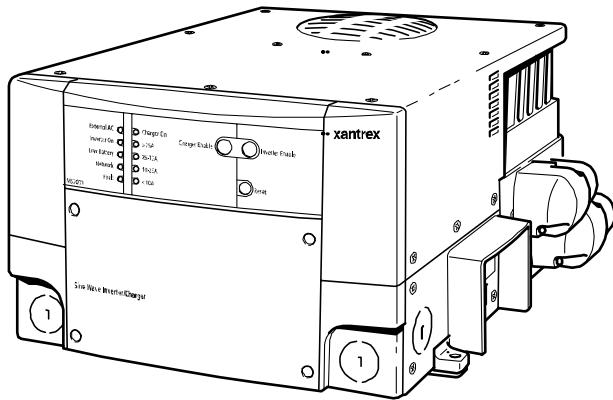


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MS2000

Installation Guide

MS2000 Sine Wave Inverter/Charger



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MS2000 Sine Wave Inverter/Charger

Installation Guide

About Xantrex

Xantrex Technology Inc. is a world-leading supplier of advanced power electronics and controls with products from 50 watt mobile units to one MW utility-scale systems for wind, solar, batteries, fuel cells, microturbines, and backup power applications in both grid-connected and stand-alone systems. Xantrex products include inverters, battery chargers, programmable power supplies, and variable speed drives that convert, supply, control, clean, and distribute electrical power.

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About This Guide

Purpose

The *MS2000 Sine Wave Inverter/Charger Installation Guide* describes the procedure for installing the MS2000 Sine Wave Inverter/Charger (MS2000).

Scope

The Installation Guide provides safety guidelines, detailed planning and setup information, and procedures for installing the inverter/charger. It does not provide information on operation, configuration, troubleshooting, and warranty and product information. Refer to the *MS2000 Sine Wave Inverter/Charger Operation Guide*.

This guide does not provide details about particular brands of batteries. You need to consult individual battery manufacturers for this information.

Audience

The Installation Guide is intended for qualified installers who need to install the MS2000. Installers should be certified technicians or electricians.

Conventions Used

The following conventions are used in this guide.



WARNING

Warnings identify conditions or practices that could result in personal injury or loss of life.



CAUTION

Cautions identify conditions or practices that could result in damage to the unit or other equipment.

Important: These notes contain information that is important for you to know, but is not as critical as a caution or warning.

Symbols Used

The following symbols are used on the product labels or in this guide.



In this guide: Important information, warnings or cautions.
On the product: Important information, warnings or cautions with further explanation in the product guides.



AC – Alternating current



DC – Direct current



Warning: Hot surface. Do not touch.



DC ground connection point



AC safety ground connection point from incoming AC source



AC safety ground connection point for AC output (to AC loads)

Abbreviations and Acronyms

For a listing of abbreviations and acronyms, refer to the *MS2000 Sine Wave Inverter/Charger Operation Guide*.

Related Information

For related materials on this Xanbus-enabled product and its available accessories, see also:

MS2000 Sine Wave Inverter/Charger Operation Guide (975-0125-02-01)

Automatic Generator Start Owner's Guide (975-0082-01-01)

System Control Panel Owner's Guide (975-0083-01-01)

Xanbus System Installation Guide (975-0136-01-01)

More information about Xantrex Technology Inc. as well as its products and services, including a complete list of Xanbus-enabled devices, is available at **www.xantrex.com**

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Important Safety Instructions

READ AND SAVE THESE INSTRUCTIONS

The *MS2000 Sine Wave Inverter/Charger Installation Guide* contains important safety instructions.

Before you install and use your MS2000 Sine Wave Inverter/Charger, be sure to read, understand, and save these safety instructions and those in the other product guides.

Read all cautionary markings on the inverter/charger, the batteries, and all appropriate sections of this guide.



WARNING: Risk of injury or loss of life

The MS2000 Sine Wave Inverter/Charger shall not be used in connection with life support systems or other medical equipment or devices.



WARNING

The following warnings identify conditions or practices that could result in personal injury or loss of life.

1. Use of accessories not recommended or sold by Xantrex Technology, Inc. may result in a risk of fire, electric shock, or injury to persons.
2. The inverter/charger is designed to be permanently connected to your AC and DC electrical systems. Xantrex recommends that all wiring be done by a certified technician or electrician to ensure adherence to the local and national electrical codes applicable in your application.
3. To avoid a risk of fire and electric shock, make sure that the existing wiring is in good condition and that the wire is not undersized. Do not operate the inverter/charger with damaged or substandard wiring.
4. To reduce risk of damage and injury, charge only rechargeable lead-acid batteries: flooded, gel, or absorbed glass mat (AGM) types. Other types of batteries may burst, causing personal injury and damage.
5. Do not operate the inverter/charger if it has received a sharp blow, been dropped, or otherwise damaged in any way. If the unit is damaged, see the Warranty and Product Information section in the *MS2000 Sine Wave Inverter/Charger Operation Guide*.

6. Do not disassemble the inverter/charger; it does not contain user-serviceable parts. Take it to a qualified service person when service or repair is required. Incorrect reassembly may result in a risk of electrical shock or fire. Internal capacitors remain charged after all power is disconnected. For instructions on obtaining service, see the section in the *MS2000 Sine Wave Inverter/Charger Operation Guide*.
7. Do not expose the inverter/charger to rain, snow, or splashing bilge water.
8. To reduce the risk of electric shock, disconnect all sources of AC and DC power from the inverter/charger before attempting any maintenance or cleaning. Turning off controls will not reduce this risk.
9. The inverter/charger must be provided with equipment grounding conductors connected to the AC input ground and chassis ground terminals.



CAUTION

Cautions identify conditions or practices that could result in damage to the unit or other equipment.

To reduce the risk of overheating, keep the ventilation openings clear and do not install the inverter/charger in a compartment with limited airflow or inadequate clearances around the unit. Refer to “Step 1: Choosing a Location for the Inverter/Charger” on page 16 for required clearance.

Explosive Gas Precautions



WARNING: Risk of explosive gases

Working in the vicinity of a lead-acid battery is dangerous. Batteries generate explosive gases during normal battery operation. For this reason, it is of utmost importance that each time before servicing equipment in the vicinity of the battery, you must read this guide and follow the instructions closely.

1. To reduce the risk of battery explosion, follow these instructions and those published by the battery manufacturer and the manufacturer of any equipment you intend to use in the vicinity of a battery. Review the cautionary markings on these products and on the engine.
2. This equipment contains components which tend to produce arcs or sparks. To prevent fire or explosion, do not install the inverter/charger in compartments containing batteries or flammable materials or in locations that require ignition-protected equipment. This includes any space containing gasoline-power machinery, fuel tanks, as well as joints, fittings, or other connections between components of the fuel system.

Personal Precautions When Working With Batteries

1. Someone should be within range of your voice or close enough to come to your aid when you work near a lead-acid battery.
2. Have plenty of fresh water and soap nearby in case battery acid contacts your skin, clothing, or eyes.
3. Wear complete eye protection and clothing protection. Avoid touching your eyes while working near batteries.
4. If battery acid contacts your skin or clothing, wash immediately with soap and water. If acid enters your eye, immediately flood the eye with running cold water for at least ten minutes and get medical attention immediately.
5. Never smoke or allow a spark or flame in the vicinity of the battery or engine.
6. Be extra cautious to reduce the risk of dropping a metal tool onto a battery. It might spark or short-circuit the battery or other electrical parts that may cause an explosion.

7. Remove personal metal items such as rings, bracelets, necklaces, and watches when working with a lead-acid battery. A lead-acid battery can produce a short-circuit current high enough to weld a ring or the like to metal, causing a severe burn.
8. Never charge a frozen battery.
9. If it is necessary to remove a battery, always remove the grounded terminal from the battery first. Make sure all the accessories are off, so as not to cause an arc.
10. Be sure the area around the battery is well ventilated.
11. Clean the battery terminals. Be careful to keep corrosion from coming in contact with your eyes.
12. Study all battery manufacturer's specific precautions such as removing or not removing the cell caps while charging and the recommended rates of charge.
13. For refillable (flooded) batteries, add distilled water in each cell until the battery acid reaches the level specified by the battery manufacturer. This helps to purge excessive gas from cells. Do not overfill. Carefully follow the manufacturer's recharging instructions.

FCC Information to the User

This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a residential environment. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instruction guide, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and the receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio/TV technician for help.

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Installation

The Installation Guide provides detailed information for installing the MS2000 Sine Wave Inverter/Charger, Echo Charger, and the battery temperature sensor.

The MS2000 is a Xanbus[®]-enabled device that typically powers the Xanbus system. For information on installing the Xanbus system, see the *Xanbus System Installation Guide*, which is available for download at www.xantrex.com.

This Installation Guide provides:

- safety instructions that must be observed during installation
- a diagram of a typical Xanbus system
- information on additional AC and DC components required
- a list of installation tools and materials
- detailed procedures for a typical installation
- installation testing procedures
- battery information

For information on operating the MS2000, see the *MS2000 Sine Wave Inverter/Charger Operation Guide*.

Installation Information

Before You Begin the Installation

Before beginning your installation:

- Read the entire Installation Guide so you can plan the installation from beginning to end.
- Read the *Xanbus System Installation Guide* to plan your network requirements.
- Assemble all the tools and materials you require for the installation.
- Review the Important Safety Instructions on page v.
- Be aware of all safety and electrical codes which must be met.



WARNING: Electrical shock and fire hazards

Xantrex® recommends all wiring be done by qualified personnel. Disconnect all AC and DC power sources to prevent accidental shock. Disable and secure all AC and DC disconnect devices and automatic generator starting devices.

It is the installer's responsibility to ensure compliance with all applicable installation codes and regulations.

Installation Codes

Applicable installation codes vary depending on the specific location and application of the installation. Some examples are:

- The U.S. National Electrical Code (NEC)
- The Canadian Electrical Code (CEC)
- Canadian Standards Association (CSA) and American Boat and Yacht Council (ABYC) standards for installation on boats.

External connections to the inverter/charger shall comply with the United States Coast Guard electrical regulations (33CFR 183, Sub Part 1).

About the Xanbus System

The Xanbus system includes the MS2000 Sine Wave Inverter/Charger and other Xanbus-enabled devices, as shown in Figure 1, “Typical Xanbus System Diagram”. Each Xanbus-enabled device interacts and communicates with the other devices on the network, creating a power system that can be precisely configured to your needs.

The MS2000 is the device that typically provides power in a Xanbus system. The System Control Panel provides configuration and monitoring capability for each device connected to the Xanbus system, such as the Automatic Generator Start and the MS2000.

In Figure 1, network connections are represented by dotted lines and conventional electrical connections are represented by solid lines. No attempt has been made to show polarity of electrical connections. Your system requirements may be more complex than the basic installation shown in Figure 1. Xantrex recommends that you consult a qualified installer or electrician to customize your installation to meet your requirements.

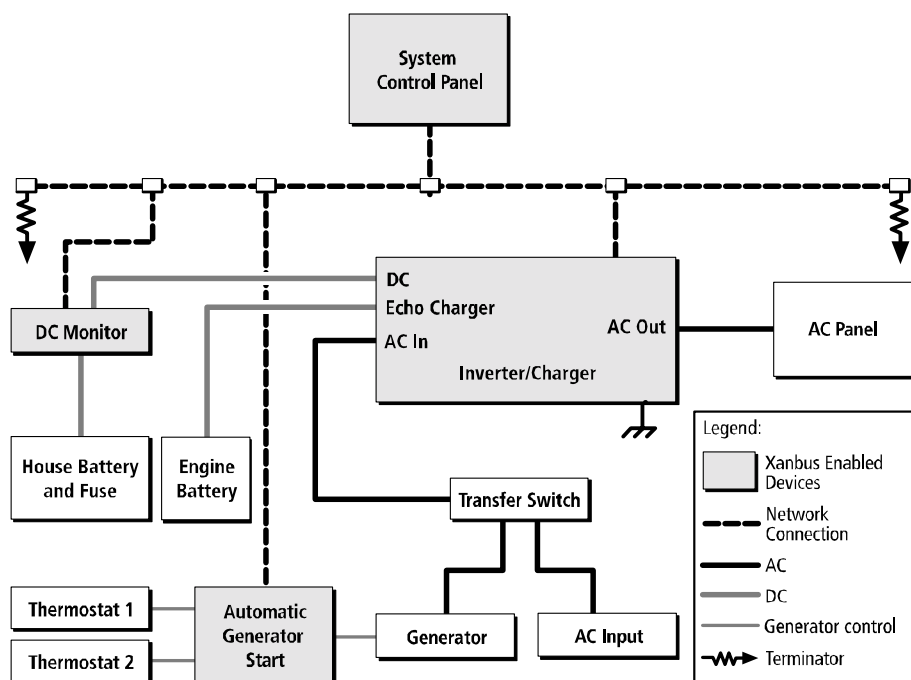


Figure 1 Typical Xanbus System Diagram

Xanbus Enabled



The Xanbus-enabled designation means that this product will work on a Xanbus network. Xanbus-enabled products are:

- Easy to use. The Xanbus network simplifies operation and automates routine tasks.
- Reliable. Software control eliminates errors due to analog signalling.
- Accurate. Digital information is less susceptible to interference and line loss.
- Upgradeable. Firmware upgrades mean your purchase will remain up to date.

For detailed instructions and a complete list of Xanbus-enabled devices, visit the website at www.xantrex.com

System Accessories

System accessories currently available that are Xanbus-enabled include the System Control Panel and Automatic Generator Start. These system accessories are available from any authorized Xantrex dealer or at www.xantrex.com Please provide the part number of the accessory to the dealer.

Other Xanbus-enabled devices will become available in the future.

Planning the Installation

This section provides information to help you plan for a basic installation of the MS2000.

As your system configuration is determined, record the details in Information About Your System on page WA-4 of the *MS2000 Sine Wave Inverter/Charger Operation Guide*.

Two Key Performance Factors

Two key factors in particular will have a major impact on system performance.

Size and Length of DC Cables

To select the appropriate size and length of DC cables, see “DC Cabling” on page 11.

The DC cables should be as short as possible and large enough to handle the required current, in accordance with the electrical codes or regulations applicable to your installation. If battery cables are in excess of 10 feet each (10 feet for the positive cable and 10 feet for the negative cable) or not of sufficient size, the voltage drop across the cables will have a negative impact on overall system performance.

Mounting Location of the MS2000

To choose an appropriate location for mounting the inverter/charger, see “Step 1: Choosing a Location for the Inverter/Charger” on page 16.

AC, DC, and Network Components

For a successful installation, you need to plan for AC, DC, and network components of the power system. The AC and DC components are described in this section and illustrated in Figure 2, “Typical Marine Electrical System” on page 7.

AC components include:

- Sources of AC input
- AC wiring
- Over-current protection and disconnect devices
- AC distribution panels

DC components include:

- Sources of DC power (batteries, for example)
- DC cables
- DC over-current protection and disconnect devices

Network considerations include:

- Cables, connectors, network connectors, and terminators for the System Control Panel and Automatic Generator Start, if installing. See Figure 1.

Detailed information on planning and installing your network is available in the *Xanbus System Installation Guide*. Refer to the system guide to determine the type of network layout to install, as well as guidelines for installing the network. This guide is available for download at www.xantrex.com

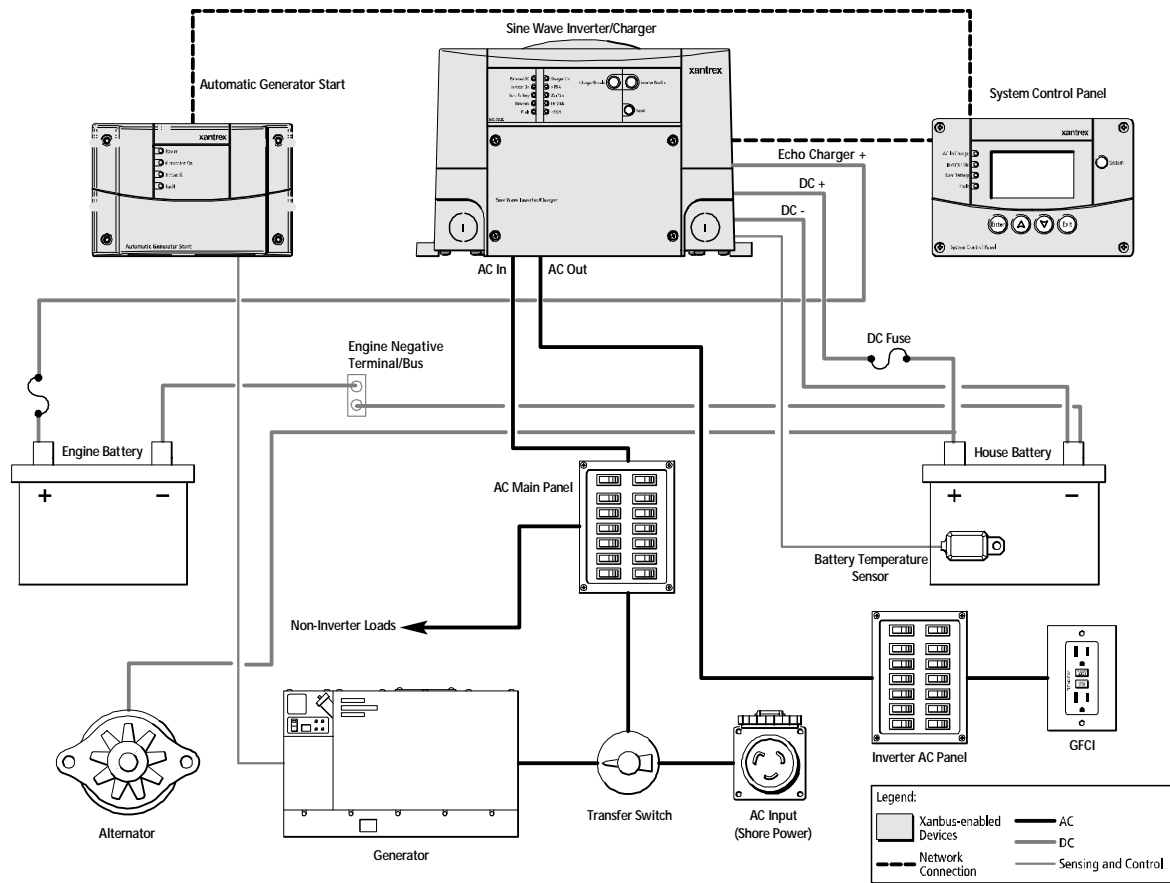


Figure 2 Typical Marine Electrical System

Important: In Figure 2, “Typical Marine Electrical System” on page 7, no attempt has been made to show all required grounding or overcurrent protection.

AC Components

AC Input

A source of 120 volts AC single-phase, 60 Hz alternating current is needed to provide energy for charging batteries and to pass through to AC loads. AC input can be supplied from an AC source like the utility grid (power company), from a generator, or from the output of a transfer switch. These sources must have their neutral conductors bonded to ground. See “AC Output Neutral Bonding” on page 9.

Disconnect and Over-Current Protection Device

To meet CSA, UL, and electrical code requirements, the AC inputs and outputs of the inverter/charger must be provided with over-current protection such as a circuit breaker or fuse and a disconnect device on both the AC input and output. Refer to your applicable installation codes and the following requirements:

AC Input Protection

The circuit breaker or fuse used to protect the MS2000 must be rated no more than 30 amps and must be approved for use on 120 VAC branch circuits. If the AC input power rating is more than 30 amps, you need to add an additional 30 amp breaker or fuse at the electrical panel to which the MS2000 AC input is wired.

AC Output

The circuit breaker or fuse must be rated at no more than 30 amps and must be approved for use on 120 VAC branch circuits.

GFCI Requirements

A GFCI (ground fault circuit interrupter) is a device that deenergizes a circuit when a current to ground exceeds a specified value that is less than that required to blow the circuit breaker. GFCIs are intended to protect people from electric shocks and are usually required in wet or damp locations.

Installation in recreational vehicles requires GFCI protection of certain branch circuits. Consult all applicable codes.

Tested GFCIs

Compliance with UL standards requires that Xantrex test and recommend specific GFCIs for use on the output of the inverter. Table 1 lists models that have been tested and will function properly when connected to the AC output of the MS2000.

Table 1 Tested GFCI Models

Manufacturer	Model Number
Hubbell	GFR5252WA
Leviton	8599-GY
Pass & Seymour	1594-W

Disconnect Devices

Each system requires a method of disconnecting the AC circuits. If the over-current protection device is a circuit breaker, it will also serve as the disconnect. If fuses are used, separate AC disconnect switches will be needed ahead of the fuses.

Distribution Panels

Some systems incorporate distribution panels both ahead of the inverter/charger (the AC source panel) and between the inverter/charger and the loads (the AC load panel). AC source panel includes a main circuit breaker, which serves as over-current protection for the panel. Additional circuit breakers serve individual circuits, one of which serves the inverter/charger.

AC Wiring

Definition	AC wiring includes all of the wires and connectors between the AC source and the inverter/charger input and all of the output wiring between the inverter/charger and the AC load panels, circuit breakers, and loads.
Type	The type of wiring required varies according to the electrical codes or regulations applicable to your installation. For marine applications, this may be solid wire in multi-conductor cables, but stranded wire is required if single conductors are used. All wiring must be rated 90 °C or higher.
Size	Wire size has to be coordinated with the overcurrent protection provided ahead of the wire involved, in accordance with the electrical codes or regulations applicable to your installation. The wiring used between the AC input circuit breaker and the inverter/charger input must be sized to match the input breaker rating. The wiring used between the AC output of the inverter/charger and the AC output breaker must also be sized to match the input breaker rating. The wiring used between the AC output breaker and your loads must be sized to match the output breaker. Typically, No. 10 AWG is required for the 30A breakers required to be on the MS2000 input and output.

AC Output Neutral Bonding

Bonding system	The MS2000 provides a system that automatically connects the neutral conductor of the inverter's AC output circuit to safety ground ("bonding" it) during inverter operation, and disconnects it ("unbonding" it) when the inverter/charger is connected to external AC or generator power. This system is designed to conform to installation codes that require single-phase AC sources such as inverters and
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generators to have their neutral conductors tied to ground at the source of power in the same way that the neutral conductor from the utility is tied to ground. These same codes specify that the neutral can only be connected to ground in one place at any one time.

Suitability

This automatic neutral-to-ground bonding system is suited for installations in which the AC input source is known to have a bonded neutral. This will be the case in most situations: in a utility feed, at an external AC hook-up, or a generator with a bonded neutral. If not, have an electrician look into bonding the source's neutral to ground. See also "AC Input and Output Isolation" on page 20.

DC Components

Batteries

The MS2000 can be installed to operate with two different battery systems—a house battery and an engine battery. Each system may be a single battery or a bank of several batteries connected in series, parallel, or series-parallel.

House battery The house battery is the large capacity, deep cycle battery that is connected to the inverter/charger's main DC terminals. The MS2000 requires the house battery to provide the DC current that the inverter converts to AC power. The house battery is a 12 volt, lead-acid deep-cycle battery or group of batteries, all of a flooded, gel, or AGM type.

Engine battery The engine battery is the battery connected to the Echo Charger output. Typically, this will be an engine starting battery or an auxiliary battery for loads other than the inverter.

For general information about batteries, see “Battery Information” on page 40.

For detailed information about specific brands of batteries, you'll need to consult individual battery manufacturers.

DC Disconnects and Over-Current Devices

The DC circuit from each battery to the inverter/charger must be equipped with a disconnect and over-current protection device. (Refer to your applicable installation code.) This usually consists of a circuit breaker, a “fused-disconnect,” or a separate fuse and DC disconnect. Do not confuse AC circuit breakers with DC circuit breakers. They are not interchangeable. The rating of the fuse or breaker must be matched to the size of cables used in accordance with the applicable installation codes. The breaker or fuse and disconnect should be located as close as possible to the battery in the positive cable. Applicable codes may limit how far the protection can be from the battery. For recommended fuse sizes, see Table 2 on page 12.

DC Cabling

DC cabling includes all of the cables and connectors between the batteries, the DC disconnect and over-current protection device, and the inverter/charger. All installations require multi-strand insulated cables as well as disconnect and over-current devices. DC cable sizes are indicated by AWG notation. Under the AWG standard, a larger gauge number indicates a smaller size diameter. Wire size is usually marked on the cables.

Important: Avoid excessive cable lengths to ensure optimum system performance.

See Table 2 for required DC cable size and required fuse size for the MS2000.
The DC cables must be copper and must be rated 90 °C minimum.

Table 2 Required DC Input Cable (copper) and Fuse Size

	From MS2000 to house battery bank	From Echo Charger to engine battery
Maximum DC Cable Length (one way)	10 feet (3 meters)	20 feet (6 meters)
Maximum Total Length (two way)	20 feet (6 meters)	n/a
Minimum Recommended Cable Size	No. 4/0 AWG	14 AWG
Maximum Battery Fuse or Breaker	300 A class T	15 A DC

DC Grounding

The inverter/charger DC (chassis) ground terminal needs to be connected to the boat's DC grounding bus by a minimum No. 1/0 AWG copper conductor, which is either rated 90 °C or is bare copper¹.

1. Per ABYC E-11, which requires No. 2/0 AWG DC supply conductors for the MS2000, but allows a DC grounding conductor one size smaller than the DC supply conductors. The larger No. 4/0 AWG cable size for DC supply conductors shown in Table 2 is recommended for inverter performance.

Unpacking and Inspecting the Inverter/Charger



WARNING: Heavy load

The MS2000 Sine Wave Inverter/Charger weighs approximately 67 lbs (30 kg). The unit is too heavy for one person to safely lift and mount. Xantrex recommends that two people lift and mount the unit. Always use proper lifting techniques during installation to prevent personal injury.

Materials List

Contents

The following materials are in the shipping box:

- MS2000 Sine Wave Inverter/Charger
- DC terminal covers (one red, one black) and four screws
- Bag containing DC terminal hardware:
 - Two flat washers
 - Two lock washers
 - Two 3/8" bolts
- Battery temperature sensor
- *MS2000 Sine Wave Inverter/Charger Installation Guide*
- *MS2000 Sine Wave Inverter/Charger Operation Guide*

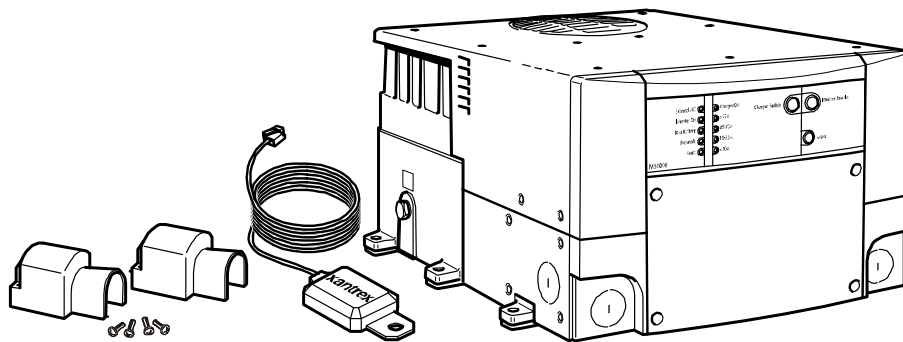


Figure 3 MS2000 Hardware Materials as Shipped

To unpack and inspect:

1. Unpack the unit and check the materials list. If anything is missing from the shipping box, contact Xantrex Customer Service. See “Contact Information” on page iii.
2. Record the serial number of the MS2000 and other purchase information in the “Warranty and Product Information” section of the *MS2000 Sine Wave Inverter/Charger Operation Guide*. You will be asked for this product information if you need to call Xantrex Customer Service.

3. Save your purchase receipt to use as proof-of-purchase, especially for warranty service. This is required if the inverter/charger should need warranty service.
4. Save the original shipping carton and packing materials. If the inverter/charger needs to be returned for service, it should be shipped in the original carton. This is also a good way to protect the inverter/charger if it ever needs to be moved.

Installation Tools and Materials

Tools

You will need the following tools to install the MS2000 and the battery temperature sensor.

- Wire stripper
- Crimping tools for fastening lugs and terminals on DC cables
- Phillips screwdriver: #2
- Slot screwdriver (1/4" wide blade max.) for AC terminals
- Slot screwdriver (1/8" wide blade max.) for Echo Charger connector
- Needle-nose pliers
- Wrench for DC terminals: 7/16"
- Wrench for DC grounding connection: 5/16"

Materials

You will need the following materials to complete your installation:

- Strain-relief clamp(s) for AC cables: 3/4" and/or 1"
- DC battery cables sized according to Table 2 on page 12
- Terminals and/or crimp connectors for DC cables (for 3/8" stud size)
- Copper wire for DC grounding sized according to Table 2 on page 12
- Terminal or crimp connector for DC grounding cable (for 1/4" stud size)
- AC and DC disconnect switches and over-current protective devices and connectors as required
- Cables for AC input and output wiring
- Six 1/4"-20 1.25" length steel screws or bolts to mount the MS2000

For a list of tools and materials required to install the network, refer to the *Xanbus System Installation Guide*, which is available for download at www.xantrex.com.

Installing the Inverter/Charger

Overview

This section provides detailed information on installing the MS2000. The overall procedure is divided into nine steps:

1. Choosing a location
2. Mounting the inverter/charger
3. Connecting the AC input wires and AC output wires
4. Connecting the DC cables
5. Connecting the Echo Charger
6. Connecting the battery temperature sensor
7. Connecting to the network
8. Performing checks prior to initial start-up
9. Testing your installation

Step 1: Choosing a Location for the Inverter/Charger



WARNING: Risk of fire or explosion

This equipment is not ignition protected, and contains components that could produce arcs or sparks. To reduce the risk of fire or explosion, do not install this equipment in compartments containing flammable materials, or in locations that require ignition-protected equipment. This includes any space containing gasoline-powered machinery, fuel tanks, or joints, fittings, or other connections between components of the fuel system.



WARNING: Fire hazard

Do not cover or obstruct the ventilation openings. Do not install this equipment in a compartment with limited airflow. Overheating may result.

The location of the inverter/charger is a key factor in system performance. Allow sufficient clearance around the unit and install in a well-ventilated compartment to prevent overheating and premature shutdown of the inverter/charger.

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

- Ventilated** Do not operate the inverter/charger in a closed-in area or restrict ventilation in any way. The inverter/charger requires air circulation to maintain optimum operating temperature and provide best performance. If the unit has inadequate ventilation, it may shut down due to overheating. The air vented through the openings should also have a path to circulate away from the inverter/charger.
- Dry** Do not allow water or other fluids to drip or splash on the inverter. Do not expose to rain, snow or water.
- Cool** Normal air temperature should be between 32 °F and 122 °F (0 °C and 50 °C)—the cooler the better within this range.
- Clearance** Allow as much space around the inverter/charger as possible. Xantrex recommends that other objects and surfaces be at least 3 inches (76 mm) away from the ventilation openings for best performance.
- Safe** Locate the inverter/charger away from battery in a separate well-ventilated compartment. Do not install the inverter/charger in any compartment containing flammable gases or liquids like gasoline.

Close to battery compartment	The length and size of your DC cables will affect performance. Use the DC cables recommended in Table 2 on page 12. The unit should not be installed in the battery compartment due to the possible presence of explosive hydrogen gas from the batteries.
Protected from battery acid and gases	Never place the inverter/charger directly above the batteries—gases from battery will corrode and damage the inverter/charger. Never allow battery acid to drip on the inverter/charger or its wiring when filling the batteries or reading their specific gravity.
Orientation	To meet regulatory requirements, the MS2000 must be mounted in an approved mounting orientation. See Figure 4 on page 19. These orientation restrictions are designed to stop dripping water, due to condensation in damp marine environments, from getting inside the MS2000.

Step 2: Mounting the Inverter/Charger

Considerations

Before mounting the MS2000, take the following two factors into account.

1. The weight of the inverter/charger requires two people to install it.
2. Mounting considerations are shown in Figure 4 on page 19 and described in Table 3 on page 19.



WARNING: Heavy load

The MS2000 Sine Wave Inverter/Charger weighs approximately 67 lbs (30 kg). The unit is too heavy for one person to safely lift and mount. Xantrex recommends that two people lift and mount the unit. Always use proper lifting techniques during installation to prevent personal injury.

The MS2000 dimensions and location of the mounting holes are provided in Figure 18 on page 39.

Mount your inverter/charger before you connect any wires or cables.

To mount the inverter/charger:

1. Remove the inverter/charger from its shipping container.
The inverter/charger is shipped on a packaging board which can also serve as a template.
2. Remove the four screws that attach the inverter/charger to the packaging board. Use the box handles provided to move the unit.

Important: Do not use the four screws that attach the unit to the template for mounting the unit. See “Installation Tools and Materials” on page 14 for recommended screw size.

3. Verify that all components are present, and record relevant product information on form WA-4 in the *MS2000 Sine Wave Inverter/Charger Operation Guide*.
4. Select an appropriate mounting location and orientation. To meet regulatory requirements, the MS2000 must be mounted in one of the two orientations shown in Figure 4.
5. Use the packaging board as a template to mark the position of the mounting screws or refer to Figure 18 on page 39.
6. Pilot drill the six mounting holes.
7. Fasten the inverter/charger to the mounting surface with the six ¼"-20 steel screws or bolts.

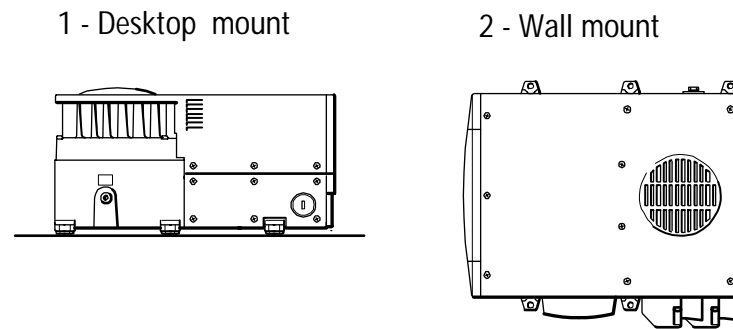


Figure 4 Approved Mounting Orientations

Table 3 Description of Approved Mounting Orientations

Number	Approved Mounting Orientation
1	Desktop
2	Wall mount orientation, on a vertical surface with DC terminals facing down.

Step 3: Connecting the AC Input and AC Output Wires



WARNING: Fire, shock, and energy hazards

Make sure wiring is disconnected from all electrical sources before handling. All wiring must be done in accordance with local and national electrical wiring codes.

General AC Wiring Considerations

AC and DC Wiring Separation Do not mix AC and DC wiring in the same conduit or panel. Consult the applicable installation code for details about DC wiring and AC wiring in vicinity to each other.

AC Input and Output Isolation The AC input and output circuits of this inverter/charger are isolated from each other when in invert mode to ensure safe operation. This isolation must be maintained in the installation, by being sure not to connect AC input and output wiring to a common point. For example, do not route the AC input and output neutrals to a common neutral bus.

AC Wiring Compartment For your reference, the AC wiring compartment is shown in Figure 5.

AC Knockouts There are two 3/4" trade-size knockouts on the front panel for AC wiring, as shown in Figure 5. For easier wiring access, there are also knockouts on either side of the unit (not shown). The side knockouts are 1" trade-size knockouts. Use the same trade size of strain relief as the trade size of the knockout (s) you are using.

AC Wiring Terminals The AC wiring terminals accept cables of a specific size. See “AC Wiring” on page 9 for required sizes.

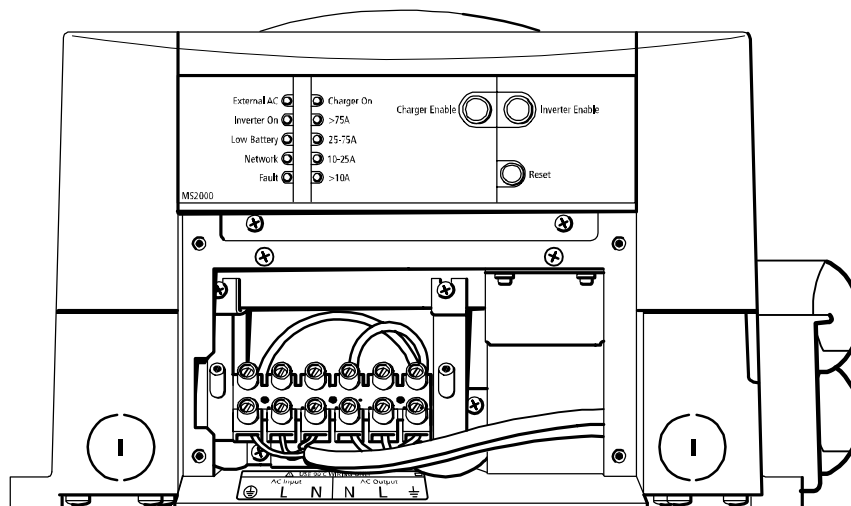


Figure 5 Front Panel with Wiring Compartment

Connecting AC Input Wires

A detailed view of the MS2000 wiring compartment with the AC compartment panel removed is shown in Figure 6. The terminal block is used to hardwire the AC input and AC output connections.



CAUTION: Equipment damage

The terminal block is split into INPUT and OUTPUT sections. Damage may occur if the unit is wired incorrectly.

Do not remove or loosen factory installed wiring.

When making the AC input and AC output connections, observe the correct color code for the appropriate AC wire, as described in Table 4.

Table 4 Color Codes for Typical AC Wiring

Color	AC Wire
Black	Line
White	Neutral
Green or bare copper	Ground

To make the AC input connections:

1. Locate the wiring compartment cover panel and remove the four screws.
2. Remove the cover panel from the unit to access the wiring compartment.
3. Remove one of the AC knockouts from the front or side of the unit. Do not leave the knockout inside the wiring compartment.
4. Install a strain-relief clamp in the AC knockout.
5. Run the AC wiring through the strain-relief clamp.
6. Strip approximately 2 inches (50 mm) off the jacket from the AC cable and separate the three wires.
7. Using the 1/4" blade slot screwdriver, loosen the wire attachment screws on the terminals. Do not remove the screws.
8. Insert the line wire into "L", the neutral wire into "N", and the ground wire into ground (⊕), as shown in Figure 6 on page 22. Observe the color codes described in Table 4.
9. Tighten the wire attachment screws. Leave some slack wire inside the wiring box.
10. Secure the strain-relief clamp on the AC input cable jacket.

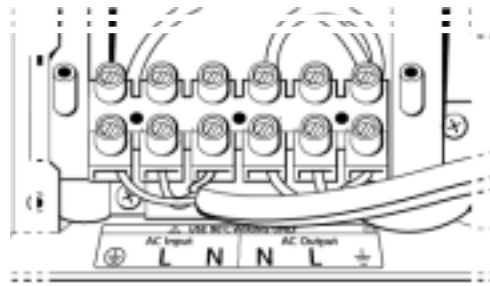


Figure 6 AC In and AC Out: Hardwiring Completed

Connecting the AC Output Wires



CAUTION: Risk of equipment damage

Do not connect the output of the inverter to any incoming AC source.

To make the AC output wiring connections:

1. Remove one of the AC knockouts from the front or side of the unit. Do not leave the knockout inside the wiring compartment
2. Install a strain-relief clamp in the AC knockout.

Important: The applicable installation code may not allow you to run the AC input and AC output wiring through the same AC knockout.

3. Run the AC wiring through the strain-relief clamp.
4. Strip approximately 2 inches (50 mm) off the jacket from the AC cable and separate the three wires.
5. Using the 1/4" blade slot screwdriver, loosen the wire attachment screws on the AC output terminals. Do not remove the screws.
6. Insert the line wire into "L", the neutral wire into "N", and the ground wire into ground (\perp), as shown in Figure 6. Observe the color codes described in Table 4.
7. Tighten the wire attachment screws. Leave some slack wire inside the wiring box.
8. Secure the strain-relief clamp on the AC output cable jacket.
9. Attach the wiring compartment cover panel and tighten the four screws.
10. Connect the outgoing AC wires to an AC load panel equipped with circuit breakers.

Step 4: Connecting the Main DC Cables

DC Connection Precaution



WARNING: Energy hazard

Connect and disconnect DC wiring only after opening the disconnect switches or breakers at all AC and DC sources.

Recommended Cable Sizes and Lengths and Fuse Size

For the best load starting surge performance, the DC cables should be as short as possible and large enough to handle the required current, in accordance with the electrical codes or regulations applicable to your installation. Avoid excessive cable lengths. **The DC cables must be copper and must be rated 90 °C minimum.**

For recommended DC cables and fuse size, see Table 2, “Required DC Input Cable (copper) and Fuse Size” on page 12. Using a longer or smaller gauge cable may cause the inverter to shut down under heavy load.

Preparing the Cables

To prepare the DC cables:

1. Cut the negative and positive cable to the required length. Strip off enough insulation so you can install the terminals you will be using.
Xantrex recommends the use of crimp connectors. The connector should be designed for a 3/8" stud size to connect to the MS2000. If a crimp connector is used, it should be crimped using the tool indicated by the connector manufacturer.
2. Cut the DC ground cable to the required length. Strip off enough insulation so you can install the terminals you will be using.
Xantrex recommends the use of crimp connectors. The connector should be designed for a 1/4" stud size to connect to the MS2000. If a crimp connector is used, it should be crimped using the tool indicated by the connector manufacturer.
3. Attach the connectors to the ends of all cables. Make sure no stray wire strands protrude from the connectors.

Guidelines for Routing the DC Cables

Follow these guidelines to ensure maximum performance.



WARNING: Fire and shock hazard

Route the cables away from sharp edges that might damage the insulation. Avoid sharp bends in the cable.

- Do not attempt to use the chassis in place of the main bank battery negative connection for grounding. The inverter requires a reliable return path directly to the battery.
- To reduce the chance of radio frequency interference, keep the positive and negative cables close together—ideally, held together by straps, loom, or insulated clamps at regular intervals.
- To ensure maximum performance from the inverter, do not route your DC cables through a DC distribution panel, battery isolator, or other device that will cause additional voltage drops. The exception is the DC fuse and Disconnect or the DC circuit breaker which is required at the battery to protect the DC wiring.
- To help avoid damage caused by reverse polarity battery connection, it is a good idea to mark each end of each cable to identify it as a positive (red) or negative (black) cable before routing the wiring.

Connecting the DC Cables to the Inverter/Charger



WARNING: Fire hazard

Use only appropriately sized copper cable. Loose connections or improper connections will overheat. Make sure the bolts supplied by Xantrex on the inverter/charger are tightened to a torque of 15–16 ft-lbs (20.4–21.7 Nm). Torque all other connections to the manufacturer's specifications. Make sure the DC cable, washers, and bolt are assembled in the order shown in Figure 7.



CAUTION: Reverse polarity damage

Before making the final DC connection or closing the DC breaker or disconnect, check cable polarity at both the battery and the inverter/charger. Positive (+) must be connected to positive (+). Negative (–) must be connected to negative (–).

To connect the DC cables:

1. Route the DC cables from the house battery bank to the inverter/charger. Observe the “Guidelines for Routing the DC Cables” on page 24.
2. Install a DC fuse and disconnect switch or a DC circuit breaker between the inverter/charger and the battery. They must be installed in the positive side of the DC circuit, as close as possible to the battery.

This protects your battery and wiring in case of accidental shorting. See Table 2 on page 12 for required fuse or breaker size. Open the DC disconnect switch or turn off the DC circuit breaker.

3. Connect one connector on the POSITIVE (+) cable to the POSITIVE DC terminal on the inverter/charger, as shown in Figure 7. The connector goes on first, then the flat washer (steel), lock washer (steel), and 3/8" bolt (brass).
4. Connect the other connector to the POSITIVE (+) terminal on the fuse or breaker. Observe polarity carefully while completing the installation.

Use a wrench to tighten the bolt to a torque of 15–16 ft-lbs (20.4–21.7 Nm) at the inverter/charger end. Observe the fuseholder or breaker manufacturer's recommendation at the other end.
5. Connect one connector on the NEGATIVE (–) cable to the NEGATIVE (–) DC terminal on the inverter/charger, as shown in Figure 7. The connector goes on first, then the flat washer (steel), lock washer (steel), and 3/8" bolt (brass).

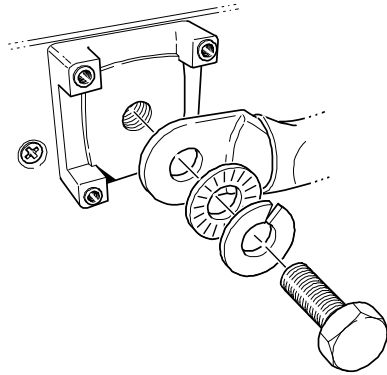


Figure 7 DC Cable Connections

6. Before proceeding, check that the cable polarity is correct: **POSITIVE (+)** on the inverter/charger is connected to the **POSITIVE (+)** on the battery, and **NEGATIVE (-)** cable is connected to the **NEGATIVE (-)** terminal on the inverter/charger.

Important: The next step is the last cable connection you need to make. A spark is normal when this connection is made.

7. Connect the other end of the **NEGATIVE (-)** cable to the **NEGATIVE (-)** terminal on the battery.
8. Use a wrench to tighten the bolt to a torque of 15–16 ft-lbs (20.4–21.7 Nm) at the inverter/charger end.
9. Attach the DC terminal covers using the screws provided to protect the DC terminals, as shown in Figure 8.

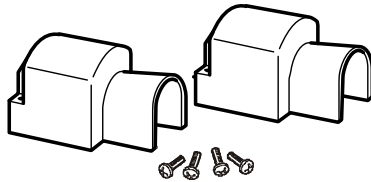


Figure 8 DC Terminal Covers

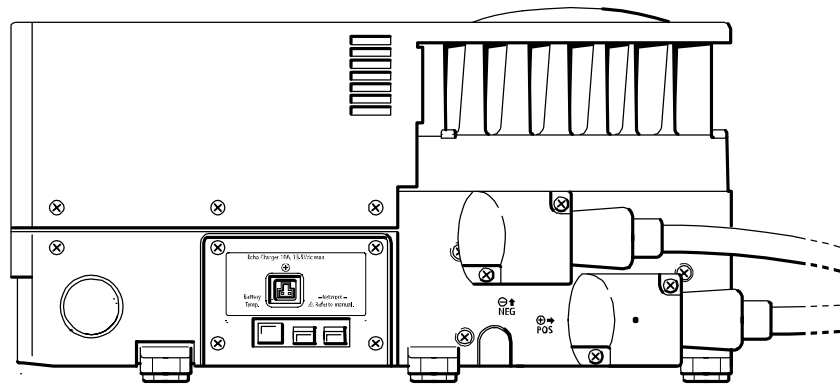


Figure 9 Completed DC Wiring

DC Grounding

The Chassis Ground point on the inverter/charger is used to connect the chassis of the inverter/charger to your system's DC grounding point, as required by regulations for some installations. Use copper wire that is either bare or provided with green insulation.

The grounding guideline given below assumes you are using the code-compliant DC supply cable and fuse sizes indicated in this Installation Guide. If you are using different sizes, refer to the applicable code for DC grounding detail.

To connect the chassis ground:

1. Using the appropriate wrench, loosen the bolt on the chassis ground point shown in Figure 10.
2. Connect the DC grounding cable (No. 1/0 AWG or larger copper cable) between the chassis ground point and the DC grounding point for your system, usually the boat's DC grounding bus.
3. Tighten the bolt to a torque of 3.5–3.8 ft-lbs (4.5–5.2 Nm).

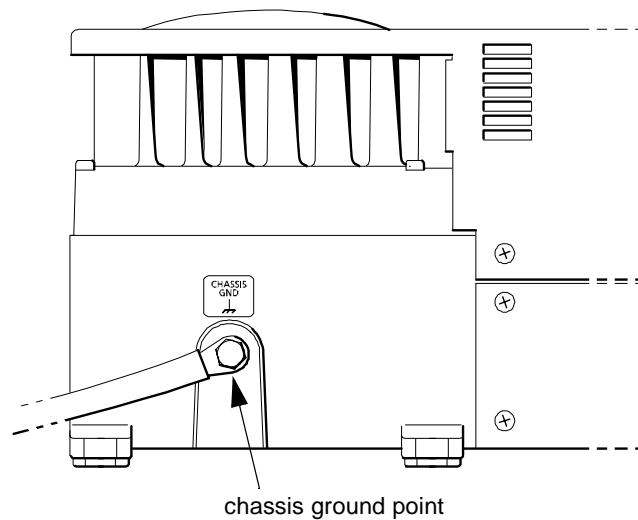


Figure 10 Completed DC Grounding

Step 5: Connecting the Echo Charger

The Echo Charger connection is made above the network and battery temperature sensor jacks. See Figure 11.

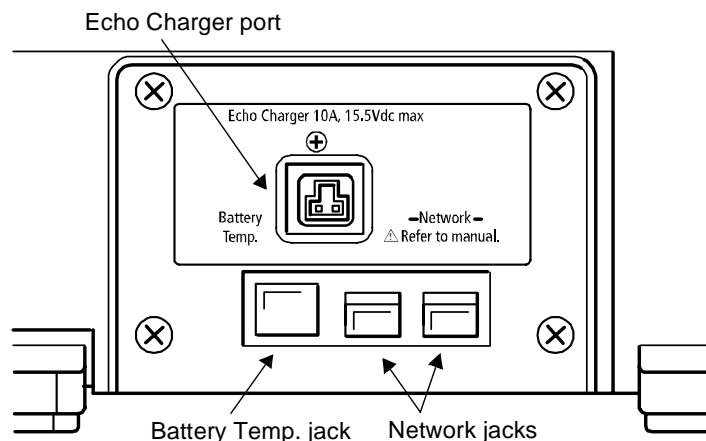


Figure 11 Echo Charger Port

The Echo Charger requires a single positive cable connected between the Echo Charger port on the MS2000 and the engine battery. That battery and the house battery bank must have their negative terminals connected to the boat's DC negative bus for the Echo Charge to function (see Figure 2 on page 7).

DC Connection Precaution



WARNING: Energy hazard

Connect and disconnect DC wiring only after opening the disconnect switches or breakers at all AC and DC sources.

Preparing the Cable

For the best charging performance, the DC cable should be as short as possible and large enough to handle the required current, in accordance with the electrical codes or regulations applicable to your installation.

Although the Echo Charger output is limited to 10 A, it is recommended to use No. 14 AWG 90 °C cable to minimize voltage drops.

To prepare the Echo Charger cable:

1. Cut the cable to the required length. Strip off 1/4" insulation on the Echo Charger connection side.
2. Remove the Echo Charger connector from the Echo Charger port on the side of the MS2000.

- Using the slot screwdriver with a 1/8" blade, press down on the tension clip through the slot located at the top of the connector. While pressing down on the tension clip, insert the end of the cable with insulation removed into the left-side round hole at the front of the connector. See Figure 12.

OR

You can also insert the screwdriver blade into the square hole above the left-side hole and twist the screwdriver to press down on the tension clip before inserting the cable.

Important: The right-side hole on the Echo Charger connector does not connect to anything internally and should not be used. If you connect the Echo Charger to the engine battery using the right-side connector, the Echo Charger will not work.

- To secure the cable, remove the screwdriver to release the tension clip.

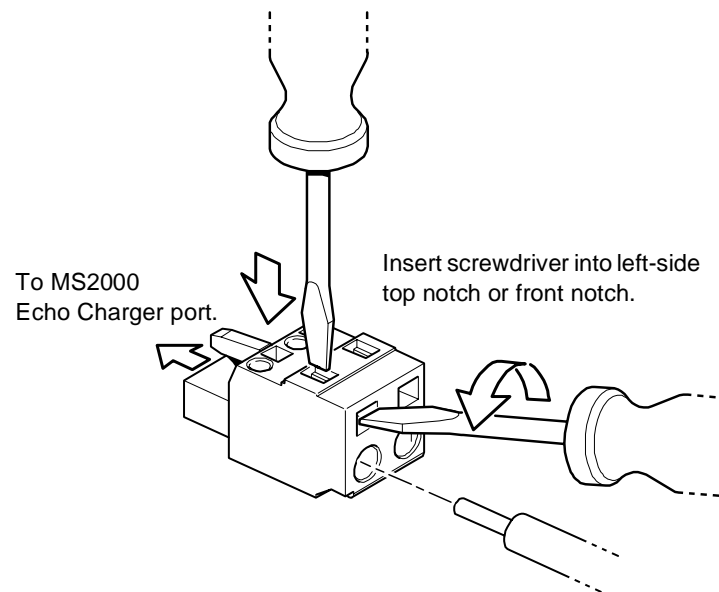


Figure 12 Inserting Cable into the Echo Charger Connector

- Install the disconnect and 15 A DC over-current protection between the other end of the cable and the battery positive (+) terminal, as close as possible to the battery in accordance with codes.
- Open the disconnect switch or remove the fuse.

Connecting the Cable



WARNING: Energy hazard

Connect and disconnect DC wiring only after opening the disconnect switches or breakers at all AC and DC sources.

To connect the Echo Charger cable:

1. Route the cable from the engine battery to the Echo Charger port on the MS2000.
2. Connect the cable to the fuse on the POSITIVE (+) terminal of the engine battery.
3. Plug the Echo Charger connector into the port on the MS2000.
4. If it is not already connected, connect the engine battery negative terminal to the engine negative terminal/bus.

This cable must be sized for all the loads on the engine battery (including start current), not just the Echo Charger.

Step 6: Connecting the Battery Temperature Sensor (BTS)

Installing a battery temperature sensor (BTS) extends the life of the house battery bank by preventing overcharging in warm temperatures and undercharging in cold temperatures. With a BTS monitoring the battery temperature, the voltage delivered to the house battery bank is adjusted according to the battery's actual temperature.

A 25-foot (7.6 m) cable is supplied with the BTS, as shown in Figure 13.

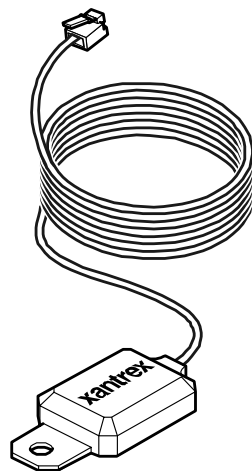


Figure 13 BTS with Cable



WARNING: Energy and explosion hazard

Review the “Important Safety Instructions” on page v.

Mounting Options

You can mount the BTS in one of two ways:

- Mounting the sensor to the negative post of one of the house batteries allows the internal battery temperature to be sensed and provides the most accurate results.
- Attaching the sensor to the side of one of the house batteries using the self-adhesive backing also provides good results in most situations.

Mounting to the Negative Battery Terminal

To mount the sensor on the negative battery terminal:

See Figure 14.

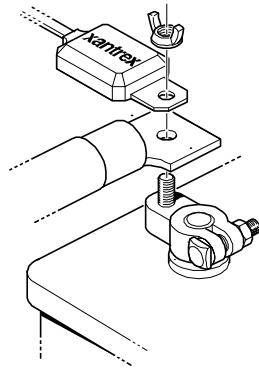


Figure 14 BTS Mounted on the Negative Battery Terminal

1. Select the battery to be monitored. The battery temperature sensor must be connected to the house battery bank, which is directly connected to the inverter/charger.
2. Switch off all devices operating from the battery, or open the battery switch (if present) to disconnect the battery.
3. Wait 10 minutes for any explosive battery gases to dissipate.
4. Remove the nut that connects the existing wiring ring terminals to the battery negative terminal stud.
5. Move or reorient the existing wiring ring terminals on the battery negative terminal stud, so there is a flat surface on which to seat the battery temperature sensor mounting plate.

You may need to bend the ring terminal crimp and/or wires slightly downward to allow the sensor to seat flush to the top surface of the upper ring terminal.

6. Mount the sensor directly on top of the ring terminal, as shown in Figure 14, and firmly tighten the terminal nut.

**WARNING: Fire hazard**

In this procedure, you must install the DC wire on the battery terminal first. Then the sensor is installed on top of the DC wire. This sequence is required to provide the best connection to the battery and to ensure correct performance of the sensor.

7. Check to ensure that the sensor and all wires are held firmly and cannot be moved.
8. Turn the battery switch on again (if you opened it in Step 2).
9. Route the sensor cable to the inverter/charger and plug it into the Battery Temp jack, as shown in Figure 15. Secure the cable along its length.

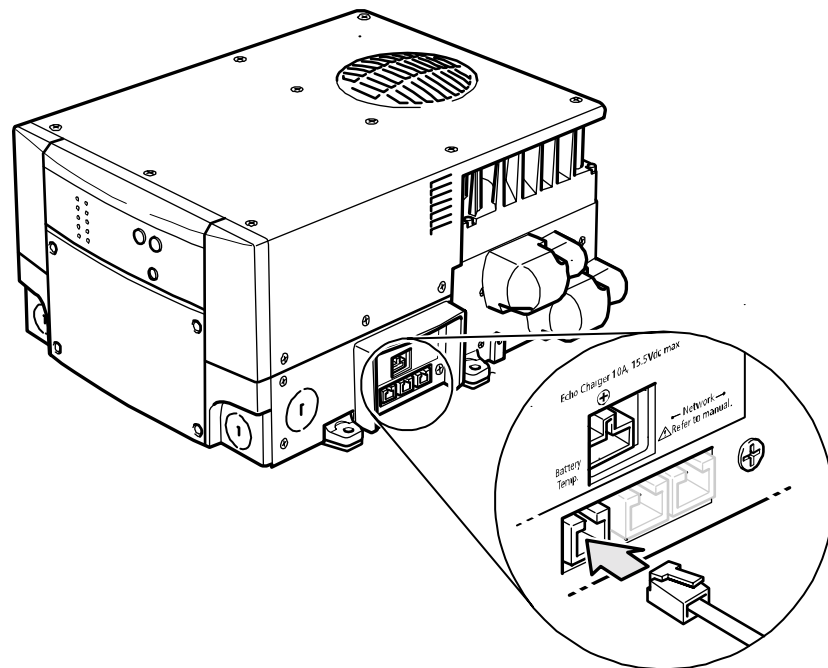


Figure 15 Connecting the BTS Cable to Battery Temp. jack

Mounting to the Side of the Battery Case

To mount the sensor on the battery case:

See Figure 16.

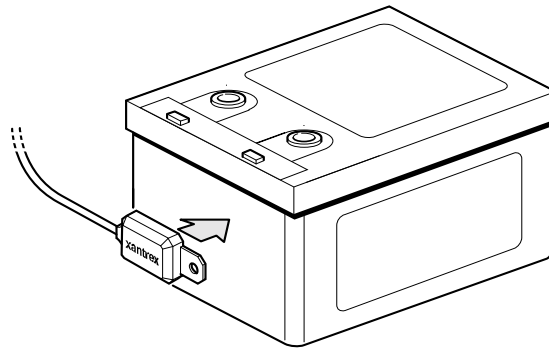


Figure 16 BTS Mounted on the Battery Case

1. Select the battery from the house battery bank to be monitored.
2. Select a side suitable for attaching the sensor.

The surface where the sensor is to be mounted must be flat and free from reinforcing ribs or other raised features. This surface must be in direct internal contact with the battery electrolyte. Do not install the sensor near the top of the battery or on the battery's top surface.
3. Clean the selected area thoroughly to remove any oil or grease that could prevent the sensor from adhering to the battery case. Allow the battery case to dry thoroughly.
4. Peel the protective backing from the self-adhesive strip on the rear of the sensor.
5. Press the sensor firmly against the clean side of the battery to fix it in place, as shown in Figure 16.
6. Route the sensor cable to the inverter/charger and plug it into the Battery Temp. jack, as shown in Figure 15. Secure the cable along its length.

Step 7: Connecting to the Network

For your reference, Figure 17 shows where the network connections are made on the MS2000. The network cable can be plugged into either one of the two network jacks on the MS2000.



CAUTION: Equipment Damage

Connect the MS2000 only to other Xanbus compatible devices.

Although the cabling and connectors used in this network system are the same as Ethernet connectors, **this network is not an Ethernet system**. Equipment damage may result from attempting to connect two different systems.

Detailed information on planning and installing your network is available in the *Xanbus System Installation Guide*. Refer to this guide to determine the type of network layout to install, as well as guidelines for installing the network.

The *Xanbus System Installation Guide* is available for download at www.xantrex.com

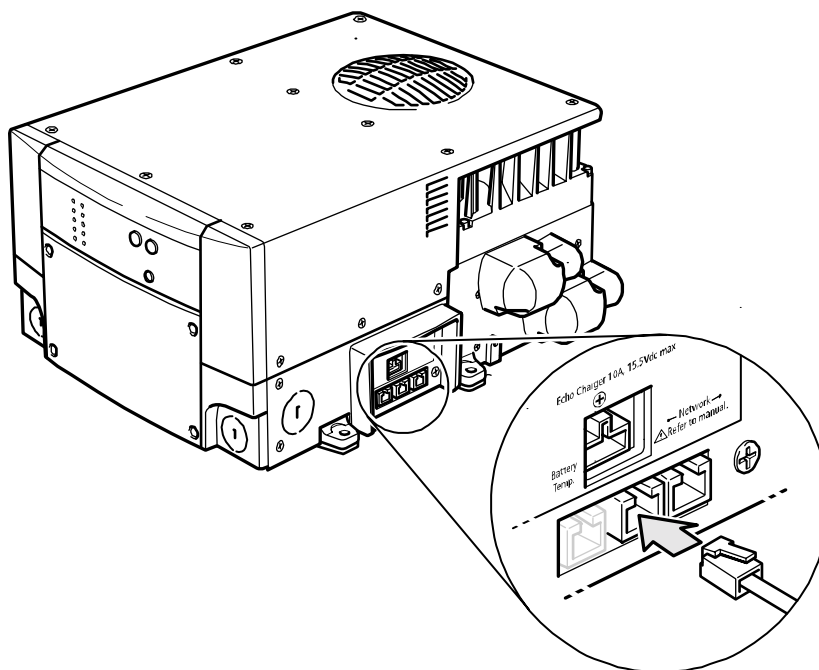


Figure 17 Connecting to a Network Jack

Step 8: Performing Checks Prior to Initial Start-Up

Before testing your installation, ensure these conditions are met:

- Chassis and AC grounds are properly installed.
- AC input connections and AC output connections are wired correctly on the terminal block and not reversed.
- Positive (+) battery cable is connected to the house bank positive (+) battery terminal through the DC fuse and disconnect switch or DC circuit breaker.
- Negative (-) battery cable is connected to the house bank negative (-) battery terminal.
- House battery voltage is within the proper range for this unit (10.3–15.3 volts DC).
- DC disconnect switch or breaker is turned off.
- Echo Charger disconnect switch is off or fuse is removed.
- Echo Charger connections are correct: positive (+) cable runs from the Echo Charger to the positive terminal of the engine battery.
- Both the house battery and the engine battery negative terminals are connected to the engine negative terminal/bus.
- AC input and output breakers are turned off.
- All connections are tight.

Step 9: Testing Your Installation



WARNING: Shock hazard

The Inverter Enable button on the MS2000 and the optional accessories do not disconnect DC or AC input power to the MS2000.

There are several tests to be performed for testing your installation. These tests will verify that:

- The MS2000 works in invert mode.
- The MS2000 works in charge mode.
- The MS2000 works in AC bypass mode.
- The Echo Charger is functioning.

Testing in Invert Mode

To test the inverter/charger in invert mode, using a 100 watt light bulb as the test load:

1. Close the DC disconnect switch or the DC circuit breaker to supply DC power to the MS2000.

The unit takes 10 to 30 seconds to initialize.

2. Verify that all lights on the front panel illuminate during the initialization stage. If other Xanbus-enabled devices are connected, the Network light will be illuminated. The Invert light illuminates only if the Invert Enable button light is also illuminated. If the unit is powered up for the first time, the Inverter On light will be off. To turn the inverter on, press the Invert Enable button.
3. Connect the MS2000 to the test light by closing the AC breaker that controls the circuit that the test light is connected to.

If the light bulb illuminates, the installation has been successful.

Testing in Charge Mode

To test the MS2000 in charge mode:

1. Close the AC supply breaker to supply AC power to the unit.
2. After a few seconds, verify that the External AC and Charger ON lights on the front panel illuminate. One of the current range lights (>75A, 25–75A, 10–25A, >10A) should also illuminate.

Important: The charging process, whether it is three-stage or two-stage charging, occurs over an extended period of time.

Testing in AC Bypass Mode

To test the MS2000 in transfer mode:

1. Close the AC supply breaker to supply AC power to the unit.
The transfer from invert to AC input power occurs.
2. Press the Charger Enable button to disable the charger. Verify that the Charger Enable light is not illuminated. AC loads will still be powered.

Testing the Echo Charger

1. Close the Echo Charger disconnect switch or replace the fuse.
2. Check the System screen on the System Control Panel and ensure the MS2000 is in the Bulk or Absorption charge cycle.
3. From the MS2000 advanced menu on the System Control Panel, verify that the Echo Charger is enabled.
4. If the Echo Charger is enabled, verify that the MS2000 advanced menu is displaying the Echo Charger current and voltage.

The current displayed will depend on the voltage level of the house bank and the voltage difference between the house battery bank and the engine battery.

Inverter/Charger Physical Specifications

For complete inverter/charger specifications, refer to the *MS2000 Sine Wave Inverter/Charger Operation Guide*.

The physical specifications of the MS2000 are shown in Figure 18 on page 39 and described in Table 5.

Table 5 MS2000 Physical Specifications

Length	16.19 inches (411 mm)
Width	14.20 inches (361 mm)
Height	8.1 inches (208 mm)
Weight	67 lbs (30 kg)
DC terminal bolt size	3/8 inch
Ground terminal bolt size	1/4 inch

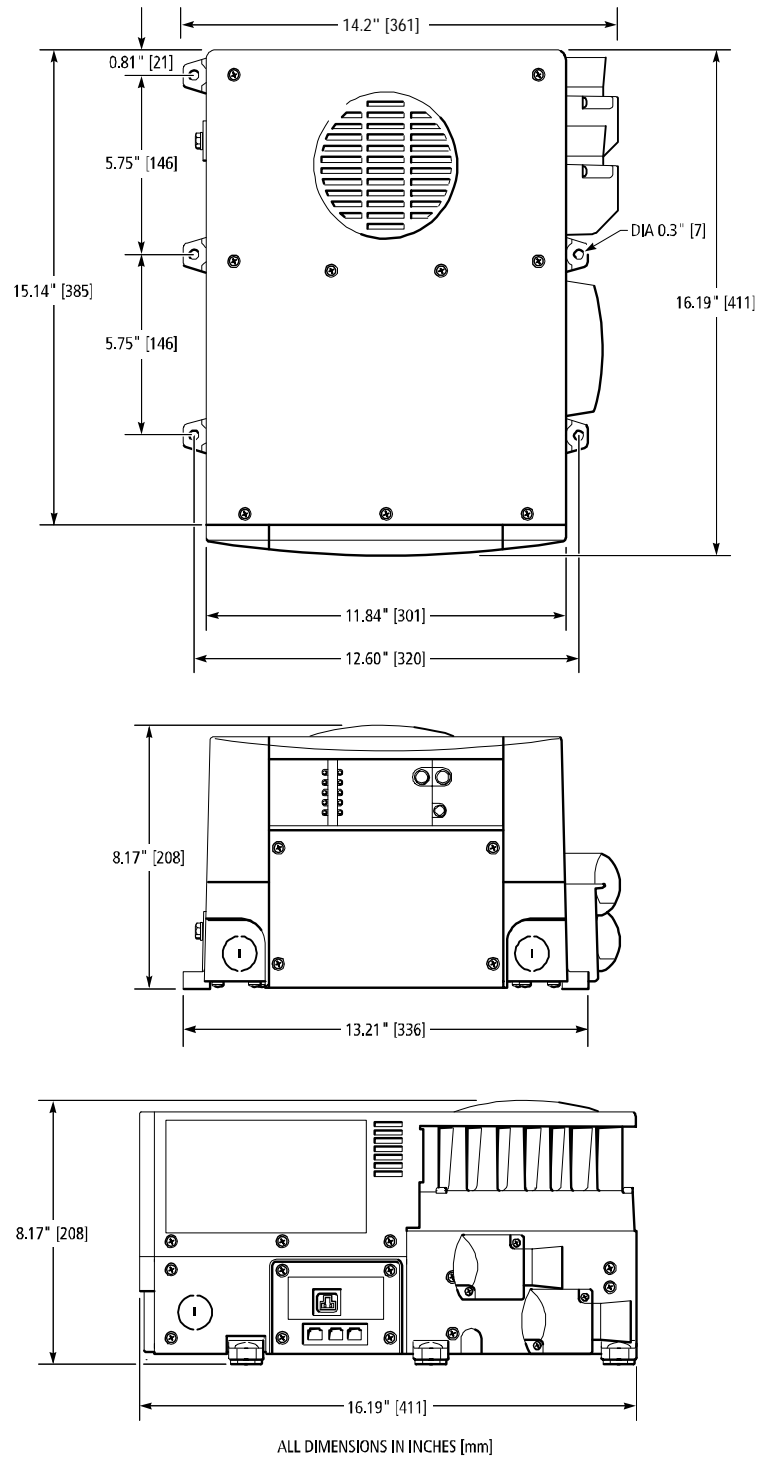


Figure 18 Inverter/Charger Dimensions

Battery Information

“Battery Information” discusses the physical make-up and characteristics of chemical storage batteries and will help you to understand the factors involved in battery selection, charging, care, and maintenance. This information is a guideline only. The manufacturer of each battery is the best authority on its use and care.

Terminology

A description of battery charger operation requires the use of terms that you may not be familiar with. The following terms appear throughout the guide.

Deep Cycle A deep cycle occurs when a battery is discharged to less than 50% of its capacity (50% depth of discharge). A deep-cycle battery is one that is intended to be deeply discharged and charged repeatedly.

Depth of Discharge (DOD) The amount of energy or charge removed from the battery bank, usually expressed as a percentage. A depth of discharge of 0% indicates a fully-charged battery, and a depth of discharge of 100% indicates a fully-discharged battery.

Electrolyte Typically sulfuric acid and water. It is commonly referred to as battery acid, and it is the fluid inside a typical lead-acid battery.

Equalization A deliberate overcharge designed to reduce sulfation and stratification in flooded (or wet) lead-acid batteries. Not necessary and harmful on Gel or sealed batteries.

Plates Made of lead and connected to the battery terminals. These are the terminals inside each cell of the battery. The essential chemical reactions of the battery occur at the plates, and they are the source of the current/voltage produced by the battery.

Sulfation As a battery discharges, its plates become covered with lead sulfate. With regular recharging, the lead sulfate leaves the plates and recombines with the electrolyte. If the lead sulfate remains on the plates for an extended period of time (over two months), it hardens, and recharging does not remove it. Sulfation reduces the effective plate area and the battery’s capacity. Equalization of flooded (or wet) batteries helps to reduce sulfation.

Stratification Over time, electrolyte tends to separate. The electrolyte at the top of the battery becomes watery while it becomes more acidic at the bottom. This effect is corrosive to the plates. Equalization of flooded (or wet) batteries helps reduce stratification.

Temperature Compensation Optimal battery charging voltage is dependent on the battery temperature. As the ambient temperature falls, the proper voltage for each charge stage needs to be increased. When the ambient temperature increases, the proper voltage for each charge stage needs to be decreased. (The BTS allows the inverter/charger to automatically rescale charge-voltage settings to compensate for ambient temperatures.) The hot, cold, and warm settings are used if a battery temperature sensor is not present. The hot setting is the default.

Battery Types

For the purposes of this discussion, there are two principal types of batteries: starting and deep-cycle. Batteries are either sealed or vented. However, there are even different kinds of these batteries. This section explains some of the differences among lead-acid batteries to help you choose a battery that best suits your needs.

Your MS2000 Sine Wave Inverter/Charger is designed for use with deep-cycle, lead-acid batteries. These batteries are designed for deep discharge service where they will be repeatedly charged and discharged. This type of battery is often labeled as a marine, recreational vehicle, or golf cart battery. Xantrex recommends that you use one or more deep-cycle batteries separated from the starting battery of your vehicle or boat.

Starting Batteries

Do not use starting batteries with your inverter; they will wear out rapidly in a deep-cycle application. The way they are rated gives a good indication of their intended use: “Cold Cranking Amps” is a measure of the amperage output of a battery intended for starting or “cranking” an engine.

Starting batteries use many thin plates to maximize the surface area of the battery. This allows very high starting current. In a deep cycle application, these batteries will limit the number of cycles that can be supported before the battery needs to be replaced.

Deep Cycle Batteries

Deep-cycle batteries are best suited for use with inverters. They are designed to have the majority of their capacity used before being recharged. Available in many sizes and types, the most common is the non-sealed, liquid electrolyte type referred to as a “flooded (or wet)” battery, commonly used in both boats and RVs. Non-sealed types have removable battery caps. The caps should be removed at least monthly so the electrolyte level can be checked. When a cell is low, only distilled water should be added. “Spring” water and regular tap water may have high mineral levels which can poison the battery chemistry and reduce battery life.

Deep-cycle, lead-acid batteries can be grouped into five categories:

- Flooded (or wet)
- Sealed flooded (“maintenance free”)
- Recombinant flooded (often “starved electrolyte”)
- Gel batteries
- AGM

Another popular and inexpensive battery of this type is the “golf cart” (T-105 or CG220 or US 2200) battery. These six-volt batteries can be connected in series to form a 12 V system and can be discharged repeatedly to 80% of their capacity without being severely damaged. This is the minimum quality of battery that should be used with the inverter in normal applications.

Some systems use the L16 type of battery. These are 6-volt batteries rated at 350Ah and are available from a number of manufacturers. They are 17 inches (43 cm) high and weigh up to 130 pounds (60 kg) each — which may be troublesome in some installations.

Type 8D batteries are available in either cranking or deep-cycle construction. The deep-cycle versions are 12-volt batteries rated at approximately 200 Ah. Since they are mostly commonly used to start truck engines, you should make sure you purchase the deep-cycle version, not the cranking version. Type 4D batteries are very similar in construction but are somewhat smaller (approximately 170 Ah).

Sealed Gel-Cell

Another type of deep-cycle battery is the sealed gel-cell. The electrolyte is in the form of a gel rather than a liquid and never requires topping up. Battery caps are not removable. The sealed construction allows the batteries to be mounted in any position without spilling. The advantages are no maintenance to the battery itself (the system still requires routine maintenance), long life (800 cycles claimed), and low self-discharge. The disadvantages are high initial cost and the possibility of damage from overcharging.

While many manufacturers produce quality flooded (or wet) batteries, only a few produce suitable gel-cells. Don't confuse gel batteries with maintenance-free batteries, which are typically standard flooded (or wet) electrolyte batteries without caps for adding water, and when the electrolyte gets low, you replace the battery.

AGM (absorbed glass mat) batteries are similar to gel-cells and deep-cycle types and can be used in inverter applications.

Environment

For long life and good performance, batteries need to be located in a protected, ventilated enclosure insulated from temperature extremes.

Location

Batteries should be located in an accessible location that allows for access to the battery caps and terminals. At least 12 to 18 inches of clearance above the batteries is recommended. They must be located as close as possible to the inverter/charger to keep the cable run short. However, do not locate the batteries in the same space as the inverter/charger unless they are of the sealed gel-cell type.

Enclosures

Batteries must be protected inside a ventilated enclosure. The enclosure should be ventilated to the outdoors from the highest point to prevent the accumulation of hydrogen gases released in the charging process. An air intake should also be provided at a low point in the enclosure to allow air to enter the enclosure to promote good ventilation.

Temperature

Effect of cold temperature

The effective capacity of a battery is reduced when the temperature is cold. This phenomenon is more significant with lead-acid type batteries than with alkaline types. When the internal temperature of a lead-acid battery is 32 °F (0 °C), the capacity can be reduced by as much as 50%. This effectively reduces the size of the system's "gas tank," requiring more frequent "refueling" by the charger. This should be considered when you design the system. If extremely low temperatures are expected where the system is going to be located, a heated equipment room should be considered.

Benefits of insulated enclosure

If the system is located in an unheated space, an insulated enclosure is highly recommended for the batteries. During the charging process, the batteries release heat due to the internal resistance of the battery. If the batteries are insulated, the heat can be kept in the batteries to keep them warmer. This will substantially increase the performance of the system.

Insulated battery enclosures also ensure that the temperatures of individual battery cells are more consistent. This prevents unequal charging, which can cause battery failure (some cells being overcharged while others are undercharged).

Protect batteries from high temperature

The batteries should also be protected from high temperature. This can be caused by high ambient temperatures, solar heating of the battery enclosure, or heat released by an engine or generator located close by. High battery temperature results in short battery life and should be avoided by ventilating the enclosure and reducing the external heat sources by shading and insulation.

Battery Bank Sizing

Purchase as much battery capacity as possible

Battery size or capacity is just as important as the battery type selected for use with your MS2000 Sine Wave Inverter/Charger. The batteries are the most important part of your system, so Xantrex recommends that you purchase as much battery capacity as possible. A large battery will extend running time and ensure that your inverter/charger delivers full rated surge. Your inverter/charger can be configured to work with batteries from 50 Ah (120 reserve minutes) to 2000 Ah (4800 reserve minutes).

Battery capacity

A number of different standards are used to rate battery energy storage capacity. Automotive and marine starting batteries are normally rated in cranking amps. This is not a relevant rating for continuous loads like an inverter. Deep-cycle batteries use a more suitable rating system, either amp-hours (Ah) or “reserve capacity” in minutes. Battery reserve capacity is a measure of how long a battery can deliver a certain amount of current—usually 25 amps.

For example, a battery with a reserve capacity of 180 minutes can deliver 25 amps for 180 minutes before it is completely discharged. Amp-hour capacity is a measure of how many amps a battery can deliver for a specified length of time—usually 20 hours.

A typical marine or RV battery rated for 100 Ah can deliver 5 amps for 20 hours ($5 \text{ A} \times 20 \text{ hours} = 100 \text{ Ah}$). This same battery can deliver a higher or lower current for less or more time, limited approximately by the 100 Ah figure (50 A for 2 hours or 200 A for 1/2 hour), but usually the capacity figure given is only accurate at the specified rate (20 hours).

The minimum battery size you can use with the MS2000 Sine Wave Inverter/Charger is 50 Ah. However, you can expect performance to suffer with such a small battery. Even if your battery is in excellent shape and is fully charged, you will likely experience poor surge power performance and unsatisfactory operating time with anything but a small AC load. **Xantrex recommends a minimum battery size of 200 Ah for moderate loads (<1000W) and greater than 400 Ah for heavy loads.**

Estimating Battery Requirements

To determine the proper battery bank size, you need to compute the number of amp-hours that will be used between charging cycles. When the required amp-hours are known, size the batteries at approximately twice this amount. Doubling the expected amp-hour usage ensures that the batteries will not be overly discharged and extends battery life. To compute total amp-hour usage, determine the amp-hour requirements of each appliance that is to be used and then add together, or the watt-hours can be totaled and converted to amp-hours.

Start with the nameplate rating of your appliances. If the wattage is marked on the appliance, you can use that number directly. Otherwise, multiply the marked voltage and amperage: $WATTS = VOLTS \times AMPS$.

Once you know the AC wattage drawn from the inverter, multiply that amount by the length of time the appliance will be used to determine the energy the load will require: $WATT-HOURS = WATTS \times HOURS$. You can then convert this to an estimate of the battery amp-hours that the appliance requires.

$BATTERY \text{ AMP-HOURS USED} = AC \text{ WATT-HOURS}/10$ (for a 12-volt battery)

—or—

$BATTERY \text{ AMP-HOURS USED} = AC \text{ WATT-HOURS}/20$ (for a 24-volt battery)

For example, a 100 W light bulb that is used for 4 hours will use 400 watt-hours (Wh) and the inverter will consume approximately 40 Ah from a 12 volt battery, or 20 Ah from a 24 volt battery.

Another useful rule of thumb is that the current drawn from the battery can be estimated from the AC output watts by using these same factors (10 for 12-volt systems, 20 for 24-volt systems). For example, when running an 800 W microwave oven, the inverter will draw approximately $800 \text{ divided by } 10 = 80 \text{ A}$ from a 12-volt battery.

Motors are normally marked with their running current rather than their starting current. Starting current may be three to six times the running current. The specification that is important in determining whether an inverter will start the motor or not is the locked rotor amps. This specification may be abbreviated to LRA or LRI. In general, if the surge capability of the inverter is in excess of the listed LRA, the inverter will start the motor. The MS2000 can surge to 5000 VA for 5 seconds; this means that the MS2000 should be able to start a motor with an LRA of less than 40 A.

If large motors will be started, you may need to increase the battery size to allow for the high start-up demand.

Battery Bank Sizing Example

The following battery sizing example illustrates a typical calculation, assuming an opportunity to charge the battery every three days:

Table 1-1 Battery Sizing Example

Appliance	(A) Power Consumption (Watts)	(B) Operating Time per Day (Hours)	Daily watt-hours needed for this appliance (= A × B)
TV & VCR	200 W	2 hours	400 Wh
Small microwave oven	800 W	15 min = 1/4 hour	200 Wh
3 lamps, 60 W each	180 W	4 hours	720 Wh
Coffee maker	600 W	15 min = 1/4 hour	150 Wh
Hair dryer	1500 W	6 min = 1/10 hour	150 Wh
Total daily watt-hours of AC load			1620 Wh
× Number of days between charges			3
= Total watt-hours of AC load between charges			4860 Wh
Battery Ah used between charges (divide by 10 for 12 volt system; divide by 20 for 24 volt system)			486 Ah
Recommended Battery Bank Size in Ah (multiply by 2)			972 Ah

This example illustrates how quickly your battery needs can escalate. To reduce the required battery bank size, you can either conserve energy by eliminating or reducing the use of some loads, or recharge more frequently.

When sizing your battery, be conservative and resist the temptation to skip the last step of this calculation (multiplying by 2). More capacity is better since you will have more reserve capacity, be better able to handle large loads and surge loads, and your battery won't be discharged as deeply. Battery life is directly dependent on how deeply the battery is discharged. The deeper the discharge, the shorter the battery life.

As your power requirements increase, you may need to use more than one battery to obtain sufficient capacity. Batteries can be connected in parallel, in series, or in series-parallel to create higher capacity systems. It is not recommended to connect batteries from different manufacturers, different types, or that have different amp-hour ratings in parallel. Improper charging and decreased battery life will result. See "Cabling & Hook-up Configurations" on page 52 for more information about battery inter-connection schemes.

Battery Bank Sizing Worksheet

The following worksheet is a guide to help you determine your battery needs. Be generous in estimating the time for which you will run each of the loads to ensure sufficient battery capacity.

Table 1-2 Battery Sizing Worksheet

Appliance	(A) Power Consumption (Watts)	(B) Operating Time per Day (Hours)	Daily watt-hours needed for this appliance (= A × B)
	W	hours	Wh
	W	hours	Wh
	W	hours	Wh
	W	hours	Wh
	W	hours	Wh
	W	hours	Wh
	W	hours	Wh
	W	hours	Wh
Total daily watt-hours of AC load			Wh
× Number of days between charges			
= Total watt-hours of AC load between charges			Wh
Battery Ah used between charges (divide by 10 for 12 volt system; divide by 20 for 24 volt system)			Ah
Recommended Battery Bank Size in Ah (multiply by 2)			Ah

Monthly Battery Maintenance

Read the section “Personal Precautions When Working With Batteries” on page vii prior to working on batteries.



WARNING: Risk of acid burns

Wear appropriate clothing, eye protection, and rubber gloves when carrying out battery maintenance activities



WARNING: Risk of fire, explosions, burns

Use caution when wearing jewellery or working with metal tools around batteries. Do not allow any metal object to contact both battery terminals at the same time. Battery explosion or failure can occur.

-
- Check electrolyte levels in flooded (or wet) batteries.

Flooded (or wet), lead-acid batteries require periodic water refills in each battery cell. Check the level of the electrolyte in each battery cell at least once a month. The level should be above the top of the plates, but not completely full. (Most batteries have a plastic cup that just touches the electrolyte when the cell is full.)

Refill the batteries with distilled water only. “Spring” water and regular tap water may have high mineral levels which can poison the battery chemistry and reduce battery life.

When filling the battery, clean the surface first to prevent dirt from entering the cell. Fill the cell to just above the plates.

Don’t overfill the batteries, or the electrolyte will leak out when the batteries are being charged.

Check the water level in the batteries frequently when performing an equalize charge and add water if necessary.

- Check battery connections for good contact with the terminals. See “Checking battery connections” on page 50.
- Maintain battery terminals. See “Reducing corrosion on battery terminals” on page 51.
- Check specific gravity with hydrometer.

Make sure readings are in accordance with the battery manufacturer’s specifications.

Preparation for Cleaning Batteries

Dirty batteries can leak current and tend to run hotter. Ultimately, this affects the performance of your inverter/charger, resulting in inefficient inverting and incomplete charging. Cleaning batteries when necessary is easy and safe when you follow these instructions.

Gather what you need before beginning the procedure. The appropriate clothing, tools, equipment, and supplies are listed as follows.

Clothing

Appropriate clothing could include old clothes, rubber boots, or old shoes. Battery acid is highly corrosive, so wear something you can discard just in case you splash some acid on yourself. Be sure to wear rubber gloves and eye protection.

Tools

- Adjustable wrench or appropriately sized ratchet and sockets for battery terminals
- Adjustable and/or locking pliers
- Torque wrench (suggested, not required)
- Soft-bristled brush (a discarded toothbrush works fine)
- 6" scrub brush
- Inexpensive 1/2" chip brush or soldering brush
- Hydrometer

Equipment

- Eye protection
- Rubber gloves
- Water hose with spray nozzle or five gallon watering bucket
- Empty spray bottle

Supplies

- Baking soda (Always keep on hand in the event of a spill.)
- Hand cleaner or soap
- Towel
- Liquid neoprene or white lithium grease (Available at automotive parts stores, battery suppliers, RV and marine stores.) Use only after reattaching cables.

Maintaining and Cleaning

Follow the appropriate procedures for maintaining and cleaning the:

- battery enclosure
- battery terminal and cable lugs
- battery cables



WARNING

Review the “Important Safety Instructions” on page v before you begin.

Battery Enclosure and Batteries

The battery enclosure should be cleaned as required; for example, if you see liquid on the battery. Also wipe off the top of batteries.

Mix four ounces of baking soda with a gallon of fresh water. Fill a spray bottle with the solution. Spray the solution on all exposed surfaces of the battery compartment, and wash down the exposed surfaces of the batteries and their enclosure. Scrub stubborn areas with the scrub brush. Baking soda will neutralize any acid that may have collected on these surfaces. Finish by rinsing with water.

Terminals & Lugs

Checking battery connections

Periodically check the battery connections for corrosion and tightness of battery terminals and cable lugs. Check every time you perform battery maintenance.

Loose battery terminals and cable lugs exposed to open air corrode rapidly. The corrosion appears as a white powder or granular foam on the terminals and on any nearby exposed metal parts. This is actually a crystallized form of sulfuric acid. If the corrosive contacts your skin, it will cause burns unless you rinse it off immediately. Most textiles that are exposed to this corrosive eventually dissolve.

The most common cause of battery system failure is loose or corroded battery terminals and cable lugs. If any white powdery residue forms between the battery cable lug and the battery terminal, remove the cable for cleaning. When it is necessary to detach a battery cable from the battery, disconnect all loads and charging sources. Using the appropriate tool, remove the negative (–) battery cable first and re-install it last.

To remove any stubborn residue, sprinkle baking soda directly on the area, and scrub with a wet toothbrush (or other soft-bristle brush). Ensure that all caps are on tight so the solution doesn't enter the battery. Add water as required and then rinse the top of the battery with clean water.

Reducing corrosion on battery terminals

Reconnect the battery cable terminals to the battery cable lugs and tighten to battery manufacturer's specifications. If you do not have a torque wrench, use an appropriate tool to tighten the bolts reasonably snug. Do not over-tighten.

After tightening the cables, evenly coat all of the exposed metal surfaces of the battery terminals and cable lugs with liquid neoprene (liquid electrical tape). Do not apply anything between the battery terminal and the cable lugs; the connection should be metal to metal.

The liquid neoprene cures to form an airtight protective layer and reduce the amount of corrosion on the battery terminals. If liquid neoprene is not available, use a light coating of white lithium grease or other sealant.

Battery Cables

Inspect all of the battery cables for missing or damaged insulation or loose connections. Inspect any openings that the cables pass through. All such openings must be equipped with a rubber grommet or conduit to prevent chafing on the battery cable. If necessary, replace worn grommets. If the cable insulation is worn, replace the battery cables.

Cabling & Hook-up Configurations

Several smaller batteries can be connected to create a battery bank of substantial size. You can connect batteries in three ways: in parallel, series, or series-parallel.

To make a larger battery bank, connect individual batteries with heavy cables. The actual size of the cable depends on whether the batteries are connected in parallel or series. Generally, the cable should not be smaller than the inverter cables—if the main cables are 4/0 AWG, the battery interconnects should be 4/0 AWG.

The best configuration is to connect the batteries in series and parallel. This requires additional cables, but reduces imbalances in the battery bank and can improve the overall performance. Consult your battery supplier for more information regarding the hook-up configuration required for your system.

Parallel Connection

Batteries are connected in parallel when all the positive terminals of a group of batteries are connected and then, separately, all the negative terminals are connected. In a parallel configuration, the battery bank has the same voltage as a single battery, but an Ah rating equal to the sum of the individual batteries. See Figure 19.

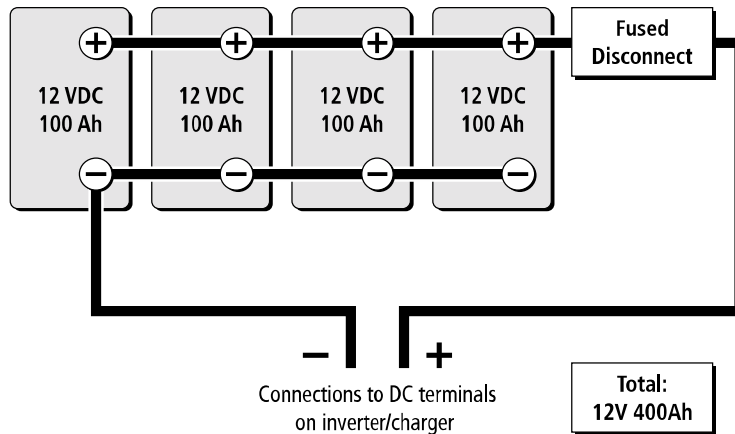


Figure 19 Batteries Connected in Parallel

Series Connection

When batteries are connected with the positive terminal of one battery to the negative terminal of the next battery, they are connected in series. In a series configuration, the battery bank has the same Ah rating of a single battery, but an overall voltage equal to the sum of the individual batteries. See Figure 20.

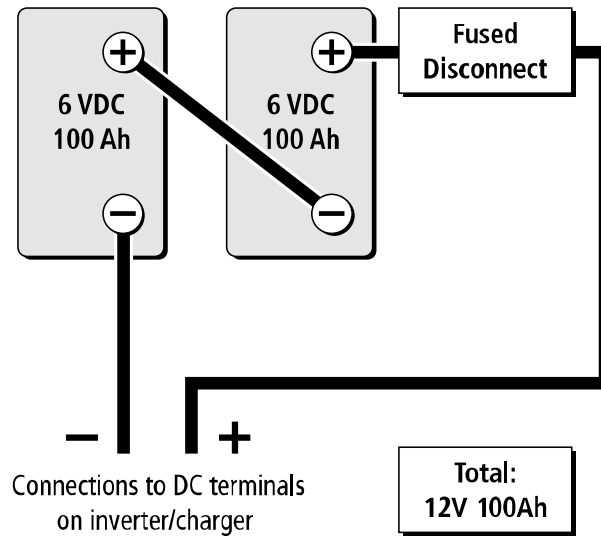


Figure 20 Batteries Connected in Series

Series-Parallel Connections

As the name series-parallel implies, both the series and parallel configurations are used in combination. The result is an increase in both the voltage and the capacity of the total battery bank. This is common with all battery-inverter system voltages. The smaller, lower voltage batteries are first connected in series to obtain the necessary voltage, and then these “batteries connected in series” sets are connected in parallel to increase the battery bank capacity. See Figure 21.

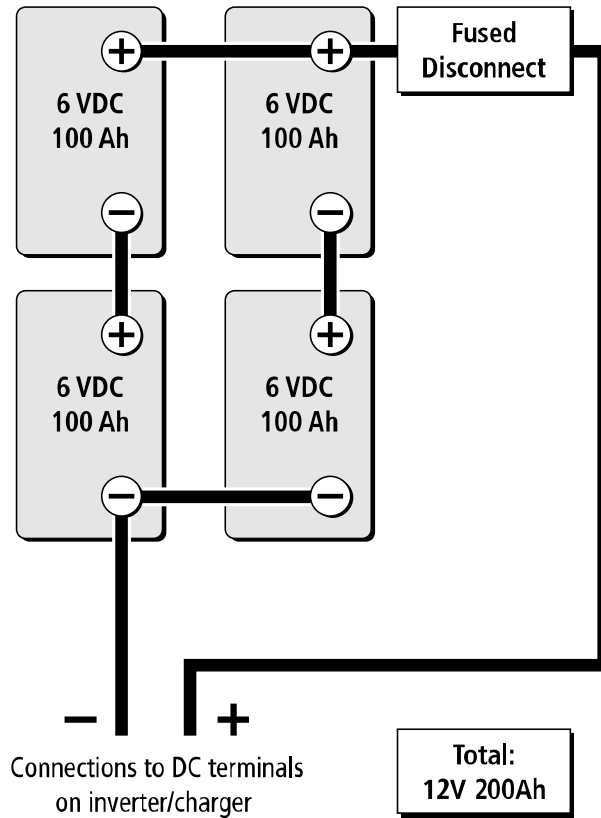


Figure 21 Batteries in Series-Parallel Connections

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