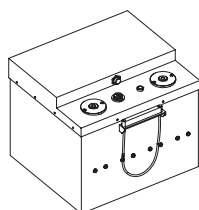


# Discover<sup>®</sup>

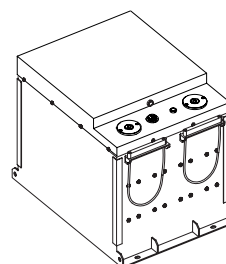
# ADVANCED ENERGY

Lithium Ion Battery

## Operating Manual



**14-24-2800 / 44-24-2800**



**12-36-6700**  
**12-48-6650 / 42-48-6650**

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## 1. SAFETY

### 1.1 Warnings, Cautions, Notes and Symbols

▲ WARNING
Important information regarding possible personal injury.
▲ CAUTION
Important information regarding possible equipment damage.
▲ NOTE
Additional information concerning important procedures and features of the battery.

### 1.2 General Warning

▲ CAUTION
Important to operate the device with care to avoid undesirable consequences.



Do not throw in the garbage. Do not dispose in fire.



Use personal protective equipment when working with batteries.



Additional information concerning important procedures and features of the battery. Read all the instructions before installation, operation and maintenance.



This product must be recycled and is made of recycled products.

▲ CAUTION
Do not disassemble or modify the battery. If the battery housing is damaged, do not touch exposed contents.

### 1.3 Fire Risk

▲ WARNING
Risk of fire - No user serviceable parts.

- Battery has a battery management system with integrated solid state relay to reduce fire risk.
- Primary suppression for lithium battery fires is water. Secondary suppression is CO<sub>2</sub>, powder and halon.

### 1.4 Electric Shock Risk

▲ WARNING
For wet and electrically uninsulated working conditions, electric shock risk is high, and can cause injury and death.

Model	Nominal System Voltage	Maximum System Voltage
14-24-2800 44-24-2800	24 V	29.2 V
12-36-6700	36V	43.8V
12-48-6650 42-48-6650	48 V	58.4 V

## 1.5 Chemical Risk

▲ WARNING
Lithium batteries are chemical risk if misoperated, mishandled or abused.

## 1.6 Do's

- Do protect terminals from short circuit before, during, and after installation
- Do wear electrically insulated gloves
- Do use electrically insulated tools
- Do wear eye protection
- Do wear safety toe boots / shoes
- Do handle battery carefully
- Do secure battery safely
- Do always assume battery terminals are energized

## 1.7 Do Not's

- Do not lift or carry the battery during usage or operation
- Do not operate or store battery outside of operating limits
- Do not short circuit battery
- Do not puncture battery
- Do not expose battery to flames, or incinerate
- Do not open battery case or disassemble battery
- Do not wear rings, watches, bracelets or necklaces when handling or working near battery
- Do not drop or crush battery
- Do not lift battery by the terminal cables
- Do not vibrate battery
- Do not expose battery to water or other fluids
- Do not expose battery to direct sunlight
- Do not dispose of battery
- Do not connect with other types of batteries
- Do not expose battery to high temperatures
- Do not install with other battery types or brands

## 1.8 DC Motor Connection

Direct connection to DC motors without proper safety protection, motor controllers, and external motor voltage clamping systems (such as high power anti-parallel diodes or braking resistor systems) may result in damage to the internal pack protection system which may result in unsafe situations. Please consult Discover technical support before directly connecting any motor loads.

## 1.9 Transportation

If the battery is not installed in equipment, it must be transported in the original package or equivalent.

Batteries are tested according to UN Handbook of Tests and Criteria, part III, sub section 38.3 (ST/SG/AC. 10/11/Rev.5). For transport the batteries belong to category UN3480, Class 9, Packaging Group II.

## 2. OPERATING LIMITS

### 2.1 Battery Operating Limits

The battery should not be operated outside these operating limits.

Operating Limits	14-24-2800 44-24-2800	12-36-6700	12-48-6650 42-48-6650
Continuous Charge Current	110A	150A	130A
Continuous Discharge Current	110A	150A	130A
Charge Voltage	27.2 V	40.8 V	54.4 V
Operating Voltage (Min / Max)	22.4 V / 29.2 V	33.6 V / 43.8 V	44.8 V / 58.4 V
Charge Temperature (Min / Max)	0°C / 45°C (32°F / 113°F)		
Discharge Temperature (Min / Max)	-20°C / 50°C (-4°F / 122°F)		
Storage Temperature (Min / Max)	-20°C / 45°C (-4°F / 113°F)		

**▲ CAUTION!**

Do not install batteries in series. Select the appropriate AES battery model for the voltage of your system.

**▲ NOTE!**

Intentional bypassing of BMS to operate battery outside maximum and minimum limits voids warranty.

### 3. Design Features & Components

#### 3.1 Battery Management System (BMS)

##### Monitoring

BMS monitors:

- Cell module voltage
- Battery voltage
- Battery current
- Battery temperature
- Battery state of charge (SOC)

##### Module Balancing

- BMS performs balancing of cell modules

##### Protection & Fault Management

- BMS sounds buzzer when fault limits are reached
- BMS generates fault when maximum operating limits are reached
- Fault events cause switch to open and battery to shut down after a 120s delay

##### Communication Ports

BMS has an isolated USB and CAN communication.

##### Data Logging

- Monitoring data
- Fault and warning events

**Data accesses with AES Dashboard software via USB**

#### 3.2 Fuse

Fuse provides back-up over-current protection.

##### **Fuse Replacement**

A blown fuse requires service from a qualified technician. Contact your Discover supplier for more information.

#### 3.3 Terminals

Terminals are button-type, M8 female.

**Terminal Torque**

9 Nm / 6.64 ft-lb

### 4. Handling

**▲ WARNING!**

Read Safety Section before installing the battery.

- Battery should be off
- Battery cables should be disconnected
- Battery terminals should be protected
- Battery handle should be used to lift battery
- Battery should be handled by two people or mechanical lift equipment
- Do not lift or carry the battery during usage or operation

## 5. Installation - Single Battery

### ▲ WARNING!

Read Safety Section before installing the battery.

### 5.1 Tools

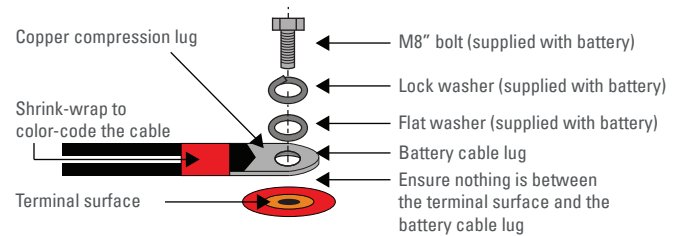
- Insulated tools sized to match nuts, bolts and cables in use
- Voltmeter
- Post cleaner and wire brush
- Personal protective equipment

### 5.2 Securing Battery

- Battery can be strapped in place with non-conductive nylon straps
- Battery may have hold down brackets at the base of the battery

### 5.3 Installation

- Check that battery is switched off
- If battery circuit has disconnect, open disconnect to isolate battery
- Clean cable connections. Broken, frayed, brittle, kinked or cut cables should be replaced
- Install and secure new battery. Be careful not to ground the terminals to any metal mounting, fixture, or body part
- Connect battery cables. Connect ground cable last to avoid sparks
- Recommended terminal torque is 9.0 Nm (6.64 ft-lb)
- Close circuit disconnect (if open)
- Turn battery switch on



### ▲ NOTE!

All cables ends must be connected to battery terminals without any washers between terminal bushings and cable ends.

Terminal burnout is caused by:

- Discharge currents exceeding allowable limits
- Improper cable installation
- Improper cable sizing
- Improper terminal torque

### ▲ NOTE!

Without exception, product experiencing terminal burn out will not be warranted.

## 6. Operation

### ▲ NOTE!

Review operating limits.

### 6.1 On-Off

- To turn the battery on press and hold switch for 2-3 seconds
- To turn the battery off press and hold switch for 2-3 seconds



### 6.2 Charging

Before operating the charger make sure to read and understand the instructions that come with the charger. Never attempt to charge a battery without first reviewing and understanding the instructions for the charger being used.

**▲ CAUTION!**

Always make sure the chargers charging curve meets the battery's charging requirement; never charge a visibly damaged battery; never charge a frozen battery.

1. Connect the charger leads to the battery.
2. Make sure that the charger lead, both at the charger and the battery side, connections are tight.
3. Turn the charger on.
4. Turn the battery on (if required).

**▲ CAUTION!**

**NOT ALL CHARGERS ARE CAPABLE OF CHARGING LITHIUM BATTERIES!**

During system design CONFIRM that your chosen charger is not capable of transient spikes that exceed the published MAXIMUM TERMINAL RATINGS of the battery

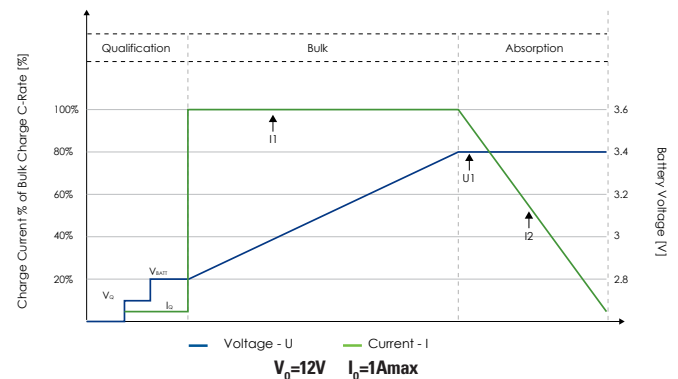
Spikes are fast, short duration electrical transients in voltage (voltage spikes), current (current spikes), or transferred energy (energy spikes) in an electrical circuit. Voltage spikes usually happen when the AC/DC adaptor is plugged in, or charge current is cut off quickly. Multi voltage chargers are made using transformers that may be capable of producing spikes that exceed the maximum ratings of the Discover AES. You must confirm with the charger supplier that the chargers being supplied:

- meet Discover's recommended charge curve, and
- are not capable of exceeding Discover's maximum terminal voltages.

### 6.3 Charge Curve

#### Charge sequence

1. Use Qualification phase for auto-on feature (optional).
2. Charge at constant current to 3.4 Vdc per cell module (Bulk).
3. Maintain constant voltage 3.4 Vdc per cell module (Absorption).
4. Terminate when charge current drops below 2A.



**▲ CAUTION!**

Do not charge battery higher than 3.4 Vdc per cell module.

**▲ NOTE!**

Recommended charge current is 0.5C.

#### Battery Auto On Qualification (if battery is equipped)

Model	V <sub>Q</sub>	I <sub>Q</sub>	V <sub>BATT</sub>
14-24-2800	Min 20V / Max 24V (I <sub>Q</sub> < 1A)	< 1 A	≥ 20 V
44-24-2800			≥ 30 V
12-36-6700	Min 20V / Max 36V (I <sub>Q</sub> < 1A)		≥ 40 V
12-48-6650	Min 20V / Max 48V (I <sub>Q</sub> < 1A)		≥ 40 V
42-48-6650			≥ 40 V

Model	Cell Modules in Series	V <sub>BATT</sub>	I1	U1	Termination Charge Current
14-24-2800	8S	≥ 20 V	110 A maximum	27.2 V	I2 ≤ 2 A
44-24-2800					
12-36-6700	12S	≥ 30 V	150 A maximum	40.8 V	
12-48-6650	16S	≥ 40 V	130 A maximum	54.4 V	
42-48-6650					

## 6.4 Discharging

- Turn on battery
- Turn on load

### ▲ NOTE!

Do not discharge battery below recommended minimum operating voltages.

### ▲ NOTE!

Do not discharge battery at rates greater than recommended operating currents.

## 6.5 Storage

Systems should be stored out of direct sunlight under the following temperature conditions:

<b>Minimum Storage Temperature</b>	-20°C / -4°F
<b>Maximum Storage Temperature</b>	45°C / 113°F

Systems should be put into storage at 80% SOC and checked monthly to ensure the system SOC does not fall below 20%. At 20% SOC the battery will self discharge in approximately 2 months.

## 7. Protection & Faults

- BMS generates faults when maximum operating limits are reached.
- BMS sounds a buzzer when fault limits are triggered.
- BMS monitors the following information for faults and warning:
  1. Cell module voltage
  2. Battery current
  3. Battery temperature

### 7.1 Faults

In the event of a fault the BMS will sound an audible buzzer warning and the system will shut off after a 120 second delay.

#### FAULT LEVELS

Parameter	Trigger Point
<b>High Temperature</b>	60°C / 140°F
<b>High Voltage</b>	3.7 V in any cell module
<b>Low Voltage</b>	2.5 V in any cell module
<b>Over Current</b>	150 A

#### CORRECTIVE ACTIONS

<b>High Temperature</b>	<ul style="list-style-type: none"> <li>• Stop discharge or charge</li> <li>• Leave the battery to cool</li> </ul>
<b>Low Temperature</b>	<ul style="list-style-type: none"> <li>• Stop discharge or charge</li> </ul>
<b>High Voltage</b>	<ul style="list-style-type: none"> <li>• If charging stop the charge</li> </ul>
<b>Low Voltage</b>	<ul style="list-style-type: none"> <li>• Do not discharge the battery. Any discharge current detected will force the battery into Low Voltage Fault</li> <li>• The user can charge the battery in Low Voltage Recovery</li> <li>• If no charge current is detected within 2 minutes the BMS will turn off the battery</li> </ul>
<b>Over Current</b>	<ul style="list-style-type: none"> <li>• Reduce current</li> </ul>
<b>Low SOC</b>	<ul style="list-style-type: none"> <li>• Stop discharge</li> <li>• Charge the battery</li> </ul>

## 8. Service & Maintenance

Batteries should be carefully inspected on a regular basis in order to detect and correct potential problems before they can do harm. This routine should be started when the batteries are first received.

### 8.1 Inspection

- Look for cracks in the case
- Check the battery, terminals and connections to make sure they are clean, free of dirt, fluids and corrosion
- All battery cables and their connections should be tight, intact, and NOT broken or frayed
- Replace any damaged batteries
- Replace any damaged cables
- Check torque on terminal bolts

## 9. Troubleshooting

### 9.1 Battery Won't Turn On

<b>Symptom</b>	Does the battery turn on for a short time then turns itself off?
<b>Description</b>	The battery is likely in a low voltage or low SOC.
<b>Action</b>	Connect to charger and turn on the battery.

<b>Symptom</b>	Was the battery left on or stored for extended periods of time?
<b>Description</b>	The battery will turn itself off at 5% SOC. If left sitting at a low SOC, the battery may have discharged itself completely and cannot be used.
<b>Action</b>	Do not use. Replace and recycle.

## 10. Recycling and Disposal

Batteries must not be mixed with domestic or industrial waste. Discover's Advanced Energy Systems are recyclable and must be processed through a recognized recycling agency or dealer. Please contact Discover<sup>®</sup> or your servicing dealer for details.





## 10. 14-24-2800 / 44-24-2800 TECHNICAL SPECIFICATIONS

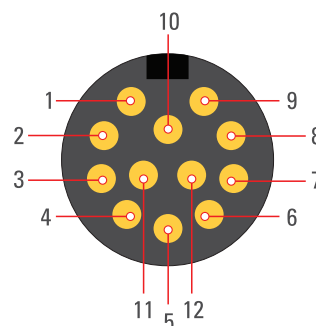
Electrical Specifications	
Nominal Voltage	25.6 V
Charge Voltage	27.2 V
Maximum Voltage	29.2 V
Minimum Voltage	20 V
Nominal Capacity	110 Ah
Nominal Energy	2816 Wh
Max Continuous Charge Current	110 A
Max Continuous Discharge Current	110 A
Fuse	150 A Internal Fuse. Provides backup over-current protection
Cell Chemistry	LiFePO4
Cell Modules	8S 22P
Self-Discharge 25°C / 77°F	< 3% per month (battery off)

Fault Limits	
OverTemperature - Discharge Protection	> 60°C/140°F for 120s
OverTemperature - Charge Protection	> 60°C/140°F for 120s
LowTemperature - Discharge Protection	< -20°C/-4°F for 120s
Low Temperature - Charge Protection	< -20°C/-4°F for 120s
Over Voltage Protection	> 3.7 V in any cell module for 60s
Under Voltage Protection	< 2.5 V in any cell module for 5s
Over Current Protection	> 150 A

Mechanical Specifications	
Battery Dimensions (HxWxD)	276 x 338.5 x 329.5 mm
Battery Weight	40 kg
Shipping Dimensions (HxWxD)	380 x 430 x 390 mm
Shipping Weight	48.4 kg
Terminal	M8
Terminal Hardware	M8 Stainless Steel Bolt, Flat Washer, Lock Washer (Supplied)
Terminal Torque	9.0 Nm +/- 3
Case Material	Powder Coated Cold Rolled Steel
Enclosure IP Rating	IP 55
Charge Temperature Range	0°C/45°C (32°F/113°F)
Discharge Temperature Range	-20°C/50°C (-4°F/122°F)
Storage Temperature Range	-20°C/45°C (-4°F/113°F)

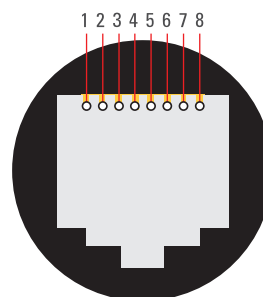
Operational Specifications	
Battery Management System (BMS)	Integrated, with Solid State Relay (SSR)
Cell Balancing	Passive balancing during charge when Cell Voltage > 3.35 V
Non-Volatile Memory	Yes
Lifetime Logged Data	<ul style="list-style-type: none"> <li>• Time</li> <li>• High/low average cell module voltage</li> <li>• Balancing, Fault and Relay State</li> <li>• Battery SOC, Current, Voltage, Temperature</li> <li>• Charge Energy In/Out</li> </ul>
Communication Ports	<ul style="list-style-type: none"> <li>• Isolated USB</li> <li>• Isolated CAN (AEBus)</li> <li>• Isolated XANBUS (44-24-2800 only)</li> </ul>
Communication Connector	USB Type A Female Circular 12 Pin Standard (14-24-2800 only) RJ45 Jack x2 (44-24-2800 only)

### Circular 12 PIN (14-24-2800)



Pin 3	AEBus CAN GND
Pin 4	AEBus CAN High
Pin 5	AEBus CAN Low
Pin 6	LED GND
Pin 7	LED +5V
Pin 8	Key/Reset +
Pin 9	Key/Reset -
Pin 11	AEBus CAN +5V

### RJ45 AEBus (44-24-2800)



Pin 3	AEBus CAN GND
Pin 4	AEBus CAN Low
Pin 5	AEBus CAN High
Pin 6	AEBus + 5V

Regulatory Approvals	UN 38.3, IEC 62133
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## 11. 12-36-6700 TECHNICAL SPECIFICATIONS

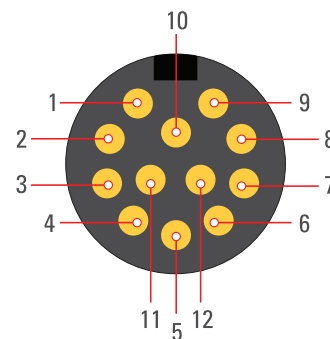
Electrical Specifications	
Nominal Voltage	38.4 V
Charge Voltage	40.8 V
Maximum Voltage	43.8 V
Minimum Voltage	30 V
Nominal Capacity	175 Ah
Nominal Energy	6720 Wh
Max Continuous Charge Current	150 A
Max Continuous Discharge Current	150 A
Fuse	150 A Internal Fuse. Provides backup over-current protection
Cell Chemistry	LiFePO4
Cell Modules	12S 35P
Self-Discharge 25°C / 77°F	< 3% per month (battery off)

Fault Limits	
OverTemperature - Discharge Protection	> 60°C/140°F for 120s
OverTemperature - Charge Protection	> 60°C/140°F for 120s
LowTemperature - Discharge Protection	< -20°C/-4°F for 120s
LowTemperature - Charge Protection	< -20°C/-4°F for 120s
Over Voltage Protection	> 3.7 V in any cell module for 60s
Under Voltage Protection	< 2.5 V in any cell module for 5s
Over Current Protection	> 150 A

Mechanical Specifications	
Battery Dimensions (HxWxD)	375 x 338.5 x 471.5 mm
Battery Weight	88 kg
Shipping Dimensions (HxWxD)	490 x 440 x 570 mm
Shipping Weight	99.9 kg
Terminal	M8
Terminal Hardware	M8 Stainless Steel Bolt, Flat Washer, Lock Washer (Supplied)
Terminal Torque	9.0 Nm +/- 3
Case Material	Powder Coated Cold Rolled Steel
Enclosure IP Rating	IP 55
Charge Temperature Range	0°C/45°C (32°F/113°F)
Discharge Temperature Range	-20°C/50°C (-4°F/122°F)
Storage Temperature Range	-20°C/45°C (-4°F/113°F)

Operational Specifications	
Battery Management System (BMS)	Integrated, with Solid State Relay (SSR)
Cell Balancing	Passive balancing during charge when Cell Voltage > 3.35 V
Non-Volatile Memory	Yes
Lifetime Logged Data	<ul style="list-style-type: none"> <li>•Time</li> <li>•High/low average cell module voltage</li> <li>•Balancing, Fault and Relay State</li> <li>•Battery SOC, Current, Voltage, Temperature</li> <li>•Charge Energy In/Out</li> </ul>
Communication Ports	<ul style="list-style-type: none"> <li>•Isolated USB</li> <li>•Isolated CAN (AEBus)</li> </ul>
Communication Connector	USB Type A Female Circular 12 Pin Standard

**Circular 12 PIN (12-36-6700)**



Pin 3	AEBus CAN GND
Pin 4	AEBus CAN High
Pin 5	AEBus CAN Low
Pin 6	LED GND
Pin 7	LED +5V
Pin 8	Key/Reset +
Pin 9	Key/Reset -
Pin 11	AEBus CAN +5V

Regulatory Approvals	UN 38.3
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## 12. 12-48-6650 / 42-48-6650 TECHNICAL SPECIFICATIONS

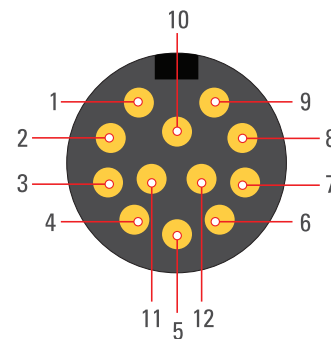
Electrical Specifications	
Nominal Voltage	51.2 V
Charge Voltage	54.4 V
Maximum Voltage	58.4 V
Minimum Voltage	40 V
Nominal Capacity	130 Ah
Nominal Energy	6656 Wh
Max Continuous Charge Current	130 A
Max Continuous Discharge Current	130 A
Fuse	150 A Internal Fuse. Provides backup over-current protection
Cell Chemistry	LiFePO4
Cell Modules	16S 26P
Self-Discharge 25°C / 77°F	< 3% per month (battery off)

Fault Limits	
OverTemperature - Discharge Protection	> 60°C/140°F for 120s
OverTemperature - Charge Protection	> 60°C/140°F for 120s
LowTemperature - Discharge Protection	< -20°C/-4°F for 120s
LowTemperature - Charge Protection	< -20°C/-4°F for 120s
Over Voltage Protection	> 3.7 V in any cell module for 60s
Under Voltage Protection	< 2.5 V in any cell module for 5s
Over Current Protection	> 150 A

Mechanical Specifications	
Battery Dimensions (HxWxD)	375 x 338.5 x 471.5 mm
Battery Weight	87 kg
Shipping Dimensions (HxWxD)	490 x 440 x 570 mm
Shipping Weight	98.9 kg
Terminal	M8
Terminal Hardware	M8 Stainless Steel Bolt, Flat Washer, Lock Washer (Supplied)
Terminal Torque	9.0 Nm +/- 3
Case Material	Powder Coated Cold Rolled Steel
Enclosure IP Rating	IP 55
Charge Temperature Range	0°C/45°C (32°F/113°F)
Discharge Temperature Range	-20°C/50°C (-4°F/122°F)
Storage Temperature Range	-20°C/45°C (-4°F/113°F)

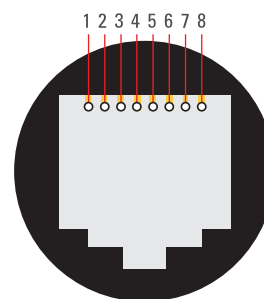
Operational Specifications	
Battery Management System (BMS)	Integrated, with Solid State Relay (SSR)
Cell Balancing	Passive balancing during charge when Cell Voltage > 3.35 V
Non-Volatile Memory	Yes
Lifetime Logged Data	<ul style="list-style-type: none"> <li>• Time</li> <li>• High/low average cell module voltage</li> <li>• Balancing, Fault and Relay State</li> <li>• Battery SOC, Current, Voltage, Temperature</li> <li>• Charge Energy In/Out</li> </ul>
Communication Ports	<ul style="list-style-type: none"> <li>• Isolated USB</li> <li>• Isolated CAN (AEBus)</li> <li>• Isolated XANBUS (42-48-6650 only)</li> </ul>
Communication Connector	USB Type A Female Circular 12 Pin Standard (12-48-6650 only) RJ45 Jack x2 (42-48-6650 only)

### Circular 12 PIN (12-48-6650)



Pin 3	AEBus CAN GND
Pin 4	AEBus CAN High
Pin 5	AEBus CAN Low
Pin 6	LED GND
Pin 7	LED +5V
Pin 8	Key/Reset +
Pin 9	Key/Reset -
Pin 11	AEBus CAN +5V

### RJ45 AEBus (42-48-6650)



Pin 3	AEBus CAN GND
Pin 4	AEBus CAN Low
Pin 5	AEBus CAN High
Pin 6	AEBus + 5V

Regulatory Approvals	UN 38.3, IEC 62133
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