DISCOVER ENERGY SYSTEMS

APPLICATION NOTE:

OPEN LOOP INTEGRATION WITH AES LiFePO$_4$ BATTERY

#320 - 13711 International Place, Richmond, BC, V6V 2Z8, Canada

+ 1.778.776.3288

info@discoverlithium.com

discoverlithium.com

885-0030 REV B

DISCOVER
ENERGY SYSTEMS

AUDIENCE

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

No responsibility is assumed by Discover Energy Systems for any consequences arising out of the use of this material.

MESSAGES AND WARNINGS

Before using the battery, read all instructions and cautionary markings on the unit and all appropriate sections of the owner's manual and this application note.

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

Read power conversion device manuals, for guidance on product features, functions, parameters, and how to use the product safely.

OVERVIEW

There are some notable differences when configuring your Discover AES installation versus conventional lead-acid batteries.

This Application Note provides information about the integration of Discover AES Lithium batteries in systems with open-loop communications.

Discover reference documents:

- Discover AES 42-48-6650 Data Sheet
- Discover AES 44-24-2800 Data Sheet
- Discover AES 44-48-3000 Data Sheet
- Discover AES $LiFePO_4$ Battery 44-24-2800 42-48-6650 44-48-3000 Manuals

Visit www.discoverlithium.com for the most recent version of published documents.

TOOLS

Use the controller interface supplied with the power conversion device (charger or chargers) to configure the Open Loop settings for use with AES $LiFePO_4$ Batteries.

To obtain historical data logs of a battery with cell data, please download and use AES Dashboard Software for PC. Use the appropriate USB cable to connect with the battery.

- AES Dashboard Software for PC

Visit www.discoverlithium.com for the most recent version of AES Dashboard software.

#320 - 13711 International Place, Richmond, BC, V6V 2Z8, Canada
discoverlithium.com
+ 1.778.776.3288
info@discoverlithium.com

DISCOVER
ENERGY SYSTEMS

1. Theory of Operation

An Open Loop system using lithium batteries is also known as a drop-in lead-acid replacement system.

AES batteries must be set up to work with Power Conversion and Monitoring devices in either an Open Loop or Closed Loop configuration.

The charge and discharge settings in an Open Loop configuration are set up manually through the controller for the Power Conversion device at the time of installation. This compares to a Closed Loop configuration where charge and discharge settings are dynamically controlled by the BMS of the AES Battery over a connection with the Power Conversion device's communication network.

Note: Closed Loop communication with a Power Conversion device network requires the use of an LYNK Gateway Communication device available from Discover Battery. For details please refer to the LYNK Gateway Communication User Manual available from www.discoverlithium.com website, or contact your Discover Battery provider for assistance.

The Open Loop settings in this document are for AES batteries in an off-grid application.

2. Battery Operating Limits

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

Maximum Operating Limits	44-24-2800	44-48-3000	42-48-6650
Continuous Charge Current*	110 Adc	57 Adc	130 Adc
Continuous Discharge Current*	110 Adc	57 Adc	130 Adc
Peak Current (3 seconds)	300 Adc	219 Adc	300 Adc
Operating Voltage (Min / Max)	22.4 V / 29.2 V	44.8 V / 58.4 V	44.8 V / 58.4 V
Charge Temperature (Min / Max)	0°C / 45°C (32°F / 113°F)		
Discharge Temperature (Min / Max)	-20°C / 50°C (-4°F / 122°F)		
Storage Temperature (Min / Max)	-20°C / 45°C (-4°F / 113°F)		

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

⚠ NOTICE

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

⚠ NOTICE

Do not use or install a battery temperature sensor.

#320 - 13711 International Place, Richmond, BC, V6V 2Z8, Canada
discoverlithium.com
+ 1.778.776.3288
info@discoverlithium.com

DISCOVER
ENERGY SYSTEMS

3. Minimum Battery Capacity

Battery capacity must be sized correctly for the systems:

- Total charge power
- Total load discharge power
- Total load surge power

Using very large solar arrays with battery banks that are too small can exceed the operating limits of the battery to charge and possibly lead to the BMS triggering over-current protection. Battery capacity must be sized to accept the maximum charge current of the system, or the charging devices must be curtailed to charge below the operating limit of the installed batteries. This value is derived by adding together the charge capacities of all inverter/chargers and solar charge controllers in the system. Additionally, battery peak capacity must be sized to support the surge requirements demanded by the load attached to the inverter. Match the sum of all inverter peak power values with the sum of all battery peak battery current values.

System Size	Peak Current Adc	Constant Current Adc	Rated Energy kWh
44-24-2800			
1 Battery	300 Adc	110 Adc	2.816 kWh
2 Battery	600 Adc	220 Adc	5.632 kWh
3 Battery	900 Adc	330 Adc	8.448 kWh
4 Battery	1200 Adc	440 Adc	11.264 kWh
5 Battery	1500 Adc	550 Adc	14.080 kWh
44-48-3000			
1 Battery	219 Adc	57 Adc	2.918 kWh
2 Battery	438 Adc	114 Adc	5.836 kWh
3 Battery	657 Adc	171 Adc	8.754 kWh
4 Battery	876 Adc	228 Adc	11.672 kWh
5 Battery	1095 Adc	285 Adc	14.590 kWh
42-48-6650			
1 Battery	300 Adc	130 Adc	6.650 kWh
2 Battery	600 Adc	260 Adc	13.300 kWh
3 Battery	900 Adc	390 Adc	19.950 kWh
4 Battery	1200 Adc	520 Adc	26.600 kWh
5 Battery	1500 Adc	650 Adc	33.250 kWh

4. Recommended Battery Operating Settings

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

Recommended Operating Settings	44-24-2800	44-48-3000	42-48-6650
Continuous Charge / Discharge Current	< 78 A	< 40 A	< 92 A
Charge Voltage (Bulk/Absorb)	27.6 V	55.2 V	55.2 V
Charge Voltage (Float)	26.8 V	53.6 V	53.6 V
Low Voltage Disconnect	24 V	48 V	48 V
Operating Temperature	20°C (68°F)		

#320 - 13711 International Place, Richmond, BC, V6V 2Z8, Canada
discoverlithium.com
+ 1.778.776.3288
info@discoverlithium.com

DISCOVER
ENERGY SYSTEMS

5. Power Conversion Device Settings

The settings for AES batteries in an Open Loop configuration are as follows below. This section presumes familiarity with the control panel used to configure and monitor the power conversion device. Refer to the product manuals for the safe and correct operation of the power conversion device.

Settings	44-24-2800	44-48-3000	42-48-6650
Inverter Settings			
Low Battery Cut Out Voltage	24.0 V	48.0 V	48.0 V
Low Battery Cut Out Delay	5 sec	5 sec	5 sec
Restart Voltage after LBCO	26.0 V	52.0 V	52.0 V
Charger Settings			
Bulk Voltage	27.6 V	55.2 V	55.2 V
Absorption Voltage	27.6 V	55.2 V	55.2 V
Absorption Voltage Time Limit [1]	1.0 < 3.0 Hr	1.0 < 3.0 Hr	1.0 < 3.0 Hr
Absorption Termination Current	2 A	2 A	2 A
Float Voltage	26.8 V	53.6 V	53.6 V
Equalization	Disabled	Disabled	Disabled
Temperature Compensation	Disabled	Disabled	Disabled
Charge Current per battery installed (Recommended < Maximum) [2]	Installed x (78 A < 110 A)	Installed x (40 A < 57 A)	Installed x (92 A < 130 A)
MPPT Charge Controller Settings			
Bulk Voltage [3]	27.8 V	55.4 V	55.4 V
Absorption Voltage [3]	27.8 V	55.4 V	55.4 V
Absorption Voltage Time Limit [1]	1.0 < 3.0 Hr	1.0 < 3.0 Hr	1.0 < 3.0 Hr
Absorption Termination Current	2 A	2 A	2 A
Float Voltage	26.8 V	53.6 V	53.6 V
Equalization	Disabled	Disabled	Disabled
Temperature Compensation	Disabled	Disabled	Disabled
Charge Current per battery installed (Recommended < Maximum) [2]	Installed x (78 A < 110 A)	Installed x (40 A < 57 A)	Installed x (92 A < 130 A)

(1) The recommended minimum is 1.0 hour. A longer period of time may be required for multiple batteries to achieve a smooth completion of charge.
(2) Set to a lower value if necessitated by the capacity of the charger.
(3) Set Charge Controller Bulk and Absorb targets at 0.2 V above the charger setpoints to favour solar charging.

#320 - 13711 International Place, Richmond, BC, V6V 2Z8, Canada
discoverlithium.com
+ 1.778.776.3288
info@discoverlithium.com

DISCOVER ENERGY SYSTEMS

6. Calibration and Verification of the Charger Set Points for AES $LiFePO_4$ Batteries in Open Loop Systems

⚠ NOTICE

The accuracy of voltage and current regulation varies between power electronic vendors and across models. Verify the output of a charge cycle against the expected settings to confirm the performance of the power electronics with battery data logs exported using AES Dashboard Software.

After completing the initial configuration of the charging sources (inverter/charger and charge controllers), validate and confirm that the set charge points actually match the voltage at the battery terminals during a charge cycle.

There are many reasons why the voltage at the battery terminals may not match the Bulk, Absorb and Float settings. Common reasons include resistance, poor connections, differing cable lengths, etc. However, the leading cause is that voltage regulation, particularly with older power electronics, is not very precise.

Output voltage variances that may have been acceptable for lead-acid batteries will no longer fall within the tolerances required for proper charging and maintenance of a lithium battery. To reduce the risk of premature failure due to improper charging, take the following steps to ensure that the system is configured properly.

1. Confirm the charger(s) target VDC has been set to 55.2 VDC for Bulk and Absorb stages and that the Float target is set to 53.6 VDC.
2. Allow the system to run a complete daily cycle or, at least one full charge/discharge cycle.
3. After a full cycle, pull the data logs using AES Dashboard Software (for PC) from at least one of the batteries. Review the charge voltages from the data set by following these steps:
    a. Under "System Amps" (Column M) identify the positive numbers that indicate energy going into the battery and "charging".
    b. Highlight the "Terminal Voltage [mV]" readings in Column P associated with charging current. Convert these from mV to volts by dividing by 1000.
4. Determine the average terminal voltage during charging and compare it with the programmed voltage set point.
    a. If the terminal voltage reading from the battery data log is below the 55.2 V target for Bulk and Absorb stages, increase the setting on the charger(s) to compensate by the amount they differ (typically not more than 1.2 VDC).
    b. If the terminal voltage reading from the battery data log is above the 55.2 V target for Bulk and Absorb stages, decrease the setting on the charger(s) to compensate by the amount they differ (typically not more than 0.5 VDC).
5. Using the same process as Step 4 above, to calibrate the Float voltage parameters. The data required to calibrate the Float stage will be found at the end of the charge cycle once the SOC (%) field nears or is equal to, 100% SOC. The Float voltage target should be 53.6 VDC.
6. If changes had to be made to calibrate output, run the system for another day, or at least for a charge and discharge cycle, then pull that day's data log and start the verification process again from Step 3.

Note, it is better to round up on calibration set points and be slightly over the recommended charging targets for Bulk, Absorb and Float than slightly under.

Taking the time to properly calibrate and charge Discover lithium batteries will ensure warranty compliance, maximize expected service life, and optimize battery capacity.

DISCOVER
ENERGY SYSTEMS

7. Glossary of Terms, Abbreviations, and Acronyms

BMS	Battery Management System
Closed Loop	The battery management system is communication charge configurations to the power conversion devices
DOD	Depth of Discharge
Open Loop System	There is no communication between the battery management system and the power conversion devices. Also known as a drop-in lead-acid replacement system.
SOC	State of Charge
VPC	Volts per Cell