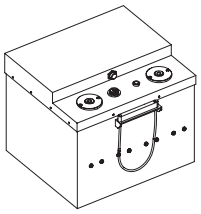
Discover®

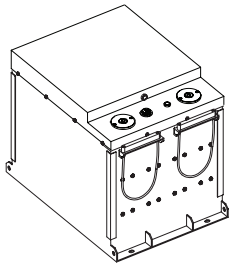
ADVANCED ENERGY

Lithium Ion Battery

Operating Manual



14-24-2800 / 44-24-2800



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

805-0001 REV G

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Richmond, BC, V6V 2E9, Canada
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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
It is 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 (BMS) with integrated solid state relay to reduce fire risk.
- Primary suppression for lithium battery fires is water. Secondary suppression is CO2, 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 a 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 immerse battery in water
- 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 dissemble 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.

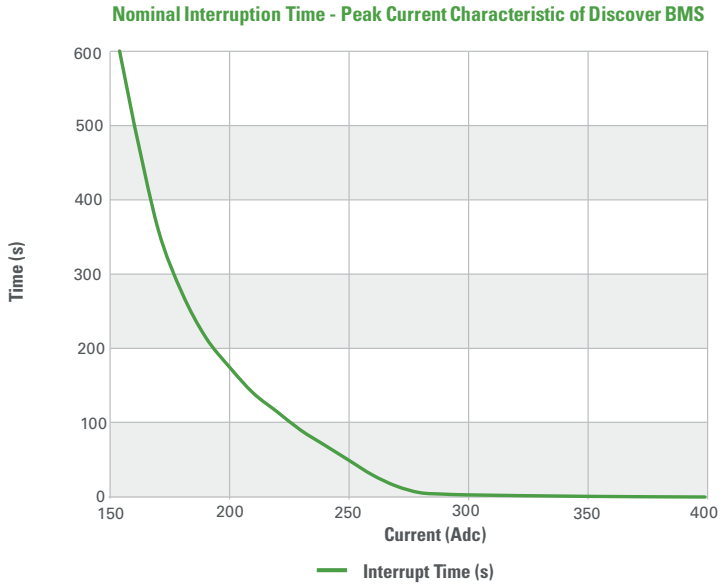
2. MAXIMUM OPERATING LIMITS

2.1 Maximum Battery Operating Limits

The battery should not be operated outside these operating limits, the BMS will open its internal relay and disconnect the battery if any of these limits are exceeded.

Maximum Operating Limits	14-24-2800 44-24-2800	12-36-6700	12-48-6650 42-48-6650
Continuous Charge Current*	110 Adc	150 Adc	130 Adc
Continuous Discharge Current*	110 Adc	150 Adc	130 Adc
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)		

* Effects of AC Ripple must be taken into consideration when sizing and configuring your system.



▲ NOTE!

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

2.2 Recommended Battery Operating Settings

Although the battery is capable of performing at higher operating limits, the following settings are recommended to maximize battery health and account for unforeseen external conditions.

Recommended Operating Settings	14-24-2800 44-24-2800	12-36-6700	12-48-6650 42-48-6650
Max Continuous Charge Current	< 78 A	< 106 A	< 92 A
Max Continuous Discharge Current	< 78 A	< 106 A	< 92 A
Charge Voltage (Bulk/Absorb)	27.2 V	40.8 V	54.4 V
Low Voltage Disconnect	24 V	36 V	48 V
Operating Temperature	20°C (68°F)		

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. Use accessory harness 790-0018 to connect battery to computer with AES Dashboard Software

Data Logging

- Monitoring data
- Fault and warning events

Logged data can be accessed using AES Dashboard software via the USB port (Win32 / Win64 supported)

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

▲ WARNING!
Read Safety Section before installing the battery.

▲ CAUTION!

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

5.1 Tools

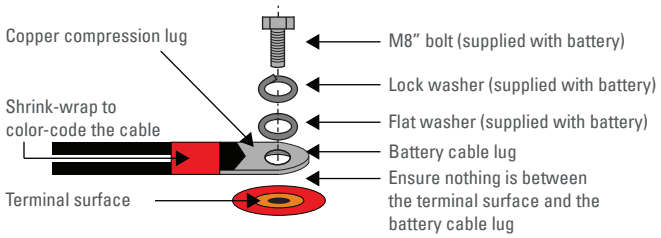
- Insulated tools sized to match nuts, bolts and cables in use
- Voltmeter
- Post cleaner and wire brush
- Personal protective equipment

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 the battery circuit has a 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 cable ends must be connected to battery terminals without any washers between terminal bushings and cable ends.

Terminal burnout is caused by:

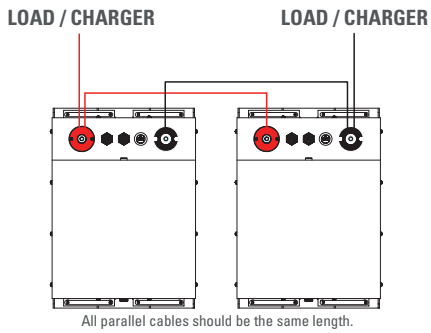
- Discharge currents exceeding allowable limits
- Improper cable installation
- Improper cable sizing
- Improper terminal torque

▲ NOTE!

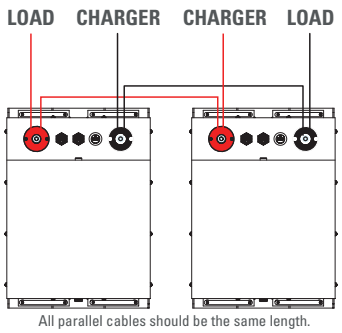
Without exception, product experiencing terminal burn out will not be warranted.

5.4 Parallel Battery Wiring

Parallel wiring examples. Actual wiring requirements may vary. Consult with your local authority having jurisdiction.



All parallel cables should be the same length.



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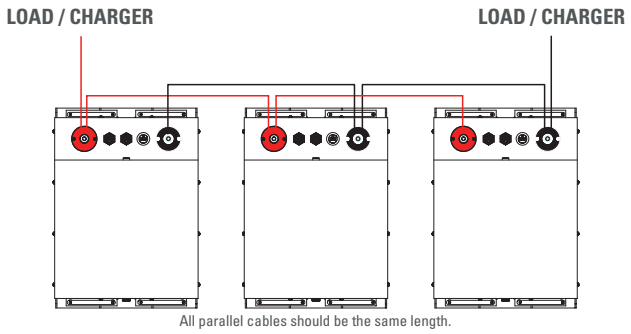

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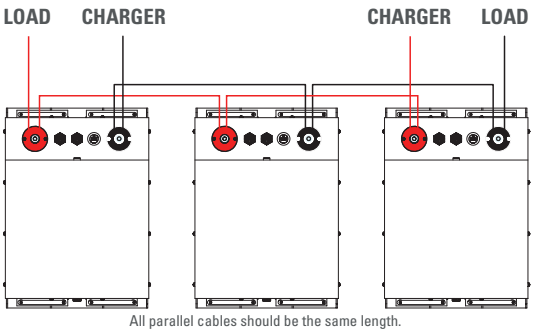
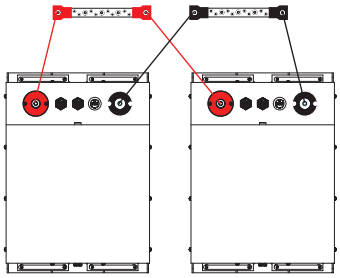
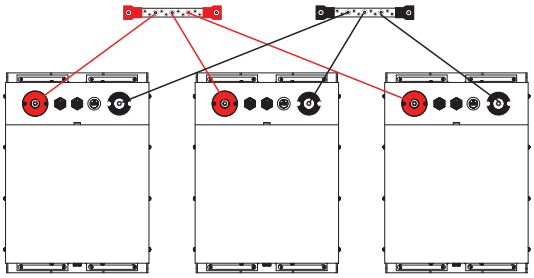


All parallel cables should be the same length.

ALTERNATE 1


All cables should be the same length.

ALTERNATE 2


All cables should be the same length.

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.

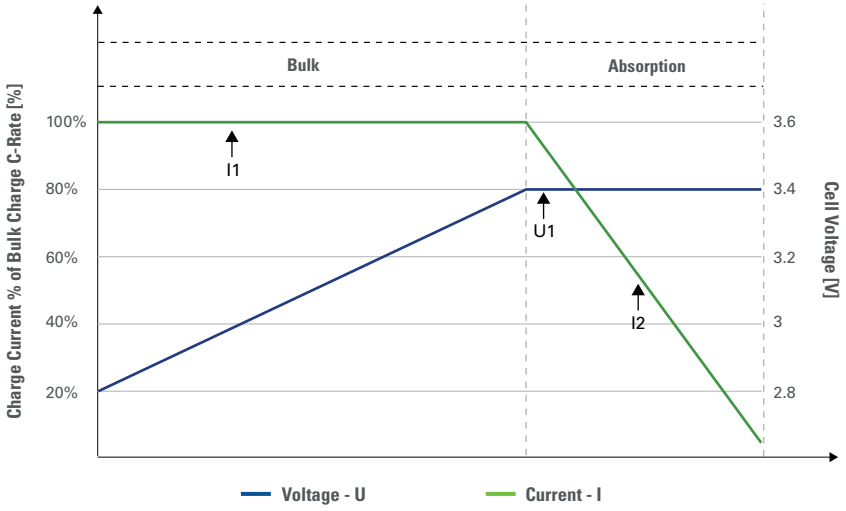
Spikes are fast, short duration electrical transients in voltage (voltage spikes), current (current spikes), or transferred energy (energy spikes) in an electrical circuit. Voltage spikes usually happen when the AC/DC adaptor is plugged in, or charge current is cut off quickly. Multi voltage chargers 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. Charge at constant current to 3.4 V per cell module (Bulk).
2. Maintain constant voltage 3.4 V per cell module (Absorption).
3. Terminate when charge current drops below 2A.



▲ CAUTION!

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

▲ NOTE!

Recommended charge current is 0.5C.

Model	Cell Modules in Series	I1	U1	Termination Charge Current
14-24-2800	8S	110 Adc maximum	27.2 V	I2 ≤ 2 A
44-24-2800				
12-36-6700	12S	150 Adc maximum	40.8 V	
12-48-6650	16S	130 Adc 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:

Minimum Storage Temperature	-20°C / -4°F
Maximum Storage Temperature	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.

▲ CAUTION!
Do not store a discharged battery. Recharge battery after every use. Batteries that have self-discharged to a severely discharge state are not recoverable.

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

▲ NOTE!
Refer to device technical specification tables at the end of this manual for Fault Limits.

CORRECTIVE ACTIONS

High Temperature	• Stop discharge or charge • Leave the battery to cool
Low Temperature	• Stop discharge or charge
High Voltage	• If charging stop the charge • Confirm proper charge algorithm is being used
Low Voltage	• Do not discharge the battery. Any discharge current detected will force the battery into Low Voltage Fault • The user can charge the battery in Low Voltage Recovery • If no charge current is detected within 2 minutes the BMS will turn off the battery
Over Current	• Reduce current
Low SOC	• Stop discharge • Charge the battery

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

8.2 Firmware Updates

Consult Discover's website for firmware updates that may include significant improvements.

9. Troubleshooting

9.1 Battery Won't Turn On

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

Symptom	Was the battery left on or stored for extended periods of time?
Description	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.
Action	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® or your servicing dealer for details.

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

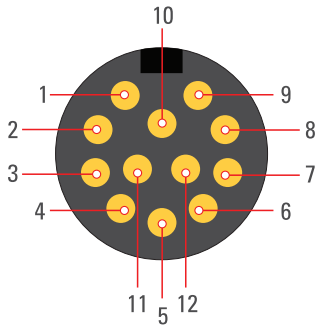
Electrical Specifications	
Nominal Voltage	25.6 V
Charge Voltage	27.2 V
Maximum Voltage	29.2 V
Minimum Voltage	20 V
Nominal Capacity	110 Ah
Nominal Energy	2816 Wh
Max Continuous Charge Current	110 Adc
Max Continuous Discharge Current	110 Adc
Fuse	150 A Internal Fuse. Provides backup over-current protection
Cell Chemistry	$LiFePO_4$
Cell Modules	8S 22P
Self-Discharge 25°C / 77°F	< 3% per month (battery off)

Fault Limits	
Over Temperature - Discharge Protection	> 60°C/140°F for 120s
Over Temperature - Charge Protection	> 60°C/140°F for 120s
Low Temperature - 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 Adc

Mechanical Specifications	
Battery Dimensions (HxWxD)	276 x 347.5 x 329.5 mm
Battery Weight	40 kg
Shipping Dimensions (HxWxD)	470 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)

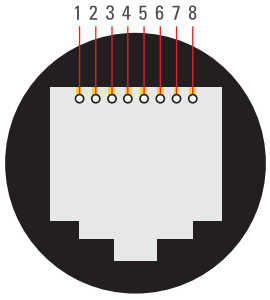
Operational Specifications	
Battery Management System (BMS)	Integrated, with Solid State Relay (SSR)
Cell Balancing	Passive balancing during charge when Cell Voltage > 3.35 V
Non-Volatile Memory	Yes
Lifetime Logged Data	• Time • High/low average cell module voltage • Balancing, Fault and Relay State • Battery SOC, Current, Voltage, Temperature • Charge Energy In/Out
Communication Ports	• Isolated USB • Isolated CAN (AEBus) • Isolated XANBUS (44-24-2800 only)
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, UL 2271, UL 1973

UN38.3 PASSED
TRANSPORT SAFETY CERTIFIED

FUNCTIONAL SAFETY c UL us LISTED LITHIUM-ION STATIONARY APPLICATION BATTERY

FUNCTIONAL SAFETY c UL us LISTED LITHIUM-ION LEV BATTERY

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11. 12-36-6700 TECHNICAL SPECIFICATIONS

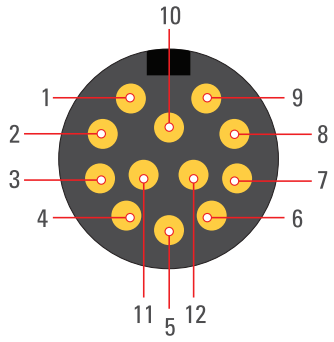
Electrical Specifications	
Nominal Voltage	38.4 V
Charge Voltage	40.8 V
Maximum Voltage	43.8 V
Minimum Voltage	30 V
Nominal Capacity	175 Ah
Nominal Energy	6720 Wh
Max Continuous Charge Current	150 Adc
Max Continuous Discharge Current	150 Ad
Fuse	150 A Internal Fuse. Provides backup over-current protection
Cell Chemistry	$LiFePO_4$
Cell Modules	12S 35P
Self-Discharge 25°C / 77°F	< 3% per month (battery off)

Fault Limits	
Over Temperature - Discharge Protection	> 60°C/140°F for 120s
Over Temperature - Charge Protection	> 60°C/140°F for 120s
Low Temperature - 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 Adc

Mechanical Specifications	
Battery Dimensions (HxWxD)	375 x 347.5 x 471.5 mm
Battery Weight	88 kg
Shipping Dimensions (HxWxD)	570 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	• Time • High/low average cell module voltage • Balancing, Fault and Relay State • Battery SOC, Current, Voltage, Temperature • Charge Energy In/Out
Communication Ports	• Isolated USB • Isolated CAN (AEBus)
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

UN38.3 PASSED
TRANSPORT SAFETY CERTIFIED

12. 12-48-6650 / 42-48-6650 TECHNICAL SPECIFICATIONS

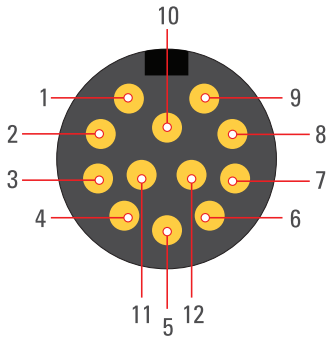
Electrical Specifications	
Nominal Voltage	51.2 V
Charge Voltage	54.4 V
Maximum Voltage	58.4 V
Minimum Voltage	40 V
Nominal Capacity	130 Ah
Nominal Energy	6656 Wh
Max Continuous Charge Current	130 Adc
Max Continuous Discharge Current	130 Adc
Fuse	150 A Internal Fuse. Provides backup over-current protection
Cell Chemistry	$LiFePO_4$
Cell Modules	16S 26P
Self-Discharge 25°C / 77°F	< 3% per month (battery off)

Fault Limits	
Over Temperature - Discharge Protection	> 60°C/140°F for 120s
Over Temperature - Charge Protection	> 60°C/140°F for 120s
Low Temperature - 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 Adc

Mechanical Specifications	
Battery Dimensions (HxWxD)	375 x 347.5 x 471.5 mm
Battery Weight	87 kg
Shipping Dimensions (HxWxD)	570 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	• Time • High/low average cell module voltage • Balancing, Fault and Relay State • Battery SOC, Current, Voltage, Temperature • Charge Energy In/Out
Communication Ports	• Isolated USB • Isolated CAN (AEBus) • Isolated XANBUS (42-48-6650 only)
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)



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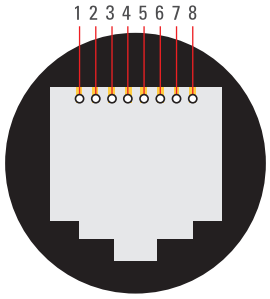
Pin 4	AEBus CAN High
Pin 5	AEBus CAN Low
Pin 6	LED GND
Pin 7	LED +5V
Pin 8	Key/Reset +
Pin 9	Key/Reset -
Pin 11	AEBus CAN +5V

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, IEC62133, UL 2271, UL 1973

UN38.3 PASSED
TRANSPORT SAFETY CERTIFIED

FUNCTIONAL SAFETY c UL us LISTED LITHIUM-ION STATIONARY APPLICATION BATTERY

FUNCTIONAL SAFETY c UL us LISTED LITHIUM-ION LEV BATTERY