THINGMAGIC MICRO AND MICRO-LTE USER GUIDE

TM_Micro_Micro-LTE-
UG Rev 10012019

JADAK
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Version 10012019

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REVISION HISTORY

Date	Version	Description
7/2012	01 Rev1	• First Draft for early-access release.
11/2012	02 Rev1	• Updated Dev Kit section with additional board details. • Fixed thermal duty cycle table.
12/2012	02 RevA	• Updated Authorized Antenna • List added information on modular certification.
2/2013	03 RevA	• Corrected RESET line mode default baud rate to 115200. • Added full hardware integration pages with pin locations.
3/2012	04 RevA	• Various bug fixes.
5/2013	05 RevA	• Removed old Transmit Mode reference from Pwr Mgmt. • Updated product image on cover. • Added details to thermal considerations section. • Added details to the Micro HW Integration section. • Added additional Authorized Antennas.
12/2013	06 RevA	• Corrected Power Consumption table for SLEEP and Shutdown modes.
3/2014	07 RevA	• Added Japan region support info. • Updated dimensional drawing with tolerances.
1/2015	08 RevA	
9/2015	09 RevB	• Added information about return loss based antenna detection, including potential to get 405 error if no region selected. • Added information about NA2 and NA3 regions. • Added information about new Gen2V2 fault codes: 425h and 426h.
3/2016	10 RevA	• Added information about 500 kHz power supply switching frequency. • Added additional information to section on loading and saving of configuration information on the module. • Restored hardware integration information that was left out of the previous release.
6/2017	10 RevB	• Added RED certification.

Date	Version	Description
5/02/2018	050222018	• Updated for format and technical verification. • Added new regional setting choices in a new table for all regions. • Added information about new metadata fields. • Added information about additional fields that can be stored in memory. • Added information about settings that can be changed during continuous operation. • Added information about Micro vs Micro-LTE. • Added information about solder-down Micro Carrier Board. • Added diagram for board-to-board connector. • Minimum RF power level changed from 0 dBm to -10 dBm (tested with URA).
5/26/2018	TM_Micro_Micro-LTE-UG Rev 06292018	• Updated to user documentation standards.
9/17/2018	09172018	• Regional Frequency Quantization table added. • Supported Regions Frequency table updated.
10/01/2019	10012019	Correction to physical size dimensions

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1 Introduction

This document applies to both the ThingMagic Micro module and the ThingMagic Micro-LTE module. Both modules are referred to as “Micro” in this document. ThingMagic Micro 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 Micro modules and derivative products can be 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.

Micro vs. Micro-LTE

JADAK offers two versions of the Micro module: the ThingMagic Micro module (Order Number M6E-M) and the ThingMagic Micro-LTE module (Order Number M6E-MICRO). The difference between these modules is that the Micro module is capable of read speeds in excess of 750 tags per second and the Micro-LTE module has a sustained limit of 50 tags per second.

The read rate restriction of the Micro-LTE module is applied in this way:

If the Micro-LTE module has not transmitted for more than 1 second, it can read up to 50 tags as fast as the Micro (at a rate in excess of 750 tags per second – approximately 70 msec total). After the limit of 50 tags is read, the module can read an additional tag each 20 msec. Therefore, in the first second, the reader is able to read nearly 100 tags, but the next second it will read only 50. The module continues to receive permission to read additional tags every 20 msec whether it is actively attempting to read or not, until a maximum limit of 50 is reached.

Release Notes

The information in this document is relevant to Micro modules with Firmware Ver. 1.B.2 and later. It explains how to set up the Micro Readers, how to configure them for network operation, and how to use the browser-based interface. If you operate the Micro module with firmware newer than this, refer to the corresponding Firmware Release Notes for operational differences from what is in this User Guide. Release notes include new features or known issues as well as all changes since this User Guide was last updated. Release notes are downloaded from the same web site where you obtained this document.

2 Hardware Overview

The following section provides detailed specifications of the Micro hardware.

Hardware Interfaces

The Micro supports two monostatic bidirectional radio frequency (RF) antennas through two U.FL connector or edge side-pads. See Cables and Connectors for more information on antenna connector parts and Micro Hardware Integration for antenna edge via locations and layout guidelines.

The maximum RF power that can be delivered to a 50 ohm load from each port is 1 Watt, or +30 dBm (regulatory requirements permitting).

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

Antenna Requirements

The performance of the Micro 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. 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

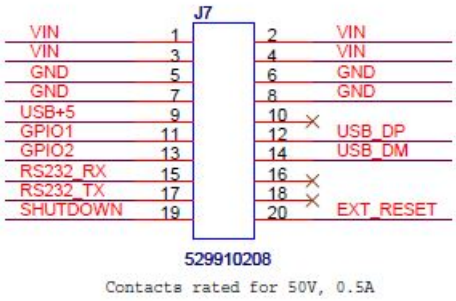
Caution: **The Micro DOES NOT support automatic antenna detection via DC current sensing. As of firmware version 1.7.1, it uses a return loss measurement across all channels in the defined region. For previous versions of firmware, when writing applications to control the Micro you MUST explicitly specify the antennas to operate on. Using the MercuryAPI, this requires creation of a SimpleReadPlan object with the list of antennas set and that object set as the active / reader/read/plan. For more information see the** MercuryAPI Programmers Guide **| *Level 2 API* | *Advanced Reading* | *ReadPlan* section.**

Digital/Power Interfaces

The digital connector provides power, serial communications signals, shutdown and reset signals to the Micro module, and access to the GPIO lines. These signals are provided through edge side-pads and the Molex 53748-0208 connector. See Cables and Connectors for more information on parts.

See Micro Hardware Integration for pinout details of both connections and layout guidelines

Micro Digital Connector Signal Definition



Digital Power Interfaces

Edge Via Pin #	Molex 53748-0208 Pin #	Signal	Signal Direction (In/Out of Micro)	Notes
1-15, 21, 23, 29, 31	5-8	GND	P/S Return	Must connect all GND pins to ground
25, 27	1-4	Vin	P/S Input	3.5 to 5.25VDC. Must connect all Vin supplies.
22	11	GPIO1	Bi-directional	Input 5VDC tolerant, 16mA Source/ Sink
24	13	GPIO2	Bi-directional	
28	15	UART_RX_TTL	In	
26	17	UART_TX_TTL	Out	
18	14	USB_DM	Bi-directional	USB Data (D-) signal
16	12	USB_DP	Bi-directional	USB Data (D+) signal
20	9	USB_5VSENSE	In	Input 5V to tell module to talk on USB
19	19	SHUTDOWN	In	• HIGH or Open Circuit to ENABLE module • LOW or Ground to SHUTDOWN
17	20	RESET	Bi-directional	• HIGH output indicates Boot Loader is running • LOW output indicates Application Firmware is running
30	U.FL	Antenna 1	Bi-directional	U.FL connector closest to the Molex connector
32	U.FL	Antenna 2	Bi-directional	U.FL connector closest to the module's edge

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 Molex connector or edge side-pads. 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 TTL interface when planning to operate the module in Tag Streaming/Continuous Reading mode. The TTL interface (both the module side and the host side) cannot detect physical disconnections, unlike 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

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 Micro 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. (256 bytes is the maximum data packet size.)

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 three USB pins (USB_DM, USB_DP, and USB_5VSENSE). Do not tie the USB_5VSENSE to a 5V power source, as this will prevent the interface from detecting when the USB interface is connected or disconnected.

General Purpose Input/Output (GPIO)

The two GPIO connections, provided through the Micro Digital Connector Signal Definition, may be configured as inputs or outputs using the MercuryAPI. In the module, the GPIO pins connect through 100 ohm resistors to the high current PA0 and PA1 pins of the AT91SAM7S processor. Consult the Micro 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 internal 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 Micro module configures its GPIOs as inputs to avoid driving current into circuitry that may not be prepared for this. 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 Micro 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. For more details, see the language specific reference guide contained within the MercuryAPI SDK document directory with a command reference guide in the most common format for that language.

Reset Line

Upon power up, the RESET line is configured as an input. The input value will determine whether the Boot Loader will wait for user commands (when pulled LOW) or immediately load the Application Firmware image and enter application mode (when left open). After the RESET line is sensed and acted upon, this line is configured as an output line to indicate when the module returns to Bootloader mode (this usually indicates an application firmware failure). If the module goes into bootloader mode, the line is 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 (10k to ground).

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

Shutdown Line

Caution: The polarity of the shutdown line is opposite from the 4-port M6e module.

The SHUTDOWN line must be set HIGH (Vin level) or Open Circuit to ENABLE the module.

In order to shutdown/reset/power cycle the module, the line can be set LOW or pulled to Ground. Switching from high to low to high is equivalent to performing a power cycle of the module. All internal components are powered down when set low.

Power Requirements

RF Power Output

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

- Minimum RF Power = -10 dBm
- Maximum RF Power = +30 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.

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.

- 3.5 to 5.25 VDC.
- 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 supplies should have a switching frequency of 500 kHz or above to ensure that the switching frequency does not fall within the receive baseband signal range, which is centered around 250 kHz.

Power Consumption

The following table defines the power consumption specifications for the Micro in various states of operation. See Power Management for details.

Micro Power Consumption

Operation	RF Transmit Power Setting (dBm)	Nominal DC Power[1] (Watts)
Active Reader (RF On)	+30	5.5
	+27	3.5
	+23	2.5
	+10	2.0
No Tag Reading (Micro idle) Power Mode = FULL	n/a	0.325
No Tag Reading (Micro idle) Power Mode = MINSAVE	n/a	0.06
No Tag Reading (Micro idle) Power Mode = SLEEP	n/a	0.008
Shutdown Line enabled	n/a	0.0003

[1] Power consumption is defined for TTL UART operation. Power consumption may vary if the USB interface is connected. Power consumption is defined for operation into a 17dB return loss load or better.

NOTE: These nominal values should be used to calculate metrics, such as battery life. Power consumption may increase, up to 8W, during operation into return losses worse than 17dB and high ambient temperatures. Power consumption will also vary based on Supported Regions in use.

Environmental Specifications

Thermal Considerations

There are two ways of mounting the Micro. See Micro Hardware Integration for additional details. One is to solder the board to the motherboard using its side edge-pads, with the RF shield facing upward. The other is to use the board-to-board connectors to connect to the motherboard and solder the 4 tabs on the shield to the motherboard as well. The orientation with the side edge-pads soldered down is best for wicking heat away from the module.

Most applications involve the module transmitting periodically to inventory tags in the field. The longer the transmitter is on in relation to its off time (the “duty cycle”), the faster the temperature will rise. The module will not transmit if the temperature is at a dangerous level, but will transmit again as soon as the temperature drops – often so quickly it is hardly noticeable. Other factors that affect the time before the module begins to protect itself is the ambient temperature and the power level at which the module is transmitting. These factors are represented in the following table, which give the typical minutes of transmission time before thermal protection is enabled.

Thermal Calculations

Mounting	Ambient Temp (°C)	RF Power (dBm)	Duty Cycle %	Time (m) to reach max temperature
Soldered down	-40	30	98	No restriction
Soldered down	25	23	98	No restriction
Soldered down	25	30	80	No restriction
Soldered down	25	30	90	7.34
Soldered down	25	30	98	5.99
Soldered down	60	23	50	No restriction
Soldered down	60	23	60	7.59
Soldered down	60	23	80	2.24
Soldered down	60	23	98	1.46
Soldered down	60	30	30	No restriction
Soldered down	60	30	50	4.17
Soldered down	60	30	60	1.99
Soldered down	60	30	80	1.11
Soldered down	60	30	98	0.98
Board to board	-40	30	98	No restriction
Board to board	25	23	50	No restriction
Board to board	25	23	60	2.93
Board to board	25	23	80	2.22

Thermal Calculations (Continued)

Mounting	Ambient Temp (°C)	RF Power (dBm)	Duty Cycle %	Time (m) to reach max temperature
Board to board	25	23	98	1.24
Board to board	25	30	40	No restriction
Board to board	25	30	50	6.68
Board to board	25	30	60	2.49
Board to board	25	30	80	1.5
Board to board	25	30	98	1.06
Board to board	60	23	30	5.64
Board to board	60	23	50	1.13
Board to board	60	23	60	0.81
Board to board	60	23	80	0.54
Board to board	60	23	98	0.29
Board to board	60	30	15	No restriction
Board to board	60	30	30	1.98
Board to board	60	30	50	0.73
Board to board	60	30	60	0.56
Board to board	60	30	80	0.27
Board to board	60	30	98	0.27

Thermal Management

Heatsinking

For high duty cycles, it is essential to use the surface mount configuration - as shown in Micro Hardware Integration, *Sample Board Layout Using Surface Mount Option* - where all edge side-pads are soldered to a carrier or mother board, with a large area of ground plane, that will either radiate heat or conduct the heat to a larger heatsink. A high density of PCB side-pads from the top to bottom of the board will efficiently conduct heat to a bottom mount heatsink. Often the weak link in thermal management design is not the thermal interface from the Micro to the heatsink, but rather the thermal interface from the heatsink to the outside world.

Duty Cycle

In comparison to many RFID modules, the Micro has much higher read rate when running at comparable duty cycles. As such, very high duty cycles are often not necessary to meet performance requirements with the Micro. If overheating occurs, try reducing the duty cycle of operation. This involves modifying the RF On/Off (API parameter settings /reader/read/asyncOnTime and asyncOffTime) values. Start with 50% duty cycle using 250ms/250ms On/ Off.

If your performance requirements can be met, a low enough duty cycle can result in no heat sinking required. With adequate heat sinking you can run continuously at 100% duty cycle.

Thermal Resistance

The measured thermal resistance from the on-board temperature sensor to the top ground plane of surface mount carrier board is approximately 4.8°C per watt. This roughly translates to supporting 100% duty cycle if the carrier board is maintained at 52°C or less.

Electro-Static Discharge (ESD) Specification

IEC-61000-4-2 and MIL-883 3015.7 discharges direct to operational antenna port tolerates max 2KV 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 Micro 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 Micro 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.

Authorized Antennas

This device has been designed to operate with the antennas listed below, and having a maximum gain of 6 dBiL. Antennas having a gain greater than 6 dBiL in any orientation are strictly prohibited for use with this device without regulatory approval. Antennas of the same type as listed here, and equal or lesser gain, are permitted by FCC. The required antenna impedance is 50 ohms.

Micro Authorized Antennas

Vendor	Model	Type	Polarization	Linear Gain[1] (dBi)
Laird	S9025P	Patch	Circular	4.3
Laird	S8658WPL	Patch	Circular	6.0
MTI Wireless	MTI-262013	Patch	Circular	6.0
MTI Wireless	MTI-242043	Patch	Circular	6.0
MTI Wireless	MT-242025	Patch	Circular	5.1
Laird	FG9026	Dipole	Linear	6.0

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

FCC Modular Certification Considerations

Novanta has obtained FCC modular certification for the Micro 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 one of the antennas 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 (e.g. dipole, circularly polarized patch, etc.), 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 those listed in the module's FCC filing, see Authorized Antennas, a *class II permissive change* must be requested from the FCC. Contact us at 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.

Assembly Information

Cables and Connectors

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

Mating Connectors for the data/power interface if making a board-to-board connection:

- Power-I/O: Molex 52991-0208
- RF: Lighthorse LTI-IPXSF66GT-X1 or LTI-IPXSF54GT

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

Antennas

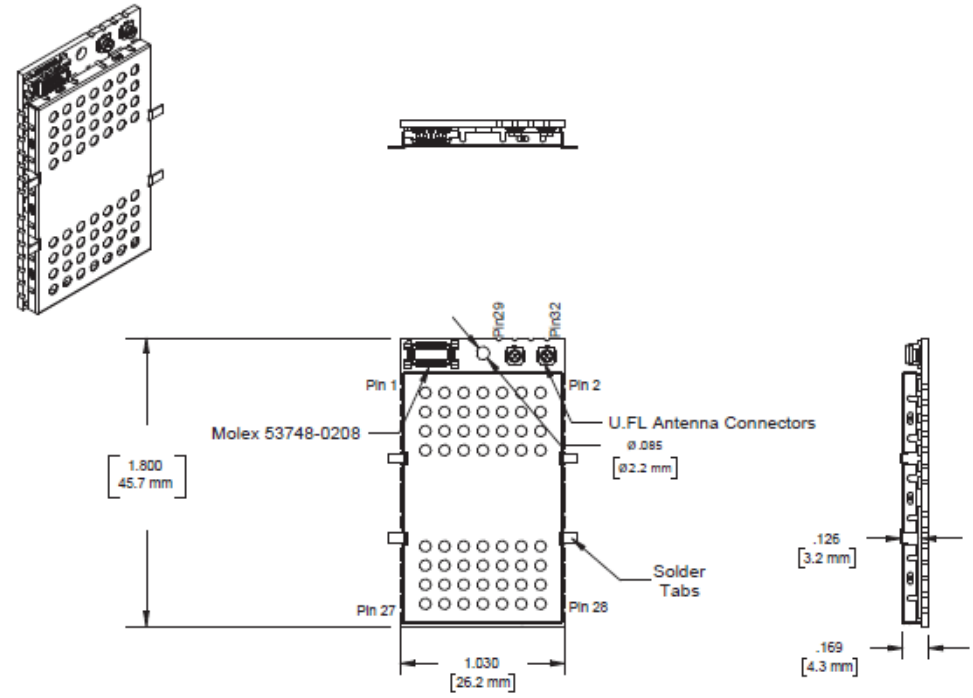
The antenna interface on the board is compatible with connectors from several sources (under several names):

- Hirose U.FL
- Amphenol IPX

- IPEX MHF

Micro Mechanical Drawing

Micro Mechanical Drawing
Note Tolerances for dimensions +/- 0.2mm or 0.008 in



Connector

Pin	Function
1	Vin
2	Vin
3	Vin
4	Vin
5	Gnd
6	Gnd
7	Gnd
8	Gnd
9	USB_5VSENSE
10	V3R3_MCU
11	GPIO1
12	USB_DP
13	GPIO2
14	USB_DM
15	RS232_RX
16	Erase Flash
17	RS232_TX
18	CopvSambaROM
19	Shutdown
20	Reset

Mating Connectors for Flip Mount
Power-I/O: Molex 52991-0208
RF: Lighthorse LTI-IPXSF54GT,
or a standard U.FL cable which must
be connected before mounting the module.

Edge Vias

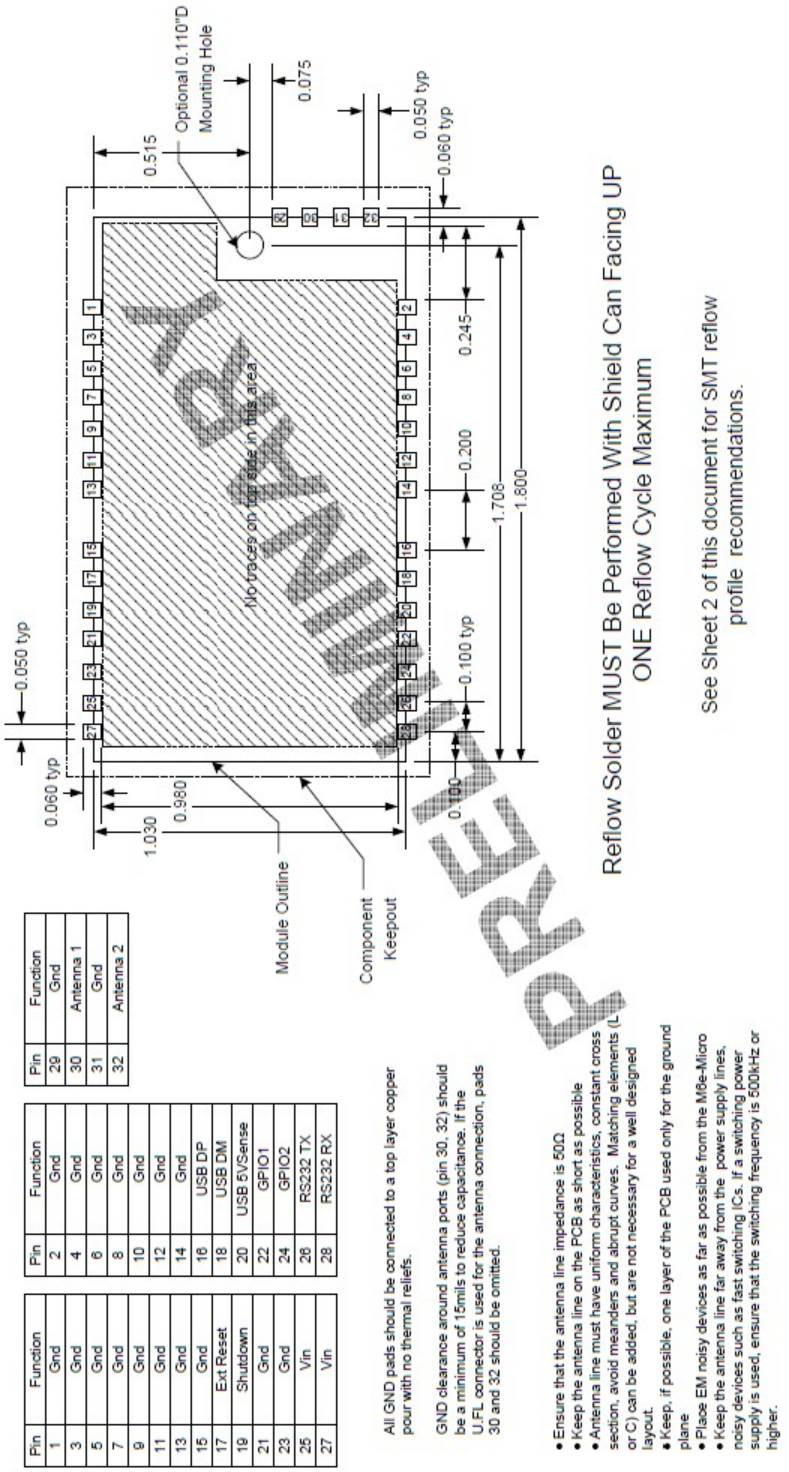
Pin	Function
1	Gnd
2	Gnd
3	Gnd
4	Gnd
5	Gnd
6	Gnd
7	Gnd
8	Gnd
9	Gnd
10	Gnd
11	Gnd
12	Gnd
13	Gnd
14	Gnd
15	Gnd
16	USB_DP
17	Reset
18	USB_DM
19	Shutdown
20	USB_5VSENSE
21	Gnd
22	GPIO1
23	Gnd
24	GPIO2
25	Vin
26	RS232_TX
27	Vin
28	RS232_RX
29	Gnd
30	Antenna 1
31	Gnd
32	Antenna 2

Micro Hardware Integration

In addition to the design and process recommendation shown on the following pages, consider the following:

There is the potential for 24 MHz harmonics (signals of a frequency that are an integer multiple of 24 MHz) to radiate from pins 22 through 28 of the Micro. If emissions testing shows such harmonics, the easiest fix is to put bypass capacitors (typically 39 to 100pf) directly at the offending pins on the carrier board. Note that higher values are not necessarily better. At these frequencies, capacitors have both inductance and capacitance, and the ideal capacitor value will have series resonance near the most offending frequency. Therefore, it will look more like a short circuit to the frequencies around 900 MHz than its value would suggest. 39pF has been good for around 900 MHz in sample board layouts.

SMT Reflow Profile



Pin	Function
1	Gnd
3	Gnd
5	Gnd
7	Gnd
9	Gnd
11	Gnd
13	Gnd
15	Gnd
17	Ext Reset
19	Shutdown
21	Gnd
23	Gnd
25	Vin
27	Vin

Pin	Function
2	Gnd
4	Gnd
6	Gnd
8	Gnd
10	Gnd
12	Gnd
14	Gnd
16	USB DP
18	USB DM
20	USB 5VSense
22	GPIO1
24	GPIO2
26	RS232 TX
28	RS232 RX

Pin	Function
29	Gnd
30	Antenna 1
31	Gnd
32	Antenna 2

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SMT Reflow Profile

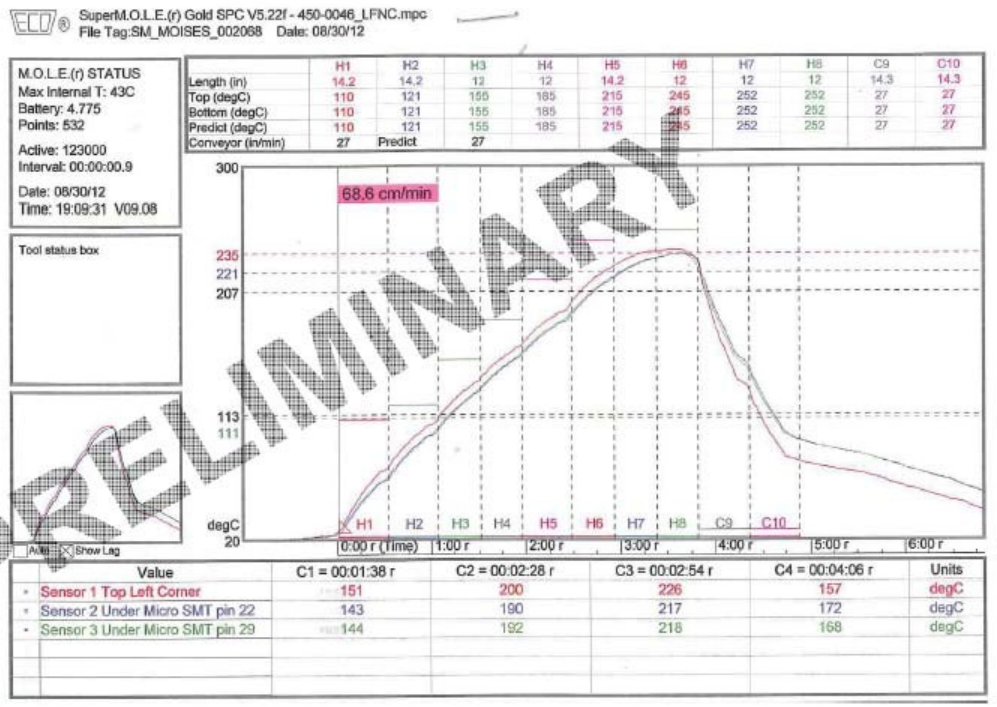
Short profiles are recommended for reflow soldering processes. Peak zone temperature should be adjusted high enough to ensure proper wetting and optimized forming of solder joints.

Generally speaking, unnecessary long exposure and exposure to more than 245C should be avoided.
The profile shown has been used to assemble panelized boards similar to those on Sheet 4 of this document .
For analyzing and adapting solder profiles a carrier board was prepared with thermocouples (TC) as described in the table.

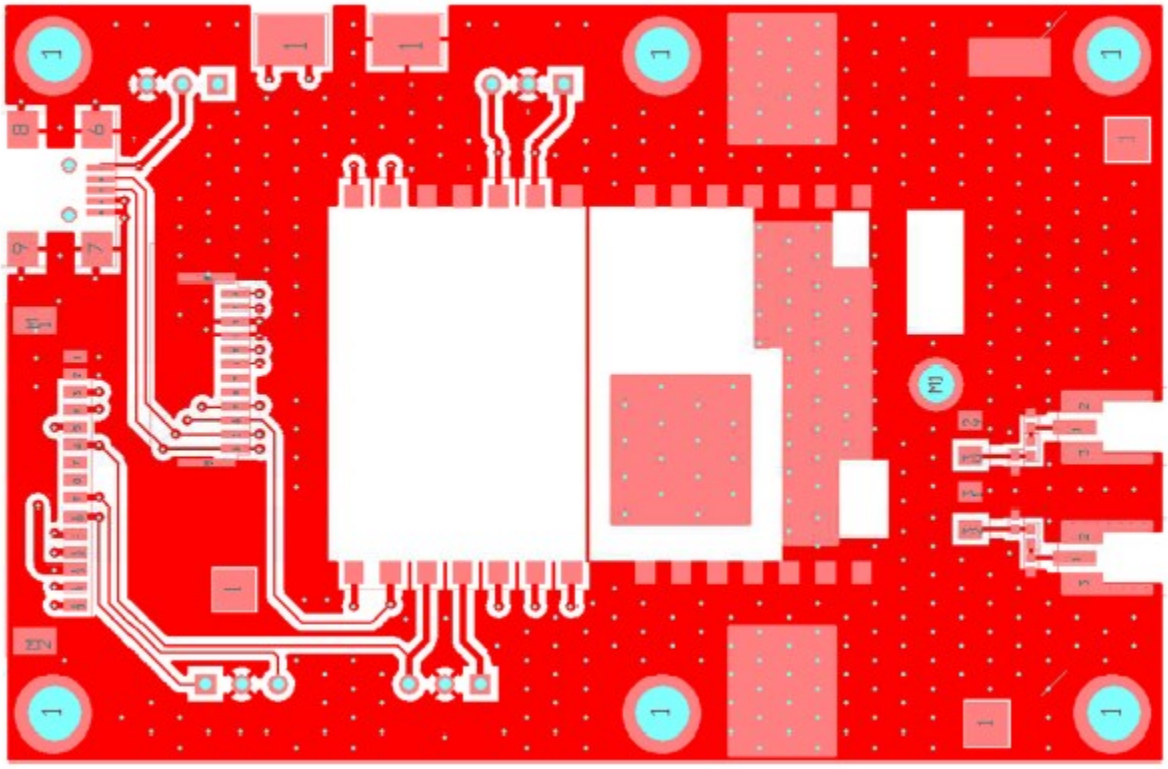
To not overstress the assembly, the complete reflow profile should be as short as possible. Here an optimization considering all components on the application must be performed. The optimization of a reflow profile is a gradual process. It needs to be performed for every paste, equipment and product 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 can not be given.

Reflow Solder MUST Be Performed
With Shield Can Facing UP

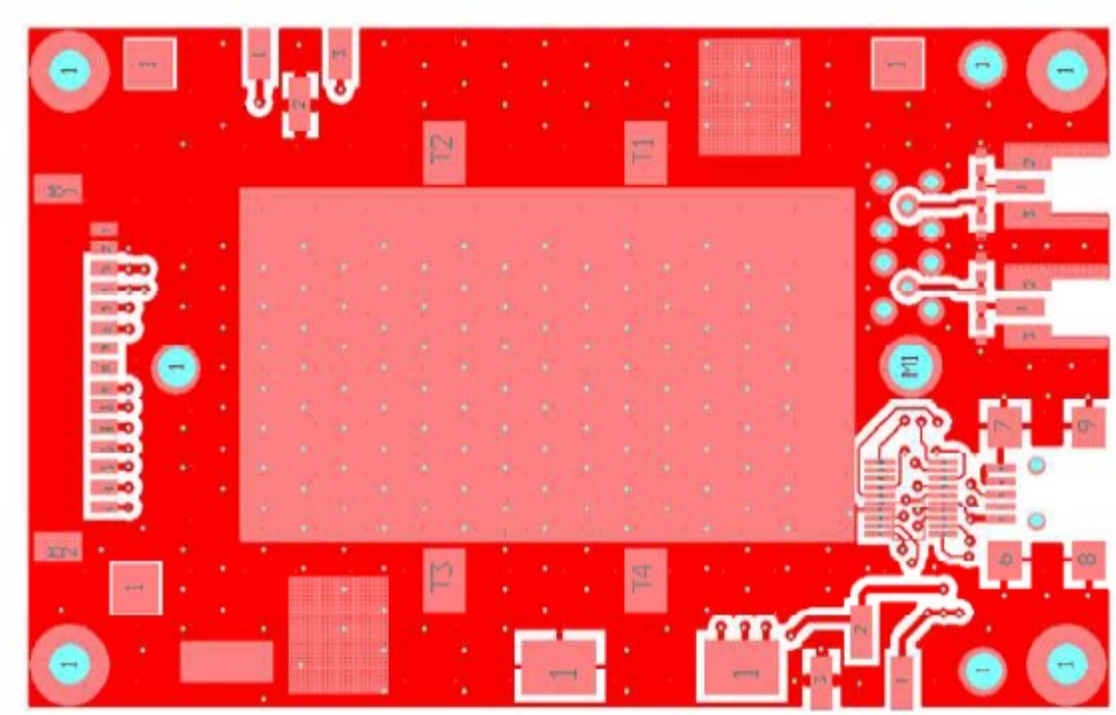
ONE Reflow Cycle Maximum



Sample Board Layout Using Surface Mount Option



Sample Board Layout Using Connectorized 'Flip' Option



3 Firmware Overview

The following section provides detailed description of the Micro firmware components.

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 command to switch control from bootloader to application is issued internally, but the module's acknowledgement is sent to the host. Looking for this acknowledgement in the API Transport Log is a good way to determine if the module has rebooted (due to input DC power supply inadequacy, for example).

NOTE: Unlike previous ThingMagic modules, the Micro bootloader should effectively be invisible to the user. The Micro 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 Micro

Applications to control the Micro 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 Micro

New features developed for the Micro 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 Micro 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.

4 Communication Protocol

The following is an overview of the low level serial communications protocol used by the Micro.

Serial Communication Protocol

The serial communication between a computer (host) and the Micro 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 Micro does not support programming to the serial protocol directly. All user interaction with the Micro 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

Caution: Please contact rfid-support@jadaktech.com before beginning the process of getting regulatory approval for a finished product using the Micro.

Supported Regions

The Micro 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. 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.

These are the characteristics of the supported regions. JADAK has not obtained certification for all regions as most will not certify a module alone, but our customers have successfully certified devices which incorporate the Micro module.

Supported Regions

Region Name	Country or Region	Serial Interface Region Code[1]	Lowest Frequency Permitted (kHz)	Highest Frequency Permitted (kHz)	Smallest Step Size (kHz)	Maximum Dwell Time (sec)	Lowest Channel in Hop Table	Highest Channel in Hop Table	LBT Level[2]
NA	North America	0x01	902000	928000	250	0.4	902750	927250	None
NA2	North America	0x0D	917400	927200	200	0.4	917400	927200	None
NA3	North America	0x0E	917500	922500	100	0.4	917500	922500	None
IN	India	0x04	865000	867000	100	4	865200	865200	None
JP	Japan	0x05	922200	920800	100	4	916800	922200	-74 dBm
PRC	China	0x06	920125	924875	125	2	920625	924375	None
EU3	Europe	0x08	865600	867600	100	4	865700	867500	Optional at -72 dBm
KR2	Korea	0x09	917000	923500	100	0.4	917300	920300	None
AU	Australia	0x0B	920000	926000	250	0.4	920750	925250	None
NZ	New Zealand	0x0C	922000	927500	250	0.4	922250	927250	None
MY	Malaysia	0x10	919000	923000	250	0.4	919250	922750	None
ID	Indonesia	0x11	923000	925000	125	0.4	923125	924875	None
PH	Philippines	0x12	918000	920000	250	0.4	918250	919750	None
TW	Taiwan	0x13	922000	928000	250	0.4	922250	927750	None
MO	Macao	0x14	920000	925000	250	0.4	920250	924750	None

Supported Regions

Region Name	Country or Region	Serial Interface Region Code[1]	Lowest Frequency Permitted (kHz)	Highest Frequency Permitted (kHz)	Smallest Step Size (kHz)	Maximum Dwell Time (sec)	Lowest Channel in Hop Table	Highest Channel in Hop Table	LBT Level[2]
RU	Russia	0x15	866000	868000	200	0.4	866200	867800	None
SG	Singapore	0x16	920000	925000	100	0.4	920100	924900	None
VN	Vietnam	0x19	866000	869000	50	0.4	866450	867250	None
TH	Thailand	0x1A	920000	925000	250	0.4	920750	924250	None
AR	Argentina	0x1B	915000	928000	250	0.4	915250	927250	None
HK	Hong Kong	0x1C	865000	868000	100	0.4	865100	867900	None
BD	Bangladesh	0x1D	925000	927000	100	0.4	925400	926600	None

[1] If Region=0, it is unconfigured and the module will not transmit. This is represented as "None" in the API and "Select" (to encourage user action) in Universal Reader Assistant.

[2] LBT is "Listen Before Talk". If a carrier is detected above the threshold, the channel will not be used.

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

The PLL is set automatically to the closest frequency - based on the minimum frequency step size for the current region - that matches the specified value. The Micro has an absolute minimum step size of 25 kHz. Each region also has a minimum quantization based on regulatory specifications, which may be greater. When manually setting frequencies the module will round down for any value that is not an even multiple of the supported frequency quantization. For example, in the NA region, setting a frequency of 902,999 kHz results in a setting of 902,750 kHz.

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

Frequency Hop Table

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

- Contains up to 62 slots.
- Valid frequencies for the region currently selected.

- Changes not stored in flash, thus changes made are not retained after a power cycle or a restart of the boot loader.
- Inability to change individual entries after uploading without reloading the entire table.
- Frequencies used in the order of entries in the table.

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

Protocol Support

The Micro has the ability to support many different tag protocols. Using the MercuryAPI ReadPlan classes the Micro 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

ISO 18000-6C (Gen2)

The Micro 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	Not supported in PRC Region

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

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

IP-X

The Micro 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 Micro 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`

Antenna Ports

The Micro has two monostatic antenna ports. Each port is capable of both transmitting and receiving. The modules also support Using a Multiplexer, allowing up to 8 total logical antenna ports, controlled using two GPIO lines and the internal physical port Antenna1/ Antenna2 (A1/A2) switching.

NOTE: The Micro 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 A1/ A2 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 8 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 Micro Physical Port
1	Low	Low	A1
2	Low	Low	A2
3	Low	High	A1

GPIO 1 & 2 Used for Antenna Switching (Continued)

4	Low	High	A2
5	High	Low	A1
6	High	Low	A2
7	High	High	A1
8	High	High	A2

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 Micro Physical Port
1	Low	A1
2	Low	A2
5	High	A1
6	High	A2

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 1 and 3 both result in GPIO1=Low and Micro port A1 active.

Only GPIO 2 Used for Antenna Switching

Logical Antenna Setting	GPIO Output 2 State	Active Micro Physical Port
1	Low	A1
2	Low	A2
3	High	A1
4	High	A2

Port Power and Settling Time

The Micro 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.

Tag Handling

When the Micro 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 Micro 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 Micro 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 Micro "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 Micro and put into the buffer. The buffer is put into a circular mode that keeps the buffer from filling. This allows for the Micro 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 Micro 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 Micro 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. **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.
Gen2 “Q” Value	The value of “Q” indicates the number of slots offered in the inventory cycle during which the tag was read (2^Q slots with “Q” from 0 to 15)
Gen2 Backscatter Link Frequency	250 or 640 kHz
Gen2 Target	“A” or “B”

Power Management

The Micro 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 Micro 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 Micro is idle.

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 Micro 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 may add up to 50 ms of delay from idle to RF on when initiating an RF operation. It 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.
- **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.

Event Response Times

The following table provides some metrics on how long common Micro 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 Micro 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
- Gen2 TARI
- Gen2 Session
- Gen2 target
- Gen2 Q
- Autonomous Trigger
- Autonomous Read Plan
- Hop Table and Hop Time (“Dwell Time”)
- Duty Cycle (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.

Some settings can now be changed dynamically while continuous reading is active. No additional commands are needed; the API simply now supports the relevant “set parameter” command during continuous reading where it would have returned an error before. The settings include:

- 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 (only the value – you cannot change an output into an input or vice-versa dynamically)

6 Specifications

Micro Specifications

Ordering Information	
Module	M6E-M
Development Kit	M6E-M-DEVKIT
Physical	
Dimensions	46 mm L x 26 mm W x 4.3 mm H (1.8 in L x 1.0 in W x 0.16 in H)
Tag Transponder Protocols	
RFID Protocol Support	EPCglobal Gen 2V2 (ISO 18000-63) with DRM. Optional AEI ATA, IP-X and ISO 18000-6B
RF Interface	
Antenna Connector	Two 50 Ω connections (board-edge or U.FL) supporting two monostatic antennas
RF Power Output	Separate read and write levels, command-adjustable from -10 dBm to +30 dBm* in 0.5 dB steps, accurate to +/- 1 dBm
Regulatory	Pre-configured for the following regions: FCC (NA, SA) 902-928 MHz; ETSI (EU) 865.6-867.6 MHz; TRAI (India) 865-867 MHz; KCC (Korea) 917-920.8 MHz; ACMA (Australia) 920-926 MHz; SRRC-MII (P.R. China) 920-925 MHz; MIC (Japan) 916.8-922.2 MHz; 'Open' (Customizable channel plan; 865-869, 902-928 MHz)
Data/Control Interface	
Physical	28 board-edge connections or Molex low profile connector (53748-0208) providing DC power, communication, control and GPIO signals
Control/Data Interfaces	UART; 3.3V logic levels 9.6 to 921.6 kbps / USB 2.0 interface (12 Mbps)
GPIO Sensors and Indicators	Two 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: 3.5 to 5.25 V **DC power consumption @ RF level: 5.5 W @ +30 dBm***; 3.5 W @ +27 dBm; 2.5 W @ +23 dBm; 2.0 W @ 0 dBm
Power Consumption when not transmitting	0.32 W
Idle Power Saving Options	Standby: 0.06 W Sleep: 0.008 W Shutdown: 0.0003 W
Environment	
Certification	USA (FCC 47 CFR Ch. 1 Part 15); Canada (Industrie 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	Survives 1 meter drop during handling
Performance	
Max Read Rate	Up to 750 tags/second using high-performance settings
Max Tag Read Distance	Over 9 meters (30 feet) with 6 dBi antenna (36 dBm EIRP)
Specifications subject to change without notice.	

Duty cycle restrictions, based on temperature, apply at power levels above +23 dBm **Will operate below +3.5 V with reduced input line noise immunity ***Best case with good antenna matching

Micro-LTE Specifications

Ordering Information	
Module	M6E-MICRO
Development Kit	M6E-MICRO-DEVKIT
Physical	
Dimensions	46 mm L x 26 mm W x 4.3 mm H (1.8 in L x 1.0 in W x 0.16 in H)
Tag Transponder Protocols	
RFID Protocol Support	EPCglobal Gen 2V2 (ISO 18000-63) with DRM. Optional AEI ATA, IP-X and ISO 18000-6B
RF Interface	
Antenna Connector	Two 50 Ω connections (board-edge or U.FL) supporting two monostatic antennas
RF Power Output	Separate read and write levels, command-adjustable from -10 dBm to +30 dBm* in 0.5 dB steps, accurate to +/- 1 dBm
Regulatory	Pre-configured for the following regions: FCC (NA, SA) 902-928 MHz; ETSI (EU) 865.6-867.6 MHz; TRAI (India) 865-867 MHz; KCC (Korea) 917-920.8 MHz; ACMA (Australia) 920-926 MHz; SRRC-MII (P.R. China) 920-925 MHz; MIC (Japan) 916.8-922.2 MHz; 'Open' (Customizable channel plan; 865-869, 902-928 MHz)
Data/Control Interface	
Physical	28 board-edge connections or Molex low profile connector (53748-0208) providing DC power, communication, control and GPIO signals
Control/Data Interfaces	UART; 3.3V logic levels 9.6 to 921.6 kbps / USB 2.0 interface (12 Mbps)
GPIO Sensors and Indicators	Two 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: 3.5 to 5.25 V **DC power consumption @ RF level: 5.5 W @ +30 dBm***; 3.5 W @ +27 dBm; 2.5 W @ +23 dBm; 2.0 W @ 0 dBm
Power Consumption when not transmitting	0.32 W
Idle Power Saving Options	Standby: 0.06 W Sleep: 0.008 W Shutdown: 0.0003 W
Environment	
Certification	USA (FCC 47 CFR Ch. 1 Part 15); Canada (Industrie 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	Survives 1 meter drop during handling
Performance	
Max Read Rate	Up to 50 tags/second
Max Tag Read Distance	Over 9 meters (30 feet) with 6 dBi antenna (36 dBm EIRP)
Specifications subject to change without notice.	
Duty cycle restrictions, based on temperature, apply at power levels above +23 dBm **Will operate below +3.5 V with reduced input line noise immunity ***Best case with good antenna matching	

7 Compliance and IP Notices

Communication Regulation Information

Contact rfid-support@jadaktech.com before beginning the process of getting regulatory approval for a finished product using the Micro.

Micro, Micro-LTE Regulatory 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 Micro 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 25cm 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 25cm 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-M”

or

“Contains FCC ID: QV5MERCURY6E-M.”

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 25 cm 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 Micro (or appropriate model number you are filing with IC) transmitting module FCC ID: QV5MERCURY6E-M (IC: 5407A-MERCURY6EM)”

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 25 cm 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-M (IC:5407A-MERCURY6EM)"

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.

EU RED Declaration of Conformity

Novanta
The Innovation Advantage

European Union Declaration of Conformity for
M6E-M RFID Reader Module

Manufacturer:	Novanta Corporation
Address:	125, Middlesex Turnpike Bedford, MA 01730
Object of the declaration: Product Model Numbers:	M6E-M, M6E-MICRO
Object description: Product Description:	865-869 MHz and 902 to 928 MHz Radio Frequency Identification (RFID) Reader / Interrogator Module.
This declaration of conformity is issued under the sole responsibility of the manufacturer. 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 CS22409.

It is required that antenna gain must +6 dBiL 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	May 8, 2017
Signature	

Document No. 875-0215-01 Rev A

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: • Make sure the command is supported in the currently running program. • Check the documentation for the opCode the host sent and make sure it is correct and supported. • 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. 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.
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 Micro supports powers between 5 and 30 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. 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: • No tag in the RF field • Read/write power too low • Antenna not connected • 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 Micro 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_V2_AUTHEN_FAILED	425h	This is an error returned by Gen2v2 tags. Most often it means that an attempt was made to authenticate a tag with returned data using Key0, which is not supported by NXP UCODE DNA tags (only key1 is supported).	Use key1 to have the tag return an encrypted challenge with encrypted data.
FAULT_GEN2_PROTOCOL_V2_UNTRACE_FAILED	426h	This is an error returned by Gen2v2 tags. For NXP UCODE DNA tags, it most often means that an attempt was made to change Untraceable settings with a zero Access Password.	Check the access password being sent. It must be non-zero to change the untraceable setting, but can be set to zero for operations thereafter.
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 Micro 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.
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: • Reduce duty cycle • Add heat sink
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: • Make sure antenna VSWR is within module specifications • Make sure antennas are correctly attached before transmitting • 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.

Tag ID Buffer Fault Errors (Continued)

Message	Code	Cause	Solution
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. 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.
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

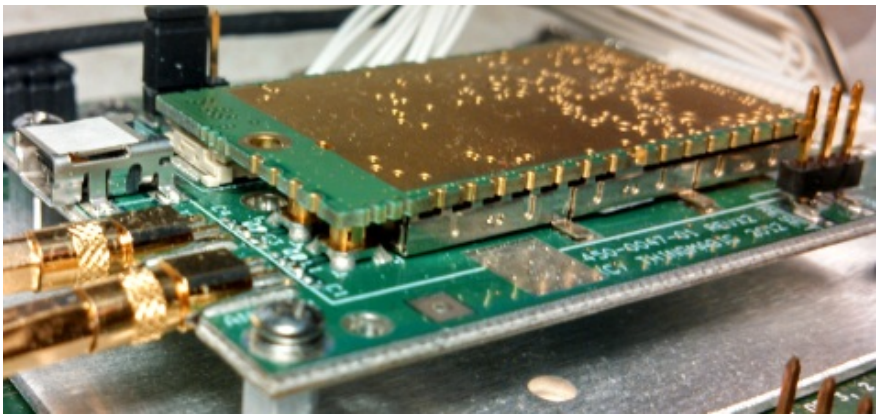
Development Kit Hardware

Components Included in the M6E-M_DEVKIT:

- The Micro module and carrier board
- 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.

NOTE: The Micro module is mounted on a carrier board in the bottom-up "Flip Mount" orientation on the Development Kit.

Micro Module on Carrier Board



This mounting method allows for easy replacement of the module, but allows the module to overheat very quickly. If it is necessary to test the module in continuous reading mode, we recommend using a Micro Carrier Board, which has the carrier soldered down to a daughterboard and features an aluminum heat spreader beneath the board.

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

1. Plug in the USB cable to the Micro (Dev Kit) and PC.
2. Windows should report it has "Found New Hardware - Micro" 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. "Micro" should now be shown under the Model list. Select it and click **Next,** then **Finished**.

NOTE: The Micro 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 Micro. 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 M6eMicro (COM#).

NOTE: The carrier board can be used independently of the Dev Kit motherboard via the USB connector on the carrier board. If the carrier board is to be powered by the USB connector, a jumper (nearest the USB connector) must be installed that connects "VIN" to "+5USB" (these labels are silkscreened on the carrier board).

NOTE: For higher power applications (requiring higher Power Consumption than a USB port can provide), leave the jumper off, and connect power through the test point loops or through the dev kit.

Development Kit Jumpers

J8

Jumpers to connect Micro I/O lines to dev kit.

J9

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

J10, J11

Jump pins OUT to GPIO# to connect Micro GPIO lines to output LEDs. Jump pins IN to GPIO# to connect Micro GPIO to corresponding input switches SW[3,4]GPIO#. Make sure GPIO lines are correspondingly configured as input or outputs (see Configuring GPIO Settings).

J13, J15

Not used.

J14

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

J16

Jump pins 1 and 2 or 2 and 3 to reset dev 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

The jumper at J19 that connects Shutdown to ground must be REMOVED. With this jumper removed, the module is always operational. The shutdown switch has no effect on the Micro. To put the Micro into shutdown mode is to reinstall the jumper at J19. See Micro Digital Connector Signal Definition for details on the Shutdown Line. AUTO_BOOT controls Reset Line.

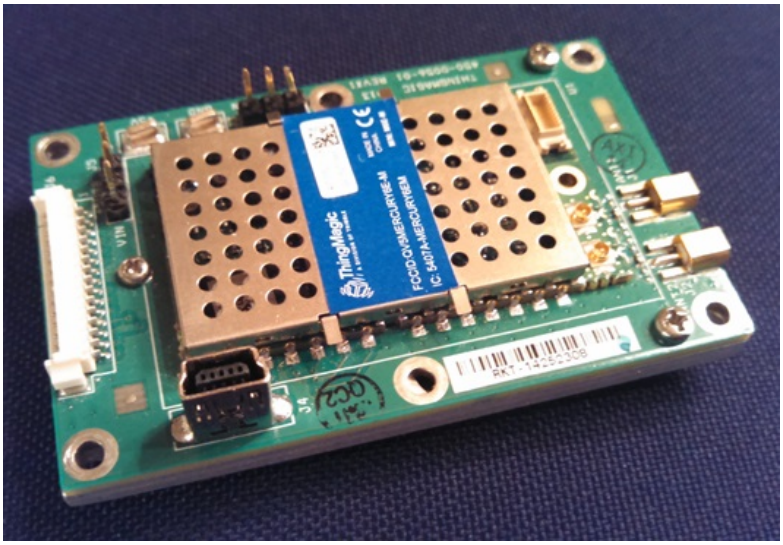
Development Kit Schematics

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

Micro Carrier Board

If all the flexibility of the Development Kit is not needed or if the module in the Development Kit heats up too much during testing, we recommend purchasing a Micro Carrier Board.

Micro Carrier Board



This board can be mounted directly on top of the metal mounting plate of the Development Kit motherboard and the edge connector is pin-for-pin compatible with the M6e module and the “Flip Mount” daughterboard. This module may also be accessed independently of the Development Kit motherboard by inserting a USB connector into the on-board socket and adding a jumper between the “VIN” and “+5USB” pins on the jumper between the module and the white power/control connector.

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.

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

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

ElectroStatic Discharge (ESD) Considerations

Warning: The Micro 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 Micro-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 Micro 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 Micro 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 Micro 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 Micro's environment to eliminate ESD failures. The steps vary depending on the required Micro 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 Micro 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 Micro, Micro enclosing housing (e.g., Vega 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 Micro 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 Micro 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 Micro antenna detect methods.)
- Install a Minicircuits SHP600+ high pass filter in the cable run at the Micro (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 Micro ESD survival level.

NOTE: The SHP600+ is not rated for the full +30 dBm output of the Micro 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 Micro 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 Micro 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 Micro 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.
- 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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