Lithium Iron Phosphate LiFePO4 - Generic Charge Settings/ Battery Cell Balancing and Monitoring Required

These Charge Settings are designed for Generic 12.8V Nominal (4 X 3.2V Cell) LiFePO4 Battery Banks which may or may not include a Battery Monitoring System (BMS). Though the settings are conservative to prevent possible harm to the battery, individual battery cell balancing must be maintained.

MSView Controller settings configuration files: Lithium LiFePO4 Generic Custom Settings Config Files

Unlike lead-acid batteries, lithium-ion batteries can operate well with a partial state of charge (PSOC) over long periods of time. In addition, Lithium batteries can be stressed if an Absorption Charge Stage is applied on an ongoing basis. This is especially the case if there is no cell balancing which is often included with lithium batteries with a high quality BMS.

The following settings use the High Voltage Disconnect Fault feature of Morningstar controllers so it can operate as an ON/OFF Switching Controller rather than a Voltage Regulation Charge Controller.

Cell voltages should be monitored to verify that the battery cells remain balanced.

These custom settings were provided to Morningstar from a customer who is an off-Grid end user in Southern California. The settings were used with the following solar/battery system with an RV.

Controllers Used: Tristar MPPT 60
Input Power (W): 600W; 2X) Battery Type & Voltage: CALB CA180FI - Lithium Cell LiFePO4 (3.2V/180Ah); 12 Cells (3 strings of 4); Total 540Ah @ 12.8V
Input Type: PV only, LG 300 watt solar panels, 2 units
Environment: Mobile Application in warm Mediterranean environment.
Temperature variations: 5°C to 40°C
Humidity: Dry

These settings were reviewed by Morningstar and are considered to be safe to use at least in the milder temperatures of Southern California. Customers who are considering locations with ambient temperatures below freezing may need to consider a low temperature disconnect and the use of low temperature foldback settings that are only available with the Prostar and ProStar MPPT controllers. As noted above cell balancing is another important consideration. Very high charge and discharge rates > C/2 for example might also be considered more risky.

Morningstar Corporation is not affiliated by ownership with any Lithium LiFePO4 Battery manufacturers and battery charging requirements should be reviewed for the specific battery model being used with these settings.

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Application Details provided from the Morningstar customer who is an off-grid end user.

Before putting battery in service each cell should be bottom balanced to 2.75V. The absorb voltage is set to 14.00 volts which is higher than the 13.88 volts (3.47 V/per cell) we want as our maximum charge voltage. We never want our batteries to enter the absorb or float states. The High Voltage Disconnect (HVD) parameter is set to 13.88 volts* and the High Voltage Reconnect (HVDR) parameter is set to 13.29 volts* (3.323vpc).
Battery will charge in BULK mode until it reaches 13.88 volts. At 13.88 volts HVD creates a “FAULT” condition, the solar panels are disconnected from the system, and charging halts. When the battery voltage drops to 13.29 volts or below, charging resumes in BULK mode (the ABSORB voltage of 14.00 was never reached so the controller

remains in BULK charge mode) and the charge cycle starts over again.
There is some concern with attempting to maintain a high charge on the battery. Lithium cells do not like remaining at 100% charge for long periods. This should not be a problem as the charge stops just short of 100% and there is always some load, even if it is only the solar controller itself drawing current.
They should be stored at around 50% charge for long term storage. For RV service, when the RV won't be used for some time, the battery should be allowed to discharge to about 50% and then disconnected from all load and charging sources.
HVD may need adjustment. The main requirement is that at the HVD set point no individual battery cell exceeds 3.5V. If this requirement is not met, then either HVD should be lowered or the cells rebalanced to meet the requirement.
HVDR may need adjustment such that when a heavy load is applied and battery voltage sags, available solar power is switched on to assist. The overall goal is to set HVDR such that, under normal operating conditions where good solar input is available, the end of day state of charge of the battery should be somewhere around 90%.
* The precise voltage settings are dependent on the specific battery chemistry and may need adjustment. The discharge curves show that different chemistries can have a voltage difference of as much a 0.3 volts across the curve so all settings would be changed to match the cell chemistry. The settings below are based on CALB CA-180 series cells.
My TS-MPPT-60 controller reads the battery voltage off the battery sense terminals at 0.06 volts lower than the actual voltage read by a Fluke 115 Digital Multi Meter with no load or charge current present. If the DMM reads 13.38 volts the MPPT-60 reads it as 13.32 volts. This is an offset error of 0.06 volts. All programmed values can be adjusted to compensate for this error. [It this case the settings were programmed to .06V below the desired setpoints for HVD and HVDR.

Absorb voltage = 14.00 V; This value should never be reached so is not important.
Temperature Compensation = disable = 0.0 V/ degC
Absorption Time = 20 min. Unused. Batteries never go to absorb state.
Absorption Ext Voltage = Not enabled
Battery Service Reminder = Not enabled No water or service. [MS - Monitor cell voltages & Ah Capacity]
Float = Not enabled [MS - Can be set < HVDR as a precaution if Absorption stage is enabled]
Equalize = Not enabled
High Voltage Disconnect HVD = 13.88 V (3.47 V/per cell)
High Voltage Reconnect HVDR = 13.31 V (3.328 V/per cell)
Max Regulation Limit = 14.06 V Set as a precaution.
Max Battery Current - Optional
Array Voltage Fixed Target = disabled
LED G –> G/Y 75%+ = 13.31 V (3.328 V/per cell)
LED G/Y –> Y 50% - 74% = 13.21 V (3.303 V/per cell)
LED Y –> Y/R 25% - 49% = 13.06 V (3.265 V/per cell)
LED Y/R –> R 10% or below = 13.01 V (3.253 V/per cell)

More information regarding these settings provided by Morningstar

Load Settings (where applicable for controller models which include LVD 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)

These settings are available for all Morningstar controllers which have custom settings except the SunSaver Duo which does not include high voltage disconnect protection.

These are considered open-loop settings. Battery Cell Voltages should be monitored especially if there is no BMS. If there is an internal BMS where the cell voltages can not be measured and there is no cell monitoring, there is no ability to determine if there are potential issues with the individual battery cells. Morningstar is unable to provide feedback regarding the quality of different lithium LiFePO4 battery models. Therefore, it is the customer's responsibility to evaluate the reliability of any battery used with these or similar settings.

Lithium Battery Cell imbalances may cause cell over-voltages which could trigger an internal disconnect with the internal BMS. Ideally this can be detected well before there could ever be a problem and an external switch can be used to disable charging before this can occur. Since the batteries are unlikely to ever get charged above 90-95% with these settings it is unlikely to ever be a problem unless there is a fairly large imbalance with the battery.

These settings are also unlikely to stress the battery cells which has reportedly been a problem with voltage regulation settings with the same or higher voltages.

Though these settings are likely to work well without any issues with most all of commonly available 12.8V nominal voltage (4 X 3.2V Cell) LiFePO4 batteries on the market, there is no guarantee that the battery cells for a particular battery will remain balanced. The higher the charge and discharge rates are the more likely the battery cells can become stressed and more unbalanced. Therefore, very high charge rates which are often indicated on many lithium spec sheets should be avoided.

According to several sources LiFe PO4 batteries are better able to handle some overcharging stress than many other types of lithium batteries, though stressing the batteries should be avoided.

These settings were based on a forum discussion from a solar installer in Australia with successful off-grid lithium system installations. According to this installer "Tests over the past 7 years have shown that if you float LiFePo4 cells, or use any other lead acid charging protocol, their life drops dramatically." They indicated that the only method that worked for them was using moderate voltage with on-off switching instead of voltage regulation.

There might be more appropriate open-loop settings than these with higher voltages and which incorporate voltage regulation for certain makes and models of lithium batteries. Batteries with high quality BMS might be available which would work very well with less conservative settings and with Absorption and Float voltage regulation. The battery manufacturer should be consulted for what would be considered the best solar settings for their batteries.

Recommended products by Morningstar:

12V systems:
~~SunSaver Duo~~ (Does not have HVD. Configuration File not available)
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, 48V, 60V nominal systems)
TriStar MPPT 600V (compatible with 12V, 24V, 36V, 48V and 60V 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/

Other links
Morningstar Best Practices by Battery Chemistry
Morningstar Custom Settings Info Pages