



### Technical Datasheet



#### Scope:

This document provides a high-level overview of the Li-ion Tamer Rack Monitor system and is *not* a user manual. Reference *Li-ion Tamer Engineering Specification.pdf*, which is an all-inclusive user manual.

#### Product Description:

The Li-ion Tamer Rack Monitor is a low-power and compact device that monitors lithium-ion batteries for increased safety. The Rack Monitor consists of three primary components, (1) The Li-ion Tamer Controller, (2) The Li-ion Tamer Off-Gas Monitors, and (3) the cables for connecting the sensors to the controller, controller to power, and signal distribution.

The Off-Gas Monitors are to be installed near or at the battery rack and are aggregated at the Controller which also distributes power to the monitors. The Controller contains proprietary logic to diagnose when and where single-cell off-gas events have happened. Off-gas events occur early in the failure mode of lithium-ion batteries and awareness as to when off-gas events occur provides a very early warning of failures and enables prevention of these failures with proper mitigation.

#### Key Features:

- Early warning of lithium-ion battery failures
- Enable thermal runaway prevention with proper mitigation actions
- Single cell failure detection without electrical or mechanical contact of cells
- Extended product lifetime
- Calibration-free product
- Highly reliable output signal
- Low power consumption
- Compatible with all lithium-ion battery form factors and chemistries
- Easy installation
- Independent and redundant perspective on battery health
- Auto diagnostic capabilities
- Reduction/removal of false positive signals
- Several communication protocols including digital outputs and serial communication

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### System Specifications

The Li-ion Tamer Rack Monitoring system is designed to be compatible with a lithium-ion battery system, including environmental specifications and target lifetime. The lifetime of the Li-ion Tamer product has been validated through accelerated lifetime testing to validate the system’s life is comparable to a typical lithium-ion battery system.

#### Power consumption specifications

Detail	Specification
Controller (no sensors)	2.4 W (@ 24VDC)
	1.4 W (@ 12 VDC)
Sensor	275 mW (@ 5 VDC)
Controller (fully populated, 15 sensors)	6.6 W (@ 24 VDC)
	5.6 W (@ 12 VDC)
Fuse Rating	3.5 A

#### Environmental specifications

Condition	Specification
Temperature	-10 to +60°C
Humidity	5 to 95% RH
Max temperature change	8.6°C/min

#### Product life specifications

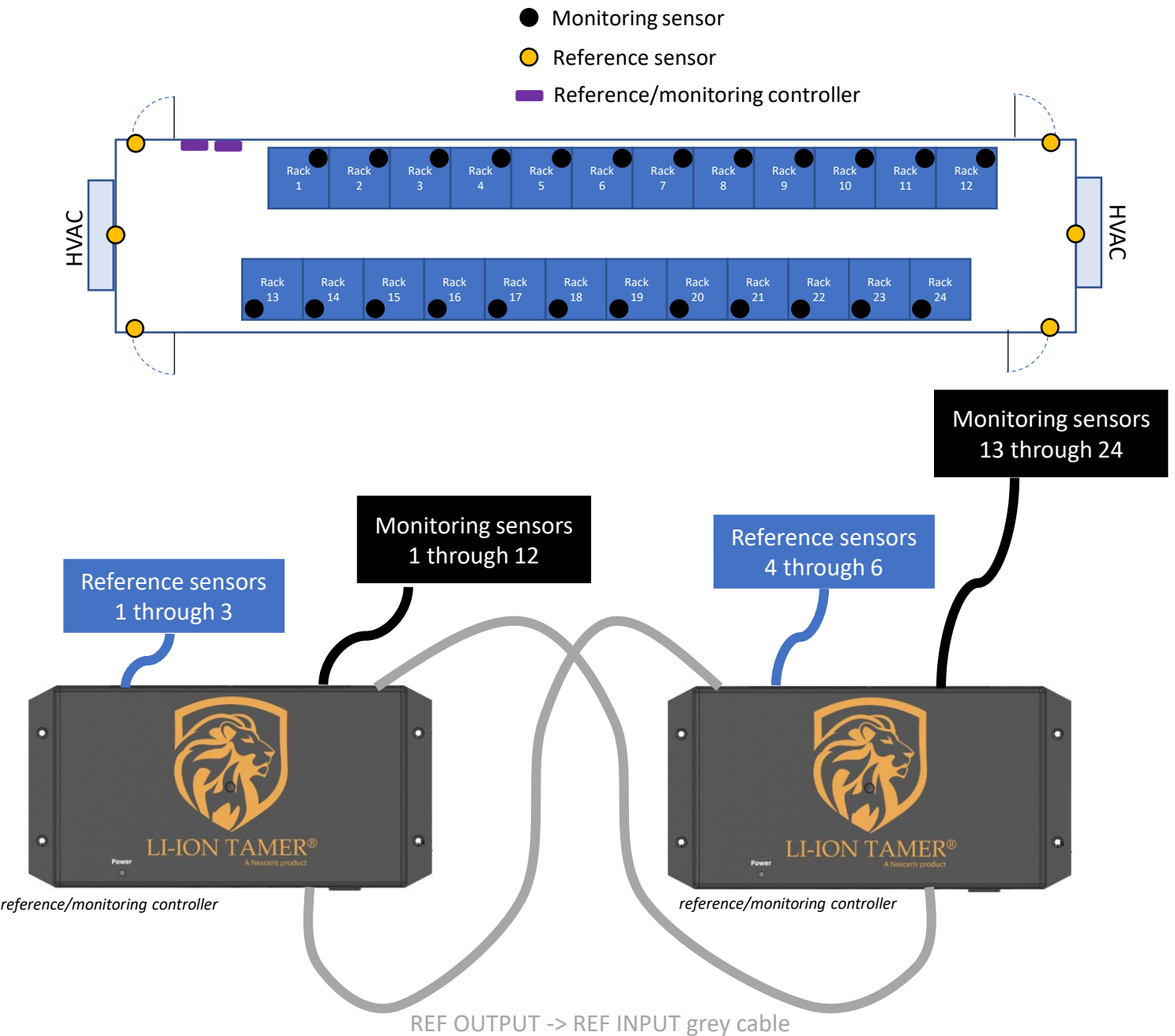
Detail	Specification
Target lifetime	10 years
Warranty	1 year

#### Designed for certifications

Detail	Certification
Ordinary Location	UL/IEC 61010
EMC	EN 60326-1 for EU Directive (2014/30/EU)
RoHS	RoHS 2 2011/65/EU

**Example System Configuration**

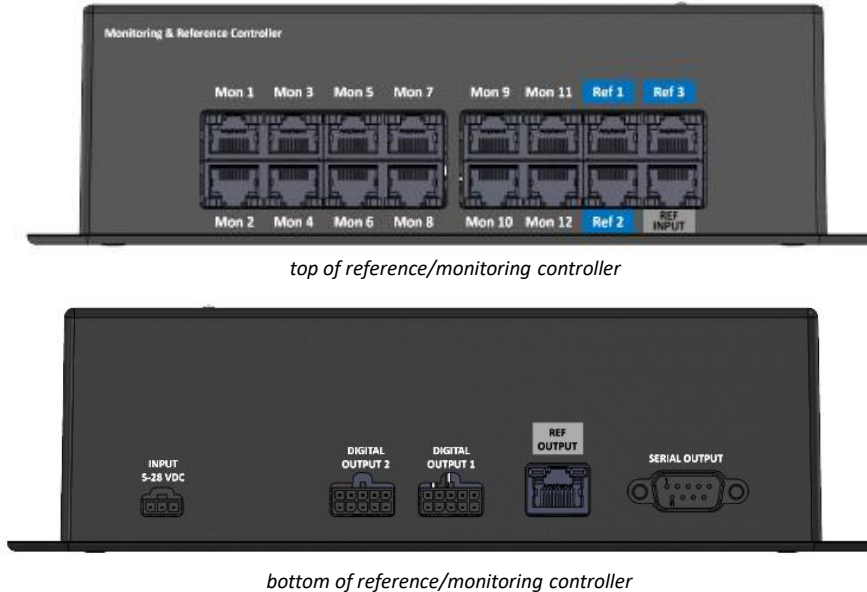
- Standard 40-foot shipping container full of twenty-four (24) battery racks
- Two (2) HVAC units on the ends of the container
- Four (4) doors for entry
- Two (2) reference/monitoring controllers for aggregating 24 monitoring sensors and 6 reference sensors
- Please note the system below is meant to communicate the types of sensors and controllers and is not a real system





### Controller Description

The controller is a critical component of the Li-ion Tamer Rack Monitoring System. Below is a depiction of the sensor input face of the combined monitoring and reference controller. Monitoring sensors are connected to the monitoring controller with black shielded ethernet cable and reference sensors are connected to the reference controller with blue shielded ethernet cable.



- If a system has more than 12 battery racks, the controller utilizes the “REF OUTPUT” connector to transmit the reference sensor signals into the “REF INPUT” connector of additional controllers with a grey shielded ethernet cable.
- All controllers have an input power range of 8 – 28 VDC.
- Up to 15 total sensors can be aggregated per reference/monitoring controller, at most 12 monitoring sensors and 3 reference sensors.
- A power LED is located on the front/top face of the controller to indicate when the controller has power.
- Output signals are communicated through the monitoring controllers in digital outputs or MODBUS communication (see [Communication Protocols](#) section for more information).
- The controllers are 210 (W) x 113 (L) x 63 (H) [mm] in dimension (see [Hardware Details](#) section for more information).
- The sensor input connectors on the controllers have LED lights for diagnosing when a sensor has experienced a malfunction (see [Troubleshooting](#) section for more information).

Controller specifications	
Detail	Specification
Dimensions	210 (W) x 113 (L) x 63 (H) [mm]
Input power range	8 – 28 VDC
Earth ground connection	Required
Max sensors per controller	12 (monitoring), 3 (reference)
Communication protocols	Digital outputs/MODBUS

### Controller Power and Earth Ground

The controllers should be mounted according to the procedure below. Additionally, a mounting template is available from Nexceris to locate mounting holes for the controller.

1. Disable any unused sensor ports, detailed in Li-ion Tamer Engineering Specification
2. Secure controller to mounting surface using four (4) mounting holes.
3. Connect controller to earth ground and power via Power Cable (PN 241157) according to the table below. Earth grounding the controller provides earth ground to the sensor network and reduces signal noise due to EMI.
4. Make all connections to the controller.

NOTE: If required, the power input can be connected to a DC power supply with a battery back-up.

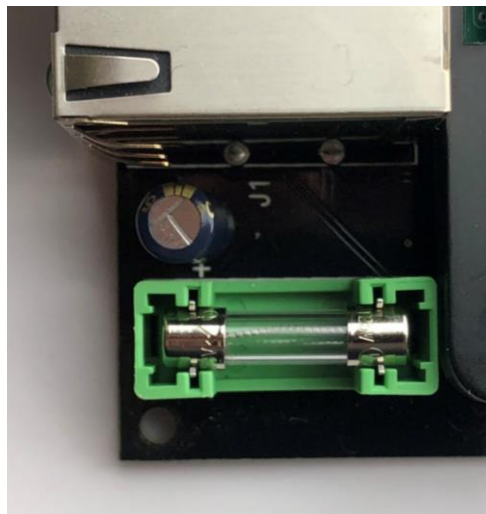


Molex Connector Pins

Controller Power Connection Specification		
Molex Connector Pin Numbers	PN 241157 Conductor Color	Function
1	Red	VDC+
2	Black	GND
3	Clear (drain wire)	Earth Ground

### Fuse Replacement

The controller and sensor network power is protected by a 3.5A fuse which is located on the printed circuit board inside the controller. Fuses must be replaced with an appropriate substitute 3.5A fuse.



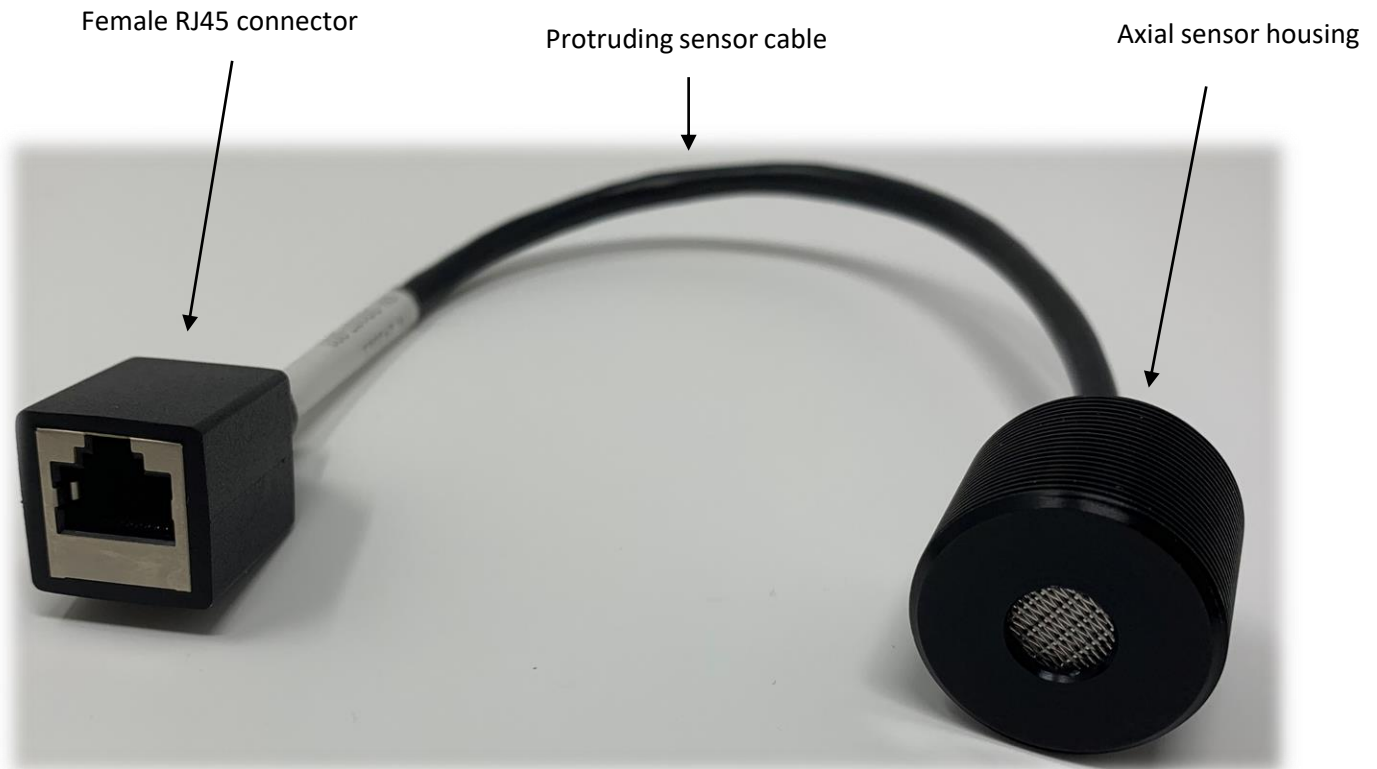


### Sensor Description

The off-gas sensor are the other critical components of the Li-ion Tamer Rack Monitoring system. The sensors are acutely sensitive to battery off-gassing compounds. Off-gassing compounds are characteristic of off-gas events, which occur prior to thermal runaway. The off-gas sensors are designed to provide indication as to when off-gas events occur. High-level gas detection specifications are shown below.

Gas detection specifications	
Detail	Specification
Target gases	Lithium ion battery off-gassing compounds
Min. detection threshold	<1 ppm/sec
Response time	5 seconds
Fault detection	Single cell failure

The sensors come in two different types, reference and monitoring sensors, both of which are fundamentally the same. The only difference between the two types of sensors is that one is monitoring the battery rack (monitoring sensor) and the other is monitoring the ambient environment (reference sensor). Monitoring sensors (PN 241022) have **black** cable protruding from the axial sensor housing and reference sensors (PN 241023) have **blue** cable protruding from the axial sensor housing. The off-gas monitor terminates in a shielded, female RJ45 connector. The color of this connector corresponds to the sensor type. This connector enables the usage of male-to-male shielded ethernet cable to connect the sensors to the controller.



## Communication Protocols

The Li-ion Tamer controller has two types of communication protocols: digital outputs and MODBUS serial communication. Both communication protocols convey if a monitoring sensor has activated and which monitoring sensor has activated. This gives the end user of the Li-ion Tamer Rack Monitor the ability to understand precisely which battery rack has experienced an off-gas event. Output signals originate from the monitoring controllers and not the reference controllers.

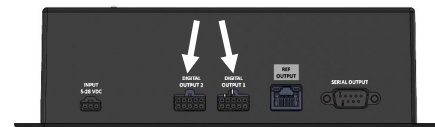
Li-ion Tamer recommends that the output signal is used to electrically isolate the battery system. Off-gas events often occur early enough in the failure mode of a lithium-ion battery that failure can be avoided. The Li-ion Tamer output signal can also be used as one of other coincident signals as an input into a fire panel for initiating fire suppression.

## Digital Outputs

Digital Output Communication Specifications	
Detail	Specification
Connector type	2x 10-pin Molex
Signal type	Digital
Signal level, normal	HIGH, 8 – 28 VDC (Input voltage) 100mA max per channel
Signal level, alarm	LOW, ~0 VDC

Digital Output Connector 1		
Pin	Status	Wire Color
1	Monitoring Sensor 1	Blue
2	Monitoring Sensor 2	Orange
3	Monitoring Sensor 3	White
4	Monitoring Sensor 4	Green
5	Monitoring Sensor 5	Red
6	Monitoring Sensor 6	White/Black
7	Monitoring Sensor 7	Red/Black
8	Monitoring Sensor 8	Green/Black
9	Sensor Error*	Orange/Black
10	GND	Black

Digital Output Connector 2		
Pin	Assignment	Wire Color
1	Monitoring Sensor 9	Blue
2	Monitoring Sensor 10	Orange
3	Monitoring Sensor 11	White
4	Monitoring Sensor 12	Green
7	Alarm Any**	Red/Black
9	Sensor Error*	Orange/Black
10	GND	Black



\*Sensor error will go into the alarm signal level if any sensor has malfunctioned or lost power (see [Troubleshooting](#) section for more details).

\*The sensor error signal is opposite the other signals. When the sensor error state is in the normal state is LOW (~0 VDC) and the alarm state is HIGH (input power)

\*\*Alarm Any will go into the alarm signal level if any signal from Monitoring Sensor 1 through 12 has gone into the alarm signal level.

The output signals are failsafe in nature and, therefore, if the controller were to lose power, the output signals would drop to 0 VDC, synonymous with the alarm state.

## MODBUS Communication

MODBUS serial communication is included as a feature in the Li-ion Tamer Rack Monitoring system. The specifications of the MODBUS communication protocol are covered in the tables below. The outputs are comparable to the **Digital Outputs** section, where there is an output for each monitoring sensor, an Alarm Any output, and a Sensor Error output. **Each bit from the serial string is either a 1 or 0, 1 being alarm state and 0 being normal state.** The controller natively has MODBUS RTU. MODBUS TCP/IP adapters are also available<sup>1</sup> upon request.

Outputs	Function Code	Index
Monitoring Sensor 1	01 (0x01)	0
Monitoring Sensor 2	01 (0x01)	1
Monitoring Sensor 3	01 (0x01)	2
Monitoring Sensor 4	01 (0x01)	3
Monitoring Sensor 5	01 (0x01)	4
Monitoring Sensor 6	01 (0x01)	5
Monitoring Sensor 7	01 (0x01)	6
Monitoring Sensor 8	01 (0x01)	7
Monitoring Sensor 9	01 (0x01)	8
Monitoring Sensor 10	01 (0x01)	9
Monitoring Sensor 11	01 (0x01)	10
Monitoring Sensor 12	01 (0x01)	11
Alarm Any	01 (0x01)	15
Sensor Error	01 (0x01)	16
Heartbeat***	04 (0x04)	5

\*\*\* The Heartbeat is a watchdog timer that continuously increases every second (until 3600 then resets to 0). It can be used to confirm that the controller is giving live information and has not timed out, frozen, or lost power.



### MODBUS communication specifications

Detail	Specification
Description	Modbus RTU over RS232
Baud rate	9600
Parity	None
Stop bit	One
Hardware	RS232 3-wire (TX, RX, ground)

<sup>1</sup> The MODBUS TCP/IP adapter is part number US2000B from [www.usconverters.com](http://www.usconverters.com) and is pre-configured to give the MODBUS TCP/IP signal an IP address of 192.168.0.7. This can be configured otherwise as well. The adapter also requires external power (8 – 36 VDC).





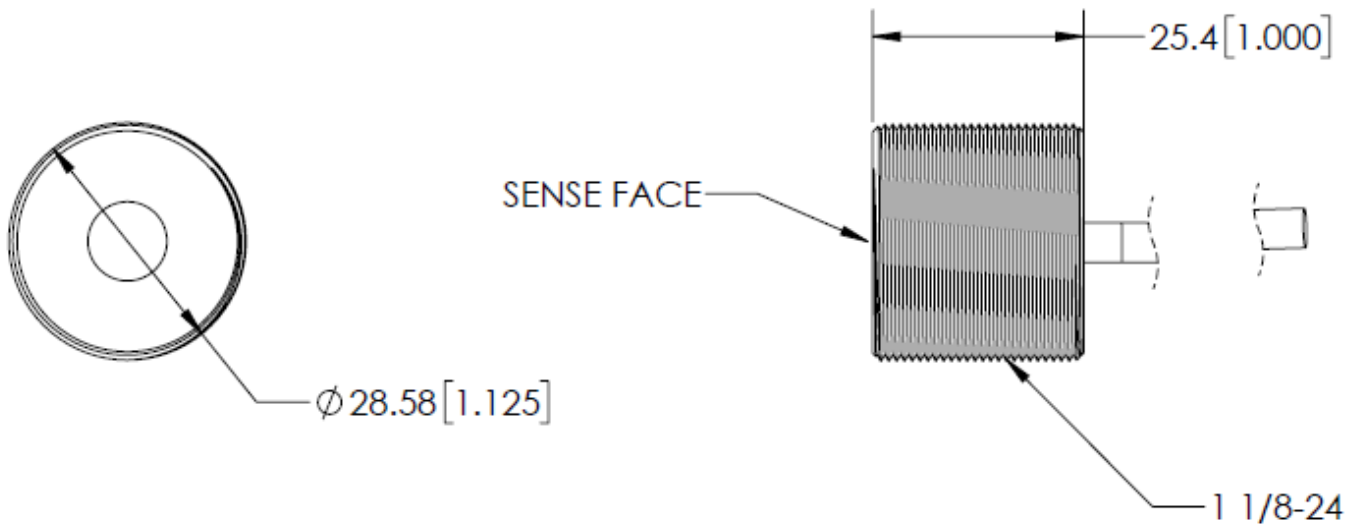
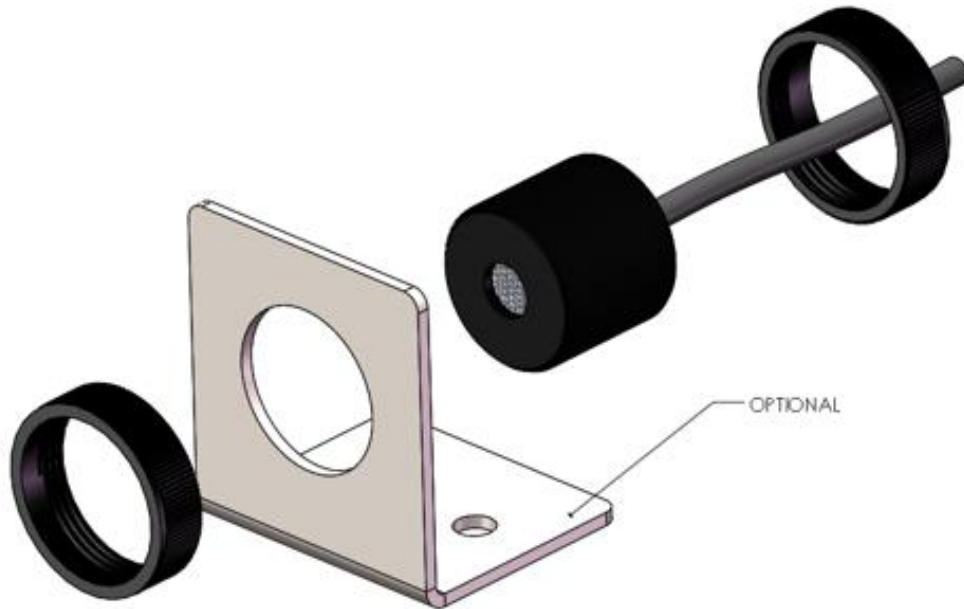
Hardware Details

Controller



Hardware Details

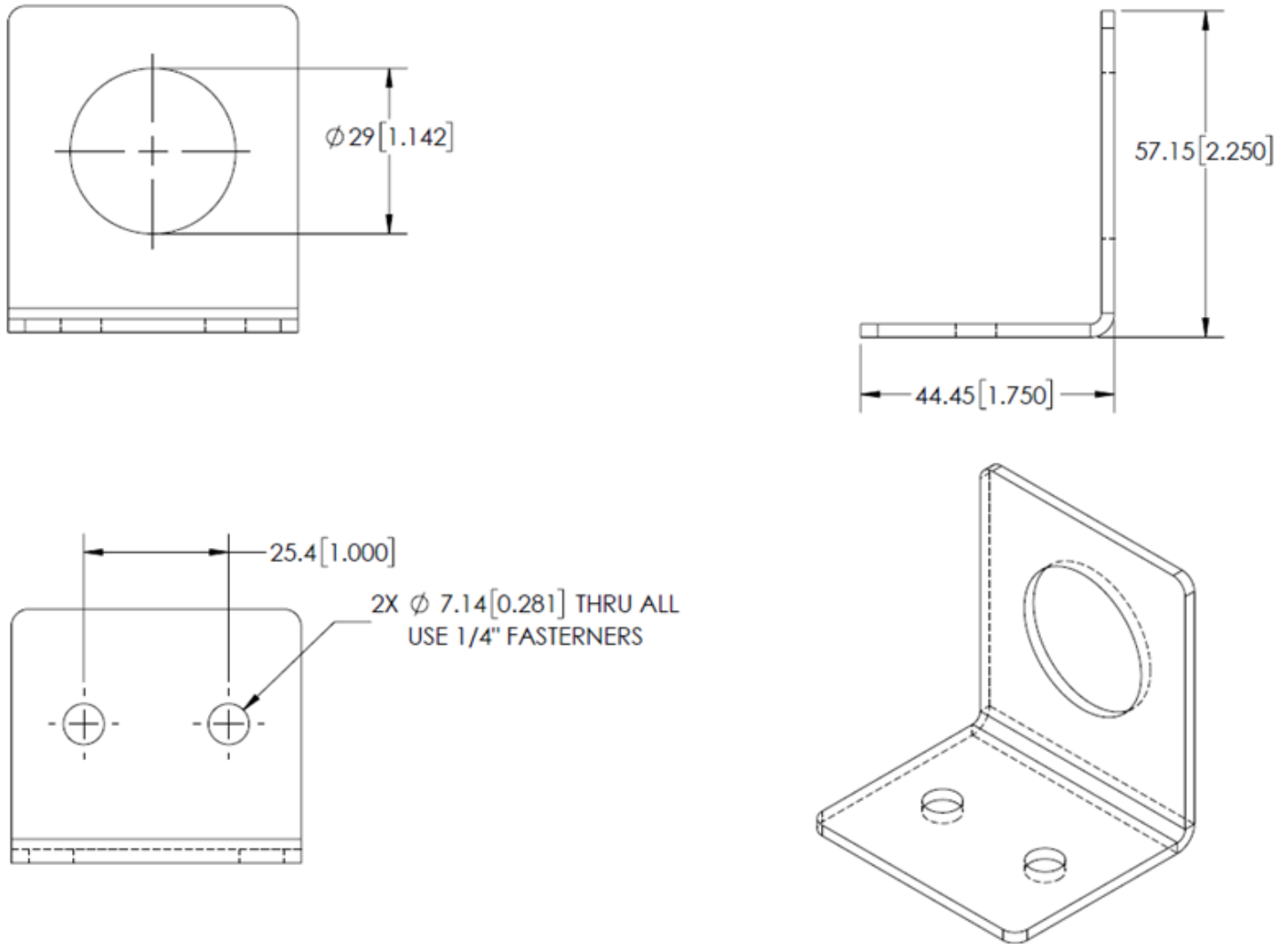
Sensor



**Hardware Details**

**Sensor Mounting Bracket**

A mounting bracket is used as the medium to mount the sensor to it's mounting location. The mounting bracket is included as a standard part of any Li-ion Tamer system.



**Notice:** This device detects off-gas from lithium-ion batteries. It does not prevent fires or thermal runaway. This device is not a stand-alone safety device and should be incorporated into a proper safety system. If the device responds, there is a risk of battery fault which could lead to thermal runaway. To avoid injury, leave the area immediately.