RAIN RFID Test Procedure for RAIN Reader Tag Reporting Round Robin

RAIN RFID Alliance Whitepaper

V.7.0

March 2022

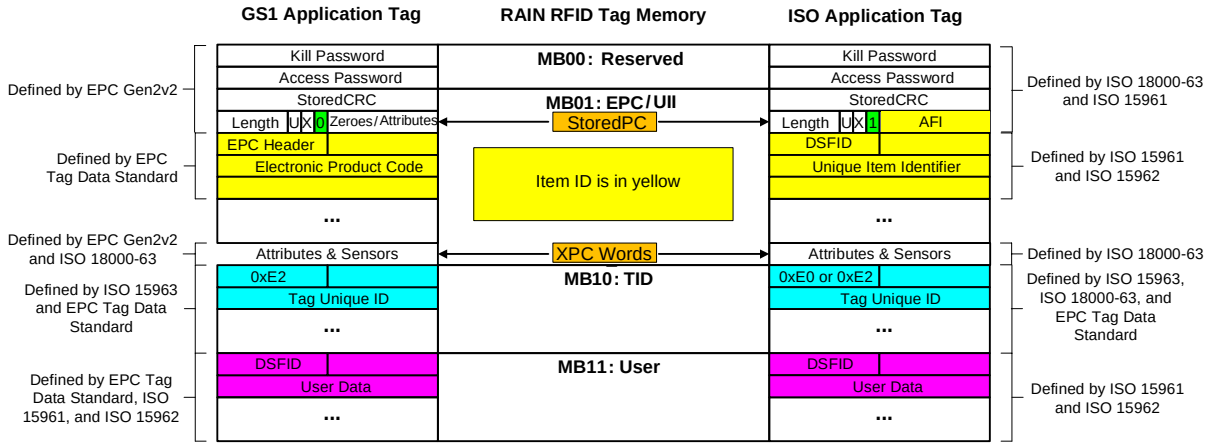
Table of Contents

1 Introduction

This document describes the test procedure to be used for reader tag reporting during the round robin study conducted by the RAIN RFID Alliance. It is part of a larger effort to address Acid RAIN and RAIN flooding, more generally referred to as tag clutter. Other activities with the RAIN RFID Alliance are addressing proper encoding of tags, but encoding solutions only partially solve tag clutter. The current situation with RFID readers and host software significantly contributes to tag clutter. Very few RFID readers properly handle an ACK reply and correctly report the PC, XPC, and the complete item identifier values to the host software. The term "item identifier" or "item ID" is being used here instead of EPC Code and Unique Item Identifier (UII) to simplify discussions.

2 Tag encodings

There are only two types of possible tag encodings used by RAIN RFID. A tag always reports to a reader which of the two encoding types exists in its tag memory. This is reported via the Toggle (T) indicator bit that is part of the StoredPC word in MB01 and the information is always sent to a reader during inventory operations as part of tag reply to an ACK command. The tag is using a GS1 encoding when T=0, and the tag is using an ISO encoding when T=1. The following graphic illustrates the two different encoding types and the relevant standards that apply to the memory contents.



Toggle (T) indicator bit shown highlighted in **green**

A GS1 application encoding has two components for the item ID (EPC Code):

1. EPC header (8 bits) which defines the type of item identifier and how to decode the remaining bits to obtain the filter value and item identifier

   e.g. EPC header = 0x30 = SGTIN-96
2. Remaining bits are for the filter value, partition value, and item identifier

An ISO application encoding has three components for the item ID (UII):

1. Application Family Identifier (AFI) (8 bits) defines the type of item identifier
2. Data Storage Format Identifier (DSFID) (8 bits) defines how to decode the remaining bits to obtain the item identifier

e.g. 6-bit encoding, 7-bit encoding, octet encoding, bit-stream encoding, URN Code 40 encoding

3. Remaining bits for the item identifier

NOTE: The DSFID does not exist when the AFI is sufficient to define how to decode the remaining bits to obtain the item identifier (e.g. a Monomorphic-UII encoding).

A new ISO application encoding scheme was created in 2021 for the RAIN Alliance. Information about the RAIN Alliance ISO Numbering System is available at https://rainrfid.org/technology/rain-alliance-iso-numbering-system . The details of the tag encoding are published in "RAIN Alliance Tag Encoding Guideline for use with the RAIN Application Family Identifier (AFI)" and available for download on the RAIN Alliance website.

3 Test tags

There are fourteen test tags that cover a wide range of possibilities provided by the RAIN RFID protocol. Eight of the tags focus mostly on mandatory features supported by the protocol, and six of the tags support major optional features of the protocol such as untraceability, crypto, and sensors. All tag encodings are provided in Annex A as well as the corresponding tag reply to an ACK command and an RCI example. The tag summary below has mandatory features highlighted in yellow and optional features highlighted in green.

Tag	ISO proprietary encoding	ISO RAIN Alliance Number encoding	GS1 SGTIN-96 encoding	Tag reporting it has User memory	Tag reporting it is killable	Tag reporting it is nonremoveable	Tag reporting a hazardous material	Tag with untraceably hidden User memory	Tag with AES-128 TAM1	Tag with AES-128 TAM2 (Rev0)	Tag with AES-128 TAM2 (Rev1)	Tag with Grain-128A TA.1	Tag with sensor reporting no sensor alarm	Tag with sensor reporting a sensor alarm	Tag reporting a snapshot sensor measurement
EM-1			X	X									X		
EM-2			X	X										X	
EM-3	X			X	X				X		X	X			
EM-4			X	X											X
Impinj-1	X			X											
Impinj-2			X	X			X								
Impinj-3			X	X		X									
Impinj-4			X	X	X										
NXP-1			X												
NXP-2	X														
NXP-3	X			X	X	X	X		X	X					
NXP-4			X	X	X	X	X	X	X	X					
NXP-5		X													
NXP-6		X													

NOTE: ISO supports multiple numbering systems using AFI.

3.1 Mandatory feature tags

These are the tags labelled Impinj-1, Impinj-2, Impinj-3, Impinj-4, NXP-1, NXP-2, NXP-5 and NXP-6.

Impinj-1 should be reported as an ISO proprietary encoded tag by a reader to a host application.

Impinj-2 should be reported as a GS1 SGTIN-96 encoded tag by a reader to a host application and that it is a hazardous material.

Impinj-3 should be reported as a GS1 SGTIN-96 encoded tag by a reader to a host application and that it is non-removeable.

Impinj-4 should be reported as a GS1 SGTIN-96 encoded tag by a reader to a host application and that it is killable.

NXP-1 should be reported as a GS1 SGTIN-96 encoded tag by a reader to a host application.

NXP-2 should be reported as an ISO proprietary encoded tag by a reader to a host application.

NXP-1 and NXP-2 have identical 96-bit encodings, but one uses a GS1 SGTIN-96 encoding and the other uses an ISO proprietary encoding. These tags should be reported as two separate tags by a reader to a host application.

NXP-5 and NXP-6 should be reported as an ISO encoded tags by a reader to a host application, showing the AFI 0xAE indicating it is a RAIN Alliance Number encoding. If the reader is capable of decoding the RAIN Alliance Number, then it must show that it is a RAIN Alliance Number, the XRA CIN and the application specific tag data. RCI is used to illustrate this capability.

3.2 Optional feature tags

These are the tags labelled EM-1, EM-2, EM-3, EM-4, NXP-3, and NXP-4.

EM-1 should be reported as a GS1 SGTIN-96 encoded tag by a reader to a host application. This is a basic alarm sensor tag with no alarm reported.

EM-2 should be reported as a GS1 SGTIN-96 encoded tag by a reader to a host application. This is a basic alarm sensor tag with an alarm reported.

EM-3 should be reported as an ISO proprietary encoded tag by a reader to a host application and that it is killable. This is a crypto tag using AES-128 Rev1 and supports TAM1 with KeyID0 and KeyID1, TAM2 with KeyID1, and using Grain-128A and supports TA.1 with KeyID4.

EM-4 should be reported as a GS1 SGTIN-96 encoded tag by a reader to a host application. This is a Snapshot Sensor tag reporting a sensor measurement value and the measurement value may change over time. The SGTIN-96 value never changes regardless of the sensor measurement value.

NXP-3 should be reported as an ISO proprietary encoded tag by a reader to a host application and that it is killable, non-removeable, and a hazardous material. This is a crypto tag using AES-128 Rev0 and supports TAM1 with KeyID0 and TAM2 with KeyID1.

NXP-4 should be reported as an ISO proprietary encoded tag by a reader to a host application and that it is killable, non-removeable and a hazardous material. This is a crypto tag using AES-

128 Rev0 and supports TAM1 with KeyID0 and TAM2 with KeyID1. The tag also has untraceably hidden User memory but is not reporting it has untraceable memory.

EM-1 and EM-2 are identical tags with different encodings. Reporting an alarm condition results in use of XPC_W1, so one tag reports it and one tag does not report it.

EM-3, NXP-3, and NXP-4 all support AES-128 crypto operations for Tag Authentication. The NXP tags were first to market and implement ISO/IEC 29167-10:2015 and commonly referred to as Rev0 of the standard. The EM tag implements ISO/IEC 29167-10:2017 and commonly referred to as Rev1 of the standard. Rev1 added support for Interrogator Authentication, Mutual Authentication, and ISO/IEC 15693 tags. Rev1 also corrected a security weakness that was identified in Rev0 regarding the TAM2 operation.

NXP-3 and NXP-4 have identical 96-bit encodings, but one uses a GS1 SGTIN-96 encoding and the other uses an ISO proprietary encoding. These tags should be reported as two separate tags by a reader to a host application.

4 Testing

The intent of testing is for a vendor to evaluate their reader product(s) along with their demo App(s) that are normally provided to their customers. This is often a starting point for newcomers to RAIN RFID and a basis for how people begin to form their understanding of our technology. It is important to our industry that this learning experience is done with readers that correctly read tags and report the essential information to a host application. It is also important for the host application, i.e. the vendor demo App, to properly report the essential information to the user.

Sheet A – mandatory feature tags

1. Use your demo App for reading the test tags.
2. Place sheet with mandatory feature tags in front of the reader.
3. Capture a screenshot that reports the number of different tags identified.
    a. If it is less than 8, then please investigate whether or not the reader provides all necessary data from tags.
    b. If more than 8 tags, then please check whether there are other tags in the environment and repeat the test.
    c. If it is exactly 8, then check that the item id is correct for all tags.
4. For all tags identified in #3 above, capture a screenshot showing if the tag is GS1 encoded or ISO encoded. NOTE: This can be simplified to showing the PC word.
5. For all tags identified in #3 above, capture a screenshot showing the indicators for Killable, Non-removeable, and HazMat. NOTE: This can be simplified to showing the PC word.
6. For all tags identified in #3 above, capture a screenshot of the first 2 words (or more) of tag's User memory.
    a. If the tag has User memory, then check that the data is correct for all tags.
    b. If the tag has no User memory or an error occurs trying to read User memory, then capture a screenshot for the attempted read.

Sheet B – optional feature tags

1. Use your demo App for reading the test tags.
2. Place sheet with optional feature tags in front of the reader.
3. Capture a screenshot that reports the number of different tags identified.
    a. If it is less than 6, then please investigate whether or not the reader provides all necessary data from tags.
    b. If more than 6 tags, then please check whether there are other tags in the environment and repeat the test. NOTE: EM-4 is a Snapshot Sensor tag, and the item id will remain constant but a change in sensor measurement data might occur.
    c. If it is exactly 6, then check that the item id is correct for all tags.
4. For all tags identified in #3 above, capture a screenshot showing if the tag is GS1 encoded or ISO encoded. NOTE: This can be simplified to showing the PC word.
5. For all tags identified in #3 above, capture a screenshot showing the indicators for Killable, Non-removeable, and HazMat. NOTE: This can be simplified to showing the PC word.
6. For all tags identified in #3 above, capture a screenshot showing the indicators for sensors and crypto responses. NOTE: This can be simplified to showing the XPC_W1 and XPC_W2 words.
7. For all tags identified in #3 above, capture a screenshot of the first 4 words (or more) of tag's User memory.
    a. If the tag has User memory, then check that the data is correct for all tags. NOTE: NXP-4 has untraceably hidden User memory that can only be read using the Access password and the *Untraceable* command.
    b. If the tag has no User memory or an error occurs trying to read User memory, then capture a screenshot for the attempted read operation.
8. For all AES-128 crypto tags (EM-3, NXP-3, NXP-4) in #3 above, capture a screenshot of Tag Authentication using TAM1 with KeyID0. NOTE: This requires use of either the *Authenticate* or *Challenge* command, and may require the use of the *ReadBuffer* command.
9. For all AES-128 crypto tags (EM-3, NXP-3, NXP-4) in #3 above, capture a screenshot of Tag Authentication using TAM1 with KeyID1. NOTE: This requires use of either the *Authenticate* or *Challenge* command, and may require the use of the *ReadBuffer* command.
10. For all AES-128 crypto tags (EM-3, NXP-3, NXP-4) in #3 above, capture a screenshot of Tag Authentication using TAM2 with KeyID1 and cryptographically read one block of User memory starting at Word 0. NOTE: This requires use of either the *Authenticate* or *Challenge* command, and may require the use of the *ReadBuffer* command.
11. For the Grain-128A crypto tag (EM-3) in #3 above, capture a screenshot of Tag Authentication using TA.1 with KeyID4. NOTE: This requires use of either the *Authenticate* or *Challenge* command, and may require the use of the *ReadBuffer* command.
12. For the Grain-128A crypto tag (EM-3) in #3 above, capture a screenshot for a Tag Authentication with a cryptographic read for 4 words of User memory starting at Word 0 using the *AuthComm* command with KeyID4.

5 Reporting

Individual results will not be published. RAIN will only report how many requests for the test tags were received and shipped for testing.

It is not required to share your results with the RAIN RFD Alliance. However, some feedback can be provided to you on your results should you want to improve your tag reporting. Collect all the screenshots from the above tests for evaluation. Insert them into an MS Word document and label them accordingly. Include the name of the reader product(s) and the demo App(s) used for the test. Please send them to **rainroundrobin@rainrfid.org**.

Any test results provided may be reported anonymously by the RAIN RFID Alliance, if approved by the participant. Participants may publish whether they participated in the RAIN RFID reader round robin test, as well as their own results with the test tags.

6 References

[1] EPC™ Radio-Frequency Identity Protocols Generation-2 UHF RFID Standard, Specification for RFID Air Interface Protocol for Communications at 860 MHz – 960 MHz (www.gs1.org/standards/epc-rfid/uhf-air-interface-protocol)

[2] ISO/IEC 18000-63, Information technology — Radio frequency identification for item management — Part 63: Parameters for air interface communications at 860 MHz to 960 MHz Type C

[3] EPC Tag Data Standard (www.gs1.org/standards/epcrfid-epcis-id-keys/epc-rfid-tds/1-13)

[4] ISO/IEC 15961-1, Information technology — Radio frequency identification (RFID) for item management: Data protocol — Part 1: Application interface

[5] ISO/IEC 15961-2, Information technology — Data protocol for radio frequency identification (RFID) for item management — Part 2: Registration of RFID data constructs

[6] ISO/IEC 15961-3, Information technology — Data protocol for radio frequency identification (RFID) for item management — Part 3: RFID data constructs

[7] ISO/IEC 15962, Information technology — Radio frequency identification (RFID) for item management — Data protocol: data encoding rules and logical memory functions

[8] ISO/IEC 15963-1, Information technology — Radio frequency identification for item management — Part 1: Unique identification for RF tags numbering systems

[9] ISO/IEC 15963-2, Information technology — Radio frequency identification for item management — Part 2: Unique identification for RF tags registration procedures

[10] ISO/IEC 29167-10, Information technology — Automatic identification and data capture techniques — Part 10: Crypto suite AES-128 security services for air interface communication

[11] ISO/IEC 29167-13, Information technology — Automatic identification and data capture techniques — Part 13: Crypto suite Grain-128A security services for air interface communication

[12] RAIN Reader Communication Interface Guideline (https://rainrfid.org/technology/rain-communication-interface-rci)

[13] RAIN Alliance Tag Encoding Guideline for use with the RAIN Application Family Identifier (AFI)

7 Background and Contributors

This document was developed within the RAIN RFID Technical Workgroup. The following contributors played a major role in shaping the final document:

Jim Springer	(EM Microelectronic)
Josef Preishuber-Pflügl	(CISC Semiconductor)
Bernhard Hinteregger	(STMicroelectronics)
Craig Alan Repec	(GS1)
Claude Tetelin	(GS1)
Bertus Pretorius	(Tönnjes)
Matt Robshaw	(Impinj)
Steve Halliday	(RAIN RFID)
John Armstrong	(MonsoonRF)
Don Ferguson	(Lyngsoe Systems)
James Goodland	(NXP Semiconductors)
Sven Hofmann	(race|result)
Nikias Klohr	(race|result)
Thomas Frederick	(Clairvoyant Technology)
Harinath Reddy	(JADAK)

Annex A Tag Encodings

This annex provides a summary of all tag encodings used for the reader round robin tests.

Memory words highlighted in green represent the information needed by a host application to determine the item identifier represented by the tag. Memory words having values indicated in red represent information needed by a host application to distinguish between GS1 and ISO encodings, to obtain item attributes indicating a hazardous material or possibly used to support GDPR requirements, or to obtain sensor information. A "?" indicates a dynamic value that might change based on reader commands or sensor measurement results.

A.1 Tag Encoding for EM-1

SGTIN-96 encoding
has User memory
Access password = 0x1111'2222
Kill password = 0x0000'0000
all memory is permalocked
all passwords are permalocked

$MB01_2$: EPC	**Word 0h StoredCRC**	**Word 1h StoredPC**	**Word 2h EPC MSW**	**Word 3h**	**Word 4h**	**Word 5h**	**Word 6h**	**Word 7h EPC LSW**
	xxxx	0x3400	0x3030	0x6666	0x7777	0x8888	0x9999	0xCCCC

$MB11_2$: User	**Word 0h**	**Word 1h**	**Word 2h**	**Word 3h**	**more**
	0x1E1F	0x4567	0x0000	0x0000	0x0000

ACK reply =	**3400**	**3030**	**6666**	**7777**	**8888**	**9999**	**CCCC**	**CRC**

RCI tag read report:

```
{"Report":"TagEvent","PC":":3400","Scheme":"SGTIN",
                    "EPC":":3030:6666:7777:8888:9999:CCCC"}
```

A.2 Tag Encoding for EM-2

SGTIN-96 encoding + Sensor Alarm
has User memory
Access password = 0x1111'2222
Kill password = 0x0000'0000
all memory is permalocked
all passwords are permalocked

$MB01_2$: EPC	Word 0h StoredCRC	Word 1h StoredPC	Word 2h EPC MSW	Word 3h	Word 4h	Word 5h	Word 6h	Word 7h EPC LSW
	xxxx	0x3600	0x3030	0x6666	0x7777	0x8888	0x9999	0xDDDD

Word 21h XPC_W1
0x0800

$MB11_2$: User	Word 0h	Word 1h	Word 2h	Word 3h	more
	0x1E1F	0x4567	0x0000	0x0000	0x0000

ACK reply =	3E00	0800	3030	6666	7777	8888	9999	DDDD	CRC

RCI tag read report:

```
{"Report":"TagEvent","PC":":3E00:0800","Scheme":"SGTIN",
                    "EPC":":3030:6666:7777:8888:9999:DDDD"}
```

A.3 Tag Encoding for EM-3

ISO proprietary encoding + Killable
has User memory
Access password = 0x1111'2222
Kill password = 0x3333'4444
all memory is permalocked
all passwords are permalocked
AES-128 Rev1 crypto support (*Challenge*, *Authenticate*, *ReadBuffer*)
AES-128 crypto keyID 0x00 = 0x1122'3344'5566'7788'9900'1122'3344'5566
AES-128 crypto keyID 0x01 = 0x9988'7766'5544'3322'1100'1122'3344'5566
Grain-128A crypto support (*Challenge*, *Authenticate*, *ReadBuffer, AuthComm*)
Grain-128A crypto keyID 0x04 = 0x BBBB'BBBB'BBBB'BBBB'BBBB'BBBB'BBBB'BBBB

$MB01_2$: UII	Word 0h StoredCRC	Word 1h StoredPC	Word 2h EPC MSW	Word 3h	Word 4h	Word 5h	Word 6h	Word 7h EPC LSW
	xxxx	0x3701	0x3030	0x6666	0x7777	0x8888	0x9999	0xEEEE

Word 21h XPC_W1
0x00?4

$MB11_2$: User	Word 0h	Word 1h	Word 2h	Word 3h	more
	0x1E1F	0x4567	0x89AB	0xCDEF	0x0000

ACK reply =	3F01	00?4	3030	6666	7777	8888	9999	EEEE	CRC

RCI tag read report:

```
{"Report":"TagEvent","PC":":3F01:00?4","AFI":"01",
                    "UII-PROPRIETARY":":3030:6666:7777:8888:9999:EEEE"}
```

A.4 Tag Encoding for EM-4

SGTIN-96 encoding + Snapshot Sensor
has User memory
Access password = 0x1111'2222
Kill password = 0x0000'0000
all memory is permalocked
all passwords are permalocked

MB01$_2$: EPC	Word 0h StoredCRC	Word 1h StoredPC	Word 2h UII MSW	Word 3h	Word 4h	Word 5h	Word 6h	Word 7h UII LSW
	xxxx	0x3600	0x3030	0x6666	0x7777	0x8888	0x9999	0x0000

Word 21h XPC_W1
0x81?0

MB11$_2$: User	Word 0h	Word 1h	Word 2h	Word 3h	more
	0x1E1F	0x4567	0x0000	0x0000	0x0000

ACK reply =	4600	81?0	????	3030	6666	7777	8888	9999	0000	CRC

RCI tag read report:

```
{"Report":"TagEvent","PC":":4600:81?0:????","Scheme":"SGTIN",
                    "EPC":":3030:6666:7777:8888:9999:0000"}
```

A.5 Tag Encoding for Impinj-1

ISO proprietary encoding
has User memory
Access password = 0x1111'2222
Kill password = 0x0000'0000
all memory is permalocked
all passwords are permalocked

MB01$_2$: UII	Word 0h StoredCRC	Word 1h StoredPC	Word 2h UII MSW	Word 3h	Word 4h	Word 5h	Word 6h	Word 7h UII LSW
	xxxx	0x3501	0x3030	0x1111	0x2222	0x3333	0x4444	0x5555

MB11$_2$: User	Word 0h	Word 1h
	0x1E1F	0x4567

ACK reply =	3501	3030	1111	2222	3333	4444	5555	CRC

RCI tag read report:

```
{"Report":"TagEvent","PC":":3501","AFI":"01",
                    "UII-PROPRIETARY":":3030:1111:2222:3333:4444:5555"}
```

A.6 Tag Encoding for Impinj-2

SGTIN-96 encoding + Hazardous Material
has User memory
Access password = 0x1111'2222
Kill password = 0x0000'0000
all memory is permalocked
all passwords are permalocked

$MB01_2$: EPC	Word 0h StoredCRC	Word 1h StoredPC	Word 2h EPC MSW	Word 3h	Word 4h	Word 5h	Word 6h	Word 7h EPC LSW
	xxxx	0x3401	0x3030	0x1111	0x2222	0x3333	0x4444	0x6666

$MB11_2$: User	Word 0h	Word 1h
	0x1E1F	0x4567

ACK reply =	3401	3030	1111	2222	3333	4444	6666	CRC

RCI tag read report:

```
{"Report":"TagEvent","PC":":3401","Scheme":"SGTIN",
                    "EPC":":3030:1111:2222:3333:4444:6666"}
```

A.7 Tag Encoding for Impinj-3

SGTIN-96 encoding + Nonremovable
has User memory
Access password = 0x1111'2222
Kill password = 0x0000'0000
all memory is permalocked
all passwords are permalocked

$MB01_2$: EPC	Word 0h StoredCRC	Word 1h StoredPC	Word 2h EPC MSW	Word 3h	Word 4h	Word 5h	Word 6h	Word 7h EPC LSW
	xxxx	0x3402	0x3030	0x1111	0x2222	0x3333	0x4444	0x7777

$MB11_2$: User	Word 0h	Word 1h
	0x1E1F	0x4567

ACK reply =	3402	3030	1111	2222	3333	4444	7777	CRC

RCI tag read report:

```
{"Report":"TagEvent","PC":":3402","Scheme":"SGTIN",
                    "EPC":":3030:1111:2222:3333:4444:7777"}
```

A.8 Tag Encoding for Impinj-4

SGTIN-96 encoding + Killable
has User memory
Access password = 0x1111'2222
Kill password = 0x0000'0000
all memory is permalocked
all passwords are permalocked

$MB01_2$: EPC	Word 0h StoredCRC	Word 1h StoredPC	Word 2h EPC MSW	Word 3h	Word 4h	Word 5h	Word 6h	Word 7h EPC LSW
	xxxx	0x3404	0x3030	0x1111	0x2222	0x3333	0x4444	0xFFFF

$MB11_2$: User	Word 0h	Word 1h
	0x1E1F	0x4567

ACK reply =	3404	3030	1111	2222	3333	4444	FFFF	CRC

RCI tag read report:

```
{"Report":"TagEvent","PC":":3404","Scheme":"SGTIN",
                    "EPC":":3030:1111:2222:3333:4444:FFFF"}
```

A.9 Tag Encoding for NXP-1

SGTIN-96 encoding – note, the EPC is identical to the UII of NXP-2 and NXP-5
has no User memory
Access password = 0x1111'2222
Kill password = 0x0000'0000
all memory is permalocked
all passwords are permalocked

$MB01_2$: EPC	Word 0h StoredCRC	Word 1h StoredPC	Word 2h EPC MSW	Word 3h	Word 4h	Word 5h	Word 6h	Word 7h EPC LSW
	xxxx	0x3000	0x3030	0x6666	0x7777	0x8888	0x9999	0xAAAA

ACK reply =	3000	3030	6666	7777	8888	9999	AAAA	CRC

RCI tag read report:

```
{"Report":"TagEvent","PC":":3000","Scheme":"SGTIN",
                    "EPC":":3030:6666:7777:8888:9999:AAAA"}
```

A.10 Tag Encoding for NXP-2

ISO proprietary encoding – note, the UII is identical to the EPC of NXP-1 and the UII of NXP-5
has no User memory
Access password = 0x1111'2222
Kill password = 0x0000'0000
all memory is permalocked
all passwords are permalocked

$MB01_2$: UII	Word 0h StoredCRC	Word 1h StoredPC	Word 2h UII MSW	Word 3h	Word 4h	Word 5h	Word 6h	Word 7h UII LSW
	xxxx	0x3101	0x3030	0x6666	0x7777	0x8888	0x9999	0xAAAA

ACK reply =	3101	0x3030	0x6666	0x7777	0x8888	0x9999	0xAAAA	CRC

RCI tag read report:

```
{"Report":"TagEvent","PC":":3101","AFI":"01",
                    "UII-PROPRIETARY":":3030:6666:7777:8888:9999:AAAA"}
```

A.11 Tag Encoding for NXP-3

ISO proprietary encoding + Killable + Nonremovable + Hazardous material
has User memory
Access password = 0x1111'2222
Kill password = 0x3333'4444
all memory is permalocked
all passwords are permalocked
AES-128 Rev0 crypto support (*Authenticate*, *ReadBuffer*)
AES-128 crypto keyID 0x00 = 0x1122'3344'5566'7788'9900'1122'3344'5566
AES-128 crypto keyID 0x01 = 0x9988'7766'5544'3322'1100'1122'3344'5566

$MB01_2$: UII	Word 0h StoredCRC	Word 1h StoredPC	Word 2h EPC MSW	Word 3h	Word 4h	Word 5h	Word 6h	Word 7h EPC LSW
	xxxx	0x3701	0x3030	0x6666	0x7777	0x8888	0x9999	0xBBBB

Word 21h XPC_W1
0x00?7

$MB11_2$: User	Word 0h	Word 1h	Word 2h	Word 3h	more
	0x1E1F	0x4567	0x89AB	0xCDEF	0x0000

ACK reply =	3F01	00?7	3030	6666	7777	8888	9999	BBBB	CRC

RCI tag read report:

```
{"Report":"TagEvent","PC":":3F01:00?7","AFI":"01",
                    "UII-PROPRIETARY":":3030:6666:7777:8888:9999:BBBB"}
```

A.12 Tag Encoding for NXP-4

SGTIN-96 encoding + Killable + Nonremovable + Hazardous material
has untraceably hidden User memory
Access password = 0x1111'2222
Kill password = 0x3333'4444
all memory is permalocked
all passwords are permalocked
AES-128 Rev0 crypto support (*Authenticate*, *ReadBuffer*)
AES-128 crypto keyID 0x00 = 0x1122'3344'5566'7788'9900'1122'3344'5566
AES-128 crypto keyID 0x01 = 0x9988'7766'5544'3322'1100'1122'3344'5566

$MB01_2$: EPC	Word 0h StoredCRC	Word 1h StoredPC	Word 2h EPC MSW	Word 3h	Word 4h	Word 5h	Word 6h	Word 7h EPC LSW
	xxxx	0x3400	0x3030	0x6666	0x7777	0x8888	0x9999	0xBBBB

Word 21h XPC_W1
0x00?7

$MB11_2$: User	Word 0h	Word 1h	Word 2h	Word 3h	more
	0x1E1F	0x4567	0x89AB	0xCDEF	0x0000

ACK reply =	34?7	3030	6666	7777	8888	9999	BBBB	CRC

RCI tag read report:

```
{"Report":"TagEvent","PC":":34?7","Scheme":"SGTIN",
                    "EPC":":3030:6666:7777:8888:9999:BBBB"}
```

A.13 Tag Encoding for NXP-5

ISO encoding for the RAIN Alliance number using a 2-digit (1-byte) XRA CIN: 48 (0x30 and as a string "0") – note, the UII is identical to the EPC of NXP-1 and the UII of NXP-2
has no User memory
Access password = 0x1111'2222
Kill password = 0x0000'0000
all memory is permalocked
all passwords are permalocked

$MB01_2$: UII	Word 0h StoredCRC	Word 1h StoredPC	Word 2h UII MSW	Word 3h	Word 4h	Word 5h	Word 6h	Word 7h UII LSW
	xxxx	0x31AE	0x3030	0x6666	0x7777	0x8888	0x9999	0xAAAA

ACK reply =	31AE	0x3030	0x6666	0x7777	0x8888	0x9999	0xAAAA	CRC

RCI tag read report:

```
{"Report":"TagEvent","PC":":31AE","AFI":":AE",
                    "UII":":3030:6666:7777:8888:9999:AAAA"}
```

A.14 Tag Encoding for NXP-6

ISO encoding for the RAIN Alliance number using an 8-digit (4-byte) XRA CIN: 173040846 (0xD2C1C94E and as a string "RAIN". Note, a 9-digit number is used to facilitate the string encoding, see RCI K.2.1. NXP-6 is encoded as a string.
has no User memory
Access password = 0x1111'2222
Kill password = 0x0000'0000
all memory is permalocked
all passwords are permalocked

$MB01_2$: UII	Word 0h StoredCRC	Word 1h StoredPC	Word 2h UII MSW	Word 3h	Word 4h	Word 5h	Word 6h	Word 7h UII LSW
	xxxx	0x31AE	0xD2C1	0xC94E	0x2069	0x7320	0x636F	0x6F6C

ACK reply =	31AE	0xD2C1	0xC94E	0x2069	0x7320	0x636F	0x6F6C	CRC

RCI tag read report:

```
{"Report":"TagEvent","PC":":31AE","AFI":":AE",
                    "UII":":D2C1:C94E:2069:7320:636F:6F6C"}
```

Annex B Tests using RCI

This annex provides the commands and responses of the mandatory and optional featured tags using RCI. The following sets of SpotProfiles (RCI 6.6) and responses (RCI 7.4) are provided:

1. Basic inventory.
2. Basic inventory with User memory (2 words).
3. Basic inventory with User memory (4 words).
4. Basic inventory with User memory (2 words) and TID (the MDID is extracted from the TID – TID Interpretation is in Ver 5, not yet spec'ed).
5. Basic inventory with TAGUSE and Sensor interpretation (RCI Annex E.2 and H).
6. Crypto and access password for EM-3 (AES-128-1 and GRAIN-128A), NXP-3 (AES-128-0) and NXP-4 (AES-128-0) (RCI Annex I).

The user memory configuration is as follows:

- No user memory (UMI=0_2): NXP-1 and NXP-2.
- 2 words user memory (UMI=1_2): IMPINJ-1, IMPINJ-2, IMPINJ-3 and IMPINJ-4.
- ≥4 words user memory (UMI=1_2): EM-1, EM-2, EM-3, EM-4, NXP-3 and NXP-4 (hidden and the U-Flag is not set).

In all cases the default settings are used, which are:

- Report FirstSeen of all tags in the ReadZone. Therefore only unique tags inventoried will be reported.
- The ReadZone must be started and stopped. The command sequence is:
  1. Set the SpotProfile
     `{"Cmd":"AddProf",…}`
  2. Start all ReadZones
     `{"Cmd":"StartRZ"}`
  3. All tags in the ReadZone are reported.
     `{"Report":"TagEvent",…}`
     …
  4. Stop all ReadZones
     `{"Cmd":"StopRZ"}`

  The RCI **ThisTag** (RCI 6.8) may also be used. **ThisTag** will be active for a duration set by **ThisTagTO** (RCI 6.3.5). The default is 1000 ms.
  `{"Cmd":"ThisTag"}`

The tag can be reported in any order. In this document, the order is listed as follows:

- Sheet A: Impinj-1, Impinj-2, Impinj-3, Impinj-4, NXP-1, and NXP-2.
- Sheet B: EM-1, EM-2, EM-3, EM-4, NXP-3, and NXP-4.

The PC word is interpreted by RCI and as such is not reported by default. The XPC words are reported by default, including for EPC tags where the last 8 bits of XPC_W1 is mapped to the PC word (T=0, XI=0 and RFU/AFI > 0).

B.1 Basic inventory

Note the reporting of the PC and XPC words.

B.1.1 SpotProfile

```
{"Cmd":"AddProf"}
```

Report FirstSeen of all tags and the PC and XPC words if it contains additional information.

B.1.2 Sheet A report

Impinj-1, Impinj-2, Impinj-3, Impinj-4, NXP-1, NXP-2, NXP-5, and NXP-6.

```
{"Report":"TagEvent","AFI":":01",
                     "UII-PROPRIETARY":":3030:1111:2222:3333:4444:5555"}
```

The PC word is not reported since there is no additional data than what RCI interpreted.

```
{"Report":"TagEvent","Scheme":"SGTIN","PC":":3401",
                     "EPC":":3030:1111:2222:3333:4444:6666"}
{"Report":"TagEvent","Scheme":"SGTIN","PC":":3402",
                     "EPC":":3030:1111:2222:3333:4444:7777"}
{"Report":"TagEvent","Scheme":"SGTIN","PC":":3404",
                     "EPC":":3030:1111:2222:3333:4444:FFFF"}
{"Report":"TagEvent","Scheme":"SGTIN",
                     "EPC":":3030:6666:7777:8888:9999:AAAA"}
```

The PC word is not reported since there is no additional data than what RCI interpreted.

```
{"Report":"TagEvent","AFI":":01",
                     "UII-PROPRIETARY":":3030:6666:7777:8888:9999:AAAA"}
```

The PC word is not reported since there is no additional data than what RCI interpreted.

```
{"Report":"TagEvent","AFI":":AE",
                     "UII":":3030:6666:7777:8888:9999:AAAA"}
```

The PC word is not reported since there is no additional data than what RCI interpreted.

```
{"Report":"TagEvent","AFI":":AE",
                     "UII":":D2C1:C94E:2069:7320:636F:6F6C"}
```

The PC word is not reported since there is no additional data than what RCI interpreted.

B.1.3 Sheet B report

EM-1, EM-2, EM-3, EM-4, NXP-3, and NXP-4

```
{"Report":"TagEvent","Scheme":"SGTIN",
                     "EPC":":3030:6666:7777:8888:9999:CCCC"}
```

The PC word is not reported since there is no additional data than what RCI interpreted.

```
{"Report":"TagEvent","Scheme":"SGTIN","PC":":3E00:0800",
                     "EPC":":3030:6666:7777:8888:9999:DDDD"}
{"Report":"TagEvent","AFI":":01","PC":"3F01:00?4",
                     "UII-PROPRIETARY":":3030:6666:7777:8888:9999:EEEE"}
{"Report":"TagEvent","Scheme":"SGTIN","PC":"4600:81?0:????",
                     "EPC":":3030:6666:7777:8888:9999:0000"}
{"Report":"TagEvent","AFI":":01","PC":"3F01:00?7",
                     "UII-PROPRIETARY":":3030:6666:7777:8888:9999:BBBB"}
{"Report":"TagEvent","Scheme":"SGTIN","PC":":34?7",
                     "EPC":":3030:6666:7777:8888:9999:BBBB"}
```

B.2 Basic inventory with User memory (2 words)

Note tags with no user memory are indicated by UMI=0_2. RCI will not attempt to read MB11 and report such reads with an empty string "", with ErrID 34 (Spot Error). In the case of an air protocol read error, the data will be report as null, with the ErrID 34.

B.2.1 SpotProfile

```
{"Cmd":"AddProf","Read":[[3,0,2,1]]}
```

Report FirstSeen of all tags with the first 4 words of User memory if the UMI bit is set to 0_2.

B.2.2 Sheet A report

Impinj-1, Impinj-2, Impinj-3, Impinj-4, NXP-1, NXP-2, NXP-5, and NXP-6.

```
{"Report":"TagEvent","AFI":":01",
                     "UII-PROPRIETARY":":3030:1111:2222:3333:4444:5555",
                     "MB":[{"ID":3,"Start":0,"Data":":1E1F:4567"}]}
```

The PC word is not reported since there is no additional data than what RCI interpreted.

```
{"Report":"TagEvent","Scheme":"SGTIN","PC":":3401",
                     "EPC":":3030:1111:2222:3333:4444:6666",
                     "MB":[{"ID":3,"Start":0,"Data":":1E1F:4567"}]}
{"Report":"TagEvent","Scheme":"SGTIN","PC":":3402",
                     "EPC":":3030:1111:2222:3333:4444:7777",
                     "MB":[{"ID":3,"Start":0,"Data":":1E1F:4567"}]}
{"Report":"TagEvent","Scheme":"SGTIN","PC":":3404",
                     "EPC":":3030:1111:2222:3333:4444:FFFF",
                     "MB":[{"ID":3,"Start":0,"Data":":1E1F:4567"}]}
{"Report":"TagEvent","Scheme":"SGTIN","ErrID":34,
                     "EPC":":3030:6666:7777:8888:9999:AAAA",
                     "MB":[{"ID":3,"Start":0,"Data":""}]}
```

The PC word is not reported since there is no additional data than what RCI interpreted.

RCI noted UMI=0_2, it did not attempt to read MB11$_2$.

```
{"Report":"TagEvent","AFI":":01","ErrID":34,
                     "UII-PROPRIETARY":":3030:6666:7777:8888:9999:AAAA",
                     "MB":[{"ID":3,"Start":0,"Data":""}]}
```

The PC word is not reported since there is no additional data than what RCI interpreted.

RCI noted UMI=0_2, it did not attempt to read MB11$_2$. "" indicates there is no data.

```
{"Report":"TagEvent","AFI":":AE","ErrID":34,
                     "UII":":3030:6666:7777:8888:9999:AAAA",
                     "MB":[{"ID":3,"Start":0,"Data":""}]}
```

The PC word is not reported since there is no additional data than what RCI interpreted.

RCI noted UMI=0_2, it did not attempt to read MB11$_2$. "" indicates there is no data.

```
{"Report":"TagEvent","AFI":":AE","ErrID":34,
                     "UII":":D2C1:C94E:2069:7320:636F:6F6C",
                     "MB":[{"ID":3,"Start":0,"Data":""}]}
```

The PC word is not reported since there is no additional data than what RCI interpreted.

RCI noted UMI=0_2, it did not attempt to read MB11$_2$. "" indicates there is no data.

B.2.3 Sheet B report

EM-1, EM-2, EM-3, EM-4, NXP-3, and NXP-4


```
{"Report":"TagEvent","Scheme":"SGTIN",
                     "EPC":":3030:6666:7777:8888:9999:CCCC",
                     "MB":[{"ID":3,"Start":0,"Data":":1E1F:4567"}]}
```


The PC word is not reported since there is no additional data than what RCI interpreted.


```
{"Report":"TagEvent","Scheme":"SGTIN","PC":":3E00:0800",
                     "EPC":":3030:6666:7777:8888:9999:DDDD",
                     "MB":[{"ID":3,"Start":0,"Data":":1E1F:4567"}]}
{"Report":"TagEvent","AFI":":01","PC":"3F01:00?4",
                     "UII-PROPRIETARY":":3030:6666:7777:8888:9999:EEEE",
                     "MB":[{"ID":3,"Start":0,"Data":":1E1F:4567"}]}
{"Report":"TagEvent","Scheme":"SGTIN","PC":"4600:81?0:????",
                     "EPC":":3030:6666:7777:8888:9999:0000",
                     "MB":[{"ID":3,"Start":0,"Data":":1E1F:4567"}]}
{"Report":"TagEvent","AFI":":01","PC":"3F01:00?7",
                     "UII-PROPRIETARY":":3030:6666:7777:8888:9999:BBBB",
                     "MB":[{"ID":3,"Start":0,"Data":":1E1F:4567"}]}
{"Report":"TagEvent","Scheme":"SGTIN","PC":":34?7","ErrID":34,
                     "EPC":":3030:6666:7777:8888:9999:BBBB",
                     "MB":[{"ID":3,"Start":0,"Data":null}]}
```


RCI noted UMI=1_2, it did attempt to read MB11$_2$ but failed since user memory is not directly accessible. The result is an air protocol error. The data is therefore indicated with a null.

B.3 Basic inventory with User memory (4 words)

Note tags with no user memory are indicated by UMI=0_2. RCI will not attempt to read MB11 and report such reads with an empty string "", with ErrID 34 (Spot Error). In the case of an air protocol read error, the data will be report as null, with the ErrID 34.

B.3.1 SpotProfile


```
{"Cmd":"AddProf","Read":[[3,0,4,1]]}
```


Report FirstSeen of all tags with the first 4 words of User memory if the UMI bit is set to 0_2.

B.3.2 Sheet A report

Impinj-1, Impinj-2, Impinj-3, Impinj-4, NXP-1, NXP-2, NXP-5, and NXP-6.


```
{"Report":"TagEvent","AFI":":01","ErrID":34,
                     "UII-PROPRIETARY":":3030:1111:2222:3333:4444:5555",
                     "MB":[{"ID":3,"Start":0,"Data":null}]}
```


The PC word is not reported since there is no additional data than what RCI interpreted.

RCI noted UMI=1_2, it did attempt to read MB11$_2$ but failed since it reached end of memory. null indicates there are a data read error.


```
{"Report":"TagEvent","Scheme":"SGTIN","PC":":3401","ErrID":34,
                     "EPC":":3030:1111:2222:3333:4444:6666",
                     "MB":[{"ID":3,"Start":0,"Data":null}]}
```

RCI noted UMI=1₂, it did attempt to read MB11₂ but failed since it reached end of memory. null indicates there are a data read error.

```
{"Report":"TagEvent","Scheme":"SGTIN","PC":":3402","ErrID":34,
                     "EPC":":3030:1111:2222:3333:4444:7777",
                     "MB":[{"ID":3,"Start":0,"Data":null}]}
```

RCI noted UMI=1₂, it did attempt to read MB11₂ but failed since it reached end of memory. null indicates there are a data read error.

```
{"Report":"TagEvent","Scheme":"SGTIN","PC":":3404","ErrID":34,
                     "EPC":":3030:1111:2222:3333:4444:FFFF",
                     "MB":[{"ID":3,"Start":0,"Data":null}]}
```

RCI noted UMI=1₂, it did attempt to read MB11₂ but failed since it reached end of memory. null indicates there are a data read error.

```
{"Report":"TagEvent","Scheme":"SGTIN","ErrID":34,
                     "EPC":":3030:6666:7777:8888:9999:AAAA",
                     "MB":[{"ID":3,"Start":0,"Data":""}]}
```

The PC word is not reported since there is no additional data than what RCI interpreted.

RCI noted UMI=0₂, it did not attempt to read MB11₂. "" indicates there is no data.

```
{"Report":"TagEvent","AFI":":01","ErrID":34,
                     "UII-PROPRIETARY":":3030:6666:7777:8888:9999:AAAA",
                     "MB":[{"ID":3,"Start":0,"Data":""}]}
```

The PC word is not reported since there is no additional data than what RCI interpreted.

RCI noted UMI=0₂, it did not attempt to read MB11₂. "" indicates there is no data.

```
{"Report":"TagEvent","AFI":":AE","ErrID":34,
                     "UII":":3030:6666:7777:8888:9999:AAAA",
                     "MB":[{"ID":3,"Start":0,"Data":""}]}
```

The PC word is not reported since there is no additional data than what RCI interpreted.

RCI noted UMI=0₂, it did not attempt to read MB11₂. "" indicates there is no data.

```
{"Report":"TagEvent","AFI":":AE","ErrID":34,
                     "UII":":D2C1:C94E:2069:7320:636F:6F6C",
                     "MB":[{"ID":3,"Start":0,"Data":""}]}
```

The PC word is not reported since there is no additional data than what RCI interpreted.

RCI noted UMI=0₂, it did not attempt to read MB11₂. "" indicates there is no data.

B.3.3 Sheet B report

EM-1, EM-2, EM-3, EM-4, NXP-3, and NXP-4

```
{"Report":"TagEvent","Scheme":"SGTIN",
                     "EPC":":3030:6666:7777:8888:9999:CCCC",
                     "MB":[{"ID":3,"Start":0,"Data":":1E1F:4567:0000:0000"}]}
```

The PC word is not reported since there is no additional data than what RCI interpreted.

```
{"Report":"TagEvent","Scheme":"SGTIN","PC":":3E00:0800",
                     "EPC":":3030:6666:7777:8888:9999:DDDD",
                     "MB":[{"ID":3,"Start":0,"Data":":1E1F:4567:0000:0000"}]}
{"Report":"TagEvent","AFI":":01","PC":"3F01:00?4",
                     "UII-PROPRIETARY":":3030:6666:7777:8888:9999:EEEE",
                     "MB":[{"ID":3,"Start":0,"Data":":1E1F:4567:89AB:CDEF"}]}
{"Report":"TagEvent","Scheme":"SGTIN","PC":"4600:81?0:????",
                     "EPC":":3030:6666:7777:8888:9999:0000",
                     "MB":[{"ID":3,"Start":0,"Data":":1E1F:4567:0000:0000"}]}
{"Report":"TagEvent","AFI":":01","PC":"3F01:00?7",
```

```
                    "UII-PROPRIETARY":":3030:6666:7777:8888:9999:BBBB",
                    "MB":[{"ID":3,"Start":0,"Data":":1E1F:4567:89AB:CDEF"}]}
{"Report":"TagEvent","Scheme":"SGTIN","PC":":34?7","ErrID":34,
                    "EPC":":3030:6666:7777:8888:9999:BBBB",
                    "MB":[{"ID":3,"Start":0,"Data":null}]}
```

RCI noted UMI=1_2, it did attempt to read MB11_2 but failed since user memory is not direct accessible. The result is an air protocol error. The data is therefore indicated with a null.

B.4 Basic inventory with User memory (2 words) and TID

B.4.1 SpotProfile

```
{"Cmd":"AddProf","Read":[[2],[3,0,4,1]]}
```

Report FirstSeen of all tags with TID and the first 4 words of User memory if the UMI bit is set to 0_2. Note, the default is read the first 96 bits with maximum 3 retries.

Only the MDID is shown in the reported TIDs.

It is important to note that the TID may be longer than 96 bits. Older tags, with TIDs starting with E0, are only 64 bits long.

B.4.2 Sheet A report

Impinj-1, Impinj-2, Impinj-3, Impinj-4, NXP-1, NXP-2, NXP-5, and NXP-6.

```
{"Report":"TagEvent","AFI":":01",
                    "UII-PROPRIETARY":":3030:1111:2222:3333:4444:5555",
                    "MB":[{"ID":2,"Start":0,"Data":":E280:1170:2000:????:????:????"},
                          {"ID":3,"Start":0,"Data":":1E1F:4567"}]}
```

The PC word is not reported since there is no additional data than what RCI interpreted.

```
{"Report":"TagEvent","Scheme":"SGTIN","PC":":3401",
                    "EPC":":3030:1111:2222:3333:4444:6666",
                    "MB":[{"ID":2,"Start":0,"Data":":E280:1170:2000:????:????:????"},
                          {"ID":3,"Start":0,"Data":":1E1F:4567"}]}
{"Report":"TagEvent","Scheme":"SGTIN","PC":":3402",
                    "EPC":":3030:1111:2222:3333:4444:7777",
                    "MB":[{"ID":2,"Start":0,"Data":":E280:1170:2000:????:????:????"},
                          {"ID":3,"Start":0,"Data":":1E1F:4567"}]}
{"Report":"TagEvent","Scheme":"SGTIN","PC":":3404",
                    "EPC":":3030:1111:2222:3333:4444:FFFF",
                    "MB":[{"ID":2,"Start":0,"Data":":E280:1170:2000:????:????:????"},
                          {"ID":3,"Start":0,"Data":":1E1F:4567"}]}
{"Report":"TagEvent","Scheme":"SGTIN","ErrID":34,
                    "EPC":":3030:6666:7777:8888:9999:AAAA",
                    "MB":[{"ID":2,"Start":0,"Data":":E280:6894:2000:????:????:????"},
                          {"ID":3,"Start":0,"Data":""}]}
```

The PC word is not reported since there is no additional data than what RCI interpreted.

RCI noted UMI=0_2, it did not attempt to read MB11_2.

```
{"Report":"TagEvent","AFI":":01","ErrID":34,
                    "UII-PROPRIETARY":":3030:6666:7777:8888:9999:AAAA",
                    "MB":[{"ID":2,"Start":0,"Data":":E280:6894:2000:????:????:????"},
```

{"ID":3,"Start":0,"Data":""}]}

The PC word is not reported since there is no additional data than what RCI interpreted.

RCI noted UMI=0_2, it did not attempt to read MB11_2. "" indicates there is no data.

{"Report":"TagEvent","AFI":":AE","ErrID":34,
"UII":":3030:6666:7777:8888:9999:AAAA",
"MB":[{"ID":2,"Start":0,"Data":":E280:6894:2000:????:????:????"},
{"ID":3,"Start":0,"Data":""}]}

The PC word is not reported since there is no additional data than what RCI interpreted.

RCI noted UMI=0_2, it did not attempt to read MB11_2. "" indicates there is no data.

{"Report":"TagEvent","AFI":":AE","ErrID":34,
"UII":":D2C1:C94E:2069:7320:636F:6F6C",
"MB":[{"ID":2,"Start":0,"Data":":E280:6894:2000:????:????:????"},
{"ID":3,"Start":0,"Data":""}]}

The PC word is not reported since there is no additional data than what RCI interpreted.

RCI noted UMI=0_2, it did not attempt to read MB11_2. "" indicates there is no data.

B.4.3 Sheet B report

EM-1, EM-2, EM-3, EM-4, NXP-3, and NXP-4

{"Report":"TagEvent","Scheme":"SGTIN",
"EPC":":3030:6666:7777:8888:9999:CCCC",
"MB":[{"ID":2,"Start":0,"Data":":E280:B040:3C00:????:????:????"},
{"ID":3,"Start":0,"Data":":1E1F:4567"}]}

The PC word is not reported since there is no additional data than what RCI interpreted.

EM-1 has a 16-word TID that includes full self-declaration of tag features as defined in TDS.

{"Report":"TagEvent","Scheme":"SGTIN","PC":":3E00:0800",
"EPC":":3030:6666:7777:8888:9999:DDDD",
"MB":[{"ID":2,"Start":0,"Data":": E280:B040:3C00:????:????:????"},
{"ID":3,"Start":0,"Data":":1E1F:4567"}]}

EM-1 has a 16-word TID that includes full self-declaration of tag features as defined in TDS.

{"Report":"TagEvent","AFI":":01","PC":"3F01:00?4",
"UII-PROPRIETARY":":3030:6666:7777:8888:9999:EEEE",
"MB":[{"ID":2,"Start":0,"Data":": E2C0:B102:2000:????:????:????"},
{"ID":3,"Start":0,"Data":":1E1F:4567"}]}

EM-3 has an 8-word TID.

{"Report":"TagEvent","Scheme":"SGTIN","PC":"4600:81?0:????",
"EPC":":3030:6666:7777:8888:9999:0000",
"MB":[{"ID":2,"Start":0,"Data":": E280:B120:2000:????:????:????"},
{"ID":3,"Start":0,"Data":":1E1F:4567"}]}
{"Report":"TagEvent","AFI":":01","PC":"3F01:00?7",
"UII-PROPRIETARY":":3030:6666:7777:8888:9999:BBBB",
"MB":[{"ID":2,"Start":0,"Data":": E2C0:6892:2000:????:????:????"},
{"ID":3,"Start":0,"Data":":1E1F:4567"}]}
{"Report":"TagEvent","Scheme":"SGTIN","PC":":34?7","ErrID":34,
"EPC":":3030:6666:7777:8888:9999:BBBB",
"MB":[{"ID":2,"Start":0,"Data":": E2C0:6892:2000:????:????:????"},
{"ID":3,"Start":0,"Data":null}]}

RCI noted UMI=1_2, it did attempt to read MB11_2 but failed since user memory is not direct accessible. The result is an air protocol error. The data is therefore indicated with a null.

B.5 Basic inventory with TAGUSE and Snapshot Sensor interpretation

B.5.1 SpotProfile

```
{"Cmd":"AddProf",InterpretData:["TAGUSE":null,"SNAPSHOTSENSOR":null]}
```

See RCI E.2. RCI Version 5 will add the tag use indicator "USERDATA", which is included below.

The PC and XPC words are not shown since their values are interpreted by the RCI interpretation as set by the application. The application may force the report of the PC and XPC words as follows:

```
{"Cmd":"AddProf",InterpretData:["TAGUSE":null,"SNAPSHOTSENSOR":null],"ReportPC":true}
```

B.5.2 Sheet A report

Impinj-1, Impinj-2, Impinj-3, Impinj-4, NXP-1, NXP-2, NXP-5, and NXP-6.

```
{"Report":"TagEvent","AFI":":01",
                     "TagIndicator":["USERDATA"],
                     "UII-PROPRIETARY":":3030:1111:2222:3333:4444:5555"}
{"Report":"TagEvent","Scheme":"SGTIN","PC":":3401",
                     "TagIndicator":["USERDATA","HAZMAT"],
                     "EPC":":3030:1111:2222:3333:4444:6666"}
{"Report":"TagEvent","Scheme":"SGTIN","PC":":3402",
                     "TagIndicator":["USERDATA","NONREMOVE"],
                     "EPC":":3030:1111:2222:3333:4444:7777"}
{"Report":"TagEvent","Scheme":"SGTIN","PC":":3404",
                     "TagIndicator":["USERDATA","KILLABLE"],
                     "EPC":":3030:1111:2222:3333:4444:FFFF"}
{"Report":"TagEvent","Scheme":"SGTIN",
                     "TagIndicator":[],
                     "EPC":":3030:6666:7777:8888:9999:AAAA"}
```

The PC word is not reported since there is no additional data than what RCI interpreted.

```
{"Report":"TagEvent","AFI":":01",
                     "TagIndicator":[],
                     "UII-PROPRIETARY":":3030:6666:7777:8888:9999:AAAA"}
```

The PC word is not reported since there is no additional data than what RCI interpreted.

```
{"Report":"TagEvent","AFI":":AE",
                     "TagIndicator":[],
                     "UII":":3030:6666:7777:8888:9999:AAAA"}
```

The PC word is not reported since there is no additional data than what RCI interpreted.

```
{"Report":"TagEvent","AFI":":AE",
                     "TagIndicator":[],
                     "UII":":D2C1:C94E:2069:7320:636F:6F6C"}
```

The PC word is not reported since there is no additional data than what RCI interpreted.

B.5.3 Sheet B report

EM-1, EM-2, EM-3, EM-4, NXP-3, and NXP-4

```
{"Report":"TagEvent","Scheme":"SGTIN",
```

```
                    "TagIndicator":["USERDATA"],
                    "EPC":":3030:6666:7777:8888:9999:CCCC"}
{"Report":"TagEvent","Scheme":"SGTIN","PC":":3E00:0800",
                    "TagIndicator":["USERDATA","SENSORALARM"],
                    "EPC":":3030:6666:7777:8888:9999:DDDD"}
{"Report":"TagEvent","AFI":":01","PC":"3F01:00?4",
                    "TagIndicator":["USERDATA","KILLABLE"],
                    "UII-PROPRIETARY":":3030:6666:7777:8888:9999:EEEE"}
{"Report":"TagEvent","Scheme":"SGTIN","PC":"4600:81?0:????",
                    "TagIndicator":["USERDATA","SNAPSHOTSENSOR"],
                    "EPC":":3030:6666:7777:8888:9999:0000",
                    "SNAPSHOTSENSOR":{"ResponseCode":{"Code":0,"Desc":"OK"},
                                      "VenDef":±???}}
```


The sensor is a vendor defined snapshot sensor (sensor type = 0000). It is a capacitive sensor that reports a 10-bit signed integer value.


```
{"Report":"TagEvent","AFI":":01","PC":"3F01:00?7",
                    "TagIndicator":["USERDATA","KILLABLE","NONREMOVE","HAZMAT"],
                    "UII-PROPRIETARY":":3030:6666:7777:8888:9999:BBBB"}
{"Report":"TagEvent","Scheme":"SGTIN","PC":":34?7",
                    "TagIndicator":["USERDATA","KILLABLE","NONREMOVE","HAZMAT"],
                    "EPC":":3030:6666:7777:8888:9999:BBBB"}
```


B.6 Crypto and access password

The application must know the password/key to be used for a specific tag. As such the SpotProfile must indicate the targeted tag(s) with **EncodingType** and/or **MBMask**, see RCI 6.6.2.

The RCI ThisTag command may be used.

Both the proxy and reader decrypt methods are shown over the 3 test cases.

Key diversification is not used.

B.6.1 EM-3: AES-128-1

B.6.1.1 Tag authentication by-proxy

The SpotProfile:


```
{"Cmd":"AddProf","EncodingType":":01","MBMask":[[1,112,16,":FFFF",":FFFF"]],
                 "AccessPW":":1111:2222",
                 "TagAuth":{"Crypto":"AES-128-1",
                            "Key":null,
                            "KeyID":0,
                            "Report":"PROXY"}}
```


This will target tags with AFI=0x01 and MB01 word 7 containing 0xFFFF.

The application does the crypto.

The report:


```
{"Report":"TagEvent","AFI":":01","PC":"3F01:00?4",
                    "UII-PROPRIETARY":":3030:6666:7777:8888:9999:EEEE",
                    "TagAuth":{"Result":"?",
                               "Suite":"AES-128-1",
                               "Key":null,
                               "Challenge":":????…:????",
```

```
                                    "Response":":????…:????"}}
```

B.6.1.2 Private data by-reader

```
{"Cmd":"AddProf","EncodingType":":01","MBMask":[[1,112,16,":FFFF",":FFFF"]],
                 "AccessPW":":1111:2222",
                 "PrivateData":[{"Crypto":"AES-128-1",
                                 "Key":":9988:7766:5544:3322:1100:1122:3344:5566",
                                 "KeyID":1,
                                 "Report":"OPEN",
                                 "MemProf":[2]}]}
```

This will target tags with AFI=0x01 and MB01 word 7 containing 0xFFFF.

The reader does the crypto.

The report:

```
{"Report":"TagEvent","AFI":":01","PC":"3F01:00?4",
                     "UII-PROPRIETARY":":3030:6666:7777:8888:9999:EEEE",
                     "PrivateData":{"Result":"OK",
                                    "MemProf":[{"ID":2,"Start":0,
                                                "Data":":1E1F:4567:89AB:CDEF…"}]}}
```

B.6.2 EM-3: GRAIN-128A

B.6.2.1 Tag authentication by-reader

The SpotProfile:

```
{"Cmd":"AddProf","EncodingType":":01","MBMask":[[1,112,16,":FFFF",":FFFF"]],
                 "AccessPW":":1111:2222",
                 "TagAuth":{"Crypto":"GRAIN-128A",
                            "Key":":1122:3344:5566:7788:9900:1122:3344:5566",
                            "KeyID":0,
                            "Report":"OPEN"}}
```

This will target tags with AFI=0x01 and MB01 word 7 containing 0xFFFF.

The reader does the crypto.

The report:

```
{"Report":"TagEvent","AFI":":01","PC":"3F01:00?4",
                     "UII-PROPRIETARY":":3030:6666:7777:8888:9999:EEEE",
                     "TagAuth":{"Result":"OK"}}
```

B.6.2.2 Private data by-proxy

```
{"Cmd":"AddProf","EncodingType":":01","MBMask":[[1,112,16,":FFFF",":FFFF"]],
                 "AccessPW":":1111:2222",
                 "PrivateData":[{"Crypto":"GRAIN-128A",
                                 "Key":null,
                                 "KeyID":1,
                                 "Report":"PROXY",
                                 "MemProf":[2]}]}
```

This will target tags with AFI=0x01 and MB01 word 7 containing 0xFFFF.

The reader does the crypto.

The report:

```
{"Report":"TagEvent","AFI":":01","PC":"3F01:00?4",
                     "UII-PROPRIETARY":":3030:6666:7777:8888:9999:EEEE",
```

```
                    "PrivateData":{"Result":"?",
                                   "MemProf":[{"ID":2,"Start":0,
                                               "Suite":"GRAIN-128A",
                                               "Key":null,
                                               "Challenge":":????…:????",
                                               "Response":":????…:????"}]}}
```

B.6.3 NXP-3 and NXP-4: AES-128-0

In this case, both tags use the same UII/EPC, access password and keys. The tags are therefore targeted with only the UII/EPC data.

Tag authentication and private data is done in the same SpotProfile.

B.6.3.1 By-reader

The SpotProfile:

```
{"Cmd":"AddProf","MBMask":[[1,112,16,":FFFF",":BBBB"]],
                 "AccessPW":":1111:2222",
                 "TagAuth":{"Crypto":"AES-128-0",
                            "Key":":1122:3344:5566:7788:9900:1122:3344:5566",
                            "KeyID":0,
                            "Report":"OPEN"},
                 "PrivateData":[{"Crypto":"AES-128-0",
                                 "Key":":9988:7766:5544:3322:1100:1122:3344:5566",
                                 "KeyID":1,
                                 "Report":"OPEN",
                                 "MemProf":[2]}]}
```

This will target tags with AFI=0x01 and MB01 word 7 containing 0xBBBB.

The reader does the crypto.

The reports:

```
{"Report":"TagEvent","AFI":":01","PC":"3F01:00?7",
                     "UII-PROPRIETARY":":3030:6666:7777:8888:9999:BBBB",
                     "TagAuth":{"Result":"OK"},
                     "PrivateData":{"Result":"OK",
                                    "MemProf":[{"ID":2,"Start":0,
                                                "Data":":1E1F:4567:89AB:CDEF…:????"}]}}
{"Report":"TagEvent","Scheme":"SGTIN","PC":":34?7",
                     "EPC":":3030:6666:7777:8888:9999:BBBB",
                     "TagAuth":{"Result":"OK"},
                     "PrivateData":{"Result":"OK",
                                    "MemProf":[{"ID":2,"Start":0,
                                                "Data":":1E1F:4567:89AB:CDEF…:????"}]}}
```

The data is for the length of the crypto suite crypto block of which the data beyond the first 4 words is undefined.

B.6.3.2 By-proxy

The SpotProfile:

```
{"Cmd":"AddProf","MBMask":[[1,112,16,":FFFF",":BBBB"]],
                 "AccessPW":":1111:2222",
                 "TagAuth":{"Crypto":"AES-128-0",
                            "Key":null,
                            "KeyID":0,
```

```
                    "Report":"PROXY"},
                "PrivateData":[{"Crypto":"AES-128-0",
                                "Key":null,
                                "KeyID":1,
                                "Report":"PROXY",
                                "MemProf":[2]}]}
```

This will target tags with MB01 word 7 containing 0xBBBB.

The application does the crypto.

The reports:

```
{"Report":"TagEvent","AFI":":01","PC":"3F01:00?7",
                     "UII-PROPRIETARY":":3030:6666:7777:8888:9999:BBBB",
                     "TagAuth":{"Result":"?",
                                "Suite":"AES-128-0",
                                "Key":null,
                                "Challenge":":????…:????",
                                "Response":":????…:????"},
                     "PrivateData":{"Result":"?",
                                    "MemProf":[{"ID":2,"Start":0,
                                                "Suite":"AES-128-0",
                                                "Key":null,
                                                "Challenge":":????…:????",
                                                "Response":":????…:????"}]}}
{"Report":"TagEvent","Scheme":"SGTIN","PC":":34?7",
                     "EPC":":3030:6666:7777:8888:9999:BBBB",
                     "TagAuth":{"Result":"?",
                                "Suite":"AES-128-0",
                                "Key":null,
                                "Challenge":":????…:????",
                                "Response":":????…:????"},
                     "PrivateData":{"Result":"?",
                                    "MemProf":[{"ID":2,"Start":0,
                                                "Suite":"AES-128-0",
                                                "Key":null,
                                                "Challenge":":????…:????",
                                                "Response":":????…:????"}]}}
```

B.7 RAIN Alliance Number (AFI=0xAE)

NXP-5 and NXP-6 are encoded with a RAIN Alliance number as indicated by the AFI (AFI=0xAE).

There are two ways to interpret the RAIN Alliance number:

1. As binary with the XRA CIN a digital number (the default).
2. As a string with the XRA CIN a string.

B.7.1 As a binary: NXP-5 and NXP-6

B.7.1.1 SpotProfile

RCI will by default report ISO tags with AFI=0xAE as APP, instead of UII using the SpotProfile as in B.1.1.

```
{"Cmd":"AddProf"}
```

The following SpotProfile will SELECTfilter for both NXP-5 and NXP-6:

```
{"Cmd":"AddProf","EncodingType":{"APP":[11,22]}}
```

B.7.1.2 Report

```
{"Report":"TagEvent","XRA-CIN":48,"APP":":3066:6677:7788:8899:99AA:AA"}
```

The 1-byte XRA CIN is stripped from the data.

The PC word is not reported since there is no additional data than what RCI interpreted.

```
{"Report":"TagEvent","XRA-CIN":173040846,"APP":":2069:7320:636f:6f6c"}
```

The 4-byte XRA CIN is stripped from the data.

The PC word is not reported since there is no additional data than what RCI interpreted.

B.7.2 As a string: NXP-6

B.7.2.1 SpotProfile

RCI will interpret a RAIN Alliance Number as a string when it is explicitly selected for in the SpotProfile.

```
{"Cmd":"AddProf","EncodingType":{"APPstring":["RAIN"]}}
```

B.7.2.2 Report

```
{"Report":"TagEvent","XRA-CIN":173040846,"APPstring":"RAIN is cool"}
```

The 4-byte XRA CIN is converted to a string from the EBV-8 encoding using the 7-bit ASCII character set. The XRA IN is NOT stripped from the data.

The PC word is not reported since there is no additional data than what RCI interpreted.

ABOUT RAIN RFID ALLIANCE

The RAIN RFID Alliance is an organization supporting the universal adoption of RAIN UHF RFID technology. A wireless technology that connects billions of everyday items to the internet, enabling businesses and consumers to identify, locate, authenticate, and engage each item. The technology is based on the EPC Gen2 UHF RFID specification, incorporated into the ISO/IEC 18000-63 standard.

Join the RAIN RFID Alliance to enable connectivity for your business and consumers: identify, locate, authenticate, and engage items in our everyday world. For more information, visit www.RAINRFID.org.

RAIN RFID Alliance

401 Edgewater Place, Suite 600

Wakefield, MA, 01880, USA

Visit the RAIN RFID website – RAINRFID.org.

If you are interested in learning more about the RAIN RFID Alliance, contact us at info@rainrfid.org.