

TECHNICAL PUBLICATIONS

CT 3500 Hardware Guide

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PREFACE

Purpose

This guide is as an overview of the hardware characteristics and specifications for the CT 3500.

Notation

Hardware components and hardware labels in this document might not be exactly as shown and are subject to change without notice.

CAUTION: This safety symbol warns of possible hazards to personnel, equipment, or both. It includes hazards that will or can cause personal injury, property damage, or death if the hazard is not avoided.

Note: A note indicates information with no potential hazard. A note indicates points of interest or provides supplementary information about a feature or task.

Bulleted lists highlight information where order or sequence is not crucial.

Battery Safety Warnings

CAUTION: DO NOT short circuit or expose the battery to temperatures above the maximum rated temperature.

CAUTION: Always follow local disposal guidelines to properly dispose of the Lithium-ion battery and the device.

CAUTION: Store in a cool, well-ventilated area. Elevated temperatures will result in shortened battery life.

CAUTION: DO NOT throw the internal battery or the device into fire.

CAUTION: DO NOT replace the battery. Changing the battery without ORBCOMM's permission could violate regulatory conformity.

CAUTION: If Shipping the device, contact your local shipping carrier for safe shipping guidelines.

1 OVERVIEW

The CT 3500 enables complete visibility and remote reefer management on land, rail or sea. It provides comprehensive reports, analytics and alerts to help streamline container operations and drive efficiencies.

The CT 3500 utilizes a rugged, IP67 enclosure that houses all electronics, power control, and antennas. External interfaces are available through a rugged external connector.

The CT 3500 can be powered externally through the main connector or through the internal rechargeable battery. While operating on battery, the CT 3500 is capable of powering the refrigerated container microcontroller to read critical information even when the container is not connected to external power.

Figure 1: CT 3500



2 SPECIFICATIONS

2.1 Temperature

Parameter	Value
Operating temperature range	-40°C to +85°C (-40°F to +185°F)
Recommended storage temperature range	-40°C to +85°C (-40°F to +185°F) Storage for extended periods of time outside of -20°C to +25°C (-4°F to +77°F) can result in non-recoverable battery capacity loss.
Internal battery operating temperature range	-20°C to +60°C (-4°F to +140°F)
Internal battery charging temperature range	0°C to +45°C (32°F to +113°F)

2.2 Electrical Specifications

The main power source for the CT 3500 is external power provided by the refrigerated container. While operating on external power, the input power also charges the device's internal back up battery. When external power is removed the device operates using its internal battery at a somewhat reduced feature set.

2.2.1 Power Supply Voltage

Parameter	Value
Power supply voltage (AC) range	15 V to 36 V, 50 Hz to 60 Hz

2.2.2 Input Power

Mode	Maximum Input Power
Cellular Transmit	6.65 W
Battery Charge	4 W
Cellular Transmit + Battery Charge	10 W

2.3 Power Connector

The CT 3500 uses a 12-pin, IP67 M12 A-Code Key connector.

[Table 1](#) maps to the layout shown in [Figure 2](#).

Figure 2: PIN Connector View

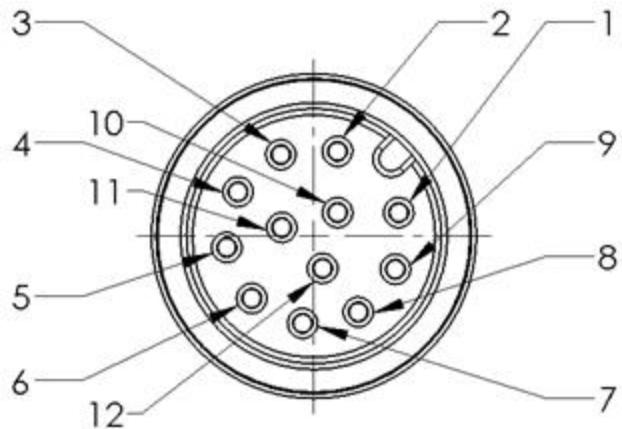


Table 1: Electrical Pin Assignment

PIN	Function	PIN	Function
1	VIN (24 VAC)	7	Console RS-232 Tx
2	Digital Input	8	Analog Ground
3	1-Wire	9	Analog Input
4	12 V Power Out	10	Configurable I/O
5	Reefer Serial B (RS-232-RX)	11	Reefer Serial A (RS-232-TX)
6	Ground	12	Console RS-232 Rx

2.4 I/O Interface

The device supports one (1) optional configurable I/O that operates independently in one of six (6) modes.

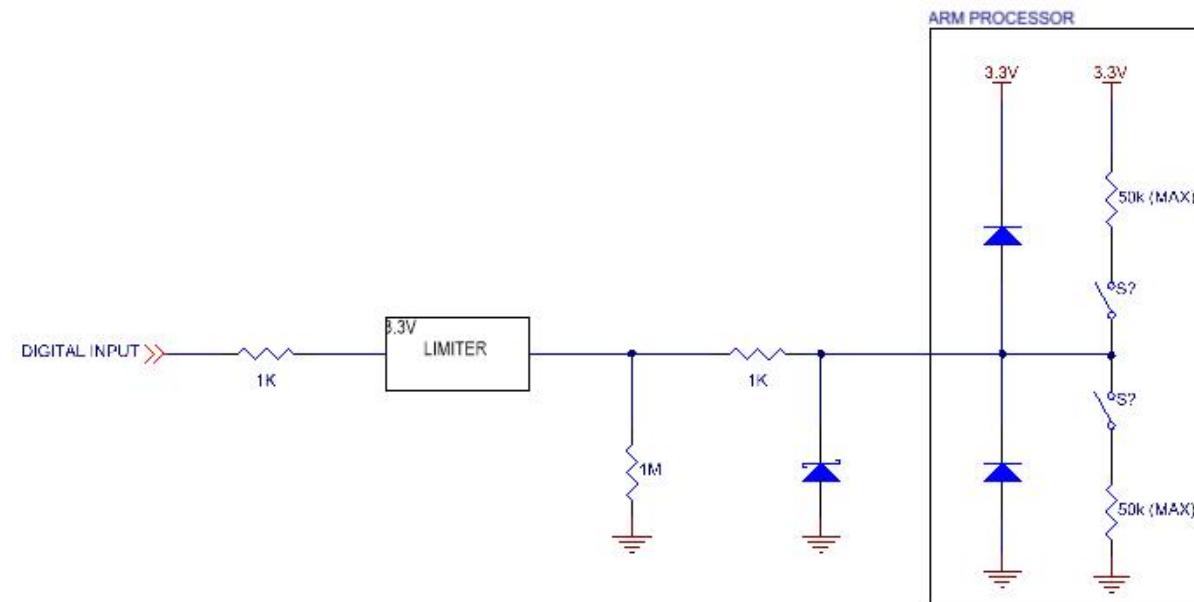
- Digital input with weak ($1\text{ M}\Omega$) pull-down
- Digital input with 30 to 50 K pull-down
- Digital input with 30 to 50 K pull-up
- Analog input with 0 to 2.5 V range
- Digital output – push-pull
- Disabled (equivalent to analog input)

The configurable I/O is protected for load dump, ESD, and reverse polarity.

2.4.1 Digital Input

Figure 3 shows a schematic of the I/O when configured as a digital input.

Figure 3: Digital Input



Input Type	S1	S2
With pull-down	Open	Closed
With pull-up	Closed	Open
With weak pull-down	Open	Open

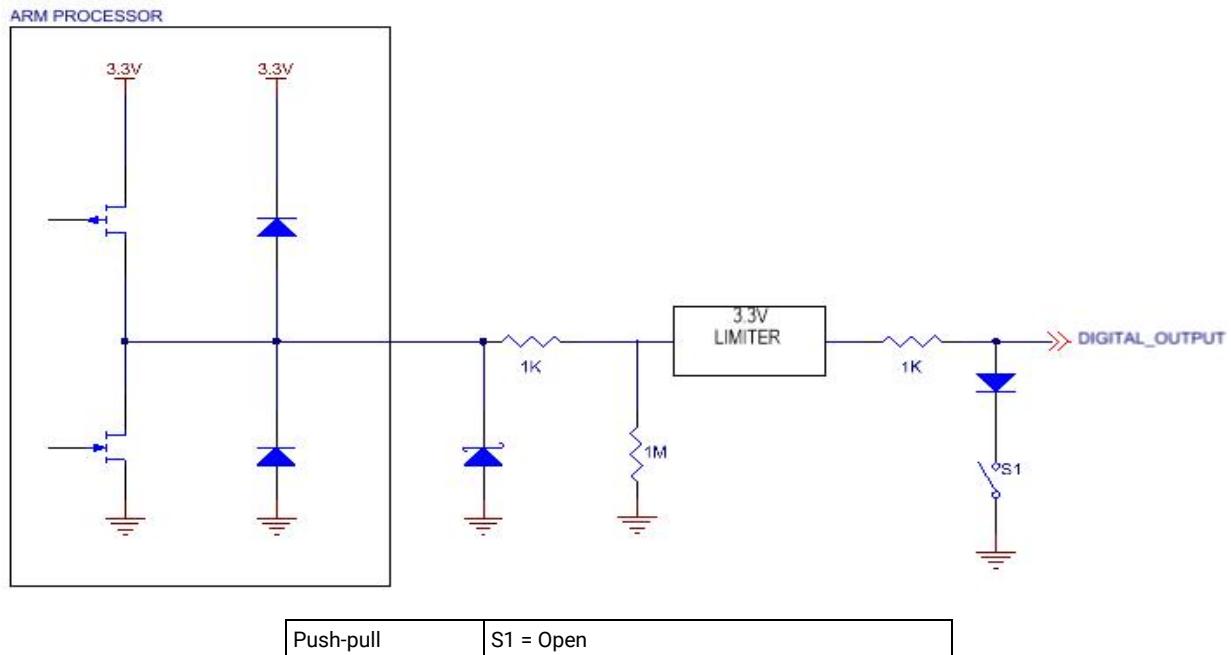
The input specifications are provided in the table below.

Parameter	Min.	Typical	Max.	Units
Input low range	-10	-	1.15	V
Input high range	2.30	-	58	V
Input current, pull-up/pull-down disabled (weak 1MΩ pull-down still in place); $V_{in} = 3.0$ V	-	3	-	µA
Input source current, pull-up enabled ($V_{in} = 0.0$ V)	-	75	-	µA
Input sink current, pull-down enabled ($V_{in} = 3.3$ to 150 V)	-	24	-	µA
Input bandwidth	1	-	-	kHz

2.4.2 Digital Output

Figure 4 shows a schematic of the I/O when configured as a digital output.

Figure 4: Digital Output



2.4.2.1 Push-pull

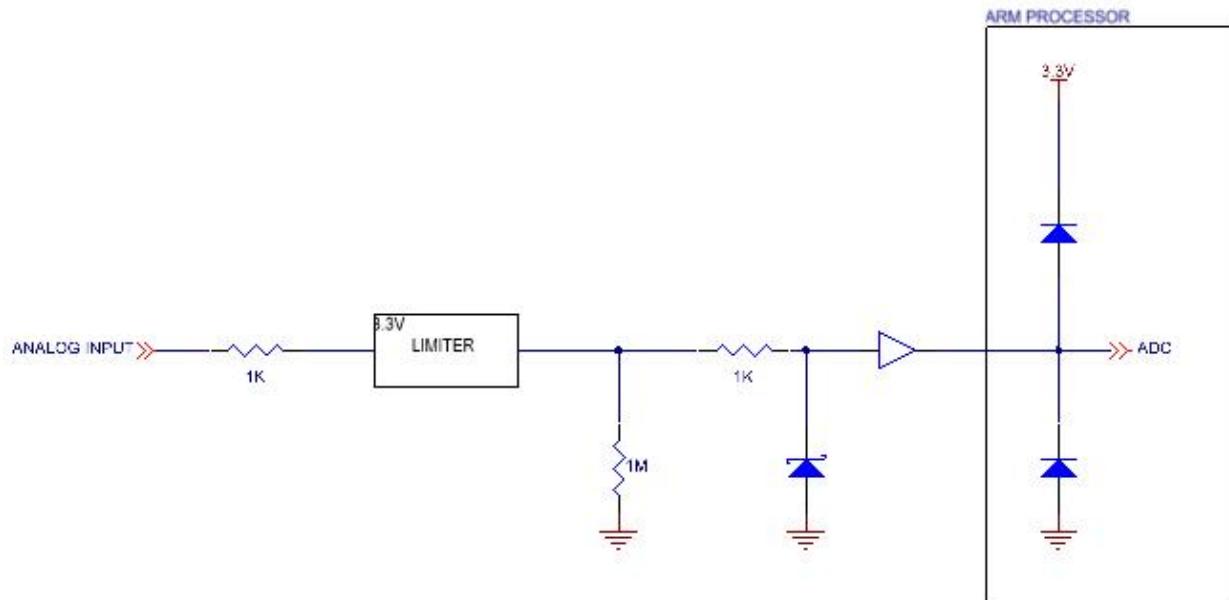
In the push-pull configuration the output is driven directly from the microprocessor.

Parameter	Min.	Typical	Max.	Units
Output high voltage - open circuit	2.8	-	-	V
Output high voltage (sourcing 25 μ A)	2.8	-	-	V
Output low voltage (sinking 25 μ A)	-	-	0.5	V
Output bandwidth	100	-	-	Hz

2.4.3 Analog Input

Figure 5 shows a schematic of the I/O when configured as an analog input.

Figure 5: Analog Input



Parameter	Min.	Typical	Max.	Units
Input impedance	-	1	-	MΩ
Measurement range	0	-	2.5	V
Resolution (12 bits)	-	0.6	-	mV
Proportional measurement error	-	-	1.5	%
Offset error	-	-	2	LSB
Voltage limits	-10	-	58	V

2.5 Dedicated Inputs

The device includes a dedicated digital input and a dedicated analog input.

2.5.1 Digital Input

The I/O characteristics of the dedicated digital input are below.

Parameter	Min.	Typical	Max.	Units
Input low	-	-	1	V
Input high	2	-	-	V
Input current, $V_{in} = 3$ V	-	9.7	-	µA
Input source current, pull-up enabled ($V_{in} = 0$ V)	-	15	-	nA
Input sink current, pull-down enabled ($V_{in} = 3$ to 58 V)	-	33	-	µA
Input bandwidth	1	-	-	kHz

2.5.2 Analog Input

The analog input can operate in one of two modes:

- 0 to 5 V analog input
- Thermistor input

The I/O characteristics of the dedicated analog input are below.

Parameter	Min.	Typical	Max.	Units
Input bandwidth	1	-	-	kHz
Processor ADC				
Measurement range	0	-	2.5	V
Resolution (12 bits)	-	0.6	-	mV
Proportional measurement error	-	-	1.5	%
Offset error	-	-	2	LSB
Temperature Analog Input				
Typical input impedance	-	>1	-	MΩ
Voltage limits	-	-	2.5	V
Analog Input				
Typical input impedance	-	50	-	kΩ
Voltage limits	-	-	2.5	V
Thermistor Input				
Pull-up resistance	-	7.5	-	kΩ
Pull-up voltage	-	2.5	-	V

2.6 Serial Interface

2.6.1 Console RS-232

The device includes a dedicated console RS-232 interface for configuration. The console RS-232 is asynchronous with 1 start bit, 8 data bits, no parity, 1 stop bit; the minimum baud rate is 9600 bps, while the maximum rate is 115.2 kbps.

The electrical characteristics of the console RS-232 are:

Parameter	Min.	Typical	Max.	Units
RIN upper-level input voltage	2.7	-	-	V
RIN lower-level input voltage	-	-	-2.7	V
RIN input threshold for disconnect	-0.3	-	0.3	V
ROUT high-level input voltage	2.7	-	-	V
ROUT low-level input voltage	-	-	0.4	V
DIN high-level input voltage	2.0	-	-	V
DIN low-level input voltage	-	-	0.8	V
DOUT High-level output voltage (3 kΩ load)	-	5.4	-	V
DOUT Low-level output voltage (3 kΩ load)		-5.4		V

2.6.2 Reefer RS-232

The device includes a reefer RS-232 interface. The reefer RS-232 is asynchronous with 1 start bit, 8 data bits, no parity, 1 stop bit; the minimum baud rate is 9600 bps, while the maximum rate is 115.2 kbps.

The electrical characteristics of the reefer RS-232 are:

Parameter	Min.	Typical	Max.	Units
RIN	-5.0	-5.4	-	V
RIN upper-level input voltage	2.7	-	-	V
RIN lower-level input voltage	-	-	-2.7	V
RIN input threshold for disconnect	-0.3	-	0.3	V
ROUT	-	5.4	-	V
ROUT high-level input voltage	2.7	-	-	V
ROUT low-level input voltage	-	-	0.4	V
DIN high-level input voltage	2.0	-	-	V
DIN low-level input voltage	-	-	0.8	V
DOUT High-level output voltage (3 kΩ load)	-	5.4	-	V
DOUT Low-level output voltage (3 kΩ load)		-5.4		V

2.7 12 V Power

The device has a dedicated power output to enable powering the reefer when external power is unavailable. You can enable or disable the 12 V power output.

Specifications for the 12 V power:

Parameter	Min.	Max.	Units
Voltage	11.8	12.3	V
Current	-	2000	mA

2.8 1-Wire

The 1-wire interface supports 3 V devices on the bus.

At stand speed the 1-Wire supports up to 39 devices over a 200-foot CAT5 cable.

The electrical characteristics are:

Parameter	Min.	Typical	Max.	Units
Input high voltage	1.98	-	-	V
Input low voltage	-	-	0.66	V
Output low voltage	-	-	0.2	V
Load current @ 3V	-	4	-	mA

2.9 Battery

2.9.1 Battery Voltage Measurement

The device can measure the input voltage over the range 5 V to 8.4 V to an accuracy of ± 55 mV.

2.9.2 Internal Battery

The device includes a long life, rechargeable internal battery.

The electrical specifications for the battery are below.

Parameter	Min.	Typical	Max.	Units
Capacity	2500	-	-	mAh
Voltage (nominal)	-	7.2	-	V
Current output	3	-	-	A
Over discharge limit	-	6	-	V
Charge temperature	0 / 32	-	45 / 113	°C / °F
Discharge temperature	-20 / -4	-	60 / 140	°C / °F

2.9.3 Battery Controller

The battery system includes hardware battery control that monitors and controls the charge and discharge of the device's battery pack.

Discharge is controlled such that no battery discharge is allowed over the battery pack maximum discharge temperature. The high temperature cutoff requirement is to ensure CE safety compliance.

Charging is limited to between the minimum and maximum charging temperature of the battery pack. Temperature is monitored using the thermistor internal to the battery pack.

Charge controller electrical specifications:

Parameter	Min.	Typical	Max.	Units
External Charge Voltage	21.2	-	35	V
Charge Current	-	-	400	mA
Charge Temperature	0 (32)	-	45 (113)	°C (°F)
Float Voltage	8	-	8.4	V
Charge Time	-	-	6	Hours

2.10 RF Specifications

2.10.1 Antennas

The cellular module operates with a single internal antenna covering all applicable cellular bands.

The LoRAWAN interface functions as a backup to the cellular module. The LoRAWAN modem is always powered on when connected to external power and can be powered off to save energy. LoRAWAN and cellular can not be powered simultaneously.

The cellular antenna is shared with the high frequency LoRAWAN bands. The low frequency antenna is a separate internal antenna.

Parameter	Value
LoRAWAN	(low frequency) 433 MHz and 470 MHz (high frequency) 868 MHz and 915 MHz

2.11 Cellular Communications

The CT 3500 includes a cellular module cable of global cellular communications over LTE, 3G, and 2G networks. The table shows the specifications.

Parameter	Value
LTE category	Cat 4
LTE bands	1, 2, 3, 4, 5, 6, 7, 8, 12, 13, 19, 20, 25, 26, 28, 38, 39, 40 and 41
UMTS/HSPA+ Bands	1, 2, 4, 5, 6, 8, and 19
GSM Bands	2, 3, 5, and 8

2.12 GNSS

A fully integrated GNSS solution that supports GPS, GLONASS, BeiDou, and Galileo.

The manufacturer's specifications are shown in the table that follows.

Figure 6: Multi-GNSS Specifications

Parameter	GPS	GLONASS	BeiDou
Time to First Fix			
Cold Start	30 s	27 s	28s
Aided Start	3s	4 s	6 s
Hot Start	1 s	1 s	1 s
Sensitivity			
Tracking	-163 dBm	-164 dBm	-162 dBm
Cold Start	-147 dBm	-147 dBm	-147 dBm
Hot Start	-156 dBm	-156 dBm	-156 dBm
Accuracy			
Horizontal Position (CEP) 1	2.5 m / 2.0 m		
Velocity	0.05 m/s		
Heading	0.3 degrees		

2.13 Temperature Sensor

Measures an internal temperature over the range of -40 to +85°C (-40° to +185°F), with a typical accuracy of $\pm 2^\circ\text{C}$ and an accuracy of $\pm 3^\circ\text{C}$ over the full range.

2.14 Accelerometer

The accelerometer detects motion, tilt, and shock.

The following table shows the specifications for the accelerometer.

Parameter	Condition	Min.	Typical	Max.	Units
Acceleration Range	software selectable	-	± 2	-	g
		-	± 4	-	g
		-	± 8	-	g
		-	± 16	-	g
Bandwidth Filtering	Selectable via digital interface	8	-	1000	Hz
Sensitivity	2 g	-	1024	-	LSB/g
	4 g	-	512	-	LSB/g
	8 g	-	256	-	LSB/g
	16 g	-	128	-	LSB/g

2.15 Magnet Switch

The device includes a magnetic switch, on the connector face, to allow local interaction. The switch can wake the device from sleep and perform other software defined actions.

2.16 BLE

The BLE allows the device to communicate as a peripheral with a mobile phone or other BLE enabled host for configuration. Additionally, it allows the device to communicate as a host to wireless sensors.

The characteristics for the BLE are:

Parameter	Min.	Typical	Max.	Units
Frequency	2404	-	2480	MHz
Bluetooth version compliance	-	5.0	-	-
Receive input sensitivity	-	-94	-	dBm
Output power	-	8	-	dBm
Available RAM	256	-	-	kB
Available Flash	1	-	-	MB
BLE External Memory	The device includes 16 Mbit of nonvolatile onboard flash storage. The flash is capable of 1000,000 write cycles.			
BLE RF Interface	The BLE system includes an internal antenna.			

2.17 NVM Storage

Parameter	Value
Nonvolatile onboard flash storage	128 MB
Write-erase cycles (per operating life)	100,000

2.18 EEPROM

Parameter	Value
External EEPROM	16 KB

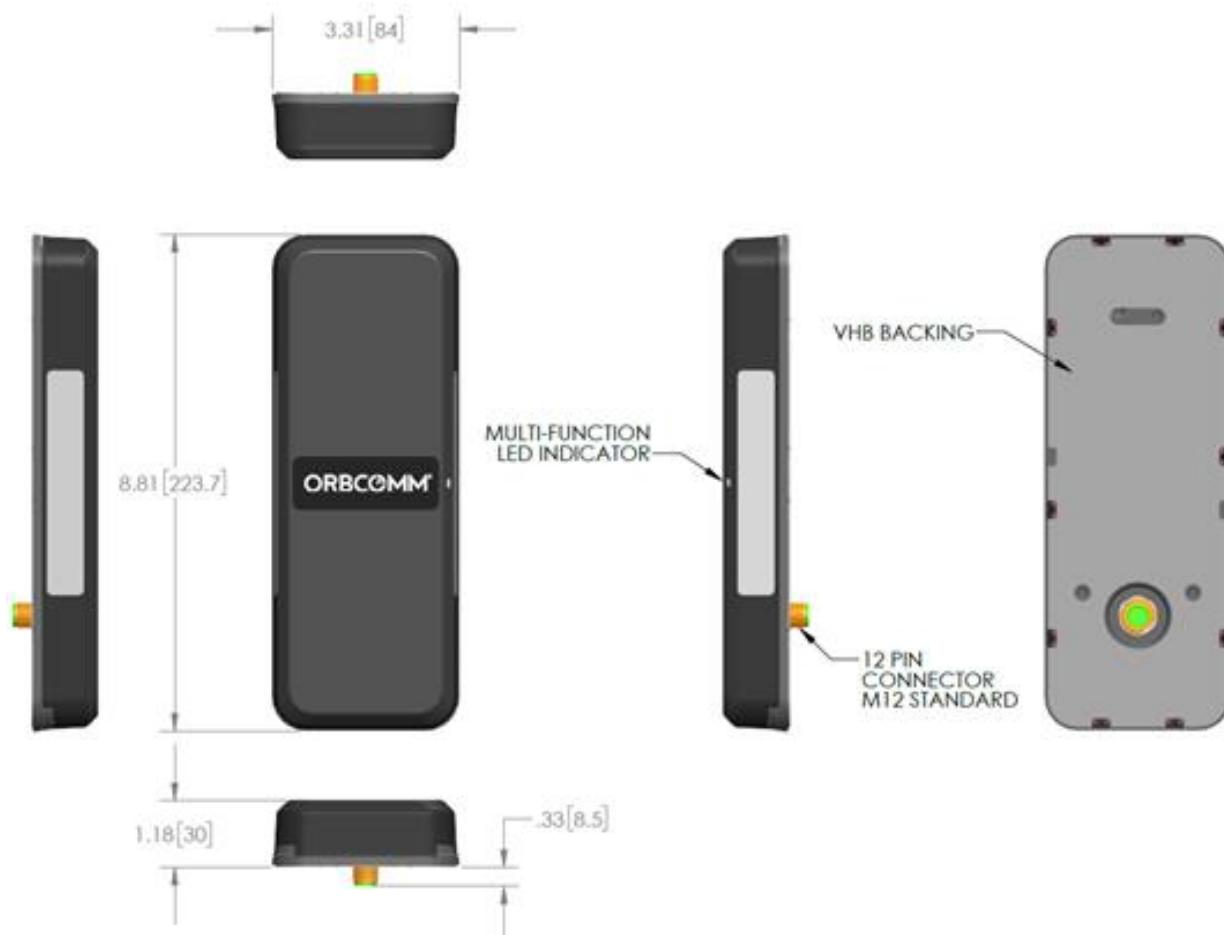
2.19 LED

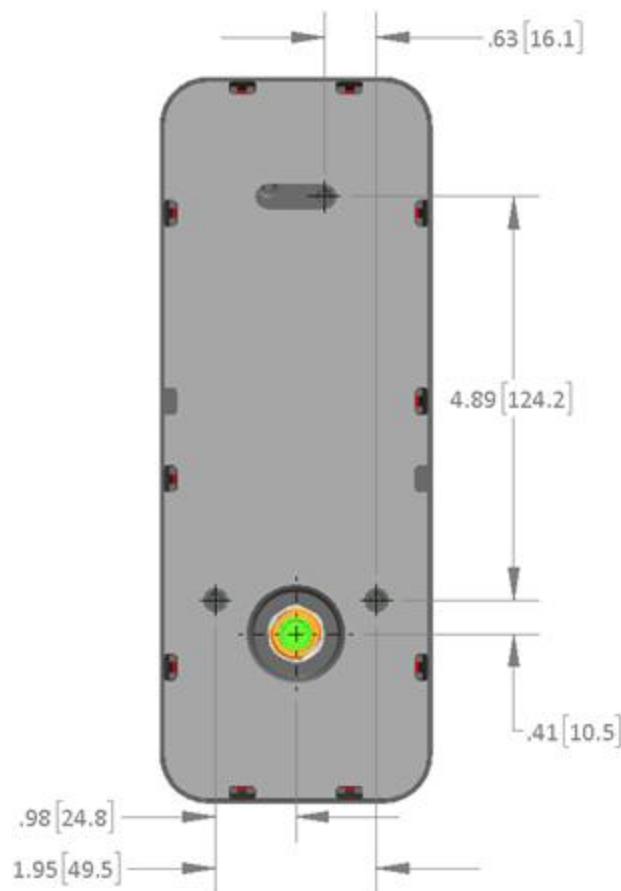
The device has a single tri-color LED. The LED indicates general device health indicator during initial power on and is dark (OFF) otherwise.

2.20 Mechanical

The weight of the CT 3500 is ~420 g (15 oz).

Units are shown in inches [millimeters].





2.21 Environmental

Parameter	Description	
Vibration	The device meets all its specifications during exposure to random vehicular vibration levels per AAR-S-9401, section 3.2.4.2.	
Humidity	The device meets all its specifications during exposure to 90% relative humidity at +85°C (185°F), per the test methodology of SAE J1455, section 4.2.3 (8-hour humidity cycle per figure 4a)	
Mechanical Shock	The device meets all its specifications after exposure to positive and negative saw tooth shock pulses with peaks of 40 G and durations of 11 ms as specified in AAR S-9401 3.2.4.3(2009)/MIL-STD-810G (2008), section 516.8, 2.3.2c Procedure I (Functional Shock), Figure 516.6-10 & Table 516.6-II Ground Equipment.	
Thermal Shock	The device meets all of its specifications after a thermal shock test as detailed in SAE J1455, section 4.1.3.2	
Handling Drop	The device meets all its specifications after a handling drop test as specified in SAE J1455, section 4.11.3.1.	
Immersion	The device meets all of its specifications after a 6-hour alternating hot / cold salt water immersion test as detailed in SAE J1455, section 4.3.3.2. These immersions were performed without a cable mating with the circular connector.	
Ingress - Solid Foreign Objects	The enclosure provides protection against ingress of solid foreign objects of IP5X as specified in IEC-60529, section 13.4 and 13.6, Category 1.	
Ingress - Water	The enclosure provides protection against ingress of water of IPX7 as specified in IEC-60529, section 14.2.7 and 14.3.	
Pressure Washing	The device provides protection against ingress of water after exposed to a pressure wash test IPX9K as per ISO 20653 Table 7 and Figure 7.	
Salt Spray Atmosphere	The device meets all of its specifications after a salt spray test as detailed in SAE J1455, section 4.3.3.1.	
Exposure to Chemicals and Oils	The device meets all of its specifications after a light to moderate splash test as detailed in SAE J1455 section 4.4.3.2, for the following chemicals: Window Washer Solvent Soap and Detergents Antifreeze Water Mixture Steam Aluminum brightener (acid wash) Degreasers Dust Control Agents (magnesium chloride) Diesel Fuel Moisture Control Agents (calcium chloride) Ether Ammonia Kerosene Gasoline Spray Paint Fuel Additives Alcohol Freon Waxes Kerosene Paint Stripper Spray Paint	
Fungus	The device meets all of its specifications after a fungus test as detailed in SAE J1455, section 4.6.3.	
ESD	The device meets all its specifications after exposure of the enclosure to 6 kV ESD air discharge per IEC61000-4-2, level 3.	

3 COMPLIANCE

ISED (Canada)

- **IC compliance statement**

This device complies with Industry Canada license-exempt RSS standard(s). Operation is subject to the following two conditions: (1) This device may not cause interference, and (2) this device must accept any interference, including interference that may cause undesired operation of the device.

Le présent appareil est conforme aux CNR d'Industrie Canada applicable aux appareils radio exempts de licence. L'exploitation est autorisée aux deux conditions suivantes: (1) l'appareil ne doit pas produire de brouillage, et (2) l'utilisateur de l'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement.

FCC (USA)

- **FCC compliance statement**

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. “

CE MARK (Europe)

- RED 2014/53/EU
- EU Declaration of Conformity

Hereby, ORBCOMM Inc. declares that the radio equipment types listed in this document comply with Directive 2014/53/EU.

The full text of the EU declaration of conformity is available from <http://www2.orbcomm.com/eudoc>.

RoHS

- Restriction of Hazardous Substances (RoHS)¹

REACH

WARNING:

- The minimum 20 cm (8 in.) separation distance from the device is required for RF exposure safety for all persons.
- Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.
- This device contains licence-exempt transmitter(s)/receiver(s) that comply with Innovation, Science and Economic Development Canada's licence-exempt RSS(s). Operation is subject to the following two conditions: (1) This device may not cause interference. (2) This device must accept any interference, including interference that may cause undesired operation of the device.

¹European Union's (EU) Directive 2002/95/EEC "Restriction of Hazardous Substances" (RoHS) in Electronic and Electrical Equipment.

- L'émetteur/récepteur exempt de licence contenu dans le présent appareil est conforme aux CNR d'Innovation, Sciences et Développement économique Canada applicables aux appareils radio exempts de licence. L'exploitation est autorisée aux deux conditions suivantes :
 - 1) L'appareil ne doit pas produire de brouillage;
 - 2) L'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement.

Ingress Protection

- CT 3500: IP67