TRF7960 Evaluation Module

ISO 15693 Host Commands

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RFID

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Edition 1 – April 2008

This is the first edition of this **TRF7960 EVM Host Commands** Application Note.

It describes how to send valid ISO15693 commands to the Texas Instruments HF-I Transponders using the following products:

TRF7960EVM (Evaluation Module)

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PREFACE

Read This First

About this Manual

This **Application Note (11-06-26-009)** is written for the sole use by TI's RFID Customers who are engineers experienced with Radio Frequency Identification Devices (RFID).

Conventions

Certain conventions are used in order to display important information in this manual, these conventions are:

WARNING:

A warning is used where care must be taken or a certain procedure must be followed, in order to prevent injury or harm to your health.

CAUTION:

This indicates information on conditions, which must be met, or a procedure, which must be followed, which if not heeded could cause permanent damage to the system.

Note:

Indicates conditions, which must be met, or procedures, which must be followed, to ensure proper functioning of any hardware or software.

Information:

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TRF7960 EVM ISO15693 Commands

J.A.Goulbourne, TI Northampton.

Abstract

With the introduction of the TRF7960 Transceiver, Texas Instruments raised the bar on performance and ease of integration. The TRF7960 evaluation module (EVM) was produced to demonstrate the transceiver's functionality and to facilitate integration.

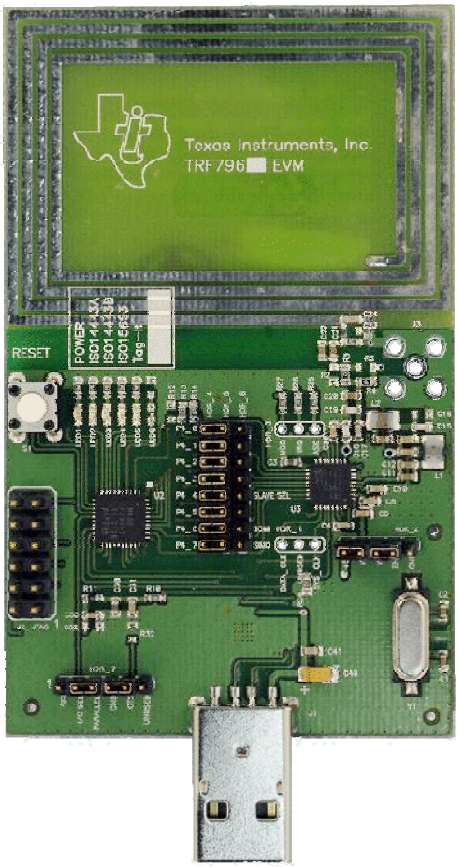

Figure 1. The TRF7960 Evaluation Module

This application note explains how to configure the EVM for the ISO15693 protocol (13.56 MHz HF transponders). It also details the structure and formats of the individual commands.

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CHAPTER 1

Introduction

This chapter introduces you to Software protocols

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1 Software Protocols

1.1 The TRF7960 EVM Protocol

The EVM protocol has a general form as shown below:

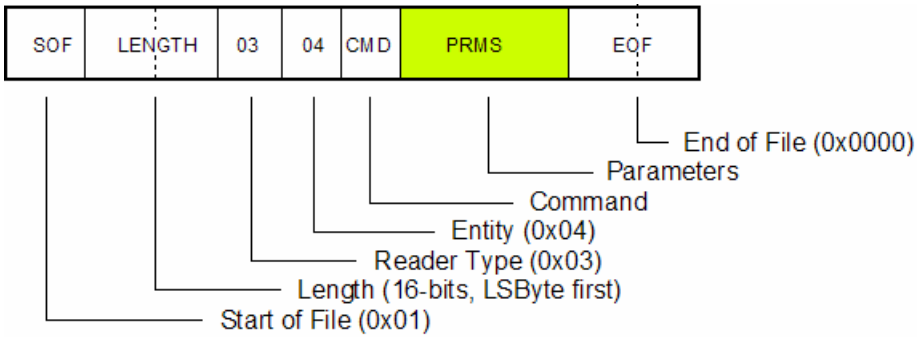

Figure 2. TRF7960 EVM Host Protocol Format

The protocol begins with a 0x01 (Start Of File) byte, then 2-bytes for the length (Least Significant Byte first). Bytes 5 and 6 are always 0x03 and 0x04 respectively and they are followed by a command byte. Table 1 shows the commands that are described in this document.

Command	Parameters	Example
0x10 – Write Register	Address, Data, Address, data,	010C000304**10002101**00000
0x14 – Inventory Request	Flags, command code, data	010B000304**14040100**0000
0x18 - ISO Request	Flags, command code, data	010B000304**18002000**0000

Table 1. EVM Command Codes

The 'PRMS' byte contains the parameters associated with the command and finally, the 2-byte EOF which is always 0x0000 completes the format.

1.2 The ISO15693 Protocol

The structure of ISO15693 commands is detailed in the standard:

ISO/IEC 15693-3. Identification cards – Contact-less integrated circuit(s) cards – Vicinity cards – Part3: Anti-collision and transmission protocol.

The general form is:

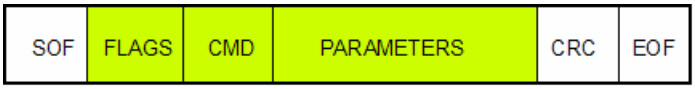

Figure 3. General Format of ISO15693 Request

When the TRF7960 EVM is configured for ISO15693, the fields shown in green in Figure 3 replace the field marked “PRMS” in figure 2. The EVM will then take that data, add the EOF and SOF and calculate the CCITT CRC-16 checksum before transmitting to a tag.

1.3 Combined Protocol Example

To see what happens, we can take a simple ‘Read Single Block’ command as an example:

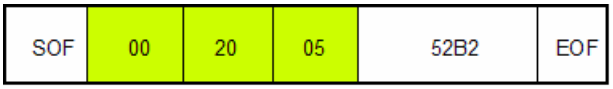

Figure 4. ISO15693 Read Block 5 Command

Figure 4 shows the complete ISO15693 Read Block 5 format.

The data in green is inserted into the TRF7960 EVM Protocol and the total Host Command is as shown in Figure 5

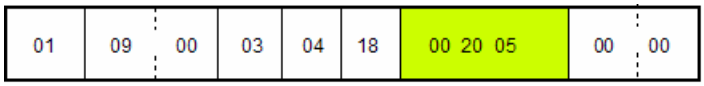

Figure 5. TRF7960 EVM Read Block 5 Command

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CHAPTER 2

Configuring the EVM

This chapter describes how to configure the TRF7960EVM for ISO156593 operation.

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2 Configuring the EVM for ISO15693 Operation

The EVM is configured for ISO15693 by using command 0x10 to write to the register. The examples below describe some of the various options and show the request/ responses from the EVM:

```
>> 010C0003041000210100000 0
<< 010C0003041000210100000 0
Register write request.
```

Information:

In this document ">>" indicates a request string and "<<" indicates a response string.

These are not part of the protocol and are added to make things clearer

The above request writes to the register to set up ISO15693 protocol with 1- out-of-4 modulation and full power

```
>> 010C0003041000310100000 0
<< 010C0003041000310100000 0
Register write request
```

The above request writes to the register to set up ISO15693 protocol with 1-out-of-4 modulation and half power

```
>> 010C0003041000310100000 0
<< 010C0003041000310100000 0
Register write request
```

The above request writes to the register to set up ISO15693 protocol with 1-out-of-256 modulation and full power

```
>> 010C0003041000310101000 0
<< 010C0003041000310101000 0
Register write request
```

The above request writes to the register to set up ISO15693 protocol and 1-out-of-256 modulation and half power

The EMV is now configured to accept ISO15693 commands.

CHAPTER 3

Tag Memory Allocation

This chapter details the memory allocations of the different Texas Instruments HF-I transponders

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3 Texas Instruments' Tag Memory

Texas Instruments has three ICs – HFI-Plus, HF-I Pro and HF-I Standard. To understand the ISO 15693 commands, it is first necessary to know how the memory of each of the three ICs is structured.

The memory map of the 2k-bit HF-I Plus transponder is shown in Figure 6.

	Lock	MSB LSB	Page
Unique ID	×	64-bits R/O e.g. E007000012345678	
	×		
DSFID		8-bits	
AFI		8-bits	
IC Reference	×	24-bits R/O	
User Data 1		32-bits R/W	0
User Data 2		32-bits R/W	1
User Data 3		32-bits R/W	2
User Data 4		32-bits R/W	3
User Data 5		32-bits R/W	4
User Data 6		32-bits R/W	5
User Data 63		32-bits R/W	62
User Data 64		32-bits R/W	63

Figure 6. HF-I Plus Memory Map

3.1 HF-I Plus Memory Locations

The Read Only (R/O) Unique ID (UID) is accessed using the ***Inventory*** command and this value can be used to address individual tags. The UID number will be similar to "E007000123456789"

The 8-bit Data Structure Format Identifier (DSFID) field is a location to write information to about the structure of the User memory.

The 8-bit Application Family Identifier (AFI) field allows tags to be assigned family groups.

The IC reference contains information about the IC itself and is mask programmed.

The HF-I Plus has 2048-bits of User memory. Each of the 64 pages can be individually read, programmed and locked.

3.2 HF-I Pro Memory Map

The memory map of the 256-bit HF-I Pro transponder is shown in Figure 7

	Lock	MSB LSB	Page
User Data 1		32-bits R/W	0
User Data 2		32-bits R/W	1
User Data 3		32-bits R/W	2
User Data 4		32-bits R/W	3
User Data 5		32-bits R/W	4
User Data 6		32-bits R/W	5
User Data 7		32-bits R/W	6
User Data 8		32-bits R/W	7
Unique ID	×	32-bits R/O	8
		32-bits R/O	9
AFI		8-bits	10
User Data 64		32-bits Password	11

Figure 7. HF-I Pro Memory Map

3.3 HF-I Pro Memory Locations

A total of 256-bits of User memory is available. This memory (colored cyan) comprises 8 pages × 32-bits. This memory is Read Write (R/W) and can be irreversibly locked.

Pages 8 and 9 constitute the 64-bit UID. This is a unique value that is R/O and will be similar to “E007C40123456789”.

Page 10 uses the 8 least significant bits for AFI data but if the AFI is not used, this page can be used as a further 32-bits of User Memory. Page 11 is used to store the password that is required to change the data in locked blocks (0xA4 -Write SingleBlockPWD command) and to KILL (0xA5) the tag.

Note:

Before the password can be used, page 11 must be locked. Once locked, the data can no longer be read.

3.4 HF-I Standard Memory Locations

The HFI-Standard tag memory is the same as the HF-I Pro except there is no page 11 (Password).

As a result, no password related commands are available. This means that the KILL (0xA4) and WriteSingleBlockPWD (0xA5) commands can not be used.

CHAPTER 4

The ISO/IEC 15693 Protocol

This chapter details the ISO15693 Protocol.

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4 The ISO15693 Protocol

4.1 ISO 15693 Flags

The ISO15693 flags configure the tag IC. Such things as Date-rate, type of sub-carrier and option flags can all be set. The 8-bits are defined as follows:

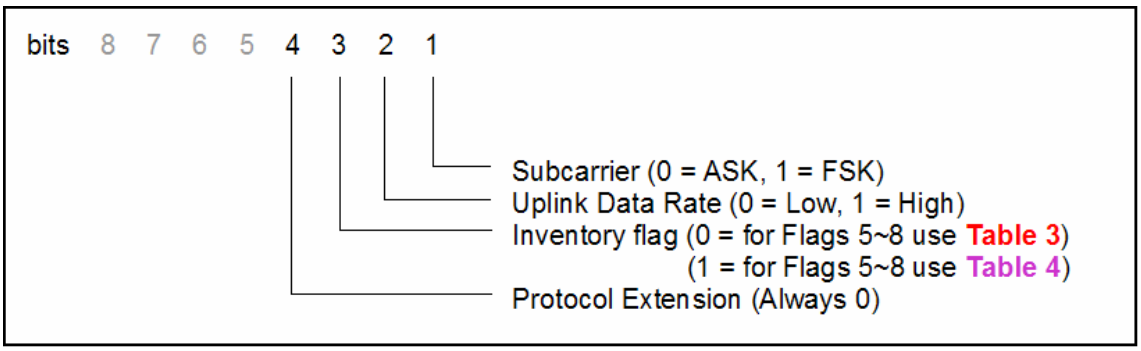

Table 2. ISO15693 Protocol Flags

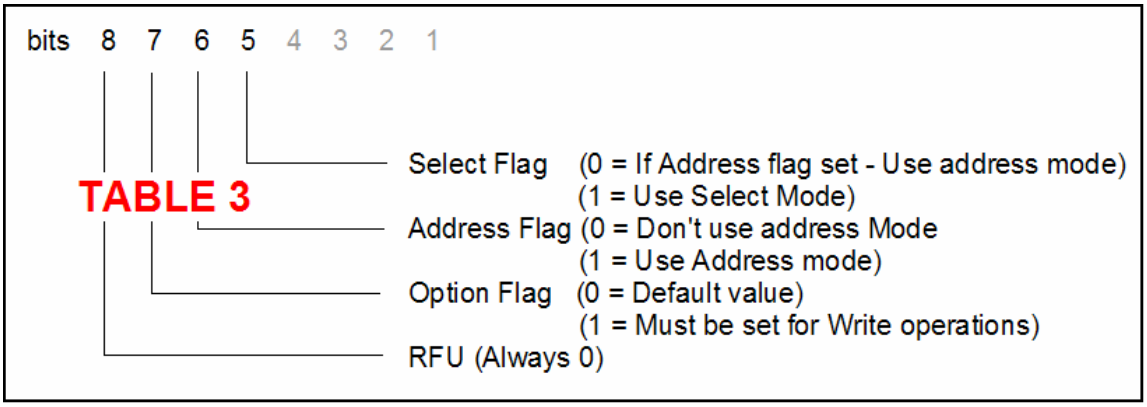

Table 3. ISO15693 Inventory Flag not Set

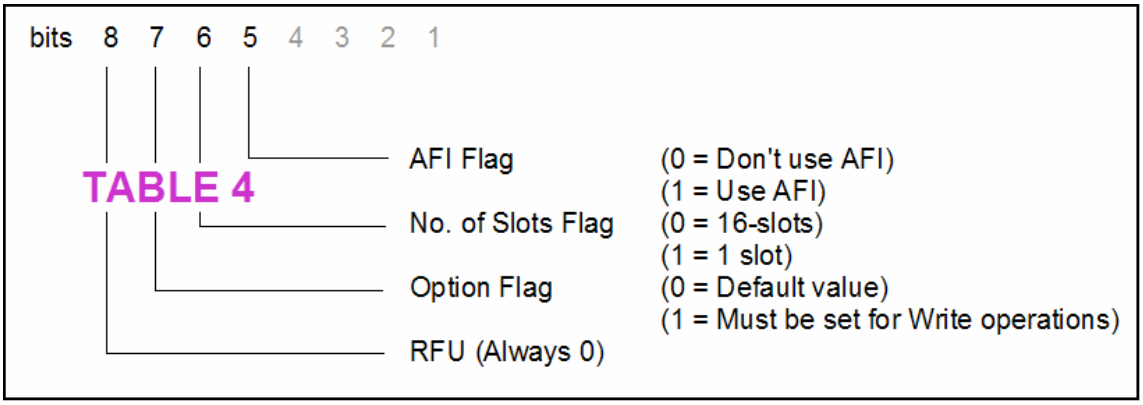

Table 4. ISO15693 Inventory Flag Set

As an example, for the Inventory Command to use 1-slot, the ISO15693 flags are:

```
>> 010B000304142401000000
```

0x0100 (Parameters)
0x24 (ASK, Low data rate, Inventory, No AFI, 1-slot)
0x14 (Inventory command)

And to use 16-slots:

```
>> 010B000304140401000000
```

0x0100 (Parameters)
0x04 (ASK, Low data rate, Inventory, No AFI, 16-slots)
0x14 (Inventory command)

4.2 ISO15693 Standard commands

Table 5 lists the standard ISO15693 commands.

Cmd	Command Type	Tag Type	Function	Option Flag
01	Mandatory	All	Inventory	No
02	Mandatory	All	Stay Quiet	No
20	Optional	Std, Pro, Plus	Read Single Block	No
21	Optional	Std, Pro, Plus	Write Single Block	Yes
22	Optional	Std, Pro, Plus	Lock Block	Yes
23	Optional	Plus only	Read Multiple Blocks	No

24	Optional	Plus only	Write Multiple Blocks	Yes
25	Optional	Plus only	Select	No
26	Optional	Plus only	Reset to Ready	No
27	Optional	Plus only	Write AFI	Yes
28	Optional	Plus only	Lock AFI	Yes
29	Optional	Plus only	Write DSFID	Yes
2A	Optional	Plus only	Lock DSFID	Yes
2B	Optional	Plus only	Get System Information	No
2C	Optional	Plus only	Get Multiple Block Security Status	No

Table 5. Standard ISO15693 Commands

In addition there are TI custom commands.

Cmd	Command Type	Tag Type	Function	Option Flag
A2	Custom	Plus only	Write 2 Blocks	Yes
A3	Custom	Plus only	Lock 2 Blocks	Yes
A4	Custom	Pro only	KILL	Yes
A5	Custom	Pro only	Write Single Block PWD	Yes

Table 6. TI Custom ISO15693 Commands

4.3 Response Codes

ISO15693 responses contain a status byte which the EMV extracts and appends [inside square brackets] to the response. Table 7 shows some of the possible responses.

Response Code	Meaning
[]	No status Information
[00]	Command was successful
[0101]	Command not supported
[0102]	Command not recognised (e.g. Format error)
[0103]	Option not supported

[010F]	Unknown error
[0110]	Block not available (out of range)
[0111]	Block already locked (can't be locked again)
[0112]	Block already locked – contents can't be changed
[0113]	Programming was unsuccessful
[0114]	Locking/Kill was unsuccessful
[01A1]	Start block must be even
[01A2]	One or both blocks already locked
[01B0]	Read Access denied

Table 7. Response codes

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CHAPTER 5

ISO 15693 Commands

This chapter describes the ISO15693 Commands

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5 Individual ISO15693 EVM Commands

The following sections describe the requests and responses for each command.

5.1 Inventory

The request/response for an Inventory command with 1-slot is:

```
>> 010B000304142401000000
<< 010B000304142401000000
ISO 15693 Inventory request.
[9080C2E5D2C407E0,7F]
```

This shows that tag “E007C4D2E5C28090” responded. The request/response for an Inventory command with 16-slots is:

```
>> 010B000304140401000000
<< 010B000304140401000000
ISO 15693 Inventory request.
[9080C2E5D2C407E0,7F]
[,40]
[,40]
[,40]
[,40]
[,40]
[,40]
[379EC2E5D2C407E0,7F]
[,40]
[,40]
[,40]
[,40]
[,40]
[,40]
[,40]
[,40]
```

This shows that tag “E007C4D2E5C28090” responded in slot 0 and “E007C4D2E5C29E37” in slot 7.

5.2 Stay Quiet (0x02)

The Stay Quiet request/response sequences will be similar to:

```
>> 01120003041820021052FE01000007E00000
<< 01120003041820021052FE01000007E00000
Request mode.
[]>
```

This shows a request to tag ID E007000001FE5210 to Stay Quiet. No tag responds to a Stay Quiet request, so even if the command fails the reader will still return the same response

5.3 Read Single Block (0x20)

The request/responses to perform an unaddressed Read of block 0x05 will be similar to:

```
>> 010B000304180020050000
<< 010B000304180020050000
Request mode.
[0078563412]
```

"[78563412]" is the block data (12345678) that was read.

5.3.1 Read Single Block (Addressed)

The request/responses from an addressed read (Address is "E007804651E49C57") of block 0x05 will be similar to:

```
>> 1130003041820205 79CE451468007E0050000
<< 0113000304182020579CE451468007E0050000
Request mode.
[0078563412]
```

5.4 Write Single Block (0x21)

The Write Single Block command must have the Option flag set (0x**40**) and the data must be LSByte first. The ISO15693 format is shown in the figure below:

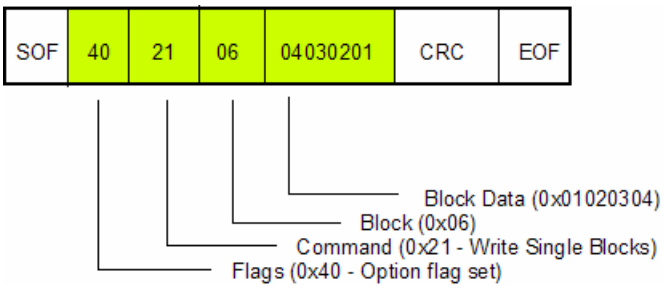

Figure 8. Write Single Block Format

This translates into the following TRF7960 EVM request/responses

```
>> 010F000304184021060403020 10000
<< 010F0003041840210604030201 0000
Request mode.
```

```
[00]
```

The [00] response indicates that the command succeeded. For other possible responses see Table 7.

5.4.1 Write Single Block (Addressed)

For an addressed Write Single Block, both Address and Option flags (0x**90**) must be set. In this example the address is E007C4D2E5C28090, the block is 0x06 and the data is 0x22334455. The EVM request/responses will be similar to:

```
>> 0117000304186021908 0C2E5D2C407E00655443322 0000
<< 011700030418602190 80C2E5D2C407E00655443322 0000
Request mode.
[00]
```

5.5 Lock Block (0x22)

For the Lock Block command the Option flag (0x40) must be set. In this example the block to be locked is 0x06. The TRF7960 EVM request/responses will be similar to:

```
>> 010B000304184022060000
<< 010B00030418 4022060000
Request mode.
[]
```

5.5.1 Lock Block (Addressed)

For an addressed Lock Block command, the Option and Address flags (0x90) must be set. In this example the address is E007C4D2E5C28090 and the block is 0x06. The TFR7960 EVM request/responses will be similar to the following:

```
>> 011300030418602290 80C2E5D2C407E0060000
<< 011300030418602290 80C2E5D2C407E0060000
Request mode.
[]
```

5.6 Read Multiple Blocks (0x23)

In this example the start block is 0x01 and the number of blocks is 02 The TRF7960 EVM request/responses will be similar to the following:

```
>> 010C0003041800230102 0000
<< 010C0003041800230102 0000
```

```
Request mode.
[0011111111222222222]
```

5.6.1 Read Multiple Blocks (Addressed)

In this example the address is E007804651E49C57, the start block is 01 and number of blocks is 02)

```
>> 0114000304182023579CE451468007E001020000
<< 0114000304182023579CE451468007E001020000
Request mode.
[0011111111222222222]
```

5.7 Write Multiple Blocks (0x24)

In this example the request is to program pages 0x0A, 0x0B and 0x0C with 0xAAAAAAAA, 0xBBBBBBBB and 0xCCCCCCCC. The GUI sends iterative Write Single Block commands

```
>> 010F0003041840210AAAAAAAAA0000
<< 010F0003041840210AAAAAAAAA0000
Request mode.
[00]
>> 010F0003041840210BBBBBBBBB0000
<< 010F0003041840210BBBBBBBBB0000
Request mode.
[00]
>> 010F0003041840210CCCCCCCCC0000
<< 010F0003041840210CCCCCCCCC0000
Request mode.
[00]
```

5.7.1 Write Multiple Blocks (Addressed)

This example to tag E007804651E49C57 is to write to blocks 0x07, 0x08 and 0x09 with 0xEEEEEEEE, 0xFFFFFFFF and 0x10101010 respectively. The GUI sends multiple Write Single Block commands:

```
>> 0117000304186021579CE451468007E007EEEEEEEE0000
>> 0117000304186021579CE451468007E007EEEEEEEE0000
Request mode.
[00]
>> 0117000304186021579CE451468007E008FFFFFFFF0000
<< 0117000304186021579CE451468007E008FFFFFFFF0000
Request mode.
[00]
>> 0117000304186021579CE451468007E009101010100000
```

```
<< 0117000304186021579CE451468007E009101010100000
Request mode.
[00]
```

5.8 Select (0x25)

This command is only allowed as an addressed command. In this example tag E007804651E49C57 is instructed to enter Select state.

Note that the select flag is set.

```
>> 0112000304182025078B5812000007E00000
<< 0112000304182025078B5812000007E00000
Request mode.
[00]
```

5.9 Reset to Ready (0x26)

This command returns all selected tags to the normal state. The request/responses will be similar to:

```
>> 010A0003041810260000
<< 010A0003041810260000
Request mode.
[00]
```

5.10 Write AFI (0x27)

This command writes a code to a tag that tells it which family of applications that tag belongs too. In this example the family code is 0x**30** - access control.

The request/responses of the Write AFI command will be similar to:

```
>> 010B000304184027300000
<< 010B000304184027300000
Request mode.
[00]
```

5.10.1 Write AFI (Addressed)

In this example the Address is E00700001258B807 and the AFI is 0x**30**. The request/responses will be similar to:

```
>> 0113000304186027078B5812000007E0300000
<< 0113000304186027078B5812000007E0300000
Request mode.
```

```
[00]
```

5.11 Lock AFI (0x28)

The AFI can be locked to prevent it being changed. The request/responses will be similar to:

```
>> 010A0003041840280000
<< 010A0003041840280000
Request mode.
[]
```

5.11.1 Lock AFI (Addressed)

This example locks the AFI of tag E00700001258B87B. The request/responses will be similar to:

```
>> 0112000304186028078581200000 7E00000
<< 0112000304186028078581200000 7E00000
Request mode.
[]
```

5.12 Write DSFID (0x29)

The DSFID is used to provide information about how the memory of a tag is configured. In this example 0x**AA** is written into the DSFID field. The request/responses to this command will be similar to:

```
>> 010B000304184029AA0000
<< 010B000304184029AA0000
Request mode.
[00]
```

5.12.1 Write DSFID (Addressed)

In this example the tag addressed is E00700001258B807 and the DSFID data is 0x**AA.** The request/responses will be similar to:

```
>> 0113000304186029078581200000 7E0AA0000
<< 0113000304186029078581200000 7E0AA0000
Request mode.
[00]
```

5.13 Lock DSFID (0x2A)

The DSFID field can also be locked to prevent the data being changed. This example shows the expected request/responses:

```
>> 010A00030418402A0000
<< 010A00030418402A0000
Request mode.
[]
```

5.13.1 Lock DSFID (Addressed)

This example show the locking of the DSFID field for tag E00700001258B807. The request/responses will be similar to:

```
>> 011200030418602A07B85812000007E00000
<< 011200030418602A07B85812000007E00000
Request mode.
[]
```

5.14 Get System Information (0x2B)

This command returns tag information. The request/responses will be similar to:

```
>> 010A00030418002B0000
<< 010A00030418002B0000
Request mode.
[000F07B85812000007E0AA303F0388]
```

The System information is decoded as follows:

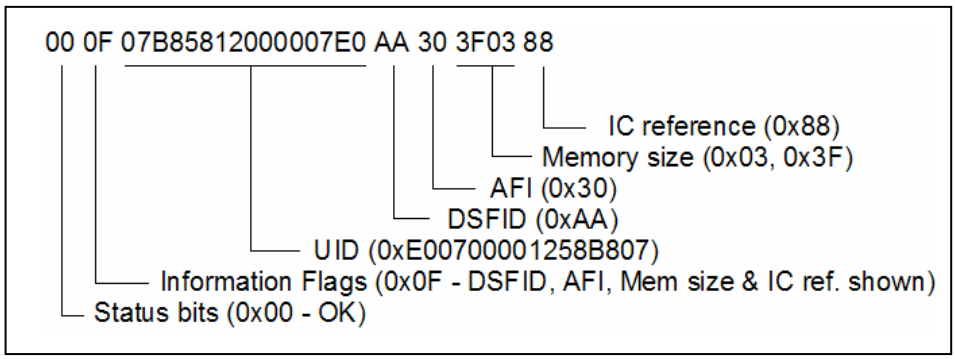

Figure 9. System Information

5.14.1 Get System Information (Addressed)

This example requests the system information from tag E00700001258B807. The request/responses will be similar to:

```
>> 011200030418202B07B85812000007E00000
<< 011200030418202B07B85812000007E00000
Request mode.
[000F07B85812000007E0AA303F0388]
```

5.15 Get Multiple Block Security Status (0x2C)

This command returns the status of multiple blocks, indicating if they are locked or open. In this example, the security status of blocks 01 to 04 is requested:

```
>> 010C00030418002C01030000
<< 010C00030418002C01030000
Request mode.
[0001010100]
```

From the response it can be seen that the status (0x00) is OK and blocks 01, 02 and 03 are locked (0x010101) and block 04 is unlocked (0x00)

5.15.1 Get Multiple Block Security Status (Addressed)

This example requests the security status from tag E00700001258B807 for blocks 01 to 04. The request/responses will be similar to:

```
>> 011400030418202C07B85812000007E001030000
<< 011400030418202C07B85812000007E001030000
Request mode.
[0001010100]
```

5.16 Write 2 Blocks (0xA2)

This custom command instructs the tag (not the reader) to program 2 consecutive blocks. All custom commands require the manufacturer code (TI's is 0x**07**) to follow the command. In this example the Start Block is 0x02 and Data is 0xAAAAAAAA and 0xBBBBBBBB respectively.

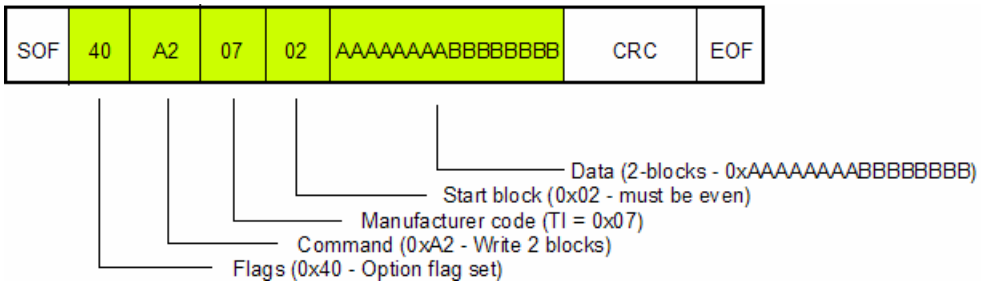

Figure 10. Write 2 Blocks Format

This translates into the following EVM request/responses:

```
>> 01140003041840A20702AAAAAAAABBBBBBBB0000
<< 01140003041840A20702AAAAAAAABBBBBBBB0000
Request mode.
[]
```

5.16.1 **Write 2 Blocks** (Addressed)

This example request tag E00700001258B81E to write 2 blocks starting with block 0x00. the data to be written is 0xEEEEEEEE and 0xFFFFFFFF. The request/responses will be similar to:

```
>> 011C0003041860A2071EB85812000007E000EEEEEEEEFFFFFFFF0000
<< 011C0003041860A2071EB85812000007E000EEEEEEEEFFFFFFFF0000
Request mode.
[]
```

5.17 **Lock 2 Blocks** (0xA3)

This is a custom command to request the tag (not the reader) to lock 2 consecutive blocks. In this example the start block is 0x02. The ISO15693 format is shown in the figure below:

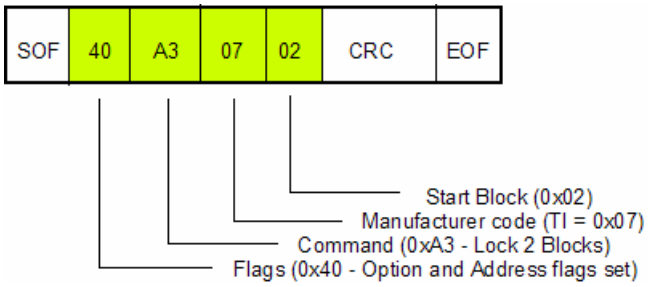

Figure 11. Lock 2 Blocks Format

This translates to the following TRF7960 EVM command:

```
>> 010C0003041840A307020000
<< 010C0003041840A307020000
Request mode.
[]
```

5.17.1 Lock 2 Blocks (Addressed)

This example requests tag 0xE00700001258B81E to lock 2 blocks starting at block 0x00.

```
>> 01140003041860A3071EB85812000007E0000000
<< 01140003041860A3071EB85812000007E0000000
Request mode.
[]
```

5.18 **Kill** (0xA4)

This is a Texas Instruments' HF-I Pro custom command to permanently disable a tag and requires a password to be programmed into page 11 (0x0B) and locked. In this example the password is 0x12345678 and the UID is E007C4A509C247A8. The ISO15693 format is shown in Figure 11

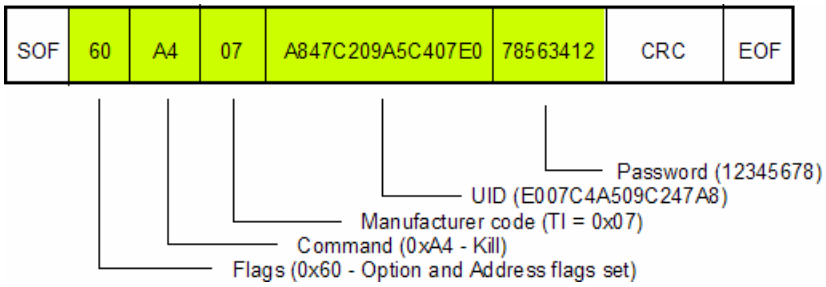

Figure 12. Kill Command Format

This translates into the following EVM request/responses:

```
>> 01170003041863A407A847C209A5C407E0785634120000
<< 01170003041863A407A847C209A5C407E0785634120000
Request mode.
[]
```

5.19 **Write Single Block Password** (0xA5)

This is a Texas Instruments' HF-I Pro custom command to write data to an already locked location. To do this the 32-bit password locked in block 11 (0x0B) must be known, as well as the UID. All data is MSByte first. In the example the address is 0xE007C4A509C2477C, the password is 0x1234567 and the data is 0x77777777. The ISO format is shown in the figure below:

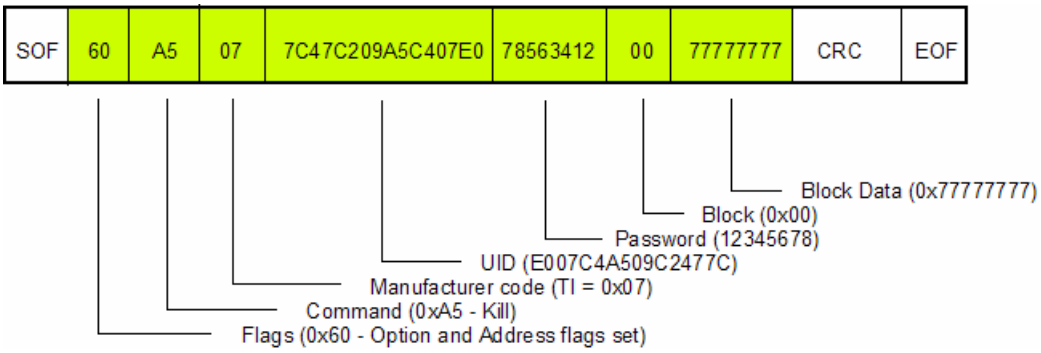

Figure 13. WriteSingleBlockPWD format

This translates into the following EVM request/responses:

```
>> 011C0003041863A5077C47C209A5C407E07856341200777777770000
<< 011C0003041863A5077C47C209A5C407E07856341200777777770000
Request mode.
[]
```

Appendix A

Appendix A - Terms & Abbreviations

A list of the abbreviations and terms used in the various TI manuals can now be found in a separate manual:

TI-RFID Product Manuals – Terms & Abbreviations

Document number 11-03-21-002

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