

NEC Energy Solutions ALM[®] 12V35 Batteries with Morningstar Solar Charge Controllers

This application note was developed through a collaborative effort between NEC Energy Solutions and Morningstar Corporation in response to requests from system designers seeking to leverage ALM[®] 12V35 batteries with Morningstar charge controllers.

The NEC Energy Solutions ALM[®] family of advanced lithium-ion batteries delivers exceptional performance, long service life, and robust safety for tough, critical applications. Available in a variety of standard sizes, the ALM[®] family offers up to twice the usable energy, 50X greater cycle life, and much faster charging than typical lead-acid batteries. The ALM[®] family incorporates NEC Energy Solutions EverSafe™ Battery Technology, with protection at the cell, battery, and system level. The ALM[®] 12V35 is a line of 35Ah batteries available in standard (s), intelligent (i), and High Power (HP) series to match application requirements. The ALM[®] i-Series offer integrated CAN or SMBus communications for access to critical battery status, usage tracking, State of Charge (SOC), run time to empty, and other parameters.

Morningstar controllers have been used to regulate battery charging in a wide variety of battery types over the last several decades. The proprietary software and innovative features associated with these controllers, results in greater energy harvest and prolonged battery life. All Morningstar controllers are equipped with electronic and environmental protections and the robust Morningstar product portfolio accommodates virtually any off-grid solar application.

Systems incorporating both ALM[®] 12V35 batteries and Morningstar charge controllers are well suited to a wide range of PV+Storage applications. The information in the application note is intended as a guide to help configure settings on various Morningstar controllers to charge NEC Energy Solutions ALM[®] 12V35 batteries. Performance may vary depending on use conditions and application.

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NEC Energy Solutions ALM[®] 12V35 Batteries

Models: ALM[®] 12V35 Family of 12 Volt Batteries ([See data sheet for safety information](#))

Battery Chemistry: Lithium-Ion: Lithium Nanophosphate[®] (LiFePO4)

BMS: EverSafe™ battery technology. Protection at the cell, battery and system level

Charging Details:

Regulation Voltage Range: 13.6-14.4 V (14.4V recommended)*

High Voltage Disconnect: 16V or adjustable

Max. Charger Overvoltage Protection (no damage): 60 V

Terminal Cut-Off Voltage: 9.8 V (Typical)

Under-voltage Limit (Absolute Min. Terminal Cut-Off Voltage): 8 V

Max. Continuous Charge Current: 105A (210 A for 12V35i HP model)

Operating Temperature Range: -40°C to + 60°C

Temperature compensation: To prevent undercharged batteries in warm conditions or over-voltage in cold conditions do not use controllers without disabling temperature compensation.

*Note about Absorption Regulation Voltage range: Lower regulation voltages will take longer to reach full SOC.



The wide regulation voltage range and low cut-off voltage limit are unique to the ALM® family lithium-ion batteries. Another advantage is the cell-level overvoltage protection which allows the battery to continue charging without disconnecting from the controller.

Cold Temperature max recommended current

Temp (°C)	Max. Charge Rate Do not exceed	Discharge Current Limit > 1 minute loads	Discharge Current Limit < 1 minute loads
-40°C	.5A	2.1A	12A†
-30°C	1.75A	3.4A	18A†
-20°C	7A	7.6A	33A†
-10°C	10.5A	17.8A†	52A†
0°C	17.5A	52.5A†	>60A†
10°C	35A	>60A†	>60A†

For charge acceptance, do not exceed the limits specified. Charging at higher rates may cause result in engaging the ALM® 12V35's protection circuitry to engage or result in shorter battery life.

Max. discharge current to prevent early LVD trips is based on the following Low Voltage Disconnect (LVD) settings.

LVD = 12.75V (with 1 minute delay) LVD current compensation = -10mV/A. Instant LVD @ 10V

†Note - or < max. load current rating of controller.

The ALM® 12V35 Family of 12 Volt Batteries have a limited five-year warranty and are sold exclusively pursuant to NEC Energy Solutions, Inc. terms and conditions. Additional information available upon request.

Recommended products by Morningstar:

12V systems:

SunSaver Duo (no LVD; Can charge 2 separate Batteries with a single array)

12-24V systems:

ProStar MPPT (includes low temperature foldback to limit the max. charge current)

SunSaver MPPT

ProStar (PWM) Gen 3 (includes low temperature foldback to limit the max. charge current)

12-48V systems:

TriStar MPPT (compatible with 12V, 24V, 36V and 48V nominal systems)

TriStar MPPT 600V (compatible with 12V, 24V, 36V and 48V nominal systems)

TriStar (PWM) model TS-45 (compatible with 12V, 24V, 36V and 48V nominal systems)

Communications hardware required for programming Custom Settings with MSView:

ProStar MPPT, ProStar (Gen 3), SunSaver MPPT, SunSaver Duo

UMC-1 USB MeterBus Adapter <http://www.morningstarcorp.com/products/usb-meterbus-adapter/>

MSC PC RS-232 MeterBus Adapter- <http://www.morningstarcorp.com/products/pc-meterbus-adapter/>

EMC-1 Ethernet MeterBus Converter- <http://www.morningstarcorp.com/products/ethernet-meterbus-converter/>

TriStar, TriStar MPPT, TS-MPPT-600V

Includes an RS-232 port for connection to a PC.

EMC-1 Ethernet MeterBus Converter- <http://www.morningstarcorp.com/products/ethernet-meterbus-converter/>

Tripp Lite U209-000-R USB / Serial DB-9 (RS-232) Adapter Cable (not available from Morningstar)

All TS-MPPT-60 (150V and 600V) models also include an Ethernet port and EIA-485 port.

MSView Software Download: <http://www.morningstarcorp.com/msview/>

MSView Controller settings configuration files:

<http://www.morningstarcorp.com/wp-content/uploads/2017/02/NEC-Custom-Settings-Config-Files.zip>

Recommended Settings; Morningstar Custom Settings Basic Setup Overview:

Absorption Voltage Settings: 13.6-14.4 V (14.4V recommended)

Disable Float: No Float setting needed. Batteries can stay in Absorption indefinitely. Custom settings required.

No Equalization required: Equalization is handled by the ALM® BMS internally. Auto-Equalize can be disabled with many Morningstar products using DIP Switches or completely disabled with custom settings.

Disable temperature compensation: Temperature compensation is typically not used with Lithium batteries. This can be disabled by not connecting the remote temperature sensor for the TriStar and TriStar MPPT controllers or with custom settings. Note: Since it is possible to disable the Temperature Compensation by not installing a Remote Temperature Sensor (RTS) with the TriStar and TriStar MPPT controllers it is possible to use the TriStar and TriStar MPPT controllers with some of the factory presets instead of using custom settings. However, the default Float voltage settings might not be considered optimal with ALM® family batteries.

ProStar MPPT – Models PS-MPPT-25, PS-MPPT-25M, PS-MPPT-40, PS-MPPT-40M

It is not recommended to use any of the factory presets with the ProStar MPPT controllers.

Set DIP Switches 2&3 for 12V (2 OFF, 3 ON), 24V (2 ON, 3 OFF) or auto-detect nominal voltage with Switches 2&3 DOWN/OFF.

ProStar MPPT Custom Options: Using MSView ProStar MPPT Setup Wizard

Set DIP Switches for Custom Settings (Switches 4,5&6 UP/ON)

Absorption Voltage14.4 V

Absorption Time..... 1 hr

Enable Absorption Extension Not Required

Battery Temperature Compensation..... 0.0 V/°C (Disabled)

Low Temperature Foldback See below

Charge Mode – Float Settings

Enable Float Optional

Float Voltage14.4V

Float Timeout 60 min

Enable Float Cancel Not Required

Charge Mode – Equalize and HVD Settings

Equalize Do not Enable

Enable Battery HVD Not Required (Charging HVD)

Enable Maximum Regulation Limit Not Required

Maximum Regulation Limit Not Required

Enable Battery Current Limit Optional

Battery Current Limit Optional

Load Settings

Low Voltage Disconnect12.75V

Low Voltage Reconnect 13.3V

Delay Before LVD1 m (possibly higher for cold temperatures)

Load Current Compensation 0.01 Ωs (V/A) (reduces LVD Voltage with larger loads)

Enable HVD/ High Voltage Disconnect/Reconnect..... Enable/14.9V/14.0V (Load HVD)

LED transition voltages (Green Only - Green and Yellow)... 13.9V

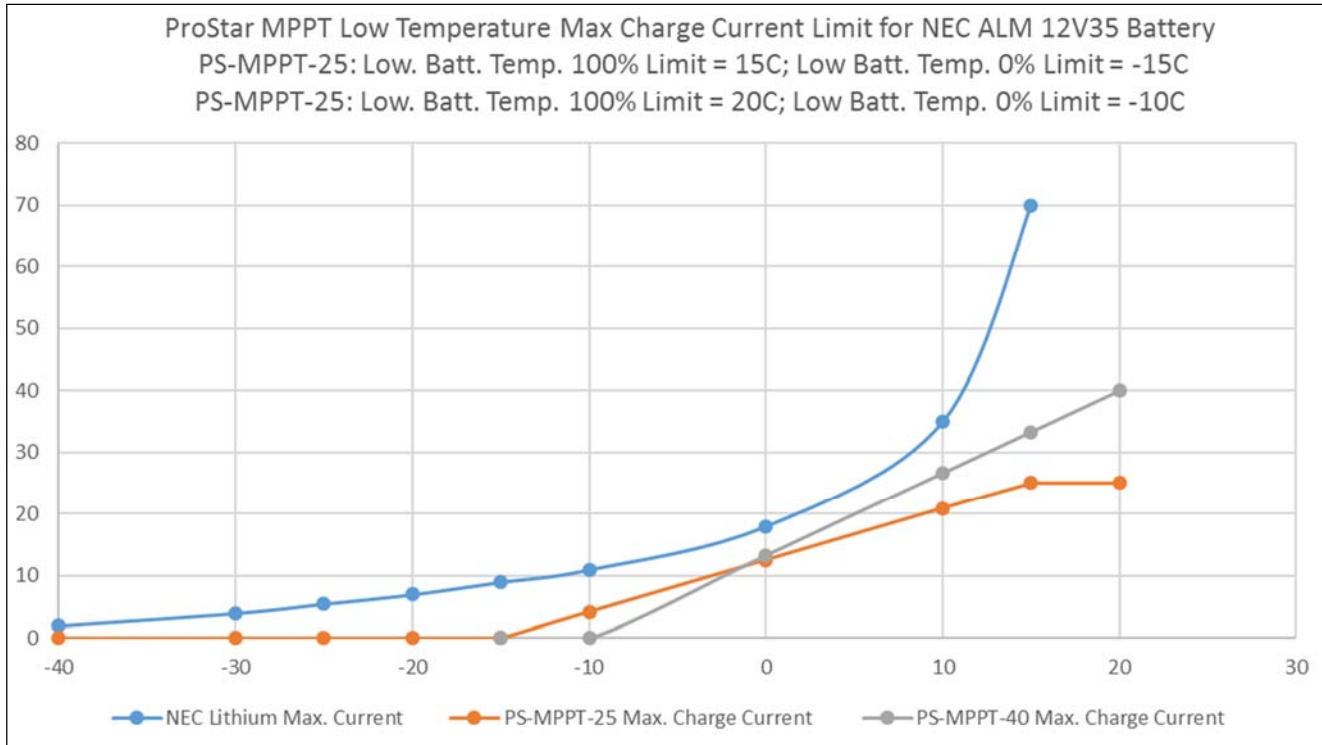
LED transition voltages (Green and Yellow - Yellow Only)... 13.5V

LED transition voltages (Yellow Only - Yellow and Red)..... 13.2V

LED transition voltages (Yellow and Red – Red Only)..... 12.8V

* Settings will multiply to achieve the nominal battery voltage (1=12V, 2=24V).

Another unique setting with the ProStar MPPT controllers is the setting for the Low Temperature Foldback. The NEC Energy Solutions ALM[®]12V35 battery includes a table of max. charging current levels for low battery cell temperatures. The graph below displays the maximum current in blue with a custom programmed Low Temperature Foldback for the PS-MPPT-25 controller. This will allow the controller to continue to operate when the battery is exposed to low temperatures as measured with the RTS and allows it to recover the battery operation during low temperature conditions.



ProStar MPPT model PS-MPPT-25M Low Temp. Foldback Custom Settings.

Low Battery Foldback High Limit = 15°C
 Low Battery Foldback Low Limit = -15°C

ProStar MPPT model PS-MPPT-40M Low Temp. Foldback Custom Settings.

Low Battery Foldback High Limit = 20°C
 Low Battery Foldback Low Limit = -10°C

Please note that at this time custom settings for temperature Limits less than 0°C can only be programmed with the Meter Display version of the ProStar MPPT models PS-MPPT-25M and PS-MPPT-40M. All other settings can first be programmed using MSView or with the Meter Display.

Caution: RTS temperature readings may not always equal minimum battery cell temperatures.

SunSaver MPPT – Model SS-MPPT-15L

It is not recommended to use any of the factory presets with the SunSaver MPPT controllers. For 24 volt systems, the battery voltage must be greater than 15.5 volts to properly detect a 24V battery. The 12/24 volt battery detection is automatic and the check is only performed at start-up.

SunSaver MPPT Custom Options: Using MSView SunSaver MPPT Setup Wizard

Set DIP Switch for Custom Settings: (Switch 1 ON/UP)

Important: Charge Setting 1 (Jumper inserted) and Charge Setting 2 (Jumper removed): Program both with compatible settings to prevent the possibility of any problems.

Absorption Voltage 14.4 V
 Disable Float..... Checked (Optional)
 Disable Equalize Checked

Shared Charge Settings

Battery Temperature Compensation..... 0.0 V/°C (Disabled)

Load Settings

Low Voltage Disconnect (LVD) 12.75V
 Low Voltage Reconnect (LVR) 13.3V
 Delay Before LVD 1 m (possibly higher for cold temperatures)
 Load Current Compensation 0.01 Ωs (V/A) (reduces LVD Voltage based on size of load)
 Enable HVD/ High Voltage Disconnect/Reconnect..... Enable/14.9V/14.0V (Load HVD)

Misc Settings/LED Transition Settings (Suggestions)

LED Rising transition voltage (Yellow - Green) 13.9V
 LED Falling transition voltage (Green - Yellow) 13.5V
 LED Rising transition voltage (Red - Yellow) 13.2V
 LED Falling transition voltage (Yellow - Red) 12.8V

* Settings will multiply to achieve the nominal battery voltage (1=12V, 2=24V).

TriStar MPPT (150V) – Models TS-MPPT-30, TS-MPPT-45 and TS-MPPT-60

Set DIP Switches 2&3 for 12V (2 OFF, 3 ON), 24V (2 ON, 3 OFF) or 48V (2 ON, 3 ON) or auto-detect nominal voltage with Switches 2&3 DOWN/OFF. Load Control not included. See Load Control Options Section below.

Disable temperature compensation. Temperature compensation is typically not used with Lithium batteries. Disable temperature compensation by not connecting the RTS or with custom settings.

Preset Options

Set DIP Switches 4,5&6 are used to select the battery charging settings.

The following Presets with no RTS connected are viable solutions.

Settings Switches 4 - 5 - 6	Battery Type	Absorp. Stage (Volts)	Float Stage (Volts)	Equalize Stage (Volts)	Absorp. Time (Minutes)	Equalize Time (Minutes)	Equalize Interval (Days)
off-off-off	1 - Gel	14.00	13.70		150		
off-off-off	2 - Sealed*	14.15	13.70	14.40	150	60	28
off-on-off	3 - Sealed*	14.30	13.70	14.60	150	60	28
off-on-on	4 - AGM/Flooded	14.40	13.70	15.10	180	120	28
on-off-off	5 - Flooded	14.60	13.50	15.30	180	120	28
on-off-on	6 - Flooded	14.70	13.50	15.40	180	180	28
on-on-off	7 - L-16	15.40	13.40	16.00	180	180	14
on-on-on	8 - Custom	Custom	Custom	Custom	Custom	Custom	Custom

* "Sealed" battery type includes gel and AGM batteries

Table 4-1. Battery charging settings for each selectable battery type

As indicated in battery charging settings table the first four Presets are compatible with ALM® 12V35 batteries (1- Gel; 2- Sealed*; 3- Sealed*; 4- AGM/Flooded). Setting 4 is the most optimal setting for fastest charging.

Shared Settings	Value	Units
Absorption Extension Voltage	12.50	Volts
Absorption Extension Time	Absorption Time + 30	minutes
Float Exit Timeout	60	minutes
Float Cancel Voltage	11.50	Volts
Equalize Timeout	Equalize Time + 60	minutes
Temperature Compensation Coefficient*	- 5	millivolts / °C / cell

* 25°C reference

Table 4-2. Battery settings that are shared between all battery types

Set DIP Switch 7 UP to Enable Auto-Equalize with Battery Type 2- Sealed if desired. Battery types 3- Sealed and 4- AGM/Flooded should have DIP Switch 7 DOWN/OFF to disable Auto-Equalize since the Equalize voltage exceeds the max. Voltage for the ALM® 12V35 battery.

TriStar MPPT Custom Options: Using MSView TriStar MPPT Setup Wizard

Set DIP Switches for Custom Settings (Switches 4,5&6 UP/ON)

Charge Mode – Absorption, Temp Comp, & Reminder

Absorption Voltage14.4 V
Absorption Time..... 1 hr
Enable Absorption Extension Not Required
Battery Temperature Compensation..... 0.0 V/°C (Disabled)
Battery Service Reminder..... Not Required
Charge Mode – Float Settings
Enable Float Not Required
Float Voltage 13.6-14.4V (If enabled)
Float Timeout 60 min
Enable Float Cancel Not Required
Charge Mode – Equalize & HVD Settings
Equalize Do not Enable
Enable Battery HVD Not Required
Enable Maximum Regulation Limit Not Required
Enable Battery Current Limit Optional
Battery Current Limit Optional
LED transition voltages (Green Only - Green and Yellow)... 13.9V
LED transition voltages (Green and Yellow - Yellow Only).. 13.5V
LED transition voltages (Yellow Only - Yellow and Red)..... 13.2V
LED transition voltages (Yellow and Red – Red Only)..... 12.8V

* Settings will multiply to achieve the nominal battery voltage (1=12V, 2=24V, 4=48V).

SunSaver Duo – Model SSD-25

The SunSaver Duo is designed to provide PWM Charging Control for one or two (separate) 12V batteries at the same time. Load Control not included. See Load Control Options Section below.

While it is possible to use the SunSaver Duo with two different battery settings, temperature compensation is a shared setting. Therefore, it is not optimal to use the SunSaver Duo with both a lithium and lead acid battery at the same time where temperature compensation requirements conflict.

Voltage Sense is not included with the SunSaver Duo.

SunSaver Duo Custom Options: Using MSView SunSaver Duo Setup Wizard

Set DIP Switch 4 for Custom Settings: (Switch 4 ON/UP)

Important: There are 4 Settings options, two for each battery: Program all with compatible settings to prevent the possibility of any problems.

Absorption Voltage 14.4V
Disable Float..... Checked (Optional)
Disable Equalize Checked
Max. Regulation Limit 14.5V
Common Setpoints
Battery Temperature Compensation..... 0.0 V/°C (Disabled)

TriStar (PWM) – Models TS-45 and TS-60

Set DIP Switches 2&3 for 12V (2 OFF, 3 ON), 24V (2 ON, 3 OFF) or 48V (2 ON, 3 ON) or auto-detect nominal voltage with Switches 2&3 DOWN/OFF. Load Control not included. See Load Control Options Section below.

Disable temperature compensation. Temperature compensation is typically not used with Lithium batteries. Disable temperature compensation by not connecting the RTS and/or with custom settings.

See manual for more information regarding the TriStar (PWM) controller.

ProStar Gen 3 (PWM) – Models PS-15, PS15M, PS30, PS30M

Use ProStar MPPT settings. The new ProStar Gen 3 also includes Low Temperature Foldback settings.

Load Control Options (for controllers which do not include load control)

Options for providing DC Load Control for TriStar MPPT, TriStar and SunSaver Duo solar controllers.

Add DC Load control with TriStar (PWM) controller or with Relay Driver and relay. Many inverters include LVD settings that are adjustable. Load control should include high voltage protection in case there is a battery cell overvoltage condition which could deliver a high voltage to the load. The TriStar controller include high voltage protection for loads. This can be provided with one of the channels of the Relay Driver but may not be fast enough to protect against voltage surges. The ProStar MPPT and new ProStar Gen 3 are the only controllers which include Cold Temperature foldback to reduce max. charge current based on battery RTS (sense) temperature. It is possible to use one of the channels of a Relay Driver to disable charging based on RTS temperature or ambient temperature.



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