, the greater possibility for failure. A vendor can get credit in the Conformance Badge by passing in just one mode. At the other extreme, test time can become excessive for vendors wishing testing at a large number of Tari's. What are the minimal and maximal test requirements?

A: Vendors are required to test at least one mode at their minimum and maximum Tari. If a Reader only supports one Tari, that Tari is tested and it is shown in the Conformance Badge. If a Reader supports two or more Tari's, testing must occur at minimum and maximum Tari (at least two modes). The vendor can choose to get tested at up to six Tari's, at as many modulation types, PIE ratios, DR's, BDR's, and encoding values as they wish. The Conformance Badge will indicate the Tari's tested, not to exceed six values.

Q6: Numerous interrogator **by demonstration** items in the conformance document specify testing "At center frequency closest to center of supported band". What exactly does this mean?

A: The Gen2 protocol accommodates Readers from any region that regulates UHF RFID between 860 and 960 MHz. Multiple operational frequency bands must therefore be supported in conformance testing. For tests in which "At center frequency closest to center of supported band" is specified as a test condition, the vendor declares this frequency to the testing facility according to the following criteria:

a) If the Reader is to be certified for operation in North America and supports subcarrier signaling, then the channelization specified in Table 6.10 must be supported and the Reader is tested at 915.25 MHz which is the supported channel frequency closest to the center of the band.

b) If the Reader is to be certified for operation in North America and does not support subcarrier signaling, the Reader is tested at the channel frequency closest to the band center that the Reader supports. The vendor declares that frequency. The vendor may support a sub-band of the FCC band.

c) If the Reader is to be certified for operation in a region other than North America, the Reader is tested at the channel frequency closest to the band center that the Reader supports. The vendor declares that frequency. The vendor may support a sub-band of the regional band.

If a Reader supports multiple regions, certification is achieved by separately testing each band according to the above guidelines.

The center frequency definition has significance for Multi-Interrogator spectral mask testing (6.3.1.2.11, Figure 6.6). The following clarifies the procedures for Multi-Interrogator testing:

a) If the Reader is to be certified for operation in North America and supports subcarrier signaling, the spectral mask requirement (Figure 6.6) is centered at a valid channel frequency (Table 6.10) for purposes of compliance test. For the purposes of defining the testing mask, a channel is 500 kHz wide.

b) If the Reader is to be certified for operation in North America and does not support subcarrier signaling, the spectral mask is centered at the vendor declared frequency for purposes of compliance test. For the purposes of defining the test mask, a channel is a maximum of 500 kHz wide. The vendor declares the channel width.

c) If the Reader is to be certified for operation in a region other than North America, the spectral mask is centered at the vendor declared frequency for purposes of compliance test. For the purposes of defining the test mask, channel width is determined by local regulations and is 200 kHz for a CEPT-regulated region.

Q7: The conformance document (6.3.1.2.1) specifies that dense-interrogator testing can be limited to the minimum or maximum temperature at which the Reader supports (see Test Condition excerpt below). How does this statement affect me in conformance testing?

Test conditions:

Temp: max(–40, minimum supported temperature) and min(65, maximum supported temperature). If supported temperature range exceeds –25 or 40 then testing will also be performed at –25 or 40 respectively. All temperatures are in ºC (all +/– 3 ºC)

A: The intent of this wording to provide a certification path for Readers rated for narrower or wider temperature ranges while preventing spectral pollution when they are operated outside their rated range.

The reader vendor declares their rated temperature range on the conformance application form and shows evidence in their by-design documentation that the rated temperature is specified in their product specification. The test facility tests over the declared range. If the vendor passes, the tested range is listed in the vendors Conformance Badge. It is the end users responsibility to deploy the Reader in an environment that does not exceed the tested limits.

For Readers with rated ranges beyond the –40 or 65 limits, testing shall also be performed at –40 or 65, respectively. For Readers with rated ranges between –25 and –40 or between 40 and 65, testing shall also be performed at a –25 or 40, respectively.

Q8: For purposes of testing Reader power-up settling time, what defines the end of the settling time interval? The T_s and T_{hs} settling time intervals are shown in Figures 6.3 and 6.5, respectively, in the Gen2 protocol specification.

A: The T_s and T_{hs} intervals end when the envelope settles to within 5% of its 100% electric field strength level.

Q9: The conformance document (6.3.1.2.6 and 6.3.1.2.7) specifies that the Reader RF envelope shall rise and fall monotonically between the specified power limits. Measurement parameters are not specified, so it is feasible that a Reader can fail the monotonicity test due to measurement uncertainty. What is the test procedure that accounts for measurement uncertainty?

A: The test set recovers a time-sampled profile of the rising and falling ramp of the RF envelope. Within the regions that the monotonicity requirements apply, samples are compared to all previous samples. In the case of a falling ramp, the current sample must be less than the previous sample within the measurement tolerance of the test set. For example, if the test set power measurement error is ±2%, than the current sample can not exceed any of the previous samples by more than 2%. The test facility shall establish the measurement accuracy of the test set.

Q10: Testing of Reader modulated RF envelope characteristics and symbol durations are specified in 6.3.1.2.3 and 6.3.1.2.5 of the conformance document. These parameters are determined based on A and B measurements as shown in Figure 6.2 of the Gen2 protocol specification. In test, how is A determined?

A: In 6.3.1.2.5 of the Gen2 protocol specification, A is referred to as the maximum amplitude of the RF envelope. In Figure 6.2, A is shown as the midpoint between the maximum and minimum ripple excursions. The ripple represents inter-symbol interference associated with the band-limiting of the transmit symbols. Inter-symbol interference can case the RF envelope to exceed the maximum amplitude of an un-modulated signal with the same power. For consistency with the Gen2 protocol specification, the value of A in 6.3.1.2.3 and 6.3.1.2.5 shall be determined by measuring the un-modulated envelope immediately preceding modulation from the first Reader command issued after the end of the settling interval following a power up. The test facility shall determine the optimal measurement time to establish an accurate estimate of A.