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Part Numbers:
007-56178-001 U1-40/
007-56179-001 U1-45/
007-56180-001 U1-50/

Revision Date:
02/15/19
Please read all contents of this User’s Guide prior to the installation of U1LiFe Batteries

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U1LiFe™ Series Battery User’s Guide - Rev: 02/15/19

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# Table of Contents

## Battery Specifications and General Information
- Overview .................................................................................................................................................. 5
- Specifications ........................................................................................................................................ 5
- Mechanical Architecture ..................................................................................................................... 6
- Dimensions .......................................................................................................................................... 6
- Terminal Specifications .......................................................................................................................... 6
- Battery Identifier Format ..................................................................................................................... 7
- Warranty Violations ............................................................................................................................. 7
- Certifications ........................................................................................................................................ 7

## Regulations
- Safety Regulations ............................................................................................................................... 8
- Transporting Lithium Ion Batteries ..................................................................................................... 9
- Moving Batteries within Your Installation .......................................................................................... 10
- Transporting Batteries to Different Location .................................................................................... 10
- Regulations by Cell/Battery Size ....................................................................................................... 11
- Following UN and DOT Regulations ................................................................................................. 11
- Environmental Regulations .............................................................................................................. 11

## Battery Performance
- Differences between U1Life and Sealed Lead Acid Batteries ............................................................ 12
- Cell Balancing ...................................................................................................................................... 12
- Discharge Performance ....................................................................................................................... 12
- Cycle Life ........................................................................................................................................... 12

## Installation
- Before You Start ................................................................................................................................. 13
- Unpacking ........................................................................................................................................... 13
- Visual Inspection ................................................................................................................................. 13
- Waking the Battery .............................................................................................................................. 13
- Installation Requirements .................................................................................................................. 13
- Connecting the Battery ....................................................................................................................... 14
- Disconnecting the Battery ................................................................................................................... 14
# Operation

Before You Start ......................................................................................................................... 15  
SMBus Communications............................................................................................................... 15  
RJ-45 Connector Pinout ............................................................................................................... 15  
Integrated Module Protection .................................................................................................... 16  
Battery LED Status Indicators .................................................................................................. 16  
Tips for Optimizing Performance ............................................................................................. 16  
Selecting a Battery Charger ...................................................................................................... 16  
U1LiFe Operating Parameters Table .......................................................................................... 17  

# Maintenance, Storage and Disposal

Maintenance Charging ............................................................................................................... 18  
Shelf Life ..................................................................................................................................... 18  
Battery Case Visual Inspection ................................................................................................ 18  
Voltage Checking ....................................................................................................................... 18  
Battery Storage ........................................................................................................................ 18  
Disposal ....................................................................................................................................... 18  
Recycling ..................................................................................................................................... 19  

# Troubleshooting

Terminal Voltage Absent or Low ................................................................................................. 20  
SMBus Not Communicating or Returns Invalid Data ................................................................. 20  
U1LiFe Rapidly Depletes Energy between Charges .................................................................. 21  
Battery Current Disappears when Charging .......................................................................... 21  
Voltage Drops Abruptly ............................................................................................................ 21  

# Emergency and First Aid Procedures

Emergency Procedures for a Melting or Smoking Battery ...................................................... 22  
First Aid Procedures for Human Contact/Exposure to Battery .............................................. 22  
Contact Information ................................................................................................................. 22  

# Glossary

Terminology ............................................................................................................................... 23  
Terminology (continued) ........................................................................................................... 24
## Battery Specifications and General Information

### Overview

The Inventus Power U1LiFe™ is a Lithium Iron Phosphate battery with integrated cell protection and balancing circuitry. The Inventus Power U1LiFe includes an integrated microprocessor to provide host communication (SMBus) as well as pack protection for over/under-voltage, over charge/discharge current, short circuit and over/under temperature conditions.

### U1 12V Specifications

<table>
<thead>
<tr>
<th>Parameter</th>
<th>U1-40</th>
<th>U1-45</th>
<th>U1-50</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nominal Voltage</td>
<td>12.8 Volts</td>
<td>12.8 Volts</td>
<td>12.8 Volts</td>
</tr>
<tr>
<td>Nominal Capacity</td>
<td>38.4 Amp Hour (491.52Wh)</td>
<td>44.8 Amp Hour (573.44Wh)</td>
<td>51.2 Amp Hour (655.36Wh)</td>
</tr>
<tr>
<td>Continuous Discharge Current</td>
<td>20 Amps</td>
<td>20 Amps</td>
<td>20 Amps</td>
</tr>
<tr>
<td>Pulse Discharge Current</td>
<td>28 Amps&lt;10 secs 50 Amps &lt;30ms 110 Amps &lt;15ms, 310 Amps &lt;827us (@25°C)</td>
<td>28 Amps&lt;10 secs 50 Amps &lt;30ms 110 Amps &lt;15ms, 310 Amps &lt;827us (@25°C)</td>
<td>28 Amps&lt;10 secs 50 Amps &lt;30ms 110 Amps &lt;15ms, 310 Amps &lt;827us (@25°C)</td>
</tr>
<tr>
<td>Operating Temperature Range</td>
<td>-20°C to +60°C</td>
<td>-20°C to +60°C</td>
<td>-20°C to +60°C</td>
</tr>
<tr>
<td>Storage Temperature Range</td>
<td>-40°C to +60°C</td>
<td>-40°C to +60°C</td>
<td>-40°C to +60°C</td>
</tr>
<tr>
<td>Maximum Charge Voltage</td>
<td>14.4 Volts</td>
<td>14.4 Volts</td>
<td>14.4 Volts</td>
</tr>
<tr>
<td>Float Charge Voltage</td>
<td>13.8 Volts</td>
<td>13.8 Volts</td>
<td>13.8 Volts</td>
</tr>
<tr>
<td>Max Charging Current @25°C</td>
<td>20 Amps</td>
<td>20 Amps</td>
<td>20 Amps</td>
</tr>
<tr>
<td>Weight</td>
<td>12.95 lbs / 5.87 kg</td>
<td>13.01 lbs / 5.94 kg</td>
<td>14.20 lbs / 6.46 kg</td>
</tr>
<tr>
<td>Dimensions (LxWxH)</td>
<td>209x137x185mm</td>
<td>209x137x185mm</td>
<td>209x137x185mm</td>
</tr>
<tr>
<td>Communication</td>
<td>SMBus</td>
<td>SMBus</td>
<td>SMBus</td>
</tr>
<tr>
<td>Operating Humidity</td>
<td>20% to 80%</td>
<td>20% to 80%</td>
<td>20% to 80%</td>
</tr>
<tr>
<td>Shipping Classification</td>
<td>Class 9</td>
<td>Class 9</td>
<td>Class 9</td>
</tr>
<tr>
<td>Case Flame Rating</td>
<td>UL-94 V-0</td>
<td>UL-94 V-0</td>
<td>UL-94 V-0</td>
</tr>
</tbody>
</table>
Mechanical Architecture

The battery consists of a top and bottom plastic clamshell, housing the cells and the printed circuit assembly. An RJ45 connector facilitates the SMBus interface to the outside world. The battery output terminals use M6x1mm bolts for secure power connections.

Terminal Specifications

The U1LiFe utilizes a custom brass terminal, with a 1/4-20 female thread. The terminals are capable of currents in excess of 25 Amps.
Battery Identifier Format

Battery Identifier format – TJ[WW]WWWWWWSSSSYYYYYMMDD – Identifier may be 21 or 23 digits.

TJ = Factory Location
W = Work order number - can be 6 or 8 characters
S = Battery Serial Number
Y = Year
M = Month
D = Day

Warranty Violations

Please contact Inventus Power Customer Support for free consultation if you have any questions about the handling, operation and safe use of this battery before proceeding further.

CAUTION: Performing any of the following actions will immediately void your warranty on the product and could lead to a potentially dangerous situation

1. Breaking the lid and exposing the circuit boards and battery assemblies
2. Operating the battery in an environment where the temperature is higher than 60°C (140°F)
3. Modifying or tampering with the RJ-45 SMBus communication interface and internal data logging functions
4. Connecting U1LiFe in a series configuration

If you believe that in the course of using the U1LiFe power system, you will conflict with any of the above listed conditions or any other safety precautions listed in this manual, please DO NOT proceed any further. Contact Inventus Power immediately for guidance and information.

Certifications

All U1 12V series batteries have been certified to the following safety and performance standards;

- UL2054
- IEC62133
- EN60601-1-2
- UN38.3
- UL1642

* Copies of the certifications are available upon request.
The chapter discusses the safety, EMC, environmental and transportation regulations applicable to the Inventus Power U1LiFe battery. The transportation material presented here is not all-inclusive of the regulations required to ship a product, but is meant to inform you of the complexity involved in doing so. Anyone involved in the integration of Lithium Ion battery packs into a host product must review the regulations cited here to meet compliance standards with industry regulations.

The U1LiFe 12V battery must be used in accordance with the manufacturer’s specifications and guidelines for recommended use. When used properly and in accordance with these instructions, the battery/power system is a safe, reliable and convenient energy storage solution.

**CAUTION: Misuse or abuse of the U1LiFe 12V Battery may result in personal injury or fire**

### Safety Regulations

- Keep all original packaging. International law dictates that the batteries are shipped under UN 3480, Class 9 rules for hazardous goods/dangerous materials.
- **Burn Hazard**
- Abusive operation of the battery (e.g. overcharge, crush, puncture, excessive heat or moisture) may produce smoke. In such an event, ventilate the area.
- Extinguish any flames with copious amounts of water, use a carbon dioxide, dry-powder fire extinguisher, or cover with sand or mud (therefore removing excess oxygen from the flame).
- **DO NOT** short circuit external contacts.
- **DO NOT** expose to temperatures above 60ºC (140ºF).
- **NEVER** charge the battery without charge protection circuitry and equipment approved by Inventus Power™.
- Remove all jewelry or other metallic objects during the installation of the battery.
- Exercise care in handling any charged battery, particularly when placing it inside a container with metal objects.
- **DO NOT** throw the battery away in the trash.
- Dispose of the battery properly in accordance with local regulations. Visit the Rechargeable Battery Recycling Corporation’s website at www.rbrc.com for more information.
- **DO NOT** use with other types of batteries connected in series or parallel with the U1LiFe Battery.
- **UN 38.3** — Requirements for safe transportation of Lithium Ion batteries.
<table>
<thead>
<tr>
<th>Symbol</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>![Triangle]</td>
<td>Important safety information will follow.</td>
</tr>
<tr>
<td>![No Fire]</td>
<td>DO NOT dispose of battery in fire.</td>
</tr>
<tr>
<td>![Recycle]</td>
<td>RECYCLE! Battery may require recycling in accordance with local laws. Regardless, recycling is encouraged. Contact local regulatory authorities for more information. DO NOT include battery with lead acid battery recycling.</td>
</tr>
<tr>
<td>![Trash]</td>
<td>DO NOT dispose of battery in the trash.</td>
</tr>
<tr>
<td>![Shock]</td>
<td>Shock Hazard - Labels may be located on or inside the equipment to alert people that dangerous voltage may be present.</td>
</tr>
<tr>
<td>![Burn]</td>
<td>Burn Hazard - Labels may be located on or inside the equipment to alert people that surface temperature may be dangerous.</td>
</tr>
</tbody>
</table>

**Transporting Lithium-ion Batteries**

This section discusses the regulations governing the transportation of Lithium Ion cells and batteries both within the United States and internationally. You should read and understand all relevant regulations discussed in this section before shipping Inventus Power U1LiFe 12V batteries.

**NOTE:** The regulations discussed in this manual apply to Lithium Ion cells and batteries. Once the Inventus Power U1LiFe is integrated into a host product, the host product may be subject to additional transportation regulations that require additional certification testing. Since Inventus Power can’t anticipate every possible configuration and application of the Inventus Power™ U1LiFe, you must verify that your Inventus Power U1LiFe powered host product is compliant with all applicable regulations.
Moving Batteries within Your Installation

- Place the battery terminal protective caps on the battery terminals prior to removing the battery from its current location, to prevent accidental shorts or arcing from occurring if a terminal touches a metal object.
- Avoid heavy vibration during transportation.
- Avoid throwing, dropping, rolling and excessive stacking during loading and transportation.
- Make sure that all cables and external connectors are disconnected and removed from the battery prior to moving it.

Transporting Battery to a Different Location

If the battery needs to be shipped to a different location or sent back to Inventus Power for any reason:

1. Disconnect all cables, both power and communications from the batteries. (reference section “Disconnecting the Battery” for proper disconnection procedure)

2. Place the protective caps on the battery terminals prior to removing the battery from its current location, to prevent accidental shorts or arcing from occurring if a terminal touches a metal object.

3. All large Lithium Ion batteries are considered “Dangerous Goods” by the US Department of Transportation, and as a result, transporting them by common carrier (whether by ground or by air) requires compliance with UN DOT regulations UN3480, Class 9 - “Dangerous Goods”.

4. Pack the batteries in “Dangerous Goods” certified boxes and packaging materials as specified by the Department of Transportation (DOT). The packaging must protect the contents from reasonable handling damage and prevent short circuits from taking place. Ideally, one would use the original box if it’s still in good condition.

5. The package should be prepared for shipment and shipping documents should be signed by an individual who is certified to handle and prepare the paperwork and products that have been designated as “Dangerous Goods” for shipment.

IMPORTANT: The U1LiFe 12V power system is shipped in a specially designed box to provide maximum protection for the contents. We strongly recommend that you save this box and use it whenever you need to transport or ship the battery. Please follow all local laws/regulations regarding the shipment of Lithium-Ion batteries.
Regulations by Cell/Battery Size

Lithium Ion batteries and cells are considered Class 9 which is one of nine classes of hazardous materials or dangerous goods defined in the UN, US and other regulations. As a class 9 material, cells and batteries must meet UN testing and packaging requirements as well as shipping regulations.

Following UN and DOT Regulations

Failure to comply with UN and DOT regulations while transporting Class 9 Hazardous Materials (Dangerous Goods) may result in substantial civil and criminal penalties.

Environmental Regulations

The battery pack is compliant with the following environmental regulations:

• EU Directive 2002/95/EC for Restriction of Hazardous Substances (RoHS)
• EU Directive 2006/66/EC on batteries and accumulators and waste batteries and accumulators
• EU Directive 1907/2006 on the Registration Evaluation Authorization and Restriction of Chemicals (REACH)
• Management Methods for Controlling Pollution Caused by Electronic Information Products Regulation (China RoHS)
Battery Performance

Differences between U1LiFe and Sealed Lead Acid batteries

The integrated cell protection and balancing circuitry responsible for the durability and additional safety features of the Inventus Power U1LiFe battery, also cause functional behavior that differs from typical lead-acid batteries.

Some major differences are:

- No voltage at the terminals does not necessarily indicate a bad battery. With a lead-acid battery, finding no voltage at the terminals often indicates the battery has reached the end of its life. With the U1LiFe battery, no voltage at the terminals typically means one of two things; the battery is in “Ship Mode” (set when leaving factory) or the cell protection circuitry has interrupted current to protect the battery. Simply connect the battery to a charger to restore voltage to the terminals.

- State of Charge (SOC) with a U1LiFe battery appears constant, then drops suddenly. Voltage for a U1LiFe remains relatively constant throughout the depth-of-discharge, while voltage for a lead-acid battery decreases at a linear rate. Therefore, determining a U1LiFe’s SOC using the same methods to determine a lead-acid battery’s SOC creates the impression that the U1LiFe has a full charge then loses power abruptly. A steady voltage across the depth-of discharge is normal behavior for the U1LiFe. The U1LiFe BMS uses custom algorithms to report SOC to the user via SMbus output.

- Inventus Power U1LiFe will exhibit 6 to 8 times the cycle life of lead acid batteries.

Cell Balancing

Over time, the cells inside a battery pack diverge in both capacity and State of Charge (SOC). The U1LiFe has integrated circuitry to continuously monitor the capacity and SOC of each individual cell string. This information is used to balance the battery and ensure maximum capacity.

Discharge Performance

In typical room temperature, the U1LiFe voltage remains virtually flat during discharge and capacity doesn’t change significantly, no matter how fast the discharge.

Cycle Life

The U1LiFe’s cycle life is determined by ambient temperature and charge/discharge rates. Under optimal conditions, the U1LiFe can deliver thousands of cycles.
Installation

Before You Start

Please read all the safety and warranty information provided in this document prior to installing and/or operating the battery.

**IMPORTANT:** Remove all jewelry or other metallic objects from your hands and body during the installation and removal of the battery packs and peripherals.

The U1LiFe power system should be professionally installed and handled. Please contact Inventus Power Technical Support for free consultation if you have any questions about the handling, operation and safe use of this battery before proceeding further.

Unpacking

- Do not discard the packaging, both the cardboard box and interior inserts, for the U1LiFe Battery. This packaging is specifically designed for the safe shipment of the U1LiFe Battery for both ground and air shipments. Use this packaging if the U1LiFe Battery must be transported to a new location.
- Remove the protective battery terminal covers from the terminals. Retain these covers in the event that you need to remove or move the battery at some future time.

Visual Inspection

- Please inspect each battery carefully. Report any damage from shipping to Inventus Power immediately.

Waking the Battery

- Batteries are delivered from the factory in “Ship Mode”. In this mode output to the battery terminals as well as SMBus communications are disabled. There will be no voltage at the terminals and no SMBus communications until the battery is awakened by the charger applying a charge voltage.

Installation Requirements

- Do not connect U1LiFe 12V batteries in series. Connecting in series exceeds the voltage limit of the integrated protection circuitry, leaving the module without critical safety features such as over-voltage and over-temperature protection. (Special applications require factory application consultation)
- Remove jewelry and other metal objects from your hands and body during installation of the battery.
Installation Requirements (Continued)

- A Phillips screwdriver is required to tighten the terminal screws of the U1LiFe battery. Terminal bolts must be torqued to 25 in-lbs to 30 in-lbs.
- Do not install U1LiFe Battery above heat generating equipment.
- Do not install U1LiFe Battery where liquid is likely to contact battery terminals or RJ-45 ports.

Connecting the Battery

**CAUTION: Failure to follow proper connection sequence can result in damage to the battery.**

- Remove power to the vehicle/device prior to installation of the U1LiFe power system(s).
- Remove all other batteries from the system prior to replacing them with U1LiFe batteries.
- Fasten the battery in position via means supplied in the mobile or stationary device.
- If the battery charger is integrated with the device drawing power from the U1LiFe battery, then please follow manufacturers recommended sequence for battery connection.
- Attach the negative cable from the device to the negative terminal on the battery.
- Attach the positive cable from the device to the positive terminal on the battery.
- Attach the communications cable (RJ45) if needed.

Disconnecting the Battery

**CAUTION: Failure to follow proper disconnection sequence can result in damage to the battery.**

- Remove power to the vehicle/device prior to the removal of the U1LiFe power system(s).
- If the battery charger is integrated with the device drawing power from the U1LiFe battery, then please follow manufacturers recommended sequence for battery disconnection.
- Disconnect the communications cable (RJ45) if one is attached.
- Disconnect the positive cable from the positive terminal in the battery.
- Disconnect the negative cable from the negative terminal on the battery.
Operation

Before You Start

Please read all the safety and warranty information provided in this document prior to installing and/or operating the battery.

CAUTION: Failure to follow the following safety instructions may result in personal injuries or damage to the equipment!

- Do not expose the U1LiFe to heat in excess of 58°C during operation, 60°C in storage; do not incinerate or expose to open flames.
- Do not short circuit the U1LiFe.
- Do not charge or discharge the U1LiFe outside of its stated operating temperature range. Reduce charging limits for lower operating temperatures.
- Do not connect U1LiFe in series. Connecting in series exceeds the voltage limit of the integrated protection circuitry, leaving the module without critical safety features such as over-voltage and over-temperature protection. (Special applications require factory application consultation)

SMBus Communications

- Communications are disabled until the battery is awakened by the charger applying a charge voltage.
- Voltage, current, temperature as well as a variety of other data can be read from the battery using SMBus.
- An RJ-45 interface is used as the communication interface between the battery and a connected device.

RJ-45 Connector Pinout

Pinout for connection for the SMBus battery using a standard RJ45 connector:

<table>
<thead>
<tr>
<th>Pin</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>GND</td>
</tr>
<tr>
<td>2</td>
<td>Reserved</td>
</tr>
<tr>
<td>3</td>
<td>Reserved</td>
</tr>
<tr>
<td>4</td>
<td>Reserved</td>
</tr>
<tr>
<td>5</td>
<td>Reserved</td>
</tr>
<tr>
<td>6</td>
<td>SCL</td>
</tr>
<tr>
<td>7</td>
<td>SDA</td>
</tr>
<tr>
<td>8</td>
<td>5V Reserved</td>
</tr>
</tbody>
</table>

Top View of RJ-45 Connector
Integrated Module Protection

The U1LiFe includes integrated protection circuitry to prevent the battery module from exceeding its voltage limits. The module’s circuitry interrupts either charging or discharging current if the battery is in danger of exceeding current, voltage or temperature limits.

Battery LED Status Indicators

Status LED’s are located just above the RJ-45 ports. LED’s will come on when the following conditions are detected:

<table>
<thead>
<tr>
<th>Error Description</th>
<th>Green LED</th>
<th>Yellow LED</th>
</tr>
</thead>
<tbody>
<tr>
<td>Over Discharge Current</td>
<td>ON</td>
<td>OFF</td>
</tr>
<tr>
<td>Over Charge Current</td>
<td>ON</td>
<td>OFF</td>
</tr>
<tr>
<td>Charging Over Temperature</td>
<td>OFF</td>
<td>ON</td>
</tr>
<tr>
<td>Discharging Over Temperature</td>
<td>OFF</td>
<td>ON</td>
</tr>
<tr>
<td>Charge Over Voltage Protection</td>
<td>ON</td>
<td>ON</td>
</tr>
</tbody>
</table>

See Operating Parameters Table at end of this section for detailed explanations.

Tips for Optimizing Performance

By following the tips listed below, one can assure long life and high performance of the U1LiFe power system:

- Charge all batteries fully prior to first use of the vehicle/device.
- Allow battery to charge fully overnight periodically.
- Use at temperatures below 40ºC.
- Charge battery annually to 35% - 50% State of Charge.
- Ensure that all batteries are secured into position to minimize damage from shock and vibration.
- Periodically inspect electrical connections to ensure screws are tight and no corrosion is present.
- Use recommended torque ratings for the bolts.
- Proper thermal management will maximize life; this includes adequate air cooling.

Selecting a Battery Charger

A LiFePo4 charger is recommended for max battery life and capacity (i.e. Mascot 3240) Most 2 stage (CC/CV) SLA chargers can be used if they meet the following requirements:

- Constant Current (CC) is less than 20 amps
- Constant Voltage (CV) is 14.2 volts to 14.7volts
- Float Voltage is 13.7 volts to 13.9 volts
### U1LiFe™ 12V Series Operating Parameters Table

#### Over Current Charge Protection

<table>
<thead>
<tr>
<th>Charge Current Exceeds</th>
<th>Duration</th>
<th>Result</th>
<th>Recovery</th>
</tr>
</thead>
<tbody>
<tr>
<td>30 amps</td>
<td>10 sec</td>
<td>Charging Disabled</td>
<td>When Over Current condition is removed, U1 will re-enable charging within 30 seconds.</td>
</tr>
<tr>
<td>50 amps</td>
<td>10 ms</td>
<td>Charging Disabled</td>
<td></td>
</tr>
<tr>
<td>110 amps</td>
<td>1.5 ms.5</td>
<td>Charging Disabled</td>
<td></td>
</tr>
</tbody>
</table>

#### Over Current Discharge Protection

<table>
<thead>
<tr>
<th>Discharge Current Exceeds</th>
<th>Duration</th>
<th>Result</th>
<th>Recovery</th>
</tr>
</thead>
<tbody>
<tr>
<td>28 amps</td>
<td>10 sec</td>
<td>Discharging Disabled</td>
<td>When Discharge Current is less than -0.1 amp, U1 will enable discharging</td>
</tr>
<tr>
<td>50 amps</td>
<td>30 ms</td>
<td>Discharging Disabled</td>
<td></td>
</tr>
<tr>
<td>110 amps</td>
<td>15 ms</td>
<td>Discharging Disabled</td>
<td></td>
</tr>
<tr>
<td>310 amps</td>
<td>827 μs</td>
<td>Discharging Disabled</td>
<td></td>
</tr>
</tbody>
</table>

#### Cell Over Voltage Protection

<table>
<thead>
<tr>
<th>Any Cell Voltage Exceeds</th>
<th>Duration</th>
<th>Result</th>
<th>Recovery</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.8 vdc</td>
<td>2 sec</td>
<td>Charging Disabled</td>
<td>When all cell voltages less than 3.45 vdc</td>
</tr>
<tr>
<td>4.05 vdc</td>
<td>3.3 sec</td>
<td>Fuses Blown</td>
<td>Fuses Blown - Unrecoverable</td>
</tr>
</tbody>
</table>

#### Cell Under Voltage Protection

<table>
<thead>
<tr>
<th>Any Cell Voltage is Less Than</th>
<th>Duration</th>
<th>Result</th>
<th>Recovery</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.0 vdc</td>
<td>2 sec</td>
<td>Battery Terminals Disabled</td>
<td>All cell voltages &gt; 2.0vdc</td>
</tr>
</tbody>
</table>

#### PreCharge Protection Mode

<table>
<thead>
<tr>
<th>Conditions</th>
<th>Result</th>
<th>Recovery</th>
</tr>
</thead>
<tbody>
<tr>
<td>Enter PreCharge Mode Any Cell Voltage &lt; 2.2v and Pack Voltage &lt; 9.2v</td>
<td>Charging Current limited to 1 amp</td>
<td></td>
</tr>
<tr>
<td>Exit PreCharge Mode All Cell Voltages &gt; 2.22v or Pack Vltg &gt; 9.2v</td>
<td>Fast Charging Enabled</td>
<td></td>
</tr>
<tr>
<td>PreCharging Timeout If preCharging for more than 10 hrs</td>
<td>Disable Charging and Discharging</td>
<td></td>
</tr>
</tbody>
</table>

#### Thermal Protection

<table>
<thead>
<tr>
<th>Over Temperature During</th>
<th>Temp. Range</th>
<th>Result</th>
<th>Recovery</th>
</tr>
</thead>
<tbody>
<tr>
<td>Charging</td>
<td>0 - 70 °C</td>
<td>Charging Disabled</td>
<td>5 °C &lt; Temperature &lt; 65 °C</td>
</tr>
<tr>
<td>Discharging</td>
<td>&gt; 75 °C</td>
<td>Discharging Disabled</td>
<td>Temperature &lt; 70 °C</td>
</tr>
</tbody>
</table>

#### Cell Balancing (Occurs during Charging and Sleep Mode)

<table>
<thead>
<tr>
<th>During</th>
<th>Start Conditions</th>
<th>Stop Conditions</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Charging</td>
<td>Cell Difference &gt; 20 mV between any cells</td>
<td>Cell Difference &lt; 10 mV between all cells</td>
<td></td>
</tr>
<tr>
<td>Sleep</td>
<td>Rest time &gt; 2 hrs and Cell Difference &gt; 10 mV between any cells</td>
<td>Cell Difference &lt; 5 mV between all cells</td>
<td></td>
</tr>
</tbody>
</table>

#### Charge Termination

<table>
<thead>
<tr>
<th>Conditions</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current Termination Pack Voltage &gt; 14.2 vdc and (0.1 amps &lt; Current &lt; 2.0 amps) for 60 seconds</td>
<td>Charging Disabled</td>
</tr>
<tr>
<td>Voltage Termination Any Cell &gt; 3.6 vdc for 5 seconds</td>
<td>Charging Disabled</td>
</tr>
</tbody>
</table>

#### Discharge Termination

<table>
<thead>
<tr>
<th>Conditions</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>RSOC% (State of Charge) RSOC% = 0s</td>
<td>Discharging Disabled</td>
</tr>
</tbody>
</table>

#### Battery Sleep Mode

<table>
<thead>
<tr>
<th>Conditions</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Begins When SMBus comms are inactive and Not Charging or Discharging for 10 secs</td>
<td>Battery Self Discharge &lt; 200uA</td>
</tr>
</tbody>
</table>

#### Float Charging

<table>
<thead>
<tr>
<th>Conditions</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Begins When Pack Voltage &lt; 13.8 vdc and Charger Voltage is between 13.5 and 14.1 vdc</td>
<td>Charging Enabled</td>
</tr>
</tbody>
</table>

#### Battery Ship Mode

<table>
<thead>
<tr>
<th>Conditions</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Begins When Pack Vltg &lt; 9.2 vdc or SMBus “ShipMode” command issued.</td>
<td>No Voltage at Terminals, No SMBus Comms</td>
</tr>
</tbody>
</table>
Maintenance, Storage, and Disposal

Maintenance Charging

The U1LiFe can be stored in an environment with temperatures between -40°C and +60°C and between 10% and 90% relative humidity, non-condensing. In addition, you can store the U1LiFe at altitudes up to 25,000 ft. For long storage periods at 25°C, charge the battery every two years. For temperatures above 40°C, charge the battery annually. Do not store the U1LiFe at temperatures above 60°C.

Shelf Life

U1LiFe battery packs ship from the factory at 35% SOC and can retain at least 10% SOC after 1 year of storage at temperatures not exceeding 25°C. Note that higher storage temperatures reduce impedance and accelerate the rate of self-discharge. Following this one year period the SOC can fall below 10%, and the terminals become disconnected (open). The U1LiFe can remain in this state for a minimum of one more year. To reactivate the terminals, the battery must be recharged.

Battery Case Visual Inspection

Please perform regular visual inspections of the battery case. If the battery case is found to have dents, discoloration, or appears to be damaged in any way, DISCONTINUE USE IMMEDIATELY. Please contact Inventus Power for assistance with evaluating the product for continued usability.

Voltage Checking

The voltage of the battery can be monitored during normal operation or as part of standard tests performed periodically to assess the health of the battery. If you find any single battery’s voltage is under 10V at room temperature, the battery has been over-discharged or is self-discharging due to some defect/parasitic load. Discontinue use until the fault can be corrected and the battery recharged.

Battery Storage

- Store in an open, well ventilated, dry, area, between -40°C and 60°C (-40°F and 140°F) for maximum life.
- Do not expose the battery to extremes of temperature over 60°C (140°F).
- Do not expose the battery directly to sources of heat.
- Do not expose the battery to direct sunlight or moisture and/or precipitation
- Handle each battery carefully to avoid sharp impacts or extreme pressure on the case.

Disposal

Do not incinerate or dispose of the battery. Return end-of-life or defective batteries to your nearest recycling center as per the appropriate local regulations.
Recycling

For information about recycling, visit the Rechargeable Battery Recycling Corporation website at:

www.call2recycle.org/

The EPA classifies spent batteries as “universal wastes” instead of “dangerous goods.” The shipping requirements for universal wastes are available at the EPA website at:

www.epa.gov
Troubleshooting

The U1LiFe is an extremely reliable battery that provides greater useful life than comparable 12V lead-acid batteries. Despite the high reliability of the U1LiFe, you may encounter situations where the battery module does not operate as expected. These situations are typically the result of misuse, abuse or a non-optimal operating or storage environment. The information below details potential issues you may encounter with the U1LiFe and the appropriate troubleshooting procedures.

Terminal Voltage Absent or Low

Possible Cause(s):

- Protection circuitry is active - Verify all LED’s are off
- The battery is in “ship mode”. Ship mode will disable output at terminals (voltage reads close to zero) and disable SMBus communications.
- The battery has encountered a Cell Under Voltage condition and has disabled output to terminals and disabled SMBus communication.

Possible Solution(s):

- Connect the battery to a charger momentarily to wake the battery. This will recover terminal voltage and enable SMBus communications. If CUV condition exists, you will need to charge the battery until all cell voltages exceed the CUV limit.

SMBus Not Communicating or Returns Invalid Data

Possible Cause(s):

- RJ45 cable problem
- The battery is in “ship mode”. This is the default mode when leaving the factory.
- Ship mode will disable output at terminals (voltage reads close to zero) and disable SMBus communication.
- The battery has encountered a Cell Under Voltage condition and has disabled output to terminals and disabled SMBus communication.

Possible Solution(s):

- Verify RJ45 cable is connected properly
- Connect the battery to a charger momentarily to wake the battery. This will recover terminal voltage and enable SMBus communications. If CUV condition exists you will need to charge the battery until all cell voltages exceed the CUV limit.
U1LiFe™ 12V Series Battery User Manual

U1LiFe Rapidly Depletes its Energy between Charging

Possible Cause(s):

- The battery is out-of-balance.
- The battery has reached the end of its useful service life.

Possible Solution(s):

- Apply a float charge (13.6 V) for 48 hours to balance the battery pack’s cells.
- Replace the battery pack.

Battery Current Disappears when Charging

Possible Cause(s):

- Charging Current too high
- Charging Voltage too high
- Battery Temperature too high
- Cell Over Voltage condition exists
- Battery is fully charged

Possible Solution(s):

- Determine error condition if LED’s are lit.
- Verify Charging Current is correct
- Verify Charging Voltage is correct
- Verify Battery Temperature is within Operating Range
- Cells may be imbalanced. Apply a float charge (13.6 V) for 48 hours to balance the battery pack’s cells.

Voltage Drops Abruptly

This is normal for LiFePO4 cells. Constant voltage throughout the battery’s SOC ensures maximum usable life. Once the Relative State of Charge (RSOC%) goes to 0%, the U1LiFe circuitry enables under-voltage protection, which creates an open circuit at the terminals.
Emergency and First Aid Procedures

Emergency Procedures for a Melting or Smoking Battery

- If a battery begins to smoke or melt, remove charging source immediately.
- If possible, move the battery to a well-ventilated area, preferably outside.

Use a fire extinguisher, either carbon dioxide, dry chemical or appropriate foam to spray the hot battery. If a fire extinguisher is not available, use copious amounts of water, or cover the battery with sand.

First Aid Procedures for Human Contact/Exposure to Battery Content

In the event of exposure to battery contents the following could occur:

- Vapor or mist is irritating to the eyes, mucous membranes and respiratory tract.
- Causes eye and skin irritation.
- Exposure can cause nausea, dizziness and headache.

In case of contact with the battery’s electrolyte:

- Immediately flush eyes with copious amounts of water for at least 15 minutes.
- Assure adequate flushing of the eyes by separating the eyelids with fingers.
- Flush skin with water.
- Remove and wash contaminated clothing promptly.

If inhaled:

- Remove oneself to fresh air.

If not breathing or difficulty breathing:

- Give artificial respiration.
- If breathing is difficult, give oxygen.

If swallowed:

- Wash out mouth with water provided person is conscious.

In all cases - CALL A PHYSICIAN!
Glossary

Definitions and Acronyms Terminology

**ACR** – Alternating Current Resistance.

**ADC** – Analog to Digital Convertor

**AFE** – Analog Front End

**Ah** – Amp Hour is a unit of measure of charge that can be stored or delivered to/from a 12 battery.

**Battery** – One or more cells which are electrically connected together by permanent means, including case, terminals and markings.

**BCM** – Battery Control Module – The Battery Control Module is necessary to aggregate information from modules and communicate with the system the ESS resides in.

**BMS** – Battery Management System – The Battery Management System refers to the collection of electronics responsible for monitoring and controlling the ESS.

**C-Rate** – An electrical current corresponding to that which will fill or empty a cell in one hour.

**CC** – Constant Current – A method to charge or discharge a battery in which the current is held constant independent of the battery’s terminal voltage.

**CE** – Consultants Europe - Tests and Certifies safe and compliant product operation in Europe

**Cell** – A single encased electrochemical unit (one positive and one negative electrode) which exhibits a voltage differential across two terminals.

**CID** – Current Interrupt Device – A small device integrated into a cell designed to interrupt the flow of current through its terminal when too much pressure or current exists in the cell.

**CHG FET** – Charge FET

**CV** – Constant Voltage – A method to charge a battery in which the terminal voltage is held constant, and the current is determined by the power path impedance or some active current limiting.

**COV** – Cell Over Voltage

**CUV** – Cell Under Voltage

**DOD** – Depth of Discharge
Glossary (Continued)

**DSG FET** – Discharge FET

**DVT** – Design Verification Testing

**ESS** – Energy Storage System

**FCC** – RF Emissions governing body in the United States

**FD** – Fully discharged

**NR** – Non Removable mode

**OCC** – Over Current Charge

**OCD** – Over Current Discharge

**OCV** – Open Circuit Voltage – voltage reading of a battery when there is no current going in or out of it.

**OEM** – Original Equipment Manufacturer – in reference to this document, the maker of the equipment into which an ESS is installed and used.

**OTC** – Over Temperature Charging

**OTD** – Over Temperature Discharging

**PTC** – Polymeric Positive Temperature Coefficient

**QMAX** – Maximum Chemical Capacity

**SBS** – Smart Battery System

**SMBus** – System Management Bus

**SOC** – State of Charge

**SOT** – Safety Over Temperature

**TCA** – Terminate Charge Alarm

**TCO** – Thermal Cutoff

**TDA** – Terminate Discharge Alarm

**UL** – Underwriter Laboratories - Tests and Certifies safe and compliant product operation in North America
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