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

RAIN RFID Alliance Guideline

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1. Introduction

The RAIN Alliance has a registered ISO/IEC 15961 Application Family Identifier (AFI) and it is the hex value "0xAE". The use of the RAIN AFI shall indicate that the tag encoding is for a closed system application using a proprietary or vendor-defined data format. The tag encoding shall include a Company Identifying Number (CIN) assigned by the RAIN Alliance to identify the owner of the tag data.

2. Tag encoding

This tag encoding guideline applies only to Memory Bank 01 (UII Memory). MB01 contains three mandatory addressed areas and two optional addressed areas:

1. **StoredCRC** – This is a mandatory 16-bit value stored in UII Memory at Word 0x00 (bit addresses 0x00 to 0x0F). The value is calculated by the tag itself.
2. **StoredPC** (a.k.a. PC Word) – This is a mandatory 16-bit value stored in UII Memory at Word 0x01 (bit addresses 0x10 to 0x1F). The PC Word contains the following fields:
   a. **L** (Length) – This 5-bit value is stored at bit addresses 0x10 to 0x14. **L** shall be set accordingly for the number of 16-bit words necessary for the **UII** (see below) in the tag reply to an *ACK* command.
   b. **UMI** (User Memory Indicator) – This 1-bit value is stored at bit address 0x15. **UMI** is set by the tag itself.
   c. **XI** (**XPC_W1** Indicator) – This 1-bit value is stored at bit address 0x16. This bit indicates if **XPC_W1** is included in the tag reply to an *ACK* command. **XI** is set by the tag itself.
   d. **T** (Toggle Indicator) – This 1-bit value is stored at bit address 0x17. **T** shall be set **T**=1 when using the RAIN AFI.
   e. **AFI** (Application Family Identifier) – This 8-bit value is stored at bit addresses 0x18 to 0x1F. **AFI** shall be set **AFI**=0xAE when using the RAIN AFI.
3. **UII** (Unique Item Identifier) – This is a mandatory area of variable length and starts in UII Memory at Word 0x02 (bit addresses 0x20 and higher). The **UII** shall begin with the CIN assigned by the RAIN Alliance starting at bit address 0x20. The CIN shall be encoded using the EBV-8 format described below. The remainder of the **UII** encoding following the CIN shall be considered as proprietary or vendor-defined encoding that is defined by the entity identified by the CIN.
4. **XPC_W1** – This is an optional 16-bit value stored in UII Memory at Word 0x21 (bit addresses 210 to 21F). If a tag implements XPC_W1, then most of the value is calculated by the tag itself. **XPC_W1** contains the following fields, which are recommended to be set appropriately for the object associated with the tag:
   a. **TN** (Tag Notification Indicator) – This 1-bit value is stored at bit address 0x21B. This is an optional bit that is IC vendor defined and may or may not be supported by the tag.
   b. **NR** (Nonremovable Indicator) – This 1-bit value is stored at bit address 0x21E. It is recommended that **NR** be set as appropriate for the tagged object.
   c. **H** (HazMat Indicator) – This 1-bit value is stored at bit address 0x21F. It is recommended that **H** be set as appropriate for the tagged object.
5. **XPC_W2** – This is an optional 16-bit value stored in UII Memory at Word 0x22 (bit addresses 220 to 22F). If a tag implements XPC_W2, then the value is calculated by the tag itself.

3. EBV-8 encoding format

EBV (Extensible Bit Vector) is a data structure with an extensible range. An EBV is an array of blocks with each block containing a single extension bit followed by a specific number of data bits. For EBV-8, there are 8 bits in one block and each block contains an extension bit followed by 7 data bits.

The data value represented by an EBV-8 is simply the bit string formed by the data bits as read from left-to-right, ignoring the extension bits. Because each block has 7 available data bits, an EBV-8 can represent numeric values between 0 and 127 with a single block. To represent the value 128, set the extension bit to 1 in the first block, and append a second block to the EBV-8. In this manner, an EBV-8 can represent arbitrarily large data values. RAIN CIN values are in the range 0 to 99,999,999 so the corresponding EBV-8 encoding will require from 1 to 4 bytes of memory.

Number (i.e. RAIN CIN)		EBV-8 Encoding							
		Byte 1		Byte 2		Byte 3		Byte 4	
		ext	data	ext	data	ext	data	ext	data
0	$2^0 - 1$	0	0000000	n/a		n/a		n/a	
1	2^0	0	0000001	n/a		n/a		n/a	
127	$2^7 - 1$	0	1111111	n/a		n/a		n/a	
128	2^7	1	0000001	0	0000000	n/a		n/a	
16,383	$2^{14} - 1$	1	1111111	0	1111111	n/a		n/a	
16,384	2^{14}	1	0000001	1	0000000	0	0000000	n/a	
2,097,151	$2^{21} - 1$	1	1111111	1	1111111	0	1111111	n/a	
2,097,152	2^{21}	1	0000001	1	0000000	1	0000000	0	0000000
268,435,453	$2^{28} - 1$	1	1111111	1	1111111	1	1111111	0	1111111

4. UII encoding examples

The following examples illustrate the proper tag encoding for the **UII** based on the EBV-8 encoding length required for the CIN issued by RAIN. All the examples assume the most common of RAIN tags which have MB01 (UII Memory) comprised of the 16-bit **StoredCRC**, the 16-bit **StoredPC**, and a 96-bit **UII** encoding.

4.1. UII encoding for a 1-byte CIN

Assume an entity is issued the 2-digit CIN = 12 by RAIN, which is the 1-byte value 0x0C using EBV-8 encoding. The UII memory is then encoded as follows with the 96-bit UII shaded in green:

Memory Bank 01 (UII Memory)

MB01 Bit Address	MB01 Word Address	msb 0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	lsb F
00_h – $0F_h$	00_h	**StoredCRC**															
10_h – $1F_h$	01_h	**StoredPC**															
		L=00110_2					**UMI**	**XI**	**T**=1	**AFI** = 0xAE							
20_h – $2F_h$	02_h	**CIN byte 1** = 0x0C								data byte 1							
30_h – $3F_h$	03_h	data byte 2								data byte 3							
40_h – $4F_h$	04_h	data byte 4								data byte 5							
50_h – $5F_h$	05_h	data byte 6								data byte 7							
60_h – $6F_h$	06_h	data byte 8								data byte 9							
70_h – $7F_h$	07_h	data byte 10								data byte 11							

4.2. UII encoding for a 2-byte CIN

Assume an entity is issued the 4-digit CIN = 1,234 by RAIN, which is the 2-byte value 0x8952 using EBV-8 encoding. The UII memory is then encoded as follows with the 96-bit UII shaded in green:

Memory Bank 01 (UII Memory)

MB01 Bit Address	MB01 Word Address	msb 0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	lsb F
00_h – $0F_h$	00_h	**StoredCRC**															
10_h – $1F_h$	01_h	**StoredPC**															
		L=00110_2					**UMI**	**XI**	**T**=1	**AFI** = 0xAE							
20_h – $2F_h$	02_h	**CIN byte 1** = 0x89								**CIN byte 2** = 0x52							
30_h – $3F_h$	03_h	data byte 1								data byte 2							
40_h – $4F_h$	04_h	data byte 3								data byte 4							
50_h – $5F_h$	05_h	data byte 5								data byte 6							
60_h – $6F_h$	06_h	data byte 7								data byte 8							
70_h – $7F_h$	07_h	data byte 9								data byte 10							

4.3. UII encoding for a 3-byte CIN

Assume an entity is issued the 6-digit CIN = 123,456 by RAIN, which is the 3-byte value 0x87C440 using EBV-8 encoding. The UII memory is then encoded as follows with the 96-bit UII shaded in green:

Memory Bank 01 (UII Memory)

<table>
<tr><th>MB01 Bit Address</th><th>MB01 Word Address</th><th>msb
0</th><th>1</th><th>2</th><th>3</th><th>4</th><th>5</th><th>6</th><th>7</th><th>8</th><th>9</th><th>A</th><th>B</th><th>C</th><th>D</th><th>E</th><th>lsb
F</th></tr>
<tr><td>$00_h – 0F_h$</td><td>00_h</td><td colspan="16">StoredCRC</td></tr>
<tr><td rowspan="2">$10_h – 1F_h$</td><td rowspan="2">01_h</td><td colspan="16">StoredPC</td></tr>
<tr><td colspan="5">L=00110_2</td><td>UMI</td><td>XI</td><td>T=1</td><td colspan="8">AFI = 0xAE</td></tr>
<tr><td>$20_h – 2F_h$</td><td>02_h</td><td colspan="8">CIN byte 1 = 0x87</td><td colspan="8">CIN byte 2 = 0xC4</td></tr>
<tr><td>$30_h – 3F_h$</td><td>03_h</td><td colspan="8">CIN byte 3 = 0x40</td><td colspan="8">data byte 1</td></tr>
<tr><td>$40_h – 4F_h$</td><td>04_h</td><td colspan="8">data byte 2</td><td colspan="8">data byte 3</td></tr>
<tr><td>$50_h – 5F_h$</td><td>05_h</td><td colspan="8">data byte 4</td><td colspan="8">data byte 5</td></tr>
<tr><td>$60_h – 6F_h$</td><td>06_h</td><td colspan="8">data byte 6</td><td colspan="8">data byte 7</td></tr>
<tr><td>$70_h – 7F_h$</td><td>07_h</td><td colspan="8">data byte 8</td><td colspan="8">data byte 9</td></tr>
</table>

4.4. UII encoding for a 4-byte CIN

Assume an entity is issued the 8-digit CIN = 12,345,678 by RAIN, which is the 4-byte value 0x85F1C24E using EBV-8 encoding. The UII memory is then encoded as follows with the 96-bit UII shaded in green:

Memory Bank 01 (UII Memory)

<table>
<tr><th>MB01 Bit Address</th><th>MB01 Word Address</th><th>msb
0</th><th>1</th><th>2</th><th>3</th><th>4</th><th>5</th><th>6</th><th>7</th><th>8</th><th>9</th><th>A</th><th>B</th><th>C</th><th>D</th><th>E</th><th>lsb
F</th></tr>
<tr><td>$00_h – 0F_h$</td><td>00_h</td><td colspan="16">StoredCRC</td></tr>
<tr><td rowspan="2">$10_h – 1F_h$</td><td rowspan="2">01_h</td><td colspan="16">StoredPC</td></tr>
<tr><td colspan="5">L=00110_2</td><td>UMI</td><td>XI</td><td>T=1</td><td colspan="8">AFI = 0xAE</td></tr>
<tr><td>$20_h – 2F_h$</td><td>02_h</td><td colspan="8">CIN byte 1 = 0x85</td><td colspan="8">CIN byte 2 = 0xF1</td></tr>
<tr><td>$30_h – 3F_h$</td><td>03_h</td><td colspan="8">CIN byte 3 = 0xC2</td><td colspan="8">CIN byte 4 = 0x4E</td></tr>
<tr><td>$40_h – 4F_h$</td><td>04_h</td><td colspan="8">data byte 1</td><td colspan="8">data byte 2</td></tr>
<tr><td>$50_h – 5F_h$</td><td>05_h</td><td colspan="8">data byte 3</td><td colspan="8">data byte 4</td></tr>
<tr><td>$60_h – 6F_h$</td><td>06_h</td><td colspan="8">data byte 5</td><td colspan="8">data byte 6</td></tr>
<tr><td>$70_h – 7F_h$</td><td>07_h</td><td colspan="8">data byte 7</td><td colspan="8">data byte 8</td></tr>
</table>

5. Background and Contributors

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

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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.

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