# User's Manual
# Wireless Autani Transceiver (WAT3)

Model Number: 1000153

Fully Integrated IEEE 802.15.4 Transceiver Module

Document Number: 80253

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| Version | Date | Changed By | Revision Description |
|---|---|---|---|
| 1 | 10-15-2013 | MEP | Initial Release |
| 2 | 03-04-2014 | MEP | Updated regulatory information |
| 3 | 12-11-2014 | MEP | Updated +3dBm to +8dBm on page 4 and 12 |
| | | | |

# Table of Contents

# 1. Description

The Wireless Autani Transceiver (WAT3) provides a cost-effective RF transceiver for 2.4 GHz IEEE 802.15.4 wireless networks.  The WAT3 is based on the Ember EM35X System-on-a-chip (SoC) and it has been designed to support larger, denser, sleepier, more mobile, secure, and resilient wireless networks.
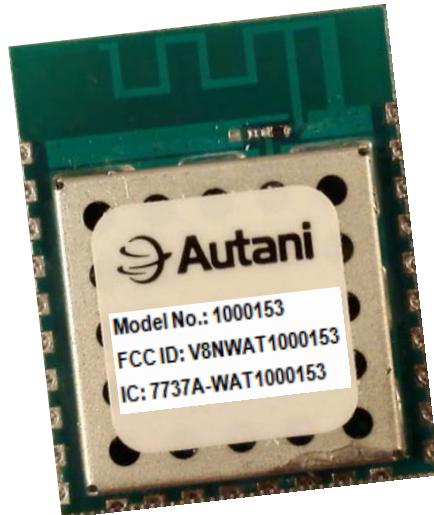
**Features:**

- Design for EmberZNet networks

- Miniature footprint: 1.000" x 0.800"

- Integrated PCB antenna

- 16 RF channels

- Integrated hardware support for Ember development environment

- Non-intrusive debug port (SIF)

- AES 128-bit encryption

- Low power consumption

- Constant RF output power over 2.1V - 3.6V voltage range

- FCC and IC Certified

- 128KB Flash Memory

- 5KB SRAM

- 16-bit XAP2b microprocessor

- 16 general purpose inputs and outputs (GPIO)

- UART, SPI, and I2C interfaces

- Integrated ADC with 12-bit maximum resolution

- **Made in USA**

# 2. Ordering Information

| Part Number | Description |
|---|---|
| 1000153-01 | Wireless Autani Transceiver (WAT3) |

# 3. Specifications

## 3.1 Absolute Maximum Ratings

Note: Exceeding the maximum ratings may cause permanent damage to the module

| Parameter | Min | Max | Unit |
|---|---|---|---|
| Power Supply Voltage ($V_{DD}$) | 2.1 | 3.6 | V |
| Voltage on any digital pin | -0.3 | $V_{DD}$+0.3 | V |
| Storage Temperature | -25 | 70 | $^{o}$C |

## 3.2 Recommended Operating Conditions

Note: Operating conditions outside those listed here may cause inappropriate behavior.

| Parameter | Min | Typ | Max | Unit |
|---|---|---|---|---|
| Power Supply Voltage ($V_{DD}$) | 2.1 | 3.3 | 3.6 | V |
| Operating Temperature | 0 | 25 | 60 | $^{o}$C |
| Logic Input Low Voltage | 0 | | 0.2x$V_{DD}$ | V |
| Logic Input High Voltage | 0.8x$V_{DD}$ | | $V_{DD}$ | V |
| RF Tx Power (Ch11-Ch26) | | | +8 | dBm |

## 3.3 Electrical Specifications

| Parameter | Min | Typ | Max | Unit |
|---|---|---|---|---|
| *General Characteristics* | | | | |
| RF Frequency Range | 2.400 | | 2.4835 | GHz |
| Data Rate | | 250 | | Kbps |
| Processor core frequency | | 12 | | MHz |
| Flash Memory | | 128 | | KB |
| SRAM | | 5 | | KB |
| *Power Consumption* | | | | |
| Transmit Mode | | 36.0 | | mA |
| Receive Mode | | 36.0 | | mA |
| Processor Only Mode | | 8.0 | | mA |
| Sleep Mode | | | 1 | uA |
| *Logic Characteristics* | | | | |
| Logic Input High | $0.8 \times V_{DD}$ | | $V_{DD}$ | V |
| Logic Input Low | 0 | | $0.2 \times V_{DD}$ | V |
| Logic Output High | $0.82 \times V_{DD}$ | | $V_{DD}$ | V |
| Logic Output Low | 0 | | $0.18 \times V_{DD}$ | V |
| Output Source/Sink Current | | | 4 | mA |
| Output Source/Sink Current high current pad: GPIO[16:13] | | | 8 | mA |
| Logic High Input Current | | | 0.5 | uA |
| Logic Low Input Current | | | -0.5 | uA |
| Input Pull-up Resistance | | 30 | | kΩ |
| Input Pull-down Resistance | | 30 | | kΩ |

# 4. WAT3 Peripherals and Capabilities

The WAT3 Module provides 16 GPIO ports that are shared with alternate functions within the EM35X SoC. The alternate functions can be used on a variety of different GPIO. All GPIOs are configurable as input, output, or bi-directional and have an internal pull-up or pull-down.

The WAT3 Module offers two serial controllers, a multi-channel 12-bit Analog-to-Digital converter (ADC), and two16-bit timers. Serial Controller SC1 can be configured for SPI (master only), I2C (master only), or UART. Serial Controller CS2 can be configured for SPI (master or slave) or I2C (master). The ADC can be configured to provide anywhere from 5 to 12 bits of precision on 4 single-ended channels or 2 differential channels in addition to monitoring the supply voltage. The 16-bit timers have configurable clock sources, a loadable start point, two output compare registers, two input capture registers, and can be configured to operate up/down counting, single shot counting, and pulse width modulation (PWM).

The WAT3 Module provides access to the SIF module programming and debugging interface.

Please consult the EM35X datasheet for detailed information about using the peripherals.

| WAT3 Module Pin Assignment | | | |
|---|---|---|---|
| *Pin #* | *Name* | *Type* | *Description* |
| 1 | IO17_PC6 | DI/DO | PC6, OSC32B, nTX_Active |
| 2 | IO18_PC7 | DI/DO | PC7, OSC32A_EXT |
| 3 | Ground | GND | Ground |
| 4 | $V_{DD}$ | $V_{DD}$ | Power Supply Input |
| 5 | RST# | DI | Processor Reset, active low |
| 6 | IO11_PB3 | DI/DO | PB3, TIM2C3,SC1nCTS, SC1SCLK |
| 7 | IO12_PB4 | DI/DO | PB4, TIM2C4, SC1nRTS, SC1nSSEL |
| 8 | IO0_PA0 | DI/DO | PA0, TIM2C1, SC2MOSI |
| 9 | IO1_PA1 | DI/DO | PA1, TIM2C3, SC2SDA, SC2MISO |
| 10 | IO2_PA2 | DI/DO | PA2, TIM2C4, SC2SCL, SC2SCLK |
| 11 | IO3_PA3 | DI/DO | PA3, SC2nSSEL, TRACECLK, TIM2C2 |
| 12 | IO4_PA4 | DI/DO/AI | PA4, ADC4, PTI_EN, TRACEDATA2 |
| 13 | IO5_PA5 | DI/DO/AI | PA5, ADC5, PTI_DATA, nBOOTMODE, TRACEDATA3 |
| 14 | IO6_PC1 | DI/DO/AI | PC1, ADC3, SWO, TRACEDATA0 |
| 15 | IO7_PB5 | DI/DO/AI | PB5, ADC0, TIM2CLK, TIM1MSK |
| 16 | IO8_PB0 | DI/DO/AO | PB0, VREF, IRQA, TRACECLK, TIM1CLK, TIM2MSK |
| 17 | IO9_PB1 | DI/DO | PB1, SC1MISO, SC1MOSI, SC1SDA, SC1TXD, TIM2C1 |

| 18 | IO10_PB2 | DI/DO | PB2, SC1MISO, SC1MOSI, SC1SCL, SC1RXD, TIM2C2 |
| 19 | JTCLK | DI | SWCLK, JTCK |
| 20 | JTDO_PC2 | DO | PC2, JTDO, SWO |
| 21 | JTDI_PC3 | DI | PC3, JTDI |
| 22 | JTMS_PC4 | DI/DO | PC4, JTMS, SWDIO |
| 23 | IO16_PB7 | DI/DO | PB7, ADC2, IRQC, TIM1C2 |
| 24 | IO15_PB6 | DI/DO | PB6, ADC1, IRQB, TIM1C1 |
| 25 | IO14_PA7 | DI/DO | PA7, TIM1C4, REG_EN |
| 26 | IO13_PA6 | DI/DO | PA6, TIM1C3 |
| 27 | JRST_PC0 | DI/DO | JTRST, PC0 |
| 28 | Ground | GND | Ground |

Unused GPIO should be left unconnected.  The EM35X should be configured to hold unconnected GPIO in a known state with internal pull-up/pull-down resistors.

DI = Digital Input

DO = Digital Output

AI = Analog Input

AO = Analog Output

$V_{DD}$ = Power Input

GND = Ground

# 5. Antenna

The WAT3 Module includes an integrated PCB trace antenna. The PCB antenna employs a meandering F-antenna design that is very compact and supports omni-directional signal radiation. To maximize the antenna efficiency an adequate ground should be provided on the base board. The position of the module on the base board and overall design of the product enclosure contributes to the antenna's performance.

Here are some guidelines to help ensure antenna performance:

- Keep all copper (planes and traces) away form the antenna portion of the module

- Keep the antenna away from metal parts (i.e. enclosures, large heat sinks, etc…)

- Keep internal wiring and other components away from the Antenna

- Do not place the antenna inside a metal enclosure

- Keep plastic enclosures ½ in. or more from the antenna

# 6. Dimensions

## 6.1 WAT3 Module
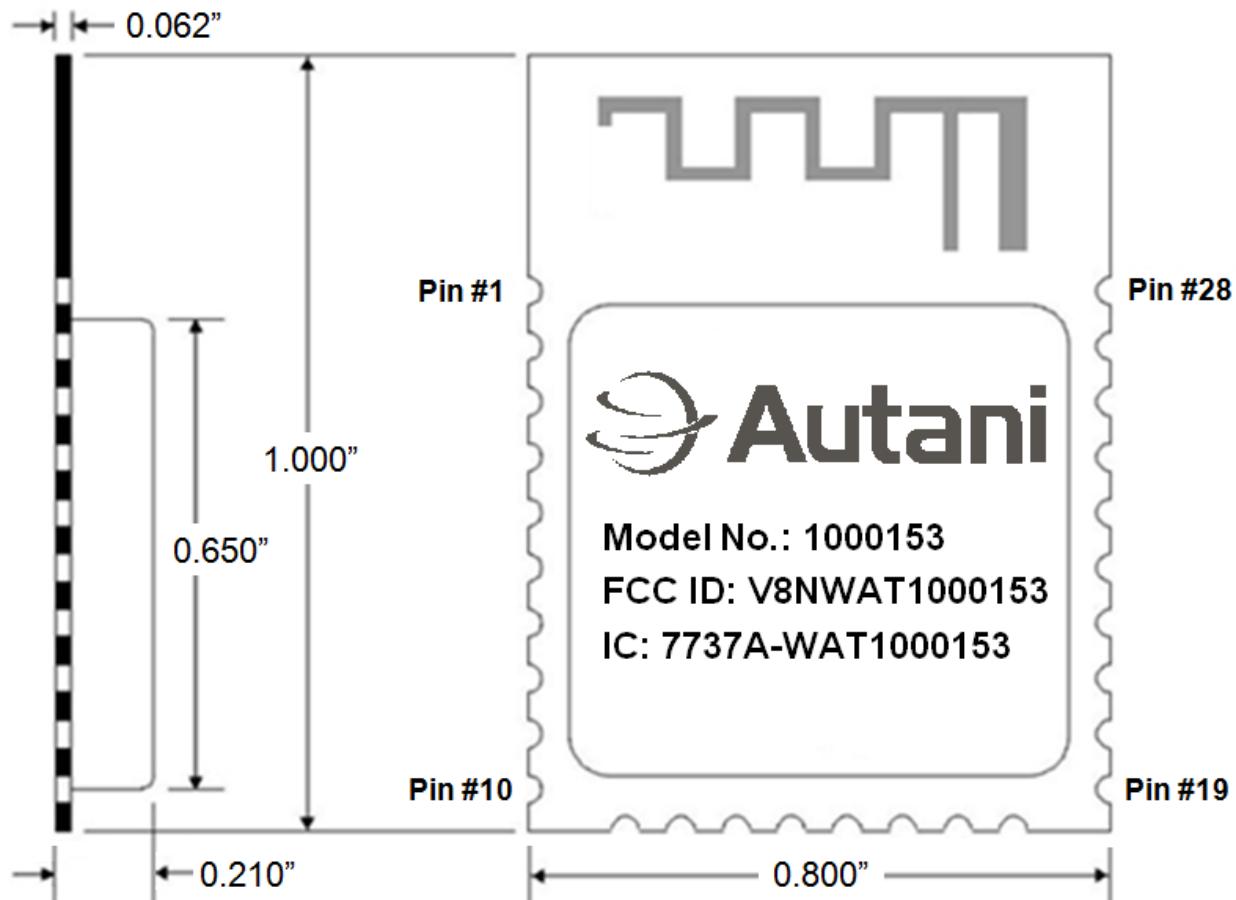
## 6.2 Recommended Land Pattern

Recommended Base PCB Board Edge

Pin #1

0.050"
Typ 28 Pads

0.080"

0.030"

0.100"

0.030"

0.100" Typ 28 Pads
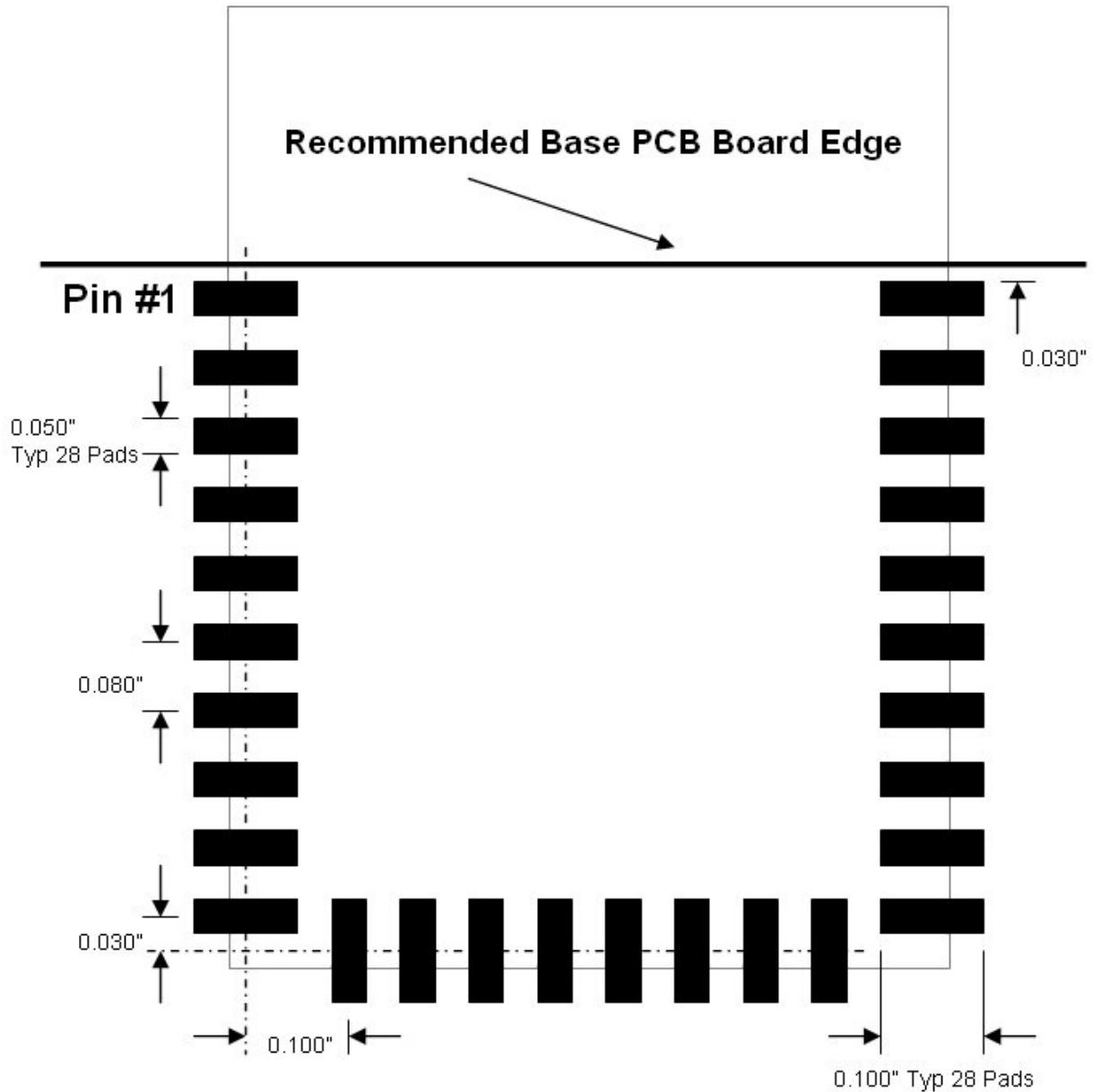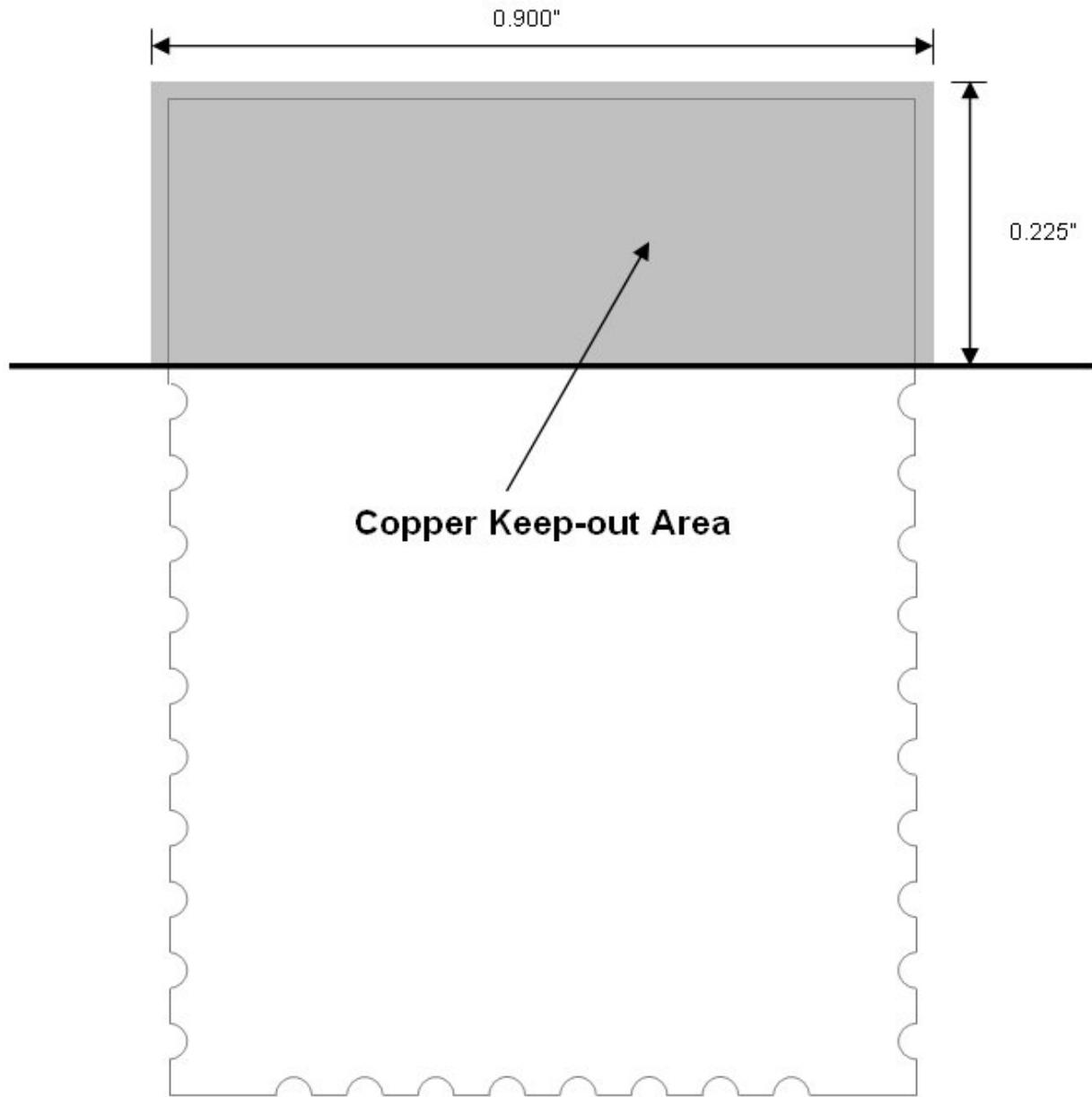
## 6.3    Keep-out Area



For maximum antenna performance hang the antenna keep-out area over the edge of the base board. Placing a ground plane on the layer directly beneath the WAT3 Module will allow you to run traces under this area. The WAT3 board can be placed on a base board without antenna overhang as long as all copper is kept away from the antenna keep-out area.

# 7.    Certifications

## 7.1    FCC – United States

The WAT3 Module complies with Part 15 of the Federal Communications Commission rules and regulations.  To continue compliance with Part 15 the end user MUST include a visible label on the outside of the final product which indicates the internal radio module is FCC approved.  The exterior label can use wording such as: "Contains FCC ID: V8NWAT1000153".  To meet the section 15.209 emissions requirements in the restricted bands of section 12.205, the transceiver transmitter power for the EM35X can be set no higher than +8dBm for all channels.  Any modifications to the WAT3 Module may violate the rules of the FCC and make operation of the module unlawful.  The user is responsible for obtaining compliance for unintentional radiators on the final product.

**NOTE 1:** 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 radiates 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 or more 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.

**NOTE 2:**  The WAT3 Module complies with the FCC RF radiation exposure limits set forth for an uncontrolled environment.  The WAT3 Module must be installed and/or operated with a minimum distance of 8 in. (20 cm.) between the antenna and people.

**NOTE 3:** 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

## 7.2    IC – Canada

The WAT3 Module is IC certified.  The labeling requirements for Industry Canada are similar to those of the FCC.  A visible label must be placed on the outside of the final product clearing indicating the IC Labeling of the internal WAT3 Module.  The user is responsible for the end product complying with ICES-003 (Unintentional Radiators).

# 8. Processing

**CAUTION**: The WAT3 Module contains extremely sensitive electronic circuitry.  Handle board with proper ESD protection at all times.

## 8.1    Reflow Soldering

A convection soldering oven is recommended.  Preheat the assembly at a rate of $3^oC$/sec and stop at a final temperature of 150-200$^oC$.  Limit time above solder paste liquid temperatures to 20-40 seconds, do not exceed 260$^oC$.  Allow the assembly to cool at a rate no greater than $6^oC$/sec.  Use of "no clean" solder is highly recommended as all cleaning methods carry some risk of damaging the module and its markings.

## 8.2    Repeat Reflow Soldering

Repeated reflow after the WAT3 Module has been populated is discouraged.

## 8.3    Wave Soldering

If wave soldering is required on the base board due to the use of leaded components, it is recommended that only a single pass is used.

## 8.4    Hand Soldering

Hand soldering is possible but should be done with care to avoid excessive heat application to the WAT3 Module.

## 8.5    Optical Inspection

After soldering the WAT3 Module to the base board, an optical inspection is recommended to check for the following:

- Accurate alignment and centering of the module over the pads.
- Appropriate solder joints.
- Unintended solder bridges.

## 8.6 Module Rework

The WAT3 Module can be unsoldered from the base board.  Take care not to overheat the module.  Never attempt to rework the module itself, any such attempts will invalidate any manufactures warranty and potentially cause the module to violate FCC and IC specifications.

## 8.7 Alterations

Any and all alterations to the WAT3 Module are highly discouraged and are completed at the consumer's risk.  Such actions will invalidate any manufactures warranty and potentially cause the module to violate FCC and IC specifications.

# 9.  References

[1].    EM35X Datasheet (http://www.silabs.com/products/wireless/zigbee/Pages/default.aspx)

[2].    FCC Part 15

(http://transition.fcc.gov/Bureaus/Engineering_Technology/Documents/bulletins/oet63/oet63rev.pdf)