ThingMagic

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Mercury® 6e - Transcore Developer’s Guide

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Introduction to the Mercury6e-Transcore Module

The ThingMagic® Mercury®6e embedded module is an RFID engine that you can integrate with other systems to create RFID-enabled products which support the custom Transcore tag protocols: eGo, SeGo, ATA and Allegro/Title-21.

The *Arbser* utility provides an easy to use command line interface to configure the reader, read from and write tags, and demonstrate the modules capabilities. *ArbSer* can issue the Command Set that is detailed in this document in thier hex format. For information about the *ArbSer* application, see Appendix B: Using the ArbSer Application.

This document is for developers and explains how to incorporate the Mercury6e-Transcore (M6e-TC) into a third-party host system.

Hardware Overview

The M6e-TC module is based on the Mercury5e (M5e) embedded module, designed to be incorporated into products requiring powerful RFID capabilities in a small form factor.

The following table shows the basic features of the M6e-TC hardware:

Features of the M6e-TC Hardware

Item	M6e-TC
Processor	Atmel AT91SAM7SE-256
Flash memory	256 kB
On-chip RAM	32 kB
RF Architecture	ASIC Intel R2000 with ThingMagic front end for improved sensitivity
Input Power Requirements	+5VDC
Communication Interfaces	• High-speed serial interface • USB with auto-detect
Protocols supported	eGo, SeGo, ATA, Allegro/Title-21, Gen2
Dimensions: (L x D x H)	78 x 63 x 8 mm
Regions supported	NA, OPEN

The M6e-TC is a single board modules designed for more space-constrained applications. The digital and analog electronics are on the same circuit board.

Microcontroller

The M6e-TC uses the Atmel ARM7 microcontroller with 256 kB of on-chip flash memory for storage of all calibration and program data.

RFID ASIC

All base-band analog circuitry and PLL circuitry are contained within the Intel R2000 RFID ASIC with ThingMagic front end for improved sensitivity.

Connectors

The M6e-TC supports one MMCX connectors for a single monostatic antenna.

M6e-TC Digital Connectors

The digital connector provides power, serial communications signals, and access to the GPIO inputs and outputs. The communications interface for the M6e-TC is a 14-pin digital connector. This connector provides power, serial communications signals, including USB support, and access to the GPIO inputs and outputs. See the following table:

Pin-out of 14-pin Digital Communications Connector

Pin #	Signal
1	GND
2	GND
3	GND
4	+5V
5	+5V
6	USB_+5V (Input to M6e-TC)
7	Digital Output 1
8	Digital Output 2
9	Digital Input 1
10	Digital Input 2
11	RS-232 RX TTL from host
12	RS-232 TX TTL to host
13	USB_DM
14	USB_DP

Firmware Overview

The software (SW) for the M6e-TC consists of two separate programs that coexist in flash memory:

- The boot loader, which is started at power on, is not field upgradable. It is programmed into flash when the module is manufactured.

- The application firmware, which implements the actual reader functionality, is field upgradable.

Boot Loader

The boot loader provides low-level functionality. This program provides a customer interface for upgrading the application firmware and storing data into flash.

When a module is powered up or reset, the boot loader code is automatically copied from sector 0 of flash into the Microprocessor’s on-chip RAM, and executed. The boot loader provides the following features:

- Ability to read / write / erase flash memory
- Upgrade application FW
- Change serial baud rate
- Verify image CRC

Application Firmware

The application firmware (FW) is an important software component of the module. It contains the protocol code as well as all the user interfaces to set and get various system parameters. The application FW is started using the **Boot Firmware** command in the boot loader; it does not start by itself upon power up.

Note

You can use the Arbser utility to upgrade the reader firmware.

Verifying Application FW Image CRC

The application FW has an image level Cyclic Redundancy Check (CRC) embedded in it to protect against corrupted firmware during an upgrade process. (If the upgrade is unsuccessful, the CRC will not match the contents in flash.) When the boot loader starts the application FW, it first verifies that the image CRC is correct. If this check fails, then the boot loader does not start the application FW.

The upgrade process uses a series of individual 250-byte packet write operations to ensure that an upgrade is successfully completed for the complete image. It also ensures that the application FW in flash was not corrupted accidently, and can be expected to perform properly when executed.

Functionality of the Embedded Modules

This section highlights some of the functionality of the modules. The details for using the serial commands to control this functionality are found in Overview of the Communication Protocol.

Regional Support

The modules have differing levels of support for operation and use under the laws and guidelines of several regions.

Note

A region must be set before the module will perform any RF operations.

The regional support is shown in the following table.

Supported Regions

Region	Regulatory Support	M6e-TC
North America (NA)	FCC 47 CFG Ch. 1 Part 15 Industrie Canada RSS-210	Yes
Open Region	No regulatory compliance enforced	Yes

The regional functionality is set using a single serial command, Set Configuration Commands. Setting the Region configures the regional default settings including:

- Loads the Frequency Hop Table with the appropriate table for the selected region.
- Sets the PLL frequency to the first entry in the hop table, even if the RF is off.
- Selects the transmit filter, if applicable.

Note

The Open Region allows the module to be manually configured within the full capabilities supported by the hardware. No regulatory limits, including: frequency range, channel spacing and transmit power limits, are enforced. The Open Region should be used with caution.

Frequency Setting

The modules have a PLL synthesizer that sets the modulation frequency to the desired value. Whenever the frequency is changed, the module must first power off the modulation, change the frequency, and then turn on the modulation again. Since this can take several milliseconds, it is possible that tags are powered off during a frequency hop. In addition to setting the default regional settings, the modules have commands that allow the transmit frequency to be set manually.

C A U T I O N !

Use these commands with extreme caution. It is possible to change the module's compliance with the regional regulations.

Frequency Units

All frequencies in the Mercury embedded products are expressed in kHz using unsigned 32-bit integers. For instance, a carrier frequency of 915 MHz is expressed as 915000 kHz.

The PLL is set automatically to the closest frequency - based on the minimum frequency quantization for the current region - that matches the specified value. The Mercury embedded modules have an absolute minimum quantization of 50 kHz. Each region also has a minimum quantization based on regulatory specifications, which may be greater. The following table details the frequency quantization in kHz for each region setting.

Regional Frequency Quantization

Region	Frequency Quantization	Minimum Frequency	Maximum Frequency
NA	250 kHz	902,000 kHz	928,000 kHz
Open	50 kHz	860,000 kHz	930,000 kHz

When manually setting frequencies the module will round down for any value that is not an even multiple of the supported frequency quantization.

For example: In the NA region, setting a frequency of 902,999 kHz results in a setting of 902,750 kHz.

When setting the frequency of the module, any frequencies outside of the valid range for the specified region are rejected.

Frequency Hop Table

The frequency hop table determines the frequencies used by the modules when transmitting. The hop table characteristics are:

- Contains up to 62 slots.
- Valid frequencies for the region currently selected.
- Changes not stored in flash, thus changes made are not retained after a power cycle or a restart of the boot loader.
- Inability to change individual entries after uploading without reloading the entire table.
- Frequencies used in the order of entries in the table.

If necessary for a region, the hop table can be randomized to create a pseudo-random sequence of frequencies to use. This is done automatically using the default hop tables provided for each region.

Frequency Hop Interval

When hopping frequencies the period of time the module will stay on an individual frequency is defined by the Hop Interval. This value is based on the region's regulatory requirements and indicates the maximum time the reader will stay on a frequency which maybe lower than that allowed by the regulatory requirements.The supported regions and their maximum hop interval is defined in the following table:

Maximum Frequency Hop Interval

Region	Max Hop Interval
NA	200 ms
Open	400 ms

RF Power Setting

The power setting is calibrated at the factory and parameters are stored in flash memory to ensure the power output is within +/– 1 dB of the desired setting. The power limits are set by both hardware limitations and enforced by the firmware.

Power Units

All power values are reported in centi-dBm. Therefore, a power setting of 2500 corresponds to 25 dBm. All power values in the serial interface are specified as signed 16-bit integers. A dBm means power referenced to 1mW. Therefore, the conversion from watts to dBm is:

$$\text{dBm} = 10 \log_{10}(\text{power in mW})$$

For example: 0.1W = 100mW = 20dBm and 1W = 1000mW = 30dBm.

Power Calibration

A power calibration event occurs when the Power set point is changed, the Frequency is changed, or the RF field is turned on. The power calibration routine calibrates the power within 10 ms.

Note

Power calibration only occurs once when the RF power is turned on. It does not occur periodically when the RF field is on.

This is not an issue during normal operation,= since a frequency hop occurs within the regulatory hop interval (see Maximum Frequency Hop Interval for region specific values) and thermal drift does not affect the power level significantly. However, in CW waveform mode (**Transmit CW Signal**), no power calibration occurs unless the power or frequency is changed. Thus, it is possible to experience thermal drift in this usage if the unit is left to transmit continuously for a significant period of time.

TX Read Power

The TX read power is used for all non-write commands to tags. This may include, but is not limited to, commands to read a tag ID and read tag data.

TX Write Power

The TX write power is used only during commands that change a tag’s state. This includes commands for **Lock**, **Kill**, as well as **Tag ID Write** and **Tag Data Write**.

Note

During Write commands, which both write to and verify the written contents, the entire operation will be done at the Tx Write Power, including tag singulation and the write verify.

Antenna Ports

Monostatic Mode

The M6e-TC has one antenna port which both transmits and receives.

To set up the module to use a single antenna in monostatic mode, connect the antenna to port 1 (labeled J1 on Printed Circuit Board) which is responsible for both TX and RX communication.

Power Management

The modules use different methods and levels of power management.

Power Modes

The M6e-TC was designed for power efficiency and offers several different power management modes, set using Set Power Mode (98h). The following lists the current modes being offered:

- *Full Power Mode* – In this mode, the unit operates at full power to attain the best performance possible. This mode is only intended for use in cases where power consumption is not an issue. This is the default Power Mode at startup.
- *Minimal Saving Mode* – This automatically executes basic power savings that do not severely degrade system performance May result in a nominal 1 ms additional delay.
- *Medium Saving Mode* – This mode may add up to 50 ms of delay between commands. It performs more aggressive power savings, such as automatically

shutting down the analog section between serial commands, and then restarting it whenever a tag command is issued.

- *Maximum Saving Mode* – This mode essentially shuts down the digital and analog boards, except to power the bare minimum logic required to wake the processor. It can take up to 150 ms to wake the processor and execute the desired command.

Note: In *Maximum Saving Mode* the USB interface is disabled and the RS232 interface communication speed is limited to 9600 baud.

Tag Buffer

The Tag buffer stores tags, and their metadata, found using the **Read Tag Multiple** command. The size of the tag buffer for each module is defined in the following table:

Tag Buffer Size

	M6e-TC
Tag Buffer Size in Tag ID entries	190

Each tag entry consists of a fixed number of bytes. The size depends on the value set for the Max EPC Length parameter in Set Reader Configuration(9Ah). Each entry consists of the following fields:

Tag Buffer Entry

Total Entry Size	Field	Size	Description
18 bytes (Max EPC Length = 96bits)	EPC Length	2 bytes	Indicates the actual EPC length of the tag read. Cannot exceed the Max EPC length setting.
	PC Word	2 bytes	Contains the Protocol Control bits for the tag.
	EPC	12 bytes	Contains the tag's EPC value padded with trailing zeros if the size is less than the Max EPC Length size.
	Tag CRC	2 bytes	The tag's CRC.
68 bytes (Max EPC Length = 496bits)	EPC Length	2 bytes	Indicates the actual EPC length of the tag read. Cannot exceed the Max EPC length setting. Varies by Protocol: • **Gen2** = PCWord + EPC ID + CRC • **Other** = EPC ID + CRC
	PC Word	2 bytes	Contains the Protocol Control bits for the tag.
	EPC	62 bytes	Contains the tag's EPC value padded with trailing zeros if the size is less than the Max EPC Length size.
	Tag CRC	2 bytes	The tag's CRC.

In addition to the tag EPC data each entry contains meta data about how, where and when the tag was read. When using the Get Tag Buffer (29h) command you can choose to get the following tag meta data returned with each tag extracted from the tag buffer:

Tag Read Meta Data

Meta Data Field	Description
Antenna ID	The antenna on with the tag was read.
Read Count	The number of times the tag was read on [Antenna ID].
Timestamp	The time the tag was read, relative to the time the command to read was issued, in milliseconds. If the Tag Read Meta Data is not retrieved from the Tag Buffer between read commands there will be no way to distinguish order of tags read with different read command invocations.
Frequency	The frequency on which the tag was read
RFU	Reserved for Future Use - ThingMagic Only
LQI/RSSI	The receive signal strength of the tag response.
Protocol ID	The tag's Protocol ID as defined by the Tag Protocol IDs table

Whenever a Tag entry is placed in the buffer, it uses up a single entry with the EPC section containing the *maximum EPC length* number of bits, regardless of the actual EPC size of the tag read. The extra bits in the entry are padded with trailing zeros.

After the **Multi-Protocol Tag Read** command finishes, it places all of the found tags into the Tag buffer, and then returns the number of tags found to the user. Only unique tags read on each antenna are added to the Tag buffer; none of the entries show repeated Tag EPCs. Repeated reads on an antenna will cause the Read Count field to be incremented for that tag entry. Multiple **Get Tag Buffer** commands must be sent to read out the Tags. The Tag buffer acts as a First In First Out (FIFO) — the first Tag found by the reader is the first one to be read out. See Get Tag Buffer (29h).

The Tag buffer is reset only when the **Clear Tag Buffer** command is sent. See Clear Tag Buffer (2Ah). This allows multiple **Multi-Protocol Tag Read** commands to be used to acquire one consistent tag buffer set.

Flash Memory

The M6e-TC has on-board flash memory. This flash is divided into four different sectors of varying sizes. Table 4 shows the memory map for the M6e-TC. Only sector 0x03 is set aside for user data and the other sectors are used by the application FW. The flash sector utilities simplify the interface providing a means to develop interfaces that work across these platforms.

Flash Memory Sector Mapping

Sector	Access	Code	M6e-TC Start Address	M6e-TC Size (bytes)	Erase Password	Write Password
BootLoader	Read Only	0x01	0x000000	16 kB	na	na
Application	Read/Write	0x02	0x00C000	208 kB	0x08959121	0x02254410
User Memory	Read/Write	0x03	0x008000	16 kB	0x79138766	0x76346700
Hardware Info	Read Only	0x04	0x004000	16 kB	na	na
Application Data (RAM)			0x200000	32 kB		

Accessing the Flash

The flash is accessed only through the boot loader program. Flash is not accessible while the application FW is running.

All accesses to flash are in terms of two-byte word addresses and word lengths. Thus, the **Write Flash Sector**, **Read Flash Sector**, **Erase Flash Sector**, and **Modify Flash Sector** commands all use the same argument types. The maximum amount of flash that can be written or modified at a single time is 125 words, and the maximum amount of flash that can be read at a single time is 124 words. This is a limitation of the serial interface and data packet sizes. Multiple data packets are used to read/write/modify a larger area of flash.

When using the **Erase Flash Sector** or **Write Flash Sector** commands, the correct password must be provided to complete the operation. This is done to protect against accidentally erasing or writing to the flash. See Boot Loader Commands.

Upgrading Application FW

The application FW is upgraded in flash. New versions of firmware are released in a .sim binary file format . The .sim binary file format is a compressed file format that stores the data in raw binary.

Serial and USB Interfaces

The M6e-TC module can communicate to a host processor via the TTL logic level RS-232 serial protocol or via Universal Serial Bus (USB) protocol, both accessed on the 14-pin M6e-TC Digital Connectors.

The module does not need to be software configured to operate on one or the other interface, just send data over the interface to use it. However, the following considerations should be made when using one or both interfaces:

- Once a command is initiated on one interface, the entire synchronous operation (full command and response) must be completed on that interface. Upon completion of an operation a new command can be sent on either interface.
- If both interfaces are to be used the user is responsible for maintaining order of execution. If commands are sent on both interfaces simultaneously execution order cannot be guaranteed.
- When setting the baud rate via Set Baud Rate (06h) this changes the communication speed on the RS232 Interface only, whether set using the RS232 interface or USB. The USB speed is not changed. USB communication speed is dictated by the USB protocol and has a maximum bitrate of 12Mbps.
- When configuring Power Modes, using Maximum Saving Mode (0x03) will shut off the USB interface. If Set Power Mode (98h) is called using the USB interface and mode 0x03 is specified the module will instead be set to Medium Saving Mode (0x02). In order to set the module to mode 0x03 the command must be called using the RS232 interface.
- Power consumption will increase by 1 to 2 milliamps when the USB interface is connected.
- A level converter could be necessary to interface to other devices that use standard 12V RS-232.
- Only three pins are required for RS232 communication (TX, RX, and GND). Hardware handshaking is not supported.
- The interfaces use an interrupt-driven FIFO that empties into a circular buffer.
- The developer is responsible for ensuring that the host processor’s RS232 receiver has the capability to receive up to 256 bytes of data at a time without overflowing.

Installing the USB Driver

Windows

When connecting to the M6e-TC through the USB interface from a Windows PC a few installation steps are required for Windows to recognize the M6e-TC and properly configure the communications protocol. In order to use the USB interface with Windows you must have the *m6etc.inf* file. The installation steps are:

1. Plug in the USB cable to the M6e-TC (devkit) and PC.
2. Windows should report is has “Found New Hardware - M6e-TC Serial” and open the Hardware Installation Wizard.
3. Select the *Install from a list or specific location (Advanced)* option, click *Next*.
4. Select *Don’t search*..., click *Next,* then *Next* again.
5. Click *Have Disk* and navigate to where the *m6etc.inf* file is stored and select it, click *Open,* then *OK*.
6. “Mercury6eTC” should now be shown under the *Model* list. Select it and click *Next* then *Finished*.

Note

The M6e-TC driver file has not been Microsoft certified so compatibility warnings will be displayed. These can be ignored and clicked through.

7. A COM port should now be assigned to the M6e-TC. If you aren’t sure what COM port is assigned you can find it using the Windows Device Manager:
   a. Open the *Device Manager* (located in *Control Panel* | *System*).
   b. Select the *Hardware* tab and click *Device Manager*.
   c. Select *View* | *Devices by Type* | *Ports (COM & LPT)*
      The device appears as **Mercury6eTC (COM#)**.

General Purpose Inputs/Outputs (GPIO)

The M6e-TC modules has four TTL level signals, two 3.3/5V serial input sensor ports (GPIO inputs) and two output indicator ports (GPIO outputs) of up to 24 mA, available on the 14-pin digital connector. These can be controlled via the **Get User GPIO Inputs** and **Set User GPIO Outputs** commands.

For further information, see Get User GPIO Inputs (66h) and Set User GPIO Outputs (96h).

Default Settings

Since default settings may change across release and be different across platforms we recommend using the Get Configuration Commands to obtain default settings.

None of the configurable settings in the application FW are saved in non-volatile memory. Thus the system will always boot up in the same default state, regardless of how it was previously configured.

Overview of the Communication Protocol

The serial communication between a computer (host) and the reader is based on a synchronized command-response/master-slave mechanism. Whenever the host sends a message to the reader, it cannot send another message until after it receives a response. The reader never initiates a communication session; only the host initiates a communication session.

This protocol allows for each command to have its own timeout because some commands require more time to execute than others. The host manages retries, if necessary. The host keeps track of the state of the intended reader if it reissues a command.

Host-to-Reader Communication

Host-to-reader communication is packetized according to the following diagram. The reader can only accept one command at a time, and commands are executed serially, so the host waits for a reader-to-host response before issuing another host-to-reader command packet.

Header	**Data Length**	**Command**	**Data**	**CRC-16 Checksum**

Hdr	**Len**	**Cmd**		- - - - -		**CRC HI**	**CRC LO**

1 byte	**1 byte**	**1 byte**	**0 to** *N* bytes	2 bytes

The fields are summarized in the following table.:

Field	Length	Description
Header (Hdr)	1 byte	Defines the start of the packet. Equal to 0xFF
[1]Data Length (Len)	1 byte	Defines the length, *N*, of the data field contained in the packet.
Command	1 byte	Specifies the command that the reader is to execute.
Data	*N* bytes (0 to 250)	Defines the binary data required by the reader for use with a command. This could, for example, represent transponder data to be written. The length, *N*, can vary between 0 and 250 bytes.
CRC-16 Checksum (CRC HI, CRC LO)	2 bytes	CRC-16 checksum (high order byte first). CRC polynomial is CCITT CRC-16, with a preload of 0xFFFF. This does not fully specify the operation of the CRC, see CCITT CRC-16 Calculation.

1.Minimum packet length is 5 bytes; the maximum packet length is 255 bytes.

Reader-to-Host Communication

The following diagram defines the format of the generic Response Packet sent from the reader to the host. The Response Packet is different in format from the Request Packet.

Header	**Data Length**	**Command**	Status Word	**Data**		**CRC-16 Checksum**	
Hdr	**Len**	**Cmd**	Status Word	- - - - -		**CRC HI**	**CRC LO**
1 byte	**1 byte**	**1 byte**	*2 bytes*	0 to *M* bytes		2 bytes	

The fields are summarized in the following table.:

Field	Length	Description
Header (Hdr)	1 byte	Defines the start of the packet. Equal to 0xFF
[1]Data Length (Len)	1 byte	Defines the length, *M*, of the data field contained in the packet. Length can be 0 – 248 bytes
[2]Command	1 byte	OpCode of the last command received
[3]Status Word	2 bytes	Specifies the status of the last command, Successful = 0x0000, else it contains a fault code.
Data	*M* bytes (0 to 248)	Defines the binary data returned by the reader in response to a command. This could, for example, represent data read from a transponder. Data length, *M*, can be a minimum of 0 and a maximum of 248 bytes.
CRC-16 Checksum (CRC HI, CRC LO)	2 bytes	CRC-16 checksum (high order byte first). CRC polynomial is CCITT CRC-16, with a preload of 0xFFFF. This does not fully specify the operation of the CRC, see CCITT CRC-16 Calculation.

1.The minimum packet length is 7 bytes and the maximum packet length is 255 bytes.
2.Each host command receives a response from the reader. In the response packet, the Header, Data Length, Command, Data, and Checksum are functionally similar to the command packet.
3.The only difference is the addition of the Status Word field. The Status Word has two types of values. A Status Word value of 0 (Zero) means the command received was successful. Any other value represents a fault.

CCITT CRC-16 Calculation

The same CRC calculation is performed on all serial communications between the host and the reader. The CRC is calculated on the Data Length, Command, Status Word, and Data bytes. The header (SOH, 0xFF) is not included in the CRC.

A sample implementation of the CCITT CRC-16 algorithm is shown in this section. The **CRC_calcCrc8()** function is written to calculate the CRC one byte at a time, with the calculated value stored in crc_calc. The crc_calc value must be pre-loaded the first time the **CRC_calcCrc8()** function is called with 0xFFFF to initialize the calculated CRC. The final value of crc_calc is sent as the 16-bit CRC at the end of the message.

An example implementation of CRC calculation, taken from the Arbser source CrcUtils.c, is shown here:

```
/** @fn void CRC_calcCrc8(u16 *crcReg, u16 poly, u16 u8Data)
* @ Standard CRC calculation on an 8-bit piece of data.  To make it
* CCITT-16, use poly=0x1021 and an initial crcReg=0xFFFF.
*

*  Note:  This function allows one to call it repeatedly to continue
*        calculating a CRC.  Thus, the first time it's called, it
*        should have an initial crcReg of 0xFFFF, after which it
*        can be called with its own result.
*
* @param *crcRegPointer to current CRC register.
* @param poly  Polynomial to apply.
* @param u8Datau8 data to perform CRC on.
* @return None.
*/

void CRC_calcCrc8(u16 *crcReg, u16 poly, u16 u8Data)

{
   u16 i;
   u16 xorFlag;
   u16 bit;
   u16 dcdBitMask = 0x80;


   for(i=0; i<8; i++)
   {
// Get the carry bit.  This determines if the polynomial should be
// xor'd with the CRC register.

         xorFlag = *crcReg & 0x8000;

         // Shift the bits over by one.
         *crcReg <<= 1;

         // Shift in the next bit in the data byte
         bit = ((u8Data & dcdBitMask) == dcdBitMask);
         *crcReg |= bit;

         // XOR the polynomial
         if(xorFlag)
         {
               *crcReg = *crcReg ^ poly;
         }

         // Shift over the dcd mask
         dcdBitMask >>= 1;
   }
}
```

Format for Microprocessor Reply to Host

There are three different types of replies that the microprocessor can make to the host as follows:

- Acknowledge that the command was properly processed (ACK)
- Return a fault code
- Provide data that is requested by the host

This section describes each of these three types.

Unless otherwise specified, all commands return, as part of the Reply message, a status word with an ACK or a Fault. Those commands that return a Data Reply message are clearly shown.

Microprocessor ACK Message

Many of the commands require the microprocessor to perform a function, but do not require the microprocessor to send data back to the host. However, since the host cannot send a message until the microprocessor replies, an ACK is sent.

The ACK message contains no data. It returns the same OpCode that was sent originally to the microprocessor, sets the Status Word to 0x0000 (zero) and the Data Length to 0x00 (zero).

The following shows an example of an ACK message to an **Erase Flash** command.

FF	**00**	**07**	**00 00**	**F4 27**
SOH	Length	OpCode	Status	CRC

The value in the OpCode field (0x07) is the same as the **Erase Flash** OpCode, 0x07.

Microprocessor Fault Reply Message

If a problem occurs during the execution of a command, the microprocessor returns a non-zero status value. Although this usually implies a fault or error, sometimes the non-zero status simply indicates a condition of the system. For instance, when executing a **Read Tag Single** command, if no tags are found, a status code of 0x0400 is returned. An example of a fault reply message is shown for the **Erase Flash** command.

FF	**00**	**07**	**02 00**	**F6 27**
SOH	Length	OpCode	Status	CRC

A list of error codes is included in Appendix C: Error Messages. Refer to this list when encountering any non-zero status codes.

Microprocessor Data Reply Message

If the requested command requires that the microprocessor returns data, then the microprocessor creates a message similar to the Microprocessor ACK Message with the data length set to a non-zero value. Since this command does not require a data field, the length field is set to Zero.

FF	**00**	**07**	**00 00**	**F4 27**
SOH	Length	OpCode	Status	CRC

Here is an example of a Reply message with Data Field Length not zero. This message happens to be a successful reply to **Read Tag Single** command.

FF	**0A**	**21**	**00 00**	**C8 05 07 A8 00 84 C4 FF**	**9E E0**	**F7 25**
SOH	Length	OpCode	Status	Tag ID	Tag CRC	CRC

Command Set

The following list defines the OpCodes that are used in the embedded modules firmware. As these products grow, more OpCodes will be added to enhance the functionality of the product. The timeout for the commands are in milliseconds. The maximum value for any user-configurable timeout is 65,535msec (0xFFFF), unless otherwise noted. The OpCodes are divided into five main categories:

- 0x00 – 0x1F: Boot Loader Commands
- 0x20 – 0x5F: Application Tag Commands - Depending on the current protocol setting will correspond to:
  - Multi-Protocol Tag Commands
  - Allegro/Title-21 Tag Commands
  - eGo/SeGo Tag Command Set
  - ATA Tag Command Set
  - Gen2 Tag Commands
- 0x60 – 0x8F: Get Configuration Commands
- 0x90 – 0xBF: Set Configuration Commands
- 0xC0 – 0xCF: FCC Test Commands

Boot Loader Commands

The BootLoader is automatically started upon power up, and allows access to the on-board flash memory along with other commands. The program exits only when the **Boot Firmware** command is received. Once that occurs, the firmware image starts executing and sends back a reply to the **Boot Firmware** command. The BootLoader can also be started using command 0x09, **Start BootLoader**.

The following table shows which commands are supported by the Boot loader and in some cases the application.

Boot Loader Commands

OpCode	Command Name	Arguments	Return	BL	App
0x02	Flash Read Sector (02h)	Address, Sector, bytes	Data	Y	N
0x03	Get Boot Loader/Firmware Version (03h)	none	Acknowledge	Y	N
0x04	Boot Firmware (04h)	none	Acknowledge	Y	N
0x06	Set Baud Rate (06h)	Baud Rate	Acknowledge	Y	Y
0x07	Erase Flash Sector (07h)	Sector Number, password	Ack	Y	N
0x08	Verify Image CRC (08h)	none	Acknowledge	Y	N
0x09	Start Bootloader (09h)	none	Acknowledge	N	Y
0x0C	Get Current Program (0Ch)	none	1 Byte indicating program currently running	Y	Y
0x0D	Write Flash Sector (0Dh)	Sector enum, memory offset, length, data to write	none	Y	N
0x0E	Get Sector Size (0Eh)	Sector enum	Size of sector in bytes	Y	N
0x0F	Modify Flash Sector (0Fh)	Sector enum, memory offset, length to read	Data in flash	Y	N

Flash Read Sector (02h)

The **Flash Read Sector** command reads the contents of flash from the specified sector and offset address. Since the length of the Microprocessor reply packet is limited to 248 bytes, reading the application firmware data requires multiple read commands.

Note

Length is defined as the number of 16-bit words, and the maximum value of length is 124 words.

In this example, the sector number 02 indicates the application area. This command reads the first five data elements of the application, which is equivalent to the original command (using data length of 05). The sector codes can be found in Flash Memory Sector Mapping..

FF	06	02	00	00	00	00	02	05	FA	59
SOH	Length	OpCode	Start Address				Sector	Num Bytes To Read	CRC	

The reply to this command looks like this

FF	0A	02	00	00	01	23	45	67	89	AB	CD	EF	01	23	BC	ED
SOH	Length	OpCode	Status		Word 1[1]		Word 2[2]		Word 3		Word 4		Word 5		CRC	

1.Word 1 contains the data located at address 0x208000.
2.Word 2 contains the data at address 0x208001, and so forth. (Remember that the Microprocessor data is word addressed.)

Get Boot Loader/Firmware Version (03h)

The **Get Boot Loader** command returns the Boot Loader, Hardware, and Application version numbers. The Boot Loader, Hardware, and Application FW version numbers are stored in flash. The Boot Loader and Hardware version numbers are each 32-bit numbers. The application has a 96-bit version code. The command to retrieve firmware version is shown in the following table.

FF	00	03	1D	0C
SOH	Length	OpCode	CRC	

Responses

A sample response for the M6e-TC is as follows:

FF	14	03	00 00	07 09 17 00	01 00 00 01	20 07 10 12	09 05 12 00
SOH	Length	OpCode	Status	BootLoader Ver	Hardware Ver	Firmware Date	Firmware Version

00 00 00 10	6B CC
Supported Protocols	CRC

The following information is embedded in the reply to the command:

- The boot loader version is 07.09.17.00. This number is in hex format.
- HW Version is 01000001. For a definition, see Returned HW Versions.
- The application firmware was compiled on 2007-October-12.
- The application firmware version is 09.05.12.00. This number is in hex format.
- The protocol supported by this firmware – Gen2 and ISO 18000-6C.

Returned Hardware Version Table

The following table provides a definition of each HW version returned by the **Get Boot Loader/Firmware Version** command.

Returned HW Versions

Module	Defined	Version	Description
M6e-TC	HW_VERID_1_0W	0x10000001	A0 and B0 prototypes

If the **Get Boot Loader/Firmware Version** command returns a different value than those listed in the table, you should contact support@thingmagic.com.

Boot Firmware (04h)

The **Boot Firmware** command tells the boot loader to run the current firmware image stored in flash in the following sequence:

1. If flash is locked application firmware is run.

1. If flash is not locked: the application firmware image CRC verified and flash is locked before it is run.
2. If the image is invalid, a fault code is returned to the host.
3. If the application firmware is started successfully, it sends the response to the **Boot Firmware** command.

FF	**00**	**04**	**1D 0B**
SOH	Length	OpCode	CRC

The response is identical to the response to a **Get Version** command, except that the OpCode is 0x04 instead of 0x03.

Note

The Application Firmware boot up time takes approximately 600ms the first time it is run after a new firmware installation. Subsequent boot up times will be approximately 50ms.

Set Baud Rate (06h)

The **Set Baud Rate** command has a default baud rate of 9600 bps. Since the code method of specifying the baud rate is processor dependent, a new interface was created to make the modules easily interchangeable.

The following table shows the hexadecimal equivalent for each baud rate:

Baud Rate (decimal)	Baud Rate (hex)
9600	0x00002580
19200	0x00004B00
38400	0x00009600
57600	0x0000E100
115200	0x0001C200
230400	0x00038400
460800	0x00070800
921600	0x000E1000

In the following example, the baud rate is specified as a 32-bit value. This example sets the baud rate to 115200:

FF	**04**	**06**	**00**	**01**	**C2**	**00**	**FD**	**30**
SOH	Length	OpCode	Baud Rate				CRC	

The response to baud rate change is sent at the baud rate that the **Set Baud Rate** command was transmitted. Once the baud rate has changed, the new rate is in effect until the baud rate is changed by power cycling the reader. The baud always reverts to 9600 after a power cycle.

Note

Set baud rate has no effect on the USB interface speed, only the RS232 interface, whether executed from the RS232 interface or USB.

Erase Flash Sector (07h)

The **Erase Flash Sector** command erases the sector specified by the sector number. as defined by Flash Memory Sector Mapping.

The following example shows the command to erase sector 2 of the flash.

FF	05	07	08	95	91	21	02	7F	91
SOH	Length	OpCode	Password				Sector	CRC	

Verify Image CRC (08h)

After uploading a new application firmware image, the application CRC can be checked with the **Verify Image CRC** command. The application CRC is already embedded in the firmware image, so this command calculates the firmware's CRC in flash and compares it to the pre-stored value. It returns a fault code if the application firmware fails the CRC checks. A failed CRC means that the application cannot run, and needs to be downloaded again.

FF	00	08	1D	07
SOH	Length	OpCode	CRC	

The boot loader runs this command automatically before loading the application the first time it is I run. If the CRC check fails, the boot loader does not run the application to prevent corrupted code from executing on the Microprocessor. Subsequent invocations will not verify the CRC since the flash is locked.

Start Bootloader (09h)

The **Start Bootloader** command shuts off the analog board and starts the boot loader while inside the application. This is necessary to perform an upgrade of the firmware while the system is running.

FF	00	09	1D	06
SOH	Length	OpCode	CRC	

Get Current Program (0Ch)

The **Get Current Program** command returns a code for the current program being executed in the module. These codes are defined as follows:

Code	Program
0x21	M6e-TC Bootloader
0x22	M6e-TC Application

To get the current program command, send the following to the module:

FF	00	0C	1D 0C
SOH	Length	OpCode	CRC

The module responds as follows, indicating that it is the application program:

FF	01	0C	00 00	22	?? ??
SOH	Length	OpCode	Status	Program	CRC

Write Flash Sector (0Dh)

The **Write Flash Sector** command is used to write data to the flash memory. Before writing to flash it is imperative that the flash be erased first. Attempting to write to flash before it is erased will generate an error. Alternatively the Modify Flash Sector (0Fh) command can be used.

Loading an Application Image

A series of write flash commands is used to load a new application program image into flash. The Write Flassh Sector command verifies the CRC of the received data but does not verify the CRC of the complete application image. Use the Verify Image CRC (08h) command to verify the application once it is uploaded.

The *start address* is a 32-bit sector offset address. It is a word address, that is different from the byte address used for instruction memory. The application code must be loaded starting from word address 0x00000000. Since the flash is a 16-bit device, there must be an even number of data bytes. The number of data bytes to be written is embedded in the length of the payload (N) by the formula:

LengthDataToWriteInWords = (N – 8) / 2

The password required for each sector is defined in Flash Memory Sector Mapping.

The following example shows a Write Flash Sector command writing to the Application Sector, starting at the beginning

FF	**0F**	**0D**	**02 25 44 10**	**00 00 00 00**	**02**	**12 34 56 78 90 12**	**73 4C**
SOH	Length	OpCode	Password	Start Address	Sector	Data To Write	CRC

Note

DO NOT send a packet that spans two sectors. Split the packet into 2 separate messages, then send the first message to sector “x” and the second to sector “x+1”.

Get Sector Size (0Eh)

The size of a flash sector can be retrieved from the module using the **Get Sector Size** command. Since different products may have different flash sector sizes, this command is useful for ensuring that the module has enough memory to store the desired data. This example receives the sector size for the application area:

FF	**01**	**OE**	**02**	**D1 BF**
SOH	Length	OpCode	Sector	CRC

The response to this command is shown in the following example:

FF	**04**	**OE**	**00 00**	**00 03 40 00**	**88 54**
SOH	Length	OpCode	Status	Size of Sector	CRC

The size of the sector is returned in bytes. Sector 2 (application) is 212992 bytes.

Modify Flash Sector (0Fh)

The **Modify Flash Sector** command is used as a read-modify-write operation in the flash. Since the **Modify Flash Sector** command erases the flash sector each time it is called, it could prematurely wear out the flash if it is used too often. This command should only be used to modify a few variables (that is less than one serial packet’s worth) at a time.

This command works only for the User area.

FF	**0F**	**0F**	**79**	**13**	**87**	**66**	**00**	**00**	**00**	**00**	**03**	**12**	**34**	**56**	**78**	**90**	**12**	**4C**	**FA**
SOH	Length	OpCode	Password				Start Address				Sector	Data To Write						CRC	

Multi-Protocol Tag Commands

The application commands are used to interact with RFID tags in the field. These commands can have slightly different behavior based upon the current protocol selected in the system.

Applications Commands

OpCode	Command Name
0x29	Get Tag Buffer (29h)
0x2A	Clear Tag Buffer (2Ah)
0x2F	Multi-Protocol Tag Read (2Fh)

Get Tag Buffer (29h)

After a **Multi-Protocol Tag Read** command is executed, the found tags are stored in an internal Tag Buffer. The **Get Tag Buffer** command can perform several different operations depending on the syntax used. These operations are:

- Get tags remaining in the tag buffer
- Get tag EPCs
- Get tag EPCs and their Tag Read Meta Data.

Get Tags Remaining

To determine the number of tags remaining in the buffer, send the **Get Tag Buffer** command with a data length of zero:

FF	00	29	1D 26
SOH	Length	OpCode	CRC

This command returns the current read index, the location of the next tag to be read, and the current write index, the location where the next tag will be written. These two numbers can be used to get the number of tags left in the tag buffer:

```
Tags Left = WriteIndex - ReadIndex
```

The following response shows there are three tags left in the buffer, and the first one has already been read (the read index parameter starts counting from 0.):

SOH	Length	OpCode	Status	ReadIndex	WriteIndex	CRC
FF	**04**	**29**	**00 00**	**00 01**	**00 04**	**87 72**

Get Tag EPCs

When you want to get the tag EPCs out of the buffer and don't care about the tag read metadata, the options available with this syntax maybe useful. This syntax reads out the requested number of tags from the buffer. A maximum of 13 tags are read at a time, less if Max EPC Length is set to 496 bits. Multiple **Get Tag Buffer** commands may be required to obtain the complete results from a single **Multi-Protocol Tag Read** command. If more tags are requested than remain in the buffer an error will be returned.

All tag buffer indexes are encoded as 16-bit unsigned integers. The indexes start counting from 0. Thus, a start index of 0 indicates tag #1, and a start index of 10 would indicate tag #11.

There are two ways to read tag EPCs out of the buffer when you only want EPC values. The first way is to send a **Get Tag Buffer** command with the desired number of tags, *n.* This retrieves the next *n* tags, starting from the current read index. In the previous example, the read index was 1, indicating that one tag was already read. To read the next two tags, set the number of tags parameters to 2. This returns tags number 2 and 3 in the tag buffer:

SOH	Length	OpCode	# Tag IDs to Return	CRC
FF	**02**	**29**	**00 02**	**57 EB**

When using the **Get Tag Buffer** command in this way, the read index is automatically incremented internally. Thus, if the read index was '1' before getting two tags, then it is incremented to '3' at the end of this command.

Another way to get the second and third tags is to explicitly send the start and end indexes of the tags to read. This is used to retrieve any contiguous block of tag buffer entries at any time.

FF	04	29	00 01	00 03	CC 94
SOH	Length	OpCode	Start Idx	End Idx	CRC

Using the start and end index method does not affect the read index that is internally stored in the module. The above request returns a message with two tags. The length of each tag EPC record returned is defined based on the max EPC length configured with Set Reader Configuration(9Ah), regardless of the size of a specific tag's EPC. The sizes and fields of the EPC portion of a tag buffer entry is defined in the Tag Buffer Entry table.

For example:

- A 64-bit tag has the length set to 0x60 (16-bit PC + 64-bit tag EPC + 16-bit tag CRC), but only the first 12 bytes of the tag record is filled in, the trailing bytes, after the CRC are padded with zeros.
- An 96-bit GEN2 tag, the length is 0x80 (16-bit PC (Protocol Control) word + 96-bit tag EPC + 16-bit tag EPC CRC).

In the response below, two tag EPCs are returned. Tag #1 is a 96-bit EPC tag and tag #2 is a 64-bit EPC tag.

FF	24	29	00 00
SOH	Length	OpCode	Status

00 80	30 00	11 11 22 22 33 33 44 44 55 55 66 66	18 35
EPC Length	PC Word	Tag EPC	Tag CRC

00 60	20 00	11 11 22 22 33 33 44 44	C2 41	00 00 00 00
EPC Length	PC Word	Tag EPC	Tag CRC	Padding

D3 32
CRC

Note

Using this syntax the number of tags in the response is not specified. It must be determined by the message length.

Get Tag EPCs and Metadata

Using this syntax for getting information from the tag buffer provides several benefits:

- When at tag EPC is returned there is no padding if the actual tag EPC is shorter than the configured max EPC length. This helps minimize the amount of data returned.
- Any or all fields of the Tag Read Meta Data can be returned.
- In the event of a communication error the last Get EPC and Metadata request can be repeated.

When data is requested using this syntax the response will contain as many tags as can be fit in the response packet. The response will indicate how many tags were returned and should be processed accordingly.

This version of Get Tag Buffer takes two additional fields: the Metadata Flags which defines what metadata will be returned and the Read Options which specifies special read functionality. The following table lists the supported values for these fields.

Get EPC and Metadata Request Fields

Field	Value	Description
Metadata Flags (to specify more than one OR the values together)	0x0000	When no flags are set no meta data will be returned, only the tag EPC (including PC bits and tag CRC)
	0x0001	When bit 0 is set the Read Count will be returned
	0x0002	When bit 1 is set the LQI/RSSI will be returned
	0x0004	When bit 2 is set the Antenna ID will be returned
	0x0008	When bit 3 is set the Frequency will be returned
	0x0010	When bit 4 is set the Timestamp will be returned
	0x0020	RFU (*ThingMagic Only*)
	0x0040	When bit 6 is set the Protocol ID, as defined by the Tag Protocol IDs table, will be returned

Field	Value	Description
Read Option	0x00	Read the next set of tags from the Tag Buffer
	0x01	Re-send the last set of tags. Note: When setting this option the tags will be resent starting at the same ReadIndex as the last command. If the metadata requested is different than the last request the number of tags returned might be different. To get those 'missing' tags, additional Get Tag Buffer commands should be sent without the re-send option, otherwise it will reset the ReadIndex again.

Examples

An example command requesting Read Count, AntennaID and Timestamp Metadata Flags = 0x0001 OR 0x0004 OR 0x0010 = 0x0015 is as follows:

FF	**03**	**29**	**00**	**15**	**00**	**97 55**
SOH	Length	OpCode	Metadata Flags		Read Options	CRC

A response contains the following information:

Get EPC and Metadata Response Fields

Field	Length	Value
SOH	1 byte	0xFF
Length	1 byte	Based on data returned
OpCode	1 byte	0x29
Metadata Flags	2 bytes	Metadata contained in response
Read Options	1 byte	As sent in request
Tag Count	1 byte	Number of tags in response
Read Count	1 byte	Tag EPC/Antenna Read Count
RSSI$_1$	1 byte	Return Signal Strength Indicator
Antenna ID$_1$	1 byte	Antenna ID, 4 MSBs for TX and 4 LSBs for RX
Frequency$_1$	3 bytes	Frequency in kHz
Timestamp$_1$	4 bytes	RTC Timestamp

Field	Length	Value
RFU[1]	2 bytes	Reserved for Future Use - ThingMagic Only
Protocol ID	1 byte	Protocol ID of tag read
EPC Length	2 bytes	Number of bits in EPC including PC and CRC bits
PC Word	2 bytes	Tag EPC Protocol Control bits
EPC ID	N bytes	Tag EPC.
Tag CRC	2 bytes	Tag EPC CRC
Repeat fields starting at *Read Count* for remaining tags in message as defined by *Tag Count*		
CRC	2 bytes	Message CRC

1 - Conditionally returned depending on the Metadata Fields specified in the request.

Here is an example response to the example request specified above. The response contains two tags as specified in the Tag Count field each with its EPC info and requested tag read metadata: Read Count, AntennaID and Timestamp:

FF	34	29	00 00	00	15	00	02
SOH	Length	OpCode	Status	Metadata Flags		Read Options	Tag Count

22	11	02 50 CE F6	00 80	31 C1	11 11 22 22 33 33 44 44 55 55 66 66	FB 15
Read Count	Ant ID	Timestamp	EPC Length	PC Word	Tag EPC	Tag CRC

OE	11	04 1D 3D 3C	00 80	30 00	05 00 00 00 00 00 00 00 00 00 23 54	4A C8
Read Count	Ant ID	Timestamp	EPC Length	PC Word	Tag EPC	Tag CRC

1A B8
CRC

Clear Tag Buffer (2Ah)

The **Clear Tag Buffer** command resets the tag buffer. This clears the buffer of any current tags and reset the read index to 0. A **Multi-Protocol Tag Read** or **Read Tag Multiple** command must be issued to load new tags into the buffer.

FF	00	2A	1D 25
SOH	Length	OpCode	CRC

If **Clear Tag Buffer** or **Get Tag Buffer** is not used after a **Multi-Protocol Tag Read** to remove all tags, old tags will be left in the buffer. This means that if tags that have not been removed from the buffer are read again they will not be added to the buffer as second time, only their Read Count will be incremented.

Multi-Protocol Tag Read (2Fh)

The Multi-Protocol Tag Read command allows tag reading and inventorying commands to be performed on tags with different protocols at the same time, using a single command. This command contains the following request fields:

Multi-Protocol Tag Read Request Fields

Field	Value	Description
TM OpCode	0x2F	TM OpCode indicating a multi-protocol operation.
Timeout	[2 bytes]	Indicates how long the entire command should spend attempting the operation, in milliseconds. When TM Option=0x00 the time gets divided equally across each protocol specified.
TM Options	• 0x00 = Basic Multi-protocol search. Uses Protocol Bitmask	Indicates the operation to perform and additional fields that will be required.
Command Opcode	• 0x00 - reserved • 0x21 - tag read single • 0x22 - tag read multiple	Indicates the command that will be performed for each protocol specified.

Field	Value	Description
Search Flags	[*2 bytes - bitwise setting*] Bit 0 = Enable end on tags found Note: Least Significant Bit = bit 0	Indicates search options. When bit is set = 1 the option will be enabled. • **Bit 0 = 1** (0x01) the search will stop after the first tag is found, after completing that protocols entire timeout. i.e. if 4 protocols are specified with a 100ms timeout and a tag is found during searching on the second protocol the remaining protocols will not be searched and the command will return after 50ms. **Bit 0 = 0** all protocols will be searched, using entire timeout.
TM Option = 0x00 Fields - The following field is only used when TM Option = 0x00		
Protocol Bitmask Enables	[*4 bytes - bitwise setting*] bit 0-3 = not used bit 4 (0x00000010) = Gen2 bit 5-25 = not used bit 26 (0x04000000) = eGo bit 27 (0x08000000) = SeGo bit 28 (0x10000000) = ATA bit 29 (0x20000000) = Allegro/Title-21 Note: Least Significant Bit = bit 0	Indicates the protocols to operate on. If the protocols bit is set to ‘1’ tags of that protocol will be included in the operation. OR values together for final setting

Examples

TM Option = 0x00 Request

FF	**??**	**2F**	**?? ??**	**00**	**??**	**?? ??**	**?? ?? ?? ??**	**?? ??**
SOH	Length	OpCode	Timeout	TM Options	Cmd Opcode	Search Flags	Protocol Bitmask Enables	CRC

Response

FF	**??**	**2F**	**?? ??**	**00**	**??**	**?? ??**
SO H	Length	OpCod e	Status	TM Option	Cmd Opcode	Search Flags

??	**??**	**?? ?? ?? ....**
Protocol Id1	Protocol Response Length	Protocol Response Data (Includes Status word)

??	**??**	**?? ?? ?? ....**
Protocol Id2	Protocol Response Length	Protocol Response Data (Includes Status word)

?? ??
CRC

Note: If a multi-protocol Tag Read Single (command code 0x21) search results in zero tags found it will not be reported. Only successful searches are reported.

Allegro/Title-21 Tag Commands

The Allego/Title-21 tag commands are used to operate on Allegro/Title-21 tags and perform operations specific to those tags. These commands can only be used when the Tag Protocol of the reader is set to Allegro/Title-21 (0x001E) using Set Current Tag Protocol (93h). These commands cannot be run when in Bootloader mode, only in Application mode.

Allegro/Title-21 Tag Commands

TM OpCode	Operation Type	Allegro/Title-21 Command	Transaction Type Code
0x21	Read ID Single	Read Tag ID Single (21h)	n/a
0x24	Modify	Write Request (24h; A003h)	0xA003
		Title-21 ACK Request (24h; C000h)	0xC000
		General ACK Request (24h; F00Fh)	0xF00F
0x28	Read	Title-21 Read Request (28h; 8000h)	0x8000
		Read Request (28h; C003h)	0xC003
		Random Number Request (28h; D001h)	0xD001
		TDMA Read Request (28h; E003h)	0xE003
0x2C	Reset	Jump to Reset Request (2Ch; D203h)	0xD203

Command Syntax

All Allegro/Title-21 tag commands, except Read Tag ID Single, follow the same standard syntax. The commands are grouped into three ThingMagic M6e-TC OpCodes, as defined in the Allegro/Title-21 Tag Commands table, indicating their general operation type. In addition to the 1 of 3 OpCodes each command will have the following fields:

Standard Request Fields

Field	Value	Description
TM OpCode	0x24	TM OpCode
Timeout	[2 bytes]	Indicates how long the command should spend attempting the operation, in milliseconds.
TM Options	0x00	Reserved for Future Use.
Transaction Type Code	[2 bytes]	Allegro/Title-21 code indicating operation to perform.

The remaining fields for each command are as defined by Transcore based on the Transaction Type Code. They occur in the same order and require the same values as described in the [Transcore doc reference].

Read Tag ID Single (21h)

The **Read Tag ID Single/Tag Detect** command performs a search operation and returns the first Allegro/Title-21 tag it finds.

Read Tag ID Single Request Fields

Field	Value	Description
TM OpCode	0x21	TM OpCode
Timeout	[2 bytes]	Indicates how long the command should spend attempting the operation, in milliseconds.
TM Options Note: This and following fields are optional.	Bit 4 *(LSB=bit 0)*)	• **0 -** Metadata flags must not be passed and Meta Data will not be returned. • **1** - Metadata flags must be passed and the corresponding Metadata shall be returned with the tag EPC.
Metadata Flags (to specify more than one OR the values together)	0x0000	When no flags are set no meta data will be returned, only the tag EPC.
	0x0001	When bit 0 is set the Read Count will be returned
	0x0002	When bit 1 is set the LQI/RSSI will be returned
	0x0004	When bit 2 is set the Antenna ID will be returned
	0x0008	When bit 3 is set the Frequency will be returned
	0x0010	When bit 4 is set the Timestamp will be returned
	0x0020	When bit 5 is set the RFU (*ThingMagic Only*) will be returned
	0x0040	When bit 6 is set the Protocol is returned.

Examples

An example, without TM Options, command:

FF	02	21	00 FA	D6 1B
SOH	Length	OpCode	Time-out (ms)	CRC

ACK Response

FF	**04**	**21**	**00 00**	**?? ?? ?? ??**	**?? ??**
SOH	Length	OpCode	Status	Tag ID	CRC

NACK Response

FF	**00**	**21**	**?? ??**	**?? ??**
SOH	Length	OpCode	Status	CRC

No Response

FF	**00**	**21**	**04 00**	**B4 83**
SOH	Length	TM OpCode	Status	CRC

Write Request (24h; A003h)

The Write Request command writes data to the specified area of the specified tag. A non-acknowledge (NACK) error response shall be returned if an invalid password was included in the request. This command contains the following request fields:

Write Request Fields

Field	Value	Description
TM OpCode	0x24	TM OpCode for tag modification operations
Timeout	[2 bytes]	Indicates how long the command should spend attempting the operation, in milliseconds.
TM Options	0x00	Reserved for Future Use.
Transaction Type Code	0xA003	Allegro/Title-21 code indicating operation to perform.
Options	[1 byte]	Command specific options
Page Number	[2 bytes]	Indicates which page of the tag is to be written to.
Tag ID	[4 bytes]	*Optional,* based on value of Options parameter. Indicates the ID of the tag to operate on.
User Password/ Global Password	[4/8 bytes]	Optional, based on the value of the Options parameter. The password to operation on the tag, if required.
Page Data Byte Count	[1 byte]	Indicates the number of data bytes to follow.
Page Data Bytes	[N bytes]	Data to write to the tag.

Examples

An example command requesting ? be written to tag ? with a User Password = 0x? is:

FF	**0E + *N***	**24**	**?? ??**	**00**	**A0 03**	**??**	**?? ??**
SOH	Length	TM OpCode	Timeout (ms)	TM Option	Transaction Type Code	Option	Page Number

?? ?? ?? ??	**?? ?? ?? ??**	**??**	**NN NN**	**?? ??**
Tag ID	User/Global Password	Page Data Count	Page Data	CRC

ACK Response

SOH	Length	TM OpCode	Status	TM Option	Transaction Type Code	Options	Tag ID	Page Number	Page Data Count (if requested)	Page Data		CRC
FF	**0C + (*N+1*)**	**24**	**00 00**	**00**	**A0 03**	**??**	**?? ?? ?? ??**	**?? ??**	**??**	**NN**	**NN**	**?? ??**

NACK Response

SOH	Length	TM OpCode	Status	TM Option	Transaction Type Code	Options	Tag ID	CRC
FF	**0B**	**24**	**04 0A**	**00**	**A0 03**	**??**	**?? ?? ?? ??**	**?? ??**

No Response

SOH	Length	TM OpCode	Status	CRC
FF	**00**	**24**	**04 00**	**E4 26**

Title-21 ACK Request (24h; C000h)

The Title-21 ACK Request command informs the tag that the reader has successfully received the tag ID. This will result in the tag not responding to any message whose transaction type is identical to the most recently received message for a specified period of 10 seconds, as defined in Title 21 release 1. This command contains the following request fields:

Title-21 ACK Request Fields

Field	Value	Description
TM OpCode	0x24	TM OpCode for tag modification operations
Timeout	[2 bytes]	Indicates how long the command should spend attempting the operation, in milliseconds.
TM Options	0x00	Reserved for Future Use.
Transaction Type Code	0xC000	Allegro/Title-21 code indicating operation to perform.
Tag ID	[4 bytes]	Indicates the ID of the tag to operate on.
Reader ID	[4 bytes]	The reader number for the reader that is acknowledging the receipt of the message.
Transaction Status Code	[2 bytes]	Code indicating the status of the transaction.

Examples

An example command requesting an ACK from tag XXX from reader XXX is:

FF	**0D**	**24**	**?? ??**	**00**	**C0 00**	**?? ?? ?? ??**	**?? ?? ?? ??**	**??**	**??**	**?? ??**
SOH	Length	OpCode	Time-out (ms)	TM Option	Transaction Type Code	Tag ID	Reader ID	Transaction Status Code		CRC

ACK Response

FF	**03**	**24**	**?? ??**	**00**	**C0 00**	**?? ??**
SOH	Length	TM OpCode	Status	TM Option	Transaction Type Code	CRC

NACK Response

FF	**0B**	**24**	**?? ??**	**00**	**C0 00**	**??**	**?? ?? ?? ??**	**?? ??**
SOH	Length	TM OpCode	Status	TM Option	Transaction Type Code	Options	Tag ID	CRC

No Response

FF	**00**	**24**	**04 00**	**E4 26**
SOH	Length	TM OpCode	Status	CRC

General ACK Request (24h; F00Fh)

The General ACK Request, or Sign Off Request, command informs the tag that it should not respond to any commands from the reader for the specified time period. This command contains the following request fields:

General ACK Request Fields

Field	Value	Description
TM OpCode	0x24	TM OpCode for tag modification operations
Timeout	[2 bytes]	Indicates how long the command should spend attempting the operation, in milliseconds.
TM Options	0x00	Reserved for Future Use.
Transaction Type Code	0xF00F	Allegro/Title-21 code indicating operation to perform.
Options	[1 byte]	Command specific options
Tag ID	[4 bytes]	Indicates the ID of the tag to operate on.
Time Out	[1 byte]	Indicates the amount of time the tag shall ignore commands from the reader, in seconds from 0-127.
Condition Code Bits	[1 byte]	Represents a condition applicable to a tolling environment.
LCD Message Page Pointer	[1 byte]	Tag memory page where the LCD message to be displayed is stored in ASCII. Valid range = 0x02 - 0x0F.

Examples

An example command requesting an ACK from tag XXX from reader XXX is:

FF	**0C**	**24**	**?? ??**	**00**	**F0 0F**	**??**	**??**	**??**	**??**	**??**	**??**	**??**	**??**	**??**	**??**
SOH	Length	OpCode	Timeout (ms)	TM Option	Transaction Type Code	Option	Tag ID				Time Out	Condition Code	LCD Page Ptr	CRC	

ACK Response

FF	**03**	**24**	**?? ??**	**00**	**F0 0F**	**??**	**??**
SOH	Length	TM OpCode	Status	TM Option	Transaction Type Code	CRC	

NACK Response

FF	**0A**	**24**	**?? ??**	**00**	**F0 0F**	**??**	**? ?**	**? ?**	**? ?**	**? ?**	**??**	**??**
SOH	Length	TM OpCode	Status	TM Option	Transaction Type Code	Options	Tag ID				CRC	

No Response

FF	**00**	**24**	**04 00**	**E4**	**26**
SOH	Length	TM OpCode	Status	CRC	

Title-21 Read Request (28h; 8000h)

The Title-21 Read Request command reads the Title-21 tag ID from the tag. This command contains the following request fields:

Title-21 Read Request Fields

Field	Value	Description
TM OpCode	0x28	TM OpCode for Read operations
Timeout	[2 bytes]	Indicates how long the command should spend attempting the operation, in milliseconds.
TM Options	0x00	Reserved for Future Use.
Transaction Type Code	0x8000	Allegro/Title-21 code indicating operation to perform.
Agency Code	[2 byte]	Agency operating the reader installation.

Examples

An example command requesting an ACK from tag XXX from reader XXX is:

FF	**04**	**28**	**?? ??**	**00**	**80 00**	**?? ??**	**?? ??**
SOH	Length	OpCode	Time-out (ms)	TM Option	Transaction Type Code	Agency Code	CRC

ACK Response

FF	**0A**	**28**	**00 00**	**00**	**80 00**	**?? ?? ?? ??**	**?? ??**
SOH	Length	TM OpCode	Status	TM Option	Transaction Type Code	Tag ID	CRC

NACK Response

FF	**0B**	**28**	**?? ??**	**00**	**80 00**	**?? ??**
SOH	Length	TM OpCode	Status	TM Option	Transaction Type Code	CRC

No Response

FF	**00**	**28**	**04 00**	**25 AA**
SOH	Length	TM OpCode	Status	CRC

Read Request (28h; C003h)

The Read Request command reads data from the specified area of the specified tag. This command contains the following request fields:

Read Request Fields

Field	Value	Description
TM OpCode	0x28	TM OpCode for tag modification operations
Timeout	[2 bytes]	Indicates how long the command should spend attempting the operation, in milliseconds.
TM Options	0x00	Reserved for Future Use.
Transaction Type Code	0xC003	Allegro/Title-21 code indicating operation to perform.
Options	[1 byte]	Command specific options. • Determines whether the AntiPlayBack/BIST data will be included in the response.
Start Page Number	[2 bytes]	Indicates which page of the tag is to be read.
Page Count	[1 byte]	Number of pages to read.
Tag ID	[4 bytes]	*Optional,* based on value of Options parameter. Indicates the ID of the tag to operate on.
User Password/ Global Password	[4/8 bytes]	Optional, based on the value of the Options parameter. The password to operation on the tag, if required.

Examples

An example command requesting XXX be written to tag XXX with a User Password = 0xXXX is:

FF	**0C**	**28**	**?? ??**	**00**	**C0 03**	**??**	**?? ??**	**??**	**?? ?? ?? ??**	**?? ??**
SOH	Length	TM OpCode	Timeout (ms)	TM Option	Transaction Type Code	Option	Page Number	Page Count	Tag ID	CRC

ACK Response

FF	**?? + *N***	**28**	**00 00**	**00**	**C0 03**	**??**	**?? ?? ?? ??**	**?? ??**	**?? .. ..**	**??**	**NN**	**NN**	**?? ??**

SOH	Length	TM OpCode	Status	TM Option	Transaction Type Code	Options	Tag ID	Page Number	AntiPlay-Back (0, 1, 2) [Based on Options]	Page Count	Page Data	CRC

NACK Response

FF	0B	28	04 0A	00	C0 03	??	?? ?? ?? ??	?? ??
SOH	Length	TM OpCode	Status	TM Option	Transaction Type Code	Options	Tag ID	CRC

No Response

FF	00	28	04 00	25 AA
SOH	Length	TM OpCode	Status	CRC

Random Number Request (28h; D001h)

The Random Number Request command requests a 32-bit random number from the specified tag which is used in the P/W authentication scheme. This command also specifies which page is to be read or written to with the encrypted P/W on the next cycle. This command contains the following request fields:

Random Number Request Fields

Field	Value	Description
TM OpCode	0x28	TM OpCode for tag modification operations
Timeout	[2 bytes]	Indicates how long the command should spend attempting the operation, in milliseconds.
TM Options	0x00	Reserved for Future Use.
Transaction Type Code	0xD001	Allegro/Title-21 code indicating operation to perform.
Options	[1 byte]	Command specific options
Tag ID	[4 bytes]	Indicates the ID of the tag to operate on.
Page Number	[2 bytes]	Species which page is to be operated on in the next transaction.
Next Command	[2 bytes]	Specifies which command the reader will be sending ot the tag on the next transaction, by Transaction Type Code. Only Read and Write Request commands are supported.

Examples

An example command:

FF	**0C**	**28**	**?? ??**	**00**	**D0 01**	**??**	**?? ?? ?? ??**	**?? ??**	**?? ??**	**?? ??**
SOH	Length	TM OpCode	Timeout (ms)	TM Option	Transaction Type Code	Option	Tag ID	Page Number	Next Command	CRC

ACK Response

FF	**?? + *N***	**28**	**00 00**	**00**	**D0 01**	**?? ?? ?? ??**	**?? ??**	**?? ??**
SOH	Length	TM OpCode	Status	TM Option	Transaction Type Code	Random Number	ATA Page Number	CRC

NACK Response

FF	**0B**	**28**	**04 0A**	**00**	**D0 01**	**??**	**?? ?? ?? ??**	**?? ??**
SOH	Length	TM OpCode	Status	TM Option	Transaction Type Code	Options	Tag ID	CRC

No Response

FF	**00**	**28**	**04 00**	**25 AA**
SOH	Length	TM OpCode	Status	CRC

TDMA Read Request (28h; E003h)

The TDMA Read Request command returns the tag ID from the **first tag to respond** only. This command contains the following request fields:

TDMA Read Request Fields

Field	Value	Description
TM OpCode	0x28	TM OpCode for tag modification operations
Timeout	[2 bytes]	Indicates how long the command should spend attempting the operation, in milliseconds.
TM Options	0x00	Reserved for Future Use.
Transaction Type Code	0xE003	Allegro/Title-21 code indicating operation to perform.
Options	[1 byte]	Command specific options
Number of Slots	[1 byte]	Specifies how many slots are available for the tags to choose from. Valid values from 0x01-0xFF

Examples

An example command is:

FF	**??**	**28**	**?? ??**	**00**	**E0 03**	**??**	**??**	**?? ??**
SOH	Length	TM OpCode	Timeout (ms)	TM Option	Transaction Type Code	Option	Number of Slots	CRC

ACK Response

FF	**0B**	**28**	**00 00**	**00**	**E0 03**	**??**	**?? ?? ?? ??**	**?? ??**
SOH	Length	TM OpCode	Status	TM Option	Transaction Type Code	Option	Tag ID	CRC

NACK Response

FF	**0B**	**28**	**04 0A**	**00**	**E0 03**	**??**	**?? ?? ?? ??**	**?? ??**
SOH	Length	TM OpCode	Status	TM Option	Transaction Type Code	Options	Tag ID	CRC

No Response

FF	**00**	**28**	**04 00**	**25 AA**
SOH	Length	TM OpCode	Status	CRC

Jump to Reset Request (2Ch; D203h)

The Jump to Reset Request command requests the tag perform a hard reset. The reset will occur the same as a hardware reset and the decision is made by the tag to perform a cold boot or a warm boot by analyzing the first 32 bits of page 0000 in the tag. If the bits are all 0s or all 1s, then a cold boot will be performed, otherwise a warm boot will occur. This command contains the following request fields:

Jump to Reset Request Fields

Field	Value	Description
TM OpCode	0x2C	TM OpCode for tag modification operations
Timeout	[2 bytes]	Indicates how long the command should spend attempting the operation, in milliseconds.
TM Options	0x00	Reserved for Future Use.
Transaction Type Code	0xD203	Allegro/Title-21 code indicating operation to perform.

Examples

An example command is:

FF	**05**	**2C**	**?? ??**	**00**	**D2 03**	**?? ??**
SOH	Length	TM OpCode	Timeout (ms)	TM Option	Transaction Type Code	CRC

NACK Response

FF	00	2C	04 00	65 2E
SOH	Length	TM OpCode	Status	CRC

eGo/SeGo Tag Command Set

The eGo/SeGo tag commands are used to operate oneGo/SeGo tags and perform operations specific to those tags. These commands can only be used when the Tag Protocol of the reader is set to eGo/SeGo (0x001B or 0x001C) using Set Current Tag Protocol (93h). These commands cannot be run when in Bootloader mode, only in Application mode.

eGo/SeGo Tag Commands

OpCode	Command Name
0x21	Read Tag ID Single (21h)
0x22	Read Tag ID Multiple (22h)
0x24	Write Tag Data (24h)
0x25	Lock Tag Data (25h)
0x28	Read Tag Data (28h)
0x2D	Custom Tag Operations (2Dh)

Command Syntax

All eGo/SeGo tag commands follow the same standard syntax. Each command has the following common fields followed by additional fields required for the specific operation being performed:

Standard Request Fields

Field	Value	Description
TM OpCode	0xXX	TM OpCode as defined in eGo/SeGo Tag Commands
Timeout	[2 bytes]	Indicates how long the command should spend attempting the operation, in milliseconds.
TM Options	0x01	Must be set to 0x01, indicating Command Type and eGo/SeGo specific fields to follow.
Command Type	[1 byte]	Depending on the operation indicates either the Group Select Options to apply or a specific sub-command.

Group Select Options

The following table defines the Command Type values to use for the desired Group Select Option when performing a Read Tag ID Single (21h), Read Tag ID Multiple (22h) or Write Tag Data (24h). The Group Select Option along with the Select Fields (Byte Address, Byte Mask and Word Data) determine which tags will respond to the specified query.

Group Select Options

***Command Type* Value**	**Group Select Option**	**Tag Selection Behavior**
0x00	GROUP_SELECT_EQ	All tags in the field whose data EQUALS the specified Select Fields will respond.
0X01	GROUP_SELECT_NE	All tags in the field whose data does NOT EQUAL the specified Select Fields will respond.
0X02	GROUP_SELECT_GT	All tags in the field whose data is GREATER THAN the specified Select Fields will respond.

***Command Type* Value**	**Group Select Option**	**Tag Selection Behavior**
0X03	GROUP_SELECT_LT	All tags in the field whose data is LESS THAN the specified Select Fields will respond.
0X04	GROUP_UNSELECT_EQ	All tags **except** those in the field whose data EQUALS the specified Select Fields will respond.
0X05	GROUP_UNSELECT_NE	All tags **except** those in the field whose data does NOT EQUAL the specified Select Fields will respond.
0X06	GROUP_UNSELECT_GT	All tags **except** those in the field whose data is GREATER THAN the specified Select Fields will respond.
0X07	GROUP_UNSELECT_LT	All tags **except** those in the field whose data is LESS THAN the specified Select Fields will respond.

Read Tag ID Single (21h)

The **Read Tag ID Single** command executes a query for tags matching the criteria specified by the Command Type and subsequent fields and returns the first tag found.

Read Tag ID Single Request Fields

Field	Value	Description
TM OpCode	0x21	TM OpCode
Timeout	[2 bytes]	Indicates how long the command should spend attempting the operation, in milliseconds.
TM Options	Bit 0	• **1** - Indicates Command Type and additional fields to follow.
	Bit 4 *(LSB=bit 0)*)	• **0 -** Metadata flags must not be passed and Meta Data will not be returned. • **1** - Metadata flags must be passed and the corresponding Metadata shall be returned with the tag EPC.
Metadata Flags (to specify more than one OR the values together)	0x0000	When no flags are set no meta data will be returned, only the tag EPC (including PC bits and tag CRC)
	0x0001	When bit 0 is set the Read Count will be returned
	0x0002	When bit 1 is set the LQI/RSSI will be returned
	0x0004	When bit 2 is set the Antenna ID will be returned
	0x0008	When bit 3 is set the Frequency will be returned
	0x0010	When bit 4 is set the Timestamp will be returned
	0x0020	When bit 5 is set the RFU (T*hingMagic Only*) will be returned
	0x0040	When bit 6 is set the Protocol is returned.
Command Type	[1 byte]	Indicates the Group Select criteria to apply as defined in Group Select Options.
Byte Address	[1 byte]	
Byte Mask	[1 byte]	
Word Data	[8 bytes]	

Examples

An example command:

FF	**0E**	**21**	**?? ??**	**01**	**00**	**??**	**??**	**?? ?? ?? ?? ?? ?? ?? ??**	**?? ??**
SOH	Length	OpCode	Time-out (ms)	TM Option	Command Type	Byte Address	Byte Mask	Word Data	CRC

ACK Response

FF	**0C**	**21**	**?? ??**	**01**	**??**	**?? ?? ?? ?? ?? ?? ?? ?? ?? ??**	**?? ??**
SOH	Length	OpCode	Status	TM Option	Command Type	Tag Data	CRC

NACK Response

FF	**02**	**21**	**?? ??**	**01**	**??**	**?? ??**
SOH	Length	OpCode	Status	TM Option	Command Type	CRC

No Response

FF	**00**	**21**	**04 00**	**B4 83**
SOH	Length	TM OpCode	Status	CRC

Read Tag ID Multiple (22h)

The **Read Tag ID Multiple** command performs a search for the specified period of time then returns the number of tags that have been found. Afterwards, multiple Get Tag Buffer (29h) commands can be sent to receive the found tag IDs.

Standard Syntax

The search criteria for the Standard Syntax which allows control over the select criteria is specified by the Command Type and subsequent fields.

Read Tag ID Multiple Request Fields

Field	Value	Description
TM OpCode	0x22	TM OpCode
TM Options	0x01	Indicates Command Type and additional fields to follow.
Search Flags	0x0000	Reserved for Future Use.
Timeout	[2 bytes]	Indicates how long the command should spend attempting the operation, in milliseconds.
Command Type	[1 byte]	Indicates the Group Select criteria to apply as defined in Group Select Options.
Byte Address	[1 byte]	
Byte Mask	[1 byte]	
Word Data	[8 bytes]	

Examples

An example command requesting :

FF	10	22	01	00 00	?? ??	00	??	??	?? ?? ?? ?? ?? ?? ?? ??	?? ??
SOH	Length	OpCode	TM Option	Search Flags	Timeout (ms)	Command Type	Byte Address	Byte Mask	Word Data	CRC

ACK Response

FF	??	22	?? ??	01	00 00	??	?? ??	?? ??
SOH	Length	OpCode	Status	TM Option	Search Flags	Command Type	Tag IDs Detected	CRC

NACK Response

FF	02	22	?? ??	01	??	?? ??
SOH	Length	OpCode	Status	TM Option	Command Type	CRC

No Response

FF	**00**	**22**	**04 00**	**84 E0**
SOH	Length	TM OpCode	Status	CRC

Minimal Syntax

The **Read Tag ID Multiple** command can also be used in a reduced syntax format. In this case only the Timeout is specified. This syntax performs a search for the specified period of time with no selection criteria, returning the number of tags that have been found.

Example

FF	**02**	**22**	**03 E8**	**E5 6A**
SOH	Length	OpCode	Timeout (ms)	CRC

An example response is as follows:

FF	**01**	**22**	**00 00**	**02**	**46 BA**
SOH	Length	OpCode	Status	# Tag IDs Found	CRC

Write Tag Data (24h)

The **Write Tag Data** command writes data to a tag. The tag to write to, the location and the data to write are specified in the fields as defined below:

Write Tag Data Request Fields

Field	Value	Description
TM OpCode	0x24	TM OpCode
Timeout	[2 bytes]	Indicates how long the command should spend attempting the operation, in milliseconds.
TM Options Note: TM Options field combines bits 0-4 indicating the verification method and bits 5 & 6 for authentication information. For the final TM Options setting, the two "fields" should be OR'd.	[1 byte] excluding bits 5 & 6 *(LSB = bit 0)*	• **0x00** = A READ is executed after the WRITE has reported success for verification. Lock if requested. Note: When 0x00 the Command Type is implicity = 0x0D and the Command Type 1 byte field should be removed from the request command. • **0x01** = No verification is executed after WRITE reports success. • **0x02** = A READ_VERIFY is executed after the WRITE reports success for verification. • **0x03** = Only used with Command Type = 0x0E or 0x93. Indicates extra *Select* fields will be specified.
	bits 5 & 6 *(LSB = bit 0)*	Specify authentication method to use: • **0x00** = authentication is disabled and *Key* values must not be passed. • **0x20** = RFU • **0x40** = authentication is enabled and *Key* values must be passed. • **0x60** = RFU
Command Type Note: If TM Options bits 0-4=0 then the Command Type is implicity = 0x0D and this byte should not be specified in the request command.	0x0D	Indicates the eGo/SeGo **Write by Byte** operation will be used.
	0x8D	Indicates the eGo/SeGo **Write by Page** operation will be used
	0x0E	Indicates the eGo/SeGo **Write Multiple** operation will be used.
	0x93	Indicates the eGo/SeGo **Streamlined Group Select Equal Page Write** operation will be used.

Field	Value	Description
Lock	[1 byte]	• **0x00** = no lock • **0x01** = lock the data specified by Write Data **Write by Page** won't lock if authentication information is not specified. **Write multiple** won't lock
Write Address	[1I4byte]	Indicates the start address of tag memory to be written: • **4 Byte Address** when TM Option = 0xX0 • **1 Byte Address** otherwise
Select Command Type	[1 byte]	Indicates the Group Select criteria to apply as defined in Group Select Options. Only passed when TM Option=0x03. For Command Type = 0x0E, indicates Select Type For Command Type = 0x93, RFU
Select Address	[1 byte]	Only passed when TM Option=0x03.
Select Mask	[1 byte]	Only passed when TM Option=0x03. For Command Type = 0x0E, indicates Select Mask For Command Type = 0x93, RFU
Tag ID I Select Data	[8 bytes]	When: • Command Type = 0x0D, 0x0E or 0x8D: **8 bytes = Tag ID** • Command Type = 0x93 AND TM Options=0x03: **[1 byte] = Select Data** **[7 bytes] = RFU** • Command Type = 0x93 AND TM Options=0x01 or 0x02 **[1 byte] = Select Address** **[1 byte] = Select Data** **[6 bytes] = RFU**
Write Data	[1I8 byte]	Indicates the data to be written to the specified tag starting at the specified address. • **1 Byte** when Command=0x0D and 0x0E • **8 Bytes (1 page)** when Command=0x8D and 0x93
Key Address	[1 byte]	Only passed when authentication enabled in TM Options.
Key Length in Bytes	[1 byte]	Only passed when authentication enabled in TM Options.

Field	Value	Description
Key	[0-N bytes]	Only passed when authentication enabled in TM Options. Note: Value passed with MSB first.

Examples

An example command requesting :

FF	**0F**	**24**	**?? ??**	**01**	**0D**	**??**	**??**	**?? ?? ?? ?? ?? ?? ?? ??**	**??**	**?? ??**
SOH	Length	OpCode	Timeout (ms)	TM Option	Command Type	Lock	Write Address	Tag ID	Write Data	CRC

ACK Response

When Command Type = 0x0D or 0x0E,

FF	**03**	**24**	**?? ??**	**??**	**0D I OE**	**??**	**?? ??**
SOH	Length	OpCode	Status	TM Option	Command Type	Verified Write Data	CRC

When Command Type = 0x8D

FF	**0A**	**24**	**?? ??**	**??**	**8D**	**?? ?? ?? ?? ?? ?? ?? ??**	**?? ??**
SOH	Length	OpCode	Status	TM Option	Command Type	Verified Write Data	CRC

When Command Type = 0x93

FF	**13**	**24**	**?? ??**	**??**	**93**	**??**	**?? ?? ?? ?? ?? ?? ?? ??**	**?? ?? ?? ?? ?? ?? ?? ??**	**?? ??**
SOH	Length	OpCode	Status	TM Option	Command Type	Tag ID Length	Tag ID (*length defined by ID Length*)	Verified Write Data	CRC

Note

ACK Status will be:
0x0000 FAULT_SUCCESS_CODE
0x0403 FAULT_WRITE_PASSED_LOCKED_FAILED

NACK Response

FF	**02**	**24**	**?? ??**	**01**	**0D**	**?? ??**
SOH	Length	OpCode	Status	TM Option	Command Type	CRC

No Response

FF	**00**	**24**	**04 00**	**E4 26**
SOH	Length	TM OpCode	Status	CRC

Lock Tag Data (25h)

The **Lock Tag Data** command locks and unlocks a tag's memory locations. The tag to (un)lock and memory location to be (un)locked are specified in the fields as defined below:

Lock Tag Data Request Fields

Field	Value	Description
TM OpCode	0x25	TM OpCode
Timeout	[2 bytes]	Indicates how long the command should spend attempting the operation, in milliseconds.
TM Options	0x01	Indicates Command Type and additional fields to follow.
Note: TM Options field combines bit 0 indicating general processing information and bits 5 & 6 indicating authentication method. For the final TM Options setting, the two "fields" should be OR'd.	bits 5 & 6 *(LSB = bit 0)*	Specify authentication method to use: • **0x00** = authentication is disabled and *Key* values must not be passed. • **0x20** = RFU • **0x40** = authentication is enabled and *Key* values must be passed. • **0x60** = RFU

Field	Value	Description
Command Type	0x00	Performs a QueryLock, immediate followed by an UnLock
	0x01	Performs a QueryLock, immediate followed by a Lock
	0x0F	LockByte operation. Performs QLock/Lock/QLock
	0x10	UnLock Byte. Performs QLock/UnLock/QLock
	0x11	QueryLock
	0x8F	Lock Page. Performs QLock/Lock/QLock
	0x90	UnLock Page. Performs QLock/UnLock/QLock
Lock Address	[1 byte]	Indicates the address of tag memory to be (un)locked.
Tag ID	[8 byte]	Indicates the Tag ID of the tag to be (un)locked.
Key Address	[1 byte]	Only passed when authentication enabled in TM Options.
Key Length in Bytes	[1 byte]	Only passed when authentication enabled in TM Options.
Key	[0-N bytes]	Only passed when authentication enabled in TM Options. Note: Value passed with MSB first.

Examples

An example command requesting :

FF	**0D**	**25**	**?? ??**	**01**	**0F**	**??**	**??**	**??**	**??**	**??**	**??**	**??**	**??**	**??**	**??**	**??**
SOH	Length	OpCode	Timeout (ms)	TM Option	Command Type	Lock Address	Tag ID								CRC	

ACK Response

When Command Type = 0x00 or 0x01

FF	**03**	**25**	**?? ??**	**??**	**00 I 01**	**??**	**?? ??**
SOH	Length	OpCode	Status	TM Option	Command Type	(Un)Lock Response	CRC

When Command Type = all others

FF	**04**	**25**	**?? ??**	**??**	**??**	**??**	**??**	**?? ??**
SOH	Length	OpCode	Status	TM Option	Command Type	Lock Response	Query Lock Response	CRC

NACK Response

FF	**03**	**25**	**?? ??**	**??**	**??**	**??**	**?? ??**
SOH	Length	OpCode	Status	TM Option	Command Type	Lock Response	CRC

No Response

FF	**00**	**25**	**04 00**	**F4 07**
SOH	Length	TM OpCode	Status	CRC

Note

For eGo Plus tags a key must be provided for lock/unlock operations. If a key is not provided then the tag will not respond. In that case a **status=0x0400** is the expected command response.

Read Tag Data (28h)

The **Read Tag Data** command reads data from a tag. The tag to read from and the location to read the data from are specified in the fields as defined below:

Read Tag Data Request Fields

Field	Value	Description
TM OpCode	0x28	TM OpCode
Timeout	[2 bytes]	Indicates how long the command should spend attempting the operation, in milliseconds.
TM Options Note: TM Options field combines bits 0-4 indicating general processing information and bits 5 & 6 indicating authentication method. For the final TM Options setting, the two “fields” should be OR’d.	[1 byte]	Indicates Command Type and additional fields to follow: • **0x01** = For Standard Read Operations
	bits 5 & 6 *(LSB = bit 0)*	Specify authentication method to use: • **0x00** = authentication is disabled and *Key* values must not be passed. • **0x20** = RFU • **0x40** = authentication is enabled and *Key* values must be passed. • **0x60** = RFU
Command Type	0x0C	eGo/SeGo Read, or Protected Read
	0x0B	eGo/SeGo Data_Read
	0x12	eGo/SeGo Read_Verify Note: Requires a Write to occur **immediately** before.
	0x80	eGo/SeGo Streamline_Group_Select_Equal_Page_Read Note: Only works with eGo Plus tags.
	0x92	eGo/SeGo Read_Verify_Page Note: Requires a Write to occur **immediately** before.
RFU	[1 byte]	Reserved for Future Use
Read Byte Count	[1 byte]	Number of bytes starting at *Read Address* to read. Can request 1 to 8 bytes.
Read Address	[1 byte]	Indicates the start address of tag memory to be read.

Field	Value	Description
Tag ID I Select Data	[8 bytes]	When: • Command Type = 0x0B, 0x0C, 0x12 or 0x92: **8 bytes = Tag ID** • Command Type = 0x80 **[1 byte] = Select Address** **[1 byte] = Select Data** **[6 bytes] = RFU**
Key Address	[1 byte]	Only passed when authentication enabled by TM Options.
Key Length in Bytes	[1 byte]	Only passed when authentication enabled by TM Options.
Key	[0-N bytes]	Only passed when authentication enabled by TM Options. Note: Value passed with MSB first.

Examples

An example command requesting :

FF	**0F**	**28**	**?? ??**	**01**	**0C**	**??**	**??**	**??**	**?? ?? ?? ?? ?? ?? ?? ??**	**?? ??**
SOH	Length	OpCode	Timeout (ms)	TM Option	Command Type	RFU	Read Byte Count	Read Address	Tag ID	CRC

ACK Response

FF	**??**	**28**	**?? ??**	**01**	**0C**	**??**	**?? ??**
SOH	Length	OpCode	Status	TM Option	Command Type	Read Data	CRC

When Command Type = 0x80

FF	**??**	**28**	**?? ??**	**??**	**80**	**??**	**?? ?? ?? ?? ?? ?? ?? ??**	**?? ?? ?? ?? ?? ?? ?? ??**	**?? ??**
SOH	Length	OpCode	Status	TM Option	Command Type	Tag ID Length	Tag ID (*length defined by ID Length*)	Read Data	CRC

NACK Response

FF	**02**	**28**	**?? ??**	**01**	**0C**	**?? ??**
SOH	Length	OpCode	Status	TM Option	Command Type	CRC

No Response

FF	**00**	**28**	**04 00**	**25 AA**
SOH	Length	TM OpCode	Status	CRC

Custom Tag Operations (2Dh)

The **Custom Tag Operations** command provides access to several eGo/SeGo tag specific operations including: Fail, Success, Initialize, Resend, Read_All_Data, Read_All_Lock, and RN_Request. The operation to be performed is indicated by the Command Type field:

Custom Tag Operations Request Fields

Field	Value	Description
TM OpCode	0x2D	TM OpCode
Timeout	[2 bytes]	Indicates how long the command should spend attempting the operation, in milliseconds.
TM Options	0x01	Indicates Command Type to follow.
Command Type	0x08	Fail
	0x09	Success
	0x0A	Initialize
	0x15	Resend
	0x81	RN Request
	0x82	Tag Authentication. When specified the *Key* fields also must be passed.
	0x83	Mutual Authentication. When specified the *Key* fields also must be passed.

Field	Value	Description
Key Address	[1 byte]	Only passed when Command=0x82 or 0x83.
Key Length in Bytes	[1 byte]	Only passed when Command=0x82 or 0x83.
Key	[0-N bytes]	Only passed when Command=0x82 or 0x83. Note: Value passed with MSB first.

Examples

An example command requesting :

FF	**04**	**2D**	**?? ??**	**01**	**0C**	**?? ??**
SOH	Length	OpCode	Timeout (ms)	TM Option	Command Type	CRC

ACK Response

FF	**05**	**2D**	**?? ??**	**01**	**0C**	**?? ... NN**	**?? ??**
SOH	Length	OpCode	Status	TM Option	Command Type	Tag Data (0-N based on Command Type)	CRC

NACK Response

FF	**02**	**2D**	**?? ??**	**01**	**??**	**?? ??**
SOH	Length	OpCode	Status	TM Option	Command Type	CRC

No Response

FF	**00**	**2D**	**04 00**	**75 0F**
SOH	Length	TM OpCode	Status	CRC

ATA Tag Command Set

The ATA tag commands are used to perform operations specific to ATA tags. These commands can only be used when the Tag Protocol of the reader is set to ATA (0x001D) using Set Current Tag Protocol (93h). These commands cannot be run when in Bootloader mode, only in Application mode.

ATA Tag Commands

OpCode	**Command Name**
0x21	Read Tag ID Single (21h)
0x22	Read Tag ID Multiple (22h) *[Not yet Implemented]*

Command Syntax

All ATA tag commands follow the same standard syntax. Each command has the following common fields followed by additional fields required for the specific operation being performed:

Standard Request Fields

Field	Value	Description
TM OpCode	0xXX	TM OpCode as defined in ATA Tag Commands
Timeout	[2 bytes]	Indicates how long the command should spend attempting the operation, in milliseconds.

Read Tag ID Single (21h)

The **Read Tag ID Single/Tag Detect** command performs a search operation and returns the first ATA tag it finds.

Read Tag ID Single Request Fields

Field	Value	Description
TM OpCode	0x21	TM OpCode
Timeout	[2 bytes]	Indicates how long the command should spend attempting the operation, in milliseconds.
TM Options Note: This and following fields are optional.	Bit 4 *(LSB=bit 0)*)	• **0 -** Metadata flags must not be passed and Meta Data will not be returned. • **1** - Metadata flags must be passed and the corresponding Metadata shall be returned with the tag EPC.
Metadata Flags (to specify more than one OR the values together)	0x0000	When no flags are set no meta data will be returned, only the tag EPC.
	0x0001	When bit 0 is set the Read Count will be returned
	0x0002	When bit 1 is set the LQI/RSSI will be returned
	0x0004	When bit 2 is set the Antenna ID will be returned
	0x0008	When bit 3 is set the Frequency will be returned
	0x0010	When bit 4 is set the Timestamp will be returned
	0x0020	When bit 5 is set the RFU (*ThingMagic Only*) will be returned
	0x0040	When bit 6 is set the Protocol is returned.

Examples

An example, without TM Options, command:

FF	**02**	**21**	**?? ??**	**?? ??**
SOH	Length	OpCode	Time-out (ms)	CRC

ACK Response

FF	**0A**	**21**	**?? ??**	**?? ?? ?? ?? ?? ?? ?? ??**	**?? ??**
SOH	Length	OpCode	Status	Tag ID	CRC

NACK Response

FF	**00**	**21**	**?? ??**	**?? ??**
SOH	Length	OpCode	Status	CRC

No Response

FF	**00**	**21**	**04 00**	**B4 83**
SOH	Length	TM OpCode	Status	CRC

Read Tag ID Multiple (22h)

[Not yet implemented]

Gen2 Tag Commands

The Gen2 tag commands are used to operate on Gen2 tags and perform operations specific to those tags. These commands can only be used when the Tag Protocol of the reader is set to Gen2 (0x0005) using Set Current Tag Protocol (93h). These commands cannot be run when in Bootloader mode, only in Application mode.

Gen2 Tag Commands

OpCode	Command Name	Arguments	Return	BL	App
0x21	Read Tag Single (21h)	Timeout (ms)	Tag ID	N	Y
0x22	Read Tag Multiple (22h)	Timeout (ms), Antennas Flag	Multiple Tag IDs	N	Y
0x23	Write Tag EPC (23h)	Timeout (ms), lock bit, password, tag ID	None	N	Y
0x24	Write Tag Data (24h)	Timeout (ms), lock bit, address, data	None	N	Y
0x25	Lock Tag (25h)	Timeout (ms), protocol specific data	None	N	Y
0x26	Kill Tag (26h)	Timeout (ms), protocol specific data	None	N	Y
0x28	Read Tag Data (28h)	Timeout (ms), Address, Tag ID	Tag data	N	Y
0x29	Get Tag Buffer (29h)	various	various	N	Y
0x2A	Clear Tag Buffer (2Ah)	none	none	N	Y
0x2D	Gen2 Tag Specific (2Dh)	Timeout (ms), Chip Type, option, Kill password, Access password, Tag ID	none	N	Y
0x2E	Erase Block Tag Specific (2Eh)	Timeout (ms), chip type, option addr, mem bank, number of words to erase	none	N	Y

Tag Singulation/Select Functionality

Many of the Gen2 tag commands now support the ability to singulate a specific tag or inventory only tags matching a defined criteria, i.e. matching on values in the EPC, TID and User Memory banks.

Select Algorithm and Parameters

The algorithm used to perform a Gen2 Select and its impact on subsequent Gen2 Query operations on a population of tags is determined by several user defined settings which either correspond directly to or are used to determine the various Gen2 Select and Query parameters as defined by the EPCGlobal Gen2 v1.2 Specification. The current user controlled options are:

Gen2 Session (User Controlled)

This setting determines which tag inventory flag is altered when a tag responds to a Gen2 Query (each flag has a unique persistence profile, as defined by the Gen2 Specification). The value of Gen2 Session is set using the Set Protocol Configuration (9Bh) command. The supported values are 0, 1, 2, or 3.

Select Invert (User Controlled)

This setting is used to determine the Gen2 Action value sent in the Gen2 Select command. The value of Select Invert is defined using bit 3 of the Select Option field in the Tag Singulation Fields. The supported values are:

- **0** (False) - Tags which match the Select criteria are to respond. Set Gen2 Action=0.
- **1** (True) - Tags which DO NOT match the Select criteria are to respond. Set Gen2 Action=4.

The settings specified for Gen2 Session and Select Invert determine the settings within the Select command which is sent before the corresponding Gen2 Query and the settings in the subsequent Gen2 Query(s). These implicit settings used by the Gen2 Select are:

Gen2 Action (defined by Select Invert)

This parameter can be one of 8 values, as defined by the Gen2 specification, which determine which of 4 possible flag actions (assert, de-assert, negate, or leave alone) will be done if the criteria matches and, similarly, which of the 4 possible flag actions will be done if the criteria does not match. Only two values are currently used:

- **0 -** Assert (or put in state “A” for inventory flags) the target flag if there IS a match; de-assert (or put in state “B” for inventory flags) the target flag if there IS NOT a match.
- **4 -** Assert (or put in state “A” for inventory flags) the target flag if there IS NOT a match; de-assert (or put in state “B” for inventory flags) the target flag if there IS a match

Gen2 Target (Static)

This setting determines which inventory flag or SL flag is going to have its state determined by the matching algorithm. Currently always set to ‘4’, indicating the Gen2 Select command modifies a tag’s SL flag.

The following table defines the currently supported User Settings and the resulting behavior of the Gen2 Select and Gen2 Query:

Gen2 Select and Query Behavior

User Settings	Select Behavior	Query Behavior	Comments
• Gen2 Session = 0,1,2,3 • Invert = 0	Gen2 Select Settings: • Target = 4 • Action = 0 If tags match the criteria, put their SL flag in the ‘Assert’ state; and SL of non-matching tags into the ‘De-assert’ state.	Gen2 Query Settings: • SEL = 3 • Target = “A” • Session = [User Defined] Ask tags to respond if their SL flag is in the ‘Assert’ state and their session appropriate inventory flag is in the ‘A’ state. Once a tag responds, it puts the inventory flag in the ‘B’ state, preventing further matches until the inventory flag’s Flag Persistence Rules returns it to the ‘A’ state.	Tag state persistence before a Query is based on SL flag persistence; Tag state persistence after a Query is based on inventory flag corresponding to the Session used.
• Gen2 Session = 0,1,2,3 • Invert = 1	Gen2 Select Settings: • Target = 4 • Action = 4 If tags match the criteria, put their SL flag in the ‘De-assert’ state; and SL of non-matching tages into the ‘Assert’ state.		

Select Process

The following defines how the Select process works when attempting to select tags that match a defined criteria:

1. The Reader issues a Select containing the desired tag memory values and instructions for the tag to assert if its contents matches that specified in the request (and, conversely, de-assert the SL flag if it does not match) as defined by the Tag Singulation Fields. The de-assert will generally have no effect because the de-asserted state is the default, but is helpful if tags still have their SL flag asserted from a previous Select.
   – Tags that are selected, at this point, are not selected within a specific Session. The persistence of their state depends entirely on that of the SL flag.
2. A Query is issued which specifies the flag settings which must match before a tag will respond:
   – The SL flag must be asserted
   – The Session flag for session 0, 1, 2, or 3 (specific Session value is in the Query and depends on the reader's Session setting) must be 'A' (the default value).
3. Matching tags will respond to the Query, but after responding, will change their own state in the following way:
   – The Inventory flag corresponding to the Session specified in the Query will be changed to the 'B' state.
   – The SL flag will remain asserted (per its ongoing Flag Persistence Rules)
4. If subsequent indentical Queries are issued (identical to the first), this tag will remain silent until the Flag Persistence Rules for the inventory flag that was put into the 'B' state cause the flag to fall back into the 'A' state. At that point, the tag will respond again (assuming that the persistence rules of the SL flag are still keeping it in the 'assert' state).

Note

A search with **Invert=1** specified will perform the same steps except in step 1 the tag will "**de-assert** if its contents matches that specified in the request (and, conversely, **assert** the SL flag if it does not match) as defined by the Tag Singulation Fields."

Note

A Select will be performed once per antenna when Select is specified during a Read Tag Multiple (22h) with multiple antennas configured.

Flag Persistence Rules

Session 0

- Keeps state as long as tag is energized

- Returns to default state as soon as the tag is no longer energized

Its state will often get reset during the course of executing a single command, for example, between inventory rounds, or when there is a frequency hop, or when a new antenna is selected during a Read Tag Multiple search. the result is that when the session is set to ‘0’, all tags will respond to every appropriate Query, considerably lengthening the time to inventory a large population of tags. Session 0 is typically used for operations where a single tag is expected to be in the field, for example, printers.

Session 1

- Keeps its state between 0.5 and 5 seconds, regardless of whether the tag is energized or not.

The intent is that when the session is set to 1 the tag will respond to an appropriate Query immediately, and then respond periodically if the Query is repeated by the reader. This allows a larger population of tags to be reliable read. Session 1 is typically used in applications where a large population of tags is being continuously inventoried allowing for it to be determined when tags enter and leave the field.

Session 2, 3 and SL Flags

- Keeps state as long as the tag is energized.
- Keeps its state for at least 2 seconds after the tag is no longer energized and will refresh its state if the tag is re-energized during that period.

The intent is that when the session is set to ‘2’ or ‘3’ a tag will only respond once to an appropriate Query, then remain silent as the Query is repeated by the reader to elicit responses from other tags. Typically used in operations when you are performing an action on tag or population of tags which you do not want/need repeated.

Operations supporting Tag Singulation/Select

The commands currently supporting tag singulation through Select are:

- Read Tag Single (21h)
- Read Tag Multiple (22h)
- Write Tag Data (24h)
- Lock Tag (25h)
- Kill Tag (26h)

- Read Tag Data (28h)

The following fields apply to all the specified commands. Please check each command for exact order, and any exceptions, as they may not all correspond with the order below.

Tag Singulation Fields

Field	Values	Description
Select Option	0x00	Select functionality is disabled. First tag found will be the tag operated on. No other Tag Singulation Fields should be specified. Option field must **always** be specified.
	0x01	Select on the value of the EPC. Requires all fields except the *Select Address* field.
	0x02	Select on contents of TID memory bank (Gen2 bank 0x02). Requires all fields.
	0x03	Select on contents of User Memory memory bank (Gen2 bank 0x03). Requires all fields.
	0x04	Select on contents of the EPC memory bank (Gen2 bank 0x01). Requires all fields.
	0x08	Sets Invert Flag. This results in tags NOT matching the specified Tag Singulation Fields will be returned, as defined in Select Algorithm and Parameters.
Select Address	4 bytes	Contains the offset, in bits, within the memory bank, specified by the *Option* value, at which the comparison is to start. NOTE: specifying *Option=0x04* and *Select Address=0x20* is the equivalent, for Gen2 v1 tags, of specifying *Option=0x01*, both specify a comparison against the tag EPC ID data. Note: Addresses are always zero-based. Specifying 0x00 indicates starting at the first address location.
Select Data Length	1 byte	Contains the length of the data (*Select Data*) to be compared, in bits, to the EPC when *Option*=0x01, or to the data beginning at *Select Address* for other options.
Select Data	M bytes	Contains the data to be compared against the specified tag data (memory bank and address, or EPC as specified by the *Option* value)

Read Tag Single (21h)

The **Read Tag Single** command will search for a tag for the specified timeout or a single tag is found, whichever comes first. The search criteria is specified using the Tag Singulation Fields. If Option=0x00 is specified it will return with the first tag it finds, otherwise it will only return Success and the found EPC if a tag matching the specified criteria is found. If no tag is read, a fault code is returned.

In addition to the Tag Singulation Fields the basic **Read Tag Single** command takes a 16-bit timeout value in milliseconds. The command will return after a tag is found or the timeout expires, whichever happens first.

The basic syntax which returns only the tag EPC is defined in Get Tag EPC. With additional Option bits set Read Tag Single can also return Tag Read Meta Data using the syntax in Get Tag EPC and Meta Data.

Get Tag EPC

The following example shows a search requesting a tag matching the following criteria for a max timeout of 1000 ms. This example uses the Tag Singulation/Select Functionality with Option=0x03, indicating Tag Selection based on the contents of User Memory, specifically:

Memory Bank = User Memory.

Starting Address = bit 32

Select Data = 0x1234

FF	0A	21	03 E8	03	00 00 00 20	10	12	34	E5 AC
SOH	Length	OpCode	Timeout (ms)	Option	Select Address	Select Data Length	Select Data		CRC

If Option=0x00 or 0x01 were used then the unused Tag Singulation Fields must be removed from the request.

The response to this command varies depending upon the number of bits in the tag EPC of the tag found. The general response format is shown here:

FF	M+3	21	03	00 00	M bytes	?? ??	?? ??

SOH	Length	OpCode	Option	Status	EPC	TagCRC	CRC

Get Tag EPC and Meta Data

In addition to getting the tag EPC value returned you can also get Tag Read Meta Data for the found tag. This version of Read Tag Single requires bit 4 of the Option flag to be set and takes an additional Metadata Flags field which defines what metadata will be returned The following table lists the supported values for these fields.

Read Tag Single Get EPC and Metadata Request Fields

Field	Value	Description
Option	Bit 4=0 (0x0X)	No Metadata flags are specified and Meta Data will not be returned. This is the Get Tag EPC syntax. The lower bits (X) are specified as defined by Tag Singulation/Select Functionality.
	Bit 4=1 (0x1X)	Indicates that Metadata flags are to follow and the corresponding Metadata shall be returned with the tag EPC. The lower bits (X) are specified as defined by Tag Singulation/Select Functionality.
Metadata Flags (to specify more than one OR the values together)	0x0000	When no flags are set no meta data will be returned, only the tag EPC (including PC bits and tag CRC)
	0x0001	When bit 0 is set the Read Count will be returned
	0x0002	When bit 1 is set the LQI/RSSI will be returned
	0x0004	When bit 2 is set the Antenna ID will be returned
	0x0008	When bit 3 is set the Frequency will be returned
	0x0010	When bit 4 is set the Timestamp will be returned
	0x0020	When bit 5 is set the RFU (T*hingMagic Only*) will be returned
	0x0040	When bit 6 is set the Protocol is returned.
These fields are followed by the Tag Singulation/Select Functionality, used the same as defined in the Get Tag EPC syntax, if necessary.		

A response can contain the following information:

Read Tag Single Get EPC and Metadata Response Fields

Field	Length	Value
SOH	1 byte	0xFF
Length	1 byte	Based on data returned
OpCode	1 byte	0x21
Options	1 byte	As sent in request
Metadata Flags	2 bytes	Metadata contained in response
Read Count[1]	1 byte	Tag EPC/Antenna Read Count
RSSI[1]	1 byte	Return Signal Strength Indicator
Antenna ID[1]	1 byte	Antenna ID, 4 MSBs for TX and 4 LSBs for RX
Frequency[1]	3 bytes	Frequency in kHz
Timestamp[1]	4 bytes	RTC Timestamp
RFU[1]	2 bytes	Reserved for Future Use - ThingMagic Only
Protocol ID	1 byte	Protocol ID of tag read
EPC ID	N bytes	Tag EPC.
Tag CRC	2 bytes	Tag EPC CRC
CRC	2 bytes	Message CRC

1 - Conditionally returned depending on the Metadata Fields specified in the request.

An example command requesting AntennaID and Timestamp

```
Metadata Flags = 0x0004 OR 0x0010 = 0x0014
```

with no tag singulation criteria, just return the first tag found, is as follows:

FF	05	21	01	E8	10	00	14	2F 6D
SOH	Length	OpCode	Timeout		Options	Metadata Flags		CRC

Here is an example response to the example request specified above. The response contains the tag EPC info of the found tag and the requested tag read metadata: AntennaID and Timestamp:

FF	16	21	00 00	10	00	14
SO H	Length	OpCode	Status	Options	Metadata Flags	

11	00	BB	5F	04	01	23	45	67	89	AB	CD	EF	01	23	45	67	E6 C8
Ant ID	Timestamp				Tag EPC												Tag CRC

37 C4
CRC

Here is another example request and response showing the use of Tag Singulation/Select Functionality and getting the tag metadata for the specified tag:

This command requests the same tag read metadata as the previous example (AntennaID and Timestamp) except now it is selecting a tag with a specific EPC value (EPC=0x111122223333444455556666), which requires adding the appropriate Tag Singulation Fields after the Read Tag Single Get EPC and Metadata Request Fields along with updating the Option field to set the appropriate flag for the tag singulation based on EPC value

FF	12	21	01	E8	11	00	14
SOH	Length	OpCode	Timeout		Options	Metadata Flags	

60	11	11	22	22	33	33	44	44	55	55	66	66	9F	CE
Select Data Length	Select Data (EPC)												CRC	

The response contains the requested metadata and the tag EPC matching the requested tag EPC:

FF	16	21	00	00	11	00	14
SOH	Length	OpCode	Status		Options	Metadata Flags	

22	0F	C8	CD	B7	11	11	22	22	33	33	44	44	55	55	66	66	18	35
Ant ID	Timestamp				Tag EPC												Tag CRC	

FE	7D
CRC	

Read Tag Multiple (22h)

The **Read Tag Multiple** command supports several different levels of functionality. In addition to performing a Basic Search Operation for all tags in the field it can also perform advanced searching and perform operations on the tags found. The different syntax for Read Tag Multiple are defined as follows:

- Basic Tag Inventory - Searches for and returns all tags in the field.
- Tag Inventory with Select - Searches for and returns all tags in the field meeting Select criteria as defined by Tag Singulation Fields specified.
- Tag Inventory With Embedded Operations - Allows for operations (Write Tag Data, Lock Tag, Kill Tag, Read Tag Data) to be performed on each tag inventoried.

Basic Tag Inventory

The **Read Tag Multiple** command performs a search for the specified period of time then returns the number of tags that have been found. Afterwards, multiple **Get Tag Buffer** commands can be sent to receive the found tag EPCs along with tag read metadata, including the antenna the tag was read on. The command allows the user to specify the method to use when multiple monostatic antennas are connected. The user can set the two byte Search Flag to enable automatic Multi-Antenna Search:

Read Tag Multiple Search Flags

[2]Flag Value	Antenna Usage
0x0000	Use single antenna as configured by the most recent Set Antenna command.
[1]0x0001	Automatically search on both monostatic antennas, **starting with Antenna 1**. The search cycles through antennas moving to the next antenna when no more tags are found on the current antenna. It stops when the search timeout expires.
[1]0x0002	Automatically search on both monostatic antennas, **starting with Antenna 2**. The search cycles through antennas moving to the next antenna when no more tags are found on the current antenna. It stops when the search timeout expires.
0x0004	An embedded command is specified in the request and will be executed on each inventoried tag. Note: This bit should only be set when using the Tag Inventory With Embedded Operations syntax.
Note: 1- Only one of these flags should be set since both Antenna 1 and 2 cannot be the starting antenna. 2 -Multiple Flags can be set (perform a binary OR) to specify different behaviors. ex: Search Flags = 0x0006 indicates a multiple antenna search starting on antenna1 is to be performed and the embedded command specified it to be executed on each tag.	

For example, the syntax for a Read Tag Multiple with automatic multi-antenna search starting with antenna1 is:

FF	**04**	**22**	**00 01**	**03 E8**	**3F 8E**
SOH	Length	OpCode	Antennas Flag	Timeout (ms)	CRC

The response format for both is the following:

FF	**01**	**22**	**00 00**	**02**	**46 BA**
SOH	Length	OpCode	Status	# Tag IDs Found	CRC

Tag Inventory with Select

If you want to inventory only tags meeting a specific criteria this syntax should be used. The search criteria is specified using the Tag Singulation Fields. If Option=0x00 is specified it will perform the same search as the Basic Tag Inventory syntax. Otherwise, it will return the number of tags found matching the specified criteria. The tag EPCs and Meta Data will be available in the Tag Buffer. If no tags are found, a fault code is returned. The required fields are as follows:

Read Tag Multiple with Select Fields

Field	Value	Description
Select Options	[1 byte]	The Options value of the Tag Singulation Fields
Search Flags	[2 bytes]	Read Tag Multiple Search Flags indicating antenna usage. Bit 3 must be 0, no embedded commands.
Timeout	[2 bytes]	Indicates how long the command should spend searching.
Access Password	[4 bytes]	The Access Password of the tags expected to be inventoried, if they are locked. If the tags are not locked specify 0x00000000. Note: If the memory used for tag singulation of inventoried flags is read locked and have different passwords, only tags with matching passwords will be successfully inventoried.
Tag Singulation Fields		The remaining, appropriate fields depending on the value of Select Options.

Here is an example request and response showing the use of Tag Singulation/Select Functionality to inventory tags which meet a specific criteria:

This command will inventory all tags with an EPC value ending in 0x66, which requires adding the appropriate Tag Singulation Fields to the Basic Tag Inventory syntax

FF	**0F**	**22**	**04**	**00**	**00**	**03**	**E8**
SOH	Length	OpCode	Options (EPC Mem)	Search Flags		Timeout	

00	00	00	00	00	00	00	78	08	66	DE	C0
Access Password				Select Address (bits)				Select Data Length (bits)	Select Data	CRC	

Note

The Select Options field of the Tag Singulation Fields in the request is specified at the beginning of the command followed by the Search Flags, Timeout, Access Password then the rest of the Tag Singulation Fields. This is different than the typical format for Select fields. Also, this syntax always requires an Access Password be specified. If the tags are not locked it can be set to 0x00000000

The response contains the number of tags found matching the Select criteria specified. Use Get Tag Buffer (29h) to access the tag EPCs and Tag Read Meta Data:

FF	04	22	00	00	04	00	00	02	B7	6E
SOH	Length	OpCode	Status		Options (EPC Mem)	Search Flags		Tag Found	CRC	

Tag Inventory With Embedded Operations

In addition to inventorying tags, Read Tag Multiple can be used to perform an operation on each tag in a population of tags. Starting with the Tag Inventory with Select syntax to define the population of tags the operation is to be performed on, the Search Flag bit 3 (0x0004) can be set to indicate embedded commands are to be performed on the inventoried commands. The required fields are as follows:

Read Tag Multiple Embedded Command Fields

Field	Value	Description
Select Options	[1 byte]	The Options value of the Tag Singulation Fields
Search Flags	[2 bytes]	Bit 3 of the Read Tag Multiple Search Flags must be set indicating this request contains embedded command(s).
Timeout	[2 bytes]	Indicates how long the command should spend searching AND performing the embedded command. It may be desirable to specify a longer timeout if a large number of tags are likely to get the embedded command executed on them.
Access Password	[4 bytes]	The Access Password of the tags expected to be inventoried, if they are locked. If the tags are not locked specify 0x00000000. Note: If inventoried flags are locked and have different passwords, only tags with matching passwords will get a successful execution of the embedded command.
Tag Singulation Fields		The remaining, appropriate fields depending on the value of Select Options.
Embedded Command Count	[1 byte]	The number of embedded commands to follow. [Currently only supports one]
Embedded Command Length	[1 byte]	Length of embedded commands. Follows standard Length value calculation: number of bytes after OpCode.
Embedded Command OpCode	[1 byte]	The OpCode of the embedded command. Currently supports: • Write Tag Data (24h) • Lock Tag (25h) • Kill Tag (26h) • Read Tag Data (28h)
The fields and values required by the embedded command.		Note: The embedded commands do not support Tag Singulation as it is already performed during the inventory operation. The Options field for the embedded command **must be 0x00**. Note: The **Timeout** field for embedded commands **must be 0x0000.**

Here is an example request and response showing the use of Tag Singulation/Select Functionality to inventory tags which meet a specific criteria and then setting the Access password on each using Write Tag Data (24h) as an embedded command:

This command will inventory all tags with an EPC value ending in 0x34, which requires adding the appropriate Tag Singulation Fields to the Basic Tag Inventory syntax then will use Write Tag Data (24h) to write 0x12345678 into the Reserved Memory Bank starting at Word address 0x00000002 (Access Password)

FF	**1E**	**22**	**04**	**00 04**	**03 E8**	**00 00 00 00**	**00 00 00 78**	**08**	**34**
SOH	Length	OpCode	Options (EPC Mem)	Search Flags	Timeout	Access Password	Select Data Address (bits)	Select Data Length (bits)	Select Data

01	**0C**	**24**	**03 E8**	**00**	**00 00 00 02**	**00**	**12 34 56 78**	**?? ??**
Embd Cmd Count	Embd Cmd Length	Embd Cmd OpCode	Embd Cmd Timeout (Not Used)	Embd Cmd Options (Must be 0x00)	Write Address (Words)	Write Mem-Bank	Write Data	CRC

The response contains the number of tags found matching the Select criteria specified and the number of embedded command operations which succeeded and failed. Use Get Tag Buffer (29h) to access the tag EPCs and Tag Read Meta Data for the Tags Found. Tags in the buffer may or may not have had successful execution of the embedded command on them:

FF	**0A**	**22**	**00 00**	**04**	**00 04**	**03**	**01**	**24**	**00 03**	**00 00**	**?? ??**
SOH	Length	OpCode	Status	Options	Search Flags	Tag Found	Embd Cmd Count	Embd Cmd OpCode	Operations Succeeded	Operations Failed	CRC

Note

Depending on the Gen2 Session/User Mode used the Operations Succeeded/Failed counts can be misleading since in Session 0, for example, the tag may respond many times during an inventory round and the command may be attempted many times. This would result in counts higher than the actual number of tags the operation succeeded or failed on. The above commands were run in User Mode = Portal.

Write Tag EPC (23h)

The **Write Tag EPC** command takes the following data elements:

FF	M + 4	23	03 E8	00	00	M bytes	?? ??
SOH	Length	OpCode	[1]Timeout (ms)	[2]RFU	[3]RFU	[4]Tag EPC (M bytes)	CRC

1.16-bit timeout value in milliseconds. Due to tag difference some tags may require more time to write than others. Experimentation may be required to determine the optimal timeout.
2.Reserved for Future Use, this field is required but ignored.
3.Reserved for Future Use, this field is required but ignored
4.Up to 496-bit (Depending on EPC Length parameter set in Set Reader Configuration) tag ID to write to the Tag.

The reader sends a Fault Code / ACK response back to the host.

An example of **Write Tag EPC** command sequence of events and format is shown next:

1. Starts a timer on the reader.
2. Wakes the tag.
3. Programs the tag with the EPC ID
4. Reads the tag and verifies if the write succeeded.

Note

The verify operation uses the same power level as the write operation. It does not change to the Read power level.

5. Sends back an ACK if OK or a fault code for timeout or other faults.

FF	0C	23	03 E8	00	00	11 22 33 44 55 66 77 88	5D D8
SOH	Length	OpCode	Timeout (ms)	RFU	RFU	EPC ID	CRC

Bytes 6 and 7, identified as Reserved for Future Use (RFU) are ignored, although still required in the command. EPC values up to 496-bits are supported, depending on EPC Length parameter setting in Set Reader Configuration(9Ah).

Write Tag Data (24h)

The **Write Tag Data** command writes to the specified memory bank and data address location within that memory bank of a tag. The tag which will be written to can be specified using the Tag Singulation Fields or, if Option=0x00 of the Tag Singulation Fields is specified, it will attempt to write to the first tag it finds. If no tag is in the field, the memory location doesn’t exist or is unwriteable, or the Select criteria cannot be satisfied a fault code is returned.

In addition to the Tag Singulation Fields the Write Tag Data command takes several fields which specify the data which will be written to the tag. These fields are:

Write Tag Data Fields

Field	Value	Description
Write Address	4 bytes	The Address field is the offset in the specified Memory Bank, in 16-bit words, where the contents of the Data field is written. It corresponds to the *WordPtr* argument in the Gen2 specification. Note: Addresses are always zero-based. Specifying 0x00 indicates starting at the first address location.
Write MemBank	1 byte	The MemBank field specifies which of the tag's memory banks the data is to be written to. The values correspond to the Memory Bank values as specified in the *Gen2* specification. They are: 0x00 = Reserved 0x01 = EPC 0x02= TID 0x03 = User Memory
Write Data	N bytes	The data to be written to the tag in Memory bank [MemBank] starting at address [Address].
Access Password	4 byes	The Access Password for the tag, if the tag is locked. For an unlocked tag AccessPwd=0x00000000. Note: When Option=0x00 is specified the Access Password is not used.

The following example will attempt to write to Reserved Memory to set the Kill password=0x11112222. It will write this data to a tag matching the following criteria for a max timeout of 1000 ms.

Memory Bank = User Memory.

Starting Address = bit 32

Select Data = 0x1234

The Reserved Memory bank is not locked so the Access Password is zero

FF	17	24	03 E8	03	00 00 00 00	00	00 00 00 00	00 00 00 20	10	12	34
SOH	Length	OpCode	Time-out (ms)	Option	Write Address	Write MemBank	Access Password	Select Address	Select Data Length	Select Data	

11 11 22 22	3E 71
Write Data	CRC

If Option=0x00 or 0x01 is used then the unused Tag Singulation Fields must be removed from the request.

Note

If Option=00, the write tag data is performed without any select criteria resulting the first tag found being written. In that case there is no way to determine what tag gets written to unless there is only one tag in the RF field.

Lock Tag (25h)

The **Lock Tag** command locks the specified memory bank of a tag. The tag which will be locked can be specified using the Tag Singulation Fields or, if Option=0x00 of the Tag Singulation Fields is specified, it will attempt to lock the first tag it finds. If no tag is in the field, the memory location doesn't exist or is unlockable, or the Select criteria cannot be satified a fault code is returned.

In addition to the Tag Singulation Fields the Lock Tag command takes several fields which specify how the tag is to be locked. These fields are:

Lock Tag Fields

Field	Value	Description
AccessPwd	4 byes	The Access Password for the tag. In order to lock a tag the Access Password must be non-zero. To set the access password using the Write Tag Data (24h) command.
Mask Bits[1]	2 bytes	The Mask bits specify which fields should be modified according to the Actions bits. When a Mask Bit =0 the corresponding Action bit is not applied and the current lock setting is retained. When a Mask Bit =1 the corresponding Action bit is applied and the new lock setting is implemented.
Action Bits[1]	2 bytes	The Action bits specify whether to assert or deassert a lock behavior for the associated memory location. Action Bits are only applied if the corresponding Mask Bits =1.

1-The Mask and Action bits correspond to the identically named fields described in Section 6.3.2.10.3.5 of the Gen2 specification.

The values of the Mask and Action bits indicate how a tag is to be locked. The 10 Least Significant Bits of each 16-bit argument are used to indicate the lock behavior for each memory bank (Action Bits) and which of those behaviors to apply (Mask Bits). These bits and their corresponding behaviors are:

	First Byte								**Second Byte**							
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
	Unused						Kill Pwd		Access Pwd		EPC Mem		TID Mem		User Mem	
Mask	X	X	X	X	X	X	Set?	Set?	Set?	Set?	Set?	Set?	Set?	Set?	Set?	Set?
Action	X	X	X	X	X	X	R/W	Perm	R/W	Perm	W	Perm	W	Perm	W	Perm

For each bit in the Mask field where Set?=1 the corresponding Action bit will be applied and the specified lock setting (R/W, W. Permanent) will be asserted (1) or de-asserted (0). Please see the Gen2 specification for more information on Lock Action functionality.

Note

Passing 0xFFFF in the **Mask** field and 0x0000 in the **Action** field unlocks all the memory banks.

The following example shows an attempt to apply a temporary (not permanent) Write lock on the EPC memory (Option=0x01) of a tag whose EPC ID=0x111122223333444455556666 and whose access password=0x11223344:

FF	**18**	**25**	**03 E8**	**01**	**11 22 33 44**	**00 20**	**00 20**	**60h**	**11 11 22 22 33 33 44 44 55 55 66 66**	**9E 7A**
SOH	Length	OpCode	Timeout (ms)	Option	Access Password	Mask Bits	Action Bits	Select Data Length	Select EPC ID	CRC

Kill Tag (26h)

The **Kill Tag** command kills the specified tag. The tag which will be killed can be specified using the Tag Singulation Fields or, if Option=0x00 of the Tag Singulation Fields is specified, it will attempt to kill the first tag it finds. If no tag is in the field, the kill password is zero, or the Select criteria cannot be satified a fault code is returned.

In addition to the Tag Singulation Fields the Kill command takes the tag's Kill Password and an extra 1 byte field for future use (RFU).

The following example shows an attempt to kill a tag whose EPC ID=0x112233445566778899AA and whose Kill password=0x11112222:

FF	**13**	**26**	**03 E8**	**01**	**11 11 22 22**	**00**	**50**	**11 22 33 44 55 66 77 88 99 AA**	**DD DB**
SOH	Length	OpCode	Timeout (ms)	Option	Kill Password	RFU	Select Data Length	Select EPC ID	CRC

Note

If the tag's kill password is set to 0, the protocol does not allow the tag to be killed. A non-zero kill password must be set (using the **Write Tag Data** command) before the kill command succeeds. The RFU field should be set to 0.

Read Tag Data (28h)

The **Read Tag Data** command reads the specified memory bank at data address location within that memory bank of a tag. The tag which will be read can be specified using the Tag Singulation Fields or, if Option=0x00 of the Tag Singulation Fields is specified, it will attempt to read from the first tag it finds. If no tag is in the field, the memory location doesn't exist or is read locked, or the Select criteria cannot be satified a fault code is returned.

In addition to the Tag Singulation Fields the Read Tag Data command takes several fields which specify the data which will be read from the tag. These fields are:

Read Tag Data Fields

Field	Value	Description
Read MemBank	1 byte	The MemBank field specifies which of the tag's memory banks the data is to be read from. The values correspond to the Memory Bank values as specified in the *Gen2* specification. They are: 0x00 = Reserved 0x01 = EPC 0x02= TID 0x03 = User Memory
Read Address	4 bytes	The Address field is the offset in the specified Memory Bank, in 16-bit words, to start reading from. It corresponds to the *WordPtr* argument in the Gen2 specification. Note: Addresses are always zero-based. Specifying 0x00 indicates starting at the first address location.
WordCount	1 byte	The number of words (16 bit chunks) of data to read from memory bank [MemBank] starting at offset [ReadAddress].
Access Pass-word	4 byes	The Access Password for the tag, if the tag is read locked. For an unlocked tag AccessPwd=0x00000000.

The Basic syntax which returns only the requested Tag Data is defined in Get Tag Data. With additional Option bits set, Read Tag Data can also return Tag Read Meta Data using the syntax in Get Tag Data and Meta Data.

Get Tag Data

The following example will attempt to read the Kill Password (the first 2 words) from Reserved Memory. It will read this data from a tag matching the following criteria for a max timeout of 1000 ms.

Memory Bank = User Memory.

Starting Address = bit 32

Select Data = 0x1234

The Reserved Memory bank is not locked so the Access Password is zero

FF	**14**	**28**	**03 E8**	**03**	**00**	**00 00 00 00**	**02**	**00 00 00 00**
SOH	Length	OpCode	Time-out (ms)	Option	Read MemBank	Read Address	Word-Count	Access Password

00 00 00 20	**10**	**12 34**	**D1 E7**
Select Address	Select Data Length	Select Data	CRC

If Option=0x00 or 0x01 is used then the unused Tag Singulation Fields (including the Access Password) must be removed from the request.

The response to this **Read Data** command example is:

FF	**05**	**28**	**00 00**	**03**	**11 11 22 22**	**10 BF**
SOH	Length	OpCode	Status	Option	Data	CRC

Read Tag Data Response

The length field of the data returned is 2 times the WordCount value in the original command, because the return packet length is counted in bytes, plus 1 byte for the Option specified.

Get Tag Data and Meta Data

In addition to getting the tag data returned you can also get Tag Read Meta Data for the found tag. This version of Read Tag Data requires bit 4 of the Option flag to be set and takes an additional Metadata Flags field which defines what metadata will be returned. The following table lists the supported values for these fields.

Read Tag Data Get Data and Metadata Request Fields

Field	Value	Description
Option	Bit 4=0 (0x0X)	No Metadata flags are specified and Meta Data will not be returned. This is the Get Tag Data syntax. The lower bits (X) are specified as defined by Tag Singulation/Select Functionality.
	Bit 4=1 (0x1X)	Indicates that Metadata flags are to follow and the corresponding Metadata shall be returned with the tag EPC. The lower bits (X) are specified as defined by Tag Singulation/Select Functionality.
Metadata Flags (to specify more than one OR the values together)	0x0000	When no flags are set no meta data will be returned, only the tag EPC (including PC bits and tag CRC)
	0x0001	When bit 0 is set the Read Count will be returned
	0x0002	When bit 1 is set the LQI/RSSI will be returned
	0x0004	When bit 2 is set the Antenna ID will be returned
	0x0008	When bit 3 is set the Frequency will be returned
	0x0010	When bit 4 is set the Timestamp will be returned
	0x0020	When bit 5 is set the RFU (*ThingMagic Only*) will be returned
	0x0040	When bit 6 is set the Protocol is returned.
These fields are followed by the Read Tag Data Fields then the Tag Singulation/Select Functionality (set appropriate bits in the Option field defined above, do not specified an additional Option field), used the same as defined in the Get Tag Data syntax, as necessary.		

A response can contain the following information:

Read Tag Data Get Data and Metadata Response Fields

Field	Length	Value
SOH	1 byte	0xFF
Length	1 byte	Based on data returned
OpCode	1 byte	0x21
Options	1 byte	As sent in request
Metadata Flags	2 bytes	Metadata contained in response
Read Count[1]	1 byte	Tag EPC/Antenna Read Count
RSSI[1]	1 byte	Return Signal Strength Indicator
Antenna ID[1]	1 byte	Antenna ID, 4 MSBs for TX and 4 LSBs for RX
Frequency[1]	3 bytes	Frequency in kHz
Timestamp[1]	4 bytes	RTC Timestamp
RFU[1]	2 bytes	Reserved for Future Use - ThingMagic Only
Protocol ID	1 byte	Protocol ID of tag read
Tag Data	N bytes	Request Tag Data.
CRC	2 bytes	Message CRC

1 - Conditionally returned depending on the Metadata Fields specified in the request.

The following example will attempt to read the Access Password (the first 2 words) from Reserved Memory. It will read this data from a tag matching the following criteria for a max timeout of 1000 ms.

Memory Bank = EPC.

Starting Address = bit 120 (beginning of the last byte of the EPC value: 16 PC bits + 16 CRC bits + 88 EPC bits)

Select Data = 0x34

The Reserved Memory bank is not locked so the Access Password is zero

FF	**15**	**28**	**03 E8**	**14**	**00 14**	**00**	**00 00 00 02**	**02**	**00 00 00 00**
SOH	Length	OpCode	Time-out (ms)	Option	Meta Data Flags	Read MemBank	Read Address	Word-Count	Access Password

00 00 00 78	**08**	**34**	**9C 0E**
Select Address	Select Data Length	Select Data	CRC

The response to this **Read Data** command example is:

FF	**0C**	**28**	**00 00**	**14**	**00 14**	**22**	**00 00 00 15**	**12 34 56 78**	**B2 B4**
SOH	Length	OpCode	Status	Option	Meta Data Flags	Antenna ID	Timestamp	Tag Read Data	CRC

Get Tag Buffer (29h)

See Get Tag Buffer (29h) in Multi-Protocol Tag Commands.

Clear Tag Buffer (2Ah)

See Clear Tag Buffer (2Ah) in Multi-Protocol Tag Commands.

Gen2 Tag Specific (2Dh)

The **Gen2 Tag Specific** command is a generic command providing an interface for operations proprietary to certain Gen2 tag silicon. The supported commands are grouped by tag silicon type, indicated by the **Chip Type** field. Each Chip Type may have multiple unique commands associated with it, indicated by the **Sub Command** field.

Alien Higgs Silicon (Chip Type=0x01)

Tags with Alien Higgs Silicon support the following proprietary commands:

Alien Higgs Sub Commands

Sub Command value	Alien Higgs Command
0x01	Partial Load Image
0x03	Full Load Image

Partial Load Image

Sub Command=0x01

If the first bit of Sub Command is 1 (Sub Command=0x01), the **Gen2 Tag Specific** command writes an EPC with a length of up to 96-bits, plus the Kill and Access passwords without locking in a single command.

The format for this command is as follows:

FF	18	2D	03 E8	01	01	00 00 00 00	00 00 00 00
SOH	Length	OpCode	Timeout (ms)	Chip Type	Sub Command	Kill Password	Access Password

11 22 33 44 55 66 77 88 99 AA BB CC	45 64
Tag ID	CRC

Full Load Image

Sub Command=0x03

If the second bit of Sub Command is 1 (Sub Command=0x03), the **Gen2 Tag Specific** command will also modify the Lock bits (locking the tag according to the Alien Higgs Lock Bits) and the Alien Higgs PC Bits.

The format is extended as follows:

FF	1C	2D	03 E8	01	03	01 23 45 67	89 AB CD EF
SOH	Length	OpCode	Timeout (ms)	Chip Type	Sub Command	Kill Password	Access Password

00 02	30 00	11 22 33 44 55 66 77 88 99 AA BB CC	?? ??
Lock Bits	PC Word	Tag ID	CRC

The Lock Bits correspond to the Higgs TID Bank configuration bits with the same name and are shown in the following table:

Alien Higgs Lock Bits

Bit Number	15	14	13	12	11	10	9	8	7	6
Field Name>	X	X	X	X	X	X	X	X	X	X
Default Values	X	X	X	X	X	X	X	X	X	X
Lock Values	X	X	X	X	X	X	X	X	X	X

5	4	3	2	1	0
APW Lock	APW P-lock	KPW Lock	KPW P-lock	EPC Lock	EPC P-lock
0	0	0	0	0	0
1	1	1	1	1	1

Currently, only the first six bits of this field are used. A value of zero in each bit field keeps the corresponding memory segment unlocked. To lock any of the **Kill** and **Access** passwords or the EPC, temporarily or permanently, set the corresponding bit fields in the Lock Bits word to 1. For additional information, refer to the Higgs Tags Application Notes

(Currently available at http://www.alientechnology.com/docs/
Load_Image_Application_Note_1.pdf - Contact Alien Technology for more details).

The PC Word field, in the table on the previous page, corresponds to the PC Word in the Tag EPC memBank defined in the Gen2 Specification and is shown in the following table:

Alien Higgs PC Bits

Bit Number	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Field Name	PC Bits					RFU	RFU				NSI Bits					
Default Values	X	X	X	X	X	0	0	0	0	0	0	0	0	0	0	0

The PC Word in the **Write Tag Specific** command allows you to specify the NSI Bits and the length of the EPC that you want to write into the tag. The RFU bits are always zero and the PC Bits are determined by the EPC length as specified in the Gen2 Specification and the Higgs Tags Application Notes.

To use the extended format of the **Gen2 Tag Specific** command but keep the NSI bits intact, set option=0x03. This signals the reader to ignore the NSI bits of the PC Word sent to the reader along with the command.

In the example on the previous page, after the execution of the **Gen2 Tag Specific** command, the reader writes the 96-bit EPC 0x112233445566778899AABBCC, the Kill Password 0x01234567, the Access Password 0x89ABCDEF into the tag without changing the NSI bits of the tag and locks the EPC memBank.

However, to access and write the NSI bits into the tag, set the third bit of the option field to 1 (option=0x07). In the example, if option is set to 0x07, the NSI bits are overwritten by zeros.

The following table summarizes the option field values and the action that is taken:

Bit	Number		
2	1	0	Action
0	0	0	Invalid Value
0	0	1	**Gen2 Tag Specific** without locking and without NSI bits being overwritten
0	1	0	Invalid Value
0	1	1	**Gen2 Tag Specific** with locking and without NSI bits being overwritten
1	0	0	Invalid Value
1	0	1	**Gen2 Tag Specific** without locking and with NSI bits being overwritten by zeros
1	1	0	Invalid Value
1	1	1	**Gen2 Tag Specific** with locking and with NSI bits being overwritten by values that you specify

NXP Silicon (Chip Type=0x02)

Tags with NXP Silicon support the following proprietary commands as specified in the *SL31CS1202 G2XM UCode Functional Specification* (please contact NXP for details):

NXP Sub Commands

Sub Command value	NXP Command
0x01	Set ReadProtect
0x02	Reset ReadProtect
0x03	Change EAS
0x04	EAS Alarm
0x05	Calibrate

All NXP-proprietary commands contain the following fields:

NXP Common Fields

Field	Value
Length	1 byte
OpCode	0x2D
Timeout	2 bytes
Option	0x02 for NXP
Sub Command	NXP Sub Commands
Access Password	4 bytes, tag's access password Note: Must be non-zero for Set/ Reset ReadProtect and Change EAS Note: EAS Alarm does not take the Access Password field.

In addition to the common fields some commands have additional required fields as indicated below.

Set ReadProtect

The NXP command Set ReadProtect causes the commands Read, Write, Kill, Lock, Access, Set ReadProtect, Change EAS, EAS Alarm and Calibrate to be disabled until a "Reset ReadProtect" is received. This command uses only the common fields and is invoked with the following command:

FF	08	2D	03 E8	02	01	12 34 56 78	?? ??
SOH	Length	OpCode	Timeout (ms)	Chip Type	Sub Command	Access Password	CRC

The response to the Set ReadProtect command is a simple ACK with standard status:

FF	00	2D	00 00	1D 25
SOH	Length	OpCode	Status	CRC

Reset ReadProtect

The NXP command Reset ReadProtect restores normal operation to a tag which is in ReadProtect mode. This command uses only the common fields and is invoked with the following command:

FF	**08**	**2D**	**03 E8**	**02**	**02**	**12 34 56 78**	**? ? ? ?**
SO H	Length	OpCode	Timeout (ms)	Chip Type	Sub Com-mand	Access Password	CRC

The response to the Reset ReadProtect command is a simple ACK with standard status:

FF	**00**	**2D**	**00 00**	**1D 25**
SOH	Length	OpCode	Status	CRC

Change EAS

The NXP command Change EAS sets or resets the EAS system bit. When set, the tag will return an alarm code if an "EAS Alarm" command is received. This command takes an additional field:

- **Change EAS** (1 byte: 0x01=Set EAS; 0x02=Reset EAS)

It is invoked with the following command:

FF	**09**	**2D**	**03 E8**	**02**	**03**	**00 00 00 00**	**00**	**? ? ? ?**
SO H	Length	OpCode	Timeout (ms)	Chip Type	Sub Com-mand	Access Password	Change EAS	CRC

The response to the Change EAS command is a simple ACK with standard status:

FF	**00**	**2D**	**00 00**	**1D 25**
SOH	Length	OpCode	Status	CRC

EAS Alarm

The NXP command EAS Alarm causes the tag to return coded information, but only when the tag has its EAS system bit set. This command requires several fields in addition to the common fields

- **Divide Ratio as Per Gen2 (DR)** (1 byte: Current fixed to 0x01, M5e and M5e-C only support DR=64/3)
- **Miller Cycles (M)** (1 byte: Current fixed to 0x02, M5e and M5e-C only support M=4)
- **TrExt as Per Gen2** (1 byte: Current fixed to 0x01, M5e and M5e-C only support extended Pilot Tone)

It is invoked with the following command:

FF	**07**	**2D**	**03 E8**	**02**	**04**	**01**	**02**	**01**	**?? ??**
SOH	Length	OpCode	Timeout (ms)	Chip Type	Sub Com-mand	DR	M	TrExt	CRC

The response to the EAS Alarm command contains 8 bytes of EAS Alarm Data, only if Status=0x0000. The format of the response is:

FF	**0A**	**2D**	**00 00**	**02**	**04**	**[8 bytes]**	**?? ??**
SOH	Length	OpCode	Status	Chip Type	Sub Com-mand	[EAS Alarm Data]	CRC

Calibrate

The NXP command Calibrate causes the tag to return a random data pattern that is useful in some frequency spectrum measurements. This command uses only the common fields and is invoked with the following command:

FF	**08**	**2D**	**03 E8**	**02**	**05**	**11 11 22 22**	**?? ??**
SOH	Length	OpCode	Timeout (ms)	Chip Type	Sub Com-mand	Access Password	CRC

The response to the Calibrate command contains 32 bytes of Calibrate Data, only if Status=0x0000. The format of the response is:

FF	**42**	**2D**	**00 00**	**02**	**05**	**[64 bytes]**	**?? ??**
SOH	Length	OpCode	Status	Chip Type	Sub Com-mand	[Calibrate Data]	CRC

Note

If the tag is a G2XL without User Memory the *Calibrate Data* response field will contain 64 bytes of ‘00’.

Erase Block Tag Specific (2Eh)

The **Erase Block Tag Specific** command is used for Tag specific block erases. The format for this command is as follows:

FF	**0A**	**2E**	**03 E8**	**00**	**00**	**00 00 00 02**	**01**	**01**	**7B 38**
SOH	Length	OpCode	Timeout (ms)	Chip Type	Option	Address	Mem Bank	Word Count	CRC

Currently, the only acceptable Chip Type is 0x00 (indicates standard support of any tag supporting the Block Erase command as specified in the Gen2 Specification) and the only permissible option is 00 (Block Erase). The 32-bit Address field is the zero-based offset from the MemBank origin, in 16-bit words, where the contents of the tag memory will be erased. It corresponds to the *WordPtr* argument in the Gen2 command specification.

The 8-bit MemBank field specifies which of the tag's memory banks is to be addressed. It corresponds to the Gen2 argument of the same name. Its values are as mentioned for **Write Tag Data** command. Word Count specifies the number of 16-bit words to be erased. In the format example, data starting at word=0x02 (the third word) of EPC memory, which corresponds with the first word of the EPC ID, is erased .

Get Configuration Commands

The Get commands listed in the following table are used to get settable parameters from the Mercury Embedded module. All of the commands have a data length of zero, and return data or a fault code. These commands cannot be run in the Bootloader.

Get Configuration Commands

OpCode	Command Name	Arguments	Return
0x10	Get Hardware Version (10h)	Option, Mask	Hardware Information
0x61	Get Antenna Configuration (61h)	Option	Antenna configuration
0x62	Get Read TX Power (62h)	Return Option (1 byte)	Read TX Power Setting (and optionally Min. and Max power)
0x63	Get Current Tag Protocol (63h)	none	Current Tag Protocol
0x64	Get Write TX Power (64h)	none	Write TX Power Setting
0x65	Get Frequency Hop Table (65h)	none	Current Frequency Hop Table
0x66	Get User GPIO Inputs (66h)	none	GPIO Input Data
0x67	Get Current Region (67h)	none	Current region being used
0x68	Get Power Mode (68h)	none	Current power mode setting
0x69	Get User Mode (69h)	none	Current user mode setting
0x6A	Get Reader Configuration(6Ah)	none	Current reader configuration options set
0x6B	Get Protocol Configuration (6Bh)	Protocol, Parameter (2 bytes)	Parameter Value
0x6C	Get Reader Statistics (6Ch)	Option, Statistics	Reader Statistics
0x70	Get Available Protocols (70h)	none	Available Protocols
0x71	Get Available Regions (71h)	none	Available regions.
0x72	Get Current Temperature (72h)	none	Current module temperature

Get Hardware Version (10h)

The Get Hardware Version command is used to get information about the module it is executed on. Most of the information is not currently user-relavant but will often be required by ThingMagic Support to help diagnose problems.

Get Hardware Version Fields

Field	Value	Description
Option	0x00	Indicates the Data Flags will following specifying the information to be returned
	0x01	M6e-TC Only - Indicates the FPGA TM and TC versions should be returned. Note: Do Not pass Data Flags when using Option=0x01.
Data Flags	0x00	When no flags are set all data will be returned.

The format of this command is:

FF	**02**	**10**	**00**	**00**	**F0 93**
SOH	Length	OpCode	Option	Data Flags	CRC

Example

The following command returns the FPGA TM and TC versions:

FF	**01**	**10**	**01**	**?? ??**
SOH	Length	OpCode	Option	CRC

The follow is an example response containing the FPGA TM and TC versions:

FF	**08**	**10**	**00 00**	**12 34 56 78**	**00 10 01 04**	**B9 5E**
SOH	Length	OpCode	Status	FPGA TM Version	FPGA TC Version	CRC

Get Antenna Configuration (61h)

The **Get Antenna Configuration** command returns the current antenna configuration including which antennas are set to transmit and receive, and which ports have antennas attached.

Reliable antenna detection requires that an attached antenna pass at least a small amount of DC current. Many antennas do not pass DC current. Due to such antennas an indication that a port is terminated is always accurate, but an indication that a port is not terminated may not be accurate.

The format of the command is:

FF	**00**	**61**	**00**	**1D 6E**
SOH	Length	OpCode	Option	CRC

The reply is formatted similar to the **Set Antenna Port** command. Data byte 01 returns the current TX antenna, and data byte 02 returns the current RX antenna. The default, and currently only, antenna configuration is TX on port #1 and RX on port #1.

FF	**02**	**61**	**00 00**	**01**	**01**	**4E 21**
SOH	Length	OpCode	Status	TX Ant Num	RX Ant Num	CRC

The **Get Antenna Configuration** command also includes an option that also returns information on which port(s) the antenna is connected.

For example, a command is sent:

FF	**01**	**61**	**01**	**1D 6E**
SOH	Length	OpCode	Option	CRC

The response returns the ports for TX and RX and also detects whether an antenna is connected to the port:

FF	05	61	00 00	01	01	00	?/ ??
SOH	Length	OpCode	Status	TX Ant Num	RX Ant Num	Port 1 Not Connected	CRC

Get Read TX Power (62h)

The **Get Read TX Power** command returns the current TX power and, optionally, the minimum and maximum power levels supported by the module (and region setting) for reading tags, in centi-dBm.

The option field allows you to specify what data you want returned:

Option	Data returned
0x00	Returns only the current TX power.
0x01	Returns the current TX power and the maximum and minimum power levels for this module.

The following example gets the full set of power data:

FF	01	62	01	BE BC
SOH	Length	OpCode	Option	CRC

The example response contains the option specified followed by 2 byte fields for each power value:

current = 0x0BB8 = 3000 centi-dBm = 30.00 dBm
max = 0x0BB8 = 3000 centi-dBm = 30. 00 dBm
min. = 0x01F4 = 500 centi-dBm = 5.00 dBm

FF	07	62	00 00	01	0B B8	0B B8	01 F4	1F B7
SOH	Length	OpCode	Status	Option	Current centi-dBm	Max centi-dBm	Min centi-dBm	CRC

Get Current Tag Protocol (63h)

The **Get Current Tag Protocol** command returns the currently set tag protocol(s). This is the protocol being used by the reader. The following table assigns a 16-bit code to each available protocol. This table will be updated as new protocols are added:

Tag Protocol IDs

Protocol Name	16-bit Code
None Selected	0x0000
EPC0 / EPC0+ Matrics	0x0001
EPC1	0x0002
ISO 18000-6B	0x0003
EPC0+ Impinj	0x0004
GEN2	0x0005
UCODE	0x0006
iPico	0x0007
eGo	0x001B
SeGo	0x001C
ATA	0x001D
Allegro/Title-21	0x001E

The command format is shown in the following example:

SOH	Length	OpCode	CRC	
FF	00	63	1D	6C

Note

The supported protocols vary depending on the hardware and firmware in use.

The reply is similar to the **Set Current Tag Protocol** command. Only one protocol can be set at a time:

SOH	Length	OpCode	Status		Current Protocol		CRC	
FF	02	63	00	00	00	1B	??	??

Get Write TX Power (64h)

The **Get Write TX Power** command returns the current TX power and, optionally, the minimum and maximum power levels supported by the module for reading tags, in centi-dBm.

The option field allows you to specify what data you want returned:

Option	Data returned
0x00	Returns only the current TX power.
0x01	Returns the current TX power and the maximum and minimum power levels for this module.

The following example gets the full set of power data:

FF	01	64	01	B8 BC
SOH	Length	OpCode	Option	CRC

The example response contains the option specified followed by 2 byte fields for each power value:

current = 0x0BB8 = 3000 centi-dBm = 30.00 dBm
max = 0x0BB8 = 3000 centi-dBm = 30.00 dBm
min. = 0x01F4 = 500centi-dBm = 5.00 dBm

FF	07	64	00 00	01	0B B8	0B B8	01 F4	FF BC
SOH	Length	OpCode	Status	Option	Default centi-dBm	Max centi-dBm	Min centi-dBm	CRC

Get Frequency Hop Table (65h)

The **Get Frequency Hop Table** command gets the current frequency hop table used in the Microprocessor:

FF	**00**	**65**	**1D**	**6A**
SOH	Length	OpCode	CRC	

The reply format is similar to the **Set Frequency Hop Table** command. The length must be set to a multiple of four, and a maximum of 62 hop frequencies is returned. The frequencies are returned in kHz. Thus, frequency #1 (0xDC370) corresponds to 902,000 kHz:

FF	**0C**	**65**	**00**	**00**	**00**	**0D**	**C3**	**70**	**00**	**0D**	**F6**	**38**	**00**	**0E**	**26**	**12**	**60**	**B2**
SOH	Length	OpCode	Status		Freq #1				Freq #2				Freq #3				CRC	

Get User GPIO Inputs (66h)

The **Get User GPIO Inputs** command returns the status of the User Input GPIO lines:

FF	**00**	**66**	**1D**	**69**
SOH	Length	OpCode	CRC	

The status of the GPIO lines is returned.

FF	**02**	**66**	**00**	**00**	**00**	**01**	**CA**	**B2**
SOH	Length	OpCode	Status		Input #1	Input #2	CRC	

Get Current Region (67h)

The **Get Current Region** command gets the current region and, optionally, specific parameters for that region set in the reader. Currently available region codes are shown in the following table. Details on the Regulatory Compliance for each region can be found in Regional Support::

Region codes

Region	Code
NA	0x01
Open	0xFF

To get the current region send the following command:

FF	**00**	**67**	**1D 68**
SOH	Length	OpCode	CRC

The command generates the following reply, which indicates that the reader is set to the NA region:

FF	**01**	**67**	**00 00**	**01**	**B4 80**
SOH	Length	OpCode	Status	Region	CRC

Get Power Mode (68h)

The **Get Power Mode** command returns the current Power Mode of the unit. The values for the available Power Modes are shown in the table.

Available power modes

Hex	Power Mode
0x00	Full power mode
0x01	Minimal saving mode .
0x02	Medium saving mode.
0x03	Maximum saving mode.
0x04-0xFF	Reserved for future use.

Note

If Set Power Mode (98h) is called using the USB interface and mode 0x03 is specified the module will instead be set to 0x02. In order to set the module to mode 0x03 the command must be called using the RS232 interface.

The command gets the current power mode setting from the module:

FF	00	68	1D 67
SOH	Length	OpCode	CRC

The example reply shows that the system is in the medium power saving mode:

FF	01	68	00 00	02	A4 BD
SOH	Length	OpCode	Status	Power Mode	CRC

Get User Mode (69h)

The **Get User Mode** command returns the type of application in which the M5e/M5e-Compact can be used. The available user modes are shown in the table:

Available User Modes

Hex	User Mode
0x00	NONE (Default)
0x01	PRINTER
0x02	Unsupported
0x03	PORTAL
0x04	HAND HELD

The command gets the current user mode setting from the module:

FF	00	69	1D 66
SOH	Length	OpCode	CRC

The example reply shows the current user mode setting:

FF	01	69	00 00	01	97 8F
SOH	Length	OpCode	Status	User Mode	CRC

Get Reader Configuration(6Ah)

The **Get Reader Configuration** command returns the current reader configuration as defined in Set Reader Configuration(9Ah):

Send the following command to get the current transmit mode:

FF	00	6A	1D 65
SOH	Length	OpCode	CRC

The example reply shows the current reader configuration Options setting:

FF	02	6A	00 00	00 01	BF D3
SOH	Length	OpCode	Status	Options	CRC

Get Protocol Configuration (6Bh)

The **Get Protocol Configuration** command is used to get current protocol-specific configuration parameters settings as specified in Set Protocol Configuration (9Bh).

Send the following command to get the current Gen2 Session configuration parameter value:

FF	02	6B	05	00	3A	6F
SOH	Length	OpCode	Protocol	Parameter	CRC	

The example reply shows the Gen2 session is set to S2 (0x02):

FF	03	6B	00	00	05	00	02	08	76
SOH	Length	OpCode	Status		Protocol	Parameter	Value	CRC	

Get Reader Statistics (6Ch)

The Get Reader Statistics command allows the user to get and reset various statistics on the reader operation. The command takes the following fields:

Get Reader Statistics Request Fields

Field	Value
Option (1 byte)	• 0x00 - Get statistics specified by the Statistics Flag • 0x01 - Reset the specified statistic.
Statistics Flag (1 byte)	Each bit corresponds to a specific statistic to be returned. See the Available Statistics table for bit values.

Available Statistics

Statistics Flag Bit	Statistic
Bit 0 (0x01)	**RF On Time (ms)**- Indicates the aggregate time the transmitter has been on, in milliseconds, since the counter was last reset. Returned value contains 8 bytes (4 on the M5e-Compact), 4 bytes for each antenna. Note: Clock rolls over every 2^{32} milliseconds and must be taken into account by user application.
Note: Multiple statistics can be requested by a single command by performing a binary OR (setting each desired Statistics Flag bit to 1) on the desired flags and sending the result as the Statistics Flag byte.	

The response to a Get Reader Statistics command contains the following information:

Get Statistics Response Fields

Field	Description
Status (2 bytes)	Standard response status
Option (1 byte)	Same as the Requested Value
Requested Statistics Flag (1 byte)	Same as the Requested Value
For each individual statistics requested as part of the Requested Statistics Flag the following fields will be repeated according to the Statistics Response value. They will be in bit value order.	
Statistic Flag (1 byte)	The bit corresponding to the requested statistic.
Data Length (1 byte)	Indicates how many bytes are in this statistics response value.
Statistics Response Value (N bytes as indicated by Data Length)	The response value of the statistic as specified in Available Statistics

To request the RF On Time send the following command:

FF	**02**	**6C**	**00**	**01**	**4F 89**
SOH	Length	OpCode	Option	Statistics Flag	CRC

The response, containing the RF On Time would look like:

FF	**08**	**6C**	**00 00**	**00**	**01**	**01**	**04**	**00 00 08 4C**	**D7 D9**
SOH	Length	OpCode	Status	Option	Requested Stats Flag	Stat Flag (RF On)	Data Length	Antenna1 RF On Time	CRC

To reset the RF On Time statistic send the following command:

FF	**02**	**6C**	**01**	**01**	**4E 89**
SOH	Length	OpCode	Option	Statistics Flag	CRC

Get Available Protocols (70h)

The **Get Available Protocols** command returns the list of protocols that the reader is capable of reading. The protocol codes are defined in Get Current Tag Protocol (63h). The total number of protocols in the system cannot exceed 32. The command is generated as follows:

FF	**00**	**70**	**1D 7F**
SOH	Length	OpCode	CRC

The following Microprocessor response shows that the reader is capable of reading one protocol – GEN2:

FF	**02**	**70**	**00 00**	**00 05**	**3B 75**
SOH	Length	OpCode	Status	Protocol #1	CRC

Get Available Regions (71h)

The **Get Available Regions** command returns the list of regions that the reader is capable of working in. The total number of regions in the system cannot exceed 248. The list of region codes are found in Region codes. The command is generated as follows:

FF	**00**	**71**	**1D 7E**
SOH	Length	OpCode	CRC

The response shows that this reader is capable of reading in two regions – NA and Open:

FF	**02**	**71**	**00 00**	**01**	**FF**	**?? ??**
SOH	Length	OpCode	Status	Region#1	Region#2	CRC

Get Current Temperature (72h)

The **Get Current Temperature** command returns the current board component temperature on the module in degrees Celsius as a signed 8-bit integer. This information can be used to determine if the module is exceeding its recommended operating temperature range. If the returned value exceeds the values specified in the table below an effort should be made to reduce the ambient temperature of the module or reduce the module’s duty cycle.

Module	Warning Temperature
M6e-TC	105°C

The command is generated as follows:

FF	**00**	**72**	**1D 7D**
SOH	Length	OpCode	CRC

The response returns a signed 8-bit integer in degrees Celsius, 0x24 = 36°C

FF	**01**	**72**	**00 00**	**24**	**48 23**
SOH	Length	OpCode	Status	Temperature in Celsius	CRC

Set Configuration Commands

The Set commands are used to set configurable values in the firmware. Since the values are not stored in flash, these values are reset to the default values whenever the application firmware is restarted. These commands cannot be run in the Bootloader. The application responds with a fault code / ACK to all commands.

The following table lists the Set commands:

Set Configuration Commands

OpCode	Command Name	Arguments	Return
0x91	Set Antenna Port (91h)	Antenna Port Selected	none
0x92	Set Read TX Power (92h)	Read TX Power Setting	none
0x93	Set Current Tag Protocol (93h)	Protocol ID	none
0x94	Set Write TX Power (94h)	Power in centi-dBm	none
0x95	Set Frequency Hop Table (95h)	Table of hop frequencies in kHz	none
0x96	Set User GPIO Outputs (96h)	GPIO output states	none
0x97	Set Current Region (97h)	Region Codes, LBT	none
0x98	Set Power Mode (98h)	PowerMode Enums, Timeout (ms)	none
0x99	Set User Mode (99h)	UserMode Enums, Timeout (ms)	none
0x9A	Set Reader Configuration(9Ah)	Reader Configuration Options (bitwise)	none
0x9B	Set Protocol Configuration (9Bh)	Protocol, Parameter, Value (3 bytes)	none

Set Antenna Port (91h)

The **Set Antenna Port** command sets the antenna port to the number specified. The transmitter and receiver ports are specified, currently on port 0x01 is supported on the M6e-TC. Each antenna port is an 8-bit value set up as a bit mask. Thus, only one of the eight bits should be set at a time. The example below sets both antennas to bit mask 0x01, which would correspond to the first antenna in the system.

FF	02	91	01	01	70 3B
SOH	Length	OpCode	TX Ant Num	Rx Ant Num	CRC

Valid settings for this command are:

TX = 1 RX = 1

All other settings will result in an error.

Set Read TX Power (92h)

The **Set Read TX Power** command sets the power level to be used for reading tags. The power is specified as a 16-bit value in centi-dBm. For instance, a power of 25 dBm is 2500 centi-dBm, which is 0x09C4.

FF	02	92	09 C4	48 9D
SOH	Length	OpCode	Power in centi-dBm	CRC

Set Current Tag Protocol (93h)

To select a protocol, send the **Set Current Tag Protocol** code to the reader. A table of valid protocol codes is found in Get Current Tag Protocol (63h). The following example sets the protocol to GEN2:

FF	02	93	00 05	51 7D
SOH	Length	OpCode	Current Protocol	CRC

Only protocols that are enabled in the reader are available. These protocols are listed in the version information for the application, described in Get Boot Loader/Firmware Version (03h).

Set Write TX Power (94h)

The **Set Write TX Power** command sets the power level to use for writing to tags. This is necessary because a write operation may require a different RF power setting than a read command. The format and arguments of this command are identical to the **Set Read TX Power** command:

FF	02	94	09 C4	28 5B
SOH	Length	OpCode	Power in centi-dBm	CRC

Set Frequency Hop Table (95h)

The **Set Frequency Hop Table** command sets the list of frequencies to use when hopping. Each frequency is encoded as a 32-bit value in kHz. For instance, 915MHz is encoded as 915000kHz, which is 0x000DF638. The maximum number of hop frequencies is 62, since that is the maximum number of 32-bit values that can be sent using a message packet. If fewer values are used, only those values are populated in the table and the rest of the slots are ignored.

Note

The data length of this message encodes the number of frequencies to populate into the hop table. The length must be divisible by four for the message to be properly formatted.

This example shows a command that sets up a table with only three values:

FF	0C	95	00	0D	C3	70	00	0D	F6	38	00	0E	26	12	C1	8F
SOH	Length	OpCode	Freq #1				Freq #2				Freq #3				CRC	

The generated hop table has values of 902MHz, 915MHz, and 927.25MHz. For the US region, valid frequencies are 902MHz – 928MHz. If any of the values in the table are invalid, then none of the values are recorded.

The **Set Frequency Hop Table** command should be used for debug only, as there should be no reason to modify the frequency hop table in the field.

C A U T I O N !

Any changes to the frequency hop table could put you out of compliance with the Local Regulatory Requirements (for example, FCC, ETSI, MIC).

Set User GPIO Outputs (96h)

There are two GPIO outputs available for use. The **Set User GPIO Outputs** command has been "overloaded" to create a mechanism to return the current state of both GPIO pins. To set either GPIO Output pin, send the following command. Note that the data length is 2 bytes:

FF	02	96	01	01	28	E0
SOH	Length	OpCode	GPIO #	Output Value	CRC	

This example sets the GPIO Output #1 to ‘1’ (high). To get the current status of the GPIO output pins, send the same command, with the length set to 0:

FF	**00**	**96**	**1D**	**99**
SOH	Length	OpCode	CRC	

The response looks similar to the **Get User GPIO Inputs** command:

FF	**02**	**96**	**00**	**00**	**00**	**01**	**29**	**E0**
SOH	Length	OpCode	Status		Output #1	Output #2	CRC	

Set Current Region (97h)

The **Set Current Region** command sets the current region for use in the reader. The list of region codes are found in Region codes. See Regional Support for more information on regional functionality.

Setting the region performs the following:

1. Frequency hop table is set to the default for the region.
2. Any other region specific settings are set (i.e. LBT) to default values unless otherwise specified. Currently only LBT is configurable for regions supporting it.

The Set Current Region command supports two command syntaxes:

- The **basic syntax** for all regions where only the region code is specified. For example, to set the region to KR:

FF	**01**	**97**	**03**	**4B**	**BE**
SOH	Length	OpCode	Region	CRC	

- The **extended syntax** allowing the region code plus LBT Enabled (if supported by Region) to be set. For example, to set the Region to EU3 and Enable LBT:

FF	**02**	**97**	**08**	**01**	**19**	**FD**
SOH	Length	OpCode	Region	LBT Enable	CRC	

Note

When LBT is disabled in the Open region the M6e-TC will implement frequency hopping as implemented for the NA region with a frequency hop interval of 400ms.

Set Power Mode (98h)

The **Set Power Mode** command can set the M6e-TC to four different power management modes. See Available power modes.

Use the **Set Power Mode** command to set the power mode to maximum saving mode by sending the following:

FF	01	98	03	44	BE
SOH	Length	OpCode	Power Mode	CRC	

Set User Mode (99h)

Use the **Set User Mode** command to set the user mode to the type of application in which the M6e-TC will be configured for the optimal Search Strategy settings for a particular protocol.

Send the following to set the user mode to printer:

FF	01	99	01	45	BC
SOH	Length	OpCode	User Mode	CRC	

The list of user modes and their corresponding session are found in Available User Modes. Setting the User Mode to an unsupported value will not modify the current setting.

Set Reader Configuration(9Ah)

The **Set Reader Configuration** command is used to set several configuration options on the reader. The configuration options, defined in the table below are enabled bitwise, although the option value is specified in hexidecimal (2 bytes). One example configuration and the corresponding Options value is specified in the command example below. For other combinations the hex value for Options will need to be calculated by OR’ing the bits for each setting.

Available Configuration Options

Option Bit/ Mode	Bit Value (4 LSBs shown)	Reader Configuration setting
Bit 1 EPC Length	$XX0X_2$ (Default)	Maximum EPC length of 96 bits
	$XX1X_2$	Maximum EPC length of 496 bits

Send the following to support EPC values up to 496 bits:

FF	02	9A	00	02	C0	52
SOH	Length	OpCode	Options		CRC	

Note

When using Max EPC length=96 the reader will still "see" tags with longer EPCs but they will not be passed up to the user or stored in the tag buffer. As a result there will be a performance impact when inventorying tags (when there are both tags with 96 bit and greater than 96 bit EPCs) as the reader will still be processing the longer EPC tags and discarding them.

Set Protocol Configuration (9Bh)

The **Set Protocol Configuration** command is used to set protocol-specific configuration parameters. The table below defines the currently available protocol-specific parameters which can be set and the supported settings. Additional parameters will be supported in the future.

Protocol Configuration Settings

Protocol Value	Parameter	Option	Value
0x05 (Gen2)	**Gen2 Session** used for Inventory commands. (**0x00**)	N/A	0x00 (S0 - Default)
			0x01 (S1)
			0x02 (S2)
			0x03 (S3)
	Gen2 Q Value (**0x12**)	Dynamic (**0x00**) - Automatically adjust Q value.	N/A
		Static (**0x01**) - User specified Q Value between 0 and 15.	1 byte (0x00-0x0F)
0x1B (eGo)	n/a		
0x1C (SeGo)	n/a		
0x1D (ATA)	n/a		
0x1E(Allegro/Title-21)	n/a		

Note

Setting the parameters using **Set Protocol Configuration** will override the implicit value set by a previous call to **Set User Mode**. Likewise, a subsequent call to Set User Mode will override the parameters set by Set Protocol Configuration. **Get Protocol Configuration** will always return the current setting regardless of whether it was set by Set Protocol Configuration or Set User Mode.

Set Gen2 Session

The following example sets the Gen2 session to S2:

FF	03	9B	05	00	02	DC	EA
SOH	Length	OpCode	Protocol	Parameter	Value	CRC	

Set Q Value

The Q valued can be set to a static user specified value or to dynamically change based on ThingMagic internal algorithms. When using the dynamic Q setting the Value parameter is dropped in the command.

The following example statically sets the Q value to 6:

FF	**04**	**9B**	**05**	**12**	**01**	**06**	**80**	**A9**
SOH	Length	OpCode	Protocol	Parameter	Option	Value	CRC	

The following example sets dynamic Q value adjusting:

FF	**03**	**9B**	**05**	**12**	**00**	**CE**	**E8**
SOH	Length	OpCode	Protocol	Parameter	Option	CRC	

FCC Test Commands

The following OpCodes are used for test purposes including regulatory certification testing. These commands cannot be run in the Bootloader.

Note

Set Power Mode to Full 0x00 before running FCC commands.

FCC Test Commands

OpCode	Command Name	Arguments	Return	BL	App
0xC1	Set Operating Frequency (C1h)	Frequency in kHz	none	N	Y
0xC3	Transmit CW Signal (C3h)	CW mode, [timeout]	none	N	Y

Set Operating Frequency (C1h)

The **Set Operating Frequency** command takes a 32-bit frequency value, expressed in kHz. For instance, to set the frequency to 915.26MHz, send the data value 915260 (0x000D F73C) to the reader.

FF	04	C1	00 0D F7 3C	F3 B7
SOH	Length	OpCode	Freq to Set	CRC

Transmit CW Signal (C3h)

The **Transmit CW Signal** command turns the Continuous Wave (CW) signal On or Off or enables a PRBS signal. Sending 0x00 turns Off the CW signal; sending 0x01 turns On the CW signal; Sending 0x02 turns on a PRBS signal. The CW signal is transmitted at the last used power level.

This example shuts off CW:

FF	01	C3	00	1F BD
SOH	Length	OpCode	CW	CRC

Some regulatory testing requires a PRBS (Pseudo-Random Bit Sequence) signal to simulate data transmission. To send a PRBS signal, along with sending CW=0x02, the Length field must be changed to 0x03. This indicates PRBS will be used and an extra 2 byte Timeout field must be added. When this PRBS mode is used the CW signal is on until the timeout expires, during that period the reader does not respond to commands.

The following example generates a PRBS CW signal for 256 ms, 100% duty cycle:

FF	03	C3	02	01 00	01 00
SOH	Length	OpCode	CW/PRBS	Timeout	CRC

Appendix A: Hardware Details

This Appendix details the mechanicals for the M6e-TC including the pin 1 location for the serial connector.

Mechanicals

The following figures detail the hardware layout of the M6e-TC Module.

M6e-TC Mechanicals

Antenna Connector

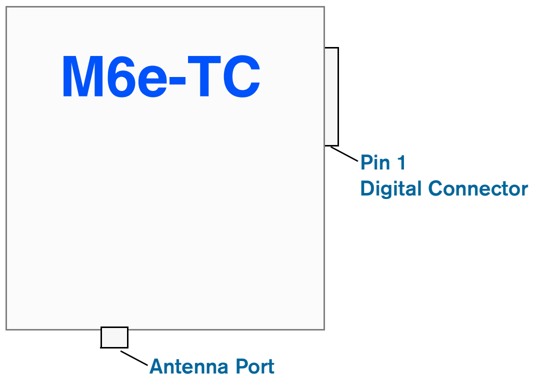
The M6e-TC has one MMCX connector for interfacing to the antenna.

Communications Connector

The communications interface on the module provides power, serial communications signals, and access to the GPIO inputs and outputs.

The M6e-TC has a 14-pin connector. For the interface pin-out, see M6e-TC Digital Connectors.

The following figure shows a diagram of the M6e-TC communications interface as you face the boards.



Connectors

The connectors used for the communications interface on the M6e-TC are as follows:

- JST SM14B-SRSS-TB

Mating Connector:

- **Connector Shell**: JST SHR-14V-S-B
- **Crimp Contacts**: JST SSH-003T-PO.2-H

Appendix B: Using the ArbSer Application

This appendix explains how to use the ArbSer application. This application provides some simple commands for using the Mercury embedded modules to read tags.

The ArbSer program is a simple terminal program with which you can communicate with the M4e, M5e, M5e-C, and M6e-TC modules. It provides several pre-formed commands, as well as a raw message interface that can be used to generate any command. The source code is part of the developer's kit to provide an example of the message format and CRC calculation.

The executable was built using a Windows 2000 PC. If the host PC's operating system is different, the executable should be rebuilt using Microsoft Visual C++ 6.0, or other compatible compiler. If building ArbSer on another platform, some work may be necessary to integrate the serial port properly.

ArbSer provides a help message if it is called with no argument:

C:\> ArbSer

ArbSer Version 3.2.0.

Usage: **ArbSer** <baud> <COM port> <option>

Default baud rate is 9600. To use 115200: ArbSer 115200 <options>

Default COM port is COM1. To use COM3: **ArbSer** <baud> *-c3* <options>

Only one option can be used at a time:

-eraseApp – Erase application FW only (sectors 1-8).

-genMsg – Generates a msg and prints it to console.

-go – Start the application FW.

-l5a MercuryE – Load the application FW into FLASH

-l5f x.dat <addr> – Load Program file x.dat at FLASH address <addr>

-msg xx xx xx ... – Send properly formatted msg (appends SOH and CRC).

-raw xx xx xx ... – Send raw hexadecimal msg (illegal msgs possible).

-ver – Returns the version information.

When using ArbSer, the serial port and baud rate can be changed from the default of COM1 and 9600 bps. Then, one of the options must be selected. The most useful ones are '*-go*', '*-msg*', and '*-ver*'. These commands provide the ability to exercise every feature of the modules.

Reading a Tag

Now that the module is connected to the PC and is powered on, the ArbSer.exe program is used to communicate with it. Send the sequence of commands described in this section.

The raw hexadecimal output sent through the serial port is shown following the ArbSer command. This is an example of the exact serial traffic sent to the Microprocessor.

Get Version Command

When the unit is first powered up, the boot loader is running. Verify that the module is alive by sending a **Get Version** command:

C:\> **ArbSer** *–ver*

< Equivalent to: FF 00 03 1D 0c >

Valid message received:

```
Data Length = 14
OpCode   = 03
Status   = 00 00
Data[000]  = 03
Data[001]  = 01
Data[002]  = 00
Data[003]  = 05
Data[004]  = FF
Data[005]  = FF
Data[006]  = FF
Data[007]  = FF
Data[008]  = 20
Data[009]  = 04
Data[010]  = 11
Data[011]  = 03
Data[012]  = 03
Data[013]  = 01
Data[014]  = 00
Data[015]  = 06
Data[016]  = 00
```

```
Data[017]  = 00
Data[018]  = 00
Data[019]  = 07
CRC      = 42EA
```

The module returns its version information. In the previous example, the version number shows the following:

- Boot loader version #3.1.5
- Application FW build date: 11/03/2004
- Application FW version #3.1.6
- 3 protocols enabled (EPC0, EPC1, ISO18000-6B).

Boot Firmware Command

Next, send a **Boot Firmware** command:

C:\> **ArbSer** *–go*

< Equivalent to: FF 00 04 1D 0B >

```
Valid message received:

 Data Length = 14

 OpCode   = 04

 Status   = 00 00

 Data[000]  = 03

 Data[001]  = 01

 Data[002]  = 00

 Data[003]  = 05

 Data[004]  = FF

 Data[005]  = FF

 Data[006]  = FF

 Data[007]  = FF

 Data[008]  = 20

 Data[009]  = 04

 Data[010]  = 11

 Data[011]  = 03

 Data[012]  = 03

 Data[013]  = 01

 Data[014]  = 00

 Data[015]  = 06

 Data[016]  = 00

 Data[017]  = 00

 Data[018]  = 00

 Data[019]  = 07

 CRC      = 4B6A
```

This returns the same version information as the `-ver` command previously documented. Now that the application FW has been started, the reader is ready to accept protocol commands. To read an EPC0 tag, place the tag about one foot away from the antenna. Then send the following series of commands.

Set Current Region Command

Before you can start reading tags with the M5e, M5e-C and M6e-TC, you must set the region in which the reader resides.

For example, if the region is the European Union, using the **Set Current Region** command, set the region as follows:

C:\> **ArbSer** –msg 01 97 02

<Equivalent to: FF 01 97 02 4B BE>

Valid message received:

Data Length = 00

OpCode = 93

Status = 00 00

CRC = 371A

Set Current Tag Protocol Command

When the application FW first starts, there is no default protocol loaded. Thus, the protocol to use must be specified.

For this example, the protocol is set to EPC0 using the **Set Current Tag Protocol** command:

```
C:\> ArbSer –msg 02 93 00 01

< Equivalent to: FF 02 93 00 01 51 79 >

Valid message received:

 Data Length = 00

 OpCode   = 93

 Status   = 00 00

 CRC      = 371A
```

Set Read TX Power Command

The default read power setting for the modules is 26.5 dBm. This should be adequate to read the tag from 1 foot. If a different power setting is desired, it should be entered now. The following **Set Read TX Power** command sets the power level to 25.0 dBm (0x09C4):

```
C:\> ArbSer –msg 02 92 09 C4

< Equivalent to: FF 02 92 09 C4 FC E5 >

Valid message received:

 Data Length = 00

 OpCode   = 92

 Status   = 00 00

 CRC      = 273B
```

Set Antenna Port Command

The default antenna port configuration is a 2-port antenna, with TX on port 1 and RX on port 2. If a different configuration is being used, it should be changed before attempting to read tags. For example, to use a one-port configuration that uses only port 1, use the **Set Antenna Port** command:

```
C:\> ArbSer –msg 02 91 01 01

< Equivalent to: FF 02 91 01 01 70 3B >

Valid message received:

 Data Length = 00

 OpCode   = 91

 Status   = 00 00

 CRC      = 1758
```

Finally, the module is ready to execute a read command. The timeout for the read can be set anywhere from 0 ms to 65,536 ms. Using the **Read Single Tag ID** command, the timeout is set to 1 s, which is 1000 ms (0x03E8):

```
C:\> ArbSer –msg 02 21 03 E8
< Equivalent to: FF 02 21 03 E8 D5 09 >
Valid message received:
 Data Length = 0E
 OpCode   = 21
 Status   = 00 00
 Data[000]  = 12
 Data[001]  = 34
 Data[002]  = 56
 Data[003]  = 78
 Data[004]  = 9A
 Data[005]  = BC
 Data[006]  = DE
 Data[007]  = F0
 Data[008]  = AA
 Data[009]  = BB
 Data[010]  = CC
 Data[011]  = DD
 Data[012]  = 23
 Data[013]  = 79
 CRC      = 2384
```

The module should now return the tag ID of the tag. In this example, the 96-bit EPC0 tag ID is (0x12 34 56 78 9A BC DE F0 AA BB CC DD) with a tag ID CRC of 0x2379.

Unexpected Results

Sometimes you do not get the results that you expected. The following sections explain some problems that can occur when the previously listed sequence of commands are used. The following sections explain some of the frequently encountered errors.

Serial Communication Does Not Work

If serial communications fails to work using the **ArbSer** command, check the following:

- The baud rate is correct.
- If the baud rate of the boot loader or application FW was changed, then specify the current baud rate using ArbSer. For example, “ArbSer <baudrate> ...”.
- The correct COM port is being used.
- ArbSer does not return an error if it is able to open the specified COM port. Currently, ArbSer works on COM1 to COM9.
- The commands are properly formed.
- If no SOF byte (0xFF) is used, or an incorrect CRC or number of data elements is specified, then the Microprocessor does not respond to the message at all.
- The module is properly connected and powered on.
- The serial cable should not be a NULL modem cable.
- The PC serial port is working properly.

  An RS-232 line checker is helpful for this.

A simple way to check that serial communications is working is to try sending a **Get Version** command. If a valid response is received, then the physical communication layer is intact and working properly. That is to say that the baud rate, COM port, and cables are all fine.

Commands Return a Non-Zero Status Code

If a command returns a non-zero status code, this is not always an error. However, if a non-zero code is received in response to a **Set** command, such as **Set Current Tag Protocol**, **Set Read TX Power**, or **Set Antenna Port** commands, it is likely that one of the following problems exists:

- The module is still executing the boot loader program.

Send a **Boot Firmware** command to verify that the application FW is running. If the boot loader is currently running, then a set command will return a 0x0101 status code, indicating an invalid OpCode.

- The parameter(s) to the set command are invalid. If an invalid parameter is sent, then a 0x0105 status code is returned, indicating an invalid parameter value.
- If the wrong number of data elements is used, then a 0x0100 status code (wrong number of data) is returned. This could be the result of an ill-formed command, or accidentally using the wrong OpCode.

No Tag ID is Returned

If the **Read Tag ID Single** command returns an error code of 0x0400 (no tag found), then most likely it is a set up related issue. Check the following items:

- The antenna is properly connected to the unit and configured using the **Set Antenna Port** command.
- The tag is the right protocol (that is EPC0) and that the protocol has been set using the **Set Current Tag Protocol** command.
- Try using a longer timeout, such as 30 seconds, and varying the tag's location in relation to the antenna.
- It is also possible the tag may be erased or damaged. Without a second "known good" reader, it is difficult to tell if this is the case. If a "known good" tag is available, try to read it.

Appendix C: Error Messages

The following error codes were incorporated into the reader for help in locating errors.

Common Error Messages

The following table lists the common faults discussed in this section.

Fault Message	Code
FAULT_MSG_WRONG_NUMBER_OF_DATA – (100h)	100h
FAULT_INVALID_OPCODE – (101h)	101h
FAULT_UNIMPLEMENTED_OPCODE – 102h	102h
FAULT_MSG_POWER_TOO_HIGH – 103h	103h
FAULT_MSG_INVALID_FREQ_RECEIVED (104h)	104h
FAULT_MSG_INVALID_PARAMETER_VALUE - (105h)	105h
FAULT_MSG_POWER_TOO_LOW - (106h)	106h
FAULT_UNIMPLEMENTED_FEATURE - (109h)	109h
FAULT_INVALID_BAUD_RATE - (10Ah)	10Ah

FAULT_MSG_WRONG_NUMBER_OF_DATA – (100h)

Cause

If the data length in any of the Host-to-M5e/M5e-Compact messages is less than or more than the number of arguments in the message, the reader returns this message.

Solution

Make sure the number of arguments matches the data length.

FAULT_INVALID_OPCODE – (101h)

Cause

The opCode received is invalid or not supported with the current version of code.

Solution

Check the documentation for the opCode the host sent and make sure it is supported.

FAULT_UNIMPLEMENTED_OPCODE – 102h

Cause

Some of the reserved commands might return this error code.

This does not mean that they always will do this since ThingMagic reserves the right to modify those commands at anytime.

Solution

Check the documentation for the opCode the host sent to the reader and make sure it is supported.

FAULT_MSG_POWER_TOO_HIGH – 103h

Cause

A message was sent to set the read or write power to a level that is higher than the current HW supports.

Solution

Check the HW specifications for the supported powers and insure that the level is not exceeded.

The M5e 1 Watt units support power from 5 dBm to 30 dBm.

The M5e-Compact units support power from 10 dBm to 23 dBm.

FAULT_MSG_INVALID_FREQ_RECEIVED (104h)

Cause

A message was received by the reader to set the frequency outside the supported range

Solution

Make sure the host does not set the frequency outside this range or any other locally supported ranges.

FAULT_MSG_INVALID_PARAMETER_VALUE - (105h)

Cause

The reader received a valid command with an unsupported or invalid value within this command.

For example, currently the module supports two antennas, 1 and 2. If the module receives a message with an antenna value other than 1 or 2, it returns this error.

Solution

Make sure the host sets all the values in a command according to the values published in this document.

FAULT_MSG_POWER_TOO_LOW - (106h)

Cause

A message was received to set the read or write power to a level that is lower than the current HW supports.

Solution

Check the HW specifications for the supported powers and insure that level is not exceeded. The M5e supports powers between 5 and 30 dBm. The M5e-Compact units support power from 10 dBm to 23 dBm.

FAULT_UNIMPLEMENTED_FEATURE - (109h)

Cause

Attempting to invoke a command not supported on this firmware or hardware.

Solution

Check the command being invoked against the documentation.

FAULT_INVALID_BAUD_RATE - (10Ah)

Cause

When a **Set Baud Rate** (0x06h) command is issued for a rate that is not specified in the Baud Rate table, this error message is returned.

Solution

Check the table of specific baud rates and select a baud rate. Send the baud rate in the hex format. See Set Baud Rate (06h).

Bootloader Faults

The following table lists the common faults discussed in this section.

Fault Message	Code
FAULT_BL_INVALID_IMAGE_CRC	200h
FAULT_BL_INVALID_APP_END_ADDR	201h

FAULT_BL_INVALID_IMAGE_CRC – 200h

Cause

When a **Verify Image CRC** (0x08), or **Boot Firmware** (0x02) command is issued, the reader checks the image stored in flash and returns this error if the calculated CRC is different than the one stored in flash.

Solution

The exact reason for the corruption could be that the image loaded in flash was corrupted during the transfer or corrupted for some other reason.

To fix this problem, reload the application code in flash.

FAULT_BL_INVALID_APP_END_ADDR – 201h

Cause

When a **Verify Image CRC** (0x08), or **Boot Firmware** (0x02) command is issued, the reader checks the image stored in flash and returns this error if the last word stored in flash does not have the correct address value.

Solution

The exact reason for the corruption could be that the image loaded in flash got corrupted during the transfer or, corrupted for some other reason.

To fix this problem, reload the application code in flash.

FPGA Faults

The following table lists the common faults discussed in this section.

Fault Message	Code
FAULT_PROGRAM_ERASE_FAILED – 2E0h	2E0h
FAULT_PROGRAM_FAILED – 2E1h	2E1h
FAULT_PROGRAM_VERIFY_FAILED – 2E2h	2E2h
FAULT_PROGRAM_OPERATION_FAILED – 2E3h	2E3h
FAULT_PROGRAM_NOT_LOADED – 2E4h	2E4h

FAULT_PROGRAM_ERASE_FAILED – 2E0h

Cause

When a boot firmware (0x02) is issued during an FPGA image load and the erase of the FPGA FlashROM pages fails

Solution

Power cycle the module and reload the FPGA load application and FPGA image. If problem persists try a previous version of the FPGA Loag Image application with the same DAT file.

FAULT_PROGRAM_FAILED – 2E1h

Cause

When a boot firmware (0x02) is issued during an FPGA image load and the programming of the FPGA FlashROM pages fails.

Solution

Power cycle the module and reload the FPGA load application and FPGA image. If problem persists try a previous version of the FPGA Loag Image application with the same DAT file.

FAULT_PROGRAM_VERIFY_FAILED – 2E2h

Cause

When a boot firmware (0x02) is issued during an FPGA image load and the verification of the FPGA FlashROM pages fails.

Solution

Power cycle the module and reload the FPGA load application and FPGA image. If problem persists try a previous version of the FPGA Load Image application with the same DAT file.

FAULT_PROGRAM_OPERATION_FAILED – 2E3h

Cause

When a boot firmware (0x02) is issued after the FPGA image is loaded and the verification of the FPGA version and testing of the 16-bit FPGA-ATMEL parallel interface fails.

Solution

Power cycle the module and reload the FPGA load application and FPGA image. Check that the FPGA TM and TC version numbers start with 0x1234xxxx and 0x0010, respectively. If problem persists contact support@thingmagic.com.

FAULT_PROGRAM_NOT_LOADED – 2E4h

Cause

When a boot firmware (0x02) is issued and the FPGA DAT file has not been loaded.

Solution

Power cycle the module and reload the FPGA load application and FPGA image. If problem persists try a previous version of the FPGA Load Image application with the same DAT file.

Flash Faults

The following table lists the common faults discussed in this section.

Fault Message	Code
FAULT_FLASH_BAD_ERASE_PASSWORD – 300h	300h
FAULT_FLASH_BAD_WRITE_PASSWORD – 301h	301h
FAULT_FLASH_UNDEFINED_ERROR – 302h	302h
FAULT_FLASH_ILLEGAL_SECTOR – 303h	303h
FAULT_FLASH_WRITE_TO_NON_ERASED_AREA – 304h	304h
FAULT_FLASH_WRITE_TO_ILLEGAL_SECTOR – 305h	305h
FAULT_FLASH_VERIFY_FAILED – 306h	306h

FAULT_FLASH_BAD_ERASE_PASSWORD – 300h

Cause

A command was received to erase some part of the flash but the password supplied with the command was incorrect.

Solution

Make sure that you have the correct password for the flash sector.

Go to the Erase Flash Sector (07h) section for more information about the flash passwords and sectors.

FAULT_FLASH_BAD_WRITE_PASSWORD – 301h

Cause

A command was received to write some part of the flash but the password supplied with the command was not correct.

Solution

Make sure that you have the correct password for the flash sector.

Check the Write Flash Sector (0Dh) for more information about the flash passwords and sectors.

FAULT_FLASH_UNDEFINED_ERROR – 302h

Cause

This is an internal error and it is caused by a software problem in module.

Solution

Contact support at support@thingmagic.com.

FAULT_FLASH_ILLEGAL_SECTOR – 303h

Cause

An erase or write flash command was received with the sector value and password not matching.

Solution

Make sure that you have the correct password for the flash sector.

Go to Accessing the Flash for more information about the flash passwords and sectors.

FAULT_FLASH_WRITE_TO_NON_ERASED_AREA – 304h

Cause

The module received a write flash command to an area of flash that was not previously erased.

Solution

Erase that sector of flash and then, try and rewrite to it.

FAULT_FLASH_WRITE_TO_ILLEGAL_SECTOR – 305h

Cause

The module received a write flash command to write across a sector boundary that is prohibited.

Solution

If the data spans two sectors, separate the data into two messages.

FAULT_FLASH_VERIFY_FAILED – 306h

Cause

The module received a write flash command that was unsuccessful because data being written to flash contained an uneven number of bytes.

Solution

Verify that the data being sent is an even number of bytes.

Protocol Faults

The following table lists the common faults discussed in this section.

Fault Message	Code
FAULT_NO_TAGS_FOUND – (400h)	400h
FAULT_NO_PROTOCOL_DEFINED – 401h	401h
FAULT_INVALID_PROTOCOL_SPECIFIED – 402h	402h
FAULT_WRITE_PASSED_LOCK_FAILED – 403h	403h
FAULT_PROTOCOL_NO_DATA_READ – 404h	404h
FAULT_AFE_NOT_ON – 405h	405h
FAULT_PROTOCOL_WRITE_FAILED – 406h	406h
FAULT_NOT_IMPLEMENTED_FOR_THIS_PROTOCOL – 407h	407h
FAULT_PROTOCOL_INVALID_WRITE_DATA – 408h	408h
FAULT_PROTOCOL_INVALID_ADDRESS – 409h	409h
FAULT_GENERAL_TAG_ERROR – 40Ah	40Ah
FAULT_DATA_TOO_LARGE – 40Bh	40Bh
FAULT_PROTOCOL_INVALID_KILL_PASSWORD – 40Ch	40Ch
FAULT_PROTOCOL_KILL_FAILED - 40Eh	40Eh
FAULT_PROTOCOL_BIT_DECODING_FAILED - 40Fh	40Fh
FAULT_GEN2 PROTOCOL_OTHER_ERROR - 420h	420h
FAULT_GEN2_PROTOCOL_MEMORY_OVERRUN_BAD_PC - 423h	423h
FAULT_GEN2 PROTOCOL_MEMORY_LOCKED - 424h	424h
FAULT_GEN2 PROTOCOL_INSUFFICIENT_POWER - 42Bh	42Bh
FAULT_GEN2 PROTOCOL_NON_SPECIFIC_ERROR - 42Fh	42Fh
FAULT_GEN2 PROTOCOL_UNKNOWN_ERROR - 430h	430h

FAULT_NO_TAGS_FOUND – (400h)

Cause

A command was received (such as like read, write, or lock) but the operation failed. There are many reasons that can cause this error to occur.

Here is a list of possible reasons that could be causing this error:

- No tag in the RF field
- Read/write power too low
- Antenna not connected
- Tag is weak or dead

Solution

Make sure there is a good tag in the field and all parameters are set up correctly. The best way to check this is to try few tags of the same type to rule out a weak tag. If none passed, then it could be SW configuration such as protocol value, antenna, and so forth, or a placement configuration like a tag location.

FAULT_NO_PROTOCOL_DEFINED – 401h

Cause

A command was received to perform a protocol command but no protocol was initially set. The reader powers up with no protocols set.

Solution

A **Set Current Tag Protocol** (63h) command must be sent followed by resending the desired command.

FAULT_INVALID_PROTOCOL_SPECIFIED – 402h

Cause

A **Set Current Tag Protocol** (63h) command was received for a protocol value that is not supported with the current version of SW.

Solution

This value is invalid or this version of SW does not support the protocol value. Check the documentation for the correct values for the protocols in use.

FAULT_WRITE_PASSED_LOCK_FAILED – 403h

Cause

During a Write Tag Data for ISO18000-6B or UCODE, if the lock fails, this error is returned. The write command passed but the lock did not. This could be a bad tag.

Solution

Try to write a few other tags and make sure that they are placed in the RF field.

FAULT_PROTOCOL_NO_DATA_READ – 404h

Cause

A **Read Tag ID** or **Data** command was sent but did not succeed.

Solution

The tag used has failed or does not have the correct CRC. Try to read a few others to check the HW/SW configuration.

FAULT_AFE_NOT_ON – 405h

Cause

A command was received for an operation, like read or write, but the minimum required configuration has not been set.

Solution

Check that the region has been set, then rerun the command.

FAULT_PROTOCOL_WRITE_FAILED – 406h

Cause

This fault can occur when an operation such as write, lock, kill, set password, or initialize, fails. There are many reasons for failure.

Solution

Check that the tag is good and try another operation on a few more tags.

FAULT_NOT_IMPLEMENTED_FOR_THIS_PROTOCOL – 407h

Cause

A command was received which is not supported by a protocol.

Solution

Check the documentation for the supported commands and protocols.

FAULT_PROTOCOL_INVALID_WRITE_DATA – 408h

Cause

In EPC0+, the first two bits determine the tag ID length. If the first two bits are 0b00, then the tag ID must be 96-bits. Otherwise the tag ID is 64 bits.

Solution

Make sure that the first two bit have the correct values depending in the Tag ID length.

FAULT_PROTOCOL_INVALID_ADDRESS – 409h

Cause

A command was received attempting to access an invalid address in the tag data address space.

Solution

Make sure that the address specified is within the scope of the tag data address space and available for the specific operation. The protocol specifications contain information about the supported addresses.

FAULT_GENERAL_TAG_ERROR – 40Ah

Cause

This error is used by the M5e GEN2 module. This fault can occur if the read, write, lock, or kill command fails. This error can be internal or functional.

Solution

Make a note of the operations you were performing and contact ThingMagic at http://support.thingmagic.com

FAULT_DATA_TOO_LARGE – 40Bh

Cause

A command was received to Read Tag Data with a data value larger than expected or it is not the correct size.

Solution

Check the size of the data value in the message sent to the reader.

FAULT_PROTOCOL_INVALID_KILL_PASSWORD – 40Ch

Cause

An incorrect kill password was received as part of the **Kill Tag** (26h) command.

Solution

Check the password.

FAULT_PROTOCOL_KILL_FAILED - 40Eh

Cause

Attempt to kill a tag failed for an unknown reason

Solution

Check tag is in RF field and the kill password.

FAULT_PROTOCOL_BIT_DECODING_FAILED - 40Fh

Cause

Attempting to operate on a tag with an EPC length greater than the Maximum EPC length setting.

Solution

Call Set Reader Configuration(9Ah) to set the Max EPC to 496 bits.

FAULT_GEN2 PROTOCOL_OTHER_ERROR - 420h

FAULT_GEN2_PROTOCOL_MEMORY_OVERRUN_BAD_PC - 423h

FAULT_GEN2 PROTOCOL_MEMORY_LOCKED - 424h

FAULT_GEN2 PROTOCOL_INSUFFICIENT_POWER - 42Bh

FAULT_GEN2 PROTOCOL_NON_SPECIFIC_ERROR - 42Fh

FAULT_GEN2 PROTOCOL_UNKNOWN_ERROR - 430h

Analog Hardware Abstraction Layer Faults

FAULT_AHAL_INVALID_FREQ – 500h

Cause

A command was received to set a frequency outside the specified range.

For example, in North America the frequency range is from 902 MHz to 928 MHz.

Solution

Check the values you are trying to set and be sure that they fall within this range.

FAULT_AHAL_INVALID_FREQ – 501h

Cause

With LBT enabled an attempt was made to set the frequency to an occupied channel.

Solution

Try a different channel.

Tag ID Buffer Faults

The following table lists the common faults discussed in this section.

Fault Message	Code
FAULT_TAG_ID_BUFFER_NOT_ENOUGH_TAGS_AVAILABLE – 600h	600h
FAULT_TAG_ID_BUFFER_FULL – 601h	601h
FAULT_TAG_ID_BUFFER_REPEATED_TAG_ID – 602h	602h
FAULT_TAG_ID_BUFFER_NUM_TAG_TOO_LARGE – 603h	603h

FAULT_TAG_ID_BUFFER_NOT_ENOUGH_TAGS_AVAILABLE – 600h

Cause

A command was received to get a certain number of tag ids from the tag id buffer. The reader contains less tag ids stored in its tag id buffer than the number the host is sending.

Solution

Send a **Get Tag ID Buffer** command to ascertain how many tags are in the buffer. You can get the exact number of tags as long as they are less than or equal to the number returned by the previous command.

FAULT_TAG_ID_BUFFER_FULL – 601h

Cause

The tag id buffer is full.

Solution

Send **Clear Tag ID Buffer** or **Get Tag ID Buffer** command with the number of tags to read, to get more space See Get Tag Buffer (29h) for more information.

FAULT_TAG_ID_BUFFER_REPEATED_TAG_ID – 602h

Cause

The module has an internal error. One of the protocols is trying to add an existing TagID to the buffer.

Solution

Report this problem to ThingMagic at http://support.thingmagic.com.

FAULT_TAG_ID_BUFFER_NUM_TAG_TOO_LARGE – 603h

Cause

The module received a request to retrieve more tags than is supported by the current version of the software.

Solution

Locate the maximum number of supported tags in the TagID buffer in this document Get Tag Buffer (29h).

System Errors

FAULT_SYSTEM_UNKNOWN_ERROR – 7F00h

Cause

The error is internal.

Solution

Make note of the operations you were executing and contact ThingMagic at http://support.thingmagic.com.

FAULT_TM_ASSERT_FAILED – 7F01h

Cause

An unexpected Internal Error has occurred.

Solution

The error will cause the module to switch back to Bootloader mode. When this occurs make note of the operations you were executing, save FULL error response and contact ThingMagic at support@thingmagic.com.

Appendix D: FPGA Support

This appendix explains how to create and update Field Programmable Gate Array (FPGA) images for the M6e-TC.

Creating an FPGA Image DAT File

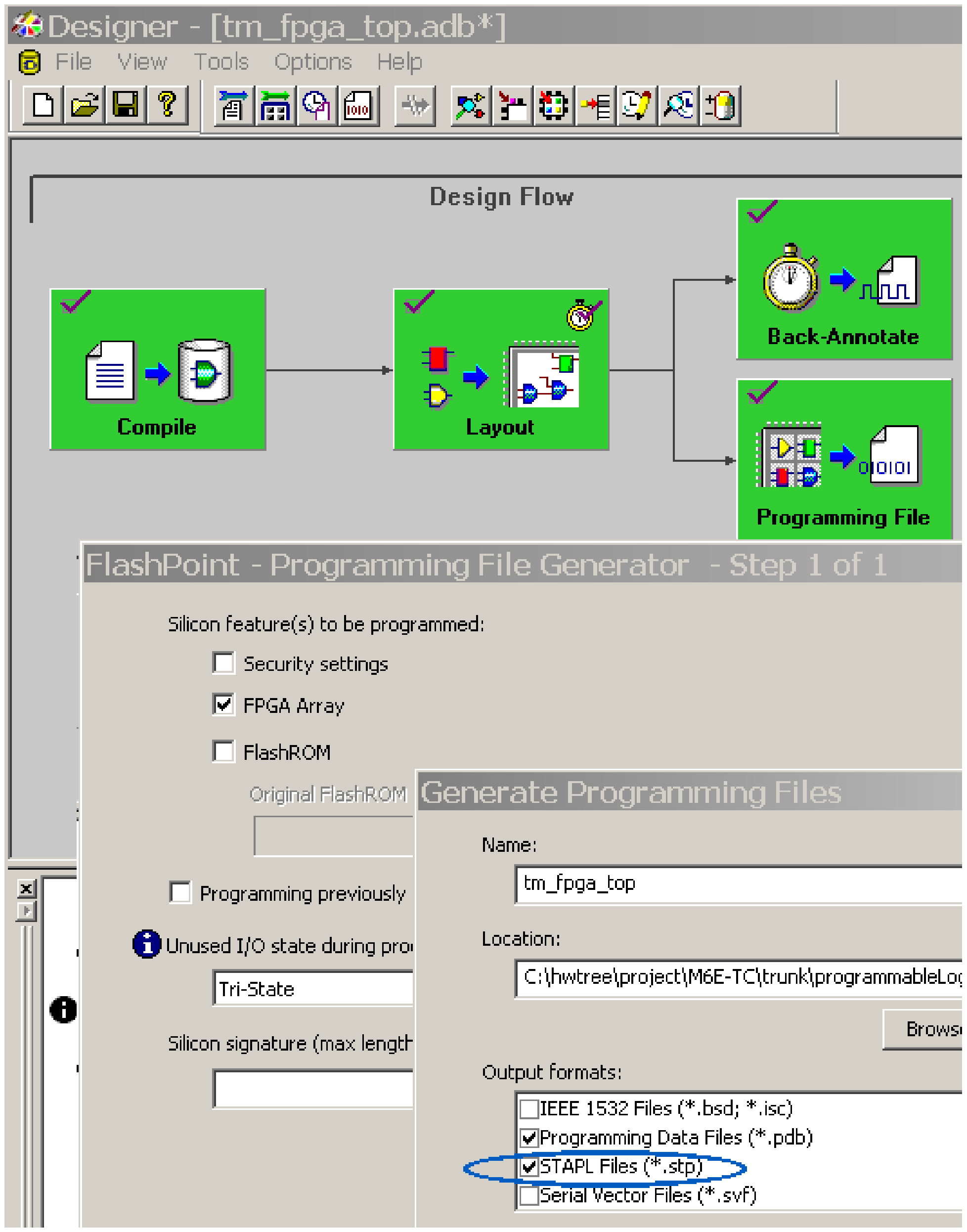
Creating an FPGA Image DAT file requires the use of an Actel programming environment. In the following instructions the use of Libero 8.4 is assumed. The process for other Libero versions or Actel programming environments may vary. This process assumes Verilog files have been pre-compiled and you are at the compiling stage.

In order to create an FPGA image DAT file from STAPL output the following programs are required:

- **Libero Designer** - Verilog/VHDL complier to build the STAPL (.stp) file.
- **datgen.exe** - Windows command line tool for converting the STAPL output to a .dat binary format.

Follow these steps to build the DAT file:

1. **Generate the STAPL file** - When generating output from *Designer* make sure to select the STAPL files option for the Output files to be generated as shown below.



FlashPoint - Programming File Generator - Step 1 of 1

Silicon feature(s) to be programmed:

- [ ] Security settings
- [x] FPGA Array
- [ ] FlashROM

Original FlashROM

- [ ] Programming previously

Unused I/O state during pro

Tri-State

Silicon signature (max length

Generate Programming Files

Name:

tm_fpga_top

Location:

C:\hwtree\project\M6E-TC\trunk\programmableLo

Brows

Output formats:

- [ ] IEEE 1532 Files (*.bsd; *.isc)
- [x] Programming Data Files (*.pdb)
- [x] STAPL Files (*.stp)
- [ ] Serial Vector Files (*.svf)

2. **Generate the DAT file** - Once the *.stp file has been generated it can be fed into the datgen.exe utility to generate the .dat file. datgen must be run from the command line. Typical output, using the STAPL file: *tm_fpga_top.stp* file as its input, is shown below:

```
C:\>datgen tm_fpga_top.stp

DirectC Version 2.x
Copyright (C) 2002 - 2007 Actel Corporation

Checking STAPL file CRC value..
Actual CRC = 7D55
Reading STAPL file...

Generating .dat files...
Image size = 129680
Data compression = 0
Stapl Target ID = 3A121CF
Tool version = 1
Map version = 1
Core Support = 1
FROM support = 0
NVM support = 0
NVM_Block0 support = 0
NVM_Block1 support = 0
NVM_Block2 support = 0
NVM_Block3 support = 0
NVM verifiy = 0
Pass key support = 0
AES key support = 0
Core security Status = 0
From Security Status = 0
NVM_BLOCK0 Security Status = 0
NVM_BLOCK1 Security Status = 0
NVM_BLOCK2 Security Status = 0
NVM_BLOCK3 Security Status = 0
Image CRC = 244B
Done.

C:\>dir *.dat

03/13/2009  02:15 PM           129,680 tm_fpga_top.dat
1 File(s)        129,680 bytes
0 Dir(s)  23,756,279,808 bytes free
```

3. The resulting tm_fpga_top.dat can now be loaded onto the M6e-TC using the process described in Loading an FPGA Image.

W A R N I N G !

When loading an FPGA Image onto the M6e-TC, the Verification process checks the 16 most significant bits of the FPGA TM and TC version numbers. To pass, the TM and TC versions must start with 0x1234xxxx and 0x0010xxxx, respectively. When incrementing version numbers in the Verilog/VHDL files be sure to only change the 16 least significant bits.

Loading an FPGA Image

The ArbSer (see Appendix B: Using the ArbSer Application) program can also be used to load FPGA images. In order to load an FPGA image the following files are required:

- **Arbser.exe** - minimum version 3.2.0.
- **m6etc_fpga_mod.sim** - FPGA load application image to be loaded into the M6e-TC which will be used to update the FPGA image defined by the FPGA Image file.
- **FPGA Image file** - FPGA image file in DAT format to be loaded into the M6e-TC FPGA.

The following describes how to load an image onto the M6e-TC FPGA. These steps must be followed carefully. If FPGA Faults occur please follow the suggested solution and retry the image load.

1. Load the FPGA load application program into the M6e-TC using the following command:

```
> arbser -l5a m6etc_fpga_mod.sim
```

2. Load the FPGA image file into flash within the application sector at address 0x8000.

```
> arbser -l5f [fpgaimage.dat] 8000
```

3. Initiate the image load.

```
> arbser -go
```

   This executes the FPGA application program and starts the FPGA programming process. The FPGA's FlashROM is erased, the FPGA image is loaded and, finally, the image is verified (see Note below). This operation takes about three minutes to complete and should not be interrupted. On successful completion the FPGA version information is verified and write and read verify operations are performed to check the ATMEL <> FPGA interface. If these checks pass, the M6e-TC responds with status and version information similar to the response for the Get Version Command but with opcode=0x04 and the module returns to the Boot Loader mode.

4. Once the FPGA load has successfully completed the M6e-TC Application firmware must be reloaded using the following command:

```
> arbser -l5a [M6e-TC App Firmware .sim]
```

`For FPGA version information use the` Get Hardware Version (10h) `command..`