



# MM Series Inverters



Owner's Manual



**Sensata**  
Technologies

Thank you from all of us at Sensata Technologies for purchasing this MM Series inverter. The MM Series is a product under the Magnum Energy brand from Sensata. We understand there are many purchasing options in the marketplace, and are pleased that you have decided on a Magnum product. This product was proudly assembled and tested in the United States.

We are committed to providing quality products and services. We hope your experience with us is pleasant and professional.

### **Disclaimer of Liability**

The use of this manual and the conditions or methods of installation, operation, use, and maintenance of the MM inverter are beyond the control of Sensata Technologies. Therefore, this company does not assume responsibility and expressly disclaims liability for loss, damage, or expense whether direct, indirect, consequential or incidental that may arise out of or be in any way connected with such installation, operation, use, or maintenance.

Due to continuous improvements and product updates, the images shown in this manual may not exactly match the unit purchased.

### **Restrictions on Use**

The MM Series inverter may only be used in life support devices and systems with the express written approval of Sensata Technologies. Failure of this inverter can reasonably be expected to cause failure of that life support device or system, or to affect the safety or effectiveness of that device or system. If the MM Series inverter fails, it is reasonable to assume the health of the user or other persons may be endangered.

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### **Document Information**

Description – MM Series Owner’s Manual

Part Number and Revision – 64-0008 Rev C

Date Published – April 2016

This entire manual is available for download—with many of the diagrams available in color—under the Library menu on our website.

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Record the unit’s model and serial number in case you need to provide this information in the future.	
<b>Model:</b>	<b>Serial Number:</b>
<input type="checkbox"/> MM612	L1
<input type="checkbox"/> MM1212/MM1212-G	M1

## Conventions Used in this Manual

### Safety Symbols

To reduce the risk of electrical shock, fire, or other safety hazard, the following safety symbols have been placed throughout this manual to indicate dangerous and important safety instructions.



**WARNING:** This symbol indicates that failure to take a specified action could result in physical harm to the user.



**CAUTION:** This symbol indicates that failure to take a specified action could result in damage to the equipment.



**Info:** This symbol indicates information that emphasizes or supplements important points of the main text.

## IMPORTANT PRODUCT SAFETY INSTRUCTIONS

This manual contains important safety instructions that must be followed during the installation and operation of this product. Read all instructions and safety information in this manual before installing or using this product.

- All electrical work must be performed in accordance with local, state, and federal electrical codes.
- This product is designed for indoor/compartment installation. It must not be exposed to rain, snow, moisture, or liquids of any type.
- Use insulated tools to reduce the chance of electrical shock or accidental short circuits.
- Remove all jewelry such as rings, watches, bracelets, etc., when installing or performing maintenance on the inverter.
- Always disconnect the batteries or energy source prior to installing or performing maintenance on the inverter. Live power may be present at more than one point since an inverter utilizes both batteries and AC. Turning off the inverter may not reduce this risk. As long as AC power is connected, it will pass through the inverter regardless of the ON/OFF power switch setting.
- Always verify proper wiring prior to starting the inverter.
- Do not operate the inverter if it has been damaged.
- Do not dismantle the inverter; there are no user-serviceable parts contained in this product. Attempting to service the unit yourself could cause electrical shock. Internal capacitors remain charged after all power is disconnected.
- No AC or DC disconnects are provided as an integral part of this inverter. Both AC and DC disconnects must be provided as part of the system installation.
- No overcurrent protection for the battery supply is provided as an integral part of this inverter. Overcurrent protection of the battery cables must be provided as part of the system installation.
- No overcurrent protection for the AC output wiring is provided as an integral part of this inverter. Overcurrent protection of the AC output wiring must be provided as part of the system installation.

## **IMPORTANT BATTERY SAFETY INSTRUCTIONS**

- Wear eye protection such as safety glasses when working with batteries.
- Remove all jewelry such as rings, watches, bracelets, etc., when installing or performing maintenance on the inverter.
- Never work alone. Always have someone near you when working around batteries.
- Use proper lifting techniques when working with batteries.
- Never use old or untested batteries. Check each battery's label for age, type, and date code to ensure all batteries are identical.
- Batteries are sensitive to changes in temperature. Always install batteries in a stable environment.
- Install batteries in a well ventilated area. Batteries can produce explosive gasses. For compartment or enclosure installations, always vent batteries to the outside.
- Provide at least one inch of air space between batteries to provide optimum cooling.
- Never smoke when in the vicinity of batteries.
- To prevent a spark at the battery and reduce the chance of explosion, always connect the cables to the batteries first. Then connect the cables to the inverter.
- Use insulated tools at all times.
- Always verify proper polarity and voltage before connecting the batteries to the inverter.
- To reduce the chance of fire or explosion, do not short-circuit the batteries.
- In the event of accidental exposure to battery acid, wash thoroughly with soap and water. In the event of exposure to the eyes, flood them for at least 15 minutes with running water and seek immediate medical attention.
- Recycle old batteries.

### **SAVE THESE INSTRUCTIONS**

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### 1.0 Introduction

Congratulations on your purchase of an MM Series inverter from Sensata Technologies. This product is designed to be powerful, yet simple to use, and engineered to provide you with years of trouble-free use.

Please read this chapter to familiarize yourself with the features and benefits of your particular MM Series model.



MM612/MM1212

MM1212-G

*Figure 1-1, MM Series Inverters*

#### 1.1 MM Series Models

**MM612** – a 600-watt inverter with 7-amp AC transfer relay. The AC input and output are provided with pigtail wires to allow hardwiring to an AC distribution panel. Features neutral-to-ground switching for mobile applications.

**MM1212** – a 1200-watt inverter/charger with 12-amp AC transfer relay and 70-amp, 4-stage PFC charger. The AC input and output are provided with pigtail wires to allow hardwiring to a main AC distribution panel and an inverter sub-panel. Features neutral-to-ground switching for mobile applications. Includes a 15' battery temperature sensor.

**MM1212-G** – a 1200-watt inverter/charger with 12-amp AC transfer relay and 70-amp, 4-stage PFC charger. AC input is provided by a standard 3 ft. plug-in power cord, and the AC output is provided by a standard GFCI two-plug outlet. Features neutral-to-ground switching for mobile applications. Includes a 15' battery temperature sensor.

#### 1.2 How an Inverter/Charger Works

An inverter takes direct current (DC) from your batteries and turns it into alternating current (AC), like you use at home. With MM Series models that have the battery charger feature, it also takes alternating current (when connected to a generator or to shorepower) and transforms it into direct current to recharge your batteries.

There are three modes of operation associated with this inverter:

**Inverter Mode:** DC from the batteries is transformed into AC for powering your boat or RV accessories.

**Standby Mode (MM1212/MM1212-G models):** The unit operates as a battery charger to convert incoming AC power into DC power to recharge the batteries while continuing to pass the incoming AC power directly to the inverter's output—to power any AC loads.

### 1.3 What Appliances run from a Modified Sine Inverter

Today's inverters come in two basic output waveforms: modified sine (which is actually a modified square wave) and pure sine wave. Modified sine wave inverters approximate a pure sine waveform.

The output of a modified sine wave inverter will run most electronic and household items—including but not limited to TV, VCR, satellite dish receiver, computers, and printers. Some devices such as rechargeable power supplies for phones, drills, and other like devices may not run or be damaged by modified sine wave inverters.

### 1.4 Appliances and Run Time

The MM Series inverter can power a wide range of household appliances including small motors, clocks, and other electrical devices. As with any appliance using batteries for power, there is a certain length of time that it can run—this is called "run time". Actual run time depends on several variables including the size and the type of appliance, the type of batteries installed in your application, as well as the battery's capacity and age. Other factors such as the battery's state of charge and temperature can also affect the length of time your appliances can run.

Depending on your inverter capacity, larger electrical appliances such as coffee pots and hair dryers can be used for short durations. However, loads that are used for longer periods such as stoves or water heaters can quickly drain your batteries and are not recommended for inverter applications. All electrical appliances are rated by the amount of power they consume. The rating is printed on the product's nameplate label, usually located on its chassis near the AC power cord. Even though it is difficult to calculate exactly how long an inverter will run a particular appliance, the best advice is trial and error. Your MM Series inverter has a built-in safeguard that automatically protects your batteries from being over-discharged.

### 1.5 Standard Features and Benefits

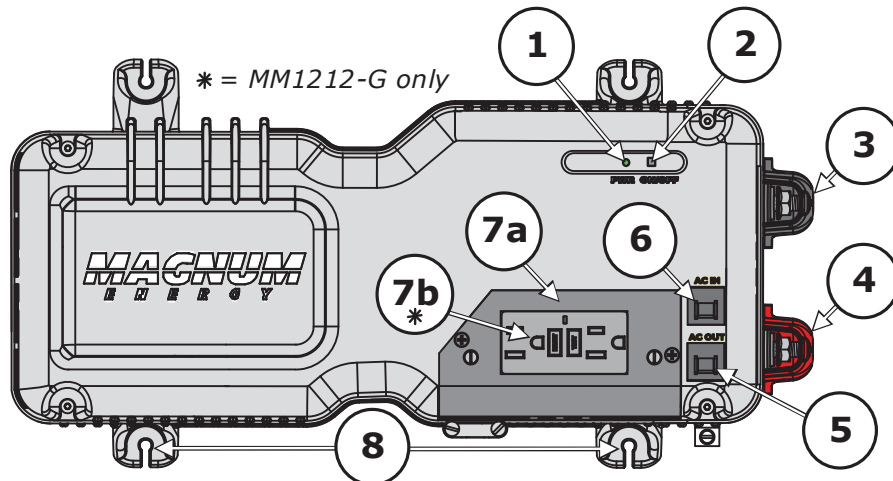
The MM Series inverter converts 12 volts direct current (VDC) power from your battery to 120 volts alternating current (VAC) power. On models with the multi-stage battery charger feature, the incoming AC power is optimized using Power Factor Correction (PFC) technology to keep the inverter's battery bank fully charged. This inverter's die-cast aluminum baseplate ensures maximum durability and a cooler, more efficient operation. The inverter is equipped with the following features:

- 600 or 1200 watts continuous (depending on model) at 25°C (77°F)
- Numerous protection features to ensure safe operation
- AC transfer switch circuitry; allowing incoming AC power to continue to pass through to power loads even if the inverter is off
- Dead battery charging (MM1212 & MM1212-G models) for batteries that are extremely low
- Automatic 4-stage battery charger with power factor correction and temperature compensation—for optimum battery charging (models with battery charger and using the Battery Temperature Sensor)
- True RMS output voltage regulation to ensure the inverter will deliver the correct amount of power—within the DC input voltage range and the continuous output power level
- Quick connection accessory and remote ports—easily accepts several optional remote controls and the Battery Temperature Sensor



## Introduction

1. **Inverter Status Indicator** – this green light emitting diode (LED) illuminates to provide information on the inverter's operation.
2. **Power ON/OFF Switch** – momentary pushbutton switch that turns the inverter on or off.
3. **Negative DC Terminal (black)** – the inverter's connection to the negative terminal on the 12 VDC battery bank.
4. **Positive DC Terminal (red)** – the inverter's connection to the positive terminal on the 12 VDC battery bank.
5. **Output Circuit Breaker (AC Out)** – this circuit breaker provides another layer of overload protection. This is not a branch circuit-rated breaker. Separate AC output breakers are required on the output.
6. **Input Circuit Breaker (AC In)** – this circuit breaker protects the unit's internal wiring and pass-thru relay.
7. **a) AC Wiring Compartment** – provides access for all AC input and output hardwiring connections on the inverter (*MM612 & MM1212 models only*).  
**b) GFCI Outlet** – a Ground Fault Circuit Interrupter (GFCI) outlet with test and reset capability (*MM1212-G model only*).
8. **Mounting Flanges (x4)** – used to secure the inverter to a shelf/wall.



*Figure 1-2, Top Side Features*

9. **Warning and Information Label** – provides pertinent information for safely using the inverter.
10. **REMOTE Port Connection** – a RJ11 connector that allows an optional remote control to be connected.
11. **ACCESSORY Port Connection** – a RJ11 connector (only available for models with the battery charger) to allow the Battery Temperature Sensor (BTS) or various MM accessories (e.g., MM-DCLD) to be connected. The BTS provides information that enables the multi-stage PFC battery charger to "fine tune" the battery charge voltages.
12. **Intake Vent** – ventilation openings to pull in air to help keep the inverter cool for peak performance.
13. **Exhaust Vent** – ventilation openings that allow heated air to be removed by the internal cooling fan.
14. **Model/Serial Number Label** – includes model/serial number and provides specifications and information on the inverter and charger. See the **Specifications** on page 28 for more information.

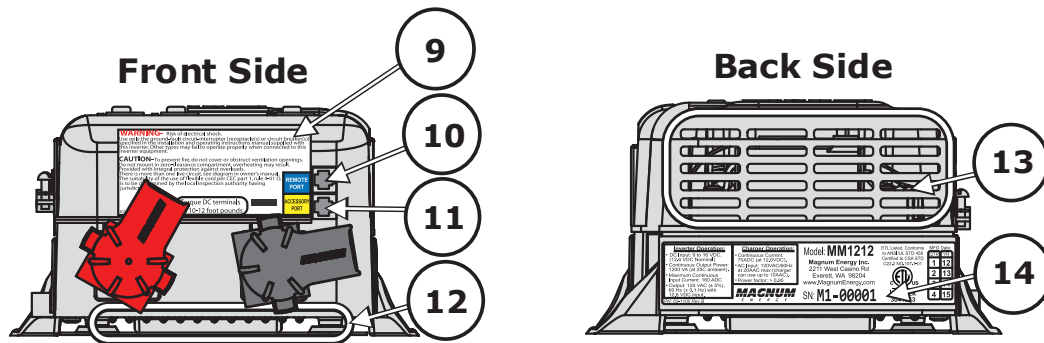


Figure 1-3, Front and Back Side Features

15. **AC Output Connection** – AC knockout (output) for hardwiring (MM612 & MM1212 models only). **Note:** MM1212-G models include an attached 3 ft. standard plug-in power cord.
16. **AC Input Connection** – AC knockout (input) for hardwiring (MM612 & MM1212 models only). **Note:** MM1212-G models have a GFCI outlet.
17. **DC Ground Terminal** – this connection is used to tie the exposed chassis of the inverter to the DC grounding system. This terminal accepts CU/AL conductors from #14 AWG to #6 AWG (2.1 mm<sup>2</sup> to 13.3 mm<sup>2</sup>).

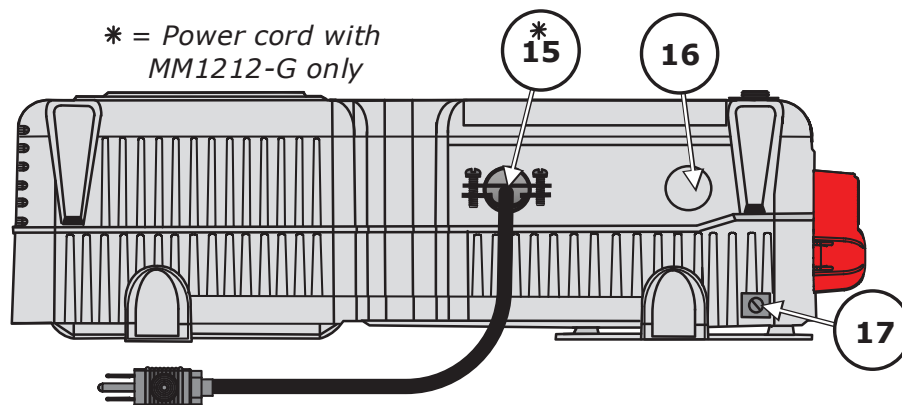


Figure 1-4, Left Side Features

## 1.6 Battery Temperature Sensor (MM1212 & MM1212-G)

A plug-in external Battery Temperature Sensor (BTS) is provided for units with the battery charger feature. When installed, the BTS automatically adjusts the battery charger's BULK, ABSORB, and FLOAT voltage set-points based on temperature for better charging performance and longer battery life. If the temperature sensor is NOT installed and the batteries are subjected to large temperature changes, battery life may be shortened.

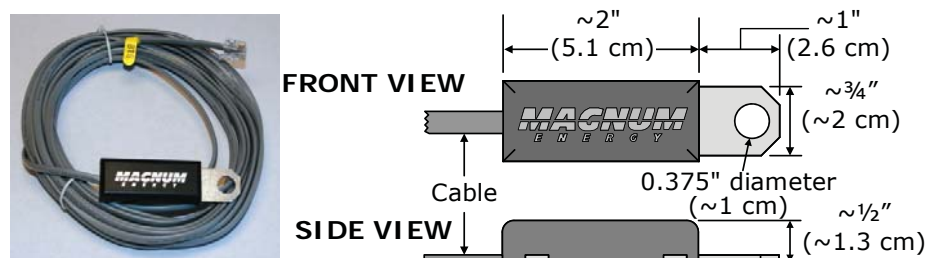


Figure 1-5, Battery Temperature Sensor

### 2.0 Installation

#### 2.1 Pre-Installation

Before installing the inverter, read the entire Installation section. The more thorough you plan in the beginning, the better your inverter needs will be met.



**WARNING:** Installations should be performed by qualified personnel, such as a licensed or certified electrician. It is the installer's responsibility to determine which safety codes apply and to ensure that all applicable installation requirements are followed. Applicable installation codes vary depending on the specific location and application of the installation.



**Info:** Review the "Important Product Safety Information" on page ii and the "Important Battery Safety Instructions" on page iii before any installation.

The basic system diagrams shown in Figures 2-3 & 2-4 should be reviewed to assist you in planning and designing your installations.

##### 2.1.1 Unpacking and Inspection

Carefully remove the MM Series unit from its shipping container and inspect all contents. Verify the following items are included:

- MM Series inverter
- Red and black DC terminal covers
- AC access cover with two screws
- Two 1/2" hex-head Flange nuts (installed on the DC terminals)
- Battery Temperature Sensor (*MM1212 & MM1212-G models only*)
- MM Series Owner's Manual

If items appear to be missing or damaged, contact your authorized Magnum Energy dealer or Sensata Technologies.

If at all possible, keep your shipping box. It will help protect your inverter from damage if it ever needs to be returned for service.

Save your proof-of-purchase as a record of your ownership; it will also be needed if the unit should require in-warranty service.

Record the unit's model and serial number in the front of this manual in case you need to provide this information in the future.

#### 2.2 Locating and Mounting the Inverter



**WARNINGS:**

- Do not mount the inverter near any flammable or combustible fluid or components.
- Provide adequate clearance/ventilation to the inverter.
- Mount only on a "non-combustible" surface.
- Maximum ambient temperature around the inverter must not exceed 77°F (25°C) to meet power specifications.

The inverter should only be installed in a location that meets the following requirements:

**Clean and Dry** – The inverter should not be installed in an area that allows dust, fumes, insects, or rodents to enter or block the inverter's ventilation openings. This area also must be free from any risk of condensation, water, or any other liquid that can enter or fall on the inverter. The inverter uses stainless

steel fasteners, plated copper busbars, and a powder-coated aluminum base. Also, the internal circuit boards are conformal coated. The above measures are undertaken to help fight the harmful effects of corrosive environments. However, the life of the inverter is uncertain if used in any of these types of environments, and inverter failure under these conditions is not covered under warranty.

**Cool** – The inverter should be protected from direct exposure to the sun or any equipment that produces extreme heat. The ambient air temperature should be between 32°F (0°C) and 104°F (40°C)—the inverter’s output specifications are rated at 77°F (25°C), so the cooler the better within this range.

**Ventilated** – In order for the inverter to provide full output power and avoid over-temperature fault conditions, do not cover/block the inverter’s ventilation openings or install this inverter in an area with limited airflow. Allow as much clearance around the inverter’s intake and exhaust ventilation openings as possible (Figure 1-3, Items 12 & 13). At the minimum, allow an airspace clearance of 3” (7.5 cm) on all sides to provide adequate ventilation.

If installed in an enclosure, a fresh air intake opening must be provided directly to the front side (intake vent) and an exhaust opening on the back side (exhaust vent) of the inverter. This will allow cool air from the outside to flow into the inverter, and heated air to exit away from the inverter and the enclosure. When mounted in an enclosed compartment, airflow must be at least 59 cfm in order to maintain no more than a 68°F (20°C) rise in compartment temperature. Minimum clearances can be reduced if airflow is increased, but in no case should clearance around the inverter be less than 2” (5 cm) on all sides.

**Safe** – Keep any flammable/combustible material (e.g., paper, cloth, plastic, etc.) that may be ignited by heat, sparks, or flames at a minimum distance of 2 feet (60 cm) away from the inverter. Do not install this inverter in any area that contains extremely flammable liquids like gasoline or propane, or in locations that require ignition-protected devices.

**Close to the battery bank** – As with any inverter, it should be located as close to the batteries as possible. Long DC wires tend to lose efficiency and reduce the overall performance of an inverter. However, the unit should not be installed in the same compartment as the batteries or mounted where it will be exposed to gases produced by the batteries. These gases are corrosive and will damage the inverter; also, if these gases are not ventilated and if allowed to collect, they could ignite and cause an explosion.

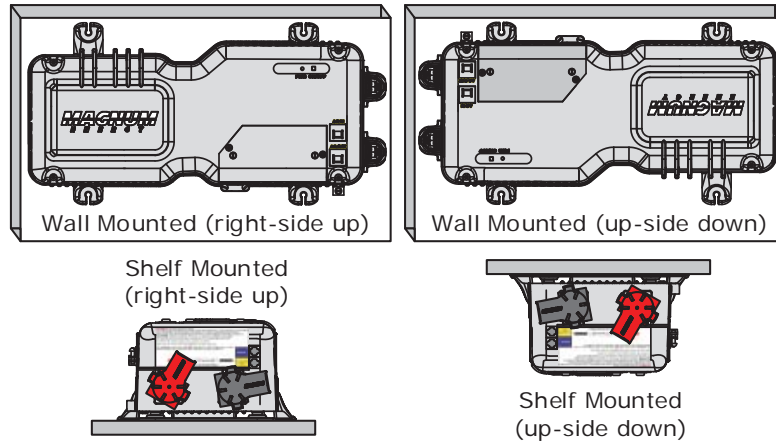
**Accessible** – Do not block access to the inverter’s remote control and accessory ports. Also allow enough room to access the AC and DC wiring connections, as they will need to be checked and tightened periodically.

**Mounting Orientation** – To meet regulatory requirements, the MM Series inverter can only be mounted on a horizontal surface (shelf or table) or a vertical surface (wall or bulkhead) either right-side up or up-side down, as shown in Figure 2-1. The inverter must be mounted on a “non-combustible” surface, and this surface and the mounting hardware must be capable of supporting at least twice the weight of the inverter. After determining your mounting position, use the base of the inverter’s chassis as a template to mark your mounting screw locations. Remove the inverter, and then drill pilot holes into the mounting surface.

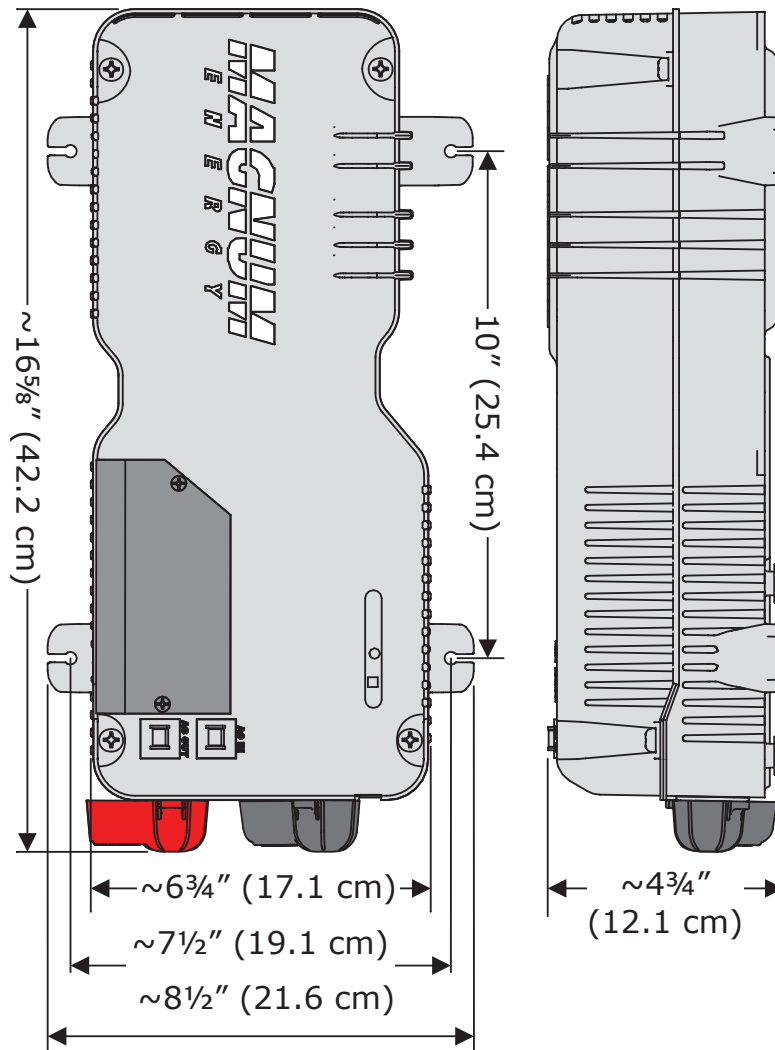
## Installation

If this unit is used in a mobile application, you may want to place flexible washers or bushings between the mounting surface and the inverter's mounting flanges to reduce vibration.

Refer to Figure 2-2 for unit dimensions. After the inverter has been properly mounted, proceed to the DC Wiring section.



**Figure 2-1, Approved Mounting Orientations**



**Figure 2-2, MM Series Inverter Dimensions**

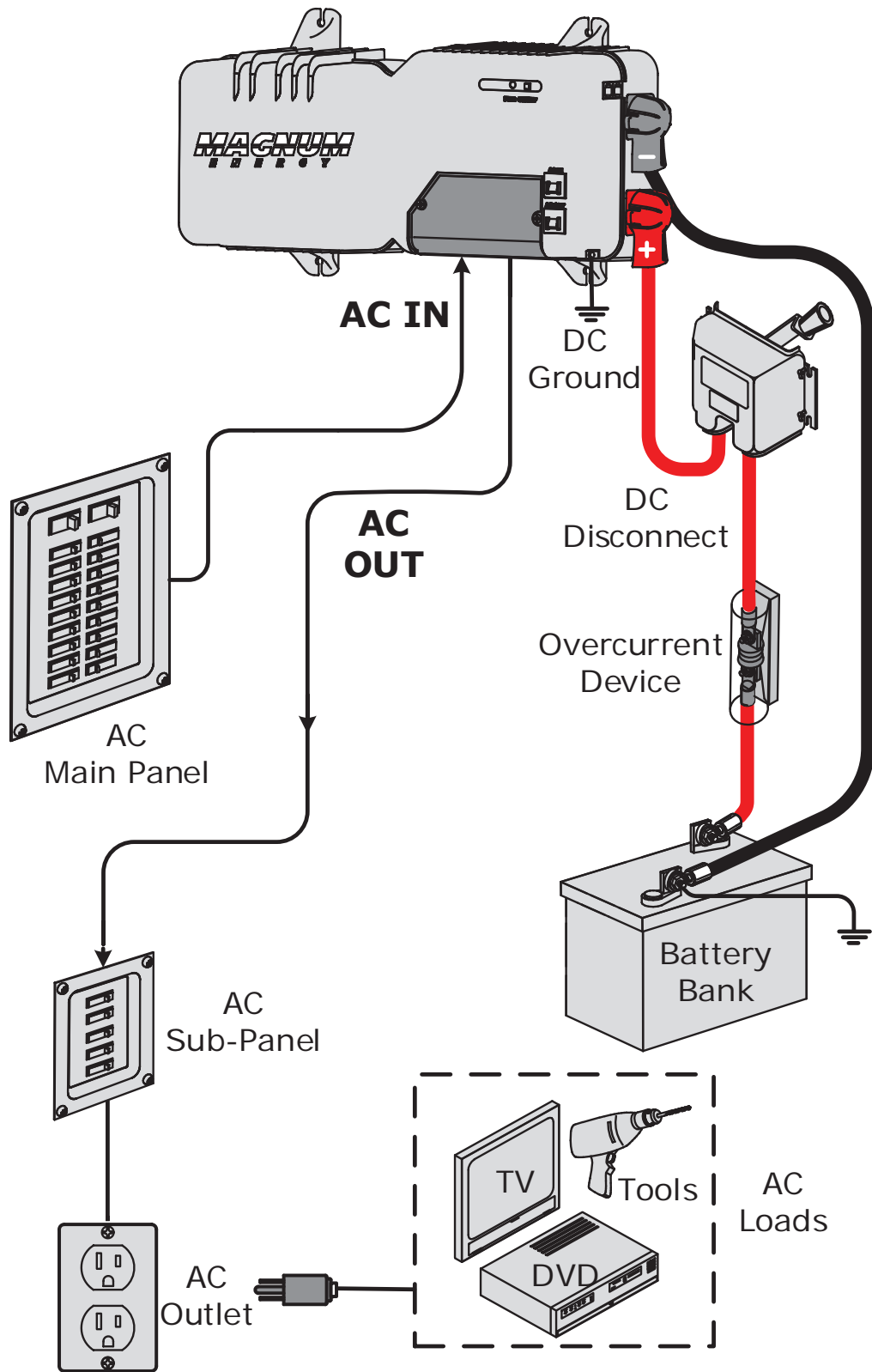


Figure 2-3, Basic Installation Diagram (MM612/MM1212)

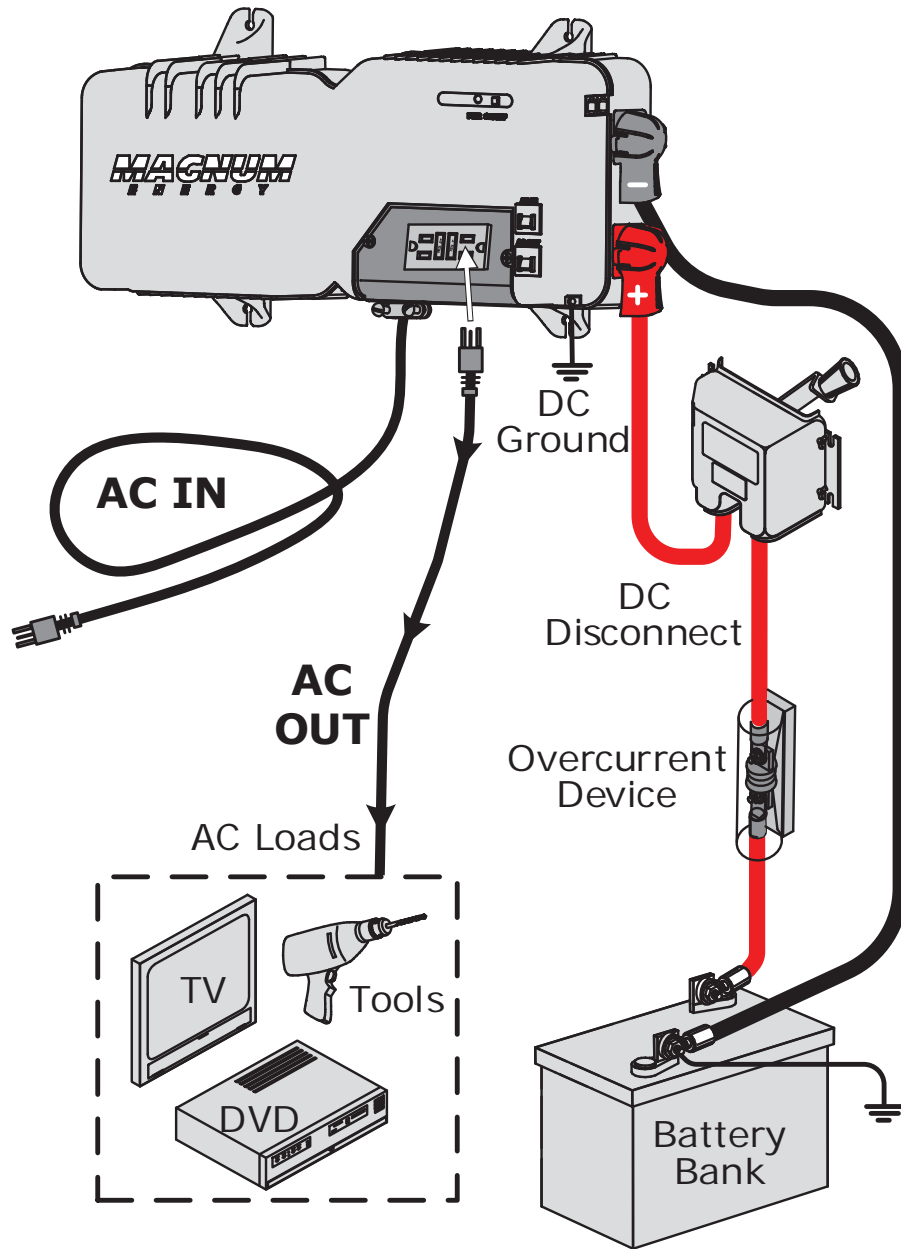


Figure 2-4, Basic Installation Diagram (MM1212-G)

## 2.3 Wiring Guidelines

- Before connecting any wires, determine all wire routes to and from the inverter throughout the RV or vehicle/boat.
- Conductors passing through walls, bulkheads, or other structural members must be protected to minimize insulation damage such as chafing, which can be caused by vibration or constant rubbing.
- Always check for existing electrical, plumbing, or other areas of potential damage prior to making cuts in structural surfaces, bulkheads, or walls.
- Make sure all wires have a smooth bend radius and do not become kinked.
- AC & DC overcurrent protection must be provided as part of installation.
- Do not attempt to use a vehicle metal frame in place of the DC negative connection or DC ground. The inverter requires a reliable negative and ground return path directly to the battery.
- DC wires and cables should be tied together with wire ties or electrical tape approximately every 6 inches (40.1 cm). This helps improve the surge capability and reduces the effects of inductance, which improves the inverter waveform and reduces the wear of the inverter's filter capacitors.
- Use only copper wires with a minimum temp rating of 75°C (167°F).
- To ensure the maximum performance from the inverter, all connections from the battery bank to the inverter should be minimized; the exceptions are the DC overcurrent disconnect in the positive line and a shunt in the negative line. Any other additional connection will contribute to additional voltage drops, and these extra connections points may loosen during use.
- All wiring to the battery terminals should be checked periodically (once a month) for proper tightness. The torque requirement for the DC terminals is between 10 to 12 foot-pounds (13.6 to 16.3 N-m). If you don't have a torque wrench, ensure all DC terminals are tight and cannot move.



**CAUTION:** Be aware that overtightening and mistreading the nuts on the DC terminals can cause the bolts to strip and snap/break off.

## 2.4 DC Wiring

This section describes the inverter's required DC wire sizes and the recommended disconnect/overcurrent protection, and how to make the DC connections to the inverter and the battery bank.

### 2.4.1 DC Wire Sizing and Overcurrent Protection

It is important to use the correct DC wire to achieve maximum efficiency from the system and reduce fire hazards associated with overheating. See Table 1 to select the minimum DC wire size needed based on your inverter model. If the distance from the inverter to the battery bank is greater than 3 feet (91.4 cm), use the bottom part of Table 1 to help determine the minimum recommended cable sizes for longer distances. Always keep your wire runs as short as practical to prevent low voltage shutdowns, and to keep the DC breaker from nuisance tripping (or open fuses) because of increased current draw. Undersized cables can also lower the inverter's peak output voltage as well as reduce its ability to surge heavy loads.



**Info:** The DC wires must be color coded with colored tape or heat shrink tubing; RED for positive (+), BLACK for negative (-), and GREEN for DC ground.



## Installation

The DC wires must have soldered and crimped lugs, crimped copper compression lugs, or aluminum mechanical lugs. Soldered connections alone are not acceptable for this application.

**Table 1, Recommended DC Wire/Overcurrent Device**

		Inverter Model	
		MM612	MM1212/MM1212-G
Maximum Continuous Current <sup>1</sup>		80 amps	160 amps
DC Grounding Electrode Wire Size <sup>2</sup>		#6 AWG (13.3 mm <sup>2</sup> )	#8 AWG (8.36 mm <sup>2</sup> )
Minimum DC Wire Size <sup>3</sup> [75°C rating in free air]		#6 AWG (13.3 mm <sup>2</sup> ) [95 amps]	#1 AWG (42.4 mm <sup>2</sup> ) [195 amps]
Maximum DC Fuse Size <sup>4</sup>		90 amps with time delay	175 amps with time delay
Increased size for longer distance	5 to 10 feet =	#6 AWG (13.3 mm <sup>2</sup> )	#1 AWG (42.4 mm <sup>2</sup> )
	10 to 15 feet =	#4 AWG (21.1 mm <sup>2</sup> )	#1/0 AWG (53.3 mm <sup>2</sup> )

**Note<sup>1</sup>** – Maximum Continuous Current is based on the inverter's continuous power rating at the lowest input voltage with an inefficiency factor.

**Note<sup>2</sup>** – Per the NEC, the DC grounding electrode conductor can be a #6 AWG conductor if that is the only connection to the grounding electrode and that grounding electrode is a pipe, rod, or plate electrode.

**Note<sup>3</sup>** – Wire size is based on the requirements needed to increase efficiency and reduce stress to the inverter.

**Note<sup>4</sup>** – The next larger standard size overcurrent device may be used if the derated cable ampacity falls between the standard overcurrent devices found in the NEC.

If the inverter is expected to operate at a distance greater than three feet from the battery bank, the DC wire will need to be increased to overcome the increase in resistance—which affects the performance of the inverter. Continue to use the overcurrent device and DC ground wire previously determined from Table 1 and then, refer to the bottom part of Table 1 to determine the minimum DC wire size you need for various distances based on your inverter model.

### 2.4.2 DC Overcurrent Protection

For safety and to comply with electrical code regulations, you must install a DC overcurrent protection device in the positive DC cable line to protect your DC cables. This DC overcurrent device must be DC rated and can be a fuse or circuit breaker. It must be correctly sized according to the size of DC cables being used, which means it is required to open before the cable reaches its maximum current carrying capability, thereby preventing a fire. See Table 1 to select the DC overcurrent device needed based on the minimum wire size according to your inverter model.

Electrical systems in mobile installations typically do not require using a DC disconnect, although an overcurrent protection device is still required. Because the DC disconnect is not required, a fuse is usually used as the overcurrent device in these installations. These installations also do not normally use

conduit, so the fuse must be installed in the ungrounded conductor (usually the positive DC cable line) within 18 inches (45.7 cm) of the battery—to protect the DC wiring system.

If using a fuse, we recommend using a class-T type or equivalent. This fuse type is rated for DC operation, can handle the high short-circuit currents, and allows for momentary current surges from the inverter without opening.

### 2.4.2 DC Grounding

The inverter should always be connected to a permanent, grounded wiring system. The idea is to connect the metallic chassis of the various enclosures together to have them at the same voltage potential, which reduces the possibility for electric shock. For the majority of installations, the inverter chassis and the negative battery conductor are connected to the system’s ground bond via a safety-grounding conductor (bare wire or green insulated wire) at only one point in the system. Per the NEC, the size for the grounding conductor is usually based on the size of the overcurrent device used in the DC system. Refer to Table 1 to select the appropriate DC ground wire based on the overcurrent device used for your inverter model.

If using this inverter in a vehicle, DO NOT connect the battery negative (-) cable to the vehicle’s safety ground. Connect it only to the inverter’s negative battery terminal. If there are any non-factory installed DC appliances on board the vehicle, DO NOT ground them at the safety ground. Ground them only at the negative bus of the DC load center (as applicable).

### 2.4.3 DC Cable Connections

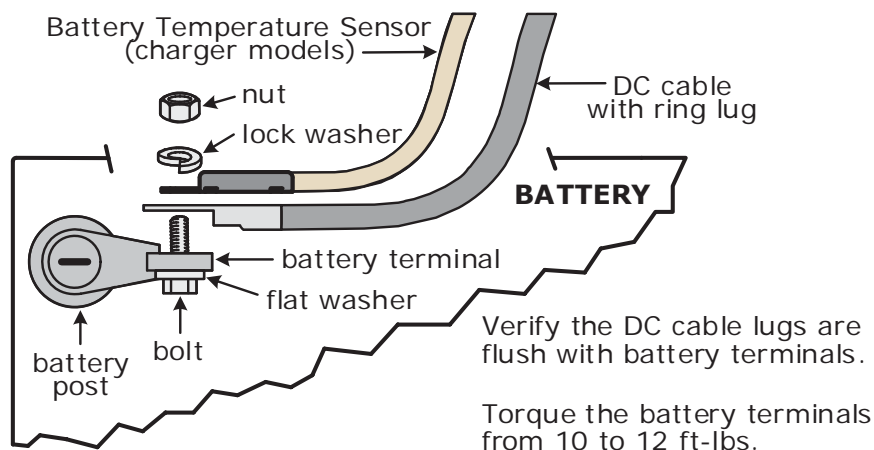
When connecting the DC cable to the battery or to the inverter’s DC terminals, the hardware should be installed in the correct order to prevent high resistance connections which will heat up and could cause the connections to melt. Use Figures 2-5 and 2-6 as a guide to stack the hardware correctly. Tighten the terminal connections from 10 to 12 foot-pounds (13.6 to 16.3 N-m).



**CAUTION:** Do not put anything between the DC cable ring lug and the battery terminal post or the inverter’s DC terminal. If antioxidant grease or spray is used, apply it once all the connections have been made and are properly tightened.



**CAUTION:** Overtightening or misthreading nuts on the DC terminals will cause the bolts to strip and snap/break-off.



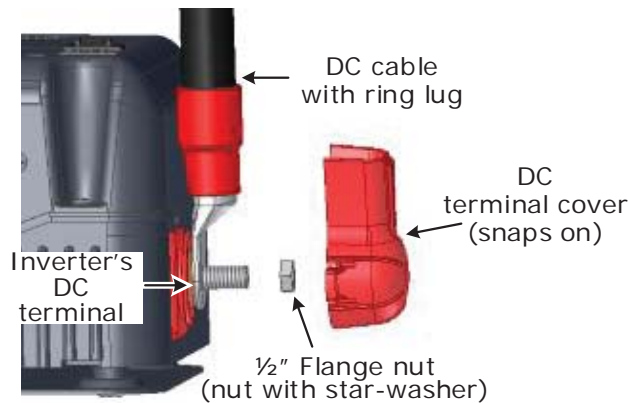
**Figure 2-5, DC Cable to Battery Terminals**

## Installation



**CAUTION:** The inverter is NOT reverse polarity protected (negative and positive connected backwards). Verify the correct voltage polarity BEFORE connecting the DC wires, or damage may occur.

Crimped and sealed copper ring terminal lugs with a 5/16" hole should be used to connect the DC wires to the inverter's DC terminals.



*Figure 2-6, DC Cable to Inverter's DC Terminals*

### 2.5 Battery Bank Wiring



**WARNING:** Lethal currents will be present if the positive and negative cables attached to the battery bank touch each other. During the installation and wiring process, ensure the cable ends are insulated or covered to prevent touching/shorting the cables.



**Info:** DO NOT connect the DC wires from the battery bank to the inverter until: 1) all DC/AC wiring is complete, 2) the correct DC and AC overcurrent protection have been installed, and 3) the correct DC voltage and polarity have been verified.



**Info:** For optimum performance, a minimum battery bank of 200 AHr is recommended.

Depending upon the type of batteries you use in the installation (6 or 12 VDC), the batteries must be wired in series, parallel, or series-parallel to provide 12 VDC (see Appendix B – Battery Information, for guidance on wiring batteries together). The interconnecting DC wires must be sized and rated exactly the same as those that are used between the battery bank and the inverter. Place the batteries as close as practical to the inverter, preferably in an insulated and ventilated enclosure. Allow adequate space above the batteries to access the terminals and vent caps (as applicable). Also, allow at least 1" (2.5 cm) of space between the batteries to provide good air flow. DO NOT mount the batteries directly under the inverter.



**Info:** To ensure the best performance from your inverter system do not use old or untested batteries. Batteries should be of the same size, type, rating, and age.



**CAUTION:** Install batteries in a well ventilated area. Batteries can produce explosive gasses. For compartment or enclosure installations, always vent batteries to the outside.

### 2.5.1 Inverter to Battery Bank Wiring



**WARNING:** Ensure all sources of DC power (i.e., batteries, solar, wind, or hydro) and AC power (utility, shorepower or AC generator) are de-energized (i.e., breakers opened, fuses removed) before proceeding.



**CAUTION:** The inverter is NOT reverse polarity protected. If this happens, the inverter will be damaged and will not be covered under warranty. Before connecting the DC wires from the batteries to the inverter, verify the correct battery voltage and polarity using a voltmeter. If the positive terminal of the battery is connected to the negative terminal of the inverter and vice versa, severe damage will result. If necessary, color code the cables with colored tape or heat shrink tubing; RED for positive (+), and BLACK for negative (-) to avoid polarity confusion.



**Info:** The DC overcurrent device (i.e., fuse or circuit breaker) must be placed in the positive (RED) DC cable line between the inverter's positive DC terminal and the battery's positive terminal (RED); as close to the battery as possible.

#### DC Ground Wire

Route an appropriately sized DC grounding wire (GREEN or bare wire) from the inverter's DC Ground Terminal (Figure 1-4, Item 17) to a dedicated system ground. Recommended tightening torque is 45 in-lbs (5.1 N-m).

#### DC Negative Wire

Route an appropriately sized DC negative wire (BLACK) from the negative terminal of the first battery string to the inverter's negative terminal (see Figure B-3 for reference).

#### Battery Temperature Sensor (MM1212/MM1212-G models only)

Connect the RJ11 connector end of the BTS to the ACCESSORY Port (Figure 1-3, Item 11) on the inverter. Connect the other end of the BTS to the negative terminal of the first battery string (in same place as the negative DC wire above)—refer to Figure 2-5 for the correct hardware placement.

#### DC Positive Wire

Mount the DC fuse block and disconnect (or circuit breaker) as near as practical to the batteries, and then remove the fuse (or open the circuit breaker).



**WARNING:** DO NOT close the DC fuse/DC disconnect (or close DC circuit breaker) to enable battery power to the inverter at this time. This occurs in the **Functional Test** after the installation is complete.

Route and connect an appropriately sized DC positive wire (RED) from the DC fuse block (or circuit breaker assembly) to the inverter's positive DC terminal. Connect a short wire (same rating as the DC wires) to one end of the fuse block and the other end of the short wire to the positive terminal of the last battery string (see Figure B-3). This is essential to ensure even charging and discharging across the entire battery bank.

Ensure the DC wire connections (on the batteries, inverter, and fuse lugs/DC circuit breaker) are flush on the surface of the DC terminals and the hardware (lock washer and nut) used to hold these connections are stacked correctly (see Figures 2-5 & 2-6).

Verify all DC connections are torqued from 10 to 12 ft-lbs (13.6 to 16.3 N-m).

## Installation

Once the DC connections are completely wired and tested, coat the terminals with an approved anti-oxidizing spray.

Press on the red and black terminal covers to the inverter's DC connectors to secure them in place.

If batteries are in an enclosure, perform a final check of the hold down brackets and all connections. Close and secure the battery enclosure.

### 2.6 AC Wiring (MM612 & MM1212 models)

This section describes the required AC wire size and the overcurrent protection needed. It also provides information on how to make the AC connections.

#### 2.6.1 Neutral to Safety Ground Bonding

Electrical safety standards for wiring mobile (RV, boat, or truck) installations require the AC source (inverter, shorepower, or a generator) to have the neutral conductor tied to ground. These standards also require that the AC neutral be connected to safety ground in only one place at any time (often called a "bond"). If more than one bond is established, currents can circulate between neutral and ground and cause ground-loop currents. These "ground-loops" can trip GFCIs and cause an electric shock hazard.

In mobile installations there may be multiple AC sources, which means there is the potential of having multiple neutral-to-ground connections. Therefore, ensure that the inverter does not also connect neutral-to-ground while the other AC source is powering the inverter loads. While inverting, the MM Series inverters use an internal relay that automatically connects the AC neutral output terminal to the vehicle/boat's ground. However, when an external AC source is connected, another neutral-to-ground connection is introduced in the system. When the MM inverter is connected to this external AC source, the internal relay automatically opens the neutral-to-ground connection. This keeps two neutral-to-ground connections from occurring at the same time.

#### 2.6.2 AC Wiring Connections

For all hardwired inverter models, the AC input and output wiring is performed in the AC wiring compartment. This compartment is located on the top panel (see Figure 1-2, Item 7a). If installed, remove the two Phillips screws on the cover to access the AC wiring compartment and locate the inverter's AC wiring. There is a label located in the AC access compartment with information on which wires are used for the AC input and output. You can also refer to Table 2 to match the inverter's AC wires to the appropriate AC wire connection.

**Table 2, Wire Color to AC Wire Connection**

	Wire Color (Label)	Wire Connection
AC IN	Black (HOT IN)	Hot In
	White (NEUT IN)	Neutral In
AC OUT	Red (HOT OUT)	Hot Out
	White w/ Black Stripe	Neutral Out
AC GROUND	Green (GROUND)	AC IN & AC OUT Ground

The AC wires inside the AC compartment are #16 AWG (1.3 mm<sup>2</sup>) with a temperature rating of 105°C (221°F). All AC connections should be made using an approved connector for your application (e.g., split bolt, twist-on wire connectors, etc.). Ensure the wire connectors used are rated for the size and number of wires you are connecting.

After connecting the wires together, gently pull the wires to ensure they are securely held together. No bare wire should be exposed.



**Info:** Per UL certification, non-metallic sheathed cable (i.e., Romex™) or a SO flexible cord with listed strain reliefs are allowed to be used to connect to the inverter—no conduit connections allowed.

After all AC wiring in the inverter is complete—prior to re-attaching the AC access cover—review all wiring to ensure connections are correct and secure.

### 2.6.3 AC Wire Size and Overcurrent Protection

The AC input and output wiring must be sized per the NEC and local electrical safety code requirements to ensure the wire’s ability to safely handle the inverter’s maximum load current. After determining the proper AC wire sizes, the inverter’s AC input (unless you are using a flexible cord) and output wires are required to be protected against overcurrent and have a means to disconnect the AC circuits.

Overcurrent protection must be provided by fuses or circuit breakers, and must be properly sized and rated for the wire they are protecting and the appliances being powered.

An external disconnect device is required for both the AC input and AC output wiring. Most inverter’s that are hardwired use a service/distribution panel wired to the inverter’s input (main panel), and a dedicated panel between the inverter’s output wiring and the AC loads (sub-panel). These systems use the circuit breakers provided in the panels as the overcurrent protection and the AC disconnect. If fuses are used, then separate AC disconnect switches will be needed.

Based on information from the NEC, Table 3 provides the minimum AC wire size and the suggested breaker size based on the inverter model. However, larger wire size may be required because of voltage drop. The AC wire sizes provided in this table assume using only copper wire and a temperature rating of 75°C (167°F) or higher. A minimum of #14 AWG (2.1 mm<sup>2</sup>) is required for all AC wiring.

**Table 3, Minimum Wire Size to Circuit-breaker Size**

Inverter Model	AC Input			AC Output		
	Input Breaker	Minimum Wire Size	Suggested Breaker Size	Output Breaker	Minimum Wire Size	Suggested Breaker Size
MM612	7 amps	#14 AWG (2.1 mm <sup>2</sup> )	10 amps	8 amps	#14 AWG (2.1 mm <sup>2</sup> )	10 amps
MM1212	20 amps	#12 AWG (3.3 mm <sup>2</sup> )	20 amps	12 amps	#14 AWG (2.1 mm <sup>2</sup> )	15 amps

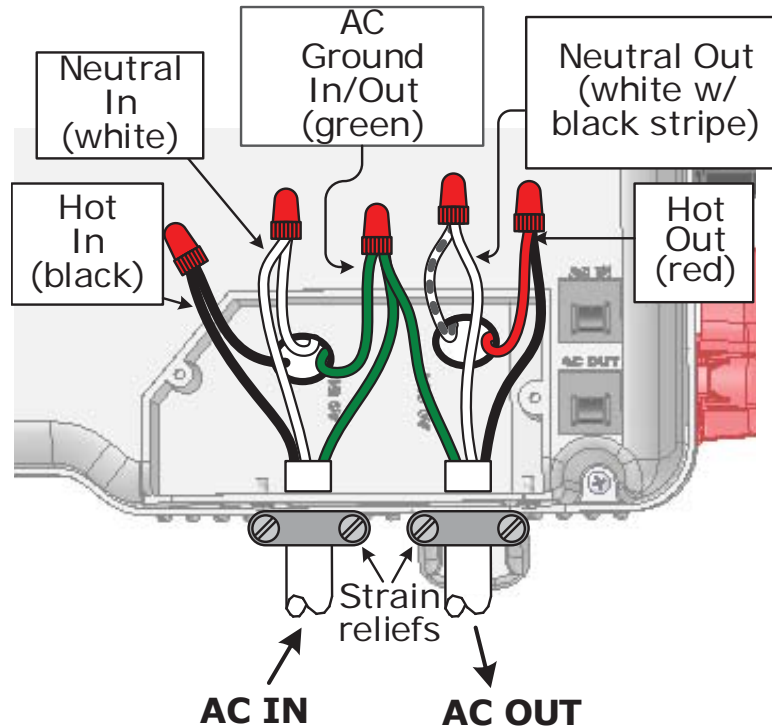
## Installation

### 2.6.4 AC Input Wiring

Your inverter has an AC transfer feature that passes the AC input power to the inverter's output. Connection to the AC input is made by hardwiring from a distribution panel as described below (Figure 2-7):

1. Run an appropriately sized 2-conductor plus ground cable (from the AC distribution panel) through a strain relief on the AC IN opening. Refer to Table 3 for minimum wire size and overcurrent protection required for the AC input wiring.
2. Remove about two inches of the insulating jacket from the AC cable, and then separate the three wires and strip about 3/4" of insulation from each wire.
3. Using approved AC wire connectors, connect the incoming Hot In, Neutral In, and Ground wires to the MM Series' AC wires colored black (HOT IN), white (NEU IN), and green (AC GROUND) respectively.
4. After making the AC input connections, secure the AC input cable by tightening the strain relief.

The AC input wiring in the inverter is complete. Review all AC wiring to ensure all connections are correct and secure.



**Figure 2-7, AC Wiring Connections (MM612/MM1212 only)**

### 2.6.5 AC Output Wiring



**CAUTION:** The inverter's AC output must never be connected to an AC power source. This will cause severe damage to the inverter and is not covered under warranty.

When hardwiring the output of the inverter, a cable must be routed from the inverter's output to an AC distribution panel (sub-panel) that provides overcurrent protection to the loads powered by the inverter. Connect the AC output to this distribution panel using the following instructions (Figure 2-7):

1. Remove the 1/2" knockout on the AC Output Connection (see Figure 1-4, Item 15)—use a utility knife to cut through the round slot.
2. Discard this knockout and install a 1/2" strain relief in the AC OUT opening. You may need to file the opening edge to fit properly.
3. Run a 2-conductor plus ground cable through the strain relief on the AC OUT opening. Refer to Table 3 for minimum wire size and overcurrent protection required for the AC output wiring.
4. Remove two inches of the insulating jacket from the AC cable, and then separate the three wires and strip about 3/4" of insulation from each wire.
5. Using approved AC wire connectors, connect the outgoing Hot Out, Neutral Out, and AC Ground wires to the MM Series' AC wires colored red (HOT OUT), white with black stripe (NEU OUT), and green (AC GROUND) respectively. Gently pull on the wires to ensure they are securely held together, and check to see that no bare wire is exposed.
6. After making the AC output connections, secure the AC output cable by tightening the strain relief.
7. Connect the outgoing AC wires to an AC load panel equipped with overcurrent protection (e.g., circuit breakers).

The AC output wiring in the inverter should be complete. Before reattaching the AC access cover, ensure all AC wiring connections are correct and secure.

### 2.6.6 Ground-Fault Circuit Interruption (GFCI) Breakers

If installing this inverter in the wiring system of a mobile application (RV/marine/truck), a GFCI may be installed to protect some branch circuits powered by this inverter. In compliance with UL standards, Sensata has tested the following GFCIs and has found that they function properly when connected to the inverter's AC output (there are others on the market that will work just as well): *Shock Sentry™ #XGF15V-SP, Leviton Smart Lock #8899-A, Hubbel #GF520EMBKA*



**WARNING:** Risk of electric shock. Use only the GFCIs [receptacles or circuit breaker(s)] specified in this manual. Other types may fail to operate properly when connected to this inverter.

### 2.6.7 Inverter Warning Label

The warning label (see Figure 2-8) is provided to inform all personnel that an inverter is installed in your electrical system. Affix this label in a clearly visible location at the electrical panel that is being powered by the inverter. This is necessary because it might be falsely assumed that the panel is no longer "hot" after AC power has been shut off—when in fact power may actually still be available due to the inverter automatically powering the panel.

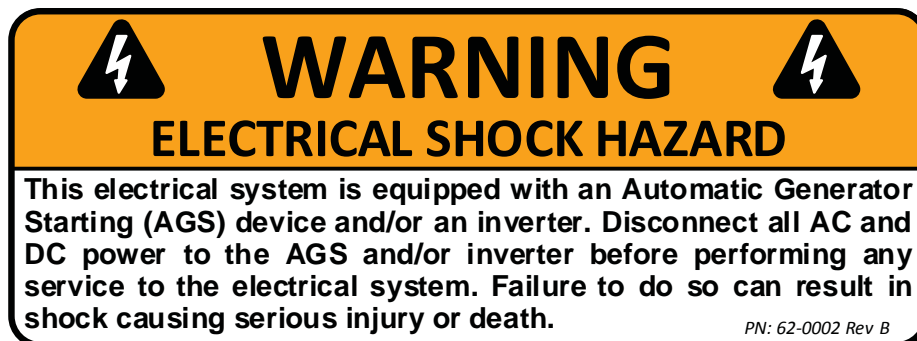


Figure 2-8, Warning Label



### 2.7 Functional Test

After all electrical connections to the inverter, batteries, AC source, and loads (using a sub-panel) have been completed, follow these steps to test the installation and the inverter's operation.

1. Check the battery voltage and polarity before connecting the batteries to the inverter. Use a multimeter to verify 10 to 15 VDC at the batteries' positive and negative terminals.
2. Apply battery power to the inverter by switching the DC disconnect on (or close the DC circuit-breaker). The inverter will remain off, but the green status indicator on the front of the inverter will quickly blink once to indicate that DC power has been connected and is ready to be turned on.
3. Prior to turning on the inverter, make sure all connected loads (e.g., appliances) are switched off or disconnected from the AC outlets.
4.
  - a. If a remote switch is connected, press the ON/OFF switch to turn the inverter on.
  - b. If there is not a remote switch connected, lightly press and release the inverter's ON/OFF power switch—located on the top of the inverter—to turn the inverter on.

Verify the inverter's status indicator is blinking—indicating the inverter is providing AC power.
5. Check the output voltage of the inverter by connecting a multimeter to the outlets powered by the inverter. Verify the voltage is 120 VAC +/- 5 VAC.
6. Turn on or connect a load to the outlets and verify it comes on. Continue to keep the load connected and turned on.
7. Press the remote ON/OFF switch to turn the inverter off. If the remote is not used, press and release the inverter's ON/OFF power switch to turn the inverter off. The inverter's status indicator and the connected load should go off.
8. Apply AC power to the inverter's AC input. After the AC input power is qualified (approximately 15 seconds), the incoming AC power will transfer through the inverter to the inverter's AC output and power the connected load. Verify the inverter's status indicator and the connected load comes on.
9. Even though the connected load is on, the inverter is currently disabled/off. Press the remote's ON/OFF switch (or press and release the ON/OFF power switch on the inverter) to enable/turn on the inverter.
10. Disconnect the incoming AC power to the inverter. Verify the connected load remains on, but now is powered by the inverter.

If the inverter passes all the steps, the inverter is ready for use.

If the inverter fails any of the steps, refer to the Troubleshooting section.

## 3.0 Operation

### 3.1 Operating Modes

The MM Series inverter has two normal operating routines. Inverter mode, which powers the loads using the batteries, and Standby mode, which transfers the incoming AC power (i.e., shorepower or a generator) to power the loads and recharge the batteries. This inverter also includes an extensive protection circuitry that shuts down the inverter under certain fault conditions.

#### 3.1.1 Invert Mode

When the inverter is first powered up, it defaults to the OFF mode. The momentary ON/OFF power switch (Figure 1-2, Item 2) must be lightly pressed to turn the inverter on. Subsequently pressing this switch alternately turns the inverter off and on.

- **Inverter OFF** – When the inverter is off, no power is used from the batteries to power the AC loads and the status LED will be off. If AC power from an external source (shorepower or generator) is connected and qualified on the inverter’s AC input, this AC input power will pass through the inverter to power the AC loads. However, if this AC power is lost, the AC loads will no longer be powered because the inverter is off. When the inverter is turned on, it operates either by “Searching” or “Inverting”, depending on the connected AC loads.
- **Searching** – When the inverter is first turned on, the automatic Search feature is enabled. This feature is provided to conserve battery power when AC power is not required. In this mode, the inverter pulses the AC output looking for an AC load (i.e., electrical appliance). Whenever an AC load (greater than 5 watts) is turned on, the inverter recognizes the need for power and automatically starts inverting. When there is no load (or less than 5 watts) detected, the inverter automatically goes back into Search mode to minimize energy consumption from the battery bank. When the inverter is “Searching”, the inverter’s green LED flashes.



**Info:** The factory default value for the Search feature is 5 watts. It can be turned off or adjusted from 5 to 50 watts using the ME-RC50 remote display.

- **Inverting** – When a load greater than 5 watts is connected to the inverter output, the MM Series “inverts” the DC power from the battery and supplies 120 VAC power to your sub-panel. The inverter’s green LED flashes once every 2 seconds to indicate it is inverting. The amount of time the inverter can be inverting and providing power is directly related to the amount of AC loads that are connected, and the capacity of the battery bank.

#### 3.1.2 Standby Mode (MM1212/MM1212-G models)

The MM1212/MM1212-G Series models feature an automatic transfer relay and an internal battery charger when operating in Standby mode. Standby mode begins whenever AC power (shorepower or generator) is connected to the inverter’s AC input. Once the AC voltage and frequency of the incoming AC power is within the AC input limits, an automatic AC transfer relay is activated. This transfer relay passes the incoming AC power through the inverter to power the AC loads on the inverter’s output. This incoming power is also used to activate a powerful internal battery charger to keep the battery bank charged in case of a power failure.

## Operation

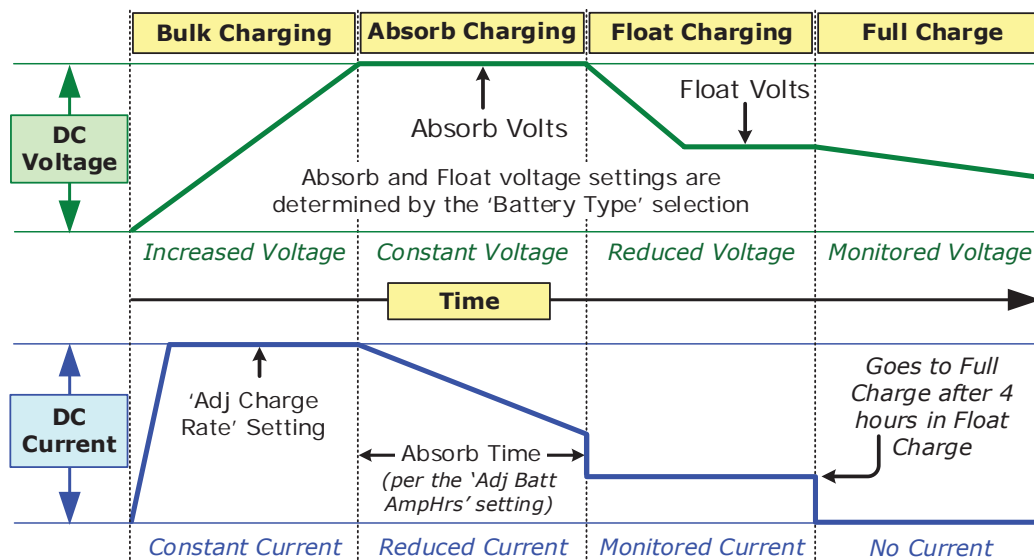
**Battery charging** – The MM1212/MM1212-G Series models are equipped with an active Power Factor Corrected (PFC) multi-stage battery charger. The PFC feature is used to control the amount of power used to charge the batteries in order to obtain a power factor as close as possible to 1 (or unity). This causes the battery charger to look like a resistor to the line (forces the charge current wave shape to mirror the voltage wave shape). This feature maximizes the real power available from the AC power source (shorepower or generator), which translates into less power wasted and a greater charging capability than most chargers available today.

When an AC power source is connected to an inverter that has a battery charger, the inverter monitors the AC input for acceptable voltage. Once the inverter has accepted the AC input, the AC transfer relay will close and charging will begin. Once charging, the DC voltage is monitored to determine the charging stage. If the DC voltage is low ( $\leq 12.9$  VDC), the charger begins bulk charging. If the DC voltage is high ( $> 12.9$  VDC), the charger skips the initial Bulk/Absorb Charging stages and goes directly to float charging.

The multi-stage charger can use up to five different charging stages to help monitor and keep the batteries healthy. The five stages include an automatic 4-stage charging process (Bulk, Absorb, Float, and Full Charge), and a manual Equalization (EQ) charge stage. The automatic 4-stage charge process provides complete recharging and monitoring of the batteries without damage due to overcharging (see Figure 3-1). The Equalization stage (requires the ME-RC50 remote) is used to stir up stratified electrolyte and reverse any battery plate sulfation that might have occurred.

While charging, the unit may go into Charger Back-off protection which automatically reduces the charge current to the batteries. This is caused by:

1. The internal temperature is too hot—the charger automatically reduces the charge rate to maintain temperature; or,
2. The AC input voltage falls  $< 85$  VAC—the charger reduces the charge current to zero to help stabilize the incoming AC voltage; or
3. FET temperature.



**Figure 3-1, Automatic 4-Stage Charging Graph**

The automatic 4-stage charging process includes:

- **Bulk Charging:** This is the initial stage of charging. While bulk charging, the charger supplies the battery with constant current. The charger remains in bulk charge until the absorption charge voltage is achieved (14.6 VDC)\*—as determined by the *Battery Type* selection\*\*.
- **Absorb Charging:** This is the second charging stage and begins after the bulk voltage has been reached. Absorb charging provides the batteries with a constant voltage and reduces the DC charging current in order to maintain the *Absorb Voltage* setting. The absorb charging time is 120 minutes—as determined by the *Battery AmpHrs* selection\*\*.
- **Float Charging:** The third charging stage occurs at the end of the absorb charging time. While float charging (also known as a maintenance charge), the batteries are kept fully charged and ready if needed by the inverter. The Float Charging stage reduces battery gassing, minimizes watering requirements (for flooded batteries), and ensures the batteries are maintained at optimum capacity. In this stage, the charge voltage is reduced to the float charge voltage (13.4 VDC)\*—as determined by the *Battery Type* selection\*\*—which can maintain the batteries indefinitely.
- **Full Charge (Battery Saver™ mode):** The fourth stage occurs after four hours of float charging. The Full Charge stage maintains the batteries without overcharging, preventing excessive loss of water in flooded batteries or drying out of GEL/AGM batteries. In this stage, the charger is turned off and begins monitoring the battery voltage. If the battery voltage drops low ( $\leq 12.7$  VDC), the charger will automatically initiate another four hours in float charge.

**Transfer time** – While in Standby mode, the AC input is continually monitored. Whenever AC power falls below the VAC dropout voltage (80 VAC = default), the inverter automatically transfers back to Inverter mode with minimum interruption to your appliances—as long as the inverter is turned on (inverter waits approximately 15 seconds to ensure the AC source is stable before transferring). The transfer from Standby to Inverter mode averages about 16 milliseconds. While the MM1212 Series is not designed as a computer UPS system, this transfer time is usually fast enough to hold them up. However, the *VAC Dropout* setting has an effect on the ability of the loads to transfer without resetting. The lower this setting (requires a ME-RC50 or ME-ARC50 remote to adjust), the longer the effective transfer will be and therefore, the higher the probability for the output loads to reset. This occurs because the incoming AC voltage is allowed to fall to a level that is so low that when the transfer does occur, the voltage on the inverter's output has already fallen to a low enough level to reset the loads. The disadvantage of a higher VAC dropout setting is that smaller generators (or large generators with an unstable output) may nuisance transfer. This commonly happens when powering loads that are larger than the generator can handle—causing the generator's output voltage to constantly fall below the inverter's input VAC dropout threshold.

\* – Voltage settings are based on the BTS being disconnected, or at a temperature of 77°F (25°C). If a BTS is installed, these voltage settings will increase if the temperature around the BTS is below 77°F (25°C), and decrease if the temperature around the BTS is higher than 77°F (25°C).

\*\* – The MM Series uses changeable settings (see Table 5, *Inverter Default Settings*) that are adequate for most installations. However, if you determine that some of your operating parameters need to be changed, the ME-RC50 remote control can be purchased to allow changes to those settings.

### 3.2 Battery Temperature Sensor Operation

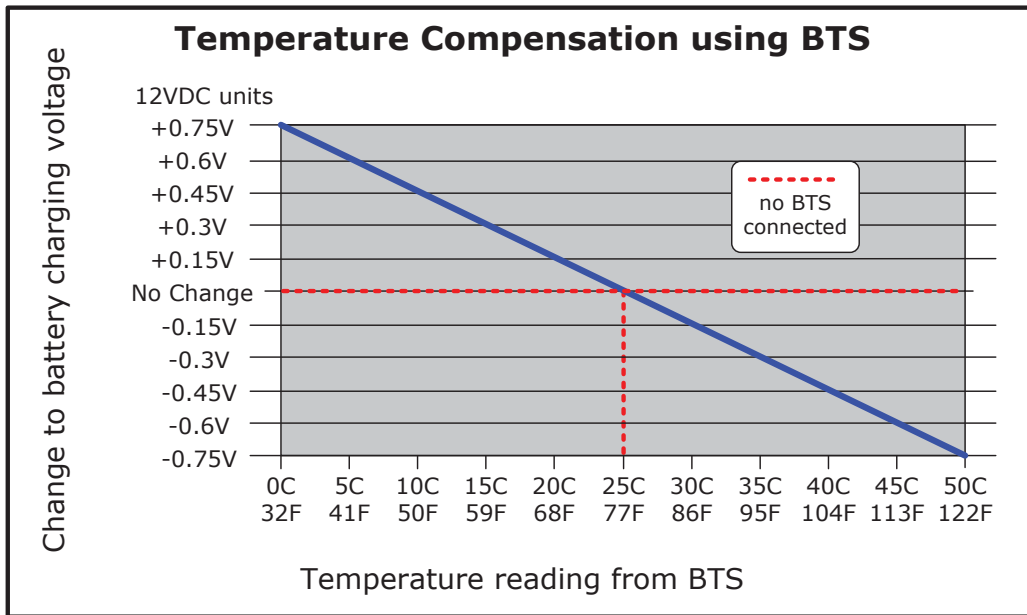
The plug-in Battery Temperature Sensor (BTS) is used to determine the battery temperature around the batteries. This information allows the multi-stage battery charger to automatically adjust the battery charge voltages for optimum charging performance and longer battery life.

When the BTS is installed, if the temperature around the BTS is below 77°F (25°C) the absorb and float charge voltage increases. If the temperature around the BTS is higher than 77°F (25°C), the absorb and float charge voltage decreases. See Figure 3-2 to determine how much the charge voltage changes (increases or decreases) as the temperature reading of the BTS changes. For example, the nominal absorb charge voltage for a flooded battery at 77°F (25°C) is 14.6 VDC. If the battery temperature is 95°F (35°C), the absorb charge voltage would decrease to 14.3 VDC (14.6 VDC - 0.3 change).

If the temperature sensor is NOT installed, the charge voltages will not be compensated and the battery will maintain the charge it had at a temperature of 77°F (25°C). The life of the batteries may be reduced if they are subjected to large temperature changes when the BTS is not installed.



**Info:** When the BTS is connected, the battery charger uses a value of -5mV/°C/Cell from 0 to 50°C to change the charge voltage based on temperature.



*Figure 3-2, BTS Temperature to Charge Voltage Change*

### 3.3 Protection Circuitry Operation

The inverter is protected against fault conditions, and in normal usage it will be rare to see any. However, if a condition occurs that is outside the inverter's normal operating parameters, then it will shut down and attempt to protect itself, the battery bank, and your AC loads. If there is a condition that causes the inverter to shut down, it may be one of the conditions listed below. Refer also to the Troubleshooting section to diagnose and clear the fault.

**Low Battery** – The inverter will shut off whenever the battery voltage falls to the Low Battery Cut Out (LBCO) level to protect the batteries from being over-discharged. After the inverter has reached the LBCO level and turned off, the inverter will automatically restart after one of the following conditions:

1. AC power is applied and the inverter begins operating as a battery charger.
2. Battery voltage rises to the Low Battery Cut In (LBCI) level.

The inverter’s status LED turns off when a low battery fault condition occurs. Refer to Table 4 to determine the LBCO and LBCI levels for your particular inverter model.

- **High Battery** – In the event the battery voltage approaches the High Battery Cut Out (HBCO) level, the inverter will automatically shut down to prevent the inverter from supplying unregulated AC output voltage. The inverter’s status LED turns off when a high battery fault condition occurs. The inverter will automatically restart when the battery falls to the High Battery Cut In (HBCI) level. Refer to Table 4 to determine the HBCO and HBCI levels for your particular inverter model.



**Info:** High battery voltage may be caused by excessive or unregulated voltage from solar panels or other external charging sources.

- **Overload** – During Inverter and Standby modes, the inverter monitors the DC and AC current levels. In the event of a short-circuit or an overload condition for more than a few seconds, the inverter will shut down. To start operating after this fault, the inverter needs to be restarted (turned back on) after the inverter’s AC loads are reduced/removed.
- **Over-temperature** – If internal power components begin to exceed their safe operating temperature level, the inverter will shut down to protect itself from damage. The inverter’s status LED turns OFF to indicate the over-temperature fault condition. The inverter will automatically restart after the units cools down.
- **Internal Fault** – The inverter continually monitors several internal components and the processor communications. If a condition occurs that doesn’t allow proper internal operation, the inverter will shut down to protect itself and the connected loads. The inverter will need to be reset to start operating (see Section C-3.1).

**Table 4, Inverter Battery Turn On/Off Levels**

Inverter Battery Turn On/Off Levels	Inverter Model	
	MM612	MM1212/MM1212-G
HBCO	16.0 VDC	16.0 VDC
HBCI	15.5 VDC	15.5 VDC
LBCI	≥12.5 VDC	≥12.5 VDC
LBCO (one minute delay)	10.0 VDC (9.0 - 12.2 VDC)	10.0 VDC (9.0 - 12.2 VDC)
LBCO (immediate)	8.5 VDC	8.5 VDC

### 3.4 Inverter Startup

**ON/OFF Switch** – The inverter can be turned on and off by lightly pressing and releasing the Power ON/OFF switch on the front of the inverter. When the inverter is first connected to the batteries, or when its automatic protection circuit has turned the inverter off, the ON/OFF switch will need to be pressed to start the unit. Once the inverter has been turned on, pressing the Power ON/OFF switch alternately turns the inverter on and off.



**WARNING:** The Power ON/OFF control switch does not turn on or off the charger feature. If AC power (utility or generator) is connected and qualified on the AC input, this AC power will also be available on the AC output and is not controlled by the Power ON/OFF switch.

**Status LED Indicator** – The status indicator is a green LED (Light Emitting Diode) that provides information on the operational mode of the inverter. Watch this indicator for at least 10 seconds to determine the inverter's operational condition from the information below:

#### Inverter Mode

- *Off* – Indicates the inverter is off; there is no AC power from the inverter, shorepower, or generator at the inverter's output terminals.
- *Blinks On (once every second)* – The inverter is on and is using energy from the battery. The inverter is either providing full power to the loads connected to the inverter, or it's in Search mode and ready to supply AC power to the connected loads.

#### Protection Mode

There are five fault conditions that will cause the inverter to shut down; Low Battery, High Battery, Over-temperature, AC Overload, and Internal faults. If your inverter has shut down, monitor the status indicator and count the number of blinks that occur every four seconds to determine the particular reason for the shutdown. Once you have determined the reason for the shutdown, refer to the Troubleshooting section to help diagnose/clear the fault condition.

- *Blinks On (1 time every four seconds)* – Low Battery fault
- *Blinks On (2 times every four seconds)* – High Battery fault
- *Blinks On (3 times every four seconds)* – Over-temperature fault
- *Blinks On (4 times every four seconds)* – AC Overload fault
- *Blinks On (5 times every four seconds)* – Internal fault

#### Charge Mode (MM1212/MM1212-G models)

The green LED status indicator provides additional information:

- *Blinks Off (once every four seconds)* – The unit is charging the batteries connected to the inverter. The external AC power (shorepower or generator) connected to the inverter's input is passing through the inverter and is powering the AC loads connected to the inverter's output.

### 3.5 Factory Default Settings

Your MM Series inverter uses default settings that are adequate for most installations. However, if you determine that some of your operating parameters need to be changed, the optional ME-RC50 remote allows you to control the operation and to customize the programming parameters of the inverter and/or charger.

**Table 5, Inverter Default Settings**

Function	Default Settings	
	MM612	MM1212/MM1212-G
Search Watts	NA	5W
LowBatCutOut	10.0 VDC	
Battery AmpHrs	400 AmpHrs (Absorb Time = 90 minutes)	
Battery Type	Flooded – Liquid Lead Acid (Absorb = 14.6 VDC, Float = 13.4 VDC)	
Charge Rate	NA	100%
VAC Dropout	NA	80VAC

To help you determine if you need the ME-RC50 remote\*, information on the settings that can be changed is provided below. The settings once programmed are saved in non-volatile memory and will be preserved until changed—even if DC power to the inverter is lost (the ME-RC50 must always be connected).

- **Search Watts:** This setting allows you to enable the power-saving Search mode circuitry and to adjust the power level at which the inverter will “wake up” and start inverting. This function is not available on the MM612 model, and is adjusted to 5W (“wakes up” and inverts if loads exceed 5 watts) on the MM1212 and MM1212-G models.
- **LowBatCutOut:** This setting determines when the inverter will turn off based on low battery voltage (inverter turns off automatically after battery voltage has been below this setting for more than one minute). This protects the batteries from over-discharge and the AC loads from unregulated power (brown-outs).
- **Battery AmpHrs:** This setting allows the user to input the battery bank size in amp hours, which provides information to the charger on how long to charge the batteries in the Absorb Charging stage.
- **Battery Type:** Sets the type of batteries being used in the system which provides information to the charger to determine what voltage level to charge the batteries.
- **Charge Rate:** This setting uses a percentage of the charger’s maximum output to determine the output charge rate. This setting can be used to limit the amount of current that the charger can use (leaving more current available to power loads); or, to ensure small battery banks are not overheated because of a charge rate that is too high.
- **VAC Dropout:** Sets the minimum AC voltage that can be present on the AC input before the unit transfers from Transfer mode to Invert mode. This protects the AC loads from utility outages and brown-outs.

\* Visit our website ([www.SensataPower.com](http://www.SensataPower.com)) for more information.



## 4.0 Troubleshooting

The MM Series inverter is a fairly simple device to troubleshoot. There are only two active circuits (AC and DC), as well as a charging circuit in some of the models. Use the following chart to help you troubleshoot any issues.

**Table 6, Troubleshooting Guide**

Symptom	Possible Cause	Recommended Solution
<b>Low Battery Voltage</b> (status indicator blinks x1/4 secs)	The battery voltage level has dropped below the Low Battery Cut Out (LBCO) set-point for more than one minute (10.0 VDC = LBCO default).	Battery voltage too low. Check fuses/circuit-breakers and cable connections, and battery voltage at inverter's terminals. Batteries may need to be charged—fault condition will automatically clear when the battery voltage exceeds 12.5VDC.
<b>High Battery Voltage</b> (status indicator blinks x2/4 secs)	The battery voltage is above 15.5 VDC. The inverter automatically resets and resumes operation when the battery voltage drops below 15.5 VDC.	Usually occurs only when an additional charging source (alternator, solar panels or other external charging sources) is used to charge the battery bank. Reduce or turn off any other charger to the inverter batteries to allow the voltage level to drop.
<b>Over-temperature condition</b> (status indicator blinks x3/4 secs)	The internal temperature of the inverter has risen above acceptable limits; caused by loads too great for the inverter to operate continuously, or by lack of ventilation to the inverter. Once unit cools, it automatically resets and resumes operation.	Reduce the number of electrical loads that you are operating, this will avoid a repeat Overtemp shutdown if the cause was too many loads for the ambient conditions.
		Check ventilation around the inverter, ensure cool air is available to pass through the inverter.
<b>AC Overload</b> (status indicator blinks x4/4 secs)	The inverter has turned off because the connected loads are larger than the inverter's output capacity, or the output wires are shorted.	Reduce the AC loads connected to the inverter or remove all AC output wiring, and then restart the inverter.
<b>Internal fault</b> (status indicator blinks x5/4 secs)	This fault occurs when an internal fault is detected.	To clear, an inverter reset is required. Remove DC power to the inverter, or press and hold down the inverter's power switch for 15 seconds (until green Status LED lights). If this fault does not clear, the unit will need to be serviced.
<b>Inverter's status light is off</b>	Inverter is switched OFF, or there is no DC voltage (battery) connected to inverter.	Switch the inverter ON. Connect a battery with correct voltage to the inverter.
<b>AC input won't connect (AC IN on remote blinks)</b>	Incoming AC voltage will not be accepted if it is below the VAC Dropout setting (80VAC = VAC Dropout default).	Check the incoming AC voltage to the input of the inverter, ensure it is present and above the VAC dropout level.
<b>Appliances turn off and on; or there is low AC output power</b>	Loose AC output connections.	Tighten AC output connections.
	Loose/corroded battery cables.	Clean and tighten all cables.
	Low batteries.	Recharge or replace batteries.
<b>Inverter AC output voltage too low or too high when using an AC voltmeter</b>	Wrong type of voltmeter used (displays 90 VAC to 130 VAC depending on the battery voltage).	Most meters are made to read "average AC voltage". AC output of the MM is a modified waveform which requires using a "true" RMS voltmeter to correctly read the output voltage.
<b>While charging, DC charge voltage is higher or lower than expected</b>	If the Battery Temperature Sensor is installed, it will increase or decrease the DC voltage level depending on temperature around the battery sensor.	This is normal.

## 5.0 Specifications

**Table 7, MM Series Specifications**

MODEL	MM612	MM1212/ MM1212-G
<b>Inverter Specifications</b>		
Input battery voltage	9 to 16.0 VDC	
Nominal AC output voltage	120 VAC +/- 5%	
Output frequency/Accuracy	60 Hz +/- .01%	
1msec surge current	27A	42A
100msec surge current	11A	23 A
5 sec surge power	1100W	2100W
30 sec surge power	1000W	1750W
5 min surge power	950W	1450W
30 min surge power	675W	1375W
Continuous output power	600 VA	1200 VA
Input DC current (at 12.6Vdc)	60A	125A
Inverter efficiency (peak)	95%	
Transfer time	16 msec	
AC transfer capability	7A	12A
Pwr Consumption – Search (typical)	3W	5W
Pwr Consumption – No load (typical)	10W	18W
Output AC waveform type	Modified Sine Wave	
<b>Charger Specifications</b>		
Continuous output @25 °C	NA	70 ADC
Charger efficiency (maximum)	NA	88%
Power factor	NA	> 0.95
Input current @ rated output	NA	9 AAC
Temperature compensation	NA	Yes, with BTS
<b>General Features and Capabilities</b>		
Protection circuitry	Low/High Battery, Over-temp & Overload	
Corrosion protection	PCB's conformal coated, powder coated chassis	
Output circuit breaker	7A switchable	15A switchable
Input circuit breaker	8A	20A
Internal cooling	Yes, 0 to 59 cfm variable speed	
AC output	Hardwire	Hardwire/GFCI outlet
AC input	Hardwire	Hardwire/Power cord
UL listing	ETL to UL/cUL458, CSA C22.2 #107.1-01	
<b>Environmental Specifications</b>		
Operating temperature	-20°C to +60°C (-4°F to 140°F)	
Non-operating temperature	-40°C to +70°C (-40°F to 158°F)	
Operating humidity	0 to 95% RH non-condensing	
<b>Physical Specifications</b>		
Dimensions (L x W x H)	16.6" x 8.4" x 4.7" (42cm x 21cm x 12cm)	
Mounting	Shelf or wall (top or bottom up)	
Weight	14 lbs. (6.4 kg)	20 lbs. (9 kg)
Shipping weight	18 lbs. (8.2 kg)	23 lbs. (10.5 kg)

*Specifications @ 25°C (77°F) – Subject to change without notice*

### Appendix A – Remotes and Optional Equipment

#### A-1 Remote Controls

There are several remotes that enable you to monitor and switch the inverter on/off from a convenient location. The remotes connect to the REMOTE port located on the front side of the MM Series inverter (see Figure 1-3, Item 10).

Depending on your inverter model, you can select one of the following remotes:

- **MM-R** – Provides three LED indicators for identifying inverter status, and includes a remote ON/OFF switch (with 25' cable). This remote is for the MM612 model inverter (without the battery charger feature).
- **MM-RC** – Provides six LED indicators for identifying inverter and charger status, and includes a remote ON/OFF switch (with 25' cable). This remote is for the MM1212/MM1212-G model inverters with the battery charger feature.
- **ME-RC50** – Full feature remote with backlit LCD display and LED indicators for identifying inverter and charger status. Provides full menu access for easy selection and adjustment (comes with 50' cable). The ME-RC50 is used for many inverter models and has additional features that are not functional with the MM Series inverter. However, it can be used with all MM Series inverter models.

#### A-2 Optional Equipment and Accessories

The following Magnum components are available for use with MM Series inverters. Some of these items are required—depending upon the intended use of the inverter.

##### Auto Generator Start Controller

The ME-AGS-N Automatic Generator Start controller (Network version) is designed to automatically start your generator based on low battery condition or high temperature. It works with 12, 24, and 48-volt battery banks and includes a 4-position DIP (Dual In-line Package) switch which provides the ability to change the relay timing configurations to allow compatibility with a wider range of generators.

##### Battery Monitor Kit

The ME-BMK Battery Monitor Kit is a single battery bank amp-hour meter that monitors the condition of the battery and provides information to let you know how much energy you have available and to plan your electrical usage to ensure the battery is not being over-discharged. The ME-BMK-NS version does not include a DC shunt—order the ME-BMK to receive a 500A/50mv DC shunt.

##### Fuse Block/Fuses

The Magnum Fuse/Fuse-blocks are used to protect the battery bank, inverter, and cables from damage caused by DC short circuits and overloads. They include a slow-blow fuse with mounting block and protective cover. The 125 and 200-amp models use an ANL type fuse and the 300 and 400-amp models use a Class-T fuse.

##### DC Load Disconnect

The MM-DCLD (DC Load Disconnect) pigtail adapter is designed to provide a means to DISABLE the inverter function when a 12-volt DC signal is removed.

##### Ignition Switch Activate

The MM-ISA (Ignition Switch Activate) is a pigtail adapter is designed to automatically ENABLE the inverter function when a 12-volt DC signal is supplied.

## Appendix B – Battery Information

### B-1 Battery Bank Sizing

The size of the battery bank determines how long the inverter can power the AC loads without recharging. The larger the battery bank, the longer the run time. Size your battery bank to the system's AC load requirements and the length of time required to run the load from the batteries. In general, the battery bank should not be discharged more than 50%.

### B-2 Battery Types

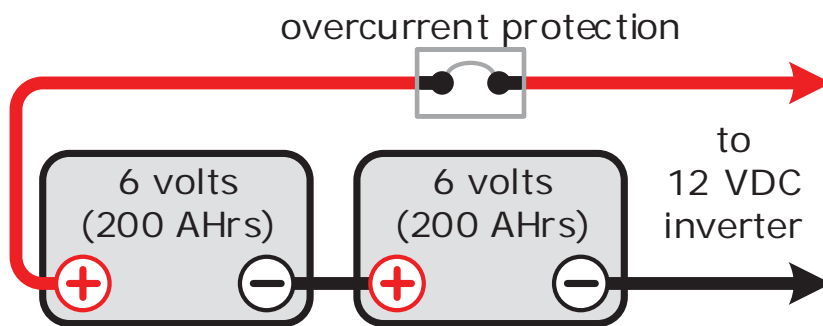
Batteries are available in different sizes, amp-hour ratings, voltage, and chemistries; they also come in liquid or gel, vented or non-vented, etc. They are also available for starting applications (such as an automobile starting battery) and deep discharge applications. Only the deep cycle types are recommended for inverter applications. Choose the batteries best suited for the inverter installation and cost. Use only the same battery type for all batteries in the bank. For best performance, all batteries should be from the same lot and date. This information is usually printed on a label located on the battery.

### B-3 Battery Configuration

The battery bank must be wired to match the inverter's DC input voltage specifications (12 VDC). In addition, the batteries can be wired to provide additional run time. The various wiring configurations are:

- **Series Wiring**

Wiring batteries in a series increases the total battery bank output voltage. A series connection combines each battery in a string until the voltage matches the inverter's DC requirement. Even though there are multiple batteries, the capacity remains the same. In the example below (Figure B-1), two 6 VDC/200 AHr batteries are combined into a single string—resulting in a 12 VDC/200 AHr bank.



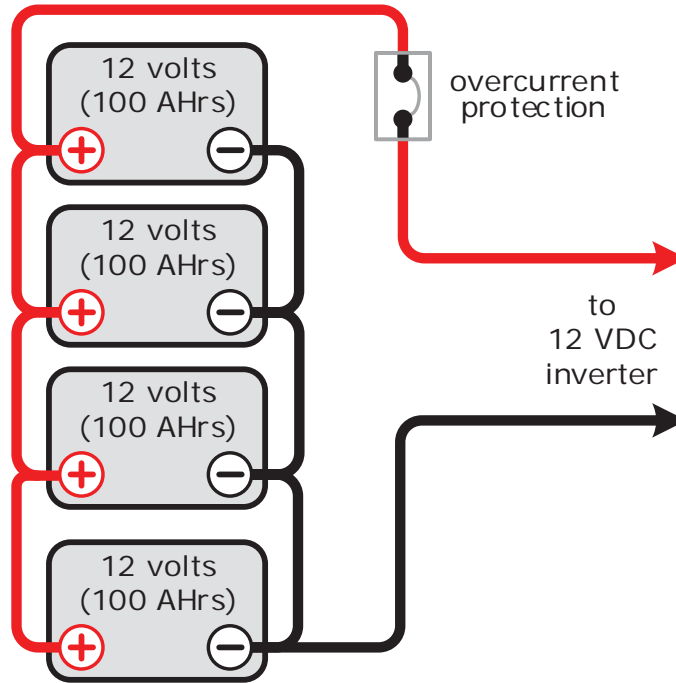
**12 volt battery bank (total capacity = 200 AHrs)**

*Figure B-1, Series Battery Wiring*

## Appendix B – Battery Information

- **Parallel Wiring**

Wiring the batteries in parallel increases the total run time the batteries can operate the AC loads. A parallel connection combines overall battery capacity by the number of batteries in the string. Even though there are multiple batteries, the voltage remains the same. In the example below (Figure B-2), four 12 VDC/100 Ahr batteries are combined into a single 12 VDC/400 Ahr battery bank.

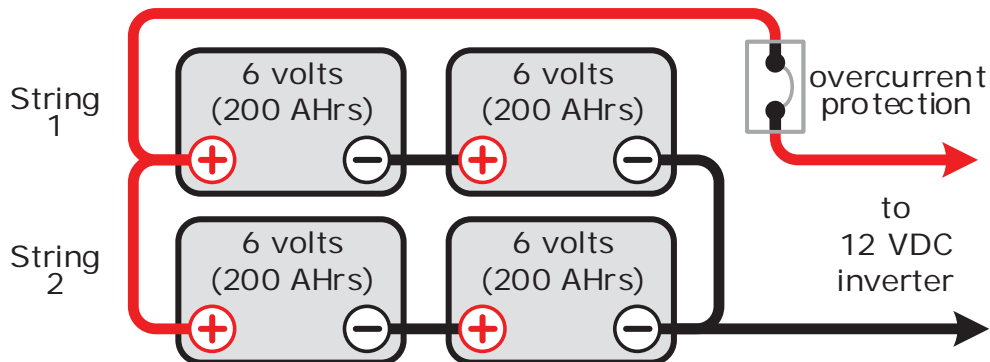


**12 volt battery bank (total capacity = 400 AHrs)**

*Figure B-2, Parallel Battery Wiring*

- **Series-Parallel Wiring**

A series-parallel configuration increases both voltage (to match the inverter's DC requirements) and capacity (to increase run time for operating the loads) using smaller, lower-voltage batteries. In the example below (Figure B-3), four 6 VDC/200 Ahr batteries are combined into two strings resulting in a 12 VDC/400 Ahr battery bank.



**12 volt battery bank (total capacity = 400 AHrs)**

*Figure B-3, Series-Parallel Battery Wiring*

## Appendix C – Preventive Maintenance

### C-1 Recommended Inverter and Battery Care

The MM Series inverter is designed to provide you with years of trouble-free service. Even though there are no user-serviceable parts, it is recommended that every 6 months you perform the following maintenance steps to ensure optimum performance and to extend the life of your batteries.



**WARNING:** Prior to performing these checks, switch both the AC and DC circuits off.

- Visually inspect your batteries for cracks, leaks, or swelling—replace if necessary.
- Use baking soda to clean and remove any electrolyte spills or buildups.
- Check and tighten all battery hold-down clamps.
- Clean and tighten (10 to 12 foot-pounds) all DC terminals (battery and inverter) and connecting cables.
- Check and fill battery water levels (Liquid Lead Acid batteries only).
- Check individual battery voltages (replace those that vary more than 0.3 VDC of each other).
- Check all cable runs for signs of chafing—replace if necessary.
- Check the inverter’s cooling vents—clean as necessary.

### C-2 RV/Marine Off-Season Storage

When placing a coach/boat into seasonal storage, perform the following to ensure the system is properly shut down (or properly configured for seasonal storage). This is especially important for maintaining the batteries.

- Perform the recommended maintenance steps noted above.
- Fully charge the batteries.
- Connect shorepower (if available) and verify that the breaker to the battery charger is switched on.
- Verify the inverter is switched off.
- Switch off all unnecessary AC and DC loads.

### C-3 Resetting the Inverter

Under some fault conditions (e.g., an internal fault), the inverter will need to be reset. Prior to performing any reset, ensure all AC power (utility, generator, shorepower) is removed from the inverter’s input.



**CAUTION:** If AC is connected while performing an inverter reset, damage may occur.

#### C-3.1 Performing an Inverter Reset (i.e., soft reset)

To perform an inverter reset (also known as a “soft reset”):

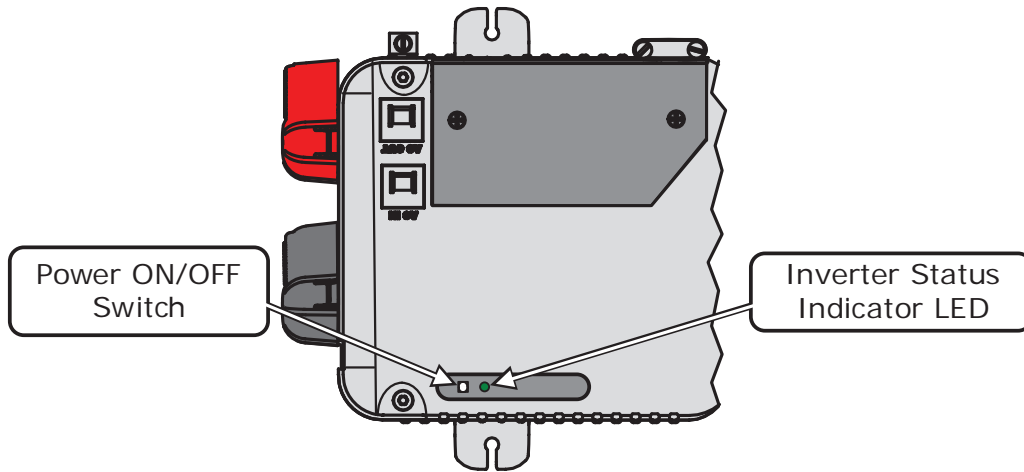
1. Press and hold the Power ON/OFF switch (see Figure C-1) for approximately fifteen (15) seconds until the Inverter Status Indicator LED comes on and flashes rapidly.
2. Once the rapid flashing has begun, release the Power ON/OFF switch. The Status LED will go off after the pushbutton is released.
3. After the inverter reset is completed, press the Power ON/OFF switch to turn the inverter on.

## Appendix C – Preventative Maintenance

If the inverter reset fails, you will need to perform a power reset using the procedure below. In either case, if an internal fault does not clear, the inverter will require repair at an Authorized Service Center (ASC).



**Info:** The Power ON/OFF switch is a small momentary type pushbutton which operates by lightly pressing and releasing. Be careful not to apply too much force when pushing or the switch might break.



*Figure C-1, Performing an Inverter Reset*

### C-3.2 Performing a Power Reset (i.e., hard reset)

To perform a power reset (also known as a “hard reset”):

1. Open the inverter’s positive DC disconnect (or disconnect the positive battery cable to the inverter).



**CAUTION:** If removing all battery power (positive and negative) to the inverter, do not remove the DC negative connections to the inverter or any accessory until all positive battery connections have been disconnected. This will prevent damage to the inverter or to any network connected accessory.

2. Ensure the inverter and the remote are disconnected from all AC and DC power.
3. After the inverter has been disconnected from all power for 30 seconds, reconnect the inverter DC disconnects (or reconnect the positive battery cable) and resume operation.



**Info:** If DC disconnects are not used, there may be a momentary spark when the positive battery cable is connected to the inverter’s terminal. This is normal and indicates that the inverter’s internal capacitors are being charged.

## Appendix D – Warranty/Service Information

### D-1 Warranty Information

Sensata Technologies warrants the MM Series inverter to be free from defects in material and workmanship that result in product failure during normal usage, according to the following terms and conditions:

1. The limited warranty for the product extends for 24 months beginning from the product's original date of purchase.
2. The limited warranty extends to the original purchaser of the product and is not assignable or transferable to any subsequent purchaser.
3. During the limited warranty period, Sensata will repair or replace (with factory new or rebuilt replacement items) at Sensata's option any defective parts, or any parts that will not properly operate for their intended use—if such repair or replacement is needed because of product malfunction or failure during normal usage. The limited warranty does not cover defects in appearance (cosmetic or decorative), or any structural or non-operative parts. Sensata's limit of liability under the limited warranty shall be the actual cash value of the product at the time the original purchaser returns the product for repair, determined by the price paid by the original purchaser. Sensata shall not be liable for any other losses or damages.
4. Upon request from Sensata Technologies, the original purchaser must prove the product's original date of purchase by a dated bill of sale, itemized receipt.
5. The original purchaser shall return the product prepaid to Sensata, or to one of Sensata's Authorized Service Centers (ASC). After the completion of service under this limited warranty, the product will be returned prepaid to the original purchaser via a non-expedited surface freight within the contiguous U.S. and Canada; this excludes Alaska and Hawaii.
6. If Sensata repairs or replaces a product, its warranty continues for the remaining portion of the original warranty period or 90 days from the date of the return shipment to the original purchaser, whichever is greater. All replaced products and parts removed from repaired products become the property of Sensata Technologies.
7. This limited warranty is voided if:
  - the product has been modified without authorization
  - the serial number has been altered or removed
  - the product has been damaged through abuse, neglect, accident, high voltage, or corrosion
  - the product was not installed and operated according to the owner's manual

**A RETURN MATERIAL AUTHORIZATION (RMA) NUMBER IS  
REQUIRED BEFORE RETURNING ANY PRODUCT**



### D-2 How to Receive Repair Service

If your product requires warranty service or repair, contact either:

- An authorized service center, at [www.SensataPower.com](http://www.SensataPower.com), or,
- Sensata Technologies at:
  - Telephone: 425-353-8833
  - Fax: 425-353-8390
  - Email: [MagnumWarranty@Sensata.com](mailto:MagnumWarranty@Sensata.com)

If returning your product directly to Sensata for repair, you must:

1. Return the unit in the original, or equivalent, shipping container.
2. Receive a Return Materials Authorization (RMA) number from the factory prior to the return of the product to Sensata for repair.
3. Place RMA numbers clearly on the shipping container or on the packing slip.

When sending your product for service, please ensure it is properly packaged.

**Damage due to inadequate packaging is not covered under warranty.**

We recommend sending the product by traceable or insured service.



Magnum Energy Products

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