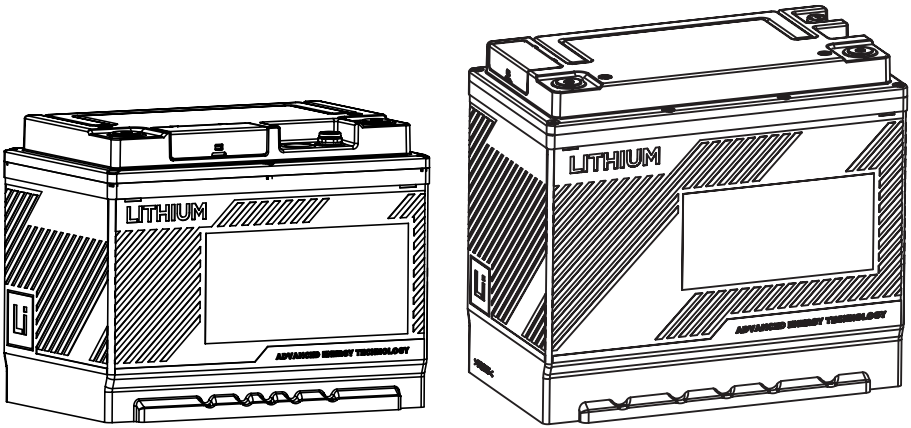
DISCOVER
ENERGY SYSTEMS



AES BLUE

Premium Lithium Battery

INSTALLATION AND OPERATION MANUAL

BATTERY MODELS

AES-B-G24-12V-H
AES-B-G24-24V
AES-B-GC12-12V-H
AES-B-GC12-24V

805-0083 REV A

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Introduction

The AES BLUE is a battery that can operate independently or in a battery bank configuration where multiple batteries are connected in parallel.

1. AUDIENCE, MESSAGES, WARNINGS, GENERAL SAFETY, PERSONAL PROTECTIVE EQUIPMENT

1.1 Audience

Configuration, installation, service, and operating tasks should only be performed by qualified personnel in consultation with local authorities having jurisdiction and 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 Warning, Caution, Notice, and Note Messages

Messages in this manual are formatted according to this structure.

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

Important information regarding hazardous conditions.

⚠ 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 damage the equipment but not result in personal injury.

NOTE
Ad hoc information concerning important procedures and features unrelated to personal injury or equipment damage.

1.3 General Warnings

Do not crush, disassemble or dispose of the battery in fire or the garbage.

This product is made of recyclable materials and must be recycled.

⚠ WARNING

ELECTRIC SHOCK AND FIRE HAZARD

- This equipment must only be installed as specified.
- Do not install the battery in series.
- Do not disassemble or modify the battery.
- If there is damage to the battery case, do not touch exposed contents.
- There are no user-serviceable parts inside.

Failure to follow these instructions may result in death or serious 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.

⚠ WARNING

ELECTRIC SHOCK AND FIRE HAZARD

Do not lay tools or other metal parts across the terminals.

Failure to follow these instructions may result in death or serious injury.

⚠ CAUTION

HEAVY OBJECT

When lifting, follow appropriate standards.

Failure to follow these instructions may result in injury.

⚠ CAUTION

ELECTRIC SHOCK HAZARD

- 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.
- Follow the "Safe Handling Procedures" below when working with the battery.

Failure to follow these instructions may result in injury.

1.4 Safe Handling Procedures

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

- Use personal protective equipment when working with batteries.
- Do not dispose of the battery in a fire.
- Promptly dispose of or recycle used batteries following local regulations.
- Do not disassemble, open, crush, bend, deform, puncture or shred.
- Do not modify, re-manufacture, or attempt to insert foreign objects into the battery, immerse or expose the battery to water or other liquids, fire, explosion, or other hazards. If the user suspects damage to the battery due to water, heat, or other reason, take it to a service center for inspection.
- Only use the battery for the system for which it is specified.
- Do not lift or carry the battery while in operation.
- The battery is heavy. When lifting the battery, follow appropriate standards.
- Only lift, move, or mount following local regulations.
- Take care when handling battery terminals and cabling.
- Do not expose the battery to high temperatures.
- Do not submerge the battery.
- Do not install the battery with the faceplate down.
- Only use the battery with a charging system that meets specifications. Using a battery or charger that does not meet specifications 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 with only another battery that meets the specifications of the system. Using a battery that does not meet specifications may present a risk of fire, explosion, leakage, or other hazards.
- Do not drop the battery. If the battery is dropped, especially on a hard surface, and the user suspects damage, take it to a service center for inspection.

1.5 Personal Protective Equipment

When handling or working near a battery:

- Use Personal Protective Equipment, including clothing, glasses, insulated gloves, and boots.
- Do not wear metal rings, watches, bracelets, or necklaces.

1.6 Emergency Procedure

Unusual Odor

- If there is a burning smell
  - Turn OFF the power conversion equipment.
  - Call the installer and schedule an immediate inspection.

Fire

- If there is smoke or other signs of fire:
  - Call 911 (or the emergency phone number in your area).
  - If there is an emergency STOP button, press it to shut down the system.
  - Do not attempt to put out the fire.
  - Do not spray water or other fire retardants.

2. ITEMS SHIPPED IN THE BOX

Table 2-1, AES BLUE box contents

Items	Description
1	Battery
1	QR Code (online manual)
2	M8x16 Terminal Bolt

3. SPECIFICATIONS

All specifications in this document are published @25°C / 77°F.

3.1 Electrical Specifications

Table 3-1, AES BLUE Electrical Specifications

Electrical Specifications	AES-B-G24-12V-H	AES-B-G24-24V	AES-B-GC12-12V-H	AES-B-GC12-24V
Nominal Voltage	12.8 V	25.6 V	12.8 V	25.6 V
Energy	1280 Wh	1170 Wh	2560 Wh	2560 Wh
Capacity 1 Hr	100 Ah	45 Ah	200 Ah	100 Ah
Charge Bulk Voltage - Bulk Vdc	13.8 – 14.2 V	27.6 – 28.4 V	13.8 – 14.2 V	27.6 – 28.4 V
Charge Absorption Voltage - U1 MAX	13.8 V	27.6 V	13.8 V	27.6 V
Charge Float Voltage - U2	13.4 – 13.6 V	26.4 – 26.8 V	13.4 – 13.6 V	26.4 – 26.8 V
Charge Termination Current	2.5 A	1.15 A	5 A	2.5 A
Low Voltage Disconnect Recommended	12 V	24 V	12 V	24 V
Low Voltage Disconnect (1)	10 V	20 V	10 V	20 V
Max Discharge Current	100 A	45 A	150 A	100 A
Max Charge Current	100 A	45 A	150 A	100 A
Recommended Charge Current	50 A	22.5 A	100 A	50 A
Peak Discharge Current (3 seconds)	300 A	120 A	375 A	300 A
Fuse	200 A	80 A	250 A	200 A
Self Discharge - Battery ON	≤ 10 mA			
Self Discharge - Hibernation (2)	≤ 1 mA			

(1) Low Voltage Disconnect is based on 2.5 VPC under load. In no load conditions, do not allow the battery to self-discharge below 3.0 VPC.

(2) For information on when the battery enters hibernation, refer to 6.3 Battery Management System Hibernation.

NOTE

Reduce the charge termination current to increase the time available for the internal balancing function.

3.2 Mechanical Specifications

Table 3-2, AES BLUE Mechanical Specifications

Mechanical Specifications	AES-B-G24-12V-H	AES-B-G24-24V	AES-B-GC12-12V-H	AES-B-GC12-24V
Chemistry	$LiFePO_4$			
Total Length	262 mm (10.3 in)		312 mm (12.2 in)	
Body Width	175 mm (6.9 in)		177 mm (7.0 in)	
Height	210 mm (8.3 in)		276 mm (10.8 in)	
Terminal	M8 Terminal			
Terminal Torque	8 to 10 Nm (5.9 to 7.4 ft-lb). **DO NOT EXCEED 10 Nm (7.4 ft-lb).**			
Weight	11.5 k (25.3 lb)		20 kg (44.1 lb)	
IP Rating	IP67			
Case Material	PBT/PC UL94-V0, Flame Retardant			

3.3 Environmental Specifications

Do not operate or store the battery outside of these specifications.

Table 3-3, AES BLUE Environmental Specifications

Environmental Specifications	All Models
Charge Operating Temperature Range (1) (2)	0°C to 55°C (32°F to 131°F)
Discharge Operating Temperature Range (1)	-20°C to 60°C (-4°F to 140°F)
Storage Temperature (1 month) (2)	-20°C to 45°C (-4°F to 113°F)
Storage Temperature (6 months) (2)	-10°C to 30°C (14°F to 86°F)
Relative Humidity	5 to 90%, non-condensing

(1) Specifies the temperature of the cells and not the ambient temperature. Ambient temperature and cell temperature may not be the same.
(2) Storage outside of specified temperatures will result in permanent capacity loss and void the warranty.

3.4 Protections Specifications

Table 3-4, AES BLUE Protection Specifications

Protection Specifications	AES-B-G24-12V-H	AES-B-G24-24V	AES-B-GC12-12V-H	AES-B-GC12-24V
Overvoltage				
Protection (1) (2)	>14.6 V for 2 seconds	>29.2 V for 2 seconds	>14.6 V for 2 seconds	>29.2 V for 2 seconds
Recovery (1)	<13.8 V for 5 seconds	<27.6 V for 5 seconds	<13.8 V for 5 seconds	<27.6 V for 5 seconds
Undervoltage				
Protection (3)	<10.0 V for 3 seconds	<20.0 V for 3 seconds	<10.0 V for 3 seconds	<20.0 V for 3 seconds
Recovery (3)	>10.8 V for 5 seconds	>21.6 V for 5 seconds	>10.8 V for 5 seconds	>21.6 V for 5 seconds

Protection Specifications	AES-B-G24-12V-H	AES-B-G24-24V	AES-B-GC12-12V-H	AES-B-GC12-24V
Over-Charge Current				
Protection [2]	>110 A (±5 A) for 10 seconds	>50 A (±2 A) for 10 seconds	>160 A (±5 A) for 10 seconds	>110 A (±5 A) for 10 seconds
Recovery [2] [4]	32 seconds, or apply discharge current			
Over-Discharge Current				
Protection [2] [5]	> 110 A (±5 A) for 10 seconds	> 70 A (±2 A) for 10 seconds	> 160 A (±5 A) for 10 seconds	> 120 A (±5 A) for 10 seconds
Secondary Protection [2] [5]	> 330 A for 320 ms	> 450 A for 500 ms	> 550 A (±120 A) for 320 ms	> 216 A for 320 ms
Recovery [2] [4]	32 seconds, or apply charge current			
Over-temperature in Charge				
Protection [6]	Cell temperature above 55°C (131°F) for 4 seconds and a charge current is detected.			
Recovery [6]	Cell temperature below 50°C (122°F) for 4 seconds.			
Under-temperature in Charge				
Protection [6]	Cell temperature below 0°C (32°F) for 4 seconds and a charge current is detected.			
Recovery [6]	Cell temperature above 5°C (41°F) for 4 seconds.			
Over-temperature in Discharge				
Protection [6]	Cell temperature above 60°C (140°F) for 4 seconds.			
Recovery [6]	Cell temperature below 55°C (131°F) for 4 seconds.			
Under-temperature in Discharge				
Protection [6]	Cell temperature below -20°C (-4°F) for 4 seconds.			
Recovery [6]	Cell temperature above -15°C (5°F) for 4 seconds.			
Main Disconnect [7] Over-temperature				
Protection	105°C (221°F) for 4 seconds	90°C (194°F) for 4 seconds	105°C (221°F) for 4 seconds	90°C (194°F) for 4 seconds
Recovery	75°C (167°F) for 4 seconds	70°C (158°F) for 4 seconds	75°C (167°F) for 4 seconds	70°C (158°F) for 4 seconds

[1] Overvoltage protection monitors individual cell voltages. Protection is triggered and an internal relay in the battery is opened when any cell is over 3.65 VPC and recovers when all cells are below 3.45 VPC for 1 second. Voltages are provided for guidance only.

[2] Three consecutive overvoltage, over-charge current, or over-discharge current protection events will lock the battery. To recover the battery:

- Overvoltage: Apply a discharge
- Over-charge current: Apply a discharge
- Over-discharge current: Apply a charge.

[3] Undervoltage protection monitors the voltage of individual cells. Protection is triggered and an internal relay in the battery is opened when any cell is at or below 2.5 VPC. Recharge the battery to 2.7 VPC to recover and continue discharge. Voltages are provided for guidance only.

[4] During over-charge recovery, discharge is still available. And conversely, during over-discharge recovery, charge is still available.

[5] For time versus current interrupt details, refer to Figure 1. Fuse Overcurrent Protection Time Curve.

[6] Specifies the temperature of the cells and not the ambient temperature. Ambient temperature and cell temperature may not be the same.

[7] Solid state relays (SSR) in the BMS act as the main disconnect.

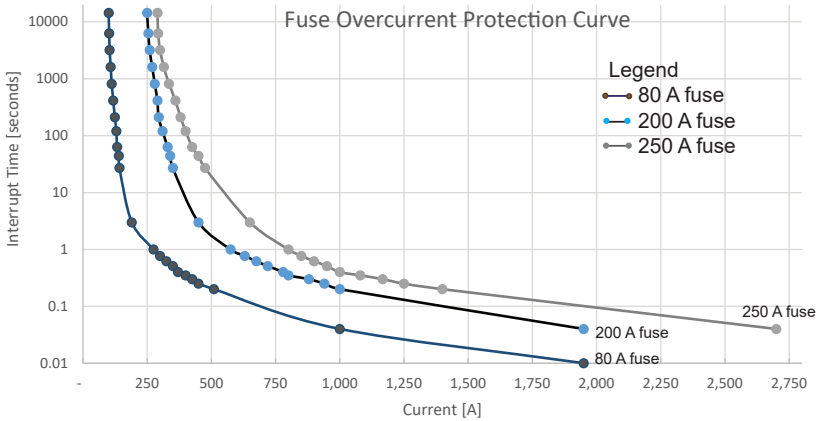

Figure 1. Fuse Overcurrent Protection Time Curve

3.5 Internal Heating Specifications

Heating is available on the following battery models.

Table 3-5, AES BLUE Internal Heating Specifications

Heating Specifications	AES-B-G24-12V-H	AES-B-GC12-12V-H
Heating Power (1)	25 W	50 W
Heating On (2)	• Battery cell temperature is 15°C (59°F) or less, and • Charge current detected.	
Heating Off (2)	• Battery cell temperature is greater than 15°C (59°F), or • No charge current detected.	

(1) In a cold environment where the battery is cooled to -20°C (-4°F), and the heater is started to apply a charge, it takes about 8 hours to raise the battery temperature to 5°C (41°F), at which point the battery can begin charging.

(2) Specifies the temperature of the cells, not the ambient temperature. Ambient temperature and cell temperature may not be the same.

3.6 Minimum Specifications for Battery Systems

Install AES BLUE batteries in parallel in a battery bank configuration to increase system capacity. Overall battery system capacity must be correctly sized to meet the requirements of the load and account for:

- Total Max Charge Current
- Total Recommended Charge Current
- Total Peak Current
- Total Max Discharge Current

If charging for 1 hour or less at a time, the total charging capacity of all charging sources in the system should not exceed the Max Charge Current operating limit of all the batteries in the system. The same is true if discharging for 1 hour or less at a time. The total discharging capacity of all loads in the system should not exceed the Max Discharge Current operating limit of all the batteries in the system.

If charging and discharging for repeated cycles, the total charging capacity of all charging sources in the system should not exceed the Recommended Charge Current operating limit of all the batteries in the system.

If the Max Charge Current or Max Discharge Current is exceeded for any battery in the system, the BMS in that battery will trigger the over-current protection and disconnect. The charging system's maximum charge current must be below the operating limit of installed batteries or be curtailed.

If the Recommended Charge Current is exceeded for multiple cycles, the battery is quicker to trigger the over-temperature protections and disconnect.

The sum of all the Peak Current values for the attached loads must be less than the Peak Current of the battery system, including inrush current values for any motors, and surge values for any inverters.

NOTICE

- Exceeding the Peak Current, or continually exceeding the Max Charge Current, Max Discharge Current, or Recommended Charge Current of all the batteries in the system will lead to triggering the battery BMS over-temperature protection quicker, resulting in disconnection of all batteries in the system.
- Disconnection will result in a voltage spike (Load Dump), which may damage any component electrically attached to the battery system.

For AES BLUE batteries installed in parallel in a battery bank configuration, the sum of all battery capacities provides the overall capacity value for the battery system. Tables 3-6, 3-7, 3-8, 3-9 provide DC capacity values for sample battery systems.

Table 3-6, AES-B-G24-12V-H System Size Specifications

System Size	Peak Current	Max Discharge Current	Recommended Charge Current	Max Charge Current	Energy/ Usable Capacity	Reserve capacity at 25 A
1 battery	300 A	100 A	50 A	100 A	1280 Wh	240 minutes
2 batteries	600 A	200 A	100 A	200 A	2560 Wh	480 minutes
3 batteries	900 A	300 A	150 A	300 A	3840 Wh	720 minutes
4 batteries	1200 A	400 A	200 A	400 A	5120 Wh	960 minutes

Table 3-7, AES-B-G24-24V System Size Specifications

System Size	Peak Current	Max Discharge Current	Recommended Charge Current	Max Charge Current	Energy/ Usable Capacity	Reserve capacity at 25 A
1 battery	120 A	45 A	22.5 A	45 A	1170 Wh	108 minutes
2 batteries	240 A	90 A	45 A	90 A	2340 Wh	216 minutes
3 batteries	360 A	135 A	67.5 A	135 A	3510 Wh	324 minutes
4 batteries	480 A	180 A	90 A	180 A	4680 Wh	432 minutes

Table 3-8, AES-B-GC12-12V-H System Size Specifications

System Size	Peak Current	Max Discharge Current	Recommended Charge Current	Max Charge Current	Energy/ Usable Capacity	Reserve capacity at 25 A
1 battery	375 A	150 A	100 A	150 A	2560 Wh	480 minutes
2 batteries	750 A	300 A	200 A	300 A	5120 Wh	960 minutes
3 batteries	1125 A	450 A	300 A	450 A	7680 Wh	1440 minutes
4 batteries	1500 A	600 A	400 A	600 A	10240 Wh	1920 minutes

Table 3-9, AES-B-GC12-24V System Size Specifications

System Size	Peak Current	Max Discharge Current	Max Charge Current	Recommended Charge Current	Energy/ Usable Capacity	Reserve capacity at 25 A
1 battery	300 A	100 A	100 A	50 A	2560 Wh	240 minutes
2 batteries	600 A	200 A	200 A	100 A	5120 Wh	480 minutes
3 batteries	900 A	300 A	300 A	150 A	7680 Wh	720 minutes
4 batteries	1200 A	400 A	400 A	200 A	10240 Wh	960 minutes

4. TRANSPORTATION

UN38.3

Transport it in the original package or equivalent if the battery is not installed in equipment. Per the UN Handbook of Tests and Criteria, the battery is tested to part III, subsection 38.3 (ST/SG/AC.10/11/ Rev. 5). For transportation, the battery belongs to category UN3480, Class 9.

5. HANDLING

Before handling:

- Keep the battery away from sparks and flames
- Disconnect the cables from the battery, first the negative cable and then the positive cable
- Wait one minute to allow the battery to enter hibernation
- Do not lift or carry the battery while it is in use or operation
- Protect battery terminals from short-circuiting and touch
- Use the battery handle to lift the battery
- Do not lift the battery by attached battery cables.

6. FEATURES

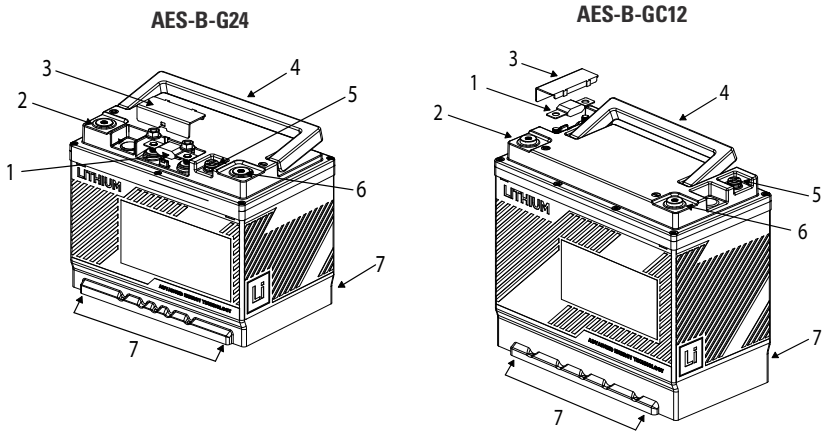

Figure 2. AES BLUE Battery Components

Item	Description
1	Fuse
2	Positive M8 Button Terminal (16 mm depth)
3	Fuse Cover
4	Handle
5	PTFE membrane vent
6	Negative M8 Button Terminal (16 mm depth)
7	Battery hold-down

6.1 Battery Management System Protections

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

1. **Overvoltage:** Charge voltages that are too high.
2. **Undervoltage:** Overdischarge of battery cells causing voltage that is too low.
3. **Overcurrent:** Current that is too high when powering up a load (high inrush current) or from a sustained charging or discharging current above the specified limit.
4. **Over-temperature:** Cell temperature that is too high during charge or discharge.
5. **Under-temperature:** Cell temperature that is too low during charge or discharge.

For trigger and recovery values, refer to Table 3-4, AES BLUE Protection Specifications.

The BMS reconnects when it hits recovery thresholds. If the BMS disconnects due to low-voltage protection, charging will allow the BMS to reconnect. A physical disconnect switch is recommended to reconnect the battery if the system has a constant parasitic draw.

NOTE
• Charge and discharge have different operating temperature limits. • If the BMS disconnects the battery in response to temperature or current limits, wait for the temperature or current to reach normal operating limits before operating the battery.

6.2 Battery Fuse

The Battery fuse is intended to protect the electronic components of the battery's internal BMS from any high currents. Compared to the BMS, fuses are relatively inexpensive and easy to replace in the field.

NOTE
Additional external DC fusing may be required to protect the battery cables from DC overcurrent and to meet installation codes. Check with the local authority having jurisdiction for information.

6.3 Battery Management System Hibernation

The BMS enters hibernation when the battery is inactive —charge/discharge current is less than 0.5 A and there is no communication— for one minute. The BMS exits hibernation on applying charge current, discharge current, or Bluetooth communication.

When the BMS is in hibernation mode, it reduces the consumption of energy from the BMS and minimizes Bluetooth communication.

6.4 Battery Management System Bluetooth Communication

The BMS can communicate important battery operating information such as the State of Charge, cell voltage, temperature, and total throughput as part of a diagnostic report via Bluetooth to devices such as mobile phones and tablets. Battery data is then viewable using the AES BLUE App, which is downloadable from the Apple Store or Google Play Store.

NOTE
Bluetooth communication is available even while the battery is in hibernation.

6.5 Battery Management System Cell Balancing

The cell balancing circuits in the battery compare all the cells in the battery and begin balancing the cell voltage at 3.3 VPC. Balancing occurs when there is as little as 15 mV difference between cells.

6.6 Internal Heating (AES-B-G24-12V-H, AES-B-GC12-12V-H)

Both the AES Blue 12V models are equipped with internal heating. When the battery's internal temperature is below 15°C (59°F) and the battery is connected to a charging source, a portion of the energy is diverted to the internal heating element to avoid the under-temperature fault.

The heating stops when:

1. The battery's internal temperature rises above 15°C (59°F).
   - Once the cell temperature reaches this threshold, all the energy is directed to charging the cells.
2. There is no charge current.

After the heating stops, if the battery's internal temperature drops below 15°C (59°F) for 4 seconds and the battery is connected to a charging source, the heater turns ON again.

For information about internal heating, refer to 3.4 Protections Specifications and 3.5 Internal Heating Specifications.

NOTE
Charging and heating can occur simultaneously. However, the BMS will not allow charging to continue when cell temperature is below 0°C (32°F) for 4 seconds.

6.7 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 indicates that the product has no ingress of dust particles and no ingress of a harmful quantity of water when immersed in 1 meter of water for up to 30 minutes.

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

6.8 PTFE Membrane Vent

The PTFE Membrane Vent enables the free passage of gases and vapors and allows the equalization of pressure between the internal case and ambient conditions. This helps to protect and preserve the internal components of the battery.

7. INSTALLATION

⚠ WARNING

ELECTRIC SHOCK AND FIRE HAZARD

- This equipment must only be installed as specified.
- Do not install the battery in series.
- Do not disassemble or modify the battery.
- If the battery case has been damaged, do not touch exposed contents.
- There are no user-serviceable parts inside.

Failure to follow these instructions may result in death or serious injury.

⚠ CAUTION

FIRE AND BURN HAZARD

- Do not install the battery in a zero-clearance compartment.
- Compartment ventilation is required.

Failure to follow these instructions may result in injury.

NOTE

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

7.1 Tools

- Insulated tools sized to match nuts, bolts, and cables
- RMS type Voltmeter
- Personal protective equipment

7.2 Location

⚠ WARNING

FIRE HAZARD

Do not install the battery in living or working areas.

Failure to follow these instructions may result in death or serious injury.

Install the battery in locations that meet the following requirements:

1. **Do not install in direct sunlight.** Avoid installing the battery in an area with a high ambient temperature or an area exposed to UV rays.
2. **Moderate temperatures.** The ambient temperature should be between 0°C and 40°C (32°F and 104°F). Ambient temperatures of 15°C to 25°C (59°F to 77°F) are ideal for maximizing $LiFePO_4$ battery life. Do not install in an engine bay or near a component that produces significant heat that could expose the battery to temperatures greater than 40°C (104°F).
3. **Away from flammables.** Do not install the battery in an area where gasoline fuel or other flammables are present.

4. **Ventilation.** Do not install in zero-clearance compartments. Maintain at least 50 mm (2 inches) above the top cover for open airflow. The area should include vents to allow airflow to the outdoors.
5. **Orientation.** Install the battery in any direction other than upside down. Do not install with the top of the battery pointing down.
6. **Secure the battery.** 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 hold-downs.

NOTE

- Use only non-conductive material for 'over the top' hold-downs.
- Using this product in a location that does not meet requirements will void the warranty

7.3 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 rated for a minimum 90°C (194°F). Terminate the cables with lugs that fit the DC terminals.
2. **Minimum cable lengths.** Select a location that minimizes the length of battery cables to reduce the voltage drop from impedance, which could lead 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 (+) is connected to positive (+), and negative (-) is connected to negative (-). Verify the polarity of all connections before energizing batteries.

7.4 DC Protection

⚠ CAUTION

FIRE HAZARD

Undersized fuses and disconnects may become overloaded and potentially cause a fire.

Failure to follow these instructions may result in injury.

To protect the system and DC battery cables, additional DC overcurrent protection and a DC disconnect are recommended.

1. **Appropriate size.** Size the fuses and disconnects following 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 close to the battery and installed in the positive cable. Local 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.
- The local electrical code in your area may require both positive and negative DC disconnects. Refer to the applicable code and check with the authority having jurisdiction to confirm local requirements.

7.5 Terminal Connections and Hardware

The terminal connections and hardware should meet the following requirements:

1. **Connect to the battery terminal**. 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: 8 to 10 Nm (5.9 to 7.4 ft-lb). Periodically check to ensure torque is correct.

NOTICE

Exceeding 10 Nm (7.4 ft-lb) of torque on the terminal connections will damage the terminal and void the warranty.

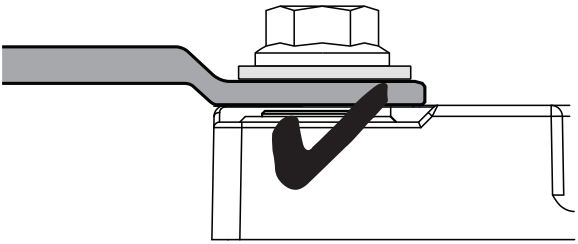

Figure 3. Correct Installation (cable lug in direct contact with battery terminal)

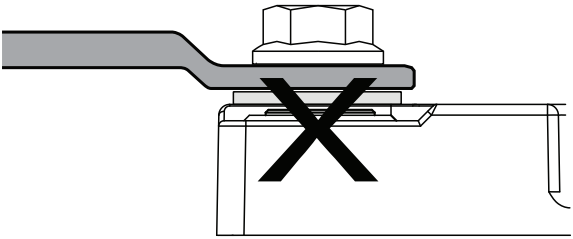

Figure 4. Incorrect Installation (washer between cable lug and battery terminal)

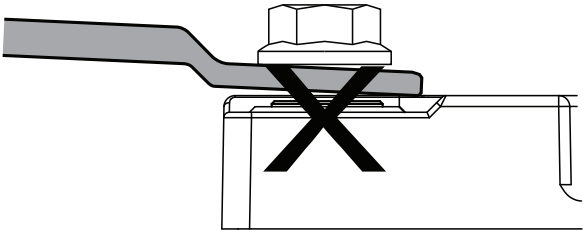

Figure 5. Incorrect Installation (cable lug angled against battery terminal)

NOTICE

- If any adjustments are made after installing the battery in its final destination, re-torque the terminals.
- Failure to torque to specifications may increase resistance, lower voltage, and potentially burn out the terminals and void the warranty.

NOTE

Without exception, a product experiencing terminal burnout will void the warranty.

7.6 Single Battery Installation Procedure

Install equipment following the standards set by the local authority having jurisdiction.

⚠ CAUTION

FIRE HAZARD

Use cables that meet specifications. Undersized cables can become hot and potentially catch fire.

Failure to follow these instructions can result in minor to moderate injury.

To optimize performance, battery cables (battery to load and battery to charger) must meet the following requirements:

1. **Minimum cable length.** Select a location that minimizes the length of battery cables to reduce the voltage drop.
2. **Equal cable gauge.** The battery cables should be the same gauge.
3. **Equal cable length.** The battery cables should be of equal length.

7.6.1 Installation Procedure

⚠ CAUTION

ELECTRIC SHOCK AND FIRE HAZARD

- Take precautions to avoid bridging the terminals.
- Do not contact the terminals with metal mountings, fixtures, or body parts.

Failure to follow these instructions may result in injury.

Install equipment following the standards set by the local authority having jurisdiction.

1. If the circuit in which the battery is installed has a disconnect, open the disconnect to isolate the battery.
2. Let the battery sit for over a minute. During this time, do not use Bluetooth to connect to the battery.
3. Use a DMM or other voltage measuring device to confirm the circuit is de-energized.
4. Ensure the cable connections are clean and in working order.
5. Install and secure the battery. Be careful not to make contact between the terminals and any metal mountings, fixtures, or body parts.
   You can secure the battery to standard battery trays with the B1/B3 hold-down ledges.
   The battery may also be strapped in place with over-the-top holds.
6. Connect battery cables taking care to connect the positive (+) cable to the positive (+) terminal. Connect the negative (-) cable to the negative (-) terminal last to avoid sparks.
   A short circuit may damage the battery and void the warranty. Refer to 7.5 Terminal Connections and Hardware.
7. Torque all battery terminals to the recommended torque of 8 to 10 Nm (5.9 to 7.4 ft-lb) to secure cable lugs.
8. If open, close the disconnect for the circuit.

NOTICE

- If any adjustments are made after installing the battery in its final destination, re-torque the terminals.
- Failure to torque to specifications may increase resistance, lower voltage, and potentially burn out the terminals and void the warranty.
- Exceeding 10 Nm (7.4 ft-lb) of torque on the terminal connections will damage the terminal and void the warranty.
- Avoid short circuits. Short circuits may damage the battery and will void the warranty.
- Some inverter-chargers support temperature-compensated charging. Disable temperature compensated charging on the charger or inverter.
- Do not use or install a battery temperature sensor.

7.7 Parallel Battery Installation Procedure

⚠ CAUTION

FIRE HAZARD

Use cables that meet specifications. Undersized cables can become hot and may potentially catch fire.

Failure to follow these instructions may result in injury.

Install equipment following the standards set by the local authority having jurisdiction.

Batteries connected in parallel must meet the following requirements:

1. **Same model.** Batteries must be the same model.
2. **Equal voltage.** The batteries must be within 50 mV (0.05 V) of each other before they are installed in parallel.

Battery cables must meet the following requirements to optimize performance:

1. **Minimum cable length.** Select a location that minimizes the length of battery cables to reduce voltage drop from the impedance.
2. **Equal cable gauge.** The interconnection cables (battery to battery) should be the same gauge.
3. **Equal cable length.** The interconnection cables should be of equal length.

7.7.1 Installation Procedure

⚠ CAUTION

ELECTRIC SHOCK AND FIRE HAZARD

- Take precautions to avoid bridging the terminals.
- Do not contact the terminals with metal mountings, fixtures, or body parts.

Failure to follow these instructions may result in injury.

Install equipment following the standards set by the local authority having jurisdiction.

1. If the circuit where the batteries are installed has a disconnect, open the disconnect to isolate the batteries.
2. Let the batteries sit for over a minute. During this time, do not use Bluetooth to connect to any of the batteries.
3. Use a DMM or other voltage measuring device to confirm the circuit is de-energized.
4. Ensure the cable connections are clean and in working order.
5. Install and secure the new batteries. Be careful not to make contact between the terminals and any metal mountings, fixtures, or body parts.
   You can secure the batteries to standard battery trays with the B1/B3 hold-down ledges. The batteries may also be strapped in place with over-the-top holds.
6. Connect the batteries in parallel.

Preferred Connection Method: Busbar

A busbar system is the recommended method of connecting multiple batteries in parallel. The busbar should be sized to handle the operating current of all the batteries, loads, and inverter-chargers.

If you are unable to use the busbar connection method and are connecting four or fewer batteries in parallel, consider using the alternative connection method. Refer to Alternative Connection Method: Battery Cables.

7. Connect the positive (+) battery cables to the positive (+) terminals on all the batteries.

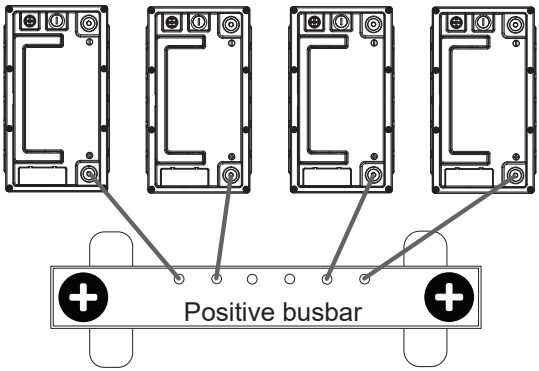

Figure 6. Connect Batteries to Busbar

8. Connect the other end of the positive battery cables to the terminals on the positive busbar.
9. Next, connect the negative (-) battery cables to the negative (-) terminals on the batteries, and connect the other end of the negative battery cables to the terminals on the negative busbar.
10. Confirm ALL the cable lugs fit snugly and are tightened with the recommended torque on the terminal hardware. Battery terminals: 8 to 10 Nm (5.9 to 7.4 ft-lb).
11. Connect the loads and chargers.

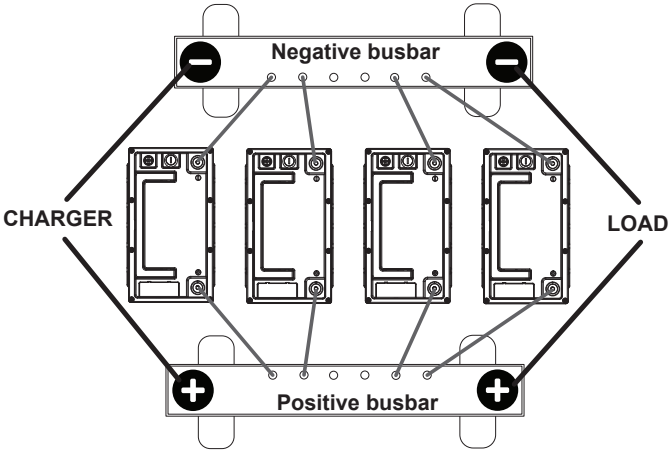

Figure 7. Connect Batteries, Charger, and Load to Busbar

12. Connect the load's positive (+) cable to the positive busbar, then the load's negative (-) cable to the negative busbar.
13. Connect the charger's positive (+) cable to the positive busbar, then the charger's negative (-) cable to the negative busbar.
14. Confirm ALL the cable lugs fit snugly and are tightened with the recommended torque of 8 to 10 Nm (5.9 to 7.4 ft-lb) to secure cable lugs and complete the parallel installation.

Alternative Connection Method: Battery Cables

Using a busbar system to connect multiple batteries in parallel is preferred over using this alternative connection method.

NOTICE
Connect a maximum four batteries using this alternative connection method. Charging and discharging with more than four batteries connected will lead to unbalanced battery cells.

7. Connect the battery positive (+) cables between the battery positive (+) terminals so they fit snugly to the terminal hardware.

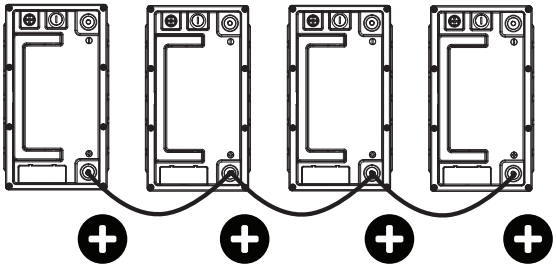

Figure 8. Positive Parallel Connections

8. Connect the battery negative (-) cables between the battery negative (-) terminals so they fit snugly to the terminal hardware.

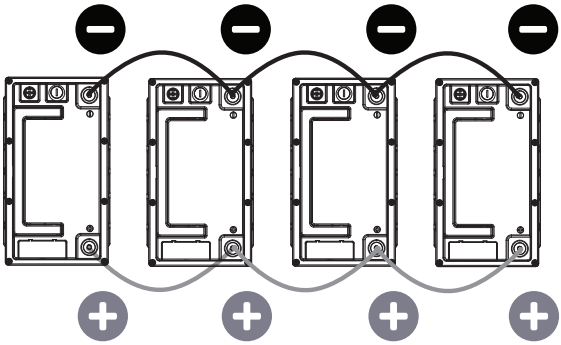

Figure 9. Negative Parallel Connections

9. Connect the load's positive (+) cable then the load's negative (-) cable to the opposite ends of the paralleled batteries.

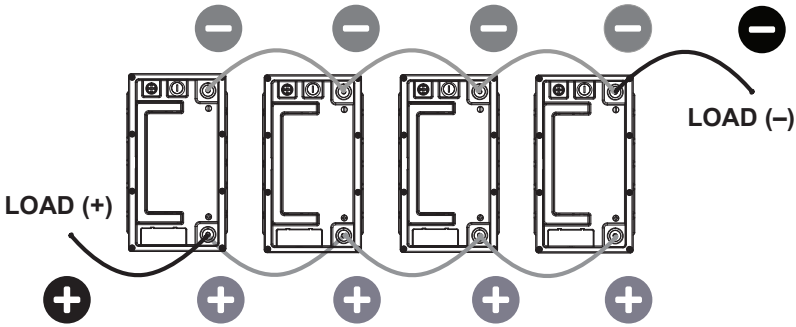

Figure 10. Load Connections

10. Connect the charger's positive (+) cable then the charger's negative (-) cable to the opposite ends of the paralleled batteries.

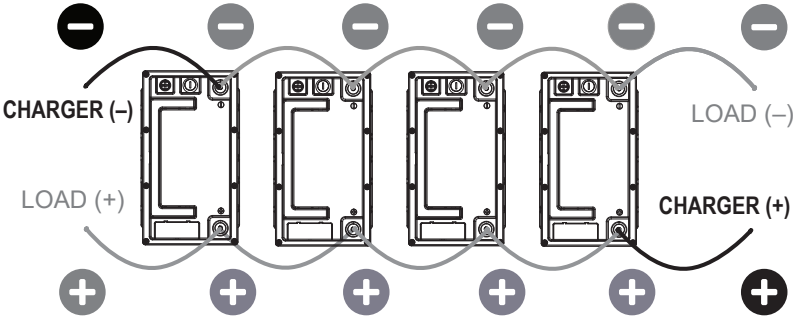

Figure 11. Charger Connections

11. Torque all the battery terminals to the recommended terminal torque of 8 to 10 Nm (5.9 to 7.4 ft-lb) to secure cable lugs.

NOTICE

- If any adjustments are made after installing the battery in its final destination, re-torque the terminals.
- Failure to torque to specifications may increase resistance, lower voltage, and potentially burn out the terminals and void the warranty.
- Exceeding 10 Nm (7.4 ft-lb) of torque on the terminal connections will damage the terminal and void the warranty.
- Failure to properly torque battery terminal nuts may increase resistance and lower voltage which may lead to burnout of the terminals and void the warranty.

NOTE

- Whenever replacing an old battery in a parallel string, use a battery of the same model, capacity, and voltage.
- Before installing the battery in parallel, charge each battery to 100% SOC.

8. OPERATION

The BMS prevents battery operation outside of specified operating conditions. Understand each of these protections and how to set up the system accordingly. Refer to Table 3-4, AES BLUE Protection Specifications.

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

8.1 Low Voltage Cut-Off

Program the low voltage cut-off on the power conversion equipment, as controlled by the application, at or above the Low Voltage Disconnect Recommended values in Table 3-1, AES BLUE Electrical Specifications. This action disconnects the load before the BMS enters undervoltage protection.

8.2 BMS Hibernation

The BMS enters hibernation mode if there is no charge or discharge activity and no Bluetooth communication for 1 minute.

In hibernation, the BMS:

- Reduces the consumption of energy
- Minimizes Bluetooth communication.

This protection helps safeguard the battery from over-discharge.

The battery exits hibernation mode and reactivates the BMS when there is a charge current, discharge current, or Bluetooth communication.

8.3 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 on Apple's App store or Google Play store.

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.

NOTICE
The state of charge displayed by the AES BLUE app has an accuracy of ±5%.

8.4 Charging

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

NOTICE

- Always confirm that the charging device is incapable of producing transient spikes that exceed the published terminal voltage limits for the battery.
- Always confirm the charging curve meets the battery's charging requirement.
- Never charge a visibly damaged or frozen battery.

8.4.1 When to Charge the Battery

- **Opportunity charging is OK.** Charging the battery after every use will not reduce its cycle life.
- **Fully charge every 4 cycles.** Every 4 cycles, fully charge the battery so the inverter-charger reaches the charge termination criteria. This ensures the battery cells are balanced and that each battery cell is fully charged.
- **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 charge current extends life.** Charging at 50% of nominal current or lower helps extend the battery cycle life.
- **Charge within the proper temperature range.** Ensure that charging is within the charge temperatures specified in Table 3-3, AES BLUE 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 void the warranty.
- Do not continually leave the battery in a partial state of charge as that will unbalance the battery cells. Fully charge the battery every 4 cycles so each battery cell is fully charged. If the end of charge criteria is not regularly performed, multiple balancing charges may be required to fully charge each battery cell.

  To perform a balancing charge, reduce charge termination to 100 mA and maintain 13.4 to 13.6 / 26.8 to 27.2 V for 10 hours.
- Charging the battery when it is below 0°C will cause irreversible damage and void the warranty.

8.4.2 What to Use to Charge the Battery

Use a Lithium $LiFePO_4$ charger. Use a charger with a dedicated $LiFePO_4$ charging algorithm that matches the AES Blue charging profile and parameters. For charging parameters refer to Table 3-1, AES BLUE Electrical Specifications and Figure 12. Charge Graph.

8.4.3 Charging with Alternators

It is possible. Charging with an alternator is possible. However, using one of the following is REQUIRED:

- Voltage regulator
- Battery isolator
- DC/DC converter

Not recommended. It is not recommended to directly charge from an alternator for the following reasons:

- 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 be created, potentially damaging the alternator and BMS and other electronics in the system.
- $LiFePO_4$ batteries are so efficient the alternator may overheat and burn itself out over extended periods of output at, or close to, peak current.

8.5 Charging Profile

AES Blue $LiFePO_4$ battery charging should include both Bulk and Absorption phases. For charging parameters, refer to Table 3-1, AES BLUE Electrical Specifications.

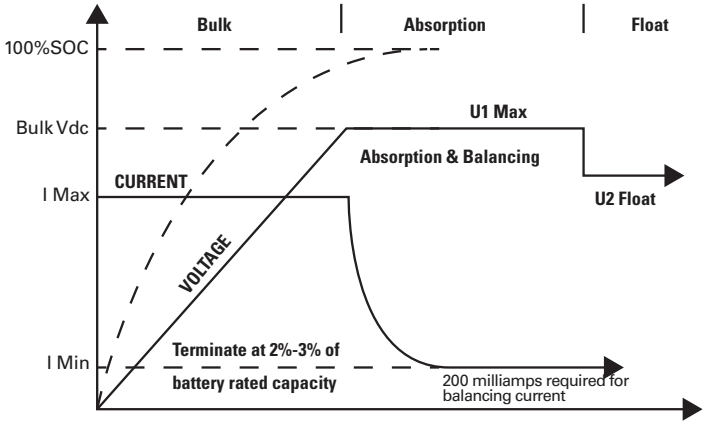

Figure 12. Charge Graph

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

8.5.1 Bulk Charge

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

If the charging source is a generator or other charge source that is inefficient 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 and 95% SOC.

Refer to Table 3-1, AES BLUE Electrical Specifications, for charging parameters.

8.5.2 Absorption Charge

Absorption phase. The second phase of the charging process is Absorption Charge, also called the constant voltage phase. In this phase, the charger reduces current accordingly to maintain the desired voltage.

Refer to Table 3-1, AES BLUE Electrical Specifications, for charging parameters.

8.5.3 Do Not Equalize Charge

⚠ CAUTION

FIRE AND BURN HAZARD

Do not perform an equalization charge on lithium batteries.

Failure to follow these instructions may result injury.

Do not perform an equalization charge. Do not perform an equalization charge on Lithium batteries. Equalization charging is intended for lead-acid batteries only.

An equalization charge is a purposeful overcharge that targets a voltage above the standard charge voltage to remove sulphate crystals that form on lead-acid plates over time.

8.5.4 Float Charge

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

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

If needed, refer to Table 3-1, AES BLUE Electrical Specifications, for float parameters.

9. BLUETOOTH

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

The App communicates with one battery only at a time.

NOTICE
The state of charge displayed by the AES BLUE app has an accuracy of ±5%.

10. ROUTINE INSPECTION

⚠ CAUTION

ELECTRIC SHOCK HAZARD

- 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.
- Follow 1.4 Safe Handling Procedures when working with the battery.

Failure to follow these instructions may result in injury.

Periodically inspect the battery:

1. Ensure that all DC cables are secure and fasteners are torqued properly.
2. Inspect and clean network and battery connectors of dirt and debris.
3. Ensure all networking cables and connectors are secure and tight.
4. Ensure that the installation location is clean and free from debris.
5. Inspect for cracks or bulging in the battery case.
6. Replace any damaged batteries.
7. Replace any damaged cables.

11. REPLACING THE FUSE

There is an inline fuse in the positive terminal (CHNBEL MIG.02 series).

⚠ CAUTION

ELECTRIC SHOCK HAZARD

- 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.
- Follow 1.4 Safe Handling Procedures when working with the battery.

Failure to follow these instructions may result in injury.

Table 11-1. AES BLUE Fuse Specifications

Discover Service Part Number	960-0082		960-0081	960-0080
Applicable Battery Model	AES-B-G24-12V-H	AES-B-GC12-24V	AES-B-GC12-12V-H	AES-B-G24-24V
Fuse Rating	32 V, 200 A		32 V, 250 A	32 V, 80 A
Fuse Terminal Torque	8 to 10 Nm (5.9 to 7.4 ft-lb). **DO NOT EXCEED 10 Nm (7.4 ft-lb).**			

Replacing the fuse should be performed by qualified personnel only.

- 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 7.5 Terminal Connections and Hardware, 7.6 Single Battery Installation Procedure, and 7.7 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 that 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. Open the fuse cover, remove the nuts holding the fuse, and replace it with a new fuse, paying strict attention to orientation and the fuse ratings in Table 11-1. AES BLUE Fuse Specifications.
5. Torque the nut holding the new fuse from 8 to 10 Nm (5.9 to 7.4 ft-lb). DO NOT EXCEED 10 Nm (7.4 ft-lb).
6. After removing the terminal protection, reinstall the battery into the system and replace the fuse cover.
7. Close the disconnect, if installed, to complete the circuit of equipment and energize the battery system.

NOTICE

- Failure to torque to specification may increase resistance and lower voltage, leading to burnout of the terminals and voiding the warranty.
- Exceeding 10 Nm (7.4 ft-lb) of torque will damage the fuse terminal and cause the battery case to crack and void the warranty.

12. STORAGE

Leaving the battery connected to a trickle load or power electronics will cause the battery to discharge 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 perform at least one full discharge and charge cycle before returning the battery to service.

1. **Store at 95% SOC or more.** To store the battery for up to 6 months, store the battery at 95% SOC or more. It must remain disconnected from all loads and power electronics during storage.
2. **Check SOC every six months.** Recharge the battery to above 95% SOC every six 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 discharge, resulting in irreversible damage and voiding the warranty.
- Storing the battery outside specified temperatures will result in irreversible damage and void the warranty.

NOTICE

- Storing or leaving the battery at 0% SOC will result in irreversible damage and void the warranty.
- Allowing the battery to self-discharge below an open-circuit voltage of 3.0 VPC could cause irreversible damage and void the warranty.

13. RELATED INFORMATION

Find information about Discover Energy Systems at discoverlithium.com.

For warranty information, see 885-0043 Discover AES BLUE Battery Warranty Policy.

14. GLOSSARY OF TERMS, ABBREVIATIONS, AND ACRONYMS

AFB Arc Flash Boundary	**LFP** $LiFePO_4$, Lithium Iron Phosphate
BMS Battery Management System	**RMS** Root Mean Square
DMM Digital Multimeter	**SOC** State of Charge
DOD Depth of Discharge	**VPC** Volts Per Cell
IBF Bolted Fault Current	