GenStar MPPT™

Solar DC System Controller

Installation, Operation and Maintenance Manual

Solar Battery Charger & Load Controller

With

TrakStar™ Maximum Power Point Tracking Technology

GenStar MPPT™

MODELS

GS-MPPT-60M-200V

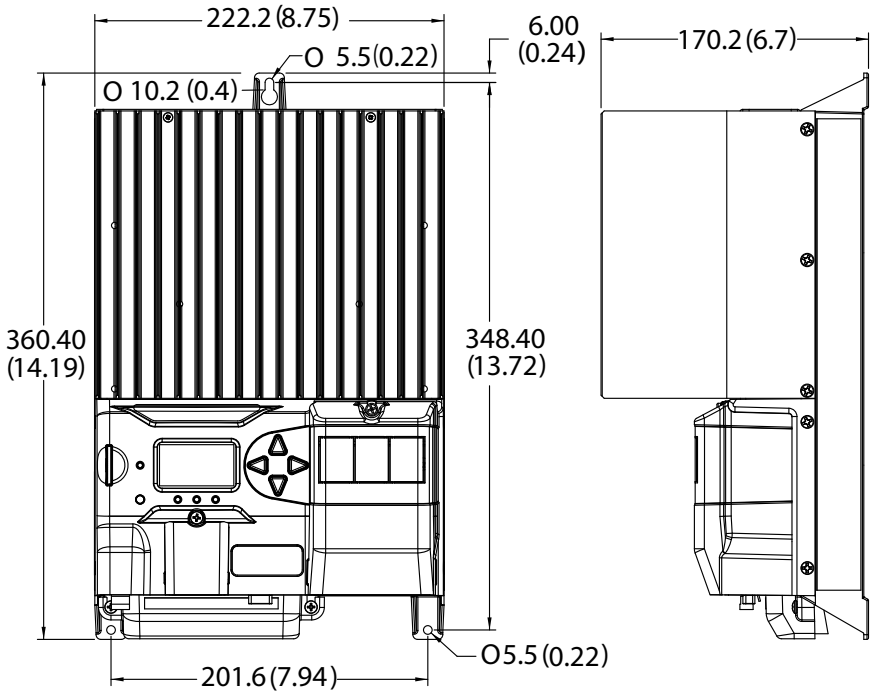
GS-MPPT-80M-200V

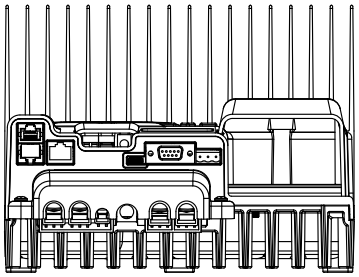
GS-MPPT-100M-200V

TRAKSTAR™ MAXIMUM POWER POINT TRACKING

MORNINGSTAR INTEGRATEDSERIES WORLD'S LEADING SOLAR CONTROLLERS & INVERTERS

DIMENSIONS [millimeters (inches)]





SPECIFICATION SUMMARY

	GS-MPPT-60	GS-MPPT-80	GS-MPPT-100
Nominal Battery Voltage	12-24-48V	12-24-48V	12-24-48V
Maximum PV Open-circuit Voltage[1]	200V	200V	200V
Nominal Maximum Output Power	800-1600-3200W	1075-2150-4300W	1350-2700-5400W
Maximum Recommended PV Input Power[2]	1200-2400-4800W	1600-3200-6400W	2000-4000-8000W
Maximum Charge Current[3]	60A	80A	100A
Rated Load Current	30A	30A	30A

[1] Array voltage should never exceed this limit

[2] 150% of Nominal Maximum Output Power

[3] Charge Current - Load Current = Net Battery Current

TABLE OF CONTENTS

1.0 IMPORTANT SAFETY INSTRUCTIONS

SAVE THESE INSTRUCTIONS.

This manual contains important safety, installation, operating and maintenance instructions for the GS-MPPT-60M-200V, GS-MPPT-80M-200V, GS-MPPT-100M-200V. For safety purposes, these instructions must be followed during installation, operation and maintenance of the GenStar MPPT solar controller.

The following symbols are used throughout this manual to indicate potentially dangerous conditions or mark important safety instructions:

WARNING: Indicates a potentially dangerous condition. Use extreme caution when performing this task.

CAUTION: Indicates a critical procedure for safe and proper operation of the controller.

NOTE: Indicates a procedure or function that is important to the safe and proper operation of the controller.

Safety Information

- Read all of the instructions and cautions in the manual before beginning installation.
- There are no user serviceable parts inside the GenStar MPPT. Do not disassemble or attempt to repair the controller.

WARNING: Risk Of Electrical Shock.

NO POWER OR ACCESSORY TERMINALS ARE ELECTRICALLY ISOLATED FROM DC INPUT, AND MAY BE ENERGIZED WITH HAZARDOUS SOLAR VOLTAGE. UNDER CERTAIN FAULT CONDITIONS, BATTERY COULD BECOME OVER-CHARGED. TEST BETWEEN ALL TERMINALS AND GROUND BEFORE TOUCHING.

- External solar and battery disconnects are required.
- Disconnect all sources of power to the controller before installing or adjusting the GenStar MPPT.
- There are no fuses or disconnect s inside the GenStar MPPT Do not attempt to repair.

Installation Safety Precautions

The GenStar MPPT controller must be installed by a qualified technician, in accordance with the electrical regulations of the country of installation.

Throughout this manual, NEC guidance is provided to meet general safety requirements, and to inform of best installation practices. It is the installer's responsibility to ensure that installation complies with all local safety and code requirements.

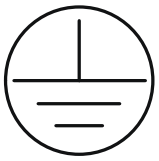
WARNING: SHOCK HAZARD

These installation and servicing instructions are for use by qualified personnel only. To reduce the risk of electrical shock, do not perform any servicing other than that specified in the operating instructions, Unless qualified to do so.

WARNING: Shock Hazard

This unit is not provided with a GFDI device. This charge controller must be used with an external GFDI device as required by the Article 690 of the National Electrical Code for the installation location.

- Mount the GenStar MPPT indoors. Prevent exposure to the elements and do not allow water to enter the controller.
- Install the GenStar MPPT in a location that prevents casual contact. The GenStar MPPT heatsink can become very hot during operation.
- Use insulated tools when working with batteries.
- Avoid wearing jewelry during installation.
- The battery bank must be comprised of batteries of same type, make, and age.
- Certified for use in negative ground systems, or positive ground with floating array
- Do not smoke near the battery bank.
- Power connections must remain tight to avoid excessive heating from a loose connection.
- Use properly sized conductors and circuit interrupters.
- The grounding terminal is located in the case, and is identified by the symbol below:



Ground Symbol

- This charge controller is to be connected to DC circuits only. These DC connections are identified by the symbol below:

Direct Current Symbol

A means of disconnecting all power supply poles must be provided. These disconnects must be incorporated in the fixed wiring. The GenStar MPPT negative power terminals are common, and must be grounded as instructions, local codes, and regulations require.A permanent, reliable earth ground must be established with connection to the GenStar MPPT ground terminal.The grounding conductor must be secured against any accidental detachment.

- Servicing of batteries should be performed, or supervised, by personnel knowledgeable about batteries, and the proper safety precautions.
- Be very careful when working with large lead-acid batteries. Wear eye protection and have fresh water available in case there is contact with the battery acid.
- Remove watches, rings, jewelry and other metal objects before working with batteries.
- Wear rubber gloves and boots
- Use tools with insulated handles and avoid placing tools or metal objects on top of batteries.
- Disconnect charging source prior to connecting or disconnecting battery terminals.

- Determine if battery is inadvertently grounded. If so, remove the source of contact with ground. Contact with any part of a grounded battery can result in electrical shock. The likelihood of such a shock can be reduced if battery grounds are removed during installation and maintenance (applicable to equipment and remote battery supplies not having a grounded supply circuit).
- Carefully read the battery manufacturer's instructions before installing / connecting to, or removing batteries from, the GenStar MPPT.
- Be very careful not to short-circuit the cables connected to the battery.
- Have someone nearby to assist in case of an accident.
- Explosive battery gases can be present during charging. Be certain there is enough ventilation to release the gases.
- Never smoke in the battery area.
- If battery acid comes into contact with the skin, wash with soap and water. If the acid contacts the eye, flush with fresh water and get medical attention.
- Be sure the battery electrolyte level is correct before starting charging. Do not attempt to charge a frozen battery.
- Recycle the battery when it is replaced.

2.0 GENERAL INFORMATION

2.1 Overview

Thank you for choosing the GenStar MPPT charge controller with TrakStar™ MPPT Technology. The GenStar MPPT is a maximum power point tracking solar battery charger. The controller features a smart tracking algorithm that finds and maintains operation at the power source's peak power point, maximizing energy harvest.

The GenStar MPPT battery charging process is designed for long battery life and improved system performance. GenStar MPPT is compatible with Lithium, Lead-acid, Ni-Cad and Flow battery systems. Self-diagnostics and electronic error protections prevent damage when installation mistakes or system faults occur. The controller also features several communication ports, and terminals for remote battery temperature and voltage measurement.

Please take the time to read this operator's manual to become familiar the many benefits the GenStar MPPT can provide for your PV systems. Some examples:

- Rated for 12 or 24, and 48 Volt systems, and 60, 80 or 100 Amps of charging current
- ReadyRail expansion system for relay operation, current monitoring and battery management
- Fully-protected with automatic and manual recovery
- Easily selectable preset charging profiles
- Continuous self-testing with fault notification
- LED indications, push-button and meter key functions
- Battery and PV Input terminals sized for #1/0 AWG (53.5 mm^2) wire
- DC Load terminals sized for #6 AWG (13.3 mm^2) wire
- Digital meter display
- 5-year warranty (see Section 7.0)

2.2 Models and Ratings

There are three Models of the GenStar MPPT controller:

GenStar-MPPT-60
maximum 60 Amps continuous battery current

GenStar-MPPT-80
maximum 80 amps continuous battery current

GenStar-MPPT-100
maximum 100 amps continuous battery current

All GenStar models:
On-board meter display
30 Amp load current rating
12, 24 and 48 Volt DC systems
Maximum 200 Volt DC open-circuit solar input voltage
SD Card: USB-C (data port); RS--232, EIA-485, Ethernet (RJ-45), MS CANBus (not available with this release)

2.3 Features - Exterior

GenStar MPPT exterior and meter features are shown in Figures 2-1 and 2-2 below. A brief description of each feature follows the figures.

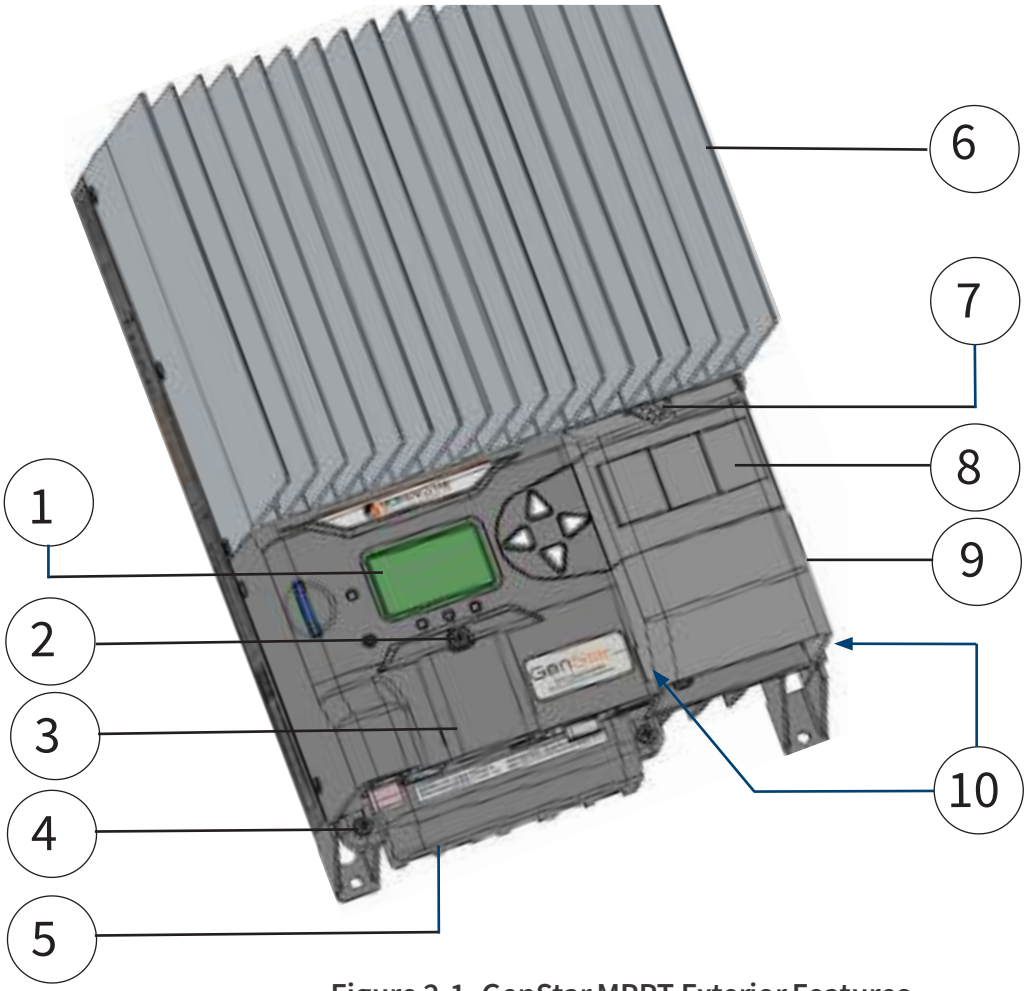


Figure 2-1. GenStar MPPT Exterior Features

EXTERIOR FEATURES:

1 - Meter Display Screen
LCD read-out for setting and programming navigation

2 - Coin Cell / Accessory Cover Screw

3 - Coin Cell / Accessory Cover
Plastic protective cover for accessory terminals and coin cell compartment

4 - Power Terminal Cover Screw (one of 2)

5 - Power Terminal Cover
Plastic protective cover for power terminal lugs and communication ports

6 - Heatsink
Aluminum heatsink to dissipate GenStar MPPT heat

7 - ReadyBlock Cover Screw

8 - ReadyBlock Tabs
Removable plastic protective panels for ReadyBlock installation

9 - ReadyBlock Cover
Plastic protective cover for ReadyBlocks and ReadyRail™

10 - ReadyBlock Cover Clips and Anchor Hole Locations
(2) Plastic extension flanges to secure cover in molded plastic anchors

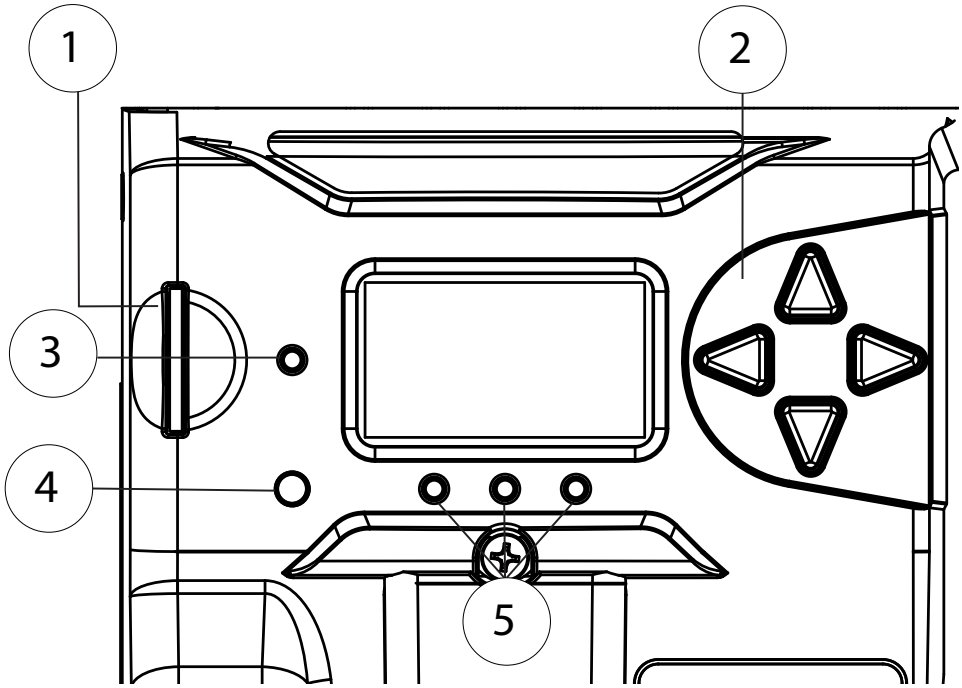


Figure 2-2. Meter Features

METER FEATURES:

1 - SD Card Slot
Has SD card installed. External memory card slot for saving configurations and updating firmware

WARNING: RISK OF EXPLOSION

When loading a system image configuration from an SD Card, ensure that the destination device has the same system voltage, battery profile, and RTS; otherwise, there is a potential risk of system damage or bodily injury.

2 - Meter Directional Buttons
Meter navigational controls

3 - Charging Status LED
Unit Charging State and Fault and Alarm indicator

4 - Programmable Soft-key
Push-button control for command activation

5 - State-of-charge LEDs
Approximate battery state-of-charge indicators.

NOTE:
Indicator becomes more precise when ReadyShunt or Ready BMS is installed.

2.4 Features - Interior

GenStar MPPT exterior features are shown in Figure 2-3 below. A brief description of each feature follows the figure.

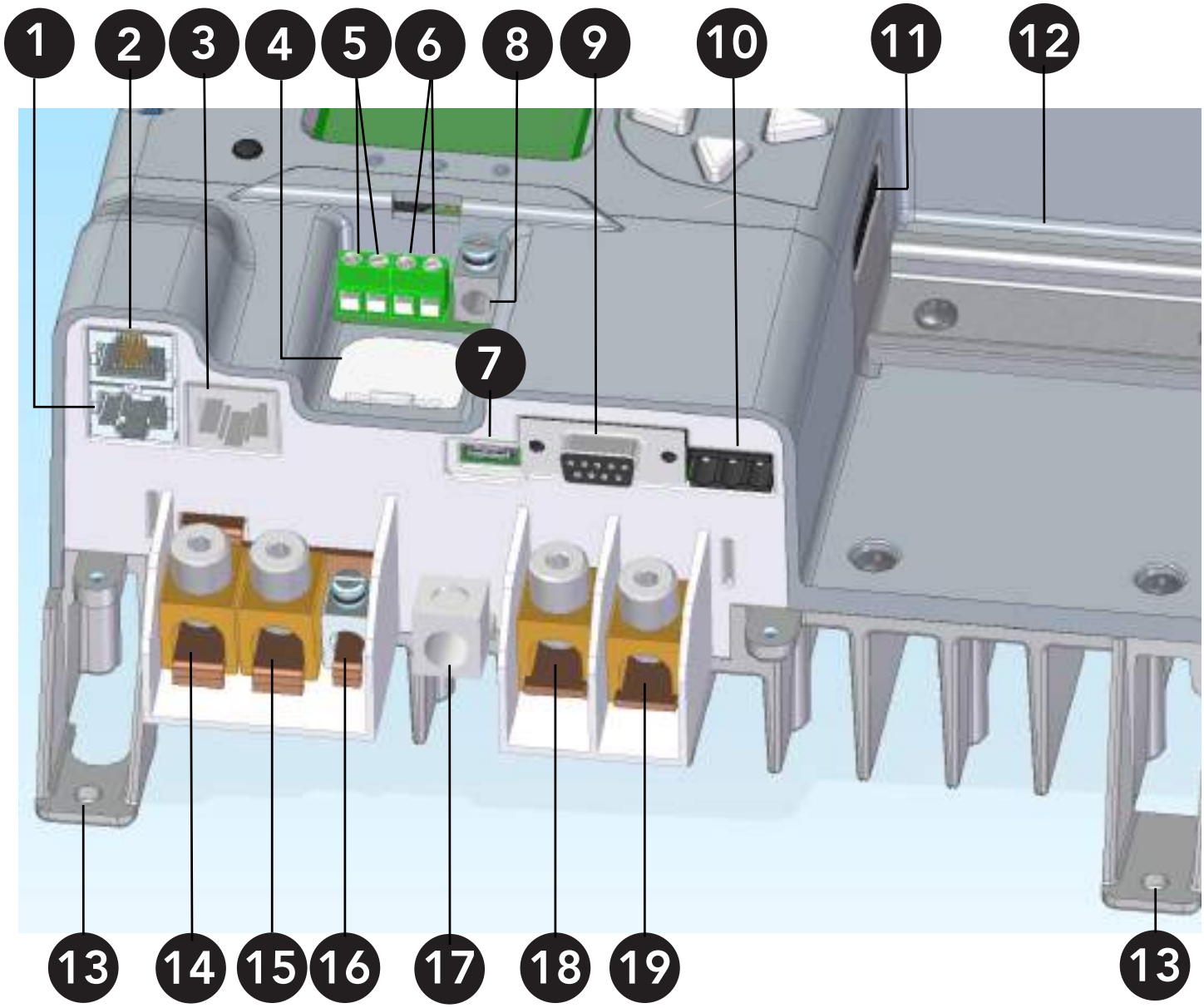


Figure 2-3. GenStar MPPT Interior Features

1 and 2 - MS-CAN In and Out Ports
Proprietary Morningstar device communication protocol ports

3 - Ethernet Port
RJ-45 socket for LAN/Internet connection

4 - Coin Cell (CR-2032)
Back-up battery for the real-time clock

5 - Battery Voltage Sense Terminals
Terminals for battery voltage input provide accurate battery voltage measurement

6 - Remote Temperature Sensor Terminals
Connection points for a Morningstar RTS to remotely monitor battery temperature

7 USB-C Port
USB-C data / Modbus port

8 - Positive Load Terminal Lug
Positive connection point for loads

9 - Serial RS-232 Port
9-pin serial connector (female DB9)

10 - EIA-485 Port
3-terminal connection for serial 485 networks (removable plug connector)

11 - ReadyRail Connection
20-PIN female ReadyRail connection interface for ReadyBlocks

12 - ReadyRail
Standard 35mm DIN mounting plate for mounting snap-in ReadyBlocks

13 - Lower Mounting Screw Holes (2)
Used to secure lower part of GenStar MPPT to the wall

14 and 15 - Battery/PV Common Negative Terminal
Connection points for battery or PV (-) power cable

16 - Negative Load Terminal Lug
Negative connection point for loads

17- Equipment Grounding Terminal Lug
Chassis grounding point for system equipment

18 - PV Positive Terminal Lug
Connection point for PV positive cable

19 - Battery Positive Terminal Lug
Connection point for battery positive cable

2.5 Optional Accessories

The following Morningstar accessories are available for purchase separately from your authorized Morningstar dealer:

Ground-fault Protection Device (GFPD-600V)

The GFPD-600V detects power source ground faults and interrupts current as required by the U.S. National Electrical Code. For a PV array with a maximum open circut voltage less than 150V, a GFPD-150V can be used for ground fault protection.

READYBLOCK BOS ACCESSORIES:

See product manuals at www.morningstarcorp.com/support/library/

ReadyRelay (RB-Relay)

The ReadyRelay is an expansion block that adds AC and DC-rated relay dry contact hardware functionality and firmware control and logic to the Morningstar GenStar MPPT charge controller.

ReadyShunt (RB-Shunt)

The ReadyShunt is an expansion block designed to display measured branch circuit currents and Amp-hours. When used in the battery circuit, the ReadyShunt acts as a battery meter providing state-of-charge (SOC) %, batter y charging current limiting and other functionality.

ReadyBMS (RB-BMS)

The ReadyBMS provides simple visibility of battery performance, hands-free settings and optimized battery control. Through the ReadyBMS, the GenStar MPPT will report any data variable contained in the battery BMS. The Block can also interface with lithium batteries for, "closed loop", charging and data reporting.

2.6 Tools Required

Pencil

5/32” Hex wrench

1/8" (3 mm) bit

#2

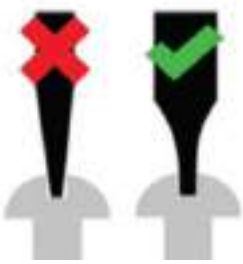
3/32" (2.5 mm)

3/16"- load screws[1] (5 mm)

1/14" (6.5 mm)

MOUNTING:

[1] To prevent slippage or damage to the screw head, use a non-tapered, "hollow ground", 3/16” (5mm) bit tip flathead screw-driver.



3.0 INSTALLATION AND COMMISSIONING

3.1 General Installation Notes

- Read through the entire installation section first before beginning installation.
- Be very careful when working with batteries. Wear eye protection. Have fresh water available to clean any contact with battery acid.
- Use insulated tools and avoid placing metal objects near the batteries.

WARNING: EQUIPMENT DAMAGE OR RISK OF EXPLOSION
Never install the GenStar MPPT in an enclosure with vented/flooded batteries. Battery fumes are flammable and will corrode and destroy the GenStar MPPT circuits.

WARNING: RISK OF FIRE
Over-current protection device interrupt ratings must be a minimum of 2kA, 3kA and 5kA for 12V, 24V, and 48V systems, respectively.

CAUTION: EQUIPMENT DAMAGE
When installing the GenStar MPPT in an enclosure, ensure sufficient ventilation. Installation in a sealed enclosure will lead to over-heating and a decreased product lifetime.

CAUTION: EQUIPMENT DAMAGE
When installing the GenStar MPPT be certain to observe correct polarity when wiring the battery to the controller battery terminals. THERE IS NO REVERSE BATTERY POLARITY PROTECTION.

CAUTION: Equipment Damage
The GenStar MPPT is designed to regulate ONLY solar (photovoltaic) power. Connection to any other type of power source (e.g. wind turbine or generator) may void the warranty. However, other power sources can be connected directly to the battery.

- For indoor use only. Do not install in locations where water can enter the controller.
- CSA C22.2 #107.1 per Clause 15.4.1.3 requires the installer to apply the additional label on or adjacent to the battery, in a location where it is visible prior to removal of guards, opening of a battery enclosure, etc.

  "WARNING: WHEN A GROUND-FAULT IS INDICATED, BATTERY TERMINALS AND CONNECTED CIRCUITS MAY BE UNGROUNDED AND HAZARDOUS."

- Be certain that battery terminals and other bare live parts of connected circuits are installed in enclosures or otherwise guarded against inadvertent contact.
- Loose power connections and /or corroded wires may result in resistive connections that melt wire insulation, burn surrounding materials, or even cause fire. Ensure tight connections and use cable clamps to secure cables and prevent them from swaying in mobile applications.
- Preset charging profiles are designed for lead acid and 4, 8 or 16 cell Lithium LiFePO4 batteries. Custom settings can be used for varied charging requirements (see section 5.2.3 for details). Note that some batteries may not be compatible.
- The GenStar MPPT battery connection may be wired to one battery, or a bank of batteries. The following instructions refer to a singular battery, but it is implied that the battery connection can be made to either one battery or a group of batteries in a battery bank.

- The GenStar MPPT uses corrosion-resistant fasteners, an anodized aluminum heat sink, and conformal coating to protect it from harsh conditions. However, for long service life, extreme temperatures and marine environments should be avoided.
- The GenStar MPPT prevents reverse current leakage at night, so a blocking diode is not required in the system.
- The maximum power wire size is 1/0 AWG / 53.5 mm2 (multi-strand). Torque tightly up to 100 in-lb (11.3 N-m).
- The maximum equipment grounding terminal wire size is #2 AWG / 33.6 mm2 (multi-strand). Torque tightly up to 50 in-lb / 5.65 N-m.
- The maximum load terminal wire size is #6 AWG / 13.3 mm2 (multi-strand). Torque tightly up to 35 in-lb / 3.9 N-m.
- Use caution to ensure that all wire strands (especially fine strands) are contained in the terminal lug wire slot. Clamped wire heads are recommended for this purpose.
- Verify that the highest temperature compensated solar array open-circuit voltage (Voc) will not exceed 200V, and that load current will not exceed 30 Amps.
- Verify that the system battery will maintain voltages between 10-72.
- To achieve greater total charging current, multiple controllers can be installed in parallel on the same battery bank.
- Each controller in the system must have its own solar array.
- The load terminals of multiple GenStar controllers can only be wired together if the total load draw does not exceed 30 Amps.

3.2 Mounting

Refer to Figures 3-1 and 3-2.

CAUTION: Risk of Burns
Install the GenStar MPPT in a location that prevents casual contact. The GenStar MPPT heatsink can become very hot during operation.

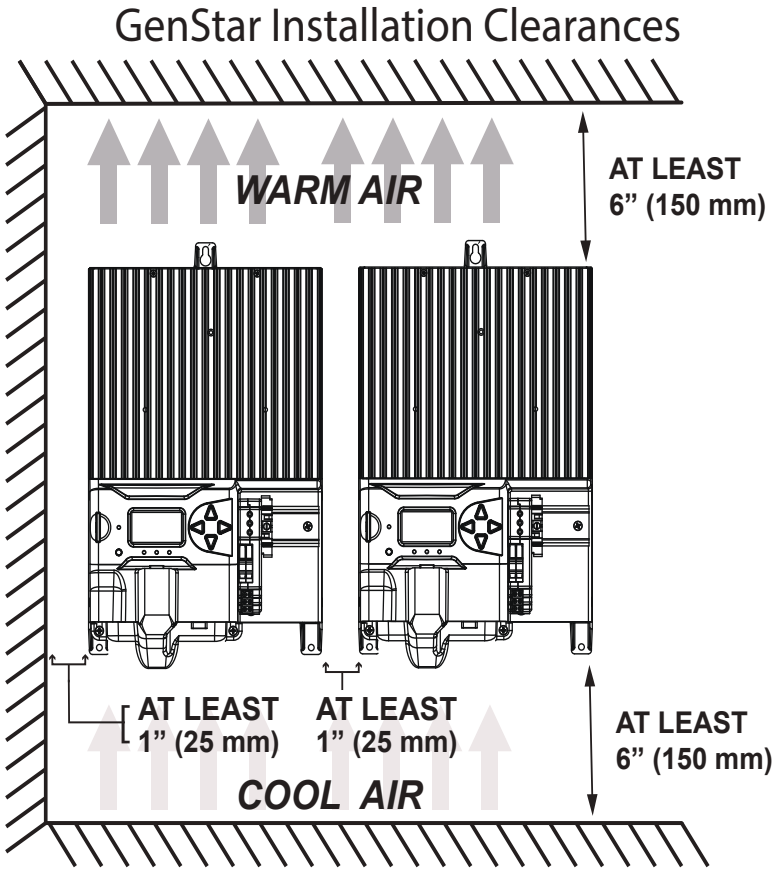


Figure 3-1. Required mounting clearance for proper air flow

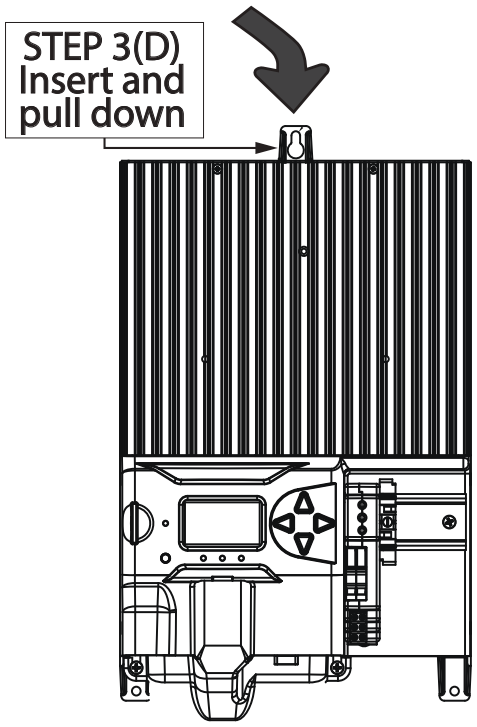


Figure 3.2 - Hanging GenStar using keyhole slot

1. **Choose mounting location**

   A. Locate the GenStar MPPT on a vertical surface that is protected from direct sun, high temperatures, and water.

2. **Wiring accessibility and air flow clearance**

   A. Plan and confirm wire routing access.

   B. Verify that there is at least 6" (150mm) of space above and below the unit, and at least 3" (75 mm) around the heatsink - see Figure 3-1.

3. **Drill holes and hang controller**

   A. Place the GenStar template on the wall where the unit will be mounted.

   B. Mark and drill (1)-1/8" (3.175 mm) hole in the top end (slot) of the template keyhole, and two (2) lower holes for the frame holes.

   C. Drive a #10 screw (included) into the drill hole to 1/4 in. (6.35 mm) from flush with the wall.

   D. Place the controller circular keyhole area over the wall screw, and pull the unit down to lock the screw into the slot.

4. **Finish securing the controller -** use only panhead screws (included)

   A. Drive the keyhole screw flush with the frame mounting hole.

   B. Use two screws to secure the (2) unit lower frame holes flush with the wall.

3.3 Overcurrent Protection and Disconnect Switches

NOTE: Definition

Overcurrent protection devices are defined as breakers or fuses. Strictly, a disconnect switch is device that only breaks a circuit - but provides no overcurrent protection.

WARNING: SHOCK AND FIRE HAZARDS

Installation must comply with all U.S. National Electrical Code, Canadian Electrical Code or local code requirements.

WARNING: Shock and Fire Hazards

Solar, load, and battery overcurrent protection are required in the system. These protection devices are external to the GenStar MPPT controller, and must be sized as required by the NEC or local code requirements.

WARNING: SHOCK AND FIRE HAZARDS

Circut Breakers or fused disconnect switches can serve as a means of disconnection, and should be at a readily accessible location. For best practices and safety guidance, see NEC 690 ,"Part III - Disconnecting Means", for disconnect requirements for PV systems, in addition to other code requirements.

WARNING: SHOCK AND FIRE HAZARDS

Fuses, single-pole circuit breakers, or single-pole disconnect switches must only be installed on ungrounded system conductors. The NEC allows and may require the use of double-pole breakers or double-pole disconnect switches which break both the grounded and ungrounded conductors of the PV array or load conductors.

WARNING: SHOCK AND FIRE HAZARDS

When using a disconnect switch, install a fuse or breaker in series to provide overcurrent protection.

CAUTION:

All breakers, fuses and disconnect switches must be rated for the maximum voltage of the circuit or higher. These devices are external to the GenStar MPPT controller.

BATTERY OVER-CURRENT PROTECTION DEVICE SIZING

The U.S. NEC requires the installation of DC breakers or fused disconnect switches in all battery circuits in order to provide both a means of disconnection and overcurrent protection.

The battery breaker or fused disconnect switch(es) should be located near the battery or the battery busbar. Where the controller battery terminals are more than 1.5m (5 feet) from the battery, or where circuits from these terminals pass through a wall or partition, U.S. NEC requires that a means of disconnection be provided at the battery and solar controller with overcurrent protection at the DC (battery) power source.

The minimum battery **disconnect switch** current rating is the current rating of the controller being installed. To provide over-current protection when using a disconnect switch, a properly sized fuse or breaker **must be** installed in series.

Battery breakers or fuses must be sized with a minimum of 125% of the continuous output current rating of the solar controller. Recommended battery circuit fuse or breaker current ratings:

MODEL	Battery Circuit Breaker/Fuse Rating
GS-MPPT-60M-200V	75 or 80 Amps
GS-MPPT-80M-200V	100 Amps
GS-MPPT-100M-200V	125 Amps

Table 3-1. Battery Circuit Breaker/Fuse Current Ratings Meeting U.S. National Electrical Code

PV Input Over-Current Protection Device (Ocpd) And Disconnect Switch Ratings

WARNING: SHOCK AND FIRE HAZARDS

The solar array open-circuit voltage (Voc) at the worst-case (coldest) module temperature must not exceed the PV disconnect or overcurrent protection voltage ratings.

As defined in NEC Section 690.9, PV input disconnect switches must have a current rating greater than or equal to the maximum PV array current (Isc) multiplied 1.25. PV array I_{sc} = # of strings multiplied by the module Isc (STC) rating.

Note that individual PV string circuits do not require disconnects.

NEC Section 690.9 provides requirements for **overcurrent protection**. These requirements are based on the maximum PV array current which equals 1.25 multiplied by array I_{sc}, as defined in NEC Section 690.9.

The PV input breaker or fuse rating should not be less than the next higher breaker rating above 156% of the PV array I_{sc}. Maximum PV breaker or fuse ratings are :

MODEL	Maximum PV Breaker or fuse Rating
GS-MPPT-60M-200V	80 Amps
GS-MPPT-80M-200V	100 Amps
GS-MPPT-100M-200V	125 Amps

Table 3-2. PV Input Circuit Maximum Breaker or Fuse Current Ratings

String breakers or fuses are also required for parallel strings and are typically included with the PV string combiner. There may be other code requirements specific to the installation of a particular PV array.

As allowed for in NEC Section 690.9(A), PV input overcurrent protection is not required if both of the following conditions are met:

1. PV wire ampacity is sufficient to carry the maximum PV array current (ampacity is greater than 156% of PV array I_{sc})
2. The maximum PV array current (125% of PV array I_{sc}) is less than the maximum input I_{sc} current rating of the controller and PV disconnect rating.

If 156% of PV array I_{sc} is greater than the maximum PV input breaker or fuse current rating, the PV array breaker or fuse should be located at the output of the PV array combiner.

Load Output Overcurrent Protection Devices (OCPD) and Disconnect Switches

The output/load breaker or fuse rating must be no greater than 40 Amps.

The load fuse or breaker must be sized at a minimum of 125% of the maximum load output current. The maximum load output current is the sum of the branch load circuits or the controller load output current rating.

The load/output breaker or fused disconnect switch should be located near the load output terminals of the controller.

The load output disconnect switch must have a minimum current rating greater than or equal to the fuse current rating, but is not required to be higher than the load output current rating of the controller..

3.4 Wiring

WARNING: FIRE HAZARD

If multiple units are used in parallel for more charging current, the battery conductor wiring must be sized for the total sum of all the current ratings of the combined controllers.

CAUTION:

U.S. installed wiring must conform to all current U.S. NEC, ANSI/NFPA 70 requirements, and to any local regulations. Non-U.S. installations must meet all national and local requirements of the country of installation.

Before connecting any wires, read the instructions in Section 3.4, and lay out the lengths and routes needed.

When wiring, secure and contain wire runs as required by code.

Three (3) ferrite chokes are included for individual installations around an RTS cable, PV (+) and (-) cables (in one choke) and an Ethernet cable. See Figures 3-3 and 3-4 for installation details conforming to FCC Class B EMI requirements. Each core must be installed as close to the GenStar MPPT as possible.
Proper wire type and size is required for all installations. ***Use only UL-listed Class B or Class C stranded wire rated for 300 Volts and 75°C or higher.***
Copper wire is recommended instead of aluminum due to its ease of use, superior conductivity, strength and thermal expansion properties.

Battery and PV input terminal sizes:

8 - 1/0 AWG (10 - 53.5mm^2)

Load terminal wire sizes:

14 - 6 AWG (2.5 - 13.3mm^2)
Conductor ampacity (current carrying capacity) ***must be*** greater than the maximum current expected in the power circuits.

Accepted practice for system design requires that DC conductors are sufficiently sized to limit voltage drop losses to 2% or less. The table in Appendix C provides wire sizing information and distances for required maximum 2% voltage drop in GenStar MPPT wiring applications.

Also see Appendix C, “Wire Sizing”, for copper wire sizing instructions, including minimum wire sizing requirements.

For Accessory Wiring, refer to schematic in Figure 3.3 below when following 3.4.1 and 3.4.2 on next pages.

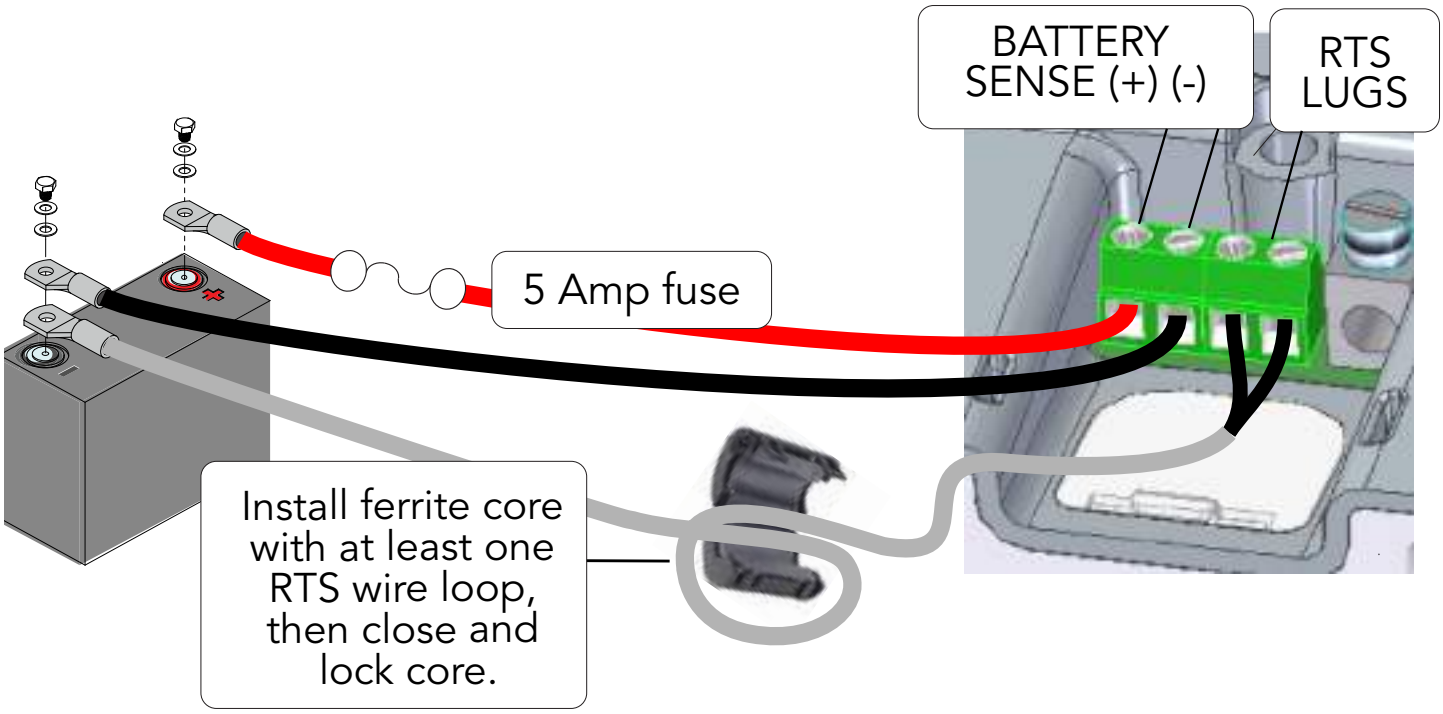


Figure 3-3. Accessory installation detail

3.4.1 Battery Voltage Sense Wires

Refer to Figure 3-3 above.

WARNING: Fire Hazard
When connecting Battery Sense Wires, install a 5 Amp fuse in the (+) sense wire, within six inches (150 mm) of the (+) battery terminal.

Due to connection and cable resistance, voltage drops are unavoidable in all power cables that carry current (See Figure 3.3 above). If Battery Sense wires are not used, the controller must use the voltage reading at the battery power terminals for regulation. This voltage may differ from the actual battery bank voltage due to voltage drop.

Battery Voltage Sense is a high impedance connection that enables the GenStar MPPT to measure the battery terminal voltage precisely with small gauge wires that have no voltage drop. When connected directly to the battery, the sense wires will improve battery charging accuracy. Battery voltage sense wires are recommended, but may not be necessary when using larger battery cables and/or shorter battery wire lengths.

Generally accepted wiring practice is to limit voltage drops between the charger and the battery to 2%. Even properly sized wiring with 2% drop can result in a 0.3 volt drop for 14.4V charging. Voltage drops will cause some undercharging of the battery.

The controller will begin Absorption or limit equalization at a lower battery voltage because the controller measures a higher voltage at the controller's terminals than is the actual battery voltage. For example, when the Absorption Target Voltage is 14.4V, if there is a 0.3 volt drop between the controller and battery, the controller will sense 14.4V at its battery terminals when the battery voltage is only 14.1V. This will make the controller enter Absorption stage too prematurely.

Note that the battery sense wires will not power the controller, and the sense wires will not compensate for losses in the power wires between the controller and the battery. The battery sense wires are used to improve the accuracy of the battery charging.

The two sense wires can range in size from 1.0 to 0.25 mm^2 (16 to 24 AWG), and should be cut to length as required to connect the battery to the voltage sense terminals. The two-position terminal - to the left of the Load (+) terminal (beyond the RTS terminals) (see Figures 3-3 and 3-4) is used for the battery sense connections. A twisted pair cable is recommended but not required. Use UL rated 300 Volt conductors. The voltage sense wires may be pulled through conduit with the power conductors.

After observing correct polarity, connect both battery voltage sense wires to the GenStar MPPT at the two-position Battery Sense terminal, and to battery (+) and (-) terminals. No damage will occur if the polarity is reversed, but the controller cannot read a reversed sense voltage.

Tighten the connector screws to 5 in-lb (0.56 N-m) of torque.

The maximum length allowed for each battery voltage sense wire is 98 ft (30 m).

Connecting the voltage sense wires to the RTS terminal will cause an alarm.

NOTE:

If the battery input voltage is greater than 5 Volts different from the Battery Sense, due to voltage drops or faulty connections, the Battery Sense input will not be recognized by the GenStar MPPT. An alarm will be set until the condition has been corrected.

Although not required to operate the GenStar MPPT controller, a battery voltage sense connection is recommended for best performance.

3.4.2 Remote Temperature Sensor With Ferrite Choke

Refer to Figure 3-3 above.

CAUTION: EQUIPMENT DAMAGE

To enable temperature compensation settings (mV/ °C) which are required for Lead-acid batteries, an RTS must be used. Otherwise, charging will be based on a temperature of 25°C. Use of an RTS is strongly recommended.

An RTS can be added at any time during system installation (refer to Figure 3-3).
All **lead-acid** battery charging settings are based on 25°C (77°F). The GenStar MPPT default Lead- acid battery temperature compensation presets are -30mV/ °C @ 12V. This means that if the battery temperature varies by just 5°C, the charging target regulation voltage should change by 0.15 Volts for a 12 Volt battery. This is a substantial change in battery charging, so it is important to always use the included Remote Temperature Sensor (RTS) with lead-acid batteries.

Lithium batteries do not require temperature compensation. Therefore, temperature compensation is disabled for all of the GenStar MPPT lithium battery presets. However, if the lithium battery temperature drops below freezing or becomes very hot during charging, it can cause irreversible harm to the battery. Therefore, where the battery temperature can get excessively low or high, it is important to use the low or high temperature foldback settings together with an RTS. During these conditions, the foldbacks will allow charging to taper off or become disabled. All of the GenStar lithium battery presets include low temperature foldback settings. See Configuration Section 4.2.5 for details on foldback settings.

CAUTION:

The RTS must be used to enable low and high temp foldback settings which are often used with lithium batteries.

WARNING: Equipment Damage

Never place the temperature sensor inside a battery cell. Both the RTS and the battery will be damaged.

NOTE:

The RTS cable may be shortened if the full length is not needed. if a length of cable is removed, be sure to re-install the ferrite choke on the RTS cable as close as possible to the controller. This choke ensures compliance with electromagnetic emissions standards.

INSTALLATION

Connect the RTS to the two-position terminal located immediately to the left of the Load (+) terminal (see Figures 3-3 and 3-4).

The RTS is supplied with 33 ft (10 m) of 22 AWG (0.34 mm2) cable. There is no polarity, so either wire (+ or -) can be connected to either screw terminal. The RTS cable may be pulled through conduit along with the power wires. Tighten the connector screws to 5 in-lb (0.56 N-m) of torque. Separate installation instructions are provided inside the RTS bag.

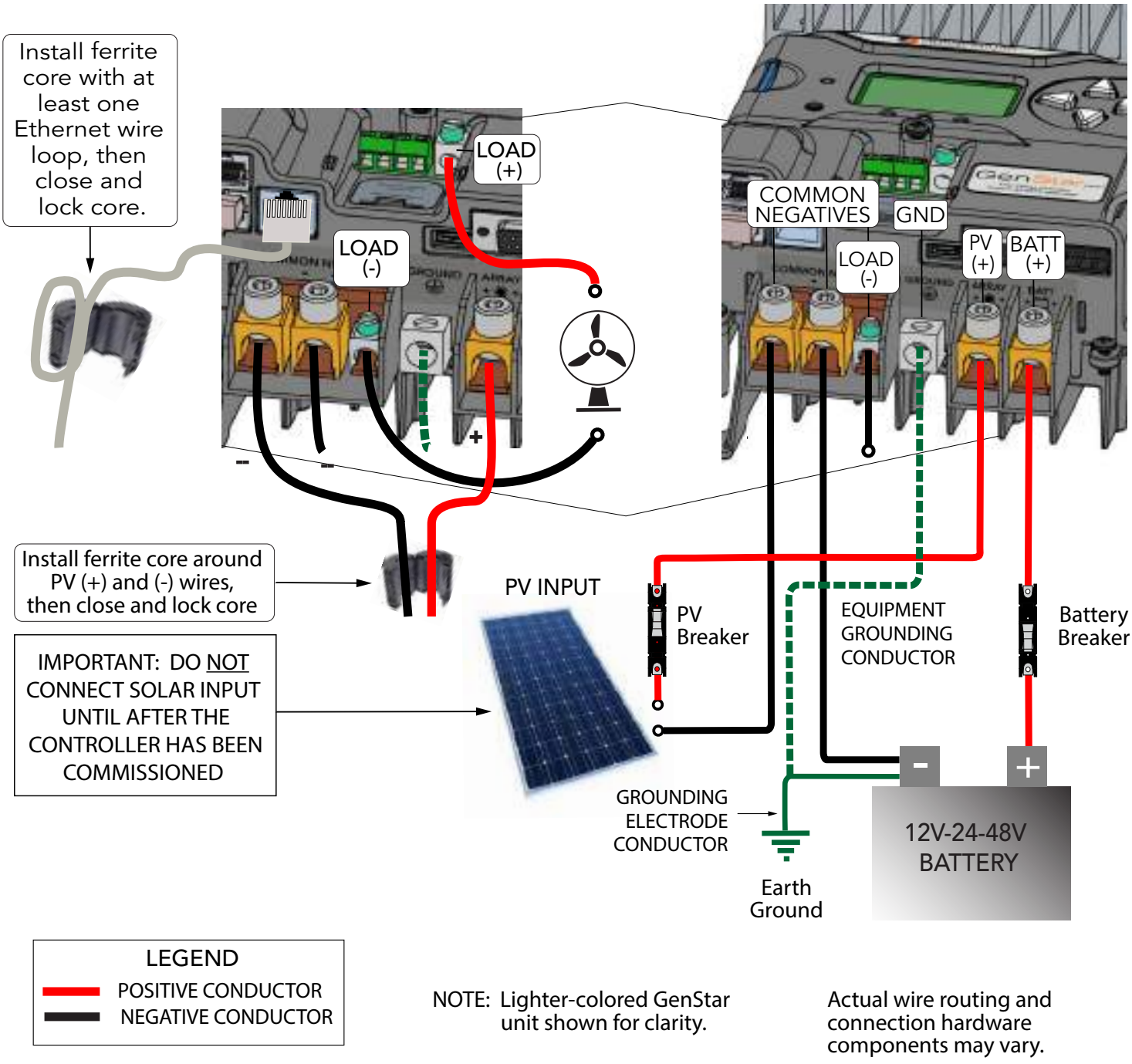


Figure 3-4. GenStar MPPT Power Wiring

3.4.3 Grounding and Ground Fault Interruption

Refer to Figure 3-4 above.

For safety and effective lightning protection, it is recommended and may be required by code, that the negative conductor of the charging system be properly grounded (refer to Figure 3-4). Do not connect the negative system wire to the case grounding terminal. The GenStar MPPT does not have internal ground fault protection; but where the NEC requires the use of a ground fault protection device (GFPD), ***the system electrical negative must be bonded through a GFPD to earth ground at only one point.***

SYSTEM GROUNDING

The DC system should be bonded to ground with a connection to the primary battery circuit. It can be bonded to ground directly or through an AC service panel if there is an inverter installed in the system. For the DC system grounding electrode conductor (GEC) sizing requirements, refer to NEC Section 250.166, or applicable local regulations or code.

WARNING: Shock Hazard
This unit is not provided with a GFDI device. This charge controller must be used with an external GFDI device as required by the Article 690 of the National Electrical Code for the installation location.

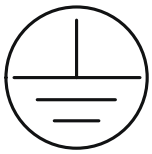
WARNING: Shock Hazard
When a ground fault is indicated, battery terminals and connected circuits might be ungrounded and hazardous..

WARNING: Risk Of Electrical Shock.
NO POWER OR ACCESSORY TERMINALS ARE ELECTRICALLY ISOLATED FROM DC INPUT, AND MAY BE ENERGIZED WITH HAZARDOUS SOLAR VOLTAGE. UNDER CERTAIN FAULT CONDITIONS, BATTERY COULD BECOME OVER-CHARGED. TEST BETWEEN ALL TERMINALS AND GROUND BEFORE TOUCHING.

NOTE:
Follow local electrical installation code and use green/yellow, green or transparent insulated grounding-earthing wire.

EQUIPMENT GROUNDING

Use copper wire to connect the grounding terminal in the case, and other dead metal, to earth ground. The grounding terminal is identified by the ground symbol on the case, just above the terminal, as shown below:



Ground Symbol

Recommended minimum sizes for equipment copper grounding wire:

- GenStar MPPT-60 8 AWG (8.37 mm2)
- GenStar MPPT-80 6 AWG (13.3 mm2)
- GenStar MPPT-100 4 AWG (21.1 mm2)

Torque the GenStar equipment ground terminal to 50 in-lb / 5.65 N-m maximum using a 1/4" (6.5 mm) flathead screwdriver.

3.4.4 BATTERY CONNECTIONS

Refer to Figure 3-4 above.

1. Before wiring, verify that all system breakers and disconnect switches are in the OPEN/DISCONNECTED position, and that all fuses are removed from their holders.

WARNING: SHOCK HAZARD - LIVE EQUIPMENT GROUND CONNECTION
Keep the battery (-) cable and GEC disconnected from the battery bank (-) post while installing the system or while system wires are exposed.

CAUTION: EQUIPMENT DAMAGE

Locate battery breakers or fused disconnects for easy access and free from hydrogen gas/sulfuric acid fumes.

2. Connect the battery bank and Genstar battery with a positive wire.
   A. Fit a positive wire between the battery bank (+) post or busbar and the GenStar battery (+) terminal.

   B. Using a short wire on the battery side, install a correctly sized in-line breaker or fused disconnect switch in the OPEN position as close to the battery (+) post or busbar as possible.

   C. Connect the long wire from (A) to the vacant breaker terminal from (B), and then the other end to the GenStar battery (+) terminal.

   D. Where GenStar battery terminals are more than five (5) feet from the battery, or where circuits from these terminals pass through a wall or partition, U.S. NEC requires that overcurrent protection be provided at the solar controller in addition to providing overcurrent protection at the DC battery power source.

   E. Torque the GenStar battery terminals to 100 in-lbs (11.3 Nm) maximum using a 5/32” Hex wrench.

3. Prepare the negative wire for connection.
   A. Fit a negative wire between the battery (-) post and GenStar MPPT battery (-) terminal.

   B. Connect the controller end to the GenStar battery (-) terminal. ***DO NOT CONNECT THE BATTERY END OF THE NEGATIVE WIRE AT THIS TIME.***

3.4.5 SOLAR CONNECTIONS

Refer to Figure 3-4 above.

WARNING: SHOCK HAZARD - LIVE EQUIPMENT GROUND CONNECTION

Keep the PV array (-) wiring disconnected during installation, and when system wires are exposed.

1. Wire the PV array according to NEC Section 690 or applicable local regulations or code. Use caution, since the solar array will produce current whenever it is in sunlight (refer to Figure 3-4 above).
2. According to the combiner installation instructions, wire the PV array string (+) wire(s) to a solar combiner box that includes fuse holders or breakers. **DO NOT INSTALL COMBINER FUSES OR CLOSE COMBINER BREAKERS AT THIS TIME.**
3. Fit and connect a positive wire between the GenStar PV input (+) terminal and the OPEN/DISCONNECTED combiner PV (+) disconnect switch or breaker. **DO NOT CLOSE THE DISCONNECT AT THIS TIME.**
4. Fit and connect a negative wire between the GenStar PV (-) input terminal and the PV (-) busbar or combiner terminal. **DO NOT CONNECT THE ARRAY STRING (-) WIRE(S) TO THE COMBINER BOX AT THIS TIME.** This can be achieved by not connecting the PV (-) MC-4 connectors or the PV (-) wire(s) to the transistion box, combiner box or the PV (-) disconnect.
5. Torque the GenStar PV terminals to the 100 in-lbs (11.3 Nm) maximun using a 5/32" Hex wrench

3.4.6 LOAD CONNECTIONS

refer to Figure 3-4 in section 3.4.2.

CAUTION: Equipment Damage

Do not wire any AC inverter to the load terminals of the GenStar-MPPT. Damage to the load control circuit may result. An inverter should be wired directly to the battery. If there is a possibility that any other load will sometimes exceed the GenStar's maximum load current rating, the device should be wired directly to the battery or battery bank. If load control is required, contact Morningstar Technical Support for assistance.

CAUTION: Equpiment Damage

Do not wire multiple GenStar MPPT load outputs together in parallel to power DC loads with a current draw greater than 30 Amps. Equal current sharing cannot be assured and an over-load condition will likely occur with one or more controllers.

CAUTION: Equpiment Damage

Exercise caution when connecting loads with specific polarity before energizing a load circuit. A reverse polarity connection may damage the load. Always double check load connections before applying power.

1. OPEN any load disconnects or breakers, and turn OFF any loads.
2. Connect positive and negative wires to the load, and to any load busbars or load panel terminals.
3. Install a correctly sized load/output breaker or fused disconnect switch in the OPEN position located near the load output terminals of the controller.
4. Connect the positive and negative load wires (either directly, or from a junction) to the GenStar load terminals.
5. *Torque the GenStar load terminals to 35 in-lb / 3.9 N-m maximum using a 3/16" (5 mm) flathead screwdriver.*

Do not close any load disconnects or breakers at this time.

3.4.7 READYBLOCK INSTALLATION

For complete documentation, refer to each ReadyBlock's installation and operation instructions.

Warning: Shock Hazard

Do not install or remove a ReadyRelay while the GenStar is powered ON. Always disconnect the battery, PV array and other power sources in the system before working on ReadyRelay wiring.

See Section 2.6 for a brief description of Morningstar ReadyBlock BOS Accessories. To access the ReadyRail and install a ReadyBlock, remove the ReadyBlock cover by loosening the screw at the top of the cover (See Figure 2-1. GenStar MPPT Exterior Features in Section 2.3).

The ReadyBlock Installation diagram, Figure 3-5, shows how to secure the ReadyBlock to the GenStar ReadyRail and then slide it to the left to join the connection pins to the female communications socket of the GenStar.

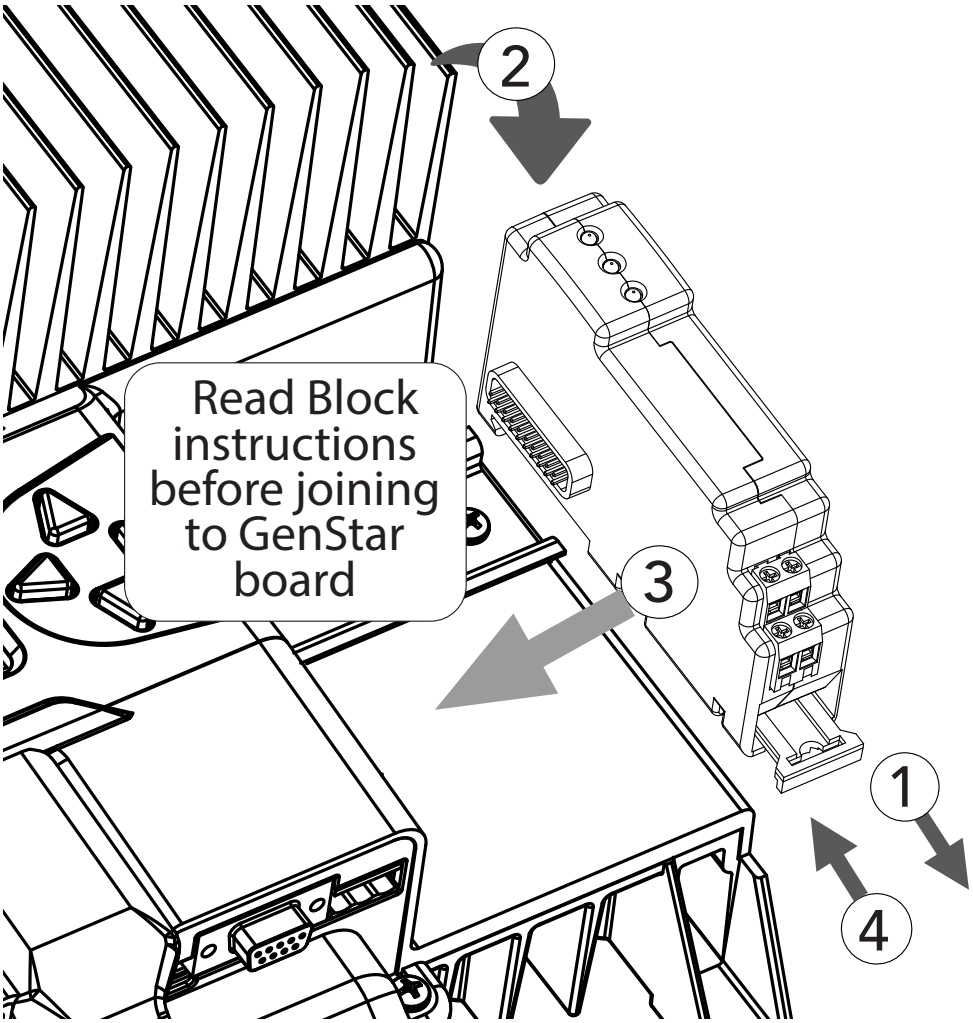


Figure 3-5. Ready Block Installation - **refer to separate Block documentation for complete instructions**

The GenStar can accommodate up to three (3) ReadyBlocks. Install additional ReadyBlocks in the same manner as the first ReadyBlock. Refer to the ReadyBlock manuals for wiring and communication cable installation instructions.

Use a knife to cut out the ReadyBlock Tabs for each corresponding block(s) being installed before replacing the ReadyBlock cover.

BMS BLOCK NOTES:

Only one BMS Block is supported per system. If multiple BMS blocks are present, a system alarm will trigger and a status message will indicate which of the BMS blocks is active for collecting data from a BMS-battery

Additonal Notes:

- When using a BMS block, only a single battery (or a bank of parallel batteries) is supported in a network of host controllers.
- When using a BMS block, only a single manufacturer of batteries is supported. If the battery-bank is changed to a new manufacturer, the user only needs to change the battery configuration type for the BMS block.
- When using a BMS block, only a single battery model is supported. If a network of parallel batteries is employed, to work properly with the BMS block, all of the batteries must be of the same model.

3.4.8 Final Connections

WARNING: EQUIPMENT DAMAGE

Connecting the battery cables with reverse polarity will permanently damage the GenStar.

WARNING: EQUIPMENT DAMAGE

Connecting the solar array to the battery terminal will permanently damage the GenStar.

1. Confirm that the battery wire polarity is correct, and that the fused battery disconnect switch or breaker are in the OPEN position. Connect the system battery (-) cable to the GenStar battery (-) terminal. If the system is to be grounded at the battery, make the GEC connection at the battery (-) post also.
2. Confirm that the PV array wire polarity is correct, and that the fused PV disconnect switch or breaker is in the OPEN position. Connect the PV array (-) negative wire(s) to negative combiner box connection or PV(-) disconnect.
3. With all disconnects and system breakers OPEN/OFF, insert properly sized battery, PV and load fuses - where applicable - into the fuse holders.
4. Verify the correct battery and solar wiring voltage

   A. To verify correct battery wiring voltage and polarity, test the voltage between the (+) battery side of the battery breaker or fused switch and a GenStar (-) terminal.

   B. To verify correct solar wiring voltage and polarity, test the voltage between the array side of the PV (+) fused switch or breaker, and a GenStar (-) terminal.

3.4.9 Power-Up and Verify System Operation

NOTE:

Carefully observe the LEDs after each connection. The LEDs will indicate proper polarity and good connections

The commissioning menu will appear with the first start-up from the factory or after a factory reset and the GenStar MPPT will not operate until after it is commissioned. See Section 3.5 Commissioning / Initial Configuration for details.

1. Power ON the controller by the battery breaker or fused disconnect switch.
2. Watch and verify that the Charging Status LED lights solid green, and then the three battery state-of-charge (SOC) LEDs blink in sequence (G-Y-R), confirming proper start-up. If they do not light, check the battery polarity (+/–) and battery voltage.
3. Next, the green, yellow or red LED will light depending on the battery state-of-charge (SOC). Confirm that one of these LEDs is on before going to the next step.
4. CLOSE the fused solar disconnect switch or breaker. If the solar input is connected while in sunlight, the charging LED indicator will light.
5. Confirm proper connection by observing the charging LED.
6. CLOSE the fused load disconnect switch or breaker, and turn the load ON to verify a proper connection.

If the load does not turn on, it could be for various reasons:

- the GenStar MPPT is in LVD (red LED on)
- there is a short circuit in the load (LEDs blinking R/G – Y)
- there is an overload condition (LEDs blinking R/Y - G)
- the load is not connected, not working, or turned off

After all connections have been completed, observe the LEDs to make sure the controller is operating normally for system conditions.

3.4.10 To Power-down

WARNING: Equipment Damage

*ONLY disconnect the battery from the GenStar MPPT **AFTER** the solar input has been disconnected. Damage to the controller may result if the battery is removed while the GenStar MPPT is charging.*

1. OPEN the solar disconnect switch or breaker.
2. TEST the voltage between the PV side and other side of the disconnect switch or breaker to ensure that ISOLATION from the solar input has been achieved.
3. If a load is connected, OPEN the load disconnect or breaker.
4. OPEN the battery circuit breaker or disconnect switch to ISOLATE the controller.

3.5 Commissioning / Initial Configuration

Commissioning requires the user to enter and confirm important settings required for basic operation. For all other settings, see Configuration Section 4 for complete details on LiveView and programming. These settings beyond commissioning can be made using LiveView, or the local meter (with some limitations).

Methodology

Commissioning can only be done via the local meter.

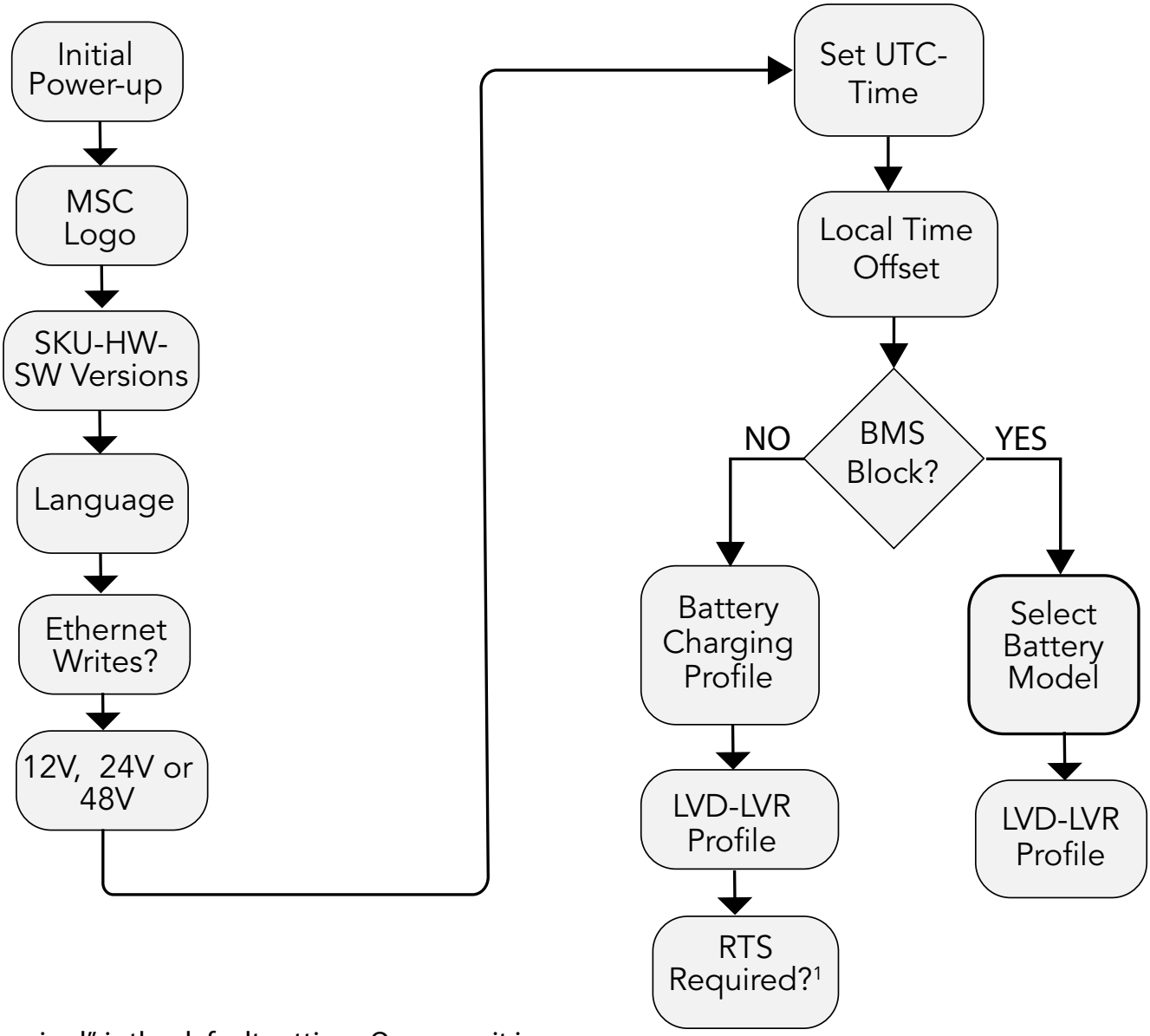
Commissioning Menu

The commissioning menu - see Figure 3-6 below - only appears on first start-up from the factory, and after a, “Factory Reset", of the GenStar MPPT. The directional arrows are used to navigate vertically and horizontally through the meter display map. In the commissioning menu, the right arrow is used to move to a screen to adjust the setting.

Stand-alone Commissioning Settings

The current GenStar operates only as a stand-alone controller, and must be programmed with preset or custom settings. The GenStar cannot currently be programmed to operate in a synchronized mode with other controllers in the system.

The commissioning flowchart in Figure 3-6 illustrates the selectable options required to prepare the GenStar MPPT for operation or further programming.



[1] "RTS Required", is the default setting. Once a unit is commissioned with this default, a subsequent change to, "RTS not required", necessitates that the unit be re-commissioned via a Factory Reset using the local meter - Installer Setup\Commands\Factory Reset. Also see RTS Start-up and Run-time Behavior Tables below.

Figure 3-6 Commisioning Flowchart

RTS START-UP and RUN-TIME Behavior Tables

Start-Up Behavior	RTS Required -YES (Default Setting)	RTS Required - NO (Default must be changed in factory reset-new commisioning)
RTS not connnected at start-up	Fault - no charging	Normal Charging using 25 celcius
RTS connected at start-up	Normal charging using RTS temperatiure	Normal charging using RTS temperature

Table 3-3 GenStar MPPT Start-Up Behavior

Run Time Behavior	RTS REQUIRED - YES (Default Setting)	RTS REQUIRED - NO (Defaults mus be changes in Installer Setup)
RTS disconnected	Fault - no charging	CONTINUED CHARGING at 25 Celcius ref. ALARM ET
RTS reconnected	Clears fault, then normal charging using RTS temperature	Normal charging using RTS temperature

Table 3-4 Genstar MPPT Run-time Behavior

4.0 CONFIGURATION

4.1 Adjusting Settings

All settings - excluding factory reset and controlling Ethernet writes - can be configured using Morningstar LiveView web pages. See the main LiveView web page for locations and screens. The configuration sections describe all settings details in terms of LiveView screens, and many settings are also accessible within the Setup-Installer Setup on-board meter menus shown below in Figure 4-1.

CAUTION:

*To effect changes, always use the **Save Button** in upper right corner of the settings area.*

4.1.1 Using the Meter Display

To adjust LCD display appearance, menu-screen behavior, or language, use the Display and Button menu.

Structure and Navigation

See Figure 4-1

Four lighted triangular directional control keys allow movement to reach any desired point on the meter layout. A lit key indicates a valid direction in the layout. The current location is indicated on the display with a column heading, and a bold descriptor.

The GenStar MPPT's meter map consists of two main axes. Using the horizontal arrows buttons, the user can scroll right to access more settings, or left to return to the previous screen. Pressing the down arrow button will move to the next lower listing. From a main screen, pressing the up arrow will return to the next main screen up. Scrolling down will continue to move through the subsequent main menu listings. Scrolling to the right, and then down, allows the user to advance to new options in branches and sub-branches. Scrolling to the left will return to the previous menu listing.

See the included complete GenStar MPPT Meter Map insert, also available on the Morningstar website GenStar MPPT at: https://www.morningstarcorp.com/wp-content/uploads/meter-map-genstar-mppt-en.pdf

Programmable Soft-key (maps command functions)

The GenStar MPPT features a programmable “Soft-key” push-button that can be programmed to turn on and off loads, start manual equalization, or other commands. The Soft-key button is located at the lower left corner of the meter interface (see Figure 2.2 in Section 2.3). The button can be programmed to control up to two commands - one command with a momentary press, and another with a prolonged (longer than 2 seconds) press. Soft-key commands can be programmed in the Display and Button menu on the Meter Display or the Meter Display Page in LiveView Installer Setup (see Section 4.2.9 Meter Display).

Accessing Installer Setup

From the Setup menu, scroll down to, and select, Installer Password. Use the directional arrows to enter the 3-digit Installer Password (141).

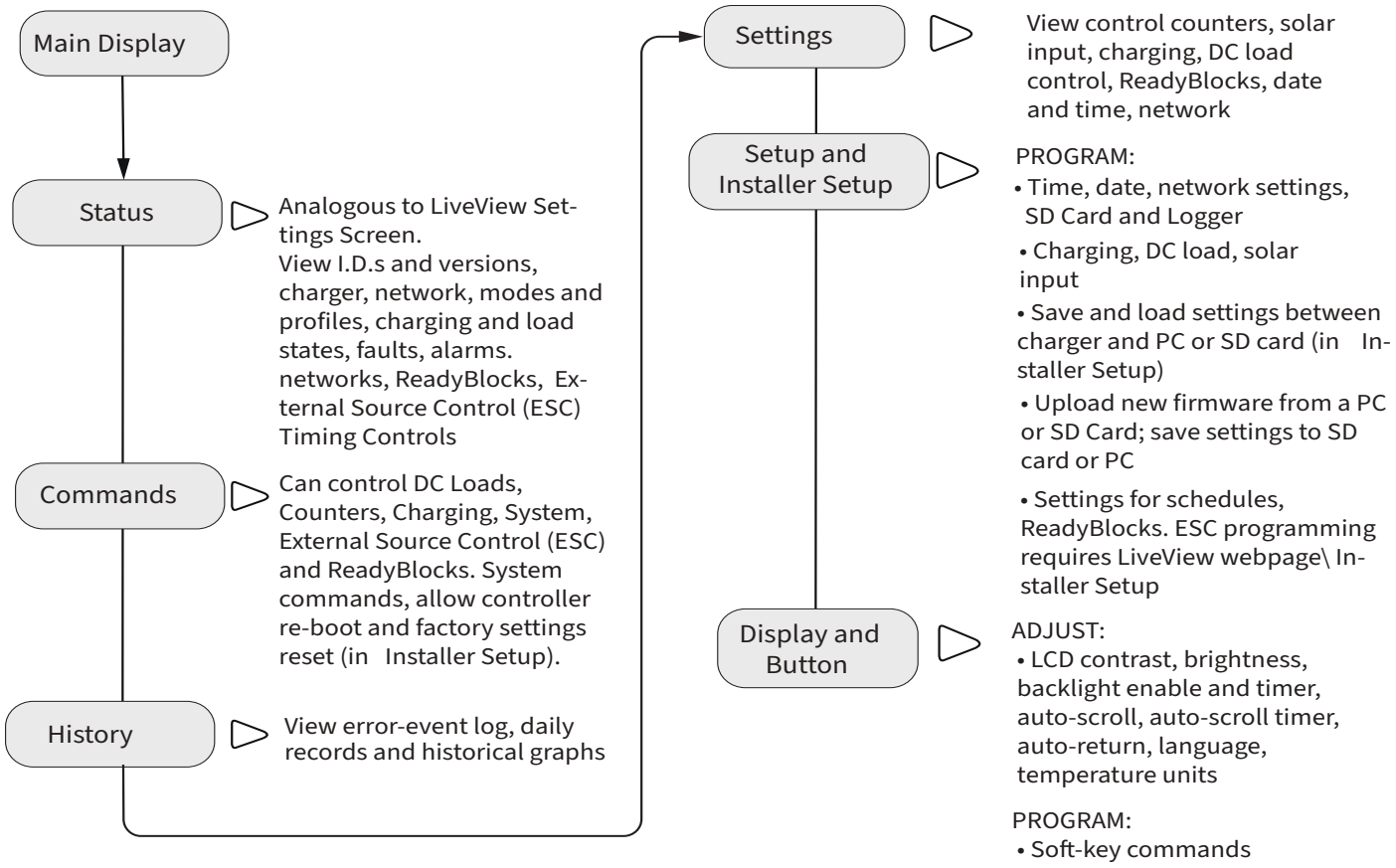


Figure 4-1. Main Local Meter Display Menus

4.1.2 Using Morningstar Mobile

(Mobile App)

Morningstar Mobile is an app available for use with Android or iOS devices, and can be downloaded to a mobile device from either the Google Play Store (Android) or the Apple App Store (IOS).

Android

Apple iOS

Android
https://play.google.com/store/apps/details?id=com.morningstar.android

Apple iOS
https://apps.apple.com/us/app/morningstar-mobile/id1638164491

Bluetooth® must be enabled in the Network\ Modbus setup menu to use Morningstar Mobile. See section 4.2.2.

The user must have access to the GenStar meter display to pair and connect to the mobile app. The app will prompt the user to verify a 6 digit pin on both the app and on the GenStar meter display during pairing.

The application uses Bluetooth LE to communicate with the GenStar, and replicates most of the Morningstar LiveView webpage (see Section 4.1.3 below).

Morningstar Mobile includes much of the functionality seen in the LiveView sections described below.

4.1.3 Using the LiveView UI

LiveView is an interface that serves Morningstar application web pages directly from the GenStar MPPT. The web pages closely coincide with the GenStar MPPT meter layout and functions.

GenStar cannot be commissioned using LiveView. Commissioning requires use of the unit's meter interface. The various LiveView-local meter categories, and their uses, are summarized in Figure 4-1 above.

The GenStar MPPT has an RJ-45 Ethernet port for connection to a LAN/WAN. For temporary LiveView setup, a Cat 5 or 6 Ethernet cable can be connected between a PC/laptop and a GenStar MPPT Ethernet port. If the GenStar MPPT was connected to the LAN during installation, LiveView can be accessed via LAN/wireless connection.

A DHCP-enabled router will automatically assign an IP address and network settings to the GenStar MPPT. After the original assignment, network settings can be changed using LiveView Setup\Network or Installer Setup\Network page, if desired.

Using a Web browser, the GenStar MPPT's LiveView Web pages can be accessed via two methods:

1) Enter the GenStar MPPT's IP address into the Address bar, e.g., http://192.168.1.253. The IP address can be found in the meter display in Settings\Network.

2) Scan the QR code on the serial label with a mobile device or enter the GenStar MPPT's NetBIOS name [product abbreviation + 8-digit serial no.] into the address bar, e.g., http://GSMPPT22070007. The GenStar product abbreviation is GSMPPT.

4.1.4 LiveView Screen

The LiveView Screen shows five real-time cards:

- **Battery Flow Diagram** - showing Charge, Battery and Load summaries
- **Array Details** - showing array voltage, current, MPPT sweep values, and charge moved, charging current and charging power
- **Charge Controller Details** - showing battery charging state, net charging current, voltage and heat-sink temperature
- **ReadyBlocks** - showing up to (3) ReadyBlocks: Shunt ratings, Relay assignments, BMS system details
- **Errors** - showing daily and total set faults and alarms

4.1.5 Settings Screen

The Settings Screen displays all informational and configured system details. The screen is divided into the following areas:

- **IDs and versions**: View firmware and hardware versions, serial number, key, user interface version and UI build date
- **Charger**: View battery/bank size and all charging parameters
- **Network:** View all network names, addresses, IDs and time servers
- **Meter Display**: View all screen settings, languages, units and programmed soft-key functions
- **Modes and Profiles:** View operating mode, ESC mode, battery profile, LVD-LVR profile
- **DC Load:** View all low voltage disconnect (LVD) and reconnect thresholds, LVD and SOC disconnect timers, SOC disconnect and reconnect percentages, load current compensation value
- **Solar Inputs:** MPPT, fixed voltage, or percentage of Voc
- **ReadyBlocks:** Check type of block in each of three positions - an indication of, "Empty", is shown if no blocks are installed in a position.
- **External Source Timing Controls:** View settings for Primary Generator Warm-up Time, Primary Generator Cool-down Time, Primary Generator Max. Run-time, Primary Generator Min. Run-time

4.2 Setup and Installer Setup

Setup menus are available in both Setup and Installer Setup. Setup allows only limited system settings, schedule programming, and other non-critical adjustments. Setup can be used by non-installers and operators.

Installer Setup offers four additional category menus of higher level programming. See Sections 4.2.4 Load Control, 4.2.5 Charger, 4.2.7 Ready-Blocks and 4.2.8 External Source Control/ESC for full details.

NOTE:
MODBUS writes over Ethernet must be enabled to change any settings in LiveView. For security purposes, the, "MODBUS writes over Ethernet", enable/disable setting can only be modified on the local meter display.

Several Installer settings are originally chosen during commissioning, but changes to the installer settings can only be made in the Installer Setup menus after the Installer Password 141 has been entered. Installer settings also include the six (6) basic setup topics described below.

4.2.1 Date and Time (Setup and Installer Setup)
4.2.2 Network Settings (Setup and Installer Setup)
4.2.3 SD Card and Logger (Setup and Installer Setup)
4.2.4 Load Control (Installer Setup)
4.2.5 Charger (Installer Setup)
4.2.6 Schedules (Setup and Installer Setup)
4.2.7 ReadyBlocks (Installer Setup)
4.2.8 External Source Control/ESC (Installer Setup)
4.2.9 Meter Display (Setup and Installer Setup)
4.2.10 Save and Load (Setup and Installer Setup)

Once all settings adjustments have been made for a given setup menu it must be saved before navigating to another setup menu or a different view. If any settings changes have been made in a setup menu without being saved, an “Abandon Changes” prompt will appear. Select Okay to save the new settings or select Cancel to abandon changes to leave the setup menu without saving.

NOTE: EEPROM SETTINGS EDIT FAULT

When saving new settings, an EEPROM Settings Edit Fault may occur. Not all settings will cause this fault. After all settings have been modified, the EEPROM Settings Edit Fault can be cleared with a Reboot Control Command (See 5.6 Alarms and Faults and 5.8.4 System Commands).

4.2.1 Date and Time

(Setup and Installer Setup)

UTC (Universal Time Coordinated) is set at the factory. If the coin cell remains in place, UTC may not need adjustment. Conduct a web search for, "current UTC time", to confirm time is set correctly. Set the Date and Time in Installer Setup\Date and Time. The internal precision clock is used for log data time-stamping, ESC control, schedules, and other time-based functions. There are two options for keeping accurate time:

1. Internal clock uses the GenStar MPPT's built-in real-time clock. The coin cell battery allows *Time* and *Date* to be retained through power cycles. If using the internal clock, UTC time and date are entered, and an offset for local time zone is entered. Note that the local offset must be adjusted when a time zone changes to DST, and back.
2. Time server - if the GenStar MPPT is connected to the Internet, it has the ability to periodically update time and date from a time server(s). Go to Installer Setup\Network to specify up to three (3) time server addresses.

4.2.2 Network Settings

(Setup and Installer Setup)

If the GenStar MPPT is connected to a DHCP router, and the DHCP option is selected, network settings will automatically be assigned. If authorized, MODBUS Ethernet will show, “ENABLED”.

Network Settings displays the current network settings configuration.

NOTE:

To change network settings remotely, first set the unit's on-board meter (Installer Setup) to allow remote writes over Ethernet. ***For security reasons, the, "MODBUS writes over Ethernet" enable/disable setting can only be modified on the local meter display. This a safety feature to prevent unintended changes to custom settings, but it is not a replacement for proper network security. This feature does not block write commands on an EIA-485 network. Never connect units to an open or unprotected network.***

Use the menus to configure.

MODBUS Settings

MODBUS and MODBUS TCP/IP are open standard protocols for communication between connected devices on serial and Ethernet networks respectively. The GenStar MPPT supports Modbus communication via serial (EIA-485/RS-232/USB ports) and Ethernet.

MODBUS ID and MODBUS IP Port - assign IDs as desired

All devices on a serial MODBUS network must have a unique MODBUS ID. All devices on an Ethernet MODBUS network must have a unique ID and common MODBUS IP port configuration.

Bridge Ethernet MODBUS TCP/IP requests with MODBUS Serial Messages

An Ethernet MODBUS TCP/IP message with a MODBUS ID that differs from the GenStar MPPT MODBUS ID will be, "bridged", and sent out as a serial MODBUS message on the GenStar MPPT's EIA-485, RS-232, and USB serial ports (see Figure 2.3 in Section 2.4). A response from a connected device on any of those serial networks will be packaged by the GenStar MPPT and sent as a MODBUS TCP/IP response back to the Ethernet network.

Wireless

Enable Wireless to turn on the Bluetooth® signal and use the Morningstar Mobile app.

TCP/IPv4

Adjust Ethernet connection parameters.

Time Servers

(Installer Setup)

If the GenStar MPPT is connected to the Internet, it has the ability to periodically synchronize time and date from a time server. There are three default, public NTP servers, which users can modify as necessary.

SNMP

(Installer Setup only)

Edit SNMP Read Community (default: public) and SNMP Write Community Strings (default: private) [see section 6.6 for more information about SNMP].

4.2.3 SD Card and Logger

(Setup and Installer Setup)

The GenStar MPPT includes an **SD Card** for auxiliary data storage. The SD Card screen will display the SD Card Status and Total Storage. Choose one of the four options for data management: Format SD Card; Delete Log Data; Delete Settings File; or Delete Firmware File. The SD Card menu offers the following information and functions:

SUMMARY

Status:
The SD card is detected-not detected

Total Storage:
Total addressable storage of the SD Card

ACTIONS

Format SD Card:
Format the SD Card (FAT32). WARNING: erases all contents on the card and creates system directories

Delete Event Log Data:
Delete event log data files from the /EVENTLOG directory only

Delete Daily Log Data:
Delete Daily Log Data files from the /DAILYLOG directory only

Delete Settings File:
Delete configuration setting files saved in the /SETTINGS directory

Delete Firmware File:
Delete firmware update file(s) in /FIRMWARE directory

LOGGED DATA STORAGE

Use the Setup or Installer Setup Logged Data Storage drop-down to enable internal logging, or internal and SD Card logging.

There are three different loggers. The daily and hourly Loggers total and record important data once a day and hourly, respectively. The Event Logger records high-speed operational, network, and system-level information.

Choose to log data to the GenStar MPPT internal memory only or also allow log data storage on an SD Card. If the SD card is removed, the GenStar MPPT will continue logging to internal memory only. By selecting, "Internal and SD Card", and using an SD Card, the maximum amount of logged data will be substantially increased.

4.2.4 Load Control

(Installer Setup/Load)

The GenStar MPPT controller provides Load Control settings for the built in load controller. Selecting the Standard Button provides seven (7) different preset LVD/LVR load profiles (4 for lead acid batteries and 3 for Lithium batteries). See Table 5-4. GenStar MPPT Preset LVD-LVR (Load Control) Profiles in Section 5.3.

If a Standard preset LVD/LVR load profile is selected, the Copy to Custom button can be selected to start a custom profile using the selected preset values. When the Custom button is selected, the user has full flexibility to enter any desired load control values.

Custom settings can also provide State-of-charge (SOC) Load control settings options. These Low SOC Disconnect/Reconnect (LSOCD-LSOCR) settings will disconnect and reconnect the load based on battery SOC% (if available) for load control. The LSOC settings will only be enabled if SOC% is available from a ReadyShunt or a ReadyBMS.

- Ready Shunt must be configured as a Net Branch Type Shunt (see section 4.2.7 ReadyBlocks)
- ReadyBMS must be selected during commissioning with a supported battery (see section 3.5 Commissioning / Initial Configuration)

The following four (4) custom load control options are available to the right of the Custom button in LiveView:

1) Voltage Only - Enables LVD-LVR load control settings

2) State-of-charge (SOC) ONLY - Enables LSOCD-LSOCR load control settings

3) State-of-charge (SOC) and Voltage - Enables both LVD-LVR and LSOCD-LSOCR load control settings

4) Always On - load terminal voltage is never interrupted-disabled

After setting State-of-charge (SOC) and Voltage, when either the battery voltage drops below LVD or SOC is below LSOCD, the disconnect process (including LVD/LSOCD warning) will begin. After an LVD or LSOCD has disconnected the load, the load will not be reconnected again until both the battery voltage is above LVR and SOC is above LSOCR.

Load Current Compensation settings are available with the LVD-LVR settings only. LVD/LSOCD Warning Time settings are applied to both the LVD-LVR and LSOCD-LSOCR settings and will provide a notification before disconnecting the load. Load High Voltage Disconnect and Reconnect (HVD-HVR) settings can be used to protect voltage sensitive loads. See Section 5.3 for more information about Load Current Compensation, LVD/LSoCD Warning Time and HVD-HVR settings.

Caution:
Due to the possiblity of SOC inaccuracies, SOC ONLY settings may be risky. It is recommended to use SOC and Voltage settings so there is a backup LVD setting to ensure that the battery is not overdischarged.

4.2.5 Charger

(Installer Setup)

Also refer to LiveView or meter map for all custom settings options.

Solar Input Mode

MPPT (default)
Allow the controller to use its TrakStar Maximum Power Point Tracking algorithm to determine the optimal solar array voltage operating point.

Fixed Vmp
Disables the MPPT algorithm and uses the specified value as a static source voltage operating point.

Voltage to %VOC
Disables the MPPT algorithm and instead uses a percentage of measured input source open-circuit voltage as the static voltage operating point. Open-circuit voltage (Voc) of the input source is measured by the controller periodically.

Battery Bank Definitions:

- **Battery size in Amp-hours**. Battery bank Ah capacity is always required when using the ReadyShunt with a Net shunt or BMS Block to measure the battery SOC and vital for system informational purposes.
- **Battery SOC Efficiency** is a required setting when using the ReadyShunt with a Net shunt to measure the battery bank SOC. Efficiency settings are set for one-way efficiency. Lead Acid (94%) and Lithium (99%) presets or custom settings are available.

- **Battery Current Limit**, If enabled, the control will limit its net charge current into the battery (GenStar net current or Net Shunt battery current if present) to the given limit. If disabled, the control will contribute up to its maximum rated current.
- **Battery Current Limit Requires Shunt**. Requires a ReadyShunt with Net shunt to measure battery current. Used to limit battery current when there are external charging sources.
- **Closed-loop BMS**. Enabled when commissioned with a BMS Block for closed-loop battery management
- **RTS Required**. Enabled or disabled during commissioning to require an RTS for temperature compensation to operate.

NOTE:

If Battery Current Limit Requires Shunt or RTS Required is disabled, it does not disable current limiting based on a Net Shunt or temperature compensation with an RTS. It just won't cause a fault if not present.

Battery Charge Settings

WARNING: EQUIPMENT DAMAGE

Improper battery charge settings can severely damage batteries. Take great care when applying any charging settings.

See Section 5.2 for descriptions of many charging settings, and, "Installer Setup", below, for additional variable descriptions.

Define the charging parameters for the battery. Choose a standard charging preset from a range of batteries, OR enter a custom profile if needed.

Copy to Custom

Copies the values in the Standard Profile column to the Custom Profile column. Use this feature to start with a standard charging profile that is close to the desired configuration, copy to custom, and then edit the values for a specific charging application.

Preset options are described in Section 5.2.2. Refer to the battery manufacturer's documentation for guidance.

For more standard settings information, and further custom settings adjustment, expand the Installer Setup bar at the bottom of the section.

Battery State-of-Charge (SOC) LED Transitions

(also see SOC measurements in Section 4.2.7)

The battery SOC LED transitions will be based on the selected criterion - an estimation based on battery voltage or SOC percentage in the case of ReadyBMS or ReadyShunt applications.

Enter the battery SOC LED transition voltages or SOC percentages that correspond with the desired

LED color or color combination for that voltage or SOC percentage. When there is no SOC percentage value available from a ReadyBMS or a ReadyShunt, the LEDs will display an estimated state-of-charge (SOC) based on the battery voltage.

INSTALLER SETUP SETTINGS

Maximum Regulation Voltage
Sets the absolute maximum battery voltage limit. The charger will not charge above this value regardless of charge stage target voltage or temperature compensation effects. Note that the default Max Regulation Voltage setting is disabled for all presets.

Maximum Equalization Current Limit
Sets an absolute limit on the amount of Equalization Stage charging current.

Battery High Voltage Disconnect-Reconnect (HVD-HVR)
Set voltages at which charging current ceases (HVD) and then resumes (HVR)

Temperature Compensation Coefficient (mV/°C)
Set to adjust the charging set-point to optimize charging for different battery temperatures

Minimum Temperature Compensation Limit
Set the lowest temperature at which temperature compensation will occur. Temperature compensation will not occur below this temperature.

Maximum Temperature Compensation Limit
Set the highest temperature at which temperature compensation will occur. Temperature compensation will not occur above this temperature.

Low-Temperature Current Foldback (0%, 100%) - low and high temperature settings
Protects lithium batteries from being charged in cold conditions by defining the bounds of charge current reduction due to low battery temperatures. Configuration can be done in either LiveView or the meter display interface, using the Installer Setup Password 141.

The low temperature-0% limit defines the temperature at which the controller will stop providing battery charging current. The high temperature-100% limit defines the lowest temperature at which the controller will deliver 100% of the controller's rated output charging current. Charging current is tapered linearly from 100-0% between high and low temperature settings

High-Temperature Current Foldback (100%, 0%) - low and high temperature settings
Defines the bounds of charge current reduction due to high battery temperatures. Using the Installer Setup password, configuration can be done in either LiveView or the meter display interface using the Installer Setup Password 141.

The high temperature-0% limit defines the temperature at which the controller will stop providing battery charging current. The low temperature-100% limit defines the highest temperature at which the controller will deliver 100% of the controller's rated output charging current. Charging current is tapered linearly from 100-0% between low and high temperature settings

Absorption End - Amps
Set a net current threshold below which the controller will transition from the Absorption to the Float Stage - see Absorption End Amps Time below.

Absorption End - Amps, Time
Set the time required below Absorption End Amps threshold for the controller to transition from the Absorption to the Float Stage.

4.2.6 Schedules

(Setup and Installer Setup)

Use the Schedules Page to define schedules for ReadyRelay functions. The following ReadyRelay functions can be scheduled and require one of the following relay assignments in ReadyBlock configuration (see Section 4.2.7).

- External Source Control (ESC)
- Command/Schedule

For Relay-ESC scheduling, the Schedules Page Menu sets only the Relay-ESC timing for when each of the Custom ESC Start-Stop conditions take effect (see Section 4.2.8). ESC schedules can be set in the ESC Custom Settings menus or in the Schedules menu. Command/Schedule relays can be scheduled in the Schedules menu only.

4.2.7 ReadyBlocks™ and ReadyShunt SOC Measurements

(Installer Setup)

ReadyBlock Configuration

Installed blocks will populate the ReadyBlock Configuration Box in the LiveView webpage. The ReadyShunt can also be configured in the local display meter. The location of each block is indicated by positions 1-3, relay A or B for each Relay Block, and shunt A or B for each Shunt Block. Position 1 is the left-most block. Relay A is on the left, and relay B is on the right. Shunt A uses the upper-tier terminals, and Shunt B uses the lower-tier terminals. Choose a block to configure. See ReadyRelay, ReadyShunt and ReadyBMS instructions below.

ReadyRelay (RB-Relay)

The ReadyRelay is an expansion block that adds AC and DC-rated relay dry contact hardware functionality and firmware control and logic to the Morningstar GenStar MPPT charge controller. The ReadyRelay can be used to provide additional load control, external charging source control and other signaling functionality.

Relay Function

Choose how a relay will function: Threshold; Faults and Alarms; Charge Stage; External Source Control (ESC) Start-Stop; Command/Schedule. Each of the two Relay Block relays can be configured for a unique function:

1. **Threshold - no scheduling.** Choose whether the threshold will be reached from a rising (lower) or a falling (higher) value, relative to the threshold; choose a variable, and then enter the desired ON and OFF thresholds, along with desired delays. Activate ReadyRelays using Command buttons (after configuration in LiveView Installer Setup\ ReadyBlock\Relay assignment).
2. **Faults/Alarms - no scheduling.** Programming will activate a relay to control optional devices based on

specifically occurring fault conditions:

A. When charging has stopped due to a fault

B. When charging has stopped due to high battery voltage

C. When Load has disconnected due to a fault

D. When the load has been disconnected due to high battery voltage

E. An over-temperature alarm has occurred

F. Charging current is being limited

3. **Charging Stage - no scheduling.** Toggles the relay for use with optional devices when the selected charge period - Bulk, Absorption, Float, Equalization, Night - is active. Optionally, relay start and exit delays can be set.
4. **External Source Control (ESC) Start-Stop.** A) Assign a relay to, “ESC Start-Stop” signal. B) Save and proceed to LiveView\Installer Setup\ESC setup and program accordingly for Manual or Custom. Manual provides ON-OFF Commands only. Custom provides conditional automated start-stop with schedule control options. See Section 4.2.8 External Source Control (ESC). Also see Section, "5.8.5 - ESC Commands".

NOTE:

To enable the use of the Manual or Automatic Source Control Profiles, an External Source Control (ESC) control signal must be assigned to a relay (block) — see Section 4.2.8 on ESC.

5. **Command/Schedule.** Provides ON-OFF Scheduling with manual ON-OFF Commands. Only relays that have been configured for "Command/Schedule" function can be controlled by, “ ReadyBlock”, Relay Commands.

NOTE:

Proper generator/auxiliary equipment relay wiring is required - see ReadyRelay manual for terminal connections diagram.

ReadyShunt (RB-Shunt)

The ReadyShunt is an expansion block designed measure and display net current flow into the battery, or to measure and display source or load auxiliary current.

Battery state-of-charge (SOC) reporting

Viewable in the, "LiveView", tab of the LiveView program, under "Battery Summary"

A ReadyShunt block and external shunt(s) can be used to monitor SOC for reporting, and can enable SOC based load control (see Section 4.2.4 - Load Control - above). When a ReadyBMS is configured during commissioning, it governs all aspects of charging and state-of-charge (SOC) reporting - even with a ReadyShunt installed. Without a ReadyBMS, an installed NET shunt at the battery and a ReadyShunt Block assignment in Installer Setup can enable an SOC sub-system with specific operating parameters - see "Shunt Block Net Shunt Configuration" below for details.

For ReadyShunt installation procedures, refer to the ReadyShunt manual at:

morningstarcorp.com\support library.

For Shunt Block Configuration for SOC see ReadyShunt manual p. 16, Figure 5-3 for wiring diagram.

After a ReadyShunt is installed:

1. Always make sure to update the Firmware to the latest version available (see Section 5.10 Firmware Updates)
2. Access the GenStar unit by opening a LiveView web page - see Section 4.1.3.
3. Go to Installer Setup\ ReadyBlocks, and choose the desired Shunt Block.
4. Enter "SOC" for the name
5. Enter the external shunt full-scale Millivolt and Amp ratings.
6. Assign the branch type as "NET". Note that a branch type change will cause a fault, and a system re-boot is required.

DEFINITIONS

NOTE:

Currently, voltage and current setpoints, and full SOC duration time are only configurable via Modbus register value assignment. After any changes to SOC-related value assignments, the controller must be re-booted.

Battery Current

The net battery charging current; the charging current that is measured by the NET battery shunt.

Current Setpoint

The assigned current value that indicates 100% SOC. If an Absorption End-Amps setting is made in Battery Charging Setup, it must be less than or equal to the Current Setpoint - otherwise, full SOC will not be reported.

- **CALCULATION:** A default of 2% of battery capacity (A-h) equals the current setpoint in Amps. Also see Condition #2 below. ***Battery capacity is entered in Installer Setup\Charger\Battery Info.***

Voltage Setpoint

The calculated voltage, based on programmed Absorption voltage, that when exceeded by actual battery voltage, is an indicator of 100% SOC - see Condition #1 below.

Full SOC Determination

The battery SOC will be reported at 100% when the two conditions below are true, and after a default cumulative duration of five minutes is reached.

- Condition 1: (based on calculated SOC Voltage Setpoint): Battery voltage is greater than or equal to the Voltage Setpoint
- Condition 2: (based on calculated SOC Current Setpoint): Battery current is less than or equal to the Current Setpoint

Partial SOC Determination

Once full charge has been verified, the GenStar algorithm can then calculate a subsequent existing charge level, and use full capacity to express SOC as a percentage.

SOC Programming Applications

1. **SOC LED percentage threshold variables** - select SOC percentages to be used for battery SOC LED transitions - see Default Battery SOC LED Percentages Table in Section 5.5 Battery State-of-Charge (SOC)

LED Transitions.

2. **Load disconnect-reconnect thresholds** - using LiveView, load disconnect and reconnect can be programmed based on a state-of-charge percentage - see Section 4.2.4 Load Control
3. **Variable for ReadyRelay threshold** - an SOC percentage can be used as a variable assigned to trigger a relay for ON-OFF threshold settings.
4. **Variable for ReadyRelay ESC** - an SOC percentage can be used as a variable assigned as a Start or Stop condition for an external source input to the battery bank.

ReadyBMS (RB-BMS)

The BMS Block can also interface with lithium batteries for, "closed loop", charging control and data reporting. Closed loop communication and integration is developed and tested in tandem between Morningstar and a limited number of lithium battery manufacturers including the following:

- Deka (duration)
- Discover Advanced Energy (AES)
- Pylon Technologies Co., Ltd. (PylonTech)
- WeCo S.r.l.

See the Energy Storage Partner™ program (ESP) webpage for BMS Closed Loop Setup Guides for the manufacturers listed above. BMS Closed Loop Setup Guides will be available for additional manufacturers on the ESP webpage as they become available.
https://www.morningstarcorp.com/energy-storage-partner-program/
BMS closed loop integration must be enabled during commissioning by selecting YES when promped for “BMS Block?” and selecting the battery model from the dropdown list (see Section 3.5 Commissioning / Initial Configuration).

4.2.8 External Source Control (ESC)

(Installer Setup)

NOTE:
To enable the use of the Manual or Automatic Source Control Profiles, a ReadyRelay must be programmed for ESC Start/Stop as seen in Section 4.2.7 Relay Function #4. As of this publication, only one ESC profile can be set up for the system. If multiple relays are set up for ESC Start/Stop they will all share the same ESC settings.

INTRODUCTION

The ReadyRelay can be used for manual or automated on/off control of external charging sources. The GenStar External Source Control (ESC) settings provide basic and advanced on/off control for an external charging source. ESC is used for hybrid off-grid solar PV systems that have a backup generator or fuel cell and can also be used for grid connected solar backup systems.

With hybrid off-grid solar PV systems, the ESC typically remains off/ disconnected while system loads are powered by the battery and solar PV array. When the Solar production is unable to keep up with the load usage, the ESC can be called on to recharge the battery as needed. With grid backup systems, the ESC (grid) might be set up to remain on much of the time and be disconnected during the day to power the load from the battery and solar PV array.

ESC SETUP OVERVIEW

1. Set a ReadyRelay for ESC Start/Stop
2. Set ESC Timing Controls
3. Set an ESC Mode (Manual or Custom)
4. If using Custom for automated Start - Stop control
    a. Select desired Control Criteria option(s) (at least one Emergency or Start Charging)
    b. For each Control Criteria option, set ESC Control Conditions (if needed)
    c. Set ESC Schedule(s)

ESC PROGRAMMING

Opening ESC Screen:

The ESC LiveView screen displays ReadyRelay assignment(s) at the top. Below that are the following two drop-down menus.

- ESC Timing Controls: provides minimum and maximum runtime and minimum offtime for the external source.
- ESC Modes: determines the conditions that will trigger start and stop control of the ESC relay in addition to weekly schedules when each condition is active.

All of the ESC Timing Controls and Modes are disabled by default.

ESC TIMING CONTROLS

The ESC Timing Control settings can be programmed to allow the external charging source to operate for a sufficient amount of time (Minimum Run Time), prevent it from operating for too long (Maximum Run Time) or prevent it from being started again too soon after shutting off (Minimum Off Time).

Minimum Run Time: Sets the least duration the external source can operate.

Maximum Run Time: Sets the greatest duration the external source can operate.

Minimum Off Time: Sets a requirement of time elapsed from turning off before the external source can start again.

CAUTION:
ESC Timing settings are disabled by default. To prevent the possibility of the ESC Run Time being too short or too long, or from starting again too soon, ESC Timing settings are recommended.

Timing Controls always remain in effect and will always delay or interrupt (not disable) all types of ESC controls until the minimum or maximum timing condition has been met. This includes all control initiated by ESC Custom Mode settings, even “Emergency Charging” and “Prohibit Operation” (see Modes Setup - Custom below), in addition to all ESC Enable and Disable Commands. The only exception is the ESC E-Stop Command that will ignore the Minimum Run Time setting. See Section 5.8.5 External Source Control (ESC) Commands.

Therefore, it is important that the Timing Control settings are set correctly. For example, the Maximum Run Time should not be set for less than the longest desired amount of runtime for the charging source.

An example of ESC Timing Controls are displayed in the graph in Figure 4.2 below.

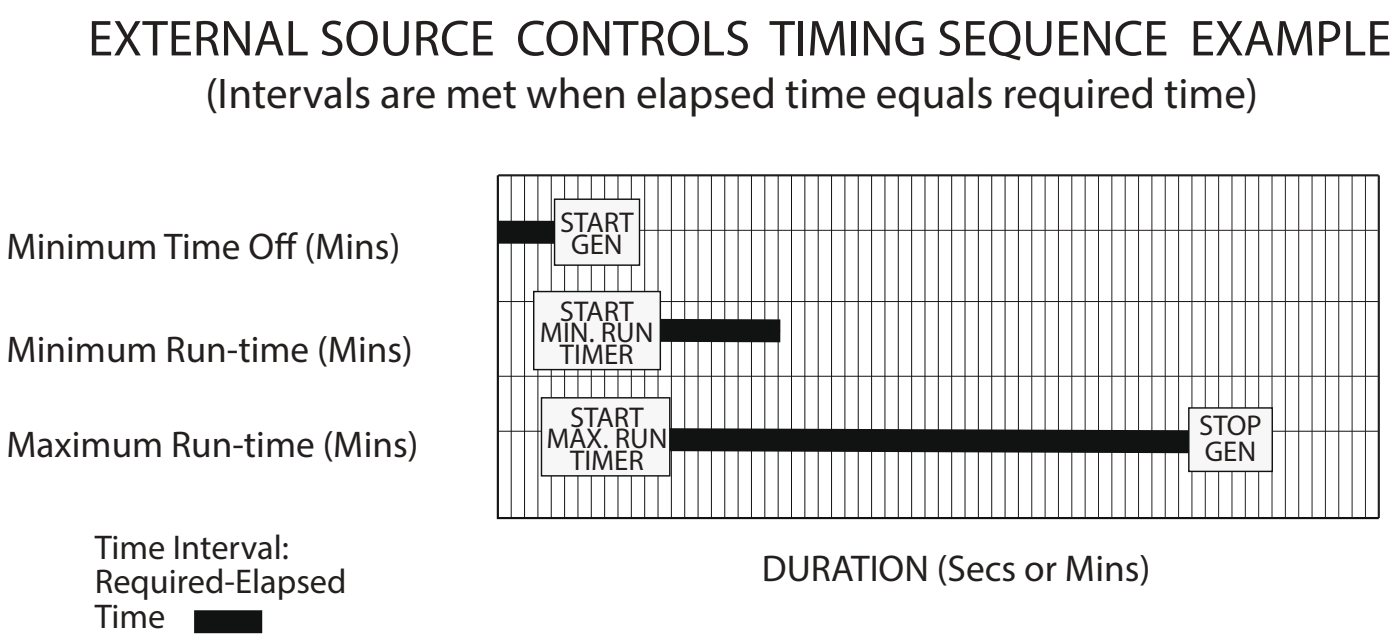


Figure 4-2 External Source Control Timing

ESC MODES SETUP SCREENS

The drop-down menu provides options for Disabled, Manual or Custom Profiles:

DISABLED
External Source Control function is disabled

MANUAL
External Source start/stop control can be triggered manually via an “ESC” Command or Soft-key. Use LiveView ESC Commands, display-meter commands or Soft-key (see Sections 4.1.1 and 4.2.9) to start or stop an external source manually. Note that Manual ESC Enable and Disable commands will not override ESC Timing controls.

CUSTOM

External Source Control can be triggered automatically using Custom ESC settings for an ESC Start-Stop assigned relay. When Custom Mode is chosen, a Custom ESC setup screen with four (4) Control criteria options will appear below on the left.

1. Start Charging: Set Start, Stop and Schedule criteria for ESC (can be prohibited or paused)

2. Emergency Charging: Set Start, Stop and Schedule criteria for ESC (Always active - no schedule settings, can be prohibited, cannot be paused)

3. Pause Charging: Set Pause, Resume and Schedule criteria to pause and resume charging (overrides Start Charging settings only)

4. Prohibit Operation: Set Schedule (no other criteria/conditions) when ESC charging is prohibited (overrides Start Charging and Emergency Charging)

There is also a “use factory defaults” option on the right. The factory defaults include an Emergency Charging (Avoid LVD) preset and a Start Charging (Low Battery / Bulk) preset.

After selecting a scheduling-control option, select from a drop-down list of presets or “use custom settings”. Note that all presets can be modified after they are selected.

Multiple ESC Controls

Multiple ESC Control criteria options can be programmed at the same time, each with its own ESC settings and schedule. After selecting from Emergency Charging, Start Charging (1, 2, and 3), Pause Charging, or Prohibit Charging, the corresponding Custom ESC Card will be displayed.

At least one Emergency Charging or Start Charging custom setting must be used to enable (Start) ESC charging. The only difference between Emergency Charging settings options and Start Charging settings options are the presets.

Prohibit Operation will always override all Emergency Charging and Start Charging operation and Pause Charging will only override ESC Start Charging operation, but not Emergency Charging operation.

Typically the Start Charging settings are programmed so they will start ESC operation before the Emergency Charging settings. In this way, the Emergency charging settings act as a backup to the Start Charging settings, and remain active when the Start Charging operation is paused or not scheduled.

ESC Control Conditions

Start and Stop Control Conditions are set in the Start Charging and Emergency Charging ESC Cards. Pause and Resume Control Conditions are set in the Pause Charging ESC Card. ESC Control Conditions are not available for Prohibit Charging.

The factory defaults and presets include ESC Control Conditions settings. These settings can be modified by selecting the wrench icon. Alternatively, Custom ESC Control Condition settings can be selected and set.

The following applies to Pause and Resume Control Conditions also.

ESC Start and Stop Charging Control Conditions will be paired for each ESC Card only. Only the paired Stop Conditions or end of the Schedule will deactivate the ESC Start Charging condition once it has been started.

Set the Start charging conditions so that the charging is only started when charging is needed and not started when it is not needed. Set the paired Stop charging conditions so it is coordinated with the Start Charging Conditions to meet a specific amount of charging after it has been started.

NOTE:

When setting custom ESC Control Conditions, it must always include both a Start charging setting and a Stop Charging setting.

Each ESC Control Condition (for Start, Stop, Pause or Resume) can be set with up to 4 different conditions and combined logically with "any" (OR) or "all" (AND). Two or more Conditions can be combined with “any” or “all” into a group. Once there are two conditions in a group, a second group of Condition(s) can be formed.

For Example:

Group 1		Group 2
all (Condition 1 and Condition 2)	AND	any (Condition 3 or Condition 4)

Once set, a summary of the Start, Stop, Pause or Resume conditions will be displayed in the ESC Card describing the control conditions.

For Example: “Start charging when Battery Voltage is less than 23.4V for 5 minutes **OR** LVD Warning occurs for 1 minute”

ESC Schedules

(Schedules entered in Custom ESC Setup OR Installer\Schedules)

Each Custom ESC Card includes Schedule Settings on the right. Each of the ESC Schedules can also be set in the Schedules Setup menu (Section 4.2.6 Schedule).

By specifying various schedules, a broad schedule structure can be achieved. If there are no ESC Control criteria set, the ESC Control will operate according to a Schedule only. If ESC Control Conditions is set, the ESC Schedule determines when Start Charging (1, 2, and 3) or Pause Charging operations are active. Emergency Control Conditions are always active with no schedule settings.

ESC Control operation will not start before, or extend beyond the ESC schedule. For example, if Charging starts 1 minute before the Schedule ends the charging will also stop, unless overridden by Minimum Run Time.

Types of Control Conditions

Four different types of conditions can be used: Simple Condition, Variable Comparison, Range Condition, Event.

SIMPLE CONDITION

Select a Variable, Threshold value and Delay Time.

Example: Stop Charging 1: when Battery Voltage > 26.4 V for 1 hour

VARIABLE COMPARISON (may not have a viable use)

Select two different Variables for relational comparison (< or >) and a Delay Time

RANGE CONDITION (Simple Condition is typically used instead)

Select a Variable, upper and lower values for the Range and Delay Time.

EVENT

Select a type of Event and Delay Time

Example: Start Emergency Charging: when LVD Warning occurs for 1 minute

The Time Delay settings can provide some certainty that conditions are not just temporary, and will not, "falsely", trigger the control. Another reason to use the delay might be to allow a certain amount of charging time after reaching a Stop condition.

WARNING:

To prevent overcharging of the battery or unintended run-time of the charging source, ESC Stop Condition Settings should be considered very carefully. For example, if an Event Stop setting is set to Stop charging when Charge Stage Absorption occurs, it will only be triggered after the GenStar solar controller has reached the Absorption Charge Stage and will not be triggered during Bulk, Night or Solar Controller Fault.

Table 4.1 provides all of the ESC Control Condition Presets available for the GenStar MPPT controller. The battery voltages in the table are for a 12V Nominal system (multiply by 2 for 24V or by 4 for 48V).

Factory Defaults	**Start Condition**	**Stop Condition**
Emergency Charging Start Charging 1	LVD occurs for 1 min Battery Voltage ≤ 11.8V for 5 min	Battery Voltage ≥ 12.1V for 1 hour Battery Voltage ≥ 13.3V for 1 hour
Start Charging (1,2,3)	**Start Condition**	**Stop Condition**
On a Schedule	On Schedule (can add)	On Schedule (can add)
Low battery / Bulk	Battery Voltage ≤ 11.7V for 5 min	Battery Voltage ≥ 13.3V for 1 hour
Low SOC / Bulk	Battery SOC ≤ 20% for 5 min	Battery SOC ≥ 75% for 1 hour
Large DC Load / Reduced DC Load	Net Battery Current < -20 A for 30 min	Net Battery Current ≥ -10A for 10 min
Emergency Charging	**Start Condition**	**Stop Condition**
Avoid LVD	LVD occurs for 1 min	Battery Voltage ≥ 12.1V for 1 hour
Low Battery Voltage	Battery Voltage ≤ 11.5V for 1 min	Battery Voltage ≥ 13.1V for 1 hour
Pause Charging	**Pause Condition**	**Resume Condition**
On a Schedule	On Schedule (can add)	On Schedule (can add)
Prohibit Charging	**No Conditions allowed**	**No Conditions allowed**
On a Schedule	N/A	N/A

Table 4-1 ESC Control Conditions Presets (12V Nominal - Schedules not shown)

4.2.9 Meter Display

(Setup and Installer Setup)

The Meter Display settings include the following Settings Tabs.

- **Language:** (English, Español, Deutsche, Français) and Temperature (Celcius, Fahrenheit)
- **Screen Settings:** Backlight Timer, Brightness, Contrast
- **Main Displays:** Auto-Scroll and Auto Return
- **Map Soft-key Commands:** Momentary Press and Press and Hold -- hold time is >2 seconds

4.2.10 Save and Load

(Setup and Installer Setup)

The GenStar System Settings can be saved as a system image configuration file to the GenStar SD card with LiveView or the meter display - Setup\Save & Load. To Save settings enter a filename and select Save (the filename can have up to 8 characters). Load settings from the SD Card by choosing a file and then clicking on the Load button. After loading the settings to the controller, review and verify the Settings in the Setup menu or in the individual setup menus.

WARNING: RISK OF EXPLOSION

When loading a system image configuration from an SD Card, ensure that the destination device has been commissioned for the same system voltage, battery profile, and RTS; otherwise, there is a potential risk of system damage or bodily injury.

5.0 OPERATION

5.1 TrakStar™ MPPT Technology

The GenStar MPPT utilizes Morningstar's TrakStar Maximum Power Point Tracking technology to extract maximum power from the solar module(s). The tracking algorithm is fully automatic and does not require user adjustment. Trakstar technology will track the array maximum power point voltage (Vmp) as it varies with weather conditions, ensuring that maximum power is harvested from the array through the course of the day.

Current Boost:

In many cases, TrakStar MPPT technology will "boost" the solar charge current. For example, a system may have 2 amps of solar current flowing into the GenStar MPPT and five amps of charge current flowing out to the battery. The GenStar MPPT does not create current! Rest assured that the power into the GenStar MPPT is the same as the power out of the GenStar MPPT. Since power is the product of voltage and current (Volts x Amps), the following is true*:

1. Power Into the GenStar MPPT = Power Out of the GenStar MPPT
2. Volts In x Amps In = Volts Out x Amps Out

* assuming 100% efficiency i.e. if no losses in wiring and conversion existed.

If the solar module's Vmp is greater than the battery voltage, it follows that the battery current must be proportionally greater than the solar input current so that input and output power are balanced. The greater the difference between the maximum power voltage and battery voltage, the greater the current boost. Current boost can be substantial in systems where the solar array is of a higher nominal voltage than the battery as described in the next section.

High Voltage Strings and Grid-tie Modules

Another benefit of TrakStar MPPT technology is the ability to charge 12 or 24 volt batteries with solar arrays of higher nominal voltages. A 12 volt battery bank can be charged with a 12, 24, 36 or 48V nominal off-grid solar array. Certain grid-tie solar modules may also be used as long as the solar array open circuit voltage (Voc) rating will not exceed the GenStar MPPT 200V maximum input voltage rating at worst-case (lowest) module temperature. The solar module documentation should provide Voc vs. temperature data.

Higher solar input voltage results in lower solar input current for a given input power. High voltage solar input strings allow for smaller gauge solar wiring. This is especially helpful for systems with long wiring runs between the solar array and the GenStar MPPT.

An Advantage Over Traditional Controllers

Traditional controllers connect the solar module directly to the battery when recharging. This requires that the solar module operate in a voltage range that is below the module's Vmp. In a 12V system, for example, the battery voltage may range from 10 - 15 Vdc but the module's Vmp is typically around 17V. Figure 5.1 - below - shows a typical current vs. voltage output curve for a nominal 12V off-grid module.

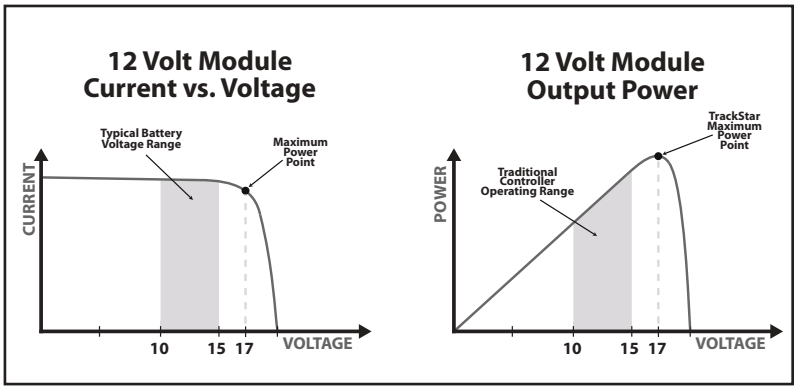


Figure 5.1. Nominal 12 volt solar module I-V curve and output power graph

5.2 GenStar MPPT Charging

Charging is completely adjustable to accommodate a variety of battery chemistries. The GenStar MPPT system batteries will have different charging requirements based on application, mode of operation, season, usage schedules, load profile, etc. The GenStar MPPT's charging algorithms and settings have the capability to provide optimal charging, with flexibility for very specific demands. The charger also offers easy to use preset profiles that will facilitate good battery health.

5.2.1 Four-Stage Charging Algorithm

The GenStar MPPT offers a 4-stage battery charging algorithm for rapid, efficient, and safe battery charging. Figure 5-2, below, shows the sequence of stages. The first charging stage is Bulk followed by Absorption or Equalize, and then Float. Note that the Equalize and Float stages are optional depending on the charging requirements of the battery.

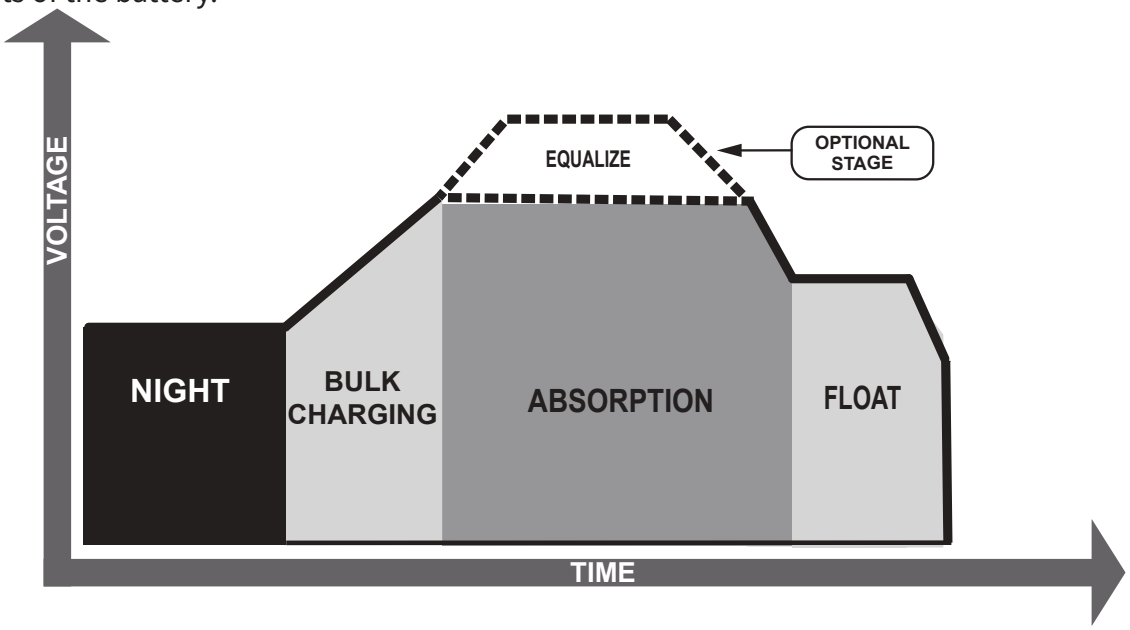


Figure 5-2. GenStar MPPT 4-stage charging algorithm

Bulk Charging Stage

During Bulk charging, the battery is not at 100% state of charge and battery voltage has not yet charged to the Absorption voltage set-point. The controller will deliver 100% of available solar power to recharge the battery.

Absorption Stage

When the battery has recharged to the Absorption voltage set-point, constant-voltage regulation is used to maintain battery voltage at the Absorption set-point. This prevents heating and excessive battery gassing. The battery is allowed to come to full state of charge at the Absorption voltage set-point. The green Battery SOC LED will blink once per second during Absorption charging.

The battery must remain in the Absorption charging stage for a cumulative 150-180 minutes, depending on battery type, before transition to the Float stage will occur. However, Absorption time will be extended by 30 minutes if the battery discharges below 12.50 volts (12V system) the previous night.

The Absorption set-point is temperature compensated through either the on-board local temperature sensor, or an optional Remote Temperature Sensor (RTS), if connected.

Float Stage

After the battery is fully charged in the Absorption stage, the GenStar MPPT reduces the battery voltage to the Float voltage set-point. When the battery is fully recharged, there can be no more chemical reactions and all the charging current is turned into heat and gassing. The float stage provides a very low rate of maintenance charging while reducing the heating and gassing of a fully charged battery. The purpose of float is to protect the battery from long-term overcharge. The green Battery SOC LED will blink once every two (2) seconds during Float charging.

Once in Float stage, loads can continue to draw power from the battery. In the event that the system load(s) exceed the solar charge current, the controller will no longer be able to maintain the battery at the Float set-point. Should the battery voltage remain below the Float set-point for a cumulative sixty minute period, the controller will exit Float stage and return to Bulk charging. The Float set-point is temperature compensated through the included Remote Temperature Sensor (RTS), if connected.

Equalization Stage

WARNING: Risk of Explosion
Equalizing vented batteries produces explosive gases. The battery bank must be properly ventilated.

CAUTION: Equipment Damage
Equalization increases the battery voltage to levels that may damage sensitive DC loads. Verify all system loads are rated for the temperature compensated Equalize voltage before beginning an Equalization charge.

CAUTION: Equipment Damage
Excessive overcharging and gassing too vigorously can damage the battery plates and cause shedding of active material from the plates. An equalization that is too high or for too long can be damaging. Review the requirements for the particular battery being used in your system.

Certain batteries benefit from a periodic boost charge to stir the electrolyte, level the cell voltages, and complete the chemical reactions. Equalization (EQ) charging raises the battery voltage above the standard

absorption voltage so that the electrolyte gases. The green Battery SOC LED will blink rapidly two (2) times per second during equalization charging. The duration of the equalize charge is determined by the selected battery type. See table 5-1 in this section for more details. The Equalization Time is defined as time spent at the equalization set-point. If there is insufficient charge current to reach the equalization voltage, the EQ will terminate after an additional 60 minutes to avoid over gassing or heating of the battery. The GenStar MPPT meter, or LiveView, can also be used to set EQ voltage and duration.

The Equalization set-point is temperature compensated with use of the included Remote Temperature Sensor (RTS), if connected.

Why Equalize?

Routine equalization cycles are often vital to the performance and life of a battery - particularly in a solar system. During battery discharge, sulfuric acid is consumed and soft lead sulfate crystals form on the plates. If the battery remains in a partially discharged condition, the soft crystals will turn into hard crystals over time. This process, called, “lead sulfation”, causes the crystals to become harder over time and more difficult to convert back to soft active materials. Sulfation from chronic undercharging of the battery is the leading cause of battery failures in solar systems. In addition to reducing the battery capacity, sulfate build-up is the most common cause of buckling plates and cracked grids. Deep cycle batteries are particularly susceptible to lead sulfation.

Normal charging of the battery can convert the sulfate back to the soft active material if the battery is fully recharged. However, a solar battery is seldom completely recharged, so the soft lead sulfate crystals harden over a period of time. Only a long controlled overcharge, or equalization, at a higher voltage can reverse the hardening of sulfate crystals.

When to Equalize?

The ideal frequency of equalizations depends on the battery type (lead-calcium, lead-antimony, etc.), the depth of discharging, battery age, temperature, and other factors. One very broad guide is to equalize flooded batteries every 1 to 3 months or every 5 to 10 deep discharges. Some batteries, such as the L-16 group, will need more frequent equalizations.

The difference between the highest cell and lowest cell in a battery can also indicate the need for an equalization. Either the specific gravity or the cell voltage can be measured. The battery manufacturer can recommend the specific gravity or voltage values for your particular battery.

Preparation for Equalization

First, confirm that all of the system loads are rated for the equalization voltage. Disconnect any loads at risk of damage due to the high input voltage.

If Hydrocaps are used, be sure to remove them before starting an equalization. Replace the Hydrocaps with standard battery cell caps. The Hydrocaps can get very hot during an equalization. After the equalization is finished, add distilled water to each cell to replace gassing losses. Check that the battery plates are covered.

Equalize a Sealed Battery?

The GenStar MPPT Preset Charging Settings (Table 5-1 in this section) includes one sealed battery charging profile with an Equalization Voltage Column. This is a minimal, “boost”, cycle to level individual cells. This is not a true equalization, and will not vent gas from sealed batteries that require up to 14.6V equalization charging (12V battery). The GenStar MPPT Preset Charging Settings also includes three Sealed/ Flooded battery profiles which can be used with sealed batteries that have a charging requirement of 14.5-14.8V (12V battery). However, these equalization voltage settings are intended strictly for flooded batteries only. Sealed batteries must never be equalized when using these profiles.

5.2.2 Charging Profiles

GenStar MPPT offers eight (8) preset battery charging profiles, as seen in Tables 5-1 below. These standard charging settings are suitable for lead-acid batteries ranging from sealed (gel, AGM, maintenance-free) to Flooded and Lithium cells. All voltage settings listed are for nominal 12 Volt batteries. Multiply the voltage settings by two (2) or (4), for 24 and 48 Volt systems, respectively.

NOTE:

These settings are general guidelines for use at the operator's discretion. The GenStar MPPT can also be custom programmed to satisfy a wide range of charging parameters. Consult the battery manufacturer for optimal battery charge settings.

GenStar MPPT Preset Charging Profiles (@ 25°C)

Battery Type-Preset	Absorption Voltage	Float Voltage	Equalization Voltage	Absorption Time	Equalization Time	Equalization Timeout
	Volts	Volts	Volts	Minutes	Minutes	Minutes
1 - Sealed	14.1	13.7	Disabled	150	Disabled	Disabled
2 - Sealed	14.3	13.7	14.6[1]	150	60	120
3 - Sealed / Flooded	14.5	13.6	15.0[1]	180	60	120
4 - Sealed / Flooded	14.6	13.5	15.2[1]	180	120	180
5 - Sealed / Flooded	14.8	13.5	15.4[1]	180	120	180
6 - LiFePO4 - Low[2]	13.6	13.5	Disabled	180	Disabled	Disabled
7 - LiFePO4 - Medium[2]	13.9	13.5	Disabled	20	Disabled	Disabled
8 - LiFePO4 High[2]	14.2	13.5	Disabled	15	Disabled	Disabled

Table 5-1. GenStar MPPT Preset Battery Charging Profiles

CHARGING PRESET NOTES:

[1] For Presets 2-5, an equalization charging stage can be initiated manually using the Start Equalization Command from the local meter or LiveView. The auto equalization interval can only be set up using custom settings.

[2] ***CAUTION:***

LiFePO4 settings are for 4, 8 and 16-cell LiFePO4 batteries only

All settings, including charging stage voltages and timing, can be custom programmed using the local meter or LiveView. LiveView includes additional advanced custom programming options.

CAUTION: EQUIPMENT DAMAGE

Do not equalize sealed batteries with preset or custom settings unless recommended by the battery manufacturer. To prevent the possibility of unintended equalization, use custom settings to disable all equalization

CAUTION:

Settings may not be compatible with all models of these battery types.

Table 5-2 shows all of the high voltage disconnect and reconnect presets for each charging profile. Table 5-3 shows the shared settings that are common to all GenStar charging presets.

GenStar MPPT HVD-HVR Preset Charging Settings

Charging Profile Battery Type-Preset	Solar HVD Volts	Solar HVR Volts
Lead Acid Charge Presets 1-5	Highest set-point in charging profile [+ 0.5V (@ 25ºC)][1]	13.81
6 - LiFePO4 - Low	14.2	13.6
7 - LiFePO4 - Medium	14.4	13.6
8 - LiFePO4 High	14.45	13.6

[1] **Lead Acid Solar HVD/ HVR settings are temperature compensated.**

Table 5-2. GenStar MPPT HVD-HVR Preset Charging Settings

Table 5-3 shows the shared settings that are common to all GenStar charging presets.

GenStar MPPT Shared Settings

Shared Settings	Lead-Acid Value	Lithium Value
Absorption Extension Voltage	12.5	Disabled
Absorption Extension Time	Absorption Time + 30	NA
Float Exit Time-out Voltage	12.6	13.3
Float Exit Time-out	60	60
Float Cancel Voltage	12.0	Disabled
Equalize Time-out	Equalize Time +60	N/A
Temperature Compensation Coefficient	-30	Disabled
Compensation Temperature Range	- 20 to +40	NA
Low Temperature Foldback 100%	Disabled	+2
Low Temperature Foldback 0%	Disabled	0

Table 5-3. GenStar MPPT Shared Preset Charging Settings

5.2.3 Charging Variables

Each charging variable described in this section is graphically illustrated with examples below:

Absorption Extension Threshold

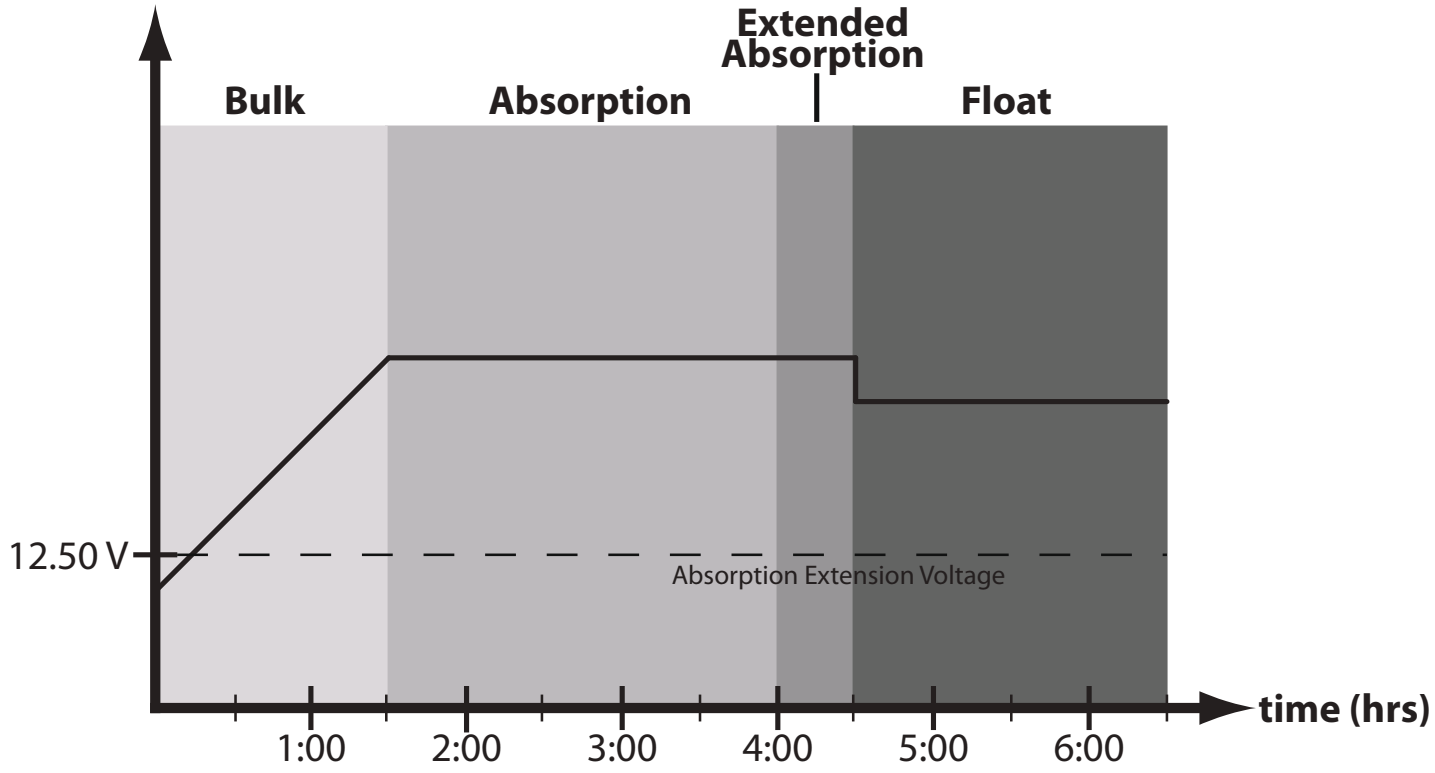


Figure 5-3. Absorption Extension Charging Profile

If battery voltage discharges below the Absorption Extension Threshold the previous night, Absorption charging will be extended on the next charge cycle as shown in the example in Figure 5-3 above.

The voltage threshold and extension time depend on the chosen standard profile or custom settings.

Float Timeout and Float Exit Threshold

After entering the Float stage, the Float Timeout setting is applied in case the battery voltage drops due to insufficient solar charge or heavy system loads.

- With Float Timeout enabled and Float Exit Threshold disabled, the Float Timeout counts the cumulative time that the battery voltage drops below the temperature compensated Float Voltage.
- With both Float Timeout and Float Exit Threshold enabled, the Float Timeout will count the cumulative time that the battery voltage is less than the Float Exit Threshold Voltage.
- When the Float Timeout time expires, the GenStar MPPT exits Float and begins a new Bulk / Absorption charge cycle.
- Float Timeout = 60 min for all preset charging profiles
- Float Exit Threshold = 12.6 for lead acid profiles (1-5)
- Float Exit Threshold = 13.3 for lithium profiles (6-8)

Float Exit Time-out Voltage Threshold

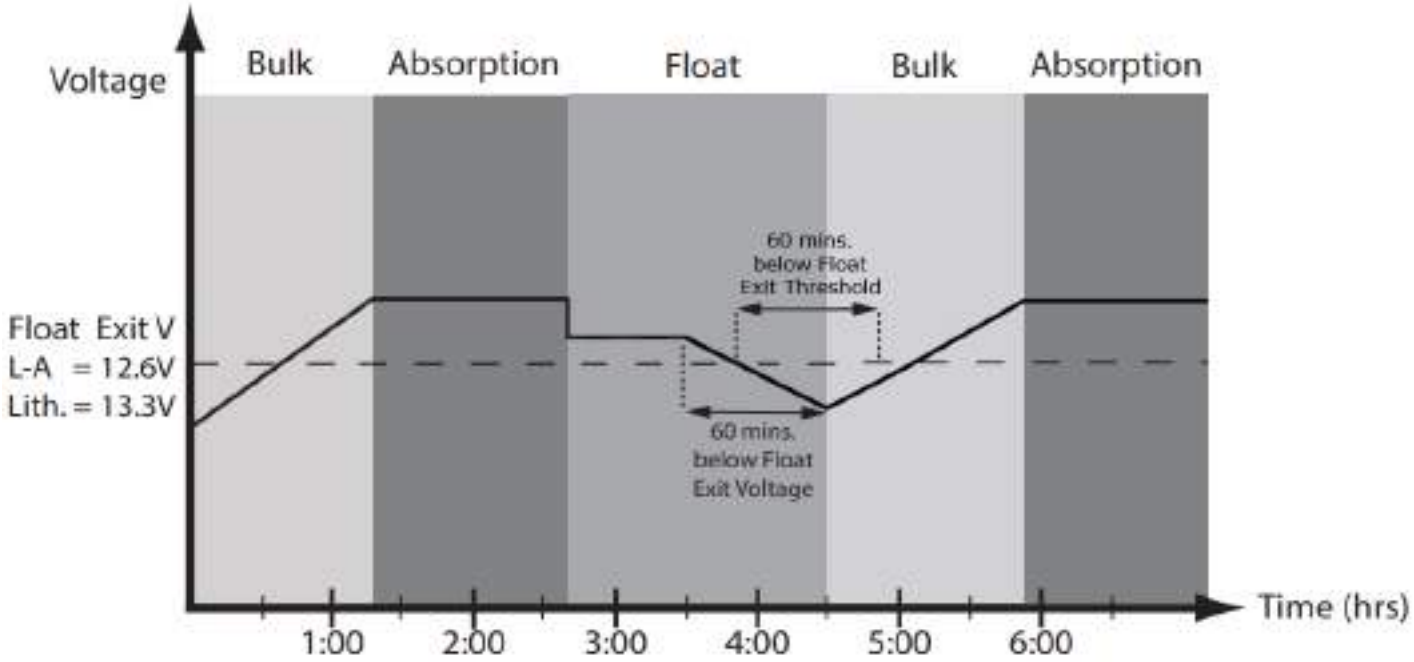


Figure 5-4. Float Exit Time-out Voltage Charging Profile

In Figure 5-4 above, the Float Timeout is set for 60 min. A system load turns on at 3:30 hrs during the Float stage and runs for one hour, then turns off at 4:30 hrs. During this time the load current draw is higher than the charge current so there is a net discharge causing the battery voltage to drop. If the Float Exit Threshold is disabled, the GenStar will exit Float 60 minutes after dropping out of Float and begin a new Bulk / Absorption cycle. If the Float Exit Threshold was set in this example, the battery voltage will need to drop below the Float Exit Threshold Voltage for > 60 minutes before the GenStar will drop out of Float.

NOTE:

The Float Exit Threshold Voltage should be set to < battery rest voltage so that the Float Timeout only counts the time that the battery is actually discharging. Longer Float Timeout and/or lower Float Exit Threshold settings will require the battery to reach a lower SOC before exiting Float.

Float Cancel Voltage

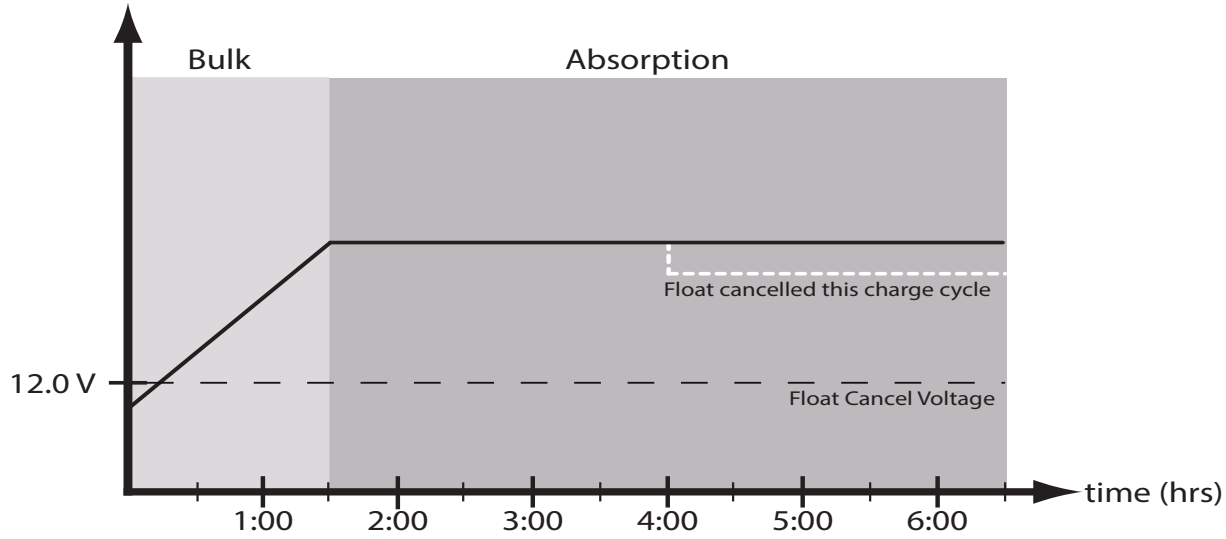


Figure 5.5. Float Cancel Charging Profile

For Lead-acid presets, the battery bank discharges below 12.0 volts (24.0 volts @ 24 V) the previous night, Float charging stage will be cancelled for the next charge cycle. Figure 5-5 above, illustrates this concept. At 0:00 hrs (dawn), battery voltage is below the Float Cancel threshold voltage. The diagram shows where Float stage would have occurred if Float was not canceled. ***Float cancel voltage is disabled for Lithium presets (6-8).***

Equalization Time-out

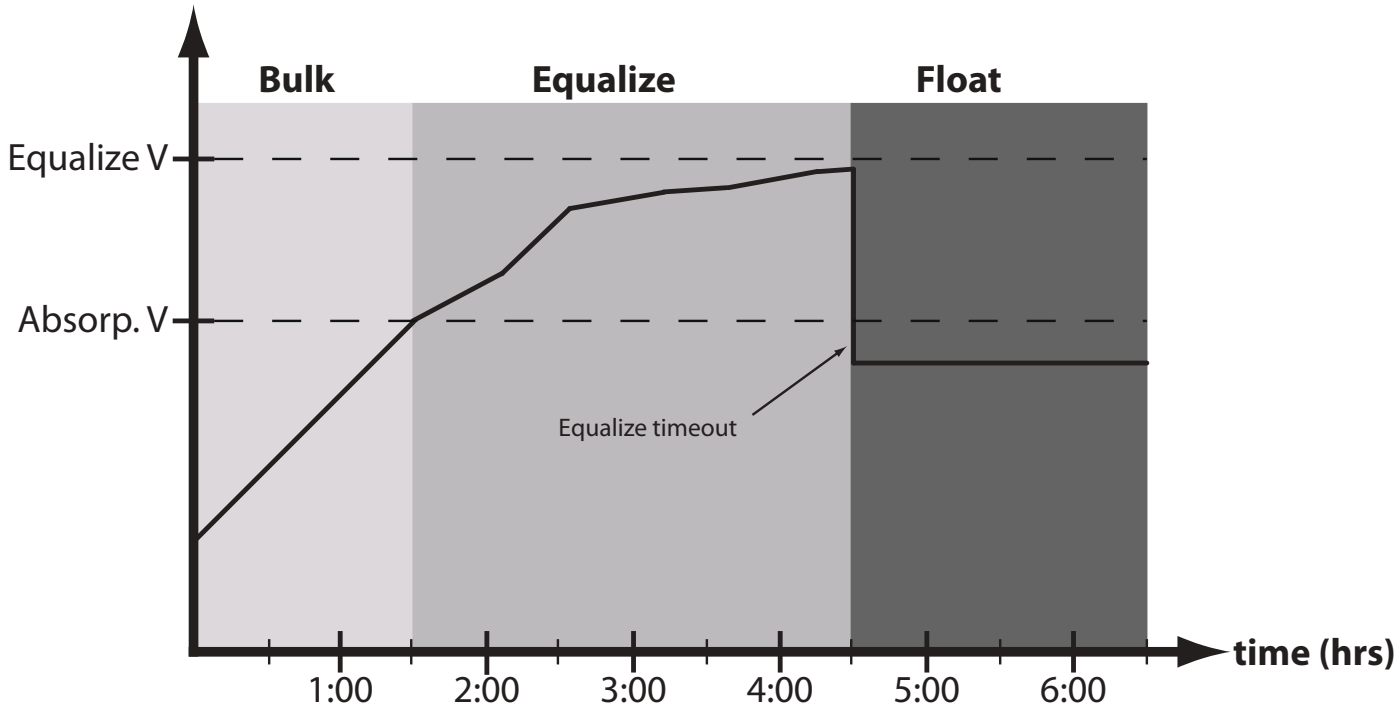


Figure 5.6. Equalize Time-out Charging Profile

The charging profile in figure 5-6 above, shows an *Equalization Time-out* event. The time-out timer begins as soon as battery voltage exceeds the Absorption voltage set-point. If there is insufficient charging current or system loads are too large, the battery voltage may not reach the Equalization set-point. Equalization Time-out is a safety feature that prevents high battery voltage for extended periods of time which may damage the battery. Equalization time-out duration depends on the chosen preset, and is also customizable.
Equalaization Time-out is disabled for Lithium presets (6-8).

5.3 Load Control Information

The primary purpose of the load control function is to disconnect system loads when the battery has discharged to a low state of charge, and to reconnect system loads when the battery is sufficiently recharged. System loads may be lights, DC appliances, or other electronic devices. The total current draw of all loads must not exceed the GenStar 30 Amp maximum load rating.

Low Voltage Disconnect/Reconnect Profiles

GenStar MPPT offers seven (7) Low Voltage Disconnect/Reconnect (LVD/LVR) Profiles for load control, as seen in Tables 5-4 below. This includes current compensation (mV/A) values. All voltage and mV/A settings listed are for nominal 12 Volt batteries. Multiply the voltage settings by two (2) or (4), for 24 and 48 Volt systems, respectively.

GenStar MPPT Low Voltage Disconnect/Reconnect (LVD-LVR) Profiles

Load Control Type-Preset	LVD	LVR	LVD Warning	Current Comp.
	Volts	Volts	Minutes	mV/A
1 - Lead Acid	11.10	12.60	10	0
2 - Lead Acid	11.50	12.80	10	-4
3 - Lead Acid	11.70	12.90	20	-6
4 - Lead Acid	12.00	13.20	20	-6
5 - Lithium LiFePO4	12.50	13.15	1	0
6 - Lithium LiFePO4	12.70	13.25	2	-1
7 - Lithium LiFePO4	12.85	13.30	5	-2

Table 5-4. GenStar MPPT Preset LVD-LVR (Load Control) Profiles

Current Compensation

Each load control profile specifies its own current compensation - some being zero. Under load, the battery voltage will sag in proportion to the current draw of the load. Without a current compensation feature, a short-term large load could cause a premature LVD. Current Compensation settings are inversely proportional to the battery bank amp hours. Therefore, it is important not to set the Current Compensation too high for larger battery banks.

LVD Warning/LVD/LSoCD Warning Time

As the battery discharges, the Battery SOC LEDs will transition from green to yellow and then from yellow to flashing red. The LEDs flash red when the battery voltage is < LVD or SOC < LSOCD set-point. If the battery voltage remains below the LVD or LSOCD set-point for longer than the LVD Warning time, the load will disconnect and a solid red Battery SOC LED indication will be displayed.

The amount of time between a green SOC indication and load disconnect will depend on many factors including:

- rate of discharge (amount of load draw)
- capacity of the battery
- health of the battery
- LVD set-point

Load HVD/HVR

Load HVD/HVR is disabled for all lead-acid load control profiles (1-4). Load HVD is not temperature compensated and therefore, should only be used with lead acid batteries if HVD is higher than the maximum temperature compensated regulation voltage or Maximum Regulation Voltage setpoint. Load HVD/HVR is 14.8V / 13.7V for all of the LiFePO4 load control profiles (6 - 8).

5.4 Factory Reset Procedure

Factory Reset must be done using the on-board meter display. Navigate to Setup\Advanced Setup\Installer Setup, and enter Installer Password 141. Then navigate to Commands\Factory Reset and choose that option. After a factory reset, the unit will need to be re-commissioned.

☞ ***NOTE: RESTORING SETTINGS AFTER A FACTORY RESET***

If you wish to restore the settings after a factory reset, make sure the settings have been saved to the internal SD card before performing the factory reset. Settings can be saved with the meter display or with LiveView. When saving the settings a system image is created. The system image is a copy of ALL of the settings, including the commissioning settings. The complete system image configuration can then be quickly loaded after recommissioning.

WARNING: Risk of Explosion

When loading a system image configuration from an SD Card, ensure that the destination device has been commissioned for the same system voltage, battery profile, and RTS; otherwise, there is a potential risk of system damage or bodily injury.

5.5 LED Indications

The GenStar MPPT meter face (see Figure 2-2) houses one Charging Status LEDs (left of screen) and a set of three battery State-of-Charge LEDs (beneath screen - horizontal).

Charging Status LED

The Charging Status LED indicates charging status and any existing solar input error conditions. The Status LED is on when charging during the day and off at night. The Status LED will flash red whenever an error condition(s) exists. Table 4.4 lists the Status LED indications.

Status LED Color	Indication	Operating State
None	Off (with heartbeat[1])	Night
Green	On Solid (with heartbeat[2])	Charging
Red	Flashing	Error
Red	On Solid (with heartbeat2)	Critical Error

[1] heartbeat indication flickers the Status LED on briefly every 5 seconds

[2] heartbeat indication flickers the Status LED off briefly every 5 seconds

NOTES:

1) R flashing is generally a user addressable fault / error

2) R charging status LED ON with heartbeat blink OFF every 5 secs is a critical fault that generally requires service. See, "Solid Charging Status LED with Self-test (R-Y-G) SOC Faults", in Section 5.6 Faults and Alarms.

SOC LEDs

The Green, Yellow or Red State-of-Charge LEDs are used for general indications and charging indications.

LED Display Key

G = green
Y = Yellow
R = red
Y - R = yellow and red flashing
G / Y = Green and Yellow are both lit at the same time
G / Y - R = Green & Yellow both lit, then red flashing sequentially
G-Y-R = green, yellow and red flashing sequentially

Sequencing LED patterns (faults) repeat until the fault is cleared

General LED Indications

The State of Charge LED's provide the following Start-up and Factory reset indications.

Normal Start-up LED Indication: G for 3 seconds, G-Y-R Flashing, then battery charge status

Start-up Bootload Failed LED Indication: G/Y/R for 3 seconds the STOP on Y

Factory Reset LED Indication: All LED 3 times, then R-Y-G

SOC LED Charging Indications

The Green, Yellow and Red State-of-Charge LEDs are used to indicate the following charging states.

State	SOC LED Indications
Equalize start request	G / Y / R - G / Y / R - G - G
Equalize cancel request	G / Y / R - G / Y / R - R - R
Equalizartion stage	G flashing (2 per sec)
Absorption stage	G flashing (1 per sec)
Float stage	G flashing (1 per 2 secs)

Battery State-of-Charge (SOC) LED Transitions

During the Bulk Stage, or when the controller is not charging, the Green, Yellow, and Red SOC LEDs will indicate the SOC according to the Battery SOC LED Transition Settings. Battery State-of-Charge (SOC) LED transitions are based on voltage thresholds. When SOC percentage is available from an installed ReadyShunt or ReadyBMS accessory (see Battery State-of-Charge (SOC) Reporting in Section 4.2.7) the SOC LED transitions will be based on SOC percentage.

Factory Default Battery SOC LED Voltage Thresholds

Battery SOC LEDs	Voltage Threshold
Green	battV > 13.3V
Green / Yellow	13.0V < battV <= 13.3V
Yellow	12.65V < battV <= 13.0V
Yellow / Red	battV <= 12.65V
Red	During LVD

Note that voltage threshold State-of-Charge LED displays are only approximate indications of battery charge state, and have variable accuracy during charging and discharging. In addition, the factory default Battery SOC LED indication settings are not appropriate for all battery types and system designs. Therefore, the SOC LED transition settings can be custom programmed to provide a more accurate representation of SOC. The following voltage threshold settings are suggested to better indicate actual SOC.

Suggested Lead-Acid Battery SOC LED Voltage Threshold Settings

Battery SOC LEDs	Voltage Threshold
Green	battV > 13.3V
Green / Yellow	13.0V < battV <= 13.3V
Yellow	12.5V < battV <= 13.00V
Yellow / Red	battV <= 12.50V
Red	During LVD

☞ ***NOTE:***

Thresholds are more representative of SOC during Bulk Charging. Lower settings can be used to better indicate SOC during periods of battery discharge.

Suggested Lithium (LFP) Battery LED Voltage Threshold Settings

Battery SOC LEDs	Voltage Threshold
Green	battV > 13.4V
Green / Yellow	13.25V < battV <= 13.4V
Yellow	13.1V < battV <= 13.25V
Yellow / Red	battV <= 13.1V
Red	During LVD

Factory Default Battery SOC LED SOC Percentages - for use with ReadyBMS or ReadyShunt accessory:

Battery SOC LEDs	Condition
Green	SOC > 80%
Green / Yellow	60% < SOC <= 80%
Yellow	40% < SOC <= 60%
Yellow / Red	SOC <= 40%
Red	LVD or Low SOC Disconnect

Ethernet Jack Indications

Two (2) small LEDs can be found on the Ethernet RJ-45 jack inside the wiring box. These LEDs indicate the LAN/WAN network link and activity status as follows:

Condition	Green LED	Yellow LED
Network Connection OK	ON	OFF
Network Activity	ON	Blinking
Error	OFF	ON

5.6 Alarms and Faults

Alarms and faults are indicated with LEDs on the unit, and with brief descriptions in LiveView web interface. Alarms are generally informational (see ReadyBlock Alarms below), and faults cause interruption in operation.

Alarms

Battery Sense Out of Range / Disconnected
(only alarm with LED indications)

Charging Status LED: Flashing red. Battery SOC LEDs: R/Y - G/Y sequencing. A battery sense wire is disconnected. Inspect the battery sense connections. This alarm is set when the voltage at the battery sense terminals differs by more than five volts from the voltage at the battery terminals.

Current Limit
The array power exceeds the rating of the controller. This alarm indicates that the GenStar MPPT is limiting battery current to the maximum current rating.

Heatsink Temperature Sensor Open / Shorted
The heatsink temperature sensor is damaged. Contact your Authorized Morningstar Dealer for service.

High Input Voltage Current Limit
The GenStar MPPT will limit the solar input current as the solar array Voc approaches the maximum input voltage rating. The array Voc should never exceed the 200 Volt maximum input voltage - see the array voltage de-rating graph in Appendix.

High Temperature Current Limit

The GenStar MPPT will limit the solar input current if the heatsink temperature exceeds safe limits. Solar charging current will be tapered back (to 0 Amps if needed) to reduce the heatsink temperature. The GenStar MPPT will operate with full-rated current up to +45°C (at full power) and may derate at higher ambient temperatures. Systems with higher array input voltages will have higher internal temperatures resulting in a greater amount of high temperature current-limiting above +45°C. Maximum charging current yield depends on many factors, including sufficient airflow, and good ventilation can greatly reduce the amount of de-rating. If the controller frequently reports this alarm condition, corrective action should be taken to provide better air flow, or to move the controller to a cooler location.

Load Short Circuit

Charging Status LED: Flashing red. Battery SOC LEDs: R/G-Y sequencing. Fully protected against load wiring short-circuits. After two (2) automatic load reconnect attempts (10 seconds between each attempt) the GenStar MPPT will wait, and then automatically reconnect the load, once the short is cleared.

RTS Open

The Remote Temperature Sensor is not connected to the controller. Use of the RTS is recommended for proper battery charging.

Uncalibrated

The controller was not factory calibrated. Contact your Authorized Morningstar Dealer for service.

READYBLOCK ALARMS

A BMS, Shunt or Relay Block can trigger the following alarms on the host which will trigger a disconnection (shutdown) of the charge controller.

BMS Block Removed

If the host is configured to use a battery that requires BMS communication and a BMS block is not connected to the Ready Rail (BlockBus), this alarm will be present until a BMS block is connected.

BMS Lost Communication

If for any reason the ReadyBMS is present and communication with a battery is lost, this alarm will be present until communication is re-established.

BMS Sense Error

BMS sense voltage reading has diverged from expected value

BMS Sense Disconnect

BMS sense was connected, but has been disconnected

Shunt or Relay Block

If the host is configured in any way to use a ReadyShunt or ReadyRelay. and one of those blocks is not connected to the Ready Rail (BlockBus), this alarm will be present until the required block is connected.

Faults

EEPROM Custom Settings Edit

Battery Status LED: Flashing red. Battery SOC LEDs: R-Y-G sequencing. A value has been modified in custom settings memory. The controller will stop charging and indicate a fault condition. After all settings have been modified, the controller must be reset with a reboot control command in LiveView or on the display or by removing and then restoring power to the controller. The new programmed settings will be used after the reset.

Firmware Update Failure

The firmware update was not successfully programmed. The controller will not indicate the full power-up SOC LED sequence of G-Y-R when power to the controller is reset. Instead, the controller will display green, and then stop on yellow. The yellow LED will continue to be lit and the controller will not complete start up or begin charging. Re-try the firmware update. The firmware must be successfully loaded before the controller will start up.

High Heatsink Temperature

Charging Status LED: Flashing red. Battery SOC LEDs: R-Y sequencing. The heatsink temperature has exceeded safe limits and the load is disconnected. The load will automatically reconnect when the heatsink cools to a safe temperature.

High Solar Voltage Disconnect

Charging Status LED: None. Battery SOC LEDs: R-Y-G. If the solar input open-circuit voltage (Voc) exceeds the 185 Volt maximum rating, the array will remain disconnected until the Voc falls to 175V

Solar Battery High Voltage Disconnect (HVD)

Charging Status LED: Flashing red. Battery SOC LEDs: R-G sequencing. This fault is set when battery voltage is above normal operating limits. The controller will disconnect the solar input and set a Solar High Voltage Disconnect fault. This fault is commonly caused by other charging sources in the system, charging the battery above the GenStar MPPT regulation voltage. Recovery occurs at HVD re-connect threshold, and the fault will clear automatically.

Load High Voltage Disconnect (HVD)-disabled by default for lead-acid presets

Charging Status LED: None. Battery SOC LEDs: R-G sequencing. This fault is set when battery voltage is above the Load HVD setpoint if enabled. The controller will disconnect the load output and set a Load High Voltage Disconnect fault. This fault is designed to protect sensitive loads from excessive voltage. Recovery occurs at Load HVD re-connect threshold, if programmed, and the fault will clear automatically.

Battery Over-current

Charging status LED: Flashing red. Battery SOC LEDs: R/Y-G sequencing. While rare, if battery current exceeds approximately 130% of the controller's output current rating, this fault can occur. The fault is generally related to fast, large battery voltage transients (connecting a very heavy or capacitive load like an inverter) that are faster than the controller can regulate, and it shuts off to protect the circuitry. The controller will automatically re-start in 10 seconds.

Load Over-current

Charging Status LED: Flashing red. Battery SOC LEDs: R/Y-G sequencing. If the load current exceeds the maximum load current rating, the GenStar MPPT will disconnect the load. The greater the overload the faster the load will be disconnected. A small overload could take a few minutes to disconnect. The GenStar MPPT will attempt to reconnect the load two (2) times. Each attempt is approximately 10 seconds apart. If

the overload remains after two (2) attempts, the load will remain disconnected until power is removed and re-applied.

Load Short Circuit
Battery SOC LED sequence: R/G - Y (similar to load overcurrent is R/Y - G). The GenStar MPPT will attempt to reconnect the load two (2) times. Each attempt is approximately 10 seconds apart. If the overload remains after two (2) attempts, the load will remain disconnected until power is removed and re-applied.

Remote Temperature Sensor (RTS)
Charging Status LED: Flashing red. Battery SOC LEDs: R/Y - G/Y sequencing. A bad RTS connection or a severed RTS wire has disconnected the temperature sensor during charging. See Tables 3.3 and 3.4 in Section 3 for RTS Start-up and Run-time operation and issues.

SOLID CHARGING STATUS LED with SELF-TEST (R-Y-G) Battery SOC FAULTS

Verify that nothing has been miswired. If not, the error is likely critical. the table below lists a few common critical faults. See local meter display (Status Menu) for specific error. Contact an authorized Morningstar dealer for support.

Charging Status LED[1]	Fault	Battery SOC LEDs
Solid red	PV FET Short	R-Y-G sequencing
Solid red	Load FET Short	R-Y-G sequencing
Solid red	Load FET Open	R-Y-G sequencing
Solid red	Damaged heatsink temperature sensor	R-Y-G sequencing
Solid red	Software	R-Y-G sequencing

[1] Solid R Charging Status LED ON with heartbeat blink OFF every five seconds is a critical fault that generally requires service. See local meter display (Status Menu) for specific error.

STAND-ALONE CHARGING STATUS LED INDICATIONS

Charging Status LED	Condition
OFF (with heartbeat ON every 5 sec)	Not charging
Green solid (with heartbeat OFF every 5 sec)	Charging
Momentary flashing red, then solid red[1]	Charger fault[1]

[1] See unit meter display (refer to meter map for location) for specific error.

5.7 LiveView Menus

LiveView is Morningstar web pages served directly from the GenStar MPPT. The web pages closely coincide with the GenStar MPPT meter layout and functions. Many LiveView pages are organized into cards, which are rectangular areas that group commands, settings, and other information. Cards can be rearranged or hidden to suit a user's application preferences.

5.8 Commands

Commands can be accessed in the main LiveView dashboard, or in the primary meter screen.Commands are used to control the functions in Sections 5.8.1 - 5.8.6 below.

☞ ***NOTE:***

To use the Commands in LiveView or Morningstar Mobile, MODBUS writes over Ethernet must be enabled. For security purposes, the, "MODBUS writes over Ethernet", enable/disable setting can only be modified on the local meter display.

5.8.1 Load Commands

Control loads with the following Load control commands.

Load Output Disconnect/ Reconnect
Disconnect and Reconnect the load. Useful for service/maintenance activities or ensuring that all of the loads in the system do not run for a period of time.

Load - LVD Override (XX min))
LVD Override will turn on the load when it has been shut off due to a LVD or LSOCD event. If the battery voltage is above the LVD set-point and/or SOC is above the LSOCD set-point, the load will recover early from an LVD without having to wait for LVR or LSOCR recovery. If the voltage is below the LVD set-point and/or SOC is below the LSOCD set-point, the LVD Override will only recover the load temporarily. It will trigger an LVD Warning alarm and then enter LVD again after the LVD Warning Time (XX min) has expired.

5.8.2 Counters Commands

Clear-reset counters using commands:

All Resettable Counters
Resets the Resettable A-h and Resettable kW-h counter values to zero. Resettable counters are intended to track mostly in the short-term, for example, accumulations since a battery replacement, or a new load was added to a system.

All Total Counters
Clears the Total A-h and Total kW-h counter values to zero. Total counters are intended to track long-term / lifetime accumulations of a system.

5.8.3 Toggle Battery Charger Command

Connect or disconnect charging functions using commands:

Manual Equalization
Manually start or stop an equalize charge on a lead-acid battery. This command is only functional for battery

charging profiles with Equalization enabled

Battery Charger
Override normal operation and force the battery charger to a disconnected state. The GenStar MPPT will not charge the battery while the charger is in disconnected state.

5.8.4 System Commands

Activate System commands:

Reboot Control
Software resets the GenStar MPPT. All controller functions, including battery charging and power to the loads, will cease until the reboot is complete.

5.8.5 External Source Control (ESC) Commands

Control external source signal with commands:

- **ESC Enable:** Override the current ESC state and energize the ESC relay while still taking into account the Timing Controls (max runtime and min offtime). Only available for Custom ESC Mode.
- E**SC Disable:** Override the current ESC state and de-energize the ESC relay while still taking into account the Timing Controls (min runtime). Only available for Custom ESC Mode.
- **Manual Generator Control (Enable/ Disable):** Manually turn on/off the ESC relay while still taking into account the Timing Controls (max runtime and min offtime for Enable; min runtime for Disable). Only available for Manual ESC Mode.
- **E-Stop:** De-energize the ESC relay immediately.

5.8.6 ReadyRelay Commands

ReadyRelays that have been configured for the Command/Schedule function (Section 4.2.7 Relay Function #5) can be toggled ON-OFF with the ReadyRelay Commands.

If a Schedule has also been set, the relay can only be controlled when it is not scheduled to be on.

Installed Relay Blocks will be listed by positions 1-3 (maximum), and show Relay A and/or B. Position 1 is the first block on the left.

5.9 History

The History Page consists of Daily Records, Event Logging and Ah and kWh Counters as indicated below. The Event Logger provides real-time stamping of system events on all aspects of operation. Combined, the history features provide a full picture that allows users to assess performance and investigate operational issues.

Daily Records

Displays the following records for up to 3-4 years in time - depending on how many daily variables are logged:

- Battery NET (A-h)
    - Charging Timers (mins)
        - Absorption
        - Float
        - Equalize
- Max. Battery Voltage (V)
- Min. Battery Voltage (V)
- Max. Battery Temperature (°C)
- Min. Battery Temperature (°C)
- Array Voltage max
- GenStar Charge kWh
- GenStar Charge Ah
- GenStar Load Ah
- System Net Battery Ah
- System Charge kWh
- GenStar Net Battery Ah
- System Charge Ah
- System Load Ah
- Shunt (1a, 1b, 2a...) Ah (if installed)
- Control reset (Yes, No)
- Faults & Alarms

The GenStar can store a finite number of daily records internally. However, the data size of daily records will expand as data from ReadyBlocks and other accessories are added. This will reduce the maximum number of records that can be stored internally.

With the 8 GB SD card, nearly an infinite number of daily records can be stored (files only). The records on the SD card are not shown in LiveView.

Event Logging

All loggable variables are recorded, and can be filtered by event type, date range, specific date and some assignments within an Event Type. Event Types and variables may change depending on current firmware reporting parameters.

Event logging can be configured either in LiveView webpage or in local meter display.

A complete list of logged variables can be seen in local meter display or LiveView/History/Event Log

Loggable events are divided into Event Types (and examples for each type):
Battery
Issues (Errors) - Faults and alarms
Network - Time servers, LAN connections
ESC - ESC events
Command - DC load output disconnected System

Counters

The Counters tab includes the accumulated Daily (today), Resettable and Total Ah and kW values. This includes the same Ah and kWh variables as indicated in the Daily Records above.

The Resettable and Total Counters can be cleared using the Counters Commands indicated in Section 5.8.2.

5.10 Firmware Updates

It is recommended to keep the GenStar MPPT controller updated with the latest version of the firmware as it becomes available. Refer to the GenStar MPPT Firmware Updates Guide, available on the GenStar MPPT Firmware page, for complete firmware update instructions: https://www.morningstarcorp.com/technical-doc-genstar-firmware-updates-guide/

There are four ways to update the firmware for the GenStar MPPT controller:

- SD Card
- LiveView Webpage
- Morningstar Mobile App
- MSLoad™ Windows Utility program

Download Firmware

To use an SD Card, LiveView or MSLoad™, the GenStar MPPT firmware must first be downloaded from the Morningstar website at https://www.morningstarcorp.com/firmware/genstar-mppt-firmware/. The firmware file will download to your computer as a ZIP folder, and will need to be extracted for use. Once extracted, save the GenStar firmware file to an easily accessible location, e.g., desktop.

SD Card

1. Copy the downloaded firmware file to the /FIRMWARE directory of the SD card (included).
2. Insert SD card into the side slot to the left of the GenStar MPPT meter
3. Navigate to Setup\Firmware\Load Firmware
4. Select the desired firmware file, and confirm loading from the SD Card
5. A progress bar will indicate loading of firmware update into the GenStar MPPT memory. This will take several minutes.
6. When complete, select Okay to update the GenStar MPPT firmware

After loading the firmware file into GenStar MPPT memory the GenStar will need to be rebooted. Wait for the green flashing LED to become solid before rebooting the controller again to complete the process (note that the Green LED flashing will stop once and start again after approx. 45 seconds).

LiveView Webpage

To update firmware via an RJ-45/Ethernet connection, first follow the instructions in 4.1.3 to set up a LiveView connection in a Web browser. Select the "Update" tab and then select "Choose a File", select the new GenStar firmware .msc file and click the "Upload" button. Follow the prompts to reboot the controller. It may take up to 10 minutes or more depending on the speed of the connection to complete the firmware update.

CAUTION:

The controller may fail to properly reboot after a firmware update leaving the system offline and without power. It is recommended to be physically near the device during the firmware update in the event a manual power cycle is needed to bring the system back online. Before starting, always select the checkbox to automatically reboot after the update on the Update tab and then select reboot when prompted during the update. ***The system will lose power during a reboot.***

Morningstar Mobile App

The Morningstar Mobile App includes the latest version of the GenStar firmware when installing or updating the app. See Section 4.1.2 for information about the Morningstar Mobile App. After connecting to the GenStar MPPT controller, select the firmware update icon on the bottom right of the mobile app and follow the directions on the screen to update the firmware.

NOTE:

Keep the Morningstar Mobile App open and maintain a Bluetooth connection with the GenStar MPPT controller during the Firmware update. If the connection is lost, it may be necessary to cycle power to the GenStar and re-start the firmware update.

MSLoad™ Windows Utility program

For USB, RS-232 or EIA-485 serial connections, download MSLoad™ from morningstarcorp.com to a PC. With access to the new firmware (.msc) file, start MSLoad™ and when prompted, choose the desired file. Refer to the README file included with MSLoad™ for detailed instructions.

5.11 Inspection and Maintenance

Table 5-5 below lists the recommended maintenance schedule to keep the GenStar MPPT performing optimally.

WARNING: RISK OF ELECTRICAL SHOCK

No power or accessory terminals are electrically isolated from DC input, and may be energized with hazardous solar voltage. Under certain fault conditions, battery could become over-charged. Test between all terminals and ground before touching.

WARNING: SHOCK HAZARD

Disconnect all power sources to the controller before removing the wiring box cover. Never remove the cover when voltage exists on the GenStar MPPT power connections.

Schedule	Maintenance Items
2 weeks after installation	Re-tighten power terminal connections to specified torque values.
3 months after installation	Re-tighten power terminal connections to specified torque values.
Monthly or After Each Equalization	Inspect the battery bank. Look for cracked or bulging cases, and corroded terminals. For wet cell (flooded type) batteries, make sure the water level is correct. Wet cell water levels should be checked monthly or according to the manufacturer's recommendations.
Annually	Clean the heatsink fins with a clean, dry rag . Inspect all wiring for damage or fraying. Inspect for nesting insects. Re-tighten all wiring terminal connections to specified torque values. Inspect the system earth grounding for all components. Verify all grounding conductors are appropriately secured to earth ground.

Table 5-5. Maintenance Schedule

6.0 NETWORKING AND COMMUNICATIONS

6.1 Introduction

NOTE:
MS-CAN (CANbus) functionality is not available with initial release.

The GenStar MPPT provides several communication options. The GenStar MPPT uses a proprietary protocol for the MS-CAN network and the non-proprietary open standard MODBUS™ and MODBUS TCP/IP™ protocols for RS-232, EIA-485, and Ethernet networks. Additionally, HTTP and NTP are supported for web page and real-time clock support.

Hardware and third party software that supports the MODBUS™ protocol can be used to communicate with a GenStar MPPT.

The GenStar MPPT controller includes several communications ports as shown in Figure 6-1.

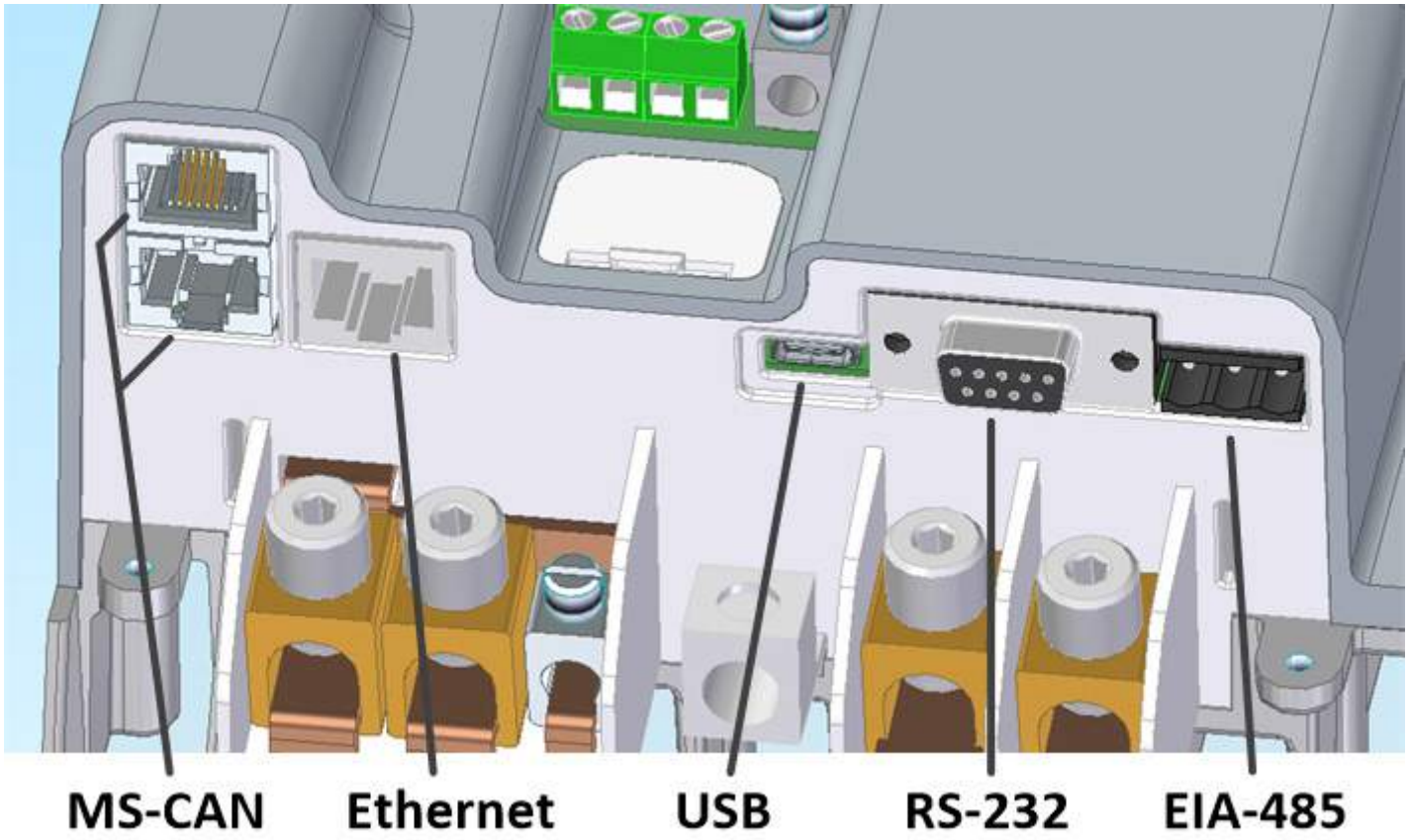


Figure 6-1 Communication Ports on the Genstar

Table 6-1 below provides a summary of supported features for each communication interface.

	MS-CAN	USB-C	RS-232	EIA-485	Ethernet
Connect a GS-MPPT to other Morningstar devices	•				
Connect multiple GS-MPPT together in a network	•			•	•
Update firmware		•	•		•
Modbus communications			•	•	•
LiveView web app: View data, change settings, update firmware					•

Table 6-1. Communications summary

Multiple communication ports can be used simultaneously - **note that the USB-C, RS-232, and EIA-485 connections share hardware, and therefore cannot be used simultaneously.** For example, a GenStar MPPT controller can use Ethernet and a EIA-485 with a router to be connected with a Local Area Network (LAN) and the Internet simultaneously.

6.2 Morningstar MS-CAN

(*MS-CAN functionality is not available with this release.*)

Morningstar's proprietary MS-CAN allows communication between compatible Morningstar products. Use MS-CAN to:

- Display net system data for multiple GenStar MPPT systems
- Share battery temperature information across multiple GenStar MPPT controllers
- Synchronize charging stages across multiple GenStar MPPT controllers
- Aggregate data and centrally control Morningstar load devices like SureSine inverters

6.3 Serial RS-232

The serial port connection on the GenStar MPPT is a standard 9-pin isolated RS-232 port. See Figure 2-3 (#9) for the port location.The GenStar MPPT communicates through the serial port via the open standard MODBUS™ protocol.

Connect the GenStar MPPT to the serial port for:

- Modbus RTU communications
- Controller firmware updates with MSLoad™ firmware utility. LiveView or SD Card firmware updates are recommended for faster uploads.

NOTE:
The RS-232 and EIA-485 ports share hardware. Both ports cannot be used simultaneously.

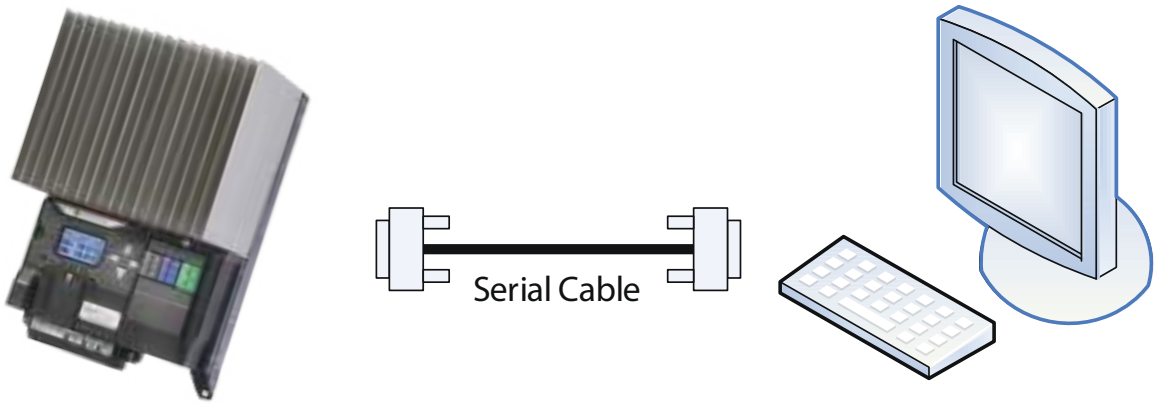


Figure 6-2. A serial connection between a PC and the GenStar MPPT

Default Serial Port Settings:

- 9600 Baud rate
- 8 data bits
- 1 or 2 stop bits
- no parity

6.4 Modbus and ModbusIP via EIA-485

EIA-485 is a networking standard for serial communication between multiple devices on a bus. The GenStar MPPT communicates over an EIA-485 network via the open standard MODBUS™ protocol. Use EIA-485 networking to:

- Modbus RTU communications
- Controller firmware updates with MSLoad™ firmware utility. LiveView or SD Card firmware updates are recommended for faster uploads. (See section 5.10)
- Bridge an Ethernet connection through a GenStar MPPT to an EIA-485 network

Each device in the EIA-485 network must have a unique MODBUS™ Address. Change the GenStar MPPT Modbus address from the device Modbus address as required for each device.

A bridged Ethernet connection through a GenStar MPPT to an EIA-485 network can provide an Ethernet connection through a Genstar MPPT to a EIA-485 network. The Genstar unit used to bridge the Ethernet connection to the EIA-485 network must have, "Bridging", enabled in either its local meter or in LiveView.

EIA-485 WIRING

The EIA-485 port has three (3) connections: GND, Data A, Data B. Data A & B are differentially driven data lines that carry the network data. The GenStar MPPT supplies isolated power to the EIA-485 network, eliminating the need for an external bus power source in many cases.

WARNING: SHOCK HAZARD

Before wiring, verify that all system breakers and disconnect switches are in the OPEN/DISCONNECTED position, and that all fuses are removed from their holders.

Connections:

1. From left to right, connect GND, Data A, Data B wires to the GenStar EIA-485 terminals.
2. Connect GND, Data A and Data B wires (with the same order and orientation as on the GenStar EIA-485 terminals) to a desired bus-connected controller, e.g., another GenStar.
3. If a desired bus-connected (EIA-485 compatible) controller is not a GenStar, a voltage supply will need to be provided to the bus at the connected controller.

Networks requiring power can be supplied by an external source. The source voltage must be between 8-16 Vdc. For 12 Volt systems, the network can be powered directly from the system battery. For 24, 36, and 48 Volt systems, use a DC-DC converter.

CAUTION: EQUIPMENT DAMAGE

Tapping power off of individual batteries in a series string of batteries can cause a voltage imbalance. Damage to the batteries may result. Always use a DC-DC converter to power the EIA-485 network if the nominal system voltage is greater than 12 volts.

NOTE:

The RS-232 and EIA-485 ports share hardware. Both ports cannot be used simultaneously.

NOTE:

Termination resistors may be required to prevent interference from reflected signals. If required, install termination resistors at both ends of the data bus across Data A and Data B to match the characteristic impedances of the communication cables (120Ω for RS-485 single twisted pair, 100Ω for Category 5 Ethernet).

For more information on EIA-485 networking, refer to the, “Morningstar Communications Document”, on the Morningstar website at:

www.morningstarcorp.com

6.5 Ethernet

CAUTION: RISK OF TAMPERING

The GS-MPPT does not feature built-in network security. It is the responsibility of the user or network administrator to place the GS-MPPT behind a network firewall to prevent unauthorized access.

The Ethernet port supports HTTP, MODBUS TCP/IP™, and NTP protocols to provide a fully web-enabled interface between the GenStar MPPT and a LAN/WAN network or the internet. Use the Ethernet connection to:

- View the LiveView web app - see Section 4.1.3 - from a PC or mobile device on the same LAN/WAN
- Communicate with the GenStar MPPT via Modbus TCP/IP

This section provides a summary of the feature. For detailed information about Ethernet connectivity and networking, refer to the, “Morningstar Communications Document”, on the Morningstar website at:

www.morningstarcorp.com

6.6 Simple Network Management Protocol (SNMP)

SNMP is an IP-based communications protocol. Some uses and advantages include:

- favors a centralized system network management
- allows simultaneous mass device polling and reporting
- allows coil reads and writes
- supports an unlimited number of pollable devices
- low system latency, i.e., minimal system processing resources are used
- low-level security Community Strings are included and verified with each query

NOTE:
Firmware may not be updated using SNMP writes
SNMPv3 supported with Firmware version 3.0.0
SNMPv2c supported with Firmware Version 2.2.6 to 2.3.4

A MIB File
Available at morningstarcorp.com - serves as a directory of system information available for retrieval from the GenStar MPPT using an SNMP ***GET*** Command***,*** or from the MIB itself***.*** The GET Command is described below.

An Object Identifier (OID)
Is a component of a MIB File that contains either a single, or a collection of variables, e.g., solar specific values which can be queried by, or configured from, an SNMP Browser on a Network Management System (NMS)/Manager monitoring computer.

SNMP commands can retrieve, manage, modify, and parse GenStar MPPT data. The GenStar unit acts as an SNMP Agent.

There is various third-party, licensed NMS software available for using SNMP to monitor the GenStar MPPT. NMS MIB files, along with a MIB importer and SNMP browser applications, may be required to set up and run SNMP communications.

An industry-standard GenStar MPPT MIB File with OIDs and scaling factors is contained in a zip file that can be downloaded at **https://www.morningstarcorp.com/support/library/?_document_product=23774&_document_type=technical-document.** The following commands are supported:

SET
The SNMP SET operation is used by the management applications and applets to modify the value of the managed object. If needed for an application, one or more MIB variables can be modified by using the SNMP SET operation.

SNMP WRITE PROCESS

1. Write the new value for a given setting:

   A. SNMP SET SETTING_OID NEW_VALUE

2. Write the new value to EEPROM by writing "TRUE" to the EEPROM session apply coil:

   C. SNMP SET EEPROM_SESSION_APPLY_OID TRUE [Writing "FALSE" to this coil will cancel the write operation, and then require repeating Step 1.]

4. Perform a soft re-boot (which loads the newly written value(s) from EEPROM) by writing “TRUE” to the reset coil:

   A. SNMP SET RESET_OID TRUE

GET
A Manager-to-Agent request to retrieve the value of a variable or list of variables on a specific OID. Retrieval of the specified variable values is an atomic operation by the Agent, i.e., it will not be completed without all requested values returned.

GETNEXT
A Manager-to-Agent request to discover available variables and their values. Method used by SNMP manager to work through an ordered list of OIDs according to the standard MIB hierarchy. Returns a response with variable binding for the next variable in the MIB.

GET BULK
A sequence of GetNext requests, allowing a large segment of the MIB hierarchy to be queried by the SNMP manager from a managed device.

RESPONSE
Used by the SNMP agent to deliver requested information. Also acts as an acknowledgment.

DEFAULT PORT ASSIGNMENTS

Port 80 - MODBUS HTTP
Port 161 - SNMP Agent Receiving Port
33333 is Morningstar's registered IANA enterprise number and
1.3.6.1.4.1 is the standard address to the “enterprises” node, so
Morningstar Enterprise OID = 1.3.6.1.4.1.33333

SNMP Troubleshooting

Confirm data inconsistency with other MS monitoring platforms, e.g., MODBUS TCP, HTTP-LiveView, and then ensure the following:

- MIB files are current and all reference MIBs are uploaded simultaneously, i.e., MORNINGSTAR.mib, and GenStar MPPT.mib
- Each OID references the appropriate data value type listed in the MIB file
- Community String names are properly configured (they will reset after a factory reboot). Write Community should be set to, “private”. Read Community should be set to, "public".
- Network monitoring software is set to SNMPv3 with Firmware version 3.0.0 and later or SNMPv2c with Firmware Version 2.2.6 to 2.3.4
- Correct IP address and Root OID are used for SNMPWalk

6.7 Network Information

Connect to the GenStar MPPT via an Ethernet network (LAN/WAN) or connect the controller directly to a PC using an Ethernet cable. Use CAT-5 or CAT-5e twisted pair Ethernet cables with RJ-45 connectors. A network diagram for both scenarios is shown in Figure 6-3 below.

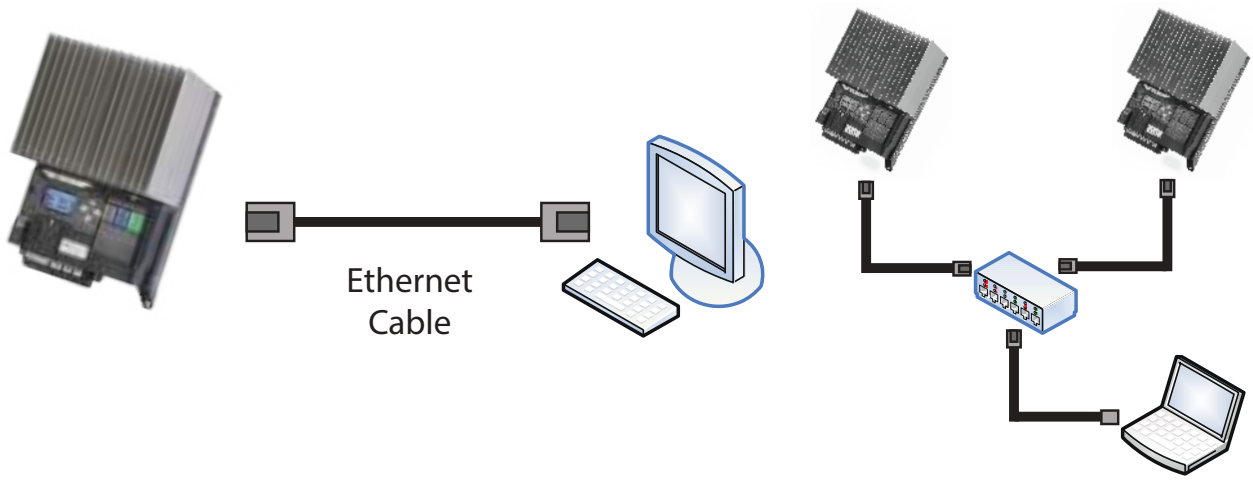


Figure 6-3. Ethernet network diagrams

Factory Default Network Settings

DHCP	Enabled
LiveView Web Address	http://gsmppt + serial number[1]
IP Address	169.254.x.y (with no acknowledgement from the DHCP server)
Subnet Mask	255.255.255.0
Gateway	192.168.1.1
Primary DNS Server	169.254.1.1
MODBUS TCP/IP™ Port	502
MODBUS TCP/IP™ HTML	80

[1] The LiveView web address is unique to each controller. If the GenStar MPPT serial number is 09501234, then the GenStar MPPT's LiveView address is: http://gsmppt09501234. For reference, the LiveView web address is printed on the serial label on the side of the unit.

The controller's MAC Address is located on the serial label on the side of the controller.

Two (2) LEDs on the Ethernet jack indicate link and activity status.

Condition	Green LED	Yellow LED
Network Connection OK	ON	OFF
Network Activity	ON	Blinking
Error	OFF	ON

6.8 Accessing LiveView Web Pages

Connect the GenStar MPPT controller to the network using an Ethernet cable. Wait up to five to ten minutes for the controller to connect to the network. Open a web browser on a PC or mobile device on the network. Enter the LiveView web address in the address bar of the web browser. LiveView webpages are context-aware and will properly format to the device's screen size.

Also see Configuration Section 4.2.2 Network Settings for further details.

7.0 TROUBLESHOOTING

WARNING: RISK OF ELECTRICAL SHOCK.

NO POWER OR ACCESSORY TERMINALS ARE ELECTRICALLY ISOLATED FROM DC INPUT, AND MAY BE ENERGIZED WITH HAZARDOUS SOLAR VOLTAGE. UNDER CERTAIN FAULT CONDITIONS, BATTERY COULD BECOME OVER-CHARGED. TEST BETWEEN ALL TERMINALS AND GROUND BEFORE TOUCHING.

WARNING: Shock Hazard

A means of disconnecting all power supply poles must be provided. These disconnects must be incorporated in the fixed wiring. Open all power source disconnects before removing controller wiring cover, or accessing wiring.

7.1 LED Fault Indications

Fault	Charging status LED	Battery SOC LEDs
Battery Over-current	Flashing Red	R/Y-G sequencing
Custom Settings Edit	Flashing Red	R/Y-G sequencing
Firmware Update Failure	No G-Y-R startup sequence - Green and then solid Yellow	
High Heatsink Temperature	Flashing red	R-Y sequencing
High Solar Voltage Disconnect	Flashing red	No errors
Load High Voltage Disconnect	None	R-G sequencing
Load Over-current	Flashing red	R/Y-G sequencing
Load Short Circuit	Flashing red	R/Y-G sequencing
Remote Temperature Sensor (RTS)	Flashing red	R/Y - G/Y sequencing
Solar Short-Circuit	Off	No errors
Solar-Battery High Voltage Disconnect	Flashing red	R-G sequencing

Table 7-1 LED Fault Indicators

See section 5.6 Faults and Alarms for detailed descriptions.

7.2 Battery Charging and Performance Issues

Problem:

No LED indications, controller does not appear to be powered

Solution:

With a multi-meter, check the voltage at the battery terminals on the GenStar MPPT. Battery voltage must be 9 Vdc or greater. If the voltage on the battery terminals of the controller is between 9 and 72 Vdc, and no LEDs are lit, contact your authorized Morningstar dealer for service. If no voltage is measured, check wiring connections, fuses, and breakers.

Problem:

The GenStar MPPT is not charging the battery.

Solution:

Check the three (3) battery SOC LEDs. If they are flashing in a sequence, to determine the cause, see Sections 5.6 and 6.1 of this manual. Meter and LiveView will display active faults and alarms.

If the LED indications are normal, check the fuses, breakers, and wiring connections in the power source wiring. With a multi-meter, check the array voltage directly at the GenStar MPPT solar input terminals. Input voltage must be greater than battery voltage before charging will begin.

Problem:
Controller makes buzzing and humming noises.

Solution:
No action is required. This is expected due to magnetic resonance and circuit switching.

If troubleshooting does not correct the problem, please refer to Morningstar's Warranty Claim Procedure in Section 8.

8.0 WARRANTY & POLICIES

WARRANTY

LIMITED WARRANTY - Morningstar Solar Charge Controllers and Inverters

Integrated Series products, SureSine Family (Gen 2) inverters and other Morningstar *Professional Series™* products, except the SureSine™-300 Classic (Gen 1) inverter, are warrantied to be free from defects in materials and workmanship for a period of FIVE (5) years from the date of shipment to the original end user. Warranty on replaced units, or field-replaced components, will be limited only to the duration of the original product coverage.

Morningstar *Essentials Series™ products,* and SureSine™-300 Classic (Gen 1) inverter, are warrantied to be free from defects in materials and workmanship for a period of TWO (2) years from the date of shipment to the original end user. Warranty on replaced units, or field-replaced components, will be limited only to the duration of the original product coverage.

Morningstar will, at its option, repair or replace any such defective units.

CLAIM PROCEDURE:

Before requesting warranty service, check the operator's manual, including any troubleshooting section, to verify product failure. To begin the warranty replacement process, contact your authorized Morningstar distributor or dealer for assistance with troubleshooting and, if necessary, obtaining an RMA number.

An RMA number must be issued by Morningstar prior to return of any unit(s) under this warranty. Required RMA information:

A. purchase location - business or company name - and date

B. full model and serial numbers (SN is 8-digits on unit bar label)

C. failure behavior, including LED indications

D. array configuration, panel Pmax, Voc, Vmp, Isc, and nominal battery voltage - these

E. specifications are needed to receive assistance.

F. multi-meter available (for field troubleshooting)

After the dealer is contacted, and is not able to assist with warranty claim, contact Morningstar Technical support at support@morningstarcorp.com. Please provide proof of date and place of purchase, and all details listed in preceding paragraph.

WARRANTY EXCLUSIONS AND LIMITATIONS:

This warranty does not apply under the following conditions:

- Damage by accident, negligence, abuse or improper use
- PV or load currents exceeding the ratings of the product
- Unauthorized product modification or attempted repair
- Damage occurring during shipment
- Damage resulting from acts of nature such as lightning, weather extremes, or infestation

(Cont.)

THE WARRANTY AND REMEDIES SET FORTH ABOVE ARE EXCLUSIVE AND IN LIEU OF ALL OTHERS, EXPRESS OR IMPLIED. MORNINGSTAR SPECIFICALLY DISCLAIMS ANY AND ALL IMPLIED WARRANTIES, INCLUDING, WITHOUT LIMITATION, WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE. No Morningstar distributor, agent or employee is authorized to make any modification or extension to this warranty.

MORNINGSTAR IS NOT RESPONSIBLE FOR INCIDENTAL OR CONSEQUENTIAL DAMAGES OF ANY KIND, INCLUDING BUT NOT LIMITED TO LOST PROFITS, DOWN-TIME, GOODWILL OR DAMAGE TO EQUIPMENT OR PROPERTY.

Morningstar Corporation

8 Pheasant Run, Newtown, PA 18940 USA

(215) 321-4457

www.morningstarcorp.com

support@morningstarcorp.com

R20-4/23

9.0 TECHNICAL SPECIFICATIONS

	GS-MPPT-60M-200V	GS-MPPT-80M-200V	GS-MPPT-100M-200V
Electrical:			
Maximum Battery Charge Current	60 Amps	80 Amps	100 Amps
Maximum Input Voltage (Voc)	ALL: 200 Volts		
MPPT Operating Voltage Range	ALL: > battery voltage + 1 Volt; < 180 Volts		
Max. Input Current (Imp/Isc)	56/60 Amps	75/80 Amps	94/100 Amps
Nominal Operating Voltage	ALL: 12-24-48 VDC		
Battery Voltage Range	ALL: 9-72V (charging); 10-72V (load); Power OFF < 8V		
Maximum Load Current	30 Amps	30 Amps	30 Amps
Maximum Self-consumption	< 2.4 Watts (12/24V); < 3.2 Watts (48V)		
Grounding Leg	ALL: Negative (pos. ground compatible with array float)		
Real Time Clock (RTC)	ALL: With coin cell (CR-2032)		
Peak Efficiency	ALL: 99%		
Transient Surge Protection	ALL: 4500 Watts/port		
Nominal Maximum Output Power (Watts)	12, 24, 48 Volts 800, 1600, 3200	12, 24, 48 Volts 1064, 2128, 4256	12, 24, 48 Volts 1330, 2660, 5320
Mechanical:			
Dimensions (cm/in)	36.4/14.3 (H) x 22.2/8.7 (W) x 17.0/6.7 (D)		
Weight (lb/kg)	14.625 / 6.63	15.625 / 7.09	16.4375 / 7.46
Wire Size Range:			
Battery and PV input terminals	10 - 53.5 mm^2 / #8 - 1/0 AWG		
Load terminals	2.5 - 13.3 mm^2 / #14 - 6 AWG (EXCEPT fine-stranded #6)		
Equip. grounding terminals	2.5 - 33.6 mm^2 / #14 - 2 AWG		
Battery voltage sense and RTS	0.25 - 1.0 mm^2 / #24 - 16 AWG		
Maximum torque:			
Battery and PV input terminals	100 in-lb / 11.3 N-m		
Load terminals	35 in-lb / 3.9 N-m		
Equip. grounding terminals	50 in-lb / 5.65 N-m		
Battery voltage sense and RTS	5 in-lb / 0.565 N-m		
Enclosure	IP20, Type 1		
Battery Charging:			
4-stage Charging:	Bulk, Absorption, Float, Equalization		
Temperature compensation Coefficient:	-30mV/12 volt/ºC (shared for Lead-acid presets; disabled by default for Lithium presets)		
Temperature-compensated set-points:	Absorption, Float, Equalize, HVD, HVDR (solar)		

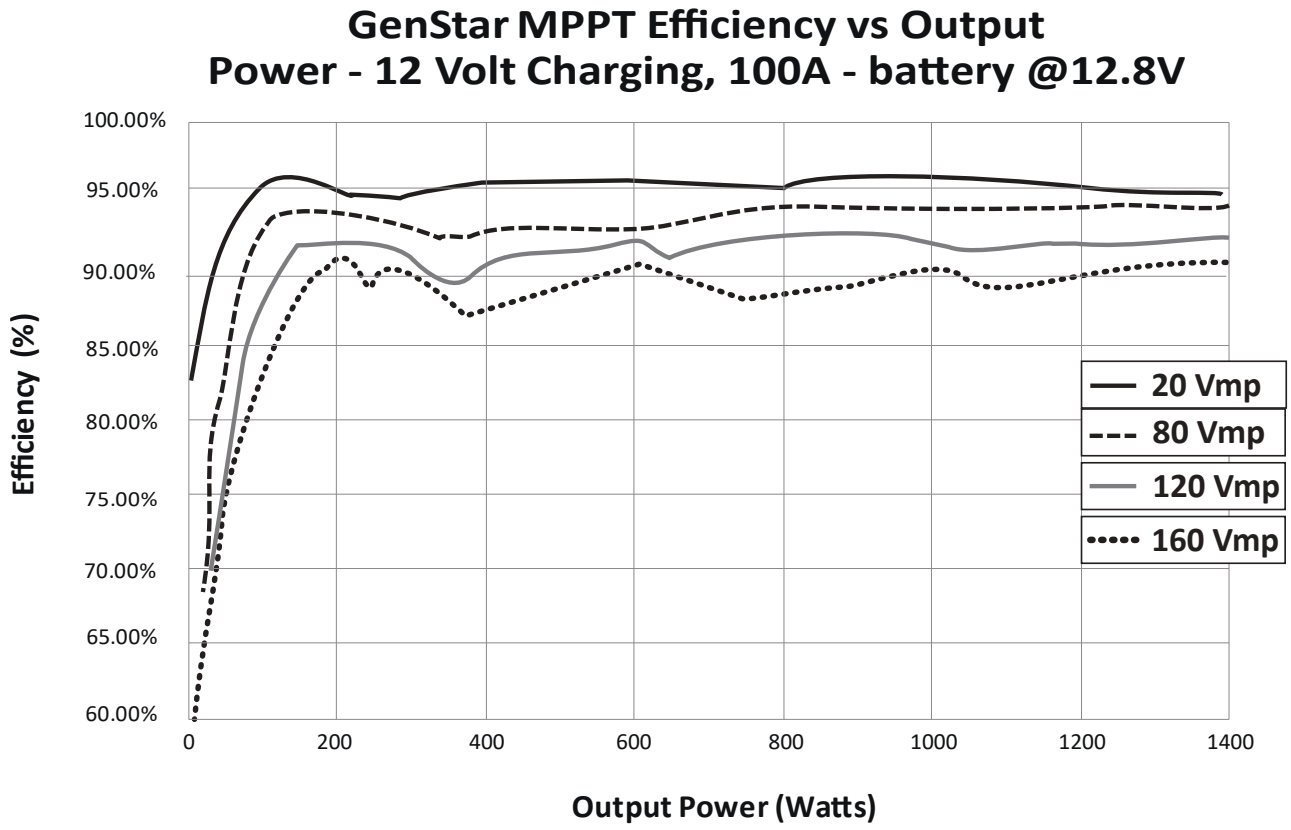
	GENSTAR MPPT - all models
Communication-Interfaces:	
SD Card	Yes (8 GB included)
USB-C for data	Yes
RS-232 Port	Yes
EIA-485 Port	Yes
Ethernet/RJ-45 Port	Yes
Controller Area Network (CAN)	Yes
Bluetooth Low Power	Yes
Supported Protocols	Modbus, ModbusIP, HTTP, SNMP v2c, Bluetooth LE
Datalogging Capacity & Capability	Internal (LiveView): 3 to 4 years daily records; 35,000 to 140,000 events (event frequency can vary greatly) Nearly infinite with 8 GB SD card (datafiles only)
Local Display:	
Digital Meter:	
Resolution	128 x 64
Viewing Area	70mm x 40mm
Display Color Backlight	Blue on white
Operating Temperature	-20°C to +60°C
Storage Temperature	-50°C to +80°C
Environmental:	
Maximum Operating Altitude	3000 meters
Ambient Operating Temperature Range	-30°C to +60°C (current may de-rate above 45°C)[1]
Storage Temperature	-50ºC to +80ºC
Humidity	100% n.c.
Tropicalization	Conformally coated PCBs; Marine-rated terminals

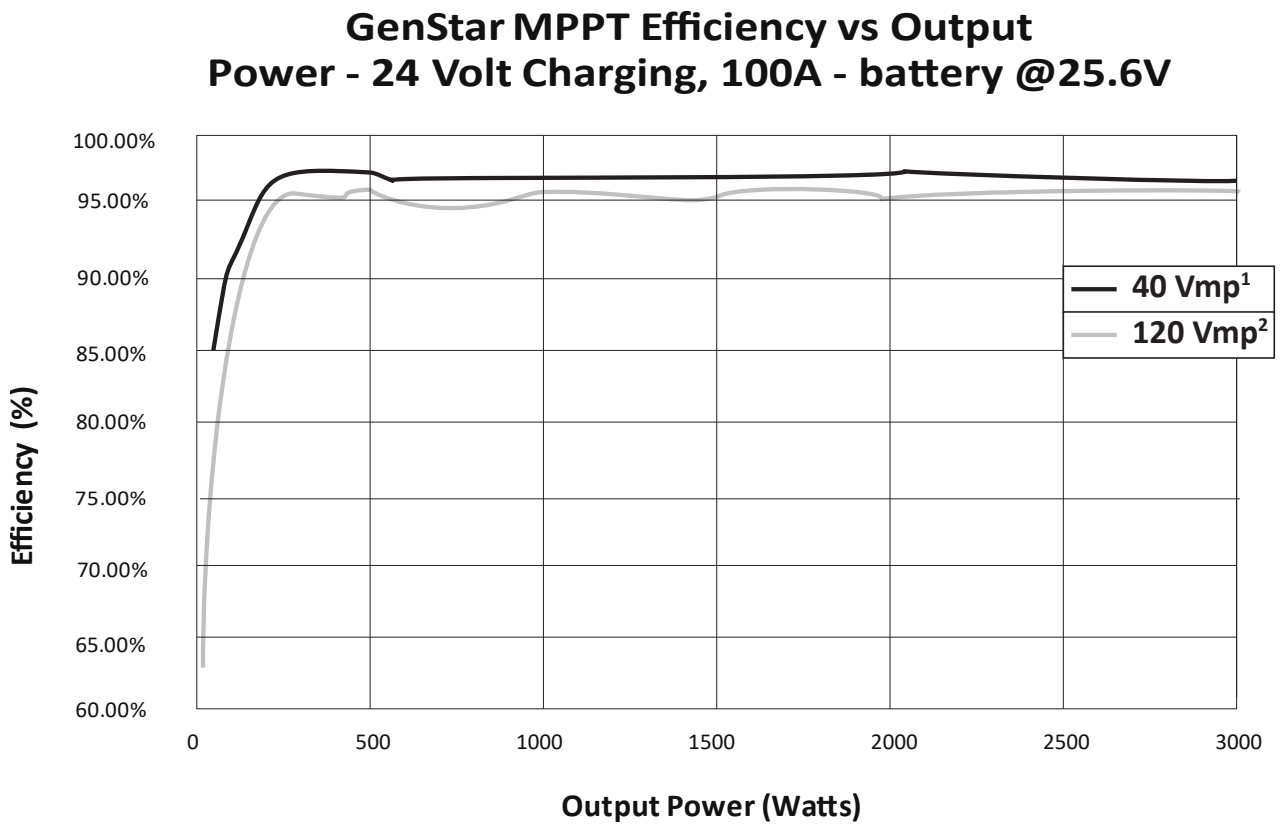
* Thermal performance depends on the model and system parameters. See operating manual and Heat Dissipation of GenStar MPPT Controllers Inside Enclosures white paper for further performance characteristic data and information.

Protections:	
Reverse night	Battery removal
Power-up against any active faults	Low temp foldback
Reverse polarity - array	High temp. foldback
Solar short-circuit	Solar high voltage
Solar overload	Load over-current
High heatsink temperature - current de-rating	Heatsink temperature Limit
High heatsink temperature - load disconnect	High voltage (solar, battery, load)
Load short-circuit	Short-circuit

[*] Thermal performance depends on the model and system parameters.

Efficiency Graphs



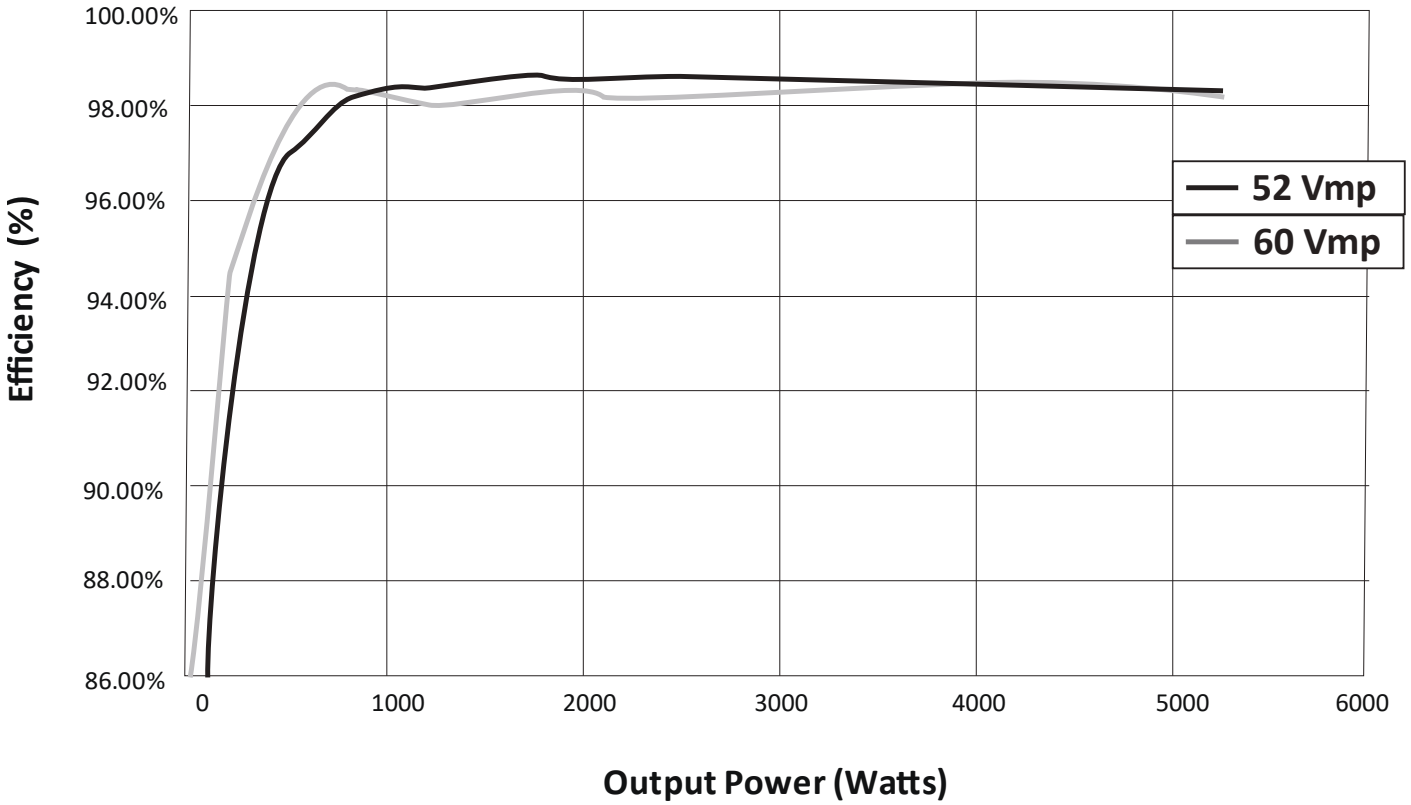


NOTES:

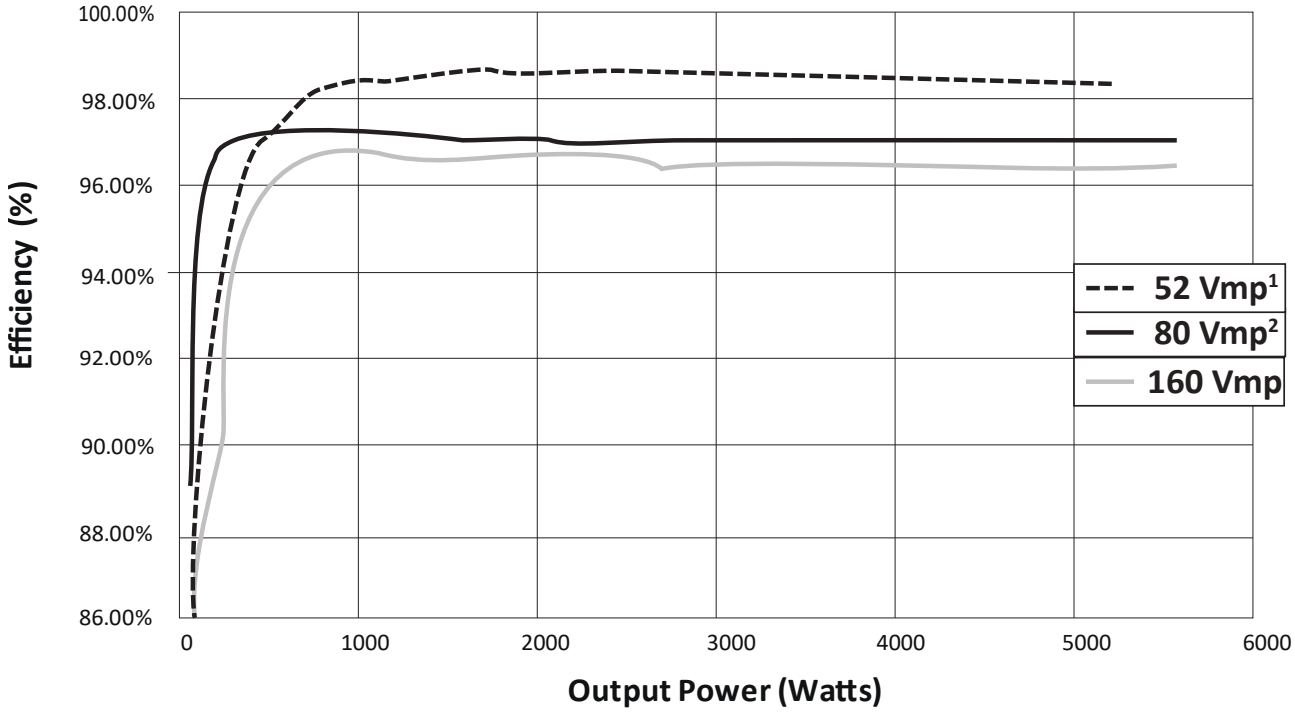
[1] 80 Vmp curve is very close to 40 Vmp, but most power points are slightly less efficient.

[2] 160 Vmp curve is very close to 120 Vmp, but most power points are slightly less efficient.

GenStar MPPT Efficiency vs Output Power - 48 Volt Charging, 100A - Battery @51.2V



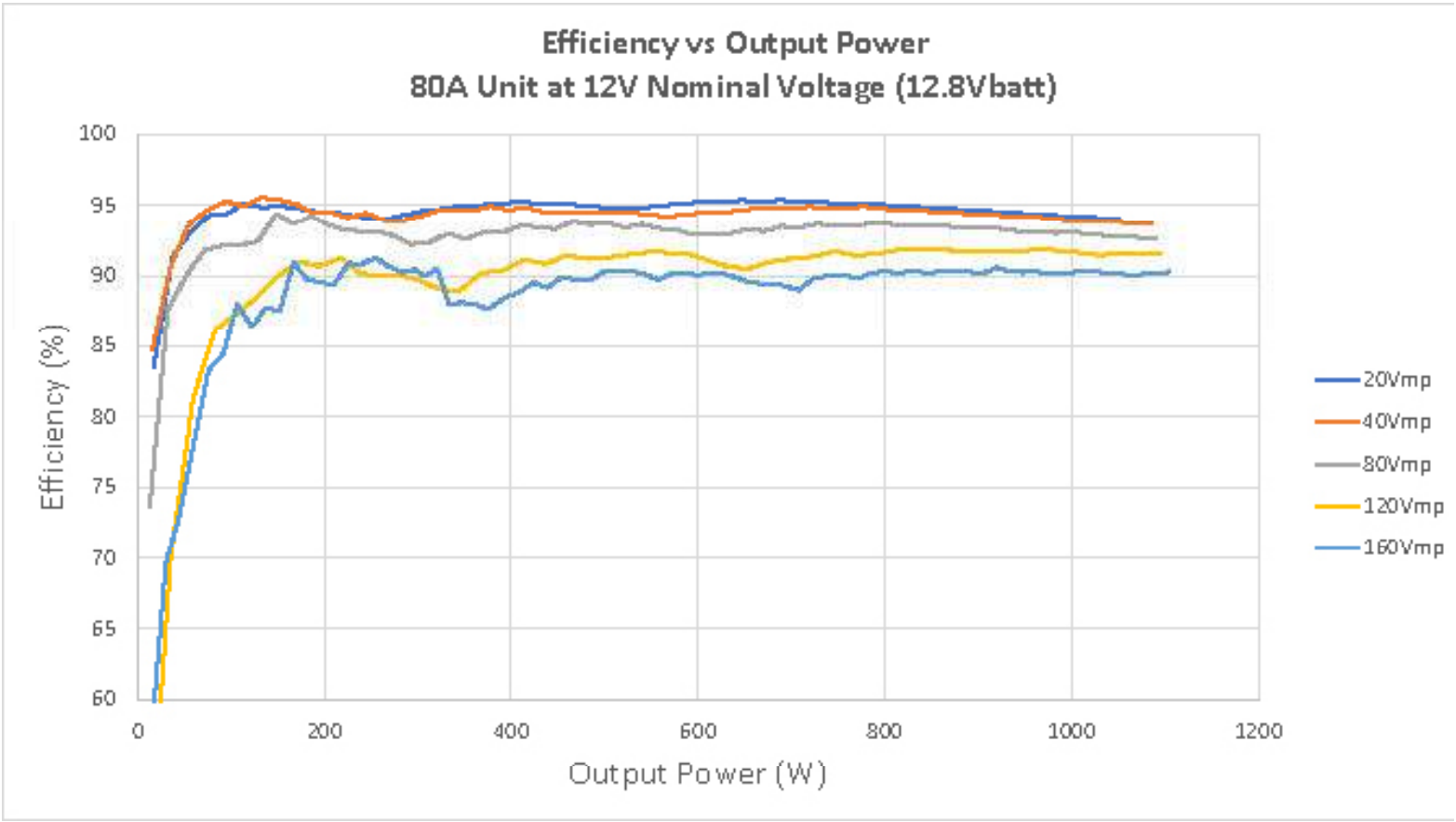
GenStar MPPT Efficiency vs Output Power - 48 Volt Charging, 100A - battery @51.2V

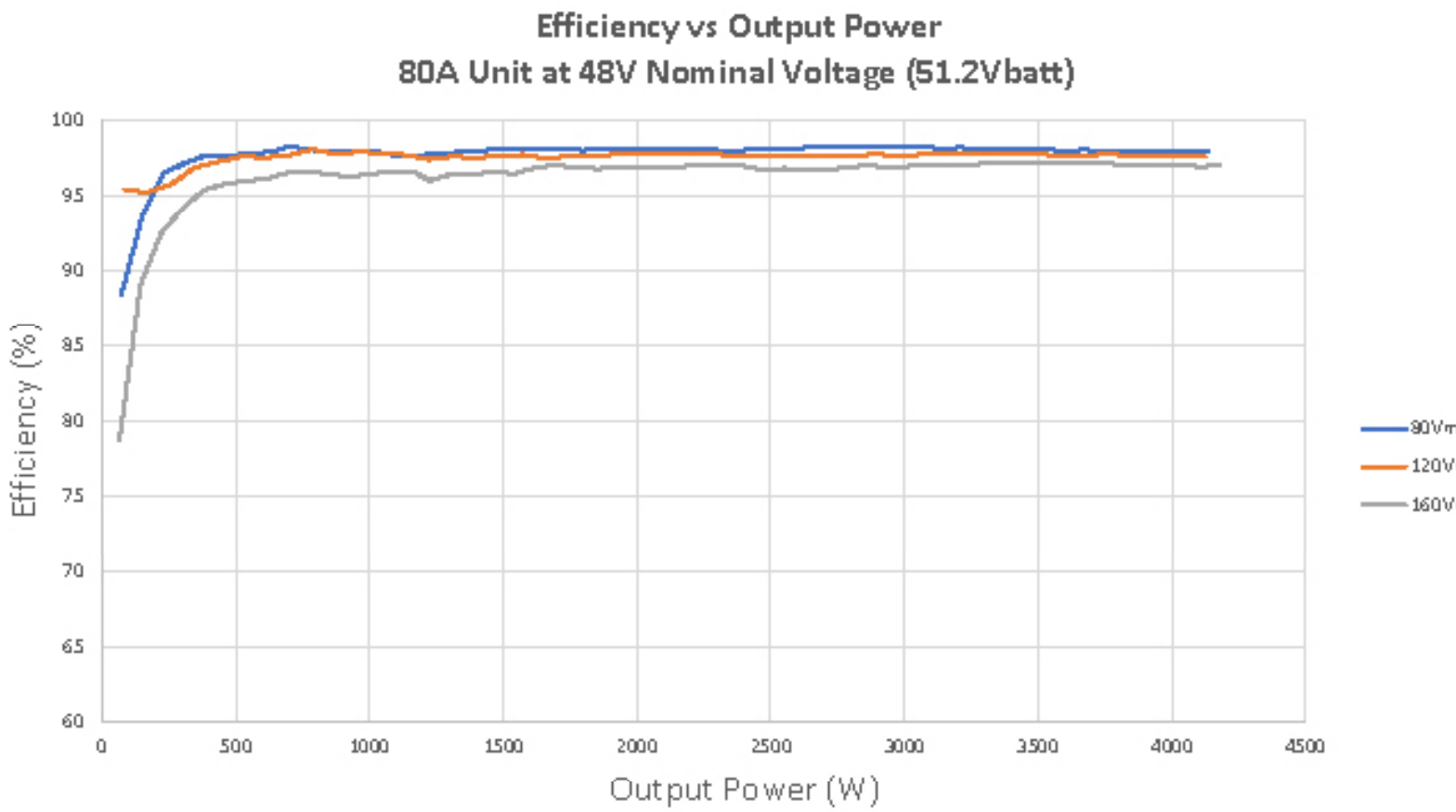


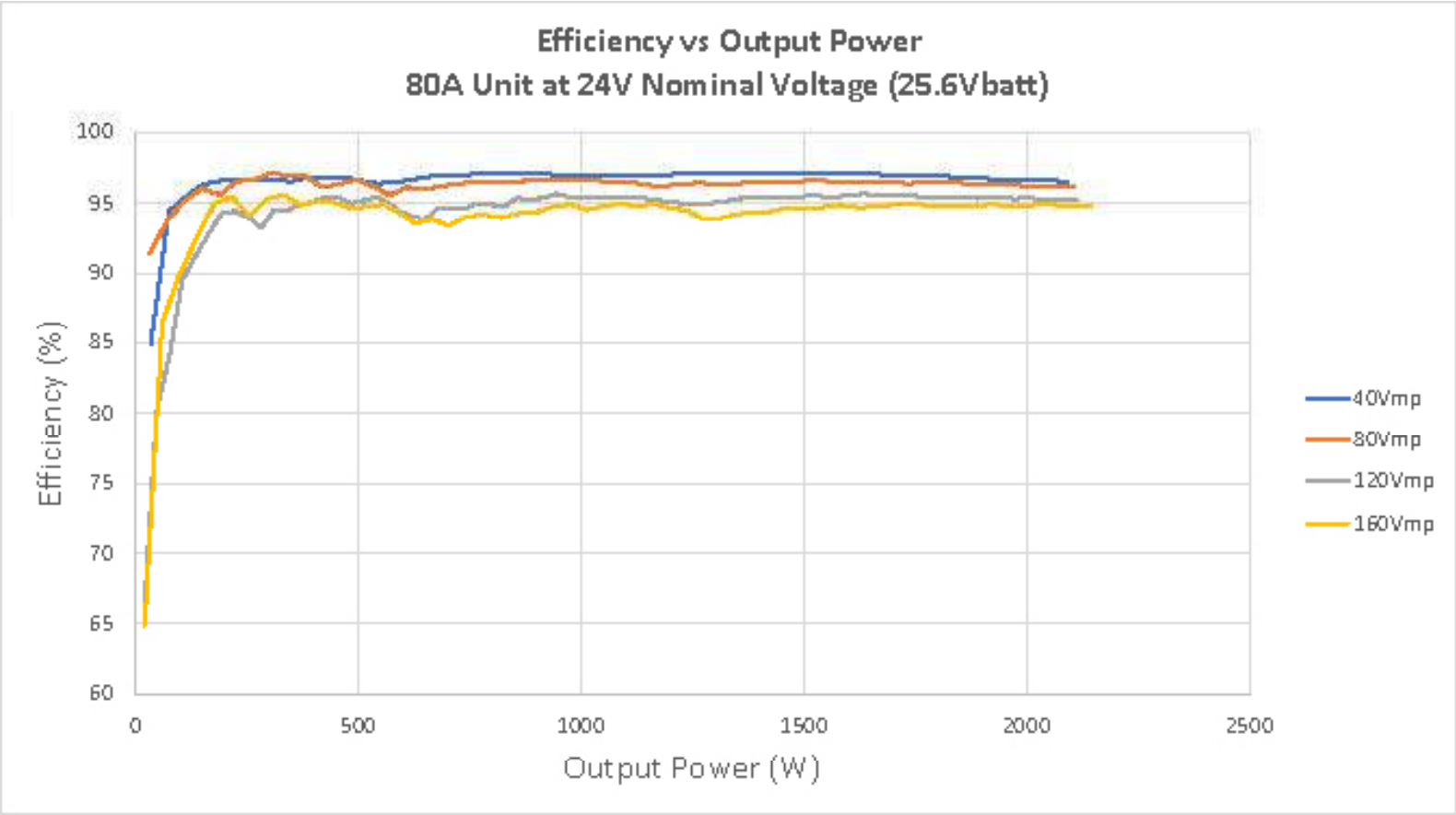
NOTES:

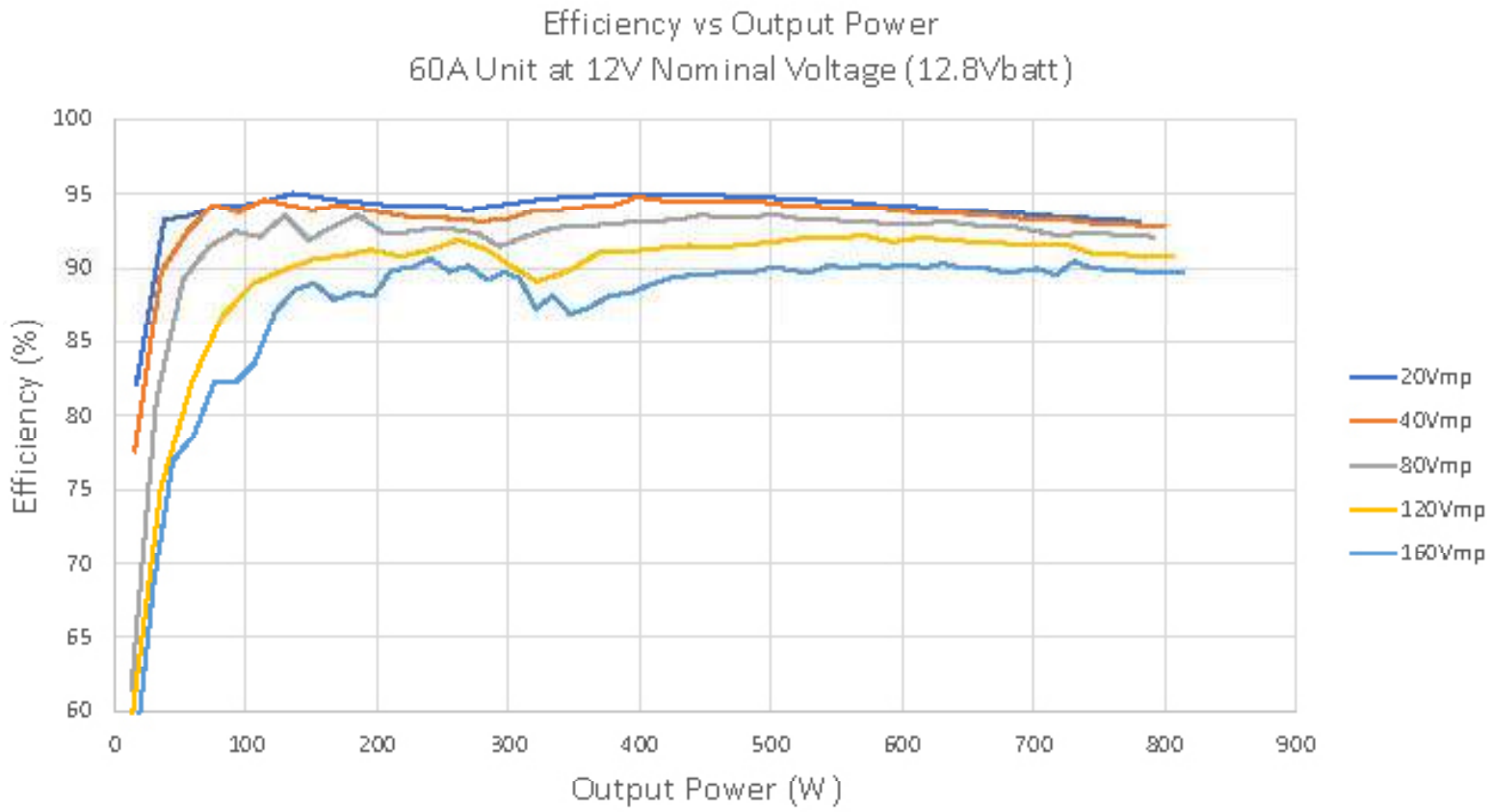
[1] 60 Vmp curve is very close to 52 Vmp, but most power points are slightly less efficient.

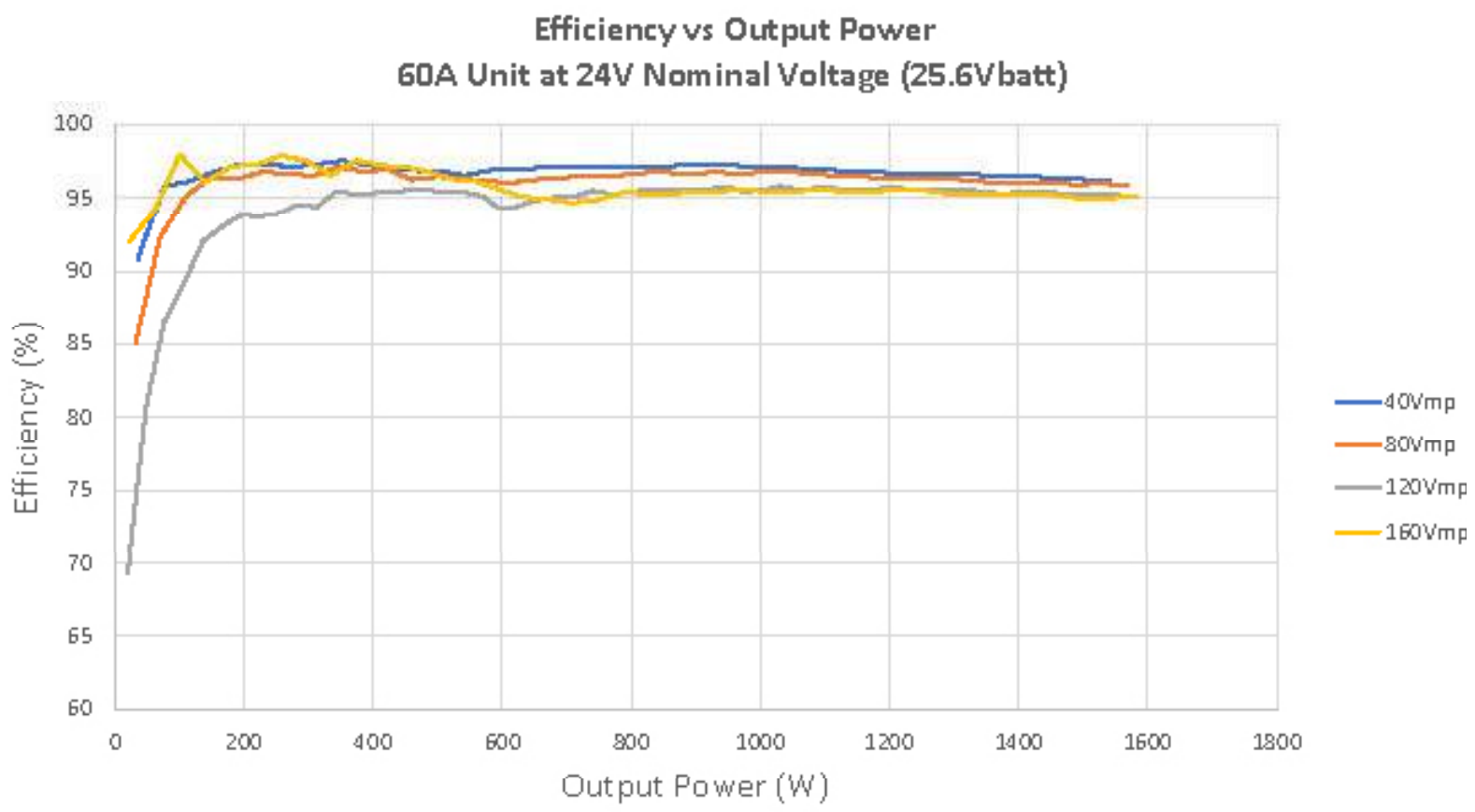
[2] 120 Vmp curve is very close to 80 Vmp, but most power points are slightly less efficient.

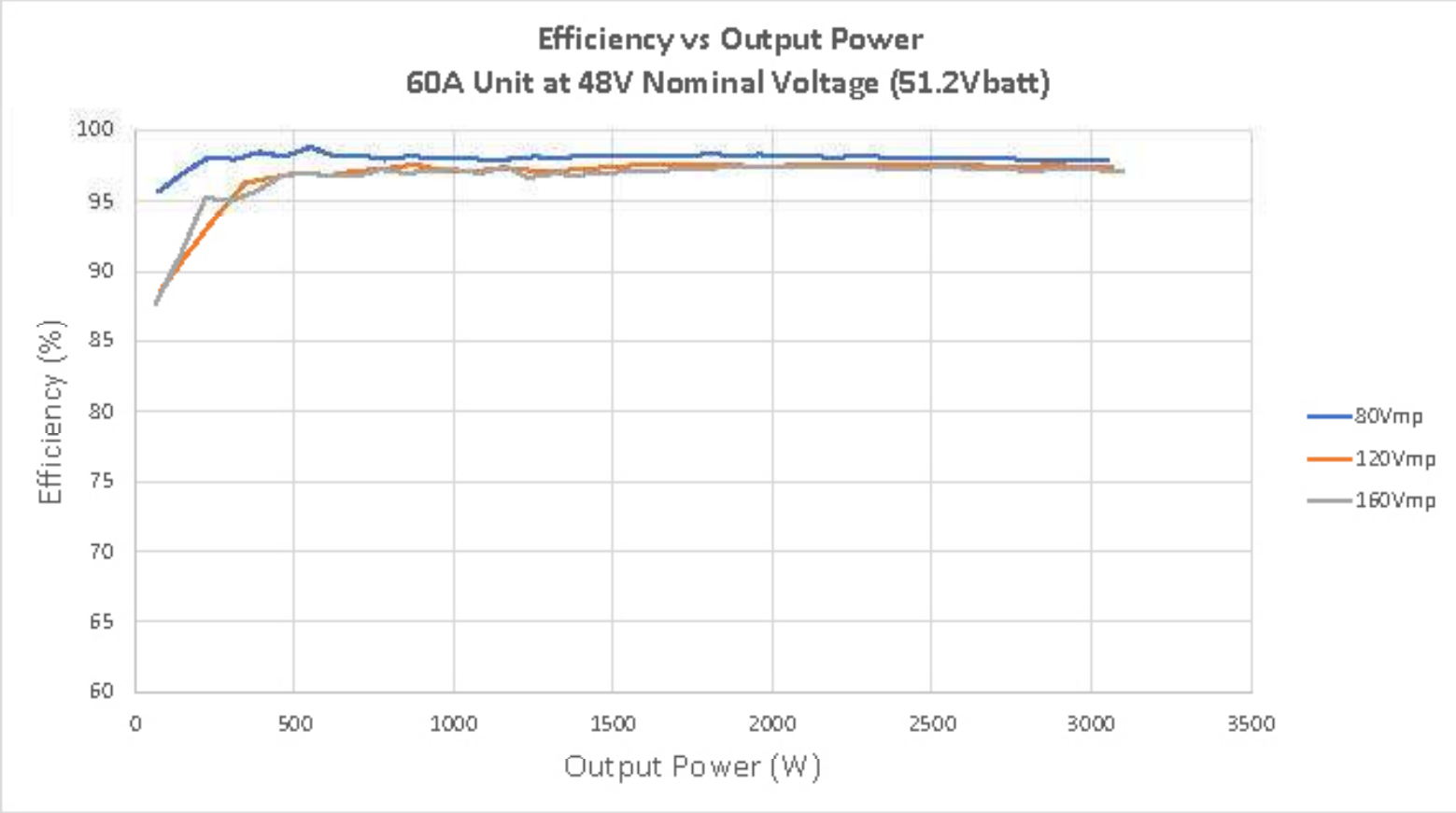

Efficiency vs Output Power
80A Unit at 12V Nominal Voltage (12.8Vbatt)
Efficiency (%)
100
95
90
85
80
75
70
65
60
0
200
400
600
800
1000
1200
Output Power (W)
20Vmp
40Vmp
80Vmp
120Vmp
160Vmp


Efficiency vs Output Power
80A Unit at 48V Nominal Voltage (51.2Vbatt)
Efficiency (%)
100
95
90
95
90
75
70
65
60
0
500
1000
1500
2000
2500
3000
3500
4000
4500
Output Power (W)
90Vmp
120Vm
160Vm


Efficiency vs Output Power
80A Unit at 24V Nominal Voltage (25.6Vbatt)
Efficiency (%)
100
95
90
85
80
75
70
65
60
0
500
1000
1500
2000
2500
Output Power (W)
40Vmp
80Vmp
120Vmp
160Vmp


Efficiency vs Output Power
60A Unit at 12V Nominal Voltage (12.8Vbatt)
Efficiency (%)
100
95
90
85
80
75
70
65
60
0
100
200
300
400
500
600
700
800
900
Output Power (W)
20Vmp
40Vmp
80Vmp
120Vmp
160Vmp


Efficiency vs Output Power
60A Unit at 24V Nominal Voltage (25.6Vbatt)
Efficiency (%)
100
95
90
85
80
75
70
65
60
0
200
400
600
800
1000
1200
1400
1600
1800
Output Power (W)
40Vmp
80Vmp
120Vmp
160Vmp


Efficiency vs Output Power
60A Unit at 48V Nominal Voltage (51.2Vbatt)
Efficiency (%)
100
95
90
85
80
75
70
65
60
0
500
1000
1500
2000
2500
3000
3500
Output Power (W)
80Vmp
120Vmp
160Vmp

APPENDIX - WIRE SIZING INFORMATION

Wire sizing requirements are based on the ampacity (current carrying capacity) of conductors. The NEC includes Ampacity Tables which are used to determine the ampacity for a given wire size as indicated in Section 310.15.

GenStar power terminals are rated for 75ºC. When wires with a 90°C temperature rating are used with terminals that have a 75°C temperature rating, wire ampacity at 75°C must be used.

Wire ampacity requirements for the battery, PV array and load circuits are:

Controller battery wire ampacity must be greater than or equal to 125% of maximum continuous current (battery current rating of the controller)

PV array wire ampacity must meet both of the following requirements:

Must be greater than or equal to 156% of PV Array Isc without correction and adjustment factors

Must be greater than or equal to 125% of PV Array Isc with correction and adjustment factors

Load wire ampacity must be greater than or equal to the load breaker current rating.

NEC Section 240.4(D) requires a maximum breaker or fuse rating for smaller wire sizes as follows:
14 AWG Copper: 15 Amps OCPD and wire ampacity
12 AWG Copper: 20 Amps OCPD and wire ampacity
10 AWG Copper: 30 Amps OCPD and wire ampacity

Therefore, where load circuit-breakers or fuses are larger than indicated above, a larger wire must be used.

Correction and adjustment factors may also be required to account for the following:

- Maximum ambient temperature
- temperatures at different parts of the circuit (rooftops or engine rooms for example)
- wire terminal temperature ratings
- multi-conductor cables
- conduit fill and other factors

Celsius to Fahrenheit Conversions

ºCelsius	ºFahrenheit
30	86
35	95
40	104
45	113

Table A-1. Celsius to Fahrenheit Conversions

Minimum Battery Wire Sizing - 75°C rated copper

MODEL	Wire Size in a raceway, cable, or earth[1]		Wire Size in free air[2]		Metric Wire Size3 (mm^2)
	@30°C	30°-45°C	@30°C	30°-45°C	
GS-MPPT-60	#4 AWG	3 AWG > 40°C	#6 AWG	#6 AWG	16 - 25
GS-MPPT-80	#3 AWG	2 AWG > 30°C 1 AWG > 40°C	#4 AWG	#4 AWG	25 - 35
GS-MPPT-100	#1 AWG	1/0 > 30°C 2/0 > 40°C	#4 AWG	3 AWG > 30°C 2 AWG > 40°C	35 - 50

1 Per NEC 2021 [see NEC Table 310.15(b)(16)], ampacity for not more than three current-carrying conductors in a raceway, cable, or earth (buried)

2 Per NEC 2021 [see NEC Table 310.15(b)(17)], ampacity for conductors in free air

3 Estimated. See local code requirements for metric cable sizing

Table A-2. Minimum DC battery wire sizes for 75°C copper

Minimum Output/Load Wire Sizing (based on breaker or fuse sizes)

Breaker or fuse Rating	@30°C	Metric Wire Size (mm^2)
15 Amps	#14 AWG	2.5
20 Amps	#12 AWG	4
25 Amps	#10 AWG	6
30 Amps	#10 AWG	6
40 Amps	#8 AWG	10

Table A-3. DC load output wire sizes

2% Voltage Drop Chart for 75°C or 90°C Stranded Copper Wire

Maximum 1-way distance (feet), 12 Volt system - multiply values by (2) for 24 Volt,

and by (4) for 48V, system

Wire Size (AWG)	100A	90A	80A	70A	60A	55A	50A	45A	40A	35A	30A	25A	20A	15A
4/0[1]	23.5	26.1	29.4	33.6	39.2	42.8	47.0	52.3	58.8	67.2	78.4	94.1	117.6	156.8
3/0[1]	18.7	20.7	23.3	26.7	31.1	33.9	37.3	41.5	46.7	53.3	62.2	74.7	93.3	124.5
2/0[1]	14.8	16.4	18.5	21.1	24.6	26.9	29.6	32.9	37.0	42.3	49.3	59.2	73.9	98.6
1/0	11.7	13.0	14.7	16.7	19.5	21.3	23.4	26.0	29.3	33.5	39.1	46.9	58.6	78.1
#1	9.3	10.3	11.6	13.3	15.5	16.9	18.6	20.6	23.2	26.5	31.0	37.1	46.4	61.9
#2	7.4	8.2	9.2	10.5	12.3	13.4	14.7	16.4	18.4	21.1	24.6	29.5	36.9	49.1
#3	5.8	6.5	7.3	8.3	9.7	10.6	11.7	13.0	14.6	16.7	19.5	23.3	29.2	38.9
#4	4.6	5.2	5.8	6.6	7.7	8.4	9.3	10.3	11.6	13.3	15.5	18.6	23.2	31.0
#6			3.6	4.2	4.9	5.3	5.8	6.5	7.3	8.3	9.7	11.6	14.6	19.4
#8					3.1	3.3	3.7	4.1	4.6	5.3	6.1	7.4	9.2	12.3
#10									2.9	3.3	3.8	4.6	5.8	7.7
#12												2.9	3.6	4.8
#14													2.3	3.0

[1]Wires sizes larger than 1/0 AWG must be terminated at a splicer block located external to the GenStar MPPT. Use 1/0 AWG or smaller wire to connect to the GenStar MPPT to the splicer block.

Table A-4. Maximum 1-way wire distance for 12 Volt systems, stranded copper, 2% voltage drop

Maximum 1-way distance (meters), 12 Volt system - multiply values by (2) for 24 Volt, and by (4) for 48V, system

Wire Size (mm^2)	100A	90A	80A	70A	60A	55A	50A	45A	40A	35A	30A	25A	20A	15A
120[1]	7.6	8.5	9.6	10.9	12.7	13.9	15.3	17.0	19.1	21.8	25.5	30.6	38.2	51.0
95[1]	6.1	6.7	7.6	8.7	10.1	11.0	12.1	13.5	15.2	17.4	20.2	24.3	30.4	40.5
70[1]	4.4	4.9	5.5	6.3	7.3	8.0	8.8	9.8	11.0	12.6	14.7	17.6	22.0	29.4
50	3.1	3.4	3.8	4.4	5.1	5.5	6.1	6.8	7.6	8.7	10.2	12.2	15.3	20.3
35	2.3	2.5	2.8	3.2	3.8	4.1	4.5	5.0	5.6	6.4	7.5	9.0	11.3	15.0
25	1.6	1.8	2.0	2.3	2.7	3.0	3.3	3.6	4.1	4.6	5.4	6.5	8.1	10.8
16				1.5	1.7	1.9	2.1	2.3	2.6	2.9	3.4	4.1	5.2	6.9
10							1.3	1.4	1.6	1.8	2.2	2.6	3.2	4.3
6											1.3	1.5	1.9	2.6
4												1.0	1.3	1.7
2.5													0.8	1.1

[1]Wires sizes larger than 50 mm^2 must be terminated at a splicer block located external to the GenStar MPPT. Use 50 mm^2 or smaller wire to connect to the GenStar MPPT to the splicer block.

Table A-5. Maximum 1-way wire distance for 12 Volt systems, stranded copper, 2% voltage drop

FOR CURRENT DETAILED CERTIFICATION LISTINGS, REFER TO:
https://www.morningstarcorp.com/support/library
Under, “Type”, choose, “Declaration of Conformity (DOC)”, to view a list of product DOCs.

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Morningstar Corporation

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