+1 408 730 5390
www.intelyt.com
1885 De La Cruz Blvd, Ste 203
Santa Clara, CA 95050

iCHIME™ IDC-ICH-V3.4 User's Manual (WIP)

Version: 1.02
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I. Background

The Intelyt iCHIME™ is 2.4 GHz bi-directional radio transceiver. A user may configure the device to support tracking shipping containers in a worldwide supply chain using the Marine Asset Tag Tracking System (MATTS) communication protocol. An iCHIME™ 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 Intelyt's iTAG™. The iCHIME™ also supports the same command list as Intelyt's iTAG™. The iCHIME™ is user configurable to periodically transmit the iCHIME™'s status via the MATTS radio network. The iCHIME™ may operate as standalone device or may be used as a radio transceiver for devices that communicate data as a part of a larger system.

There is no external user interface to an iCHIME™ except the battery charging contacts. All iCHIME™s should use an Intelyt provided charging station.

[EXTERNAL PHOTOS REMOVED FOR CONFIDENTIALITY]

Figure 1: iCHIME™ IDC-ICH-V3.4 Device

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II. Radio Operation

The iCHIME™ is controlled via the radio network 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.

III. Other Components

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

1. There is an onboard temperature sensor integrated with the iCHIME™. The default iCHIME™ data packet includes the device temperature, radio signal strength, and battery status.
2. The iCHIME™ has non-volatile on-board data storage which may collect data for later upload.
3. The iCHIME™ provides date and time stamps for all data. The onboard clock for the iCHIME™ is set to UTC automatically by gateways in the network or from a communicating iTAG™.

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IV. Brief Operational Description

The iCHIME™ represents the 'parts' of a shipment – each carton or crate is linked to an iCHIME™ by scanning the carton / crate ID barcode and the iCHIME™ barcode. The iCHIME™ is either attached to the side of the carton / crate or placed inside. Once all iCHIME™s have been scanned for the shipment, they are activated and will regularly communicate with an associated iTAG™ when requested to do so by the iTAG™. Upon arrival each iCHIME™ is placed back onto a charging station where it automatically resets itself for the next shipment.

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V. Functional Block Diagram

The iCHIME™ integrates a low power microcontroller and a 2.4 GHz radio. The iCHIME™ includes a software user interface for radio control and data transmission.

NOTE: Please refer to the ***iTAG™ Command List*** for a complete list of operating commands that control both the iTAG™ and the iCHIME™.

The iCHIME™ is equipped with an integrated trace antenna rated at 3.5 dBi. All mobile applications will utilize the integral antenna provided with the iCHIME™.

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

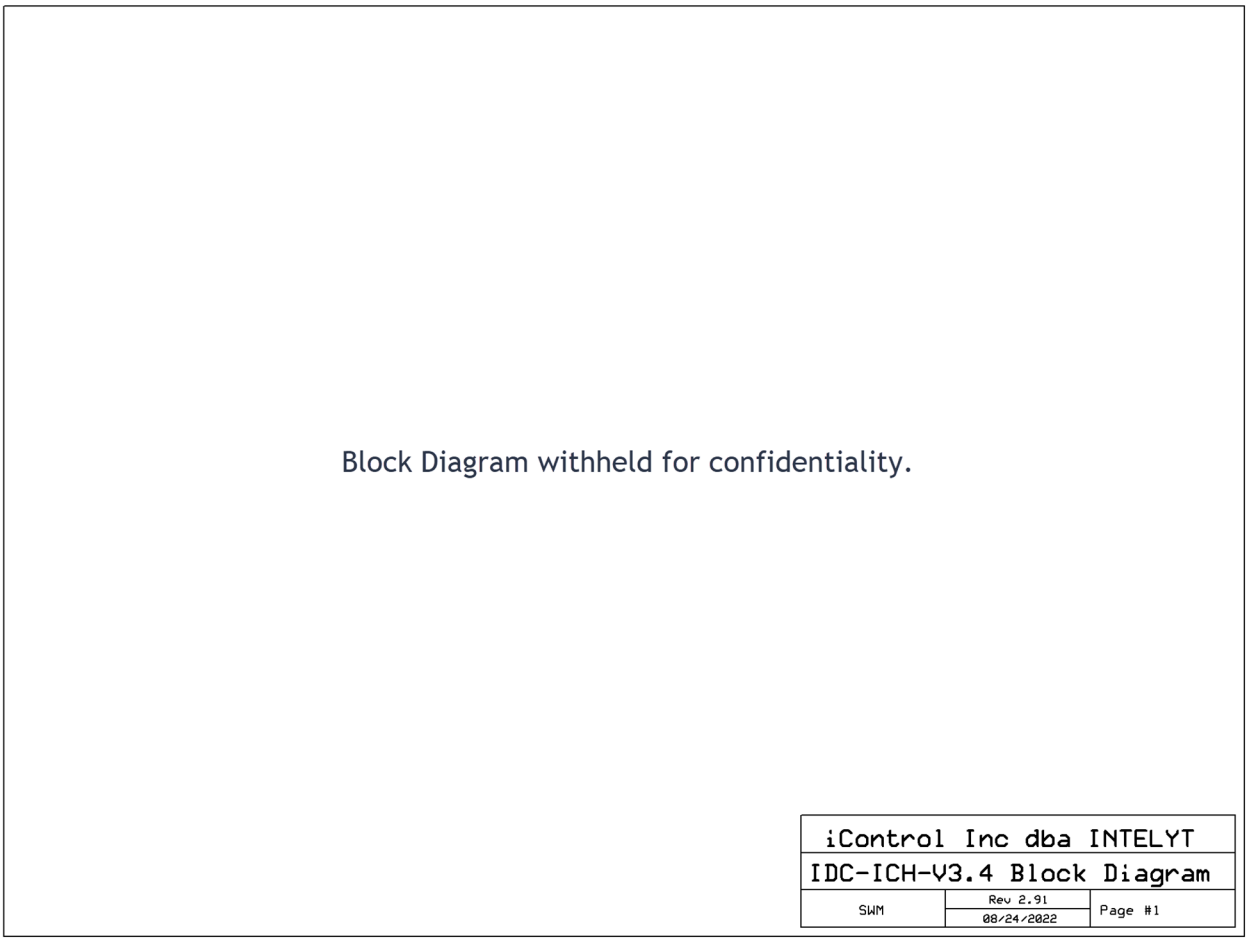

Figure 2: iCHIME™ IDC-ICH-V3.4 Functional Block Diagram

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VI. Absolute Maximum and Typical 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
Charger Supply Voltage	-0.3	30	V	Polarity protected. Onboard LI controller. Users must utilize an Intelyt provided charging station for the iCHIME™.
Voltage On Any Digital pin	-0.3	3	V	N/A
Input RF Level		10	dBm	
Storage Temperature Range	-50	85	C	
Operating Ambient Temperature	-40	50	C	

Table 1: Absolute Maximum Ratings

Parameter	Min	Typ	Max	Units
Charger Supply Operating Voltage	4.75	5	6.6	V
Battery Voltage	2.3	3.6	4.2	V
Battery Capacity		2.15		Wh
Output RF Level			14.45	dBm
2.4 Ghz Radio Channel	11	21	25	

Table 2: Typical Operation Ratings

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

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VII. General Characteristics

PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT
Power mode 1 → active	Digital regulator on, 16-MHz RCOSC and 32-MHz crystal oscillator off. Start-up of 16-MHz RCOSC		4		µs
Power mode 2 or 3 → active	Digital regulator off, 16-MHz RCOSC and 32-MHz crystal oscillator off. Start-up of regulator and 16-MHz RCOSC		0.1		ms
Active → TX or RX	Initially running on 16-MHz RCOSC, with 32-MHz XOSC OFF		0.5		ms
	With 32-MHz XOSC initially on			192	µs
RX/TX and TX/RX turnaround				192	µs
RADIO PART					
RF frequency range (1)	Programmable in 1-MHz steps, 5 MHz between channels for compliance with [1]	2405		2475	MHz
Radio baud rate	As defined by [1]		250		kbps
Radio chip rate	As defined by [1]		2		MChip/s
Flash erase cycles				20	k cycles
Flash page size			2		KB

(1) Programmable in 5 MHz steps starting at 2405 MHz per IEEE 802.15.4

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VIII. Radio Specification (Transmit Mode)

PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT
Nominal output power	Delivered to a single-ended 50-Ω load through a balun using maximum-recommended output-power setting [1] requires minimum –3 dBm			14.45	dBm
Spurious emissions Measured conducted according to stated regulations. Only largest spurious emission stated within each band.	Max recommended output power setting[1] 25 MHz–1000 MHz (outside restricted bands) 25 MHz–2400 MHz (within FCC restricted bands) 25 MHz–1000 MHz (within ETSI restricted bands) 1800–1900 MHz (ETSI restricted band) 5150–5300 MHz (ETSI restricted band) At 2 × f_c and 3 × f_c (FCC restricted band) At 2 × f_c and 3 × f_c (ETSI EN 300-440 and EN 300-328)[2] 1 GHz–12.75 GHz (outside restricted bands) At 2483.5 MHz and above (FCC restricted band) f_c= 2480 MHz[3]		–60 –60 –60 –57 –55 –42 –31 –53 –42		dBm
Optimum load impedance	Differential impedance as seen from the RF port (RF_P and RF_N) towards the antenna		69 + j29		Ω

Parameter	Condition		Typical	Unit
Emission with TXPOWER = 0xE5	Conducted 2•RF (FCC restricted band) Conducted 3•RF (FCC restricted band)		–51.8 –49.5	dBm
Max Error Vector Magnitude (EVM)	IEEE 802.15.4 requires max. 35% Measured as defined by IEEE 802.15.4	TXPOWER = 0xF5, f = IEEE 802.15.4 channels	17	%
		TXPOWER = 0xE5, f = IEEE 802.15.4 channels	12.5	
		TXPOWER = 0xD5, f = IEEE 802.15.4 channels	7.8	
		TXPOWER = 0xC5 f = IEEE 802.15.4 channels	4.4	

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IX. Radio Specification (Receive Mode)

Parameter	Condition	Typical	Unit
Receive Sensitivity HGM	1 % PER, IEEE 802.15.4 requires -85 dBm	–99	dBm
Receive Sensitivity LGM	1 % PER, IEEE 802.15.4 requires -85 dBm	–95.5	
Saturation HGM	IEEE 802.15.4 requires -20 dBm	–2	
Saturation LGM	IEEE 802.15.4 requires -20 dBm	–1	

PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT
Adjacent-channel rejection, 5-MHz channel spacing	Wanted signal –82 dBm, adjacent modulated channel at 5 MHz, PER = 1 %, as specified by [1]. [1] requires 0 dB		49		dB
Adjacent-channel rejection, –5-MHz channel spacing	Wanted signal –82 dBm, adjacent modulated channel at –5 MHz, PER = 1 %, as specified by [1]. [1] requires 0 dB		49		dB
Alternate-channel rejection, 10-MHz channel spacing	Wanted signal –82 dBm, adjacent modulated channel at 10 MHz, PER = 1%, as specified by [1] [1] requires 30 dB		57		dB
Alternate-channel rejection, –10-MHz channel spacing	Wanted signal –82 dBm, adjacent modulated channel at –10 MHz, PER = 1 %, as specified by [1] [1] requires 30 dB		57		dB
Channel rejection ≥ 20 MHz ≤ –20 MHz	Wanted signal at –82 dBm. Undesired signal is an IEEE 802.15.4 modulated channel, stepped through all channels from 2405 to 2480 MHz. Signal level for PER = 1%.		57 57		dB
Co-channel rejection	Wanted signal at –82 dBm. Undesired signal is 802.15.4 modulated at the same frequency as the desired signal. Signal level for PER = 1%.		–3		dB
Blocking/desensitization 5 MHz from band edge 10 MHz from band edge 20 MHz from band edge 50 MHz from band edge –5 MHz from band edge –10 MHz from band edge –20 MHz from band edge –50 MHz from band edge	Wanted signal 3 dB above the sensitivity level, CW jammer, PER = 1%. Measured according to EN 300 440 class 2.		 –33 –33 –32 –31 –35 –35 –34 –34		dBm
Spurious emission. Only largest spurious emission stated within each band. 30 MHz–1000 MHz 1 GHz–12.75 GHz	Conducted measurement with a 50-Ω single-ended load. Suitable for systems targeting compliance with EN 300 328, EN 300 440, FCC CFR47 Part 15 and ARIB STD-T-66.		< –80 –57		dBm
Frequency error tolerance(1)	[1] requires minimum 80 ppm		±150		ppm
Symbol rate error tolerance(2)	[1] requires minimum 80 ppm		±1000		ppm

(1) Difference between center frequency of the received RF signal and local oscillator frequency.
(2) Difference between incoming symbol rate and the internally generated symbol rate

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X. Module Unique Address Identification

Each iCHIME™ is assigned a unique 8-byte MAC address by Intelyt. The MAC address is used for radio network address identification. The MAC address is saved in protected flash memory and cannot be modified by the user. Figure 4 depicts the communication protocol between and Intelyt iCHIME™ and an Intelyt iGATE™ reader. The communication protocol utilizes a unique 8-byte MAC address defined by the IEEE 802.15.4 standard.

In Figure 3, The iCHIME™ address is (0x0035A92300000002) while the iGATE™ address is (0x0035A9230A010203).

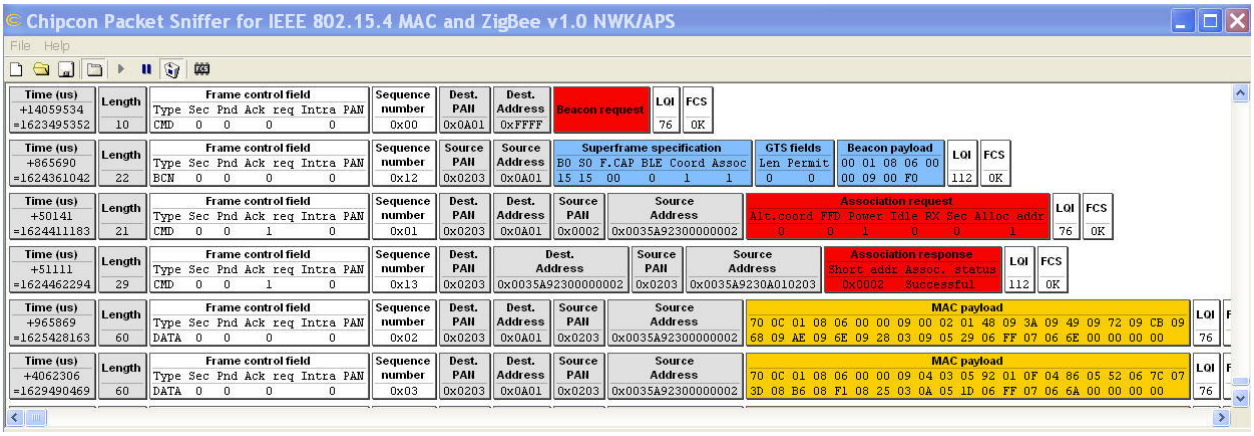

Figure 3: Radio Sniffer Capture of iCHIME™ Communication

XI. 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 an installation.

Warning:
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.

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

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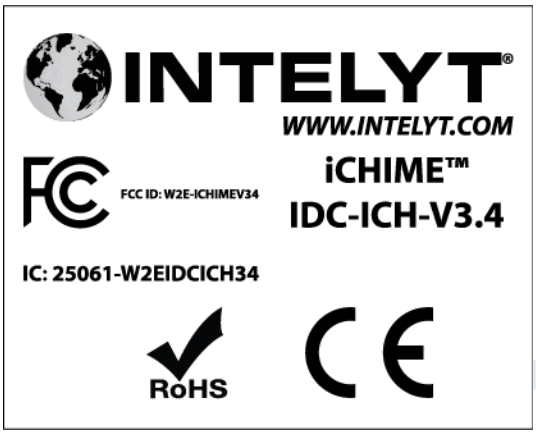
Radio Frequency Exposure:

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.

Markings:
To satisfy FCC exterior labeling requirements the following label must remain on the exterior of the product. **FCC ID: W2E-ICHIMEV34**



XII. 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.

XIII. General Warnings

Dispose of used batteries according to the instructions listed in the Intelyt Product Information Sheet. Intelyt products contain recyclable materials and should not be put into the municipal waste stream. Refer to the following website for additional recycling information (https://www.techwalla.com/articles/how-to-dispose-of-lithium-ion-batteries). Do not dispose of in fire.

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This equipment design typically applies to commercial or industrial equipment expected to be installed in locations where only adults are normally present. This equipment is not suitable for use in locations where children are likely to be present.

XIV. Canada

[English] This device complies with Innovation, Science and Economic Development Canada's license-exempt RSSs. 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.

[English] Radiation Exposure Statement: This equipment complies with the IC RSS-102 radiation exposure limits set forth for an uncontrolled environment. This equipment should only be installed and operated with a minimum distance of 20cm between the radiator and your body.

[French] Cet appareil est conforme aux flux RSS exemptes de licence d-Innovation, Science et Développement économique Canada. L'opération est soumise aux deux conditions suivantes:

(1) Cet appareil ne doit pas provoquer d'interférence; et
(2) Cet appareil doit accepter toute interference, y compris les interférences susceptibles de provoquer un fonctionnement indésirable de l'appareil.

[French] Énoncé d'exposition aux rayonnements: Cet équipment est conforme auz limites d'exposition aux rayonnements ioniques RSS-102 Pour un environment incontrôlé. Cet équipment doit etre installé et utilisé avec un Distance minimale de 20cm entre le radiateur et votre corps.

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XV. List of Certifications

Certification	Status	ID / Report #
USA FCC	Pending	W2E-ICHIMEV34
European Union CE	Pending	
Canada ISEDC	Pending	25061- W2EIDCICH34
RTCA DO-160G Section 21 Category H	Passed	EMCS93763-GEN
UN38.3	Passed	See vendor battery docs
RoHS	Compliant	See Intelyt RoHS Declaration of Conformity

Table 3: List of device certifications