# THINGMAGIC M6e USER GUIDE


TM_M6e-UG
Rev 01292019

JADAK
A Novanta Company

## COPYRIGHT INFORMATION



Version 01292019



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# REVISION HISTORY

| Date | Version | Description |
|---|---|---|
| 4/2010 | 01RevA | • First Draft for beta release. |
| 8/2010 | 01RevB | • Updated GPIO content.<br>• Added FCC regulation info section. |
| 12/2010 | 02Rev1 | • New development kit content.<br>• Added approved antennas list.<br>• Updated power consumption data.<br>• Updated Gen2 settings. |
| 2/2011 | 02 Rev2 | • Updated Regulatory info. |
| 5/2011 | 03 RevA | • Added M6e-A info.<br>• Updated ESD info. |
| 1/2012 | 04 RevA | • Updated development kit getting started section.<br>• Added new M6e-PRC frequency range info.<br>• New ISO6b settings, including delimiter specific info. |
| 2/2012 | 05 RevA | • Fixed ISO6b delimiter information. |
| 7/2012 | 06 RevA | • Added warnings about using TTL interface in continuous reading mode.<br>• Added new 128-byte limit to tag read data metadata.<br>• Added info on new Universal Reader Assistant 2. |
| 2/2013 | 07 RevA | • Corrected default bootloader/RESET mode baud rate to115200.<br>• Corrected RESET line pull-down resistance to 1.5kohms. |
| 9/2013 | 08 RevA | • Added antenna detection requirements info. |
| 3/2016 | 09 RevA | • Incorporated more information about module variants - M6e-A, M6e-PRC, M6e-JIC.<br>• Mentioned antenna detection via return loss measurement, introduced in FW 1.19.0.<br>• Mentioned saving settings and autonomous operation, introduced in FW 1.19.0.<br>• Removed notes on limitations, which have since been eliminated by subsequent firmware revisions (see release notes for details).<br>• Updated address in cover copyright.<br>• All references to “CN” region changed to “PRC2”. |
| 6/2017 | 09 RevB | • RED Declaration of Conformity added. |
| 01/31/2018 | 875-0053-09 RevB | • Updated with Novanta Corporation information. |
| 12/2/2018 | TM_M6e-UG Rev 12022018 | • Updated to user documentation standards.<br>• Incorporated M6e firmware v1.21.2 release notes. |
| 1/29/2019 | TM_M6e-UG Rev 01292019 | • Updated warnings to specify M6e-A module. |

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# 1 Introduction

This document applies to the ThingMagic M6e high-performance, 4-port Ultra High Frequency (UHF) RAIN® Radio Frequency Identification (RFID) module, as well as the M6e-A, M6e-PRC, and M6e-JIC modules. All versions are referred to as M6e in this manual, with any exceptions expressly noted. ThingMagic M6e is a high performance, embedded module that you can integrate with other systems to create RFID-enabled products. This document is for hardware designers and software developers.

Applications to control the M6e module and derivative products can be written using the high level MercuryAPI Ver. 1.29.4 and later. The MercuryAPI supports Java, .NET and C programming environments. The MercuryAPI Software Development Kit (SDK) contains sample applications and source code to help developers get started demoing and developing functionality. For more information on the MercuryAPI see the MercuryAPI Programmers Guide and the MercuryAPI SDK, available on www.jadaktech.com. Note that the M6e-JIC module requires firmware version 1.21.0 or higher.

## M6e Variations

There are four hardware variations of this module.

**M6e**

Designed to operate in the North American (902-928 MHz) and European (865-858 MHz) regulatory regions. The North American region is limited to a transmit power of +30 dBm to conform to FCC regulations for unrestricted use of a module of this type.

**M6e-A**

Operates in the same bands as the M6e module but will transmit at power levels up to +31.5 dBm in the North American region. There are additional restrictions that a user must adhere to operate a module of this power level in regions that adhere to FCC regulations.

**M6e-PRC**

Obsolete. This module was designed for the Chinese market and operates in both the high China band (920 to 925 MHz) and the low China band (840 to 845 MHz). It has been replaced by the M6e-JIC module.

**M6e-JIC**

This module is designed to meet the demanding requirements for high power UHF RFID modules in China (920 to 925 MHz), Japan (916.8 to 920.8 MHz), and Israel (915 to 917 MHz) bands.

## Release Notes

The information in this document is relevant to M6e modules with Firmware Ver. 1.21.2 and later. This firmware is compatible with the M6e, M6e-A and M6e-JIC modules. This firmware is not compatible with any other ThingMagic modules such as the Micro or Nano modules.

M6e firmware version 1.21.2 has been developed in conjunction with version 1.29.4 of the MercuryAPI and should be used with that version (or higher) to achieve best results. Previous versions of the API will not support all the features of this firmware release. See the API release notes and MercuryAPI Programmers Guide for further information on its features and functions.

# 2 Hardware Overview

## Hardware Interfaces

### Antenna Connections

The M6e supports four monostatic bidirectional RF antennas through four MMCX connectors: labeled J1 through J4 on the module. See Cables and Connectors for more information on antenna connector parts.

The maximum RF power that can be delivered to a 50 ohm load from each port is 1.4 Watts, or +31.5 dBm (regulatory requirements permitting).

**NOTE: The RF ports can only be energized one at a time.**

**NOTE: FCC/NA Region max RF power is 30 dBm for the M6e module. For 31.5 dBm operation in the FCC/NA Region the M6e-A module must be purchased.**

### Antenna Requirements

The performance of the M6e is affected by antenna quality. Antennas that provide good 50 ohm match at the operating frequency band perform best. Specified sensitivity performance is achieved with antennas providing 17 dB return loss or better across the operating band. (A higher numerical value indicates a better match.) Damage to the module will not occur for any return loss of 1 dB or greater. Damage may occur if antennas are disconnected during operation or if the module sees an open or short circuit at its antenna port.

### Antenna Detection

To minimize the chance of damage due to antenna disconnection, the M6e supports antenna detection. Detection can be done automatically or manually, the choice of which is configured through API calls.

- Automatically if the antenna passes DC current.
- Manually by doing periodic checks of the ability of ports to pass DC.
- Manually by doing periodic checks to determine if the return loss is below a value that indicates an antenna is present (a value of -10 dBm is a good threshold).

Regardless of how the reader is used, it is generally recommended that antenna detection be enabled as it helps protect the module from possible damage.

For antennas to be detected automatically by DC current, the M6e antenna must pass some DC current across the center pin and ground, i.e., must present between 0 Ohms and 10 kOhms DC resistance.

## Digital/Power Connector

The digital connector provides power, serial communications signals, shutdown and reset signals to the M6e module, and access to the GPIO inputs and outputs. These signals are provided through connector part number: Molex 53261-1571 - 1.25mm pin centers, 1 amp per pin rating, which mates with Molex housing p/n 51021 -1500 with crimps p/n 63811-0300. See Cables and Connectors for more information on typical cable parts.

*M6e Digital Connector Signal Definition*

| Molex 53261-1571 Pin Number | Signal | Signal Direction (In/Out of M6e) | Notes |
|---|---|---|---|
| 1 | GND | P/S Return | Must connect both GND pins to ground |
| 2 | GND | P/S Return | |
| 3 | +5VDC | P/S Input | Must connect both 5V supplies |
| 4 | +5 VDC | P/S Input | |
| 5 | GPIO1 | Bi-directional | Input 5VDC tolerant, 16mA Source/Sink |
| 6 | GPIO2 | Bi-directional | |
| 7 | GPIO3 | Bi-directional | |
| 8 | GPIO4 | Bi-directional | |
| 9 | UART_RX_TTL | In | In (Pull-down with +10k Ohm to Ground) |
| 10 | UART_TX_TTL | Out | Out |
| 11 | USB_DM | Bi-directional | USB Data (D-) signal |
| 12 | USB_DP | Bi-directional | USB Data (D+) signal |
| 13 | USB_5VSENSE | In | Input 5V to tell module to talk on USB |
| 14 | SHUTDOWN | In | Pull LOW to enable module. Set HIGH to disable all 5V Inputs and shutdown module. |
| 15 | RESET | Bi-directional | HIGH output indicates Boot Loader is running. LOW output indicates Application Firmware is running.<br>Note: Not 5V tolerant. |

Reconnection to the module may not possible if the host PC is restarted while auto read is in progress. To reconnect to the module, the user must either reboot the module or unplug and re-plug the USB cable.

### Control Signal Specification

The module communicates to a host processor via a TTL logic level UART serial port or via a USB port. Both ports are accessed on the 15-pin Digital/Power Connector. The TTL logic level UART supports complete functionality. The USB port supports complete functionality, except the lowest power operational mode.

**NOTE: Power Consumption specifications apply to control via the TTL UART.**

**NOTE: It is not recommended to use the UART interface when planning to operate the module in Tag Streaming/Continuous Reading mode. The UART interface (both the module side and the host side) cannot detect physical disconnections, as can the USB Interface, simplifying reconnection.**

### TTL Level UART Interface

#### TTL Level TX

- V-Low: Max 0.4 VDC
- V-High: 2.1 to 3.3 VDC
- 8 mA max

#### TTL Level RX

- V-Low: -0.3 to 0.6 VDC
- V-High: 2.2 to 5 VDC
- (Tied to ground through a 10k ohm pull-down resistor)

A level converter could be necessary to interface to other devices that use standard 12V RS232. Only three pins are used for serial communication (TX, RX, and GND). Hardware handshaking is not supported. The M6e serial port has an interrupt-driven FIFO that empties into a circular buffer.

The connected host processor's receiver must have the capability to receive up to 256 bytes of data at a time without overflowing.

### Supported Baud Rates

- 9600
- 19200
- 38400
- 115200
- 230400
- 460800
- 921600

**NOTE: The baud rate in the Boot Loader mode depends on whether the module entered the bootloader mode after a power-up or through an assert or "boot bootloader" user command. Upon power up if the Reset Line is LOW then the default baud rate of 115200 will be used. If the module returns to the bootloader from Application Firmware mode, then the current state and baud rate will be retained.**

## USB Interface

Supports USB 2.0 full speed device port (12 Megabits per second) using the two USB pins (USB_DM and USB_DP).

**Serial Number Added to USB Device Descriptor**

Adding a serial number to the USB device descriptor allows the host to assign a COM port number which follows the device regardless of which physical USB port it is plugged into.

## General Purpose Input/Output (GPIO)

The four GPIO connections, provided through the M6e Digital Connector Signal Definition, may be configured as inputs or outputs using the MercuryAPI. The GPIO pins connect through 100 ohm resistors to the high current PA0 to PA3 pins of the AT91SAM7X processor. Consult the M6e Specifications for additional details.

Pins configured as inputs must not have input voltages that exceed voltage range of -0.3 volts to +5.5 volts. In addition, during reset the input voltages should not exceed 3.3V.

Outputs may source and sink 16 mA. Voltage drop in the series 100 ohm resistor will reduce the delivered voltage swing for output loads that draw significant current.

Input Mode

- TTL compatible inputs
- Logic low < 0.8 V
- Logic high > 2.0V
- 5V tolerant

Output Mode

- 3.3 Volt CMOS Logic Output with 100 ohms in series
- Greater than 1.9 Volts when sourcing 8 mA
- Greater than 2.9 Volts when sourcing 0.3 mA
- Less than 1.2 Volts when sinking 8 mA
- Less than 0.2 Volts when sinking 0.3 mA

Module power consumption can be adversely affected by incorrect GPIO configuration. Similarly, the power consumption of external equipment connected to the GPIOs can also be adversely affected. The following instructions will yield specification-compliant operation.

On power up, the M6e module configures its GPIOs as inputs to avoid contention from user equipment that may be driving those lines. The input configuration is as a 3.3 volt logic CMOS input and will have a leakage current not in excess of 400 nA. The input is in an undetermined logic level unless pulled externally to a logic high or low. **Module power consumption for floating inputs is unspecified**. With the GPIOs configured as inputs and individually pulled externally to either high or low logic level, module power consumption is as listed in the M6e Power Consumption table.

GPIOs may be reconfigured individually after power-up to become outputs. This configuration takes effect either at API execution or a few tens of milliseconds after power up if the configuration is stored in nonvolatile memory. The automated configuration into outputs is prevented if the module is held in the boot

loader by Reset Line being held low. Lines configured as outputs consume no excess power if the output is left open. Specified module power consumption is achieved for one or more GPIO lines set as output and left open. Users who are not able to provide external pull ups or pull downs on any given input, and who do not need that GPIO line, may configure it as an output and leave it open to achieve specified module power consumption.

### Configuring GPIO Settings

The GPIO lines are configured as inputs or outputs through the MercuryAPI by setting the reader configuration parameters /reader/gpio/inputList and /reader/gpio/outputList. Once configured as inputs or outputs the state of the lines can be Get or Set using the gpiGet() and gpoSet() methods, respectively. See the language specific reference guide for more details.

### Reset Line

Upon power up, the RESET line (pin 15) is configured as an input. The input value will determine whether the Boot Loader will wait for user commands (if pulled LOW) or immediately load the Application Firmware image and enter application mode (if left open or pulled up). After that action is completed, the line is configured by the firmware as an output line. Whenever the module is in bootloader the line is in the bootloader state and driven high.

Once in application mode, the RESET line is driven low. If the module returns to the bootloader mode, either due to an assert or “boot bootloader,” the RESET line will again be driven high.

To minimize power consumption in the application, the RESET line should be either left open or pulled weakly low (1.5k ohm to ground).

See Note about baud rate applicable when using TTL Level UART Interface.

## Power Requirements

### RF Power Output

The M6e supports separate read and write power levels which are command adjustable via the MercuryAPI. Power levels must be between:

- Minimum RF Power = +5 dBm
- Maximum RF Power = +31.5 dBm (+/- 0.5 dB accuracy above +15 dBm)

**NOTE: Maximum power may have to be reduced to meet regulatory limits, which specify the combined effect of the module, antenna, cable and enclosure shielding of the integrated product.**

**NOTE: FCC regulations limit the maximum RF Power to 30 dBm in NA Region. For 31.5 dBm operation in the NA Region the M6e-A must be purchased.**

## Special RF Power Output Requirements for the M6e-A

Warning: Operation of the M6e-A requires professional installation to correctly set the TX power for the RF cable and antenna selected.

### Power Settings for Authorized Antennas and Cables

The M6e-A has been designed to operate with the antennas listed in Authorized Antennas list using the cables in the M6e-A Authorized Cables list. For any combination of antenna and cable the maximum RF power is determined from antenna gain (Max Linear Gain value from antenna list) and antenna cable loss (Insertion Loss value from cable list) using the formula:

*Pmax = 36 dBm - Antenna Gain + Cable Loss*

For example, for the Laird S8658WPL and the ThingMagic CBL-P6 6ft cable the following calculation can be performed:

*Max linear antenna gain = 6 dBiL*

*Minimum cable insertion loss = 0.8 dB*

*Pmax = 36 - 6 + 0.8 = 30.8 dBm*

The maximum RF power that may be set using this configuration is 30.8 dBm (see Warning above).

### Power Supply Ripple

The following are the minimum requirements to avoid module damage and ensure performance and regulatory specifications are met. Certain local regulatory specifications may require tighter specifications.

- 5 Volt +/- 5%.
- Less than 25 mV pk-pk ripple all frequencies.
- Less than 11 mV pk-pk ripple for frequencies less than 100 kHz.
- No spectral spike greater than 5 mV pk-pk in any 1 kHz band.
- Power supply switching frequency equal or greater than 500 kHz.

**Caution: Operation in the EU Region (under ETSI regulatory specs) may need tighter ripple specifications to meet ETSI mask requirements.**

### Power Consumption

The following table the power/transmit mode settings and power consumption specifications for the M6e. Additional details about Power/Transmit Modes can be found in the Power Management section.

*M6e Power Consumption*

| Operation Power/Transmit Mode | RF Transmit Power Setting (dBm) | Max Power[1] (Watts) | Voltage (Volts) | Current (mA) |
|---|---|---|---|---|
| Transmit CW<br>Transmit Mode=DRM | +31.5 | 7.5[2] | 5.0 +/- 5% | 1400 |
| Tag Reading<br>Transmit Mode=DRM | +31.5 | 7.5[2] | 5.0 +/- 5% | 1400 |

*M6e Power Consumption*

| Operation Power/Transmit Mode | RF Transmit Power Setting (dBm) | Max Power[1] (Watts) | Voltage (Volts) | Current (mA) |
|---|---|---|---|---|
| Tag Reading<br>Transmit Mode=Power Save | +30 | 5.8 | 5.0 +/- 5% | 1060 |
| Tag Reading<br>Transmit Mode = DRM + PreDistortion | +30 | 6.2 | 5.0 +/- 5% | 1200 |
| Tag Reading<br>Transmit Mode = DRM | +17 and below | 4 | 5.0 +/- 5% | 800 |
| No Tag Reading (M6e idle)<br>Power Mode = FULL | N/A | 0.35 | 5.0 +/- 5% | 60 |
| No Tag Reading (M6e idle)<br>Power Mode = MINSAVE | N/A | 0.12 | 5.0 +/- 5% | 20 |
| No Tag Reading (M6e idle)<br>Power Mode = SLEEP | N/A | 0.005 | 5.0 +/- 5% | 1.0 |
| Boot | N/A | 0.12 | 5.0 +/- 5% | 20 |
| Shut Down | N/A | < 0.001 | 5.0 +/- 5% | < 200uA |
| In Rush Current and Power, M6e<br>Power up and/or any state change | N/A | 7.5 | 5.0 +/- 5% | 1500 Max |

[1] Power consumption is defined for TTL RS232 operation. Power consumption may vary if the USB interface is connected.

[2] Power consumption is defined for operation into a 17dB return loss load or better. Power consumption may increase, up to 8.2W, during operation into return losses worse than 17dB and high ambient temperatures.

## Environmental Specifications

### Operating Temperature

The M6e module may be considered as a single electronic component. It is designed so that all the internal components have safe margins to their thermal limits when the heat spreading plate (bottom, non-labeled side) does not exceed 70°C. The heat spreading plate temperature must not exceed 70° C. Heat sinking will be required for high duty cycle applications.

When heat spreading plate reaches 70°C, the RF Shield (top, antenna connector side) may exceed 70°C, which is acceptable.

## Electro-Static Discharge (ESD) Specification

IEC-61000-4-2 and MIL-883 3015.7 discharges direct to operational antenna port tolerates max 1200 volt pulse.

**NOTE: Survival level varies with antenna return loss and antenna characteristics. See ElectroStatic Discharge (ESD) Considerations for methods to increase ESD tolerances.**

**Warning: The M6e antenna ports may be susceptible to damage from Electrostatic Discharge (ESD). Equipment failure can result if the antenna or communication ports are subjected to ESD. Standard ESD precautions should be taken during installation and operation to avoid static discharge when handling or making connections to the M6e reader antenna or communication ports. Environmental analysis should also be performed to ensure static is not building up on and around the antennas, possibly causing discharges during operation.**

## Mounting Screw Clearance

The M6e requires clearance for #2-56 or 2.5mm socket head screws in 4 places.

## Assembly Information

### Cables and Connectors

The following are the cables and connectors used in the M6e Developer's Kit interface board:

#### Digital Interface

The cable assembly used consists of the following parts:

- 2 Connector Shells [Molex 51021-1500] with 15 Crimp Contacts each [Molex 50079-8100]
- 1 Wire (#28 AWG 7x36 - Black, Teflon) for Pin 1 connection [Alpha 284/7-2]
- 14 Wires (#28 AWG 7x36 - White, Teflon) for other connections [Alpha 284/7-1]

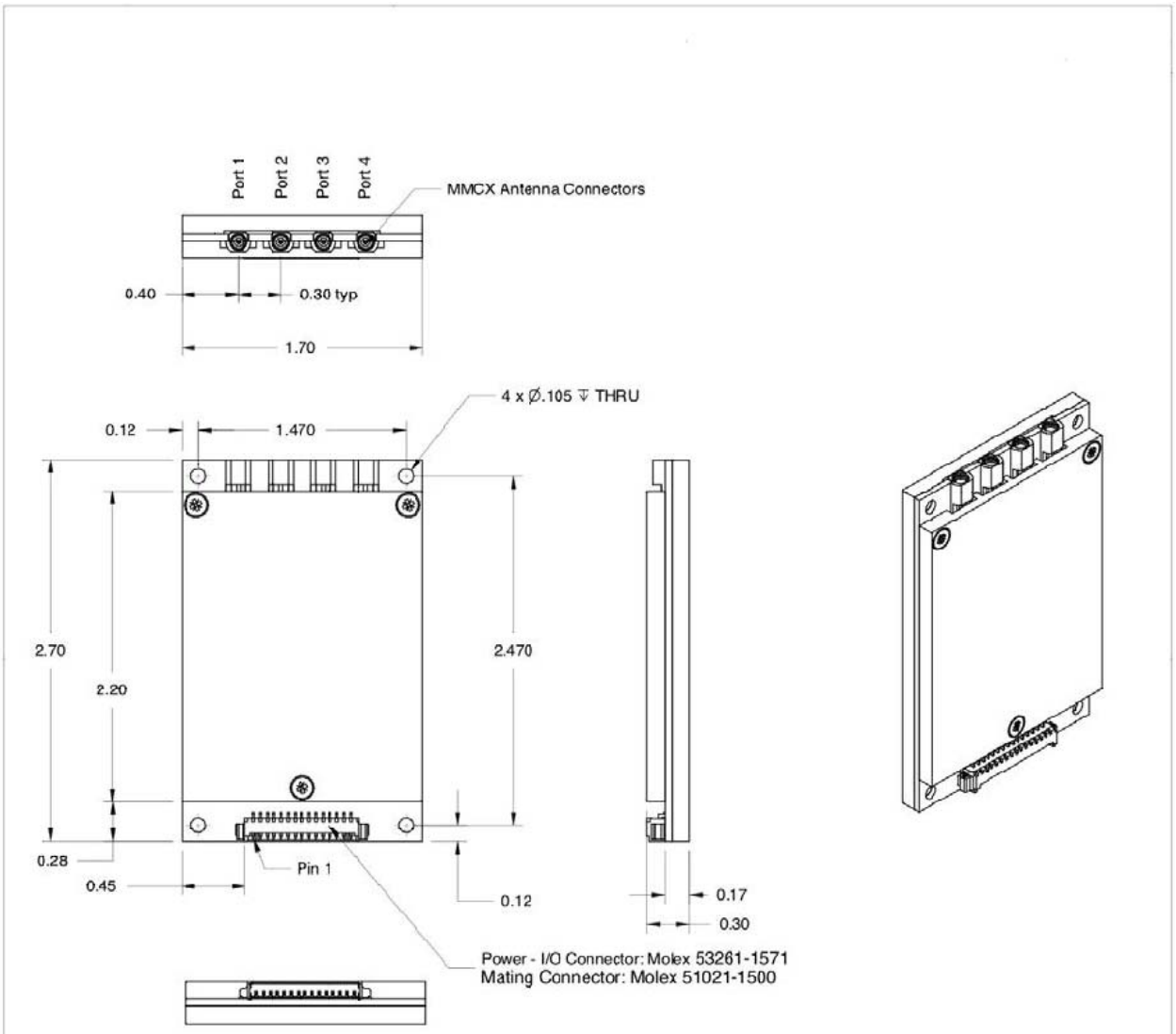
**NOTE: Pin numbers and assignments are shown in the M6e Digital Connector Signal Definition table.**

## Antennas

The cable assembly used to connect the "external" RP-TNC connectors on the M6e Development kit to the M6e MMCX connectors consists of the following parts:

- 1 Reverse TNC Bulkhead Jack Connector
- 1 LMR-100A Coaxial Cable
- 1 MMCX Right Angle Plug Connector

## M6e Mechanical Drawing



## Authorized Antennas

This device has been designed to operate with the antennas listed below, and having a maximum gain of 6 dBiL. Antennas not included in this list or having a gain greater than 6 dBiLare strictly prohibited for use with this device. The required antenna impedance is 50 ohms.

*M6e Authorized Antennas*

| Vendor | Model | Linear Gain[1] (dBi) |
|---|---|---|
| ThingMagic | ANT-WB-6-2025 | 5.1 |
| ThingMagic | ANT-NA-9025 (obsolete) | 3.4 |
| ThingMagic | ANT-NB-7-2031 | 6.0 |
| ThingMagic | ANT-WB-12-2043 | 6.0 |
| ThingMagic | ANT-WB-10-2048 | 6.0 |

[1] These are circularly polarized antennas, but since most tag antennas are linearly polarized, the equivalent linear gain of the antenna should be used for all calculations.

## M6e-A Authorized Cables

The following table contains the cable loss values for authorized shielded coaxial cables provided by ThingMagic:

*M6e-A Authorized Cables*

| Cable Description | ThingMagic Part Number | Insertion Loss |
|---|---|---|
| 6' RTNC to RTNC Cable | CBL-P6 | 0.8 dB |
| 12' RTNC to RTNC Cable | CBL-P12 (obsolete) | 1.5 dB |
| 20' RTNC to RTNC Cable | CBL-P20 | 2.4 dB |
| 20' RTNC to RTNC Plenum Cable | CBL-P20-PL (obsolete) | 2.4 dB |
| 25' RTNC to RTNC Cable | CBL-P25 (obsolete) | 3.0 dB |

# 3 Firmware Overview

## New Features - Version 1.21.2

### Margin Read Support for Monza6 Tags

MarginRead is an EPC Gen2 compliant custom command supported by tag chips with the “Integra” feature. This command allows a reader to explicitly verify that the non-volatile memory (NVM) in the tag chip is not weakly written, guaranteeing a minimum margin on NVM. It is used for quality control to ensure data integrity and for failure analysis.

There are several ways that the MarginRead command could be used with Monza 6. A recommended use of MarginRead is independent verification of the encoding quality, either on a sample basis or for diagnosis during failure analysis.

#### MarginRead Description

When data is written to a tag using the Gen2 protocol, charge is built up in the memory cells until they reach the appropriate level. Once that happens, the tag returns a "done" signal telling the interrogator (reader) or encoding system that the write operation has completed successfully.

It is a known field issue that not all encoding systems properly wait for the "done" signal and instead issue a read operation to check if the data is correct. A read operation may return correct data even if the write operation did not complete successfully.

A partially charged memory cell might retain data for a limited time but then it will lose data integrity over time. Data retention could be for an unpredictable amount of time from a few minutes to several years.

A fully charged memory cell will retain data for a long period of time. Specifically, the Monza 6 tag is expected to retain data for up to 50 years.

The MarginRead command allows customers to check if Monza 6 tag chip memory cells are fully charged.

MarginRead may be used for diagnostics for data integrity issues in the field. If MarginRead indicates an issue, then the encoding method should be investigated.

Refer Mercury API v1.29.4 release notes for API commands to work with this functionality.

### NXP UCODE7 Configuration Support

Prior to UCODE 7, NXP supported a set of custom commands that could change the configuration word values. Unfortunately, these commands that were developed for the G2i line of tags do not work for the UCODE 7 tags. A new custom command has been implemented in M6e FW to change NXP UCODE7 configuration word for M6e modules (Nano does not support custom commands).

UCODE7 no longer supports ChangeConfig commands. An alternative way to change the configuration word for UCODE7 tags has been developed.

UCODE7 configuration word contains 2 different types of bits:

1. Action bits: meant to trigger a feature upon a SELECT command on the related bit:
   Parallel encoding (at address 0x202)
   Tag Power indicator (at address 0x204)

2. Permanent bits: permanently stored bits in the memory
   Max. Backscatter Strength (at address 0x209)
   PSF Alarm bit (at address 0x20F)

Refer Mercury API v1.29.4 release notes for API commands to work with this functionality.

**Gen2 Parameters in Metadata**

Now that modification of the Gen2 parameters are allowed at will, it is desirable to include current Gen2 settings as metadata when tags are read so that the active setting under which the tag was read is reported.

For example, Gen2 Q value can change dynamically so a user trying to determine the best static value would benefit from knowing the value that the automated algorithm selected. Gen2 parameters included in metadata are:

- Gen2 Q
- Gen2 Link Frequency
- Gen2 Target

Gen2 Q, BLF and Target parameters have been added to the TagReadData.TagMetadata method. The Read code sample in the MercuryAPI SDK shows how to activate this functionality.

**Support for Acura Gen2V2 Tags**

NMV2D tag support has been added in M6e FW, which returns 352 (256+96) bits in TAM2 reply for ProtModes 0x02 and 0x03 and 256 bits for ProtModes 0x00 and 0x01. Previous release version of FW v1.7.1 replies with 256 bits irrespective of any ProtMode.

The NMV2D tag supports the same set of commands as NXP UCODE AES tag except following:

- NXP UCODE AES tag chip only supports ProtMode=1 while NMV2D tag supports ProtModes=0,1,2,3.
- Untrace-Access and Untrace-Authen commands do not work for NMV2D tag as they do for UCODE AES tag.

Refer to the Authenticate, ReadBuffer and Untraceable code samples in the MercuryAPI SDK to test this functionality.

**Support for GEN2V2 Embedded Tag Ops**

In previous firmware releases, GEN2V2 operations that supported the NXP UCODE DNA tag were only available as stand-alone, single tag functions. Now support for embedded tag operations has been added for both NXP UCODE DNAtag and the NMV2D tag. This allows for high speed secure reading in Asynchronous modes.

Refer to the Authenticate, ReadBuffer and Untraceable code samples in the MercuryAPI SDK to test this functionality.

**Gen2V2 Support**

The M6e supports the Gen2V2 features of the NXP DNA tags. These features include:

- “Untraceable”. Ability to limit reading of all or part of EPC, TID and User memory fields by unauthorized readers.
- Ability to download and activate security keys.
- Ability to authenticate tag using random challenge strings and AES encryption.
- Ability to obtain memory data in encrypted form, which can be successfully decoded if the host knows the key that has been activated on the tag.
- Ability to obtain authentication and encrypted memory data from a tag buffer rather than the tag backscattering that information to the reader immediately.

These capabilities are supported in the 1.27 version of the API and may be demonstrated using code samples and the version of Universal Reader Assistant which is distributed with the API.

### Denatran Tag Support

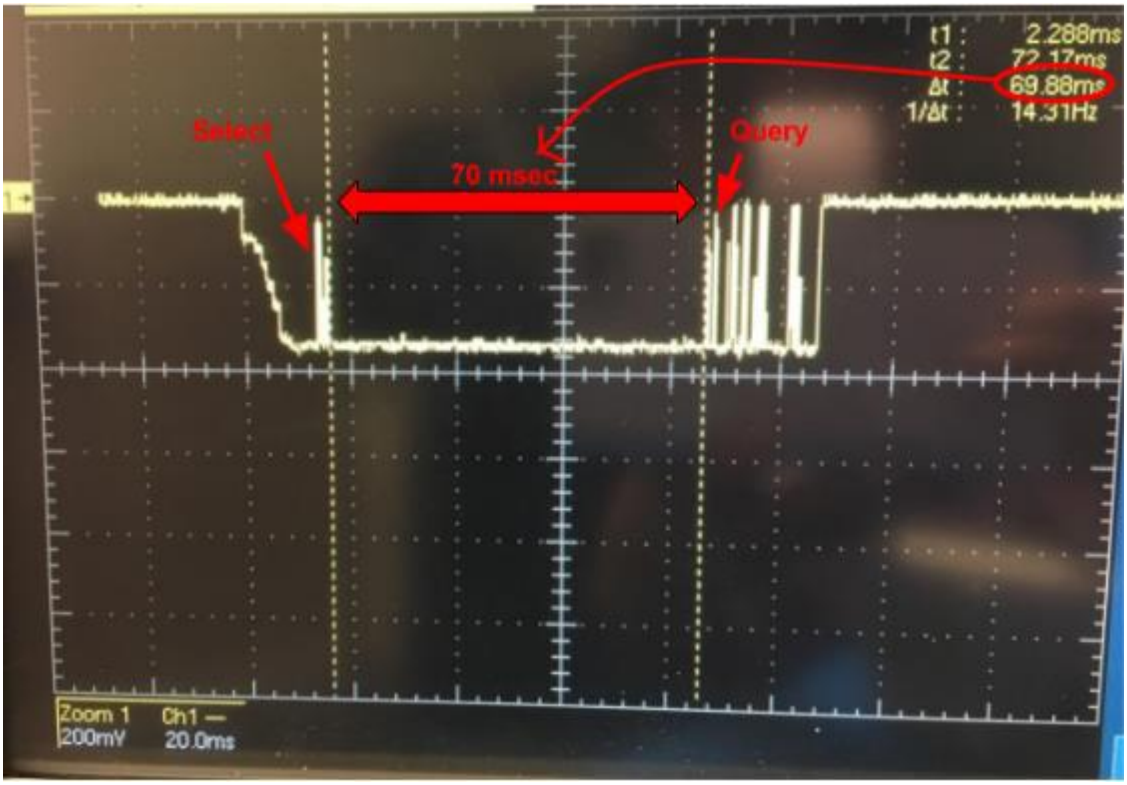
The M6e module supports the Denatran extension to the Gen2 protocol as a licensed feature.

### Configurable T4 for Gen2 Protocol

Some sensor tags use a Select command to trigger sensor reading. The time the reader waits between the Select command and start of inventory (when the Query command is sent) is controlled by a Gen2 parameter called the “T4 timer.” This has been updated so that the T4 timer can be set to a larger value to ensure sufficient time for the sensor tag to obtain its reading before having to report it to the reader.

The parameter ‘PROTOCOL_PARAM_GEN2_T4’ has been added to set/get the Gen2 T4 parameter with sub command for 0x9b and allows T4 to be set in milliseconds.

T4 value is 4-byte in length and specified in milliseconds. Minimum value of T4 allowed for 250 kHz (25us, 12.5us, 62.5us Tari) is 440usec (0x1B8) and for 640 kHz (6.25us Tari) is 220usec (0xDC). Maximum value allowed is 1sec (0xF4240). Here is an oscilloscope trace of the reader output signal showing the effect of changing this setting.




Refer Mercury API v1.29.4 release notes for API commands to work with this functionality.

**Ability to "Read Data" Immediately After Sending a "Write EPC" or "Write Data" Command**

Some sensor tags require the module to write to a memory bank to trigger the sensor measurement, then read the sensor data field without dropping power between if the two operations are done as separate commands. This functionality supports streamlining read-then-write operations for other applications as well.

Read Data support has been added as an option for the Write EPC and Write Bank Data commands. This allows the module to read the data from any of the memory banks following a successful write operation of data to any memory bank (or write EPC) through a single command. The standard commands to Write Tag Data and Write Tag EPC optionally includes the read memory bank, read word address, and read count to implement this feature.

For more details on the application interface, refer to WriteTag code sample in the MercuryAPI SDK.

**Decoupling Antenna Selection from AsyncOnTime**

Previously when reading continuously, the reader returned to antenna one (or the first antenna in the configured list) at the beginning of each AsynchOnTime cycle. This encouraged users to configure a high value for AsyncOnTime to ensure all antennas would be activated each read cycle. Now some of the settings can be changed without interrupting reading and take effect only at the beginning of the next AsyncOnTime cycle, allowing users to set this value as low as possible.

The antenna selection algorithm has been changed to recall the last antenna that was active in the previous read cycle and start with that antenna for the next AsyncOnTime cycle. This way, the active antenna cycles through the list with regularity and the AsynchOnTime can be optimized so on-the-fly settings take effect as quickly as possible.

The ReadAsync code sample can be run to see the effect of this change.

Refer Mercury API v1.29.4 release notes for API commands to test this functionality.

### Support for Additional Regions

To achieve the optimum channel frequencies to permit the greatest number of channels while still meeting out-of-band emissions standards for Asian regions and Russia, the following additional channels have been added. Regions that are added in current firmware version have the following characteristics.

*Additional Regions*

| Region | Region Number | Region Number | Low Channel Boundary | High Channel Boundary | Min Step Size (Quantization) | Hop Table | Max RF Power Allowed |
|---|---|---|---|---|---|---|---|
| Malaysia | MY | 0x10 | 919 MHz | 923 MHz | 250 kHz | 921750, 919250, 920750, 922250, 919750, 921250, 920250, 922750 | 31.5 dBm |
| Indonesia | ID | 0x11 | 923 MHz | 925 MHz | 125 kHz | 924625, 923375, 924125, 923875, 924375, 923625, 924875, 923125 | 31.5 dBm |
| Philippines | PH | 0x12 | 918 MHz | 920 MHz | 250 kHz | 919250, 918750, 919750, 918250 | 31.5 dBm |
| Taiwan | TW | 0x13 | 922 MHz | 928 MHz | 250 KHz | 926250, 924750, 922250, 925750, 923250, 927750, 926750, 924250, 922750, 925250, 923750, 927250 | 30 dBm |

*Additional Regions*

| Region | Region Number | Region Number | Low Channel Boundary | High Channel Boundary | Min Step Size (Quantization) | Hop Table | Max RF Power Allowed |
|---|---|---|---|---|---|---|---|
| Macao | MO | 0x14 | 920 MHz | 925 MHz | 250 kHz | 923250, 921750, 924250, 922750, 920250, 923750, 921250, 924750, 922250, 920750 | 31.5 dBm |
| Russia | RU | 0x15 | 866 MHz | 868 MHz | 200 kHz | 866600, 867800, 866200, 867000, 866400, 867600, 866800, 867200 | 31.5 dBm |
| Singapore | SG | 0x16 | 920 MHz | 925 MHz | 100 kHz | 923100, 921900, 924300, 920700, 922500, 923700, 921300, 924900, 920100 | 31.5 dBm |

**NOTES:** **Maximum Dwell Time 0.4 sec for all these regions (same as North American region)**

**Max RF power limit is that given in table or whatever the module is capable of, whichever is lower.**

**Any channel frequency can be requested that is between the upper and lower bounds, but the module will silently round down to the nearest channel that is the lower bound plus an integer multiple of quantization steps.**

The new Asian regions have been added to Reader.Region method. Refer Mercury API v1.29.4 release notes for more information.

**Support for Set/get Quantization Value and Minimum Frequency in Open Region**

The Open region as defined in previous releases was intended for testing only. To permit the most flexibility in defining channels, it allowed a minimum channel step size (quantization) of 25 kHz. The Open region is not recommended to support channel plans which could not be easily accommodated by changing the hop

table of existing regions, because such a small step size will result in lower channel frequency stability. (This setting not only defines the minimum step size that can be set, but also represents how often the channel is nudged back to its desired value, with more frequent nudges creating a more stable channel.)

To allow the Open region to be used more flexibly, the setting of the quantization value is now permitted. It may be any value between 15 kHz and 6 MHz but must divide evenly into 6 MHz (6000 kHz). If not, an error will be returned (error code number 105).

To permit the largest quantization value possible, setting the minimum frequency value for the Open region is allowed. (Smaller quantization values are often driven by the rule that all channels must be an integral multiple of the quantization value above the minimum frequency value.)

Only the Open region supports changing of the quantization value. Quantization values less than 100 kHz are not recommended except for laboratory testing to maintain a high degree of channel frequency stability and prevent interference with other readers or RF services.

Refer to Mercury API v1.29.4 release notes to activate this functionality.

## Operational Notes

When the Truncation filter is applied, the tags will return data even if the Access Password is not correct. (Ref# 5075)

The implementation of the command and response logic for Denatran tags is incomplete. Please contact ThingMagic support for details. (Ref # 5078)

**No Ability to "Get" Saved Value of Settings**

The module firmware can save many settings in flash memory. As of firmware version 1.21.1, the module can report the following values from flash memory but is not yet available to users.

- Baud Rate
- Region
- Protocol
- Hop Table
- Hop Time
- Read Power
- Per-port Read Power
- Antenna Configuration
- Gen2 Session
- Gen2 Target
- Gen2 "M" value
- Gen2 Backscatter Link Frequency
- Gen2 TARI
- Gen2 Q
- Enable Filtering Value
- Trigger Read GPIO Value

## Boot Loader

The boot loader provides low-level functionality and hardware support for configuring communication settings, loading Application Firmware, and storing and retrieving data to/from flash.

When a module is powered up or reset, the boot loader code is automatically loaded and executed. The M6e bootloader should effectively be invisible to the user. The M6e is by default configured to auto-boot into application firmware and for any operations that require the module be in bootloader mode the MercuryAPI will handle the switching automatically.

## Application Firmware

The application firmware contains the tag protocol code along with all the command interfaces to set and get system parameters and perform tag operations. The application firmware is, by default, started automatically upon power up.

### Programming the M6e

Applications to control the M6e module and derivative products are written using the high level MercuryAPI. The MercuryAPI supports Java, .NET and C programming environments. The MercuryAPI Software Development Kit (SDK) contains sample applications and source code to help developers get started demoing and developing functionality. For more information on the MercuryAPI see the MercuryAPI Programmers Guide and the MercuryAPI SDK, available on www.jadaktech.com.

### Upgrading the M6e

New features developed for the M6e are made available to existing modules through an Application Firmware upgrade, along with corresponding updates to the MercuryAPI to make use of the new features. Firmware upgrades can be applied using the MercuryAPI to build the functionality into custom applications or using the MercuryAPI SDK demo utilities.

### Verifying Application Firmware Image

The application firmware 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 firmware, it first verifies that the image CRC is correct. If this check fails, then the boot loader does not start the application firmware and an error is returned.

## Custom On-Reader Applications

The M6e does not support installing customer applications on the module. All reader configuration and control is performed using the documented MercuryAPI methods in applications running on a host processor.

The M6e supports Autonomous Operation, where configuration settings and a basic read plan can be stored in the module and executed whenever the module is power up, or whenever it is both powered up and a selected GPI line is asserted.

### Autonomous Operation Support

A read plan can be saved which allows the module to automatically begin continuously reading, and optionally return data memory values, whenever the module is powered or whenever one of its GPI lines is asserted. An Autonomous Configuration Tool is available to configure the settings and read plan necessary to implement this feature.

# 4 Communication Protocol

## Serial Communication Protocol

The serial communication between a computer (host) and the M6e 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 must manage retries, if necessary. The host must keep 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.

*Host-To-Reader Communication*

| Header | Data Length | Command | Data | CRC-16 Checksum |
|---|---|---|---|---|
| Hdr | Len | Cmd | - - - - - | CRC Hi I CRC LO |
| 1 byte | 1 byte | 1 byte | 0 to 250 bytes | 2 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.

*Reader-To-Host Communication*

| Header | Data Length | Command | Status Word | Data | CRC-16 Checksum |
|---|---|---|---|---|---|
| Hdr | Len | Cmd | | - - - - - | CRC Hi I CRC LO |
| 1 byte | 1 byte | 1 byte | 2 bytes | 0 to 248 bytes | 2 bytes |

### 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 is not included in the CRC.

## User Programming Interface

The M6e does not support programming to the serial protocol directly. All user interaction with the M6e must be performed using the MercuryAPI.

The MercuryAPI supports Java, .NET and C programming environments. The MercuryAPI Software Development Kit (SDK) contains sample applications and source code to help developers get started demoing and developing functionality. For more information on the MercuryAPI see the MercuryAPI Programmers Guide and the MercuryAPI SDK, available on www.jadaktech.com.

# 5 Functionality

## Supported Regions

The M6e has differing levels of support for operation and use under the laws and guidelines of several regions. The regional support is shown in the following table.

*Supported Regions*

| Region | Regulatory Support | Notes |
|---|---|---|
| North America (NA) | FCC 47 CFG Ch. 1 Part 15<br>Industrie Canada RSS-210 | Supported in M6e and M6e-A modules only. |
| European Union (EU3) | Revised ETSI EN 302 208 | Supported in M6e and M6e-A modules only. By default, EU3 will use four channels. EU3 region can also be used in a single channel mode. These two modes of operation are defined as:<br>**Single Channel Mode**<br>• Set by manually setting the frequency hop table to a single frequency. In this mode the module will occupy the set channel for up to four seconds, after which it will be quiet for 100ms before transmitting on the same channel again.<br>**Multi-Channel Mode**<br>• Set by leaving the default or manually setting more than one frequency in the hop table. In this mode the module will occupy one of the configured channels for up to four seconds, after which it may switch to another channel and immediately occupy that channel for up to four seconds. This mode allows for continuous operation. |
| Korea (KR2) | KCC (2009) | The first frequency channel (917,300kHz) of the KR2 region will be derated to +22dBm to meet the new Korea regulatory requirements. All other channels operate up to +30dBm. In the worst case scenario, each time the derated channel is used it will stay on that channel for 400ms. The fastest it will move to the next channel, in the case where no tags are found using that frequency, it will move to the next channel after 10 empty query rounds, approximately 120ms. |

*Supported Regions*

| Region | Regulatory Support | Notes |
|---|---|---|
| People's Republic of China (PRC & PR2) | SRRC, MII | The PRC specifications limits channels 920 to 920.5MHz and 924.5 to 925.0MHz to transmitting at 100mW or below. The default hop table uses only the center channels which allow 2W ERP, 1W conducted, power output. If the hop table is modified to use the outer, lower power channels the RF level will be limited to the outer channels limit, 100mW or +20dBm.<br>Note: With the M6e-PRC hardware the 840 to 845MHz band is also supported as the PR2 region. It is not supported on the standard M6e, M6e-A, or M6e-JIC modules. |
| Australia (AU) | ACMA LIPD Class License Variation 2011 (No. 1) | |
| New Zealand (NZ) | Radiocommunications Regulations (General User Radio License for Short Range Devices) Notice 2011 | |
| Open Region | No regulatory compliance enforced | Allows the module to be manually configured within the full capabilities supported by the hardware, see Regional Frequency Quantization table. No regulatory limits, including: frequency range, channel spacing and transmit power limits are enforced. The Open Region should be used with caution. |

The regional functionality is set using the MercuryAPI. Setting the region of operation configures the regional default settings including:

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

## 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 M6e has commands that allow the transmit frequency to be set manually.

**Warning: 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 M6e are expressed in kHz using unsigned 32-bit integers. For instance, a carrier frequency of 915 MHz is expressed as 915000 kHz.

The hop table for any region may consist of any permitted channels within the frequency limits for that region. A permitted channel is one that is at the lowest permitted frequency or is a multiple of the minimum channel step size, up to the highest permitted frequency. The following table gives the frequency limits and minimum channel step size for all regions.

*Regional Frequency Quantization*

| Region | Min Channel Separation | Minimum Frequency | Maximum Frequency | Modules Supported |
|---|---|---|---|---|
| NA | 250 kHz | 902,000 kHz | 928,000 kHz | M6e, M6e-A |
| EU3 | 100 kHz | 865,600 kHz | 867,600 kHz | M6e, M6e-A |
| IN | 100 kHz | 865,000 kHz | 867,000 kHz | M6e, M6e-A |
| KR2 | 100 kHz | 917,000 kHz | 923,500 kHz | M6e, M6e-A |
| PRC | 250 kHz | 920,125 kHz | 924,875 kHz | M6e, M6e-A, M6e-PRC, M6e-JIC |
| PRC2 | 250 kHz | 840,000 kHz[1] | 845,000 kHz[1] | M6e-PRC |
| AU | 250 kHz | 920,750 kHz | 925,250 kHz | M6e, M6e-A |
| NZ | 250 kHz | 922,250 kHz | 927,250 kHz | M6e, M6e-A |
| IS | 250 kHz | 915,000 kHz | 917,000 kHz | M6e-JIC |
| JP | 100 kHz | 916,800 kHz | 920,800 kHz | M6e-JIC |
| Open | 25 kHz | 865,000 kHz<br>902,000 kHz | 869,000 kHz<br>928,000 kHz | M6e, M6e-A<br>(See Note) |
| [1]M6e-PRC and M6e-JIC have different ranges for their Open region. 840 to 845 MHz and 920 to 925 MHz for M6e-PRC, 915 to 925 MHz for the M6e-JIC. | | | | |

The user may define channels in a hop table to the nearest kHz (within the high and low frequency limits) without receiving an error message, but if that request is not for a permitted channel, the actual frequency used by the reader will be the first permitted channel below the requested frequency. For example, in the NA region, setting a frequency of 902,999 kHz results in a setting of 902,750 kHz.

An error message will result if an attempt is made to set channels outside of the allowed frequency range for a region. Changing regions will automatically re-install the default hop table for that region, erasing any custom channels which may have been defined.

### Frequency Hop Table

The frequency hop table determines the frequencies used by the M6e when transmitting. The hop table characteristics are:

- Contains up to 62 frequencies.
- Valid frequencies for the region currently selected.
- Inability to change individual entries after uploading without reloading the entire table.

- Frequencies used in the order of entries in the table. If regulatory requirements state that channels must be hopped in random order, then the frequency list of channels must be randomized before downloading the hop table into the module.

## Antenna Ports

The M6e has four monostatic antenna ports. Each port is capable of both transmitting and receiving. The modules also support Using a Multiplexer, allowing up to 16 total logical antenna ports, controlled using two GPIO lines and the internal physical port J1/J2/J3/J4 switching.

**NOTE: The M6e does not support bistatic operation, that is, transmitting on one port and receiving on another.**

### Using a Multiplexer

Multiplexer switching is controlled through the use of the internal module physical port J1/J2/J3/J4 switch along with the use of one or more of the General Purpose Input/Output (GPIO) lines. In order to enable automatic multiplexer port switching the module must be configured to use *Use GPIO as Antenna Switch* in /reader/antenna/ portSwitchGpos.

Once the GPIO line(s) usage has been enabled the following control line states are applied when the different Logical Antenna settings are used. The tables below show the mapping that results using GPIO 1 and 2 for multiplexer control (as is used by the ThingMagic 1 to 4 multiplexer) allowing for 16 logical antenna ports.

**NOTE: The Logical Antenna values are static labels indicating the available control line states. The specific physical antenna port they map to depends on the control line to antenna port map of the multiplexer in use. The translation from Logical Antenna label to physical port must be maintained by the control software.**

*GPIO 1 & 2 Used for Antenna Switching*

| Logical Antenna Setting | GPIO Output 1 State | GPIO Output 2 State | Active M6e Physical Port |
|---|---|---|---|
| 1 | Low | Low | J1 |
| 2 | Low | Low | J2 |
| 3 | Low | Low | J3 |
| 4 | Low | Low | J4 |
| 5 | Low | High | J1 |
| 6 | Low | High | J2 |
| 7 | Low | High | J3 |
| 8 | Low | High | J4 |
| 9 | High | Low | J1 |
| 10 | High | Low | J2 |

*GPIO 1 & 2 Used for Antenna Switching (Continued)*

| Logical Antenna Setting | GPIO Output 1 State | GPIO Output 2 State | Active M6e Physical Port |
|---|---|---|---|
| 11 | High | Low | J3 |
| 12 | High | Low | J4 |
| 13 | High | High | J1 |
| 14 | High | High | J2 |
| 15 | High | High | J3 |
| 16 | High | High | J4 |

If only one GPIO Output line is used for antenna control, the combinations of the available output control line states (the GPIO line in use and the module port) result in a subset of logical antenna settings which can be used.

*Only GPIO 1 Used for Antenna Switching*

| Logical Antenna Setting | GPIO Output 1 State | Active M6e Physical Port |
|---|---|---|
| 1 | Low | J1 |
| 2 | Low | J2 |
| 3 | Low | J3 |
| 4 | Low | J4 |
| 9 | High | J1 |
| 10 | High | J2 |
| 11 | High | J3 |
| 12 | High | J4 |

**NOTE: The "missing" logical antenna settings are still usable when only one GPIO line is used for antenna control and simply results in redundant logical antenna settings. For example, using only GPIO 1, logical setting 4 and 8 both result in GPIO1=Low and M6e port J4 active.**

*Only GPIO 2 Used for Antenna Switching*

| Logical Antenna Setting | GPIO Output 2 State | Active M6e Physical Port |
|---|---|---|
| 1 | Low | J1 |

*Only GPIO 2 Used for Antenna Switching*

| Logical Antenna Setting | GPIO Output 2 State | Active M6e Physical Port |
|---|---|---|
| 2 | Low | J2 |
| 3 | Low | J3 |
| 4 | Low | J4 |
| 5 | High | J1 |
| 6 | High | J2 |
| 7 | High | J3 |
| 8 | High | J4 |

**Multiplexing up to 32 Ports**

The M6e module can use 3 GPO lines to control an external multiplexer which expands one RF port to 8 RF ports.

The following table provides the list of all possible “logical” antenna ports and how the selection of that port affects the GPO line state and which physical antenna is active. If you are using fewer than 3 GPO lines to control the module or using fewer than the 4 physical ports, do not include the logical ports in your port list that do not correspond to desired GPO and antenna configurations. When a port is not defined as a GPO control, you can assume it is low with respect to the chart.

**NOTE: Use of fewer than the maximum number of ports and GPO lines will result in gaps in the logical antenna list. This is desirable because assigning additional GPO lines to multiplexer control will not change the port assignments already established with fewer lines. If the non-contiguous numbering is undesirable, you have the option to rename any logical port.**

*Mapping of Logical Antenna Numbers to GPO Lines and RF Ports*

| Logical Antenna Number | GPO 3 | GPO 1 | GPO 2 | Physical Antenna Number |
|---|---|---|---|---|
| 1 | Low | Low | Low | 1 |
| 2 | Low | Low | Low | 2 |
| 3 | Low | Low | Low | 3 |
| 4 | Low | Low | Low | 4 |
| 5 | Low | Low | High | 1 |
| 6 | Low | Low | High | 2 |
| 7 | Low | Low | High | 3 |
| 8 | Low | Low | High | 4 |
| 9 | Low | High | Low | 1 |

*Mapping of Logical Antenna Numbers to GPO Lines and RF Ports*

| Logical Antenna Number | GPO 3 | GPO 1 | GPO 2 | Physical Antenna Number |
|---|---|---|---|---|
| 10 | Low | High | Low | 2 |
| 11 | Low | High | Low | 3 |
| 12 | Low | High | Low | 4 |
| 13 | Low | High | High | 1 |
| 14 | Low | High | High | 2 |
| 15 | Low | High | High | 3 |
| 16 | Low | High | High | 4 |
| 17 | High | Low | Low | 1 |
| 18 | High | Low | Low | 2 |
| 19 | High | Low | Low | 3 |
| 20 | High | Low | Low | 4 |
| 21 | High | Low | High | 1 |
| 22 | High | Low | High | 2 |
| 23 | High | Low | High | 3 |
| 24 | High | Low | High | 4 |
| 25 | High | High | Low | 1 |
| 26 | High | High | Low | 2 |
| 27 | High | High | Low | 3 |
| 28 | High | High | Low | 4 |
| 29 | High | High | High | 1 |
| 30 | High | High | High | 2 |
| 31 | High | High | High | 3 |
| 32 | High | High | High | 4 |

The additional GPO line is configured just like the first two, using the /reader/antenna/ portSwitchGpos parameter. Once GPO lines are configured to act as multiplexer controls, you may use the virtual port numbers as if they were physical ports on the reader.

**Port Power and Settling Time**

The M6e allows the power and settling time for each logical antenna to be set using the reader configuration parameters /reader/radio/portReadPowerList and / reader/antenna/settlingTimeList, respectively. The order the antennas settings are defined does not affect search order.

**NOTE: Settling time is the time between the control lines switching to the next antenna setting and RF turning on for operations on that port. This allows time for external multiplexers to fully switch to the new port before a signal is sent, if necessary. Default value is 0.**

### Support for Return Loss Measurement

The firmware estimates the return loss of individual antenna ports, based on multiple readings at multiple channels within the active region. (For the North American region, with 50 channels, this measurement can take as long as 600 msec). The return loss value can be obtained through the API by getting the "/reader/antenna/returnloss" parameter value as well as by using the "CmdGetAntennaReturnLoss" method. The sample code "ReaderStats" illustrates the recommended method for obtaining this information. The values returned will look like this:

Antenna Return Loss

Antenna 1 | 30

Antenna 2 | 4

Which indicates a return loss of 30 dB for antenna 1, and 4 dB for antenna 2.

This measurement loses accuracy as the numbers increase due to the impact of internal signal reflections that increasingly obscure the measurement of the small signal reflected only at the antenna.

The return loss is measured at an RF level of +15 dB to limit impact to other services that are running in the same region while the return loss measurement is being made.

**NOTE: The M6e uses a small amount of DC current to detect antennas. Use of this method to determine if an antenna is present and of the return loss to determine if the antenna is tuned to the correct frequency is the best way of ensuring maximum performance for the channel of operation.**

## Protocol Support

The M6e has the ability to support many different tag protocols. Using the MercuryAPI ReadPlan classes the M6e can be configured to single or multi-protocol Read operations. The current protocols supported are (some may require a license to enable):

- ISO 18000-6C (Gen2)
- IP-X
- ISO 18000-6B
- AEI ATA

## ISO 18000-6C (Gen2)

The M6e supports multiple ISO-18000-6C profiles including the ability to specify the Link Frequency, encoding schemes, Tari value and modulation scheme. The protocol options are set in the MercuryAPI Reader Configuration Parameters (/reader/gen2/*). The following table shows the supported combinations:

*ISO 18000-6C (Gen 2) Protocol Configuration Options*

| Backscatter Link Frequency (kHz) | Encoding | Tari (usec) | Modulation Scheme | Notes |
|---|---|---|---|---|
| 250 | Miller (M=8) | 12.5 | PR-ASK | |
| 250 | Miller (M=4) | 12.5 | PR-ASK | |
| 250 | Miller (M=2) | 12.5 | PR-ASK | |
| 250 | FM0 | 12.5 | PR-ASK | |
| 250 | Miller (M=8) | 25 | PR-ASK | |
| 250 | Miller (M=4) | 25 | PR-ASK | Default |
| 250 | Miller (M=2) | 25 | PR-ASK | |
| 250 | FM0 | 25 | PR-ASK | |
| 250 | Miller (M=8) | 25 | PR-ASK | |
| 640 | FM0 | 6.25 | PR-ASK | |

**NOTE: It is important that the /reader/baudRate is greater than /reader/ gen2/BLF, in equivalent frequency units. If it is not, then the reader could be reading data faster than the transport can handle and send, and the reader's buffer might fill up.**

### Protocol-Specific Functionality

The host can "get" many settings when it first connects to a module to determine whether the settings are as desired or need to be changed. Now, an additional "get" can determine if any optional Gen2 extensions have been enabled for the module. (Only one custom extension is offered - IAV Denatran support.) The parameter to get protocol extensions is /reader/Gen2/ProtocolExtension.

See the MercuryAPI Programmers Guide and language specific reference guides for details on supported Gen2 command functionality.

## IP-X

The M6e supports multiple IP-X profiles including the ability to specify the Return Link Frequency, encoding and modulation scheme. The two profiles are treated as distinct protocols, the individual parameters are not configurable as with the other protocols. The following table shows the supported combinations:

*IP-X Protocol Configuration Options*

| Return Link Freq (kHz) | Modulation Scheme | Notes |
|---|---|---|
| 64 | PWM | Protocol ID = TagProtocol.IPX64 |
| 256 | PWM | Protocol ID = TagProtocol.IPX256 |

**NOTE: The two link rates are effectively two different protocols and treated as such. IP-X tags are fixed to one of the two frequencies and cannot communicate on the other, unlike ISO 18000-6B/C tags which can operate under multiple profiles.**

## ISO 18000-6B

The M6e supports multiple ISO-18000-6B profiles including the ability to specify the Return Link Frequency, encoding, Forward Link Rate and modulation scheme. The protocol options are set in the MercuryAPI Reader Configuration Parameters (/reader/ iso18000-6b/*). The following table shows the supported combinations:

*ISO 18000-6B Protocol Configuration Options*

| Return Link Freq (kHz) | Return Encoding | Forward Link Freq (kHz) | Forward Encoding | Modulation Depth |
|---|---|---|---|---|
| 40 | FM0 | 10 | Manchester | 11% |
| 40 | FM0 | 10 | Manchester | 99% |
| 160 | FM0 | 40 | Manchester | 11% |
| 160 | FM0 | 40 | Manchester | 99% (default) |

### Delimiter

ISO18000-6B tags support two delimiter settings on the transmitter. Not all tags support both delimiters, some tags require the delimiter be set to 1, but the default is 4.

The delimiter setting is set using the MercuryAPI Reader Configuration Parameter:

```
/reader/iso180006b/delimiter
```

In addition to setting the delimiter to 1, a TagFilter of the class ISO180006b.Select must be used in order to read certain ISO18000-6b tags, specifically one of the following options must be used:

```
GROUP_SELECT_EQ

GROUP_SELECT_NE

GROUP_SELECT_GT

GROUP_SELECT_LT

GROUP_UNSELECT_EQ

GROUP_UNSELECT_NE

GROUP_UNSELECT_GT

GROUP_UNSELECT_LT
```

## AEI ATA

### AEI ATA Protocol with Stop Trigger Read Plan

The AEI ATA protocol is supported on the M6e module with an optional license key. The ATA protocol is supported under a Stop Trigger Read Plan so that results can be provided continuously instead of at the end of a read cycle.

Universal Reader Assistant now supports readers which have been licensed to read the AEI ATA or IP-X protocols. The “Tag Inspector” tab can interpret the information in AEI ATA tags per the AAR S-918 encoding standard.

## Tag Handling

When the M6e performs inventory operations (MercuryAPI Read commands) data is stored in a Tag Buffer until retrieved by the client application, or streamed directly to the client if operating in Tag Streaming/ Continuous Reading mode.

### Tag Buffer

The M6e uses a dynamic buffer that depends on EPC length and quantity of data read. As a rule of thumb it can store a maximum of 1024 96-bit EPC tags in the TagBuffer at a time. Since the M6e supports streaming of read results the buffer limit is, typically, not an issue. Each tag entry consists of a variable number of bytes and consists of the following fields:

*Tag Buffer*

| Total Entry Size | Field | Size | Description |
|---|---|---|---|
| 68 bytes (Max EPC Length = 496bits) | EPC Length | 2 bytes | Indicates the actual EPC length of the tag read. |
| | PC Word | 2 bytes | Contains the Protocol Control bits for the tag. |
| | EPC | 62 bytes | Contains the tag’s EPC value. |
| | Tag CRC | 2 bytes | The tag’s CRC. |
| Tag Read Metadata | | | |

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.

### Tag Streaming/Continuous Reading

When reading tags during asynchronous inventory operations (MercuryAPI Reader.StartReading()) using an */reader/read/asyncOffTime*=0 the M6e "streams" the tag results back to the host processor. This means that tags are pushed out of the buffer as soon as they are processed by the M6e and put into the buffer. The buffer is put into a circular mode that keeps the buffer from filling. This allows for the M6e to perform continuous search operations without the need to periodically stop reading and fetch the contents of the buffer. Aside from not seeing "down time" when performing a read operation, this behavior is essentially invisible to the user as all tag handling is done by the MercuryAPI.

**NOTE: It is recommended the USB Interface be used when operating the M6e in continuous reading mode. When the TTL Level UART Interface is used, it is not possible for the module to detect a broken communications interface connection and stop streaming the tag results.**

### Tag Read Metadata

In addition to the tag EPC ID resulting from M6e inventory operation each TagReadData (see MercuryAPI for code details) contains metadata about how, where and when the tag was read. The specific metadata available for each tag read is as follows:

*Tag Read Metadata*

| Metadata Field | Description |
|---|---|
| Antenna ID | The antenna on with the tag was read. If the same tag is read on more than one antenna there will be a tag buffer entry for each antenna on which the tag was read. When Using a Multiplexer, if appropriately configured, the Antenna ID entry will contain the logical antenna port of the tag 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 Metadata 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. |
| Tag Data | When reading an embedded TagOp is specified for a ReadPlan the TagReadData will contain the first 128 words of data returned for each tag.<br>**NOTE: Tags with the same TagID but different Tag Data can be considered unique and each get a Tag Buffer entry if set in the reader configuration parameter /reader/tagReadData/ uniqueByData. By default it is not.** |
| Frequency | The frequency on which the tag was read. |
| Tag Phase | Average phase of tag response in degrees (0°-180°). |
| LQI/RSSI | The receive signal strength of the tag response in dBm. |
| GPIO Status | The signal status (High or Low) of all GPIO pins when tag was read. |

### Meta-data Control at Module Level

The meta-data selection information is transferred to the module and the module only reports desired values, resulting in a small increase in performance under some circumstances. No additional configuration parameters are necessary to take advantage of this feature.

### Filtering on Tag Length and EPC Truncation

The Universal Reader Assistant can filter based on tag length and EPC truncation:

- Only return tags if the EPC is of the expected length, which weeds out stray and phantom tags.
- Only announces tags whose EPCs contain a certain beginning value and length. The desired EPC value includes both the PC word (which gives the EPC length) and the desired starting value for EPC. Tags do not respond if they do not have that start value and length; they only respond with the unique portion of their EPC (not the shared prefix value) to increase performance.

Note that “EPC Truncate” is difficult to distinguish between a normal filter on EPC ID because the part of the EPC that is not reported by the tag is appended to the EPC as reported in the tag results screen.

## Power Management

The M6e is designed for power efficiency and offers several different power management modes. The following power management modes affect the power consumption during different periods of M6e usage and impact performance in different ways. The available power management modes are:

- Power Modes - Set in /reader/powerMode. Controls the power savings when the M6e is idle.
- Transmit Modes - Set in /reader/radio/enablePowerSave. Controls power savings while transmitting.

### Power Modes

The Power Mode setting (set in /reader/powerMode) allows the user to trade off increased RF operation startup time for additional power savings. The details of the amount of power consumed in each mode is shown in the table under M6e Power Consumption. The behavior of each mode and impact on RF command latency is as follows:

- **PowerMode.FULL** – 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.
- **PowerMode.MINSAVE** – This mode performs more aggressive power savings, such as automatically shutting down the analog section between commands, and then restarting it whenever a tag command is issued. This mode may add up to 50 ms of delay from idle to RF on when initiating an RF operation.
- **PowerMode.SLEEP** – This mode essentially shuts down the digital and analog boards, except to power the bare minimum logic required to wake the processor. This mode may add up to 100 ms of delay from idle to RF on when initiating an RF operation. **PowerMode.SLEEP is not supported when using the USB interface**. Using the setting PowerMode.MEDSAVE is the same as SLEEP.

**NOTE: See additional latency specifications under Event Response Times.**

### Transmit Modes

The Transmit Mode setting (set in /reader/radio/enablePowerSave) allows the user to trade off RF spectral compliance with the Gen2 DRM Mask for increased power savings while transmitting. The details of the amount of power consumed in each mode is shown in the table under Power Consumption. The behavior of each mode is as follows:

#### DRM Compliant Mode

This mode maximizes performance in dense reader environments, minimizing interference when used with other M6e or similar DRM-compliant readers, and is fully compliant with the Gen2 DRM spectral mask.

#### Power Save Mode (non-DRM Compliant)

This mode reduces the power consumption during RF operations but is not 100% compliant with the DRM spectral mask. This can result increased interference with other readers and reduce overall systems performance.

### Event Response Times

The following table provides some metrics on how long common M6e operations take. An event response time is defined as the maximum time from the end of a command (end of the last bit in the serial stream) or event (e.g. power up) to the response event the command or event causes.

*Event Response Times*

| Start Command/ Event | End Event | Time (msecs) | Notes |
|---|---|---|---|
| Power Up | Application Active (with CRC check) | 1500 | This longer power up period should only occur for the first boot with new firmware. |
| Power Up | Application Active | 120 | Once the firmware CRC has been verified subsequent power ups do not require the CRC check be performed, saving time. |
| Tag Read | RF On | 20 | When in Power Mode = FULL |
| Tag Read | RF On | 50 | When in Power Mode = MINSAVE |
| Tag Read | RF On | 120 | When in Power Mode = SLEEP |
| Change to MINSAVE | PowerMode.MINSAVE | 5 | From Power Mode = FULL |
| Change to SLEEP | PowerMode.SLEEP | 5 | From Power Mode = FULL |

### Save and Restore Configuration

The M6e supports saving module and protocol configuration parameters to the module flash to provide configuration persistence across boots. This was introduced to support Autonomous Operation, but can also be used to reduce the amount of communication necessary to bring a module up to operating state following a reboot. The parameters that can be saved include:

- Region
- Baud Rate (for serial interface)
- Default Protocol
- RF power
- Antenna search list
- Gen2 “M” value
- Gen2 BLF (Tari will be 25 usec if BLF=250 and 6.25 usec if BLF=640)

- Gen2 Session
- Gen2 target
- Gen2 Q
- Gen2 TARI
- Autonomous Trigger
- Autonomous Read Plan
- Hop Table (necessary to operate legally in some regions)
- Hop Time Dwell Time (maximum time reader can occupy a channel)
- Duty Cycle for Autonomous Read Plan (to limit temperature rise given that only continuous reading is supported for a saved Autonomous Read Plan)

See the MercuryAPI Programmers Guide and sample applications for details on saving and restoring reader configuration. The Autonomous Configuration Tool provides an easy way to store and restore settings in the module.

**Set the Duty Cycle for Continuous Reading**

The module can control the duty cycle, allowing the host less interaction with the module and permitting greater control under Autonomous Operation. The Autonomous Configuration Tool supports duty cycle control, to complement support in emerging versions of module firmware. This allows the module firmware to control duty cycle to save battery life and reduce temperature rise.

**Change Settings During Continuous Reading**

A subset of available settings can be changed while the reader is actively reading. This allows the host to optimize settings on-the-fly. Settings that are supported during continuous reading are:

- Global TX Read Power
- Global TX Write Power
- Gen2 BLF
- Gen2 TARI
- Gen2 Encoding (“M” value)
- Gen2 Q
- Gen2 Session
- Gen2 Target
- GPO line state (and learn the value of GPI lines).

**NOTE: You cannot change the sense of a line (i.e., input to output) during continuous reading.**

No special command is needed to set parameters during continuous reading. The API will automatically send the correct command to the module based on its knowledge of the state the module is in.

Universal Reader Assistant can change settings during continuous reading. Any settings in the “Display Gen2 Settings” category can be altered, as well as the global read and write power levels (although write power is of limited use since the “write” tag operation cannot be specified under continuous reading in the Universal Reader Assistant).

Changes to the power levels are applied silently. Changes to Gen2 parameters result in a pop-up progress bar which disables further changes until the one you made is applied.

## License Handling

The M6e module supports protocols and features that are activated by installation of a license key. The Universal Reader Assistant Firmware Update panel is used to install license keys.

# 6 Specifications

## M6e Specifications

| Ordering Information | |
|---|---|
| M6e | +30 dBm North America, +31.5 dBM Europe |
| M6e-A | +31.5 dBM in all regions, requires contract |
| M6e-JIC | PRC high and low bands |
| M6e-LIC-2F | License for optional IPX and ISO 18K-6B protocols (Gen2 standard) |
| M6e-DEVKIT | Development Kit North/South America, EU, IN, KR |
| **Physical** | |
| Dimensions | 69 mm L x 43 mm W x 7.5 mm H (2.7 in L x 1.7 in W x 0.3 in H) |
| **Tag Transponder Protocols** | |
| RFID Protocol Support | EPCglobal Gen 2 (ISO 18000-6C) with DRM; ISO 18000-6B and IP-X Optional; EPCglobal G2V2 (ISO 18000-63) pending market availability |
| **RF Interface** | |
| Antenna Connector | Four 50 Ω MMCX connectors supporting four monostatic antennas |
| RF Power Output | Separate read and write levels, command-adjustable from +5 dBm to +31.5 dBm (1.4W) with .5 dBM accuracy above +15 dBm[1] |
| Regulatory | Pre-configured for the following regions: FCC (NA, SA); ETSI (EU); TRAI (India); KCC (Korea); ACMA (Australia); SRRC-MII (P.R. China); 'Open' (Customizable 865-869 and 902-928 MHz) |
| **Data/Control Interface** | |
| Physical | 15-pin low-profile connector providing DC power, communication, control and GPIO signals |
| Control/Data Interfaces | UART with 3.3/5V logic levels from 9.6 to 921.6 kbps; USB 2.0 full speed device port (up to 12 Mbps); Shutdown control and reset indicators |
| GPIO Sensors and Indicators | Four 3.3V bidirectional ports configurable as input (sensor) ports or output (indicator) ports |
| API support | C#/.NET, Java, C |
| **Power** | |
| DC Power Required | DC Voltage: 5V +/- 5%;<br>DC power consumption when reading: 6.7 W @ +31.5 dBm; 4.2 W @ power levels under +17 dBm |
| Idle Power Consumption | 0.25 W |
| Power Saving Options | Standby: 0.12 W<br>Sleep: 0.005 W<br>Shutdown: 0.00025 W |
| **Environment** | |
| Certification | USA (FCC 47 CFR Ch. 1 Part 15); Canada (Industry Canada RSS-21 0); EU (ETSI EN 302 208 v3.1.1, RED 2014/53/EU) |
| Operating Temp. | -40°C to +60°C (case temperature) |

| | |
|---|---|
| Storage Temp. | -40°C to +85°C |
| Shock and Vibration | Designed to be installed in host devices which are required to survive 5 foot drops to concrete |
| **Performance** | |
| Max Read Rate | Up to 750 tags/second using high-performance settings |
| Max Tag Read Distance | Over 9 meters (30 feet) with 6 dBiL antenna (36 dBm EIRP) |
| Specifications subject to change without notice.<br>[1]Maximum power may have to be reduced to meet regulatory limits, which specify the combined effect of the module, antenna, cable and enclosure shielding of the integrated product. Adequate heat sinking required to run continuously at maximum power. | |

# 7 Compliance and IP Notices

The M6e module is available in two North American variants. The corresponding regulatory information follows:

**M6e**: This module is covered under an FCC Modular Approval license and is limited to 30dBm RF Output power when used in the FCC/NA Region.

**M6e-A**: This module is covered under an FCC Limited Modular Approval license and can be operated at the full 31.5dBm RF Output Power with certain restrictions.

## M6e Communication Regulation Information

EMC FCC 47 CFR, Part 15

Industrie Canada RSS-210

**Federal Communication Commission (FCC) Interference Statement**

This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio/TV technician for help.

This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

FCC Caution: Any changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate this equipment.

This transmitter module is authorized to be used in other devices only by OEM integrators under the following conditions:

1. The antenna(s) must be installed such that a minimum separation distance of 35cm is maintained between the radiator (antenna) & user's/nearby people's body at all times.

2. The transmitter module must not be co-located with any other antenna or transmitter.

As long as the two conditions above are met, further transmitter testing will not be required. However, the OEM integrator is still responsible for testing their end-product for any additional compliance requirements required with this module installed (for example, digital device emissions, PC peripheral requirements, etc.).

**NOTE: In the event that these conditions cannot be met (for certain configurations or co-location with another transmitter), then the FCC authorization is no longer considered valid and the FCC ID cannot be used on the final product. In these circumstances, the OEM integrator will be responsible for reevaluating the end product (including the transmitter) and obtaining a separate FCC authorization.**

The OEM integrator has to be aware not to provide information to the end user regarding how to install or remove this RF module in the user manual of the end product.

**User Manual Requirement**

The user manual for the end product must include the following information in a prominent location:

"To comply with FCC's RF radiation exposure requirements, the antenna(s) used for this transmitter must be installed such that a minimum separation distance of 35cm is maintained between the radiator (antenna) & user's/nearby people's body at all times and must not be co-located or operating in conjunction with any other antenna or transmitter."

AND

"The transmitting portion of this device carries with it the following two warnings:

"This device complies with Part 15...."

AND

"Any changes or modifications to the transmitting module not expressly approved by JADAK could void the user's authority to operate this equipment" "

**End Product Labeling**

The final end product must be labeled in a visible area with the following:

*"Contains Transmitter Module FCC ID: QV5MERCURY6E"*

or

"Contains FCC ID: QV5MERCURY6E."

## Industry Canada

Under Industry Canada (IC) regulations, this radio transmitter may only operate using an antenna of a type and maximum (or lesser) gain approved for the transmitter by Industry Canada. To reduce potential radio interference to other users, the antenna type and its gain should be so chosen that the Equivalent Isotropically Radiated Power (EIRP) is not more than that necessary for successful communication.

This radio transmitter (identify the device by certification number, or model number if Category II) has been approved by Industry Canada to operate with the antenna types listed below with the maximum permissible gain and required antenna impedance for each antenna type indicated. Antenna types not included in this list, having a gain greater than the maximum gain indicated for that type, are strictly prohibited for use with this device.

Operation is subject to the following two conditions: (1) this device may not cause interference, and (2) this device must accept any interference, including interference that may cause undesired operation of the device.

To reduce potential radio interference to other users, the antenna type and its gain should be so chosen that the Equivalent Isotropically Radiated Power (EIRP) is not more than that permitted for successful communication.

This device has been designed to operate with the antennas listed in the Authorized Antennas table. Antennas not included in these lists are strictly prohibited for use with this device.

To comply with IC RF exposure limits for general population/uncontrolled exposure, the antenna(s) used for this transmitter must be installed to provide a separation distance of at least 35cm from all persons and must not be colocated or operating in conjunction with any other antenna or transmitter.

**End Product Labeling**

The final end product must be labeled in a visible area with the following:

“Contains ThingMagic M6e (or appropriate model number you are filing with IC) transmitting module FCC ID: QV5MERCURY6E (IC: 5407A-MERCURY6E)”

## Industrie Canada (French Canadian)

Conformément à la réglementation d'Industrie Canada, le présent émetteur radio peut fonctionner avec une antenne d'un type et d'un gain maximal (ou inférieur) approuvé pour l'émetteur par Industrie Canada. Dans le but de réduire les risques de brouillage radioélectrique à l'intention des autres utilisateurs, il faut choisir le type d'antenne et son gain de sorte que la puissance isotrope rayonnée équivalente (p.i.r.e.) ne dépasse pas l'intensité nécessaire à l'établissement d'une communication satisfaisante.

Le présent émetteur radio (identifier le dispositif par son numéro de certification ou son numéro de modèle s'il fait partie du matériel de catégorie I) a été approuvé par Industrie Canada pour fonctionner avec les types d'antenne énumérés ci-dessous et ayant un gain admissible maximal et l'impédance requise pour chaque type d'antenne. Les types d'antenne non inclus dans cette liste, ou dont le gain est supérieur au gain maximal indiqué, sont strictement interdits pour l'exploitation de l'émetteur

Le fonctionnement de l’ appareil est soumis aux deux conditions suivantes:

1. Cet appareil ne doit pas perturber les communications radio, et

2. cet appareil doit supporter toute perturbation, y compris les perturbations qui pourraient provoquer son dysfonctionnement.

Pour réduire le risque d'interférence aux autres utilisateurs, le type d'antenne et son gain doivent être choisis de façon que la puissance isotrope rayonnée équivalente (PIRE) ne dépasse pas celle nécessaire pour une communication réussie.

L’ appareil a été conçu pour fonctionner avec les antennes énumérés dans les tables Antennes Autorisées. Il est strictement interdit de l’ utiliser l’ appareil avec des antennes qui ne sont pas inclus dans ces listes.

Au but de conformer aux limites d'exposition RF pour la population générale (exposition non-contrôlée), les antennes utilisés doivent être installés à une distance d'au moins 35cm de toute personne et ne doivent pas être installé en proximité ou utilisé en conjonction avec un autre antenne ou transmetteur.

Marquage sur l' étiquette du produit complet dans un endroit visible: "Contient ThingMagic transmetteur, FCC ID: QV5MERCURY6E (IC:5407A-MERCURY6E)"

## Authorized Antennas

This device has been designed to operate with the antennas listed in Authorized Antennas.

Antennas not included in this list are strictly prohibited for use with this device.

## M6e-A Communication Regulation Information

EMC FCC 47 CFR, Part 15

Industrie Canada RSS-210

**Federal Communication Commission (FCC) Interference Statement**

This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio/TV technician for help.

This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

FCC Caution: Any changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate this equipment.

**Warning: Operation of the M6e-A module requires professional installation to correctly set the TX power for the RF cable and antenna selected.**

This transmitter module is authorized to be used in other devices only by OEM integrators under the following conditions:

1. The antenna(s) must be installed such that a minimum separation distance of 35cm is maintained between the radiator (antenna) & user's/nearby people's body at all times.

2. The transmitter module must not be co-located with any other antenna or transmitter.

As long as the two conditions above are met, further transmitter testing will not be required. However, the OEM integrator is still responsible for testing their end-product for any additional compliance requirements required with this module installed (for example, digital device emissions, PC peripheral requirements, etc.).

**NOTE: In the event that these conditions cannot be met (for certain configurations or co-location with another transmitter), then the FCC authorization is no longer considered valid and the FCC ID cannot be used on the final product. In these circumstances, the OEM integrator will be responsible for reevaluating the end product (including the transmitter) and obtaining a separate FCC authorization.**

The OEM integrator has to be aware not to provide information to the end user regarding how to install or remove this RF module in the user manual of the end product.

**User Manual Requirement**

The user manual for the end product must include the following information in a prominent location:

"To comply with FCC's RF radiation exposure requirements, the antenna(s) used for this transmitter must be installed such that a minimum separation distance of 35cm is maintained between the radiator (antenna) & user's/nearby people's body at all times and must not be co-located or operating in conjunction with any other antenna or transmitter."

AND

"The transmitting portion of this device carries with it the following two warnings:

"This device complies with Part 15...."

AND

"Any changes or modifications to the transmitting module not expressly approved by JADAK could void the user's authority to operate this equipment" "

**End Product Labeling**

The final end product must be labeled in a visible area with the following:

*"Contains Transmitter Module FCC ID: QV5MERCURY6E-A"*

or

"Contains FCC ID: QV5MERCURY6E-A."

## Industry Canada

Under Industry Canada (IC) regulations, this radio transmitter may only operate using an antenna of a type and maximum (or lesser) gain approved for the transmitter by Industry Canada. To reduce potential radio interference to other users, the antenna type and its gain should be so chosen that the Equivalent Isotropically Radiated Power (EIRP) is not more than that necessary for successful communication.

This radio transmitter (identify the device by certification number, or model number if Category II) has been approved by Industry Canada to operate with the antenna types listed below with the maximum permissible gain and required antenna impedance for each antenna type indicated. Antenna types not included in this list, having a gain greater than the maximum gain indicated for that type, are strictly prohibited for use with this device.

Operation is subject to the following two conditions: (1) this device may not cause interference, and (2) this device must accept any interference, including interference that may cause undesired operation of the device.

To reduce potential radio interference to other users, the antenna type and its gain should be so chosen that the Equivalent Isotropically Radiated Power (EIRP) is not more than that permitted for successful communication.

This device has been designed to operate with the antennas listed in the Authorized Antennas table. Antennas not included in these lists are strictly prohibited for use with this device.

To comply with IC RF exposure limits for general population/uncontrolled exposure, the antenna(s) used for this transmitter must be installed to provide a separation distance of at least 35cm from all persons and must not be colocated or operating in conjunction with any other antenna or transmitter.

**End Product Labeling**

The final end product must be labeled in a visible area with the following:

“Contains ThingMagic M6e (or appropriate model number you are filing with IC) transmitting module FCC ID: QV5MERCURY6E-A (IC: 5407A-MERCURY6EA)”

## Industrie Canada (French Canadian)

Conformément à la réglementation d'Industrie Canada, le présent émetteur radio peut fonctionner avec une antenne d'un type et d'un gain maximal (ou inférieur) approuvé pour l'émetteur par Industrie Canada. Dans le but de réduire les risques de brouillage radioélectrique à l'intention des autres utilisateurs, il faut choisir le type d'antenne et son gain de sorte que la puissance isotrope rayonnée équivalente (p.i.r.e.) ne dépasse pas l'intensité nécessaire à l'établissement d'une communication satisfaisante.

Le présent émetteur radio (identifier le dispositif par son numéro de certification ou son numéro de modèle s'il fait partie du matériel de catégorie I) a été approuvé par Industrie Canada pour fonctionner avec les types d'antenne énumérés ci-dessous et ayant un gain admissible maximal et l'impédance requise pour chaque type d'antenne. Les types d'antenne non inclus dans cette liste, ou dont le gain est supérieur au gain maximal indiqué, sont strictement interdits pour l'exploitation de l'émetteur

Le fonctionnement de l’ appareil est soumis aux deux conditions suivantes:

1. Cet appareil ne doit pas perturber les communications radio, et

2. cet appareil doit supporter toute perturbation, y compris les perturbations qui pourraient provoquer son dysfonctionnement.

Pour réduire le risque d'interférence aux autres utilisateurs, le type d'antenne et son gain doivent être choisis de façon que la puissance isotrope rayonnée équivalente (PIRE) ne dépasse pas celle nécessaire pour une communication réussie.

L’ appareil a été conçu pour fonctionner avec les antennes énumérés dans les tables Antennes Autorisées. Il est strictement interdit de l’ utiliser l’ appareil avec des antennes qui ne sont pas inclus dans ces listes.

Au but de conformer aux limites d'exposition RF pour la population générale (exposition non-contrôlée), les antennes utilisés doivent être installés à une distance d'au moins 35cm de toute personne et ne doivent pas être installé en proximité ou utilisé en conjonction avec un autre antenne ou transmetteur.

Marquage sur l’ étiquette du produit complet dans un endroit visible: "Contient ThingMagic transmetteur, FCC ID: QV5MERCURY6E-A (IC:5407A-MERCURY6EA)"

## EU RED Declaration of Conformity

Novanta
The Innovation Advantage

### European Union Declaration of Conformity for M6E RFID Reader Module

| | |
|---|---|
| Manufacturer: | Novanta Corporation |
| Address: | 125, Middlesex Turnpike<br>Bedford, MA 01730 |
| Object of the declaration:<br>Product Model Numbers: | M6E, M6E-A |
| Object description:<br>Product Description: | 865-869 MHz and 902 to 928 MHz Radio Frequency Identification (RFID)<br>Reader / Interrogator Module. |
| This declaration of conformity is issued under the sole responsibility of the manufacturer.<br>The object of the declaration described above is in conformity with the following relevant European Union harmonization Legislation: | |
| Directives: | |
| Identifier | Date |
| 2014/53/EU | 16 April 2014 |
| 2011/65/EU w/ Amendments M1-M30 | 19 April 2016 |

The object described above conforms to the requirements of EU directives through full compliance with the following standards:
European Standards

| Standard | Amendments |
|---|---|
| ETSI EN 302 208 V3.1.1 (2016-11) | None |
| ETSI EN 301 489-3 V2.1.0 (2016-09) | Draft |
| CENELEC EN 50581:2012 | None |

The notified body Curtis-Straus LLC, NB1797 performed review of test reports on the object of this declaration and issued the EU-type examination certificate CS22410.

It is required that Module set power in dBm, less antenna cable loss in dB, plus antenna gain in dBdL, must be +33 dBmERP or less to allow the object to operate as intended, and to be covered by this EU declaration of conformity.

| Authorized on Behalf of Novanta Corporation: | |
|---|---|
| Name | Eva Gravius |
| Function | VP Engineering |
| Address | North Syracuse, New York |
| Date | September 21, 2017 |
| Signature |  |

Document No. 875-0212-01 Rev B

**Novanta Corporation**
125 Middlesex Turnpike Bedford, MA 01730-1409 Tel: 781-266-5700 Fax: 781-266-5114 www.novanta.com

# Appendix A: Error Messages

*Common Fault Errors*

| Message | Code | Cause | Solution |
|---|---|---|---|
| FAULT_MSG_WRONG_NUMBER_OF_DATA | 100h | If the data length in any of the messages is less than or more than the number of arguments in the message, the reader returns this message. | Make sure the number of arguments matches the data length. |
| FAULT_INVALID_OPCODE | 101h | The opCode received is invalid or not supported in the currently running program (bootloader or main application) or is not supported in the current version of code. | Check the following:<br>• Make sure the command is supported in the currently running program.<br>• Check the documentation for the opCode the host sent and make sure it is correct and supported.<br>• Check the previous module responses for an assert (0x7F0X) which will reset the module into the bootloader. |
| FAULT_UNIMPLEMENTED_OPCODE | 102h | Some of the reserved commands might return this error code.<br>This does not mean that they always will do this since JADAK reserves the right to modify those commands at any time. | Check the documentation for the opCode the host sent to the reader and make sure it is supported. |
| FAULT_MSG_POWER_TOO_HIGH | 103h | A message was sent to set the read or write power to a level that is higher than the current hardware supports. | Check the hardware specifications for the supported powers and ensure that the level is not exceeded. The M6e 1-Watt units support power from 5 dBm to 30 dBm. |
| FAULT_MSG_INVALID_FREQ_RECEIVED | 104h | A message was received by the reader to set the frequency outside the supported range. | Make sure the host does not set the frequency outside this range or any other locally supported ranges. |

*Common Fault Errors (Continued)*

| Message | Code | Cause | Solution |
|---|---|---|---|
| FAULT_MSG_INVALID_PARAMETER_VALUE | 105h | The reader received a valid command with an unsupported or invalid value within this command. For example, currently the module supports four antennas. If the module receives a message with an antenna value other than 1 to 4, it returns this error. | 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 | A message was received to set the read or write power to a level that is lower than the current hardware supports. | Check the hardware specifications for the supported powers and ensure that level is not exceeded. The M6e supports powers between 5 and 31.5 dBm. |
| FAULT_UNIMPLEMENTED_FEATURE | 109h | Attempting to invoke a command not supported on this firmware or hardware. | Check the command being invoked against the documentation. |
| FAULT_INVALID_BAUD_RATE | 10Ah | When the baud rate is set to a rate that is not specified in the Baud Rate table, this error message is returned. | Check the table of specific baud rates and select a baud rate. |

*Bootloader Fault Errors*

| Message | Code | Cause | Solution |
|---|---|---|---|
| FAULT_BL_INVALID_IMAGE_CRC | 200h | When the application firmware is loaded the reader checks the image stored in flash and returns this error if the calculated CRC is different than the one stored in flash. | 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 | When the application firmware is loaded 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. | 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.<br>To fix this problem, reload the application code in flash. |

*Flash Fault Errors*

| Message | Code | Cause | Solution |
|---|---|---|---|
| FAULT_FLASH_BAD_ERASE_PASSWORD | 300h | A command was received to erase some part of the flash but the password supplied with the command was incorrect. | When this occurs make note of the operations you were executing, save FULL error response and send a test case reproducing the behavior to rfid-support@jadaktech.com. |
| FAULT_FLASH_BAD_WRITE_PASSWORD | 301h | A command was received to write some part of the flash but the password supplied with the command was not correct. | |
| FAULT_FLASH_UNDEFINED_ERROR | 302h | This is an internal error and it is caused by a software problem in module. | |
| FAULT_FLASH_ILLEGAL_SECTOR | 303h | An erase or write flash command was received with the sector value and password not matching. | |
| FAULT_FLASH_WRITE_TO_NON_ERASED_AREA | 304h | The module received a write flash command to an area of flash that was not previously erased. | |
| FAULT_FLASH_WRITE_TO_ILLEGAL_SECTOR | 305h | The module received a write flash command to write across a sector boundary that is prohibited. | |
| FAULT_FLASH_VERIFY_FAILED | 306h | The module received a write flash command that was unsuccessful because data being written to flash contained an uneven number of bytes. | |

*Protocol Fault Errors*

| Message | Code | Cause | Solution |
|---|---|---|---|
| FAULT_NO_TAGS_FOUND | 400h | A command was received (such as read, write, or lock) but the operation failed. There are many reasons that can cause this error to occur, including:<br>• No tag in the RF field<br>• Read/write power too low<br>• Antenna not connected<br>• Tag is weak or dead | 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 tags of the same type to rule out a weak tag. If none passed, then it could be software configuration such as protocol value, antenna, and so forth, or a placement configuration like a tag location. |
| FAULT_NO_PROTOCOL_DEFINED | 401h | A command was received to perform a protocol command but no protocol was initially set. The reader powers up with no protocols set. | A protocol must be set before the reader can begin RF operations. |
| FAULT_INVALID_PROTOCOL_SPECIFIED | 402h | The protocol value was set to a protocol that is not supported with the current version of software. | This value is invalid or this version of software does not support the protocol value. Check the documentation for the correct values for the protocols in use and that you are licensed for it. |
| FAULT_WRITE_PASSED_LOCK_FAILED | 403h | 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. | Try to write a few other tags and make sure that they are placed in the RF field. |
| FAULT_PROTOCOL_NO_DATA_READ | 404h | A command was sent but did not succeed. | The tag used has failed or does not have the correct CRC. Try to read a few other tags to check the hardware/software configuration. |
| FAULT_AFE_NOT_ON | 405h | A command was received for an operation, like read or write, but the AFE was in the off state. This will also occur for a M6e module if antenna detection is enabled, but no region has been selected. | Make sure the region and tag protocol have been set to supported values. |
| FAULT_PROTOCOL_WRITE_FAILED | 406h | An attempt to modify the contents of a tag failed. There are many reasons for failure. | Check that the tag is good and try another operation on a few more tags. |
| FAULT_NOT_IMPLEMENTED_FOR_THIS_PROTOCOL | 407h | A command was received which is not supported by a protocol. | Check the documentation for the supported commands and protocols. |

*Protocol Fault Errors (Continued)*

| Message | Code | Cause | Solution |
|---|---|---|---|
| FAULT_PROTOCOL_INVALID_WRITE_DATA | 408h | An ID write was attempted with an unsupported/incorrect ID length. | Verify the Tag ID length being written. |
| FAULT_PROTOCOL_INVALID_ADDRESS | 409h | A command was received attempting to access an invalid address in the tag data address space. | 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 | This error is used by the GEN2 module. This fault can occur if the read, write, lock, or kill command fails. This error can be internal or functional. | Make a note of the operations you were performing and contact rfid-support@jadaktech.com. |
| FAULT_DATA_TOO_LARGE | 40Bh | A command was received to Read Tag Data with a data value larger than expected or it is not the correct size. | Check the size of the data value in the message sent to the reader. |
| FAULT_PROTOCOL_INVALID_KILL_PASSWORD | 40Ch | An incorrect kill password was received as part of the Kill command. | Check the password. |
| FAULT_PROTOCOL_KILL_FAILED | 40Eh | Attempt to kill a tag failed for an unknown reason. | Check tag is in RF field and the kill password. |
| FAULT_PROTOCOL_BIT_DECODING_FAILED | 40Fh | Attempt to operate on a tag with an EPC length greater than the Maximum EPC length setting. | Check the EPC length being written. |
| FAULT_PROTOCOL_INVALID_EPC | 410h | This error is used by the GEN2 module indicating an invalid EPC value has been specified for an operation. This fault can occur if the read, write, lock, or kill command fails. | Check the EPC value that is being passed in the command resulting in this error. |
| FAULT_PROTOCOL_INVALID_NUM_DATA | 411h | This error is used by the GEN2 module indicating invalid data has been specified for an operation. This fault can occur if the read, write, lock, or kill command fails. | Check the data that is being passed in the command resulting in this error. |

*Protocol Fault Errors (Continued)*

| Message | Code | Cause | Solution |
|---|---|---|---|
| FAULT_GEN2 PROTOCOL_OTHER_ERROR | 420h | This is an error returned by Gen2 tags. It is a catch-all for error not covered by other codes. | Check the data that is being passed in the command resulting in this error. Try with a different tag. |
| FAULT_GEN2_PROTOCOL_MEMORY_OVERRUN_BAD_PC | 423h | This is an error returned by Gen2 tags. The specific memory location does not exist or the PC value is not supported by the tag. | Check the data that is being written and where it is being written to in the command resulting in this error. |
| FAULT_GEN2 PROTOCOL_MEMORY_LOCKED | 424h | This is an error returned by Gen2 tags. The specified memory location is locked and/or permalocked and is either not writable or not readable. | Check the data that is being written and where it is being written to in the command resulting in this error. Check the access password being sent. |
| FAULT_GEN2 PROTOCOL_INSUFFICIENT_POWER | 42Bh | This is an error returned by Gen2 tags. The tag has insufficient power to perform the memory-write operation. | Try moving the tag closer to the antenna. Try with a different tag. |
| FAULT_GEN2 PROTOCOL_NON_SPECIFIC_ERROR | 42Fh | This is an error returned by Gen2 tags. The tag does not support error specific codes. | Check the data that is being written and where it is being written to in the command resulting in this error. Try with a different tag. |
| FAULT_GEN2 PROTOCOL_UNKNOWN_ERROR | 430h | This is an error returned by M6e when no more error information is available about why the operation failed. | Check the data that is being written and where it is being written to in the command resulting in this error. Try with a different tag. |

*Analog Hardware Abstraction Layer Fault Errors*

| Message | Code | Cause | Solution |
|---|---|---|---|
| FAULT_AHAL_INVALID_FREQ | 500h | A command was received to set a frequency outside the specified range. | Check the values you are trying to set and be sure that they fall within the range of the set region of operation. |
| FAULT_AHAL_CHANNEL_OCCUPIED | 501h | With LBT enabled an attempt was made to set the frequency to an occupied channel. | Try a different channel. If supported by the region of operation turn LBT off. |
| FAULT_AHAL_TRANSMITTER_ON | 502h | Checking antenna status while CW is on is not allowed. | Do not perform antenna checking when CW is turned on. |

*Analog Hardware Abstraction Layer Fault Errors (Continued)*

| Message | Code | Cause | Solution |
|---|---|---|---|
| FAULT_ANTENNA_NOT_CONNECTED | 503h | An attempt was made to transmit on an antenna which did not pass the antenna detection when antenna detection was turned on. | Connect a detectable antenna (antenna must have some DC resistance). |
| FAULT_TEMPERATURE_EXCEED_LIMITS | 504h | The module has exceeded the maximum or minimum operating temperature and will not allow an RF operation until it is back in range. | Take steps to resolve thermal issues with module:<br>• Reduce duty cycle<br>• Add heat sink<br>• Use Power Save Mode (non-DRM Compliant) |
| FAULT_POOR_RETURN_LOSS | 505h | The module has detected a poor return loss and has ended RF operation to avoid module damage. | Take steps to resolve high return loss on receiver:<br>• Make sure antenna VSWR is within module specifications<br>• Make sure antennas are correctly attached before transmitting<br>• Check environment to ensure no occurrences of high signal reflection back at antennas. |
| FAULT_AHAL_INVALID_ANTENA_CONFIG | 507h | An attempt to set an antenna configuration that is not valid. | Use the correct antenna setting or change the reader configuration. |

*Tag ID Buffer Fault Errors*

| Message | Code | Cause | Solution |
|---|---|---|---|
| FAULT_TAG_ID_BUFFER_NOT_ENOUGH_TAGS_AVAILABLE | 600h | 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. | Send a test case reproducing the behavior to rfid-support@jadaktech.com. |
| FAULT_TAG_ID_BUFFER_FULL | 601h | The tag id buffer is full. | Make sure the baud rate is set to a higher frequency that the /reader/gen2/BLF frequency.<br>Send a test case reproducing the behavior to rfid-support@jadaktech.com. |
| FAULT_TAG_ID_BUFFER_REPEATED_TAG_ID | 602h | The module has an internal error. One of the protocols is trying to add an existing TagID to the buffer. | Send a test case reproducing the behavior to rfid-support@jadaktech.com. |

*Tag ID Buffer Fault Errors (Continued)*

| Message | Code | Cause | Solution |
|---|---|---|---|
| FAULT_TAG_ID_BUFFER_NUM_TAG_TOO_LARGE | 603h | The module received a request to retrieve more tags than is supported by the current version of the software. | Send a test case reproducing the behavior to rfid-support@jadaktech.com. |

*System Fault Errors*

| Message | Code | Cause | Solution |
|---|---|---|---|
| FAULT_SYSTEM_UNKNOWN_ERROR | 7F00h | The error is internal. | Send a test case reproducing the behavior to rfid-support@jadaktech.com. |
| FAULT_TM_ASSERT_FAILED | 7F01h | An unexpected internal error has occurred. | 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 send a test case reproducing the behavior to rfid-support@jadaktech.com. |

# Appendix B: Getting Started – Development Kit and Carrier Board

## Development Kit Hardware

Components Included in the development kit:

- The M6e module
- Power/interface developer's board
- One USB cable
- One antenna
- One coax cable
- One 9V power supply
- International power adapter kit
- Sample tags
- The Quick Start Guide that details which documents and software to download to get up and running quickly, along with details on how to register for and contact support.

## Set Up the Development Kit

### Connecting the Antenna

JADAK supplies one antenna that can read tags from 20' away with most of the provided tags. The antenna is monostatic. Use the following procedure to connect the antenna to the Development Kit.

1. Connect one end of the coax cable to the antenna.
2. Connect the other end of the cable to the antenna port 1 connector on the Development Kit.

### Powering Up and Connecting to a PC

After connecting the antenna you can power up the Development (Dev) Kit and establish a host connection.

1. Connect the USB cable (use only the black connector) from a PC to the developer's kit. There are two Development Kit USB Interfaces options.
2. Plug the power supply into the Development Kit's DC power input connector.
3. The LED next to the DC input jack, labeled DS1, should light up. If it doesn't light up check jumper J17 to make sure the jumper is connecting pins 2 and 3
4. Follow the steps based on the Development Kit USB Interfaces used and make note of the COM port or /dev device file, as appropriate for your operating system the USB interface is assigned.
5. To start reading tags start the Demo Application (Universal Reader Assistant).

**Caution: While the module is powered up, do not touch components. Doing so may damage the Dev Kit and M6e module.**

## Development Kit USB Interfaces

### USB/RS232

The USB interface (connector labeled USB/RS232) closest to the power plug is to the RS232 interface of the M6e through an FTDI USB to serial converter. The drivers for it are available at http://www.ftdichip.com/Drivers/VCP.htm.

Follow the instructions in the installation guide appropriate for your operating system.

### Native USB

To use the M6e native USB interface (connector labeled USB), if on Windows, a few installation steps are required for Windows to recognize the M6e and properly configure the communications protocol. In order to use the USB interface with Windows you must have the M6e-USBDriver.inf file. The installation steps are:

1. Plug in the USB cable to the M6e (Dev Kit) and PC.
2. Windows should report it has “Found New Hardware - Mercury6eUltra” 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 m6ultra.inf file is stored and select it, click **Open**, then **OK**.
6. “Mercury6eUltra” should now be shown under the Model list. Select it and click **Next,** then **Finished**.

**NOTE: The M6e 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. 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 Mercury6eUltra (COM#).

## Development Kit Jumpers

### J8

Jumpers to connect M6e I/O lines to the development kit.

### J9

Header for alternate power supply. Make sure DC plug (J1) is not connected if using J9.

### J10, J11, J13, J15

Jump pins OUT to GPIO# to connect M6e GPIO lines to output LEDs. Jump pins IN to GPIO# to connect M6e GPIO to corresponding input switches SW[3-6]GPIO#. Make sure GPIO lines are correspondingly configured as input or outputs (see Configuring GPIO Settings).

**J14**

Can be used to connect GPIO lines to external circuits. If used jumpers should be removed from J10, J11, J13, J15.

**J16**

Jump pins 1 and 2 or 2 and 3 to reset development kit power supply. Same as using switch SW1 except allows for control by external circuit.

**J17**

Jump pins 1 and 2 to use the 5V INPUT and GND inputs to provide power. Jump pins 2 and 3 to use the development kit's DC power jack and power brick power.

**J19**

Jump SHUTDOWN to GND to enable module. While grounded SHUTDOWN pushbutton (SW2) will break circuit and shutdown the M6e. See M6e Digital Connector Signal Definition. AUTO_BOOT controls Reset Line.

## Development Kit Schematics

Available upon request from rfid-support@jadaktech.com.

## Demo Application

A demo application which supports multi-protocol reading and writing is provided in the MercuryAPI SDK package and as a standalone application. Both are available from the www.JADAKtech.com. The executable for this example is included in the MercuryAPI SDK package under /cs/samples/exe/Universal-Reader-Assistant.exe.

**NOTE: The Universal Reader Assistant included in the MercuryAPI SDK maybe an older revision than the one available for standalone download.**

See the Readme.txt in /cs/samples/Universal-Reader-Assistant/Universal-ReaderAssistant for usage details.

See the MercuryAPI Programmers Guide for details on using the MercuryAPI.

## Notice on Restricted Use of the Development Kit

The Developers Kit (Dev Kit) is intended for use solely by professional engineers for the purpose of evaluating the feasibility of applications.

The user's evaluation must be limited to use within a laboratory setting. This Dev Kit has not been certified for use by the FCC in accordance with Part 15 of the FCC regulations, ETSI, KCC or any other regulatory bodies and may not be sold or given for public use.

Distribution and sale of the Dev Kit is intended solely for use in future development of devices which may be subject to regional regulatory authorities governing radio emission. This Dev Kit may not be resold by users for any purpose. Accordingly, operation of the Dev Kit in the development of future devices is deemed within the discretion of the user and the user shall have all responsibility for any compliance with any regional regulatory authority governing radio emission of such development or use, including without limitation reducing electrical interference to legally acceptable levels. All products developed by user must be approved by the appropriate regional regulatory authority governing radio emission prior to marketing or sale of such products and user bears all responsibility for obtaining the prior appropriate regulatory approval, or approval as needed from any other authority governing radio emission.

# Appendix C: Environmental Considerations

## ElectroStatic Discharge (ESD) Considerations

**Warning: The M6e antenna ports may be susceptible to damage from Electrostatic Discharge (ESD). Equipment failure can result if the antenna or communication ports are subjected to ESD. Standard ESD precautions should be taken during installation to avoid static discharge when handling or making connections to the M6 reader antenna or communication ports. Environmental analysis should also be performed to ensure static is not building up on and around the antennas, possibly causing discharges during operation.**

### ESD Damage Overview

In M6e-based reader installations where readers have failed without known cause, ESD has been found to be the most common cause. Failures due to ESD tend to be in the M6e Power Amplifier (PA) section. PA failures typically manifest themselves at the software interface in the following ways:

- RF operations (read, write, etc.) respond with **Assert - 7F01** - indicating a fatal error. This is typically due to the module not being able to reach the target power level due to PA damage.
- RF operations (read, write, etc.) respond with **No Antenna Connected/Detected** even when a known good antenna is attached.
- Unexpected **Invalid Command errors**, indicating command not supported, when that command had worked previously. A command may become unsupported when the reader, during its self-protection routines, has returned to the bootloader to prevent any further damage. This jump to boot loader caused by power amp damage occurs at the start of any read tag commands.

Determining that ESD is the root cause of failures is difficult because it relies on negative result experiments, i.e., it is the lack of failure after a configuration change, rather than a positive flag wave that identifies it as ESD. Such flag waves are sometimes available at the unpackaged transistor level under high power microscopy. The remoteness of microscopic examination from the installed field failures is indicative of the high cost of using such analysis methods for investigating ESD issues. Most ESD issue resolutions use the negative result experiments to determine success.

ESD discharges come with a range of values with vaying degrees. There will be a distribution of ESD intensities in some installations of the bare M6e that have an ESD failure problem. There may be an issue without knowledge of a limit in the statistics of those intensities. For the bare M6e equipped with the mitigation methods described below, there may be an occasional ESD discharge that exceeds any given mitigation, resulting in failure. Many installations will have some upper bound on the value of ESD events given the geometry of that installation.

Several sequential steps are recommended for a) determining ESD is the likely cause of a given group of failures, and b) enhancing the M6e's environment to eliminate ESD failures. The steps vary depending on the required M6e output power in any given application.

### Identifying ESD as the Cause of Damaged Readers

The following are some suggested methods to determine if ESD has caused reader failures, i.e., ESD diagnostics. Some of these suggestions have the negative result experiment issue.

- Return failed units for analysis.
  Analysis should determine if it is the power amplifier that has failed, but won't be able to definitively identify that the cause is ESD. However, ESD is one of the more common causes of PA failure.
- Measure ambient static levels with static meter, for example, *AlphaLabs SVM2*.
  Note the static potentials floating detected. High static doesn't mean discharges, but should be considered cause for further investigation. High levels that keep changing are highly indicative of discharges.
- Touch some things around the antenna and operating area.
  If you feel static discharges, that is an indication of what is in front of the antenna. What gets to the M6e is also strongly influenced by the antenna installation, cabling, and grounding discussed above.
- Use the mean operating time statistic before and after one or more of the changes listed below to quantitatively determine if the change has resulted in an improvement. Be sure to restart your statistics after the change.

**Common Installation Best Practices**

The following are common installation best practices to ensure the readers isn't being unnecessarily exposed to ESD, in even low risk environments. These should be applied to all installations, full power or partial power, ESD or not:

- Ensure that M6e, M6e enclosing housing (e.g., M6 reader housing), and antenna ground connection are all grounded to a common low impedance ground.
- Verify R-TNC knurled threaded nuts are tight. Don't use a thread locking compound that would compromise the grounding connection of the thread to thread mate. If there is any indication that field vibration might cause the R-TNC to loosen, apply RTV or other adhesive externally.
- Use antenna cables with double shield outer conductors, or full metallic shield semi rigid cables. JADAK specified cables are double shielded and adequate for most applications. ESD discharge currents flowing on the outer surface of a single shield coaxial cable have coupled to the inside of coaxial cables, causing ESD failure. Avoid RG-58. RG-223 is preferred.
- Minimize ground loops in coaxial cable runs to antennas. Tying both the M6e and antenna to ground (per item 1) leads to the possibility of ground currents flowing along antenna cables. The tendency of these currents to flow is related to the area of the conceptual surface marked out by the antenna cable and the nearest continuous ground surface. When this conceptual surface has minimum area, these ground loop currents are minimized. Routing antenna cables against grounded metallic chassis parts helps minimize ground loop currents.
- Keep the antenna radome in place. It provides significant ESD protection for the antenna's metallic parts and protects the antenna from performance changes due to environmental accumulation.
- Keep careful track of serial numbers, operating lifetimes, and numbers of units operating in order to determine the mean operating lifetime. This number indicates if you have a failure problem, ESD or otherwise. After any given change, it also indicates whether things have improved and if the failures are confined to one instantiation or distributed across your population.

**Raising the ESD Threshold**

For applications where full M6e power is needed for maximum tag read range and ESD is suspected, the following components are recommended additions to the installation to raise the level of ESD the reader can tolerate:

- Select or change to an antenna with all radiating elements grounded for DC. The MTI MT-262031-T(L,R)H-A is recommended. The Laird IF900-SF00 and CAF95956 are not recommended. The grounding of the antenna elements dissipates static charge leakage, and provides a high pass

characteristic that attenuates discharge events. (This also makes the antenna compatible with the M6e antenna detect methods.)

- Install a Minicircuits SHP600+ high pass filter in the cable run at the M6e (or Vega or other finished reader) end. This additional component will reduce transmit power by 0.4 dB which may affect read range in some critical applications. However the filter will significantly attenuate discharges and improve the M6e ESD survival level.

**NOTE: The SHP600+ is not rated for the full +31.5 dBm output of the M6e reader at +85°C. Operation at reduced temperature is acceptable, but has not been fully qualified by JADAK.**

- Install a Diode Clamp* circuit immediately outboard from the SHP600 filter. This will reduce transmit power by an additional 0.4 dB, but in combination with the SHP600 will further improve the M6e ESD survival level.
  * Not yet productized. Needs DC power. Contact rfid-support@jadaktech.com for details.

**Further ESD Protection for Reduced RF Power Applications**

In addition to the protective measures recommended above, for applications where reduced M6e RF power is acceptable and ESD is suspected, the following protective measures can also be applied:

- Install a one watt attenuator with a decibel value of +30 dBm minus the dBm value needed for tag power up. Then run the reader at +30 dBm instead of reduced transmit power. This will attenuate inbound ESD pulses by the installed decibel value while keeping the tag operation generally unchanged. Attenuators of 6 dB have been shown to not adversely affect read sensitivity. Position the attenuator as close to the M6e as feasible.
- As described above, add the SHP600 filter immediately adjacent to the attenuator, on the antenna side.
- If required, add Diode Clamp adjacent to the SHP600, on the antenna side.

## Variables Affecting Performance

**Environmental**

Reader performance may be affected by the following environmental conditions:

- Metal surfaces such as desks, filing cabinets, bookshelves, and wastebaskets may enhance or degrade reader performance.
- Antennas should be mounted far away from metal surfaces that may adversely affect the system performance.
- Devices that operate at 900 MHz, such as cordless phones and wireless LANs, can degrade reader performance. The reader may also adversely affect the performance of these 900 MHz devices.
- Moving machinery can interfere with the reader performance. Test reader performance with moving machinery turned off.
- Fluorescent lighting fixtures are a source of strong electromagnetic interference and, if possible, should be replaced. If fluorescent lights cannot be replaced, keep the reader cables and antennas away from them.
- Coaxial cables leading from the reader to antennas can be a strong source of electromagnetic radiation. These cables should be laid flat and not coiled.

**Tag Considerations**

There are several variables associated with tags that can affect reader performance:

- Application Surface: Some materials, including metal and moisture, interfere with tag performance. Tags applied to items made from or containing these materials may not perform as expected.
- Tag Orientation: Reader performance is affected by the orientation of the tag in the antenna field. The ThingMagic antenna is circularly polarized, so it reads face-to but not edge-to.
- Tag Model: Many tag models are available, each with its own performance characteristics.

**Multiple Readers**

- The reader adversely affects performance of 900 MHz devices. These devices also may degrade performance of the reader.
- Antennas on other readers operating in close proximity may interfere with one another, thus degrading performance of the readers. If antennas from different readers are facing each other, they should have opposite polarity for best performance (e.g., right-hand polarized antenna facing a left-hand polarized antenna).
- Interference from other antennas may be eliminated or reduced by using either one or both of the following strategies:
    - Affected antennas may be synchronized by a separate user application using a time-multiplexing strategy.
    - Antenna power can be reduced by reconfiguring the RF Transmit Power setting for the reader.

**NOTE: Performance tests conducted under typical operating conditions at your site are recommended to help optimize system performance.**

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