

# THINGMAGIC® M3e LF/HF RFID SECURE MODULE USER GUIDE



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A Novanta Company

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## REV CONTROL:

**Launch Version 1 Rev 09012020**

**Version 2 Rev 10022020**

**Version 3 Rev 12042020**

**Version 3.1 Rev 03122021**

**Version 3.2 Rev 06212021**

**Version 3.3 Rev 06242021**

**Version 3.4 Rev 0728021**

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### 3 Introduction

This document applies to the ThingMagic M3e embedded module High Frequency (HF- 13.56MHz) and Low Frequency (LF 125KHz and 134.2KHz) Radio Frequency Identification (RFID) module reader that can be integrated into host systems to create RFID-enabled products. The M3e module HW supports 134.2 KHz tags, decoding of 134.2 KHz tags will be supported in a future FW release. This document is for hardware designers and software developers.

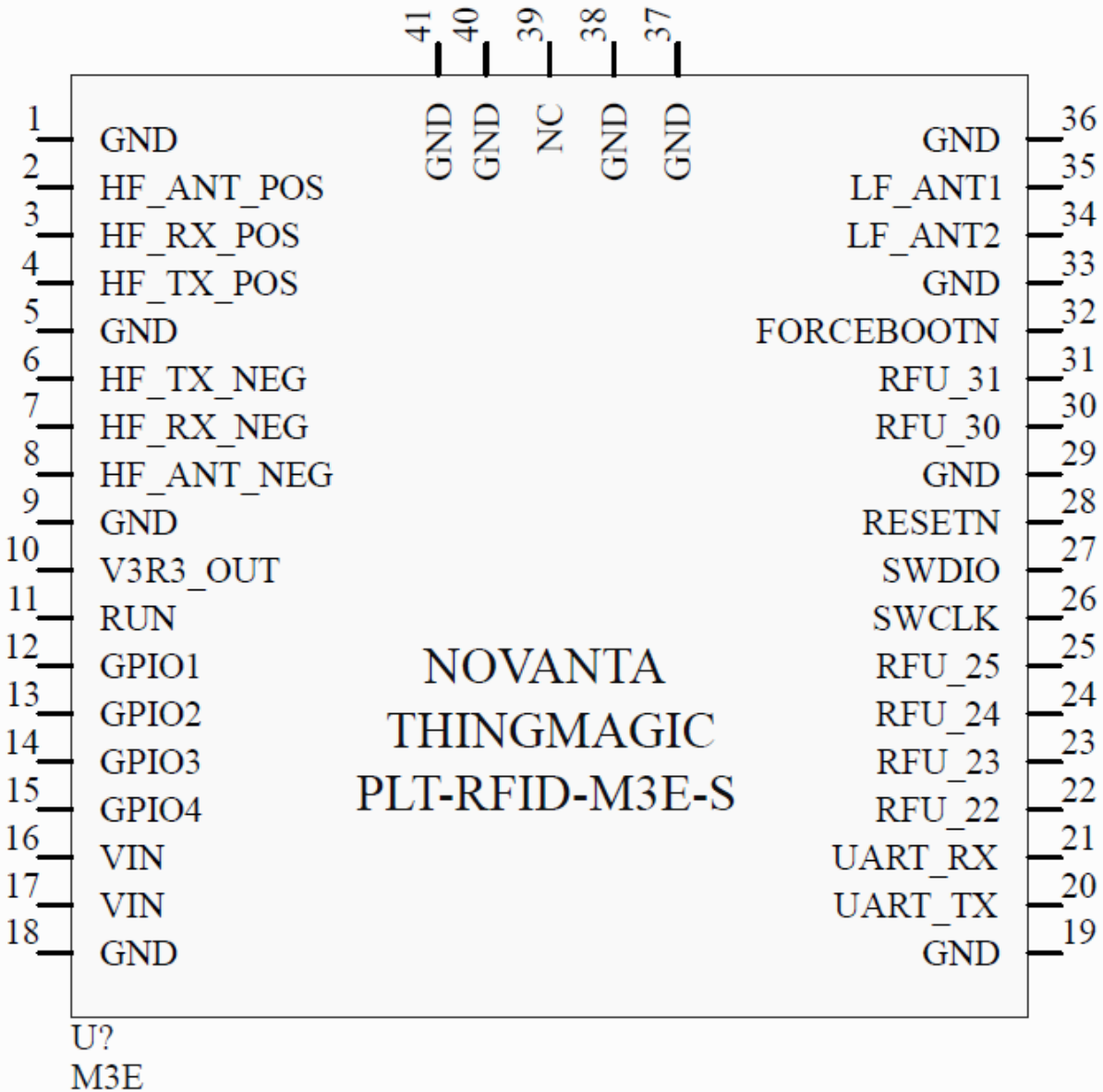
The M3e module supports complex HF RFID tag interactions as well supports reading of both HF and LF ID cards to authenticate personnel across a wide spectrum of security environments. The M3e module also supports writing HF ID Cards.

Applications to control the ThingMagic M3e module can be written using the high level MercuryAPI version 1.35.00.00 and later. The MercuryAPI supports Java, C# 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](#) , Mercury API Release Notes and the [MercuryAPI SDK](#), available on [www.jadatech.com](http://www.jadatech.com).

## 4 Hardware Overview

### 4.1 Module Pin-out

Figure 1: Module Pin-out



### 4.2 Antenna Connections

ThingMagic M3e provides connections for a single HF antenna and simultaneously a single LF antenna.



## 4.3 Antenna Requirements

The HF antenna port supports direct connection to external antenna circuit with 1 uH nominal inductance.

The nominal inductance for an external, 125 kHz/134.2 kHz differentially driven coil antenna is 505  $\mu$ H. The series resistance of the antenna should be lower than 6.5 ohms.

## 4.4 Digital/Power Interfaces

The edge “via” connections provide power, serial communications signals, an enable control, access to the GPIO lines and antenna connections to ThingMagic M3e module.

*Table 1: Digital Connector Signal Definition*

Edge Via Pin #	Signal	Input/Output	Notes
1,5,9,18,19,29,33,36,37,38,40,41	GND	Signal Return	Must connect all GND pins to ground as they also serve to remove heat from the module.
10	V3R3	DC Power Output	3.4V DC output. Maximum load 5 mA. Turns off when ENABLE is pulled low. Leave unconnected if not used.
11	Run	Enable/Shutdown	TTL input that turns the module off and reduces its power consumption to nearly zero. Hi=Enable, Low=Shut down module. If left unconnected, module will stay in ENABLE state.

Edge Via Pin #	Signal	Signal Direction (In/Out of ThingMagic M3e)	Notes
12	GPIO1	Bidirectional GPIO	Each line configurable as input or output interface (by default it is an input with internal pull-down).
13	GPIO2	Bidirectional GPIO	
14	GPIO3	Bidirectional GPIO	
15	GPIO4	Bidirectional GPIO	
16,17	Vin	Power Supply Input	3.3 to 5.5VDC. Pins 16 and 17 are internally connected. Connect DC power source to both pins to ensure sufficient current carrying capacity.
20	UART_TX	Out	UART Serial output, 3.3V logic.
21	UART_RX	In	UART Serial input, 3.3V logic. Must be low when module is powered on or off.

22	RFU	Out	Reserved for Future Use
23	RFU	In	Reserved for Future Use
24	RFU	In	Reserved for Future Use
25	RFU	In	Reserved for Future Use
26	JTAG CLK	In	
27	JTAG Data	In/Out	
28	RESETN		Processor reset, active low pin
30	RFU	In/Out	Reserved for Future Use
31	RFU	In	Reserved for Future Use
32	ForceBootN	In	<p>Input at power up. If LOW the device will stay in the bootloader and will not jump to the application. Leave OPEN, undriven for normal operation.</p> <p>After power up, ForceBootN becomes a logic output:  HIGH output indicates Boot Loader is running.  LOW output indicates Application Firmware is running.  Include 2.2 kOhm series resistance in this signal if connected externally</p>
39	RFU	NA – No connect	Reserved for Future Use

*Table 2: Digital Input Voltage Limits*

Specification	Limits
Input Low-level Voltage	0.8 V max to indicate low state; no lower than -0.3 V.
Input High-level Voltage	2.0 V min to indicate high state; 3.6 V max when module is powered up, <u>no more than 0.3 V to prevent damage when module is shut down or turned off.</u>

*Table 3 Digital Output Voltage and Current Limits*

Specification	Limits
Output Low-level Voltage	0.4 V t maximum
Output High-level Voltage	2.9 V minimum
Output Low-level Sink Current	+2 mA maximum
Output High-level Source Current	-2 mA maximum

## 5 Control Signal Specification

The module can communicate to a host processor via a below mentioned interfaces-

1. I/O's are not 5 V tolerant. Maximum I/O input voltage is Edge Via Pin 10 voltage +0.4 Volts
2. UART with 3.3V logic levels from 9.6 to 460.8 kbps

The TTL logic level UART serial port, accessed on the edge "vias." The TTL logic level UART supports complete functionality.

### 5.1 TTL Level UART Interface

Only three pins are required for serial communication (TX, RX, and GND). Hardware handshaking is not supported. This is a TTL interface; a level converter is necessary to connect to devices that use a 12V RS232 interface.

The RX line is a 3.3-volt logic CMOS input and is internally pulled up with a resistance value of between 20 and 60 k $\Omega$  (40 k $\Omega$  nominal). It must be low before the module is turned off and low before the module is turned on. This can be ensured if interface drivers are used that are powered by the module itself, as shown in the interface board example.

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

These are the baud rates supported on the interface (bits per second):

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

**NOTE: Upon initial power up, the default baud rate of 115200 will be used. If that baud rate is changed and saved in the application mode, the new saved baud rate will be used the next time the module is powered up. (Check the firmware release notes to confirm that saving of settings is supported.)**

Recommended maximum receiver baud-rate errors for various character sizes are shown in the table below.

*Table 4: Recommended Maximum Receiver Baud Rate Errors*

Baud rate	Recommended max Rx error	
	Min (-2%)	Max (+2%)
9600	9412	9796
19200	18823	19592
38400	37647	39184
57600	56470	58775
115200	112941	117551
230400	225882	235102
460800	451765	470204

## General Purpose Input/Output (GPIO)

M3e has 4 bi-directional GPIO Pins.

The four GPIO connections, provided through the [ThingMagic M3e Digital Connector Signal Definition](#), may be configured as inputs or outputs using the MercuryAPI. The GPIO pins should connect through 1 k $\Omega$  resistors to the module to ensure the input Voltage limits are maintained even if the module is shut off.

Module power consumption can be increased by incorrect GPIO configuration. Similarly, the power consumption of external equipment connected to the GPIOs can also be adversely affected.

On power up, ThingMagic M3e module configures its GPIOs as inputs to avoid contention from user equipment that may be driving those lines. The input configuration is a 3.3-volt logic CMOS input and is internally pulled down with a resistance value of between 20 and 60 k $\Omega$  (40 k $\Omega$  nominal).

Lines configured as inputs must be low whenever the module is turned off and low at the time the module is turned on.

GPIOs may be reconfigured individually after power up to become outputs. Lines configured as outputs consume no excess power if the output is left open.

## 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`. The state of the lines can be Get or Set using the `gpioGet()` and `gpioSet()` methods, respectively. See the programming language-specific reference document included with the Mercury API.

## Run Line

- The run line turns off the power supplies.
- Pull down to turn off the power supplies.
- Leave open to operate.
- This line is pulled up to module Vin through a 1 M Ohm resistor
- Turn off time = TBD
- Turn on time = 22 ms

## DC Power Requirements

Voltage: 3.0 - 5.5 VDC

Current: 0.3 A typical at 5.0 V when reading; idle and sleep modes supported

## 5.2 Power Supply Ripple

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

- 3.0 to 5.5 VDC

## 5.3 Idle DC Power Consumption

When not actively transmitting, the ThingMagic M3e module falls back into one of 3 idle states, called “power modes”. There are 5 enumerated idle power modes defined in the API, but the M3e module only supports 3 options, so three of the settings behave identically. Each successive power mode turns off more of the module’s circuits, which must be restored when any command is executed, imposing a slight delay. The following table gives the power consumption levels and the delay to respond to a command for each. See [Idle DC Power Consumption](#) for details.

*Table 5: ThingMagic M3e Power Consumption*

Power Mode	DC Power Consumption (mW)
ACTIVE	1100
IDLE	180
SLEEP	145

These nominal values should be used to calculate metrics such as battery life. To determine the absolute maximum DC power that would be required under any condition, consider temperature, channel of operation, and antenna return loss.

# 6 Environmental Specifications

## 6.1 Thermal Considerations

The module will operate within its stated specifications over a temperature range of -40° to 65°C at mounting surface.

### 6.1.1 Heatsinking

No heat Sync Required up to 65°C

### 6.1.2 Temperature Sensor

ThingMagic M3e module has an integrated temperature sensor, located near the components which generate the most heat. The temperature can be obtained through the user interface as a status indication. This information is also used by the firmware to prevent transmission when the module is too hot or too cold to operate properly. The Operating Temperature limits for allowing transmission are -40°C to +65°C (case temperature).

**NOTE: The temperature level at which transmission is prevented, +85°C, is higher than the +65°C operating limit for two reasons: (1) The temperature indicated by the on-board sensor will always be higher than ambient temperature, due to heat generated by internal components, and (2) the temperature limit for transmission is chosen to prevent damage to the components, while the +65°C limit for operation is chosen to ensure that all specifications are met.**

## 6.2 Electro-Static Discharge (ESD) Specification

The Electro-Static Discharge Immunity specifications for ThingMagic M3e are as follows:

IEC-61000-4-2 discharges direct to operational antenna port tolerates max 1.5 KV contact discharge. It will tolerate a 1.5 kV air discharge on the I/O and power lines. It is recommended that protective diodes be placed on the I/O lines.

**NOTE: Survival level varies with antenna characteristics. See [ElectroStatic Discharge \(ESD\) Considerations](#) for methods to increase ESD tolerances.**



**Warning: The ThingMagic M3e antenna port 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 ThingMagic M3e 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.**

## 6.3 Shock and Vibration

ThingMagic M3e module is specified to survive a 1-meter drop onto a hard surface. It will also survive the following vibration limits:

18 shocks (3 in each direction of 3 different axis) of 1000g at 23°C applied via the mounting surface. Sinusoidal vibration of 1.0" peak-to-peak displacement from 5 to 13 Hz, 10g acceleration from 13 to 500 Hz and 1.0g from 500 to 2000 Hz.

## 7 FCC Modular Certification Considerations

Novanta has obtained FCC modular certification for the ThingMagic M3e module. This means that the module can be installed in different end-use products by another equipment manufacturer with limited or no additional testing or equipment authorization for the transmitter function provided by that specific module. Specifically:

- No additional transmitter-compliance testing is required if the module is operated with antennas meeting the requirements listed in the FCC filing.
- No additional transmitter-compliance testing is required if the module is operated with the same type of antenna as listed in the FCC filing, as long as it has equal or lower gain than the antenna listed. Equivalent antennas must be of the same general type, and must have similar in-band and out-of-band characteristics (consult specification sheet for cutoff frequencies).

If the antenna is of a different type or has higher gain than the max listed in the module's FCC filing, see Section 16 Authorized Antennas, a *class II permissive change* must be requested from the FCC. Contact us at [rfid-support@jadaktech.com](mailto:rfid-support@jadaktech.com) for assistance.

A host using a module component that has a modular grant can:

1. Be marketed and sold with the module built inside that does not have to be end-user accessible/replaceable, or
2. Be end-user plug-and-play replaceable.

In addition, a host product is required to comply with all applicable FCC equipment authorizations, regulations, requirements and equipment functions not associated with the RFID module portion. For example, compliance must be demonstrated to regulations for other transmitter components within the host product, to requirements for unintentional radiators (Part 15B), and to additional authorization requirements

for the non-transmitter functions on the transmitter module (for example, incidental transmissions while in receive mode or radiation due to digital logic functions).

To ensure compliance with all non-transmitter functions, the host manufacturer is responsible for ensuring compliance with the module(s) installed and fully operational. For example, if a host was previously authorized as an unintentional radiator under the Declaration of Conformity procedure without a transmitter certified module and a module is added, the host manufacturer is responsible for ensuring that after the module is installed and operational the host continues to be compliant with Part 15B unintentional radiator requirements. Since this may depend on the details of how the module is integrated with the host, we will provide guidance to the host manufacturer for compliance with Part 15B requirements.

## 8 Physical Dimensions

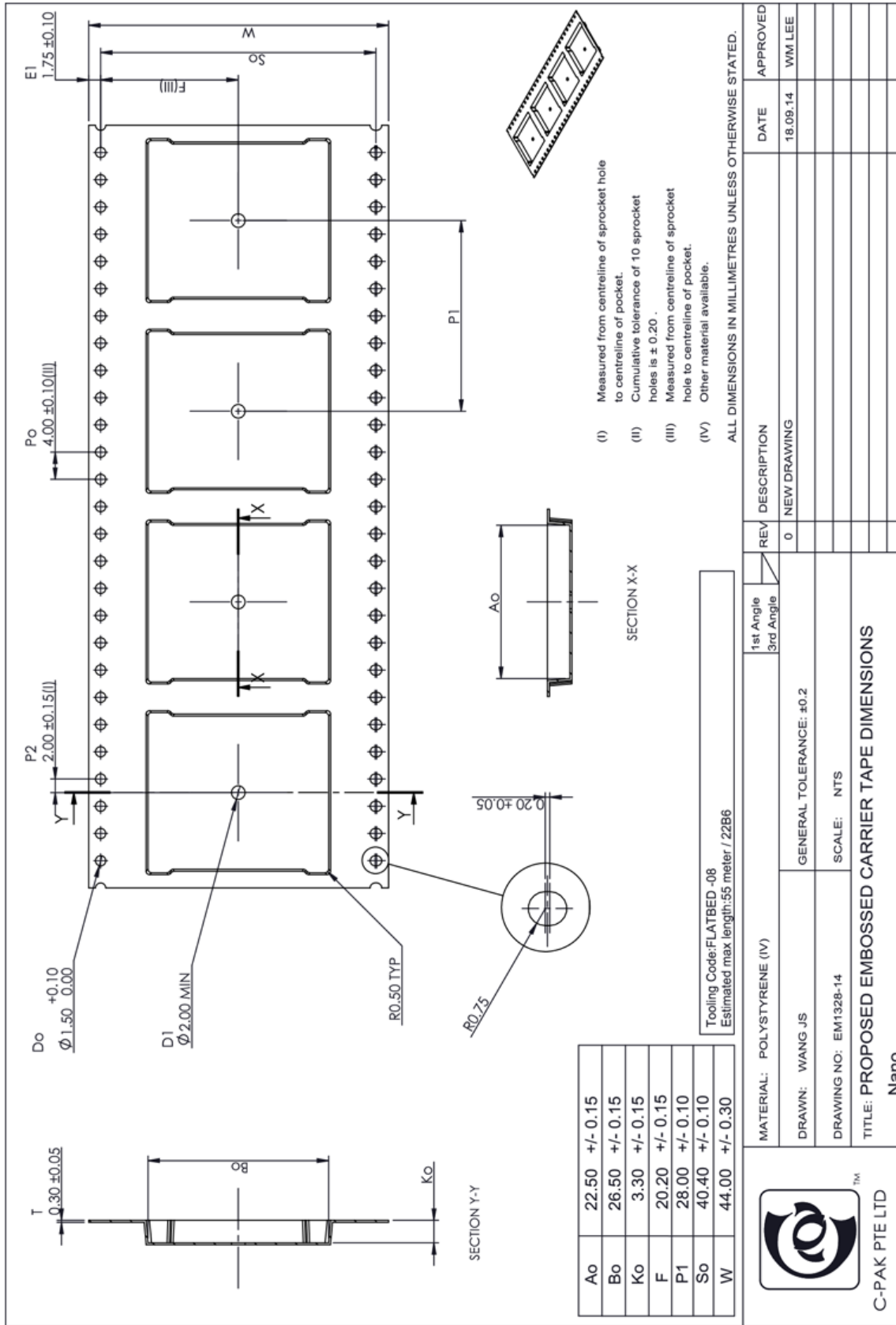
The dimensions of the ThingMagic M3e module are shown in the following diagram and table:

*Table 6: Module Dimensions*

Attribute	Value
Width	22 +/-0.2 mm
Length	26 +/-0.2 mm
Height (includes PCB, shield, mask and labels)	3.0 maximum
Mass	3g

The M3e is delivered in a tape-and-reel package. The reel measures 13 inches by 4 inches. The following drawing gives the dimensions of the tape:

Figure 2: Tape-and-Reel Dimensions





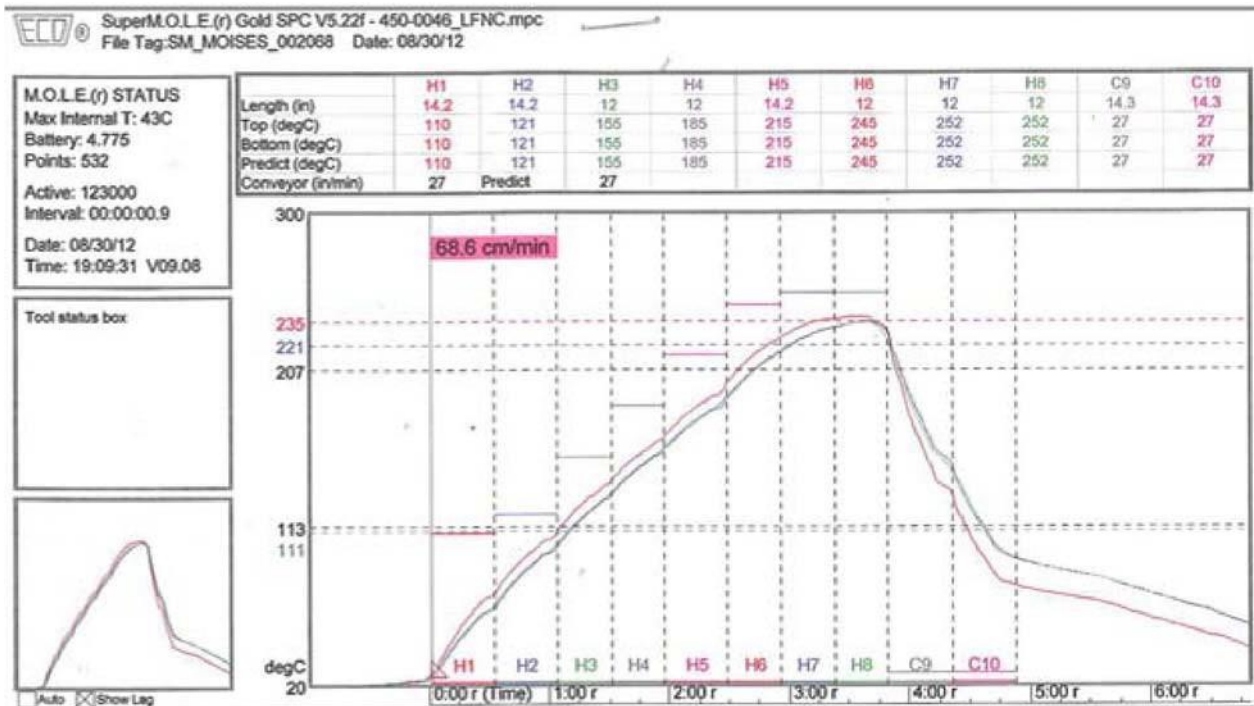
## 9 SMT Reflow Profile

Short reflow profiles are recommended for soldering processes. Peak zone temperature should be adjusted high enough to ensure proper wetting and optimized forming of solder joints.

Unnecessary long exposure and exposure to more than 245°C should be avoided.

To not overstress the assembly, the complete reflow profile should be as short as possible. An optimization considering all components on the application must be performed. The optimization of a reflow profile is a gradual process. It needs to be performed for every paste, equipment, and product combination. The presented profiles are only samples and valid for the used pastes, reflow machines and test application boards. Therefore a "ready to use" reflow profile cannot be given.

Figure 3: SMT Reflow Profile



There must be only be one reflow cycle, maximum.

# 10 Hardware Integration

ThingMagic M3e can integrate with other systems to create RFID-enabled products. This chapter discusses requirements for a host board design and characteristics of the M3e Carrier Board offered in the Development Kit and for applications where standard connectors are required to interface the module with a host board-

## 10.1 Host Board Design

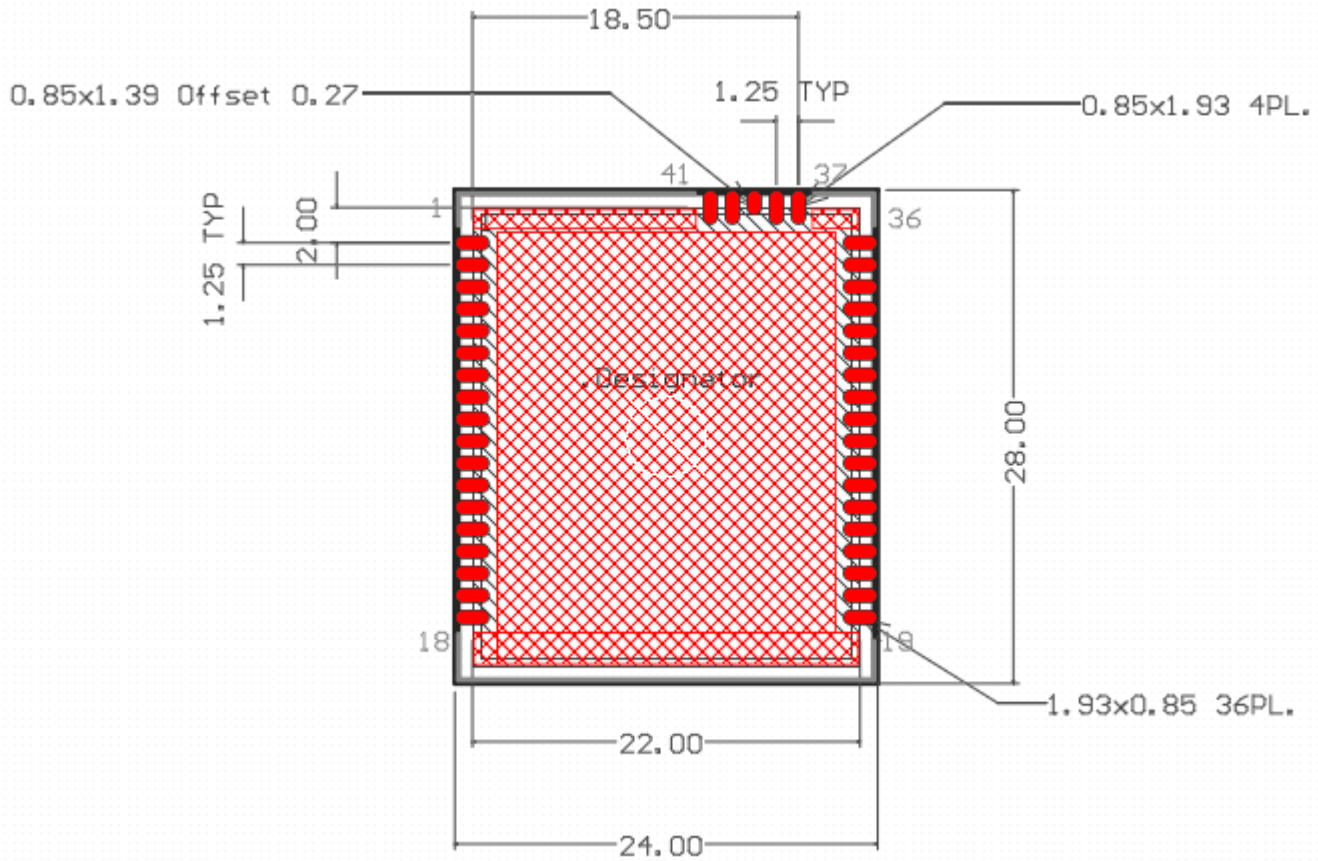
### 10.1.1 Landing Pads

The M3E Web Site Support page provides a down loadable .zip file containing an Altium compatible schematic symbol and footprint. See <provide URL here>. This footprint passes 0.25 mm spacing check. For those unable to utilize these down loadable design support tools pictorial and tabular information is provided here.

Figure 4 M3E Schematic Symbol

		41	40	39	38	37			
1	GND	GND	GND	NC	GND	GND	GND	36	
2	HF_ANT_POS						LF_ANT1	35	
3	HF_RX_POS						LF_ANT2	34	
4	HF_TX_POS						GND	33	
5	GND						FORCEBOOTN	32	
6	HF_TX_NEG						RFU_31	31	
7	HF_RX_NEG						RFU_30	30	
8	HF_ANT_NEG						GND	29	
9	GND						RESETN	28	
10	V3R3_OUT						SWDIO	27	
11	RUN						SWCLK	26	
12	GPIO1	<b>NOVANTA THINGMAGIC PLT-RFID-M3E-S</b>						RFU_25	25
13	GPIO2							RFU_24	24
14	GPIO3							RFU_23	23
15	GPIO4							RFU_22	22
16	VIN						UART_RX	21	
17	VIN						UART_TX	20	
18	GND						GND	19	

Figure 5 M3E Footprint Pictorial



10.1.2 Footprint notes:

1. Body size is 22 mm x 26 mm. Minimum placement keep out is 24 x 28 mm. See tables below.
2. Cross hatch is via and trace keep out area. Novanta does not recommend any routing in the PCB layer immediately beneath the M3E module.
3. All GND connections of the schematic should be via'ed to a ground plane to facilitate heat removal from the M3E.

The following table list pads details for the M3E.

Table 7 Tabular Footprint Pads

PIN NUMBER	LAYER	PAD CENTER X	PAD CENTER Y	PAD SHAPE	PAD SIZE X	PAD SIZE Y	ROTATION
		mm	mm		mm	mm	Deg
1	Top Layer	-11	11	Round	1.93	0.85	0
2	Top Layer	-11	9.75	Round	1.93	0.85	0
3	Top Layer	-11	8.5	Round	1.93	0.85	0
4	Top Layer	-11	7.25	Round	1.93	0.85	0
5	Top Layer	-11	6	Round	1.93	0.85	0
6	Top Layer	-11	4.75	Round	1.93	0.85	0
7	Top Layer	-11	3.5	Round	1.93	0.85	0
8	Top Layer	-11	2.25	Round	1.93	0.85	0
9	Top Layer	-11	1	Round	1.93	0.85	0

10	Top Layer	-11	-0.25	Round	1.93	0.85	0
11	Top Layer	-11	-1.5	Round	1.93	0.85	0
12	Top Layer	-11	-2.75	Round	1.93	0.85	0
13	Top Layer	-11	-4	Round	1.93	0.85	0
14	Top Layer	-11	-5.25	Round	1.93	0.85	0
15	Top Layer	-11	-6.5	Round	1.93	0.85	0
16	Top Layer	-11	-7.75	Round	1.93	0.85	0
17	Top Layer	-11	-9	Round	1.93	0.85	0
18	Top Layer	-11	-10.25	Round	1.93	0.85	0
19	Top Layer	11	-10.25	Round	1.93	0.85	0
20	Top Layer	11	-9	Round	1.93	0.85	0
21	Top Layer	11	-7.75	Round	1.93	0.85	0
22	Top Layer	11	-6.5	Round	1.93	0.85	0
23	Top Layer	11	-5.25	Round	1.93	0.85	0
24	Top Layer	11	-4	Round	1.93	0.85	0
25	Top Layer	11	-2.75	Round	1.93	0.85	0
26	Top Layer	11	-1.5	Round	1.93	0.85	0
27	Top Layer	11	-0.25	Round	1.93	0.85	0
28	Top Layer	11	1	Round	1.93	0.85	0
29	Top Layer	11	2.25	Round	1.93	0.85	0
30	Top Layer	11	3.5	Round	1.93	0.85	0
31	Top Layer	11	4.75	Round	1.93	0.85	0
32	Top Layer	11	6	Round	1.93	0.85	0
33	Top Layer	11	7.25	Round	1.93	0.85	0
34	Top Layer	11	8.5	Round	1.93	0.85	0
35	Top Layer	11	9.75	Round	1.93	0.85	0
36	Top Layer	11	11	Round	1.93	0.85	0
37	Top Layer	7.5	13	Round	0.85	1.93	0
38	Top Layer	6.25	13	Round	0.85	1.93	0
39	Top Layer	5	13.27	Round	0.85	1.39	0
40	Top Layer	3.75	13	Round	0.85	1.93	0
41	Top Layer	2.5	13	Round	0.85	1.93	0

The following table defines recommended minimum placement keep out or courtyard.

*Table 8 Minimum Placement Keep Out*

Layer	What	START X	START Y	END X	END Y	WIDTH
		mm	mm	mm	mm	mm
Top Courtyard	Track	-12	-14	-12	14	0.4
Top Courtyard	Track	-12	-14	12	-14	0.4
Top Courtyard	Track	-12	14	12	14	0.4
Top Courtyard	Track	12	-14	12	14	0.4

The following table defines a suggest assembly layer area.

*Table 9 Assembly Layer Area*

Layer	What	START X	START Y	END X	END Y	WIDTH
		mm	mm	mm	mm	mm
Top Assembly	Track	-11.8	-13.8	-11.8	13.8	0.4
Top Assembly	Track	-11.8	-13.8	11.8	-13.8	0.4
Top Assembly	Track	-11.8	13.8	11.8	13.8	0.4
Top Assembly	Track	11.8	-13.8	11.8	13.8	0.4

ThingMagic M3e module mounts to the host board via the landing pads. These pads are at a pitch of 1.25 mm. The ThingMagic M3e module uses routed-through via connections with 0.6 mm diameter edge vias. The pads of the ThingMagic M3e module underside should align with the copper pads of the footprint, with a pad exposure extending outside the M3e edge by a nominal 1.0 mm. The module pad positional tolerance shall be not more than +/-0.2 mm to support contact alignment during fixturing.

The circuitry connecting the RF pads of the M3e shall be optimized for connecting to controlled impedance traces. The RF pads of the M3E symbol are those with HF\_ prefixes, and LF\_ prefixes. For pad and trace dimensions, refer to the document [Advice for Carrier Board Layout](#), downloadable from the website.

The area beneath the module should be kept clear of traces and copper.

# 11 Firmware Overview

## 11.1 Boot Loader

The boot loader provides module functionality until the module application firmware can start up as well as when the module firmware is in the process of being updated. This program provides the low-level hardware support for configuring communication settings, loading [Application Firmware](#) and storing data that needs to be remembered across reboots.

When a module is powered up or reset, the boot loader code is automatically loaded and executed.

**NOTE: ThingMagic M3e bootloader should effectively be invisible to the user. The ThingMagic M3e is configured to auto-boot into application firmware and return transparently to the bootloader for any operations that require the module to be in bootloader mode.**

**NOTE: M3e supports a ForceBootN pin. When this input is pulled LOW through a 2.2 kOhm resistance during power up, the M3e will remain in bootloader mode. The M3e will also revert to 115200 baud rate. This is helpful for the case in which the application FW becomes corrupt and a new image of the application FW needs to be loaded. Exiting bootloader mode to the application firmware will restore any previously configured baud rate.**

If ForceBootN is left open during power up, the M3e will auto-boot into application firmware. After power up, ForceBootN becomes an output. When in application firmware, ForceBootN will be driven logic LOW by M3e. If in bootloader mode, ForceBootN will be driven logic HIGH by M3e. In order to avoid contention on the ForceBootN pin, the User must stop driving ForceBootN before entering the Application FW and prior to any power cycle. Failure to do so may result in damage to the M3e module

## 11.2 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.

### 11.2.1 Programming for ThingMagic M3e

Applications to control the ThingMagic M3e module are written using the high level MercuryAPI. The MercuryAPI supports Java, C# 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.jadatech.com](http://www.jadatech.com).

### 11.2.2 Upgrading the ThingMagic M3e

New features developed for the ThingMagic M3e are made available through an Application Firmware upgrade, released with corresponding updates to the MercuryAPI to make use of the new features. The MercuryAPI SDK contains applications which will upgrade firmware for all ThingMagic readers and modules, as well as source code that allows developers to build this functionality into their custom applications.

### 11.2.3 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 bootloader 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.

### 11.2.4 Custom On-Reader Applications

The ThingMagic M3e does not support installing custom applications on the module. All reader configuration and control are performed using the documented MercuryAPI methods in applications running on a host processor.

## 11.3 Serial Communication Protocol

ThingMagic does not support bypassing the MercuryAPI to send commands to the ThingMagic M3e module directly, but some information about this interface is useful when troubleshooting and debugging applications which interface with the MercuryAPI.

The serial communication between MercuryAPI and ThingMagic M3e 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 time-out because some commands require more time to execute than others. MercuryAPI must manage retries, if necessary. MercuryAPI must keep track of the state of the intended reader if it reissues a command.

## 11.4 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.

*Table 10: 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	

## 11.5 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.

*Table 11: Reader-To-Host Communication*

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

## 11.6 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.



## 12 Regulatory Support



**Caution:** Please contact [rfid-support@jadaltech.com](mailto:rfid-support@jadaltech.com) before beginning the process of getting regulatory approval for a finished product using the ThingMagic M3e. We can supply documents, test reports and certifications to the test house, which will greatly accelerate the process.

### 12.1 Protocol Support

The M3e module supports complex HF RFID tag interaction as well as possessing the flexibility to read both HF and LF cards.

The HF protocols supported by M3e are mentioned below-

- ISO15693
- ISO14443A/B

The M3e supports 125 KHz and 134.2 KHz LF protocols.

**134.2 KHz operation and support for ISO14443B tags will be supported in a future Firmware release.**

### 12.2 Power Management

ThingMagic M3e is designed for power efficiency and offers several power management modes. When transmitting, the power consumption can be minimized by using the lowest RF power level that meets the application requirements and powering the module with highest DC input Voltage.

A “Power Mode” setting determines the power consumed during periods that the module is not actively transmitting. Power Modes - is set in `/reader/powerMode`.

## 13 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 [Idle DC Power Consumption](#). The behavior of each mode and impact on RF command latency is as follows:

- **PowerMode.NORMAL** - Tag Read
- **PowerMode.IDLE** -
- **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 20 ms. of delay from idle to RF on when initiating an RF operation.

**NOTE:** See additional latency specifications under [Event Response Times](#).



## 14 Specifications

RFID	
RF Frequency:	HF: 13.56 MHz LF: 125 kHz and 134.2 kHz <sup>2</sup>
Supported Transponders <sup>1</sup>	<b>HF:</b> ISO 15693 (HID™ iCLASS, HID™ iCLASS SE, ICODE SLI, ICODE SLI-S, ICODE SLI-L, ICODE SLIX, ICODE SLIX-S, ICODE SLIX-L, ICODE DNA), ISO 14443A (MIFARE Classic, MIFARE Classic EV1, MIFARE DESFire EV1, MIFARE DESFire EV2, MIFARE Plus, MIFARE SMART MX, NTAG2xx) <b>LF:</b> (read only) 125 kHz (HID Prox II, HID PROX, HID DuoProx II, HID Micro Prox, HID ProxKey III, AWID, EM4100, HITAG1/S, HITAG2)
Antenna:	HF: Tuned for nominal 1 μH nominal differentially driven loop antenna LF: Compatible with a differentially driven coil antenna with a nominal inductance of 505 μH
Read Range:	LF: up to 5 cm (2.0", Antenna & Tag dependent) HF: up to 5 cm (2.0", Antenna & Tag dependent)
Physical	
Dimensions:	26 mm x 22 mm x 3 mm
Mounting:	Solder down (SMT)
User Interface and Software	
Control/Data Interface:	UART (TTL), I2C, SPI (I2C and SPI in future release) ResetN (Shutdown) line
SDK/API:	ThingMagic Mercury API
GPIO	4 bi-directional TTL
Electrical	
DC Power Requirements	Voltage: 3.0- 5.5 VDC Current: 0.3 A typical at 5.0 V when reading; idle and sleep modes supported
Safety, Regulatory and Environmental Compliance:	FCC Class B, Industrie Canada (IC), RED 2014/53/EU, CE, ROHS, REACH, WEEE
Environmental	
Operating Temp.:	-40° to 65°C at mounting surface
Relative Humidity:	95% RH non-condensing
Vibration:	18 shocks of 1000g at 23°C applied via the mounting surface. Sinusoidal vibration of 1.0" peak-to-peak displacement from 5 to 13 Hz, 10g acceleration from 13 to 500 Hz and 1.0g from 500 to 2000 Hz.
Ordering	
PLT-RFID-M3E-X	ThingMagic M3e module with LF/HF RFID
PLT-RFID-M3E-S	ThingMagic M3e module with Secure LF/HF RFID, HF/LF encrypted badge reading capabilities when activated with the optional additional secure crypto license activation (must purchase license separately)
PLT-RFID-M3E-S-LIC	HF/LF RFID secure crypto license (can only be applied to the M3ES module)

**All specifications subject to change without notice.** <sup>1</sup>Contact JADAK for latest transponder support list. <sup>2</sup> Future Release

## 15 Compliance and IP Notices

### Communication Regulation Information

Contact [rfid-support@jadaktech.com](mailto:rfid-support@jadaktech.com) before beginning the process of getting regulatory approval for a finished product using the ThingMagic M3e.

### 15.1 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 ThingMagic M3e 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. To comply with Federal Communication Commission's (FCC) RF radiation exposure requirements, the antenna(s) used for this transmitter must be installed such that a minimum separation distance of 0 cm is maintained between the radiator (antenna) & user's/nearby people's body always and must not be co-located or operating in conjunction with any other antenna or transmitter.
2. The transmitter module must not be co-located with any other antenna or transmitter.

If 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 must 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.

## 15.2 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 0 cm 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 Novanta could void the user’s authority to operate this equipment” “

## 15.3 End Product Labeling

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

*“Contains Transmitter Module FCC ID: QV5MERCURY3ET “*

or

“Contains FCC ID: QV5MERCURY3ET.”

## 15.4 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.

**This device contains licence-exempt transmitter(s)/receiver(s) that comply with Innovation, Science and Economic Development Canada’s licence-exempt RSS(s).**

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 21 cm from all persons and must not be colocated or operating in conjunction with any other antenna or transmitter.

## 15.5 End Product Labeling

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

"Contains ThingMagic M3e (or appropriate model number you are filing with IC) transmitting module FCC ID: 5407A-MERCURY3ET

## 15.6 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

### **Cet appareil contient des émetteurs/récepteurs exempts de licence qui sont conformes aux RSS exempts de licence d'Innovation, Sciences et Développement économique Canada.**

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 0 cm de toute personne et ne doivent pas être installés en proximité ou utilisés en conjonction avec un autre antenne ou transmetteur.

Marquage sur l'étiquette du produit complet dans un endroit visible: "Contient ThingMagic transmetteur, FCC ID: QV5MERCURY3ET (IC: 5407A-MERCURY3ET)"

## 16 Authorized Antennas

### 16.1 HF Antenna

The M3e module has been certified using an HF Antenna with the following parameters.

- *Antenna type:* PCB Loop antenna

- *PCB Material:* FR-4
- *Dimensions:* 70.8mm × 70.8mm
  
- *Number of Turns:* 2
- *Inductance* = 950nH nominal
- Matching circuit on the PCB antenna board to match for maximum power from the M3e module.

**NOTE: HF antenna with dimensions less than or equal to the dimensions of this antenna as mentioned above can be used with the M3e module for operation at 13.56MHz according to FCC/IC/ETSI regulatory requirements**

## 16.2 LF Antenna

The M3e module has been certified using an LF Antenna with the following parameters.

- Outer Dimension: Width × Length = 54.25mm × 43.18mm
- Operating Frequency = 125kHz
- Self-Resonance Frequency ≥ 1MHz
- Inductance = 505μH nominal
- DC Resistance ≤ 7 Ω
- Quality Factor ≥ 40 (at 125kHz)

## 17 Development Kit

Components included in the kit:

- ThingMagic M3e soldered onto carrier board
- Power/interface developer's board
- One USB cable
- One HF antenna embedded in the Carrier Board
- One LF Antenna Coil assembly that connects to the Carrier Board.
- One 9V power supply
- International power adapter kit
- Sample tags
- Quick Start Guide below

### 17.1 Dev Kit Quick Start Guide



**Warning: Never mount the carrier board so that it is resting flat against the metal plate of the Development Kit main board:**

## 17.2 Antennas

Both the HF antenna and the LF antenna are attached to the Carrier Board.  
The HF antenna is embedded in the PCB of the Carrier Board.  
The LF antenna is connected to the Carrier Board.

## 17.3 Powering Up and Connecting to a PC

*Figure 6: Developers Kit*



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. Use the interface that is labeled "USB/RS232." The one labeled "USB" is not supported by ThingMagic M3e module.
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 ThingMagic M3e module.

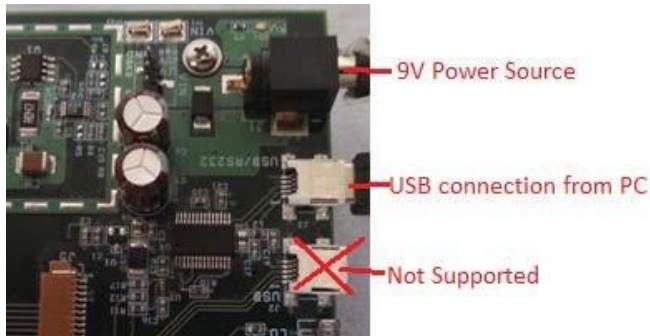
## 17.4 USB/RS232

The Dev Kit has 2 USB connectors, only one is supported. The USB interface (connector labeled USB/RS232) closest to the power plug is to the RS232 interface of the ThingMagic M3e through an FTDI USB to serial converter. The drivers for it are available at [http:// www.ftdichip.com/Drivers/VCP.htm](http://www.ftdichip.com/Drivers/VCP.htm).

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

ThingMagic M3e does not support a USB port directly, so the "USB" port on the Development Kit is inoperable.



*Figure 7: Dev Kit USB Connections*

A COM port should now be assigned to the ThingMagic M3e. 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 USB SerialPort (COM#).

## 17.5 Development Kit Jumpers -

The dev kit comes pre-populated with jumpers for tag reading and typical operation.

For more information about Jumper functionality contact JADAK

## 17.6 Development Kit Schematics

Available upon request from [rfid-support@jadaktech.com](mailto:rfid-support@jadaktech.com).

## 17.7 Demo Application

A demo application which supports multi-protocol reading and writing is provided in the MercuryAPI SDK package. The executable for this example is included in the MercuryAPI SDK package under /cs/samples/exe/Universal-Reader-Assistant.exe and is also available for direct download from the website.

**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.

## 17.8 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-



## 18 Appendix C: Environmental Considerations

This appendix details environmental factors that should be considered relating to reader performance and survivability.

### 18.1 ElectroStatic Discharge (ESD) Considerations



**Warning:** The ThingMagic M3e antenna port 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 ThingMagic M3e 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.

#### 18.1.1 ESD Damage Overview

In ThingMagic M3e-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 ThingMagic M3e 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 confirmation is only possible if the failed components are isolated, taken apart, and examined under high power microscopy. Often, concluding that ESD was the cause of a failure is inferred if conditions that could produce ESD are present, anti-ESD precautions have not been taken, and other possible causes are eliminated.

ESD discharges come with a range of values. For many installations, ThingMagic M3e has been successfully deployed and operating. For a different installation with ThingMagic M3e, a failure problem from ESD may result in some distribution of ESD intensities occurring. Without knowledge of a limit in the statistics of those intensities, there may be the bigger charge in the future. For the bare ThingMagic M3e equipped with the mitigation methods described below, there will be the rogue ESD discharge that exceeds any given mitigation, and results in failure. Fortunately, many installations have some upper bound on the value of ESD events given the geometry of that installation.

Several sequential steps are recommended to a) determining the ESD is the likely cause of a given group of failures, and b) enhance the ThingMagic M3e's environment to eliminate ESD failures. The steps vary depending on the required ThingMagic M3e output power in any given application.

### 18.1.2 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*. 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 ThingMagic M3e 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.

### 18.1.3 Common Installation Best Practices

The following are common installation best practices to ensure the reader 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 ThingMagic M3e, reader housing, and antenna ground connection are all grounded to a common low impedance ground.
- Verify antenna connections.
- Minimize ground loops in connections to antennas.

## 18.2 Environmental

Reader performance may be affected by the following environmental conditions: Avoid placing Antennas near metallic and/or magnetic surfaces.



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