

# GENASUN

## Users Manual

For 12/24V BMS and  
Genasun GLi Lithium Batteries

GLi-12-100  
GLi-12-200  
GLi-12-360  
GLi-24-100  
GLi-24-180

Manual Revision February 2014



# 1. Introduction

Congratulations on the purchase of your Genasun Lithium Battery System. This manual will describe the typical installation procedures and outline the differences between our batteries and lead-acid batteries, with which you are probably already familiar.

Aside from the substantial savings in weight and gains in efficiency over lead-acid batteries, there are two other important differences to keep in mind when switching to lithium batteries. First, the battery voltage limits and ranges are somewhat different. Second, the battery system contains circuitry to protect and isolate the batteries in the case of abnormal conditions. These functions are totally transparent under normal operation, but should be kept in mind when planning the system.

## 2. Safety Guidelines

Please follow these instructions and keep them close to the battery system for future reference. Ensure that all work is carried out by qualified personnel only, in accordance to this manual.



Do not smoke near the battery! Do not use any naked flame or other sources of ignition. Risk of explosion and fire.



Wear protective eye-glasses and clothing while working on the Li-ion Battery.



Explosion and fire hazard. Prevent excessive charge and discharge currents, short circuits, and over-discharge. Use insulated tools. Be careful not to rest tools or other metallic items on the battery. Do not wear any metallic items such as watches, bracelets, or necklaces that may accidentally contact the battery terminals, or other current conducting parts of the system. In case of fire, you must use a type D, foam or CO<sub>2</sub> fire extinguisher.



Seek immediate medical attention if skin or eyes come in contact with battery material (electrolyte or powder). In case of contact, affected areas must immediately be flushed with water. Then seek medical assistance. Any affected clothing should be rinsed out with water.



Never try to open or dismantle the Lithium battery. Electrolyte is very corrosive. In normal working conditions contact with the electrolyte is impossible. If the battery casing is damaged do not touch the exposed electrolyte or powder because it is corrosive.



Over-charging or over-discharging the Lithium battery can result in damage and can be dangerous. The Genasun Lithium Control pack and relays must be used as directed to prevent over-discharge and over-charging.



Lithium batteries are heavy. Make sure they are properly mounted and secured to prevent accidents. This is critical in mobile and marine applications. Lithium batteries are sensitive to excessive mechanical shock. Always handle with care.



Genasun Lithium batteries operate up to 14.2V (28.4V for 24V systems), and discharge down to 11.0V (22.0V). Note that this voltage range is different than some lead acid batteries. Check to make sure these voltages are within range of the connected load(s). Ensure that this voltage range will not damage the connected load(s) or other batteries that may be charged from the Genasun bank.



**CAUTION!** Terminals of the Lithium battery are always live. Ensure that no metallic items (such as tools or jewelry) contact a terminal, and create a short circuit.

**CAUTION!** Do not over-charge, or over-discharge the battery. Charging the lithium battery after it was discharged below the discharge cut-off voltage, or overcharging the battery, may release a harmful mixture of gases or cause a fire. Failing to comply with the operating instructions, or repairs made with anything other than original parts, or repairs made without authorization will void all guarantees and warranties.

## SHIPPING AND TRANSPORTATION

The Lithium battery must be transported in the original or equivalent packaging.

- Only lift the battery at the handles.
- DO NOT lift the battery at the terminals.
- Do not stand below a Lithium battery while it is hoisted.
- Care must be taken to protect the Lithium battery from falling, short circuits, or damaging mechanical shocks.
- Lithium batteries must be suitably stacked and secured on pallets per ADR and RID special provision 598. Stacking is only allowed for Lithium batteries stored in the original packaging.

## DISPOSAL OF LITHIUM BATTERIES

Batteries marked with the recycling symbol should be processed via a recognized recycling agency. By agreement, they may be returned to the manufacturer. Batteries must not be mixed with domestic or industrial waste.

## USE OF THIS MANUAL

This manual explains the requirements for the safe and effective installation, operation and maintenance of the Genasun GLi Lithium Batteries (further referred to as “Lithium battery” or “Lithium batteries”). Each person that works on the Lithium battery must be familiar with the contents of this manual, and must follow the instructions, warnings, and guidelines herein. Installation of, and work on, the Lithium battery may only be carried out by qualified, authorized, and trained personnel, consistent with the locally applicable standards and taking into consideration the safety guidelines and measures.

## APPLICABILITY AND VALIDITY OF THE MANUAL

All of the specifications, provisions, and instructions contained in this manual apply solely to the Lithium batteries listed on the cover page of this manual.

## GUARANTEE SPECIFICATIONS

Any actions, installations, or uses outside the specifications of this manual will void the guarantee and may be harmful or fatal.

The guarantee is limited to the costs of repair and/or replacement of the product. Costs for installation labor or shipping of the defective parts are not covered by this guarantee. Battery damage as a result of over-charging, over-discharging, and mechanical or water damage will not be compensated. Bypassing any of the safety features of the Lithium battery, or charging after an over-discharge event, will invalidate the guarantee. The Genasun Lithium Control Pack (CP1 or CP2) must be used with this Lithium battery. Failure to do so will render the guarantee invalid.

## LIABILITY

Genasun accepts no liability for consequential damage due to use of the Lithium battery, or possible errors in the manuals and their results.

## USE FOR INTENDED PURPOSE

The Lithium battery is constructed to be used as described by the applicable safety and technical guidelines. Only use the Lithium battery in accordance with the specifications of this manual. Only use the Lithium battery in a closed, well-ventilated area that is protected from rain, moisture, dust, and condensation. Failure to follow these requirements is not considered to be consistent with the intended purpose. Genasun is not liable for any damage resulting from use outside the intended purpose.

**WARNING** Never use the Lithium battery in locations where there is danger of gas or dust explosion or potentially flammable products!

## WARNING REGARDING LIFE SUPPORT APPLICATIONS

The Lithium battery is not sold for applications in medical equipment. The Lithium battery is not intended for use as a component of any life support system.

## SAFETY AND PRECAUTIONS OF THE BMS

Genasun battery systems contain advanced electronics to ensure safe operation. The Lithium Control Pack in combination with the batteries provides the following:

- Protection against over-charge
- Protection against over-discharge
- Protection against over-temperature
- Protection against under-temperature
- Protection against short-circuit

## IMPORTANT INSTALLATION GUIDELINES

- Never under any circumstances make connections (temporary or permanent) directly to the batteries or to the “battery side” of the contactors. All chargers and loads must be isolated from the batteries by the charge and discharge contactors. The BMS controls the contactors and will close them when all parameters are within limits for battery operation. Direct connections to the battery other than through the BMS will invalidate the warranty and may create a risk of battery damage or fire.
- The aluminum battery racks provide compression to the battery cells, and must not be removed. The rack bolts are factory adjusted, and a gap is normal between rails and endplates.
- If a battery bank does not start (contactors do not remain closed with switch in the run position, and/or there is an alarm from the BMS), contact the installer or dealer for your batteries. You may view or log the BMS system data while the BMS switch is in the start position as described later in this manual. This data may be helpful for troubleshooting.
- Post-commissioning isolation test for each battery: a) with the BMS off, try turning on various chargers and loads, and b) use an ammeter inserted in series on the negative circuit by removing the negative cable to ensure current is absolutely zero.
- Make sure no stray strands from the main conductors make their way into any battery cell BMS module electronics.

- Protect the battery system from water. While all of the electronics in the battery system have been conformally coated to resist humidity, the system is NOT WATERPROOF, and measures must be taken to prevent direct exposure to water. Water damage is the responsibility of the customer and will not be covered under warranty. Note that Genasun lithium batteries do not need venting like lead-acid batteries, so the battery boxes can be completely watertight, provided there is enough cooling to prevent overheating. Do not expose the Lithium battery to rain, snow, spray, moisture, or condensation.
- Chargers (i.e., shore power, solar charge controllers, fuel cells, alternator regulators, etc.) must be set for 14.2V or less for 12V nominal systems, or 28.4V or less for 24V nominal systems.
- Lithium batteries do not require topping up with water. Never open the battery. Do not add acid or distilled water.
- Short circuiting or reversing polarity will lead to serious damage to the Lithium battery, equipment connected to the Lithium battery, and the wiring. Fuses between batteries and equipment cannot prevent damage caused by reversed polarity, and the warranty will be void.
- Protect the wiring with fuses, in accordance with local standards.
- Connection and protection must be done in accordance with local standards.
- Do not work on the Lithium battery or system if it is still connected to a power source.
- Only allow changes in your electrical system to be carried out by qualified electricians.
- Check the battery wiring at least once a year. Loose connections, damaged cables, and other defects must be corrected immediately.

### **3. Mechanical Installation**

The Lithium battery system should be mounted in a location free from exposure to water and protected from mechanical damage. If there is no suitable battery compartment available, the use of conventional plastic battery boxes is recommended. The batteries must be securely mounted to prevent movement, especially in the event of a capsizing or rollover. Aluminum handles have been provided on each end of the battery for lashings or straps. Do not place straps or other point loads on the plastic battery cover.

The Battery Management System (BMS) should be mounted close enough to the batteries to make connection with the data cables. The BMS should be mounted in a dry location and protected from drips caused by condensation, splashes, or leaks. Usually, a nearby

bulkhead will provide a satisfactory location. The BMS may be mounted using the 4 holes in the mounting flanges.

## 4. Electrical Installation

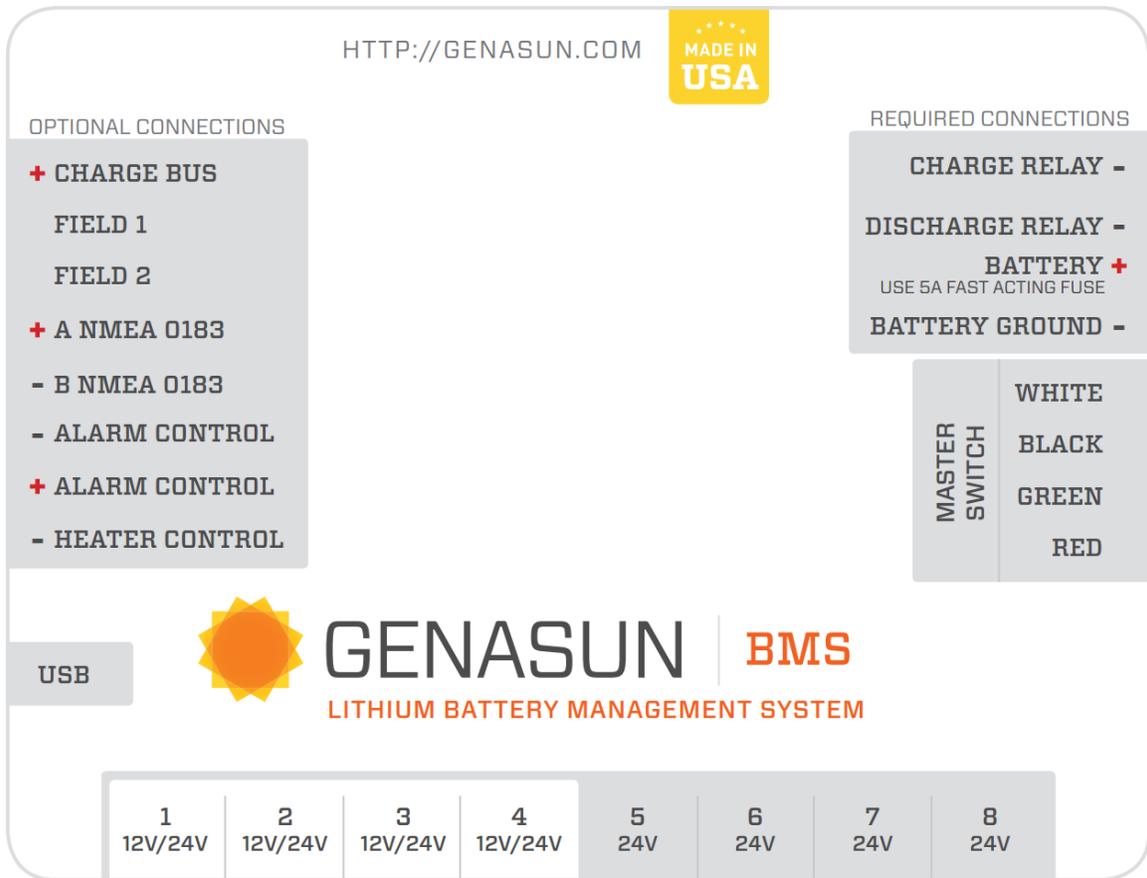
**CAUTION:** Batteries are always live. Exercise extreme caution while making connections in order to avoid short circuits, fire, and other damage. Insulate the handles of all metal tools with tape or heat-shrink tubing, or use rubber-coated tools. Tape off any exposed cable ends during assembly.

The diagram at the end of this manual shows a sample installation of a Genasun lithium battery system. Chargers and loads are connected separately through the **CHARGE** and **DISCHARGE** relays of the BMS. Providing separate connections for chargers and loads allows the system to function gracefully during an over-charge or over-discharge situation. This configuration also prevents system damage by preventing a situation where chargers and loads are connected together while the battery is disconnected.

Genasun marine lithium systems are typically divided into two redundant banks of equal capacity. Smaller systems will be packaged as two batteries, but larger 24V systems may be comprised of several battery modules connected in series. In the latter case, battery modules will be shipped marked with a letter: “A” or “B”. All of the “A” modules should be connected in series to form one bank, and all of the “B” modules should be connected in series to form the second bank, as each set has been selected to function optimally together.

Connections to the BMS are made through pluggable terminal blocks, which can be removed from the BMS for convenience while making connections.

An image of the BMS label is shown below for reference.



## Required BMS Connections

The following connections are required for BMS/battery operation:

**Master Switch White, Black, Green, Red:** The switch cable may be trimmed to length, and the 4 wires connected to the terminals designated with the matching color.

**Battery +:** Connect to the positive terminal of the batteries through a 5A fast-acting fuse such as an ATC/ATO automotive style. Make sure the fuse DC voltage rating is appropriate for the system.

**Battery -:** Connect to the battery negative/ground. If a shunt is used for battery SOC monitoring, the shunt should be between the battery and this connection. Because this connection will typically carry large pulsed currents created by the relays and their coil economizers, we recommend keeping this connection “short and fat”, i.e., 12-14 AWG and with a short run to the battery negatives.

**Charge Relay -:** Connect the negative terminal of the CHARGE relay here. The positive terminal should be connected to the BMS **Battery +** terminal, i.e., to the positive battery terminal through the 5A fast-acting fuse. This output is protected against inductive spikes; no additional protection is required.

**Discharge Relay -:** Connect the negative terminal of the DISCHARGE relay here. The positive terminal should be connected to the BMS **Battery +** terminal, i.e., to the positive battery terminal through the 5A fast-acting fuse. This output is protected against inductive spikes; no additional protection is required.

**Battery Data Cables:** These RJ-style cables should be connected to the matching connectors in the BMS. Any cable may be connected to any jack. For 12V systems, only 4 connections are used, and these should be plugged into positions 1-4 on the left side of the BMS.

**Field 1/Field 2:** Required if an alternator is used, see next section.

## Optional BMS Connections

The following connections are optional for basic BMS operation, but may be required or useful in some systems. Please observe the voltage and current ratings for these outputs (listed at end of manual).

+ **Charge Bus:** Connecting this terminal to the CHARGE bus will allow the system to automatically turn on when the power switch is in the RUN position and voltage is present on the CHARGE bus. If this terminal is not connected, the system must be manually started by briefly holding the power switch in the START position.

**Field 1/Field 2:** These terminals are connected inside the BMS when it is safe for an alternator to charge the battery system. The alternator field connection should be run through these terminals. In case of an overcharge, the connection is opened before the CHARGE relay is opened, allowing time for the field current to decay and preventing a potentially damaging voltage surge. No polarity needs to be observed, and these terminals are galvanically isolated from the rest of the system.

+**A/-B NMEA 0183:** NMEA 0183 4800 baud differential serial data outputs for system status information. Isolated listeners may be connected directly to these terminals. Non-isolated listeners should be connected between +**A** and battery ground. **DO NOT GROUND -B.**

-/+**Alarm Control:** An alarm may be connected to these terminals for audible error warnings. The output voltage is equal to the battery voltage.

-**Heater Control:** This is an open-collector output for control of an external heater, either directly or through a relay. This output is pulled low when the minimum temperature inside the battery is lower than approximately 3°C. This output can safely drive an inductive load without additional protection. If the heater is to be powered from the batteries, it is recommended to connect the positive heater line to the CHARGE bus.

**USB:** Standard Micro B USB connection for system status and firmware programming.

Operation of this connection is described in more detail elsewhere in this manual.

## Alternators/Regulators

Alternator fields **MUST** be connected as shown in the diagram in order to prevent damage to the alternator rectifier diodes or other system components should the CHARGE relay open while the alternator is charging. This is a special protection feature unique to the Genasun Battery Management System. Note: if dual alternator regulators are used (to drive dual alternators), then run each field wire to one BMS per regulator. In this case the field wiring to each alternator will be separate circuits rather than joined as shown in the diagram.

## Connecting to the Batteries

Genasun batteries are supplied with cable-clamp connections for 8 to 1/0 AWG cable, or may be configured for use with 8mm or 5/16" ring terminals. For cable clamp connections, insert cables and tighten the clamp securely with a 1/4" Allen wrench. For ring terminal connections, the ring terminal should be placed over any bus bars and under any PCB that may be present, and the stud nut carefully tightened to **15 ft-lbs.** using a torque wrench and a fresh lock washer. Ensure that the stud is fully threaded into the battery prior to tightening. If the ring terminal will be touching the battery terminal directly, use an anti-corrosive zinc paste for aluminum connections such as Penetrox or Noalox.

Stud/Ring Terminal Size:	8mm or 0.313" (5/16") nominal
Battery Stud Torque:	15 ft-lbs

In some cases, a BMS circuit board (typically green) will be covering the desired connection point. In this instance, the nut and washer should be removed, and the stud unscrewed from the battery terminal, taking care not to damage the stud threads. The ring terminal should then be inserted under the BMS circuit board, and the stud screwed in through the BMS circuit board and ring terminal.

To avoid stripping the aluminum battery terminals, the stud must be screwed in fully. A dial caliper may be used to check that the stud insertion depth matches the original insertion depth. Place a flat washer, then a fresh lock washer onto the stud over the BMS PCB. Then, tighten down a nut to **15 ft-lbs** using a torque wrench. **The use of a torque wrench is essential to avoid stripping the delicate aluminum battery terminals.**

## 5. System Configuration

After installation, your Genasun battery system requires no additional configuration, however the systems used to charge and monitor the battery must be set appropriately. All chargers should be set for a simple **float voltage of 14.2V (28.4V for 24V nominal systems), with no temperature compensation.** This type of charging is variously

called Constant-Current/Constant-Voltage, CC/CV, or Forced Float, among other terms.

## 6. Charging Sources and Monitors

For solar charging, Genasun manufactures a range of lightweight, high-performance MPPT solar charge controllers that are available to suit most solar panel configurations.

For shore-power (AC) chargers, temperature compensation should be disabled by removing the external temperature sensor or taking other configuration steps specific to the charger. The charge voltage should be set to 14.2V/28.4V. If multi-stage charging cannot be disabled, all voltages should be set to 14.2V/28.4V. Failing that, the charge curve must be adjusted such that the maximum voltage reached (variously called “Bulk”, “Boost”, or “Absorption”) is 14.2V/28.4V or less.

Inverter-chargers should be connected to the CHARGE bus, if they will be primary charging sources, or the DISCHARGE bus, if not. Both charging and discharging are possible from either bus, and the batteries will be equally protected with either choice.

For alternator charging, Genasun manufactures an appropriate alternator regulator that is compatible with most externally regulated alternators with an isolated or P-type field. Due to the excellent charge acceptance of Genasun Lithium batteries, alternators should be specified for continuous operation at full power (i.e., full field).

Battery monitors vary, but for a good starting point, set the Peukert exponent to 1 and the Charging Efficiency Factor (CEF) to 100%.

## 7. Battery Operation

To start the battery, hold the switch in the momentary **START** position briefly, then allow it to return to the center **RUN** position. The relays should click on, and power should now be present at both the **CHARGE** and **DISCHARGE** connections. The BMS may beep briefly on startup. If the optional **+Charge Bus** connection is made and power is present on the **CHARGE** bus, the battery will start up as soon as the switch is set to the **RUN** position. The switch LED indicator will light when the battery is powered on. To turn the system off, turn the switch to the **OFF** position, the non-momentary, off-center switch position. Like any batteries, Genasun Lithium batteries should not be switched off while chargers are running, especially alternators. To prevent accidental turn-off, the battery switches have an interlock tab, which must be pushed towards center in order to turn the batteries off.

When the boat will be left unattended, the batteries should be switched off unless a solar panel or other charging source is present and active.

Genasun Lithium batteries have a reserve tank function, leaving a few percent of capacity in the battery. To access this reserve capacity in an emergency or for power while starting up a charger, simply power cycle the battery.

## 8. Thermal Management

Genasun batteries measure their internal temperature at several locations distributed throughout the battery. The BMS uses this information to prevent charging and/or discharging if the temperature is too high or too low. The BMS can also control an external heater to prevent the batteries from becoming too cold. The table below describes the behavior of the charge and discharge contactors and the heater control with temperature.

Charge contactor	Undertemperature	Disconnect	0°C
		Reconnect	1°C
	Overtemperature	Disconnect	45°C
		Reconnect	44°C
Discharge contactor	Undertemperature	Disconnect	-20°C
		Reconnect	-19°C
	Overtemperature	Disconnect	55°C
		Reconnect	54°C
Heater control	Undertemperature	Disconnect	3°C
		Reconnect	2°C

In order to prevent overheating, the heater control output will be disconnected if any cell is above 30°C, even if other cells are below 2°C. Cooling the batteries below -20°C does not cause damage; however, the BMS will prevent electrical operation below this point. Do not attempt to charge the batteries, if they are below 0°C. If manually rewarming cold batteries, warm them slowly or take care to keep the humidity down to prevent the formation of frost or condensation.

## 9. Maintenance

The M8 nuts on each battery cell should occasionally be re-torqued to 15 ft-lbs., taking care to avoid stripping the aluminum battery terminals. Occasionally inspect the battery racks for loose hardware. **ONLY** if loose, the ¼-20 battery rack hardware should be torqued to **5 ft-lbs.** To avoid stripping the aluminum threads, **DO NOT** make any adjustments without a torque wrench. For longest life, bring the batteries to 50-70% state of charge before storage.

## 10. Troubleshooting

The BMS includes an alarm output for alarm codes. These alarm codes are also visible on the power switch LED. Beeping may continue for a short time after faults are corrected due to the buzzer buffer. The beep codes are listed in the table below. A "•" represents a short beep, while a "-" represents a long beep. If the battery is over-discharged, the switch may need to be held in the **START** position to register beep/blink codes.

PROBLEM	BEEP CODE	SOLUTION
Undervoltage	••	Charge batteries
Overvoltage	•••	Set chargers to 14.2V/28.4V or less
Too Hot	••••	Increase ventilation or wait for batteries to cool
Too Cold	•••••	Enable heater or otherwise raise ambient temperature
Comm. Error	– – ••	Check data cables between batteries and BMS

During the first charge, or after the battery has been stored during the off-season, the cells within a battery bank may be unbalanced. When the batteries near full charge, the BMS may turn off the CHARGE relay while the cells are equalized. In this case, the switch LED will slowly pulse. No action is necessary, and the batteries may be used as normal. Charging will be automatically reenabled when equalization is complete.

## 11. NMEA 0183 Output

The NMEA 0183 output provides minimum and maximum battery cell voltages in millivolts and minimum and maximum battery cell temperatures in degrees Celsius. Here is an example sentence (\*5C is an NMEA checksum):

```
$GNSLI,3200,3210,20,22*5C
```

## 12. Viewing System Data via USB

The Battery Management System includes a standard Micro B USB connection for monitoring and logging system data, as well as reprogramming, all through Genasun's GenaView software. GenaView may be downloaded from the Genasun website.

If your computer does not automatically detect the Genasun BMS USB serial port, you may need to download the FTDI driver, available at the URL below:

<http://www.ftdichip.com/Drivers/VCP.htm>

The GenaView software can be used to log data from the BMS. The data is in NMEA 0183 format. The sentence looks like this:

```
$GNSLI,CC,FW,0,3200,202,01, ... ,3,3205,195,01,FL,TFL,EN,TEN*CKSM
```

CC is a cycle count in hex format that resets to 0 after FFFFFFFF. FW is the firmware version. This is followed by four (12V configuration) or eight (24V configuration) sets of four values:

1. a zero-indexed cell ID
2. the cell voltage in millivolts
3. the cell temperature in tenths of a degree Celsius
4. a byte in hex format, which in normal operation will read either 10 or 11. Any other

reading indicates a failed or disconnected cell module and will cause bit 12 to be set in FL/TFL (see below).

FL and TFL are identical 16-bit words in hex format that can be used to isolate the cause of a problem in a battery system. Each set bit corresponds to a thrown flag:

Bit	Flag
0	overvoltage charge
1	overvoltage field
2	overvoltage discharge
3	unused, always 0
4	undervoltage charge
5	undervoltage field
6	undervoltage discharge
7	insufficient supply voltage to the BMS
8	undertemperature charge
9	undertemperature discharge
10	overtemperature charge
11	overtemperature discharge
12	failed or disconnected cell module
13	cell module detected on unexpected port
14	undertemperature heater
15	overtemperature heater

EN and TEN are usually identical bytes in hex format that indicate which outputs are enabled. EN reflects the current state of the outputs. TEN reflects the desired state of the outputs. These will only differ, for example, when the desired state includes a disabled charge relay, but the field relay must be disabled and a delay timer must expire before the charge relay can be disabled. Each set bit corresponds to an enabled output:

Bit	Output
0	Discharge
1	Charge
2	bootstrap (controls power to BMS)
3	unused, always 0
4	Field
5	Heater
6	unused, always 0
7	unused, always 0

### 13. BMS Specifications

Supply voltage:	8.5-33V
Recommended fuse:	5A Fast Acting
Running supply current, including LED:	<30mA (excludes external relays)
Size:	5.9x3.7x1.4” 150x94x35mm
Maximum Continuous Output Current:	
Charge Relay -:	10A
Discharge Relay -:	10A

-/+Alarm Control:	3A
-Heater Control:	10A
Total of above four currents:	15A
Field 1 /Field 2:	10A

## **14. Warranty and Service**

Your Genasun battery system is warranted against defects in materials and workmanship for a period of three years from the date of purchase. The warranty is prorated in years two (2) and three (3). This warranty does not cover normal decrease in battery capacity resulting from use, or mechanical or water damage. This warranty does not cover damage due to incorrect connections, operation outside of the rated conditions, or other abuse. In no event will Genasun LLC be held liable for incidental or consequential damages resulting from product failure.

To obtain technical support, repairs, or other service, please contact your installer or dealer.

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# Genasun Lithium Iron Phosphate Battery System

## Typical Dual-Bank Marine Installation

