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A123 Systems ALM 12V7 User's Guide

End User Documentation

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Chapter 1

About this Document

This chapter includes the following sections:

Overview

A123's ALM 12V7 Lithium Ion battery (UL model number Series PSL000001) is designed as a drop-in replacement for the 12 volt 7 Ah lead-acid batteries that typically serve as a standby power source in many high-availability and service-critical applications. The Series PSL000001 is recognized as a standalone battery only. To ensure a seamless replacement process, the ALM 12V7 features identical dimensions to 12V7 lead-acid batteries, uses the same 0.250" faston terminal tabs and works with typical lead-acid chargers.

The ALM 12V7 battery consists of eight ANR26650 cells in a four series, two parallel (4S2P) configuration with integrated cell protection and balancing circuitry. The ALM 12V7 includes a user-replaceable 30 A fuse. Furthermore, an integrated microprocessor protects the battery pack from over-voltage, under-voltage, and over-temperature conditions.

Purpose of this Document

This guide provides detailed specifications for the ALM 12V7 as well as guidance on the safe and effective operation and configuration of multiple ALM 12V7 batteries used as building blocks in various applications. It also provides information on how to safely connect multiple batteries up to a maximum configuration of four batteries in series and two batteries in parallel (4S2P), as well as how to charge and discharge the batteries.

How this Document is Organized

This document is divided into the following parts:

- Chapter 2, Regulations

  Discusses the safety, EMC, environmental and transportation regulations applicable to the ALM 12V7 battery.

- Chapter 3, ALM 12V7 Description and Specifications

  Discusses the Lithium Ion technology inside the ALM 12V7 and its advantages compared to traditional lead-acid batteries.

- Chapter 4, Configuration and Operation

  Discusses how to safely connect multiple ALM 12V7 batteries and details for charging and discharging multiple ALM 12V7s.

- Chapter 5, Troubleshooting

  Discusses behavior unique to the ALM 12V7 compared to traditional lead-acid batteries, and how to operate the battery in those circumstances.

- Appendix A, Glossary

  Glossary of terms.

Chapter 2

Regulations

The chapter discusses the safety, EMC, environmental and transportation regulations applicable to the ALM 12V7 battery.

The transportation material presented here is not all-inclusive of the regulations required to ship a product, but is meant to inform you of the complexity involved in doing so. Anyone involved in the integration of Lithium Ion battery packs into a host product must review the regulations cited here and meet compliance standards with industry regulations.

The information contained herein is for informational purposes only and is not legal advice or a substitute for legal counsel.

This chapter includes the following sections:

Safety Regulations

- UL subject 1973 - Batteries for use in Light Electric Rail (LER) Applications and Stationary Applications.
- CE — Recognized to EU consumer safety, health and environmental regulations. Signifies conformity with EMC directive (2004/108/EC)
- FCC Part 15 Subpart B Class A — standards regulating unintentional emissions of radio frequencies from a digital device.
- UN 38.3 — Meets section 38.3 of the UN Recommendations on the Transport of Dangerous Goods - Manual of Test Criteria.

Transporting Lithium Ion Batteries

This section discusses the regulations governing the transportation of Lithium Ion cells and batteries both within the United States and internationally. You should read and understand all relevant regulations discussed in this section before shipping ALM 12V7 batteries. This section includes the following sections:

- Overview on page 2-2
- Regulations by Cell/Battery Size on page 2-3
- Following UN and DOT Regulations on page 2-3

NOTE

The regulations discussed in this manual apply to Lithium Ion cells and batteries. Once the ALM 12V7 is integrated into a host product, the host product may be subject to additional transportation regulations that require additional certification testing. Since A123 Systems can't anticipate every possible configuration and application of the ALM 12V7, you must verify that your ALM 12V7-powered host product is compliant with all applicable regulations. Refer to Table 2-2 on page 2-4 for a list of UN numbers to reference to find applicable regulations for your application.

Overview

Rechargeable lithium ion (including lithium ion polymer) cells and batteries are considered dangerous goods. The regulations that govern their transport are based on the UN Recommendations on the Transport of Dangerous Goods Model Regulations. Transport of dangerous goods is regulated internationally by:

- International Civil Aviation Organization (ICAO) Technical Instructions
- International Air Transport Association (IATA) Dangerous Goods Regulations
- International Maritime Dangerous Goods (IMDG) Code

In the United States, transportation is regulated by Title (part) 49 of the Code of Federal Regulations or CFR's. Title 49 CFR Sections 100-185 of the U.S. Hazardous Materials Regulations (HMR) contains the requirements for transporting cells and batteries. Refer to the following sections within 49 CFR for specific information.

- Section 173.185 - Shipping requirements for Lithium cells and batteries
- Section 172.102 - Special Provisions
- Sections 172.101, 178 - Further information and specifications on packaging

The Office of Pipeline and Hazardous Materials Safety Administration (PHMSA), which is within the U.S. Department of Transportation (DOT), is responsible for drafting and writing the U.S. regulations that govern the transportation of hazardous materials (also known as dangerous goods) by air, rail, highway and water.

Regulations by Cell/Battery Size

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

Following UN and DOT Regulations

Failure to comply with UN and DOT regulations while transporting Class 9 Hazardous Materials (Dangerous Goods) may result in substantial civil and criminal penalties. Table 2-1 outlines a process that you can follow to help ensure that cells and batteries are shipped per the required regulations.

Table 2-1 Suggested Steps for Regulatory Compliance

Step Number	Process step	Comments
1	Ensure use of UN certified packaging if applicable.	All dangerous goods must be shipped in UN certified packaging.
2	Packaging of cell or battery.	Pack per regulations.
3	Package labeling.[a]	Ensure that packaging container has all required labeling.
4	Fill out proper shipping documentation.	Complete shipper's declaration for dangerous goods, airway bill, and so on.
5	Ship package.	Ensure that shipping company can ship dangerous goods.

a. Refer to Table 2-2 on page 2-4 for proper shipping names and UN numbers for lithium ion batteries.

Table 2-2 lists the proper shipping name for lithium ion batteries and the corresponding UN number.

Table 2-2 Proper Shipping Names and UN numbers

Proper Shipping Name	UN Number
Lithium ion batteries	UN 3480
Lithium ion batteries packed with equipment	UN 3481
Lithium ion batteries contained in equipment	UN 3481

Environmental Regulations

The battery electronics and its enclosure is compliant with the following environmental regulations:

- EU Directive 2011/65/EC for on the restriction of the use of certain hazardous substances in electrical and electronic equipment (RoHS)
- EU Directive 2006/66/EC on batteries and accumulators and waste batteries and accumulators
- EU Directive 1907/2006 on the Registration Evaluation Authorization and Restriction of Chemicals (REACH)
- Management Methods for Controlling Pollution Caused by Electronic Information Products Regulation (China RoHS)

Chapter 3

ALM 12V7 Description and Specifications

The ALM 12V7 consists of eight ANR26650 cells using patented Nanophosphate® technology, and is intended as a replacement for the common 12v7 lead-acid battery.

This chapter details the advantages of the technology behind the ALM 12V7 in the following sections.

- The ALM 12V7 on page 3-1
- ALM 12V7 Specifications on page 3-3
- Safety on page 3-8

The ALM 12V7

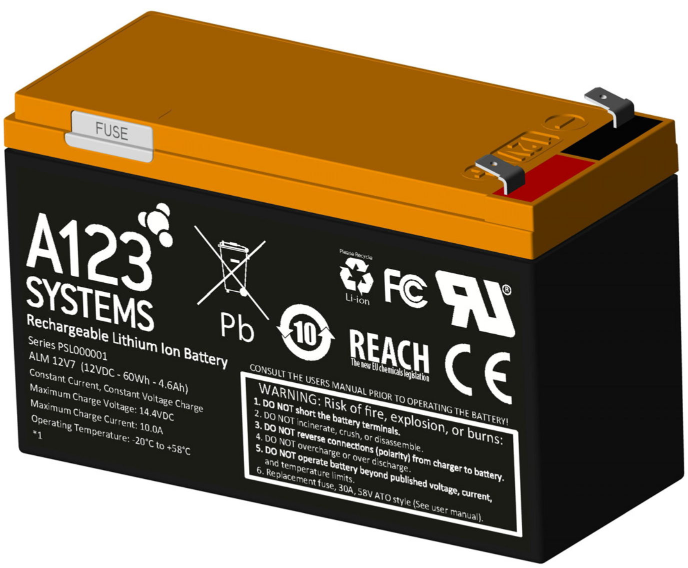


Figure 3-1 ALM 12V7 Battery

The ALM 12V7 battery consists of eight ANR26650 cells arranged in a four in series and two in parallel configuration (4S2P) with integrated cell protection and balancing circuitry. A123 Systems designed the ALM 12V7 as a drop-in replacement for the 12 volt 7 Ah lead-acid batteries that typically serve as a standby power source in many high-availability and service-critical applications. To ensure a seamless replacement process, the ALM 12V7 features identical dimensions to 12V7 lead-acid batteries, uses the same 0.250” faston terminal tabs and works with the same chargers.

Functional Differences from Lead-Acid ALM 12V7 Batteries

The ALM 12V7’s integrated cell protection and balancing circuitry is responsible for safety and protection of the pack. Additional safety features of the ALM 12V7 battery also cause functional behavior that differs from typical lead-acid batteries. The two biggest differences are:

- **No voltage at the terminals does not necessarily indicate a bad battery.**

  With a lead-acid battery, finding no voltage at the terminals often indicates the battery has reached the end of its life. With the ALM 12V7 battery, no voltage at the terminals typically means the cell protection circuitry has interrupted current to protect the battery. The pack disconnects the cells from the battery terminal, resulting in no voltage present at the terminals. Connect the battery to a charger to restore voltage to the terminals. With the ALM 12V7 battery, no voltage at the terminals could mean:

  - The cell protection circuitry has interrupted current to protect the battery. The pack disconnects the cells from the battery terminal.
  - The cell protection circuitry has disconnected the cells from the terminals to reduce current consumption, thus maximizing shelf life.
  - The fuse is open.

- **State of Charge (SOC) with an ALM 12V7 appears constant, then drops suddenly.**

  Voltage for an ALM 12V7 remains relatively constant throughout the depth-of-discharge, while voltage for a lead-acid battery decreases at a linear rate. Therefore, determining an ALM 12V7’s SOC using the same methods to determine a lead-acid battery’s SOC creates the impression that the ALM 12V7 has a full charge then loses power abruptly. A steady voltage across the depth-of-discharge is normal behavior for the ALM 12V7. Refer to Discharge Performance on page 3-5 for more details.

ALM 12V7 Specifications

Table 3-1 ALM 12V7 Specifications

Specification	Description
Maximum Continuous Discharge Current	22.5 A
Maximum Pulse Discharge Current	30 A[a]
Ambient Operating Temperature Range	-20°C to +58°C
Maximum Operating Altitude	10,000 ft[b]
Operating Relative Humidity (non-condensing)	20% to 80%
Nominal Operational Voltage	13.2 V
Minimum Voltage	2 V @ any cell
Maximum Voltage	4.0 V @ any cell
Nominal Capacity	5 Ah
Standard Charge Voltage	14.4 V
Minimum Charge Voltage	13.8 V
Float Charge Voltage	14.0 V
Standard Charge Current at 25°C	3 A
Maximum Continuous Charge Current at 25 °C	10 A

a. Refer to the LittleFuse PN 142.6185.5302 specifications.

b. The maximum operating temperature decreases by a factor of 1.1°C per 1,000 ft of elevation above 7,500 ft.

Mechanical Dimensions

Figure 3-2 details the mechanical dimensions of the ALM 12V7 battery.

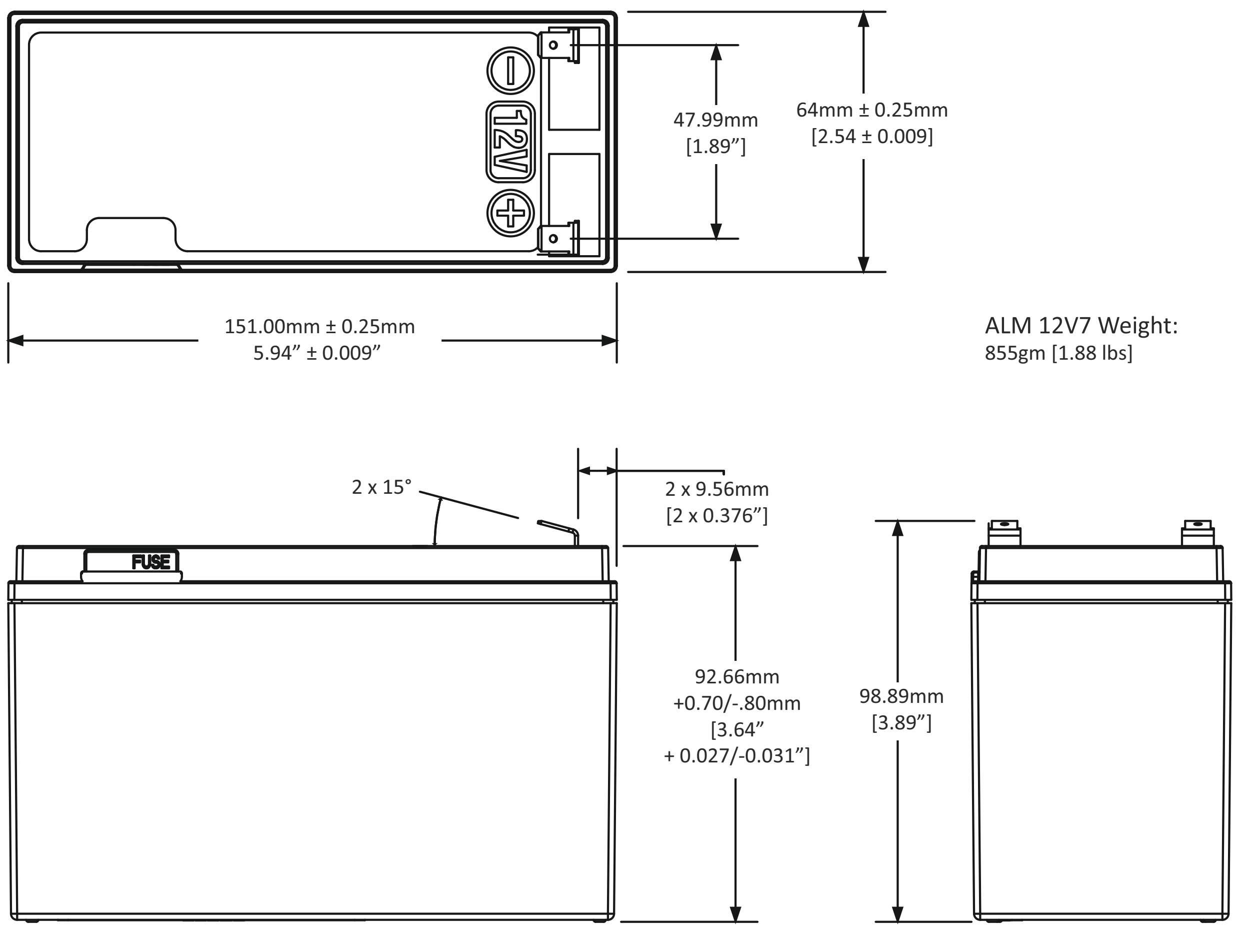


Figure 3-2 ALM 12V7 Mechanical Dimensions

The ALM 12V7 consists of the following components:

1. 12V7
2. Fuse plug
3. 30 A 58 V ATO®-style blade fuse

Discharge Performance

As shown in the typical room temperature discharge curve in Figure 3-3, the ALM 12V7's voltage remains virtually flat during the discharges and the capacity doesn't change significantly, no matter how fast the discharge is.

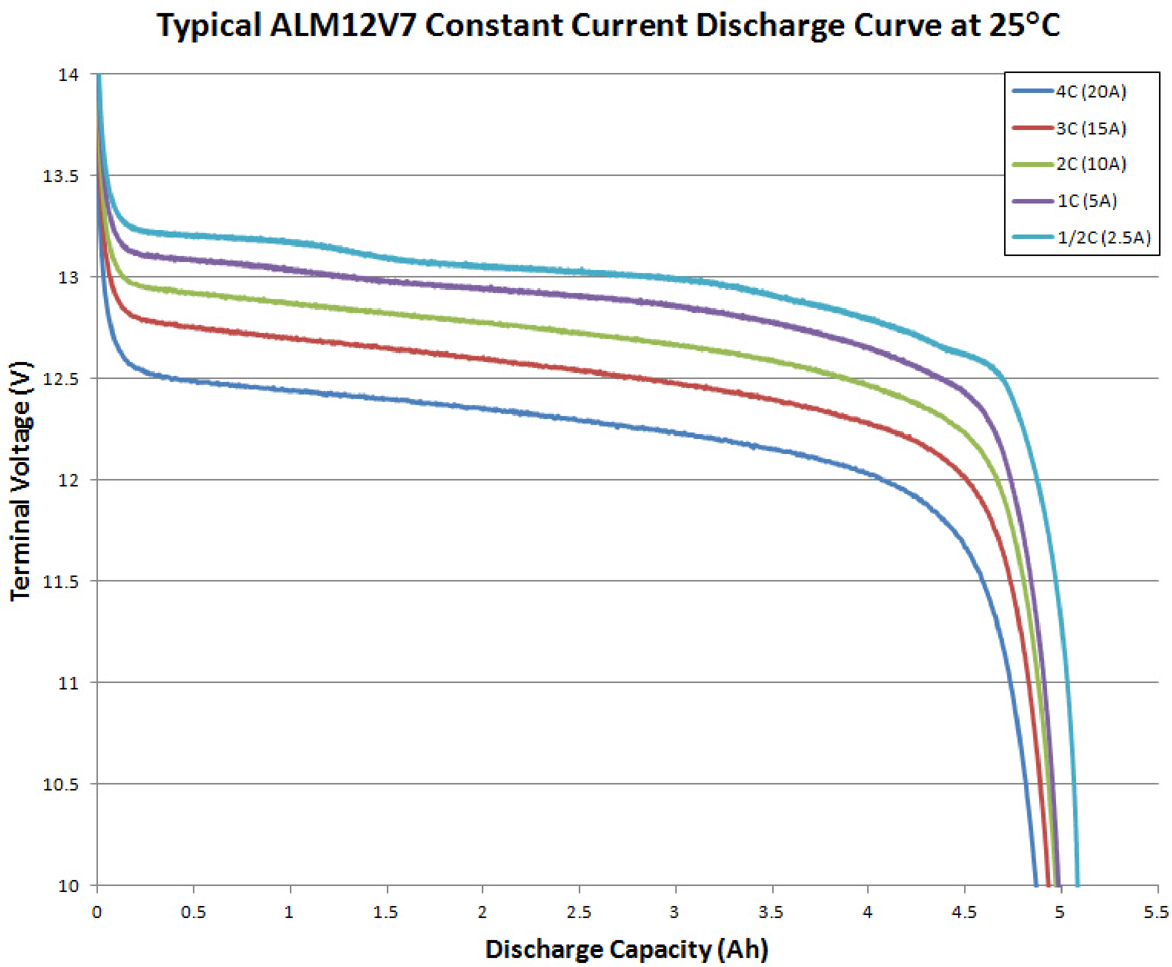


Figure 3-3 Room Temperature Discharge

Cell resistance changes with cell temperature. The warmer the ambient and/or cell temperature, the lower the resistance. Conversely, lower temperatures negatively impact the cell's ability to hold voltage under higher loads. Figure 3-4 and Figure 3-5 illustrate the impact ambient temperature has on the ALM 12V7's ability to hold voltage.

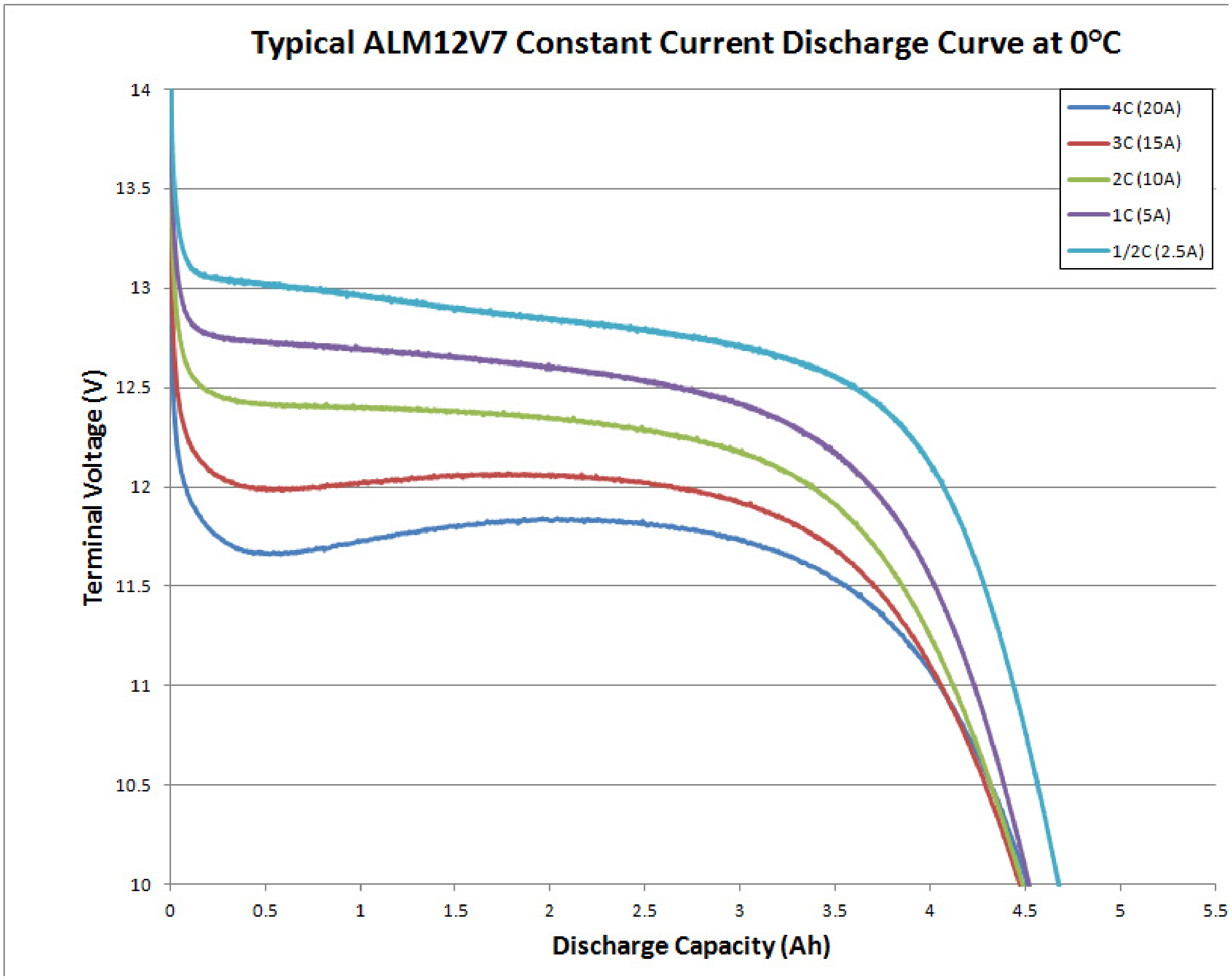


Figure 3-4 Discharge Curve at 0°C

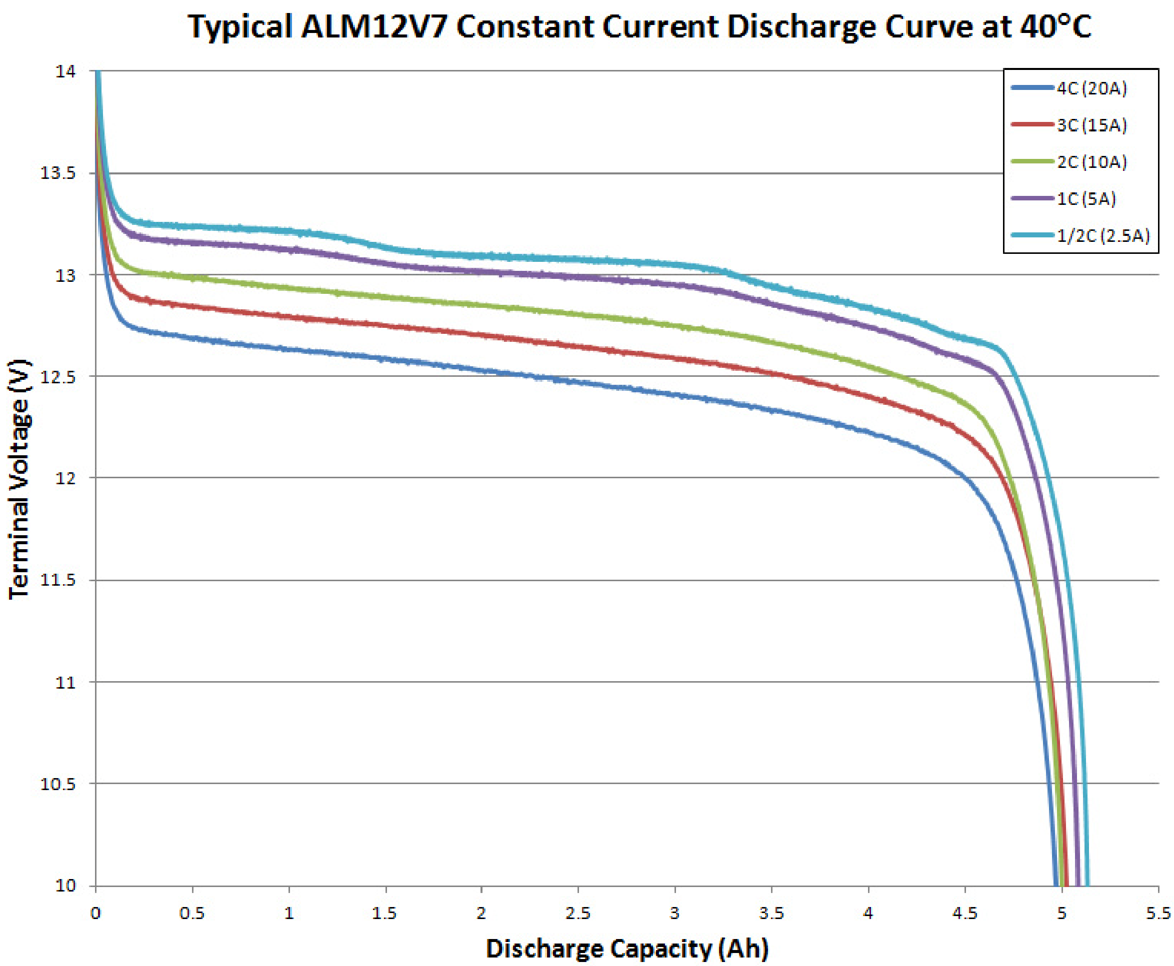


Figure 3-5 Discharge Curve at 40°C

Shelf Life

All ALM 12V7 battery packs ship from the factory at 50% SOC and can retain at least 10% SOC after 1 year of storage at temperatures not exceeding 25°C. Note that higher storage temperatures reduce impedance and accelerate the rate of self-discharge.

Following this 1 year period the SOC could fall below 10%, and the terminals become disconnected (open). The ALM 12V7 can remain in this state for a minimum of 2 more years. To reactivate the terminals, the battery must be recharged.

Cycle Life

The ALM 12V7's cycle life is determined by the 26650 cells inside it, as well as ambient temperature and charge/discharge rates. Under optimal conditions, the cells can deliver thousands of 1C charge/1C discharge cycles at 100% Depth of Discharge (DOD).

Terminal Specifications

The ALM 12V7 battery uses the same 0.250” by 0.032” Faston terminals found on 12V7 lead-acid batteries, and is compatible with any appropriately-sized receptacle.

Safety

A123’s Nanophosphate® cells are more abuse tolerant than other Lithium Ion cells; however, correct handling of the ALM 12V7 battery is still important to ensure safe operation.

WARNING

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

- Do not expose the ALM 12V7 to heat in excess of 58 °C during operation, 60 °C in storage; do not incinerate or expose to open flames.
- Do not short circuit the ALM 12V7. This opens the 30 A user-replaceable fuse.
- Do not charge or discharge the ALM 12V7 outside of its stated operating temperature range. Reduce charging limits for lower operating temperatures.
- Do not connect more than four batteries in series. Connecting more than four batteries in series will damage the integrated protection circuitry, leaving the battery without critical safety features, such as over-voltage and over-temperature protection.

Storage

A123 Systems ALM 12V7 can be stored in an environment with temperatures between -40°C and +60°C and between 10% and 90% relative humidity, non-condensing. In addition, you can store the ALM 12V7 at altitudes up to 25,000ft. For long storage periods at 25°C, charge the battery every three years. For temperatures above 40°C, charge the battery annually. Do not store the ALM 12V7 at temperatures above 60°C.

Disposal

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

Chapter 4

Configuration and Operation

This chapter discusses configuring, charging and discharging the ALM 12V7 in the following sections.

NOTE

The series PSL000001 is UL Recognized as a standalone battery only and has not been evaluated for series and/or parallel configuration.

Terminology

This chapter discusses configuring and operating ALM 12V7 batteries using the following terminology:

Table 4-1 Configuration Terminology

Terminology	Definition
Cell	Refers to an individual ANR26650 cell that is the basis for the ALM 12V7 battery. Each ALM 12V7 contains eight ANR26650 cells combined in a 4S2P configuration.
Module or Battery Module	The ALM 12V7 battery.
Series String	A string of cells arranged in series to achieve higher voltage.
Parallel String	A string of cells arranged in parallel to achieve higher capacity.
Battery System	Batteries connected in series and/or in parallel to achieve higher voltage and/or capacity.

Configuration Options

You can arrange A123's ALM 12V7 batteries in series and/or in parallel to achieve higher operating voltages and capacities for your intended application, with a maximum configuration of 4S2P. An external BMS or other electronics are not required to configure multiple ALM 12V7s.

CAUTION

Do not connect more than four ALM 12V7 batteries in series, as the total voltage exceeds the limits of the integrated protection circuitry. Compromising the integrated protection circuitry increases the risk of an over-voltage or over-temperature event that may damage the ALM 12V7 and the host equipment.

CAUTION

Do not short circuit the ALM 12V7. This opens the 30 A user-replaceable fuse.

Connect the ALM 12V7 batteries using 10 AWG wire and the proper receptacle that fits a 0.250" by 0.032" Faston terminal tab. The 10 AWG wire is necessary to carry the maximum current allowed by the user-replaceable 30 A fuse in each battery. Refer to Figure 4-1 for an illustration of the components used to connect multiple ALM 12V7s.

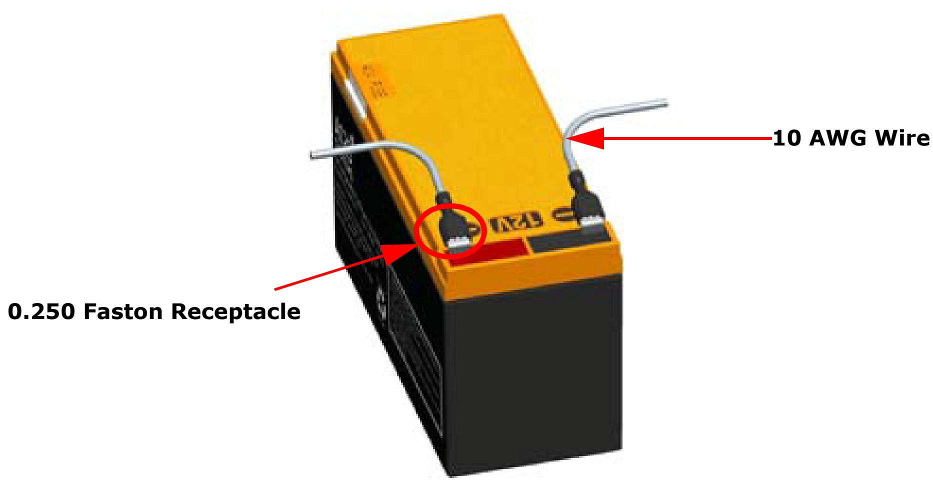


Figure 4-1 Components Used to Connect Multiple ALM 12V7s

NOTE

Do not connect ALM 12V7 batteries to batteries of other chemistries or ALM batteries of different capacities. For example, do not connect an ALM 12V7 to a lead-acid 12V7.

Series Strings

The batteries can be combined together in series strings to achieve higher operating voltages by connecting the positive terminal of one battery to the negative terminal of the next battery. The maximum number of ALM 12V7s you can connect in a series is four. Figure 4-2 illustrates two ALM 12V7s connected in series, for a 2S1P configuration.

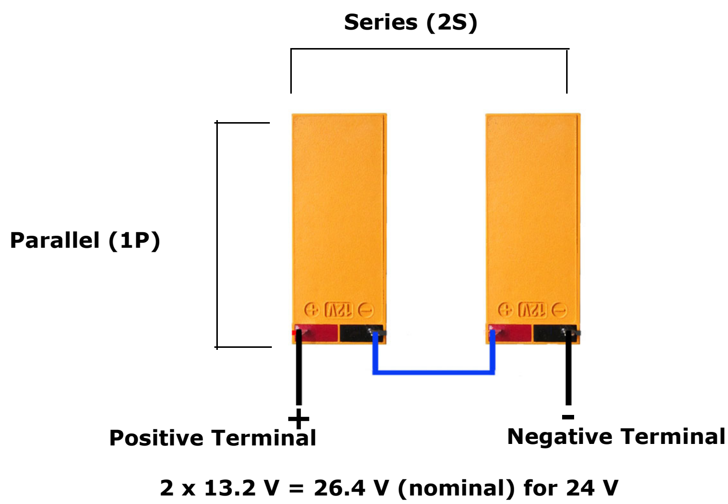


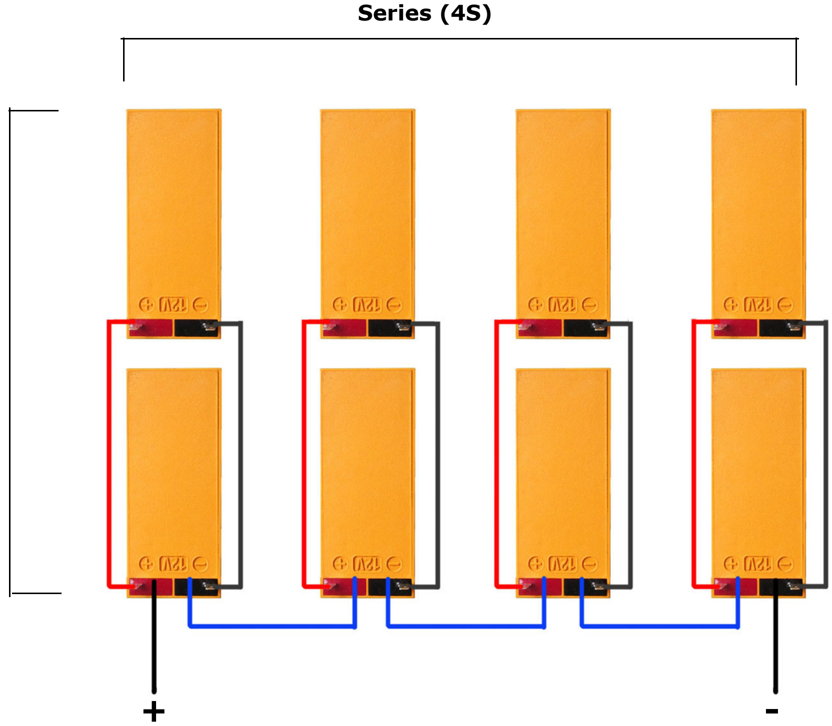
Figure 4-2 Connecting Batteries in Series (2S1P Configuration)

- Two batteries in series: 2 x 13.2 V = 26.4 V (nominal) for 24 V applications
- Three batteries in series: 3 x 13.2 V = 39.6 V (nominal) for 36 V applications
- Four batteries in series: 4 x 13.2 V = 52.8 V (nominal) for 48 V applications

Parallel Strings

You can combine batteries together in parallel strings to achieve higher operating energy by connecting like-polarity terminals of adjacent batteries. To combine batteries in parallel strings, connect all like-polarity wires on adjacent batteries to an appropriately sized terminal block for your application. Reference local electrical codes for terminal block specifications. Refer to Figure 4-3 for an example of eight ALM 12V7 batteries connected together in a 4S2P configuration. The maximum number of 12v7 series strings that you can connect in parallel is two.

Parallel string configurations greater than 4S2P, for higher charge currents, are not supported at this time.



Series: 4 x 13.2 V = 52.8 V (nominal) for 48 V
Parallel: 2 x 5.0 Ah = 10.0 Ah (nominal)

Figure 4-3 Example of a 4S2P Configuration

- Two series strings in parallel: 2 x 5.0 Ah = 10.0 Ah (nominal)

Charging Multiple Batteries

This section describes how to charge and discharge ALM 12V7 batteries configured in series or parallel up to a maximum configuration of 4S2P.

CAUTION

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

- Do not connect more than four batteries in series. Connecting more than four batteries in series exceeds the voltage limit of the integrated protection circuitry, leaving the battery without critical safety features such as over-voltage and over-temperature protection.
- Do not short circuit the ALM 12V7. This opens the 30 A user-replaceable fuse.
- Do not connect more than two battery strings in parallel.

Charging Batteries or Battery Systems

The ALM 12V7 is compatible with common 12V7 lead-acid battery chargers of 10 A or less. Chargers that require the detection of voltage at the battery terminals to charge may fail to wake the ALM 12V7 from a state of under-voltage protection. Constant Voltage (CV) chargers may result in an inrush of current due to the low impedance of the cells, interrupting the charge. Reset the charger and continue charging normally if the charger trips.

Determine the end-of-charge voltage for the battery system by multiplying the number of batteries connected in series by the maximum recommended charge voltage of a single battery (14.4 V), as shown in Equation 1.

Eq. 1 (Number of batteries s in series) x (Recommended Maximum Charge Voltage, battery) = Charge Voltage, String

To charge a single ALM12V7 battery, the maximum charge voltage is 14.4 V and the maximum charge current is 10 A. Any inrush current should not exceed the removable fuse specification.

Refer to Table 4-2 for recommended charge currents and voltage.

Table 4-2 Examples for Charging Multiple Batteries

Example	Description
Example 1	If the battery string has two batteries in parallel (2P), and the recommended charge current per battery is 10 A, then the charge current for this parallel string is 10 A.
Example 2	If the battery string has four batteries in series (4S), and the recommended charge voltage per battery is 14.4 V, then the end of charge voltage for this series string is 57.6 V: (4 batteries, series) x (14.4 V) = 57.6 V

Once you reach end-of-charge voltage, apply a constant voltage hold at this voltage until the current decays to almost zero. This charges the cells to 100% state of charge (SOC). Refer to Figure 4-4 for an illustration.

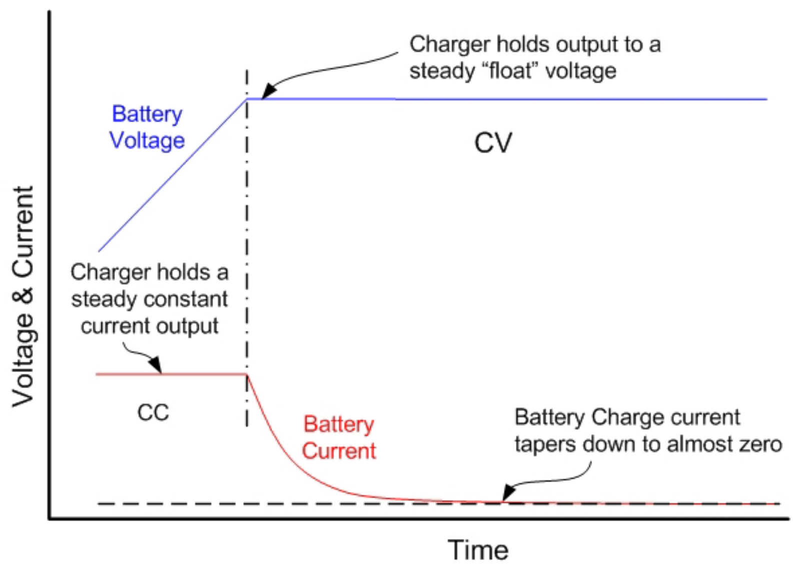


Figure 4-4 Battery Voltage and Current During Recharge

Relationship Between Charge Limits and Temperature

Due to the chemistry of Lithium Ion cells, the cells cannot accept as much charge current at lower temperatures without risking permanent loss of capacity. As the cells' temperature rises during the charging process, they can gradually accept higher currents.

To maintain optimum performance and durability of the ALM 12V7, A123 Systems recommends the following charge limits based on ambient temperature.

Table 4-3 Charge Rate by Temperature Recommended Float Charge Method for an ALM 12V7 Battery System

Temperature (°C)	Charge Rate
-20	C/5 (1.0 A)
-10	C/2 (2.5 A)
0	1C (5.0 A)
10	2C (10.0 A)
20	2.2C (11A)

Recommended Float Charge Method for an ALM 12V7 Battery System

If you hold the voltage of the battery system at the end-of-charge voltage (after reaching 100% SOC) for prolonged periods of time, lower the end-of-charge voltage to the recommended float-charge voltage. Determine the recommended float voltage by multiplying the number of batteries connected in series by the recommended float-charge voltage of a single battery (14.0 V), as shown in Equation 2.

Eq. 2 (Number of batteries in series) x (14.0 V) = Float Charge Voltage, battery system

Discharging Battery Systems

Recommended Discharge Method for Strings

Parallel Strings allow increased energy and increase capacity permitting longer run time. The total capacity of the system is shown in Equation 3.

Eq. 3 (Number of batteries in parallel) x (5.0 Ah) = max system capacity

Discharge Temperature Limits

For optimum life, do not discharge a battery system at a current that is higher than the maximum continuous discharge current of 22.5A per battery. When discharging the battery at a current that is higher than 1C rate, allow for a rest time in between charge and discharge cycles to limit the cell temperature rise. The battery pack has an Over Temperature Protection (OTP) circuitry that opens the terminals when the temperature increase creates an unsafe operating condition. Do not operate the battery pack outside of the operational temperature range specified in Table 3-1 on page 3-3.

At low temperatures, the maximum available discharge current decreases due to increased internal impedance at lower temperatures. Refer to Discharge Performance on page 3-5 for more details.

Integrated Battery Protection

The ALM 12V7 includes integrated protection circuitry to prevent the battery from exceeding its voltage limits. The battery's circuitry interrupts either charging or discharging current if the battery is in danger of exceeding upper or lower voltage or temperature limits.

Over Voltage and Under Voltage

The ALM 12V7's circuitry continuously monitors cell voltage and can interrupt either charge or discharge current in the event that a cell's voltage exceeds safe operating limits.

The protection circuitry interrupts current if the voltage on any single cell rises above 4.0 V or falls below 2 V.

- If the voltage on a single cell falls below 2 V, the protection circuitry enables under-voltage protection, preventing continued discharge until you charge the battery.
- If the voltage on a single cell rises above 4.0 V, the protection circuitry enables over-voltage protection, preventing continued charging until the voltage falls. The protection circuitry disables over-voltage protection once the voltage falls below 3.6 V.

NOTE

Under-voltage protection creates an open circuit, removing voltage from the terminals. With a lead-acid battery, finding no voltage at the terminals often indicates the battery has reached the end of its life. With the ALM 12V7 battery, no voltage at the terminals typically means the cell protection circuitry has interrupted current to protect the battery. Simply connect the battery to a charger to restore voltage to the terminals.

Over Temperature

The ALM 12V7's circuitry continuously monitors the battery pack's temperature. The battery pack has an Over Temperature Protection (OTP) circuit that will open the terminals when the temperature increase creates an unsafe operating condition. Do not operate the battery pack outside of the operational temperature range specified in Table 3-1 on page 3-3.

Balancing

Over time, the cells diverge in both capacity and SOC. The ALM 12V7 continuously monitors the cell voltage, and the balancing circuitry and firmware will insure that all the cells are properly balanced. Completely balancing the battery can take up to 48 hours. The ALM 12V7 balances continuously and does not require maintenance balancing. An advantage of the balancing circuitry and firmware is that any system configuration of ALM 12V7 (max 4S2P) is also automatically balanced with no requirement for an external battery management system.

Fusing

User-Replaceable Fuse

A 30 A 58 V, user-replaceable, ATO®-style blade fuse manufactured by LittleFuse (PN 142.6185.5302) protects the ALM 12V7 from short circuits. If required, you must replace the fuse with a LittleFuse (PN 142.6185.5302).

To Replace the 30 A 58 V Fuse:

1. Hold the fuse plug at the lower lip (indicated in Figure 4-5), then remove it.

Figure 4-5 Removing the Fuse Plug

2. Remove the 30 A fuse using an ATO fuse puller, commonly available in hardware or automotive supply stores.
3. Replace the fuse with a 30 A 58 V, ATO®-style blade fuse manufactured by LittleFuse (PN 142.6185.5302).
   a. Place the top of the replacement fuse in the fuse plug. Covering the fuse with the fuse plug prior to inserting the fuse into the battery pack is the easiest way to ensure proper fitment of the fuse plug.

Figure 4-6 Fuse Fitment in the Fuse Plug

b. Insert the replacement fuse and fuse plug into the battery pack.

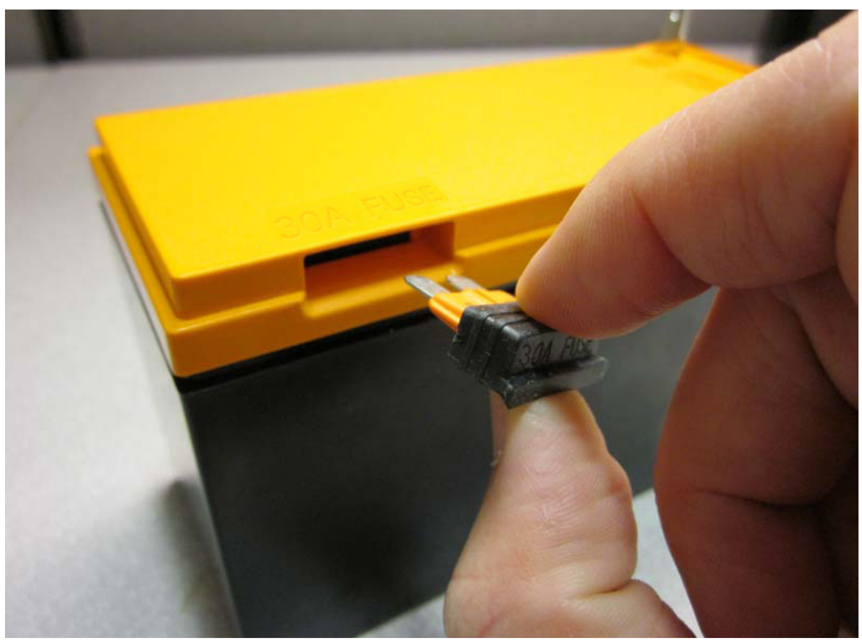


Figure 4-7 Inserting the Fuse and Fuse Plug into the ALM 12V7

c. Ensure that the fuse plug is flush with the battery, as shown in Figure 4-8.

Figure 4-8 Fuse Plug Flush with the ALM 12V7 Battery

4. Connect the battery to a charger to wake the battery.

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Chapter 5

Troubleshooting

The ALM 12V7 is an extremely reliable battery that provides greater useful life than comparable 12V7 lead-acid batteries. Despite the high reliability of the ALM 12V7, you may encounter situations where the battery does not operate as expected. These situations are typically the result of misuse, abuse or a non-optimal operating or storage environment. This chapter details potential issues you may encounter with the ALM 12V7 and the appropriate troubleshooting procedures.

Charger Trips using Constant Voltage

Problem

CV charger trips when charging the ALM 12V7. This is due to the low impedance of the battery creating a current inrush.

Solution

Reset the charger and try again.

Terminal Voltage Absent or Low

Problem

Using a multimeter to check terminal voltage shows the terminal voltage is low.

Possible causes for this problem are:

- Open fuse
- The voltage of a cell within the battery dropped below 2 V, causing the microprocessor to enable under-voltage protection.
- The battery's SOC dropped below 5% from either an extended idle period or heavy use, enabling under-voltage protection.
- The battery overheated, causing the microprocessor to enable over-temperature protection.

Solution

To resolve situations where terminal voltage is absent or low:

1. Allow the battery to cool and then recheck terminal voltage.
2. Inspect the fuse and replace it if necessary. Use only fuses that meet the specifications described in Fusing on page 4-9. Ensure the replacement fuse's voltage rating is appropriate for your application.
3. Connect the battery to a charger to wake the battery and recover terminal voltage. Depending on the battery's voltage and state of balance it may take up to 48 hours to completely charge and balance the battery.

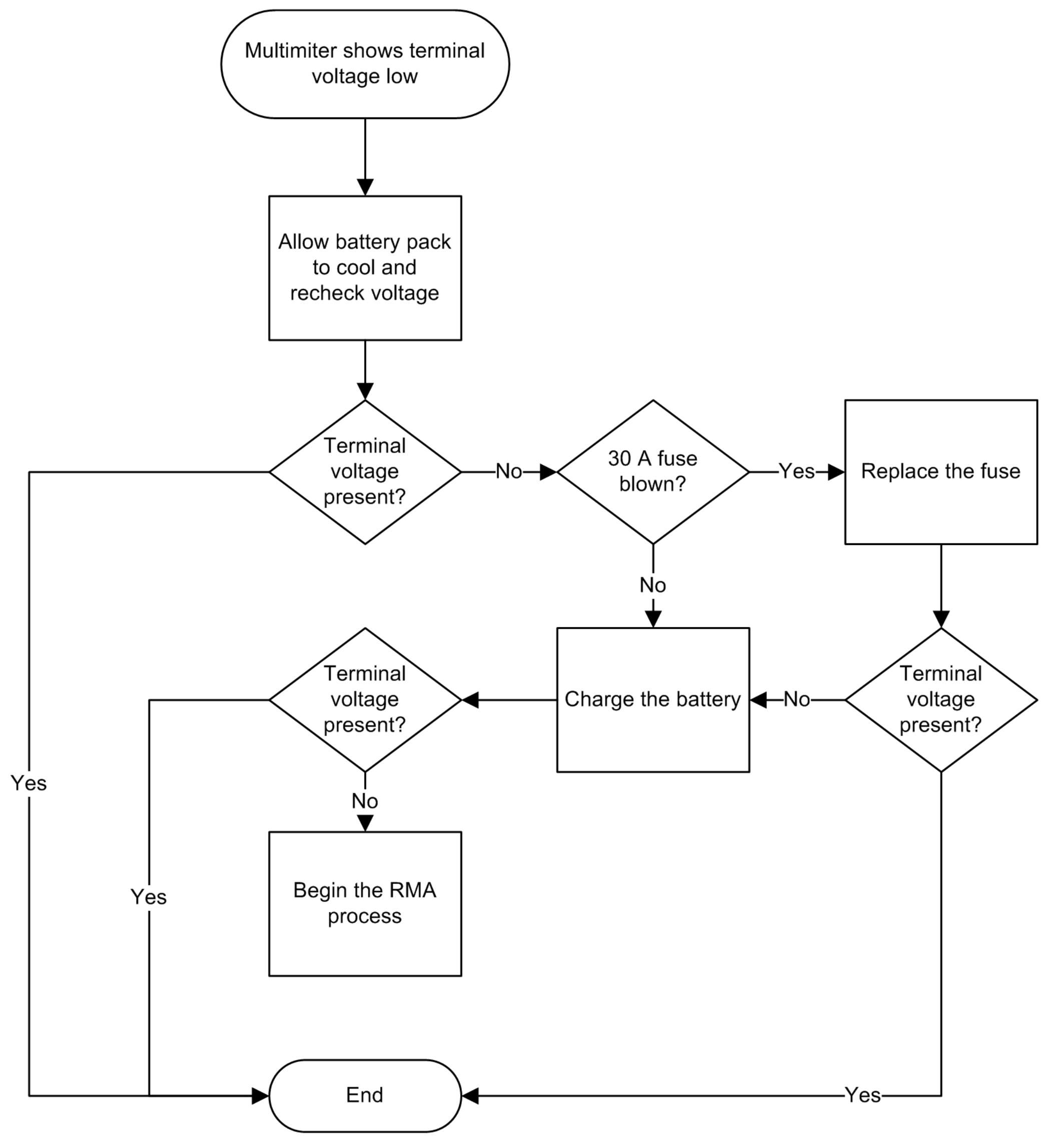

Figure 5-1 Terminal Voltage Low or Absent Troubleshooting Flow Chart

Battery Rapidly Depletes Energy between Charges

Problem

The ALM 12V7 rapidly depletes its energy between charging. Possible causes for this problem are:

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

Solution

To resolve situations where the battery rapidly depletes its energy between charges:

1. Apply a float charge (14.0 V, 10 A) for 48 hours to balance the battery pack's cells.
2. Replace the battery.

Battery Current Disappears when Charging

Problem

Battery current disappears when charging. Possible causes for this problem are:

- The battery overheated, enabling over-temperature protection.
- The battery pack is out-of-balance.
- Charger voltage is too high.

Solution

To resolve situations where current disappears when charging:

1. Allow the battery to cool.
2. Apply a float charge (14.0 V, 10 A) for 48 hours to balance the battery pack's cells. For more details on charging battery batteries or strings, refer to Charging Batteries or Battery Systems on page 4-5.
3. Reduce charger voltage to 14.4 V or less.

30 A Fuse Opens Frequently

Problem

The user-replaceable 30 A fuse opens (“blows”) frequently. Possible causes for this problem are:

- The fuse was replaced with a fuse that does not meet the specifications detailed in User-Replaceable Fuse on page 4-9.
- Failure to ensure correct polarity when connecting the battery pack to other battery packs or a host product’s output terminals.
- The battery exceeded maximum current specifications while charging or discharging the battery.

Solution

To resolve situations where the battery’s 30 A fuse opens frequently:

1. Ensure you are using a fuse that meets the fuse specifications detailed in User-Replaceable Fuse on page 4-9.
2. Verify correct polarity on all connections.
3. Do not exceed maximum current specifications while charging or discharging the battery.

Voltage Drops Abruptly

Problem

Battery voltage appears constant, then drops abruptly.

Solution

This is normal for A123’s cells. Constant voltage throughout the battery’s SOC ensures maximum usable life. Once the voltage of a cell within the battery drops below 2 V, the ALM 12V7’s circuitry enables under-voltage protection, which creates an open circuit at the terminals.

Refer to The ALM 12V7 on page 3-1 for more details on the cell technology within the ALM 12V7.

Appendix A

Glossary

The following table describes the terminology used in this document.

Table A-1 ALM 12V7 Terminology Descriptions

Acronym/Term	Description
ACR	Alternating Current Resistance.
AH	Amp-Hour is a unit of measure of charge that can be stored or delivered to/from a battery.
Battery	One or more cells which are electrically connected together by permanent means, including case, terminals and markings.
BCM	Battery Control Module – The Battery Control Module is necessary to aggregate information from batteries and communicate with the system the ESS resides in.
BMS	Battery Management System – The Battery Management System refers to the collection of electronics responsible for monitoring and controlling the ESS.
C-Rate	An electrical current corresponding to that which will fill or empty a cell in one hour.
CC	Constant Current – A method to charge or discharge a battery in which the current is held constant independent of the battery's terminal voltage.
CE	Consultants Europe - Tests and Certifies safe and compliant product operation in Europe
Cell	A single encased electrochemical unit (one positive and one negative electrode) which exhibits a voltage differential across two terminals.

Table A-1 ALM 12V7 Terminology Descriptions

Acronym/Term	Description
CID	Current Interrupt Device – A small device integrated into a cell designed to interrupt the flow of current through its terminal when too much pressure or current exists in the cell.
CV	Constant Voltage – A method to charge a battery in which the terminal voltage is held constant, and the current is determined by the power path impedance or some active current limiting.
DVT	Design Verification Testing
ESS	Energy Storage System
iSOC	Current based SOC algorithm
OCV	Open Circuit Voltage – voltage reading of a battery when there is no current going in or out of it.
OEM	Original Equipment Manufacturer – in reference to this document, the maker of the equipment into which an ESS is installed and used.
FCC	RF Emissions governing body in the United States
UL	Underwriter Laboratories - Tests and Certifies safe and compliant product operation in North America
vSOC	Voltage based SOC algorithm

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A123 Systems, LLC.
155 Flanders Rd | Westborough MA 01581
Customer Service Phone: 508-497-7100
www.a123energy.com

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