

AES BLUE

Premium Lithium Battery

INSTALLATION AND OPERATION MANUAL

BATTERY MODELS

DLB-G24-12V

DLB-G24-24V

DLB-G24-36V

DLB-GC12-12V

DLB-GC12-24V

1. Audience, Safety, Messages, and Warnings	3
1.1 Audience	3
1.2 Safety, Messages, and Warnings	3
2. Specifications	5
2.1 Electrical Specifications	5
2.2 Mechanical Specifications	6
2.3 Environmental Specifications	6
2.4 Protection Specifications	6
2.5 Specifications for System Sizing	7
2.6 Regulatory	8
3. Transportation	8
4. Handling	8
5. Design and Features	9
5.1 Battery Management System Protections	9
5.2 Battery Fuse	10
5.3 Battery Management System Low Power Hibernation	10
5.4 Battery Management System Bluetooth Communications	10
5.5 Ingress Protection IP67	10
5.6 Membrane Vent	11
6. Installation	11
6.1 Tools	11
6.2 Location	11
6.3 DC Cables	12
6.4 DC Protection	12
6.5 Terminal Connections and Hardware	13
6.6 Single Battery Installation Procedure	14
6.7 Parallel Battery Installation Procedure	14
7. Operation	17
7.1 Low Voltage Cut-Off	17
7.2 BMS Hibernation	17
7.3 State of Charge	17
7.4 Charging	18
7.4.1 When to Charge the Battery	18
7.4.2 What to Charge the Battery with	18
7.4.3 Charging with a Lead-Acid Charger	19
7.4.4 Charging with Alternators	19
7.5 Charging Profile	19
7.5.1 Bulk Charge	20
7.5.2 Absorption Charge	20
7.5.3 Equalization Charge	21
7.5.4 Float Charge	21
8. Bluetooth	21
9. Routine Inspection	21
10. Replacing the Fuse	21
11. Storage	22
12. Related Information	23
13. Glossary of Terms, Abbreviations, and Acronyms	23

1. AUDIENCE, SAFETY, MESSAGES AND WARNINGS

1.1 Audience

Certain configuration, installations, service, and operating tasks should only be performed by qualified personnel in consultation with local utilities and/or authorized dealers. Qualified personnel should have training, knowledge, and experience in:

- Installing electrical equipment
- Applying applicable installation codes
- Analyzing and reducing hazards involved in performing electrical work
- Installing and configuring batteries

1.2 Safety, Messages and Warnings

- Do not disassemble, open, crush, bend, deform, puncture or shred.
- Do not modify, re-manufacture attempt to insert foreign objects into the battery, immerse or expose to water or other liquids, expose to fire, explosion or other hazards.
- Only use the battery for the system for which it is specified.
- Do not lift or carry the battery while in operation.
- Only lift, move, or mount in accordance with local regulations.
- Take care when handling battery terminals and cabling.
- Only use the battery with a charging system that has been qualified for the system. The use of an unqualified battery or charger may present a risk of fire, explosion, leakage, or other hazards.
- Do not short circuit a battery or allow metallic conductive objects to contact battery terminals.
- Replace the battery only with another battery that has been qualified for the system. The use of an unqualified battery may present a risk of fire, explosion, leakage, or other hazards.
- Promptly dispose or recycle used batteries in accordance with local regulations.
- Avoid dropping the device or battery. If the device or battery is dropped, especially on a hard surface, and the user suspects damage, take it to a service center for inspection.

WARNING

Important information regarding hazardous conditions that may result in personal injury or death.

CAUTION

Important information regarding hazardous conditions that may result in personal injury.

NOTICE

Important information regarding conditions that may result in damage to the equipment, but not personal injury.

NOTE

Ad hoc information concerning important procedures and features of the battery not related to personal injury or equipment damage.

Before using the battery, read all instructions and cautionary markings on the unit and all appropriate sections of this manual.



⚠ WARNING

This equipment must only be installed as specified. Do not disassemble or modify the battery. If the battery case has been damaged, do not touch exposed contents. No user-serviceable parts inside. Failure to follow these instructions may result in injury.

⚠ WARNING

CHEMICAL HAZARD: Do not touch the exposed contents of a Lithium cell. **Failure to follow these instructions may result in death or serious injury**

⚠ CAUTION

FIRE AND BURN HAZARD: Do not cover or obstruct the heat sink or install the battery in a zero-clearance compartment. Compartment ventilation is required. **Failure to follow these instructions can result in minor to moderate injury.**

⚠ CAUTION

ELECTRIC SHOCK: Do not touch the energized surfaces of any electrical component in the battery system. Before servicing the battery, follow all procedures to fully de-energize the battery system and use safe handling procedures when handling the battery. **Failure to follow these instructions may result in injury.**



CAUTION: Hot Surfaces. Do not touch when hot.



CAUTION: Heavy Object. When lifting, follow appropriate standards.



Do not dispose of the battery in the garbage. Do not dispose of the battery 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 recyclable materials.

2. SPECIFICATIONS

Specifications are published at 25°C / 77°F

2.1 Electrical Specifications

Table 2-1. DLB Electrical Specifications

Electrical Spec	DLB-G24-12V	DLB-G24-24V	DLB-G24-36V	DLB-GC12-12V	DLB-GC12-24V
Nominal Voltage	12.8 V	25.6 V	38.4 V	12.8 V	25.6 V
Energy	1280 Wh	1167 Wh	1167 Wh	2560 Wh	2560 Wh
Capacity 1Hr	100 Ah	45.6 Ah	30.4 Ah	200 Ah	100 Ah
Reserve Capacity 25A	240 minutes	120 minutes	76 minutes	480 minutes	240 minutes
Charge Bulk Voltage - Bulk VDC	13.8 - 14.2 V	27.6 - 28.4 V	41.4 - 42.6 V	13.8 - 14.2 V	27.6 - 28.4 V
Charge Absorption Voltage - U1 MAX	13.8 V	27.6 V	41.4 V	13.8 V	27.6 V
Charge Float Voltage - U2	13.6 V	27.2 V	40.8 V	13.6 V	27.2 V
Charge Termination Current ^a	2.5 A	1.15 A	0.75 A	5 A	2.5 A
Low Voltage Disconnect Voltage	12 V	24 V	36 V	12 V	24 V
Max. Continuous Discharge Current	100 A	45 A	30 A	150 A	100 A
Nominal Charge Current	50 A	22.5 A	15 A	100 A	50 A
Max. Continuous Charge Current	100 A	45 A	30 A	150 A	100 A
Peak Discharge Current (2 seconds)	250 A	120A	120 A	250 A	250 A
Fuse	200 A	75 A	75 A	200 A	200 A

^a Charge current termination is permitted to be less than specified. When the charger termination current is lowered the internal balancing function has more time to operate.

2.2 Mechanical Specifications

Table 2-2. DLB Mechanical Specifications

Mechanical Spec.	DLB-G24-12V	DLB-G24-24V	DLB-G24-36V	DLB-GC12-12V	DLB-GC12-24V
Chemistry	LiFePO ₄				
Length	262 mm (10.3 in)			312 mm (12.2 in)	
Width	175 mm (6.9 in)			177 mm (7.0 in)	
Height	210 mm (8.3 in)			276 mm (10.8 in)	
Terminal	SAE 5/16" stud terminal				
Terminal Torque	8 to 10 Nm (5.9 to 7.4 ft-lb). DO NOT EXCEED 10 Nm (7.4 ft-lb).				
Weight	11.5kg (25.3lb)			20kg (44.1lb)	
IP Rating	IP 67				
Case Material	UL94-VO PBT/PC				

2.3 Environmental Specifications

Table 2-3. DLB Environmental Specifications

Environmental Spec.	All Models
Charge Temperature ^a	0°C to 55°C (32°F to 131°F)
Discharge Temperature ^a	-20°C to 60°C (-4°F to 140°F)
Storage Temperature (1 month) ^b	-20°C to 45°C (-4°F to 113°F)
Storage Temperature (6 months) ^b	-10°C to 30°C (14°F to 86°F)

^aThis is the specified temperature of the cells, and not ambient. Ambient temperature and cell temperature may not be the same.

^bStorage outside of specified temperatures will result in permanent capacity loss and invalidate the warranty.

2.4 Protection Specifications

Table 2-4. DLB Protection Specifications

Protection Spec.	DLB-G24-12V	DLB-G24-24V	DLB-G24-36V	DLB-GC12-12V	DLB-GC12-24V
Overvoltage					
Protection ^a	> 14.6 V for 1 second	> 29.2 V for 1 second	> 43.8 V for 1 second	> 14.6 V for 1 second	> 29.2 V for 1 second
Recovery ^a	< 13.8 V for 5 seconds	< 27.6 V for 5 seconds	< 41.4 V for 5 seconds	< 13.8 V for 5 seconds	< 27.6 V for 5 seconds
Overvoltage Hibernation	3 Consecutive overvoltage protections. Discharge battery to recover.				
Undervoltage					
Protection ^b	< 10 V for 3 seconds	< 20 V for 3 seconds	< 30 V for 3 seconds	< 10 V for 3 seconds	< 20 V for 3 seconds
Recovery ^b	> 10.8 V for 1 second	> 21.6 V for 1 second	> 32.4 V for 1 second	> 10.8 V for 1 second	> 21.6 V for 1 second
Undervoltage Hibernation	3 Consecutive undervoltage protections. Charge battery to recover.				

Protection Spec.	DLB-G24-12V	DLB-G24-24V	DLB-G24-36V	DLB-GC12-12V	DLB-GC12-24V
Overcurrent					
Protection	> 110 A for 2 seconds	> 49.5 A for 2 seconds	> 33 A for 2 seconds	> 160 A for 2 seconds	> 110 A for 2 seconds
Recovery	20 seconds after the load or charge is removed.				
Over-temperature in Discharge					
Protection ^c	Cell temperature above 60°C (140°F).				
Recovery ^c	Cell temperature below 55°C (131°F) for 4 seconds.				
Under-temperature Discharge					
Protection ^c	Cell temperature below -20°C (-4°F).				
Recovery ^c	Cell temperature above -15°C (5°F) for 4 seconds.				
Over-temperature in Charge					
Protection ^c	Cell temperature above 55°C (131°F) and a charge is detected.				
Recovery ^c	Cell temperature below 50°C (122°F) for 4 seconds.				
Under-temperature in Charge					
Protection ^c	Cell temperature below 0°C (32°F) and a charge is detected.				
Recovery ^c	Cell temperature above 5°C (41°F) for 4 seconds.				
^a Overvoltage protection monitors individual cell voltages and will trigger with any cell over 3.65 VPC and recover when all cells are below 3.45VPC. Nominal voltages are provided for guidance only. ^b Undervoltage protection monitors individual cell voltages and will trigger with any cell under 2.5 VPC and recover when all cells are above 2.7VPC. Nominal voltages are provided for guidance only. ^c This is the specified temperature of the cells, and not ambient. Ambient temperature and cell temperature may not be the same.					

2.5 System Size Specifications

Table 2-5. DLB-G24-12V System Size Specifications

System Size Specifications	Peak Current	Constant Current	Energy / Usable Capacity	Reserve Capacity at 25A
1 Battery	250 A	100 A	1280 Wh	240 minutes
2 Battery	500 A	200 A	2560 Wh	480 minutes
3 Battery	750 A	300 A	3840 Wh	720 minutes
4 Battery	1000 A	400 A	5120 Wh	960 minutes

Table 2-6. DLB-G24-24V System Size Specifications

System Size Specifications	Peak Current	Constant Current	Energy / Usable Capacity	Reserve Capacity at 25A
1 Battery	120 A	45 A	1167 Wh	120 minutes
2 Battery	240 A	90 A	2334 Wh	240 minutes
3 Battery	360 A	135 A	3501 Wh	360 minutes
4 Battery	480 A	180 A	4668 Wh	480 minutes

Table 2-7. DLB-G24-36V System Size Specifications

System Size Specifications	Peak Current	Constant Current	Energy / Usable Capacity	Reserve Capacity at 25A
1 Battery	120 A	30 A	1167 Wh	76 minutes
2 Battery	240 A	60 A	2334 Wh	152 minutes
3 Battery	360 A	90 A	3501 Wh	228 minutes
4 Battery	480 A	120 A	4668 Wh	304 minutes

Table 2-8. DLB-GC12-12V System Size Specifications

System Size Specifications	Peak Current	Constant Current	Energy / Usable Capacity	Reserve Capacity at 25A
1 Battery	250 A	150 A	2560 Wh	480 minutes
2 Battery	500 A	300 A	5120 Wh	960 minutes
3 Battery	750 A	450 A	7680 Wh	1440 minutes
4 Battery	1000 A	600 A	10240 Wh	1920 minutes

Table 2-9. DLB-GC12-24V System Size Specifications

System Size Specifications	Peak Current	Constant Current	Energy / Usable Capacity	Reserve Capacity at 25A
1 Battery	250 A	100 A	2560 Wh	240 minutes
2 Battery	500 A	200 A	5120 Wh	480 minutes
3 Battery	750 A	300 A	7680 Wh	720 minutes
4 Battery	1000 A	400 A	10240 Wh	960 minutes

2.6 Regulatory

Table 2-10. DLB Regulatory

DLB Regulatory	All Models
Transportation	UN38.3
EMC	EN 61000-6-1: 2007

3. TRANSPORTATION

If the battery is not installed in equipment, it must be transported in the original package or equivalent. Batteries are tested according to the UN Handbook of Tests and Criteria, part III, subsection 38.3 (ST/SG/AC. 10/11/ Rev. 5). For transport, the batteries belong to category UN3480, Class 9.

4. HANDLING

Prior to handling:

- Keep the battery away from sparks and flames
- Battery cables must be disconnected
- Battery terminals must be protected from short-circuiting and touch
- A battery handle must be used to lift the battery
- Do not lift or carry the battery while it is in use or operation
- Do not lift the battery by the attached battery cable

5. DESIGN AND FEATURES

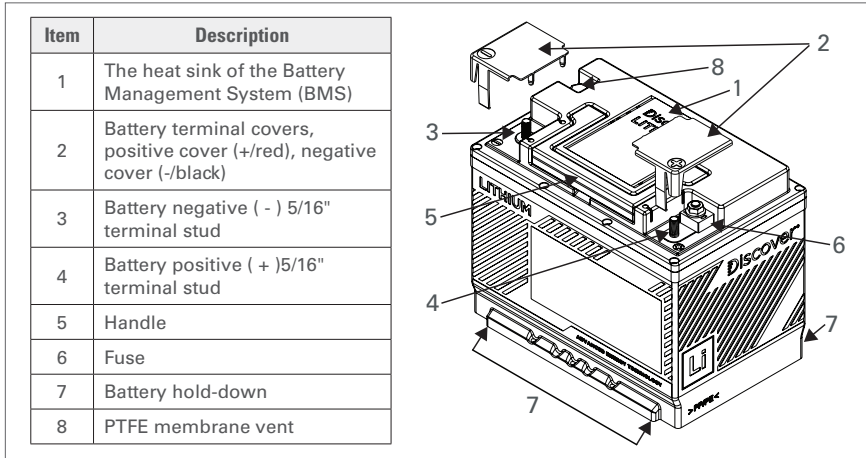


Figure 1. Battery Features.

5.1 Battery Management System Protections

The Battery Management System's (BMS) primary function is to monitor cell module voltage and temperature, and battery current. The BMS uses this information to maintain cell operation within specification. If a parameter falls outside of operating specifications the BMS will disconnect and protect the battery from:

1. **Over voltage.** Over voltage protection occurs when charge voltages are too high.
2. **Under voltage.** Under voltage protection occurs during discharge when the voltage is discharged too low.
3. **Over-current.** Over-current protection can occur during charge or discharge. This may happen when powering up a load (short and high inrush current) or during sustained currents above specified limits.
4. **Over-temperature.** Over-temperature protection can occur during charge and discharge.
5. **Under-temperature.** Under-temperature protection can occur during charge and discharge.

Refer to **Table 2-4. DLB Protection Specifications** for trigger and recovery values.

The BMS will reconnect when recovery thresholds are met. If the BMS disconnects due to low voltage protection, the loads must be removed before the BMS will be able to reconnect. If the system has a constant parasitic draw a physical disconnect switch is recommended to aid in reconnecting the battery.

NOTE

Charge and discharge have different operating temperature limits.

NOTE

If the BMS disconnects responding to temperature or current limits, wait for the temperature or current to reach normal operating limits.

5.2 Battery Fuse

The Battery fuse is intended to protect the electronic components of the Battery's internal BMS from a high externally generated current. Fuses are relatively inexpensive and easy to replace in the field, as compared with the BMS which is a high-cost item to replace.

NOTE

Additional external DC fusing is required to protect the battery cables from DC over-current and to meet installation codes.

5.3 Battery Management System Low Power Hibernation

After 10 continuous minutes of < 300 mA charge or discharge activity, the battery will enter hibernation mode reducing the consumption of energy from the BMS and Bluetooth communications to minimum levels. The internal relay will open and disconnect terminals.

NOTE

Residual voltage may still be detected at the terminals when the battery is in Low Power Hibernation mode.

5.4 Battery Management System Bluetooth Communications

The BMS communicates important battery operating information such as the State of Charge, voltage, operating current, temperature, and diagnostic logs via Bluetooth communications to devices such as mobile phones and tablets. Battery data is then viewable using the AES BLUE Battery Monitor App, which is either downloaded from the Apple Store or Google Play Store .

5.5 Ingress Protection IP67

Ingress protection rates the degree of protection provided by mechanical casings and electrical enclosures against intrusion, dust, accidental contact, and water under specified conditions. The IP67 rating includes testing that indicates no ingress of dust particles and no ingress of a harmful quantity of water when immersed for up to 30 minutes.

IP codes provide guidance on suitability for use under different environmental conditions. IP ratings do not indicate fitness for purpose or confer a performance guarantee.

5.6 Membrane Vent

Membrane vents enable the free passage of gases and vapors and allow for the equalization of the pressure between the internal case and ambient conditions. This helps to protect and preserve the internal components of the battery.

6. INSTALLATION

WARNING

ELECTRIC SHOCK AND FIRE HAZARD: This equipment must only be installed as specified. Do not disassemble or modify the battery. If the battery case has been damaged, do not touch exposed contents. No user-serviceable parts inside.
Failure to follow these instructions may result in injury.

CAUTION

FIRE AND BURN HAZARD: Do not cover or obstruct the heat sink or install the battery in a zero-clearance compartment. Compartment ventilation is required.
Failure to follow these instructions can result in minor to moderate injury.

NOTE

It is the responsibility of the installer to ensure that all applicable installation requirements and standards are met.

6.1 Tools

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

6.2 Location

The battery should be installed in locations that meet the following requirements:

1. **Do not install in direct sunlight.** Avoid installing the battery in an area with high ambient temperature.
2. **Moderate temperatures.** Ambient temperatures of 15°C to 20°C (59°F to 68°F) are ideal for extending LiFePO₄ battery life. Do not install in the Engine Bay as this will expose the battery to elevated temperatures greater than 40°C (104°F).
3. **Ventilated.** Do not install in zero-clearance compartments. Maintain at least 50 mm (2 inches) above the top cover for open airflow.
4. **Proper orientation.** The battery may be installed in any orientation other than upside down. Do not install upside down.
5. **Hold-downs.** The battery is designed with standard B1/B3 hold-down ledges for use with standard battery trays. The battery may also be strapped in place with over-the-top holds.

- 6. Minimum cable lengths.** Select a location that minimizes the length of battery cables in order to reduce voltage drop from impedance leading to reduced performance.

NOTICE

Only a non-conductive material that covers less than 20% of the heat sink for 'over the top' hold-downs may be used.

NOTE

Warranty will be void if operated outside of these conditions.

6.3 DC Cables

⚠ CAUTION

FIRE HAZARD: Undersized cables can become hot and may potentially catch fire. Failure to follow these instructions can result in minor to moderate injury.

The DC battery cables should meet the following requirements:

- 1. Copper-stranded cable.** DC cables must be stranded, copper, and must be rated 90 °C minimum. The cables must be terminated with lugs that fit the DC terminals snugly.
- 2. Minimum cable lengths.** Select a location that minimizes the length of battery cables in order to reduce voltage drop from impedance leading to reduced performance.
- 3. Appropriate cable gauge.** The cables should be capable of carrying the normally expected current, plus a margin of safety.
- 4. Proper polarity.** Positive (+) connected to positive (+), and negative (-) connected to (-).

6.4 DC Protection

⚠ CAUTION

FIRE HAZARD: Undersized fuses and disconnects may become overloaded and potentially cause a fire. Fuses and disconnects are required to open before the cable reaches its maximum current carrying capability. Failure to follow these instructions can result in minor to moderate injury.

To protect the system and DC battery cables, additional DC over-current protection and a DC disconnect switch are required.

- 1. Appropriate size.** Fuses and disconnects must be sized in accordance with local codes to protect the wiring in the system and are required to open before the cable reaches its maximum current carrying capability.
- 2. Install protection in the positive cable.** The fuse and disconnect should be located as close as possible to the battery and must be installed in

the positive cable. Applicable codes may limit how far the protection can be from the battery.

NOTE

AC circuit breakers and DC circuit breakers are not interchangeable. Check the label on the circuit breaker to ensure it is the correct type and rating. Use only DC circuit breakers.

NOTE

Local electrical code in your area may require both positive and negative DC disconnect switches. Always refer to the applicable code and check with the authority having jurisdiction to confirm local requirements.

6.5 Terminal Connections and Hardware

The terminal connections and hardware should meet the following requirements:

1. **Connect to the battery terminal.** Do not connect the cable lug to the fuse post. All cable lugs must be in direct contact with the battery terminal deck. Do not put washers between the terminal deck and cable lug.
2. **Use the proper torque.** Use a torque wrench to properly adjust terminal hardware torque. Periodically check to ensure torque is correct.

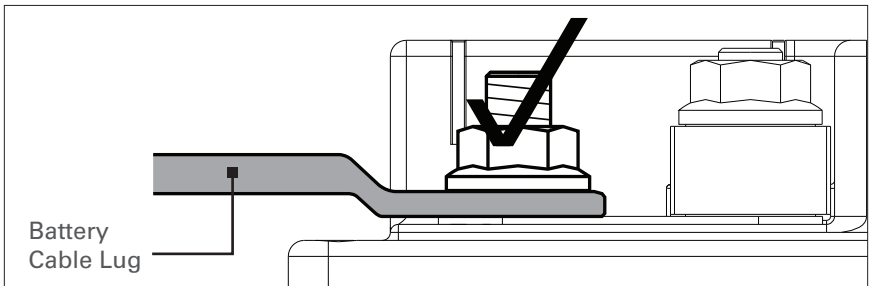


Figure 2. Correct Installation.

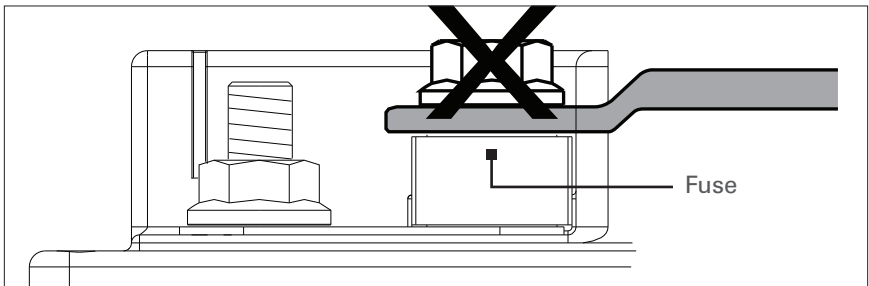


Figure 3. Incorrect Installation.

NOTICE

Failure to properly secure a terminal nut to the specified torque value may increase resistance and lower voltage which may lead to burnout of the terminals and void the warranty. Exceeding 10 Nm (7.4 ft-lb) of torque will damage the terminal and void the warranty.

6.6 Single Battery Installation Procedure

⚠ CAUTION

FIRE HAZARD: Undersized cables can become hot and may potentially catch fire.
Failure to follow these instructions can result in minor to moderate injury.

Battery cables (battery to load and/or battery to charger) must meet the following requirements to optimize performance:

1. **Minimum cable lengths.** Select a location that minimizes the length of battery cables in order to reduce voltage drop from the impedance.

Equipment must be installed in accordance with the standards set by the local authority having jurisdiction

1. If the circuit of equipment that the battery is installed in has a disconnect, open the disconnect to isolate the battery.
2. Ensure the cable connections are clean and serviceable.
3. Install and secure the battery. Be careful not to make contact between the terminals and any metal mounting, fixture, or body part.
4. Connect battery cables taking care to connect the positive (+) cable to the positive (+) terminal. Connect negative (-) cable last to avoid sparks. Short circuits may damage the battery and this will void the warranty.
5. Torque all battery terminals to the recommended terminal torque of 8 to 10 Nm (5.9 to 7.4 ft-lb) to secure cable lugs. **DO NOT EXCEED 10 Nm (7.4 ft-lb)**
6. Close circuit disconnect (if open).

NOTICE

Failure to torque up to specifications may increase resistance and lower voltage and may lead to burnout of the terminals and invalidate the warranty. Exceeding 10 Nm (7.4 ft-lb) of torque will damage the terminal and void the warranty.

6.7 Parallel Battery Installation Procedure

⚠ CAUTION

FIRE HAZARD: Undersized cables can become hot and may potentially catch fire.
Failure to follow these instructions can result in minor to moderate injury.

Batteries used in a parallel system must meet the following requirements:

1. **Same model.** Batteries must be the same model, age, capacity, and voltage.
2. **Equal voltage.** Always ensure that batteries are within 50mV (0.05V) of each other before installing them in parallel.

Battery cables (battery to load and/or battery to charger) must meet the following requirements to optimize performance:

1. **Minimum cable lengths.** Select a location that minimizes the length of battery cables in order to reduce voltage drop from the impedance.

Interconnection cables (battery to battery) must meet the following requirements to optimize performance:

1. **Equal cable gauge.** The interconnection cables should be the same gauge.
2. **Equal cable length.** The interconnection cables should be of equal length.

Equipment must be installed in accordance with the standards set by the local authority having jurisdiction.

1. If the circuit of equipment that the batteries are installed in has a disconnect, open the disconnect to isolate the batteries.
2. Ensure the cable connections are clean and serviceable.
3. Install and secure new batteries. Be careful not to make contact between the terminals and any metal mounting, fixture, or body part.
4. Connect battery positive (+) cables between the battery positive (+) terminals with snugly tightened terminal hardware.

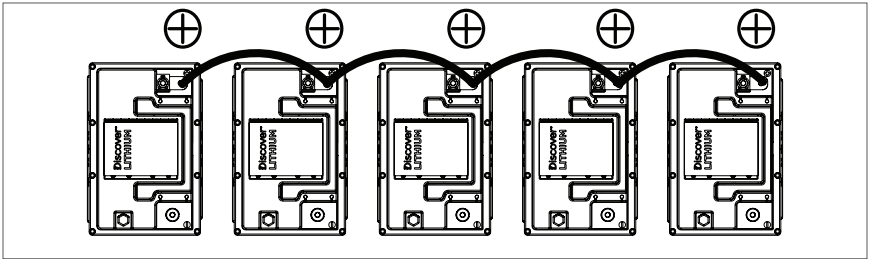


Figure 4. Positive Parallel Connections.

5. Connect battery negative (-) cables between the battery negative (-) terminals with snugly tightened terminal hardware.

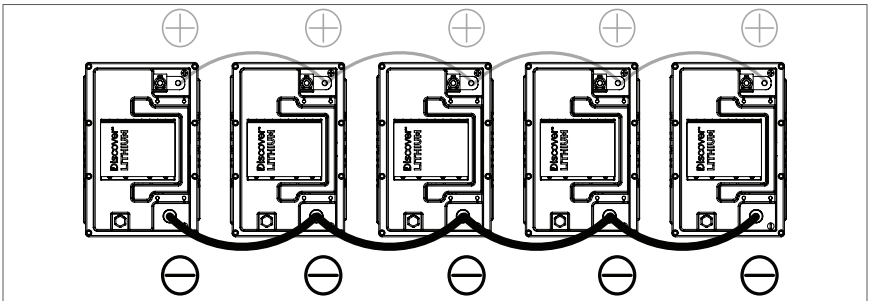


Figure 5. Negative Parallel Connections.

6. Connect the load positive (+) cable and load negative (-) cable to the opposing ends of the parallel batteries.

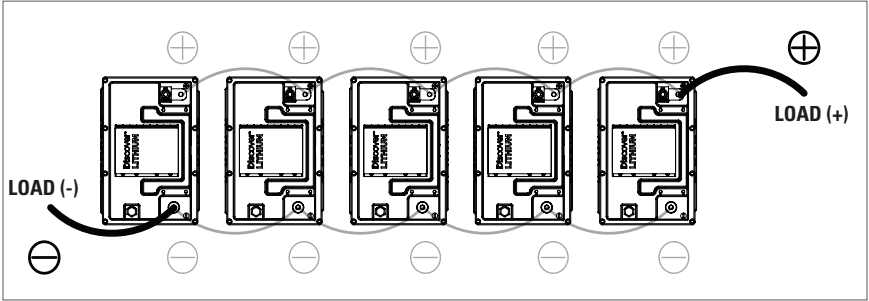


Figure 6. Load Connections.

7. Connect the charger positive (+) cable and charger negative (-) cable to the opposing ends of the parallel batteries.

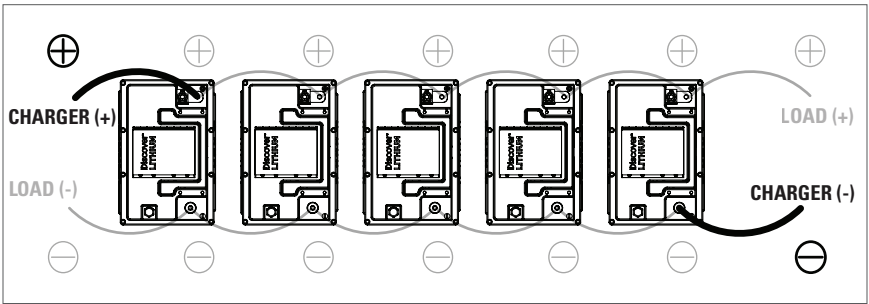


Figure 7. Charger Connections.

8. Torque all battery terminals to the recommended terminal torque of 8 to 10 Nm (5.9 to 7.4 ft-lb) to secure cable lugs. DO NOT EXCEED 10 Nm (7.4 ft-lb).

NOTICE

Failure to properly secure a terminal nut to the specified torque value may increase resistance and lower voltage which may lead to burnout of the terminals and void the warranty. Exceeding 10 Nm (7.4 ft-lb) of torque will damage the terminal and void the warranty.

NOTE

Whenever replacing an old battery in a string, use a battery of the same age, model, capacity, and voltage.

NOTE

Before installing the battery in parallel, ensure that each battery is charged to 100% SOC.

7. OPERATION

The Battery BMS prevents battery operation outside of specified operating conditions. Make sure to understand each of these protections and how to set up the system accordingly. Refer to **Table 2-4. DLB Protection Specifications.**

NOTICE

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

7.1 Low Voltage Cut-Off

The low voltage cut-off, as controlled by the application, should be programmed at or above the Low Voltage Disconnect Voltage value given in **Table 2-1. DLB Electrical Specifications.** This ensures that the load will disconnect before the BMS is forced to enter low voltage protection.

NOTICE

Storing or leaving the battery at 0% SOC will lead to irreversible damage.

7.2 BMS Hibernation

The BMS will enter hibernation mode if there is no charge or discharge activity detected for 10 minutes, or if the battery triggers low or high voltage protection three consecutive times. During this time, the BMS will disconnect the internal SSR. This protection helps safeguard the battery from becoming over-discharged.

The battery will exit hibernation mode by:

- **Applying a charge current.** If the battery is in low voltage protection and hibernation mode a small charge current will reactivate the BMS.
- **Applying charge or discharge current.** If the battery is not in low voltage protection but is in hibernation mode a charge or discharge current will activate the BMS.

7.3 State of Charge

A Bluetooth App for mobile devices provides real-time access to the battery state-of-charge, voltage, operating current, temperature, status and a diagnostic report. Search for AES BLUE Battery Monitor App on Apple's App Store or Google Play.

A voltage-based battery meter that is designed for lead-acid batteries will not provide an accurate state of charge (SOC) for lithium. Use a battery meter that measures current, rather than voltage, for lithium batteries.

7.4 Charging

Each electrical system will have different characteristics and balance-of-system components. Modifications to charger settings may be required to optimize the system performance of each.

NOTICE

Always confirm that the charging device is incapable of producing transient spikes that exceed the published terminal voltage limits for the battery.

NOTICE

Never charge a visibly damaged or frozen battery.

NOTICE

Always confirm the charging curve meets the battery's charging requirement.

7.4.1 When to Charge the Battery

- **Opportunity charging is OK.** Charging the battery after every use will not reduce its cycle life.
- **Partial state of charge is OK.** If the battery SOC is greater than 10% at the end of discharge, it does not require an immediate charge.
- **Charge if below 10% SOC.** If the battery has been discharged below 10% SOC it must be charged within 24 hours to avoid permanent damage to the battery. Otherwise irreversible damage to the battery cells will occur in a very short period of time.
- **Low currents extend life.** Charging at 50% of nominal current or lower helps extend battery cycle life.
- **Proper temperature.** Ensure charging is within the charge temperatures specified in **Table 2-3 DLB Environmental Specifications**.

NOTICE

The battery must be charged within 24 hours if it has been discharged below 10% SOC. Otherwise irreversible damage to the battery cells will occur in a very short period of time and the warranty will be invalid.

NOTICE

Charging the battery when it is below 0°C will cause irreversible damage and invalidate the warranty.

7.4.2 What to Charge the Battery with

Use a Lithium LiFePO₄ charger. Use a charger with a dedicated LiFePO₄ charging algorithm that matches the DLB charging profile and parameters. For charging parameters refer to **Table 2-1. DLB Electrical Specifications** and **Figure 8 DLB Charge Graph**.

7.4.3 Charging with a Lead-Acid Charger

⚠ CAUTION

FIRE AND BURN HAZARD: Do not perform an equalization charge on lithium batteries. Failure to follow these instructions can result in minor to moderate injury.

- **Not recommended.** For the reasons stated below, it is not recommended to use a lead-acid charger.
- **It is possible.** Short-term charging with a lead-acid charger is possible only if the bulk and absorption voltages are equal to or below the bulk voltage. Refer to **Table 2-1 DLB Electrical Specifications** for charging parameters and **Figure 8 DLB Charge Graph**.
- **Gel profiles.** GEL profiles are typically the lead-acid settings closest to the recommended Lithium settings.
- **No equalization.** Do not perform an equalization charge on lithium batteries.
- **No temperature compensation.** Temperature compensation must be disabled.

NOTICE

Some lead-acid charge profiles are within the LiFePO₄ charging voltages, however many will exceed the BMS high voltage protection limits. This will result in the BMS disconnecting at the end of the charge cycle, likely causing the charger status indicator to display an error.

7.4.4 Charging with Alternators

- **Not recommended.** For the reasons stated below, it is not recommended to use an alternator as a charge source.
- **It is possible.** Charging with an alternator is possible. However, use one of the following is REQUIRED:
 - Voltage regulator, battery isolator, or DC/DC converter

NOTICE

If the alternator charge voltage or current is too high, the BMS will protect the battery by disconnecting the battery from the system. In a one-battery system, a large voltage spike may also be created, potentially damaging both the alternator and BMS.

NOTICE

LiFePO₄ batteries are so efficient the alternator may burn itself out over extended periods of output at or close to peak current.

7.5 Charging Profile

DLB LiFePO₄ battery charging should include both Bulk and Absorption phases. For charging parameters refer to **Table 2-1. DLB Electrical Specifications**.

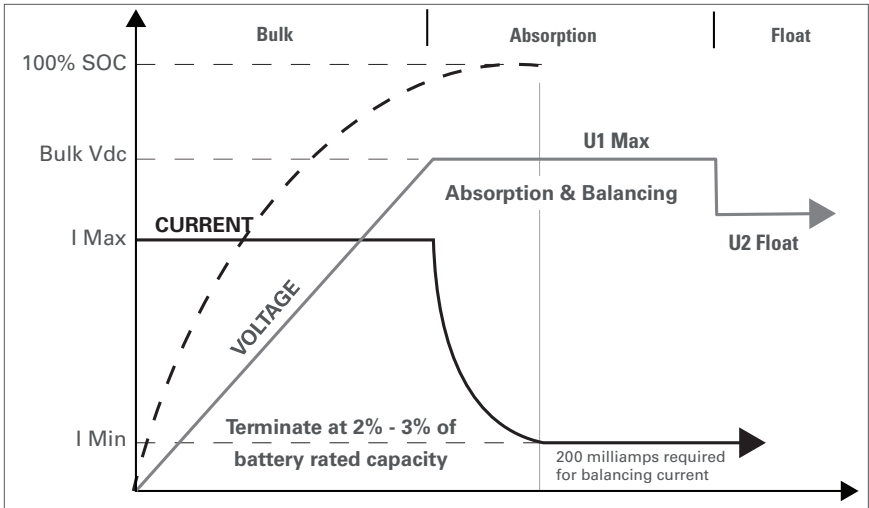


Figure 8. Charge Graph.

NOTE

Charging at 50% of nominal current or lower will extend battery cycle life.

7.5.1 Bulk Charge

Bulk phase. The first phase of the charging process is the Bulk charge, also referred to as the constant current phase. This is when the maximum amount of current from the charger is directed to the battery until the maximum voltage is reached. The Bulk phase will recharge the battery to approximately 90%-95% SOC.

If the charging source is a generator or other charge source that is not efficient at low output current a single-stage charge may be appropriate. A single-stage charge will only complete the Bulk phase portion of the charge curve. This method should return the battery to between 90-95% SOC.

Refer to **Table 2-1 DLB Electrical Specifications** for charging parameters.

7.5.2 Absorption Charge

Absorption phase. The second phase of the charging process is Absorption Charge, also referred to as the constant voltage phase. This is when the charger reduces current accordingly to maintain the desired voltage.

Refer to **Table 2-1 DLB Electrical Specifications** for charging parameters.

7.5.3 Equalization

⚠ CAUTION

FIRE AND BURN HAZARD: Do not perform an equalization charge on lithium batteries. Failure to follow these instructions can result in minor to moderate injury.

Do not equalize charge. Do not equalize charge Lithium batteries. Equalization charging is intended only for lead-acid batteries. Equalization charge is a purposeful overcharge that targets a voltage above standard charge voltage in order to remove sulphate crystals that form on lead-acid plates over time.

7.5.4 Float Charge

Float phase. Float charge, the third phase of charging is optional. During this stage, the battery is maintained at 100% SOC for extended periods of time counteracting any self-discharge or parasitic loads.

- **Not necessary.** Float charging is not necessary.

If needed refer to **Table 2-1 DLB Electrical Specifications** for float parameters.

8. BLUETOOTH

A Bluetooth App for mobile devices provides real-time access to the battery state-of-charge, voltage, operating current, temperature, status and a diagnostic report. Search for Discover Blue on Apple's App Store or Google Play.

- **One Battery.** The App will only communicate with one battery at a time.
- **No Bluetooth when the battery is in hibernation mode.** Bluetooth is only active when the battery is not in hibernation mode. Ensure that there is a charge or discharge current to activate Bluetooth communications.

9. ROUTINE INSPECTION

Periodically inspect the battery system:

1. Ensure that the DC cables are secure and fasteners are tight
2. Ensure that the installation location is clean and free from debris
3. Inspect for cracks in the battery casing
4. Replace any damaged batteries
5. Replace any damaged cables

10. REPLACING THE FUSE

⚠ CAUTION

ELECTRIC SHOCK: Do not touch the energized surfaces of any electrical component in the battery system. Before servicing the battery, follow all procedures to fully de-energize the battery system and use safe handling procedures when handling the battery. Failure to follow these instructions may result in injury.

Table 10-1. DLB Fuse Specifications

Discover Part Number	170-0035	170-0033
Fuse Rating	200A	75A
Applicable	DLB-G24-12V DLB-GC12-12V DLB-GC12-24V	DLB-G24-24V DLB-G24-36V
Fuse Terminal Torque	8 to 10 Nm (5.9 to 7.4 ft-lb). DO NOT EXCEED 10 Nm (7.4 ft-lb).	

This task should be performed by qualified personnel:

- Use only Insulated tools
- Wear Personal protective equipment
- The battery system must be de-energized
- Battery cables must be disconnected
- Battery terminals must be protected from short-circuiting and touch

Refer to **Section 6.5 Terminal Connections and Hardware**, **Section 6.6 Single Battery Installation Procedure** and **Section 6.7 Parallel Battery Installation Procedure**.

1. Ensure that the DC system is de-energized and, the battery charger and all loads are disconnected. If the battery is in a DC circuit of equipment has a disconnect, open the disconnect to isolate the battery.
2. If connected to others, remove the battery and isolate it.
3. Protect the battery terminals from short-circuiting and touch by covering them with terminal covers or electrically rated tape.
4. Install the fuse on the battery fuse post. The battery will not operate if the battery fuse is installed on the battery terminal post.
5. Remove the nut holding the fuse and replace it with a new fuse paying strict attention to orientation and the fuse ratings in **Table 10-1 DLB Fuse Specifications**.
6. Torque the nut holding the new fuse to 8 to 10 Nm (5.9 to 7.4 ft-lb). **DO NOT EXCEED 10 Nm (7.4 ft-lb).**
7. After removing the terminal protection, reinstall the battery into the system.
8. If installed, close the disconnect to complete the circuit of equipment and energize the battery system.

NOTICE

Failure to properly secure a terminal nut to the specified torque value may increase resistance and lower voltage which may lead to burnout of the terminals and void the warranty. Exceeding 10 Nm (7.4 ft-lb) of torque will damage the terminal and void the warranty.

11. STORAGE

Leaving the battery connected to a trickle load, or to power electronics will cause the battery to be discharged during storage. Without any load, the battery will self-discharge by approximately 3% per month while in storage. After storage, charge the battery to 100% SOC and then perform at least 1 full discharge and charge cycle before returning the battery to service.

1. **Store at 95% SOC or greater.** To store the battery for a period of up to 6 months, the battery must be initially put into storage at 95% SOC or greater. It must remain disconnected from all loads and power electronics during the storage period.
2. **Check SOC every 6 months.** Recharge the battery to above 95% SOC at least every 6 months.
3. **Proper storage temperature.** Ensure storage is within the temperatures specified below.
 - 1 Month storage temperature -20°C to 45°C (-4°F to 113°F)
 - 6 Month storage temperature -10°C to 30°C (14°F to 86°F)

NOTICE

Leaving the battery connected to a load or power electronics during storage may subject the battery to a trickle drain which could result in irreversible damage and void the warranty.

NOTICE

Storage outside of specified temperatures will result in irreversible damage and void the warranty.

NOTICE

Storing or leaving the battery at 0% SOC will cause irreversible damage and void the warranty.

NOTICE

Allowing the battery to self-discharge below an open-circuit voltage of 3.0 VPC will cause irreversible damage and void the warranty.

12. RELATED INFORMATION

Find information about Discover Energy Systems at discoverlithium.com

For warranty information, see 885-0021 Discover AES BLUE Warranty Policy.

13. GLOSSARY OF TERMS, ABBREVIATIONS, AND ACRONYMS

<u>DLB</u> <i>Discover AES BLUE</i>	<u>LFP</u> <i>LiFePO₄ Lithium Iron Phosphate</i>
<u>BMS</u> <i>Battery Management System</i>	<u>SOC</u> <i>State of Charge</i>
<u>DOD</u> <i>Depth of Discharge</i>	<u>VPC</u> <i>Volts Per Cell</i>

