



Lithium Iron Phosphate Battery Custom Settings

Introduction:

The charge and load control profiles provided in this paper are intended to be used with Lithium Iron Phosphate (LiFePO₄ or LFP) battery brands/models that *are not yet included* in the [Morningstar Energy Storage Partner \(ESP\) program](#). However if your LFP battery model *is* included in the ESP program, we recommend using the settings provided in the related compatibility tech docs for that particular battery brand and model.

Lithium Iron Phosphate (LiFePO₄ or LFP) batteries are a type of lithium battery that have become the most commonly used lithium battery in the offgrid solar market. One of the reasons for this is that LFP batteries have better thermal and chemical stability than other lithium-ion chemistries. This provides better safety and reliability for off-grid solar applications.

Morningstar Energy Storage Partner (ESP) Program

Morningstar's Energy Storage partner Program (ESP) was formed in 2018 as an ongoing collaboration with selected premium battery manufacturers with advanced technologies/chemistries. A team effort, ESP verifies, confirms and thoroughly documents recommended custom charge settings along with best practices, to provide system designers and installers with as close to a "plug and play" solution as possible when choosing an energy storage solution for a new solar electric system or upgrading an existing one.

Morningstar has partnered with over 20 manufacturers of LFP batteries. In that process we've learned a lot about how to optimize LFP battery charging for specific performance objectives which we've detailed below. Therefore, we are introducing three new charge & load profiles specifically designed for LFP batteries to our presets for our new product lines. These new charge & Load profiles cover a range of settings that have been specified with our LFP battery ESP partners. The first products to be introduced with these new LFP presets are the GenStar MPPT solar charge controllers.

LFP batteries

With a nominal cell voltage of 3.2V/cell, LFP batteries are configured in series to create nominal voltage batteries as follows.

# of Cells in Series	4	8	15	16
Battery Nominal Voltage	12.8 V	25.6 V	48 V	51.2 V
Operational Voltage Range	12 - 14.4 V	24 - 28.8 V	45 to 54 V	48 to 57.6 V

These operational voltage ranges are ideal as a "drop-in" replacement for 12V, 24V and 48V nominal lead acid batteries. Note that both 15-cell and 16-cell 48V nominal batteries are available on the market. Therefore, it is extremely important when installing a 48V LFP battery to determine whether it has 15 or

16 cells. This can be determined by comparing the voltage ratings of the battery with the voltages above. Though **we only provide presets for 4-cell, 8-cell and 16-cell LFP batteries** with the GenStar MPPT controller and other new controllers, this paper includes additional voltage setpoints for 15-cell, 48V nominal voltage LFP batteries and has a ratio of ~ 15/16 of the 16-cell settings.

Supported Morningstar Controllers

The following is a list of Morningstar Products that include custom programming settings that can support LFP batteries.

Legacy Controllers supported by MSView

TriStar MPPT 600V

TriStar MPPT (150V)

TriStar (PWM)

ProStar MPPT

ProStar (PWM)

SunSaver MPPT

Relay Driver (for Load Control Circuits or on/off control of generators or AC rectifiers)

To learn more about custom programming see Morningstar's MSView Setup Wizard Videos.

[MSView Setup Wizard – Part 1: Overview & Custom Settings](#)

[MSView Setup Wizard – Part 2: TS-MPPT DIP Switch Settings](#)

[MSView Setup Wizard – Part 3: Example TriStar MPPT Setup Wizard Walkthrough](#)

The GenStar MPPT Solar Charge Controller includes three new factory presets with the 4/8/16 Cell LFP settings included in this paper. The GenStar MPPT controller is supported by LiveView 2.0 for custom programming which is used for implementing the 15 Cell (48V) LFP settings or making further adjustments to the preset values. The GenStar MPPT controller also includes a digital interface which also allows users to input custom settings.

Lithium Iron Phosphate Battery Custom “Open Loop” Settings

The charge and load profiles presented in this paper are being provided as a good starting point for custom programming Morningstar controllers to be used with Lithium Iron Phosphate (LiFePO₄ or LFP) batteries. Once loaded into the Setup Wizard in MSView these settings can be adjusted as needed for the system in accordance with the battery manufacturer's charging requirements.

These charge settings are used when there is no communication between the controller and the Battery Management System (BMS) of the LFP battery. This is often referred to as “open loop” settings. “Closed loop” charging involves communications between the controller and the BMS allowing greater control from the BMS to better charge the battery with less risk. The GenStar MPPT controller is the first Morningstar controller which will include an option for closed loop capabilities.

There are three charge settings and three load settings to select from, “Low”, “Medium” and “High”. These three settings correspond to the range of settings that we have developed with different manufacturers depending on their recommendations for off grid solar applications.

Charge Settings Considerations

There are no hard and fast rules regarding when to use higher or lower open loop charge settings. Lithium batteries include a Battery Management System (BMS) that can implement an internal battery disconnect in the event of an internal fault, high or low temperatures, high or low battery voltages or other conditions. Generally speaking the use of lower voltage charge settings can prevent a high voltage cutout of the BMS and a higher voltage LVD setting can prevent a low voltage cutout of the BMS.

Here are some considerations when deciding on what charge setting to use.

- Never exceed the maximum voltage settings provided by the manufacturer.
- With the wide temperature ranges and variability of charging of Off-Grid Systems, more conservative settings with lower voltage setpoints are often recommended.
- Lower charge settings may charge the batteries to ~ 90-95% SOC and prevent high battery or cell voltage faults and put less stress on the battery. This can optimize battery cycle life.
- Higher charge settings can balance the cells more since cell balancing occurs during the voltage regulation stage. This can increase the usable capacity of the battery.
- Higher open loop charge settings can be more suitable for applications where the battery is not going to be charged on a daily basis.
- Higher charge settings should never be used for off-grid solar PV systems which can have little or no-load usage as it can overcharge the batteries.
- Lower voltage settings should be considered for systems that have higher charge rates $> C/5$ or where large loads may be disconnected. This can cause one of the battery cells to exceed the max cell voltage after entering the absorption stage.

Monitoring of the system with Morningstar Live View or MSView and the battery manufacturer's monitoring platform is recommended to determine if adjustments to the settings may be considered. If there is a battery disconnect during high power charging is a nuisance and can potentially cause a voltage surge causing damage to loads or the controller. This is not likely to be a problem, but may not always be covered under warranty and incidental damage to loads is not covered under warranty.

Load Settings Considerations

It is also important to consider the load control settings carefully. Low Voltage Disconnect (LVD) is intended to keep the batteries from being over-discharged. When the voltage reaches LVD the loads will be disconnected. However, there is still a small amount of discharge current due to the self consumption of the controller and any other equipment that may be connected.

There is not very much battery capacity below 12.5V with a 12.8V nominal voltage LFP battery and voltage drops off rapidly below 12.6V. Therefore, the lowest LVD setting we are providing is 12.5V. In some cases self consumption of the controller and other equipment such as an inverter can bring the voltage below the battery or battery cell low voltage cutoff point at which point the BMS will disconnect the battery internally. If this happens the controller shuts off and is no longer able to charge the battery until voltage is applied to the battery terminals again in which case higher LVD settings should be used. This could especially be a problem for remote sites.

12V settings are entered into the MSView Setup Wizard as indicated in the highlighted columns in the table below. The voltage setting is multiplied by 2 for the 24V setpoints and by 4 for the 48V setpoints.

Here is a link to MSView Configuration Files for all of these settings profiles to be loaded into the MSView Setup Wizard.

<https://www.morningstarcorp.com/wp-content/uploads/Generic-LFP-MSView-Configuration-Files.zip>

Note: For the GenStar MPPT controller, the **nominal voltage** (12V, 24V or 48V) settings are entered into the Installer Battery Charge Settings in LiveView.

Charge Control Settings

Battery Type	Absorption Voltage			Float Voltage			Absorption Time
Battery Nominal Voltage	12.8V	25.6V	51.2V	12.8V	25.6V	51.2V	Minutes
4/8/16 Cell LFP Low	13.6	27.2	54.4	13.5	27	54	180
4/8/16 Cell LFP Medium	13.9	27.8	55.6				20
4/8/16 Cell LFP High	14.2	28.4	56.8				15
Battery Nominal Voltage	12V		48V	12V		48V	Minutes
15 Cell LFP Low	12.75		51	12.65		50.6	180
15 Cell LFP Medium	13		52				20
15 Cell LFP High	13.3		53.2				15

Shared Charge Settings (MSView and Live View)

Shared Setting	Value	Units
Float Timeout	1	Hours
Battery High Voltage Disconnect/ Reconnect: HVD / HVR (4/8/16-cell)	14.45 / 13.6	Volts
Battery High Voltage Disconnect/ Reconnect: HVD / HVR (15-cell)	13.55 / 12.75	Volts
Temperature Compensation Coefficient *	Disabled = 0	millivolts / °C / 12V
Compensation Temperature Range	NA	
Low Temperature Folback 100%	+2	degrees °C
Low Temperature Foldback 0%	0	degrees °C
Disabled Settings	Absorption Extension, Float Cancel, Equalize: (Voltage, Time, Interval, Timeout), Battery Current Limit	

Shared Charge Settings (Live View) - GenStar MPPT only

Shared Setting	Value	Units
Float Exit Time-out Voltage (4/8/16 cell)	13.3	Volts
Float Exit Time-out Voltage (15 cell)	12.5	Volts
Additional Disabled Settings	Absorption End-Amps, Absorption End-Amps Time, Equalize Max Current Limit, High Temperature Foldback	

Load Control Settings

Battery Type	LVD			LVR			LVD Warning
Battery Nominal Voltage	12.8V	25.6V	51.2V	12.8V	25.6V	51.2V	Minutes
4/8/16 Cell LFP Low	12.5	25.0	50.0	13.15	26.3	52.6	1
4/8/16 Cell LFP Medium	12.7	25.4	50.8	13.25	26.5	53.0	2
4/8/16 Cell LFP High	12.85	25.7	51.4	13.3	26.6	53.2	5
Battery Nominal Voltage	12V		48V	12V		48V	Minutes
15 Cell LFP Low	11.7		46.8	12.3		49.2	1
15 Cell LFP Medium	11.9		47.6	12.4		49.6	2
15 Cell LFP High	12.05		48.2	12.45		49.8	5

Caution: Settings are not suitable with all LFP battery models and different systems may require different charge and load control parameters for optimized performance.

Caution: "4/8/16 LFP" settings are for 4 (12V), 8 (24V) and 16 (48V) cell LFP batteries only. Use the "15 Cell LFP" Settings for 15 (48V) cell LFP batteries only.

Enter the highlighted 12V setpoints in the MSView Setup Wizard (except the GenStar MPPT). The 12V values are multiplied by 2 for the 24V setpoints and by 4 for the 48V setpoints. For the GenStar MPPT controller, the nominal voltage (12V, 24V or 48V) settings are entered into the Installer Battery Charge Settings in LiveView. Settings parameters can vary among different controllers.

Notes:

The performance of systems using these settings may vary depending on use conditions and application. Lithium batteries include a Battery Management System (BMS) that can implement an internal battery disconnect in the event of an internal fault, high or low temperatures, high or low battery voltages, or other conditions. If there is a low voltage cutout then it is recommended to increase the LVD setting. If there is a high voltage cutout, one should consider lowering the charge voltage or applying current limiting. Poor performance may also be due to an imbalance between battery cells or between batteries in a battery bank. Contact the battery manufacturer for information about how best to balance battery cell voltages and batteries within a battery bank.

LED Transitions	4/8/16 Cell			15 Cell	
	12V	24V	48V	12V	48V
● Green only	> 13.35	> 26.7	> 53.4	> 12.5	> 50
●● Green-Yellow	13.2	26.4	52.8	12.35	49.4
● Yellow only	13.05	26.1	52.2	12.25	49
●● Yellow Red	12.95	25.9	51.8	12.15	48.6
● Red only	< 12.95	< 25.9	< 51.8	< 12.15	< 48.6

Additional Settings Options

Equalize = Not enabled

Battery Current Limit = Optional (Max recommended charge current = $C/2$ or $C/1$)

Optional calculation for LVD - Load Current Compensation:

Load Current Compensation = $1.8 / (\text{Total Battery Bank Ah})$ ohms (V/A)

The configuration file downloads we offer are set to 0 ohms (V/A)

Load HVD:

These settings are available for the Morningstar controllers listed below:

12, 24V or 48V Systems

TriStar (PWM): Solar Charging Control or Load Control (LVD)

TriStar MPPT (150V) and TriStar MPPT 600V: Solar Charging Control Only

GenStar MPPT: Charge and Load control (includes low temperature foldback); Includes 4/8/16 Cell LFP PreSets.

12, 24V Systems

ProStar MPPT: Charge and Load control (includes low temperature foldback)

SunSaver MPPT: Charge and Load control

ProStar (PWM): Charge and Load control (includes low temperature foldback)

Communications hardware required for programming Custom Settings with MSView:

ProStar MPPT, ProStar (Gen 3), SunSaver MPPT

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-

<https://www.morningstarcorp.com/products/ethernet-meterbus-converter/>

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

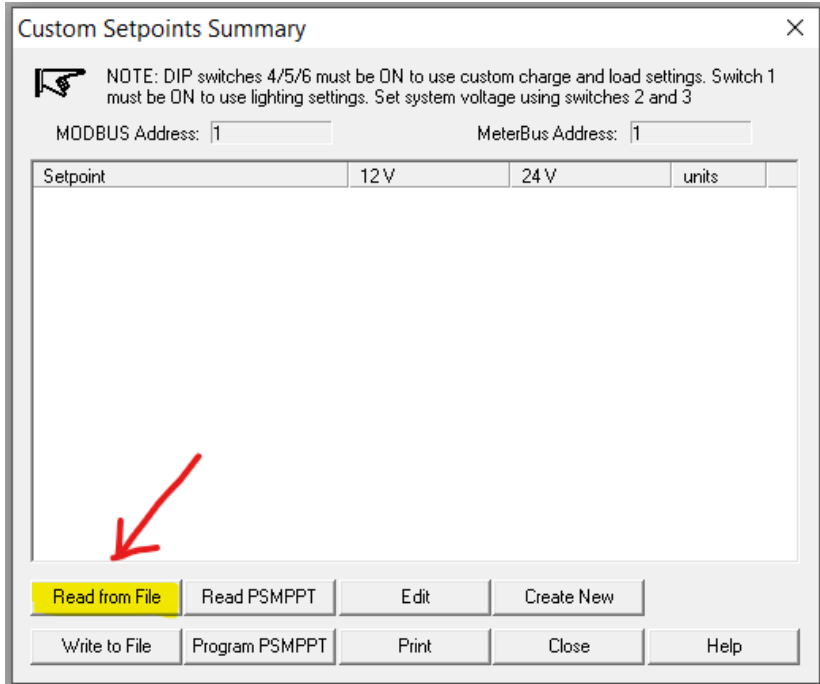
All TS-MPPT-60 (150V and 600V) models also include an Ethernet port and EIA-485 port.

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

MSView Configuration Files:

<https://www.morningstarcorp.com/wp-content/uploads/Generic-LFP-MSView-Configuration-Files.zip>

Read Configuration File into MSView Setup Wizard to program controller.



Note that The GenStar MPPT, ProStar MPPT (with display) and ProStar (PWM) (with display) controllers can be programmed using the digital display.

Morningstar recommends that you review the battery settings in this document with your battery manufacturer with consideration of the usage, environment and other factors to minimize the chance for any unforeseen performance or safety issues. Morningstar makes no representation, warranty or assumption of liability regarding the settings provided and information presented regarding the various charging requirements for any type of battery or model.