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iCHIME Module
Operating Manual

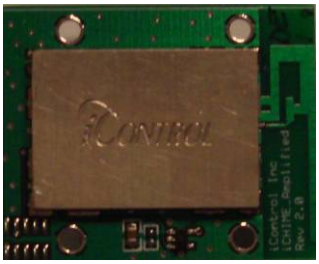
Background.

The iCHIME is 2.4GHz bi-directional radio transceiver. A User may configure the device to operate as a Radio Frequency Identification Device (RFID) to support tracking shipping containers in a worldwide supply chain using the Marine Asset Tag Tracking System (MATTS) communication protocol. An iCHIME module utilizes a low power, wireless, radio operating in the 2.4 GHz band as its primary mode of communication. The wireless radio operates in compliance with IEEE Standard 802.15.4-2006. The iCHIME utilizes the same radio, processor, and User interface software as iControl's iTAG module. The iCHIME also supports the same command list as iControl's iTAG module. The iCHIME is User configurable to periodically transmit the iCHIME's status using a data interface available via the User connector. The module may operate as stand alone device or may be used as a radio transceiver for devices that communicate data as a part of a larger system.

The User interface for the module is a twenty (20) pin connector on the bottom of the module.

iTAG Repeater for
iCHIME modules

iCHIME Reader utilizing an
Internal iCHIME Module



iCHIME Module

Figure 1 iCHIME and Related Devices

iCHIME Radio Operation.

The iCHIME is controlled via a serial port interface (RS232 UART) for initial configuration and checkout. All commands for controlling the iCHIME radio are identified in the iTAG Command List. Once a User as completed the initial iCHIME configuration, complete control and operation of the iCHIME can be accomplished through the radio interface using the same commands available in the iTAG Command List.

The radio in the iCHIME is normally operated in a power saving mode with the receiver periodically enabled and "listening" for commands or data requests. A key element to the power saving mode is the principle of "tag-talks-last". In this mode, battery power is conserved by only responding to messages that are sent directly to the specific iCHIME MAC address or mutual broadcast address. For a majority of iCHIME operation, the iCHIME is in a deep power saving mode (~98% of the time). The iCHIME will only transmit when it receives a properly encrypted message while its receiver is active. The encrypted message directed to the iCHIME may include information about which channel the iCHIME uses for further transmissions. Once, the communication parameters are exchanged, there will typically be a period a several seconds of active radio transmission as the iCHIME relays data. The data transmitted may either be security data destined for government servers, and/or commercial data destined for the end customer. This data may originate from internal flash storage or it may be received and relayed from another compatible device.

Other Features.

In addition to the wireless radio, the iCHIME provides other features for system integration.

1. Two RS-232 serial UARTs are available for the User to communicate to the module from secondary systems to transmit data via the radio transceiver. The User has complete control for setting the baud rate, data interval and packet format for data transmission.
2. The iCHIME hosts eight channels of 13 bit resolution Analog to Digital conversion. These inputs can be used to monitor external sensors attached to the iCHIME (temperature, pressure, vibration, etc.) . The iCHIME user interface includes command and data handling support to issue alarms or automate behavior based on thresholds for these input.
3. There is an onboard temperature sensor integrated with iCHIME. The default iCHIME data packet includes the temperature data.

Functional Block Diagram.

The iCHIME module integrates a low power microprocessor and a 2.4Ghz radio . The iCHIME module also includes a software User interface for radio control and data transmission. Additionally, the iCHIME can retrieve User data via the two serial UARTs or provide up to 8 channels of analog to digital data.

Note: Please note that the iCHIME uses the same command list as the **iTAG command list** . For iCHIME command and control, please refer to the *iTAG Command List* for a complete description of commands that control the iCHIME module.

The iCHIME module is equipped with an integrated trace antenna rated at 3.0 dBi. Most embedded mobile applications will utilize the integral antenna provided with the iCHIME module.

Optionally, a micro coax connector may be utilized to connect external antenna to the iCHIME module. iControl can provide iCHIME modules with external antenna connectors that are certified and licensed for external antenna operations.

NOTE: Users may not modify the antenna or it's connection in anyway or risk violating radio law.

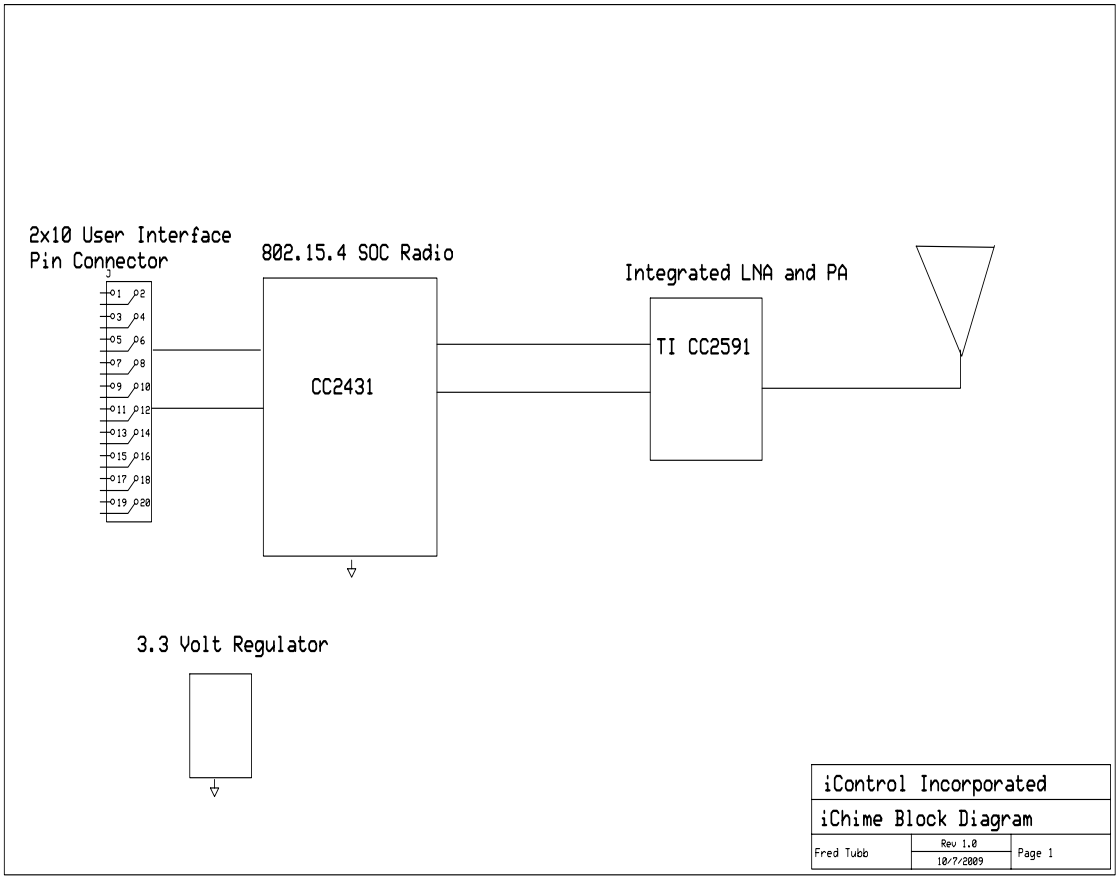


Figure 2 iCHIME Block Diagram

Absolute Maximum Ratings.

Under no circumstances must the absolute maximum ratings giving in this table be violated. Stress exceeding one or more of the limiting values may cause permanent damage to the device.

Parameter	Min	Max	Units	Condition
Supply Voltage	-0.3	6.0	V	All supply pins must have same voltage
Voltage on any digital pin	-0.3	3.6	V	
Input RF level		10	dBm	
Storage temperature range	-50	150	C	
Operating ambient temperature	-40	85	C	

Figure 3 Maximum Ratings

Caution! *ESD sensitive device. Precaution should be used when handling the device in order to prevent permanent damage.*

General Characteristics.

Parameter	Min	Typ	Max	Unit	Condition/Note
Wake-Up and Timing					
Power mode 1 → power mode 0		2		µs	Digital regulator on, High Speed RCOSC and crystal oscillator off. Start-up of High Speed RCOSC.
Power mode 2 or 3 → power mode 0		54		µs	Digital regulator off, High Speed RCOSC and crystal oscillator off. Start-up of regulator and High Speed RCOSC.
Active → RX 32MHz XOSC initially OFF. Voltage regulator initially OFF		450		µs	Time from enabling radio part in power mode 0, until RX starts. Includes start-up of voltage regulator and crystal oscillator. Crystal ESR=16Ω.
Active → TX 32MHz XOSC initially OFF. Voltage regulator initially OFF		525		µs	Time from enabling radio part in power mode 0, until TX starts. Includes start-up of voltage regulator and crystal oscillator. Crystal ESR=16Ω.
Active → RX Voltage regulator initially OFF		250		µs	Time from enabling radio part in power mode 0, until RX starts. Includes start-up of voltage regulator.
Active → TX Voltage regulator initially OFF		320		µs	Time from enabling radio part in power mode 0, until TX starts. Includes start-up of voltage regulator.
Active → RX or TX			192	µs	Radio part already enabled. Time until RX or TX starts.
RX/TX turnaround			192	µs	
Radio part					
RF Frequency Range	2400		2483.5	MHz	Programmable in 1 MHz steps, 5 MHz steps for compliance with [1]
Radio bit rate		250		kbps	As defined by [1]
Radio chip rate		2.0		MChip/s	As defined by [1]

iCHIME Radio Specification (Transmit).

Parameter	Min.	Typ.	Max.	Unit	Condition / Note
Overall					
RF Frequency Range	2400		2483.5	MHz	Programmable in 1 MHz steps, 5 MHz steps for compliance with [1]
Transmit Section					
Transmit bit rate	250		250	kbps	As defined by [1]
Transmit chip rate	2000		2000	kChips/s	As defined by [1]
Nominal output power	7	10		dBm	Delivered to a single ended 50 Ω load through a balun. [1] requires minimum –3 dBm
Programmable output power range		0		dB	Output power is not user programmable
Harmonics 2nd harmonic 3rd harmonic		 -37 -51		 dBm dBm	At max output power delivered to a single ended 50 Ω load through a balun. See page 53.
Spurious emission 30 - 1000 MHz 1– 12.75 GHz 1.8 – 1.9 GHz 5.15 – 5.3 GHz			 -36 -30 -47 -47	 dBm dBm dBm dBm	Maximum output power. Complies with EN 300 328, EN 300 440, CFR47 Part 15 and ARIB STD-T-66
Error Vector Magnitude (EVM)			20	%	Measured as defined by [1] [1] requires max. 35 %
Optimum load impedance **Receive Section**		115 + j160		Ω	Differential impedance as seen from the RF-port (RF_P and RF_N) towards the antenna. For matching details see the Input / Output Matching section on page 53.
Receiver Sensitivity	-90	-94		dBm	PER = 1%, as specified by [1] Measured in 50 Ω single endedly through a balun. [1] requires –85 dBm

iCHIME Radio Specification (Receive).

Parameter	Min.	Typ.	Max.	Unit	Condition / Note
Saturation (maximum input level)	0	10		dBm	PER = 1%, as specified by [1] Measured in 50 Ω single endedly through a balun. [1] requires –20 dBm
Adjacent channel rejection + 5 MHz channel spacing		46		dB	Wanted signal @ -82 dBm, adjacent modulated channel at +5 MHz, PER = 1 %, as specified by [1]. [1] requires 0 dB
Adjacent channel rejection - 5 MHz channel spacing		39		dB	Wanted signal @ -82 dBm, adjacent modulated channel at -5 MHz, PER = 1 %, as specified by [1]. [1] requires 0 dB
Alternate channel rejection + 10 MHz channel spacing		58		dB	Wanted signal @ -82 dBm, adjacent modulated channel at +10 MHz, PER = 1 %, as specified by [1] [1] requires 30 dB
Alternate channel rejection - 10 MHz channel spacing		55		dB	Wanted signal @ -82 dBm, adjacent modulated channel at -10 MHz, PER = 1 %, as specified by [1] [1] requires 30 dB
Channel rejection ≥ + 15 MHz ≤ - 15 MHz	39			dB	Wanted signal @ -82 dBm. Undesired signal is a 802.15.4 modulated channel, stepped through all channels from 2405 to 2480 MHz. Signal level for PER = 1%.
Blocking / Desensitisation +/- 5 MHz from channel centre +/- 10 MHz from channel centre +/- 20 MHz from channel centre +/- 50 MHz from channel centre		 -24 -24 -24 -23	 -50 -45 -40 -30	 dBm dBm dBm dBm	Wanted signal 3 dB above the sensitivity level, CW jammer, PER = 1%. Maximum values according to EN 300 440 class 2.
Spurious emission 30 – 1000 MHz 1 – 12.75 GHz			 −57 −47	 dBm dBm	Complies with EN 300 328, EN 300 440 class 2, CFR47, Part 15 and ARIB STD-T-66
Frequency error tolerance	-300		300	kHz	Difference between centre frequency of the received RF signal and local oscillator frequency [1] requires 200 kHz
Symbol rate error tolerance			120	ppm	Difference between incoming symbol rate and the internally generated symbol rate [1] requires 80 ppm

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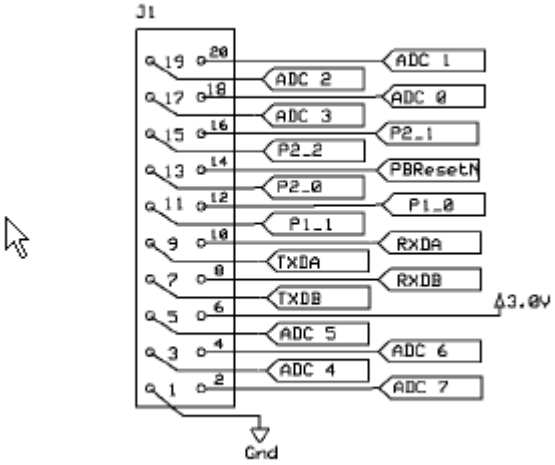
OEM Installation Instruction:

An OEM integrator utilizes the 2x10 x2mm pin header connector on the bottom of the iCHIME. To apply power, utilize serial data, and connect to analog interfaces, the OEM must provide a 2x10 x 2mm pin socket on their integrating electronics.

Interface Specification.

The interface diagram noted below is for the mating connector on the User's electronics. All interfaces to the radio are buffered to prevent User interface electronics from interfering with the operation of the radio.

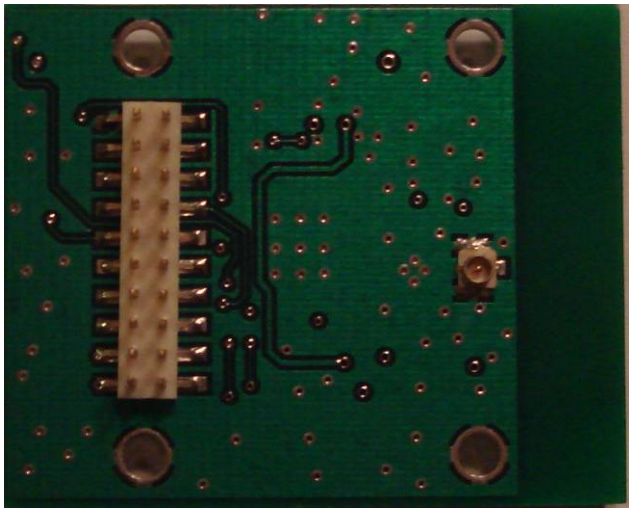
(Top View) Users Mating Connector for iCHIME Module

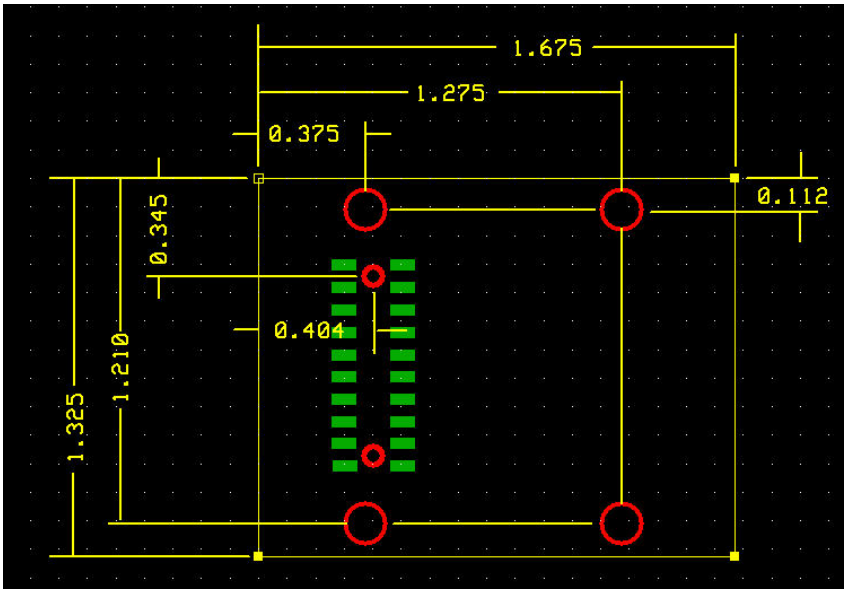


PIN	Name	Type	Description
1	GND	PWR	Ground
2	Analog 7	I	Analog Channel 7 (0-3.3 V input)
3	Analog 4	I	Analog Channel 4 (0-3.3 V input)
4	Analog 6	I	Analog Channel 6 (0-3.3 V input)
5	Analog 5	I	Analog Channel 5 (0-3.3 V input)
6	VIN	PWR	3.3-6.0 V input
7	TXDB	Output	Serial Port B transmit output (0-3.3V)
8	RXDB	Input	Serial Port B receive input (0-3.3V)
9	TXDA	Output	Serial Port A transmit output (0-3.3V)
10	RXDA	Input	Serial Port A receive input (0-3.3V)
11	P1_1	I/O	General Purpose I/O (0-3.3 V input)
12	P1_0	I/O	General Purpose I/O (0-3.3 V input)
13	P2_0	I/O	General Purpose I/O (0-3.3 V input)
14	PBReset	Input	Reset Pin, Active low, if not used keep float
15	P2_2	I/O	General Purpose I/O (0-3.3 V input)
16	P2_1	I/O	General Purpose I/O (0-3.3 V input)
17	Analog 3	I	Analog Channel 3 (0-3.3 V input)
18	Analog 0	I	Analog Channel 0 (0-3.3 V input)
19	Analog 2	I	Analog Channel 2 (0-3.3 V input)
20	Analog 1	I	Analog Channel 2 (0-3.3 V input)

Module Mechanical Specification.

The iCHIME module is manufactured on a 0.062" thick FR4 PCB substrate. There are four 0.10" mounting holes which may be used to secure the module in an enclosure or to mount on a host motherboard. All radio components are integrated under a mechanically secure, tamperproof RF shield.





iCHIME Module Mechanical Dimensions (in inches)

Module Unique Address Identification.

Each iCHIME module is assigned a unique 8 byte MAC address by iControl Incorporated. The MAC address is used for radio network address identification. The MAC address can not be modified by the User and is located in protected flash memory. Figure 5 depicts the communication protocol between iControl iCHIME and the iGATE reader. The communication protocol utilizes a unique 8 byte MAC address defined by the IEEE 802.15.4 standard.

In Figure 5,

The iCHIME address is (0x0035A923000000002).

The iGATE address is (0x0035A9230A010203)

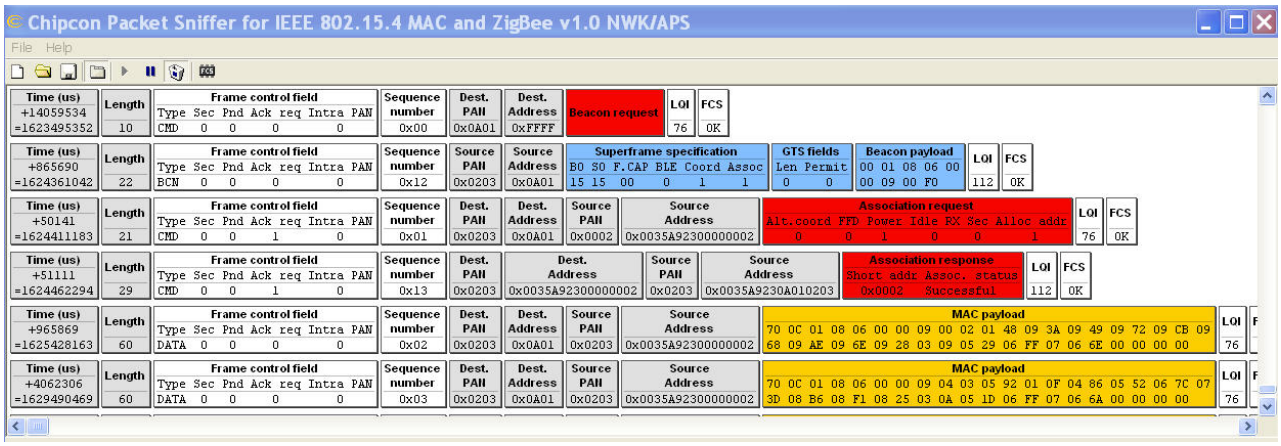


Figure 10

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FCC Compliance:

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.

Troubleshooting:

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:

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

Conditions:

Operation is subject to the following two conditions:
1. This device may not cause harmful interference
2. This device must accept any interference received, including interference that may cause undesired operation.

Markings:

To satisfy FCC exterior labeling requirements the following text must be placed on the exterior of the product.

Contains Module FCC ID: **FCC ID: W2E-ICHIMEV20**

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FCC Warnings:

Modifications: Modifications not expressly approved by the manufacturer could void the user's authority to operate the equipment under FCC Rules.

Radio Frequency Exposure:

Notes:

1) For mobile or fixed location transmitters the minimum separation distance is 20cm, even if calculators indicate the MPE distance is less.

2) This equipment has been evaluated in accordance with the FCC bulletin 56 "Hazards of radio frequency and electromagnetic fields" and bulletin 65 " Human exposure to radio frequency and electromagnetic fields.

3) Safe operation in an uncontrolled environment will result if the following distances from the device are maintained as a minimum.