ISO 15693-Compliant Secure Memory

MAX66140

General Description

The MAX66140 combines 1024 bits of user EEPROM with secure hash algorithm (SHA-1) challenge-and-response authentication (ISO/IEC 10118-3 SHA-1), a 64-bit unique identifier (UID), one 64-bit secret, and a 13.56MHz ISO 15693 RF interface in a single chip. The memory is organized as 16 blocks of 8 bytes plus three more blocks—one for the secret and two for data and control registers. Except for the secret, each block has a user-readable write-cycle counter. Four adjacent user EEPROM blocks form a memory page (pages 0 to 3). The integrated SHA-1 engine provides a Message Authentication Code (MAC) using data from the EEPROM of the device and the 64-bit secret to guarantee secure, symmetric authentication for both reading and writing to the device. Memory protection features are write protection and EPROM emulation, which the user can set for each individual memory page. Page 3 can also be read protected for enhanced authentication strength. The MAX66140 supports all ISO 15693-defined data rates, modulation indices, subcarrier modes, the selected state, application family identifier (AFI), data storage format identifier (DSFID), and the Option_flag bit for read operations. Memory write access (except for AFI, DSFID, and the corresponding lock bytes) is accomplished through custom commands using a write buffer with readback and copy-to-memory function.

Applications

Driver Identification (Fleet Application)

Access Control

eCash

Asset Tracking

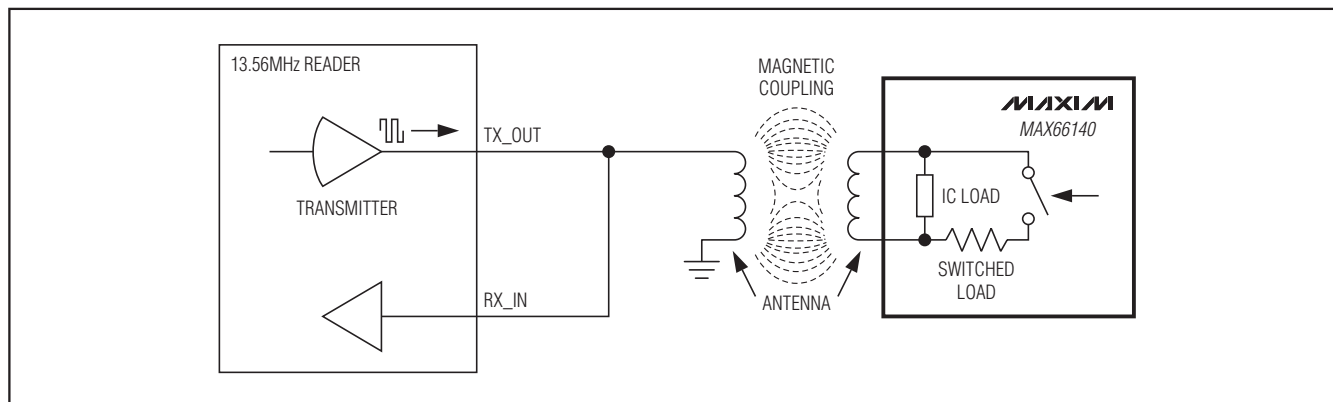*Mechanical Drawings appear at end of data sheet.*

Features

♦ **Fully Compliant with ISO 15693 and ISO 18000-3 Mode 1 Standard**

♦ **13.56MHz ±7kHz Carrier Frequency**

♦ **1024-Bit Secure User EEPROM with Block Lock Feature, Write-Cycle Counter, and Optional EPROM-Emulation Mode**

♦ **64-Bit UID**

♦ **512-Bit SHA-1 Engine to Compute 160-Bit MAC and to Generate Secrets**

♦ **Mutual Authentication: Data Read from Device is Verified and Authenticated by the Host with Knowledge of the 64-Bit Secret**

♦ **Read and Write (64-Bit Block)**

♦ **Supports AFI and DSFID Function**

♦ **10ms Programming Time**

♦ **Write: 10% or 100% ASK Modulation Using 1/4 (26kbps) or 1/256 (1.6kbps) Pulse Position Coding**

♦ **Read: Load Modulation Using Manchester Coding with 423kHz and 484kHz Subcarrier in Low (6.6kbps) or High (26kbps) Data-Rate Mode**

♦ **200,000 Write/Erase Cycles (Minimum)**

♦ **40-Year Data Retention (Minimum)**

♦ **Read Compatible with Existing 1Kb ISO 15693 Products on the Market**

Ordering Information

PART	TEMP RANGE	PIN-PACKAGE
MAX66140E-000AA+	-25°C to +50°C	ISO Card
MAX66140K-000AA+	-25°C to +50°C	Key Fob

+Denotes a lead(Pb)-free/RoHS-compliant package.

Typical Operating Circuit

For pricing, delivery, and ordering information, please contact Maxim Direct at 1-888-629-4642, or visit Maxim's website at www.maxim-ic.com.

MAX66140

ISO 15693-Compliant Secure Memory

ABSOLUTE MAXIMUM RATINGS

Maximum Incident Magnetic Field Strength 141.5dBµA/m
Operating Temperature Range ....-25°C to +50°C

Relative Humidity ....(Water Resistant)
Storage Temperature Range ....-25°C to +50°C

Stresses beyond those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

ELECTRICAL CHARACTERISTICS

(T_A = -25°C to +50°C, unless otherwise noted.) (Note 1)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
SHA-1 ENGINE						
SHA-1 Computation Time	t_{CSHA}	(Note 1)	Refer to the full data sheet.			ms
EEPROM						
Programming Time	t_{PROG}	(Note 1)	9		10	ms
Endurance	N_{CYCLE}	At +25°C (Note 2)	200,000			Cycles
Data Retention	t_{RET}	(Note 3)	40			Years
RF INTERFACE						
Carrier Frequency	f_C	(Notes 4, 5)	13.553	13.560	13.567	MHz
Activation Field Strength (Note 1)	H_{MIN}	At +25°C, MAX66140E		110.5		dBµA/m
		At +25°C, MAX66140K		122.0		
Write Field Strength (Note 1)	H_{WR}	At +25°C, MAX66140E		110.7		dBµA/m
		At +25°C, MAX66140K		122.4		
Maximum Field Strength	H_{MAX}	At +25°C (Note 1)		137.5		dBµA/m
Power-Up Time	t_{POR}	(Notes 1, 6)			1.0	ms

Note 1: Guaranteed by simulation, not production tested.
Note 2: Write-cycle endurance is degraded as T_A increases. Not 100% production tested; guaranteed by reliability monitor sampling.
Note 3: Guaranteed by 100% production test at elevated temperature for a shorter time; equivalence of this production test to data sheet limit at operating temperature range is established by reliability testing.
Note 4: System requirement.
Note 5: Production tested at 13.56MHz only.
Note 6: Measured from the time at which the incident field is present with strength greater than or equal to $H_{(MIN)}$ to the time at which the MAX66140's internal power-on reset signal is deasserted and the device is ready to receive a command frame. Not characterized or production tested; guaranteed by simulation only.

MAXIM

ISO 15693-Compliant Secure Memory

MAX66140

Detailed Description

The MAX66140 combines 1024 bits of user EEPROM, 128 bits of user and control registers, a 64-bit UID, one 64-bit secret, a 512-bit SHA-1 engine, and a 13.56MHz ISO 15693 RF interface in a single chip. The memory is organized as 19 blocks of 8 bytes each. Except for the secret, each block has a user-readable write-cycle counter. Four adjacent user EEPROM blocks form a memory page (pages 0 to 3). Memory protection features include write protection and EPROM emulation, which the user can set for each individual memory page. Page 3 can also be read protected for enhanced authentication strength. The MAX66140 is accessed through ISO 15693-compliant memory and control function commands. The data rate can be as high as 26.69kbps. The MAX66140 supports AFI and DSFID. Applications of the MAX66140 include driver identification (fleet application), access control, electronic cash, and asset tracking.

Overview

Figure 1 shows the relationships between the major control and memory sections of the MAX66140. The device has six main data components: 1) 64-bit UID, 2) 64-bit read/write buffer, 3) four 256-bit pages of user EEPROM, 4) two 8-byte blocks of user and control registers, 5) 64-bit secret's memory, and 6) a 512-bit SHA-1 engine. Figure 2 shows the applicable ISO 15693 commands and their purpose. The network function commands allow the master to identify all slaves in its range and to change their state, e.g., to select one for further communication. The protocol required for these network function commands is described in the *Network Function Commands* section. The memory and control functions access the memory of the MAX66140 for reading and writing. The protocol for these memory and control function commands is described in the *Memory and Control Function Commands* section. All data is read and written least significant bit (LSb) first, starting with the least significant byte (LSB).

Parasite Power

As a wireless device, the MAX66140 is not connected to any power source. It gets the energy for operation from the surrounding RF field, which needs to have a minimum strength as specified in the *Electrical Characteristics* table.

Unique Identification Number (UID)

Each MAX66140 contains a factory-programmed and locked identification number that is 64 bits long (Figure 3). The lower 36 bits are the serial number of the chip. The next 8 bits store the device feature code, which is 03h. Bits 45 to 48 are 0h. The code in bit locations 49 to 56 identifies the chip manufacturer, according to ISO/IEC 7816-6/AM1. This code is 2Bh for Maxim. The code in the upper 8 bits is E0h. The UID is read accessible through the Inventory and Get System Information commands.
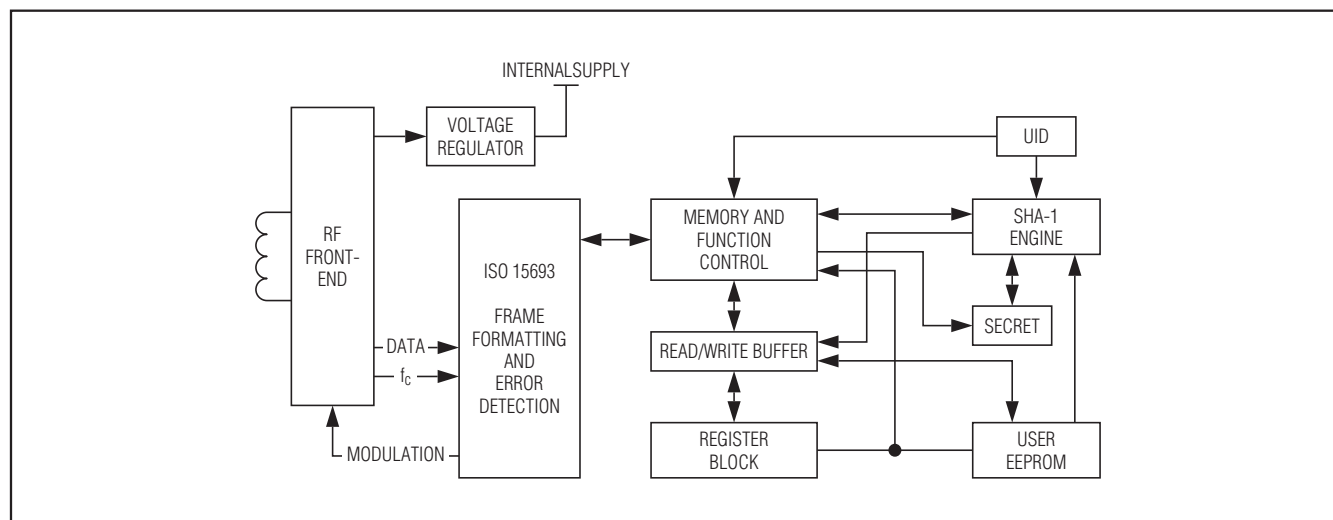

Figure 1. Block Diagram

ISO 15693-Compliant Secure Memory

MAX66140

MAXIM

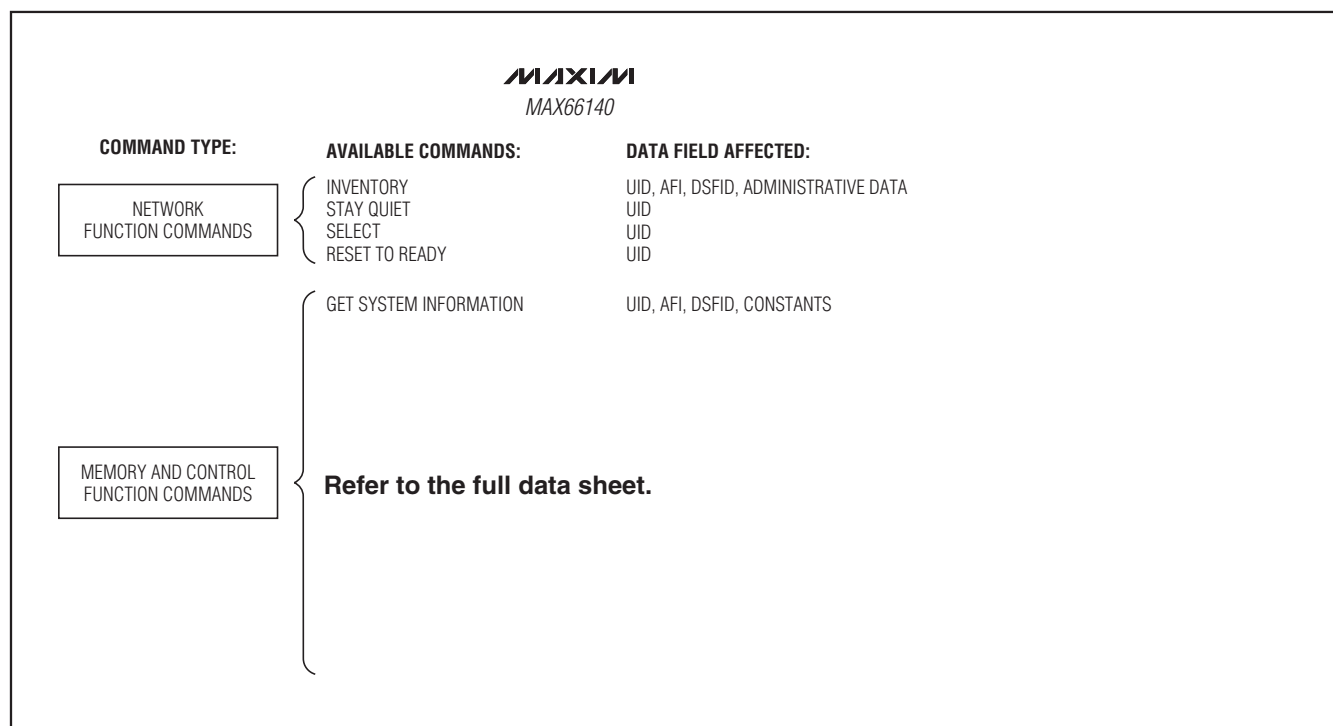*MAX66140*

COMMAND TYPE: **AVAILABLE COMMANDS:**   **DATA FIELD AFFECTED:**

NETWORK
FUNCTION COMMANDS

INVENTORY   UID, AFI, DSFID, ADMINISTRATIVE DATA
STAY QUIET   UID
SELECT   UID
RESET TO READY   UID

GET SYSTEM INFORMATION   UID, AFI, DSFID, CONSTANTS

MEMORY AND CONTROL
FUNCTION COMMANDS

Refer to the full data sheet.

Figure 2. ISO 15693 Commands Overview

MSB				LSB
64 57	56 49	48 45	44 37	36 1
E0h	2Bh	0h	Feature Code (03h)	36-Bit IC Serial Number
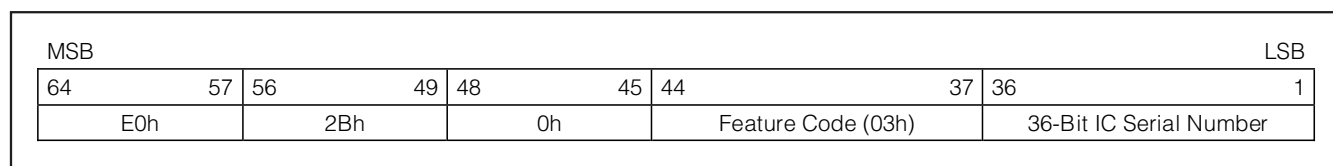
Figure 3. 64-Bit UID

_____Detailed Memory Description

Refer to the full data sheet for this information.

MAXIM

ISO 15693-Compliant Secure Memory

MAX66140

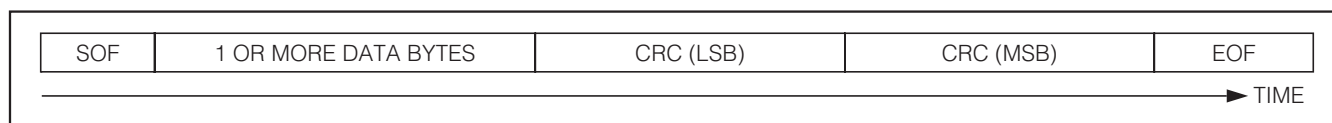| SOF	1 OR MORE DATA BYTES	CRC (LSB)	CRC (MSB)	EOF

TIME

Figure 5. ISO 15693 Frame Format

ISO 15693 Communication Concept

The communication between master and MAX66140 (slave) is based on the exchange of data packets. The master initiates every transaction; only one side (master or slaves) transmits information at any time. Each data packet begins with a start-of-frame (SOF) pattern and ends with an end-of-frame (EOF) pattern. A data packet with at least 3 bytes between SOF and EOF is called a frame (Figure 5). The last 2 bytes of an ISO 15693 frame are an inverted 16-bit CRC of the preceding data generated according to the CRC-16-CCITT polynomial. This CRC is transmitted with the LSB first. For more details on the CRC-16-CCITT, refer to ISO 15693 Part 3, Annex C.

For transmission, the frame information is modulated on a carrier frequency, which in the case of ISO 15693 is 13.56MHz. The subsequent paragraphs are a concise description of the required modulation and coding. For

ISO 15693-Compliant Secure Memory

MAX66140

full details including graphics of the data coding schemes and SOF/EOF timing, refer to ISO 15693-2, Sections 7.2, 7.3, and 8.

The path from **master to slave** uses amplitude modulation (Figure 6); the modulation index can be either in the range of 10% to 30% or 100% (ISO 15693-2, Section 7.1). The standard defines two pulse-position coding schemes that must be supported by a compliant device. Scheme A uses the "1 out of 256" method (Figure 7), where the transmission of 1 byte takes 4.833ms, equivalent to a data rate of 1655 bits/s. The location of a modulation notch during the 4.833ms conveys the value of the byte. Scheme B uses the "1 out of 4" method (Figure 8), where the transmission of 2 bits takes 75.52µs, equivalent to a data rate of 26,484 bits/s. The location of a modulation notch during the

75.52µs conveys the value of the 2 bits. A byte is transmitted as a concatenation of four 2-bit transmissions, with the least significant 2 bits of the byte being transmitted first. The transmission of the SOF pattern takes the same time as transmitting 2 bits in Scheme B. The SOF pattern has two modulation notches, making it distinct from any 2-bit pattern. The position of the second notch tells whether the frame uses the "1 out of 256" or "1 out of 4" coding scheme (Figures 9 and 10, respectively). The transmission of the EOF pattern takes 37.76µs; the EOF is the same for both coding schemes and has one modulation notch (Figure 11).

The path from **slave to master** uses one or two subcarriers, as specified by the Subcarrier_flag bit in the request data packet. The standard defines two data rates for the response, low (approximately 6,600 bits/s) and high (approximately 26,500 bits/s). The Data_rate_flag bit in the request data packet specifies the response data rate. The data rate varies slightly depending on the use of one or two subcarriers. The LSb is transmitted first. A compliant device must support both subcarrier modes and data rates.

In the **single subcarrier** case, the subcarrier frequency is 423.75kHz. One bit is transmitted in 37.76µs (high data rate) or 151µs (low data rate). The modulation is the on/off key. For a logic 0, the subcarrier is on during the first half of the bit transmission time and off for the second half. For a logic 1, the subcarrier is off during the first half of the bit transmission time and on for the second half. See Figure 12 for more details.

In the **two subcarrier** cases, the subcarrier frequencies are 423.75kHz and 484.28kHz. The bit duration is the same as in the single subcarrier case. The modulation is equivalent to binary FM. For a logic 0, the lower subcarrier is on during the first half of the bit transmission time, switching to the higher subcarrier for the second half. For a logic 1, the higher subcarrier is on during the
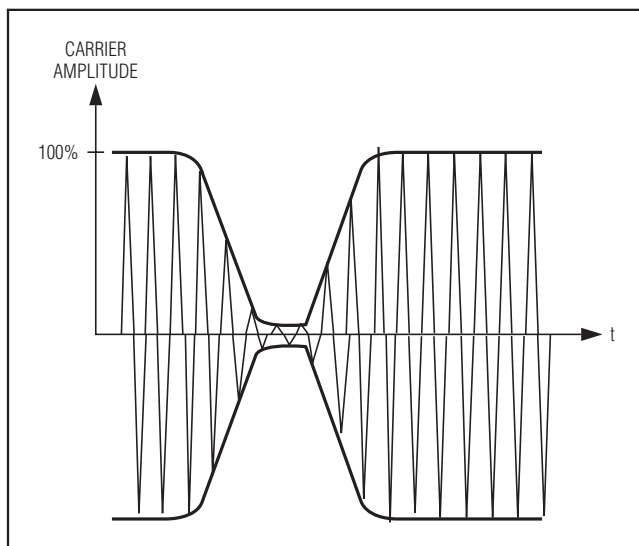

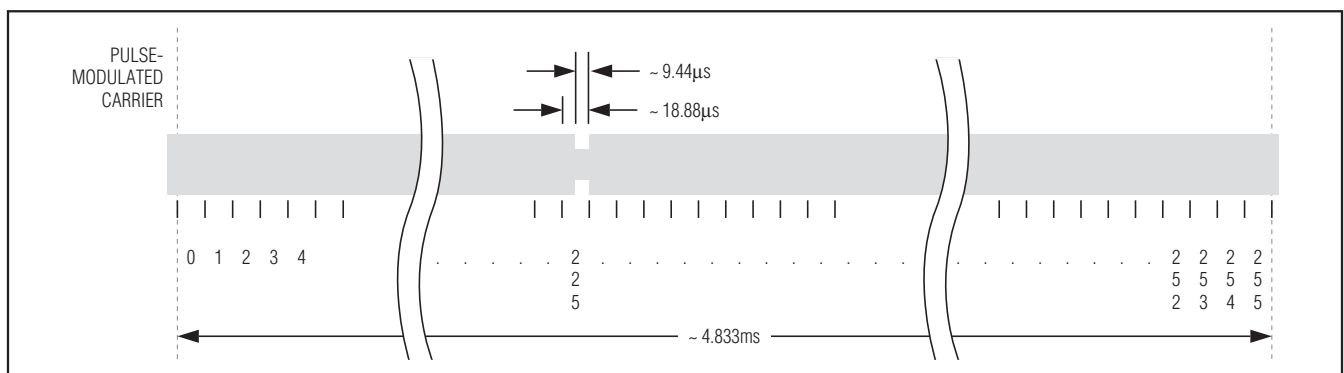Figure 6. Downlink Modulation (e.g., Approximately 100% Amplitude Modulation)

Figure 7. Downlink Data Coding (Case "1 Out of 256")

MAXIM

ISO 15693-Compliant Secure Memory

first half of the bit transmission time, switching to the lower subcarrier for the second half. See Figure 13 for details. The transmission of the SOF pattern takes the same time as transmitting 4 bits (approximately 151µs at a high data rate or approximately 604µs at a low data rate). The SOF is distinct from any 4-bit data sequence. The EOF pattern is equivalent to a SOF being transmitted backwards. The exact duration of the SOF and EOF varies slightly depending on the use of one or two subcarriers (Figures 14 and 15, respectively).

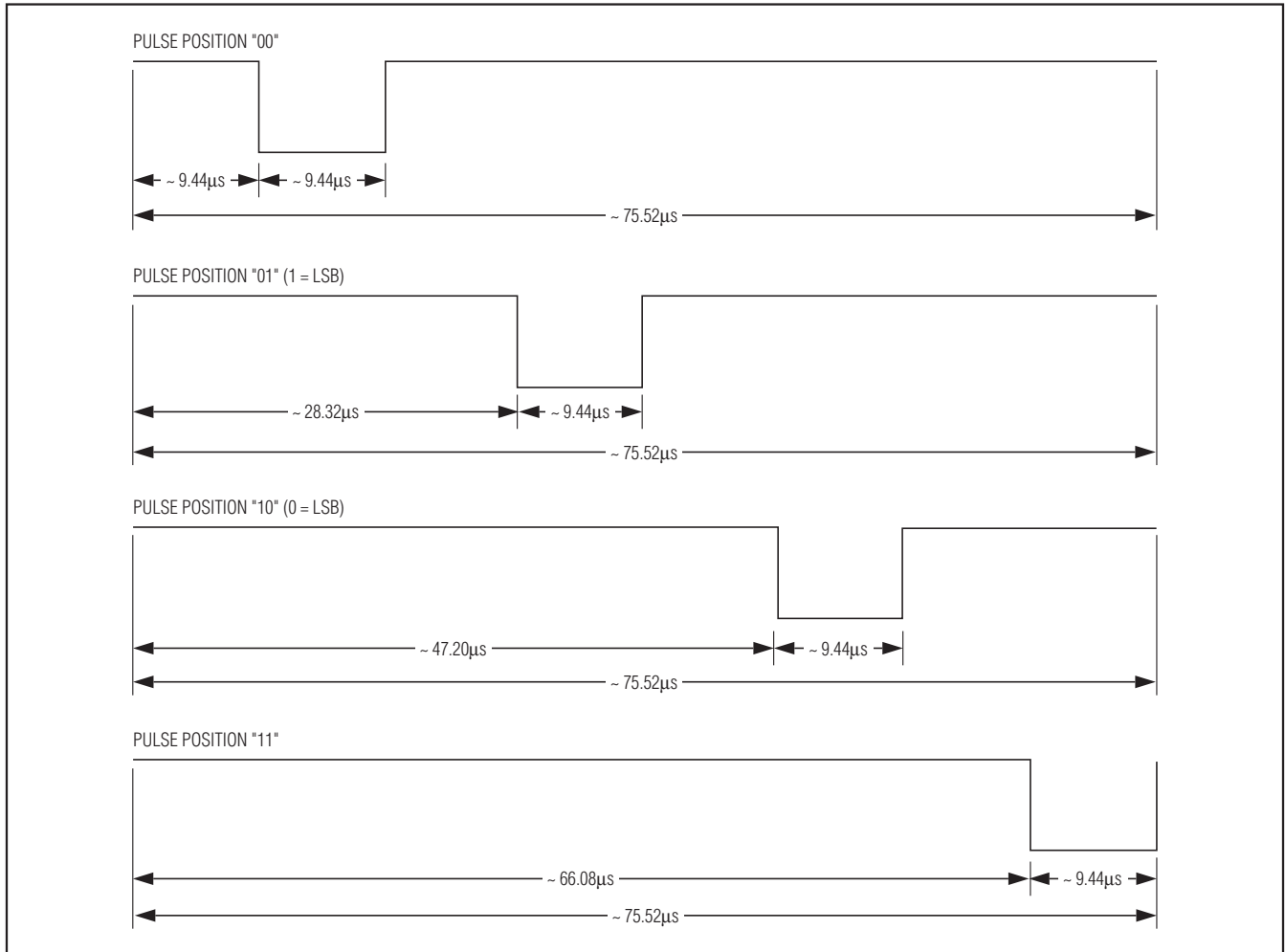PULSE POSITION "00"

~ 9.44µs   ~ 9.44µs   ~ 75.52µs

PULSE POSITION "01" (1 = LSB)

~ 28.32µs   ~ 9.44µs   ~ 75.52µs

PULSE POSITION "10" (0 = LSB)

~ 47.20µs   ~ 9.44µs   ~ 75.52µs

PULSE POSITION "11"

~ 66.08µs   ~ 9.44µs   ~ 75.52µs

Figure 8. Downlink Data Coding (Case "1 Out of 4," Carrier Not Shown)

~ 9.44µs   ~ 37.76µs   ~ 37.76µs   ~ 9.44µs

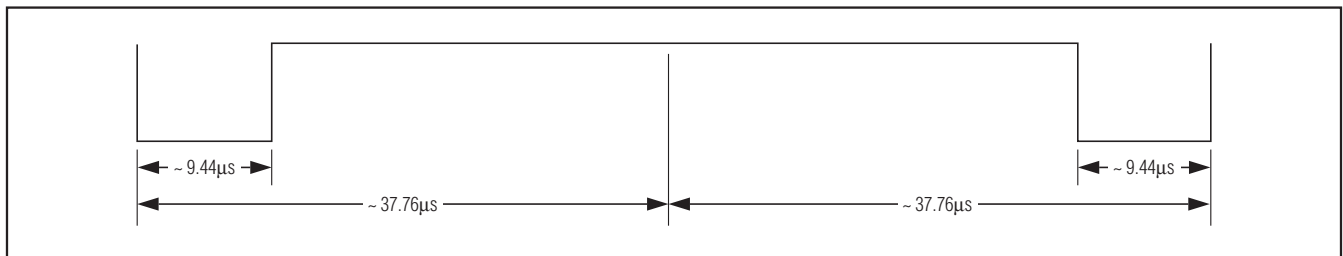*Figure 9. Downlink SOF for "1 Out of 256" Coding (Carrier Not Shown)*

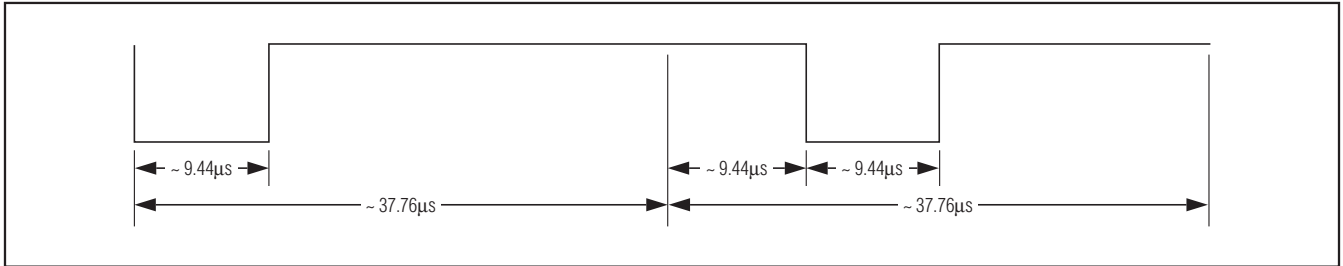# ISO 15693-Compliant Secure Memory

MAX66140

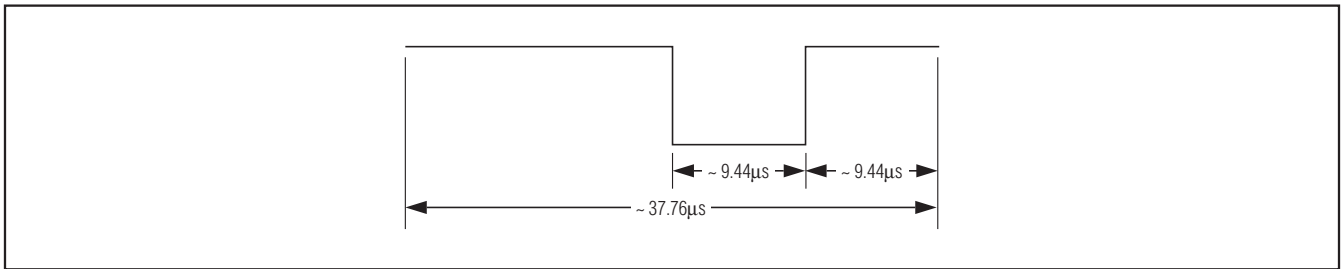Figure 10. Downlink SOF for "1 Out of 4" Coding (Carrier Not Shown)

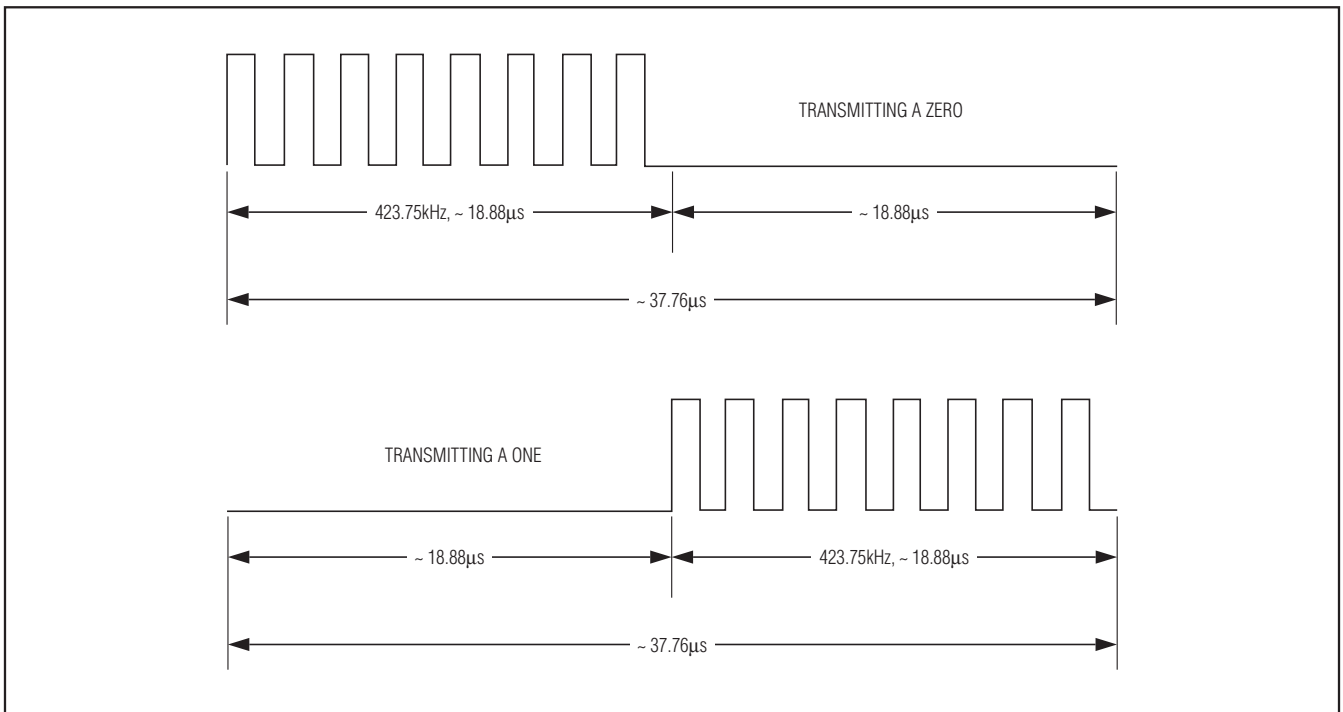Figure 11. Downlink EOF (Identical for Both Coding Schemes, Carrier Not Shown)

Figure 12. Uplink Coding, Single Subcarrier Case (High Data-Rate Timing)

MAXIM

ISO 15693-Compliant Secure Memory
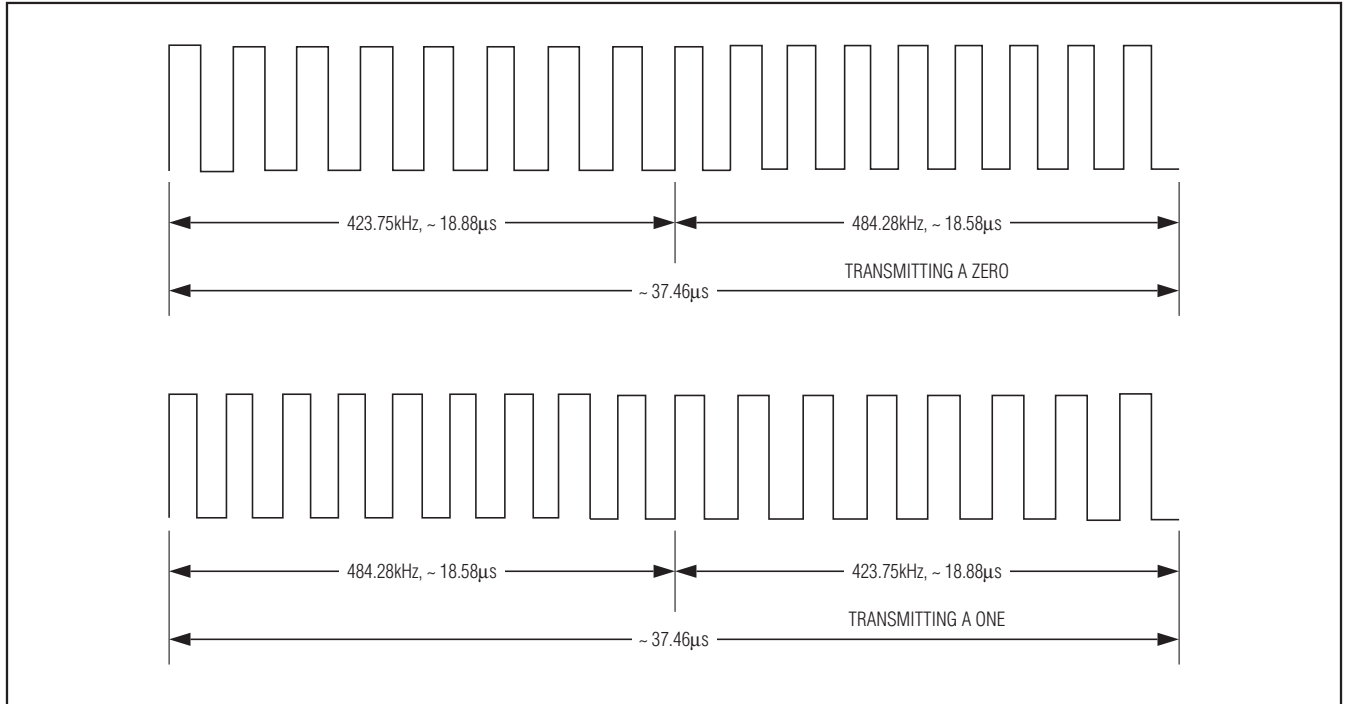
MAX66140

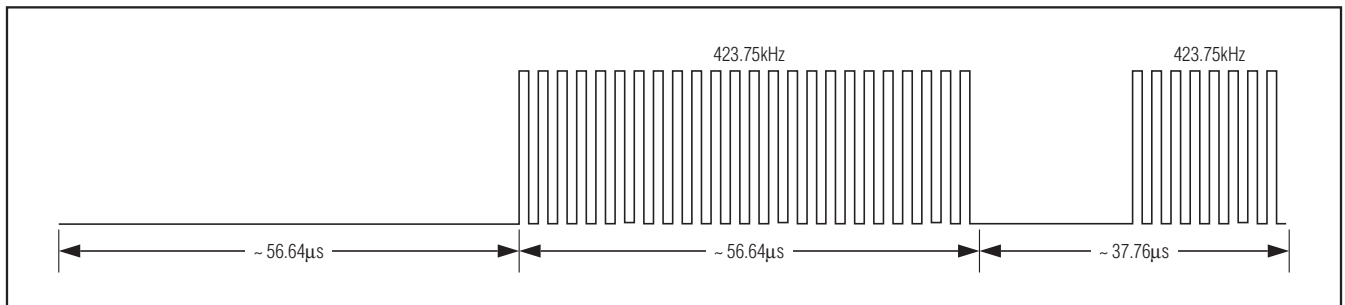Figure 13. Uplink Coding, Two Subcarriers Case (High Data-Rate Timing)

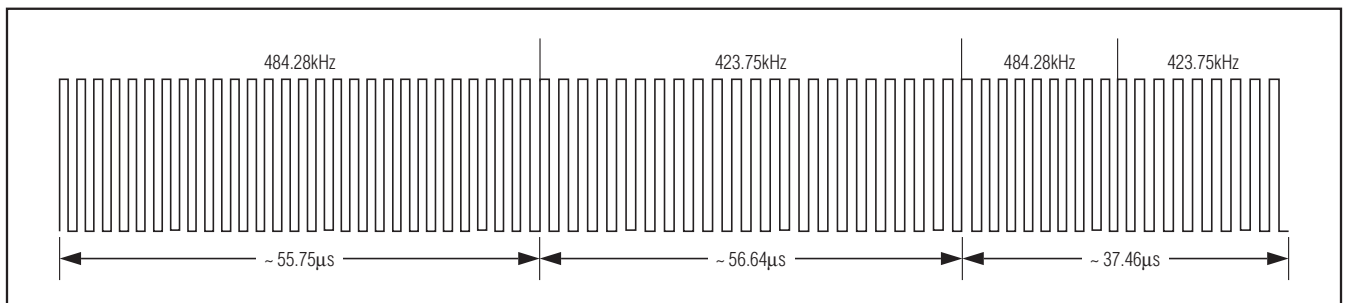Figure 14. Uplink SOF, Single Subcarrier Case (High Data-Rate Timing)

Figure 15. Uplink SOF, Two Subcarriers Case (High Data-Rate Timing)

ISO 15693-Compliant Secure Memory

ISO 15693 Slave States and Address Modes

Initially, the master has no information whether there are any RF devices in the field of its antenna. The master learns the UIDs of the slaves in its field from the responses to the Inventory command, which does not use the Address_flag and the Select_flag bits. The state transitions are controlled by network function commands. Figure 16 shows details.

ISO 15693 defines four states in which a slave can be plus three address modes. The states are power-off, ready, quiet, and selected. The address modes are nonaddressed, addressed, and selected. The addressed mode requires that the master include the slave's UID in the request, which increases the size of the requests by 8 bytes. Table 5 shows which address mode is applicable depending on the slave's state and how to set the Address_flag and the Select_flag bits for each address mode.

ISO 15693 States and Transitions

Power-Off State

This state applies if the slave is outside the master's RF field. A slave transitions to the power-off state when leaving the power-delivering RF field. When entering the RF field, the slave automatically transitions to the ready state.

Ready State

In this state, a slave has enough power to perform any of its functions. The purpose of the ready state is to have the slave population ready to process the inventory command as well as other commands sent in the addressed or nonaddressed mode. A slave can exit the ready state and transition to the quiet or the selected state upon receiving the Stay Quiet or Select command sent in the addressed mode.

Quiet State

In this state, a slave has enough power to perform any of its functions. The purpose of the quiet state is to silence slaves that the master does not want to communicate with. Only commands sent with the addressed mode are accepted and processed. This way the master can use the nonaddressed mode for communication with remaining slaves in the ready state, which minimizes the size of the request data packets. As long as no additional slaves arrive in the RF field, it is safe for the master to continue communicating in the nonaddressed mode. A slave can exit the quiet state and transition to the ready or the selected state upon receiving the Reset to Ready or Select command sent in the addressed mode.

Selected State

In this state, a slave has enough power to perform any of its functions. The purpose of the selected state is to isolate the slave that the master wants to communicate with. Commands are accepted and processed regardless of the address mode in which they are sent, including the Inventory command. With multiple slaves in the RF field, the master can put one slave in the selected state and leave all the others in the ready state. This method requires less communication than using the quiet state to single out the slave for communication. For a slave in the selected state, the master can use the selected mode, which keeps the request data packets as short as with the nonaddressed mode. A new slave entering the RF field cannot disturb the communication, since it stays in the ready state. A slave can exit the

Table 5. Slave States and Applicable Address Modes

SLAVE STATES	ADDRESS MODES		
	NONADDRESSED MODE (Address_flag = 0; Select_flag = 0)	ADDRESSED MODE (Address_flag = 1; Select_flag = 0)	SELECTED MODE (Address_flag = 0; Select_flag = 1)
Power-Off	(Inactive)	(Inactive)	(Inactive)
Ready	Yes	Yes	No
Quiet	No	Yes	No
Selected	Yes	Yes	Yes

МАХIМ

ISO 15693-Compliant Secure Memory

RESPONSE LEGEND:

☐ RESPONSE TO *RESET TO READY*
◇ RESPONSE TO *SELECT*
○ NO RESPONSE

ADDRESS MODE LEGEND:

[N] NONADDRESSED
[A] ADDRESSED
[S] SELECTED

POWER-OFF

OUT OF FIELD | IN FIELD

NOTE 1

READY

OUT OF FIELD

OUT OF FIELD

☐ RESET TO READY [A]
MATCHING UID

SELECT [A]
MATCHING UID

☐ RESET TO READY
[N, A, S]

○ SELECT [A],
NONMATCHING UID

○ STAY QUIET [A]
MATCHING UID

◇

○ STAY QUIET [A] MATCHING UID

QUIET

SELECTED

SELECT [A] MATCHING UID   ◇

NOTE 2

NOTE 3

NOTE 1: THE SLAVE PROCESSES THE INVENTORY COMMAND AND OTHER COMMANDS PROVIDED THAT THEY ARE SENT IN THE [N] OR [A] ADDRESS MODE.
NOTE 2: THE SLAVE PROCESSES ONLY COMMANDS SENT IN THE [A] ADDRESS MODE.
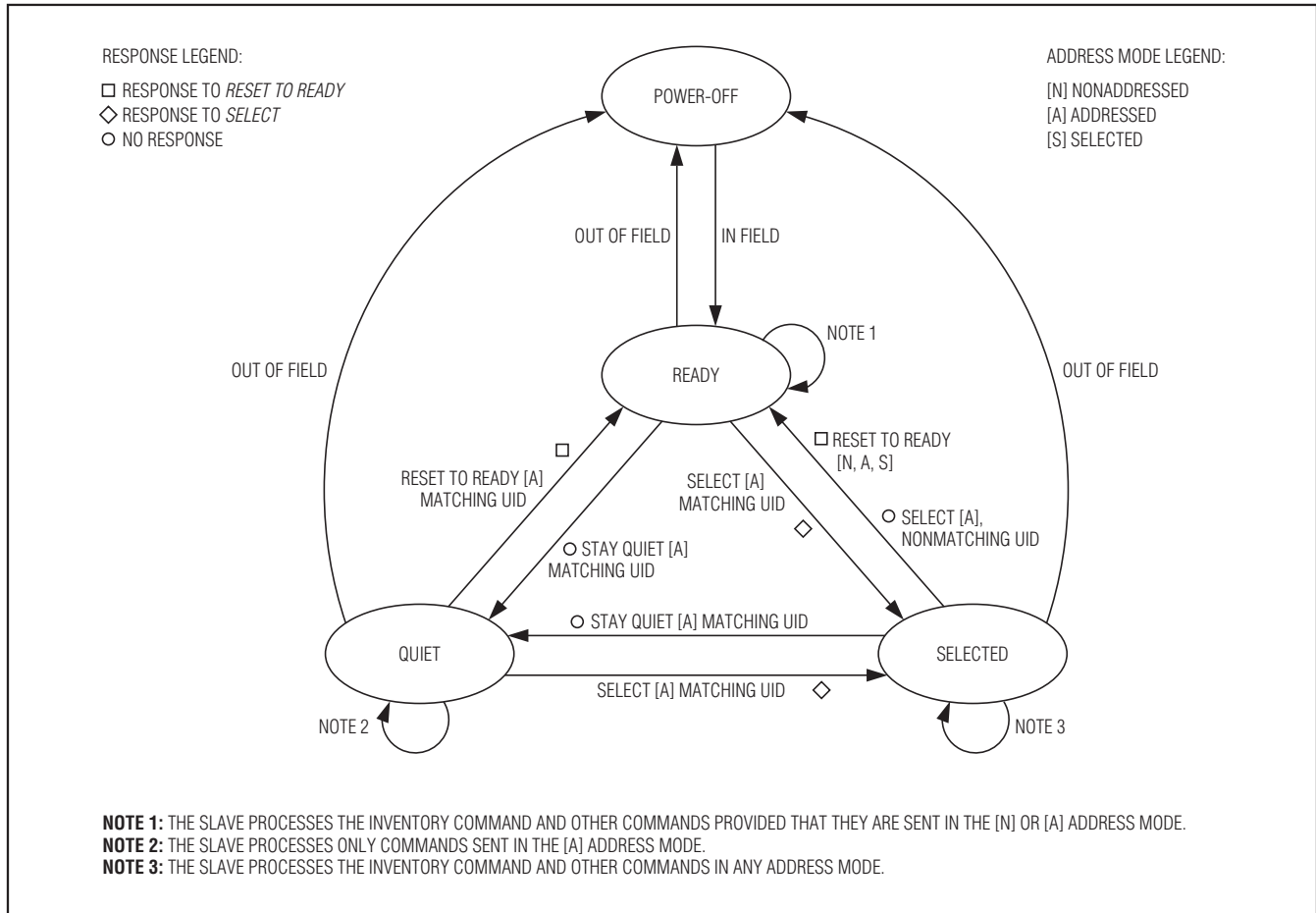**NOTE 3:** THE SLAVE PROCESSES THE INVENTORY COMMAND AND OTHER COMMANDS IN ANY ADDRESS MODE.

Figure 16. ISO 15693 State Transitions Diagram

selected state and transition to the ready or the quiet state upon receiving the Reset to Ready command sent in any address mode or the Stay Quiet command sent in the addressed mode. A slave also transitions from selected to ready upon receiving a Select command if the UID in the request is different from the slave's own UID. In this case the master's intention is to transition

another slave with the matching UID to the selected state. If the slave already in the selected state does not recognize the command, e.g., due to a bit error, two slaves could be in the selected state. To prevent this from happening, the master should use the Reset to Ready or the Stay Quiet command to transition a slave out of the selected state.

ISO 15693-Compliant Secure Memory

MAX66140

Request Flags

The command descriptions on the subsequent pages begin with a byte called request flags. The ISO 15693 standard defines two formats for the request flags byte. The state of the Inventory_flag bit controls the function of the bits in the upper half of the request flag byte. The function of the request flags is as follows:

Request Flags, Inventory_flag Bit Not Set

BIT 8 (MS)	BIT 7	BIT 6	BIT 5	BIT 4	BIT 3	BIT 2	BIT1 (LS)
0	Option_flag	Address_flag	Select_flag	0	Inventory_flag (= 0)	Data_rate_flag	Subcarrier_flag

Bits 8 and 4: No Function

These bits have no function. They must be transmitted as 0.

Bit 7: Options Flag (Option_flag)

This bit is used with block read commands to include the block security status in the response. If not applicable for a command, the Option_flag bit must be 0.

Bit 6: Address Flag (Address_flag)

This bit specifies whether all slaves in the master's field that are in the selected or ready state process the request (bit = 0) or only the single slave whose UID is specified in the request (bit = 1). If the Address_flag bit is 0, the request must not include a UID. The combination of both the Select_flag and Address_flag bits being set (= 1) is not valid.

Bit 5: Select Flag (Select_flag)

This bit specifies whether the request is processed only by the slave in the selected state (bit = 1) or by any slave according to the setting of the Address_flag bit (bit = 0).

Bit 3: Inventory Flag (Inventory_flag)

This bit must be 1 for the Inventory command only. For all other commands, this bit must be 0.

Bit 2: Data Rate Flag (Data_rate_flag)

This bit specifies whether the response data packet is transmitted using the low data rate (bit = 0) or the high data rate (bit = 1).

Bit 1: Subcarrier Flag (Subcarrier_flag)

This bit specifies whether the response data packet is transmitted using a single subcarrier (bit = 0) or two subcarriers (bit = 1).

ABRIDGED DATA SHEET

ISO 15693-Compliant Secure Memory

Request Flags, Inventory_flag Bit Set

BIT 8 (MS)	BIT 7	BIT 6	BIT 5	BIT 4	BIT 3	BIT 2	BIT 1 (LS)
0	0	Nb_slots_flag	AFI_flag	0	Inventory_flag (= 1)	Data_rate_flag	Subcarrier_flag

Bits 8, 7, and 4: No Function

These bits have no function. They must be transmitted as 0.

Bit 6: Slot Counter Flag (Nb_slots_flag)

This bit specifies whether the command is processed using a slot counter (bit = 0) or without using the slot counter (bit = 1).

Bit 5: Application Family Identifier Flag (AFI_flag)

To detect only slaves with a certain AFI value, the AFI_flag bit must be 1 and the desired AFI value must be included in the request. If the least significant nibble of the AFI in the request is 0000b, slaves process the command only if the most significant nibble of the AFI matches. If the AFI in the request is 00h, all slaves process the command regardless of their AFI.

Bit 3: Inventory Flag (Inventory_flag)

This bit must be 1 for the Inventory command only. For all other commands, this bit must be 0.

Bit 2: Data Rate Flag (Data_rate_flag)

This bit specifies whether the response data packet is transmitted using the low data rate (bit = 0) or the high data rate (bit = 1).

Bit 1: Subcarrier Flag (Subcarrier_flag)

This bit specifies whether the response data packet is transmitted using a single subcarrier (bit = 0) or two subcarriers (bit = 1).

Network Function Commands

The command descriptions show the data fields of the request and response data packets. To create the complete frame, an SOF, 16-bit CRC, and EOF must be added (see Figure 5). The ISO 15693 standard defines four network function commands: Inventory, Stay Quiet, Select, and Reset to Ready. This section describes the format of the request and response data packets.

Inventory

This command allows the master to learn the UIDs and DSFIDs of all slaves in its RF field in an iterative process. It is the only command for which the Inventory_flag bit must be 1. The Inventory command uses two command-specific parameters, which are the mask length and the mask pattern. The mask allows the master to preselect slaves for responding to the Inventory command. The LSb of the mask aligns with the LSb of the slave's UID. The master can choose not to use a mask, in which case all slaves qualify, provided they are not excluded by the AFI criteria (see the *Request Flags* section). The maximum mask length is 60 (3Ch, if Nb_slots_flag = 0) or 64 (40h, if Nb_slots_flag = 1). The mask pattern defines the least significant bits (as many as specified by the mask length) that a slave's UID must match to qualify for responding to the Inventory command (case Nb_slots_flag = 1). If the slot counter is used (Nb_slots_flag = 0), the value of the slot counter extends the mask pattern at the higher bits for comparison to the slave's UID. The slot counter starts at 0 after the inventory request frame is transmitted and increments during the course of the Inventory command with every subsequent EOF sent by the master. The processing of an Inventory command ends when the master sends the SOF of a new frame.

MAXIM

ISO 15693-Compliant Secure Memory

MAX66140

Request Data for the Inventory Command

REQUEST FLAGS	COMMAND	AFI (NOTE 1)	MASK LENGTH	MASK PATTERN (NOTE 2)
(1 Byte)	01h	(1 Byte)	(1 Byte)	(Up to 8 Bytes)

Note 1: The AFI byte is transmitted only if the AFI_flag bit is set to 1. The AFI byte, if transmitted, narrows the range of slaves that qualify for responding to the request.

Note 2: The mask pattern is transmitted only if the selection mask length is not 0. If the mask length is not an integer multiple of 8, the MSB of the mask pattern must be padded with 0 bits. The LSB of the mask pattern is transmitted first.

Response Data for the Inventory Command (No Error)

RESPONSE FLAGS	DSFID	UID
00h	(1 Byte)	(8 Bytes)

This response is generated only if a slave qualifies to respond. In case of an error in the request, slaves do not respond.

When receiving the Inventory command, the slave devices in the RF field enter the collision management sequence. If a slave meets the conditions to respond, it sends out a response data packet. If multiple slaves qualify, e.g., AFI, mask, and slot counter are not used, the response frames collide and are not readable. To receive readable response frames with the UID and DSFID, the master must eliminate the collision.

Not knowing the slave population, the master could begin with a mask length of 0 and activate the slot counter. By using this method and going through all 16 slots, the master has a chance to receive clean responses (i.e., the slave is identified) as well as colliding responses. To prevent a slave that has been identified from further participating in the collision management sequence, the master transitions it to the quiet state. Next, the master issues another Inventory command where the slot number that previously generated a collision is now used as a 4-bit mask, and runs again through all 16 slots. If a collision is found, another inventory command is issued, this time with a mask that is extended at the higher bits by the slot counter value that produced the collision. This process is repeated until all slaves are identified. For a full description of the Inventory command processing by the slave device and the timing specifications, refer to ISO 15693 Part 3, Sections 8 to 9.

Stay Quiet

This command addresses an individual slave and transitions it to the quiet state. The request must be sent in the addressed mode (Select_flag bit = 0, Address_flag bit = 1). The slave transitioning to the quiet state does not send a response.

Request Data for the Stay Quiet Command

REQUEST FLAGS	COMMAND	UID
(1 Byte)	02h	(8 Bytes)

Select

This command addresses an individual slave and transitions it to the selected state. The request must be sent in the addressed mode (Select_flag bit = 0, Address_flag bit = 1). The slave transitioning to the selected state sends a response. If there was a slave with a different UID in the selected state, then that slave transitions to the ready state without sending a response.

／VI/IXI/VI

ISO 15693-Compliant Secure Memory

Request Data for the Select Command*

REQUEST FLAGS	COMMAND	UID
(1 Byte)	25h	(8 Bytes)

*If this command is processed without any error, the slave responds with a response flags byte of 00h.

Reset to Ready

This command addresses an individual slave and transitions it to the ready state. To address a slave in the quiet state, the request must be sent in the addressed mode (Select_flag bit = 0, Address_flag bit = 1). To address a slave in the selected state, the request can be sent in any address mode. The slave transitioning to the ready state sends a response.

Request Data for the Reset to Ready Command*

REQUEST FLAGS	COMMAND	UID**
(1 Byte)	26h	(8 Bytes)

*If this command is processed without any error, the slave responds with a response flags byte of 00h.
**The UID is transmitted only in the addressed mode.

Memory and Control Function Commands

The command descriptions show the data fields of the request and response data packets. To create the complete frame, an SOF, 16-bit CRC, and EOF must be added (see Figure 5). ISO 15693 defines three address modes, selected, addressed, and nonaddressed, which are specified through the setting of the Select_flag bit and the Address_flag bit. The memory and control function commands can be issued in any address mode. To access slaves in the quiet state, the addressed mode is required. The addressed mode requires that the master include the slave's UID in the request.

ISO 15693-Compliant Secure Memory

MAX66140

Error Indication

Depending on the complexity of a function, various error conditions can occur. In case of an error, the response to a request begins with a response flags byte 01h followed by one 1-byte error code.

Table 6 shows a matrix of commands and potential errors. If there was no error, the response begins with a response flags byte 00h followed by command-specific data, as specified in the detailed command description.

If the MAX66140 does not recognize a command, it does not generate a response.

Table 6. Error Code Matrix

Refer to the full data sheet for this information.

/N/1/XI/N

ISO 15693-Compliant Secure Memory

MAX66140

Detailed Command Descriptions

In the request data graphics of this section, the UID field is shaded to indicate that the inclusion of the UID depends on the address mode.

Get System Information

This command allows the master to retrieve technical information about the MAX66140. The IC reference code indicates the die revision in hexadecimal format, such as A1h, A2h, B1h, etc.

Request Data for the Get System Information Command

REQUEST FLAGS	COMMAND	UID
(1 Byte)	2Bh	(8 Bytes)

Response Data for the Get System Information Command (No Error)

RESPONSE FLAGS	INFO FLAGS	UID	DSFID	AFI	NUMBER OF BLOCKS	MEMORY BLOCK SIZE	IC REFERENCE
00h	0Fh	(8 Bytes)	(1 Byte)	(1 Byte)	13h	07h	(1 Byte)

For additional command descriptions, refer to the full data sheet.

ISO 15693-Compliant Secure Memory

MAX66140

CRC Generation

The MAX66140 uses two different types of CRCs. One CRC is an 8-bit type. The equivalent polynomial function of this CRC is $X^8 + X^5 + X^4 + 1$.

The other CRC is a 16-bit type, generated according to the CRC-16-CCITT polynomial function (see Figure 18) $X^{16} + X^{12} + X^5 + 1$. This CRC is used for error detection in request and response data packets and is always communicated in the inverted form. After all data bytes are shifted into the CRC generator, the state of the 16 flip-flops is parallel-copied to a shift register and shifted out for transmission with the LSb first. For more details on this CRC, refer to ISO/IEC 15693-3, Annex C.

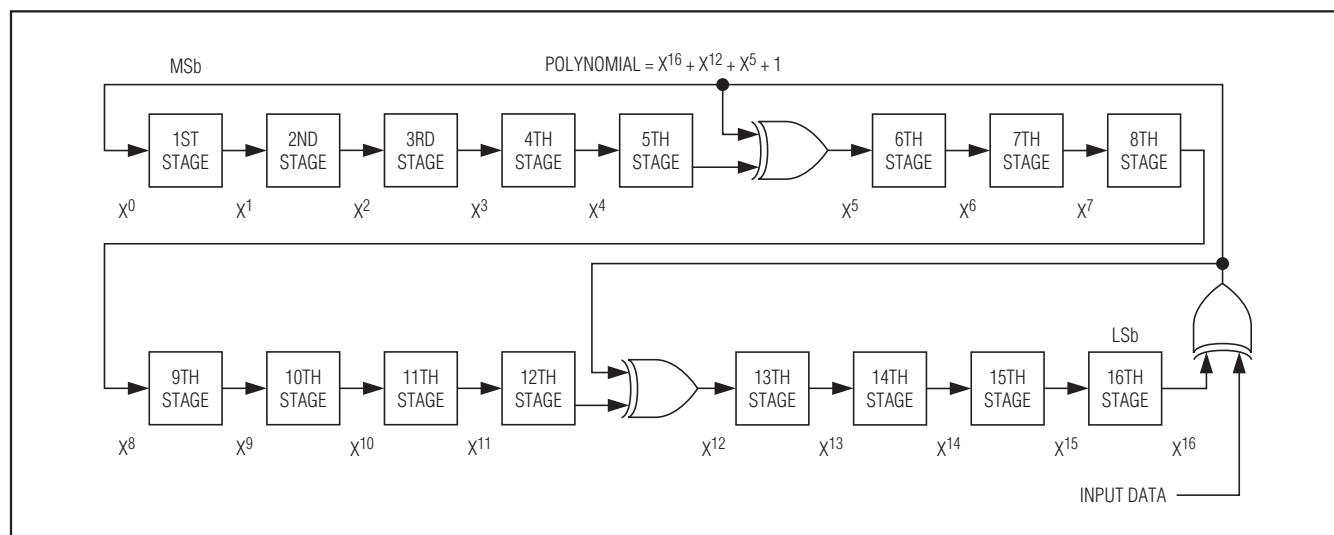# ISO 15693-Compliant Secure Memory
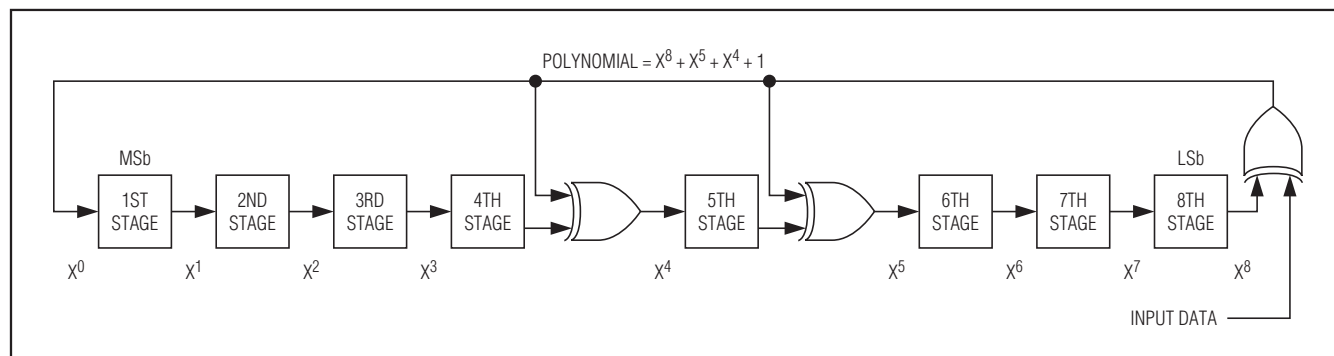
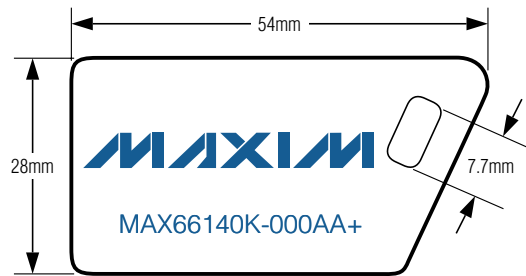Figure 17. 8-Bit CRC Generator

Figure 18. CRC-16-CCITT Generator

ISO 15693-Compliant Secure Memory

MAX66140

TOP VIEW

54mm

28mm

MAXIM

MAX66140K-000AA+

7.7mm

SIDE VIEW

1.6mm

KEY FOB

TOP VIEW

85.60mm

3.49mm

14.29mm

53.98mm

MAX66140E-000AA+

SIDE VIEW

0.76mm

ISO CARD

MAXIM
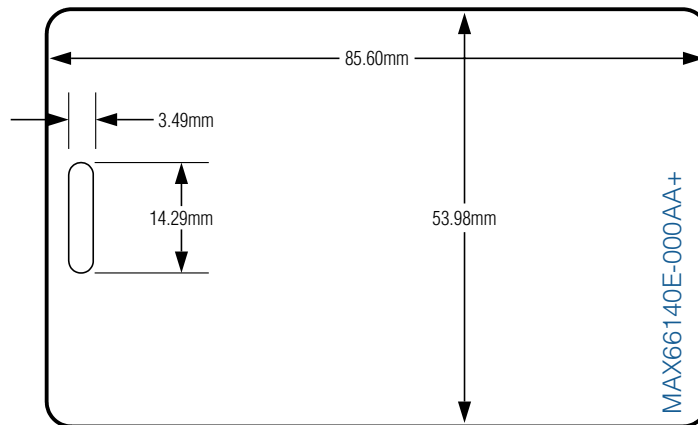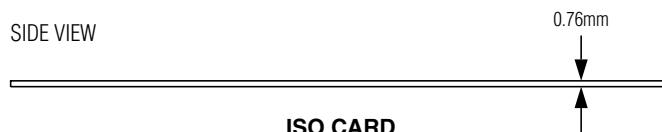
ABRIDGED DATA SHEET

ISO 15693-Compliant Secure Memory

REVISION NUMBER	REVISION DATE	DESCRIPTION	PAGES CHANGED
0	4/10	Initial release	—
1	1/11	Added ISO card option to the _Ordering Information_ and _Mechanical Drawings_	1, 2, 3, 36

MAX66140

**Maxim Integrated Products, 120 San Gabriel Drive, Sunnyvale, CA 94086 408-737-7600** _____ **37**